STATISTICIANS GO TO WASHINGTON

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The issues of climate change are difficult challenges to policy makers. One difficulty arises because of the large number of uncertainties associated with various aspects of climate change. Hence, statistical reasoning plays fundamental roles in climate science and should play a role in climate change policy development. To demonstrate the value of statisticians in this context, the American Statistical Association has formed its Climate Change Policy Advisory Committee, co-chaired by Amy Braverman, NASA-JPL, and Mark Berliner, Ohio State University, and operated with the invaluable help of Steve Pierson, ASA Director of Science Policy. The goals of the Committee are to (1) help policy makers in understanding and assessing of statistical analyses and conclusions regarding climate change, and (2) raise awareness of statistical science and scientists.

Our primary contacts have been with U.S. Congressional committee staffers and with members of the Congressional Research Service. We have also made contact with researchers at the U.S. Environmental Protection Agency (EPA), as well as with groups similar to ours representing sister scientific societies such as the American Association for the Advancement of Science and the American Physical Society.

To set some perspective, the generally accepted status of climate change science as expressed by the Intergovernmental Panel on Climate Change (IPCC) is that warming of the climate system is "unequivocal" and is "very likely" caused by human activities. The usage of the phrase "very likely" in IPCC statements is their code for "probability $\geq .90$." Similar conclusions can be found in publications of the U.S. Global Change Research Program, U.S. EPA, and other research groups. However, these suggestions do not by themselves dictate policy. Rather, quantification of uncertainties in climate behavior and its impacts as well as future behavior of humans (e.g., emissions) lies at the heart of policy making. Policy makers seek to balance *unknown* (i) costs of remediation and (ii) costs of impacts of climate change. (Of course, political issues also enter the motivations of members of Congress.) That is, the problem is one of decision making in the presence of uncertainty, a phrase often used as a definition of the discipline of statistics.

Through a series of conference calls and visits to Congress, we offer explanations of statistics and uncertainty, review/comment on issues involving statistics, and decision support. We have been asked about the reliability of the science related to the claims of anthropogenic climate change (e.g., are the data sufficient to support the conclusions? What else is needed?); statistical information about related issues (e.g., global oil budget, economics and energy, local (i.e., constituency) impacts of climate change and associated legislation; and clarifications regarding apparent differing views among scientists about the role of human activities in climate change.

A few selected and brief examples indicate the sort of issues we address. First, a major theme of our efforts involves clarification of the sources and quantifications of uncertainty, and how to respond to those quantifications. The problems are difficult in the

climate change context because there are multiple sources and treatments of uncertainty as well as the need to bridge many disciplines (e.g., physics, chemistry, biology, economics, engineering, etc.). For example, what does the aforementioned probability statement of IPCC mean and how did they at it? IPCC lists a variety of sources of uncertainty: natural unpredictability of the chaotic climate system as well as that of human systems; incomplete science and imperfect models; data errors, incomplete/inappropriate data, parameter uncertainties. Faced with such a difficult problem quantification of uncertainty involves "weight of evidence" considerations based on data, models, and expert judgment. A recurring point is that uncertainty does not equal ignorance nor mandate inaction.

We often need to explain "statistical" statements. For example, compare the following two claims:

1. Global warming is likely to lead to increased severity of hurricanes.
2. Global warming caused Hurricane Katrina to be as severe as it was.

The key is that "climate" is statistical by nature. It describes typical, not specific, behaviors.

Depending on their experience, statisticians will not be surprised by the difficulties in communicating with policy makers and their advisers. Non-math communication of science and statistics is necessary. We cannot expect policy makers to understand the science and/or the statistics nor expect them to ignore politics.

Finally, we hope that our efforts will spur statisticians to become more engaged climate change decision support and encourage more research in decision theory/support and policy making by the statistics community.