

NMA Analysis Center

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Abstract

This report summarizes the activities of the NMA Analysis Center in 2010 and outlines the planned activities for 2011. The NMA had in 2010 two main goals. The first goal was to adapt the multi-technique geodetic software GEOSAT to deliver to the IVS Combination Center unconstrained SINEX solutions compatible with the solutions from the other IVS Analysis Centers. The other was to be accepted as an IVS Associate Analysis Center. NMA was accepted as an IVS Associate Analysis Center on 28 October 2010. NMA has performed lots of activity during 2010 to modify the software to be as compatible as possible with the other VLBI software used to deliver results to the IVS. The overall agreement between the GEOSAT solution and results from the other IVS Analysis Centers are satisfactory. However, some discrepancies still exist and have to be addressed.

1. Introduction

During recent years the Norwegian Mapping Authority (NMA) has started a close collaboration with Forsvarets forskningsinstitutt (FFI, Norwegian Defense Research Establishment) to use and further develop the geodetic multi-technique software GEOSAT ([1, 2]). One of the main goals of this project has been to use the VLBI module of GEOSAT to establish NMA as an IVS Analysis Center and to deliver unconstrained Solution Independent Exchange format (SINEX) solutions for the IVS combined solutions ([3]).

To produce VLBI solutions for IVS is the first part of a larger strategic plan from NMA. The next step is to include other geometric geodetic techniques (GNSS and SLR) in a common solution, in which the different techniques are combined at the observation level. The long term goal of this large effort is to also include data from the gravity satellites GRACE and GOCE and from satellite altimetry.

2. NMA Analysis Activities in 2010

The NMA has in collaboration with FFI made a large effort to make the GEOSAT software compatible with other VLBI analysis software.

One of the first challenges that had to be solved was how to extract an unconstrained SINEX solution from the Square-Root Information Filter (SRIF) matrix given by GEOSAT. A first test solution was sent to the IVS Combination Center in autumn 2009. During 2010 several solutions covering all VLBI sessions with at least four stations from 1994 to present were submitted to the IVS Combination Center. The first solution was presented at the 6th IVS General Meeting, Hobart, Australia [5]. The overall agreement between the NMA-GEOSAT solution and the solutions from the other ACs is satisfactory for this first comparison. However, some discrepancies have been found (see [5] for details). This revealed some issues that have to be investigated. The NMA is in an iterative process with the IVS Combination Center to sort out these issues.

The discrepancies between results from GEOSAT and results from other IVS Analysis Centers may have several reasons. Differences in the underlying models are one possible explanation. For a short description of the main features of the software, see Section 4. The use of 3D-raytracing instead of VMF1 ([4]) is likely to produce some systematic differences. GEOSAT was therefore

extended with the option to use the VMF1 mapping function. The first results using VMF1 have been compared to the other solutions. This has reduced the discrepancies. During the iterative process with the IVS Combination Center some other discrepancies in the software were also revealed, and the software was updated. To what extent the use of a Kalman filter approach instead of a Least Square Adjustment may introduce differences is unknown, but it is not likely that it would give long-term systematic differences.

3. NMA Planned Analysis Activities in 2011

The NMA will in 2011 continue the iterative process with the IVS Combination Center to make the GEOSAT solution as compatible as possible with the other software. As soon as the GEOSAT solution is in satisfactory agreement with the other solutions, NMA will start to deliver unconstrained normal equations in SINEX format to the IVS-EOP combination on a routine basis. Tests of different models are also planned, for instance a comparison of results using VMF1 and 3D-raytracing.

4. The GEOSAT Software

During the last 28 years FFI has developed a software package called GEOSAT for the combined analysis of VLBI, GNSS (GPS, Galileo, GLONASS), SLR and other types of satellite tracking data (DORIS, PRARE, altimetry, gravity, radar, direction, Deep Space Network, etc.) The observations are combined at the observation level with a consistent analysis strategy and consistent models. With this procedure, the time-evolution of the common multi-technique parameters (for example EOP, geocenter, troposphere, or clock parameters) is treated consistently across the techniques.

GEOSAT is based on an upper diagonal factorized Kalman filter which allows the estimation of time variable parameters, such as the troposphere and clocks, as stochastic parameters. The tropospheric delays in various directions are mapped to tropospheric zenith delay using ray-tracing. Meteorological data from ECMWF with a resolution of six hours is used to perform this ray-tracing. The ray-tracing depends both on elevation and azimuth angle. Atmospheric pressure corrections are applied ([7]). Other models are following the IERS and IVS conventions [6].

5. Staff

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