Problematic CORS HW/monumentation detection

(Experience based on SKPOS CORS)

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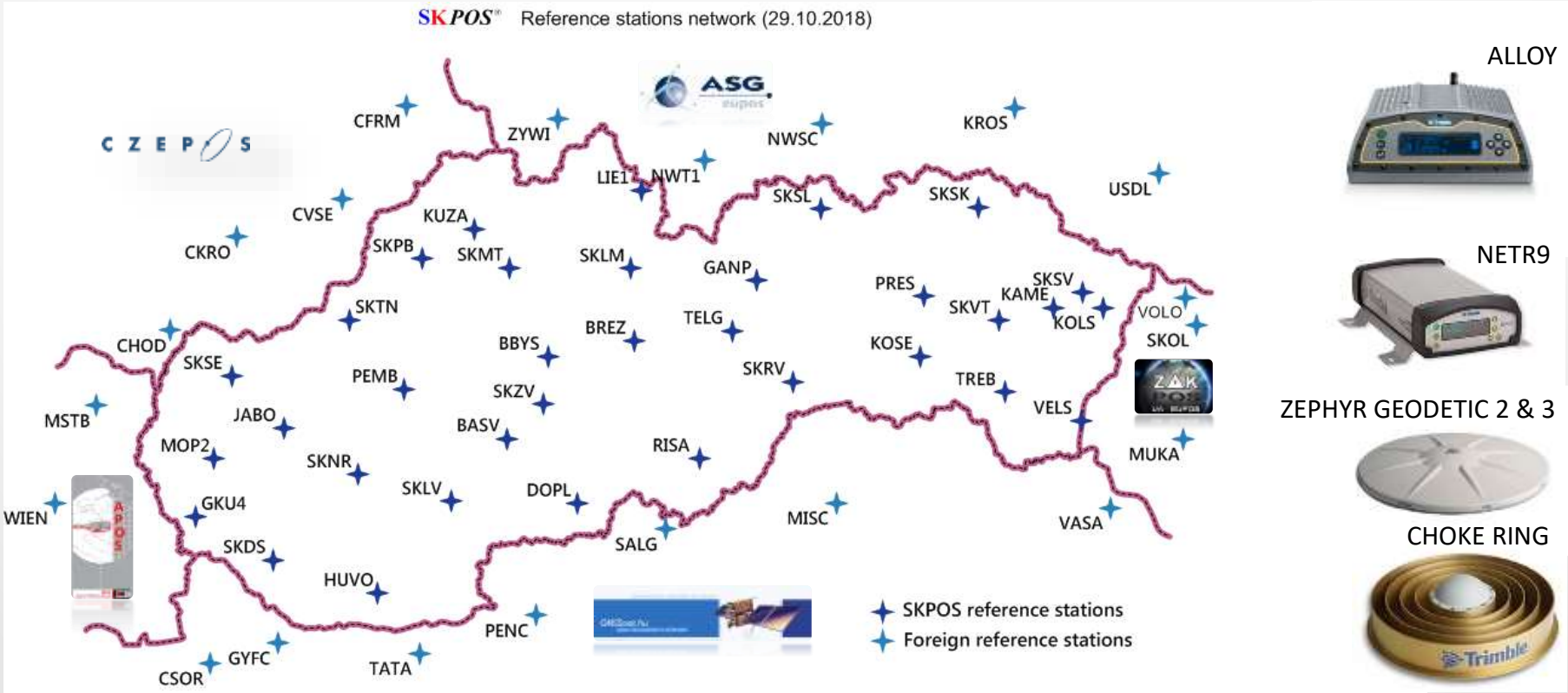
- SKPOS
- SKPOS Quality Control Management
- Computation of reference coordinates
- Problems detected in Time Series
- HW problems at SKPOS stations
- Analysis

SKPOS – real time determination system

- **34 Slovak permanent stations (19 individually calibrated)**
  - All stations equipped with TRIMBLE receivers and antennas
  - All stations observe GPS+GLONASS+Galileo+Beidou signals
- **21 foreign permanent stations (APOS, gnssnet.hu, CZEPOS, ASG-EUPOS, ZAKPOS)**



ALLOY

NETR9

ZEPHYR GEODETIC 2 & 3

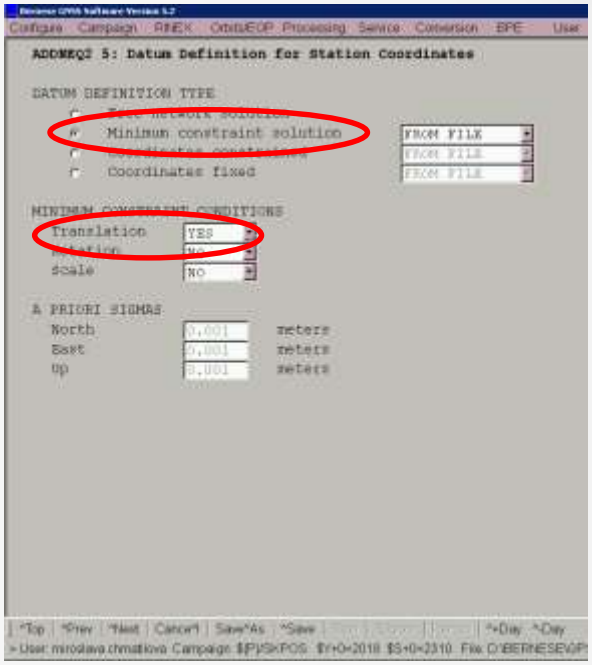
CHOKE RING

SKPOS Quality Control Management

- Permanent monitoring and analysis of:
  - network integrity and its components
  - network solution quality
  - RINEX data quality
  - Time Series

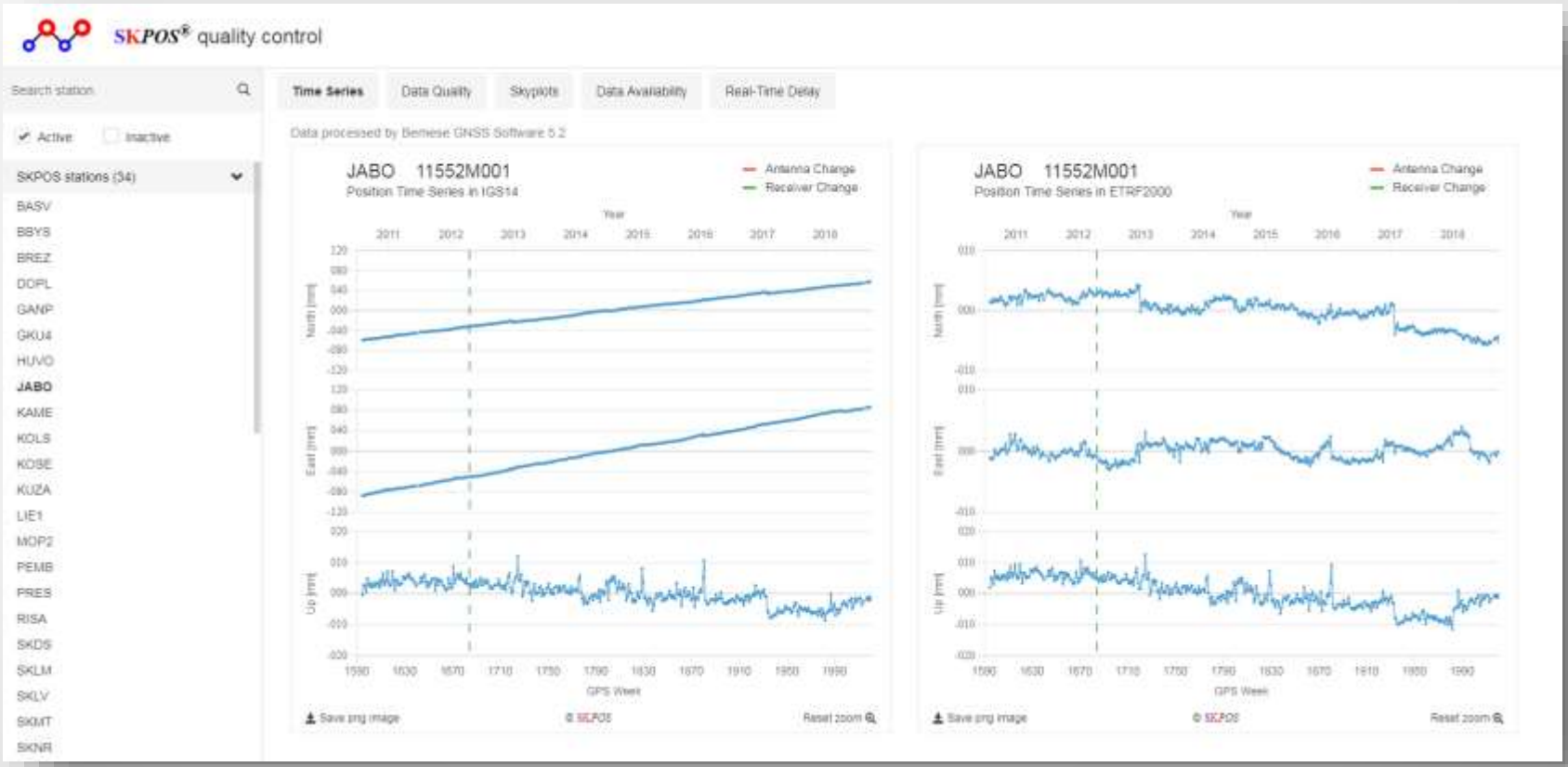
Computation of reference coordinates

- Bernese GNSS Software 5.2
- Routine processing for each day
  - ✓ IGS14 reference frame
  - ✓ Absolute antenna phase center models
  - ✓ IGS precise ephemeris
  - ✓ GPS+GLONASS
- Adjustment
  - ✓ Minimum constraint condition – no net translation to selected EPN stations
- Daily solutions combined into weekly (SINEX)
  - ✓ XYZ coordinates in IGS14
- Time Series of weekly solutions
  - ✓ IGS14, ETRF2000



SKPOS stations Time Series monitoring

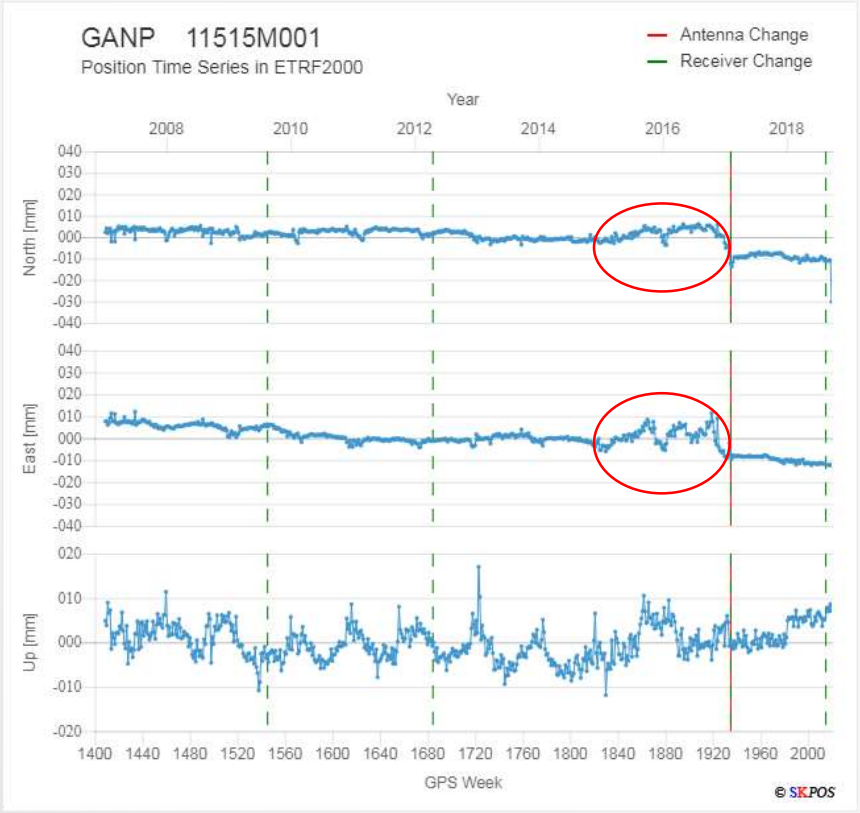
- New SKPOS application (SKPOS Quality Control)
- „RAW“ Time Series visualization



SKPOS stations Time Series monitoring Detected problems

- GANP station

since March 2015 increasing residuals in N, E components



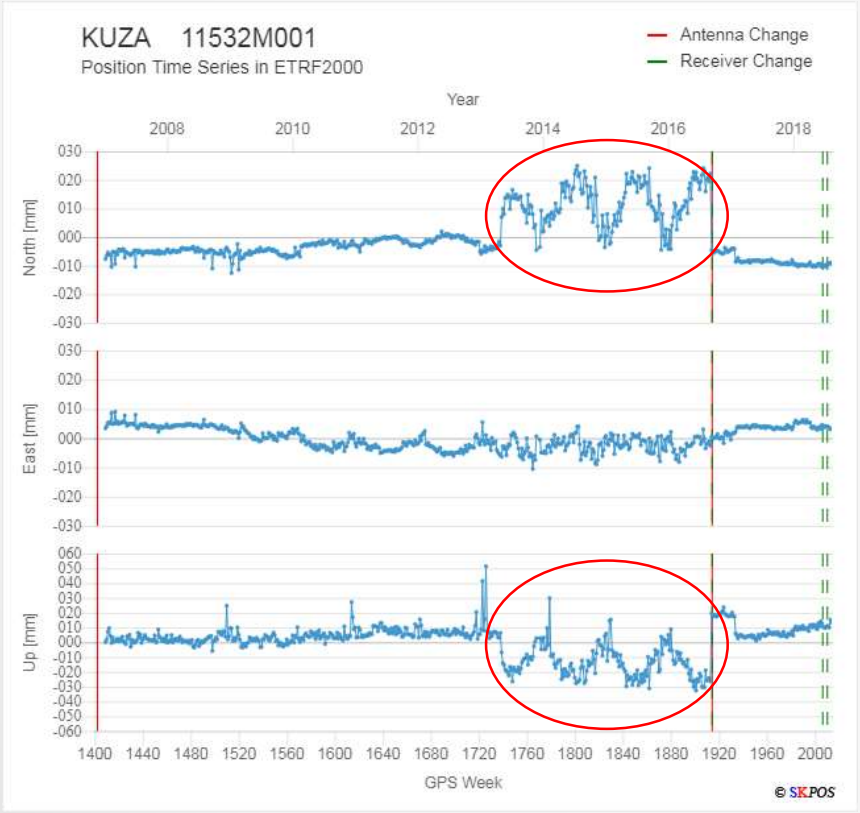
Receiver: Trimble NETR9
Antenna: TRM55971.00 NONE (series 3013)

SKPOS stations Time Series monitoring Detected problems

- KUZA station

since March 2013 significant periodicity

with 2.5 cm amplitude in N, U components



Receiver: Trimble NETR9

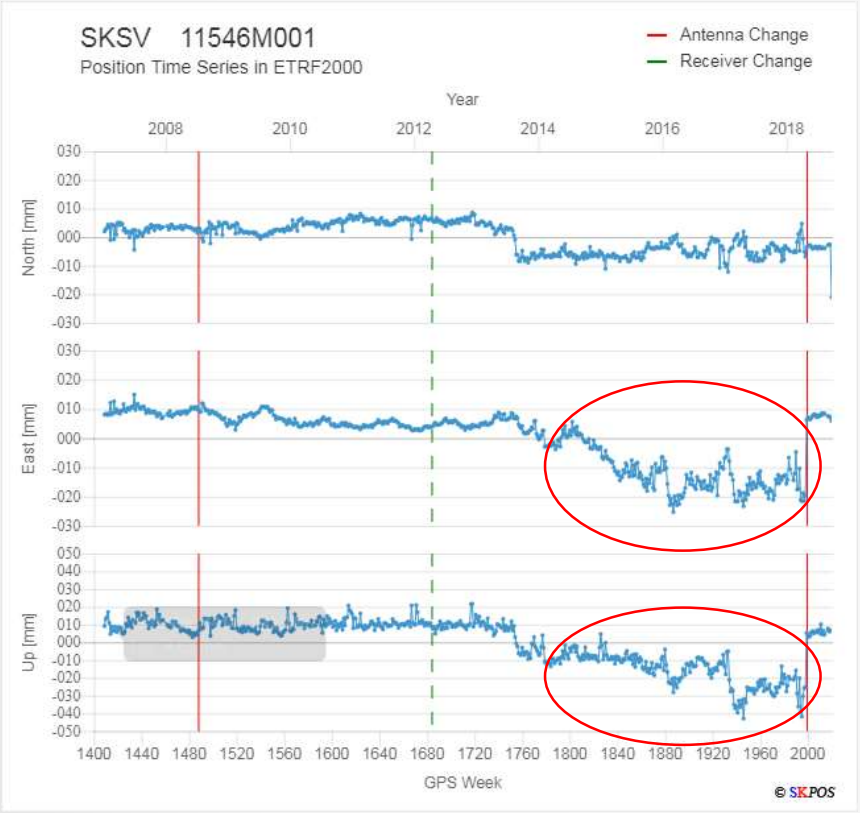
Antenna: TRM55971.00 NONE (series 3013)

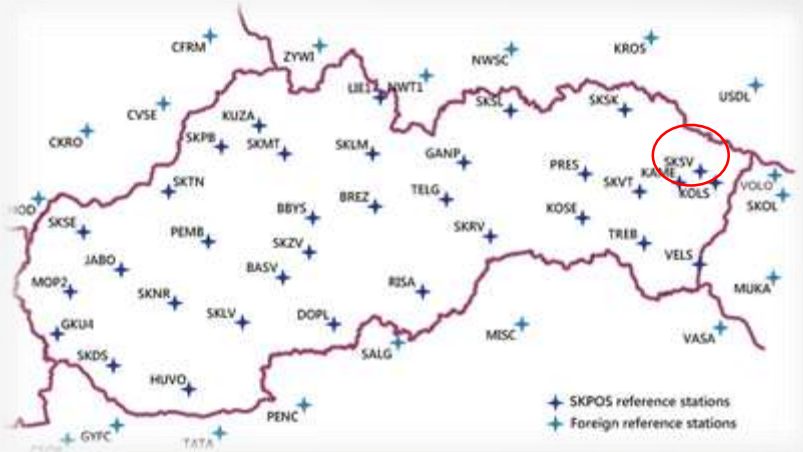
SKPOS stations Time Series monitoring Detected problems

- SKSV station

since July 2014 decreasing trend

in E, U components





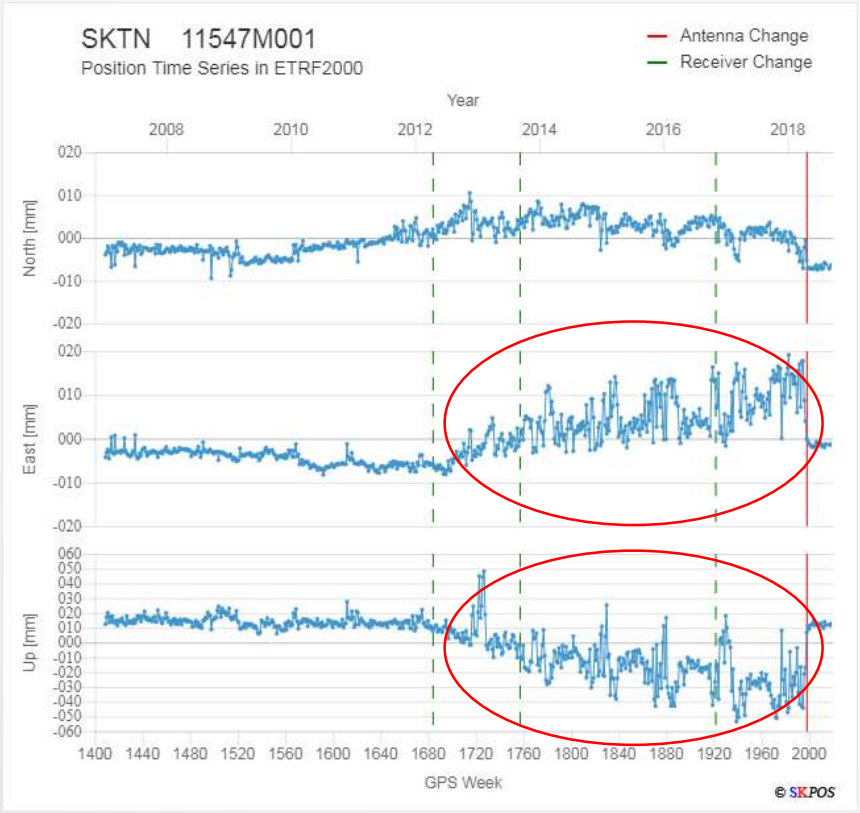
Receiver: Trimble NETR9

Antenna: TRM55971.00 NONE (series 3013)

SKPOS stations Time Series monitoring Detected problems

- SKTN station

since April 2012 increasing trend in E and decreasing trend in U component



Receiver: Trimble NETR9
Antenna: TRM55971.00 NONE (series 3013)

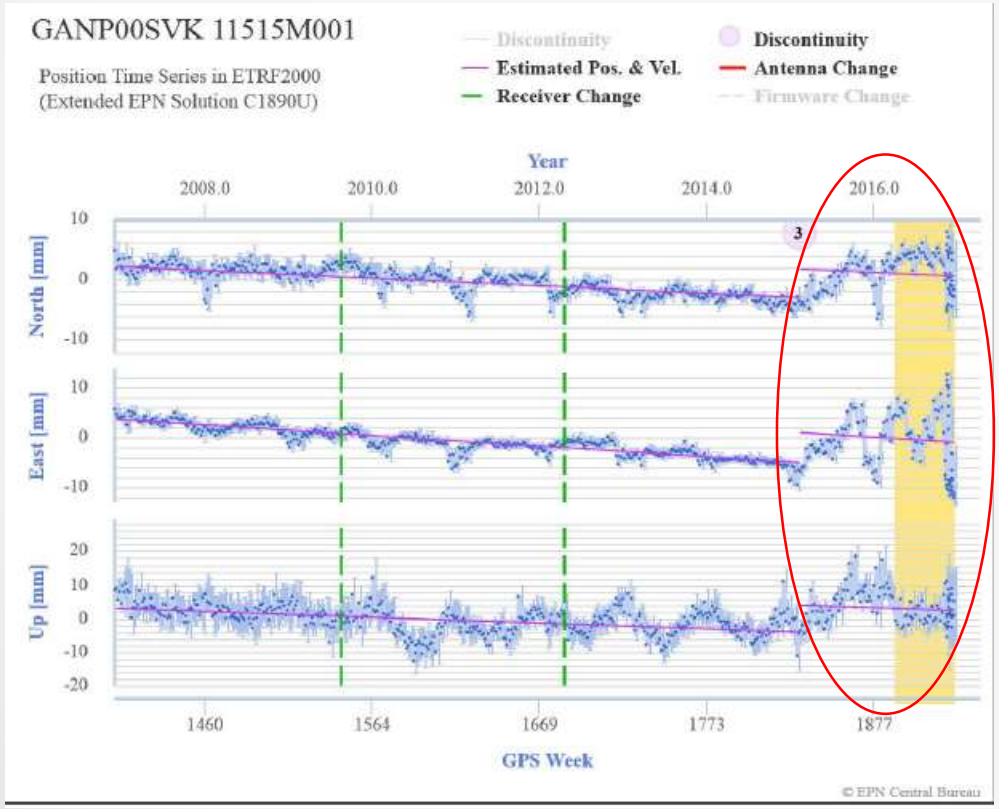
Possible reasons of detected problems

- Wrong way of coordinates calculation
- Wrong binary files software conversion to RINEX
- Wrong reference station hardware
  - Receiver, Antenna, Cable
- Problem with monumentation
- Anomalies caused by local geodynamics

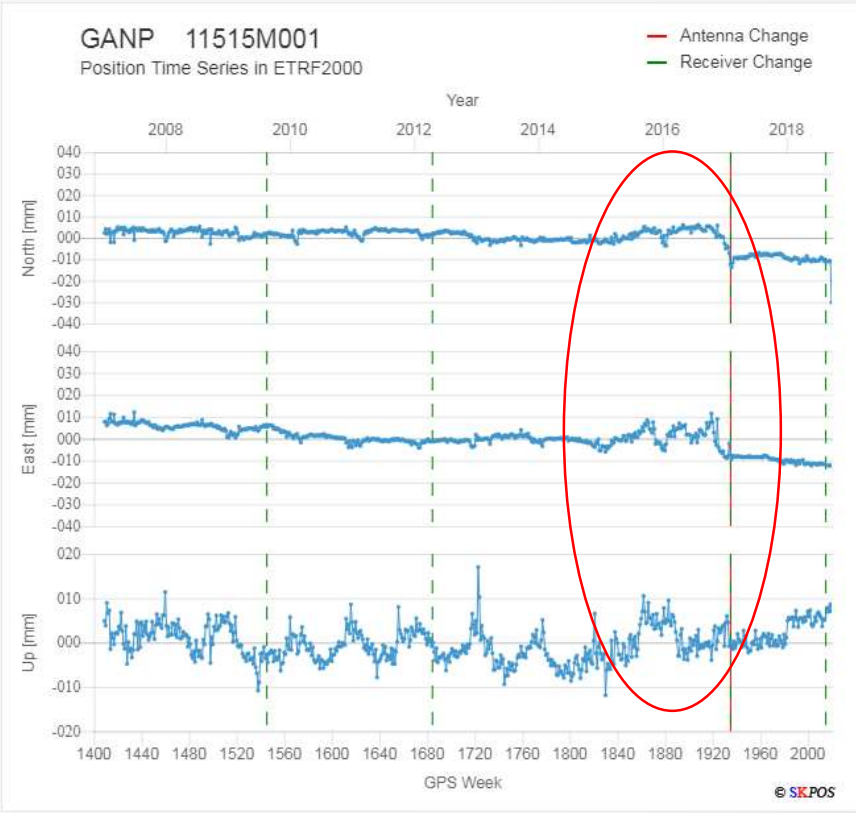
Consistency of EPN and SKPOS solution checking

- GANP

EPN



SKPOS



Possible reasons of detected problems

- ~~Wrong way of coordinates calculation~~
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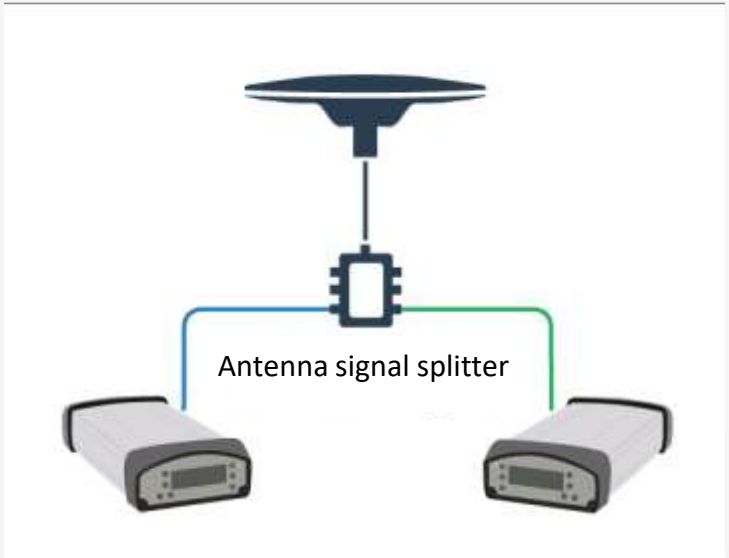
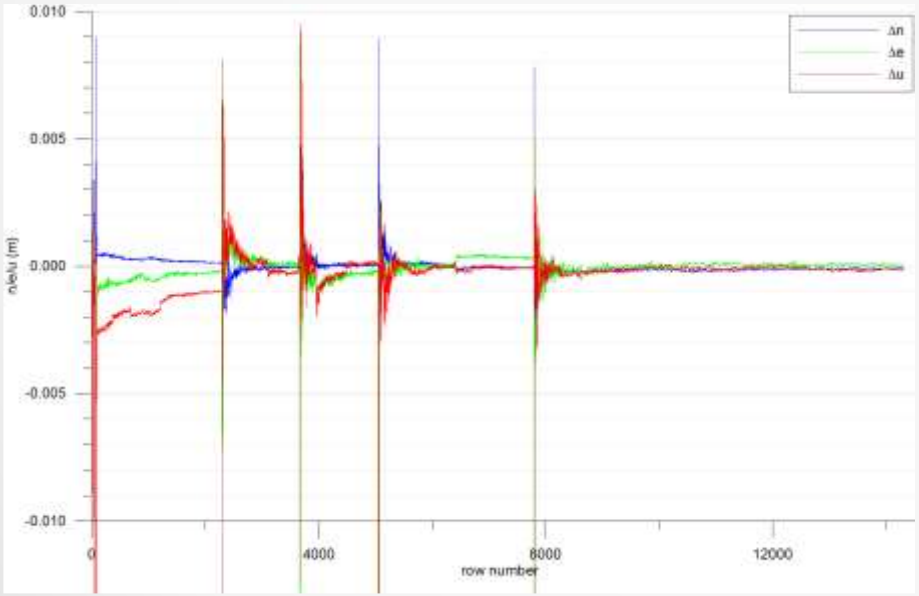
Wrong reference station HW
GNSS receiver check

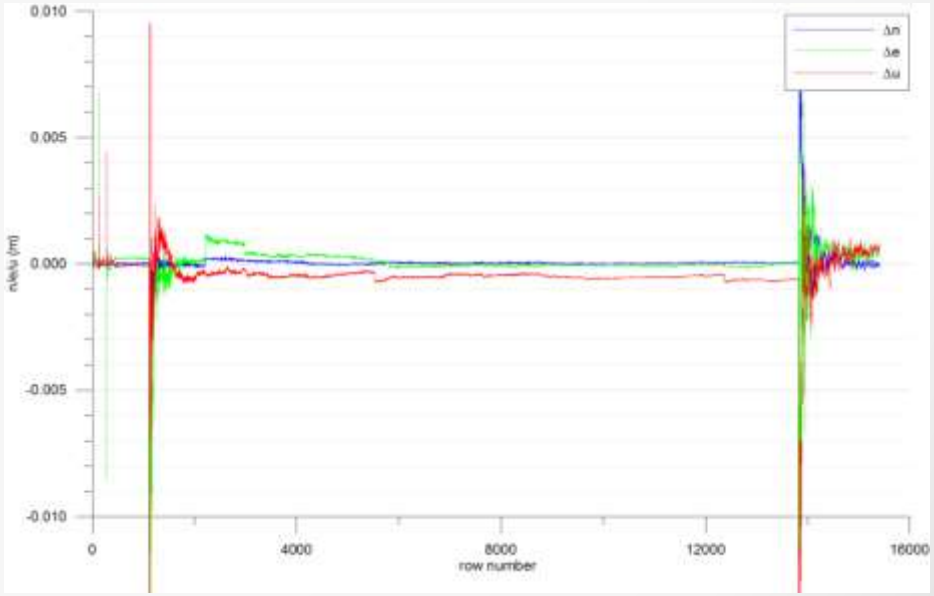
- Two receivers simultaneously connected to one antenna
- KUZA, SKTN, SKVK and GANP receivers checked during 2015
- Dual receiver was in operation for one month
- Coordinates computation by Trimble Pivot Platform



Wrong reference station HW
GNSS receiver check

- Trimble Pivot Platform
- Hourly and 15min steps for about one month
- Differences in the coordinates (Δn, Δe, Δu)





Wrong reference station HW
GNSS receiver check

Tab.1 Coordinates comparison of two receivers simultaneously connected to one antenna at each station.

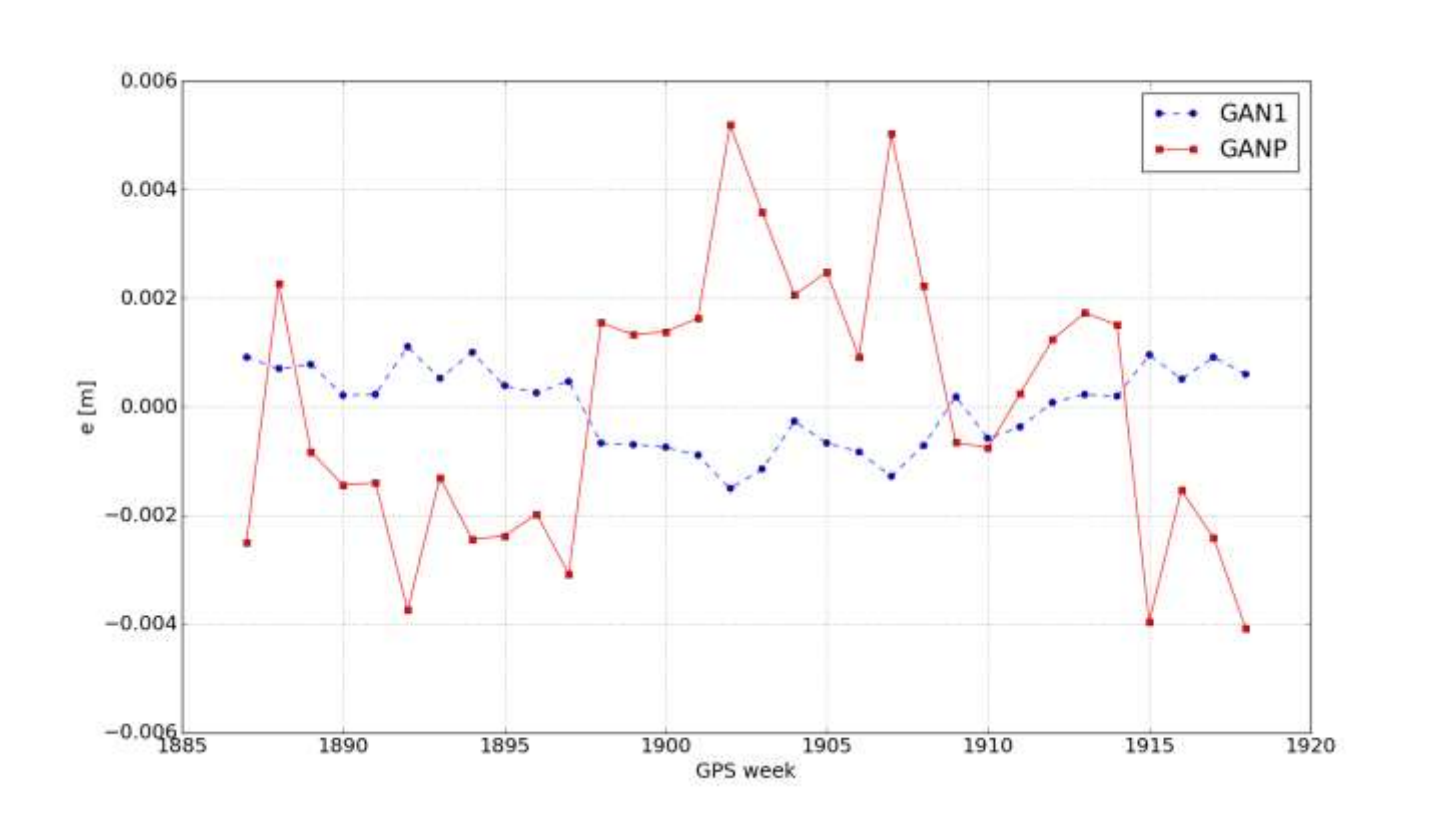
Station	GANP [mm]			KUZA [mm]			SKTN [mm]			SKVK [mm]		
Residuals	*Δn*	*Δe*	*Δu*	*Δn*	*Δe*	*Δu*	*Δn*	*Δe*	*Δu*	*Δn*	*Δe*	*Δu*
Average	5,17	14,91	0,09	0,21	0,29	0,53	0,12	0,11	0,30	2,03	1,54	2,86
STD	0,07	0,08	0,09	0,77	1,48	2,51	0,88	1,24	1,24	2,01	2,37	2,45
Median	5,17	14,91	0,06	0,13	0,13	0,15	0,04	0,11	0,49	1,38	0,43	2,71

Problem with monumentation
Monumentation check

- Two antennas situated on the same monumentation simultaneously tracking GNSS signals - GANP and GAN1

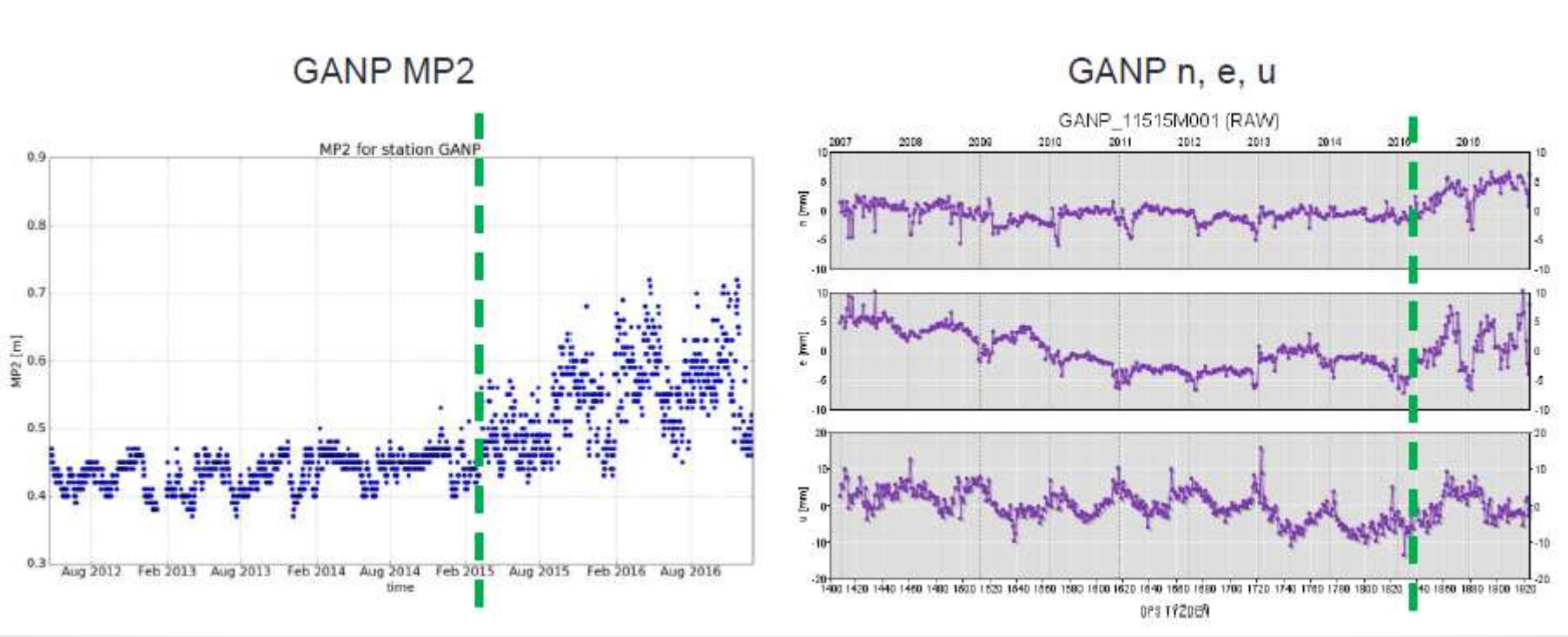
Problem with monumentation
Monumentation check

- GAN1 added to processing in Bernese 5.2
- permanent monitoring was done from 9.3.2016 to 5.2.2017
- analyses of results confirmed problem with antenna not with monumentation



Problem with monumentation
Monumentation check

- GANP analyses on MP2 confirmed problem with antenna and not with monumentation

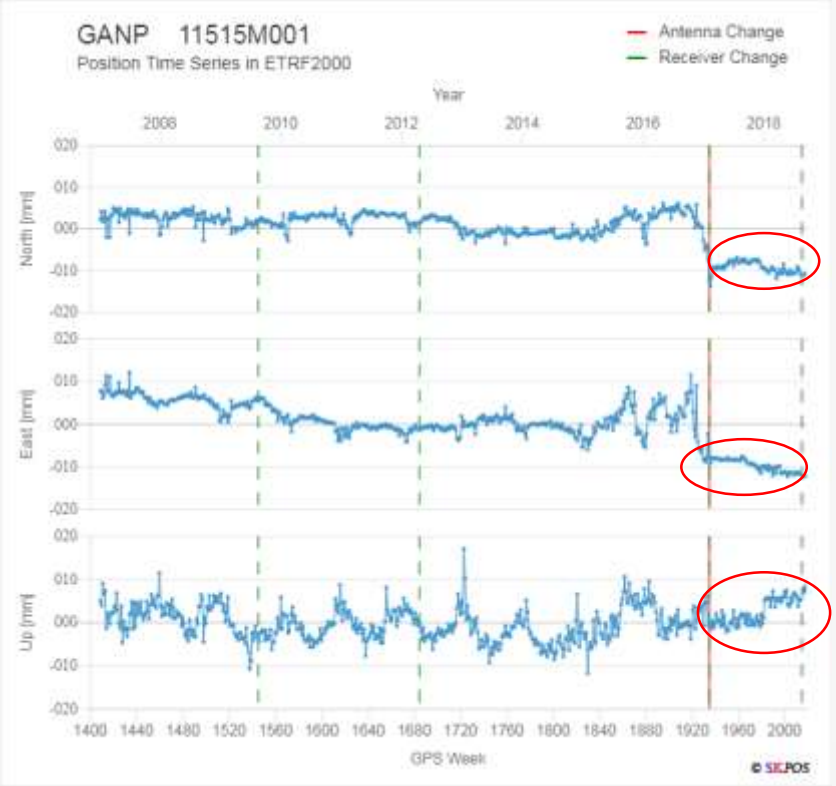


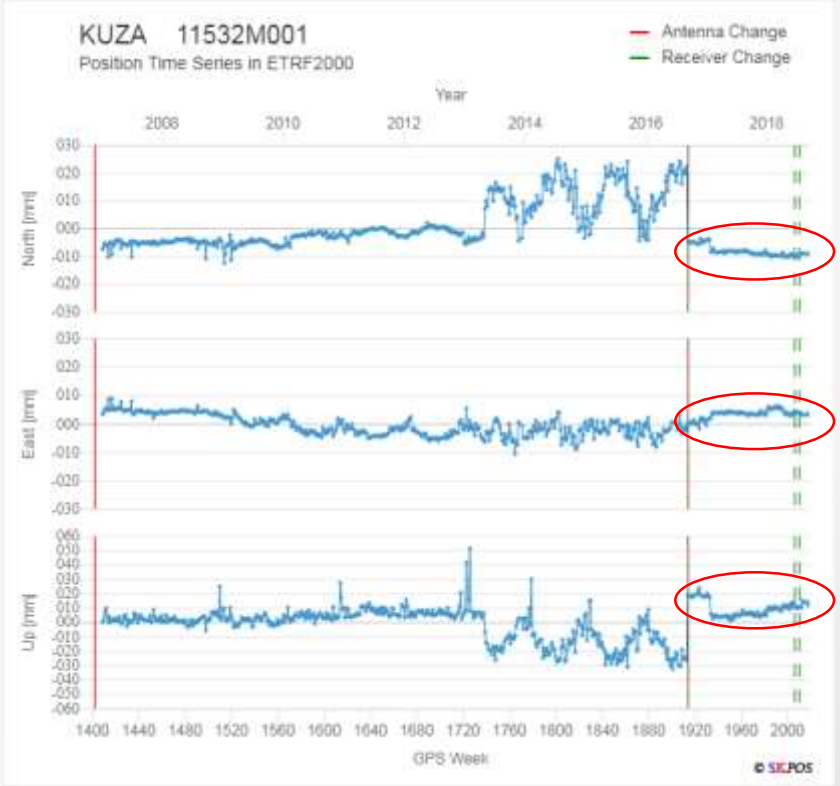
Possible reasons of detected problems

- ~~Wrong way of coordinates calculation~~
- ~~Wrong binary files software conversion to RINEX~~
- Wrong reference station hardware
  - ~~Receiver~~, Antenna, ~~Cable~~
- ~~Problem with monumentation~~
- ~~Anomalies caused by local geodynamics~~

Wrong reference station HW
GNSS antenna check

- Wrong antennas were replaced:
  - GANP – 6.2.2017
  - KUZA – 14.9.2016
  - SKSV - 3.5.2018
  - SKTN – 24.4.2018





SKPOS Data Quality monitoring
New application

- New web app: **SKPOS Quality Control**
- Since September 2018
- Permanent RINEX data quality monitoring
  - ✓ % observations
  - ✓ # observations
  - ✓ MP1, MP2, MP5
  - ✓ cycle slips (under development)
- SKPOS + foreign stations in our solution
- TEQC monitoring replaced by G-Nut/Anubis
- Daily updated plots
- Alarm mails

App found out problem with L2 frequency lost at Trimble Choke Ring antennas

- BASV, BBYS, KAME, KOSE

✓ problem with induction coil

✓ serviced in Sep 2018

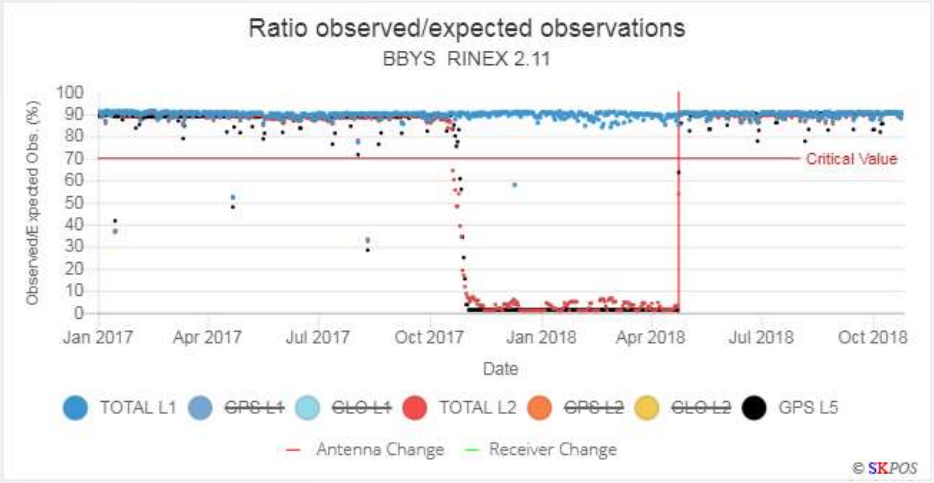
Satellite Tracking | Skyplot | Receiving Info | Multipath | Raw Data Analysis | Storage Integrity

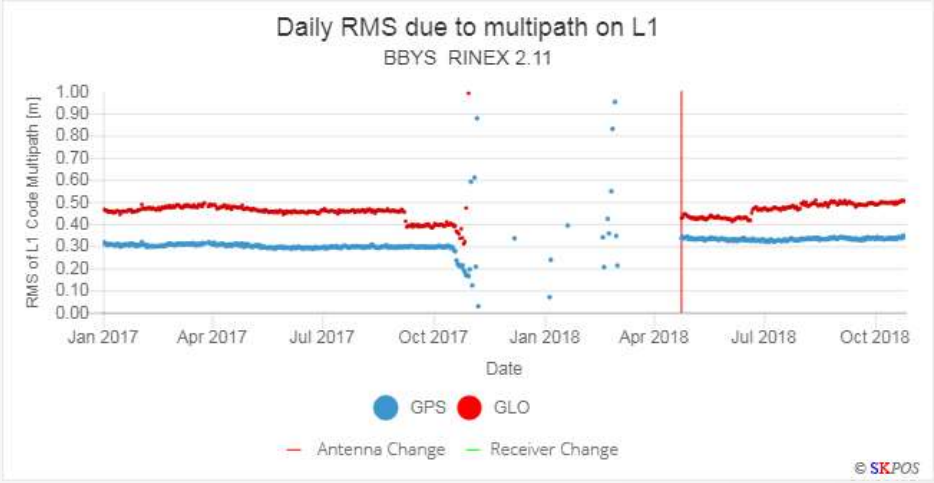
	Sat	El [°]	Az [°]	SNR (CA/P1/E1)	SNR (L2/L2C/L2C..	SNR (L5/E5/I
↗	C02	8	108	- / - / - / 31		-
↗	C05	23	131	- / - / - / 35	-	-
↘	C08	28	40	- / - / - / 40	-	-
↘	C10	1	103	-	-	-
↓	C11	34	49	- / - / - / 46	-	-
↗	C13	43	66	- / - / - / 45	-	-
↓	E02	50	97	- / - / 48	-	-
↘	E07	17	255	- / - / 41	-	-
↘	E11	11	33	- / - / 38	-	-
↘	E14	66	111	- / - / 50	-	-
↗	E19	0	348		-	-
→	E20	17	308	- / - / 36	-	-
↑	E30	70	310	- / - / 50	-	-
↑	G02	29	123	46	-	-
↗	G06	30	76	45	-	-
↗	G12	79	347	52	-	-
↗	G14	16	321	40	-	-
↓	G17	11	44	44	-	-
↓	G19	29	48	44	-	-
↓	G24	57	156	50	-	-
↑	G25	41	276	49	-	-
↑	G29	12	213	43	-	-
↗	G32	30	294	46	-	-

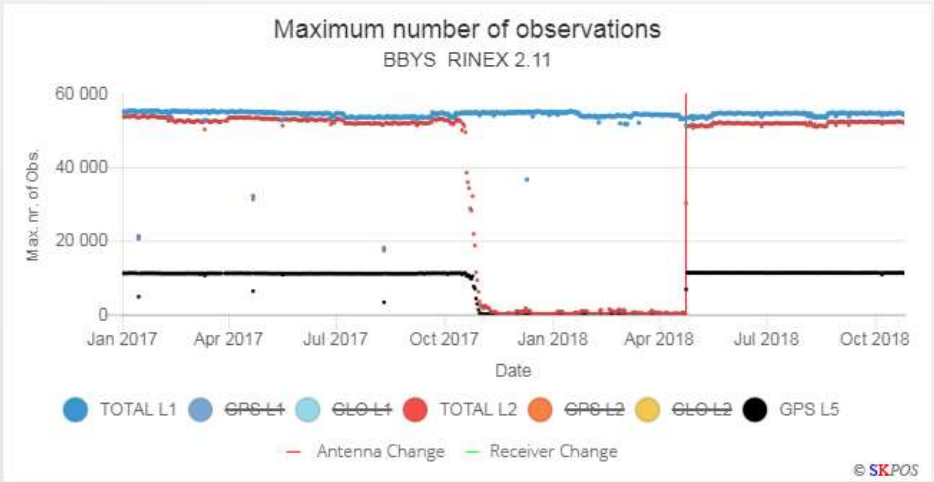
Problem! No L2 data!

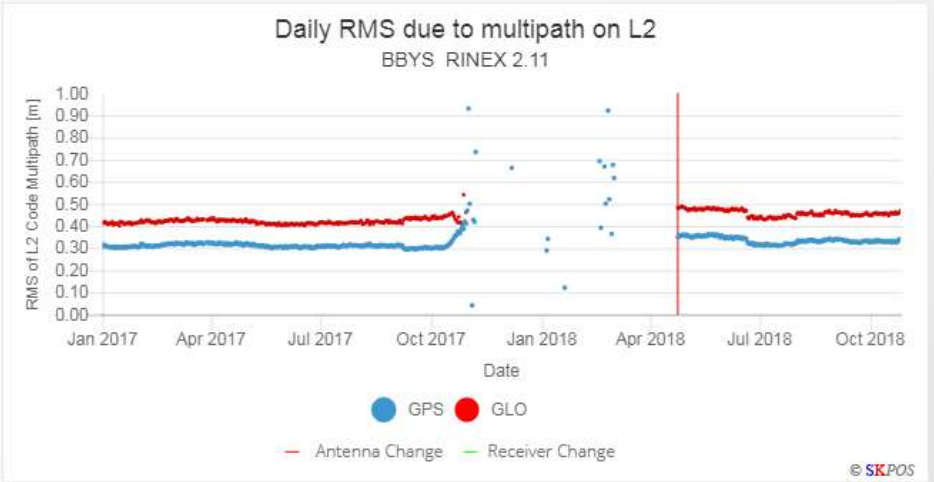
App found out problem with L2 frequency lost at Trimble Choke Ring antennas

- BBYS



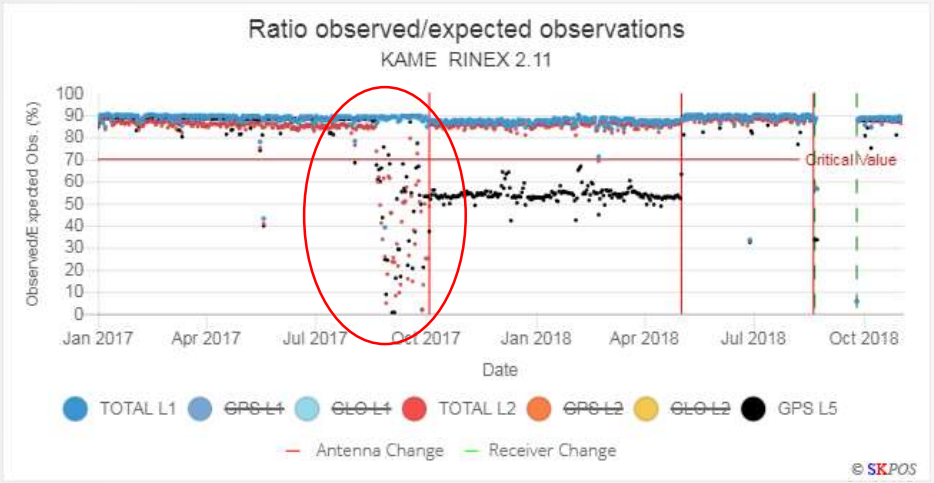


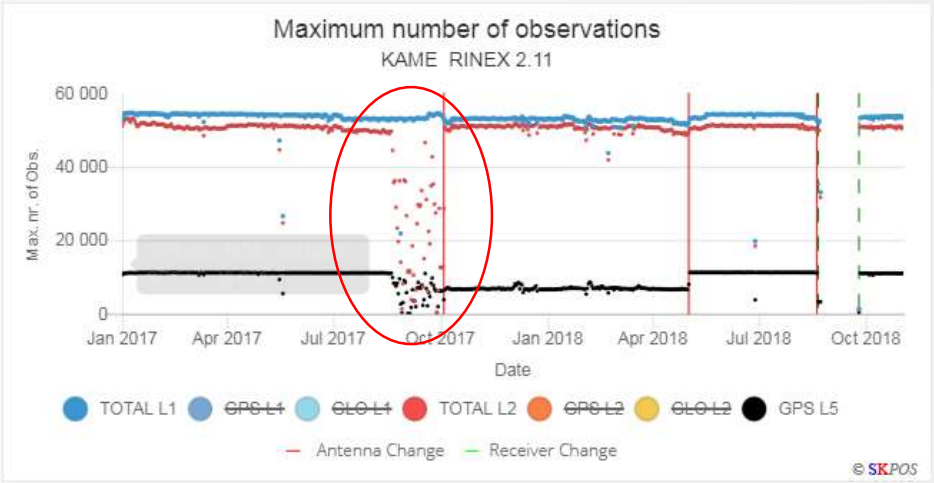


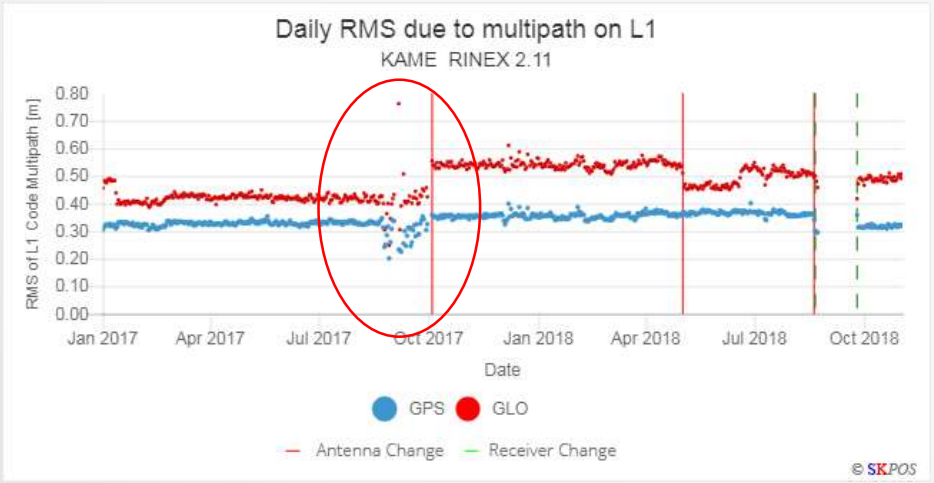


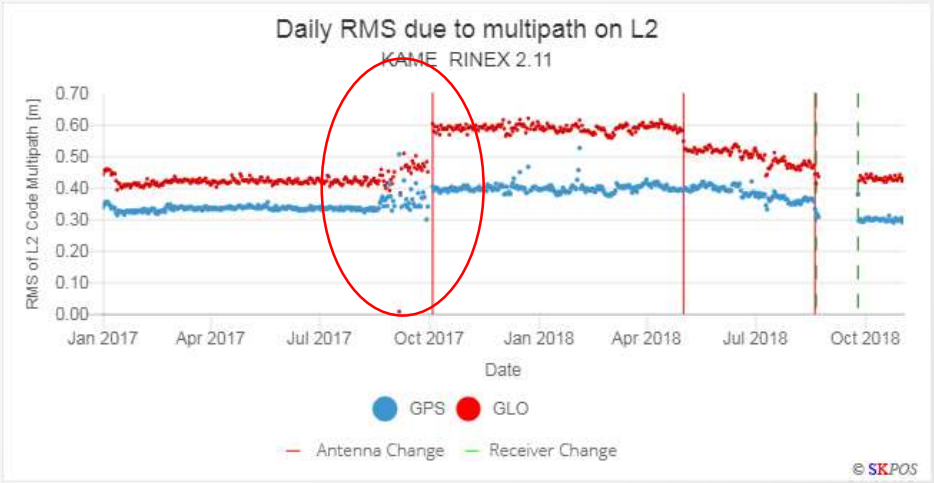
App found out problem with L2 frequency lost at Trimble Choke Ring antennas

- KAME



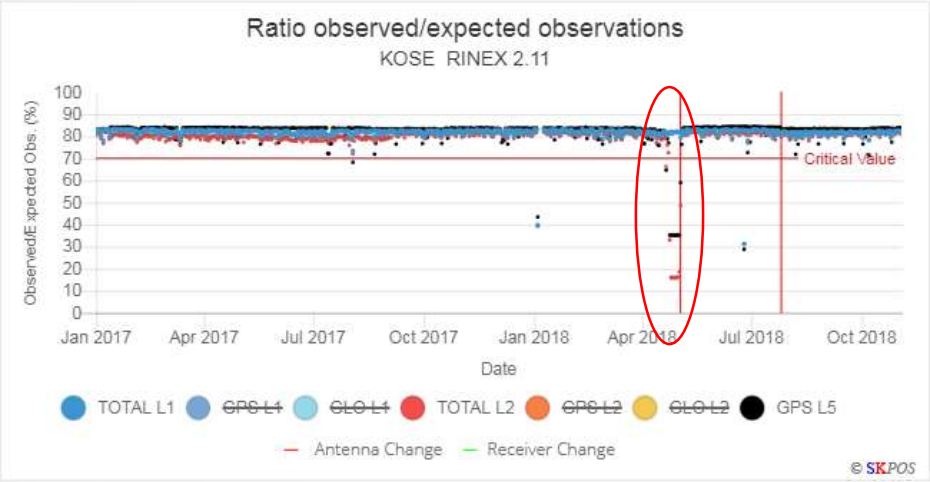


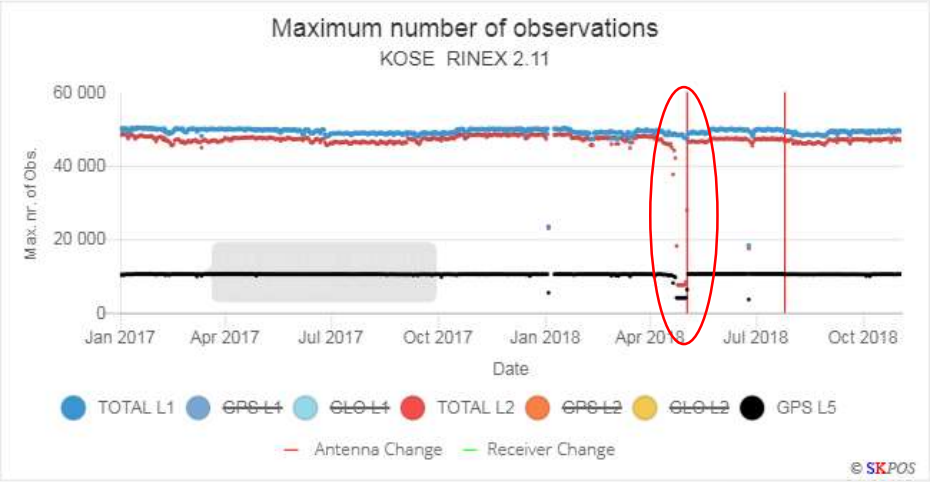


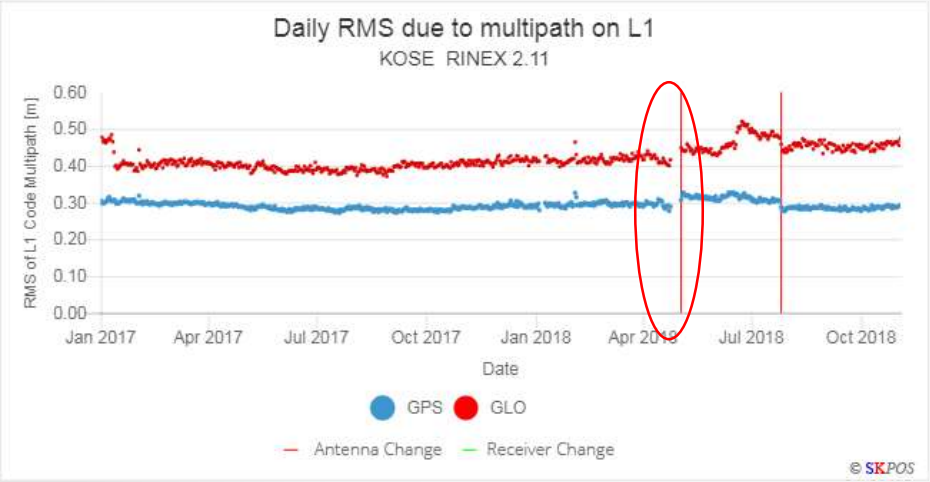


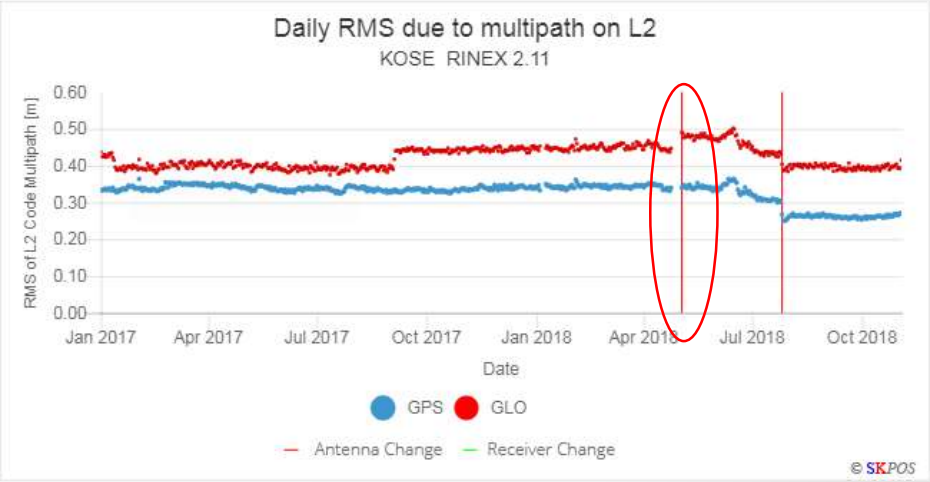
App found out problem with L2 frequency lost at Trimble Choke Ring antennas

- KOSE



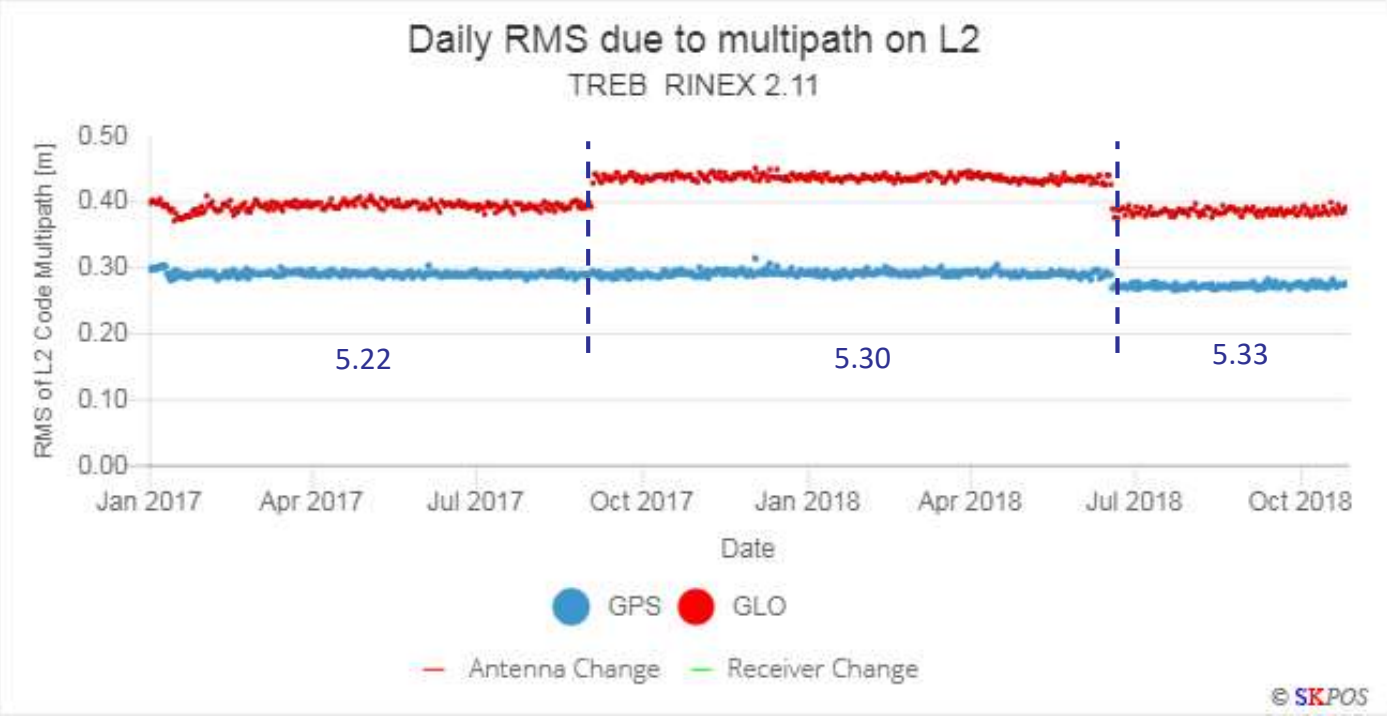






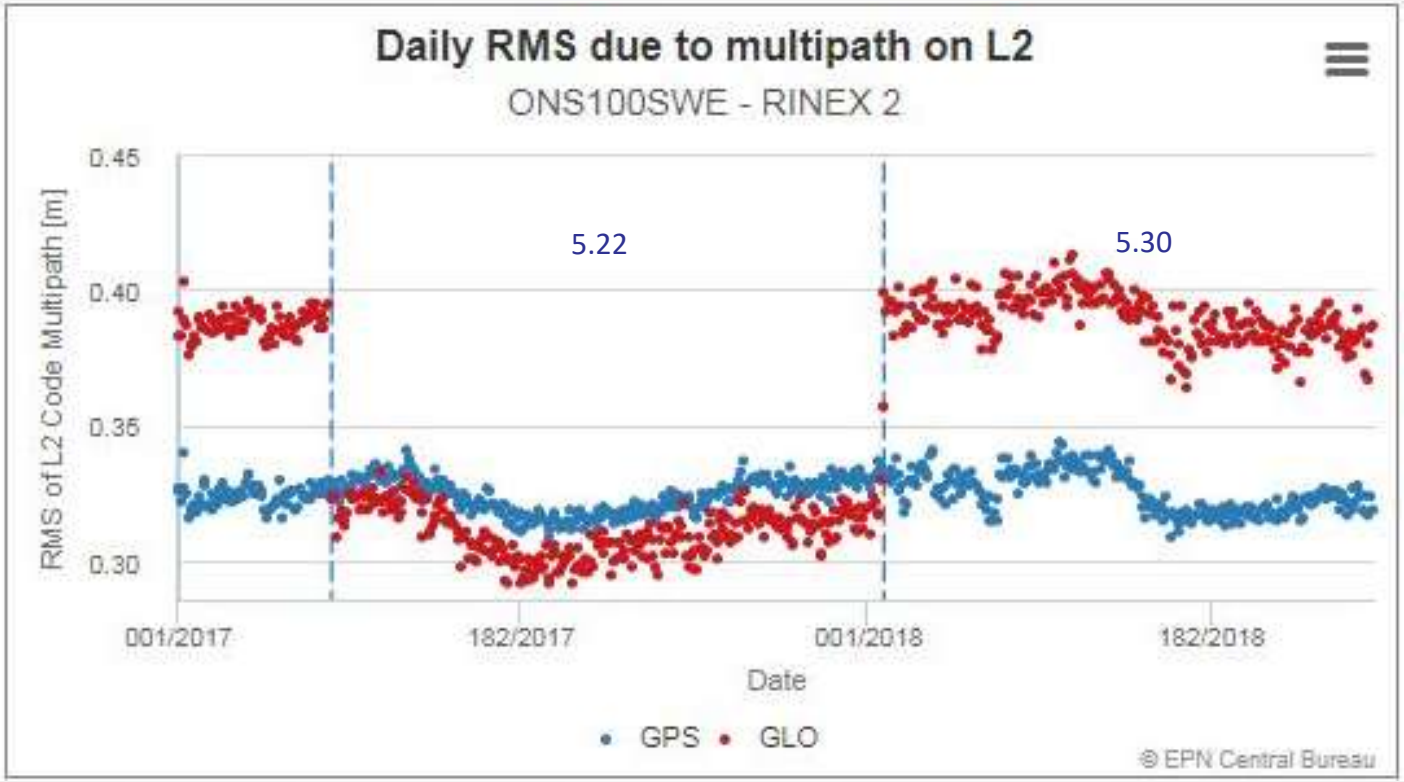
App detected problem with Trimble NETR9 firmware version 5.30

- Detected jump on L2 multipath (GLONASS)



App detected problem with Trimble NETR9 firmware version 5.30

- Same problem detected at all EPN stations with Trimble NETR9 receiver and upgrade from 5.22 to 5.30



Summary

- Finding up problems of reference station HW or anomaly behavior is hard work which need a long time
- There are more manners how to find out problems
- Performed analysis confirmed problem with GNSS antennas on few SKPOS stations
- New application for monitoring confirmed that can help us to find out different kind of problems, but time series monitoring will be needed for future as well

Thank you for your attention

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