Idea297

PROPOSITION OF GEOPHYSICAL INVESTIGATIONS IN ANTARCTICA

By the Royal Observatory of Belgium (Uccle) and the European Center for Geodynamics and Seismology (Walferdange, GD Luxemburg)

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Abstract

The Royal Observatory of Belgium and the European Center for Geodynamics and Seismology propose to conduct, from the 2007-2008 IPY, annual absolute gravity, permanent GPS and seismic measurements at the future Belgian station in Antarctica. The gravimetric and geodetic studies aim at decoding the ice mass variability processes of the large ice sheets, which is a key factor in the polar environmental changes, while the seismological investigations will be dedicated to explore the lithosheric structure under the studied region. In these researches, we intend to develop a co-operation with our Japanese colleagues.

1. COMBINE ANNUAL ABSOLUTE GRAVITY MEASUREMENTS AND PERMANENT GPS MEASUREMENTS TO EVALUATE THE ICE MASS CHANGES

Climate research indicates that global warming is occurring. Sea level rise, driven by the thermal expansion of water in the oceans and the melting of glaciers and ice sheets, has occurred at a rate of about 2 mm/year over the last 100 years. However, it is still unclear what fraction of the sea level trend is driven by changes in the mass balance of Antarctica. Understanding the relationship and feedback mechanisms between climate warming, ice sheet mass, and sea level rise, is difficult for many reasons including our ability to monitor the ice mass variability of the large ice sheets.

Numerous satellite altimeteric missions have recently been launched (Iceat and Cryosat) which will provide information on the change in surface. Interpreting this data in terms of a surface mass requires information on the density of ice in the column, which varies significantly over time. We propose an experiment to utilize contemporary geodetic techniques to provide information on the ice mass balance of the Antarctic Ice sheet, in the vicinity of the future Belgian station. This experiment will provide data which can be used to convert the satellite altimetric data into mass balance information.

The idea is relatively straightforward. The earth is an elastic body (with relatively well determined long wavelength elastic properties) whose response (surface deformation or gravity change) to a surface load can be accurately modeled. Conversely, if we measure a deformation (or gravity change), we can use our knowledge of the earth properties to infer changes in the surface load. Thus we go to the edge of the ice sheet, we measure deformations, and we can invert these deformations in terms of changing ice mass. The problem with this approach is that the earth in the vicinity of Antarctica is currently deforming due to past-changes in ice load as well, i.e. glacial isostatic adjustment (GIA). Observations of crustal motion, then, contain elastic motions due to present day ice changes and viscoelastic deformations due to GIA. We can separate these two contributions to the deformation by measuring both deformation and changes in gravity.

We propose a program to install continuously operating GPS at bedrock sites around the proposed Belgian Antarctic Observatory. The experience of the Research School for Earth Sciences (Canberra, Australia) indicates that autonomous GPS sites (solar powered) can provide up to 250 days of observations (site positioning) per year, which would be sufficient to extract a trend in the deformation within 3 years.) These proposed GPS crustal deformation observations will be supported with annual observations of absolute gravity at the Belgian observatory itself. The ECGS hopes to be able to obtain a smaller absolute gravimeter A10, which would allow us to make measurements at additional sites with much less trouble. Given the noise on the absolute gravity and GPS data, we expect to be able to extract useful information on the mass balance of the region (an area of 500 km) within 7 years.

This observation program is complimentary to the program already underway at the Japanese Syowa Station in Antarctica. A continuously operating superconducting gravimeter exists at the station and has been operating for close to 7 years. These observations are supplemented with annual absolute gravity observations. The team (ECGS and ROB) have close ties to the Japanese team doing gravity there. We propose to work with our Japanese colleagues to establish an observing scenario that maximizes the resources of both groups.

2. IMPLANTATION OF A BROAD-BAND SEISMIC STATION

The Royal Observatory of Belgium proposes also to install a broad-band seismic station at the Belgian station in Antarctica. It should complete the coverage of the Antarctica in seismic stations and help to better understand the lithospheric structure around the Belgian station site by the modelling of receiver functions from teleseismic events.

From the technical point of view, ROB and ECGS are qualified in the fields of gravimetry and global positionning system and are in possession of the same instruments. The cooperation between the two institutes secures the continuity of the measurements during the years even in case of deficiency of one of the equipments.