GC43B-03 1415h

Why are warming estimates based on borehole temperature records greater than multiproxy reconstructions?

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Reconstructions of Northern Hemisphere surface temperature change based on borehole temperature-depth profiles indicates 0.7±0.1° C of ground warming between pre-industrial time and the 1961-1990 mean surface air temperature (SAT). SAT data show another 0.4° C of most recent warming; thus the total surface warming may be as much as 1.1° C [*Harris and Chapman, GRL,* 2001]. In contrast most multiproxy records suggest significantly less warming, about 0.7° C, over the same time period. The geothermal results imply that Earth has greater sensitivity to climatic forcings than implied by multiproxy reconstructions. We first verify that the mid latitude (30° − 60° N) transient temperature profile, constructed from the global database of temperature profiles, shares much information in common with the Northern Hemisphere SAT record at site collocated with boreholes. The combination of an initial temperature (the primary free parameter) with the last 140 years of SAT data yields a synthetic temperature profile that is an excellent fit to observations, accounting for 99% of the observed variance. This strong correlation suggests that over large areas and long time-scales ground and air temperatures are responding to similar forcings. The discrepancy between warming estimates from temperature profiles and multiproxy warming is troubling. Attempts to reconcile these results by investigating potential biases in temperature profiles, including snow cover, and topography have been unsuccessful. We suggest that the discrepancy in warming estimates may be due to the different frequency contents of the two records. Temperature profiles contain longer period information than multiproxy records. We highlight the proxy reconstruction of *Espers et al.* [*Science,* 2002] which provides good agreement with borehole temperature reconstructions and retains longer period information than other proxy reconstructions.

GC43B-04 1430h

An evaluation of the effects of deforestation on subsurface temperatures

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Changes in land surface conditions such as deforestation or forest fires modify the energy balance at the ground surface. Such energy imbalances appear as subsurface transient thermal signals superimposed on the climatic signal and the steady state geothermal field. Borehole temperature data located in areas affected by deforestation need to be corrected for the non-climatic energy perturbations in order to be used in climatological studies. Here we show a first order approach to correct borehole temperature data for the effects of deforestation. We simulate the ground surface temperature (GST) variation after deforestation using a combined gamma-logistic function, describing the forest floor organic matter decay and recovery after a clear-cut. The forest floor organic matter acts as an insulating layer, and its variation, which is driven mostly by the microbial activity and the quantity and quality of the litter inputs, affects the energy balance at the air-ground interface. After deforestation, the thickness of the organic matter layer decreases allowing more energy to be absorbed into the subsurface. The ground surface temperature increases monotonically to account for the soil temperature difference between the forest and open areas. However, as the secondary forest approaches the equilibrium state, the GST will decrease to near its pre-harvest value. Results of this study suggest that the proposed correction method can be applied if the time and the magnitude of deforestation are known. We show that the effects of deforestation on the subsurface temperatures, though important, are much smaller than previously thought. These results may also allow land surface models to use geothermal data in regions of known land disruption, in order to optimize long-term land-surface energy exchange parameterizations.

GC43B-05 1445h

Atmosphere-land surface coupling in the high northern latitude tundra-taiga transition zone

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The position of northern hemisphere polar frontal zone in summer is highly correlated with the northern limits of the boreal forest. A great deal of discussion concerns the idea as to whether the tundra-taiga limit plays a passive or an active role in determining the preferred position of this polar climate transition zone. Of particular interest in these discussions is the role played by surface albedo in determining the differential heating of the atmosphere along this transition zone during the spring and summer seasons. In order to realistically simulate the surface energy balance involved in atmosphere/land coupling, a new surface albedo module is being developed for the Lund-Potsdam-Jena dynamic global vegetation model (LPJ-DGMV). The physics of this module is based upon a novel semi-empirically derived light scattering theory. A preliminary discussion of this line of research will be presented along with a discussion of implications for past vegetation distributions in the simulations of glacial inception climate that have been performed using the NCAR climate system model version 1.4 (CSM 1.4) and the LPJ-DGVM model. Simulations of both the modern climate and the climate during the most recent period of glacial inception (116 000 years ago) will be presented.

GC44A CC: 524 C Thursday 1530h

Continental Energy Balance, Land-Surface Processes, and Surface Temperature III

Presiding: **R N Harris,** University of Utah**; H Beltrami,** St. Francis Xavier University

GC44A-01 1530h

Evaluating the Common Procedure to Determine the Energy Balance at the Earth's Surface from Space

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The common procedure to determine the energy balance and, hence, the brightness temperature at the earth's surface on the basis of satellite data will be evaluated by discussing the inherent procedural and stochastic errors. The evaluation will be performed for aerodynamically smooth surfaces like the surfaces of natural water systems and snow packs as well as aerodynamically rough surfaces covered by low and tall vegetation elements.

URL: http://www.gi.alaska.edu/~kramm/S04

GC44A-02 1545h

Assessing seasonal and annual coupling relationships between air and subsurface temperatures: What can these relationships tell us about ground surface temperature reconstructions?

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Ground surface temperature (GST) reconstructions determined from temperature profiles measured in terrestrial boreholes, when averaged over the northern hemisphere, estimate a surface warming of approximately 1 K during the interval AD 1500-2000. Other traditional proxy-based estimates suggest less warming during the same interval. Seasonal filters' in both borehole- and proxy-based reconstructions have been suggested as one possible explanation of these differences. Here we quantify seasonal decoupling between GST and surface air temperature (SAT) signals and assess the potential for this decoupling to cause seasonal biases in borehole-based temperature reconstructions. SAT and subsurface temperature time series have been measured and analyzed at Fargo, North Dakota; Prague, Czech Republic; and Cape Hatteras National Seashore, North Carolina. Extrapolation of subsurface annual signals to the ground surface yield amplitude and phase estimates of annual GST signals at these sites. When compared to the annual SAT signals, annual GST signals are modestly attenuated and negligibly phase shifted relative to SAT; the amplitude attenuation and phase shift ranges are approximately 7.6-22.5% and 4.6-8.4 days, respectively. Of the three analyzed sites, amplitude attenuation was greatest at Fargo and least at Cape Hatteras. At Fargo, the most extreme winter site in our study, attenuation occurred predominantly in the winter season when snow cover and/or subsurface freezing inhibit cooling of the subsurface. At Prague, a site with approximately the same amount of annual rain-equivalent precipitation as Fargo but milder winters, amplitude attenuation was relatively balanced between both winter and summer seasons. At Cape Hatteras, where winter effects are largely absent, attenuation was distributed primarily in the summer season due to evapotranspiration effects. Our results illustrate that decoupling between annual GST and SAT signals is driven by processes occurring in both summer and winter seasons, suggesting that seasonal effects throughout the year must be considered to accurately assess annual relationships between SAT and GST, and the evolution of annual relationships over much longer timescales.

GC44A-03 1600h

Ground warming patterns in the northern hemisphere during the last five centuries

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Changes in the Earth's surface energy balance recorded underground have been used to reconstruct the temperature of the ground surface for the last 500 years in the northern hemisphere. We reconstructed ground surface temperature histories (GSTHs) from temperature versus depth profiles measured in 558 sites distributed between 30°and 60°N in the northern hemisphere using an inversion algorithm based on singular value decomposition. We show that that the ground has warmed about 1.0 K in the last 500 years. Spatial analysis reveals that spatial variability is important. Local short term oscillations are superposed to the general warming trend. Recent cooling is observed in Canada and Central Europe. The largest warming occurred during the last 50 years over the whole hemisphere and is more intense over the North American continent and South-Eastern Asia. To facilitate comparisons with previous northern hemisphere studies we computed an hemispheric average using several spatial averaging methods including a "cosine" projection algorithm. Although ground surface and air temperatures comparison is rather problematic, the weighted average northern hemisphere GSTH shows some consistency with multiproxy reconstructions for the last two centuries.

GC44A-04 1615h

GCM-Scale Blending Heights From the BOREAS Observations

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GCM modeling studies which examine the interaction between the land surface and the atmosphere above heterogeneous terrain, have shown that the air characteristics above different surface patches become

horizontally homogeneous at approximately one third of the height of the planetary boundary layer (PBL). In order to determine the consistency between this model behavior and observations, radiosonde data from the BOREAS experiment were analyzed. The data used in this analysis were from temporally concurrent measurements (daytime or afternoon), taken over a wide enough range of surface types and on scales comparable to a GCM grid size. An algorithm similar in nature to that used in the GCM studies and other observational studies was used to compute blending heights. Blending heights were observed over more than 50% of the vertical soundings from seven locations that were analyzed. The ratio between PBL height and blending heights varied between spring and summer seasons, as expected. Seasonal averages of the daily maximum height of the blending height from spring and summer seasons will be presented. The relation between blending height and surface ground temperature as well as air temperature will also be discussed.

GC44A-05 1630h

Complexity of mid-Holocene climate variability revisited

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The mid-Holocene (8,000 to 4,000 BP) has long been interpreted as a warm stable interval and the 6,000-year BP has been the preferred target date used in paleoclimate modeling exercises. However, recent high-resolution proxy-records from around the world reveal that the mid-Holocene contained considerable climate variability at century to millennial scales. Moreover, the evidence shows that the mid-Holocene may not have been as warm on a global scale. We present a mean-continental temperature reconstruction for North America that suggest temperature variations on the order of $\pm$ 0.2°C during the Holocene. This is compared to several other climate proxy records around the world. At this scale, it is difficult to identify synchronicities, leads and lags due to regional differences in climate, proxy sensitivity to climate change and dating control, except in cases of high climate variability such as the LIA. It appears that the mid-Holocene is also an interval of high climate variability. We discuss possible scenarios including synchronicity, leads and lags during the mid-Holocene on a global scale.

URL: http://www.uottawa.ca/academic/arts/geographie/lpcweb/

GC44A-06 1645h

Climate change inferred from borehole temperatures: minimal "snow effect" from North America

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Borehole temperature-depth profiles contain information about surface ground temperature histories over time scales of several centuries and in particular prior to the widespread availability of surface air temperature records [*Huang et al, Nature, 2000; Harris and Chapman, GRL, 2001*]. Borehole-based reconstructions on the regional and hemispheric scale yield significantly different magnitudes of warming in the past 500 years when compared to proxy-based reconstructions. Borehole reconstructions suggest that the Northern Hemisphere warming has been about 1.1 °C while proxy methods indicate warming closer to 0.7 °C [*Mann et al, Nature, 1999*]. One suggested reconciliation of borehole and proxy reconstructions is that long-term variations in seasonal snow cover may bias the borehole record. A spurious long-term warming signal relative to SAT trends could be introduced by alteration of the duration or onset of seasonal snow cover over the course of decades or longer. We have developed a "snow effect" model that predicts transient warming or cooling of the surface ground temperature due to changes in the onset, duration, and depth of snow events [*Bartlett et al, in review*]. We use our model to compute the response of ground temperatures at the regional scale to seasonal snow cover of the past century in North America. Snow and air temperature data used in the model come from the United States Historical Climatology Network (NOAA-NCDC NDP-070) and the Canadian Daily Climatic Dataset (CDCD). Results indicate that variations in snow onset and duration have had the greatest influence in Central North America, leading to ground warming on the order of 0.1-0.2 °C / 100 yrs in this region relative to SAT trends. Other regions within North America have experienced negligible effects over the past century. We conclude that the magnitude of the snow effect in North America is insufficient to reconcile completely regional borehole and proxy reconstructions of climate change. References:

Bartlett, M.G., D. S. Chapman, and R. N. Harris, Snow and the ground temperature record of climate change, *JGR - Earth Surface*, submitted, 2004.

Harris, R. N. and D. S. Chapman, Mid-Latitude (30°-60° N) climatic warming inferred by combining borehole temperatures with surface air temperatures. *GRL*, 28, 747-750, 2001.

Huang, S., H. N. Pollack, and P. Y. Shen, Temperature trends over the past five centuries reconstructed from borehole temperatures, *Nature*, 403, 756-758, 2000.

Mann, M. E., R. S. Bradley, and M. K. Hughes, Global-scale temperature patterns and climate forcing over the past six centuries, *Nature*, 392, 779-787, 1998.

GC51A CC: 220 C-E Friday 0830h

Multiangle Remote Sensing of the Terrestrial Environment IV Posters

Presiding: **N G Loeb,** Hampton University**; A Lyapustin,** NASA Goddard Space Flight Center

GC51A-01 0830h POSTER

Comparing the Retrieval of Cloud-top Height by Different EOS Terra Sensors

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The Moderate Resolution Imaging Spectroradiometer (MODIS) and the Multi-angle Imaging Spectroradiometer (MISR) are two of the instruments aboard the Terra Earth Observing System (EOS). Algorithms for the retrieval of cloud-top heights have been implemented in order to get a product that can be applied in climate change studies, climate modeling and atmospheric research. Cloud height information can be used to analyze the Caribbean climate and to understand deforestation patterns on rain forests. The algorithms to retrieve this kind of information are based on CO2 slicing method and stereo matching methods. Cloud height information appears in terms of cloud top pressures. To compare MODIS cloud top pressures with MISR cloud top heights, it is important to look for a good atmospheric profile for the Caribbean such as by looking at field instrument observations. Available data from MODIS and MISR is geolocated in different latitudes and longitudes. MISR technique is an innovative method that assigns height values in a geometric form. As part of this study it is intended to assimilate the sensors paths through the Caribbean over a period of every 16 days. In order to compare MODIS cloud-top pressures and MISR cloud-top heights, cloud-top pressures must be converted into cloud-top heights. Radiosonde observations can be used to get pressure-height profiles over the Caribbean. Also this kind of data can be used to validate MODIS and MISR parameters. Do cloud height measurements from MODIS can be better comparing to MISR measurements? Do cloud height measurements from MODIS or MISR can be used to classify cloud types?

GC51A-02 0830h POSTER

Current Status of Cloud Masks for the Multi-angle Imaging SpectroRadiometer

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The Multi-angle Imaging SpectroRadiometer (MISR) on-board EOS-Terra makes observations at 9 angles (1 nadir, 8 oblique) in the visible and near-infrared. Cloud detection is a critical part of the MISR mission, but is made more complicated by the fact that there are no spectral channels longward of 866 nm in wavelength. This has led to the development of several novel approaches to cloud detection. For MISR, three independent cloud masks have been developed: the Radiometric Camera-by-camera Cloud Mask (RCCM), the Stereoscopically-Derived Cloud Mask (SDCM), and the Angular Signature Cloud Mask (ASCM). This poster will demonstrate the current status of the three MISR cloud masks and the strengths and weaknesses inherent in each. Methods of evaluating the cloud masks will also be shown, including visible inspection and comparisons with the Moderate Resolution Imaging Spectroradiometer (MODIS). Finally, analyses of the minimum detectable optical depths will be demonstrated, through the use of ground based data.

GC51A-03 0830h POSTER

Multiangle Remote Sensing of Optically Thin Cirrus Clouds From MISR Using Support Vector Machines

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Thin cirrus clouds, those with optical depths less than 1, can potentially have large radiative effects on the atmospheric and surface energy budgets in regions where they are prevalent. They also present an impediment to the retrieval of clear sky properties such as aerosol optical depth, temperature profiles, etc. Such clouds, however, are notoriously difficult to detect using standard satellite remote sensing techniques. The unique multiangle sensing capability of the Multiangle Imaging SpectroRadiometer (MISR) on NASA's Terra satellite, in particular the availability of cameras with view angles as large as 70.5 degrees, gives MISR the ability to detect thin cirrus clouds that are invisible to nadir-looking instruments. While MISR has been operational for over four years and many scenes containing thin cirrus have been examined on a per case basis, there remains a need to objectively and automatically identify just the cirrus clouds within any given scene. Based on our previous work applying machine learning technology to develop a more robust MISR cloud mask, we have developed a thin cirrus cloud detector for MISR, using Support Vector Machines (SVMs), and taking advantage of spectral, spatial and angular signature information from MISR's 45.6, 60 and 70.5-degree cameras. For a few representative cases, we will demonstrate the accuracy of the SVM cirrus retrieval, especially in comparison to a traditional nadir-looking retrieval, emphasizing the usefulness of the multiangle approach. We then show how this trained SVM can be used to generate a climatology of thin cirrus clouds.

GC51A-04 0830h POSTER

Multiangle Remote Sensing of Cloud Properties From POLDER-1 and POLDER-2

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