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 operate a cooperative global infrastructure to provide the highest quality Global Navigation Satellite System (GNSS) data products for scientific, educational and commercial use. 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). It is also a service of the World Data System of the International Council for Science (ICSU/WDS).

The IGS data products are freely available to all users. They include GNSS satellite ephemerides, Earth rotation parameters, global tracking station coordinates and velocities, satellite and tracking station clock information, zenith troposphere path delay estimates, and global ionosphere information. These products contribute to IERS objectives of realizing the International Terrestrial Reference Frame (ITRF) and monitoring Earth orientation parameters.

This report highlights IGS activities of interest to the IERS during 2011.

IGS Tracking Network

At the end of 2011, there were 436 GNSS tracking stations within the IGS network (Figure 1). Approximately 70% of these provide data on a weekly or more frequent basis and are included in IGS weekly combination solution.

A number of IGS stations are co-located with other geodetic techniques to promote combination and inter-comparisons of products and systems. The number of these has remained unchanged since 2010; 25 stations are collocated with VLBI, 37 with SLR, and 55 with DORIS. Accuracy of the tie surveys between the different observing systems remains a limiting factor in the ITRF realization. This is being addressed within the International Association of Geodesy, Global Geodetic Observing System (IAG/GGOS) Bureau for Network and Communications (BNC) and by a number of IGS participating agencies.

Many IGS Network stations have multiple capabilities to support a range of applications. 141 stations deliver GLONASS data in addition to GPS to support the generation of the IGS GLONASS orbit product. 134 stations are co-located with external high-precision frequency standards and are used in production of the IGS clock products. A subset of the network provides meteorological data used in the generation of the IGS troposphere product. Many IGS stations provide data in real-time to support emerging low latency applications.

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

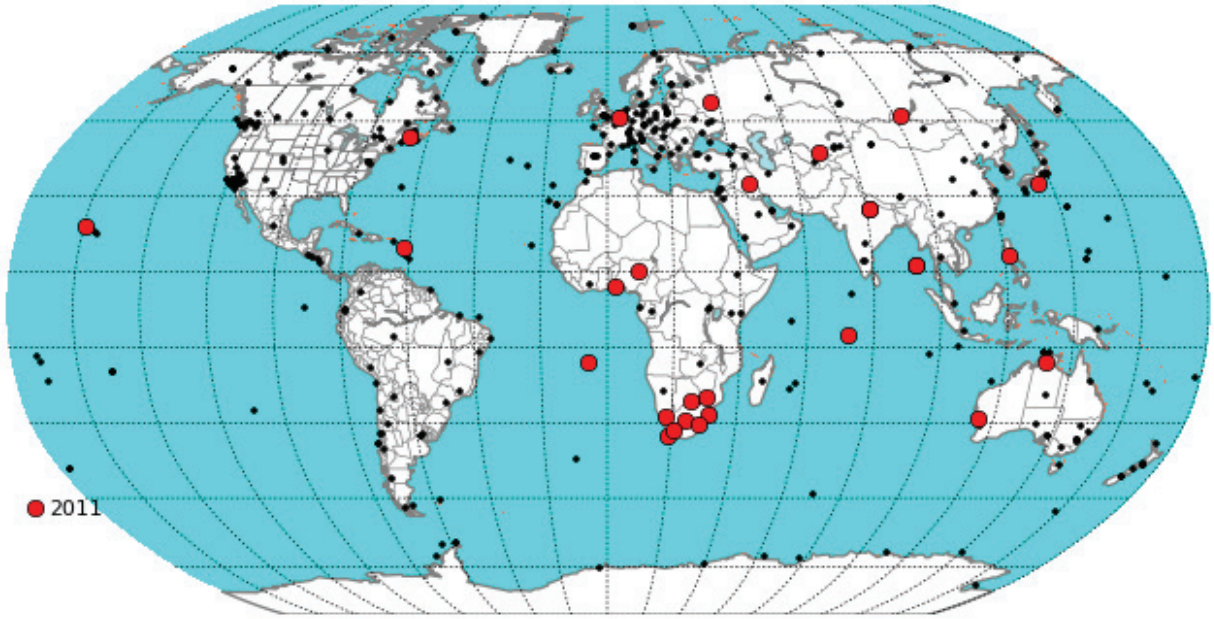

Fig. 1: IGS Global Tracking Network as of December 2011. New stations introduced during 2011 are depicted in RED.

IGS Products Quality

The IGS Analysis Centers (see <http://igs.org/organization/centers.html#ac>) have continued to improve product precision and consistency. Table 1 gives an overview of the estimated quality of the IGS core products at the end of 2011.

Table 1: Quality of the IGS core products at end of 2011.

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	2.0 cm	2.5 cm	3 cm	5 cm
GPS Satellite Clocks	0.05 ns	0.1 ns	~0.2 ns	~5 ns
Station Clocks	0.05 ns	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			

IGS orbit and clock quality is depicted in Figure 2, which shows a significant improvement of these products over time. Final orbits agreed at a level of approximately 2 cm at end of year 2011. Final satellite clock solutions agreed at approximately 5 ns. IGS is expecting an improved IERS diurnal and semi-diurnal EOP tide

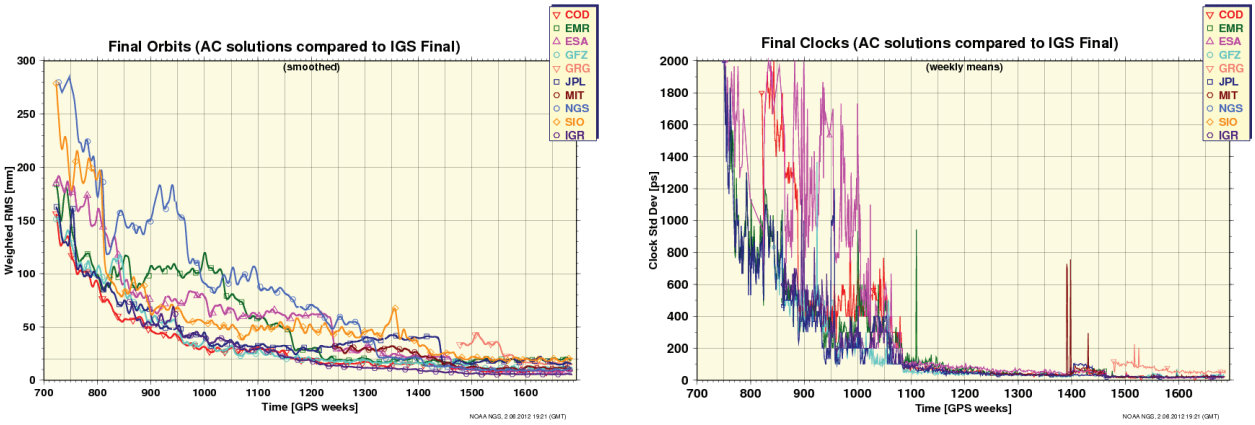

Fig. 2: (a) Weighted RMS differences of all AC's and IGS final orbits to the IGS final combined orbit. (b) Standard deviation of IGS final clock solutions.

model and is developing improved radiation pressure models in order to further improve orbit quality.

Historical quality of the IGS Final Earth Rotation Parameters is shown in Figures 3 and 4. The Final X and Y-Pole solutions agreed at approximately 0.05 mas in 2011. The Final Length of Day Solutions agreed at approximately 0.02 ms/day.

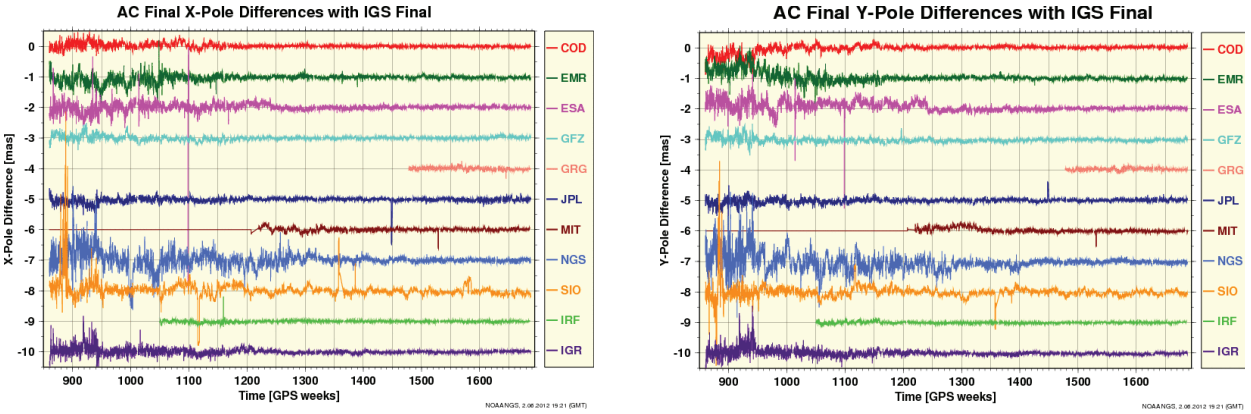

Fig. 3: (a) X-pole differences between IGS Analysis Centers. (b) Y-pole differences between IGS Analysis Centers.

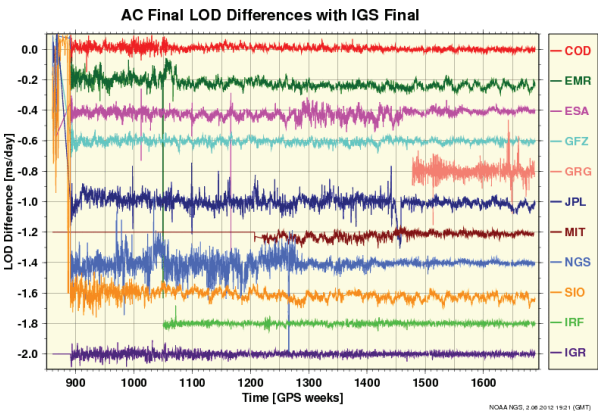

Fig. 4: Length of Day differences between IGS Analysis Centers.

Details related to the IGS products are available on the IGS web site at <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 at <http://acc.igs.org/>.

IGS08 Reference Frame Introduced

Effective April 17, 2011 the IGS adopted the new IGS08 reference frame, which is closely related to ITRF08. The IGS08 computations were based on a selected globally distributed subset of 232 well performing ITRF08 ground stations. Coincidentally, the IGS also adopted a new ground antenna calibration model (IGS08.atx) based on absolute calibration of the antennas. Satellite phase center offsets were also re-estimated based on ITRF05 to ITRF08 scale differences. Details relating to IGS08 and the IGS08.atx antenna model are contained in IGSMAIL-6354 and IGSMAIL-6355 respectively. Effects on ground station coordinates arising from the IGS05 to IGS08 datum shift, as well as the change over to the new antenna models are discussed in IGSMAIL-6356 and IGSMAIL-6401. The IGSMAIL archive is available online at <http://igscb.jpl.nasa.gov/pipermail/igsmail/>.

2010 Reprocessing Campaign Results Finalized

Results of the first IGS reprocessing campaign (Repro1) covering the period 1994–2007 were announced in April 2010 (see IGSMAIL-6136). Since that time, a number of important details have been resolved (see IGSMAIL-6445). Related product files have now been finalized and distributed to the IGS Global Data Centers for access by users. Details relating to the Repro1 Campaign are available online at <http://acc.igs.org/reprocess.html>.

Radome Experiment in Progress

Radomes at 21 IGS stations that are co located at SLR or VLBI sites have not been calibrated to IGS standards. Station operators were asked to participate in an experiment to assess the effects of these radomes by removing them for a two-month period during 2011. Four stations have been able to respond in 2011, though the experiment will continue into 2012 to allow more time for additional stations to participate. Results are anticipated in 2012.

Multi-GNSS Global Experiment (M-GEX)

A call to participate in a focused Multi-GNSS experiment was circulated in June by the GNSS Working Group (see IGSMAIL-6459 and <ftp://igs.org/pub/resource/pubs/IGS M-GEX VF.pdf>). This was developed to establish a data set of new GNSS signals, including the Russian GLONASS, the Japanese QZSS and European Galileo, available for experimentation. The project is to run from February to August 2012. Participating stations are anticipated to eventually form the core of a multi-GNSS IGS network and service. Details relating to the M-GEX project are available online at <http://igs.org/mgex/>.

Table 2: IGS Stations asked to participate in Radome Experiment.

Agency	Station ID	Antenna Type*	Radome Type	Schedule
JPL	AREQ	AOAD/M_T	JPLA	2011
JPL	CRO1	ASH701945G_M	JPLA	2011
JPL	FAIR	ASH701945G_M	JPLA	2012
JPL	GODE	AOAD/M_T	JPLA	TBD
JPL	MDO1	AOAD/M_T	JPLA	2012
JPL	SANT	AOAD/M_T	JPLA	2012
JPL	SHAO	AOAD/M_T	JPLA	TBD
JPL	TIDB	AOAD/M_T	JPLA	Not Possible
SIO	MONP	ASH701945B_M	SCIS	TBD
NICT	KGNI	ASH701945C_M	SCIS	TBD
NICT	KSMV	ASH700936E	SCIS	TBD
BKG	LHAZ	ASH701941.B	SNOW	TBD
NMA	NYA1	ASH701941.B	SNOW	TBD
NMA	NYAL	AOAD/M_B	DOME	TBD
LMV	ONSA	AOAD/M_B	OSOD	TBD
GSI	SYOG	AOAD/M_T	DOME	TBD
GSI	TSKB	AOAD/M_T	DOME	2011
GSI	TSK2	AOAD/M_T	DOME	2011
WHU	WUHN	ASH700936E	ENCL	TBD
GA	YARR	ASH701073.1	DOME	TBD
GA	YAR2	AOAD/M_T	JPLA	2012

**See IGS08.atx for antenna and radome definitions.*

Real-time Pilot Project Update

The strategy for an official IGS real-time product is being developed, and is expected to be introduced in 2012. Rational for the IGS real-time product is articulated in the statement entitled “Why Is IGS Involved in Real-time GNSS?,” which is available online at <ftp://igs.org/pub/resource/pubs/IGS_why_in_RT.pdf>.

There were 188 stations participating in the Real Time Pilot Project at the end of 2011 (see <http://igs.org:2101/home>). Real-time protocols and station standards are being addressed by Real-time Project participants in coordination with the Data Center Working Groups and the Infrastructure Committee. Standards for the real-time GNSS messages are being developed in cooperation with the Radio Technical Commission for Maritime Services, Subcommittee on Differential GNSS (RTCM/SC104), which is the principal international standards organization for real-time GNSS services.

Receiver Independent Exchange Format (RINEX)

IGS established in December 2011 a joint IGS/RTCM-SC104 RINEX Working Group chaired by IGS in order to underlined the importance of RINEX for IGS and to assume leadership in maintenance and further development of RINEX. Main tasks are the establishment of RINEX 3 as a standard for new signals and GNSS

systems, to develop and implement a transition plan to the new format and to encourage and support the development of open software tools for data handling and quality control.

Troposphere Product in Production

As of July 2011, the responsibility for the production of the IGS troposphere product has transitioned from JPL to USNO (see IGSMAIL-6443). Daily zenith path delay estimates will continue to be generated with an approximate three-week latency for all active IGS sites based on Precise Point Positioning. The resulting product files will continue to be available through the CDDIS Global Data Center at <ftp://cddis.gsfc.nasa.gov/gps/products/troposphere/zpd>.

Combination Software Upgrade

An effort to update the IGS combination software is being jointly planned by the CODE and ESOC analysis centers together with TU Vienna. The first major revision of this software since IGS began generating combination products in 1994 is envisioned to allow for Multi-GNSS product combination and to improve traceability of the IGS products and maintainability of the software. The upgrade project will be initiated in 2012 and is anticipated to take 1–2 years depending on availability of resources to complete the work.

Site Guidelines Revised

IGS Site Guidelines have been revised to reflect currently recommended best practices. The new Guidelines include procedures for upgrading station equipment, prescribing periods of operation where old and new equipment are operated simultaneously to assure that discontinuities are properly mapped. In addition, stricter antenna requirements have been introduced as recommended during the 2008 IGS Workshop, and guidelines for real-time stations were added. The IGS Governing Board has provisionally accepted the new guidelines and plans to formally adopt them by mid-2012 after comments by the broad IGS community are integrated. Once completed, the new guidelines will be posted on the IGS website.

Network Information System Improved

IGS network information systems are being upgraded to improve information content and consistency. A prototype IGS network interface, which provides better access to station data and quality control (QC) information, is now operating at <http://network.igs.org/>. In addition, site log metadata are now contained in a relational database, which is operating in parallel to the current site log system. This is already facilitating improvements in site metadata accuracy and accessibility. Network performance monitoring reports will be derived from metadata and quality control information that give an aggregate view of the network's performance, including threshold compliance with IGS guidelines, data availability and quality parameters. These will soon be available on the IGS website.

International Coordination and Outreach

The CB coordinates extensively with many external organizations to promote the IGS and develop key partnerships with participants and users. This has continued as a hallmark activity in 2011, which was highlighted by these activities:

- International Association of Geodesy/Global Geodetic Observing System (IAG/GGOS): The IGS coordinated extensively with GGOS, including participating on the Coordinating Board and within the Bureau for Networks and Communications.
- United Nations/International Committee on GNSS (ICG): Working Group D on reference frames and timing applications is chaired by the IGS CB Director. IGS representatives are participating in planning of the International GNSS Monitoring and Assessment System (iGMAS). The 6th ICG Meeting in Tokyo was attended by several IGS participants.
- International Earth Rotation & Reference Systems Service (IERS): IGS and IERS have continued to extensively cooperate in the realization of ITRF, as well as reciprocally participate on each other's Boards.
- Radio Technical Commission for Maritime Services, Subcommittee on Differential GNSS (RTCM/SC104): The IGS holds voting membership on this international standards organization for Differential GNSS.
- International Federation of Surveyors (FIG): FIG represents the single largest user community of IGS products, and is also a potential channel for extending the IGS network. IGS and FIG are coordinating to reach out to users, as well as to advocate for precision geodesy within organizations such as ICG. A number of IGS participants attended FIG Working Week in Marrakech, Morocco (May 2011).

Additionally, IGS reached out to a number of user communities by participating in scientific workshops and conferences, including: AfricaGEO in Capetown, the International Council of Science/ World Data System Meeting in Paris, the European Geophysical Union Meeting in Vienna, the International Union of Geodesy and Geophysics Meeting in Melbourne, the Institute of Navigation in Portland and the American Geophysical Union Meeting in San Francisco.

Publications and Meetings

The 2011 IGS Technical Reports containing summaries of all of the principal IGS activities will be available online by mid-2012 at <ftp://igs.org/pub/resource/pubs/2011_techreport.pdf>.

Many papers, articles and presentations relating to IGS were published or presented in 2011. A partial listing of these is available online at <http://tinyurl.com/IGS-bibli>.

A significant number of meetings and workshops were attended by IGS participants in 2011. A listing of these is available online at <http://igs.org/events/>. The next IGS Workshop will take place from July 23 to 27, 2012, at University of Warmia and Mazury in Olsztyn, Poland.

Summary The IGS has continued its delivery of high quality products to the IERS, which represent a significant contribution to the realization of the ITRF. The quality of the IGS results continue to improve analysis methodologies are constantly refined, historical data reprocessed and GNSS technologies evolve. More information regarding the IGS and related activities can be found on the IGS Central Bureau website (see: <http://www.igs.org/>).

Steven Fisher
on behalf of all IGS participants
who supported this body of work