



Federal Agency for
Cartography and Geodesy

Global and Regional Real-Time Infrastructure for open access use

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Tutorial on (Open) Real-Time Infrastructure and Applications in Europe (and beyond)
EUREF 2017 Symposium, May 17-19, 2017, Wrocław, Poland



Outline

- Introduction
- Standardization
- Open Access Data and Products
- Summary

Real Time GNSS Examples for Applications

Navigation



Precise Farming



Earth System Monitoring



Atmosphere Monitoring



Surveying



Real Time GNSS

- Large number of applications require positioning data in real time
- A number of commercial players
 - E.g. Trimble, Hexagon, Fugro, Veripos, ...
 - Closed source data
 - Proprietary data formats
 - No combination of different data sources
- Global and regional best effort infrastructure supports those applications based on open standards and an open data policy

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GNSS Standardisation



RTCM Special Committee 104 (RTCM-SC104)

- Committee to develop open international standards on DGNSS
- Working groups
 - GLONASS (Alexei Zinoviev)
 - Galileo (Hans-Jürgen Euler)
 - QZSS (Rui Hirokawa)
 - BeiDou (Shao Wei Han)
 - State Space (Gerhard Wübbena)
 - RINEX (Ken MacLeod)
 - Biases (Ken MacLeod)
 - ...
- Procedure
 1. Proposal
 2. Interoperability test (3 independent software implementations and testing)
 3. CDV (Committee draft for vote)



GNSS Standardisation

Observation Messages

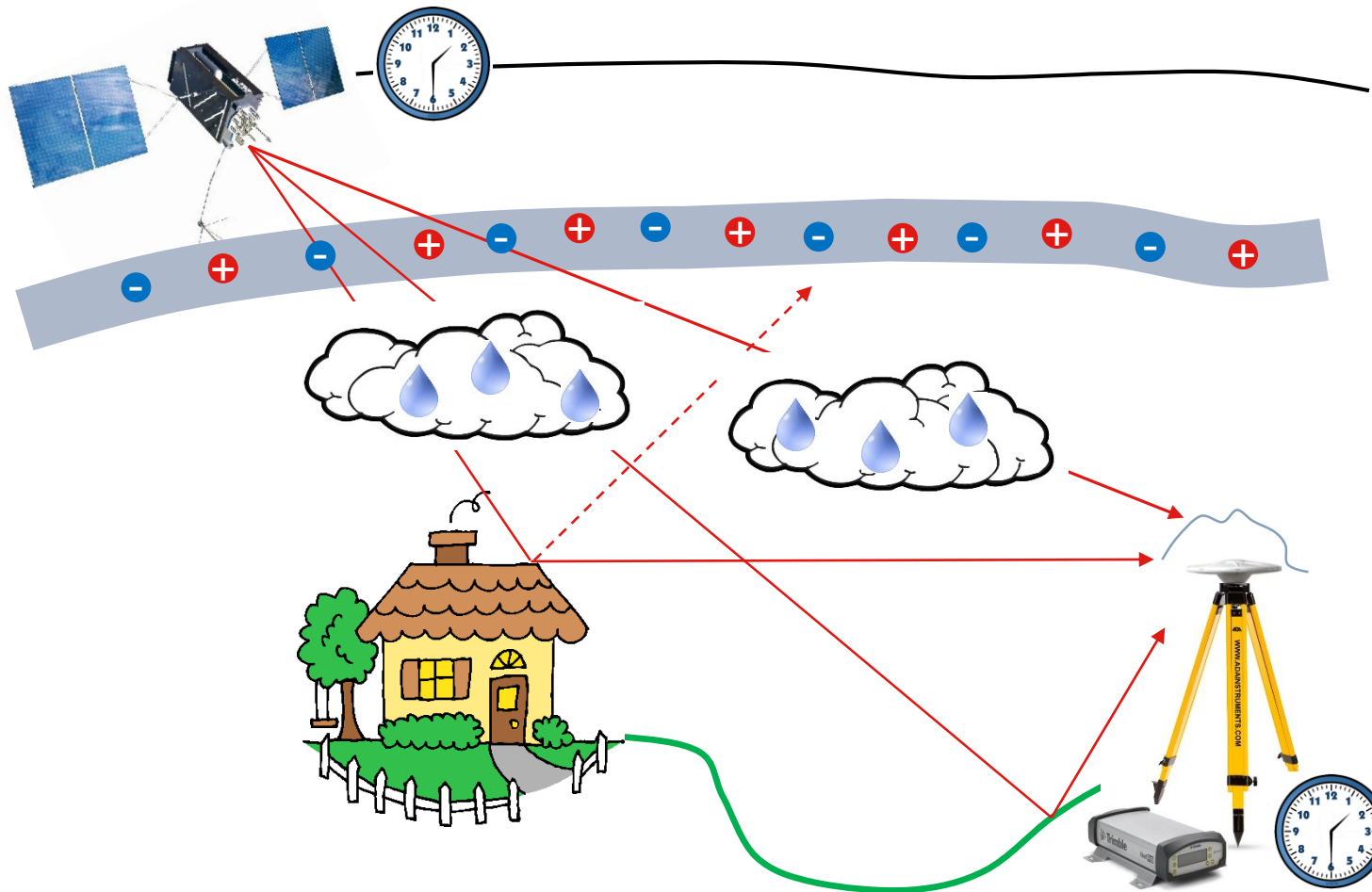
- Conventional observation messages for GPS and GLONASS (message numbers 1001..1004; 1009..1012)
- Multi Signal Messages (MSM) for all constellations (GPS, GLONASS, Galileo, SBAS, QZSS, BDS, IRNSS*), message numbers 1071..1077; ...

Navigation Messages

- GPS, GLONASS, Galileo F/NAV, Galileo I/NAV, SBAS*, QZSS, BDS*

* RTCM proposal

Realtime Positioning with GNSS



Satellite
Orbit error
Clock error
Biases

Atmosphere
Ionosphere
Troposphere

Antenna Receiver
Receiver Clock
PCV
Multipath
Biases

GNSS Standardisation

Satellite

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Biases

SSR Correction Messages (*Proposal)

Orbit and Clock corrections (G, R, E*, J*, (C*))

Satellite Code biases (G, R, E*, J*, (C*))

Satellite Phase biases*

Ionosphere VTEC*

Under development:

Ionosphere STEC (global and regional)

Troposphere

Compression

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IGS Real-Time-Service



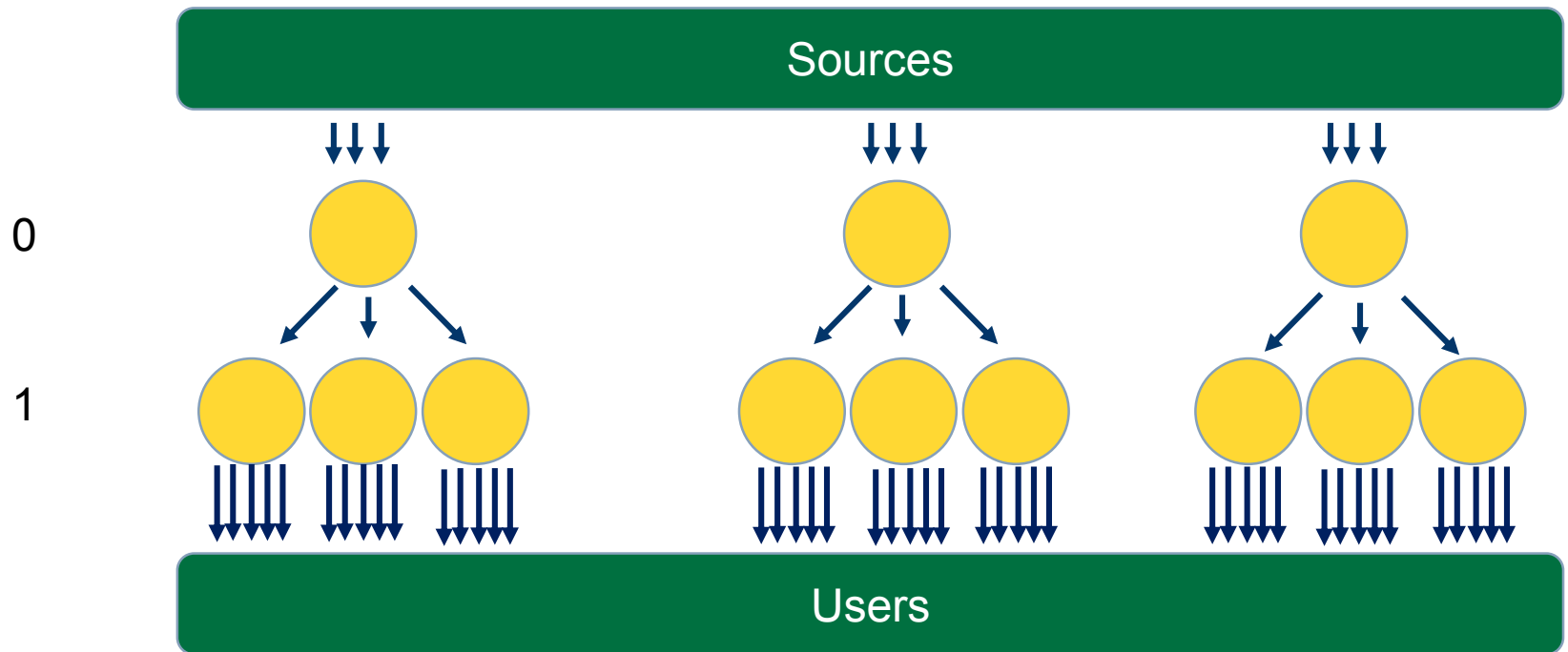
<http://rts.igs.org>

- IGS – a voluntary federation of over 200 self-funding agencies, universities, and research institutions in more than 100 countries
- 2002: Development of a IGS Real-Time-Service starts
- 2005..2007:
 - Development of NTRIP basics
- 2007..2012:
 - Pilot Project
 - MSM to be compatible with RINEX 3
 - Joined RTCM
- April 2013: Launch of IGS RT-Service
- Registration for IGS real time products:
<http://www.igs.org/rts/access>

Provision of real time data

Caster hierarchy

Level



Each caster adds approximately 0.2 .. 0.3 s of latency

IGS Real-Time Service Data sources



<http://rts.igs.org>

Global Ntrip Casters (Level 0)

- BKG
 - <http://igs-ip.net>
 - <http://mgex.igs-ip.net>
 - <http://products.igs-ip.net>
- IGS Central Bureau (UCAR Cosmic Program)
- Crustal Dynamics Data Information System (CDDIS, NASA)

Global Ntrip Casters (Level 1)

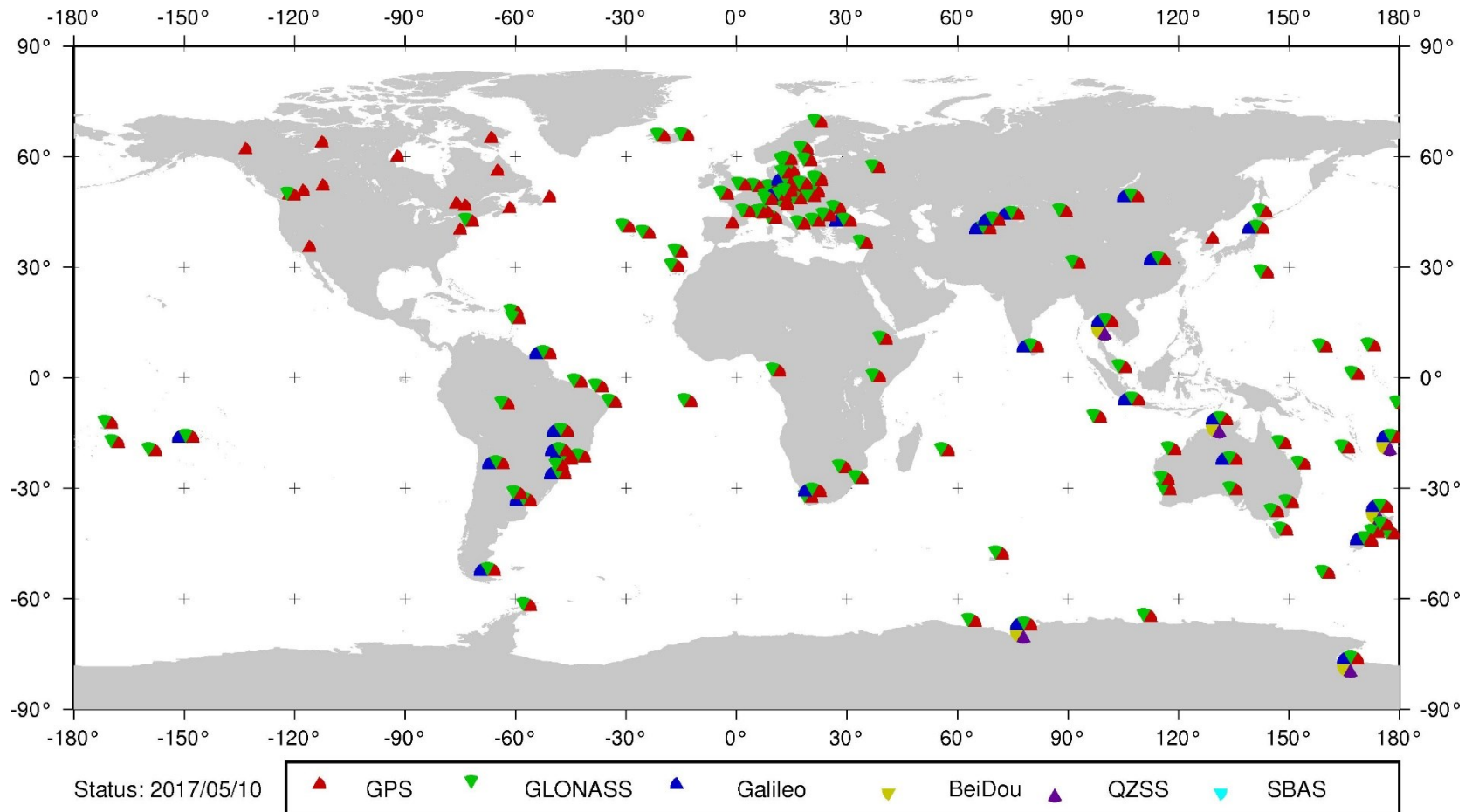
- Geoscience Australia (<http://auscors.ga.gov.au/registration/>)
- Wuhan University
- Shanghai Astronomical Observatory

IGS-Network

igs-ip.net



www.igs.org

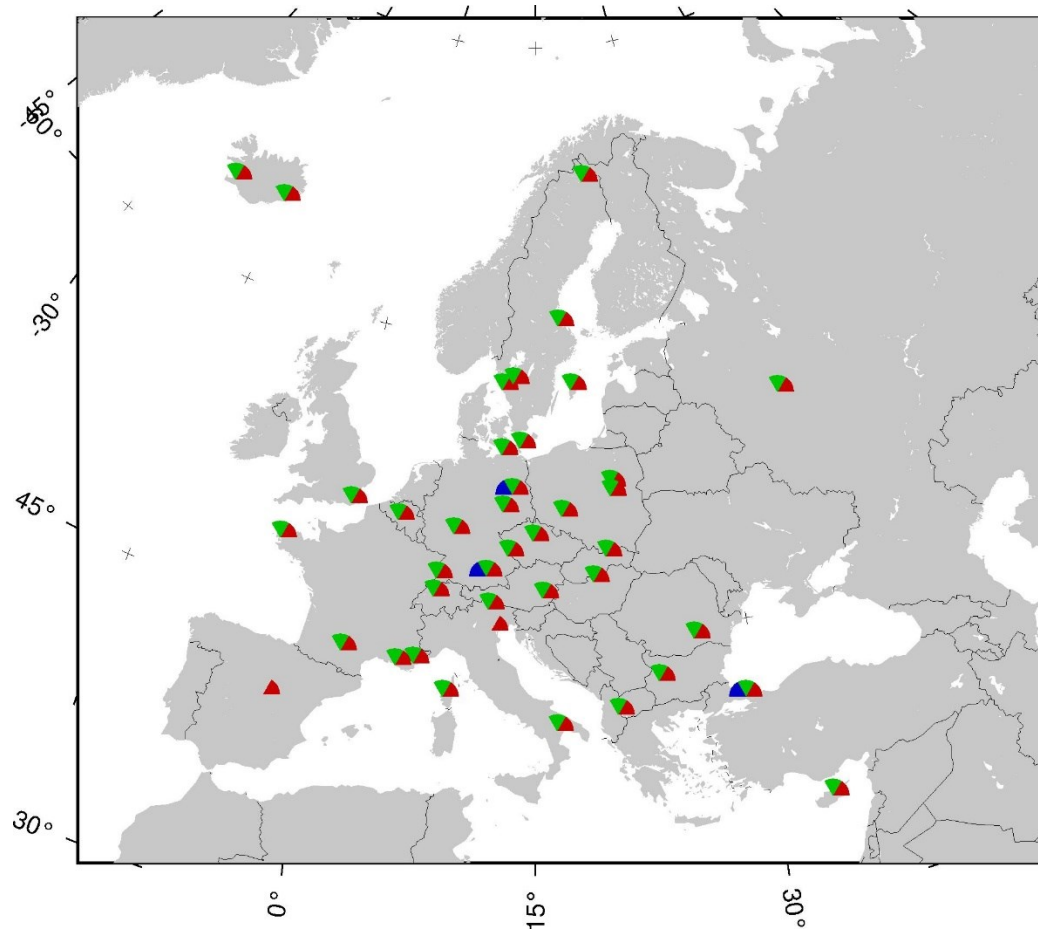


IGS-Network

igs-ip.net



www.igs.org



-  GPS
-  GLONASS
-  Galileo
-  BeiDou
-  QZSS
-  SBAS

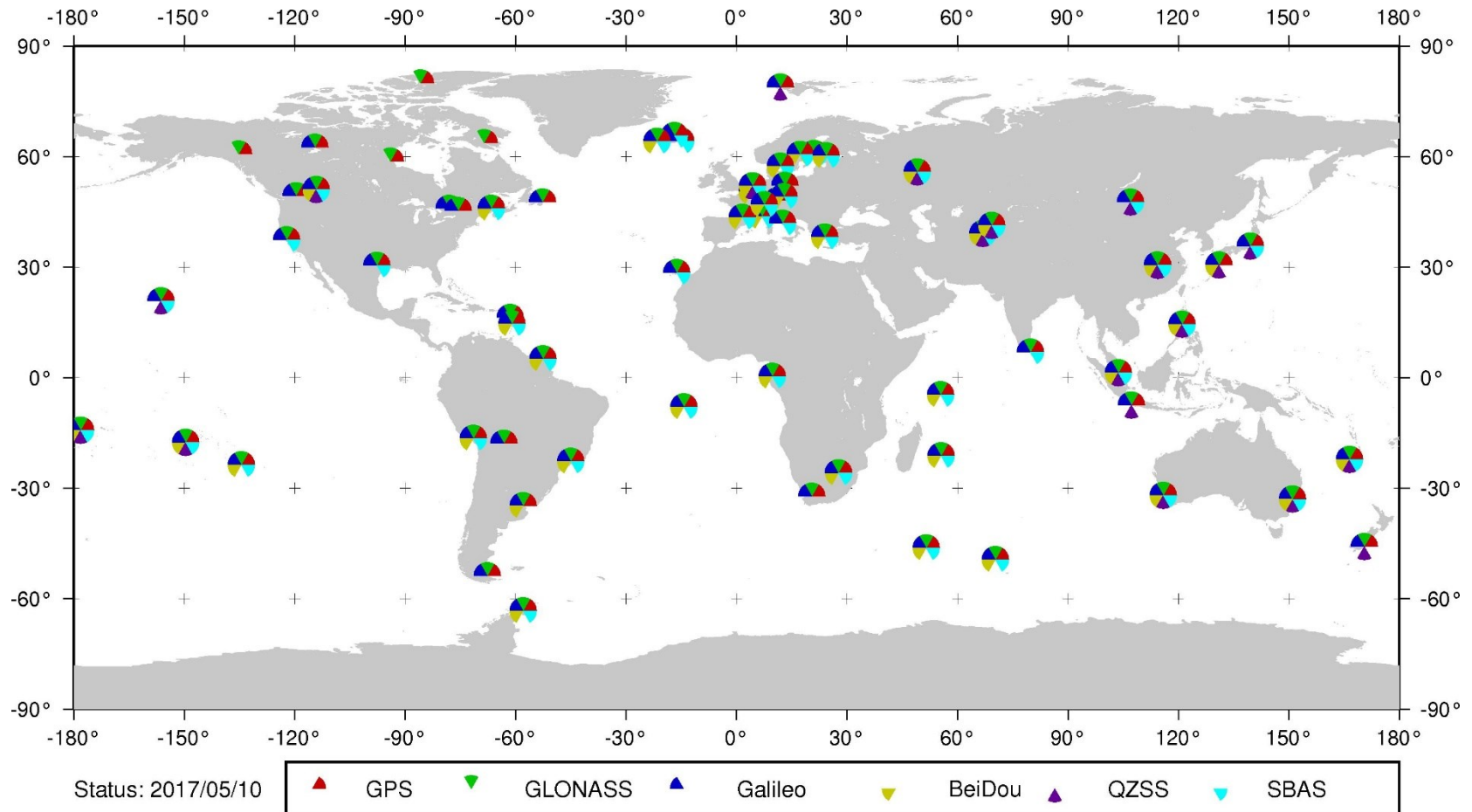
Status: 2017/05/10

IGS-Network

mgex.igs-ip.net



www.igs.org

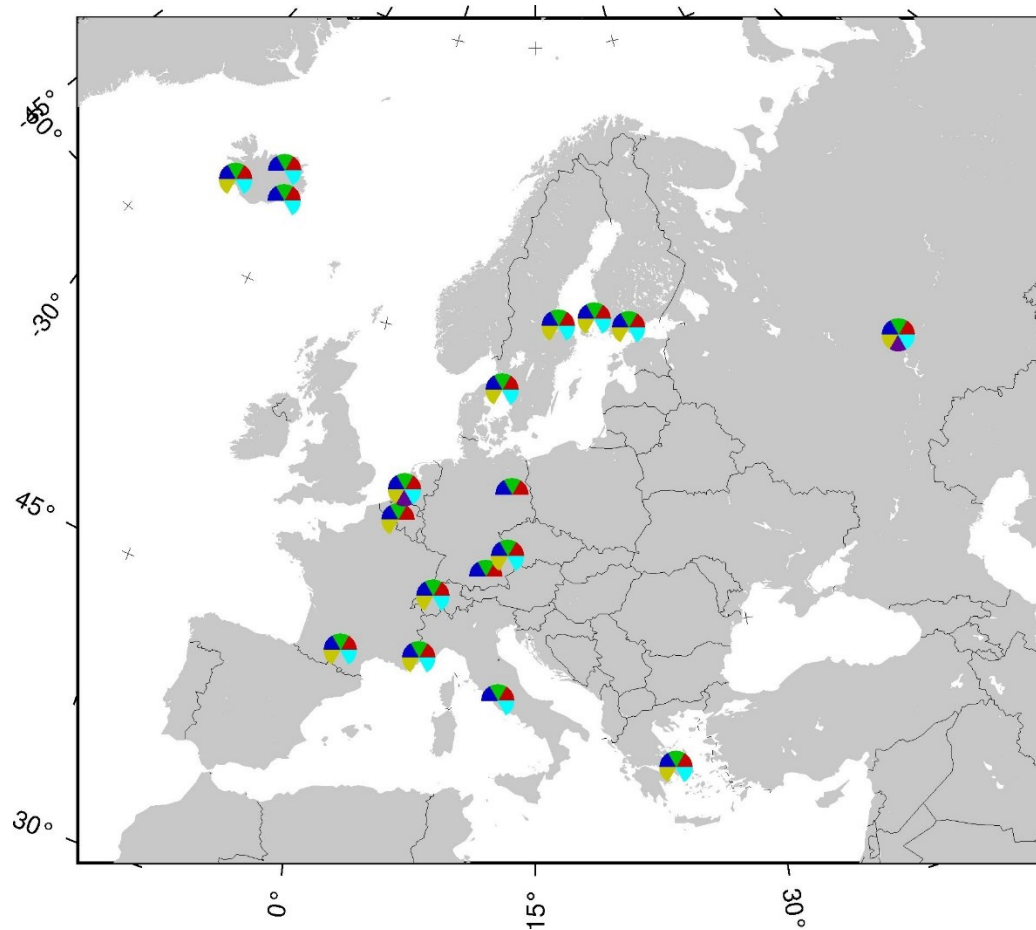


IGS-Network

mgex.igs-ip.net



www.igs.org



- GPS
- GLONASS
- Galileo
- BeiDou
- QZSS
- SBAS

Status: 2017/05/10

EUREF Permanent GNSS network



<http://www.epncb.oma.be>

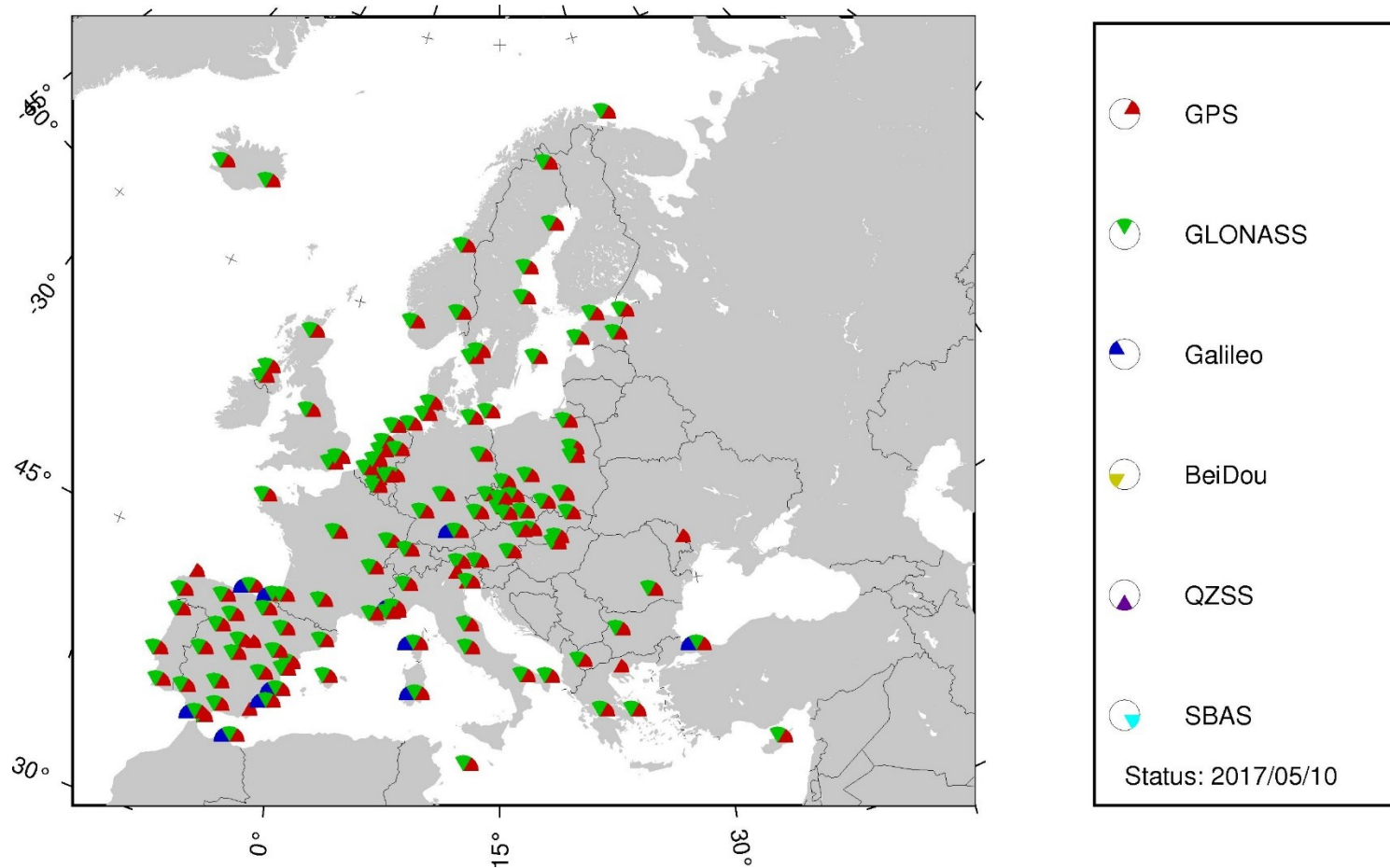
Regional Ntrip Casters for Europe

- EUREF-IP (euref-ip.net, BKG, Germany)
- ASI – eGeos (euref-ip.asi.it, ASI, Italy)
- EUREF-IP (euref-ip.be, ROB, Belgium)

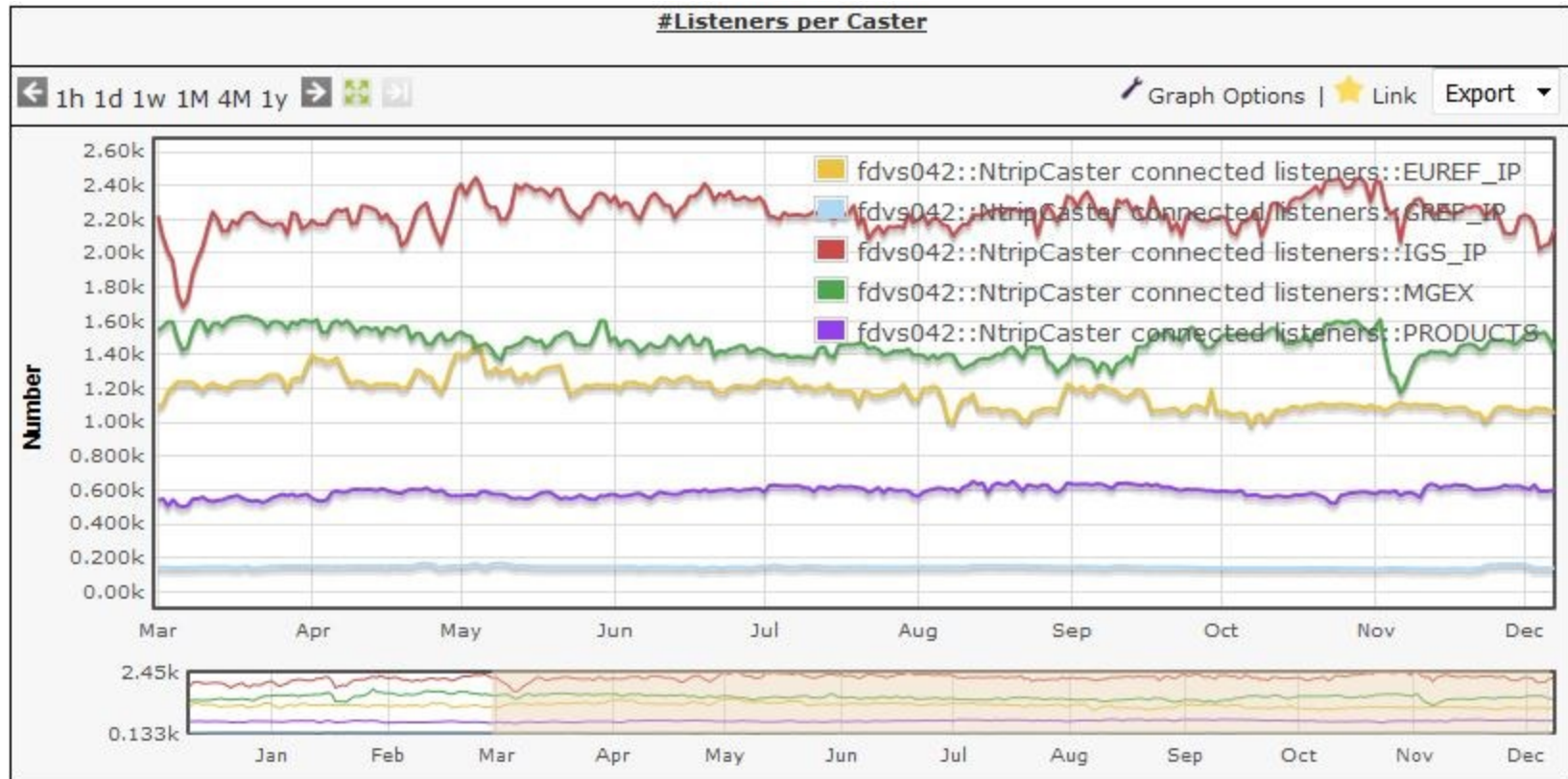
Local Ntrip Casters for Europe

There is a number of different local casters from different European countries, please consult

<http://www.epncb.oma.be>



Ntrip Broadcaster Users at BKG



IGS ACs



Federal Agency for Cartography and Geodesy, Germany



ESOC Darmstadt, Germany



Natural Resources, Ottawa, Canada



Helmholtz Center Potsdam, GFZ German Research Center for Geosciences, Potsdam, Germany



Centre National D'Études Spatiales, Toulouse, France



GMV, Madrid, Spain



Deutsches Zentrum für Luft- und Raumfahrt, Oberpfaffenhofen, Germany



Wuhan University, Wuhan, China

IGS-RTS: Products

<http://products.igs-ip.net/>



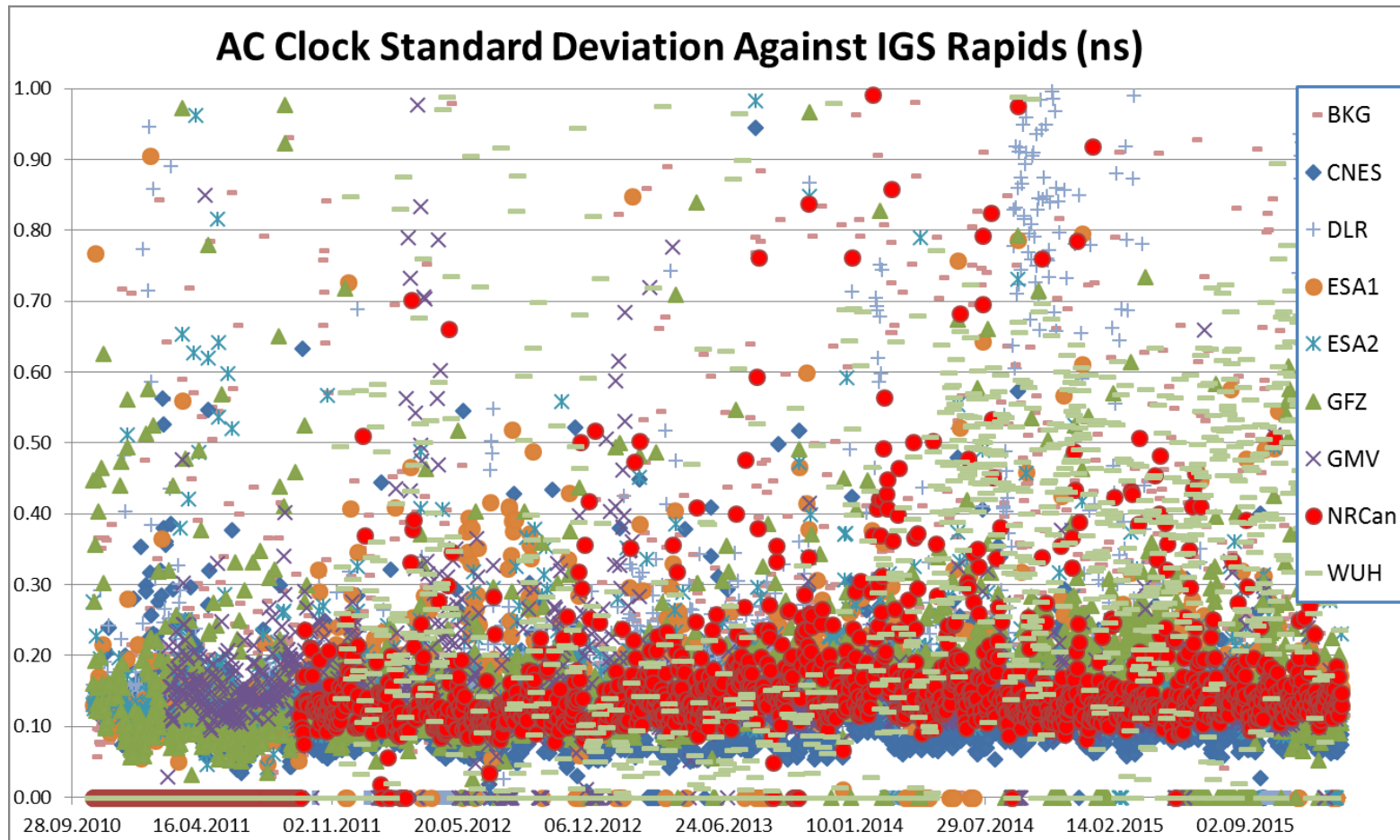
AC	Mountpoints with Message Types and Update Rates	
BKG	CLK00/10 (CoM/APC): 1057(60),1058(5) CLK01/11 (CoM/APC): 1057(60),1058(5),1063(60),1064(5)	
CNES	CLK90/91 (CoM/APC): 1059(5),1060(5),1065(5),1066(5),1264(56),1265(10) CLK92/93 (CoM/APC): 1059(5),1060(5),1065(5),1066(5),1242(5),1243(5),1261(5),1264(60),1265(15)	
DLR	CLK20 (APC): 1059(5),1060(5) CLK21 (APC): 1059(10),1060(10),1066(10)	
ESA	CLK52/53 (CoM/APC): 1059(1815),1060(5)	GPS Orbits and Clocks
GFZ	CLK70/71 (CoM/APC): 1060(5)	GLONASS Orbits and Clocks Galileo Orbits and Clocks
GMV	CLK80/81 (CoM/APC): 1059(5),1060(5),1066(5)	BDS Orbits and Clocks CODE Biases
NR Can	CLK22 (APC): 1059(5),1060(5)	Phase Biases
Wuhan	CLK15/16 (CoM/APC): 1059(5),1060(5)	VTEC

IGS RT Products

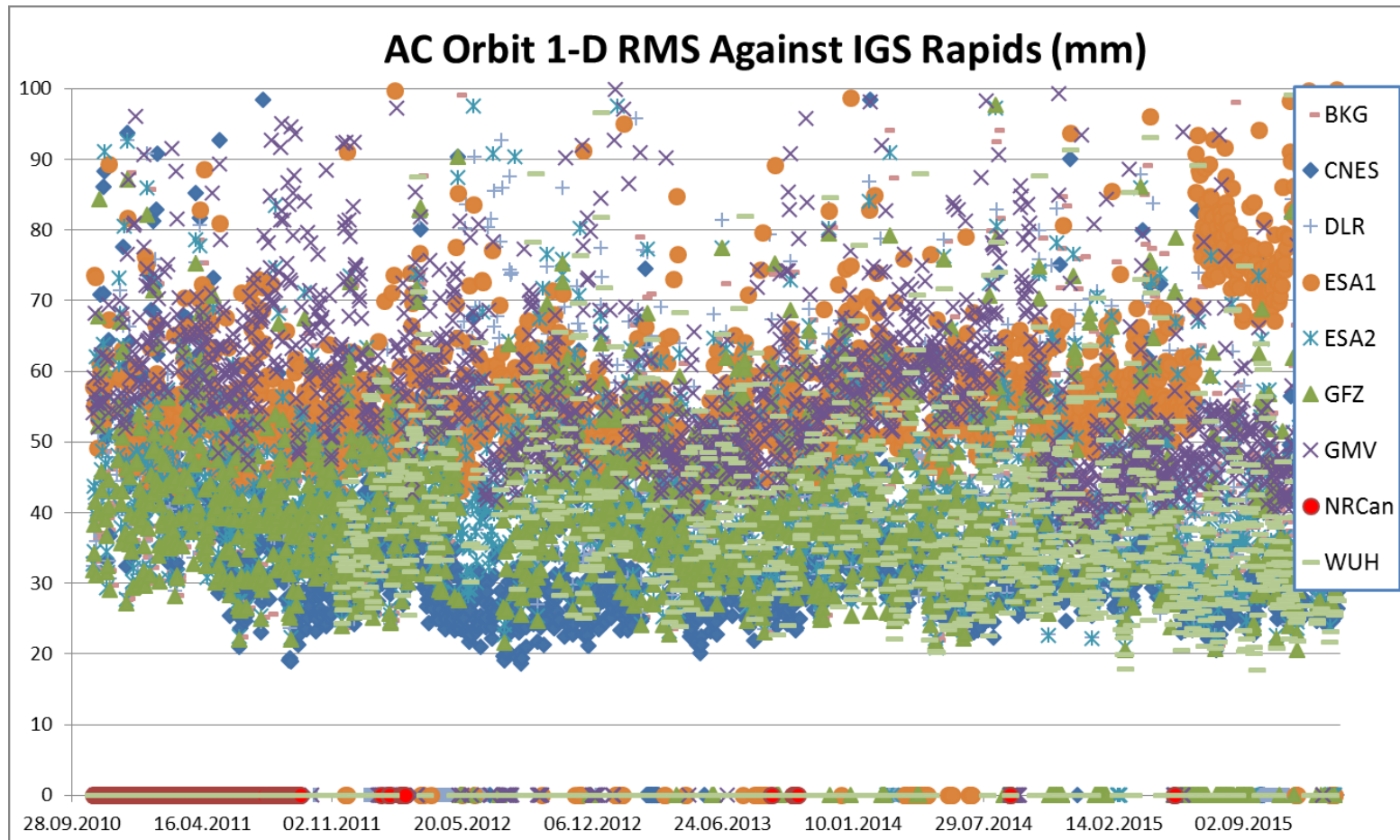
Stream	Description	RTCM-Messages	RP	CC/Software
IGS01 IGC01	GPS only orbit / clock correction, orbit: average value from all contributions clock: weighted average	1059(5),1060(5)	APC CoM	ESOC/ RETINA
IGS02 IGC02	GPS only orbit / clock correction, Kalman filter combination orbit: extracted from one specific AC clock: estimated using clocks from individual ACs as pseudo observations	1057(60), 1058(10), 1059(10)	APC CoM	BKG / BNC
IGS03 IGC03	GPS + GLONASS same procedure as for IGS02/IGC02	1057(60), 1058(10), 1059(10), 1063(60), 1064(10), 1065(10)	APC CoM	BKG / BNC

IGS RT Products Performance

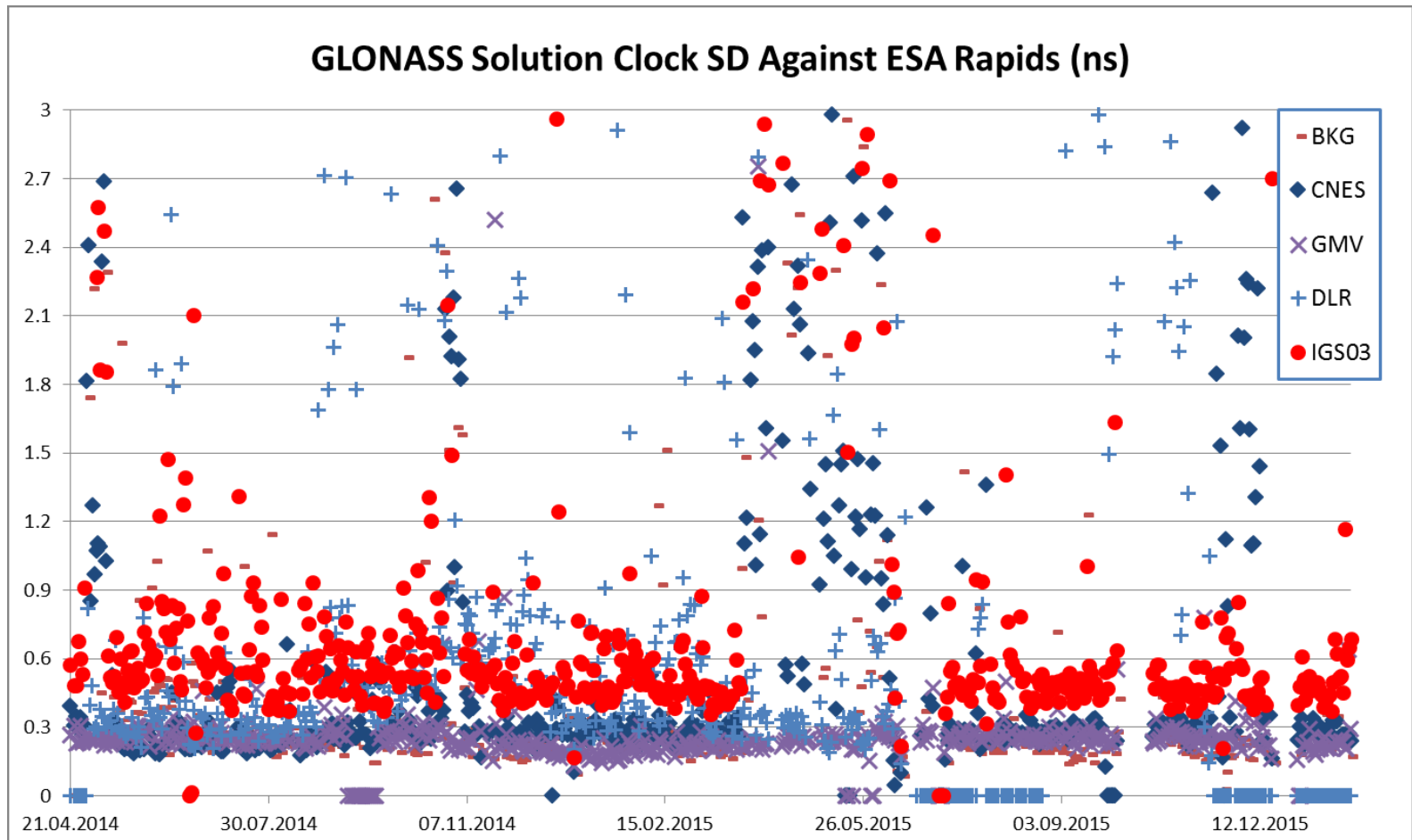
GPS - clocks



IGS RT Products Performance GPS - Orbits

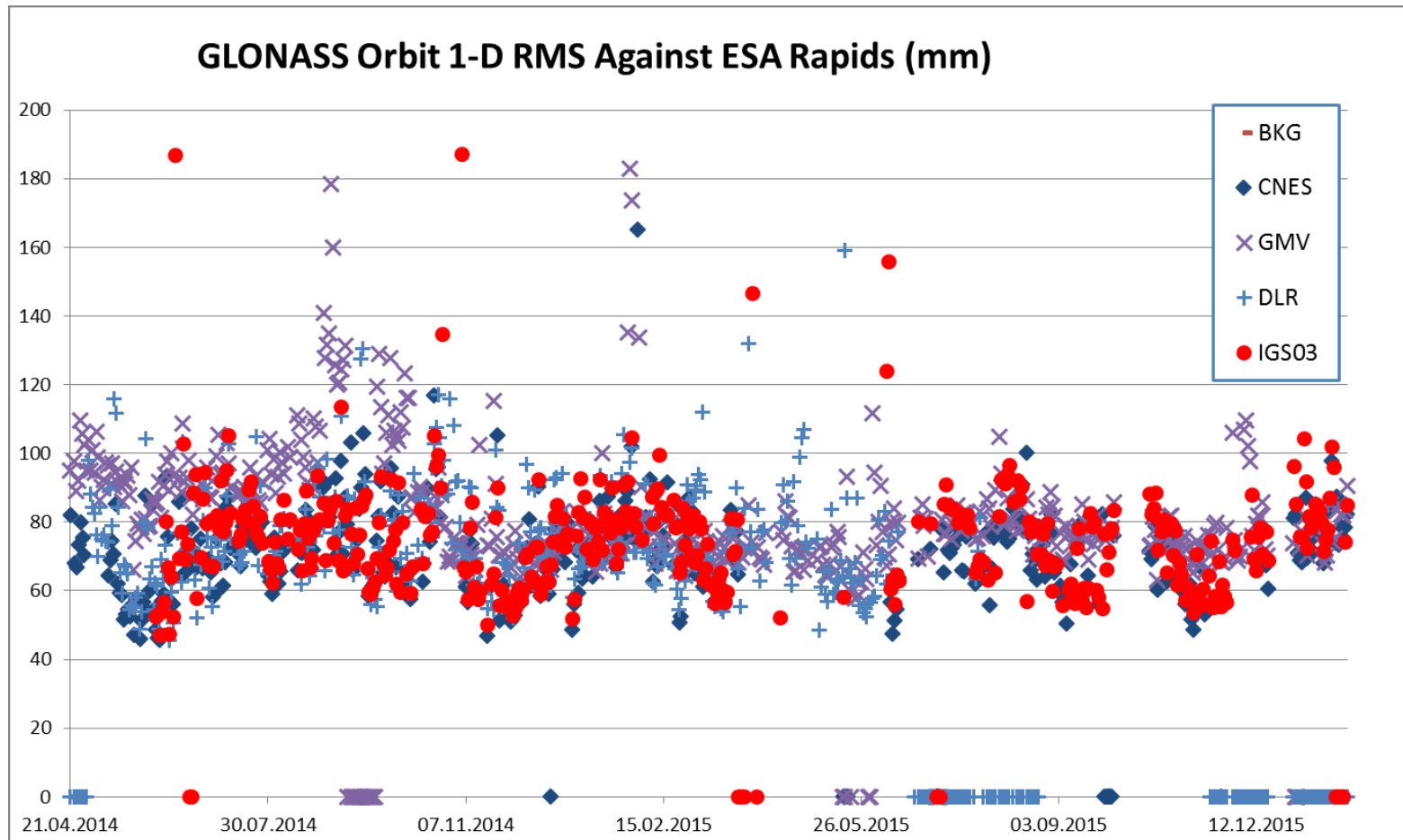


IGS RT Products Performance GLONASS - Clocks



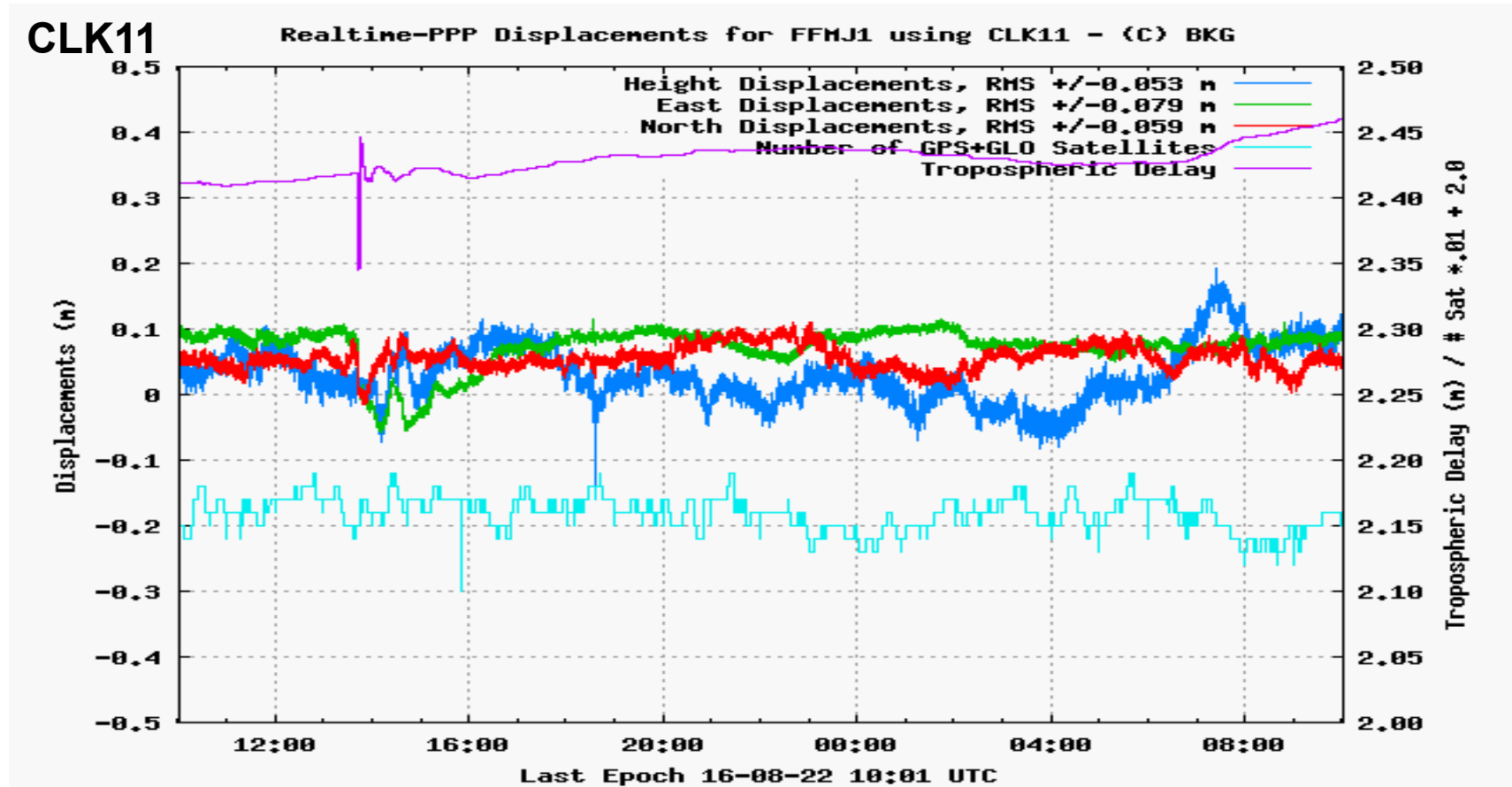
IGS RT Products Performance

GLONASS - Orbits



IGS RT Products Performance

PPP Products

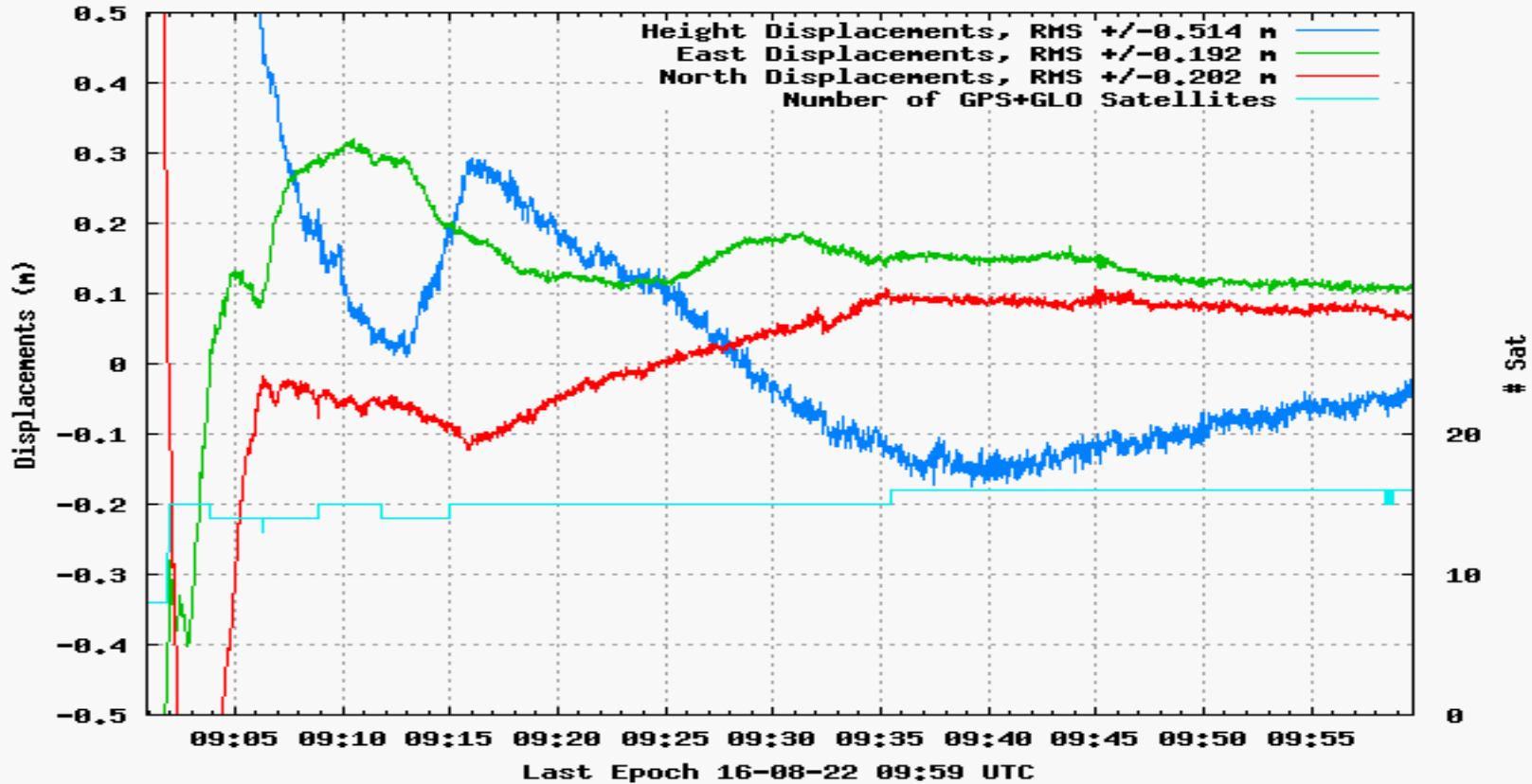


IGS RT Products Performance

PPP Results: Convergence Time

IGS03

Realtime-PPP Displacements for FFMJ1 using IGS03 - (C) BKG



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Summary

IGS and EUREF provide a powerful infrastructure to support real time GNSS applications based on best effort of a large number of contributors (station providers, data centers, analysis and combination centers)

The services support the development and use of open standards for observations and products. An open data policy is widely implemented.

The development of open standards for observations and correction products needs additional effort for development, testing and implementation.

Thank you for your kind attention!

I would like to thank the GNSS real-time group at BKG, Section Satellite Navigation, especially

- Wolfgang Söhne
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- Erwin Wiesensarter
- Peter Neumaier

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