

# National report for Slovakia

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4) Slovak Academy of Sciences, Earth study institute



**EUREF 2018 SYMPOSIUM**

AMSTERDAM 30 May – 1 June 2018



# SLOVAKIA



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# Outline

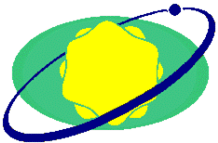
- Slovakian activities towards to EPN
- News from:
  - SKPOS<sup>®</sup> (Slovak real time determination system)
  - national levelling network
  - national gravimetric network
- R&D
  - Geodetic and Cartographic Institute activities
  - Slovak University of Technology activities
  - Slovak Academy of 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



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# SUT - EPN Local Analysis Center activity

## EPN subnetwork computation:

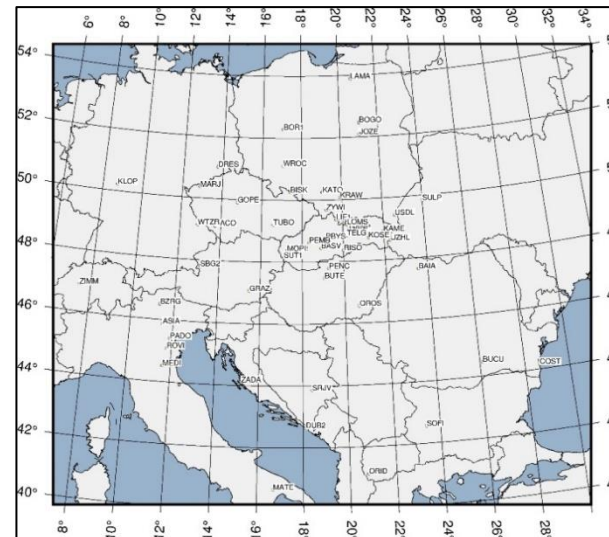
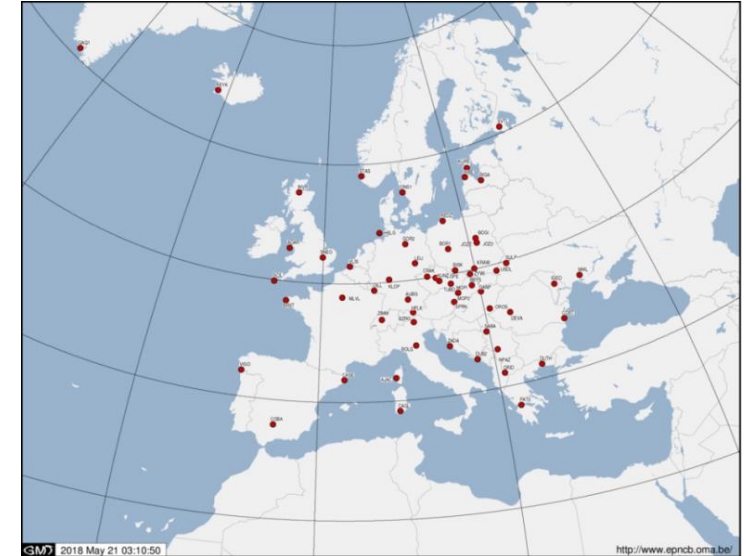
- 61 currently processed EPN permanent stations
- Bernese GNSS Software Version 5.2
- reference frame IGS14

## Analysis Centre Solutions:

- Final Weekly Coordinate Solution (1180 - now)
- Final Daily Coordinate Solution (1180 - now)
- **Rapid Daily Coordinate Solution (in the coming weeks)**

## CEPER network computation:

- 55 permanent stations in region of Central Europe,
- GPS/GLONASS and GLONASS only solutions: GPS week 1774
- Testing GPS/GLONASS /GALILEO and **GALILEO only solutions on selected points (mostly within Slovakia)**



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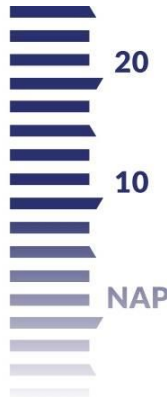
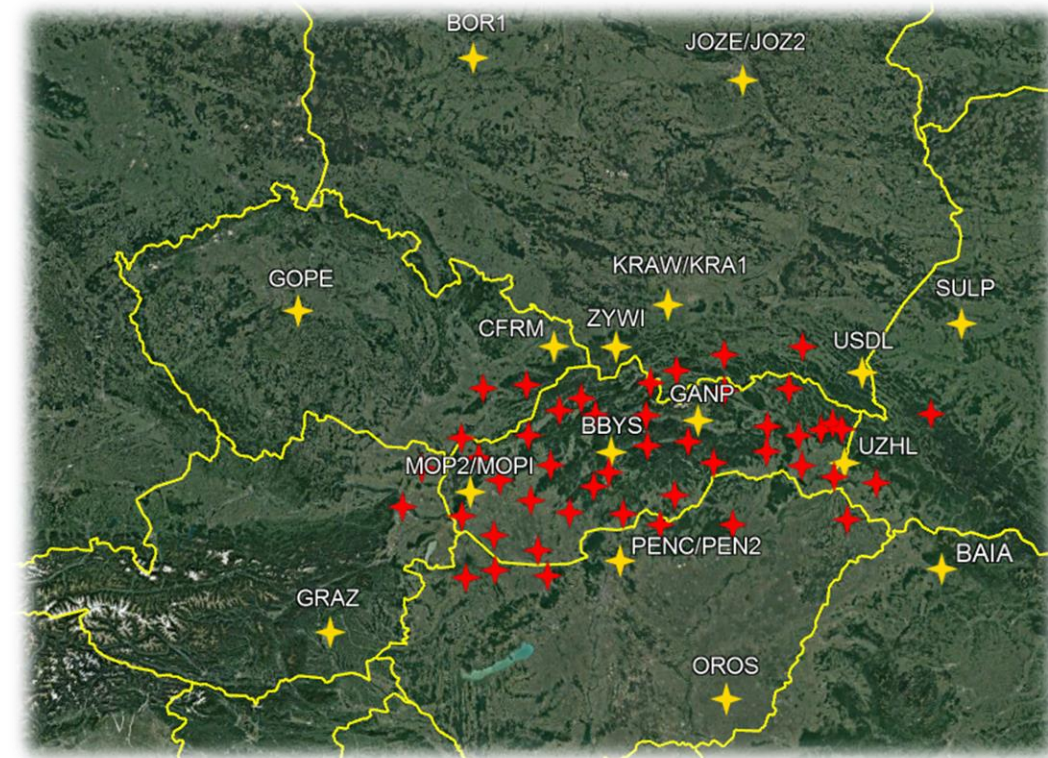
# GKU – EPN Operational center activity



## Slovak subnetwork solution (GKUwww7.SNX):

- weekly solution
  - 14 EPN reference stations
  - 34 Slovak reference stations
  - 20 foreign reference stations
- New reference frame (IGS14) and an updated set of antenna calibrations (igs14.atx) adopted from GPS week 1983.
- Start of reprocessing older data in IGS14
- Plan for introduction of Galileo PCV on new replaced antennas

## EUREF PERMANENT NETWORK DENSIFICATION



# Slovakian EPN permanent stations

## Slovakian EPN Real-time service permanent stations

MOP2



Class A

MOPI



Class B

ROYAL OBSERVATORY OF BELGIUM

EUREF Permanent GNSS Network

HOME ORGANISATION NETWORK & DATA PRODUCTS & SERVICES DOCUMENTATION NEWS, EVENTS & LINKS

home / Network & Data / Maps

Maps

Interactive Downloadable

SATELLITE SYSTEM: GPS GLONASS GALILEO BEIDOU QZSS SBAS

DATA FLOW: ONLY DAILY DAILY & HOURLY DAILY, HOURLY & REAL-TIME

NETWORKS: IGS ITRF2014

Update map

STATIONS RESPONDING TO THE IGS ITRF2014

Select a station -

LEGEND: Providing daily, hourly & real-time data Providing daily & hourly data Providing only daily data

BBYS



Class A

GANP



Class B



# EPN permanent station BBYS Choke ring antenna replaced due to problem with L2 frequency

- BBYS Trimble Choke Ring antenna (installation date 09/2012) had lost observations on L2 frequency from mid October 2017
- only 5 years in operation!
- 3<sup>rd</sup> similar case in Slovakia!?
- antenna was replaced by Trimble Zephyr geodetic model 3



Sat	Ei [°]	Az [°]	SNR (CA/P1/E1)	SNR (L2/L2C/L2C...)	SNR (L5/E5/...
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	-	-

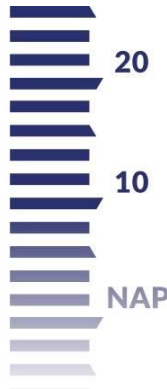
**Problem!  
No L2  
data!**



Choke Ring



Zephyr geodetic model 3





# Slovak real-time determination system

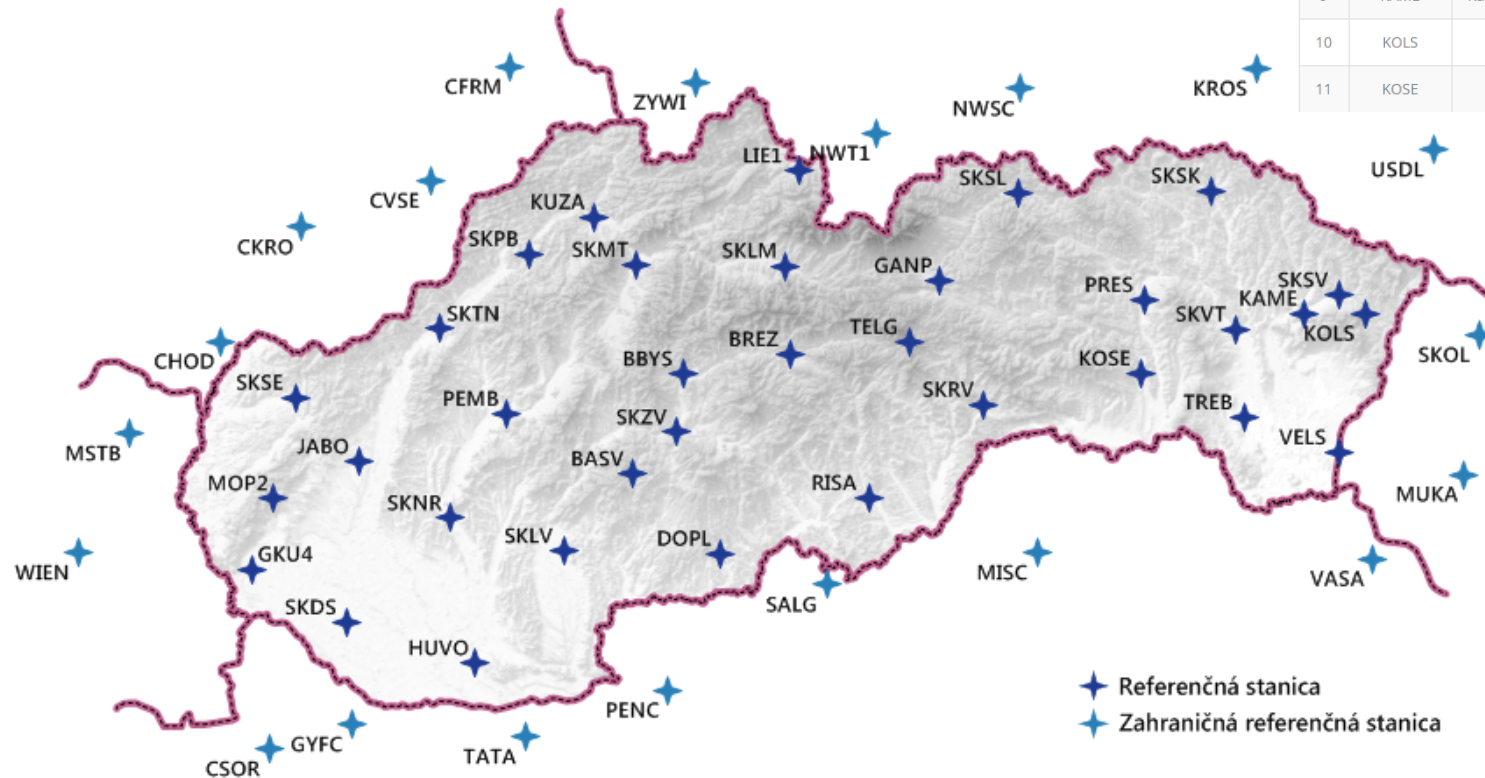
**SKPOS<sup>®</sup>**



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## CORS infrastructure (May 2018)

- **34 Slovakian reference stations (20 individual calibrated)**
  - 29/34 stations observe GPS+GLONASS+Galileo+BeiDou
  - Network density: average distance is 44,6 km
- **20 foreign reference stations (APOS, gnssnet.hu, CZEPOS, ASG-EUPOS, ZAKPOS)**



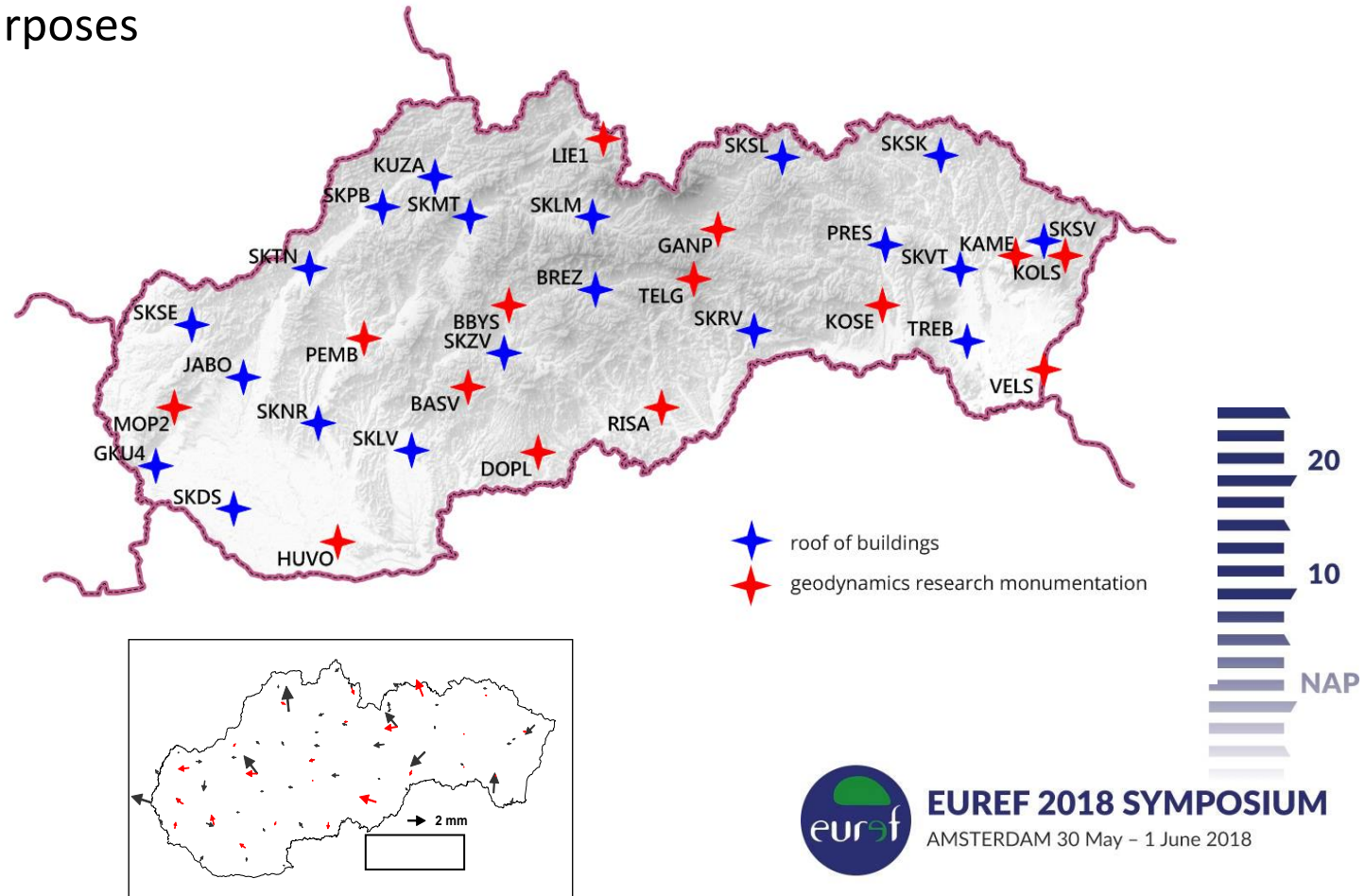
### Reference stations

#	Reference station	Location	Coordinates <small>Change format</small>			Antenna	Receiver
			ETRS89 (ETRF2000) epoch 2008.5				
			X (m)	Y (m)	Z (m)		
1	BASV	Banská Štiavnica	4009952.2193	1374556.6500	4750511.3543	TRM55971.00 NONE	TRIMBLE NETR9
2	BBYS	Banská Bystrica	3980359.1445	1382291.8716	4772771.7709	TRM115000.00 NONE ↓	TRIMBLE NETR9
3	BREZ	Brezno	3963889.0095	1414440.8746	4777131.8796	TRM55971.00 NONE ↓	TRIMBLE NETR9
4	DOPL	Dolné Plachtince	4019049.1891	1408890.6541	4732383.5840	TRM55971.00 NONE	TRIMBLE NETR9
5	GANP	Gánovce	3929181.8684	1455236.5018	4793653.7059	TRM59800.00 SCIS ↓	TRIMBLE NETR9
6	GKU4	Bratislava	4072810.9838	1258556.7518	4728707.6004	TRM55971.00 NONE ↓	TRIMBLE NETR9
7	HURB	Hurbanovo	4055516.0743	1338280.1018	4707504.3201	TRM55971.00 NONE	TRIMBLE NETR9
8	JABO	Jaslovské Bohunice	4035866.0213	1285295.0839	4753013.4000	TRM55971.00 NONE ↓	TRIMBLE NETR9
9	KAME	Kamenica nad Cirochou	3892532.3544	1572220.3322	4785952.5545	TRM115000.00 NONE ↓	TRIMBLE NETR9
10	KOLS	Kolonica	3884965.6417	1591340.3019	4786138.9208	TRM59800.00 SCIS	TRIMBLE NETR9
11	KOSE	Košice	3926968.7490	1526728.4960	4772720.4345	TRM115000.00 NONE ↓	TRIMBLE NETR9



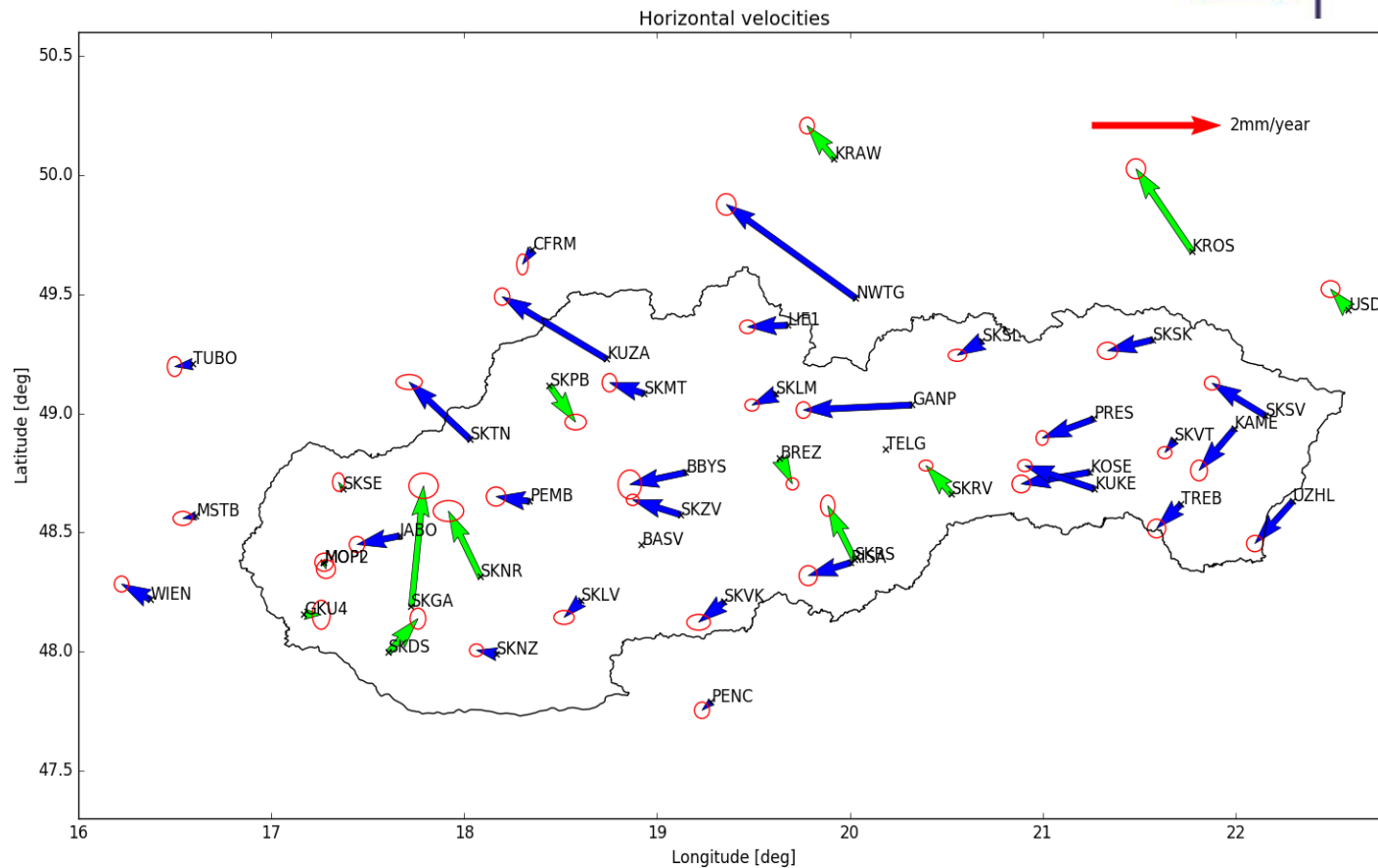
## CORS infrastructure for geokinematics

- 14 of 34 slovakian SKPOS permanent stations (41%) have monumentation suitable for geodynamics/geokinematics research purposes

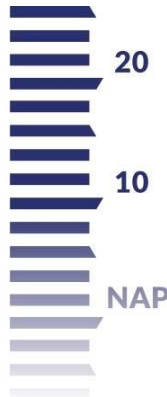
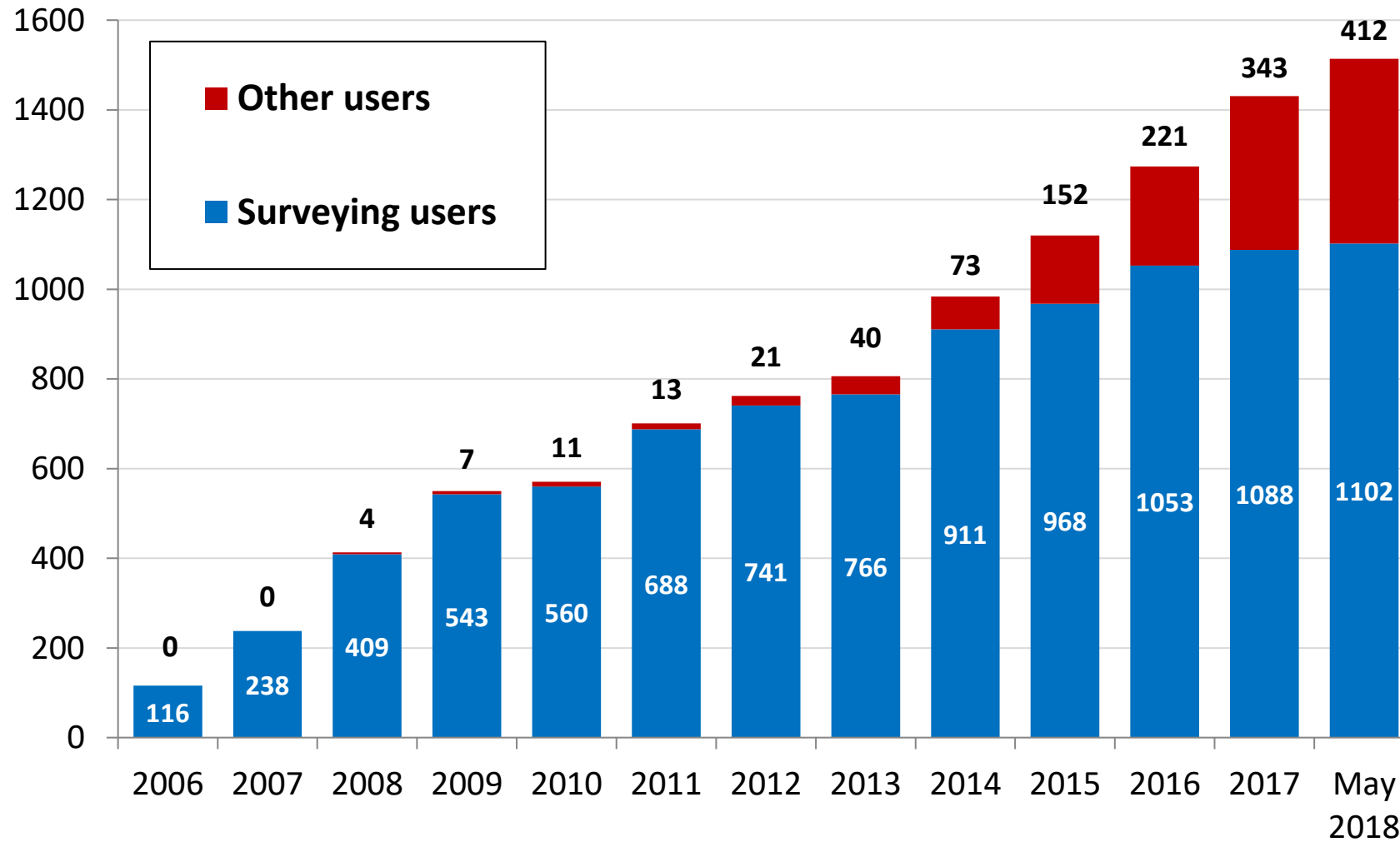


## Geodynamics research: HZ velocities (2007-2017)

eliminated: jumps + outliers + period + weights

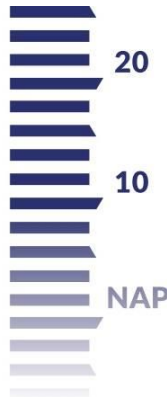
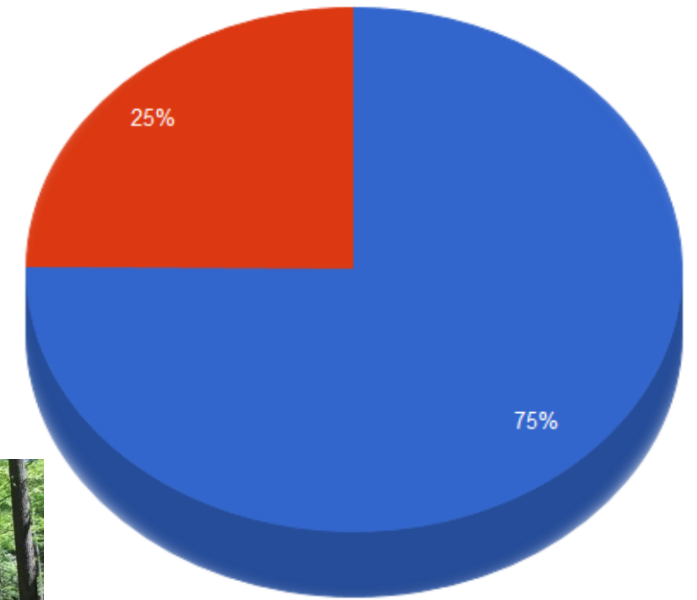


## Number of users



## Type of users

- Surveying fields (cadastre, surveying, mapping, GIS) - **75%**
- Other fields (precise agriculture, machine guarding) - **25%**

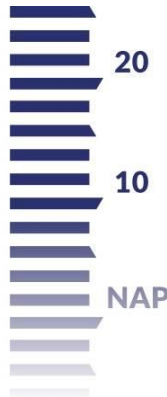
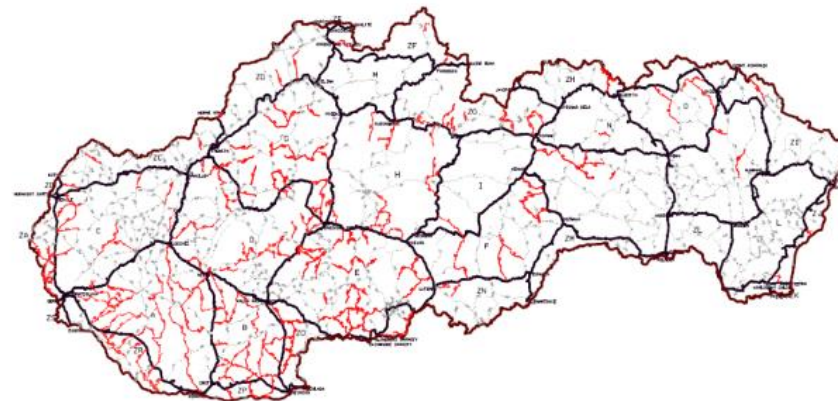


# National levelling network



# National levelling network

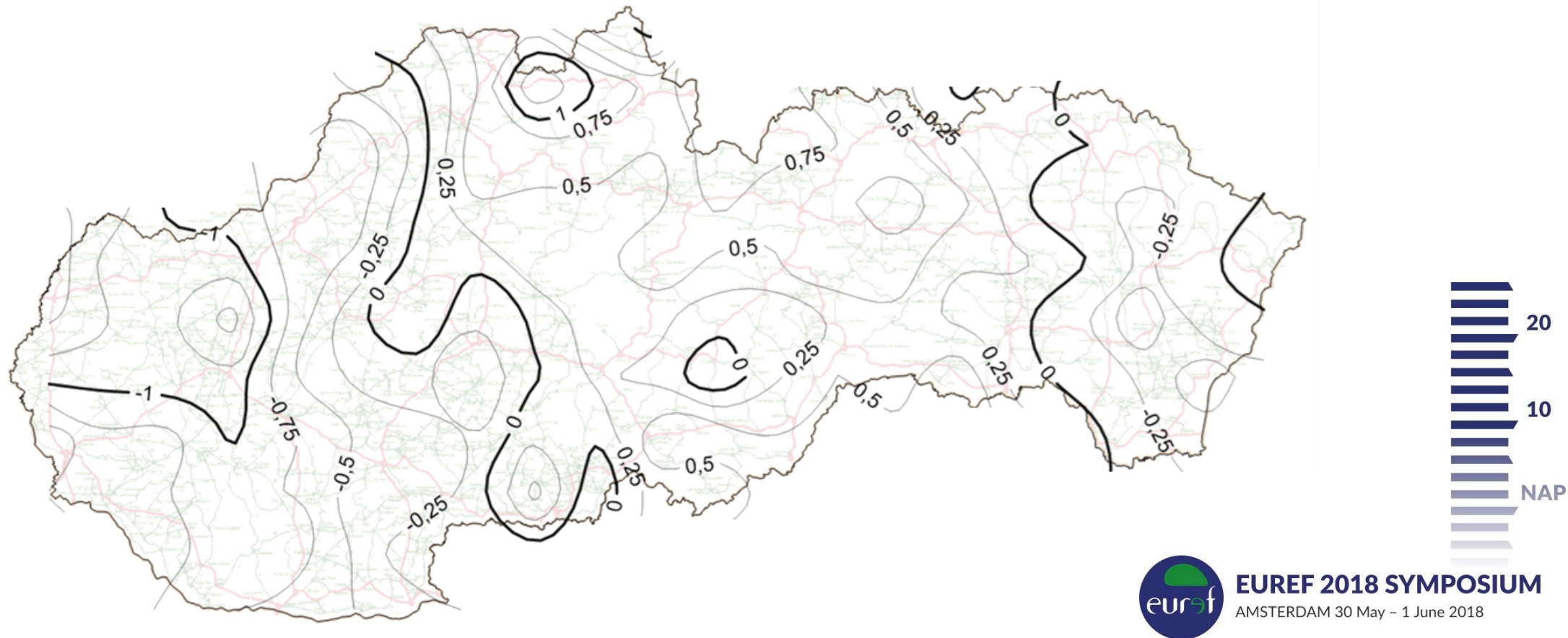
- 1996 – 2002: 1<sup>st</sup> order lines measurements
  - Original: 3787 km, 11 035 points, 68 lines
  - Additional measurements: 1180 km
- 1987 – 2017: 2<sup>nd</sup> order lines measurements
  - 76% from 2003-2017
  - 24% from 1987-1996
- 2016: start of computation of the new vertical reference system realization
  - plan divided into 5 phases
  - new realization estimated for 2020





# Recent vertical movements computation

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

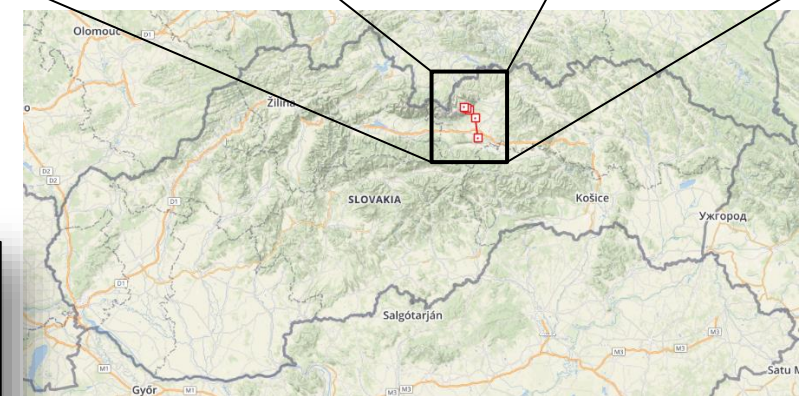
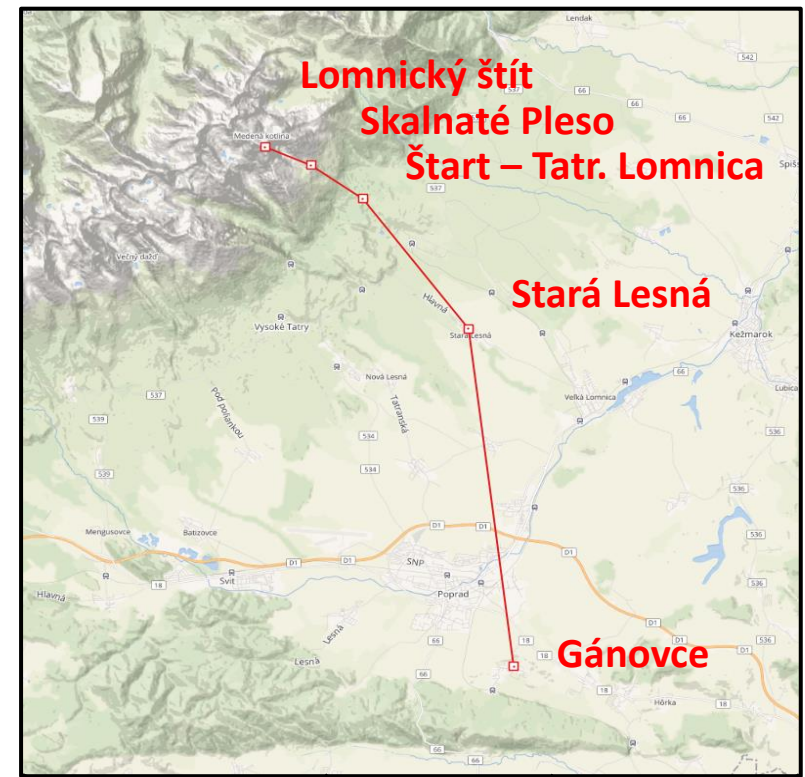
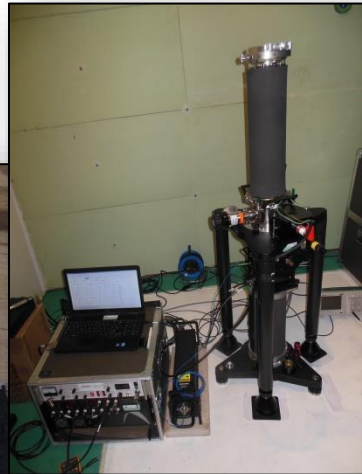


# National gravimetric network



# New vertical gravimetric baseline

- Locality: Tatra mountains (5 points)
- Gravity difference: 4406,6  $\mu\text{Gal}$
- Height difference: 1935 m
- Highest point: Lomnický peak 2634 m
- Absolute measurements done by FG5X-251 (GOP, CZE)
- Heights:
  - Levelling (4 points)
  - Trigonometric altitude (1 pt)



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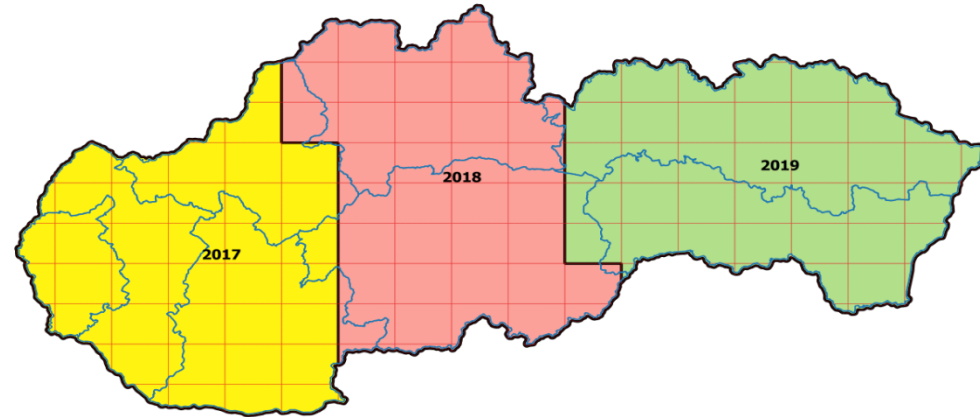
# Geodesy, Cartography and Cadastre Authority of Slovak Republic news



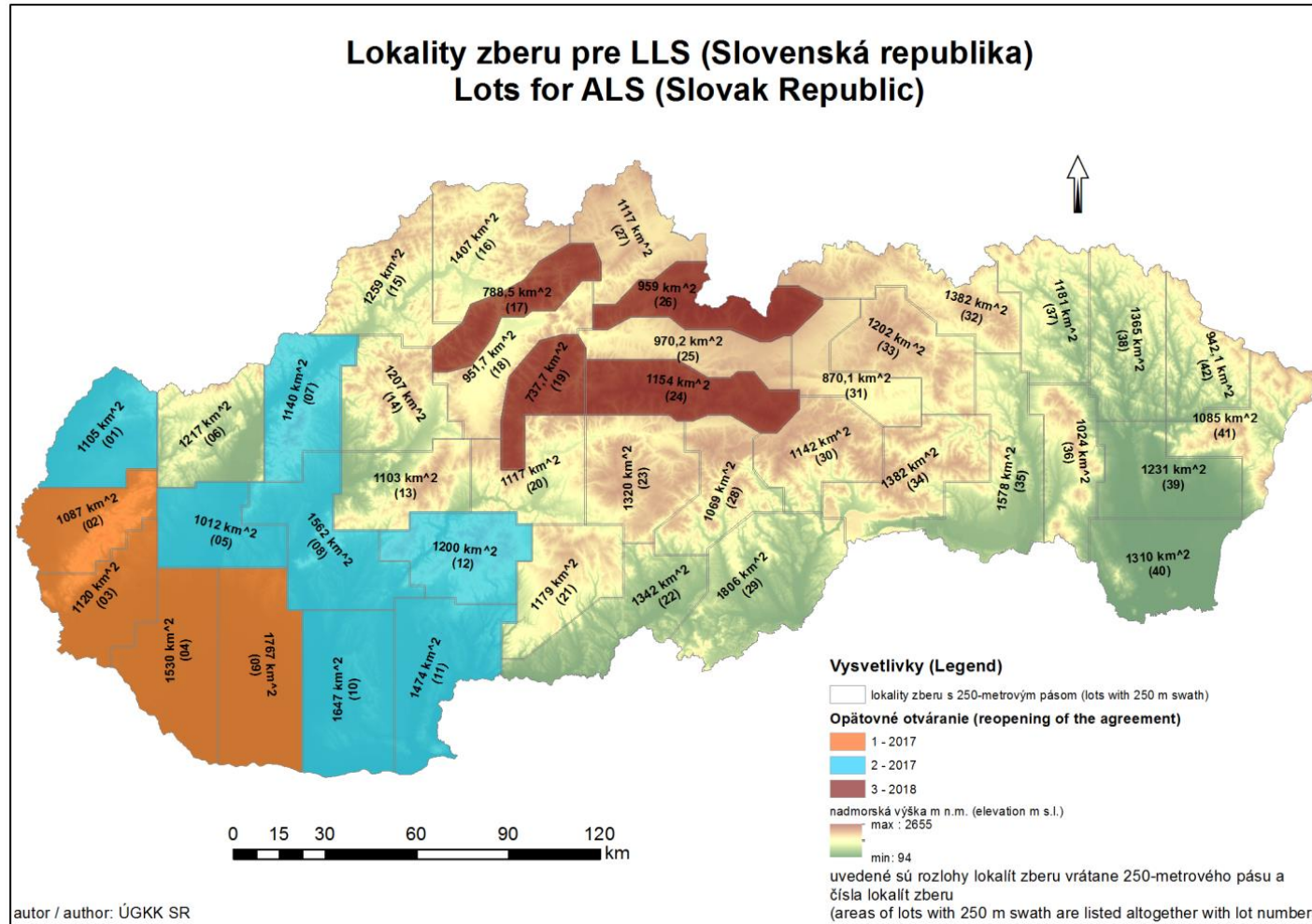
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# Orthophotos of Slovakia

- Cooperation between GCCA and Ministry of agriculture
- Quality parameters:
  - GSD – 0,25 m,
  - $RMSE_{xy}=0,35$  m
- Data are provided free of charge:
  - raster data
  - wms 1.3.0
  - Geoportal



# Digital elevation model (in progress)



autor / author: ÚGKK SR

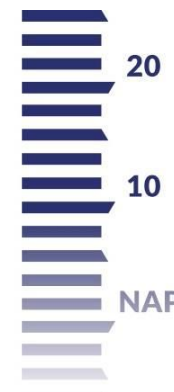
- airborne laser scanning
- density min.5 points/m<sup>2</sup>
- $m_{XY} \leq 0,50$  m in ETRS89-TM34
- $m_h \leq 0,20$  m in ETRS89
- DEM 1m resolution

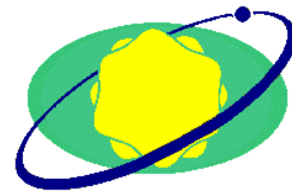
# EPSG codes for all Slovakian reference systems and transformations

From 02/2018

Source reference system	Target reference system	EPSG code of transformation
S-JTSK (JTSK03)	S-JTSK (JTSK)	EPSG::8364
S-JTSK (JTSK)	S-JTSK (JTSK03)	EPSG::8364
ETRS89 (ETRF2000)	S-JTSK (JTSK03)	EPSG::8365
S-JTSK (JTSK03)	ETRS89 (ETRF2000)	EPSG::8367
ETRS89 (ETRF2000)	S-JTSK (JTSK)	EPSG::8442
S-JTSK (JTSK)	ETRS89 (ETRF2000)	EPSG::8443
ETRS89 (ETRF2000) 3D	ETRS89 (ETRF2000) 2D + Bpv	EPSG::8361
ETRS89 (ETRF2000) 2D + Bpv	ETRS89 (ETRF2000) 3D	EPSG::8361
ETRS89 (ETRF2000) 3D	ETRS89 (ETRF2000) 2D + EVRF2007	EPSG::8362
ETRS89 (ETRF2000) 2D + EVRF2007	ETRS89 (ETRF2000) 3D	EPSG::8362
ETRS89 (ETRF2000) 2D + Bpv	ETRS89 (ETRF2000) 2D + EVRF2007	EPSG::8363
ETRS89 (ETRF2000) 2D + EVRF2007	ETRS89 (ETRF2000) 2D + Bpv	EPSG::8363

Geodetic reference system	Frame	Frame code	EPSG code
ETRS89	Slovenský terestrický referenčný rámec 2009	SKTRF09 = ETRF2000	EPSG::4937 (3D - $\phi\lambda h$ ) EPSG::4258 (2D - $\phi\lambda$ ) EPSG::4936 (3D - XYZ)
S-JTSK	Jednotná trigonometrická sieť katastrálna	JTSK	EPSG::2065 (Ferro) EPSG::5513 (Greenwich))
	Jednotná trigonometrická sieť katastrálna 2003	JTSK03	EPSG::8352 (Greenwich)
Baltic vertical system after adjustment	Baltský výškový systém po vyrovnaní	Bpv = Bpv (1957)	EPSG::8357
EVRS	Slovenský vertikálny referenčný rámec 2005	SKVRF05 = EVRF2000	EPSG::5730





# Slovak University of Technology R&D activities

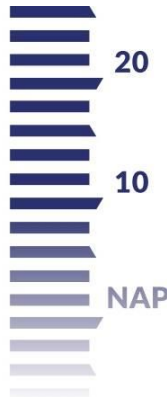
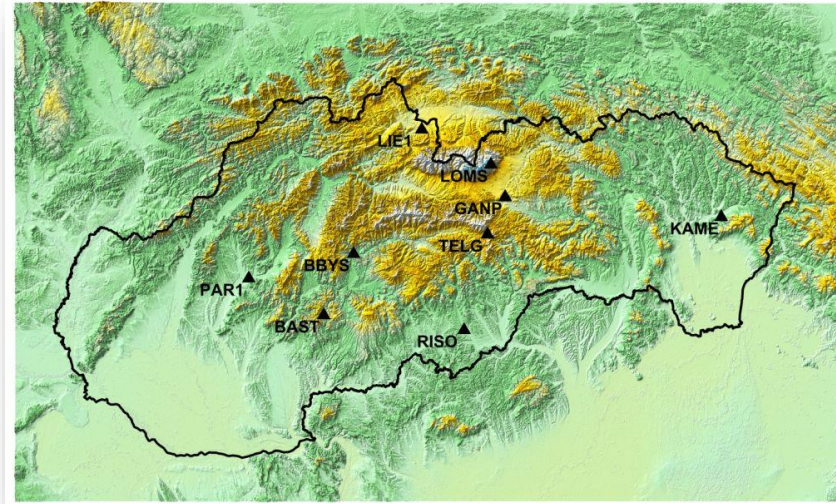


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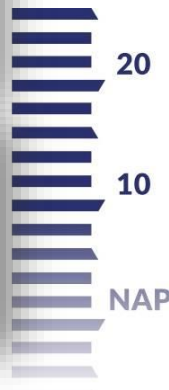
# National center for diagnosing the Earth surface deformations in Slovakia

- ITMS research project
- 9 absolute gravity / GNSS permanent stations
- Activity in 2017/2018:
  - FG5X-247 gravimeter measurement on all points in June 2017
  - FG5X-247 gravimeter comparison of Absolute Gravimeters EURAMET.M.G-K3 Wettzell in 2018



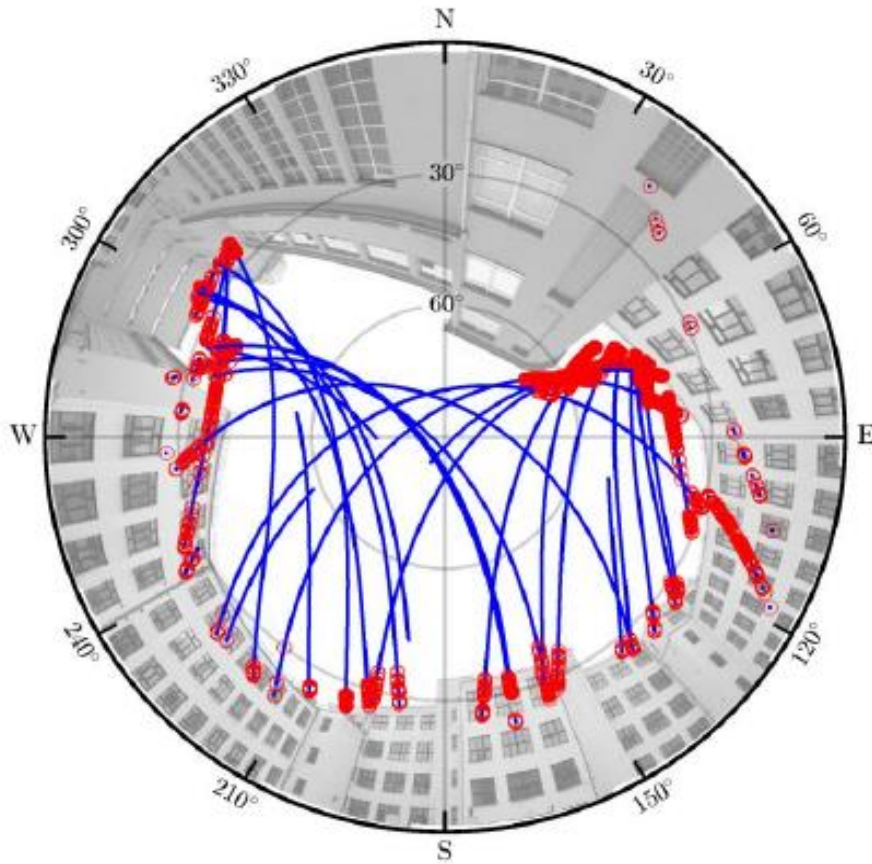
# New integrated monitoring station Hurbanovo

- 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.



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# GNSS phase multipath detection

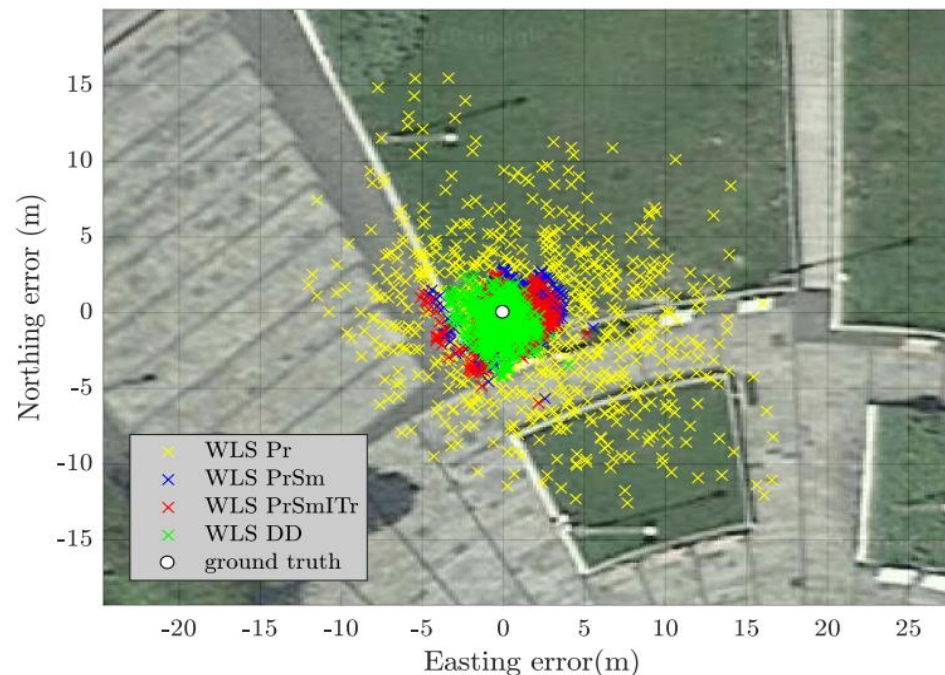


- phase multipath detector exploits the combination of three-frequency SNR measurements
- computed detection statistics is compared to values gathered in “low” multipath environment
- continuing work on use of two-frequency measurements, which would enable also multipath detection for GLONASS system

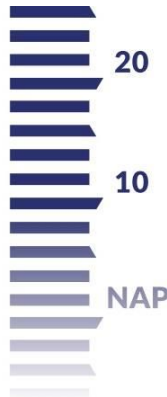
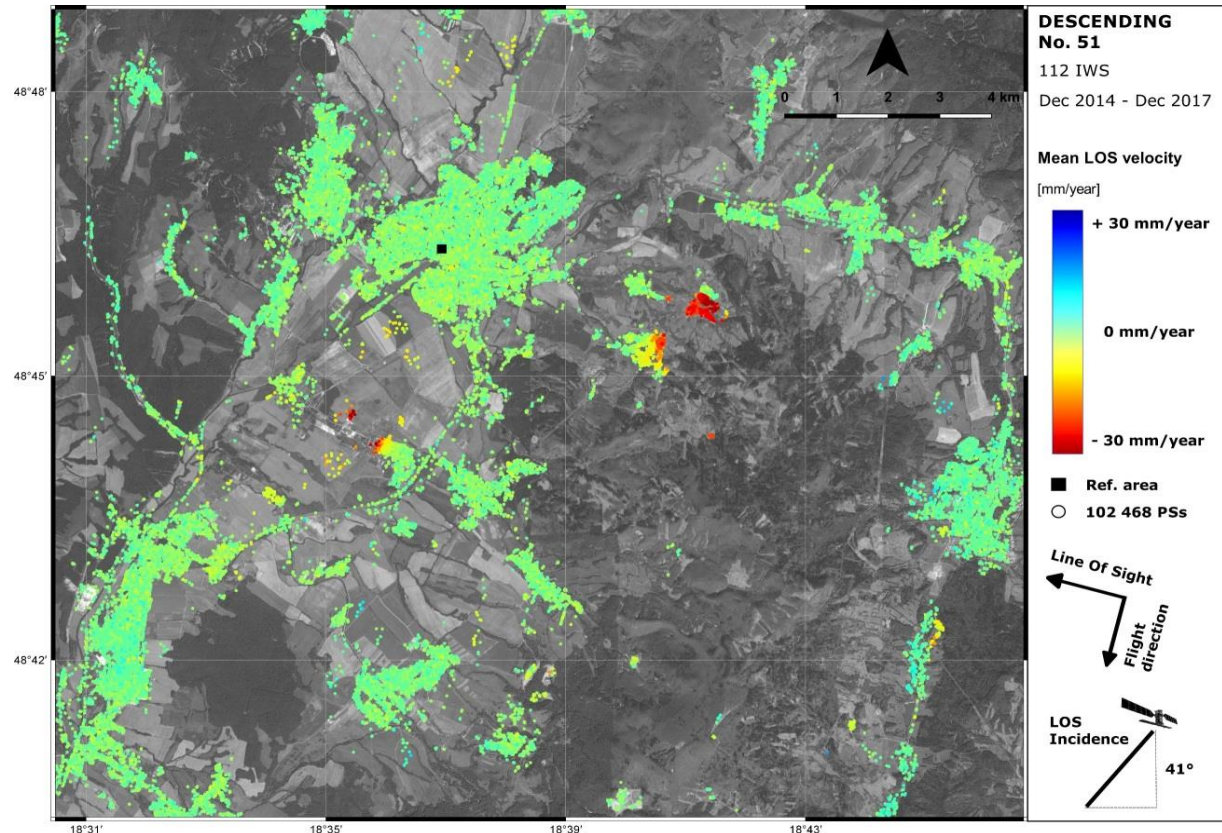
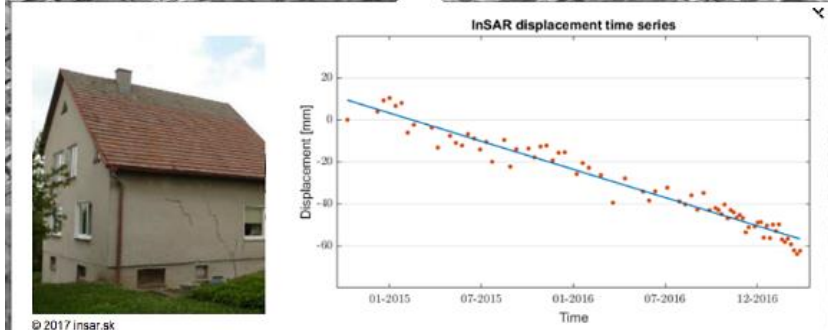
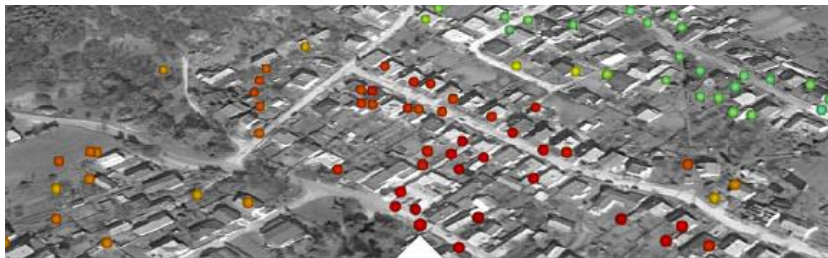


# Processing Android raw measurements

- Android OS 7.0 and higher provide opportunity to access raw measurements on Android devices – raw time, phase, doppler and SNR measurements,
- experiments show limitation in hardware, manufacturers using duty-cycling technology which disrupts continuous observation of phases,
- proposed method for filtering using doppler measurements



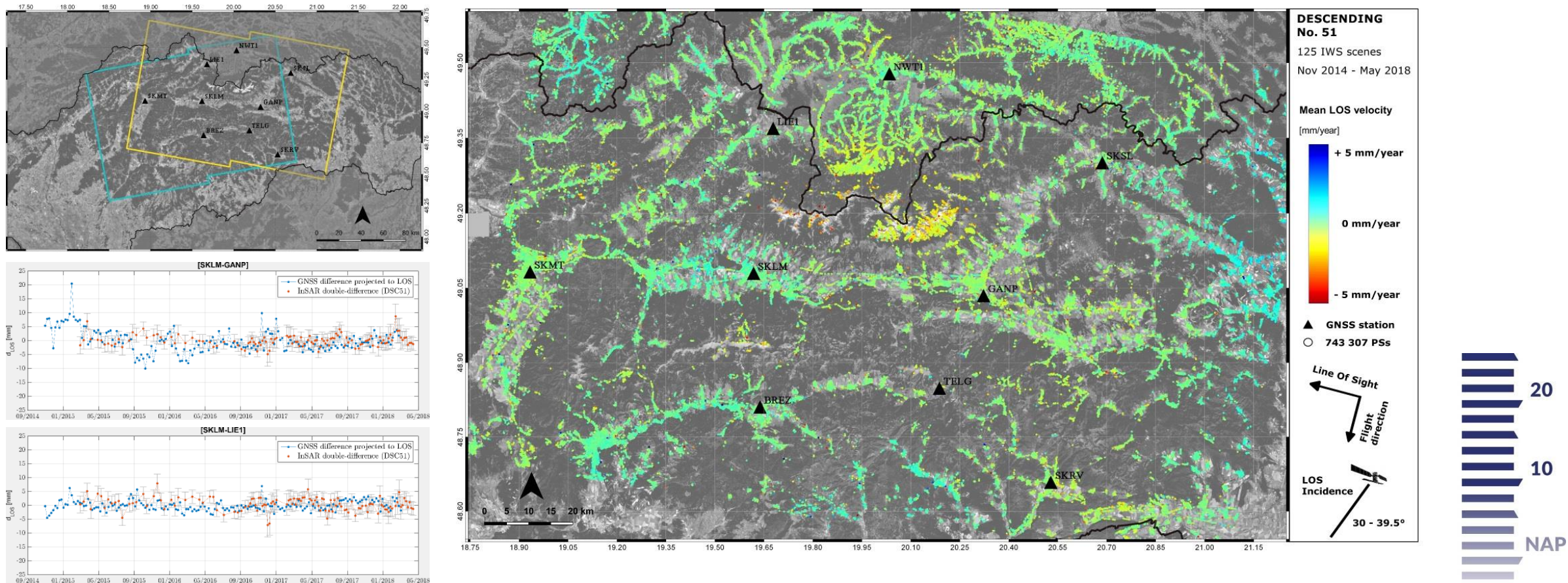
# Sentinel-1 Multi-temporal InSAR for monitoring of geohazards (undermined and landslide)



More in:

CZIKHARDT, R. et al., 2017, Ground Stability Monitoring of Undermined and Landslide Prone Areas by Means of Sentinel-1 Multi-Temporal InSAR, Case Study from Slovakia. *Geosciences* 2017, 7, 87.

# A pilot study on the Sentinel-1 MT-InSAR surface deformation monitoring system for Slovakia

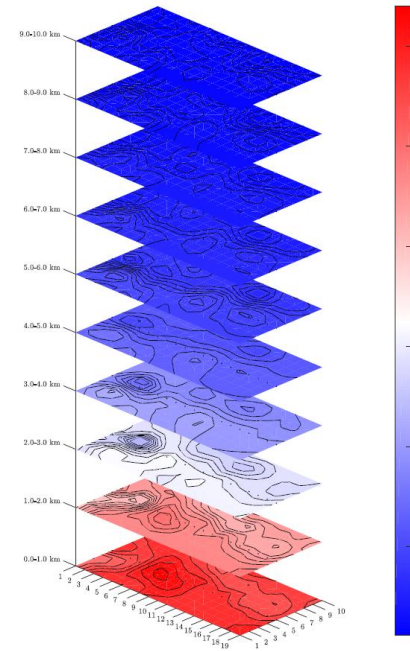
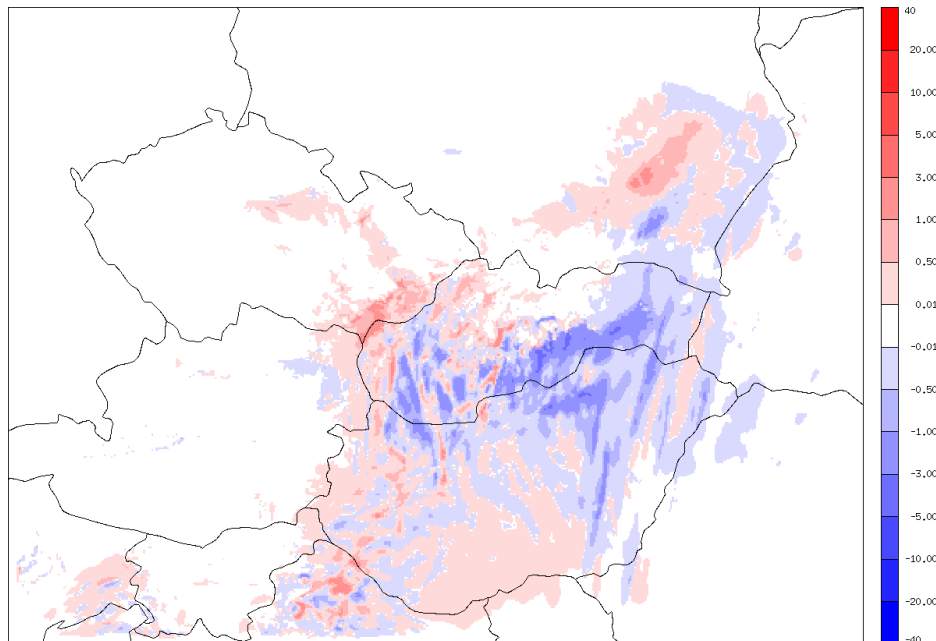


For more information we invite you to  
Poster Session, Poster N.10

CZIKHARDT, R.; PAPČO, J.; DROŠČÁK, B., FERIANC, M.

# GNSS meteorology – ZTD data assimilation

- Assimilation of zenith total delays in AROME/SHMU with three-dimensional data assimilation system. Minimal difference is -4.9 mm and maximal difference is +2.7 mm of accumulated rainfall over 12 hour forecast



Determination of water vapour distribution in troposphere via tomography reconstruction based on slant total delays from stations in Slovakia.





# Slovak Academy of Science R&D activities

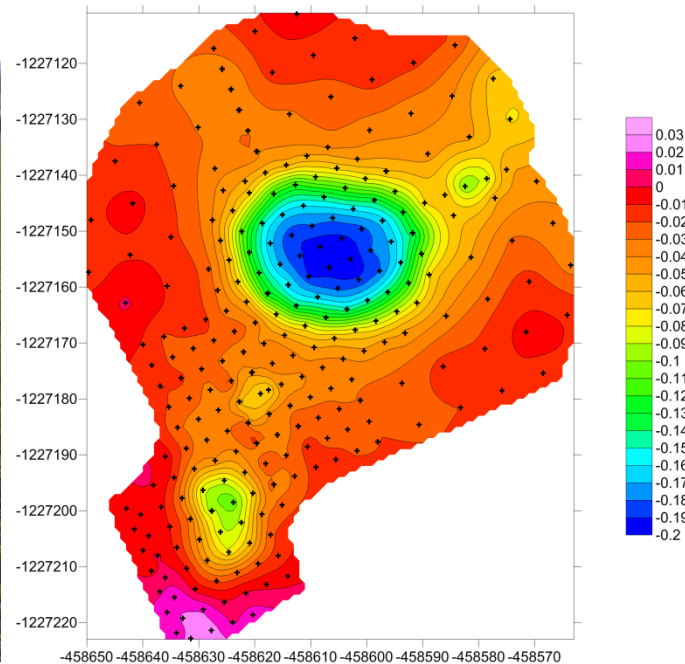


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# Geophysical and geodetic monitoring undermined area in DP Baňa Nováky

- A system of geophysical and geodetic methods applied to map recent or former sinkholes and assess the risk of future sinkholes
- The results indicate the presence of multiple anomalies – former sinkholes, which are also correlated with the sinkholes identified from historical aerial photographs
- One of measured anomalies was verified by drilling

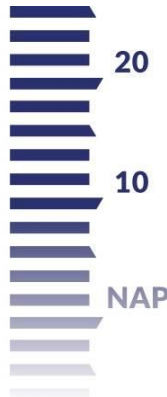


GCG 2017



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Thank you for your attention



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