Report to the Nordic Geodetic Commission, Working Group for Geodynamics

The major profile of activities in Space Geodesy at Chalmers concerns atmosphere remote sensing using microwave radiometry, GNSS and other satellites, and VLBI. This report concentrates on solid earth applications.

Earth Rotation

An important research topic for geodetic VLBI is the investigation of variations in the earth's rotation and the interaction with geodynamical processes in the earth's spheres, i.e. the atmosphere, the oceans and the earth's interior. Figure 1 shows the variations in length-of-day, i.e. the excess of a constant length of day of 86,400 s. Clearly visible are the strong El-Niño events in 1983 and 1997/1998 (positive excess) and the La-Niña event in 1989 (negative excess). These events are large-scale mass redistributions in the tropical ocean-atmosphere system and influence the rotation of the solid earth. VLBI is the only technique that can observe earth rotation with long term stability and is thus an important source of information for a better understanding of global geodynamical processes.

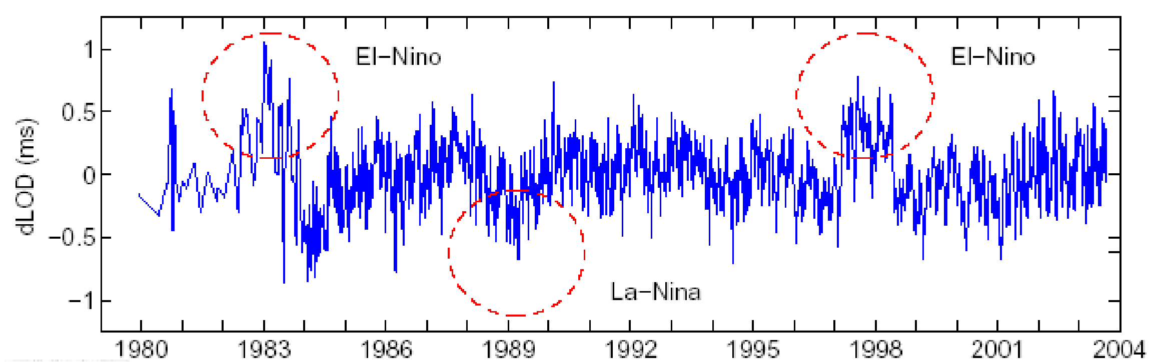

Figure 1: Length-of-day variations derived from VLBI data. To clearly show the short term anomalies, long-term periodic signatures and the lengthening of the day have been removed.

The BIFROST GPS Project

Continuous GPS observations are used to infer deformation of the earth crust. In previously presented results we have been able to conclude interstation velocity at a resolution of less than 0.1 mm/yr in the horizontal and 0.2 to 0.3 mm/yr in the vertical coordinates (Scherneck et al. 2003).

The networks of stations that form the instrumental basis for BIFROST extend throughout the Baltic Shield area. The primary process leading to crustal deformation in this area is glacial isostatic rebound, i.e. the slow creeping of the earth mantle that gradually will attain equilibrium, the disequilibrium having been created in the succession of the melting of the Pleistocene ice sheet in Fennoscandia. This process started roughly 20,000 years before present. The motions that we observe in BIFROST can be reconciled with model computations employing visco-elastic earth structure and an ice history. Figure 2 shows a viscosity profile of the mantle resolved by BIFROST (Milne et al. 2004).

The GPS-inferred motion presents a unique type of information. Traditionally, postglacial rebound has been studied on behalf of its vertical component, using geological height markers and sea level observations. The change of sea level, however, is composed of oceanic and solid earth contributions, each of them covering a range of scales in time and space; some important signatures are difficult to discern in time series, and some indicators are known to have large systematic offsets. GPS measurements, on the other hand, have demonstrated its advantages as it can (1) uniformly cover a wide geographic area with a reasonable station spacing, (2) measure vertical position independent of sea level, and (3) observe horizontal deformation.

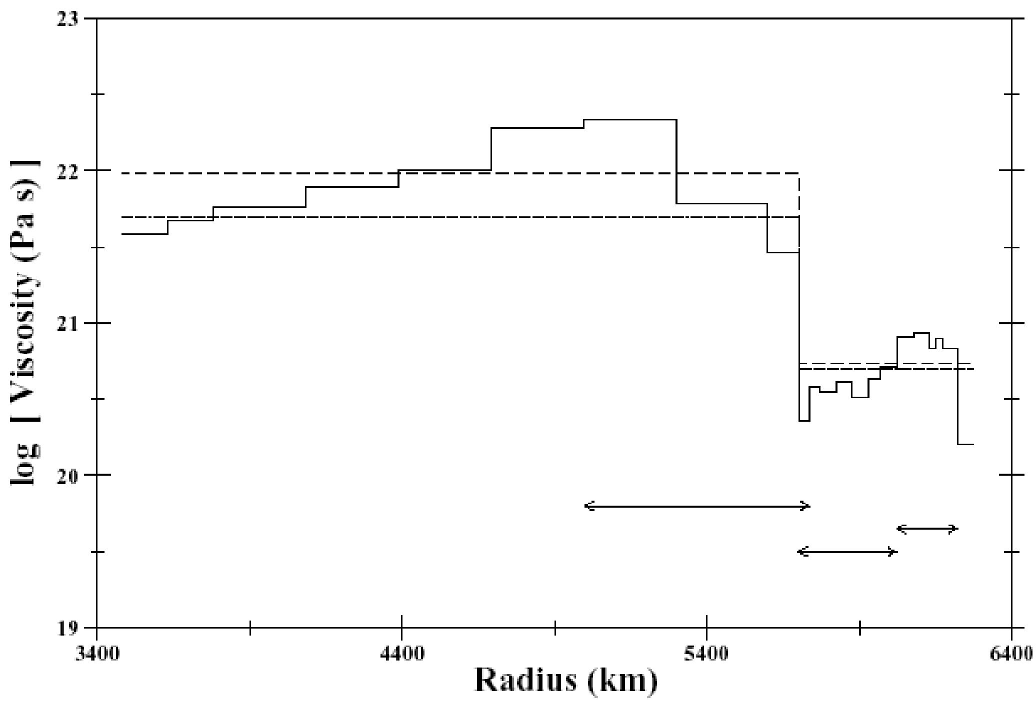

Figure 2: Viscosity profile determined from BIFROST-GPS data using Bayesian inversion. The prior solution is indicated by a dotted line and represents a two-layer viscosity structure with an interface depth of 670 km. The solid line shows a solution where all layers were allowed to vary independently. The dashed line shows a solution where the viscosity layers in the upper and in the lower mantle were perfectly correlated, so only the viscosity jump at the interface was allowed to adjust. Also the thickness of the elastic lithosphere was iterated—from 96 km to 103±8 km. The resolution capability is sufficient for estimation of three independent layers; it is illustrated by the three lines at the bottom right of the figure.

GPS Reprocessing

The GPS networks in our area are SWEPOS in Sweden, FinnRef in Finland, SATREF in Norway, and additional stations are operated in a continuous mode in Denmark, Russia, and the Baltic states. The infrastructure, equipment, and performance have, especially since the end of 1996, become very stable. During 2003 special efforts have been devoted to the GPS derived motions by adding new analysis strategies and thus strengthen the reliability of the result. A new GPS analysis software package (GAMIT/GLOBK) has been implemented and five years of data (mid 1998 to mid 2003) have been analysed. In this analysis the BIFROST network has been extended to include stations also from Norway, Denmark and the Baltic countries. This extension is significant as it encompasses now almost all of the area of postglacial uplift. Derived station velocities agree in general with former result to better than 1 mm/yr in a very preliminary analysis. Some inconsistencies in the former results have also been removed by the new analysis.

Ocean Tide Loading

The Space Geodesy group runs an Internet service that provides parameters for ocean tide loading. The phenomenon concerns the deformation of the earth surface under the changing pressure of the water load in the tidal oscillations in the oceanic basins of the Earth. The service is available at http://www.oso.chalmers.se/~loading. Until March 2004 the service has been called 1863 times to deliver parameters for a total of 32476 geographic locations.

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