3.4 Technique Centres

3.4.1 International GNSS Service (IGS)

General

The International Global Navigation Satellite System Service (IGS) is a federation of more than 200 world-wide agencies and institutions that pool resources and expertise to provide the highest quality GNSS data, products, and services to support high-precision applications of Global Navigation Satellite Systems (GNSS). It is a service of the International Association of Geodesy (IAG), one of the associations of the International Union of Geodesy and Geophysics (IUGG).

The IGS operates a global network of GNSS tracking stations, data centers and data analysis centers to provide data and derived data products that are essential for Earth science research, multidisciplinary positioning, navigation and timing (PNT) applications and education. The IGS is committed to providing the highest quality GNSS observation data and products freely to scientific user communities. The IGS products include GNSS satellite ephemerides, Earth rotation parameters, global tracking station coordinates and velocities, satellite and tracking station clock information, zenith tropospheric path delay estimates, and global ionospheric maps. 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.), scientific satellite orbit determination, ionosphere monitoring, climatological and weather research, and time and frequency transfer.

IGS Status and Activities in 2007

Tracking Network

A total of 13 new stations were added to the IGS network in 2007, and 9 were decommissioned, resulting in the 384 stations depicted in Figure 1. Most of these return observation data on an hourly or more frequent basis, and 115 of these return data in near real time. The network supports multiple requirements for diverse applications. Many IGS stations are co-located with other geodetic techniques to promote combination and inter-comparisons of products and systems. 132 stations are designated as “reference frame stations” that consistently contribute to the IGS ITRF computations, and 134 stations are co-located with external high-precision frequency standards and are used in generating the IGS clock products. A subset of the network provides meteorological data useful for ground-based precipital water vapor measurements. All station data and products are available freely to users from four global data centers and additional regional and operational data centers. A breakdown of the stations used by the principal applications and collocations with the other geodetic techniques is shown in Table 1. A complete list-

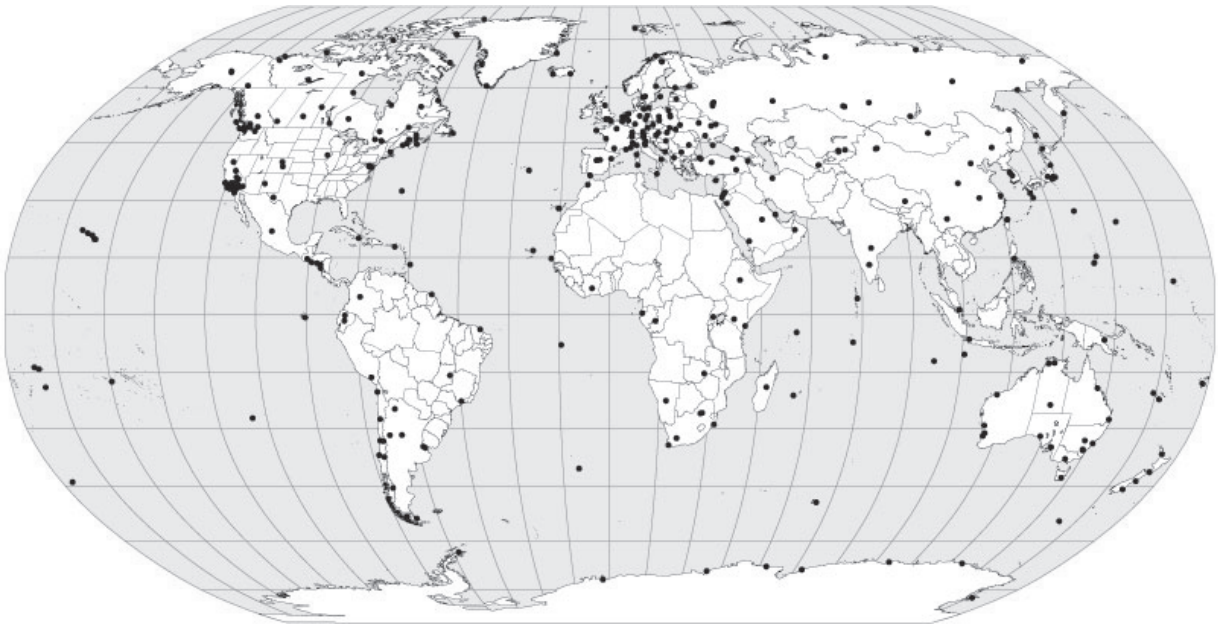

Fig. 1: IGS Global Tracking Network provides high quality tracking data used in support of diverse applications, including contributing to the realization of the ITRF.

ing of IGS network stations and related information can be found online at <http://igs.org/network/netindex.html>.

Table 1: Breakdown of stations by principal applications and co-location with other geodetic techniques.

Total Stations	**384**
Reference Frame	132
Clock Products	134
Multi GNSS (GPS+GLONASS)	84
Sub Hourly	240
Real-time	95
Co-Locations:	
VLBI Co-located	25
SLR Co-located	35
DORIS Co-located	54
Tide Gauge Co-located	103

Data Product Quality

Table 2 gives an overview of the estimated quality of the IGS core products at the end of 2007. Details related to the IGS products can be found online at <http://igs.org/components/compindex.html>.

A number of quality evaluations of the IGS products can be found in the Products section of the IGS Analysis Coordinator web site at <http://acc.igs.org/>.

Table 2: Quality of the IGS Core Products

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	2 cm	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)	2 mm / 6 mm			

Improvements to the IGS Combined Products

The IGS Analysis Centers (see <http://igs.org/organization/centers.html#ac>) have steadily improved their precision and consistency during 2007. The combined and rapid orbit quality is depicted in Figures 2 and 3, which agree at a level of 7 mm.

Other notable items in 2007 related to the combined products include:

- Since GPS week 1406 (17-Dec-2007) the combined clock products are provided with a sampling rate of 30 s in addition to the usual 5-min products (*.clk; *.clk_30s). Three ACs (COD, JPL, MIT) are providing clock solutions with a 30 second sampling rate.
- Starting GPS week 1411 (21-Jan-2007) the absolute antenna phase model was used in the older Bernese 4.3 version (only offsets for satellite and elevations for station antennas) to generate the so-called Precise-Position-Navigation (PPN) tables in the combination summary files (for weeks 1400 to 1410 the old relative model was still used).
- The AIUB group has supported the introduction of the new Bernese 5.0 into combination procedures by developing a long-arc routine for Bernese 5.0 as needed by IGS combination analysis. The Bernese 5.0 software was implemented at GFZ in September 2007. The new software has been used in routine generation of the IGS combined products since GPS week 1446 (23-Sep-2007). It has now been transferred to NGS for use in the ACC activities there.

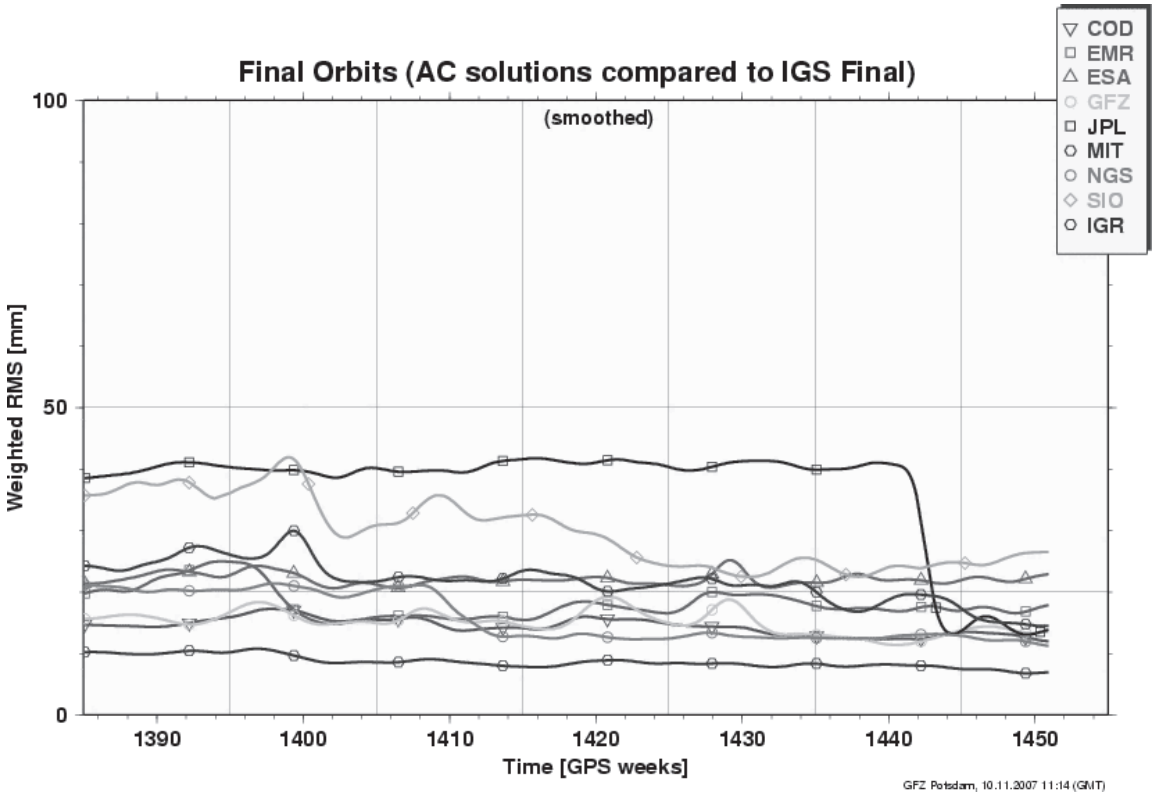

Fig. 2: Weighted RMS differences of all AC's and IGS final orbits to the IGS final combined orbit.

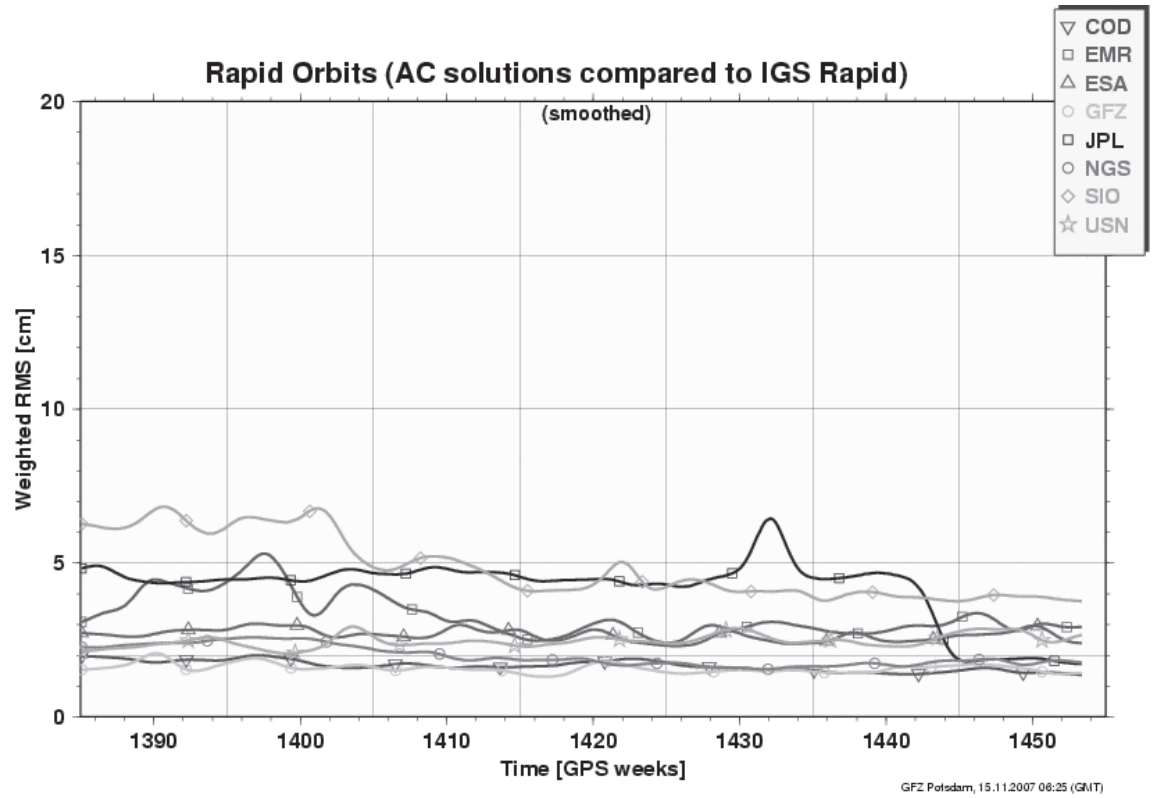

Fig. 3: Weighted RMS differences of all AC's rapid orbits to the IGS rapid combined orbit.

- The JPL weekly solutions were used for comparison only (excluded from the combined SINEX products) between GPS week 1400 and 1444. The JPL solution was reintroduced on GPS week 1445 as issues that caused inconsistent performance were resolved. Antenna height inconsistencies were corrected by JPL concurrently.
- The combined weekly SINEX solutions have progressed from about 250 stations at the beginning of the year to about 280 stations (Figure 4). The number of reference frame stations was about 120 at the beginning of the year and is now about 110 stations. Most of the ACs station processing increase came from the MIT and NGS weekly solutions. Starting with GPS week 1435 the number of stations reported by MIT increased from about 150 to about 250. Similarly, starting with GPS week 1428, the NGS solution increased from about 170 to 200.

IGS Reprocessing Campaign

The reprocessing of all historical data since 1994 has proceeded at early stage in 2007. The plan is to apply the newest analysis conventions consistently over the whole time series to resolve inconsistencies caused by many model and parameter changes in the past, especially by the introduction of the absolute antenna model in 2006.

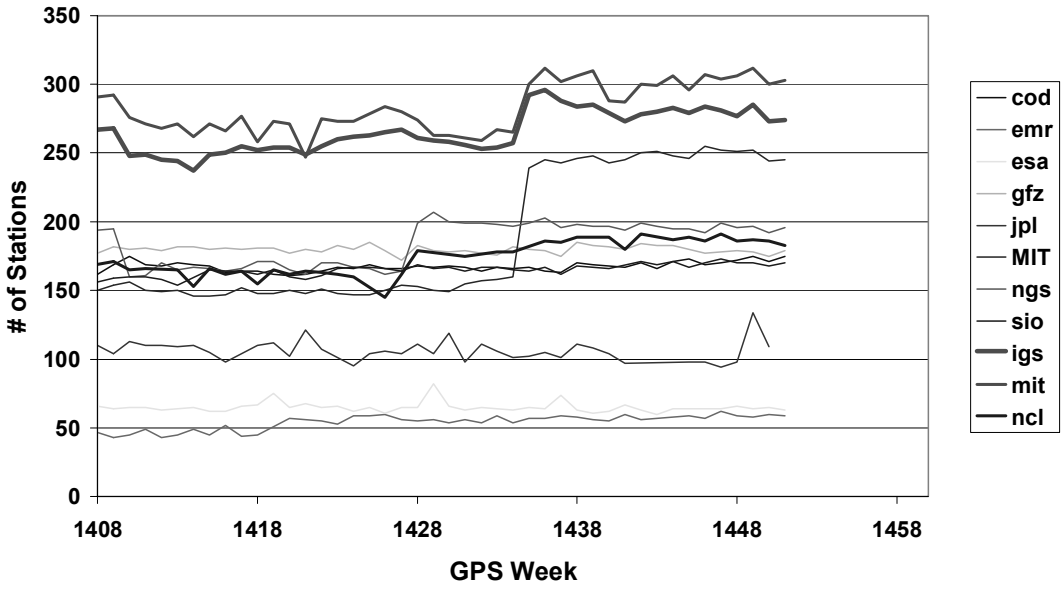

Fig. 4. Number of stations processed by Analysis Centers on a weekly basis in 2007.

In 2007, a reprocessing test campaign (GPS weeks 1042 to 1059 in early 2007) was analyzed by ESA, MIT, NGS, SIO, PDR and GFZ, and included more than 300 stations. The combination results for the station coordinates and orbit/clock/ERP revealed that there are still some issues to be resolved. An additional issue to be resolved is the lack of ACs providing clock solutions in the reprocessing campaign. Currently only ESA and MIT are providing clock solutions.

Analysis Center Coordinator Transition

The IGS Analysis Coordinator responsibility has been handed-off from GFZ to NGS, with the transition of the combination software completed by the end of 2007. Implementation of Bernese 5.0 software was required as an initial step, as the previous version was no longer being supported. The entire combination software, including all FTP (in and out) and web presentation tools, were installed on NGS hardware in November 2007, and NGS and GFZ systems were run in parallel for a one-week test period where identical results were produced by both systems. Integration of the IGS analysis within the NGS environment is being completed at end of year anticipating that the official IGS product will be generated at NGS starting end of January 2008. The GFZ processing will continue in parallel as back up until deemed unnecessary. GFZ will also continue to perform the combination for the reprocessing campaign for the foreseeable future.

Summary

Throughout 2007, the IGS has continued its delivery of high quality products to the IERS. The quality of the IGS results continues to improve, as analysis methodologies are constantly being refined and historical data reprocessed. The IGS is continuing its reprocessing campaign to strengthen its historical contribution to the realization of the ITRF. More information regarding the IGS and related activities can be found on the IGS Central Bureau web site <http://www.igs.org/> or at the Analysis Center Coordinator web site <http://acc.igs.org/>.

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