An Overview of the International GNSS Service (IGS)

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Abstract: The Global Navigation Satellite System (GNSS) is the navigation system which provides the geographic coordinate of a particular location on the Earth irrespective of time, weather and at any conditions. The International GNSS Service (IGS) based on GNSS have more than 500 stations around the world, controlled by International Association of Geodesy (IAG). Currently, the IGS analysis centres provide the three-dimensional position and velocity solution of stations on a daily basis. These combined solutions contribute to International Terrestrial Reference Frame (ITRF). The IGS stations play a significant involvement in relative GNSS positioning. The relative GNSS positioning system is used to get the high level of accuracy of another type of GNSS stations like permanent GNSS stations, campaign mode GNSS stations. The IGS stations also contribute in the field of climate modelling, meteorology and space weather applications. The main aim of this article is to present an overview of IGS stations and its contribution in different field.

Keywords: IGS, ITRF, IAG, GNSS.

Introduction

The International GNSS Service (IGS), established by International Association of Geodesy (IAG) in June 1994, was initially known as International GPS Service. The name of IGS from GPS to GNSS has been changed in March 2005, when it was freely available for high precision GNSS satellite user [1]. At present (in May 2017), a total of 506 stations exist in the IGS Network (Fig. 1) all over the world [2]. The highest-quality of GNSS data in support of research, earth observation, and the terrestrial reference frame is provided by IGS. In rewards, society is also getting benefit in navigation, timing, and other applications. The IGS station's global ionosphere map (GIM) contains the two hourly maps (total 13 maps in a day) of global vertical total electron content (VTEC) estimated from the permanent tracking sites and become a trustworthy source for ionospheric information since 1998 [3,4]. The ionosphere maps are released with a spatial resolution of 2.5^0 latitude and 5^0 longitude. Generally, during storm period diurnal GIM ionospheric error level remains in a range up to 10-20% to the actual diurnal peak value, but GIM shows better performance in the middle-latitude ionosphere at 140 elevation angle cutoff within 1000 km of the source station [5]. There are several papers published based on ionospheric and tropospheric investigation [4, 6-8] etc based on the reference observation data from IGS stations. Mukul et al. [9] used IGS network in accuracy analysis of the 2014-2015 global shuttle radar topography mission (SRTM) 1 arc-sec C-Band height model. They reported that 335 stations out of 427 in the IGS Network were practical, because some stations were out of the SRTM zone (latitude greater than 600N and 570S). The GNSS using IGS or with respect to IGS is a tool that has been recently (1996 onwards) developed to evaluate the displacements surface with an accuracy of few millimeters in seismically active regions. The dislocation modelling simulates the measured surface displacement and velocity in the field due to the causative faults or slip that can be modelled to understand where strain is accumulating in the seismic area. The high-precision IGS is used to geodetically constrain the motion of stations in the seismological areas and examine the deformation of crust. Numerous research outputs have been published for crustal deformations which are very difficult to countable. Many techniques like forward modelling [10], finite element method [11], inverse theory [12] including software like Coulomb [13] etc are used to determine the crustal deformation. Basically, the IGS stations are used as base stations during the process of GNSS data.

The IGS also contributes for expanding and densifying to the ITRF, and the ITRF offers a consistent reference frame or datum to refer the positions of a particular location at any time around the world. The IGS expands the number of stations significantly to make the reference frame readily available on recognition of ITRF. The datum transformation is the determination of parameters needed to move coordinates from one system to another. There are several methods implemented in transformation like least squares method, surface fitting or miscellaneous algebraic methods. In geodesy surveying barycentric coordinates [14] and, the 7-parameter Helmert transformation (also known as 7-parameter similarity transformation) has become important with the advent of modern GNSS surveying techniques. Yetkin and Ansari [15] have presented the 7- and 9-parameter Helmert coordinate transformation between two ITRF solutions (2005 and 2008) of Turkish permanent GNSS network (TPGN) and IGS in Turkey. There are various types of coordinate transformations techniques like projectivity, affine, similarity and euclidean transformation in rectangular form and has also been used by Ansari et al. in 2017 [16] and these transformations were also validated by the standard Bursa-Wolf and Molodensky-Badekas models. At this time the accuracy of IGS products is enough for the enhancement and expansion of the ITRF, rotation of Earth, deformation of solid Earth and variations of the liquid Earth monitoring. The accuracy is also perfect for the determination satellite orbits, monitoring of ionosphere, and precipitable water vapor recovery measurements.

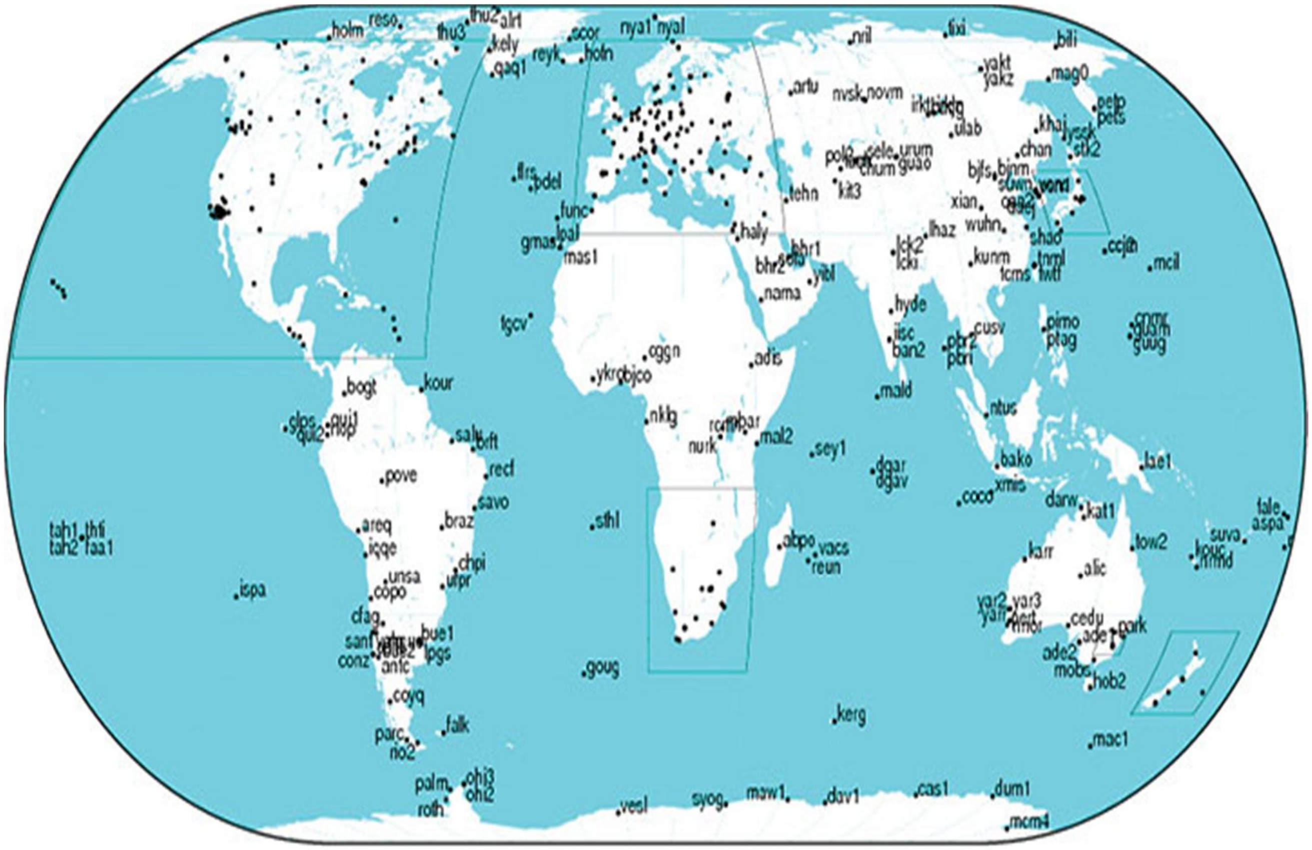

Figure1. The IGS station Network

The IGS at a Glance

The IGS make sure to open the high-quality of GNSS products since 1994. These products allow accessing of the global reference frame for scientific, commercial and educational purposes. The Summary of IGS at a glance is listed here [17]:

- More than 200 universities, research institutions, and funding agencies from more than 100 countries are working mutually to afford the highest precision GNSS orbits of the satellites.
- They are offering highest precision products without cost for scientific development and advantage of the public. These products sustain a variety of applications in a wide range that contact practically millions of users in all segments.
- These products are supporting to the realization of ITRF and providing tracking data from over 500 worldly reference stations.
- These products are supporting scholarly publications to geodetic research.
- Implementation as a component of the world data system and global geodetic observing system.

The IGS Products

The IGS gathers, distributes and records the GNSS observation data of adequate accuracy to convince the objectives of an extensive range of testing and applications (Table I). These data are used to produce the products for interested users [18].

Table 1. The IGS products

GPS Satellite Ephemerides / Satellite & Station Clocks					
Type	*Accuracy*		*Latency*	*Updates*	*Sample Interval*
Broadcast	orbits	~100 cm	real time	----	daily
	Sat. clocks	~5 ns RMS ~2.5 ns SDev			
Ultra-Rapid (predicted half)	orbits	~5 cm	real time	at 03, 09, 15, 21 UTC	15 min
	Sat. clocks	~3 ns RMS ~1.5 ns SDev			
Ultra-Rapid (observed half)	orbits	~3 cm	3 - 9 hours	at 03, 09, 15, 21 UTC	15 min
	Sat. clocks	~150 ps RMS ~50 ps SDev			
Rapid	orbits	~2.5 cm	17 - 41 hours	at 17 UTC daily	15 min
	Sat. & Stn. clocks	~75 ps RMS ~25 ps SDev			5 min
Final	orbits	~2.5 cm	12 - 18 days	every Thursday	15 min
	Sat. & Stn. clocks	~75 ps RMS ~20 ps SDev			Sat.: 30s Stn.: 5 min
GLONASS Satellite Ephemerides					
Type	*Accuracy*		*Latency*	*Updates*	*Sample Interval*
Final	~3 cm		12 - 18 days	every Thursday	15 min
Geocentric Coordinates of IGS Tracking Stations					
Type	*Accuracy*		*Latency*	*Updates*	*Sample Interval*
Final positions	horizontal	3 mm	11 - 17 days	every Wednesday	weekly
	vertical	6 mm			
Final velocities	horizontal	2 mm/yr	11 - 17 days	every Wednesday	weekly
	vertical	3 mm/yr			
Earth Rotation					
Type	*Accuracy*		*Latency*	*Updates*	*Sample Interval*
Ultra-Rapid (predicted half)	Polar motion	6.2 mm	real time	at 03, 09, 15, 21 UTC	daily integrations at 00, 06 12, 18 UTC
	Ploar motion rate	9.3 mm/day			
	Length of day	23 mm			
Ultra-Rapid (observed half)	Polar motion	1.55 mm	3 - 9 hours	at 03, 09, 15, 21 UTC	daily integrations at 00, 06, 12, 18 UTC
	Ploar motion rate	7.75 mm/day			
	Length of day	4.6 mm			
Rapid	Polar motion	1.24 mm	17 - 41 hours	at 17 UTC daily	daily integrations at 12 UTC
	Ploar motion rate	6.2 mm/day			
	Length of day	4.6 mm			
Final	Polar motion	0.93 mm	11 - 17 days	every Wednesday	daily integrations at 12 UTC
	Ploar motion rate	4.65 mm/day			
	Length of day	4.6 mm			
Atmospheric parameters					
Type	*Accuracy*		*Latency*	*Updates*	*Sample Interval*
Final tropospheric zenith path delay with N, E gradients	4 mm (ZPD)		< 4 weeks	daily	5 minutes
Final ionospheric TEC grid	2-8 TECU		~11 days	weekly	2 hours; 5 deg (lon) x 2.5 deg (lat)
Rapid ionospheric TEC grid	2-9 TECU		<24 hours	daily	2 hours; 5 deg (lon) x 2.5 deg (lat)
Another Product					
• IGS Final products (IGS) • IGS Rapid products (IGR) • IGS Ultra-rapid products (IGU)					

The IGS Organisation

The IGS organization consists of the following components (Table 2) [18]:

Table 2: The IGS organization

Code	IGS Organization	Responsibilities
ACs	Analysis Centers	To analyze the IGS station data for the submissions IGS the products like orbits, clocks, position of station
ACC	Analysis Center Coordinator	To combine the submissions of Acs and to outline the classic IGS products like GNSS orbits, clocks
AM	Associate Members	The persons affiliated with contributing organizations those are the electorate body of the IGS Governing Board spend majority of their time on work contributes to the IGS
AACs CB	Associate Analysis Centers Central Bureau	To produce specialized or derived products with coordinators that combine AC submissions to form IGS Products Executive office provides overall coordination and day-to-day management of the information systems, network and Infrastructure
COs	Contributing Organizations	Any agency or entity that participates in at least one of the above mentioned components
DCs GB	Data Centers Governing Board	To archive and provide open access to IGS data and products An international body which sets policy and direction for the IGS. Some positions are elected and others are appointed
IC	Infrastructure Committee	A permanent body established to ensure that the data requirements for the highest quality GNSS products are fully satisfied while also anticipating future needs and evolving circumstances
SOAs	Station-Operating Agencies	They manage the IGS network stations according to the IGS Site guidelines and transmit the data to IGS Data Centers
WGs	Working Groups	Incubator through Pilot Projects with particular focus on components, products and infrastructural elements within Working Groups

The IGS Working Groups

The IGS technical Working Groups work on topics of particular interest to the IGS, such as improving the IGS products and infrastructure [19]:

- Antenna (Est. 2008)
- Bias and Calibration (Est. 2008)
- Clock Products (Est. 2003)
- Data Center (Est. 2002)
- Ionosphere (Est. 1998)
- Multi-GNSS (Est. 2003)
- Multi-GNSS Extension (MGEX) (Est. 2016)
- Real-time (Est. 2001)
- Real-time (RTS) (Est. 2001)
- Reference Frame (Est. 1999)
- RINEX (Est. 2001)
- Space Vehicle Orbit Dynamics (Est. 2011)
- Tide Gauge (TIGA) (Est. 2001)
- Troposphere (Est. 1998)

Conclusions

The IGS station networks are being implemented throughout the world following the establishment of the GNSS analysis plays a precious role for the study of Earth sciences, Oceanic sciences, climate sciences and many other applications. These networks play outstanding performance in the society. We have summarized few of them in the present study. We hope the IGS will develop more in future and will solve many problems for the benefit of human beings.

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