Modelling the flow and mass budget of the Patagonian ice fields

Supervisors

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Project description

The Patagonian ice field (PIF, Figure 1) is the largest ice mass in the Southern Hemisphere outside of Antarctica and forms a complex system of ice domes and outlet glaciers (almost all experiencing iceberg calving into the ocean or freshwater lakes). Observations suggest that virtually all of the associated glaciers have been thinning during the last few decades. This mass loss is important because of its contribution to global sea level (Schaefer et al. estimate ~2 mm by the end of the century from changing snowfall/melt alone), as well as its impact on local water budgets and seasonal water availability for agriculture, sanitation and industry.

Projection of the effect of future climate change on PIF presents a great challenge for three main reasons. First, the extremely mountainous relief of the South Andes leads to complex local atmospheric circulation patterns which generate both very high rates of snowfall and huge spatial variability in both snowfall and melt. Second, the complex geometry of the ice-flow system means that a high-resolution flow model must be used to accurately capture these features. Third, significant mass loss occurs through calving which is a poorly understood process that is likely to be controlled primarily by oceanic change.

The proposed project combines expertise in ice-flow modelling (Bristol), regional climate modelling (BAS), satellite observation and geophysical data analysis (Exeter) and will develop a numerical model of the PIF's flow and mass budget, which will be used to understand contemporary change within the ice mass. The model could also be used to make projections of future PIF change, although this is likely to beyond the scope of a PhD project. The project will benefit enormously from an existing collaboration with Universidad Austral de Chile, who bring both expertise in surface mass budget modelling and a wealth of field observations of PIF meteorology, flow, mass budget and thickness.

The project will be based around the advanced ice-flow models BISICLES (Cornford et al. 2013), which is ideally suited to this application because of its adaptive-mesh capability that resolves fine features (such as individual outlets glaciers) in an efficient computation framework. It will also employ the regional climate modelling using the Weather Research and Forecasting (WRF) model (a next-generation, non-hydrostatic mesoscale modelling system), which will be used to generate high-resolution meteorological forcing for surface mass budget calculations.

References

Cornford, SL, et al. (2013) Adaptive mesh, finite volume modeling of marine ice sheets, Journal of Computational Physics 232, 529-549, doi:10.1016/j.jcp.2012.08.037

Schaefer, M, et al. (2013) Modeling past and future surface mass balance of the Northern Patagonia Icefield, Journal of Geophysical Research 118, 571-588, doi:10.1002/jgrf.20038

Figure 1. The 13,000-km^2 Southern Patagonian ice field giving an impression of scale and complexity of the this ice system. Photo taken by crew member on the International Space Station on one of the rare clear days in the southern Andes Mountains. From NASA education website.