American Meteorological Society's Environmental Science Seminar Series

Arctic Sea Ice Melt and Shrinking Polar Ice Sheets: Are Observed Changes Exceeding Expectations?

Is the Arctic sea ice cover melting faster than expected? If so, what are the contributing factors and why was the rate of melting unanticipated? How much sea ice cover has been lost in terms of extent and volume? What are the implications of both the loss of sea ice and the rate of loss? Is the Greenland ice sheet losing its mass faster than anticipated? If so, what are the contributing factors and why was the rate of loss unanticipated? What are the implications of continued accelerated ice loss from the Greenland ice sheet with respect to Sea Level Rise? Is the Antarctic Ice Sheet getting bigger or smaller and by how much and how fast? Are there parts of the Antarctic ice sheet that are gaining mass and parts that are losing mass? If so, what are the contributing causes? What are the implications of continued ice mass loss in Antarctica, especially the decay of ice shelves?

Public Invited*

Monday, November 26, 2007
12:00 Noon - 2:00 pm
Dirksen Senate Office Building, Room 106
Washington, DC

Buffet Reception Following

Moderator:

Dr. Anthony Socci, Senior Science Fellow, American Meteorological Society

Speakers:

Dr. Mark Serreze, Senior Research Scientist, NOAA National Snow and Ice Data Center, Cooperative Institute for Research in Environmental Sciences (CIRES), University of Colorado, Boulder, CO

Scott B. Luthcke, Geophysicist, NASA Goddard Space Flight Center's Planetary Geodynamics Laboratory, Greenbelt, MD

Dr. Konrad Steffen, Professor of Climatology and Remote Sensing and Director of the Cooperative Institute for Research in Environmental Sciences (CIRES), University of Colorado, Boulder, CO

Program Summary

Rates of Change in Arctic Sea Ice Cover: Causation, Extent and Implications

- Since the advent of routine monitoring via satellite in 1979, the area of the Arctic Ocean covered with sea ice, known as ice extent, has declined in all months, most strongly in September. The rate of ice loss appears to have accelerated in recent years. Sea ice extent for September 2007 was the lowest ever recorded, beating the old record set in September 2005 by 23%, an area the size of Texas and California combined.

- Essentially all state-of-the-art global climate models indicate that sea ice extent should be declining over the period of observations, pointing strongly to a role of increased greenhouse gas concentrations. However, the observed rate of decline in September exceeds that from nearly all models. While natural climate variability explains part of the observed rapid ice loss, it appears that the models, as a group, are underestimating the sensitivity of the ice cover to the effects of greenhouse warming.

- There is strong evidence that reductions in sea ice extent have been accompanied by substantial thinning. There is growing recognition that once the ice thins sufficiently, it will become sensitive to a "kick" from natural climate variations that, through feedback mechanisms such as ocean warming in ice free regions due to solar radiation, result in rapid loss of the remaining summer ice cover.

- Transition to an ice-free Arctic Ocean in summer could occur as early as 2030. While climate simulations suggest that ice loss may have impacts on weather patterns well beyond the Arctic, little is known at this time. While ice loss will have adverse ramifications for Arctic ecosystems and the peoples of the Arctic, given the current trajectory, the region will also become accessible to shipping and resource exploitation. The summer of 2007 saw the fabled Northwest passage open for the first time since regular monitoring began in 1972.

Recent Observations on Changes in Polar Land Ice Mass

Mass changes of the Earth's ice sheets and glacier systems are of considerable importance because of their sensitivity to climate change and their contribution to rising sea level. Recent changes in the cryosphere highlight the importance of methods for directly observing the complex spatial and temporal variation of land ice mass flux. Since its launch in March of 2002, the NASA/DLR Gravity Recovery and Climate Experiment (GRACE) mission has been acquiring ultra-precise inter-satellite K-band range and range-rate (KBRR) measurements enabling a direct mapping of static and time-variable gravity. These data provide new opportunities to observe and understand ice mass changes at unprecedented temporal and spatial resolutions. Through the detailed reduction of these GRACE KBRR data, we have computed multi-year time series of surface mass flux for Greenland and Antarctica coastal and interior ice sheet sub-drainage systems as well as the Alaskan glacier systems. These mass flux solutions provide important observations of the seasonal and inter-annual evolution of the Earth's land ice as well as overall trends.

The gravity observations show the Greenland ice sheet is losing significant mass at the low elevation coastal regions that is not compensated for by gains in the high elevation interior resulting in an overall rate of loss of 154±10 Gt/yr. In addition strong inter-annual variations are observed such as the large mass loss of 2005 resulting from higher surface temperatures and a longer melt season. The gravity observations show the Antarctic ice sheet is losing mass at the rate of 105±30 Gt/yr with the loss concentrated from the western Antarctic ice sheet and in particular at the tip of the peninsula. The high elevation regions of the Antarctic ice sheet are showing no significant rate of change in mass. The Alaskan mountain glaciers are observed to be losing mass at a rate of 98±8 Gt/yr with the largest losses observed in the Yakutat Icefields and Glacier Bay regions. The combination of GRACE high-resolution mass flux observations together with the surface elevation change and surface melt observations is beginning to reveal a detailed understanding of the Earth's high latitude land ice evolution.

Greenland Ice Sheet: Dynamic Response to Recent Climate Warming

Recent rapid changes in marginal regions of the Greenland ice sheet show mainly acceleration and thinning, with some glacier velocities increasing more than twofold. Recent data show a high correlation between periods of heavy surface melting and increase in glacier velocity. A possible cause is rapid melt water drainage to the glacier bed, where it enhances basal sliding.
An increase in melt water production in a warmer climate could have major consequences on ice-flow rate and mass loss. Melt extent on the ice sheet for 2007 was the largest ever recorded since the beginning of satellite measurements in 1979, beating the old record set in 2005 by 10%, an area.

The Greenland Ice Sheet is losing mass, and that this has most likely been accelerating since the mid 1990s. Although Greenland has been thickening at high elevations, because of the predicted increase in snowfall, this gain is more than offset by an accelerating mass loss, with a large component from rapidly-thinning and accelerating outlet glaciers. The mass balance decreased from near balance in the early 1990's to minus 100 Giga tons (Gt) or even less than 200 Giga tons of ice for the most recent observations in 2006.

The likely sensitive regions for future rapid changes in ice volume are those outlet glaciers in Greenland like the Jakobshavn Isbrae, with an over-deepened channel reaching far inland. Inclusion of these processes in models will likely demonstrate that the Intergovernmental Panel on Climate Change's 4th Assessment (2007) Report underestimated sea-level projections for the end of the 21st Century.

Biographies

Dr. Mark Serreze received his BS and MS from the University of Massachusetts, Amherst, in 1982 and 1984, respectively. His MS work focused on the energy and mass balance of a small ice cap on Northern Ellesmere Island in the Canadian high Arctic. After a brief stay at the Lamont Doherty Environmental Observatory, he entered the PhD program within the Department of Geography at the University of Colorado, Boulder, graduating in 1989. His dissertation addressed Arctic sea ice circulation and its links with atmospheric variability. He is now a Senior Research Scientist at the National Snow and Ice Data Center, part of the Cooperative Institute for Research in Environmental Sciences at the University of Colorado.

His early research focused on variability in Arctic weather patterns, and aspects of the Arctic's hydrologic cycle. Over time it became increasing clear that the Arctic environment was rapidly changing, characterized by increases in surface air temperature, thawing of permafrost, and most notably, a shrinking sea ice cover. Dr. Serreze's research over the past decade has largely turned to understanding these synergistic changes.

Community service has included contributions to the National Science Foundation, the National Oceanographic and Atmospheric Administration, and the World Climate Research Programme. He is a member of the American Geophysical Union and the American Meteorological Society. As of October 2007, Dr. Serreze had authored or co-authored 84 publications in peer-reviewed journals and 8 book chapters. His textbook with Roger Barry, "The Arctic Climate System", published in 2005 by the Cambridge University Press, won an award from the Atmospheric Science Librarians International.

Scott B. Luthcke is a geophysicist at NASA Goddard Space Flight Center's Planetary Geodynamics Laboratory. His research focuses on the reduction of satellite tracking and altimeter data for planetary science investigations. His recent research focuses on the recovery of local time variable gravity solutions for cryopsheric and hydrologic mass flux investigations. Scott is currently a member of the ICESat, GRACE and Jason-2/OSTM science teams and is a member of the American Geophysical Union. Scott has authored 25 scientific peer-reviewed papers including his recent paper on Greenland mass flux published in the November 24, 2006 issue of *Science*. He received a BS in Physics from the University of Maryland and an MS in Physics from the Johns Hopkins University. He has received the NASA/GSFC Exceptional Achievement award (2006) and the NASA/GSFC Honor Award in Earth Science (2007).

Dr. Konrad Steffen received his education at the Swiss Federal Institute of Technology (ETH) in Zurich, Switzerland. He studied first electrical engineering and then graduated in natural sciences; with a master degree in 1977 on the climatology of the high Canadian Arctic, and a Ph.D. degree in 1983 on the climate impact of an ice free ocean. He s a Professor at the University of Colorado teaching climatology and remote sensing and his research involves the study of processes related to climate variability and change, cryospheric interaction in Polar Regions, and sea level rise based on in-situ measurements, satellite observations, and model approximations. He has lead field expedition to the Greenland ice sheet and other Artic regions for the past consecutive 33 years to measure the dynamic response of the ice masses under a warming climate; since 1990 he established a climate monitoring network on the Greenland ice sheet with a total of 22 instrument towers transmitting data via satellite link every hour for process studies and model verification. He participated in the field measurements and first publication that proposed the dynamic response of the

Greenland ice sheet to climate warming in 2002.His work has been featured by several TV stations and popular science paper.

Dr. Steffen serves on a number of national and international committees, most notably he is the co-chair of the World Meteorological Organization (WMO) World Climate Research Program (WCRP) Climate and Cryosphere Program (CliC), the vice president of the IUGG Association of Cryospheric Sciences, the former vice president of the Commission for Snow and Ice for the International Association for Hydrological Sciences, a member of the subcommittee on Earth science to advise the NASA administrator, and he is leading the cryosphere chapter for the for the U.S. Climate Science Program, Synthesis and Assessment Product 3.4 on Abrupt Climate Change.

Dr. Steffen is the director of the Cooperative Institute for Research in Environmental Sciences (CIRES), the largest research unit at the University of Colorado Boulder Campus. He has published over 75 scientific papers in peer-review journals, and 5 book chapters

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Please see our web site for seminar summaries, presentations and future events: http://www.ametsoc.org/seminar

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