Activities of GKU
EPN Operational Centre

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GKU (Geodetic and Cartographic Institute Bratislava)
EPN Operational Centre

Geodetic and Cartographic Institute Bratislava

SKPOS®

EUREF Permanent Network
Densification

EUPOS®
European Position Determination System

Contents

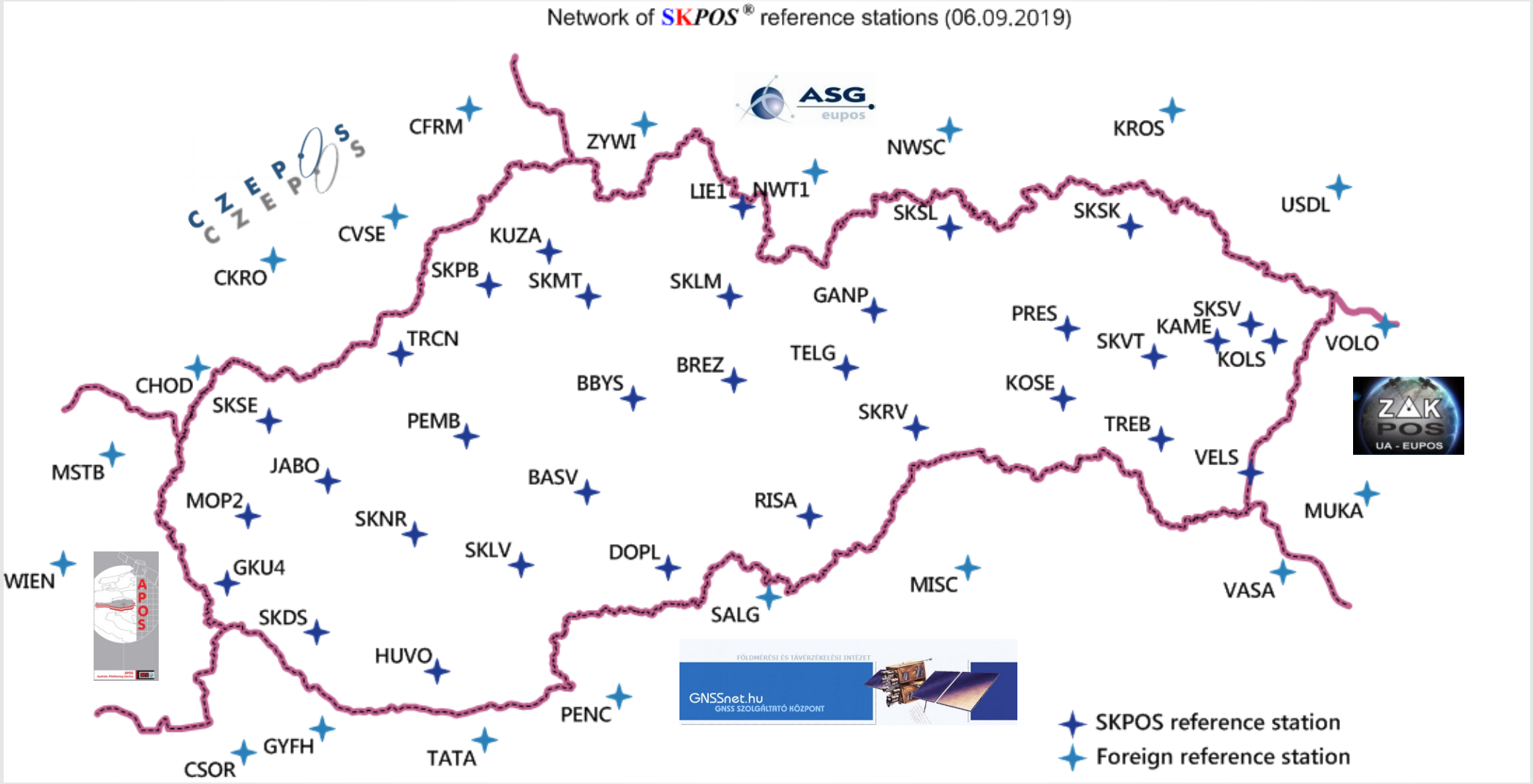
- ✓ **SK*POS*®** network status
- ✓ Real-time service status
- ✓ Website news

Real-time service

- ✓ Processing strategy
- ✓ Processing campaigns
- ✓ Solutions generated
- ✓ Coordinates computation
- ✓ Velocity computation
- ✓ Data quality monitoring

Post-processing

SKPOS® - Network status



SKPOS® - Network status

- 33 SKPOS stations:
  - ✓ 33/33 equipped with Trimble HW
    - receivers: NETR9, ALLOY (firmware version 5.42)
    - antennas: Zephyr Geodetic 2 & 3, ChokeRing
  - ✓ 33/33 tracking: GPS, GLO, GAL, BDS, QZS, SBS, IRS (ALLOY)
  - ✓ 20/33 individual antenna calibration
  - ✓ 15/33 stabilization suitable for geodynamic research
- 20 foreign stations:
  - ✓ AT: APOS (2)
  - ✓ PL: ASG-EUPOS (5)
  - ✓ HU: gnssnet.hu (7)
  - ✓ CZ: CZEPOS (4)
  - ✓ UA: ZAKPOS (2)

SKPOS® - Network status

- New GNSS/InSAR integrated station PEM200SVK

NEW

  - ✓ 10m from PEMB00SVK GNSS permanent station
  - ✓ GKU – SUT cooperation

SKPOS® - Real-time service status

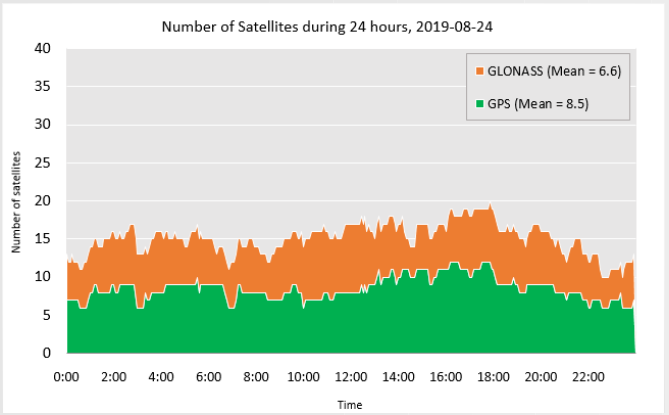
- + 1 800 active users
- Control Software: Trimble Pivot Platform 4.3
  - ✓ RTXNet Processor **Galileo** **BeiDou**
- 33 SKPOS stations
  - ✓ 33/33 real-time corrections: GPS, GLO, GAL, BDS

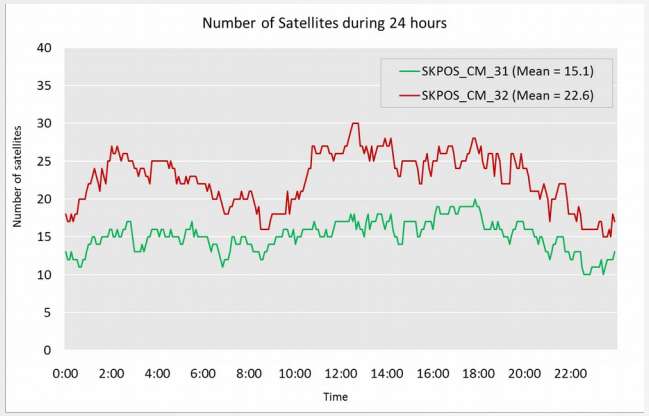
SKPOS® - Real-time service status

GPS+GLO vs. GPS+GLO+GAL+BDS

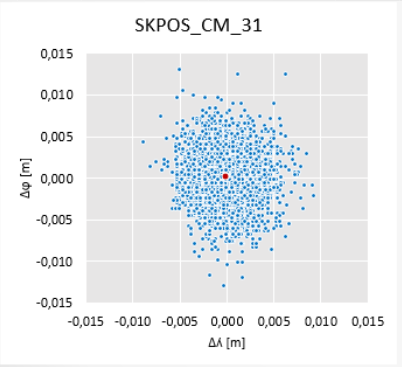
- 24h RTK test
  - ✓ at GNSS/InSAR integrated station PEM200SVK
  - ✓ 10m from PEMB00SVK permanent GNSS station

	SKPOS_CM_31	SKPOS_CM_32
Rover	Trimble NetR9	Trimble NetR9
Software	RTKNAVI	RTKNAVI
Format	RTCM 3.1	RTCM 3.2 MSM5
GNSS	GPS, GLO	GPS, GLO, GAL, BDS

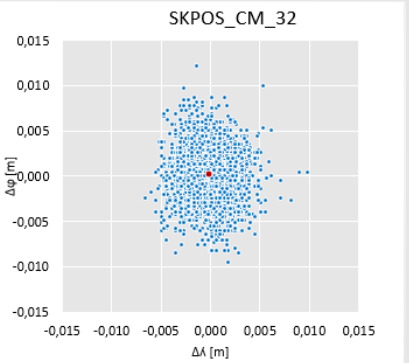


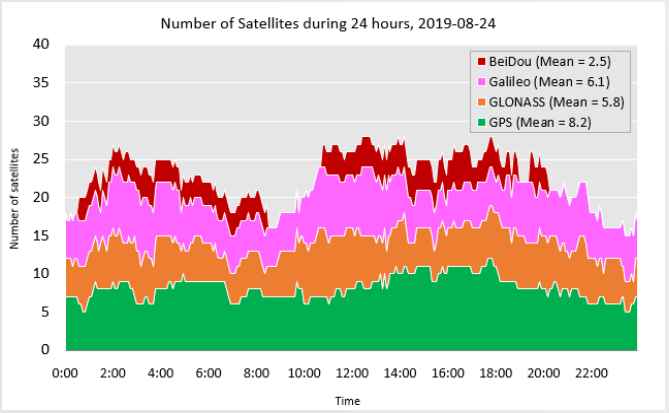


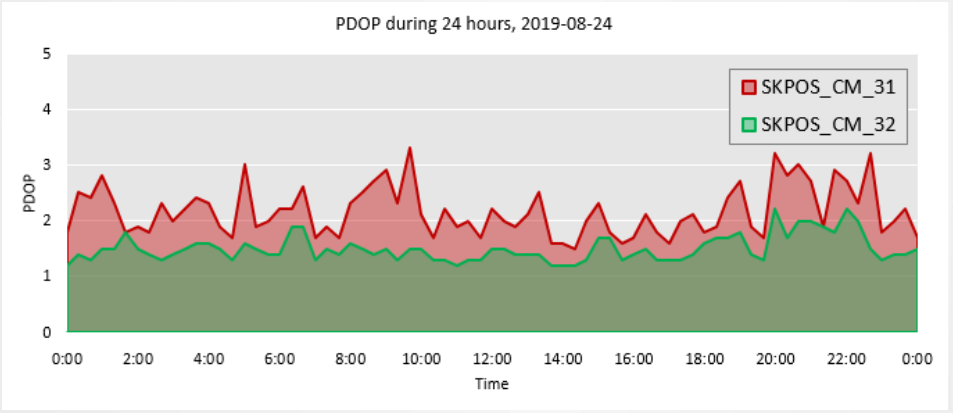
STD_DEV = 2.0 mm

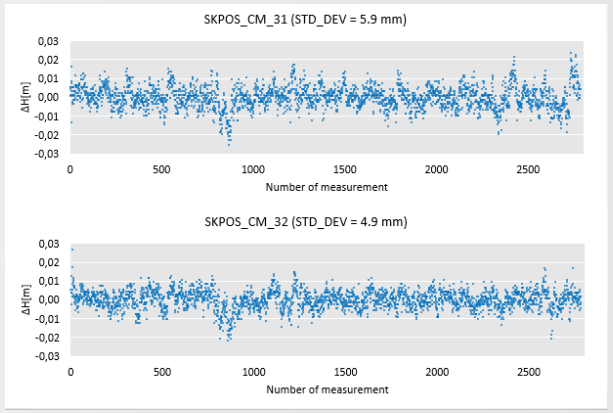


STD_DEV = 1.7 mm





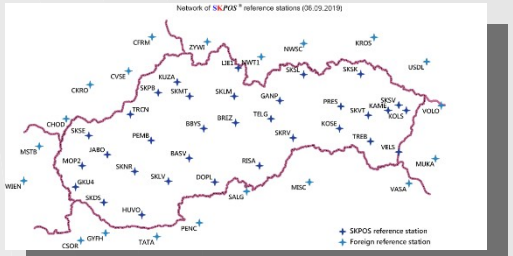




SKPOS® website news

http://skpos.gku.sk/en/stanice.php

- Slovak / English version
- Map
- Station list
  - ✓ location
  - ✓ reference coordinates (X,Y,Z / B,L,h)
  - ✓ HW components
  - ✓ antenna calibration files
  - ✓ sitelogs
- Actual information



Reference stations

#	Reference station	Location	Coordinates Change format ETRS89 (ETRF2000) epoch 2008.5			Antenna	Receiver	Site log
			X (m)	Y (m)	Z (m)			
1	BASV	Banská Štiavnica	4009952.2193	1374556.6500	4750511.3543	TRM59800.00 SCIS	TRIMBLE NETR9	Site log
2	BBYS	Banská Bystrica	3980359.1362	1382291.8714	4772771.7528	TRM59800.00 NONE	TRIMBLE NETR9	Site log
3	BREZ	Brezno	3963889.0095	1414440.8746	4777131.8796	TRM55971.00 NONE	TRIMBLE NETR9	Site log
4	DOPL	Dolné Plachtince	4019049.1891	1408890.6541	4732383.5840	TRM55971.00 NONE	TRIMBLE NETR9	Site log
5	GANP	Gánovce	3929181.8685	1455236.5018	4793653.7059	TRM59800.00 SCIS	TRIMBLE ALLOY	Site log
6	GKU4	Bratislava	4072810.9833	1258556.7507	4728707.6032	TRM115000.00 NONE	TRIMBLE NETR9	Site log
7	HUVO	Hurbanovo	4072066.0743	1338280.1018	4707504.3201	TRM55971.00 NONE	TRIMBLE NETR9	Site log
8	JABO	Jaslovské Bohunice	4035866.0213	1285295.0839	4753013.4000	TRM55971.00 NONE	TRIMBLE NETR9	Site log
9	KAME	Kamenica nad Cirochou	3892532.3584	1572220.3325	4785952.5647	TRM59800.00 SCIS	TRIMBLE NETR9	Site log
10	KOLS	Kolonica	3884965.6154	1591340.3231	4786138.9493	TRM115000.00 NONE	TRIMBLE NETR9	Site log

Actual information

2019-09-06 All Trimble NetR9 and Trimble Alloy receivers has been upgraded to the newest firmware version 5.42

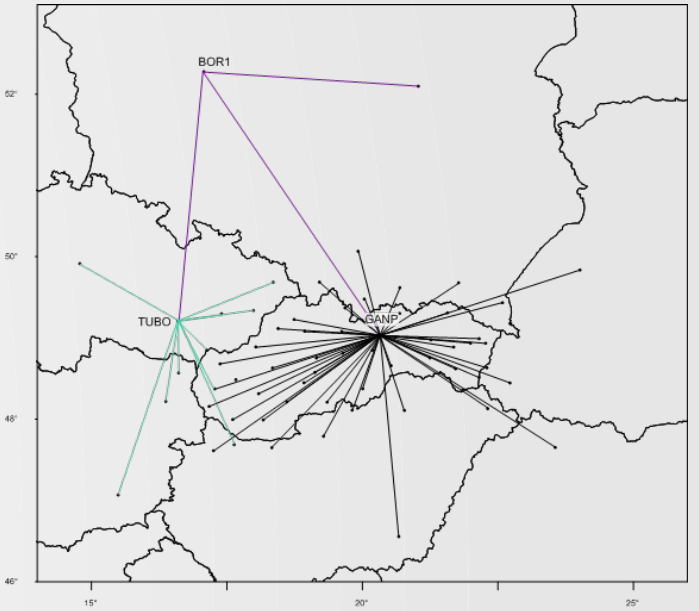
2019-08-14 An antenna has been changed today at Kolonicke sedlo (KOLS) reference station. An updated GNSS antenna type can be found in the list of reference stations

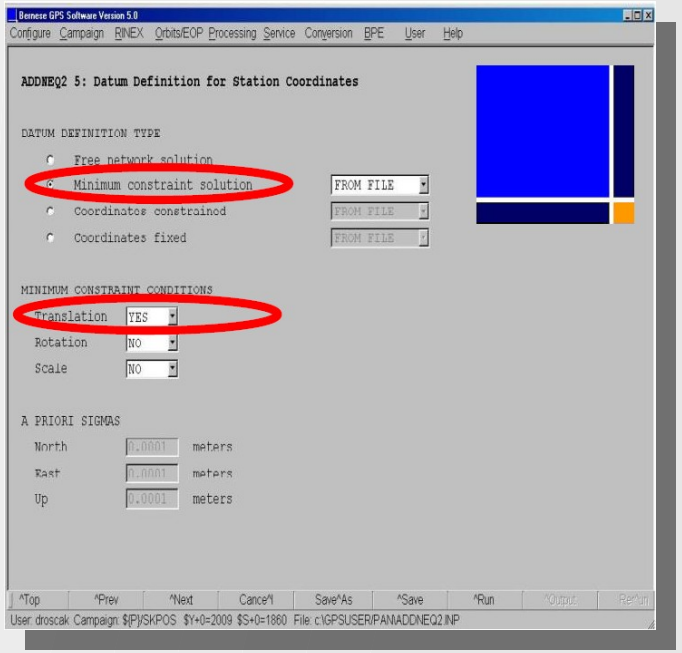
Post-processing activities

Processing strategy

Bernese GNSS Software 5.2 (RNX2SNX.PCF)

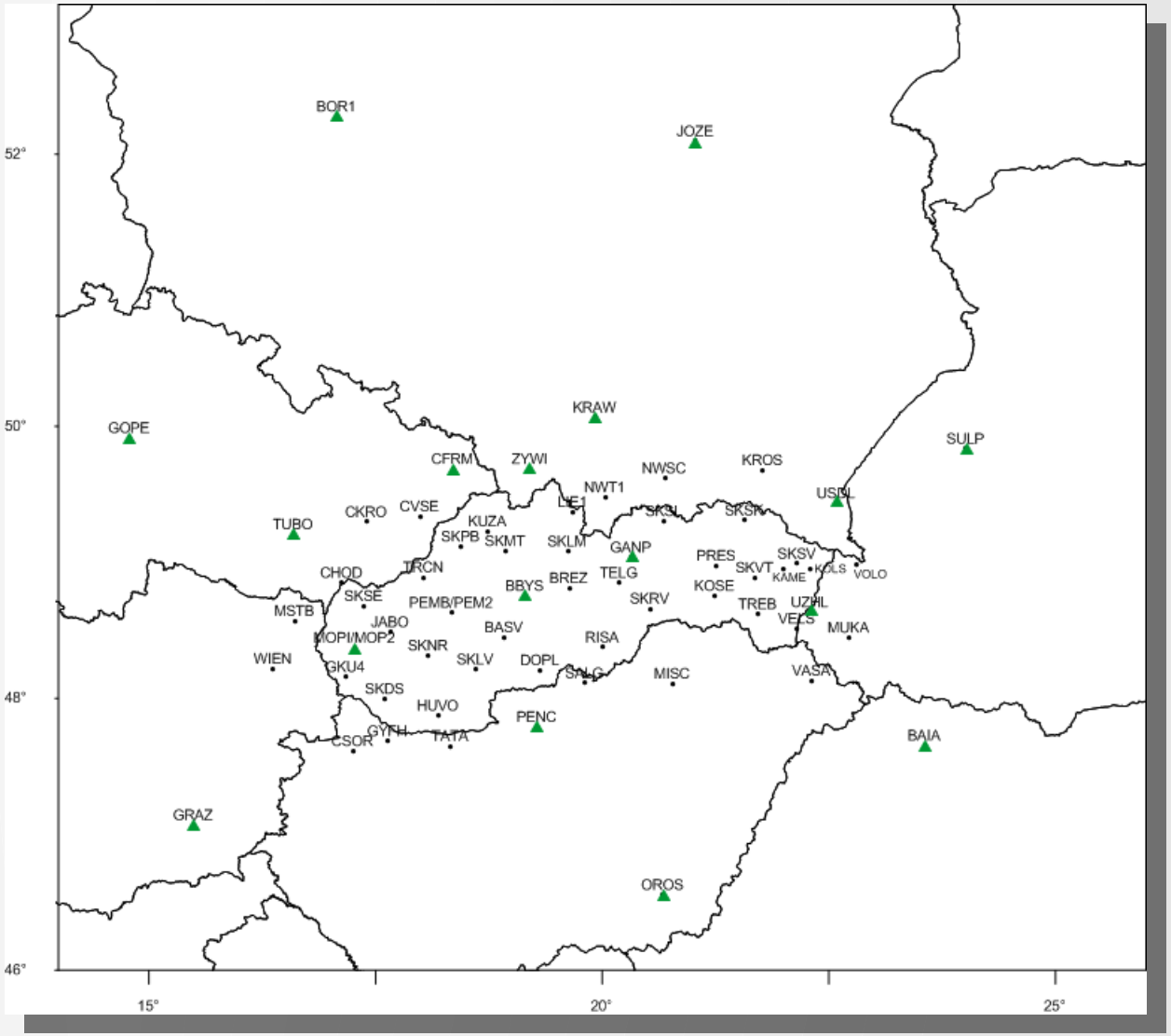
- **Measurement models**
  - ✓ Preprocessing: phase preprocessing by baselines using triple-differences
  - ✓ Basic observable: carrier phase (code only for receiver clock synch.)
  - ✓ Modelled observable: double-differences, ionosphere-free linear combination
  - ✓ Ground antenna: IGS14 model (except stations with indiv. abs. calibration)
  - ✓ Satellite antenna: IGS14 model
  - ✓ EPN coordinates: EPN_A_IGS14.SSC
  - ✓ Processing strategy: DEFINED (BOR1, TUBO, GANP vs. JOZE, GOPE, PENC)
  - ✓ Troposphere: VMF
  - ✓ Ionosphere: regional ionosphere model for ambiguity resolution
- **Estimated parameters**
  - ✓ Adjustment: least-square algorithm
  - ✓ Station coordinates: Minimum constraint (no-net-translation) fixed at 7 EPN stations
  - ✓ Troposphere: absolute 5 m / relative 5 m
  - ✓ Ionosphere: no estimated
  - ✓ Ambiguity resolution: QIF strategy
  - ✓ Satellite clock bias: not estimated (eliminated by double-differences)
  - ✓ Receiver clock bias: estimated during preprocessing using code measurements





Stations included in processing

- SKPOS stations:
  - ✓ GKU
  - ✓ SUT
  - ✓ Topographic Institute Banska Bystrica
  - ✓ Vihorlat Observatory
- Foreign SKPOS stations:
  - ✓ APOS
  - ✓ ASGEUPOS
  - ✓ CZEPOS
  - ✓ HUNET
  - ✓ ZAKPOS
- EPN stations:
  - ✓ EPN class A
  - ✓ EPN class B
- **TOTAL: 66 stations**



Processing campaigns

- **SKPOS (GPS+GLO)**
  - ✓ Daily solutions
  - ✓ RINEX v2 data
  - ✓ final IGS products
  - ✓ since 1.1.2007
- **WEEK CMB**
  - ✓ Weekly solution
  - ✓ Combination of daily NEQ systems
  - ✓ Max. tolerated residuals:
    - North, East: 15 mm
    - Up: 30 mm
  - ✓ Weekly coordinates comparison

- **WEEK ECC**
  - ✓ Weekly cumulative solution
  - ✓ Daily coordinates comparison within GPS week
  - ✓ Combination of weekly NEQ systems
  - ✓ Max. tolerated residuals:
    - North, East: 15 mm
    - Up: 30 mm
- **SKPOS (GPS+GLO+GAL)**
  - ✓ RINEX v3 data
  - ✓ final CODE MGEX products
  - ✓ since 1.7.2019 – test campaign
  - ✓ since 1.1.2020 – official SKPOS campaign (+GAL)
- **REPRO**
  - ✓ complete reprocessing until 2007
  - ✓ expected start date: January 2020

Solutions generated

- Daily solution:
  - ✓ SKPwwwwd.SNX
- Weekly solution:
  - ✓ SKPwwww7.SNX
- Weekly ECC cumulative solution:
  - ✓ GKUwwww7.SNX -> EUPOS Combination Centre (ECC)

EPN Densification solution

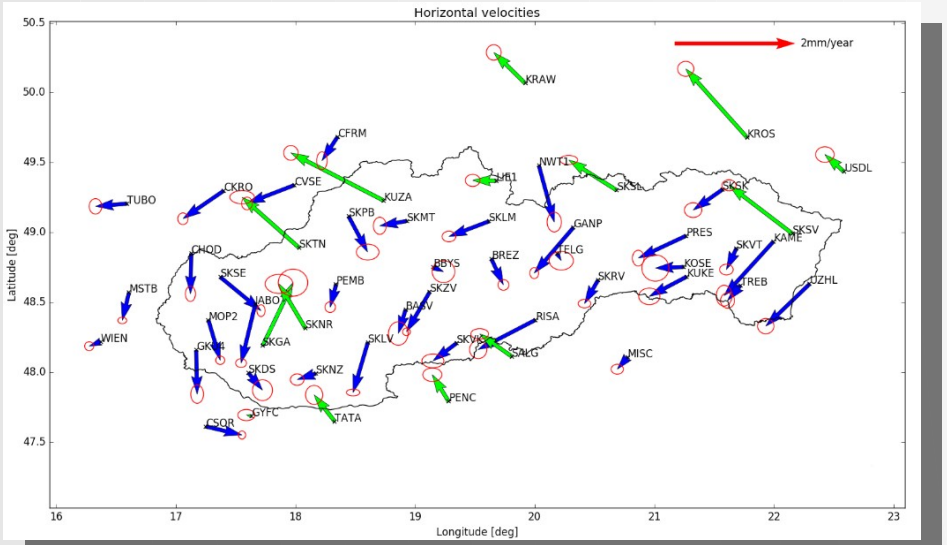
Coordinates computation

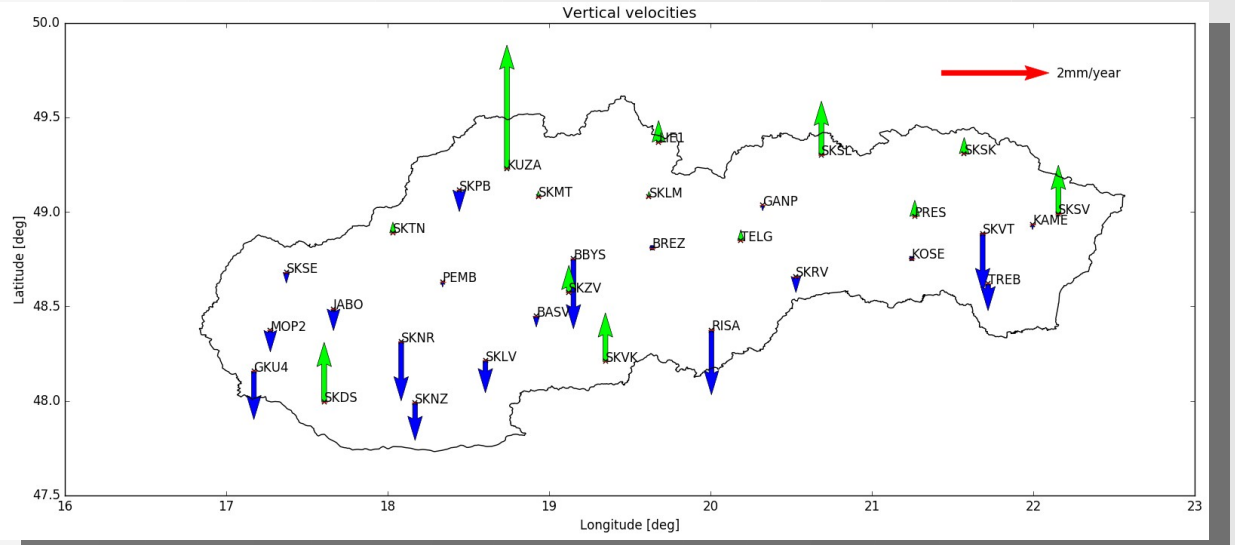
- When?
  - ✓ New reference station
  - ✓ Antenna change
  - ✓ After reprocessing
- How?
  - ✓ Bernese GNSS Software (ADDNEQ2) – combining NEQ
  - ✓ At least 4 weekly NQ0 files
  - ✓ latest EPN class A station coordinates (SSC file) + SKPOS reference coordinates
  - ✓ Minimum constraint solution fixed at:
    - ➢ 7 EPN stations + 3-4 surrounding SKPOS stations
- Validation?
  - ✓ Residuals check at fixed stations (ADDNEQ2.OUT)
  - ✓ Coordinates comparison
- Update?
  - ✓ Reference coordinates in IGS14 (2008.5)
  - ✓ Reference coordinates in ETRF2000 (2008.5)
  - ✓ Update: SKPOS.SSC, SKPOS.CRD, website, applications, receiver, control software
  - ✓ Reprocessing back to the antenna change date / start station

Velocity computation

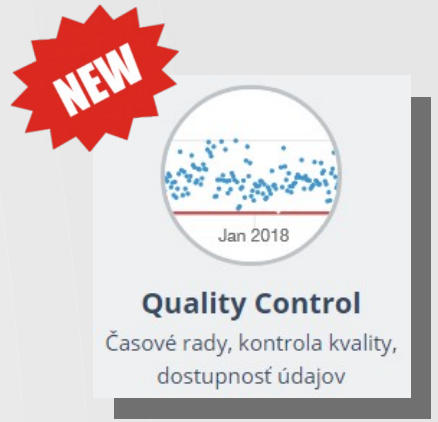
TS PRO application

- Time series analysis
- Horizontal and vertical velocities estimation
  - ✓ eliminated: jumps (Bernese - FODITS), season variation, anomalies, outliers
- Residual velocities = represent geodynamic of Slovakia towards Eurasian tectonic plate





SK*POS*® Quality Control



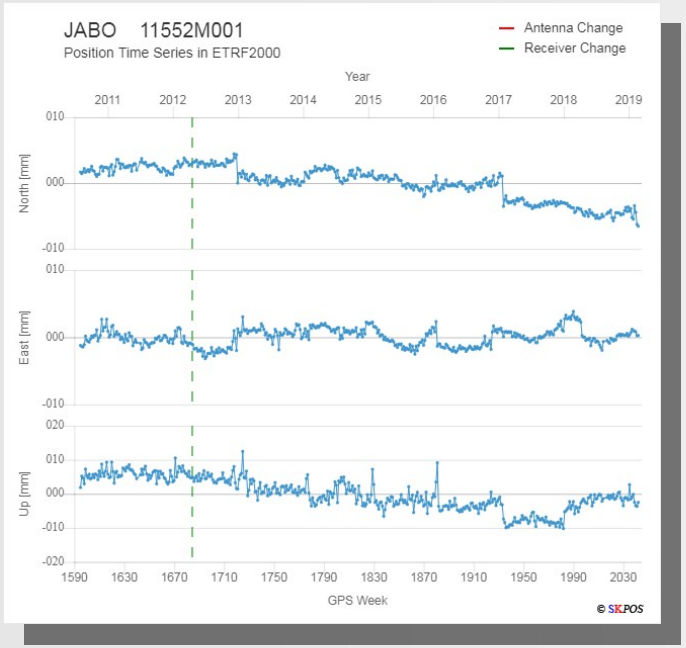
- web application developed at GKU for monitoring:
  - ✓ Time Series
  - ✓ Ambiguity resolution
  - ✓ Data Quality:
    - ➢ Number and percentage of observations
    - ➢ Multipath errors
    - ➢ Cycle slips
    - ➢ SNR
  - ✓ Skyplots
  - ✓ RINEX availability
  - ✓ Real-time data delay (SITE → control software)

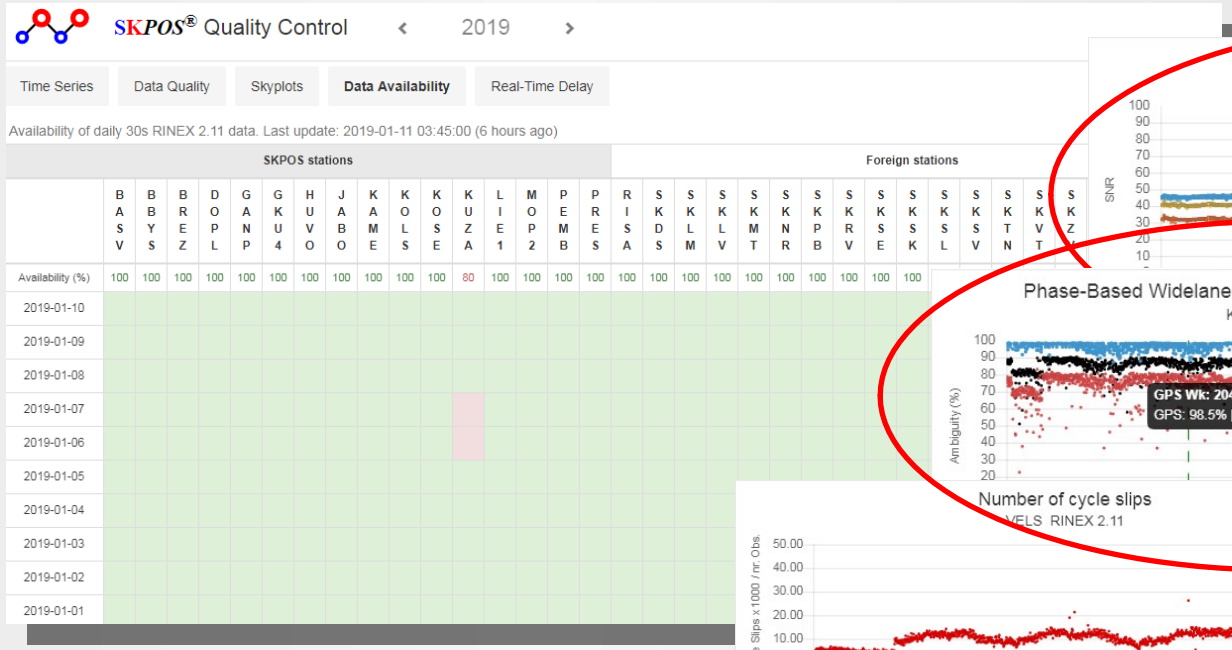
SK*POS*® Quality Control

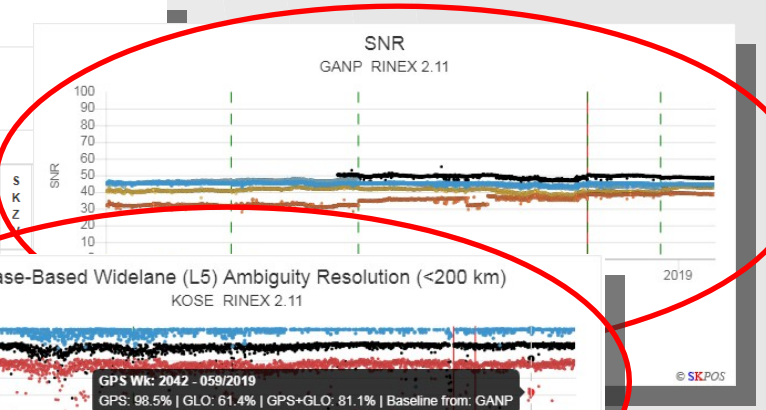
- Input data:
  - ✓ SINEX (Bernese GNSS Software 5.2)
  - ✓ RINEX v2 (G-Nut/Anubis 2.2.3)
  - ✓ Real-time data (Trimble Pivot Platform)
- Output data:
  - ✓ Plots
    - Time series
    - Ambiguity resolution
    - Observations, cycle slips, multipath errors, SNR
    - Skyplots
  - ✓ Tables
    - RINEX availability
    - Real-time data delay
- 86 stations (SKPOS / foreign SKPOS / EPN)

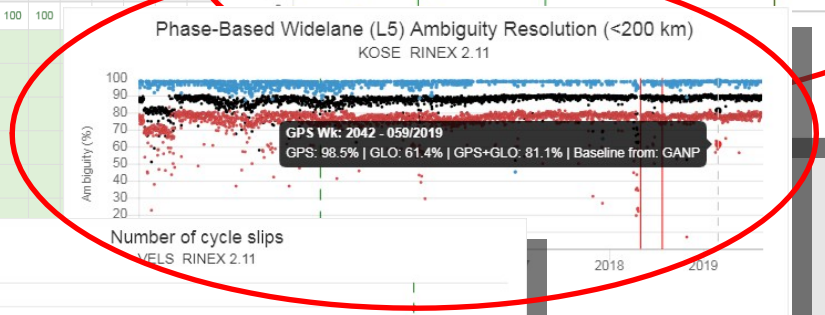
SKPOS® Quality Control

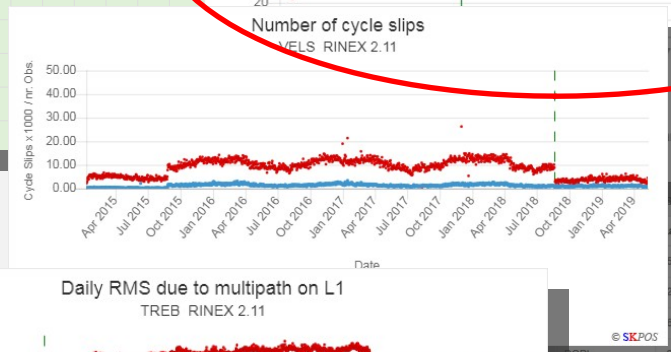
RINEX v2
GPS+GLO

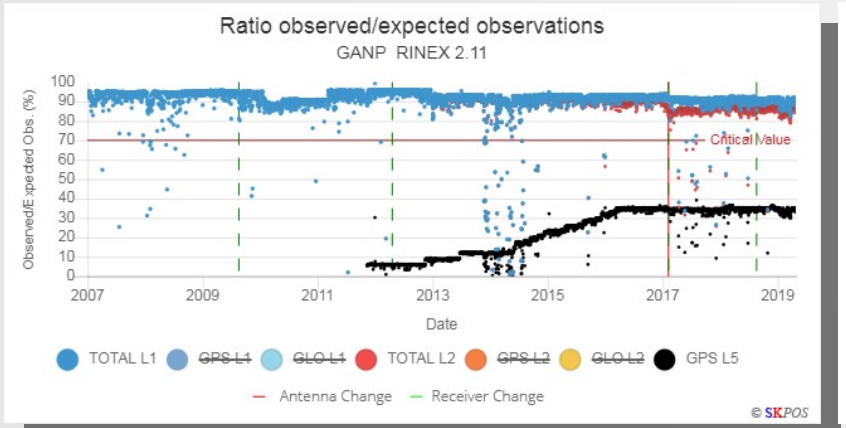


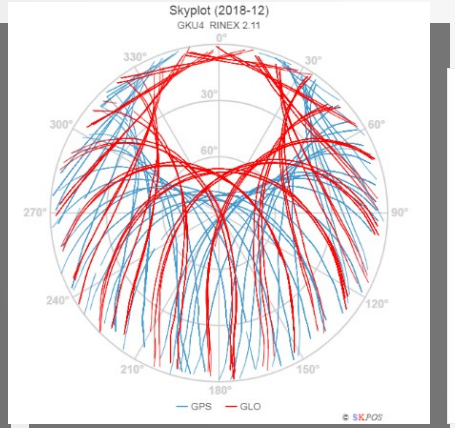


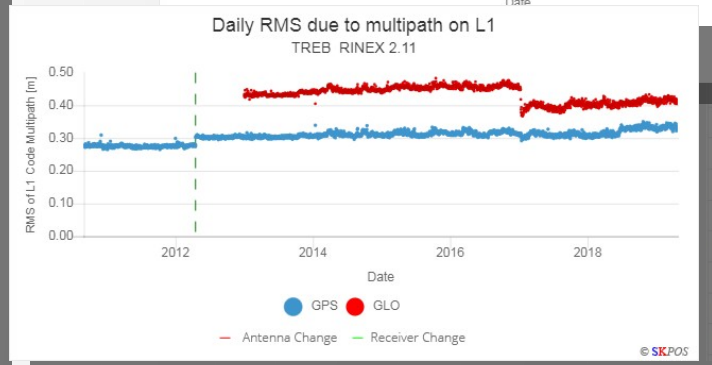


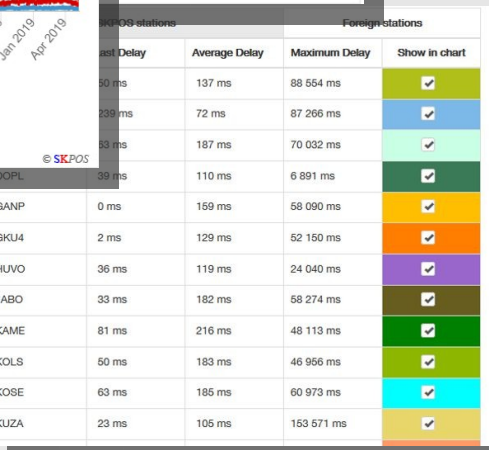






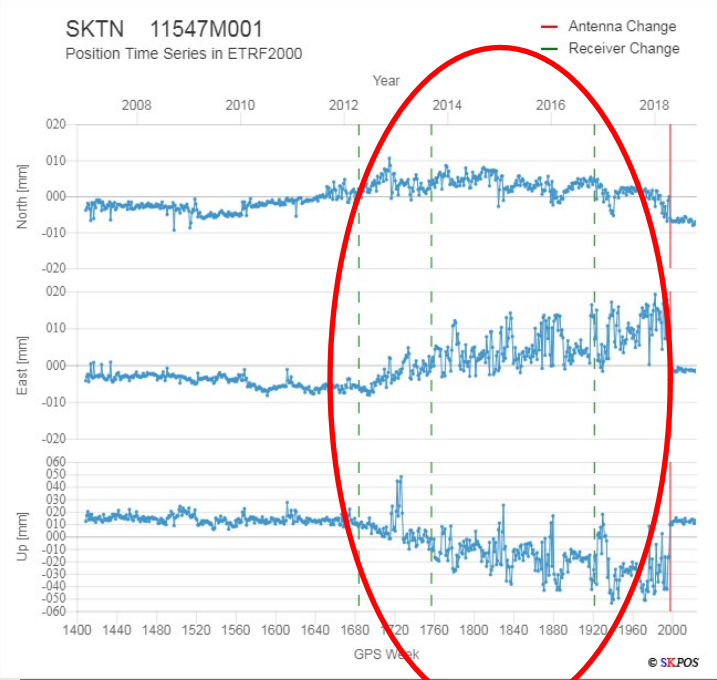






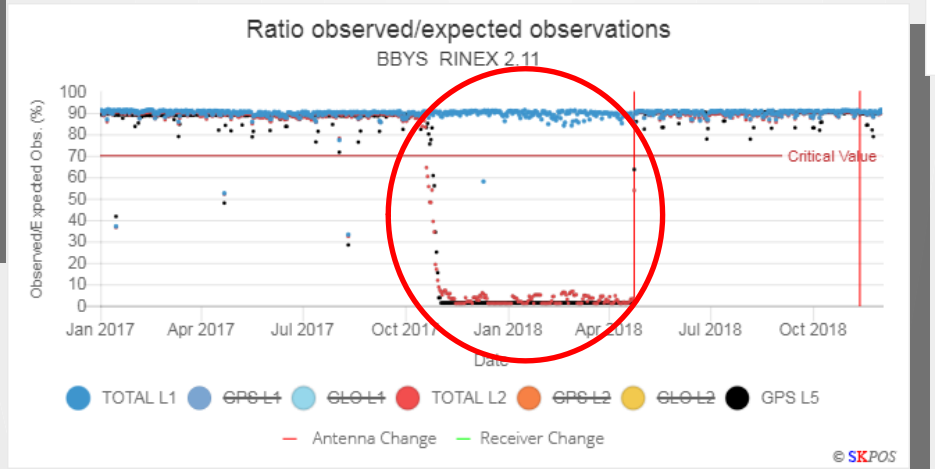
SKPOS® Quality Control

Antenna problems (Trimble ZG-2, S/N: 3013)

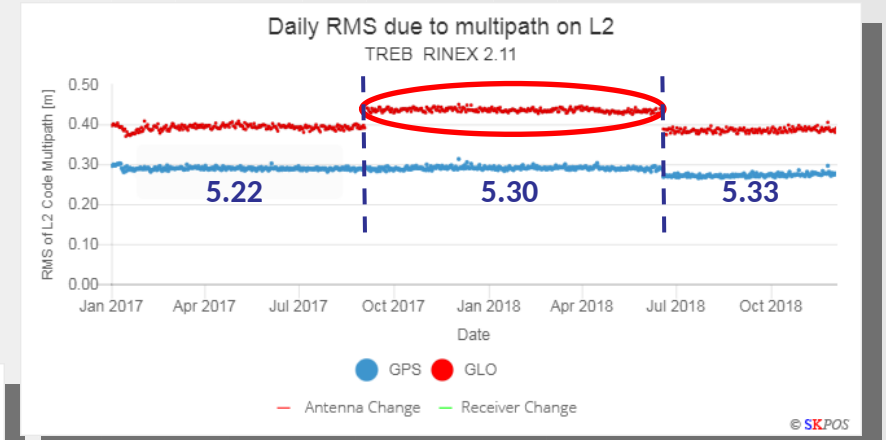


Detected problems

Lost signals at L2, L5 freq. (Trimble ChokeRing)



Trimble NETR9 firmware v5.30 problem



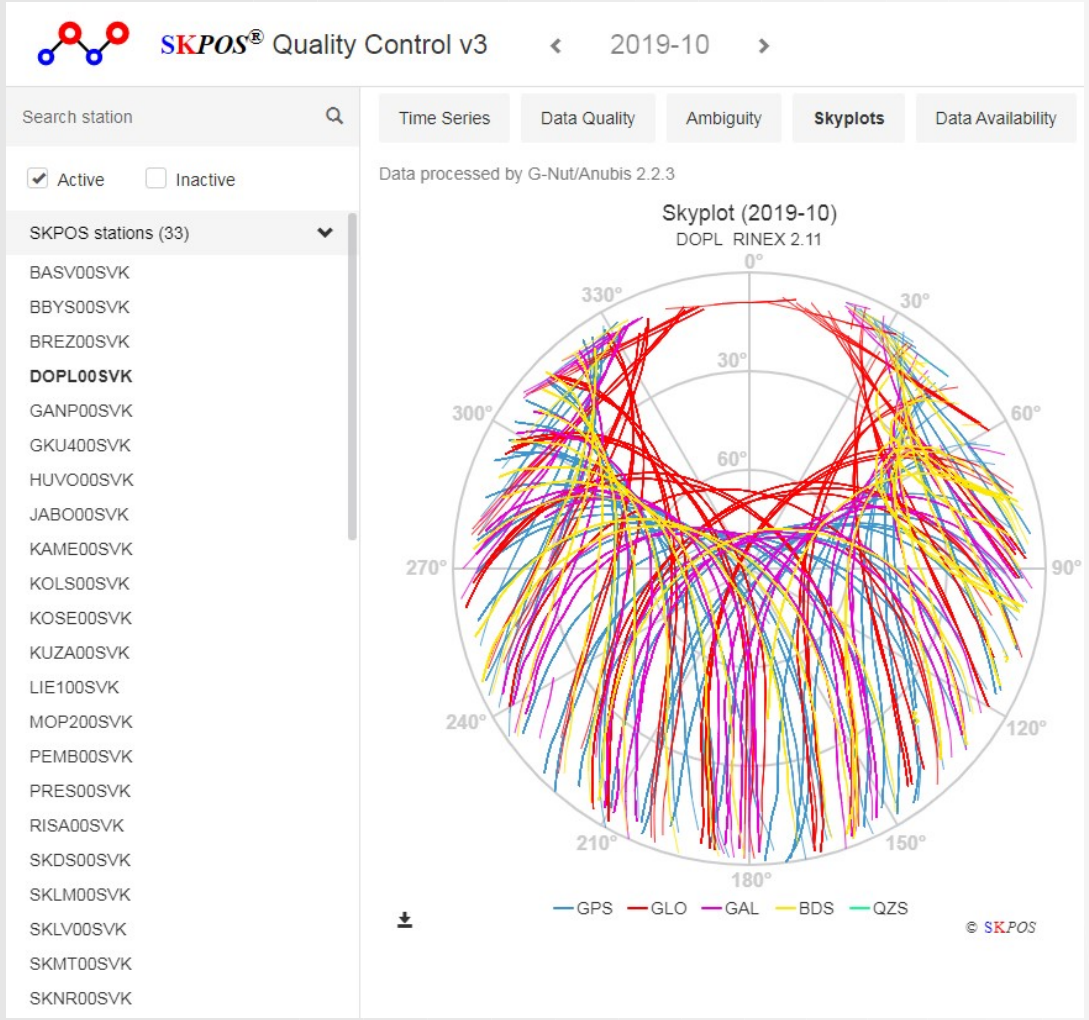
NEW

SKPOS® Quality Control v3

(under development)

RINEX v3

GPS+GLO+GAL+BDS+QZS



Availability of daily 30s RINEX v3. Last update: 2019-10-08 03:45:00 (3 hours ago)

	SKPOS stations																Foreign stations																	
	BASV00SVK	BBYS00SVK	BREZ00SVK	DOPL00SVK	GANP00SVK	GKU400SVK	HUVO00SVK	JABO00SVK	KAME00SVK	KOLS00SVK	KOSE00SVK	KUZA00SVK	LIE100SVK	MOP200SVK	PEMB00SVK	PRES00SVK	RISA00SVK	SKDS00SVK	SKLM00SVK	SKLV00SVK	SKMT00SVK	SKNR00SVK	SKPB00SVK	SKRV00SVK	SKSE00SVK	SKSK00SVK	SKSL00SVK	SKSV00SVK	SKVT00SVK	TELG00SVK	TRCN00SVK	TREB00SVK	VELS00SVK
Availability (%)	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35
2019-10-07																																		
2019-10-06																																		
2019-10-05																																		
2019-10-04																																		
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2019-09-28																																		
2019-09-27																																		
2019-09-26																																		
2019-09-25																																		
2019-09-24																																		

Conclusion

- 1.1.2020 – SKPOS Quality Control v3 (official version)
- 1.1.2020 – Bernese GNSS processing using RINEX v3 data
- 1.1.2020 – Bernese GNSS Processing using Galileo
- 2020 – complete reprocessing (2007 - 2020)
  - ✓ fixed all bugs in Bernese processing
  - ✓ new coordinates estimation
  - ✓ new velocity estimation

Thank you!

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