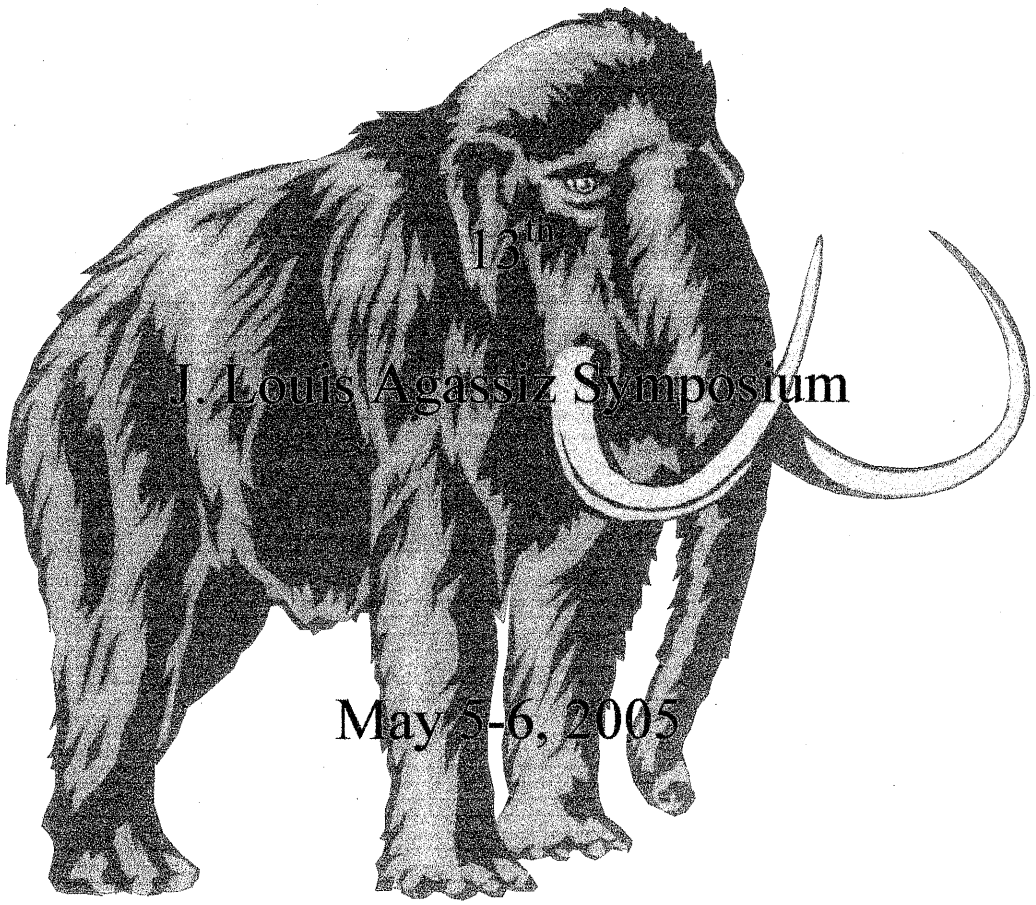
CLIMATE CHANGE INSTITUTE



13th

J. Louis Agassiz Symposium

May 5-6, 2005

Sawyer Environmental Research Center
University of Maine
Orono

13th J. Louis Agassiz Symposium – Program

Thursday, May 4

8:00 - Coffee and Pastries

8:25 - Introductions - "Welcome"

8:30 – J. Kelley, D. Belknap, A. Cooper "Sea-Level Change and Nearshore Stratigraphy: A Comparison of Northern Ireland, UK and the Western Gulf of Maine, USA"

8:45 – Peter Leach, Daniel Belknap, Brian Robinson "Marine Geophysics and Vibracoring Applied to the Search for Submerged Prehistory in Damariscotta River, Maine, USA"

9:00 – Daniel Belknap, Allen Gontz, Joseph Kelley "Calibrating and updating the Maine Quaternary relative sea-level curve"

9:15 – Kristin Sobolik "Prehistoric turtle remains from the Northeast"

9:30 – Alice Kelley, David Sanger "Paleoindian sites in the central Penobscot Valley: absent or undiscovered?"

9:45 – Daniel Dixon, Paul Mayewski, Susan Kaspari, Sharon Sneed, Michael Handley, Douglas Introne, Karl Kreutz "IC, ICPMS and oxygen isotope measurements from the 2002 and 2003 ITASE traverses"

10:00 BREAK

10:30 – J.L. Fastook, J.W. Head, D. Marchant, D. Shean "Ice Sheet Modeling: Mass Balance Relationship for Map-Plane Ice Sheet Reconstruction, Application to Tharsis Montes Glaciation"

10:45 – Roger Hooke, Jim Fastook "Thermal conditions at the bed of the Laurentide Ice Sheet in Maine during deglaciation: Implications for landforms"

11:00 – Aitabala Sargent "Better Physics in Embedded Models"

11:15 – Bruce Williamson, Karl Kreutz, Paul Mayewski, Nancy Bertler, Michael Handley, Erich Osterberg "Spatial distribution of trace metal chemistry in glacier surface snow from three accumulation zones in the Dry Valleys, Antarctica"

11:30 – A.V. Kurbatov, G.A. Zielinski, N.W. Dunbar, P.A. Mayewski, E.A. Meyerson, S.B. Sneed "Siple Dome A tephra at 1261 C.E. and possible link with the 1259 event"

11:45 - Susan Kaspari, Paul Mayewski, Shichang Kang, Karl Kreutz, Sharon Sneed, Doug Introne, Mike Handley "A Calibrated Climate Proxy for the Summer Asian Monsoon Developed from a Mount Everest Ice core"

12:00 LUNCH

1:00 – Bill Sneed "Texture of ice and snow on a glacier in Svalbard"

1:15 – Gordon Hamilton, Bill Sneed, Jack Kohler "Changes in ice cap geometry in northeast Svalbard, or lack thereof"

1:30 – Sea Birkel "Re-evaluating the volumetric contribution of the Laurentide Ice Sheet to sea-level changes during the last glacial termination"

1:45 – Gordon Bromley "Post-LGM evolution of Reedy Glacier, Antarctica, as an indicator of current ice sheet stability"

2:00 – Aaron Putnam "A Comparison of Chronologies from Moraine Sequences Deposited by the West Antarctic Ice Sheet and Independent Alpine Glaciers in the Ohio Range, Antarctica"

2:15 – Brenda Hall, George Denton, Rus, Hoelzel, Ana Topf, Carlo Baroni, Burney LeBoeuf "Late-Holocene sea-ice variations and climate in the Ross Sea inferred from southern elephant seals"

2:30 - BREAK

2:45 – Jim Roscoe "Latitudinal Trends in Hunter-Gatherer Diets and the 'Tropical Exception'"

3:00 – Terry Hughes "Holistic modeling in glaciology"

KEYNOTE SPEAKER

3:15 – Jean-Daniel Stanley Sunken History "Ancient Human Settlements Beneath the Mediterranean: Interpreting the Role of Natural Hazards and Human Activity"

Friday, May 7

8:00 - Coffee and Pastries

8:30 – Kirk Maasch, Fei Chai, James Fastook, Peter Koons "Modeling tutorial"

10:00 - BREAK

10:30 - K.J. Kreutz, D.S. Introne, B. Larrabee, S. Wentworth, A. Wanamaker, M. Turner, and T. Hawley "Tracing Maine's hydrologic cycle using stable isotopes"

10:45 - Stephen Norton, Michael Handley, Erich Osterberg, Tiffany Wilson "Atmospheric deposition of cadmium in the northeastern USA"

11:00 - Alan Wanamaker, Karl Kreutz, Bernd Schöne, Scott Feindell, Douglas Introne, "Interpreting the growth histories of the ocean quahog (Arctica islandica) in the Gulf of Maine, USA: A potential proxy for paleo-environmental conditions"

11:15 – Leigh Stearns, Gordon Hamilton, Niels Reeh "Multi-decadal records of ice dynamics on large East Greenland outlet glaciers, from satellite imagery and terrestrial measurements"

11:30 – Coen Hofstede "Deriving the geometry of Jacobshavn Isbrae from field observations"

11:45 – Paul Mayewski "ICARA (Ice Core Archive Recovery Activity) and "Secrets of the Last Glaciers" - A science plan and a movie"

12:00 - LUNCH

1:00 - Marianne Lagerklint, Molly Schauffler "Communicating with the communities we serve: Education and Outreach opportunities for the University of Maine Climate Change Institute"

1:15 – Hal Borns "Maine's Ice Age Trail: an educational experience for Geo/Eco Traveler"

1:30 - Brian Robinson "Mapping the Bull Brook Paleoindian Site"

1:45 - Bertrand Gilman Pelletier "Glacial Lake Levels and Paleoindian Settlement Patterns at Munsungan Lake, Northern Maine"

2:00 - Kurt Rademaker, Daniel Sandweiss, Michael Malpass, Adan Umire, Pablo de la Vera Cruz "Alca Obsidian and Early Coast-Highland Interaction in Southern Peru"

2:15 – Dan Sandweiss, Linda Perry, Dolores Piperno, Kurt Rademaker, Michael Malpass, Louis Fortin, Ben Morris, Adán Umire, Pablo de la Vera "New Evidence for Early Agriculture in the South-Central Andes"

Abstracts

Thursday, May 4

Sea-Level Change and Nearshore Stratigraphy: A Comparison of Northern Ireland, UK and the Western Gulf of Maine, USA

Kelley, Joseph T., Dept. of Earth Sciences; Belknap, Daniel F., Dept. of Earth Sciences; Cooper, Andrew, Environmental Science, Univ. of Ulster

Northern Ireland, UK and Maine, USA possess broadly similar rock-framed coastal zones that have experienced similar late Quaternary histories. Recent seismic reflection observations and underwater vibracores allow us to evaluate their Quaternary evolution. Following glaciation, each was transgressed owing to isostatic depression of the land. Each emerged to a lowstand position, - 60m at 10.5 ka in Maine, -30 m at an unknown time in NI. Sea level has risen at varying rates in coastal Maine. During a mid-late Holocene slowdown in the rate of sea-level rise, extensive estuarine deposits apparently collected in many areas. Sea level has risen at decreasing rates since then, and much of the inner shelf has lost any regressive sediment. Two exceptions to this include lowstand deltas that continued to form up to recent times off large rivers. These possible terrestrial deposit preserved during transgression include freshwater wetland deposits contained in bedrock depressions. These deposits have not been directly observed, but are inferred to underlie and source natural gas fields in muddy embayments. Off Northern Ireland sea level rose several meters above present in the middle Holocene. It fell to the present location and is more or less stable today. Out to – 30 m depth, fine sand dominates vast areas off large beaches and rivers, though no lowstand deltas are yet recognized. In Belfast Lough, a mujddy embayment, a sand deposit was cored over glacial-marine mud in several places. This appears to be a beach or shoreface deposit that is overlain by a sequence of intertidal to subtidal materials. Radiocarbon dates are awaited from Northern Ireland.

Marine Geophysics and Vibracoring Applied to the Search for Submerged Prehistory in Damariscotta River, Maine, USA

LEACH, Peter A., Climate Change Institute and Dept. Anthropology; BELKNAP, Daniel F., Dept. Earth Sciences and ROBINSON, Brian S., Climate Change Institute and Dept. Anthropology

Damariscotta River is well known geologically (Shipp, 1989; Belknap et al., 1994) and archaeologically (Sanger and Sanger, 1986). Ceramic Period *Crassostrea virginica* oyster middens exist in the upper Damariscotta, including the famous Glidden and Whaleback middens and smaller oyster and clam middens. The inhabitants of these sites utilized a robust oyster population that can be seen in at least one relict reef in Salt Bay dated to 1325 +/- 40 radiocarbon YBP. In the middle Damariscotta River oyster shell middens are conspicuously absent, yet a massive (700m long, 3 thick) oyster bioherm exists at Dodge Basin, 3m below Holocene mud. We have conducted research to investigate whether human populations also utilized this earlier oyster resource. Shipp (1989) first identified this oyster bioherm upstream of Glidden Ledge in the middle Damariscotta River. This ledge acted as a barrier to saltwater intrusion prior to transgression. A dated salt marsh peat occurs below the bioherm, at 15 mbsl and 6340 +/- 55 BP. Oysters may have arrived shortly after, and at least by 4835 +/- 60 BP. If the oysters were used by humans, any existing archaeological sites would have been submerged by late Holocene sea-level rise.

Our research design employs seismic reflection profiling, side-scan sonar, and vibracoring. Complete seismic reflection profiling coverage of Dodge Basin provided data on sub-surface lithologic units, as well as oyster reef configuration. Oyster bioherms have a unique, 'chaotic' reflector that is readily identifiable on seismic profiles. After examining the seismic data, nine vibracores were taken in order to: 1) collect a complete Holocene to Pleistocene stratigraphic sequence, 2) collect oyster bioherm deposits overlying salt-marsh peat, 3) investigate areas of high archaeological site potential, and 4) retrieve

sufficient data to reconstruct the paleogeography of Dodge Basin. 1 meter contour interval maps have been created for the current bathymetry of Dodge Basin and the spatial configuration of the relict oyster reef. Through a combination of geophysical and geologic methods it may be possible to refine the search for submerged prehistoric sites by using a spatially restricted, easily identifiable, and geologically preserved biological resource. This method is here termed the relict biological indicator model for submerged prehistoric sites. Given the broad geographic range of *C. virginica*, this methodology for refining the search for submerged prehistoric sites is pertinent to areas outside Damariscotta River.

Calibrating and updating the Maine Quaternary relative sea-level curve

BELKNAP, Daniel F., Dept. Earth Sciences, School of Marine Sciences, and Climate Change Institute, GONTZ, Allen M., Dept. Earth Sciences, and KELLEY, Joseph T., Dept. Earth Sciences, School of Marine Sciences, and Climate Change Institute.

Radiocarbon dates between 16 and 12 ka (calendar years) from well-preserved mollusks and barnacles in the Presumpscot Formation glaciomarine mud provide minimum sea-level elevation constraints, but associated shoreline and delta deposits are required to constrain paleo-sea level well. These datable fossiliferous localities have been investigated by Bloom (1963), Stuiver and Borns (1975), Thompson and Borns (1985), Belknap et al., (1987), Retelle and Weddle (2001) and Borns et al. (2004). Various interpretations of the effect of a purported reservoir effect from these marine shells, in particular with comparison to the western New England varve sequence, may affect this portion of the curve by 400-900 years or more. Relative sea level fell rapidly from the postglacial highstand to a lowstand ca. 60 m below present at 12 ka, under the influence of isostatic rebound (Barnhardt et al., 1995). Post-lowstand transgression was equally rapid, to an interval of slower change –30 to –20 mbsl 11.5 ka to 8 ka (Kelley et al., 1992). This interpretation is the result of dated shells from inner shelf vibracores. New data further constrain the timing of the lowstand and onset of the plateau in the curve. The mid-late Holocene transgression is best constrained by data from salt-marsh peats, which provide relatively precise indications of MHW. Salt-marsh foraminifera refine determinations of paleoenvironments and the use of AMS dating further focuses precision of the late Holocene curves (Gehrels, 1994; Gehrels et al. 1996, 2002). Deglacial and Holocene data were compiled into a database including age, elevation, geographic location, paleoenvironment, and a relative measure of quality. We sort the 348 sea-level data points by reliability, calibrate them uniformly using CALIB 5.0, and interpret indicative meaning to a quantifiable error range. Comparison of older published and unpublished data to more complete modern studies is likely to never be totally resolved. However, preliminary results confirm the study by Gehrels and Belknap (1995) that there is no evidence of significant mid-to-late Holocene differential warping along the coast. Deglacial curves at various locations normal to the known isostatic uplift pattern suggest longer-term along-coast deformations, as earlier identified from the deformation of the isobases. This detailed analysis ultimately can inform modeling of lithospheric responses on short time and spatial scales, such as the margins of the Gulf of Maine, for comparison to other regions.

Prehistoric turtle remains from the Northeast

Kristin D. Sobolik Department of Anthropology and Climate Change Institute University of Maine

The identification of turtle remains from prehistoric sites in the northeastern United States is growing as more archaeologists are becoming aware of the importance of bone assemblages to the interpretation of prehistoric lifeways and paleoenvironments, as well as how to technically identify turtle bone from other animal bone. For this presentation, I provide a list of turtle species identified from northeastern archaeological sites, a review of their ecology, and the types of interesting and important questions that can be answered through the analysis of such remains. Turtles were used extensively by prehistoric peoples for food, rattles, and containers, and each turtle species has a unique ecological pattern; therefore, their remains can tell modern researchers about prehistoric lifeways as well as paleoenvironments.

Paleoindian sites in the central Penobscot Valley: absent or undiscovered?
Alice Kelley, Department of Earth Sciences and David Sanger, Department of Anthropology and Climate Change Institute.

Paleoindian artifacts represent the earliest record of human occupation in New England and the Canadian Maritimes, circa-11,000-9,000 yrs. BP. Identified on the basis of diagnostic fluted points and associated artifacts, sites from this time period discovered in Maine are attributed to lithic procurement to the north, in the Munsungan area, and occupation and travel camps in the southern portions of the state. However, no sites from the Paleoindian period are recognized in the central Penobscot drainage. This lack of evidence suggests that people at this time either did not use the region, or predictive models developed in southern Maine and elsewhere are not applicable to this region. Paleogeographic reconstructions of the central Penobscot Valley based on Almquist and Sanger's (1999) and Hu and Davis (1994) Pushaw Lake investigations show that the landscape in the central Penobscot Valley during the Late Pleistocene and Early Holocene was much different from that in other portions of the state. The landscape at this time was dominated by widespread, largely unproductive lakes, and the high, large, sandy, well-drained sites apparently favored by Paleoindians in southern Maine are notably absent in the study area. Formation of these lakes is interpreted to be the result of a poorly drained, recently deglaciated landscape mantled with fine-grained glaciomarine sediment combined with local, short-term postglacial isostatic tilting. In addition, the Penobscot River had a higher discharge than at present, its watershed including that of Moosehead Lake and meltwater from the last remnants of the Laurentide Ice Sheet. This evidence suggests that the existing Paleoindian occupation model does not apply to the central Penobscot Valley. Instead, travel and occupation sites in this area will be found on limited, well-drained deposits, such as eskers or paleodunes associated with now extinct lakes, in areas of relatively flat water on the Penobscot, or on "thorofare" locations that allow movement between lake basins with the minimum of water crossings. These thorofare locations have the potential of providing travel routes, as well as focusing the movement of herd animals, such as caribou, providing hunting opportunities. The only Paleoindian site in Maine east of the Penobscot River is outside the river's watershed, but is in a thorofare setting. This limited, but compelling, evidence suggests that other Paleoindian sites exist in the Penobscot Valley, but have not been located due to a lack of recognition of landscape change through time.

IC, ICPMS and oxygen isotope measurements from the 2002 and 2003 ITASE traverses
Daniel Dixon, Paul Mayewski, Susan Kaspari, Sharon Sneed, Michael Handley, Douglas Introne, Karl Kreutz

A collection of 100 surface snow samples collected approximately every 30 km along the ITASE-02 Byrd to Pole and ITASE-03 LGT traverses. Each sample is analyzed for 35 different elements, 8 major ions and oxygen isotope content. Can IC and oxygen Isotope measurements taken from ice cores along the same route be used to verify the seasonality of the surface snow samples and thus verify the spatial distribution of typical summer snow chemical concentrations?

10:00 BREAK

Ice Sheet Modeling: Mass Balance Relationship for Map-Plane Ice Sheet Reconstruction, Application to Tharsis Montes Glaciation

J. L. Fastook (Climate Change Institute and Computer Science, University of Maine, Orono ME 04469, USA), J. W. Head (Department of Geological Sciences, Brown University, Providence RI 02912, USA), D. Marchant (Department of Earth Sciences, Boston University, Boston MA 02215, USA), D. Shean (Department of Geological Sciences, Brown University, Providence RI 02912, USA)

Deposits on the flanks of the large Tharsis Montes volcanoes (Arsia, Pavonis, and Ascraeus Mons) have been recognized to be of glacial origin. These Amazonian-aged deposits display three distinct facies, ridged, knobby, and smooth, each of which can be associated with different glacial processes. The outermost ridged facies is thought to be the imprint of ice-margin drop moraines recording the fluctuations of a stable cold-based ice sheet. Inside this is the knobby facies, interpreted as a sublimation till deposited as the ice sheet sublimated during a period of major contraction of the ice sheet. Finally, contained within both of these is the smooth facies which may contain debris-covered glacial ice, similar to rock glaciers found in the Dry Valleys of Antarctica. The deposits form fans trending to the northwest from each of the volcanoes and have been described elsewhere. Steady-state flowband profiles have been shown to produce reasonable ice sheet configurations of a few hundred to a thousand meters thickness. However, flowband modeling makes estimates of volumes difficult, and steady-state modeling does not allow for the possibility that these ice sheets never attained full equilibrium configurations during the transient climatic conditions that accompany the large oscillations in obliquity that dominate the Martian climate.

Postulated chronologies for ice sheet behavior are emerging as a better understanding of Mars climate change driven by major variation in the obliquity is seen as allowing for ice sheets to form near the equator at high elevations on the flanks of the large volcanoes. Ice sheet models, coupled with reasonable assumptions about the climate, can obtain estimates for the volumes of these ice sheets, better constraining the water budget for the planet. Ice sheet models usually involve an integrated momentum-conservation equation based on the flow law of ice coupled with a mass-conservation, or continuity equations to yield a differential equation for ice extent and thickness as a function or time.

Thermal conditions at the bed of the Laurentide Ice Sheet in Maine during deglaciation: Implications for landforms

Roger LeB. Hooke, Department of Earth Sciences and Climate Change Institute; James Fastook, Department of Computer Sciences and Climate Change Institute;

We used a map-plane finite difference model to simulate retreat of the Laurentide Ice Sheet in Maine during the last deglaciation. An unexpected but, in retrospect, logical steepening of the ice surface occurs during retreat, leading to higher velocities and greater advection of cold ice into the ablation area. The latter compensates for the greater energy dissipation resulting from the former, so basal melt rates at equivalent distances from the margin remain roughly constant. Within 200 km of the margin, basal melt rates average ~12 mm a^{-1}. Over the next 100 km they decline to ~5 mm a^{-1} and remain at this level for another 100 km. Within the resolution of the model, ~12 km, there are no areas in which the ice sheet is frozen to the bed. This is inconsistent with the presence of ribbed moraine in the vicinity of Mt. Katahdin. By integrating the melt rate between the margin and a topographic divide in northern Maine and multiplying by the width of a flow band typically subtended by an esker we obtained a discharge at the margin of ~4 m^3 s^{-1}. This is sufficient to build an esker without additional input of water from the glacier surface. Between ~50 and ~250 km from the margin, temperature gradients in the basal ice are in excess of 0.2 K m^{-1}. Such gradients will conduct upward into the ice all of the additional viscous heat generated in water flowing in a developing semicircular conduit less than a few centimeters high, thus inhibiting enlargement of a conduit to a size in which an esker could form. Under such conditions, we hypothesize that esker sedimentation occurs only within a few kilometers of the margin where basal temperature gradients are lower. This may explain why eskers are typically segmented, with later segments lapping onto earlier ones.

Better Physics in Embedded Models
Aitabala Sargent, University of Maine

The commonly used shallow ice approximation neglects all stresses except the basal drag, an assumption that is very good for inland ice but may be very poor for fast-flowing, low-surface slope ice streams, where longitudinal stresses may not only be important, but may in fact be the dominant stress.

Treating the ice streams as barely-grounded ice shelves is another approach, which may be seen as the opposite end member in a spectrum of approximations. In this approximation the only stresses are the longitudinal stresses, the basal drag is not included in the fundamental formulation, but instead is added on as a small correction after integrating the vertical dimension with the assumption of no basal drag.

The only way to truly quantify the importance of longitudinal stresses is to solve the full momentum equation with none of the limiting assumptions that go into either the shallow-ice or the barely-grounded ice shelf approximations.

An implementation of a 2D solution of the full momentum equation is presented. Two examples dealing with 1) iceberg arcing and 2) lakes beneath ice sheets are also presented.

Spatial distribution of trace metal chemistry in glacier surface snow from three accumulation zones in the Dry Valleys, Antarctica
Bruce Williamson, Karl Kreutz, Paul Mayewski, Nancy Bertler, Michael Handley, Erich Osterberg.

Because the Dry Valleys of southern Victoria Land, Antarctica, contain a large proportion of exposed soil and bedrock relative to other areas of the continent, some authors have expressed interest in the question of transport of Dry Valleys dust and whether it may provide a source for aerosols found at other sites (e.g. Delmonte et al., 2004). To answer this question will require, among other information, more knowledge regarding dust transport and chemistry within the Dry Valleys themselves. Toward this end, during November 2003, snowpit and shallow core samples were collected from three glacier accumulation zones in the Dry Valleys region, and these samples have been analyzed for a variety of trace metal concentrations, including among others Al, Ca, Fe and the rare earth elements (La, Ce, Pr, Nd, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm and Yb). These three sites represent three points of an area that spans approximately 65km from north to south and approximately 10 km east to west. The Clark glacier (the site the furthest to the north, at 77.41° N, 162.37° E) shows consistently higher concentrations for most trace metals, though there are exceptions to this trend. This presentation will include discussion of the spatial distribution of trace metals among these sites as well as examining the broader context surrounding each site with the goal of beginning to explain observed patterns.

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Siple Dome A tephra at 1261 C.E. and possible link with the 1259 event

Kurbatov A.V.[1], Zielinski G. A.[1], Dunbar N. W. [2], Mayewski P. A.[1], Meyerson E. A.[1], Sneed S.B.[1]
[1] Climate Change Institute [2]N.M.B.M.M.R./E&ES Department, New Mexico Tech

The Siple Dome A (SDMA) ice core volcanic record contains two sulfate spikes at 1259 and 1262 C.E. A tephra compositionally similar to Mt. Melbourne volcano, Antarctica is found in1251-1321 C.E. interval (Dunbar et al., 2003) in the Siple Dome B ice core. This 'Melbourne' tephra was correlated with 1321+/-25 C.E. and 1254 +/- 2 C.E. tephra layers found respectively in Taylor (Hawley et al., 2003) and Talos Domes (Stenni et al., 2002), and 1262 C.E. sulfate spike in the SDMA ice core.

Previously the 1259 C.E. acidity spike "from unknown eruption somewhere in the Northern Hemisphere" (Hammer et al., 1980) was identified in records from Crete and Camp Century ice cores, Greenland. Radiometrically dated eruption of El Chichon volcano, Mexico was proposed as a source for this acidity peak by Tilling et al., (1984). Langway et al. (1988) also suggested that1259 event registered in both Greenland and Antarctica is associated with tropical volcanic eruption. One of the largest Holocene volcanic signals in the in ice core from Agassiz Ice Cap, Canada (Fisher and Koerner, 1988) was attributed to 1259 C.E. event. Composition of particles found in ice cores from Greenland and Antarctica in filtered from ice samples collected from 1259 layer (Palais et al., 1992) was reported similar to El Chichon volcano, Mexico but small differences in TiO_2, Fe_2O_3, and MgO contents were noted. The 1259 event was found later in many ice cores drilled in both hemispheres (Langway et al., 1995; Clausen et al., 1997, Budner and Cole-Dai, 2003).

Unfortunately a revised stratigraphy of the El Chichon volcano changes the timing of this eruption to 1320-1407 C.E. (Espindola et al., 2000), thus making the 1259 acidity peaks less likely caused by El Chichon. The only known relatively large volcanic eruption from this time interval that could produce such a sulfate increase is the large Quilotoa eruption (VEI = 6), Ecuador (Barberi et al., 1995). Comparison of available geochemical data from Quilotoa volcano (Rosi et a. 2004) and published glass shards samples from South Pole and GISP2 ice cores (Palais et al, 1992) provide less conclusive correlations but certainly that the timing of the El Chichon eruption is not correct for this event.

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A Calibrated Climate Proxy for the Summer Asian Monsoon Developed from a Mount Everest Ice core

Susan Kaspari, Paul Mayewski, Shichang Kang, Karl Kreutz, Sharon Sneed, Doug Introne, Mike Handley

A 108 m ice core recovered in 2002 from the col of the East Rongbuk Glacier, Mt. Everest is used to develop a climate proxy for the summer Asian monsoon. The high-resolution record is dated by seasonal variations of D and soluble ions (Na^+, K^+, Mg^{2+}, Ca^{2+}, Cl^-, NO_3^- and SO_4^{2-}), and verified by peak Cs^{137} and activity in 1963. The dominant source of Ca^{2+} is from arid regions in central Asia, whereas Cl^- comes from both arid regions and marine air masses from the Bay of Bengal and Arabian Sea. Using NCEP reanalysis from 1948-2001, the Ca^{2+} (Cl^-) timeseries is positively (inversely) correlated with surface pressure over the Tibetan Plateau during the monsoon season. D is inversely correlated with NCEP precipitation rate in the vicinity of the core site, verifying that D is controlled by the amount effect. Combined, the Ca^{2+}, Cl^- and D timeseries enable central Asian summer surface pressure and monsoon precipitation intensity of the Himalaya to be reconstructed over the past 300+ years. Smoothing the timeseries indicates that Cl^- has decreased, whereas Ca^{2+} and D have increased to present. This suggests higher surface pressure over the Tibetan Plateau and a weakening of the Asian monsoon over the period of the record.

12:00 LUNCH

Texture of ice and snow on a glacier in Svalbard

William Sneed

Texture is notoriously difficult to define and there are almost as many definitions for it as there are researchers studying it. For our purposes we will define texture as the spatial distribution of gray levels (gray tones) over a local area that has some degree of orderliness to the distribution. We propose to use texture as a means of discriminating the various snow and ice facies found on a glacier and delineating their bounds. Some facies, for example, superimposed ice, seem to be undetectable using the purely spectral properties of visible-wavelength satellite imagery. It is hoped that by taking into account both the spectral properties and their spatial distribution these recalcitrant facies can be mapped.

Changes in ice cap geometry in northeast Svalbard, or lack thereof
Gordon Hamilton, Bill Sneed, Climate Change Institute
Jack Kohler, Norwegian Polar Institute

The effects of climate change on components of the Arctic system are already underway, most notably in the duration and extent of sea ice cover. Here, we use satellite remote sensing and archival data to examine changes in glaciers and ice caps in Svalbard for evidence of climate change in northern Barents Sea region. Most glacier mass balance studies in Svalbard have focused on relatively small glaciers near the maritime northwest coast of the archipelago where conditions might not be representative of other regions. We have reconstructed a record of margin extent for a well-defined ice cap in northeastern Svalbard, where polar conditions dominate and near regions of the Barents Sea where a recent reduction in sea ice has been noted. The results show that the ice cap has maintained nearly the same spatial extent for the last few decades, despite the summit of the dome lying almost entirely below the zone of snow accumulation. We hypothesize that superimposed ice (melted and refrozen snow) is a significant source of mass input. The potential importance of superimposed ice accumulation complicates the response of glaciers and ice caps in the region to climate warming.

Re-evaluating the volumetric contribution of the Laurentide Ice Sheet to sea-level changes during the last glacial termination
Sean Birkel

Eustatic sea level at the Last Glacial Maximum (LGM) is not yet precisely known. Measurements taken from drill cores recovered from drowned coral reefs indicate values between 120 and 135 m below present. One way in which to assess the magnitude of sea-level depression is by reconstructing former ice sheets. However, it is difficult to say the volumetric contribution of each with certainty. Previous modeling indicates that the Laurentide Ice Sheet (LIS) contained on the order of 70 % of the total sea level trapped on land during the LGM. To date, there are many scattered datasets that constrain the margins of the ice sheet both temporally and spatially. A comprehensive evaluation of the LIS based on geologic data has not been completed since CLIMAP. For that reason, I propose to compile dates of terminal positions, reconstruct the LIS using the University of Maine Ice Sheet Model (UMISM) and evaluate its total contribution to sea level at the LGM and at several stages during the glacial termination.

Post-LGM evolution of Reedy Glacier, Antarctica, as an indicator of current ice sheet stability
Gordon Bromley

Reedy Glacier (86°S) is a major outlet glacier of the East Antarctic Ice Sheet which, like many other outlet glaciers flowing into the Ross Sea Embayment, has been shown to respond to volume changes in the West Antarctic Ice Sheet. The advance of grounded ice through the Ross Sea at the LGM blocked the mouths of the outlet glaciers causing a significant change in surface profile and elevation. Subsequent recession of the Ross Sea grounding line and removal of this damming effect during the Holocene caused lowering and steepening of glacier profiles and the isolation of drift sheets, moraines, and erratics on adjacent mountainsides. Because Reedy Glacier currently emerges from the Transantarctic Mountains ~100 km behind the grounding line its surface profile and thickness are still partially controlled by the size and thickness of the West Antarctic Ice Sheet. Mapping and surface-exposure dating of depositional landforms alongside Reedy Glacier has revealed changes in surface elevation and profile that are contemporaneous with the Holocene retreat of the Ross Sea grounding line. Additionally, reconstruction of the glacier at the LGM has provided insight into the former surface elevation, and therefore volume, of this part of the West Antarctic Ice Sheet. Ultimately, a fully constrained record of the deglaciation of Reedy Glacier will be crucial in ascertaining the current stability of the West Antarctic Ice sheet and will indicate whether deglaciation of the Ross Sea has ended or is ongoing.

A Comparison of Chronologies from Moraine Sequences Deposited by the West Antarctic Ice Sheet and Independent Alpine Glaciers in the Ohio Range, Antarctica
Aaron E. Putnam

The West Antarctic Ice Sheet (WAIS) contains 3.8 million km^3 of ice and has the potential to raise global mean sea level by as much as six meters under conditions allowing for its complete collapse. Such sea-level rise will have adverse consequences for human society. In order to determine the likelihood of a WAIS collapse further study is required to assess the stability of the ice sheet under changing climate conditions. The purpose of this study is to develop a glacial chronology from moraines and perched erratics deposited by the WAIS and independently controlled alpine glaciers in the Ohio Range, southern Transantarctic Mountains (84° 45' S, 114° W) in an effort to compare ice-sheet versus alpine-glacier responses to a fluctuating climate. Boulders from ice-cored moraines and perched erratics were sampled for ^{10}Be, ^{26}Al, ^{3}He, and ^{21}Ne surface exposure dating, and differential GPS was used to determine precisely topographic and spatial distributions of the deposits. One hypothesis is that alpine glaciers independent of the WAIS in this region will show a direct response to local climate, predominantly precipitation. Moraines deposited from the WAIS in other regions demonstrate that the ice sheet advanced during periods of lower temperature and sea level. Studies comparing outlet glacier deposits that reflect WAIS behavior, with moraines from independent alpine glaciers in the McMurdo Sound/Dry Valleys region suggest an out-of-phase relationship, and the same phasing is expected in the Ohio Range. Any correlations between the glacial geologic record in the Ohio Range and other Southern Hemisphere climate records, including Antarctic ice cores, will also be examined.

Late-Holocene sea-ice variations and climate in the Ross Sea inferred from southern elephant seals
Hall, Brenda L., and Denton, George H., Climate Change Institute; Hoelzel, Rus, and Topf, Ana, School of Biological and Biomedical Sciences, University of Durham; Baroni, Carlo, Dipartimento di Scienze della Terra, Universita di Pisa; LeBoeuf, Burney, Institute of Marine Sciences, University of California- Santa Cruz

Our discovery of abandoned southern elephant seal (*Mirounga leonina*) colonies along the western coast of the Ross Sea allows us to reconstruct sea-ice and climate variations over the past 6000 years. Southern elephant seals are predominantly Subantarctic animals. They are sensitive to sea ice, preferring to exist in areas of open water with little or no pack ice. Their former presence in the Ross Sea, more than 3400 km from the nearest present-day colony, indicates that sea-ice conditions and probably temperatures must have been less severe in the past. When combined with records of former Adelie penguin colonies, we are able to reconstruct the following: i) moderate sea ice with both seals and penguins present at 4000-6000 ^{14}C yr B.P., ii) more severe sea ice at 2300-4000 ^{14}C yr B.P., with the disappearance of seals, iii) the greatest reduction in sea ice at 1000-2300 ^{14}C yr B.P. with the explosion of seals and disappearance of penguins, and iv) very severe sea ice after about 1000 years ago with the local extinction of seals and the return of penguins only to the most favorable spots.

2:30 - BREAK

Latitudinal Trends in Hunter-Gatherer Diets and the 'Tropical Exception'.
Jim Roscoe

A number of studies have used the Ethnographic Atlas to examine how latitude affects hunter-gatherer diets. These studies reveal an unexpected discontinuity. Dietary patterns in the tropics diverge from trends apparent in higher latitudes. This 'tropical exception' remains something of a puzzle. This paper argues that there is no 'tropical exception': what has been detected is an artifact of biases in the representation of forager societies in the Atlas, in particular of marked latitudinal variations in those with access to water and hence to aquatic resources.

Holistic modeling in glaciology
Terence J. Hughes

Recent weaking or disintegration of ice shelves in front of Antarctic and Greenland ice streams and outlet glaciers has led to a simultaneous rapid increase in ice discharge velocity by up to a factor of two. This reopens an old question: Do confined ice shelves at the end of ice streams buttress the ice streams? This question can be answered only by a holistic approach to ice-sheet modeling in which the force balance is satisfied along the whole length of an ice-sheet-flowband, not just at points along the flowband. In the case of ice streams and outlet glaciers, this requires knowing the side shear stress and the longitudinal force gradient, in addition to the basal shear stress, all along the flowband. In a geometrical force balance, the quantity that links these three is the ratio of basal water pressure P(w) to ice overburden pressure P(i). In this study, it is shown that side shear stress is directly proportional to this ratio and basal shear stress is proportional to one minus the ratio, so that side shear picks up the resistance to gravitational motion as ice-bed uncoupling reduces basal shear, in the case of stream flow. Transitions from sheet flow to stream flow to shelf flow are quantified as changes in this ratio of pressures. Resistance to stream flow is dominated by a longitudinal pulling stress that varies as the square of this ratio. This ratio is also used to extend the classic theory of basal sliding for sheet flow to include stream flow. It is also shown how variations of this ratio can be used to quantify the ability of an ice shelf to buttress an ice stream. The nature of this ratio therefore emerges as a major problem to be solved by glaciology. Whillans Ice Stream entering the Ross ice Shelf in Antarctica is proposed as the best candidate for addressing this problem.

KEYNOTE SPEAKER

Sunken History: Ancient Human Settlements Beneath the Mediterranean Interpreting the Role of Natural Hazards and Human Activity

Jean-Daniel Stanley
Professor and Director, Geoarchaeology Program
Smithsonian Institution, NMNH, Washington, D.C.

Submerged coastal settings in the Mediterranean provide a rich geological and archaeological history. A number of mid- to late Holocene settlements (<3000 BP) serve as ideal areas to study nearshore natural processes and human effects. Coastal sites selected for this presentation are located off Egypt (Herakleion, Eastern Canopus) and Southern Italy (Kaulonia, Pompeii). They include those destroyed by the combined interplay of sea-level rise and land lowering by isostatic depression, as well as by volcanic activity, flooding, earthquakes, tsunamis, powerful wave surges, and human-triggered soil liquefaction. Multidisciplinary studies, including sedimentary petrology, faunal analysis, geophysics, and geochemistry, serve to resolve how and when sites subsided. This historical record is therefore important for the future as well. Humans have continued to migrate toward the Earth's coastal zones, and about 70% of the world's population is now concentrated within 100 km of ocean shorelines. By integrating historic documentation, archaeology and earth sciences, we can better interpret past events and also help devise protective measures for the increasingly populated areas along our modern coasts.

Friday, May 7

Modeling tutorial – An overview of climate models: strengths and shortcomings
Kirk Maasch, Fei Chai, James Fastook, Peter Koons

In decreasing order of response times:

- Atmospheric models

- Ocean models

- Ice Sheet models

- Solid Earth models

10:00 – BREAK

Tracing Maine's hydrologic cycle using stable isotopes
K.J. Kreutz[1], D.S. Introne[1], B. Larrabee[2], S. Wentworth[3], A. Wanamaker[1], M. Turner[4], and T. Hawley[4]

[1]Climate Change Institute and Department of Earth Sciences, University of Maine
[2]NOAA Weather Observer, Sebec Lake, Maine
[3]Indian Island School System, Maine
[4]National Weather Service, Caribou and Gray, Maine

The stable isotopic (^{18}O and D) composition of natural waters provides a powerful tool for investigating present and past variability in the hydrologic cycle. For example, various studies in Maine have used the isotopic composition of river outflow and preserved lake carbonates to infer changes in discharge rate and water balance. No systematic study has addressed the modern variability of precipitation isotopes on various timescales (intra-event to annual), and therefore the mechanisms controlling isotope fractionation that are relevant to hydrologic research in Maine remain unclear. Here we present isotope data from weekly precipitation samples collected as part of routine meteorological observations at Sebec Lake, Maine, during the period 2002-2004. In general, the pattern of ^{18}O/ D follows the expected relationship with temperature on seasonal timescales (i.e., depleted w.r.t. the heavy isotope in winter and enriched in summer). However, despite similar winter temperature ranges during 2002/03 and 2003/04, ^{18}O/ D values during 2002/03 are significantly lower (~100‰). Anomalous precipitation amounts during fall and winter 2003/04 may be linked to the observed isotope variability, and therefore we are examining atmospheric patterns during those time periods to identify coeval changes in moisture source and trajectory. We will discuss our ongoing sample collection efforts that are expanding to a network across Maine, as well as the implications for various hydrologic/paleoclimate research projects in Maine.

Atmospheric deposition of cadmium in the northeastern USA

Stephen A. Norton[1], Michael Handley[2], Erich C. Osterberg[2], Tiffany Wilson[2]
[1] Bryand Global Sciences Center
[2] Sawyer Environmental Research Center

Anthropogenic cadmium (Cd) emissions originate largely from nonferrous metal smelting (particularly for zinc) and incineration of waste. Atmospheric pollution with Cd in the northern hemisphere has been documented through study of ice cores, and accumulations of lake sediment and peat. Ice cores suggest that Cd pollution started about 200+ years ago, generally in agreement with data from lake sediment cores and peat cores.

Lake sediment cores, dated by ^{210}Pb, were collected from Spectacle Pond (SP, 1999) in Massachusetts, USA and Side Pistol Lake (SPL, 2002) and Sargent Mountain Pond (SMP, 2004) in Maine, USA. SP is a kettle lake in granitic sand and gravel, and has almost no surface inflow. The ^{210}Pb dating for SP yielded ages about 10 years too young based on the start of the decline (1970-1975) of deposition of stable Pb from the atmosphere. SPL is a drainage lake on granite with several inlets and one outlet. SMP is on granite with little soil in its small catchment. It is virtually a collection basin for precipitation and thus very responsive to changes in atmospheric deposition. SMP and SPL cores were analyzed for total Cd and stable Cd isotopes. The SP core was analyzed only for total Cd. For SP (Massachusetts) and SMP (Maine) USA, maximum Cd concentrations are reached in the late 1960s and are 1.7 and 1.1 g/kg – more than 10 times background values. Accumulation rates peak at the same time as concentration and are 0.05 and 0.016 g/cm^2/y – most of which is anthropogenic and more than 10 times background (Figure). Cd concentration-age and Cd accumulation rate-age relationships in SMP and SP are similar for background values, timing and magnitude of increase to peak values, and the decrease nearly to background values over the last three decades. If data are normalized for background values, variable sedimentation rate within lakes, and focusing differences between the lakes, the two records are even closer in behavior. They are clearly not in synchroneity with the drainage lake, SPL (Figure). SPL continued to receive relatively high amounts of Cd derived from elevated atmospheric deposition on the catchment over the past 100+ years. This lag in lake response to decreased atmospheric deposition is also indicated in the isotopic data. For SMP, concentrations of individual isotopes increase and decrease synchronously with total concentration. The Cd isotopic ratios at SPL and SMP depart synchronously from background values well before concentration is significantly changed, providing a more sensitive indication of the onset of pollution. The ratios return nearly to background synchronously with the concentration. For the drainage lake (SPL), there is a lag in the isotopic recovery to background values, as for the lag in the recovery of the concentration. Kettle-like lakes more clearly reflect changes in atmospheric deposition.

Interpreting the growth histories of the ocean quahog (*Arctica islandica*) in the Gulf of Maine, USA: A potential proxy for paleo-environmental conditions

Alan D. Wanamaker Jr.[1,2], Karl J. Kreutz[1,2], Bernd R. Schöne[3], Scott Feindell[4], Douglas Introne[1,2]

[1]Climate Change Institute [2]Department of Earth Sciences [3]Institute for Geology and Paleontology, INCREMENTS Research Group, Goethe University [4]Darling Marine Center

Very few long-term physical oceanographic records exist for Gulf of Maine. Despite efforts to understand the current oceanography in the Gulf of Maine (i.e., The Gulf of Maine Ocean Observing System-GoMOOS), little is known about its past environments. Furthermore, with the lack of long-term temperature records for the gulf, it is not possible to determine if there has been significant warming in response to natural and anthropogenic climate forcings. Because the Gulf of Maine supports a rich and dynamic ecosystem, it is of great interest to understand if particular climate forcings may influence its biological and physical processes.

The ocean quahog (*Arctica islandica)* is a long-lived (commonly > 100 year) bivalve that is abundant in the Gulf of Maine in water depths greater than 20 – 30 m. *A. islandica* is a filter feeder that depends on particles suspended near the seafloor, which were produced in the photic zone. Annual growth lines are recorded in the shell of the animal, which allows for the development of an absolute chronological record during its life span. Information recorded in these annual shell layers includes a geochemical signature of water properties (temperature and salinity), and morphological characteristics (thickness of annual bands) that may reflect ambient conditions such as water temperature and/or food supply. Because of these relationships, it is possible to use growth data from *A. islandica* to reveal long-term trends in bottom temperatures, ocean circulation changes, or food availability.

Standardized growth indices (SGIs) are presented for multiple animals collected from the gulf, creating regional SGI chronologies. These chronologies were compared to possible climate forcing mechanisms that may affect the oceanography in the Gulf of Maine. The results indicate that growth studies using *A. islandica* can help reveal aspects of past ocean environments in the Gulf of Maine.

Multi-decadal records of ice dynamics on large East Greenland outlet glaciers, from satellite imagery and terrestrial measurements

Leigh Stearns, Gordon Hamilton, Climate Change Institute
Niels Reeh, Technical University of Denmark

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.

Deriving geometry of Jacobshavn Isbrae from field observations
Coen Hofstede

Jacobshavn Isbrae is the fastest ice stream in the world. From approximately 1964 to 1997 Jacobshavn Isbrae seems to have been nearly in steady state. The calving front did not change it's position much neither did the ice thickness or surface velocities change much. Between 1997 and 2001, the front of Jacobshavn Isbrae underwent significant thinning, some 60m and a 30% increase in surface velocity. In 2003, the velocities had increased to nearly twice the velocities of 1997. The calving front retreated rapidly, some 12km, between 2001 and 2003.

We will work with photogrammetrically derived velocity data from 2 sets aerial photographs from 1985 when the ice stream must have been close to steady state. One data set covers an area from about 100km x 100km around the snout of Jacobshavn Isbrae. A second data set, derived from the same photographs set, focuses on the snout over an area of 12km x 18km. Jacobshavn Isbrae flows through a channel, at least the last 70 km. Strain rates are calculated and interpreted with respect to geometry. With the assumption of basal sliding and steady state it is possible to derive the cross sectional area of the ice flux. Channel depth will thus be estimated. This derived channel depth will than be compared to a bedrock data set derived from the radar and laser data collected in the period 1997-2003.

ICARA (Ice Core Archive Recovery Activity) and "Secrets of the Last Glaciers" - A science plan and a movie
Paul Mayewski

My talk will include:

(1) description of a recently developed scientific plan (ICARA).

(2) a 7-minute clip covering our recent trips to Tasman Glacier, New Zealand and the Cordillera Darwin, Chile from an emerging documentary describing climate change.

12:00 - LUNCH

Communicating with the communities we serve: Education and Outreach opportunities for the University of Maine Climate Change Institute
Marianne Lagerklint and Molly Schauffler

For many of us, communicating our research to the public is not our priority as research and campus teaching usually take precedence from day to day. The University's Land and Sea Grant Mission, however, mandates excellence in all three – teaching, research, and public service. Most of us would like to do more to share our research with the non-scientific public but do not know about available opportunities or do not have the time to make the arrangements. In response to discussions at our December retreat, we identify here opportunities for expanding existing outreach initiatives, making those initiatives more visible, and we explore new outreach possibilities. Some of these may be synergistic efforts with other environmental research or education units on and off campus. Vocal support for strengthening environmental research outreach in an interdisciplinary way has been widespread and encouraging. In this presentation we will report our progress towards a final 2005 assessment of outreach needs and opportunities for the Climate Change Institute. The report will be completed in July.

Maine's Ice Age Trail: an educational experience for Geo/Eco Traveler
Hal Borns

Maine's Ice Age Trail Map leads geo/eco travelers through the wonderfully displayed late glacial landforms and stratigraphy in the eastern coastal zone from Bar Harbor to Lubec, Eastport and Calais. Key scientific stops, with explanations are all located on public roads or property. Features seen at these stops, as a group, will document and explain in text diagrams and photos. The glacial-marine and later relative sea-level changes following about 15,000 ^{14} C yr B.P.

The fundamental NSF-supported research upon which this history is based was done primarily by faculty and students from the University of Maine, and geologists from the Maine Geological Survey. The funds for the project were granted by the National Science Foundation and Maine Office of Tourism. The design and rendering of the map is under the supervision of Michael Herman of the Canadian-American Center, University of Maine.

Mapping the Bull Brook Paleoindian Site
Brian Robinson

One of the major research components of the Bull Brook archaeological project is to reconstruct the original site plan showing a ring-shaped settlement pattern of artifact concentrations. Ring-shaped patterns of houses are relatively common among mobile hunters and gatherers, who periodically gather in large groups for communal hunting and various other social functions. The Bull Brook site in Ipswich, Massachusetts is the largest such pattern known from the Pleistocene in North America. I have discussed the ring-shaped pattern in previous Agassiz presentations. Major progress has been made on the mapping project by analysis of measured-plans, still photographs, and home movies from the 1950s, compiled on GIS registered aerial photographs.

Glacial Lake Levels and Paleoindian Settlement Patterns at Munsungan Lake, Northern Maine
Bertrand Gilman Pelletier Jr.

The primary objective of this presentation is to outline a research project which will determine whether higher lake levels influenced paleoindian settlement strategies at the 'Munsungun' chert quarry. Relict shorelines and prehistoric channels suggestive of an ice damned lake are located near paleoindian sites at Munsungan Lake. Higher Pleistocene lake levels would have affected site selection and could explain the lack of paleoindian sites on modern shorelines. Stagnation moraines are present near paleoindian sites in the area indicating the possible presence of valley glaciers near the Munsungun chert source. Until recently, these landforms were thought to predate the presence of humans in the region however; previous research has documented a re-advance of glacial ice at Oxbow, Maine during the Younger Dryas period (11,000 -10,000 rcy BP) coeval with the paleoindian occupation of the area. Summer 2005 field work will evaluate the relationship between lake levels and the distribution of archaeological sites at Munsungan Lake, with specific emphasis on the Early Paleoindian period. The reconstruction of the paleogeography of the Munsungan Lake basin will determine if Maine's earliest inhabitants utilized raised lakeshores in an Ice Edge Environment during the Younger Dryas period.

Alca Obsidian and Early Coast-Highland Interaction in Southern Peru

Kurt Rademaker[1], Daniel Sandweiss[1], Michael Malpass[2], Adan Umire[3], and Pablo de la Vera Cruz[3]
[1]University of Maine Climate Change Institute, [2]Ithaca College Dept. of Anthropology, [3]Instituto Nacional de Cultura del Peru

Recent geoarchaeological investigations in the Andes of southern Peru are providing valuable information about the early human settlement of South America, the possible relationship between the highlands and the coast, and adaptation to the ice age environments of this area. Obsidian (volcanic glass) artifacts found within 11,400-13,000 cal yr B.P. strata at the coastal site Quebrada Jaguay by a UMaine team in the 1990s were sourced to a geological deposit 165 km (103 miles) away, near the town of Alca in the remote highland Cotahuasi valley. Alca was one of the two most important obsidian sources in Peru, as artifacts made of Alca obsidian have been found at archaeological sites throughout the southern Andes dating from all time periods – it was used by numerous civilizations, from early peoples to the Inca. During preliminary work in 2004, we successfully located the 534 ha (1,320 acre) core deposit of the Alca obsidian source. This new discovery, at 4,800 m (15,750 ft) elevation and with over 20 associated quarry, workshop, and habitation sites, makes Alca the largest known obsidian source in Peru. Many of these sites are situated atop lateral moraines in the Quebrada Pulhuay; other sites located on the plateau above the Pulhuay cirque apparently predate or are contemporary with deposition of a diamicton containing striated boulders. The association of these sites with glacial landforms suggests that the sites may be quite ancient, possibly contemporary with Quebrada Jaguay – these sites may be the direct connection between early coastal and highland settlements that we have been seeking.

New Evidence for Early Agriculture in the South-Central Andes

Dan Sandweiss (University of Maine), Linda Perry (Smithsonian Institution), Dolores Piperno (Smithsonian Institution), Kurt Rademaker (University of Maine), Michael Malpass (Ithaca College), Louis Fortin (University of Maine), Ben Morris (University of Maine), Adán Umire (CIARQ-Peru), and Pablo de la Vera (INC-Peru)

How did people first enter and travel through western South America? Did the follow the spine of the high Andes, move along the desert coast, or both? Our discovery in the 1990s of a Paleoindian-age (9000-13,000 cal yr BP) fishing camp in southern Peru reopened the debate over the coastal route, but the presence of Alca obsidian from the adjacent highlands obscured the picture. To understand the relation between early settlers on the coast and in the highlands, we investigated three preceramic sites near the Alca obsidian source and tested one of them through excavation. Although we found part of a well-preserved preceramic house, a suite of consistent radiocarbon dates placed the occupation at 3700-4000 cal yr BP, far too recent to inform on the question of early Andean people. However, microfossil analysis of sediments from this house identified remains of maize, potato, and arrowroot. These finds push back by a millennium the history of maize and tuber agriculture in what became the heartland of Andean empires such as the Inca and provide the earliest direct evidence of highland interaction with the Amazonian lowlands.