3.6.2.5 Forsvarets forskningsinstitutt (FFI)

Introduction

FFI has during the last 20 years developed a software package called GEOSAT (Andersen, 1995) for the combined analysis of VLBI, GPS, SLR and other types of satellite tracking data (GLONASS, DORIS, PRARE and altimetry). The observations are combined at the observation level with a consistent model and consistent analysis strategies. The data processing is automated except for some manual editing of the SLR observations.

In the combined analysis of VLBI, GPS and SLR observations the data are processed in arcs of 24 hours defined by the duration of the VLBI session. The result of each analyzed arc is a state vector of estimated parameter corrections and a Square Root Information Filter array (SRIF) containing parameter variances and correlations. The individual arc results are combined into a multiyear global solution using a Combined Square Root Information Filter and Smoother program called CSRIFS. With the CSRIFS program any parameter can either be treated as a constant or a stochastic parameter between the arcs. The estimation of multiday stochastic parameters is possible and extensively used in the analyses. The advantages of the combination of independent and complementary space geodetic data at the observation level is discussed in (Andersen, 2000).

Status

The GEOSAT software has during 2003 undergone extensive changes and improvements. This work will continue through 2004. No major IERS-related multiyear analyses have been performed with the software in 2003.

The most important changes implemented in 2003 are described in the following.

A new major software component of GEOSAT has been developed for 3D raytracing through the atmosphere. A complete 3D atmospheric model provided daily by ECMWF is input to the software. Based on the available tracking (VLBI, GPS, or SLR) for that specific date, a set of tables for each active station is automatically generated with information about the time delay in the different elevation and azimuth directions. Also statistical information concerning the variability of relevant parameters are extracted from the ECMWF data. This information is used in the estimation filter as time-dependent parameter constraints. In typically 70 % of the so far analyzed sessions this seems to be a very good strategy. In principle it should be possible to investigate the quality of the ECMWF numerical weather model regarding the pressure, temperature and humidity parameters. No mapping functions are used anymore in GEOSAT. Different interpolation schemes are under testing. An interpolation strategy has been found where the interpolation error is presently 1 mm or less down to an elevation cutoff of 2.7 degrees. A new model/parameterization for the atmospheric delay is under consideration in GEOSAT. The status is that some individual VLBI-only sessions have been analyzed. A clear reduction in a posteriori residuals (typically 20-25 %) is observed using the ECMWF data. The Grueger model is default for the MW refractive index and the Ciddor model is default for the optical or near optical wavelengths. The Ciddor model implementation has been verified against Ciddor's own software.

The pressure loading tables provided by Leonid Petrov is implemented in GEOSAT. For stations not included in Petrov's table a simple pressure scaling model is used where the load scale parameter is automatically estimated in the analysis. A grid of reference pressure values has been derived by averaging the surface pressure levels provided by NCEP during the last 20 years.

A model for thermal deformation of the VLBI antenna structure has been included. Thermal coefficients and thermal time delays can in principle be estimated.

The station eccentricity file has been checked in great detail and updated with all the most current log files of VLBI, GPS, and SLR. The eccentricity information is treated as a new observation type in GEOSAT in addition to the VLBI, GPS, and SLR observation types.

The GEOSAT software calculates one set of station coordinates and velocities for a reference marker at a colocated station in addition to the eccentricity vector to each different antenna reference point. The software has been extended so that observations from several active VLBI systems, GPS receivers and SLR systems all will contribute to the estimation of the parameters for the station reference marker. The instruments could be operating either simultaneously or in different time windows.

The IERS 2003 Conventions have been fully implemented including the new EOP parameterization.

The absolute GPS satellite antenna phase center table published by Rothacher recently has been implemented as an a priori model. The parameters will be estimated during the analysis.

All relevant partial derivatives have been verified against numerical partial derivatives.

In the global processing of several years of data the stable sources listed by Feissel et al. will automatically be estimated as constants while the others will be estimated as random walk parameters or session parameters. A set of defining stations satisfying certain criterias is automatically estimated as constants where the other stations are estimated as constants during a certain interval (between one day and one month).

Future plans

We plan to implement an orbital overlap scheme for automatic evaluation of the orbit quality (GPS, LAGEOS). Observations from the GALILEO navigation system will be applied when available. Only minor changes in GEOSAT are required for this extension.

References

Andersen, P. H. (1995) High-precision station positioning and satellite orbit determination. PhD Thesis, NDRE/Publication 95/01094.

Andersen, P. H. (2000) Multi-level arc combination with stochastic parameters. Journal of Geodesy (2000) 74: 531-551.

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