The Evolution of International Cooperation in Climate Science

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International regimes in the scientific sphere have been surprisingly successful in arriving at a consensus on 1) reliable factual statements about the world and 2) clear, actionable advice to policy-makers. The history leading to the Intergovernmental Panel on Climate Change (IPCC) exemplifies how this success relies upon the norms, rules, and procedures the scientific community has developed since the seventeenth century. By the very nature of climate, scientists had to study it across national boundaries. Already in the nineteenth century, meteorologists formed occasional international collaborations and simple coordinating bodies. From the 1950s onward, these expanded into elaborately organized global research programs involving thousands of experts. The programs chiefly studied daily weather, but when research pointed to the possibility of global warming, it raised scientific questions that could only be addressed through international cooperative studies and policy questions that demanded international negotiations. When governments formed the IPCC, geoscientists based it upon the social systems developed in their earlier cooperative efforts.

The constitution of the IPCC looked like a recipe for paralysis and perhaps was intended to be. The governments promoting the panel had grown wary of demands for sweeping policy changes from self-appointed bodies of scientists; a body governed by official government representatives could be relied on to avoid radical environmentalist sentiments. The IPCC's reports to policy-makers would require a consensus of essentially every competent climate scientist plus the unanimous consensus of political appointees from all the participating nations. As might be expected, the IPCC's earliest summary pronouncements were beaten into a mush of weasel-worded statements that called only for more research.

By 2001, the panel had turned its procedural restraints into a virtue: Whatever it did manage to say would have unimpeachable authority. In the teeth of opposition from the fossil fuels industry—the greatest concentration of economic power the world had ever seen—the IPCC issued what is arguably the single most important policy advice any body has ever given. If the world economy continued its trajectory, the IPCC declared, before the end of the century climate change would probably bring severe harm to many nations and quite possibly global catastrophe. It was a call for nothing less than a wholesale restructuring of the world's economies and ways of living.[1]

1. For general history of these developments see Weart (2008) and the much larger online version Weart (2010).

Whether or not governments paid heed, in fulfilling its declared purpose of providing advice, the IPCC has rightly been considered a remarkable success. Taking this as an example, we may set two criteria for the effectiveness of an international regime in the scientific sphere. Does it arrive at a consensus on frank, clear, objective, and significant statements about the nature of the world? (For example, human emissions of greenhouse gases will raise global temperatures by a few degrees in the coming century.) And through these statements, does it implicitly or explicitly set an agenda for policy negotiations and action, with a clear statement of the desirable outcome or outcomes? (For example, nations severely restrict their emissions of greenhouse gases.) Whether the advice is followed will depend on social, ideological, political, and economic forces far beyond the scope of the particular regime; thus, regime effectiveness must be judged by the clarity and forcefulness of the advice rather than whether it is ultimately followed.

The IPCC, although exceptional in the scope of its mission and effort, is not unique in its methods and outcome. In particular, a requirement for consensus, and the procedures and norms that make it workable, are found in the decision-making of many other international regimes that employ scientific research to address environmental problems. As a survey by Breitmeier et al. (2006, 231–32) showed, these regimes have been more effective than many would expect. What made this possible? The answer lies in a fact already noted by international relations scholars: The IPCC worked in accord with "the rules, norms, and procedures that govern science at large" (Skodvin, 2000, 157). The purpose of the present paper is to explore just what this meant, by describing the historical process that brought it about.

First Efforts to Coordinate Climate Research

Meteorologists of different nationalities had long cooperated in the loose informal fashion traditional for all scientists, reading one another's publications and visiting one another's universities. Already for nearly a century they had been reaching beyond that. As a leading meteorologist later remarked: "One of the unique charms of geophysical science is its global imperative" (Smagorinsky, 1970, 25). In blunt practical terms, you can't predict the weather if you don't know what's happening beyond your national borders.

In the second half of the nineteenth century, meteorologists got together in a series of international congresses, which led to the creation in 1879 of an *International Meteorological Organization*. Run mainly by the directors of national weather services, the organization encouraged the spread of meteorological stations and the exchange of weather data. It made ceaseless efforts at standardization—there was limited value in exchanging data when different nations measured the temperature, for example, at different times of day. Since the organization had no official status in any nation and depended on voluntary and haphazard contributions, its efforts were often ignored. By the 1930s the leaders recognized their effort needed some sort of official status with governments, and they began to explore possible mechanisms (Edwards, 2010, 51–9).

Meanwhile, scientists who were interested in climate also met one another, along with specialists concerned with many other subjects of geophysical research, in an International Union of Geodesy and Geophysics, which was established in 1919. It became known as IUGG—one of the first of countless acronyms that would infest everything geophysical and international. Specialties relevant to climate included meteorology, oceanography, and volcanology, each represented within IUGG by a semi-autonomous association. There were a number of similar unions that fostered cooperation among national academies and scientific societies, sponsoring a variety of committees and occasional grand international congresses, gathered under the umbrella of the International Council of Scientific Unions (ICSU). IUGG, along with an association of astronomers, was the first of these unions. Geophysicists needed international cooperation for their research more than most other scientists did (Greenaway, 1996, 48–50, passim). And oceanographers' research expeditions could scarcely function without permission to resupply at foreign ports.

IUGG, with other groups in ICSU, organized sporadic programs of coordinated observations. The leading example was an *International Polar Year* (1932–33), carried out in cooperation with the International Meteorological Organization. Scientists arranged all these matters among themselves, involving diplomats only where absolutely necessary. In making their arrangements, they relied on a heritage of principles and practices for collaboration that the scientists had learned in the course of their education and socialization into the scientific community: Joint use of experimental facilities, discussion based on reason and data, respect for leaders who had established their credentials through important scientific publications, and so forth, all established during the nineteenth century or earlier.

None of these organizations did much to advance research on climate. Up through the mid-twentieth century, climatology was mainly a study of regional phenomena. The climate in a given region was believed to be set by the sunlight at the particular latitude, along with the configuration of nearby mountain ranges and ocean currents, with the rest of the planet scarcely involved. However, climatology textbooks did feature diagrams of the entire globe, divided into climate zones by temperature and rainfall. Hopes for a fundamental science of climate pushed climatologists toward a global perspective, as they drew on data compiled by people of many nationalities.

World War II greatly increased the demand for international cooperation in science and not only toward military ends. Some of those who worked for cooperation hoped to bind peoples together by invoking interests that transcended the self-serving nationalism that had brought so much horror and death. When the Cold War began, it only strengthened the movement. If tens of millions had recently been slaughtered, nuclear arms could slay hundreds of millions. Creating areas where cooperation could flourish seemed essential. Science, with its long tradition of internationalism, offered some of the best opportunities.

Fostering transnational scientific links became an explicit policy for many of the world's democratic governments, not least the United States. It was not just that gathering knowledge gave a handy excuse for creating international organizations. Beyond that, the ideals and methods of scientists, their open communication, and their reliance on objective facts and consensus rather than command would reinforce the ideals and methods of democracy. As political scientist Clark Miller (2001, 171, passim) has explained, American foreign policy-makers believed the scientific enterprise was "intertwined with the pursuit of a free, stable, and prosperous world order." Scientists themselves were still more strongly committed to the virtues of cooperation. For some, like oceanographers, international exchanges of information were simply indispensable for the pursuit of their studies. To many, the free association of colleagues across national boundaries meant yet more: It meant advancing the causes of universal truth and world peace (e.g., Hamblin 2002, 14).

Study of the global atmosphere seemed a natural place to start. In 1947, a world meteorological convention, arranged in Washington, D.C., explicitly made the meteorological enterprise an "intergovernmental" affair—that is, one to which each nation appointed an official representative. In 1951, the International Meteorological Organization was succeeded by the *World Meteorological Organization* (WMO), an association of national weather services. The WMO soon became an agency of the United Nations. That gave meteorological groups access to important organizational and financial support and brought them a new authority and stature.

All the organizational work for weather prediction did little to connect the scattered specialists in diverse fields who took an interest in climate change. A better chance came in the mid 1950s, when a small band of scientists got together to push international cooperation to a higher level in all areas of geophysics. They aimed to coordinate their data gathering and—no less important—to persuade their governments to spend an extra billion or so dollars on research. The result was the International Geophysical Year (IGY) of 1957–58.

IGY with its unprecedented funding was energized by a mixture of altruistic hopes and hard practical goals. Scientists expected in the first place to advance their collective knowledge and their individual careers. The government officials, who supplied the money, while not indifferent to pure scientific discovery, expected the new knowledge would have civilian and military applications. The U.S. and Soviet governments further hoped to win practical advantages in their Cold War competition. It is a moot question whether, in a more tranquil world, governments would have spent so much to learn about seawater and air around the globe. For whatever motives, the result was a coordinated effort involving several thousand scientists from sixty-seven nations (Needell, 2000, ch. 11; Greenaway, 1996, ch. 12).

Climate change ranked low on the list of IGY priorities. IGY's official reports scarcely noticed many meteorological subjects, for example computer modeling. With such a big sum of new money, there was bound to be something for topics that happened to be related to climate. Highly important work was done under IGY auspices on projects from drilling cores of ancient ice to measuring the level of carbon dioxide gas (CO_2) in the atmosphere. No less important, the task of spending all that IGY money appropriately pushed meteorologists, oceanographers, and other earth scientists to coordinate their work, at both the national and international levels, to an extent that had been sadly missing until then. The field of geophysics rose to a new level of strength and cohesion as an international community. This community as a whole constituted a sort of rudimentary international regime. For its effectiveness, it not only relied on procedures long established in the scientific community but was also busily engaged in elaborating and codifying procedures for its specific needs.

The effort still fell far short of gathering the kind of data from around the globe that would be needed to understand the atmosphere well. For example, even at the peak of IGY there was only one station reporting upper-level winds for a swath of the South Pacific Ocean fifty degrees wide—one-seventh of the earth's circumference (Lorenz, 1967, 26, 33, 90–91, ch. 5). The lack of data posed insuperable problems for atmospheric scientists, in particular those who hoped to build computer models that could show a realistic climate, or even just predict weather a few days ahead.

Conversations among mid-level officials, and a 1961 report from the U.S. National Academy of Sciences, brought the problem to the attention of the U.S. government. Addressing the United Nations General Assembly in 1961, President John F. Kennedy called for "cooperative efforts between all nations in weather prediction and eventually in weather control." The president mentioned that one result would be "a better understanding of the processes that determine the system of world climate," but the primary goal he offered was the traditional one, improved weather predictions (Edwards, 2010, 223; Kennedy, 1961).

The first step would be worldwide gathering and exchange of data. WMO eagerly took up the proposal, quickly organizing a world weather watch using the new satellites as well as traditional balloons and so forth. The watch has continued down to the present as the core WMO activity. It has served weather forecasters everywhere, scarcely impeded by the Cold War and other international conflicts—a striking demonstration of how science can transcend nationalism (even if the original motives included a strong nationalist component).

Among the most important, and most obscure, jobs of the meteorologists was to agree on standards for exchanging data: How many times a day should a station measure the wind, for example, and at what times, and exactly how? As the historian of science Edwards (2004, 2010) has pointed out, imposing standards meant overcoming formidable obstacles, ranging from perceived national interests and diverging legal requirements to the cost of new instrumentation and sheer bureaucratic inertia. The standardization gradually achieved by the world weather watch capped more than a century of difficult negotiations and formed the seldom appreciated but essential foundation for everything that the world's scientists would eventually be able to say about climate change. A simple statement like, "2010 was globally the warmest year on record" hid within it the lifework of hundreds of specialists and hundreds of thousands of meticulous observers.

The world weather watch and WMO had reached the status of an international regime. Indeed, they are paradigmatic of such regimes, prominent among the examples that Ruggie (1975: 570–72) gave in his classic paper on the need to restructure international institutions to deal with the ever greater scope of scientific and technological developments. In defining the term "international regime [as] a set of mutual expectations, rules and regulations, plans, organizational energies, and financial commitments, which have been accepted by a group of states," Ruggie highlighted the system of national weather bureaus exercising their capabilities "in accordance with a collectively defined and agreed-to plan and implementation program."

WMO was effective because it did tie together preexisting national systems by negotiating consensual technical standards and guidelines for communication. As Edwards pointed out, "It marked the successful transfer of standard-setting and coordinating powers from national weather services to a permanent, globalist intergovernmental organization . . . a genuinely global infrastructure." What made for this success in binding the national agencies was not a hierarchical authoritarian control, but norms for behavior and rules of procedure that already had been worked out within the scientific community (Edwards, 2010, 242, 250). The elaborate structure of committees, making their decisions largely by consensus, and the exchanges of increasingly standardized data could never have functioned if scientists had not long been familiar with such committees and exchanges in their everyday work at their home institutions, down to the individual university department or government agency.

Meanwhile ICSU, determined not to be left out, decided to join WMO in organizing global meteorological research. As a union of independent, mostly academic, scientific groups, ICSU often took a different view of affairs than WMO, a UN-administered confederation of governmental agencies. Their negotiations were ponderous and sometimes frustrating. Nevertheless, in 1967 the two organizations managed to set up a Global Atmospheric Research Program (GARP). The program's primary goal was better weather forecasting, but the organizers, with an eye on the steadily rising curve of atmospheric CO_2, meant to study climate too.

The organization was inevitably complex. An international committee of scientists would set policy, helped by a small full-time planning staff in Geneva. Panels of specialists would design individual projects, while boards of government representatives would arrange for funding and other support. Also necessary was an additional layer: national panels to guide the participation by each individual nation (for the U.S., the group was appointed by the National Academy of Sciences).

Already by 1973 the observing system for GARP and the world weather watch was in place, seven satellites—four of them built by the U.S.—and one each by the SU, the European Space Agency, and Japan. Evidently the organizational complexities were not a hindrance but an advantage, at least in the hands of people who knew how to work the system (Edwards, 2004; Fleagle, 2001, 57, 97; Perry, 1975, 661; Conway, 2008).

The chair of GARP's organizing committee during its crucial formative years (1964–71) was Swedish meteorologist, Bert Bolin. He had started his career working in Chicago on the arcane mathematics of atmospheric circulation and won a high reputation by devising equations for weather prediction computers in Princeton and back in Stockholm. As the importance of the greenhouse effect came into view, he became an expert on the chemical and biological operations of CO_2. Yet it was less for his wide-ranging scientific savvy that Bolin was chosen to organize GARP than for his unusual ability to communicate and inspire people. It helped that he was based in traditionally neutral Sweden, but it was more important that, as one colleague put it, Bolin was "a brilliant and honest scientist, who listened to and respected diverse views." Self-effacing and soft-spoken, as Bolin developed his diplomatic skills, he would become the mainstay of international climate organizing efforts, culminating in his service as the first chair of the IPCC from 1988 to 1997.[2] For the purposes of this article, Bolin may be seen as a living embodiment of the long-standing norms of the scientific community, in particular, a commitment to seeking consensus through extended, fact-based, rational discussion.

Among Bolin's difficult tasks was getting people not only from different countries but from different geophysics fields to find a common language. The central activity of GARP was coordinating international research projects, which gathered specialized sets of data on a global scale, complementing the routine record-keeping of the world weather watch. The

2. The key organizing committee was the *Committee on Atmospheric Sciences*; Bolin became chair of GARP itself in 1967. See Bolin (2007, 20–23). Short biographies and obituaries of Bolin may be found on the Internet; the quote is from Watson (2008).

process was never straightforward. Great heaps of raw data are meaningless in themselves but must be standardized by elaborate processing using methods that are themselves subject to lengthy discussion and negotiation (Edwards, 2010).

Although GARP included research on climate, it was aimed more at meteorology. Global climate, one scientist recalled "was considered a very subordinate field compared with synoptic forecasting, atmospheric research, and so forth." Some even questioned whether WMO should work in climatology at all (Taba, 1991, 106). In the late 1960s, an environmental movement was everywhere on the rise, and officials could no longer ignore global changes. As a first step in 1969, WMO's commission for climatology established a working group on climate forecasts. Meanwhile, WMO passed a resolution calling for global monitoring of climate and atmospheric pollutants, including CO_2. Climate was also among the many topics addressed by a Scientific Committee on Problems of the Environment (SCOPE), established by ICSU officials in 1969 as an international framework for collecting environmental data and for related research. The SCOPE committee, aware of the CO_2 greenhouse problem, promoted the first extensive studies of how carbon passes through bio-geochemical systems (Greenaway, 1996, 1761–82).

Approaches to Policy Advice

Climate scientists met one another in an increasing number of scientific meetings, from cozy workshops to swarming conferences. Such meetings had a long heritage in more narrow scientific disciplines. They could be carried to a successful conclusion—such as the traditional issuance of some sort of consensus statement at the close—only because scientists already understood, from generations of experience, effective ways to organize and conduct such meetings.

The first significant conferences where scientists discussed climate change included the topic as just one of several "Global Effects of Environmental Pollution," to quote the title of a two-day symposium held in Dallas, Texas in 1968 (Singer, 1970). This pathbreaking symposium was followed by a month-long "Study of Critical Environmental Problems" (SCEP) organized at the Massachusetts Institute of Technology in 1970. All but one of the participants at MIT were residents of the U.S., and some felt that environmental issues demanded a more multinational approach, particularly to meet the need for standardized global research programs. This led directly to a second, more comprehensive gathering of experts from fourteen nations in Stockholm in 1971, funded by an assortment of private and government sources. The Stockholm meeting focused specifically on climate change—a "Study of Man's Impact on Climate," SMIC (Barrett and Landsberg, 1975, 16; SCEP, 1970; Matthews et al., 1971; Wilson and Matthews, 1971). Breaking away from the environmental movement's usual local and regional concerns to focus on global problems, the lengthy SCEP and SMIC meetings were "bonding experiences as well as opportunities for scientific exchange" (Edwards 2010, 361).

The exhaustive SMIC discussions failed to work out a consensus: Some scientists believed greenhouse gases were warming the earth, others suspected pollution from particles was cooling it. Nevertheless, all agreed in issuing a report with stern warnings about the risk of severe climate change. The climate could shift dangerously "in the next hundred years," the scientists declared, and "as a result of man's activities" (Wilson and Matthews, 1971, 125–29). What should be done? Like almost all scientists at the time, SMIC experts mainly called for more research, to determine how serious the problem really was. They recommended a major international program to monitor the environment, much larger and better integrated than the scattered efforts of the time, as well as more research with computer models and so forth.

The SMIC meeting had been organized specifically to prepare for a pioneering UN conference on the human environment that was held the following year, again in Stockholm. The SMIC Report was "required reading" for the delegates (Kellogg and Schneider, 1974, 121; see Kellogg, 1987 and for government-level negotiations in general, Brenton, 1994). Heeding the report's recommendations, along with voices from many directions calling attention to other global problems, the UN conference set in motion a vigorous new United Nations Environment Programme (UNEP). From this point forward, gathering data and other research on the climate was a concern—although only one among many—of the UN's environmental activities (Hart and Victor, 1993, 662; Fleagle, 1994, 174).

Meanwhile, the GARP committee set up a series of internationally coordinated large-scale observations of the oceans and atmosphere. As usual, the main goal was improved short-term weather prediction, but as usual, the findings could also be useful for climate studies. The pilot project was named the GARP Atlantic Tropical Experiment (GATE, an acronym containing an acronym). The aim of the exercise was to understand the enormous transport of moisture and heat from tropical oceans into the atmosphere wherever cumulus clouds billowed up. As one participant boasted, GATE was "the largest and most complex international scientific undertaking yet attempted." In summer 1974, a dozen aircraft and forty research ships from twenty nations made measurements across a large swath of the tropical Atlantic Ocean, along with a satellite launched specially to linger overhead (Robinson, 1967; Fleagle, 1994, 170–73; GARP, 1975; Perry, 1975, quote at 663). Increasingly in such studies, not only would one find teams from different nations cooperating, but also the individual members within a single team might come from a half dozen nations. This was possible, of course, because of the traditional norms and procedures of international exchange (in particular, studying and teaching at foreign universities) that had prevailed among scientists for centuries.

Meanwhile, the world public's climate anxieties were jumping higher as savage droughts and other weather disasters struck several important regions. The WMO secretary-general took note in 1975 of "the many references to the possible impacts of climatic changes on world food production and other human activities at various international meetings," including both a special session of the UN General Assembly and a World Food Conference in 1974. WMO resolved to take the lead in this newly prominent field, organizing an increased number of conferences and working groups on climate change. GARP planners decided to give additional stress to climate research, making what one leader called a "belated, though earnest, and sincere" effort to bring in oceanographers and polar researchers (WMO, 1975, ix; Perry, 1975, 66–7).

If we pause to consider the state of affairs in the early 1970s, we see a rudimentary international regime in climate studies, comprised of components of various intergovernmental organizations, ad hoc conferences, and research programs such as GATE. From various platforms this regime was already making a consensus statement about the nature of the world: Climate change caused by humans might be a serious problem for the future. However tentative and vague, this consensus led to a consensus on clear policy advice: More money and organizational effort should be devoted to climate research. That advice did not infringe on established political or economic interests, and it was taken up with little controversy.

Through all this, climate scientists had little direct access to policy-makers. If they convinced their contacts among lower-level officials that climate change posed a risk, these officials themselves had scant influence with the higher reaches of their governments. The best opportunities lay elsewhere. As one scholar commented, “national research had in many countries a better chance of influencing international policy than domestic policy” (Nolin, 1999, 138). By the mid 1970s, when science officials in various countries became so concerned about climate change that they began to contemplate policy actions, they found sympathetic ears among officials in UN organizations. One notable example was Robert M. White, who in his position as head of the U.S. weather bureau, and afterward of the agency responsible for all government meteorology and oceanography (NOAA), was his nation’s official representative to WMO. Already in the early 1960s, Bob White had been one of the founders of the world weather watch. Now in all his official capacities he pressed for cooperative research on climate change, using American government commitments to influence WMO and vice versa.

Scientists’ demands for action led to a 1978 International Workshop on Climate Issues, held under WMO and ICSU auspices in Vienna, where the participants organized a pioneering World Climate Conference. Their mode of organization was crucial, setting a standard for many later efforts. Participation was by invitation, mostly scientists and some government officials. Well in advance, the conference organizers commissioned a set of review papers inspecting the state of climate science. These were circulated, discussed, and revised. Then more than three hundred experts from more than fifty countries convened in Geneva in 1979 to examine the review papers and recommend conclusions. The experts’ views were diverse, and they managed to reach a consensus only that there was a “serious concern that the continued expansion of man’s activities”—including in particular emissions of CO_2— “may cause significant extended regional and even global changes of climate.” Effects might become visible by the end of the century, so governments should start preparing for “significant social and technological readjustments” along with sponsoring more research (WMO, 1979, 1–2). This cautious statement about an eventual “possibility” was scarcely news, and it caught little attention.

Conferences and other international bodies shied away from any statement that might seem partisan. Scientific societies since their outset (in particular, the foundation of the Royal Society of London in the seventeenth century) had explicitly held themselves apart from politics. This tradition was doubly strong in international science associations, which could not hope to keep cooperation going if they published anything but facts that all agreed upon. Every word of key statements was negotiated, sometimes at great length. When journalists at a press conference after SCOPE issued a report asked a leader of the work what he thought governments should do, he replied, “They should read the report.”

When the journalists said, “Okay, but what next?” he replied, “They should read it again” (Greenaway, 1996, 179, quoting F. Warner).

The most influential work of those who attended the 1978 Vienna conference was structural. Besides organizing the 1979 Geneva meeting, they called for a climate program established in its own right, to replace the miscellaneous collection of uncoordinated “meteorological” studies. The government representatives in WMO and the scientific leaders in ICSU took the advice and in 1979 launched a World Climate Programme (WCP) with various branches. These branches included groups that coordinated routine global data-gathering, plus a World Climate Research Programme (WCRP).

WCRP was the successor to the portion of GARP that had been concerned with climate change. It inherited GARP’s organization and logistics, including WMO administrative support plus its own small staff, and an independent scientific planning committee (Thompson et al., 2001; Jäger, 1992, iii; Fleagle, 1994, 176; Lanchbery and Victor, 1995, 31). As in GARP, the new organization’s main task was planning complex international research projects. For example, under WCRP an International Satellite Cloud Climatology Project collected streams of raw data from the weather satellites of several nations, channeling the data through a variety of government and university groups for processing and analysis. The vast data sets were stored in a central archive, managed by a U.S. government agency.

Up to this point, the U.S. had dominated climate discussions (as it dominated most scientific affairs), while the rest of the world’s advanced nations were digging out of the ruins of the World War II. But now that the other economies and research establishments had recovered, international exchanges became crucial. The driving force, as one observer remarked, was “a small group of ‘entrepreneurs,’ who promoted what they viewed as global rather than national interests.” Blurring the distinction between government officials and nongovernmental actors, they organized a series of quasi-official international meetings, which were increasingly influential (Bodansky, 1997, quote at section 4.1.6). Some of the meetings were formally sponsored by WMO others by ICSU or UNEP.

The most important initiative was a series of invitational meetings for meteorologists sponsored by all three organizations, with particular impetus from UNEP’s farsighted director, the Egyptian Mostafa Tolba. Beginning in 1980, the meetings gathered scientists for intense discussions in Villach, a quiet town in the Austrian Alps. A historic turning point was the 1985 Villach conference, where experts from twenty-nine countries both rich and poor, representing a variety of widely separated fields, exchanged knowledge and argued over ideas. By the end of the meeting, they had formed a prototype of an international climate science community—a community with a firm consensus. From their review of the evidence that had accumulated in the past half-dozen years, the Villach scientists agreed that greenhouse gases could warm the earth by several degrees, with grave consequences. And this was not a matter for some future century, the harm would begin within their own lifetimes.[3]

It was Bolin who wrote the five-hundred-page report of the Villach conference, quietly translating the group’s scientific findings into a bold warning: “In the first half of the next century a rise of global mean temperature could occur which is greater than any in man’s

3. On Villach see Franz (1997), quote (by J.P. Bruce) at 16; see also Pearce (2005), Pearce (2010, 34–7).”Statement by the UNEP/WMO/ICSU International Conference,” preface to Bolin et al. (1986, xx–xxi).

history." As usual, the scientists called for more research. The report also took a more activist stance than scientists had normally taken. Brought together as individual researchers in their personal capacities, with no official governmental responsibilities, they felt free to respond to the alarming conclusions that emerged from their discussions. In their concluding statement, the Villach group pointed out that governments made many policies (building dams and dikes, managing farmlands and forests, etc.) under the assumption that the climate would be the same in the future as in the past. That was no longer a sound approach. Indeed, the prospect of climate change demanded more than a passive response. Pointing out "the rate and degree of future warming could be profoundly affected by governmental policies," the Villach report called on governments to consider positive actions, even a "global convention" to prevent too much global warming. Climate science, in short, was no longer just a matter for scientists (Bolin et al., 1986, xx–xxi).

The press took no notice, but Bolin, Tolba, and others made sure that the Villach recommendations came to the attention of the international scientific leadership. As a practical result, in 1986, WMO, UNEP, and ICSU jointly established an *Advisory Group on Greenhouse Gases* (AGGG). It was a small, elite committee of experts. For funding and advice, it relied largely on individual scientists and environmental organizations that were already advocating policies to restrain climate change. AGGG organized international workshops and promoted studies, aiming eventually to stimulate further world conferences. In particular, a workshop in Bellagio, Italy, in 1987 included among its two dozen participants not only scientists but politicians and policy experts. They took a first stab at policy by proposing a target: The world should not warm up faster than 0.1degree Celsius per decade. Some of those present began to lay plans for a major conference to be held the following year in Toronto (Agrawala, 1999a, 1999b).

Sponsored by UNEP and WMO plus the government of Canada, the 1988 "World Conference on the Changing Atmosphere: Implications for Global Security," nicknamed the Toronto Conference, was another meeting by invitation dominated by scientist experts, not official government representatives, who would have had a much harder time reaching a consensus (there were a few ministers among the threehundred attendees, but most countries were represented by relatively junior people with no authority). The participants were further emboldened by a conference held in Montreal in 1987 that had succeeded in negotiating a protocol for restricting emissions harmful to the planet's protective ozone layer. The Toronto Conference's report concluded that changes in the atmosphere due to human pollution "represent a major threat to international security and are already having harmful consequences over many parts of the globe." For the first time, a group of prestigious scientists called on the world's governments to set strict, specific targets for reducing greenhouse gas emissions. Immediate action was needed, they said, to negotiate an "international framework convention" as a condition for national legislation. That was the Montreal Protocol model: Set targets internationally, and let governments come up with their own policies to meet the targets. Some participants did not wish to step beyond strictly scientific findings into the realm of politics, but the conference set these hesitations aside: Their report declared that by 2005 the world should push its emissions some 20 percent below the 1988 level. Observers hailed the setting of this goal as a major accomplishment, if only as a marker to judge how governments responded (it would turn out that in 2005 the world's emissions were well above the 1988 level).[4]

These UN-sponsored efforts were only one strand, although the central one, in a tangle of national, bilateral, and multinational initiatives, governmental and nongovernmental (see e.g., Pomerance, 1989, 265–67). Countless organizations were now seeking to be part of the climate action. Of course, none of this work was actually done by abstract "organizations." It was made to happen by a few human beings. Among these Bert Bolin was the indispensable man, chairing meetings, editing reports, and promoting the establishment of panels.

The Research Enterprise Transformed

While some scientists and officials tentatively proposed policy changes, many more were pushing for better international research projects. Although ICSU's SCOPE program had produced some useful work, such as reports on the global carbon cycle, that was barely a beginning (Bolin et al., 1979; Bolin, 1981). WCRP's work was likewise useful, but as an organization under the supervision of WMO (which is to say, the heads of national weather services), WCRP was naturally preoccupied with meteorology. All this was too narrow for the scientists who were taking up the new "climate system" approach, which was building connections among geophysics, chemistry, and biology. They decided they needed a new administrative body.

Spurred especially by U.S. scientists acting through their National Academy of Sciences, around 1983, various organizations came together under ICSU to develop the International Geosphere-Biosphere Program (IGBP). Starting up in 1986, IGBP built its own large structure of committees, panels, and working groups (National Academy of Sciences, 1986; International Council of Scientific Unions, 1986; Fleagle, 1994, 195). The drawback, as one climate scientist pointed out, was a feeling that "an IGBP should be in the business of measuring or modeling everything at once from the mantle of the earth to the center of the sun!" Pressed to study many immediate environmental concerns, IGBP did not put climate change high on its list of priorities (Bolin, 2007, 39; quote: Schneider, 1987, 215).

WCRP remained active in its sphere, launching international collaborations in meteorology and related oceanography. Like IGBP and other international scientific programs, WCRP had no significant funds of its own. It was a locus of panels, workshops, draft reports, and above all, negotiations. Scientists would hammer out an agreement on the research topics that should get the most attention over the next five or ten years, and who should study which problem in collaboration with whom. The scientists would then go back to their respective governments, backed by the international consensus, to beg for funds for the specific projects.

In each case one of the organizers' first tasks was to find a meaningful and pronounceable acronym—a mode of naming emblematic of organizations with distinct if transient identities, stuck together from independent components. The first great effort had been what is sometimes called the largest scientific experiment ever conducted: The First GARP Global Experiment, FGGE (pronounced "figgy"). During 1978 to 1979, large numbers of aircraft, drifting buoys, ships, balloons, and satellites made observations with the participation of some 140 nations. It took several years to process the data, but the result was standardized weather numbers covering

4. WMO (1989); Lanchbery and Victor (1995, 31–2); Bolin (2007, 48); Jäger (1992, v); Agrawala (1999b,115–16).

the entire globe in a uniform grid through the course of an entire year—exactly what computer teams needed as a reality check for their climate models (Edwards, 2010, 244–46, 250).

Other important examples of projects that gathered data internationally were the Tropical Ocean and Global Atmosphere Programme (TOGA), the World Ocean Circulation Experiment (WOCE), and the Joint Global Ocean Flux Study (JGOFS, which surveyed the carbon in the world's oceans). Scheduled to run through the mid 1990s, these were complex institutions, coordinating the work of hundreds of scientists and support staff from a variety of institutions in dozens of nations under the auspices of WCRP.

Climate theory, as embodied in ever more elaborate supercomputer models, was not exempt from these trends. Now that there were uniform bodies of real-world data, it was possible to compare how well different models performed in their attempts at simulating the climate. One pioneering effort, completed in 1989, brought together twenty team leaders at thirteen institutions—each with its own computer model—in seven nations from Canada to China (Cess et al., 1989, 890). (A subsequent effort in the early 1990s involved more than twice as many models.) The crucial product of this and similar efforts would be a paper of a few pages in a leading journal such as *Nature* or *Science*. Each of the authors, twenty in this case, had to sign off on the article, so there were intense negotiations over wording. Once consensus was achieved, the paper still had to win approval from peer reviewers and editors, which usually entailed additional negotiations over wording. For most such projects the result was not, as so often in documents that required a consensus of diplomats, a cloud of ambiguous generalities, it was a tightly worded array of definite statements, ranging from specific to general.

The success of such publications in reaching definite factual conclusions was the essential foundation for any later success that international bodies might achieve in arriving at general factual statements and policy advice. (The IPCC's reports, in particular, would explicitly stand upon thousands of footnoted references to the scientific literature.) Of course, all this relied utterly on the principles and practices of peer review that had been developed by editors of scientific journals and their communities, mainly in the nineteenth and early twentieth centuries but with continued discussion and refinements down to the present day.

Projects with multiple contributors were becoming common in all the sciences, a consequence of the increasing specialization within each discipline plus increasing value in making connections between disciplines.[5] Versatile scientists like Bert Bolin, who had mastered fields ranging from the mathematics of atmospheric circulation to the geochemistry of CO_2, were a vanishing breed. In one large historical bibliography of climate science (Weart, 2010), nearly all the papers written before 1940 were published under a single name and only a few were the work of two authors. Of papers written in the 1980s, fewer than half had one author. Many of the rest had more than two, and a paper listing, say, seven authors was no longer extraordinary. The trend would continue through the 1990s as single-author papers became increasingly rare.

Some of the projects were explicitly interdisciplinary. For example, in the late 1970s, specialists in computer modeling got together with paleontologists—one could hardly imagine

5. For a variety of studies of multi-institutional scientific collaborations and their governance see the reports of the American Institute of Physics Center for History of Physics, online http://www.aip.org/history/publications.html.

two types of scientific discipline that were more unlike—to test whether the models were robust enough to simulate a climate different from the present one. The Cooperative Holocene Mapping Project (COHMAP) expanded through the 1980s, recruiting a variety of domestic and foreign collaborators. Some of them would devote most of their research careers to the project. Typical of such projects, all the collaborators would convene from time to time in large assemblies run on republican principles. These principles were not entirely "democratic" in the sense of universal equality: Equal rights in decision-making were restricted to an elite group of acknowledged leaders. These leaders would gather in smaller meetings, "Often hosted in home settings where conversations were unhurried and brainstorming was lively" (Webb, 2007, 107). In these face-to-face meetings as well as in countless interactions through mail, telephone, and publications, computer models confronted paleontological data in a continual dialogue, each discrepancy forcing one side or the other to go back and do better. Ultimately, the modelers produced a good simulation of the global climate data that the paleontologists worked up for a warm period eight thousand years ago.

Two scientists described the developments of the 1980s as a "revolution" in the social structure of climate science. The field was propelled to a new level not only by great improvements in scientific tools such as computers and satellites but equally by great improvements in international networking thanks to cheap air travel and telecommunications. "Huge teams of highly skilled people can review each other's work, perform integrated assessments, and generate ideas" far better than the mostly isolated individuals of earlier decades, they pointed out. "A steady diet of fresh scientific perspectives helps to maintain regular doses of funding, helped in turn by an endless round of conferences" (O'Riordan and Jäger, 1996, 2).

Climate research nevertheless remained, comparatively, quite a small field of science. Whereas any substantial sub-field of physics or chemistry counted its professionals in the thousands, the scientists dedicated full-time to research on the geophysics of climate change in the 1980s numbered only a few hundred worldwide.[6] Since these climate scientists were divided among a great variety of fields, any given subject could muster only a handful of true experts. They knew each other well, by reputation and often personally.

What role could the small international climate science community play among the mighty political and economic forces that were coming to bear on climate policy? The existing scientific organizations, however well-crafted to coordinate research projects, seemed incapable of taking a stand in policy debates. As one knowledgeable observer put it, "Because WCRP was seen as largely the vehicle of physical scientists, while IGBP was viewed largely as the vehicle of scientists active in biogeochemical cycles, and because both WCRP and IGBP were seen as scientific research programs, neither seemed to afford the venue that could generate the necessary confidence in the scientific and policy communities" (Fleagle, 1994, 179). Events like the Toronto Conference were all very well, but a report issued after a brief meeting could not command much respect. And it did not commit any particular group to following up systematically.

The Advisory Group on Greenhouse Gases (AGGG) set up in 1986 had served well in keeping the issue in the forefront through activities like the Toronto Conference. However,

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6. Estimate of 200 to 300: Gee (1989). The IPCC study published in 1995, aiming at comprehensive international inclusion extending into the biological sciences and impact studies, had about five hundred "authors" plus more than five hundred "reviewers" who submitted suggestions.

the group lacked the official status and connections that could give their recommendations force. Besides, they had little money to spend on studies. AGGG's reliance on a few private foundations and its connections with outspoken environmentalists raised suspicions that the group's recommendations were partisan. An even more fundamental drawback was the group's structure. It was a tiny elite committee. This model had worked well for a century but was now rendered obsolete by the scope of the climate problem. As one policy expert explained, "Climate change spans an enormous array of disciplines, each with their own competing schools of thought. . . . Seven experts, even with impeccable credentials, . . . could not credibly serve as mouthpieces of all these communities" (Agrawala, 1999a, 166, see also Agrawala, 1999b).

Policy-makers concerned about climate looked for a way to supersede AGGG with a new kind of institution. The principal impetus came from the U.S. government, where the Environmental Protection Agency, the State Department, and others were pushing for an international convention to restrict greenhouse gases. Conservatives in the administration of President Ronald Reagan might have been expected to oppose the creation of a new and prestigious body to address climate change (the Department of Energy, which had its own climate studies underway, was particularly resistant). But the conservatives feared still more the strong environmentalist pronouncements that independent bodies of scientists were increasingly likely to issue, as seen at Villach and Toronto. The U.S. administration along with some other governments were also wary of control by WMO or any other body that was part of the UN structure. Better to form a new, fully independent group under the direct control of representatives appointed by each nation (Bolin, 2007, 47; Agrawala, 1999b, 176–77; Pearce, 2010, 38).

Responding to pressure from the U.S. and others, in 1988 WMO and UNEP collaborated in creating the Intergovernmental Panel on Climate Change. AGGG was not formally abolished, but within two years that small body ceased to meet, as most of the world's climate scientists were drawn into IPCC's processes. IPCC was neither a strictly scientific nor a strictly political body but a unique hybrid. The political representatives, by virtue of the consensus rule, would hold veto power over every word of the summaries that were the essential product for policy-makers. But the scientists, represented by the lead authors of their reports, would also hold an effective veto by virtue of their prestige and unimpeachable expertise. Once a consensus was forged among all parties, it would not be questioned by any well-constituted and representative political or scientific body.

International Regimes and Democracy

The roots of IPCC's strength reached very deep. Most people were scarcely aware that IPCC, and virtually every other international initiative discussed here, relied on a key historical development: The worldwide advance of democracy. It is too easy to overlook the obvious fact that international organizations govern themselves in a republican fashion, with vigorous free debate among all members and votes in councils of elite leaders. Often, as in IPCC, decisions among the dozens or hundreds of elite leaders are made by a negotiated consensus in a spirit of equality, of mutual accommodation, and of commitment to the community process—all of which are seldom celebrated, but essential, components of the republican political culture

(Weart, 1998, 61). Note also that majority voting is normally important in this political culture, but in many cases consensus is even more important.

It is an important historical fact that such international regimes have been created chiefly by governments that felt comfortable with such mechanisms at home, that is, democratic governments. Nations like Nazi Germany, Communist China, and the former SU did little to create international organizations (aside from front groups under their own thumb), and often participated in them awkwardly. Happily, in the second half of the twentieth century, nations under democratic governance became globally predominant. That encouraged the proliferation of international institutions that were democratic, or at any rate elite-based republican, exerting an ever stronger influence in world affairs (Weart, 1998, 262–67). The democratization of international relationships was the foundation upon which IPCC took its stand. If the world had been governed mainly by monarchies and tyrannies, where norms for decision-making were based strictly on power and hierarchy, such an institution could never have been created, let alone heeded.

These developments were visible in all areas of human endeavor, but often came first in science, internationally and democratically minded since its origins. Indeed, the procedures and norms of the scientific community are historically inextricable from the development of a cosmopolitan, egalitarian civil society (Nyhart and Broman, 2002). From the seventeenth century forward, a community of savants flourished in Europe and across the Atlantic, men and a few women who wrote letters to one another for public discussion, frequently on scientific subjects—a community named, for good reason, the “Republic of Letters.” And from the seventeenth century forward, it was scientists more than anyone who met as equals in specialized clubs and societies, often with foreign associates present. Week-by-week they hammered out rational understandings as they sought agreement on the validity of the latest theories and experiments. This spirit was taken up in the enlightenment salons, freemason lodges, and other venues where scientists and foreigners were welcomed and honored. These institutions played a central role in the wildfire spread of republicanism in the eighteenth and early nineteenth centuries (Jacob, 2006, 41–4, 134; Jacob, 1991). In negotiating pronouncements on climate, scientists did not so much borrow procedures from modern democracy as collect on a loan they had made centuries earlier.

It worked both ways. The international organization of climate studies helped fulfill some of the hopes of those who, in the aftermath of World War II, had worked to build an open and cooperative world order. If IPCC was the outstanding example, in other areas, ranging from disease control to fisheries, panels of scientists were becoming a new voice in world affairs (Miller, 2001, esp. 212–13). Independent of nationalities, they wielded increasing power by claiming dominion over views about the actual state of the world—shaping perceptions of reality itself. Such a transnational scientific influence on policy matched dreams held by liberals since the eighteenth century. It awoke corresponding suspicions in the enemies of liberalism.

Looking back over this long history, we see a trajectory toward a greater willingness and ability to agree upon frank, objective, and significant factual statements, leading to clear policy advice that was explicit in the agenda to be pursued and the desirable outcome. This was success in terms of the purposes for which the regime was created. The success was made possible by the appropriation and arduous refinement and development of norms, rules, and procedures that originated in the larger scientific community, with deep connections to the principles and practices of republican governance.

In scope and potential consequence, nothing remotely like the IPCC ever existed before. The founders of the International Meteorological Organization, farsighted though they were, could scarcely have imagined such a development. If the trajectory can be extended a few decades ahead, much that now seems out of the question might be negotiated into action.

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