# Extract of the paper "Learning physical geodesy. Application case to geoid undulation computation"

**Pablo Rodríguez-Gonzálvez [1], Cristina Allende-Prieto [2], Manuel Rodríguez-Martín [3]**

[1] Department of Mining Technology, Topography and Structures, Universidad de León, 24401 Ponferrada, Spain. Email: p.rodriguez@unileon.es

[2] Department of Mining Exploitation and Prospecting, Universidad de Oviedo, 33600, Mieres, Spain. Email: callende@uniovi.es

[3] Department of Mechanical Engineering, University of Salamanca, 49029 Zamora, Spain. Email: ingmanuel@usal.es

## Abstract

The present article shows a novel approach for the acquisition of competences related to physical geodesy in the Bachelor's Degree in Geomatics using virtual materials to promote the autonomous learning and support it during exceptional periods of confinement, like the Covid-19 pandemic. More specifically, the article is focused in the geoid undulation determination, which is a critical issue in hydraulic works, land subsidence, and civil projects. So, this concept has to be learned in the Bachelor's Degree in Geomatics for the proper acquisition of competences. The approach is aimed to three-dimensional fitting techniques and statistical analysis to improve the comprehension and interpretation of the different local geoid models from the same set of field measurements, and therefore the conclusions and analysis derived from them for the subsequent Geomatic practical works. The current contribution is originated from the virtual laboratories' paradigm, as it is proposed the use of virtual materials for the acquisition and evaluation of competences and skills in an asynchronous way, that can be use not only for and e-learning or b-learning programs, but also as support for traditional face to face programs. The present contribution will help the students to contextualize the theoretical knowledge, so better understand the challenges they will face in the working market as future professionals.

## Citation

P. Rodriguez-Gonzalvez, C. Allende-Prieto, and M. Rodríguez-Martín. 2020. Learning physical geodesy. Application case to geoid undulation computation. In *Eighth International Conference on Technological Ecosystems for Enhancing Multiculturality (TEEM'20)*. Association for Computing Machinery, New York, NY, USA, 84–90. DOI: https://doi.org/10.1145/3434780.3436546

## Keywords

Educational innovation; ICT; E-Learning; Engineering; Virtual laboratory; Physical Geodesy

## Link to the publisher

https://dl.acm.org/doi/10.1145/3434780.3436546

## References


[1] Bernhard Hofmann-Wellehof and Helmut Moritz. 2006. *Physical Geodesy* (2nd. ed.). Springer, Austria.

[2] Fernando Sanso. 1987. Problema de contorno de la geodesia física. *IV Curso de geodesia superior*, 156, 37-96.

[3] María Amparo Núñez, Ángel Martín, Josep A. Gili and Ana Belén Anquela. 2008. High-precision geoid determination in small areas: A case study in Doñana National Park (Spain). *Studia Geophysica et Geodaetica*, 52, 3, 361-380. DOI: https://doi.org/10.1007/s11200-008-0026-y

[4] Guoquan Wang and Tomás Soler. 2015. Measuring land subsidence using GPS: ellipsoid height versus orthometric height. *Journal of surveying engineering*, 141, 2, 05014004, 12 pp. DOI: https://doi.org/10.1061/(ASCE)SU.1943-5428.0000137

[5] David Lago González and Pablo Rodríguez-Gonzálvez. 2019. Detection of Geothermal Potential Zones Using Remote Sensing Techniques. *Remote Sensing*, 11, 20, 2403, 20 pp. DOI: https://doi.org/10.3390/rs11202403

[6] Samia Rochdane, Abdennabi El Mandour, Mohammed Jaffal, Mahjoub Himi, Albert Casas, Mostafa Amrhar and Morad Karroum. 2015. Geometry of the eastern Haouz and Tassaout aquifers, Western Morocco: Geophysical and hydrogeological approach. *Hydrological Sciences Journal*, 60, 1, 133–144. DOI: https://doi.org/10.1080/02626667.2014.979174

[7] Mirahmad Mirghasempour and Ali Yaser Jafari. 2015. The Role of Astro-Geodetic in Precise Guidance of Long Tunnels. *The International Archives of Photogrammetry, Remote Sensing and Spatial Information Sciences*, XL-1, W5, 453-457. DOI: https://doi.org/10.5194/isprsarchives-XL-1-W5-453-2015

[8] Ruben Heradio, Luis de la Torre, Daniel Galán, Francisco Javier Cabrerizo, Enrique Herrera-Viedma and Sebastian Dormido. 2016. Virtual and remote labs in education: a bibliometric analysis. *Computers & Education*, 98 (July 2016), 14–38. DOI: https://doi.org/10.1016/j.compedu.2016.03.010

[9] Özedn Mirçik and Ahmet Zeki Saka 2018. Virtual laboratory applications in physics teaching. *Canadian Journal of Physics*, 96, 7, 745-750. DOI: https://doi.org/10.1139/cjp-2017-0748

[10] Kang Hao Cheong and Jin Ming Koh. 2018. Integrated virtual laboratory in engineering mathematics education: Fourier theory. *IEEE Access*, 6, 58231-58243. DOI: https://doi.org/10.1109/ACCESS.2018.2873815

[11] Manuel Rodríguez-Martín and Pablo Rodríguez-Gonzálvez. 2019. Learning methodology based on weld virtual models in the mechanical engineering classroom.

*Computer Applications in Engineering Education*, 27, 5, 1113-1125. DOI: https://doi.org/10.1002/cae.22140

[12] Manuel Rodríguez-Martín and Pablo Rodríguez-Gonzálvez. 2019. Materiales formativos 3D desde ingeniería inversa para el aprendizaje de la inspección de soldaduras. *DYNA Ingeniería e industria*, 94, 3, 238-239. DOI: http://dx.doi.org/10.6036/8798

[13] Arturo Soriano, Pedro Ponce and Arturo Molina. 2020. Virtual Laboratory to Face New Challenges in the Industry: Virtual Laboratory as Part of the New Education Age. *Revolutionizing Education in the Age of AI and Machine Learning* (pp. 114-129). IGI Global.

[14] Francisco José García-Peñalvo, Alfredo Corell, Víctor Abella-García, Mario Grande. 2020. La evaluación online en la educación superior en tiempos de la COVID-19. *Education in the Knowledge Society*, 21, 12, 26 pp. DOI: https://doi.org/10.14201/eks.23013

[15] John Anthony Rossiter. 2016. Low production cost virtual modelling and control laboratories for chemical engineering students. In *Proceedings of 20th IFAC Symposium on Automatic Control in Aerospace*, Quebec, 230-235. DOI: https://doi.org/10.1016/j.ifacol.2016.07.182

[16] Manuel Rodríguez-Martín, Pablo Rodríguez-Gonzálvez, Alberto Sánchez-Patrocinio and José Ramón Sánchez. 2019. Short CFD simulation activities in the context of fluid-mechanical learning in a multidisciplinary student body. *Applied Sciences*, 9, 22, 4809, 17 pp. DOI: https://doi.org/10.3390/app9224809

[17] Ministry of Science and Innovation (Government of Spain). Orden CIN/353/2009, de 9 de febrero, por la que se establecen los requisitos para la verificación de los títulos universitarios oficiales que habiliten para el ejercicio de la profesión de Ingeniero Técnico en Topografía. (February 2009).

[18] Manuel Rodríguez-Martín and Pablo Rodríguez-Gonzálvez. 2018. Learning based on 3D photogrammetry models to evaluate the competences in visual testing of welds. In *Proceedings of the 2018 IEEE Global Engineering Education Conference*. IEEE. Santa Cruz de Tenerife, Spain, 1582-1587. DOI: https://doi.org/10.1109/EDUCON.2018.8363422

[19] Pablo Rodríguez-Gonzálvez, Manuel Rodríguez-Martín, Beatriz Alonso-Cortés Fradejas and Ildefonso Alvear-Ordenes. 2018. 3D Visualization Techniques in Health Science Learning. Application case of Thermographic Images to Blood Flow Monitoring. In *Proceedings of Sixth International Conference on Technological Ecosystems for Enhancing Multiculturality (TEEM'18)*. ACM, New York, NY, USA, 373-380. DOI: https://doi.org/10.1145/3284179.3284243

[20] Instituto Geográfico Nacional. 2020. Geodesy: Viewer, Queries and Resources. Retrieved July 21, 2020 from http://www.ign.es/web/ign/portal/gds-area-geodesia

[21] International Centre for Global Earth Models. 2020. Calculation of Gravity Field Functionals on Ellipsoidal Grids. Retrieved July 21, 2020 from http://icgem.gfz-potsdam.de/calcgrid

[22] Octave. 2020. Scientific Programming Language Version 5.2. Retrieved 20 July, 2020 from https://www.gnu.org/software/octave/

[23] Munther Gdeisat and Francis Lilley, 2012. MATLAB® by Example: Programming Basics. Newness, USA.

[24] Wolfram Research Inc. 2020. Mathematica. Version 12.1 Retrieved 20 July, 2020 from https://www.wolfram.com/mathematica

[25] Hossein Nahavandchi and Ali Soltanpour. 2006. Improved determination of heights using a conversion surface by combining gravimetric quasi-geoid/geoid and GPS-levelling height differences. *Studia Geophysica et Geodaetica*, 50, 2, 165-180. DOI: https://doi.org/10.1007/s11200-006-0010-3

[26] Piroska Zaletnyik, Lajos Volgyesi, István Kirchner and Béla Paláncz. 2007. Combination of GPS/leveling and the gravimetric geoid by using the thin plate spline interpolation technique via finite element method. *Journal of Applied Geodesy*, 1, 4, 233-239. DOI: https://doi.org/10.1515/jag.2007.025

[27] Nikolaos K. Pavlis, Simon A. Holmes, Steve C. Kenyon and John K. Factor. 2012. The development and evaluation of the Earth Gravitational Model 2008 (EGM2008). *Journal of geophysical research: solid earth*, 117, B4, B04406, 38 pp. DOI: https://doi.org/10.1029/2011JB008916

[28] Christoph Förste, Sean L. Bruinsma, Oleg Abrikosov, Jean-Michel Lemoine, Jean Charles Marty, Frank Flechtner, G. Balmino, F. Barthelmes, R. Biancale. 2014. EIGEN-6C4 The latest combined global gravity field model including GOCE data up to degree and order 2190 of GFZ Potsdam and GRGS Toulouse. *GFZ Data Services*. DOI: http://doi.org/10.5880/icgem.2015.1

[29] José Antonio Sánchez Sobrino, Adolfo Daldan Mourón, Antonio Barbadillo Fernández. 2009. El nuevo modelo de Geoide para España EGM08-REDNAR. *Topografía y Cartografía: Revista del Ilustre Colegio Oficial de Ingenieros Técnicos en Topografía*, 26, 155, 4-16.

[30] Alberto Alonso-Izquierdo, et al. 2020. Specific mathematical software to solve some problems. *Calculus for Engineering Students* (pp. 327-347). Elsevier Inc. DOI: https://doi.org/10.1016/B978-0-12-817210-0.00022-9

[31] CloudCompare. 2020. CloudCompare Version 2.11.0 [GPL software]. Retrieved July 21, 2020 from http://www.cloudcompare.org/

[32] Pablo Rodríguez-Gonzálvez, Jesús Garcia-Gago, Javier Gomez-Lahoz, and Diego González-Aguilera. 2014. Confronting Passive and Active Sensors with Non-Gaussian Statistics. *Sensors* 14, 8, 13759-13777. DOI: https://doi.org/10.3390/s140813759