PROPOSAL FOR INQUA PROJECT (2008-2011)

COMMISSION/COMMITTEE:
1. PALCOMM 2. TERPRO

WORKING GROUP(S)/SUB-COMMISSION(S) : To be determined

Project title: *Meltwater routing and Ocean-Cryosphere-Atmosphere response* **(MOCA)**
Associated sub-project #1: *Constraining North American DEGLACiation* **(NDEGLAC)**
Sub-project #2: *Constraining Eurasian DEGLACiation* **(EDEGLAC)**

Co-Leaders:
Lev Tarasov, Memorial University of Newfoundland and Labrador, lev@physics.mun.ca
Trond Dokken, Bjerknes Centre for Climate Research, trond.dokken@bjerknes.uib.no
Timothy Fisher, University of Toledo, timothy.fisher@utoledo.edu
Richard Gyllencreutz, University of Bergen, richard.gyllencreutz@geo.uib.no
Hans Renssen, Vrije Universiteit Amsterdam, hans.renssen@falw.vu.nl
Chris Stokes, University of Durham, c.r.stokes@durham.ac.uk

Confirmed international participation (correspondents and preliminary workshop participants)
Canada: Art Dyke, Jim Teller, Trevor Bell, W. R. Peltier, Anne de Vernal, Claude Hillaire-Marcel, Daniel Kerr, Andre Blais-Stevens, Michel Parent, Isabelle McMartin, David Piper, John Shaw, Brian Todd
France: Didier Roche, Masa Kageyama
Germany: Henning Bauch, Robert Spielhagen, Gerhard Krinner
Japan: Ayako Abe-Ouchi
Norway : Oystein Lohne, Jan Mangerud, John Inge Svendsen
Sweden : Claes Hattestrand, Martin Jakobsson, Krister Jansson, Johan Kleman, Martin Margold, Arjen Stroeven
United Kingdom: Grant Bigg
United States of America : Tom Lowell, Leonid Polyak, Anne Jennings, John T. Andrews

(Note, recruitment of participants is ongoing and will be facilitated by face to face contact at up-coming meetings (eg. Spring 2008 EGU). Given the scope and demand, we expect large and diverse participation from both sides of the Atlantic.)

Duration: 2008-2011

Main objectives:

The principal objective is to establish a constrained regional meltwater and iceberg discharge chronology for the northern hemisphere during the last deglaciation with well-defined error bars. The consequent objective is to establish a good conceptual understanding of the interactions between the cryosphere, ocean, and atmosphere associated with this chronology.

Context: The INTIMATE project has made great strides towards building a standard stratigraphic chronology for the North Atlantic, a key component toward understanding polar climate dynamics. However, meltwater mediated interactions between land ice and climate are poorly constrained. Furthermore, records from the Arctic Ocean await a similar assessment. These facets are critical to improving our understanding of rapid climate change associated with meltwater-induced changes in ocean circulation and sea-ice extent. This large task requires close collaboration between the glaciological, paleoceanographic, and climate modelling communities.

The specific goals of the project are to:

1. Jointly assess existing terrestrial and marine records for deglacial ice-sheet extent and meltwater floods and paleooceanographic records for the Arctic and North Atlantic
2. Refine ice margin chronologies and generate max/min bounds for each timeslice
3. Refine deglacial ice (thickness and velocity bounds) and meltwater chronologies for the Northern Hemispheric ice-sheets through calibrated modelling using both terrestrial and oceanographic records as constraints.
4. Evaluate the relative roles of dynamic (punctuated) ice streaming versus steady meltwater runoff and proglacial lake drainage
5. Evaluate the climatic processes associated with past meltwater and iceberg discharges through both modeling and comparison against relevant paleoceanographic and terrestrial data.
6. Further forge the interdisciplinary links between the glaciological, Quaternary terrestrial, paleoceanographic, and climate modeling communities that are required to adequately decipher and understand past Earth and climate system dynamics especially in the context of mid-high latitude regions and abrupt climate change.

Methods/approach:
The first phase of the project will be to re-examine and cross-correlate existing terrestrial and marine records, reconstructions, and interpretations of deglacial ice-sheet extent (and ice streaming) and associated meltwater routing with a focus on defining clear max/min bounds at each timeslice. For the Eurasian part, this project will be a continuation and further development of the ongoing work with the DATED database at the University of Bergen, Norway (Gyllencreutz et al, 2007, http://www.gyllencreutz.se/research.html), and a collaboration between University of Bergen, Memorial University of Newfoundland, and University of Toronto, that is already established. Building on previous work, a series of maps will be sequentially circulated and marked up. An initial workshop at the fall 2008 PMIP meeting will draft interim margin chronologies and bounds for constraining the calibrated modeling. The workshop will also scope the details of the rest of the project in collaboration with the PMIP community.

Subsequent meetings will: 1) further cross-correlate terrestrial and oceanographic records of past meltwater and iceberg discharges and 2) iteratively evaluate/analyze interim model results and refine constraint data sets on the basis of these results (from both ice and climate modeling). Thus the latter part of the project, after the erection of an initial constrained deglacial meltwater chronology will be iterative refinement of a self-consistent climate, ice, and meltwater chronology. This will involve incorporation of climate modelling into the data-calibrated model system in collaboration with the PMIP community. Several iterations will be required in order to converge to a well-constrained probability distribution of mutually-consistent deglacial ice, meltwater, and climate chronologies. It is also expected that the process will define and motivate critical field campaigns to address poorly constrained regions and temporal intervals.

It should be especially noted that the integration of data and modeling will provide clear objective error bars for derived chronologies, a key and critical feature of this proposal. The Bayesian calibration/data assimilation procedure combines large ensemble runs of 3D models with artificial neural networks and Markov Chain Monte Carlo techniques. This means that the procedure generates self-consistent probability distributions of model results with respect to model fit to observational constraint data, which represents a paradigm shift in modelling. Furthermore, the glacial systems model used in the calibration includes a 3D dynamical ice sheet module, visco-elastic bedrock response module, meltwater drainage and lake storage solver, and a gravitationally-self-consistent sealevel solver. As such, glacial flow features, relative sealevel data, strand-lines, and other geophysical proxies can be directly compared to model results.

The rational for the associated sub-projects derives from the challenging scope of the overall project. There are major regional uncertainties in margin extent and associated meltwater routing pathways for both ice complexes, especially that for North America. A well-constrained meltwater and iceberg chronology cannot be developed without a well-constrained ice (including streaming) chronology. The sub-projects will offer the opportunity to bring together the large and diverse expertise on the topic, build a more clearly defined ice margin chronology with min/max bounds, and refine the subsequent results from calibrated glacial systems modeling. This will in turn feed into the development and evaluation of resultant meltwater chronologies derived from data assimilation into glacial system models. The sub-project approach allows close cross-fertilization between the large different communities and project levels while retaining reasonable project scopes. It should also be noted, that each sub-project will involve members from both sides of the Atlantic and from glaciological, terrestrial, and oceanographic communities.

Consideration will also be given to addressing inputs from Greenland, but with the hope that on-going efforts will provide adequate data resources for the calibrated modelling.

Anticipated results:

Our first objective is to construct a clearly constrained and mutually consistent deglacial ice and meltwater chronology (with objective error bars) for the Northern Hemisphere. This will also provide guidance for ongoing and future field campaigns with regards to regions and types of data most needed to further constrain the chronology.

Our second objective is to produce a good conceptual understanding of the associated meltwater and climate interactions. This is a critical issue with respect to past and potential future abrupt climate change dynamics.

Workshops/meetings (date and venue if known):

North American Workshop focused on compilation of interim ice and oceans constraint dataset, scoping of whole project, and drafting of PMIP experiments to feed into the data-assimilating model — Sept. 2008
Venue: PMIP workshop, Estes Park, Colorado, USA

European Workshop focused on compilation of draft constraint dataset — 2009
Tentative: EGU

North American Workshop (focus: construction of refined constraint data set taking into account results of initial calibrated modelling) — Spring 2009
Venue: Canadian Quaternary Association Meeting

Meltwater and Ocean Workshop, — 2010
(focus: results of calibrated modeling, and analysis of initial climate model responses and resultant further refinement of constraint datasets)

Final Meltwater and Ocean Workshop, — ?? 2011
(focus: regional meltwater chronologies and associated climate interactions)
section of session at INQUA Congress

Publications:

Each of the last 3 workshops will produce at least one synthesis paper for publication in an INQUA sponsored journal. The output of the final workshop will also include a probability distribution of mutually consistent ice,meltwater, and climate chronologies. Furthermore, there will be a special journal issue produced from the Congress session.

Links to other INQUA or non-INQUA Projects (list):
This project will closely link/collaborate with PMIP and ORMEN (Ocean Reconstruction and Modelling of the European deglaciatioN). Links will also be sought with other relevant projects such as APEX.

Fit to PALCOMM mission (max 1⁄2 page): The project will deliver a clearly constrained deglacial ice and regional meltwater chronology and therefore address an outstanding need for the paleoclimate modeling community (this is especially critical to proposed themes for the next phase of PMIP). This product will derive from interactions between experts in the field and large-scale objective data assimulation with glacial systems modeling and thus provide a broad synthesis of data, current conceptual understanding, and modeling. Finally, by bringing together glaciologists, glacial geologists, paleoceanographers, and climate modellers, this project should facilitate significant improvements of our understanding of the role of meltwater in past climate change. As such, all three key priorities of the current PALCOMM call for proposals are well addressed.

Plans for including young scientists in project leadership:
All the current leadership are early to mid career scientists. We will also encourage active participation by younger scientists including PhD students.

References:
Gyllencreutz, R., Mangerud, J. Svendsen, J.-I., Lohne, Ø., 2007. DATED – A dating Database and GIS-based Reconstruction of the Eurasian Deglaciation. Geological Survey of Finland Special Paper. 46, 113-120. [http://arkisto.gtk.fi/sp/sp46.pdf