Ice sheet modeling, sea level and isostasy

PALSEA

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This 4th PALSEA workshop was hosted and co-sponsored by the Harvard Centre for the Environment and was an opportunity for a wide-ranging discussion amongst scientists active in the collection and analysis of relevant sea level and ice sheet data sets, and the modeling and development of theory for representing changes in the oceans and cryosphere.

Anders Carlson presented results on geochemical fingerprinting of ocean sediment to differentiate areas of Greenland where the ice sheet had retreated during the Last Interglacial (LIG) (Colville et al. 2011). Bob Kopp presented efforts to extend his Bayesian analysis of the Glacial Isostatic Adjustment (GIA) response during the LIG using relative sea level (RSL) data to attribute sea-level rise (Kopp et al. 2009). Maureen Raymo presented exploratory work looking at Mid-Pliocene Warm Period (MPWP) RSL indicators alongside GIA modeling from Jerry Mitrovica (Raymo et al. 2011). Early modeling results indicate that the GIA response globally varies by the order of ten meters and can plausibly explain much of the divergence of the RSL data for this period.

Andrea Dutton and Bill Thompson presented two methodologies for interpreting fossil coral indicators of RSL for the LIG. Their results show differences but also similarities, most particularly that there is at least one period during which sea level appears to fall and then rise again by up to several meters (for full discussion see PALSEA website: http://eis.bris.ac.uk/~glyms/working_group.html).

Christian Schoof presented his work on grounding line stability (e.g. Schoof 2007), which has been incorporated into ice sheet models. Richard Hindmarsh talked about validation of the marine ice-sheet instability theory. A fresh look at the theoretical underpinnings by Schoof (2007) emphasizes the importance of the boundary layer near the grounding line. He presented evidence from an analogous flow situation, the ice shelf calving front, to show that the boundary layer theory operates as expected. The Weertman instability hypothesis (1974) suggests that there is a positive feedback causing the collapse of a marine ice sheet sitting on a bed that slopes down inlands. Natalya Gomez coupled a 1D dynamic ice-sheet model to a sea-level model with viscoelastically deforming Earth model and found that the sea-level fall predicted during periods of ice-sheet reduction could stabilize ice sheets, reducing the effectiveness of the Weertman instability mechanism and slowing down ice sheet retreat (Gomez et al., in press).

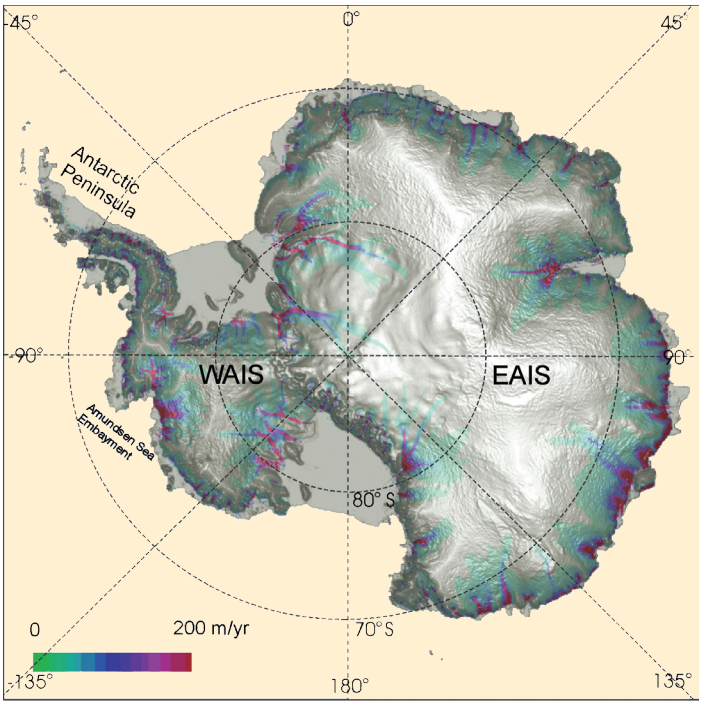

Figure 1: Surface topography derived from satellite radar altimetry and steady-state ice flow rates for the Antarctic ice sheet for the present-day (Bamber et al. 2007). Reprinted with permission from Elsevier.

David Pollard discussed the complications for modeling the Antarctic ice sheet posed by sequence stratigraphy data of the ice sheet. In particular, records from the New Jersey margin (Miller et al. 2005) show large fluctuations in sea level, which are not easily captured by the model. Ayako Abe-Ouchi presented challenges in coupled ice sheet-climate modeling, especially in simulating rapid changes (Abe-Ouchi et al. 2007). For example, the model does not currently simulate the precise timing and character of the termination of the last glacial period and the glacial inception at the conclusion of the LIG.

Glenn Milne presented results of GIA modeling of RSL data from the Greenland coast (Long et al. 2010). Reconciling these data with existing GIA models of the Laurentide ice sheet collapse is an ongoing challenge.

Shawn Marshall led a discussion on observed processes that may drive rapid ice sheet responses in the present day. Discussion centered on the effect of melt ponds on the albedo of the ice sheets and in particular the multi-year accumulation of heat in the ice sheet. This effect increases the scope for the formation of melt channels to move fluid to the base of the ice sheet, where it reduces friction with the bed. Ben Horton presented a new RSL record from the east cost of the USA covering the last two millennia (Kemp et al., in press) demonstrating that modern sea-level rise is anomalous compared to the pre-industrial period. Finally, Jonathan Bamber presented preliminary results of an elicitation exercise, which asked experts on ice sheet dynamics to assess the likelihood of several scenarios regarding ice sheet and ice shelf stability in the next centuries. For example, the question was posed "how much will the WAIS contribute to sea-level rise in the twenty first century". There was broad agreement between experts, though the opinion of some experts acted as clear outliers.

Selected references

Full reference list online under:
http://www.pages-igbp.org/products/newsletters/ref2012_1.pdf

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