forcing. This all greenhouse heat is used up in evaporation and the warming of the earth is zero. 3, The identity of the two rates double-checked the two independent proofs. Therefore experimentally no greenhouse warming is triply proved.

A new branch of science Pleistocene Climatology is developed to study the theoretical origin of no greenhouse warming. Climatology, like mechanics of a large number of particles, is of course complex and unwieldy. If totally order-less then there is no hope. However, if some regularity appears, then a systematic treatment can be done to simplify the complexity. The rigid bodies are subjected to a special simplifying condition (the distances between all particles are constant) and only 6 degrees of freedom are significant, all others are sidetracked. To study the spinning top there is no need to study the dynamics of every particle of the top by Newton's laws through super-computer. It only needs to solve the Euler equations without computer.

In climate study the use of super-computer to study all degrees of freedom of the climate is as untenable as the study of the spinning top by super-computer. Yet in spite of the complexity there is strict regularity as seen in the ice ages, which works as the simplifying conditions to establish a new science *Pleistocene climatology*. See my book *Greenhouse Warming and Nuclear Hazards* just published (www.PeterFongBook.com). This time the special condition is the presence of a permanent body of ice (thus Pleistocene), and the existence of two thermostats, the polar ice and the clouds, with the specific simplifying condition being the *neutral equilibrium condition of phase transition* of ice and water. As Boltzmann has done, the equilibrium condition staffs off all trivial degrees of freedom an simplifies the problem. Indeed it is the equilibrium condition that determines no greenhouse warming. The very fact that in the past century no decent theory of ice ages has been developed means that the climate study has missed the essential point(like the Euler equations for the spinning top). The greenhouse warming theory is now worked out as a special case (pp. 145-179) of the ice age theory (pp.113-144) in a canonical formulation that distinguishes itself from all makeshift theories.

On neutral equilibrium of phase transition: 1. No restoring force so that a small forcing can drive a large change, such as the ice age. 2,The temperature is always constant, the origin of thermostat, the basis of no global warming. Then why is the earth not at 100°C? New Idea. Cloud is the fourth phase of water, lowering the "boiling point" to the dew point of the cloud (pp.145-179). What if the cloud covers the whole sky, then the dreaded global warming will commence in earnest? But this will happen 2000 years later yet the fossil fuels will be gone in 300 years. Phase transition is a chemical equilibrium, not in the *general circulation model* , which cannot solve climate problems with super-computer.

GC31B MC: 308 Wednesday 0830h

Climate Observing System Challenges I *(joint with A, B, H, OS)*

Presiding: **B A Wielicki,** Nasa Langley Research Center**; R E Davis,** Scripps Institutionof Oceanography

GC31B-01 0830h INVITED

A Climate Observing System: Where are we, Where are we Going?

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Climate research and monitoring have both an operational and a research element. Operational implies a long-term commitment to the mission, such as ensuring that there are few gaps in the data record, that the data are acquired and preserved, and that mission costs remain affordable. Operational missions have broad mandates in regards to data acquisition. On the other hand, research missions are focused on specific scientific questions. There is less urgency to maintain absolute data continuity. An observational strategy for climate research requires a blend of long-term, carefully calibrated measurements (which are sometimes perceived to be the purview of the operational agencies) as well as short-term, focused process studies (which are perceived to be the purview of the research agencies.) Although long time series are used to detect climate change, many processes, such as ocean circulation, are only revealed on decadal scales. Thus such time series often fill a dual role of climate change detection as well as process study. The National Polar-orbiting Operational Environmental Satellite System (NPOESS) represents an enormous opportunity, but its implementation for climate research and monitoring requires considerable thought, planning, and leadership. Coordination with NASA research satellites, integration of new technology and new capabilities, attention to data stability and continuity, and scientific insight into data processing are some of the issues facing NPOESS.

Climate observing systems will require a strong research element for a long time to come. Although some aspects of the observing system can be turned over to an operational agency, it is clear that we still need more research and analysis on climate processes, sampling strategies, and processing algorithms. An appropriate forum is needed where discussions of the balance of climate observing requirements for research with short-term forecasting requirements can take place. At present, such decisions are sometimes made on an ad hoc basis, if they are made at all. Such a situation cannot continue as both policymakers and the general public increasingly demand knowledge regarding the Earths climate.

GC31B-02 0900h INVITED

Climate Observing Systems: Data System Challenges

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Existing observing and data systems have provided considerable information about past climate variations and changes. The recent reports by the Intergovernmental Panel on Climate Change, the National Research Council, and the USGCRP National Assessment of Climate Variability and Change are testaments to a vast array of knowledge. These reports also expose some serious deficiencies in our ability to discern past climate variations and change which lead to substantial uncertainties in key climate state, climate feedback, and climate forcing variables.

How significant are these uncertainties? For climate trends that have our highest confidence, like the change in mean global surface temperature, the 95 percent confidence intervals amount to about two-thirds of the calculated change. With such large uncertainties it is exceedingly difficult to discern accelerated changes. For other variables, especially variables related to climate feedbacks and forcings (with exceptions for long-lived and well-mixed greenhouse gases like CO_2 or CH_4) or climate and weather extremes, we often have little or no information to discern trends or cannot objectively assess confidence intervals.

Do we know how to reduce existing uncertainties? First and foremost, a climate observation oversight and monitoring capability is needed that tracks the gathering of the data, the processing system, and the performance of the observations, especially time-dependent biases. An organized capability does not now exist, but could be developed at a new and/or existing centers. This center(s) should then have the means and influence to fix problems and be able to establish requirements for new in-situ and satellite observing including related data systems. Such a capability should complement the following: (1) Climate observations from both space-based and in-situ platforms that are taken in ways that address climate needs and adhere to the ten principles outlined by the NRC (1999 Adequacy of Climate Observing Systems) and GCOS. An international framework is vital. (2) A global telecommunications network and satellite data telemetry capacity to enable data and products to be disseminated. (3) A climate observations analysis capability that produces global and regional analyses of various products for the atmosphere, oceans, land surface and hydrology, and the cryosphere. (4) Four dimensional data assimilation capabilities that process the multivariate data in a physically consistent framework to enable production of the analyses, not just for the atmosphere but also for the oceans, land surface and so on. (5) Global climate models that encompass all parts of the climate system and which are utilized to design effective sampling strategies and evaluate observations.

These improvements primarily relate to the data system, after the observation has been made, but they must be accompanied with a concerted effort to improve our instrumentation, platforms, and sampling resolutions for key climate variables.

How much would such a data system cost? Practical experience has shown that an effective archive and access system can be designed for about 5 to 10 percent of the total cost of the observing system. Building on a solid investment in data management infrastructure and hardware (including data quality control, access, and long-term stewardship), a comparable investment would be required to address oversight, monitoring, data analysis, data assimilation, and adherence to the ten principles. An implementation time frame on the order of five to ten years is probably a realistic time frame, similar to the planning and implementation horizon of major new observing systems.

GC31B-03 0925h

Simulated Climate Change by the Community Climate System Model

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Simulations from the Community Climate System Model (CCSM) are presented that consider the predicted magnitude and spatial patterns of natural climate variability and anthropogenically forced climate change. These simulations will consider changes from the inter-annual to century time scales for both the 20th and 21st centuries. Special focus will be given to the simulated variability and change in Earth's hydrologic cycle.

Changes in top-of-atmosphere climate fields will be discussed in terms of the magnitude and spatial distribution of change and required accuaracy of satellite observations to detect predicted future climate change related to increased greenhouse gases and aerosols. Changes in surface climate variables will also be considered in terms of observational accuracy, with special attention to predicted changes in ocean properties.

GC31B-04 0940h

Detection of Trends: Techniques and Monitoring Strategies to Optimize Trend Detection

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A large number of monitoring programs are established to detect trends in a variety of environmental parameters. Many of these programs have not yet detected significant trends, and there is some concern from the scientific community, the general public and program managers as to how long they will take to produce significant results. Methods are available for addressing the question of how long it takes to detect a given trend. The methods are applicable to most environmental data, particularly those relevant to climate change and ozone depletion. Conclusions from these analyses have been quite surprising. Some parameters, such as total column ozone and CO2, are particularly conducive to trend detection. Additionally, some locations appear to be much more agreeable for detecting trends than others. Accuracy, precision, continuity in datasets and spatial resolution or number of monitoring stations are quantifiably critical in trend detection. Some datasets appear to be limited in their ability to detect trends because of calibration uncertainty while others are limited because of the natural variability. General methods will be briefly covered, and some ideas will be proposed as to how to optimize networks and monitoring programs for the detection of trends.

GC31B-05 1015h

A Global Paleoclimate Observing System to Complement GCOS and GOOS

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Valuable high quality data on climatic and oceanographic conditions can be expected as plans for a Global Climate Observing System (GCOS), and a Global Ocean Observing System (GOOS) unfold. But these systems will not provide the long-term perspective that is necessary to capture the full spectrum of natural variability. Only high resolution (annually resolved) paleoclimatic data can provide information about the long-term variability of natural systems, of which the limited instrumental record is just a brief part. To realistically model and predict future changes, we must be able to capture in the models the overall range of natural variability that is relevant to society in the near future. What is needed is a large-scale program designed to collect, calibrate and analyse paleoclimate records from natural archives (such as tree rings, banded corals, banded speleothems, laminated sediments etc), in order to build up a detailed picture of climate and environmental variability in the past. This Global Paleoclimate Observing System (GPOS) would complement the GCOS and GOOS networks, and give a comprehensive perspective on contemporary and anticipated future climate changes. We propose specific steps to move forward with this plan, and provide examples to illustrate the potential benefits of such action

URL: http://www.pages.unibe.ch/

GC31B-06 1030h

Absolute Accuracy of Surface Irradiance Observations for Climate Research Applications

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The pursuit of absolute accuracy in broadband surface irradiance observations has been ongoing for over a century. While considerable progress has been made in the accuracy of direct solar beam observations, climate applications also require high accuracy observations of diffuse solar and thermal infrared irradiance, particularly when observations from different organizations and/or different eras need to be combined to evaluate certain processes and long-term changes. International standards for direct solar irradiance based on cavity radiometers have been established and are widely accepted, but no similar standards, or even widely organized efforts, exist to address the diffuse solar and infrared measurement needs. The lack of irradiance reference standards has been manifested in some recent research efforts. One such effort was the DOE/ARM ARESE II field program where extensive radiometric observations were compared to detailed radiative transfer calculations to investigate the completeness of the models. Another consequence of the current surface irradiance measurement capabilities is highlighted in international and national efforts to maintain sustained long-term observational programs to not only establish variations in radiation climatologies, but to also investigate climate model radiative computational capabilities, and to test the adequacy of satellite retrieved surface radiation quantities. In both of these projects, as well as similar ones, the need for known absolute compatibility between one set of radiometric observations and another observation or model calculation is paramount to the success of the investigations. This presentation will discuss the present status of absolute broadband solar and thermal infrared irradiance measurement capabilities suitable for addressing both campaign and network observations, as well as on going efforts of individuals, the ARM program, and the international Baseline Surface Radiation Network.

GC31B-07 1045h

Development of a Reference Sonde System for Climate Monitoring

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Global radiosonde data represent an increasingly valuable resource for studies of climate change, such as studying global tropospheric temperature and moisture variations and trends. The usefulness of radiosonde data for long-term climate monitoring, however, is limited by sensor accuracy, by data reporting practices, and by the fact that sonde and sensor types vary by location and with time. Numerous studies and reports have called for a reference sonde to serve as a transfer standard to compare and connect data from past, present and future sonde systems. A reference sonde can also serve as a calibration and quality-control tool for operational radiosondes and for many remote sensing systems, as a sensor test bed to facilitate the development of new radiosonde sensors, and as part of a larger development of a climate monitoring system. In the longer term, regular deployments of reference sondes will help ensure homogeneity and interoperability of radiosonde data records over both time and space. Special deployments will help researchers develop reliable correction schemes for historic radiosonde data.

We are planning to develop a reference sonde system at the atmospheric technology division (ATD) at NCAR. The development will take full advantage of existing fabrication capabilities, sensor calibration systems, and high-level instrument and RF engineering expertise within ATD. Our strategy is to start from ATD's existing GPS-dropsonde infrastructure, select current best sensors, calibrate them through NCAR to NIST, incorporate the reference sonde into all NCAR/ATD deployments, set up data access infrastructure and finally conduct operational tests. We will develop a reference sonde that has a flexible infrastructure and can be easily adapted to many types of sensors and many modes of deployment. In addition, to reduce costs, the reference sonde will be recoverable by using its internal GPS receiver as well as with a locator beacon/tracking receiver. We are currently working on developing a simple version of reference radiosonde for the International H2O Project (IHOP_2002).

GC31B-08 1100h

The Abysmal State of Abyssal Time Series: An Acoustic Challenge

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The 20th century rise in global sea level by 18 cm has not been explained. The rise has been continuous and linear since the previous century. It cannot be predominantly the result of thermal expansion. Global ocean warming (as recently compiled by Levitus and his collaborators) started too late, is too non-linear and too weak to account for the recorded rise. It is not impossible that the global warming has been underestimated for lack of adequate observations in the southern hemisphere, and at abyssal depths. Time series of abyssal temperatures are badly lacking. Tomographic methods have the required precision, vertical resolution and horizontal integration to accomplish this task.

A more likely explanation is to attribute most of the sea level rise to melting of polar ice sheets. There are two difficulties: the required melting is considerably larger than has generally been estimated, and there are serious restrictions imposed by astronomic measurements of the Earth?s rotation.

GC31B-09 1115h

Performance of Longwave Radiation Instruments: Comparisons Between Measured and Modeled Irradiances During Arctic Winter

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The longwave downward irradiance depends directly on the magnitude of the greenhouse effect. A recent comparison of longwave downward irradiances between global climate models and the best available surface measurements showed an especially large disagreement at observation sites with cold and dry climates. Accurate measurements and modeling of this irradiance is therefore required to detect and monitor possible changes in the greenhouse effect. The low water vapor content and the frigid meteorological conditions in the Arctic make measurements and modeling of the longwave downward irradiance a special challenge. The International Pyrgeometer and Absolute Sky-scanning Radiometer Comparison (IPARSC-II), which was conducted at DOEs Atmospheric Radiation Measurement (ARM) program site in Barrow, Alaska provided a unique opportunity to compare high accuracy longwave downward irradiance measurements and radiative transfer model computations during arctic winter. Continuous measurements over a 10 days period in early March 2001 with frequent clear-sky conditions yielded longwave downward irradiances between 120 and 160 W m^{-2}. Participants from 12 international institutions deployed 15 pyrgeometers, which were field-calibrated against the Absolute Sky-scanner. High accuracy radiosondes equipped with chilled mirror hygrometers and a Dobson spectrometer provided data that were used as input for the radiative transfer model computations.

GC31B-10 1130h

Enhancing NASA'S Contribution to Arctic Sea Ice and Ocean Studies

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In a recent report by the National Academies, an interdisciplinary committee assessed NASA's polar geophysical datasets in the context of the science questions driving the Earth Science Enterprise (ESE) and other avenues of polar research. The report examines data sets in terms of the major ESE themes: ongoing changes in polar climate and the biosphere, forcings of the polar climate system, responses and feedbacks to the forcing, consequences of change in the polar regions, and prediction of such changes. It includes a matrix of science needs and available data sets and, from that, identifies high-priority measurement needs, many of which are directly relevant to Arctic sea ice and ocean studies. The greatest overall needs are improved measurements of polar precipitation, surface albedo, freshwater discharge from terrestrial regions, surface temperatures and turbulent fluxes, permafrost extent and dynamics, ocean salinity, ice sheet mass flux, land surface characteristics, and sea ice thickness.

Some sea ice and polar ocean data sets are in relatively good shape. An example is sea ice concentration, although summer values are still questionable. Another example is sea ice velocity, obtained by both satellites and buoys. On the other hand, some data sets are still quite poor. An example is sea ice thickness, although recent preliminary work indicates this may be measurable via satellites. Sea surface temperature (SST) observations from satellites require special in situ calibration at low SST. Sea surface salinity (SSS) is not currently observed from satellites, although efforts are now underway to do this. However, the precision of this measurement is relatively low, and is worst at low SST. This is particularly unfortunate given the crucial role that SSS plays in the Arctic freshwater budget and in the Arctic (and indeed the global) thermohaline circulation.

GC31B-11 1145h

Atmospheric Observations of the Carbon Cycle.

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The atmospheric concentration of CO_2 determines its climate forcing. Significant changes in the operation of the carbon cycle, either caused by climate change or directly by human action such as land use and fossil fuel combustion, will not only influence the average CO_2 concentration but also leave recognizable signatures in the atmosphere, in the form of spatial gradients and temporal trends. The interpretation of spatial gradients in the atmospheric boundary layer is severely hampered by sparseness of the current data and by a lack of quantitative understanding of mixing between the boundary layer and the free troposphere. What is needed is more intense sampling through the depth of the troposphere. The accuracy requirements are severe: a hypothetical uniform source of CO_2 of 1 Pg (10^{15}g) C/year over the contiguous U.S. would create a change of CO_2 averaged over the entire atmospheric column of about 0.4 ppm. A level of accuracy of 0.1-0.2 ppm is a challenge for conventional measurements from airplanes. The challenge is more daunting for satellite measurements from which systematic biases will have to be eliminated to that level of accuracy. A combination of both methods will likely be needed.

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