Slovak real-time positioning service as an integral part of *EUPOS*

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Important Milestones for SKPOS

- Initial ideas about SKPOS
  - November 2001, Vienna - 2nd UN/USA Regional Workshop on the Use of GNSS
  - March 2002, Berlin – Workshop on Multifunctional Reference Stations Systems in Europe

- SKPOS realisation
  - Beginning of 2006 – SKPOS hardware purchase
  - May 2006 – first SKPOS station initialization (SKGA)
  - November 2006 – first official user registration
  - May 2007 – full SKPOS network constellation (21 stations)

Formation of *EUPOS*

- *EUPOS* is an international initiative and cooperation
- unified regional DGNSS ground-based infrastructure for real-time positioning and navigation
- mosaic of national segments operating according to common standards
- interoperability of the national positioning services

Slovak Real-Time Positioning Service - SKPOS

Legislation

- 2003 - amendment of the law on geodesy and cartography
- new task - to operate a GNSS real-time positioning service

Financing

- pre-accession EU programme Phare
- financial memorandum 2003
- tender failed in 2005
- in 2006 - financing from the state budget
- since November 2006 - SK*POS* in operation

SKPOS Infrastructure

- ## reference stations network
  - ### 21 stations (GPS/GLONASS) + 1 external GPS station
    - receivers: Trimble NETR5
    - antennas: Zephyr Geodetic Model 2

- ## communication lines
  - ### virtual private network
    - GNSS data have highest priority
    - cadastral data

- ## National Service Centre
  - Trimble networking software
  - Bernese GPS software 5.0
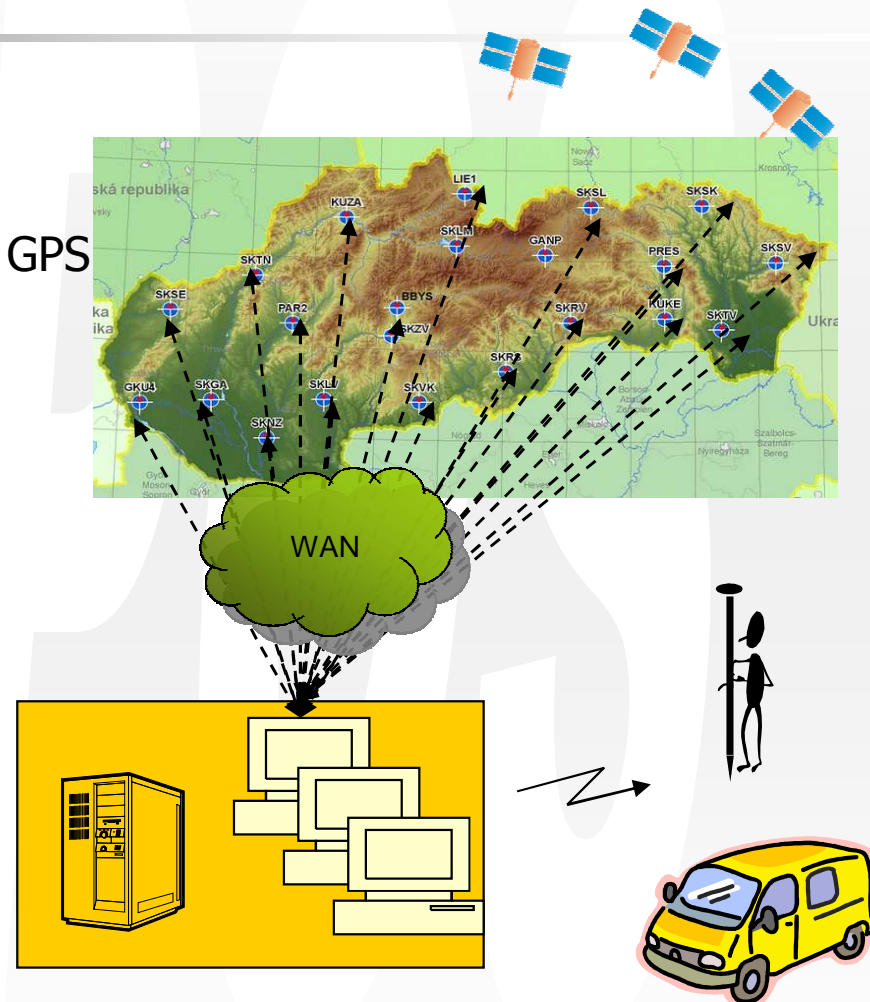
Distribution of the reference stations

Monumentations

foto 1/07
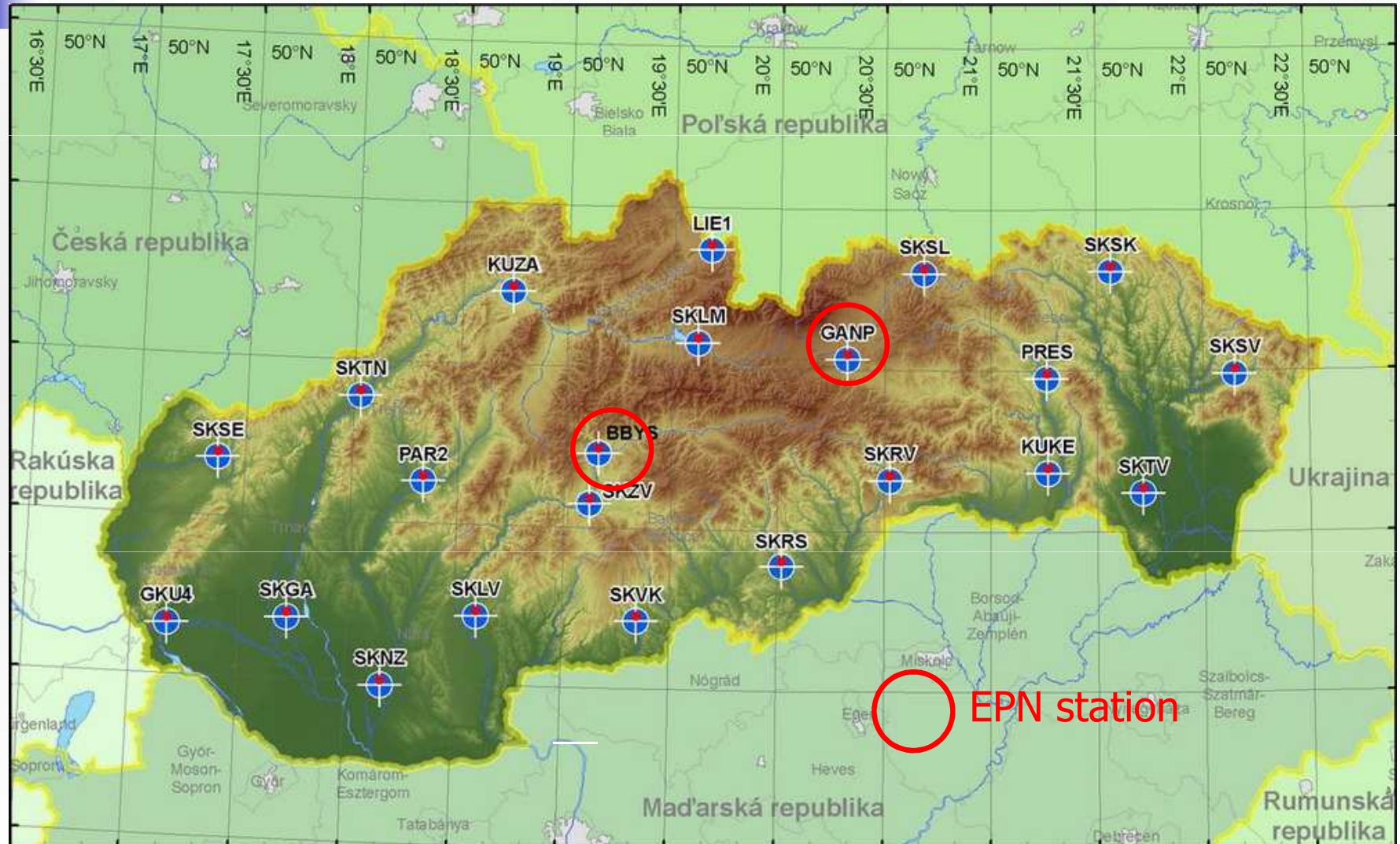
Antenna calibration on robot

BERLIN -Senatstadt

GARBSEN – Geo++

SKPOS services

real-time services

- **SKPOS-dm** – differential corrections by code measurements, accuracy **1 m – 0,5 m for dynamic objects and 0,3 m for static objects**

- **SKPOS-cm** – differential corrections by carrier phase measurements, accuracy **2 – 4 cm**.

post-processing services

- **SKPOS-mm** – code and phase measurements for postprocessing, centimetre to sub – centimetre accuracy

Data distribution

|			
SKPOS-dm	NTRIP caster	http://www.skpos.gku.sk:2101/	free of charge
SKPOS-cm	NTRIP caster	http://www.skpos.gku.sk:2101/	free of charge
SKPOS-mm	web server	http://www.skpos.gku.sk	charged

Close Cross-border cooperation

- Main activity
    - Providing data (RTCM, Rinex) for other neighboring services - GNSSnet.hu, ASG-EUPOS, APOS, CZEPOS
    - Comparison of processing results - coordinates and time series character on overlap stations.
- Purpose
    - Verification of processing strategy,
    - Verification of station quality,
    - Improved RTK surveying accuracy in close border areas.
- Example of results
    - Comparison consistency on cm level with AGS-EUPOS, APOS, GNSSnet.hu,
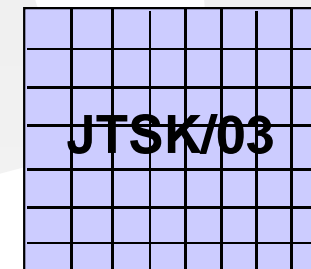   - Recognized false antenna calibration on WIEN station.

Transformation into the national coordinate system
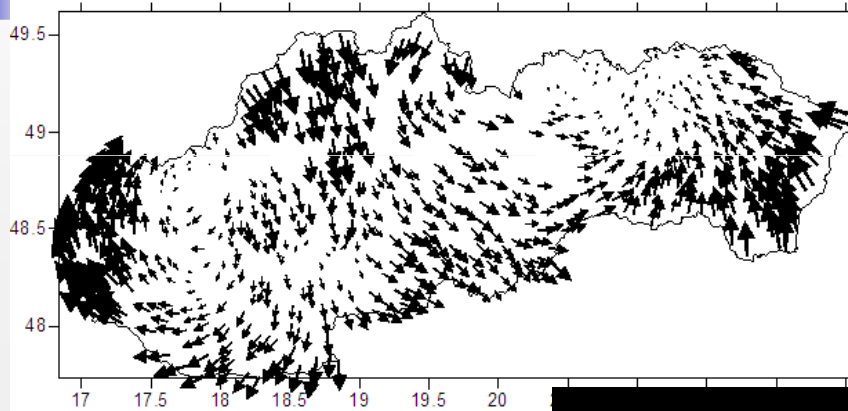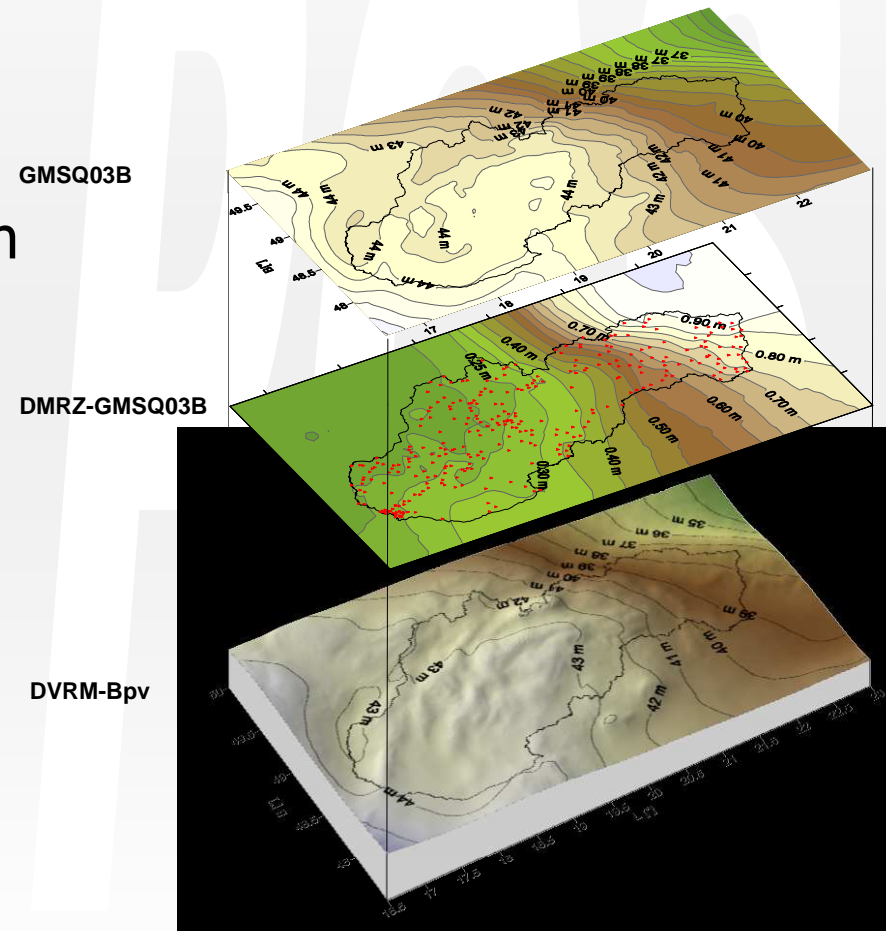

local distortions up to 1.3 m
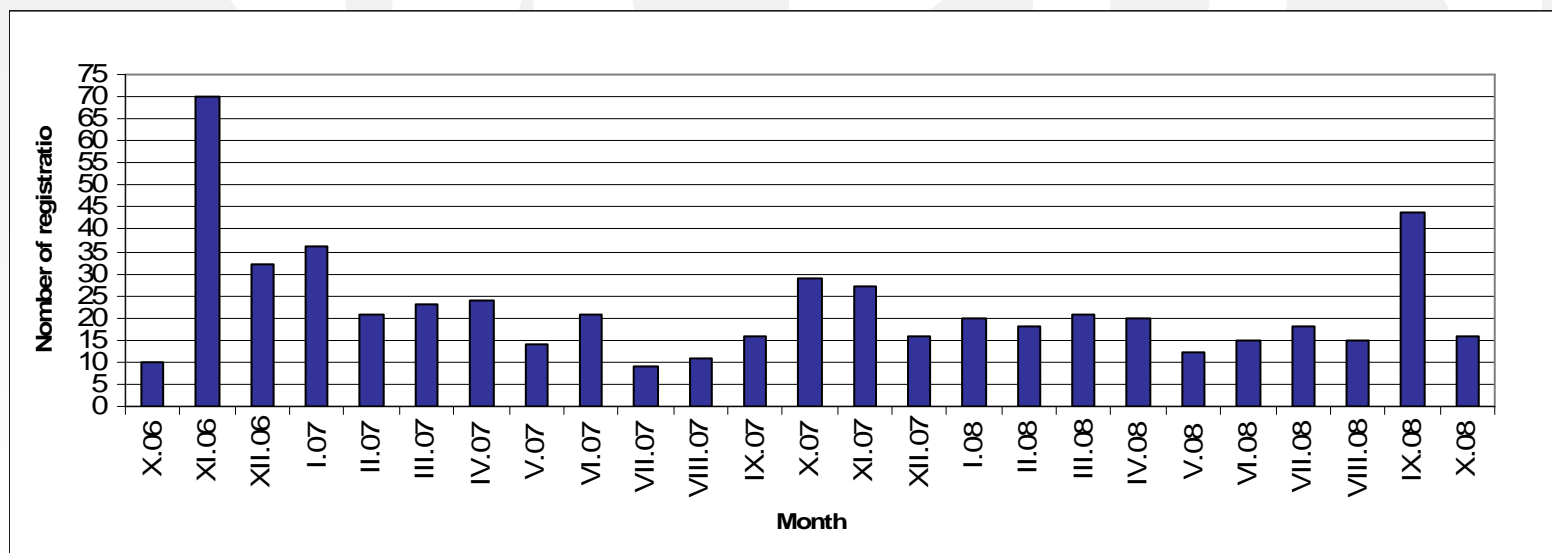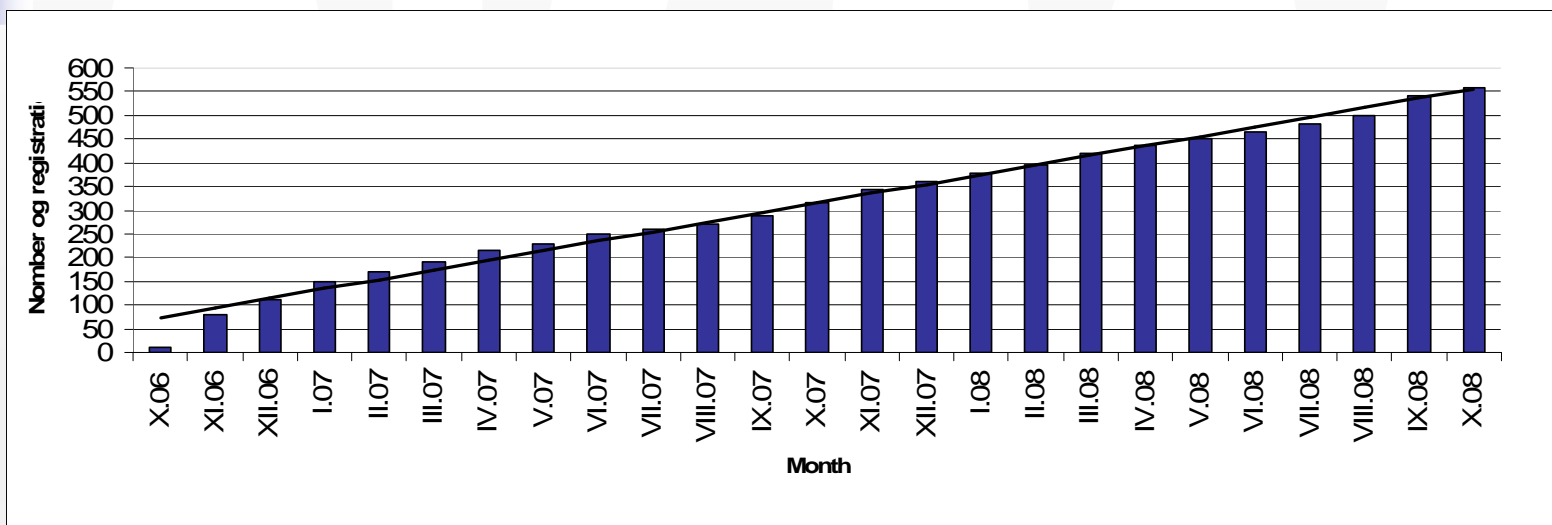
JTSK − = **JTSK/03**
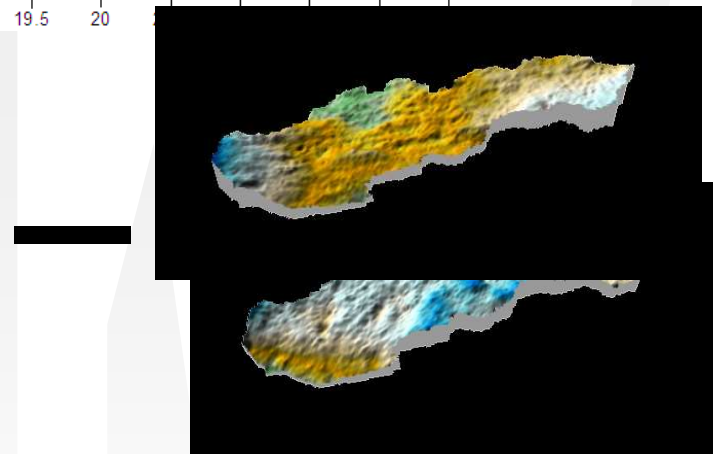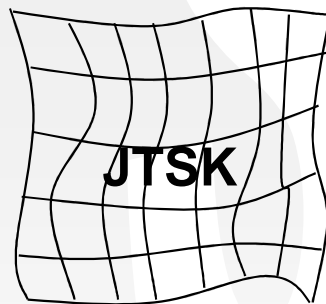
ETRS89

Global par.

tX = 485.021 m
tY = 169.465 m
tZ = 483.839 m

uX = -7.786342
uY = -4.397554
uZ = -4.102655

dK = 0

Transformation into the national height system

- gridded data 600 x 600 m
- accuracy of the transformation 3.5 cm (1σ)

GMSQ03B

DMRZ-GMSQ03B

DVRM-Bpv

SKPOS users

SKPOS coordinates

- Bernese GPS software v.5.0
- Fixed to EPN/IGS stations
- ITRF2000
- ETRF2000 (epoch 2006.636)

Monitoring of the network stations stability

- Routine processing of 49 stations
    - Bernese Software 5.0,
    - ITRF2005 (epoch 2000.0),
    - GLONASS included,
    - Results = sets of daily and weekly coordinates and covariances
- Residuals creation
    - Modified strategy developed by LAC SUT,
    - Transformation to „*neu*" topocentric system,
    - Graphic interpretation (weekly residuals) as time series
- Time series analysis
    - Least square estimation of the 1st order of harmonic analysis,
    - Trend and annual period determination.
- Conclusions and results
    - Comparison with critic values,
    - Stations sorting according results (stabile, periodic, outlier...),
    - Solving detected and unexpected station character

Processed stations network
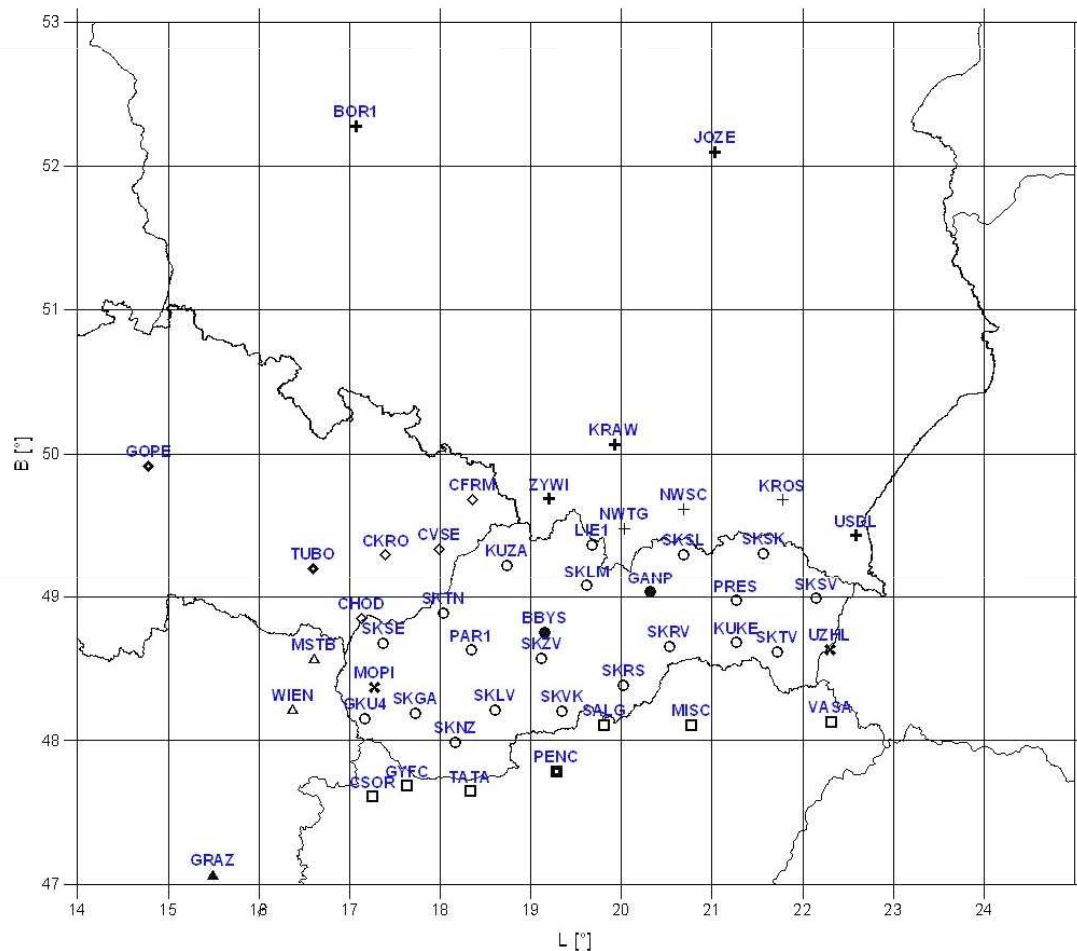
SKPOS	23/3 EPN
APOS	3/1 EPN
GNSSnet.hu	7/1 EPN
CZEPOS	6/2 EPN
ASG-EUPOS	8/5 EPN
EPN	2
Totally	49 stations

Residuals creation

- Residual equation
  - Reduction of mean network (LAC SUT strategy),
  - BOR1 – reference point,
  - ITRF2005 velocity model

$$d\mathbf{X}_i(t) = \mathbf{X}_i(t) - \mathbf{X}_{Oi} - \mathbf{v}_{ITRF\,2005\,i}(t - t_O) - \mathbf{A} \cdot \mathbf{T}$$
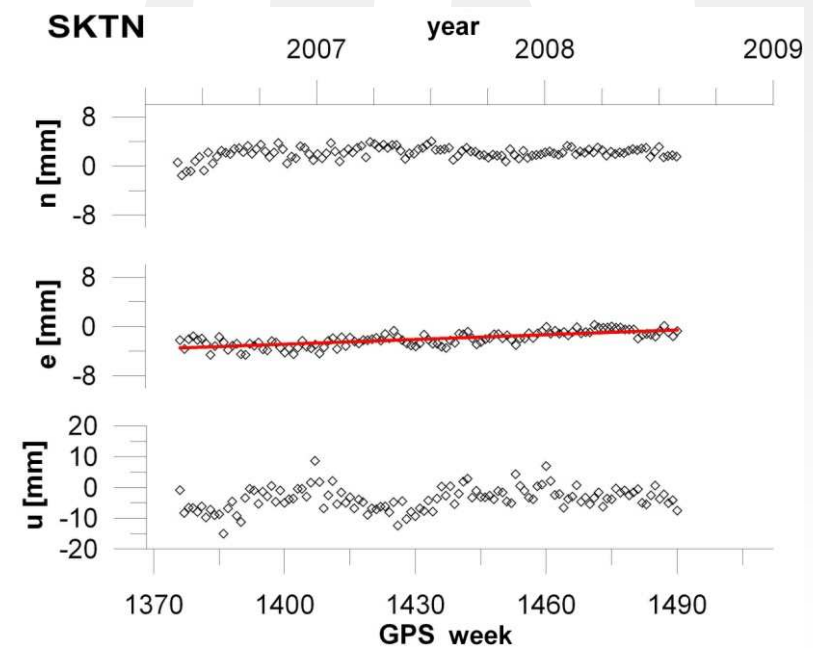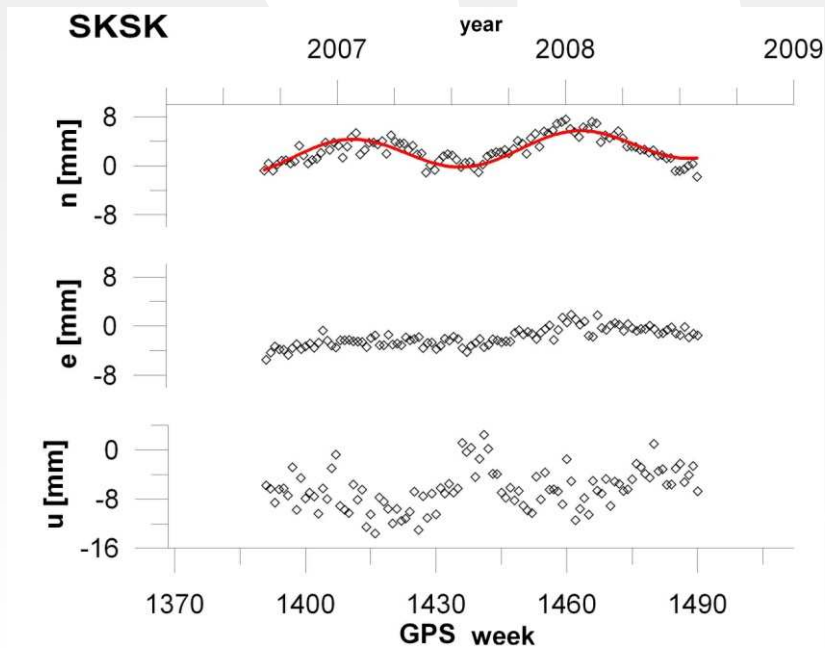
- Topocentric system

$$d\mathbf{N}_i(t) = \begin{pmatrix} dn_i(t) \\ de_i(t) \\ du_i(t) \end{pmatrix} = \mathbf{R}(B_i, L_i) \cdot d\mathbf{X}_i(t)$$
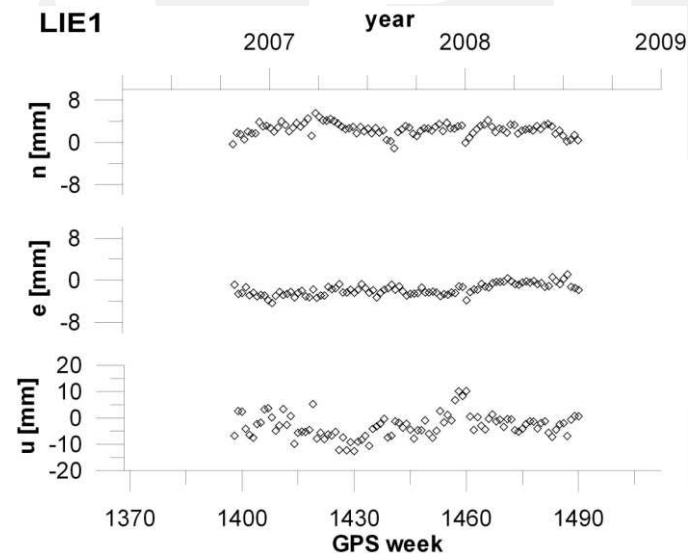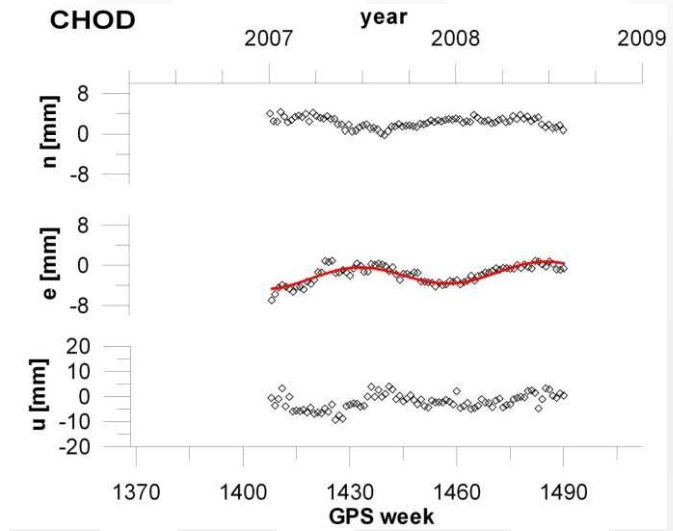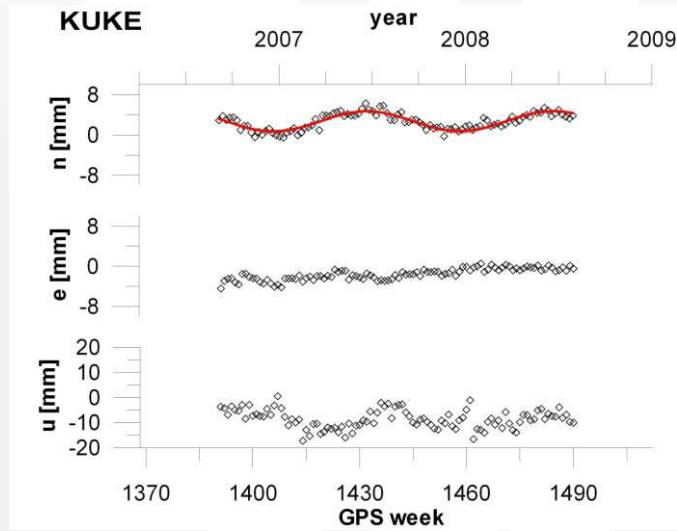
Timeseries analysis

- 1st order harmonic analysis (**a** - trend, **A** − periodicity).

$$y = \mathbf{a} \cdot t + b + \mathbf{A} \cdot \cos\left(\frac{2 \cdot \pi}{52} \cdot t - \varphi\right)$$

Time series other examples

Future plans for development

- Hardware
  - densification of the network: 3 – 4 more GNSS stations,
  - independent quality monitoring stations,
  - absolute phase centre calibration of all antennas

- Software, computation and analysis
  - Continual transition to ETRF2005 in net software,
  - Contribute to evaluation of systematic effects (multipath) and troposphere modeling,
  - Enhanced quality of transformation to national 2D system and local vertical datum.