UNIVERSITY OF ZAGREB FACULTY OF GEODESY
Department of Geomatics, Chair for State Survey
Fra Andrije Kačića Miošića 26, HR–10000 Croatia

CROPOS – Current Status and Implementation of T7D Transformation Model

Prof. dr. sc. Tomislav Bašić

e-mail: tomislav.basic@geof.hr

"Establishing the European Spatial Reference System in Slovenia", Ljubljana, 24. Nov. 2010

Introductory remarks

This lecture builds on:

- *"Introduction and implementation of ESRS in Croatia"* (T. Bašić). Zveza geodetov Slovenije, 37. Geodetski dan, "S koordinatami v Evropi", 16.11.2007, Hotel Perla, Nova Gorica, Slovenia; *Geodetski vestnik*, ISSN: 0351-0271, Volume 51, Issue 4, 751-762, UDK: 528.236(497.5).
- *"Unique transformation model and a new Croatian geoid model"* (T. Bašić). CGS&SGA "1st CROPOS Conference", Zagreb, 8-9, June 2009. SGA: Reports on the scientific and professional projects 2006-2008, Ed. M. Bosiljevac, 5-21, Zagreb 2009.
- *"CROPOS – positioning easier than ever"* (M. Marjanović & T. Bašić), INF-0002, Trimble Dimensions 2010 conference "Converge, Connect and Collaborate" (5th), 8-10, November 2010, Las Vegas, USA.

CROPOS – launched on 9th of Dec. 2008

- CROPOS is a reference GNSS network of permanent stations of the Republic of Croatia enabling its users to determine a location with the GNSS technology in the real time with an accuracy of 2 cm for position and 4 cm in height on the entire Croatian territory

Importance:

- Introduction and application of new geodetic reference systems (datums) of the Republic of Croatia
- Homogenization of coordinate system
- Same accuracy of measurement and coordinate determination at the entire territory
- Utilization of the unique measurement methods - standardization in performing of geodetic works
- Faster and more efficient performing of geodetic works

CROPOS – Basics

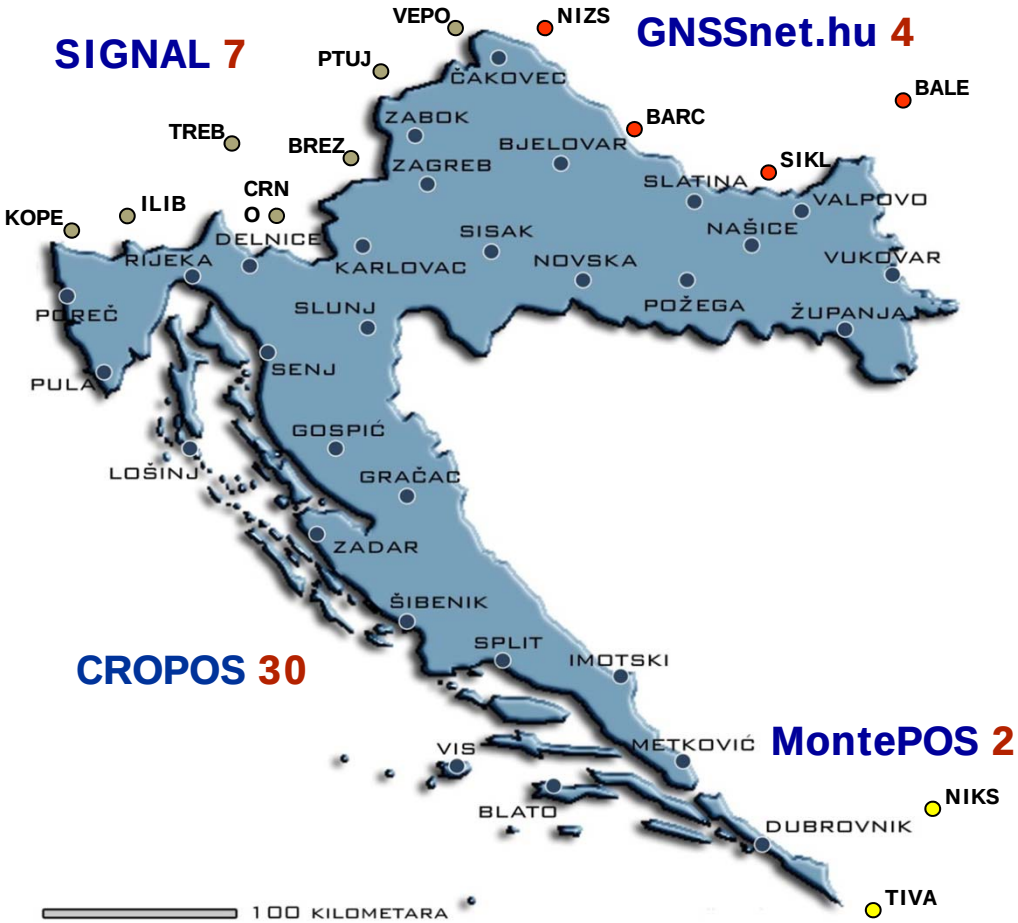
- Collecting the data from the reference stations that are placed at 30 locations at the territory of the Republic of Croatia
- Reference station real-time GNSS data exchange with the neighbouring countries
- Networking and computing the real-time correction parameters
- Distribution of measuring data and real-time correction parameters to the users
- Monitoring of the system operation and users support
- 24/7/365 service availability

CROPOS – Current Status

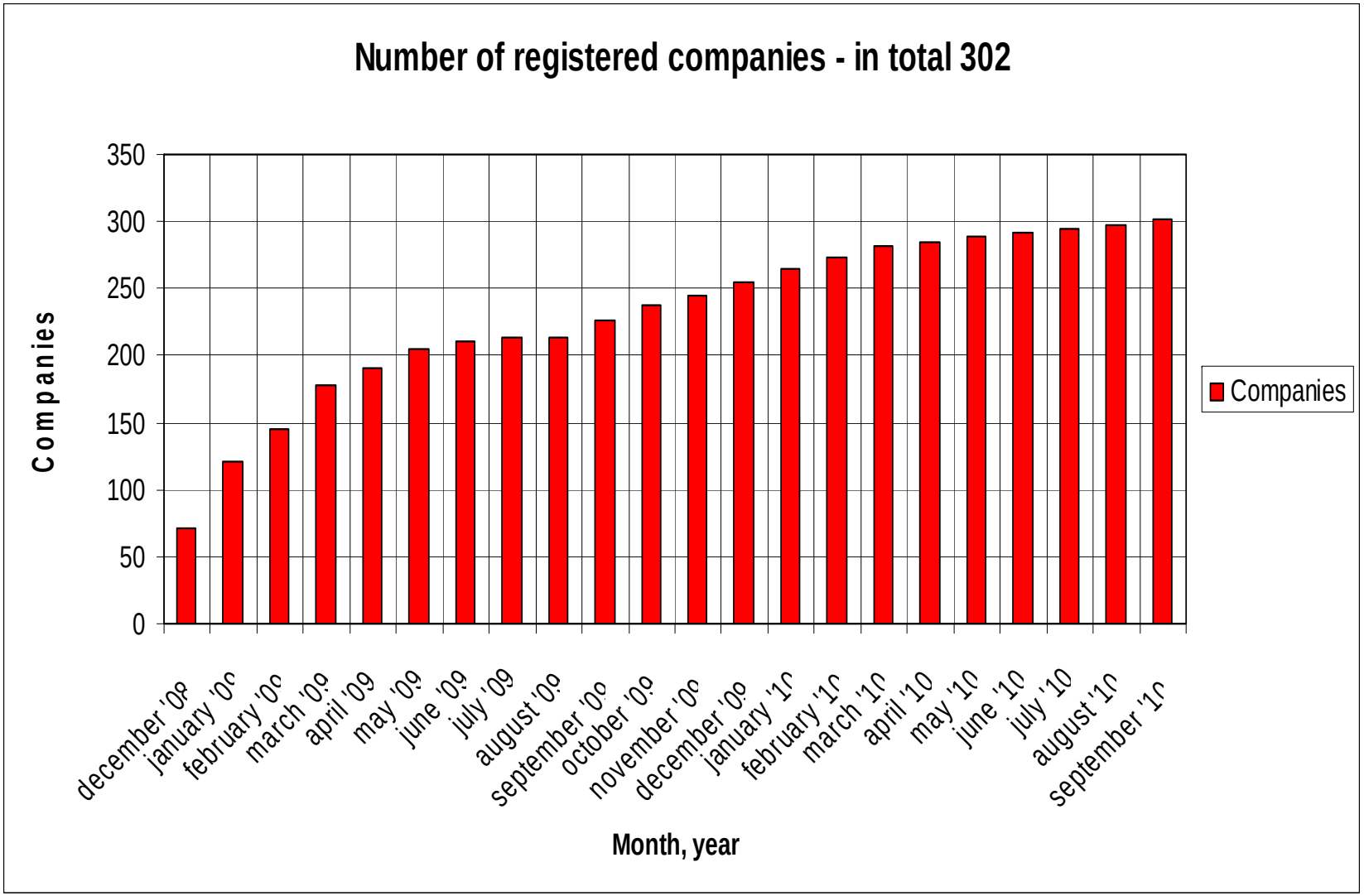
- Hardware upgrade: data storage (+ 2 TB), tape backup (1 GB)
- Software update: Trimble GPSNet Ver. 2.730, GNSS receiver firmware Ver. 4.03
- Implementation of system for remote administration and system control of servers
- New application for user administration and charging, additional system usage statistics
- Processing of RINEX data in order to monitor and analyse stability of CROPOS reference frame – GPS week solutions

CROPOS – Current Status (43 stations)

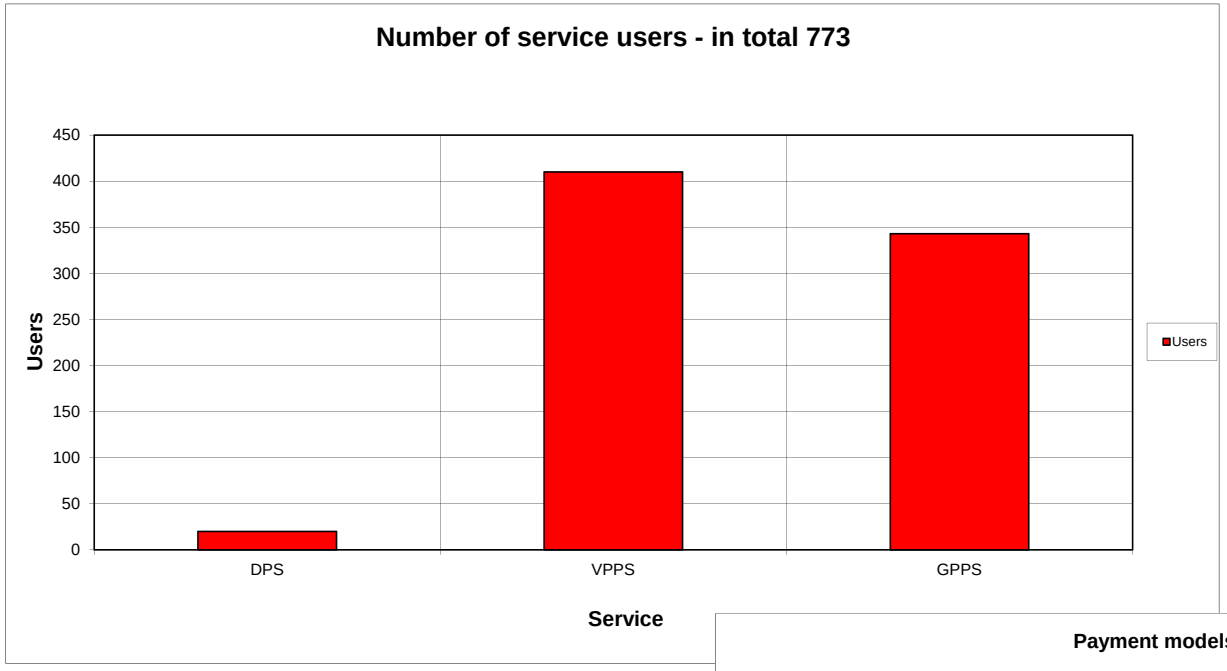
www.cropos.hr



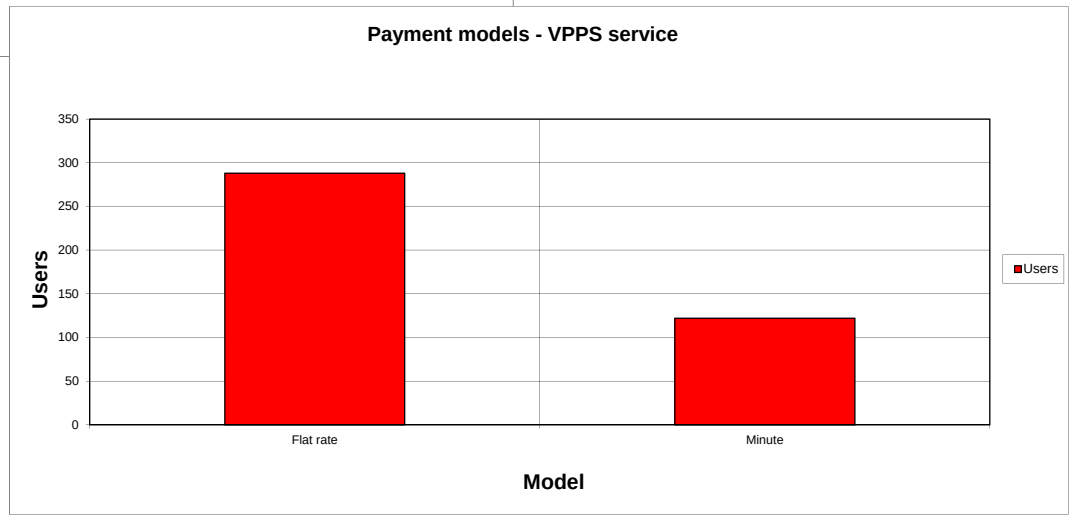
CROPOS Statistics



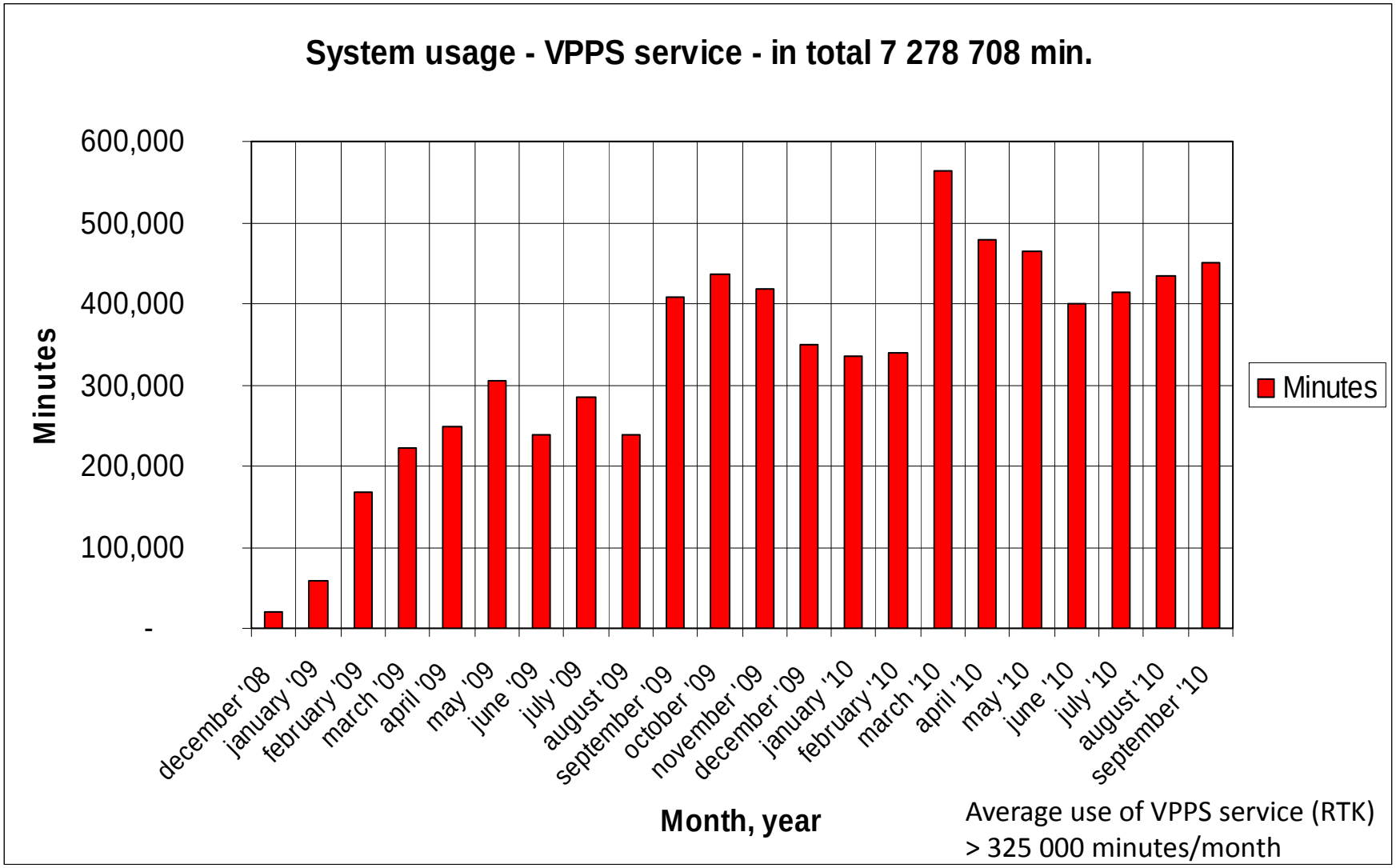
CROPOS Statistics ...



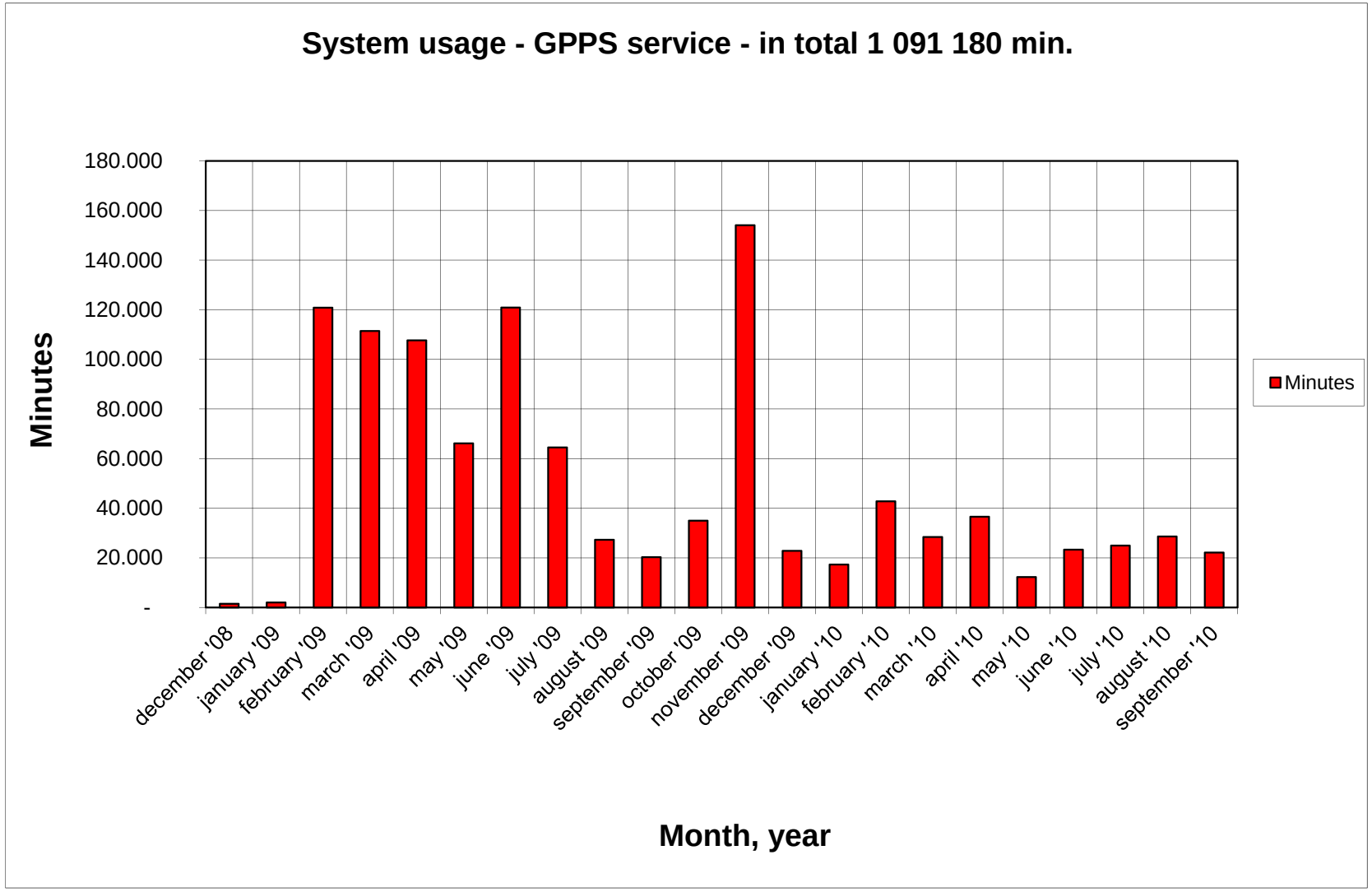
Average of 40 users connected at the same time during working hours (max. 79)



CROPOS Statistics ...



CROPOS Statistics ...

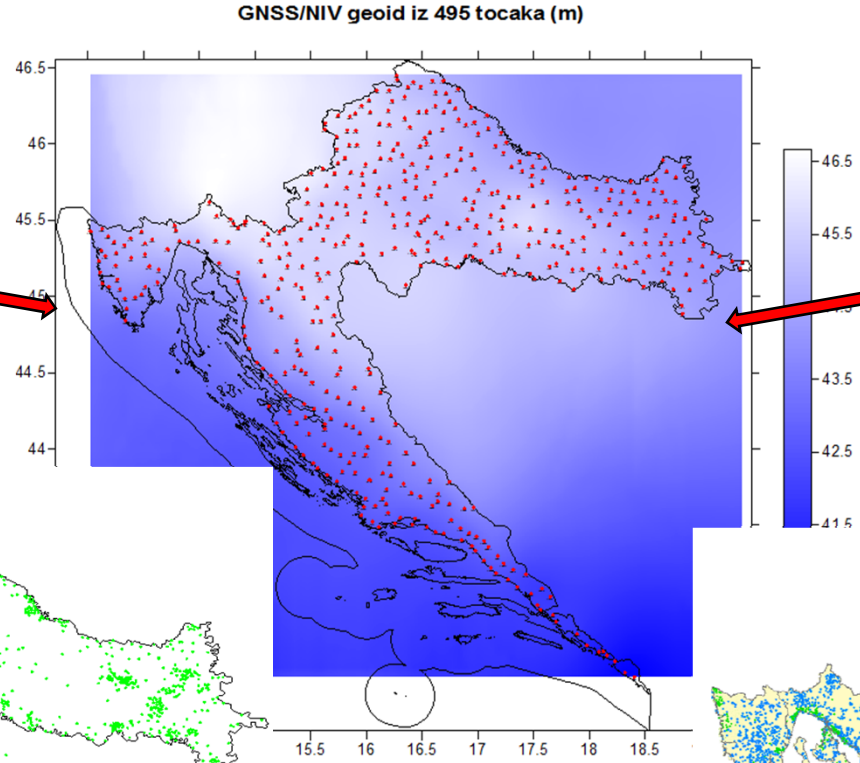


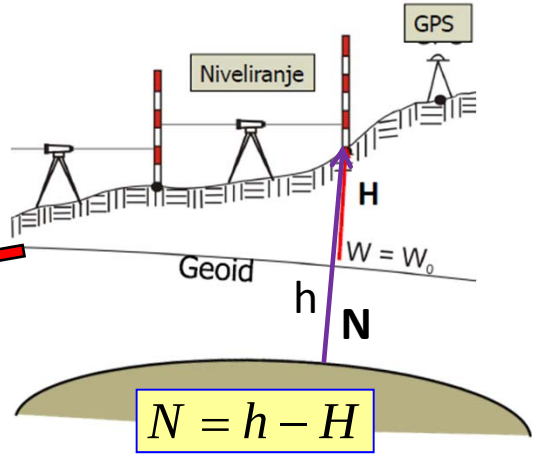
HRG2009 – New Geoid Solution

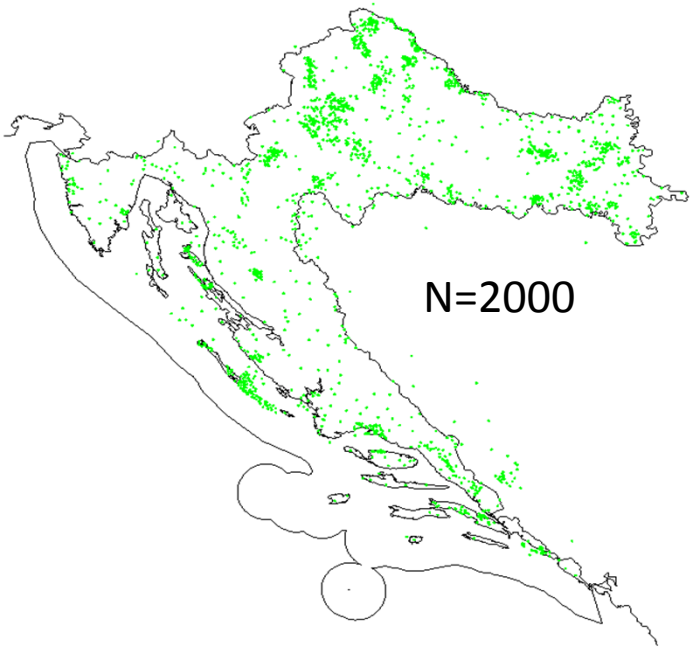
- Data:
  - Earth's gravity field - free air gravity anomalies (~ 30000)
  - Satellite altimetry in the Adriatic Sea (400)
  - Global geopotential model EGM2008
  - High frequencies field structures modeled with the help of 3" x 3" Shuttle Radar DEM's
  - Discrete geoid undulations obtained by GNSS/leveling on the mainland (495)
- Least squares collocation calculation technique
- Geoid surface point raster 30" x 45"
- Internal accuray $\sigma = 2 – 3$ cm
- Absolute accuracy based on comparison with GNSS/Leveling values (59 points – not included in model); $\sigma = \pm 3.5$ cm

GNSS/Leveling and transformation points

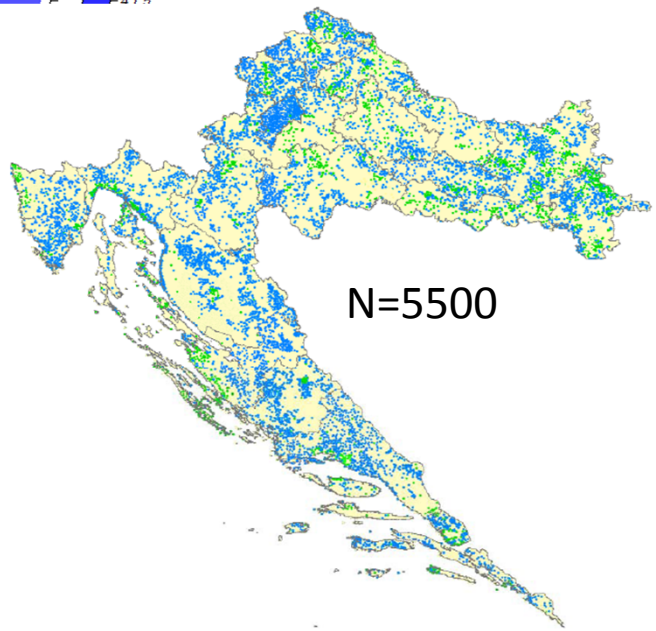
CROPOS



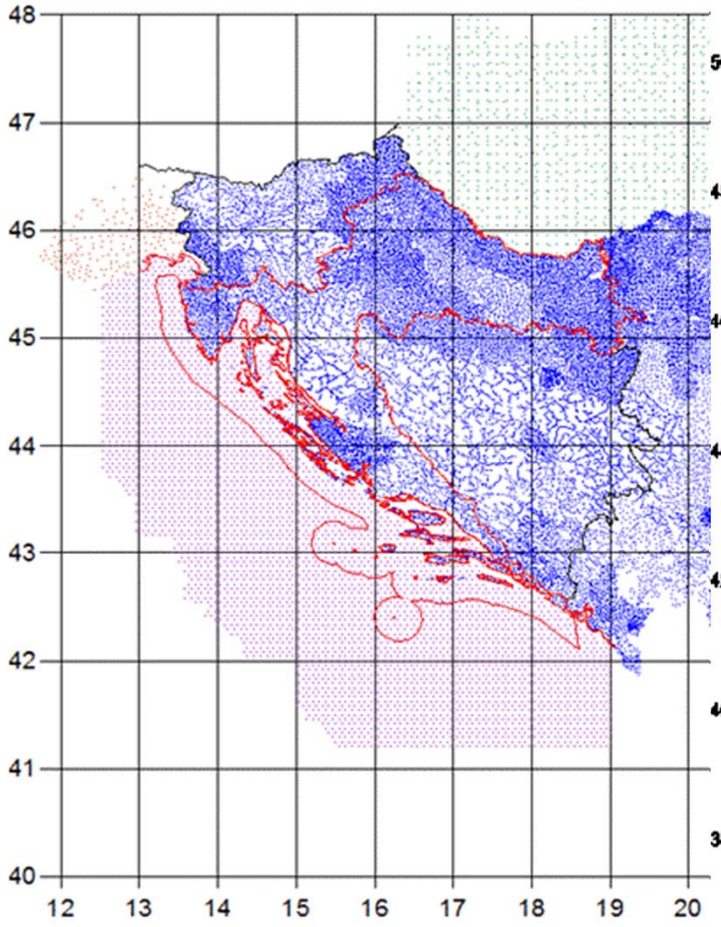


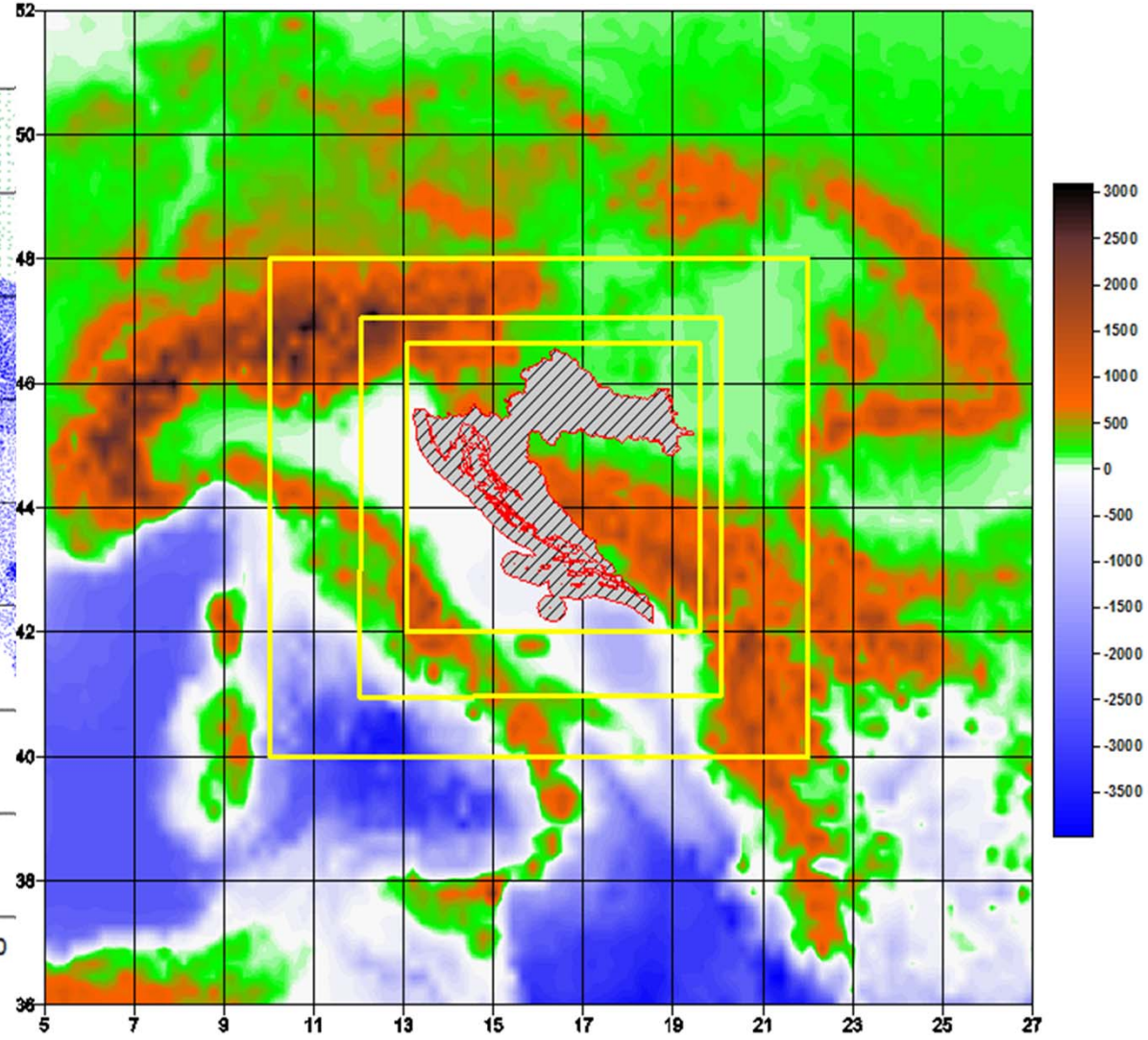


CROPOS

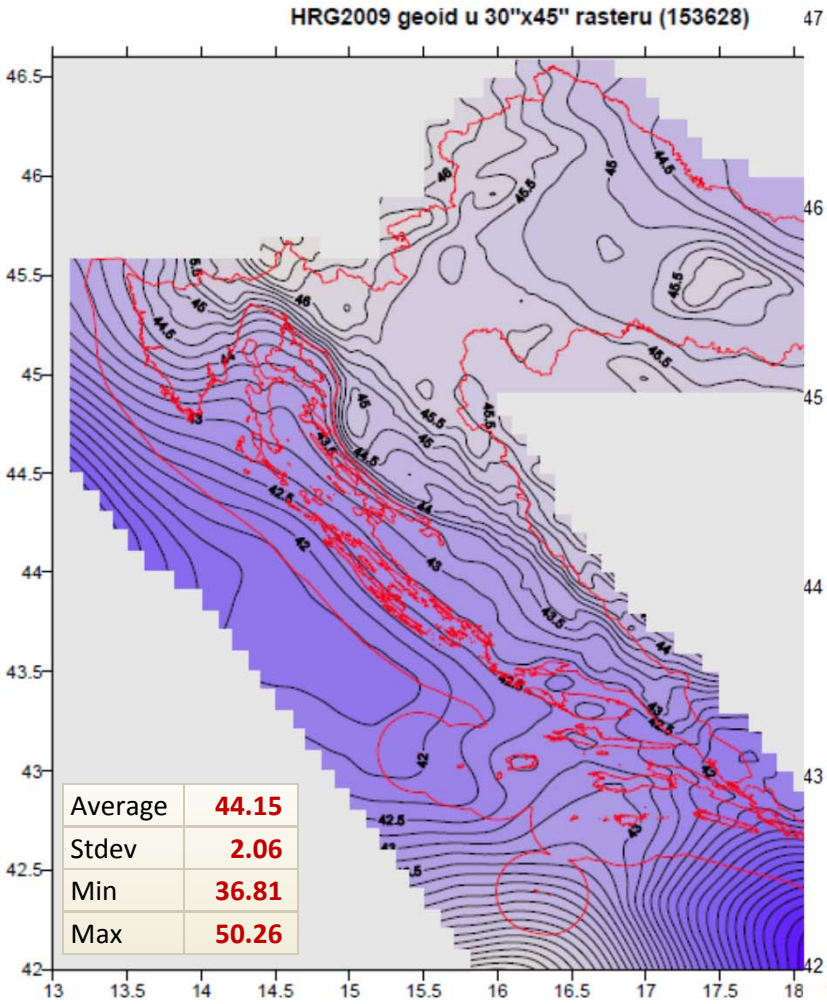


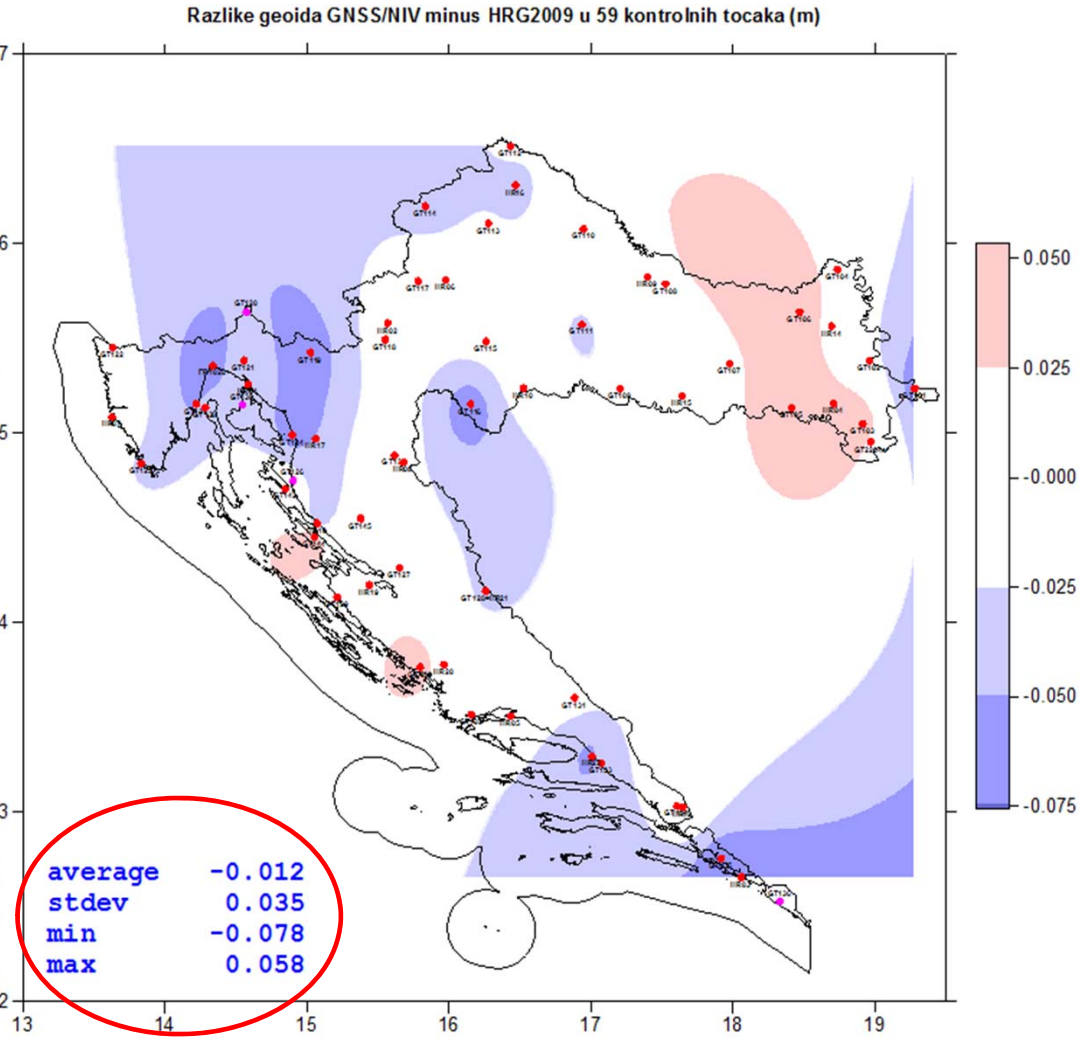
Gravity data and DTM (3"x3" i 1′x1′ SRTM)





HRG2009


HRG2009 geoid u 30"x45" rasteru (153628)
Average 44.15
Stdev 2.06
Min 36.81
Max 50.26


Razlike geoida GNSS/NIV minus HRG2009 u 59 kontrolnih tocaka (m)
average -0.012
stdev 0.035
min -0.078
max 0.058
0.050
0.025
-0.000
-0.025
-0.050
-0.075

T7D – new transformation model

- Unique transformation model HTRS96<>HKDS - uniform, reliable and simple transformation system, available to all users
- GRID transformation for the whole Croatian territory, consisting of 7-parameter transformation and a proper raster predicted values of distortion, both in plane coordinates and height

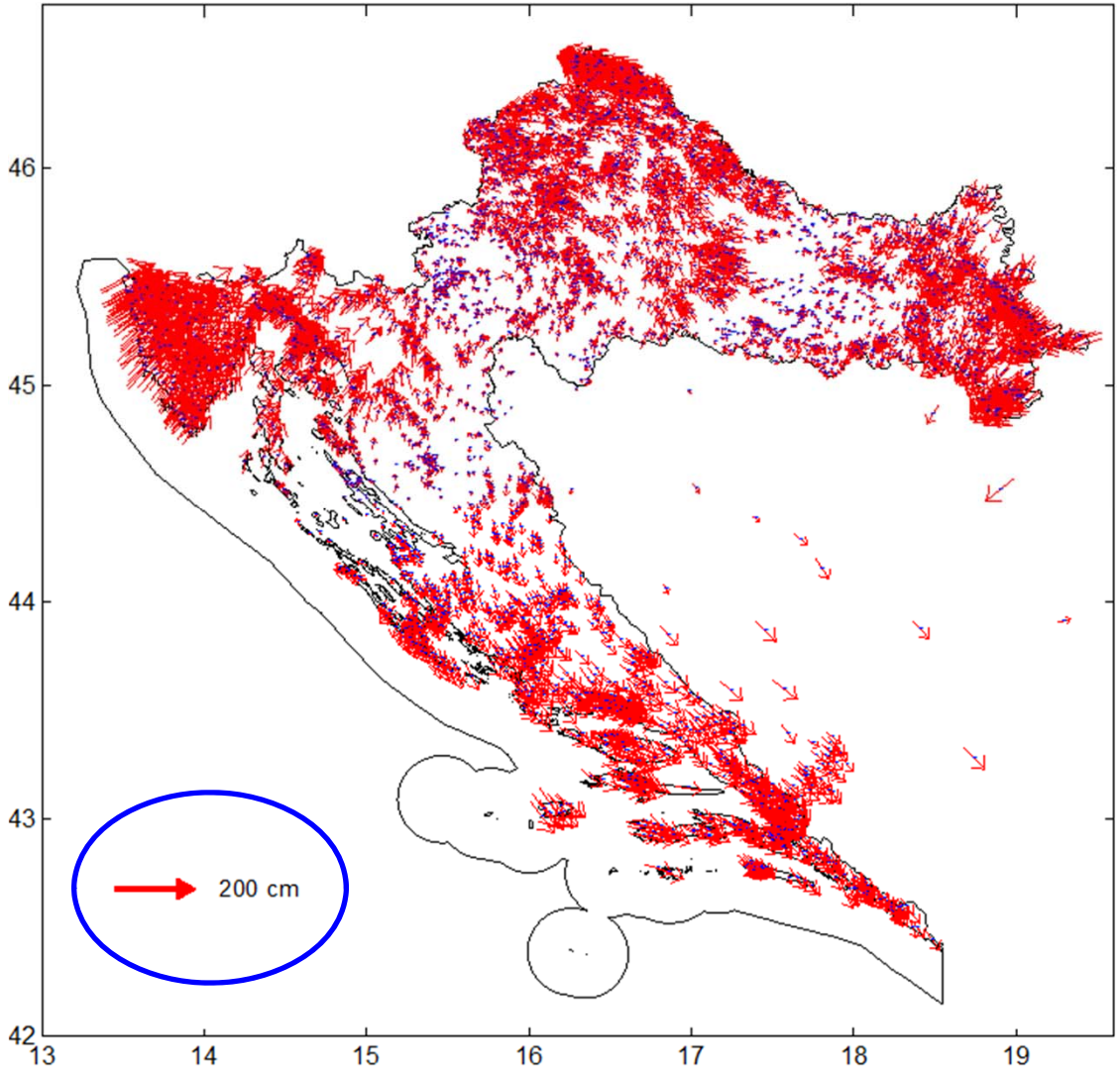
Transformation Problems:

- ETRF00 (R05), 1989.0 (ETRS89)
  - GRS80
  - φ, λ, h (X, Y, Z)
  - Ellipsoidal heigth: h
- HTRS96/TM
  - GRS80
  - N, E, H (Transverse-Mercator projection)
  - Orthometric heigth: H = h – N (HVRS71)
- HDKS
  - Bessel
  - y, x, H (Gauss-Krüger projection)
  - Orthometric heigth : H = h – N (Trieste)

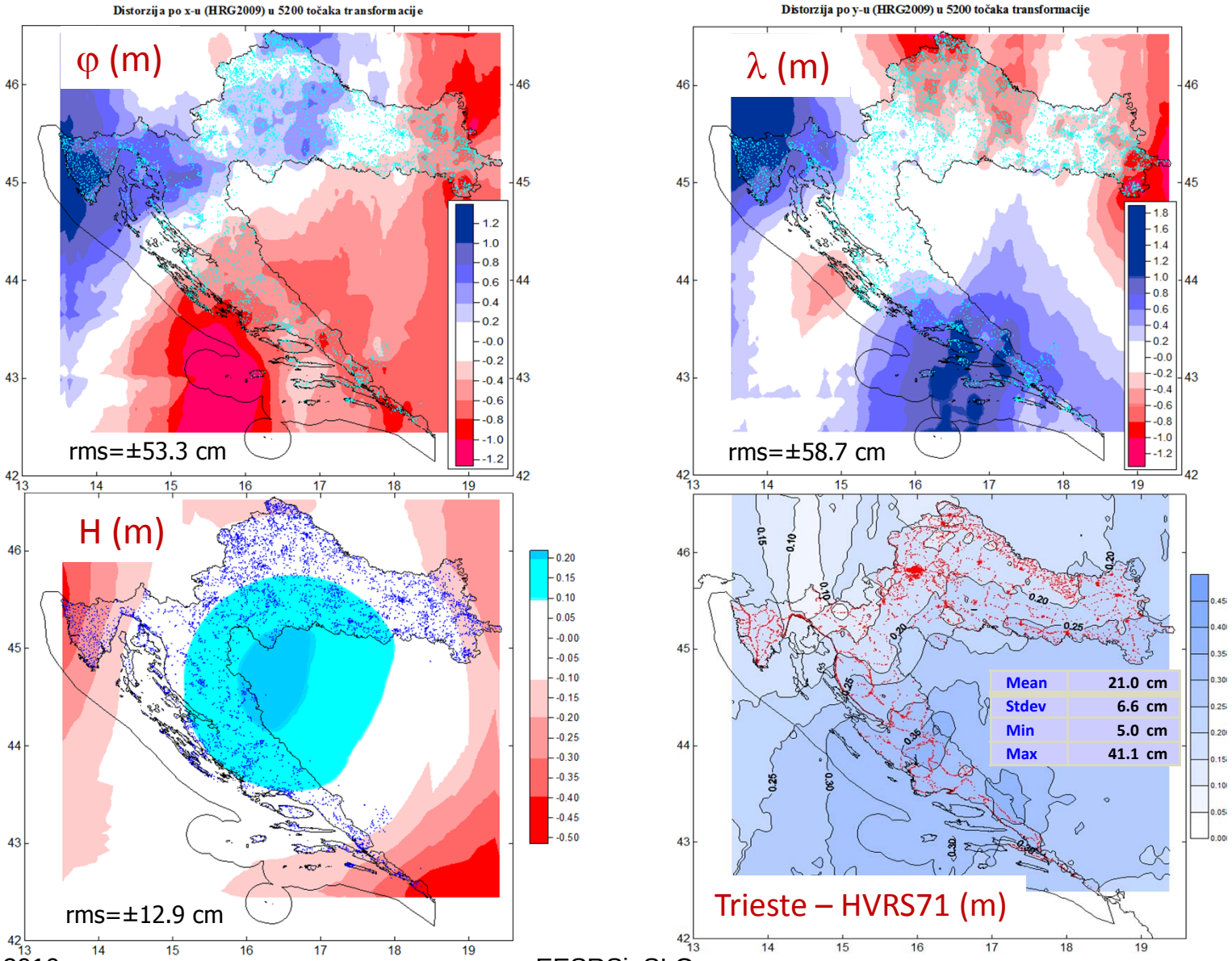
T7

N = 5200	Transformation parameters	Accuray estimation (m_0=0.804 m)
Tx	-546.62 m	±0.59 m
Ty	-162.38 m	±0.66 m
Tz	-469.48 m	±0.59 m
Rx	5.905 "	±0.019 "
Ry	2.074 "	±0.022 "
Rz	-11.510 "	±0.019 "
μ	4.439 ppm	±0.075 ppm

σ_φ	±0.53 m
σ_λ	±0.59 m
σ_h	±0.13 m
2D	±0.79 m
3D	±0.80 m



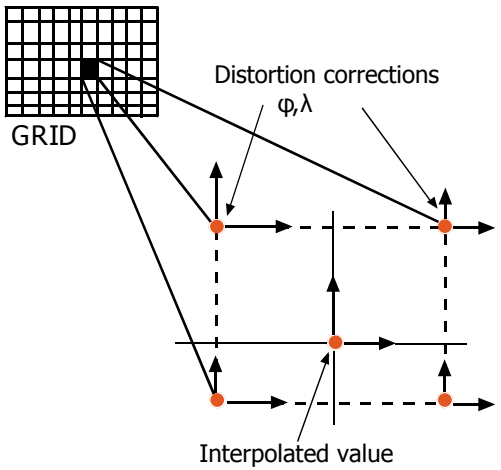
Positional and height distortion



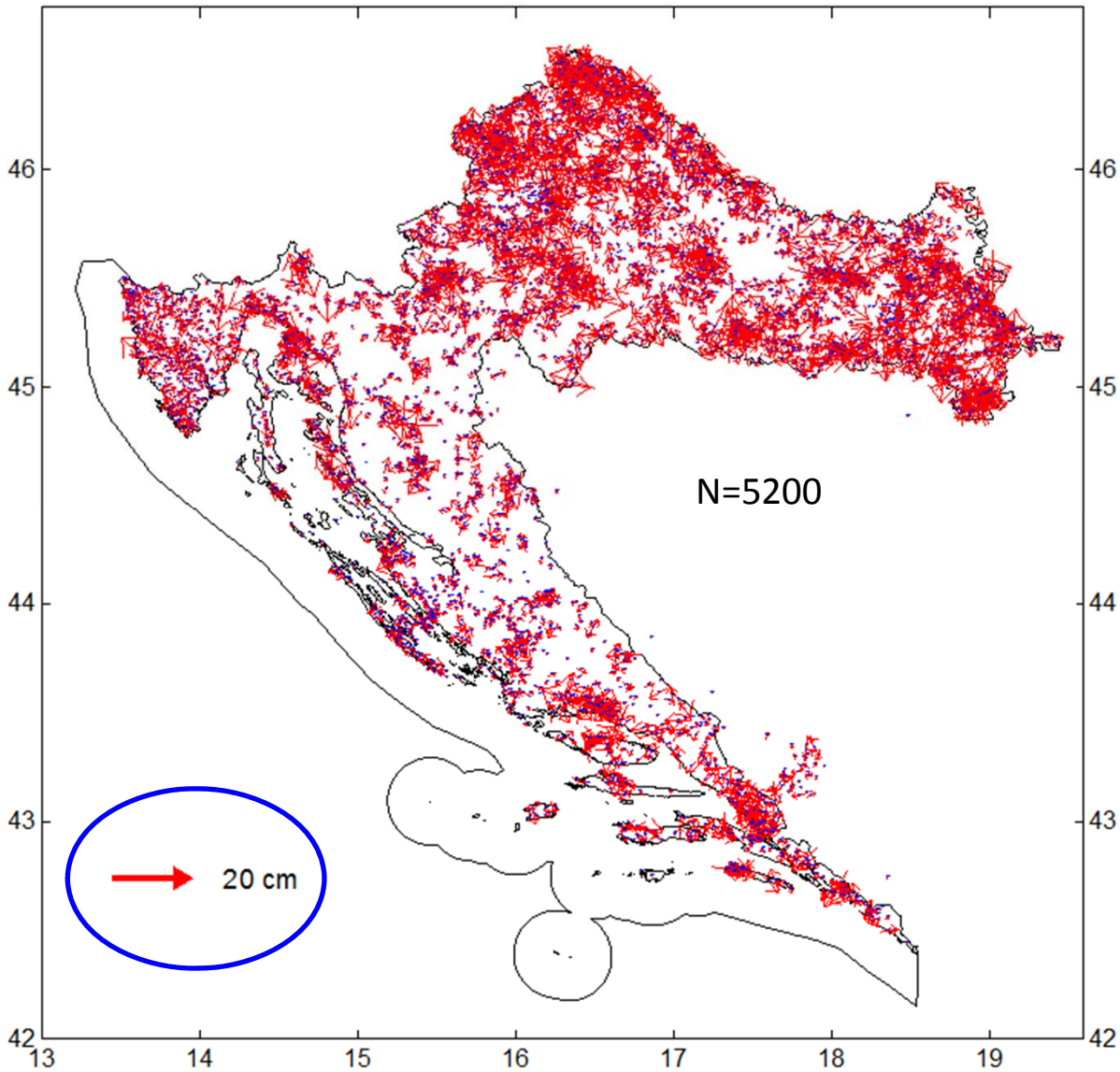
T7D

7P + (δφ, δλ)

(bi-linear interp.)

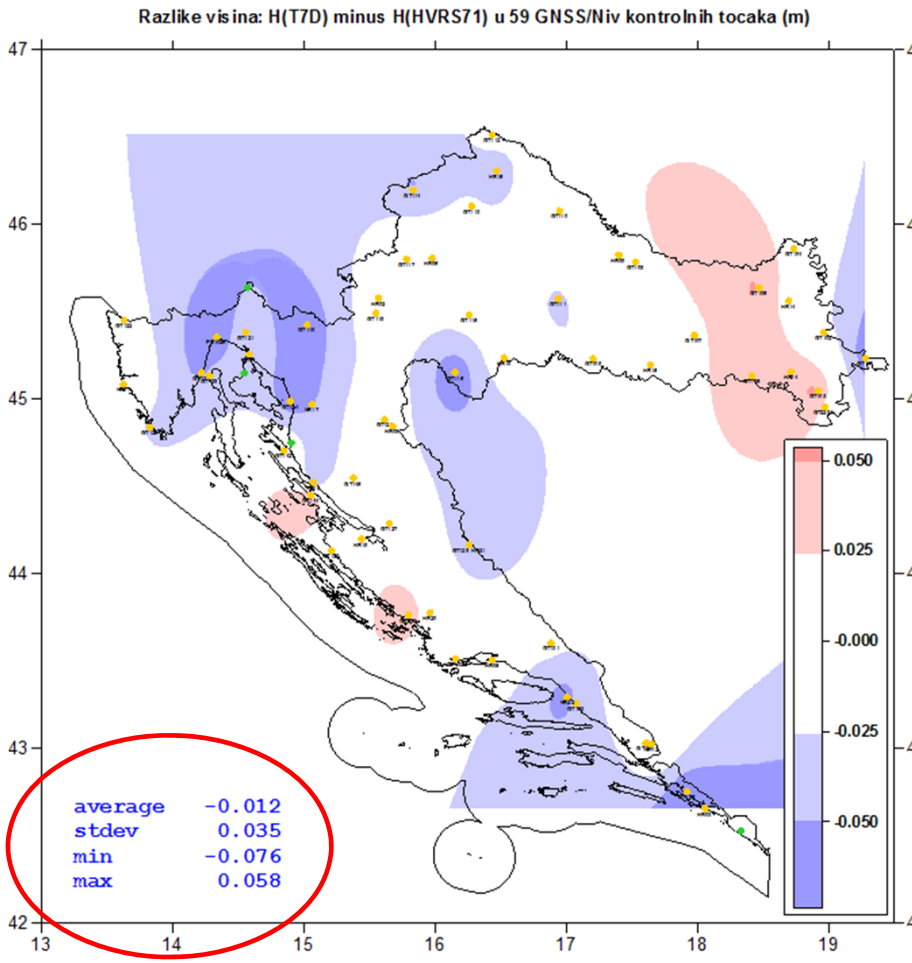


σ_φ	±0.041 m
σ_λ	±0.041 m
σ_h	±0.001 m
2D	±0.058 m
3D	±0.058 m

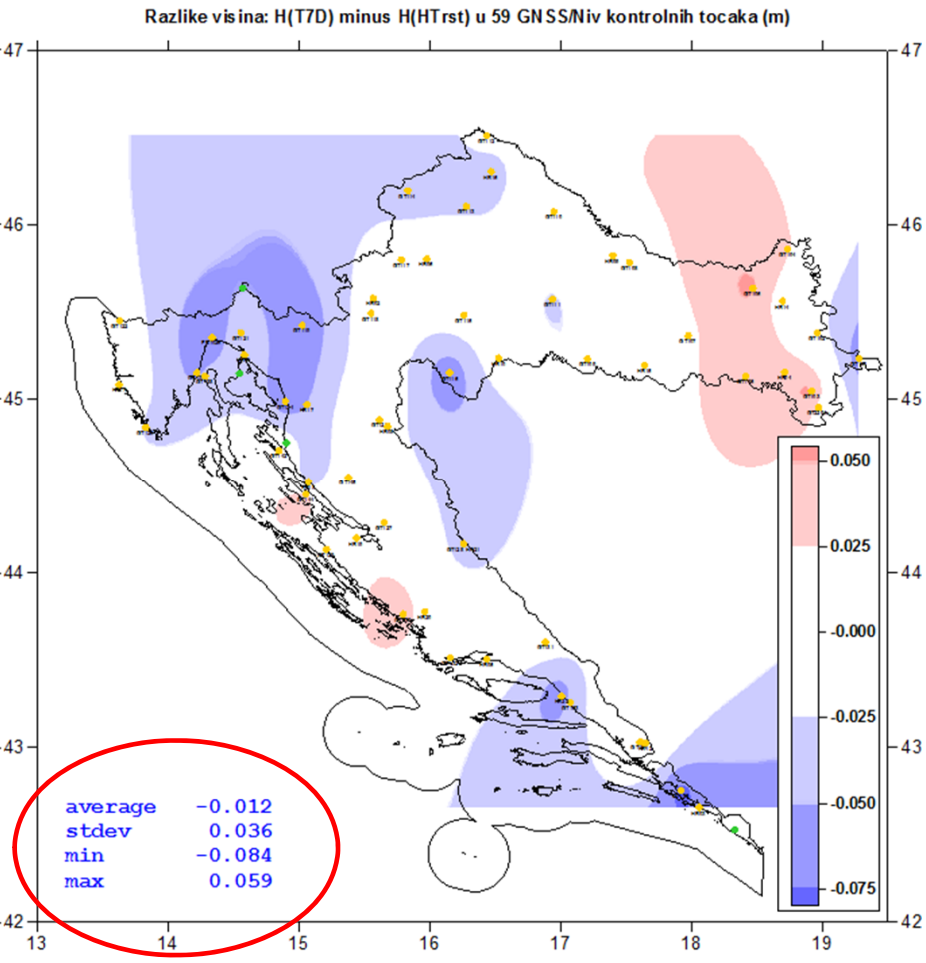


Control of height transformation using T7D model

HVRS71



Trieste



Upgrading CROPOS

- Implementation of T7D model in CROPOS in oder to facilitate on-line transformation of coordinates in real time (on site)
- Trimble Transformation Generator (TTG): standalone application, installed on a separate server, which allows the preparation RTCM 3.1 transformation messages 1021 and 1023 for users (it is possible to select multiple types of transformation depending on user choice – *source table*)

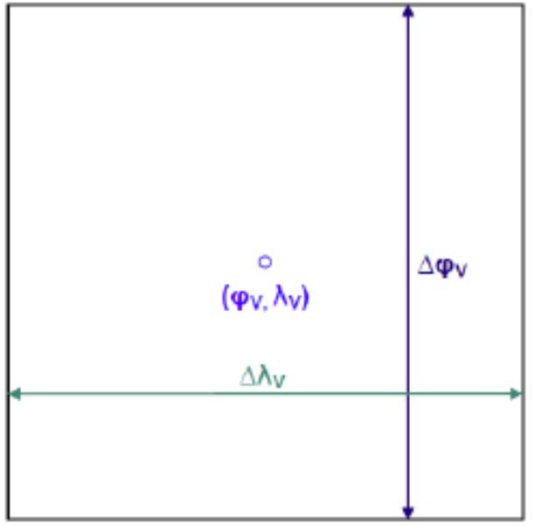
Implementation of T7D in CROPOS

TTG new services > update CROPOS source table

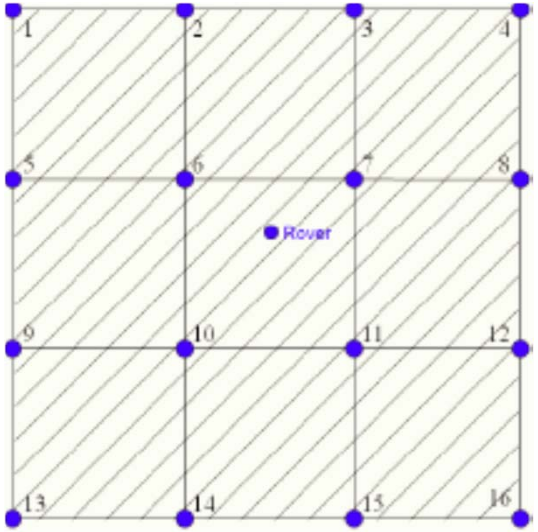
- CROPOS_VRS_HTRS96

  HTRS96/TM – on-line geoid model
- CROPOS_VRS_HDKS

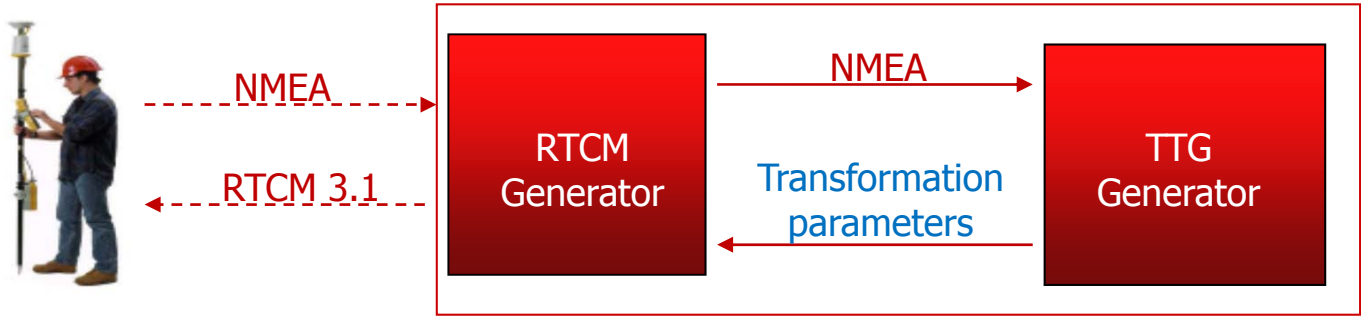
  HDKS – datum transformation & on-line geoid model

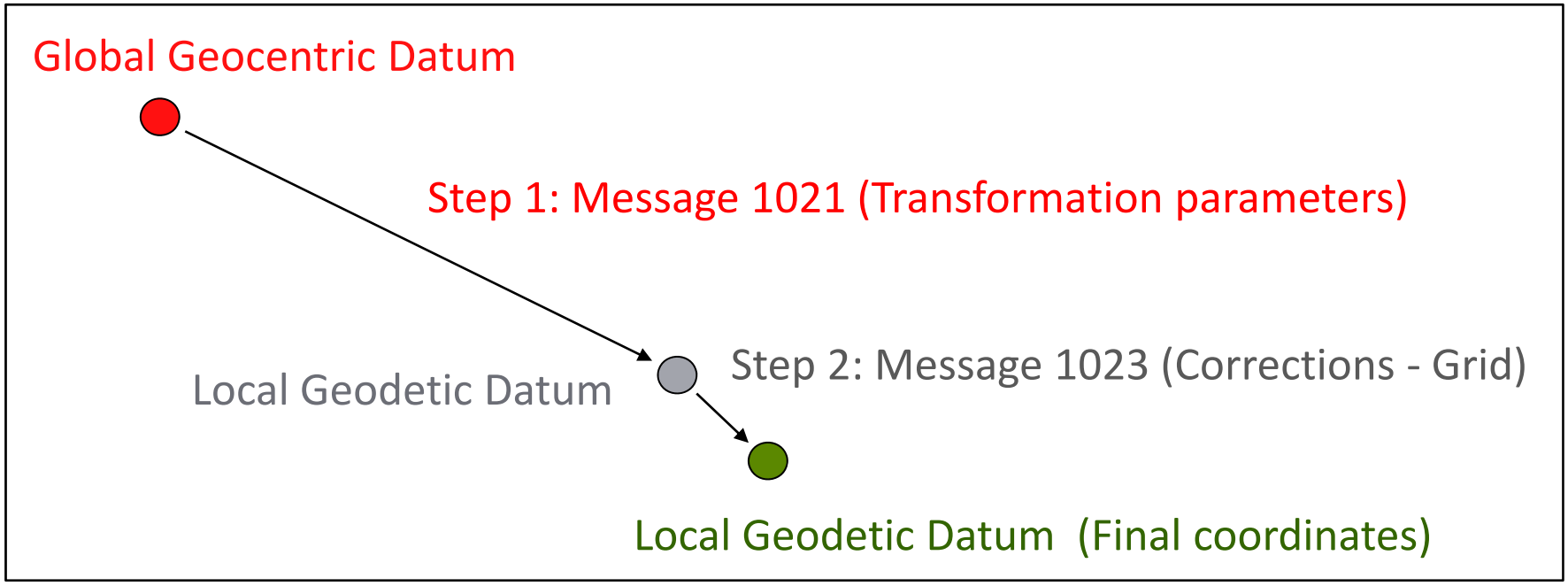


- RTCM 3.1
  - Message 1021
    - 7 parameter transformation (Tx, Ty, Tz, dM, Rx, Ry, Rz)
  - Message 1023
    - Transformation corrections (δφ, δλ or δN)



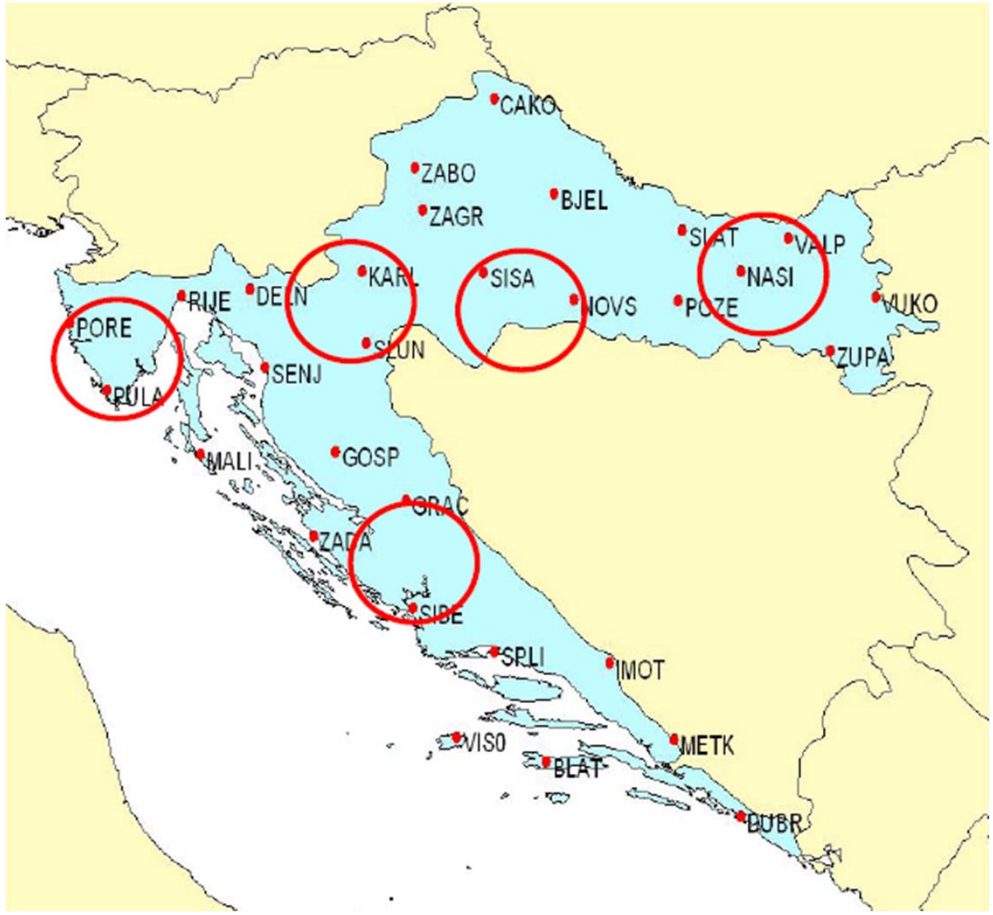
Transformation Data Flow





Testing of on-line geoid model

- 1000 points (September/November 2010)
- Comparison of heigths: on-line geoid model vs post-processing geoid model



First results

ID	H (m) CROPOS	H (m) T7D	ΔH (mm)
1011719	400.124	400.125	-1
1010883	387.532	387.532	0
1011777	211.111	211.111	0
1018843	90.913	90.912	+1
1018868	151.783	151.784	-1
1005817	94.426	94.425	+1
1021685	35.003	35.003	0
1021683	57.500	57.499	+1
1021830	221.837	221.838	-1

Future Activities

- Official use of on-line geoid model – January 1st, 2011
- Preparing of grid files for positional datum transformation and their testing in on-line mode (Spring 2011)
- Processing of RINEX data in order to monitor and analysis stability of CROPOS reference frame – GPS week solutions
- Use of CROPOS data and processing results in geodynamic research
- Organization of “2nd CROPOS User Conference”

Conclusion

- CROPOS project – successfull story
- User trust – reliable and accepted system
- “With CROPOS positioning easier than ever”

HVALA – THANKS !