Other Analysis Center Developments & Studies of General Interest

Oral

(1) Validation of GNSS Satellite Orbits
C. Flohrer, G. Beutler, R. Dach, W. Gurtner, U. Hugentobler*, M. Ploner, S. Schaer

Precise GNSS orbits are the basis for precise positioning and the primary product of the IGS. Independent validation of orbits with SLR indicates radiation pressure modeling problems. Orbit prediction over several weeks allows it to assess the quality of the orbit model also for satellites that are not equipped with retroreflectors. Satellite orbit overlaps at day boundaries give further indications on orbit modeling problems. Unexplained features can be identified in orbit overlaps of IGS orbits. Analysis of the observed inconsistencies help to further increase the accuracy of the IGS orbits.

(2) The relative contribution of the annual and draconitic periods in GPS station position spectra
Paul Barrett (USNO)

We present the results of a spectral analysis of GPS station positions. The data consists of ten years (1996-2005) of weekly ITRF2005 coordinates for 169 stations. The spectrum of the north coordinate shows power at the fundamental, first, and second harmonics of the annual period, and the second, third and fifth harmonics of the draconitic (or GPS precession; 1.04 cycles per year) period. However, in the east and up coordinates, the power in the second and fifth harmonics of the draconitic period is barely discernible. The draconitic periods are shown to be the result of systematic errors in the GPS processing, since they are only evident in the spectra of individual stations and not in the spectra when all stations are combined into a single data set.

(3) Toward correcting InSAR images for tropospheric delay
A. Moore (JPL), S. Owen (JPL), F. Webb (JPL), S. Granger (JPL), E. Fetzer (JPL), E. Fielding (JPL), E. Fishbein (JPL), F. Bjorndahl (Chalmers), J. Lofgren (Chalmers)

We are pursuing a multisensor approach, including GPS, to characterize and determine regional tropospheric delay to improve the removal of tropospheric artifacts from Interferometric Synthetic Aperture Radar (InSAR) images. Water vapor measurements from the Atmospheric InfraRed Sounder (AIRS) are compared with water vapor estimates derived from ground-based GPS receivers in Japan and Southern California for several months in 2005 and 2007. AIRS is a polar orbiting hyper-spectral infrared sounder flown aboard NASA's Earth Observing System (EOS) Aqua platform providing high resolution 3-dimensional observations of water vapor, temperature and trace gases from space. AIRS produces both daytime and nighttime water vapor retrievals and is able to generate some retrievals in the presence of clouds. GPS and AIRS have complementary spatial and temporal characteristics that suggest a combined product for InSAR correction. We processed GPS measurements from the Japan GEONET network and the Southern California Integrated GPS Network (SCIGN) of ground-based receivers using the Global Mapping Function (GMF) described by Boehm et al. (2005). A robust method (Bevis et al. 1992) is used to derive water vapor from tropospheric path delay measured at several GPS receiver sites. To compare GPS-derived water vapor with AIRS-retrieved water vapor, we use surface pressure estimates from the National Center for Environmental Prediction (NCEP) reanalysis or the European Center for Medium-Range Weather Forecasting model to convert GPS total zenith delay to real water vapor and hydrostatic estimates. We find a favorable correlation between GPS-derived water vapor measurements and the AIRS-retrieved quantities. We have also identified simple metrics based on the GPS zenith wet delay that identify time periods when atmospheric dynamics are favorable for effective removal of tropospheric delay. Additionally, we are investigating interpolated ECMWF data as an InSAR correction product, potentially with GPS data included.

(4) Making Good from Bad: Can We Use GPS Multipath To Measure Soil Moisture Content?
K. Larson (U Colo.), A. Bilich (NOAA), V. Zavorotny (NOAA), J. Braun (UCAR), E. Small (U Colo.)

No abstract submitted.

Poster

(1) GOP AC's developments for the ultra-rapid orbit product
J. Dousa

The last three years of developments in the GOP analysis center for the ultra-rapid orbit contribution is presented. The GOP ultra-rapid orbit solution is based on the combination of the six-hour normal equation, which were saved using highly efficient and non-redundant pre-processing. The developments consisted of the problematic satellite handling (no data, manoeuveres), orbit model refinements (RPR parameters, long-arc handling, stochastic parameters), the SP3 accuracy code improvements, the ambiguity resolution, the network reconfiguration and other small routine system refinements. All the estimated parameters were improved by a factor of 3-4 within the last three years.

(2) ESOC New Developments and Innovations
T.A. Springer (ESA/ESOC), F. Dilssner (ESA/ESOC), E. Schoenemann (TU Darmstadt), I. Romero (ESA/ESOC), J. Tegedor (ESA/ESOC), F. Pereira (ESA/ESOC), J. Dow (ESA/ESOC)

Since 2006 the Navigation Support Office at ESOC has been working on its new analysis software, called Napeos, for all its activities. Although the main focus for Napeos was GNSS processing the developments kept the SLR and Doris processing capabilities intact. The development was completed by September 2007 at which point the software was extensively tested for its IGS operational capabilities. For that purpose the whole year 2007 was reprocessed generating a GPS only and a GPS/GLONASS combined solution. The main focus of this reprocessing was robustness of the software to ensure that it could process the full year without any malfunctioning.

After successful completion of the tests Napeos was put into operations for the ESOC IGS activities. It replaced the old software for the ESOC IGS final and IGLOS products starting with GPS week 1463 (20-January-2008). Next followed the ESOC rapid products on day 2 of GPS week 1469 (4-March-2008). The Ultra-rapid products were replaced starting with the solution of 18 hours, on day 2 of GPS week 1471 (18-March-2008). Our poster will highlight the significant improvements of the quality of the ESA IGS contributions. The key features of the Napeos IGS analysis are:

- Full IERS 2003 compliance
- Undifferenced GNSS processing. GPS, GLONASS, ***and*** Galileo
- Non-overlapping processing using 24-hour solutions
- No day boundary continuity constraints
- Fast!!! (Final orbit solution takes 30 minutes using 100 stations on a Linux PC with Intel Fortran compiler)

Currently for improving our IGS products we are focussing on the following themes:

- Earth albedo and infra-red radiation modelling
- Orbit predictions to improve the Ultra-rapid orbits
- Normal equation stacking for longer (GLONASS) arcs.
- Effects of network geometry and number of stations

ESOC is heavily involved in LEO precise orbit determination (POD), especially ENVISAT and METOP-A. ENVISAT POD is based on SLR and Doris tracking whereas METOP-A is based on GPS tracking. With the IGS results and the comparisons of the LEO orbits we have demonstrated the Napeos is fully state of the art in these areas. This implies that we could use Napeos also to become an analysis centre for the IDS and ILRS. We are currently studying the efforts required regarding joining these technique services. In particular we are interested in contributing a TRF solution from each of these three techniques for the upcoming ITRF realisation.

(3) Progress at the United States Naval Observatory Analysis Center
Christine Hackman (USNO), Paul Barrett (USNO), Victor Slabinski (USNO), Jeffrey Tracey (USNO), William Wooden (USNO)

The United States Naval Observatory (USNO) has participated in the International GNSS Service as an analysis center since 1997. This report will summarize the quality and consistency of our rapid and ultra-rapid products, with emphasis on areas of improvement. We will also outline developments underway designed to enhance our offerings in the future.

(4) Usage of the UT1-like Quantity UTGPS at the United States Naval Observatory
Jeffrey Tracey (USNO)

USNO produces a daily UT1-like quantity called UTGPS. Propagated GPS satellite orbits are compared to observed IGS combined Rapid Product orbits. This yields an angle, converted to a UT1 difference, between the nodes of the two series of orbits. This angle is added to the observed value for UT1 from the previous day to produce a UT1-like quantity, UTGPS, for the current day. The propagated orbits are obtained using GIPSY/OASIS II with gravitational accelerations from standard models. Empirical models of solar radiation pressure are used to estimate acceleration of the orbit normal. UTGPS is used routinely in the USNO's (IERS RC/PC) combination of UT1-UTC.

(5) Activities at the CODE Analysis Center
S. Schaer, R. Dach, M. Meindl, H. Bock, A. Jäggi, S. Lutz, L. Ostini, L. Prange, A. Steinbach, D. Thaller, P. Walser, G. Beutler

An overview of the analysis activities at CODE will be given. Specific issues relevant to the IGS are addressed.

(6) CODE's New High-Rate GPS Clock Product
H. Bock, R. Dach, S. Schaer, M. Meindl, G. Beutler

IGS rapid and final GPS clock products traditionally include clock corrections at intervals of 5 minutes. On January 24, 2004 (start of GPS week 1255), CODE started to contribute with high-rate clock products with a sampling of 30 seconds. For all applications depending on 1-Hz tracking data, (interpolated) 30-second clock corrections are no longer sufficient for highest quality requirements. As a consequence of this, we started to densify our 30-second results to 5 seconds using an efficient algorithm based on epoch-differenced phase observations from the IGS 1-Hz tracking network.

(7) Representation of the Earth Rotation Parameters
U. Hugentobler

Currently CODE's Earth rotation parameters are excluded from the IGS ERP combination because the daily piece-wise representation of the time evolution of the pole parameter is introducing a smoothing at frequencies around one day. The combination has to take care that products delivered to the combination adhere to the same standards in order to get an interpretable combination product. Alternative ways of ERP representation nevertheless need to be studied and discussed. The poster intends to evaluate piecewise linear representations and to address pros and cons.

(8) Recent Developments and Plans from the JPL Analysis Center
S. Desai (JPL), W. Bertiger (JPL), B. Haines (JPL), D. Kuang (JPL), M. Miller (JPL), C. Lane (JPL), F. Webb (JPL), J. Weiss (JPL)

We present an overview of the recent developments in the processing of global GPS data at the Jet Propulsion Laboratory IGS Analysis Center. We also describe changes that we will implement before we begin to reprocess these data for our submission to the IGS reprocessing campaign. We detail the resulting improvements in accuracy of the primary products, namely the estimates of the precise GPS orbits and clocks, Earth orientation parameters, and zenith troposphere at the GPS sites, as well as the impact on various geodetic and orbit determination applications. We also provide details of the changes to the models and capabilities of the GIPSY-OASIS software system, particularly with regards to the new capabilities of the version 5.0 release of GIPSY.

(9) Improvements in Analysis of Large GPS Networks at JPL
S. Owen (JPL), F. Webb (JPL), B. Newport (JPL), D. Dong (JPL), A. Moore (JPL), S. Kedar (JPL)

No abstract submitted.

(10) An Improved Empirical Model for the Effect of Long-Period Ocean Tides on Polar Motion
R. Gross (JPL)

The second-degree zonal tide raising potential, which is responsible for tidal changes in the Earth's rotation rate and length-of-day, is symmetric about the polar axis and hence can excite the Earth's polar motion only through its action upon nonaxisymmetric features of the Earth like the oceans. Ocean tides excite polar motion in the diurnal, semidiurnal, and long-period tidal bands. Here, ocean tidal excitation of polar motion in the long-period tidal band, specifically at the Mm (monthly), Mf (fortnightly), and Mt (9-day) tidal frequencies, is studied. Spectra of observed polar motion excitation functions exhibit peaks at the prograde and retrograde fortnightly tidal frequencies. In fact, except at seasonal and longer periods, these are the largest peaks in the observed spectra after atmospheric and nontidal oceanic effects are removed from the observations. An empirical model for the effect of the monthly, fortnightly, and 9-day ocean tides upon polar motion excitation is obtained by least-squares fitting periodic terms at these tidal frequencies to observed polar motion excitation from which atmospheric and nontidal oceanic effects have been removed. The resulting empirical model is compared with predictions from hydrodynamic ocean tide models.

(11) GNSS Data Analysis in GAPS, the GPS Analysis and Positioning Software, Using IGS Products

R. F. Leandro (UNB, Trimble), R. B. Langley (UNB), M. C. Santos (UNB)

Precise point positioning (PPP) is becoming a popular technique for determining point coordinates using a GPS (Global Positioning System) receiver. In this technique, observations produced by a single receiver are used to determine the three coordinate components, as well as other parameters, such as the receiver clock error and total neutral atmosphere delay. The technique is said to be "precise" because precise information, such as satellite orbits and clock errors, is used in the data processing. More than that, it’s also precise because the resulting position coordinates are precise (and accurate).

The idea behind our present work is that PPP software, together with the required precise products such the ones provided by the International GNSS Service (IGS), can be used not only for positioning, but for a variety of other tasks, such as signal analysis. The fact that the observation model used for accurate error modeling has to take into consideration the several effects present in GPS signals, and that observations are undifferenced (in its pure form, there are no differences between receivers nor between satellite measurements), makes PPP a powerful data analysis tool which is sensible to a variety of parameters. The PPP application developed at UNB (University of New Brunswick), called GAPS (GPS Analysis and Positioning Software), has been designed and built in order to take advantage of precise products, resulting in a data analysis tool for determining parameters other than position, receiver clock error, and neutral atmosphere delay. These other estimated parameters include ionospheric delays, code biases, satellite clock errors, and code multipath among others. In all cases, the procedures were developed in order to be suitable for real-time as well as post-processing applications. The package has been configured to accept an observation file in RINEX 2.10 or 2.11 format, and there is an ongoing effort to introduce also RINEX 3.00 capabilities to the software. GAPS currently handles GPS observations only, L2C-signal inclusive, and it is being re-designed and re-written in order to better handle other types of GNSS data (Galileo, GLONASS, and GPS L5). Necessary IGS product files for processing the observations are automatically retrieved from one of the IGS global data centers. Each of the data analysis outputs listed above will be discussed in the poster.

GAPS is also available on line via a web interface, which can be easily run from anywhere. In addition to signal analysis outputs, GAPS provides state-of-art PPP results, including position, receiver clock errors, and neutral atmosphere delays, from static (batch) or kinematic (epoch-by-epoch) mode processing. All aspects briefly mentioned above make GAPS a novel application, with innovations mainly in the field of GPS data analysis, available to the user community. One of the main accomplishments in GAPS development is that it takes advantage of very precise satellite products made available by IGS, coupled with a very complete observation error modeling to make possible a variety of analyses based on GPS data. In the poster, GAPS is presented as an online application available for data analysis and positioning, all procedures used in it are outlined, the innovative aspects related to each of its procedures are pointed out, and results obtained using it are presented and compared with other sources.

(12) Surface load models and validation by GPS positioning

R. Biancale (CNES), F. Perosanz (CNES), J.-C. Marty (CNES), S. Melachroinos (CNES), S. Loyer (CLS)

Load effects are due to surface mass variations and affect directly station positioning. Some of these effects are usually taken into account in station positioning (like ocean tides loading), some others not, depending on the access to load models. For instance meteorological atmospheric pressure variations are still not used generally in reference system computation; load from continental water or snow or oceanic non IB response are in the same way often neglected. However effects range from mm to cm. On one hand, we propose to discuss the way to compute load deformations. We will show some validations of modelled loading effects through PPP GPS solutions.