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Pen portraits of Presidents – Professor Raymond Hide, CBE, ScD, FRS

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Introduction

Professor Raymond Hide (Figure 1) was a supreme example of a geophysicist who was much honoured in his lifetime. He covered a very wide area of geophysics from geomagnetism, meteorology, geodesy, oceanography and related aspects of planetary physics. A full appreciation of his life and achievements can be found at Read (2019) and a brief *Weather* obituary at Read (2017).

Raymond Hide was born to relatively humble beginnings on 17 May 1929 in Bentley, a mining village in South Yorkshire and now part of Doncaster. His father, Stephen Hide, had various jobs, particularly after World War I, selling and maintaining miners' lamps at the local pithead. His mother, Edna (née Cartlidge) worked after World War I as a council warden looking after old people living alone in Bentley.

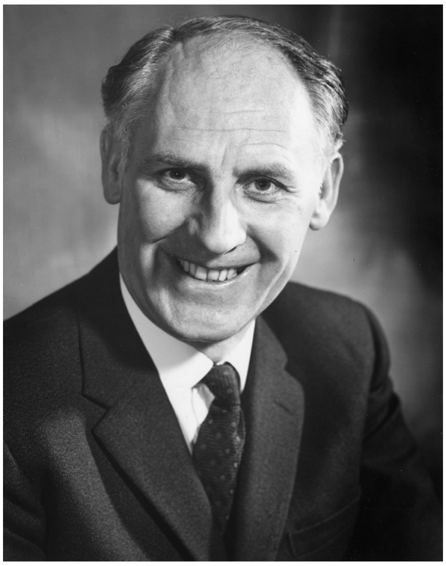

Figure 1. Raymond Hide at about the time he was President of the Royal Meteorological Society.

Raymond showed much ability from a very early age. His grandmother taught him to read, write and do addition before he was three. Despite this, Raymond had a difficult younger childhood, largely because his father suffered greatly from the effects of poison gas in World War I for the remainder of his life. The family then broke up after his father's suicide in 1940. Remarkably, this spurred Raymond on to achieve his potential, gaining a place at the Doncaster Percy Jackson Grammar School. Here he thrived greatly, becoming head boy and securing a state scholarship to Manchester University. He went on to graduate in Physics in 1950 with first class honours.

Early development of scientific interests

His period at Manchester (1947–1950) had a fundamental influence on his developing scientific interests. In particular, this brought him into contact with P.M.S. (later Lord) Blackett FRS, a leading world scientist in cosmic ray physics who became a Nobel Prize winner. Blackett had in 1947 developed a novel theory for the generation of Earth's magnetism, based on the idea that the magnetic field was caused by a new fundamental physical effect whereby the magnetic field was proportional to the angular momentum of the rotating body. This theory was in competition with a dynamo hypothesis promoted by Sir Edward Bullard FRS, where the seat of the magnetic field was placed in the liquid core of the Earth. Raymond Hide became involved as an undergraduate in a critical test of the two hypotheses that must have particularly appealed to him from a nostalgic perspective. This involved testing whether the field increased or decreased with depth in a deep coal mine. The field actually increased, supporting the dynamo hypothesis, and further laboratory work by Blackett confirmed this.

Inspired by his experience at Manchester, Raymond Hide went to Cambridge to study for a PhD in the Department of Geodesy and Geophysics (1950–1953). What followed surprised Raymond (Hide, 2010), and set him on his long meteorological path at the same time as vigorously continuing his geomagnetic interests. Raymond's initial experiments at Cambridge used a rotating cylindrical annulus of water spinning about a vertical axis in the presence of a horizontal temperature gradient. The motivation for this setup was the hope that such rotating annulus experiments might produce interesting results to provide insights into the motions of the Earth's liquid core. There were theoretical reasons why such experiments should be useful to investigate the mechanisms of the now generally accepted dynamo theory of Earth's magnetism. However, the significance of these experiments turned out to be much wider. In 1951 the Cambridge mathematician and Plumian Professor of Astronomy and Experimental Philosophy, Sir Harold Jeffries, happened to be passing the laboratory. He noted that the meandering (Rossby) wave-like flow occurring at the time in the annulus was reminiscent of the circulation of the atmosphere which Jeffries had researched many years before, particularly at the Meteorological Office during and after the First World War. Raymond was then further encouraged to consider the meteorological significance of his experiments by leading scientists in the Department of Meteorology at Imperial College, including the famous dynamicist, E.T. Eady.

During the three years of his PhD, Raymond Hide carried out a wide variety of experiments with the rotating annulus and an impressed horizontal temperature gradient. He particularly concentrated on fundamental changes in the flow that occurred as the rotation rate was increased. He found that there were three main types of flow: (a) symmetrical flow at low rotation rates where the fluid simply moved around the annulus, (b) an intermediate stage when the rotation rate increased enough to give an asymmetrical flow that often looked rather like Rossby waves, and (c) a chaotic high rotation phase where the flow broke up into small-scale chaotic eddies. He discovered the phenomenon of flow vacillation that occurred for some cases of the middle type of flow, mainly near the transition to the third, chaotic, phase. Here a meandering jet stream often gave way to separate vortex-like eddies which then decayed when the meandering Rossby wave-like flow was recreated. Similar phenomena can be seen in the atmosphere. A related seminal finding was that, in the middle (b) phase that looked most like the atmosphere, heat transfer across the annulus was dominated by sloping convection, just as seen in the atmospheric phenomenon of baroclinic instability (which had been discovered in the 1940s), dominating middle and higher latitudes of the Earth. At low rotation rates, horizontal heat transfer across the annulus was quite different, being dominated by a single convection cell with rising motion near the warm sidewall and sinking motion near the cold sidewall and thus more like the Earth's tropics. A feature of Raymond's approach to these and many related phenomena was very thorough quantitative analyses in the context of the relevant fluid dynamics.

A rapidly developing international reputation

At the end of his PhD, Raymond Hide was given the opportunity to spend some time in USA with the astrophysicist, and later Nobel Prize winner, Subramanyan Chandrasekar FRS. The most important outcomes of the visit were first to meet Professor David Fultz from the Department of Meteorology at the University of Chicago. Fultz had already shown much interest in Raymond's annulus work during his PhD. Fultz had observed some but not all of the phenomena Raymond had found when investigating thermally driven circulations in a rotating tank made from an American dishpan. This later led to Fultz's group repeating Raymond's experiments in a thermally driven rotating annulus and his findings were all confirmed. The second outcome was an unexpected contact with the Nobel Prize winning physical chemist, Harold Urey. Urey sparked what became Raymond's long-term interest in planetary atmospheric dynamics through a discussion on Jupiter's Great Red Spot.

As a result of his many thorough experiments using the annulus, Raymond became one of the founding fathers of what later became known as Geophysical Fluid Dynamics. His major results from this time were fully published in Hide (1958), delayed because of the need to complete three years of compulsory National Service in 1954–1957. Fortunately, he was usefully employed during this period by temporarily becoming a government senior research fellow at the Harwell Atomic Energy Establishment, working in their plasma physics division. Here he co-authored papers on shock waves in electrically conducting plasma, notably one in *Nature*.

After leaving Harwell, Raymond was appointed in 1957 to a university lectureship at Kings College, University of Durham, later becoming the University of Newcastle. Here he built up a small laboratory working on a variety of fluid dynamical problems, including Taylor columns and aspects of magnetohydrodynamics related to the Earth's magnetic field. The latter included the important topic of secular variations in the geomagnetic field (Hide, 1966a).

A major development in Raymond's career occurred in 1961. He was encouraged to take up a position as a full professor of physics and geophysics at the Massachusetts Institute of Technology (MIT) in the USA. Here he created a substantial fluid dynamics laboratory and attracted a very strong team of researchers to pursue the full range of his wide interests in fluid dynamics, including planetary atmospheres and their interiors. MIT was an excellent place to build such a team as it already hosted some of the most prominent researchers in the world in dynamical meteorology, such as Jules Charney and Edward Lorenz. It is clear from Hide (2010) that Raymond was much inspired by the seminal early work on non-linear dynamics related to atmospheric predictability, vacillation and deterministic chaos carried out while he was at MIT by Ed Lorenz. This was also the advent of the era of space exploration and Raymond was early to appreciate the potential of spacecraft to explore the dynamics of the atmospheres and interiors of the planets (e.g. Hide, 1966b) though he was never to take up a formal role in specific projects, probably because of the bureaucracy involved. Raymond's work at this time took on further significance as Lorenz (1967), noted in his famous book on the general circulation of the atmosphere that, '*while consideration of water vapour may yet play an essential role in the Tropics, it appears to be no more than a modifying influence in temperate latitudes because the hydrodynamical phenomena found in the atmosphere, including even cyclones, jet streams and fronts, also occur in the laboratory apparatus where there is no analogue of the condensation process*'.

Period at the Met Office

Starting in the late 1960s, the Met Office under its relatively new Director-General John Mason (later Sir John) greatly expanded its research base (Folland and Mitchell, 2020). In 1967, Raymond was persuaded by John Mason to take up a deputy chief scientific officer post to set up a new Geophysical Fluid Dynamics Laboratory (known as Met O21). After a number of years at the Met Office occupying this position, Raymond was further promoted to Chief Scientific Officer and it is thought that, at the time, he was the most senior research scientist in the civil service. The aim of his appointment was to carry out fundamental research in fluid dynamics, including stimulating broadly related research in any relevant part of the Met Office. An important additional aim was to foster the research skills of promising young Met Office scientists in an intellectually stimulating environment before they moved to more senior roles elsewhere in the Met Office. In many ways this created a culture somewhat akin to that in a university, and aspects of this approach were indeed repeated in other parts of the Met Office. Some 30 or more staff passed through the group between 1967 and the late 1980s and many indeed became prominent scientists or senior Met Office leaders. During this period, Raymond published extensively and cemented his position as a world leader in the application of geophysical fluid dynamics to a very wide variety of problems. These included problems of planetary dynamics which continued to interest him and where he made further original contributions. A typical international activity is shown in Figure 2.

Throughout this period, Raymond's group at the Met Office continued to carry out some ingenious variations on the theme of his original rotating annulus experiments to explore various properties of sloping convection in a rotating fluid. Such variations included the use of conically sloping endwalls to introduce dynamical effects similar to the spherical curvature of a planet. This would change the stability and speed of propagation of baroclinic waves (Hide and Mason, 1975), giving them a character more like the classical atmospheric Rossby wave and even leading to the formation of new eddy-driven jet streams. Some experiments explored different distributions of heating and cooling by using internal heating in addition to heating or cooling at the side boundaries. The internal heating was obtained by passing a high voltage alternating electric current through the fluid, and colleagues at the time report that Raymond had to be physically restrained on one occasion from demonstrating the stability of the flow in this experiment by stirring the tank with a metal ruler! This version of the experiment also led to the discovery of some intriguing flows in which sloping convection took the form of chains of compact oval eddies that resembled the large anticyclonic vortices (such as the Great Red Spot) seen in the atmospheres of Jupiter and Saturn (Read and Hide, 1983). Other experiments measured the heat transfer in rotating annulus flows using a clever calorimetry technique, also demonstrating how meridional barriers (such as mountain ranges or the coastal boundaries of the oceans) can help to increase poleward heat transport in an atmosphere or ocean. The group also developed numerical models of the experimental flows, laying the foundations for testing numerical modelling techniques through verification against experimental measurements.

Although Raymond did very little of this experimental and numerical modelling work himself at this time, he would regularly hold stimulating and wide-ranging discussions with the rest of the group, brainstorming new ideas and suggesting new directions for the experimental programme. Fundamental to his approach was to use basic concepts from the start to more clearly illuminate complex problems. Such was the deluge of new ideas from him that his team soon learned to wait until any given proposal was mentioned on at least two separate occasions before acting upon it. His group often hosted distinguished academic visitors from both the UK and abroad. It also pioneered the Met Office's engagement with the UK Research Councils' Cooperative Awards in Science and Engineering (CASE) research studentship

Figure 2. Raymond Hide (right) with Ray Bates (Irish Met Service, centre) and Peter Davies (University of Dundee, left) at an ALPEX planning meeting in 1978 on the island of San Giorgio, Venice. (© Peter Davies.)

scheme, co-supervising a succession of bright young PhD students from the universities of Leeds, Reading, Imperial College and Oxford.

The 1980s also saw the development of so-called chaos theory in mathematics. Amongst other things, this led in 1980 to Raymond and members of his group (including the co-author of this paper) being invited to a memorable meeting at Warwick University alongside other physicists and engineers, in which the Warwick mathematicians attempted (largely unsuccessfully!) to communicate their then arcane theories to their bemused guests. Eventually, however, this did lead to some novel experiments in Raymond's group to test these ideas and apply them to measure the predictability and complexity of real fluid flows in the laboratory. Similar concepts are now being used in operational ensemble numerical weather prediction to evaluate the reliability of weather forecasts.

It might first appear that atmospheric dynamics and that of the Earth's interior are separate issues. However, this is not the case and the link is shown by the small, but now readily detectable, changes in the length of the day (LOD). It had long been known that decadal variations in LOD of around 5ms related angular momentum exchanges between the Earth's fluid core and the overlying mantle and Raymond had long been interested in the mechanisms. However, it became clear that much shorter time scale variations occurred over intervals from days to the interannual timescale, which seemed too fast to be due to coupling between the core and the mantle and yet were still around 1–2ms in magnitude. In the late 1970s, an opportunity arose to test the idea that the atmosphere played a large part in LOD fluctuations. This arose through the unprecedented expansion in daily worldwide observations, albeit initially just for a period of a year or so, created by the World Climate Research Programme's First GARP[1] Global Experiment (1978/1979). The LOD results were published by Raymond and co-authors in 1980 in *Nature* (Hide *et al*., 1980). Such variations can now be calculated routinely as observations have permanently greatly expanded. Accordingly, somewhat later, Raymond and others were able to show that the El Niño–La Niña fluctuations cause axial atmospheric angular momentum variations and changes in the LOD interannually.

During his period at the Met Office, Raymond took on a wide range of leadership roles in meteorology, geophysics and astronomy. Notably for the emphasis of this paper, he became President of the Royal Meteorological Society in 1974–1976 and an Honorary Fellow of the Royal Meteorological Society in 1989. His numerous honours and awards are discussed in the last section of this paper.

After retirement from the Met Office

By the late 1980s, the Met Office was moving towards being an executive agency of the Ministry of Defence, which finally occurred in April 1990. This change of status brought to a head a tension over priorities within the Met Office research programme, between applied research or technical development and more fundamental, curiosity-driven science that had existed at least since the Rothschild Report on UK government science and technology in the 1970s (and continues to this day). As Raymond moved towards retirement, his group was seen as too academic for the Met Office with no viable 'customers' and so was wound down. The remaining research was moved to the University of Oxford where Raymond took over as Director of the Robert Hooke Institute. This was an institutional collaboration in atmosphere–ocean physics and fundamental geophysical fluid dynamical research between the Met Office, the University of Oxford and NERC's Institute of Oceanographic Sciences that had begun under Sir John Houghton (with encouragement from Raymond) in 1980. By the late 1980s, however, tensions over finances and differences over scientific priorities between the University and the other partners had developed which, despite Raymond's diplomatic efforts, eventually led to a decision to end the partnership. Raymond retired in 1992 and the Hooke Institute was then wound down. Raymond remained at Oxford for several years as professor emeritus, continuing to research mainly theoretical problems, including those relating to the dynamo theory of Earth's magnetism. On moving to London in 1998, he was invited to become an honorary senior research investigator at Imperial College. He remained a regular visitor to Imperial College until his health started to fail in late 2013. It was perhaps appropriate that his last paper was on the subject that started his long and remarkably productive adventure in geophysical fluid dynamics – the dynamo theory of Earth's magnetism (Hide, 2011).

A summary of Raymond Hide's life

Raymond received a very impressive series of national and international awards and leadership appointments across geophysics. Not all are listed here; a full list is available in Read (2019). As early as 1964, he became a Fellow of the American Academy of Arts and Sciences and shortly after a Fellow of the American Geophysical Union in 1967. A major award was Fellowship of the Royal Society in 1971 and in 1990 he became a Commander of the British Empire. He was especially delighted to become a member of the Pontifical Academy of Sciences in 1996, and in this capacity met both Popes John Paul II and Benedict XVI. He became President of the Royal Meteorological Society in 1974–1976, President of the European Geophysical Society in 1982–1984 and President of the Royal Astronomical Society in 1983–1985, a unique combination. He was awarded several honorary DScs and became both an Honorary member of the European Geophysical Society and Honorary Fellow

Figure 3. Raymond Hide in later life, with his wife Anne. (© Kathryn Singleton, Raymond's daughter.)

[1]GARP – Global Atmospheric Research Programme

of the Royal Meteorological Society in 1989. In 1997 he became Honorary Fellow of Jesus College, Oxford and in 2001 Honorary Fellow of Gonville and Caius College, Cambridge. He was also Gresham Professor of Astronomy from 1984–1990. Raymond won a number of prestigious scientific awards including the Chree Medal of the Institute of Physics, the Holweck Medal of the Societé Francaise de Physique and Institute of Physics, the Gold Medal of the Royal Astronomical Society, the Hughes Medal of the Royal Society, the Richardson Medal of the European Geophysical Society and the Symons Gold Medal of the Royal Meteorological Society.

Raymond had a long married life, marrying Ann Licence in 1957, and they were together (Figure 3) until she died in 2015. They had two daughters, Kathryn and Julia (the latter sadly passed away in 2018), both of whom lived nearby to where Raymond and Ann retired in West London, and a son, Steve who had moved sometime previously to Colombia, South America. Raymond's health started to fail in the late 1990s but he remained productive until 2013 when he suffered a mini-stroke. He died peacefully on 6 September 2016 after a long period of illness.

Despite his difficult and turbulent early life, Raymond was an irrepressibly gregarious and outgoing personality who was seldom at a loss for words or short of an amusing story to tell. Though not a serious follower of music (despite having a daughter who was a professional opera singer), he often carried around with him a set of harmonicas that he would deploy at the drop of a hat – if the occasion allowed! His wide knowledge, grounded on fundamental physical principles, and his energetic enthusiasm, made him a fount of new ideas and ways of thinking, so he was often sought out by colleagues across the world for his advice and help on difficult and challenging problems. But he was also unstintingly generous with his time and support, especially for younger scientists and students, leaving a lasting legacy among several generations of meteorologists and geophysicists who remember him with gratitude and affection.

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