The Consistency Among Different Terrestrial Reference Frames in Greece: The Crucial Role of ETRS89 and the Accurate Velocities Estimation

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EUREF Symposium, 26-28 May, Ljubljana, Slovenia

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What we will discuss

- The relation between the Hellenic Geodetic Reference System of 1987 (HGRS1987, Greece's official geodetic Reference System) and ITRS (BTS, BIH Terrestrial System)
- 2. The differences between the theoretical and practical computations of the HGRS1987 through ITRS, respectively.
- 3. The assessment of HGRS1987 through ETRS89
- 4. The importance of the old-WEGENER pillars for the assessment
- 5. The in-situ re-measurement of some WEGENER sites with RTK

HGRS1987



Veis 2008

- HGRS1987 was realized by 3D-shifting of the initial BTS87 coordinates (the predecessor of ITRS). The scale and the orientation of HGSR1987 are constrained to those of BTS87 (HEMCO 1987)
- The realization was based on satellite observations at 30 stations, nation-wide (SLR, GPS, DOPPLER)- These 30 stations belonged also to the old Greek Geodetic Datum (GR-Datum).
- The coordinates of the 30 stations estimated at HGRS1987, by the 3D-shifting of the BTS87 coordinates.
- The transformation between the GR-Datum and the HGRS1987 for the rest ~26000 pillars of the Greek Triangulation Network was materialized through similarity transformation parameters that were estimated for the 30 stations (common station between HGRS1987 and GR-Datum, accuracy ~ 30 cm).

WEGENER Platforms in Greece



Springer et al. 1994

- WEGENER/MEDLAS was an ambitious international project for the investigation (80s) of Mediterranean Basin's geophysical behavior using mobile-SLR campaigns.
- In Greece, 6 sites were occupied during this project (Askites, Karitsa, Dionysos, Kattavia, Xrisokelaria, Roumeli)
- These 6 sites belong also to the set of the 30 fundamental HGRS1987 and the ITRS* 2 ties between HGRS1987 and ITRS !!!

* The satellite observations at the 6 sites are old and not updated (since 1992). However, they are included in all ITRFs (fortunately!)

ETRS89 and Greece: HTRS07



Katsampalos et al. 2009

- Since 2007, Greece maintains a CORS network of 98 stations (Hellenic Positioning System-HEPOS).
- HEPOS refers to the Hellenic Terrestrial Reference System of 2007-HTRS07. HTRS07 is a local densification of ETRS89 (ETRF2005/epoch 2007.5, Katasampalos et al. 2010).
- ETRS89 and HGRS1987 are connected through a sophisticated mathematical procedure (Helmert transformation + gridding) with a consistency of 8.3 cm rms (nation-wide, Kotsakis and Katsampalos 2008).

The HGRS1987 through HTRS07 is de facto officially accepted!



The assessment of the HGRS1987 at the WEGENER platforms (results*)

	δX (cm)	δY (cm)	δr (cm)
Dionysos	-24.2	-31.8	39.9
Askites	-2.2	21.9	22.0
Karitsa	43.4	105.3	113.9
Katavia	29.9	64.0	70.6
Roumelli	-64.5	-28.2	70.3
Xrisokellaria	-102.4	16.9	103.8

- rms : ~55 cm both for East and North, components, respectively, ~ 77 cm horizontal
- There <u>is an obvious discrepancy</u> between the initial (theoretical) and the practical (officially accepted) computation, respectively (at the level of 55 cm).
- Can we find (or at least investigate) the reason of this discrepancy?

* theoretical minus practical computation, $X \rightarrow Easting$. $Y \rightarrow North, r \rightarrow horizontal$

7-parameter Helmert transformation between BTS87 and the HTRS07

parameter	value		1-σ
tx (m)	1.279	+-	1.458
ty (m)	-3.038	+-	1.455
tz (m)	-3.072	+-	0.993
ds (ppm)	0.562	+-	0.2215
rx (arcsec)	0.128	+-	0.0462
ry (arcsec)	-0.009	+-	0.0326
rz (arcsec)	0.068	+-	0.0323

- Purpose: Validation of the level of the consistency between these two systems (frames)
- 3D rms: 51 cm (26 cm w/o Dionysos something happened?)

Residuals per component (x,y,z) and the 3D residuals

	ex(cm)	ey (cm)	ez (cm)	e3d (cm)
Dionysos	81.6	-2.2	68.9	106.8
Askites	-18.5	-1.0	19.8	27.1
Karitsa	-21.9	4.0	-9.0	24.0
Katavia	-14.3	-2.4	-10.3	17.7
Roumeli	-14.1	4.6	-27.1	30.9
Xrisokellar	-12.9	-3.0	-42.2	44.2

• Fairly consistent scale (56.2 cm/1000 km) and orientation, considering the oldness of BTS87 !

HTRS07 in situ

- We re-measured 3 sites (Askites, Karitsa and Kattavia) using RTK modus. The RTK coordinates are automatically expressed in HGRS1987 projection coordinates.
- Comparison between the:

(a) ITRF-wise HGRS1987 (ITRF2014 coordinates + velocities \rightarrow HTRS07 \rightarrow HGRS1987)

(b) in situ RTK measurements according to the CORS corrections and maintenance

Consistency between these two implementations

Askites (Evros Perfecture)



Kattavia(Rhodes, East Mediterranean)





Karitsa(Ioannina Prefecture)





ITRF-wise vs in-situ HGRS1987*

	δX (cm)	δY (cm)	δr(cm)
Katavia	-1.8	7.8	8.0
Askites	2.7	1.1	2.9
Karitsa	3.6	-0.9	3.7

- Good consistency between the two versions, taking into account the old and mobile SLR measurements. Below the nation-wide rms of 8.3 cm
- However, the Kattavia station seems to deviate from the continental sites
- More sites and comparisons!

Conclusions and results

- The consistency between the theoretical and practical HGRS1987 computations found at the level of 55 cm per component/70 cm horizontal.
- The theoretical computation is not used in practice; only for investigations.
- The consistency between BTS87 and HTRS07 estimated at the level of **51** cm or even better (<u>Dionysos seems to have some inherited problems</u>). Fair enough, taking into account the old-observations and the geophysical behavior of the country.
- The ITRF-wise and the in-situ HGRS1987 seems to be (for now!!!) consistent.
- A part of the classical Greek Triangulation Network should be constantly measured using GNSS!
- A publicly-accessible velocity model should be elaborated!
- A wish/solicitation to IERS: To estimate the coordinates and the coordinates for the 'seniors' of the WEGENER/MEDLAS project!

Acknowledgments

- Dipl. MSc. Eng. **Georgios Michailidis** voluntarily measured the Karitsa site. <u>Without any remuneration</u>, he drove from Ioannina to Karitsa and stayed there for many hours!
- BSc. Eng. **Manolis Nedas** voluntarily measured the Kattavia site. He did it during his honeymoon, <u>without any remuneration</u>. We also thank his wife for her patience!
- Dipl. Eng. **Spyros Sypsas** planned to travel to the Xrisokellaria site. However due to the Corona-virus-related transportation restrictions, the travel was cancelled. Nevertheless, we thank him!

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Thank you for your attention!

For any comment, remark, suggestion, question please do not hesitate to contact us: dampatzi@geo.auth.gr