

# National report of Slovakia 2016

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**Donostia - San Sebastian**  
**May 25th - 27th, 2016**



EUREF 2016, annual symposium  
25-27.May 2016, San Sebastian, Spain

# Outline

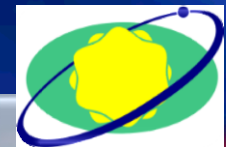
- Slovakian activities and contributions to EPN
- Status, activities and news from:
  - **SKPOS**® (Slovak real time determination system)
  - national levelling network
  - national gravimetric network
- Research and development
  - Activities of Geodetic and cartographic institute
  - Activities of Slovak university of Technology
- Other news from Slovakia



# Slovakian EPN Operational centers



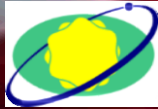
Geodetic and Cartographic Institute  
Bratislava (GKÚ)



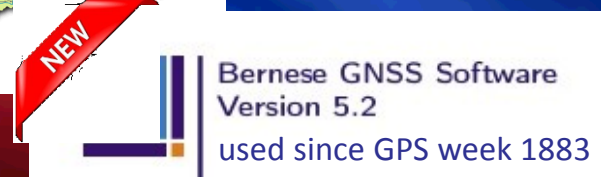
Slovak University of Technology in  
Bratislava (SUT)



# Slovakian EPN Local analysis center



Slovak University of  
Technology in Bratislava (SUT)



GM 2016 May 16 03:10:42

<http://www.epncb.oma.be/>

- 4 new EPN permanent stations added to LAC SUT network solution (IRBE, NPAZ, ONS1, SABA)
- GMF: Vienna Mapping Function is used instead Niell Mapping Function
- GPS and GLONASS observations are used since GPS week 1878
- ESA ephemerides are used



# Slovakian EPN permanent stations

EPN CB HOME

## EUREF PERMANENT NETWORK

ROB \*\*\*\*\*  
GNSS RESEARCH GROUP \*\*\*\*\*  
EUREF euref

NETWORK & DATA	PRODUCTS & SERVICES	DOCUMENTATION
<a href="#">Working stations</a>   <a href="#">Station list</a>   <a href="#">Maps</a>   <a href="#">Tracking status</a>   <a href="#">Data access</a>   <a href="#">Proposed stations</a>   <a href="#">Station log submission</a>   <a href="#">Station picture submission</a>	<a href="#">Data analysis</a>   <a href="#">Daily/weekly positions</a>   <a href="#">Positions &amp; velocities</a>   <a href="#">Tropospheric delays</a>   <a href="#">ETRF/ITRF transformation</a>   <a href="#">Position time series</a>   <a href="#">Satellite orbit &amp; clock correction streams</a>	<a href="#">Formats</a>   <a href="#">Guidelines</a>   <a href="#">Equipment &amp; calibration</a>   <a href="#">Papers</a>   <a href="#">FAQ</a>

**MAPS**


Locate station on map

Antenna manufacturers:  
3S NAVIGATION  
AOA  
ASHTECH


Status:  
ACTIVE  
INACTIVE  
FORMER

Update map


**MOPI**




**MOP2**



**GANP**



**BBYS**



The map shows the locations of these four stations in Slovakia, marked with red circles and connected by red lines to their respective photographs. The stations are located near Bratislava (MOP2), Poprad (MOPI), and Košice (GANP and BBYS).

# Slovakian EPN Real-time permanent stations

EPN CB  
HOME

## EUREF PERMANENT NETWORK

GNSS

**ORGANISATION**

About | Components | Working groups | Management | Contributors | Collaborations | Site map

**NETWORK & DATA**

Station list | Maps | Tracking status | Data access | Proposed stations | Station log submission | Station picture submission

**PRODUCTS & SERVICES**

Data analysis | Daily/weekly positions | Positions & velocities | Tropospheric delays | ETRF/ITRF transformation | Position time series | Satellite orbit & clock correction streams

**DOCUMENTATION**

Formats | Guidelines | Equipment & calibration | Papers | FAQ

**NEWS**

News | Mails | FTP server

NETWORK & DATA > **MAPS**

**INTERACTIVE MAP**

**Legend**

Station status (active, inactive, former) ▼

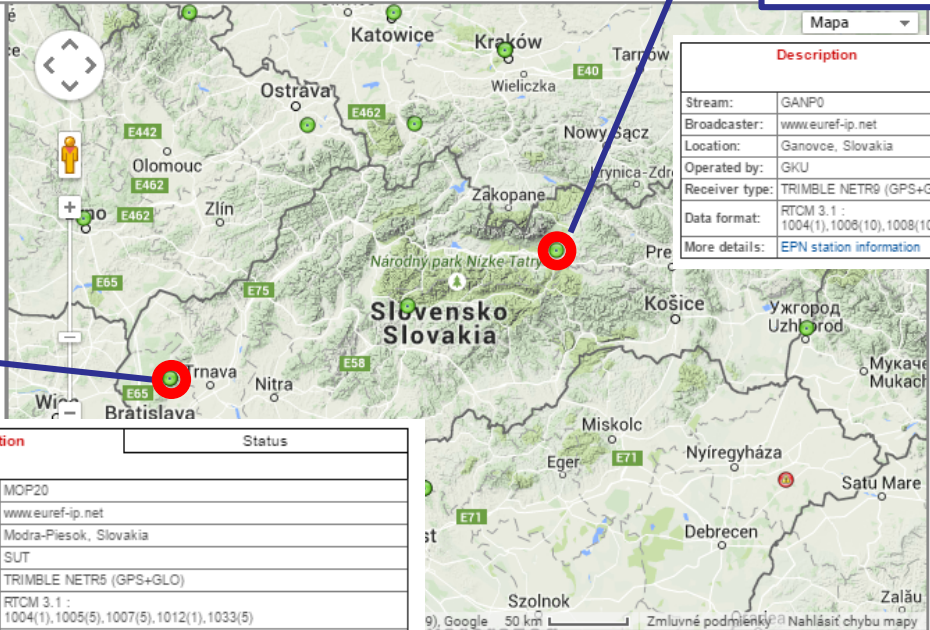
Active Inactive Former

Locate station on map


Antenna manufacturers:

3S NAVIGATION  
AOA  
ASHTech


Status:  
ACTIVE  
INACTIVE  
FORMER



**MOP2**



**GANP**

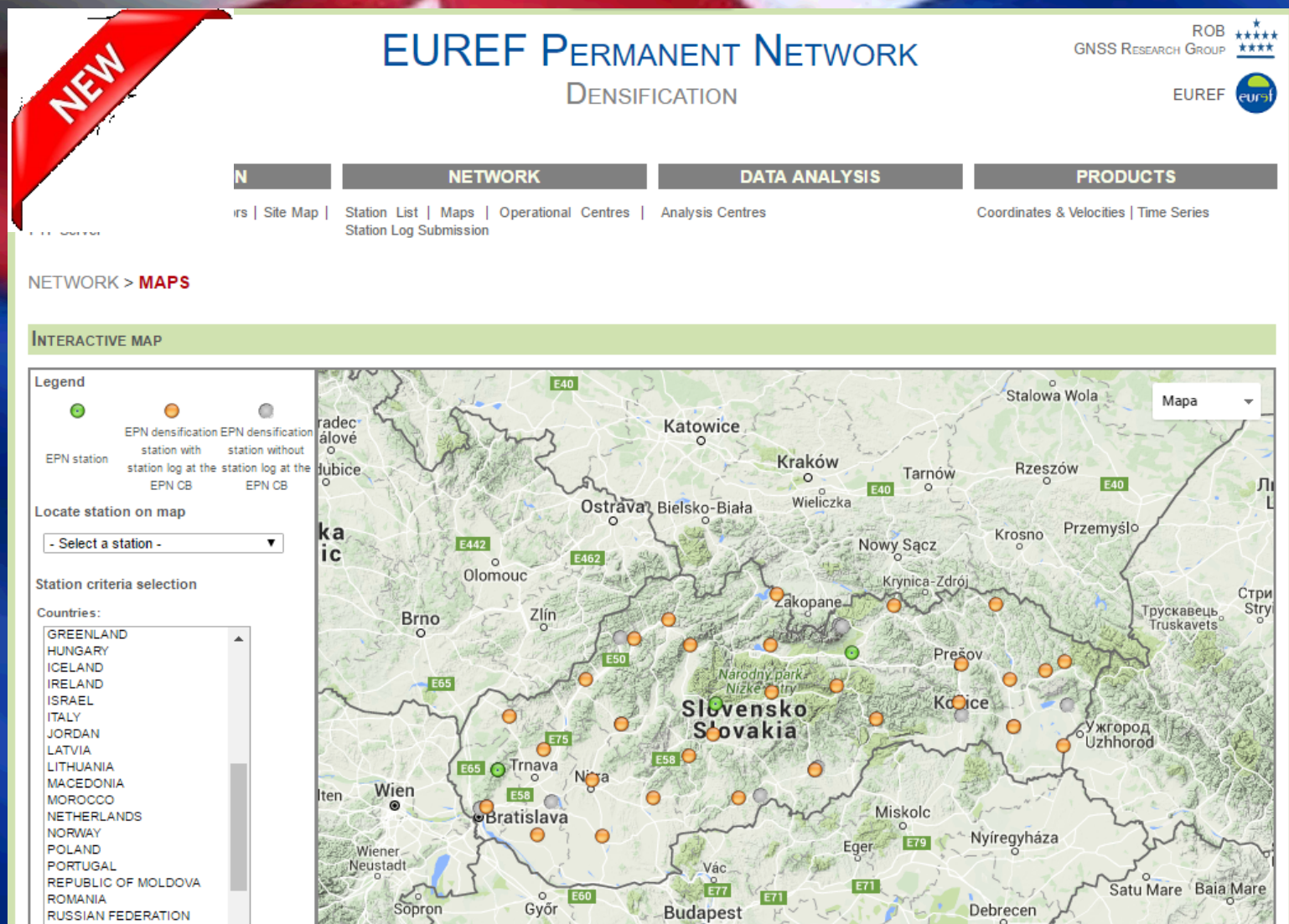


Description	Status
Stream: MOP20	
Broadcaster: www.euref-ip.net	
Location: Modra-Piesok, Slovakia	
Operated by: SUT	
Receiver type: TRIMBLE NETR5 (GPS+GLO)	
Data format: RTCM 3.1 : 1004(1), 1005(5), 1007(5), 1012(1), 1033(5)	
More details: <a href="#">EPN station information</a>	

Description	Status
Stream: GANP0	
Broadcaster: www.euref-ip.net	
Location: Ganovce, Slovakia	
Operated by: GUK	
Receiver type: TRIMBLE NETR9 (GPS+GLO+GAL+BDS+QZSS+SBAS)	
Data format: RTCM 3.1 : 1004(1), 1008(10), 1008(10), 1012(1), 1013(10), 1019(10), 1020(10), 1033(10), 1230(10)	
More details: <a href="#">EPN station information</a>	



# Slovakian contribution to EPN Densification



Status and news from Slovakian real-time  
determination system - **SKPOS**<sup>®</sup>

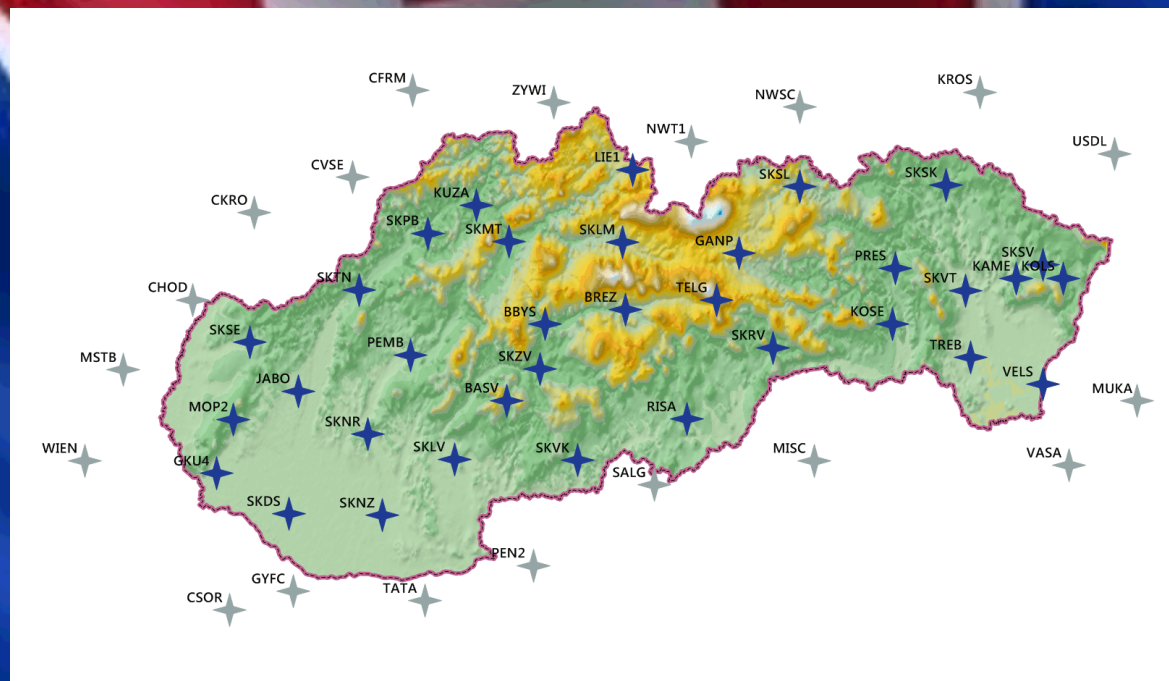


2006 – 2016 => 10 years of **SKPOS**<sup>®</sup>



## infrastructure status (May 2016)

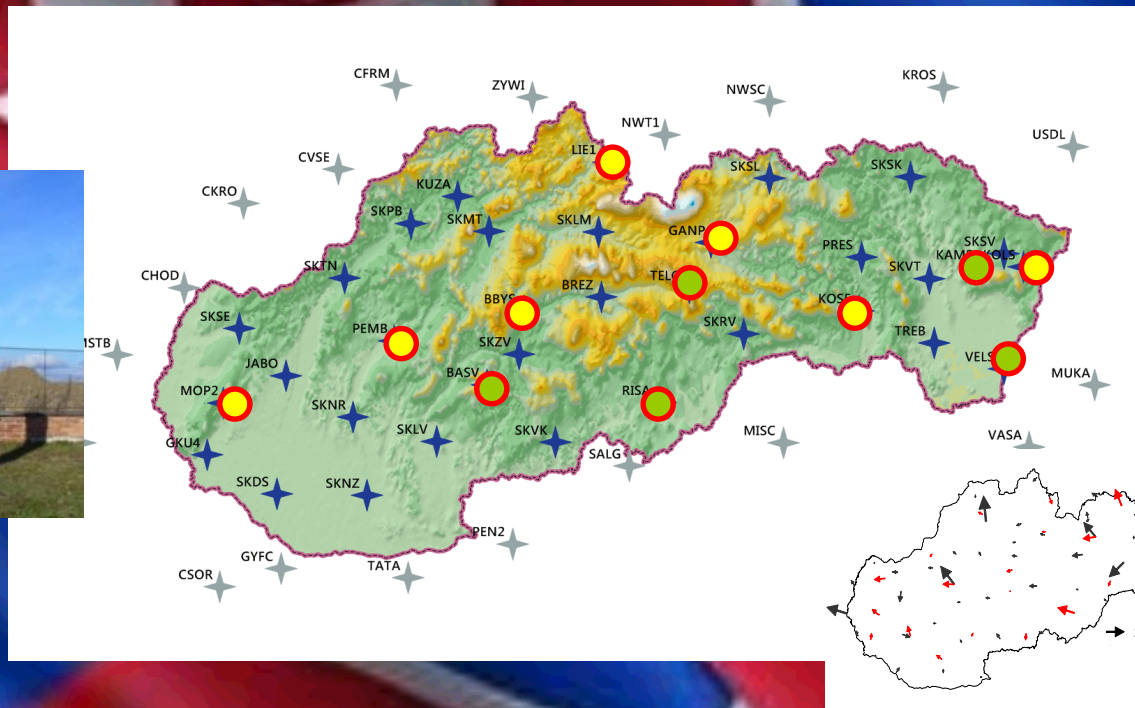
- **34 Slovakian permanent stations (14 individual calibrated)**
  - All stations observe GPS+GLONASS signals (few Galileo)
  - Network density - average distance between stations : 44,6 km
- **19 foreign permanent stations (APOS, gnssnet.hu, CZEPOS, ASG-EUPOS, ZAKPOS)**
- -----
- **Totally 53 permanent stations**



# SKPOS<sup>®</sup>

## infrastructure for geodynamics research

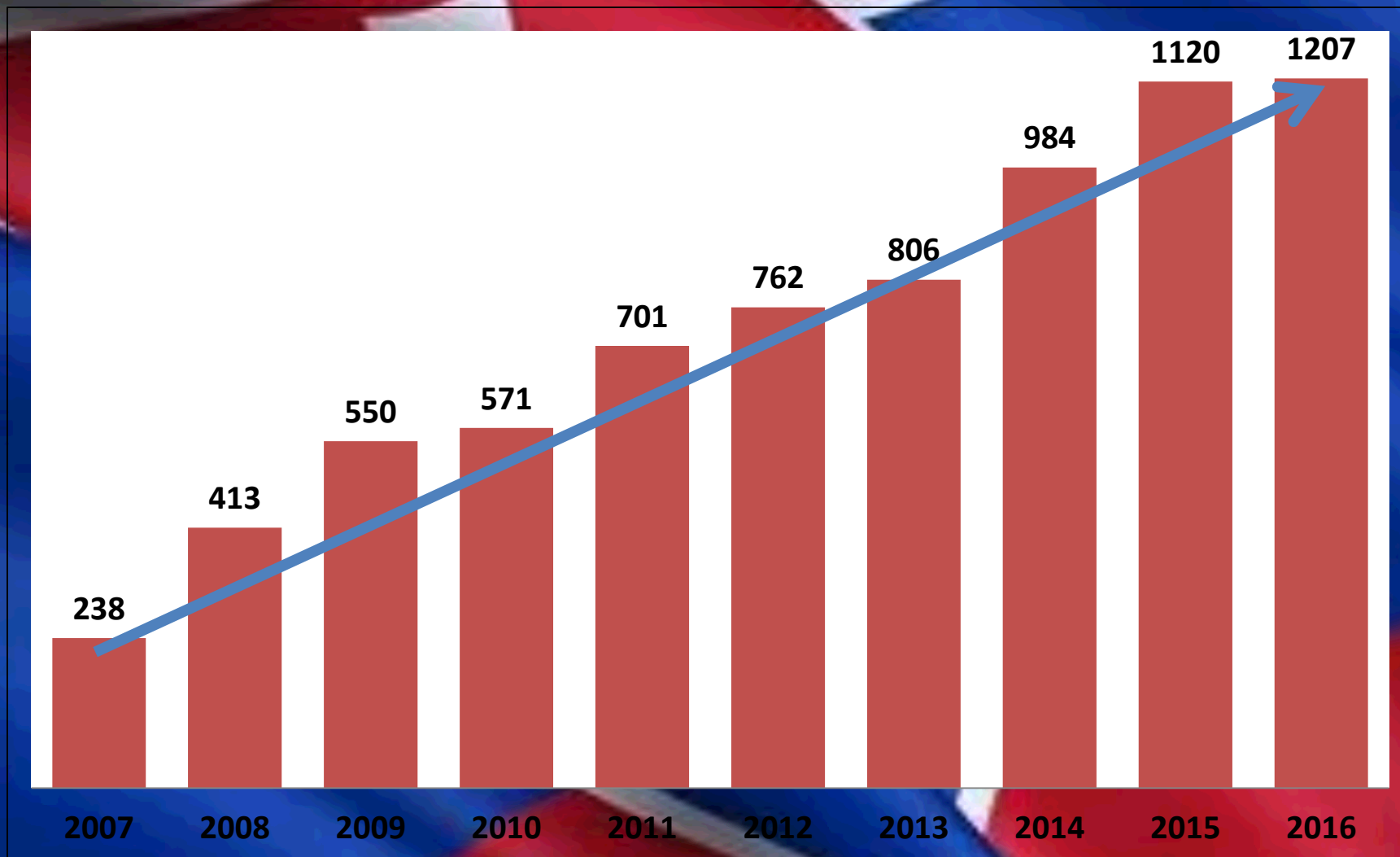
- 12 from 34 slovakian SKPOS<sup>®</sup> permanent stations have monumentation suitable for geodynamic research purposes
  - 7 stations reinforced-concrete pilier monumentation
  - 5 stations deep drilled braced mark monumentation (5m deep)





**SKPOS<sup>®</sup>**

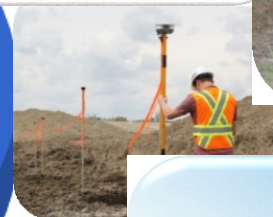
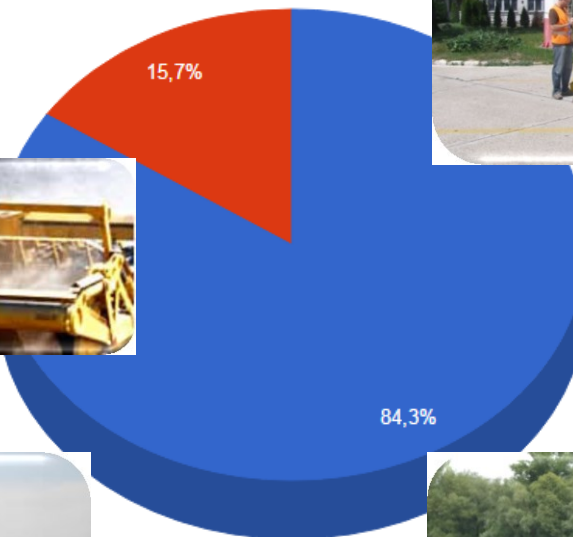
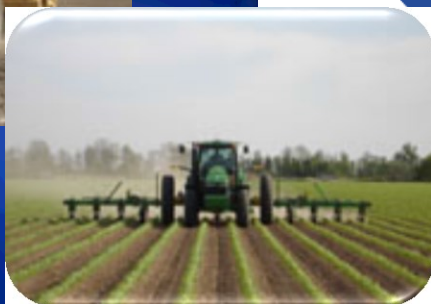
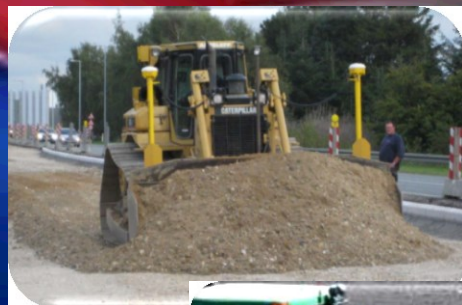
number of users



# SKPOS<sup>®</sup>

## type of users

- Surveying fields (cadastre, surveying, mapping, GIS) - **84%**
- Other fields (precise agriculture, machine guarding) - **16%**







**SKPOS<sup>®</sup>**

packages - data formats - charges

Package	Content	Duration	Format	Flat rate
SKPOS_mm	RINEX 1000 h	year	RINEX 2.x, 3.x	50 €
SKPOS_cm (year)	RTK unlimited + 50 h RINEX	year	RTCM 2.3, 3.1, CMRx, CMR+	50 €
SKPOS_cm (month)	RTK unlimited	month	RTCM 2.3, 3.1, CMRx, CMR+	19 €
SKPOS_dm	DGNSS unlimited	year	RTCM 2.1	20 €

# New **SKPOS**<sup>®</sup> web page

- 13.10.2015 – new (redesign) web page was launched
- Full of interesting information (SVK/ENG):

- News
- Infrastructure
- Packages and prices
- Quality Monitoring
- Availability Monitoring
- Registration

<http://skpos.gku.sk>





# New SKPOS<sup>®</sup> registration a ordering system

## User interface

**NEW**



**SKPOS<sup>®</sup>**  
Slovenská priestorová observačná služba

Slovenská priestorová observačná služba (SKPOS<sup>®</sup>) je multifunkčný nástroj na presnú určovanie polohy objektov a javov pomocou globálnych navigačných družicových systémov (ďalej GNSS). Služba umožňuje používateľom pracovať on-line alebo dodatočne v zálohových geodetických referenčných systémoch ETRS89 a S-JTSK (v realizácii [JTSK03]). SKPOS<sup>®</sup> pozostáva zo siete permanentných referenčných staníc GNSS pripojených pomocou privátnej virtuálnej siete do Národného servisného centra nachádzajúceho sa na Geodetickom a kartografickom ústave v Bratislave. Národné servisné centrum je vybavené riadiacim softvérom služby, ktorý spravuje namerané družicové observácie zo siete permanentných referenčných staníc a zároveň generuje tzv. sieťové korekcie pre používateľov využívajúcich službu v reálnom čase a údaje službu na dodatočné spracovanie pre používateľov vybavených postprocesingovým softvérom.

**Aktuálne informácie**

- 19.11.2015 Upgrade firmvéru prijímačov Trimble NetR9 na verziu 5.10/5.02
- 13.10.2015 Spustenie nového webu služby SKPOS
- 13.10.2015 Spustenie online registrácie do služby SKPOS
- 06.10.2015 Upgrade riadiaceho softvéru služby Trimble Pivot Platform na verziu 3.5.8
- 25.08.2015 Upgrade firmvéru prijímačov Trimble NetR9 na verziu 5.03/5.02 a prijímačov Trimble NetR8 na verziu 4.87/3.62
- 10.08.2015 Nastavenie absolútnej kalibrácie na referenčnej stanici BBY5
- 10.03.2015 Upgrade riadiaceho softvéru služby Trimble Pivot Platform na verziu 3.5.6, pripojenie novej referenčnej stanice VELS do sieťového riešenia služby
- 01.03.2015 Úprava služieb SKPOS: zrušenie limitov RTK meraní v službách SKPOS\_cm a SKPOS\_dm
- 18.02.2015 Pripojenie zahraničnej stanice KROS do sieťového riešenia služby
- 03.02.2015 Upgrade firmvéru prijímačov Trimble NetR9 na verziu 4.93/4.93

© 2015 · Geodetický a kartografický ústav Bratislava



**NEW**

**nového používateľa**

efla

Fyzická osoba bez živnostenského listu  
Fyzická osoba so živnostenským listom  
**Fyzická osoba**  
Režijná organizácia ÚGKK SR  
Orgány štátnej správy - príspevkové organizácie  
Orgány štátnej správy - rozpočtové organizácie  
VÚC, mesto, obec

Formát: 0123456789  
IČ DPH: IČ DPH  
Formát: SK0123456789

**Štatutárny zástupca**

Titul pred menom: Titul pred menom  
Meno: Meno  
Priezvisko: Priezvisko  
Titul za menom: Titul za menom

**Fakturačná adresa**

Ulica: Ulica  
Číslo domu: Číslo domu  
Obec: Obec  
PSČ: PSČ  
Štát: Slovenská republika

**Kontaktné údaje**

E-mail: E-mail  
Telefónne číslo: Telefónne číslo  
Formát čísla: +421 901 234 567

Korešpondenčná adresa: ☒ rovnaká ako fakturačná adresa

[Pokračovať v registrácii](#)

From 13.10.2015

**NEW**

**SKPOS<sup>®</sup>**  
Slovenská priestorová observačná služba GNSS

**Vytvoriť účet**

**Registrácia nového používateľa + objednanie služby**

**Výber služby**  
SKPOS\_cm/RTK pre 1 zariadenie (rok neobmedzené RTK + 50 |

**Prístupové meno**  
login1

**Heslo:**  
\*\*\*\*\*

**Potvrdiť heslo:**  
\*\*\*\*\*

**tný kód:** 2Z83g

**tný kód:** 2Z83g

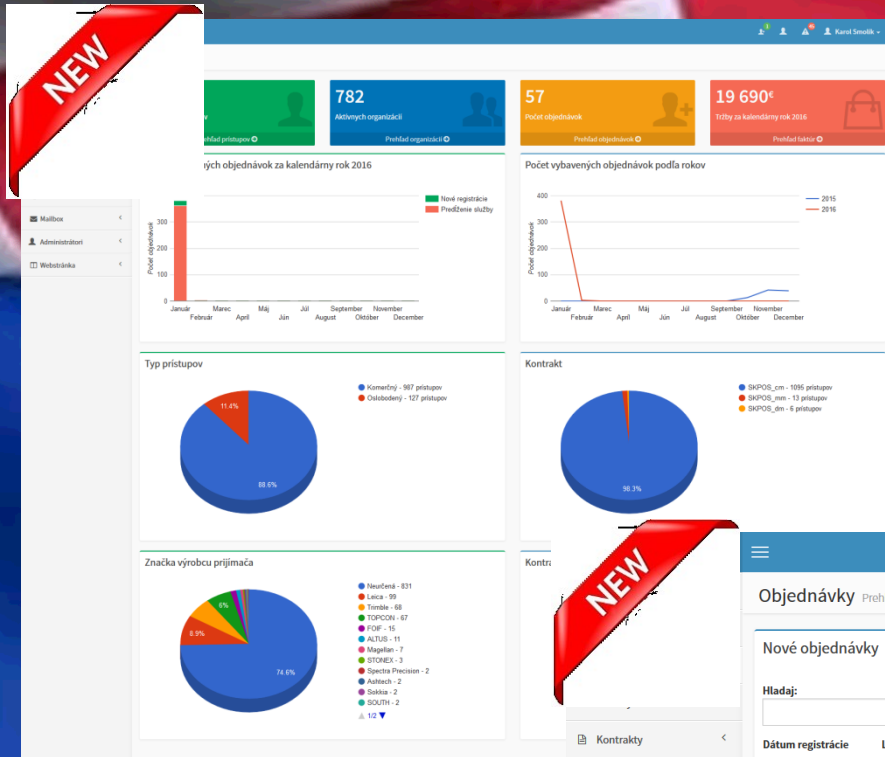
n so spracovaním svojich osobných údajov v zmysle platných ných obchodných podmienok.  
n so Všeobecnými obchodnými podmienkami, s ktorými som bol mený/á a porozumel/a som im.

[Späť](#) [Registrovať za 50,- EUR](#)

KONTAKT © COPYRIGHT 2015, GKÚ BRATISLAVA

# New SKPOS® registration a ordering system

## Administrator interface



From 13.10.2015

**NEW**

Objednávky Přehled nových objednávek

Typ objednávky: Předřezání služby Nová registrace Nový přístup Nový přístup uživatele

Hledat:

Dátum registrace	Login	Kontrola údajů	Vyžádání faktury	Vložení faktury	Odeslání faktury	Potvrzení platby	Aktivace	Vymazání
2016-02-02 06:38:42	chupacova1	Kontrola	Vyžádat fakturu	Vložit fakturu	Odeslat fakturu	Potvrdit platbu	Aktivovat	Vymazat
2016-02-02 05:32:47	arcehovyskum1	Elena Beřová 2016-02-02 05:37:09	Elena Beřová 2016-02-02 05:37:13	Vložit fakturu	Odeslat fakturu	Potvrdit platbu	Aktivovat	Vymazat
2016-02-01 15:45:18	geo2011	Kontrola	Vyžádat fakturu	Vložit fakturu	Odeslat fakturu	Potvrdit platbu	Aktivovat	Vymazat
2016-02-01 13:53:28	mihalda1	Elena Beřová 2016-02-01 13:54:57	Elena Beřová 2016-02-01 13:55:02	Vložit fakturu	Odeslat fakturu	Potvrdit platbu	Aktivovat	Vymazat
2016-02-01 11:35:57	xhlavackova1	Elena Beřová 2016-02-01 12:02:31	Elena Beřová 2016-02-01 12:02:35	Vložit fakturu	Odeslat fakturu	Potvrdit platbu	Aktivovat	Vymazat
2016-02-01 09:14:14	geotime	Elena Beřová 2016-02-01 09:29:05	Elena Beřová 2016-02-01 09:29:10	Elena Beřová 2016-02-01 12:06:27	Elena Beřová 2016-02-01 12:06:36	Potvrdit platbu	Aktivovat	Vymazat
2016-02-01 07:52:01	maseva1	Elena Beřová 2016-02-01 08:02:34	Elena Beřová 2016-02-01 08:02:38	Elena Beřová 2016-02-01 12:36:50	Elena Beřová 2016-02-01 12:36:55	Potvrdit platbu	Aktivovat	Vymazat

Kontrakty  
Využívání služby  
Nastavení  
Mailbox  
Administrátoři  
Webstránka

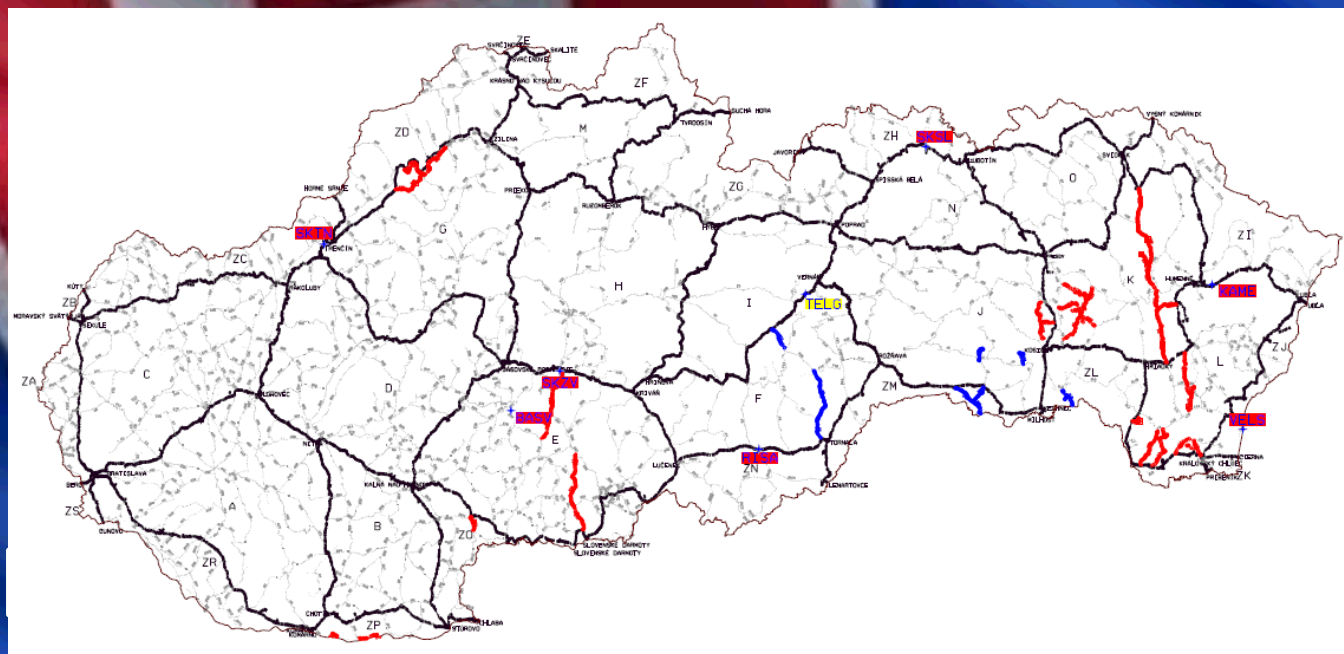
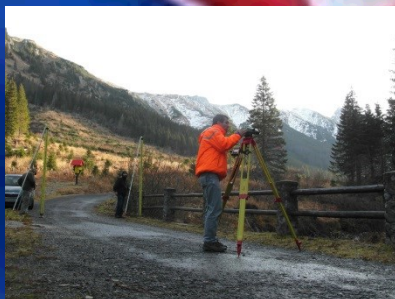


The background of the slide is a close-up, slightly blurred image of the Swiss flag. It features a red shield with a white cross in the center, set against a blue background. The flag is draped, creating folds and shadows.

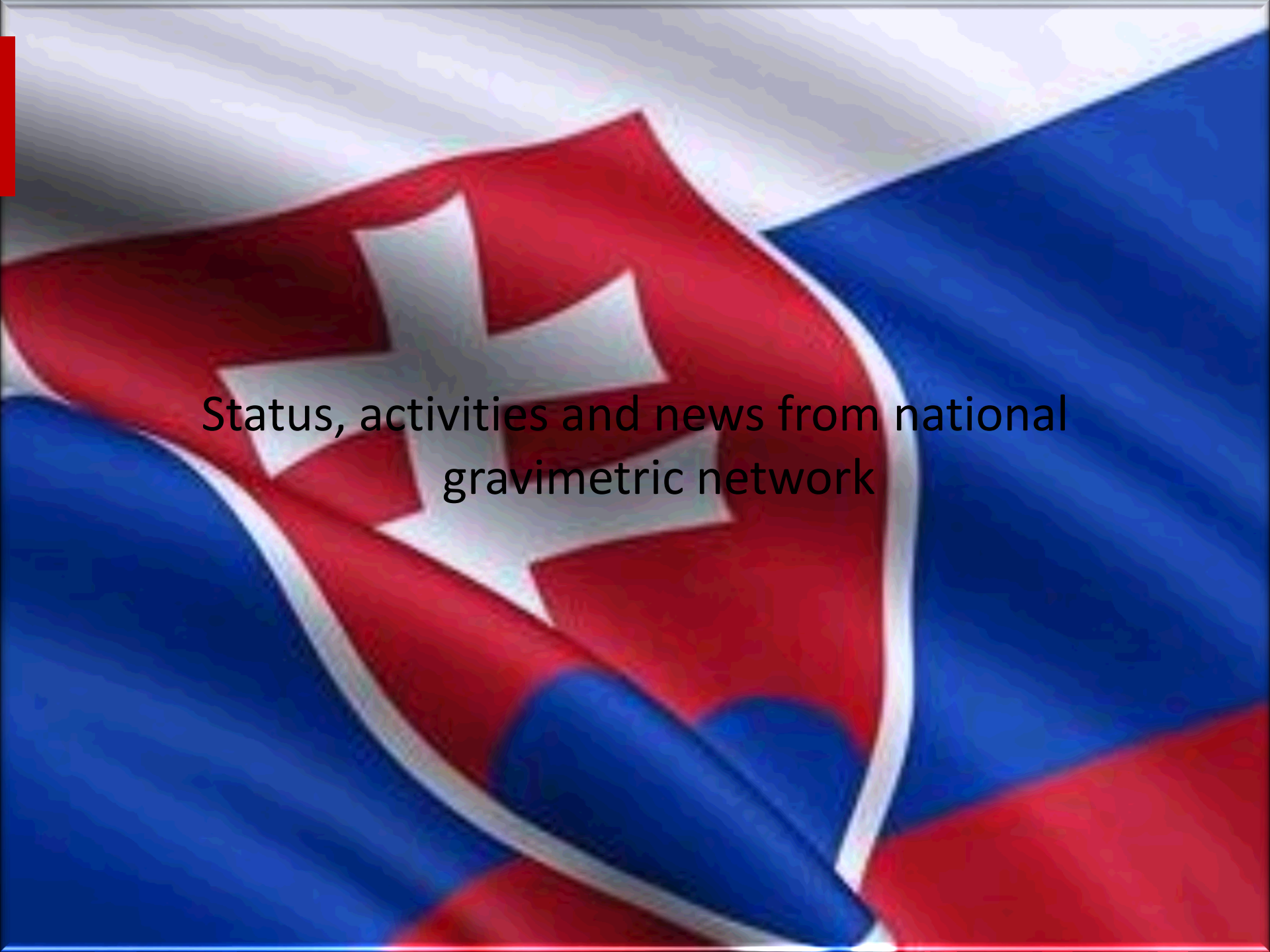
Status, activities and news from national levelling  
network

# National levelling network

- Measurements in 2015:
  - 564 km of 2<sup>nd</sup> order levelling lines
  - worked done by 3 levelling groups
- 2020 target: New vertical reference system realization (data from 1987 - 2016) – more information in Droscak et al. presentation



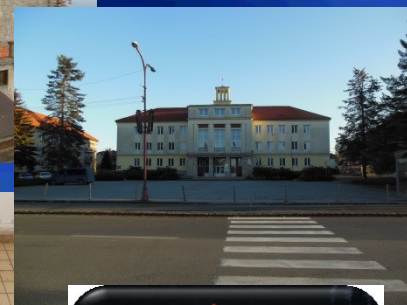


The background of the slide is a close-up, slightly blurred image of the Swiss flag. The flag features a large white cross on a red field, which is set against a blue background. The flag is draped, creating folds and shadows that add depth to the image. A small red rectangular element is visible in the top-left corner.

Status, activities and news from national  
gravimetric network

# National gravimetric network

- Renovation of Slovakian gravimetric baseline:
  - 2 monumentations for absolute measurements
  - 4 monumentations for relative measurements
  - 64 gravity difference measured
  - worked done by 1 leveling groups
- 2020 target: New Slovakian gravimetric baseline (partly in Tatra mountain region)



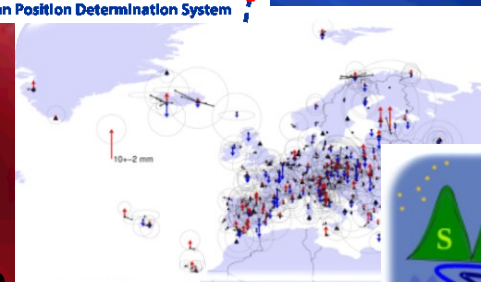




Research and development

# Projects supported by data from SKPOS<sup>®</sup>

- EPN real-time analysis project
- ECC (EUPOS Combination Centre)
- EUPOS monitoring system
- Project „National center for diagnosing the earth surface deformations in Slovakia“
- SES - Space Emergency System in Transcarpathian region
- EGVAP



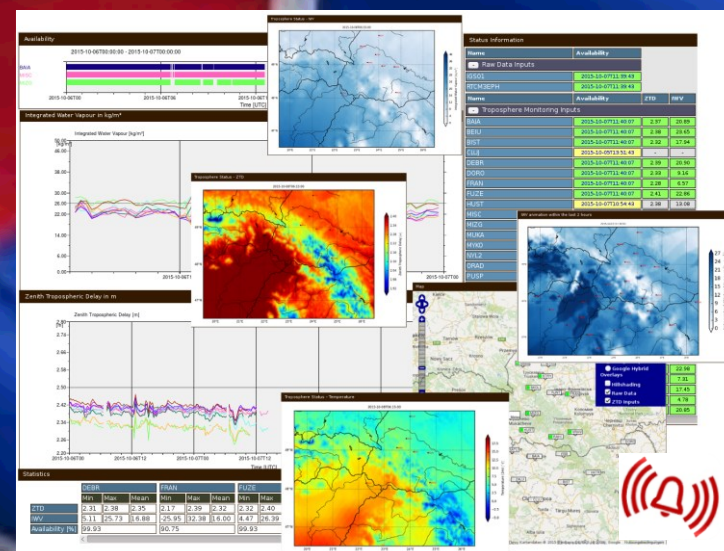
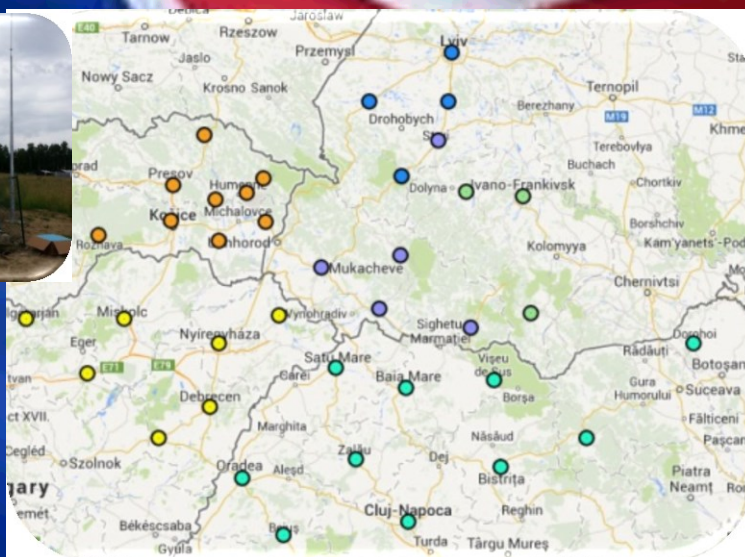


# Space emergency system

- Multilateral project: Ukraine-Slovakia-Hungary-Romania
- Agreement signed in December 2015
- goal: creation of Space emergency system
- more: [www.meteognss.net](http://www.meteognss.net)
- GKU contributes with data from **SKPOS**®

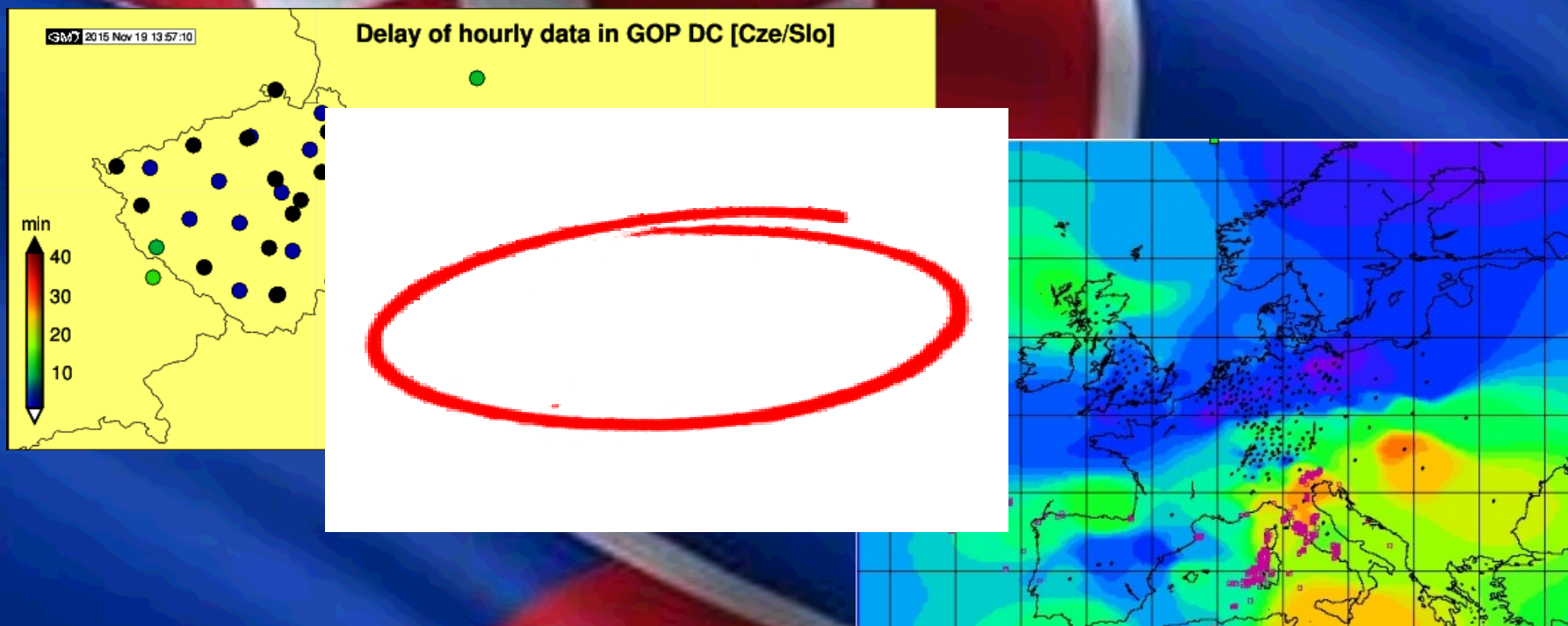


Program cezhraničnej spolupráce ENPI  
Maďarsko-Slovensko-Rumunsko-Ukrajina

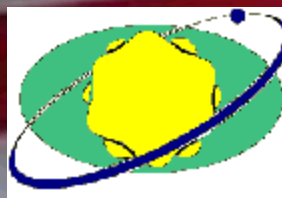


# E-GVAP programme

- EUMETNET GPS Water Vapour Programme
- data from **SKPOS**<sup>®</sup> stations supports E-GVAP via GOP data center (Tropnet)







Slovak University of Technology  
Research and development activities

# National center for diagnosing the Earth surface deformations in Slovakia

- ITMS research project (<http://www.geokinetatika.sk>)
- Surface deformations monitored on 9 geodynamics points by
  - Permanent GNSS stations
  - Absolute gravity measurements

WE SUPPORT RESEARCH ACTIVITIES IN SLOVAKIA  
THE PROJECT IS CO-FINANCED FROM THE EU SOURCES

**NATIONAL CENTER FOR DIAGNOSING THE EARTH SURFACE DEFORMATIONS IN SLOVAKIA**  
ITMS: 26220220108  
START OF THE PROJECT: 1 DECEMBER 2010 / END OF THE PROJECT: 30 NOVEMBER 2013

**ABOUT THE PROJECT**

**MONITORED SITES NETWORK**

**SATELLITE AND GRAVIMETRIC MEASUREMENTS ANALYSIS**

**PROJECT OUTPUT**

**CONTACT**

The aim of the National Center For Diagnosing the Earth Surface Deformations in Slovakia is to identify the Earth surface deformations on the basis of research results by applying the satellite, gravimetric and tropospheric measurements.

The output of the national center is a permanently updated database of earth crust dynamics in Slovakia focused on determination of risk areas for construction and monitoring of large structures.

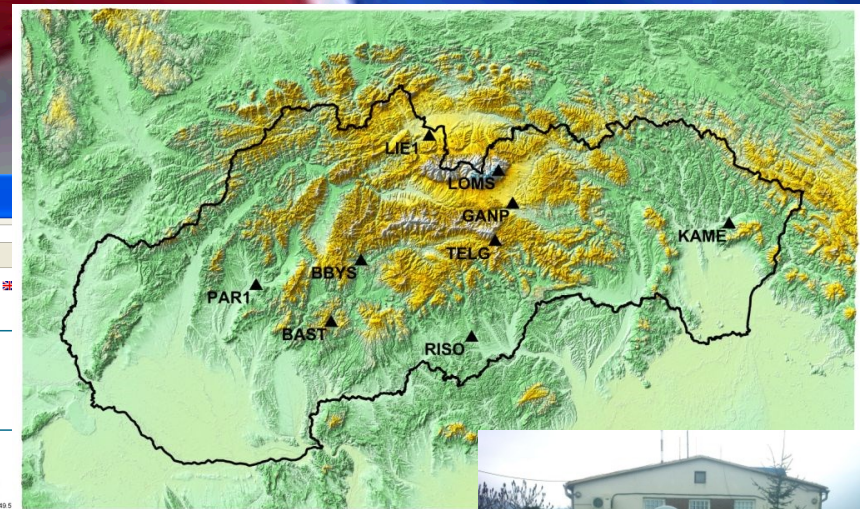
The national center carries out the measurements of geometric and physical variations on the Earth's surface on 9 reference stations of the monitoring network.

The position variations at all sites of the monitoring network are continually tracked by GNSS receivers. On the regular basis, the absolute and relative gravimetric measurements are carried out at the network sites as well as levelling measurements for improving the vertical deformation information.

**Sieť monitorovaných bodov**



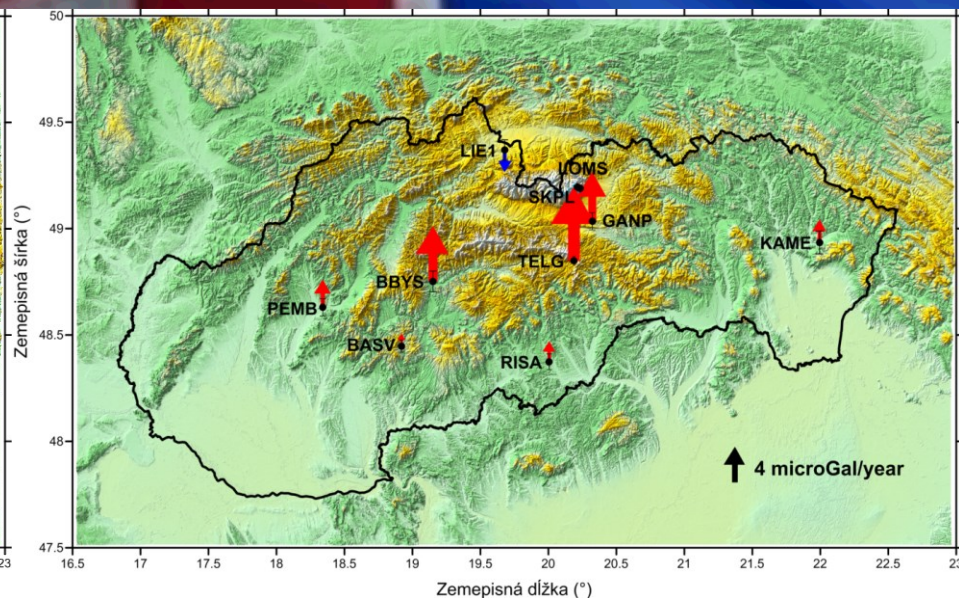
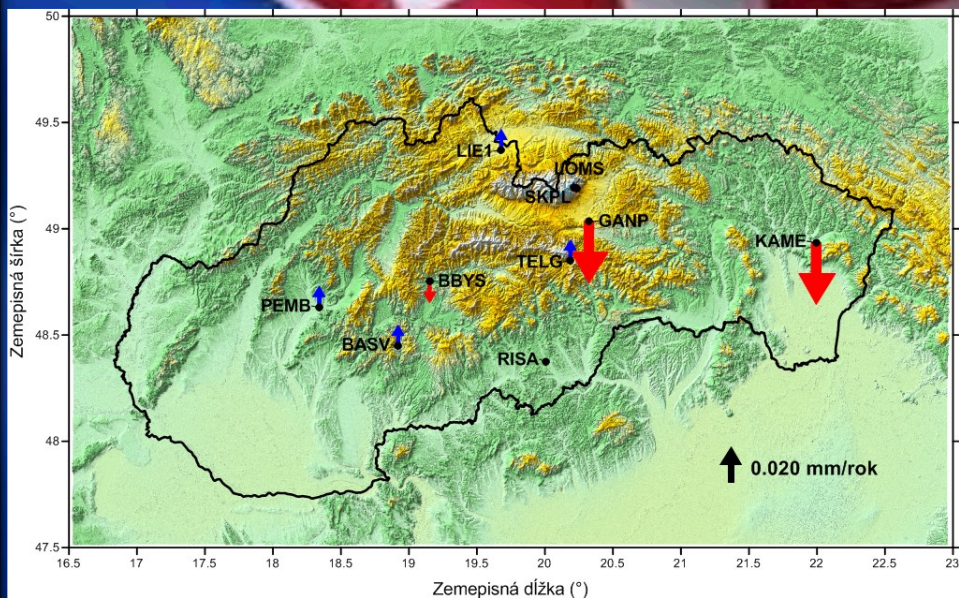
The monitoring network





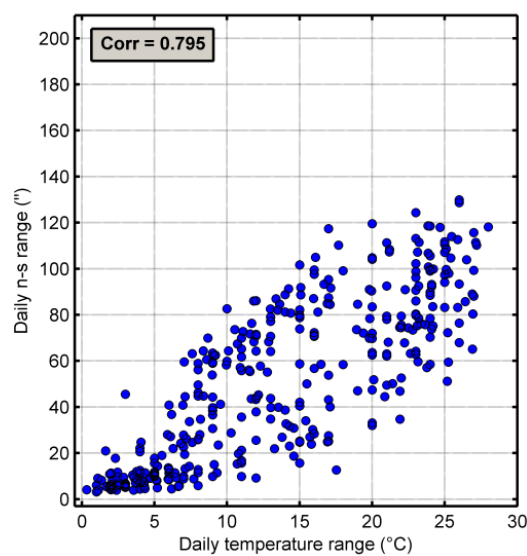
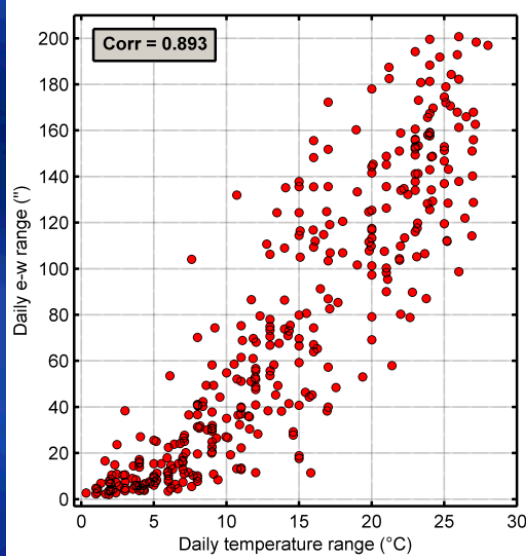
# National center for diagnosing the Earth surface deformations in Slovakia

- Preliminary results (only 1.3 year):
  - vertical velocities (left picture)
  - absolute gravity changes (right picture)



# Short-term and Long-term variability of antenna position due to thermal bending of pillar monument at permanent station SUT1

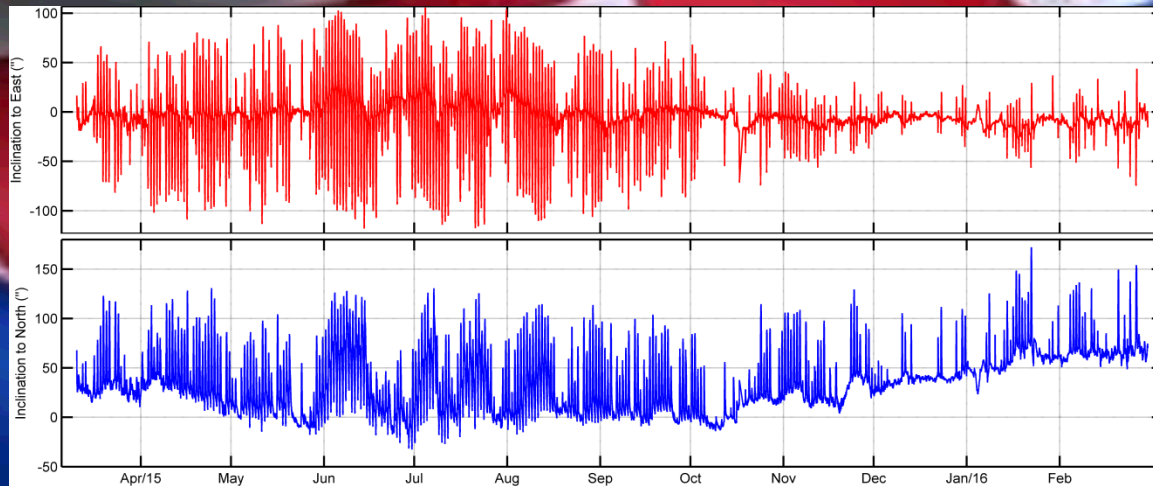
- The most significant impact on concrete pillar movements has diurnal variability of temperature and the sunshine activity. Effects of these factors is warming up of pillar's sun-side and consequent inclination from the sun. Inclination's direction is determined by irregular thermal expansion of pillar.



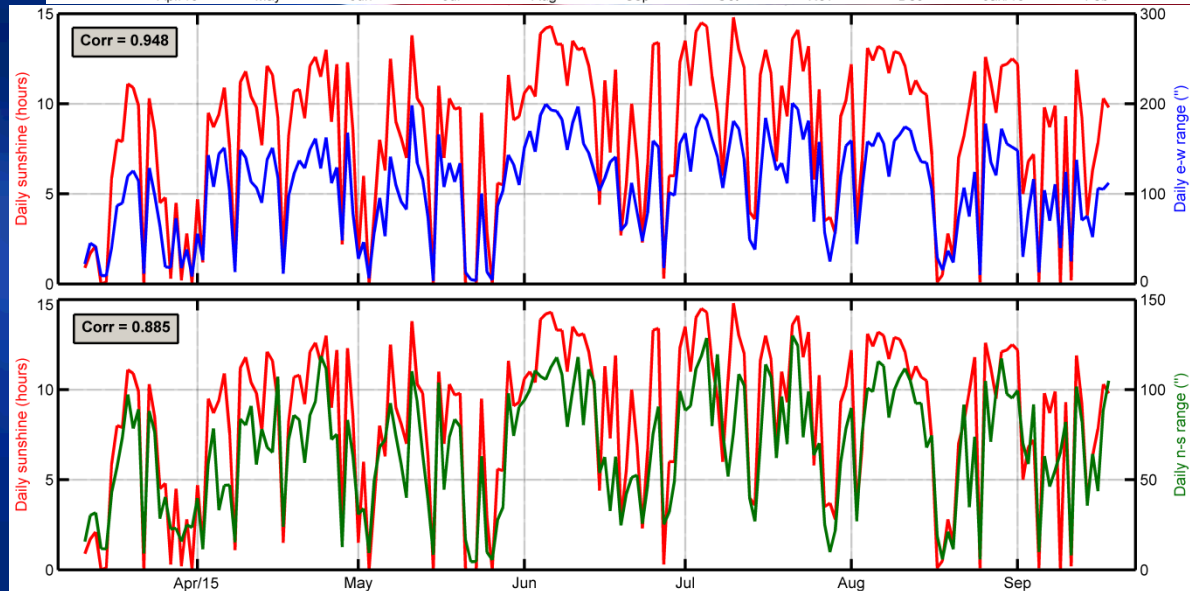
Daily temperature range versus inclination ranges (east-west and north-south) observed at SUT1 pillar. Daily variability of temperature ranges from 0 to 28°C (experiment was made throughout the year). To these ranges belong values from 0" to 200" in east-west direction and from 0" to 130" in north-south direction.



# Short-term and Long-term variability of antenna position due to thermal bending of pillar monument at permanent station SUT1



Long-term time series of inclination observations at SUT1 pillar.



Time series of daily inclination ranges in east-west (in blue) and north-south (in green) constituents observed at SUT1 pillar, and the duration of daily sunshine (in red). Correlation between daily inclination's range and sunshine hours is strong in case of stable sunny or cloudy weather throughout the day, in case of varying weather the correlation is low.



# Multi-sensor InSAR deformation monitoring over buildings and infrastructures in Bratislava (SLOVAKIA)

- Persistent Scatterer InSAR analysis spanning **24 years** (1992 - 2016) of spaceborne SAR measurements using ERS, ENVISAT, TERRASAR-X, RADARSAT-2 and SENTINEL-1.

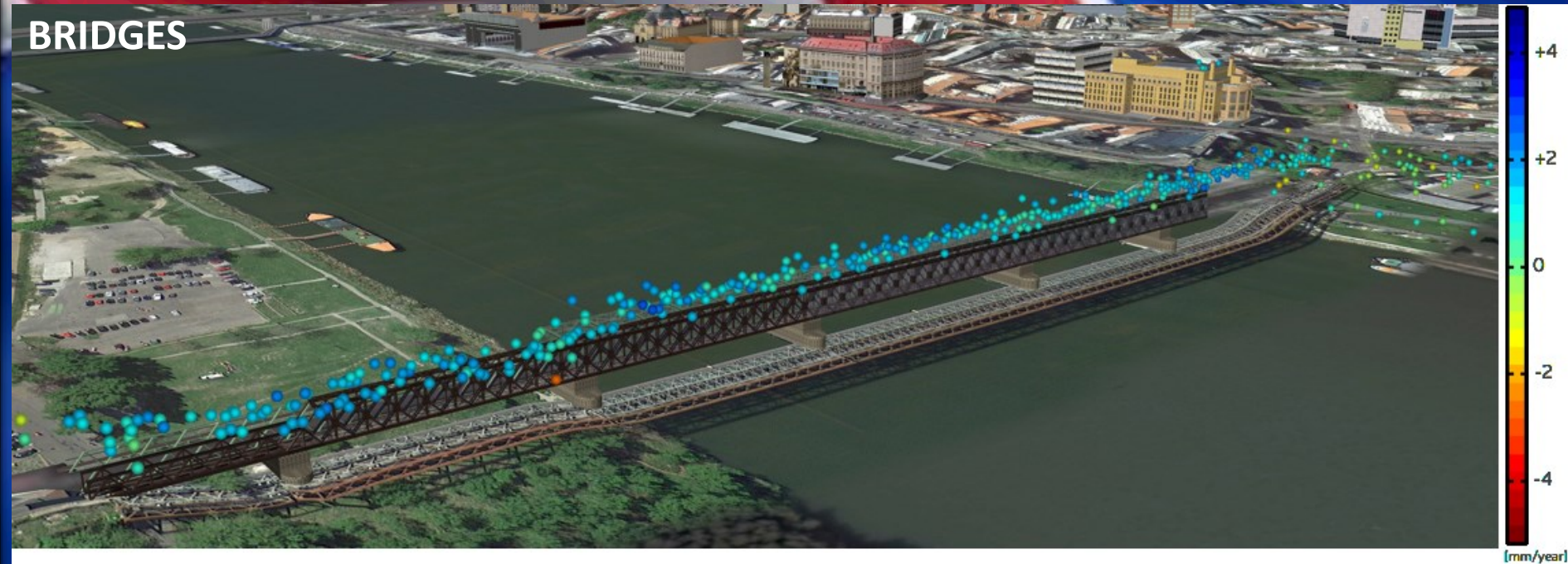




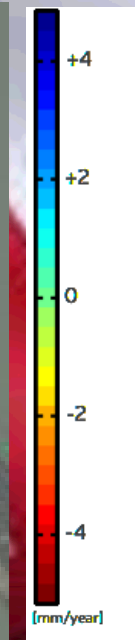
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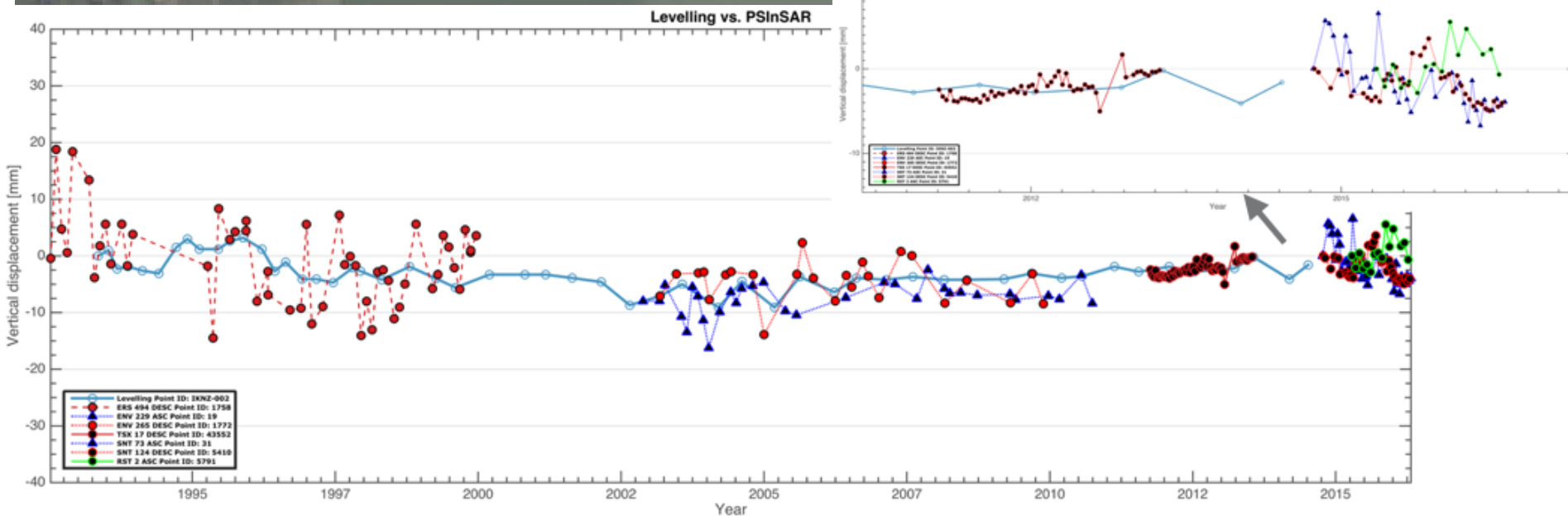
## BRIDGES



# DAMS



Comparison with ground truth measurements (levelling) over strategic objects such as dams.





# A data mining approach for multivariate outlier detection in heterogeneous 2D point clouds

Input

Coherence Thresholded

Our approach

[mm/year]

50

40

30

20

10

0

-10

-20

-30

Original data (9247 pts)

Coherence > 0.7 (5514 pts)

Outlier-free data (8318 pts)

post\_analysis

Input

DBSCAN

Eps  MinPts

PCA

<input type="checkbox"/> HEIGHT	<input type="checkbox"/> VEL
<input type="checkbox"/> HEIGHT WRT DEM	<input type="checkbox"/> SIGMA VEL
<input type="checkbox"/> SIGMA HEIGHT	<input type="checkbox"/> CUMDISP
<input type="checkbox"/> KTEMP	<input type="checkbox"/> SEASONAL
<input type="checkbox"/> COHER	<input type="checkbox"/> INV. COHER

k  cutoff  %

Coefficients

Minimum Coherence

Rejection Criterion

Jaccard Coefficient

Deformation map over area of active landslides in Prievidza, Slovakia.

## References:

- M. Bakon, I. Oliveira, D. Perissin, J. Sousa and J. Papco, "A data mining approach for multivariate outlier detection in heterogeneous 2D point clouds: An application to post-processing of multi-temporal InSAR results," Geoscience and Remote Sensing Symposium (IGARSS), 2016 IEEE International, Beijing, 2016



Other news

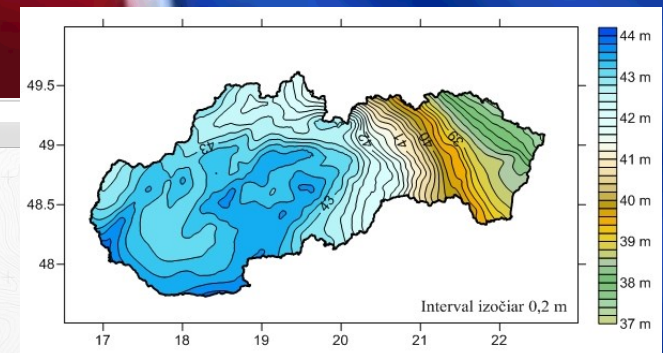


# Slovakian quasigeoid DVRM

- since March 2015 available for free of charge
- <https://www.geoportal.sk/en/geodeticke-zaklady/download/>
- DVRM is intended for the transfer of ellipsoidal heights determined using GNSS in the ETRS89 system to the system of normal heights Bpv

The screenshot shows the Geoportal website interface. The main navigation bar includes links for GEODETTIC CONTROL, CADASTRE, ZBGIS, ARCHIVE, APPLICATIONS, SERVICES, INSPIRE, and FAQ. The 'Download' section is highlighted in the left sidebar. The main content area displays a table of download links for various data sets, including the DVRM (Digital Vertical Reference Model) and the SKPOS information leaflet.

Download	Download (zip)
Transfer interpolation table JTSK03 <-> JTSK	Download (zip)
Technical report: Coordinate system of Unified Trigonometric Cadastral Network and its relation to the European Terrestrial Reference System 1989 (version 2.0)	Download (pdf)
Digital Vertical Reference Model - DVRM05	Download (gem) Leica
Model is intended for the transfer of ellipsoidal heights determined using GNSS in the ETRS89 system to the system of normal heights Bpv.	Download (gem) Trimble
	Download (gem) Topcon
	Download (gem) Maelan
	Download (gem) Altus
	Download (gem) JTSK
	Download (dat) ASCII
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SKPOS information leaflet	Download (pdf)





Thank you  
for your attention