Climate Change Lessons from the Past: A Key to Prediction

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Since ancient times humans have modified their local and regional environment, but only since the Industrial Revolution has human activity had a significant measured effect at the planetary scale. Human impact on the composition of the global atmosphere is now without question. Human disturbance of biogeochemical cycles may now be approaching a critical level. Over the past few decades concentrations of atmospheric gases (eg., CO_2, CH_4, N_2O) have been increasing dramatically and have moved into a range unprecedented for the past million years. This increase has produced serious concern regarding the heat balance of the global atmosphere. Greenhouse gases are, however, only part of the human problem. For example, sulfur gases and dusts can reinforce or counteract greenhouse gas effects on local to regional scales. While remarkable efforts are underway to resolve the history and significance of the human influences on climate, pollution and resource depletion, our understanding of climate change is still hampered by a lack of knowledge of the processes which underlie natural climate variations.

The task of understanding climate change and predicting future climate change would be complex enough if only natural forcing mechanisms were involved. It is significantly more daunting due to the introduction of anthropogenic forcing and even more so considering the limitations in available records. Earth history provides a unique opportunity to: (a) assess the temporal and spatial characteristics of climate variability prior to any anthropogenic forcing, (b) assess the natural rates of change associated with the evolution of the Earth system, (c) understand how physical and biospheric systems interact across multiple time and space scales, (c) define the nature of the sensitivity of the Earth's climate and biosphere to a large number of forcing factors, (d) examine the integrated climatic, chemical and biological response of the Earth system to a variety of perturbations, and (e) to test the predictions of numerical models for conditions significantly different from the present day. In effect, the paleoclimate record provides a series of cases and lessons upon which our understanding of climate change can be constructed and tested.

The paleo perspective has provided some significant surprises concerning climate change, changes in atmospheric chemistry and the response of natural systems to climate change. The most recent dramatic new discovery is the verification that rapid and massive reorganizations in the ocean-atmosphere system, rapid climate change events, occur at frequent intervals throughout at least the last glacial cycle (the last ~130,000 years). The largest of these events are characterized by changes in climate that are close to the order of glacial/interglacial cycles. Perhaps most surprising is the demonstration that these rapid climate change events turn on and off in decades or less and may last centuries to millennia. Further these events are globally distributed and found in a variety of paleoenvironments (ocean, atmosphere and land). Several potential causes for these events have been proposed, but without a more detailed understanding of the relative phasing of these events from region to region, definitive causal mechanisms cannot be constructed.

Of greatest consequence to humans is the fact that subdued versions of these events are documented during our current interglacial (the Holocene; which began ~11,500 years ago). While subdued relative to earlier events, they are still sufficient to significantly perturb natural systems and still operate at rapid rates (years to decades). Thus one of the most important tasks for paleoclimatologists is improving our understanding of Holocene climate, for it is within the Holocene that the boundary conditions for modern natural climate variability can be identified and from which the relative importance of natural versus anthropogenic climate forcing can be assessed.

Regular patterns in climate variability can be identified on the decadal to millennial scale. This finding is particularly encouraging since one of the end goals of climate change research is predictability. However, deconvolving predictable patterns at the regional scale and determining the temporal baseline from which predictably can be assessed will require more dense spacing of paleodata.

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Few instrumental records precede the era of anthropogenic involvement; thus it is necessary to supplement and hindcast this data with paleoclimate records. Fortunately, many paleodata series afford detailed views of pertinent climate indicators (eg., temperature, precipitation, ENSO, monsoon). On the other hand, since there are no true analogs in the paleoclimate record for modern or future climate it is essential to utilize both modern observational and paleoclimate records to solve this complex problem.

New advances in paleoclimate research reaffirm the necessity to: (1) view climate change over varying time scales; (2) utilize a variety of globally distributed paleoclimate records that monitor change throughout the earth system and; (3) focus attention on well-dated, highly resolved multivariate paleoclimate records. This paleodata is essential for understanding global environmental change and its potential impact on humans, assessing human influence on the global environment and for the evaluation of predictive climate models.

ABOUT PAUL MAYEWSKI

Paul A. Mayewski was born in Edinburgh, Scotland and attended school in the United States, receiving a PhD from the Institute of Polar Studies, Ohio State University, in 1973.

He is Director of the Climate Change Research Center (CCRC) and Professor in the Institute for the Study of Earth, Oceans and Space and Department of Earth Sciences at the University of New Hampshire. He has been the leader of more than twenty-five scientific expeditions to the Antarctic, the Arctic and the Himalayas. He has published in excess of 150 papers in peer-reviewed journals such as *Nature* and *Science* and chairs several national and international scientific committees. His papers have been instrumental in understanding a wide range of scientific problems including, for example: the chemistry of the remote atmosphere, acid rain, the ozone hole, the global distribution of the Chernobyl nuclear accident, identification of massive and rapid change in climate, controls on climate change, histories of volcanic activity, biomass burning, aridity events, storm activity, sea ice extent and glacier fluctuations. He has developed collaborative scientific programs with several countries (eg., India, China, Iceland, France, Denmark, Nepal).

His expeditionary and scientific achievements have been highlighted in numerous articles and interviews including, for example: *Discover*, *Harper's Magazine*, *The New York Times*, *Good Morning America*, several BBC/PBS film series, and National Public Radio's *Fresh Air*.

Dr. Mayewski has served for eight years as Chief Scientist for the Greenland Ice Sheet Project Two (GISP2), a multi-institutional National Science Foundation project that has revolutionized our understanding of climate change. Currently he and his colleagues at CCRC are organizing several multi-disciplinary, multi-institutional research efforts dedicated to understanding climate change on global to regional scales, such as: ITASE (the International Trans-Antarctic Scientific Expedition), HIPP (the Himalayan Paleoclimate Program) and NECC (the New England Climate Consortium).

He has been accorded several honors, such as: the naming of an Antarctic mountain peak, inclusion in Sigma Xi and Phi Kappa Phi, the 1995 Citation of Merit from the Explorers Club, a French Senior Research Fellowship (CNRS), and as a guest of the Chinese Academy of Sciences in 1996 he was given a personal audience with scientific officials in the Forbidden City, Beijing.