LARGE SCALE MODELING OF ANTARCTICA AND GREENLAND CONSTRAINED USING LIDAR AND SAR DATA FROM DESDYNI

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1. INTRODUCTION

Trying to predict the evolution of the ice mass balance in Antarctica and Greenland is a major challenge that needs to be addressed in order to provide reasonable estimates of future sea level rise in the 21st century. The IPCC (Inter Governmental Panel on Climate Change) report AR4 (Assessment Report 4) [1] identified this challenge as a priority, and one of the key uncertainties in the final assessment of future sea level rise. In order to respond to this challenge, large scale ice flow models need to be developped, that incorporate a wide range of physics, and that can run on heavily parallelized architectures. These models need to be constrained using satellite data in order to provide reasonable agreement with current observed ice flow, and to improve confidence in future predictions.

2. DESDYNI MISSION

The DESDynI mission provides a unique opportunity to constrain ice flow models, by combining acquisition of Lidar and L-band SAR data. Both sets of data will be used to simultaneously constrain different aspects of ice flow models. Lidar data will be used to validate current simulations of surface evolution, in which thinning rate signatures on the surface can be identified for whole catchment basins, and compared against predicted signatures. This should allow calibration of time sensitive aspects of the surface mass balance models used to predict the future shape of the ice sheet.

L-band SAR data will be used to acquire surface velocity data over the same catchment basins. This velocity captures major components (surface strain rates, stresses, etc) of the ice sheet dynamics, and therefore will help validate models that simulate the response of ice sheets to major perturbations, such as increased melt rates under ice shelves, or major calving events at the terminus of glaciers and ice shelves.

Furthermore, altimetry and surface velocity data can be used to invert for unknown parameters needed to better constrain ice flow models. Such parameters include the ice rheology and the bedrock friction. We will be using an approach similar to the one used in *MacAyeal* [1993] [2], *Schmeltz* [2002] [3], *Vieli* [2003] [4], *Larour et al* [2005] [5], *Khazendar et al* [2007] [6] and *Khazendar et al* [2009] [7] among others. This approach is based on the use of inverse control methods, in which a best fit with observed surface velocities is used to invert for an unknown parameter in a diagnostic model. Here, we will try and invert the bedrock friction at the base of the ice sheet, as well as the ice rigidity. Both parameters are unknown, cannot be measured in situ, and are key in determining the behaviour of the ice flow, and indirectly, the magnitude of the ice mass outflux. Such parameters are therefore critical if we are to correctly assess the amount of ice released into the water, and hence sea level rise.

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3. CONCLUSION

The simultaneous acquisitions of Lidar and SAR data will allow unprecedented validation of existing ice sheet models, in which interactions between surface mass balance and ice dynamics can be explored. Such effects include acceleration of ice flow caused by the thinning of ice or the propagation of gravity waves diffused upstream by adjustment of the ice surface. The unique opportunity presented by DESDynI in terms of ice flow model calibration and validation will be presented, along with specific studies for typical catchment basins in Antarctica and Greenland, in which bedrock friction and ice rheology will be inverted, then used to carry out forward ice flow transient simulations.

4. REFERENCES

[1] Intergovernmental Panel on Climate Change, *Fourth Assessment Report: Climate Change 2007: The AR4 Synthesis Report*, Geneva: IPCC, 2007.

[2] DR MacAyeal, "A tutorial on the use of control methods in ice-sheet modeling," *Journal of Glaciology*, vol. 39, no. 131, pp. 91–98, 1993.

[3] M Schmeltz, E Rignot, TK Dupont, and DR MacAyeal, "Sensitivity of pine island glacier, west antarctica, to changes in ice-shelf and basal conditions: a model study," *Journal of Glaciology*, vol. 48, no. 163, pp. 552–558, 2002.

[4] A Vieli and AJ Payne, "Application of control methods for modelling the flow of pine island glacier, west antarctica," *Annals Of Glaciology*, vol. 36, pp. 197–204, 2003.

[5] E Larour, E Rignot, I Joughin, and D Aubry, "Rheology of the ronne ice shelf, antarctica, inferred from satellite radar interferometry data using an inverse control method," *Geophysical Research Letters*, vol. 32, no. 5, pp. 1–4, MAR 8 2005.

[6] A. Khazendar, E. Rignot, and E. Larour, "Larsen b ice shelf rheology preceding its disintegration inferred by a control method," *Geophysical Research Letters*, vol. 34, no. 19, pp. 1–6, OCT 4 2007.

[7] E. Rignot Khazendar, A. and E. Larour, "Roles of marine ice, rheology, and fracture in the flow and stability of the brunt/stancomb-wills ice shelf," *Geophysical Research Letters*, vol. 114, pp. 1–9, 2009.