15th Meeting of the International Committee on
Global Navigation Satellite Systems

iGMAS Update and Assessment of Multi-GNSS Performance

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iGMAS TEAM

2021-09-08

01 iGMAS Update

02 Assessment Results

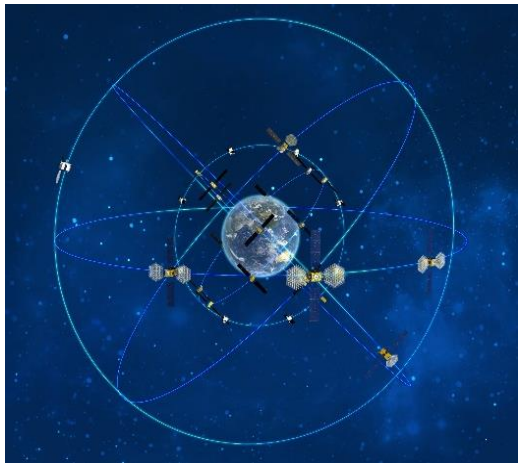
03 Summary

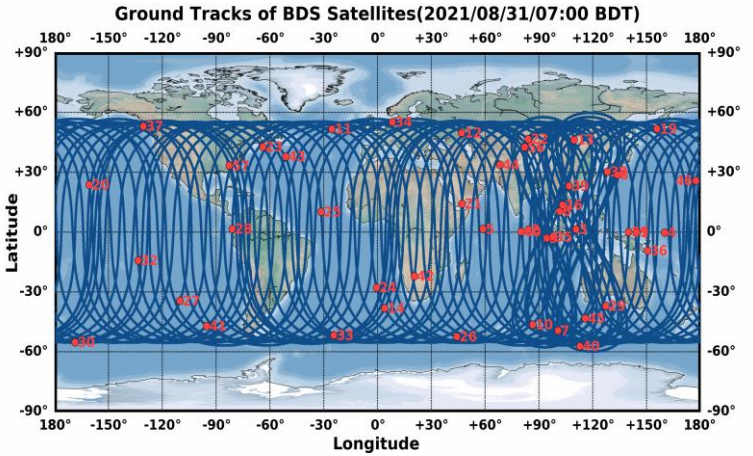
01

iGMAS Update

01 iGMAS Update

- BDS-3 officially started to provide services to global users on July 31, 2020.
- "BeiDou Navigation Satellite System Open Service Performance Standard(Version3.0)", May 2021.





01 iGMAS Update

The international GNSS Monitoring and Assessment System (iGMAS) has started the services from 2014 (www.igmas.org). To better assess the performance of BDS-3 and other navigation satellite systems, iGMAS has been improved gradually on:

- Infrastructure
- iGMAS Products
- Specifications
- iGMAS Activities

1.1 iGMAS Infrastructure Update

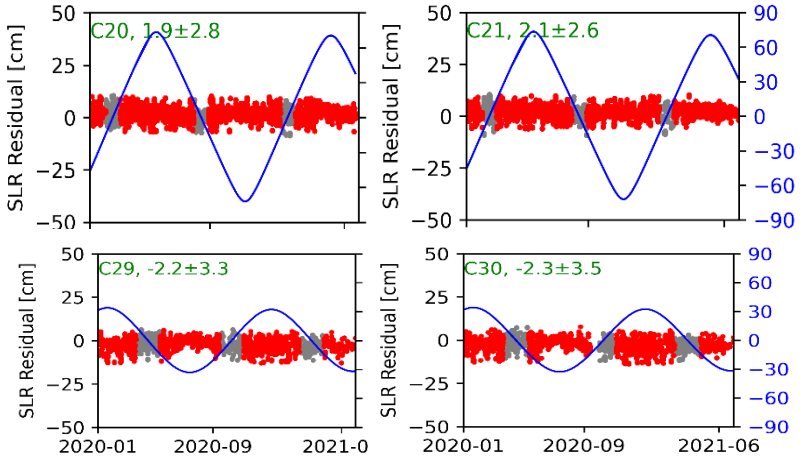
- Receivers of the new generation have been deployed and capable of tracking all open signals of GNSS.

GPS:L1,L2P,L2C,L5; BDS:B1I, B1C, B2a, B3I; GLO:G1,G2; **GAL**:E1,E5A,E5B

1.2 iGMAS Products Update

- Precise orbit and clock products of BDS-3 have been provided since Sep.2019
- BDS-2(B1I+B2I) ---> BDS-2/BDS-3(B1I+B3I)+ BDS-3(B1C+B2a)
- The interval of final/rapid satellite clock products is adjusted from 300s to 30s

http://www.igmas.org/



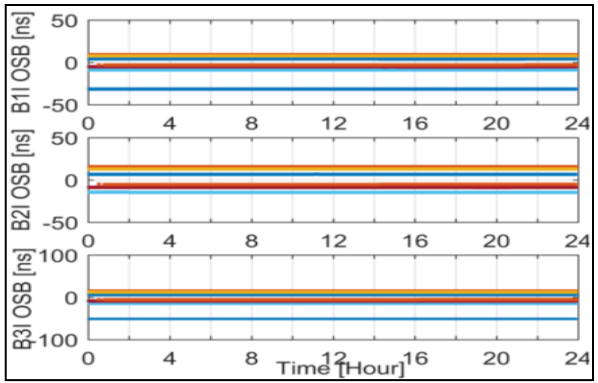
Statistics of SLR residuals

1.2 iGMAS Products Update

◆Multi-frequency GNSS code and phase bias products including UPD and OSB.

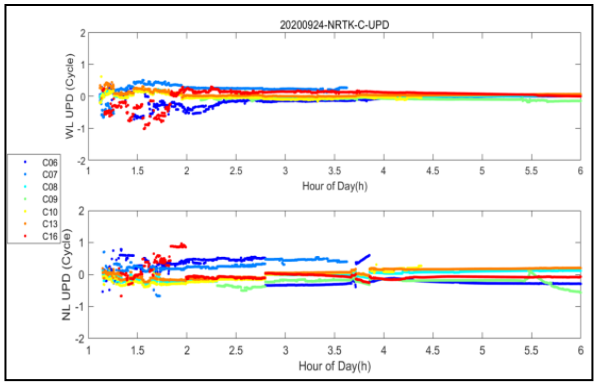
◆Precise orbit products for LEO satellites such as GRACE-C/D and Swarm-A/B/C.

◆Real-time orbit, clock, UPD, and tropospheric/ionospheric delays in support of PPP-RTK.



BDS phase OSB

LEO precise orbit products



Real-time UPD of BDS

1.3 iGMAS Specifications

National Standard	
➢ Quality requirements for iGMAS – Part 1 : Observation data	GB/T 39396.1-2020
➢ Quality requirements for iGMAS – Part 2 : Products	GB/T 39396.2-2020
➢ iGMAS File Format – Part 1: Observation Data	GB/T 39397.1-2020
➢ iGMAS File Format – Part 2: Product	GB/T 39397.2-2020
➢ Monitoring and assessment parameters of iGMAS	GB/T 39398-2020

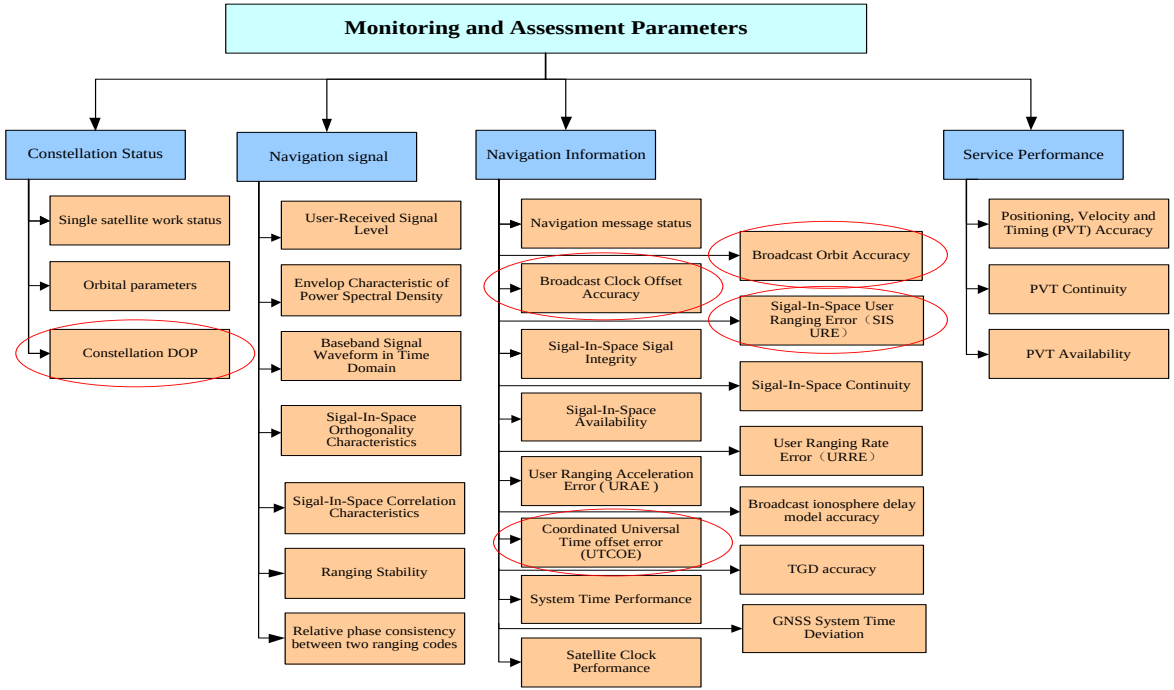
1.4 iGMAS Activities

- An iGMAS workshop was held in Xian with more than 100 participants from institutions and universities.
- The main topics of the workshop were the improvement of GNSS precise products and innovation applications.

02

Assessment Results

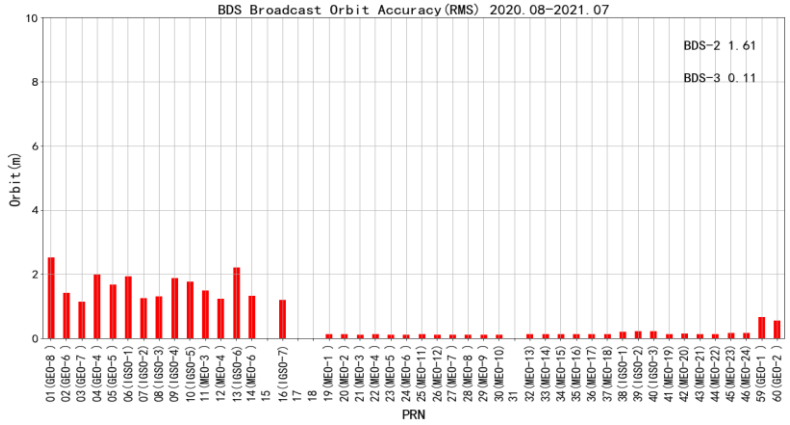
02 iGMAS Monitoring and Assessment Parameters

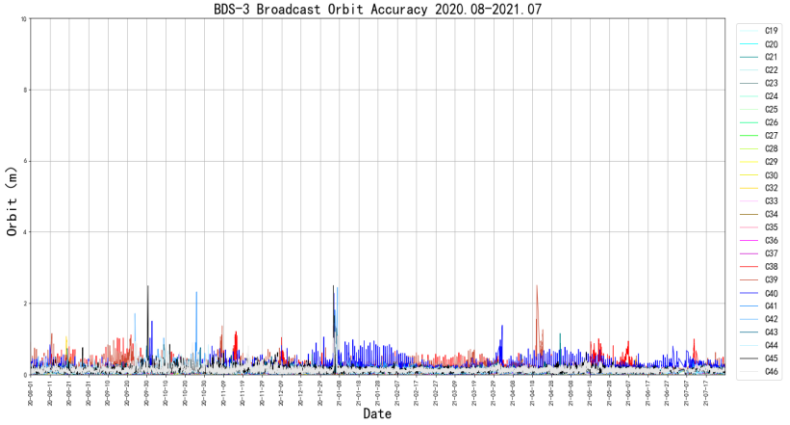


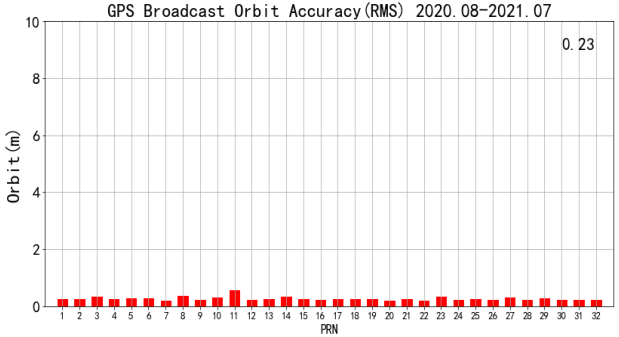
- Twenty-nine (29） monitoring and assessment parameters of four (4) types are defined in iGMAS
- The monitoring and assessment reports have been published routinely

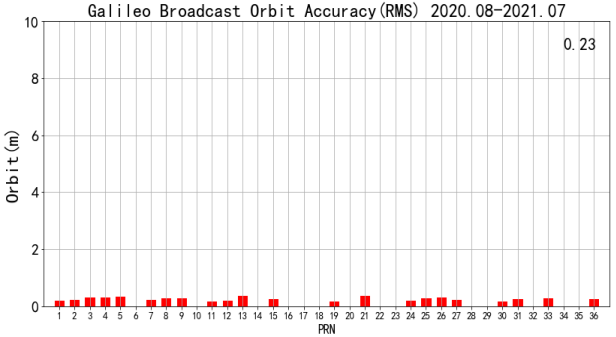
2.1 Broadcast Ephemeris Accuracy (Orbit)

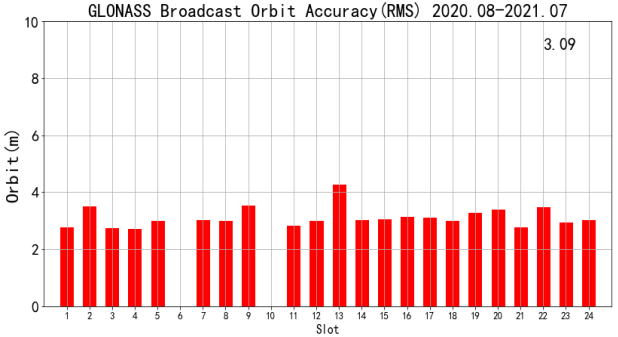
- The orbit accuracy of broadcast ephemeris during 2020.07-2021.07





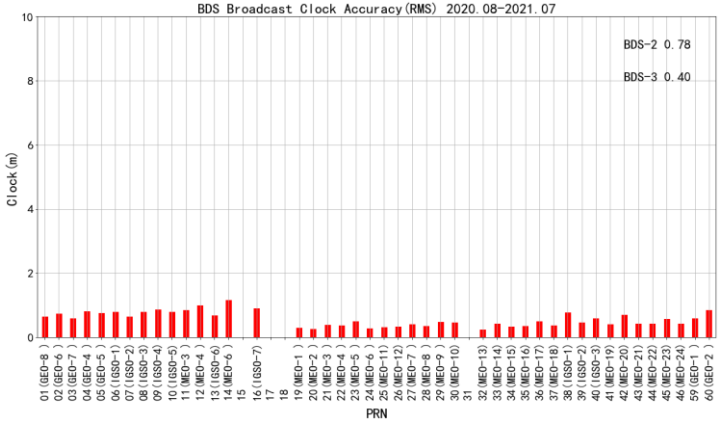


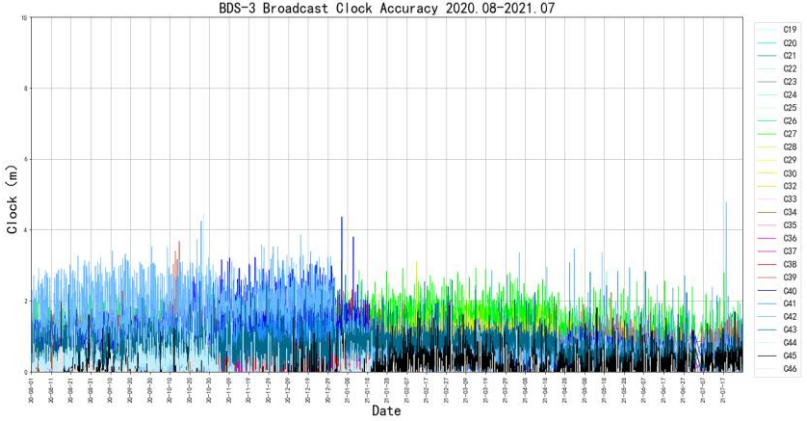


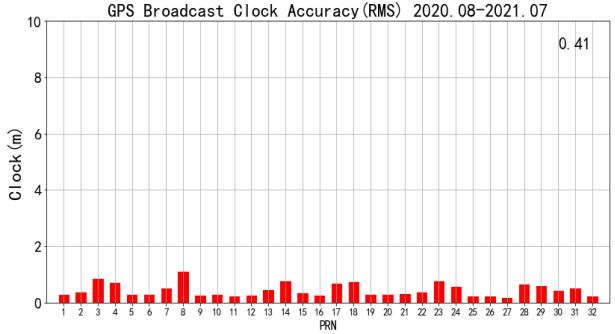


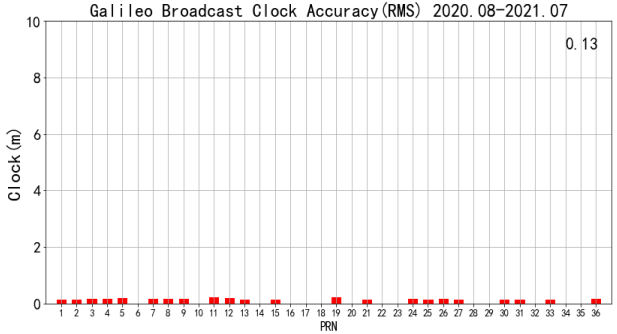
2.2 Broadcast Ephemeris Accuracy (Clock)

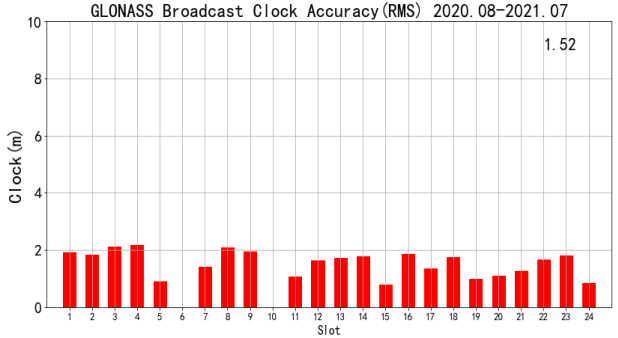
- The clock accuracy of broadcast ephemeris during 2020.07-2021.07





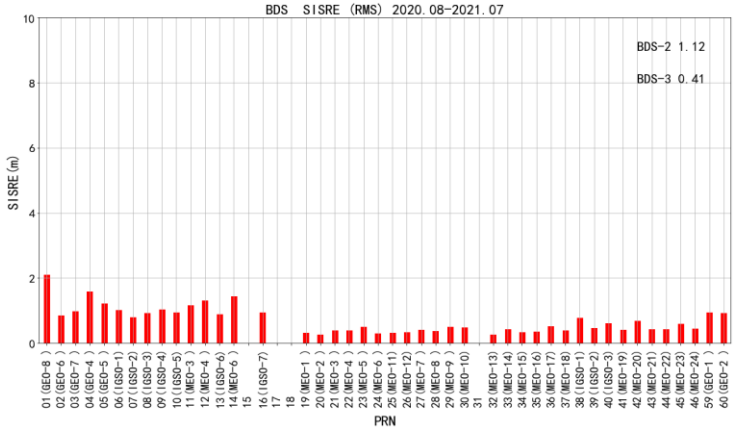


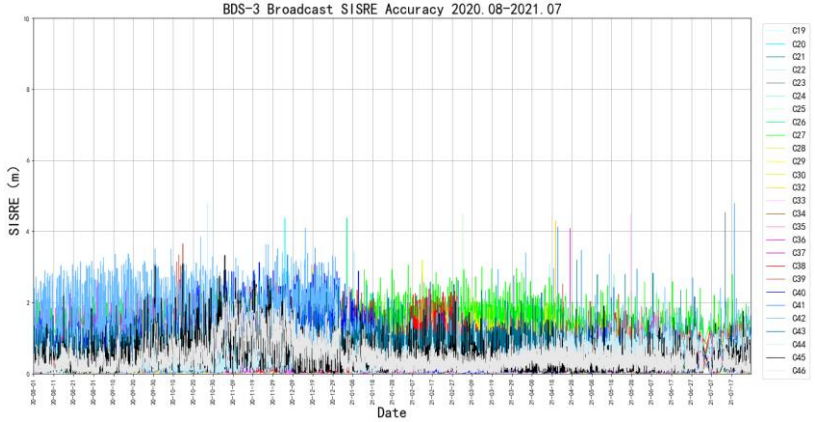


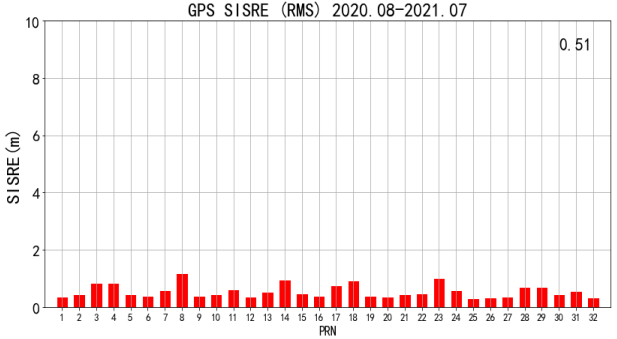


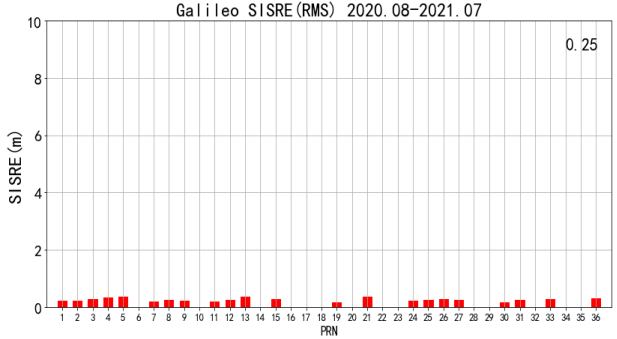
2.3 Broadcast Ephemeris Accuracy (SISRE)

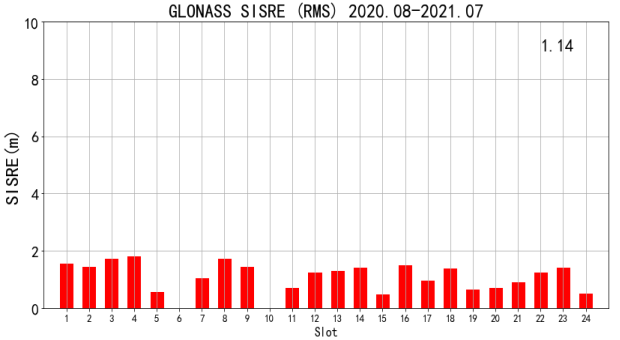
- The SISRE of broadcast ephemeris during 2020.07-2021.07











2.3 UTCOE

➢ Methodology

- Using absolutely calibrated receiver connected to UTC(NTSC) which is bridged to UTC or UTC(k) with BIPM rapid UTC product, i.e. UTCr-UTC(k)

➢ Time Reference Source

- BDS time connects with UTC via UTC(NTSC). UTC is taken as BDS time reference source.
- GPS time reference source is UTC(USNO).
- GLONASS time reference source is UTC（SU）.
- Galileo time reference source is UTC.

➢ Statistic Method and Step

- Yearly RMS&95% over one year moving window for BDS , GPS , GLONASS and Galileo .

UTCO_ref :

$$BDT_{SIS} - UTC_r = -[UTC(NTSC) - BDT_{SIS}] - [UTC_r - UTC(NTSC)]$$

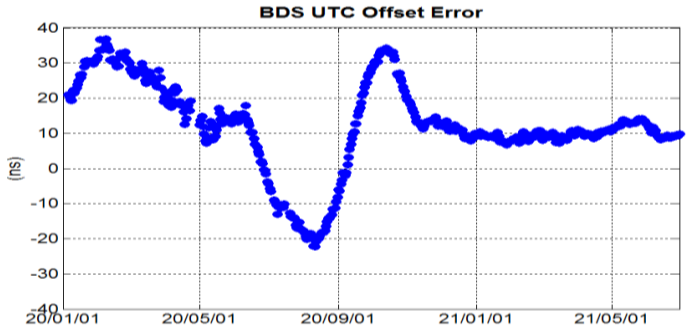
$$GST_{SIS} - UTC_r = -[UTC(NTSC) - GST_{SIS}] - [UTC_r - UTC(NTSC)]$$

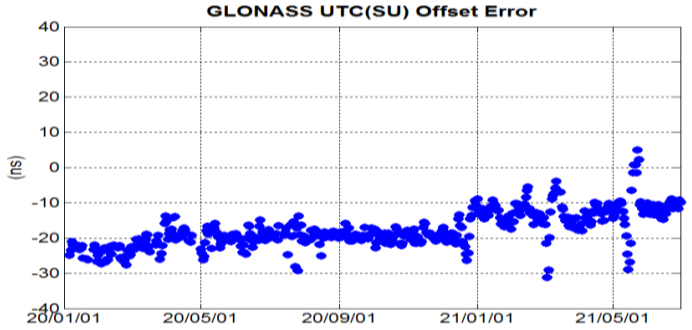
$$GPST_{SIS} - UTC(USNO) = -[UTC(NTSC) - GPST_{SIS}] + [UTC_r - UTC(USNO)] - [UTC_r - UTC(NTSC)]$$

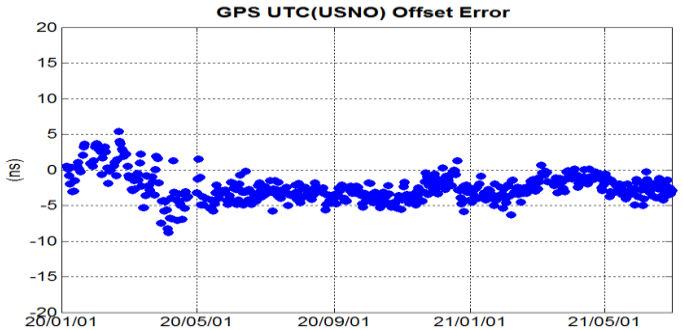
$$UTC(SU) - GLONASST_{SIS} = [UTC(NTSC) - GLONASST_{SIS}] + [UTC_r - UTC(NTSC)] - [UTC_r - UTC(SU)]$$

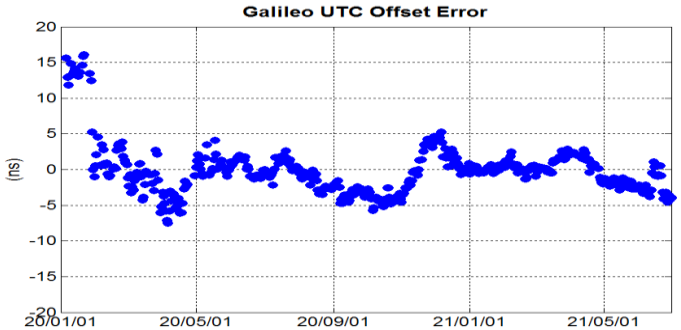
2.3 UTCOE

◆UTCOE of BDS, GPS, GLONASS and Galileo from 2020.01.01-2021.6.30









2.3 UTCOE

◆ The UTCOE evaluation results of BDS/GPS/GLONASS/Galileo

Items	BDS	GPS	GLONASS	Galileo	BDS	GPS	GLONASS	Galileo
	2020 (Jan.1~Dec.31) Unit: ns				2021(Jun.1~Jun.30) Unit: ns			
95%	**33.11**	5.38	25.92	11.84	**13.39**	4.24	17.88	3.29
RMS	**20.28**	3.44	20.45	4.18	**10.08**	2.71	13.46	1.72
AVG	**13.04**	-2.59	-20.23	-0.06	**9.93**	-2.40	-12.64	-0.36
STD	**15.55**	2.26	2.99	4.18	**1.75**	1.25	4.63	1.68
MAX	**36.77**	8.80	29.33	16.13	**14.17**	6.29	31.21	4.54

➢ **BDS UTCOE is greatly improved in 2021 due to the more closely steering of BDS Time to UTC than in 2020.**

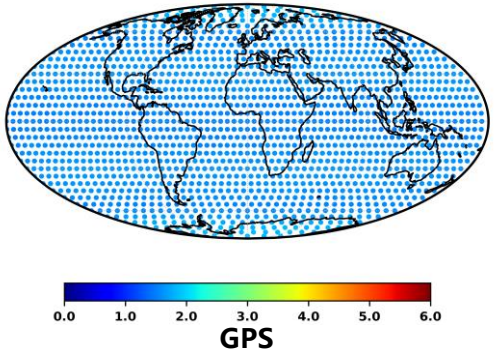
2.5 PDOP

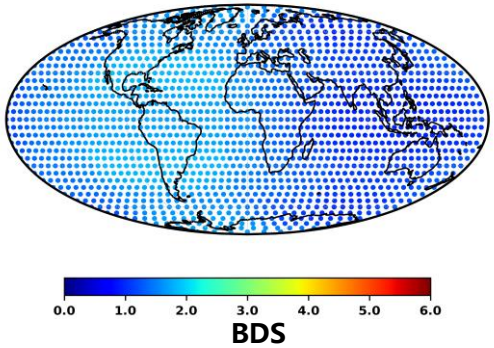
◆ Methodology

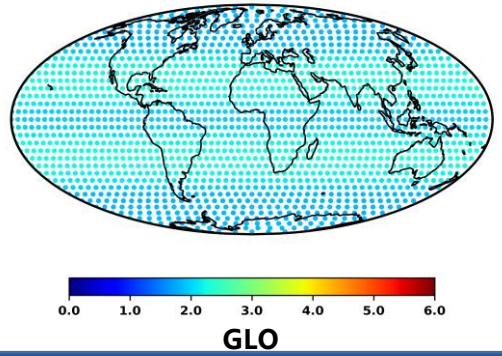
- Grid Division is based on Equal-Arc (Equal-Area) principle.
- Arc interval is 5 degrees.
- Time simple is 300s here.
- Space scope is S90-N90.
- Availability statistic is based on PDOP <6.

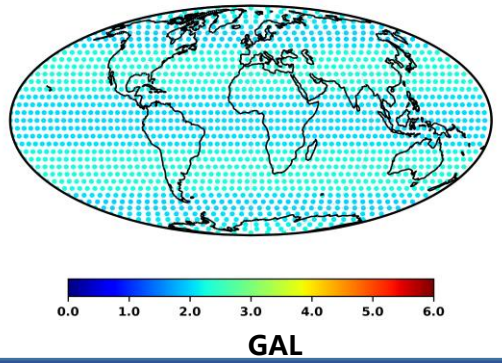
2.5 PDOP

- PDOP Average value during 2021.09.08 – 2021.09.17. (Elevation angle: 5° , Interval: 300s)



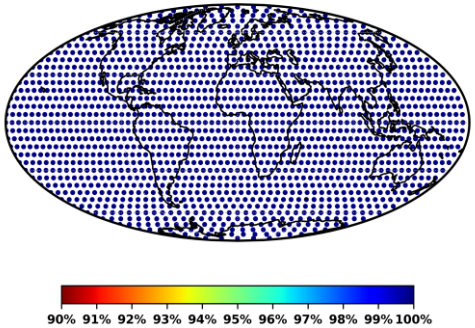




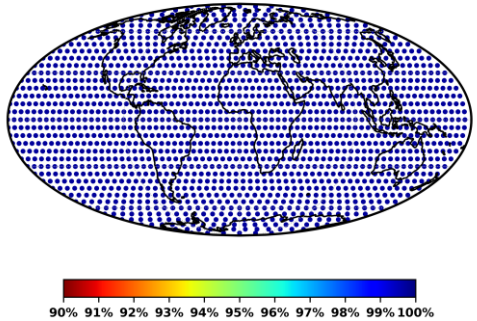


2.5 PDOP

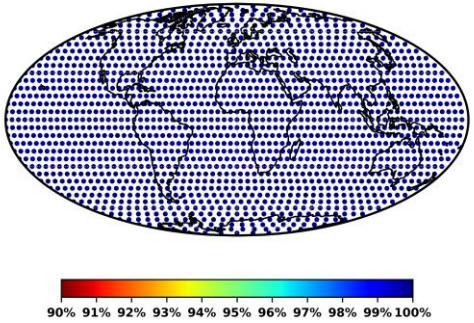
◆ Availability during 2021.09.08 – 2021.09.17. (Elevation angle: 5°, Interval: 300s, PDOP <6.)



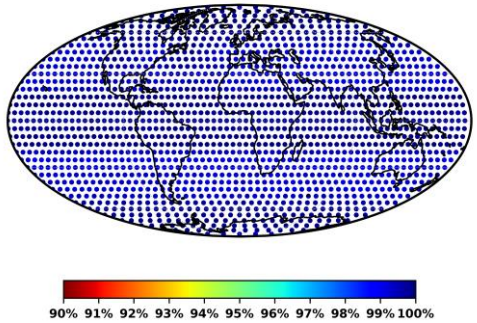
GPS



BDS

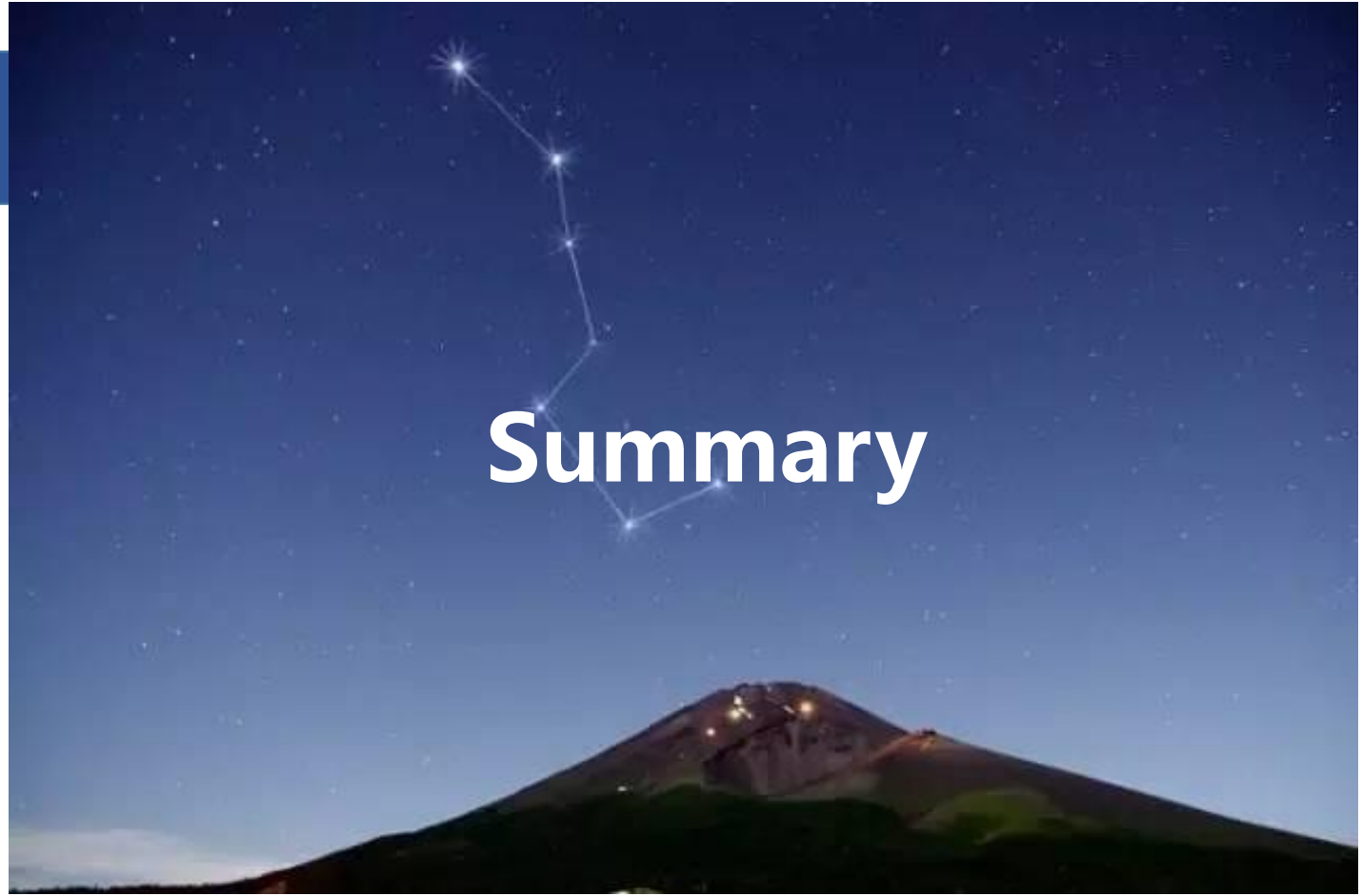


GLO



GAL

03



Summary

03 Summary

- **The BDS-3 service performance has been evaluated for one year after its full operation, the results show that its performance has been remarkably improved compared with that of BDS-2.**

- **China highly values the role of GNSS monitoring and evaluation with a responsible attitude to users. The BDS national standards have been released for users to better understand, apply and evaluate BDS.**

03 Summary

- **The algorithms and references are critical for GNSS assessment. Currently, the unification of algorithms is ongoing.**

  Recommendation: To encourage community to carry out research and coordination for the consistency of the references.


Thank you !
http://www.igmas.org