STSM Scientific report.

August 10th 2010

Beneficiary: Louise Sandberg Sørensen and Jens Emil Nielsen, DTU-Space, Copenhagen, Denmark
Host: Giorgio Spada, Università di Urbino Carlo Bo (Urbino, Italy)
Period: from 11/07/2010 to 16/07/2010
Place: Urbino (Italy)
Reference code 1: COST-STSM-ECOST--ES0701-160610-000000

This STSM scientific report is sent on behalf of both Louise Sandberg Sørensen and Jens Emil Nielsen.

The purpose of the STSM's entitled, *Implementing present-day gravity change calculations in SELEN (1 and 2)*, was to expand the output of SELEN (a code for solving the Sea level Equation, http://www.fis.uniurb.it/spada/SELEN_minipage.html) with maps of rates of present-day free-air and solid surface gravity anomalies. The theory about the Green functions of these anomalies should be discussed, and another goal was to implement changes in SELEN to be able to output gravity disturbance anomalies at any given altitude above the Earth. The latter is relevant for studies using GRACE data. We also wanted to get an idea of the work needed to implement different ice loading histories.

During the stay we looked into the implementation of Green functions in SELEN and the theory behind these. The Green functions for both solid-surface and free-air gravity anomalies were implemented in the code.
We had a brush up on the changes in SELEN from version 2.7 (the version we used during the COST Action GIA summer school in Gävle) to 3.0. We had a discussion on ice models with Florence Colleoni (CMCC Bologna) and talked about using different time-steps in the ice histories.

We also worked with a specific case of calculating the elastic response (vertical displacement) of the Earth as a result of the present-day mass changes in the Greenland ice sheet derived from ICESat data. This work is also highly relevant to the EU project ice2sea.
See Fig. 1.

In order to be able to correct the GRACE derived gravity changes for PGR using SELEN, the theory behind the normalization of the (rate of change of) Stokes coefficients was touched. The rate of change of the Stokes coefficients derived by SELEN are now consistent with the definition of fully-normalized harmonics in order to be comparable with the monthly GRACE gravity models derived by the GRACE processing centres (CSR, JPL, GFZ).
See Fig. 2.

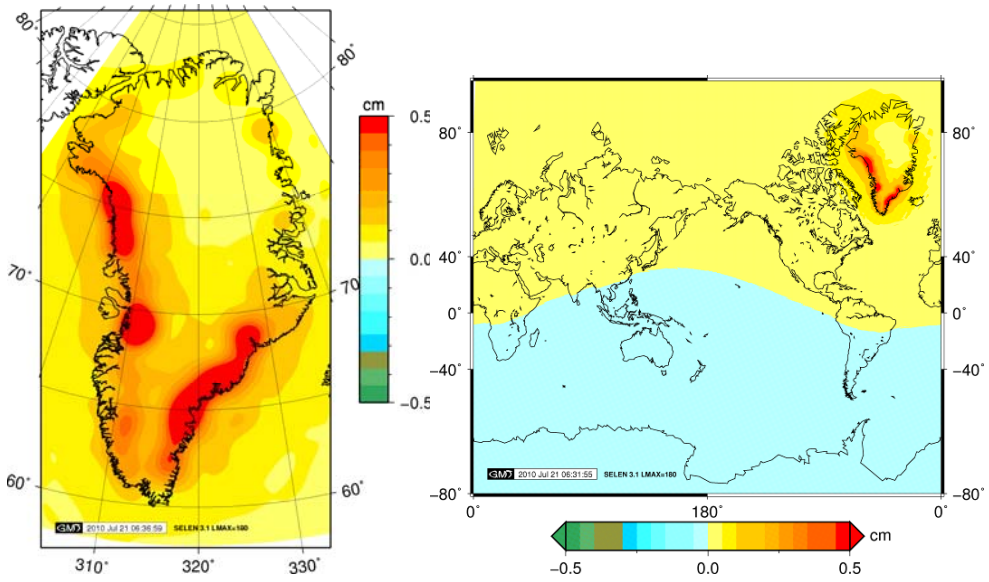
We have gained insight in implementing Green functions and will use this in the future to implement the Green function for the tilt. We know how to use SELEN with ALMA (a Love numbers calculator, see http://www.fis.uniurb.it/spada/ALMA_minipage.html) to use the full PREM density and shear modulus layering in our calculations. This can be used in e.g. sensitivity

studies of GIA to Earth models. We have seen how to calculate the elastic response due to change in ice mass.

In the near future will we continue to collaborate on the following topics:

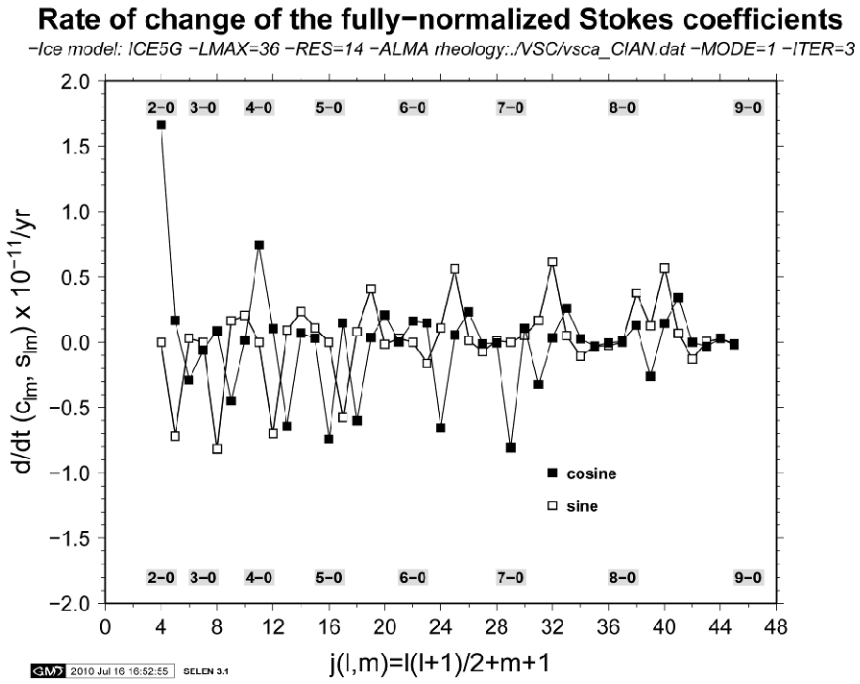
- Implementing the Green function for the tilt.
- The possibility of SELEN to produce maps of gravity change described in units of water equivalent.
- Studies of GIA when the harmonic degree 1 term and “ice-breaker” routines to allow for a high spatial resolution are implemented in SELEN.
- Maps of the free-air anomaly (not the rate).

Besides these issues, we will use the new implementations in SELEN in a study on GIA in Greenland. The study will look at GIA caused by different ice models and sensitivity on the Earth model. The aim is to write an article on GIA in Greenland, and it will be done in further collaboration with Giorgio Spada.



(a) (b)

Figur 1. *Elastic vertical displacement caused by present-day changes of the Greenland Ice Sheet derived from ICESat data. (a) In Greenland, (b) On a global scale.*



Figur 2. *Rate of change of the fully normalized Stokes coefficients driven by GIA. This result is based on ICE-5G.*