

# REPUBLIC OF NORTH MACEDONIA

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**AGENCY FOR REAL ESTATE  
CADASTRE**

**Department for Geodetic Works**

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***RIGA, November 2023***

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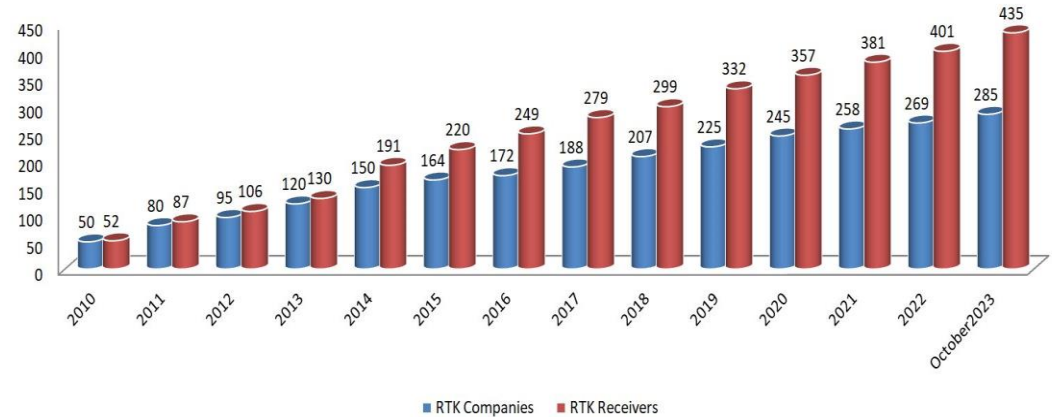
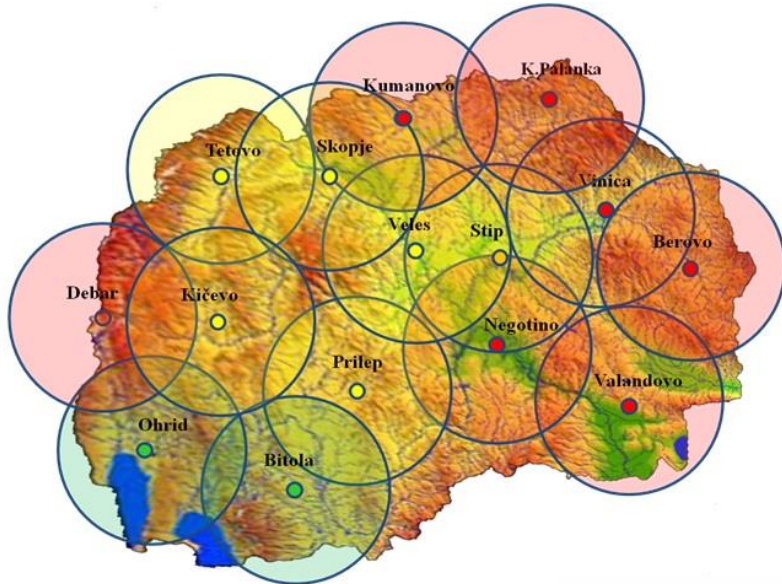
## INTRODUCTIONS

- Current status of MAKPOS system;
- Implementation of the unique transformation model for the entire country through the MAKPOS system;
- Implementation of the qGeoid model through the MAKPOS system;
- Implementation of qGeoid model in GNSS\Leveling
- Conclusion remarks

# CURRENT STATUS OF ACTIVE GNSS NETWORK - MAKPOS



Since January 2020 - 3G NETWORK: GPS/GLONASS/GALILEO



## Main characteristics

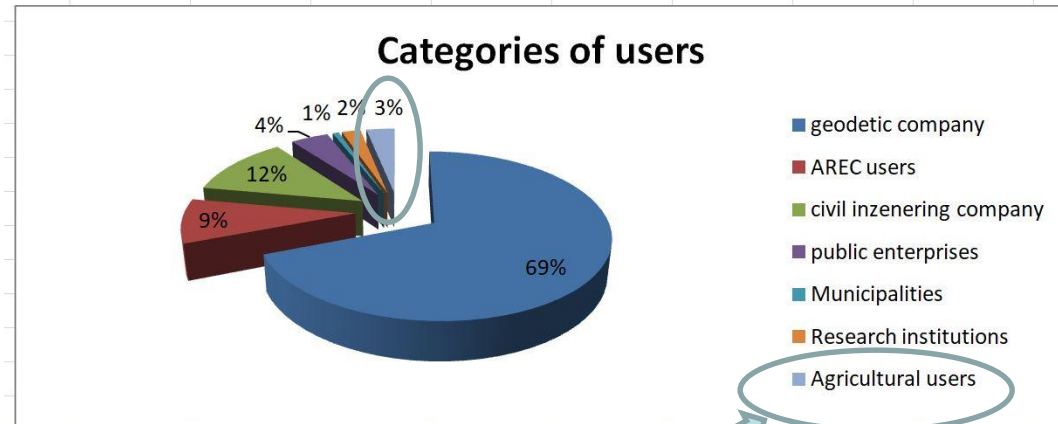
- Number of stations: 15
- Interdistance: ~50 km
- Control center: AREC - Skopje
- Services: DGPS, RTK, PP
- Communication lines: VPN, ADSL
- Data distribution: GPRS, Internet



GR10 and GR 30



Leica AR25



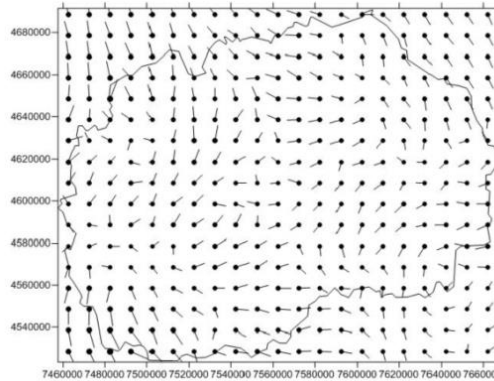
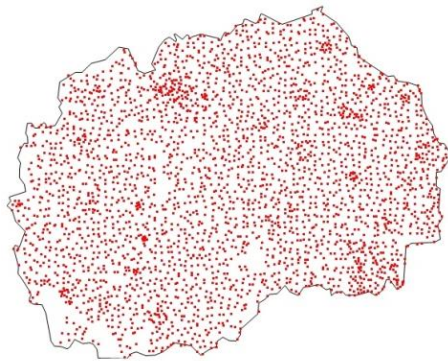
From 2023 new categories of user (precise agriculture users)

# DETERMINATIONS OF GRID MODEL

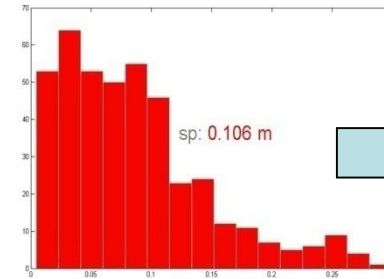
## State grid model

grid: 3 x 3 km  
total: ~ 3000 point

Graphical interpret. of residuals resolutions 10 km



Model testing



~ 10 cm

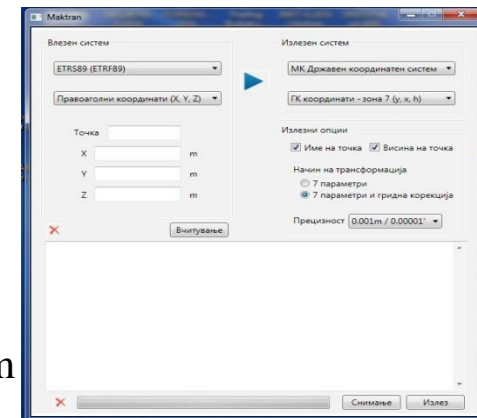
7P Xelmert transf. + grid model

ASCII format – **gridxy.dat**;

update of grid model 2012 ~

This model is currently apply in MAKTRAN software and in MAKPOS system

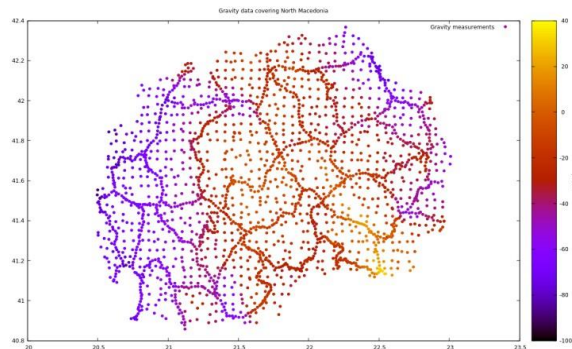
Maktran is software for coordinate transf. develop by AREC (online version is free of charge from 01.11.2023)



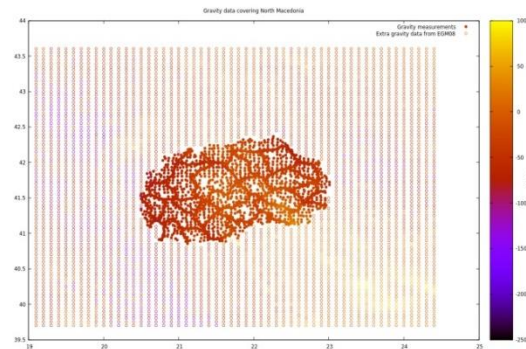
# DETERMINATIONS OF GRAVIMETRIC Q GEOID MODEL

## First national gravimetric qazi geoid model (model 2020)

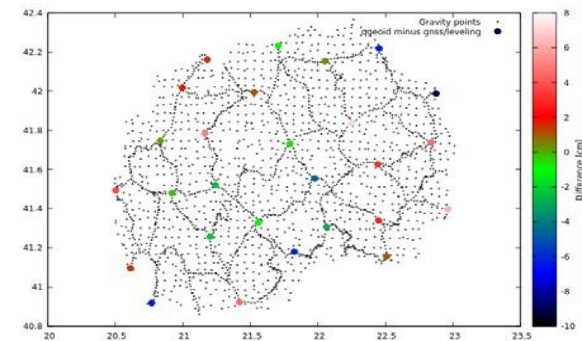
First calculations done in 2020, (supported by Statens Kartverk – (Norwegian Mapping authority))



Gravimetric measure point



Gravimetric measure point  
+  
EGM08 data



27 GNSS/leveling point

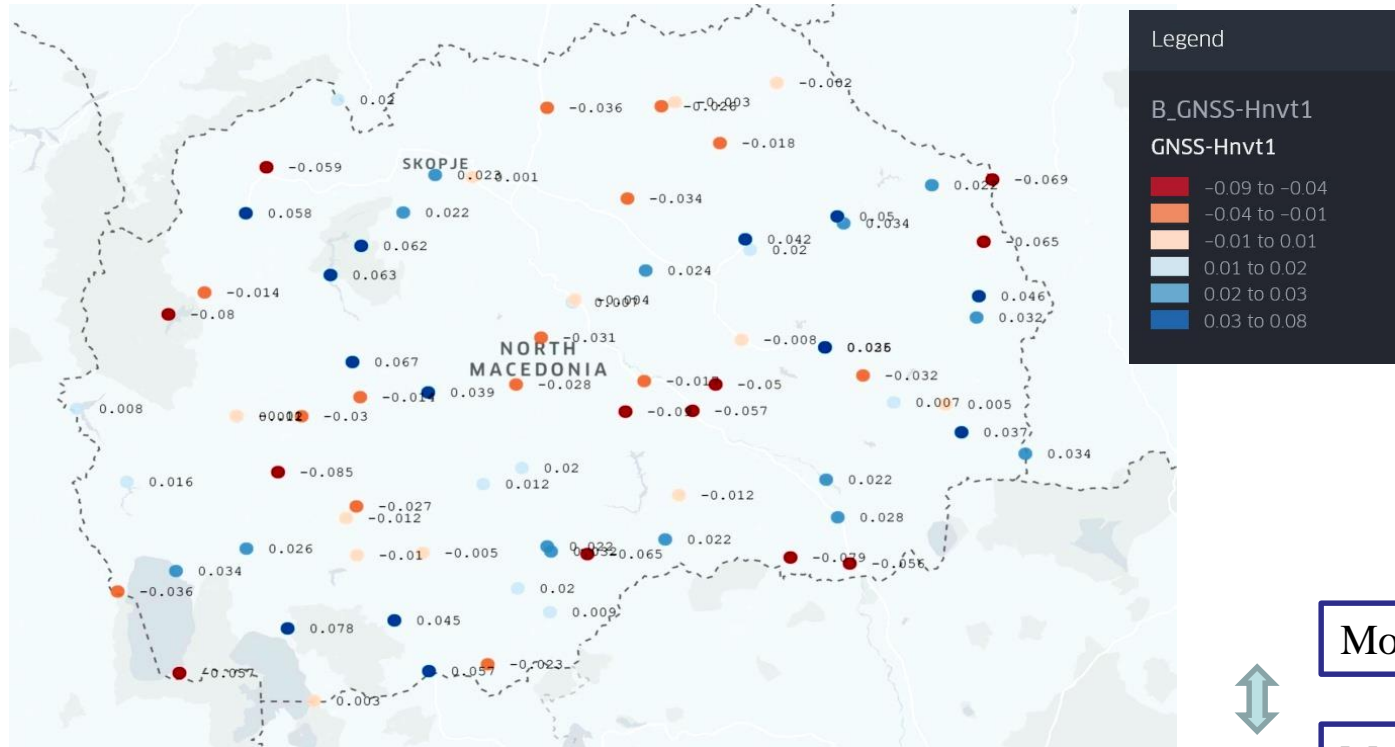
Input data:

- 2310 gravity measure point (all NVT3 benchmark 1098 + grid 5x5 km)
- 27 GNSS / Leveling point, combine connection point (1 point ~ 50 km)
- Gravimetric data EGM08 (~ 150 KM around territory of Macedonia),
- DTM 50 m resolution.



# DETERMINATIONS OF GRAVIMETRIC Q GEOID MODEL

-Updated model in 2023y



Connection point of model 2 from 2023y

Model 1, sd ~4,5 cm

Model 2, sd ~4,0 cm

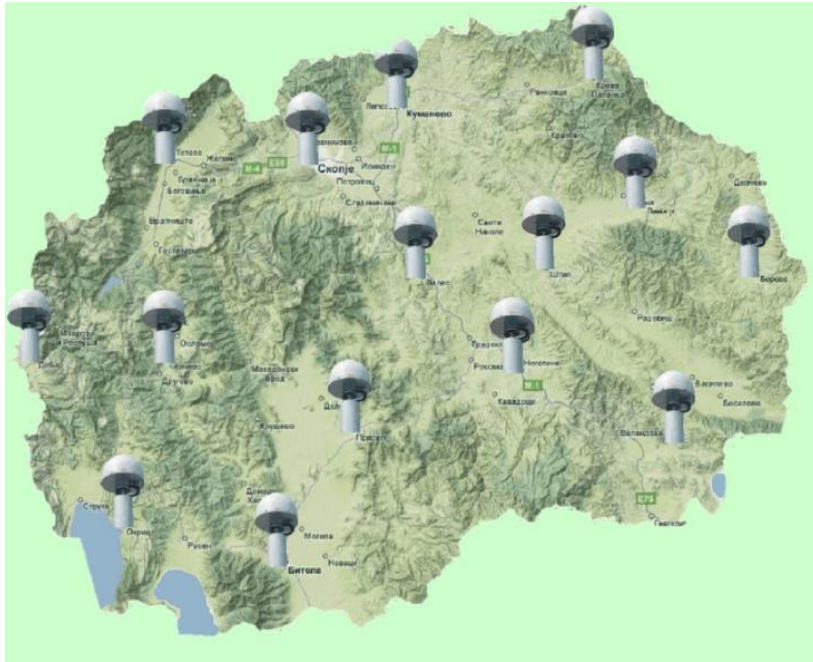


- Data set of second model consists of the 27 point from model 2020 with updated values + 58 new points.
- We get SD around 4.5 cm for first, and 4.0 cm for second model after removing all stations deviating more than 10 cm from the geoid, (a total of 77 points for second model).

# SETTING OF GRID AND GEOID MODEL THROUGH MAKPOS SYSTEM

We have define new spider product for direct applications of grid and geoid model through MAKPOS RTK system

1. MKD\_GRID (grid model)
2. MKD\_GRID\_QGEO (grid + geoid model)



New GNSS setting for users:

- Use auto coordinate system
- Server MAKPOS, port: 9002
- NTRIP mountpoint CSCS\_QGEO

# IMPLEMENTATIONS OF GRID AND GEOID MODEL THROUGH MAKPOS SYSTEM

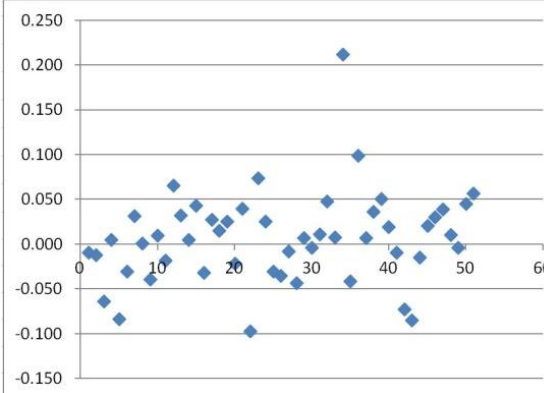
Perform test measurement with new MAKPOS product during 2023 year



Point	NVT1	Measure height (MAKPOS QGEO)	Differences	
	h [m]	h [m]	[m]	
H [FR SK]	252.241	252.250	-0.009	0.000142078
L2-7	238.194	238.206	-0.012	0.00021432
L2-4	232.217	232.280	-0.064	0.004400951
AГT1E1 AKN	249.410	249.405	0.005	6.91866E-06
AГT1E2 CKN	252.417	252.500	-0.083	0.007385626
N6	375.666	375.696	-0.030	0.001078444
N7	304.221	304.189	0.032	0.000832919
N8	308.877	308.876	0.001	3.02644E-06
L36-R1	364.684	364.723	-0.039	0.001775751
105	497.023	497.013	0.010	4.98483E-05
N2	269.189	269.207	-0.018	0.00043847
N18	150.789	150.723	0.065	0.003926317
N19	124.709	124.677	0.032	0.000856167
N23	76.882	76.876	0.005	6.05324E-06
V7-R2	79.033	78.990	0.043	0.001615665
L40R16	263.694	263.725	-0.031	0.001171444
L39R6	282.961	282.934	0.027	0.000598896
N27	393.155	393.140	0.016	0.000165388
N20	339.481	339.455	0.026	0.000527177
L1R16	493.073	493.052	-0.021	0.000572887
L1R22	454.904	454.944	0.040	0.001367629
V1R12	779.260	779.163	-0.097	0.009890009
109	481.758	481.832	0.074	0.00508772
L1R34	542.267	542.292	0.025	0.000503108
N1	951.621	951.590	-0.031	0.001113265
M112	753.263	753.228	-0.035	0.001448477

● Tested 51 point with RTK measurement:

- NVT3 nodal point,
- NVT3 Fundamental point,
- NVT3 benchmark,
- MAKREF (Passive GNSS network)

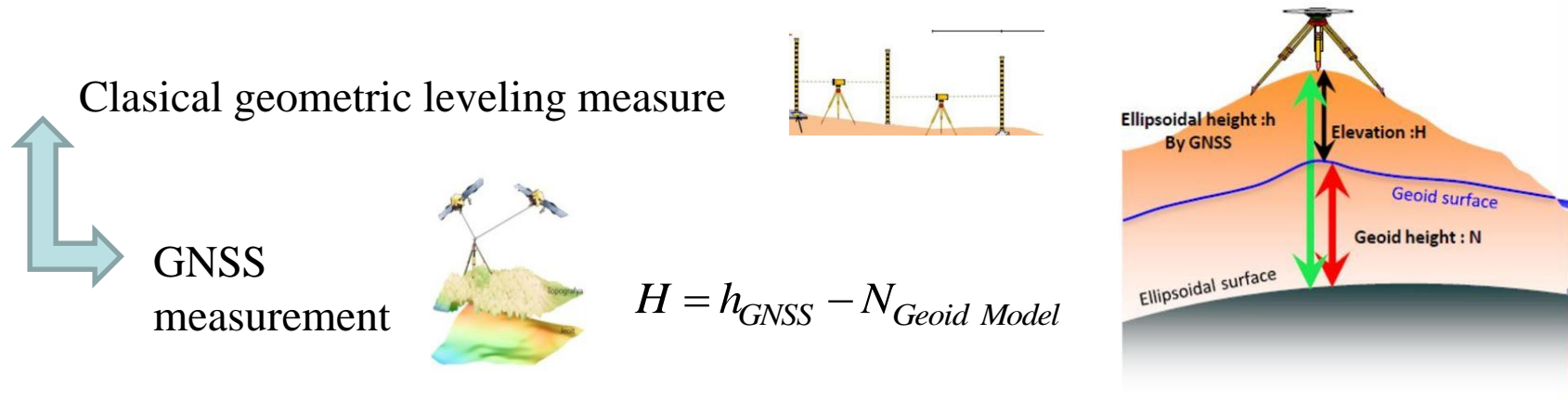


max	0.099 m
> 0.05	6 points
0 - 0.05	24 points
(-0.1) - (-0.05)	6 points
(-0.05) - 0	15 points
(-0.05) - (0.05)	77%
sd	0.041



# IMPLEMENTATIONS OF GEOID MODEL IN GNSS LEVELING

Define of precise quazi-geoid model for transformations of height define with GNSS technique into the state height refernce system



Accuracy is directly depended of quality of geoid model and of quality of GNSS measurement metod

$$\sigma_H = \sqrt{\sigma_{GNSS}^2 + \sigma_{Geoid model}^2}$$

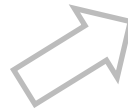
## CONCLUSION REMARKS

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Fast acquisitions of geo data into the State coordinate system (2D+1D)



Homogeneity of data in whole territory of RM with height 3D accuracy



**BENEFITONS OF IMPLEMENTATIONS OF  
GRID AND GEOID MODEL INTO MAKPOS  
SYSTEM**



Determinations of height data of official height system through GNSS measurement



The aim is to achieve the height level of interoperability of national set of geospatial data used by all relevant subject.

## CONCLUSION REMARKS

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Accuracy of determinations of vertical component (height) with GNSS technique its increasing continuously.

By combining satellite positioning and a high-precision geoid model, an elevations can be determined in range of ~4 sm.

For many of geodetic applications this is enough accurate, having in mind high quality of gravimetric geoid model.

For short distance, classic leveling is steel most appropriate technique, but GNSS technique is rapidly approached in terms of accuracy and their evaluations.

If height determinations by GNSS survey utilizing geoid model is possible, it is less cost and more efficient.