

The Second International Conference on Global Warming and the Next Ice Age

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The Second International Conference on Global Warming and the Next Ice Age (GWNIA) met in Santa Fe, New Mexico, from July 17-19, 2006. The Conference was sponsored by the Center for Space Science and Exploration of the Los Alamos National Laboratory, and co-sponsored by the American Meteorological Society and the University of Washington. The conference attracted over 120 scientists from 14 countries with expertise in observations, theory, and modeling of climate change. This conference, like its predecessor in 2001 in Halifax, Nova Scotia, aimed to provide a venue for detailed discussions of how Earth's climate responds to natural and anthropogenic forcings besides long-lived greenhouse gases (GHGs). The organizers and participants recognized that Earth's climate is a complex dynamical system that is responding to an array of imperfectly constrained forcings, monitored by observational systems with limited sensitivity and coverage. The conference delegates then discussed the shortcomings of current models, observations, and theory and developed a path forward on how best to address these shortcomings. An Aerosol Workshop followed the Conference that focused on climate prediction uncertainties caused from anthropogenic aerosol forcing and how to understand and reduce them (July 20-21).

Representative Tom Udall of New Mexico met with participants informally, then welcomed conference attendees with a taped presentation and expressed appreciation for research contributing to understanding of climate change. He also announced a congressional bill that he has introduced that would enable a cap and trade program for carbon dioxide to help mitigate the risks of potential climate change. Introductory remarks by senior Los Alamos National Laboratory (LANL) officials stressed the inter-relationships between climate change research, energy security, and threat reduction.

Petr Chylek (LANL), conference chair and lead organizer (Manvendra Dubey (LANL) was the co-organizer), opened the conference with a brief review of both recent and paleo climate variability. Christopher Folland (Hadley Centre, UK Met Office) discussed worldwide decadal to inter-decadal climate variability, with a focus on the North Atlantic region. Observations show that spatial patterns of sea surface temperature (SST) and night mean air temperature (NMAT) warming are

very similar. The Hadley Center attributes much of the winter European warming in the decades 1965-1995 to the change from a generally negative to a generally strong positive phase of the North Atlantic Oscillation (NAO). However, this positive phase now seems to be ending. The Hadley Centre also believes that some of the current rapid warming of the North Atlantic is due to an accelerating thermohaline circulation related to the Atlantic Multidecadal Oscillation (AMO), though this is controversial. However, they predict a natural thermohaline circulation (THC) slow-down starting in about the next decade, which could be enhanced by increasing greenhouse gases.

Careful attribution of regional climate change between natural and anthropogenic causes was the subject of many lively discussions. V. Ramaswamy (Geophysical Fluid Dynamics Laboratory, GFDL) gave participants an overview of observed and modeled 20th century climate change. Comparisons of the GFDL model to satellite data show that relative humidity has remained nearly constant in the upper troposphere. This suggests that global warming triggers H₂O feedbacks similar in strength to those used in general circulation models (GCMs). Christopher Essex (University of Western Ontario) presented an applied mathematician's view of the Butterfly Effect, carefully distinguishing integration errors arising from initial conditions from those arising from the simplification of processes. Steve Schwartz (Brookhaven National Lab) used observations to derive an effective heat capacity and an adjustment time of the Earth's Climate System (about five years, shorter than many other estimates), whose ratio is the climate sensitivity parameter. Removing the direct GHG forcing from the sensitivity estimate yields an estimate of the total non-GHG direct and indirect forcing. Many subsequent presentations demonstrated that climate models continue to improve representations of processes that were previously over-simplified or completely neglected as intractable.

Dr. Yoram Kaufman (Goddard Space Flight Center, GSFC), one of conference organizers, died in an accident a few weeks before the conference. In two sessions dedicated to him and in many other talks, speakers noted Yoram's many contributions to satellite remote sensing and climate studies. After a moment of silence, Yoram's family expressed their sense that continuing our research with Yoram's positive attitude would help to keep his spirit alive.

Satellite measurements yield convincing data for the spatio-temporal distribution of indirect aerosol effects. Lorraine Remer (GSFC) presented a personal history of the MODIS aerosol retrieval algorithms, which have helped to constrain aerosol direct radiative forcing. Yoram's approach to inferring how aerosols increase cloud lifetime or cloud fraction over the Atlantic is being applied globally by other groups. Ilan Koren (GSFC) described how AERONET (Aerosol Robotic Network) data gaps implicitly contain information about cloud fraction that can be used to understand local aerosol cloud interactions. Ralph Kahn (Jet Propulsion Laboratory) described why MISR (Multi-angle Imaging SpectroRadiometer) and MODIS (Moderate Resolution Imaging SpectroRadiometer) retrieved Aerosol Optical Depths (AODs) are more accurate over land and ocean, respectively. MISR can also retrieve aerosol plume height using stereo methods. Brad Henderson (LANL) demonstrated that optimal satellite viewing angles for retrieving AOD occur at medium scattering angles where the phase function is less sensitive to assumed aerosol properties. Polarimetric remote sensing platforms are increasing the spatial coverage and accuracy of measured aerosol size distributions and refractive indices. Didier Tanre (University of Science and Technology, Lille, France) described the polarimetric principles of the PARASOL (Polarization and Anisotropy of Reflectance for Atmospheric Sciences coupled with Observations from a Lidar) that is used to characterize aerosols. Brian Cairns (Columbia University) described the NASA Glory mission, which uses similar principles to measure the freezing transition in clouds. Ilan Koren (GSFC) advocated a Glory-like mission, which would retrieve very accurate liquid cloud droplet size distributions.

The "Next Ice Age" conference theme often manifested itself in animated discussions based on widely varying interpretations of observational data, its meaning, and future implications. G. Kukla (Lamont Doherty Earth Observatory) expects low orbital obliquity to warm the dark tropical oceans at the expense of Polar Regions, thereby increasing meridional vapor transport and glaciation. He argues that this natural pattern is consistent with the present warming. Based on an interglacial at ~400,000 years ago, A. Berger and M. F. Loutre (Catholic University, Louvain, Belgium) estimate that the current interglacial would persist for another 14,000 years in the absence of anthropogenic forcing. L. Franzen (Goteborg University, Sweden) described how peatlands could modulate climate by storing carbon. He speculates that cosmic dust deposition

alters climate through ocean fertilization and dimethyl sulfide emissions, and also explains some observed millennial scale variability such as the Little Ice Age. J. Sachs (University of Washington) used coccolithophores to infer significant North Atlantic slope water-cooling during the Holocene, consistent with variations in Gulf Stream movements relative to the North American coast.

Paal Brekke (Norway) reviewed ways in which sun might affect climate. He noted that recent results indicate less direct solar radiation variation on the century time scale than previously thought. R. Willson (Columbia University) reviewed the problems of homogenizing satellite solar radiance observations with different satellite offsets (a problem common to many satellite data). He expressed concerns about the continuity of future missions.

Ernest Palle (Big Bear Solar Observatory, New Jersey Institute of Technology) showed that cosmic ray production is correlated with mid- plus high-level cloud amount over the ISCCP record. Nicholas Scafetta (Duke University) used ^{14}C records to infer total solar irradiance (TSI) forcing of recent and paleoclimate temperature changes. He suggested that up to 50% of the 20th century global warming could be explained by solar radiation variability. J. Veizer (University of Ottawa) reviewed the evidence for solar output variation effects on the water cycle. John Christy (University of Alabama, Huntsville) described three regions where surface temperature measurements disagree with recent trends from specific GHG-driven models. Roger Pielke (Colorado State University) raised many concerns about surface temperature records used by IPCC. He showed clear evidence of some bad sites and thus the likelihood of bad local/regional trends. He recommends using ocean heat content to quantify energy storage, e.g. from increasing greenhouse gases.

Positive feedback processes in the stable nocturnal boundary layer amplify changes in surface diurnal temperature range, such as the reduction induced by GHGs, according to R. McNider (University of Alabama, Huntsville). Pinhas Alpert (Tel Aviv University) showed that reduced total hemispheric irradiance at many stations worldwide, often described as Global Dimming, could be explained by the increase in anthropogenic aerosols emanating from cities exceeding about 20,000 inhabitants. Dimming is not generally seen in truly rural areas. C. Tomasi (Institute of Atmospheric Sciences and Climate, CNR, Bologna) reported evidence for natural (volcanic and

biomass) and anthropogenic aerosol trends in the Arctic, but found no anthropogenic trends in the Antarctic.

Ross McKittrick (University of Guelph) argued that half of the tropospheric temperature trends over the land surface in the 20th century were attributable to sampling biases due to Urban Heat Islands. Petr Chylek (LANL) showed that Greenland temperature had a previous warm period centered around 1930 and that the rate of warming was higher in 1920-30 than 1995-2005. Temperature variations correlated negatively to the NAO index. He also showed a high resolution (1km²) reconstruction of Greenland melting areas. High resolution data is needed to understand what is really happening to the Greenland ice sheet.

Qiang Fu (University of Washington) emphasized the importance of the lower tropospheric lapse rate for the water vapor feedback on climate. Bill Gray (Colorado State University) pointed out strong multidecadal variations in North Atlantic hurricanes. He considers this is due to variations in the AMO whose influence is partly through sea surface temperature but importantly also through changes in vertical wind shear in the hurricane development regions.

Other talks and posters delved into the finer details of hurricane predictability (J. Reisner, LANL), lightning (X.-M. Shao, LANL), electric infrastructure damage (S. Fernandez, LANL), and correlations of hurricanes over oceans with tornados over land (J. Marusek). Ocean biogeochemical and hydrological cycle feedbacks to climate were also discussed (Scott Elliott, E. Kennel, and Bryan Travis, LANL).

Mark Jacobson (Stanford University) emphasized the importance of carefully representing aerosol shape and mixing state on optical properties and indirect effects. He noted that aerosols typically reduce surface winds by stabilizing the boundary layer. Stefan Kinne (Max Planck Institute for Meteorology) showed that estimates of shortwave (SW) clear-sky top-of-atmosphere (TOA) aerosol direct radiative forcing (ADRF) is very robust whereas all-sky estimates are much less robust due to absorption uncertainties. Charlie Zender (University of California, Irvine) showed that absorbing aerosols amplify natural snowpack-albedo feedbacks and that soot and dust in snowpacks have caused significant warming in past and present climates. Alex Hall (University of California, Los

Angeles) showed that modeled snow albedo feedback (SAF) is an excellent predictor of a model's sensitivity to GHG forcing. The range of model-predicted snow albedo is unrealistic and currently explains much of the inter-model spread in SAF and climate response. Peter Buseck (Arizona State University) showed that the 3-D fractal geometry of complex soot particles lead to significantly more efficient extinction than properties based on 2-D soot imagery. The widely used OPAC soot optical properties are based on incorrect properties but fortuitously lead to approximately correct results.

Clear-sky ice super-saturated regions (ISSRs) occur more frequently in nature than in models due to parameterization shortcomings, according to Peter Spichtinger (Swiss Federal Institute of Technology, Zurich). Hartwig Volz (RWE Research, Germany) theorized that the effect of waves on sea surface emissivity causes important climate feedbacks, which models currently neglect.

The conference's final session highlighted important connections between climate and energy issues. Hans Ziock (LANL) showed that widespread carbon sequestration is required to stabilize atmospheric levels below 1000 ppmv. DOE pilot programs have demonstrated the feasibility of geologic storage, although scaling remains a challenge, according to George Guthrie (LANL). Manvendra Dubey (LANL) noted that hydrogen-based fuels could help mitigate growth of GHGs and also improve air quality. Characterizing natural hydrogen variability now, before the widespread adoption of hydrogen fuels, would provide an important baseline for the assessment of future anthropogenic changes.

Plenary discussions highlighted a number of issues requiring attention before the third GWNIA conference planned for 2011. The following were identified as priorities of global climate research: (a) Improvement of the global quality and coverage of in situ and satellite climate observations; (b) Determination of the sign and size of cloud feedback through a targeted observation of cloud properties and dynamics; (c) To decrease the uncertainty in a number of forcing factors of climate change, particularly the forcing due to anthropogenic and natural aerosols; (d) To quantify the potential impact of solar cosmic ray induced cloud nucleation induced forcing in GCMs with aerosol-cloud parametrizations (e) To involve expert statisticians in key climate change studies.

Charlie Zender¹, Chris Folland², Manvendra Dubey^{3*}, and Petr Chylek³

¹University of California, Irvine

²Hadley Centre, UK Meteorological Office

³Los Alamos National Laboratory

[*dubey@lanl.gov](mailto:dubey@lanl.gov), MS D462, LANL Los Alamos NM 87545, 505-665-3128