

**Atmosphere as a means of governing life:
weather modification and ecological conservation in
Sanjiangyuan, China**

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Thesis submitted in fulfilment of the requirements for the degree of Doctor of
Philosophy in Geography and the Environment

Hertford College
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2023

Abstract

Prominent advocates suggest that weather modification and geoengineering are crucial in addressing environmental changes in the Anthropocene, yet their practices and politics are under-examined. To fill this gap, this research explores the weather modification policies and practices in China, and develops a conceptual framework to understand the atmospheric governance. From data collected through the fieldwork in Qinghai province, this analysis of atmospheric governance is developed through four chapters. The first analytical chapter provides an overview of weather modification drawing on literatures on ‘environmentalities’, in which life is governed by modulating the environment. Based on a historical analysis of weather modification in Qinghai, it argues that atmospheric environmentality cannot be conceptualised as a singular form, but instead as variegated modes of governance with different temporalities and subjects. The remaining three analytical chapters tackle three key characteristics of atmospheric governance: focusing on its embodied, epistemic and affective dimensions. Chapter 5 emphasises the practices through which meteorologists attune to the dynamics of the weather—with what I call a weather choreography—to make the atmosphere palpable and modifiable. In Chapter 6, I pay attention to the politics of epistemology and discuss how differences between meteorologists and hydrologists in comprehending the volume of the cloud water lead to different geopolitical implications. Chapter 7 brings together the meteorological and affective senses of the atmosphere for understanding weather modification governance. I show how the policies and practices of weather modification in China have been associated with optimistic projections that convert humanised rain into hope from the air. In conclusion, I summarise the chapters’ insights to propose a conceptual framework for atmospheric governance and discuss how my analysis contributes to debates on proactive interventions in the Anthropocene.

Acknowledgements

First, I would like to express my gratitude to the Ministry of Education of Taiwan and the China Times Cultural Foundation for their generous financial support. Without their funding, this research would not have been possible. I would like to extend my appreciation to my supervisor, Prof. Jamie Lorimer, for his motivational guidance, support, and encouragement throughout the research process. His insightful suggestions and constructive feedback have been invaluable for this thesis. I am also grateful to the assessors of my transfer and confirmation of status, Prof. Anna Lora-Wainwright and Prof. Derek McCormack, for their insightful feedback and comments, which have been very helpful in the development of this thesis. Furthermore, I would like to express my special appreciation to Zhou and Wang, who provided me with crucial support during my fieldwork in Qinghai, China. Without their help, my fieldwork would have been much more challenging. I am also grateful to Prof. Shih-Shen Chien and Prof. Po-Hsiung Lin at National Taiwan University. The research collaboration with them was an important starting point for this doctoral research. I would like to thank Dr. CH Wang, Dr. HY Lu, and Dr. SM Huang from the NTU reading group for their comments on my research proposal. This research would not have been completed without the help and advice of these people, but any remaining errors or omissions are solely my responsibility.

The pursuit of a doctorate degree is a long journey and I am grateful for the companionship and encouragement of many people along the way. They have made this journey more than just a time of studying and writing, but also a period filled with joy and cherished memories. I would like to express my gratitude to my friends who were also pursuing their doctoral degrees at the University of Oxford and other institutions around the world, including Changsoon, Chojie, Josh, Yoonai, Yu-Kai, Jo-Tzu, Jun-Jay, and Kun-

Han. They provided not only academic discussions but also helpful advice for my daily life. I would also like to thank my friends who lived and travelled with me in the UK, including Ying-Yi, Cynthia, Garey, Yi-Shin, Yu-Jou, and Ming. We created many happy and unforgettable memories together. I am also grateful for my friends in Taiwan, including Kang-Li, Rou-Wen, Hsiao-Fei, Meng-Ling, Jia-Rong, Yun-Ching, and Li-Te. Their companionship made my entire doctoral journey much less lonely. Finally, I would like to express my appreciation for the unwavering support of my family, who have been an important anchor and refuge in my life and spirit.

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Chapter 1

On Proactive Atmospheric Governance

ROMAN (*anxious*): *'How do we stop him?'*

CHRISTOF (*glancing to Simeon*): *'How else?'*

Christof nods to controls on the mixing desk marked, 'WIND' and 'RAIN'.

Storm clouds roll towards Truman's boat at an alarming speed. He looks back towards the Seabaven skyline, rapidly receding behind him. Doubts invade Truman's head but he shuts them out and steers into the teeth of the storm - a look of resolve in his eyes we have never witnessed before.

Moses and Roman pace at the back of the control room. Christof is focused on his monitor. Like Truman, he steels himself for a fight.

CHRISTOF: *'Cue music...'*

SIMEON (*hesitant*): *'What music?'*

CHRISTOF (*irritated*): *'Storm music...Wagner...'*

Nicol (1998) THE TRUMAN SHOW: A Screen Play

1.1 Proactive Atmospheric Interventions

This excerpt portrays the climax of the film, *The Truman Show*, where Christof, the director of a reality TV show, creates a storm using a weather-manipulating machine to stop Truman Burbank, the protagonist and the only ‘real man’ in the show, from escaping. The film highlights the inseparability of nature and society, as Truman discovers that he is living in a hyper-artificial environment. All of Truman’s social relationships, including his ‘parents’ and ‘wife’, are portrayed by actors, and the ‘natural’ environment, such as sunlight and weather, is generated by halogen lamps and other machines controlled by the show’s director. The film’s central tension arises from the contrast between the real/natural environment and the artificial/controlled one. In the film’s final scene, the protagonist realises the artificiality of his surroundings and decides to return to the real world. However, for people living in the Anthropocene, where the distinction between natural and humanised atmospheres is blurred, the implications are the opposite of the film. Suppose there was a sequel to the film set in the not-so-distant future, say, *The Truman Show 2050*. In that case, the protagonist’s experience after escaping the controlled weather in the artificial environment would be similar: a highly humanised Earth atmosphere and an intervened climate.

Currently, most international discussions and considerations on addressing anthropogenic global warming and climate change focus on mitigation measures such as carbon reduction. The transformation toward net-zero carbon emissions has become the core agenda for international agreements between sovereign countries (Van Soest et al., 2021) and multinational businesses (Kolk, 2015). However, proactive measures that directly intervene in atmospheric conditions have also been implemented at various scales and require more attention. Humans have a long history of attempting to intervene in and control the

weather (Fleming, 2010), making it an inevitable topic for considering the climate issue in the modern world. Marvin and Rutherford (2018) argued that ‘microclimate control’ has become a crucial means of supporting reliable environments to ‘ensure the ecological and economic reproduction of urban life’ (p. 1153). These proactive atmospheric controls are enacted on multiple spatial scales. For example, McNeill (2019) suggested that air conditioning is a critical technology for tropical countries to maintain urbanism and extract value from urban space. The more frequent and severe heatwaves occurring in mid-latitude areas also show that the importance of this ‘atmospheric engineering’ (McNeill, 2019) is not limited to tropical regions.

Attempts at atmospheric control also occur at larger scales. Hong and Chien (2018) pointed out that wind direction and strength have become considerations in urban planning schemes to address various urban atmospheric problems such as the heat island effect and pollution. At the planetary scale, geoengineering has become a buzzword in the climate change discussion and is considered a Plan B for warming issues if other mitigation plans fail (Corry, 2017; Keith, 2000). As suggested by Marvin and Rutherford (2018), ‘microclimatic governance’ aimed at creating specialised microclimates is ‘emerging in specific response to the ecological changes of the Anthropocene’ (p. 1143). These atmospheric interventions and controls, which will certainly bring new bio- and geo-political tensions (Dalby, 2015; Yusoff, 2013), are particularly worthy of further discussion.

This thesis aims to contribute to the growing discussion on proactive atmospheric interventions. In her latest book, Furuata (2022) uses the idea of ‘climate media’ to refer to the technologies and processes through which atmospheric controls are operated. Furuata extends the concept of media to also include the materiality of elements that shape the atmosphere as well as the technologies for producing and modifying weather.

This conceptualisation of climate media highlights two key aspects at the core of the study of proactive atmospheric interventions. First, these interventions proactively engage in technologies and processes to shape the condition of the atmosphere. Unlike mitigation and adaptation measures, which consider the atmosphere as the outcome and condition of actions, proactive interventions aim to treat the atmosphere as the target of manipulation. Second, these interventions not only mediate control over atmospheric materiality but also mediate governance over various forms of life through the manipulation of atmospheric conditions. While the former was at the core of Furuhashi's book, the latter was not explicitly addressed in her discussion. In this thesis, my aim is to explore this alternative form of governance of life by controlling the atmosphere. I argue that measures and technologies of atmospheric intervention should not be understood simply as 'media' that mediates control over atmospheric materiality. Instead, it is crucial to see how certain forms of atmospheric intervention emerge with and are embedded within particular governance regimes. Through discussing proactive atmospheric interventions, I explore the particular form of governance that is operated through modulating the atmosphere.

1.2 Two Gaps in Atmospheric Intervention Research

Geoengineering is the ultimate form of proactive atmospheric intervention. While the implementation of geoengineering requires a thorough scientific examination of its technical feasibility and efficacy, most geoengineering scholars agree on the political complexity and potential tensions underlying this 'intentional large-scale manipulation of the environment' (Keith, 2000, p. 245). However, although many studies have focused on the governance aspects of atmospheric intervention, I suggest that there are two aspects

that have not yet been adequately addressed: the *scalar* gap and the *empirical* gap in the examination of governance issues of proactive atmospheric interventions. In referring to scalar gap, I refer to the existing literature's excessive emphasis on planetary- or international-scale governance regimes. Little attention has been paid to how a particular sovereign state and its political characteristics might inform various approaches to geoengineering. The empirical gap indicates a lack of material on the practical and operational aspects of atmospheric interventions in existing studies. In the following section, I will discuss the causes and concerns of these two gaps and suggest alternative research perspectives to fill them.

To begin with, the scalar gap is the result of an intuitive assumption that climate interventions must be founded and operated on a global scale. It is undeniable that climate change is a global phenomenon and that no person living on the planet can escape its influence. Based on the ubiquity of climate issues, Wainwright and Mann (2013, 2018) suggest that 'planetary sovereignty' will become a pivotal entity for dealing with and governing the global climate. They argue that the responses to the changing climate require collective and cumulative international actions that will lead to the rise of planetary sovereignty—or the climate Leviathan, as they call it. In other words, the need to implement global actions to respond to climate challenges becomes the 'lifeblood' (Wainwright & Mann, 2013, p. 6) of the Leviathan through which planetary sovereignty is bred.

This scalar assumption is certainly true for mitigation and carbon reduction measures, as they require aggregated efforts to be effective. Carbon reduction would not be as successful as expected if major emitting entities withdrew from international mitigation targets such as the Paris Agreement. Many studies have accepted this scalar assumption

and have emphasised transnational mechanisms when considering the politics of geoengineering. For example, Blackstock and Long (2010) paid particular attention to ‘international approval’, suggesting that geoengineering programmes should be conducted through inclusive international collaboration and communication in order to avoid a global crisis of legitimacy. Similarly, Humphreys (2011) also emphasised the importance of multilateral processes to address potential international conflicts and the unequal distribution of risk caused by geoengineering. As Corry (2017) succinctly put it, these discussions accepted a ‘heroic assumption’ of a rational and harmonious international system through which global conflicts can be solved, and geoengineering programmes can be cooperatively implemented.

For proactive atmospheric interventions like geoengineering, however, the requirement of aggregated effort does not exist. Compared to the mitigation agenda, not only does geoengineering not require collective action to work, but it is also much less expensive (Barrett, 2008) and is technically more feasible (Victor, 2008) for a single country to undertake unilaterally. This feasibility of unilateral action, as Bodansky (2013, p. 540) suggests, provides an ‘additional allure’ to sovereign states that are reluctant to engage in international cooperation. In other words, the low costs and global effects of geoengineering allow individual countries to respond to the global climate challenge without engaging in a multinational decision-making system. However, despite pointing out the potentially unilateral nature of geoengineering, these studies did not provide an alternative analytical angle on the politics of geoengineering with a different scalar perspective. Some scholars have tried to address this scalar complexity by suggesting a generalised procedural principle for governing all possible attempts at geoengineering experiments and future operations (Macnaghten & Owen, 2011). However, as Wainwright and Mann (2013) correctly pointed out, the question of implementing climate governance

must be a question of sovereignty (see also Abraham, 2020). The atmospheric intervention cannot be conceptually separated from the political regime in which it is rooted (Buck, 2019).

Wainwright and Mann's (2013, 2018) focus on sovereignty provides a useful framework for analysing the politics and governance of climate challenges. However, their emphasis on the planetary scale also creates a blind spot when analysing actions such as geoengineering and other proactive atmospheric interventions. To address this, Bellamy and Palmer (2019: p. 524) pointed out that the debates about geoengineering experimentation would benefit from 'recognising incumbent spatial and scalar categorisations (e.g., small scale vs. large scale, indoors vs. outdoors) not as fixed ontological anchors, but as relational and provisional constructs.' In this context, traditional sovereign countries remain a crucial analytical unit for understanding proactive atmospheric interventions, particularly in the case of authoritarian superpowers like China. On the one hand, China's growing economic strength allows it to become a geological force with an inevitable influence on the global atmosphere (Bennett, 2022). On the other hand, its authoritarian characteristics make it more likely to adopt measures such as geoengineering (Victor, 2008).

The concern about authoritarianism was reflected in Wainwright and Mann's (2013) conceptualisation of the two theoretical paths of climate governance sovereignty: the neoliberal capitalist climate Leviathan and the authoritarian communist climate Mao. Their distinction between the two theoretical paths of climate governance highlighted the close relationship between a particular political regime and the climate governance derived from it. However, as Abraham (2020) pointed out, Wainwright and Mann did not provide further assessment and discussion on how an authoritarian regime like China may inform climate governance differently from its neoliberal capitalist counterparts. This lack of focused

discussion on how atmospheric interventions are informed by a particular sovereign country is the first gap that I aim to fill in this thesis. The absence of analysis on specific countries also leads to the second gap that I will address.

The second gap in the existing literature on the politics of geoengineering is a lack of empirical cases that allow the study of the practical aspects of atmospheric governance. In Western countries, most geoengineering programmes are based on computer modelling and simulation, and only a few preliminary experiments have been planned. These experimental attempts, such as the Stratospheric Particle Injection for Climate Engineering (SPICE) study in the UK, are often controversial and have faced opposition. Despite being supported by the UK Engineering and Physical Sciences Research Council, the SPICE experiment was postponed due to public concerns and opposition (Macnaghten & Owen, 2011). Empirical studies of such cases provide material for examining the politics of decision-making and procedural requirements. However, focusing solely on this aspect risks missing crucial elements of the politics of atmospheric intervention.

First, while the procedural perspective addresses the criteria for governing geoengineering, it overlooks the fact that atmospheric interventions are not just subject to governance but are also a form of governance. The procedural perspective focuses on the question of ‘who should decide if and under what circumstances geoengineering should be used’ (Barrett, 2008, p. 45), but it is also important to consider the questions of why and how geoengineering and other forms of atmospheric intervention are carried out in certain ways. In other words, it is essential to analyse and understand how certain atmospheric interventions are used as a means of governing life. Examining atmospheric interventions from this perspective requires empirical cases that reveal how these practices are intertwined with political regimes.

Secondly, examining the techno-politics of geoengineering—the technologies used to intervene in the atmosphere—is as crucial as understanding its procedural politics. As many science and technology studies have shown, power relations and political tensions are present not only in decision-making processes regarding the use of technology but also in the processes of knowledge formulation and scientific practices. A study of the politics of geoengineering should not be limited to the political effects of atmospheric governance. Rather, it should also pay attention to how different forms of scientific knowledge and discourses of atmospheric intervention are generated and how these epistemic differences shape the technological practices used to intervene in the atmosphere. This approach requires empirical research on the production of knowledge and scientific practices in atmospheric intervention rather than merely studying the politics of decision-making processes.

Third, atmospheric interventions as a form of governance involve both the manipulation of the meteorological atmosphere and the modulation of the affective milieu. As many scholars have noted, the meteorological and affective aspects of the atmosphere should not be understood as distinct entities, as the governance of both aspects is often inseparable (Anderson, 2012; Choy, 2011; McCormack, 2008a; Sloterdijk, 2009). In the case of atmospheric interventions, the entanglement of the meteorological and affective atmospheres can be seen in how practitioners were affectively attuned to the milieu they were modifying. In *The Truman Show*, the weather was controlled with various emotions. The artificial storm was generated along with an affective atmosphere that was composed of crew members' hesitation and anxiety and the director's anger. The director's intent when pressing the button was not to create a pure meteorological phenomenon but rather to create an atmosphere that was both meteorologically and affectively furious and

terrifying for both Truman and the viewer. In order to gain a deeper understanding of the affective politics of atmospheric intervention, empirical cases must exceed the scope of current research on the politics of geoengineering.

To summarise, I argue that there are scalar and empirical gaps in current research on the politics of geoengineering and other forms of atmospheric intervention. These gaps obscure the understanding of some crucial aspects of atmospheric governance. On the one hand, they fail to acknowledge the central role of the sovereign state and how the particular political regime of sovereignty shapes the way the atmosphere is disrupted and governed. On the other hand, a lack of empirical cases on the actual practices of geoengineering limits our understanding of the epistemic and affective politics of atmospheric intervention. The goal of this thesis is to fill these gaps in the literature. In the following section, I will explain the approach this thesis takes and how it addresses the aforementioned issues.

1.3 Thesis Approach: A Weather Modification Study

To address the research gaps mentioned in the previous section, I chose weather modification—another emerging form of atmospheric intervention—as the research topic rather than geoengineering. Weather modification is a collective term that encompasses a range of meteorological techniques used to modify a region’s weather phenomena by enhancing or suppressing clouds, rain, snow, hail, fog, and so on. Cloud seeding, which enhances precipitation, was one of the earliest methods developed and is now the most widely used. Techniques for cloud seeding have been developed and implemented since World War II and have mainly been used to increase and secure water supplies in dry

regions in the late 20th century (Kwa, 2001). However, cloud seeding has also been experimentally implemented for various purposes other than water security, including dealing with chemical leaks and explosion accidents (Meng et al., 2017), combating haze (Linh, 2019), and preventing forest fires (Yulisman, 2020), with China leading in the use of this technique.

In the last two decades, China has undergone rapid urbanisation and economic growth, as well as the increasing implementation of environmental measures and technologies to address worsening environmental issues. Scholars refer to this as China's ecological modernisation (Mol, 2006; Rock, 2010). The Chinese government's primary goal for environmental governance is to maintain state legitimacy and consolidate state power through the use of modernisation discourses and technologies (Moore, 2014). In 2007, the Chinese government introduced the concept of 'ecological civilisation' to emphasise the importance of environmental governance and sustainability as part of the Chinese nation's modernisation (Pan, 2016). This concept further became an important ideological guideline for the Chinese political system when it was included in the Chinese Communist Party's Constitution in 2012. As a result, local governments are required to establish their environmental and ecological policies to demonstrate their political achievements¹.

¹ Under the banner of 'ecological civilisation', provincial governments in China have begun to allocate resources towards environmental protection policies. One of the most notable of these is the 'redlines policy', which places restrictions on various environmental indicators (Jiang et al., 2019). However, ecological civilisation is not merely a restrictive environmental protection policy. Local governments also use this concept to initiate development-oriented 'ecological constructions'. According to Hong et al. (2020), much of the ecological construction conducted by Chinese local governments is still based on the principles of economic development, and its implementation relies on trade-offs between different environmental indicators. For example, the protective redline for plain farmland is balanced with the increased urbanisation of hill lands.

As part of this trend, the Chinese government has extensively implemented weather modification over the past two decades. The Weather Modification Office, an official establishment within the Meteorological Bureau in China, regularly performs weather modification for various purposes, such as ecological conservation, water security, and improved food production. This study specifically focuses on weather modification carried out for the purpose of ecological restoration. This type of weather modification is mostly conducted in the relatively dry western and northern provinces of China (see Figure 1). Due to excessive human use and climate change, these regions are facing environmental degradation, including vegetation and water body reduction, as well as desertification. Weather modification was implemented in 1997 in Qinghai Province as an experiment in response to a severe drought in northern China which caused the Yellow River to dry out. Since then, weather modification has been regularly implemented in these areas as one of several strategies for environmental restoration. In these areas, weather modification is not only aimed at atmospheric intervention but also serves as a means of governing life. This long-standing and regular practice of weather modification in China provides ample empirical material for investigating the research questions posed in this thesis.

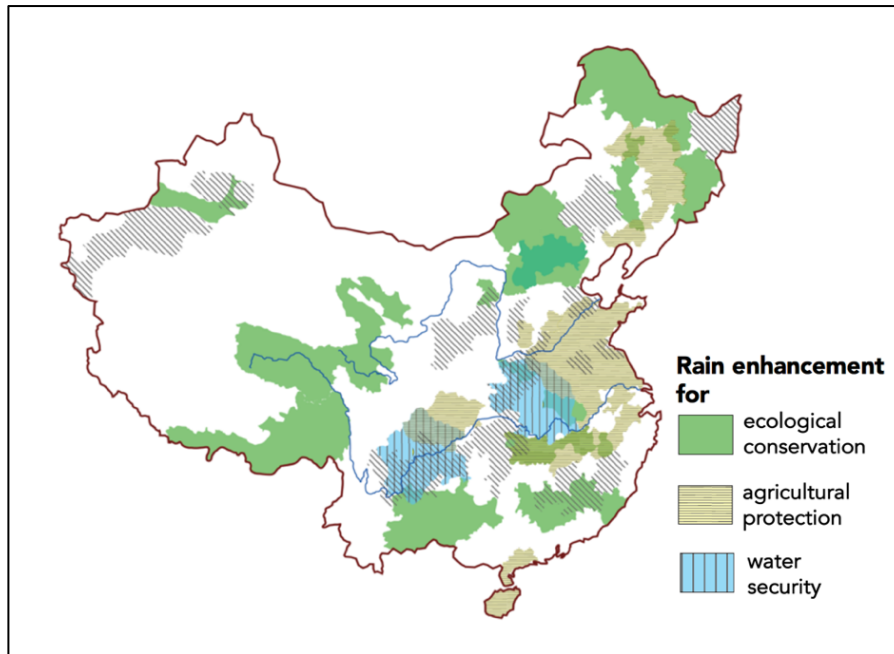


Figure 1. Weather modification operations in China

Source: Chien et al. (2017)

Using weather modification practices in China as an empirical case for understanding atmospheric governance comes with two advantages. First, as a technology that has been developed and implemented for many decades, weather modification can provide abundant material on the history and evolution of techniques, knowledge, and discourse. The widespread use of weather modification in China provide further demonstrates how weather modification technology was arranged under different governance scenarios. This thesis explores and analyses the techno- and affective politics of proactive atmospheric interventions and how these interventions have become a means of governing life. The empirical case of Chinese weather modification allows for a deeper analysis of the manipulation of the atmosphere as a form of governance. This research does not simply view weather modification practices as a measure of controlling the meteorological atmosphere per se. Instead, the thesis considers the modification of the weather in China as a broader governance regime. Within this form of governance, subjects are governed

through intervention in the atmosphere where they live. By exploring the empirical case of weather modification in China, this study takes an analytical perspective that brings the intention of a sovereign state to control the atmosphere together with its attempt to govern society.

1.3.1 Research Aims

The aim of this study is to examine the practices and politics of modulating the atmosphere as a means of governing life via an empirical case of weather modification in China. This approach engages with the current body of work in human geography and anthropology concerning the relationships between humans and the atmosphere in the Anthropocene (Choy, 2011; Ingold, 2010; McCormack, 2018) and emerging modes of governance of and through the humanised atmosphere (Sloterdijk, 2009; Wainwright & Mann, 2018; Zee, 2020). With its interrogation of the practice of weather modification, this study provides an empirical basis for a detailed discussion of the modulation of the atmosphere. As such, it not only engages in epistemological debates about the knowledge and discourse of atmospheric manipulation but also interrogates the actual practices of these processes, which are rarely described in the existing literature on proactive atmospheric interventions. It contributes an understanding of the weather modification knowledge, discourse, and practice through which different forms of life are governed, and leads to a reflection on the political implication of atmospheric intervention and the ethics of living with and within an intervened atmosphere in the Anthropocene.

1.3.2 Research Questions

In order to address the conceptual gaps in existing research on the politics of atmospheric intervention, this thesis interrogates the empirical case of weather modification in China with the main research question:

- (1) How did weather modification become a new form of governance which governs life through manipulating the atmosphere in China?

Following this ontological interrogation on how the modification of the atmosphere has become a means of biopolitical governance, I further explore three subsidiary research questions to understand the techno- and affective politics of governance:

- (2) How is weather modification informed by the practices of meteorologists?
- (3) How do scientists understand the volumetric characteristics of weather modification, and how do different epistemic understandings of volume affect weather modification?
- (4) How does the modification of the meteorological atmosphere in China also work as a way to govern the affective atmosphere, and what forms of affective politics are enacted through weather modification?

By answering these research questions, my goal is to establish a conceptual framework for understanding proactive atmospheric governance. The purpose is not only to provide a perspective solely for understanding China's weather modification. More importantly, I aim to address the two aforementioned fundamental gaps in studies of atmospheric interventions that I mentioned earlier. Specifically, I aim to illustrate how the politics of atmospheric interventions must be viewed through the embodied, epistemic, and affective aspects of practices and how these are deeply embedded within the political regime of a sovereign state.

1.4 Outline of the Thesis

The thesis is structured into eight chapters to fulfil the research aims and to address the research questions.

In Chapter 2, I bring together literature across human geography, anthropology, and science and technology studies and review the theoretical materials that I use to address the research questions. I propose a conceptual framework identifying four key aspects for understanding weather modification. To address my first research question, I discuss and develop the concept of atmospheric biopolitics, a mode of biopolitics that functions through atmospheric control. Second, I review two groups of literature to examine the techno-politics of weather modification. In doing so, I first review the idea of embodiment in scientific practices and how the embodied experience can inform meteorological practices and affect how weather is modified. Then, I outline the academic discussion on volume and discuss how epistemic differences in understanding volumetric materiality could lead to distinct forms of atmospheric intervention. The fourth area that I review in Chapter 2 involves the affective aspects of atmosphere and meteorological control. Moreover, I outline the scholarly discussion on the affective aspects of authoritarianism in China. Together, this review on affect provides the conceptual materials to address the fourth research question of this thesis.

In Chapter 3, I introduce the methodological approach that I used to conduct this research. I explain and justify my choice of fieldwork site in the Qinghai province and describe the three main methods used to collect data—namely, elite interviews, participant observation, and archive collection. I also explain how I analysed the data to address the research questions and reflect on my positionality and the limits and the ethics of this research.

After introducing the conceptual and methodological context of the research, this thesis proceeds to four analytical chapters (Chapters 4 through 7) addressing the four research questions. Chapter 4 addresses question one; Chapters 5 addresses question two; Chapter 6 address question three; and Chapter 7 addresses question four. Below, I will briefly describe the contents and arguments of the four analytical chapters.

In Chapter 4, I explore the question of how and why meteorology (and weather modification) became ecological in China. To address this question, I trace the historical trajectory of the development of weather modification in Qinghai and determine how weather modification articulates with different ideas of being ecological over different periods. In doing so, the goal is to unpack how the linkages between ‘rain’ and ‘ecological measures’ emerged, were consolidated, and evolved. The historical perspective reveals three meteorology-ecology formulations in which different ecological and meteorological aims were enacted and emphasised. First, weather modification was used as an experimental *emergency fix* to tackle individual environmental hazards such as drought. Second, weather modification was conducted as a *tool for restoration* for reversing and restoring some particular aspects of the ecosystem. Third, weather modification was extended to be an *infrastructure* for securing the ecology and the living environment. These three modes of linkage, I suggest, show the historical development of how meteorology in China became discursively and institutionally ecological. They also indicate different forms of environmentality (Anderson, 2012; Braun, 2014; Gabrys, 2014), thereby providing a framework for understanding the relationships between meteorology and ecology in the Anthropocene and for tracing the various ways through which the manipulation of the atmosphere involves the governance of life.

In Chapter 5, I scrutinise the practices of weather modification and explore the ways in which the atmosphere became palpable to be modified. What does it mean to think of the weather as palpable and as something that can be touched? While all humans experience the weather, touching raindrops or snowflakes is different from touching the atmosphere as an entire entity. Weather and the atmosphere cannot be easily conceptualised and comprehended as an entity-like whole (McCormack, 2018; Morton, 2013). In this chapter, I suggest an understanding of the practice of weather modification not simply as a process in which meteorologists use equipment and devices to intervene in an objectified atmospheric process. Instead, weather modification is conceptualised as a choreography through which the palpability of the atmosphere emerges from meteorologists' embodied attunement to the atmosphere. Just like ancient rainmakers attempted to alter the weather through a particular bodily performance, modern meteorologists touch the atmosphere through certain spatiotemporal arrangements of their bodies and devices, work, and lives. I begin Chapter 5 by introducing the spatial and temporal features of weather modification technologies and then go on to discuss how the modern rain dance is choreographed. First, I demonstrate how meteorologists arrange the presence of their bodies and devices in space and how different modes of presence choreograph the variegated spatiality of weather modification. Second, I discuss the temporality or *rhythm* of the weather modification choreography by showing how meteorologists attune with other natural and social rhythms and how this (dis)attunement informs weather modification practices.

In Chapter 6, I pay attention to the politics of epistemology and discuss how differences between meteorologists and hydrologists in perceiving and comprehending the volume and volumetric features of cloud water lead to different practical and geopolitical implications for weather modification. This chapter begins with narrating a scientific debate that occurred during the time of my fieldwork between two groups of

meteorologists and hydrologists. Both scientific groups have research projects studying and experimenting with weather modification at Sanjiangyuan. However, the way they understand the atmosphere and weather modification are significantly different. While meteorologists have criticised hydrologists for being ‘non-practical and realistic’, hydrologists have argued that the issue should be approached from a different scale than that taken by meteorologists. This scientific contest not only reflects the political tension between different scientific groups competing for the resource and discursive power of weather modification, rather, I argue that the distinction between Chinese meteorologists and hydrologists also shows their epistemic differences in perceiving volume and the volumetric features of atmospheric water. These epistemic differences lead to variegated methods, goals, and ways of evaluating weather modification. By comparing the differences between these groups, this chapter provides an epistemological rumination on the volumetric characteristics of atmospheric water and how different understandings of the atmosphere inform different ways of conducting and/or evaluating weather modification.

Chapter 7 explores the meteorological and affective aspects of the concept of atmosphere in order to better understand weather modification governance. By showing how the policies and practices of weather modification in China have been associated with optimistic projections, I argue that Chinese weather modification is not merely governance of the meteorological but also the affective atmosphere. This atmospheric governance is deeply connected with the Chinese authoritarian regime. By attaching optimistic and hopeful attributes to the meteorological atmosphere, the humanised rain transmits a feeling of hope and symbolises the competence and optimistic future of the techno-nationalist state. This chapter shows that the government’s attempt to modify the meteorological atmosphere in China cannot be understood without examining their

intentions to manipulate the affective atmosphere. Under this atmospheric governance, both the meteorological and affective aspects work together as one form of governing life.

In Chapter 8, I provide a conclusion to the thesis by bringing together the discussions and analyses from the previous chapters. Moreover, I summarise how the research findings address my research questions. I then explain how the discussions presented in the thesis form a conceptual framework for comprehending this novel form of atmospheric governance. This framework contributes to the broader academic discussions and fills the theoretical gaps identified at the beginning of Chapter 1. The chapter closes by reflecting on the research limitations and offering some remarks on the voices and perspectives of Tibetan residents, which were crucial but, unfortunately, beyond the scope of this study.

Chapter 2

Literature Review: On Atmospheric Biopolitics

The main focus of this dissertation is to investigate how weather modification operates in contemporary China as a means of governing life. Although weather-modifying technologies have been developed for over a century and implemented for many years in various countries, as discussed in Chapter 1, there has been little social science research on this issue, and a comprehensive conceptual framework is lacking. To fill this gap, this chapter aims to bring together relevant concepts and literature to provide a conceptual framework for answering the research questions and structuring the analytical chapters.

I begin by outlining the Foucauldian concept of biopolitics and the increasing scholarly focus on the environmental mode of biopolitical control. This provides the conceptual basis for addressing the first research question in Chapter 4, which seeks to understand weather modification as an atmospheric mode of biopolitics. I then expand this focus on

atmospheric governance to three additional conceptual areas, proposed as a framework for further understanding the features of this governance: embodiment, volumetric perception, and affective entanglement. First, I review the literature on weather and the human body to address the second research question on the practices of atmospheric governance in Chapter 5. Second, I draw on recent scholarly discussions on volume and volumetric materiality to address the third research question on the epistemic difference of atmospheric water, which I discuss in Chapter 6. Finally, I outline the literature on the affective aspect of the atmosphere, which I use to address the fourth research question in Chapter 7.

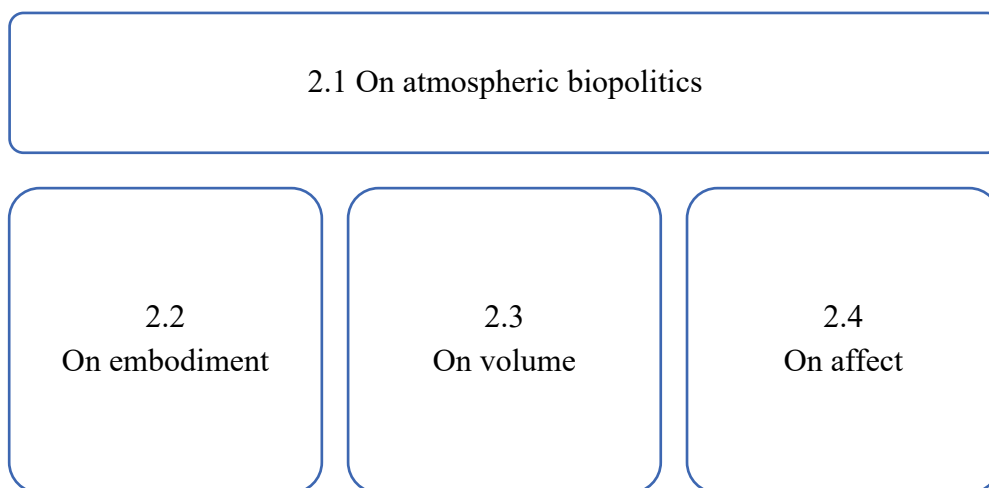


Figure 2 The conceptual framework and the key aspects for understanding weather modification

2.1 On Atmospheric Biopolitics

Weather modification refers to the intervention in and control of the meteorological atmosphere. However, attempts at modifying the weather are not solely about controlling meteorological phenomena. Modern cloud-seeding technologies were initially developed for military purposes due to their potential to be weaponised (Harper, 2008; Martin-

Nielsen, 2012). Weather warfare was banned by the international treaty of the Environmental Modification Convention in 1978, and weather modification has since been aimed primarily at civil purposes (Qiu & Cressey, 2008). In contemporary China, weather modification aims to achieve various objectives, including water resource development, ecological restoration (Chien et al., 2017), and mitigating urban micro-meteorological issues (Liu, 2019). It is evident that weather modification is not merely a technology used to control the meteorological atmosphere but is also a means of governing life on the surface. In other words, weather modification should be seen as a form of governance in which power and its influences on life are enacted by deliberately modifying the surrounding atmosphere—a form of atmospheric biopolitics. In the following section, I outline the development of the idea of biopower and biopolitics to provide a theoretical context for understanding atmospheric biopolitics and to highlight the key conceptual gap that I address with the empirical case in China.

2.1.1 From Biopolitics to Environmentalism

Biopolitics is a concept that was proposed by Michel Foucault and has become one of the most influential ideas in critical theory. Foucault distinguished between the discipline of individual bodies (anatomy-politics) and the governance of life in collective form, or biopolitics (Foucault, 2008). Biopolitics refers to the power relations, technologies, and devices (or ‘*dispositifs*’ in Foucault’s terminology) that are projected upon human populations. These power relations and technologies, such as knowledge on statistics and demography, are strategically coordinated to allow human life to be governed at the scale of the population (Lazzarato, 2002). Since then, scholars have adopted the concept of biopolitics to analyse a wide range of topics related to the governance of human and nonhuman populations (Biermann & Anderson, 2017).

The majority of scholarly work on biopolitics focuses on analysing how biopolitical governance intervenes in life through the deployment of certain dispositifs. However, in Foucault's original work, he also questioned a different type of biopower, which focuses not on the individual or population but on governing through the environment or milieu in which life is lived as an 'environmental type of intervention' (Foucault, 2008, p. 260). Although Foucault did not offer further discussion or elaboration in his work, this notion of an environmental mode of biopolitics has been developed by scholars concerned with climate change and the Anthropocene. For example, Braun (2014) suggests that a new form of governance emerged in response to climate change and extreme weather. He argues that the concerns of resilient urbanism facing the changing climate are not only about the biopolitics of urban infrastructure upon which vitality depends, but also about the nonhuman environment, which is increasingly treated as infrastructure. Under this 'new urban dispositif', biopolitics no longer works through 'molding life' but through 'modulating natural processes' (p. 60).

Similarly, Gabrys (2014) discusses the emergence of a new biopolitical paradigm in urban settings, where life is constantly surrounded and sustained by sensing and computing technologies. These technologies not only serve as the infrastructure for urban living but have also become an integral part of the environment in which life exists. Drawing on Foucault's environmental mode of biopolitics, Gabrys introduces the concept of 'environmentality' to describe a biopolitical mode in which sensing technologies become part of the environment. This environmental mode of biopolitics shifts the focus of governance from life itself to the surrounding environment. However, while life is surrounded by the environment, it is also a constitutive part of it. The operation of environmentality can also be achieved through the modulating of specific forms of life. Lorimer (2017, p. 29) suggests a rising form of probiotic environmentalities that involves

‘deliberate efforts to engineer ecologies through the introduction of keystone species.’ He uses examples of rewilding nature reserves and reworming (the use of microorganisms for therapeutic purposes) the human microbiome to illustrate a ‘probiotic turn’ in biopolitics in the Anthropocene. For Lorimer, the concept of probiotic environmentalities offers an opportunity to reimagine more-than-human relationships in the Anthropocene. For some scholars, the modulation of life forms has become a crucial tool for addressing climate risks in the new epoch. Wakefield (2020b) illustrates this emerging form of Anthropocene biopolitics with the case of artificial oyster reefs in New York, which aim to configure the vitality of nature and transform it into infrastructure.

In the Anthropocene, this form of governance modulates not only different forms of life but also planetary systems, such as the atmosphere, oceans, and various material cycles. According to Chandler (2018), this has led to a new mode of governance that departs from traditional command-and-control approaches and instead governs with the complexity and non-linearity of planetary systems. This new form of governance, which he refers to as the ontopolitics of the Anthropocene, is characterised by three distinct modes: mapping, sensing, and hacking. Mapping assumes non-linear causality, meaning that the same external stimulus may produce different responses, and governance interventions have limited power to directly impose or control outcomes. Instead, they can only indirectly influence or facilitate the processes of interactive emergence. Sensing shifts the focus from causality to correlation by developing greater real-time sensitivity through the deployment of Big Data and the Internet of Things (cf. Edwards, 2010; Gabrys, 2014). Hacking emphasises the entanglement of the human and nonhuman and seeks experimental engagement that enables the creativity of the Anthropocene. This echoes Wakefield’s (2020a) understanding of life and practices in the Anthropocene as experimental and heuristic in nature. For Wakefield, the ‘Anthropocene back loop’ represents not only a

period of destabilisation and fragmentation but also great potential for experimental transformation.

Taking these notions of ontopolitics into consideration when thinking about environmentality helps us understand that this form of governance, which operates by modulating the environment, governs *with*, rather than controls over, nonhuman dynamics. This notion is valuable for examining the environmentality of weather modification. In the following section, I delve deeper into the concept of environmentality, focusing specifically on the atmosphere, in order to explore the idea of modulating the atmosphere to govern life.

2.1.2 The Atmospheric Mode of Biopolitics

As Braun (2014) suggests, the modulation of nature has become a crucial aspect of the biopolitical condition in the age of climate change. This is especially true when considering the atmosphere. It is now impossible to think of life without considering the novel and humanised atmosphere in the Anthropocene. Through emissions from various activities, humankind has already changed and continues to alter the composition of the atmosphere. Moreover, there are an increasing number of plans to take proactive measures or to make interventions to create a more liveable atmosphere ranging from global geoengineering (Dalby, 2015; Yusoff, 2013) to regional weather modification (Chien et al., 2017). These Anthropocene interventions raise profound questions about how to live with and within the humanised atmosphere, how to deal with the emerging power relations and governance around atmospheric affairs, and how to envision alternative politics and ethics for the unfolding atmosphere (Buck, 2019; Clark, 2013).

Meanwhile, an atmospheric mode of biopolitics should imply not only the manipulation

of the meteorological atmosphere but also the control of the affective milieu. As Anderson (2012) suggests, for environmentality to function, it must involve certain affective conditions, an atmosphere in which things encounter and establish relations with others. In other words, the operation of this mode of governance lies not only in the material dispositif but also in the affective atmosphere. This urges us to think about the intertwined relations between meteorological and affective atmospheres (Choy, 2011; McCormack, 2008a), atmospheric technologies and bodies (Ash, 2013; McCormack, 2018), and atmospheric governance and life itself (Sloterdijk, 2009).

Together, the concept of the atmospheric mode of biopolitics provides a theoretical angle to interrogate weather modification operations in China. Yet, while these scholarly discussions on the atmospheric mode of biopolitics have foregrounded the conceptual relationship between modulating the atmosphere and governing life, the existing literature offers little discussion on how atmospheric biopolitics works. In what ways was the atmosphere modified? How did the ways of modifying the atmosphere influence life? What forms of life were included/excluded in atmospheric governance? These are the questions that I address in Chapter 4, where I draw on empirical cases to show that there are different temporalities of atmospheric governance that emphasise various forms of life. Within this governance, the atmosphere can be modified in the short term as a contingent plan and in the long term as an infrastructure. This discussion in Chapter 4 contributes to the literature on environmentality by further specifying the different modes in which an atmospheric environmentality can function. Though the distinction of different modes of environmentality, I point out that temporality is an important aspect to consider for understanding this form of governance.

2.2 On Embodiment

Modern weather modification is founded on scientific research into the meteorological atmosphere, utilising remote sensing technologies such as satellites and radar. However, viewing weather modification solely as an intellectual pursuit overlooks the critical aspects necessary for comprehending this new form of atmospheric governance. In this section, I explore the relationships between bodies, weather, and meteorological practices. My objective is to furnish the conceptual framework for addressing the significance of bodies in weather modification practices, which will be empirically examined in Chapter 5 to answer my second research question. To achieve this, I first examine research on the interdependent relations between bodies and weather in human geography, anthropology, and cultural studies. I then outline research on the embodiment of meteorological practices. Finally, I revisit the concept of choreography, discussing how various scholars have employed it and how it can contribute to the discussion on weather modification. Together, this section provides insights into ways of understanding and analysing the embodiment of weather and weather modification practices.

2.2.1 Body and Weather

Humanity has been building and rebuilding relationships with the weather since ancient times. Human-weather relationships are both epistemologically and affectively embodied. Throughout history, humans have taken various approaches—including mythology, storytelling, and scientific reasoning—to understanding weather phenomena. Meanwhile, people experience natural elements like wind and pouring rain in everyday life and attach emotions, such as desire or hatred, to them. These two aspects—knowing and experiencing the weather—are inseparable. This is because, as Tim Ingold suggests, knowledge can only be known by a living body, and the body is always immersed in the atmosphere or, as he

puts it, is ‘enwinded’ in a ‘weather-world’ (Ingold, 2007, 2010). Based on Ingold’s writing, Martin (2011) discusses the intermingling of the body and the enveloping weather, particularly fog, as a bond that he termed ‘body-with-world’. For Martin, this notion of ‘being-with’ foregrounds the bond between the body and the weather-world—a reciprocal ‘insertion with’ (Merleau-Ponty, 1968), rather than a connection to, each other. Under his phenomenological reading, weather and the knowledge and experience of weather are embodied.

Alongside this phenomenological view, the bond between weather and body can also be seen empirically. In conventional weather wisdom, knowing and understanding the weather involves bodily experiences. A body works as a receptor for the observation of the weather through vision, hearing, somatosensory, and other sensory functions. The embodied local weather knowledge and forecasting can also be obtained through spiritualistic senses, such as dream interpretation and shared visions with ancestors (Roncoli et al., 2002). These local knowledge systems with the weather, after Martin (2011), show the embodiment of weather knowledge, which is often disregarded by the scientific knowledge system of the weather. This does not mean that the local knowledge system is faulty or useless. Indeed, local weather knowledge can sometimes work with a scientific perspective and contribute to the overall understanding (Gearheard et al., 2010; Riedlinger & Berkes, 2001).

Bodily experience is not only at the centre of perceiving weather but is also essential to the need and desire for weather. What does it mean to desire weather? As Ingold (2007) suggests, human beings live within a ‘weather-world’ in which the very existence of humanity cannot be sustained without the existence of air. This means that air is too essential to be an object of desire. Desire could not exist without the existence of air. Certain weather phenomena, such as rain, can be just as crucial to life. Although the lack

of rain does not immediately endanger the existence of life, life could not be sustained without rain, fuelling the desire for it. In ancient times, this desire was shown in the variegated rainmaking rituals across different cultural backgrounds (Sanders, 2008; Snyder-Reinke, 2009).

Neimanis and Walker (2014) further consider of the close relationship between bodies and weather further, denying simplistic claims that bodies live in the ‘weather-world’. For them, weather and climate are not the phenomena in which humans live, but rather as something ‘of us, in us, through us’ (p. 559). They suggest a rethinking of the relationship between bodies and climate not as the interaction of ontologically separated entities but as ‘intra-active’ phenomena (after Barad, 2007). To do so, Neimanis and Walker pay specific attention to the temporality of weather bodies and regard bodies as ‘archives’ of climate and also as what makes future climates possible. This notion of the entangled temporality between weather and bodies is particularly useful when understanding weather modification practices. The process of seeding a cloud requires a temporal attunement between meteorologists’ working tempos and atmospheric dynamics (see Chapter 5 for further discussion).

2.2.2 Embodiment of Meteorological Practices

In contrast to the literature discussed above, these aspects of body entanglement were widely neglected or rejected in modern scientific meteorological epistemology and methodology. Modern meteorology, which originated in the 19th-century was first envisioned as the systematic knowledge and methods of precise, objective, and standardised observation, which is, thus, disembodied (Anderson, 2005; Whitehead, 2011). For Victorian observatory meteorologists, meteorology was a science of precision instruments and systematic measurements, unlike unscientific experience. However, this

observation-centred view was questioned by other meteorologists in the same era who suggested a more theoretical and speculative way of pursuing meteorological knowledge. For them, meteorology was not only a science of objective and precise observation of the present but also a science of forecasting, or as Fine (2009, p. 14) puts it, ‘the production of future’. While the tension and debate between observation and speculation were at the centre of 19th-century meteorology (Anderson, 2005), the two sides had one thing in common: both paradigms of meteorological knowledge production, whether obtained through standardised observation or deductive theories and models, represented a disembodied reading of atmospheric phenomena.

Still, the assertion of a bodiless epistemology has been challenged by recent science and technology studies on meteorology. Matson (2017) scrutinises how 19th-century meteorologists understood ‘atmospheric electricity’ and questions the disembodied reading. By showing how bodily encounters with electric storms informed meteorologists’ reasoning and understanding of atmospheric electricity, she suggests that the human body and its subjective sensory experiences are as crucial for meteorologists and their scientific reasoning as for other non-scientific weather experiences. For Matson, as meteorologists physically encounter and become immersed in the weather, so do both their scientific observations and their speculations on weather become embodied.

Even though remote sensing technologies and the development of computer weather modelling seemingly created more distanced and bodily disengaged scientific observations and speculations, these newer forms are not disembodied. As Myers (2015) demonstrated through her ethnography of protein modellers, the kinaesthetic experiences of the modellers inform their rendering and interpretation of computer models. Meanwhile, simulation modellers of weather and climate seldom work alone in a purely remote

laboratory setting; rather, they are mutually dependent on field experimentalists who collect and generate different types of data with their bodies immersed in the atmosphere in the field (Sundberg, 2007). In this sense, meteorological observation and speculation act as ways of ‘seeing-with’, as McCormack (2018, p. 42) suggests, wherein immersed bodies are situated within, rather than distanced from, their epistemological objects.

McCormack’s notion of sensual encounters with the atmosphere, or what he called ‘envelopment’, rather than just visual observation, is essential for analysing the embodiment of weather modification. Weather modification involves more than merely observing, theorising, and predicting the atmosphere. As its name suggests, weather modification is about intervening. It is about touching rather than just seeing the atmosphere. One must first be enveloped before the atmosphere can become palpable and modifiable. Weather modification can only be an immersed and embodied action. More importantly, weather modification is not only about whether the atmospherically immersed human can touch and make changes to the weather. It is also about how the weather becomes palpable to the human and why its palpability emerges in particular ways. This is the main theme in Chapter 5, where I discuss how weather became modifiable via certain spatiotemporal arrangements of bodies and devices, which I call the ‘choreography’ of weather modification.

2.2.3 Choreographing Air-Conditioned Bodies

Etymologically speaking, choreography is derived from the Latinised Greek words for ‘dance’ and ‘to write’, referring to the art or practice of designing the sequence of movements in dance. In the humanities and social sciences, scholars often use the concept of choreography not only in discussions of dance but also to analyse various forms of body performance that intersect with their research topics. For example, Hewitt (2005)

developed the concept of ‘social choreography’, which examines how everyday movements such as walking, stumbling, and laughter serve as a blueprint for thinking about modern social organisation. As an analytical tool, choreography has been further extended in Thompson’s (2005) science and technology study on assisted reproductive technologies, where she used the concept of ‘ontological choreography’ to refer to the dynamic coordination of the cultural, social, and material elements necessary for grasping different realities.

Although the topics of research using choreography as an analytical concept are diverse, they share a common characteristic. As an analytical concept, choreography not only emphasises bodily performance and movement but, as Foster (1998) points out, codes and conventions that were constructed in dance, rather than just how individuals perform those codes. In other words, choreography as an analytical concept re-emphasises the regulatory system of how body movements are arranged and organised. Choreography not only emphasises the design and guidance of body movements but also highlights the constraints and rules of body movements in broader contexts (Nash, 2000). These constraints are not only socially and culturally significant but may also be geographical. In Hunter’s (2015) edited book on site-specific dance performance, the authors discuss how the choreography of dance engages with particular sites and how the movement of the body is related to the place and environment, or site-conditioned. McCormack (2015, p. 80) further extends this site-specificity and points out that ‘the constraint of such choreographies is not so much provided by a grounded location but by the fluctuating contingencies of spacetimes’, which he calls ‘air-conditioned’.

Ancient rainmaking is an example of such air-conditioned dance. In the Shang dynasty in ancient China, rainmaking was conducted through rituals of dancing (see Figure 3),

sunburn, and witch-burning (Snyder-Reinke, 2009). For the Shang rainmakers, the weather was not just an external condition but a tangible thing that could be affected through choreographing penitential and sacrificial practices.² However, as discussed above, choreography is not only about body performance but also involves specific codes and regulatory systems. In the Han dynasty, Confucian scholar Dong Zhongshu proposed a different approach to influencing the weather through his cosmology of *yin* and *yang*.³ He believed that the behaviour of the weather was a reflection of society's conduct, rather than just individual bodily practices. Dong argued that rainmaking rituals required the proper arrangement of various aspects of daily life, such as clothing colour, fasting, and sexual abstinence (Snyder-Reinke, 2009). In this way, rainmaking choreography under Dong's cosmology was embodied in the governance of everyday life and manners.

Furthermore, I would like to point out that modern weather modification practices can

² Although records of early rain dance are commonly seen in oracle bone scripts from the Shang dynasty (1600–1046 BC), the details of how the ancient rainmakers arranged the dance remains unclear. *Hou Hanshu*, the official historical book of the later Han dynasty, which was completed around 445 CE, provides a brief description of how a rain dance (called *yu*) might look. Loewe (1987, p. 200; cited from Snyder-Reinke, 2009, p. 55) provides a translation: 'In times of drought, the senior officials, drawn up in order of seniority, perform the *yu* ceremony as a prayer for rain. The yang openings are closed; the officiants don black silk and set up clay dragons. They erect two rows of earthenware figures and dancing youths, which are changed once every seven days in accordance with precedent. The altar of the soil is encircled with bands of scarlet rope and scarlet drums are beaten. After prayers, they give thanks and sacrifice animals, in accordance with prescribed rite.'

³ Under Dong's cosmology, in which the change of nature corresponds with how the seculars behave, the rainmaking method was based on reconfiguring the two elemental forces, *yin* and *yang*, which were related to the drought. He believed that the drought was caused by an excess of *yang* and a shortage of *yin* in the world and, thus, could be reversed by rearranging social behaviours in a way that would balance the *yin* and *yang*. It was a complex system that involved many aspects of daily behaviours, from the colour of clothes to the timing of feasts and fasts, from a change in urban planning to a prohibition of men in the public space, and from digging ponds to preventing the cutting of forests. See Snyder-Reinke (2009, pp. 54–68) for a more detailed discussion.

also be understood as a form of air-conditioned choreography. Here, I adopt McCormack's (2015, p. 80) definition of choreography as 'the arrangement and organisation of the relations between bodies, things, and their surroundings.' Under this definition, considering choreography enables us to not only comprehend the spatiotemporal movements of bodies but also observe how various materialities unfold. As Zee (2022) points out, examining such 'choreography of substances' can help us understand how certain material configurations might serve as a medium through which political formations gain openness to shift to other configurations. This is certainly true for weather modification, which interacts with the elemental dynamics of the meteorological atmosphere. In Chapter 5, I will demonstrate how contemporary weather modification, like ancient rainmaking, is carried out through choreography of the site-specific movements of meteorologists and scientific devices. Additionally, as I will discuss in Chapter 5, weather modification practices also rely on specific dynamics of the meteorological atmosphere, exhibiting both air-conditioning and air-conditioned qualities.

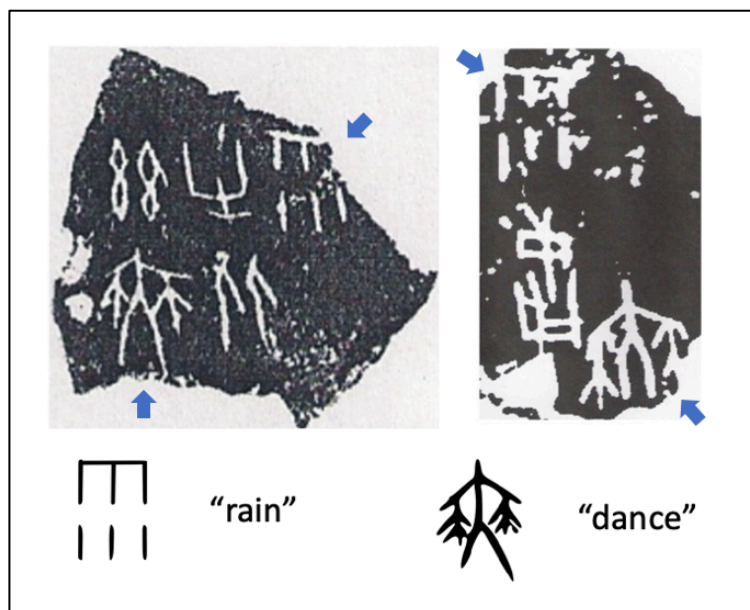


Figure 3. Ancient Chinese oracle bone scripts for 'rain' and 'dance'.

Source: Huang (2010)

2.3 On Volume

In this section of the review, I draw on the recent academic discussion of volume and engage with the scholarly debate on atmospheric water. My aim is to show that atmosphere is not merely about vertical space and atmospheric water should not simply be understood as water in the air. Instead, by distinguishing volumetric understanding of atmospheric water from different disciplines, this section provides the conceptual context for Chapter 6 to address my third research question on the epistemic politics of weather modification.

2.3.1 Atmosphere, Volume, and Vertical Reciprocity

Geographers, anthropologists, and other social scientists pay attention to volume to defy the two-dimensional cartographical perspective. This flat epistemology was challenged by scholars from different starting points. First, in political geography, researchers have pointed out that power relations unfolded through three-dimensional space, and the verticality should be considered in geopolitics topics like territories (Elden, 2013), security and warfare (Adey et al., 2013), and the potential counter-politics of verticality (Garrett & Anderson, 2018). Second, the discussion on volume also involved a consideration of the experiential senses of bodies that are immersed in different forms of volume (Anderson, 2009; Ingold, 2007; McCormack, 2018). Third, the discussion of volume also intersects with discussions on the geo-physical-chemical materiality of the earth system, which is by no means two-dimensional, and how it intertwines with the biological and the social-political world (Clark, 2011; Dalby, 2013; Kama, 2016; Squire, 2017; Wang, 2021).

This consideration of materiality resonates with the growing research on the elements in geography, anthropology, and cultural studies (Engelmann & McCormack, 2021; Squire, 2016). The wide empirical focus of the related literature shows that the materiality of

different substances, such as air (Adey, 2015), water (Steinberg & Peters, 2015; Straughan, 2012), earth, and minerals (Hawkins, 2019; Valdivia, 2015), affects their volumetric properties. While approaching volume from various angles, these studies share one thing in common. They all refuse to consider volume as simply extending the concerns on the surface to a three-dimensional Cartesian space and seeing volume in a pure vertical geometrical term. Rather, they aim at an ontological and epistemological reconsideration of volume and volumetric materiality.

Atmospheric water is the central focus of this thesis and is undeniably a volumetric substance. As its name suggests, atmospheric water exists in a suspended state in the air and is typically measured and quantified in terms of its volume or the amount of space it occupies. However, atmospheric water should not be perceived solely as water molecules floating in the air, as these molecules constantly shift between physical phases and circulate between the land, ocean, and atmosphere. According to Choy and Zee (2015), atmospheric water exists in a ‘condition of suspension’ that enables substances to disperse, shift states, and vary in relative concentration. This condition of suspension is not only about materials in an airborne state but also about the processes of becoming atmospheric and the potential of settling, which illuminate the relationship between earthly and aerial things. Adey (2010) refers to this relationship between the atmospheric and the terrestrial as ‘vertical reciprocity’ and demonstrates that atmospheric water can be conceptualised not only as the volume of suspended materials in the air but also as certain forms of volumetric relationships between the land and air. In other words, atmospheric water becomes a knowledgeable volume through the ways in which different vertical relationships are highlighted.

The discussion of this ‘vertical reciprocity’ of volumetric substances intersects with the

literature on resource geography that examines the volumetric characteristics of different resources. Scholars are concerned with the verticality of subterranean and suboceanic resources in endeavours like oil (Valdivia, 2015) and deep-sea mining (Childs, 2020) and how these volumetric materials intertwine with geopolitical tensions on the surface. This entanglement, of course, is not an a priori fact but a perspective enacted through certain knowledge practices and discourses, or as Bridge (2013, p. 56) puts it, the ‘technologies of calculation, visualisation and manipulation around volume.’ In other words, the volumetric politics of resources unfolds through certain epistemic practices of resource-making (Kama & Kuchler, 2019). In the following section, I further review how different scientists and management schemes understand atmospheric water through different approaches and how these epistemic differences lead to different volumetric imaginations.

2.3.2 Atmospheric Water as a Volumetric Resource

The idea of the water cycle depicts the movement of water within the Earth system in which water molecules change phases and move around the atmosphere, land, seas, and sub-surface. Atmospheric water and other forms of water compose the Earth’s hydrosphere. While the idea of the circulation of water depicts a holistic hydrosphere, water in various forms and phases has received very different degrees of attention and evaluation when considered as a resource. As Linton (2010) suggests, traditional discourse on water management based on a purified water balance equation (i.e., $\text{Rainfall} = \text{Evaporation} + \text{Runoff}$) regards the runoff on the surface as the potential resource to be utilised. Meanwhile, evaporation, the process of becoming atmospheric water, is often termed as losses under this discourse (Linton, 2010, p. 185). Based on this understanding, atmospheric water is conceived as inefficient, and the process of becoming atmospheric is a loss that needs to be prevented through improved water management.

This lack of attention to atmospheric water in traditional water management discourse has been challenged in recent scholarship. Echoing Linton's notion, Jackson and Head (2021) call for greater attention to the 'politics of evaporation'. Through a case study of Australia's Murray-Darling Basin, they show how evaporation turns into a field of contestation when local communities can provide a counter-discourse on evaporation to argue against the government's water management project that pursued more efficient manoeuvring by reducing evaporation. Apart from the reconceptualisation of atmospheric water, there are also a growing number of experiments and projects with more active intentions to utilise atmospheric water, such as cloud seeding (Chien et al., 2017) and atmospheric harvesting using absorption devices (Kim et al., 2018).

Like traditional hydrology, meteorology also tends to have an asymmetrical epistemic focus on atmospheric water. Concepts like the 'atmospheric river' have a selected focus on the dynamic and transport of water in its aerial state (Gimeno et al., 2014). However, this epistemic separation of the atmospheric and surface water has been rejected by some scholars. For example, Arraut et al.'s (2012) idea of aerial rivers is not merely an analogy of a topological similarity of surface rivers. It also points out the potential hydrological relationship between the aerial and surface rivers (and lakes). As Arraut et al. (2012, p. 25) note, 'aerial rivers lose water through precipitation and gain it through evaporation, while with surface rivers just the opposite takes place.' In other words, the differences between the idea of atmospheric rivers and aerial rivers not only lie in the time scale they adopt but also in the way they consider the relationships between the atmosphere and the surface.

The conceptual connection between atmospheric water and surface water is not necessarily understood as a holistic water cycle system. Instead, the atmospheric and surface water could be perceived through their particular locations and territorial relations. For instance,

Keys et al. (2017), propose the idea of precipitationshed, which is a ‘watershed of the sky in that it describes how upwind and downwind regions are connected through the flows of water vapor’ (pp. 15-16). Here, atmospheric water is not conceptualised based on its status of aerial suspension, but on the upwind-downwind relations with different surface territories. Atmospheric water is not a generalised phase of the water cycle. Instead, it is grouped into a territorial relationship with particular areas on the surface. Under this conceptualisation, atmospheric water is no longer perceived as the general term depicting the status of water molecules floating in the air. Based on upwind-downwind relations, the atmospheric water in a particular region becomes a spatial unit of conceptualisation and resource governance.

These studies show a different tendency for understanding atmospheric water not as an independent epistemic object in the air but as a phase of the material flow that connects different territories on the surface. What interests me is not merely identifying the epistemic differences among different scientific disciplines. Rather, I seek to determine how these epistemic differences in the volumetric features of atmospheric water enact water governance issues (Keys et al., 2017) and territorial politics (Jackson & Head, 2021) under the context of weather modification. This question is addressed in Chapter 6, where I compare the ontological and epistemic differences between meteorological and hydrological perspectives on the volumetric properties of atmospheric water, and how these differences lead to various geopolitical implications.

2.4 On Affect

My final research question aims to determine the intersection of the meteorological and the affective atmosphere in Chinese weather modification practice. In this part of the review, I first outline the scholarly discussion on affect and affective politics. Then, I review the literature on the relationship between affect and weather in terms of both the everyday scenario and scientific activities. Together, these two parts provide the conceptual resource for me to address the question regarding the affective aspect of Chinese weather governance in Chapter 7. Meanwhile, I also explore literature that focuses on emerging affective politics in China, where state encouraged optimism has become an aspect of authoritarian control. The literature offers a context for understanding how the affective politics of weather modification, which I address in Chapter 7, is embedded within the broader affective governance of an authoritarian regime.

2.4.1 Affect and Affective Politics

Since the 2000s, affect has been at the centre of academic discussion across a range of social sciences and humanities, which Clough (2008) identified as the ‘affective turn’. The idea of affect has then been used in human geography to understand a wide variety of topics, ranging from geopolitics (Laketa, 2016; Puar, 2009), nationalism (Closs Stephens, 2016), sound (Gallagher et al., 2017), technology (Ash, 2015), and animals (Lorimer et al., 2019). While these studies have approached affect using diverse and sometimes vague definitions, they usually share a similar concern for how affect emerges and has effects on individual and collective life. The effect and politics of affect have often been understood as a two-sided capacity to both affect and be affected by the affective atmosphere (Anderson, 2017; Thrift, 2004).

This relational reading of affect is used to explore how particular political aspects work affectively and atmospherically. For example, Closs Stephens (2016) discusses how nationalism emerged and endured through the ‘happy’ atmosphere of the London 2012 Olympic Games. For Closs Stephens, approaching nationalism atmospherically does not involve focusing on extraordinary emotions at particular moments. Instead, as she showed, the distinction between ‘hot’ and ‘mundane’ nationalism is blurred, and it is difficult, if not impossible ‘to determine the boundaries between everyday life and orchestrated displays of sovereign power’ (p. 184). In other words, the affective politics of this atmospheric nationalism is not only about how the events and national symbols induce nationalist emotions. It is also about how everyday affective experiences co-create ‘everydayness’ and ‘everywhereness’ at the time of the games. These affects can, thus, attach to different kinds of objects, materials and bodies beyond common nationalist icons like flags and monuments. This notion is insightful for considering the affective politics of weather modification in China, where the everydayness of weather and the eventful nationalistic moments intertwine. In Chapter 7, I empirically examine how the modified weather has affectively attached to a heightened sense of nationalism and has become a way to display sovereign power.

While understanding affect as a two-sided capacity of bodies contextualises the emergence and evolution of certain affective atmospheres, it is not a clear approach to answering the question of how intervention in the atmosphere could work as a way of governing affect. Here, Anderson (2017) provides a useful way of conceptualising affect. Aside from understanding affect as a bodily capacity, he suggests seeing it as an object-target of apparatus and as a collective condition that mediates how life is lived. These perspectives are useful in two ways. First, an understanding of affect as an object-target of apparatus shows how affect could become an object-target for different forms of power and

governance. This provides a perspective in which affective atmospheres are not contingent but are subjected to and informed by a particular apparatus. As Anderson (2017) clearly states, ‘affects are objects of knowledge, targets of intervention, and may be the means of intervening in life’ (p. 24), and ‘affective life is organised through multiple apparatuses that produce particular kinds of affective objects, particular kinds of subject and collectives, and are embedded in specific modalities of power’ (p. 25). This perspective is useful for the analysis in Chapter 7 on weather modification in China as an apparatus that produces affective subjects of optimism.

Second, seeing affect as a collective condition that mediates how life is lived provides a conceptual opportunity to connect the meteorological and affective atmosphere of weather modification. The attempt to modify the atmosphere not only intervenes in the physical conditions but also the affective conditions that mediate how life is lived. This is exemplified in Sloterdijk’s (2009) notion of ‘terror from the air’, in which life is governed by the usage of toxic and lethal gases and the terror caused by them. Controlling the physical condition of breath, a ubiquitous yet essential element of life, creates a similarly ubiquitous affective condition of fear. Weather modification in China demonstrated a similar and opposite example. This issue is addressed in Chapter 7, where I show how actions and discourses⁴ of weather modification work as an affective strategy by the authoritarian regime for fabricating a hopeful and optimistic affective atmosphere.

⁴ While affect involves phenomenological and non-representational aspects, this does not mean that an inspection on affect can only be carried on non-representationally. Indeed, it quite the opposite. As Anderson (2017, p. 14) suggests, the inquiry of affect ‘must pay attention to how representations function affectively and how affective life is imbued with representations.’

2.4.2 Affect and Meteorology

Meteorological and affective atmosphere are not unrelated. Weather variations are often related to emotional fluctuations at the individual level. Like all other terrestrial species on Earth, human beings live in ‘weather-worlds’ (Ingold, 2010), dwelling within the atmosphere, breathing in the air, and being affected by changes in the weather. A glorious sunny day on a summer weekend makes many people feel emotionally upbeat, while some others might enjoy a calm and cool day of drizzle. Behavioural and emotional studies have been trying to discover a pattern in the relationship between weather and people’s mood (Denissen et al., 2008; Kööts et al., 2011). While the statistical results of these studies have shown some correlation between certain weather phenomena and emotional responses, the individual differences are huge (Klimstra et al., 2011). Nevertheless, the weather has more or less accounted for some part of individuals’ emotional states.

While the effects of weather on individuals vary, weather also has an impact beyond the individual level and is related to collective affect. A prominent example of this is the emerging anxiety and fears in cultural representations and discourses about the rising temperature of the global atmosphere and the corresponding catastrophic weather events, which Glenn Albrecht (2005) termed ‘solastalgia’⁵. This is where the two meanings of the word ‘atmosphere’—meteorological and affective—meet and intertwine. As Hulme (2008, p. 5) suggests, people are now ‘living in a climate of fear about our future climate’. This relationship between weather (and its long-term pattern, climate) and collective affect not only influences how the relationship between humans and the Earth’s atmosphere is

⁵ Glenn Albrecht (2005) coined the term ‘solastalgia’ to describe the negative psychological effects that result from environmental changes impacting people in their homes. While this term does not specifically refer to any particular type of environmental change, many studies on solastalgia focus of the effects of climate change (Breth-Petersen et al., 2023; Galway et al., 2019; Tschakert & Tutu, 2010).

perceived but also has wider political implications for social class and inequality (Swyngedouw, 2013), as well as actions toward climate change (Kleres & Wettergren, 2017; Verlie, 2019).

Affect is also a crucial aspect of understanding the scientific practices of meteorologists. As discussed in Section 2.2.2, Myers (2015) provides an excellent example of how affect played a crucial role in scientific laboratory practices for her ethnography of protein crystallographers. As she documented, the affective labour of crystallography practitioners needs to be understood as an inseparable part of cultivating skills and expertise and succeeding in scientific practices. For skilled practitioners, rendering a protein model is not simply a matter of fulfilling the technical requirements. Rather, they must ‘become responsive to the demands’ of the material and “cultivated intimate knowledge of the machines” (p. 50). These affective attachments to scientific practices, as Myers suggests, are like ‘an evolving relation of obligation’ between the practitioners and their models and machines. Echoing Myers’ research, In Chapter 7, I discuss how the Chinese meteorologists were affectively attached to the scientific processes and equipment, and together with the equipment, formed an affective war against the weather.

2.4.3 Affect and Chinese Authoritarianism

For authoritarian regimes, controlling public discourses, thoughts, and ideologies is crucial for sustaining and consolidating the political dictatorship. Political propagandas, as well as the control and censorship of free speech, are both key competencies for an authoritarian regime. However, modernising authoritarian countries like China now face a conundrum where the popularisation of the Internet has made it more difficult for the government to impose highly-centralised controls over speech (Liang & Lu, 2010). While the Chinese regime has constantly been developing new and ‘smarter’ ways to censor online content,

internet users are also dynamically learning how to circumvent these restrictions (Vuori & Paltemaa, 2015; Wang & Mark, 2015). In addition to developing a rigorous censorship system, an authoritarian regime might also guide certain affective atmospheres in society to either directly or indirectly inspire a pro-government trend in order to maintain stability and control.

In China, scholars noticed that a trend of ‘positive energy’ has been rising in public media and the internet since the beginning of current president Xi’s administration. This positive energy is defined as having ‘the capacity to induce positive emotions and/or attitudes, the potential to induce constructive/conciliatory discourses and/or actions, in individuals or collectives of individuals such as the society and nation’ (Yang & Tang, 2018, p. 13). While the government and the censorship system have been working on igniting this positive atmosphere, the trend of the positive energy was not like other top-down ideological propaganda. As Chen and Wang (2019) pointed out, the positive energy operated through the emergence of ‘self-disciplined docile subjects’ who internalised the interests of the regime as their own. This affective atmosphere not only strengthens nationalism during international conflict and competition (Du, 2014) but, more importantly, it is highly effective during major public emergencies and disasters. Lu et al. (2021) show how this positive energy informed Chinese internet users’ perceptions of information and restrictive measures during the COVID-19 pandemic. During public emergencies like the pandemic, the atmosphere of positive energy consolidated the legitimacy of the government’s power and control. Yet, these affective politics are problematic. As Lu et al. (2021) pointed out, individuals tend to prioritise biased information when evaluating and sharing it online. This preference for affective attachment instead of information accuracy could sacrifice the timeliness of information.

Studies on the ‘positive energy’ in China bring two implications to the conceptual goal of the fourth research question—to understand weather modification as not only a manipulation of the meteorological atmosphere but also an intervention in the affective atmosphere. First, the affective atmosphere that consolidated the socio-political control of the regime was not directly created by top-down imposed propaganda or doctrines. The affective atmosphere emerged from the everyday practices of subjects and the ways those practices were bonded with certain affective attachments. These affective attachments were reified through practices while also shaping those practices, as shown in the COVID-19 study (Lu et al., 2021). Likewise, weather modification practices are also entangled with certain affective attachments. Hence, in Chapter 7, I explore how weather modification practitioners’ affective attachments during the operations and the ways that those operations were organised have fabricated a foundation for an optimistic perception toward modified weather—a hope from the air—to emerge. Second, the study on ‘positive energy’ also shows how traditional authoritarian propaganda and control over discourses synthesised with the positive atmosphere to form an affective governance. While the government cannot fully control the affective atmosphere, existing propaganda and censorship systems work to strategically boost certain pro-government trends (Xu et al., 2011). The selective exhibition of certain affective topics in the official media also helps encourage the emergence of positive energy. In Chapter 7, I examined how the Chinese government portray the weather and weather modification in such a way that strengthens sentiments of hope.

2.5 Conclusion

In this chapter, I review the conceptual context and resources that I use to develop my

research questions on Chinese weather modification and its function of atmospheric governance. Moreover, I introduce the theoretical tools that I use in my analysis in the following chapters. This chapter also works as a conceptual framework that highlights the key dimensions for comprehending weather modification (see Figure 1). In this section, I conclude the key conceptual implications that I draw from each section and identify how this research contributes to the literature.

In the first part of this chapter, I review the scholarly work on Foucault's idea of biopolitics and the emerging discussions on an environmental mode of biopolitical intervention. This notion of 'environmentality' (after Gabrys, 2014) provides a way to conceptualise weather modification practices in China. Based on the literature, I further discuss and develop the idea of an atmospheric environmentality in Chapter 4, where I show how the weather was modified in China to govern and shape certain forms of life. My analysis in Chapter 4 not only offers an empirical discussion of an atmospheric mode of biopolitics resonating with the literature on environmentality, but also further identifies different modes of atmospheric environmentality by distinguishing the temporalities of the atmospheric interventions and the targeted life forms. Environmentality should not be understood in a singular form, referring to a general status of governance conducted through modulating the environment. Instead, I suggest seeing it as a combination of different modes of shaping and reshaping the environment with different time scales and different life forms involved.

Next, I shift the focus of the literature review to three subsidiary topics corresponding to the last three research questions that I use to explore the key features of atmospheric governance. First, I outline the literature on bodies and weather, which emphasises the significance of the body in not only weather experiences but also in meteorological

practices. In Chapter 5, I continue to emphasise embodiment to explore the scientific practices of weather modification. This embodied practice is not only about highlighting the immersive experiences in the weather-world (Ingold, 2010). Instead, as I argue in Chapter 5, modifying the weather requires a mutual attunement between body practices and weather processes. In other words, meteorologists' bodies entangle with atmospheric processes to form the modified weather. As Neimanis and Walker (2014) would suggest, together, they are 'weathering' the world.

Secondly, to address the third research question on how the atmosphere is understood in weather modification, I review the scholarly work on volume and volumetric materiality. These studies point out that volume should not be simply understood as the verticality of space but also as how air-land relations are perceived in particular ways. Atmospheric water and its volumetric materiality are regarded differently in various scientific disciplines. This epistemic difference is at the centre of my interrogation of the epistemic politics of weather modification in Chapter 6. I suggest that different volumetric understandings of atmospheric water inform the ways that scientists comprehend and evaluate their weather modification practices and lead to various geopolitical implications.

Finally, I review the literature on affect and weather. As many scholars have pointed out, the meteorological and affective aspects of the atmosphere should not be understood apart from each other (Choy, 2011; McCormack, 2008a). This is particularly crucial when examining Chinese weather modification as a form of atmospheric governance. In Chapter 7, I discuss how the Chinese modification of the meteorological atmosphere also worked as a way to govern the affective atmosphere. Based on the empirical studies of the Chinese government's management of the optimistic affect, I argue that weather modification in China was fabricated as a means for projecting hope. In doing so, I close the gap between

the modification of the meteorological atmosphere and the manipulation of the affective milieu and fulfil the final goal of my study of weather modification as atmospheric governance.

Chapter 3

Methodology

This chapter provides an overview of the methodology and design of my research on weather modification practices in China. As discussed in Chapters 1 and 2, the purpose of this study is to provide a comprehensive perspective on atmospheric governance by examining the historical development of weather modification, the scientific knowledge and practices involved, and the affective aspect of these operations. To address these various aspects of weather modification, I used a combination of research methods, including archive study, interviews, and participant observation, to collect data. During my fieldwork, the political climate in China influenced my research methods, leading to some deviations from the original research proposal. In this chapter, I also explain the trajectory of these methodological approaches and justify the choices and adaptations made during fieldwork and data analysis.

This chapter is divided into four sections. First, I introduce the design of my research on

Chinese weather modification practices. I explain and justify my selection of sites and empirical cases and outline my fieldwork. Next, I describe the three primary methods I used to gather data. In this section, I also discuss the challenges I encountered during my fieldwork and the corresponding adjustments and adaptations I made to my data collection methods. The third section of the chapter explains how I analysed the data for the main areas of inquiry in my study on weather modification. Finally, in the fourth section, I reflect on my positionality, limitations, and the ethics of this project.

3.1 Research Design

This section provides background information on my choice of sites and cases for studying weather modification practices in China, as well as details on how I planned and conducted my fieldwork.

3.1.1 Choice of Sites and Empirical Cases

The focus of this research is to explore the form of governance that proactively intervenes in the atmosphere of the living environment. There are various cases of such atmospheric interventions, ranging from small-scale air conditioning to large-scale geoengineering. Among these cases, weather modification provides an appropriate angle for exploring the topic. It is complex enough to demonstrate how governance interacts with larger Earth systems, while it is empirically richer than geoengineering proposals, as weather modifications have been implemented for decades (Harper, 2008; Qiu & Cressey, 2008). This focus on weather modification led me to China, where weather modification has become a major mission for the governmental meteorology bureau in the past decade and has been widely implemented in almost every province (Chien et al., 2017). Although the

central meteorological administration provides guidance for weather modification, the provincial meteorology bureaus determine how and why weather modification is practically conducted. Therefore, the province is the appropriate analytical unit for understanding a particular form of weather modification practices. Among all the provinces, I chose Qinghai as the major site and empirical case for this study because of its biopolitical, geopolitical, and historical specificity.

Qinghai is the fourth largest province in China in terms of land area. It is a multi-ethnic province, with the Han Chinese being the largest ethnic group (51%), followed by the Tibetan (25%) and Hui (16%) ethnic groups. In terms of land area, over 95% of the total area belongs to one of six Tibetan autonomous prefectures. Traditionally, the Tibetan people living in these areas primarily relied on raising yaks and sheep for a living through grazing. Qinghai is also one of the provinces that have conducted ecologically-aimed weather modification, and the region of the operation, Sanjiangyuan, has long been the focus of conservation and environmental governance. Sanjiangyuan is a 130,000 km² region located in the northeastern part of the Tibetan Plateau. It consists of alpine meadows and wetlands, which are habitats for many species listed by the government as ‘protected wildlife of national importance’ (Brierley et al., 2016), including the charismatic snow leopard (*Panthera uncia*). The environmental and ecological importance of this area makes Sanjiangyuan the largest nature reserve and the first national park in China. It also incentivises weather modification experiments and operations in the region to cope with environmental degradation (see Figure 4) due to overgrazing and the changing climate (Fan et al., 2010; Yang et al., 2005). Thus, weather modification in Qinghai provides the conceptual complexity needed to discuss the biopolitical implications of proactive atmospheric governance aimed at coping with anthropogenic environmental changes.

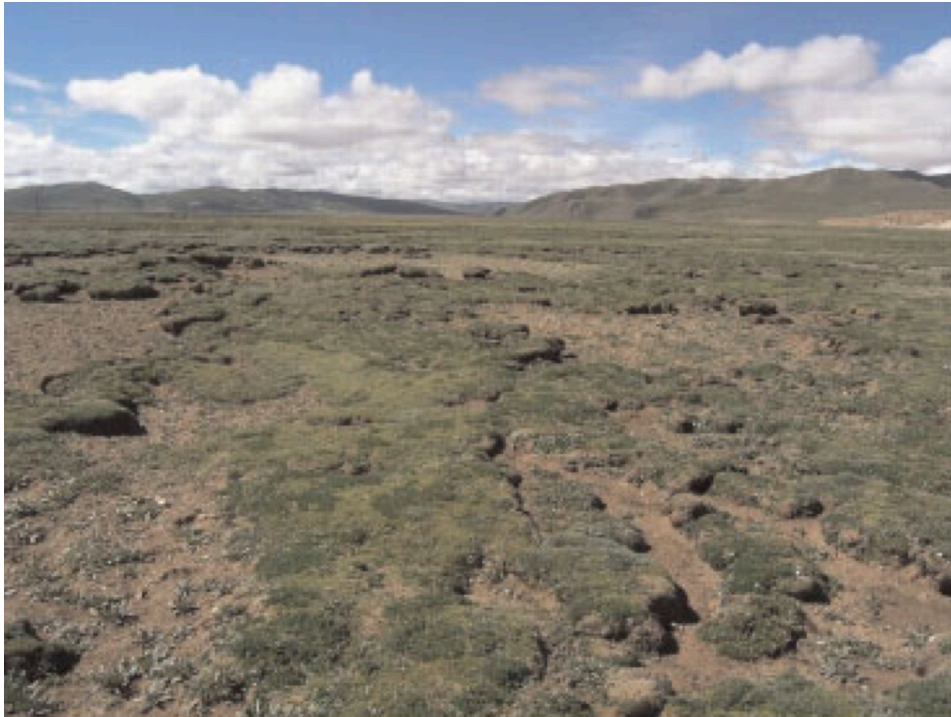


Figure 4 Alpine meadow degradation in south Qinghai

Source: Li et al. (2013)

Meanwhile, Sanjiangyuan's name, which translates to 'the source of three rivers' also highlights its geopolitical importance. As the origin of the major rivers in China and Southeast Asia, any environmental changes in the area could have significant a impact on these two densely populated regions. This environmental significance has led to many Chinese governmental and academic projects on conservation and engineering, which have incorporated weather modification (including those discussed in Chapter 4 and Chapter 6). For the Chinese government, the geopolitical specificity of Sanjiangyuan adds another layer of strategic importance to the weather modification in this area.

Qinghai province also provides rich empirical cases for understanding the historical trajectory of weather modification. Although the exploration of weather modification in communist China dates back to the 1970s, it was the cloud-seeding experiment in Qinghai

in the late 1990s that brought weather modification to the public's attention. The experiment in Qinghai then evolved into different phases, which are specified in Chapter 4. This not only provides a complex historical perspective for understanding the development of weather modification, but the differences in those phases can also identify various modes of atmospheric governance in China, addressing one of the main research questions. Finally, although Qinghai province is the primary focus of my research on weather modification practices, I also studied two supplementary sites, Beijing and Yushu (a county-level city in the Sanjiangyuan region), to provide supporting materials at the central and prefectural scale.

3.1.2 Fieldwork

The fieldwork for this research was conducted in two phases. During the first phase, which took place from July to August 2018, I spent four weeks in Xining, the capital city of Qinghai Province. The main objective of this phase was to establish connections with the meteorology bureau and weather modification office. With the help of a key contact person in the meteorology office, I was able to arrange visits and interviews with official meteorologists. Additionally, I conducted interviews with several scholars at Qinghai University who had experience working on research projects in Sanjiangyuan, focusing on ecology and hydrology. The fieldwork proceeded smoothly during this phase, and I was offered an opportunity to collaborate with a scholar from Qinghai University on their experimental project in Sanjiangyuan. Through my connection with the meteorology bureau, I also arranged a short visit to Beijing in November 2018 to interview meteorologists working in the central government.

The second phase of fieldwork was carried out from April to June 2019, taking into account that spring is the primary season for weather modification operations in Qinghai

and Yushu. The original plan for this phase was not only to conduct interviews with official meteorologists in the weather modification offices but also to conduct participant observations of ecological experiments and cloud-seeding operations in Sanjiangyuan. However, this plan was interrupted due to a sudden change in the political dynamic in Qinghai, which required a ‘research redesign’ (O'Brien, 2006). Shortly after my arrival in Qinghai in April, my main contact person in the meteorological office informed me that the bureau had become very conservative after a public dispute between meteorologists and hydrologists (see Chapter 6 for further details on this scientific argument). Meanwhile, the affiliation with Qinghai University was also put on hold due to a concern over ‘foreign-related affairs’, a vague explanation provided by the university’s contact person. Although the contact person did not provide a clear explanation, I believe this could be attributed to the then-ongoing international conflict between China and the United States, which led the university administration to adopt a more conservative stance towards international cooperation and become hesitant to associate with ‘foreign-related’ individuals, such as myself, a Taiwanese researcher based in Oxford. Nevertheless, due to this change, I adjusted my methodological approach and spent more time collecting archives that provide insights into the scientific discourses, practices, and affective atmospheres of weather modification through libraries, museums, and used bookstores.

3.2 Methods of Data Collection

3.2.1 Data for Affective Atmosphere

The main data and information in this research were collected through conventional qualitative methods, which I specify in the following sections. However, obtaining materials on the affective aspects of weather modification posed a greater challenge and required

some methodological considerations. As Anderson and Ash (2015) have noted, studying the affective atmosphere presents difficulties, as the atmosphere is both conditioned and conditioning, generated through encounters with objects while also affecting those same objects. Research on the affective atmosphere cannot solely rely on conventional social science methods that aim to represent the affective intensities of particular spacetimes. As McCormack (2013, p. 118) suggests, using methods such as interviews to capture the affective atmosphere would be ‘inadequate for apprehending the affective and processual logics of the spacetimes in which moving bodies are generative participants.’ Therefore, methodological approaches to understanding the affective atmosphere are not meant to comprehensively depict both its formation and effects. Instead, researchers choose methodological approaches based on their specific research questions.

In this research, my aim is to examine and analyse three aspects of weather modification policies and practices. Firstly, I focus on the government’s intention to conduct affective governance through the formation of a particular affective atmosphere via weather modification. I captured this affective aspect by collecting texts and media materials that highlight the state’s intentional affective projections of weather modification. This methodological approach is inspired by Closs Stephens’ (2016) research on the London Olympic Games, in which she used various media content such as blog posts, social media threads, TV campaigns, and songs to examine the affective atmosphere of nationalism through the moments of affective encounters.

Secondly, I am concerned with the affective attachment of meteorologists to weather modification during the implementation process. Scientific practice is not purely rational, and the affective attachment of practitioners to their work is an essential aspect of shaping scientific practices (Myers, 2015). Therefore, understanding the affective experience of

meteorologists during operation is crucial for comprehending weather modification as a form of affective governance. In the original research design, I intended to collect this data through participant observation. However, as previously explained, I was unable to conduct participant observation during fieldwork. Consequently, I obtained the data from the archives, with a considerable source being the diary of a Chinese meteorologist who took part in weather modification experiments. The diary documented a range of the meteorologist's affective experiences. Furthermore, my investigation of the affective atmosphere of weather modification operations is not limited to individual experiences. As Ash (2013) highlighted in his study of how interactions between humans and technological devices generate perturbations in the affective experience of spacetimes, nonhuman objects can also create atmospheres. Thus, my examination of the affective atmosphere also includes an analysis of devices and equipment used in weather modification operations.

Finally, I examine the affective aspect by considering how the institutional arrangements of weather modification contribute to affective governance. Adey's (2008) study on affective control in airports provides a similar methodological approach to my consideration of the affective governance of weather modification. He examines how the architecture and rules of movement in airports deploy affective techniques that intertwine with the discourse and system of risk management. In other words, the methodological approach to understanding affective atmosphere can focus not only on human subjects and nonhuman objects and how they act and interact but also on how those actions and interactions are institutionally arranged and deployed. To summarise, these mixed methodological considerations form the approach for this research to collect and analyse data on affective atmosphere. In the following section, I detail the methods I used to collect the various forms of data needed to analyse other topics in this thesis.

3.2.2 Interviews

I started my data collection during fieldwork by conducting interviews. These preliminary interviews not only provided data for analysis but also helped me gain access to other potential interviewees. This strategy is commonly used by researchers conducting fieldwork in China, where informal personal connections (known as *guanxi*) are crucial for gaining access, especially when the interviewees are social and political elites (Li et al., 2021). I conducted interviews with three categories of people: official meteorologists, academic scholars who worked on projects involving or related to weather modification, and local NGOs and residents (see Table 1). I began by contacting key individuals in each category who acted as gatekeepers in the field (Sæther, 2006) and arranged further interviews with their help. I purposively selected some informants based on the topics I intended to explore and also utilised the ‘snowballing’ process (Ritchie et al., 2013) to reach out to additional informants.

Methodologically, the interview approach used in this research was similar to the concept of ‘elite interviews’, which originated from political science as a method for studying the decision-making processes and political perceptions of political elites (Dexter, 1970). This approach is used when a relatively small group of people, the ‘elite’, have decisive influence or a monopoly over key information about the research topic. Here, the term ‘elite’ does not necessarily imply prestigious social, economic, or political status. Different scholars have adopted the idea of ‘elites’ to indicate various characteristics of the informants in their studies (Darbi & Hall, 2014), such as specific power in a hierarchical structure (Harvey, 2011; Robson, 2008; Zuckerman, 1972), control of certain professional skills (McDowell, 1998; Salazar & Zhang, 2013), and access to particular invisible but critical knowledge (Desmond, 2004; Parry, 1998). As Littig (2009) suggests, elite interviews are not so different from expert interviews, except that elite interviewees may have a certain power

over the research topic. The core issue for a researcher using elite interviews, then, is not to define or justify whether the informants are elite but to identify the informants' power and monopoly over the key information required to answer the research question.

In the context of this research, the official meteorologists and scientists in academia should be considered the 'elites' with regard to the research questions. On the one hand, they have the power to make decisions and implement weather-modifying experiments and policies, thus shaping how weather is modified in Qinghai. On the other hand, their skills and knowledge are essential to answering the research questions, which cannot be obtained through other means. Therefore, they became the gatekeepers who controlled access to critical data and information. As a result, adopting the elite interview method was necessary for this research on the government's weather modification practices.

The elite interview method focuses on a small group of informants, which presents a challenge in ensuring the credibility of the acquired data and information. Two factors that determine the credibility of this method are the coverage of potential informants and the heterogeneity of the interviewees (Beamer, 2002). Coverage refers to the ratio of successful interviews to the total potential informants. A higher coverage allows for a more comprehensive set of data and information. The heterogeneity of the informants also increases the comprehensiveness and credibility of the method, as it allows the researcher to access diverse perspectives among the elites of the research. In the fieldwork for this research, the total number of interviews was limited by the accessibility of the Chinese bureaucracy. However, I focused on increasing the diversity and heterogeneity of the interviewees. As shown in Table 1, the informants included not only current meteorologists involved in various weather modification tasks in Qinghai but also meteorologists from different historical periods (interviewee G2) and administrative levels

(interviewees G6 and G8). This helped me obtain key information from diverse perspectives and form a more comprehensive understanding of the issue.

Regarding the official meteorologists, the early interviews primarily focused on understanding the historical development, current operations, and major policy directions of weather modification in Qinghai. A supplementary interview with a meteorological official in the central government supported this exploration of how Qinghai's weather modification development fits into national policy. In the second phase of fieldwork, the interviews shifted to practical aspects of weather modification, such as the meteorologists' bodily and affective experiences during operations. During this phase, people from the meteorology office became more sensitive and reluctant to accept interview invitations due to public disputes that created a tense atmosphere in the bureau. The informants were more willing to share information about their published data, experimental results, and working procedures, which they considered objective, in comparison to more subjective questions on personal experiences and interpretations. This particular form of data was used in Chapters 5 and 6 to analyse how Chinese meteorologists comprehend and conduct weather modification practices.

Regarding the academic scholars, all interviews were conducted during the first phase of the fieldwork and were not affected by the changing political atmosphere in 2019. However, my request for a follow-up interview with the hydrologists after their dispute with the meteorologists was rejected. Therefore, my analysis of the hydrologists' perspective on weather modification in Chapter 6 was based on the two interviews conducted in 2018 when they were still willing to discuss their approaches to weather modification. I also relied on other second-hand materials, which I specified later in this section. Originally, I had planned to interview Tibetan herders and NGO workers who work closely with local

Tibetan communities. However, after conducting several interviews and informal chats, I discovered that most of these individuals were not aware of the operation of weather modification. Although this non-awareness is also worth analysing, I decided to abandon the plan to interview more local Tibetan herders due to potential ethical and political sensitivity surrounding the issue (see Section 3.3 for further reflections on these issues).

All interviews were conducted in a semi-structured form using a predetermined framework of questions. Questions were selected based on the informants' positions, experiences, and knowledge of the topics derived from my research questions. Before beginning the interviews, I introduced my research briefly and asked for the oral consent of the informants in order to maintain their anonymity, as specified in the research ethics form (Liang & Lu, 2006). With the consent of the interviewees, the interviews were audio recorded, and the files were encrypted before being saved to the hard drive. The transcripts of the recording were also anonymised. In addition to the formal interviews, I arranged to have some friendly 'hangouts' with some informants, such as having meals and visiting a night market. Although I did not directly quote information from these occasions, the insights gained from these informal conversations informed many of my thoughts in this research.

Table 1 List of interviewees

Name	Background	Date
Government officials		
G1	Meteorologist, Provincial Meteorological Bureau, Qinghai	6/8/2018
G2	Meteorologist (Retired), Provincial Meteorological Bureau,	13/8/2018

	Qinghai	
G3	Senior meteorologist, Provincial Meteorological Bureau, Qinghai	16/8/2018
G4	Meteorologist, Provincial Meteorological Bureau, Qinghai	16/8/2018
G5	Operational officer, Provincial Meteorological Bureau, Qinghai	16/8/2018
G6	Manager, China Meteorological Administration, Beijing	16/11/2018
G7	Meteorologist, Provincial Meteorological Bureau, Qinghai	20/5/2019
G8	Meteorologist, Prefectural Meteorological Office, Yushu	20/5/2019
G9	Operational coordinator, Weather Modification Office, Qinghai	12/6/2019
G10	Meteorologist, Weather Modification Office, Qinghai	12/6/2019

Scientists and academic scholars

S1	Atmospheric scientist, National Taiwan University	19/6/2018
S2	Ecologist, Qinghai University	8/8/2018
S3	Ecologist, Qinghai University	8/8/2018
S4	Hydrologist, Qinghai University	8/8/2018
S5	Post-doc researcher, Sanjiangyuan ecological and alpine agricultural laboratory	9/8/2018
S6	Ecologist, Qinghai University	10/8/2018
S7	Hydrologist, Tsinghua University, Beijing	16/11/2018

Residents and NGO workers

R1	College student, Qinghai University	6/8/2018
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R2	College student, Qinghai University	6/8/2018
R3	Participant of <i>Shanshui</i> (an NGO in Qinghai) project on the herding community, Yushu	19/3/2019
R4	NGO worker (<i>Shanshui</i>), Yushu	22/5/2019

3.2.3 Participant Observation

Participant observation is a method commonly used in science and technology studies to gain an ethnographic understanding of scientific practices in laboratories or experimental settings (Latour & Woolgar, 2013; Myers, 2015). In my original research design, participant observation was the method I planned to use to gather data on weather modification practices. The goal was to pay attention to the embodied and affective experiences in modifying the meteorological atmosphere through participant observation of weather modification meteorologists. During the first phase of fieldwork, I contacted the director of an experimental project and was invited to join their work at the Tibetan Plateau for participant observation in the second phase. However, due to the changing political atmosphere, this opportunity was no longer available when I visited Qinghai again in the second phase.

Although I did not have the opportunity to conduct formal participant observation, I had an unexpected ethnographical observation of the affective atmosphere in the meteorological office. In May 2019, I visited the Qinghai meteorological office for two interviews and to request permission to visit the prefectural branch of weather modification. As the interviews were several hours apart, I decided to wait in the office. During this time, I noticed a cautious atmosphere in the office. Many people who walked by would stop and interrogate me about my identity and purpose. This sensitivity was something that I had not experienced during the first phase of fieldwork. Although this

observation was not directly used as analytical material in the dissertation, it inspired me to investigate the scientific dispute between the meteorologists and the hydrologists, which I believed to be one of the reasons for the changing atmosphere. This inspiration was eventually developed in the discussion on epistemic politics in Chapter 6.

3.2.4 Archives

Archives that provide data and insights that supplement those obtained from interviews and observations are crucial for this research and offer different information that interacts with data generated by other methods (Prior, 2003). The documents collected can be divided into three main categories (Thøgersen, 2006b). The first category contains documents and texts produced by the government aimed at the public. These include traditional forms of public announcements, official news, and government publications. Recent studies have also paid attention to the government's online posts on official websites and social media accounts (King et al., 2017; Lu et al., 2016). For this category, data collection focused on documents and texts published by the Qinghai Meteorology Bureau that mention weather modification. Public announcements and official news published by the bureau were traced from their websites and also from the CNKI database (a Chinese government-supported full-text database for academic and media resources), which allowed access to early documents from the 2000s. I also followed the WeChat account of the meteorology bureau, where they occasionally posted information about their weather modification operations. These documents offered an official perspective on the implementation of cloud seeding that can be used in discursive analysis. They were also among the few sources that revealed statistical information about the operation, such as the frequency and estimated results, which were otherwise considered confidential data and not published.

The second category consists of official documents mainly used within the party-state and bureaucratic system, such as political guidelines, governmental plans, reports, and regulations. These documents often reveal the underlying logic, rationales, and concerns of government officials, which they might be reluctant to discuss in interviews (Thøgersen, 2006b). However, compared to the first type of archive, it is more difficult to access these documents. While some texts can be found on government websites (e.g., guidelines from the central government), not all documents are available on the internet, particularly those from local governments from decades ago. I obtained some of these documents from interviewees who were willing to provide them. I also visited public libraries and museums to access some of the archived files (see Figure 5). Surprisingly, I also found training materials for official meteorologists, which contained detailed explanations of the concepts and practical aspects of weather modification, in an online used bookstore.



Figure 5 Official documents on the Sanjiangyuan Projects at the Yushu Prefectural Museum.

The third category of archives that I collected consists of non-official documents, including academic publications and fieldwork diaries. Most of the academic publications, including papers and scientific reports, were collected from the government's online database. I also obtained some PowerPoint slides from scholars during interviews. These documents provided data for understanding the distinct scientific epistemologies of cloud water and weather modification, which were mainly discussed and analysed in Chapter 6. Another intriguing document that I found in the used bookstore was a collection of working diaries and fieldwork records for weather modification experiments in the late 1990s. These experimental diaries were not written in the typical 'scientific' manner. Instead, they recorded many personal embodied and emotional experiences of the experiments. These insights offered some valuable information on the affective atmosphere, which was discussed in Chapter 8.

3.2.5 Methods of Data Analysis

After completing the fieldwork, I began analysing the data by transcribing the audio recordings of interviews and creating photocopies of documents. I then categorised the data based on its relevance to my research questions: a process known as 'coding' (Auerbach & Silverstein, 2003). Initially, I tried using NVivo, a qualitative analysis software but found that I was spending more time troubleshooting than coding. Therefore, I adopted a more manual approach to the data sorting process. I scanned the texts, highlighted intriguing parts, and placed them into four initial data folders. These folders were named based on the main conceptual aspects of my research questions on weather modification: development, practice, knowledge, and affect. The folders were not mutually exclusive, and data in different categories were often conceptually interrelated. Therefore, I created a file documenting all the connections that could be used for further analysis.

Based on the four categories of data, I began to explore potential analytical angles that the

datasets could offer to answer the conceptual themes of my research questions. This process was intertwined with the progress of my writing as I worked on drafts of each analytical chapter. The arguments emerged from a dialogue between insights gained from inductive data analysis and deductive inspirations during writing. In some chapters, I began by bringing the empirical data into dialogues with existing literature to explore its potential contributions, while in other chapters, I began the other way around by first identifying interesting parts of the empirical stories and then exploring their implications.

My analysis of weather modification development provides an example of how the deductive inspiration emerging from the writing process informed my data analysis. I started by sorting the data based on the time sequence, which allowed me to develop a preliminary phasing on the historical development of weather modification in Qinghai. I then tried to identify some key characteristics of the governance on weather modification in those phases. While reading the texts from different phases, I noticed changes in the usage of certain terms in governmental documents and media, which could indicate an evolving tendency for public discourse. To verify this trend, I conducted a quantitative textual analysis using the CKNI database. This government-funded database provides the full content of academic and media texts and enables queries on the frequency with which certain words and terms were used each year. By analysing the frequency of specific terms in the texts of the database and organising them chronologically by year, I could quantitatively demonstrate the historical trajectory of the emergence of a concept or discourse in the public domain. In Chapter 4, I implemented this textual analysis to show how the discourse of the ‘national water tower’ emerged.

In contrast, my analysis of the materials related to weather modification knowledge and practices was approached from an inductive perspective. I posed specific questions

regarding the embodiment of cloud seeding practices and the epistemic differences between the two science disciplines, meteorology and hydrology. The analytical processes were similar to those used for the other categories of data. First, I sorted the materials, mainly scientific publications and reports, based on commonalities they shared. Then, I further analysed the materials within each conceptual group, identifying the characteristics of the datasets. These results allowed me to identify the various dimensions of the embodiment of weather modification in Chapter 5 and develop a comparison between the perspectives of meteorologists and hydrologists in Chapter 6.

3.3 Reflections

After outlining my research methods, this section reflects on my positionality, the limitations, and the ethics of the entire research process.

3.3.1 Positionality

As a Taiwanese citizen conducting fieldwork in China, my positionality was paradoxical due to the complex historical and geopolitical conflict between China and Taiwan. At times, being seen as ‘our own people (*xijiren*)’⁶ gave me both advantages and disadvantages, while at other times, I was treated as a quasi-outsider rather than a pure outsider that could be seen as innocuous (Hansen, 2006). This affected not only the logistics and daily life of my fieldwork, but also had an impact on interviews. Whenever an interviewee asked me where I was from and I replied ‘Taiwan’, I sensed a sudden change in the atmosphere that

⁶ The division between insiders and outsiders during fieldwork was not solely based on the nationality of the researchers. For instance, Cui (2015) noted that even as a Chinese researcher conducting interviews with citizens whom they knew prior to the research, the researcher’s positionality still created a gap and resulted in an ‘insider-outsider’ status.

triggered some subtle awareness inside their minds. This was the moment for them to change from seeing me as ‘our own’ to a quasi-outsider. This effect became more prominent during the second phase of my fieldwork, especially in the bureaucracy, where my Taiwanese citizenship was highlighted. While my background was helpful in building connections with some informants, particularly those who did not work in the government, it became more of a constraint in the later phase of my fieldwork.

This positionality as a quasi-outsider also manifested in my use of language during fieldwork. Upon listening to the audio recordings of my interviews, I noticed that I unconsciously adjusted my accent to better match that of the local people in the later stages of my research. Particularly during interviews with elite participants, I made an effort to eliminate some of the most distinctive Taiwanese accent and to modify my speech to sound more ‘Chinese’⁷. Scholars have noted that when conducting fieldwork with elites (Beamer, 2002) and in China (Thøgersen, 2006a), adopting a particular language strategy is important for obtaining data. However, the adjustment of my accent was not a deliberate language strategy aimed at achieving more efficient data collection. Rather, I was subconsciously attempting to avoid interviewees perceiving me as a Taiwanese citizen. This was a performative action aimed at preventing my accent from becoming a marker that would separate me from the insiders and make me appear more like an outsider (Sæther, 2006).

⁷ It is worth noting that there are countless accents in China that are distinct from standard Mandarin (*putonghua*). I did not attempt to replicate a standard Chinese accent, as spoken by official news reporters. Rather, my accent modification focused on eliminating some of the more noticeable pronunciations that are commonly associated with the Taiwanese accent. According to some of my Chinese friends, this modified accent might remind them of accents from southeastern provinces in China.

Such performativity in the fieldwork has been methodologically debated in the field of performance ethnography (Alexander, 2005), in which researchers engage with the culture both physically and emotionally and perform the roles in the culture they seek to understand. For some, this performative engagement not only enables a methodologically empathetic understanding of the other but also serves as a means by which to open up dialogue. Conquergood (1985) termed this ‘dialogic performance’, where the researcher’s performativity aims to bring the self and other together to question, debate and challenge each other and keep the dialogue open and ongoing. In other words, dialogic performance does not simply involve absorbing or mimicking otherness, but also reifies the tension and dynamics at the centre of dialogue (Madison, 2006). For me, although the imitation of the accent was not a deliberate strategy, it dissolved, to some extent, the tension of othering caused by my Taiwanese accent and the underlying geopolitical conflict between China and Taiwan and allowed the dialogue to continue. Intentionally or not, this performativity in the fieldwork was fundamentally entangled with my positionality and the perspective of this research. As Henry (2012, p. 535) notes, such performativity was ‘not the same as bounded performance or the efficacious expression of a human will but a pre-conscious discursive production.’

3.3.2 Limitations

As explained in this chapter, the political dynamics in the field led to some changes in the original research design. However, there is a limitation in my methodology that I need to specify. The voices of Tibetan residents living within the region of weather modification are missing from this research. Although Tibetan herders were listed as interviewees in the original plan, I did not carry out the interviews with them after a few preliminary contacts, as I realised that both the Tibetan community and the NGO working with them were completely unaware of the government’s practices of weather modification. This was not

because I thought their unawareness was unimportant or irrelevant, but rather because the situation was questionable. Interviewing Tibetan herders would have meant informing them about the weather modification operations, and I could not anticipate how they would react. Would they be pleased about it, or would they blame some of the problems on the government? If so, would their opposition to weather modification be considered problematic behaviour by the government? I had no idea. Given the sensitivity of ethnic politics in the pan-Tibetan region, I did not think it was worth taking the risk for the local community or for myself. However, despite the lack of data on their perspective in this research, I want to emphasise that their voices should not be forgotten. For a more general understanding of the ethnic politics of Tibetan herders, further details and discussions can be found in the works of Yeh (2013) and McConnell (2016), while Du (2012) provides a particular focus on the Sanjiangyuan area.

3.3.3 Ethics

In the research ethics evaluation of this research, I considered the potential trouble that my research could cause the informants and anonymised their identities. These measures were applied to reduce the risk of causing problems for them after their interviews. Similarly, although I had several informal meetings with some informants outside of the formal interview, I did not build any further connections or friendships with them. As Yeh (2006, p. 109) suggests, this distance reduces the risk for informants by providing them with the opportunity to 'honestly say they didn't know much about me'. This is particularly important as many of the informants in this research have positions in the party-state system. However, despite these measures, my research activities still caused some disturbance to the informants. A few months after I finished my fieldwork and left Qinghai, one of my sources informed me that there was an internal investigation in the government bureau reviewing the activities of being interviewed by foreign researchers like me.

Although I checked with some of the informants and confirmed that they were not affected, it is still a warning sign for researchers who plan to interview government officials in China. As political tensions both within and outside China increase, this growing sensitivity in the Chinese bureaucratic system poses an ethical problem that researchers must consider deeply (Alpermann, 2022; Glasius et al., 2018; Stoff & Tiffert, 2021).

Chapter 4

The Emergence of an Ecological Meteorology

4.1 Why is Weather Modification Ecological?

China currently holds the title of the world's largest and most active user of weather modification technologies (Chien et al., 2017). It is not only the scale of China's weather modification operations that is impressive but also the range of its uses. In addition to conventional uses, such as agriculture and water resource management, China has incorporated weather modification technologies into its ecological conservation efforts. For instance, in Sanjiangyuan, an iconic site for cloud-seeding conservation purposes, weather modification has been regularly operated since the 2000s as part of the conservation scheme. More recently, the Chinese government officially announced meteorology services, including weather modification, as one of the fundamental technologies for the national agenda of ecological civilisation. This means that ecological goals have become an official target for Chinese meteorology bureaus. In other words,

examining weather modification as a form of governance in China requires an understanding of how ecological goals became integrated into atmospheric governance.

Certainly, the Earth's atmosphere is ecological. It is not simply a physical condition that surrounds the planet's living forms; rather, it is an outcome of constant interaction with the biota. The composition of the Earth's atmosphere is not determined by chemical equilibrium; instead, it is shaped by the long-term presence of life. In other words, the atmosphere has co-evolved with the biosphere on the planet, leading to the emergence of a self-regulating system known as Gaia (Lovelock & Margulis, 1974).

Meteorology, the science of atmospheric processes and phenomena, is increasingly recognising the importance of ecological factors. To improve predictive accuracy, some meteorologists and modellers incorporate vegetation data into the Weather Research and Forecasting (WRF⁸) Model (Hong et al., 2009; Kumar et al., 2014). However, meteorologists tend to view ecological factors as variables of land surfaces, serving as inputs to the model rather than the objects of the research. For meteorologists, ecology is neither a target of their epistemological investigation nor a factor they directly manipulate or deal with.

For weather modification, which is a branch of meteorology that seeks to manipulate the weather, ecology is also not its epistemic object. The original epistemic object of weather modification was the weather itself. Developed during World War II, weather modification

⁸ The WRF Model is a numerical weather prediction system that operates on a mesoscale, specifically designed for use in atmospheric research and forecasting. Researchers can utilise WRF to produce simulations based on both observed and idealised atmospheric conditions. Due to its effectiveness, WRF has been extensively used by meteorological communities and atmospheric scientists globally.

was intended as a technology to modify weather conditions for military operations such as aircraft take-off (Harper, 2008; Martin-Nielsen, 2012). Later, it was used by the U.S. Army to alter battlefield conditions during the Vietnam War (Fleming, 2010). Civil uses of weather modification, such as for agriculture, were developed in the post-war era. During the development of weather modification, ecological conservation was seldom regarded as one of its functions. This makes the case of China worthy of further investigation.

In China, the connection between meteorology and ecological purposes witnessed in weather modification practices are not merely a case of interdisciplinary cooperation. As discussed in Chapter 2, this connection also signals the emergence of a new mode of biopolitical governance in which lives are managed not through direct manipulation and control but through the rearrangement and modification of the environment (Braun, 2014). It is an environmental mode of biopower, or 'environmentality' (Gabrys, 2014; Lorimer, 2017), which provides a starting point for discussing how manipulating weather became a means of governing life. However, viewing weather modification solely as environmentality does not provide a comprehensive understanding of how this form of governance operates. Further exploration is needed to understand how the atmosphere is used in governance, as well as which forms of life it targets. Answering these questions addresses the first research question of this thesis, which concerns the emergence of ecological meteorology.

This chapter aims to reveal how weather modification in China works as different modes of atmospheric environmentality. By examining different instances where weather modification was used for ecological purposes, this chapter aims to demonstrate how the weather modification can be used to govern lives. Specifically, it explores how and why meteorology became ecological in China and what forms of ecology were emphasised and

enacted within these meteorology-ecology formulations. To achieve this, this chapter traces the historical development of weather modification in Qinghai, examining how the linkages between ‘artificial rain’ and ‘ecological conservation’ emerged. Using discourse analysis and an examination of the underlying political economy, this chapter reveals the discursive devices used to define and perceive ecological issues. Throughout this chapter, the path of cloud-seeding operations in Qinghai since the late 1990s is followed, showing how meteorology discursively and institutionally became ecological.

I suggest examining the various aspects of the connection between meteorology and ecology that have emerged throughout the historical trajectory of weather modification in Qinghai. This chapter identifies three ways in which modified rain was used to engage with ecology: as an emergency measure, as a restoration tool, and as weather infrastructure. These modes not only provide multiple dimensions for answering the question of how meteorology becomes ecological but also describe a new mode of governance in which modifying weather becomes a means of governing what is considered ecological. The objective is to examine the historical events and policies of weather modification, through which different relationships between meteorology and ecology have been manifested, and to scrutinise the discourses and politics underlying ecological meteorology.

This chapter is organised as follows. Firstly, it discusses a weather modification experiment in 1997 that was a response to a severe environmental incident, the drying-out of the Yellow River, which caused public anxiety. During this incident, weather modification gained public attention as an emergency fix to save the degraded landscape. Secondly, it examines the policy and discourse after 2000, which viewed weather modification as a conservation tool. The political economy and discourse underlying this conservation strategy, which emphasises the ecosystem service of conserving water, are analysed.

Thirdly, it discusses the paradigm shift in meteorology after 2015 in China, when ecology was recognised as an inherent rationale of meteorology. Under the new institutional and organisational arrangement, weather modification serves as an ecological infrastructure believed to be the foundation for maintaining the integrity of the ecological system. Lastly, the chapter provides a framework for considering these meteorology-ecology relations. By proposing three potential conceptual modes of atmospheric environmentality, this chapter contributes to the academic discourse on environmental governance in the Anthropocene (Braun, 2014; Gabrys, 2014; Lorimer, 2017).

4.2 Artificial Rain as an Emergent Solution: Saving the Mother River

4.2.1 The Crisis of a Symbolic Landscape

In 1997, the Yellow River basin experienced a severe drought that led to the absence of downstream water flow for a record-breaking 226 days. This was due to the long-standing challenge of drought in the region, exacerbated by the increasing demand for water due to population growth and the construction of dams and reservoirs in the up- and mid-stream areas. While occasional river cut-offs had occurred since the 1960s, they became more frequent in the 1990s (see Figure 6 and Figure 7). The extended cut-off in 1997 highlighted the government's concern and public anxiety about drought and water-related environmental problems in Northern China. The then-premier, Li Peng, stated in the ninth Five-Year Plan that 'the Yellow River has nurtured the Chinese nation, yet it has also become our biggest problem.' Although water supply had long been a concern, the sight of the dried-out Yellow River, a symbolic icon of the origin of Chinese nationality and known as the 'mother river', deeply affected the public.



Figure 6. Exposed riverbed during the Yellow River cut-off incident

Source: People's Daily Online <http://env.people.com.cn/BIG5/41909/42116/3471435.html>

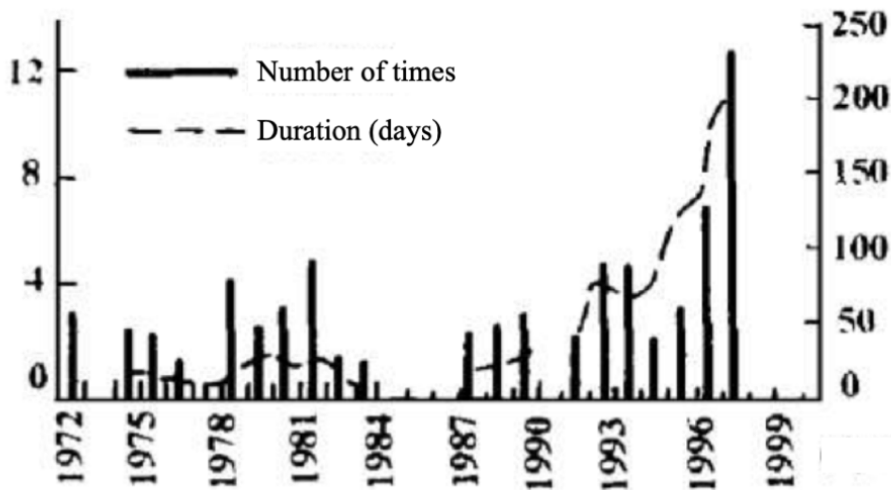


Figure 7. Times and durations of Yellow River cut-off incidents

Source: Chen and Mu (2000)

During the 1990s, environmental degradation became a growing concern in China due to rapid urbanisation and economic growth, and the degraded landscape was often framed as a problem in need of governance. In Northern China, issues such as drought-related degradation, desertification, and the disappearance of natural water bodies, as well as associated problems, such as sandstorms, dominated public perception of environmental issues (Mol & Carter, 2006). Consequently, preserving the water landscape and ensuring its ability to provide a stable water supply became a central concern of environmental governance.

This landscape approach to framing public environmental anxiety and governance can be exemplified by the issue of desertification in northern provinces, such as Gansu and Inner Mongolia. This vast area surrounding the midstream of the Yellow River is relatively dry but historically had vibrant agricultural activities due to irrigation using the river. However, since the 1980s, herders and rural residents in this area have suffered from expanding desertification, which soon raised national concern, as the growing desert turned out to be a source of sandstorms that endangered major northern cities, including Beijing. Anthropologist Jerry Zee (2015, 2017) described in his ethnography of Minqin, Gansu, how the locals and the government commonly framed the problem as an invasion of sand and the disappearance of the water landscape. The official slogan given to Minqin by then-Premier Wen Jiabao clearly demonstrates this: ‘Minqin must not become a second Lop Nur.’ Lop Nur was a vast, salty lake in Xinjiang that dried out and disappeared entirely in the 1970s. The reference to Lop Nur, in terms of the disappearance of water landscapes, reifies the problems in Minqin in a specific way. The landscape thereby became an environmental prophecy that frames the perception of the problems.

The drought landscapes, including expanding deserts and shrinking water bodies, not only represent the scene of environmental degradation but also serve as the objects to be tackled. As Zee (2017) noted, the governance of landscapes serves as a political proxy through which the government can demonstrate its ability to govern the environment by preventing and eliminating problematised landscapes. Landscape engineering, which primarily aims to modify landscapes, has become a crucial part of official actions. In Minqin, measures such as afforestation, windbreaks, and the use of artificial (plastic) plants have been employed as anti-desertification solutions (Zee, 2015). Similar approaches targeting landscapes can also be seen in the case of the Yellow River cut-off incident.

Here, the Yellow River is not just an environmental object that needs to be tackled or preserved, nor is it just a means of governance through which ecological problems can be solved. The Yellow River, considered the mother river and the origin of Chinese civilisation, has become a charismatic nonhuman subject. Lorimer (2007) defined nonhuman charisma as ‘the distinguishing properties of a nonhuman entity or process that determine its perception by humans and its subsequent evaluation’ (p. 915). While this concept was mainly developed for organisms, a charismatic landscape such as the dried-out Yellow River also holds symbolic power that shapes discourses and perceptions of the problem and informs governance conducts. The landscape of the dried-out Yellow River attracted much attention and induced greater anxiety than other representations of the drought. The charismatic landscape not only worked as a political proxy that demonstrated the efficacy of governance, but also emerged as an imaginary proxy that prophesied the nation’s dystopian environmental future if no action was taken. Such landscapes ‘must not be allowed’, as Premier Wen stated strongly, whether it is a dried-out lake that repeats the misery of Lop Nur or a cut-off of the mother river, the Yellow River.

4.2.2 A Shower of Hope

Under the discourse of saving the mother river, increasing the amount of water in the Yellow River became a persuasive solution for the Chinese government. Qinghai Province, the source of the Yellow River, played a crucial role in this approach. The Qinghai Weather Modification Office conducted its first cloud-seeding experiment soon after the cut-off incident in 1997. Although cloud seeding had been occasionally performed in Qinghai province since the late 1970s, it was mainly for agricultural purposes in populated residential regions. Little was known or done at the upper stream of the Yellow River, which is remote from residences and infrastructure. In January 1997, a scientific team of meteorologists and engineers conducted eight days of fieldwork in the upper stream of the Yellow River, investigating the area's geography, hydrology, and weather features. In their fieldwork report, the investigation team concluded that 'considering the weather and hydrological factors, it is feasible to conduct rain enhancement in this area' and suggested beginning an 'experimental airplane operation in spring and ground operation in summer' (Deli et al., 1997).

The Qinghai Power Company, which operates several hydropower plants on the Yellow River that were affected by the drought, was the first to be interested in this cloud-seeding proposal. In April 1997, a contract worth one million Chinese Yuan was signed between the power company and the meteorology office to increase the water supply by 480 million cubic metres from April to September. Although the effectiveness of the 1997 experiment fell short of the original expectation (Yang & Zhao, 1997), the impression of 'saving the mother river by cloud seeding' captured the attention of the public and national media. In June 1997, national media, including Xinhua News Agency and CCTV, reported on the experiment, which was uncommon for a marginal province like Qinghai at the time. The experiment gained national fame and the interest of provincial political leaders. The then-

provincial Governor Bai Enpei concluded in the performance review meeting in October that ‘although the result [of cloud seeding] was less than expected, it was still quite a success’ (Qinghai Weather Modification Office, 1999, p. 212) and decided to continue the experiment in the following years. A three-year province-funded project (six million CNY per annum) on the subsequent cloud-seeding experiments was approved at the end of 1997 and was suggested as the most significant investment for developing ‘cloud water resource’ in China in the late 1990s.

The success of the experiment in attracting national attention was not a coincidence. In my interview with a meteorologist who played a crucial role in the 1997 experiment, he suggested that the naming and framing of the experiment were deliberately chosen to emphasise that it was for the ‘upstream Yellow River’, even though it was initially proposed to the hydropower company for a local reservoir. The meteorologist further explained:

After the fieldwork, we decided to use the term ‘upstream Yellow River’, which turned out to trigger all the following effects. If we just called it the Longyangxia reservoir project, no one would have cared about it (Interview, G2).

The strategic naming of the cloud-seeding experiment helped to address public anxiety about the dried-out mother river. The naming of the experiment as being for the ‘upstream Yellow River’ resonated with the public, even though it was only a local reservoir project. In the meeting in which the three-year government-funded project was approved, the deputy minister of the China Meteorological Administration (the central agency for meteorology affairs) commented that weather modification at the upstream Yellow River was a ‘strategic and visionary project for the country and the mother river of the Chinese nation’ (Qinghai Weather Modification Office, 1999, p. 5).

The human-induced rain that emerged under this framing became a symbolic subject that rivalled the antagonistic dried-out river landscape. Although the issue of the Yellow River cut-off is equally, if not more, influenced by the demand side, rain appeared to be a much more charming and tangible solution. The problems were reified by degraded landscapes and exposed riverbeds while the artificially enhanced raining scene was framed as the solution. Qinghai, as the upstream of the mother river, became a frontline in combating the threat to the nation. Like the sand in Minqin, the rain in Qinghai became what Zee (2017, p. 235) called the ‘physical substrate for new modes of political fortune-telling.’

4.3 Artificial Rain as a Conservation Strategy: Securing the National Water Tower

4.3.1 The Province of Ecology

Like many other regions in Western China, Qinghai has historically been considered a peripheral province due to its remote location and underdeveloped economy. As a result, receiving media attention, such as that generated by the 1997 cloud-seeding experiment, was a rare occurrence for the province. However, at the beginning of the 21st century, the western provinces were presented with a unique opportunity to obtain national attention and secure budget allocations from the central government. China Western Development, a project led directly by then-Premier Zhu Rongji, was launched by the government in 2000 to boost economic and social development in the western region, which contributes only 20% of the country’s GDP despite covering 70% of China’s land area. For provinces like Qinghai that rely heavily on central government funding, this was a chance to compete for budget and for local political leaders to gain political achievements.

A challenge for Qinghai's political leaders was determining which goals and projects to propose to compete and secure funding. The China Western Development policy prioritised the development of infrastructure and economic growth. However, Qinghai, situated at the north-eastern edge of the Tibetan plateau, has over 90% of its land used for low-density herding or left wild. Although there are several potassium mines, it is not a major industry in the province. As a result, rather than emphasising economic development, Qinghai chose to highlight its ecological significance, presenting itself as a 'province of ecology' (*shengtai dasheng*).

This strategy of positioning Qinghai as an 'ecological province' was not only based on its environmental assets but also aligned with the growing ecological concerns of the nation at the time. In 1998, the State Planning Commission introduced the National Plan for Ecological and Environmental Construction, in which the central government identified the primary mission for Qinghai (which covers the upstream area of the Yellow River and the Yangtze River) as preventing environmental degradation to maintain the capacity to preserve water. In response to the national plan, Qinghai Province announced its own provincial plan in 1999, outlining specific objectives for 'ecological construction'.

4.3.2 Constructing the National Water Tower

In the '*Qinghai Plan for Ecological and Environmental Construction*' published in 1999 by the provincial government, the narrative started by emphasising that Qinghai covers the sources of three large rivers: the Yellow, the Yangtze, and the Mekong. Being the sources of these rivers not only refers to Qinghai's geographical location as the origin of the rivers but also highlights the importance of the water supply in these areas. These areas contribute to 49% of the water flow in the Yellow River, 25% in the Yangtze River, and

15% in the Mekong River. The plan's narrative emphasised the geographical and functional significance of the water supply in these areas, providing the main rationale for the ecological goals and measures in the plan.

The focus on the freshwater ecosystem service is also evident in the naming of relevant projects. In the 1999 plan and subsequent governmental and public texts, Qinghai is often referred to as the 'water tower of the Chinese nation' (*zhonghua shuita*). Additionally, the term Sanjiangyuan, meaning 'source of three rivers', was officially designated to refer to the region and was used in the naming of ecological construction projects, a conservation area, and a national park. The emergence of these two expressions was closely related to the Qinghai government's strategy of promoting itself as an 'ecological province' since the 2000s.

Both terms, 'Sanjiangyuan' and 'water tower of the Chinese nation', emerged around 2000 and quickly became the dominant terminology for referring to the region after the then-president of China, Jiang Zemin, inscribed Sanjiangyuan on a monument. The fact that the highest leader endorsed this term conveyed a political message that Sanjiangyuan had been elevated to the status of a national discourse. The emergence of these water-related terms can also be demonstrated through text analysis. A full-text search of the CNKI database⁹ for 'Sanjiangyuan' and 'water tower of the Chinese nation' shows that texts (including academic and newspaper articles) mentioning these terms suddenly emerged around 2000 (see Figure 8). This provides evidence of the connection between Qinghai's ecological plans and projects and an ecological discourse that places an unbalanced

⁹ The China National Knowledge Infrastructure (CNKI) is the largest and most comprehensive online database that includes the full text of journal articles, dissertations and theses, conference papers and proceedings, newspapers, and yearbooks. The earliest text it includes traces back to 1949.

emphasis on the ecosystem service of water conservation.

The discourse of Qinghai being the source of three rivers and the nation's water tower created a perceived homogeneity of these areas in two ways. On the one hand, this discourse implies a functional homogeneity of the region, as it creates a unity of the Sanjiangyuan region based on its expected ability to serve as a water source for the nation. This region's ecological and environmental governance highlighted the ecosystem service of securing the water supply. By referring to the region as an ecological region of river sources, the names keep reminding and emphasising the importance of its ecological significance for water (see Figure 9).

On the other hand, the discourse also created a perceived geographical homogeneity that unites the whole area as one region. The Sanjiangyuan region is vast, covering approximately 363,000 km², and makes up 50% of Qinghai Province. It is complex and fragmented topographically, as the entire region comprises three catchments separated by terrain. However, the naming created a cartographic sense of unity, through which the entire region was conceived and represented as a single entity. This three-in-one naming not only refers to the geographical adjacency of the sources of three rivers and their shared ecosystem service but also induces a way of geographical representation. The river's source was often portrayed through similar landscapes, such as alpine lakes and streams, that conform to the idea of being the origin of rivers (see Figure 10).

With the two aspects of the perception of homogeneity, Sanjiangyuan is portrayed as a charismatic nonhuman subject with a clear sense of purpose (the ecosystem service for water supply) and a distinct identity (the representation of iconic landscapes). These charismatic features underlying the discourse influence how humans perceive and evaluate

it (Lorimer, 2007). In 2005, the Chinese government officially announced the ‘Ecological Conservation and Construction Project on Sanjiangyuan’. This 8.5 billion RMB central government-funded environmental restoration project had the explicit goal of ‘increasing the area of grassland and improving the ability to preserve water.’ Environmental problems, such as the desertification of grassland and shrinking lakes, were portrayed as degraded landscapes, and the means of governance was biased towards the restoration of these landscapes.¹⁰

This emphasis on restoring landscapes and their ecosystem service for water conservation also influenced how the project was evaluated. A central government official concluded in a media interview¹¹ that the three most significant contributions of the project were: (1) an increase in vegetation coverage, (2) an increase in the areas of lakes and wetlands, and (3) an improvement in overall water conservation capability.

The discourse that highlights the unity of the Sanjiangyuan region as a national water tower was crucial to Qinghai’s political goal of becoming the province of ecology. This discourse successfully justified Qinghai’s designation of ‘the ecological’ as a development strategy since the Western China Development project. A significant portion of central funding received by Qinghai was allocated to projects for ‘ecological construction and conservation’. However, this emphasis on the ecological did not stem from the intrinsic value of ecology but rather the instrumental value of ecosystem services, particularly water

¹⁰ Yeh (2010) critiqued the measures aimed at landscape restoration in Sanjiangyuan, such as restriction on grazing, which have simplified the issue. The official discourse, she suggested, provided ‘weeping statements about pervasive degradation across the plateau’ (para. 9) based on methodologically questionable surveys. See also Harris (2010) for a similar critique.

¹¹ This interview conducted on 24 January 2014 was posted on the central government website: http://www.gov.cn/zxft/ft242/content_2574626.htm

supply, as the water tower of the nation. Under this discourse, Qinghai's ecology serves as a national water infrastructure,¹² and the 'province of ecology' is, in fact, the 'province of water'.

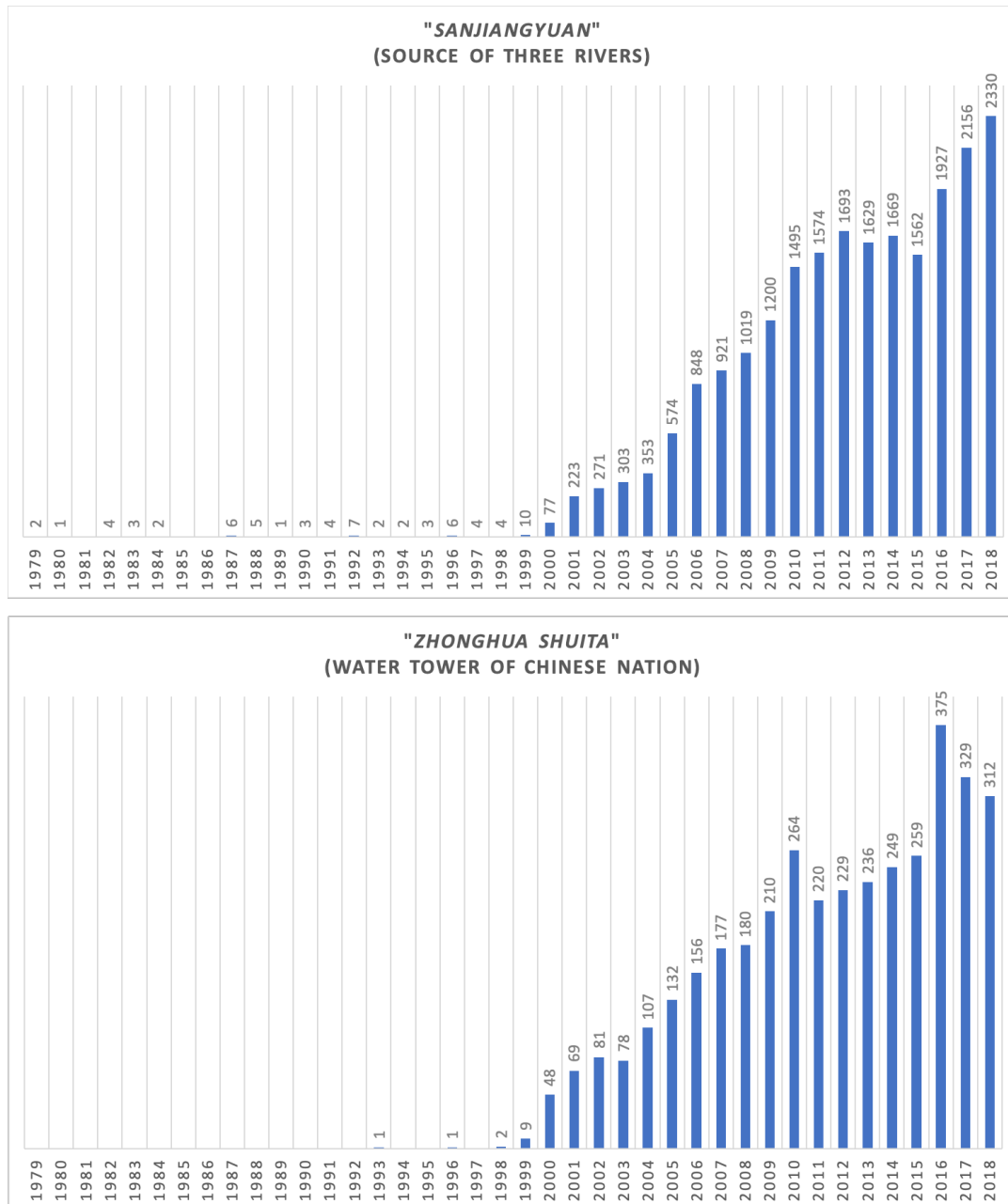


Figure 8. The number of texts mentioning the two key terms in the CNKI database.

¹² In the writing on the anti-desertification programmes at the north western China, Zee (2015) also depicted how engineered landscapes became a national infrastructure for preventing the sandstorm.



Figure 9. The entire region of Sanjiangyuan viewed based on its eco-service function



Figure 10 Common visual representations of Sanjiangyuan in Chinese media

4.3.3 Conserving the Water Tower From the Sky

The emphasis on water in Qinghai's ecological strategy highlights the importance of the province's weather modification operation. During a meeting examining the weather modification operation in 1999, Qinghai's party secretary, Tian Chengping, instructed that 'developing cloud water resources through cloud seeding is necessary for ecological conservation in the province' and requested the meteorology bureau to provide a 'weather modification programme for the alpine ecosystem' (Qinghai Weather Modification Office, 1999, p. 215). This instruction allowed for the continuation and expansion of the three-year cloud-seeding experiment and provided a new rationale for the operation. In the 2005 Plan of Ecological Construction and Conservation, the cloud-seeding programme was proposed as one of the methods for environmental restoration. Since then, cloud seeding for ecological conservation has become the primary task of Qinghai's Weather Modification Office (see Figure 11).

Meteorologists also have a strong financial incentive, in addition to the political order from provincial leaders, to be incorporated into the conservation scheme. As the ecological plan brought a huge budget allocation to Qinghai, it became an important funding source for bureaus to compete for. For a provincial-level bureau, being incorporated into the ecological plan means having the opportunity to obtain a national-level budget that surpasses any of their existing budgets. Indeed, the Qinghai meteorology bureau received 1.6 billion RMB in funding from the 2005 Plan of Ecological Construction and Conservation for operating cloud seeding in the Sanjiangyuan region. This was the single largest national-level investment for any provincial-level meteorology bureau (Chinese Meteorological Society, 2009).

Under the 2005 Plan of Ecological Construction and Conservation, weather modification gained its position as one of the conservation measures for the ‘national water tower’. The cloud-seeding operation aimed at ecological conservation became a regular task of the Qinghai Weather Modification Office rather than a temporary experiment. This not only established regular operations of cloud seeding but also reinforced the discourse that emphasised ecosystem service and perceived rain as a conservation measure.



Figure 11. Major operational areas of weather modification in Qinghai.

Most of the coloured areas, except the two at the top-right corner, operate for ecological and water conservation. Source: Qinghai Weather Modification Office

4.4 Artificial Rain as Atmospheric Infrastructure: Constructing the Eco-meteorology

4.4.1 *An Infrastructural Rain*

The 2005 Plan of Ecological Construction and Conservation ended in 2012 with positive results. Siao et al. (2016) developed an assessment framework to evaluate the plan's overall effect after eight years of implementation. Their findings indicated that 25% of degraded grassland had improved, and the water conservation capacity had increased by 15%. Although the plan included many other conservation measures, their model suggested that weather conditions, including the cloud-seeding efforts, dominated and accounted for the landscape's recovery. This approach continued in the second phase of the ecological construction and conservation plan, which began in 2013. Since then, weather modification for ecological conservation has become a regular duty for Qinghai's meteorologists. For instance, in 2019, the Qinghai Weather Modification Office conducted over 100 flights in its cloud-seeding operation, equating to an average of cloud seeding every three to four days. The modified weather is no longer a conditional operation but an everyday occurrence. In other words, this artificial rain has become somewhat infrastructural.

Infrastructure, as Larkin (2013, p. 329) suggested, refers to 'objects that create the grounds on which other objects operate, and when they do so, they operate as systems.' Infrastructure refers not only to material things but also to the enabled/enabling relations among things.¹³ Being infrastructural implies both the material and ontological articulation

¹³ Infrastructure is commonly defined as a 'system of substrates' through which the operation of technologies and everyday life are enabled. However, as Edwards (2003) pointed out, it is also important to note that infrastructures' operations are often inter-reliant (e.g., the relationship between electricity and the

of different elements and matters. As Jensen and Morita (2017) suggested, infrastructures are open-ended ontological experiments through which disjunctive elements are integrated and new relations emerge. Hence, arguing that the modified rain is infrastructural is not simply pointing out its instrumental function in enabling certain operations. It is also implying an emerging ontological articulation between rain, ecological discourses, and environmental governance.

4.4.2 Eco-meteorology

Here, meteorology has evolved into ‘eco-meteorology’, in which an inherent ontological articulation exists between the meteorological and ecological purposes. Eco-meteorology intervenes not only by providing weather information for forecasting and monitoring but also by altering the weather. This paradigm shift in meteorology was best demonstrated in 2017 when the China Meteorological Administration of the central government announced a new policy direction to ‘improve [its] meteorological service abilities for the ecological civilisation.’ The announcement clearly stated a new position for meteorology to support and restore the ecological system. Weather modification activities lie at the centre of this new direction. The policy set a clear political goal to improve cloud-seeding capability and reach 60 billion cubic metres of enhanced rain annually by 2020.

In 2017, the China Meteorological Administration established the ‘Plan for Ecological Civilisation Construction and Protective Meteorological Services’, which further specified the details of this new ecological rationale for meteorology. The plan encompasses three main services and abilities for ‘meteorological protection for ecology’. First, it includes

computer system that operates electricity). In other words, infrastructure does not function as a linear-enabling relation but as a recursive system.

meteorological services such as forecasting and monitoring that support and collaborate with typical ecological conservation measures. Second, it refers to meteorological technologies that aid in the ‘conservation and restoration’ of ecosystems. Finally, it covers meteorological abilities to deal with climate change, extreme weather conditions, and their corresponding environmental consequences. Within this ‘eco-meteorology’, weather modification plays an essential role as a means of intervention.

Eco-meteorology has taken shape in terms of institutional and organisational aspects. At the central level, the ‘National Weather Modification Development Plan 2014–2020’ adjusted its geographical divisions of operation to align with the national ecological conservation plan, demonstrating that ecological-targeting weather modification is now considered one of the main tasks. At the provincial level, new joint organisations were established to reflect this linkage. For example, in Qinghai, the Centre of Ecological Meteorology (*shengtai qixiang zhongxin*) was established in 2017 to create an ‘eco-meteorological service system’ that supports the research, monitoring, and execution of weather modification for ecological purposes. The provincial meteorology bureau also developed a collaboration framework with the forestry bureau to cooperate on conservation affairs.

The institutionalisation of eco-meteorology works as a discursive device that reifies and consolidates the ontological articulation of meteorology and ecology. It also aligns with the Chinese Communist Party’s current ideological concept of ‘ecological civilisation’ (Chen, 2017), which associates China’s ecological prosperity with its modernisation and civilisation (Goron, 2018; Weatherley & Bauer, 2021). Under this discourse, there is no difference between meteorology being ‘ecological’ and being ‘civilised’. Eco-meteorology and humanised rain serve not only as the physical elements of eco-political fortune-telling

(Zee, 2017) but also as an ideological symbol for the preservation of Chinese civilisation, in which the atmosphere needs to be ‘civilised’ just as meteorology needs to be ‘ecological’.

Considering rain as an ecological infrastructure does not simply refer to the physical arrangements and operations that involve clouds as a water resource in the air, or a ‘sky reservoir’ (Chien et al., 2017). As Jensen and Morita (2017) suggested, being infrastructural implies an ontological experiment within which new relations between things and thoughts emerge. This creates an environmentality where meteorology becomes ecological, such that weather functions as a means of environmental governance. The modified rain serves as an environmental infrastructure (Hetherington, 2018; Zee, 2022), not only supporting the proper functioning of an ecological system (in terms of its ecosystem service) but also aligning with the ‘eco-civilisation’ discourse and governance.

4.5 Three Modes of Atmospheric Environmentality

After exploring the trajectory of weather modification development in Qinghai, the question that opened this chapter can now be revisited: How does meteorology become ecological, and what modes of governance emerge as a result? As I have suggested, the various methods and objectives of weather modification not only reflect the historical trajectory of its development in China but also reveal different modes of governing life by manipulating the atmosphere. Following Gabrys’ (2014) terminology, I refer to this governance as ‘atmospheric environmentality’, in which lives are controlled, managed, and influenced through intentionally modifying the weather. Based on the empirical discussion presented in the previous sections of this chapter, I further develop the concept of environmentality and identify three distinct modes of governance with differing goals,

temporalities, and politics.

The examination of atmospheric environmentality requires a multifaceted approach. The ways in which weather modification addresses ecological issues have changed over different historical periods, and the connection between meteorology and ecology has evolved with changing socio-political conditions. This evolution has been significantly influenced by the China government. Therefore, government discourses and actions regarding the meteorology-ecology connection are crucial for understanding atmospheric environmentality. First, the objectives of weather modification operations and the ecological goals they were intended to achieve have taken different forms over time. Identifying these distinct ecological goals provides empirical insight and has conceptual implications for understanding the different modes of atmospheric environmentality. Second, the temporalities of the operations and goals of the three modes of atmospheric environmentality differ, revealing how these modes of governance perceive their relationship with the past, present, and future atmosphere. Third, the articulation of meteorology and ecology has involved various political dimensions. Together, these aspects have been woven into the atmospheric mode of governance, an environmentality in which meteorology becomes ecological and through which rain becomes a means of governing different forms of life.

4.5.1 An Emergency Fix for the Present

The first mode of atmospheric environmentality is the emergency fix, where weather modification is used as an emergent response to a natural hazard and the resulting problematic landscape. The authoritarian state also utilised this operation to demonstrate its will and capability to deal with the hazard and alleviate public anxiety. The connection between meteorology and ecology was experimental, non-standardised, and dependent on

the specific emergency. Meteorologists were only involved in ecological considerations to temporarily mitigate particular environmental events. This mode of atmospheric environmentality works in the short term as a one-time mitigation, aiming to respond to hazardous environmental events that require immediate action. The main objective of this mode of governance is to contain the hazardous event and show society the efforts taken by the authority.

This mode of atmospheric environmentality is not exclusive to China but can also be observed in other countries. For instance, during the 2019 dry season, Malaysia experienced severe smog caused by a forest fire in Southeast Asia. To combat the smoky haze, the Malaysian government employed cloud seeding to reduce the smog aerosols and alleviate the air quality issue (Linh, 2019). Similarly, this emergency mode of atmospheric environmentality has been used to address human-made disasters. For example, in 2015, a catastrophic chemical explosion occurred in Tianjin City, where about 800 tonnes of ammonium nitrate, the same chemical that caused the 2020 Beirut explosion, were accidentally ignited. The Tianjin Weather Modification Office swiftly designed and implemented an experimental weather modification project to contain the fire and prevent further incidents (Meng et al., 2017).

4.5.2 A Tool for Restoration of the Past

Unlike the first mode, which addresses individual environmental events, the second mode of atmospheric environmentality, the tool for restoration, involves modifying the weather for problematic environmental situations that require longer-term solutions. Meteorology is incorporated with ecology under this mode as a tool to aid in restoring degraded environments and their ecological services. Here, weather modification is regarded as a restoration tool for ecosystem services due to the emphasis placed on water resources in

the conservation regime. It is this selective emphasis on water resources that links cloud seeding, a meteorological technology, to ecological goals.

Compared to the first mode, which focuses on coping with each disastrous event, the second mode of atmospheric environmentality has a temporality that links to the past. This mode of governance aims to restore the environment to a baseline situation of certain ecological objectives. Ecologists and policymakers often rely on a backwards-looking assumption to establish benchmarks and goals based on past reference points for ecological restoration (Higgs et al., 2014; Ureta et al., 2020). However, establishing a baseline is often a debated issue in restoration politics, as many studies have pointed out. Some researchers unconsciously regard the environmental condition at the beginning of their research career as the ecological baseline (Pauly, 1995). Other paradigms, such as rewilding, which involves reintroducing animals that have been exterminated by humans into the wild, deploy the baseline condition in a way that excludes human influences in time and space from nature (DeSilvey & Bartolini, 2019; Jørgensen, 2015). Nevertheless, the common thread among these perspectives is that they diagnose present problems and attempt to improve conditions with reference to the past.

Although this mode of atmospheric environmentality, which views weather modification as a tool for restoration, is temporally linked to the past, it does not mean that it simply employs a time-reversal approach. As Lorimer (2020) noted, restoration efforts not only involve using past benchmarks to determine desired ecological conditions, but also represent a form of 'future pasts' that 'conjoins retrospection and futurology' (p.183). By modifying the weather, this mode of governance enacts biopolitics that selectively restores and enhances certain valued forms of ecology (such as alpine meadows and wetlands in Sanjiangyuan) while being less concerned about other forms. The atmospheric

environmentality mode is oriented towards the past not by replicating the atmospheric condition of the selected baseline year but by modulating the weather to induce changes in specific ecological objectives and their ecosystem services towards a more desirable status, which indeed ‘prospects into the future and anticipates novel ecologies’ (Lorimer, 2020, p. 161).

4.5.3 Weather Infrastructure for the Future

Finally, in the third mode of atmospheric environmentality—the weather infrastructure—the modified weather serves as an infrastructure in which an ecological rationale of constructing and maintaining a favourable condition is inherent (Wakefield, 2020b; Zee, 2015). Under this mode of governance, the connection between meteorology and ecology is ontological—an eco-meteorology through which the manipulation of weather is not a tool for mitigating a present disaster or restoring the eco-system to a past condition, but an infrastructure for pursuing a favourable environment in the future. In the Chinese case discussed in this chapter, this environmentality resonates with the Chinese Communist Party’s discourse of the ‘ecological civilisation’ that links the fortunes of civilisation with the capability to create a ‘better ecology’. Here, the idea of ecology loses almost all the physical referents and becomes a symbol of a better stage of civilisation.

Therefore, eco-meteorology is an ontopolitical form of governance (Chandler, 2018; Whatmore, 2013) that offers an optimistic outlook for the future by interweaving the atmosphere and ecology as the foundational elements for building more liveable environments. This governance approach is ontopolitical because it governs with the non-linear complexity of atmospheric systems. Weather is not simply the target that meteorological infrastructure aims to control. Instead, the complex material properties of weather systems become an inseparable part of the infrastructural capacities. It abandons

the mode of full command-and-control and embraces heuristic and radical openness to generate or 'hack' (Chandler, 2018) potential transformation (also see Wakefield, 2020a). In other words, under this mode of atmospheric environmentality, the meteorological atmosphere becomes what McCormack (2017) referred to as 'elemental infrastructure'. It is not only transformed by infrastructures but also forms part of the generative conditions for infrastructural capabilities

This form of governance is also optimistic because it is based on positive projections for shaping the future. For instance, in 2020, the Indonesian government conducted preventive cloud-seeding operations during the dry season to lower the risk of forest fires (Yulisman, 2020). This preventive and future-oriented atmospheric environmentality is seen by some, such as geoengineering advocates, as a way of addressing the consequences of climate change in addition to mitigation and adaptation. However, while this mode of atmospheric environmentality comes with significant optimistic promises and hopes, it also raises suspicions and numerous political and ethical concerns (Clark, 2013; Corner & Pidgeon, 2010; Humphreys, 2011; Minter, 2012). In Chapter 7, I will further discuss how this optimistic affect is a critical and inseparable part of atmospheric governance.

It is important to note that although these modes of atmospheric environmentality were derived from different historical periods, they are not distinct stages that replaced one another. Rather, features of all three modes of atmospheric environmentality often coexist in each empirical scenario. For example, while cloud seeding may be used as an emergency solution for occasional urban smog, it may also acquire an infrastructural meaning as it becomes institutionalised into the smog-coping scheme.

Table 2. Different modes of atmospheric environmentality

	Ecological goals	Temporality	Politics
Emergency fix	Containing and mitigating an environmental hazard	Short term; one-time reaction; present-oriented	Distributive politics and affective politics of hazard and disaster
Tool for restoration	Restoring degraded ecosystem services	Midterm; maintaining baseline year level; past-oriented	Biopolitics of ecosystem services
Weather infrastructure	Constructing favourable weather	Long term; future-oriented	Ontopolitics of atmosphere and life

4.6 Conclusion

In this chapter, I aimed to answer the empirical question of how weather modification in China is connected to ecological goals and deepen the theoretical concept of environmentality. I explored the historical trajectory of weather modification in Qinghai and how it was used to achieve different ecological goals. Through this historical review, three different modes of meteorology-ecology relations were revealed. First, after 1997, weather modification experiments were conducted in response to a severe drought in the Yellow River and were seen as an emergency measure to address public anxiety and hopes for an experimental solution to an ecological hazard. Second, weather modification was incorporated into the Sanjiangyuan conservation plan as one of the measures for ecological restoration after 2004. Weather modification became a means of maintaining ecosystem services under the discourse of Qinghai being the national water tower. Third, after the mid-2010s, Chinese meteorology underwent an ‘ecological turn’ in which ecological rationale became inherent in the government’s meteorological institutions and

organisations. Meteorology, particularly weather modification technologies, became the infrastructure for constructing ecological conditions. I argued that these modes not only demonstrate the historical trajectory of weather modification development in Qinghai but also showcase different dimensions of an emerging atmospheric environmentality that governs the biosphere through weather modification.

Conceptually, this chapter contributes to academic discussions on the environmental mode of biopower (see Section 2.1 for a detailed review) by deepening the concept of 'environmentality' with different modes of goals, temporalities, and politics. As discussed in this chapter, all three modes within this atmospheric environmentality demonstrate distinct ways in which meteorology engages with ecology. Corresponding to those ways of engagement, various dimensions of politics were also enacted through these modes. These three modes of atmospheric environmentality provide a conceptual and analytical perspective, rather than a strict classification or periodisation, that interrogates different aspects of the material and conceptual articulation between meteorology and ecology. These modes do not evolve into or replace each other but rather intertwine and emerge differently from case to case. These modes of atmospheric environmentality unpack the perplexing and intertwined dimensions that underlie contemporary Chinese governance to and through the atmosphere.

This conceptualisation proposed in this chapter is not just a theoretical tool for understanding the meteorology-ecology relations and atmospheric governance in Qinghai's weather modification operation. It also sheds light on a broader examination of atmospheric practices and politics in the Anthropocene, particularly on proactive interventions discussed in Chapter 1. The distinction of different modes of atmospheric governance in this chapter emphasises a crucial but less-discussed perspective on proactive

measures like geoengineering and weather modification, considering various temporalities. Should the intervention be an emergency plan to mitigate the damage of environmental hazards, as the Chinese and Malaysian governments attempted to tackle smog? Should it be a restoration tool for halting and reversing degraded environmental conditions to support certain ways of living, human or nonhuman, as China tried to accomplish in Sanjiangyuan? Or should it be an infrastructure that actively adjusts and modulates local and/or global atmospheric conditions for a more favourable future, as some geoengineering advocates suggest? Furthermore, what are the relations between the meteorological practices and epistemic discourses of these projects, and what politics do they enact? I address these questions in Chapters 5 (on practices), 6 (on epistemics), and 7 (on affective politics).

Chapter 5

The Choreography of the Modern Rain Dance

5.1 Choreographing the Modern Rain Dance

5.1.1 The Palpability of Weather

‘Weather modification does not create rain from nowhere. We enhance the rain, not create it.’ Nearly every interview I conducted with weather modification meteorologists began with this statement, possibly because it is the most common misconception they try to clarify to those outside the meteorology community. Meteorologists do not see weather modification as similar to the rain dances of pre-modern societies, which believed that rain could be summoned from the mysterious more-than-human world. This statement is not only about the limits of weather modification; it also emphasises a meteorological epistemology that regards weather modification as based on the scientific understanding of atmospheric physics and weather processes. Weather modification does not create artificial weather; instead, it is better understood as enhancing an existing weather process

or, as illustrated in Figure 12, squeezing more water out of an existing rain cloud. To modify the weather is, in some sense, to touch it.



Figure 12. Weather modification depicted as ‘squeezing’ more water out of the cloud.

Source: Water Resources Agency, Taiwan

What does it mean to touch the weather and to think of it as something palpable? Weather is something that everyone has experienced. As a terrestrial species, immersion in the meteorological atmosphere is a fundamental aspect of human existence (Ingold, 2007). However, palpability—the ability to be touched—is not just about passively receiving senses and feelings. Touch involves an embodied engagement with the material environments¹⁴ (Manning, 2006; Straughan, 2012). In other words, touching is a reciprocal

¹⁴ Manning (2006) rejected the simple understanding of touch as a pre-existing attribute of a static body. Instead, she suggested that touch is an act of creating spacetime that occurs when bodies move. Straughan (2012) explored the idea of touch in the case of scuba diving, further emphasising embodied aquatic engagement. Her work on the enveloped experience in water offers an interesting cross-reference to research on the atmosphere. Scuba divers perceive water as the fluid medium that envelops them, similar to how terrestrial beings are enveloped by the atmosphere. However, people tend to be unconscious of this enveloping relationship except on rare occasions (Martin, 2011). Nonetheless, the concept of touch in

relationship. The reciprocal and co-evolving relationship between humans and the atmosphere has already been explored in geography and anthropology literature (Choy, 2011; McCormack, 2008a). However, there appears to be an asymmetry in the general understanding of the interdependence between humans and the atmosphere. The affective atmosphere, as a collective milieu, shows relatively clear reciprocity in that it is shaped by the subjects it surrounds and influences how their subjective feelings and emotions emerge¹⁵ (Anderson, 2009). However, it is less clear how and to what extent the meteorological atmosphere is in a reciprocal relationship with the human subject. When scholars such as Ingold (2011) discuss humans as immersive beings within the meteorological atmosphere, they deal more with human perception, sense, and experience of the atmosphere and much less with how people influence and shape it.

The weather experience is different from touching it, but how can the weather be touched? The weather cannot easily be objectified, as it is the ever-changing variation of the gaseous elemental field of the atmosphere. It cannot be simplified to an entity-like whole accumulated from all parts of its dynamic. As McCormack (2018, p. 27) stated, ‘while it may make sense to think of the atmosphere as an entity enveloping the earth, the meteorological processes that characterise this entity are not themselves entities.’ Timothy Morton (2013) would regard weather as a ‘hyperobject’ due to its vast and massive spatiotemporal scale, which humans cannot fully comprehend or touch. While people can touch raindrops as part of their experience of rain, they can never touch rain in its entirety.

this chapter extends beyond a mere sensed experience. It involves an active intervention and modification of the fluid environment that envelops humans.

¹⁵ In addition to human subjects, this reciprocal influence of affect also applies to nonhuman objects, from animals (Lorimer et al., 2019) to technological devices (Ash, 2013), which McCormack (2018, p. 8) referred as the ‘interobjective capacity’.

Thinking of the weather as something that can be touched implies a different human–weather relationship than seeing it as an atmospheric condition that humans experience. Touching implies reciprocity between the one who touches and the object being touched. To touch the weather means to have a reciprocal influence on it rather than simply being immersed in and experiencing it. It indicates a reciprocal human–weather relationship that is different from a non-reciprocal approach, such as Ingold’s (2007) idea of the ‘weather-world’, which focuses more on perceiving, sensing, and experiencing the weather than influencing it. However, perceiving the weather as reciprocal to human actions and wills is not a new idea in human history. Indeed, it is a relatively old one. Rainmaking rituals are traditions commonly seen in ancient societies of various cultural backgrounds. These rituals reflect the desire of ancient peoples to form a connection with the atmosphere and to alter and summon particular weather phenomena. Of course, modern meteorologists would deem such rituals as unscientific superstitions that lack an empirical basis, yet the ancient rainmakers and modern weather modification meteorologists have one thing in common: They both enact their belief in human–weather reciprocity through their rainmaking practices. Through these practices, the hyperobjective weather (Morton, 2013) that is too massive to grasp becomes palpable to the actors, as it is believed that it can be changed through their actions. Hence, the palpability of weather is not an intrinsic feature of the phenomenon but something that emerges from a specific epistemology and set of practices.

5.1.2 Weather-modifying Choreography

The main argument of this chapter is that weather becomes palpable to modern meteorologists not through their scientific understanding of atmospheric physics but through their weather modification practices. Understanding how rain forms and how the

precipitation process can be influenced and modified does not make the weather palpable. The palpability of weather emerges from the practices of meteorologists and their weather modification operations. Just as the ancient rainmakers touched the weather through the arrangement of their rain dances and rainmaking lifestyles (Huang, 2010; Loewe, 1987; Snyder-Reinke, 2009), modern meteorologists reciprocally influence the weather through the choreography of their bodies, instruments, labours, and lives. Modern weather modification practices should be seen as choreographic for two reasons. Firstly, weather modification practices are embodied through the ways in which meteorologists configure their bodies and devices, and arrange their work and lives within a particular spacetime. Secondly, the arrangement of practices reciprocally interacts with the surrounding milieu, conditions, and actors, much like dancers interact with the music, other dancers, and the environment (Hunter, 2015).

I suggest that weather modification practices be thought of as choreography, not only to create a metaphorical reference to the ancient ritual of a rain dance but also to emphasise how different configurations of bodies and devices are arranged together within the practices of work and life. It is important to note that understanding weather modification as choreography does not imply a focus on the embodied practices of how individual meteorologists 'dance' to make rain. Instead, choreography is introduced as a way of thinking about the overall arrangement, distribution, and movement of bodies, devices, and forces involved. This distinction between dance and choreography is crucial because the modifiability of weather is not enacted through the phenomenological embodiment of individuals but through the way that the weather-modifying bodies and devices were arranged, or choreographed, to attune with the atmospheric fluctuation. This approach highlights how weather becomes palpable through a specific arrangement of practices. In other words, weather modification should not be seen as simply a particular technique of

intervening in the weather, just as dancing is not only about certain body movement techniques. Rather, weather modification should be understood as a way of perceiving a reciprocal human–weather relationship and, more importantly, how this relationship is enacted through the specific arrangement of embodied and reciprocal practices in spacetime.

The exploration of the palpability of weather in this chapter helps to address a part of the second question of this thesis: How weather modifying governance is practised? My aim is not only to emphasise that weather modification is a scientific practice that involves embodiment¹⁶ but also to draw attention to the embodiment to better conceptualise weather modification as a form of governance, which is the central focus of this thesis. Furthermore, I aim to show how the operation of governance is influenced by various forms of embodied engagement in weather modification practices. In other words, different ways of choreographing the modern rain dance lead to different forms of atmospheric governance.

In this chapter, I examine the weather modification practices in Qinghai and focus on the entanglements between the configurations of meteorologists' bodies and devices and the atmospheric processes subject to their weather modification practices. This chapter explores the features of the technologies and operational processes used to modify the weather and then enriches the perspective by discussing the entanglement of the body with the technologies and processes. I suggest that the atmosphere becomes palpable and modifiable for weather modification meteorologists via a particular configuration of their

¹⁶ Indeed, as many studies in the field of Science and Technology Studies have pointed out, there is no such thing as a purely intellectual scientific practice. Scientific practices inevitably involve a certain degree of embodiment (Myers, 2015).

bodies and devices. Modifying the weather, in this sense, does not refer to the manipulation of atmospheric objects but involves an embodied and reciprocal attunement—spatially and temporally—to the atmosphere.

This chapter is organised as follows. To begin with, I discuss the modern techniques of weather modification used in China, which introduces how meteorologists intervene in the weather and highlights the spatial and temporal features of the practices. The spatial and temporal particularities of the practices are essential elements that inform the features of weather modification. In other words, weather modification is a spatially and temporally specific operation that requires constant monitoring, adjustment, and prediction. In the second part of this chapter, I further discuss the spatial and temporal features of weather modification by interpreting them as the choreography of meteorologists' practices. This weather-modifying choreography involves the arrangement of both living and working, which interweave in space and time. This chapter presents the rainmaking choreography in two parts, but this structure serves merely to demonstrate and highlight the spatiality and temporality of the practices from different aspects, instead of suggesting a conceptual separation. Firstly, I demonstrate how meteorologists arrange the presence of their bodies and devices in space and how different modes of presence choreograph variegated spatiality of weather modification. Secondly, I discuss how meteorologists choreograph the temporality or rhythm of weather modification so that it attunes with other natural and social rhythms and how the (dis)attunement informs weather modification practices. This chapter is summarised in the conclusion section, and the conceptual implications are provided.

5.2 Weather Modification Method: Spatiality and Temporality

Weather modification is a specific branch of meteorology. For weather modification meteorologists, the atmosphere is not merely an epistemological target to observe and forecast. It must become a palpable object to be intervened with and modified. The palpability of the atmosphere implies not only sensory experiences but also the actions and techniques that can intervene in the weather. However, modifying the weather is not meant to change the form of a static object. Weather is the dynamic and constantly changing status of the atmosphere. Therefore, modifying the weather means moving through and interacting with the ever-changing flow and composition of the atmosphere. Rather than crafting a solid material, it is more like performing a water ballet that requires continuously moving through, with, by, or against the water flow and rhythm of the music.¹⁷ Within this scientific rainmaking dance, what dynamics do meteorologists interact with? What time-space movements and rhythms do they perform? A brief overview of the weather modification techniques can help open up these questions for further discussion of the embodiment of the modern rain dance.

5.2.1 Precipitation Physics and Cloud Seeding

Precipitation—rain and snow—comes from clouds. Clouds are a mixture of water vapour, minute water droplets, and ice crystals suspended in the air. When the water droplets and ice crystals in the clouds grow and become large enough to be pulled by the Earth's gravitational force, they fall out of the cloud and form precipitation. The ways that these droplets and crystals grow vary among different types of clouds. In warm clouds with a temperature higher 0°C, the formation of raindrops is mainly the result of the contact and

¹⁷ Serres (2008) provided a similar analogy of sailing that involves an attunement of bodies, devices, and skills with the elemental milieu and forces. See McCormack (2018, pp. 147-148) for further discussion.

coalescence of water droplets. In cold clouds below freezing point, although raindrops and snowflakes can grow from contact and coalescence, they primarily form through the Wegener–Bergeron–Findeisen (WBF) process, named after the scientists who contributed to the discovery of the process (Storelvmo & Tan, 2015). This process occurs in cold clouds containing both ice crystals and supercooled liquid water droplets (water that remains in liquid form under the freezing point). As the ice crystals and supercooled liquid water droplets have different saturation vapour pressure (the equilibrium vapour pressure in which the water molecules at the surface have the same rate of evaporation and condensation), water molecules tend to evaporate from the supercooled water droplets and deposit onto the ice crystals (see Figure 13). This process allows ice nuclei to rapidly grow larger within supercooled water droplets before falling from the cloud and forming precipitation.

According to the WBF process, sufficient ice crystals and supercooled liquid water droplets are the two essential criteria for precipitation to occur in cold clouds. Based on this process, the weather modification of cold clouds¹⁸ is aimed at the cold clouds with abundant supercooled droplets but insufficient ice nuclei to initiate the process of forming precipitation drops. By spreading particles (such as silver iodide) that serve as ice nuclei, the seeding particles boost the WBF process and, thus, enhance the formation of raindrops. This is why the process is also called cloud seeding. There are several ways to diffuse the seeding particles into the targeted cloud. Commonly used methods include ground-based

¹⁸ In comparison, the weather modification of warm clouds is done by spreading many water droplets or hygroscopic particles (such as sodium chloride, urea, or calcium chloride) to boost the coalescence process in the cloud and form larger droplets, leading to precipitation (Cotton, 1982; Silverman & Sukarnjanaset, 2000). Weather modification practices discussed in this chapter are based on the operation in Qinghai, where the seeding of cold clouds is more common.

burning diffusers, cannons, rockets, and airplane diffusers (see Figure 14).

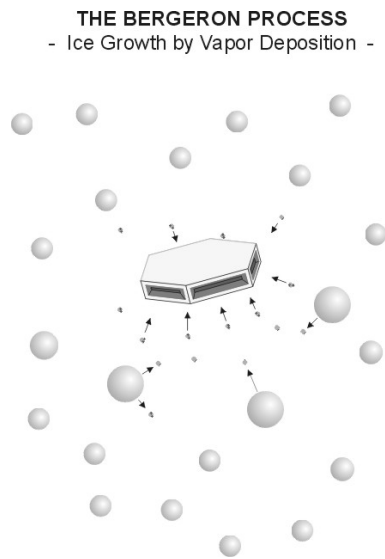


Figure 13. The evaporation and deposition of water molecules

Water molecules evaporate from supercooled liquid water droplets and deposit onto ice crystals due to the difference in saturation vapour pressure between liquid and ice.

Source: <https://personal.ems.psu.edu/~lno/Meteo437/Bergeron.jpg>



Figure 14. Common methods for spreading cloud-seeding particles.

The image in the top-left corner shows ground-based burning diffusers. The images in the top-right and bottom-right corners depict the use of cannons and rockets to launch chemicals for cloud seeding. The image in the bottom-left corner shows the use of airplanes as diffusers.

Source: Qinghai Weather Modification Office (1999) and Deng (2011).

5.2.2 The Spatiotemporal Window

The WBF process occurs when there is a difference between the saturation vapour pressure of the supercooled liquid water and ice crystals. The difference varies among different temperature ranges. The difference between the saturation vapour pressure of liquid water and ice maximises at 250 to 265 K (around -25 to -10°C; see Figure 15). This also means that, for cold cloud seeding, the highest efficiency occurs when the cloud's top temperature falls within the temperature range. This range of the cloud's top temperature is thus called the 'temperature window' for a cloud-seeding operation (Grant & Elliott, 1974).

For cloud-seeding operations, this temperature range implies a specific spatiotemporal window of operation, which makes weather modification a time-space-dependent activity. The temperature of water droplets and ice crystals in clouds depends on their altitude. Hence, the temperature window of a cloud corresponds to its vertical formation and refers to a particular layer of atmospheric height. Meanwhile, meteorologists must also consider whether the particular cloud layer contains sufficient ice nuclei. Cloud seeding only works when both criteria (temperature window and lack of ice nuclei) are met. According to the training material from the Chinese Meteorology Office, the officially recommended operation condition is when the density of ice nuclei in the temperature window is lower than 10 nuclei per litre (Wang et al., 2003). Identifying the right amount of ice nuclei in the cloud is crucial for the operation. Spreading cloud-seeding particles into a cloud which

already contains sufficient ice nuclei is not only inefficient, but it can also cause an opposite effect in which no nuclei grow large enough to become precipitation, as there are too many nuclei competing for water vapour. Indeed, over-spreading nuclei is a rain mitigation method, an opposite way of modifying weather (Zhang et al., 2009). For effectiveness, weather modification operations depend on the spatial features of the cloud, including its temperature window and nuclei density.

This spatial dependence implies a temporal dependence, as the clouds constantly change and evolve. The temperature window not only has a spatial implication of a particular height. It also implies a particular time when the proper temperature window is opened for cloud seeding. Cloud seeding can only succeed if the nuclei are distributed at the right place and time. Furthermore, as the seeding process intervenes in the evolution of the cloud, the temporality of cloud seeding co-evolves with the cloud's dynamic. The co-evolving temporality is well demonstrated in the dynamic cloud-seeding approach. Under the dynamic approach, the goal of the operation is not to spread ice nuclei to clouds that are in the right condition at the present moment. Instead, dynamic cloud seeding aims to boost vertical air currents in the cloud to induce a proper condition for raindrop formation¹⁹ (Simpson & Woodley, 1971; Woodley, 1970). For cloud-seeding operations, their temporality requires static precision and a dynamic adaptation to the clouds.

Apart from cloud physics, the spatial and temporal sensitivity of weather modification has broader implications. As weather patterns vary among different geographical locations due to the interaction between global atmospheric circulation and local environmental

¹⁹ When water vapour deposits onto the ice nuclei, it releases latent heat, which increases the buoyancy of the surrounding air and causes an uplifting flow.

conditions, the spatiality of weather modification varies. For example, the formation of clouds can be affected by topography, where water vapour is elevated with the rise of terrain. This provides an environment for the stable formation of clouds, which could be an ideal location for conducting cloud seeding. That is, location and geographical features are crucial conditions affecting weather modification methods and efficiency.

Regarding temporality, some weather phenomena and processes tend to occur during a particular time of day, while others do not have a fixed time pattern. Meanwhile, temporal synchronicity is also required with the seasonal period. For example, in Sanjiangyuan, weather modification is mainly conducted during the summer, when more appropriate weather processes exist. Furthermore, the temporality of weather modification is not only about synchronisation with present weather processes. Weather modification operations also rely heavily on forecasting the future status of the atmosphere. While some remote sensing technologies provide real-time monitoring and data about the present atmosphere, the preparation and operation of cloud seeding take time. Preparations and plans must account for the future, not the present. The temporality of weather modification is, by all means, future-oriented. On the one hand, it relies on guessing and chasing the upcoming atmospheric conditions, and on the other hand, it aims to intervene and alter that future. In this sense, the temporality of weather modification is about both the synchronicity at the present and the future.

This spatiotemporal feature of cloud seeding is why it is important to understand weather modification operations as a form of choreography. The techniques and operation of cloud seeding are dependent on specific spatialities and temporalities. These spatial and temporal features are inherent to weather modification. The inherent spatiotemporality does not only apply in terms of cloud physics or other technical and operational

considerations. Seeding the cloud is like dancing with it. Meteorologists synchronise and intervene, attune and disturb. Within this reciprocal situation where one is both the condition and is conditioned by the atmosphere, this ‘dance’ with the atmosphere and its spatiotemporality must also be embodied. In the rest of this chapter, I discuss how meteorologists’ bodily entanglements with the atmosphere are essential for the atmosphere to become palpable.

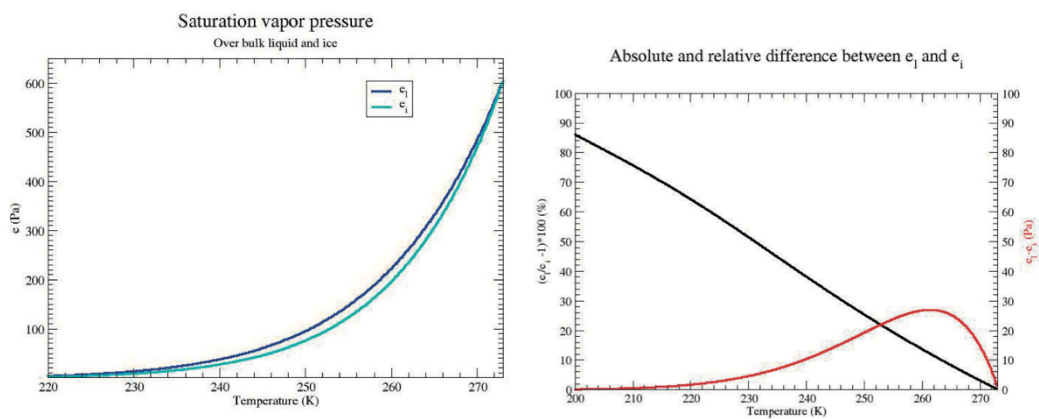


Figure 15. Saturation vapour pressure over liquid water and ice

Source: Storelvmo and Tan (2015).

5.3 The Presence of Weather-modifying Bodies

In the previous section, I discussed how the spatiality of weather modification informs the palpability of the atmosphere to make weather modifiable. This spatiality is inherent to and inseparable from the palpability of the atmosphere in terms of weather modification. To modify the weather means to grasp the particular spatiality and to entangle it reciprocally. The atmosphere is not immediately and self-evidently palpable. The atmosphere becomes palpable via different configurations of bodies and devices through a process that McCormack (2018) referred to as ‘envelopment’. This notion resists viewing the atmosphere’s palpability as a property passively sensed by entities. Instead, McCormack

suggested understanding the palpable atmosphere as the ‘potentially palpable affective materiality of the elemental spacetimes in which bodies are enveloped, spacetimes that never present themselves as fully tangible, discrete or unified entities’ (p. 7). As such, the palpability of the atmosphere—the modifiability of weather—only partially discloses to certain spatiotemporal configurations of bodies and devices.

For weather modification, what matters is not merely a spatiotemporal configuration of static bodies but also how the bodies stay and move through spacetime, their spatiotemporal choreography. Weather modification also requires a reciprocal configuration of bodies and technologies that enable the meteorologist to both attune to and disturb the atmosphere. By modifying how bodies and devices are exposed to and through the atmosphere—either attuned or disturbed—meteorologists enact a certain variation of the palpable atmosphere. Here, the term ‘attunement’ does not merely refer to a cognitive influence by others. As Stewart (2011) suggested, attunement is a process of what Heidegger called worlding, an intimate process of dwelling in spaces. It is an embodied way to trace the interconnectedness and the process of becoming with (Brigstocke & Noorani, 2016; Latham & Wagner, 2021). This means that for the atmosphere and weather to become palpable and modifiable, there must be some ways of embodying attunement with a particular spatiality that inform how the atmosphere discloses to bodies. The attunement and embodiment of spatiality do not simply refer to the status of bodies immersed in the atmosphere, nor does it merely consider bodies to be in a certain geo-location. Rather, it urges reciprocal thinking about the presence of bodies and devices—as being-in-the-atmosphere²⁰—that enable the atmosphere to be disclosed

²⁰ This idea derives from Martin Heidegger’s terminology of ‘being-in-the-world’, the concept that the essence of a being is inseparable from its environment (*umwelt*). For Heidegger, a being must and can only be a being-in-the-world rather than a subject that exists beyond an objective world. Heidegger’s idea was

in a certain way. The embodied spatiality, or ways of presence, of weather modification are essential for understanding how the weather becomes palpable and modifiable in a certain way via the particular spatial attunement of bodies and devices in the atmosphere.

How can one better understand the spatiality of attunement with the atmosphere in weather modification? I use modern rain dance to describe weather modification, not only to highlight its embodiment but also to provide an analogy for its spatiality. Reciprocally attuning with the atmosphere does not mean constantly moving and changing the spatial status with respect to the atmospheric dynamic. Dancing is not about constantly moving, nor does it mean staying still. As discussed in Chapter 2, dance choreography involves a combination and configuration of movements and pauses, flows and rests, and being near or far. The spatiality is embodied in the configuration of movement. While the movement of the body has the potential to generate different spaces (Manning, 2006; McCormack, 2008b), the arrangement of the body is also constrained and influenced by the site's specificities (Hunter, 2015). Therefore, rather than merely considering the embodied spatiality as pertaining to the geographic location of bodies, I suggest thinking of the spatial embodiment of weather modification along three axes: settlement (when and how to remain in place), movement (flows and mobility), and distance (spatial relationships between subjects).

These axes are not static descriptions of the attributes or status of bodies within space. They involve the labour, tension, and process of bodies being in space and the atmosphere. This means that the presence of bodies as being-in-the-atmosphere is not an inert and

then applied to the atmospheric immersion of life by Ingold (2007) with his term 'weather-world', and McCormack (2018), with 'being-in-the-air'.

self-evident status; rather, while never fully disclosed to bodies, the atmosphere becomes palpable in various ways due to different choreographic configurations of bodies and devices. The three axes of presence consider the embodiment of weather modification not as a particular form of being but as a process of becoming that allows the atmosphere to disclose and become modifiable in certain ways with the embodied spatiality.

5.3.1 Settlement

We did a field investigation before we conducted the experiment. That was the first time I have been there. The sites and routes were far and remote, and it was during a cold winter. No one was there. The local guide said we are the only people they know who visit those areas during the winter. (Interview, G2)

Weather modification operations require ground-based work, especially in early experimental stages, for observation and cloud-seeding operations. For example, to effectively seed the orographic cloud, which develops in response to the rise of terrain, a detailed understanding of the spatiotemporal configuration of the cloud development at a particular site is required (see Figure 16). To collect this data, meteorologists rely on weather balloons that collect information on the atmosphere—such as pressure, temperature, humidity, and wind speed—at different heights of the atmosphere at the spot. Furthermore, meteorologists rely on ground-based operation facilities to spread particles when cloud seeding (see Figure 14). Hence, accessibility, or the ability to be there, is a crucial criterion for meteorologists to understand and modify the atmosphere at a particular site. For experimental meteorologists in Qinghai in the late 1990s, one of the most challenging and laborious parts of weather modification experiments was discovering an appropriate location for their observation and experiment and travelling there.

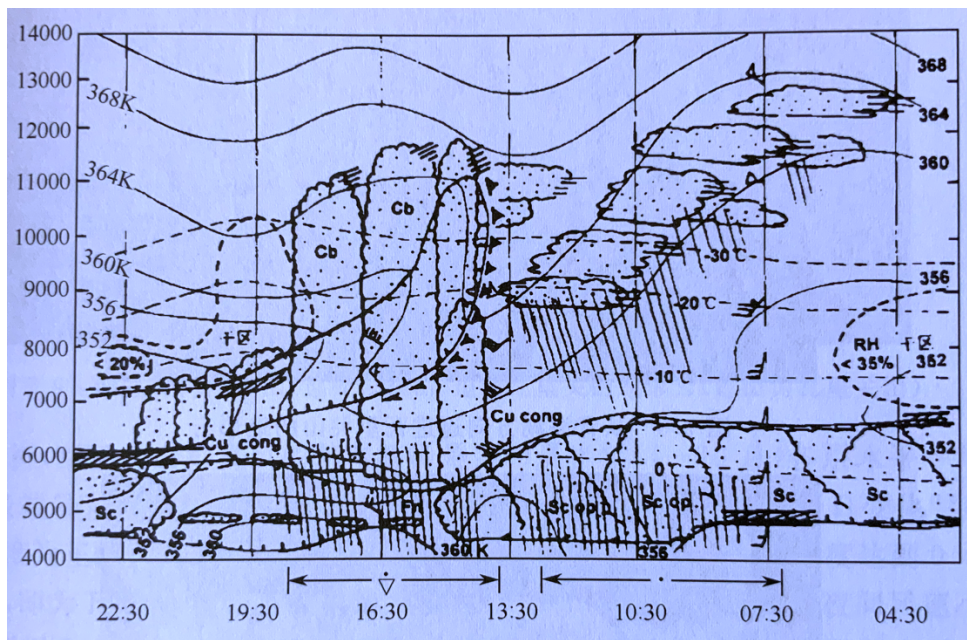


Figure 16. A spatiotemporal diagram of cloud development.

Source: Deli et al. (2012, p. 51).

However, the embodiment of settlement does not only refer to the arrival of bodies at a certain area. The atmosphere does not immediately become palpable, in terms of weather modification, simply because the bodies have arrived. The atmosphere becoming tangible and modifiable requires labour to settle and attune to the atmosphere on site. As most of the sites were far and remote from infrastructural services, it took time and effort to establish and maintain observations and operations. In this sense, attuning to the atmosphere not only means arriving, observing, understanding, and intervening at a

particular site. It also means being able to make a living. For Qinghai's experimental meteorologists in the 1990s, attunement with the weather and atmosphere, through which the atmosphere became modifiable, was exactly what Stewart (2011) referred to as a lived affect rather than a representational or cognitive process. For them, the atmosphere only became palpable after they devoted the labour and effort to settle down and make a living at the remote experimental sites. This is probably why the meteorologists decided to conclude their 1997 experimental report by mentioning the hardship of the field site settlement:

About twenty members of ground operation have been working and living in an extremely hard condition during these three months. [...] They focus on every change of the weather, day and night, in howling wind and pouring rain. Especially at the operation sites of Mentang and Waisi, the transport and logistics were inconvenient, and we could only barely maintain a basic living (Qinghai Weather Modification Office, 1999, p. 51).

Considering settlement as a way of presence of being-in-the-atmosphere not only reveals how the configuration of bodies and devices make the atmosphere become palpable; it also foregrounds the limitations of the bodies when it does not. In my interview (G2) with an experimental meteorologist who was involved in the experiment in the 1990s, he mentioned one of his failed attempts to develop an automatic ground-based cloud-seeding diffuser. In his plan, the automatic diffuser, if successful, could have been set at a remote site without any external power supply. However, this plan never succeeded, and the operational sites of their experiment have always been constrained by their capability to settle bodies and devices at certain locations. In this sense, weather modification can be seen as a site-specific dance (Hunter, 2015), the choreography of which is conditioned by

the specific site, and certainly ‘air-conditions’ (McCormack, 2015).

5.3.2 Movement

All year round, from the eastern agricultural district to Qinghai lake district, from Qaidam Basin to Sanjiangyuan, Mr Zhang, the instrument engineer of weather modification, is either at the operational site or on the way to it.

After repairing three cloud-seeding artilleries in Minhe County, Mr Zhang got another emergency call from the meteorological office of Hainan Tibetan Autonomous Prefecture. Before having time to take a rest and enjoy dinner, he has already been on a 300km late-night drive to Hainan Prefecture (Jin, 2017).

These quotes are from a report in the China Meteorological News, an official newspaper published by the China Meteorological Administration, on senior instrument engineer Mr Zhang, who oversaw the maintenance and repair of weather modification instruments in Qinghai. Mr Zhang and his intensive movement showed another way of embodied spatiality of weather modification that is noticeably different from the above-mentioned axis of settlement. Unlike the settled presence of the experimental meteorologists, the presence that Mr Zhang embodies is the opposite: constantly mobile. It is the movement enacted by people like Mr Zhang that affords the palpability of the atmosphere at each weather modification site. While the embodiment of settlement discloses the atmosphere to weather modification among the operational sites, the embodiment of movement maintains particular ways of disclosure. Without movement, the cloud-seeding operation could not have been sustained, and the atmosphere would not be as palpable and modifiable for meteorologists. Here, the capability to touch emerged through movement

(Manning, 2006).

There is another type of embodied movement that enacted and disclosed a different form of weather palpability—an aerodynamic one. Unlike the ground-based operation in the late 1990s and early 2000s, weather modification in Qinghai has been incrementally dominated by airplane operation. This aerodynamic movement enacts a different way of touching the atmosphere. While the ground-based operation can be seen as spreading the cloud-seeding particles into the cloud, an airplane operation spreads the particles within it. The aero-operation is also different from the ground-based one in terms of the type of cloud and weather process it seeds.²¹ In terms of modifying weather, the cloud's palpability appeared differently through this configuration and movement.

In an airplane operation, the aerodynamic movement embodies the attunement with the atmosphere to intervene and modify the process of rain formation. For an optimised effect, a cloud-seeding aircraft must adjust its flight route and altitude in response to the dynamic weather process (see Figure 17). However, during actual operation, a cloud-seeding aircraft might be unable to adjust and follow the optimised route due to limitations, such as the terrain or air traffic control. Therefore, the limited mobility of this aerodynamic movement is the constraint of choreographing weather modification. Meanwhile, the movement also embodied the effort of cloud seeding. In the announcement that concluded its annual weather modification work in 2019, the Qinghai Weather Modification Office decided to demonstrate its cloud-seeding efforts in terms of an accumulated distance of flight

²¹ The choice of cloud-seeding operation methods is subject to conditions like the weather system, the topography, and other operational limitations. In Qinghai, an airplane operation is mainly used for seeding the systematic stratus cloud, while a ground-based operation is usually implemented for seeding the orographic cloud (Deli et al., 2012).

(107,333 km). Again, this embodied aerodynamic movement shows how the choreography of weather modification is simultaneously atmospherically conditioning and conditioned (McCormack, 2015).

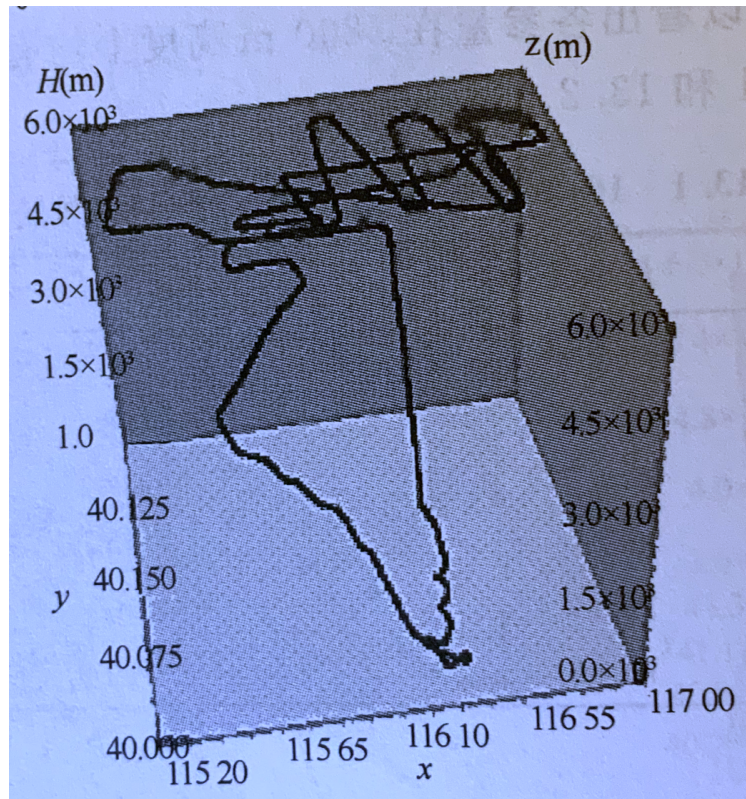


Figure 17. A 3D demonstration of an optimised flight route for an airplane cloud seeding operation

Source: Zhang et al. (2011, p. 136).

5.3.3 Distance

The locals do not understand how it works. They execute when we ask them to. [...] They also have radar and satellite data. But sometimes they just acted blindly, without even distinguishing a cloud of rain and a cloud of hail. They saw a dark cloud coming and assumed that it was going to hail. This kind of blind operation has wasted many bullets for seeding (Interview, G9).

The embodiment of both settlement and movement requires some ways of sensing the atmosphere before it becomes modifiable. There are ways of sensing at the site of the settlement, but there are also ways of sensing remotely from a distance. Through radar, satellite, and other technologies categorised as remote sensing, weather modification meteorologists can stay in a distant area and plan for an operation using the data generated by technology. Remote sensing allows labour to be divided between a planner and an executor of weather modification. While planners interpret data and plan for an operation, executors implement the plan in the field or on the aircraft. These two roles have their own ways of sensing and embodiment throughout the weather modification operation.

However, I suggest that the distinction between a planner and an executor should not be framed by their remoteness or presence/absence. As McCormack (2018, p. 52) stated, sensing is always prosthetic, whether it is mediated by bodies or technologies, and is, thus, inherently remote. However, the remoteness of sensing does not make it more or less authentic, nor does it provide a self-evident distinction between ways of sensing. Alternatively, I suggest considering the difference between a planner and an executor in terms of how the atmosphere discloses distinctively to different bodies and the way they sense. This way of framing opens an axis of embodied spatiality of weather modification that I call distance. As an axis of the embodiment of modifying the weather, distance does not refer to a physical or geographical length in space. Rather, it is relational (Manning, 2006) and implies distinct ways of disclosure in which the atmosphere's palpability is sensed differently among various spatial configurations of bodies and devices (McCormack, 2018). This notion of embodied distance foregrounds not only the difference and differentiation but also the tension between different ways of atmospheric disclosure.

The difference and tension between types of sensing and how the atmosphere discloses are vividly demonstrated in the interview quoted at the beginning of this section. The complaint came from a weather modification planner who felt dissatisfied with the disagreement and disobedience of the local executors. Although the planner attributed this to the difference in knowledge level, the gap is not merely epistemological. The tension also exists because of the differentiation of ways in which the atmosphere discloses via their different configuration of embodied sensing. For example, reading a cloud via its radar signal is not more authentic than having a visual experience with it and vice versa. Just as the planner cannot experience and understand the executor's embodied exposure to the 'dark cloud', the executor cannot resonate with the planner's sense of not being exposed to it. This tension not only shows the experiential and epistemological difference of various ways of embodied spatiality of weather modification but also reveals the very essence of the embodiment that, as McCormack (2018) suggested, will never be fully disclosed.

5.4 The Rhythm of Weather-modifying Bodies

Weather modification is a time-dependent operation in which the intervention must accommodate a particular timing in the atmospheric dynamics. However, weather modification is not merely subject to the temporality of the elemental variations in the atmosphere. To modify the weather is also to connect the past (e.g., data) and the present (e.g. real-time sensing) to predict and intervene in the future. As such, weather modification is enacted through the collision and attunement of different time frames, from the seasonal, daily, or random fluctuation of the atmosphere to the routine work shift

in the meteorology office. In this sense, weather modification must be enacted through choreographing various temporalities that arrange, articulate, and attune to different time frames. Through a particular temporal arrangement, the atmosphere in the future becomes a palpable and modifiable thing for meteorologists. The next question is how do we grasp the attunement of temporalities within the meteorological operation to further understand weather modification practices?

5.4.1 Body and Rhythm

Henri Lefebvre and his idea about rhythm analysis provide a toolkit for thinking about attunement to temporalities (Lefebvre, 2004). Rhythm is about the repetition of a measure in time and space. However, for Lefebvre, rhythm is not only concerned with absolute repetition. Instead, it is about the relationship between repetition and difference. As Lefebvre put it, ‘there is always something new and unforeseen that introduces itself into the repetitive: difference’ (p. 6). As such, to recognise rhythms necessarily means ‘to discover the bases of repetitive and differential’ (p. 6). Lefebvre’s rhythm analysis involves an ontological claim that living beings, bodies, and events are composed of a plurality of rhythms and rhythmic interactions. As he suggested, ‘there is neither separation nor an abyss between so-called material bodies, living bodies, social bodies and representations, ideologies, traditions, projects and utopias. They are all composed of (reciprocally influential) rhythms in interaction’ (p. 43).

Lefebvre’s rhythm analysis provides two insights with which to consider the attunement of temporalities when modifying the weather. First, he reminds one to consider both the repetition and the differentiation of rhythmic interactions. Second, to think about rhythm means to think with and through bodies generated through the multiplicity of rhythms (McCormack, 2013). Fine (2009) provided an excellent example of this through his

ethnographic work on weather forecasting in a meteorological office. He depicted how weather forecasts were produced through daily routines, work shifts, and temporal intensities in the forecasting office. Fine showed that predicting the future requires laborious and embodied efforts rather than merely intellectual labours. More importantly, he showed that forecasting the future does not only objectively create a connection between the past and present. It is also about how meteorologists embody, attune, and differentiate within different time frames and rhythms. This is more significant for weather modification, as it aims not only at predicting but also intervening in the future. Here, I do not suggest following Lefebvre's rhythm analysis. Instead, I suggest considering the embodied rhythms and rhythmic relations between bodies and the atmosphere (McCormack, 2008b) that the meteorologists demonstrated during the practices of weather modification and how the multiplicity of rhythms—weather processes, elemental fluctuations, workflows, work shifts, routines, and temporal tensions—reciprocally influenced each other and how weather modification was temporally choreographed.

The practice of modifying weather relies on a particular alignment of multiple temporalities and the attunement of several rhythms. It is this temporal arrangement that allows for the future atmosphere and upcoming weather to emerge as something that meteorologists can see and touch. Temporally speaking, meteorologists do not work on modifying an existing state of weather but on its processes of becoming. The modifiable atmosphere emerges differently according to the ways of attuning to various rhythms under different circumstances. In some cases, the rhythms involved are relatively steady and repetitive. For example, at some cloud seeding sites where the operations enhance the process of the orographic rain, meteorologists might encounter a regular formation of certain weather processes daily (see Figure 16). Under this circumstance, meteorologists grasp the highly repetitive rhythm of the weather process and fit them into their

modification plan. However, in most cases, this ideal and highly predictable atmospheric fluctuation does not exist. Especially for airplane cloud seeding operations, the location and the atmospheric conditions of their missions are vastly different each time. How do meteorologists handle this complex rhythmic interaction and make the atmospheric future modifiable under a particular temporal choreography? In this section, I discuss this question with a focus on the case of the mission command centre of the Qinghai Weather Modification Office, where the decisions and plans for cloud seeding are made.

5.4.2 Embodied Rhythms of Weather Modification

The mission command centre works as the brain for weather modification in Qinghai and oversees making plans and decisions for the operation. However, this does not mean that the meteorologists in the command centre only make intellectual efforts. Although they do not typically go out into the field like the experimentalists and engineers, their work also involves some degree of embodiment with the atmosphere, especially in terms of rhythm. The main tasks of the mission command centre are to predict, plan, and configure the weather modification apparatus to align with the rhythm of the atmosphere to intervene. The meteorologists in the command centre work and live with a specific workflow—a particular time frame—which divides a single weather modification task into a five phase/day temporal structure (see Table 3). This basic workflow serves as the standard procedure of the cloud-seeding operation. More importantly, the five-day workflow also provides a temporal framework through which various rhythms—variations of the weather processes, workflows of other cooperating organisations, and the work and life rhythms of individual meteorologists—can attune to and interact with each other.

Table 3. A general workflow of weather modification plans for a single cloud-seeding task in Qinghai.

Day -3 (Potential analysis)	<ul style="list-style-type: none"> ➤ Deriving data and parameters for weather modification (e.g., the height of clouds, cloud top temperature, and density of ice nuclei) on the 72-hour forecast provided by the forecast office ➤ Analysing the potential for a cloud-seeding operation (for a large area and brief timing)
Day -2 (Brief planning)	<ul style="list-style-type: none"> ➤ Predicting the potential sites for cloud seeding for each six-hour interval (where is the potential operation area for this six-hour, and where is it for the next?) ➤ Planning for the cloud-seeding methods, by the airplane or the ground-based operation
Day -1 (Detail planning)	<ul style="list-style-type: none"> ➤ Monitoring and sensing the upcoming weather processes ➤ Adjusting the prediction and plan for the weather modification operation based on real-time sensing data ➤ Planning the route (timing and location) of the cloud-seeding operation
Day 0 (Day of execution)	<ul style="list-style-type: none"> ➤ Negotiating the airspace permission for flying and the cloud-seeding operation with air traffic control ➤ Adjusting the operational path and timing based on real-time sensing data
Day +1 (Evaluating results)	<ul style="list-style-type: none"> ➤ Evaluating the results and estimating the effort of the operation

This workflow outlines a five-day rhythm that the meteorologists in the weather modification command centre work and live with in every weather modification operation. Yet, this rhythm could not occur without attuning to and interacting with other natural and social rhythms. A weather modification workflow is started when a 72-hour weather forecast of potential precipitation is received. In other words, the five-day rhythm of the

cloud seeding workflow only occurs when it is attuned to a speculative rhythm of the atmosphere in the future. For two rhythms—the weather modification workflow and the actual weather process—to match and interact with the best timing, most of the efforts and labour in the command centre are dedicated to predicting and adjusting the pace accordingly. As such, meteorologists must attune their personal rhythm of work and life to the particular rhythm of each weather process no matter whether the rain appears early in the morning or late at night. These modern rain dancers do not only dance for the rain but also, more importantly, dance with the rhythm of the rain.

The attunement of rhythms creates different tensions within the workflow. As the goal of the workflow is to match the operation with the atmospheric process at the critical moment, the rhythmic tensions of work increase as the operational moment approaches. Rhythmic tensions emerge both in terms of workload and urgency. More work is required closer to the time of operation. This makes the day before operation (Day -1) the most intense time in the meteorologist's workflow, as one meteorologist explained:

The most laborious and tiring one is the third phase. We have to do all the reports and monitoring as well as planning for the route of operation. The leader also pays most attention to us during this phase (Interview, G7).

In addition to the variety of tasks, the rhythm of the work changes. For example, meteorologists must make one forecast per day for the location and timing of the potential operational window on Day -3. However, as the time approaches, both the amount and density (for more specific locations every six hours) of the required forecast increases. In an interview (G7), a meteorologist mentioned this rhythmic tension as a 'particularly nervous period' in which the variety and tempo of tasks are significantly different. Due to

this differentiated rhythmic tensions among different days of weather modification operation, the meteorologists tend not to attune their life to regular office hours, but to the tempo of the modern rain dance they have been engaging in.

Aside from the rhythm of the weather process, the five-day workflow is also attuned to, or in some cases, interfered with by, the rhythms of other organisations. Although it is an independent office, weather modification operation relies on the data produced by other meteorological branches. The weather modification workflow inherits not only data from other meteorological branches but also their rhythmic dynamic as well. As Fine (2009, p. 56) stated, '[meteorological] products are not from a set of individuals, but from a team whose predictions flow into one another.' The cloud-seeding workflow begins based on a forecast provided by the forecast office. If the forecast is imprecise or suddenly changes, the weather modification rhythm can be interrupted. A meteorologist in the weather modification office mentioned the following constraint:

We prepared based on their forecast. For example, if they predicted a sunny day, I would not have to prepare for an operation. If it turns out to be a rainy day, I would be blamed for not arranging for an operation. But how could I know? I just followed the forecast (Interview, G7).

Another case of rhythmic interference from other organisations is possible on the day of the cloud-seeding operation (Day 0). An airplane operation requires permission from air traffic control. In Qinghai, the earliest time for this air space permission is 8 am. Hence, meteorologists must start working at 5 am on the day of operation to finalise their cloud-seeding route and submit a request for the air space. The procedure of air space control constrains the flexibility of a timely adjustment to the route and height of cloud seeding

to optimise the results in response to real-time variations in the atmosphere. The rhythm of cloud-seeding operations inherits rhythmic features from other organisations, which influence and sometimes interfere with how it attunes to the atmosphere.

The rhythm of the cloud-seeding operation is a specific rhythmic configuration of bodies and works through which meteorologists can attune to the speculative rhythm of weather in the future and, thus, be able to modify it. The palpability of the meteorological atmosphere emerges differently according to changes in these rhythmic configurations. For example, while the workflows of cloud seeding are similar between provinces in China, each province could have its own way of allocating the shifts in the workflow. For instance, in Qinghai, the shifts in the workflow are (re)assigned to the meteorologists daily. Whereas in some other provinces, an assignment lasts for a week. For meteorologists, this creates different rhythmic tensions in work and tempos of life.

We could be assigned to any day of the workflow and be in charge of all the tasks of that day. This is the way we do it in Qinghai. But my friends in another province do it differently. They were in charge of some specific tasks for an entire week. Not like us, they don't need to deal with all the tasks. [...] We cannot do what they do [a weekly shift]. It will be too intense and laborious to take (Interview, G10).

As such, every cloud seeding is its own distinct rain dance. It is distinct not only because of the unique atmospheric and environmental conditions but also because of the different ways of configuring the bodies and works—a rhythmic choreography—that connects and attunes to a speculative future.

5.5 Conclusion

In this chapter, I explored how weather emerges as something palpable and modifiable to humans. Here, the palpability of weather does not refer to the human senses and weather experiences in which humans have always been immersed. Weather palpability is not merely about the embodied experience but also the reciprocal influences that humans want to make with it. However, weather palpability is never fully disclosed to humans. Humans cannot experience and influence every aspect of atmospheric variation, which is too vast and changeable to fully comprehend (Morton, 2013). Thus, the question about the palpability of weather should not be concerned with what palpability is but how and why palpability is disclosed to certain people in a particular way.

A argued that the palpability of weather is disclosed through the way meteorologists arrange their bodies and through the practices of attempts to modify weather—through the choreography of the modern rain dance. In this sense, even though they have a significantly different ontological and epistemological understanding of weather, the modern weather modifiers and the ancient rainmakers have one thing in common. The weather becomes palpable to them in specific forms—whether it is the water molecules and ice nuclei in the clouds or the imbalance of the elemental forces of *yin* and *yang* in ancient China (Snyder-Reinke, 2009)—through their ways of choreographing rainmaking practices. The palpability is not a particular way of perceiving and understanding the weather and human–weather relationships. Rather, the palpability emerges from and embodies the spatiotemporal arrangements of work and life.

In this chapter, I traced the choreography of cloud seeding practices in Qinghai and how those arrangements of ‘air-conditioning’ bodies and devices are also temporally and

spatially 'air-conditioned' (McCormack, 2015). Spatially, weather modification took form through particular arrangements of the modes of presence—how the meteorologists' bodies and devices settle, move, and exist at a certain distance. Temporally, weather modification is practised by attuning to the various rhythms of the natural and social and the past, present, and future. A different way of choreographing the spatiotemporal practices of weather modification does not merely imply an operational and managerial difference. It also potentially alters how the weather can be modified. The weather would be palpable in a different way with different weather modification choreography.

This perspective comes with three conceptual implications. First, it foregrounds a reciprocal relationship between humans and the meteorological atmosphere. While the palpability of the hyperobjective weather will never fully be disclosed (Morton, 2013), it can become palpable and reciprocal to humans in particular ways via a certain spatiotemporal arrangement of work and life, as shown in the case of weather modification in this chapter. This notion not only addresses my research question on how weather modification was practised. Conceptually, it also broadens the consideration of atmospheric intervention. Certainly, it is more straightforward to see different forms of atmospheric intervention practices, weather modification or geoengineering, as weather choreographies that reciprocally influence the atmosphere. However, in the Anthropocene, even without those proactive atmospheric interventions, humans' way of life has already reciprocally impacted the atmosphere. In this sense, the Ancient Chinese thinker Dong Zhongshu was not that wrong: The behaviour of weather reflects the conduct of society.

Second, as palpability and reciprocity emerge through site-conditioned choreography (Hunter, 2015), every weather choreography is, to some extent, experimental. The arrangements are not based on a utilitarian desire to maximise certain efforts. Rather, it is

a heuristic attempt to try to attune to all the factors, from fluctuations in nature to the characters of institutions. On the one hand, this experimental essence of choreographing weather modification, together with the uncertainty of the weather system, forms an inherent ontopolitical tension with the government's attempt to create a well-controlled infrastructural atmosphere (Chandler, 2018; Wakefield, 2020b). On the other hand, in a country like China, experimental attempts have been restricted within the government-led meteorological profession. People outside the realm have limited information about and participation in it. It urges one to envision a more open and inclusive way of choreographing weather modification.

This notion leads to the final implication that reconsiders the relationships between humans and the weather. What matters to the relationship is not only the thoughts about the weather and the actions driven by these thoughts but also the ways in which those thoughts were practised, or choreographed, in particular forms and orders. Nevertheless, those ways of choreographing weather modification are embodied and would certainly be influenced by actors' epistemic and affective attachment to their actions. I will further address these two topics in Chapters 6 and 7.

Chapter 6

Is Cloud Water Aerial or Terrestrial?

6.1 Politics of Knowing

6.1.1 Epistemic Politics of Atmospheric Intervention

In response to emerging weather and climate challenges and concerns of the Anthropocene, optimistic technological solutions that aim to intervene in the Earth's atmosphere have increasingly been considered as a supplement or a backup plan to the emissions reduction scheme. On the planetary scale, various solar geoengineering methods have been advocated to slow the rise of global temperatures before the net-zero or negative-emissions goals are achieved. On the regional scale, weather modification has been undertaken to adjust weather patterns and to mitigate the negative social, economic, and environmental impacts of extreme weather events. These weather and climate interventions are often seen as emerging technologies that either work as independent

solutions or, in some pessimistic scenarios, have become an unavoidable measure to stay within the 2°C increase in global temperature. However, seeing these atmospheric interventions as particular technologies runs the risk of simplifying their implementation as an on-and-off switch of technology instead of a social–political process. Understanding geoengineering as a technology rather than a ‘work in progress’ (Stilgoe, 2015, p. 8) falsely assumes that these climate interventions lead to the same politics. The politics of atmospheric intervention lie not only in the decision-making moment but also in the social–cultural–political processes that deploy these weather or climate intervention measures. In other words, it is also important to consider the politics of practice (Buck, 2019; Stilgoe, 2015).

However, contemplating atmospheric interventions in terms of the politics of practices could also cause one to overlook some key insights. The Earth’s atmosphere is a mixture of various massive gaseous elements and their turbulent flux and dynamics. Its complex composition, nonlinear dynamics, and the massiveness of its volume and quantity combine to create an extremely complicated understanding of the atmosphere. Epistemologically, the observation and understanding of short-term atmospheric variations and long-term evolutions are inevitably mediated and visualised by numerical models and computations (Edwards, 2010). This means that the politics of weather and climate intervention must be woven into the fabrication of atmospheric data and knowledge.

An ontological conundrum also exists when one seeks to understand the atmosphere. Due to the atmosphere’s compositional complexity and ethereal qualities, it is difficult to perceive it as an entity or object (McCormack, 2018), and its scale and massiveness make a full understanding of it almost impossible (Morton, 2013). That is, the atmosphere can only be conceived by ways of knowing that partially disclose its properties. Certainly,

weather modification is informed by these ontological and epistemic settings. The politics of atmospheric interventions, including geoengineering and weather modification, must involve the politics of knowing. Even with a similar rationale of practice, various interventions that have distinct ontological and epistemic perspectives on the atmosphere would lead to very different political implications.

The aim of this chapter is to discuss the politics of knowing of the atmospheric intervention practices, which addresses the third research question of the thesis. While human geography and STS scholars have discussed the questions about the knowledge-making processes of weather and climate (Edwards, 2010; Mahony & Hulme, 2018), most of the existing academic discussions on atmospheric interventions mainly consider the politics of practices. One of the difficulties in expanding the discussion is that planetary geoengineering is still in its infancy and lacks empirical projects for examination. In this chapter, I engage with this gap from the lens of weather modification as a conceptual precursor to identify how various ways of conceiving and knowing the atmosphere could lead to different politics of atmospheric intervention.

6.1.2 A Debate on Volumetric Atmosphere

The discussion in this chapter is prompted by a scientific dispute between Chinese meteorologists and hydrologists. In November 2018, a group of renowned Chinese meteorologists publicly criticised²² a national research project led by a group of hydrologists. The project, with the intriguing title of ‘Sky River Engineering’, is led by Dr Wang Guangqian, a national hydrologist and academician of the Chinese Academy of

²² The article was posted on ScienceNet.cn (<http://news.sciencenet.cn/htmlnews/2018/11/420206.shtml>), a website operated by Chinese officials of science and engineering; also see Pike (2018) for a discussion of the scientific dispute.

Sciences, and his colleagues at Tsinghua University. The aim of the project is to conceptualise the idea of a 'sky river' and to develop the potential to intervene and relocate water resources in the sky, with an ultimate goal of implementing the south-north water transfer project in the sky. However, after being criticised in the meteorologists' article as 'immature, impractical, and misleading', this government-funded research and experimental project on the sky river became the centre of a scientific dispute on weather modification.

It is relatively rare to see such a public dispute among scientists in China, especially regarding a research project that has been approved and funded by the government. What is more interesting is that both sides of this scientific dispute actually share the same rationale regarding interventions in the atmosphere to achieve certain environmental goals. In other words, this dispute is not about choosing 'yes' or 'no' on weather modification practices. Rather, the dispute is about two groups of scientists contesting their interpretive and discursive power as well as access to governmental resources. From a political-economic perspective, the argument can be seen as an extension of the competition for research resources between two different scientific disciplines. For example, during my interview, one of the interviewees (G3), who has a background in meteorology, expressed dissatisfaction with the fact that the hydrologists involved in the Sky River Project gained control of a newly launched satellite that monitors water channels in the atmosphere. From the perspective of meteorologists, a satellite that monitors the atmosphere should be considered to be a meteorological facility, and, therefore, the control and management of the equipment and data should be handled by meteorologists.

In addition to the competition over power and resources, the disagreement between Chinese meteorologists and hydrologists also highlighted the differences in how they

understand atmospheric water. Both groups agree on the use of weather modification technologies, but they conceptualise atmospheric water differently. This chapter compares the ontological differences in how they conceive of atmospheric water's volume and volumetric features and the epistemological differences in the resource-making knowledge and discourses they use. I argue that when meteorologists consider the volumetric properties of atmospheric water, they tend to view it as an aerial resource. In contrast, hydrologists focus more on the connection between atmospheric water and the Earth's surface as well as its potential to become a terrestrial resource. This difference in an aerial or terrestrial perspective on atmospheric water as a volumetric resource has led to distinct strategies for operating and evaluating weather modification. Therefore, this discussion not only highlights the differences in how meteorologists and hydrologists comprehend weather and view clouds as resources but also how their ways of knowing can lead to varying implementation strategies with different biopolitical and geopolitical implications. By exploring this topic, the aim of this chapter is to address the third research question of the thesis, which focuses on the epistemic politics of atmospheric governance.

The structure of this chapter is as follows. Firstly, I combine the discussions found in meteorology, hydrology, and water resource management literature and highlight their ontological and epistemological differences in understanding the volumetric properties of atmospheric water. By revealing these differences in volumetric perspective entangled with particular resource-making processes, this section offers a conceptual context for the core discussion in this chapter of how this epistemic difference leads to distinct geopolitical implications. Secondly, I introduce the Sky River Project as an empirical case for the discussion. From a hydrological perspective, the Sky River Project provides an angle for understanding atmospheric water that differs from that of meteorology. Furthermore, I discuss the way in which Chinese hydrologists make sense of and evaluate atmospheric

water as resource. I suggest that, in contrast to the aerial emphasis in meteorology, hydrologists take a terrestrial perspective on atmospheric water. Lastly, I discuss how the epistemic difference in understanding atmospheric water leads to various methods of utilisation and governance, and how they create various geopolitical possibilities.

6.2 Atmospheric Water as Volumetric Resource

For those who seek to operate weather modification, whether meteorologists or hydrologists, cloud water is undoubtedly a volumetric resource. However, their approaches to this concept may differ significantly. On the one hand, their different disciplinary backgrounds lead to divergent ontological understandings of the volume of atmospheric water. On the other hand, these ontological differences regarding volumetric properties also lead to epistemic differences in the resource-making discourse. In this section, I briefly discuss these differences to provide a conceptual context for the following empirical examination.

6.2.1 The Volumetric Properties of Atmospheric Water

For meteorologists who engage in cloud seeding, cloud water is the most important substance that affects their operation (see Chapter 5). In fact, meteorologists have studied atmospheric water vapour not only for weather modification but also for general research. Through the study of water vapour transport, meteorologists can gain a better understanding of the dynamics and evolution of weather systems. Due to the uneven distribution of land and ocean surfaces, the existence and movement of water vapour in the atmosphere are highly heterogeneous. Scientists have discovered that, on a large scale, water vapour travels through narrow regions and forms filamentary structures known as

‘atmospheric rivers’ (see Figure 18). Especially in the middle latitudes, more than 90% of poleward horizontal water transport is concentrated in the atmospheric rivers that occupy only 10% of the hemisphere’s circumference (Zhu & Newell, 1998). These belt-shaped atmospheric events carry a significant amount of water and are critical for water resources in certain regions. For example, Guan et al. (2010) found that atmospheric rivers contributed 30–40% of total seasonal water resources during California’s winter.

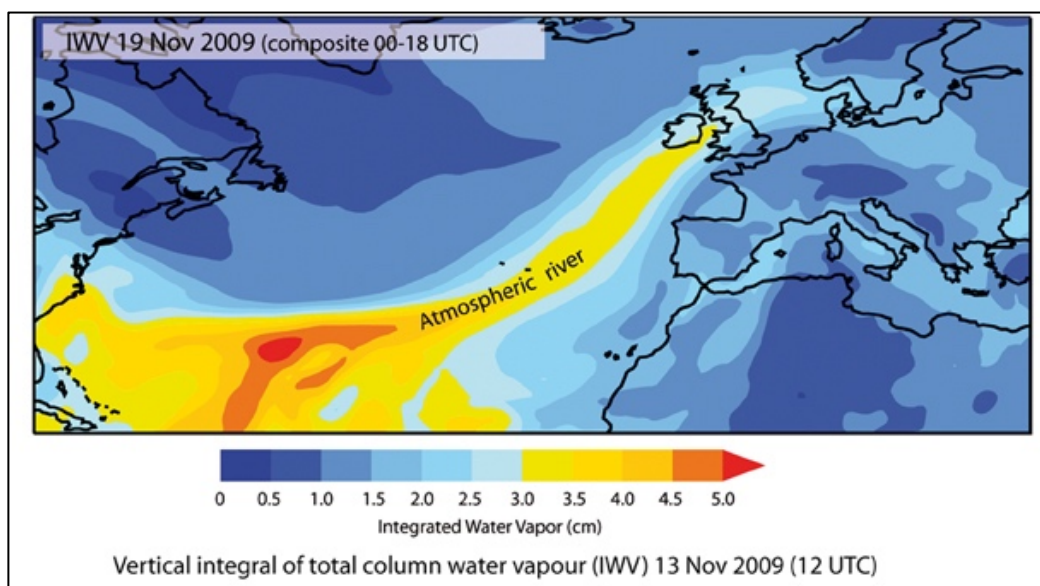


Figure 18 An atmospheric river depicted in integrated water vapour

Source: Gimeno et al. (2014)

The idea of an ‘atmospheric river’ refers to the concentrated flow of water vapour in the atmosphere, which typically occurs over a relatively short period. The volumetric properties of this concept emphasise the existence and movement of water vapour in the three-dimensional vertical space. With this concept, the volume of atmospheric water vapour is understood as the quantity of material that is suspended and occupies the aerial space. However, as I stated in Section 2.3.1, many recent scholars reject the notion of viewing volume solely as a conceptual extension of surface-to-aerial space to address

vertical geometry. Instead, these studies focused on the ‘vertical reciprocity’ of volumetric substances (Adey, 2010), which considers the processes of becoming atmospheric as well as the relationship between earthly and airy elements. Here, the volumetric properties of atmospheric water refer not only to its suspended state in aerial space but also, as suggested by Choy and Zee (2015), the potential for substances to shift state and relation.

This vertical reciprocity of atmospheric water is demonstrated in another concept used in atmospheric science that also employs the river analogy. While the concept of ‘atmospheric river’ focuses on the short-term transport of water vapour, Arraut et al. (2012) suggest a different idea that identifies the existence of long-term preferential pathways of moisture flow in the atmosphere, which they term ‘aerial river’ and ‘aerial lake’. Although the terms appear to be confusingly similar, the ideas behind the atmospheric river and the aerial river are distinct. The former describes the filamentary structure of the short-term weather event of moisture transport and emphasises the purely aerial nature of atmospheric water. In contrast, the notion of an aerial river by Arraut et al. (2012) focuses on the long-term statistical trend of the moisture transport. In this context, the volume of atmospheric water refers not only to its suspended state in the aerial space but also involves the way in which different water substances interact with the surface over a long period of time and acquire the potential to become atmospheric.

The consideration of the volumetric properties of atmospheric water and its vertical reciprocity is particularly important for understanding weather modification. This is because weather modification is concerned not only with observing the state of atmospheric water in the air but also with interfering in this atmospheric process and using it. Such utilisation must involve the consideration of cloud water’s volumetric potential of becoming other states. In other words, the consideration of the volumetric properties of

atmospheric water is inseparable from the knowledge-making process of viewing it as a resource. In the following section, I briefly discuss the academic conversation about cloud water as a resource to initiate further consideration of the relationship between volume and resource-making in this chapter.

6.2.2 Resource-Making of Atmospheric Water

As discussed in Section 2.3.2, traditional water resource management discourse does not usually consider cloud water as a management object. Cloud water is often seen as a background condition for how water enters and exits the terrestrial system through the water cycle. In this discourse, the volume of atmospheric water represents the quantity of water that re-enters the atmosphere through evaporation, which is considered a loss of water resources (Linton, 2010). However, recent hydrological theories have focused more on the relationship between the atmosphere and the surface when considering water resources. For instance, Keys et al. (2017) extended the traditional hydrological concept of the watershed to the atmosphere and conceptualised the flow of water vapour that connects upwind and downwind regions in the air. They named this three-dimensional spatial relationship the ‘precipitationshed’ (see Figure 19). Conceptually, under this theory, atmospheric water is no longer seen solely as suspended water molecules in the air but as a substance that connects upwind and downwind regions. Therefore, the volumetric capacity of atmospheric water is determined not only by its material quantity in a particular aerial spacetime but also by the relationships between various terrestrial areas.

Concepts such as precipitationshed provide a perspective for understanding the vertical reciprocity between atmospheric and terrestrial processes and offer insights into the air–land relationship in water resource management. However, it remains unclear how different understandings of the volumetric properties of atmospheric water inform the

way in which atmospheric water is conceived and governed as a resource, especially in projects of weather modification. The aim of this chapter is to uncover and discuss how epistemic differences in the volumetric properties of atmospheric water can shape resource-making processes in various weather modification discourses. Specifically, I examine the Chinese Sky River Project led by hydrologists and analyse their understanding and evaluation of the volume of atmospheric water as a resource. The goal is not only to demonstrate epistemological differences between weather modification discourses but also to highlight how various resource-making discourses can lead to distinct geopolitical implications.

In the subsequent sections of this chapter, I engage in a discussion of volume and resource-making by analysing the Chinese Sky River Project. This discussion speaks to an increasingly recognised approach in studies on the geopolitics of resources that considers the three-dimensional materiality of the substance, which is sometimes referred to as ‘political geology’ (Bobbette & Donovan, 2021; Wang, 2021). These existing discussions focus mainly on subterranean materials, whereas this chapter focuses on the atmospheric substance. By exploring how atmospheric water became a known and governable resource under specific epistemic practices of Chinese hydrologists, I demonstrate how particular volumetric properties of atmospheric water have become entangled with the resource-making processes and how the particular understanding of volume leads to certain geopolitical implications.

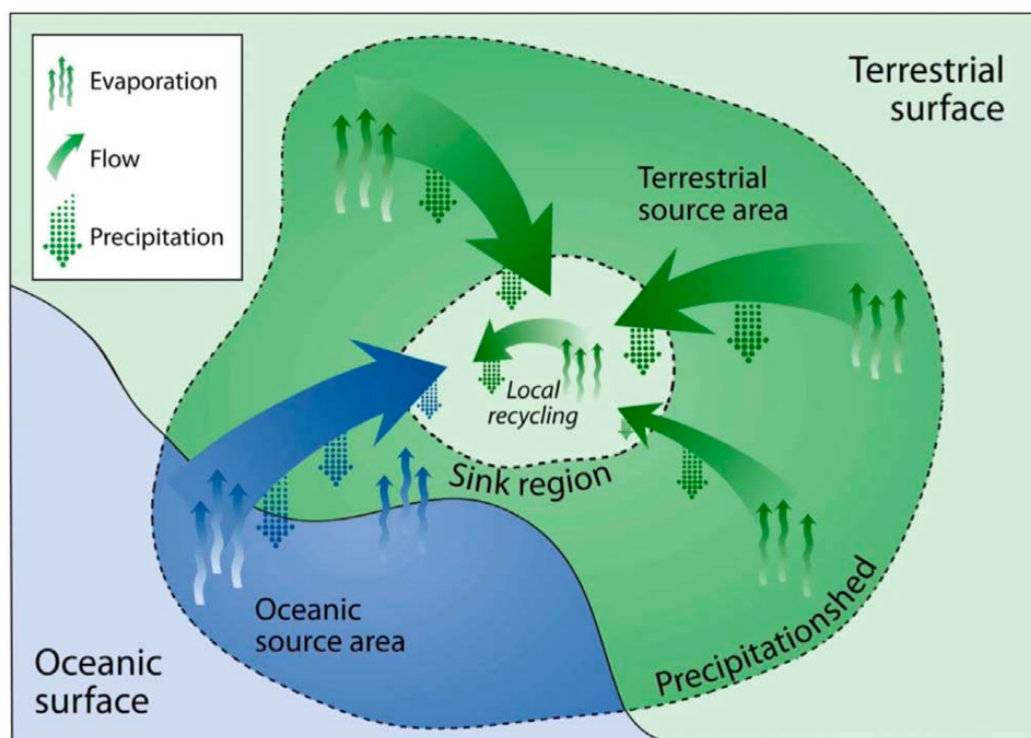


Figure 19 The conceptual diagram of a precipitation shed

Source: Keys et al. (2017, p. 16).

6.3 Hydrologists and the Sky River Project

6.3.1 A Hydraulic Dream in the Sky

As I explained in Chapter 4, China has long faced a water scarcity problem in the north and in the Yellow River basin. Tackling this water supply issue through modern hydrological engineering has been at the centre of environmental governance for communist China since Mao's era. One of the most ambitious strategies to solve the water problem in the north is to transfer water resources from the moist south. The South–North Water Transfer Project, which ultimately aims to transfer 44.8 billion cubic metres of water annually, has become the iconic hydrological construction for Communist China to demonstrate its ecological modernisation and political competency (Moore, 2014).

This achievement in hydraulic engineering inspired a group of Chinese hydrologists, mainly from Tsinghua University in Beijing, to move their focus to the sky and to engage in research on weather modification. Their ultimate goal is to replicate the effects of the South–North Water Transfer Project in the air through weather modification. In a paper published in 2016, in which the idea of sky river engineering was first proposed, the authors explicitly suggest that hydrological management of surface water in China has almost reached its limit, and, therefore, ‘it is necessary to find a new water resources management theory and method’ (Wang et al., 2016, p. 654). With this rationale in mind, they suggest paying more attention not only to the concept and phenomenon of a sky river but also to the potential hydrological implications of sky river engineering. Under this narrative, the term sky river not only indicates the physical attribute of the atmospheric phenomenon but also reflects a hydrological expectation of potential water resources in the sky. These hydrologists suggest the following in another paper:

The stochastic feature of cloud and precipitation processes causes difficulties in providing a *reasonable definition* of atmospheric water *resources*. [...] it is necessary to understand which part of atmospheric water could be potentially *transformed into surface water* [emphasis added], and then analyse its temporal and spatial variation (Wang et al., 2018, p. 110).

For hydrologists, what is important about this river analogy is more than simply how it depicts the topological attribute of moisture transfer in the atmosphere. More importantly, hydrologists are looking for a concept that provides a meaningful prediction of potential water resources in a long-term timescale, similar to surface rivers. For hydrologists, any single atmospheric water transport event is less meaningful than the summation and overall

tendency of all events in the long term. This is similar to how they think about surface rivers, where they are more concerned about the overall long-term state of the river as a whole rather than the individual short-term movement of water molecules. This notion of the sky river is clearly different from the typical concern of meteorologists regarding atmospheric water, which focuses more on the real-time and short-term dynamics, and is closer to the perspective of Arraut et al. (2012) that considers a long-term preferable pathway of water vapour in a statistical sense.

6.3.2 Developing a Hydrological Timescale

The goal of the Sky River Project, as described by the research team (Wang et al., 2016), is to first develop a theoretical model and mathematical method to understand the attributes of sky rivers and, ultimately, to find a way to integrate and use them in water resource management. In this context, the timescale of the model becomes a crucial element. The preferred timescale for hydrologists lies between that of weather (often less than a week) and climate (ranging from decades to epochs); they are either too short or too long to have practical implications for hydrological problems and solutions. To be useful, Wang et al. (2016) suggest developing a perspective on sky rivers with a ‘timescale of hydrological engineering’ (p. 653), which pays attention to dynamics from hours to years. This specific timescale is clearly demonstrated in their visualisation of the sky rivers, in which the spatial pattern of the sky rivers is depicted by the ‘annual occurrence frequency’ (see Figure 20). In contrast, meteorological depictions of atmospheric rivers tend to capture the atmospheric state at a specific moment, as indicated in Figure 18 where specific dates and times are provided on the graph. This consideration of the specific timescale also informs the way in which they build the mathematical equations. In another paper, Wang et al. (2018) provide a set of mathematical models derived from fluid mechanics in hydrology and suggest that the models offer a ‘physical generalisation of a variety of

meteorological processes’ that covers ‘both short-term meteorological events and long-term statistics of atmospheric water resources universally’ (p. 117).

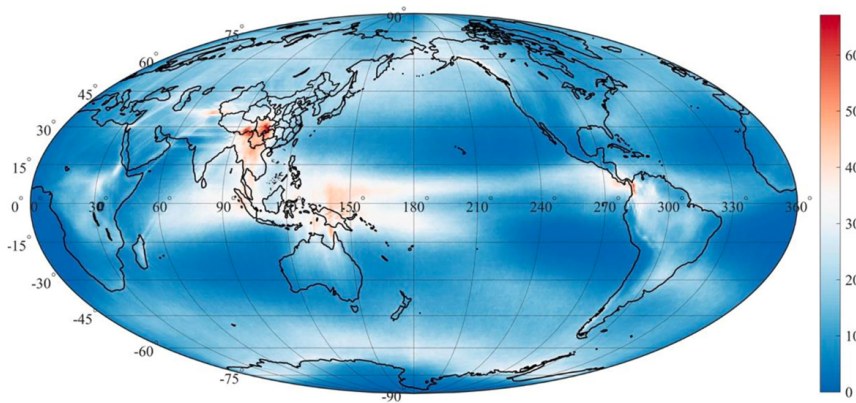


Figure 20 The annual occurrence frequency (days per year) of sky rivers.

Source: Wang et al. (2018)

This distinctive choice of timescale is not the only difference between the meteorologists’ and the hydrologists’ perspectives on atmospheric water. The aim of these Chinese hydrologists is to develop a different way of understanding the moisture flow in the atmosphere, based on their hydrological discipline. On one hand, this means they seek to consider and conceptualise water vapour in the atmosphere from a distinct timescale that differs from mainstream meteorology and climatology. On the other hand, this also demonstrates an attempt to apply hydrological knowledge (i.e., fluid mechanics) to an understanding of atmospheric water. As they suggested in the paper, the sky river is where ‘intensive transport of atmospheric water is found, behaving in a similar manner as river channels on the surface of the earth’ (Wang et al., 2018, p. 110). Based on this notion, in the next section, I continue to discuss how this hydrological perspective on weather modification and atmospheric water provides a way of seeing volumetric properties that are quite different from the aerial perspective in meteorology.

6.4 The Volume of Atmospheric Water: Aerial Versus Terrestrial

6.4.1 *An Aerial Perspective of Atmospheric Water*

For scientists who work on weather modification, the volume of cloud water—which includes water vapour, floating droplets, and snowflakes—is crucial data that demonstrate the potential water resource that can be harvested. Meteorologists can sense and calculate the volume of cloud water through the ‘cloud water path’ (CWP), which describes the total mass of water above the Earth’s surface. However, the CWP provides only an instant measure of the amount of cloud water in a given aerial space. To understand the total volume of cloud water over a longer term, weather-modification scientists need to perform further calculations based on the CWP. For example, Chen and Tien (2013) developed a model to estimate the annual volume of cloud water in the upper stream areas of the Yangtze River. In this model, they first calculated the average CWP in the selected area (i.e., the average amount of cloud water in the aerial space above the area) and then multiplied it by the length of time and size of the area. By their estimation, the total volume of cloud water in the upper Yangtze River is approximately 853 billion m³ per annum.

In this meteorological estimate, the volume of cloud water is understood as a measure of water within a certain spacetime in the air, as an aerial container of water. The volume of atmospheric water can be calculated in any given range of the atmospheric column—a sum of the amount of water in the volumetric space above the surface within the given time period and area. Here, the volume of atmospheric water considers only the existence of water mass in the aerial spacetime. Atmospheric water refers to the water contained in the selected three-dimensional space of observation. In this way of conceptualisation, the difference between atmospheric water and surface water lies in the location occupied by

the volume. In their paper, Chen and Tien (2013) calculated the ‘potential cloud water resource’²³ by subtracting the volume of precipitation (the amount that turned into surface water) from the total estimated cloud water (the amount that used to exist in the aerial spacetime). The volume of cloud water is calculated as a potential resource based on its existence in the homogenous aerial spacetime, where it is treated as a material occupying aerial volume.

6.4.2 A Terrestrial Perspective of Atmospheric Water

Compared to the aerial perspective of meteorologists, one of the most distinct features of the hydrologists’ sky rivers concept is that it considers atmospheric water to be terrestrial. For Chinese weather-modification hydrologists, the notion of sky rivers is not an aerial concept that involves only the materials and meteorological processes in the air. For them, cloud water is not merely seen as a volume suspended in the aerial space. Instead, this hydrological view adopts a perspective that focuses on several terrestrial features of atmospheric water based on conceptual and practical considerations. It is epistemologically terrestrial in three ways.

Firstly, while the idea of a sky river depicts the water transfer in the atmosphere, it is not an idea that focuses merely on the aerial space. Instead, in addition to the evolution and movement in the atmosphere, hydrologists also pay attention to the coupling between the atmospheric water and the surface water. This focus on the air–surface coupling demonstrates the emphasis on the relationship between the atmospheric water and the

²³ While this number indicates the theoretical (maximum) potential of the cloud water resource, Chen and Tien (2013) also provided a way of estimating the practical potential of cloud water utilisation, which further considers the efficacy of weather modification implementation and the probability of suitable weather conditions.

surface water. Here, the volume of atmospheric water is not merely understood as a volume in the aerial space but also is emphasised as a part of a larger circulation of the volume. Sky rivers supplement the surface water through precipitation while also being supplemented by the surface water through evaporation.

For a hydrological epistemology, the consideration of the air–surface coupling of the atmospheric water is inevitable, as the interest in the atmospheric water is derived from the core consideration of surface water of both the theoretical and practical rationale in hydrology. In the manifesto advocating for the sky river study, Wang et al. (2018, p. 109) suggest that ‘the failure of coupling [atmospheric water] with conventional surface water resources’ is one of the reasons why they propose the study so as to fully bring the atmospheric water ‘into the water resources management system’. In other words, the consideration of the air–surface coupling is not just a conceptual tool that helps hydrologists build a better understanding of the long-term trend of the atmospheric water and how it interacts with the surface. More importantly, it reveals an inherent rationale in the hydrological epistemology in which the atmospheric volume must be related, theoretically and practically, to the surface and, thus, can never be purely aerial. Here, the relationship between the atmosphere and land involves ‘vertical reciprocity’ (Adey, 2010), where atmospheric water can be seen as volumetric connections between the air and land.

Secondly, existing hydrological concepts, theories, and ways of questioning developed based on the surface water inform how hydrologists make sense of atmospheric water as a conceptual analogy and theoretical extension. The idea of sky rivers is an obvious example of this conceptual appropriation, through which the three-dimensional volumetric flux of water in the atmosphere is demonstrated by its two-dimensional projection (see Figure 18 and Figure 20) as a river on the surface. Another example of this

extension of terrestrial hydrological concepts is the consideration of the ‘basic hydrological unit’ of atmospheric water. In terrestrial conditions, basins are the basic unit for hydrological analysis and categorisation. Basins, as a basic unit with a relatively clear boundary and some similar hydrological features, are at the centre of hydrological conceptualisation and management schemes. This has led Chinese hydrologists to examine the idea of a basic unit of atmospheric water and suggest that:

We have to figure out whether there exists a concept of ‘basin’ in the atmospheric water resources. And if so, where is the ‘basin’? How does atmospheric water flow between the ‘basins’? Obviously, these two problems make the atmospheric water resources development no longer a simple meteorological issue (Wang et al., 2018, p. 110).

Echoing this inquiry, Zhang et al. (2020), a group of hydrologists from Tsinghua University, developed a model to depict the basic hydrological units of the atmospheric hydrological cycle, termed the ‘atmospheric basin’. The goal of their study was to identify ‘regional-scale areas in the global atmospheric hydrological cycle that are relatively closed with respect to moisture recycling, analogous to the terrestrial river basins’ (p. 2). By identifying these ‘quasi-independent subsystems’, these hydrologists are able to draw the boundaries of areas where intraregional water recycling plays a more important role than interregional flow. Here, the volume of atmospheric water is not perceived as its entire quantity in the aerial space. Instead, as Zhang et al. (2020, p. 20) suggest, while the atmospheric basin is referred to as being atmospheric, ‘it is still treated as a unit on the land/ocean surface’ (see Figure 21). Indeed, one of the implications of identifying the basic hydrological unit of atmospheric water is to highlight the fact that a terrestrial location simultaneously belongs to both a river basin and an atmospheric basin, which is worth considering in terms of

devising water resource management strategies. In this discourse, atmospheric water was enacted as terrestrial volume, which, as scholars explained, unfolds through the epistemic practices of resource-making (Bridge, 2013; Kama & Kuchler, 2019).

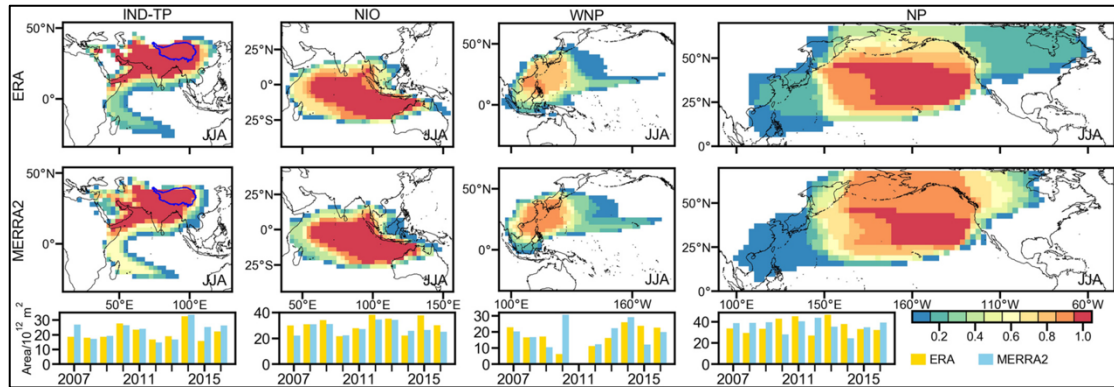


Figure 21 Atmospheric basins which are located in the Asian summer monsoon regions

Source: Zhang et al. (2020)

Thirdly, from a practical hydrological perspective and the viewpoint of water resource managers, the volume of atmospheric water can be utilised only after it precipitates on the ground and enters terrestrial water management schemes. In other words, the volume becomes a resource only after it is on the ground. Furthermore, the value of being a resource is not solely determined by the volume of atmospheric water that falls on the ground but also by the location of precipitation. In my interview with a hydrologist involved in the Sky River Project (S4), they explained that an important reason for studying and experimenting with sky river engineering on the Tibetan Plateau is due to this consideration. The same volume of cloud water falling into different basins of the Yellow River and Yangtze River, even if only tens of kilometres apart in the region, has a significant difference in terms of value as a water resource. The volume is much more valuable in the drier Yellow River basin than in the humid Yangtze River basin. In this sense, the volume of atmospheric water cannot be fully evaluated without considering its

terrestrial location.

It is important to note that the comparison of atmospheric water I made here between the meteorological aerial perspective and the hydrological terrestrial perspective does not suggest a difference between a three-dimensional and two-dimensional views. It would be problematic to simplify the hydrological epistemology as a two-dimensional way of comprehending the volume of atmospheric water. This simplification falsely ignores the long hydrological traditions engaged in the vertical aspect, such as the depth of fluid. Additionally, it risks seeing the volume as only a vertical spatial feature, which has been rejected by recent studies on volume (Bridge, 2013; Elden, 2013; Lehman, 2013; Steinberg & Peters, 2015). Indeed, the comparison made here between the two epistemologies on the volume of atmospheric water presents a counterargument to this simplification: Volume is not only about the materials and the space it occupies. It is also important to pay attention to how the volume is perceived, comprehended, calculated, visualised, and evaluated in a certain way, and how different practices and politics unfold along with it (see Table 4), which is discussed in the following section.

Table 4 Comparison of the aerial and terrestrial perspective of the atmospheric water

	Ontological understanding of volume	Epistemological difference on resource-making	Geopolitical implications of intervention practices
An aerial perspective of atmospheric water	Vertical extension of the surface territory and volumetric spacetime that contains aerial substances	Aerial-based calculation of all floating substances contained by the aerial space in a short-term period	Extending the territorial governance and accountability to the vertical column of aerial space (e.g., weather modification duty based on the administrative territory)
A terrestrial perspective of atmospheric water	A condition of suspension that inheres reciprocal connections and processes of becoming-atmospheric and resettling to the ground	Terrestrial-bounded conceptualisation (e.g., land and atmospheric basins) and evaluation of the long-term tendency of suspended water	Considering the air–land coupling as well as the upwind and downwind relationship, and intervening in the atmospheric water through governing the surface (e.g., land-based operations of precipitation interference and reforestation)

6.5 Utilising the Volume: Aerial Versus Terrestrial

In Chapter 5, I explore the official weather modification operation conducted by the China Meteorology Administration. The ethereal and gaseous weather process became a modifiable thing under meteorologists' weather-modifying choreography, through which the spatiotemporal arrangement of the bodies and equipment is attuned with the weather. These meteorological operations pay attentions, both epistemically and methodologically, mainly to the water in the aerial space. The major goal of meteorologists' weather-modification practices, as discussed in Chapter 5, is to attune with and intervene in the aerial materials and weather processes. When comparing this aerial way of perceiving atmospheric water, an interesting question to ask is this: To what kind of alternative modification practices does the Sky River Project's terrestrial perspective on atmospheric water lead?

Current official weather modification operations in China are conducted primarily using airborne vehicles such as aircraft and rockets (see Figure 14). These platforms carry and disperse cloud-seeding catalysts into the air, which enhances the formation of raindrops. By contrast, other Chinese scientists are exploring ground-based alternatives for weather modification technologies, such as lasers (Ju et al., 2012) and sound waves (Cao et al., 2021; Wei et al., 2021). For the hydrologists involved in the Sky River Project, acoustic-interference technology has the potential to be an alternative method for utilising atmospheric water resources through ground operations. For instance, Wei et al. (2021) conducted experiments on acoustic cloud interference in Qinghai by emitting low-frequency sound waves (50 Hz) into the clouds to induce the collision-coalescence process of atmospheric water molecules (see Figure 22). They suggested that this acoustic agglomeration mechanism has the ability to alter the microphysical characteristics of

clouds and that it demonstrated potential for increasing rainfall intensity by 11%–17%.

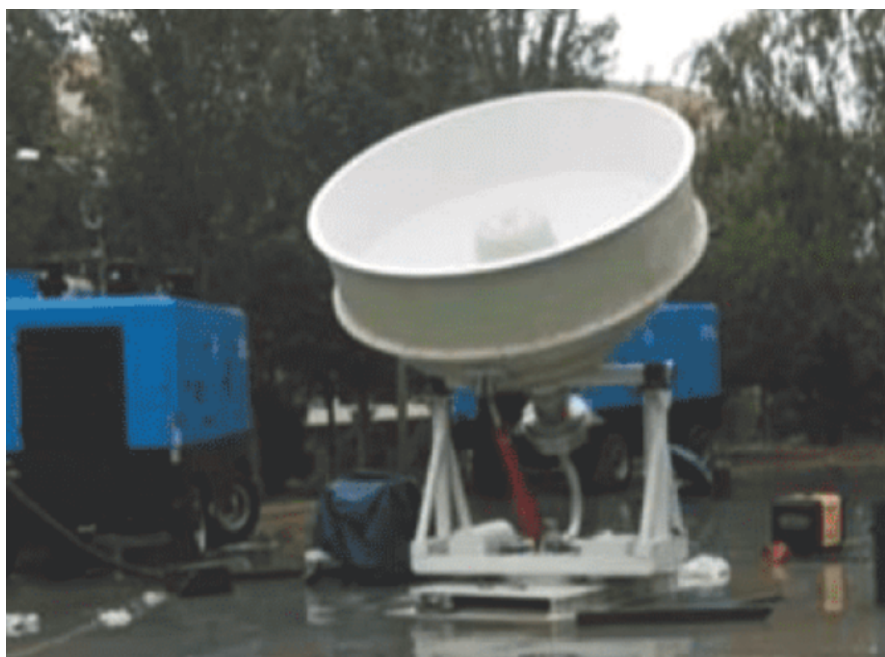


Figure 22 Low-frequency sound wave generator used in a precipitation interference experiment in Qinghai

Source: Wei et. at. (2021)

Wei et al. (2021) consider the acoustic method to have several advantages. It is a relatively low-cost, chemical-free operation and has the potential for remote control and operation. However, most importantly, this ground-based method can ‘eliminate dependence on the aircraft platform’ (p. 262). The intention of developing an alternative to the aerial operation of weather modification reflects not only their operational concerns but also reveals how various ways of understanding the atmospheric water as a resource inform the ways of utilising it. Meteorologists are concerned about the atmospheric processes of water—such as cloud formation, air circulation, and phase changing—that occur in the aerial space. Employing this view, the main goal of the weather-modification operation is to optimize these processes in the air. Therefore, the aerial operation has become the most timely, effective, and flexible method.

By contrast, hydrologists are concerned about the terrestrial bound of the atmospheric water—the relationship between the volume in the air and the volume on the ground. For them, the value of a weather-modification operation is not based on the efficacy of boosting the formation of raindrops in the air, as meteorologists might see it. Rather, hydrologists care more about the location where the rain falls. As explained by one of my interviewees (S4) in the Sky River team, there can be significant differences in the value of the same amount of atmospheric water falling into Basin A and Basin B. While the meteorologists' method aims to optimize the atmospheric processes, the technique being developed by the hydrologists has an ultimate focus on the ground.

Potential geopolitical implications underlie these different logics of weather modification. The ongoing mainstream aerial operation of weather modification in China is controlled by the meteorology office, and these operations are arranged based on existing administrative structures and territories. For example, while the Qinghai province comprises several different weather areas and hydrological basins, the weather-modification operations for the entire province are overseen by the Qinghai meteorology office, which is responsible for all weather processes within and above the administrative territories. In other words, the power and responsibility to utilise the atmospheric water are linked to the vertical space that extends from the administrative boundary. In contrast, while the hydrologists of the Sky River Project are still experimenting with their novel weather modification method, it opens up another geopolitical possibility of atmospheric water: an arrangement that is not based on existing administrative territories but on the conceptually defined surface and atmospheric basins and how they connect and interact. Here, the volumetric geopolitics are not simply a vertical extension of the geopolitical relationships on the surface. Rather, they are a three-dimensional complex involving

constantly circulating materials and, perhaps more importantly, particular ways of making sense of these aerial substances and their relationships to the ground. Atmospheric water is not simply a potential water resource in the air. It is a resource in suspension (after Choy & Zee, 2015) waiting to be conceptually and materially settled on the ground.

It is interesting and important to note that the weather-modification practices and the volumetric and geopolitical implications opened up by the air–land coupling epistemology are also plural. With a terrestrial understanding of atmospheric water, the Sky River Project aims to manage both surface and atmospheric water basins through ground-based interventions in critical locations. However, another approach to modifying and managing atmospheric water is possible under this concern of vertical reciprocity, which prioritises the intervention of the surface rather than the atmosphere. For example, by developing a numerical model of aerial rivers in Bolivia, Weng et al. (2019) reveal the potential impact of reforestation at particular upwind regions that increased surface runoff in the downwind region (see Figure 23). They suggest implementing smart reforestation projects in the upwind regions of aerial rivers, instead of traditional upstream catchment approaches, as part of the water management scheme. This demonstrates another possible volumetric geopolitical impact of atmospheric water management. Although this terrestrial engineering method towards atmospheric water has yet to be seen in China, a similar approach has been implemented in the governance of dust storms (Zee, 2020). After seeing all of these practices of atmospheric water management expanded by the perspective of air–land reciprocity, it is clear that the ways in which various regions are involved in a particular upwind–downwind relationship are profoundly informed by how air–land connections are understood.

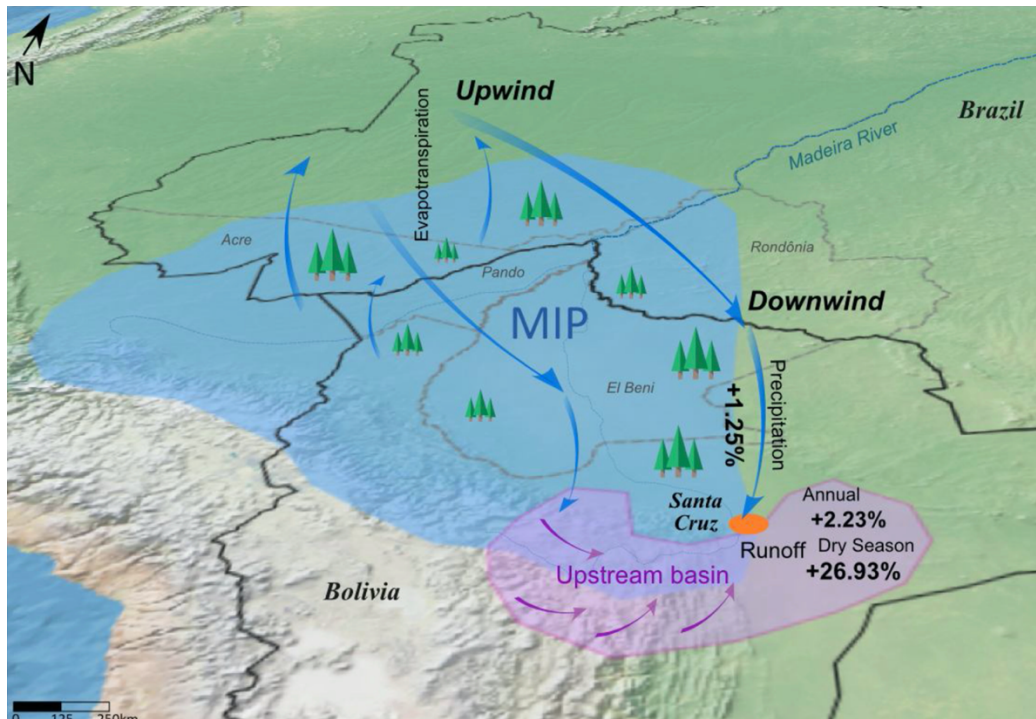


Figure 23 Reforestation and downwind area runoff

Reforestation in the upwind region of the most influential part (MIP) of the precipitationshed contributed to increasing runoff in the downwind area (Weng et al., 2019, p. 107).

6.6 Conclusion

In this chapter, I address the third research question of the thesis on the epistemic politics of weather modification. I follow the understanding of hydrologists involved in the Sky River Project and discuss how they conceived the volumetric properties of atmospheric water in their discourse on water resources. By highlighting the differences between the meteorological and hydrological ways of conceptualising atmospheric water, I argue that hydrologists regard it as a knowledgeable and manageable resource based on their terrestrial understanding of it. An underlying difference exists in how the atmospheric volume is understood, whether as a substance existing in the aerial space or as in a suspended condition, as Choy and Zee (2015) termed it, that has an inherent relationship

with the surface, a vertical reciprocity (Adey, 2010). Furthermore, this epistemic difference affect not only the ways in which atmospheric water is conceptualised as a resource but also influences how it can be utilised and managed. This difference also opens up various possible practices for modifying and managing atmospheric water resources that have different volumetric and geopolitical implications.

By examining the case of atmospheric water resource management, this chapter contributes to the latest academic discussion on the volumetric emphasis of resource geography and geopolitical debates. On the one hand, this chapter resonates with literature on the geopolitics of subterranean resources and political geology (Bobbette & Donovan, 2021), rejecting a simplistic understanding of volume as the vertical spatial extension of surface relationships. However, in the case of atmospheric water, this chapter also demonstrates the more fluid and circulated relationships of substances in volumetric space. Indeed, the volumetric feature of atmospheric water is in a state of suspension (Choy & Zee, 2015), awaiting conceptual and material settlement on the ground: to understand it, hydrologists employ terrestrial analogies and theories and create a terrestrial perspective on atmospheric water; to utilise and evaluate it, atmospheric water first needs to settle in a water basin on the surface. On the other hand, this chapter also highlights that the geopolitics of volume must intertwine with the epistemic politics of volume. The ways in which the relationships between volumetric substances are conceived inform the ways in which governing practices are enacted and how power relationships unfold through volumetric space.

Chapter 7

Hope From the Air

7.1 The Affective Politics of Weather Modification in China

7.1.1 The Affective Politics of an Authoritarian Atmosphere

The core argument of this thesis is to view weather modification in China as a new form of governance of life through modulating the enveloping atmosphere. In previous chapters, the analysis focused more on the meteorological side of the atmosphere—how the particular ways of comprehending and practising cloud seeding worked as a means of governance. However, there remains an unanswered puzzle on the affective side of this atmospheric governance. The aim of this chapter is to explore the affective side of weather modification and to complete the core concept of the thesis. In this chapter, I question how the Chinese government’s modification of weather is also an attempt to govern the affective atmosphere and how this form of atmospheric governance implicates the

characteristics of contemporary Chinese authoritarianism. The goal is to open up a discussion on the affective dimension of weather modification and to demonstrate that this governance is conducted through manipulating both the meteorological and affective atmospheres. In other words, the Chinese government's practices and discourses on modifying the weather alter not only the meteorological atmosphere in which life takes form but also shape the affective atmosphere.

A growing number of recent studies have focused on the aspect of affect when analysing the characteristics of Chinese authoritarianism (Du, 2014; Lu et al., 2021). Prior to this, social science studies tended to discuss the authoritarianism of communist China from either Weberian or Foucauldian approaches. The former approach examines how Chinese authoritarianism takes form and institutionally sustains its power and legitimacy, while the latter pays more attention to how authoritarianism functions through forming certain discourses and disciplined subjects. This rising focus on the affective aspect provides both conceptual and empirical insights into understanding contemporary Chinese authoritarianism. Conceptually, it extends the Foucauldian focus on the everydayness of authoritarianism and suggests that authoritarianism not only strengthens through certain knowledge and discourses but also can consolidate through certain affective atmospheres. Empirically, the rising focus on affect captures the emerging intention of the Chinese government to govern on and through the affective atmosphere.

Nevertheless, it would be conceptually problematic to see these approaches as separate aspects of authoritarianism. The politics of affect do not function separately from the material, institutional, and discursive dimensions of power. Instead, these aspects tend to intersect and intertwine as the characteristics of authoritarianism emerge. By discussing the affective politics of weather modification, this chapter provides an adequate example

depicting an entanglement in which the authoritarian government's intention to rule through manipulating the affective atmosphere resonates with its control over the meteorological atmosphere. This analysis contributes to the discussion on Chinese authoritarianism and indicates how the Chinese government's institutional and discursive power coincides with its affective control. Meanwhile, by focusing on the intertwining relationship between governing the meteorological and affective atmospheres, this chapter also speaks to a broader discussion on the politics of proactive atmospheric interventions, such as geoengineering. It reminds us that the affective politics of geoengineering lie not only in people's optimistic or pessimistic projections of technological solutions but also in how these affects might relate to the different forms of 'climate Leviathan' (after Wainwright & Mann, 2018), an inquiry that I raised in Chapter 1.

Authoritarian control over the affective can work through an atmosphere of fear. This atmosphere of fear unfolds in both meteorological and affective dimensions. As discussed in Chapter 1, this is exemplified in the 1998 dystopian film *The Truman Show*, in which the protagonist, Truman, lived in a town where all other people were actors and all environmental aspects, including the weather, were controlled by director Christof. When Truman attempted to escape from this control, Christof created an artificial storm to impede his attempt. However, what Christof sought to control was not merely the meteorological phenomenon. Through manipulating the weather, he also attempted to create an emotional storm that was dramatic and terrifying for Truman. The atmosphere influences the movie's characters in two ways. On the one hand, it frightens them by exposing and immersing them within a harsh and harmful weather condition. On the other hand, it also scares the characters with the horrifying milieu. Here, the two aspects of atmosphere work together and are inseparable. In the real world, this is how windborne chemical weapons and tear gas work, as a 'terror from the air' (Sloterdijk, 2009). The toxic

chemicals are biopolitically powerful not only because they suffocate people who breathe them in but also because the terrifying milieu induced by the potential use of the chemicals could profoundly inform their way of life.

7.1.2 Weather Modification and the Optimistic Milieu

However, authoritarian control over the affective domain can also work through a more positive atmosphere. Many recent empirical studies on China's political atmosphere have highlighted an increasing emphasis on 'positive thinking' by the authorities (for detailed discussion, see Section 2.4.3). Indeed, the main argument of this chapter is that weather modification in China should be understood as a form of governance that aims to create 'hope from the air'—an optimistic atmosphere that emerged through the modification of the meteorological atmosphere. This hope from the air, as I discuss later, consists of a nationalistic projection of a competent government and a techno-optimistic belief that meteorological intervention is one of the solutions to the problems that China faces. To fully understand weather modification as a form of governance, we must consider both aspects of the atmosphere—as the human-intervened weather and as the optimistic milieu—together. I suggest that this conceptual inseparability is crucial to understanding the affective politics of weather modification for three reasons.

Firstly, examining the entanglement of both aspects of the atmosphere helps to highlight the intention of governance. The governance of weather is influential not only because weather modification can alter the meteorological conditions of life but also because the manipulation of weather is deliberately framed and operated in ways that induce optimistic perceptions of the problems that society faces. These perceptions strengthen nationalism and techno-optimism that support the authoritarian regime's governance. Under this optimistic projection, cloud-seeding technology and the state system that deployed it were

portrayed as hopeful solutions to a wide range of troubles. As discussed later in the chapter, the hope from the air that the government aims to project addresses not only weather and environmental issues such as droughts and degradation but also more abstract concepts such as security, national glory, and modernisation. In this sense, the state's effort to modify the meteorological atmosphere is a simultaneous attempt to shape an affective atmosphere to consolidate authoritarian power. This notion helps one to understand how the modification of weather in China is both a part of its environmental governance and a part of the social and discursive control under the Chinese communist regime.

Secondly, the entanglement of the meteorological and the affective aspects of weather modification should also be considered at the practice level. While the state revealed its intention to govern both aspects of the atmosphere through weather modification, this intention does not automatically apply to the field of practice. This leads to a question of how the state's attempt to project the hope from the air was transcribed into meteorologists' weather modification practices. By focusing on how the optimistic atmosphere emerged with meteorological practices, the analysis provides insights into the way in which the government-favoured affects were enacted. Considering the entanglement from this angle demonstrates not only how a centralised authoritarian intention of manipulating the atmosphere was enacted at the individual level of practices but also reveal a form of governance in which the weather modification optimism was institutionally and affectively co-constructed in the authoritarian regime. In this way, the manipulation of both the meteorological and the affective atmosphere is conceptually and empirically inseparable.

Thirdly, foregrounding the affective aspect of weather modification helps identify the intention and practice of the manipulated optimism, and also creates a different angle for considering and critiquing the politics of weather modification. While the government

attempts to modulate an affective bond between weather modification and a hopeful atmosphere, this orthodox optimism faces challenges from other affective experiences. By examining how various human and nonhuman subjects provide unorthodox responses to the government-manipulated atmosphere—both the meteorological and the affective—this offers an alternative reading of weather modification that deviates from the hope from the air. Seeing weather modification as an affective governance provides a way to critique these intentional and proactive interventions to the Earth's atmosphere that is different from the biopolitical perspective discussed in previous chapters.

These three aspects establish a framework for this chapter to discuss how manipulating weather has become a form of affective governance. My primary argument is that weather modification in China governs not only the meteorological but also the affective atmosphere by projecting and practicing optimism towards humanised weather. This hope from the air is evident in the government's intention to project hope onto meteorological interventions and in the actual practices of weather modification. By discussing the nationalistic projection of a strong and competent state and the techno-optimistic belief in taming nature connected to cloud-seeding policy and practices, this chapter reveals how the governance of weather is also a governance of hope in the Chinese authoritarian regime.

In the remainder of the chapter, I first demonstrate the state's intention of projecting optimism through weather modification as a hope from the air. I discuss the Chinese government's grand narrative at the national level regarding its competence and its positive visions of meteorology and how the government projected positive beliefs about its control over the environment and society. Then, I delve into how an atmosphere of hope emerges in the operational practices of weather modification for individual scientists as

well as the meteorological bureau. I examine how a particular affective atmosphere of optimism took shape and became entangled with scientific practices and their underlying heuristic logic. Finally, I conclude this chapter by reiterating the affective aspects in weather modification practices and by providing reflections and critiques on the affective governance.

7.2 Projecting the Hope From the Air

7.2.1 Governing the Optimism in China

How did weather modification become a source of hope from the air? This section examines the affective politics of weather modification by analysing the Chinese government's intention to project optimism and hope through modified weather. The analysis focuses on the forms of hope that the government attempted to project and how these projections evolved. By demonstrating the fabrication of optimism within the overall weather modification policy, this section demonstrates that, for the Chinese government, weather modification involves the modulation of both the meteorological and the affective atmosphere. This form of authoritarian affective politics manipulates both weather and affect. On the one hand, weather modification is linked to optimistic rationales and goals and becomes a carrier of the projection of hope. On the other hand, modulated weather is also a way to demonstrate hope.

The Chinese government has been attempting to modulate optimism as part of its governance. As I reviewed in Section 2.4, a growing number of studies have indicated the importance of paying special attention to the affective dimension of nations as well as the relational processes that generate national identities and affects (Antonsich & Skey, 2017;

Closs Stephens, 2016; Merriman & Jones, 2017). China is no exception (Chen & Wang, 2019; Lu et al., 2021; Wang & Mark, 2015; Yang & Tang, 2018). These studies reveal that guiding the public towards optimistic and positive attitudes on public affairs has become an increasingly important measure of social control for the Chinese government. This trend is clearly demonstrated in Figure 24, which indicates that, since 2010, the official Chinese media has extensively used the term ‘positive energy’, indicating a positive and optimistic attitude), and the public’s use of this term in the Baidu search engine has increased correspondingly.

This trend suggests that the Chinese government is striving to promote a positive and optimistic perception of the nation and its governance, and to disseminate information that reinforces these attitudes. Alongside the use of propaganda and the censorship of information, the government seeks to cultivate a positive affective atmosphere that allow it to consolidate its control over society (Adey, 2014), particularly during social and environmental security crises such as the COVID-19 pandemic (Lu et al., 2021). As Berlant (2011, p. 24) notes, this modulated optimism enables individuals to envision a better future, as they ‘lean toward promises contained within the present moment of the encounter with their object.’ For the Chinese government, projecting optimism regarding its policies aims to facilitate society’s emotional attachment to promises that increase their affinity to governance.

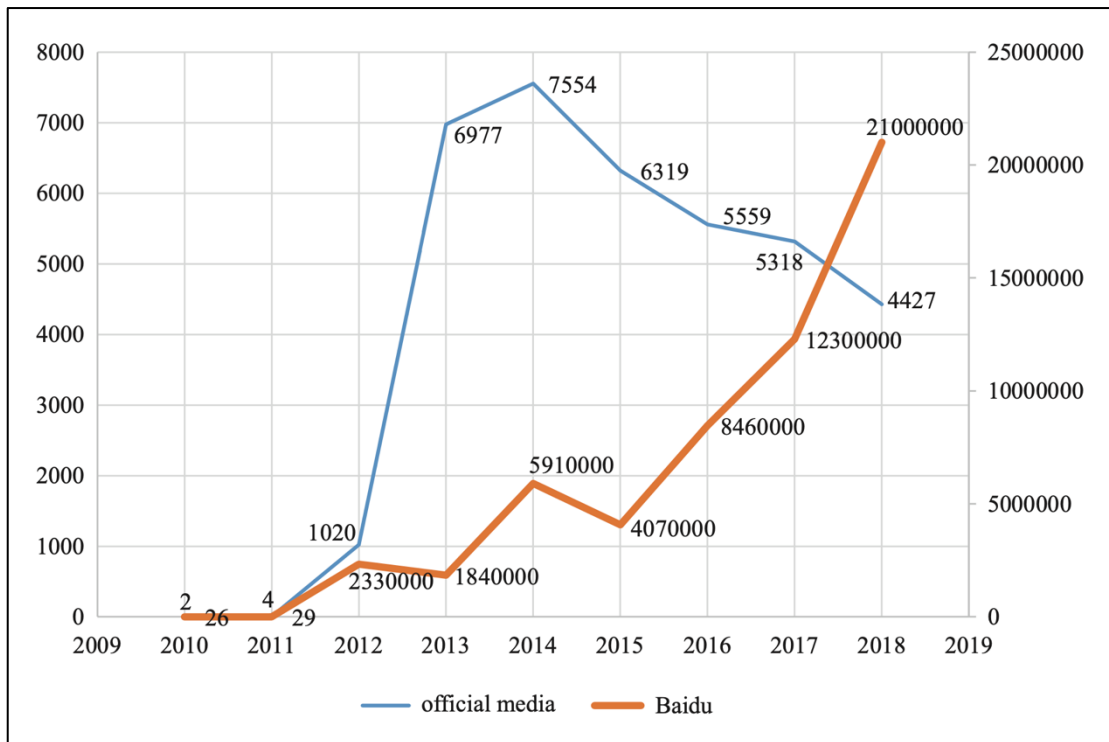


Figure 24 Occurrences of ‘Positive Energy’ on Baidu and the official Media in China

Source: Chen and Wang (2019)

7.2.2 Expanding Rationales and Inflating Optimism of Weather Modification

The Chinese government’s optimistic projection on weather modification is evident in the way it has portrayed the rationale behind it. In China, weather modification has often been depicted officially as a potential solution to specific problems. As discussed in Chapter 4, weather modification in Qinghai gained national attention during a severe drought in the Yellow River basin in 1997, as the weather modification experiments were seen as both a short-term fix and a long-term cure for the problem. At that time, cloud-seeding experiments in the upper-stream area came with hope only for resolving the drought, and weather modification was not yet a national policy that carried optimistic expectations.

However, in 2005, the Chinese State Council published Announcement Number 22, titled ‘A National Notification on Strengthening Weather Modification’, which specified the

importance of weather modification and provided guidance on cloud seeding. This marked the beginning of weather modification as an important national strategy. Since then, the State Council published two additional instructive announcements on weather modification in 2012 and 2020, each of which provides updated guidance on the operation's principles. In these three announcements, the State Council specified the rationale for conducting weather modification, which also demonstrated how the optimistic projection of solving problems through manipulating weather has evolved over time.

The government's intention to fabricate a hope from the air is evident in the ways in which those policy announcements optimistically depicted weather modification as a solution to certain social and environmental problems. Additionally, it is more vividly seen in the evolution and expansion of the rationales for weather modification (see Table 5). In the 2005 announcement, the focus was mainly on increasing benefits and mitigating hazards related to weather. The 2012 announcement expanded the goals of weather modification to include broader areas such as agriculture, environmental protection, and important social-political events. In the 2020 announcement—and the cloud cultivation plan published by the meteorology bureau in 2019—the rationales were further expanded and raised to a more abstract level, aiming to consolidate national strategic actions, promote modernisation, and increase security. This trajectory reveals that wider and more abstract scopes of expectations have been projected onto weather modification. Here, weather modification is not simply an intervention plan for the meteorological atmosphere but also becomes a symbol of optimistic expectations for the state's capability to achieve its goals and solve both ongoing and upcoming problems.

Table 5 The rationale of weather modification specified in the central policy guidance, 2005-2020.

2005 State Council Announcement No. 22	‘to increase meteorological benefit and to mitigate hazards’
2012 State Council Announcement No. 44	‘to serve for agriculture, to ease the drought, to mitigate hazards, to protect environment, and to secure important events’
2019 Cloud Cultivation Plan; 2020 State Council Announcement No. 47	‘to consolidate national strategic actions, to promote modernisation, and to increase security’

As the rationales for weather modification expanded, the process ceased to be just a meteorological promise that provided a techno-optimistic solution to weather and climate challenges. Instead, weather modification became a symbol of hope for long-term fortunes and success, where the ability to control and modify the weather was linked to the goal of building a greater nation. This optimistic projection is exemplified in an interview with Liu,²⁴ the head of the Central Meteorological Bureau, who interpreted the latest announcement in 2020 providing updated guidance and rationales for weather modification:

This announcement aims to support the national development goal of reaching an advanced level worldwide by 2035. [...] Our nation is currently at a critical strategic moment. In order to execute new ideas of progress and construct a

²⁴ The interview was published on the website of the meteorology bureau as well as the website of the State Council. The full content can be found at http://www.gov.cn/zhengce/2020-12/04/content_5566986.htm

new structure of growth for high-quality development, there is a new demand for weather modification. In the progress of rural development, weather modification is needed to support specialised and scaled-up industries in the new form of rural development. In the picture of ecological modernisation, measures like proactive cloud water development, water security protection, and environmental restoration all depend on weather modification. Weather modification also has prominent uses in preventing and mitigating hazards. The goal is to secure the victory of the socialist modern nation, serve major national strategies, and preserve the benefits of the people.

As demonstrated in the interview, weather modification was linked to a wide range of techno-nationalist strategic objectives, spanning rural development and environmental restoration to modernisation and the triumph of the socialist state. This optimistic outlook on weather modification can also be observed in the meteorological bureau's 2019 cloud cultivation document, a three-year action plan for weather modification. The plan explicitly outlined three primary goals for future weather modification efforts: to ensure the success of major national events, to advance modernisation, and to enhance overall security. Here, weather was no longer solely an object of government intervention. Through weather modification, the humanised weather was regarded as the tangible substrate of these grand national objectives. Weather modification evolved into a carrier of Chinese techno-nationalism (Kennedy, 2013; Plantin & De Seta, 2019; Poor, 2020), which brings hope from the air and carries promises of a better nation and governance.

7.2.3 Performing the Hopeful Weather

The modified weather functions not only as a carrier of optimistic projections about promises of governance but also serves as a means to demonstrate these promises and

hopes. In other words, the promise of weather modification as the hope from the air is both a conceptual and performative projection, which means that weather modification is conceptually linked to optimistic expectations and also is a way to perform hope. As Zhu (2011) has explained, the Chinese government has adopted a strategy of ‘performance legitimacy’ since the reform era, relying on demonstrated material achievements such as economic growth and social development to retain its legitimacy. Ding (2022) further notes that performance legitimacy need not be delivered only through actual material improvements but also can be demonstrated through theatrical performances of efforts and goodwill. This performative characteristic is a crucial aspect for understanding the affective politics of weather modification in China.

When it comes to weather modification, not all weather is created equal. In China, weather modification is sometimes used as part of an affective performance to construct nationalistic moments. To fabricate this ‘affective nationalism’, as Antonsich and Skey (2020) noted, is not just about weaving it into everydayness. There must be a certain spacetime, an event, where ‘more intense feelings and emotions are expressed and memorialised’ (p. 581). An event such as this is also the reason why Skey (2011) suggests the notion of ‘ecstatic nationalism’, as it is an ecstatic moment when the collective positive atmosphere emerges to celebrate or commemorate the nation (Closs Stephens, 2016). In China, weather modification is sometimes demonstrated in this ‘ecstatic’ and eventful way.

Although the rationale is to modify weather, the government does not intend to impose persistent control over the weather system. Instead, weather modification has deliberately been conducted at certain spacetimes as a way to perform hope from the air. Sometimes, weather modification has been conducted during droughts, wildfires, and incidents of

smog²⁵ to demonstrate efforts to combat these problems. A more prominent example of performative weather modification is the so-called ‘event blue’ during major events (see Figure 25). During national and international events—such as the national parade, APEC summit, and the Olympic Games—the Chinese government has conducted weather modification to guarantee a bright blue sky. By imposing temporary strict emission controls (Huang et al., 2015) and weather modification operations (McLeod et al., 2018; Nieuwenhuis, 2016), the blue sky was created not to address any specific social and environmental problems but to present a positive atmosphere. Here, the blue sky was modified not only as a meteorological atmosphere but also as an affective one. As the official media²⁶ reported, ‘the clear blue sky and puffs of white cloud brought joy and auspiciousness to the day.’

By modifying the weather during specific events and at particular times, the government enacted and performed the promise of a stronger nation. Although the modified weather such as the blue sky during political events may not directly solve any specific problems, the meteorological atmosphere was modulated to induce an optimistic affective atmosphere. Weather modification functioned as a way of exhibiting hope from the air—an optimistic projection of a better nation. That is, the affective politics of weather modification did not occur as the by-product of the manipulation of the meteorological atmosphere nor were they simply an optimistic agenda projected onto the weather modification technology by the government. The optimism demonstrated in policy rationales and the optimism performed through certain modified weather should not be

²⁵ For example, weather modification was reported to be conducted in Sichuan and Shanxi provinces in 2020 to manage forest wildfires and in Anhui province in 2018 to address smog.

²⁶ The quotation is cited from a report on the 60th national day ceremony in Beijing made by the official media Xinhua News in 2009. See http://www.gov.cn/jrzq/2009-10/02/content_1431899.htm

understood separately. For the Chinese government, weather modification was a way to modify the affective atmosphere by projecting and performing optimistic hope from the air.



Figure 25 Blue sky occurred during major events in Beijing

Source: Lu and Chan (2015)

In this section, my discussion on weather modification as an affective form of governance emphasises the government’s intention in shaping an affective atmosphere through controlling the weather. What I am suggesting is not that this form of governance seeks to manipulate people’s emotions through weather modification. Everyone has a different response to different weather conditions, and a blue sky does not necessarily evoke positive emotions. In other words, weather modification as a form of affective governance is not about shaping the weather to influence specific subjects’ emotional response. Rather, by modifying the meteorological conditions, this governance intends to create a hopeful and optimistic affective atmosphere. This atmosphere, as Anderson and Ash (2015, p. 45)

noted, should be seen as ‘affective propositions, unfinished lures to feeling a situation, site, person, or thing in a particular way that may come to condition life.’ Certainly, the affective propositions created by weather modification practices would be seen not only by the one who has been conditioned but also by the one doing the conditioning. In the following section, I shift the focus to the practices of weather modification and examine how optimistic affect is embedded in the operations.

7.3 Practising the Hope From the Air

In the previous section, I discussed how the Chinese government projected promises and hopes onto its weather modification policies. The next question is how this intention of projecting atmospheric optimism was connected to the practices of modifying the meteorological atmosphere. This examination into the practice dimension of hope from the air reveals the processes through which governmental intentions were materialised. Through these processes, the modified meteorological atmosphere (i.e., artificially enhanced rain) was coupled with optimism and formed hope in the air.

In this section, I discuss the topic from two aspects. To begin, I examine the individual aspect of the affective attachments that the weather modification practitioners made through their embodied experiences of weather modification. The discussion then focuses on the institutional aspect of how a form of techno-optimism was interwoven within the operational scheme of weather modification in China. By scrutinising these two aspects of practices, this section demonstrates how the modification of the meteorological atmosphere merges with the modulation of the affective atmosphere, forming the hope from the air.

7.3.1 Hopeful Meteorologists and the War Against Weather

Meteorologists do not work in a vacuum of affective atmosphere. Instead, they affectively attach to scientific objects, facilitators, other co-workers, and the atmosphere that they co-create (Fine, 2009). The way of being enveloped in the affective atmosphere influences scientific practices. Myers (2015) provides an excellent example of this. In her laboratory ethnography of protein modelers, she demonstrates that the affective labour of the scientists is inseparable from the cultivated skills and expertise that lead to success in scientific practices. In other words, affect is ontologically entangled with scientific practices and is a crucial aspect for understanding them. This implication applies to weather modification as well: Affect plays a pivotal role in weather modification practices and informs the way meteorologists perceive and evaluate their work.

However, two crucial differences exist between the protein modelers Myers discussed and the weather modification meteorologists in my study. Firstly, in Myers' example, the affective entanglement was demonstrated at the individual level, in which an individual protein modeler developed and attached affective labour to specific molecules, models, and machines. In comparison, unlike the protein modelers who worked with atomic-scale molecules in a laboratory setting, weather modification operates in the field and manages large-scale weather processes. As I indicated in Chapter 5, the intervention of weather processes requires the cooperation and spatiotemporal attunement among various groups of meteorologists. Therefore, the affective entanglement here is not at the individual level between any single meteorologist and their personal practice. Rather, it is more important to consider how the collective affective atmosphere emerges and intertwines with weather modification practices.

Secondly, weather modification practices reveal an opposite type of affective relationship between scientists and their work. For the protein modelers in Myers' study, affective labour evolved into a relationship of nurturing and caring for the models with which they worked. The success of the modelers was bound to the condition and 'happiness' (p. 50) of the protein molecules. In comparison, the success of a weather modification operation is not bound to the degree of maintaining the condition of the material processes but to the opposite: the degree of interruption. Instead of caring and nurturing, the affective relationship between meteorologists and weather features a strong sense of taming and conquering. For the meteorologists, weather modification is sensed as warfare against the atmosphere (Shapiro, 2001).

Here, the notion of warfare against the atmosphere is different from the common way of using the term 'atmospheric warfare' in literature (Shaw, 2016). The idea of atmospheric warfare is depicted in some literature as chemical interventions that create an inhospitable and unpleasant atmosphere for humans (Sloterdijk, 2009) and animals (Lorimer et al., 2019). Atmospheric warfare is also used by scholars to imply the deployment of aerial surveillance and violence—particularly with the rise of drone warfare in recent years (Shaw & Akhter, 2012). In these cases, atmospheres mediated conquering actions toward human enemies or nonhuman pests. In comparison, the 'atmospheric warfare' here in the case of weather modification does not imply conquering actions against other human and nonhuman subjects. Rather, weather modification is sensed by Chinese meteorologists as a war against the meteorological atmosphere with a warlike affective milieu.²⁷

²⁷ It is worthy to note that this 'atmospheric warfare' against the weather could still cause international conflicts over resources and geopolitical tensions and potentially lead to another form of 'atmospheric warfare' — a competition over atmospheric resources. For example, China's active cloud-seeding

The affective atmosphere of war and conquest surrounding the practice of weather modification was vividly recorded by Tai (1998), a participant in the early cloud-seeding experiment at the upper stream of the Yellow River in 1998, in his fieldwork diary. Tai's diary was different from other common forms of scientific records. He wrote not only about the team's scientific rationale and the technical difficulties they faced but also included rich content depicting his embodied and affective experiences during the experiment. In this diary, Tai portrayed an astonishing war-like experience during the experiment. He wrote the following:

Because of being exposed to strong UV light, every member was tanned on the face as if we had gone through a battle. Not even one battle. This day, a group of dark clouds was approaching us from the southwest at dusk. The radar indicated that it had huge rain potential, 60 dB of radar echo. Hence, nervous preparation work began. Radio communication alerted all the anti-aircraft guns to be ready. Gunners were all in their positions and loaded the guns with silver iodide shells. Radar observers closely monitored the movement of the cloud. Everything was set. 'Direction southwest. Angle 45 degrees. Distance 5000. Fire!' the commander announced. 'Boom! Boom! Boom!' With the sound of fire, the shells flew in and through the cloud. After a few seconds, a booming echo resonated from deep inside the cloud. It was the explosion of the timed gun shells that spread the silver iodide within the moist cloud. Within 10 minutes or so, a heavy rain came from the sky, a rain that could stop a big fire. Seeing rain

operations at the Tibetan plateau in recent years have triggered geopolitical tensions in South Asia and Southeast Asia (Kishimoto & Suzuki, 2021; Roy, 2018).

like this, every member was very happy and forgot all the nerves and fatigue of the work. This was my first time watching a weather modification operation in the field. The nervous scene, deafening sound, and sense of a real battle made me feel like I was participating in a real war. According to one of the members, this kind of operation is usual. No matter if it's day or night, they always need to operate as long as there are proper weather processes. Operators are always under the condition of being ready for a battle. Sometimes people are awakened from their beds in the middle of the night, driving cars to drag the guns to the field for operation, and coming back fully soaked. It feels like a real guerrilla warfare (Tai, 1998, p. 207).

In this paragraph, Tai depicted the operation as a battle and used loads of warfare analogies, not merely for rhetorical reasons. It reflected his perception of the warlike milieu and his embodied experience—tanned skin, booming sounds, and the tense and nerve-racking operation—that materialised the atmosphere. Under this warlike atmosphere, the erratic clouds became the enemy in a ‘guerrilla warfare’, and the meteorologists needed to be cautious and well prepared to be ‘ready for a battle’ all the time. After the fight, a dramatic rain from the sky became the prize of a dramatic victory. For Tai and other participants, the experiment was not *like* a war. It *was* a war against the clouds to win the rain.

Within this warlike atmosphere, there was a clear sense of taming and conquering the weather; it was not a coincidence. As discussed in Chapter 4, the weather modification experiment was first arranged as an emergent response to a severe drought that reduced the flow of the Yellow River. There was an inherent intention to fix the problematic weather, which resonated with the warlike atmosphere during the experiment. This sense of conquering was also rooted in an ideology of ‘people will conquer nature’ that arose in

communist China since Mao's era (Shapiro, 2001). Following the post-Mao reform, the ideology changed from a slogan of propaganda into an optimistic scientific belief with the trend of ecological modernisation (Mol, 2006; Muldavin, 2007; Yeh, 2009) that the progression of technologies can solve emerging environmental problems. This belief resonated with the warlike atmosphere in the weather modification operation. The meteorologists were not simply experimenting with scientific possibilities but also fighting against nature for a hopeful future. This optimistic belief was based on scientific rationality and on the affective atmosphere that emerged with the operations in the field.

The collective optimistic atmosphere and sense of conquering weather did not occur simply by adding up all participants' beliefs. For scientists, a belief cannot be reduced to something that occurs within a subject (Latour, 2010); the emergence of a belief must involve something outside the subject. As Myers (2015, p. 61) suggested, the belief for scientists 'is not a subjective affect or attitude that inheres in the scientist; rather, it is distributed among all elements of an experimental configuration.' In weather modification, for example, the operation Tai (1998) describe relied on equipment retrofitted and derived from military facilities such as cannons and rockets, as specified in Chapter 5. The cloud-seeding process, which involves shooting the catalysing chemicals into the clouds, further strengthened this sense of battle, as vividly depicted by Tai. The use of the equipment and the battle experiences it provided offered a warlike configuration that, along with the nature-taming ideology, created the warlike atmosphere (see Figure 26). Within this atmosphere, the success of the weather modification equates to a victory against nature. For the meteorologists, successfully inducing heavy rain became an achievement both rationally and affectively. The artificially induced rain not only manifested the success of the experimental operation but also a victory over the problematic weather. The pouring rain after the experiment was the reward of their victory against nature. For participants

such as Tai, the modified weather was affectively bound with the victorious milieu. Together, they created an optimistic atmosphere that reified the hope from the air.



Figure 26 Cloud seeding operated with former military devices such as the cannon and rocket launchers.

Source: Qinghai Weather Modification Office

7.3.2 Heuristic Experiments and the Institutional Optimism

Thus far, I have discussed how a hope from the air emerged from Chinese weather modification field operations, through which rainmaking actions became affectively attached to an optimistic perception of conquering nature. However, this hope from the air was reified not only as individuals' affective attachments through weather modification practices but also through an institutional root underlying the system of operation. In other words, the optimism regarding weather modification is both entangled with the field practices and integrated into the operational scheme. The aims of this section are to analyse the practice of hopeful weather from an institutional angle and to demonstrate how a techno-optimistic setting was integrated within the weather modification system in China. By revealing the intrinsic techno-optimism of the ecological weather modification scheme in Qinghai, this section demonstrates how weather modification in China institutionally created an optimistic atmosphere.

Techno-optimism refers to the belief that progress and the implementation of science and technology can lead to future benefit. While techno-optimism takes various forms in different issues and scenarios, Danaher (2022) argues that it must contain several key premises: of value that determines what is good and bad, of evaluation that determines how values can and should be evaluated, and of technology that indicates which scientific knowledge will ensure progress from bad to good. Danaher's analysis of techno-optimism provides a useful framework for examining the weather modification system in China. By discussing the value, evaluation, and technology premises of the weather modification system, this section demonstrates how techno-optimism is integrated within the cloud-seeding scheme.

The discussion begins by considering the premise of value in the weather modification system. As presented in Chapter 4, the systematic operation of weather modification in China started in the mid-2000s. Since then, this practice no longer involved only exploratory experiments for the official meteorologists but became their regular tasks. However, the termination of the experimental phase does not mean the weather modification operation is no longer experimental. As discussed in Chapter 5, the practice of modifying weather relies on meteorologists' embodied attunement with the spatiotemporal dynamics of atmosphere. In other words, although weather modification became a regular task for the meteorologists, each operation was not a replication of the previous one; indeed, it was a heuristic practice that required trial and adjustment.

Furthermore, the major rationale for implementing weather modification—to restore the degraded grassland in Qinghai—is also heuristic. Weather modification at the conservation areas was not arranged as a predetermined and precisely controlled factor in the ecological restoration effort. Rather, the seeded rain was more like a stimulant in the wild experiment

that could generate open-ended results (Lorimer & Driessen, 2014)²⁸. Here, in this system of heuristic weather modification practices, there is a premise that the existing environment is problematic and requires intervention. This provides the first foundation of the techno-optimism in the weather modification system, in which the atmospheric intervention must be better—or at least cannot be worse—than the current situation. Consequently, although the amount of rain was heuristically modified and the results were hardly anticipated, weather modification has been constantly operated. This is the value premise of the institutional optimism of weather modification: Doing something is better than doing nothing.

Under this optimistic premise, the meteorologists involved in ecological cloud seeding in Qinghai did not have a predetermined upper limit for their rain-enhancing operation. In the target areas of ecological restoration in Qinghai, cloud seeding would be implemented as long as there were suitable weather conditions. This leads to the second premise of techno-optimism regarding how to evaluate the actions and results. Due to the heuristic and open-ended nature and the value premise of the intervention, these ecologically aimed weather modification operations were not evaluated by the ecological influence they caused. Under the heuristic setting, there was no predetermined hypothesis to anticipate the causal effect of weather modification. Instead, cloud-seeding operations were evaluated based on the efforts of the actions. For the meteorologists in Qinghai, their weather modification tasks were evaluated by the number of operations and the effectiveness of each operation

²⁸ Lorimer and Driessen (2014) provided a useful conceptual comparison of two models of scientific experiments—experiments in laboratory science and wild experiments in field science. As they suggest, while laboratory experiments are ontologically and epistemologically about testing the hypothesis of transcendent orders of nature, wild experiments are deliberately designed to engage with the real world and to generate open-ended results surprises.

in terms of the amount of rain it induced. During an interview with a cloud-seeding officer in the Qinghai meteorology office, the meteorologist explained the effort-based evaluation system they faced:

We have an assigned annual target for the number of cloud-seeding operations. We need to try our best to reach the target. Otherwise, I will have to report to my manager explaining why I did not reach the goal. [...] However, I also cannot simply send an airplane [for cloud seeding] every time I see a potential precipitation process. I need to consider the effectiveness of the operation. If the operation did not create a significant precipitation effect, I will also be blamed (Interview, G10).

As the interviewee explained, their weather modification operations were evaluated based on the effort of the cloud-seeding actions, not the ecological results. This action-oriented evaluation can also be seen in the way the meteorology office presents its weather modification works to the public. In the annual report on weather modification, the meteorology office tends to emphasise the number of operations and the amount of rain it increased, rather than the ecological results. In 2017, for example, 15 aerial and 315 ground operations in Sanjiangyuan were estimated to have increased precipitation by 2.5 billion m³. In 2018, the number of aerial operations doubled. Under this evaluation method, the main focus was to demonstrate the effort that the meteorology office made in its weather modification operations.

In this weather modification scheme, the underlying premises that emphasise the efforts of active interventions create an optimistic essence in the system. On the one hand, these premises form an ontological optimism which assumes that, as long as people put effort

into modifying the weather and increasing the amount of rain, the ecological problem will improve. Although the weather modification scheme is based on a heuristic approach, it is also underpinned by an optimistic faith in the technology. Therefore, not intervening in the weather is not an option for the system. This systematic optimistic perception resonates with the affective attachment to the warfare against nature and Mao's ideology, which emphasises human efforts of intervention and focuses less on their results on nature (Shapiro, 2001). Although the heuristic essence makes the weather modification scheme not as human-deterministic as Mao's ideology, and it relies more on the wild environment to generate desired results, the scheme institutionally projects the same optimism on the efforts of human interventions.

On the other hand, since the cloud-seeding operations were evaluated mainly based on the effort involved instead of any specific ecological indicators,²⁹ it was nearly impossible for weather modification to fail. While meteorologists could face some methodological failures—such as miscalculating seeding doses and falling short of the annual target—their heuristic approach could not fail on the epistemic level. A positive environmental change will be interpreted as being contributed to by the modified weather. Even if there are few positive environmental changes or even negative changes after the operations, the results can be interpreted positively, such as the operations preventing the situation from worsening. Because of the effort-based evaluation, the weather modification scheme is indeed detached from the ecological goal it claimed to serve. This way of evaluation institutionalised a built-in optimism on intervening in the weather as a means of restoring

²⁹ Although positive environmental changes such as the increase in alpine water bodies and coverage of grassland were mentioned occasionally in the Meteorology Office's reports, they were not a structural part of the evaluation; rather, they were used to demonstrate the potential contributions of weather modification.

the degraded ecosystem.

Overall, in this section, I examine how optimism about weather modification emerged through the individual-level affective attachment of meteorologists to the practices and the institutional-level attachment to the techno-optimistic premises. Firstly, the affective connections of meteorologists in the field operation and their material configurations of the experiments enacted an optimistic perception resonating with the notion of conquering nature. Practising weather modification was like fighting a war against the weather, and the resulting rain became a symbol of victory that reified a hope for taming nature. Secondly, I highlight the fact that this optimism was intertwined not only with the experimental practices but also was rooted in the heuristic essence of the scheme. Within the scheme, the preference for intervention and the effort-based evaluation enabled an optimism about the operations that could fail only methodologically but not ontologically or epistemically. Together, both the weather modification practices as well as the system that arranges and evaluates the practices constituted an optimistic perception and hopeful affiliation to the modified weather. Through these practices, modified rain has become a material substrate of hope from the air.

7.4 Conclusion

7.4.1 A Techno-Optimistic Atmospheric Governance

In this chapter, I discuss the affective politics of weather modification in China, which addresses the final research question of this thesis. I argue that weather modification in China aims to intervene in the meteorological atmosphere and to modulate an affective atmosphere. On the policy side, the Chinese government's attempts to modify the weather

create an affective atmosphere that projects optimistic hopes onto the modulated weather. This attempt to project hope from the air is demonstrated in the expanding rationales of weather modification in policy announcements. As it carries nationalistic hopes, modifying the weather becomes a way to perform an optimistic outlook. In other words, the Chinese weather modification apparatus and practices govern life not only by informing physical atmospheric conditions but also by forming an optimistic affective atmosphere that consolidates governance. On the operational side, I demonstrate how meteorologists' affective experiences of operation are attached to a sense of conquering nature under a configuration that makes weather modification become a war against the weather. Furthermore, I demonstrate how a techno-optimistic setting, including particular ways of conceiving and evaluating the operation, inheres in the system of weather modification. Together, atmospheric governance is conducted by informing a techno-optimistic atmosphere that leads to both faith and belief in government-led scientific practices. In this optimistic atmosphere, the humanised weather becomes the material substrate of hope from the air.

This chapter makes contributions by addressing three conceptual contexts related to the atmosphere and politics of affect. Firstly, it provides an example of the intertwined relationships between the meteorological and affective atmosphere. This chapter demonstrates that attempts to modify the meteorological atmosphere are simultaneously manipulating the affective atmosphere. In contrast to Sloterdijk's (2009) concept of 'terror from the air', this chapter highlights the way in which atmospheric governance can also attach optimistic and hopeful affects to the meteorological. Secondly, this chapter speaks to studies about authoritarian governance in China, specifically those focused on the affective politics in China. It reveals that affective governance in China extends beyond promoting positive ideas to strengthening pro-government nationalist atmospheres (Chen

& Wang, 2019; Du, 2014). Finally, this chapter concludes the core argument of the thesis that weather modification in China demonstrates a new form of biopolitics through which the governance over life is conducted by modulating the atmosphere. While previous chapters have focused on the manipulation of the meteorological atmosphere, governance is by no means purely meteorological. This attempt of governing the affect was conducted not only through particular material configurations of the surroundings (Adey, 2008) but also through the optimistic settings embedded in the institutional arrangement of the practices. This chapter reveals that this new form of biopolitics also operates by modulating the affective atmosphere. The modification of the meteorological and affective atmospheres should not be understood separately, as they work together as one form of governance of life.

7.4.2 Rethinking the Weather Modification Optimism

While the techno-nationalistic projection may create an affective bond between weather-modification policy and the idea of a strong nation, this nationalism is always challenged by the heterogeneous experiences of various social groups. Chien (2019) stated that the 'blue sky' generated by the Beijing government's atmospheric control was not experienced equally by residents from different social classes. To enjoy the same blue sky, low-income residents living in underdeveloped outskirts areas suffered more from relevant restrictions. In Qinghai, this inequality was also explicit in the context of the ethnic politics of Tibetan residents (Yeh, 2013). During my fieldwork in rural Qinghai, where weather modification was regularly conducted, I noticed that many local Tibetan residents and herders were unaware of the operations. When I explained my research topic and the reason for my visit, they heard about weather modification for the first time. 'Was the recent rain caused by the government?' they would usually ask. There is a clear paradox here: Those who do not live in the modified weather are enveloped in the optimistic atmosphere brought by the

weather, while those who live within the weather are not enveloped in the same affective atmosphere.

Moreover, the techno-optimism underlying the heuristic weather-modification system is also worth scrutinising. One possible way to critique it is from a positivist perspective in which the heuristic operations could be seen as ungrounded and unrealistic. One example of this type of assessment of a bold and optimistic weather-modification experiment was presented in Chapter 6, where I discussed the dispute between hydrologists and meteorologists. A positivist would argue that the heuristic approach was based on arbitrary choices instead of well-developed hypotheses. For weather modification, this means that the amount of rain enhanced will not be based on a theoretically predicted and optimized number. Rather, the rain was heuristically enhanced, and the overall effects were open-ended. This makes the results relatively unaccountable, as the causal effects were often undetermined. However, this method of critiquing fails to capture the essence of the wild experiment in which open-ended and surprising results were at the centre of its epistemology. The complexity of the atmosphere and ecosystem, with the huge numbers of nonhuman elements and actants involved, makes it extremely difficult, if not impossible, to implement a positivist way of action and to determine clear accountability for all decisions. Actions such as weather modification and geoengineering must, to some extent, be heuristic.

The problem with weather-modification optimism is not that it was enacted and implemented heuristically, but rather that the way in which heuristic operations were organized could impede other actions required to address the original issue. As Berlant's (2011) notion of 'cruel optimism' describes, this could become an optimism that attaches to 'compromised conditions of possibility whose realization is [...] impossible' (p. 24), and

the weather-modification optimism would be a cruel one if it creates a mere fantasy that meteorological technology and atmospheric intervention can provide an ultimate solution. While asserting that the weather modification optimism in China has impeded other measures necessary for addressing environmental issues would require additional data beyond the scope of this research, there is a clear trend that weather modification is being used more widely. As weather modification becomes more commonly included in various national strategic plans,³⁰ carrying optimistic projections of its impacts, it could become an easy solution for heuristically tackling various problems, which limits the possibility for other necessary measures to be taken.

³⁰ In 2019, the China Meteorological Administration published a document known as the ‘cloud cultivation action plan’ which provided guidance for the development of weather modification in the following year. The plan explained a wide range of strategic goals in which weather modification can play a role, including rural development, hazard mitigation, international cooperation, and other more abstract targets such as modernization and national security.

Chapter 8

Conclusions

The concept of the Anthropocene marks the nonnegligible traces that human beings left in the planetary Earth systems. Meanwhile, tackling the consequences of these anthropogenic influences to planetary systems, especially the atmosphere, also became one of the main themes in the current international political agenda. While the mainstream climate actions focus on measures that mitigate the warming effect to the atmosphere, various forms of proactive interventions, including geoengineering and weather modification, have increasingly attracted greater attention. Geoengineering became a trendy idea that was discussed and experimented by scientists around the globe, and weather modification became a technology that was widely implemented in many countries including the United Arab Emirates, Saudi Arabia, Malaysia, Indonesia, and, most notably, China. This proliferation of proactive atmospheric interventions highlights a research topic which is yet to be fully scrutinised and establishes the starting point of this thesis.

How should we understand the atmospheric interventions as a new form of governance?

In this final chapter, I revisit this thesis' main theme of atmospheric governance and the insights gained from the empirical study of weather modification practices in China. Firstly, I summarise the analyses and arguments made in each chapter and examine how these discussions addressed my four research questions. Secondly, I return to the discussion I opened in Chapter 1 about the scalar and empirical gap in the existing studies on the politics of proactive atmospheric intervention. I bring together the insights gained in the preceding chapters and identify the theoretical contributions of the thesis that address the existing debates around the governance of geoengineering, climate, and the atmosphere. Together, this content forms a comprehensive perspective that this thesis presents to understand the atmospheric governance. Finally, I offer some reflections on the implications and relevant aspects that exceed the scope of this study, and suggest some directions for future research.

8.1 Summary: Research Questions and Analysis

The core concern of this thesis is to understand a rising form of atmospheric governance, in which the atmosphere is no longer considered to be a mere background condition but, rather, a means of governance. In Chapter 1, I introduce this topic by discussing various forms of 'proactive atmospheric interventions', including geoengineering and weather modification, and how these interventions have become significant aspects that cannot be ignored when facing climate change issues. However, while many researchers have focused on these technologies and their political implications, I identified two gaps in the existing literature. The first is a scale gap, with most studies approaching the politics of atmospheric

interventions with an emphasis on the planetary or international scale, overlooking how a sovereign state and its unique political characteristics can profoundly inform atmospheric governance. The second is an empirical gap, with most atmospheric intervention studies lacking sufficient empirical data to delve into the practical aspect of the topic, as the majority of the geoengineering projects are still in the simulation and experimentation stage. To address these gaps, this thesis suggests studying China's weather modification practices to further explore the topic of atmospheric governance, through which manipulating the weather has become a means of governing life. In this thesis, the discussion of this topic was further developed into four sets of research questions:

- (1) How did weather modification become a new form of governance which governs life through manipulating the atmosphere in China?
- (2) How is weather modification informed by the practices of meteorologists?
- (3) How do scientists understand the volumetric characteristics of weather modification, and how do different epistemic understandings of volume affect weather modification?
- (4) How does the modification of the meteorological atmosphere in China also work as a way to govern the affective atmosphere, and what forms of affective politics are enacted through weather modification?

To prepare conceptual tools for answering these research questions, in Chapter 2 I brought together existing research around the topics and presented a four-section framework for reviewing the literature (see Figure 2). Each of these sections addresses a part of the research questions and corresponds to subsequent analytical chapters. Firstly, I reviewed the discussions on the environment mode of biopower, a topic that was first raised by Foucault (2008) in his consideration of biopolitical governance and explored by later scholars particularly in the context of the Anthropocene (Braun, 2014; Sloterdijk, 2009).

Drawing on the concept of ‘environmentality’ (Anderson, 2012; Gabrys, 2014), I argued that China’s weather modification practices should be regarded as an atmospheric environmentality, namely a form of governance that is conducted through manipulating the atmosphere. I then identified three crucial theoretical aspects, namely *embodiment*, *volume*, and *affect*, which inform the characteristics of atmospheric governance and answer the second, third, and fourth research questions. Reviewing the embodiment of weather, I showed that embodied experiences not only shape our experiences and perceptions of weather (Ingold, 2010; Martin, 2011) but also inform the meteorological practices (Fine, 2009; Matson, 2017; McCormack, 2018). This provides the tools for discussing the embodiment of weather modification practices in Chapter 5. Then, I reviewed the discussions of various ways of understanding volume and the volumetric properties of the atmosphere and atmospheric materiality. Engaging with these epistemic debates is useful for identifying the volumetric characteristics of atmospheric governance and for examining how epistemic differences inform weather modification practices (Chapter 6). Finally, I reviewed the literature on the affective aspect of atmosphere as well as the studies of affective governance, particularly in the Chinese context. By bringing together these two groups of literature, I am able to expand the discussion in Chapter 7 of how weather modification in China is not merely a governance of the meteorological atmosphere but also the affective atmosphere. Together, these literature reviews constitute the conceptual framework for examining atmospheric governance in subsequent chapters.

The first research question was discussed in Chapter 4, in which I answered the empirical question of how weather modification in China is linked to ecological goals. I examined the historical trajectory of weather modification in Qinghai and how it was used to achieve various ecological goals, which I referred to as different modes of atmospheric environmentality. Through the historical review, three different modes of relationships and

temporalities between meteorology and ecology were identified. The first mode of the governance—that is, the emergency fix—involved using weather modification as an emergent solution to the present natural disaster. The second mode, the tool for restoration, used weather modification to restore certain ecosystem service to a baseline level in the past. The third mode worked as a weather infrastructure that modified the weather to create or maintain favourable ecological conditions. Chapter 4 contributes to the ongoing scholarly discussion surrounding the idea of environmentality by expanding the concept to include various modes with different goals, temporalities, and politics. This distinction urges a conceptual focus on different temporalities when considering the practice and politics of proactive atmospheric interventions such as geoengineering and weather modification. This conceptual exploration of weather modification as a form of atmospheric governance was further developed in Chapters 5, 6, and 7, in which I discussed the embodied, volumetric, and affective aspects of the governance to address the second, third, and fourth research questions.

In Chapter 5, I discussed the embodiment of atmospheric governance by exploring how the palpability of weather emerged to the meteorologists involved in cloud-seeding practices. I suggested that weather became palpable to the meteorologists through the embodied arrangement of their work and life, which involved a weather-modifying choreography that enabled them to attune with the weather. To illustrate this point, I discussed weather modification practices in Qinghai and highlighted how meteorologists' operations were intertwined with the ways in which they spatially and temporally arranged their bodies and devices. Spatially, I demonstrated that the settlement, movement, and distance of meteorologists' bodies and devices critically affected their ability to modify the weather. Temporally, I indicated how meteorologists and their weather modification practices needed to attune with various natural and social rhythms, including temporalities

of the past, present, and future. In other words, a specific way of choreographing weather modification practices made the weather (non)palpable in a certain way. This discussion of the embodiment of weather modification practices in Chapter 5 addressed the second research question. Additionally, it also contributed to the studies of atmospheric intervention by highlighting that embodiment was a crucial aspect for understanding these practices, as various ways of choreographing actions led to different forms of atmospheric governance.

In Chapter 6, I discussed the epistemic politics of weather modification to address the thesis's third research question and to engage with recent academic discussions of volume and volumetric materiality. I examined how hydrologists involved in the Sky River Project conceptualised the volumetric properties of atmospheric water and compared it to a typical meteorological perspective. By analysing the two perspectives, this chapter demonstrated their ontological difference in seeing volume and their epistemological difference in their resource-making processes. On one hand, an aerial perspective understands volume as vertical spacetime that contains substances. Under this perspective, the atmospheric water resource implies the quantity of water molecules contained by the aerial space in a particular period of time. On the other hand, a terrestrial perspective tends to see volume as a suspended state that involves reciprocal connections to the land and the potential of becoming terrestrial. In this sense, atmospheric water is understood and evaluated as a resource in terms of the long-term tendency of the terrestrial-bounded transition. Furthermore, this chapter explained that epistemic differences affect the ways in which atmospheric water is conceptualised as a resource and also influence how it can be utilised and managed, leading to different geopolitical implications. This chapter's exploration of the epistemic politics addresses not only the core aim of the thesis to understand weather modification as a form of atmospheric governance but also

contributes to broader academic discussions on volumetric materiality and resource-making processes.

In Chapter 7, I tackled the final research question that explores the affective dimension of atmospheric governance. I argue that weather modification in China has been associated with techno-optimistic projections that convert rain into hope from the sky, which consolidates the legitimacy of the Chinese government's governance. The empirical analysis begins by examining how the Chinese government projects nationalistic ideals onto the modulated weather, which then becomes a carrier of optimism and nationalistic hope. This fabrication of weather modification as a hope from the air works as both an ideological conception and a material performance at some eventful nationalistic moments. In addition to this fabrication of optimistic projections on weather modification, affective governance is enacted through the practices of modifying weather. I point out that the techno-optimism is intertwined with weather modification practices due to meteorologists' attachment to a sense of conquering nature during the operation and the techno-optimistic settings inherent in institutional configurations. By examining how weather modification in China also functions as affective governance, this chapter aligns with recent scholarly works that highlight the inseparable connection between the meteorological and affective dimensions of the atmosphere. As I have argued throughout this thesis, weather modification in China has become a means for governing life by shaping both the meteorological and affective atmospheres.

Taken together, these chapters answer my core research question: How does weather modification in China become a form of biopolitical governance? In contrast to the mainstream perspective discussed in Chapter 1, I provide a novel conceptual framework that offers a way to understand proactive atmospheric intervention. Firstly, I argue that

atmospheric interventions of this kind cannot be seen simply as a scientific practice but should be regarded as an emerging form of biopolitical governance, an environmentality, that works through manipulating the environment, as suggested by many scholars (Anderson, 2012; Braun, 2014; Gabrys, 2014). Based on this notion, I further contribute to the idea of environmentality by suggesting a consideration of temporality that is inherent in this form of governance and is especially crucial when discussing atmospheric and climate issues. As discussed in Chapter 4, the operation of atmospheric environmentality involves various temporalities: Some might aim to restore a past state, while others might focus on constructing infrastructural conditions for future survival. Some important biopolitical and ontopolitical implications of atmospheric environmentality lie beneath the processes of constructing and emphasising these different temporalities. Such politics that intertwine various temporalities are an inevitable topic for discussing proactive atmospheric interventions, such as geoengineering, which involve setting past-referenced benchmarks and future-envisaging projections.

Moreover, my framework highlights three essential but often overlooked aspects in discussions of proactive atmospheric intervention, particularly geoengineering. Firstly, I explain that it is crucial to consider the aspect of embodiment in atmospheric intervention. My suggestion about seeing weather modification practices as a choreography, which involves a specific spatiotemporal configuration of bodies and devices, is not just an opposition to the disembodied perspective on scientific practices, as many STS studies have repeatedly emphasised. Instead, I aim to point out that it is through these different choreographies that the atmosphere becomes palpable and modifiable to humans in specific ways. As these processes necessarily involve how people attune to the nonlinear and complex atmospheric dynamics, this atmospheric governance is not only biopolitical but also ontopolitical (Chandler, 2018). Secondly, I emphasise that atmospheric

governance does not equate simply to aerial governance but could also be a terrestrial one. This terrestrial aspect of atmospheric governance involves the material necessity of ground-based facilities (Adey, 2010) and is embedded in the epistemological level as well. As demonstrated in Chapter 6, various ways of conceptualising the volume and volumetric properties of atmospheric water lead to different governance implications. Finally, I highlight the essential affective dimension of atmospheric governance. The emphasis on the affective aspect is not designed to indicate a rhetorical symmetry between the two meanings of atmosphere. Instead, the inseparability of the meteorological and affective aspects of atmospheric governance is evident in how one mutually affects the other. While modified weather carries loads of affective projections, the affective milieu and conditions also inform the way in which weather is manipulated under governance. This is important to consider, as many atmospheric intervention projects, such as different forms of geoengineering, are framed as hopeful solutions to the climate problem.

8.2 Reimagining Proactive Atmospheric Intervention

8.2.1 Revisiting the Climate Leviathan and the Two Theoretical Gaps

Thus far, I have addressed all of the research questions regarding weather modification in China and have explained how it constitutes a form of atmospheric governance, which involves both the manipulation of the meteorological atmosphere as well as the embodied, epistemic, and affective aspects. These analyses and research findings offer a comprehensive examination of the weather modification practices in China and the conceptual framework provided in this thesis establishes an understanding proactive atmospheric interventions. Now, it is time to circle back to Chapter 1 to address the starting point of the theoretical inquiry of this research—the two conceptual gaps in the study of

proactive atmospheric intervention.

The first gap I identify in Chapter 1 is the scalar gap, which refers to the tendency in existing literature to focus on the politics of atmospheric intervention on the transnational scale and to overlook the importance of a sovereign state. This neglect may occur on the empirical level, as researchers often focus on how transnational decision-making and regulatory mechanisms might arise, rather than on how particular forms of atmospheric intervention might take form in different countries and regimes. The gap also exists on the theoretical level, as the theorisation of climate governance tends to be associated with the consideration of transnational sovereignties, which Wainwright and Mann (2013) refer to as the planetary climate Leviathan. However, as demonstrated in this thesis, the government of a sovereign state, such as China, plays an important role in informing atmospheric intervention (see also Bodansky, 2013). Many aspects of atmospheric governance are indeed embedded within the particular institutional arrangements and political regime of a sovereign state. In other words, what is needed is a way to conceptualise the climate Leviathan that considers the role of the state and its specific regime.

The second gap I identify is the lack of appropriate empirical cases that allow for a study of atmospheric interventions such as geoengineering. Most of the discussions on the politics of geoengineering have focused on a procedural perspective, which mainly related to decision-making and regulatory processes (Barrett, 2008). Because most geoengineering programs are still in the preliminary stage of modelling and simulation, they provide limited empirical data and experiences for researchers to engage in more complex discussions and to develop a comprehensive understanding of the politics of practices. Drawing on insights from the analysis of weather modification, this thesis contributes to

filling this gap by providing a more comprehensive perspective for considering the politics of geoengineering, which highlights the importance of embodied, epistemic, and affective aspects.

In other words, these two gaps have led to a common perception of the climate Leviathan and its governance and intervention in the atmosphere as a planetary sovereignty that has the power to arrange and operate scientific practices to alter the meteorological materiality in the aerial space. Drawing on insights from previous chapters in this thesis, however, I propose alternative imaginations of the climate Leviathan. It should be viewed as embedded within a specific political regime of a sovereign state and deeply informed by the ways in which various bodies, devices, thoughts, and affects are fabricated together. In the following sections, I present two theoretical propositions to address gaps in the knowledge regarding geoengineering, provide an alternative conceptualisation of the climate Leviathan, and suggest possible directions for further studies.

8.2.2 Exploring the Atmospheric Governing State

The governance of atmospheric interventions, particularly with regard to practices such as weather modification and geoengineering, necessitates consideration of the national scale. This is because atmospheric interventions cannot be extracted from the political environment in which they are developed. As Bodansky (2013, p. 540) explained, such proactive interventions can be implemented independently and thus have an ‘additional allure’ for sovereign states, particularly authoritarian regimes (Victor, 2008). This tendency for authoritarian regimes to lean towards atmospheric interventions is attributed, in part, to the limited checks and balances within their political systems. Moreover, atmospheric intervention can be used by an authoritarian regime as a strategy to cope with various environmental crises to maintain and consolidate political legitimacy, as discussed in

Chapter 4. Meanwhile, the proactive nature of atmospheric intervention technologies tends to align with techno-optimistic ideology and affective projections of the state (Chapters 6 and 7).

In essence, a key reflection of reimagining the climate Leviathan is the need to acknowledge the diverse scalar politics within various types of climate actions. Although the transboundary nature of the atmosphere and climate may suggest the importance of international collaborations (Blackstock & Long, 2010; Humphreys, 2011) or a planetary sovereignty (Wainwright & Mann, 2013, 2018), both empirical and theoretical examinations of the role of a sovereign state remain important (Abraham, 2020). The significance of the analytical scale of a nation in the context of atmospheric intervention is pronounced, as this thesis has revealed. An interesting question for future research is the inquiry into the implementation of atmospheric interventions—namely weather modification and potentially geoengineering—in political systems other than China, such as Indonesia and the UAE. Exploring these questions could reveal how atmospheric interventions are operationalised differently under various political regimes and how they contribute to a more diverse understanding of the climate Leviathan.

The scalar reflection emphasises not only the importance of understanding atmospheric intervention at the national level but also offers a framework for rethinking the nature of state governance. By analysing the relationship between the state and atmospheric governance, one can see how specific political systems manage the complex and nonlinear materiality of the atmosphere. This provides an analytical perspective for examining the biopolitical and ontopolitical characteristics of governance. For example, in addition to the aspects of temporality and volume of atmospheric governance discussed in this thesis (see Chapters 4 and 6), a potential topic for research under this rationale is to consider how

certain ways of conceiving uncertainty and risk are associated with atmospheric interventions. Compelling questions that can be explored under different political systems include how uncertainty and risk are understood and addressed, and which types of uncertainty are emphasised or ignored. These different perceptions of uncertainty and risk would inform the way in which atmospheric interventions are governed and offer a sense of understanding of the biopolitical and ontopolitical characteristics of that particular form of governance.

Finally, this notion of an atmospheric-governing state resonates with recent reflections in political geography on the volumetric aspects of geopolitics (Adey et al., 2013; Elden, 2013; Garrett & Anderson, 2018). The emergence of this atmospheric governing state implies that geopolitical tensions are inevitably volumetric. As discussed in Chapter 6, the volumetric properties involved in atmospheric intervention are not merely about considering the geometry of aerial space, but also about how the aerial and the terrestrial were associated in particular ways. The adoption of volumetric discourses by certain political regimes would lead to distinct strategies of geopolitical practices. In other words, for the atmospheric governing state, the geopolitical tensions would be informed a material competition over the volumetric space and resources as well as by an epistemic contest over the interpretations of volume and the volumetric.

8.2.3 Variegated Choreographies of Geoengineering

As stated in Chapter 1, one aim of this thesis is to provide an empirical examination of weather modification that serves as a conceptual proxy for understanding geoengineering. In doing so, this thesis offers an analytical framework opposing the mainstream perspective of geoengineering, which is often viewed as a disembodied scientific practice regarding the aerial space. Conversely, as presented in Chapters 5 and 7, the implementation of

atmospheric intervention involves various embodiments and affective aspects. In other words, when one contemplates geoengineering, it should not be seen as a singular technology (Stilgoe, 2015); instead, a focus should be placed on how different bodies, devices, and affects are configured. Geoengineering, then, should be seen as an open proposition that has variegated forms involving different ways of choreographing the practices.

One way to explore this multiplicity is to follow the exploration of weather modification presented in this thesis. For example, when considering various geoengineering methods, one can consider how the palpability of Earth's atmosphere is disclosed in different ways in the practice. Additionally, how do people in the practices attune with the spatiotemporal rhythms and elemental materiality of the Earth's atmosphere? Another example would be to examine how certain affective projections for the future are interwoven into different geoengineering proposals and promises. Raising these questions opens the inquiry of the potential variegated forms of geoengineering practices and highlights directions for future research.

Lastly, a focus on the multiplicity of geoengineering also questions the dichotomy between geoengineering and behavioural change in terms of responding to the climate crisis. The common ways of contemplating geoengineering, whether it is viewed as a saviour technology for reversing climate change or as an alternative strategy after mitigation efforts fail, tend to view geoengineering as something outside of the everyday life. However, as this thesis demonstrates, the practices of various forms of atmospheric intervention must be embedded in specific ways of life. Furthermore, as Buck (2019) noted, 'the hard thing isn't beginning the [geoengineering] project, but ending it: ensuring that what comes after engineering is livable' (p. 27). Climate governance would not end with the implementation

of geoengineering. As Buck suggests, how life should be arranged in this post-geoengineering climate is an aspect that cannot be ignored. To some extent, the everyday lives of human beings that create various impacts on in the atmosphere can also be seen as a form of atmospheric-intervening choreography, a sort of unintentional geoengineering. Seeing the embodiment and affective aspects is a reminder that geoengineering is not something outside of life. As the Gaia theory suggests (Lovelock & Margulis, 1974), life is engineering the geo while also being engineered by the geo.

8.3 Final Remarks

A significant limitation of this study, as I mentioned in Section 3.3.2, is that I failed to involve the voices of the Tibetan residents in my discussion and analysis of weather modification in Qinghai. Although some questions about the ethnic politics in Qinghai were included in my original research plan, the examination and discussion of these questions were eventually constrained by the difficulty of data collection and the potential ethical risks, which were discussed in Chapter 3. This creates a paradox. While most of this thesis focuses on how weather modification works in Qinghai, it fails to address how the local residents, especially herders and their herds, experience and respond to it. The absence of this perspective is not simply a lack of empirical material; it also means that this research lost a potentially powerful angle for critiquing atmospheric governance. However, although I do not have sufficient data to develop a comprehensive discussion on the aspect, I would like to briefly mention my notion of this ethnic issue to offer a glimpse of some possibilities to which it could lead.

This reflection began with an observation I made in the field. In my limited interactions

with local residents, I was surprised to learn that most of them were unaware of the government's weather modification activities, despite the fact that they had been living in this modulated weather for a long time. Even if the local residents knew about the cloud-seeding operations, they tended to have different affective attachments to the modulated rain. Unlike the meteorologists, the herders did not feel victorious about the successful weather-modifying operations, and the human-induced rain might not bring them hope from the air. For example, in an investigative report from IFENG, a Hong Kong media, the reporter interviewed the major of Madoi, a county in Qinghai's Tibetan autonomous prefecture, about their experiences on weather modification:

In short, herders used yak dung for heating. If it rains too much, the dung will not dry and we have nothing to burn. Besides, it is colder in the rainy days. Here in Madoi we only have a few warm months in a year. [...] Grass could not grow well if the temperature is too low. [...] Herders prefer to have rain at the night and sunlight during the day. Now, it rains in the daytime—weather modification. Most of the residents that I have visited felt that although it is good to have more rain water, it was just too cold (IFENG, 2008).

Meanwhile, for the Tibetan herders, cultural differences could also influence the way in which they perceive weather modification and the problems the operations aim to correct. For example, during my fieldwork in Yushu, another Tibetan autonomous prefecture in Qinghai, I met an NGO representative who has been working with local herders to investigate their perception of climate change. Her investigation revealed that some of the local people tend to see the change as 'natural' due to their traditional legend. In the legend, the environment would become drier due to 'the shrinking distance between the sun and

the earth'. Under this cosmology³¹, drier weather is an inevitable natural result rather than an anthropogenic problem, and weather modification is not a technology that brings hope.

For Tibetan herders, this affective difference stems not only from their cultural traditions but also from their attachments to their herds. The herders did not experience the weather alone as human beings; their herds of yaks and sheep are also enveloped in the modified weather and can be seen as animal subjects that can sense the affective intensities (Lorimer et al., 2019). These embodied affective experiences of these animals can then be sensed by the herders who were affected through 'embodied empathy' with the animals (Despret, 2013; see also Lorimer, 2008).

An anecdote among the herders I heard during my fieldwork in Yushu provides a glimpse of this bonded affective relationship. When discussing weather modification and its aim to restore the grassland, a herder suggested that more grass would not necessarily make their herds 'happier'. Instead, he reckoned, his herds were in favour of a particular type of grass, and 'just licking a short blade of the grass would make them happier than eating another type of grass.' In this sense, even if the weather modification policy achieves its goal to restore the grassland landscape, it does not mean that the herders and their livestock would feel more hopeful or happier.

Certainly, these alternative narratives have yet to form a structural critique of the official weather modification policy. The notion of heterogeneity in experiences and perceptions is a reminder that the official techno-optimistic and nationalistic narratives of weather

³¹ It is important to note that this particular cosmology was orally reported in the Yushu region during my fieldwork and could not be understood to be a general view in the traditional Tibetan cosmology.

modification are centred around Han Chinese. However, it is still possible, and even necessary, to envision some more-than-Han perspectives in the reflexion of anthropocentric techno-nationalism in future research.

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