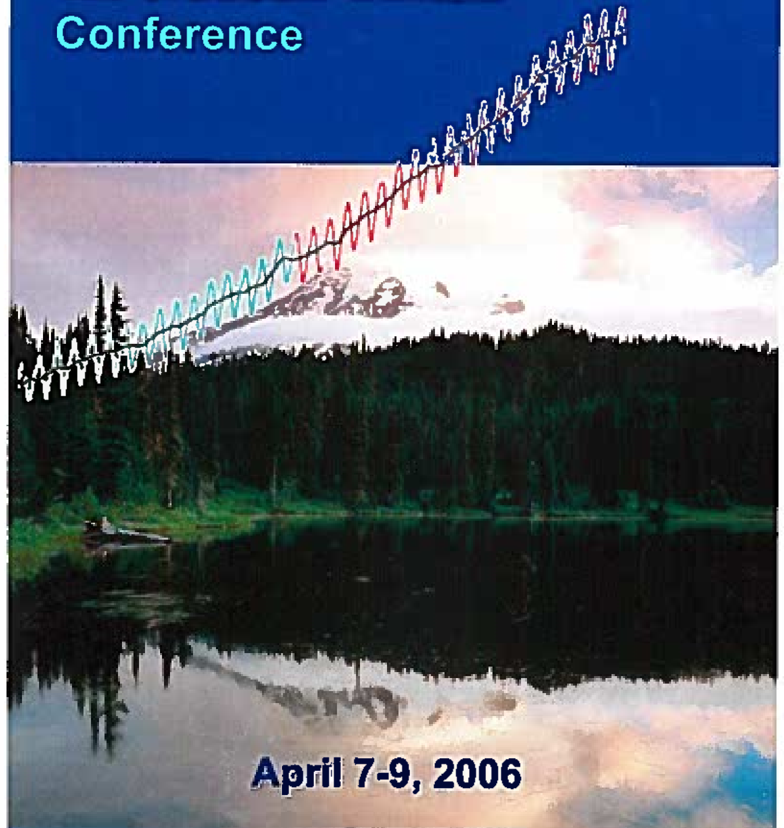
1st Graduate Climate Conference



Charles L. Pack Experimental Forest,
University of Washington

GCC 2006 Vision

The goal of the Graduate Climate Conference (GCC) is to provide a discussion forum for graduate students undertaking research on climate and climate change in an array of disciplines, including earth, atmospheric, biological, and ocean sciences. We seek to share new techniques and avenues of research, discuss recent findings and their implications, and consider the major questions in the future of climate research. The format is designed to encourage new climate scientists to grow acquainted with the details of diverse areas of climate research and to place their own research in the broader context of the climate science community. We envision fostering connections that will lead to future collaborations across disciplines and between institutions.

This event at the University of Washington's Charles L. Pack Forest in 2006 marks the first GCC and is the direct result of a decision made by a group of graduate students at the University of Washington from several climate science disciplines to design, organize, and orchestrate a conference for students from a variety of backgrounds to learn from each other. We hope this event will continue in the years to come, at different institutions and with new participants, to share and expand knowledge of climate science.

SCHEDULE OF EVENTS

Friday, April 7

7:00-8:00: Registration and Welcome Reception

8:00-9:00: Opening Remarks by Kevin Rennert

9:00-11:00: Social

Saturday, April 8

7:30-8:30: Breakfast

8:30-10:30: Session I: Radiation: Clouds, Aerosols, Ice
- Brian Magi*
- Jennifer Kay
- Louise Leahy
- Brian Medeiros
- David Mansbach
- Irina Gorodetskaya
- Larissa Back

10:30-11:00: Break

11:00-12:30: Session II: Large Scale Dynamics
- Camille Li*
- Aaron Donohoe*
- Brian Rose
- Joel Culina
- Celeste Johanson
- Ken Takahashi & Eleanor Frajka Williams

12:30-1:30: Lunch

1:30-2:45: Session III: ENSO
- Joe Casola*
- Rei Ueyama
- Robert Nicholas

3:00-4:15: Session IV: Biogeochemistry
- Roo Nicholson*
- Carrie Lee*
- Nir Krakauer
- Fanny Monteiro

4:30-5:45: Session V: Climate Impacts
- Jeremy Littell*
- Elaine Oneil
- Lauren Rogers
- Eri Saikawa

6:00-7:00: Dinner

7:30-9:30: Poster Session & Social

Sunday, April 9

7:30-8:30: Breakfast

8:30-10:30: Session VI: Paleoclimate
- Shelley Kunasek*
- Justin Wettstein
- Hans Christian Steen-Larsen
- Allegra LeGrande
- Jessie Kneeland
- Casey Saenger
- Amy Wagner

10:30-11:00: Break

11:00-12:30: Session VII: Observations
- Justin Minder*
- Michelle Koutnik
- Jennifer Adam
- Salil Mahajan

12:30-1:30: Lunch

1:30: Departure & Afternoon Hike

** denotes session chair*

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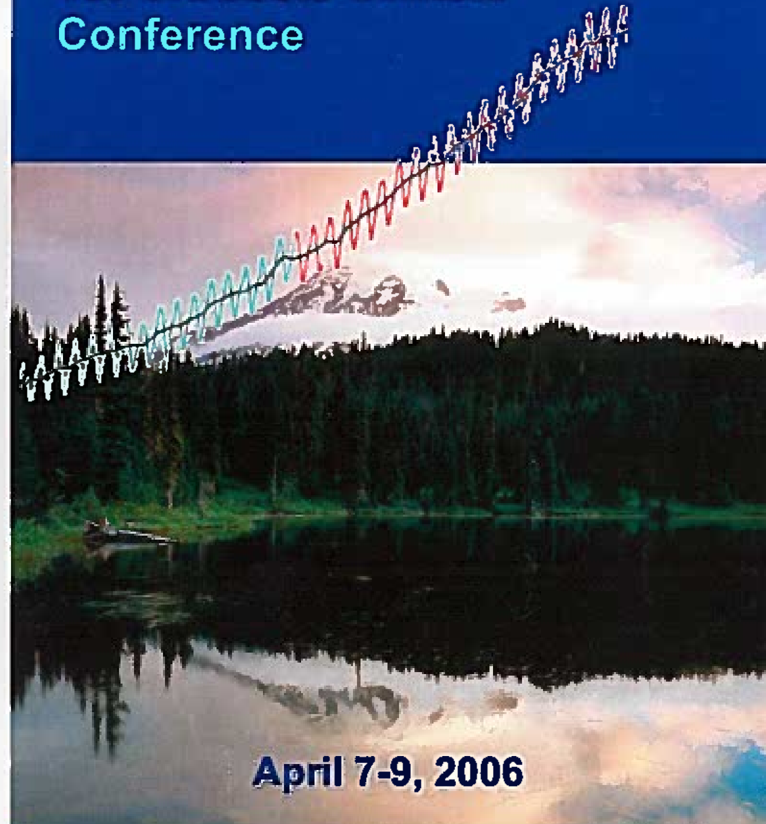
1st Graduate Climate Conference



April 7-9, 2006

Charles L. Pack Experimental Forest,
University of Washington

Session I: Radiation: Clouds, Aerosols and Ice

Brian Magi

Atmospheric Sciences, University of Washington

The Radiative Effects of Biomass Burning Aerosol in Southern Africa

Every year during the southern hemisphere winter months, Africa experiences a period of intense biomass burning. Most of these fires are anthropogenic and intended to clear fields of dead vegetation. The 2001 Intergovernmental Panel on Climate Change summary report suggested that the radiative forcing effects due to biomass burning aerosol are poorly understood. To address this issue, the University of Washington Cloud and Aerosol Research Group research aircraft collected in situ and remote sensing measurements of southern African biomass burning aerosol properties as a part of the Southern African Research Initiative (SAFARI) field campaign in August and September 2000.

I use a flexible retrieval algorithm constrained by in situ and remote sensing measurements obtained during SAFARI-2000 to retrieve solar spectral aerosol optical properties. The retrieved optical properties are used as input to a radiative transfer program which subsequently calculates the solar fluxes at different levels in the atmosphere. By examining the sensitivity of the calculated solar fluxes to the uncertainties in the input, I can estimate the uncertainty associated with the radiative transfer output. I will discuss both the radiative forcing and the uncertainty in the radiative forcing due to southern African biomass burning aerosol.

Jennifer Kay

Earth and Space Sciences, University of Washington

Cirrus Clouds and Climate 101

Cirrus clouds influence the Earth's global heat budget and therefore, the climate system. In addition to affecting the lateral and vertical transport of upper tropospheric water vapor, cirrus can result in a negative or a positive radiative forcing depending on their height and optical depth. In my presentation, I will review how cirrus cloud radiative impacts change as a function of optical depth and spatial coverage. Next, I will present modeling results that document how microphysical and dynamical processes in the atmosphere affect cirrus evolution and optical properties. To compliment my modeling results, I will describe observed cirrus inhomogeneity and optical depths using lidar observations from Lamont, OK (USA). Finally, I will review the key factors for cirrus cloud parameterization, briefly explain how cirrus clouds are parameterized in four global climate models used for the IPCC reports, and muse about the implications of my research for future improvements in cirrus cloud parameterizations. From my presentation, I hope non-cirrus researchers will understand why cirrus clouds are important, what processes control their evolution, and the current state of cirrus parameterization in weather and climate models.

Louise Leahy

Atmospheric Sciences, University of Washington

A Synthesis of Single Scattering Albedo Values of Biomass Burning Aerosol Observed over Southern Africa

Aerosol particles have a direct effect on the Earth's energy budget by scattering and absorbing solar radiation. Scattering of solar radiation by aerosols results in a loss of energy as radiation is scattered back to space from the top of the atmosphere (TOA). Absorption heats the atmosphere by trapping heat that would otherwise have been reflected back to space from TOA, increasing the energy of the Earth-atmosphere system. These processes have opposing effects on the Earth's radiation budget, and therefore it is important to know the relative magnitude of each in order to calculate the net effect of aerosols. To calculate the aerosol direct radiative effect, the advection, aging, removal processes, and radiative effects of aerosols in the atmosphere are simulated using chemical transport models often using observations as model inputs. There is a large uncertainty associated with this calculation due to the short residence time of the aerosols, the different mixing states of the aerosol chemical components and the regional differences in type and strength of emission sources.

The Southern African Regional Science Initiative (SAFARI) 2000 was a major airborne (NASA's ER-2 Aircraft, UK Met Office and University of Washington), spaceborne (Terra satellite), and ground-based (AERONET) field campaign in Southern Africa, involving scientists from over 18 countries that took place during 2000 and 2001. The main objective of SAFARI 2000 was to identify and understand the links between physical, chemical, and anthropogenic processes governing the Southern African land-atmosphere system. To date no attempt has been made to synthesize the various published results from SAFARI 2000 regarding aerosol optical properties. The purpose of this study is to compare single scattering albedo results from three independent methods, taking into account the measurement uncertainties associated with each method, with a view to presenting "best-estimates" of single scattering albedo that characterize the SAFARI 2000 biomass burning aerosol, for use in climate models and calculations of aerosol radiative effects on the Earth's radiation budget.

Brian Medeiros

Atmospheric and Oceanic Sciences, UCLA

The climate sensitivity of aqua planets

Cloud feedbacks remain a leading source of uncertainty in projections of future climate. This uncertainty arises because of the complex interactions between clouds and the environment. General circulation models (GCM) are the best available tools for studying cloud feedbacks and climate sensitivity, but are designed chiefly to simulate a realistic climate which can obfuscate the physical processes involved with feedbacks. Two state-of-the-science atmospheric GCMs using simplified aqua planet configurations are used here to understand the zonally symmetric component of climate sensitivity and the role cloud feedbacks play in it. Using several Cess-style climate change experiments the aqua planets are compared with the full GCMs. Despite the relatively simple climate, many aspects of the aqua planets are analogous to more realistic simulations, and the climate response to an increase in sea-surface temperature captures much of the behavior of the full GCM. Cloud feedbacks, especially in the Tropics, are similar to the full GCM response. The sign of the tropical cloud feedback is opposite in the full GCMs, and the aqua planets consistently have the same sign as their parent GCM. Changes in low clouds are commensurate with the climate response, while middle and high clouds show less consistent behavior across the configurations, hinting that low clouds are of vital importance in a changing climate. If the correspondence between the climate responses of aqua planets and the full GCM is robust, the aqua planet framework suggests an attractive method for investigating processes involved in simulations of climate change. In this work, we ask whether the aqua planet climate sensitivity arises from the same physical processes as in the default GCM configuration and make recommendations for future use of aqua planets.

David Mansbach

Scripps Institution of Oceanography

Low-level cloud variability over the equatorial cold tongue

Clouds play a net cooling role in today's climate, but changes in Earth's cloud coverage and characteristics are one of the biggest uncertainties in global climate change. Focused observational analysis can shed light on cloud processes and constrain and improve models. Analysis of satellite data shows that an area of pronounced cloud variability located on the southern side of the equatorial cold tongue exhibits strong negative correlation between cloud amount and atmospheric temperature advection. This is an area with high interannual variability in cloud amount and has climatological warm advection, in contrast to most subtropical stratocumulus regions, where temperature advection is cold. Lower-tropospheric stability (LTS) is found to be important here, as in previous studies, but in this region temperature advection exerts influence on cloud independent of LTS. A collection of visual synoptic cloud reports made by observers on ships over several decades also shows net increased sky coverage with anomalously cold advection. Cumuliform clouds occur more frequently with anomalously cool advection, and stratiform clouds and clear skies occur more frequently with warm advection.

This is explained if advection of warm air over cooler water serves to stabilize the surface layer, thus inhibiting the upward mixing of moisture, while cool or weak warm advection encourages air-sea fluxes and upward transport of moisture.

Anomalously cold advection south of the equator occurs when the equatorial cold tongue is weak whereas anomalously warm advection occurs when the equatorial cold tongue is strong and well defined. A potentially important negative feedback exists wherein cold advection over locally warm SSTs leads to greater moisture fluxes and sky coverage, and helps diminish SST by decreasing insolation and increasing evaporation.

Examination of three different global coupled climate models shows that none properly simulate the observed relationship between low-level cloud and temperature advection. The cloud-temperature advection relationship is captured in an atmosphere-only model forced by historical SSTs. This suggests that the coupling of atmosphere and ocean models creates a system insensitive to an important aspect of low-level cloud variability, or introduces other errors that drown out the cloud-temperature advection relationship and any ensuing coupled feedbacks.

Irina Gorodetskaya, Bruno Tremblay, Mark Cane, & Beate Liepert

Earth and Environmental Sciences, Columbia University

The cloud phase and sea ice albedo competing effects on the Arctic Ocean shortwave radiation budget in coupled models and observations

We analyze the impact of the Arctic sea ice concentrations, surface albedo, cloud amounts, and cloud liquid water and ice contents on the shortwave radiation budget in the 20th century simulations of three coupled models participating in the IPCC 4th Assessment Report. The models are: Goddard Institute for Space Studies Model (GISS-Er), UK Met Office Hadley Centre Model (UKMO HadCM3), and National Center for Atmosphere Research Climate Community System Model (NCAR CCSM3). The models agree with each other and with observations on the high Arctic mean cloud amounts in summer. However, large discrepancies are found in the cloud ice and liquid water contents. Recent ground-based observations showed that Arctic clouds have much larger liquid water contents than previously thought. Different temperature thresholds used in the parameterization of the mixed phase clouds divide the models into three categories with respect to the Arctic cloud phase: with much overestimated liquid water contents (CCSM3), extremely high ice content and very little liquid water content (GISS-Er), and small amounts of both (HadCM3). Summer sea ice concentrations and surface albedo crucial for the surface net absorbed solar radiation also vary among the models. In June, the differences between GISS-Er and CCSM models in the surface short wave incident flux and net absorbed flux averaged over the ocean north of 70°N are 52 and 27 W/m^2, respectively. In CCSM model the high surface albedo and high cloud optical thickness both contribute to significant underestimation of the surface net shortwave radiation during summer. In the GISS-Er and HadCM3 models, the surface and cloud effects tend to compensate, reducing the discrepancies in the surface net shortwave radiative balance. Despite the smallest amount of the shortwave radiation absorbed by the Arctic Ocean, the CCSM3 model predicts the earliest onset of the ice-free summers in the Arctic in response to atmospheric CO_2 doubling.

Larissa Back

Atmospheric Sciences, University of Washington

Constraints on convection: vertical motion profiles, entraining plumes and low level entraining CAPE

Convection over the tropical oceans, and the large-scale mechanisms which control it have been studied extensively. However, this is still an open area of research and there are basic questions that have not been answered. Global climate models (GCM) do not do well at simulating convection in the tropics, and even state of the art GCMs often have large errors in precipitation predictions. This short-coming affects many areas of research since tropical dynamics are closely tied to convection. Improving our understanding of convection and its interactions with the large-scale could help.

I utilize several reanalyses to examine how vertical motion profiles vary across the Pacific intertropical convergence zone (ITCZ). Idealized representations of vertical motion profiles, used in simple models and tropical meteorology classes have divergence (associated with decreasing vertical motion with height) occurring only near the tropopause. Surprisingly, there is a large (~2000km) region where climatological vertical motion profiles look quite different from these idealized representations. Maximum vertical motion is near 800mb and there is divergence through most of the troposphere, even when it is precipitating heavily. Some implications of this finding will be discussed, as well as related work using a cloud resolving model.

SESSION II: LARGE SCALE DYNAMICS

Camille Li
Atmospheric Sciences, University of Washington

The existence of a different atmospheric circulation regime in the presence of large ice sheets has implications for the stability of glacial climates. In a simulation of the Last Glacial Maximum from the NCAR Community Climate System Model CCSM3, we observe a strong, zonally oriented Atlantic jet, and associated with it, a decrease in wintertime storminess. Given the relatively short (on the order of weeks) adjustment time scale of the midlatitudes, one could imagine the possibility of abrupt climate change due to a shift between a fast, stable Atlantic jet regime and one more like today's. These jet shifts, along with changes in storminess and heat transport, the amplifying effect of sea ice and positive feedbacks with the tropics, could cause dramatic changes in the North Atlantic region as suggested by the paleoclimate record.

Aaron Donohoe
Atmospheric Sciences, University of Washington

Atmospheric Stability During the Last Glacial Maximum

Coupled general circulation models with Last Glacial Maximum ice sheet topography, orbital forcing, carbon dioxide suggest that the Last Glacial Maximum atmosphere supported fewer storms than the present day atmosphere. This result is counter intuitive given that there is more energy in the Last Glacial Maximum climate system to feed the storms: the enhanced equator to pole temperature gradient would be expected to support stronger baroclinic eddies and the stronger and more localized jets should support stronger barotropic eddies. The mechanisms leading to weaker storms during the Last Glacial Maximum are explored using normal mode analysis on the sphere and a simple rectangular three dimensional model with the general circulation output jet structure.

Brian Rose
Atmospheres, Oceans and Climate, MIT

The partition of heat transport in a simple coupled climate model

Dynamical heat transports in the atmosphere and ocean play a central role in the climate system by greatly reducing the pole-to-equator temperature difference. However, the mechanisms that set the partition of heat transport between the two fluids are not well understood. We seek a better understanding of this partition in order to make sense of the widely varying climate states of the Earth's past. Since the oceans are set in motion by the wind stress, it seems reasonable that the surface wind should play an important role in any theory of the partition.

I will describe a very simple, zonally averaged atmospheric model with eddy processes parameterized according to a mixing length theory for potential vorticity. This model is simple to solve and obeys global momentum and energy constraints; and yet it is capable of reproducing many of the gross features of the general circulation, including the surface wind pattern. This simplest of GCMs is coupled to an equally simplified ocean model via the surface wind stress and the heating. We will look at equilibrium solutions of this coupled model and try to glean some insight into the partition problem. In particular, we find that the atmospheric heat flux dominates over the oceanic flux in mid-latitudes due to its much more intense residual overturning circulation.

Joel Culina
University of Victoria

A rigorous reduction method applied to a model of atmospheric low-frequency variability (LFV)

Climate systems are multi-scale processes. Scale separation is the basis for reduction of high-dimensional climate models to low-dimensional models. High-dimensional models generally give the most accurate prediction of climate, but computation is extensive and the underlying dynamics is obscured. For example, the path of a slower-evolving 'climate' variable is muddled by the faster-evolving 'weather' variable, which is noise-like on the scale of the climate variable.
Low-dimensional models, then, have a place along-side high-dimensional models. Since the connection between the two model types is important, it is best to simplify high-dimensional models rather than work from scratch. It is also desirable that the reduction method be systematic and rigorously-based. I applied such a procedure, a stochastic reduction procedure, to a model of atmospheric low-frequency variability (LFV). This procedure is derived from theorems that prove for certain multi-scale systems, fast-evolving processes are reduced to a stochastic term. The power of this method lies in its rigor, in contrast to the more common ad hoc methods of stochastic representation.

LFV is characterized by a maximum in power among low-frequency waves, at around wavenumbers 2,3, and 4, in the wintertime extratropical troposphere. There is substantial evidence that this behavior is driven by an essentially low-dimensional system, key elements of which are persistent, recurrent and distinct wave patterns of planetary scale ('regimes'). The faster-evolving, synoptic-scale patterns are known to be necessary to the existence of LFV, but the dynamical relationship between scales is unknown. Applying the rigorous reduction method to a baroclinic, quasigeostrophic model of LFV, I will deduce these dynamics based on which of the reduced equations best reflects the full-dimensional model.

Celeste Johanson
Atmospheric Sciences, University of Washington

Satellite retrievals of tropospheric temperature reveal strong mid-latitude warming during 1979-2005 relative to the global mean temperature trend. Over the same period, the stratosphere shows strong mid-latitude cooling relative to its global mean trend.

These zonally symmetric bands of enhanced warming and cooling in the troposphere and stratosphere respectively may indicate a broadening of the Hadley circulation and a poleward shift of the jet stream. The pattern is strongest in the summer months in both hemispheres and may have wide-spread implications for both drought persistence and rainfall patterns.

Ken Takahashi[1] & Eleanor E. Frajka Williams[2]
[1]Atmospheric Sciences, [2]School of Oceanography, University of Washington

Heat Transport in Simple Models of Meridional Overturning Circulation

Sandstrom's theorem states that a closed steady circulation can only be maintained in a fluid body if the heating is applied at a lower level than the cooling in the absence of mixing. We investigate meridional overturning circulation in two simple models, Welander's one-dimensional loop model and a two-dimensional Boussinesq flow in a box. Both models have heating and cooling applied at the same level. We find that heat transport and circulation intensity depend on the type of boundary conditions, fixed flux or relaxation, even with negligible mixing. In the two-dimensional model, the intensity and geometry of heat transport--deep or confined to the surface layers--are affected by the intensity and vertical profile of mixing. Using these two simple models, with complex behavior, we draw conclusions about the use of fully three-dimensional models and the real ocean meridional overturning circulation.

SESSION III: ENSO

Joe Casola
Atmospheric Sciences, University of Washington

Weather Regimes in the North Pacific, Extreme Weather in the Western U.S., and ENSO

A clustering algorithm based on Ward's method was applied to 5-day averages (pentads) of the wintertime 500-hPa geopotential height field for 42 years of data (1958-1999) in order to identify and characterize weather regimes occurring in the North Pacific sector. The clustering technique produced four regime patterns, each exhibiting a distinctive ridge within the sector: the Off-shore Trough (OT) pattern has a ridge near the Bering Sea and a trough just to the west of the North American west coast; the Alaskan Ridge (AR) pattern has a high amplitude ridge centered in the Gulf of Alaska; the Coastal Ridge (CR) pattern exhibits a ridge aligned with the North American west coast; and the Rockies Ridge (RR) exhibits a ridge aligned with the Rocky Mountains.

The frequencies of occurrence of the four regimes have statistically significant relationships with extreme weather events in the western United States and with the phase of the El Nino-Southern Oscillation (ENSO). Consequently, these regime patterns offer a way to quantitatively understand the historical risk of some types of extreme weather events during El Nino or La Nina winters.

Rei Ueyama
Atmospheric Sciences, University of Washington

Diurnal and semidiurnal surface wind variations over the tropical Pacific Ocean

To advance our understanding of the large-scale atmospheric circulation, the daily cycle of the surface wind field over the tropical Pacific Ocean was examined. Hourly wind measurements collected from 51 moored buoys in the Tropical Atmosphere Ocean array (9°N-8°S, 165°E-180°W) from 1993 through 2004 were used to document the diurnal and semidiurnal harmonics of surface wind variability. The zonal wind component is dominated by a semidiurnal variation, with a near-uniform amplitude (~0.15 m/s) and phase (~0300 and 1500 local time) across the tropical Pacific. Semidiurnal zonal wind signals are reduced over the eastern equatorial Pacific where the difference in sea surface temperature and air temperature is minimal, indicative of stable conditions in the boundary layer. The semidiurnal cycle shows no pronounced seasonal variability and is generally well explained by atmospheric thermal tidal theory. The meridional wind, on the other hand, exhibits primarily diurnal variability (amplitudes ~0.20 m/s) with opposite phase on either side of the equator, particularly in the western Pacific (the maximum northward component ~0600-0900 local time in the Northern Hemisphere, 1800-2100 local time in the Southern Hemisphere). The diurnal cycle in meridional wind induces a diurnal cycle of surface wind divergence near the equator, with enhanced convergence in the late evening (~2100 local time). The diurnal cycle of the equatorial wind divergence may contribute to diurnal variability in convection and rainfall in the tropical Pacific. The diurnal meridional wind variations in the eastern equatorial Pacific exhibit seasonal variability, with higher amplitudes during boreal summer and autumn. The southward phase propagation of these winds (from ~1000 local time at 8°N to ~1800 local time at 8°S) may be associated with gravity waves emanating from a diurnally pulsating heat source in the intertropical convergence zone.

Robert E. Nicholas
Atmospheric Sciences, University of Washington

Precipitation and Drought in the Rio Yaqui Watershed

Characterized by a semi-arid climate, the Rio Yaqui watershed is one of the major river systems of northwest Mexico. A diverse agricultural economy, centered in the lower Yaqui Valley and anchored by highly-productive wheat and soy croplands, is dependent upon the availability of irrigation water from reservoirs in the Yaqui basin. Such an arrangement is vulnerable to disruption, as demonstrated by a recent drought. In this study, we use a statistical approach to explore the variability of precipitation and drought on seasonal to decadal timescales, and identify sources of predictability. We have developed a monthly 1900-2003 precipitation index for the Yaqui basin by merging two gridded land-surface precipitation products derived from local station data. Average annual rainfall is 553 ± 104 mm, arriving via two distinct seasonal mechanisms. Summertime (JJAS) rainfall dominates the annual total (71%) and is associated with the North American Monsoon System, but we have been unable to identify any large-scale climatic processes associated with summertime anomalies. Significantly less rain (22%) falls during winter (NDJFMA) although the absolute variance in the seasonal total is actually larger. Monthly anomalies tend to be well-correlated with one another during the winter months and the seasonal anomalies are well-correlated ($r = 0.5$) with indices of ENSO, which is known to deflect the storm track during El Nino years. Using this relationship, we develop two types of simple models for forecasting wintertime total precipitation: a deterministic linear-regression model and a probabilistic tercile model. If we employ recently-developed ENSO models rather than simply relying on persistence of current ENSO conditions, reasonably skillful forecasts of wintertime rainfall can be made up to six months out. Through analysis of our precipitation index and a 350-year proxy for wintertime rainfall based on Douglas Fir ringwidth chronologies, we find that serious droughts recur on multidecadal timescales and can be caused by persistent deficits in either season. The greatest wintertime deficits of the entire 350-year record were found to occur during the most recent drought.

ChuanLi Jiang
Applied Physics Laboratory, University of Washington

The relationship between the cross-equator southerly winds and the asymmetry in the eastern Pacific

The goal of this study is to explore the causal relationship among the cross-equator southerly winds, sea surface temperature (SST), and the precipitation asymmetry in the eastern Pacific (15°S 15°N, 120°W 70°W) on Mar. 2003. The second mode of a five-year (from Jan. 2000 to Dec. 2004) canonical EOF of the Tropical Rainfall Measuring Mission (TRMM) Microwave Imager microwave (TMI) SST and 10-meter QuikSCAT wind stress shows several interesting features: the principle component indicates a peak around Mar. 2003; a distinct meridional SST asymmetry with a warmer SST on the north eastern Pacific; a warm Costa Rica Dome; a strong cross-equator southerly winds in the eastern Pacific. In addition, the QuikSCAT winds convergence suggests that the convergence south of the equator is much weaker than the north one on Mar. 2003, and the north convergence zones is far off the equator, which might be associate with the anomalous strong cross-equator southerly winds. The comparison between the TRMM precipitation and meridional SST gradient profile suggested that the meridional SST gradient could be an important factor that contribute to the precipitation asymmetry on Mar. 2003. The SST modification owing to both the wind stress fields based on Chelton et al. linear relationship and the pressure gradient from Lindzen and Nigam hypothesis will also be addressed quantitatively. Finally we will address the possible factors that might contribute to the warm Costa Rica Dome on Mar. 2003.

SESSION IV: BIOGEOCHEMISTRY

David Nicholson, Steve Emerson, Charlie Eriksen and Chuck Stump
School of Oceanography, University of Washington

Biologically Produced Oxygen in the Subtropical North Pacific: a 4-D Seaglider Survey of Oxygen, Temperature and Salinity

Carbon export (the ocean biological pump) is a measure of the ocean's removal of carbon from atmosphere and export to the deep ocean. Carbon export been quantified at only a few locations corresponding to the primary time series stations in the ocean using the oxygen mass balance approach. This approach is based on quantifying the biological component of a surface ocean oxygen mass balance. A limitation of the one-dimensional approach used to make these estimates has been an inability to constrain mixing at the base of the permanent thermocline, and thus the flux of oxygen across this boundary. A better defined spatial and temporal data set is needed to define the physical processes controlling the flux of oxygen across the thermocline.

A Seaglider based method of measuring export production provides a 4-D (space and time) budget of oxygen, salinity and heat for the study area. With this technique we hope to decrease the errors involved in carbon export measurements as well as open the possibility for determining carbon export in a wide range of locations. An autonomous Seaglider was deployed from

February through November, 2005 in the vicinity of the Hawaii Ocean Time Series Station Aloha in the subtropical North Pacific. The Seagliders were equipped with temperature salinity and pressure sensors as well as both an Aanderaa optode oxygen sensor and a Seabird 43 oxygen sensor. Upwelling rate, and depth-averaged currents are calculated from GPS fixes and the glider flight dynamics.

During 2005 the Seaglider oxygen data quantifies a seasonal build up of oxygen in the euphotic zone and the development of a summer subsurface oxygen supersaturation maximum that was in excess of five percent. The spatial evolution of the oxygen supersaturation field will be shown.

Carrie Lee

College of Forest Resources, University of Washington

Thinning and biomass utilization: evaluating the potential to enhance carbon sequestration through forest management

There is strong consensus among the scientific community that levels of atmospheric carbon dioxide are rising rapidly and will significantly affect global climate. Means to reduce emissions through renewable energy sources and increased carbon sequestration will aid in mitigating rising greenhouse gas levels. Management of forests which, account for 90% of the annual carbon flux of terrestrial ecosystems, provides the greatest potential for increasing terrestrial carbon storage. However, there has been little agreement over the best strategy. This study examines how thinning and woody biomass utilization can be coupled as a forest management tool to increase carbon stored in forest stands and decrease carbon emissions through the generation of a renewable energy source. Measurements of tree growth and biomass, coarse and fine woody debris, and total soil carbon and nitrogen will be used to evaluate the impact of thinning and woody biomass utilization on site and soil productivity. Data measurements were conducted on a 4 x 4 matrix of treatments established in 1995 at the Sappho Long-Term Ecosystem Productivity Site (LTEP) including a no-cut control and late-seral thinned treatments with high, medium, and low levels of woody biomass removal. The Sappho LTEP is located in Sappho, WA on the Olympic Peninsula in a ~60 yr. old regenerated forest stand of primarily Western Hemlock (Tsuga heterophylla) and Douglas-fir (Pseudotsuga menziesii). Long-term site and soil productivity will be evaluated by comparing data between treatments and through time using pretreatment data collected before 1995 by LTEP researchers. Conclusions from this study will evaluate the potential to offset carbon dioxide emissions through forest management, while providing the added environmental and societal values of decreased wildfire and insect outbreak risk and increased economic opportunity for rural communities.

Nir Y. Krakauer[1] & James T. Randerson[2]

[1]Division of Geological and Planetary Sciences, California Institute of Technology, [2]Department of Earth System Science, University of California at Irvine

Carbon fluxes deduced from inversions of atmospheric CO_2: avoiding the pitfalls

Ocean and plant uptakes slow down the buildup of fossil fuel CO_2 in the atmosphere by about half. These uptakes both affect and are affected by climate, yet just where and when they are happening remains uncertain. An important method for estimating the distribution of carbon uptake over large regions involves the inversion of space and time patterns of measured atmospheric CO_2 concentrations, with the aid of atmospheric transport modeling, to deduce the CO_2 flux into or out of the surface. Here, we treat quantitatively some of the biases to which estimation of net oceanic and biosphere CO_2 fluxes is subject in such inversions. These include the diurnal and seasonal cycles in sources and sampling; emissions of reduced carbon that is oxidized to CO_2 in the atmosphere; transport of carbon in rivers; and the assumed wind-speed dependence of air-sea gas fluxes. We show that neglect of these biases in earlier inversions likely caused plant uptake in northern land regions to be overestimated and ocean and tropical uptake to be underestimated. Inversions that include careful treatment of these factors should yield more reliable information on carbon fluxes and their evolution over the coming decades.

Fanny Monteiro
Earth, Atmospheric and Planetary Sciences, MIT

Nitrogen Fixation in the North Atlantic

Nitrogen fixation is an important process for climate, since it is a main source of fixed nitrogen in tropical and subtropical waters. Because of a lack of data, indirect geochemical tracers (such as N*) are interpreted to estimate its activity. However, they reflect a combination of several processes, including nitrogen fixation, denitrification and possibly, preferential remineralization of phosphorus.
In an idealized 3D model of the North Atlantic, I explore the nitrogen and phosphorus cycles, where diazotrophs are explicitly limited by phosphate and light. I will discuss what controls the distribution of diazotrophs and nitrogen fixation in the model. I will then demonstrate that a sub-surface maximum of N*, similar to that observed in the North Atlantic, only occurs where there is preferential remineralization of phosphorus. Finally, I will present how nitrogen fixation, preferential remineralization and denitrification interact together and how they affect primary production in the gyre dynamics of the North Atlantic.

SESSION V: CLIMATE IMPACTS

Jeremy Littell
Climate Impacts Group and College of Forest Resources, University of Washington

Climate system - biosphere interactions and rapid ecosystem change in the 21st century and beyond

Climate change and climate variability impacts to ecosystem structure and function are at the heart of global change biology, and the research focus in this field should focus on the ability to predict these impacts and their ecological consequences over the next several decades and centuries. Ecosystem managers face the difficult task of identifying vulnerable processes and planning strategies for mitigating and/or adapting to the effects of climate change. Doing so requires robust scientific information on the rates and sensitivities of the most limiting processes managers wish to focus on, but our ability to estimate these rates and sensitivities is critically limited. For example, we know very little about the nature of regional-scale feedbacks to atmospheric processes that stem from terrestrial ecosystem response to climate change and variability. The role of these feedbacks is poorly understood partially because we are just beginning to understand the degree to which climate mediates ecosystem processes that lead to changes in albedo, the carbon cycle, and, ultimately, biosphere-atmosphere feedbacks. Tackling this set of problems requires understanding both (1) ecological processes sensitive to climate change and climate variability (e.g., shifts in the balance between plant mortality and recruitment-establishment via fire, insects, and climate-mediated direct mortality) and (2) atmospheric processes that are sensitive to the broad scale properties of the biosphere (e.g., $CO2$ sources/sinks, terrestrial albedo, and ecohydrology). In this talk, I use these ideas to focus on some of the largest sources of uncertainty in terrestrial ecosystem management in a warmer world with a greater appetite for ecosystem services.

Elaine Oneil
College of Forest Resources, University of Washington

Incorporating Climate Change Variables into Risk Assessments for Mountain Pine Beetle Outbreaks

The best estimates of the impacts of climate change on forested ecosystems suggest that extreme disturbance events such as massive fires and insect outbreaks will be the primary drivers of ecosystem change in the Pacific Northwest (PNW) Region. While disturbance is a common and natural part of PNW forest system dynamics, the scale and magnitude of disturbance events may well be beyond the historic range of variability for these forests. As a result, these events may have substantial implications on long term ecological integrity and sustainability at stand, landscape, regional, and global levels. To ensure sustainability of our forested systems in the face of climate change requires that we understand how climate might exacerbate disturbance cycles and how we might mitigate for such events.

To explore the dynamics of extreme disturbance events, I will use the example of the insect/host relationship between the Mountain Pine Beetle (MPB) (Dendroctonus ponderosae) and two of its major hosts, lodgepole pine (Pinus contorta) and ponderosa pine (Pinus ponderosa). Exploring what is known about climate's effects on host (tree) vigor, and insect physiology and flight patterns suggests that it is possible to segregate the impacts of climate from other variables that drive this complex disturbance relationship. My research specifically focuses on host susceptibility as a function of site, stand, and climate variables. By segregating these variables there is opportunity to estimate the impacts of climate change on the relative stability of the insect/host system thus providing a useful tool for predicting how MPB driven disturbance events will change as climate changes. The research suggests that there are also opportunities to plan for mitigation of these impacts in areas of specific ecological or economic value.

Lauren Rogers
School of Aquatic and Fishery Sciences, University of Washington

Climate, habitat diversity, and the sustainability of the Bristol Bay sockeye salmon fishery

Understanding the impacts of climate change on ecosystems is a critical goal for ecology. Marine fisheries in particular are sensitive to changes in climate, with major ecological and economic implications. The largest salmon fishery in the world occurs in Bristol Bay, Alaska, where millions of sockeye salmon (Oncorhynchus nerka) pass through on the way to their natal lakes, rivers, and streams to spawn. Taken together as a whole, Bristol Bay sockeye populations have fluctuated over 50-70 year periods in response to the Pacific Decadal Oscillation (PDO). However, at finer spatial scales, the response of sockeye salmon to climatic variation has not been uniform across rivers, or even among neighboring creeks within watersheds. These asynchronous responses may be important for the overall sustainability of the fishery since some salmon populations appear to thrive under certain environmental conditions while others do not. However, we do not understand the underlying drivers of these asynchronous population fluctuations.

I investigate how climatic variation affects sockeye salmon at different spatial and temporal scales, and explore whether geomorphic differences in the habitats used for spawning and rearing by sockeye result in asynchronous responses to climate among sockeye populations. My working hypothesis is that salmon populations do not respond coherently to changes in climate, even within the same watershed, because of habitat-specific features of the landscape that control the susceptibility of populations to changing climatic conditions. For example, I expect that populations spawning in high gradient streams are more susceptible to changes in fall precipitation due to scouring of eggs from gravel during floods, whereas populations in low gradient streams may be more susceptible to thermal conditions in summer. Using over 50 years of fine-scale demographic data on populations of sockeye salmon in the Wood River System of Bristol Bay, Alaska, I investigate how populations of sockeye salmon spawning in diverse habitats have responded to climatic variation.

Eri Saikawa
Woodrow Wilson School of Public and International Affairs, Princeton University

Transboundary air pollution is a major problem among the Northeast Asian countries. As a result of rapid industrialization, these countries experienced enormous environmental degradation, including air pollution and acid rain. Pollution travels outside the borders, creating transboundary problems. In particular, the sulfur dioxide emissions coming from China are causing problems in South Korea and Japan. Due to the adverse health and ecological impacts from air pollution and acid rain, there is a pressing need for regional cooperation to tackle the problem as soon as possible. There are multiple cooperation initiatives existing as well as bilateral ones, but they can at best be summarized as a minimal cooperation. On the other hand, political tension among China, South Korea and Japan is hindering an initiative to a certain degree. By looking at the current cooperation among these three countries, it is clear that further proactive movement is essential in order to decrease air pollution in the region. At the same time, such movement has a potential to curb carbon dioxide emissions, resulting in decreasing global warming. Using China's recent

Renewable Energy initiative as a core, there may be a way to achieve environmentally-proactive as well as economically-sound cooperation among the three countries. This presentation consists of six sections. Section 1 describes the transboundary air pollution from China to South Korea and further to Japan as well as the problem of acid rain. Section 2 discusses the adverse environmental impacts due to air pollution and climate change. Section 3 deals with existing environmental cooperation among the three countries with a comparison to the European convention on Long-Range Transboundary Air Pollution (LRTAP). Section 4 tackles the political and economic tension among the countries and the current anti-Japan movement. Section 5 describes China's current Renewable Energy initiative and finally, Section 6 explores the unique possibilities for environmental cooperation in the region using this China's new initiative.

SESSION VI: PALEOCLIMATE

Justin J. Wettstein
Atmospheric Sciences, University of Washington

Alternate Interpretations of Dust and Isotope Measurements at Greenland's Summit

Ice cores and other proxy-based indicators are unique and invaluable observations that allow us a glimpse into climates of the distant past. A clear interpretation of these carefully obtained records requires not only an understanding of the strength of the relationship between a proxy and the specific climate variable it represents, but also a sense of how this relationship may be modified in different climate regimes.

In this study, last glacial maximum (LGM) and modern climate simulations from a state-of-the-art coupled ocean and atmosphere general circulation model are compared to motivate atypical interpretations of two key Greenland ice core observations. In the first example, model output suggests that elevated dust concentrations at Greenland's summit during glacial intervals could result from increased aridity, different dust source regions, enhancement of surface winds and / or increased jet stream winds. Existing literature emphasizes the influence of modern dust source regions that are more efficient in the glacial due to a more vigorous atmospheric circulation, for which there is little convincing evidence in the model.

The second example explores the correlation of Greenland summit temperature with northern hemisphere climate in the two simulations. The purpose is to examine how much of the glacial / interglacial signal in the isotope record at Greenland may be due to enhanced temperature responsiveness at high latitudes and elevations, changes in the spatial covariance of northern hemisphere temperature, or modified modes of atmospheric variability. Existing literature tends to emphasize a less nuanced hemispheric or global significance of the Greenland isotope records.

The hope for this type of exploration is to challenge our interpretations of the proxy records and our assumptions about climate dynamics. The better we understand the proxies, the more we tend to have to change long-held assumptions about how our climate system operates.

H. C. Steen-Larsen[1] & S. J. Johnsen[2]
[1]Earth and Space Sciences, University of Washington, [2]Ice and Climate Research, University of Copenhagen

Using a Monte Carlo approach to recreate the yearly oscillation in $\delta^{18}O$ of an ice core

In precise dating of an ice core it is essential to be able to count the years back in time. One way this has been done is by looking at the summer/winter oscillation in the $\delta^{18}O$. However, since the $\delta^{18}O$ values have diffused recognizing an oscillation might be difficult. Instead of looking at the measured $\delta^{18}O$ profile in order to estimate how many yearly oscillations a given ice core includes, we try to recreate the $\delta^{18}O$ profile as it was before diffusive processes altered the values. This recreation, also known as back-diffusion, can be performed in two steps. First, we need to estimate the diffusion length. Second, we take the Fourier-transform of the $\delta^{18}O$ profile. Since diffusion is equal to the convolution of the original profile with a Gaussian-curve, back-diffusion is in the Fourier-space especially simple. To transform the back-diffused $\delta^{18}O$ from the Fourier-space we will have to estimate a cut-off value in the frequency domain so the white noise is not transformed back into the results.

The Monte Carlo method presented here will bypass any subjective estimation. By using a Monte Carlo simulation it is possible to sample solutions from the posteriori probability density. The sampling is done using a Metropolis algorithm. In this way one is able to recreate the original signal in an almost completely objective way. Hence the results from the Monte Carlo simulation are more trustworthy and return more information than the spectral method.

This method has numerous other applications. For example, extracting information from Continuous Flow Analysis data, or other data where the original profile has been smoothed by any of various known processes.

A.N. LeGrande[1], G.A. Schmidt, D.T. Shindell, C.V. Field, R.L. Miller, D.M. Koch, G. Faluvegi, & G. Hoffmann

[1]*Center for Climate Systems Research, Columbia University*

Consistent simulations of multiple proxy responses to an abrupt climate change event

Isotope, aerosol, and methane records document an abrupt cooling event across the Northern Hemisphere at 8.2 kiloyears before present (kyr), while separate geologic lines of evidence document the catastrophic drainage of the glacial Lakes Agassiz and Ojibway into the Hudson Bay at approximately the same time. This melt water pulse may have been the catalyst for a decrease in North Atlantic Deep Water formation and subsequent cooling around the Northern Hemisphere. However, lack of direct evidence for ocean cooling has lead to speculation that this abrupt event was purely local to Greenland and called into question this proposed mechanism. We simulate the response to this melt water pulse using a coupled general circulation model that explicitly tracks water isotopes and with atmosphere-only experiments that calculate changes in atmospheric aerosol deposition (specifically 10Be and dust) and wetland methane emissions. The simulations produce a short period of significantly diminished North Atlantic Deep Water and are able to quantitatively match paleoclimate observations, including the lack of isotopic signal in the North Atlantic. This direct comparison with multiple proxy records provides compelling evidence that changes in ocean circulation played a major role in this abrupt climate change event.

Jessie Kneeland

MIT

Alkenone-based Records of Holocene Cooling in Northwest Atlantic Slopewaters

Sea-surface temperature (SST) records based on alkenone unsaturation ratios will be presented from at least four different slopewater sites in the Northwest Atlantic, ranging from the Carolina Slope (about 32°N) to as far north as the Orphan Basin (about 50°N). These records primarily indicate a decrease in SST over the Holocene of several degrees Celsius in the south to as many as 8 degrees Celsius in the north. These significant Holocene decreases of SST will be discussed in terms of ocean circulation in the Northwest Atlantic and other climatological processes which can affect SST on scales of centuries to millennia.

Casey Saenger[1], Rienk Smittenberg[2], & Julian Sachs[2]

[1]*MIT/WHOI Joint Program,* [2]*University of Washington*

The Boy and his rain: reconstructing ENSO variability from lacustrine algal hydrogen isotopes.

The El Nino Southern Oscillation (ENSO) is the largest inter-annual perturbation to Earth's climate system, and is capable of causing environmental, economic and humanitarian hardship across broad regions. The present understanding of ENSO dynamics is poor, and it is unclear if ENSO events will be come more or less frequent and/or intense in response to increased global temperatures. Accurately forecasting future ENSO behavior can be significantly aided by expanding paleoclimatic records capable of forcing and validating climate models. Modern ENSO events are marked by a shift in precipitation from the western tropical Pacific Ocean to the central tropical Pacific Ocean. The lakes of the island nation of Palau, located in the western Pacific (7°30' N 134°30' E), are highly sensitive to these precipitation shifts, and experience increased evaporation during ENSO events. Differences in vapor saturation pressure cause hydrogen to be preferentially evaporated relative to deuterium, and lake water exhibits enhanced deuterium to hydrogen (D/H) ratios during ENSO events. With an additional fractionation effect, these isotopic excursions are incorporated into the structure of certain lacustrine algal lipids. Preliminary data analyzing the D/H ratio of ^{16}C fatty acids and dinosterol preserved in lacustrine sediments indicates these lipids capture decadal trends in ENSO variability. Applying the technique outlined here to longer sediment sequences has the potential to create the long term ENSO-driven paleoprecipitation records that are vital to understanding the future of Earth's climate.

Amy J. Wagner & Niall C. Slowey

Department of Oceanography, Texas A&M University

Corals at the Flower Garden Banks: Monitors of Environmental Change and North American Climate Variability

The Pacific/North American (PNA) pattern is a dominant atmospheric pattern of climate variability in the extratropical Northern Hemisphere and strongly influences the winter climate of the southeast United States. The instrumental record used to characterize the PNA pattern does not exist prior to the mid-1940s. However, information about past variability in the PNA pattern is preserved in the skeletons of long-lived corals at the reefs of the Flower Garden Banks National Marine Sanctuary (NMS). The Flower Garden Banks NMS is located ~180km south of the Texas/Louisiana border in the Gulf of Mexico and is the northernmost hermatypic reef on the United States continental shelf. It has previously been shown that linear coral extension rates at the Flower Garden Banks are highly correlated with winter air and sea surface temperatures. In addition, average winter temperatures in the southeastern United States are negatively correlated with the phase of the PNA pattern. During a positive phase of the PNA pattern, the southeast US experiences stronger and more frequent winter storms while a negative phase of the PNA pattern brings milder winters to the region. Thus, past coral extension rates at the Flower Garden Banks provide a means to reconstruct the history of temporal variations in the PNA pattern.

We collected several long cores of skeletal material from long-lived Montastrea faveolata and Siderastrea siderea coral heads from the Flower Garden Banks NMS. Annual extension rates will be determined based on X-radiographic analysis of high/low density growth bands and will be used to characterize interdecadal variability associated with changes in the PNA pattern. Preliminary counts of annual density bands indicate over 200 years of coral growth, well beyond instrumental records. In addition, the presence of winter stress bands due to below average water temperatures will indicate winters with more severe and/or frequent storms. Analysis of these results will contribute directly to our understanding of the temporal character of interannual and interdecadal variations of North American winter climate.

SESSION VII: OBSERVATIONS

Justin Minder[1], Allison Anders[2], Dale Durran[1], & Gerard Roe[3]

[1]Department of Atmospheric Sciences, University of Washington, [2]Department of Geology and Geophysics, Yale University, [3]Department of Earth and Space Sciences, University of Washington

Hydrology and Climate: Observations of Falling, Flowing, and Frozen Water

The large-scale influence of mountains on precipitation is well documented and understood. However little is known about how terrain influences precipitation patterns on smaller spatial scales (<40km), and yet it is precisely at these scales that precipitation has some of its greatest impacts on natural hazards and landscape evolution. We have worked to characterize precipitation patterns over the Olympic mountains of Washington State. By synthesizing archived mesoscale numerical weather prediction model output and observations from a dense network of precipitation gauges we have developed a detailed multi-year record of precipitation patterns at scales <10km. We consistently find, for individual storms and in the climatological average, a remarkable 1.5- to 2-fold enhancement of precipitation on the major ridges compared to the major valleys. The underlying mechanisms giving rise to this robust pattern are investigated in detail with specific case studies, combining observations and models of varying complexity. Results are being used to understand the stability of the observed patterns in a changing climate, and to assess the consequences of these patterns for natural hazards (i.e. landslides) and landscape evolution.

Michelle Koutnik, Howard Conway, & Al Rasmussen

Earth and Space Sciences, University of Washington

Blue Glacier, Olympic Mountains, Washington over the past 50 years

Monitoring of Blue Glacier began nearly 50 years ago by researchers at the University of Washington. The glacier has been losing an average of 0.56 m/yr in response to regional winter warming and drying in Western Washington since 1976. However, the retreat of Blue Glacier appears delayed compared to other glaciers in the area (e.g. South Cascade Glacier). It is likely that Blue Glacier adjusted quickly to environmental changes since the Little Ice Age, so that any current changes solely reflect recent changes in the Earth's climate. Glaciers are sensitive indicators of local climate and monitoring the evolution of many glaciers is important in order to quantify changes on a global scale.

The research program at Blue Glacier was established in the mid-1950s. Net balance has been estimated by various methods for each year since 1955. In early years, mass balance was measured repeatedly at stakes drilled into the ice. In later years, mass balance was estimated from the correlation observed in the early years between it and the equilibrium-line position late in the ablation season, observed from photographs. The time series of net balance has been adjusted to be consistent with topographic maps made in 1957 and 1987, along with laser altimetry measurements of surface elevation. These laser altimetry profiles are an important record that can be compared directly to values for the present surface to get changes in ice thickness.

Efforts over the past few years to continue the uniquely longstanding record at Blue Glacier include surface elevation measurements from kinematic GPS, placement of temperature sensors, and a snow-depth sensor capturing the current winter. This contribution will review the history of work done on Blue Glacier in the context of our current findings, as well as the connection between recent changes at Blue Glacier and other glaciers worldwide.

Jennifer Adam

University of Washington

Exploring the Effects of Precipitation Changes on the Variability of Pan-Arctic River Discharge

River runoff to the Arctic Ocean has been shown to be increasing, primarily during the winter and spring and from the major Eurasian rivers. Recent studies suggest that the increase is likely due to increased northward transport of moisture (and associated increased precipitation), but other studies show inconsistencies in long-term runoff and precipitation trends, perhaps due to uncertainty in the observational datasets. Through a combination of exploratory data analysis and land surface modeling, we estimate the uncertainty inherent in the trends derived from gridded precipitation datasets and comment on the likelihood that runoff changes are due to long-term changes in precipitation. In our exploratory data analysis, we compare the seasonal and annual trends of four observation-based half-degree gridded monthly precipitation products: University of Delaware (Udel), Climatic Research Unit (CRU), PREC/L, and GPCC's VASClim0; along with two reanalysis products: NCEP/NCAR and ERA40. Included in the comparison is a variation of the Udel dataset- created by applying an adjustment for spurious trends using high-quality station information to control for decadal scale variability. The precipitation trend characteristics are checked for consistency against R-ArcticNet v. 3.0's observed stream flow data and a published data set for large rivers from which the effects of dams have been removed. Using the trend-adjusted Udel precipitation and CRU temperature data as forcing, we run the Variable Infiltration Capacity (VIC) macroscale hydrology model over the pan-arctic land domain for the period of 1930-1989. Trends in simulated stream flow are checked for consistency against observed and "naturalized" stream flow. While precipitation changes can explain changes in observed runoff in some cases, major discrepancies exist (especially for permafrost regions). This suggests that there are other contributing factors, e.g. Permafrost degradation.

Salil Mahajan[1], Gerald R. North[1], R. Saravanan[1], & Marc G. Genton[2]
[1]Department of Atmospheric Sciences, [2]Department of Statistics, Texas A&M University

Statistical Significance of Trends in the Extremes of Monthly Precipitation Over the US

Extreme events of precipitation have a potential of impacting our social and economic activities. Observational studies suggest that there has been an increase in extremes of weather in the past decades, but it is difficult to assess their statistical significance as the real world provides just one realization of the stochastic behavior associated with precipitation variability. In this study, a stochastic model of monthly precipitation over the US was created to generate numerous realizations. These simulations were used to establish the statistical significance of the observed trends in the extremes using the Monte-Carlo scheme. The stochastic model incorporated log-normal density function to represent the skewed nature of the density function of precipitation, and also accounted for spatial correlation of precipitation among the climate regions. It is found that accounting for spatial correlation improves the stochastic model to better estimate the confidence limit bounds for the Monte-Carlo test. It is also seen that the log-normal density function accounts aptly for the skew-ness associated with monthly precipitation when averaged over spatial scales of climate regions. Monthly precipitation from various Global climate Models (GCMs) integrations of the 20th century was also analyzed. The similarity of the density function of monthly precipitation to the log-normal distribution is also exhibited coherently in all the GCM integrations. Furthermore, the similarity in the density functions of monthly precipitation of the real world data and the GCM integrations is remarkable, implying that precipitation is simulated reasonably well by the GCMs. A marginally statistically significant upward trend in the extremes of monthly precipitation over the US is observed over the past century in one of the precipitation datasets. GCM integrations of the 20th century were also subjected to the Monte-Carlo tests. No statistically significant trends in the extremes of monthly precipitation were observed in most of the GCM integrations. However, GCM integrations of the 21st century, widely display statistically significant upward trends, implying a role for anthropogenic forcing in the systematic increase of extremes of precipitation.

Poster Session

Jennifer Alltop
Earth and Environmental Science, Columbia University

A Comparative Study of Predicted Changes in Water Availability in Global Circulation Models

Of the many proposed changes that will take place in the climate system over the next century, water availability is potentially the most socially and economically dangerous. However, current Global Circulation Models (GCMs) disagree in their predictions of changes in regional water availability. By analyzing the hydrologic changes -- precipitation, evapotranspiration, soil moisture, and runoff -- from various models I will look for patterns that can be predicted in order to determine if any tendencies are induced by the model physics or by biases embedded in the models. Identification of biases or tendencies of GCMs will hopefully lead to improved intermediate range forecasts for droughts and seasonal water supplies, as well as, improved near and long term climate change predictions.

M. Berkelhammer
University of Southern California

Defending the significance of systematic $\delta^{18}O$ fluctuations recorded in the alpha cellulose from a stand of Pseudostuga macrocarpa as a proxy for ambient temperature change.

Studies have verified that there is a relationship between the $\delta^{18}O$ in precipitation and ambient temperature at the time of condensation (Dansgaard, 1964). The fluctuations in the $\delta^{18}O$ values in precipitation are preserved in the $\delta^{18}O$ in the cellulose of certain tree species (Burk and Stuvier, 1981 Borella et al. 1999, and Sauer and Siegwolf, 2003). The capacity to readily date tree rings coupled with the aforementioned relationship has provided a means to back-calculate highly resolved ambient temperature values from the oxygen isotopes in tree rings (Rebetez et al., 2003). New techniques for rapid and efficient extraction of alpha cellulose from tree cores, increased precision of mass spectrometry analysis and a desire for higher resolution Holocene temperature time series' have all increased the feasibility of this methodology and have subsequently produced increasingly convincing results (Brendel, 2000 and McCarroll and Loader, 2004). The Big Cone Spruce tree (Pseudostuga macrocarpa), a species that is endemic to the Peninsular and Transverse Ranges of southern California, has never before been the subject of an isotopic analysis however, a traditional dendrochronological analysis of the species has confirmed via ring width and density studies that the tree responds to fluctuations in winter precipitation (Fritts, 1965). The species has a spreading root system and a longevity in excess of 600 years both of which make it a suitable target for such a study. Initial results have indicated that there appears to be coherence between $\delta^{18}O$ values in the cellulose and the instrumental temperature record from the region. In order to fully account for the isotopic systematics that have generated this relationship, a series of precipitation collectors have been set up to gather local precipitation samples. In addition, analyses of local soil pore water via cryogenic vacuum extraction (Revesz and Woods, 1990) and leaf water via a toluene extraction method (Epstein and Mayeda, 1953) will be used to construct a complete picture of isotopic exchange from precipitation to cellulose in an attempt to defend the use of this method for a more extensive temperature-time series.

Mark Carson

School of Oceanography, University of Washington

Comparing methods of trend estimation of oceanic temperature data

Results are presented which demonstrate the complex nature of fitting linear trends to oceanic temperature data. Some examples of temperature data in various regions of the ocean are shown which are then compared to the mechanisms which generate linear trends statistically. Data characteristics which seem important include variance, magnitude and phase of various Fourier components, and regime changes in temperature such as the Pacific regime shift in 1977. A more complete understanding is sought which would explain how long a data record needs to be for a linear fit to properly detect real trends in the data. Lastly, linear fits are compared to non-parametric tests for trends in oceanic temperature data.

Heather D. Heuser[1], Patricia M. Anderson[1], Linda B. Brubaker[2], Ronald S. Sletten[1], Thomas A. Brown[3], & Anatoly V. Lozhkin[4]

[1] Department of Earth and Space Sciences, University of Washington, [2] College of Forest Resources, University of Washington, [3] Lawrence Livermore National Laboratory, [4] North East Interdisciplinary Science Research Institute, Far East Branch, Russian Academy of Sciences

In search of the Younger Dryas at Elikchan Lake, northeastern Siberia

The Younger Dryas (YD) was a climatic oscillation ~13,000-11,600 cal yr B.P. Likely initiated by changes in North Atlantic thermohaline circulation (THC), the YD was characterized by dramatic and abrupt climatic cooling over much of the world. The global distribution of the YD has been the focus of much attention, as most ocean-atmosphere general circulation models have predicted a significant reduction of THC in response to anthropogenic climatic warming. Although it has been referred to as a global event, analysis of paleo-data from eastern Siberia and Alaska indicate that not all high latitudes experienced a climatic response to the YD. Southern areas of Alaska reflect dramatic cooling during the YD; northern and interior Alaska registers continuous warming and/or warmer-than-present temperatures; and most of eastern Siberia shows uninterrupted warming into the Holocene.

Importantly, however, many of the studies conducted in eastern Siberia were not of high enough resolution to have recorded the YD. This study uses a multi-proxy, high resolution analysis to identify whether a YD signal is registered in a sediment core from Elikchan Lake, northeastern Siberia. The sediment core was analyzed for magnetic susceptibility, grain size, fossil pollen, and organic carbon and biogenic silica content at approximately 100 year intervals from 16,000-8,500 cal yr B.P. The data show marked changes at the glacial-interglacial transition (~11,000 cal yr B.P.), but do not reveal any abrupt changes as would be expected for the YD event.

Philip Higuera[1], Linda Brubaker[1], Pat Anderson[1], Feng Sheng Hu[2], Ben Clegg[2], Tom Brown[3], Scott Rupp[4]

[1]University of Washington, [2]University of Illinois, Urbana, [3]Lawrence Livermore National Laboratory, [4]University of Alaska, Fairbanks

The relative importance of vegetational vs. climatic controls on post-glacial fire regimes in the southern Brooks Range, Alaska

The post-glacial history of vegetation and climate in northern Alaska provides an excellent opportunity to document relationships between changes in vegetation, climate, and fire regimes. Over the past 13 k years at least four distinct vegetation assemblages have existed in the southern Brooks Range, and climate has trended towards cooler and moister conditions after maximum warmth in the early Holocene. We use multiple lake-sediment records to refine vegetation history and, for the first time, reconstruct fire history for the region with macroscopic charcoal stratigraphy. Select sites are used to reconstruct summer temperatures or moisture with fossil chironomids and oxygen isotopes. Our records suggest that frequent fires occurred during late-glacial times, when the region was approximately 3 degrees C cooler than present and dominated by birch shrub tundra. Fire occurrence decreased when vegetation assemblages changed to deciduous forests dominated by Populus, despite evidence of warmer-than-present temperatures. Coincident with a decrease in Populus and the addition of white spruce to the shrub tundra during the early Holocene, charcoal records suggest an increase in fire occurrence. Climate proxies suggest a gradual cooling on the order of 1degree C throughout the Holocene, with moistening around 6-7 k ybp. Despite this trend, the most pronounced change in fire regimes occurred with the addition of black spruce during the mid-Holocene, when both charcoal abundance and peak frequencies increased to maximum levels. Overall, millennial-scale fire history was more strongly linked to changes in vegetation than to changes in climate. These results suggest that vegetation assemblages (i.e. fuels) play an important role in mediating the effects of climatic change on fire regimes. Simple climate-fire relationships cannot, therefore, be extrapolated to predict the response of fire regimes to climatic change without considering patterns of vegetation change.

Matthew V. Kuharic[1], Alan Gillespie[1], & A. Bayasgalan[2]

[1]Earth and Space Sciences, University of Washington, [2]GeoInformatics Research and Training Center, Mongolian Technical Univ

Sediment core from ice-dammed paleolake Darhad, Mongolia

Natural exposures of sediment at 1560 m amsl on the banks of the Shargyn Gol (river) in Darhad basin (51.4°N, 99.4 °E) consist of 11 m of varved silts unconformably overlain by distal outwash from the nearby (5 km) Pleistocene Jarai Gol glaciers and 1 m of loess reworked into lacustrine deposits and capped by 1 m of unreworked loess. Uncorrected 14C dates from clam shells from the reworked loess give ages of 11,000-13,000 14C yr B.P.; larch twigs give ages of ~9300 14C yr B.P. Dates for fish scales and moss fragments from the varved sediments give ages of 33,000-50,000 14C yr B.P.

LGM sediments appear to be missing from the sequence. Darhad basin contains only small lakes today, and the most obvious explanation for deep (100-250 m) late Pleistocene lakes is damming of the basin by outlet glaciers from the Sayan ice field. To elucidate the late glacial lake history, and therefore the history of maximum ice advances from the ice field, we extracted a 91-m sediment core from the lake floor at 1547 m amsl, 10 km

NW of the town of Renchinlkhumbe. Preliminary analysis and dating suggest that Darhad basin was at least partially filled throughout much of the late Pleistocene, but it is not clear that the LGM lake level exceeding 1560 m, even though cosmogenic nuclide dating indicates moraines around the basin then. The lake appears to have persisted or reformed below 1560 m amsl even after the LGM glaciers retreated, possibly because of damming by outwash from the LGM outlet glacier rather than the ice itself.

In western Central Asia LGM glaciers were smaller than ones earlier in the last glacial cycle, which does not appear to have been the case in Mongolia. The sediments from the Darhad paleolake have the potential to elucidate aspects of the glacial and hydrologic history more thoroughly than analysis of glacial drift directly.

Shelley Kunasek

Earth and Space Sciences, University of Washington

Coupling nitrate $\delta^{17}O$ and $\delta^{15}N$ in polar ice towards quantitative determination of paleoatmospheric oxidant concentrations

Concentrations of atmospheric OH, referred to as the "oxidizing capacity" of the atmosphere, determine the lifetimes of trace gases such as methane (CH_4) and carbon monoxide (CO). Since methane is the third most important greenhouse gas, understanding natural and anthropogenic changes in the oxidizing capacity of the atmosphere is vital to a full understanding of the role of atmospheric chemistry in past and future climate changes. Recent work has demonstrated the potential for using the isotopic tracer $\delta^{17}O$ of nitrate and sulfate in polar ice cores to diagnose changes in the relative strength of different oxidation pathways (e.g. oxidation via O_3 vs. oxidation via OH). Because nitrate $\delta^{15}N$ provides complementary information concerning the atmospheric NO_2 mole fraction (NO_2/NO_x), coupling these isotopes measurements in polar ice cores may lead to quantitative determination of paleoatmospheric oxidant concentrations. Here, an atmospheric chemical box model is used to study the sensitivity of the $\delta^{17}O$ proxy to atmospheric chemistry conditions. Coupled measurements of $\delta^{17}O$ and $\delta^{15}N$ of nitrate in two snowpits from Summit, Greenland, are employed in conjunction with atmospheric concentrations of pertinent species from the GEOS-CHEM global model. The potential for applying this coupled isotope approach to polar ice core samples will be assessed based on the sensitivity study.

Deirdre Lockwood

School of Oceanography, University of Washington

Taking the Pulse of the Mekong: A River Metabolism Study

Large tropical river systems may represent a missing link in the carbon cycle. Although rivers have been represented in climate models as conduits of organic and inorganic carbon from the land to the ocean, biogeochemical processes within fluvial systems may have more of an impact on this flux than had been thought.

Research on the Amazon River suggests that outgassing of CO_2 derived from respiration of organic matter within the river may return nearly 0.5 Pg of terrestrial carbon to the atmosphere per year. If river systems throughout the tropics also behaved this way, they might recycle a substantial amount of terrestrial carbon to the atmosphere.

During flood seasons, many tropical rivers inundate and transport a large fraction of terrestrial carbon from soil and vegetation in the form of dissolved and particulate organic carbon. Primary production in the river itself adds to this carbon load. More labile carbon fractions are decomposed by bacteria to CO_2 that is outgassed or recycled within the river system. Some carbon is buried through sedimentation, and the rest is eventually transported to the ocean.

Although this story is well known, relative rates of respiration and photosynthesis-the river's metabolism-have yet to be described for most tropical rivers. To investigate these fluxes in a large tropical river system, I have been measuring ratios of the stable isotopes of dissolved oxygen and dissolved inorganic carbon throughout the Mekong River basin to determine the relative rates and sources of respiration and photosynthesis. By sampling water from first-order streams, larger tributaries, various sections of the mainstem, and floodplains and lakes, I hope to scale these measurements to estimate the net metabolic condition of the Mekong River basin.

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Atmospheric aerosols play a significant role in determining Earth's climate, both directly through scattering and absorption of solar radiation, and indirectly by impacting cloud formation processes. The high variability in the time-dependent spatial distribution of the aerosol coupled with an inadequate understanding of underlying physical processes, sometimes brought about by relatively poor characterizations of particle size-dependent chemical composition, limit our ability to quantify both the direct and indirect effects. Comprehensive studies of the relationship of aerosol optical and hygroscopic properties to particle composition as a function of size are therefore needed to improve our ability to compute radiative scattering by the aerosol on all size scales. The ongoing Elk Mountain/Laramie Aerosol Characterization Experiment (EMLACE) seeks to address these concerns by carrying out a comprehensive series of measurements at both a clean high-altitude mid-continental site, and in a small urban environment (Laramie, WY) during both summer and winter.

One study objective is to characterize the dependence of light scattering by ambient aerosol particles of known composition, on humidity. Size-resolved particle composition is being determined with an Aerodyne aerosol mass spectrometer, augmented by conventional filter pack bulk aerosol composition data. Dry particle size distributions are measured with an SMPS, a PCASP, and an APS. Two Radiance Research M903 nephelometers, separated by a Nafion tube humidifier, are used to measure light scattering from both 'dry' and 'wet' particles, at controlled low and high relative humidities, respectively. These scattering extinctions can then be compared to those calculated by Mie theory, using computed size-dependent refractive indices and particle size distributions determined by applying a hygroscopic growth model to the chemical composition and observed dry particle size distribution data. Measurements show scattering enhancement results from water uptake, even though organic material dominates the particle composition. Establishment of the quantitative linkages between scattering and particle size-resolved composition will facilitate the development of aerosol scattering parameterizations for climate models, retrievals of aerosol distributions using both satellite and ground-based remote sensing techniques, and predictions of air quality visibility impacts.

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Glacial History of the McMurdo Dry Valleys, Antarctica and the stability of the East Antarctic Ice Sheet

The glacial history of the McMurdo Dry Valleys, Antarctica is fundamental to understanding the history of the East Antarctic Ice Sheet (EAIS). The McMurdo Dry Valleys are the largest ice-free area in Antarctica and they contain deposits from the EAIS, alpine glaciers, and fjords that record the expansion of ice into the valleys. Considerable controversy exists as to how the EAIS responds to changes in the climate. One hypothesis suggests that the EAIS has persisted in its current configuration since the mid-Miocene (>13.6 Mya). This chronology is based on the age of glacial deposits found in the McMurdo Dry Valleys. The age of these deposits is confined by their stratigraphic relationship to ash layers found within the sediment and in contraction cracks. A second hypothesis postulates a number of major fluctuations in the size and glaciological conditions of the EAIS, and that the present ice sheet developed in the Pliocene (~3 Mya). This proposition is based on the record of glacial advances and retreats identified in offshore sediment cores in McMurdo Sound, Antarctica. Exposure dating with cosmogenic nuclides allows us to verify directly the timing of glacial events in the McMurdo Dry Valleys. We have sampled sediment from numerous glacial deposits in the McMurdo Dry Valleys and we are processing these samples for cosmogenic nuclide analysis. Preliminary results suggest either that the glacial deposits are quite young (~ 0.5 Ma) or that they are old, but have experienced extensive erosion. We are comparing the concentrations of multiple cosmogenic nuclides in these samples to consider the hypothesis that these deposits may have been covered and protected by less erosive cold-based ice. The glacial history of the McMurdo Dry Valleys afforded us by cosmogenic nuclide analysis will refine our understanding of how the EAIS responds to changes in climate and affects the global climate system.

Lia Ossiander

School of Oceanography, University of Washington

Control by the Iron Fist: Modeling Biogeochemistry in the Equatorial Pacific

The equatorial Pacific is one of the largest natural sources of atmospheric carbon dioxide as well as one of the most highly productive regions of the global ocean. However, much of the surface nitrate is not utilized and there is strong evidence that the region is iron-limited. Limited data suggest an iron maximum in the Equatorial Undercurrent.

The PISCES biogeochemical model is used to investigate the pathway and biogeochemical effect of a western continental iron source in the equatorial Pacific. The iron perturbation spurs an increase in biological productivity east of the dateline and a reduction in the extent of high-nitrate conditions at the surface. The maximum of phytoplankton biomass shifts upwards in the water column, likely due to light limitation. Particulate organic carbon export increases, although its spatial pattern changes due to the shifts in nutrient availability and vertical concentration of biomass. Changes in nitrate and iron fluxes between model runs are quantified, demonstrating the efficient recycling of nitrate in the equatorial band and greater scavenging loss of iron. Upwelling dynamics transport remineralized nutrients back to the surface within a narrow band near the Equator. The shift in ecosystem structure upon the addition of a western iron source suggests that terrestrial iron sources and equatorial dynamics can exert control on equatorial Pacific productivity and carbon export.

Data on dissolved iron in the western equatorial Pacific and candidate source regions will be collected during a research cruise departing Honolulu on August 15, 2006 and used to improve model simulations of the magnitude and location of the iron source.

Xin Qu & Alex Hall

Atmospheric and Oceanic Sciences, UCLA

Using the current seasonal cycle to constrain snow albedo feedback in future climate change

Divergence in simulations of climate feedbacks surrounding surface albedo, tropospheric water vapor and clouds is a major uncertainty in climate change projections. One reason for the divergence is because observed records of interannual variations of surface albedo, water vapor and clouds are usually very short and thus cannot be used to evaluate the feedbacks in climate change simulations. Taking snow albedo feedback as an example, we demonstrate that this difficulty can be circumvented by exploiting similarity between anthropogenic climate change and the present-day seasonal cycle, both of which are examples of externally-forced climate variability.

Based on scenario runs of 17 climate models used in the IPCC 4th assessment, we decompose northern hemisphere springtime snow albedo feedback in climate change simulations as the product of two terms. The first is the dependence of planetary albedo on surface albedo, representing the atmosphere's attenuation effect on surface albedo anomalies. We find in all simulations surface albedo anomalies are attenuated by approximately half in northern hemisphere land areas as they are transformed into planetary albedo anomalies. The intermodel standard deviation in this factor is surprisingly small, less than 10% of the mean. Moreover, when we calculate an observational estimate of this factor using the satellite-based ISCCP data set, we find most simulations agree with ISCCP values to within about 10%, in spite of disagreements between observed and simulated cloud fields. This suggests errors in simulated cloud fields do not result in significant error in this factor, enhancing confidence in climate models.

The second term, related exclusively to surface processes, is the change in surface albedo associated with an anthropogenically-induced temperature change in northern hemisphere land areas. It exhibits much more intermodel variability. Its standard deviation is about 1/3 of the mean, with the largest value being approximately three times larger than the smallest. We find these large intermodel variations in feedback strength in climate change are nearly perfectly correlated with comparably large intermodel variations in feedback strength in the context of the seasonal cycle. Because of this tight correlation, eliminating the model errors in the seasonal cycle will lead directly to a reduction in the spread of feedback strength in climate change. Moreover, the feedback strength in the real seasonal cycle can be measured and compared to simulated values, and thus provides a reasonable constraint to feedback strength not only in the context of the seasonal cycle, but also in context of climate change.

Ivan Ramirez
Columbia University

Hantavirus and El Nino in New Mexico

One of the potential effects from climate change in the southwest U.S. is the increase of rodent-borne infectious disease incidence and its impact on human health. Climatic factors such as temperature and precipitation may influence disease transmission through their effects on the ecology of disease vectors and animal host populations. However, it is difficult to directly attribute weather and climate events to human health impacts because pre-existing socioeconomic factors as well as environmental conditions (land use changes) may render a population to be vulnerable.

The Hantavirus Pulmonary Syndrome (HPS) was recognized as an emerging infectious disease in New Mexico after a large outbreak occurred following precipitation anomalies attributed to the 1991/1992 El Nino event and another one in 1997/1998. Researchers found correlations between the precipitation rates, deer mice population (reservoir hosts), and HPS cases. The purpose of this poster is to examine the relationship between climate and HPS, and to draw attention to the social factors, which may have contributed to the vulnerability of the most affected population, the Native Americans.

Reetta Saikku
University of Southern California

Today the ocean's overturning circulation draws heat into the Northern Atlantic and releases this heat to the atmosphere, warming Northern Europe and surrounding regions. During glacial times this circulation system was evidently less effective in transporting heat to the Northern high latitudes and this is thought to have contributed to cooler climatic conditions. According to the "bipolar see-saw" theory (work by J. Jouzel, T. Sowers and M. Bender, 1995, among others) excess heat that was not exported to the Northern Hemisphere was stored in the Southern Hemisphere and this lead to warming there. The most dramatic example of this "see-saw" phenomenon was during the transition from the last glacial into the Holocene when the warm Bolling-Allerod episode is thought to have been associated with the Antarctic Cold Reversal.

Earlier episodes of Northern Hemisphere warming/cooling as recorded in the Greenland ice core records may have similarly been associated with bipolar temperature swings. Marine core MD98-2181 (6°N and 126°E) is ideally located in the western Tropical Pacific where, at a depth of ~2100m, it is bathed in Antarctic Intermediate Water. The surface waters, on the other hand, record the Northern Hemisphere climate signal (Stott et al, 2002). High resolution oxygen isotope records for benthic and planktonic foraminifera, as well as a Mg/Ca paleotemperature record for planktonic foraminifera, will offer a unique opportunity to examine the north-south phasing of climate change at a single tropical site across Dansgaard-Oeschger events (Dansgaard et al, 1993). Data compiled for D/O events 8 and 12 will contribute to the discussion of the bipolar see-saw with one marine location recording both the Southern (benthic foraminifera deep water) and the Northern (planktonic surface water) Hemisphere signals.

Anne M. Schrag
Big Sky Institute and Land Resource and Environmental Sciences Department, Montana State University

Biophysical controls on conifer distribution and abundance in the Greater Yellowstone Ecosystem

Incorporating climate into current park natural resource management practices is complex due to the relatively short planning horizon of management institutions. Because changes in climate can be slow, subtle processes, integrating them into long-term management presents a challenge. However, with the support of the National Park Service Inventory and Monitoring Program, we are developing bioclimatic envelope models that predict the current and future abundance of conifer species in the Greater Yellowstone Ecosystem under various climate-change scenarios. Bioclimatic envelope models detail species-specific responses to changes in physical parameters and increase understanding of processes controlling current and future distribution/abundance of species. To present this methodology as a viable strategy for incorporating climate change into management practices, we used publicly available data to develop the models. Species presence and abundance data were acquired from the US Forest Service Forest Inventory and Analysis Program, the DAYMET climate model provided spatial climate data and soils data were obtained from the CONUS-SOIL dataset. Using regression tree analysis, we predicted species importance values (a combination of the basal area and number of stems of each species) as a measure of species abundance. Model results were mapped using ArcGIS to provide a visual means by which to assess the predicted distribution and abundance of conifer species within the ecosystem. This project is expected to be of particular importance with respect to whitebark pine (Pinus albicaulis), a species of special concern within the ecosystem due to its role as a food source for grizzly bears (Ursus arctos), and its decline due to an introduced fungus (white pine blister rust [Cronartium ribicola]). Expected results include the following: predictions of species distribution and abundance will be more robust for species and locations that are highly influenced by biophysical variables; and species with small ranges, or that inhabit ecotone boundaries, are most likely to be affected by future climate change. When integrated with an understanding of past changes, these models will provide information with which to design a monitoring scheme that selects sites with a priori knowledge of potential causes of change, allowing for effective monitoring in a time of limited resources.

Michael Town

Atmospheric Sciences, University of Washington

Cloud cover over the South Pole from visual observations, satellite retrievals, and surface-based infrared radiation measurements

Estimates of cloud cover over the South Pole are presented from five different data sources: routine visual observations (1957-2004; Cvis), surface-based spectral infrared (IR) data (2001; CPAERI), surface-based broadband IR data (1994-2003; Cpyr), the Extended AVHRR Polar Pathfinder (APP-x) data set (1994-1999; CAPP–x), and the International Satellite Cloud Climatology Project (ISCCP) data set (1994-2003; CISCCP). The seasonal cycle of cloud cover is found to range from 45-50% during the short summer to a relatively constant 55-65% during the winter. Relationships between Cpyr and 2-m temperature, wind direction, wind speed, and longwave radiation are investigated. It is shown that clouds warm the surface in all seasons, 0.5-1 K during summer and 3-4 K during winter. The annual longwave cloud radiative forcing is 18.5W m−2 for downwelling radiation; 10.1 Wm^{-2} for net radiation. The cloud cover data sets are intercompared during the time periods in which they overlap. The nighttime bias of Cvis is worse than previously suspected, approximately -20 percentage points. CISCCP shows some skill during the polar day, while CAPP–x shows some skill at night. The polar cloud masks from satellites reviewed here are not yet accurate enough to reliably derive surface or cloud properties over the Antarctic ice sheet. Cpyr is determined to be the best surface-based source of cloud cover in terms of the combination of accuracy and length of record. We recommend the use of the Cpyr data set for further tests of satellite retrievals and for tests of polar models.

Blake Trask & Edward L. Miles

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Developing a Multi-Scale Assessment Framework for Adaptive Capacity in the Columbia River Basin and Skagit River Watershed

As environmental change occurs - specifically climate change - developing a method for assessing the adaptive capacity of local governments could prove useful for managers, scientists, and policymakers. Right now impediments to a clear method are numerous. A significant problem is that the concept of adaptive capacity is used differently within the literature that dilutes the term's application to natural resource management and planning. Acquiring a clearer theoretical framework for the adaptive capacity of local governments can then help us begin to ask the questions about the need and requirements for adaptive capacity in a local government context.

This study's goals are to (1) to review the literature and discuss the implications of the theory surrounding supporting concepts that add meaning to adaptive capacity; (2) to apply this discussion and a refinement of adaptive capacity of local governments in a modified framework developed by Alberti et al (2003) as a decision making tool for local government officials to assess their adaptive capacity through indices; and (3) to explore the applicability of the indices for use in a multi-scale analysis of the basin and watersheds to test hypotheses about the adaptive capacity of these local governments. If such a diagnostic tool is germane to this context, it could aid users in scenario construction for environmental planning.

Mark Zelinka
Atmospheric Sciences, University of Washington

Tropical Convection and the Distribution of Upper Tropospheric Relative Humidity

The ability of the tropics to retain heat largely constrains how much energy is available for export to the rest of the planet because the tropics make up a substantial portion of the globe and receive the greatest solar radiation. Clear sky outgoing longwave radiation (OLR) is most sensitive to upper tropospheric humidity (UTH) in the tropics such that an increase in UTH tends to result in a stronger reduction in OLR than the same increase at lower levels. Because deep convection is the dominant supplier of moisture to the atmosphere above the tropical boundary layer, I seek an observationally-based statistical relationship between convective intensity and the horizontal and vertical distribution of relative humidity (RH) in the tropics. I will use retrievals of column water vapor, water vapor mixing ratio, cloud liquid water, rainrate, temperature, cloud fraction, cloud top temperature, and cloud top pressure from the Advanced Microwave Scanning Radiometer for the Earth Observing System (AMSR-E) and the Atmospheric Infrared Sounder (AIRS). I will define several proxies for convective intensity, including rainrate, area of deep convection, cloud thickness, and area of heavy rain, explore the relationships among these measures, and assess their individual effects on RH. The relative contributions of water vapor mixing ratio and temperature changes to RH changes will be addressed, and results will be analyzed for several regions over the tropical oceans.

I hypothesize that UTH will be positively correlated with both areal and vertical extent of deep convection, and negatively correlated with rainrate. Preliminary analysis of water vapor and temperature profiles between September and November 2004 has shown that, in the presence of tropical cyclones, both absolute and relative changes in RH are negative in the boundary layer and positive in the free troposphere, with positive maxima at about 600 mb and 200 mb. These effects are loosely taken to represent the effects due to strong, organized convection on the vertical humidity structure, though more thorough analysis will explicitly assess the sensitivity of the UTH structure to various measures of convective intensity.

Lori Ziolkowski
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Radiocarbon (^{14}C) is a naturally produced isotope of carbon and it decays over time. This decay allows us to "date" natural processes, such as carbon cycling in the ocean. Using radiocarbon measurements dissolved organic carbon (DOC) in the Atlantic and Pacific Ocean was dated as being 3,800 and 6,100 radiocarbon years old (Loh et al., 2004). Black carbon (BC), which results from incomplete combustion of biomass or fossil fuels, might be a source of radiocarbon-depleted (or "old") organic matter to the ocean. Fossil fuels are radiocarbon dead, meaning that they have very, very low radiocarbon values, while biomass burning produces black carbon that is replete with radiocarbon. Recently, Mannino and Harvey (2004) measured up to 7% BC in marine DOC. For my dissertation I am trying to isolate black carbon from marine organic matter for radiocarbon dating. Ultimately I would like to be able to measure the radiocarbon content of black carbon in dissolved organic carbon and address the question: Is the black carbon contributing to the ^{14}C age of the DOC?

In order to radiocarbon date the BC, a non-destructive method for measuring BC must be utilized. Currently there are two non-destructive methods for BC isolation: thermal oxidation, and chemical oxidation. Thermal oxidation is a relatively easy method to employ, however there are many artifacts associated with that method. I am currently modifying a chemical oxidation technique using concentration nitric acid, initially developed by Bruno Glaser (Glaser et al, 1998), to isolate black carbon from marine organic matter. I will report progress in the isolation of black carbon extracted from standard materials (carbon-14 free coal and modern charcoal) using modified oxidation techniques (Wolbach and Anders (1989) and Glasser et al (1998)). My progress towards estimating the radiocarbon content of BC in deep ocean particle trap material will also be reported.

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