17^{th} Annual Harold W. Borns, Jr. Symposium

Climate Change Institute
University of Maine
Orono, ME USA

May 7-8, 2009

Contents

The 2009 *Harold W. Borns, Jr. Symposium* is a unique event that brings together the University of Maine community each year for a focused discussion of emerging research and topics related to global environmental change. Presentations made by scientists and students affiliated with the Climate Change Institute University of Maine. Topics are related to natural and human dimensions of global change.

1 Day 1: Thursday, May 7

1.1 Morning Session

7:30 am Coffee and Pastries

1.1.1 8:00 Welcome and Introduction - Dr. Shaleen Jain

1.1.2 8:10 Posters Introduction. 1 slide, 2 minutes per person

1.1.3 Glaciology and Sea Level

Part 1

RAPID TRANSMISSION OF SUBTROPICAL WARMING TO THE GREENLAND ICE SHEET

Gordon Hamilton[1], Fiamma Straneo[2]
(1) Climate Change Institute, University of Maine, Orono, ME 04469, USA
gordon.hamilton@maine.edu
(2) Woods Hole Oceanographic Institution, Woods Hole, MA 02543, USA

The Greenland Ice Sheet's contribution to sea level rise more than doubled in the last five years, mostly because of increased mass flux rates from large outlets, such as Helheim Glacier in southeast Greenland. These outlet glaciers terminate at tidewater in deep fjords, which provides an intimate connection between the ice sheet and the ocean, and raises the possibility that ocean warming was the trigger for recent changes in ice dynamics. Until recently, there was little observational evidence to show that the warm waters of tropical origin, found offshore along the continental margins of southeastern and western Greenland, could cross the cold, fresh Arctic waters found on the shelf, and penetrate deep into fjords. We tested this hypothesis with a series of oceanographic measurements conducted in the summer of 2008. Our results show that warm offshore waters both penetrate and circulate deep inside Sermilik Fjord, the 100 km long fjord in East Greenland where Helheim Glacier terminates. The depth at which these waters are found, as well as the observed spatial and temporal variability all indicate that the warm waters play an active role in the fjord-glacier estuarine system and suggest that they come into contact with the glacier's terminus. The timing of Helheim Glacier's acceleration is consistent with the variability in warm water properties found offshore, in particular a recent warming in the subtropical basin. Sermilik Fjord and Helheim Glacier are typical of many fjord-glacier systems in coastal Greenland, leading us to argue that glacier-ocean interactions can explain a significant fraction of the observed increase in mass flux from the Greenland Ice Sheet.

A DROWNED, FORMERLY INHABITED BAY/LAKE SHORELINE OFF MOUNT DESERT ISLAND, MAINE

Joseph T. Kelley[1], Stefan Claesson[2], Daniel F. Belknap[1]

(1) University of Maine, Department of Earth Sciences, Orono, ME 04469-5790

(2) Ocean Process Analysis Laboratory, University of New Hampshire, Durham, NH 03824

Recovery of prehistoric tools south off Bass Harbor by scallopers led to a coring/geophysical survey of this area. At 20-30 m depth, we found two gravel ridges separated by a basin. Seismic reflection reveals the ridges as reworked moraines covered with spits extending from moraine margins. Cores through paleo-spits penetrated sandy gravel overlying mud deposits with Zostera marina, and muddy sand deposits with *Crassostrea virginica* and *Mya arenaria*. We interpret the deposits to represent lagoon and tidal flat deposits, respectively and dating from 7.8–8.8 ka. This time corresponds to a time when sea level rose very slowly in Maine. This slow rise in sea level permitted spits and estuarine deposits to accumulate, and Early to Mid-Archaic Period Native Americans to inhabit the landscape. Our research suggests that this time/depth interval is the best candidate to preserve sedimentary deposits and associated prehistoric archaeological sites and artifacts along the Maine shelf.

1.2 11:00 am Keynote Speech

Dr. Martin Hoerling Meteorologist, NOAA Earth System Research Laboratory, Boulder, Colorado Lead Scientist, NOAA Climate Change Attribution Team Chair, U.S. CLIVAR Program

1.3 Lunch

Lunch from 12:00- 1.00 pm

1.4 Poster Session

1.5 Afternoon Session

1.5.1 Climate Prediction and Modeling

Part 1

MODIFIED Morland-MacAyeal MODEL FOR ICE-STREAM FLOW
(The work is supported by CReSIS)

Sargent, Aitbala and Fastook, James
Computer Science & Climate Change Institute, University of Maine

Modeling glacier and ice sheet flow is a computationally challenging problem. To solve this problem, modelers use a number of simplifications with respect to the physics of the ice mass. The most popular approaches are reduced shallow-ice approximation (SIA) for interior ice and the Morland Equations[1] for the ice shelf flow. These models reduce the scale of the problem by integrating out the vertical dimension, taking advantage of the fact that the vertical dimension is very different from the two horizontal dimensions.

The Morland Equations apply specifically to ice shelf physics, but they have been successfully applied to the transition zone in ice streams with a modification source term in the Morland formulation [2]. While this approach does yield reasonable results, the fact that the basal drag correction term is not included in the derivation of the equations but added after the fact, violates the assumptions that go into the original integration of the vertical dimension, and hence is not self-consistent.

We present a formulation for the diagnostic equation for conservation of momentum that follows the original Morland derivation closely, but include at the outset an explicit term for the basal drag. Our approach does two things. First, by including the basal drag in the derivation of the equations, it makes the equations self-consistent. Second, since derived equations contain a term that depend on the bed gradient, it gives a formula of dependency of ice stream flow on the bed topography. This self-consistent formulation for the diagnostic equation coupled with a prognostic equation for mass conservation and solved using the Finite Element Method, is tested for a number of simplified geometries where longitudinal stresses are comparable to the basal drag.

References

[1] L.W. Morland. Unconfined ice-shelf flow. In C.J. van der Veen and J. Oerlemans, editors, Dynamics of the West Antarctic Ice Sheet. D. Reidel, Boston, 1987. [2] D. R. MacAyeal. Large-scale ice flow over a viscous basal sediment: Theory and application to Ice Stream B, Antarctica. Journal of Geophysical Research, 94(B4):4071-4087, 1989.

2 Day 2

Day 2: May 8, 2009

2.1 Morning Session

7:30 am Coffee and Pastries

2.1.1 8:00 Day 2 Overview - Dr. Andrei Kurbatov

2.1.2 8:10 Posters Introduction. 1 slide, 2 minutes per person

2.1.3 Paleoecology

LATE HOLOCENE PALEOCLIMATE RECORDS FROM LAKE TANGANYIKA, EAST AFRICA

Stager J. Curt
Climate Change Institute, and Natural Sciences, Paul Smith's College, Paul Smiths, NY 12970

New diatom records from Lake Tanganyika, Tanzania, allow the reconstruction of rainfall-driven variations in lake conductivity during the last 3800 years at 15-36 year resolution. Pollen of aquatic plants increased during periods of inferred lake dilution as a result of increased river discharge during rainy episodes, particularly ca. 1700-1400 B.P. Ancient carbon effects on AMS dates were measured by comparing 21 ages of terrestrial and aquatic materials, providing tighter chronological control than that available for most previous studies here. The Tanganyika watershed was drier than usual during much of the Little Ice Age, in opposition to wetter conditions at Victoria and Naivasha and therefore undermining the hypothesis of latitudinal ITCZ displacement 550-350 years ago. A long-term wetting trend at Tanganyika is mirrored by ^{13}C isotope fluctuations in South African stalagmites,

but uncertainty about the climatic significance of the ^{13}C signals make it unclear whether this represents regional synchrony or antiphasing.

2.2 Lunch

Lunch from 12:00- 1.00 pm

2.3 Afternoon Session

2.4 Poster Session

Climate Prediction and Modeling

BETTER PHYSICS USING FULL MOMENTUM SOLVER IN 2D VERTICAL SLICE DOMAIN, WHERE DOES LONGITUDINAL STRESS REALLY MATTER? APPLICATION TO THE THWAITES GLACIER FLOWLINE

Debra Kenneway, Aitbala Sargent, James Fastook
University of Maine

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.

5:00 pm Graduate Students Awards Ceremony

5:20 pm Closing Remarks