

GOCE GGM Evaluation

Evaluation of the latest GOCE GGMs in support of regional geoid modeling over Greece

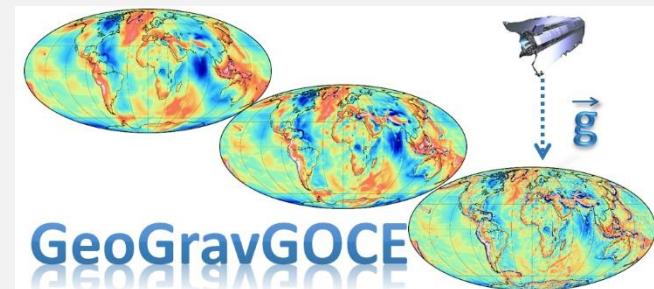
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European Geosciences Union GA 2021
Session 1.5



Vienna, Austria
April 29, 2021



Aim and methodology

In the frame of the GeoGravGOCE project, funded by the HFRI, GOCE SGG data are to be used

- for regional geoid and gravity field refinement &
- for potential determination in the frame of the International Height Reference Frame (IHRF)

An inherent step in the geoid computation with either stochastic or spectral methods is the reduction of the related disturbing potential functionals within the well-known RCR procedure

We aim to evaluate the latest, Release 6 (R6), satellite only and combined Global Geopotential Models (GGMs) which rely solely on GOCE and on land gravity data

Aim and methodology

The evaluation is performed over the established network of 1542 GPS/Levelling benchmarks over mainland Greece

The spectral enhancement approach is used, during which the GOCE-based GGMs are evaluated

- per degree up to the maximum degree of expansion coupled by EGM2008 and
- high-frequency RTM effects

This synthesis resolves wavelengths corresponding to maximum degree 216,000, hence the omission error is at the few mm-level

We evaluate TIM-R6, DIR-R6, GOCO06s and XGM2019e using EGM2008 residuals to the GPS/Levelling as the ground truth

Methodology

Combined GGM differences to d/o 216,000 as

$$\Delta N = N^{GPS/Lev} - N_{GOCE} \Big|_2^{n_1} - N_{EGM2008} \Big|_{n_1+1}^{2160} - N_{ERTM2160} \Big|_{2161}^{90,000} - N_{RTM} \Big|_{90,001}^{216,000} - N_o$$

$$N_o = \frac{GM - GM_o}{R\gamma} - \frac{W_o - U_o}{\gamma}$$

$$N_{GOCE} \Big|_2^{n_1}$$

DIR/TIM/GOCO (R6) & XGM2019 to d/o n_1

$$N_{ERTM} \Big|_{2,161}^{90,000}$$

RTM effects from ERTM2160 to d/o 90,000

$$N_{RTM} \Big|_{90,001}^{216,000}$$

SRTM3" DTM for the wider Hellenic area

Methodology – Conventions

- **ZT (zero-tide) system**

- **GRS80 ellipsoid with**

$$GM_o = 398600.5000109 \text{ m}^3 \text{s}^{-2}$$

$$U_o = 62636860.850 \text{ m}^2 \text{s}^{-2}$$

- **Latest IERS Earth's geocentric gravitational constant**

$$GM = 398600.4418 \text{ m}^3 \text{s}^{-2}$$

- **Latest IAG adopted zero-level geopotential (2015)**

$$W_o = 62636853.40 \text{ m}^2 \text{s}^{-2}$$

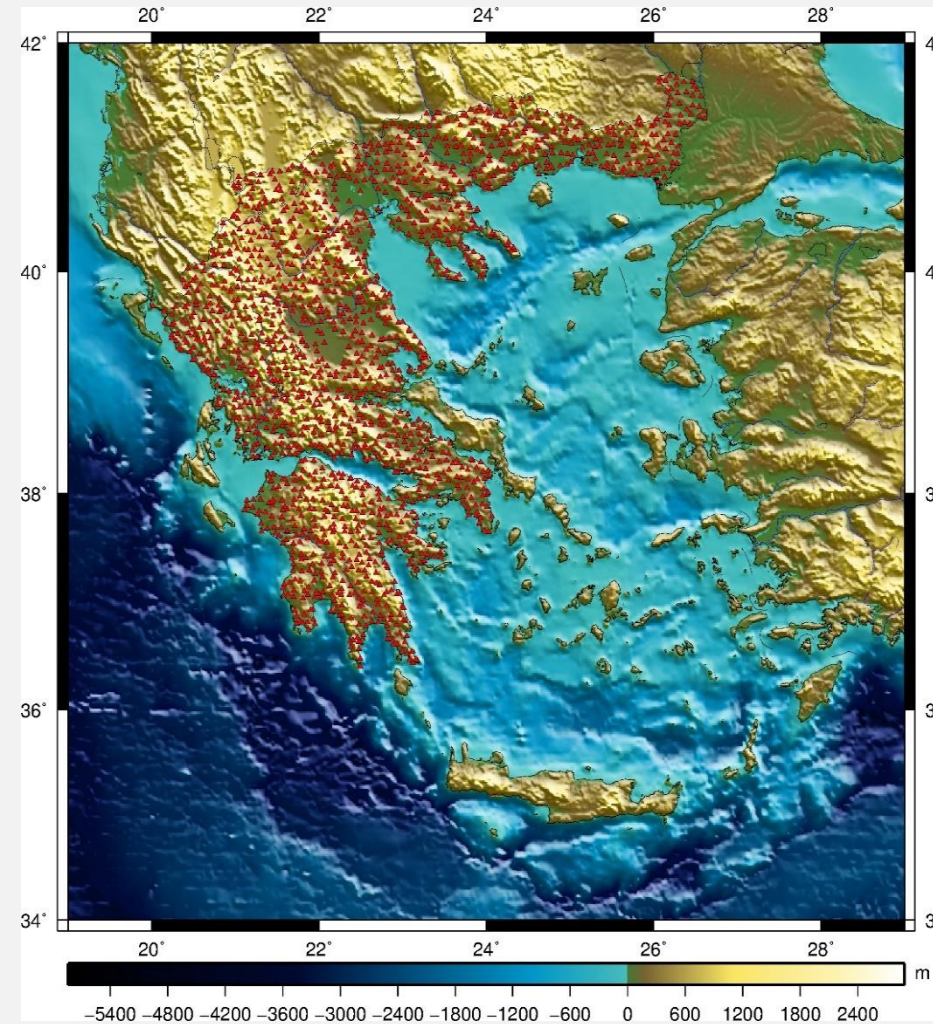
- **Mean Earth's radius has been taken equal to**

$$R = 6371008.7714 \text{ m}$$

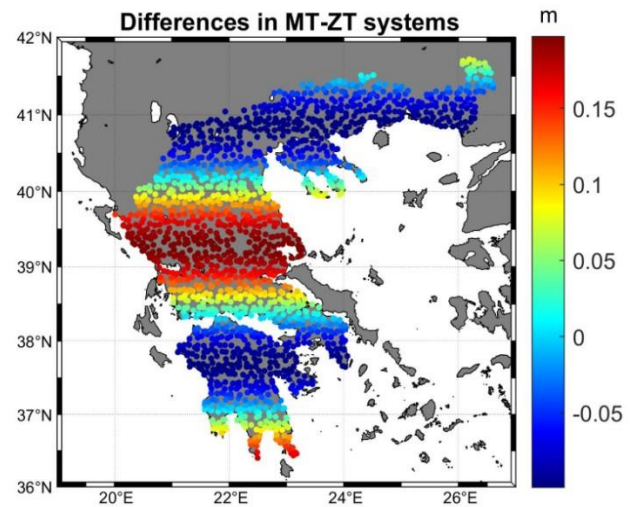
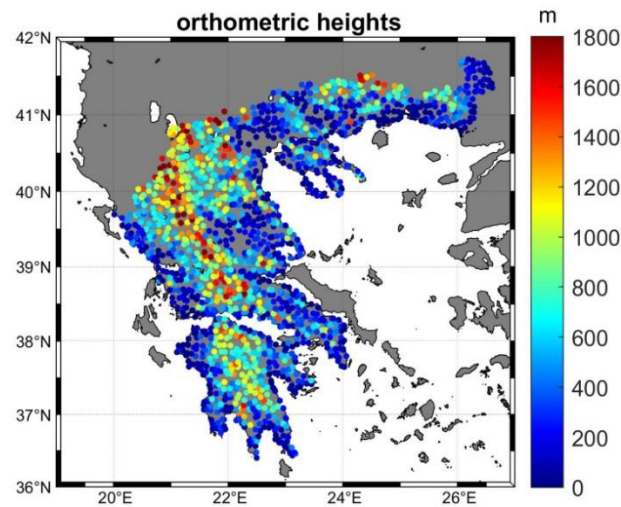
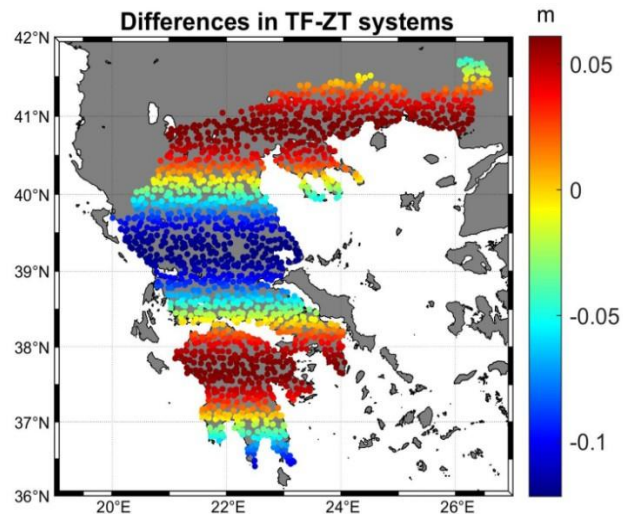
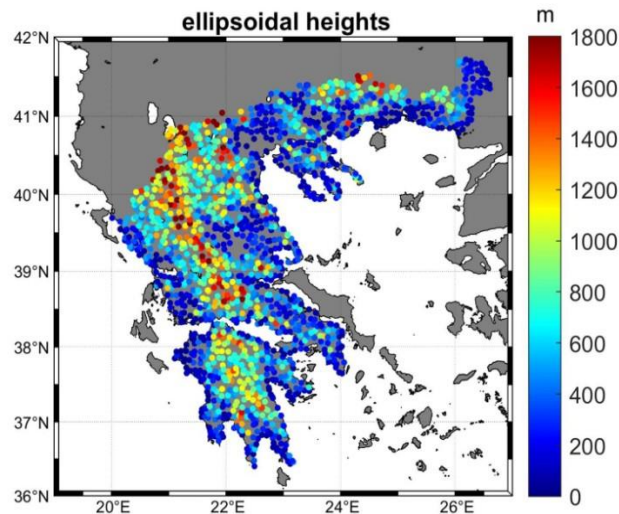
**1542 collocated
GPS/Leveling observations**

$$H_{ZT} = H_{MT} - (0.099 - 0.296 (\sin^2 \varphi))$$

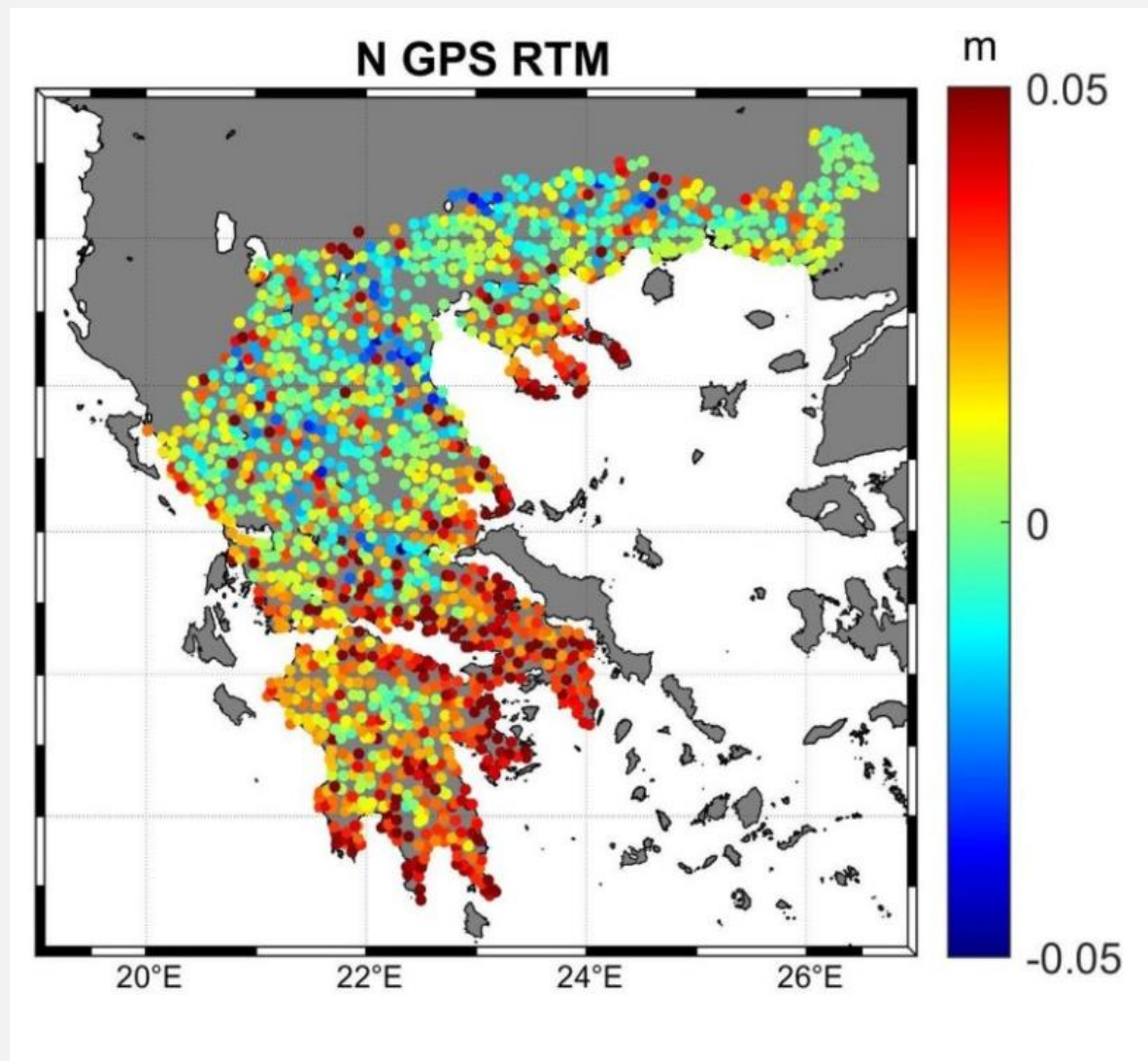
$$h_{ZT} = h_{TF} + 0.62(0.099 - 0.296 (\sin^2 \varphi))$$



TF-ZT & MT-ZT



RTM effects

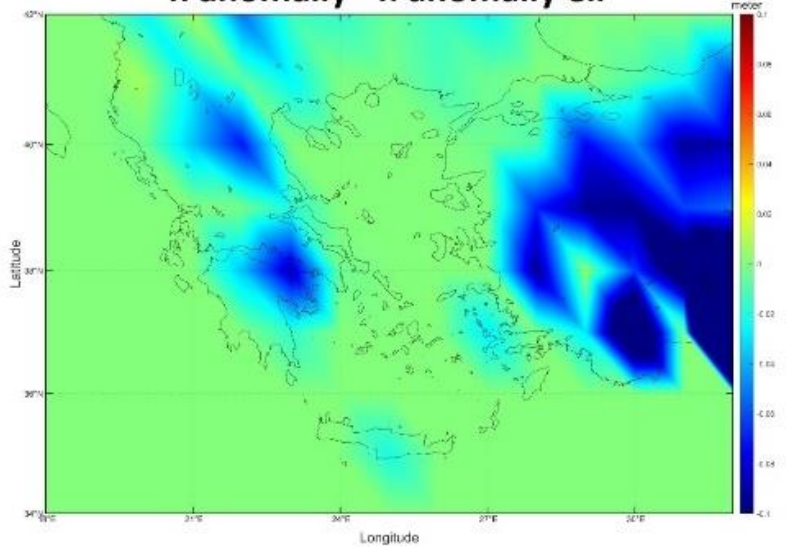


GGM characteristics

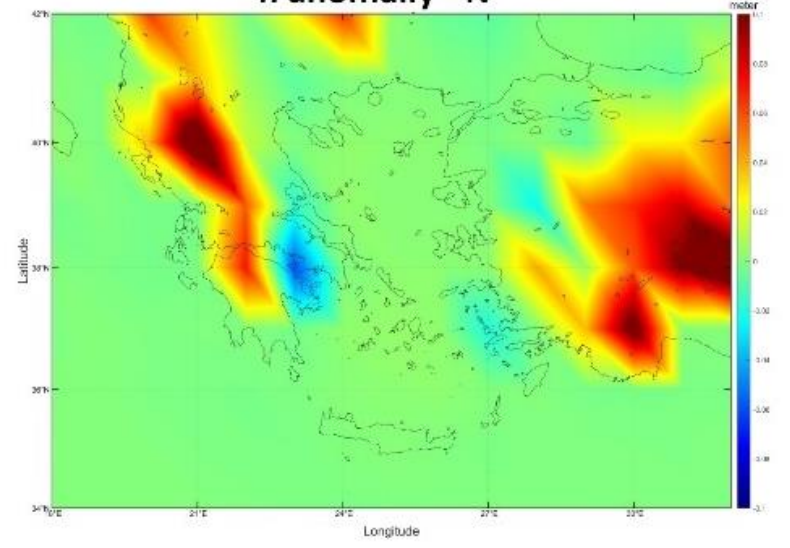
Models	nmax	Data used	Reference
EGM2008	2190	S(GRACE), G, A	Pavlis et al., 2008
XGM2019e_2159	2190	A, G, S(GOCO06s), T	Zingerle, P. et al, 2019
GOCO06S	300	S	Kvas et al., 2019
DIR_R6	300	S	Brockmann, J. M. et al., 2014
TIM_R6	300	S(GOCE)	Pail et al., 2010
SPW_R5	330	S(GOCE)	Gatti, A. et al, 2016

Greek Height Datum

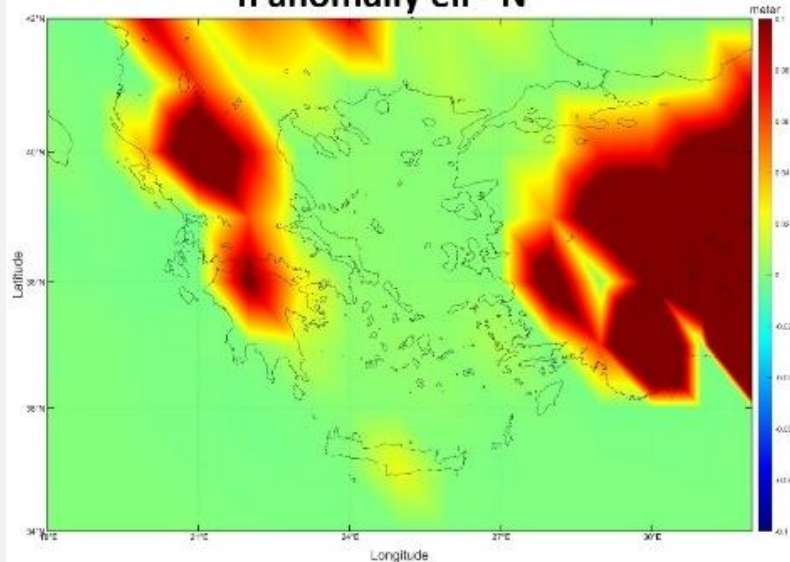
h anomaly - h anomaly ell



h anomaly - N

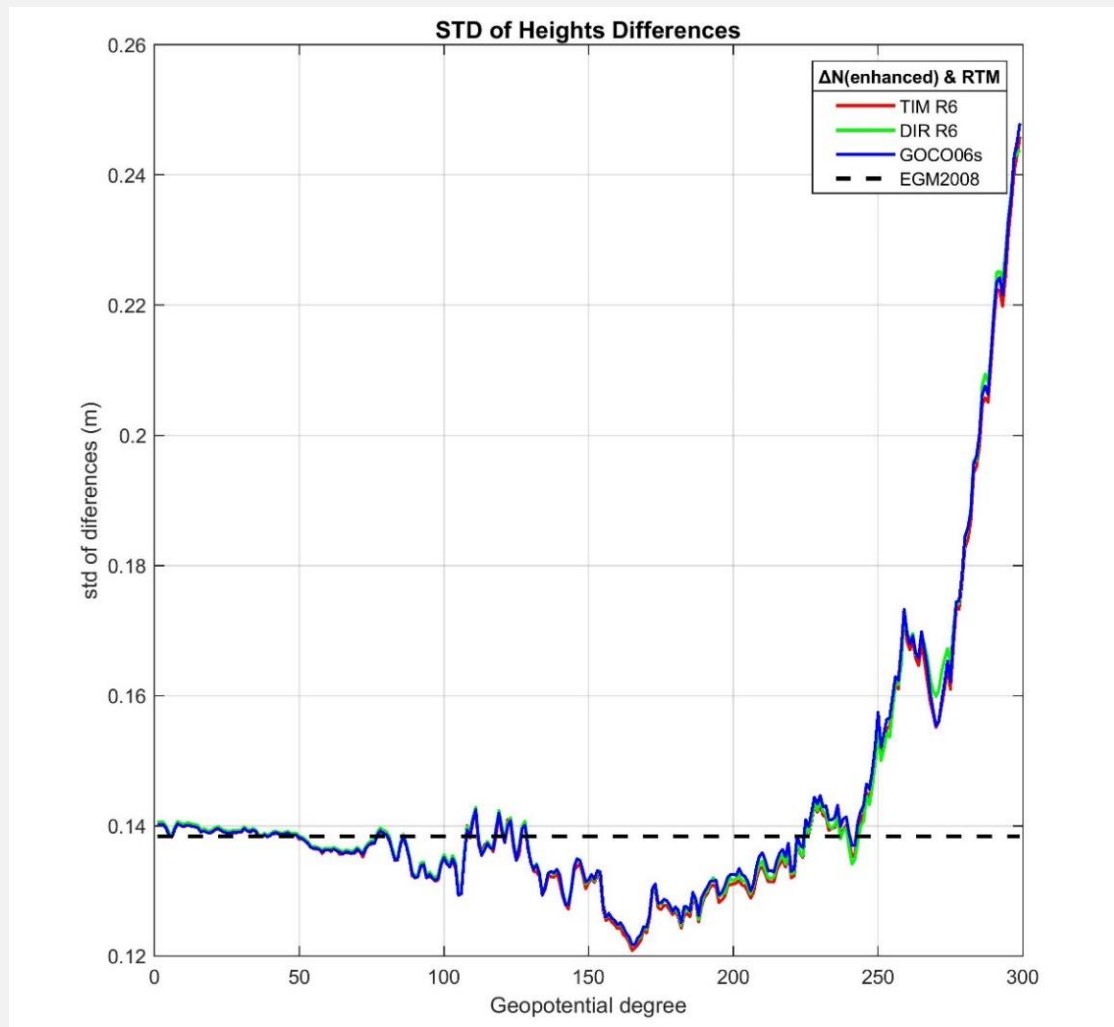


h anomaly ell - N



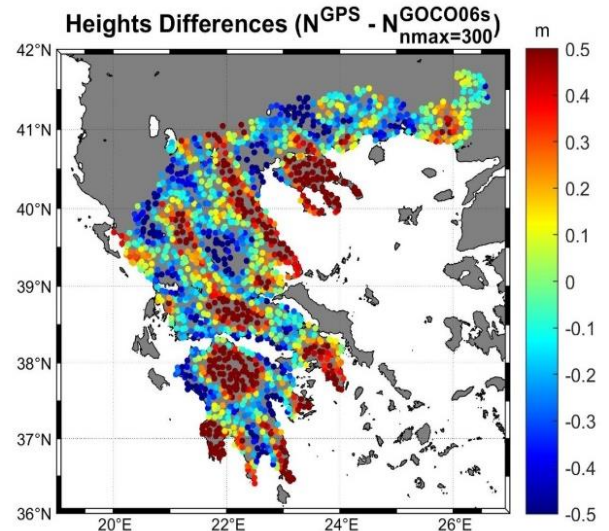
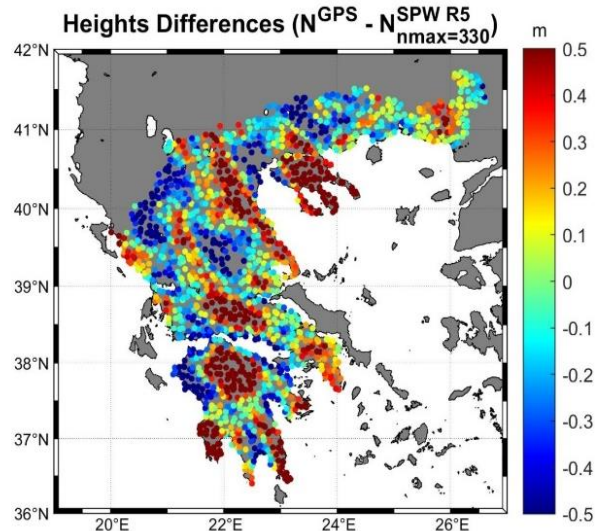
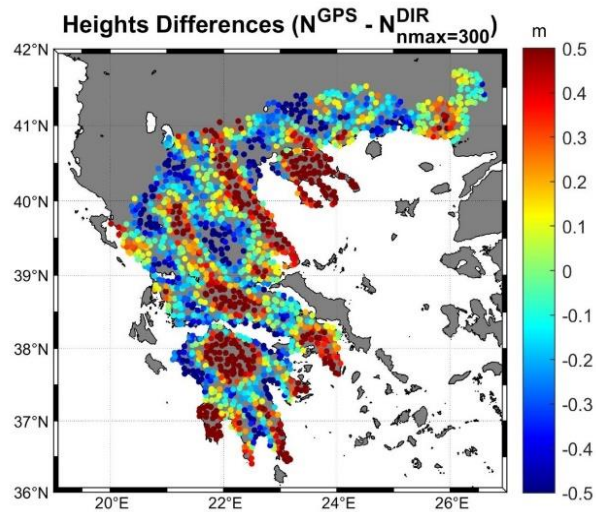
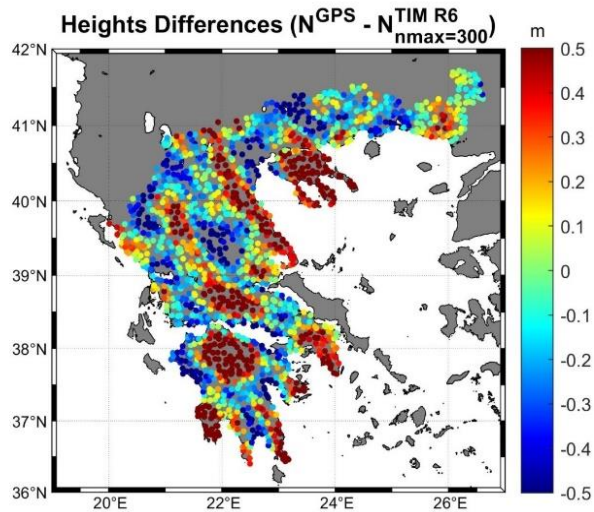
Differences between height anomalies, height anomalies on the ellipsoid and geoid heights

GGM evaluation

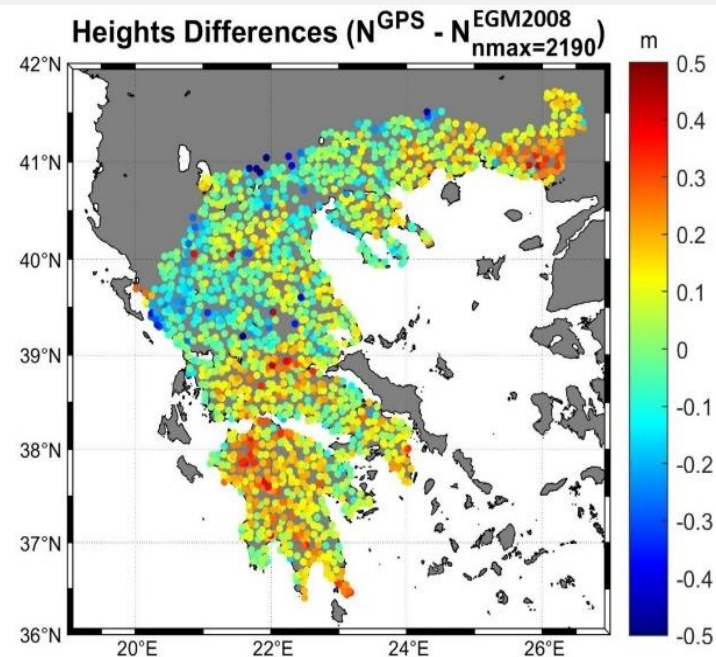
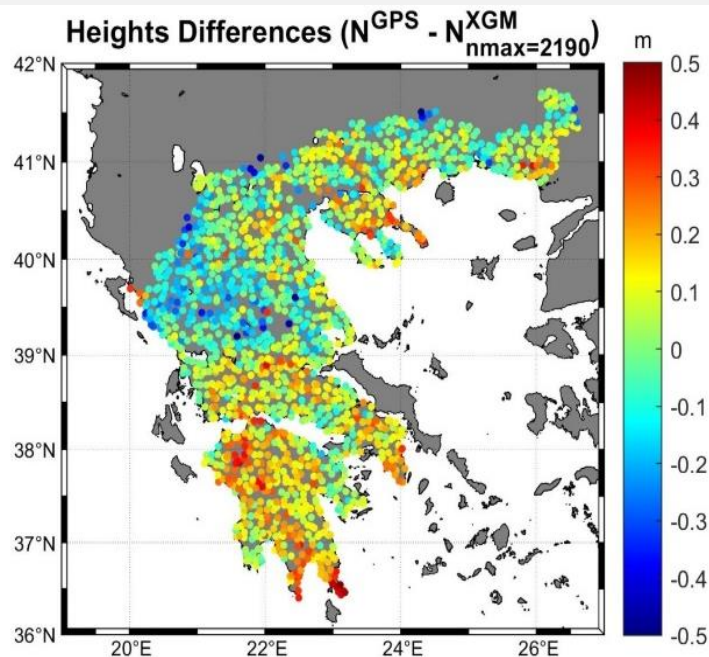


std of the geoid undulation residuals with varying d/o of expansion and EGM2008 & RTM enhancement

GGM evaluation



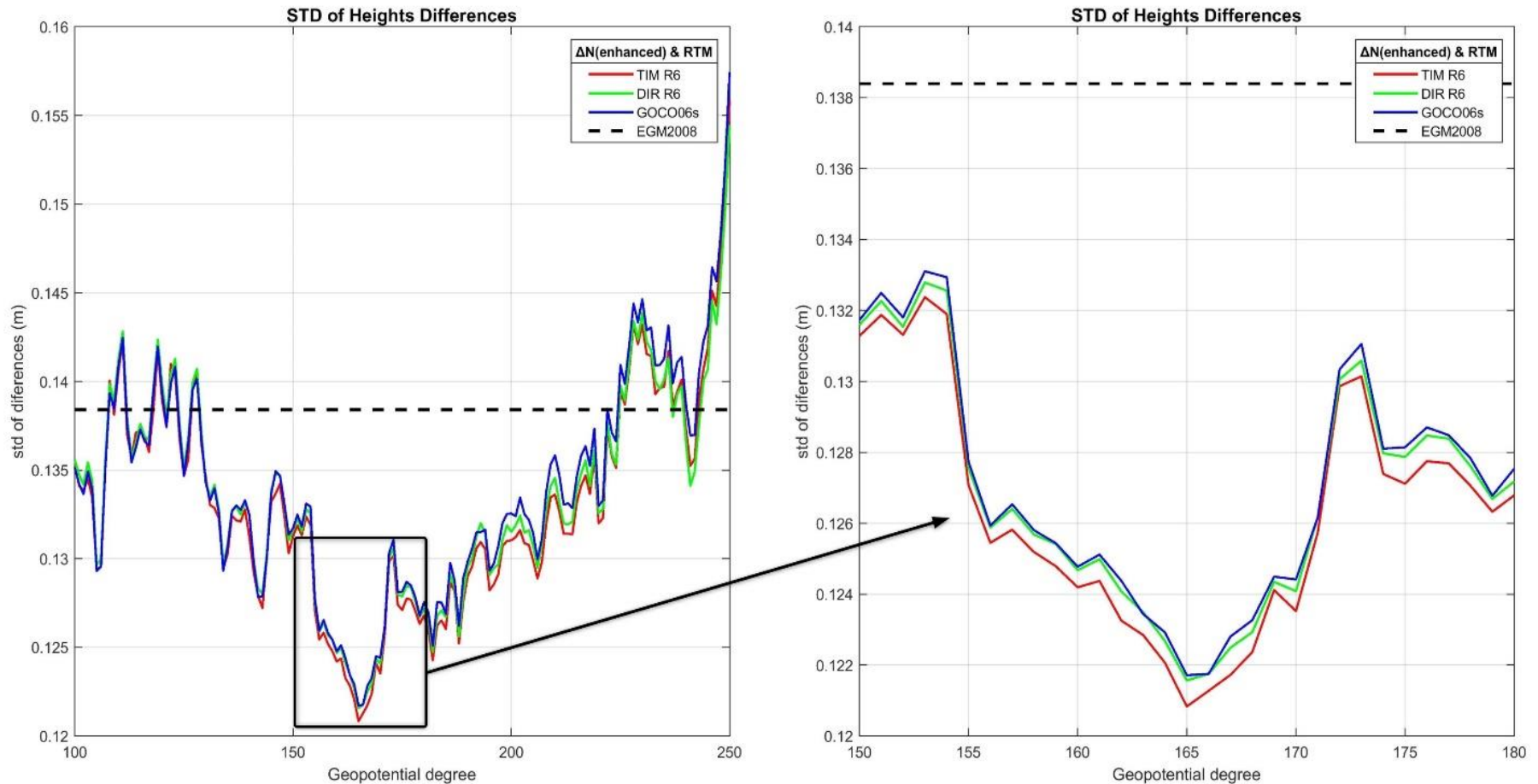
GGM evaluation



$\Delta N = h - H - \text{GGM}(\text{geoid undulation}) \text{ (m)}$

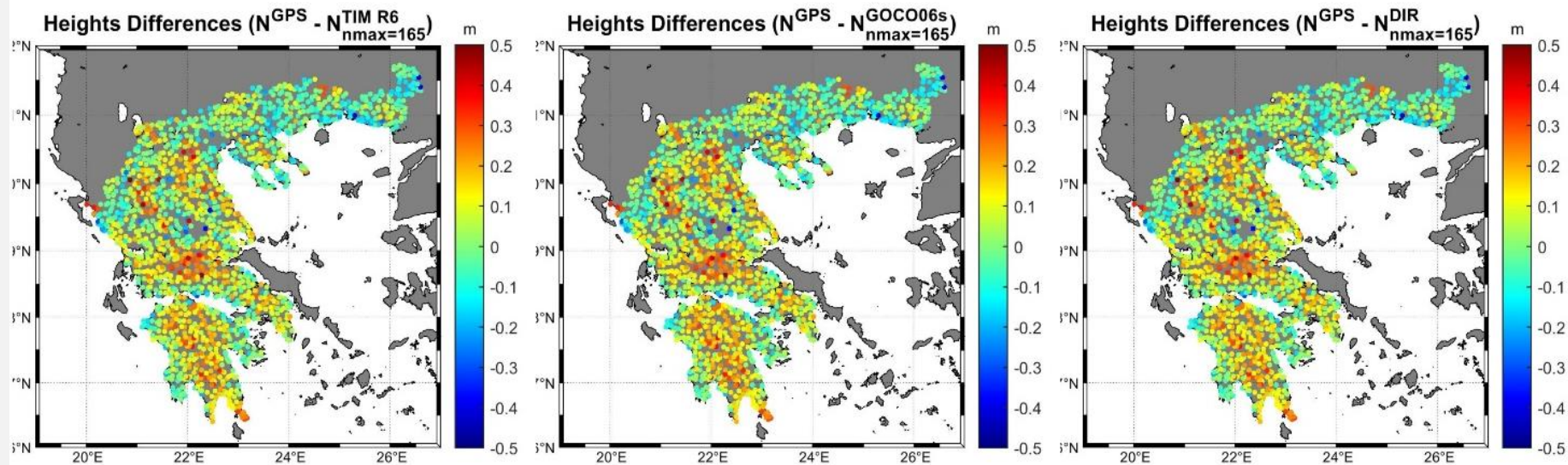
	GGM	TIM R6 (300)	XGM (2190)	SPW R5 (330)	DIR R6 (300)	GOCO06S (300)	EGM2008 (2190)
min		-1.0800	-0.4745	-1.0466	-1.0578	-1.0729	-0.4547
max		1.6897	0.5059	1.6466	1.6765	1.6975	0.4405
mean		0.1084	0.0854	0.1101	0.1092	0.1082	0.0765
std		0.4409	0.1378	0.4292	0.4381	0.4418	0.1295

GGM evaluation



std of the geoid height residuals with varying d/o and EGM2008 & RTM enhancement over Greece. Zoomed area for d/o 100-250 (left) and d/o 100-180 (right)

GGM evaluation



Geoid height differences for SH d/o 165 over Greece. Enhanced TIM-R6 (left), enhanced GOCO06s (center), enhanced DIR R6 (right)

GGM	TIM R6	DIR R6	GOCO06S
min	-0.4049	-0.4149	-0.4089
max	0.5041	0.4931	0.4981
mean	0.056	0.0494	0.0554
std	0.1221	0.1227	0.1229

Conclusions

TIM-R6 to d/o 165 will be used, enhanced with EGM2008 to d/o 2160, ERTM2160 to d/o 90,000 and then higher order effects from classic RTM up to d/o 216,000

This is about 2 cm better than EGM2008 and 2.8 cm better than XGM2190

It will be used for the reduction of GOCE SSG data prior to filtering

Results are shown in EGU21-1968 & EGU21-1680 (this vPICO session) and EGU21-1679 (session G4.2)

Acknowledgements

The research project was supported by the Hellenic Foundation for Research and Innovation (H.F.R.I.) under the “1st Call for H.F.R.I. Research Projects to support Faculty members and Researchers and the procurement of high-cost research equipment grant” (Project Number: 3488.).

GeoGravGOCE is funded by (HFRI) within its Call for Research Projects for Research and Academic Staff (HFRI/Staff) following a successful application to the General Secretariat for Research & Technology (GSRT).

