IAG REPORT

GEODETIC RESEARCH ACTIVITIES IN GREECE

FOR THE PERIOD 2019-2023

Edited by

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IAG National Correspondent

Contributions by:

- *School of Rural and Surveying Engineering, Department of Geodesy and Surveying, Aristotle University of Thessaloniki (AUTh)*
- *School of Rural and Surveying Engineering, National Technical University of Athens (NTUA) Laboratory of Geodesy*
- *University of Patras, Department of Civil Engineering, Geodesy Lab*
- *Laboratory of Geodesy and Geomatics Engineering, (GeoMatLab), School of Mineral Resources Engineering, Technical University of Crete*
- *Laboratory of Geodesy and Surveying, Department of Surveying and Geoinformatics Engineering, University of West Attica*
- *Department of Surveying and Geoinformatics Engineering of the School of Engineering of the International Hellenic University*
- *Hellenic Military Geographical Service (HMGS)*
- *Institute of Geodynamics, National Observatory of Athens (NOANET)*
- *Hellenic Cadastre*

June 2023

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FOREWORD

This report was prepared as part of the national report of the Committee of Geodesy and Geophysics of Greece, on the occasion of the 28th General Assembly of the International Union of Geodesy and Geophysics (IUGG) which will be held in Berlin, Germany, July 11-20, 2023.

The report presents the geodetic activities and the progress achieved in Geodesy by Greek Universities, Research Institutions and National Agencies for the period 2019-2023. All the Geodesy related research studies and contributions to national and international scientific projects, working groups and editorial boards lay mainly within the scope of the four Commissions of the International Association of Geodesy (IAG) according to its current structure (Commission 1: Reference Frames, Commission 2: Gravity Field, Commission 3: Earth Rotation and Geodynamics, Commission 4: Positioning and Applications).

As it is expected, research work does not necessarily cover the aims and goals of one Commission only, but covers broader and combined subjects. Moreover, given that nowadays Geodesy, both in terms of theoretical developments and practical applications, is cooperating widely with other geosciences, it is evident that in some cases the research results presented may not be strictly geodetic. This is in the sense that Geodesy offers the fundamental background, so that its products can then be used in other scientific applications and/or through other databases and processing tools. Such examples of interdisciplinary research are the use of GNSS, and satellite in general, products in geo-information and remote sensing applications, the incorporation of geoid models within oceanographic, hydrological, engineering and geodynamic studies and the exploitation of geodetic methods and databases to the prevention and mitigation of natural hazards.

The content of the report is divided in nine main sections with each section being entitled with the name of the corresponding university institute or agency. The contribution of each institute or individual scientist is reported based on the material they provided along with the respective list of literature. An attempt was made to slightly homogenize the material provided by the respective contributors. Therefore, the text and, in general, the style of each sub-report, have been maintained in the subsequent sections.

I take the opportunity to express my sincere thanks to all colleagues working at University Departments, Research Institutions and National Agencies for their contributions, extensive lists of publications and other relevant material provided for the compilation of this report.

Thessaloniki, June 2023

Prof. Emeritus Ilias N. Tziavos
Aristotle University of Thessaloniki

1. School of Rural and Surveying Engineering, Department of Geodesy and Surveying, Aristotle University of Thessaloniki (AUTh)

1.1 Laboratory of Gravity Field Research and Applications (GravLab)

Prof. I.N. Tziavos, Prof. D. Tsoulis, Prof. G.S. Vergos, Assoc. Prof. V.N. Grigoriadis

Main research activities

During the last four years the main research activities of GravLab have been directed to modeling the Earth's gravity at local and regional scales, the evaluation of potential values for the Hellenic region towards height system unification and the realization of the IHRS through the IHRF. GravLab members have participated in the Colorado geoid experiment for the determination of the geoid and the intercomparison of geoid determination methodologies within the activities of IAG's Joint Working Group 2.2.2 "The 1 cm geoid experiment". Moreover, GravLab has continued the exploitation of GOCE gradiometric observations for local and regional gravity field recovery, working on the data pre-processing and filtering and their downward continuation and combination with local data. Additionally, work on theoretical and computational aspects on potential fields has been carried out, including algorithms for the evaluation of potential harmonic coefficients of a polyhedral source and estimation procedures for third order potential derivatives. Within the frame of related projects, extensive gravity campaigns have been carried out towards filling the gaps in existing databases over Northern Greece as well as towards the modernization of the Greek Gravity Reference System. Finally, extensive work has been performed in the direction of using GRACE and GRACE/FO data for monitoring water mass variations and studying vertical deformations.

Positions held during the reporting period

During the reporting period, GravLab members held the following positions:

Prof. Tziavos has been a member of the Editorial Board of Journal of Geodesy and since October 2022 is a Professor Emeritus of the Aristotle University of Thessaloniki.

Prof. Tsoulis has been:

- Chair of ICCT/IAG's JSG T.28: Forward gravity field modelling of known mass distributions.
- Consortium member of IAG's GGOS as designated representative of ICCT.
- Associate Editor, Geophysical Prospecting (keyword: Potential Field Theory).
- Editor, Journal of Geodetic Science.
- Corresponding member, Geodetic Commission (DGK), Bavarian Academy of Sciences.

Prof. Vergos has been:

- Director of the Central Bureau of IAG's International Gravity Field Service
- Chair of IAG Commission 2 SC 2.2: Geoid, Physical Height Systems and vertical datum unification.
- Member of IAG's Committee on the Essential Geodetic Variables.
- Editor in IAG Symposia Proceedings.
- Guest Editor in Journal of Geodesy.
- Guest Editor in Remote Sensing.

Assoc. Prof. Grigoriadis has been:

- Member of IAG JWG 2.2.2: The 1 cm geoid experiment
- Vice-chair of JWG 2.2.1: Error assessment of the 1 cm geoid experiment
- Member of JSG T.37: Theory and methods related to the combination of high-resolution topographic/bathymetric models in geodesy

Research projects during the reporting period

The main research projects of GravLab during the last for years have been:

- «Geoid and Gravity Field Modelling by GOCE Satellite Gradients and Terrestrial Data – GeoGravGOCE» project, funded by the HFRI(ELIDEK)/GSRT. Duration: 23/12/2019 – 22/12/2021.
- «Modernization of the Hellenic Gravity Network – ModernGravNet» project, funded by the HFRI(ELIDEK)/GSRT. Duration: 23/12/2019 – 22/06/2022.
- EaRth Observation Tools for the promotion of DigITal Economy – Erodite» project, funded in the frame of the H2020 Erasmus+ (Erasmus+) in the frame of the EAC/A02/2019 call EAC/A02/2019. Duration: 01/2021 – 01/2024.

- "Generation and strengthening of network differential positioning services through continuously operating reference stations for land and airborne applications – GeoNetGNSS» project, funded by the European Union and National Funds through the RCM OP (KEPA/ANEM) in the frame of the action Innovation Investment Plans. Duration: 10/2021 – 10/2023.

References for the reporting period:

The complete list of publications by GravLab can be found in the Laboratory webpage http://gravlab.topo.auth.gr/publications/. A short list of the recent and representative ones is as follows:

Grigoriadis VN, Vergos GS, Barzaghi R, Carrion D, Koç Ö (2021) Collocation and FFT-based geoid estimation within the Colorado 1 cm geoid experiment. J Geod 95(52). https://doi.org/10.1007/s00190-021-01507-7.

Goyal R, Featherstone WE, Tsoulis D, Dikshit O (2020) Efficient spatial-spectral computation of local planar gravimetric terrain corrections from high-resolution digital elevation models, Geophys. J. Int., 221(3), pp 1820-1831. https://doi.org/10.1093/gji/ggaa107.

Jamet O, Tsoulis D (2020) A line integral approach for the computation of the potential harmonic coefficients of a constant density polyhedron, J Geod, 94(3), 30. https://doi.org/10.1007/s00190-020-01358-8.

Mamagianou E, Pitenis E, Natsiopoulos DA, Vergos GS, Tziavos IN (2022) GeoGravGOCE: A standalone MATLAB GUI for processing GOCE satellite gradient data. Computers and Geosciences 166,105184. https://doi.org/10.1016/j.cageo.2022.105184.

Natsiopoulos DA, Mamagiannou EG, Pitenis EA, Vergos GS, Tziavos IN (2023) GOCE Downward Continuation to the Earth's Surface and Improvements to Local Geoid Modeling by FFT and LSC. Remote Sensing 15(4):991. https://doi.org/10.3390/rs15040991.

Piretzidis D, Sideris MG, Tsoulis D (2019) Comparison of Criteria for the Identification of Correlated Orders in GRACE Spherical Harmonic Coefficients. In: Novák P., Crespi M., Sneeuw N., Sansò F. (eds) IX Hotine-Marussi Symposium on Mathematical Geodesy. International Association of Geodesy Symposia, vol 151. Springer, Cham. https://doi.org/10.1007/1345_2019_83.

Pitenis E, Mamagianou E, Natsiopoulos DA, Vergos GS, Tziavos IN, Grigoriadis VN, Sideris MG (2022) FIR, IIR and Wavelet Algorithms for the Rigorous Filtering of GOCE SGG Data to the GOCE MBW. Remote Sensing 14(13),3024. https://doi.org/10.3390/rs14133024.

Romeshkani M, Sharifi MA, Tsoulis D (2021) Estimation of gravitational curvature through a deterministic approach and spectral combination of space-borne second-order gravitational potential derivatives, Geophys. J. Int., 224(2), pp 825-842. https://doi.org/10.1093/gji/ggaa466.

Romeshkani M, Sharifi MA, Tsoulis D (2020) Joint estimation of gravity anomalies using second and third order potential derivatives, Geophys J. Int., 220(2), pp 1197-1207. https://doi.org/10.1093/gji/ggz517.

Sánchez L, Ågren J, Huang J, Wang YM, Mäkinen J, Pail R, Barzaghi R, Vergos GS, Ahlgren K, Liu Q (2021) Strategy for the realisation of the International Height Reference System (IHRS). J Geod 95(33). https://doi.org/10.1007/s00190-021-01481-0.

Tsoulis D, Gavriilidou G (2021) A computational review of the line integral analytical formulation of the polyhedral gravity signal. Geophys. Prospect., 69(8-9):1745-1760. https://doi.org/10.1111/1365-2478.13134.

Tsoulis D, Moukoulis C (2019) Processing aspects of level 2 GOCE gradiometer data for regional applications, Geophys. J. Int., 216(2), pp 1116-1131. https://doi.org/10.1093/gji/ggy485.

Tziavos IN (2020) Gravity and geoid in the Mediterranean Sea: The GEOMED project. Rend Fis Acc Lincei. https://doi.org/10.1007/s12210-020-00880-3.

Vu DT, Bruinsma S, Bonvalot S, Remy D, Vergos GS (2020) A Quasigeoid-Derived Transformation Model Accounting for Land Subsidence in the Mekong Delta Towards Height System Unification in Vietnam. Remote Sensing 12(5), 817. https://doi.org/10.3390/rs12050817.

Wang, Y.M., Sánchez, L., Ågren, J. et al. Colorado geoid computation experiment: overview and summary. J Geod 95, 127 (2021). https://doi.org/10.1007/s00190-021-01567-9.

Yang M, Hirt C, Wu B, Deng XL, Tsoulis D, Feng W, Wang CQ, Zhong M (2022) Residual Terrain Modelling: The Harmonic Correction for Geoid Heights. Surv Geophys (2022). https://doi.org/10.1007/s10712-022-09694-4.

1.2 Laboratory of Geodetic Methods and Satellite Applications (SatLab)

Prof. D. Rossikopoulos, Prof. A Fotiou, Prof. C. Pikridas, Prof. C. Kotsakis

Main research activities

During the last 4 years, the AUTH Satellite Methods and Geodetic Applications Lab has participated in research projects, providing scientific expertise and services to the above scientific areas. AUTH Lab has a critical mass of good quality research in several areas with scientific publications and papers in national and international journals and conferences over the last 4 years. Lab Members are participating as leader and cooperative partners at several Research Projects supported from National and European funds such as, Hellenic Plate Observing System (https://www.helpos.gr/), Monitoring of HeXaGoN GNSS Network and EaRth Observation Tools for the promotion of DigITal Economy – Erodite (https://www.erodite.info/). In addition, the GNSS_QC research team is participating to EUREF Technical Working Group on the creation of a European Dense Velocity model.

References for the reporting period:

A selected list of the recent publications is as follows:

Karolos I-A., Bitharis S., Tsioukas V., Pikridas C., Kontogiannis S., Gkamas T., Zinas N.: *Proposed 4.0 Industrial Management System for daily operations that poses point cloud assets with annotated real-time sensory measurements and utilizes unsupervised alert logic.* FIG Peer Review Journal [Link]

Lazos, I., Sboras, S., Chousianitis, K., Kondopoulou, D., Pikridas, C., Bitharis, S., & Pavlides, S. (2022). *Temporal evolution of crustal rotation in the Aegean region based on primary geodetically-derived results and palaeomagnetism*. Acta Geodaetica et Geophysica, 1-18. https://doi.org/10.1007/s40328-022-00379-3

Karakostas, V., Papazachos, C., Papadimitriou, E., Foumelis, M., Kiratzi, A., Pikridas, C., Kostoglou, A., Kkallas, C., Chatzis, N., Bitharis, **S.**, Chatzipetros, A., Fotiou, A., Ventouzi, C., Karagianni, E., Bonatis, P., Kourouklas, C., Paradisopoulou, P., Scordilis, E., Vamvakaris, D., Grendas, I., Kementzetzidou, D., Panou, A., Karakaisis, G., Karagianni, I., Hatzidimitriou, P., & Galanis, O. (2021). *The March 2021 Tyrnavos, central Greece, doublet (Mw6.3 and Mw6.0): Aftershock relocation, faulting details, coseismic slip and deformation*. Bulletin of the Geological Society of Greece, 58, 131-178. https://doi.org/10.12681/bgsg.27237

Chatzipetros, A., Pavlides, S., Foumelis, M., Sboras, S., Galanakis, D., Pikridas, C., Bitharis, **S.**, Kremastas, E., Chatziioannou, A., & Papaioannou, I. (2021). *The northern Thessaly strong earthquakes of March 3 and 4, 2021, and their neotectonic setting*. Bulletin of the Geological Society of Greece, 58, 222-255. https://doi.org/10.12681/bgsg.27225

Lazos I., Sboras S., Chousianitis K.**,** Bitharis S., Mouzakiotis E., Karastathis V., Pikridas C., Fotiou A., Galanakis D: *Crustal deformation analysis of Thessaly (central Greece) before the March 2021 earthquake sequence near Elassona-Tyrnavos (northern Thessaly)*. Acta Geodynamica et Geomaterialia., 18, No. 3(203), 379–385, 2021. https://doi.org/10.13168/agg.2021.0026

Sboras S., Lazos I., Bitharis S., Pikridas C., Galanakis D., Fotiou A., Chatzipetros A., Pavlides S. (2021): *Source modelling and stress transfer scenarios of the October 30, 2020 Samos earthquake: Seismotectonic implications*. Turkish J. Earth Sci, (2021) 30: 699-717. https://doi.org/10.3906/yer-2107-25

Lazos I., Chatzipetros A., Pavlides S., Pikridas C, Bitharis S. (2020): *Tectonic crustal deformation of Corinth Gulf, Greece, based on primary geodetic data*. Acta Geodynamica et Geomaterialia., 17, No. 4 (200), 413–426, 2020. https://doi.org/10.13168/agg.2020.0030

Pikridas C., Bitharis S., Katsougiannopoulos S., Spanakaki, K., Karolos, I.-A. (2019). *Study of TEC variations using permanent stations GNSS data in relation with seismic events. Application on Samothrace earthquake of 24 May 2014*. Geodesy and Cartography, 45(3), 137-146. https://doi.org/10.3846/gac.2019.10246

Bitharis S., Papadopoulos N., Pikridas C., Fotiou A., Rossikopoulos D., Kagiadakis V. (2019) *Assessing a new velocity field in Greece towards a new semi-kinematic datum*, Survey Review, 51:368, 450-459, https://doi.org/10.1080/00396265.2018.1479937

Oikonomou C., Tymvios F., Pikridas C., Bitharis S., Balidakis K., Michaelides S., Haralambous H., Charalambous D. (2018). *Tropospheric delay performance for GNSS integrated water vapor estimation by using GPT2w model, ECMWF's IFS operational model and in situ meteorological data*. Adv. Geosci., 45, 363-375, https://doi.org/10.5194/adgeo-45-363-2018.

Prof. Emeritus A. Dermanis

References for the reporting period:

Dermanis A, 2020: Geodetic Methods for Monitoring Crustal Motion and Deformation, 71 pages. In: W. Freeden and R. Rumel, eds. (2020): Handbuch der Geodäsie: Mathematische Geodasie / Mathematical Geodesy, Vol. 1., 625-695.

Dermanis A, 2020: Theory and Realization of Reference Systems, 127 pages. In: W. Freeden and R. Rumel, eds. (2020): Handbuch der Geodäsie: Mathematische Geodasie / Mathematical Geodesy, Vol. 1., 697-823.

Prof. Emeritus D. Arabelos, Prof. Emeritus M.E. Contadakis

Main research activities

In the period 2015-2019 we continue the previous scientific activity i.e. the study of the variations of different physical parameters of the Geosphere in relation to the seismic activity, in order to identify earthquake's precursory phenomena. In particular, our research focuses on three areas:

1) Direct estimation of the lower Ionosphere variations analysing the T(otal)E(lectron)C(ontent) estimations of GLONASS and GPS networks.
2) Indirect estimation of the lower Ionosphere variations by analysing the disturbances on the LF/VLF electromagnetic wave transmission induced by the disturbed lower Ionosphere.
3) Tidal triggering effect on earthquake occurrence. Researchers from other institutes have been collaborating with our group to this investigation, i.e.: Prof. T.D. Xenos and Dr. C. Skeberis from the Department of Telecommunication of AUTh, and Prof. E.M. Scordilis from the Department of Geodynamics of AUTh; Prof. P.F. Biagi, leader of the network, University of Bari, Italy; Department of Engineering of Enterprise, University of Tor Vergata, Italy; National Institute of Earth's Physics, Seismological Department, Bucharest, Romania; Austrian Academy of Sciences, Austria; Canakkale Onsekiz Mart University, Department of Geophysics, Turkey; Institute of Physics of the Earth, National Academy of Sciences, Moscow, Russia.

References for the reporting period:

Arabelos DN, Contadakis, Micheal E.; Vergos GS, Skeberis C, Xenos TD, Spatalas S, (2020). Variation of some planetary seismic hazard indices on the occasion of Lefkada, Greece, earthquake of 17 November, 2015, ANNALS OF GEOPHYSICS, Vol. 63, No. 5, p.547, 2020

Contadakis ME, Arabelos DN, Vergos GS, Skeberis C, Xenos T, Biagi PF, Scordilis EM (2020). Ionospheric turbulence from TEC variations and VLF/LF transmitter signal observations before and during the destructive seismic activity of August and October 2016 in Central Italy, ANNALS OF GEOPHYSICS, Vol. 63, No. 5, p.546, 2020

Contadakis ME, Vallianatos F, Spatalas S, Scordilis EM (2020). Lower Ionospheric turbulence variations during the intense tectonic activity in Eastern Aegean area, ANNALS OF GEOPHYSICS, Vol. 63, No. 5, p.544, 2020

Arabelos DN, Contadakis ME, Vergos GS, Scordilis EM (2019). Lower Ionospheric Turbulence Variations during the Intense Tectonic Activity of October, 2018 at Zakynthos Area, Greece, Open Journal of Earthquake Research, Vol. 8, p. 255-266, 2019

Arabelos DN, Contadakis ME, Scordilis EM (2019). Lower Ionospheric turbulence variations during the recent activity of Etna's Volcano, Sicily, in December 2018, Bulletin of the Geological Society of Greece, 2019, Vol. 55, No. 1, p.19-33

Biagi PF, Colella R, Schiavulli L, Ermini, A, Boudjada M, Eichelberger H, Schwingenschuh K, Katzis K, Contadakis ME, Skeberis C, Moldovan IA, Bezzeghoud M (2019). The INFREP Network: Present Situation and Recent Results, Open Journal of Earthquake Research, Vol. 8, p. 101-115, 2019

2. School of Rural and Surveying Engineering, National Technical University of Athens (NTUA) Laboratory of Geodesy

Research activity during the last four years (2019-2022) was mainly focused on:
Commission1: Reference Frames
Commission 3: Earth Rotation and Geodynamics
Commission 4: Positioning and Applications

I -- Scientific Conference Organization

4th Joint International Symposium on Deformation Monitoring, (2019) Athens FIG / IAG / ISPRS, May 15-17 http://jisdm2019.survey.ntua.gr/

II -- Editor in Special Issues

Retscher G., Masiero A., Goel S., Gikas V. (2022) "*New Advances in Indoor Navigation*" Geomatics, MDPI (in progress) *https://www.mdpi.com/journal/geomatics/special_issues/new_advances_Indoor_navigation*

Retscher G., Krejcar O., Gikas V., Kačmařík M. (2021) "*Advances in Localization and Navigation (GIS Ostrava 2021)*", ISPRS International Journal of Geo-Information *https://www.mdpi.com/journal/ijgi/special_issues/GIS_Ostrava_2021*

Paziewski J.D., Kealy A., Gikas V., Geng J. (2021) "*Recent Advances in Ubiquitous Positioning Systems for Mobility Applications*", Measurement Science and Technology, Meas. Sci. Technol., 32(9) *https://iopscience.iop.org/article/10.1088/1361-6501/ac0186*

Gikas V., Schwieger V., Zhang L. (2021) "*Editorial to the Special Issue: Deformation Monitoring*", Applied Geomatics 13 (1), 1-2 *https://link.springer.com/journal/12518/volumes-and-issues/13-1/supplement*

III – Book Chapters

Retscher G., Kealy A., Gikas V., Gabela J., Goel S., Li Y, Masiero A., Toth C.K., Perakis H., Błaszczak-Bąk W., Koppanyi Z., Grejner-Brzezinska D. (2020) "*A Benchmarking Measurement Campaign to Support Ubiquitous Localization in GNSS Denied and Indoor Environments*" In: Int. Ass. of Geod. Symp. Springer, Berlin, Heidelberg. *https://doi.org/10.1007/1345_2020_102*

Piniotis G., Gikas V. (2020) "*Experimental Assessment of a Ground-Based Radar Interferometer (GBRI) for the Determination of the Oscillation Parameters of Large-scale Engineering Structures*", Τιμητικός – συλλεκτικός Τόμος στη μνήμη Ευαγγελίας Λάμπρου, Πολυτεχνειούπολη Ζωγράφου, Αθήνα, 2020

Gikas V., Retscher G., Kealy A. (2019) "Collaborative Positioning for Urban Intelligent Transportation Systems (ITS) and Personal Mobility (PM): Challenges and Perspectives" in Mobility Patterns, Big Data and Transport Analytics, Elevier Inc., https://doi.org/10.1016/B978-0-12

Dovis, F., Ruotsalainen, L., Toledo-Moreo, R., Kassas, Z.Z.M., Gikas, V. (2020) "*Recent Advancements on the Use of Global Navigation Satellite System-Based Positioning for Intelligent Transport Systems*", IEEE Intelligent Transportation Systems Magazine, 2020, 12(3), pp. 6–9, 9146601 *https://ieeexplore.ieee.org/document/9146601*

Gikas, V., Retscher, G., Kahmen, H., Neuner, H., Rizos, C. (2020) "*Editorial to the Special Edition of the JAG on Deformation Monitoring*", Journal of Applied Geodesy, 2020,14 (2), 119-119 *https://www.degruyter.com/journal/key/jag/14/2/html*

Gikas V., Pantazis G., Tsakiri M. (2019) "*Selected Papers from 4th Joint International Symposium on Deformation Monitoring (JISDM 2019)*", SENSORS, MDPI *https://www.mdpi.com/journal/sensors/special_issues/JISDM2019* 812970-8.00015-4, pp381–414

IV – Journal Publications

Mpimis A., Kapsis T., Panagopoulos A.D., Gikas V., (2022) "*Cooperative D-GNSS Aided with Multi Attribute Decision Making Module: A Rigorous Comparative Analysis*", Future Internet, 14(195), MDPI, 1–17

Papathanasopoulou V., Spyropoulou I., Perakis H., Gikas V., Andrikopoulou E. (2022) "*A Data-driven Model for Pedestrian Behavior Classification and Trajectory Prediction*", IEEE Open Journal of Intelligent Transportation Systems, 3, 328–339

Filograno M.L., Piniotis G., Gikas V., Papavasileiou V., Gantes C.J. ,Kandyla M., Riziotis C. (2022) "*Comparative Assessment and Experimental Validation of a Prototype Phase-Optical Time-Domain Reflectometer for Distributed Structural Health Monitoring*", Journal of Sensors, 1–23

Retscher R., Gabela J., Gikas V. (2022) "*PBeL – Problem Based (e-)Learning of LBS in Online Teaching for Geomatics Students*", GEOMATICS, MDPI, 1, 1–29

Pagounis V., Merlemis N., Anastasiou D., Arabatzi O., Zacharis V., Tsakiri M. (2022). Compact testing of total station instruments using folded optics. Journal of Applied Engineering sciences. Vol. 12(25), issue 1/2022, Art.No 331 pp.71-76 DOI: 10.2478/jaes-2022-0011

Panou, G., & Korakitis, R. (2022). Cartesian to geodetic coordinates conversion on a triaxial ellipsoid using the bisection method. Journal of Geodesy, 96(10), 66. https://doi.org/10.1007/s00190-022-01650-9

Masiero A., Toth C., Gabela J., Retscher G., Kealy A., Perakis H., Gikas V., Grejner-Brzezinska D. (2021) "*Experimental Assessment of UWB and Vision-based Car Cooperative Positioning System*", Remote Sensing, 13(23)

Themistocleous, K., Danezis, C., Gikas, V (2021) "*Monitoring Ground Deformation of Cultural Heritage Sites Using SAR and Geodetic Techniques: The Case Study of Choirokoitia*", Cyprus, Applied Geomatics, 13(1), 37–49

Panou, G., & Agatza-Balodimou, A.-M. (2021). Direct and Indirect Estimation of the Variance–Covariance Matrix of the Parameters of a Fitted Ellipse and a Triaxial Ellipsoid. Journal of Surveying Engineering, 147(1). https://doi.org/10.1061/(ASCE)SU.1943-5428.0000342

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Retscher, G., Kealy, A., Gabela, J., Li, Y., Goel, S., Toth, C. K., Masiero, A., Błaszczak-Bąk, W., Gikas, V., Perakis, H., Koppanyi, Z., & Grejner-Brzezinska, D. (2020) "*A Benchmarking Measurement Campaign in GNSS-Denied/Challenged Indoor/Outdoor and Transitional Environments*", Journal of Applied Geodesy, 14(2), 215–229 *doi: https://doi.org/10.1515/jag-2019-0031*

Panou, G., & Korakitis, R. (2020). The direct geodesic problem and an approximate analytical solution in Cartesian coordinates on a triaxial ellipsoid. Journal of Applied Geodesy, 14(2), 205–213. https://doi.org/10.1515/jag-2019-0066

Panou, G., Korakitis, R., & Pantazis, G. (2020). Fitting a triaxial ellipsoid to a geoid model. Journal of Geodetic Science, 10(1), 69–82. https://doi.org/10.1515/jogs-2020-0105

Panou G., Mintourakis I., Paradissis D., Korakitis R., & Balodimos D.-D., (2020). Rectangular harmonic analysis applied to a regional gravity field. In: Measurements routes. Dedicated volume in honor of Professor E. Lambrou, Ziti editions, Thessaloniki, Greece, pp. 79-88.

Gabela J., Retscher G., Goel S., Perakis H., Masiero A., Gikas V., Toth C., Kealy A., Koppányi Z., Błaszczak-Bak W., Li Y. and Grejner-Brzezinska D. (2019) "*Experimental Evaluation of a UWB based Cooperative Positioning System for Pedestrians in GNSS Denied Environments*", Sensors, 19(23), 25 pgs.

Retscher G., Gikas V., Hoffer H., Perakis H, Kealy A. (2019) "*Range Validation of UWB and Wi-Fi for Integrated Indoor Positioning*", Applied Geomatics, 11, 187–195

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3. Patras University, Dept of Civil Engineering, Geodesy Lab (head: Prof S. Stiros)

During the last intra-congress period, the main focus of our research in Geodynamics was the quality of proposed (underground) seismic fault models which are derived from analysis of displacement vectors of permanent GNSS stations.

Seismic fault models are of two types: (a) Uniform slip models which correspond to one or more planar faults with uniform slip along them. Each fault defined by 9 variables and these models reflect a simplification of the seismic rupture. (b) Variable slip models which assume slip variable in each seismic fault surface and are described by tens or hundreds of variables.

Solution for the variables which define a seismic fault model corresponds to solution of a system of highly non-linear equations. In most cases this system is under-determined, i.e., it corresponds to fewer observation equations corresponding to GNSS displacement vectors than the number of unknowns. In addition, no approximate values for most unknown variables are usually known, while the signal-to noise ratio (SNR) of observations is usually very low. As a consequence, no formal network adjustment techniques for fault models are possible.

For this reason, the solution ("inversion") of fault models is based on numerical techniques, mostly on Monte Carlo-based techniques. In this approach, an algorithm searches within a "search space" for a solution which offers the best fit with observations ("minimized cost function"). Unfortunately, using this approach, no unique solution is possible since numerous solutions can minimize the cost function, while the solution depends on the initial guess of the values of unknown variables.

Our contribution to overcome this problem was in two directions:

1. New efficient inversion (adjustment) algorithm

A new inversion algorithm which approximates the search space with a gridded hyper-space was proposed. This new algorithm, known as TOPological INVersion (TOPINV) algorithm, "scans" the whole of the search space (exhaustive searches of a hyperspace approximated by a N-dimensional grid, N≥9), identifies all solutions which minimize the cost function and can pick the optimal solution. This algorithm is functional for at least up to 18 unknown variables, but is computationally very expensive.

To overcome this problem, the TOPINV algorithm was implemented in GPUs which permit parallel processing even in common computers. A problem that was solved is that GPUs are typically compatible with 3-D spaces, and certain transformations were necessary in order to adapt hyperspaces (spaces higher than in 3 dimensions) in GPUs.

The results of this research are summarized in the following publication:

Venetis, I., Saltogianni, V., Stiros, S., Gallopoulos, E. (2020). Multi-variable inversion using exhaustive grid search and high-performance GPU processing: A new perspective, *Geophys J Int*, doi: 10.1093/gji/ggaa042

2. Quality of variable slip models

Variable slip models correspond to highly under-determined observations systems, their quality cannot be easily assessed and correspond to non-unique solutions; for example, even for major earthquakes very different variable slip fault models have been proposed.

Our contribution was the investigation of the stability of variable slip fault models these models as a function of the noise in data and of the distribution of observation stations (measurement configuration). This analysis was based on synthetic data.

There was selected a representative reference fault model and an associated set of reference GNSS slip-vectors.

(i) In order to investigate the impact of noise in observations in the fault model, ten different sets of slip vectors were produced adding noise of different levels to the reference values. It was found that the increase of the observations noise led to instability of the fault models, especially away from the fault. The amplitude of the slip was found very sensitive to measurement noise.

(ii) In order to investigate the impact of the configuration of observation stations in the fault model, different observational systems were examined. It was found that stations above a fault tend to show spurious stress concentration on the fault surface.

The results of this research are summarized in the following publication:

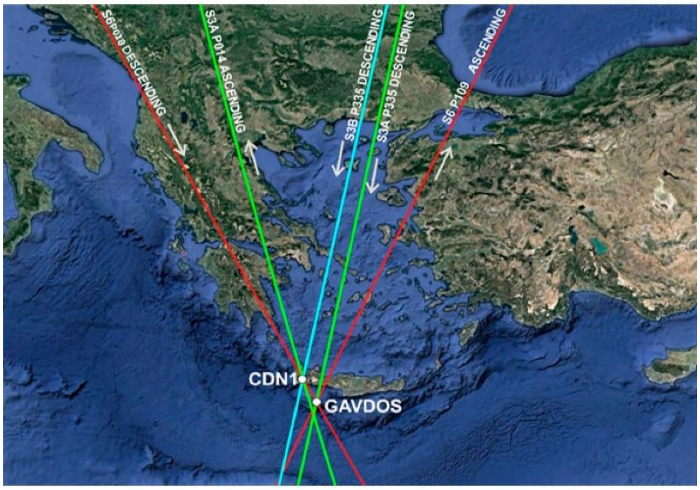
Leivadas-Stathakopoulos I, Biliani I, Stiros S, Observations noise and stability of geodetic variable slip fault models, *Geophys. J. Int*, 2022, 228, 826–838 doi: 10.1093/gji/ggab377

4. Laboratory of Geodesy and Geomatics Engineering, (GeoMatLab), School of Mineral Resources Engineering, Technical University of Crete

Prof. Stelios Mertikas, www.geomatlab.tuc.gr

During the period 2019 – 2022 research activities of GeoMatLab are focused primarily on Satellite Altimetry Calibration/Validation (Cal/Val), sea level determination, GNSS atmospheric and deformation monitoring, and remote sensing.

A ground reference infrastructure has been established in Gavdos and Crete has been continuously operating and providing absolute altimeter biases for more than 20 years. The European Space Agency recognized it in 2018 as the ESA Permanent Facility for Altimetry Calibration (ESA-PFAC). It consists of several calibration/validation sites spread over Western Crete and Gavdos islands. This facility was originally built up in 2001 to calibrate the Jason satellite altimeters, but it eventually has contributed throughout its many years of operation into calibrating all international altimeters, such as those from the European Space Agency, as well as American, French, Chinese, and Indian satellites.



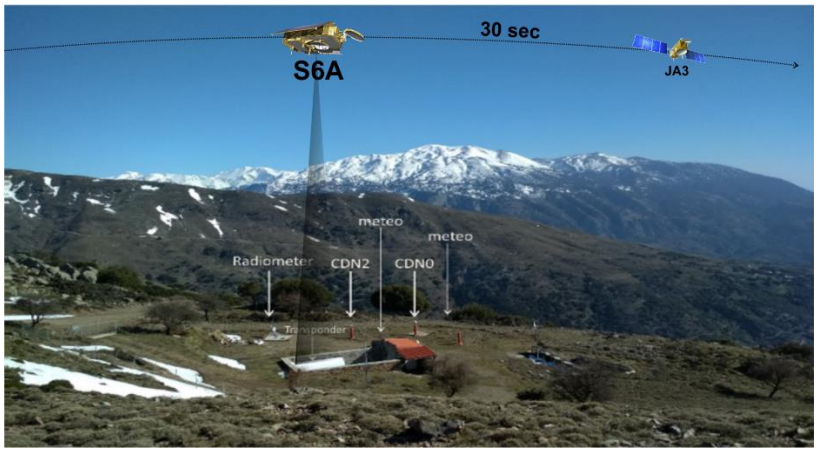


Figure 1: The two permanent transponder Calibration/Validation sites up on the mountains of west Crete (CDN1 Cal/Val site) and in Gavdos island (GVD1 Cal/Val site).

It includes a major set of permanent sea-surface Cal/Val sites and prototype scientific equipment (microwave transponders) at various locations in Crete and Gavdos. At present, this infrastructure includes 17 permanent Global Navigation Satellite System stations, 10 tide gauges, 7 meteorological systems, several communication links, two microwave transponders and a central facility for data archiving, processing, and for remotely controlling all field units. The ESA-PFAC allows calibration of satellite altimeters over ascending and descending passes and permits multi-mission calibration at crossover locations over land and sea-surface simultaneously. At the same locale, connection and cross-comparison of various altimeters can be made using the same orbits, conditions, and settings by employing diverse methods, settings, and instrumentations on the ground (sea surface and transponder) for absolute assessment.

All international altimetry missions (i.e., Sentinel-6 MF, Sentinel-3A/B and CryoSat-2 (European), Jason series (American-French), HY-2 (Chinese), and SARAL/AltiKa (Indian-French) have been calibrated at this facility as of 2004.

A new transponder site on Gavdos island was established in 2021 dedicated primarily for the operational altimeter of Sentinel-6 and Sentinel-3 with range and sigma-naught calibration. This facility is called GVD1 transponder Cal/Val site. The measurements and results of these two transponder facilities are analyzed and evaluated by a team of 15 people with representatives from the Technical University of Crete, the European Space Agency, the Eumesat in Germany, the French Space Agency (CNES), the Jet Propulsion Laboratory (NASA), the US National Oceanic and Atmospheric Administration (NOAA), and ESA collaborators from France, Spain, Italy and Germany.

Also, a new sea-surface Cal/Val site, called “SUG1”, has been established at the southwest coast of Crete. It supports calibration of the same Sentinel-3A, Sentinel-3B, Sentinel-6 and CryoSat, and HY-2B and HY-2C.

A list of recent and representative publications is given below. A complete list can be found in: www.geomatlab.tuc.gr

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5. Laboratory of Geodesy and Surveying, Department of Surveying and Geoinformatics Engineering, University of West Attica, Athens, Greece

Prof. V. Pagounis, Assoc. Prof. V. D. Andritsanos, Assoc. Prof. M. Gianniou

Commission 2: Gravity Field

The research areas of the Laboratory of Geodesy and Surveying at the Department of Surveying and Geoinformatics Engineering (University of West Attica, Athens) include gravimetry, altimetry, heterogeneous data combination in local and regional geoid and Dynamic Ocean Topography modeling and deformation monitoring. For these purposes the Laboratory is equipped with modern geodetic instruments such as GNSS geodetic receivers, geodetic levels, a gravimeter of relative measurements, and a single beam echo sounder. In addition, two tide gauges are operational in Isthmos Canal (Peloponnesus – Central Greece) since 2014 and provide local sea surface measurements every 10 sec. Gravity campaigns across Attica region were organized since 2016 and, approximately, 200 gravity benchmarks, among them the calibration line of Parnitha Mountain, were measured. A PhD work is in progress entitled "Applications of artificial intelligence in gravity Field estimations".

Current geodetic research project

Partner in **"ModernGravNet**: **Modernization of the Hellenic Gravity Network"**, funded by Hellenic Foundation for Research and Innovation (H.F.R.I.) under the "First 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: 1550) – Main investigator: V. Grigoriadis – Aristotle University of Thessaloniki.

Publications

Grigoriadis, V. N., V. D. Andritsanos and D. Natsiopoulos (2022): Validation of the Hellenic gravity network in the frame of the ModernGravNet project. Presented at the 2021 Scientific Assembly of the International Association of Geodesy "Geodesy for a Sunstainable Earth", June 28th – July 2nd, Beijing, China. Accepted for publication at the International Association of Geodesy Symposia Series. Springer eds.

Grigoriadis, V.N., V.D. Andritsanos and D. Natsiopoulos (2022): Investigation of different geoid computation techniques in the frame of the ModernGravNet project. Presented at the 2022 European Geophysical Union General Assembly, May 23rd – 27th, Vienna, Austria.

Andritsanos, V.D., V.N. Grigoriadis, D. Natsiopoulos and G.S. Vergos (2022): Zero-height geopotential level WoLVD estimation for the homogenization and modernization of the Vertical Datum of Greece. Presented at the 2022 European Geophysical Union General Assembly, May 23rd – 27th, Vienna, Austria.

Commission 3: Earth Rotation and Geodynamics

The research areas of the Laboratory of Geodesy and Surveying at the Department of Surveying and Geoinformatics Engineering (University of West Attica, Athens) include geodetic reference frames and tectonic geodesy. For these purposes the Laboratory is equipped with modern geodetic GNSS receivers, a permanent GPS reference station operating since 2010 and licenses for the Bernese, GAMIT and GipsyX software packages. The Laboratory is collaborating with many institutions in Greece and abroad. A PhD work is in progress in the field of tectonic geodesy.

Current geodetic research project

The Laboratory is participating in "TectoVision: What is controlling plate motions over the minutes to decades timescale?". European Research Council, Call ID: ERC-2021-STG, Topic: PE10 - Earth System Science https://erc.easme-web.eu/?p=101042674

Publications

K. Aspioti, D. Anastasiou, M. Gianniou, V. D. Andritsanos and V. Pagounis (2022) Velocity and strain field estimation from episodic GNSS campaigns (2012-2021) for the region of Attica, Greece. Presented at REFAG 2022 – Reference Frames for Applications in Geosciences, 17th – 20th October 2022, Thessaloniki, Greece.

Mouslopoulou V., V. Saltogianni, G.M. Bocchini, S. Cesca, J. Bedford, A. Dielforder, O. Oncken, M. Gianniou, G. Petersen (2022): "Slow-slip events destabilize upper-plate and trigger large magnitude earthquake at the western-end of the Hellenic Subduction System", EGU22-1692, https://doi.org/10.5194/egusphere-egu22-1692.

Mouslopoulou V., G.M. Bocchini, S. Cesca, V. Saltogianni, J. Bedford, G. Petersen, M. Gianniou, and O. Oncken (2021): "Slow-slip, earthquake-swarms and fault-interactions at the westernend of the Hellenic Subduction System precede the Mw 6.9 Zakynthos Earthquake, Greece", EGU21-8623, https://doi.org/10.5194/egusphere-egu21-8623

Mouslopoulou, V., G. M. Bocchini, S. Cesca, V. Saltogianni, J. Bedford, G. Petersen, M. Gianniou, O. Oncken (2020): "Earthquake swarms, slow slip and fault interactions at the western-end of the Hellenic subduction system precede the moment Mw 6.9 Zakynthos earthquake, Greece". Geochemistry, Geophysics, Geosystems, 21, e2020GC009243. https://doi.org/10.1029/2020GC009243

Saltogianni, V., V. Mouslopoulou, O. Oncken, A. Nicol, M. Gianniou, S. Mertikas (2020): "Elastic Fault Interactions and Earthquake Rupture Along the Southern Hellenic Subduction Plate Interface Zone in Greece", Geophysical Research Letters, 47, e2019GL086604. https://doi.org/10.1029/2019GL086604

Saltogianni, V., V. Mouslopoulou, O. Oncken, A. Nicol, M. Gianniou, S. Mertikas (2020): "Persistent earthquake-rupture segmentation due to variable interseismic slip accumulation within the southern Hellenic subduction plate-interface zone in Greece", Geophysical Research Abstracts, Vol. 20, EGU2020-4857, 2020.

Commission 4: Positioning and Applications

The research areas of the Laboratory of Geodesy and Surveying at the Department of Surveying and Geoinformatics Engineering (University of West Attica, Athens) include accurate positioning and applications. For these purposes the Laboratory is equipped with modern geodetic instruments such as total stations (robotic and image stations), GNSS geodetic receivers, a TOF laser scanner and a single beam echo sounder. A permanent GPS reference station is working since 2010, with a logging interval of 15 sec and 1 sec, providing accurate position data for educational and research purposes. A permanent meteorological station is working since 2017, in conjunction with the GPS station (https://labgeo.uniwa.gr), providing 24h meteorological data. The access to the GPS as well as to the meteorological station data is free for educational and research purposes.

Publications

Gianniou, M., D. Mastoris, P. Argyrakis, M. Christou (2022): "Performance of Galileo for geodetic positioning under challenging signal reception conditions", EUREF 2022 Symposium, June 1–3 2022, Zagreb, Croatia.

6. Department of Surveying and Geoinformatics Engineering of the School of Engineering of the International Hellenic University

Assistant Prof. D. Ampatzidis

Main research activities

- GNSS and SLR Processing
- Combination of different space techniques at the NEQ level
- Special applications of Least Squares Adjustment
- DEM evaluation
- GNSS levelling
- GNSS-derived deformations
- Bathymetric models assessment
- Datum transformations

Peer Reviewed Journals, Proceedings and Chapters

Mouratidis, A., D. Ampatzidis (2019). European Digital Elevation Model (EU-DEM) validation against extensive Global Navigation Satellite Systems data and comparison with SRTM DEM and ASTER GDEM in Central Macedonia (Greece), ISPRS Int. J. Geo-Inf. 2019,8,0;, doi:10.3390/ijgi8030000.

Ampatzidis D. (2019). On the assessment of the temporal evolution of global terrestrial reference frames: the VEDA approach. Acta Geodyn. Geomater., 15, No. 1 (193), 85–97. DOI: 10.13168/AGG.2019.0007.

T-M Perivolioti, A. Mouratidis, D. Terzopoulos , P. Kalaitzis, D. Ampatzidis, M. Tušer, J. Frouzova and D. Bobori (2021). Production, Validation and Morphometric Analysis of a Digital Terrain Model for Lake Trichonis Using Geospatial Technologies and Hydroacoustics. ISPRS Int. J. Geo-Inf., 10, 91. https://doi.org/10.3390/ijgi10020091.

M. Foumelis, Papazachos, C., Papadimitriou, E., Karakostas, V., Ampatzidis, D., Moschopoulos,G., Kostoglou, A., Ilieva,M., Minou, D., Mouratidis, A., KKallas, C., Chatzipetros A. (2021). On Aspects of Rapid Multidisciplinary Response to Samos-Izmir 2020 M7.0 Earthquake. Acta Geophysica. https://doi.org/10.1007/s11600-021-00578-6.

G. Moschopoulos, D. Ampatzidis, A. Mouratidis, N. Demirtzoglou, D-G Perperidou, I. Mintourakis (2021). On the problem of the transformation between the official Hellenic Geodetic Datum and the 'Old Bessel' or Old Greek Datum. A case study in the Serres region (Northern Greece). NZ Surveyor Journal, Vol. 306.

Ampatzidis, D., Wang, L., Mouratidis, A. et al. (2022) Rigorous and fast constraints transformations at the solution level: case studies for regional and global GNSS networks. GPS Solut 26, 44. https://doi.org/10.1007/s10291-022-01225-3.

Ampatzidis, D., Thaller, D., Wang, L. (2022). The Correlations of the Helmert Transformation Parameters as an Additional Auxiliary Diagnostic Tool for Terrestrial Reference Frames Quality Assessment. In: International Association of Geodesy Symposia. Springer, Berlin, Heidelberg. https://doi.org/10.1007/1345_2022_164.

Memberships

2017-now: Dimitrios Ampatzidis is a member of International Laser Ranging Service (ILRS)

2021-now: Dimitrios Ampatzidis is a member of European Space Education Resource Office (ESERO)

2019-now Dimitrios Ampatzidis is a member of Copernicus Academy of the Aristotle University Thessaloniki.

Assistant Prof. E.A. Tzanou

Main research activities

During the last four years the main research activities have been focused on the analytical gravity field and geoid modeling in support of GNSS/Levelling and the practical realization of seamless orthometric height

determination from CORS stations. Moreover, studies on the cyclo-stationarity of sea level anomalies and correlation with climatic indexes have been performed as contribution to climate variability over the Mediterranean area.

References for the reporting period:

Ampatzidis D, Tzanou EA, Demirtzoglou N, Vergos GS (2022) Strategies for the optimal combination between local 3D modern GNSS and 2D classical networks, expressed in different reference frames: Case study in Greece. Presented at the IAG Commission 1 "Reference Frames for Applications in Geosciences" – REFAG2022 Conference, October 17-20, Thessaloniki, Greece.

Natsiopoulos DA, Tzanou EA, Vergos GS (2022) Cyclo-Stationarity in Sea Level Variability from Satellite Altimetry Data and Correlation with Climate Indices in the Mediterranean Sea. In: T. Bašić (ed.), Altimetry - Theory, Applications and Recent Advances, IntechOpen, London. doi: https://doi.org/10.5772/intechopen.109013.

Natsiopoulos DA, Mamagiannou E, Tzanou EA, Triantafyllou A, Vergos GS, Tziavos IN, Ramnalis D, Polychronos V (2022) Gravity and GNSS/Leveling data collection towards developing a regional geoid model in support of the newly established GeoNetGNSS CORS network. Presented at the 3rd joint meeting of the International Gravity Field Service and Commission 2 of the International Association of Geodesy "Gravity Geoid and Height Systems 2022" – GGHS2022, Conference, September 12-14, Austin TX, USA.

Natsiopoulos DA, Mamagiannou E, Tzanou EA, Triantafyllou A, Vergos GS, Tziavos IN, Ramnalis D, Polychronos V (2022) GeoNetGNSS, a newly established CORS network in Northern Greece in support of high-accuracy positioning applications. Presented at the IAG Commission 1 "Reference Frames for Applications in Geosciences" – REFAG2022 Conference, October 17-20, Thessaloniki, Greece.

7. Hellenic Military Geographical Service's (HMGS) report to IAG (2019-2022)

Establishment of a new GNSS network alongside gravity observations

By the year 2014 until 2022 HMGS has organized yearly campaigns of simultaneous GNSS and gravity measurements in Greek territory in order to establish a new Hellenic Military Reference Frame (HMRF), aligned to the International Reference Frame 2008. In the year 2022 the project was completed, having performed GNSS and gravity measurements at almost 700 triangulation and levelling points throughout Greece. Most of the aforementioned points were triangulation pillars which had already been surveyed for the national coordinate system, the HGRS87, using classic methods many decades ago.

The implementation of the ITRF08 was held using 13 permanent GNSS stations of the IGS network whilst the data of the GNSS observations, for the direct reference, were processed with the scientific software GAMIT. Additionally, during the processing, precise IGS final orbits, grids for the ocean tide loading {Finite Element Solutions (FES2004)}, the atmospheric delay corrections (Vienna Mapping Functions 1) and non-tidal atmospheric loading corrections (for each year referenced to the earth center of mass), were used. Afterwards the GLOBK software through a Kalman filter stabilized all the stations to the ITRF08. The use of GLOBK took into consideration standard errors of the reference stations. This means that it moves the whole network in a manner that it best fits, always inside the uncertainty of each of the reference stations. The total accuracy of the network is estimated under ± 3 cm.

Figure 1- HMGS GNSS measurements

Figure 2- HMGS gravity measurements

Figure 3- The HMRF network

Publications:

Katsafados, I., Galanis, J., Zacharis, V., Paraskevas, M., Strempa, M., Forotzidou, C., Papadopoulos, N.,Kalenteridis, K. &Tsakiri, M. Combined analysis of GNSS, gravity and historic surveying data at theAlkyonides fault. 37th General Assembly (GA) of the European Seismological Commission, 19-24 Sep 2021, virtually (oral presentation).

Katsafados, I.,Paraskevas, M. &Papadopoulos, N.,Determination of velocity field for Greece processing data fromGNSS permanent stations. Technical Bulletin of HMGS no. 2021.001, HMGS, Athens (in greek).

Papadopoulos, N., Paraskevas, M., Katsafados, I., Nikolaidis, G. &Anagnostou, E. (2020). Deformation detection through the realization of reference frames. Journal of Applied Geodesy. DOI: 10.1515/jag-2019-0056.

Geoid Model Determination for the Hellenic Territory"HELLAS GEOID 2022"

The geoid "HELLAS GEOID 2022" (HG2022) constitutes the most completed modelthat HMGS produced for the Greek territory.Data comprised of gravity timeseries,orthometric and ellipsoid heights, high resolution digital terrain and depth models. Accuracy and adequacy evaluation took place for all the above datasets. Furthermore, data originated from other studies were used in order to fulfill regions with low coverage (mostly in sea and neighbor countries). Gravity signal from the heterogeneous data extracted adopting the "remove-compute-restore" technique. The Global Geoid Model that fits best in Greece is the EIGEN 6C4 in complete degree and order 2190. Contribution of average residual gravity calculated using Stokes theorem in frequency spectrum with Fourier transformation. The resulting gravimetric geoid surface adapted properly to the national height system with 5cm accuracy. For this adaption the method of collocation was enabled and the use of normally distributed points with known orthometric and ellipsoid heights.

Publications:

Paraskevas, M. &Papadopoulos, N.,Geoid Model Determination for the Hellenic Territory"HELLAS GEOID 2022"Technical Bulletin of HMGS no. 2022.002, HMGS, Athens (in greek).

Paraskevas, M., Forotzidou, C., Katsafados, I., Strempa, M., Kalenteridis, K. &Tsakiri, M. Gravitymeasurements as precursors of Earthquake, 37th General Assembly (GA) of the European SeismologicalCommission, 19-24 Sep 2021, virtually (e-poster).

Papadopoulos, N., Paraskevas, M., Katsafados, I. &Nikolaidis, G. Calculating a geoid model forGreece using gravity and GPS observations. 4th Joint International Symposium on DeformationMonitoring (JISDM), 15-17 May 2019, Athens, Greece (oral presentation).

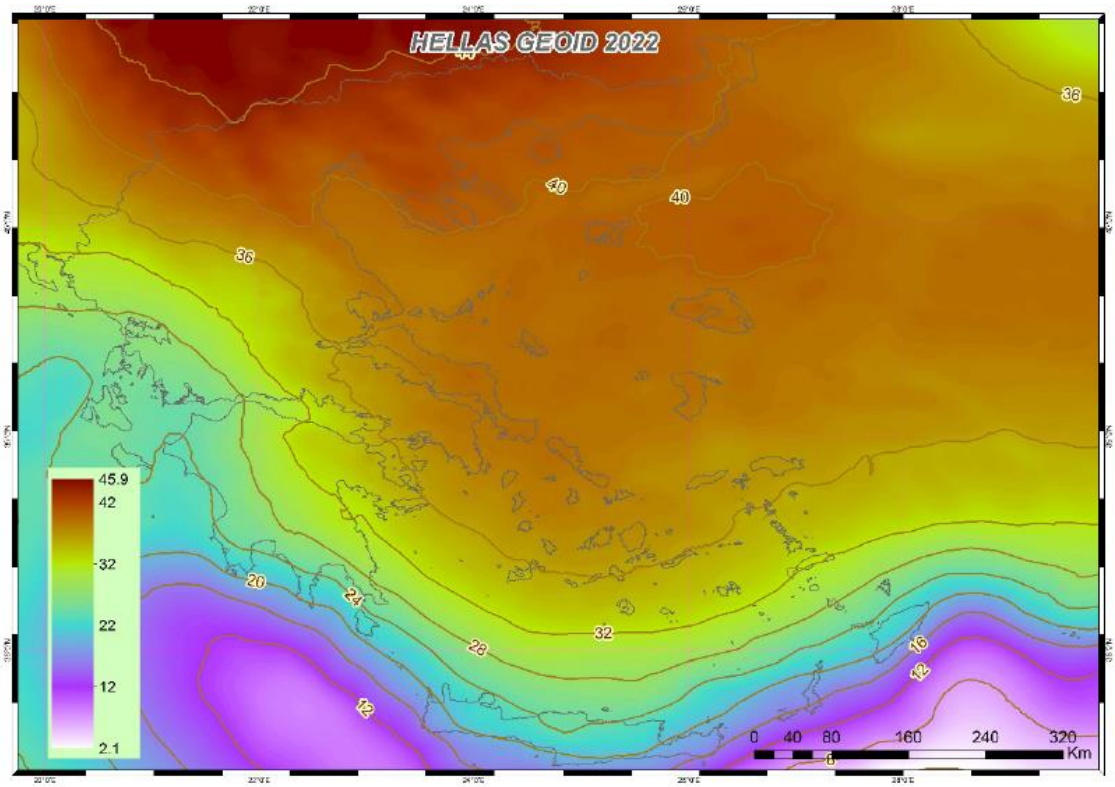

Figure 4- HELLAS GEOID 2022

Geodetic determination of the border pyramids at the borderline between the Hellenic Republic and the Republic of Albania

In the years 2021 and 2022 the HMGS, in cooperation with the corresponding public services of Albania, carried out GNSS observations and updated the coordinates of the border pyramids at the borderline between Greece and Albania. The field work was performed by joint Greek and Albanian working groups in the summers of 2021 and 2022 along the entire borderline, using entirely GNSS receivers and performing observations at static mode. The data extracted by the joint GNSS observations were processed at the level of code and phase, for the final collocation of the network and the integration in the desired reference frame, using the research / scientific software GAMIT / GLOBK version 10.71 and the commercial software Magnet Tools. The final coordinates of the pyramids are reported in the ITRF2014 reference frame at the epoch of their measurement.

Figure 5- Border pyramid

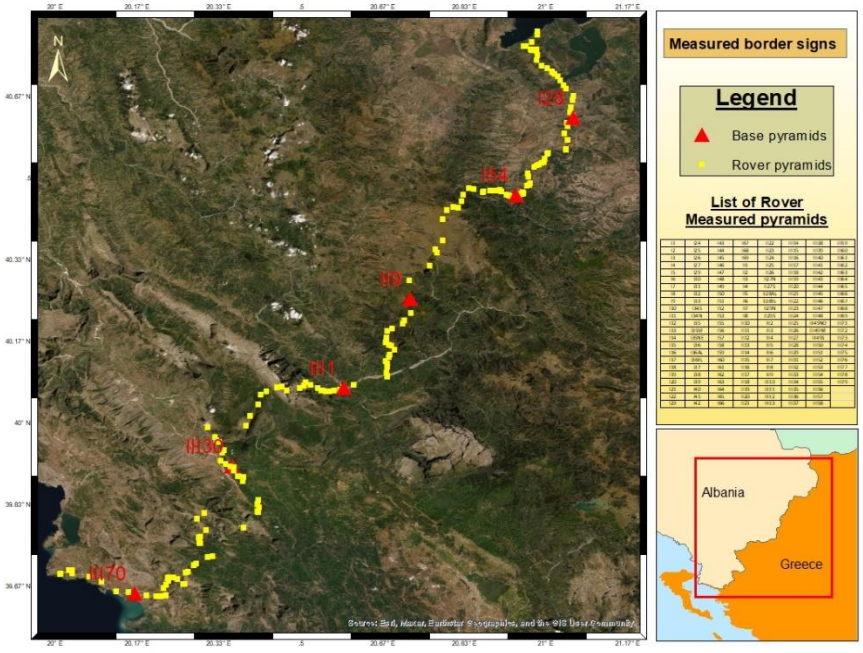

Figure 6- Measured Border Pyramids

Publications:

HMGS internal report.

8. The GNSS National Network of the Institute of Geodynamics, National Observatory of Athens (NOANET)

Scientific responsible: Dr. Konstantinos Chousianitis, Associate Researcher, chousianitis@noa.gr
Dr Athanassios Ganas , Research Director, aganas@noa.gr

1. Permanent GNSS stations and telemetry

The Institute of Geodynamics (GEIN) of the National Observatory of Athens (NOA) operates the NOANET, which is a continuously operating GNSS network in Greece, for regional studies in seismology and geodynamics. Its primary scientific role is to support high precision, real-time geodetic measurements using Global Navigation Satellite System (GNSS) observations, in order to measure and quantify coseismic, postseismic, and interseismic deformation across major fault zones, active crustal deformation processes and tectonic deformation in the plate boundary zones of the eastern Mediterranean, as well as to support GPS seismology and other earth science applications. The NOANET network has been operating since 2006, following the EUREF Permanent GNSS Network (EPN) standards. The network, as of December 2022, comprises 24 stations all of which are telemetered in real-time to the main GNSS server of the Institute of Geodynamics in Athens. All stations collect data every 1 sec and transmit them to Athens on the hour (hourly files). At some stations, 5 Hz or 10 Hz are also collected on the ring buffer and remain available for manual download for a period of 72 hours. Data archiving is performed in two modes: a) 1 sec data of each station are archived in hourly intervals and b) daily data for each station are archived in 30 sec sampling rate. The network server in Athens is collecting data in automatic mode and a daily file is created at mid-night by sub-sampling the hourly observations every 30 sec intervals. This file is converted to RINEX format and delivered to the NOA Web Server where it is available for download. Additionally, the NOANET GLASS node disseminate, on a daily basis, data from a number of continuously operating GNSS stations located throughout the Balkan region. NOANET supports a free and open data policy.

Figure 1. Relief map of Greece with locations of the permanent GNSS stations of NOANET.

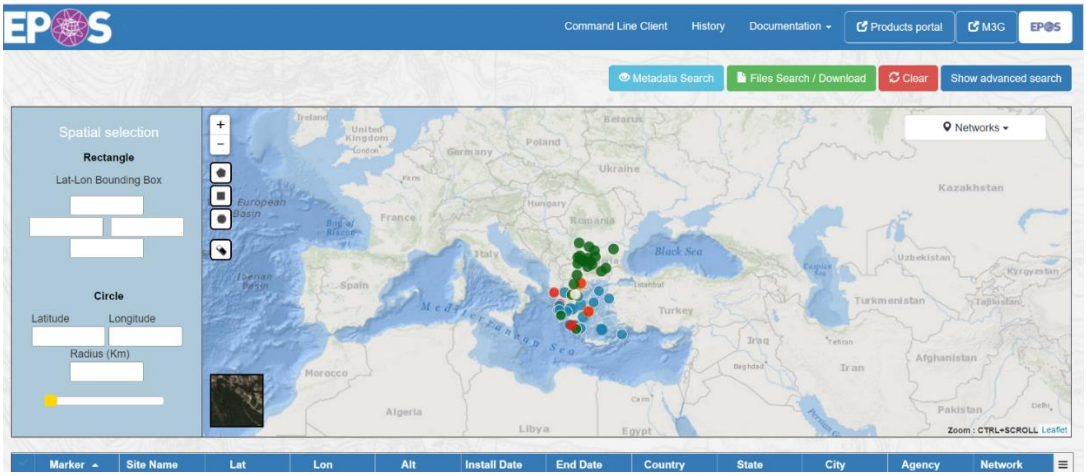

Figure 2. The NOA GLASS node for GNSS data Dissemination.

2. Hardware and software

NOA operates a mixed pool of receivers (Leica, Trimble, Topcon) and antennas for permanent GPS/GNSS observations. For the Leica and Topcon receivers, which compose the majority of the NOANET network, data transmission is performed via real-time streaming; data collected on site are immediately transmitted via telemetry to a dedicated server located at NOA. This server is equipped with two software packages, namely Leica Spider Software Suite and TopNET+, which receive and manage the incoming streams and provide remote interaction with the Leica and Topcon receivers of NOANET, respectively. Apart from data acquisition management, these software packages are able to monitor satellite and site parameters. All this relevant information is archived to supervise the network performance and detect awkward station behavior, especially during the testing and evaluation phase after the establishment of a new station. Assisted by a number of in-house developed Python programs, this software bundle enables also the monitoring of station status, data validity, integrity, and continuity. Data interruptions as well as streaming problems are detected in near-real time, and a warning system has been configured to automatically send alert messages to inform network operators in case of problems. Streamed data are stacked to binary, raw hourly files. For the rest of the NOANET stations (namely the ones equipped with Trimble receivers), data transmission and acquisition are performed in near-real time. Data collected by the receivers are recorded in hourly files and stored locally (at the receiver's internal memory). NOA has designed and implemented an array of programs to connect to these remote instruments (normally via FTP). These allow searching, identifying, and downloading the hourly files to the NOANET dedicated server at NOA. This process takes place on an hourly basis with a time lag of a few minutes. Both schemes described previously result in hourly, binary, raw (also known as receiver-manufacturer dependent) files for each of the NOANET stations. These files are in turn preedited, checked, compressed, and archived in a network attached storage (NAS) server located at NOA dedicated to hosting NOANET's GNSS data. Currently we process 30-s GPS data from permanent GNSS stations in Greece using the GAMIT/GLOBK software. All data are processed in 24-h sessions in a three step distributed approach, which is based on the "quasi-observation" theory and the reference frame is not defined until the last step of the analysis, where we realize a common reference frame applying generalized constraints while estimating a seven-parameter Helmert transformation (three network rotations, three network translations and one scaling parameter), aligning each individual daily solution to the 2014 realization of the International Terrestrial Reference Frame. We also process many IGS stations together with the NOANET and the Greek stations in order to optimize the network internal constraints. The final products are time series along with horizontal and vertical velocities. To ensure reliable velocity results we perform outlier editing and modeling of the first-order features of the time series, while temporally correlated noise is taken into account.

3. Network Funding

a) EPOS SP - European Plate Observing System Sustainability Phase, financed by the European Union Horizon 2020 Grant agreement ID: 871121, 2020-2023.
b) "Support of Research Infrastructures and Prevention of Seismic Disaster in Lixouri Municipality, Cephalonia" financed by the Municipality of Lixouri, 2021-2023.
c) "Seismotectonic investigation of western Ioannina Area – Geometry and Kinematics of active structural elements investigation based on seismological, geological and geodetic data»" financed by Energean PLC, 2022.
d) "Monitoring of ground displacements in two quarries (Greece and north Macedonia)" financed by TITAN SA, 2022.
e) "Landslide Risk Management of Attica region" M.I.S. (5050327) co-financed by Greece and the European Union (European Social Fund – E.S.F.) through the Operational Program "Human Resources Development, Education and Lifelong Learning 2014-2020", 2020-2021 http://dias-proj.civil.duth.gr/
f) "Seismicity investigation of Katakolo area, Ilia – Geometry and kinematics of active structural elements investigation based on seismological and geodetic data" financed by Energean PLC, 2019-2020.
g) HELPOS "Hellenic System for monitoring of the lithosphere", 2016-2020.

4. Websites – Portals

a) NOANET website: http://geodesy.gein.noa.gr:8000/nginfo/
b) GLASS node at NOA (Geodetic Linking Advanced Software System): http://194.177.194.250:8080/glasswebui/#/site

5. Publications in Peer-reviewed SCI Journals (2019-2022)

Kontoes, Ch., Alatza, S., Chousianitis, K., Svigkas, N., Loupasakis, C., Atzori, S., Apostolakis, A., 2022. Coseismic Surface Deformation, Fault Modeling, and Coulomb Stress Changes of the March 2021 Thessaly, Greece, Earthquake Sequence Based on InSAR and GPS Data. Seismological Research Letters, 93(5), 2584-2598, https://doi.org/10.1785/0220210112

Lazos, I., Sboras, S., Chousianitis, K., Kondopoulou, D., Pikridas, C., Bitharis, S., Pavlides, S., 2022. Temporal evolution of crustal rotation in the Aegean region based on primary geodetically-derived results and palaeomagnetism. Acta Geodaetica et Geophysica. https://doi.org/10.1007/s40328-022-00379-3

Ganas A, Hamiel Y, Serpetsidaki A, Briole P, Valkaniotis S, Fassoulas C, Piatibratova O, Kranis H, Tsironi V, Karamitros I, Elias P, Vassilakis E. 2022. The Arkalochori Mw = 5.9 Earthquake of 27 September 2021 Inside the Heraklion Basin: A Shallow, Blind Rupture Event Highlighting the Orthogonal Extension of Central Crete. Geosciences. 12(6):220. https://doi.org/10.3390/geosciences12060220

Taymaz T., Ganas A., Berberian M., Eken T., T. Serkan Irmak, Kapetanidis V., Yolsal-Çevikbilen S., Erman C., Keleş D., Esmaeili C., Tsironi V., Özkan B., 2022. The 23 February 2020 Qotur-Ravian earthquake doublet at the Iranian-Turkish border: Seismological and InSAR evidence for escape tectonics, Tectonophysics, 838, 229482, https://doi.org/10.1016/j.tecto.2022.229482.

Fernandes R, Bruyninx C, Crocker P, Menut J-L, Socquet A, Vergnolle M, Avallone A, Bos M, Bruni S, Cardoso R, Carvalho L, Cotte N, D'Agostino N, Deprez A, Andras F, Geraldes F, Janex G, Kenyeres A, Legrand J, Ngo K-M, Lidberg M, Liwosz T, Manteigueiro J, Miglio A, Soehne W, Holger S, Toth S, Dousa J, Ganas A, Kapetanidis V, Batti G. 2022. A new European service to share GNSS Data and Products. Ann. Geophys. [Internet]. 2022Jul.12 [cited 2022Jul.21];65(3):DM317 Available from: https://www.annalsofgeophysics.eu/index.php/annals/article/view/8776

Sarhosis, V., Giarlelis, C., Karakostas, C., E. Smyrou, I. E. Bal, S. Valkaniotis & A. Ganas. 2022. Observations from the March 2021 Thessaly Earthquakes: an earthquake engineering perspective for masonry structures. Bull Earthquake Eng. https://doi.org/10.1007/s10518-022-01416-w

Mesimeri, M., Ganas, A., Pankow, K.L., 2022. Multisegment ruptures and Vp/Vs variations during the 2020-2021 seismic crisis in western Corinth Gulf, Greece, Geophysical Journal International, Volume 230, Issue 1, Pages 334–348, ggac081, https://doi.org/10.1093/gji/ggac081

Tsironi, V., Ganas, A., Karamitros, I., Efstathiou, E., Koukouvelas, I., Sokos, E. 2022. Kinematics of Active Landslides in Achaia (Peloponnese, Greece) through InSAR Time Series Analysis and Relation to Rainfall Patterns. Remote Sens., 14(4), 844. https://doi.org/10.3390/rs14040844

Kassaras, I., Kapetanidis, V., Ganas, A., Karakonstantis, A., Papadimitriou, P., Kaviris, G., Kouskouna, V., Voulgaris, N., 2022. Seismotectonic analysis of the 2021 Damasi-Tyrnavos (Thessaly, Central Greece) earthquake sequence and implications on the stress field rotations. Journal of Geodynamics, 150, 101898, https://doi.org/10.1016/j.jog.2022.101898

Papathanassiou, G., Valkaniotis, S., Ganas, A., Stampolidis, A., Rapti, D., Caputo, R., 2022. Floodplain evolution and its influence on liquefaction clustering: The case study of March 2021 Thessaly, Greece, seismic sequence. Engineering Geology, 298, 106542, https://doi.org/10.1016/j.enggeo.2022.106542

Ganas, A., Elias, P., Briole, P., Valkaniotis, S., Escartin, J., Tsironi, V., Karasante, I, Kosma, Chr. 2021. Co-seismic and post-seismic deformation, field observations and fault model of the 30 October 2020 Mw = 7.0 Samos earthquake, Aegean Sea. Acta Geophys., 69, 999-1024 https://doi.org/10.1007/s11600-021-00599-1

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9. Report of Hellenic Cadastre to IAG 2019-2022

Commission 1: Reference Frames

The Hellenic Cadastre is in charge for the operation of the national RTK network HEPOS (Hellenic Positioning System) and the maintenance of HEPOS' geodetic reference frame HTRS07 (Hellenic Terrestrial Reference Frame 2007), which is the official realization of ETRS89 in Greece. In this context, the main activities of the Hellenic Cadastre in the period 2019-2021 have been:

- Monitoring of the coordinates of HEPOS stations
- Estimation of tectonic velocities of the HEPOS stations
- Estimation of crustal deformations induced by strong earthquakes (the 2020 Samos, east Aegean Sea earthquake, the 2021 Elassona, Thessaly Central Greece earthquake)
- Contribution to the EUREF Working Group "Unified European Reference": Supply of information about the vertical reference in Greece (HEPOS geoid etc.)
- Participation in the Working Group of the Geodetic and Geophysical Committee of the (Hellenic) State in order to assess the prospect of developing a new contemporary Geodetic Reference System in Greece.

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Gianniou, M., D. Mastoris, E. Mitropoulou (2021): "National Report of Greece to EUREF 2021", EUREF 2021 Symposium, May 30 - June 1 2021, Ljubljana, Slovenia.

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Commission 4: Positioning and Applications

The Hellenic Cadastre is in charge for the operation of the national RTK network HEPOS (Hellenic Positioning System). In this context, the main activities of the Hellenic Cadastre in the period 2019-2021 have been:

- Upgrading of the HEPOS network to a full GNSS system, which supports GPS, GLONASS, Galileo, BeiDou and SBAS.
- Conduction of field measurements for assessing the performance of the full GNSS services of HEPOS.
- Monitoring of the ionospheric activity over Greece and assessment of its impact on the RTK measurements.

Publications

Gianniou, M., D. Mastoris, E. Mitropoulou (2022): "National Report of Greece to EUREF 2022", EUREF 2022 Symposium, June 1-3 2022, Zagreb, Croatia.

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