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Getting to know Bill Nordhaus and Climate

On the occasion of his receipt of the Nobel Memorial Prize in Economics for the study of the economics of climate change

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I first learned about Yale University Professor William Nordhaus and his work on the economics of climate change during 1978. In October 1977 I began a Sloan Foundation fellowship at the National Academy of Sciences to work with their new Climate Research Board (CRB). One assignment was to help CRB Chairman Robert M. (Bob) White organize and lead the first UN World Climate Conference, which would take place in Geneva in February 1979. In graduate school I had tried to apply operations research, statistics, and a morsel of economics to problems of the marine environment such as oil spills. Climate was new to me, and Bob wanted me to read everything I could about climate variability and change, including the potential impacts of climate on society and the economy. The total literature was small but the field was international. Leading figures included Mikhail Budyko and Kyril Y Kondratiev (Soviet Union), Hermann Flohn (Germany), Hubert Lamb (England), Bert Bolin (Sweden), and Rolando Garcia (Argentina). American voices included Reid Bryson, Syukoro Manabe, Helmut Landsberg, Roger Revelle, and Stephen Schneider.

Researchers and environmental advocates at the time took equal interest in variability and long-term change. In the absence of an established trend, interest in climate change spanned both cooling and warming, and projections about which would prevail went in both directions. The Academy had been deeply involved in review of the potential environmental impacts of busy fleets of supersonic transports. The 1975 reports of the Climate Impact Assessment Program (CIAP) of the US Department of Transportation had considered both cooling and warming effects of the projected contrails. An expert from Resources for the Future and the University of Wyoming named Ralph d'Arge had led the economic portion of those studies. D'Arge and Co. estimated the economic effects of a 1 degree C cooling to be quite costly and a 0.5 C warming to be mildly beneficial.

Concerns about shifts to an icy regime had stimulated several studies after the unusual weather and climate of 1972-1974, when bad harvests caused the USSR to buy masses of grain from the USA and Canada, and collapse of the Peruvian anchoveta fishery also rippled globally. The Sahel experienced severe droughts at this time too. In 1975 MIT meteorologist Jule Charney published the heavily publicized and cited paper, "Dynamics of deserts and drought in the Sahel," which explored whether an increase in albedo resulting from a decrease in plant cover associated with overgrazing and desertification could cause a lasting decrease in rainfall as well as cooling. While community members offered a wide range of views and projections, the small climate field was friendly and welcoming to newcomers, and in the same workshop within a few hours one expert might present the case for a descent into ice and another for ascent into inferno.

The main locus for work on human-induced warming was the International Institute for Applied Systems Analysis (IIASA), a research institute established in Schloss Laxenburg (near Vienna) in 1972 by the US and Soviet academies and their counterparts from both sides of the Iron Curtain to study common problems of industrialized societies. Led by nuclear physicist Wolf Haefele, IIASA's energy program developed several scenarios out to the year 2100, ranging up to what 200 TW years per year of energy use might entail compared to 8 TW yr/yr in 1975. Climatic consequences explored included

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those from greenhouse gas emissions from burning coal and other hydrocarbons, waste heat from power generation, and changes in the reflectivity of the land surface and other aspects of the environment altered by large-scale deployment of solar technologies.

I might have heard about Bill and his work first at a March 1978 meeting on energy, carbon dioxide, and society convened by IIASA in nearby Baden. After the meeting I visited IIASA, where Haefele told me about recent and current work at IIASA. Haefele or Jill Williams (later Jaeger), a bright young climatologist who coordinated IIASA's climate and energy studies, might have described the work that Bill had accomplished during his 1975 sabbatical at IIASA to me.

Alternatively, I might have learned about the work through Stephen Schneider, the young, talkative, ambitious editor of the new journal *Climatic Change*. A climate modeler at the National Center for Atmospheric Research, Steve tracked everything related to climate, and was friendly with Allan H. Murphy, a climatologist interested in the value of information, who had shared an office with Bill at IIASA during 1975. Allan died in 1997 at 65 of prostate cancer, and would surely be proud that he helped introduce Bill to climate.

In any case, by the spring of 1978 I had copies of two of Bill's classic papers, first editions which I retain to this day: "Can We Control Carbon Dioxide?", IIASA Working Paper 75-63; and "Strategies for the Control of Carbon Dioxide," Cowles Foundation Discussion Paper 443 January 6, 1977. The clarity of mind and insight in the papers were obvious, as well as the importance of the fundamental control mechanism, a global carbon tax.

In 1977 in *Climatic Change* Schneider had published a landmark paper of another member of the IIASA energy group, Italian physicist Cesare Marchetti, "On geoengineering and the CO₂ problem." The paper, which probably invented the word geoengineering, explored a range of ways to prevent or compensate for greenhouse gas emissions on immense scales, from sinking billions of logs into the Black Sea (the "Black Pickle") to capturing the CO₂ at power plants and pumping it into the deep ocean (the "Gigamixer"). During 1975 Bill and Marchetti had nearby offices, so one can truly say that many of the core ideas to address climate change, both economic and engineering, were hatched in a fertile period in a corridor of a Hapsburg palace.

Bob White wanted to involve Bill in the World Climate Conference, but during 1977-1979 Bill was working in the Carter White House Council of Economic Advisors on leave from Yale. It seemed unrealistic to win Bill's attention during a period of headlines about inflation and energy security. For leadership on the economics of climate change, we turned to D'Arge, who wrote an underappreciated paper summarizing the CIAP studies and already citing Nordhaus (1977). Haefele, Williams, and their colleague Wolfgang Sassin prepared an impressively synoptic paper on energy and climate for the Conference that emphasized the imminence of decisions about greenhouse gas emissions.

An Important lesson of the first World Climate Conference for me was the difficulty of engaging economists. Nobelist Kenneth Arrow, who had worked as a weather forecaster during World War II, provided some advice and help but in the end almost no economists accepted the invitation to participate. Perhaps the issues seemed too remote or small.

Meanwhile, plans in the US to mine "dirty fossil fuel" on a large scale proposed by the US Department of Energy (led by economist James Schlesinger) and the spinoff Synfuels Corporation (led by

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economist John Sawhill) precipitated more National Academy climate studies as well as an influential report organized by the JASON advisory group of eminent physicists. For the Climate Research Board I helped organize with fellow staff members John Perry and Robert Chen the July 1979 study led by Charney in Woods Hole MA that set 1.5 to 4.5 degrees C as the likely range of warming for a doubling of atmospheric carbon dioxide.

The Charney study spurred another request. On 2 January 1980, President Carter's science advisor, Frank Press, asked the Academy to assess promptly the likely foreseeable social and economic consequences of an increasing concentration of atmospheric carbon dioxide and implications for policy. Bill, who had returned to Yale, joined the Ad Hoc Study Panel on Economic and Social Aspects of Carbon Dioxide Increase chaired by Thomas Schelling (economics, policy), and including McGeorge Bundy (government), Abram Chayes (international law), Charles Howe (hydrology), Bruce Maclaury (finance, public policy), William Nierenberg (physics, oceanography), Herman Pollack (international relations), Roger Revelle (geosciences), Joseph Smagorinsky (meteorology), Robert M. White (meteorology), Sylvan Wittwer (agronomy), and George Woodwell (ecology). The group sent Press a 10-page letter report on 18 April 1980, one of the first multidisciplinary assessments of the climate question.

The report concluded: "Present knowledge is an insufficient basis for international action to prevent climate changes or to adapt to them...First, we need to reduce the uncertainties about future carbon dioxide injections, their climatic effects, and the social and economic implications. It will be important to verify observationally the model predictions of climate change as soon as possible by carefully designed monitoring programs... We must also learn much more about the impacts of a climate change on human activities, especially agriculture and its complex interaction with society... Second, we need to learn more about how we might adapt to climate change or prevent it... The information needed to choose a balance of adaptation and prevention should be of much better quality in five or ten years...We believe we can learn faster than the problem can develop."

From mid-1979 to mid-1981 I worked most of the time at IIASA, eventually as leader of its Climate Task. I worked in close coordination with Bob White as well as Perry and Chen in DC, and kept the IIASA work focused on what the Schelling committee called injections and implications. Notably, we formed a "Carbon and Climate Gaming Group" including Swedish economist and simulation expert Ingolf Stahl. We built several games, for example, one in which major players (USSR, China, USA, Western Europe, etc.) could choose to cause more or less emissions, experience consequences of climate change, and take actions to reduce emissions and/or adapt. While IIASA warmly encouraged our work, external interest was low. Still, the assignment prepared me well for what came next.

The short Schelling report led to the formation of the Carbon Dioxide Assessment Committee (CDAC) in the spring of 1981 and a request for a much more thorough report before the end of 1983. Nierenberg assumed the chair, Nordhaus, Revelle, Schelling, Smagorinsky, and Woodwell continued as members, and they were joined by Peter Brewer (geochemistry), Lester Machta (atmospheric sciences), and Paul Waggoner (agronomy). Together with John Perry and Bill's graduate student from Yale, Gary Yohe, I did much of the work for the CDAC, and it was during this time that I came to know Bill directly.

Usually NAS committees only review and synthesize existing literature. But Chairman Nierenberg informed me forcefully at the outset of the CDAC study that too many holes gaped in the climate change story to accomplish what was needed only by review. Therefore, we should prepare, in the style of the JASONS, to define and solve problems ourselves. Beginning at the beginning, Nierenberg

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cleverly challenged Bill to offer new and better projections of future greenhouse gas emissions. Bill did a brilliant job, which Nierenberg praised effusively in front of the other committee members, thereby initiating a competition inside this talented group to display their analytical prowess.

At the end of 2 ½ years the report, titled *Changing Climate*, was complete and a landmark, the first "integrated assessment" with real depth. It contained a fistful of original components, including the first systematic proposal for the so-called "fingerprint" for detecting human-induced climate change, the first estimate of possible sea level rise incorporating both lost ice and thermal expansion of the oceans, a thorough consideration of the role of greenhouse gases beside carbon dioxide, an analysis of possible release by warming of methane hydrates from the slope sediments, the first modeled estimates of effects of climate change on US agriculture and water resources, and the first history of studies of the greenhouse effect. Although Nierenberg did not like the policy, the report was also the first to analyze carbon taxes seriously – the work of Bill and Gary.

I learned also that Bill liked good meals. We dined at the Watergate and other top Washington restaurants that ate a large part of my thin monthly paycheck. These dinners often included Bill's "parlor game" in which each guest ranked a list of 8-10 world problems; climate rarely made the top five. And I learned that Bill was a kind mentor. He allowed me to be first author with him on a paper reviewing future estimates of carbon dioxide emissions at a time when such authorship mattered greatly for my career.

During the following decade our paths crossed fruitfully in Washington and New York as well as Laxenburg and New Haven. In New Haven for several years Bill convened a monthly multidisciplinary seminar on climate. These provided me the occasion for a couple of presentations which eventually became publications: [A second look at the impacts of climate change](#) (*Am Sci* 79: 210-221, 1991) and [Does climate still matter?](#) (*Nature* 350: 649-652, 1991). In Laxenburg, with Nebojsa Nakicenovic and other IIASA colleagues, we organized a series of conferences with titles like *Costs, Impacts, and Benefits of CO2 Mitigation* (1992) and *Integrative Assessment of Mitigation, Impacts, and Adaptation to Climate Change* (1993). The quickly published proceedings accurately summarized the global state of the art and diffused the knowledge broadly. The abundance of expert contributors showed that attracting hard-thinking social scientists to climate change was a solved problem.

By the autumn of 1993 I felt that much of what could be learned about climate change (other than waiting for more observations to verify model predictions) had been learned and shifted my research to marine biodiversity, sparing land for nature, and other issues related to energy and technological evolution. In 1993 Bill published "Rolling the DICE," his paper about the Dynamic Integrated model of Climate and the Economy, which is central to the Nobel citation. DICE accomplished what Bill first glimpsed in 1975 and helped the rest of us to see.

Before closing, I will add two more comments that help explain the richness of Bill's climate work. One is his always-growing knowledge in economic history and geography and the related history of technology, exemplified in the 1980s by his familiarity with Ellsworth Huntington's (1915) *Civilization and Climate*. Second is his authentic search for limits to growth, and resulting courage to speak publicly against shoddy and very popular work by people such as Forrester-Meadows and Stern.

It is a privilege and a pleasure to have made the early climate journey with Bill.