NOTICE OF UNIVERSITY ORAL EXAMINATION

Geodesy and Geomatics Engineering

Doctor of Philosophy

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Head Hall – ADI room @ 10:00 am

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A Physically Meaningful Model of Vertical Crustal Movements in Canada Using Smooth Piecewise Algebraic Approximation: Constraints for Glacial Isostatic Adjustment Models

ABSTRACT

Different kinds of analytical models of crustal deformation have both advantages and limitations, and are appropriate to different deformation patterns. However, in wide areas where more than one geophysical phenomenon are responsible for the deformation, such as in Canada, it would be a challenge to infer a physically meaningful model that accommodates different types of scattered geodetic data, while offering the optimum approximation to them.

In this study, an efficient method, Smooth Piecewise Algebraic Approximation (SPAA), was developed to automatically compute a smooth approximation of large functional scattered re-levelling data and historical tide gauge records given over Canada and northern U.S. to thereby compile a unified map of Vertical Crustal Movements (VCM). The area of study was divided into patches and piecewise algebraic surfaces were fitted to 2D observation points and tilt between them, where constraints were enforced between the parameters of the surfaces. When the surfaces were fitted to the data, the set of constraints was imposed in such a way that rather than the surfaces being fitted sequentially, they were fitted simultaneously, using the constraints as a set-conditions which the parameters of the surfaces must also satisfy.

The VCM model accomplished in this research is computationally demanding and it is numerically manageable. It gives enough details of the movements. Enforcing the continuity and smoothness in the first derivatives throughout the surfaces, the VCM model highlights the long wavelength spatial variations of the crust in Canada, mainly due to Post Glacial Rebound (PGR).

The rate of changes of orthometric height obtained from the map of VCM was compared with the map of rate of gravity changes ($\dot{g}$) in Canada. The PGR hinge line follows the same pattern in both maps and the close correlation between two maps is easily traceable and is in a fairly good agreement with theoretical model of Jachens (1978) in different areas. Then, a map of ratio between gravity changes to height changes was compiled and physically interpreted.

The VCM was then compared with geodetic height changes based on GPS solutions in Canadian Base Network (CBN) stations. This investigation showed disagreement in Canadian prairies with the GPS solution. In this study, some of the probable causes of such inconsistencies were explored. Using VCM and geodetic height changes from CBN-GPS solution, a map of rate of geoidal height changes was also compiled and interpreted in some areas in Canada.

The map of VCM was also compared with Glacial Isostatic Adjustment (GIA) models. The VCM constraints on GIA model parameters were investigated by varying, one at a time, two key parameters: 1) viscosity in different layers, and 2) the thickness of Laurentide ice, to obtain better fits to the VCM. In Eastern Canada, the VCM is consistent with an increase in the upper mantle viscosity. In the Great Lakes, the VCM has a better agreement with the predictions of GIA computed considering a lower viscosity for different layers of mantle. This study showed also that near the center of rebound at Churchill, present day vertical crustal movement is most sensitive to the viscosity in the shallow part of the lower mantle and the transition zone. The VCM is consistent with a thinning of the Laurentide ice-sheet over the Prairies relative to both standard ice models. These analysis leads to better understanding of the trade-offs between Earth rheology and ice sheet history and hence some suggestions were made to improve GIA models.

Faculty Members and Graduate Students are invited to attend this presentation