

# Multi-GNSS Working Group

Oliver Montenbruck



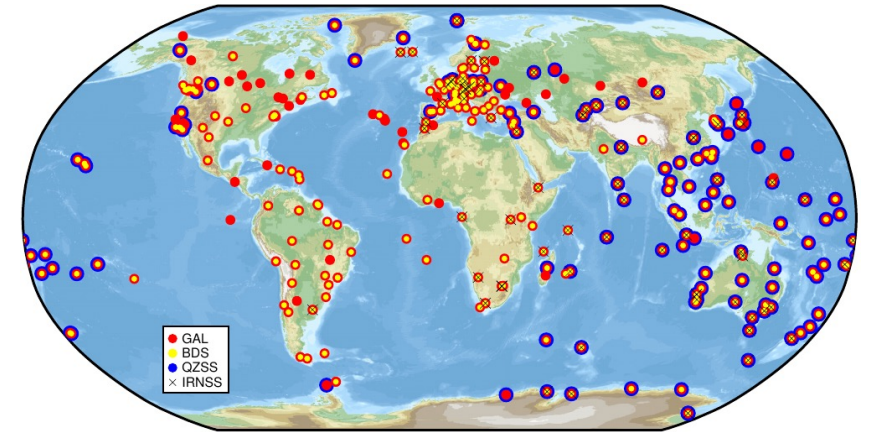
## Multi-GNSS News

- QZS-1R set healthy/operational, QZS-1 decommissioned
- Galileo E223 & E224 set healthy
- Two GLO-K1B satellites launched
- Release of GPS III antenna patterns by Lockheed Martin
- ICD and initial transmission of Galileo High Accuracy Service
  
- GLONASS excluded from ILRS tracking



# Multi-GNSS Status and Accomplishments (I)

- ~370 multi-GNSS stations
  - Improved support for modernized BeiDou-3 signals (B1C, B2a)
  - Essentially no IRNSS S-band support
- Introduction of new RINEX4 format
  - Standard released Dec. 2021
  - Routine generation of cumulative broadcast ephemerides including all nav messages
  - Native RINEX 4 obs and nav files from selected receivers in IGS network



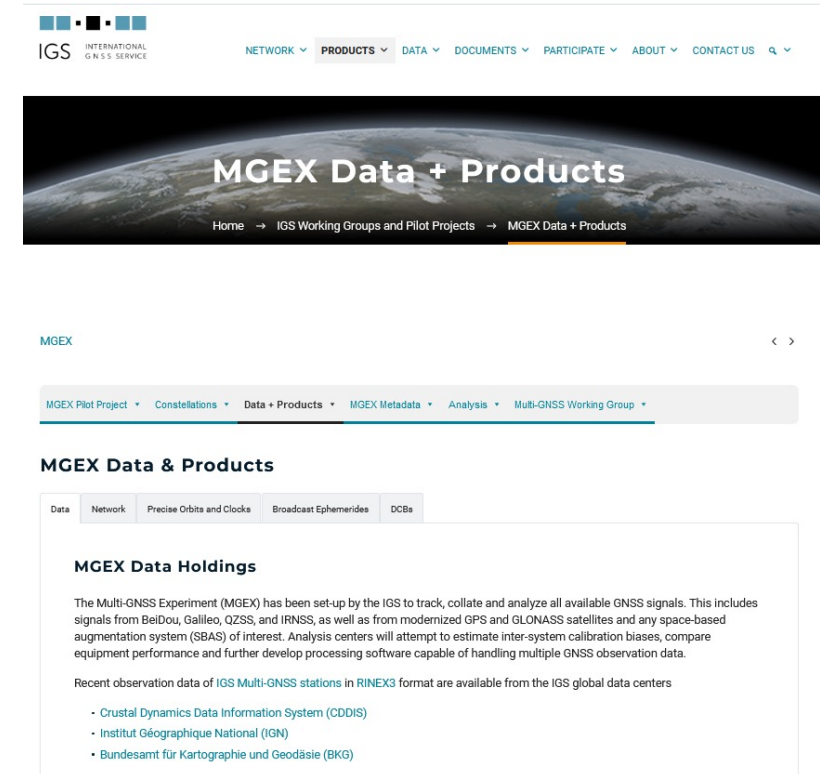
```

TABLE A21
BeiDou NAVIGATION MESSAGES - EXAMPLE
-----
> EPH C01 02
C01 2021 07 05 22 00 00-8.639377386004e-09 1.684644247878e-11 0.000000000000e+00
0.000000000000e+00-5.681202000000e+11 1.848724070797e-09-1.59311460512e+00
-1.87146166866e-05 7.4921614029989e-04 1.402891836781e-05 6.402828181646e+00
1.496000000000e+00 2.072132728513e-07 2.624951147237e-00-1.12324770212e-07
1.15188888888e-04-8.975132000000e-04 4.4718500e-01 0.000000000000e+00
6.66459124624e+04 0.000000000000e+00 8.000000000000e+02
2.000000000000e+00 0.000000000000e+00 0.000000000000e+00-9.500000000000e-09
4.660000000000e+05 0.000000000000e+00
> EPH C01 02
C01 2021 07 05 22 00 00-8.648713821498e-04 1.1700830631111e-11 0.000000000000e+00
1.000000000000e+00-2.466630200000e-04 4.02323131610e-09-1.55635993116e-01
-6.28847378838e-05 8.64881021108e-05 4.02323131610e-09-3.2616332716e-01
9.360000000000e+04 2.328304626939e-09-2.77228179876e+00-1.24163212326e-08
9.48979184262e-05 2.374942100000e-02-4.12441881898e-01-6.87992917917e-09
4.171462381612e-10 3.797494100000e-02 8.000000000000e+02
2.000000000000e+00 0.000000000000e+00 2.000000000000e+00-2.300000000000e-08
9.360000000000e+04 1.000000000000e+00
> EPH C01 02
C01 2021 07 05 22 00 00-8.537324611098e-04 1.167898935838e-11 0.000000000000e+00
-3.52733947878e-05 1.560287000000e+00 3.012601862162e-09-2.89226029318e+00
7.7297739330e-08 8.43617979346e-04 7.58979824133e-06 6.26262697926e+03
2.686000000000e+00 4.39281984910e-04 2.72741023898e+00-1.64875819102e-08
9.6665789978e-05 2.111381280000e-06-1.2328142181e-01-6.64200328280e-09
4.78423784925e-10 2.60215894109e-14 3.000000000000e+00 1.680000000000e+00
0.000000000000e+00-4.000000000000e+00 1.000000000000e+00 1.000000000000e+00
-1.48249348016e-05 2.62164483910e-09 0.000000000000e+00 1.98889700878e-08
-1.000000000000e+00 0.000000000000e+00 0.000000000000e+00 1.800000000000e+01
1.486000000000e+05
> EPH C01 02
C01 2021 07 05 22 00 00-8.539910172924e-04 1.158972198266e-11 0.000000000000e+00
-4.04433778878e-03 1.207812800000e+00 3.943199496392e-09-2.492861480739e+00
0.000000000000e+00 8.43284273947e-04 7.58118774020e-06 6.39262812216e+00
1.692000000000e+00-4.666418731077e-09-2.717449498395e+00-6.61138041200e-08
9.68647488746e-05 1.202887160000e+00 4.000000000000e+00 1.000000000000e+00
4.811014678621e-10 2.780284946077e-14 3.000000000000e+00 1.682000000000e+00
0.000000000000e+00-5.000000000000e+00 1.000000000000e+00 1.000000000000e+00
1.892000000000e+05 2.192923412979e-09 2.328304626939e-09-1.860000000000e+01
1.892000000000e+05 0.000000000000e+00 0.000000000000e+00 1.900000000000e+01
1.892000000000e+05
> EPH C01 02
C01 2021 07 05 00 00 00-8.648882186889e-04 1.158481177878e-11 0.000000000000e+00
-2.8654826866e-03-6.814062000000e-04 4.088200447478e-09-1.22981469106e+00
-6.95787021285e-05 8.44074418989e-05 4.088200447478e-09-2.28378918889e+00
9.440000000000e+04 3.732802928462e-09-2.722281889894e+00 0.000000000000e+00
9.66732169819e-05 4.629245200000e+00 2.000000000000e+00 2.000000000000e+00
3.93776117851e-10 2.72977181889e-14 3.000000000000e+00 8.640000000000e+00
0.000000000000e+00-3.000000000000e+00 1.000000000000e+00 1.000000000000e+00
1.800000000000e+05 0.000000000000e+00 0.000000000000e+00-1.748228274144e-09
8.440000000000e+04
-----
1-----110-----1---210-----1---310-----1---410-----1---510-----1---610-----1---710-----1---81

```

# MGEX Status and Accomplishments (II)

- New IGS multi-GNSS antenna model (igs20.atx)
  - Additional multi-band receiver antenna calibrations
  - Satellite-specific GPS III and BDS-3 calibrations
- Continued provision of orbit/clock products by 7 ACs
  - Mostly 5 GNSSs (GPS, GLO, GAL, BDS-2/3, QZSS)
  - Additional ACs providing ERPs
  - Hourly near real-time products (Wuhan Univ.)
  - IGS20 transition in progress
- Various bias products (DCBs, OSBs)
- Orbit/clock performance monitoring (MGEX website)
- Continued maintenance of GNSS satellite metadata file



The screenshot shows the MGEX Data + Products website. The header includes the IGS logo and navigation links: NETWORK, PRODUCTS, DATA, DOCUMENTS, PARTICIPATE, ABOUT, CONTACTUS. The main banner features a satellite view of Earth with the text "MGEX Data + Products" and a breadcrumb trail: Home → IGS Working Groups and Pilot Projects → MGEX Data + Products. Below the banner, there is a navigation menu with links: MGEX Pilot Project, Constellations, Data + Products, MGEX Metadata, Analysis, and Multi-GNSS Working Group. The main content area is titled "MGEX Data & Products" and includes a sub-menu with links: Data, Network, Precise Orbits and Clocks, Broadcast Ephemerides, and DCBs. The "MGEX Data Holdings" section contains a paragraph describing the experiment and a list of participating analysis centers: Crustal Dynamics Data Information System (CDDIS), Institut Géographique National (IGN), and Bundesamt für Kartographie und Geodäsie (BKG).

## MGEX Status and Accomplishments (III)

- Performance assessment of BDS-3 orbit/clock products
- Assessment of BDS-2/3 group delays (broadcast vs IGS)
- Assessment of manufacturer calibrations for BDS-3 PCOs
- PCO vs. TRF scale relation for different GNSSs
  
- Preparation of ILRS tracking for all BDS-3 MEO satellites (ongoing)

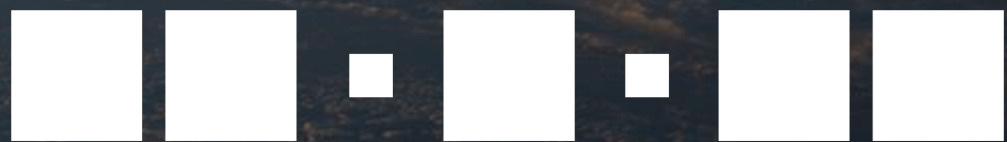


# Status of Recommendations from IGS Workshop 2022

- Relocate all MGEX products to standard IGS products directory  
*Planned for Jan 2023 including data from Jan 2022 onwards*
- Request GB approval for Satellite Metadata SINEX File Format and Product  
*Governing board meeting of 11 Dec. 2022*
- Establish a Task Force to define and implement a tool chain for multi-GNSS orbit/clock/(bias) combination and to establish an operational product.  
*Task force established Sep. 2022, work in progress*
- Study options for supporting the GPS L1/L5 user community through dedicated IGS clock or bias products  
*No activity so far*

# Combination Task Force

- Scope: coordinate and advance existing efforts for product combination across the IGS
- Call or Participation in July 2022, kick-off in Sep. 2022
- 15 members from 7 institutions, chaired by O. Montenbruck
- Results
  - Focus on combination for multi-GNSS PPP users
  - Orbit, clock+bias combination; initially no SINEX combination
  - Assessment of orbit interpolation
  - Specification of orbit combination requirements
- Next steps
  - Build up of Python s/w repository for orbit combination



IGS

INTERNATIONAL  
GNSS SERVICE

**Thank You!**

**Contact:**

Oliver Montenbruck

[oliver.montenbruck@dlr.de](mailto:oliver.montenbruck@dlr.de)