National report of Slovakia 2019

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EUREF 2019 SYMPOSIUM
TALLINN 22 May – 24 May 2019

Outline

- Slovakian activities towards to EPN
- News from:
  - SK*POS*® (Slovak real time determination system)
  - national levelling network
  - national gravimetric network
- R&D
  - Geodetic and Cartographic Institute activities
  - Slovak University of Technology activities
  - Slovak Academy of Sciences activities
- Other news

Slovakian EPN Operational and Local Analysis Centers

Geodetic and Cartographic Institute
Bratislava (GKÚ) – EPN OC

Slovak University of Technology
in Bratislava (SUT) – EPN LAC

SUT - EPN Local Analysis Center activity

<u>EPN subnetwork computation:</u>

- 59 EPN permanent stations
- Bernese GNSS Software Version 5.2
- Reference frame IGS14

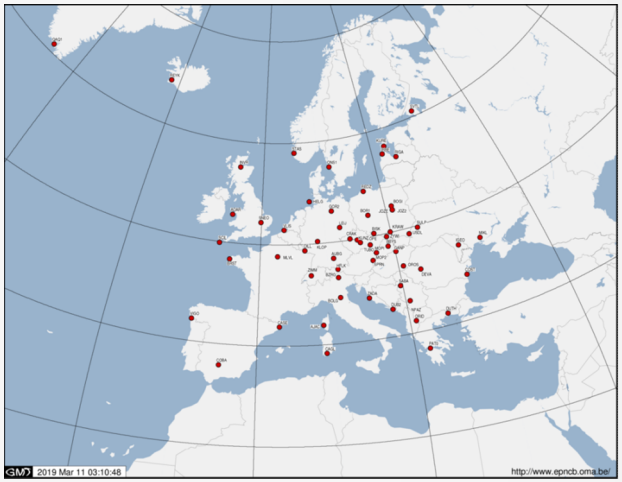
<u>Analysis Centre Solutions:</u>

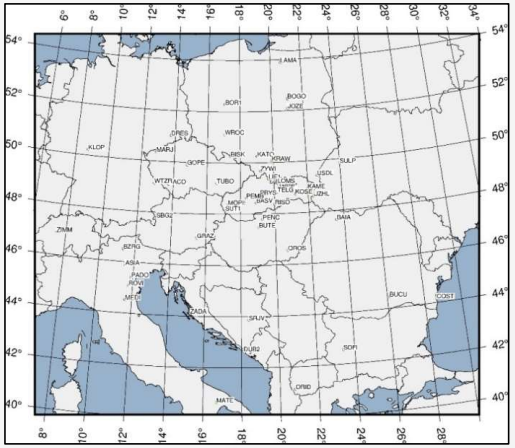
- Final Weekly Coordinate Solution (1180 - now)
- Final Daily Coordinate Solution (1180 - now)
- Rapid Daily Coordinate Solution with Galileo (2044 - now)

NEW

<u>CEPER network computation:</u>

- 55 permanent stations from Central Europe region
- GPS/GLONASS and GLONASS only solutions (1774 – now)



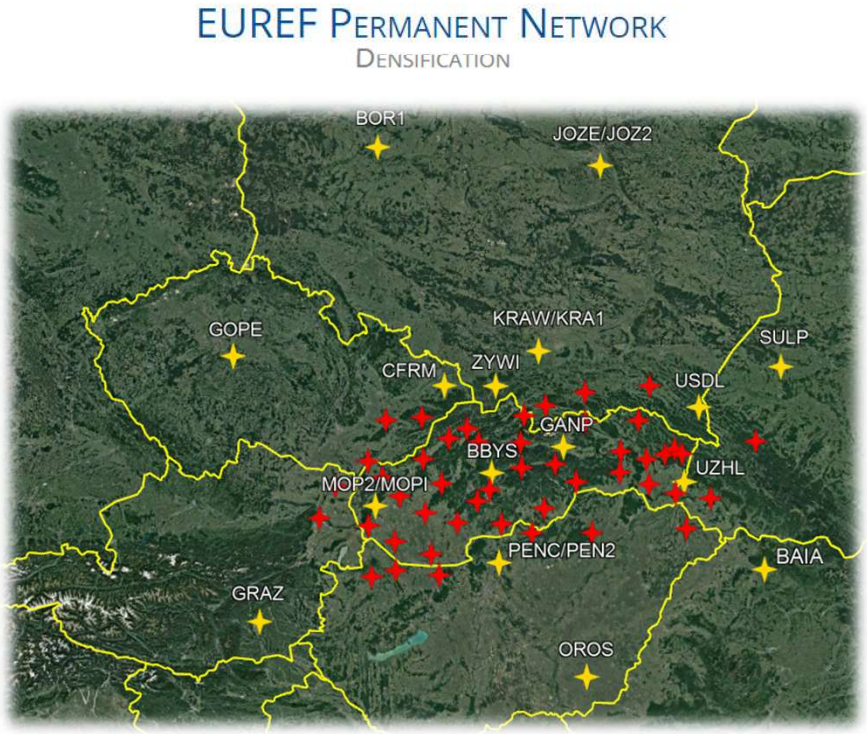


GKU – EPN Operational center activity

Bernese GNSS Software Version 5.2

Slovak subnetwork solution (GKUwwww7.SNX):

- weekly solution
  - 34 Slovak reference stations (4 EPN)
  - 32 foreign reference stations (14 EPN)
- New reference frame (IGS14) and an updated set of antenna calibrations (igs14.atx) adopted from GPS week 1983.



Slovakian EPN permanent stations

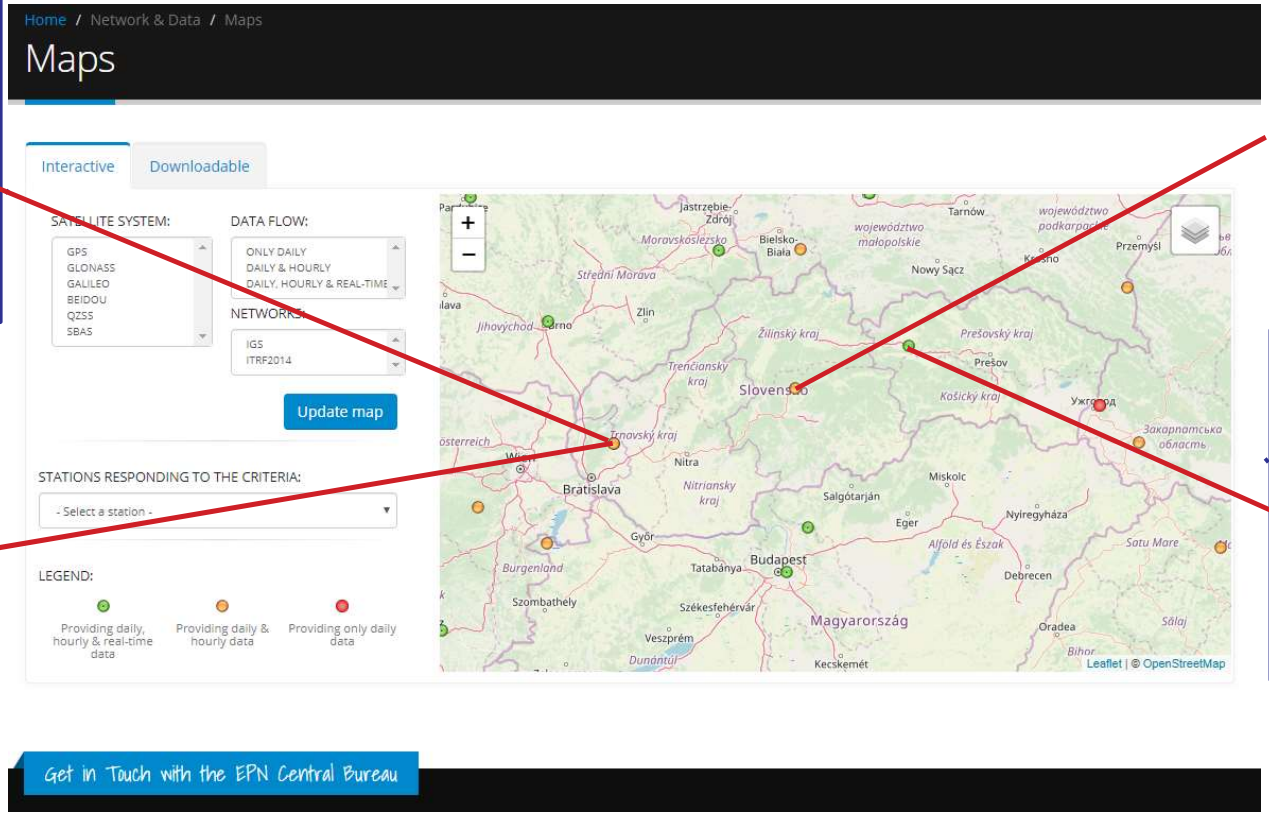
Slovakian EPN Real-time service permanent stations

MOP2

Class A

MOPI

Class B



BBYS

Class A

GANP

Class B

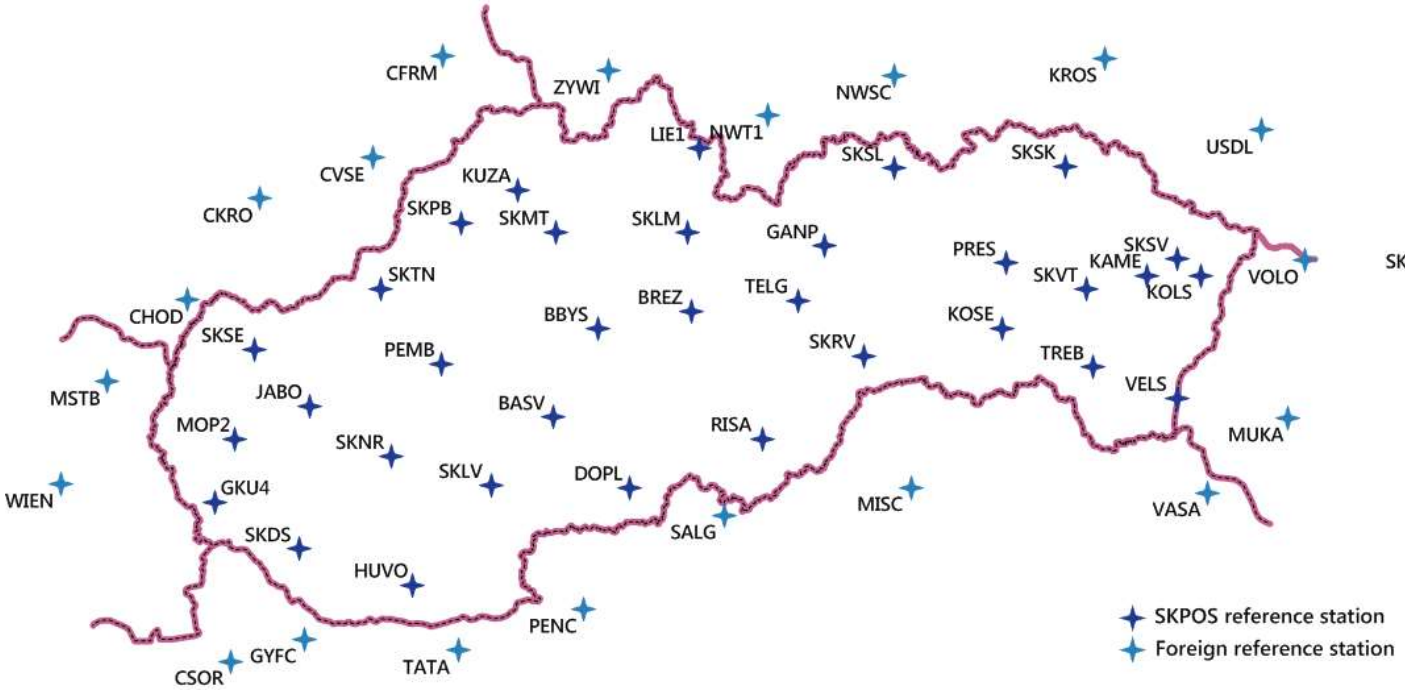
Slovak real-time positioning system

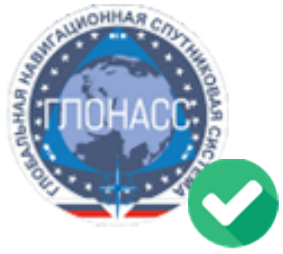
SK*POS*®

SKPOS®

CORS infrastructure (May 2019)

- **33 Slovakian reference stations (20 individual calibrated)**
  - 33/33 stations observe GPS+GLONASS+Galileo+BeiDou
  - Network density: average distance is 44,6 km
- **21 foreign reference stations (APOS, gnssnet.hu, CZEPOS, ASG-EUPOS, ZAKPOS)**

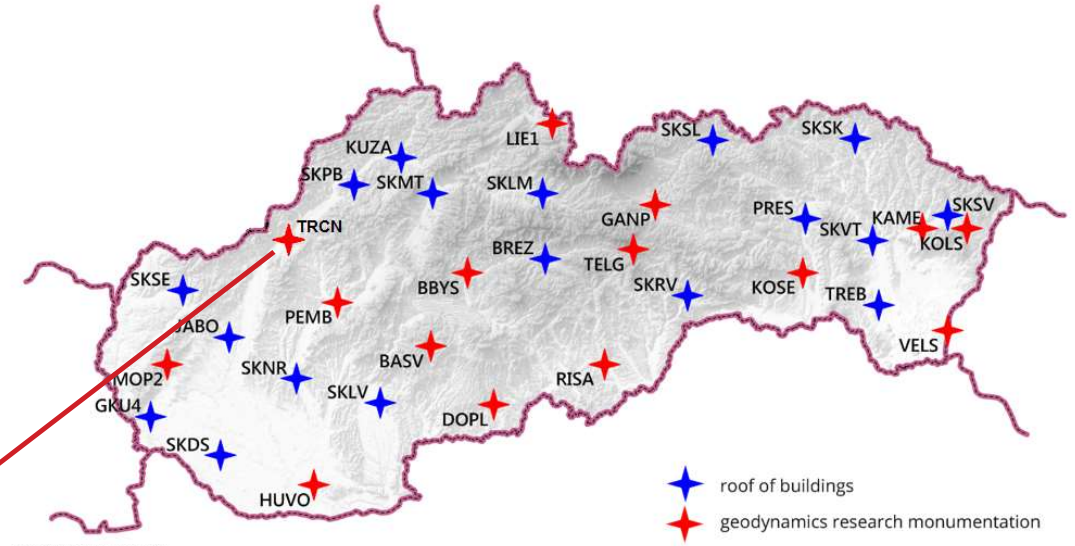


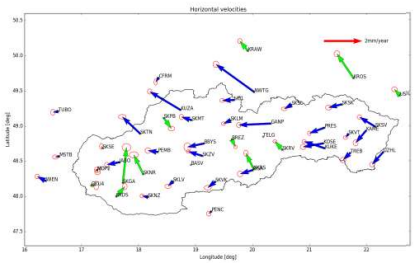


SKPOS®

CORS infrastructure for geokinematics

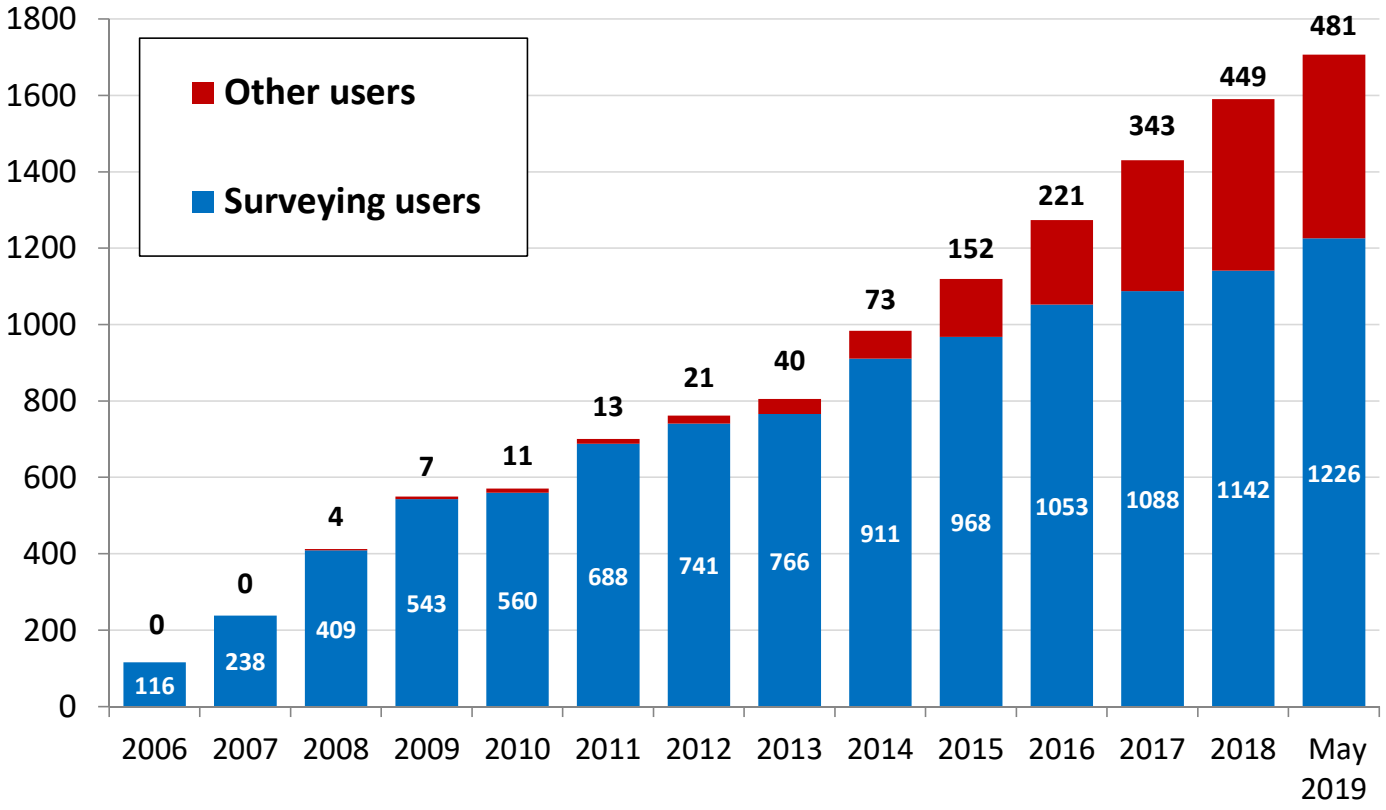
- 15 of 33 slovakian SKPOS permanent stations (45%) have monumentation suitable for geokinematics





SKPOS®

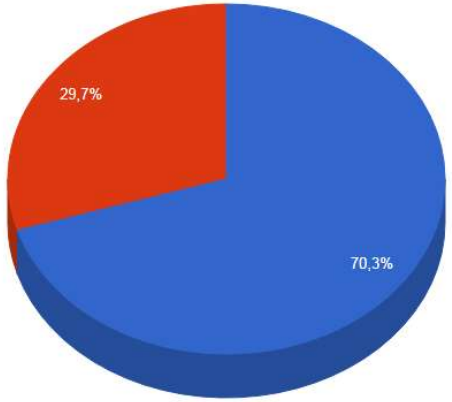
Number of users



SKPOS®

Type of users

- Surveying fields (cadastre, surveying, mapping, GIS) - **70%**
- Other fields (precise agriculture, machine guarding) - **30%**



SKPOS®

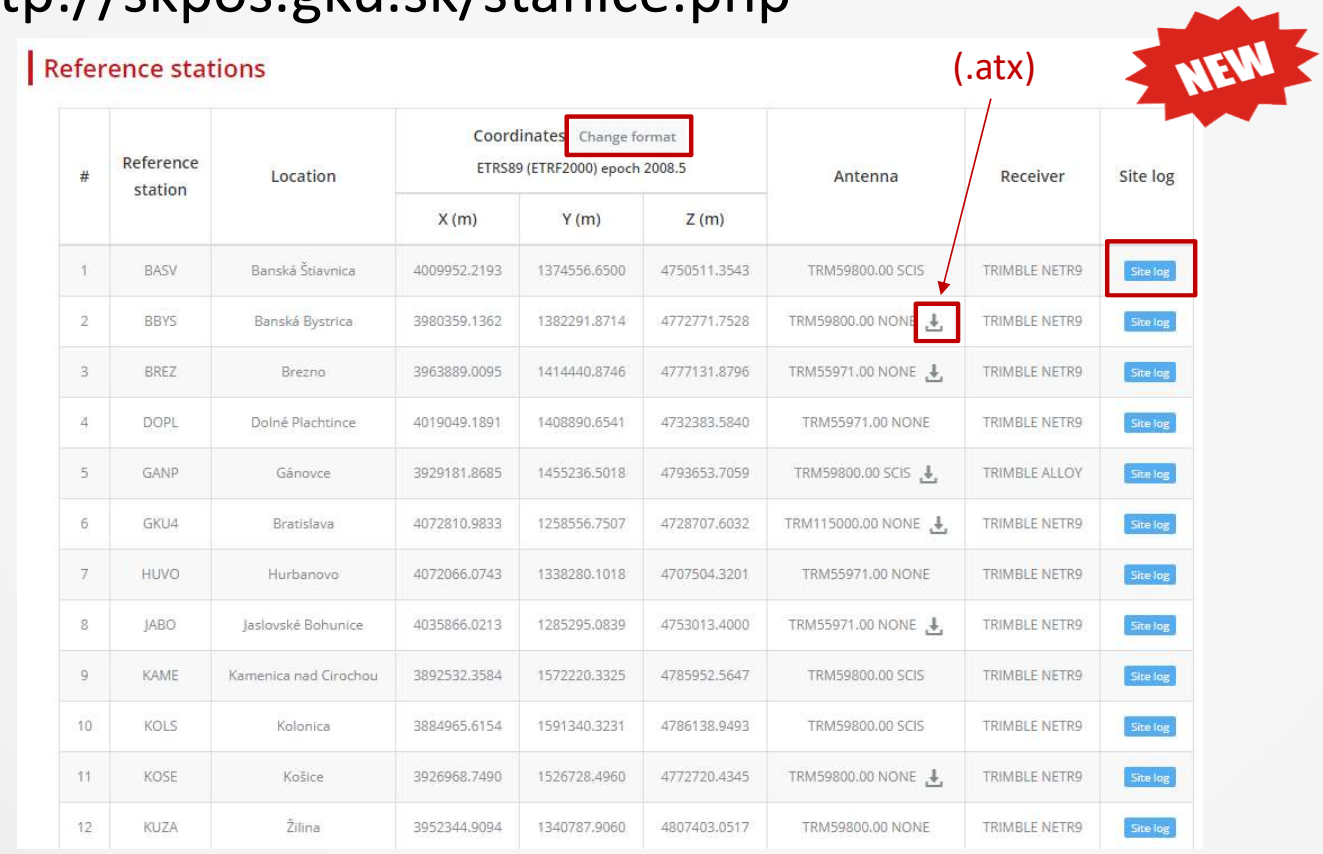
Galileo and BeiDou full support

SKPOS	Component	Date of availability	
Hardware	Antennas	2018-10-12	✓ 33 (33) stations
	Receivers		✓ 33 (33) stations
Software Trimble Pivot	RINEX from CORS		✓ 33 (33) stations
	RINEX from VRS	2018-10-16	✓
	RTK (VRS)		✓

SKPOS®

News on web

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



Reference stations

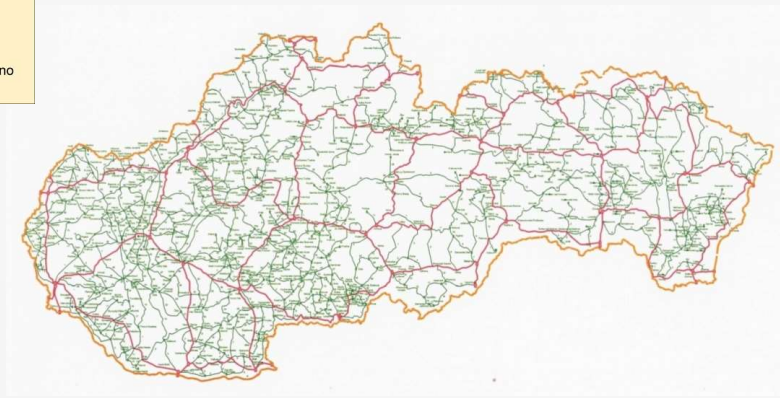
#	Reference station	Location	Coordinates Change format ETRS89 (ETRF2000) epoch 2008.5			Antenna	Receiver	Site log
			X (m)	Y (m)	Z (m)			
1	BASV	Banská Štiavnica	4009952.2193	1374556.6500	4750511.3543	TRM59800.00 SCIS	TRIMBLE NETR9	Site log
2	BBYS	Banská Bystrica	3980359.1362	1382291.8714	4772771.7528	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	TRM59800.00 SCIS	TRIMBLE NETR9	Site log
11	KOSE	Košice	3926968.7490	1526728.4960	4772720.4345	TRM59800.00 NONE	TRIMBLE NETR9	Site log
12	KUZA	Žilina	3952344.9094	1340787.9060	4807403.0517	TRM59800.00 NONE	TRIMBLE NETR9	Site log

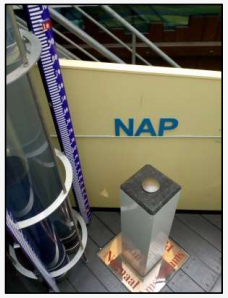
National levelling network

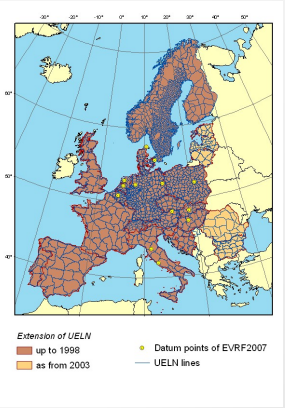
Height system

Plan to switch to the new height system
Baltic (Bpv) → EVRS (EVRFyyyy)

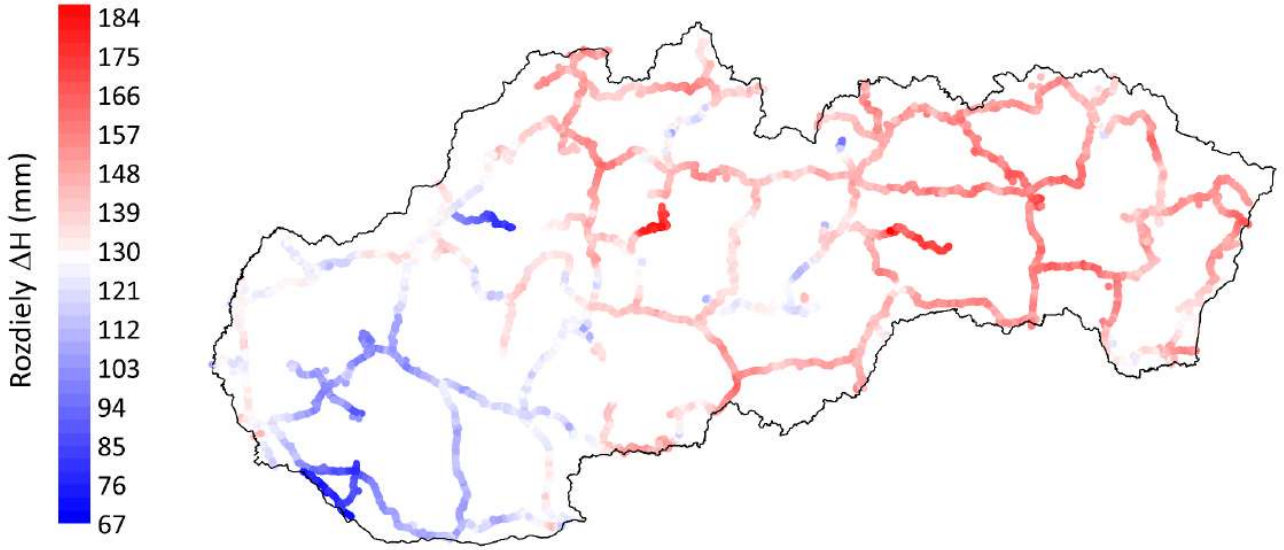
- Present status (2019):
  - **Bpv** (Bpv 1957) EPSG:8357
  - Tide gauge: Kronstadt
  - Normal heights (Molodenski)
- Plan (cca from 2025):
  - **EVRS** (EVRF2018)
  - Tide gauge: NAP (Amsterdam) $\mathbf{W_0 = W_{0E}}$ **(NAP)**
  - Normal heights / geopotential numbers







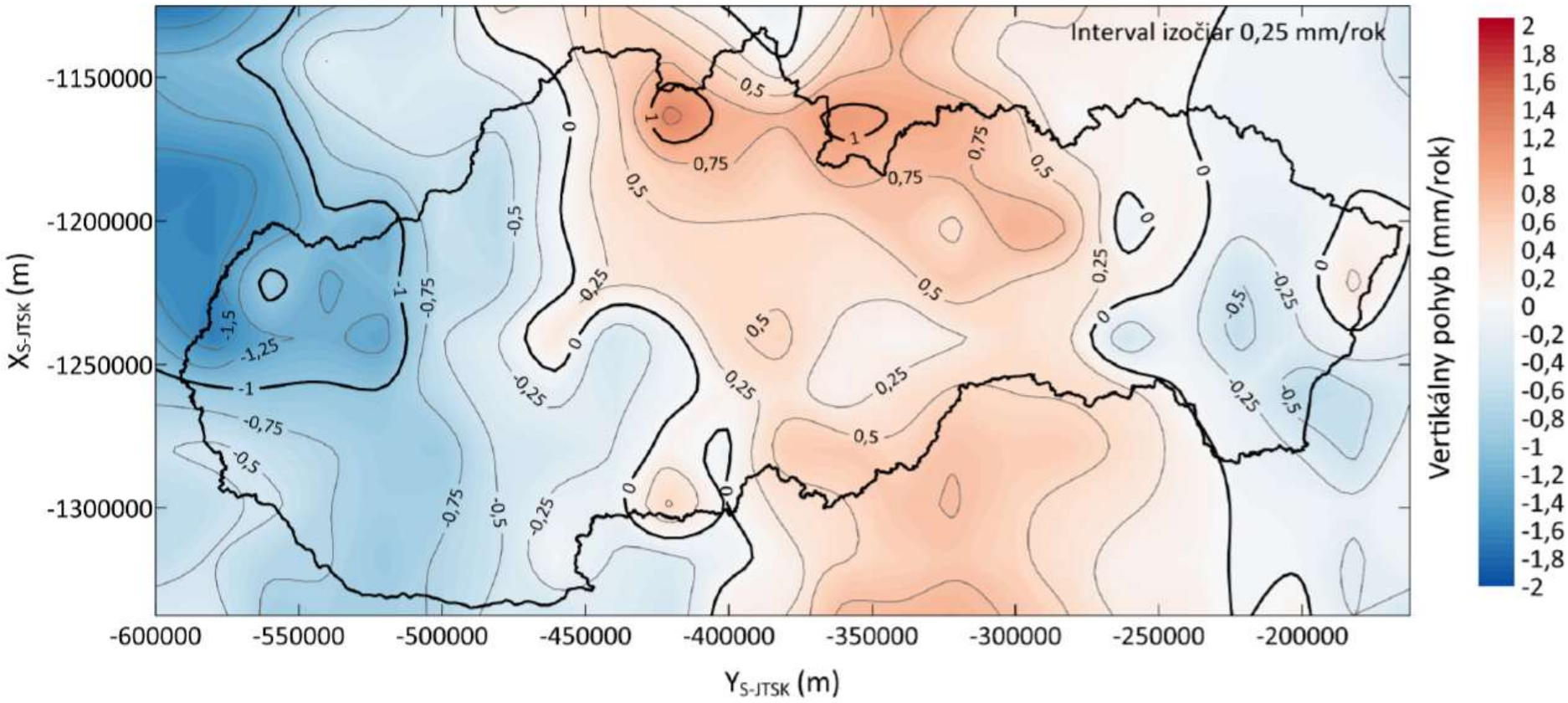
Plan to switch to the new height system
Differences between Baltic (Bpv) and EVRS (EVRF2007)



Differences (EVRS – Bpv)	
Number of values	13 753
Min value	67 mm
Max value	185 mm
Average	134 mm

Differences represents:
- Tide gauge difference (NAP – Kronstadt)
- Tide system difference
- Computation difference

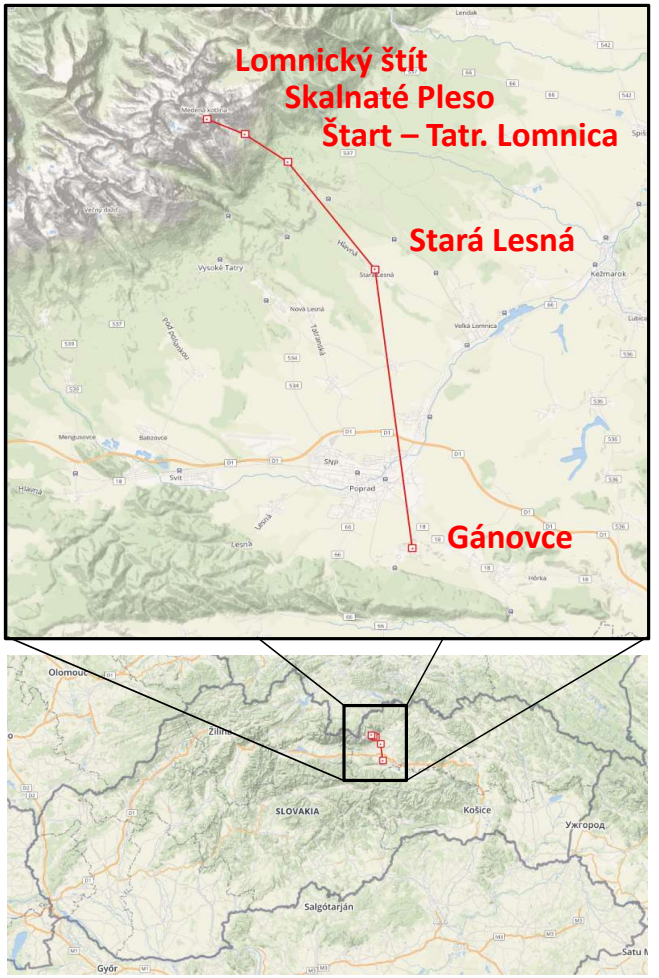
Map of the recent vertical movements from spirit levelling (1949-2016)



National gravimetric network

New absolut gravity measurements on the Vertical gravimetric baseline

- Locality: Tatra mountains (5 points)
- Gravity difference: ≈ 441 mGal
- Height difference: 1935 m
- Highest point: Lomnicky peak 2634 m
- Absolute measurements
  - in 2016 and 2017: FG5X-251 (GOP, CZE)
  - In 2018: FG5X-247 (SUT, SVK)



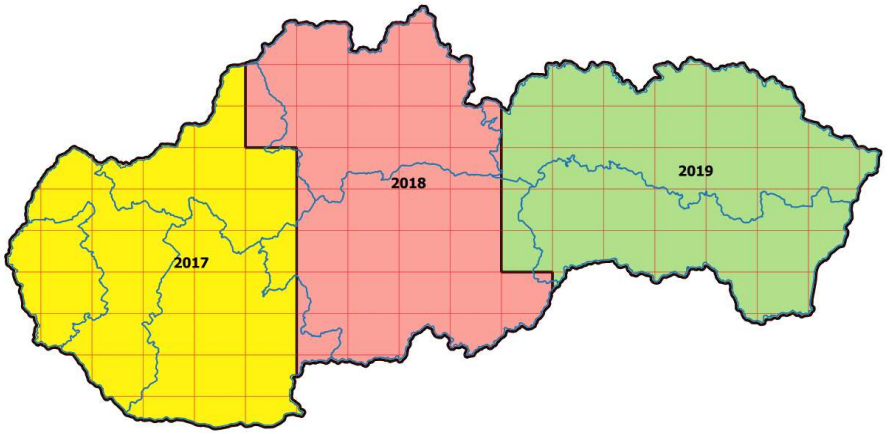
Geodesy, Cartography and Cadastre Authority of Slovak Republic news

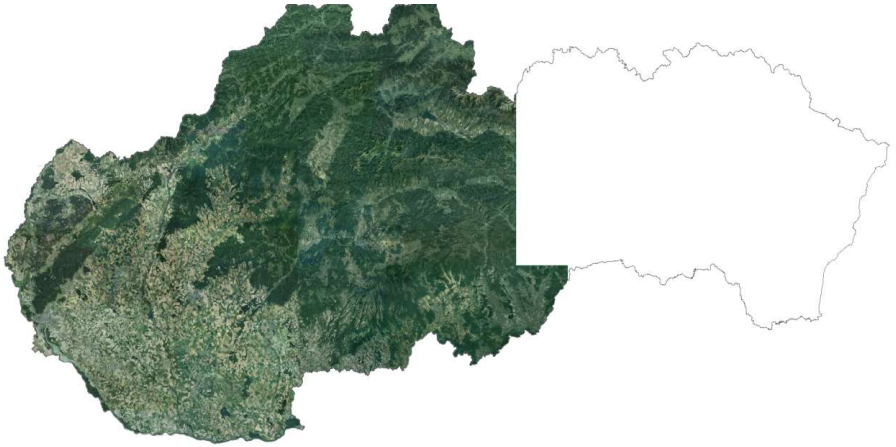
Orthophotos of Slovakia

- Cooperation between GCCA and Ministry of agriculture

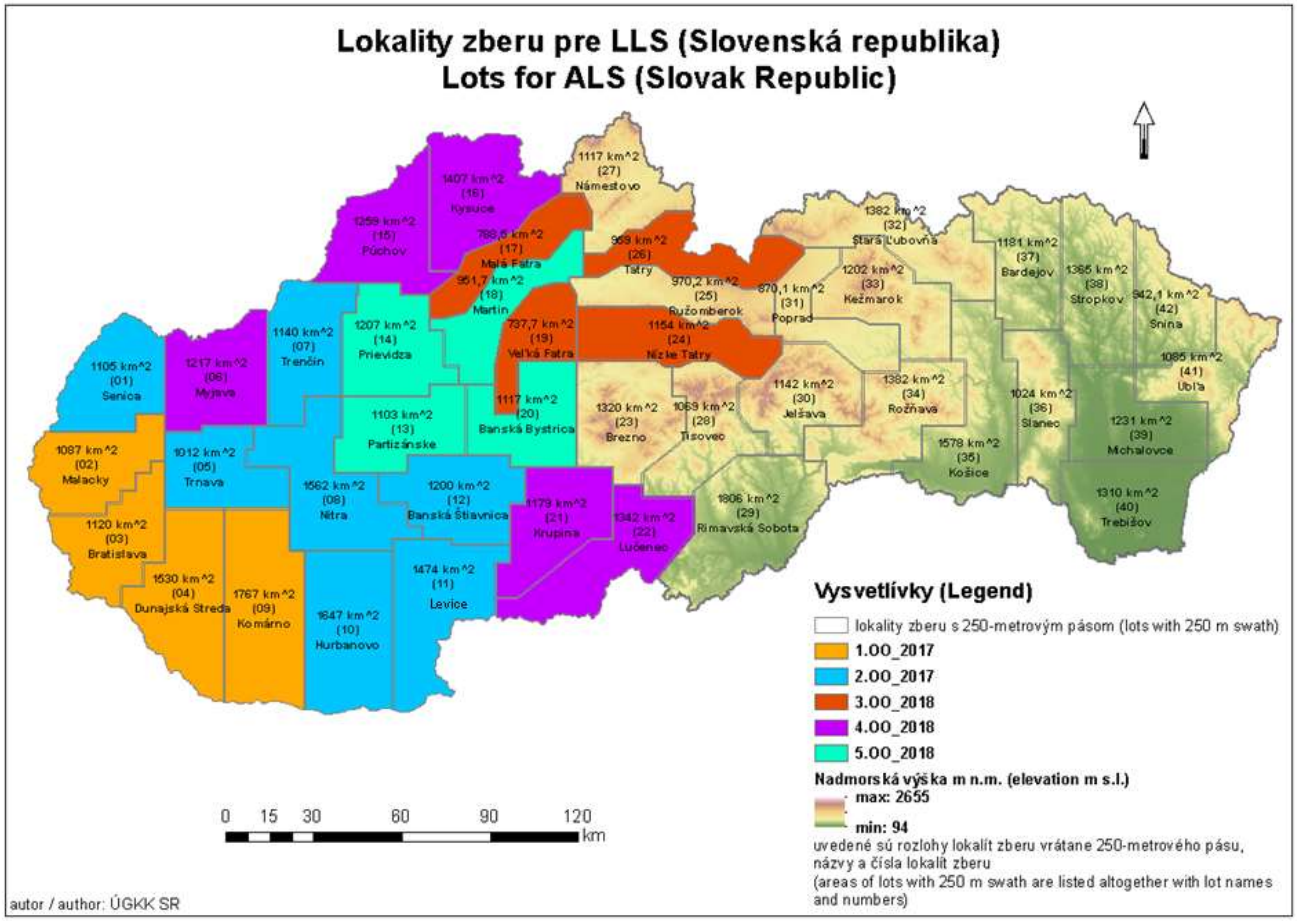
- Quality parameters:
  - GSD – 0,25 m,
  - $RMSE_{xy}$=0,35 m (West part)
  - $RMSE_{xy}$=0,30 m (Central part)

- Data are provided free of charge:
  - raster data
  - wms 1.3.0
  - Geoportal

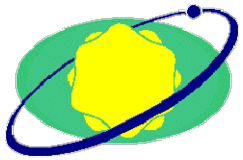




Digital elevation model (in progress)



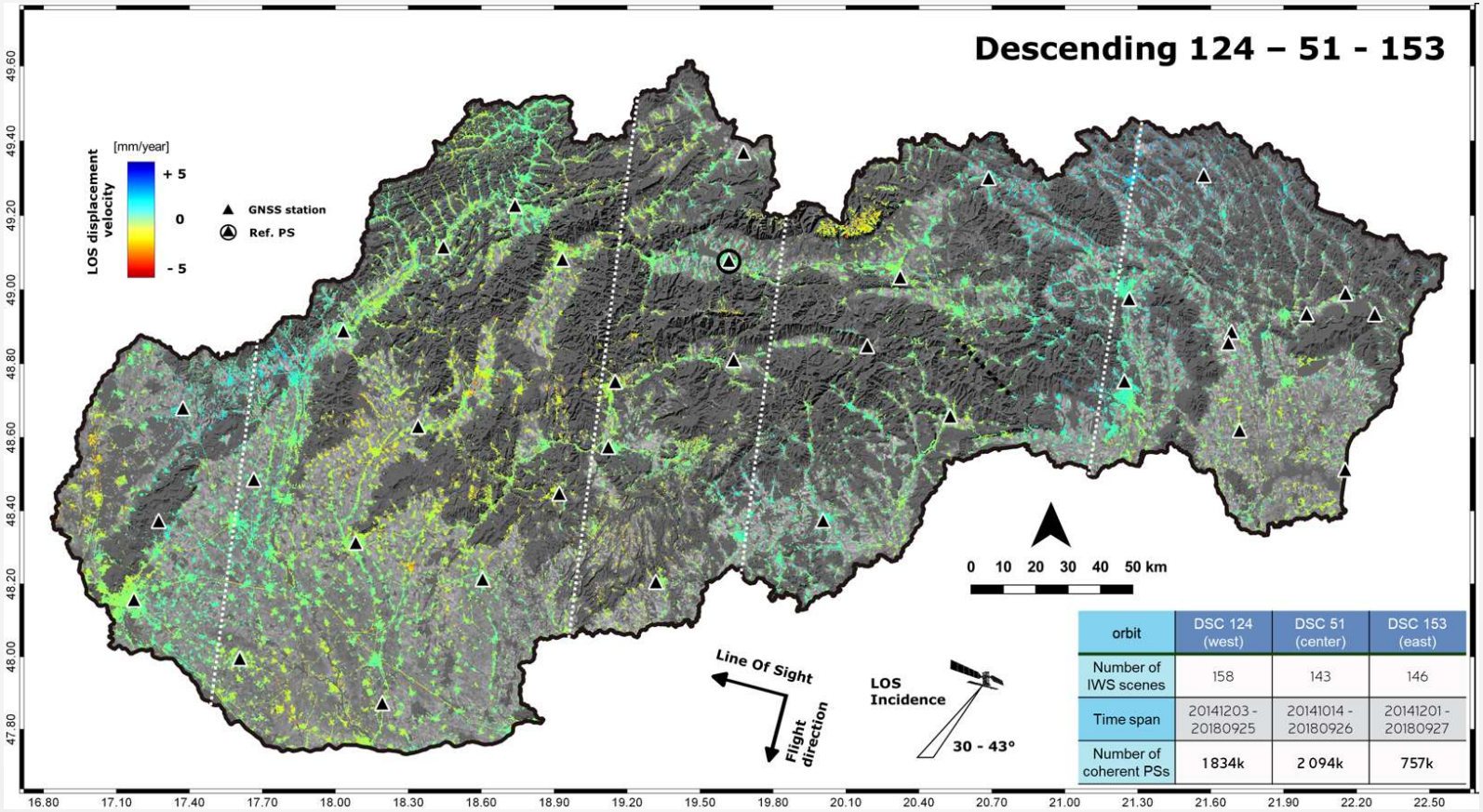
- airborne laser scanning
- density min.15 points/m^2
- $m_{XY} \leq 0{,}50$ m in ETRS89-TM34
- $m_h \leq 0{,}11$ m in ETRS89
- DEM 1m resolution



Slovak University of Technology
R&D activities

PS InSAR Sentinel-1 satellite

Surface deformation monitoring system for Slovakia (2014-2018)

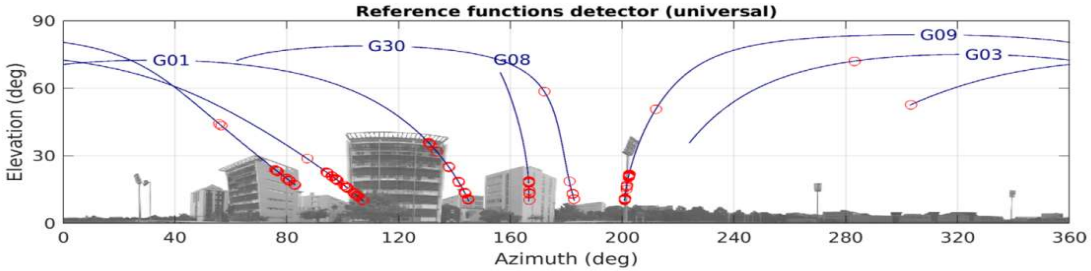


New integrated geodetic and geophysical observatory in Hurbanovo

- Instruments: relative gravimeter gPhoneX #108, absolute gravimeter FG5X-247, accelerometer, permanent GNSS station, local weather station and soil moisture sensors.
- Applications to geodynamics research, geophysics, tides and hydrology.
- Institutions: Earth Science Institute of the Slovak Academy of Sciences, Slovak University of Technology in Bratislava and Geodetic and Cartographic Institute Bratislava.

GNSS phase multipath detection

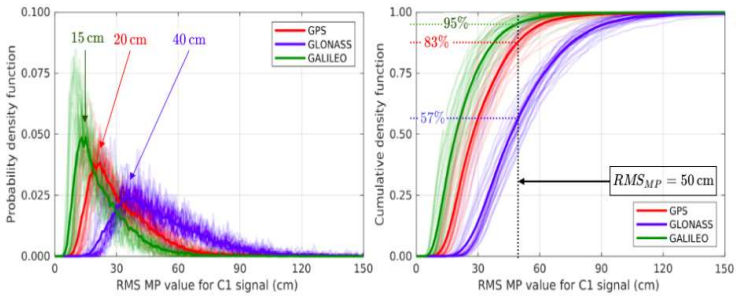
- <u>multipath detection using SNR combination</u>
  - uses actual SNR values at 2 or 3 different frequencies and compare it with reference functions obtained from measurement in low-multipath environment



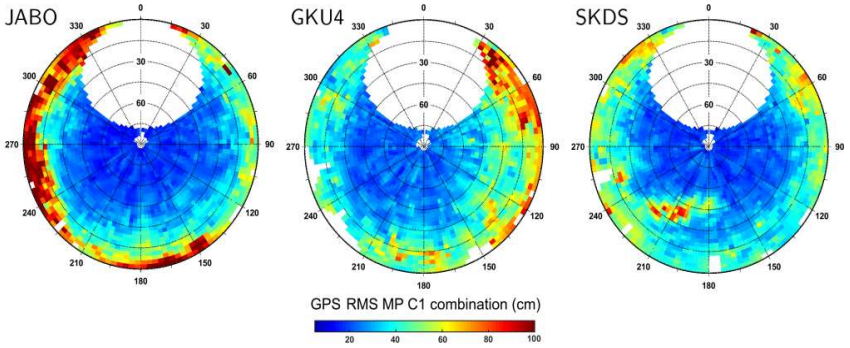
For more details see: Špánik, P., García-Asenjo , L. and Baselga, S.: Optimal combination and reference functions of signal-to-noise measurements for GNSS multipath detection, Meas. Sci. Tech. 30 (2019)

- <u>Analysis of multipath effect in **SK*POS*®** network</u>
  - assess global level of code multipath in the network and to selected stations will be examined in more detail with DD residuals testing

Overall level of code multipath at SKPOS stations

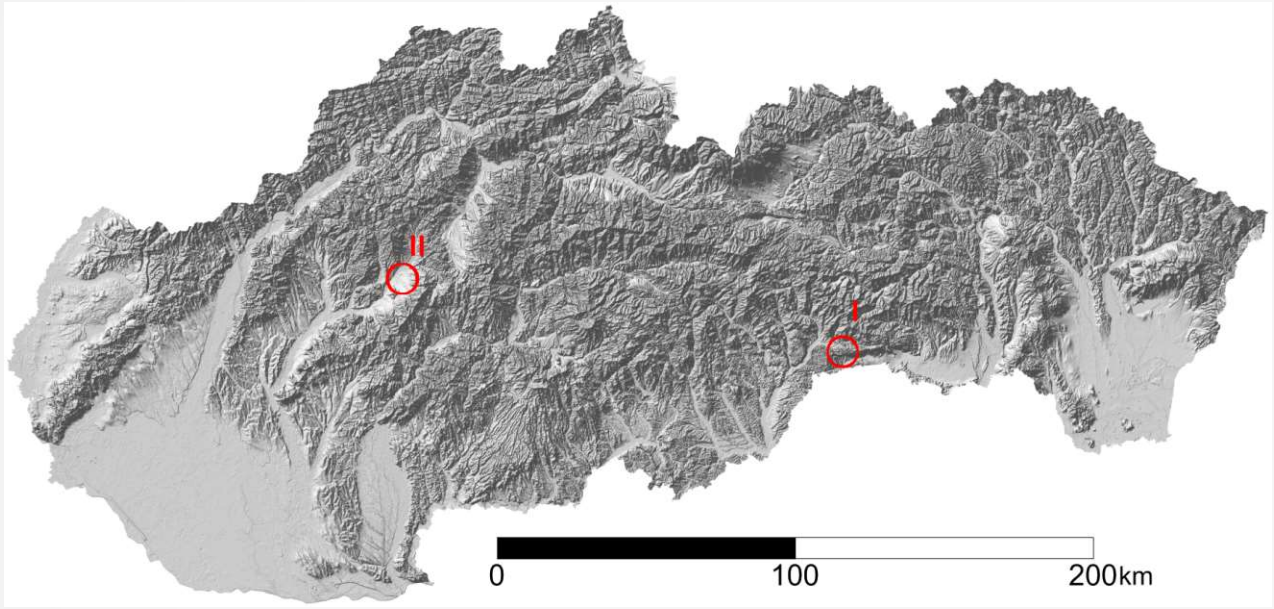


Stations selected for further investigation

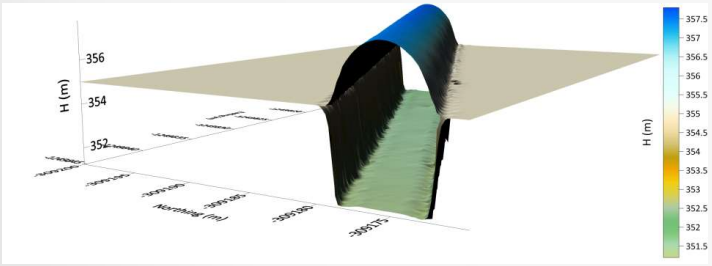


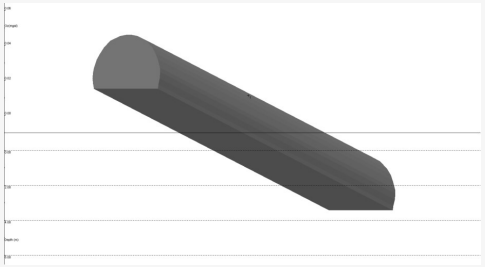
Slovak Academy of Science
R&D activities

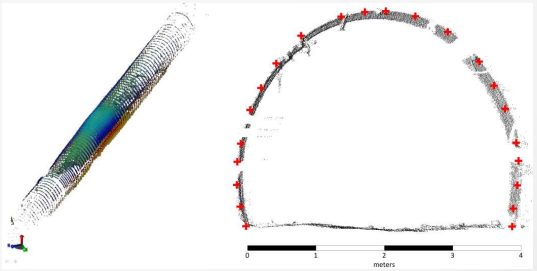
MODERN APPROACH TO ROCK DENSITY DETERMINATION FROM UNDERGROUND GRAVITY MEASUREMENTS



- TWO CASE STUDIES
  - Case study I – railway tunnel in Mesozoic karst rocks
  - Case study II – active coal mine in Neogene sedimentary basin





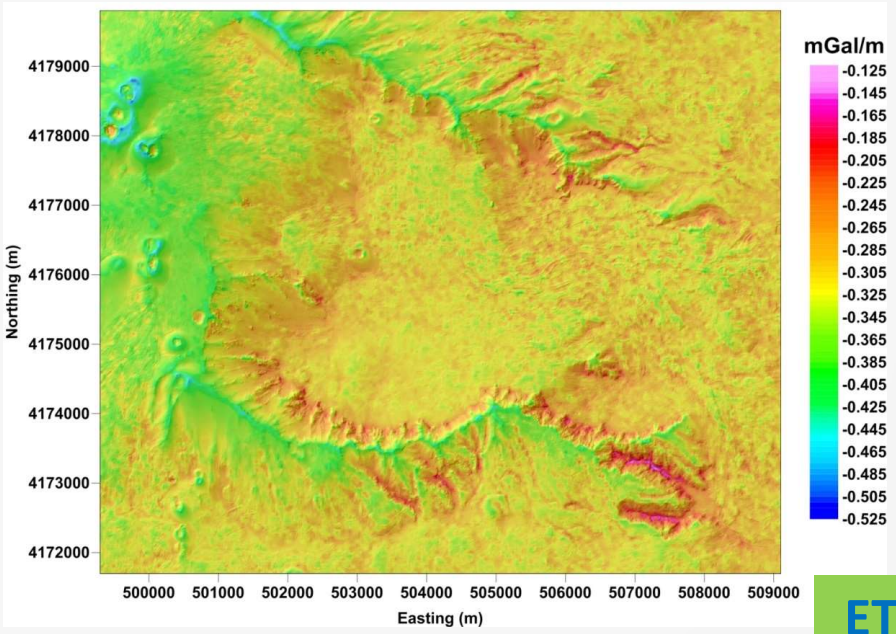


Volcano geodesy / gravimetry

- Replacing the theoretical constant (normal) FAG by the predicted VGG in estimating the Free-Air Effect (FAE)

VGG prediction based on modelling the contribution of topo-masses to VGG

- ❑ High resolution (a few meters) high accuracy (10 cm) DTM
- ❑ Correct choice of constant reference topo-density
- ❑ Numerical volumetric Newtonian integration by means of Toposk software



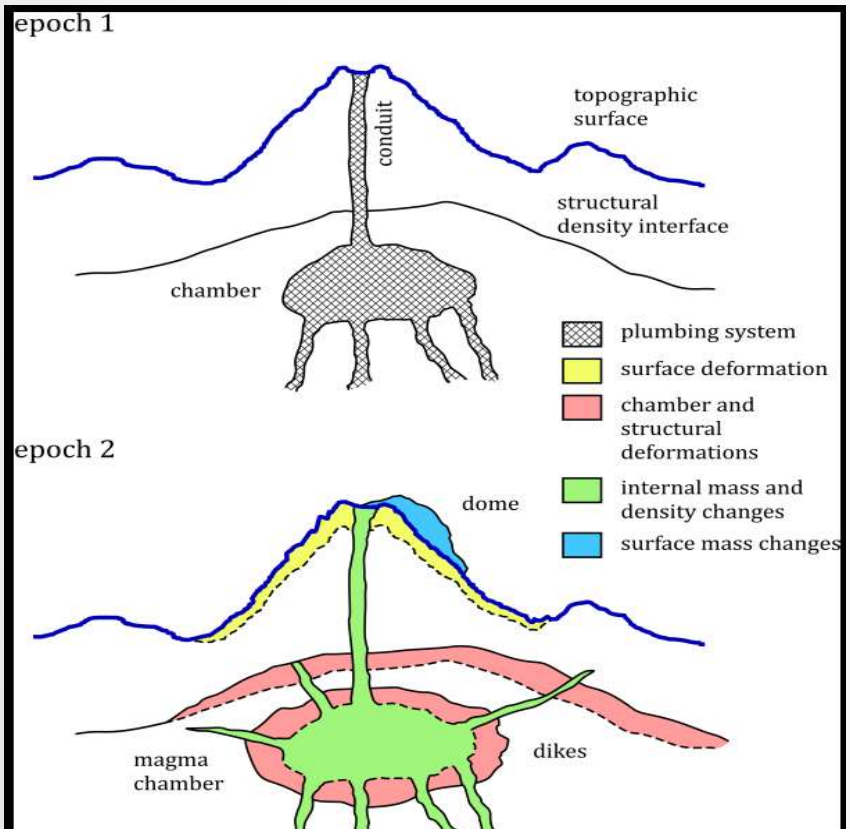
PREDICTED VGG FIELD

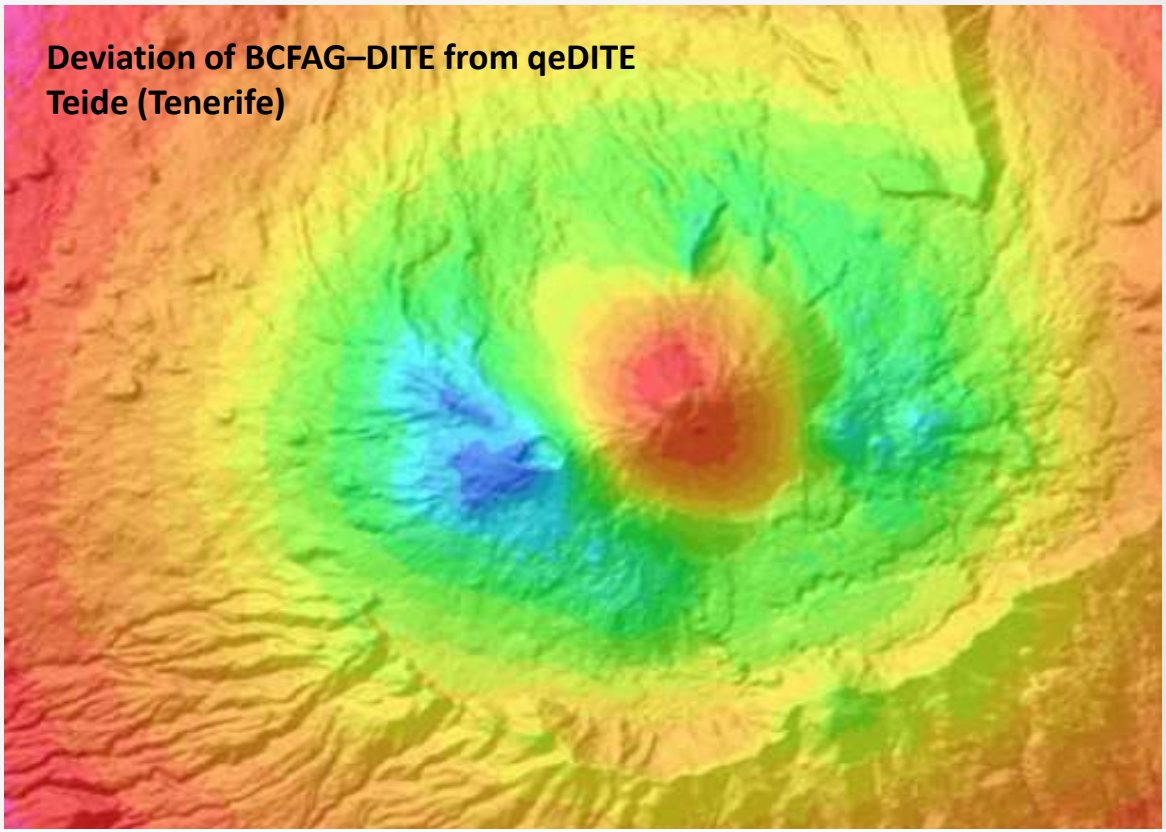
Deviates strongly from constant normal FAG in alpine and volcanic areas of prominent rugged topo-relief

ETNA

Volcano geodesy / gravimetry

- Accurate numerical evaluation of deformation-induced topographic effect (DITE)





Volcano geodesy / gravimetry

SLOVAK-ITALIAN VOLCANO GRAVIMETRIC CAMPAIGN ON ETNA IN JULY 2018

- Verification of predicted VGGs by in-situ observations
  - DEM (DTM/DMR) improvement in near-zone
  - Improvement of gravimetric topo-corrections
  - Improvement of FAE, DITE, residual time-lapse, gravity changes

Volcano geodesy/gravimetry

SLOVAK-ITALIAN VOLCANO GRAVIMETRIC CAMPAIGN ON ETNA IN JULY 2018

Zahorec Pavol, Juraj Papčo, Peter Vajda, Filippo Greco, Massimo Cantarero, Daniele Carbone (2018) Refined prediction of vertical gradient of gravity at Etna volcano gravity network (Italy). *Contributions to Geophysics and Geodesy* 48(4): 299–317, doi 10.2478/congeo-2018-0014

Vajda Peter, Pavol Zahorec, Dušan Bilčík, Juraj Papčo (2019) Deformation–induced topographic effects in interpretation of spatiotemporal gravity changes: Review of approaches and new insights. *Surv Geophys* (under review)

Vajda Peter, P Zahorec, J Papčo, D Carbone, F Greco, M Cantarero (2019) On predictability and applicability of vertical gradients of gravity in 4D volcano gravimetry: Etna (Italy) case study. *Boll Volcanol* (under review)

Thank you for your attention