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RESEARCH ARTICLE

Science diplomacy and politics: building the Global Atmospheric Research Program

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Abstract

In 1967, the World Meteorological Organisation and the International Council of Scientific Unions launched the Global Atmospheric Research Program (GARP), which lasted until 1982. The primary goals of the programme were international cooperation in global atmospheric observation to improve weather forecasting and to study climatic changes. This article examines the development phase of GARP from approximately 1961 to 1967, focusing on the US meteorologists Jule Charney and Thomas Malone and the Swedish meteorologist Bert Bolin, who contributed to its organization. It shows a variety of relationships between science and politics, beginning with President John F. Kennedy's call for scientific cooperation to ease international political tensions, followed by the diverse efforts of Charney, Malone, Bolin and others to help secure political support, and finally the protracted negotiations within the International Council of Scientific Unions to shape and organize the Global Atmospheric Research Program.

In October 1967, the World Meteorological Organization (WMO) and the International Council of Scientific Unions (ICSU) decided to launch the Global Atmospheric Research Program (GARP), the largest international programme ever undertaken in the atmospheric sciences. The primary goal of this programme, which lasted until 1982, was the achievement of international cooperation in global atmospheric observations in order to improve weather forecasting and to study climatic change. A major objective of GARP was to improve computer-based atmospheric and climate models and numerical simulations of weather and climate, which required the development and improvement of a global atmospheric database. GARP pursued large, coordinated international projects such as the GARP Atlantic Tropical Experiment (GATE) with three field measurement phases between June and September 1974, and the First Global GARP Experiment (FGGE) with coordinated observation periods from January to March and May to July 1979.[1] These projects involved the use of geostationary satellites, polar-orbiting satellites, aircraft, balloons, ships and buoys to observe the atmosphere, particularly in the tropics and subtropics, with the aim of achieving global coverage of observations.

GARP emerged at a time that proved to be enormously fruitful for the atmospheric sciences, although its development required six years of long and protracted international

[1] On GATE and FGGE see Erik M. Conway, *Atmospheric Science at NASA: A History*, Baltimore: Johns Hopkins University Press, 2008, pp. 77–89; Paul N. Edwards, *A Vast Machine: Computer Models, Climate Data, and the Politics of Global Warming*, Cambridge, MA: MIT Press, 2010, pp. 244–50.

negotiations, beginning with the call for international cooperation in space and atmospheric sciences by US president John F. Kennedy in 1961. Developing such a comprehensive programme on an international basis proved challenging, as international agreement had to be reached on the answers to many questions. What research areas and questions should such a programme focus on? How could agreement be reached among scientists, disciplines, national and international institutions and states on the directions and goals of the programme? Which institutions should be involved and how? What governance, coordination and management framework needed to be established?

A successful model for large international research programmes such as GARP was the International Geophysical Year (IGY), which ran from July 1957 to December 1958, involved sixty-seven nations, pursued research in eleven major geophysical fields, and was coordinated by ICSU.[2] In contrast to the IGY, however, there is very little historical literature on GARP. In particular, the development and organization phase of GARP has not been covered in detail.[3] The source base for the early phase of GARP's development from 1961 to 1963, which took place in the USA, includes several official reports and, above all, the recollections of the meteorologists Thomas Malone and Jule Charney, who were heavily involved in the development of GARP.[4] For the 1963–7 period, new, more comprehensive and detailed information is provided by the recently discovered GARP correspondence of the Swedish meteorologist and climate scientist Bert Bolin, which reveals the difficulties and complexities of establishing a large international research programme at ICSU.[5] It needs to be borne in mind that Charney's and Malony's accounts reflect limited, stylized personal narratives, which may contain errors and cannot be corroborated or contrasted with other sources and archival records. Likewise, Bolin's correspondence cannot be matched and complemented with other archival records and documentation and necessarily leaves many questions open. These sources are insufficient for constructing a reliable and comprehensive historical account of GARP's early development. They highlight the roles of Charney, Malone and Bolin, but do not necessarily do justice to the large number of other actors who were involved in developing such a big undertaking as GARP. Neither are these sources sufficient to fully understand details of controversial debates and conflicts that become visible in Bolin's correspondence.

[2] The historical literature on the IGY 'is massive'. Roger D. Launius, 'Toward the poles: a historiography of scientific exploration during the International Polar Years and the International Geophysical Year', in Roger D. Launius, James R. Fleming and David H. Devorkin (eds.), *Globalizing Polar Science: Reconsidering the International Polar and Geophysical Years*, New York: Palgrave Macmillan, 2010, pp. 47–81, 67, on the IGY at 67–70. On the IGY and its role as a model for other large international research programs see Frank Greenaway, *Science International: A History of the International Council of Scientific Unions*, Cambridge: Cambridge University Press, 1996, pp. 149–59, esp. 156–9.

[3] Conway, op. cit. (1), pp. 65–93; Edwards, op. cit. (1), pp. 242–50; Bert Bolin, *A History of the Science and Politics of Climate Change: The Role of the Intergovernmental Panel on Climate Change*, Cambridge: Cambridge University Press, 2007, pp. 19–27; John Perry, 'The Global Atmospheric Research Program', in Mitchell B. Wallerstein (ed.), *Scientific and Technical Cooperation among Industrialized Countries*, Washington, DC: National Academy Press, 1984, pp. 149–61.

[4] Thomas F. Malone, 'Reflections on the human prospect', *Annual Review of Energy and the Environment* (1995) 20(1), pp. 1–29; Malone, transcript of interview by Earl Droessler, American Meteorological Society Oral History Project, at https://opensky.ucar.edu/islandora/object/archives%3A7616 (accessed 25 August 2023); Malone, transcript of interview by Ronald E. Doel, 4 January 1995, American Institute of Physics, at www.aip.org/history-programs/niels-bohr-library/oral-histories/31418 (accessed 26 August 2023); Jule G. Charney, 'The atmosphere – a challenge: Charney's recollections', interview with Jule Charney by George Platzman, recorded in August 1980, in Richard S. Lindzen, Edward N. Lorenz and George W. Platzman (eds.), *The Atmosphere – A Challenge: The Science of Jule Gregory Charney*, Boston, MA: American Meteorological Society, 1990, pp. 11–85; Bolin, op. cit. (3), pp. 20–4.

[5] Bolin's correspondence was collected unprocessed in boxes and folders in the basement of the Meteorological Institute of Stockholm University (MISU). It covers an important part of the establishment phase of GARP, with several hundred letters and documents (recorded in 704 photographs). I will refer to it as 'Bolin Correspondence, [box title]'.

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With this caveat, the aim of this article is to explore the multiple relationships between science and politics, of which the development of GARP is an interesting example. The available sources make it possible to construct interesting, albeit limited, vignettes that provide important insights into science–politics relations and allow us to differentiate and illustrate different types of these relations, which can be labelled *science for policy*, the *politics of science* and *politics in science*. In the history of science, the term 'politics' serves to address a variety of different relations, developments and activities. The categories suggested above aim to help increase differentiation in the description of science–politics relations. *Science for policy* describes relations in which actors of all sorts refer to, develop, build, support or use science with the (additional) aim of furthering political goals, whether these goals directly relate to the science in question or not. The establishment of weather services, for example, serves political goals such as the support of agriculture, fishery, forestry and transport with relevant weather information. Likewise, it may also serve political goals not directly related to the science in question such as improving territorial control and nation building.

The category *politics of science*, in contrast, comprises a broad range of activities and developments, in which actors of all sorts aim at promoting specific scientific and/or political interests and developments or produce intentionally or unintentionally political effects. This category includes, for example, activities such as lobbying for specific scientific projects, institutions or research directions, or lobbying against specific types of science and scientific practices, such as the campaign of Republican politicians in the 1990s against computer simulation as an acceptable route to 'sound' scientific knowledge and as a basis for political regulation. Republican politicians lobbied instead for regulation to be based on empirical science rather than statistical analysis and computer modelling in fields such as CFC regulation for ozone protection, carbon dioxide emission regulation and dioxin-containing-chemical regulation.[6] *Politics in science*, eventually, describes political activities and relations within science or scientific institutions to pursue scientific or other interests. It comprises a large range of negotiation processes of interest about scientific practices, norms and values; the building of institutional frameworks; or the definition of directions and priorities. These categories will be introduced and discussed in more detail in the introduction to the *Epistemology and Politics of Climate Science* special issue to which this article contributes.

A related concept is the recently coined term 'science diplomacy', which can be regarded in most uses as a subcategory of *science for policy*. At its core, the term 'science diplomacy' describes how scientists, scientific organizations or scientific projects support or contribute to diplomatic purposes. In 2010, the Royal Society and the American Association for the Advancement of Science coined three definitions of science diplomacy that have been taken up by many authors. These include 'informing foreign-policy objectives with scientific advice (*science in diplomacy*)', 'facilitating international science cooperation (*diplomacy for science*)' and 'using science cooperation to improve international relations between countries (*science for diplomacy*)'. The concept of science diplomacy is more limited and specific than the categories suggested above, as it relates explicitly and solely to international relations.[7]

[6] George Brown, 'Environmental science under siege in the U.S. Congress', *Environment: Science and Policy for Sustainable Development* (1997) 39(2), pp. 12–31; Chris Mooney, *The Republican War on Science*, New York: Basic Books, 2005, Chapter 5, esp. p. 62; Bolin, op. cit. (3), p. 133–4.

[7] Royal Society and the AAAS, *New Frontiers in Science Diplomacy: Navigating the Changing Balance of Power*, London: Royal Society, 2010, p. iv; see also Simone Turchetti, Matthew Adamson, Giulia Rispoli *et al.*, 'Introduction: just Needham to Nixon? On writing the history of "science diplomacy"', *Historical Studies in the Natural Sciences* (2020) 50(4), pp. 323–39, 326; Pierre-Bruno Ruffini, *Science and Diplomacy: A New Dimension of International Relations*, Cham: Springer, 2017, especially Chapter 2. Lloyd S. Davis and Robert G. Patman (eds.), *Science Diplomacy*, Singapore: World Scientific, 2015.

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The history of GARP and the efforts of Jule Charney, Thomas Malone and Bert Bolin provide a powerful historical example involving a diversity of activities that can be characterized as *science for policy* (including science diplomacy), the *politics of science* and *politics in science*. Charney, Malone and Bolin played crucial roles in the development of GARP.[8] Jule Charney was born in 1917. He studied mathematics and physics at the University of California in Los Angeles and received his PhD in 1946 with a meteorological dissertation. In 1946, the leading Swedish meteorologist Carl-Gustaf Rossby hired him as a research associate at the University of Chicago. In 1948, he joined the Institute for Advanced Study (IAS) in Princeton as head of the Meteorological Research Group that pioneered computer-based numerical weather prediction. As a leader in numerical weather prediction, Charney established himself as a brilliant scientist. In 1956, he became professor of meteorology at MIT. In 1957, he was appointed a member of the Committee on Meteorology of the National Academy of Sciences.[9]

Thomas Malone, born in 1917 like Charney, studied meteorology at MIT and was appointed assistant professor there in 1943. In this position, he was commissioned by the American Meteorological Society (AMS) to edit the Compendium of Meteorology (1951), a comprehensive 1,300-page edited collection of articles covering the state of the art in all areas of atmospheric science.[10] This book, with many contributions from top researchers, opened the door to an unusual administrative career. In 1955 he left MIT to join Travelers Insurance in Hartford, Connecticut, to lead the Travelers Weather Research Center, and two years later became the company's director of research. In 1956 he was appointed to the National Academy of Sciences' Committee on Meteorology, where he played a leading role in developing the plan for the establishment of the National Center for Atmospheric Research (NCAR). From 1962 to 1973, Malone chaired the committee, which had been renamed the Committee on Atmospheric Sciences in 1960. Malone also served as secretary (1957–60) and president (1960–2) of the American Meteorological Society (AMS) and as vice president (1960–1) and president (1961–3) of the American Geophysical Union (AGU).[11]

Bert Bolin, born in 1925, received his MSc in 1949 and his PhD in 1956 in meteorology under Carl-Gustav Rossby at Stockholm University. In 1951 he worked with Jule Charney in Princeton on the first computerized weather forecast. Back in Stockholm, Bolin continued to focus on dynamic meteorology and weather forecasting. In the late 1950s he developed an interest in biogeochemical cycles (e.g. the circulation of carbon from fossil-fuel emissions and radioactive trace gases from nuclear bomb tests in the atmosphere) and climatic change. Rossby entrusted Bolin with important administrative tasks, including responsibility for the scientific journal *Tellus* and temporary leadership of the institute when Rossby went on sabbatical to the USA in 1956. After Rossby's sudden death in 1957, Bolin took over Rossby's role as director of the institute. In the early 1960s, Bolin was also chairman of the WMO Working Group on Numerical Methods of Weather Analysis and Forecasting and a member of the WMO Working Group on Research Aspects of Meteorological Satellites.[12]

[8] Gregory A. Good, 'Thomas F. Malone', *Eos: Transactions of the American Geophysical Union* (2013) 94(50), pp. 486–7; Norman A. Phillips, 'Jule Gregory Charney, 1917–1981', in *Biographical Memoir*, Washington, DC: National Academy of Sciences, 1995, pp. 79–113, esp. 101–2; Inez Y. Fung, 'Jule Gregory Charney (1917–1981)', in Stephen H. Schneider, Terry L. Root and Michael D. Mastrandrea (eds.), *Encyclopedia of Climate and Weather*, vol. 1, 2nd edn, Oxford: Oxford University Press, 2011, pp. 178–9; Henning Rodhe, 'Bert Bolin (1925–2007): a world leading climate scientist and science organizer', *Tellus B: Chemical and Physical Meteorology* (2013) 65(1), pp. 1–6, esp. 2.

[9] Phillips, op. cit. (8).

[10] Thomas F. Malone (ed.), *Compendium of Meteorology*, Boston, MA: American Meteorological Society, 1951.

[11] Good, op. cit. (8), pp. 486–7; David Malone, 'Thomas F. Malone, 1917–2013', in *Biographical Memoir*, Washington: National Academy of Sciences, 2014.

[12] Rodhe, op. cit. (8), pp. 1–6; 'Review of WMO Technical Note no. 118, Numerical methods of weather analysis and forecasting', *WMO Bulletin* (1962) 11(4), p. 239; 'Meteorological satellites', *WMO Bulletin* (1963) 12(1), p. 56;

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The development of GARP is a powerful example of the multiple relationships between politics and science. In a first short section, I will set the stage by summarizing the increasing politicization of the atmosphere during the early Cold War and the political contexts of a rising profile of meteorology and atmospheric science in the US. Policymakers in the USA used science as a vehicle to pursue political goals, such as measuring and controlling the atmosphere and making it an arena for international diplomacy. The second section covers the development of a call for international cooperation in space and atmospheric research and the efforts of Charney and Malone to develop the basic ideas for such a research programme in the US meteorological community. The third section describes the development efforts within the Committee on Atmospheric Sciences of the US National Academy of Sciences and Malone's efforts to establish an international research programme with ICSU as the coordinating body. Finally, the fourth section covers the deliberations and planning efforts within ICSU bodies to define and specify the directions, content and structure of GARP. In the conclusion, I discuss the relationship between science and politics in the development of GARP, referring to the categories *science for policy*, the *politics of science* and *politics in science*.

Cold War tensions and the politicization of the atmosphere

In the chaotic state of the post-war world and the increasing political and military tensions of the Cold War, science policy became a national imperative in the US. Science served military and geopolitical goals in the competition between the US and the Soviet Union, as well as international diplomatic goals, political and economic power, and national strength and identity.[13] The early Cold War era proved to be a boon for science, including the (geo-)physical disciplines. Scientists quickly learned to take advantage of political opportunities and to pursue research goals by appealing to political and military interests.[14] Atmospheric science was no exception. The tensions of the Cold War made the atmosphere a military space of high priority. New technologies developed during and after the Second World War, such as radar, rocket and satellite surveillance, and computers, promised substantial and rapid advances in knowledge of the atmosphere up to the highest reaches of the ionosphere.[15]

Cold War interests resonated particularly well with recent developments in meteorology, which had greatly expanded its links with the military during the Second World War.[16] After

'Commission on Atmospheric Chemistry and Radiation 1964', *WMO Bulletin* (1964) 13(4), p. 232. See also Carolina Granado, 'Scientific expertise in early international negotiations on climate change: Bert Bolin and the IPCC', *BJHS*, this issue.

[13] There is ample literature on US Cold War science. For example: Audra J. Wolfe, *Freedom's Laboratory: The Cold War Struggle for the Soul of Science*, Baltimore: Johns Hopkins University Press, 2018; Paul Rubinson, *Redefining Science: Scientists, the National Security State, and Nuclear Weapons in Cold War America*, Amherst: University of Massachusetts Press, 2016; Stuart W. Leslie, *The Cold War and American Science: The Military–Industrial–Academic Complex at MIT and Stanford*, New York: Columbia University Press, 1993; Greg Whitesides, *Science and American Foreign Relations since World War II*, Cambridge: Cambridge University Press, 2019; John Krige, *American Hegemony and the Postwar Reconstruction of Science in Europe*, Cambridge, MA: MIT Press, 2006; Ronald E. Doel and Kristine C. Harper, 'Prometheus unleashed: science as a diplomatic weapon in the Lyndon B. Johnson administration', *Osiris* (2006) 21, pp. 66–85.

[14] Allan A. Needell, *Science, Cold War, and the American State: Lloyd V. Berkner and the Balance of Professional Ideals*, New York: Taylor & Francis, 2000; Ronald E. Doel, 'Constituting the postwar earth sciences: the military's influence on the environmental sciences in the USA after 1945', *Social Studies of Science* (2003) 33(5), pp. 635–66.

[15] Conway, op. cit. (1); James R. Fleming, *Inventing Atmospheric Science: Bjerknes, Rossby, Wexler, and the Foundations of Modern Meteorology*, Cambridge, MA: MIT Press, 2016.

[16] John F. Fuller, *Thor's Legions: Weather Support to the U.S. Air Force and Army, 1937–1987*, Boston, MA: American Meteorological Society, 1990; Charles C. Bates and John F. Fuller, *America's Weather Warriors 1814–1985*, College Station: Texas A&M University Press, 1986.

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the war, leading meteorologists seized the unique combination of technical opportunity (the development of computers) and financial opportunity (from military agencies) to sell the possibility of predicting the weather using numerical weather prediction techniques based on physical theory and creating the means to modify weather and climate.[17] Although few meteorologists seriously believed in it, the phrase 'weather and climate modification' became a key interest and shorthand for addressing meteorological research during the 1950s and 1960s in the USA.[18] The pioneering of computer-based numerical weather prediction with the first successful simulation experiments in 1950, inspired by the meteorologist Carl-Gustaf Rossby and led by Jule Charney, was a major achievement. The development of electronic digital computers helped to make non-linear differential equations tractable by numerical approximation and fuelled great enthusiasm for building computer models of the atmosphere and experimenting with weather and climate simulation.[19] The establishment of the influential Committee on Meteorology at the US National Academy of Sciences in 1956 and of the National Center for Atmospheric Research (NCAR) in Boulder, Colorado in 1960 reflected the significantly strengthened profile of meteorology and the atmospheric sciences.[20]

In the late 1950s, the last years of Eisenhower's presidency, Cold War tensions were rising. Nuclear-tipped Soviet intercontinental ballistic missiles posed a major new threat. The launch of the first satellites, Sputnik I and Sputnik II, by the Soviet Union in the autumn of 1957 marked the beginning of the space race. The Soviet lead in the successful development and launch of satellites sent shockwaves through the US political and military establishment and led to the reorganization and aggressive intensification of US space exploration with the creation of the National Aeronautics and Space Administration (NASA) in 1958.[21]

At the same time, nuclear weapons tests in the open atmosphere, which produced increasing amounts of radioactive fallout, led to a Soviet initiative for an above-ground nuclear weapons test ban. In March 1958, the Soviets announced a unilateral halt to nuclear testing. Eisenhower followed with a one-year test ban. Negotiations on a permanent test ban began in October 1958, but broke down in 1960. Eisenhower was initially sympathetic to a test ban but faced fierce opposition from the military establishment and defence-minded senators. When Kennedy took office in January 1961, he was committed to easing tensions between the US and the Soviet Union and took a pro-test ban stance. The Kennedy administration immediately launched new initiatives to reduce international tensions and resume test ban negotiations. In the summer of 1961, Kennedy planned to meet with Soviet premier Nikita Khrushchev to work out the conflicts between the US and the Soviet Union, to make

[17] Kristine C. Harper, *Weather by the Numbers: The Genesis of Modern Meteorology*, Cambridge, MA: MIT Press, 2008; Christoph Rosol, 'Which design for a weather predictor? Speculating on the future of electronic forecasting in post-war America', in Matthias Heymann, Gabriele Gramelsberger and Martin Mahoney (eds.), *Cultures of Prediction in Atmospheric and Climate Science: Epistemic and Cultural Shifts in Computer-Based Modelling and Simulation*, New York: Routledge, 2017, pp. 68–84.

[18] Kristine C. Harper, *Make It Rain: State Control of the Atmosphere in Twentieth-Century America*, Chicago: University of Chicago Press, 2017; James R. Fleming, *Fixing the Sky: The Checkered History of Weather and Climate Control*, New York: Columbia University Press, 2010, pp. 137–224.

[19] Harper, op. cit. (17); David M. Hart and David G. Victor, 'Scientific elites and the making of US policy for climate change research, 1957–74', *Social Studies of Science* (1993) 23(4), pp. 643–80; Edwards, op. cit. (1).

[20] Fleming, op. cit. (15), pp. 195–207.

[21] Roger D. Launius, *Reaching for the Moon: A Short History of the Space Race*, New Haven, CT: Yale University Press, 2019, pp. 12–38; Whitesides, op. cit. (13), pp. 84–7; Robert A. Divine, *The Sputnik Challenge: Eisenhower's Response to the Soviet Satellite*, New York: Oxford University Press, 1993; William E. Burrows, *This New Ocean: The Story of the First Space Age*, New York: Random House, 1998, pp. 183–202.

proposals for new initiatives and to explore the possibilities for restarting talks on a test ban treaty.[22]

Promoting international cooperation: science for policy in the Kennedy administration

In early 1961, Italian physicist and MIT professor Bruno Benedetto Rossi called his MIT colleague Jule Charney. Rossi studied cosmic radiation, was one of the pioneers of rocket experimentation, and served as an adviser to Jerome Wiesner, the special assistant for science and technology in the Kennedy administration.[23] Charney recalled in an oral-history interview, 'the President would like to have something done in the way of international cooperation in the light of developments of outer space' in which 'space technology could be used for other than military purposes'. Rossi asked Charney for some ideas.[24] On 1 April 1960, the United States launched its first meteorological satellite, TIROS I, which many scientists believed would usher in a new era of meteorology. The focus on scientific applications of satellites promised opportunities for international cooperation.[25]

After Rossi's invitation, Charney called his friend and former colleague at MIT, Thomas F. Malone, in early February 1961. Malone and Charney met with Rossi and atmospheric physicist Richard Goody of Harvard University to discuss possible directions for an international research programme. According to Malone, after some discussion and random brainstorming, they eventually 'turned to the possibility of conscious or inadvertent human intervention in weather and climate', a topic in which Rossi 'immediately detected a rationale for a joint effort with other nations'. Malone, as president of the American Meteorological Society, organized a more formal meeting on 21 February 1961 at the AMS residence in Boston with other leading meteorologists, including Henry Houghton of MIT, Sverre Petterssen of the University of Chicago, Robert Fleagle of the University of Washington, David Johnson and Harry Wexler of the US Weather Bureau and Morris Tepper of NASA, to discuss the possibilities of an international research programme.[26]

After the meeting, Charney and Malone wrote a report for Rossi. Malone quoted it in his memoirs:

> We proposed '... a concerted international program aimed at the study of global weather processes with the intent of developing the scientific basis for weather prediction, thereby establishing a rational point of departure for investigating the feasibility of large-scale modification of weather and climate' to be initiated jointly by the USA and the USSR.[27]

[22] William Burr and Hector L. Montford, 'The making of the Limited Test Ban Treaty, 1958–1963', National Security Archive, 2008, at https://nsarchive2.gwu.edu/NSAEBB/NSAEBB94/index2.htm (accessed 24 August 2023); Benjamin P. Greene, *Eisenhower, Science Advice, and the Nuclear Test-Ban Debate, 1945–1963*, Stanford, CA: Stanford University Press, 2007, pp. 233–62 on Kennedy; Paul Rubinson, "'Crucified on a cross of atoms": scientists, politics, and the Test Ban Treaty', *Diplomatic History* 35(2) (2011), pp. 283–319.

[23] George W. Clark, 'Bruno Benedetto Rossi', in *Biographical Memoir*, Washington, DC: The National Academy Press, 1993.

[24] Charney, op. cit. (4), p. 73. This interview is also the source of other authors: Phillips, op. cit. (8); Malone, 'Reflections', op. cit. (4).

[25] Edwards, op. cit. (1), pp. 219–26; Conway, op. cit. (1), pp. 79–86; Zuoyue Wang, *In Sputnik's Shadow: The President's Science Advisory Committee and Cold War America*, New Brunswick, NJ: Rutgers University Press, 2008, pp. 109, 140, 183–5.

[26] Malone, interview by Earl Droessler, op. cit. (4), pp. 2–3; Malone, 'Reflections', op. cit. (4), p. 11.

[27] Malone, 'Reflections', op. cit. (4), p. 11. Malone cited the quote from 'Malone TF, convenor. 1961, Proposal for International Cooperation in Meteorology Report. Presented at PSAC Panel for Possible USA–USSR Collaboration in Space, 21 Feb., Boston'. Malone, 'Reflections', op. cit. (4), p. 28.

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Malone even went to Washington to talk to Wiesner. Wiesner endorsed the plan, which was to be proposed to Khrushchev at the Vienna summit on 3–4 June 1961. However, the summit was a diplomatic failure for Kennedy, who met a Soviet leader with very different concerns at a time of rising tensions and confrontation, not of proposals and cooperation, scientific or otherwise.[28] The Berlin Wall was built some weeks later in August 1961, and on 1 September 1961 the Soviet Union ended its moratorium and resumed nuclear testing. Kennedy's response was to authorize underground testing from mid-September 1961 and atmospheric testing from spring 1962.[29]

However, the idea of an international research programme wasn't dead. Kennedy was due to address the United Nations at the opening of its Sixteenth General Assembly in September 1961. In preparation, the administration called Malone to Washington for a meeting on 31 August with Jerome Wiesner; Detlev Bronk, president of the National Academy of Sciences and chairman of the International Panel of the President's Scientific Advisory Committee; Richard Gardner of the State Department; Pete Scoville of the CIA; and Arthur Schlesinger of the Executive Office of the President, as well as physicist Isidore Isaac Rabi and diplomat Harlan Cleveland. Malone made what he later described as 'an impassioned presentation' on the need to create an international programme to study global weather processes. Although it caused an argument between Wiesner and Gardner, they eventually decided that Malone's proposal was 'a suitable subject for President Kennedy to introduce at the United Nations'.[30]

Malone then travelled to Canberra and Sydney (11–20 September 1961) for the International Conference on Cloud Physics, organized by the Australian Academy of Science and the Commonwealth Scientific and Industrial Research Organization (CSIRO) under the auspices of the International Union of Geodesy and Geophysics (IUGG). As president of the AMS, he was invited to give the opening address in Canberra, which he used as a 'little trial balloon' to launch the idea of an international research programme.[31] In his opening address to some hundred participants, he highlighted recent advances in meteorology and the opportunities that lay ahead. He outlined what he simply called 'the meteorological problem', which consisted of four parts: '(1) *describing* this complex hydrodynamic system of the atmosphere, (2) *understanding* the physical processes which are responsible for its behavior, (3) *predicting* future states of the system, and, ultimately, (4) *controlling* such of those physical processes as may be practicable to influence future states in a beneficial manner.'[32]

Towards the end of his speech, Malone suggested a way forward in pursuit of these goals. 'I believe, however, that the time has arrived to strengthen and unify these efforts by seeking to establish, within the framework of the International Council of Scientific Unions, a committee which ... would become the focal point of an international collaborative effort in atmospheric research'. The non-governmental ICSU was the major international scientific

[28] Malone, interview by Earl Droessler, op. cit. (4), p. 3; Malone, 'Reflections', op. cit. (4), p. 11. Khrushchev's main concern was the solution of the so-called Berlin question, the Soviet demand that the Western powers leave West Berlin. Frederick Kempe, *Berlin 1961: Kennedy, Khrushchev, and the Most Dangerous Place on Earth*, New York: G.P. Putnam's and Sons, 2011, pp. 209–60.

[29] Burr and Montford, op. cit. (22), p. 4.

[30] Malone, interview by Earl Droessler, op. cit. (4), p. 4; Malone, 'Reflections', op. cit. (4), p. 11.

[31] Malone, Interview by Earl Droessler, op. cit. (4), p. 4.

[32] Thomas F. Malone, 'Some implications of progress in the atmospheric sciences, opening address, International Conference on Cloud Physics, Canberra, Australia', *Bulletin of the American Meteorological Society* (1962) 43(1), pp. 1–7, pp. 3, 6, emphasis in the original; 'International Cloud Physics Conference', *Bulletin of the American Meteorological Society* (1962) 43(1), pp. 7–8; see also Thomas F. Malone, 'Progress, purpose, and potential in the atmospheric sciences', *Bulletin of the American Meteorological Society* (1962) 43(6), pp. 229–33; Malone, 'The atmospheric sciences and the American Meteorological Society: the more recent past', *Bulletin of the American Meteorological Society* (1970) 51(3), pp. 218–20.

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institution, the parent body of many scientific unions representing scientific disciplines, including the IUGG. Malone's argument suggests that he wanted to ensure a strong position for the 'scientific and academic community' in developing a research programme outside the World Meteorological Organization, which was a governmental organization representing national weather services and operational meteorology.[33]

A few days later, on 25 September 1961, US president John F. Kennedy delivered an ambitious speech to the United Nations General Assembly in New York. Kennedy urged the world community 'to halt the spiralling nuclear arms race'. 'Mankind must put an end to war – or war will put an end to mankind.' Kennedy proposed a radical (visionary rather than realistic) six-point programme that included 'signing the test-ban treaty by all nations', a halt to the production and transfer of fissionable material for nuclear weapons and to their use in space, and an end to the unlimited testing and production of missiles as delivery systems for nuclear weapons. He proposed 'reserving outer space for peaceful use', 'further cooperative efforts between all nations in weather prediction and eventually in weather control' and 'a global system of communications satellites linking the whole world in telegraph and telephone and radio and television'.[34]

As a result of his urgent appeal, US and international diplomats prepared a resolution on international cooperation in the peaceful uses of outer space, which the UN General Assembly adopted on 20 December 1961 as Resolution 1721 (XVI). As part of this resolution, the General Assembly recommended to 'all Member States and to the World Meteorological Organization and other appropriate specialized agencies' a comprehensive study of the atmosphere in the light of developments in space. It recommended two major goals:

> (a) To advance the state of atmospheric science and technology so as to provide greater knowledge of basic physical forces affecting climate and the possibility of large-scale weather modification; (b) To develop existing weather forecasting capabilities and to help Member States make effective use of such capabilities through regional meteorological centres.

It asked the WMO to submit a report on 'appropriate organizational and financial arrangements to achieve those ends' in consultation 'with other specialized agencies and governmental and non-governmental organizations including the International Council of Scientific Unions'.[35]

The science and politics for building a global research programme

Kennedy's initiative was well timed and well placed. Satellite applications in meteorology and communications required international cooperation.[36] In March 1962, Khrushchev

[33] Malone suggested a new ICSU committee like the Committee on Space Research (COSPAR) or the Committee on Oceanic Research (SCOR) 'complementing the function' of the WMO. Malone, 'Some implications', op. cit. (32), p. 6. Malone learned from Berkner about the importance of ICSU. Berkner was ICSU president from 1955 to 1958 and travelled together with Malone to the IUGG 12th General Assembly in Helsinki, 26 July to 6 August 1960. Malone, interview by Ronald E. Doel, op. cit. (4), p. 158–9; Robert M. White, 'Science and politics, and international atmospheric and oceanic programs', *Bulletin of the American Meteorological Society* (1982) 63(8), p. 926.

[34] John F. Kennedy, 'Address in New York City before the General Assembly of the United Nations', 25 September 1961, US Department of State, Washington, DC, at https://2009-2017.state.gov/p/io/potusunga/207241.htm (accessed 26 August 2023).

[35] UN Resolution 1721 (XVI), International Co-operation in the Peaceful Uses of Outer Space, UN General Assembly, New York, 20 December 1961, section C, p. 6, at https://research.un.org/en/docs/ga/quick/regular/16 (accessed 31 August 2023).

[36] On the history of communication satellites aee Hugh R. Slotten, *Beyond Sputnik and the Space Race: The Origins of Global Satellite Communications*, Baltimore: Johns Hopkins University Press, 2022; Whitesides, op. cit. (13), pp. 178–82.

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agreed in a letter to Kennedy that the joint establishment of an operational weather satellite system would be a great service to mankind.[37] The WMO had already established an Expert Panel on Artificial Satellites in 1958. As a member of this panel, Harry Wexler, head of the US Weather Bureau, developed the idea of a global observing system. Immediately following the adoption of the UN resolution, the WMO commissioned the research directors of the US and Soviet national weather services, Harry Wexler and Victor A. Bugaev, to further develop plans for what became known as the World Weather Watch (WWW) and to prepare the report required by UN Resolution 1721.[38] The WMO also set up an advisory committee to 'advise the WMO Executive Committee concerning principal research problems in the atmospheric sciences, especially in connexion with developments in meteorological satellites' and to identify further research and education needs.[39] By this time, Bolin recalled in his memoirs, about a dozen scientific groups in the US, Europe, Japan and Australia were investigating the use of satellites to observe the weather from space. While this goal justified a major research effort, it also 'signalled a battle for resources within the USA'.[40]

The Kennedy administration was preparing for a major expansion of the nation's atmospheric research effort. In the spring of 1961, science adviser Jerome Wiesner had asked the National Academy of Sciences to 'establish national goals in the atmospheric sciences' and to 'identify those areas of research which appear fruitful from the point of view of unsolved problems or potentially great advances' to be pursued over a ten-year period. In the spring of 1962, a three-volume report, *The Atmospheric Sciences 1961–1971*, was published under the direction of University of Chicago meteorologist Sverre Petterssen, a leading researcher in weather analysis and forecasting.[41] This report, known as the Petterssen report, was based on a series of planning conferences held in the summer of 1961, which focused on major research areas and brought together 189 scientists to comment on and discuss the major problems to be tackled in the atmospheric sciences, with a further twenty-seven contributing 'by personal or written consultation'.[42]

The report recommended that spending on atmospheric research be almost tripled, from $217 million in 1961 to $605 million in 1971. Although all major areas of research would benefit from increased funding, the report emphasized Charney and Malone's original proposals for a research programme and reiterated Malone's argument about 'the meteorological problem' made in his Canberra speech in September 1961.[43] In its final chapter it proposed an 'International Atmospheric Science Program'. Part of this would be the World Weather Watch to provide improved global observational data that would

> serve a number of scientific purposes of which the following would be the principal ones: (a) Provide a firmer scientific basis for weather forecasting on different time and space scales. (b) Provide a better understanding of the processes that determine

[37] Fleming, op. cit. (15), p. 187.

[38] Edwards, op. cit. (1), p. 224–6. Edwards recounts the history of the WWW in some detail in Chapter 9. Wexler and Bugaev submitted their report in June 1961 to the WMO. WMO, *First Report on the Advancement of Atmospheric Sciences and Their Application in the Light of Developments in Outer Space*, Geneva: WMO, 1962; Harry Wexler, 'Global meteorology and the United Nations', *Weatherwise* (1962) 15(4), pp. 141–67.

[39] 'Advisory Committee', *WMO Bulletin* (1964) 13(1), pp. 48–9.

[40] Bolin, op. cit. (3), p. 20.

[41] Committee on Atmospheric Sciences, *The Atmospheric Sciences 1961–1971: A Report to the Special Assistant to the President for Science and Technology*, vol. 1, Washington, DC: NAS NRC, 1962.

[42] Helmut Landsberg, 'The atmospheric sciences 1961–1971: an essay review', *WMO Bulletin* (1962) 11(4), pp. 178–82, 179; Committee on Atmospheric Sciences, op. cit. (41), p. vii.

[43] Committee on Atmospheric Sciences, op. cit. (41), pp. 1, 5.

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> the system of world climates. (c) Provide the basis for exploring the possibilities of large-scale modification of weather and climate.[44]

Charney continued to think about the specific scientific content of an international research programme. At one meeting, he later recalled, he was struck by the idea that the atmospheric circulation should be studied 'as a whole', based on a much better observational base, which could be provided by satellites, aircraft and balloons, 'something that could be done for a limited period of time'. He presented this idea at a meeting of the Committee on Atmospheric Sciences, and in the following weeks wrote a position paper in which he argued that the understanding and numerical simulation of atmospheric processes had recently advanced so rapidly that 'it will soon be possible to analyse and predict atmospheric motions on a truly global scale for long periods of time'.[45] However, meteorological instrumentation remained 'in so primitive a state' that 'no possible extension of the observational networks along conventional lines (new stations, weather ships, etc.) can cope with the global data requirements in any foreseeable way.' The atmosphere in the southern hemisphere, in the tropics and over the oceans (which make up 70 per cent of the Earth's surface) was far less well known and understood, and since the atmosphere is global, this lack of knowledge severely hampered weather and climate forecasting. The 'limited success that has attended short-term numerical predictions and general circulation calculations suggests strongly that the availability of global data would open up an entirely new field of investigation: the study of phenomena on time scales from two or three days to infinity.' He concluded, 'The implications for long-range weather prediction, the understanding of climate, and a rational approach to climate modification are too obvious to bear comment.'[46]

Charney proposed an international research programme consisting of three parts. '(1) A carefully planned and phased instrumental development program, extending over a period of perhaps five to ten years'. A limited experiment should then be carried out as new appropriate instruments became available to equip satellites, aircraft, balloons, ships, buoys and so on. '(2) the actual measurement of the atmosphere once or twice daily for a period of several weeks or months'. On the basis of the much better and more comprehensive global observational records collected for the period of this experiment, '(3) enhanced work on the science and technology of machine computation and data processing' should follow. This last part meant the development of more comprehensive and better computer models based on the improved knowledge, and the conduct of numerical simulation experiments with improved models and better and much more comprehensive initial data to test weather and climate predictions over a period of several weeks. Charney circulated his position paper to a few close colleagues and organized a meeting at the National Academy of Sciences in Washington on 29 April 1962 to discuss the desirability and feasibility of a global observing system.[47] In the summer, at the Bjerknes Centenary Conference at the University of Bergen, he shared these plans with some international colleagues, including his colleague

[44] Committee on Atmospheric Sciences, op. cit. (41), pp. 83–4.

[45] Charney, op. cit. (4), p. 74; Phillips, op. cit. (8), pp. 101–2; Bolin, op. cit. (3), p. 20; Jule Charney, 'A suggested international meteorological observation program', Jule Charney Papers, MIT Institute Archives, MC184, Box 11, Folder 379. Charney was unsure of the timing of these events in the Platzman interview and thought of a meeting in late 1960. More probable appears a meeting in late 1961. His six-page undated proposal was probably addressed to the Committee of Atmospheric Sciences.

[46] Charney, op. cit. (45), pp. 1–3, 8.

[47] Charney, op. cit. (4), p. 74; Panel on International Meteorological Cooperation, *The Feasibility of a Global Observation and Analysis Experiment*, Washington, DC: National Academy of Science, 1966, p. viii.

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and friend Bert Bolin. According to Bolin's memoirs, Charney's proposal met with 'strong support from scientists all over the world'.[48]

While Charney was developing his ideas, the National Academy of Sciences was formally responding to UN Resolution 1721 (XVI). Its president, Detlev W. Bronk, appointed an ad hoc Committee on International Programs in Atmospheric Science and Hydrology, chaired by Sverre Petterssen, to follow up on the Petterssen report and prepare an initial outline of a programme for international cooperation. In addition, the academy appointed leading scientists representing the diversity of the atmospheric sciences to the committee, including Jule Charney and Thomas Malone. The committee's report was published in January 1963.[49] It considered research perspectives and needs in four main areas: weather forecasting and modification (Chapter 3), the upper atmosphere (Chapter 4), atmospheric chemistry (Chapter 5) and climatology and related fields (Chapter 6). Its introduction emphasized its priority:

> The area most demanding in respect to joint efforts by nations is the one discussed in Chapter 3, and it should be emphasized here that progress toward the establishment of a world-wide atmospheric surveillance program is a sine qua non insofar as progress in weather prediction and modification is concerned.[50]

The report recommended the establishment of an 'International Atmospheric Research Program (IARP)' focusing on problems that 'require atmospheric measurements on a global scale'. Such a programme should be supported by more specific programmes focusing on the use of meteorological satellites and the development of equipment and the planning of a global measurement system, the expansion of the use of data provided by meteorological satellites, and an 'International Meteorological Education Program (IMEP)'.[51] Importantly, the report emphasized the role of ICSU in working with the WMO. It recommended that ICSU and its members 'develop the basic aspects' of the programmes and 'assist WMO in the formulation of a general program' (part of recommendation 1). It recommended further that the National Academy of Sciences 'addresses itself to' ICSU to 'consider the interest and value in an international program in the atmospheric sciences' and undertake efforts to 'study and foster programs of international cooperative research' (part of recommendation 3).[52]

In 1962, Malone served as a volunteer aide to US assistant secretary of commerce John Herbert Hollomon, whose responsibilities included the US Weather Bureau. Malone used this position, as he told the story, to propose an additional UN resolution specifically inviting the non-governmental 'ICSU to participate in planning the research recommended in the 1961 UN Resolution'. In July 1962, Hollomon called and asked Malone 'to fly to Washington immediately' to meet with Hollomon and Richard N. Gardner from the State Department. By the time Malone arrived, the meeting was over. Hollomon, after 'some Indian wrestling', had persuaded Gardner to prepare a new UN resolution. According to Malone, 'Gardner and his chief, Assistant Secretary of State for International Organizations, Harlan Cleveland, were towers of strength in this initiative, both within the Department of

[48] Bolin, op. cit. (3), p. 20.

[49] Ad Hoc Committee on International Programs in the Atmospheric Sciences and Hydrology, *An Outline of International Programs in the Atmospheric Sciences*, Washington, DC: National Academy of Sciences, 1963.

[50] Ad Hoc Committee, op. cit. (49), p. 2.

[51] Ad Hoc Committee, op. cit. (49), p. 8. This recommendation built on the proposal of a IARP in the Petterssen report. Committee on Atmospheric Sciences, op. cit. (41), p. 83.

[52] Ad Hoc Committee, op. cit. (49), pp. 8–10.

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State and at the UN.'[53] On 14 December 1962, the UN General Assembly adopted Resolution 1802 (XVII) at the suggestion of the US government. The new resolution still left a leading role for the WMO, but in Section III, Sentence 5, it explicitly invited 'the International Council of Scientific Unions through its member unions and national academies to develop an expanded programme of atmospheric science research which will complement the programmes fostered by the World Meteorological Organization'.[54]

A major diplomatic operation: paving the way for GARP

While placing the International Research Programme with ICSU was a remarkable success, many other obstacles required attention and a lot of work. ICSU was a huge and complex undertaking, involving a complicated network of institutions and a wide variety of interests. The crucial task ahead was to 'to identify the ICSU body that could most effectively plan this program'.[55] ICSU consisted of unions representing scientific disciplines, such as the IUGG, which included atmospheric science. These unions consisted of a number of subsidiary associations. The IUGG, for example, had seven associations, including the International Association of Meteorology and Atmospheric Physics (IAMAP). The associations in turn ran commissions representing specific disciplines or research areas, such as the Commission on Dynamic Meteorology and the Commission on Meteorology of the Upper Atmosphere of IAMAP. In the case of interdisciplinary research programmes, ICSU occasionally established special committees, such as the non-permanent Comité spécial de l'Année géophysique internationale (CSAGI), which organized the International Geophysical Year in 1957–8, or the permanent Committee on Space Research (COSPAR).[56]

The question of how best ICSU should proceed caused much discussion. Some (such as the US National Committee) favoured a special ICSU committee (like the arrangement for the lGY). Many ICSU officials called for an inter-union committee with representation from several unions. IUGG scientists, on the other hand, wanted to keep it entirely within their union, while many IAMAP representatives saw it as IAMAP's domain. Still others (such as the director general of the UK Met Office, Graham Sutton) demanded that any such programme be the sole prerogative of the WMO, not ICSU.[57] Malone preferred a special ICSU committee. To gain support for this solution, he travelled to Toronto with IAMAP president Horace Byers, a meteorologist who supported Malone's position, to visit IAMAP's secretary general, Canadian meteorologist Warren Godson. The trip did not pay off. Godson was

[53] All quotes are from Malone, 'Reflections', op. cit. (4), p. 12; see also Malone, interview by Earl Droessler, op. cit. (4), p. 5.

[54] UN Resolution 1802 (XVII), International Co-operation in the Peaceful Uses of Outer Space, United Nations General Assembly, New York, 14 December 1962, p. 6, at https://research.un.org/en/docs/ga/quick/regular/17 (accessed 31 August 2023).

[55] Malone, 'Reflections', op. cit. (4), p. 12.

[56] For a history about ICSU and its bodies see Greenaway, op. cit. (2). For a full list of Commissions of IAMAP see 'Twelfth General Assembly, International Union of Geodesy and Geophysics, Helsinki, Finland, July 25–August 6, 1960, Meteorology and Atmospheric Physics', *Eos: Transactions of the American Geophysical Union* (1960) 41(4), pp. 582–604, 582. For a history of the IGY and the role of CSAGI see Needell, op. cit. (14), pp. 297–323.

[57] Malone, 'Reflections', op. cit. (4), p. 12–13. Malone to Kaplan, 6 June 1964, p. 3; IAMAP president Alexander M. Oboukhov and secretary Warren Godson, 'Memorandum to IAMAP Executive Committee', 12 February 1964; Warren Godson, 'International Union of Geodesy and Geophysics, CIR 3012, Atmospheric Sciences', 11 February 1964; all in Bolin Correspondence, Meteorological Institute of Stockholm University, folder IUGG-CAS 1964–5 (abbreviated in the following Bolin Correspondence, IUGG-CAS, 1964–5). The latter circular by Godson summarized the events and decisions taken.

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'understandably adamant that IAMAP undertake the task'.[58] The issue had to be taken up and resolved at the Triennial General Assembly of the IUGG. This meeting, hosted by the American Geophysical Union (AGU) in Berkeley, was held from 19 to 31 August 1963 and attended by some 2,500 scientists. As president of the AGU, Malone was the official host and responsible chair of the conference, led the US delegation – and was responsible for much of the politics. He remembered the meeting as 'very interesting' and 'very complex' and the IUGG Council meetings as a 'rough journey'.[59]

Malone's negotiations before and at the Berkeley conference had focused on key officials in the USA and in ICSU, especially on IAMAP and IUGG officers. At this point, negotiations across the Iron Curtain did not seem to have been an issue of much concern. Malone hoped to persuade IUGG officers to propose a special ICSU committee to develop an international atmospheric programme, but the IUGG Council ultimately voted against his proposal. 'A resolution recommending establishment of an Interunion Committee on Atmospheric Sciences, with IUGG acting as parent Union, was adopted without dissent.'[60] The newly elected president of IUGG, geophysicist Joseph Kaplan of the University of California, Los Angeles (succeeding Vladimir Belousov of the Soviet Union), and the new IUGG Executive Committee decided at a meeting in London in September 1963 to propose to ICSU the establishment of a Committee on Atmospheric Sciences under the joint auspices of ICSU and the IUGG. Kaplan and the IUGG secretary general, the Canadian geophysicist George D. Garland, supported Malone's proposal for an international research programme and proposed Bert Bolin as chairman of this committee.[61]

The IUGG proposal was discussed at the ICSU General Assembly in November 1963. ICSU decided to establish an Inter-Union Committee on Atmospheric Science (IUCAS), chaired by Bolin, but it was much larger than Bolin and Malone had hoped. Four unions and five IUGG associations were invited to nominate representatives. IUCAS was mandated to maintain 'close liaison' with the WMO, to invite proposals from ICSU members by 31 March 1964, to organize a first meeting to discuss proposals in the spring of 1964, and to prepare a report on the proposals submitted by June 1964, when the next meeting of the ICSU Executive Committee was to be held.[62] Over the next few weeks, Bolin tried to lobby for the appointment of supportive scientists to the committee and to get Charney on board, but to no avail. 'Within these constraints, the outlook was not too bright', Malone concluded. He was 'deeply concerned that, once more, an attempt on the part of the scientific community to be responsive to the UN Resolution' might fail. In his eyes, 'the most pressing need was to establish a mechanism within which interested scientists with diverse backgrounds could be brought together and feel comfortable'.[63] Bolin, like Malone, was convinced that IUCAS was an inappropriate vehicle for establishing an ambitious international programme. In

[58] Malone, 'Reflections', op. cit. (4), p. 12; Malone, interview by Earl Droessler, op. cit. (4), p. 5. The IUGG Executive Committee had already decided in March 1963 that IAMAP 'could assume full responsibility'. Godson, 'International Union', op. cit. (57), p. 2.

[59] Malone, interview by Earl Droessler, op. cit. (4), p. 6; National Academy of Science/National Research Council, *Annual Report Fiscal Year 1963-64*, Washington, DC: US Government Printing Office, 1967, p. 111.

[60] Malone, interview by Earl Droessler, op. cit. (4), pp. 7–8. 'Report on the Thirteenth General Assembly, IUGG', *Eos: Transactions of the American Geophysical Union* (1963) 44(4), pp. 897–1011, 951.

[61] Malone, 'Reflections', op. cit. (4), p. 12; Malone, interview by Earl Droessler, op. cit. (4), p. 8.

[62] George D. Garland, 'Decisions taken at the ICSU Executive Board and General Assembly meetings of special interest to IUGG Vienna, November 1963', *Eos: Transactions of the American Geophysical Union* (1964) 45(1), pp. 137–40, 138; 'ICSU, Xth Ordinary General Assembly', *WMO Bulletin* (1964) 13(1), p. 39. Godson, 'International Union', op. cit. (57), p. 2. Inter-Union Commission on Atmospheric Sciences, 'Report to the Executive Committee of ICSU', June 1964; Bolin to Godson, 16 December 1963; Malone to Kaplan, 6 June 1964, all in Bolin Correspondence, IUGG-CAS, 1964–5.

[63] Malone to Kaplan, 6 June 1964, p. 3, op. cit. (57).

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May 1964 he wrote to his friend and colleague at MIT, Norman Phillips: 'the formal difficulties within a hierarchy of commissions, associations, unions, special committees, scientific committees, interunion committees, etc., are just unbelievable and I think it is principally wrong to start at the top in trying to get some new program going'.[64]

Bolin still took up the challenge and took care to include and secure agreement from major important players. He strategically organized the first IUCAS meeting at the WMO headquarters in Geneva on 8–11 February 1964 to strengthen relations with the WMO and obtain its support.[65] Likewise, he included and sought consent of Soviet scientists. In spring 1964 he travelled to Moscow with Kaplan and Malone to join a meeting of the ICSU Executive Committee and discuss the work of IUCAS. During this visit they also had discussions with Alexander Mihailovich Oboukhov from Moscow State University and other Soviet scientists. Oboukhov was elected president of IAMAP in November 1963 and a member of IUCAS. He was interested in the US proposals and supportive of Bolin's and Kaplan's plans. Oboukhov was also copied in on all major letters in Bolin's correspondence file. Oboukhov also had good contact with US scientists of the IAMAP Commission on Dynamic Meteorology (CDM) such as Norman Phillips (CDM chairman) and Siegmund Fritz, chief of the Weather Bureau's Meteorological Satellite Section.[66]

Bolin scheduled the next IUCAS meeting for 15–16 May in Florence, where the 7th COSPAR Conference and Scientific Assembly took place from 11 to 20 May. This meeting was dedicated to discussing the proposals received for an international research programme. A joint meeting with COSPAR was useful to save travel costs and time for many participants and to discuss COSPAR's role in the proposed programme.[67] This pace was not universally supported. British IUCAS member Reginald Sutcliffe complained in a letter to IUGG secretary general Garland about the inadequate preparation for the Florence meeting, with only one or two 'definite national proposals' available. Sutcliffe suggested instead a meeting in the autumn for careful discussions with the WMO and national representatives.[68] Only the USA submitted a detailed proposal in the form of a new report prepared by the Committee on Atmospheric Sciences of the US National Academy of Sciences.[69] In addition to this proposal, IUCAS received smaller and less developed proposals from the Federal Republic of Germany, Thailand, Israel and New Zealand.[70]

The IUCAS meeting was held in Florence on 14 and 15 May. Kaplan was absent and sent Malone to represent him. IAMAP president Oboukhov and his alternate Sutcliffe did not join the meeting. It proved to be a difficult meeting, but Bolin managed to reach a resolution. Bolin had carefully prepared and timed a bold strategic move. He managed to get agreement in IUCAS, first, to support the US proposal (while the smaller others could be referred

[64] Bolin to Norman Phillips, 19 May 1964, Bolin Correspondence, IUGG-CAS, 1964–5. IAMAP, which hoped to lead the development of the international programme, shared Bolin's position. IAMAP president Oboukhov and secretary Godson wrote to the IAMAP Executive Committee, 'Creating a permanent IUCAS would be largely a waste of time of a great many valuable scientists, and the job that it would be asked to do has always seemed to me to be ill-defined and overlapping the jobs of other groups already in existence.' Oboukhov and Godson, 'Memorandum', op. cit. (57).

[65] Malone, 'Reflections', op. cit. (4), p. 14. Malone, interview by Earl Droessler, op. cit. (4), pp. 9–10.

[66] Malone to Kaplan, 6 June 1964; Kaplan to Bolin, 9 June 1964; Fritz to Oboukhov, 21 July 1964; Oboukhov to Fritz, 1 September 1964; all in Bolin Correspondence, IUGG-CAS, 1964–5.

[67] Malone to Kaplan, 6 June 1964, op. cit. (57). This five-page letter provided an extensive report of the Florence meeting with many background details and was copied to twenty-eight people.

[68] Notably Bolin was only copied in on the letter together with Oboukhov, Godson and others. Sutcliffe to Garland, general secretary of IUGG, 16 March 1964, Bolin Correspondence, IUGG-CAS, 1964–5.

[69] Committee of Atmospheric Sciences, 'Further views on international cooperation in the atmospheric sciences, National Academy of Sciences', Washington, DC, 1964, Bolin Correspondence, IUGG-CAS, 1964–5.

[70] Inter-Union Commission, op. cit. (62), p. 2.

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to IAMAP for consideration) and, second, to terminate IUCAS and propose the establishment of a new COSPAR working group as the coordinating body for this programme. On 20 May, five days after the conclusion of the IUCAS meeting, COSPAR held its General Assembly in Florence, which responded positively to the IUCAS proposal and resolved to establish COSPAR Working Group 6 to develop the envisaged international atmospheric research programme under the chairmanship of Bolin. In so doing, Bolin hoped to avoid the competition, conflict and constant bickering that had dogged the IUCAS deliberations from the outset.[71]

While Malone was delighted, IUGG president Kaplan was 'not at all happy over the proposed solution', as he wrote immediately to Bolin. Kaplan recognized the difficulties Bolin was facing, but a COSPAR working group to coordinate programme development was unacceptable to him. Nevertheless, Kaplan trusted Bolin and was prepared to support him. He suggested that they should 'move ahead as if the IUCAS resolution of COSPAR had been approved' by ICSU.[72] The ICSU Executive Committee met in London from 15 to 17 June 1964. It accepted in principle the US proposal and the dissolution of IUCAS. It also approved COSPAR Working Group 6, but decided that the development and coordination of a research programme would have to take place 'under the general auspices of IUGG'.[73]

Bolin, Charney and Norman Phillips (who chaired the IAMAP Commission on Dynamic Meteorology) continued to plan the scientific content of the programme. Bolin argued that the programme should be developed from the bottom up by a few scientists with

> one, for example, dealing with the dynamical problems to be considered in designing such an experiment, another carefully going through the radiation problems involved, a third becoming busy with instruments, system design, etc. ... If something good is accomplished, there will be no difficulty in securing recognition at appropriate levels.[74]

Over the next few weeks, Charney spoke to leading experts in ocean–air interaction, satellite radiometry and constant-level balloons to get their input for a comprehensive programme.[75]

Kaplan, on the other hand, took responsibility for setting up the new committee, as requested by the ICSU Executive Committee. ICSU president Harold Warris Thompson had demanded multi-union representation but was also under pressure to move quickly after much criticism of the lack of progress. He gave Kaplan and Bolin much more freedom to carefully select appropriate committee members. Kaplan appointed Bolin as chairman and Malone, who had offered his office at the National Academy of Sciences as a secretariat for the new committee, as secretary of the committee. Kaplan and Bolin also suggested including the two Soviet scientists, Alexander Obhoukov and atmospheric physicist Kirill Kondratiev, in the committee, which ICSU president Thompson accepted. By December 1964 the committee, now called the IUGG Committee on Atmospheric Science (IUGG-CAS),

[71] Malone to Kaplan, 6 June 1964, op. cit. (57), pp. 2–3; COSPAR Resolution No. 25; Bolin Correspondence, IUGG-CAS, 1964–5.

[72] Kaplan to Bolin, 8 June 1964; Kaplan to Bolin, 9 June 1964; both in Bolin correspondence, IUGG-CAS, 1964–5.

[73] Inter-Union Commission, op. cit. (62); response from ICSU to the United Nations, no date; Godson to Bolin and Phillips, 26 June 1964; Maurice Roy, president of COSPAR, to Bolin, 2 July 1964; all in Bolin Correspondence, IUGG-CAS, 1964–5. Both Godson and Roy cited from the executive committee resolution that was not found in Bolin's correspondence.

[74] Bolin reported similarly to IUGG president Kaplan. Bolin to Norman Phillips, 19 May 1964; Bolin to Kaplan, 5 June 1964, both in Bolin Correspondence, IUGG-CAS, 1964–5.

[75] Phillips to Bolin and Godson, 17 July 1964, Bolin Correspondence, IUGG-CAS, 1964–5.

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was almost complete.[76] Reginald Sutcliffe, vice president of IAMAP, strongly criticized this approach. 'I cannot believe that an acceptable alternative is the association of a few dynamicists chosen on an individual basis with powers to co-opt', he wrote. 'No doubt such an arrangement would allow certain enthusiasts to press on with their own programmes but in the long run it is far more important, in my view, to provide encouragement and stimulate activity in atmospheric science over a broad front.'[77] Unfortunately, the available sources do not provide further insight into conflicts, competition and opposing positions such as Sutcliffe's.

Bolin stuck to his demands for an 'effective working group'.[78] He helped to smooth the process by listening to critics such as Sutcliffe and Godson of IAMAP and offering compromises without deviating from the objectives. The IUGG-CAS was created to plan and coordinate the development of the atmospheric research programme. It relied on cooperative members and was largely free of conflicts over formal protocols. Kaplan and Thompson had strongly supported the process and used their standing and authority to occasionally bend strict rules and protocols. In fact, the IUGG-CAS met only three times, in February 1965, April 1966 and March 1967. The focus of the following years was the scientific preparatory work, involving many scientists and working groups, led by Charney and Bolin.[79]

As early as January 1965, Bolin informed Thompson of a 'rather precise time schedule' including 'meetings of various working groups', a 'much more complete report' in 1966 and a final symposium to discuss the research programme developed.[80] The report mentioned by Bolin was most likely that prepared by the Panel on International Meteorological Cooperation of the US National Academy of Sciences under the direction of Charney in the autumn of 1965 and published in 1966. It provided a detailed account of scientific considerations for global observations and technical considerations for monitoring techniques and platforms, including satellites, balloons and buoys, and was an important preparatory document for GARP.[81] In the summer of 1967, Bolin organized a final 'study conference' near Stockholm with some seventy participants to discuss and review the international programme. ICSU and the WMO jointly agreed in Rome in October 1967 to establish the Global Atmospheric Research Program.[82]

[76] Thompson to Kaplan, 6 August 1964. In this letter Thompson thanks Kaplan for his letters of 18 and 27 June and of 1, 21, 22 and 23 July 'and all the useful information'. Kaplan to Maurice Roy, 13 August 1964; Kaplan to Bolin, 21 Aug. 1964; Kaplan to Bolin, 11 September 1964; Kaplan to Bolin, 15 September 1964; Bolin to Kaplan, 18 September 1964; Malone to Garland, 9 October 1964; Bolin to Garland, 15 October 1964; Bolin to Kaplan, 18 September 1964; Kaplan, 'Notes on his trip to Europe', 21 August to 8 September, undated (September 1964), Kaplan to Bolin, 23 September 1964; Bolin to Charney, 25 September 1964; Bolin to Garland, 15 October 1964; Garland to Kaplan, 20 October; Thompson to Kaplan, 16 November 1964; Garland to Thompson, 1 December 1964; all in Bolin Correspondence, IUGG-CAS, 1964–5.

[77] Sutcliffe to IAMAP president Oboukhov, 4 September 1964, Bolin Correspondence, IUGG-CAS, 1964–5, with copy to Garland, Fritz, Godson, Bolin and others.

[78] Thompson to Bolin, 28 December 1964; Thompson to Bolin, 13 January 1965; both in Bolin Correspondence, IUGG-CAS, 1964–5.

[79] Godson to Bolin, 18 January 1965; Bolin to Malone, 26 January 1965, Bolin Correspondence, IUGG-CAS, 1964–5; Frederick Sargent, 'Report on the activities of the IUGG Committee on Atmospheric Sciences, 1964–67 to International Biological Unions', undated (spring 1967), Bolin Correspondence, IUGG-CAS, 1966–7.

[80] Bolin to Thompson, 17 January 1965, Bolin Correspondence, IUGG-CAS, 1964–5.

[81] Panel on International Meteorological Cooperation, op. cit. (47).

[82] Rodhe, op. cit. (8), p. 2; Robert W. Stewart, 'The first GARP global experiment: a view from inside', *South African Journal of Science* (1979) 75, pp. 560–1.

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Conclusion

It took six busy years of complicated negotiations before GARP was finally established in 1967. In 1982, after fifteen years of operation, the meteorologist and high-level administrator Robert M. White described GARP as 'a remarkably successful international scientific effort' and a model for similar future efforts. He suggested that 'we should seek to understand the underlying science and the politics [of GARP] for the guidance it can give us in planning and executing the World Climate Program in the years ahead'. Noting the 'troublesome institutional issues' that needed to be addressed for such a global programme, White praised the 'institutional innovation' of a fruitful and effective collaboration between the WMO and ICSU. Both institutions established a 'unique Joint Organization Committee' led by Bolin to coordinate GARP, which was allowed 'to operate with great independence and freedom'.[83]

The history of the development of GARP remains uncertain because of the limited sources available and the limitations of Charney and Malone's accounts. Nevertheless, these sources reveal a rich set of science policy relationships. The starting point for the development of an international programme in the atmospheric sciences was Kennedy's call for international cooperation in atmospheric and space research, which he launched as a diplomatic tool at a time of rising international political tensions. This initiative was an example of *science for policy*, in this case the goal of using science in the service of international diplomacy – in short, science diplomacy.[84] While Kennedy's diplomatic mission was an honest attempt to reduce political tensions, it also served hidden military agendas such as satellite development, intelligence and weather control as a potential weapon.[85] After Kennedy's untimely death in November 1963, Lyndon B. Johnson continued Kennedy's science diplomacy efforts in this area, strongly supporting GARP and investment in weather modification and control.[86] Robert White considered GARP's diplomatic impact as 'eminently successful'. 'It has built bridges. It has brought scientists from nations with different political ideologies together in a common endeavor.' For example, it enabled 'global communication circuits for the exchange of weather data' by allaying concerns in both Moscow and Washington.[87]

Kennedy's diplomatic initiative opened an attractive window of opportunity for scientists. Robert White called it 'a case of science taking advantage of a political situation'.[88] Coincidentally, Jule Charney and Thomas Malone together with many close colleagues came into the position of taking advantage of it and engaged in many activities that may be counted as the *politics of science*, more specifically the subcategory of politics for science. A first important step was the proposal that Charney, Malone and others made to the Kennedy administration, which was an ingenious political intervention. The proposed topic – improved and long-term weather prediction and weather and climate modification – addressed important scientific issues as well as political and military interests, and it seemed to fit well with Kennedy's diplomatic goals, even though the field of research to be

[83] White, op. cit. (33), pp. 924, 930–1.

[84] Science diplomacy has become a recent new field of study. It has been described as 'the effort to leverage science engagement and exchange in support of broader objectives beyond science discovery'. Vaughan Turekian, 'The evolution of science diplomacy', *Global Policy* (2018) 9(53), pp. 5–7. It builds on earlier concepts including 'scientific internationalism' and 'science in foreign policy'. See e.g. Joseph Manzione, '"Amusing and amazing and practical and military": the legacy of scientific internationalism in American foreign policy, 1945–1963', *Diplomatic History* (2000) 24(1), pp. 21–55; Krige, op. cit. (13); Doel and Harper, op. cit. (13). In the history of science, science diplomacy has become a booming field. See e.g. Turchetti *et al.*, op. cit. (7); Wolfe, op. cit. (13), esp. p. 199.

[85] Edwards, op. cit. (1); pp. 112–13, 189–93; Doel and Harper, op. cit. (13).

[86] White, op. cit. (33), p. 927; Doel and Harper, op. cit. (13).

[87] White, op. cit. (33), p. 931.

[88] White, op. cit. (33), p. 927.

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supported – numerical weather and climate prediction – was at that time a rather small speciality of only a few research groups.[89] We do not know whether this proposal had serious competitors in the US. In any case, Charney and Malone made ample reference to weather and climate prediction and control as political levers in the crucial early stages of building political and institutional momentum.

Malone, as a senior science administrator, was undoubtedly a strong political actor and deeply involved in the politics of making this proposal work. Malone held a key position as chairman of the National Academy of Sciences' Committee on Atmospheric Science, which helped him to support the official process of building consensus in the academic community. The two major academy reports strongly recommended international research into weather prediction and weather and climate change, although other areas were also considered.[90] Responsibility for the first report was, as climatologist Helmut Landsberg noted, 'wisely delegated' to Sverre Petterssen. It involved input from and discussion with more than two hundred scientists.[91] In addition, as committee chairman and president of both the AMS and the AGU, Malone was an obvious direct point of contact for the administration and helped to push for ICSU's involvement in setting up an international programme rather than leaving it entirely to the WMO.[92]

Competition within science for funding and support, between disciplines and research areas, between institutions (ICSU bodies as well as universities and weather services) and between nations required careful negotiation, manoeuvring and navigation throughout the development of GARP. These efforts may be counted in the *politics in science* category, about which Bolin's correspondence provides limited, but interesting, insights. Bolin's and Malone's comments highlight the difficulties of achieving consensus in a complex institution such as ICSU and its subsidiary bodies. Bolin hoped to avoid controversial discussions in large committees with diverse membership, preferring a small committee with constructive members and sufficient autonomy to develop a programme from the bottom up rather than the top down. It also seems that both Bolin and Malone wanted to avoid a committee under IUGG or IAMAP, which were the obvious bodies for an atmospheric-science programme. We can only speculate about the reasons for this. Perhaps they feared the risk of disagreement and competition between the many different research areas in the atmospheric sciences that were organized in IAMAP and the IUGG.

Malone, according to his own version of the story, was unable to get agreement in the IUGG for an ICSU special committee (not directly affiliated to any union). Instead, ICSU established an Inter-Union Committee of Atmospheric Science with broad and diverse representation. Bolin found this committee ineffective and pulled off a clever political coup by replacing IUCAS with a new working group under COSPAR to develop the proposed international atmospheric programme. Although this strategy failed, it helped Bolin get his message across. IUGG president Kaplan and ICSU president Thompson adopted a pragmatic policy, leaving Bolin and his associates much freedom to finally establish an effective IUGG Committee on Atmospheric Science in late 1964. The available sources indicate lengthy discussions and occasional controversies throughout the process, but do not reveal details.

[89] Apart from weather offices in several countries, Edwards identified three research groups in general circulation modelling in 1960 and five in 1967. Edwards, op. cit. (1), p. 168. Operational numerical weather prediction was pursued in the late 1960s in weather offices in at least some twenty countries. Anders Persson, 'Early operational numerical weather prediction outside the USA: an historical introduction. Part II: twenty countries around the world', *Meteorological Applications* (2005) 12(2), pp. 135–59.

[90] Committee on Atmospheric Sciences, op. cit. (41); Ad Hoc Committee on International Programs, op. cit. (49).

[91] Landsberg, op. cit. (42), p. 179.

[92] White, op. cit. (33), p. 926.

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Only the British meteorologist Reginald Sutcliffe emerged as a strong voice against Bolin's haste and the informal way in which Bolin and his associates were allowed to shape the IUGG-CAS according to their interests. The reasons for Sutcliffe's intervention are not entirely clear, but a degree of competition seems likely. As outgoing president of the WMO Commission on Aerology, in 1961 Sutcliffe strongly advocated raising the research profile of the WMO, establishing a 'WMO Research Board' and creating a 'WMO Research Programme'. In 1964, Sutcliffe was appointed to the WMO 'Advisory Committee' on research. He was clearly committed to better coordination of ICSU and WMO research and possibly preferred a stronger role for the WMO.[93] In addition, as vice president of IAMAP, Sutcliffe would probably have preferred a wider involvement of IAMAP scientists and research areas. In October 1967, however, Sutcliffe strongly supported GARP against the 'strident and vociferous opposition' of the director of the Met Office, Basil John Mason.[94]

Jule Charney, Thomas Malone and Bert Bolin were part of a much larger number of scientists and political actors involved in the development of GARP. The available sources do not allow a comprehensive and reliable assessment of their roles. However, they do show that Charney, Malone and Bolin were strategic and political thinkers, engaged in political negotiations and helping to build consensus for the establishment of a global atmospheric research programme. In the narrative they partly constructed for themselves, Charney emerged as the scientific mastermind who provided the scientific authority and intellectual underpinning for GARP. Malone served as the well-connected and witty string puller who, as a scientist and science administrator, played the political field in scientific and political institutions. Bolin, finally, emerges in his correspondence as a wise navigator and scientific mediator, able to find viable paths and promote progress in the labyrinth of competing ICSU bodies, scientific communities and scientists.

[93] Reginald Sutcliffe, 'The role of WMO in research', *WMO Bulletin* (1961) 10(4), pp. 203–7; 'Advisory Committee', op. cit. (39); Jonathan E. Martin, *Reginald Sutcliffe and the Invention of Modern Weather Systems Science*, West Lafayette, IN: Purdue University Press, 2021, pp. 249, 260–2, 266.

[94] Martin, op. cit. (93), p. 310. Reginald Sutcliffe, 'International Union of Geodesy and Geophysics, XIVth General Assembly, Switzerland, 1967', *WMO Bulletin* (1968) 17(2), pp. 71–3, esp. 73. The British stances on GARP appear much more complex and deserve further investigation.

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