



**16'th Annual
Harold W. Borns, Jr. Symposium
Climate Change Institute,
University of Maine**

**WOOLLEY
ROOM
COMMUNITY
CENTER**

**DORIS
TWITCHELL
ALLEN
VILLAGE**

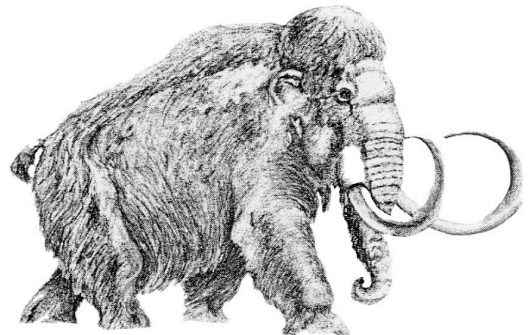
**UNIVERSITY
OF MAINE**

ORONO, ME



**Thursday, May 8
and
Friday, May 9,
2008**

**Presentations by:
University of Maine
Faculty, Students, Staff, and Guests**



**16'th Annual
Harold W. Borns, Jr. Symposium
Climate Change Institute, University of Maine**

PROGRAM

Thursday, May 8

07:30 - Coffee and Pastries

08:00 - Welcome and Introduction – Dan Belknap

GLACIAL GEOLOGY

08:15 – KELLEY, Samuel E. - Preliminary LGM chronology of the left-lateral moraine system, Pukaki Lobe, South Island, New Zealand

08:30 – DOUGHTY, Alice, DENTON, George H., HALL Brenda L., PUTNAM, Aaron, SCHAEFER, Joerg, BARRELL, David, and ANDERSEN, Bjorn. - ^{10}Be Cosmogenic Exposure-Ages from Late Pleistocene Moraines in the Maryburn Basin, New Zealand

08:45 – PUTNAM, Aaron, SCHAEFER, Joerg, DENTON, George H., KAPLAN, Michael, ANDERSEN, Bjørn, BARRELL, David, SCHWARTZ, Roseanne, FINKEL, Robert, and DOUGHTY, Alice. - Timing and duration of the Last Glacial Maximum, Termination, and late-glacial reversal inferred from ^{10}Be -dated glacial deposits in the Southern Alps of New Zealand

PALEOECOLOGY

09:00 – BELKNAP, Samuel L. III and SOBOLIK, Kristin D. - Beyond Diet and Health: Using Coprolites to Reconstruct Past Climates

09:15 – DIEFFENBACHER-KRALL, Ann C., DONER, Lisa, and NURSE, Andrea M., Quantitative reconstruction of post-glacial and Holocene temperatures and annual precipitation using pollen inference models

08:30 – SALM, Courtney R. and SAROS, Jasmine E. - Ecological Interactions Affecting Diatom-Based Inferences of Drought Frequency in Prairie Saline Lakes of the Northern Great Plains (USA)

09:45 – SAROS, Jasmine, HOBBS, William and WOLFE, Alexander P. - Rates and Mechanisms of Limnological Change in Alpine and Arctic Regions of North America.

10:00 – COFFEE BREAK

GLACIOLOGY

10:15 – HUGHES, Terence J. - Thermal Convection and the Origin of Ice Streams

10:30 – HAMILTON, Gordon S. and STEARNS, Leigh A. - Acceleration of Byrd Glacier, East Antarctica, linked to rapid drainage of subglacial lakes

10:45 – OSWALD, Gordon - Subglacial water in Greenland.

11:00 – STEARNS, Leigh A. and HAMILTON, Gordon S., Flow dynamics of Helheim Glacier, East Greenland

11:15 – SARGENT, Aitbala, FASTOOK, James, and JACOBS, Rodney - Applying SuperLU Parallel Solver to a Glacier Ice Sheet Model

11:30 – SNEED, William - Slush, Mush, and Masannartuq

11:45 – SPAULDING, Nicole., MEESE, Debra, and BAKER, Ian. - On the use of Scanning Electron Microscopy to Characterize Firn/Ice Cores

POSTERS – (On display all day, discussions during Coffee Breaks and Lunch)

KENNEWAY, Debra, SARGENT, Aitbala, and FASTOOK James - Better physics using full momentum solver in 2D vertical slice domain, where does longitudinal stress really matter? Application to the Thwaites Glacier flowline.

LAGERKLINT, Marianne, DIEFFENBACHER-KRALL, Ann, and NURSE, Andrea - The effect of the Eastern Maine Coastal Current on local climate and vegetation downeast during the Holocene

THOMPSON, Woodrow B., GRIGGS, Carol B., MILLER, Norton G., and WEDDLE, Thomas K. - Associated Terrestrial and Marine Fossils in The Late-Glacial Presumpscot Formation, Southern Coastal Maine, and the Marine Reservoir Effect on Radiocarbon Ages

12:00 – LUNCH

ANTHROPOLOGY

13:00 – OCAMPO-RAEDER, Constanza - *When the Rainbows Bring the Crayfish*: Traditional Management of River Resources in a Western Andean Valley of Southern Peru

13:15 – ROSCOE, Jim, and students in ANT490 and ANT497 - Cross-Cultural Conceptions of Climate and Weather

13:30 – ZARO, Gregory - Problem-oriented research, desertification, and the human dimension of long-term socio-ecological change

SOUTHERN HEMISPHERE CLIMATE AND ECOSYSTEMS

13:45 – BROMLEY, Gordon R. M., HALL, Brenda L., RADEMAKER, Kurt M, TODD, Claire E., SCHÄFER, Joerg, and WINCKLER, Gisela - Late-Quaternary Tropical Climate Change: Apparent synchrony between low-latitude and global records.

14:00 – CHAI, Fei, Modeling Peru Upwelling Ecosystem Dynamics: from Physics to Anchovy

14:15 – GARCÍA, Juan Luis, Pleistocene glaciations, landscape evolution and climate fluctuations in Patagonia, Southern South America.

14:30 – KURBATOV, Andrei.V., DE ALENCAR, A.S., AQUINO, F.E., AREVALO, M., GODOI, M.A., HANDLEY, Michael, INTRONE, Douglas C., JAÑA, R., MAYEWSKI, Paul A., PASSOS, H., SIMÕES, J.C., SNEED, Sharon B., and DE MENEZES TRAVASSOS, J. - Update on CASA (Climate of Antarctica and Southern America) initiative

14:45 – COFFEE BREAK

GLACIERS AND ATMOSPHERE

15:00 – KOFFMAN, Bess G., KREUTZ, Karl J., HANDLEY, Michael, SNEED, Sharon, WELLS, Mark, KURBATOV, Andrei, MAYEWSKI, Paul A. - A snowpit record of atmospheric Fe deposition in West Antarctica at the WAIS Divide site.

15:15 – DIXON, Daniel, MAYEWSKI, Paul A., SNEED, Sharon, HANDLEY, Michael, MAASCH, Kirk A., KREUTZ, Karl J., HAMILTON, Gordon S., and CARLETON, Andrew M., Reconstructing Past Antarctic Atmospheric Conditions

15:30 – POTOCKI, Mariusz. - Detroit Plateau Ice Core

16:00 – BRETON, Daniel J. - MADGE (Maine Automated Density Gauge Experiment) and MABLE (Mostly Automated Borehole Logging Experiment): New Tools for Measuring Polar Firn

GEOARCHAEOLOGY

16:15 – KELLEY, Alice R., BELKNAP, Daniel F., SANDWEISS, Daniel H., MAASCH, Kirk A., RADEMAKER, Kurt M., and REID, David A. - Paleogeography at Quebrada Jaguay, Peru: Geological Factors and Site Location.

16:30 – REID, David, SANDWEISS, Daniel H., OJEDA, Bernadino, and RADEMAKER, Kurt M. - Prehistoric Settlement Patterns of the Quebrada Jaguay Region, Southern Peru.

16:45 – RADEMAKER, Kurt, BROMLEY, Gordon, and REID, David - Quebrada Jaguay and the Terminal Pleistocene Coast-Highland Connection

KEYNOTE ADDRESS

17:00 - LAWRENCE B. CONYERS, Advances in Ground-penetrating Radar Mapping and Analysis for Geology and Archaeology,

Friday, May 9

07:30 - Coffee and Pastries

COASTAL AND SHELF GEOLOGY

08:00 – BROTHERS, Laura L., KELLEY, Joseph T., BELKNAP, Daniel F., and BARNHARDT, Walter A., Methane Source Bed Characterization in a Nearshore Pockmark Field, Belfast Bay, ME

08:15 – WILSON, Kristin R., KELLEY, Joseph T., BELKNAP, Daniel F., ALLEN, Evan S., and TANNER, Benjamin R. - Identifying a unique stratigraphic signature for Maine's salt pool environments

08:30 – KELLEY, Joseph T., and BROTHERS Laura L. - Beach Erosion at Camp Ellis, Maine: The Case of a Complex, Coupled Human-Natural System

08:45 – BELKNAP, Daniel F. and SANDWEISS, Daniel H. - Archaeological Geology of Beach Ridges in Northern Peru

NUMERICAL MODELLING

09:00 – MAASCH, Kirk A. - High-resolution regional model simulations of climate change in the northeastern United States.

09:15 – KOONS, Peter O., BIRKEL, Sean, PERRY, Randall H., NORTON, Stephen A., and JOHNSON, Scott E. - Exploring the evolution of Earth Systems via *Continental Dynamics*, *EPSCoR*, and *ITEST*

08:30 – BIRKEL, Sean D., DENTON, George H., HUGHES, Terence J., FASTOOK, James L., and KOONS, Peter O. - Climatic implications for the mechanical collapse of the Laurentide Ice Sheet

09:45 – FASTOOK, James L. and HEAD, J. W. III - A Model of Deuteronilus-Protonilus Mensae Valley Glaciation during Amazonian Mid-latitude Regional Glaciation (Mars).

10:00 – COFFEE BREAK

ARCHAEOLOGY

10:15 – FORTIN, Louis W., ZARO, Gregory D., YATES, Martin G., and ROBINSON, Brian S. - From Bedrock to Biface: Investigations on Lithic Tool Production in South Coastal Peru

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10:30 – SANDWEISS, Daniel H., MOSELEY Michael E., KEEFER, David K., and ORTLOFF, Charles. - El Niño, Earthquakes, Beach Ridges, Sand Sheets, and the End of the Late Preceamic Period on the North Central Peruvian Coast

10:45 – ROBINSON, Brian S. and ORT, Jennifer. - Pleistocene Aggregation: Demonstrating Contemporaneity at Bull Brook

GEOCHEMISTRY AND HYDROGEOLOGY

11:00 – NORTON, Stephen A., FERNANDEZ, Ivan J., AMIRBAHMAN, Aria, WILSON, Tiffany, and JACOBSON, George L. Jr. - What broke the "ferrous wheel?"

11:15 – PERRY, Randall H., NORTON, Stephen A., and KOONS, P.O. - Comparison of laboratory and whole-ecosystem chemical weathering in early post-glacial environments.

11:30 – JAIN, Shaleen - Sustainability considerations for western North American hydrosystems: Use-inspired research to understand nonstationary climate, flow regulation, and ecological flows needs.

EDUCATION AND OUTREACH

11:45 – SCHAUFFLER, Molly, HALL, Brenda, BROMLEY, Gordon. - A pilot electronic exhibit: "The Science of Climate Change: A journey to Reedy Glacier, Antarctica."

12:00 – LUNCH

CLIMATE CHANGE RECORDS

13:00 – CHAWATHE, Sudarshan S., KURBATOV, Andrei, MAYEWSKI, Paul A., and ROYER, Mark - Exploration and Visualization of Climate-Change Datasets.

13:15 – GRIGHOLM, Bjorn, MAYEWSKI, Paul A., AIZEN, Vladimir, KREUTZ, Karl J., WAKE, Cameron, KANG, Shichang, KASPARI, Susan, SNEED, Sharon, and HANDLEY, Michael, Spatial Variability of Atmospheric Dust and Potential Signatures of Anthropogenic Pollutants from Central Asian Ice Cores and Snowpits.

13:30 – KOROTKIKH, Elena, HAMILTON, Gordon, MAYEWSKI, Paul A., HANDLEY, Michael, INTRONE, Douglas C., and SNEED, Sharon B. - High-resolution glaciochemical records of the Eemian interglacial from a Mount Moulton horizontal ice core (West Antarctica)

13:45 – HALL, Brenda L., HENDERSON, Gideon M., BARONI, Carlo, and KELLOGG, Thomas B. - Holocene Radiocarbon Marine Reservoir in the Southern Ocean, from Paired $^{234}\text{U}/^{230}\text{Th}$ and ^{14}C Dates of Corals

WEATHER, CLIMATE and MODERN HUMANS

14:00 – GUILLEMETTE, Ryan, NURSE Andrea, and SMORODIN, Vladimir, Allergic Bio-Aerosol Monitoring: A collaborative effort to map and model pollen, spore, and airborne pollutants in Maine, with relation to climate change and human health.

14:15 – SMORODIN, Vladimir and FUKATA, Norihiko. - Novel Weather Modification Technology in the Context of Sustainable Eco-Development and Climatic Problems.

16:00 – UM GRADUATE RECOGNITION CEREMONY

ABSTRACTS

Archaeological Geology of Beach Ridges in Northern Peru

BELKNAP, Daniel F.^{1,2} and SANDWEISS, Daniel H.^{2,3}, Dept. Earth Sciences, 2, Climate Change Institute, 3, Dept. Anthropology, University of Maine. Belknap@maine.edu

The marine beach-ridge plains of northwest Peru preserve a record of coastal processes, climate changes, human exploitation, and human influences on geomorphology during the Late Holocene. We studied morphology and stratigraphy using leveling transects and ground-penetrating radar. The Chira beach ridge plain comprises a series of 9 major and several minor ridges that prograded seaward up to 4 km during a period of only slowly changing relative sea level over the past 5000 years. Periodic sediment inputs from the Chira river have been linked to a combination of large El Niños and inland tectonic disturbance, resulting in discrete ridges separated by low swales created during background rates of coastal progradation. All large ridges are covered by extensive shell layers and discrete middens, identified from hearths and artifacts. The prevailing southwest coastal winds blow loose sand inland in the absence of shell coverage. The outermost several hundred meters of the plain have a distinctly different hummocky morphology and much fewer shells. We hypothesize that this corresponds to the time of the Spanish conquest, extirpation of the native population, and thus removal of the source of the geomorphically protective shell layers. The shoreline deposits created during the past 500 years were extensively reworked by wind in the absence of this human landscape influence. The Piura system is very similar to the sequence described for Chira. Beach ridges at Colan and Santa are gravel, with less tendency for eolian reworking, and thus less direct human influence, but provide further evidence for timing of events and geologic, oceanographic, and climatic processes active on the northern Peruvian coast in the Late Holocene.

Beyond Diet and Health: Using Coprolites to Reconstruct Past Climates

BELKNAP, Samuel L. III- Climate Change Institute. Samuel.Belknap@umit.maine.edu, and SOBOLIK, Kristin D. - Dept. of Anthropology and Climate Change Institute, University of Maine.

Human coprolites have been used extensively to reconstruct ancient diets, providing great insight into past health and nutrition. Many of the aspects that make coprolites excellent measures of diet make them useful for local scale climate reconstructions. Coprolites represent discrete units containing material from 1-3 days of consumption. Since each coprolite contains material from a few days in undisturbed context (i.e. everything in the coprolite was eaten by the same person at similar times), plant and animal remains found in these coprolites can be used as indicators of the environmental conditions they were obtained from. In essence each coprolite is a snapshot of a portion of the environment, spanning no more than one week. I propose that using the Mutual Climate Range (MCR) approach towards climate reconstruction on the floral and faunal remains from human coprolites can provide an accurate reconstruction of past climate conditions for small temporal and spatial scales. By combining data from numerous coprolite studies from the Lower Pecos Region of Texas a mosaic of climate data can be compiled providing both local and region climate reconstructions throughout the Holocene.

Climatic implications for the mechanical collapse of the Laurentide Ice Sheet

BIRKEL^{1,2}, Sean D., DENTON^{1,2}, George H., HUGHES^{1,2}, Terence J., FASTOOK^{2,3}, James L., and KOONS^{1,2}, Peter O., 1. Department of Earth Sciences, University of Maine, 2. Climate Change Institute, University of Maine, 3. Department of Computer Science, University of Maine, sean.birkel@maine.edu

Although it is well established that the Laurentide Ice Sheet (LIS) collapsed over Hudson Bay ca. 8500 ¹⁴C years BP, the role of climate in this event is poorly known. We use a finite-element glaciological model to test the hypothesis that the ice sheet would have survived Holocene warmth had its marine-based core not disintegrated mechanically. In deglaciation experiments wherein a calving parameter with a bed-depth dependency is used, the LIS collapses in good accord with geologic data. In experiments in which this parameter is turned-off, the ice-sheet periphery undergoes a marked contraction, but the vast interior remains stable over Hudson Bay. The latter simulation uses a mass-balance scheme based on modern NCEP climate reanalyses. Our results indicate that the LIS demise was not caused by climatic amelioration; instead, the disappearance was rooted in the marine instability mechanism postulated by Weertman (1974). We conclude that, in the absence of mechanical collapse, the LIS would have persisted throughout the Holocene, and that it would still be a part of the North American landscape today. These results may have important implications for our understanding of glacial cycles.

MADGE (Maine Automated Density Gauge Experiment) and MABLE (Mostly Automated Borehole Logging Experiment): New Tools for Measuring Polar Firn

BRETON, Daniel J., Department of Physics and Astronomy, Climate Change Institute, University of Maine. daniel.breton@maine.edu

A brief overview of the theory and physical construction of the MADGE and MABLE are given, followed by data collected during journeys to East Antarctica on ITASE 2006-2007. MADGE is designed to provide high precision (+/- 0.004 g cm⁻³) and high vertical resolution (3.3mm) density profiles of ice cores using a fast gamma-ray counting system, electronic calipers and a stepper motor controlled actuator. MABLE is an instrument which logs borehole wall hardness and infrared reflectivity as a function of depth, with the goal of determining the location and length of non-recovered firn core sections.

Late-Quaternary Tropical Climate Change: Apparent synchrony between low-latitude and global records.

BROMLEY¹, Gordon R. M., HALL¹, Brenda L., RADEMAKER¹, Kurt M, TODD², Claire E., SCHÄFER³, Joerg, and WINCKLER³, Gisela, ¹Department of Earth Sciences and Climate Change Institute, University of Maine, Orono, ME, ²Department of Geosciences, Pacific Lutheran University, Tacoma, WA, ³Lamont-Doherty Earth Observatory, University of Columbia, Palisades, NY. Gordon_Bromley@umit.maine.edu

The sensitivity of the tropics to late-Quaternary climate changes has been established by a diverse range of proxies, including glacial geology, pollen and travertine records, and lake cores. However, the exact nature of these climate oscillations and their timing relative to higher-latitude changes remains unclear, limiting our understanding of the role of the tropics in climate change. We present a preliminary glacial geologic record of late-Quaternary climate change from Nevado Coropuna, southwest Perú, constrained by cosmogenic ³He ages. Although surface-exposure dating currently is less precise in the tropics than at higher latitudes, a number of important conclusions can be drawn from our dataset. First, the last glacial maximum (LGM) in southwestern Perú was broadly synchronous with the global LGM. Second, a significant readvance of glaciers on Coropuna occurred around the Late Glacial period, potentially in response to the Antarctic Cold Reversal/Younger Dryas. Third, the interval of time – ~6.5 Ka – between the LGM termination and this deglacial readvance matches the same interval in glacial records from Europe, New Zealand, and North America, further supporting low-high latitude synchrony of climate change. Fourth, having demonstrated the efficacy of surface-exposure dating in the tropical Andes, local calibration of cosmogenic ³He production rates is now critical for tropical surface-exposure chronologies to be compared to regional and global climate records.

Methane Source Bed Characterization in a Nearshore Pockmark Field, Belfast Bay, ME

BROTHERS, Laura L.¹, KELLEY, Joseph T.¹, BELKNAP, Daniel F.¹, and BARNHARDT, Walter A.²,
¹Department of Earth Sciences, University of Maine, Orono, ME. ²U.S. Geological Survey, Coastal and Marine Geology Program, Woods Hole, MA. Laura.brothers@umit.maine.edu

Biogenic natural gas deposits and circular seafloor depressions, or pockmarks, are globally occurring phenomena recognized in a variety of continental margin settings including deltas, estuaries, shelf basins, and areas of petroleum production. Associated with methane escape, pockmarks are also widespread in mid-latitude estuaries, especially in formerly glaciated regions, such as the Gulf of Maine. Despite their ubiquity, pockmarks are one of the least understood underwater landforms on the coast of northeastern North America. In Belfast Bay, Maine and similar settings in the northern Gulf of Maine, pockmarks are sourced by methane escaping from organic-rich sediments deep within the Holocene. We hypothesize that the source beds are early Holocene terrestrial (bog or lake) or estuarine (salt marsh, tidal flat, or bay) sediments that accumulated at a time of lower-than-present sea level. Results from a high-resolution Chirp seismic survey that gathered over 210 km of shore-parallel tracklines show a distinct seismic facies above the Pleistocene/Holocene unconformity. This unit ranges in thickness from 0 m to 3 m, and exhibits layered bedding. We hypothesize that this reflector represents the Holocene source bed and/or the pathway for gas-escape pockmark formation. Recently a vibracore survey collected 27 cores in precisely targeted locations identified by the Chirp profiles. Currently undergoing analysis, initial vibracore investigations indicate the presence of gas and identify a permeable bed that may act as a conduit. The permeable layer is 20-40 cm thick and is characterized by a fining-upward sequence of coarse material ranging from cobbles to coarse sand. Articulated *Mya arenaria* buried in life position rest atop the permeable layer and will be radiocarbon dated. With the continuation of vibracore analysis we anticipate the identification of a distinct organic layer as a source for the methane.

Modeling Peru Upwelling Ecosystem Dynamics: from Physics to Anchovy

CHAI, Fei, School of Marine Sciences and Climate Change Institute, University of Maine. fchai@maine.edu

The coastal waters of Peru are among the richest and most productive of ocean ecosystems with the world's largest single-species fishery, the Peruvian anchovy. Coastal upwelling brings cool, nutrient-rich deep water into the euphotic zone and thus enhances biological production at all levels of the food web. The Peru coastal upwelling ecosystem varies dramatically in responding to El Niño and Southern Oscillation (ENSO) and the Pacific Decadal Oscillation (PDO). In order to link natural climate variability (ENSO and PDO) with nutrients and plankton dynamics to Peruvian anchovy growth, distribution, and abundance, a Peru upwelling ecosystem model has been developed, which consists three components. First, a Pacific basin-wide circulation model based on the Regional Ocean Model Systems (ROMS), with 12.5-km resolution, is forced with daily air-sea fluxes derived from the NCEP reanalysis between 1990 and 2005. Second, biogeochemical processes are simulated with Carbon, Si(OH)₄, Nitrogen Ecosystem (CoSiNE) model containing multiple plankton groups. The CoSiNE model is embedded into the ROMS for the Pacific Ocean. The Pacific ROMS-CoSiNE model is integrated synchronously, and produces monthly outputs of three-dimensional temperature, current, nutrient and plankton distributions from January 1990 to December 2005. The Pacific ROMS-CoSiNE model reproduces many features similar to the observations. The third component of this upwelling ecosystem model is an anchovy dynamical model using an individual based model (IBM) approach. The IBM anchovy model takes the ROMS-CoSiNE model outputs for the Peruvian coast, and links each life-stage of the anchovy growth and reproduction with environmental conditions, such as temperature and food availability. Our analyses will focus on each sub-model system performance, their connections, and how these processes along the coast of Peru respond to ENSO and PDO natural climatic variability.

Exploration and Visualization of Climate-Change Datasets

CHAWATHE, Sudarshan S.^{1,2}, KURBATOV, Andrei², MAYEWSKI, Paul A.^{1,2}, and ROYER, Mark¹. ¹Dept. Computer Science, ²Climate Change Institute, University of Maine. chaw@gandalf.umcs.maine.edu

The P301dx system is a tool for interactive, visual exploration of diverse datasets relevant to climate-change studies. Examples of such datasets include not only typical examples of data from ice cores, but also data automatically extracted from papers and other publications, and from the Web. An integrated view of such data enables rapid discovery of connections that would otherwise be impracticable to find due to the amount of tedious work required. In addition to integrating data, P301dx allows convenient visual exploration using an intuitive visualization component. A notable feature of the system is that, in addition to providing a palette of data-manipulation tools, such as those for computing running medians, it also provides a simple but powerful graphical method for composing tools interactively.

Advances in Ground-penetrating Radar Mapping and Analysis for Geology and Archaeology

CONYERS, Lawrence B., Department of Anthropology, University of Denver, 2000 E. Asbury Street, Denver, CO, 80208, lconyers@du.edu

Near-surface sediment and soil packages contain the records of materials that can be used to reconstruct climate and environmental changes over time, as well as archaeological evidence of the people that adapted to those changes. One tool that can locate and study both the geological and cultural evidence is ground-penetrating radar, which has the ability to study stratigraphy and associated architectural features in three-dimensions. Examples from North and South America, Africa, and Asia will be used to demonstrate the utility of this geophysical method within both archeological and geological contexts.

Quantitative reconstruction of post-glacial and Holocene temperatures and annual precipitation using pollen inference models

DIEFFENBACHER-KRALL, Ann C., Climate Change Institute, Univ. Maine, DONER, Lisa, Center for the Environment, Plymouth State University, NH, and NURSE, Andrea M., Climate Change Institute, Univ. Maine. Ann_Dieffenbacher@umit.maine.edu

A compilation of pollen surface samples from 4634 sites (North American Pollen Database (NAPD) and other sources; Whitmore et al. 2005) and associated modern climate data is now publicly available. We selected a subset of 1100 sites, excluding the influence of western and southern pine species, for use as a modern training set for pollen-climate inference models (transfer functions). Mean July temperature models produce coefficients of determination (r^2) from 0.88 to 0.95 ($r^2=1.0$ is a perfect model) and root mean square errors of prediction (RMSEP) around 1 °C. Annual precipitation models yield r^2 values from 0.69 to 0.84 and RMSEPs from 100 to 130 mm. Temperature model output from Younger Dryas-age pollen from northern Maine compares favorably with chironomid-inferred temperatures for the same time period. Holocene annual precipitation from pollen models is comparable to multi-proxy, multi-core lake level reconstructions for the same region. We are currently testing various surface sample sets and inference model types to obtain the most accurate results for New England. The method can then be applied to other locations in North America using long-core data from the NAPD to create a full Holocene climate reconstruction for the US and Canada.

Reconstructing Past Antarctic Atmospheric Conditions

DIXON, Daniel^{1,2}, MAYEWSKI, Paul A.^{1,2}, SNEED, Sharon², HANDLEY, Michael², MAASCH, Kirk A.^{1,2}, KREUTZ, Karl J.^{1,2}, HAMILTON, Gordon S.^{1,2}, and CARLETON, Andrew M.³, ¹Department of Earth Sciences and ²Climate Change Institute, University of Maine, ³Dept. Geography, Pennsylvania State Univ.. daniel.dixon@umit.maine.edu

The chemical composition of Antarctic snowfall provides a representation of Antarctic atmospheric conditions. Thus, ice cores provide us with a window through which past atmospheric conditions can be viewed. The addition of seven new ice cores to the US ITASE collection allows past atmospheric conditions for the past 200+ years to be contrasted and compared at a continental-scale. Five of the new cores are sub-annually dated using the standard method (picking annual major-ion concentration peaks throughout the length of the record) and two of the cores (from the East Antarctic Plateau) are dated using a firn densification-based depth-age model.

Examination of the data reveals that non-sea-salt-Calcium (nssCa) concentrations have been rising since ~1900 AD over much of West Antarctica. Correlations between ice core nssCa concentrations and Southern Hemisphere 850 mb zonal winds (from 1948-2000) suggest a strong link between the strength of the Polar Westerlies and Dust transport into West Antarctica.

¹⁰Be Cosmogenic Exposure-Ages from Late Pleistocene Moraines in the Maryburn Basin, New Zealand

DOUGHTY, Alice, alice_doughty@umit.maine.edu, DENTON, George H., HALL Brenda L., PUTNAM, Aaron, Dept. Earth Sciences and Climate Change Institute, Univ. Maine, SCHAEFER, Joerg, Lamont-Doherty Earth Observatory, BARRELL, David, GNS, Dunedin, New Zealand, and ANDERSEN, Bjorn, Oslo, Norway

Milankovitch Theory explains the basic link between variations in earth's orbital parameters and the occurrence of ice ages. By this hypothesis, glaciers in the two polar hemispheres should respond to different insolation signals. However, existing moraine chronologies indicate that glaciers in the middle latitude Southern Hemisphere may not have responded to local insolation changes directly. In order to provide a basis for understanding what drives glaciations in the south, I developed a ¹⁰Be exposure-age chronology for moraines in the Pukaki Basin, New Zealand. My results show that the duration of the regional Last Glacial Maximum (LGM) was ~18,000 yrs, and the timing of the

termination was $17,700 \pm 600$ cal yr BP. Moraines distal to the LGM sequence yield ages of $48,500 \pm 1,100$ cal yr BP to $69,100 \pm 1,600$ cal yr BP. These findings have implications for understanding global climatic feedback mechanisms during ice ages.

A Model of Deuteronilus-Protonilus Mensae Valley Glaciation during Amazonian Mid-latitude Regional Glaciation (Mars)

FASTOOK¹, James L. and HEAD, J. W. III², 1: Climate Change Institute, Fastook@maine.edu, 2: Dept. of Geological Sciences, Brown University.

A single integrated system containing glacial features exists at ~34E, 41N in the central region between Deuteronilus and Protonilus Mensae. The valley system covers about 30,000 km², but it is only one of dozens of fretted valleys along the dichotomy boundary in this region.

Valleys in the region of Deuteronilus-Protonilus Mensae (DPM) along the dichotomy boundary display fretted terrain progressing from lowlands to upland mesas on to sinuous valleys that extend into adjacent highlands [2]. This terrain and its lineated-valley fill (LVF) has been interpreted to contain characteristics typical of integrated valley glacial systems on Earth [1,3]. It has been suggested that these features, taken as a whole, indicate that the boundary area was subjected to very large-scale regional glaciation during the Amazonian.

Head et al. [1] identify evidence for features indicative of glacial flow. Among these are: 1) localized alcoves from which emanate narrow, lobate concentric-ridged flows interpreted to be remnants of debris-covered glaciers; 2) depressions in alcoves perhaps indicating sublimation of material from relict ice-rich accumulation zones; 3) plateau ridge remnants between alcoves, typical of glacially eroded aretes; 4) horseshoe-shaped ridges upstream of topographic obstacles; 5) convergence and merging of LVF fabric in the down-valley direction; 6) deformation, distortion and folding of LVF in the vicinity of convergence; 7) LVF with pits and elongated troughs in distorted areas; 8) distinctive lobe-shaped termini where the LVF emerges into the northern lowlands, with associated pitting. From this evidence, they describe a coherent, unified flow regime extending from the upper valley reaches down to the northern lowlands.

We compare model results generated with the University of Maine Ice Sheet Model (UMISM) to features described in Head et al. [1].

[1] Head, J.W. et al. (2005) Submitted to Geophysical Research Letters Special Section on: "Hemispheres Apart: The Origin and Modification of the Martian Crustal Dichotomy."

[2] Sharp, R.P. (1973), JGR 78, 4073-4083.

[3] Lucchitta, B.K. (1984) JGR 89, B409-B418.

From Bedrock to Biface: Investigations on Lithic Tool Production in South Coastal Peru

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The Peruvian south coast is a dry and desolate landscape defined by its hyper arid environment. Archaeological survey along the Tambo-Ilo intervalley coastline suggests a long range of human occupation stretching from Pre-ceramic through Chiribaya periods, and into Spanish Colonial / Post-Colonial occupation. Lithic tool production can be seen throughout the coastline; however, it is an under-explored data set for this region and its role within human interaction remains unclear. Lithics are the dominant artifact during the pre-ceramic period, yet with the introduction of ceramic technology they generally receive less attention. This paper focuses primarily on the subsequent analysis of lithic artifacts collected during a 2006 archaeological survey of the Tambo-Ilo coast and their relation to the environment. Were local inhabitants predominantly using nearby geologic resources or were they traveling longer distances? What types of lithic tools were being created and for what purpose? Do temporal changes in the local ecological setting affect lithic typologies? By comparing the local geology, ecology and temporal setting, a better understanding of site occupation sequences is achieved. Artifacts were analyzed for variability in geologic material versus the local lithology, in addition to individual lithic attributes. The broad study was to determine the lithic source identity, distribution, and regional cultural interactions of the inhabitants between the Tambo-Ilo drainages by examining variations in coastal anthropogenic landscapes, raw material availability and lithic resource procurement expressed in artifact assemblages.

Pleistocene glaciations, landscape evolution and climate fluctuations in Patagonia, Southern South America.

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At least five Pleistocene glaciations left their imprint on the landscape of Patagonia, southern South America. Whereas glaciers during the most extensive and oldest glaciation (Patagonian Great Glaciation, >1.0 Ma BP, Caldenius, 1932) built huge moraine arcs (several tens of km wide) and huge outwash terraces grading from large ice-contact slopes, the younger glaciation (i.e. Last Glaciation, ~125 – 10 ka BP) produced a distinct inner belt of moraines that enclose the existing lakes in the region. Geologic time and the humidity gradient existing between the Pacific and Atlantic's slopes have produced a strong differentiation in morphology preservation, with sharpened younger moraines in the west side and softened and generally low relief moraines occurring to the east.

Previous preliminary mapping of the moraine system near Torres del Paine deposited during the last glaciation recognized four moraine complexes (e.g., Marden, 1993). The outermost complex is a single big moraine arc and the innermost includes two small moraine ridges. Both intermediate moraine complexes comprise 4-6 moraine crests. All of them are sharp-crested and their slopes are close to the angle of repose (~30°). A distinct "S" shape is a common attribute occurring in some inner moraine ridges. Whereas the intermediate moraine complexes may represent two major

cold phases in the region during the Last Glacial Maximum (LGM) and the innermost complex a subtle cold reversal during lateglacial time, the outermost moraine ridge may be early LGM or Oxygen Isotopic Stage 4 in age.

I have spent two field seasons mapping the landforms in detail. At present, I'm processing exposure-age samples to date these landforms and produce a robust glacial chronology, not only for the LGM, but possibly for older cold phases of the Pleistocene in the Patagonian region as well.

Caldenius, C.M., 1932: Las glaciaciones Cuaternarias en la Patagonia y Tierra del Fuego. *Geografiska Annaler*, 14: 1-164.

Marden, C.J., 1993: Late Quaternary glacial history of the South Patagonian Icefield at Torres del Paine, Chile. PhD thesis. University of Aberdeen. 298 p.

Spatial Variability of Atmospheric Dust and Potential Signatures of Anthropogenic Pollutants from Central Asian Ice Cores and Snowpits.

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The arid and semi-arid regions of central Asia contain some of the most extensive dust producing areas in the world, having major impacts on Earth's radiative balance, biogeochemical cycles, and human socio-economic systems. Major soluble ion (Na^+ , K^+ , Mg^{2+} , Ca^{2+} , Cl^- , NO_3^- , and SO_4^{2-}) and trace element (Sr, Cd, Sb, Cs, Ba, Pb, Bi, U, As, Li, Ti, Al, S, Ca, Ti, V, Cr, Mn, Fe, Co, Na, Mg, Cu, Zn, and Rare Earth Elements (REE)) data is currently being processed, analyzed, and interpreted from snow pits and ice cores from three glaciers in central Asia: Fedchenko Glacier (Pamir Mountains, Tajikistan; 5,200m a.s.l.), Inilchek Glacier (Tien Shan Mountains, Kyrgyzstan; 5,100m a.s.l.), and Guoqu Glacier (Tanggala Shan Mountains; 5,700 m a.s.l.). Statistical analysis (Empirical Orthogonal Function Analysis, Enrichment Factor Calculations (EF), and major soluble ion and trace element ratios) of glaciochemical data is being conducted to investigate the annual/inter-annual spatial and temporal variations in dust composition and concentrations, which may help elucidate the potential sources and atmospheric transport of dust in central Asia. Due to the large agricultural (e.g. cotton) and industrial activities (e.g. mining) occurring in the central Asia it is possible that glaciers in the region are recording atmospheric concentrations of anthropogenic pollutants. The analytes in the trace element suite include heavy metals (e.g. Pb, Cd, As, Bi) that are common bi-products released into the atmosphere during industrial and agricultural activities. EF calculations of heavy metals are being conducted to assess the spatial impact anthropogenic pollutants in central Asia.

Allergic Bio-Aerosol Monitoring: A collaborative effort to map and model pollen, spore, and airborne pollutants in Maine, with relation to climate change and human health.

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We hypothesize that climate change is playing a role in high asthma rates, and will do so if Earth's temperature continues to rise, or stays at its current temperature. There is considerable evidence that climate change, in the form of global warming, is increasing pollen and spore production in vegetation. Plants in scientific investigations have shown significant increases in pollen production resulting from exposure to high concentrations of CO_2 . Furthermore, warmer temperatures coupled with higher CO_2 levels may provide longer growing seasons and earlier pollen dispersal, resulting in an extended allergy season.² Allergic pollen and spores are considered asthma triggers by the New England Asthma Research Council (ARC), and thus, an increase in pollen production is expected to be a contributor in the rising asthma epidemic.¹ In 2006 the ARC compiled the most current and comprehensive investigation of asthma prevalence conducted in the New England (NE) region. The report found that Maine has the highest rate of asthma for children in NE, with 28,000 diagnosed, and is also among the highest for adult asthma rates.³ Currently there are only two pollen-monitoring stations in Maine, and we expect that state ambient alerts are not accurate, providing our citizens with false information. It is our belief that more pollen monitoring stations need to be established in Maine, and air modeling with state of the art software needs to be implemented in order to create accurate ambient air quality reports. The detection of health effects of climate change must also be investigated in order to influence national and international policies relating to public health, and allow the population to adapt to new environmental conditions.⁴

1. Adams, Mary. "The Burden of Asthma in New England; A report by the Asthma Regional Council."

<http://www.asthmaregionalcouncil.org/> Online at:

<http://www.asthmaregionalcouncil.org/documents/TheBurdenofAsthmainNewEnglandMarch2006.pdf>.

Accessed February 8, 2008.

2. Beggs, Paul J., Hilary Jane Bambrick. "Is the Global Rise of Asthma an Early Impact of Anthropogenic Climate Change?" *Environmental Health Perspectives* 113.8 (2005).

3. American Lung Association of Maine (2008) Topics > Asthma. Online at:

http://www.maine-lung.org/Topics/asthma_survey_results.asp. Accessed 02/08/2008.

4. Wilkinson P, Campbell-Lendrum DH, Bartlett CL. 2003. Monitoring the health effects of climate change. In: *Climate Change and Human Health: Risks and Responses* (McMichael AJ, Campbell-Lendrum DH, Corvalan CF, Ebi KL, Githeko A, Scheraga JD, et al., eds). Geneva: World Health Organization, 204-219.

Holocene Radiocarbon Marine Reservoir in the Southern Ocean, from Paired $^{234}\text{U}/^{230}\text{Th}$ and ^{14}C Dates of Corals

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The radiocarbon reservoir effect plagues dates of marine materials and hampers our ability to construct precise chronologies. Determination of the reservoir effect commonly relies on dates of historical (pre-bomb) samples of known age. The values obtained are then applied to dates of a range of ages with the assumption that the reservoir effect remains constant. However, variations in ocean circulation or air-sea exchange can cause temporal changes in the reservoir effect and potentially result in inaccurate chronologies. Here, we present both uranium-thorium and radiocarbon data from solitary corals from the Ross Sea region of Antarctica that span the last 6000 years. Comparison of data from the two methods allows calculation of the reservoir effect. We obtained a value of 1144 ± 120 years, which has remained largely constant through time. This value is somewhat less than those obtained previously (~ 1300 yrs), but the difference results from the method of calculation and not the basic data. Wiggles superimposed on our curve may relate to variations in ocean circulation, and we are following up on this aspect of our work.

Acceleration of Byrd Glacier, East Antarctica, linked to rapid drainage of subglacial lakes

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Byrd Glacier is the planet's second largest glacier, draining an area of East Antarctica almost equal to the entire West Antarctic Ice Sheet. The glacier sustains fast flow speeds through a fjord in the Transantarctic Mountains, and discharges ice into the Ross Ice Shelf. Any change in its flow dynamics has the potential to impact East Antarctic mass balance, the stability of the ice shelf, and hence sea level.

New satellite remote sensing measurements reveal a large (~ 100 m yr²) and short-lived acceleration of Byrd Glacier between 2006-2007. This event is anomalous in the glacier's 44-year record of ice speed. The acceleration extended along the entire 75 km trunk of Byrd Glacier, with peak speeds lasting for ~ 12 months. The timing of the acceleration coincides with the draining of two large subglacial lakes located ~ 200 km upflow from the grounding line. Lake filling and subsequent drainage is inferred from the pattern of rapid surface elevation change detected using satellite laser altimeter measurements. The lakes drained in sequence and discharged ~ 1.7 km³ of water into the Byrd fjord between June 2006 and March 2007. The termination of lake drainage coincides with a slow-down in the speed of Byrd Glacier.

Our observations provide the first direct evidence that the active subglacial drainage networks now known to exist beneath the Antarctic Ice Sheet play an important role in ice dynamics. The dynamic response of Byrd Glacier to the sudden injection of water might also be a useful analog to help explain the recent changes of Greenland's outlet glaciers.

Thermal Convection and the Origin of Ice Streams

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Ice streams are a fact of ice-sheet dynamics, draining up to 90 percent of the ice. Thermal convection in ice below the density inversion is a speculation. An attempt is made to meld the two in such a way that the speculation becomes an explanation for the fact.

The density inversion in ice sheets exists because ice warms with depth and the thermal expansion due to warming exceeds the compressibility of ice due to the increasing ice overburden with depth. As a result, a large reservoir of gravitational potential energy exists above the density inversion. Models of ice-sheet dynamics make no attempt to convert this potential energy into kinetic energy or thermal energy as ice spreads from internal ice divides to ice margins in advective flow. During spreading, up to 90 percent of this ice converges into fast currents called ice streams.

Thermal convection in fluids heated from below consists of "cells" of cool sinking fluid that enclose plumes of warm rising fluid. The plumes are pipes if there is no advective flow in the fluid due to a horizontal current induced by a surface slope or other type of forcing. If advective motion exists, the plumes will form curtains aligned in the direction of advective flow.

The side shear zones that separate fast ice streams from slower ice on each side have an "easy glide" ice fabric that facilitates both horizontal and vertical shear deformation in the ice. The thermal buoyancy stress caused by the density inversion is comparable to the gravitational driving stress caused by the surface slope of the ice sheet. Therefore both vertical and horizontal shear should be possible in the lateral shear zones of ice streams. Ice streams down draw surrounding ice, so they could be the broad sinking limbs of thermal convection flow and the lateral shear zones could be the narrow rising limbs that warms the sinking limbs as ice moves in from the sides and causes the density inversion to move upward.

Basal meltwater would be driven down the gradient of decreasing overburden ice pressure due to the surface slope that dips toward ice streams from the upstream end and from both sides. This inflowing basal water would tend to uncouple ice from the bed beneath ice streams, and give ice streams relatively free top and bottom surfaces that favors thermal convection. As sinking ice warms, the density inversion moves toward the ice surface, thereby

converting the gravitational potential energy above the density inversion into kinetic energy of motion in the ice stream and thermal energy in the shear zones alongside the ice stream.

Sustainability considerations for western North American hydrosystems: Use-inspired research to understand nonstationary climate, flow regulation, and ecological flows needs

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Western North American river systems exemplify a unique blend of complexity—highly managed and dammed, heavy reliance on water supplies, climatic influences, increasing water demand, and at-risk ecosystems. We present examples of research questions derived from the analysis of the past and current adaptive management efforts in these basins. Adaptation to climate variability and change is examined with a goal to understand the multiple time scales of hydroclimatic variability. A retrospective analysis to quantify the progressive alteration of the flow regime by regulation and response to climatic extremes illuminates the sensitivity of Columbia River and Colorado River systems to climate change. Within this context, research focused on developing low-order, illustrative models that are amenable to quick decision-analysis (to promote a dialogue between decision-makers and scientists) is also discussed.

Paleogeography at Quebrada Jaguay, Peru: Geological Factors and Site Location.

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The Quebrada Jaguay site (QJ-280) is located in the arid coastal zone of southern Peru. Terminal Pleistocene ages for material from the site range from 13,250-11,200 cal. BP, and Early Holocene dates from 8300-9000 cal. BP. While containing evidence of a strong maritime subsistence strategy, mollusks and fish, the site is located 2 km from the present day shoreline. Estimates of Terminal Pleistocene sea level places the earliest occupation of the site even farther from the coast, approximately 7-8 km. A paleogeographic analysis, including geology, geomorphology, sea-level variation, and climate change, is used to address the apparent enigma of a site containing a strong maritime focus so distant from the coast. The authors conclude that the location of QJ-208 represents the nexus of the geologically controlled resources of water, food, fuel, and lithic materials.

Beach Erosion at Camp Ellis, Maine: The Case of a Complex, Coupled Human-Natural System

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In 1867 the US Army Corps of Engineers (USACOE) built a jetty on the north side of the mouth of the Saco River, ME to facilitate commercial navigation. A beach community, Camp Ellis, soon developed on new beach land created by the collapsed ebb-tidal delta, and gradually recreational and residential interests replaced industrial in the area. For more than a century, beach erosion claimed property at Camp Ellis, with several houses protected by ~3 m high seawalls collapsing in 2007. During the same time period, a south jetty was built and extended to 1463 m and the north jetty extended to 2030 m to prevent sand from entering the estuary. Seven USACOE studies found no linkage between on-going beach erosion and episodic jetty growth until graduate student research in the 1990's demonstrated that the Saco River sourced local beaches and that the USACOE misjudged the direction of longshore sand movement. By the mid-1990's, after building a physical model at Waterways Experimental Station, the USACOE acknowledged the river as a source of beach sand, the direction of longshore transport, and a tenuous association between the jetty and erosion. This led to more than \$5 million of modeling studies on local wave behavior. The USACOE now proposes to build a \$27 million breakwater to save Camp Ellis. Continued university observational research hints at rates of river-sand introduction and suggests complex shoreface transport patterns not contemplated by USACOE models. It is possible that more expensive engineering will lead to more erosion to the north of the proposed breakwater. Also uncertain are the long-term fiscal costs associated with construction and maintenance of the breakwater and how the potentially negative consequences of such a structure would be addressed. All of these risks are to save buildings that are arguably worth less than the cost of their protection. How did all this happen? Obvious errors abound: homeowners failed to recognize the temporary nature of "new" land in the early 1900's and later refused a buyout; the USACOE failed to recognize the source of sand or direction of longshore movement, relied exclusively on physical and numerical models in the absence of observations and built accordingly; government at all levels failed to promote a buyout of properties, and instead rebuilt and added new infrastructure to an area with chronic erosion problems.

Preliminary LGM chronology of the left-lateral moraine system, Pukaki Lobe, South Island, New Zealand

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The left-lateral moraines at Lake Pukaki, South Island, New Zealand, form one of the best records of glacial retreat following the last glacial maximum (LGM) in the world. The moraines afford a unique opportunity to examine glacial response to climatic change during the LGM and termination in the mid-latitudes of the Southern Hemisphere. The importance of New Zealand for examining climate is its position as one of only two places in mid-latitude Southern Hemisphere at which mountain ranges reach an elevation high enough to support alpine glaciers. This location allows for a test of a theory put forth by Milutin Milankovich in the early 1900's. The theory states precession-based summer insolation, combined with ice sheets, as well as other feedbacks, drive the ice ages. Therefore, the

termination of the LGM should be asynchronous between the two hemispheres. Over the past two field seasons samples have been collected to form a beryllium-10 chronology of glacial retreat of the left lateral sequence of the Pukakai Lobe. Through the use of terrestrial cosmogenic nuclide dating, a glacial chronology and the timing of glacial termination can be determined for glaciers in the Mackenzie Basin at 44° S. The preliminary results from this study as well as previous work suggest that the glacial terminations are coincident in the Northern and Southern Hemispheres, a phenomenon which is in conflict with "classic" Milankovitch theory.

Better physics using full momentum solver in 2D vertical slice domain, where does longitudinal stress really matter? Application to the Thwaites Glacier flowline.

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The shallow-ice approximation neglects all stresses except basal drag, a good assumption for inland ice but poor for fast-flowing, low-surface slope ice streams, where longitudinal stresses are important, even dominant [2]. A higher-order approach couples mass- and momentum-conservation equations and solves with no neglected stresses. In developing such a full-momentum solver for the University of Maine Ice Sheet Model (UMISM) [1], we test a simplification that models a vertical slice through the ice sheet. This allows us to: 1) implement and test complex boundary conditions, and 2) evaluate longitudinal stresses.

There are two types of boundary conditions [4]: 1) Dirichlet, state variable (velocity) specified, and 2) Neumann, conserved flux (force applied on the boundary) specified. With frozen beds, Dirichlet boundary conditions are specified, since velocity is zero. With sliding, the force exerted on the ice by the bed is specified. This resistive force cannot equal or exceed the driving stress. A fraction of the driving stress does produce the characteristic concave profile, but is hard to define. A boundary-layer is a better approach. We preserve Dirichlet-type zero velocity on the boundary, and allow greater deformation within the boundary-layer to simulate sliding. This soft layer can be interpreted as deformable till or slush. Either way its thickness is negligible compared to ice thickness.

We apply this to a flowline along the Thwaites Glacier in the Amundsen Sea sector using excellent new data from the Airborne Geophysical survey of the Amundsen Sea Embayment by University of Texas [3] and British Antarctic Survey [5] teams.

[1] J.L. Fastook. *Computational Science and Engineering*, 1(1):55-67, 1993.

[2] J.L. Fastook and A. Sargent. 11th Annual WAIS Initiative Workshop, Virginia, 2004.

[3] Holt et al. *Geophys. Res. Lett.*, L09502(doi:10.1029/2005GL025561), 2006.

[4] T.J.R. Hughes. Prentice-Hall, Inc., New Jersey, 1987.

[5] Vaughan et al. *Geophys. Res. Lett.*, doi:10.1029/2005GL025588, 2006.

A snowpit record of atmospheric Fe deposition in West Antarctica at the WAIS Divide site

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Iron (Fe) is an essential micronutrient that limits primary production in the Southern Ocean, a High Nitrate, Low Chlorophyll (HNLC) region. Iron deposition to the Southern Ocean has stimulated phytoplankton blooms in Fe fertilization experiments. Phytoplankton may help control atmospheric pCO₂ through photosynthetic drawdown on both short and glacial/interglacial timescales. Measurements from the Law Dome and EPICA ice cores have constrained atmospheric Fe deposition to East Antarctica, but the spatial variability of Fe deposition to the Antarctic continent and by inference to the Southern Ocean remains poorly understood.

The West Antarctic Ice Sheet Divide Deep Ice Core (WDC; 79.468° S, 112.086° W) should yield a 100,000-year record with annual resolution to 40,000 years. In late 2005 a 3 m snow pit at the site of the present borehole was sampled at 5 cm resolution. We present the results of ICP-MS analysis of these snow pit samples, including four different Fe fractions (particulate Fe, dissolved Fe, chemically labile Fe and total Fe), which represent the first Fe data recovered from the WDC site. Based on annual variability of sulfate concentrations, the samples cover nearly 6 years. Iron flux averaged 6.3 μmol m⁻² yr⁻¹ during this time, while the average flux of chemically labile Fe was 1.8 μmol m⁻² yr⁻¹. These values are an order of magnitude higher than Holocene values measured at Law Dome, implying great spatial variability and/or dilution effects at the latter site. The percentage of chemically labile Fe varied inversely with total Fe concentration, suggesting that there is significant variability in size and/or source of Fe-bearing particles to West Antarctica. The interannual variability in Fe flux and the quantification of these four different Fe fractions have implications for biological availability of atmospherically deposited Fe to the Southern Ocean and are germane to models of ocean/atmospheric CO₂ cycling.

Exploring the evolution of Earth Systems via *Continental Dynamics*, *EPSCoR*, and *ITEST*

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Perturbation of the Earth by internal (tectonic) and external (climate) processes spans a range of temporal frequencies from femto- to kilohertz, over spatial wavelengths ranging over seven orders of magnitude, with amplitudes sufficient to influence planet rotation, continental denudation, and longitudinal river gradients. The multiscale and multidimensional response of the Earth to this broadband input provides essential information on the internal rheological structure of the Earth, the controlling physics of silicate deformation, and the controlling

parameters of surface evolution. One dominant component of Earth's response, the vertical displacement field, when acted upon by climate variables, both serves as a recorder of much of the perturbation frequencies, and defines material and boundary conditions that influence Earth's interface environmental systems. Here we describe our research strategy of three existing and developing research proposals that will take advantage of the broadband Earth response to consolidate theory on Earth mechanical/chemical evolution, to provide forecasts for future climate/earth interaction, and to engage K-12 students in exploration science through computation.

High-resolution glaciochemical records of the Eemian interglacial from a Mount Moulton horizontal ice core (West Antarctica)

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Mount Moulton blue ice area (MLT BIA) in West Antarctica provides a unique opportunity to obtain old, and yet high-resolution glaciochemical records. We conducted high-resolution sampling of a ~40 m long section of the horizontal trench A MLT BIA using the Climate Change Institute continuous melter system. The melted section covers the period from 107 to 136 ka BP. An age model was developed based on ⁴⁰Ar/³⁹Ar radiometric dates of 3 englacial tephra layers. Almost 4000 samples were examined for their soluble major ion content (Cl⁻, NO³⁻, SO₄²⁻, Na⁺, K⁺, Mg²⁺, Ca²⁺), trace elements (Sr, Cd, Cs, Li, Ba, La, Ce, Pr, Pb, Bi, U, As, Al, S, Ti, V, Cr, Mn, Fe, Co, Cu, Zn) and stable oxygen isotopes ratios. Empirical Orthogonal Function (EOF) analysis was used to determine the different sources for MLT BIA aerosols. Lithium concentrations were determined for the period covering 107 to 123.5 ka BP. Overall, Li concentration variability is low with several large peaks occurring at irregular intervals. The largest of these peaks occurred 111 kyr ago and lasted for ~ 500 yrs. Possible explanations for Li concentration anomalies include mineral dust and/or volcanic activity.

Update on CASA (Climate of Antarctica and Southern America) initiative

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Increasing concern about the timing, magnitude, and rate of future climate change requires better understanding of the relevant mechanisms governing climate variability of South America and Antarctica. Recovery of well preserved high-resolution environmental records exceeding the period of instrumental observations is crucial for predicting future climate scenarios and understanding the observed warming trends in the region. During the last two decades several ice cores were recovered from the area but increased regional warming complicated the interpretation of those records drilled at low elevation sites.

During the last two years a joint Brazilian-Chilean-US program of scientific collaboration has focused on the collection of a record that shows no evidence of melting, potentially covers a time span of at least several centuries, and is not disturbed by ice flow dynamics. Preliminary snow sampling conducted in February of 2007 at the Detroit Plateau, Antarctic Peninsula for glaciochemical and stable isotope analyses confirmed the potential presence of such an ice core record in the area.

In November-December, 2007 additional sampling of a 2 meter deep snow pit, and two 133 m and 20 m long ice cores were collected at 64° 5'11" S, 59°36'42" W, 1933 meters a.m.s.l. The measured temperature at 10 m depth was -14.1° C, which indicates a well-preserved environmental record. The depth at the drill site is around 350 meters, as estimated by GPR. A GPS-based ice flow movement monitoring network will be used to select future drill sites for the recovery of the longest and best resolved environmental record from the region.

Once developed, the glaciochemical, stable isotope and atmospheric sampling data will be used to intercalibrate overlapping parts of the ice core records with modern climate reanalysis and satellite data. Results will fill several gaps in the records of past climate, including sea-ice extent, air mass circulation, temperature, chemistry of the atmosphere, and accumulation rate.

The effect of the Eastern Maine Coastal Current on local climate and vegetation downeast during the Holocene

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The climate and the vegetation of the eastern coast of Maine are strongly moderated by the cold Eastern Maine Coastal Current that flows southward along the coast, fueled by Scotian Shelf Water. Frequent fog, created by warm winds blowing over this cold water, in combination with cooler summers and higher annual precipitation relative to the rest of Maine provide beneficial growth conditions for a narrow fringe of boreal and arctic-alpine flora extending from Mt. Desert Island to Lubec.

Changes in bathymetric configuration and sea level during the Holocene caused varying proportions in the inflow of Scotian Shelf Water and Slope Water (e.g., Lusardi 1992, Friez 1993). It is likely that the water circulation in the Gulf of Maine followed other paths than today's and probable that the Eastern Maine Coastal Current was not always present. This, along with higher air temperatures during warmer periods of the Holocene, would have impacted the

vegetation in the downeast area. Future rising sea level may cause changes in the marine circulation, which together with a climatic warming could lead to vegetational changes on the coast.

Marine cores taken beneath the Eastern Maine Coastal Current and in the Jordan Basin could provide information about variations in temperature, salinity, and degree of vertical mixing. This would be achieved through analysis of the oxygen isotopic composition of foraminiferal shells preserved in the sediment. Lake sediment cores taken from different water depths could provide terrestrial temperature and water balance records through examination of plant macrofossils, mineral grain size, organic content, gross sediment composition, and chironomid remains. Radiocarbon dating of the cores at numerous depths would allow a close comparison between the terrestrial and the marine records.

High-resolution regional model simulations of climate change in the northeastern United States

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The effects of increased levels of atmospheric CO₂ on climate are readily studied with the use of atmospheric general circulation models. While these global models do a reasonably good job of reproducing the broad-scale features of the general circulation, their coarse resolution does not allow for a detailed assessment of possible changes in local and regional climate. In particular, the detailed effects of topography, land-use, vegetation cover, and land-sea contrasts along coasts are not represented at the coarse resolution of these models. Possible changes in precipitation patterns, which are strongly influenced by such effects, cannot be examined on a regional scale. To assess potential CO₂-induced climate change in a region such as New England, a nested regional model with much higher spatial resolution must be used. It is important to note that simply scaling the output of a coarse-resolution general circulation model to a finer grid spacing is merely a statistical interpolation and does not contain any more meaningful physical information than the original low-resolution results. In contrast, results from the nested regional model are physically based, taking into account high-resolution variability in topography, land-use, vegetation cover, and land-sea interactions, thus providing a more precise spatial prediction of potential climate change.

What broke the "ferrous wheel?"

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The early paradigm for the control of biologically available phosphorus (P) in lakes was that iron (Fe) was precipitated in lakes as Fe(OH)₃. This solid adsorbed PO₄ during sedimentation. During the development of anoxia in the lake's hypolimnion, reductive dissolution of the Fe(OH)₃ released Fe and PO₄ to solution. Subsequent turnover of the lake resulted in oxygenation of ferrous to ferric Fe, precipitation of Fe(OH)₃, and resorption of the PO₄, and so on (i.e., round and round = the ferrous wheel).

We have demonstrated that in aluminum (Al)-rich sediments with extractable Al:Fe>3, and extractable Al: P >25, P is not liberated substantially from sediment during the development of anoxia. The recycling of P is short circuited, favoring oligotrophy, a state of low phytoplankton productivity. The majority of the extractable Al in the sediment is amorphous Al(OH)₃, which is produced as follows: Aluminum from the upper mineral soil is complexed by dissolved organic carbon (DOC) generated in the forest floor. The Al-DOC is transported by ground- and surface water to the lake where ultraviolet radiation photo-oxidizes the DOC, liberating Al from the DOC. The Al then precipitates as Al(OH)₃, adsorbs PO₄, and settles to the lake bottom. Because Al(OH)₃ solubility is insensitive to anaerobic conditions, the P is irreversibly lost from the water column.

We studied a long ¹⁴C-dated sediment core from Sargent Mountain Pond, Acadia National Park, Maine, USA. We found that, since about 10,000 BP, this Al(OH)₃-P sequestration mechanism has operated efficiently, causing oligotrophic conditions. The onset of this mechanism was approximately concurrent with the establishment of forest vegetation in the catchment that produced organic-rich soils. Low quality forest organic matter decomposes slowly, producing abundant DOC that readily complexes Al and leaches to the lake. Prior to that time, the lake had lower DOC, higher pH, and was likely eutrophic.

When the Rainbows Bring the Crayfish: Traditional Management of River Resources in a Western Andean Valley of Southern Peru

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The people of Lunanhuana have a unique identity that combines Coastal and Andean cultural traditions. Their economic activities, anchored on the fluctuations of the Cafete River, provide villagers with agricultural and river resources destined for consumption in the thriving national culinary industry. A sector of the population, called "Camaroneros," are exclusively dedicated to the seasonal harvest of crayfish (*Cryphiops caementarius*). A highly coveted food crayfish have been overharvested and the river has been restocked repeatedly over the past decades. The Crayfish populations have also declined due to irrigation projects, agricultural runoff, and development. The latest threat comes from the construction of a hydroelectric dam upriver, which has produced much tension with the local population but has surprisingly resulted in a positive collaboration with the Camaroneros. New management plans combine traditional and modern harvesting techniques. However Camaroneros are struggling with creating viable social institutions to protect their claims to a communal resource that is difficult to monitor, and they are uneasy

about their future relationship with the damn once it becomes operational. They are now in the process of articulating their traditional claims to crayfish resources by creating new cultural expressions (e.g., a crayfish carnival) and documenting traditional ecological knowledge relating to local weather fluctuations (e.g., rainbows, wind, rainfall) and ecological indicators. This paper will use the case of the Camaroneros of Lunahuana to propose an integrated theoretical framework that can be used to understand how they have adapted to changing environmental, social, and cultural conditions. By presenting ethnographic, geographical, and ecological data I will show how this case can be evaluated through the lens of common property theory, risk mitigation theory, and entitlement theory as a way to evaluate the relationship between resilience, adaptation, and vulnerability of a traditional resource management system.

Subglacial water in Greenland

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We have established a method for finding the extent of subglacial water in Greenland. We present a map showing where, based on PARCA/CRISIS radar flight data, basal water is found to exist in the Northern part of Greenland. Flight crossing points are investigated, and some outstanding geographical features are identified. This begins to reveal a unique 3-dimensional insight into the topography of the Greenland Ice Sheet.

Comparison of laboratory and whole-ecosystem chemical weathering in early post-glacial environments

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To quantify the contribution of continental deglaciation to local and global chemical fluxes, we compared the weathering record derived from a 13,500 year, 5.3 m lake sediment core in the Cadillac Mountain Granite of coastal Maine, exposed immediately after deglaciation, with semi-batch dissolution experiments of similar bulk rock composition.

A 5-step sequential extraction of sediment[1] indicates that weathering products of Al and Fe are virtually zero for the first 3,500 years, while P is associated with apatite ($\text{Ca}_5(\text{PO}_4)_3(\text{OH},\text{F},\text{Cl})$). Vegetation became established about 10,000 years BP, by which time calcite (CaCO_3) and apatite had been depleted in the soil and are absent from the sediment. Concurrently, Al, Fe, Mn, and P in fractions (2) and (3) increased dramatically as a consequence of production of DOC in the watershed and accelerated export of organically-bound Al, Fe, and Mn, and POC to the lake. There, photodegradation released inorganic Al, Fe, and Mn which precipitated and sorbed dissolved P from the water column[2]. Thus, the lake transitioned from near-neutral pH, high P, and high Ca, and low DOC, Al, Fe, and Mn to lower pH and Ca, very low P, and elevated organically-bound Al, Fe, and Mn.

Crushed Stonington Granite (molar ratios $\text{Ca}/\text{Na} = 0.21$; $\text{Mg}/\text{Na} = 0.085$; $\text{P}/\text{Ca} = 0.035$) was chemically weathered in laboratory batch reactors for 11 weeks. Batches were replenished with acid after one, two, four, and seven weeks of reaction. We investigated effects of pH, grain size, acid type, and DOC on accessory mineral depletion and P availability. Early dissolution was strongly non-congruent ($\text{Ca}/\text{Na} \sim 16\text{-}24$; $\text{Mg}/\text{Na} \sim 4.5\text{-}7$; $\text{P}/\text{Ca} \sim 0.1\text{-}0.5$), indicating preferential dissolution of calcic minerals (apatite, fluorite, and calcite) and biotite or hornblende, the source of Mg. Calcite became depleted before fluorite. Later, Ca/Na declined to ~ 1 as P/Ca decreased to 0.1. Mg/Na ratios remained elevated ($\sim 6.4\text{-}7.4$). After 1 week of weathering, Al and P concentrations declined, suggesting scavenging of P as a result of $\text{Al}(\text{OH})_3$ precipitation at higher pH.

The batch experiments yield weathering trajectories. Combining them with the dated changes in sediment chemistry, we are able to link specific weathering reactions to field scale kinetics.

[1] Psenner et al. (1988) *Arch. Hydrobiol. Beih. Ergebn. Limnol.* **30**, 98-103.

[2] Kopá_ek et al. (2005) *Envir. Sci. Technol.* **39**, 8784-8789.

Detroit Plateau Ice Core

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The Detroit Plateau (64°10'S, 60°0'W) is located on the northern sector of the Antarctic Peninsula at an elevation of ~ 2000 m a.s.l. The northeast limit is marked by the Russell West Glacier, from which it extends ~ 140 km in a general southwest direction to Herbert Plateau. Strong low-pressure systems passing through the adjacent Drake Passage have a major influence on the atmospheric conditions in this region. According to glaciological studies and meteorological observations the Antarctic Peninsula shows a warming trend over the last five decades. Furthermore, enhanced collapse of Larsen Ice Shelf in the last thirty years is indicative of the new unstable, changes impacting this area. Because measured temperature at 10 m depth in the Detroit Plateau ice core was -14.1°C the site is conducive to the recovery of well-preserved environmental records. Recovered by CASA (Climate of Antarctica and South America) program 133 meters ice core will provide sub seasonal level details of past temperature changes, precipitation, atmospheric circulation and air mass chemistry for at least several centuries before the instrumental era. Ice-core records are also a potential source of understanding the relation between El Niño Southern Oscillation (ENSO) and Antarctic climate features like the Antarctic Oscillation (AAO) or Southern Hemisphere Annular Mode (SAM). This study, together with other ice-core data from the Antarctic Peninsula, will shed more light on the past and present changes of the atmospheric conditions in this region.

Timing and duration of the Last Glacial Maximum, Termination, and late-glacial reversal inferred from ¹⁰Be-dated glacial deposits in the Southern Alps of New Zealand

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Determining the causes of late Quaternary glacial cycles remains a fundamental challenge to our understanding of climate change. Hypotheses attempting to address these problems are controversial due to the scarcity of well dated and reliable records from the extra-polar regions in general, and the Southern Hemisphere in particular. Our work focuses in the New Zealand Southern Alps, located at the antipode of the North Atlantic region, and which are well situated to test global ice-age hypotheses. We present a glacial chronology based on more than 100 ¹⁰Be surface-exposure ages of boulders from LGM and late-glacial moraines. Consistent ages characterized by unprecedented precision indicate that the last glacial maximum was achieved earlier than previously thought, and that ice-age conditions persisted for over 10,000 years. The New Zealand LGM ended abruptly around 18,000 years ago, in concert with the onset of Termination I. A prominent moraine deposited during a late-glacial reversal yields a mean ¹⁰Be age of ~12,800 yr. This glacial chronology exhibits a tight correspondence to other regional, southern hemisphere, and northern hemisphere LGM glacier reconstructions, as well as other proxies. From the striking agreement among these records we suggest that a global mechanism drove glacier activity in the Southern Alps during the LGM, and that insolation alone cannot be the main driving force.

Quebrada Jaguay and the Terminal Pleistocene Coast-Highland Connection

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Non-local materials recovered from well-dated Terminal Pleistocene contexts at the Quebrada Jaguay site on Peru's southern coast suggest early contact with interior Andean zones. The connection between Quebrada Jaguay and the Alca obsidian source is especially remarkable as it is the only positively demonstrated, Terminal Pleistocene material link between specific coastal and highland locales in all of South America. We report on recent interdisciplinary investigations aimed at discovering the nature of this early inter-zonal contact, including geoarchaeological study of Alca obsidian deposits, paleoenvironmental research, GIS modelling and exploration of potential coast-highland forager routes, and ongoing efforts to locate contemporary, early archaeological sites in interior zones.

Prehistoric Settlement Patterns of the Quebrada Jaguay Region, Southern Peru

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Archaeological survey around Quebrada Jaguay, a Terminal Pleistocene to Early Holocene archaeological site in southern Peru, identified an additional ~80 archaeological sites. Sites were dated to three preceramic phases: Terminal Pleistocene Jaguay Phase (~13,000-11,400 cal BP), Early to Mid-Holocene Machas Phase (~10,400-7750 cal BP), and Late Holocene Manos Phase (~3600 cal BP). By analyzing a wide range of data from sites such as subsistence remains, technology, local and exotic materials, and relation to resource zones we can begin to identify overarching settlement patterns of the region. An integral part of understanding the distribution of sites across the landscape is the zone of coastal vegetation called *lomas*. *Lomas* vegetation, found on Peru and northern Chile's desert coast, is supported by dense winter fogs and anomalous rainstorms during El Niño-Southern Oscillation events. By reconstructing the past environments of the region, we can better understand patterns of activity and changes in foraging strategies practiced by prehistoric peoples.

Pleistocene Aggregation: Demonstrating Contemporaneity at Bull Brook,

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The Bull Brook Paleoindian site is a non-stratified archaeological site with 36 artifact concentrations arranged in a large circular pattern. Fifty years ago archaeologists thought that it was highly unlikely that such a large gathering could represent a single event. Stratigraphic evidence could not be used to identify contemporaneity, and by the time the settlement plan was fully assembled, most of the site was destroyed by sand and gravel operations. At the end of our four-year research project we think the tables have been turned. We find it highly unlikely that the pattern could be coincidental, and that an organized social event is strongly implicated.

Cross-Cultural Conceptions of Climate and Weather

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If climate-change mitigation policies are to succeed globally, they need to be phrased in culturally appropriate terms. We need to know how different cultures view climate and weather, how these beliefs are structured, and, to the extent ethnometeorological regularities are uncovered, how they relate to other important cultural features such as subsistence regime and political structure. Some research already exists on cultural perceptions of climate and climate change among European and Anglo-American populations, but this scholarship has yet to be extended on a major scale to non-western cultures. Towards redress, this paper reports findings from undergraduate student

projects that probed the electronic version of the Human Relations Area Files (eHRAF) for data on non-western meteorologies.

Ecological Interactions Affecting Diatom-Based Inferences of Drought Frequency in Prairie Saline Lakes of the Northern Great Plains (USA)

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Sedimentary diatom assemblages from closed-basin lakes in arid and semi-arid regions are used to reconstruct salinity and infer past moisture balance. However, the response of lake ecosystems to climate is complex, and the extent to which intrinsic factors, including a variety of ecological interactions, complicate these signals is generally unclear. Diatom-inferred salinity for Moon Lake during the late Holocene contradicts patterns inferred through multi-proxy reconstructions at nearby Coldwater and Spring Lakes. We hypothesize that these inconsistencies are due to differences in ecological interactions across these lakes. Specifically, we suggest that intense zooplankton grazing in Moon Lake caused higher proportions of inedible diatoms to be preserved in sediments, thereby altering the diatom-inferred salinity reconstructions for this lake. The primary objective of this project is to improve drought reconstructions in prairie saline lakes of the northern Great Plains by understanding how ecological interactions, such as zooplankton grazing, affect diatom sediment records. We will achieve this by performing comparative lake studies to establish early seasonal succession patterns and timing of phyto- and zooplankton communities. Laboratory feeding experiments will determine diatom edibility for zooplankton, and field mesocosm experiments will test the extent of zooplankton grazing pressure and its effects on diatom sedimentation processes. These results will be incorporated with multi-proxy drought reconstructions to ultimately improve our understanding of patterns of drought frequency in prairie saline lakes.

El Niño, Earthquakes, Beach Ridges, Sand Sheets, and the End of the Late Preceramic Period on the North Central Peruvian Coast

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Recent research on the North Central Coast (NCC) of Peru has led to the recognition that this region was the center of early mound-building civilization in the region. Sites such as Caral demonstrate complex organization and the ability to harness significant labor to build centrally planned structures. The economic basis of this florescence was a combination of marine resources, agriculture, and probably inter-regional exchange. Because accurate dating of these early NCC sites is very recent, no one has yet discussed the rapid abandonment of the Late Preceramic sites in the region, or the later survival of related sites just north and south of the NCC. Based on many years of field work on coastal processes and cultural development on the Peruvian coast and our recent field work on the NCC, we propose that a combination of seismic activity, El Niño-associated torrential rainfall, and coastal change driven by beach ridge formation were involved in the Late Preceramic cultural termination on the NCC.

Applying SuperLU Parallel Solver to a Glacier Ice Sheet Model

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Application of SuperLU-DIST multiprocessor software package to solving large sparse systems of linear equations generated by University of Maine Ice Sheet Model (UMISM) will be presented. The UMISM is a mathematical model for the formation and disappearance of glacial ice sheets. It has been applied to the Antarctica, Greenland, Scandinavian, and Laurentide ice sheets.

The model uses conservation of mass, energy, and momentum, and constitutive relations to form partial differential equations describing ice sheet thickness, temperature, and velocity as functions of time and position. These equations are solved numerically using the finite element method. Early models were done on a 2-dimensional map plane. More recent models use better physics to describe ice velocities in regions where velocities vary significantly over short distances. These models generate systems of linear equations with sparse non diagonally dominant matrices. The iterative methods can't be used to solve these types of equations. Solving the systems with the direct methods, on the other hand, is time demanding.

The above reasons have motivated us to explore the possibility of using multiprocessors for solving these equations. We have chosen freely available solver for distributed memory parallel computers known as SuperLU-DIST. For dense matrices, the SuperLU-DIST algorithm has been shown to exhibit good scalability, that is, its efficiency (a measure of process utilization in a parallel program) can be approximately maintained as the number of processors increases. For sparse matrices, however, efficiency is much harder to predict since it depends on the sparsity pattern of the matrix.

In this work, we have explored the scalability of SuperLU-DIST applied to matrices generated by the UMISM and estimated the accuracy of the method. Test results indicate that SuperLU-DIST is a reasonable package for applying to ice sheet problem; however, to improve the accuracy of the method careful consideration must be given to *a priori* matrix transformation using knowledge of the matrix structure.

Rates and Mechanisms of Limnological Change in Alpine and Arctic Regions of North America

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Alpine and arctic ecosystems are sensitive to global change impacts, owing to their low temperatures, nival hydrological regimes, and simplified trophic structures. To assess recent rates of change in these systems, diatom species compositional turnover (quantified by the β -diversity index) was examined over the last ~450 years in paleolimnological records from North America and west Greenland. The fifty-two sites selected for this study included alpine ($n=15$) and arctic ($n=20$) lakes, in addition to a range of boreal-montane sites ($n=17$) as controls. For both arctic and alpine lakes, β -diversity indices were higher during the 20th century and differed from those of the boreal-montane sites, indicating that species turnover increased with both latitude north and altitude. During the 19th century and the time period 1550-1800, the β -diversities for the arctic and alpine sites did not differ significantly from the montane-boreal sites. Across many of these high latitude or altitude lakes, various species of the genus *Cyclotella* increased during the 20th century and drove the higher β -diversity indices during this period. Regional temperature increases during the 20th century correspond to the latitudinal trend of diatom β -diversity in arctic lakes, whereas the southward increase of anthropogenic N deposition suggests that biogeochemical impacts are most pronounced in mid-latitude alpine lakes.

A pilot electronic exhibit: "The Science of Climate Change: A journey to Reedy Glacier, Antarctica"

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Recent mass balance studies of the Greenland Ice Sheet demonstrate that the largest changes are currently taking place near the ice sheet margins. Rapid thinning rates have been observed in southeast Greenland over the past 10 years and grounding line retreats of several kilometers were measured on glaciers in northern Greenland. In this study, we investigate changes of three large glaciers in southeast Greenland: Daugaard-Jensen Gletscher, Kangerdluqsuaq Gletscher and Helheim Gletscher. Satellite images spanning 40 years are used to document changes in calving terminus location and to derive ice velocities. Imagery from the ASTER, Landsat ETM+, Landsat TM, and DISP missions are used to develop chronologies of ice motion and frontal position. In some cases, we extend the observational record using archival field measurements and aerial photographs. We shall describe key results, which include nearly constant calving front positions and steady velocity profiles.

Novel Weather Modification Technology in the Context of Sustainable Eco-Development and Climatic Problems

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Ripening of a conflict between man and nature has been predicted from immemorial times, and in most of predictions a solution was done in favor of nature. During 10,000 years more than 300 generations have been gaining material wealth by destroying planetary ecosystems of all levels, and eventually squandered Earth's reserves of development eventually. Today, in accordance with the earlier conclusions of the Roma Club reports (1972, 1974), one can see that a world is entering into a series of regional and global crises. Demographic, energetic, economical, recourses, food crises are aggravated with a global climate threat. Formulating concepts of "eco-development" (Strong, 1972) and "sustainable development" (ICED, 1987) led to outlining new paradigms of development of human civilization in the 21st century (UNO, 1987, 1992, 1997, 2002, 2004). A measure of the optimal social organization must be the degree of coordination between strategies of development of society and nature. An initial key notion in analyzing causes, sources, and mechanisms of all Earth's crises is an "ecosphere." This means a synergy of "biosphere" and "techno-sphere." The term "ecosphere" is basic in elaborating our novel multidisciplinary concept on weather, climate and environment management by effective weather modification (WM) or cloud/fog seeding technology.

As is known, the global hydrological cycle is one of the key elements in the global environment and plays many important roles in the climate system. Soil moisture is an important factor in agricultural (crops) yield, it influences soil respiration (CO₂ transport), the energy balance at the land surface (by changing the surface albedo and affecting evapotranspiration). The total amount of water in the atmosphere is evaluated as about 12,900 km³. About 10% of atmospheric water in local (stratocumulus) cloud systems can be precipitated by the novel ecologically pure technique of seeding (Fukuta). These methods are applied for redistributing and recovering water resources, preventing natural and technical crises, and easing climatic stress. Some basic programs are already tested in field experiments in USA, Japan, China, and Europe. Instead of the old probabilistic methods of evaluation a new exact objective method of radar verification has been elaborated and effectively employed. Some of these applications may have a very high economic impact in preventing threats caused by meteorological/climatic hazards. These concern technically feasible operations for preventing: (1) severe winter "freezing rains" causing power line icing and other infrastructural damage, (2) melting of mountain glaciers in such regions as the European Alps, (3) droughts, (4) floods, (5) desertification of soils, (6) hail precipitation, (7) massive forest fires, (8) tornados, etc.

But even in situations where weather modification offers potential economic benefits and where there are no overriding ecological problems, the attitudes of people towards the adoption of this offer vary greatly. A subject that impinges upon so many people as WM would give rise to legal problems from local to international scales. However interest and investment in WM is rising today due to the needs for increased water and for reduced damage from

hazardous weather/climate. Nearly two billion people are currently considered subject to severe freshwater shortages, and this number will be increased to over three billion during the next 25 years. People living in drought-prone or water-stressed regions will do what they deem necessary out of desperation. Today a variety of proven, cost-effective societal/technological approaches, no doubt, calls for innovative weather, climate and environment management.

Slush, Mush, and Masannartuq

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Satellite images of Greenland during the melting season show vast areas of surface water. During the last decade these areas have expanded to ever-higher elevations and have appeared earlier and persisted longer with each passing year. An ongoing project has been to determine the area and volume of the large ponds/lakes that dot the surface of (particularly western) Greenland during the summer. A method was developed and applied to a region of northwestern Greenland using visible/near-infrared satellite imagery. In doing so, we detected what appear to be very large regions of relatively shallow (0.5-1.5 m) of surface meltwater. However, the method is designed to work most accurately with clear water and a well-defined bottom. Neither of these conditions hold if, what we are detecting, are slush fields. For good, practical reasons little or no fieldwork has been carried out in the slush fields of Greenland. However, anecdotal evidence from native hunters and adventurers provide some clues to the depth of these fields. Recent study/work has been directed at providing a quantitative description of the physical and optical properties of slush with the goal of refining our surface meltwater volume calculations.

On the use of Scanning Electron Microscopy to Characterize Firn/Ice Cores

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Our understanding of the physical properties of firn and ice, particularly grain size and its correlation with other parameters, such as chemical content, could be greatly enhanced by taking advantage of technologies not available in the 1960's when the importance of grain size measurements began to be appreciated. This project utilizes a scanning electron microscope (SEM), equipped with a liquid nitrogen chilled cold stage, in combination with energy dispersive x-ray microanalysis (EDS), and electron back-scattered patterns (EBSP) to thoroughly describe the physical and chemical character of samples collected during the 2006-2007 ITASE traverse.

Using an SEM in the manner described above allows for the determination of firn grain area sans the pore filler required for thin-section analysis with an optical microscope. Grain areas, as determined using SEM imagery, have been found to be different (substantially smaller), than those grain areas determined using methods requiring thin-section photographs. Thus, this method can be used to refine the technique of grain size measurement. Additionally, when using SEM imagery to physically characterize firn/ice core samples the aerial porosity of a sample can be determined as well and the relationship between porosity and grain size can be discussed.

EDS analysis of impurities (which appear as bright white spots or filaments) in the same samples for which grain sizes have been calculated allows for an assessment of the relationship between chemical content, chemical location (i.e., in grain boundaries or within the crystal lattice) and grain growth. When this information is combined with crystallographic orientation data as determined using EBSP, a nearly complete picture of deformation history can be gained. This history can in turn be used to inform interpretations of paleoclimate.

Flow dynamics of Helheim Glacier, East Greenland

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Ice discharge through fast-flowing outlet glaciers now accounts for ~70% of the annual mass loss from the Greenland Ice Sheet. A series of recent changes, including calving front retreat, flow acceleration, and dynamic thinning, has caused a doubling of Greenland's contribution to sea level rise since 2000. Understanding the dynamics of outlet glaciers is critical for modeling the future stability of the Greenland Ice Sheet and predicting rates of sea level rise.

A force balance adjustment at the glacier front is one hypothesis to explain the recent changes in outlet glacier dynamics. The adjustment occurs when modest long-term thinning leads to a loss of the terminus section of a glacier. This hypothesis implies that iceberg calving is the trigger mechanism. We have assembled a suite of field and remote sensing measurements on Helheim Glacier, East Greenland, that challenges this hypothesis. High-rate GPS measurements collected near the glacier terminus during the summer of 2007 reveal several instantaneous accelerations in flow speed. These changes are linked to glacial earthquakes detected teleseismically and large calving events observed in daily satellite images. Detailed analysis of the timing of these events shows that the glacier accelerates prior to the seismic event (by about 1 hour) and possibly also before the calving retreat. These observations lead us to propose a new source mechanism for glacial earthquakes, and suggest an alternative hypothesis for the short-term changes in ice flow dynamics.

Associated Terrestrial and Marine Fossils in The Late-Glacial Presumpscot Formation, Southern Coastal Maine, and the Marine Reservoir Effect on Radiocarbon Ages

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Recent excavations for Mercy Hospital on the Fore River in Portland, Maine exposed well-preserved white spruce trees (*Picea glauca*) in marine clay of the Presumpscot Formation. The exposures were near the site where spruce logs were discovered in the Presumpscot clay in 1976 and showed identical stratigraphy. The new site revealed broken trunk segments of at least five trees lying on their sides, along with peat containing other plant fragments including twigs and needles of white spruce, buds of balsam poplar, and fossils of 20 different mosses. The plant remains occur in clay and a basal fine-sand layer in the lowest 1 m of the Presumpscot Formation. These fossiliferous sediments abruptly overlie the sloping surface of a sand and gravel deposit interpreted as a glaciomarine fan. All the trees died at the same time during winter dormancy. The oldest contained 200 rings. Barnacle fragments and complete *Mytilus edulis* valves were found within 30 cm of tree remains, enabling comparison of marine and terrestrial radiocarbon ages to evaluate the local marine reservoir effect. Radiocarbon ages of nine wood samples ranged from 11,907 +/- 31 to 11,721 +/- 40 ¹⁴C BP. Ages of associated shell samples were 12,850 +/- 65 ¹⁴C BP (*Mytilus*) and 12,800 +/- 55 ¹⁴C BP (barnacle). If this marine-terrestrial age difference of ~ 1000 years is applicable to other shell ages in SW Maine, it will reduce or eliminate the discrepancy between the marine deglaciation chronology and the ice-retreat history based on the New England varve chronology to the west. The local sea-level curve suggests the tree remains were deposited in water depths of ~ 30-37 m. The terrestrial fossil assemblage most likely washed out to sea from one of the nearby islands or peninsulas. It was buried quickly as marine clay accumulated on the sea floor.

Identifying a unique stratigraphic signature for Maine's salt pool environments

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Salt pools are shallow, water-filled depressions common to many north-temperate salt marshes. Previous work from Maine suggests that most salt pools are secondary and dynamic features, rather than primary, relict salt marsh landforms. Recent analyses of a time-series of aerial photographs from Ogunquit to Lubec, ME, reveal that the dynamic exchange between salt pools and tidal creeks may be one mechanism by which considerable surficial change occurs in Maine's salt marshes. Analyses of surficial samples and Dutch cores taken through extant and paleo-pool environments, reveal that salt pools are recognized in the stratigraphic record by dark gray, muddy sediment of high water content, often containing macrofossils of *Ruppia maritima* and *Hydrobia totteni*. Salt pool sediments have greater percent loss-on-ignition (LOI) than tidal flat or creek environments, less than or equivalent to low marsh, and less than high marsh deposits. Similarly, C/N ratios show that salt pool sediments have a lower C/N ratio and a lower percentage of organic carbon than low, high, and higher-high marsh deposits. Salt pool sediments have a C/N ratio similar to tidal flat sediments but a higher percentage of organic carbon. This study indicates that we can identify a consistent, coast-wide, stratigraphic signature for salt pools. These results may warrant a reinterpretation of previous work that attributes within-core transitions between marsh environments to relative sea-level fluctuations.

Problem-oriented research, desertification, and the human dimension of long-term socio-ecological change

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The relationship between humans and environmental change is highly complex and requires significant contributions from many disciplines. However, the integration of data across multiple fields of study, and particularly across the social and environmental divide, poses difficulties because of the structure of traditionally bounded disciplines. Ongoing research along the Peruvian south coast demonstrates that problem-oriented research (as opposed to discipline-oriented research) serves as an effective mechanism to integrate data from the social and environmental sciences. Here, problem-oriented research centered on desertification as an ecological process permits a more effective understanding of long-term socio-ecological change along the Peruvian south coast, and particularly the role of human groups over the past millennium in the creation of contemporary socio-ecological conditions.