Fugro Marinestar Improvements

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Fugro Intersite B.V.

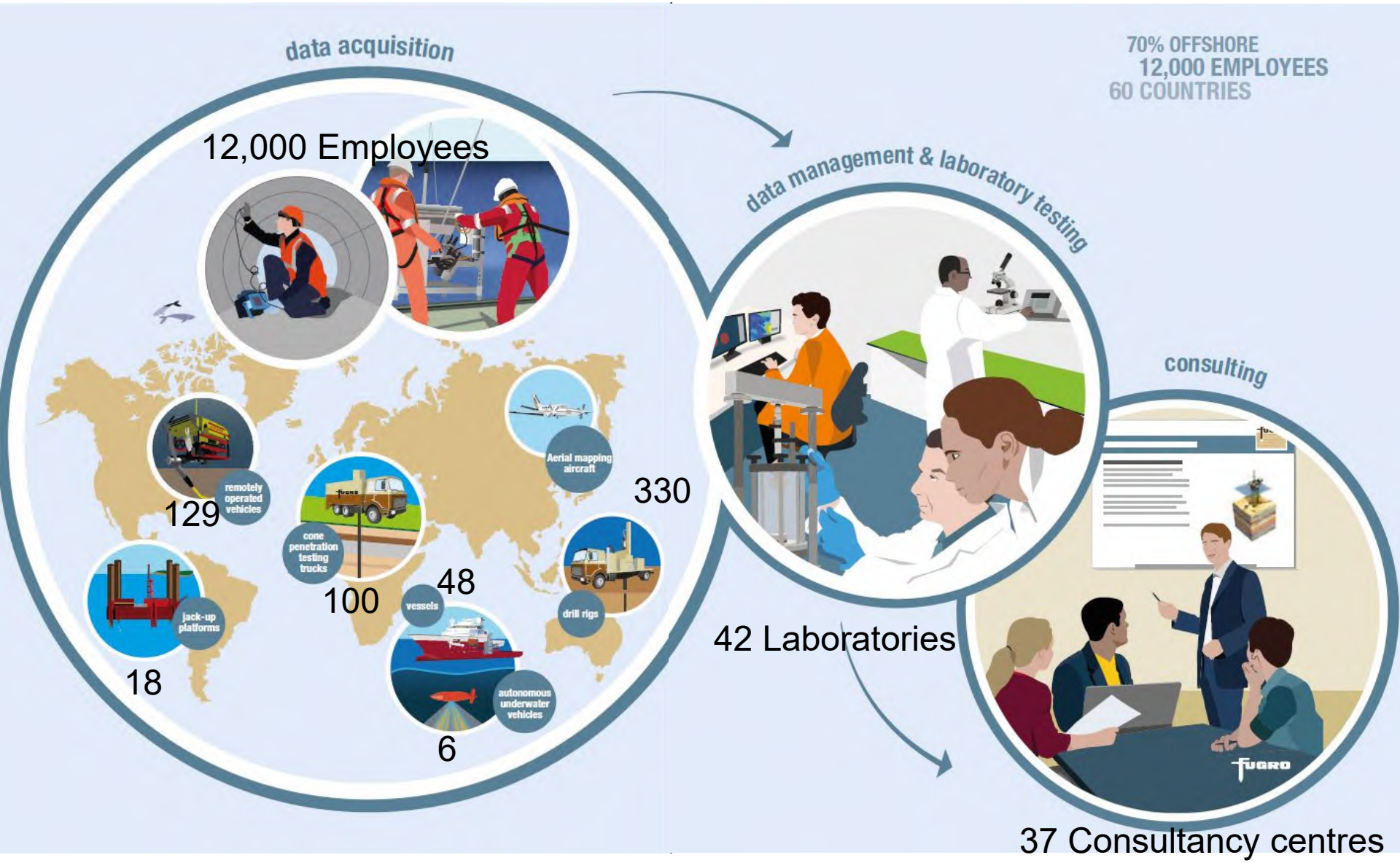
Improvements in Marinestar Positioning

Hydro 2016 Warnemünde, 10 November 2016

Overview of presentation

- The Marinestar GNSS Networks
- The supplied Services
- Satellite availability for GPS, Glonass, Beidou and Galileo
- Gradual Improvements over the years
  - Ionosphere and Scintillations
  - Clock jitter
  - Minimum Elevation
  - Maximum Age
  - Robustness
- PPP-RTK G4 : How to fix ambiguities
- PPP-RTK limitations
- Conclusions

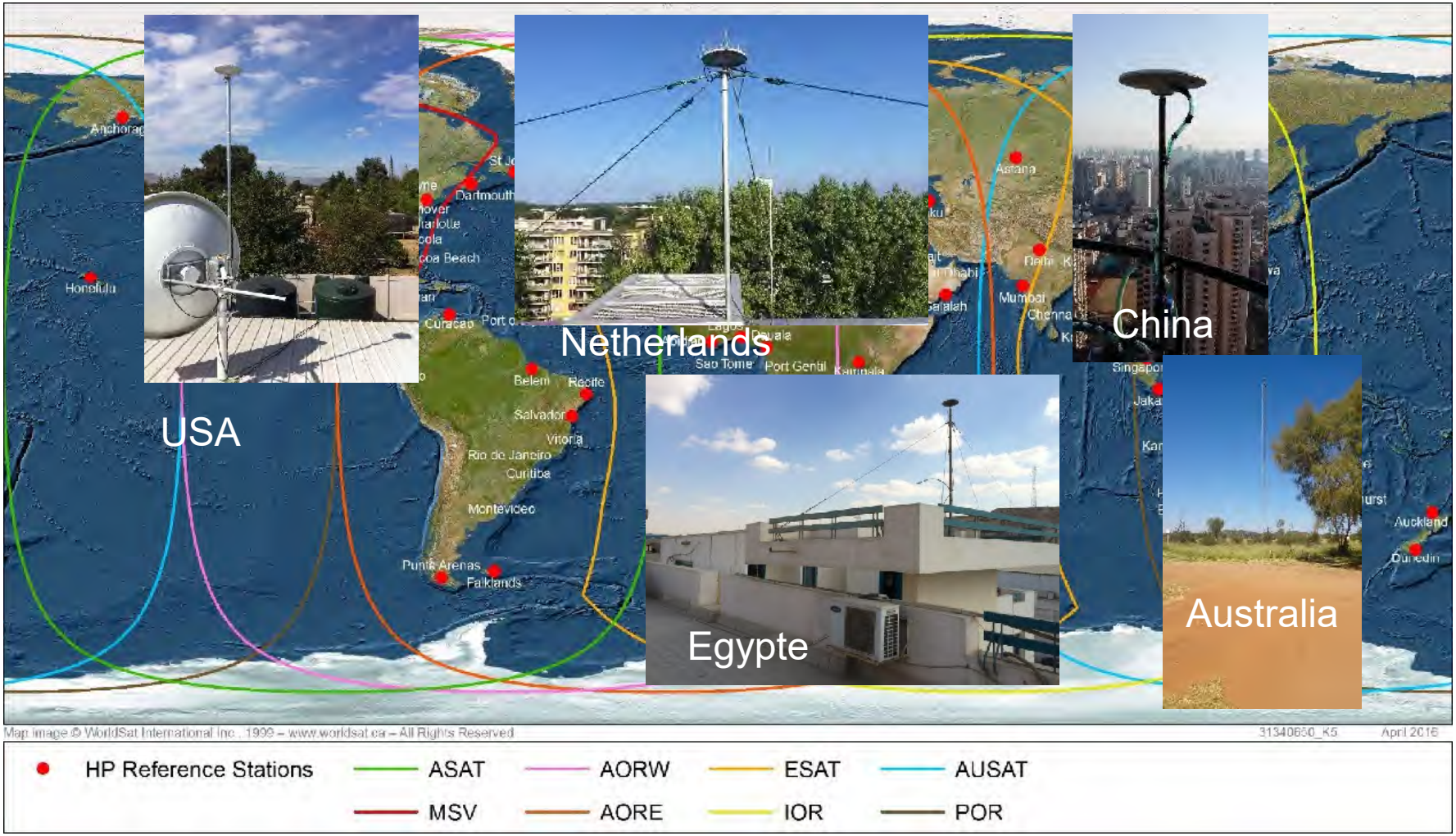
Fugro


data acquisition
12,000 Employees
remotely operated vehicles
129
cone penetration testing trucks
100
Aerial mapping aircraft
330
jack-up platforms
18
vessels
48
drill rigs
autonomous underwater vehicles
6
data management & laboratory testing
42 Laboratories
consulting
37 Consultancy centres
70% OFFSHORE
12,000 EMPLOYEES
60 COUNTRIES

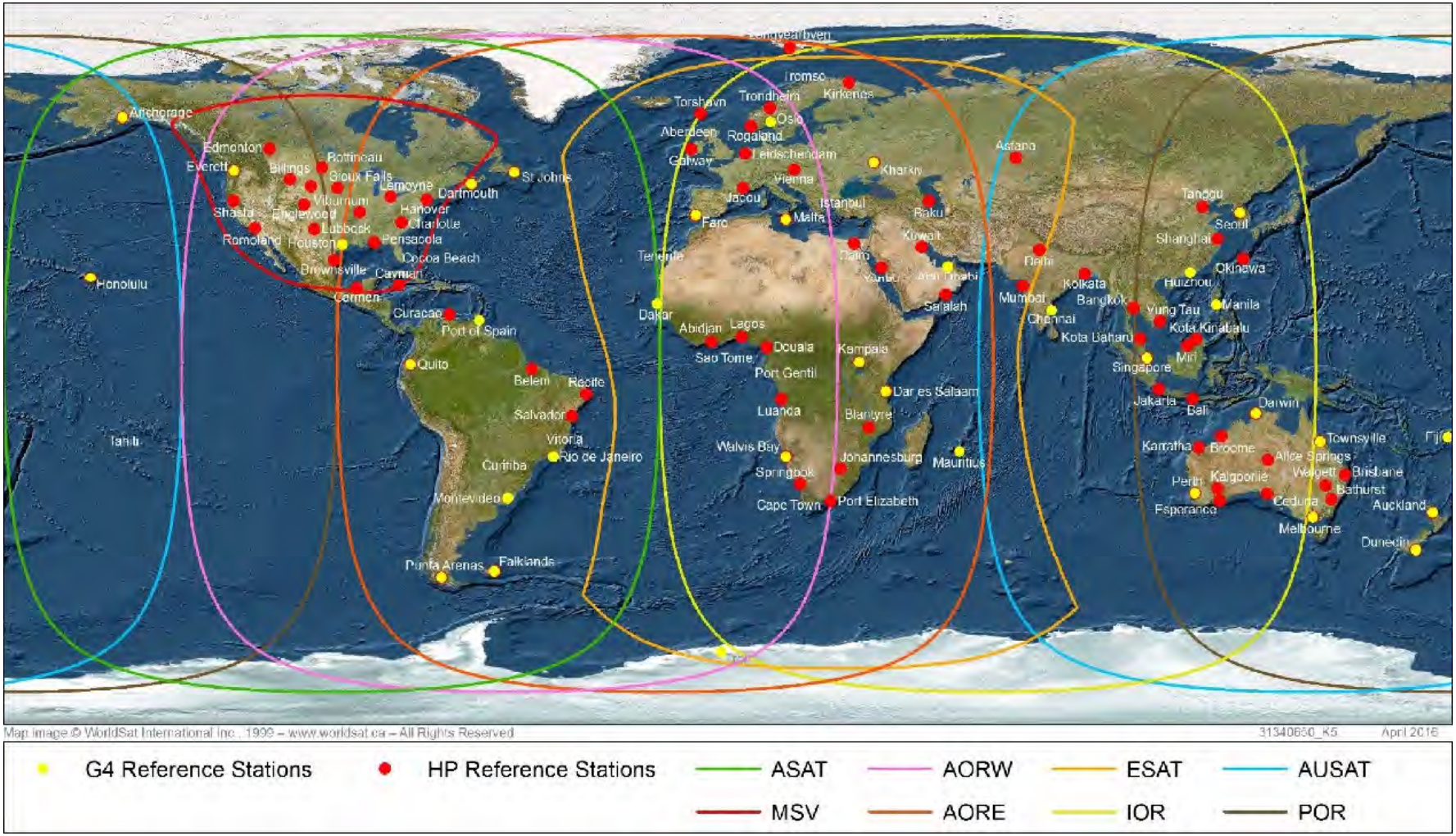
Some Questions

- Who in the audience is using positioning?
- Who uses GPS?
- Who uses Glonass
- Who uses BeiDou?
- Who will use Galileo?

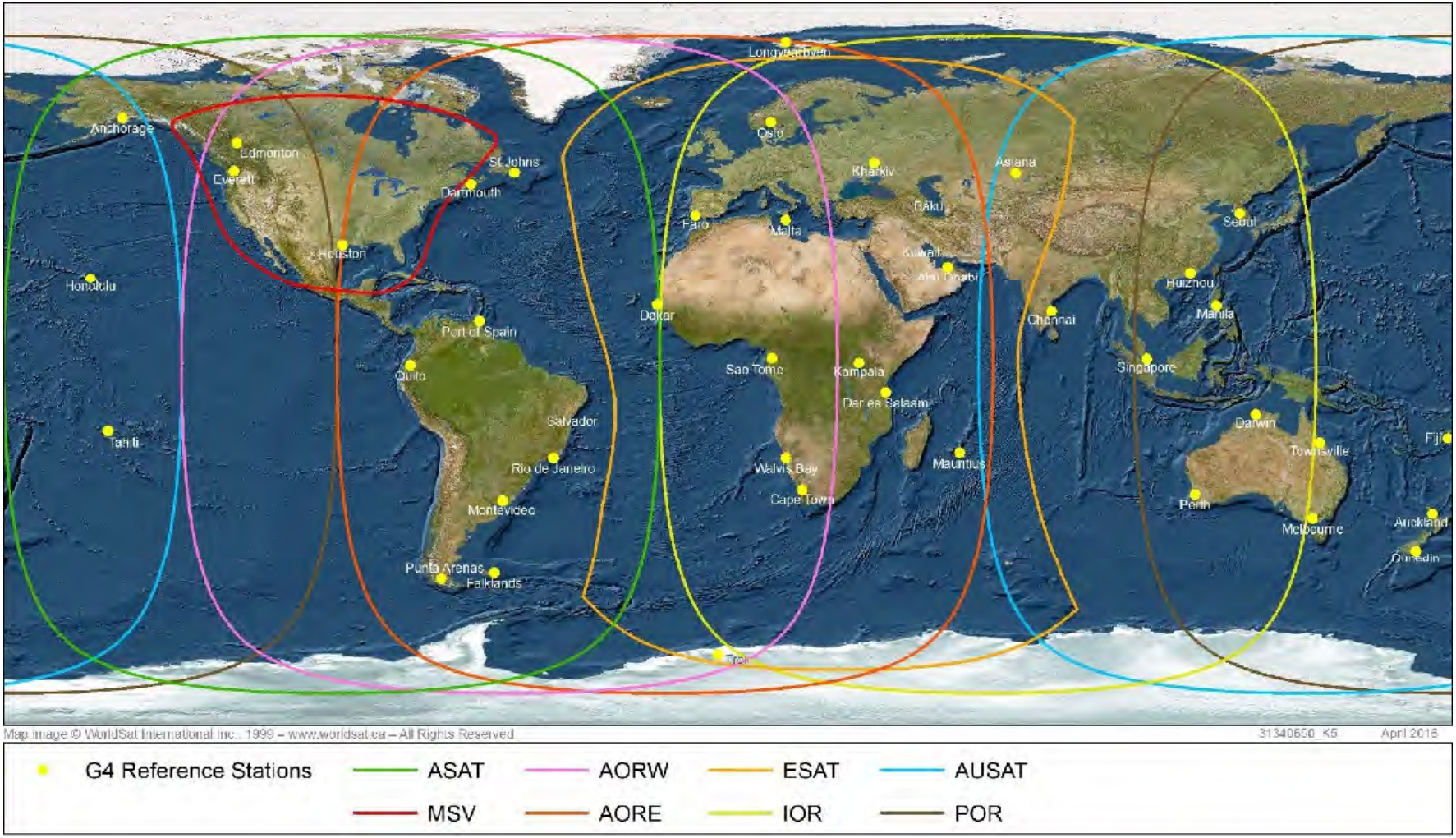
Marinestar HP GNSS Reference Station Network ~100 sites



Marinestar 8 Geostationary communication satellites



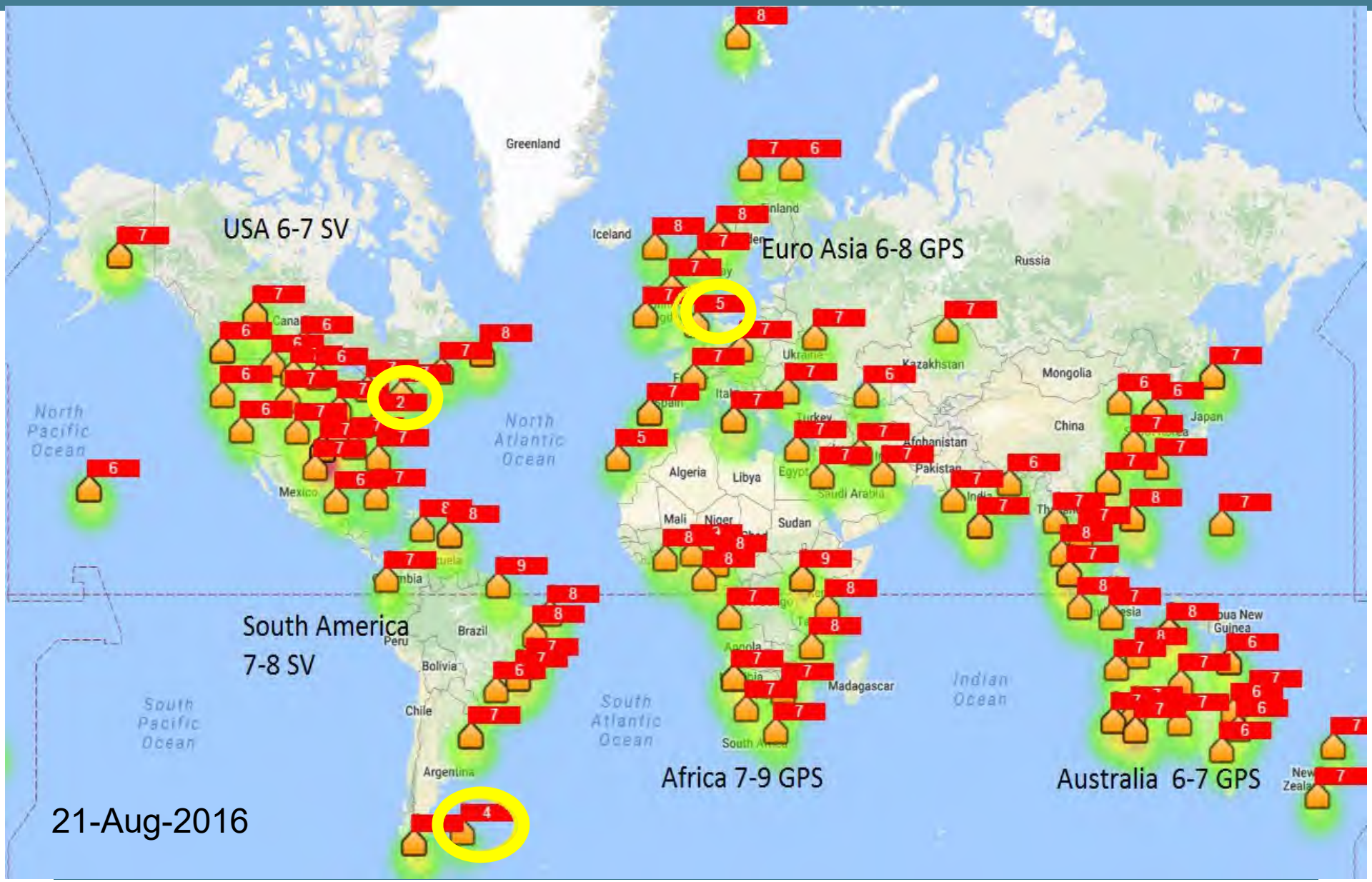
Fugro Marinestar G4 GNSS Reference Station Network



Fugro Marinestar GNSS Positioning Services

Service	Since	Accuracy	Method	System	Frequency	Technique
VBS	1996	Meter	Reference Stations	GPS/ Glonass	Single	Differential
HP	2000	Sub Decimeter	Reference Stations	GPS	Dual	Differential
G2	2009	Decimeter	Orbit1 Clock1	GPS GLONASS	Dual	PPP
XP2	2014	Decimeter	Orbit2 Clock2		Dual	PPP
G4	2015	Decimeter	Orbit2 Clock2	GPS GLONASS BeiDou Galileo	Dual	PPP
G4+	2016 (Today)	**Centimeter**	Orbit2 & Clock2 & UPDs		Dual	PPP-RTK

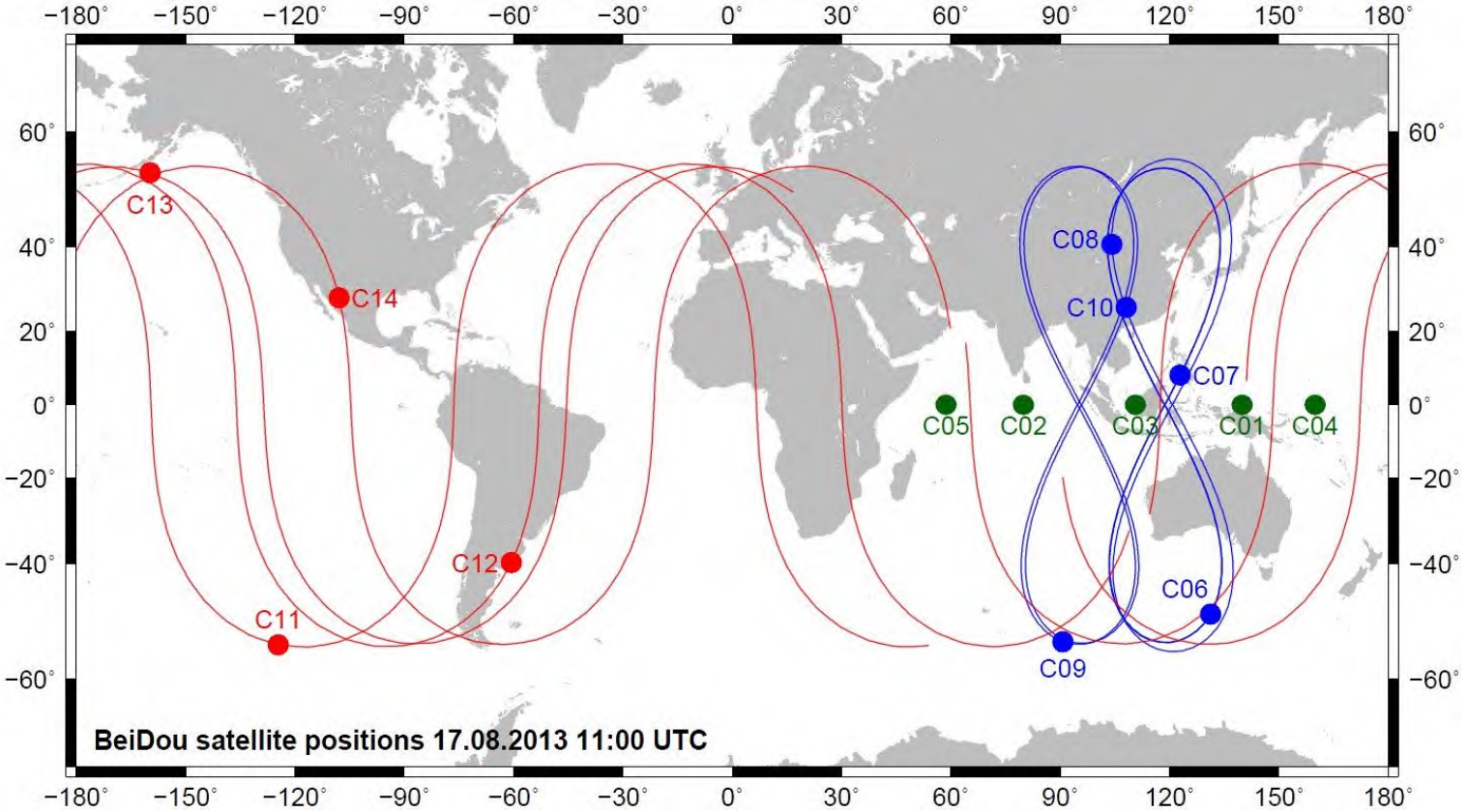
GPS Availability Minimum number of satellites



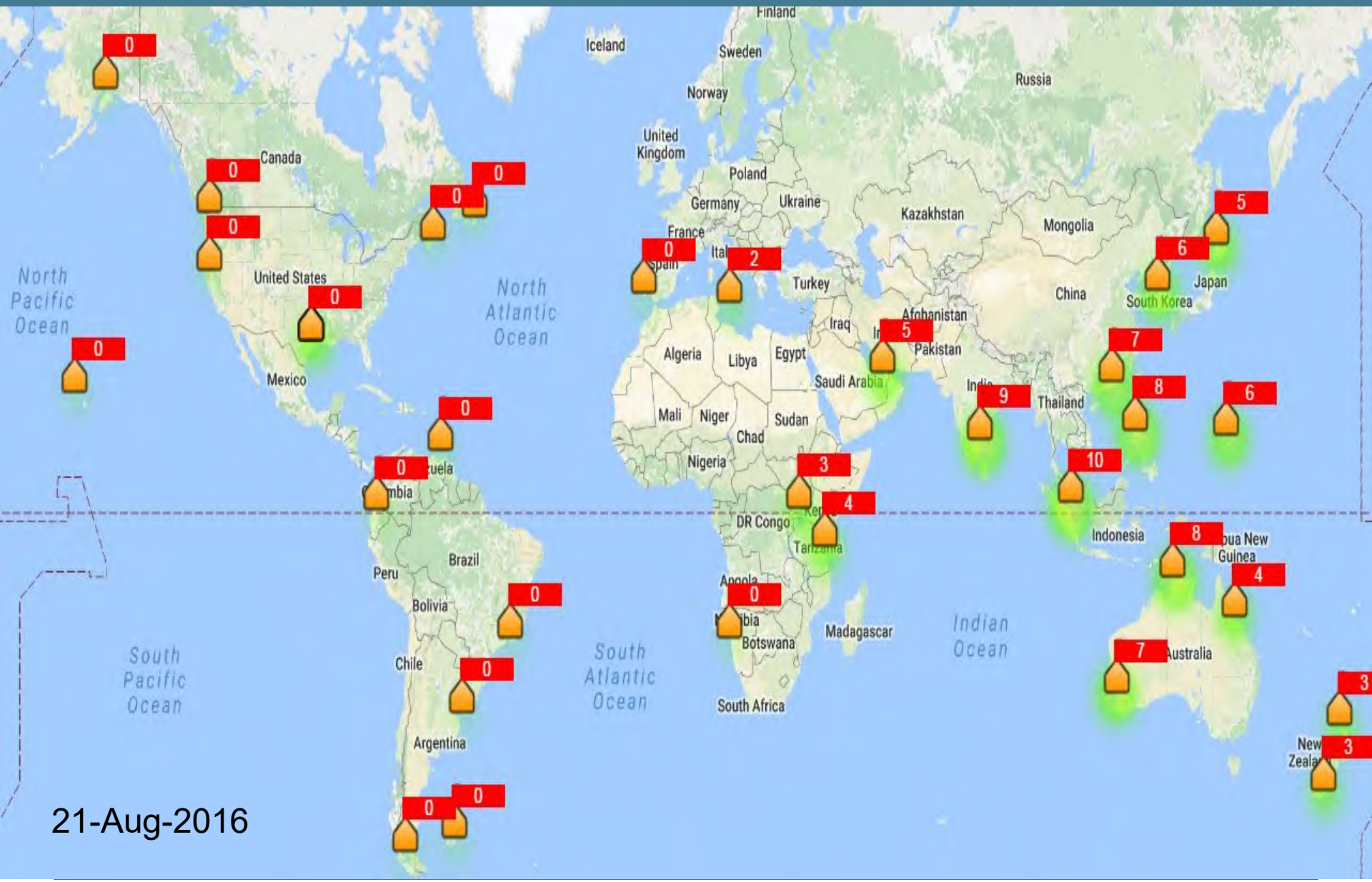
GLONASS Availability Minimum number of satellites

GNSS Systems - BeiDou

- 5 Geostationaire Earth Orbit satellites (GEO)
- 5 Inclined Geosynchronous Orbit satellites (IGSO)
- 4 Medium Earth Orbit (MEO)

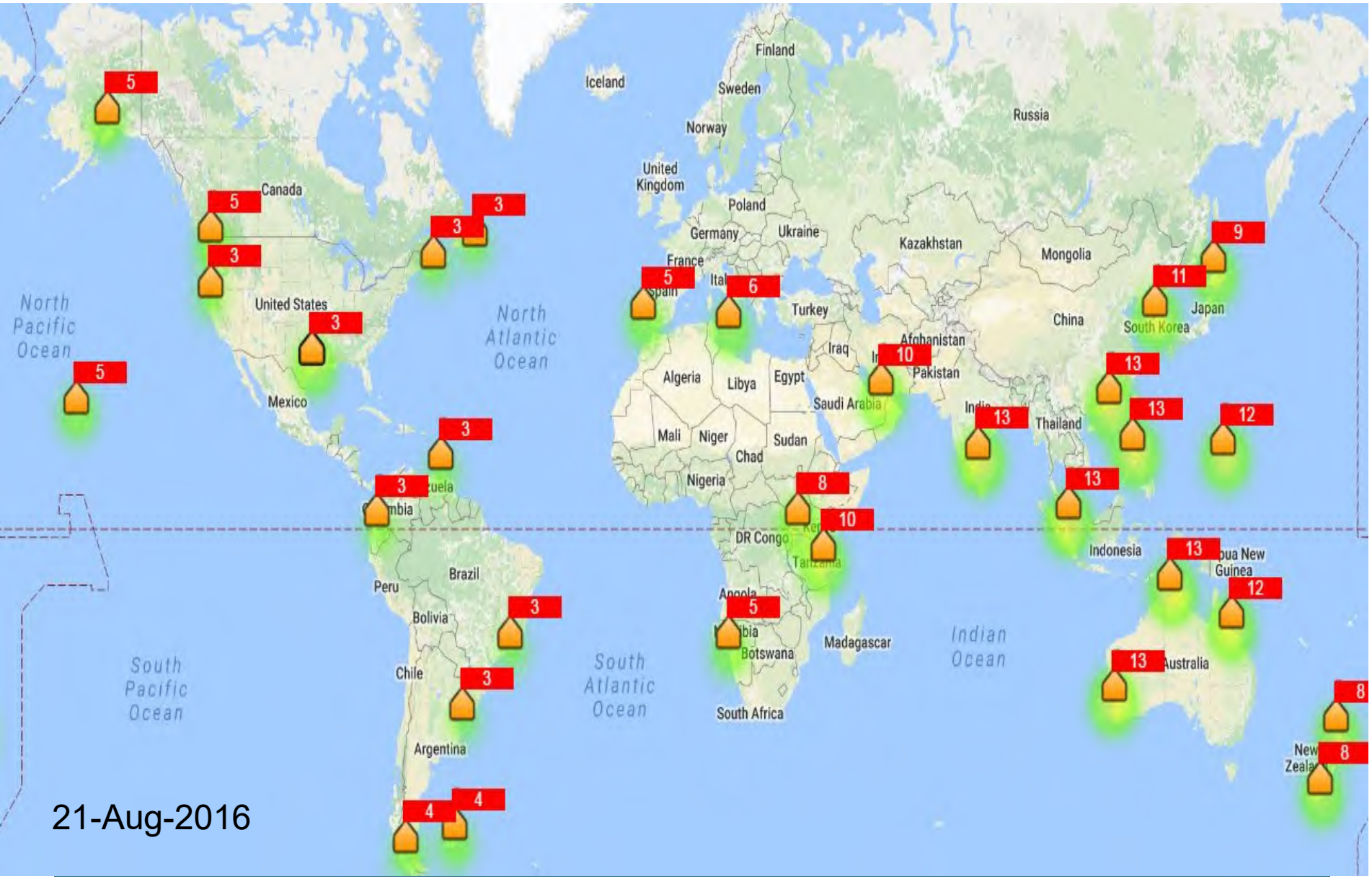


Beidou Availability Minimum number of satellites



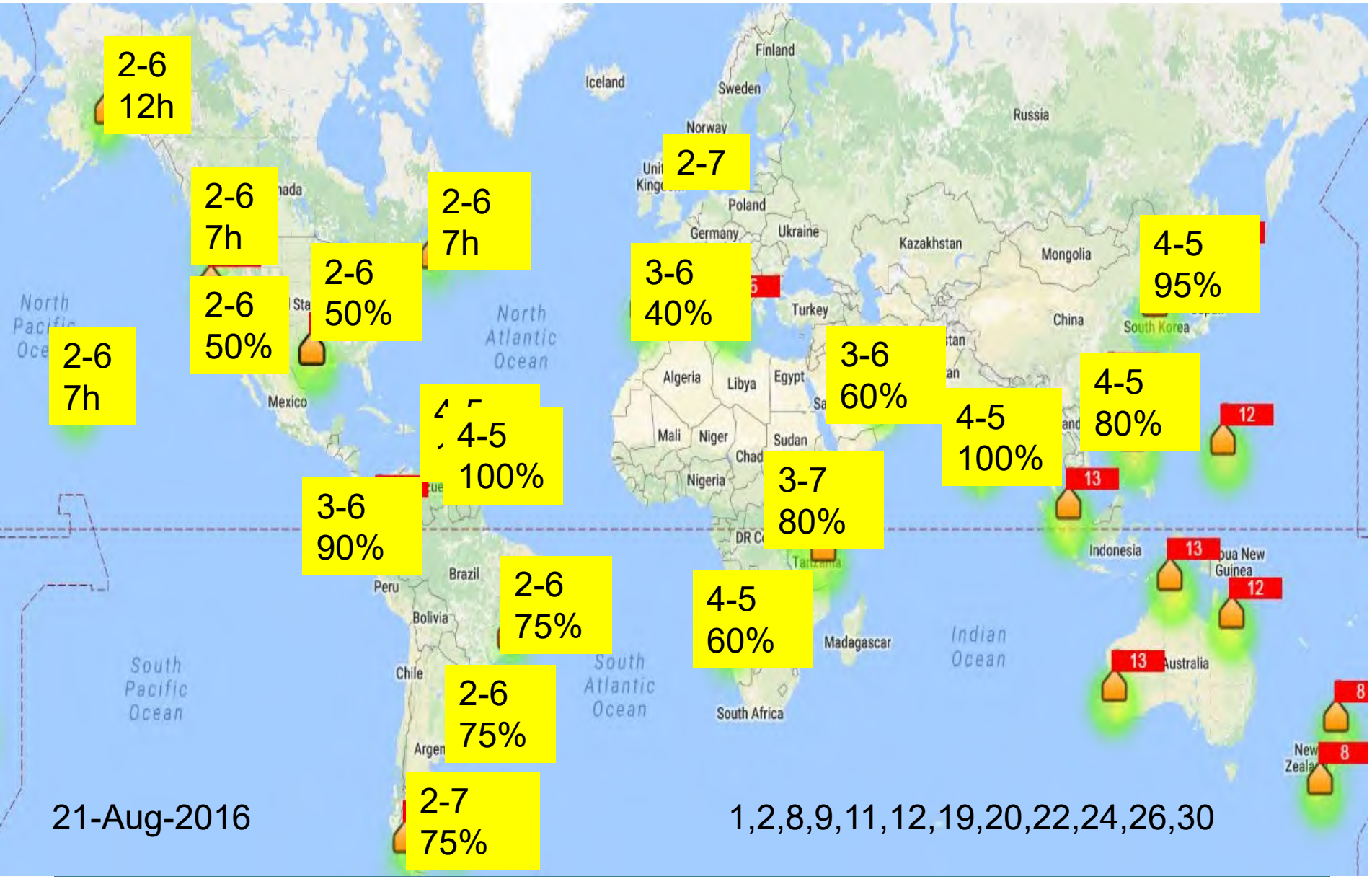
21-Aug-2016

Beidou Availability Maximum number of satellites



21-Aug-2016

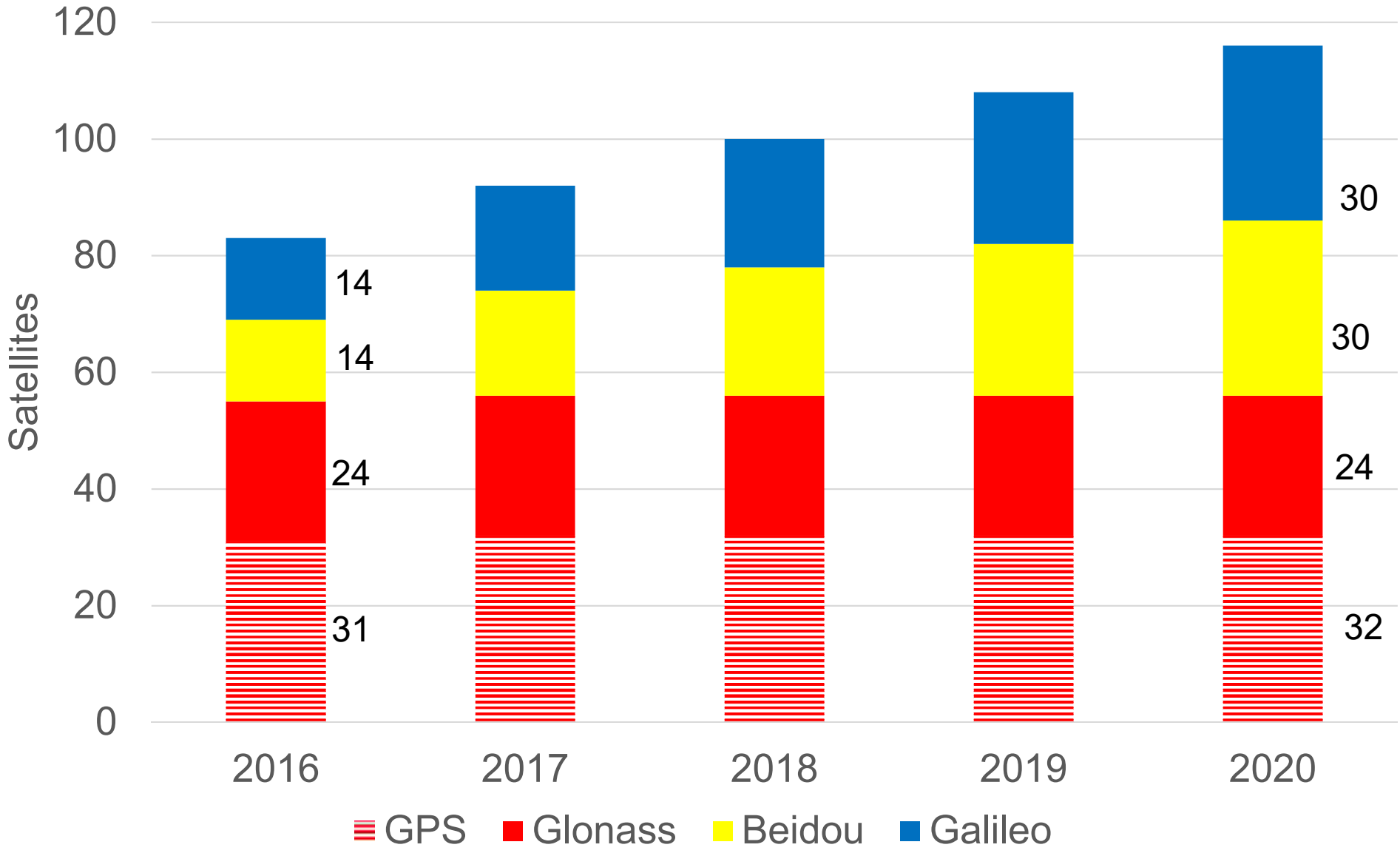
Galileo Availability



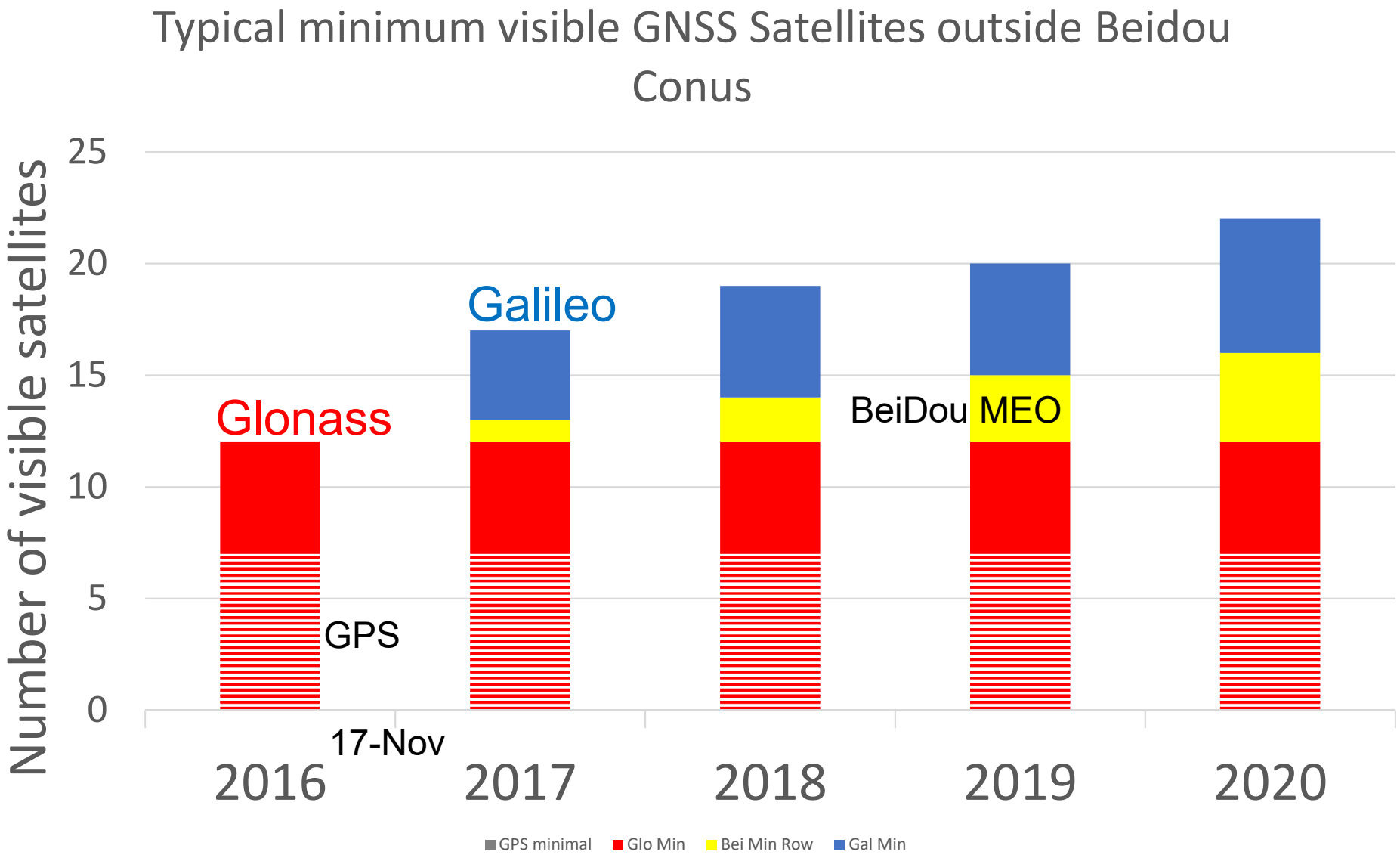
21-Aug-2016

1,2,8,9,11,12,19,20,22,24,26,30

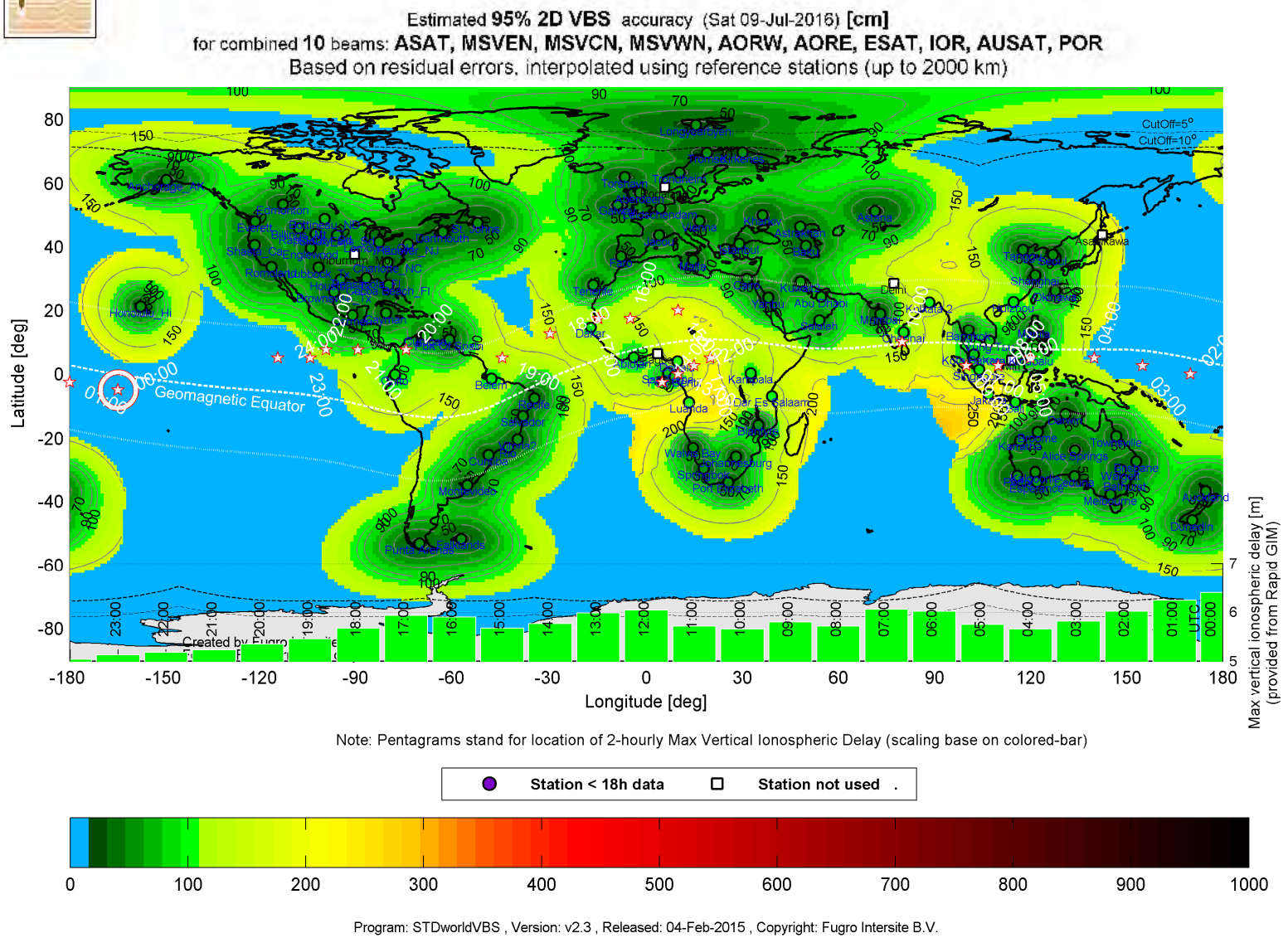
Total number of available satellites in the coming years

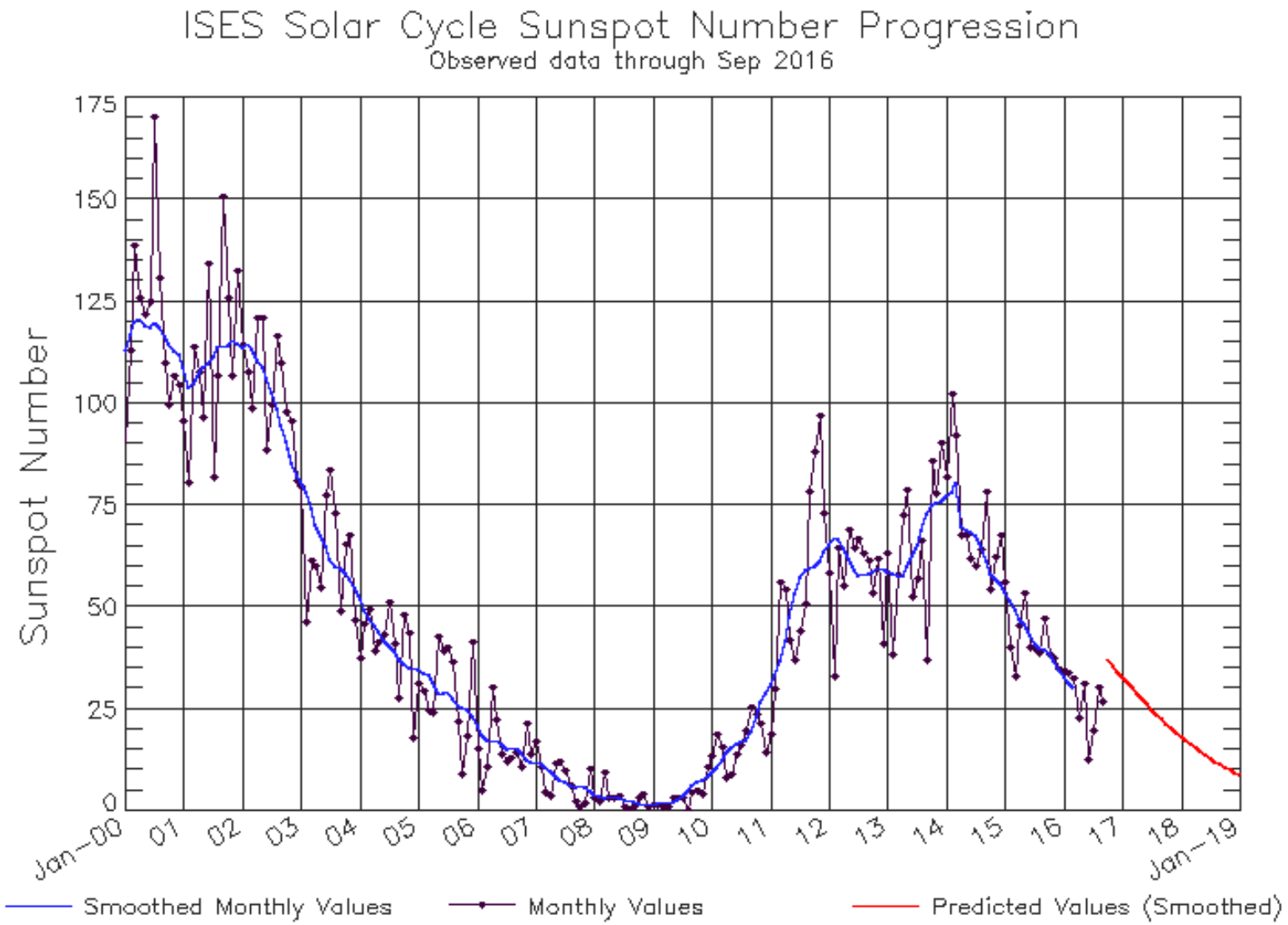


Typical minimal visible GNSS Satellites outside BeiDou Conus

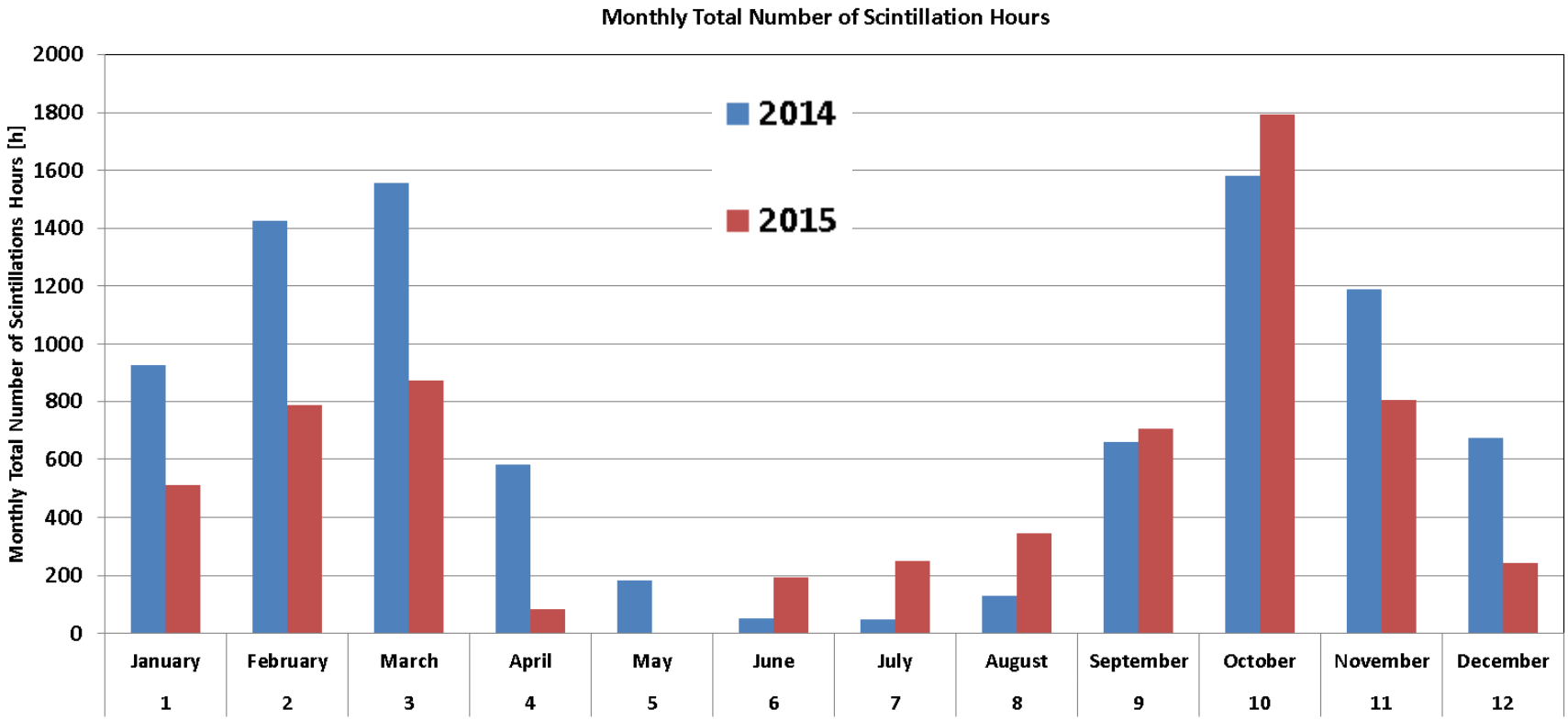


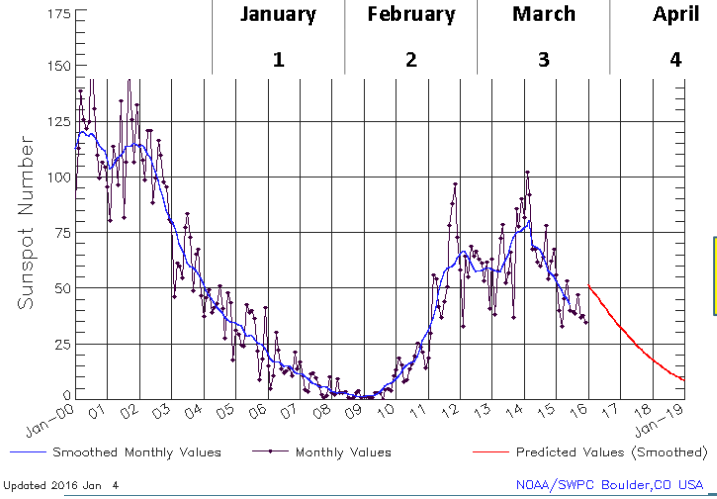
Marinestar VBS (L1 GPS Code) Performance




ISES Solar Cycle Sunspot Number Progression
Observed data through Sep 2016
Sunspot Number
175
150
125
100
75
50
25
0
Jan-00
01
02
03
04
05
06
07
08
09
10
11
12
13
14
15
16
17
18
Jan-19
Smoothed Monthly Values
Monthly Values
Predicted Values (Smoothed)
Updated 2016 Oct 3
NOAA/SWPC Boulder,CO USA

Occurrence of Scintillations (2014 and 2015)





Total Number of Scintillation hours observed in Network:

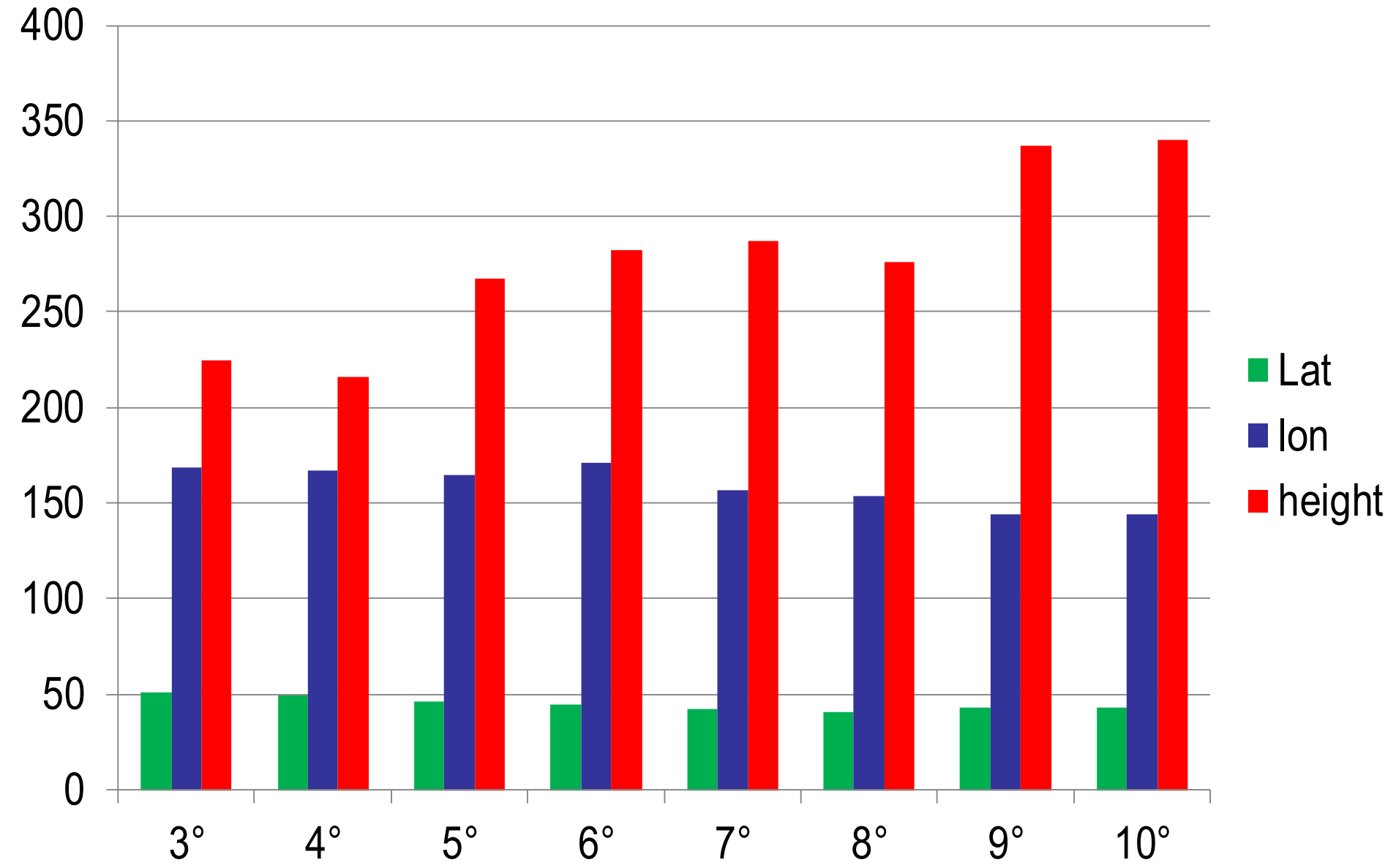
9007 h in 2014 and 6586 h in 2015.

Scintillation hours 2015 **27%** less than 2014.

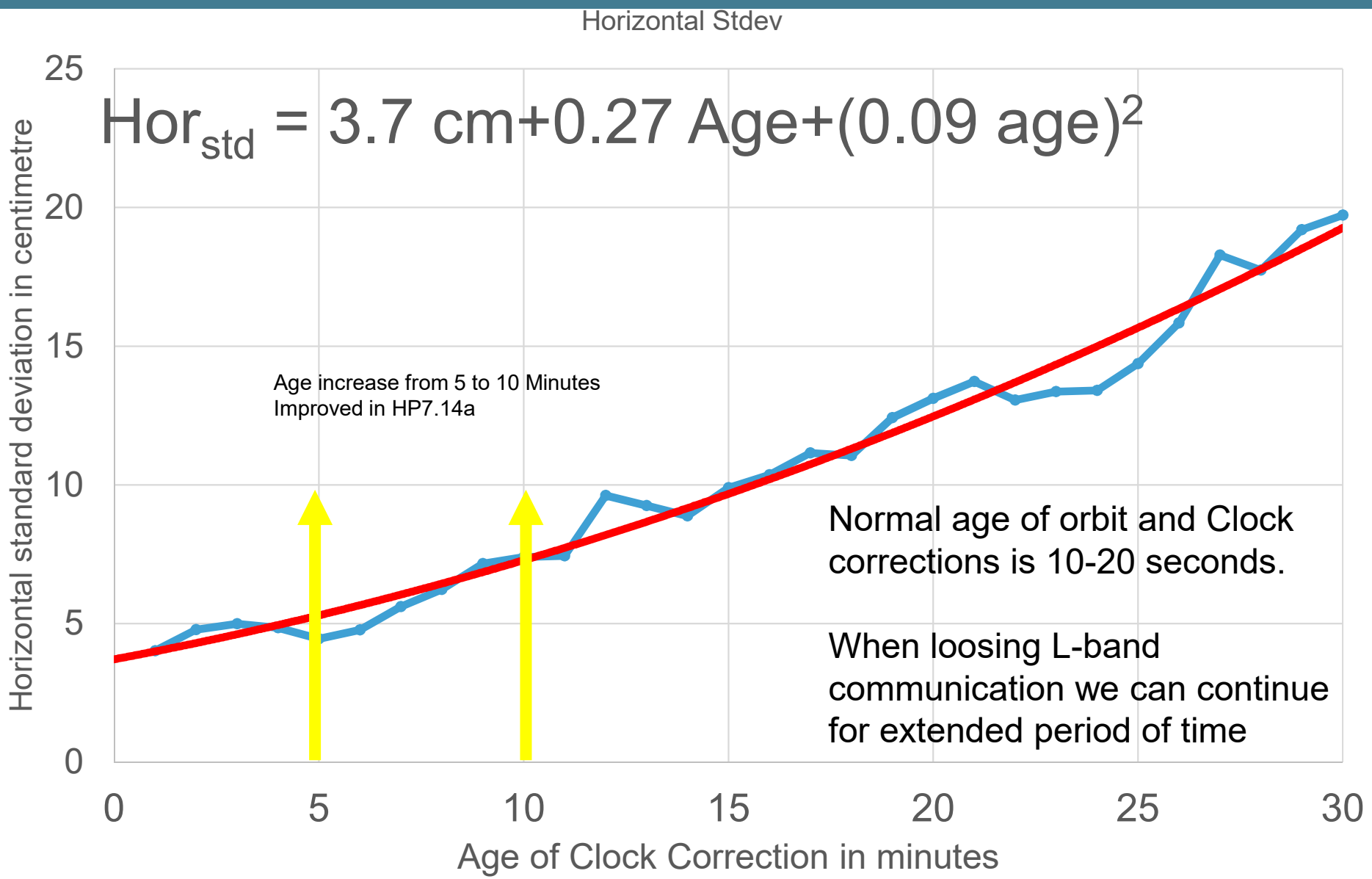
Next Solar Minimum predicted: 2019

Next Solar Maximum predicted: 2024

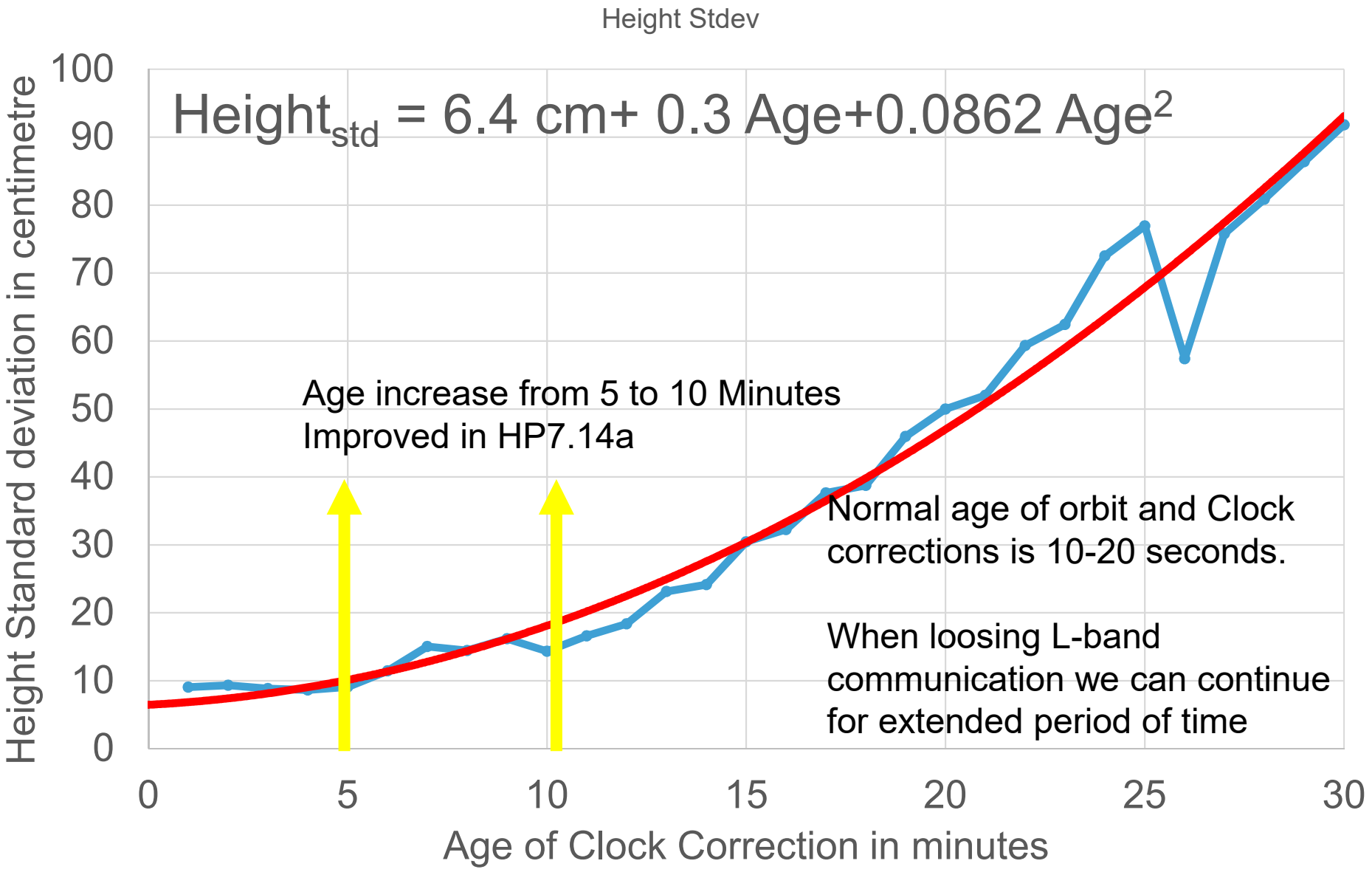
Macae Brazil December 2013 (During Scintillation)



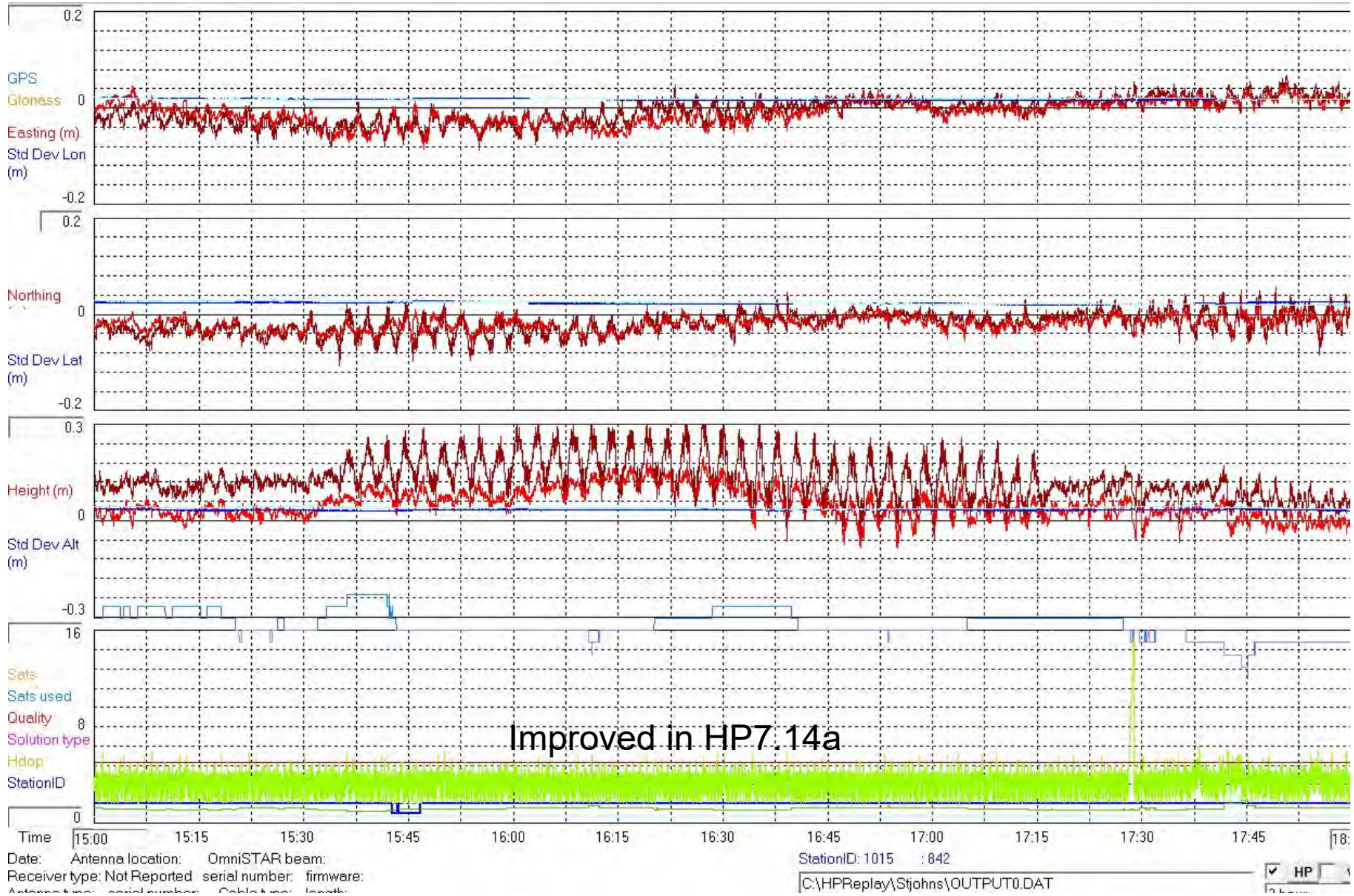
Horizontal Standard Deviation versus age



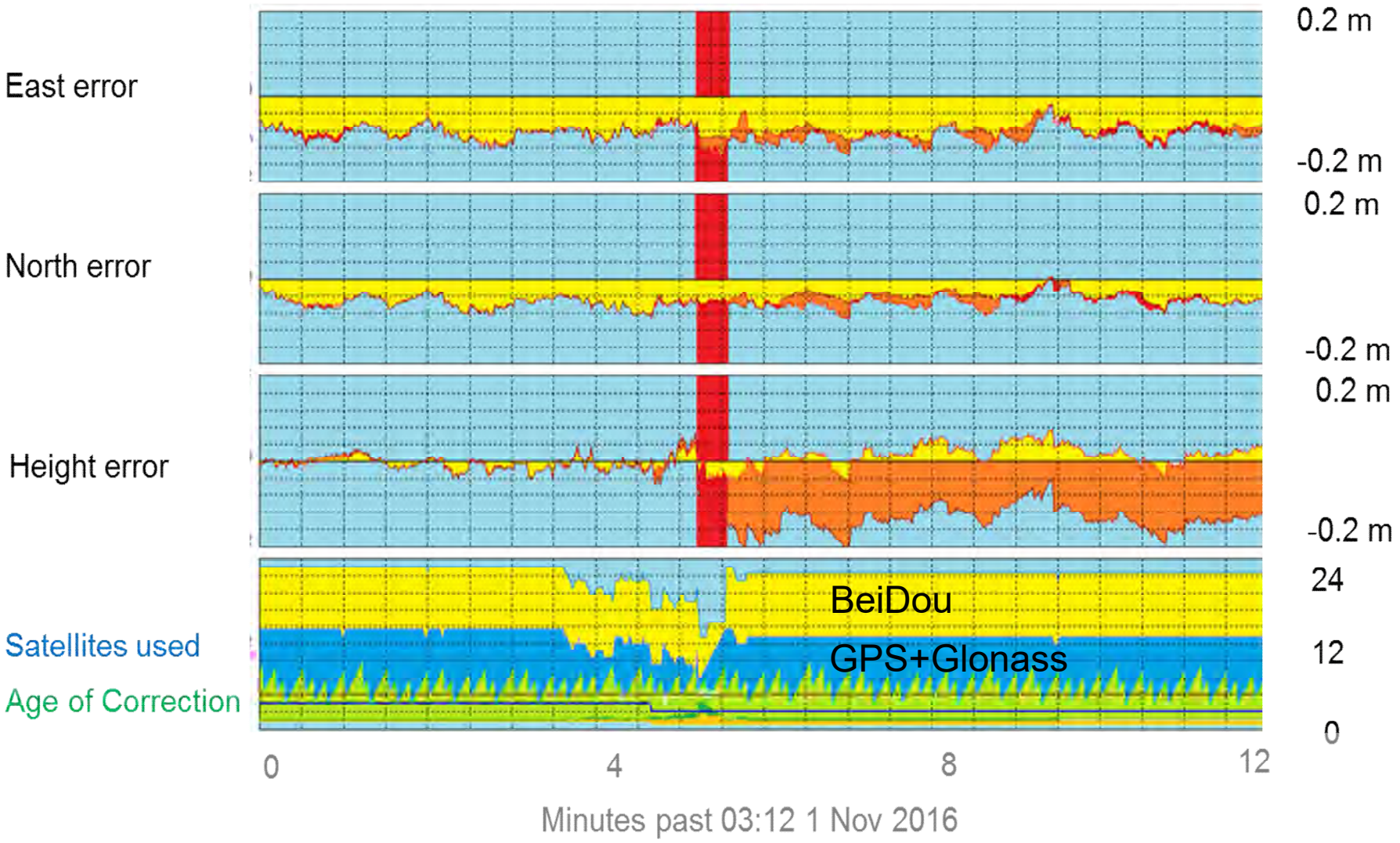
Height Standard Deviation versus age



Glonass R09 ClockJitter “St Johns”

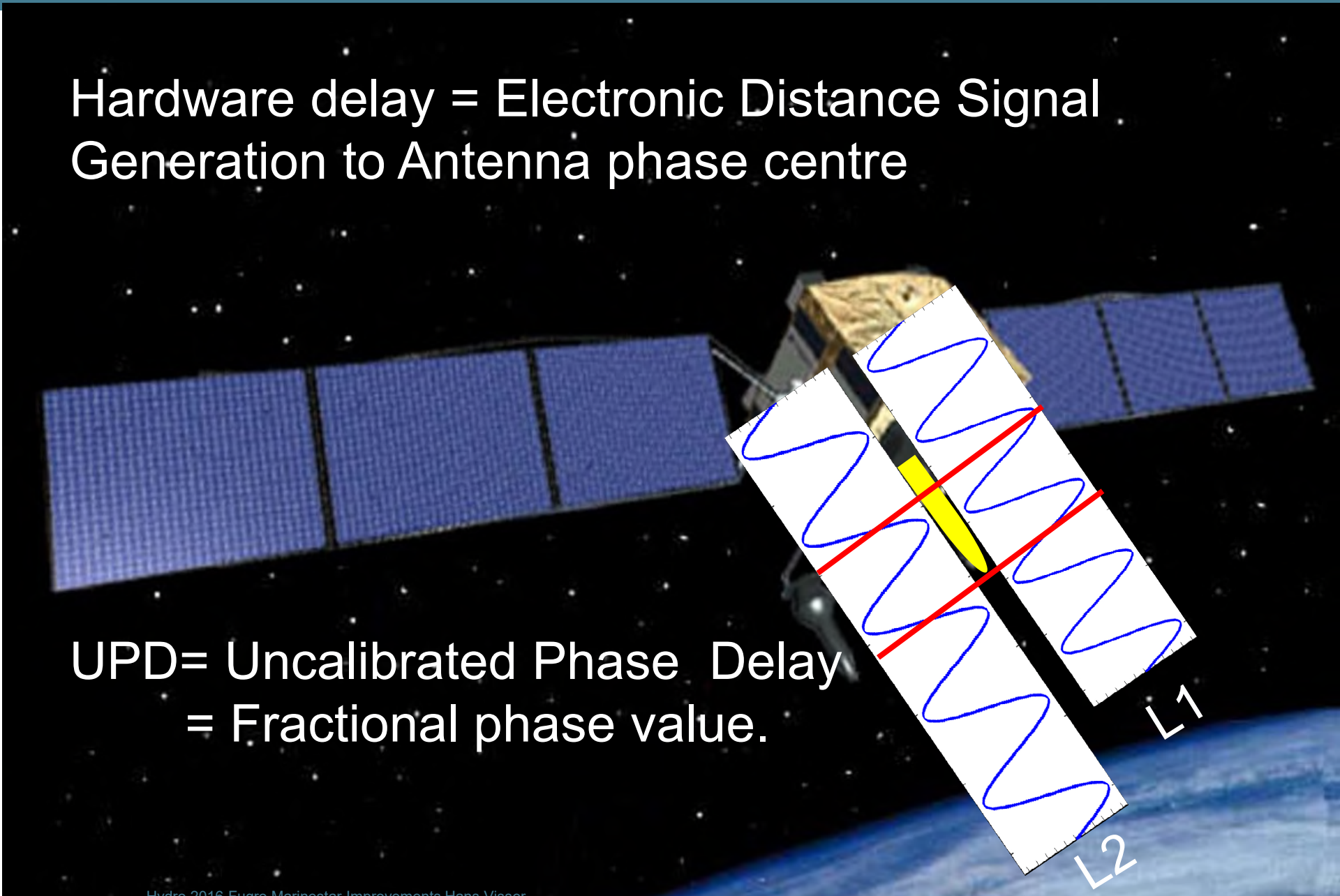


Adding BeiDou helps. (Perth)



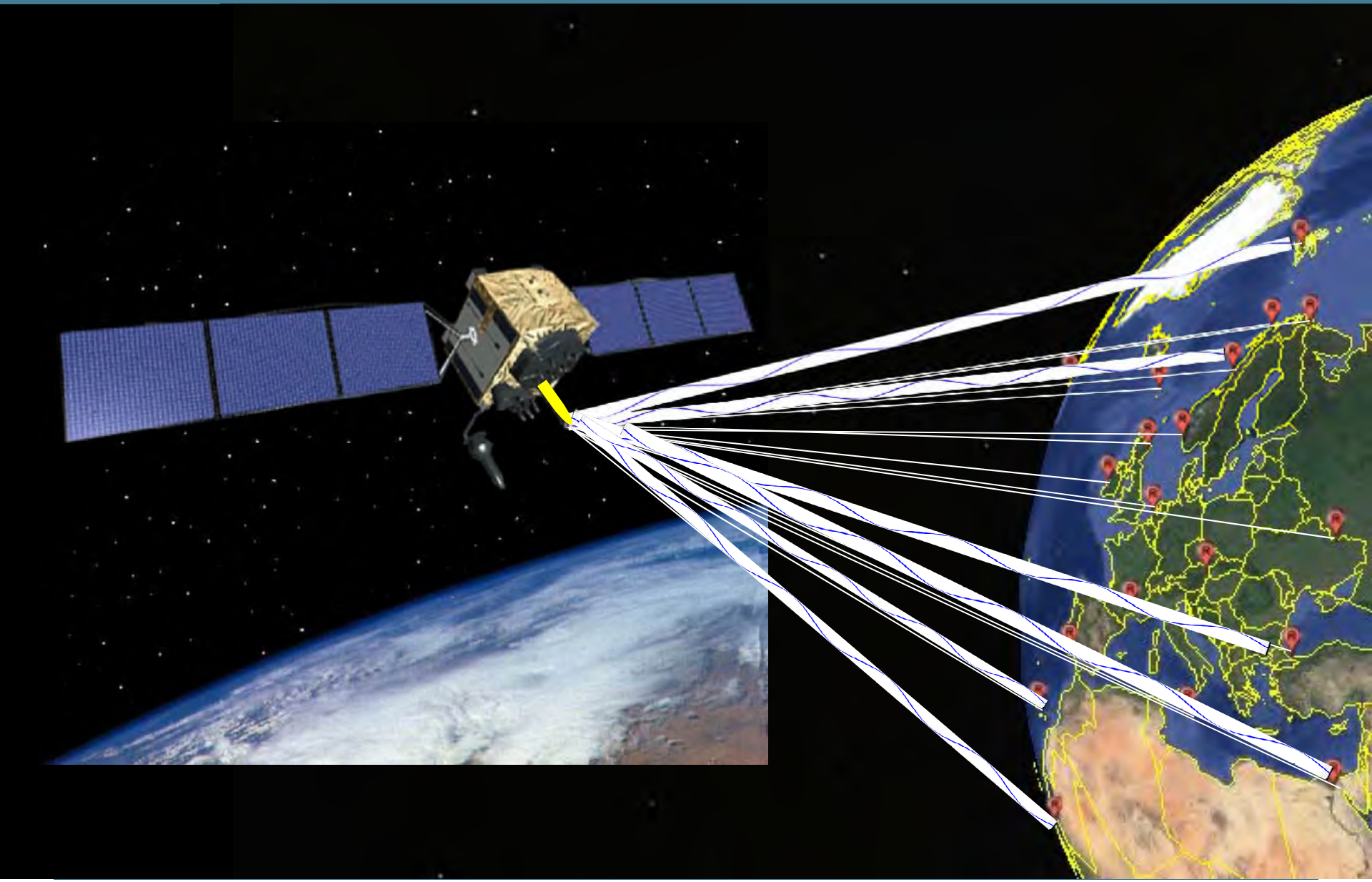
Improved in HP7.14a

Hardware delay = Electronic Distance Signal Generation to Antenna phase centre



UPD= Uncalibrated Phase Delay
= Fractional phase value.

Hardware delay estimation



PPP-RTK Principle

L1 L2 Code

UPD

L1=~19 cm

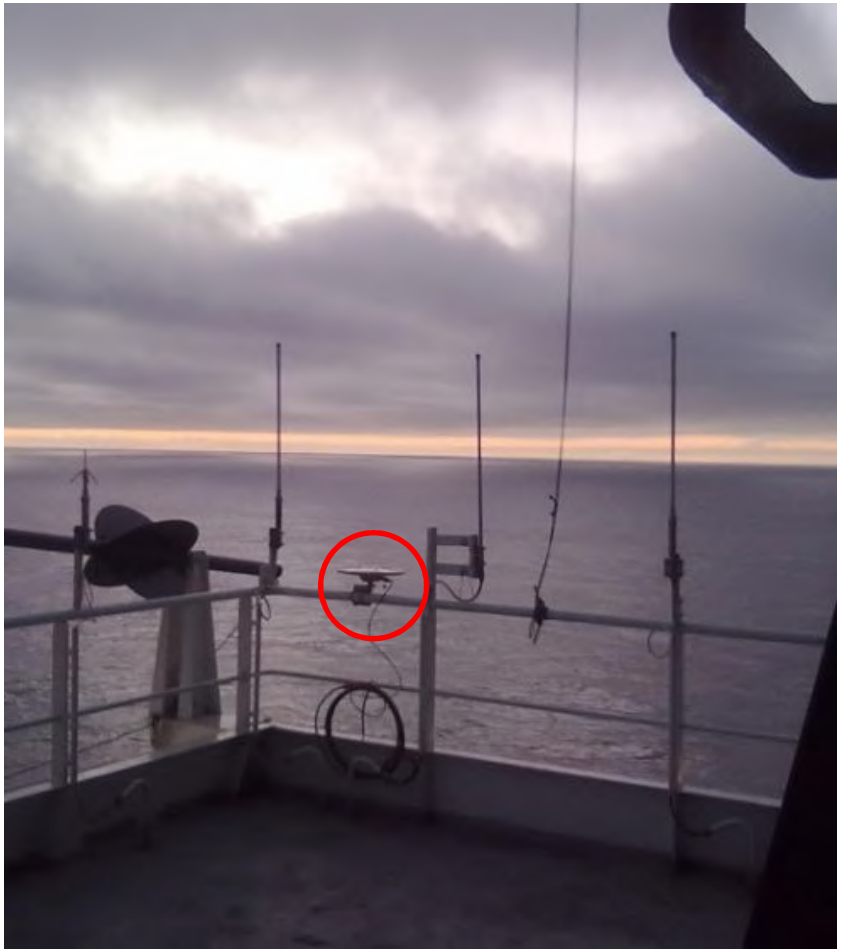
L2=~24 cm

Lwide (L1-L2)~86 cm

Lnarrow (L1+L2)=~11 cm

Apply UPD. Start with code. Fix Wide Lane, than Fix Narrow Lane
Do this for all GPS Satellites

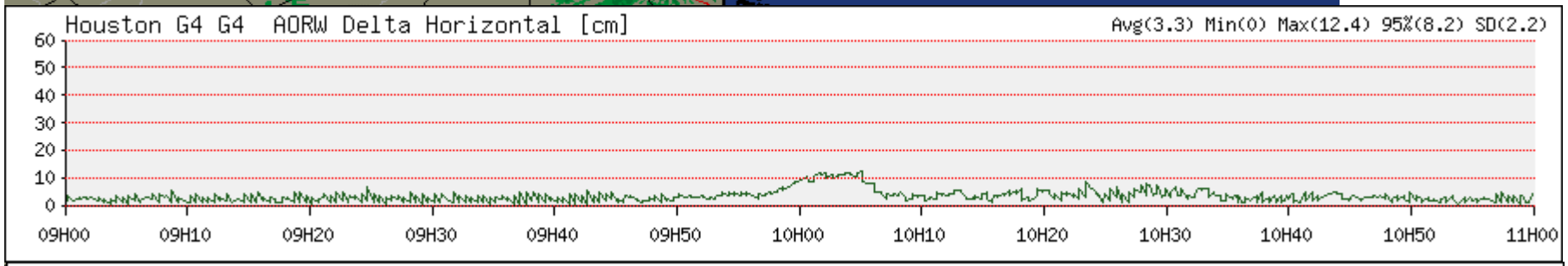
Limitations for PPP-RTK: `Antenna locations

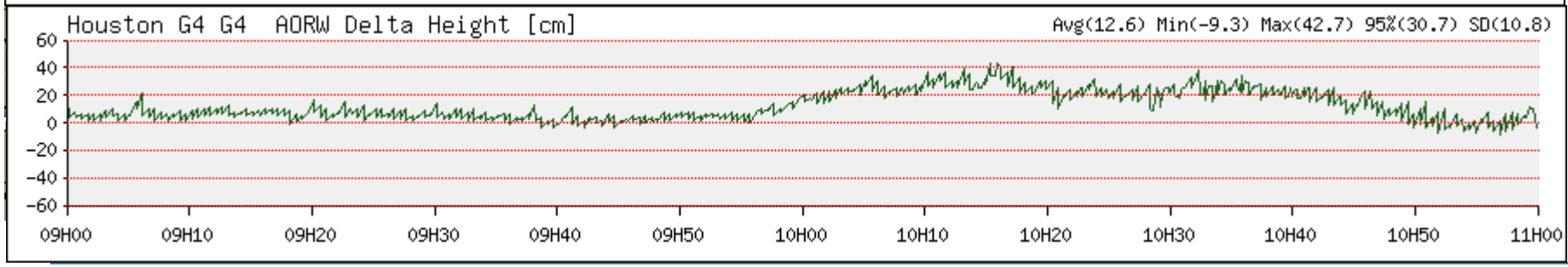


Antenna not on monkey deck

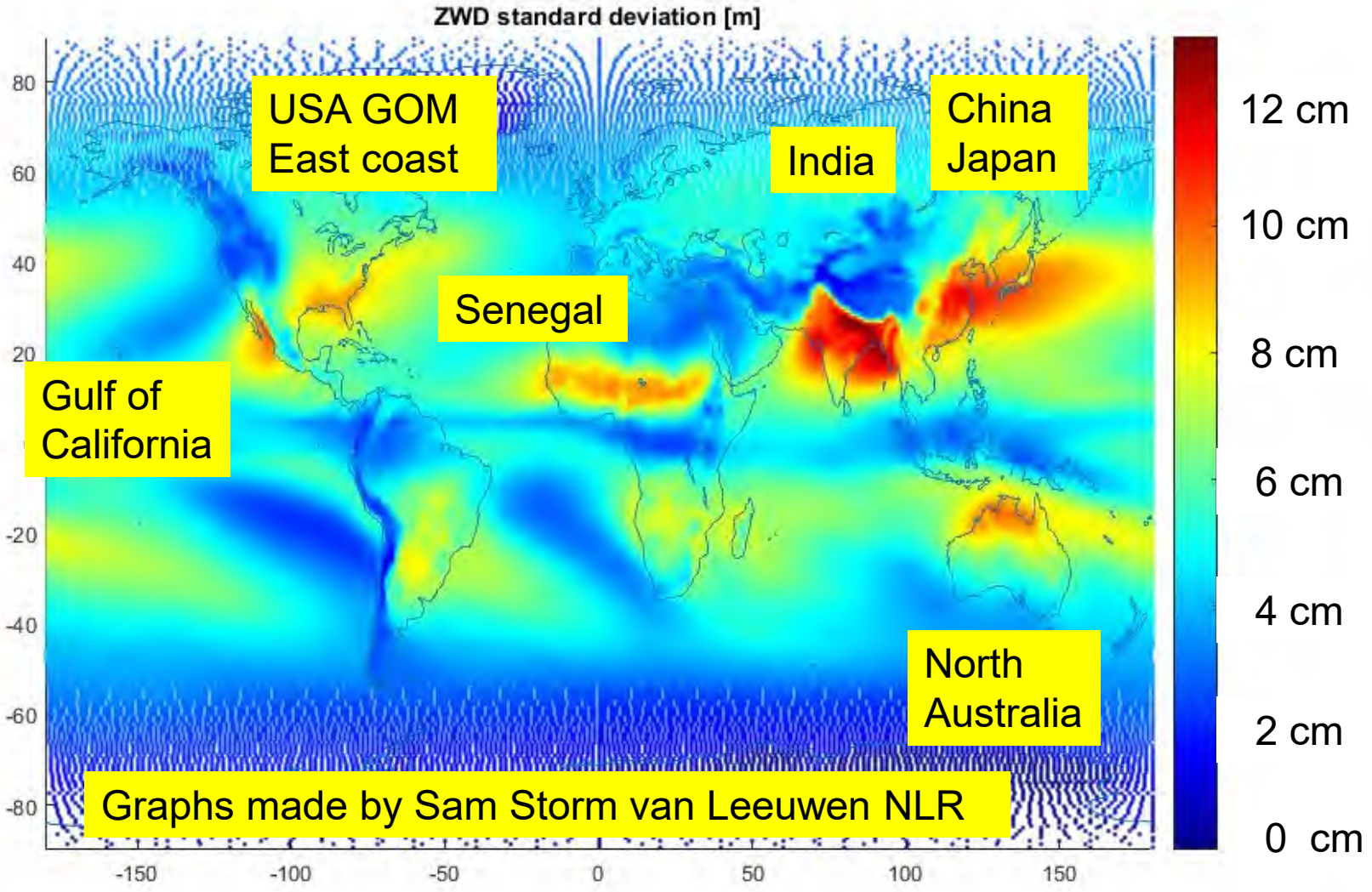
Antenna in top of the mast

PPP-RTK effect of extreme Weather

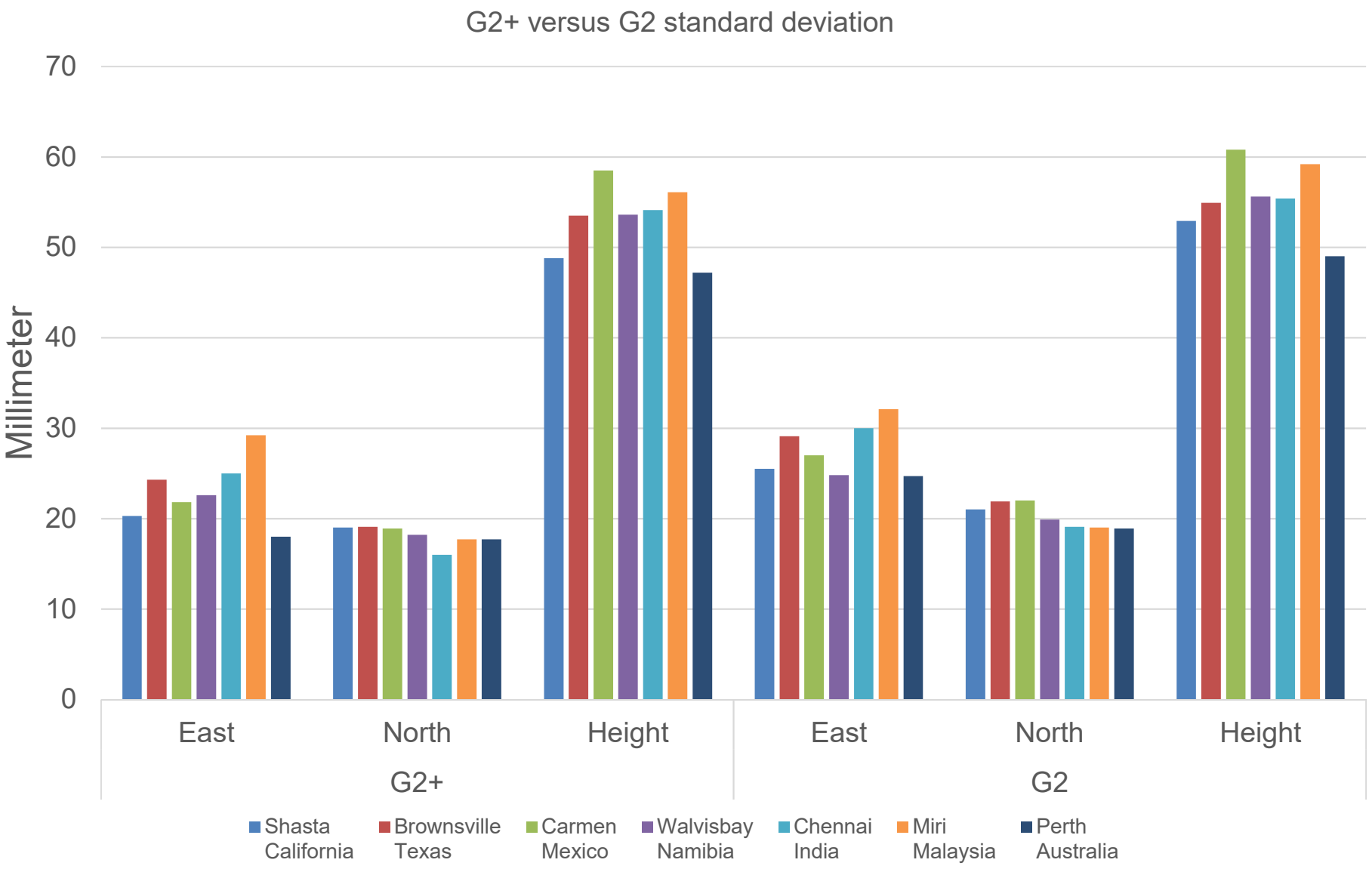




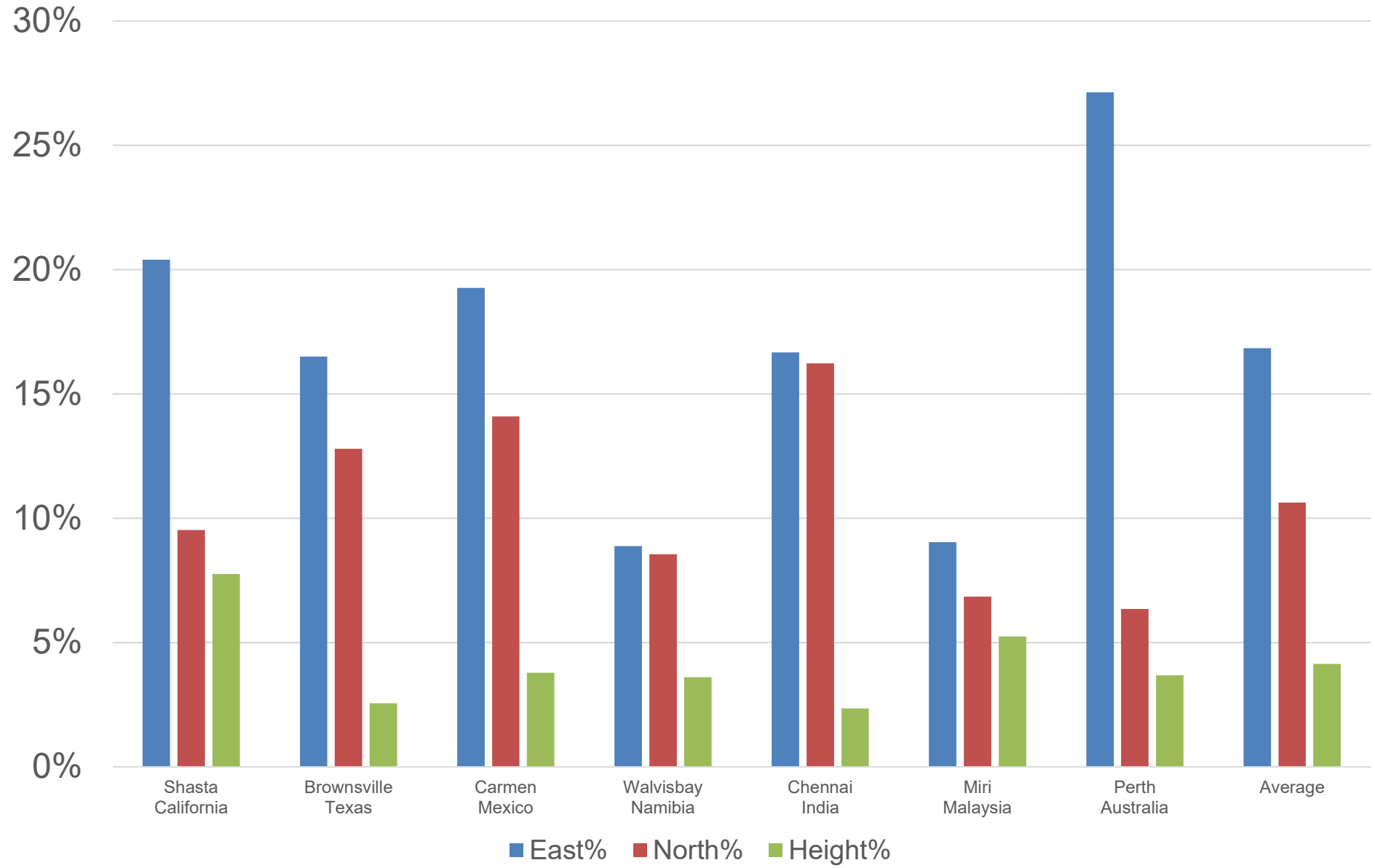
Troposphere: Standard Deviation of Zenith Wet Delay



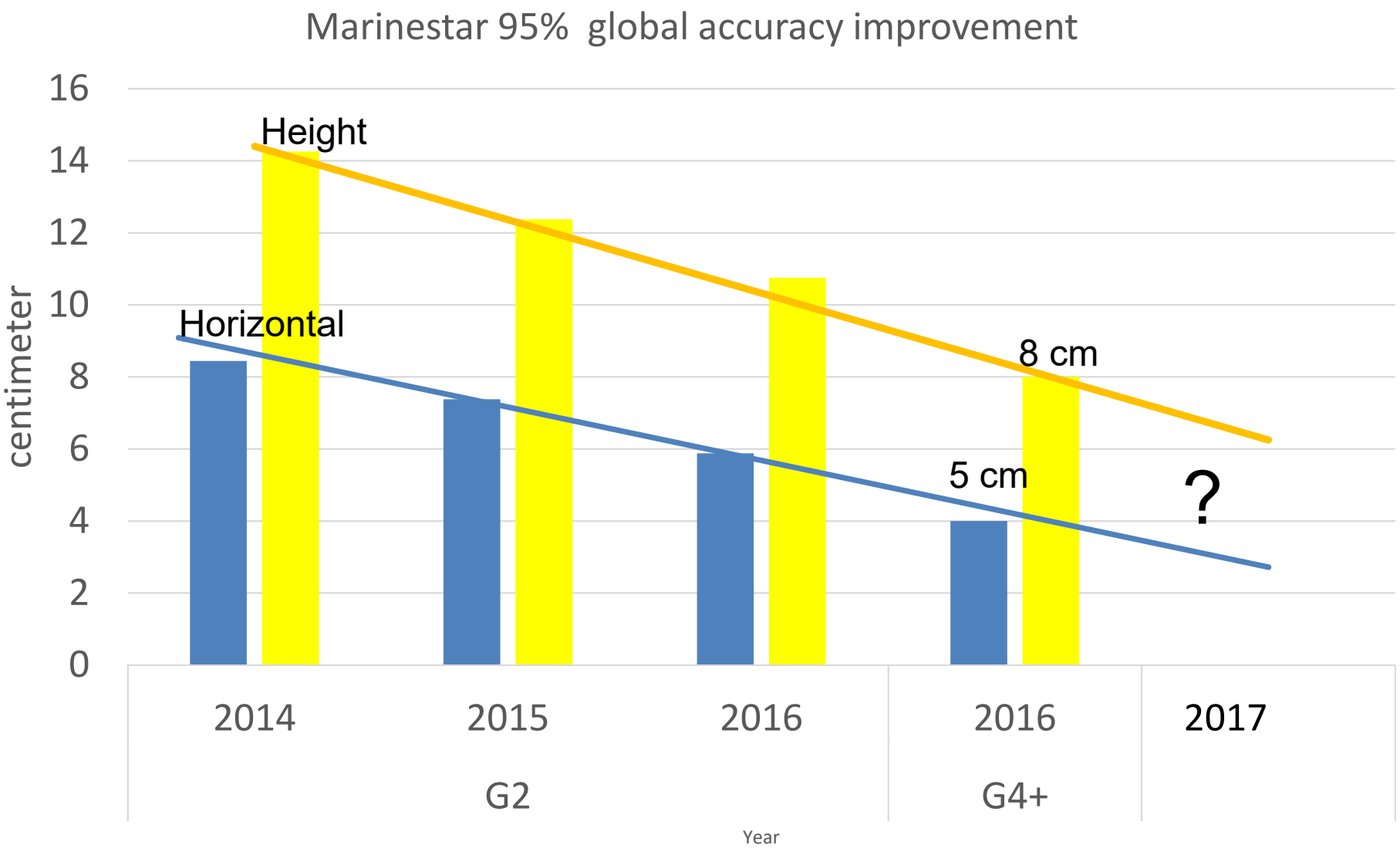
G2+ Improvements



Percentage improvement G2+ versus G2



Global improvements of Marinestar over the years



Products including Marinestar

Fugro Marinestar 9200, 9205

Trimble SPS Series

BD960, BD920, BD982,

Kongsberg 3610, 3710

Applanix
Pos MV, AP15,AP25, AP50

SBG
Apogee-E

Stema Systems
GNS982 Poe

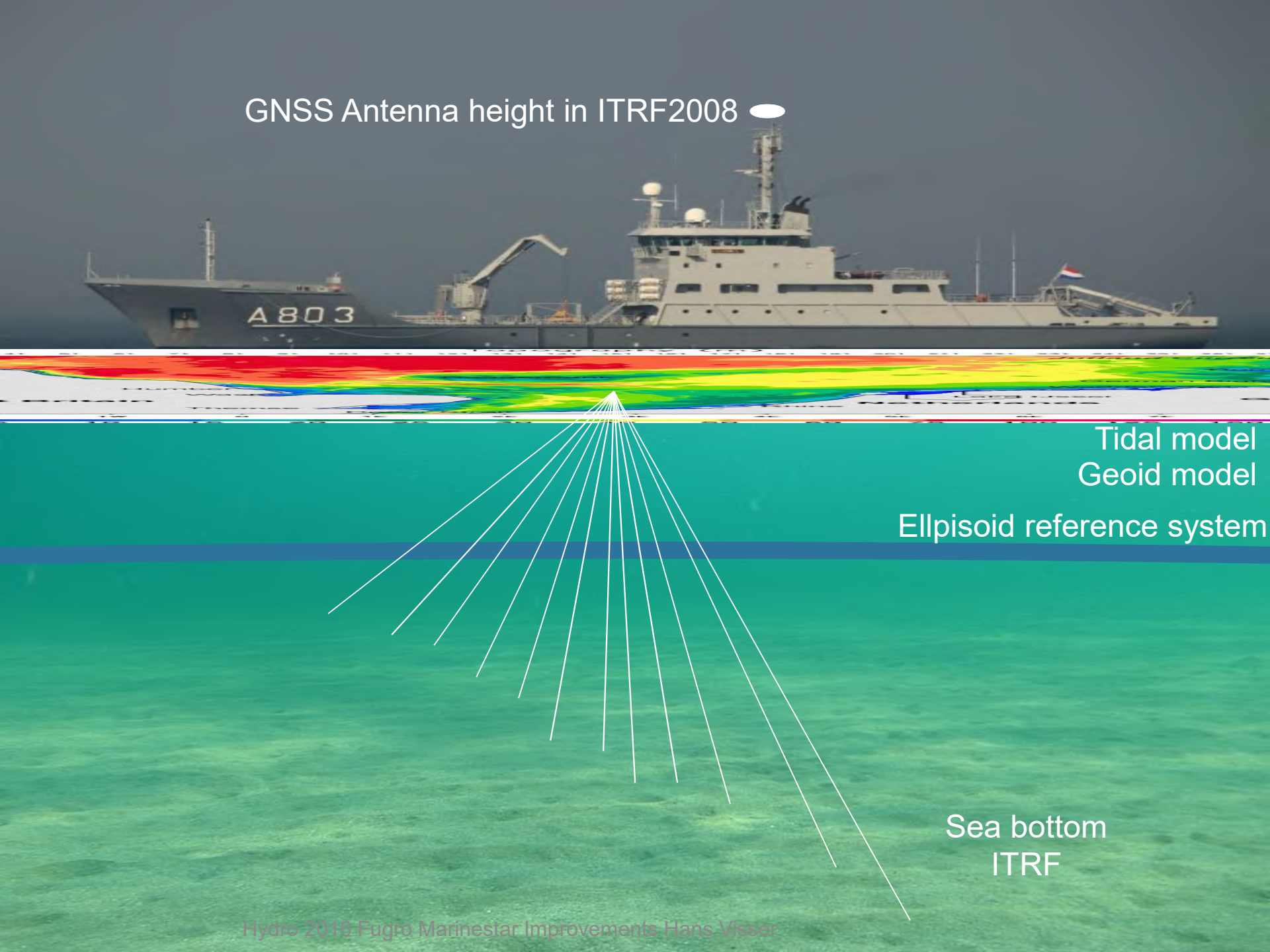
Advanced Navigation
Spatial Dual

Norbit Iwbms

Teledyne Reson
TS20, TS80

Z-Boat

and more...


GNSS Antenna height in ITRF2008
A803
Tidal model
Geoid model
Ellpisoid reference system
Sea bottom
ITRF

Conclusions

- The Ionosphere is calming. We are prepared for the next solar cycle in ~2023
- The quality of Fugro Marinestar is continuous improving
- Multiple constellations improve accuracy, availability and robustness
- PPP-RTK requires more attention of the hydrographer
  - Antenna location in the mast.
  - Radio Interference

- Horizontal standard deviation is now 4-5 cm 95%
- Height standard deviation is now 8 cm 95%

- Question: What Height accuracy is required?

Thanks for your attention

You can meet us at Booth 20

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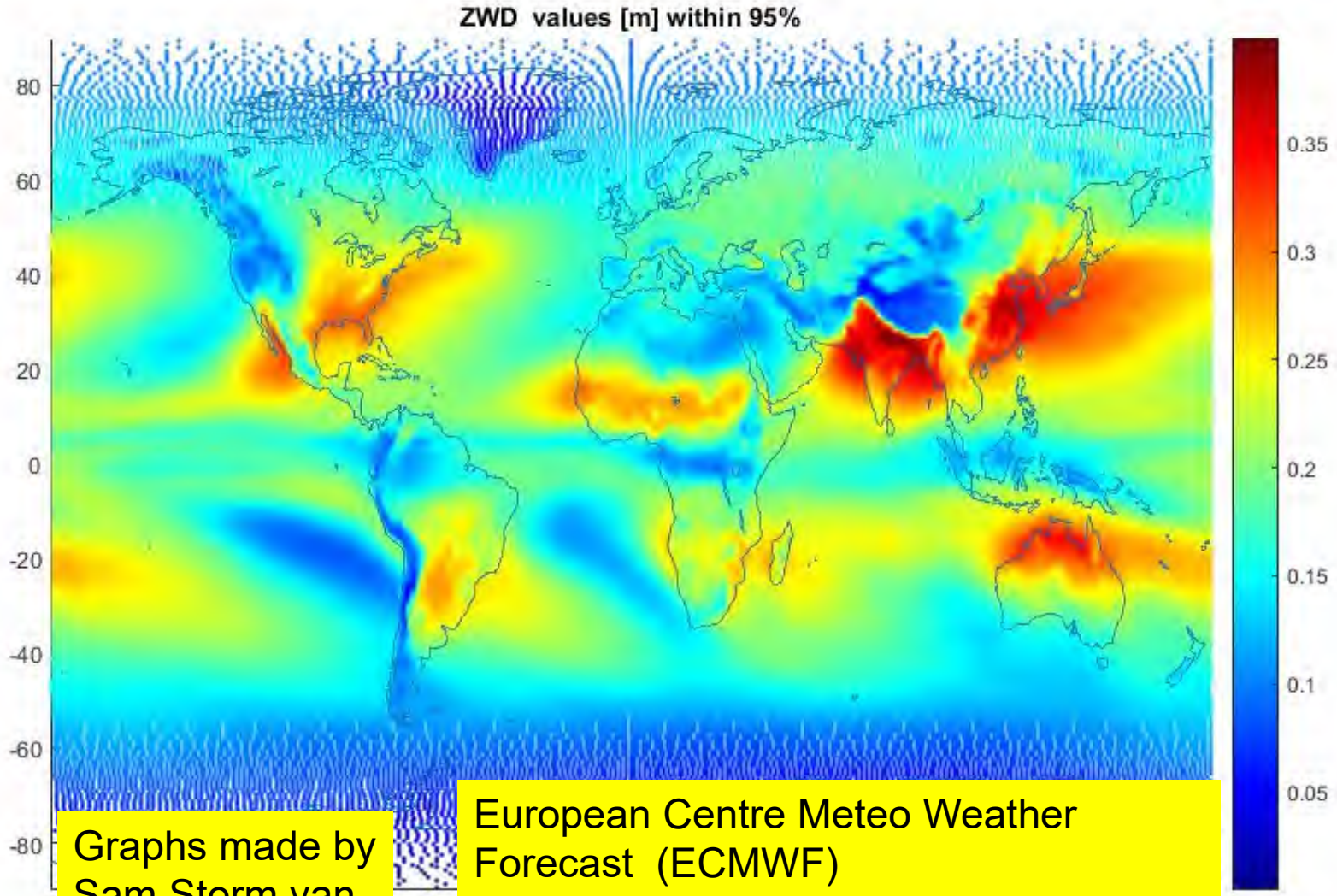
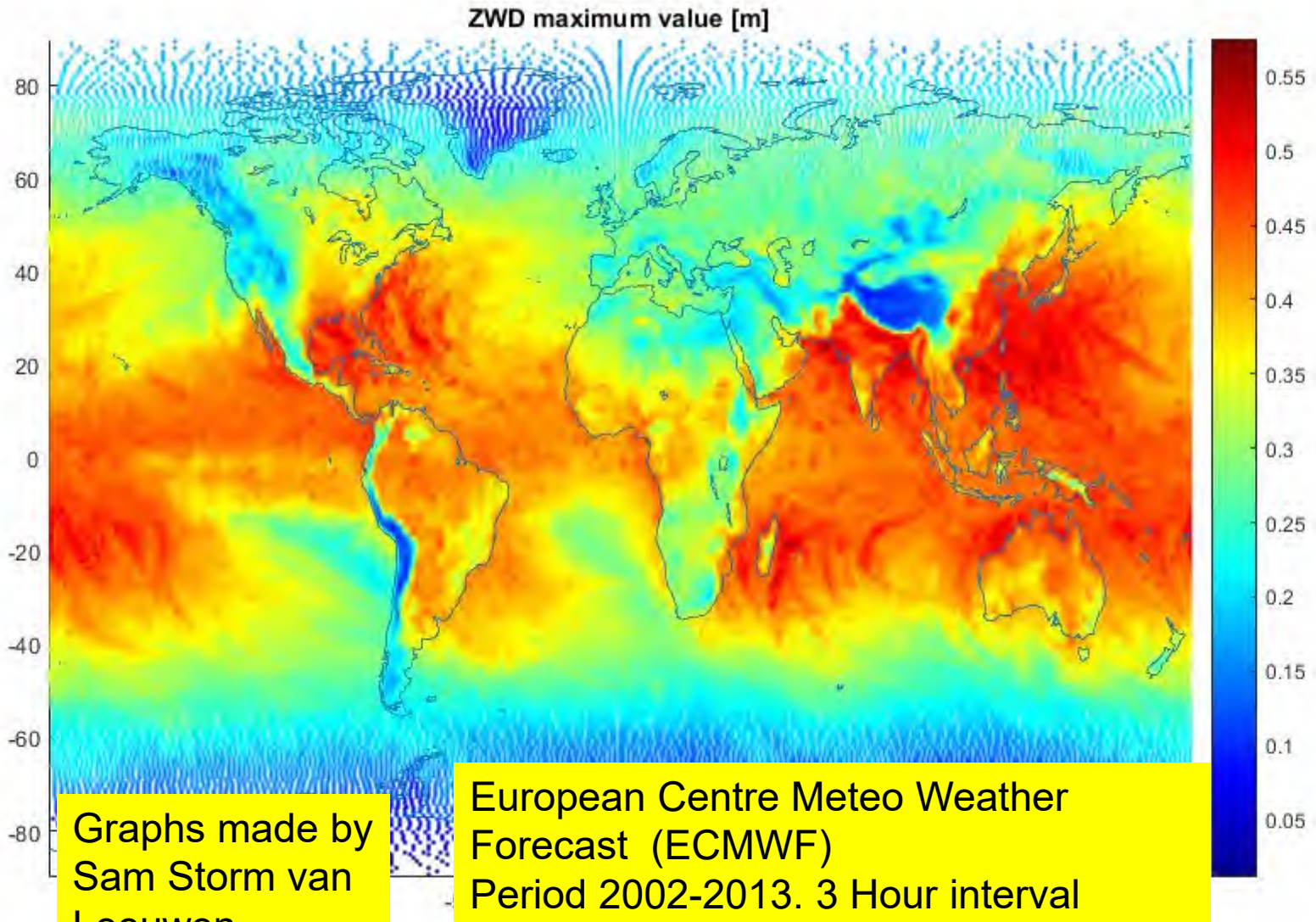
Tropospheric Zenith Wet Delays: Climate statistics



Graphs made by Sam Storm van Leeuwen NLR

European Centre Meteo Weather Forecast (ECMWF)
Period 2002-2013. 3 Hour interval
80 x 80 km Global coverage
Calculate ZWD effects. (next slides)

Troposphere Wet Zenith Delay (Max value over 12 Year)



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NLR

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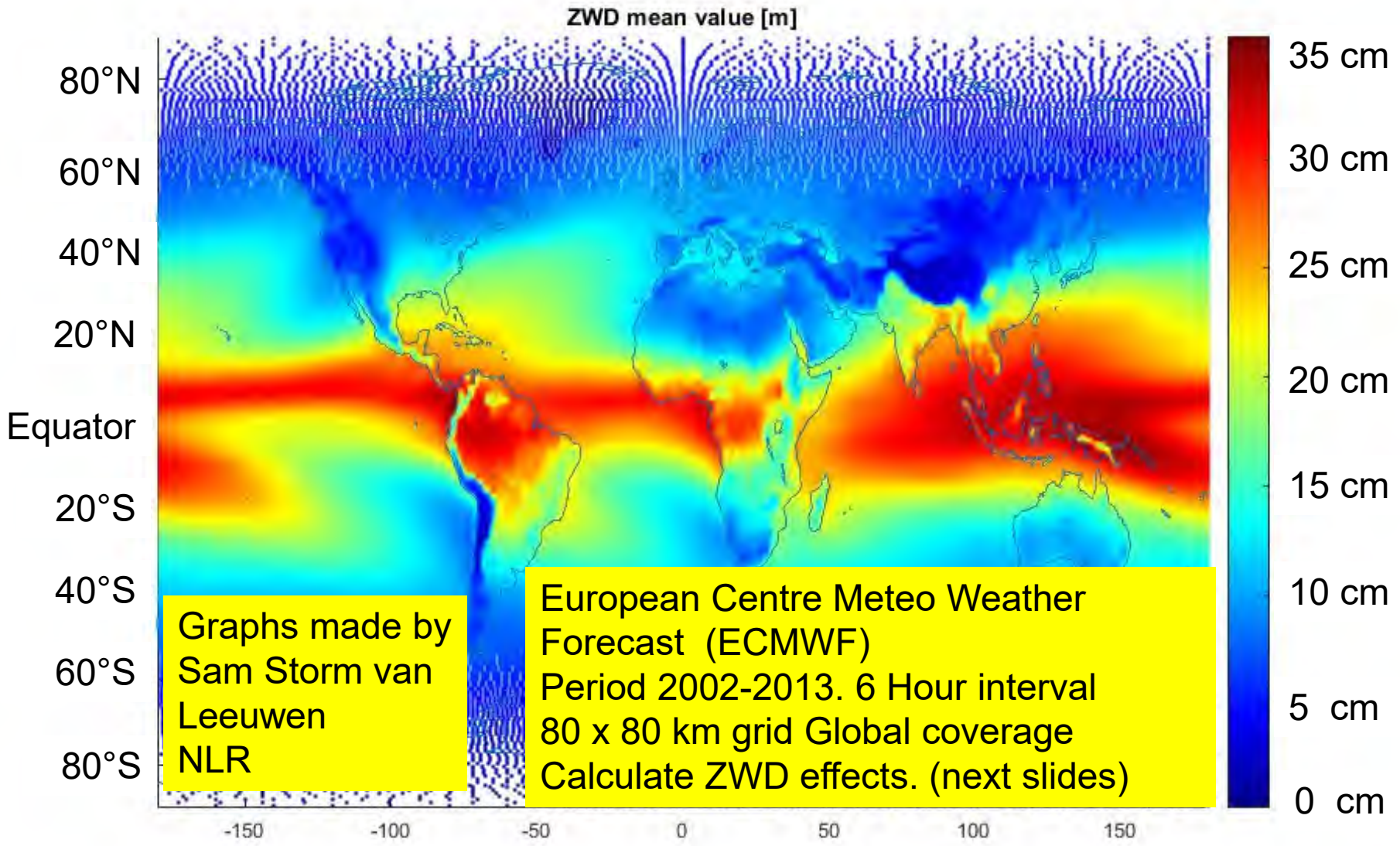
Troposphere: Wet Zenith delay: Average over 12 Year



PPP Can model and scale the Wet delay well