FFI Analysis Center

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Abstract

FFI's contribution to the IVS as an analysis center focuses primarily on a combined analysis at the observation level of data from VLBI, GPS and SLR using the GEOSAT software. This report shortly summarises the current status of analyses performed with the GEOSAT software. FFI is currently an Analysis Center for IVS and ILRS, a Technology Development Center for IVS, and a Combination Research Center for IERS.

1. Introduction

A number of co-located stations with more than one observation technique have been established. In principle, all instruments at a given co-located station move with the same velocity, and it should be possible to determine one set of coordinates and velocities for each co-located site. In addition, a constant eccentricity vector from the reference point of the co-located station to each of the individual phase centers of the co-located antennas is estimated using constraints in accordance with a priori information given by the ground surveys. One set of Earth orientation parameters (EOP) and geocenter coordinates can be estimated from all involved data types. The present dominating error source of VLBI is the water content of the atmosphere, which must be estimated. The introduction of GPS data with a common VLBI and GPS parameterization of the zenith wet delay and atmospheric gradients will strengthen the solution for the atmospheric parameters. The inclusion of SLR data, which is nearly independent of water vapour, gives new information which will help in the de-correlation of atmospheric and other solve-for parameters and lead to more accurate parameter estimates. These, and many more advantages with the combination of independent and complementary space geodetic data at the observation level, are fully provided by the GEOSAT software developed by FFI.

After five years of development and extensive validation we are proud to announce that a major revision and extension of the GEOSAT software has been completed. The most important changes implemented have been described in recent IVS Annual Reports. Much more flexibility and automation have been added. Furthermore, the latest and "best" models (mostly following the IERS Standard) and "calibration tables" and "instrumental/geophysical event tables" have been included. Analysis of tracking data to S/C's in deep space has been added. For any technique, the delay due to the troposphere is determined with 3D raytracing using the European Center for Medium-Range Weather Forecast Numerical Weather Model. No mapping functions are used, and the corrections are determined directly from interpolation in the raytracing files.

2. Staff

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3. Combination of VLBI, GPS, and SLR Observations at the Observation Level

The processing of observations in GEOSAT is performed in three steps: 1) Omc step: for each individual technique generate files of residuals (observed minus calculated, omc) and partials for a period of "one arc" (usually 24 hours). Selected parameters are estimated to generate "small" residuals so that iterating in the filter is not necessary. 2) Comb step: combine omc files for all techniques at the epoch-by-epoch level using a UD (Upper-Diagonal factorized) sequential filter. The result is a SRIF (Square-Root-Information-Filter) array for that specific arc. 3) Global step: combine all arc SRIF arrays to generate a multi-year solution. The estimation is performed with a CSRIFS (Combined Square-Root-Information-Filter-and-Smoother factorized) sequential filter.

To perform the analyses we have a dedicated array of 10 state-of-the-art Linux work stations, each with 4 CPUs, 6 GB RAM, and 1 TB disk space.

The status of the analysis by January 2009 is as follows: New in 2008 is ambiguity resolution of undifferenced GPS data. Only resolved data are used in the analysis, which has reduced the number of GPS stations in the solution for each arc from approximately 175 to typically 135. The actual stations involved in an arc change in general from day to day so that many more GPS stations will be present in the global multi-year solution. Another extension is that the rates of the Earth orientation parameters are estimated. These changes and new SLR calibrations have made it necessary to repeat the time-consuming arc level analysis several times. The omc step is completed for the period October 1, 2002 to December 31, 2007. After extensive testing a "close to optimal" mix of solve-for parameters, constraints and weighting has been found for the combined analysis at the single arc level (Step 2). Among the estimated parameters are GM, a GPS antenna phase center offset to be added to the satellite-dependent phase center offsets and variations tabulated by IGS, and time dependent estimates of the geocenter, C20, C22 and S22. So far 1201 arcs have been processed at the comb level with this strategy. This is 63% of the days in the period October 1, 2002 to December 31, 2007. The first runs at the global multi-year level (Step 3) with these 1201 arcs are presently being performed. It is too early to draw any conclusions yet.

The expected outcome will be new realizations of TRF, CRF, and EOP relying on consistent models and estimation strategies. As a by-product a file of estimated eccentricity vectors will be produced. This type of analysis is along the lines of the ideas behind the GGOS project where geometry, gravity and Earth orientation are to be simultaneously and consistently determined.

We hope to include space-bourne gravity (accelerometer, gradiometer, sat-sat range/doppler, altimetry etc.) in GEOSAT for a simultaneous analysis with VLBI, SLR and GPS. This extension will be made possible by a close collaboration between Statens Kartverk and FFI.