An analysis of ways to decarbonize conference travel after COVID-19

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Citation: Klöwer, M., Hopkins, D., Higham, J.E.S. & Allen, M. (2020). An analysis of ways to decarbonize conference travel after COVID-19, Nature, 583, 356-360. Available at: https://www.nature.com/articles/d41586-020-02057-2

Many academics are frequent flyers. Travel occurs for a variety of reasons: to attend conferences and board meetings, to conduct fieldwork, to visit collaborators, to give seminars and lectures. This often results in multiple long-haul flights per year and thousands of air miles.

We are acutely aware of the negative impacts associated with travel. The transport sector as a whole accounts for 24% of annual global emissions of carbon dioxide. Aviation is responsible for about 3%, road transport 18%, and rail less than 1% (1). The vast majority of flights are taken by a small minority of frequent flyers. In the UK, 15% of the population is responsible for 70% of the flights (2). The number of flights is closely coupled with household incomes, such that there are clear inequalities in who travels by air (3).

Academics are part of this hypermobile lifestyle. The total travel associated with attending one large academic conference can release as much carbon dioxide as an entire city. Take the American Geophysical Union's (AGU) Fall Meeting, held in San Francisco last December. We estimate its 28,000 delegates journeyed 285 million kilometres there and back — almost twice the distance between Earth and the Sun. In doing so, they emitted the equivalent of about 80,000 tonnes of CO_2 (about 3 tonnes per scientist) or the average weekly emissions of Edinburgh in Scotland (4). Other large conferences will have similarly large carbon footprints.

What can be done?

The COVID-19 pandemic has forced us to rethink what constitutes 'necessary travel'. Many of this year's conferences have been cancelled. Some have gone virtual. For example, in May the annual meeting of the European Geosciences Union (EGU), the largest European meeting of geoscientists with typically 16,000 attendees, ran its sessions and panels online. There was an upside — attendance rose to 26,000. Some climate or sustainability conferences have long done so, including the Virtual Island Summit or Virtual Blue COP25.

What happens if/when *normal* lifestyles resume? We acknowledge that for some academics occasional face-to-face interactions are likely to remain important for instance, to facilitate networking. But several steps, such as holding a conference biennially in accessible locations and increasing virtual presentations, can reduce a conference's travel emissions by 90%.

Long-haul aviation

To learn more about transport emissions from major conferences we analysed the travel patterns of delegates to the 2019 American Geophysical Union (AGU) Fall Meeting. Held most years in San Francisco, it is the largest annual global conference in the geosciences. We located the affiliations of all 24,008 presenters of talks and posters at the conference and estimated how far each travelled from their home institution, and we scaled the result up for all 28,000 attendees.

We assumed a typical mode of transport for each attendee, depending on the distance they travelled to San Francisco. Around 92% travelled more than 400km and were assumed to have flown. A car, bus or train journey was assumed for the remaining 8%.

We assigned average emissions rates to each transport type. Car, bus and train journeys were averaged into a single emission category, as their respective share among attendees is unknown. Flights produce 3-5 times more emissions per kilometre per person than overland transport. These emission factors take into account the average fuel consumption, fuel weight, deviations from the shortest distance, the number of passengers per vehicle, and indirect CO_2 effects caused by airplanes emitting at high altitudes (see SI for details, including the sensitivity to our assumptions).

Intercontinental flights are the main source of emissions: one return flight between Hong Kong and San Francisco releases more CO_2 than an average British person's activities over an entire year, or the equivalent of 10 people living in Ghana.

75% of AGU 2019 emissions were generated by intercontinental flights of greater than 8,000km (Fig. S1), produced by 36% of the attendees (about 10,000 participants) attending from outside North America. The highest-emitting 17%, about 5,000 participants, account for 39% of emissions (Fig. S2). These travelled farthest — mostly from India, Australia, Taiwan and China.

By contrast, only 2% of AGU 2019 emissions were caused by 22% of delegates who took flights under 1,500 km (Fig. S1). Changing mode would therefore make little difference to total emissions. Even if all 22% were to use trains, buses or carpools instead of planes, it would reduce total emissions by only 1%. Similarly, even for regional conferences that can be accessed via a well-connected rail network, such as the EGU held each year in Vienna, a switch from plane to train reduces emissions by 10% at most (Fig. S3).
We also assessed the impact on emissions of moving the AGU Fall Meeting to a different city in the US. Holding the conference in the middle of the country, rather than on one coast or the other, would reduce travel emissions. Chicago emerged as an optimum location, saving 12.3% in emissions (Fig. S4). Hawaii, by contrast, would increase emissions by 42% as virtually everyone would need to fly more than 4,000km to attend.

Conferences reimagined

The following 3 measures reduce travel emissions associated with international conferences.

1. Choose accessible venues. Future conference locations should be selected, in part, to minimize transport emissions. Decisions could be informed by modeling delegates' journeys, as we did. As air travel would still be necessary for delegates to attend, virtual attendance should be considered over long-haul trips whenever possible. Low carbon alternatives to air travel, such as train, bus or carpools should be encouraged for those who are able to do so and for regional meetings.

2. Increase virtual attendance. Virtual conferences should do more than replicate an in-person conference online. Text-based online forums allow discussions to continue for days or weeks in any time zone and increase the participation over in-person question and answer sessions. Virtual content should be archived and made open-access to increase outreach. Lowered fees will boost virtual attendance. For example, the EGU's virtual meeting in May was free to attend and attracted 60% more attendees than last year's in-person conference.

3. Become biennial. Some major conferences such as the Ocean Science Meeting are traditionally held biennially. All things being equal, this immediately reduces a conference's annual travel emissions by 50%. Biennial meetings could be complemented by a fully virtual conference in alternate years.

By following all 3 steps, we calculate that travel-related carbon emissions for the AGU Fall Meeting could be lowered by over 90%, if the meeting is held biennially in Chicago and with about a third of the participants, responsible for most of the emissions, attending virtually. The downside is that this would exclude many scientists based outside the USA from attending in-person, potentially resulting in a two-tier conference system, conflicting with aspirations for a *global* scientific community. Ways to improve opportunities for a wide range of researchers to participate are therefore needed.

Three hub model

Merging regional annual conferences is a possible way to lower emissions and maintain equity. For example, EGU (held in Vienna in April), and the Japan Geoscience Union, JpGU (held near Tokyo in May) complement the AGU Fall Meeting. These conferences often have sessions on similar themes and are already developing collaborative links: Prior to COVID-19, the AGU and JpGU were planning a joint in-person conference in Japan in May 2020.

Rather than having to fly to each one, we propose combining them. A single *World* Geosciences Union (WGU) would take place simultaneously in three hub locations, linked by dedicated virtual-room facilities to allow anyone to participate in any session. Attendees would travel only to their nearest hub. Chicago, Tokyo and Paris would be suitable host cities, based on current attendance patterns (see SI). Such a three-hub model would reduce travel emissions of all three unions combined by about 80%.

Time differences would have to be accommodated. A WGU might open on a Monday morning in Tokyo and run for 5 days continuously until Friday evening in Chicago. Sessions with high attendance could be held in each hub in the afternoon, to allow live late-evening and early-riser participation in the other two. Participants would have to accept sessions occurring at unconventional hours, but this is likely to be less stressful than back-to-back intercontinental flights (5).

Critics might counter that such a model would still disadvantage academics in parts of the world that are remote from these hubs, such as in the southern hemisphere**.** Academics from already-privileged parts of the world are more likely to reap the benefits of increasing their contacts, building trust and sharing informal knowledge in-person, even under our three hub model (6). Fully virtual conferences provide more equality in this respect.

But further regional meetings might join and complement the main three. The possibility of virtual attendance would help young researchers gain exposure to the entire global community at one meeting. People who might have struggled to attend anyway, for personal reasons like lack of childcare, low travel budgets or visa restrictions, could take part. For example, the Virtual Island Summit connects more than 250 island communities worldwide, especially from the Global South, which would not be possible in-person, due to vast distances and travel costs. Questions of equity are important, and need more consideration to avoid exacerbating existing inequalities.

Another issue is that the software currently used for running virtual conferences remains basic (7). Although no more than a laptop or tablet with internet is required to participate, internet connectivity can be a bottleneck for streaming video presentations. Uploaded recordings, digital posters and text-based discussions lower the technical requirements. To enhance the virtual experience without limiting access, conferences should offer platforms for both low and high bandwidth connections. Additionally, modern online community platforms are essential to provide virtual attendees opportunities to network and socialise, in the form of coffee and lunch breaks or other social events.

Conference travel is just one — albeit dominating — academic activity causing CO_2 emissions. The immediate move to online conferences in response to COVID-19 will not set a new conference convention by default, but regular and recurrent in-person conference attendance is one of the least necessary reasons for academics to travel, as academic success is generally not increased with an individual's air miles. (8)

Action points

A diverse set of actors need to be mobilized to move to a conference model which is more compatible with a net-zero carbon future, they include:

Academic associations and professional bodies should support the reorganisation of conferences around carbon emissions, virtual participation and inclusivity. They should set criteria for funding conferences — those that ignore emissions targets should not be supported. As a first step, they should immediately move to biennial conferences with fully-virtual meetings in alternate years.

Research funding bodies should consider low carbon and open-access dissemination of research outputs, supporting virtual conference presentations rather than conference travel, and rewarding regional attendance. They should consider carbon budgets as part of grant applications and contracting terms and conditions, alongside financial budgeting.

Academic institutions should reallocate conference funding from travel and accommodation costs to the costs of virtual hosting, including investment in virtual technologies, technical support and conference social media engagement. Conference funding should cover expenses for virtual attendance, and there should be mechanisms for requesting conference leave to allow full virtual participation. Promotion and research assessment exercises should recognize conference contributions under the new model. Just as academics have an annual travel budget, institutions should look to implement differentiated carbon budgets (by career stage, and other criteria) (9).

Researchers should promote and support virtual conferences wherever possible. Opportunities to present at virtual conferences should be accepted and virtual presentation should be demanded, if not offered. Role models will be crucial and senior scholars should insist on presenting invited keynotes virtually (10), or passing on these opportunities to scientists from underrepresented groups (11).

Conference organisers should consider delegate travel emission profiles when selecting host cities. Conference hubs should be created to minimise the need for long-haul flights. Most aspects of conference participation should be moved online, including the live-streaming and recording of presentations, digital posters with discussion channels, and virtual social events. Virtual presentation should be encouraged and time slot preferences accommodated. Connections between similar conferences should be established. Money saved from going virtual should be used to increase participation from the Global South.

Virtual technology providers should be encouraged to develop virtual conferencing solutions for the academic community. Open-source virtual technologies should be prioritised to prevent further dependencies on expensive licensing which creates and perpetuates exclusions.

Only through a concerted and coordinated effort will the transition towards a new model of academic conferencing gain traction. Yet as COVID-19 has taught us, changes to deeply embedded and seemingly intractable practices can happen with remarkable speed.

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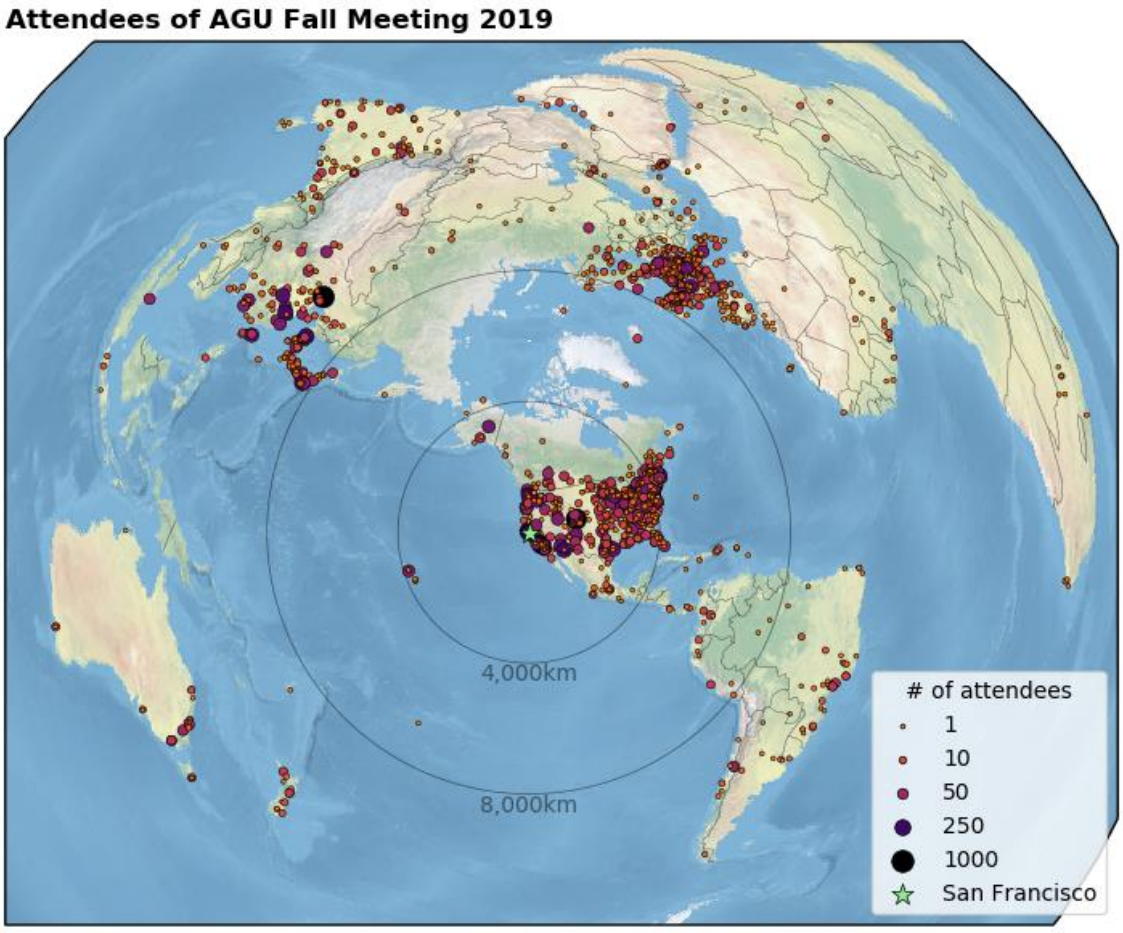
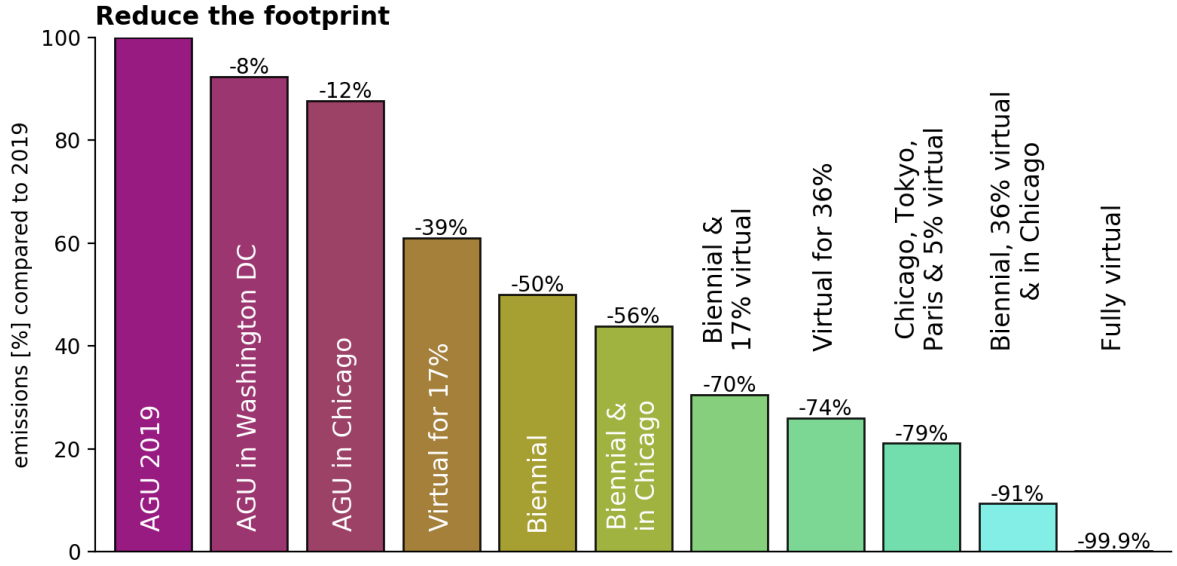
FIGURES



Strap: Most attendees of large international conferences, like the AGU Fall Meeting 2019 in San Francisco, travel North America, East Asia and Europe. Intercontinental flights between these regions dominate the carbon footprint. Flight routes to San Francisco are straight lines on this equi-distant map.



Strap: The total travel-related carbon footprint for the largest, yearly geosciences meeting is 80,000tCO2e. This is equivalent to the average weekly carbon emissions of the city of Edinburgh, UK. Certain measures such as changing the location of the host city, increasing virtual participation, holding biennial meetings or simultaneous meetings in three different locations, or 'hubs', with live-streaming between venues can reduce emissions by between 8 and almost 100% for a fully virtual meeting.

Data and materials availability All data is available in Klöwer, 2019 (12) and described in the supplementary information.

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