



Multi-GNSS activities at swisstopo – EGVAP Report 2019

wissen wohin
savoir où
sapere dove
knowing where

swisstopo

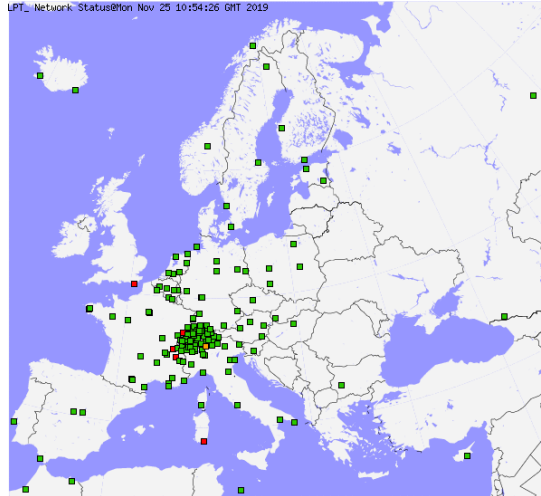
E. Brockmann, D. Ineichen, S. Lutz



Availability of solutions

http://pnac.swisstopo.admin.ch/restxt/cost_data_statistic.txt

200 sites



42 sites



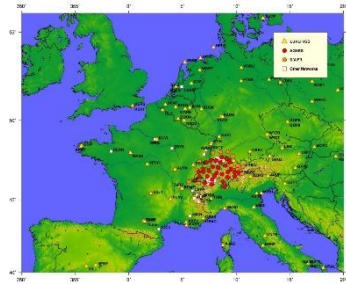
2019	Availability: LPT: 99.63 % LPTR: 96.98 %
2018	Availability: LPT: 99.49 % LPTR: 92.13 %
2017	Availability: LPT: 98.90 % LPTR: 94.91 %
2016	Availability: LPT: 99.04 % LPTR: 94.48 %
2015	Availability: LPT: 99.90 % LPTR: 99.40 %

Bernese
hourly

Trimble
real-realtime

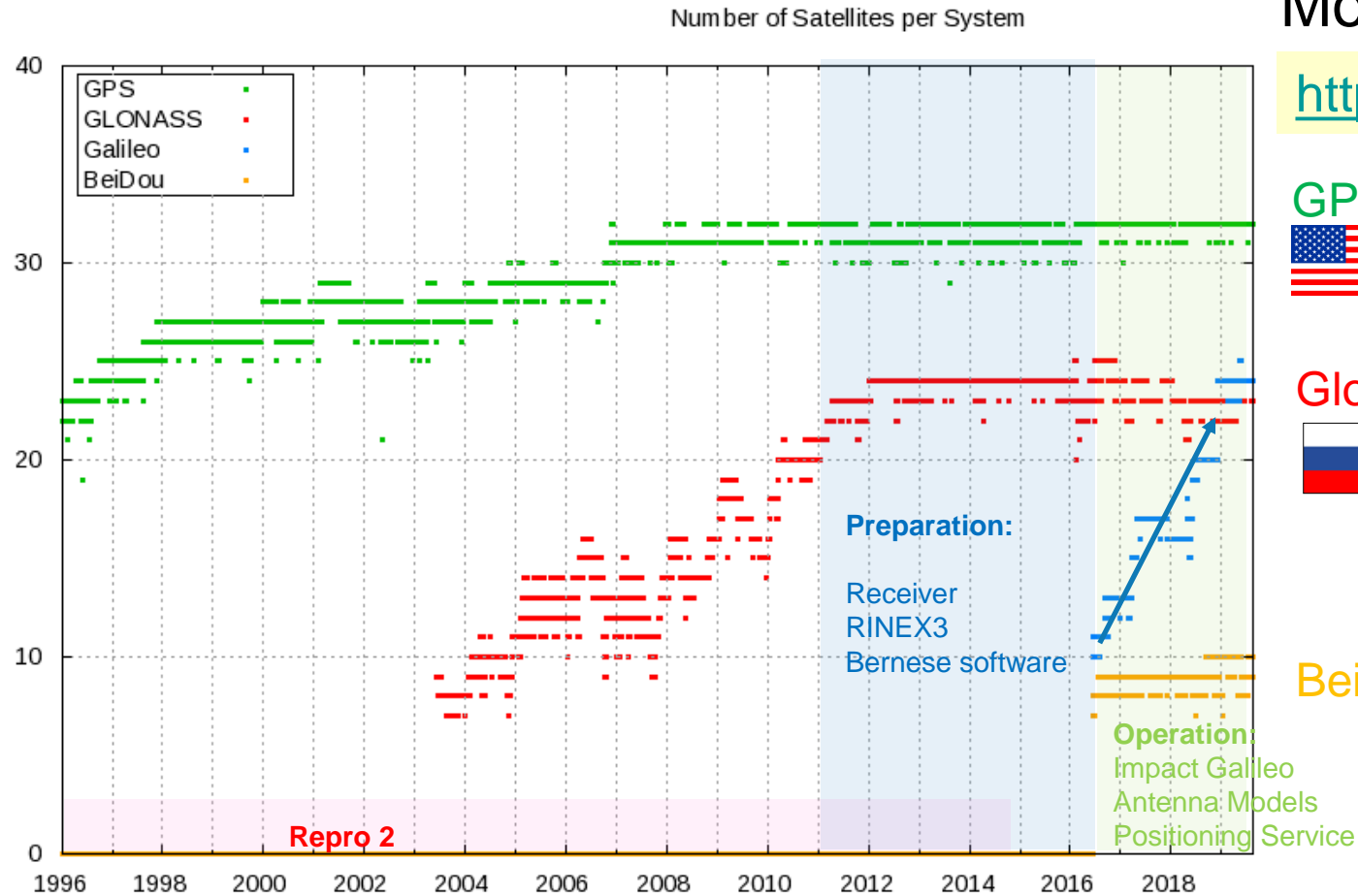


Evolution Multi-GNSS at swisstopo Permanent Analysis Center (PNAC)



Monitoring System:

<http://pnac.swisstopo.admin.ch>



GPS: 32



Glomass: 24



Galileo: 24



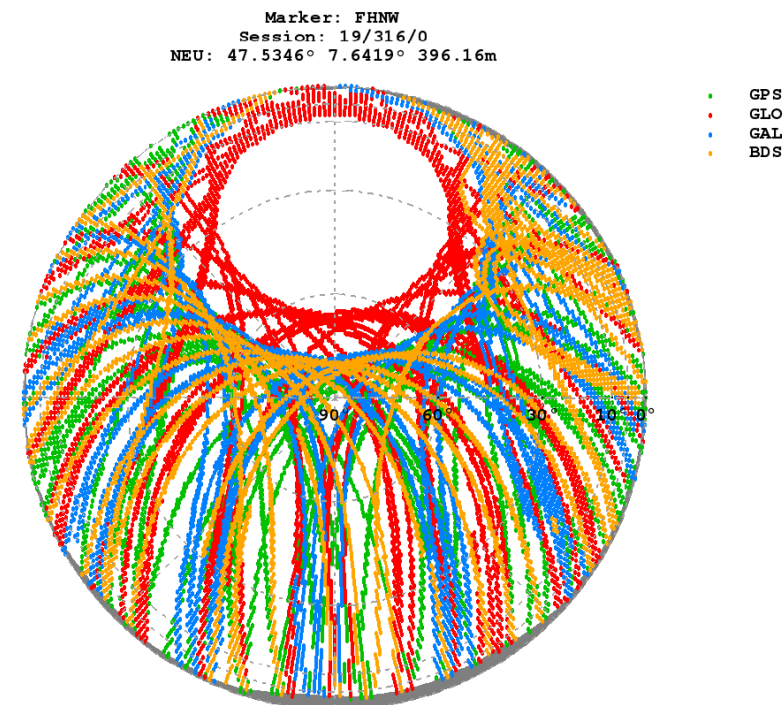
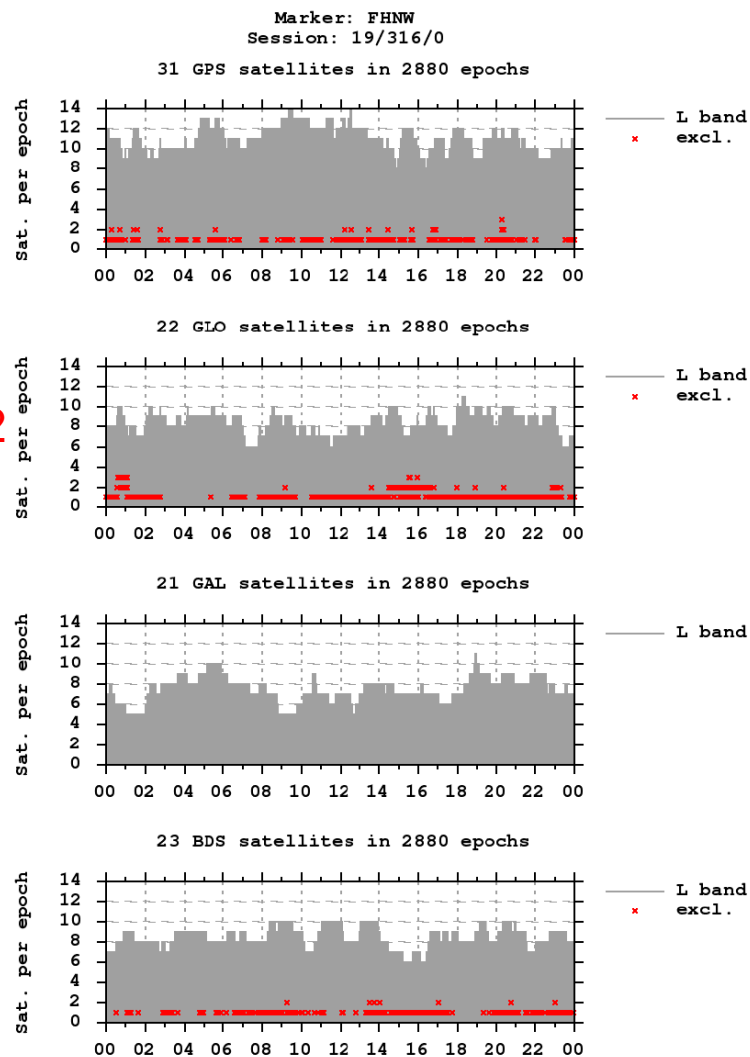
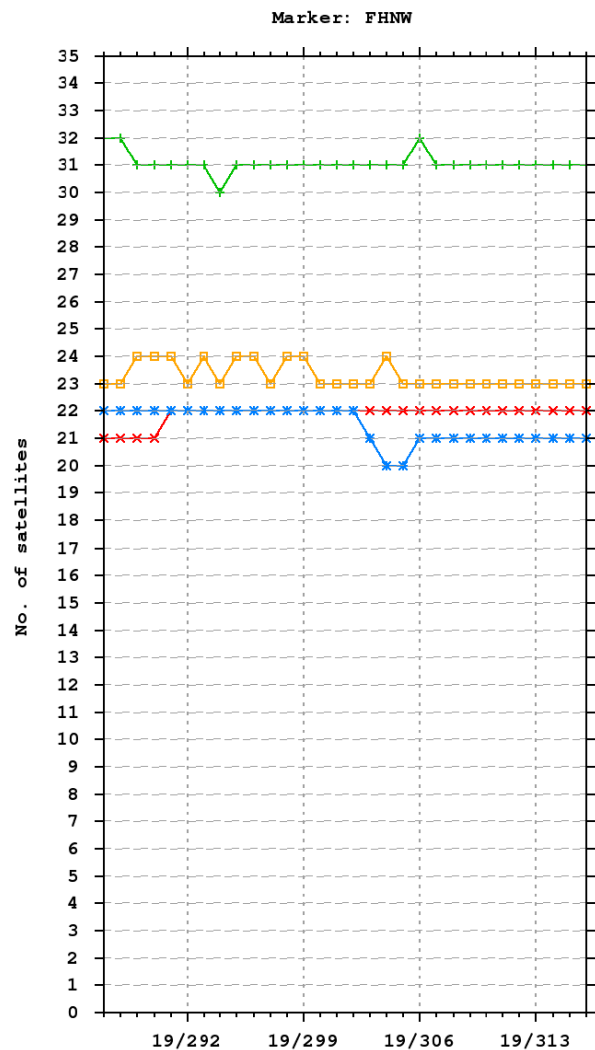
Beidou (BDS3 not yet): 10



http://pnac.swisstopo.admin.ch/pages/en/agnes_statistics.html#NUM_SAT_SYS



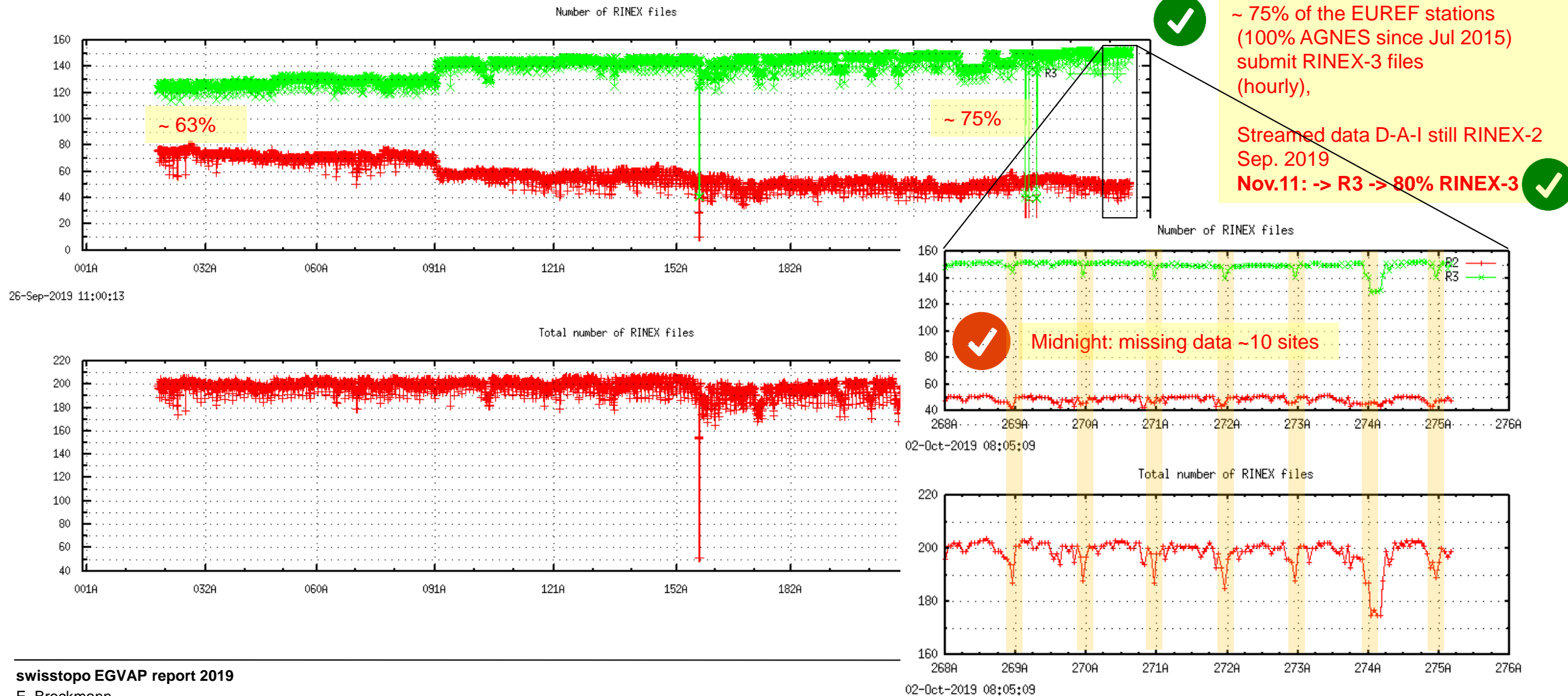
BeiDou: Nr. 2 ...





Number of RINEX-2 / RINEX-3 Files (2019 Jan-Sep)

Hourly statistics (~200 sites)





Improvements of hourly solutions

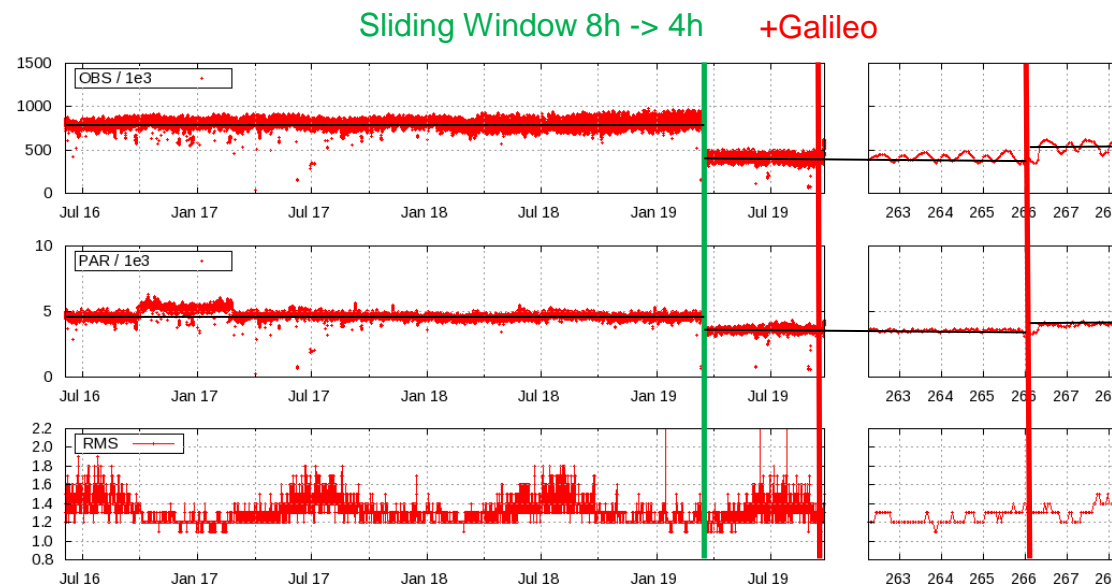
- Jan. 21, 2019: Multi-GNSS solution RTX (PPP based) instead VRS (G+R network mode)
- Jan. 23. 2019: gfortran compiler (instead Lahey)
- March 18-25, 2019: sliding window 8 -> 4 hours, Fastcount, 5 instead 4 cluster, ztd rel. weighting 1 mm -> 2 mm
- Sep. 23, 2019: Galileo inclusion;
- Nov. 11 RINEX-3 DACH sites;
- Nov. 19: IGS R3 antenna model used

~30% faster

~30% slower

(~7 minutes processing time)

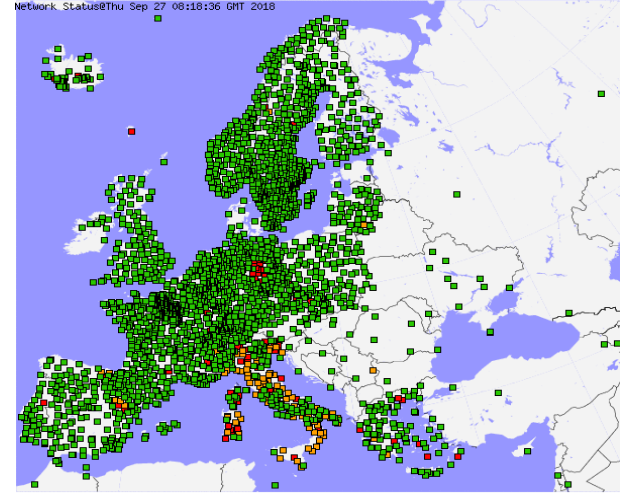
seasonal rms variations
(tropo variations in summer)





Benefit of real-time Multi-GNSS for GNSS-Meteorology

- Real real-time contribution to EUMETNET switched to Trimble from VRS3 (differential, GPS+GLO) to RTX (PPP, Multi-GNSS) 21.1.2019



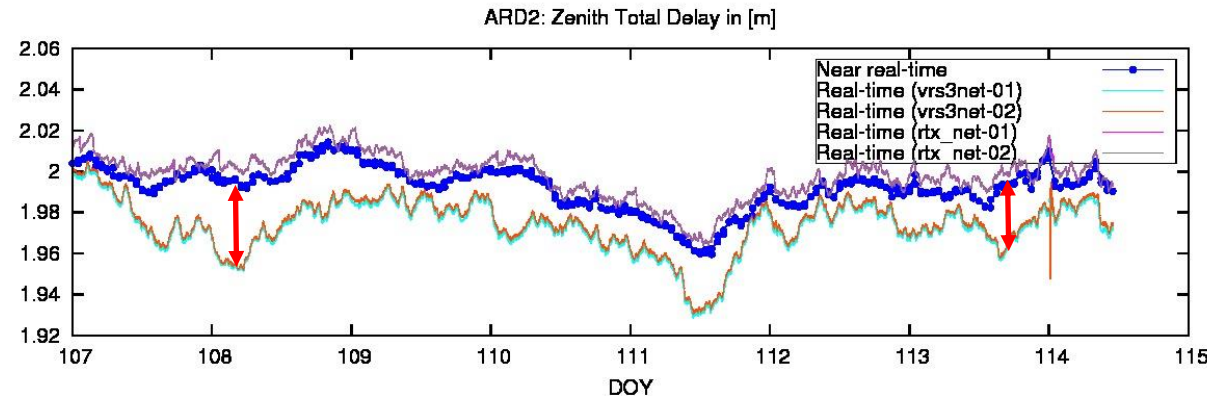
EUMETNET EGVAP

Analysis Centers: ~24

GNSS sites: >3500

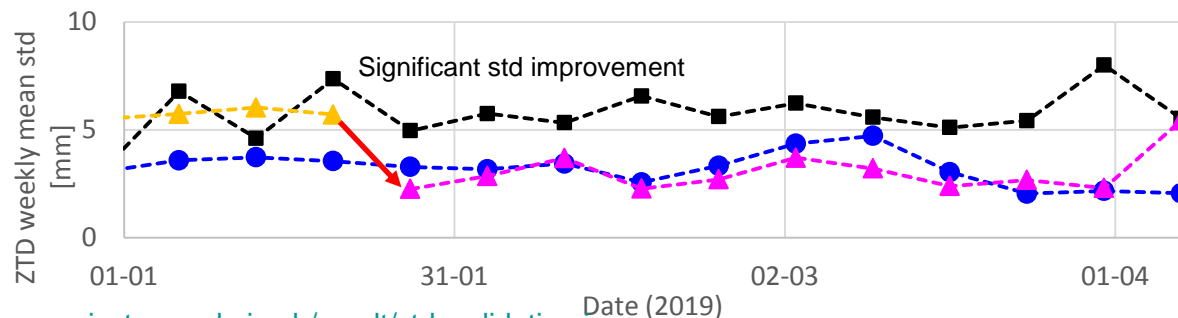
swisstopo: 2 contributions

- BSW NRT #200 (hourly)
- Real-time #42 (VRS, RTX)



24/04/2019 13:50

<http://pnac.swisstopo.admin.ch/pages/en/qsumard2.html#TROPO>



http://pnac.swisstopo.admin.ch/resplt/ztd_validation.jpg

RTX (GREG)

BSW NRT (GR)

VRS (GR)

Much better agreement
with
BSW-NRT (GR) and
BSW-PP (GREG)

NRT - PP

RS - PP

RR - PP

RX - PP

Standard deviation
(Reference: Postprocessing PP)

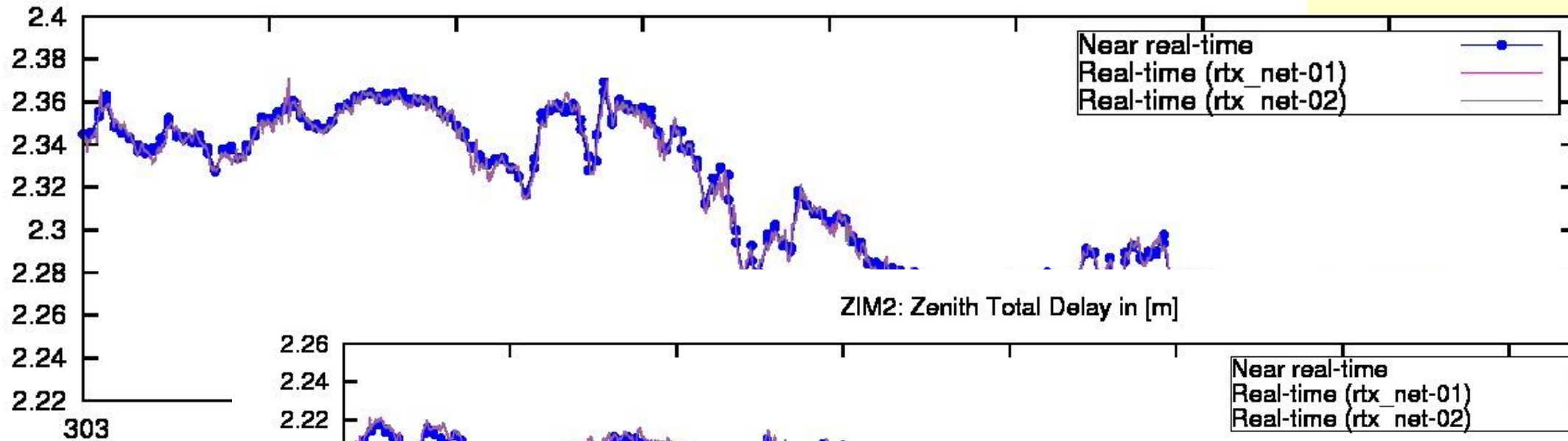


VRS real real-time STOP: 06.11.2019

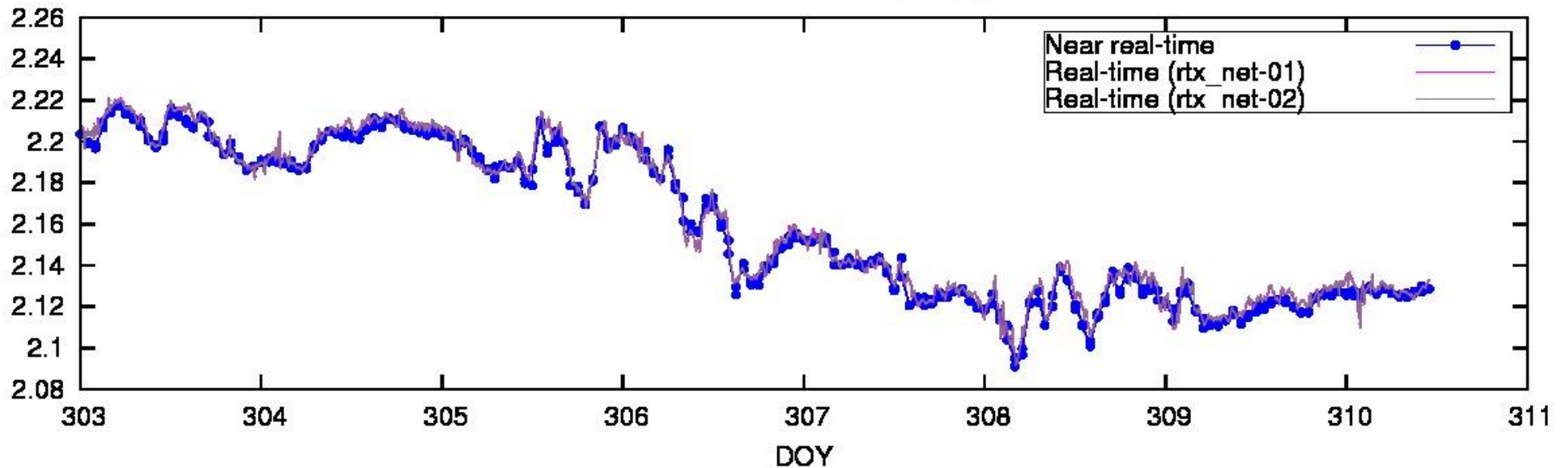


Incredibly good agreement
of **Bernese** - **RTX**

AI GE: Zenith Total Delay in [m]



ZIM2: Zenith Total Delay in [m]

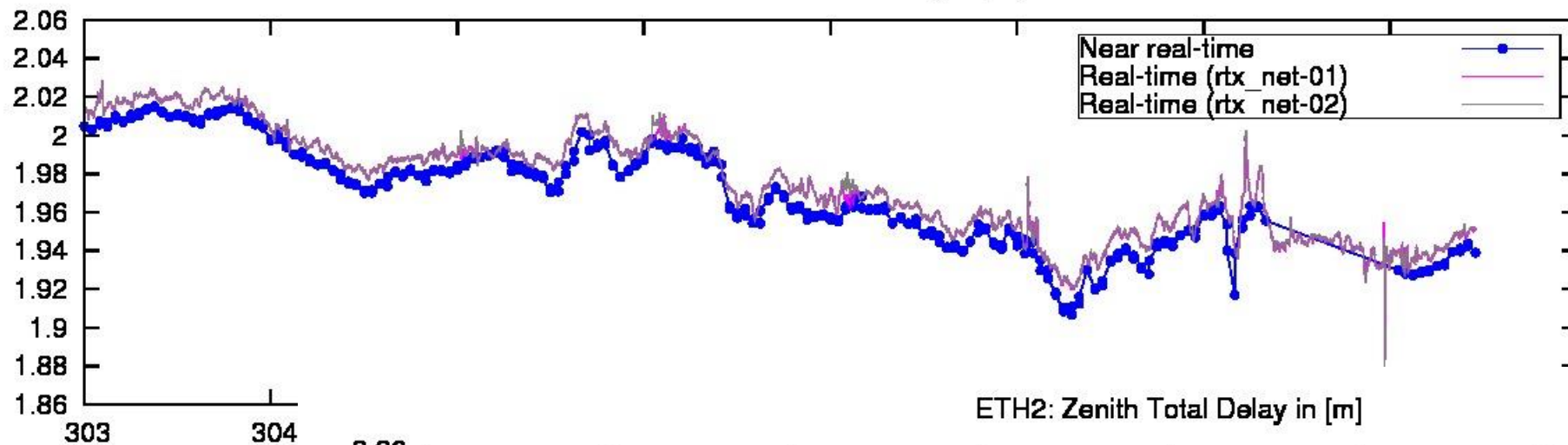


06/11/2019 13:56



Cont.

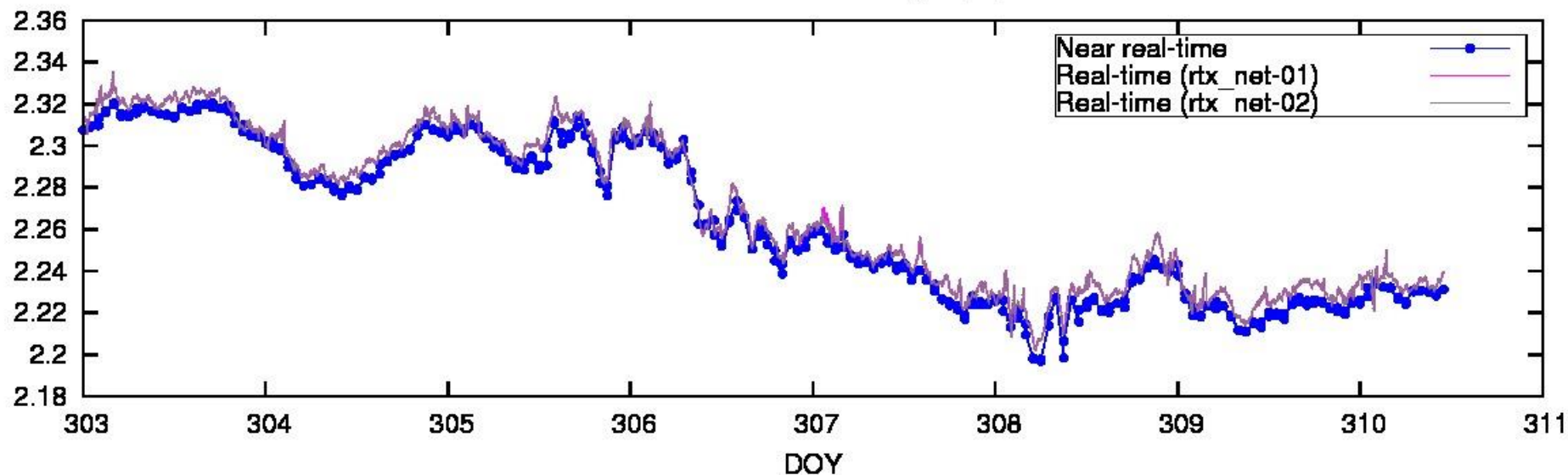
DAV2: Zenith Total Delay in [m]



DAV2: snow

ETH2: Zenith Total Delay in [m]

ETH2



06/11/2019 12:57

06/11/2019 12:57

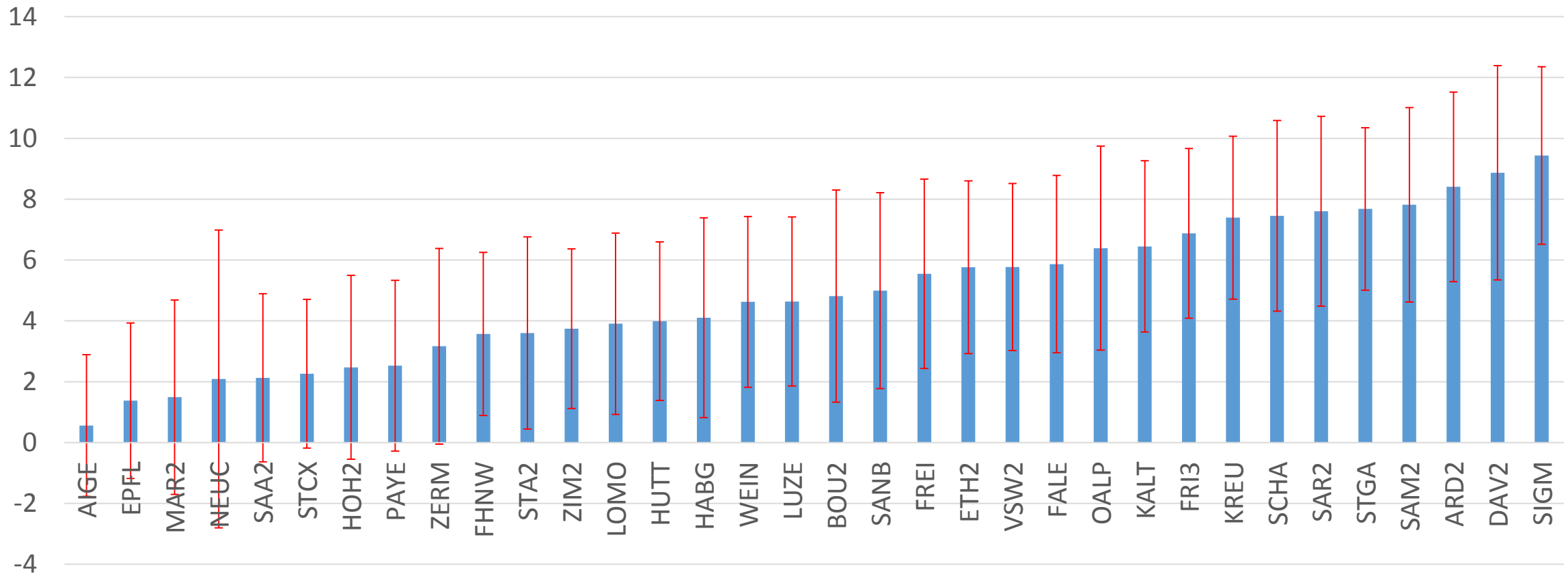
good agreement of
Bernese - RTX



BSW-RTX Bias (week 2070)

Bigger in East Switzerland ... (?)

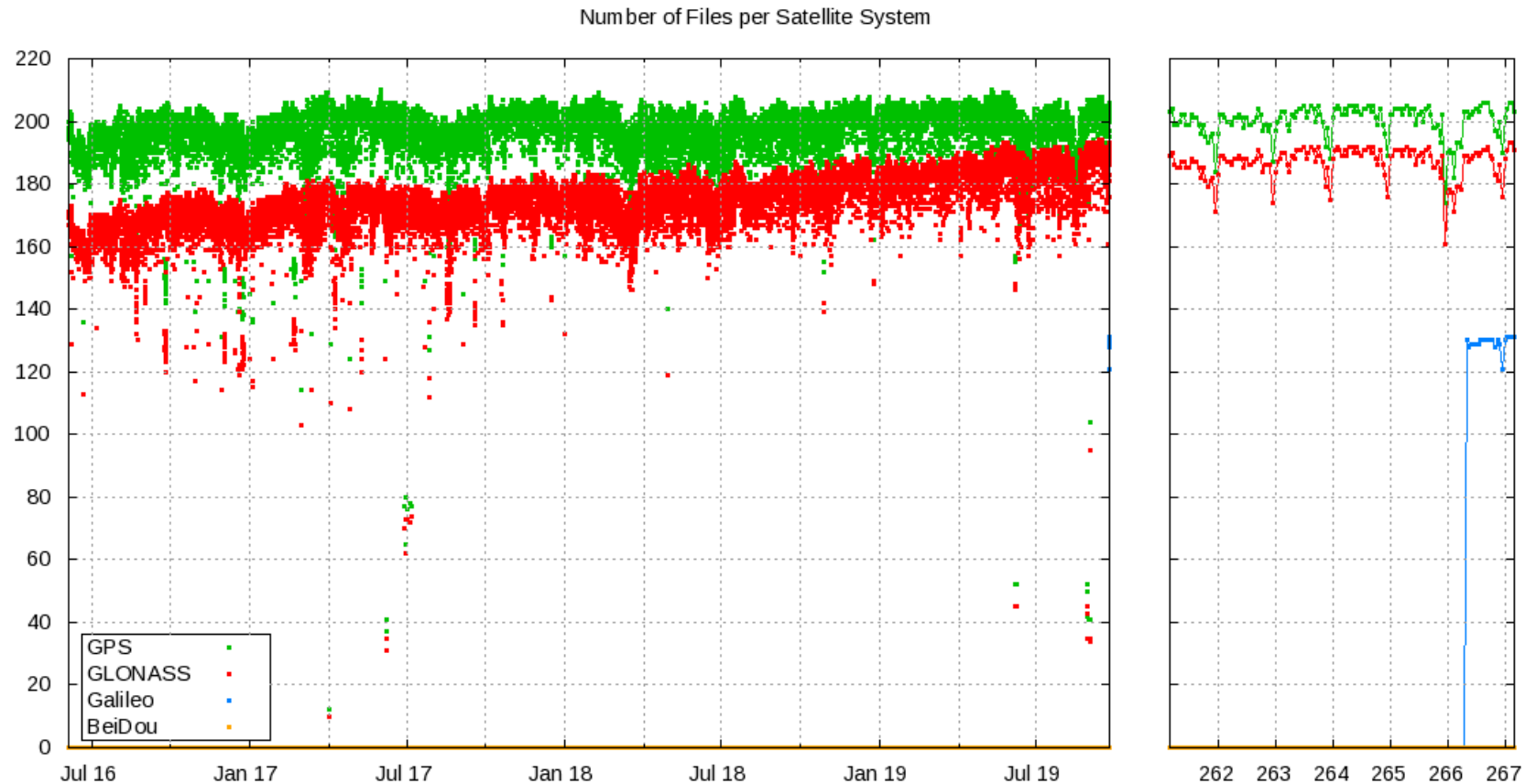
Tropo Bias BSW-RTX Week 2070 [mm]





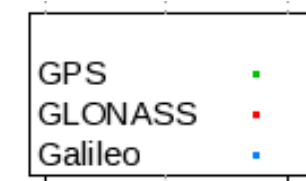
Galileo in Rapid and Ultra-Rapid products

CODE products including Galileo since 23.9.2019 (Tag 266)





Ambiguity resolution (hourly)



WL

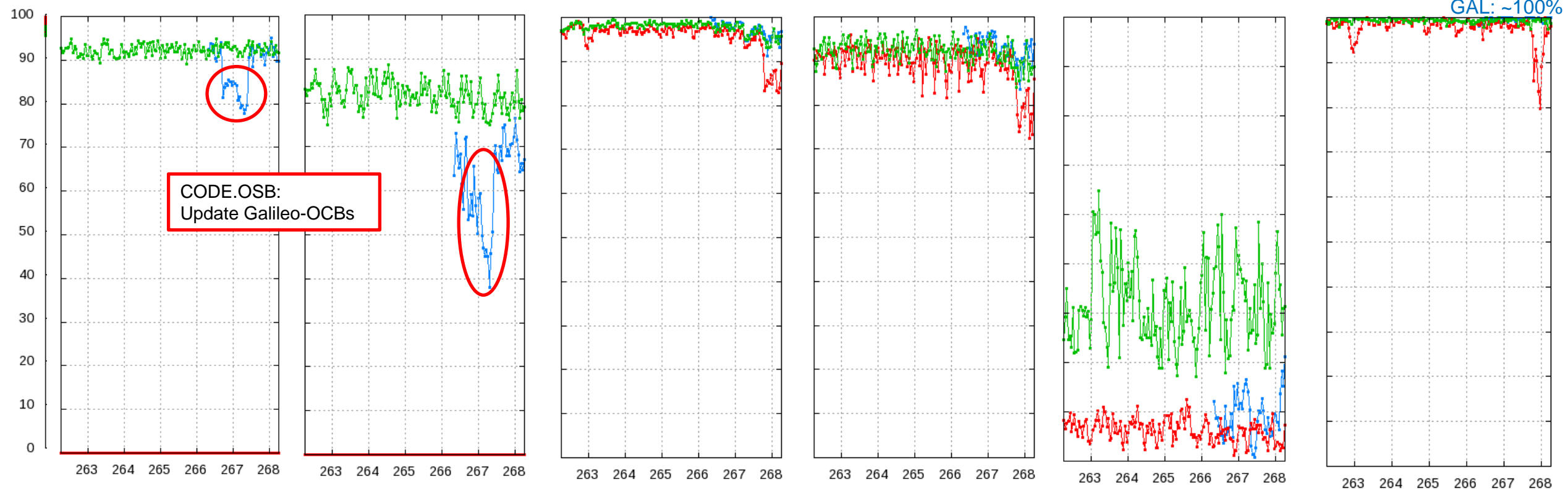
NL

L5

L3

QIF

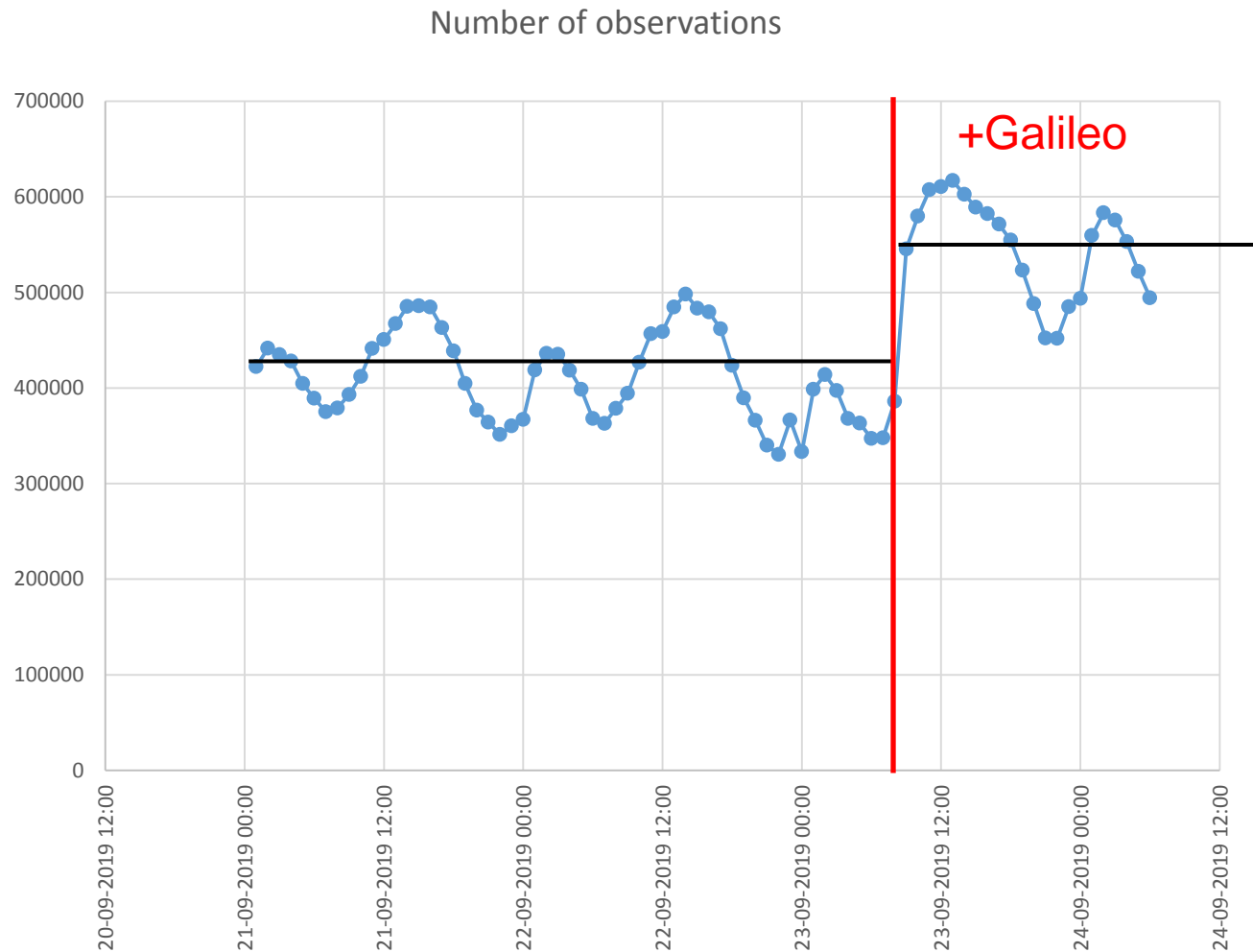
L1/L2



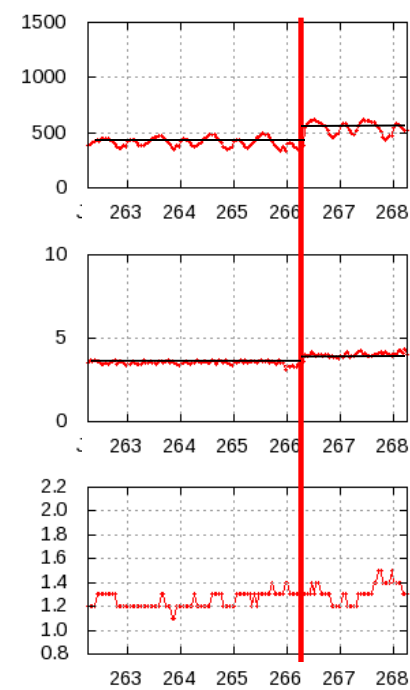
http://pnac.swisstopo.admin.ch/pages/en/amet_statistics.html#AMB_XY



Impact: # of observations



~ 25-33 % more
observations in adjustment
(4 hour data)



#OBS/1e3

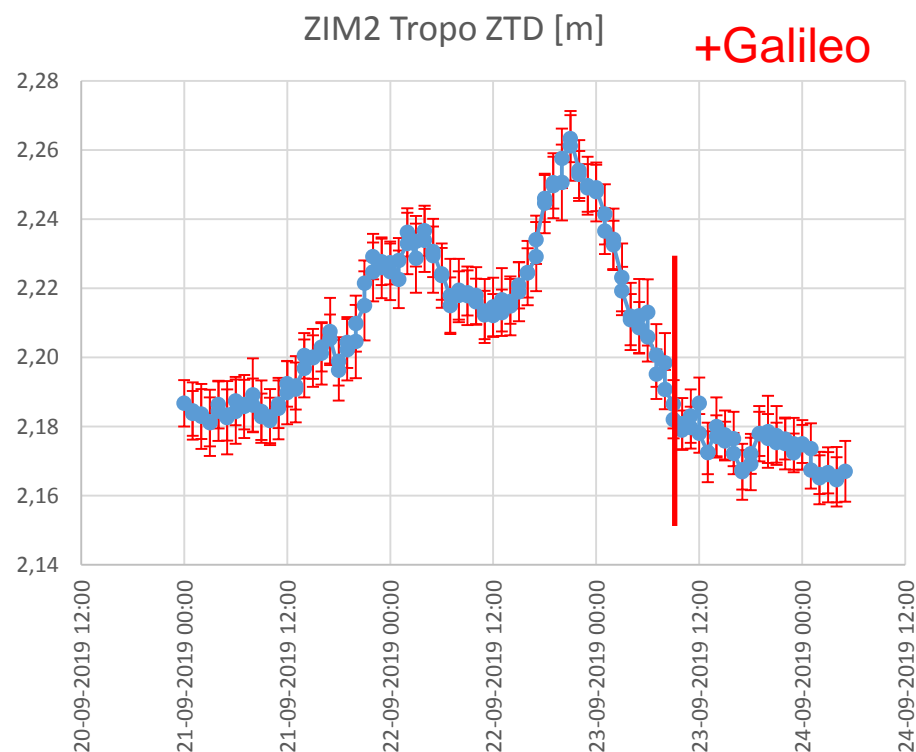
#PAR/1e3

RMS [mm]

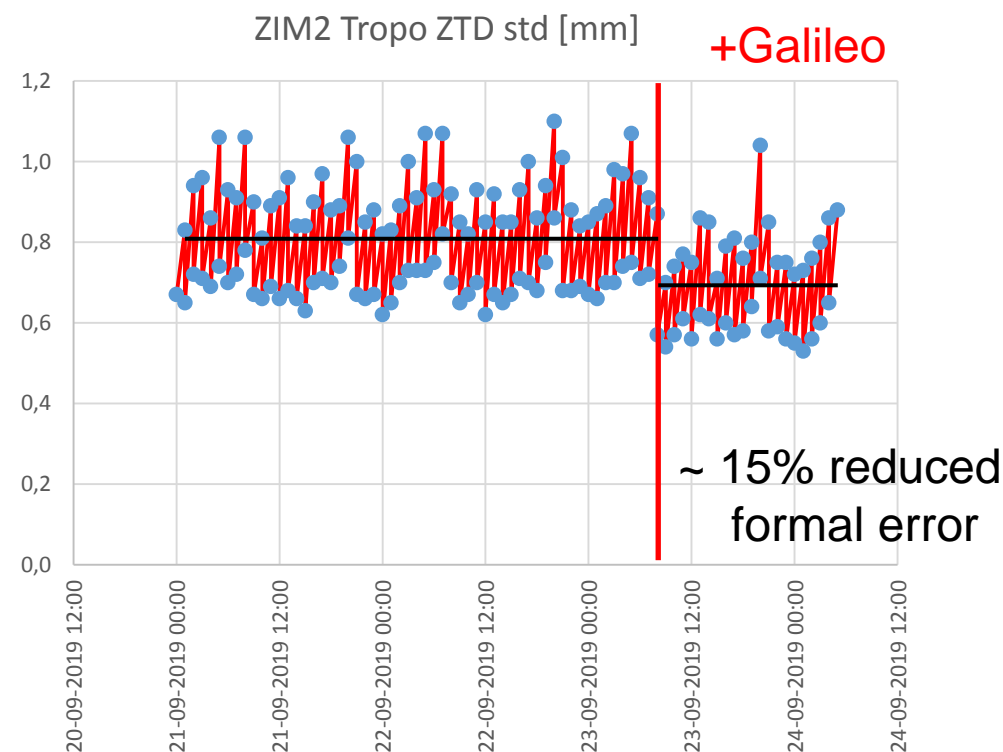


Troposphereparameter: ZIM2

Impact ZTD (+ std as error bar)

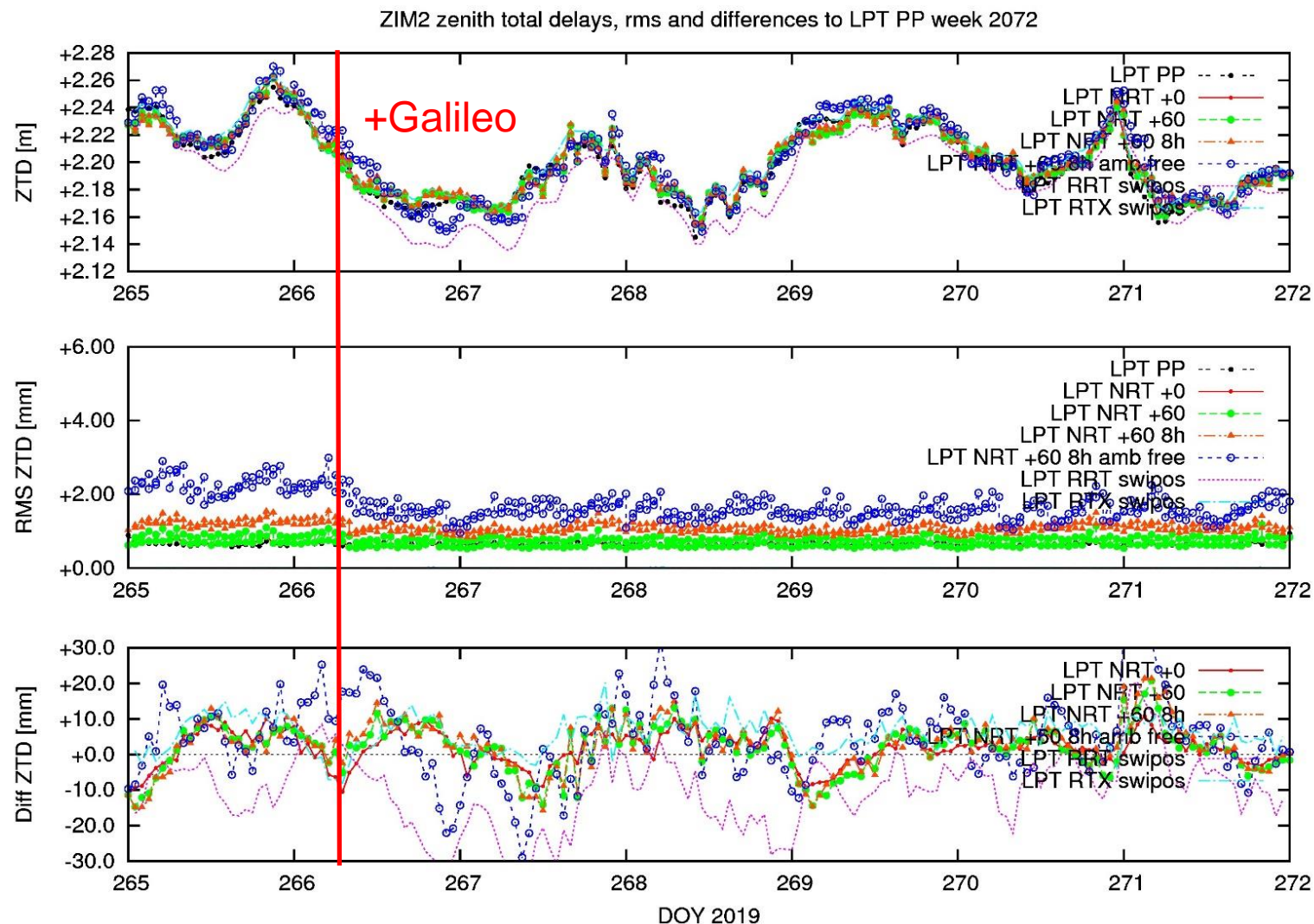


Impact standard deviation (formal error)





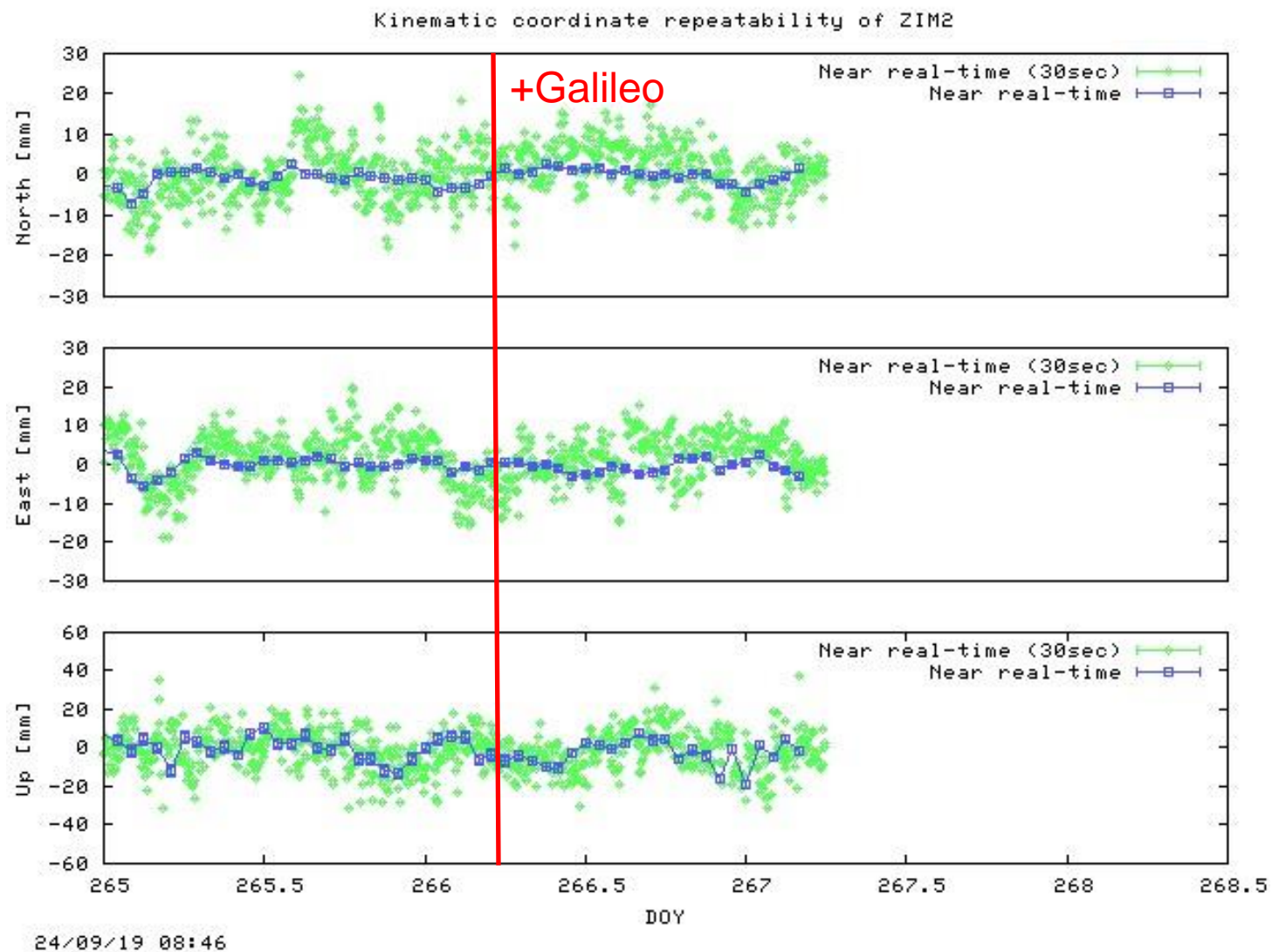
ZIM2 - Tropo validation with Post-processing



No big impact due to addition Galileo observations



Impact coordinates

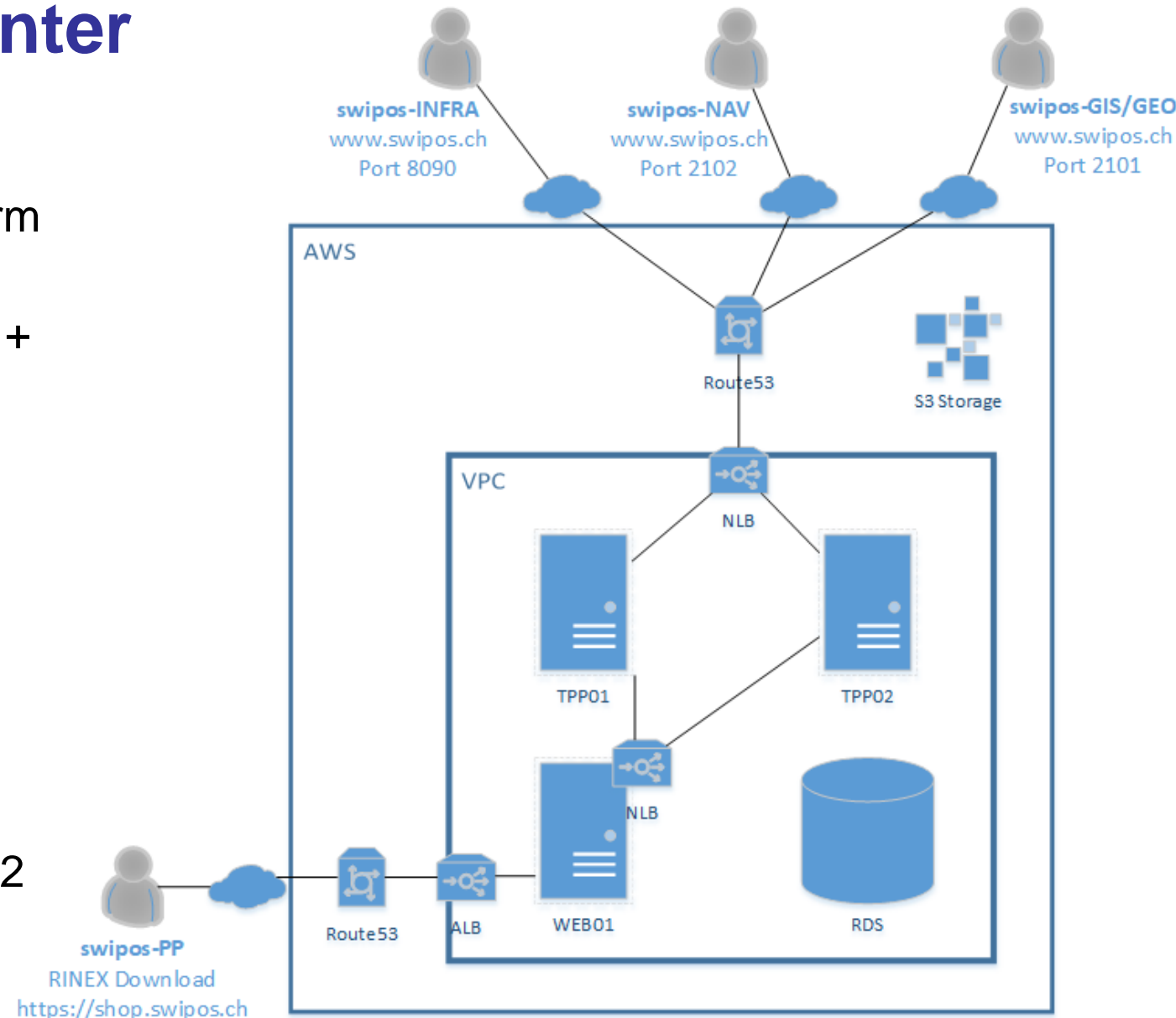


No «jumps» visible
(Galileo PCVs from GPS)



New operational center

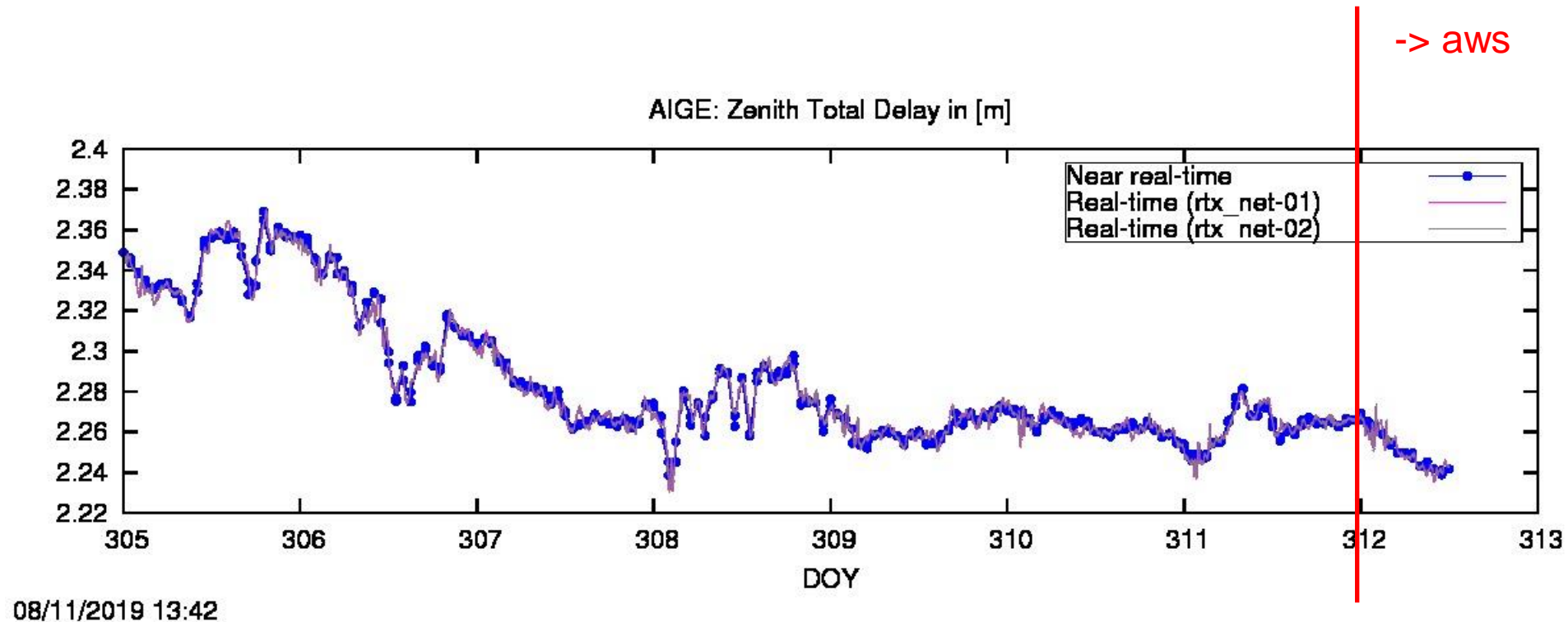
- Design principles
 - Infrastructure as code in git -> terraform & packer; generates OS image
 - Redundance: identical setup TPP01 + TPP02 (only Mac address and hostname)
- Amazon web service aws (Frankfurt)
- TPP 4.1.3. (production+ test)
- Mountpoints for data exchange D-A-F-I ready
- Rinex-3 data flow supported
- Communication station – operational center as well as swipos-INFRA: NTRIP2
- **Go-Live: 20.11.2019**





Switch from old to new real-time infrastructure: 8.11.2019 (begasoft -> aws)

- No impact visible (same RTX version)





Reference for Multi-GNSS observations

- one MIX coordinate (+TRP): N,E,U,T

4



or

- per satellite system one coordinate (+TRP):

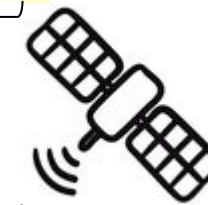
N,E,U,T | N,E,U,T | N,E,U,T | N,E,U,T

4x4



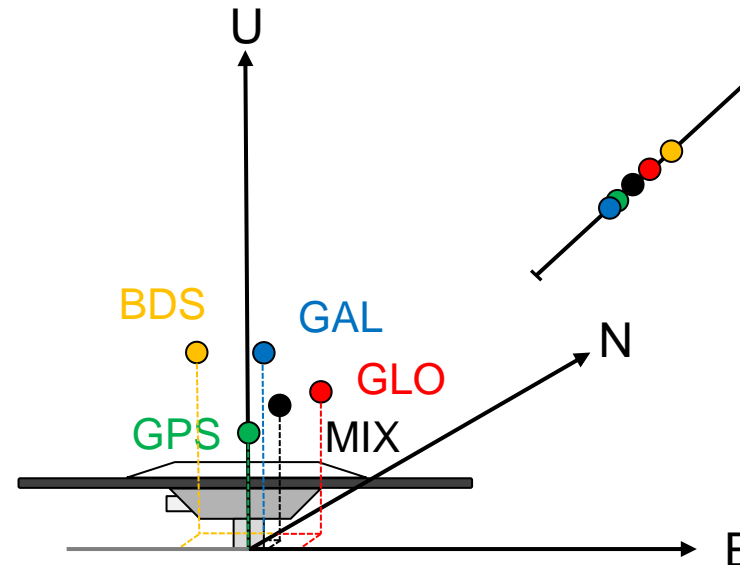
Reference dN,dE,dU,dT | dN,dE,dU,dT | dN,dE,dU,dT

12 ISTPs



T (Tropo)

ISTPs:
„Inter System
Translation Parameter“



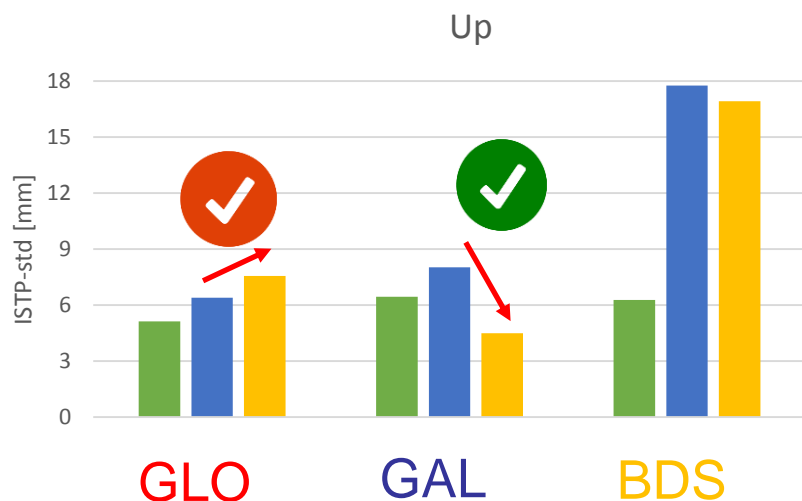
No antenna
calibrations
available for
GAL, BDS



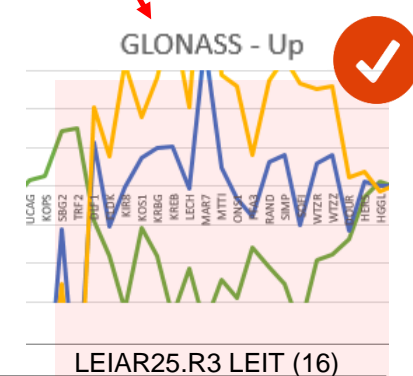
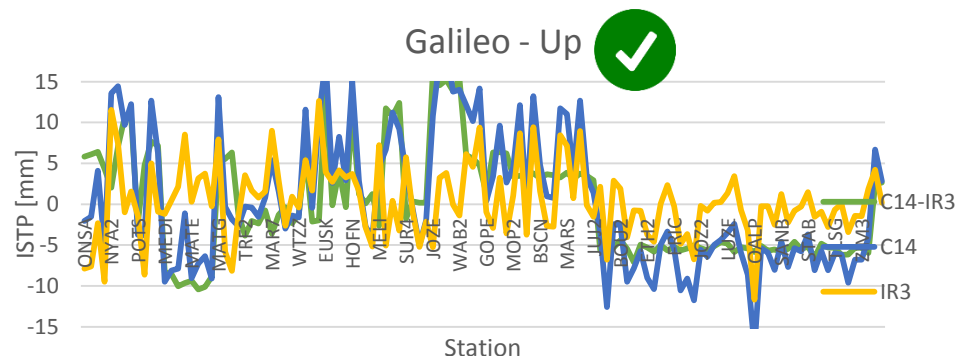
Galileo robot calibrations from Geo++

EUREF
Multi-GNSS
WG chair

- New Galileo+BeiDou antenna calibration values of Geo++ for IGS repro3 (IR3, June 2019)
- Impact study using 1 day of data (200 stations in Europe)
 - ✓ - Difference GPS-Galileo smaller with IR3 compared to C14 (I14)
 - ✓ - BeiDou values better than chamber values (vertically)
 - ✓ - LEIAR25.R3 LEIT – GLONASS values worse (IR3 10-15 mm, C14 not significant)



Not a GLO problem, but GPS+GAL

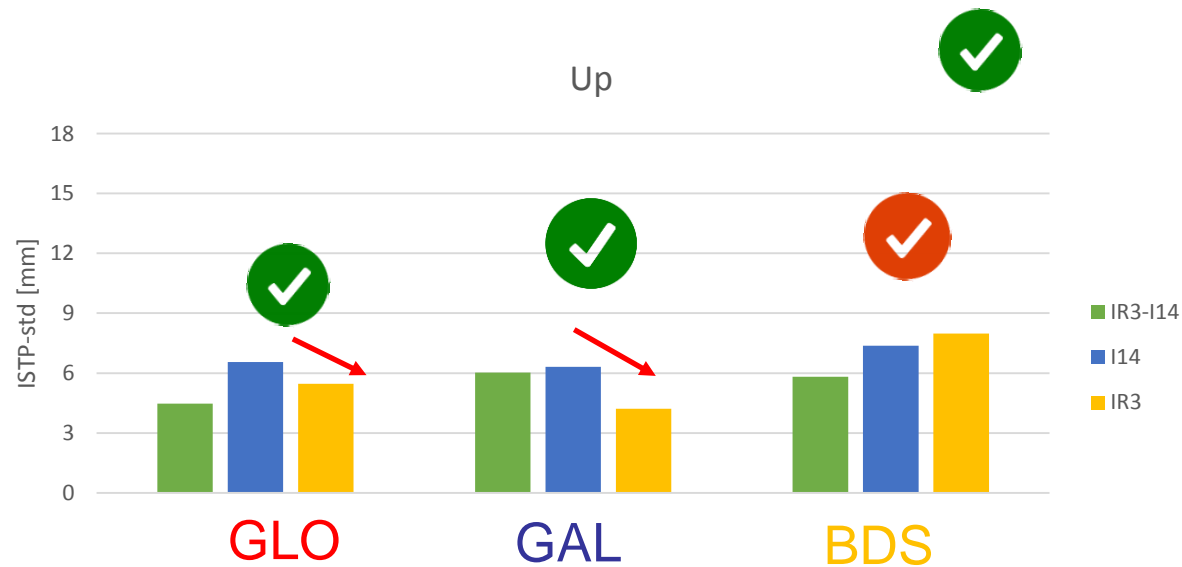




Galileo robot calibrations from Geo++ - Updated LEIAR25.R3 LEIT (13.9.2019)

EUREF
Multi-GNSS
WG chair

- Check based on a EU data set (no Swiss stations)
- E14 instead C14 PCV
- better agreement between GPS to GAL and to GLO
- BSD slightly worse; adopted values from GPS seem to work also



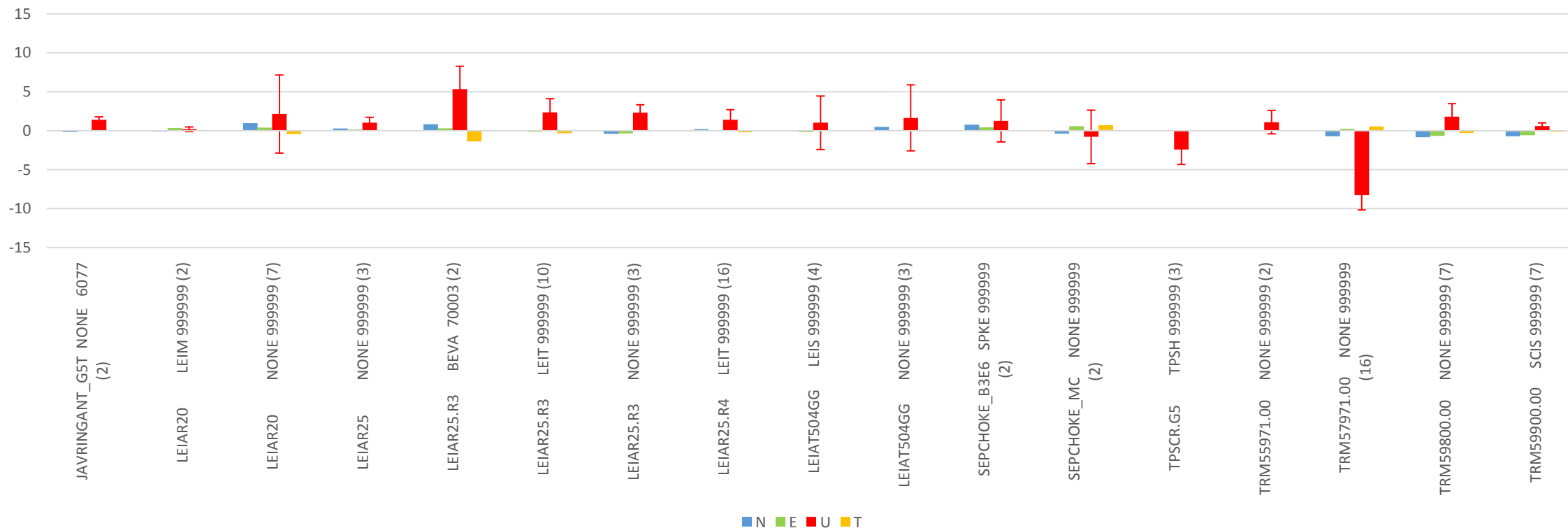
Nov. 19: IGS R3 antenna model used for hourly LPT_ processing



Impact GLONASS by antenna type

EUREF
Multi-GNSS
WG chair

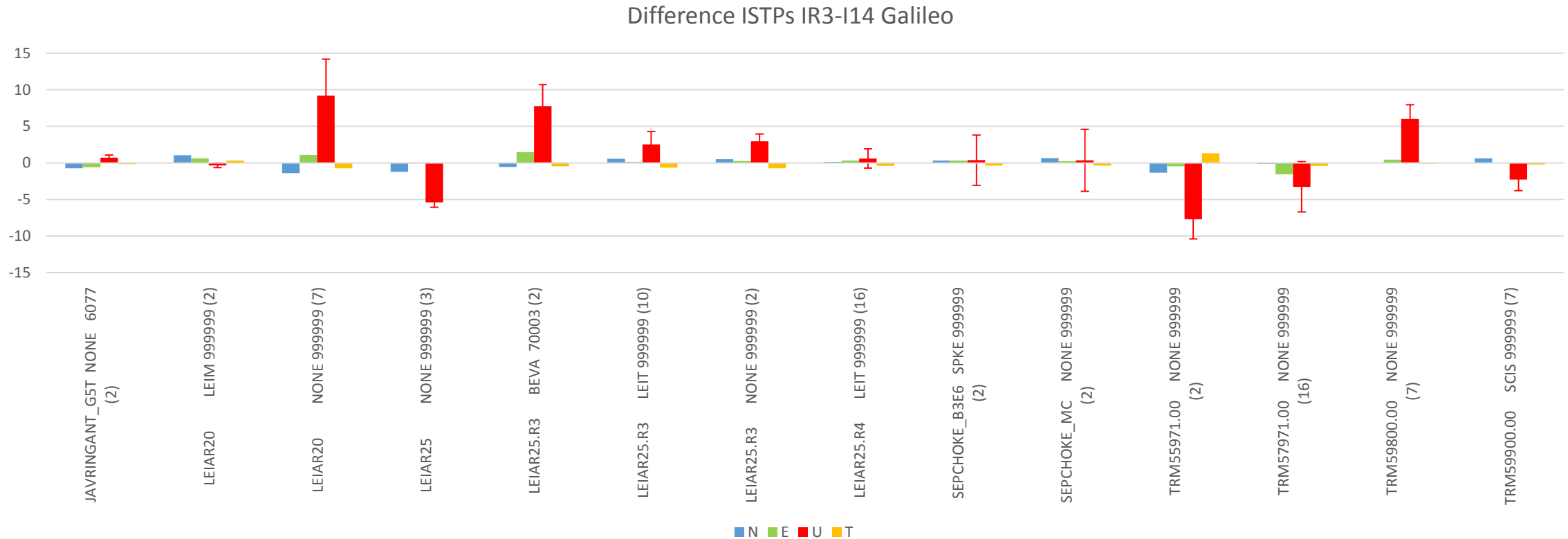
Difference ISTPs IR3-I14 GLONASS





Impact Galileo by antenna type

EUREF
Multi-GNSS
WG chair



Individual Galileo
PCVs not yet available
from Geo++



Overall impact GREC / Antenna model

EUREF
Multi-GNSS
WG chair

Used in LPT_ since Nov. 19. 2019

121 sites 1 week

	Helmert	rms [mm]
Impact GPS - GREC	hor	ver
IR3_Update	0.458	1.479
I14	0.532	1.994
E14	0.506	1.855



Up: IR3 GREC best agreement to GPS

Impact of GREC about same order of magnitude as impact of PCV change

	Helmert	rms [mm]
Impact antennamodel GREC	hor	ver
IR3_Update-I14	0.584	1.028
E14-I14	1.112	2.826



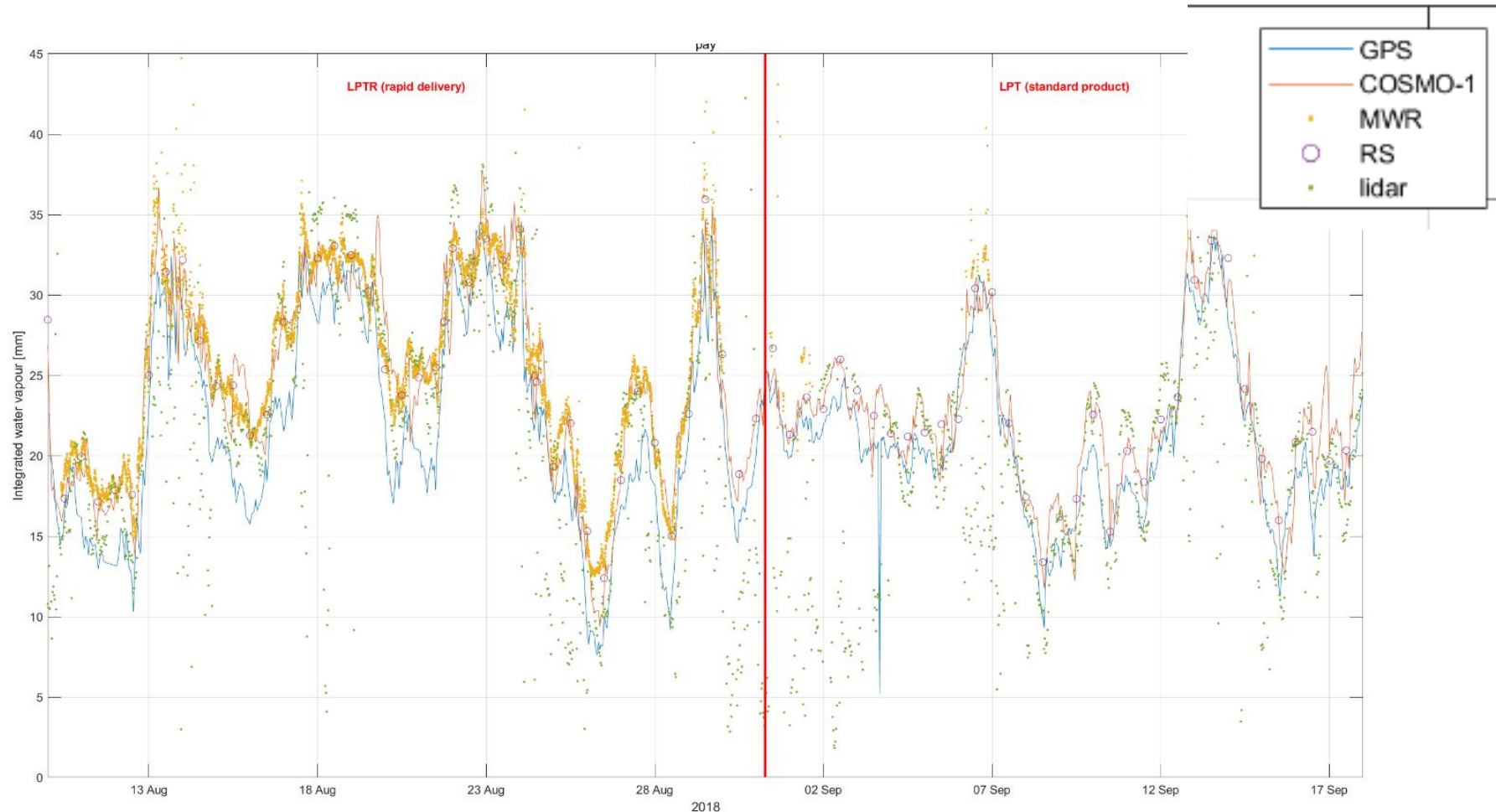
IGS antenna models
I14/IR3 closer than
EUREF antenna models



MeteoSwiss comparisons in PAYE

Courtesy: MeteoSwiss

- Data base error (usage if LPTR instead LPT_)
- Different results compared to rs_delay.f program





PAYE in GRUAN reference network

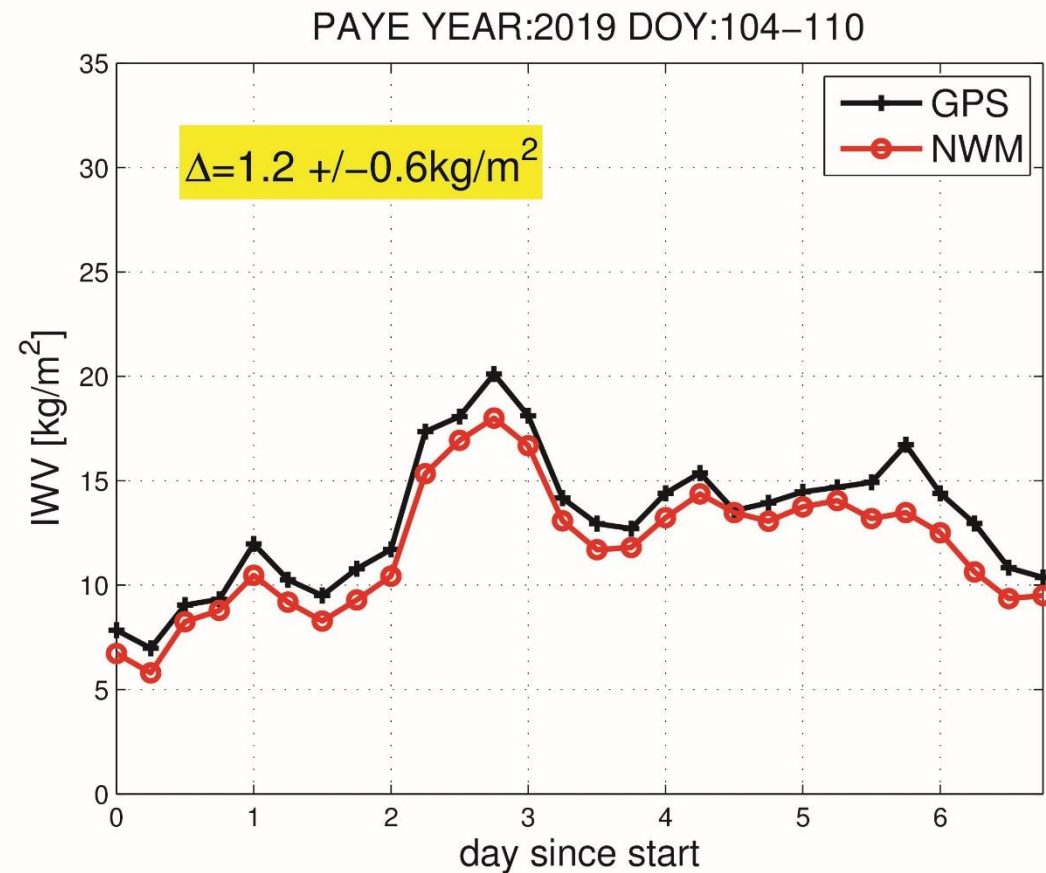
Courtesy:
Galina Dick, GFZ

GCOS Reference Upper-Air Network

The climate reference network



since 2018 also with
GNSS data support





Conclusion

- Very reliable product generation
- Lot of improvements of the hourly products
 - Faster processing
 - Galileo included
 - New antenna IR3 used
- Open points:
 - PAYE only Rinex-3 available
 - Radio sonde data (PAYE format, high resolution)
 - Real-realtime submission COST / interface BUFR -> to be started?