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ICECON

Constraining Ice Mass Changes in Coastal Dronning Maud Land, Antarctica

DURATION OF THE PROJECT
01/04/2012 - 30/06/2016

BUDGET
933.351 €

KEYWORDS
Glaciology, GNSS, post-glacial rebound, deglaciation history, Ice sheet modelling, Ice core analysis, radio-echo sounding

CONTEXT

On an international level, IceCon makes part of the PoleNet GNSS network and will contribute to SCAR programmes such as SCERCE (Solid Earth Response and influence on Cryosphere Evolution) and PAIS (Past Antarctic Ice Sheet Dynamics). Results of the IceCon project will feed into IPCC AR6 with revised contributions of the Antarctic ice sheet to sea level rise. On a national level, the IceCon project forms a continuation of previous SSD supported projects, such as ASPI, BELISSIMA and GIANT.

DESCRIPTION DU PROJET

Objectives

The IceCon project aims at a better understanding of the past and present ice volumes and extension of the Antarctic ice sheet in Dronning Maud Land (DML) through a new series of measurements and observations in conjunction with ice sheet system modelling. Knowledge of past ice volumes are important, since the ice sheet is still reacting to what happened in the past, especially since the Last Glacial Maximum (LGM), roughly 18,000 years ago, when the Antarctic ice sheet was significantly bigger. IceCon's main hypothesis is that the LGM ice sheet volume in Dronning Maud Land was not as big as previously predicted by large-scale ice sheet models, although it advanced as far onto the continental shelf.

A correct understanding of past ice volumes is especially important for PGR (Post-Glacial Rebound) corrections, hence interpretation of the present-day mass change of ice sheets through analysis of GRACE data. Both the Greenland and Antarctic ice sheets are losing mass. However, the GRACE satellite essentially measures changes in the gravity field at the surface of the Earth, which is a combined PGR and ice mass change signal. While PGR rates are generally well known for Greenland, in Antarctica useful direct measurements are mostly lacking, since there is not much ice-free area.

Methodology

Direct measurements of present-day uplift rates are possible through a network of high-resolution continuous geodetic GNSS (Global Navigation Satellite System) measurements. Two such instruments are installed at PEA (Princess Elisabeth Antarctica). However, since most of the uplift is expected closer to the coast, the IceCon project will install one continuous GNSS on Seal Nunatak (60 km North from PEA). Precise GNSS measurements should be done on a solid rock surface. However, since only a fraction of the Antarctic continent is ice free, a precise system will be installed on an ice rise as a test case for future measurements. Interpreting an uplift rate from direct measurements at the ice surface requires additional measurements to make an interpretation possible. In general, the rate of change of the ice surface is the algebraic sum of the following components:
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$$\dot{H} = \frac{\dot{b}}{\rho} + \dot{z} + \dot{L}$$

Where $\dot{b}$ is the surface mass balance (accumulation), ρ the ice density, $\dot{z}$ the submergence velocity, and $\dot{L}$ the vertical lithospheric displacement. Since we are after $\dot{L}$, which is the smallest number in this equation, a precise knowledge of the different parameters is needed. Changes in H are measured by the continuous GNSS instrument, similar to the rock station, where $\dot{H} = \dot{L}$. Surface mass balance is determined from shallow radar measurements, typically done with a high-frequency radio-echo sounder. This enables determining continuous isochronous layers over long distances and permits to determine the local variability in surface accumulation. The absolute accumulation value is then obtained by linking the radar measurements to ice cores through the firn, for which density is determined and – if possible – a precise dating is done through counting of annual layers or via co-isotopic analysis..

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Finally the submergence velocity $\dot{z}$ can be determined through the coffee-can method, which measures the relative position of a point at depth in the ice sheet compared to the surface in time. Information on the timing of deglaciation can be obtained through an analysis of the Raymond effect, which causes an upwarping of internal layering in the ice rise underneath the ice divide as a result of the non-linear rheology of the ice. All data will be integrated to constrain a state-of-the-art coupled ice-sheet/ice-shelf model and to make simulations of the deglaciation history of this coastal stretch of Dronning Maud Land.

INTERACTIONS BETWEEN THE DIFFERENT PARTNERS

The project relies on a multidisciplinary approach involving GNSS analysis, ice-penetrating radar at different frequencies, ice-core analysis (texture, density, isotopic analysis), televiewer measurements, and ice-sheet modelling at different scales (Raymond effect modelling as well as large-scale ice sheet modelling). The result is a function of the interaction between different approaches and partners. The modelling aspect leads to integration of different results into one solid framework.

EXPECTED RESULTS

We expect all data analysis done by the different partners to freely circulate between the different partners of the project. The main outcome of the project will be refined estimates of LGM ice mass change and present-day isostatic uplift rates on a regional scale (coastal area of DML) at both sides of the present-day grounding line, based on GNSS data on fixed rock and corrected for vertical strain rates for the ice rise station. The follow-up of the project is guaranteed by the project website: http://icecon2012.blogspot.com.

PARTNERS

- **Frank PATTYN** : Coordinator; ice sheet modelling; high-frequency radar; data integration
- **Jean-Louis TISON**: PI; ice-core analysis ; density ; isotopic analysis ; ice-core drilling
- **Carine BRUYNINX** : PI ; GNSS analysis ; GNSS installation and data retrieval
- **Tonie VAN DAM** : Partner ; GNSS analysis ; GRACE integration
- **Bryn HUBBARD**: Partner; hot-water drilling; televiewer and density measurements
- **Kenichi MATSUOKA**: Partner; low-frequency ice radar

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