3.4 Technique Centres

3.4.1 International GNSS Service (IGS)

General

From its mission statement, the IGS is committed to provide the highest quality GPS+GLONASS observation data and products, openly and readily available to all user communities, as the standard for global navigation satellite systems (GNSS) in support of Earth science research, multidisciplinary applications, and education. The IGS products support scientific objectives including realization of the International Terrestrial Reference Frame (ITRF) and its easy global accessibility, monitoring deformation of the solid Earth, monitoring Earth rotation, monitoring variations in the hydrosphere (sea level, ice-sheets, etc.), satellite orbit determination, ionosphere monitoring, climatological research, and time and frequency transfer. Table 1 gives an overview of the estimated quality of the IGS core products at the end of 2005.

Table 1: Quality of the IGS Core Products as of December 2005 (for details and further products see <http://igscb.jpl.nasa.gov/components/prods.html>)

Product	IGS Final	IGS Rapid	IGS Ultra Rapid	
			Adjusted	Predicted
Updates	Weekly	Daily	Every 6 h	Every 6 h
Delay	~13 days	17 hours	3 hours	Real-time
Orbits	2cm	3 cm	< 5 cm	<10 cm
Satellite Clocks	0.05ns	0.1 ns	~0.2 ns	~5 ns
Station Clocks	0.05ns	0.1 ns		
Polar Motion	0.05 mas	<0.1 mas	0.1 mas	
LOD	0.02 ms/day	0.03 ms/day	0.03 ms/day	
Station Coordinates (h/v)	3 mm / 6 mm			

Tracking Network

In 2005 another 8 sites were added to the IGS network reaching now a total of 379 sites (<http://igscb.jpl.nasa.gov/network/netindex.html>). This is the first decrease ever from 383 in 2004, due to a shift in policy to require a demonstrated benefit to a product or project, not just meeting the operational requirements of the IGS, in order to admit a station to the IGS network. In addition to the usual data transfer in daily batches, more than 200 sites (see Fig. 1) have already set up an hourly data transfer to support the IGS Ultra Rapid products and products for e.g. regional applications of various user groups, especially for near-real time tropospheric and ionospheric monitoring. A network of high-rate stations supporting Low Earth Orbiter missions (like CHAMP and GRACE) is also available for the scientific user community.

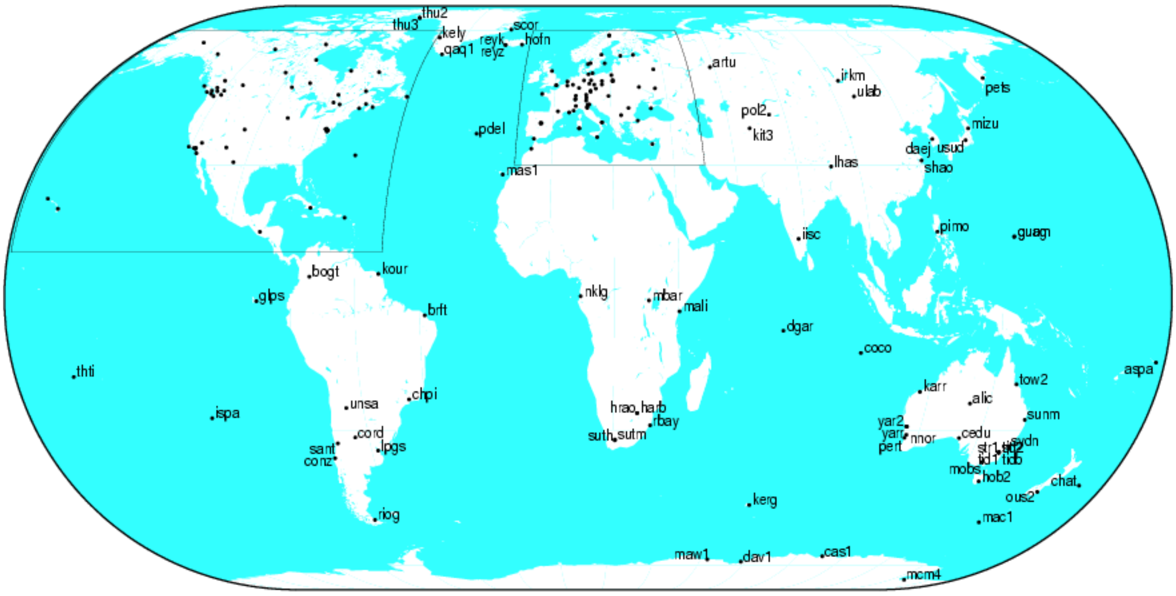


Fig. 1: IGS tracking network with hourly stations

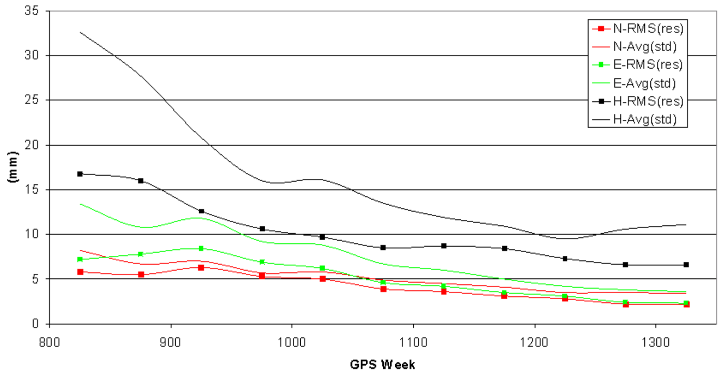
IGS contribution to ITRF2005

Weekly SINEX solutions were available starting 1996 (GPS week 837) including the following information:

- from 1996/01/21 to 1999/02/27 (837 – 998): Solutions only included station coordinates.
- from 1999/02/28 to 1999/06/05 (999 – 1012): Apparent geocenter was included
- since 1999/06/06: ERPs were included

The gradual increase of the number of stations, from about 100 in 1996 to more than 200 at present, was also accompanied with an improvement of the quality of the solutions. The time evolution statistics for the North, East and Up components for the weekly station coordinates residuals show an improvement of a factor of about 4–5 between 1996 and 2005 (Figure 2). The precision is currently at 3 mm horizontally and 6 mm vertically. Several factors are contributing to this gradual station coordinate precision improvement, namely: (1) improving station hardware, (2) processing software, and (3) gradual increase in the number of stations processed.

Fig. 2: Time evolution of residuals RMS and average Standard Deviation



One recommendation of the 2004 IGS Bern workshop was to prepare an inventory of station coordinate time series discontinuities. A list of confirmed as well as a lists of probable discontinuities were prepared. The discontinuities are considered confirmed when they are present in most time series and/or can be correlated to an equipment change or a geophysical event. For events before 1996 (the start of the IGS time series), JPL and SIO were the main sources of information. The IGS station logs were also used to attempt to correlate discontinuities with equipment changes. Attempts were also made to correlate time series discontinuities with earthquakes based on data available at the USGS earthquake center. Useful feedback was also provided by Dr. Pagarette from the University of Lisbon who shared his predictions of station displacement from recorded seismic information. The EUREF and NAREF groups also provided feedback using their time series analysis. This should ensure a high degree of consistency in the applied discontinuities between the global and regional solutions. There was also feedback from IGN and DGFI following preliminary combinations. More recently, Technical University of Munich (TUM) discontinuity information derived from their reprocessed GPS solutions was also provided and compared to the existing discontinuity list and time series. Events such as temporary excursions of station coordinates were not flagged. Some short station coordinates time series were flagged for deletion. There is some subjectivity in the identification of small discontinuities, which is, to some extent, “analyst” dependant.

Analysis Issues

Last year the quality of the submitted GPS orbit products have improved significantly by several Analysis Centers (AC) so that the overall consistency among all ACs is now better than 5 cm, 7 cm and 15 cm for the GPS Final, Rapid and predicted orbits, respectively.

For the GLONASS combination the pilot phase has ended and the official products are offered since December 2004. Four ACs (COD, BKG, ESA, since August 2005 also IAC) are contributing with analysis of GLONASS microwave data and one (MCC) with the analysis of laser data for 3 satellites. The later solution is used for validation only. The names of all products were switched from IGEX (igx) to IGLOS (igl). COD is the only AC analyzing combined GPS and GLONASS data in a rigorous way. The GLONASS orbit consistency is at a level of 5 to 10 cm.

Since February 2004 the IGS official satellite and station clock products have been aligned to a new, highly stable timescale realized by an internal ensemble of the available frequency standards dynamically weighted based on their individual instabilities. Both a Rapid (IGRT) and Final (IGST) timescale are formed with latencies of about 1 day and two weeks, respectively, and both are aligned to Universal Coordinated Time (UTC). All results and a variety of associated plots can be accessed at <https://goby.nrl.navy.mil/IGStime/index.php>. In addition to their value for clock diagnostics, these products can be used to monitor the general health of GPS tracking stations. The high stability of the IGS timescale ensures that day-boundary jumps in the station clock can be detected to better than 100 ps RMS. In determining the GPS TAI time links using a new "all-in-view" technique the BIPM is utilizing the IGS clock products and the IGS timescale in particular.

Since 2004 a new IGS Final Troposphere Product, which is based on the Precise Point Positioning (PPP) technique using the official IGS Final orbits and clocks, is provided. The PPP technique allows the generation of this product for all the available stations in the global IGS network and enables also an efficient consistent reprocessing of historical data (at present the new products are available back to 2000).

The IGS is discussing a switch to absolute calibrated antennas since the IGS Workshop in Ottawa. Those absolute models for GPS receiver antennas are available since several years and show a good consistency with values of the relative models. However, to avoid a scale bias in the TRF its introduction has to be accompanied with compatible models for the satellite antennas. Such models were derived by a common effort of GFZ and TUM, and in addition compatible GLONASS models were added by CODE. It is expected that the new model will give no scale change in the TRF and especially no significant scale drift by changing satellite constellations, as it is the case with the present model. Because any change in antenna parameters may have a significant impact on derived station heights, those changes have to be prepared very carefully. At the same time the IGS will start to apply the available radome calibrations, which will result in station coordinate changes too. Since June 2005 the IGS is running a test campaign for the new models (1) to test and validate the implementation in the software packages, (2) to study the effects on the IGS products, and (3) generate a new compatible RF. It is planned that the new absolute model will be officially adopted after the release of the ITRF2005.

The IGS is preparing a reprocessing of historical GPS data. A working group was established (1) to define the scope of the products and the data span to be included, (2) to work out a guideline for the processing strategies and standards, and (3) to call for participation and encourage involvement from the user community. The project will start after the adoption or the new absolute antenna model and the release of ITRF2005. Part of the project is an effort to complete the raw RINEX data archives.

Summary

In 2005, as in the previous years, the IGS contributed significantly to the IERS activities like maintenance and extension of the International Reference Frame and in the highly-accurate, daily-sampled Earth Rotations Parameters. The quality of the IGS products has further improved. The IGS is preparing for two major activities, the transition from the relative to the absolute antenna phase center models and the reprocessing of historical IGS data. For more detailed information on further IGS activities visit the web site at the Central Bureau at JPL (<http://igscb.jpl.nasa.gov>) or the Analysis Coordinator web pages at GFZ (<http://www.gfz-potsdam.de/igsacc>).

References

2003-04 Technical Report. IGS Central Bureau, eds. Pasadena, CA: Jet Propulsion Laboratory, 2005.

2003-04 Annual Report. IGS Central Bureau, eds. Pasadena, CA: Jet Propulsion Laboratory, 2005.

These documents are also available electronically at <http://igscb.jpl.nasa.gov/overview/pubs.html>.

Gerd Gendt, Angelyn Moore, Remi Ferland