MGEX network and observation data

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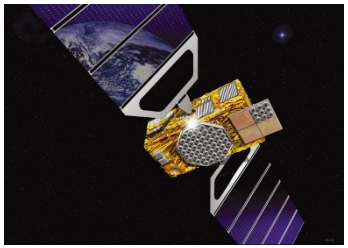
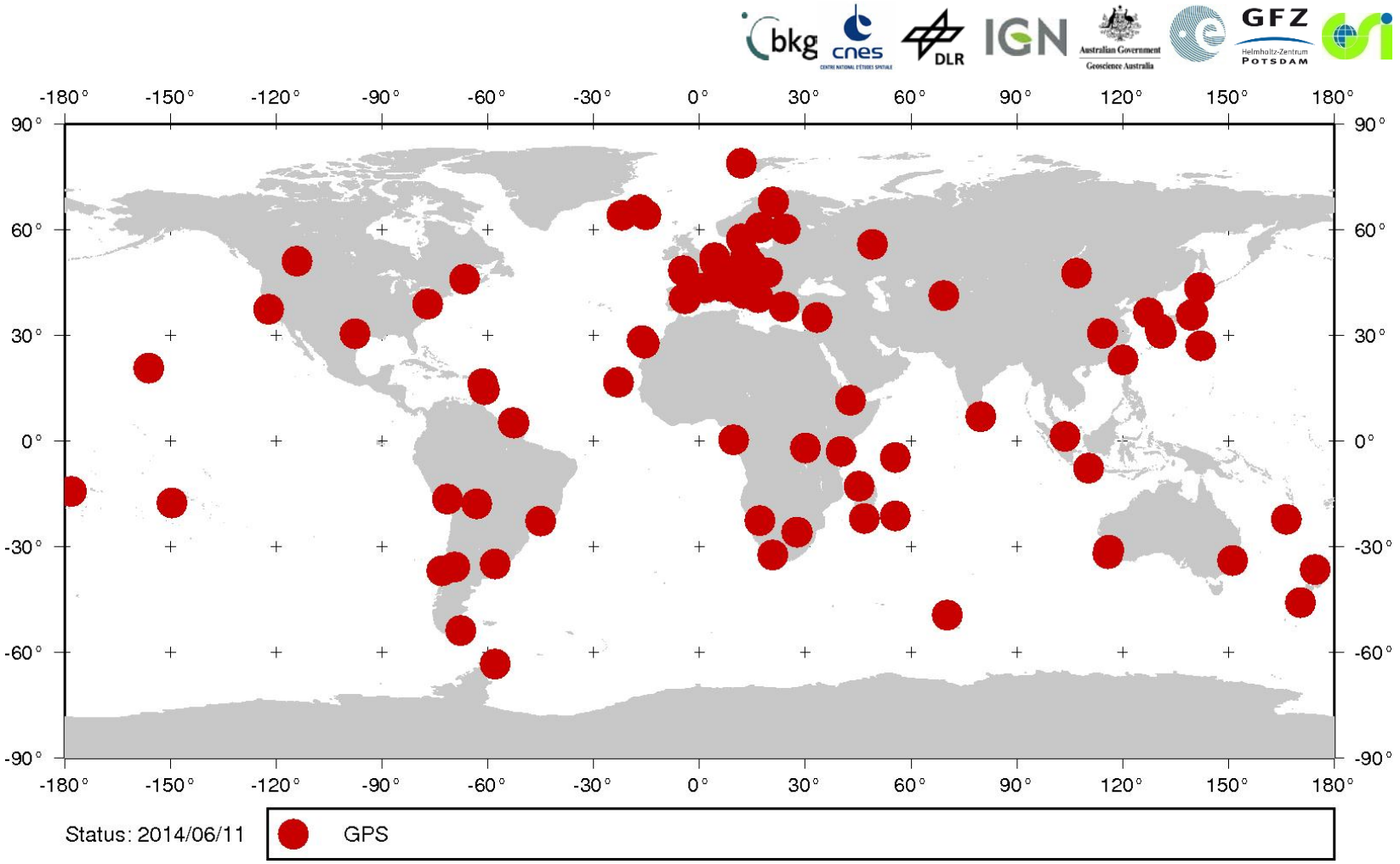
Introduction



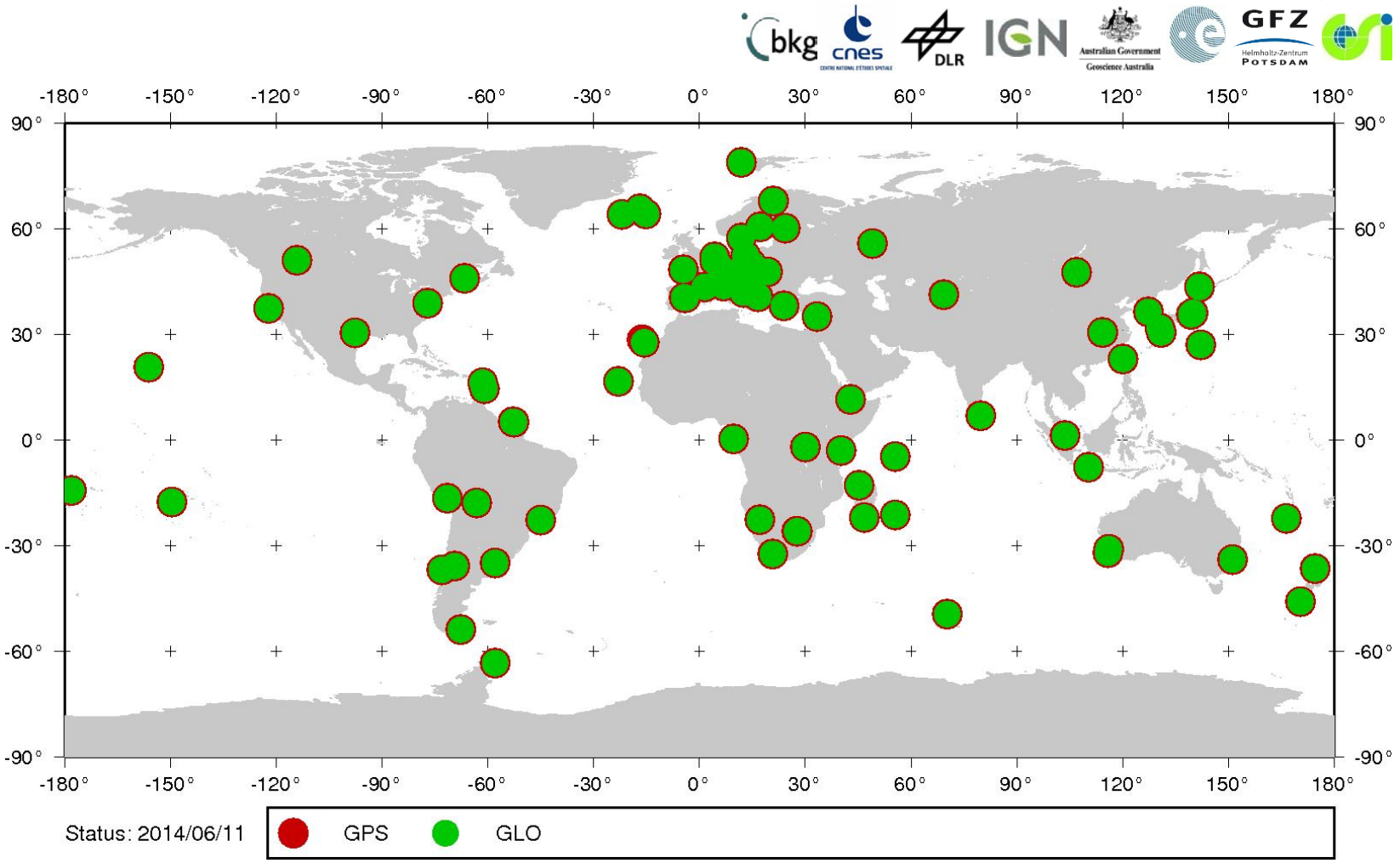
- **GPS**
  (32 SVs, IIA (7), IIR(12), IIR-M(7), IIF(6))
- **GLONASS**
  (30 SVs, 24 SVs operational)
- **BeiDou**
  (15 SVs)
- **Galileo**
  (4 SVs, IOV-Campaign)
- **SBAS**
  (1 QZSS, 4 EGNOS, 2 GAGAN, 2 MSAS, 2 SDCM, 3 WAAS)
- **IRNSS**
  (2 SVs)

Status: Mid June 2014

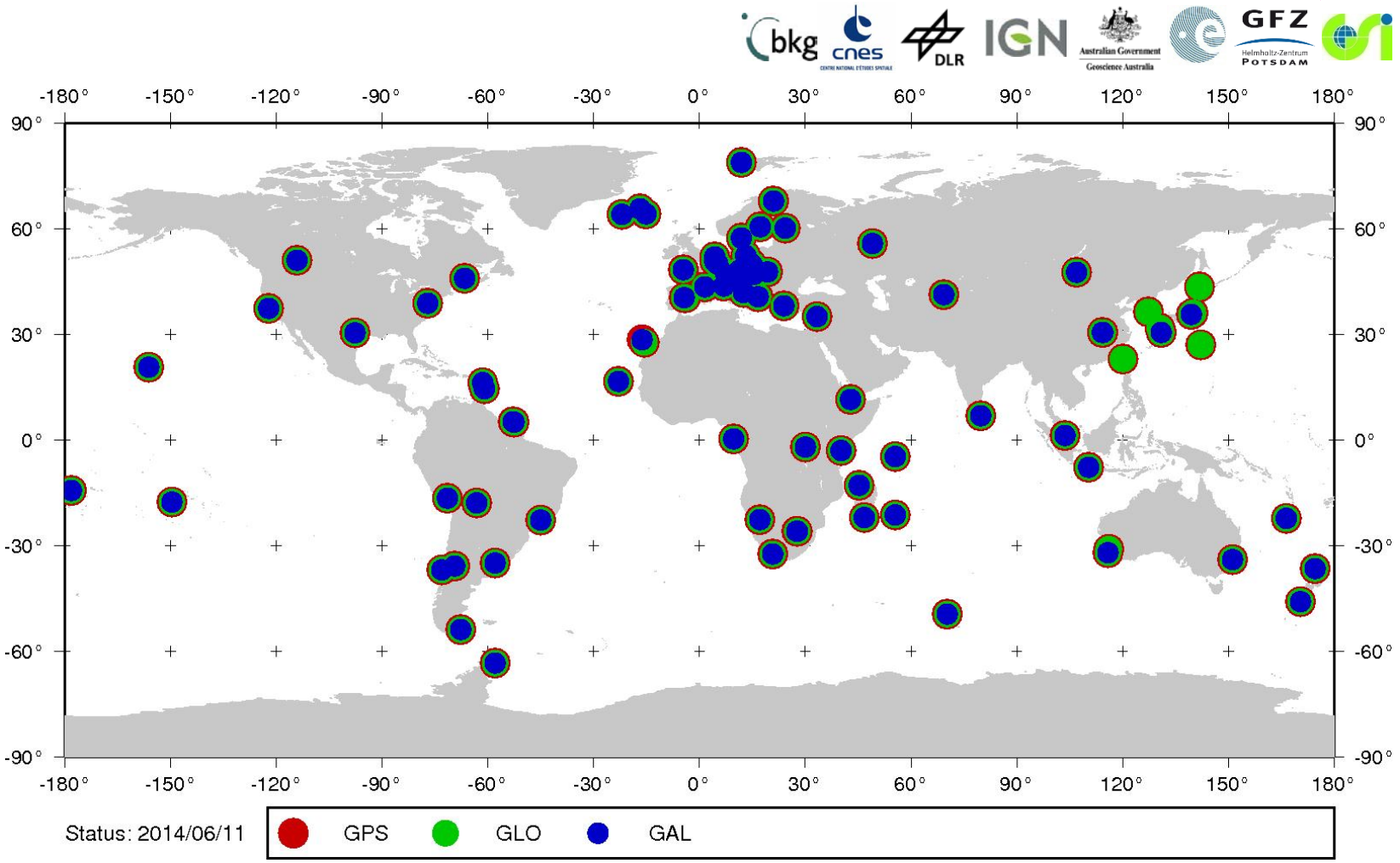
MGEX network: GNSS



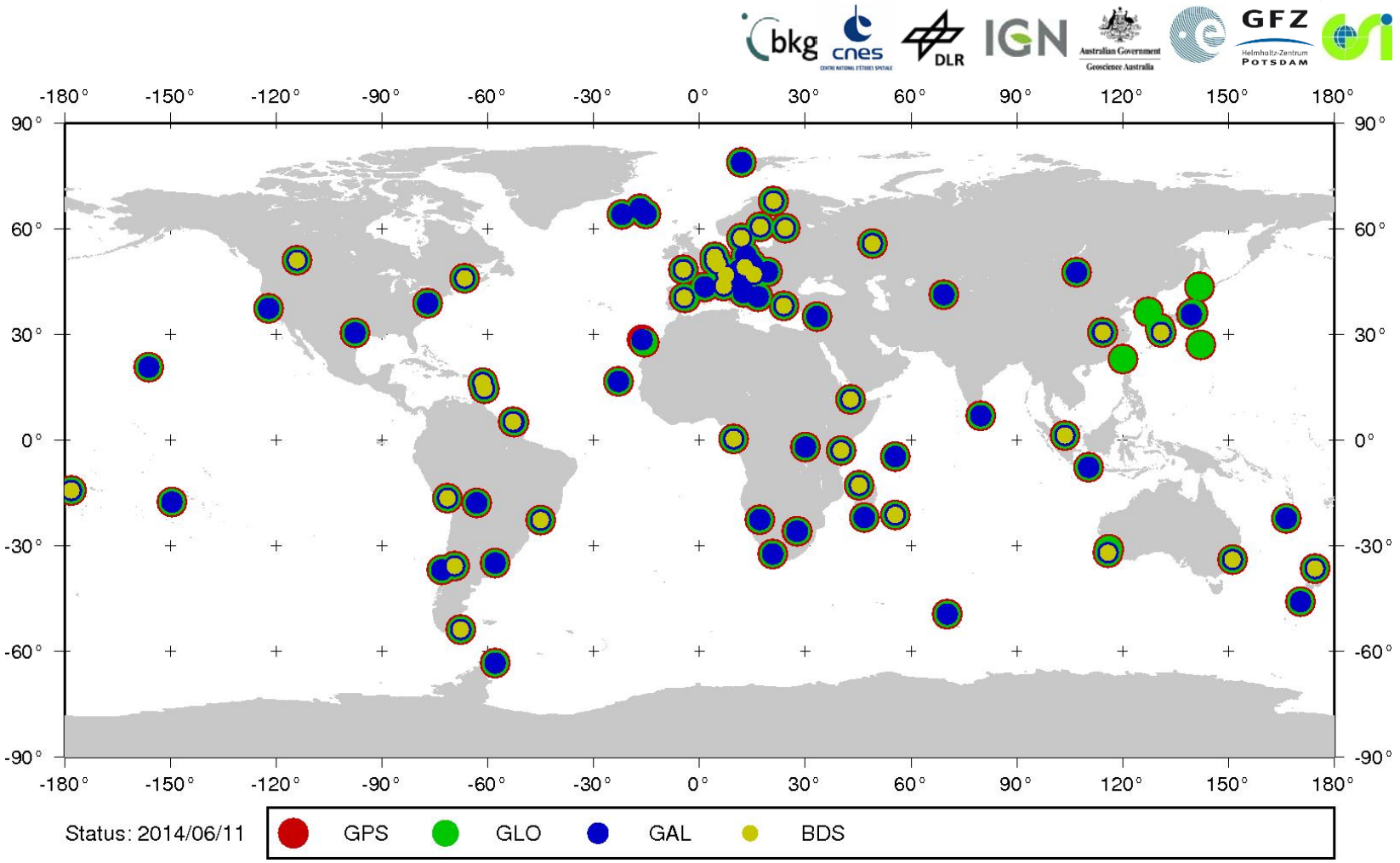
MGEX network: GNSS



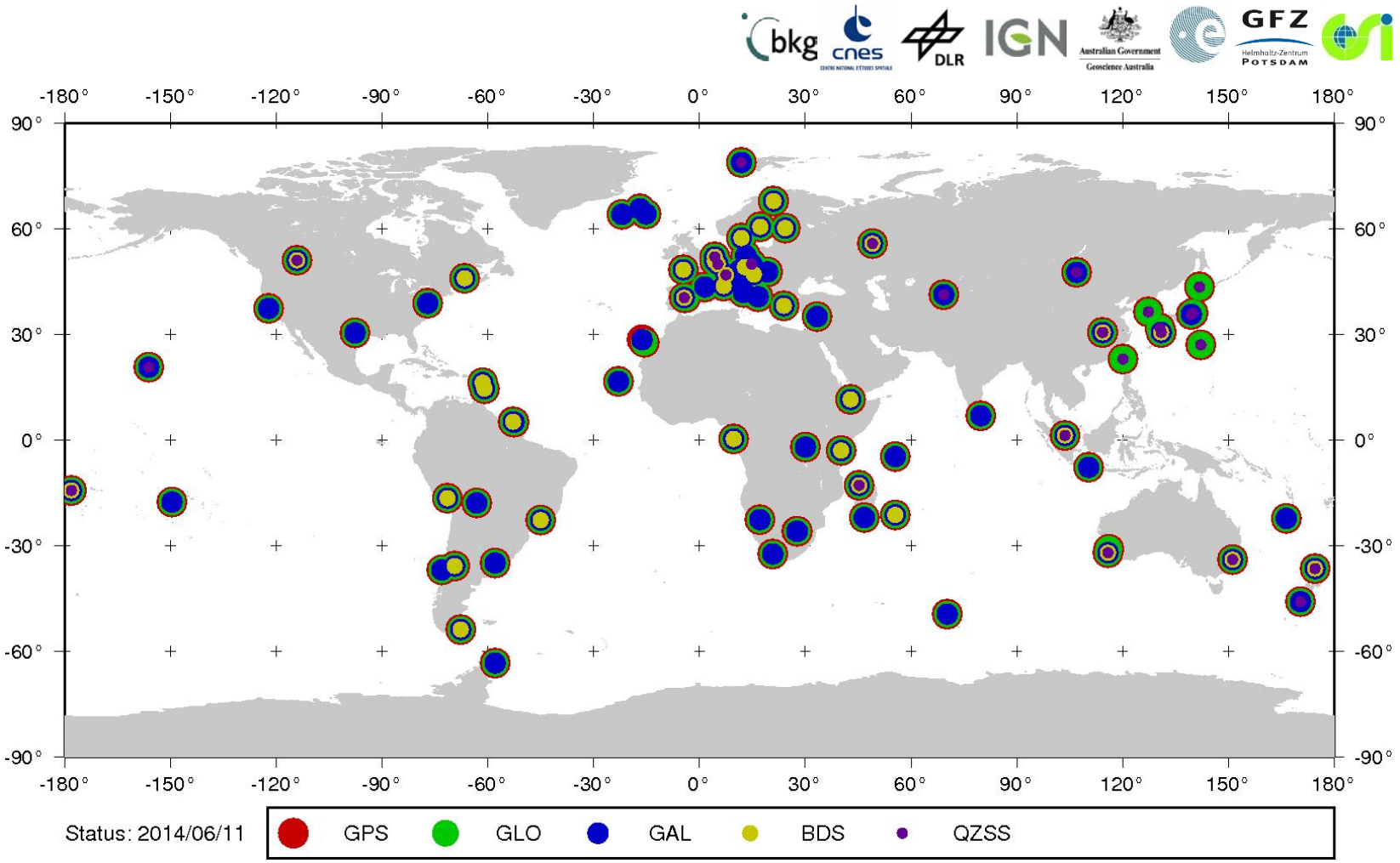
MGEX network: GNSS



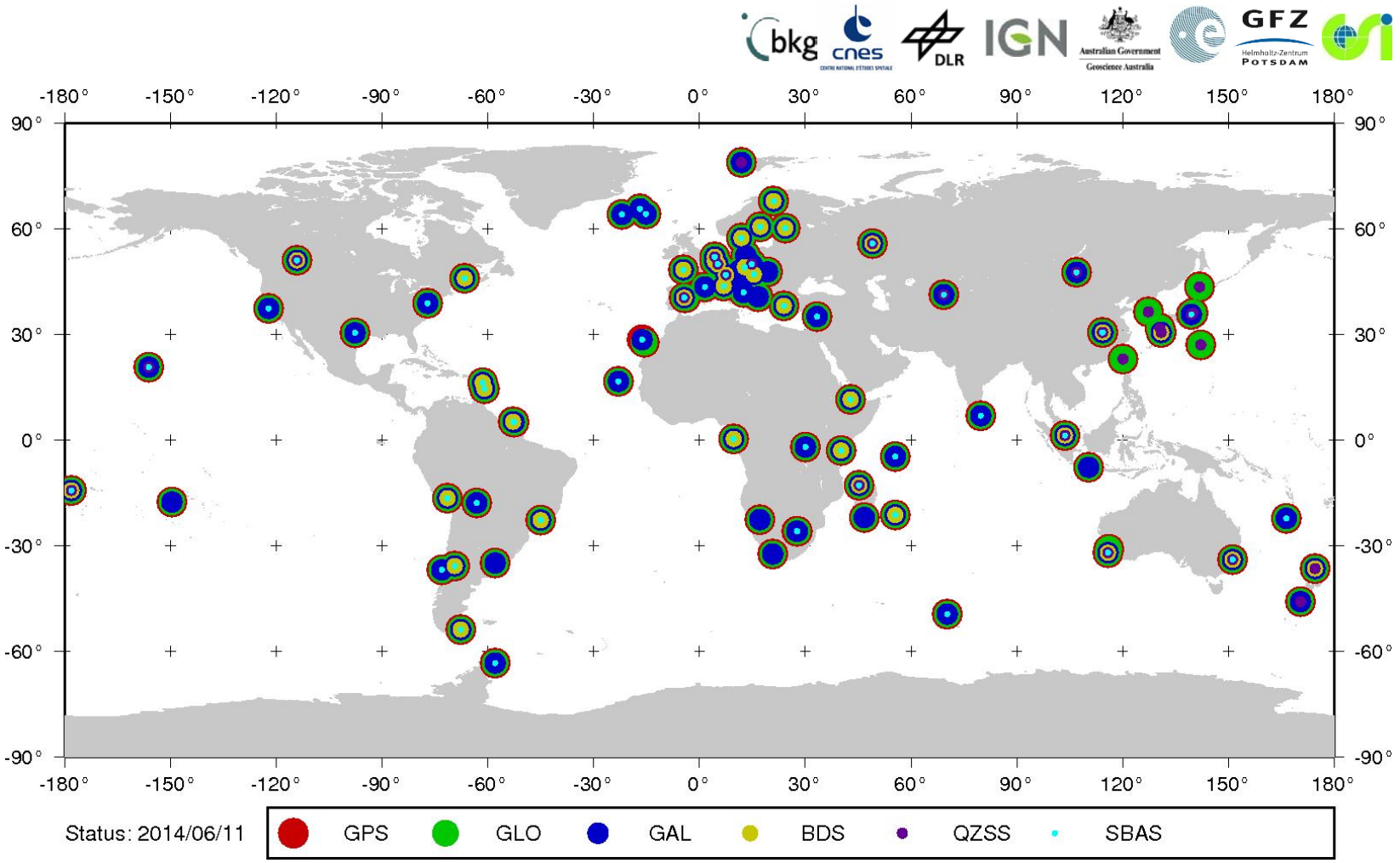
MGEX network: GNSS



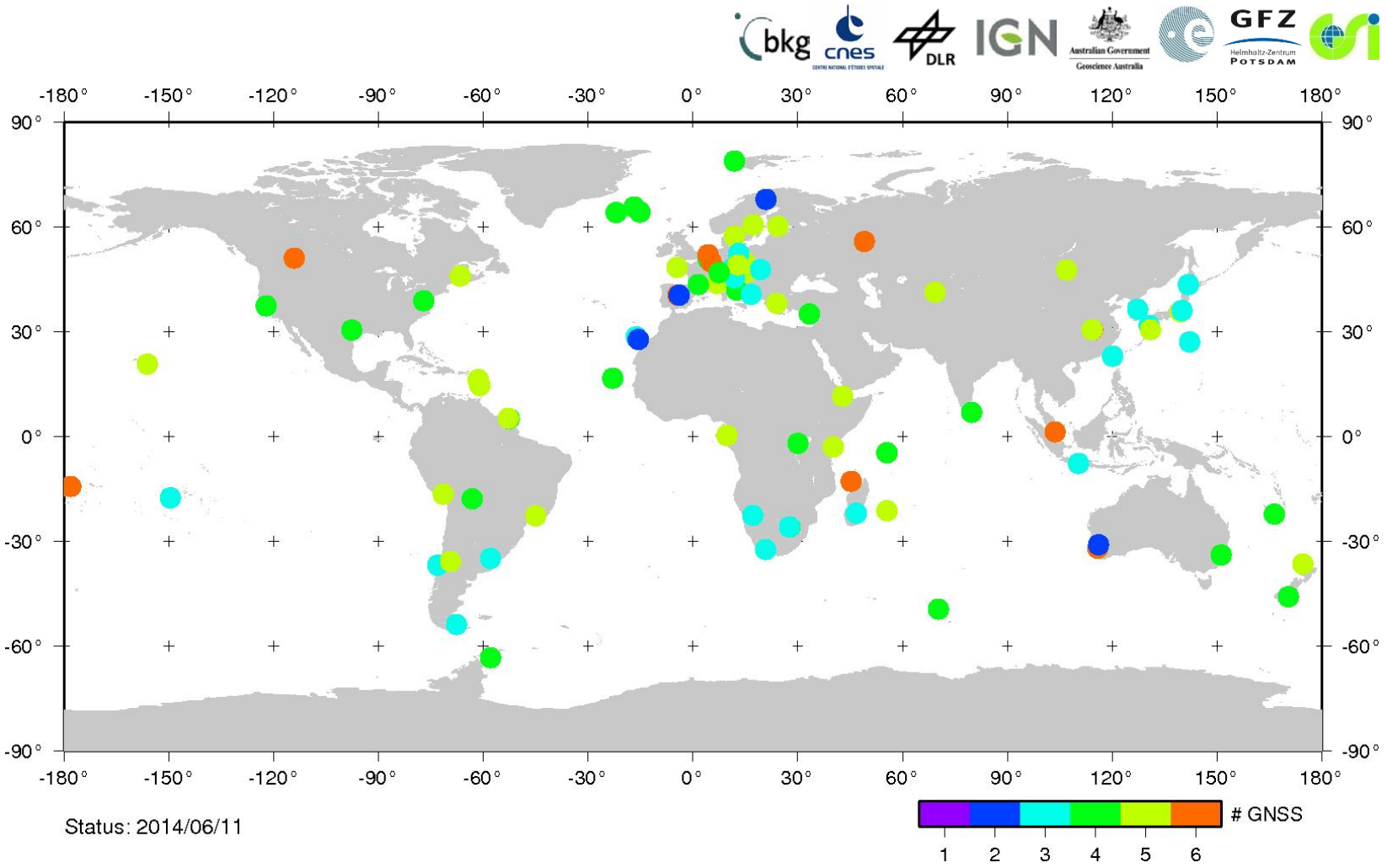
MGEX network: GNSS



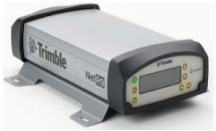
MGEX network: GNSS



MGEX network: GNSS



Receivers and Tracked Signals (1)

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

Receivers and Tracked Signals (2)

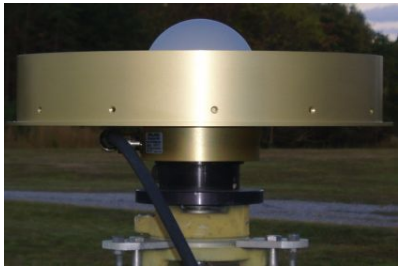
- Triple frequency tracking data available for
  - GPS (L1,L2,L5)
  - Galileo (E1, E5a, E5b, E5ab) but no E6, yet
  - BeiDou (B1,B2,B3)
- Different sets of supported signals
  - Lack of GPS L1 P(Y) measurements (Leica/NovAtel, Trimble)
  - Only E5a (but no E5b/E5ab) in numerous receivers
  - Limited BeiDou B3 tracking
  - Impacts choice of clock and ISB reference
- Different concepts for pilot/data and CBOC tracking
  - Pilot-only tracking („Q“) vs. pilot+data tracking („X“)
  - E1 BOC(1,1) vs. BOC(1,1)+BOC(6,1) tracking
  - Impact on code and phase biases remains to be explored

MGEX Tri/Quad-Band Antennas

- IGS PCV calibration (robot) for GPS/GLO L1/L2
- Prototype PCV calibrations (Bonn anechoic chamber) for new constellations/frequencies
- Merged ANTEX file under preparation/discussion

JAV_RINGANT_G3T

JAV_RINGANT_DM

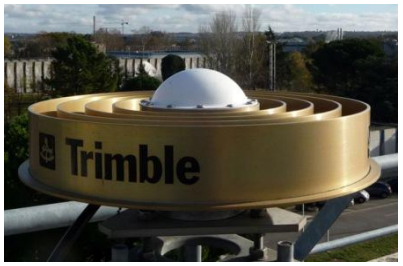


TRM57971

SEPCHOKE_MC

LEIAR25R4

TRM59800



IGS MGEX Equipment

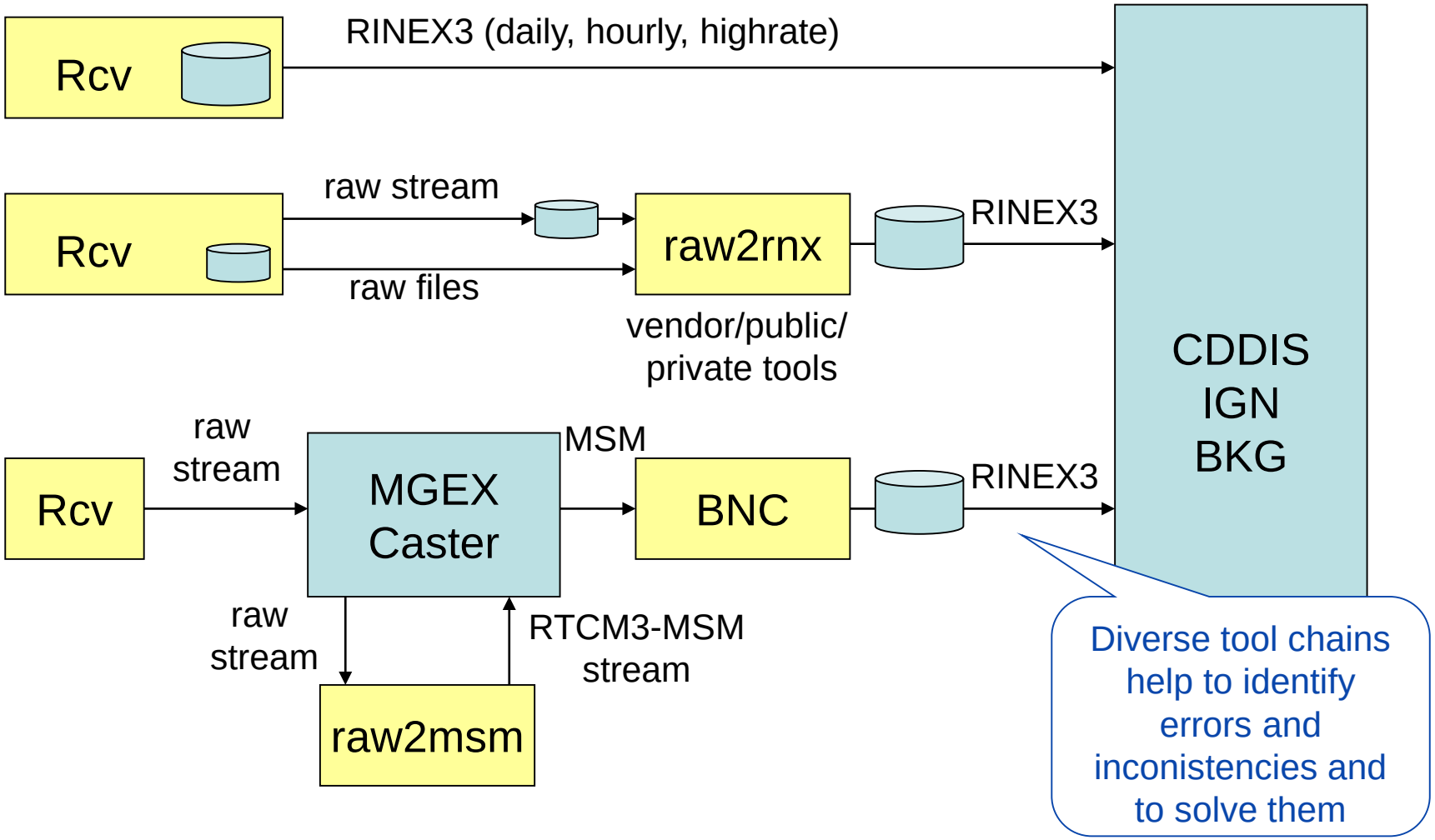
- Heterogeneous equipment
  - 5 basic receiver types
  - 6 main antenna types
- Many combinations
  - Different receiver-antenna pairs
  - Various sites with multiple receivers connected to common antenna
  - Various sites with multiple stations at short baselines
- Basis for cross-validation of equipment performance
- Open to new equipment

Station Information

- MGEX sitelog archives
  - IGS Central Bureau (Master)
    ftp://igs.org/pub/station/mgexlog
  - Copies (partly inconsistent) at IGN and BKG
- MGEX online station list
  http://www.igs.org/mgex/network.php
- Notes
  - New stations need to register with IGS CB for incorporation into official MGEX station list
  - No automatic consideration of legacy IGS stations for MGEX
  - All MGEX stations need to supply (updated) sitelogs to IGS CB

    Robert Khachikyan <robert.khachikyan@jpl.nasa.gov>

MGEX Data Flow



MGEX Data Archives

RINEX 3.x observation and navigation files

- Crustal Dynamics Data Information System (CDDIS)
  (ftp://cddis.gsfc.nasa.gov/pub/gps/data/campaign/mgex)
- Institut Géographique National (IGN)
  (ftp://igs.ign.fr/pub/igs/data/campaign/mgex)
- Bundesamt für Kartographie und Geodäsie (BKG)
  (ftp://igs.bkg.bund.de/MGEX)

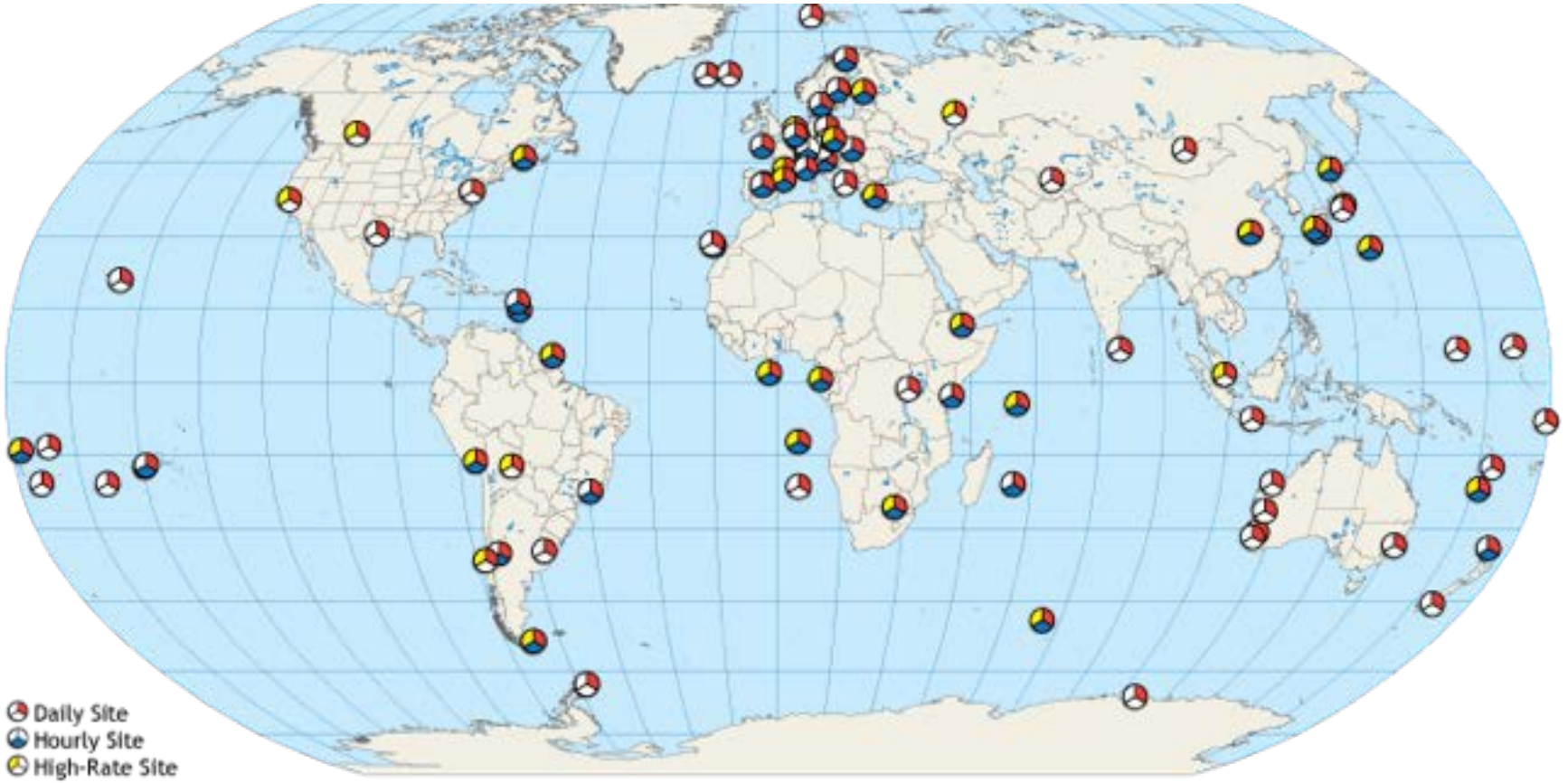
Issues:

- Inconsistent directory structures
- Inconsistent contents (not all stations and data sets in all archives, e.g. periodical updates „by hand“)

Real-time observation data streams

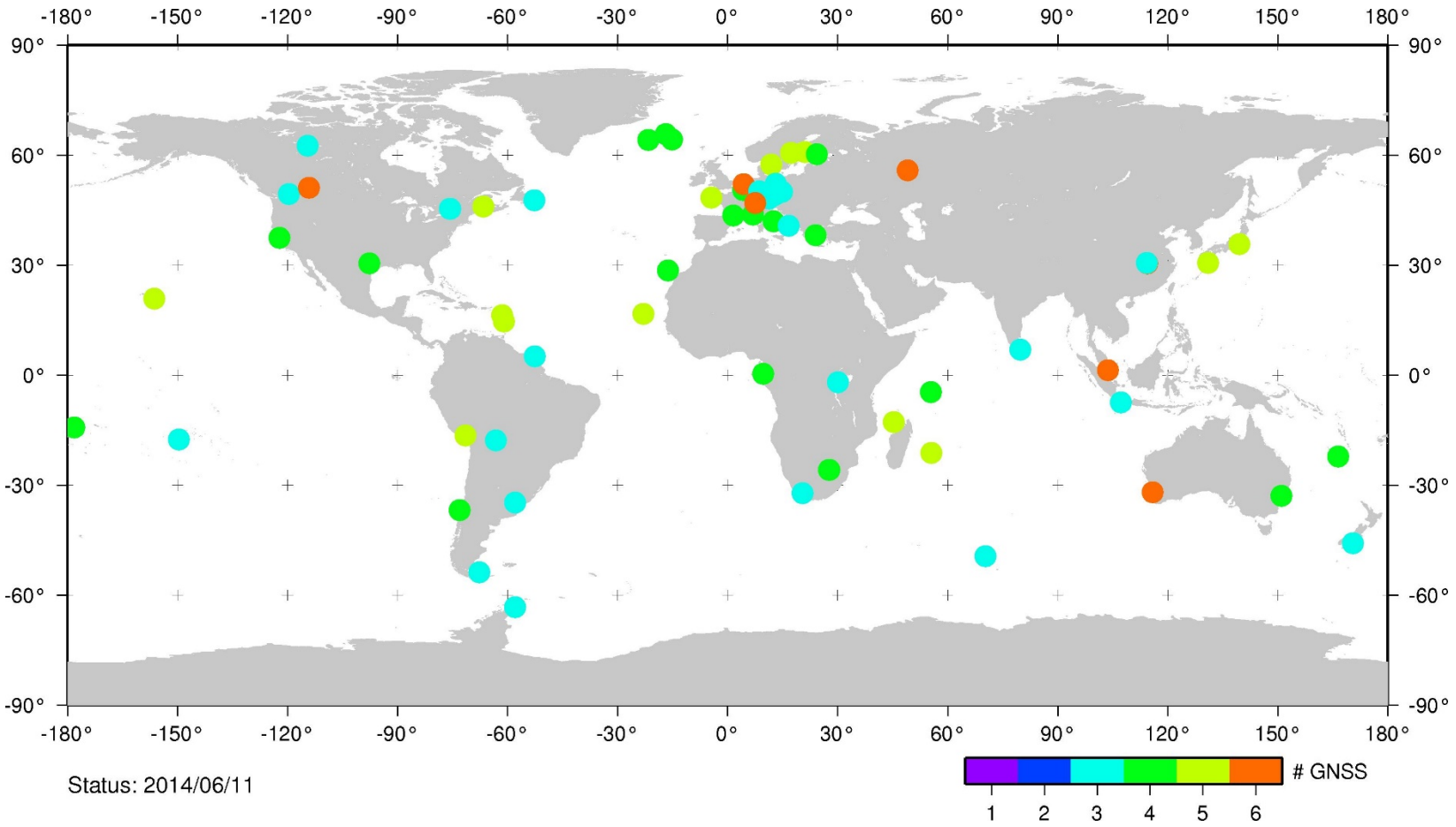
- MGEX-Caster at BKG: http://mgex.igs-ip.net/

MGEX data archive: data types



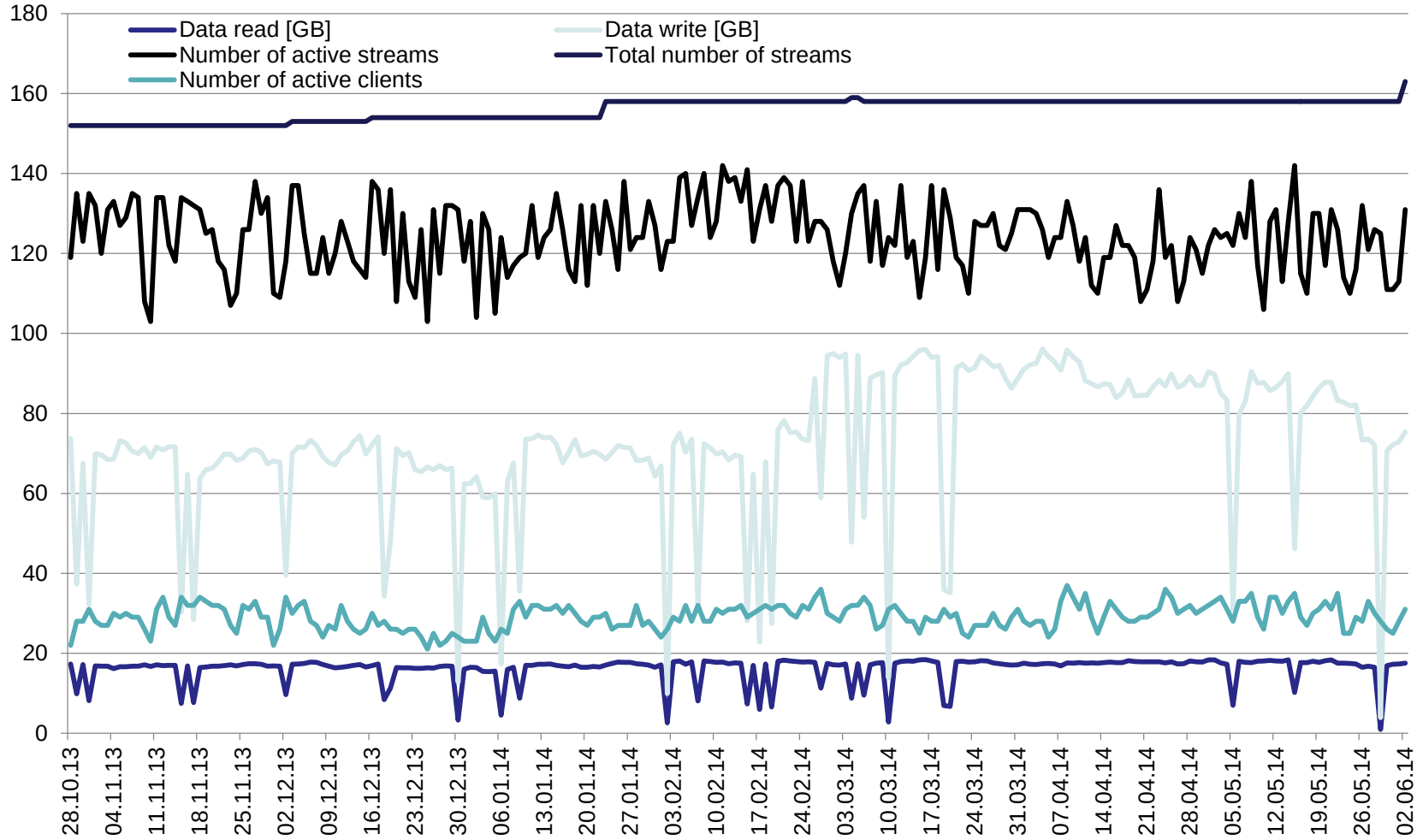
Here: CDDIS, June 2014

MGEX real-time data streams



MGEX Broadcaster: Usage

http://mgex.igs-ip.net/



Data Formats

- RINEX 3 adopted as sole format for MGEX offline observation and navigation data
- New file name convention not widely accepted by stations and users („8+3“ still used by most users, ESA provides new filenames for CDDIS archive which are saved separately)
- RTCM3-MSM promoted as standard for MGEX real-time data
- But: both standards do not keep pace with rapid GNSS evolution
  - Slow incorporation of new constallations (e.g., no IRNSS, yet)
  - Slow incorporation of new navigation data (e.g., no CNAV, yet)
  - …
- Lacking interaction of RINEX WG with MGEX world

MGEX Data Issues

- Observation types
  - Different tools use different obs types for same receiver
  - Questionable obs types (e.g. *2D for GPS P(Y)-code tracking)
  - „Spontaneous“ redefinition of BeiDou B1 obs types from *2I to *1I in RINEX 3.02
- Converter problems
  - e.g. same values for two obstypes, excessive LLIs, ...
  - Change of data during RTCM translation (e.g. clock offset correction)
  - Erroneous/inconsistent navigation data decoding …
- Tracking problems
  - e.g. varying AltBOC biases

MGEX Quality Control

- Lack of standard tool (like teqc) for quality control of multi-GNSS observations in RINEX 3.x format
- No documented/systematic performance assessment of MGEX stations and data despite extensive use of MGEX data
- Increasing number of „complaints“ by users
- Established new „QC task force“ within MGWG
  - Members: BACC, Curtin Univ., GOP
  - Review of current QC tools
  - Promotion of QC tool developments
  - General characterization of MGEX stations
- BKG Ntrip Client (BNC) could help to solve this issue:
  - Supports real-time and offline batch mode
  - Cross plattform (Windows, Linux, Unix, MacOS)
  - Graphical User Interface, command line mode
  - ASCII and graphical outputs

MGEX Quality Control: Software tools

- ANUBIS [1]
  - Developed by Geodetic Observatory Pecný (GOP)
  - XML configuration files, man/machine-readable output format
- BQC [2]
  - Developed by Bejing Aerospace Control Center (BACC/AFDL)
  - teqc inspired analysis and output
- BKG Ntrip Cient (BNC)
- Features
  - RINEX 3.x, GPS/GLO/BDS/GAL
  - Availability, SNR, (cycle-slip detection & repair), multipath

[1] Vaclavovic P.,· Dousa J., „G-Nut/Anubis – open-source tool for multi-GNSS data monitoring“, IAG (2013)
[2] Liu H., „BQC – A New Multi-GNSS Data Quality Checking Tool Kit“ (2014)

G-Nut/Anubis-QC tool for multi-GNSS data

- End-user application from the G-Nut software library
- Developed at Geodetic Observatory Pecny (GOP)
- Open-source (GNU GPLv3) at http://www.pecny.cz (GNSS – software – Anubis)

Algorithms & functionalities:

- Multipath for multi-GNSS, multi-frequency, multi-signals
- Pre-processing algorithms (clock jumps, cycle slips, …)
- Standard positioning for individual GNSS: GPS, GLO, GAL, BDS
- RINEX 2.x/3.x observation and navigation for all GNSSs

Aim at Q-monitoring (current priority):

- ✓ Quantitative check (all GNSSs & regional augmentation)
- ✓ Qualitative check (partial support for all GNSSs & regional augmentations)
- ✓ Meta data check (mainly in future)
- ✓ Standard positioning (GPS, GLO, GAL, BDS stand alone solutions)

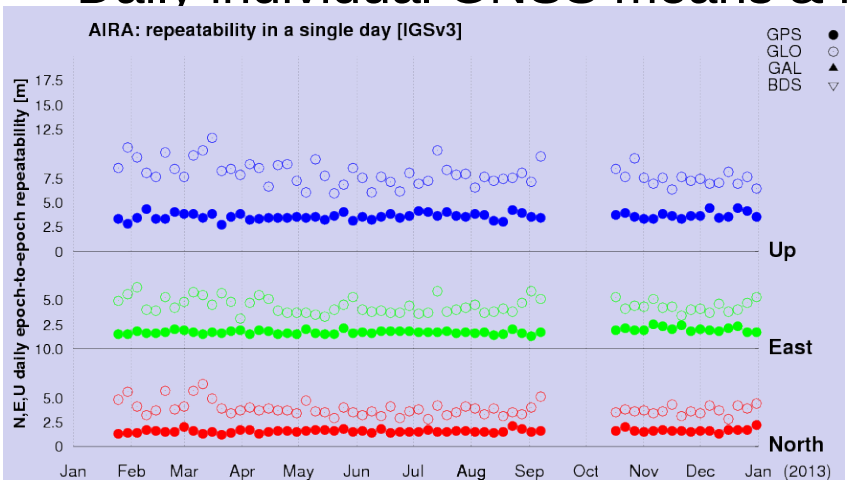
Q-monitoring at GOP for M-GEX and EUREF RINEX 3.x data pools

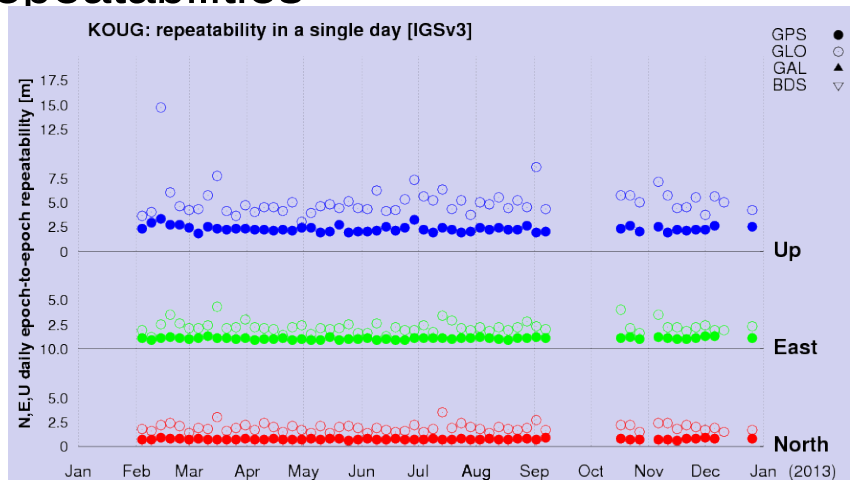
- ✓ Image web-browsing: http://www.pecny.cz (GNSS, data-center, multi-GNSS)
- ✓ QC extractions (http/ftp): http://www.pecny.cz/ftp/LDC/xtr_gnss/ (e.g. IGSv3/YEAR/DOY)

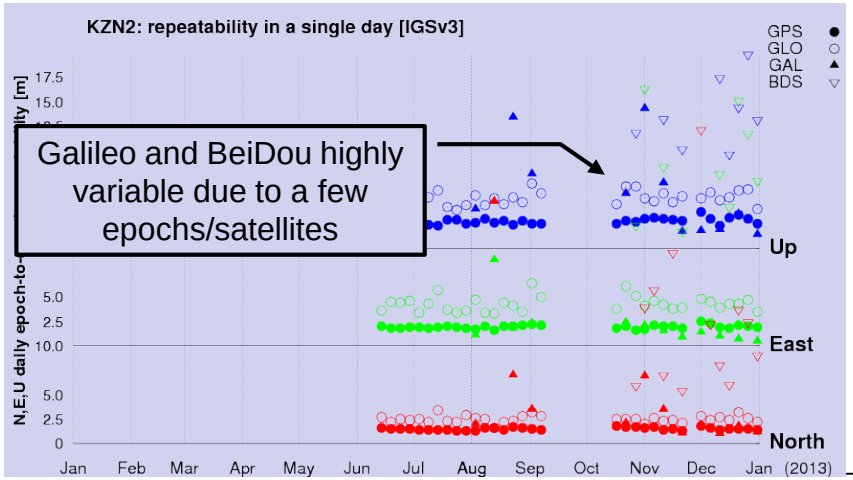
Vaclavovic P, Dousa J (2014), G-Nut/Anubis - open-source tool for multi-GNSS data monitoring, IAG Symposia Series, Vol. 143 (accepted)

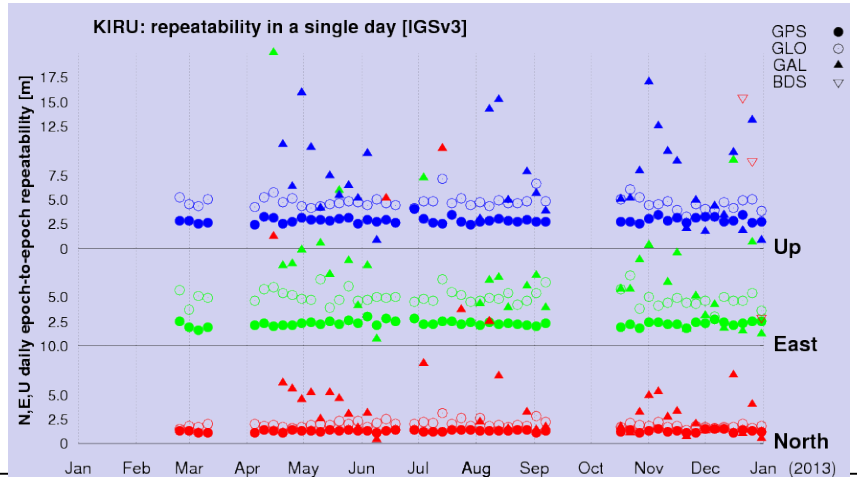
QC: stand alone GNSS positioning (examples)

- Epoch-wise stand alone GNSS standard positioning
- Daily individual GNSS means & repeatabilities



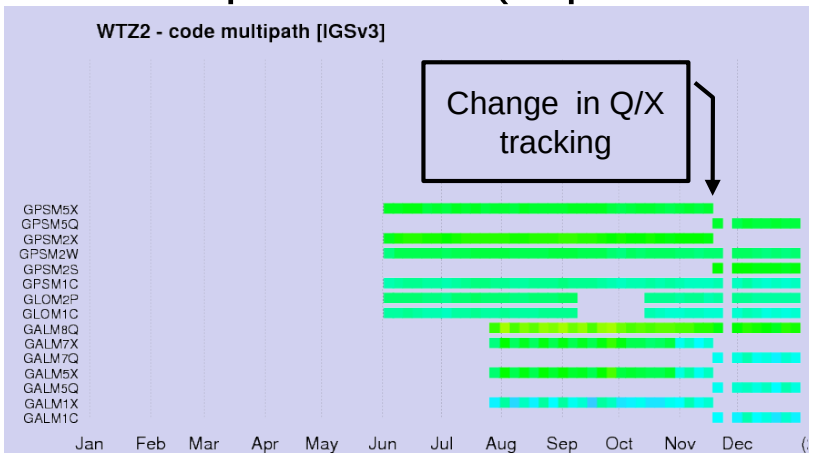


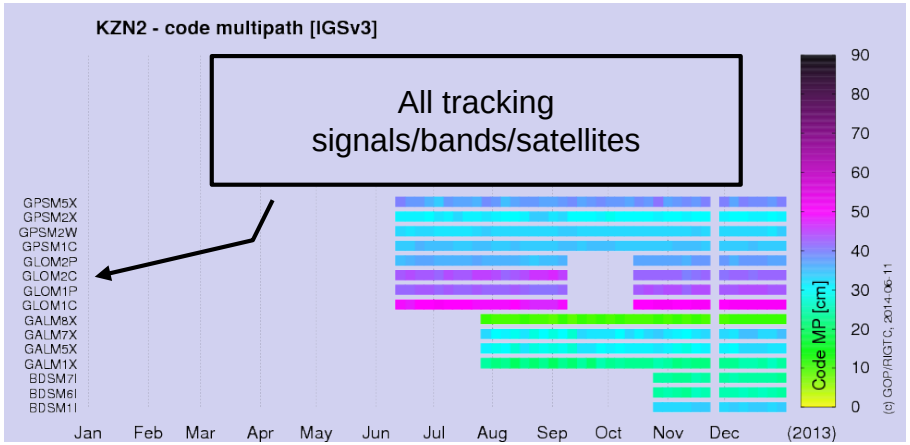


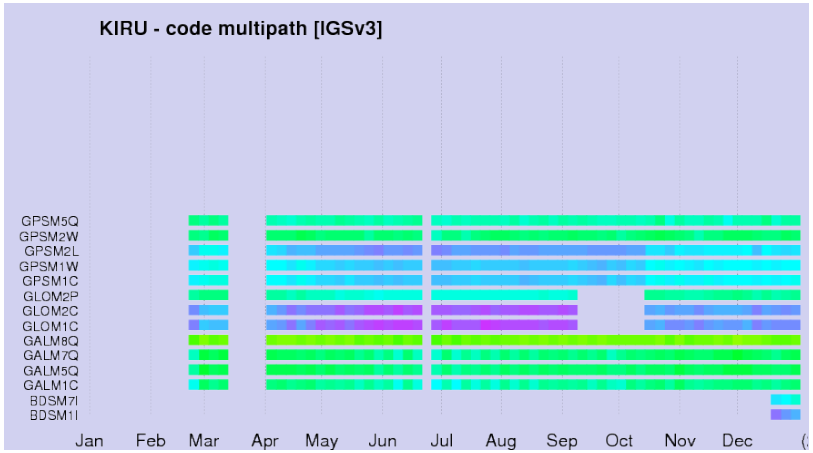


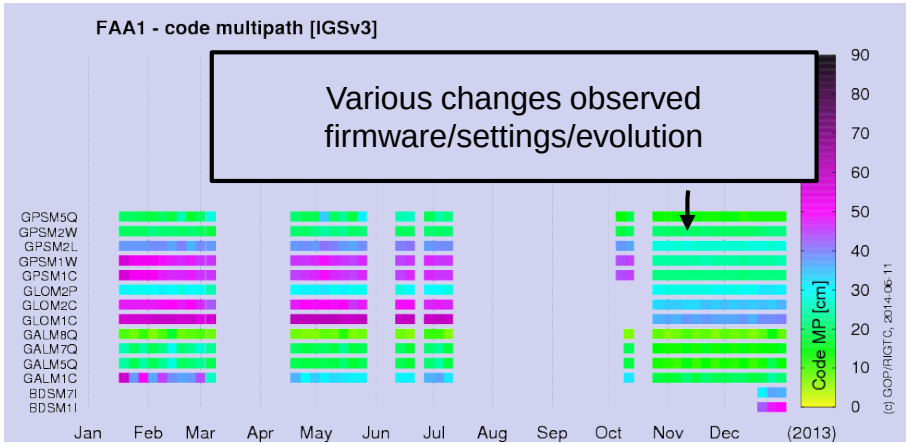
QC: multipath detection (examples)

- All signals, frequency and constellations – selected stations in 2013
- Independent of (sophisticated) pre-processing algorithms







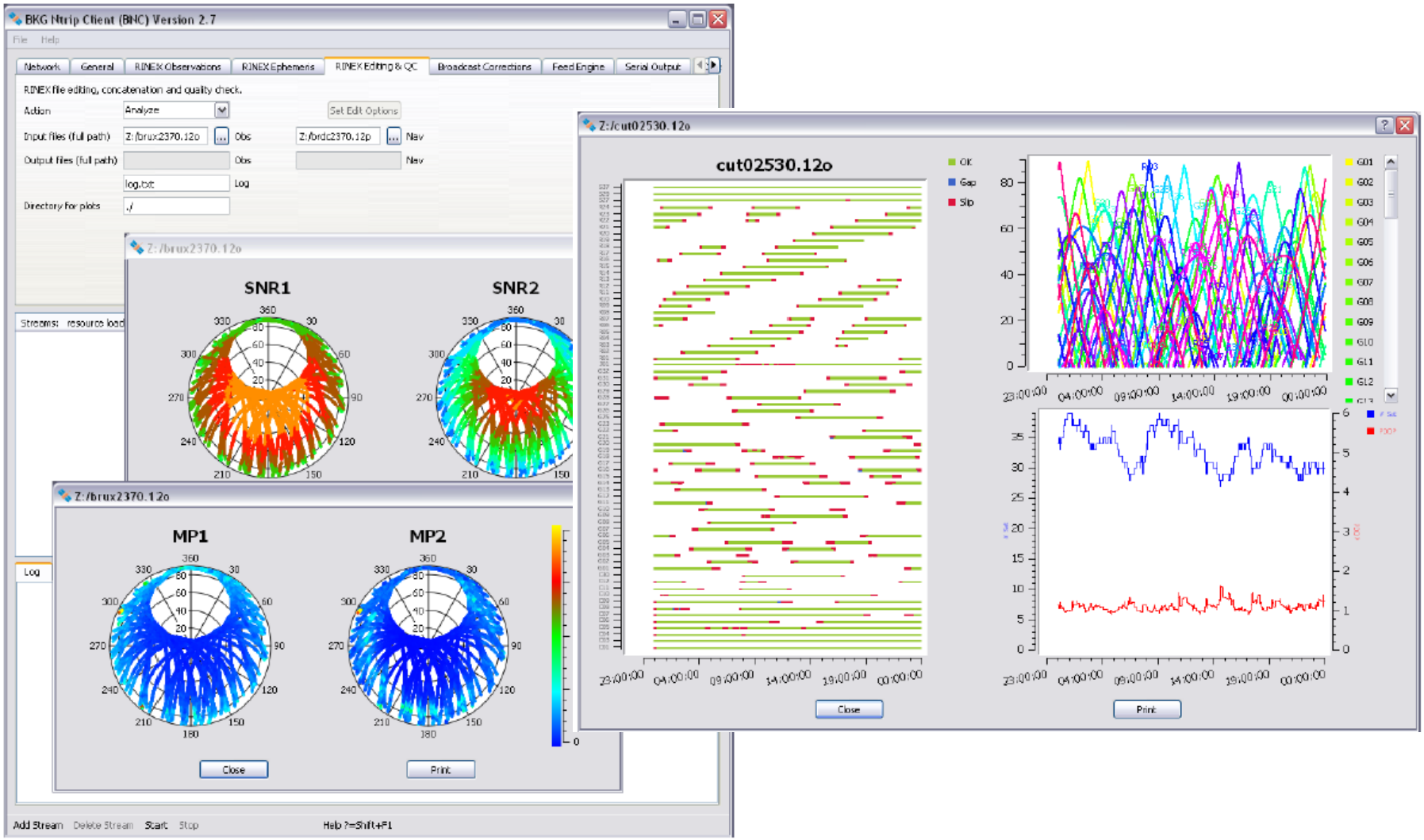


RINEX QC BKG Ntrip Client (BNC)

Features:

- Stream Translation
- File Editing and concatenation
- File Quality Check
  - Multipath analysis sky plots (see Estey and Meertens 1999)
  - Signal-to-noise ratio sky plots
  - Satellite availability plots
  - Satellite elevation plots
  - PDOP plots

RINEX QC BKG Ntrip Client (BNC)



Required Standardization

RTCM

- The RTCM SC 104 (Radio Technical Commission for Maritime Services, Special Committee 104) is in progress to develop a format combining the advantages of PPP & Real-Time Kinematic
- The so-called State Space Representation (SSR) approach is defining corrections, which will be transferred to the user e.g. via NTRIP (Network Transport of RTCM via Internet Protocol).
- SSR: Transmission of individual GNSS error components
- SSR messages - Status & Plans:
  I. Precise orbits, satellite clocks and code biases, quality indicator for GPS, GLONASS, Galileo, BDS, QZSS, SBAS [dual frequency PPP]
  II. Vertical Total Electron Content and satellite phase biases [single frequency PPP]
  III. Slant Total Electron Content and troposphere [PPP-RTK]

Summary

- MGEX provides a very good global network of multi-GNSS observing sites as well as a global data holdings and real-time data streams
- The main issues are:
  - Increase of the consistency of structure and data content of data archives
  - GNSS evolution pace vs. definition of widely accepted observation data standards
  - Development of standard qc routines (MGWG „QC task force“), some tools are available (e.g. ANUBIS, BNC, BQC)
  - Development of standards for real time applications

Thank you for your kind attention!

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