Quantitative Constraints on Pre-production Reservoir Stresses in Groningen: Project Overview

[1]Gutierrez R.E., [1]Garcia C.S., [1]Tesauro M., [2]van der Wal W., [1]van Hinsbergen D.J.J., [1]Govers R.

[1]Department of Earth Sciences, Utrecht University, Utrecht, The Netherlands.
[2]Faculty of Aerospace Engineering, Delft University of Technology, Delft, The Netherlands.

Introduction

Earthquakes in the Groningen reservoir are driven by stresses in the rocks that surround preexisting faults. As natural stresses are the consequence of tectonic forces, lithospheric body forces (LBFs) arising from lateral variations in gravitational potential energy (GPE) of the lithosphere must be studied. Relatively well known LBFs are ridge push and gravitational collapse, which are caused by lateral variations in the topography and (vertical) density structure of the lithosphere. Quantifying GPE requires choosing a level of zero potential energy or compensation depth. **Figure 1** shows GPE field for 100km and 300km compensation depths for the Eurasian plate and the difference in GPE assuming 100km and 300km levels of zero potential energy .

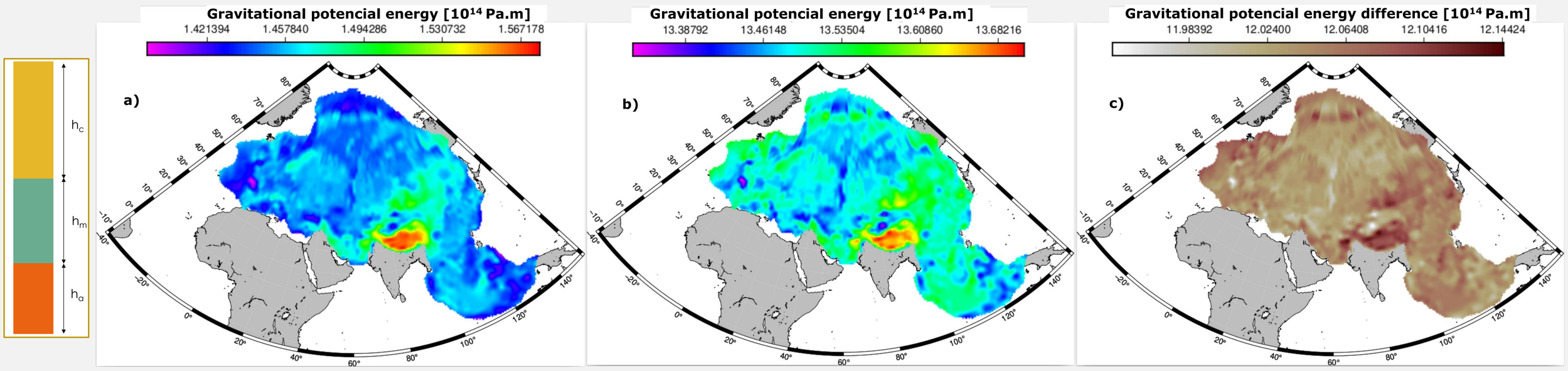

Figure 1: GPE field for a) 100km and b) 300km compensation depths for the Eurasian plate. c) Difference in GPE assuming 100km and 300km levels of zero potential energy

Selection of lithospheric models for gravitational potencial energy (GPE)

Figure 2 shows a comparison of lithospheric models as input data for GPE calculations assuming 300km of compensation depth. a) The LITHO1.0 model (Pasyanos et al. 2014) is based on seismic tomography (Love and Rayleigh wave data). b) The LithoRef18 model (Afonso et al. 2019) is based on inversion of 3-D gravity anomalies, geoid height and satellite-derived gravity complemented with seismic, thermal and petrological prior information. c) The WINTERC-G model (Fullea et al. 2021) is based on waveform tomography and gravity inversion for the temperature and composition of the lithosphere and upper mantle at global scale.

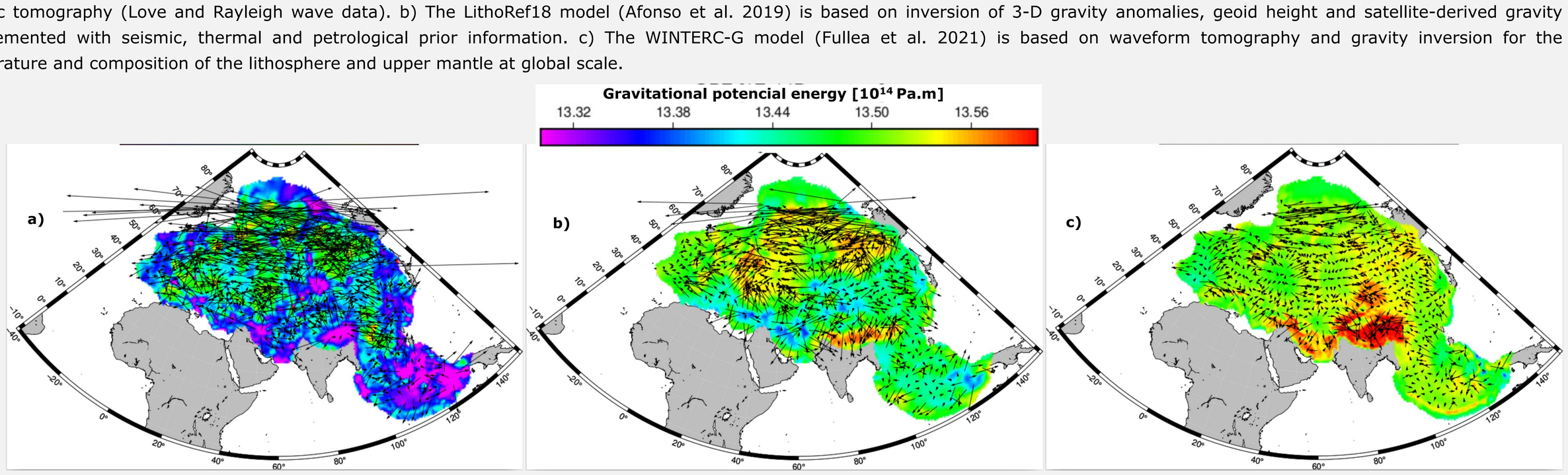

Figure 2: Force distribution (arrows) and GPE (contoured values) for a) LITHO1.0 model (Pasyanos et al. 2014). b) LithoRef18 model (Afonso et al. 2019). c) WINTERC-G model (Fullea et al. 2021)

Figure 3 shows Difference in GPE between a) LITHO1.0 (Pasyanos et al. 2014) and LithoRef18 (Afonso et al. 2019) models. b) LithoRef18 (Afonso et al. 2019) and WINTERC-G (Fullea et al. 2021) models. c) WINTERC-G (Fullea et al. 2021) and LITHO1.0 (Pasyanos et al. 2014) models

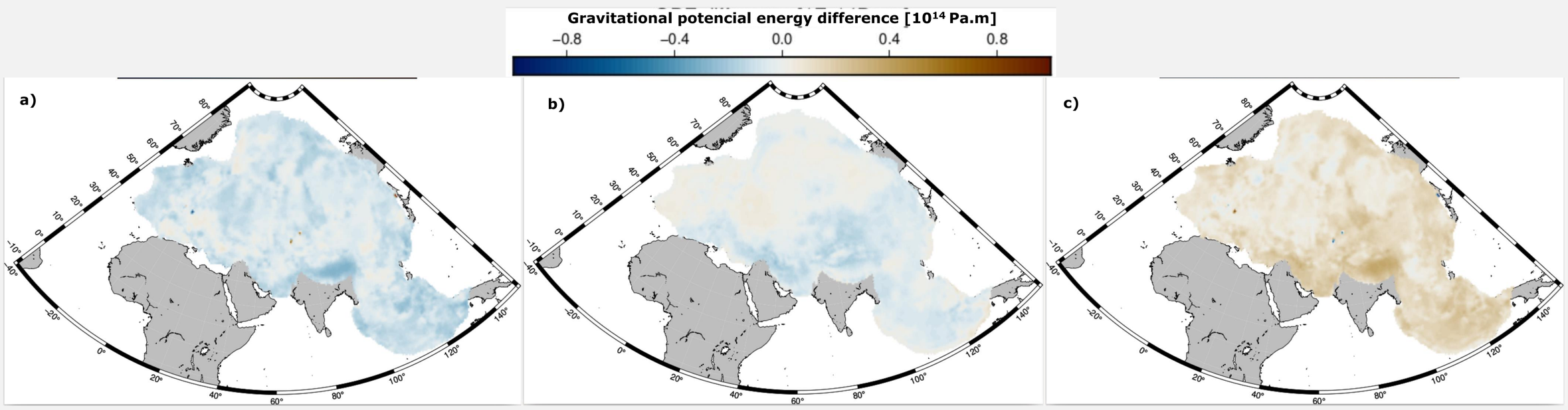

Figure 3: Difference in GPE between a) LITHO1.0 and LithoRef18 models. b) LithoRef18 and WINTERC-G models. c) WINTERC-G and LITHO1.0 models

References

- Afonso, J. C., Salajegheh, F., Szwillus, W., Ebbing, J., & Gaina, C. (2019). A global reference model of the lithosphere and upper mantle from joint inversion and analysis of multiple data sets. Geophysical Journal International, 217(3), 1602–1628
- Fullea, J., Lebedev, S., Martinec, Z., & Celli, N. L. (2021). WINTERC-G: Mapping the upper mantle thermochemical heterogeneity from coupled geophysical–petrological inversion of seismic waveforms, heat flow, surface elevation and gravity satellite data. Geophysical Journal International, 226(1), 146–191
- Pasyanos, M. E., Masters, T. G., Laske, G., & Ma, Z. (2014). LITHO1.0: An updated crust and lithospheric model of the Earth. Journal of Geophysical Research: Solid Earth, 119(3), 2153–2173