European Geosciences Union

G4.3 EDI
Geoid determination, gravity and magnetic field data and their interpretation

Moho depth evaluation using GOCE gradient data and Least Square Collocation over Iran

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23–27 May 2022

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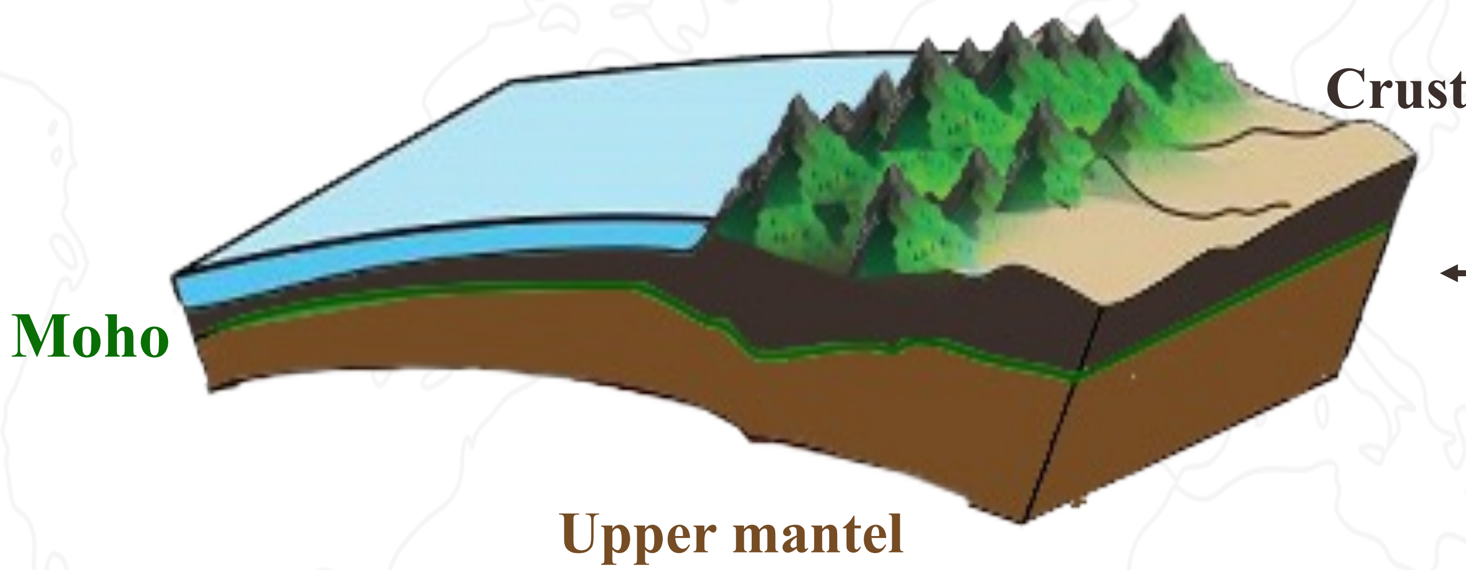
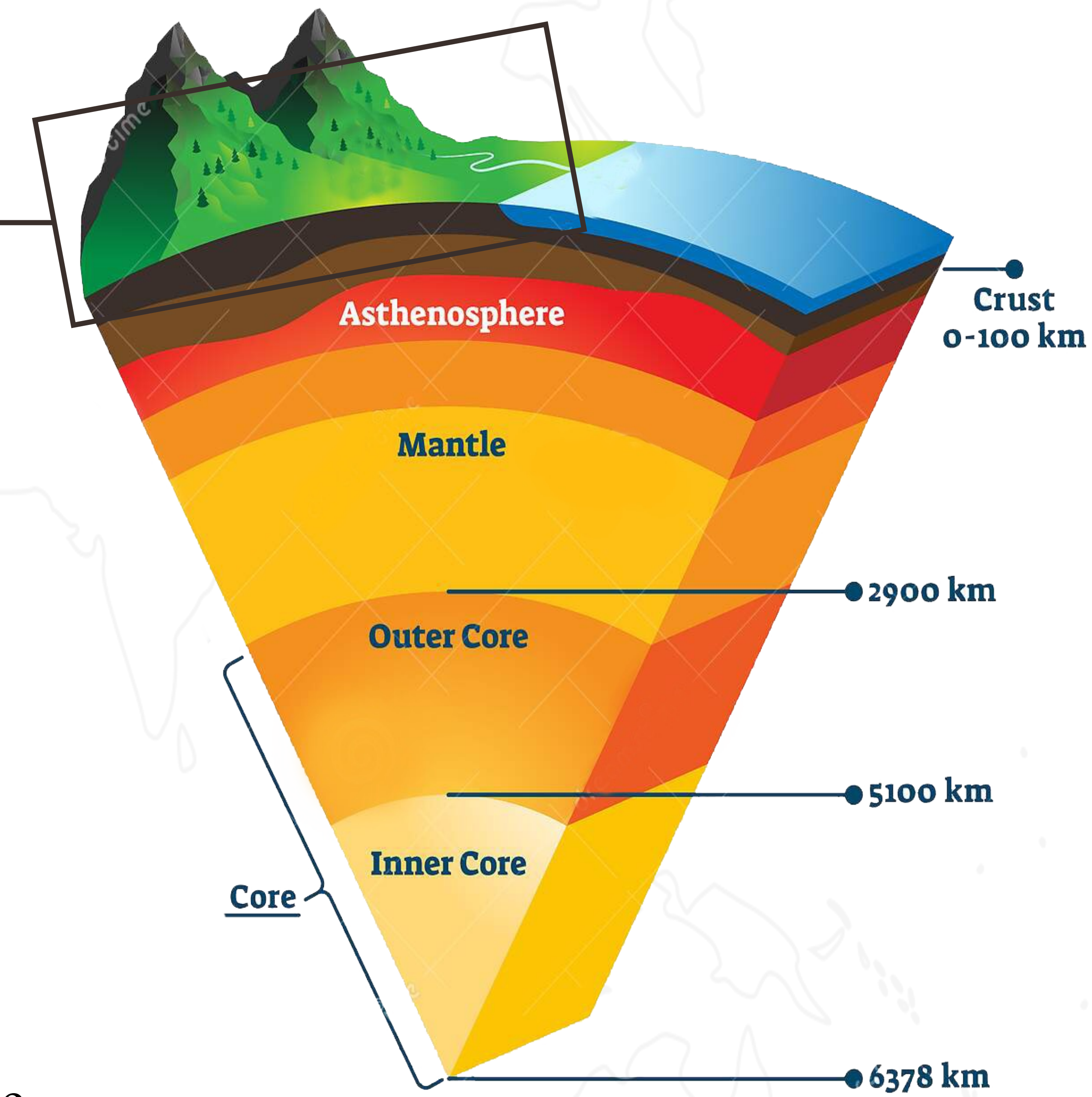
Subject Definition





Mohorovicic Discontinuity Surface: Transition layer between the upper mantel and lower crust.

Seismic	**Gravity**
More accurate & less coverage	Less accurate & More coverage

- ✓ Subduction zones
- ✓ Isostasy
- ✓ Earthquake location

Theoretical Background

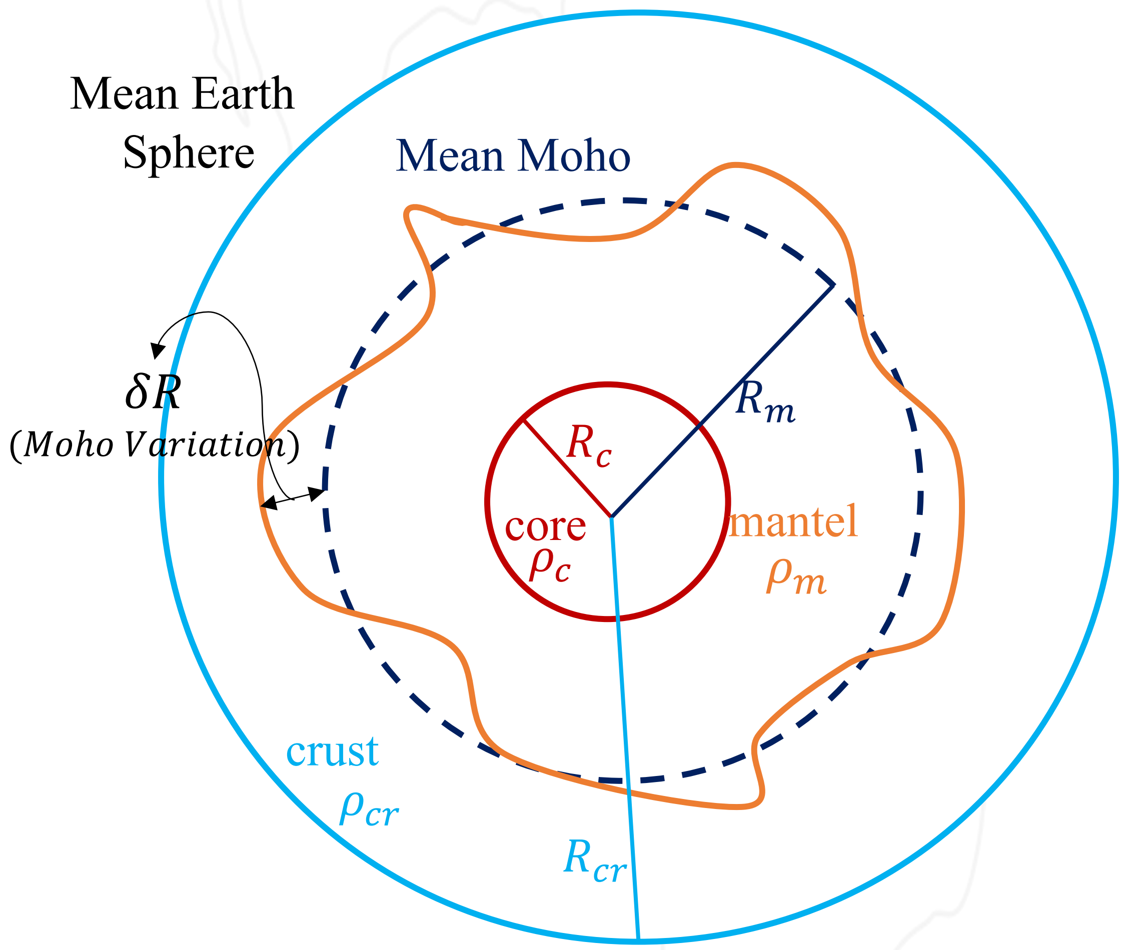
The potential of this body on a give sphere S_e outside the mean Earth sphere is:

$$T = G\left[\frac{4}{3}\pi\frac{R_c^3\rho_c}{r} + \frac{4}{3}\pi\frac{(R_m^3 - R_c^3)\rho_m}{r} + \frac{4}{3}\pi\frac{(R_{cr}^3 - R_m^3)\rho_{cr}}{r} + (\rho_m - \rho_{cr})\int_{S_m}\int_{R_m}^{R_m+\delta R}\frac{1}{l}dv\right]$$

So, by reducing in the data and using a Helmert condensation approach, the potential of a single layer on the mean Moho sphere can be represented as,

$$\delta T = G\int_{S_m}\frac{\rho_S}{l}ds$$

S_m= mean Moho sphere of radius R_m



Simplified Earth model based on three shells:
Core, **Mantel**, **Crust**

With $\rho_S = \delta R\,\Delta\rho$ is the surface density due to the condensation on a single layer, where $\Delta\rho$ is the density contrast between mantel and crust. By following the approach described in Heiskanen and Moritz (1967), one can derive the following equation,

$$\delta T = \frac{2R_m}{3}[2\pi G\rho_S - \delta\Delta g]$$

$$\rho_S = -\frac{1}{4\pi G}\left[2\frac{\partial}{\partial r}\bigg|_{r=R_m} + \frac{1}{R_m}\right]\delta T$$

linear operator relating the surface layer density to the potential δT

Inversion
Implementation

Least Square Collocation (**LSC**)

Theoretical Background

Moho Surface Density Contrast: $\rho_s = C_{\rho_s T_{zz}}(C_{T_{zz}T_{zz}} + C_{nn})^{-1}T_{zz}$

$C_{\rho_s T_{zz}}$: covariance between observation ($T_{zz} + noise$) and unknown (ρ_s)

$C_{T_{zz}T_{zz}}$: observation covariance

C_{nn} : noise covariance (n)

Base covariance function:

Tscherning-Rapp (1974)

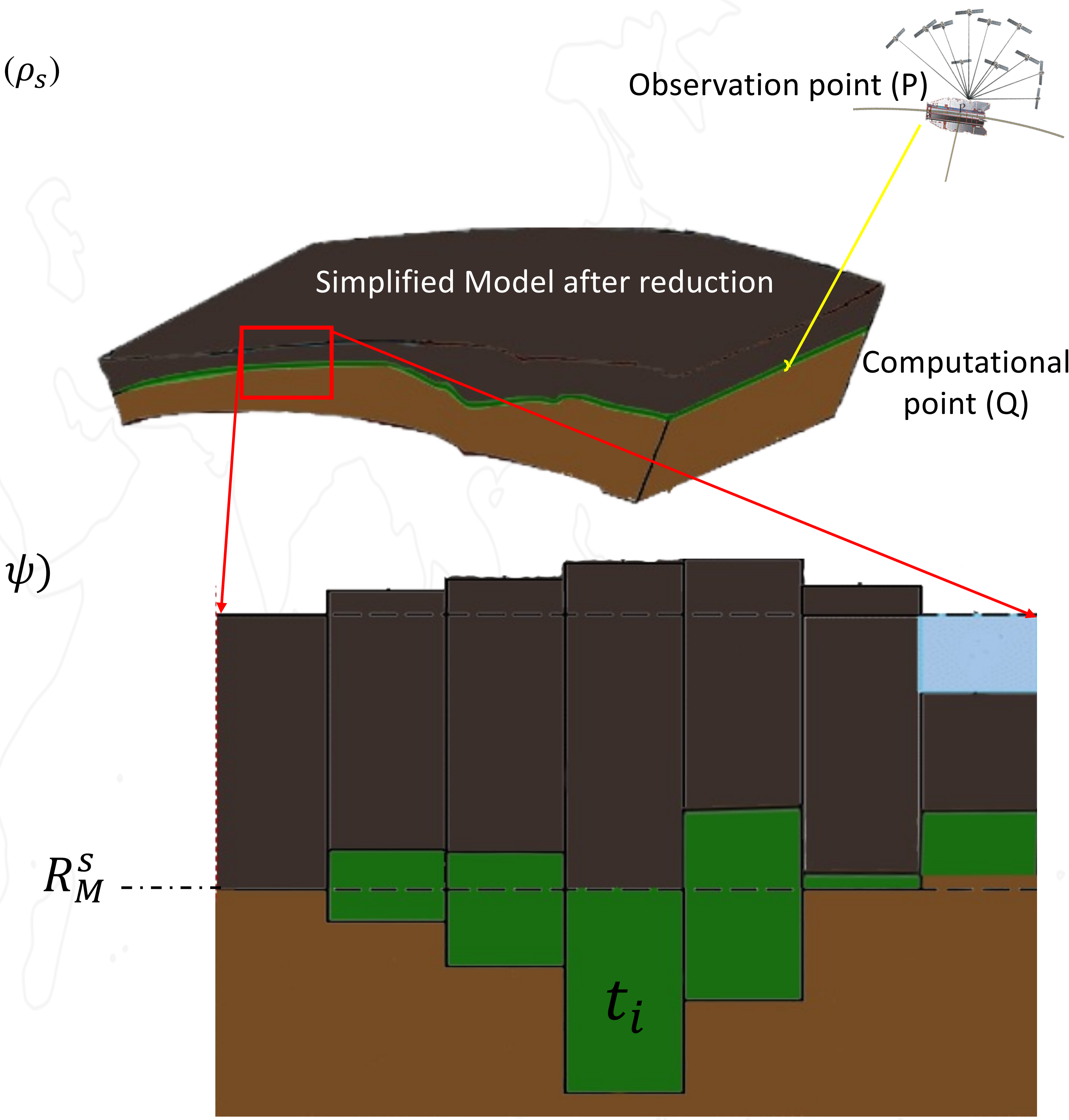
$$K(r, r', \psi) = \sum_{n=2}^{\infty} \left(\frac{R_B^2}{rr'}\right)^{n+1} \frac{A}{(n-1)(n-2)(n+B)} P_n(\cos\psi)$$

Moho depth variation:

$$t_i = \frac{\rho_s}{\Delta\rho}$$

Moho depth from the Earth's surface:

$$\text{Moho} = t_i + R_M^s$$



Results and Discussion

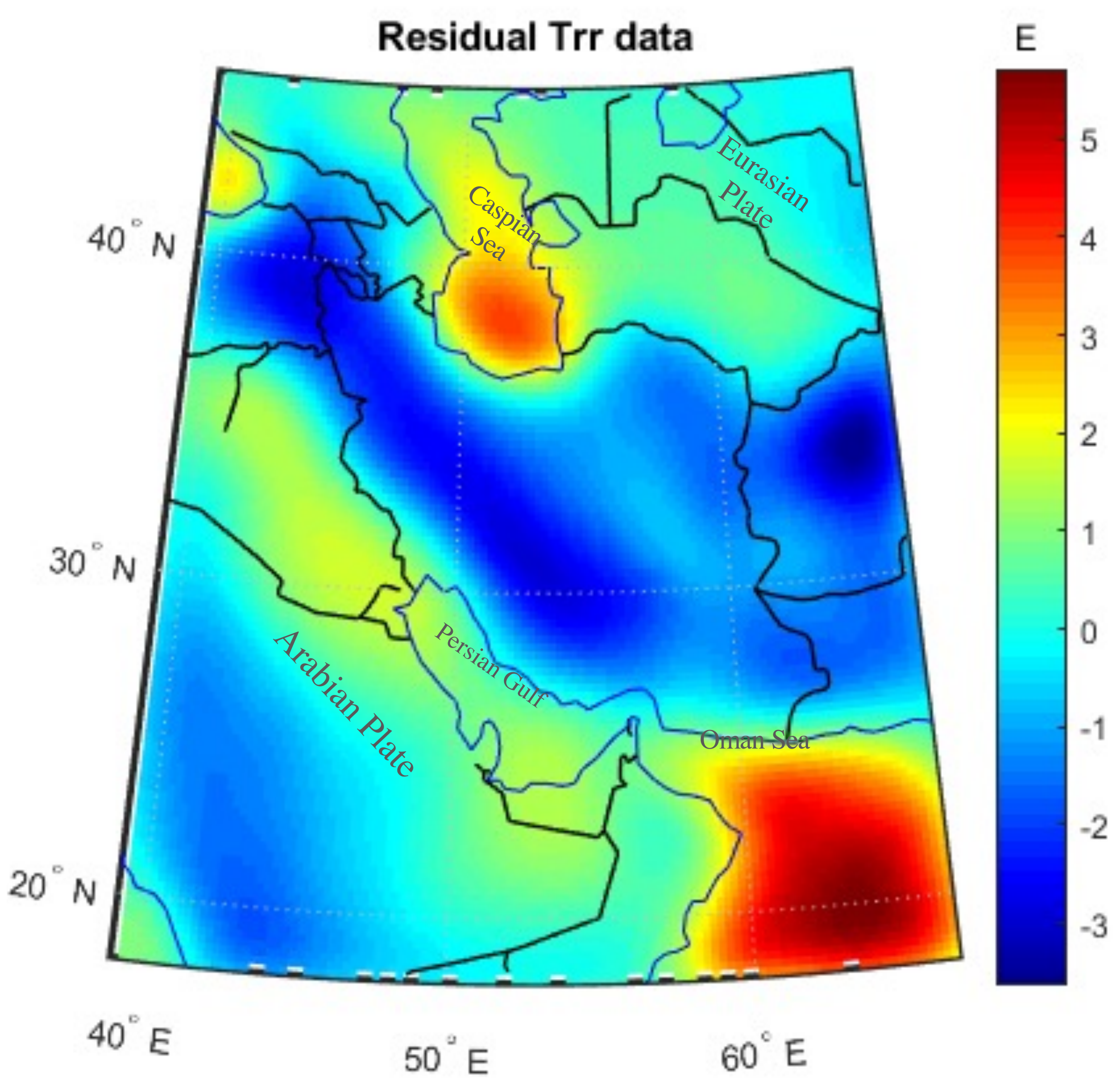
Reducing Data

GEBCO

$$T_{rr}^{res} = T_{rr}^{obs} - T_{rr}^{topo} - T_{rr}^{bathy} - T_{rr}^{sed}$$

Global Gravity Model
GO_CONS_GCF_2_TIM_R6

CRUST 1.0



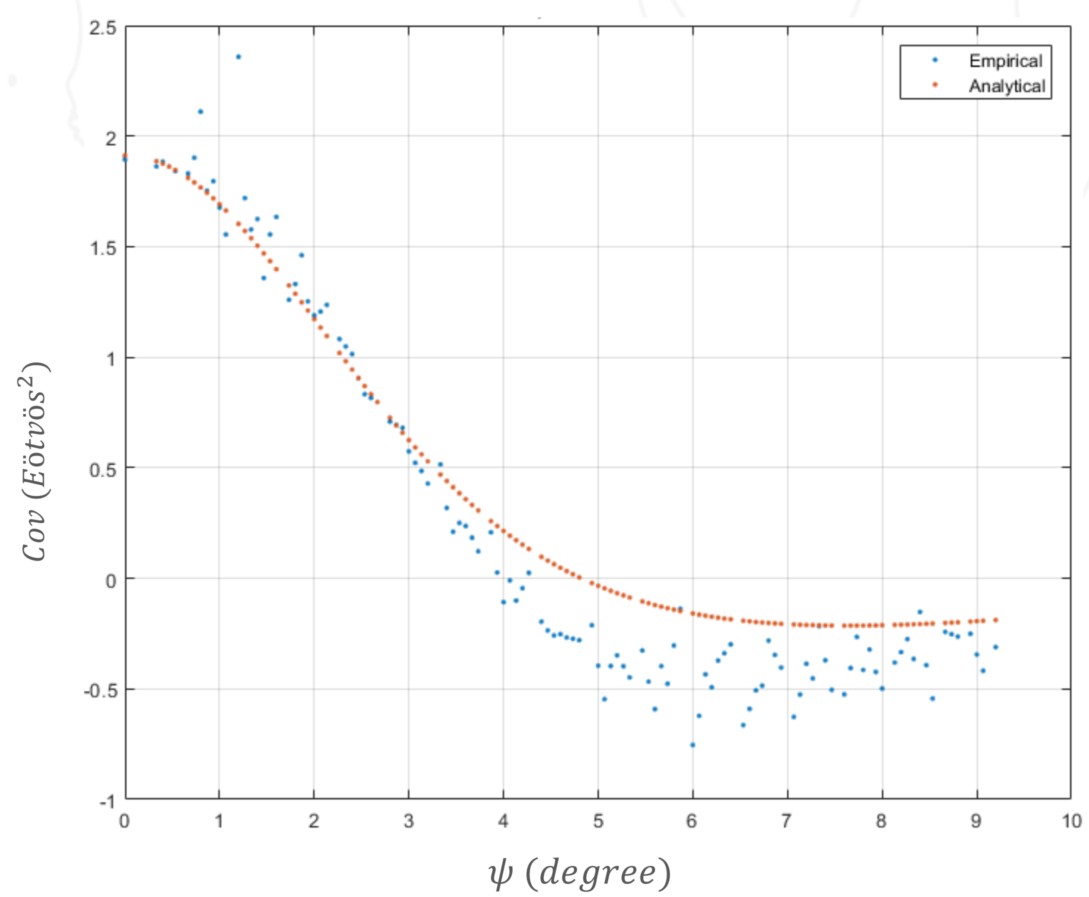
Covariance function modelling

Two steps: first, constructing the empirical covariance using the residual data (Knudsen 1987)

$$ECF(k) = \frac{1}{N_k} \sum_{i,j}^{N_k} l_i l_j$$

Second, fitting an analytical covariance to the empirical one

Heydarizadeh Shali et al. (2020)



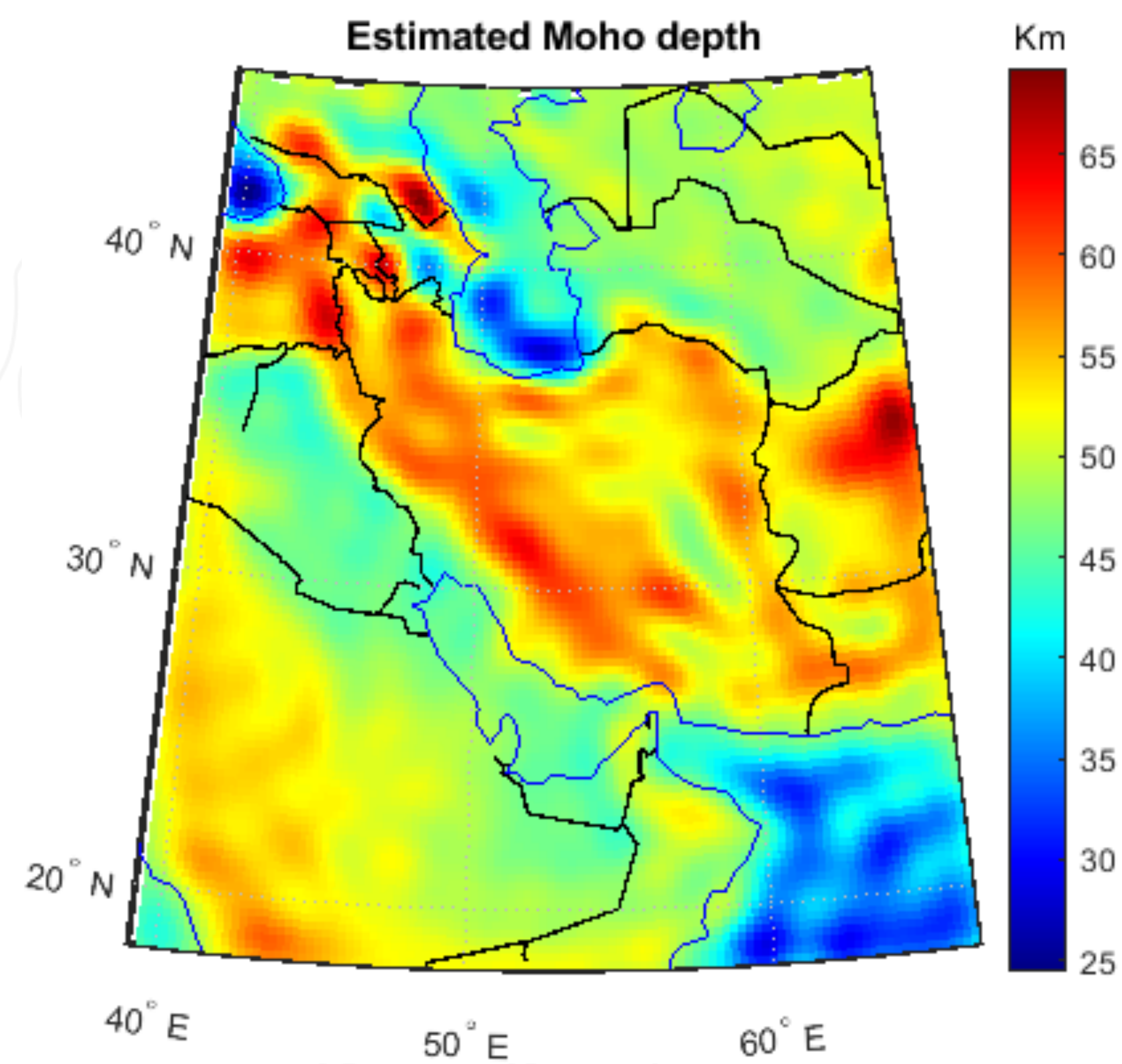
Moho Depth Estimation

Density Contrast between Mantle and Crust

$\Delta\rho = -600 \ \frac{kg}{m^3}$ Bagherbandi and Eshagh (2012)

Mean Moho depth from the Earth's Surface

$R_M^s = 45 \ km$ Heydarizadeh Shali et al. (2020)



Conclusion

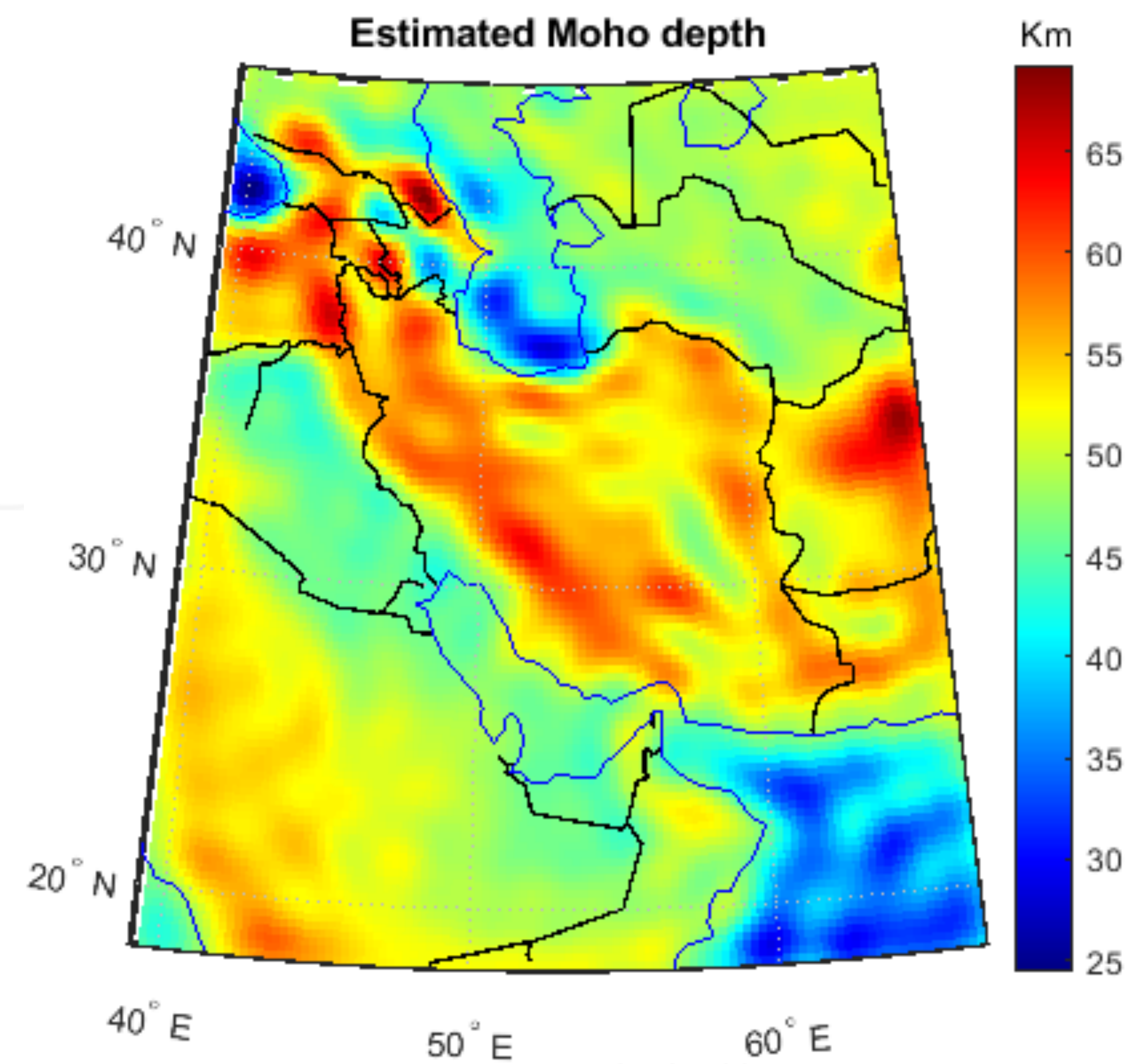
- The relationship between ρ_s and δT has been established and verified

- LSC can be properly applied, it works as a smoothing filter and it works fine also downward, providing a smoothed estimate of the unknown.

- We can exploit the homogeneity and coverage of satellite gravity data.

- Our estimates are in agreement with what is found in literature (Bagherbandi and Eshagh, 2012, and Heydarizadeh Shali et al., 2020, qualitatively, differences are in the order of 5-10 km.

- Next step is better assesment of the residuals by quantitative comparison wrt seismic estimates from the literature.



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