SEMINAR REPORT

IGS workshop 2018 – "Multi-GNSS through Global Collaboration"

Wuhan, China, 29 October – 2 November 2018.
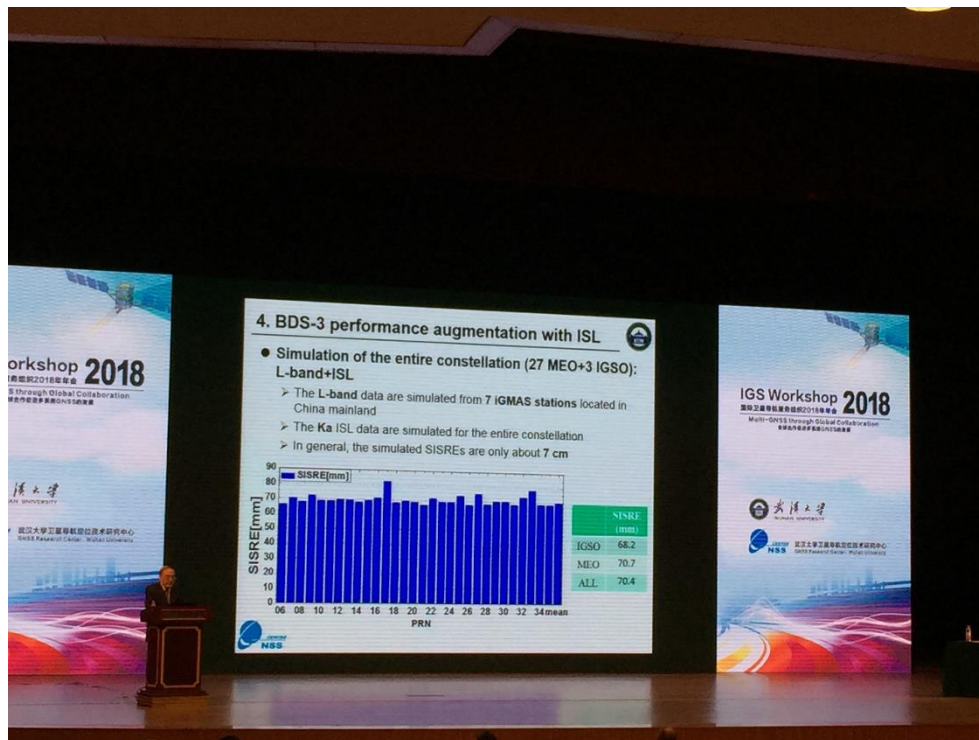
Purpose of the meeting

The workshop programme was held by IAG's International GNSS (Global Navigation Satellite System) Service (IGS) where all IGS members and users can report on recent developments and achievements and discussed solutions to current issues. The title of this year's workshop was Multi-GNSS through global collaboration which indicates a fact that along with the old GNSS, i.e., GPS (US) and GLONASS (Russia), the new ones, i.e., Galileo from EU and Beidou from China are going to be fully operational. Therefore, this year's workshop has strongly promoted the integrated development and high-precision applications of multi-GNSS through global collaboration.

For the first time the IGS workshop was taken place in China and Wuhan University hosted and organized the event. For more than a quarter of century, Wuhan University has been committed to participating in the IGS activities and contributing to the IGS products. In 1992, they began to build one of the IGS permanent tracking stations on the campus, and two decades later the IGS Analysis Centre, the Multi-GNSS analysis centre, the real-time data and analysis centre, the IGS global data centre, the ionosphere analysis centre, and the monitoring and evaluation analysis centre. Through the workshop, Wuhan University hoped to further actively participate in the IGS projects and play a greater role in the future.

Two keynote speeches have been given in the workshop with a focus on the Chinese global navigation satellite system (Beidou). The title of the first speak is "Introduction to BeiDou-3 Navigation Satellite System" which was presented by Prof. Yuanxi Yang who is a professor of Geodesy and Navigation Xian Research Institute of Surveying and Mapping. Prof. Yang has talked about the newest status of China BeiDou navigation system (BDS). After the demonstration navigation satellite system (BDS-1) and the regional navigation satellite system (BDS-2), the global BeiDou navigation system (BDS-3) is in construction and goes well. The design and functions of BDS-3 are quite different from those of BDS-1 and BDS-2. The general

constituent frame of BDS-3 and its coordinate reference system and system time were introduced. The new payloads mounted on different satellites for different objectives were elaborated. The general service contents and special service functions provided by different constellations were described in the presentation. In addition, the initial performances of the simplest system of BDS-3 were evaluated based on the available 8 MEO satellites of BDS-3. The performances of satellite orbit determination and prediction with and without the inter-satellite links (ISL) were compared and analysed.

Figure 1: The keynote speech given by Prof. Jingnan Liu. Photo: Tong Ning.

The second keynote speech was given by Prof. Jingnan Liu who is academician of Chinese academy of Engineering, Wuhan University. The title of the talk was "BeiDou augmentation and its future". According to the presentation, up to Oct. 2018, 16 BeiDou-3 satellites have been deployed in medium earth orbit. Besides the newly designed signals and different satellite buses, updated rubidium atomic frequency standards, new passive hydrogen masers, and inter-satellite links equipment have been carried. The new and improved features do not only improve the performance of BeiDou-3, but also provide promising way for construction of next generation of BeiDou system. In addition, Prof. Liu presented the performance of BeiDou-3 on-board frequency standards. Moreover, the augmented performances of BeiDou-3 precise orbit/clock determination with the inter-satellite links (ISL) were presented and analyzed. And the ISL's contribution to signal-in-space ranging errors were highlighted. Based on these analyses, the application of optical clocks, laser-based inter-satellite communication, and low earth orbiter satellites for the next generation of BeiDou were discussed.

This year's workshop comprised 10 scientific plenary sessions (see list below):

1. Analysis Centers and Reference Frames
2. Orbit Modelling
3. Troposphere
4. Infrastructure Committee, RINEX, data centres
5. Timing and Biases
6. MGEX and IGMA
7. Antennas
8. Ionosphere
9. Real-time
10. Science Applications

Conclusions and recommendations

As always, this year's IGS workshop had many interesting talks and posters. In addition, based on the works carried out in the last year each IGS working group has given summarizes and recommendations for the near future. Below you may find some of highlights from the workshop:

1. As the presentations have shown that a lot of research works have been done in the field dealing with draconitic signals. So far there is no "golden break through" with a solution that completely takes all draconitic signals out.
2. New combination software for orbit and clock products will be applied which is written by python 3 and among other changes satellite laser ranging (SLR) observations will be integrated in the combination which currently are used only for validation.
3. The IGS repro3 campaign is going to start at the end of the year of 2019 and hopefully it will be ready in 2020 where the IGb14 reference frame (aligned to ITRF2014) will be implemented. In addition, all Analysis Centres (AC) should start considering and discussing their strategies for Repro3.
4. There are some recommendations which have been given for repro3 models

   - Liaise with the International Laser Ranging Service (ILRS) to determine the low degree time variable gravity model to use for repro3 (and prediction into the future).
   - Formalize list of ACs wishing to participate in repro3 and constellations they intend to contribute.
   - Identify a priori orbit force models and provide test data sets to facilitate the implementation by ACs.
   - Encourage the creation of a data format for satellite quaternions, for comparison between ACs.
5. There are also some recommendations from antenna working group

   - Encourage to update old antenna satellite PCVs.

- Assess the impact at different possibilities to handle L5/E5 ground antenna patterns
- Identify testing periods for the verification of difference proposed ANTEX (chamber/robot/mixed)
- Determine the best way to use Galileo satellite antenna calibrations without introducing scale inconsistency between GPS/GLONASS and Galileo.
- If the satellite ANTEX file is updated, then the reference frame for IGb14 should be provided for repro3.
- Aim to have the repro3 ANTEX usable once ITRF2020 is released.
- Assess the possibility of defining a "GNSS scale" based on Galileo satellite antenna calibrations.

6. The troposphere working group is testing RINEX3 for Multi-GNSS data processing and also requested that Galileo and Beidou PCV calibration should be available in the near future.

7. It has been informed that all files in the IGS archive, e.g. rinex files, orbits and clocks products, will be compressed as .gz instead of .Z.

8. It also has been in the workshop that in US the File Transfer Protocol (FTP) will no longer be used. Instead all users should apply Hypertext Transfer Protocol Secure (HTTPs) for data transfer. So corresponding modifications on the scripts for data downloading were necessary by all users. The detail information regarding this issue will be updated in IGS website soon and some documentations will be provided.

Presentations and discussions

In total IGS workshop 2018 had about 300 experts and students from all over the world to take part in the workshop including 58 oral presentations and 122 posters.

Tong Ning from Lantmäteriet had a poster presentation with a title "Trends in the atmospheric water vapour estimated using different elevation-angle-dependent parameters in the GPS data processing".

For more information

IGS homepage: http://www.igs.org/presents/workshop2018

The next IGS workshop will be hold by UNAVCO&UCAR in 2020 and the venue will be in Boulder, Colorado, USA.