3.4 Technique Centres

3.4.1 International GNSS Service (IGS)

The International Global Navigation Satellite System Service (IGS) is a federation of more than 200 organizations from around the world that pool resources and expertise to provide the highest quality Global Navigation Satellite Systems (GNSS) data 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. These products contribute to IERS objectives of realizing the International Terrestrial Reference Frame (ITRF) and monitoring Earth orientation parameters. The IGS is a service of the International Association of Geodesy (IAG), one of the associations of the International Union of Geodesy and Geophysics (IUGG). This report highlights IGS activities of interest to the IERS during 2008–09.

IGS Tracking Network

At the end of 2009, the IGS network consists of 420 GNSS tracking stations that meet strict quality standards required to be included in generating IGS products. 132 of these were used in realizing the IGS05 reference frame, typically the oldest stations with long-term stable position time series. Of concern to the IGS reference frame product is that only 73 of the 132 used in IGS05 are still suitable for using in the reference frame solutions. A gradual decrease in the IGS05 stations is the result of equipment changes, seismic events, decommissioning, or in some instances, unknown reasons casing discontinuities in the position time series. New procedures for upgrading reference frame stations will be included in the next revision of IGS site guidelines to improve traceability as station equipment is upgraded. 93 stations have the capability to track the GLONASS satellites and contribute to generation of the GLONASS orbit product, though the GLONASS satellites have so far not been used in the IGS reference frame product. More GLONASS capable stations are urgently needed for this activity. Most stations return observation data on an hourly or more frequent basis to support the generation of the IGS rapid and ultra rapid products, which allow low latency access to the IGS reference frame. 120 IGS stations stream data in near real time to support of the real-time pilot service. The number of IGS stations that are co-located with other geodetic techniques to promote combination and inter-comparisons of products and systems has remained unchanged, and concerns over accuracy of the tie surveys remains, though is being addressed through the GGOS Bureau for Network and Communications where IGS participates.

134 stations are co-located with external high-precision frequency standards and are used in generating the IGS clock products and 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 and Figures 1–4. A complete listing of IGS network stations and related information can be found online at <http://igs.org/network/netindex.html>.

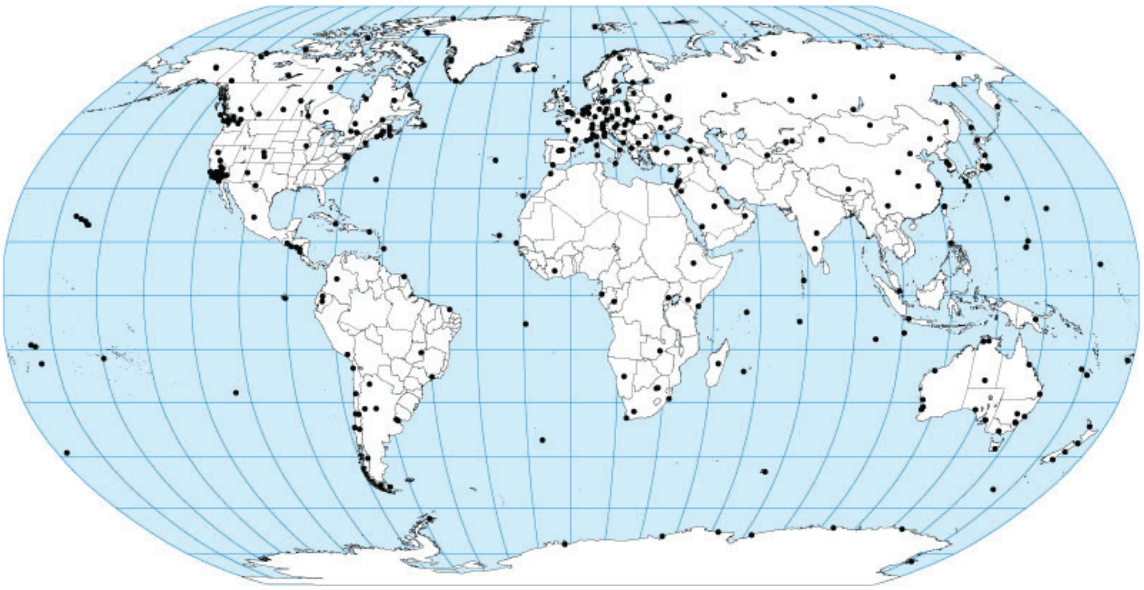

Fig. 1: IGS Global Tracking Network provides high quality tracking data used in support of diverse applications, including contributing to the realization of the ITRF.

Table 1: Summary of IGS station capabilities.

Total Stations	420
Reference Frame Stations	73
VLBI Co-located	25
SLR Co-located	37
Doris Co-located	55
Timing Lab Stations	80
Tide Gauge Project Stations	103
Multi GNSS (GPS/GLONASS)	93
Real-time Project Stations	120

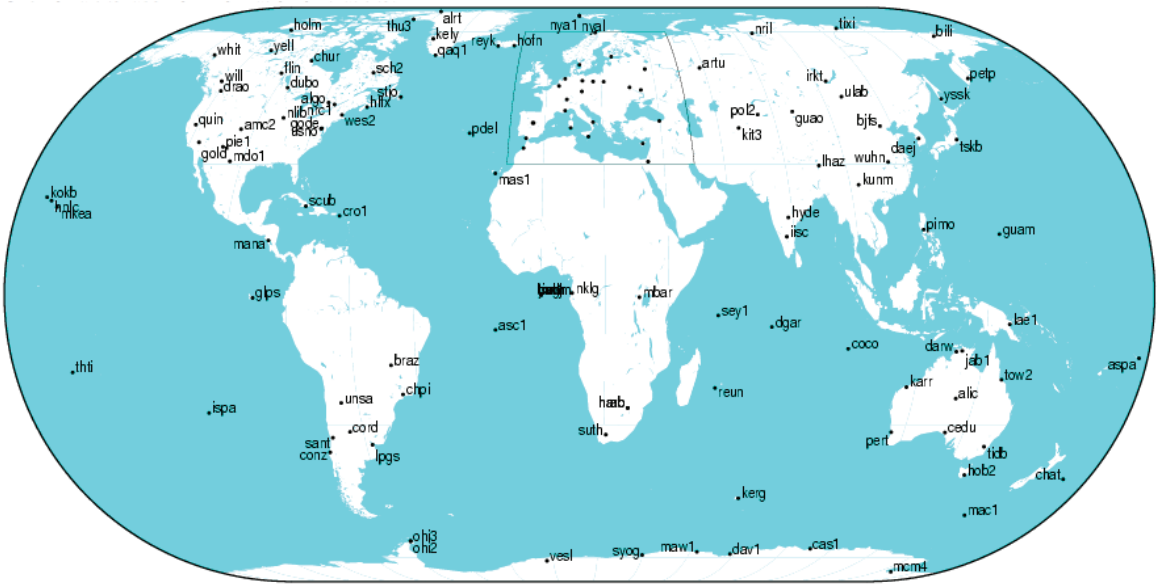

Fig. 2: IGS stations used in the realization of the IGS05 reference frame.

Fig. 3: IGS stations capable of tracking GLONASS satellites.

Quality of IGS Products

The IGS Analysis Centers (see <http://igs.org/organization/centers.html#ac>) have continued to improve product precision and consistency. Table 2 gives an overview of the estimated quality of the IGS core products at the end of 2009.

The combined and rapid orbit quality is depicted in Figures 4 and 5, which agreed at a level of approximately 3 mm at end of year 2009. Details related to the IGS products can be found on the

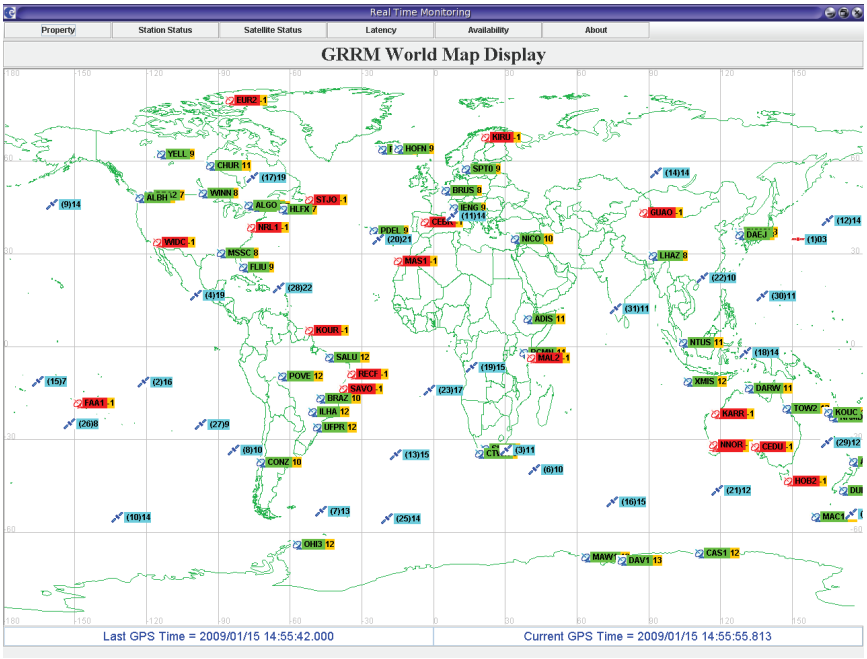

Fig. 4: Real time pilot network.

IGS web site (see <http://igs.org/components/compindex.html>). Various evaluations of the IGS product quality can be found in the Analysis Coordinator section of the IGS website (see <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
GPS Orbits	2.5 cm	2.5 cm	3 cm	5 cm
GPS 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			
GLONASS Orbits	5 cm			

Delivery of IGS SINEX Products

Weekly IGS SINEX products and related routine activities continued to be delivered on time with the support of M. Pirazewski (emr). Eight Analysis Centers (ACs) (cod, emr, esa, gfz, jpl, mit, ngs, and sio) have contributed weekly SINEX products (for acronyms see <http://igs.org/organization/centers.html#ac>). Two Global Network Associates Analysis Centers (GNAACs) (mit, ncl) have also continued to contribute independent combinations. Station coordinates are estimated for all of the IGS stations by the different ACs, with approximately 350 stations used in the weekly

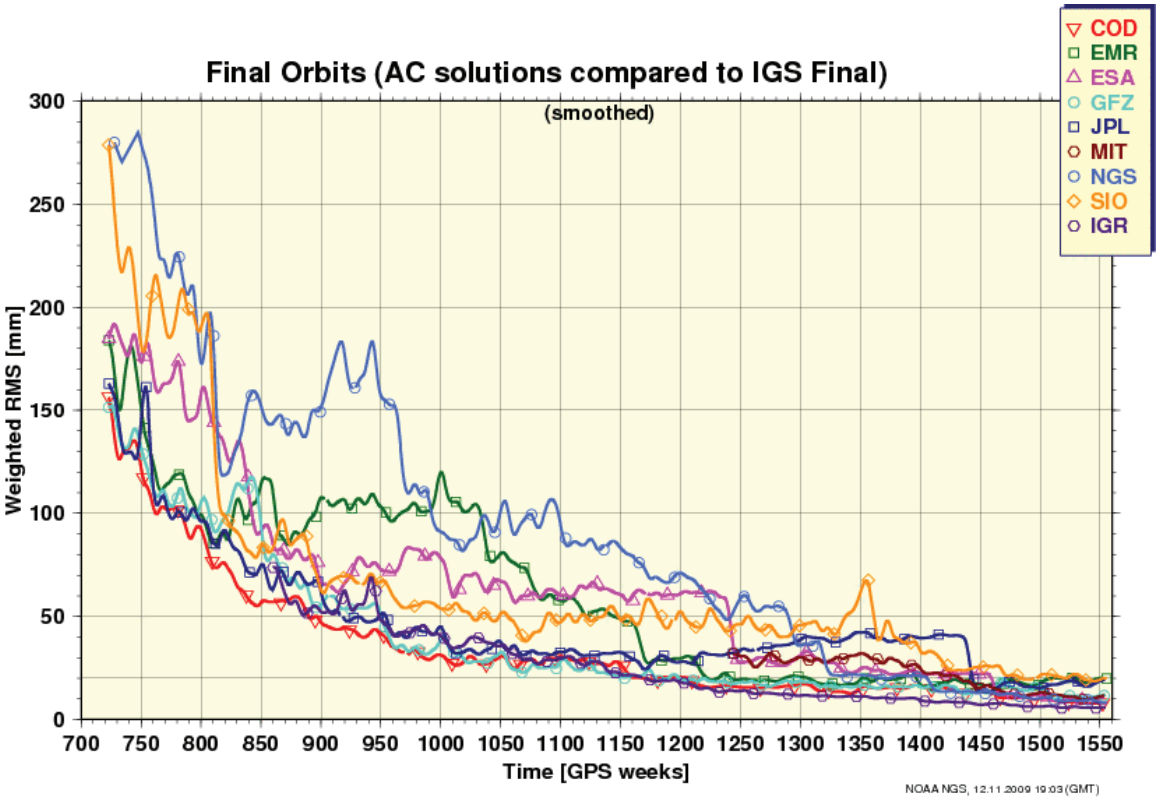

Fig. 5: Weighted RMS differences of all ACs and IGS final orbits to the IGS final combined orbit.

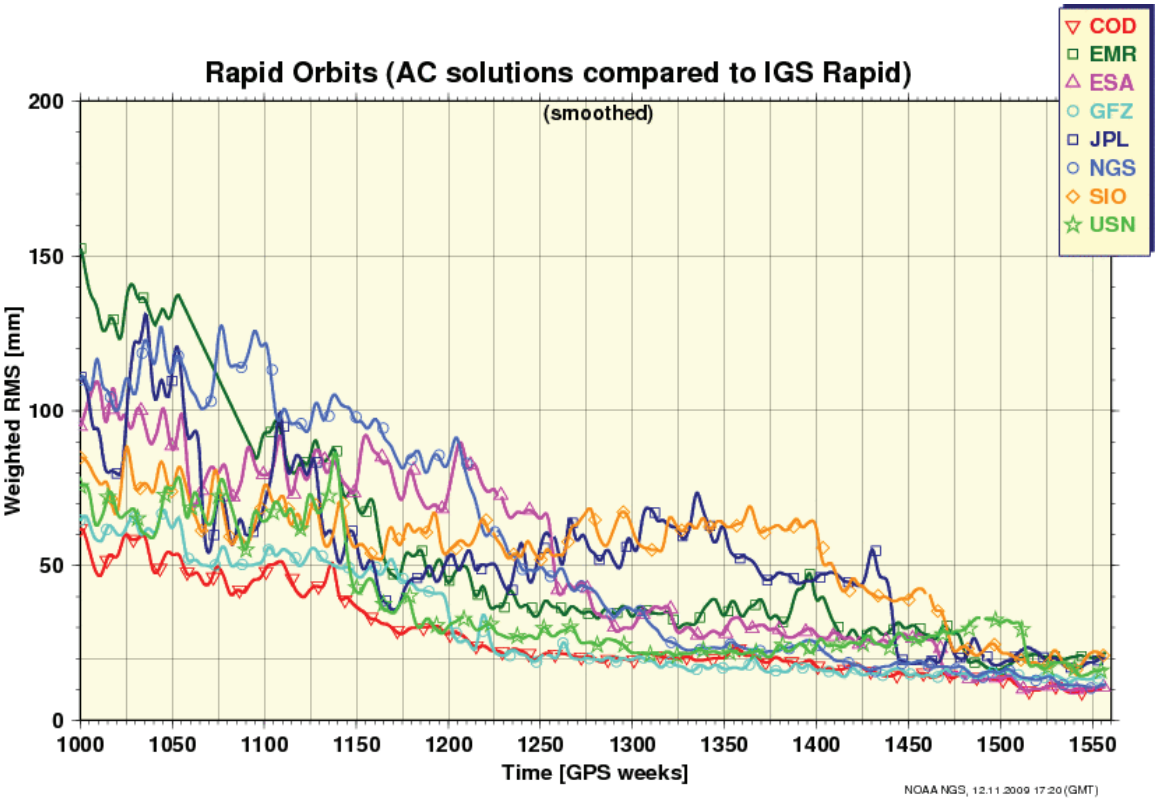

Fig. 6: Weighted RMS differences of all ACs' rapid orbits to the IGS rapid combined orbit.

combined products. Since 2008, the number of stations provided by the ACs increased at a rate of about 2 per month, though as previously mentioned, discontinuities or outages at core stations used in IGS05 is of concern that should be addressed in order to preserve the time series of these stations for as long as possible. The weekly IGS SINEX products include station coordinates, earth rotation parameters and apparent geocenter. The internal consistency of the SINEX products has been stable. The AC coordinates residuals with respect to the weekly combined product have standard deviations of 1–2mm and 3mm in horizontal and vertical components respectively. The AC pole position and rates are consistent at approximately 0.03 mas and 0.05–0.10mas/d with respect to the IGS weekly combined. The ACs weekly apparent geocenter estimates is consistent in X&Y at 3–4 mm and in Z at 7mm. The combined weekly IGS apparent geocenter is generally within 1cm of the ITRF05 origin. Several stations experience seasonal fluctuations mainly in the height component of up to several mm.

Reprocessing

Reprocessing has been a principal task of the ACs for the past several years. The main objective is to provide fully consistent IGS products, going back to 1995. Most of the IGS components have been involved in this activity, from the addition of several station data sets, to ensuring that the ACs use consistent models. A test campaign using data from GPS weeks 1042 to 1060 (1999/12/26 to 2000/05/06) was selected and all the ACs were invited to participate. 5 ACs (esa, mit, ngs, pdr, sio) contributed weekly solutions. The original combination included the station coordinates, the Earth Rotation Parameters (ERPs) and the implicit apparent geocenter. Feedback was provided to the ACs and a number of issues were resolved. For the few issues that weren't resolved, affected parameters were removed from the combination. The ACs software models and processing strategy was to be identical for the reprocessing (1995 – 2007) and production (since 2008) to ensure fully consistent IGS products. As several ACs did not contribute solutions to the original test period, additional checks were made as new ACs started contributing to the reprocessing effort. As of the beginning of 2009, 11 ACs (cod, emr, esa, gfz, gtz, jpl, mit, ngs, pdr, sio, ulr) were contributing independent solutions to the reprocessing. Some ACs have also resubmitted improved reprocessed solutions. Gfz and ulr were specifically contributing GPS stations in the vicinity of tide gauges as part of their global contribution and the TIGA working group. Ncl also provided independent combination of the ACs station coordinates. Station coordinates time series were reviewed; several discontinuities were added while others removed. The reprocessed solutions for years

between years 1997 and 2007, and the productions solutions for year 2008-2009.5 have been preliminarily prepared for ITRF2008.

Succession of Reference Frame Coordinator

The responsibility for generating the IGS reference frame product will transition from Natural Resources Canada to Institut Geographique National (IGN), France in the beginning of 2010.

Summary

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 (see <http://www.igs.org/> and <http://acc.igs.org/>).

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