

3. Simon, K.M., James, T.S., Ivins, E.R., Wilson, T.J., and Willis, M. "Ocean loading effects on predictions of uplift and gravity changes due to glacial isostatic adjustment in Antarctica", American Geophysical Union Fall Meeting, San Francisco, California, United States, Dec. 2008 (poster).

### Publications

1. Simon, K.M., James, T.S., Forbes, D.L., Telka, A.M., Dyke, A.S., and Henton, J.A. "A relative sea-level history for Arviat, Nunavut, and implications for Laurentide Ice Sheet thickness west of Hudson Bay." *Quaternary Research*, **2014**, 82,185-197.
2. Ivins, E.R., James, T.S., Wahr, J., Schrama, E.J.O., Landerer, F.W., and Simon, K. "Antarctic contribution to sea level rise observed by GRACE with improved GIA correction". *Journal of Geophysical Research*, **2013**, 118, doi:10.1002/jgrb.50208.
3. Simon, K.M., James, T.S., and Ivins, E.R. "Ocean loading effects on the prediction of Antarctic glacial isostatic uplift and gravity rates." *Journal of Geodesy*, **2010**, 84, 305-317.
4. Simon, K.M., Huismans, R.S., and Beaumont, C. "Dynamical modelling of lithospheric extension and small-scale convection: implications for magmatism during the formation of volcanic rifted margins." *Geophysical Journal International*, **2009**, 176, 327-350.
5. Clague, J.J., Froese, D., Hutchinson, I., James, T.S., and Simon, K.M. "Early growth of the last Cordilleran ice sheet deduced from glacio-isostatic depression in southwest British Columbia, Canada." *Quaternary Research*, **2005**, 63, 53-59.



University  
of Victoria

Graduate Studies

## PROGRAMME

The Final Oral Examination  
for the Degree of

DOCTOR OF PHILOSOPHY  
(School of Earth and Ocean Sciences)

**Karen Simon**

2007  
2004

Dalhousie University  
University of Victoria

MSc  
BSc

**"Improved Glacial Isostatic Adjustment Models for  
Northern Canada"**

Thursday, November 27, 2014  
9:00AM

David Turpin Building, room A144

#### Supervisory Committee:

Dr. George Spence, School of Earth and Ocean Sciences,  
University of Victoria (Co-supervisor)

Dr. Thomas S. James, School of Earth and Ocean Sciences, UVic  
(Co-Supervisor)

Dr. Roy Hyndman, School of Earth and Ocean Sciences, UVic  
(Member)

Dr. Kelin Wang, School of Earth and Ocean Sciences, UVic  
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Dr. Daniel Smith, Department of Geography, UVic (Outside  
Member)

#### External Examiner:

Dr. Glenn A. Milne, Department of Earth Sciences,  
University of Ottawa

#### Chair of Oral Examination:

Dr. Malcolm Rutherford, Department of Economics, UVic

## **Abstract**

In northern Canada, the glacial isostatic adjustment (GIA) response of the Earth to the former Pleistocene Laurentide and Innuitian ice sheets contributes significantly to the Earth's past and ongoing sea-level change and land deformation. In this dissertation, measurements of Holocene sea-level change and observations of GPS-measured vertical crustal uplift rates are employed as constraints in numerical GIA models that examine the thickness and volume history of the former ice sheets in northern North America. The study is divided into two main sections; the first provides new measurements of Holocene sea-level change collected west of Hudson Bay, while the second presents a GIA modelling analysis for the entire study area of northern Canada.

Radiocarbon dating of post-glacial deposits collected in an area just west of central Hudson Bay provides several new constraints on regional Holocene sea-level change. The field collection area is near a former load centre of the Laurentide Ice Sheet (LIS), and the sea-level measurements suggest that following deglaciation, regional sea level fell rapidly from a high-stand of nearly 170 m elevation just after 8000 cal yr BP to 60 m elevation by ~5200 cal yr BP. Sea level subsequently fell at a decreased rate (approximately 30 m since 3000 cal yr BP).

The fit of GIA model predictions to relative sea-level (RSL) data and present-day GPS-measured vertical land motion rates from throughout the study area constrains the peak thickness of the LIS to be ~3.4-3.6 km west of Hudson Bay, and up to 4 km east of Hudson Bay. The ice model thicknesses inferred for these two regions represent, respectively, a ~30% decrease and an average ~20-25% increase to the load thickness relative to the ICE-5G reconstruction (Peltier 2004), generally consistent with other studies focussing on space geodetic measurements of vertical crustal motion. Around Baffin Island, the fit of GIA model predictions to RSL data indicate peak regional ice thicknesses of 1.2-1.3 km, a modest reduction compared to ICE-5G.

A new reconstruction of the Innuitian Ice Sheet (IIS), which covered the Queen Elizabeth Islands at LGM, incorporates the current glacial-geological constraints on its spatial extent and timing history. The new IIS reconstruction provides RSL predictions that are more consistent with regional observations of post-glacial sea-level change than ICE-5G. The results suggest

that the peak thickness of the IIS was ~1600 m, approximately 400 m thicker than the minimum peak thickness indicated by glacial geology studies, but between ~1000-1500 m thinner than the peak thicknesses used in previous regional ice sheet reconstructions.

On Baffin Island and in the Queen Elizabeth Islands, however, the modelled elastic crustal response of the Earth to present-day ice mass changes is large. Accounting for this effect improves the agreement between GPS measurements of vertical crustal motion and the GIA model predictions. However, improvements such as the inclusion of spatially non-uniform mass loss and a sensitivity analysis that examines uncertainties of this effect should be incorporated into the modelling of present-day changes to glaciers and ice caps.

## **Awards, Scholarships, Fellowships**

2011 – School of Earth and Ocean Sciences Academic Scholarship, University of Victoria

2010 – Graphic Office Interiors Scholarship, School of Earth and Ocean Sciences, University of Victoria

2008 – American Geophysical Union Best Student Paper Award

## **Presentations**

1. Simon, K.M., James, T.S., Henton, J.A., and Dyke, A.S. "Measurements of paleo sea-level change and present-day vertical land motion as GIA model constraints on the evolution of the northern sector of the Laurentide Ice Sheet", Wegener General Assembly, Leeds, UK, Sept. 2014 (oral).
2. Simon, K.M., James, T.S., Dyke, A.S., and Forbes, D.L. "Refining glacial isostatic adjustment models in northern Canada: implications for ice sheet history, sea-level change, and land emergence along the west coast of Hudson Bay", American Geophysical Union Fall Meeting, San Francisco, California, United States, Dec. 2011 (oral).