Opportunities (?) for Probabilistic Assessment of Ice Sheet Response to Climate Change

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Climate policy may be implemented within a "risk management" framework, where risk is calculated as the product of a potential impact and its likelihood (the probability of occurrence, derived from scientific assessments) [Schneider, et al., 2007]. A probabilistic approach to assessing anthropogenic climate change impacts is thus a desirable, though often unattainable, objective. In particular, designing a credible quantitative projection of ice sheet response to future climate has proven to be elusive.

Earlier attempts to quantify the probability of future ice-sheet changes include both elicitations [Vaughan and Spouge, 2002], in which expert opinions are solicited and integrated into a probabilistic projection, and more traditional methods of uncertainty propagation (e.g. monte-carlo methods) [Titus and Narayanan, 1995] (TN95). The accuracy of the assessment in these latter methods depends critically upon the selection of the model(s) of the physical system; this choice determines the processes represented as well as the required input parameters. We suggest that a collection of component models (as implemented in TN95) is currently the best quantitative option for constructing a probability density function (PDF) of future ice sheet evolution, yet deciding which models to incorporate in the analysis (and how to bound the uncertainty of assumptions) poses significant challenges. For example, models available to predict basal melting at the ice-ocean interface range from detailed 3-D, fine resolution regional ocean models to crude functional relationships between global ocean temperature and melt rates. Models describing ice dynamics, glacial surface mass balance, and atmospheric variability span a similar spectrum of complexity.

Gains in our understanding of WAIS dynamics (including hydrology, ice stream behavior, and floating-grounded ice interaction), regional oceanography, and global climate likely improve our characterization of WAIS response to climate change. However, probabilistic assessments that incorporate these recent findings must be computationally feasible, the uncertainty of key parameters must be ascertained, and component inputs and outputs must be linked. We are currently exploring the feasibility of several approaches, distinguished by their choice of models of Antarctic ocean, atmosphere, and ice dynamics. In this poster, a survey of available models is presented; alternative combinations are critically examined for their ability to answer policy-relevant questions related to sea level rise, as well as their scientific validity and thoroughness. Our objective is not to define a single "correct" model, but to examine tradeoffs between comprehensiveness, fullness of uncertainty characterization, and policy-relevance, and to investigate the overall feasibility of this approach.

A complementary, ongoing research goal is a critical analysis of paleoclimatic proxies and their use in informing probabilistic assessments. Interpretations of paleoclimate data have been used to constrain processes relevant to ice sheet response (TN95) or as whole-ice-sheet analogues [Hansen, 2005] with no formal assessment of their applicability to anthropogenic warming or characterization of their uncertainty. Otto-Bliesner et al. (2006) use paleoclimate data more objectively (as a constraint on output of numerical models), but uncertainty characterization is difficult, as it is derived partially from paleoclimate data (including the validity of the proxy and experimental error), and partially on model error (both numerical and structural).

Regardless of its eventual success as a policy tool, we believe that an ongoing effort to build a quantitative probabilistic assessment will be helpful for developing a hierarchy of models, assessing the state of scientific knowledge, formulating research goals, and fostering an open discussion of the uncertainty surrounding sea level rise.

References

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