Status of the IGS-MGEX Project

R. Dach[1], O. Montenbruck[2], L. Prange[1]

(1) Astronomical Institute, University of Bern, Switzerland

(2) DLR, German Space Operations Center, Oberpfaffenhofen, Wessling, Germany

EUREF Symposium – EUREF 2014
June 3-7, 2014 in Vilnius, Lithuania

The International GNSS Service is …

… a federation of more than 200 institutions and organizations worldwide

… a Service of the International Association of Geodesy (IAG) founded in 1994

… operational since more than 20 years

… the premier source of the highest-quality GNSS data, products, and related standards and conventions

… in support of many applications that benefit the scientific community and society

… following an open data policy

… open to everybody to participate

Constellation Status (May 2014)

System		Blocks	Signals	Sats*)
GPS		IIA	L1 C/A, L1/L2 P(Y)	7
		IIR-A/B	L1 C/A, L1/L2 P(Y)	12
		IIR-M		7
		IIF		5(+1)
GLONASS		M	L1/L2 C/A + P	24

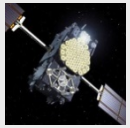
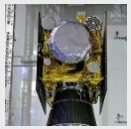
*) brackets indicate satellites not yet declared healthy/operational

Constellation Status (May 2014)

System		Blocks	Signals	Sats*)
GPS		IIA	L1 C/A, L1/L2 P(Y)	7
		IIR-A/B	L1 C/A, L1/L2 P(Y)	12
		IIR-M	+L2C	7
		IIF	+L5	5(+1)
GLONASS		M	L1/L2 C/A + P	24
		K	+L3	(1)

*) brackets indicate satellites not yet declared healthy/operational

Constellation Status (May 2014)

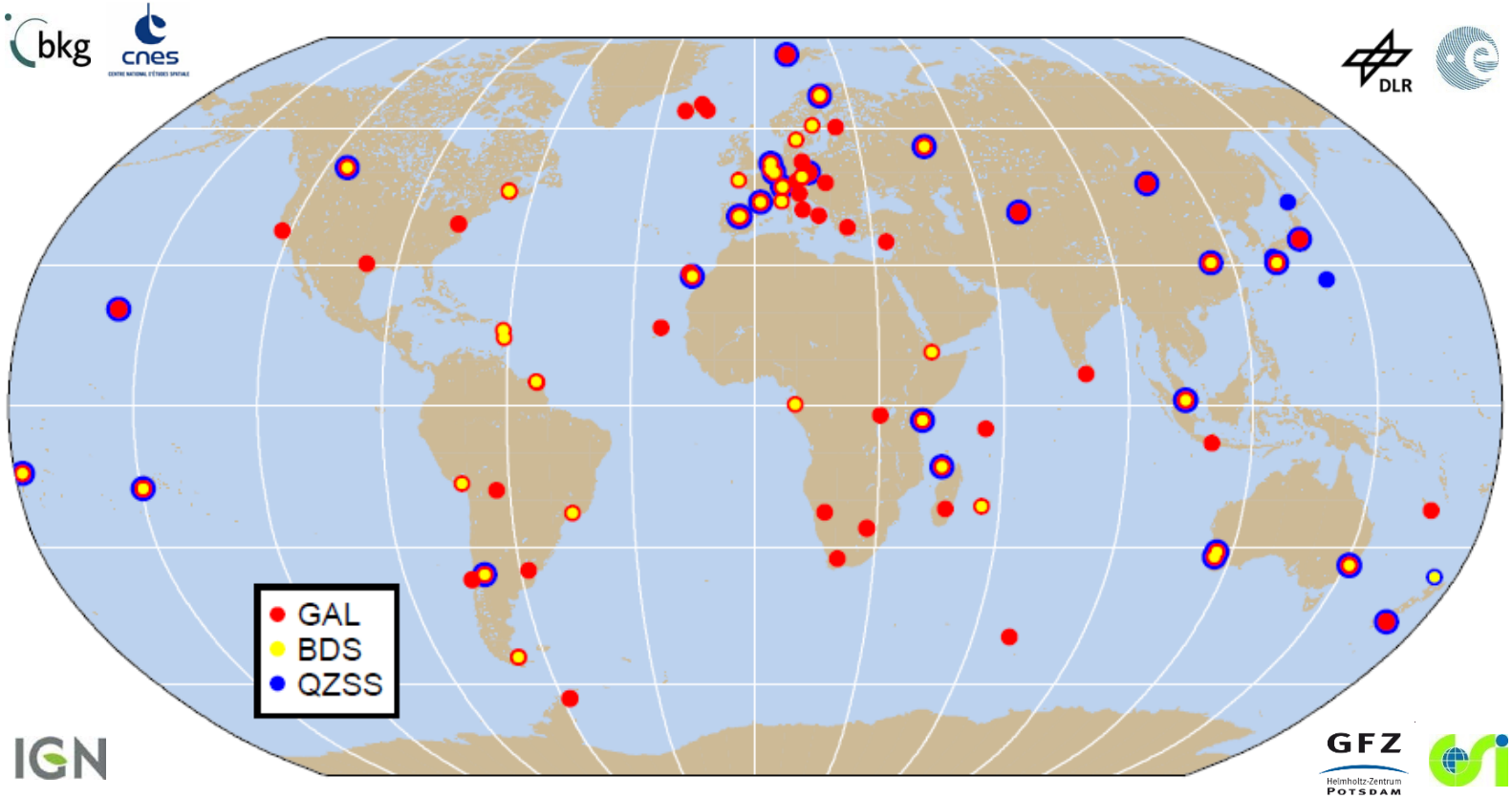
System		Blocks	Signals	Sats*)
GPS		IIA	L1 C/A, L1/L2 P(Y)	7
		IIR-A/B	L1 C/A, L1/L2 P(Y)	12
		IIR-M	+L2C	7
		IIF	+L5	5(+1)
GLONASS		M	L1/L2 C/A + P	24
		K	+L3	(1)
BeiDou		GEO	B1, B2, B3	5
		IGSO	B1, B2, B3	5
		MEO	B1, B2, B3	4
Galileo		IOV	E1, (E6), E5a/b/ab	(4)
QZSS		IGSO	L1 C/A, L1C, SAIF L2C, E6 LEX, L5	1
IRNSS		IGSO	L5, S	(2)

*) brackets indicate satellites not yet declared healthy/operational

Multi-GNSS Experiment (MGEX)

- Multi-GNSS Experiment (MGEX)
  - MGEX call-for-participation released mid-2011 (ongoing)
  - Steered by Multi-GNSS Working Group (MGWG)
- Some 27 contributing agencies from 16 countries
- Global tracking network, mostly real-time
  - State-of-the-art receivers and antenna
  - Tracking of Galileo, BeiDou, QZSS, SBAS (but no IRNSS, yet)
- Free and open access
  - Data archives at CDDIS, IGN, BKG (RINEX 3.x)
  - Real-time NTRIP caster (RTCM3-MSM)
  - Product archive at CDDIS

The IGS MGEX Network



Archive: ftp://cddis.gsfc.nasa.gov/pub/gps/data/campaign/mgex/
Streams: http://mgex.igs-ip.net

Receivers and Tracked Signals

Receiver Type		Sites	Observations
Javad TR_G2T, TRE_G3TH		29	G: 1C,1W,2X,2W,5X E: 1X,5X
Javad TRE_G3TH (v8 board)		1	G: 1C,1W,2X,2W,5X E: 1X,5X,7X,8X C: 2I,7I
Trimble NETR9		36	G:1C,2X,2W,5X E: 1X,5X,7X,8X C: 2I,6I,7I
Leica GR10/25, GRX1200+GNSS		17	G: 1C,2S,2W,5Q E: 1C,5C,7C,8Q
NovAtel OEM6		1	G: 1C,2W,5Q E: 1C,5Q
Septentrio PolaRxS/4/4TR, AsteRx3		15	G: 1C,1W,2L,2W,5Q E: 1C,5Q,7Q,8Q C: 2I,7I

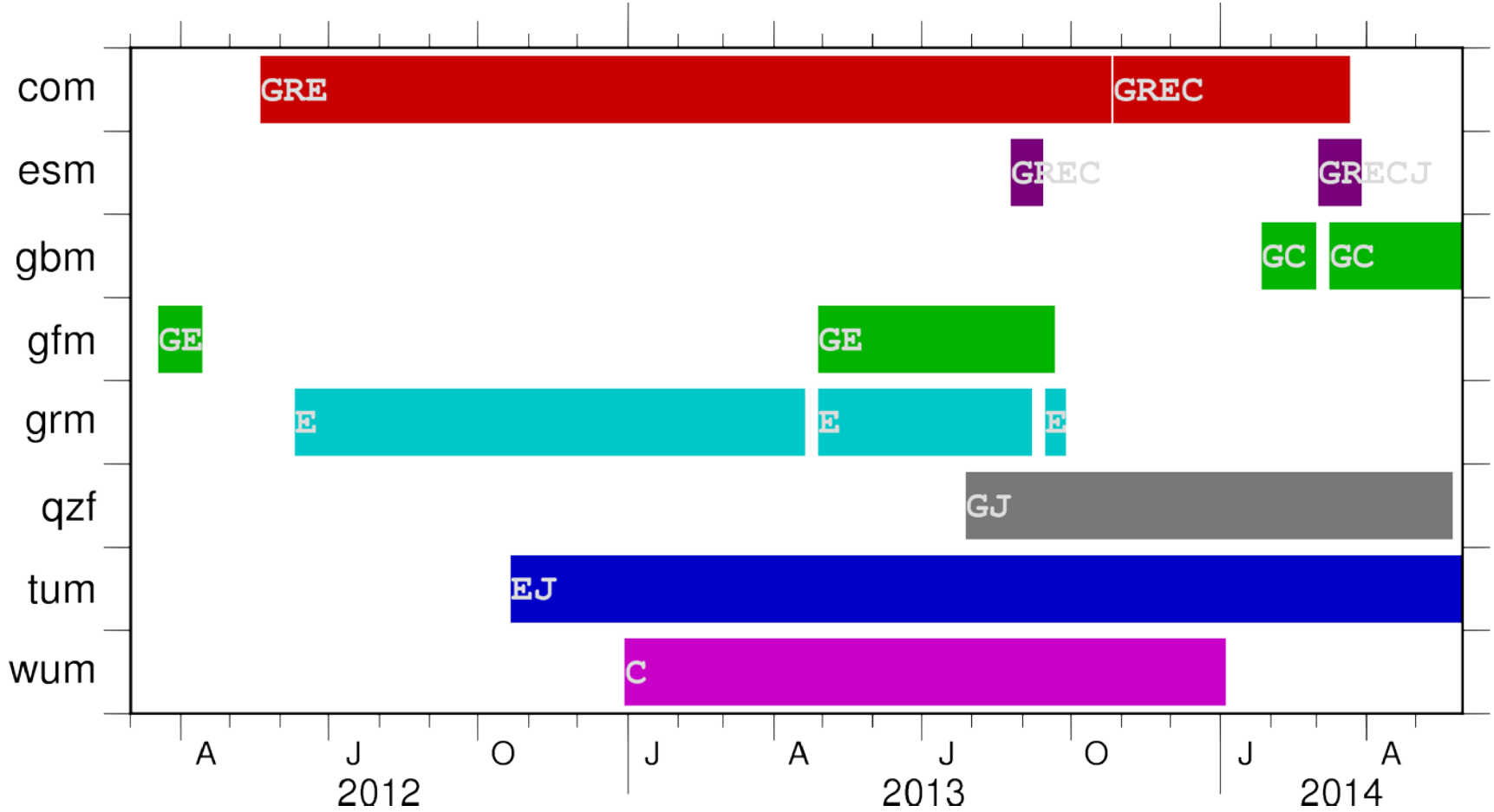
MGEX Analysis Centers and Products

Institution	ID	Systems
CNES/CLS, France	grm	GAL
CODE(AIUB), Switzerland	com	GPS+GLO+GAL(+BDS)
ESA/ESOC, Germany	esm(1)	GPS+GAL(+GLO+BDS+QZS)
GFZ, Germany	gfm	GPS+GAL
	gbm	GPS+BDS
JAXA, Japan	qzf(2)	QZS
TUM, Germany	tum	GAL+QZS
Wuhan Univ., China	wum	GPS+BDS

Products provided at ftp://cddis.gsfc.nasa.gov/pub/gps/products/mgex/

Remarks:
(1) Selected short campaigns, only
(2) Copy of JAXA precise orbit and clock product

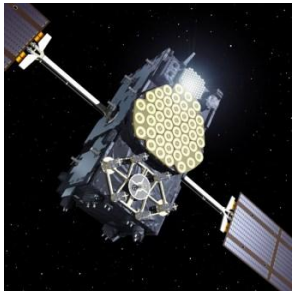
MGEX Product Availability



Status: 30-May-2014

Satellite system IDs according to the content of the precise orbit files at ftp://cddis.gsfc.nasa.gov/pub/gps/products/mgex/

Galileo Orbit and Clock Products



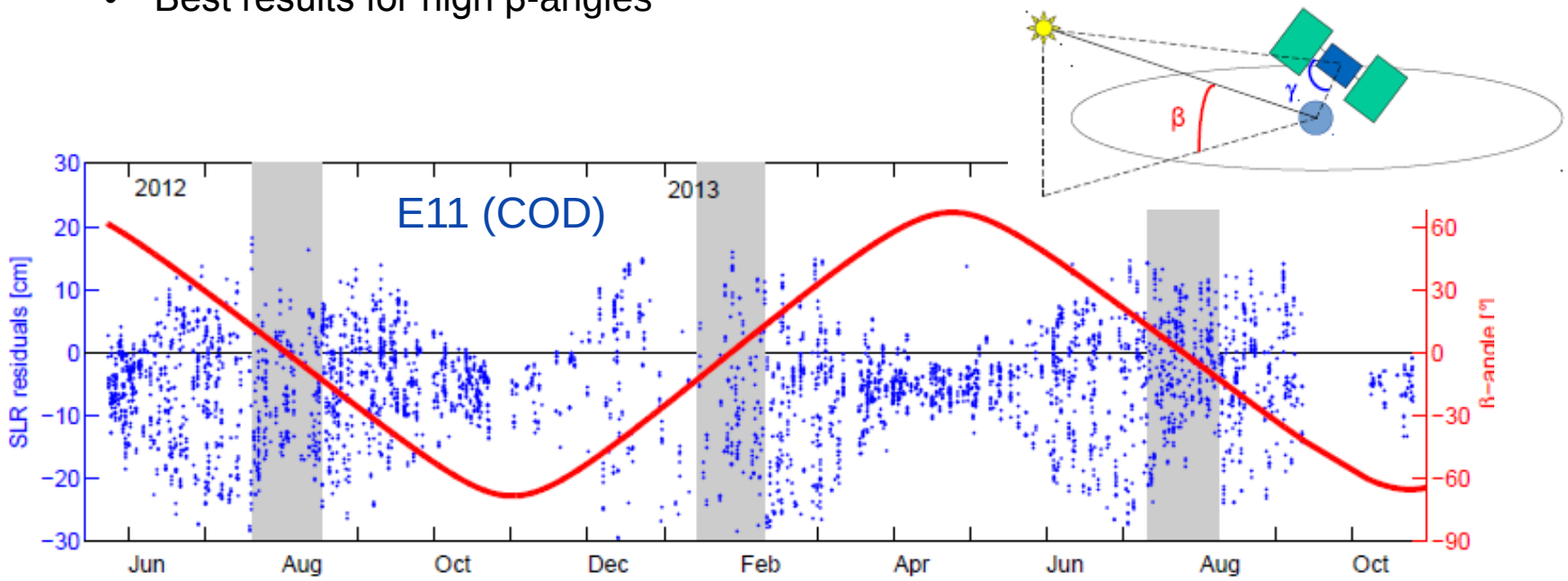
- Routine products from 4 ACs
  - Different s/w packages and processing strategies

- Orbit performance assessment
  - 3-day solutions (COD, GFZ, TUM) 2-3x better than 1-day (CNES)
  - 10-15 cm level (3D rms) consistency
  - 5-8 cm day boundary discontinuities
  - 10 cm rms SLR residuals

(Steigenberger et al., ASR, submitted)

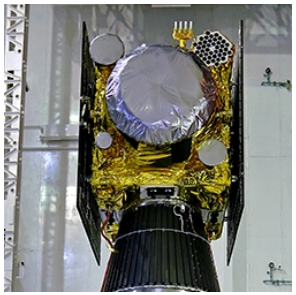
Galileo IOV – SLR Residuals

- Bias -5 cm
- 1/rev radial orbit errors with up to +/- 20 cm amplitude
- Amplitude varies with Sun-angle above orbital plane (β-angle)
  - Best results for high β-angles



(Steigenberger et al., ASR, submitted)

BeiDou Orbit and Clock Products

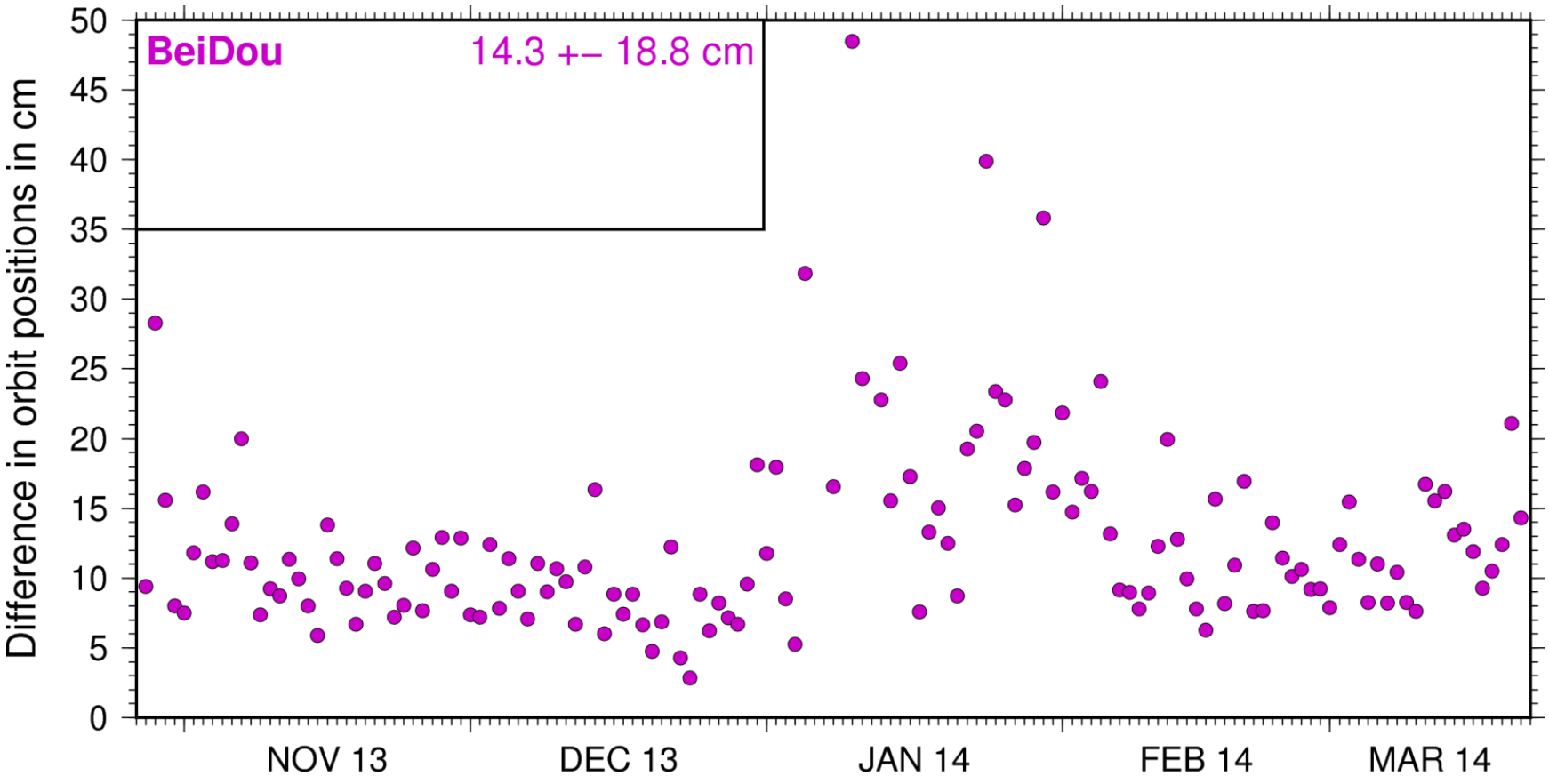


- Products from 3 ACs
  - Different s/w packages (PANDA(1), EPOS, BSW) and processing strategies
  - Different networks (MGEX-only vs. MGEX+BETS(2))
  - Only short overlapping periods available (CODE-WUH/CODE-GFZ)

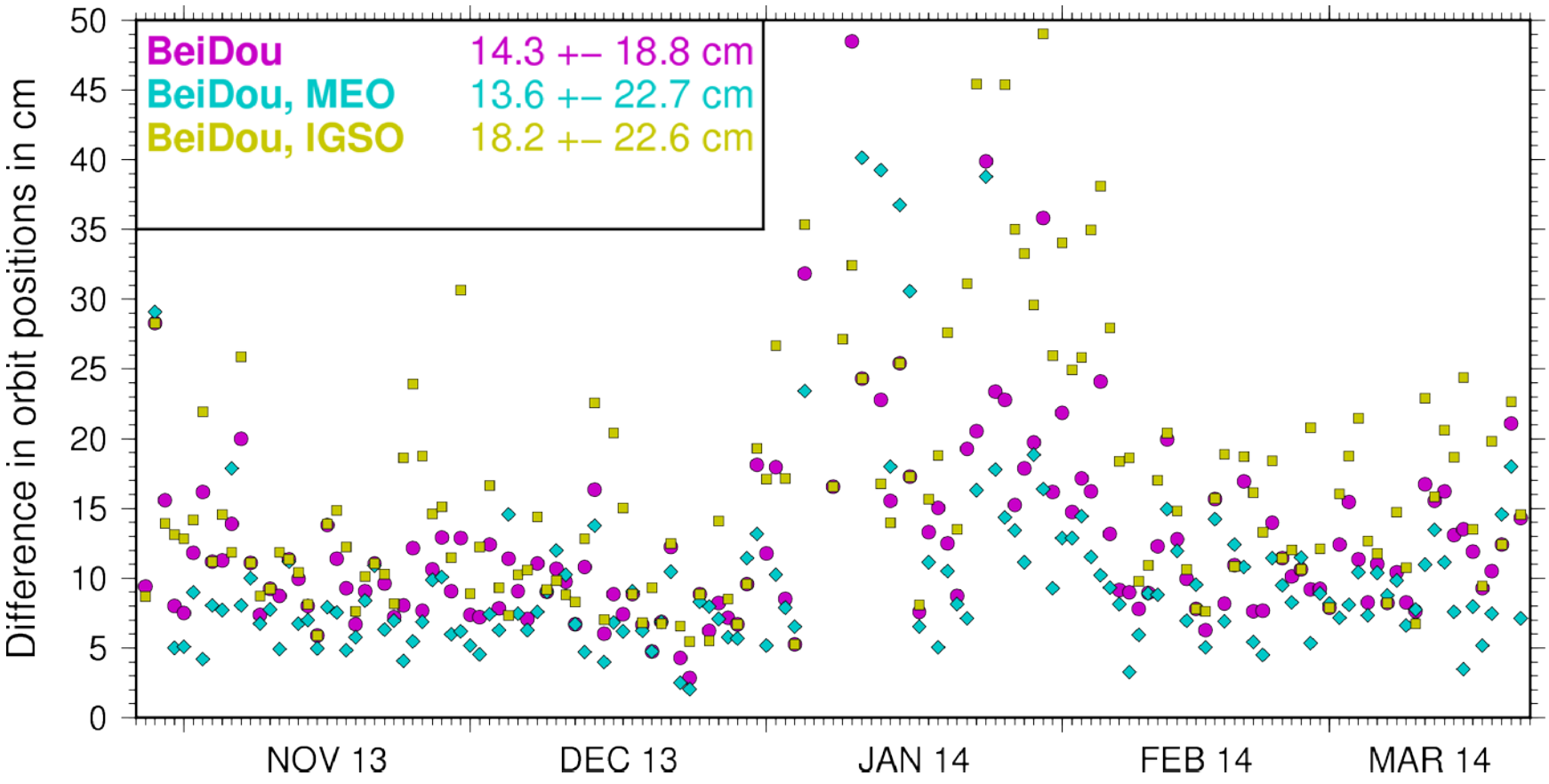
- Orbit performance assessment
  - SLR residuals (10 cm MEO/IGSO; 0.5m GEO?)

(1) Processing details from Wuhan solution are pending
(2) BeiDou Experimental Tracking Stations (BETS)

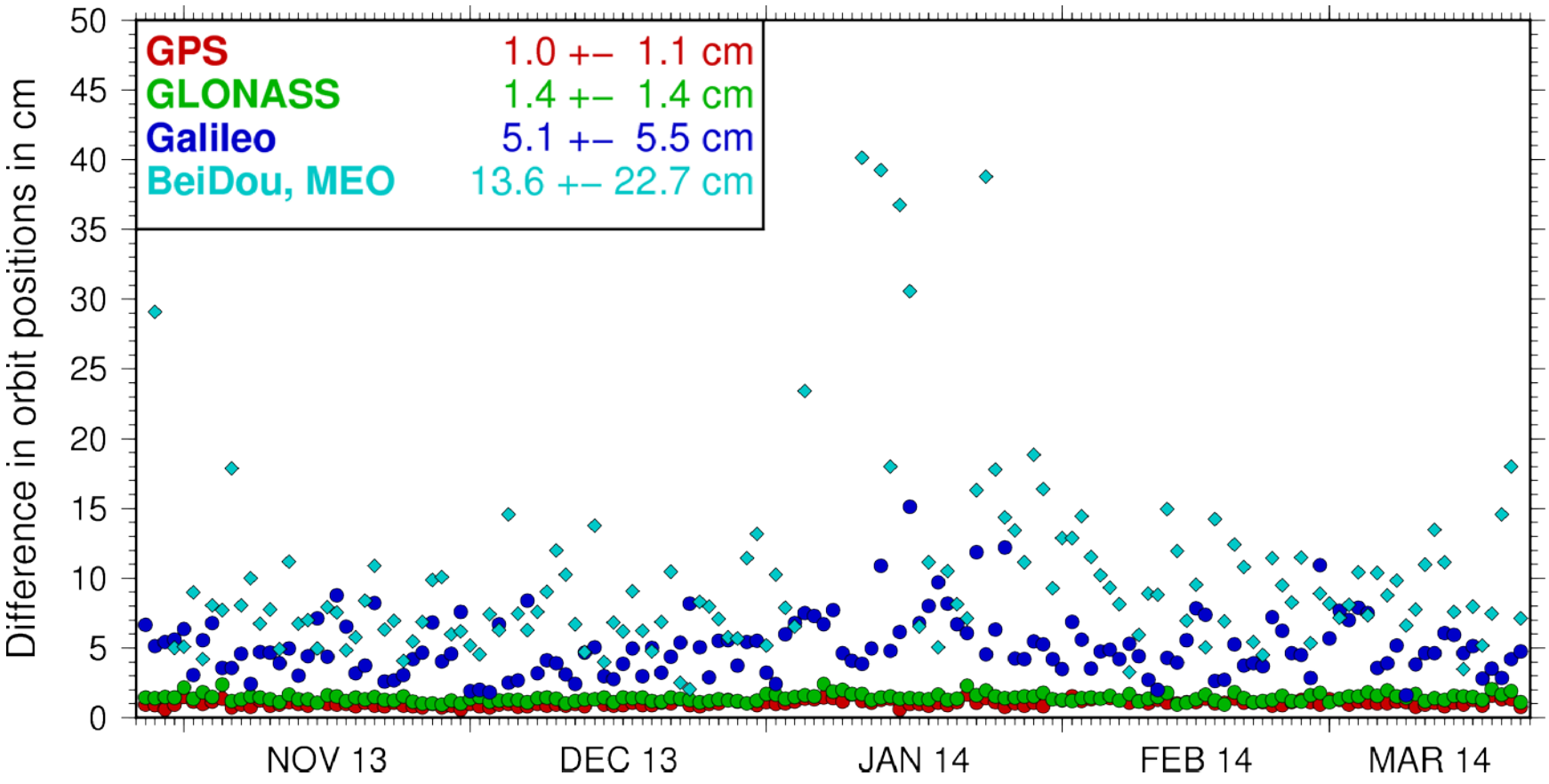
BeiDou: Orbit Overlaps (CODE)



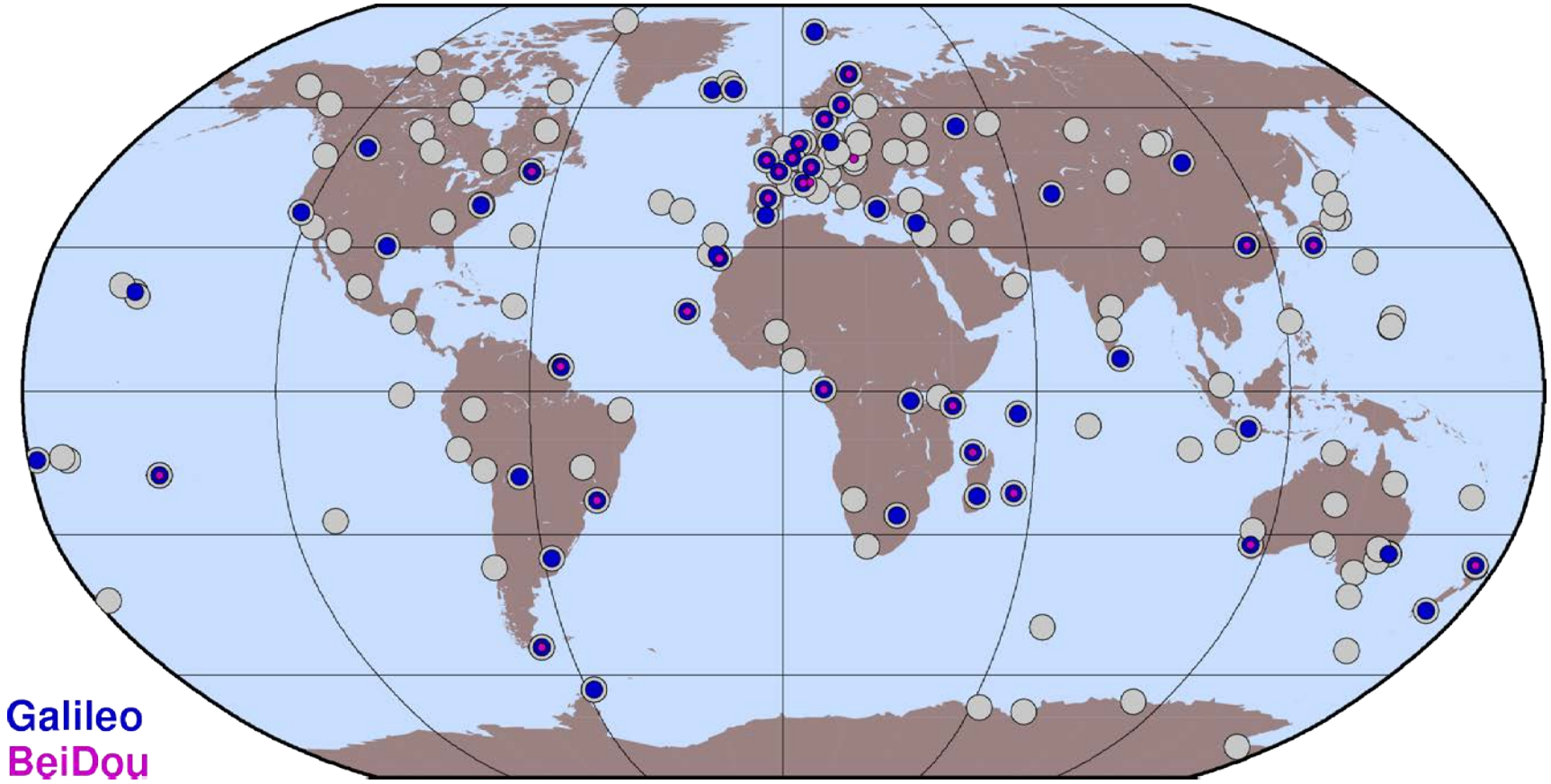
BeiDou: Orbit Overlaps (CODE)



BeiDou: Orbit Overlaps (CODE)



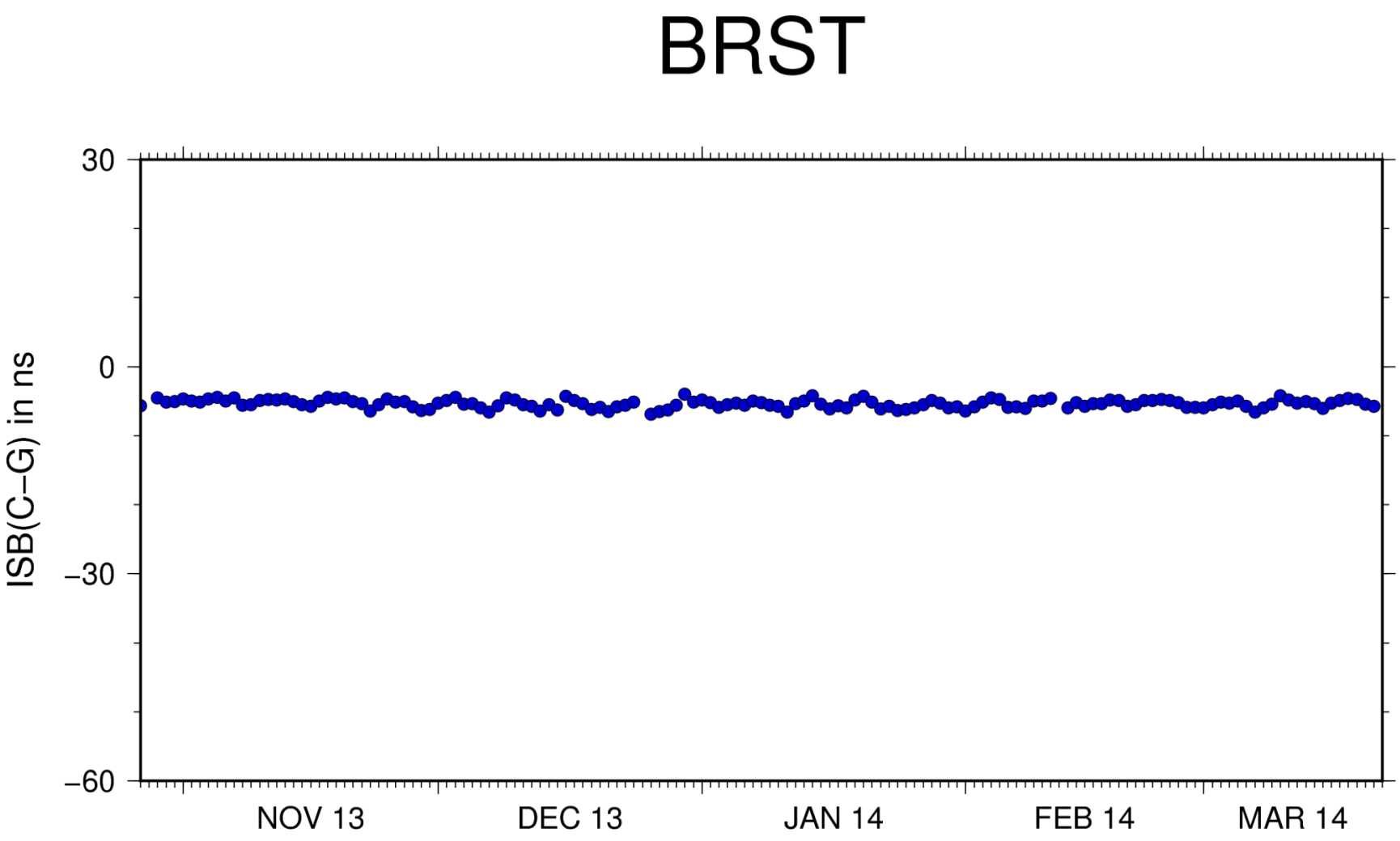
CODE: Network configuration



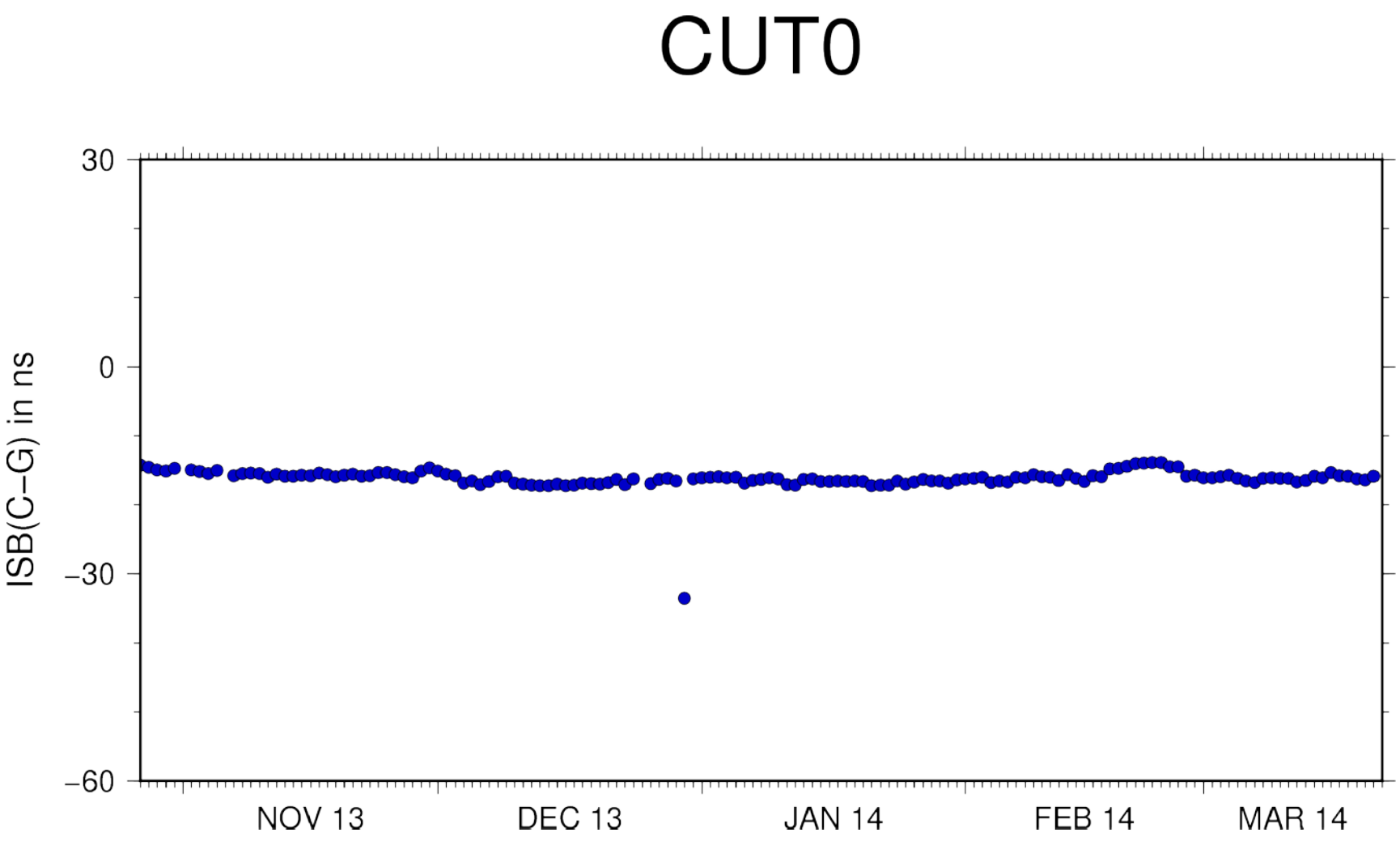
BeiDou – Open Issues

- Limited coverage of GEO/IGSO satellites by current MGEX network
- Lacking information on antenna phase center offsets and attitude modes
- No maneuver information (NABUs?)
- Will B3 signal remain accessible for tracking?
- Need common standard for clock offsets
  - All receivers provide B1/B2, only a subset offers also B3
  - B3 used for broadcast clocks
  - ACs (may) employ different conventions for intersystem biases
- Support SLR tracking for all BeiDou satellites!?

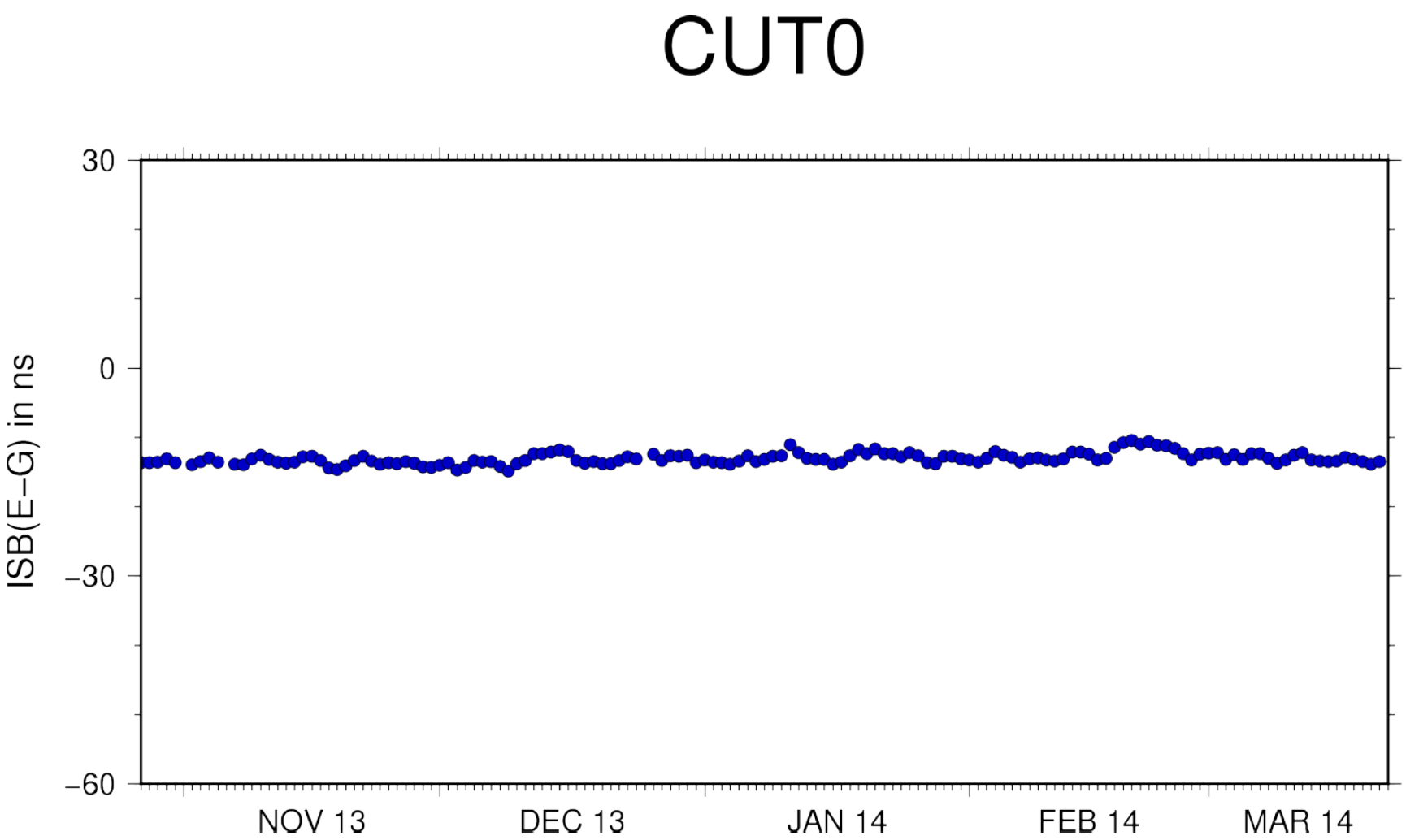
Inter-System-Bias (CODE): BeiDou



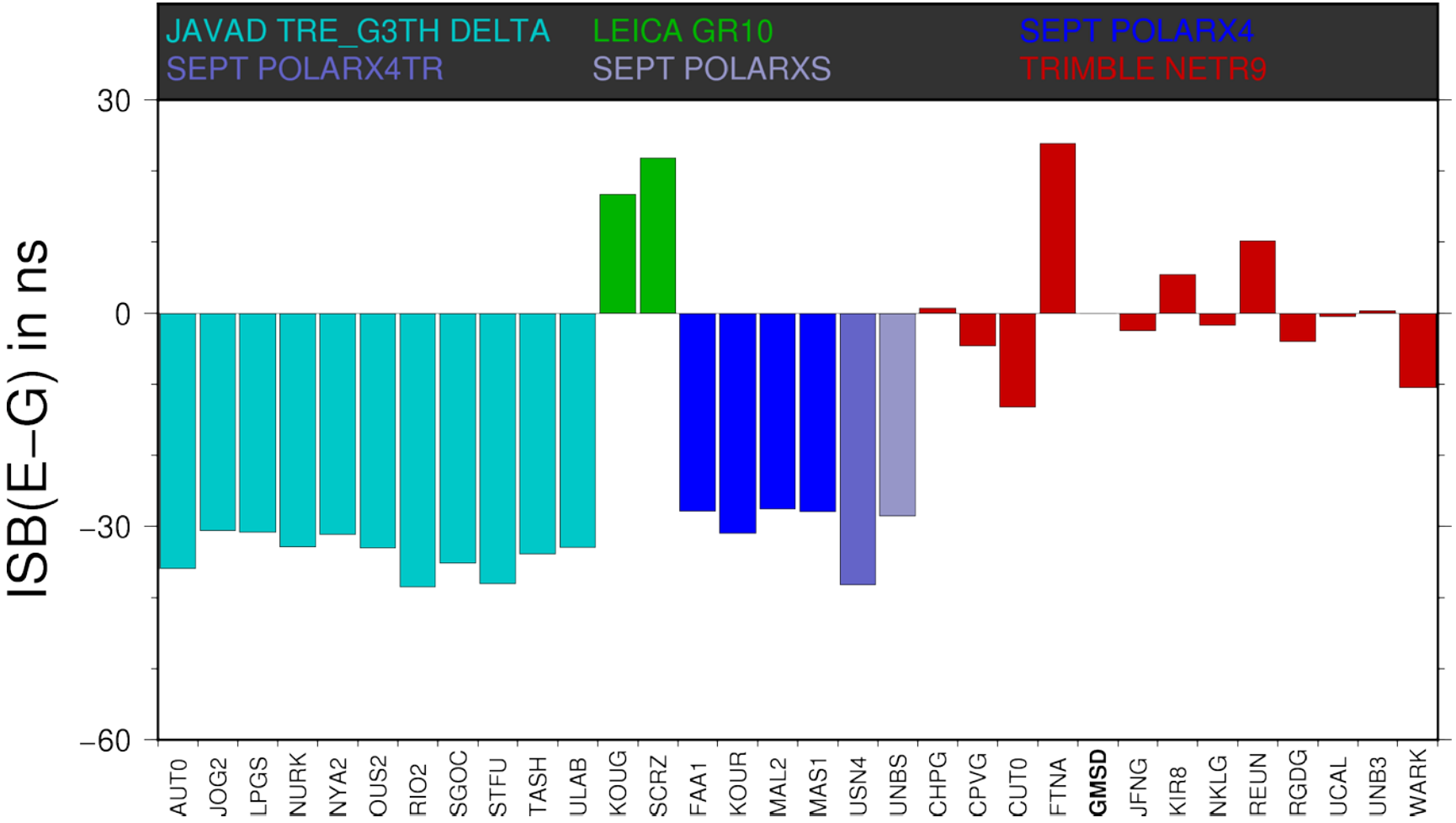
Inter-System-Bias (CODE): BeiDou



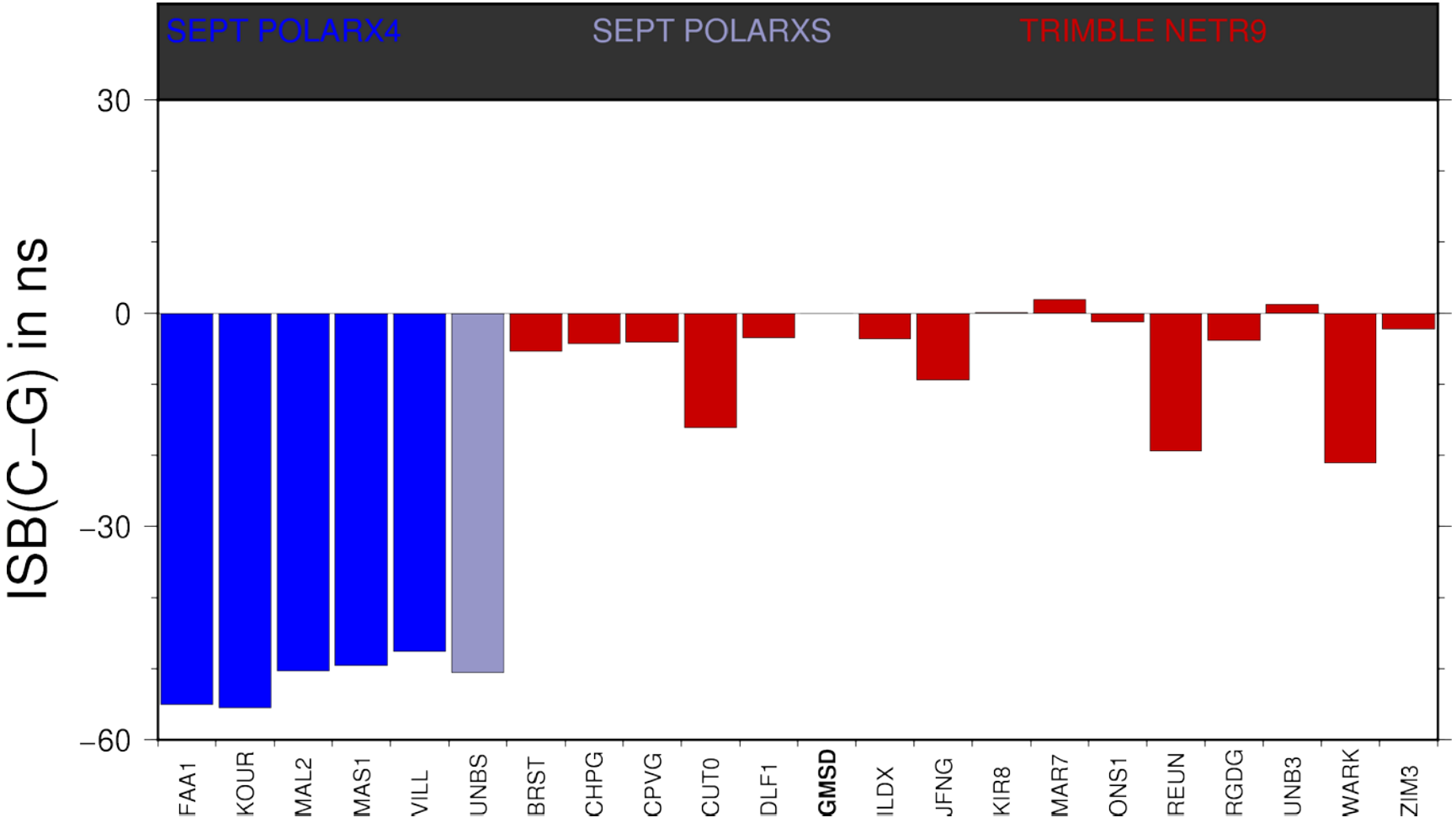
Inter-System-Bias (CODE): Galileo



Inter-System-Bias (CODE): Galileo



Inter-System-Bias (CODE): BeiDou



MGEX DCB Product

The CODE-MGEX solution is referring to:

GPS: C1P/C2P

Galileo: C1X/C5X

BeiDou: C2I/C7I

If other groups are using difference observation types, the **Differential Code Biases** become relevant.

MGEX DCB Products are available in Bias SINEX format:

- Supported constellations: GPS, GLO, BDS, GAL
- Available at

  ftp://cddis.gsfc.nasa.gov/pub/gps/products/mgex/dcb

Regional Systems: QZSS, IRNSS

There are several groups of satellites that are expected only marginally relevant for EUREF because of their «location»:

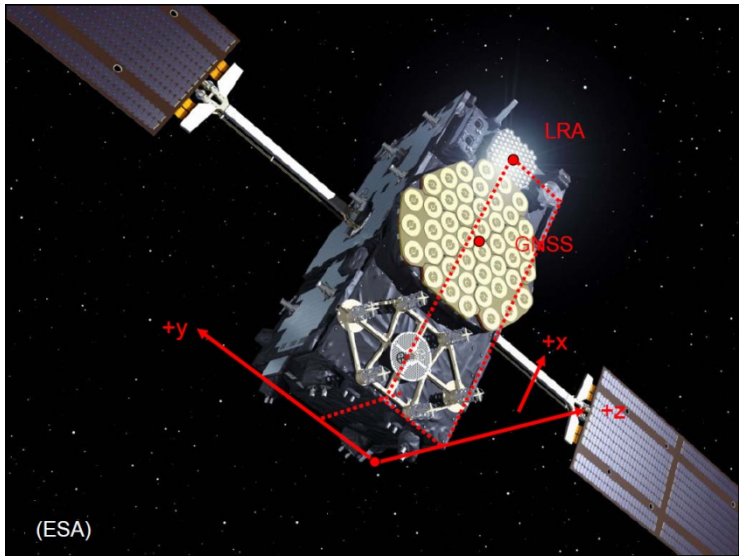
- QZSS: Quasi Zenith Satellite System, Japan
- IRNSS: Indian Regional Navigation Satellite System
- IGSO, GEO for BeiDou

These satellites are not or at least only visible in low elevations for (Central) European stations.

Their contribution to EPN products is consequently limited.

Standardization Efforts

- Continued interactions of MGWG with:
  - GNSS system providers
  - Equipment manufacturers
  - Other IGS Working Groups (Ant WG, Bias WG, RT WG)
- Recommendations, conventions and processing standards:
  - Attitude models
  - Antenna offsets and patterns
  - SRP models
- Data formats:
  - Observations and navigation data (RINEX 3.x, RTCM3.2)
  - Biases (SINEX?)
  - Orbits and attitude (ORBEX?)



IGS MGEX – http://igs.org/mgex/

- Central portal for MGEX related information
- Entry point for data and product servers