University of Paris

Institut de physique du globe de Paris

Isostasy Revisited: A Novel Approach to an Age-Old Theory

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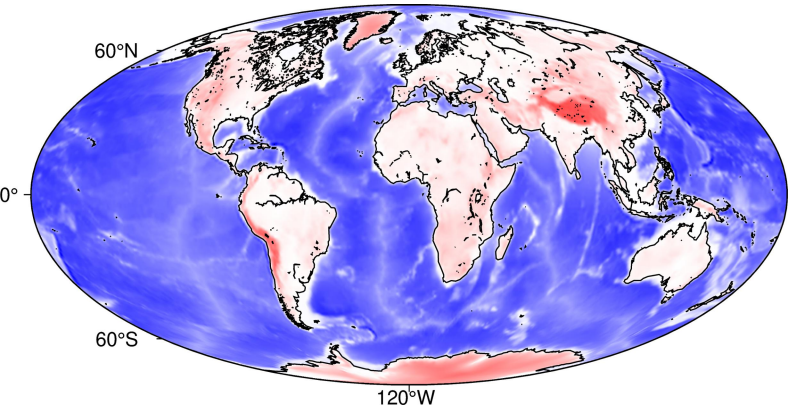
Shayan Kamali

Supervisors:
Dr. Alessandro Forte
Dr. Marianne Greff

March 2024

Observed Topography



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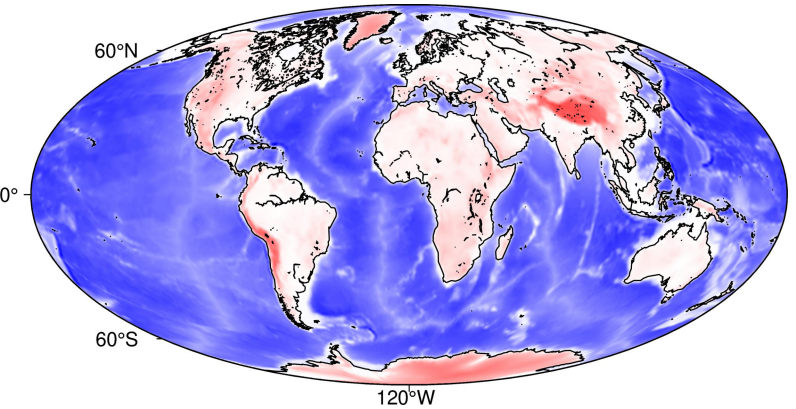
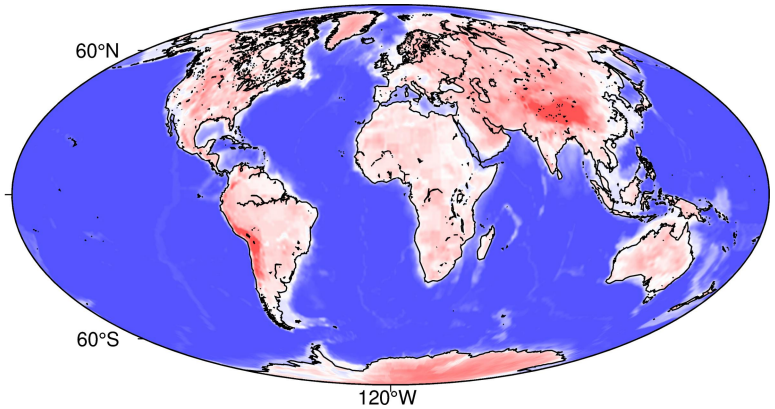


Isostatic Topography



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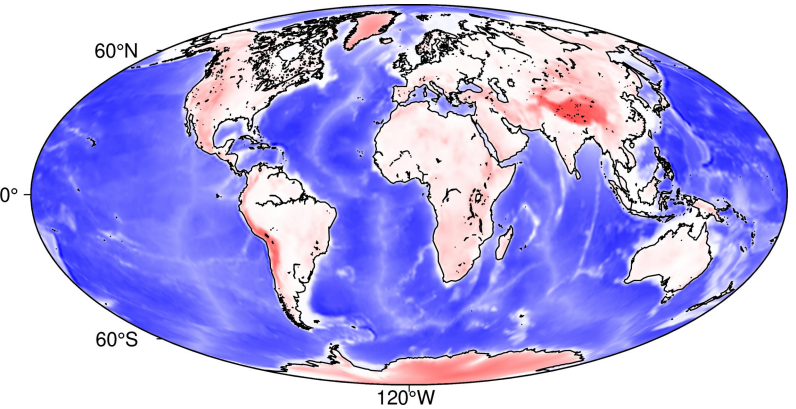

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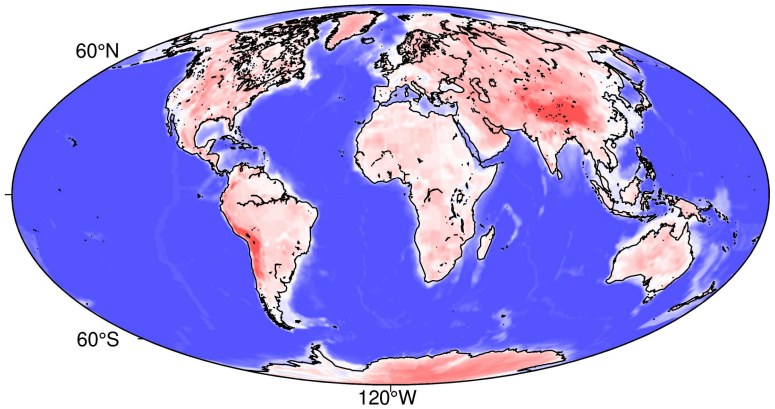

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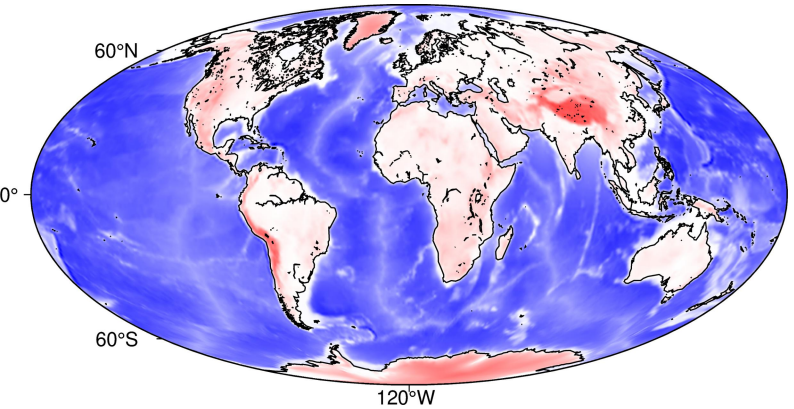

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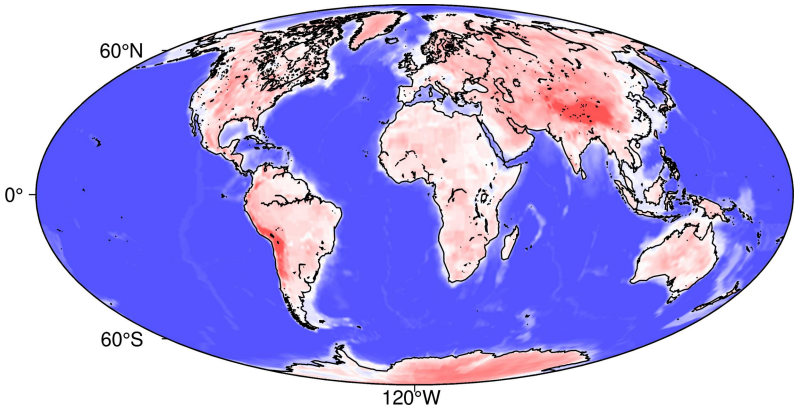

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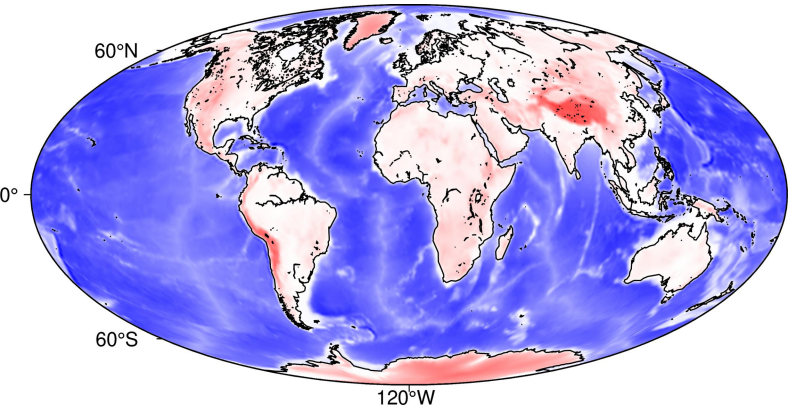

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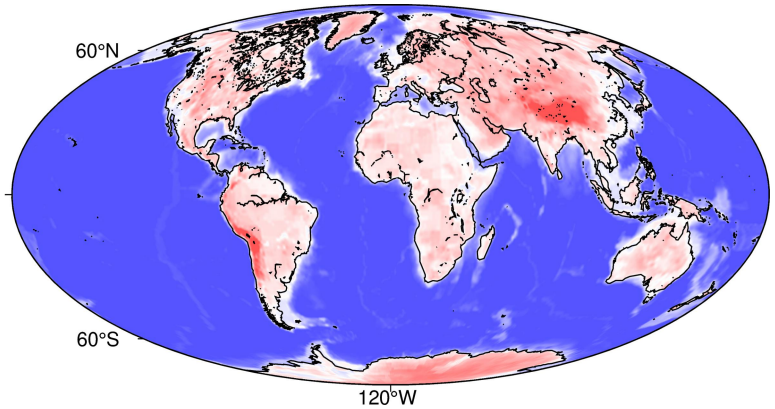

Residual topography and geoid provides global constraints on the amplitude and spatial distribution of density anomalies in the convecting mantle.

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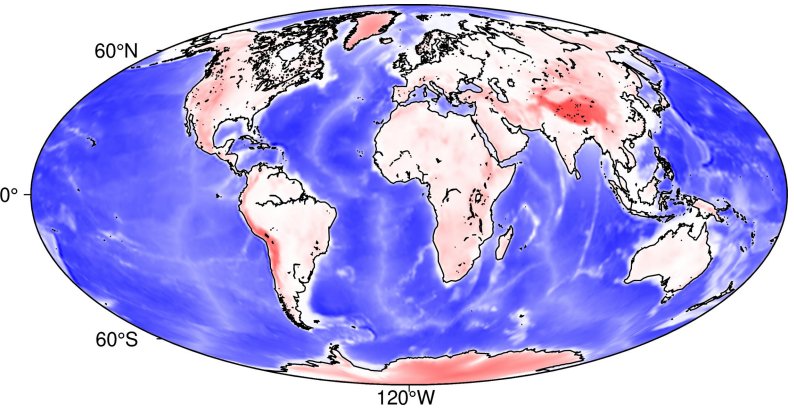

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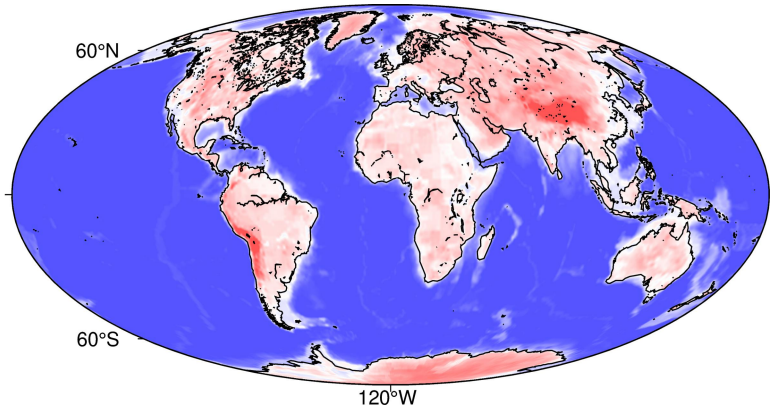

Simplification

- **Viscous**
- **Compressible**
- **Self-gravitating**
- **Density heterogeity**

Residual topography and geoid provides global constraints on the amplitude and spatial distribution of density anomalies in the convecting mantle.

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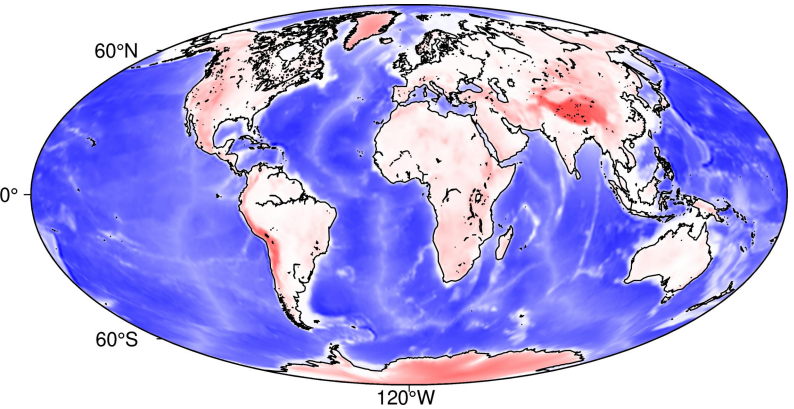

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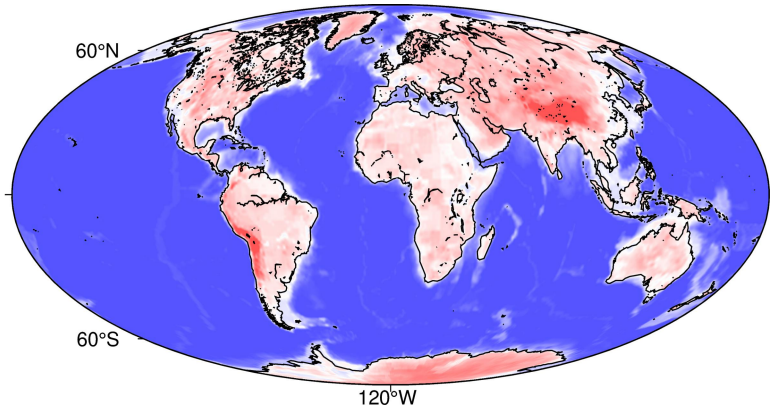

Questions

- **How much these constraints are uncertain due to crustal models uncertainty?**
- **How can isostatsy be geodynamically consistent?**

Residual topography and geoid provides global constraints on the amplitude and spatial distribution of density anomalies in the convecting mantle.

Simplification

- **Viscous**
- **Compressible**
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- **Geodynamic observable and lateral density variation**

Corresponding kernel function

$$\delta \mathrm{O}_{\ell}^{m} = f_{\ell} \int_{b}^{a} K_{\ell}\left(\eta; r'\right) \left(\rho_1\right)_{\ell}^{m}\left(r'\right) \mathrm{d}r'$$

Geodynamic observable

Lateral density variation

- **Geodynamic observable and lateral density variation**

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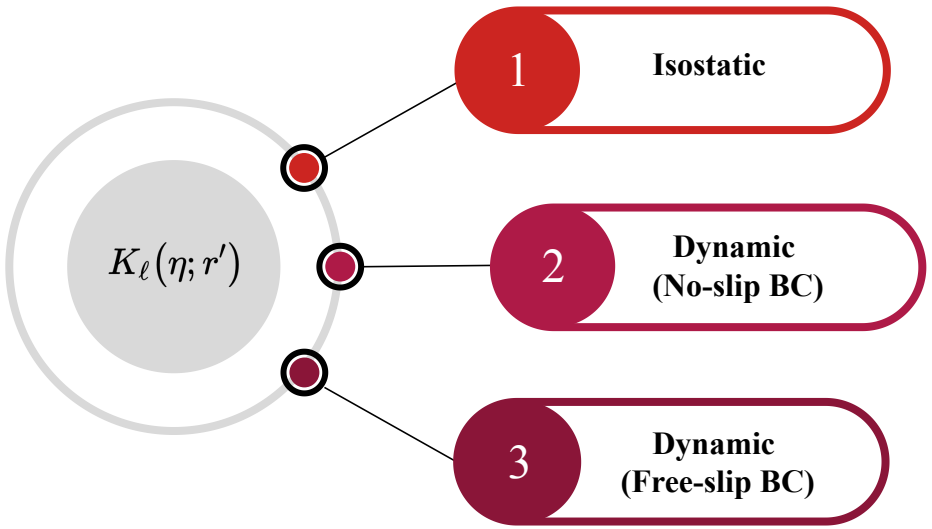
Geodynamic observable

Lateral density variation



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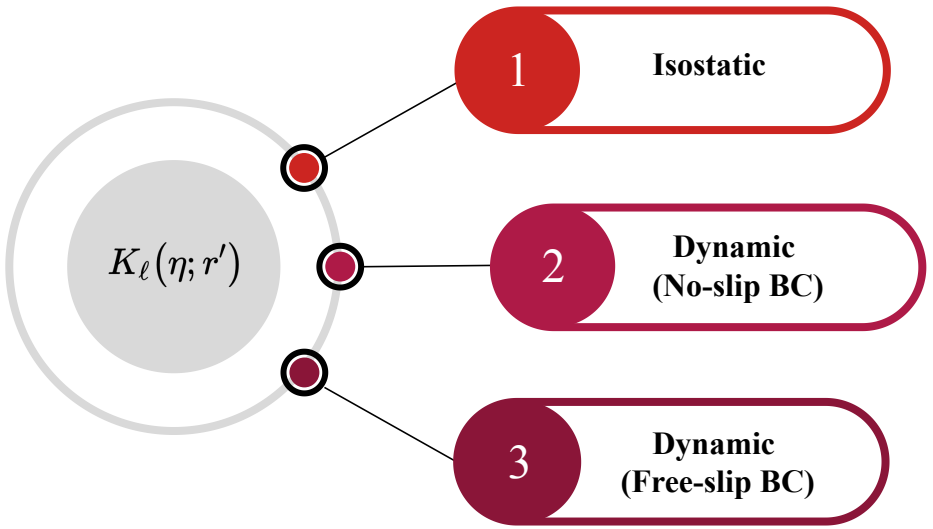

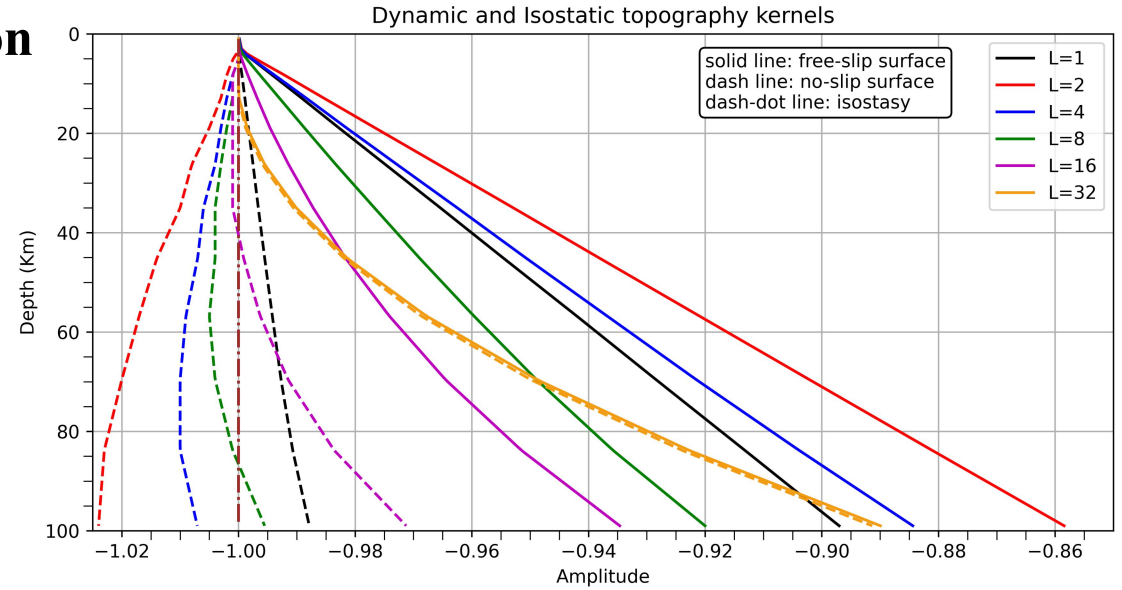

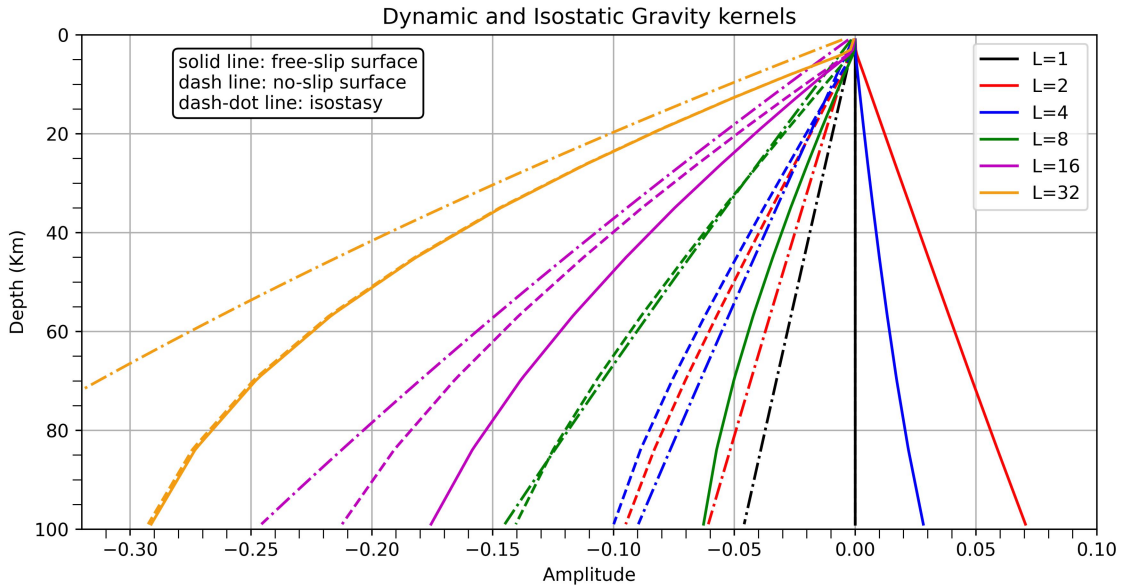

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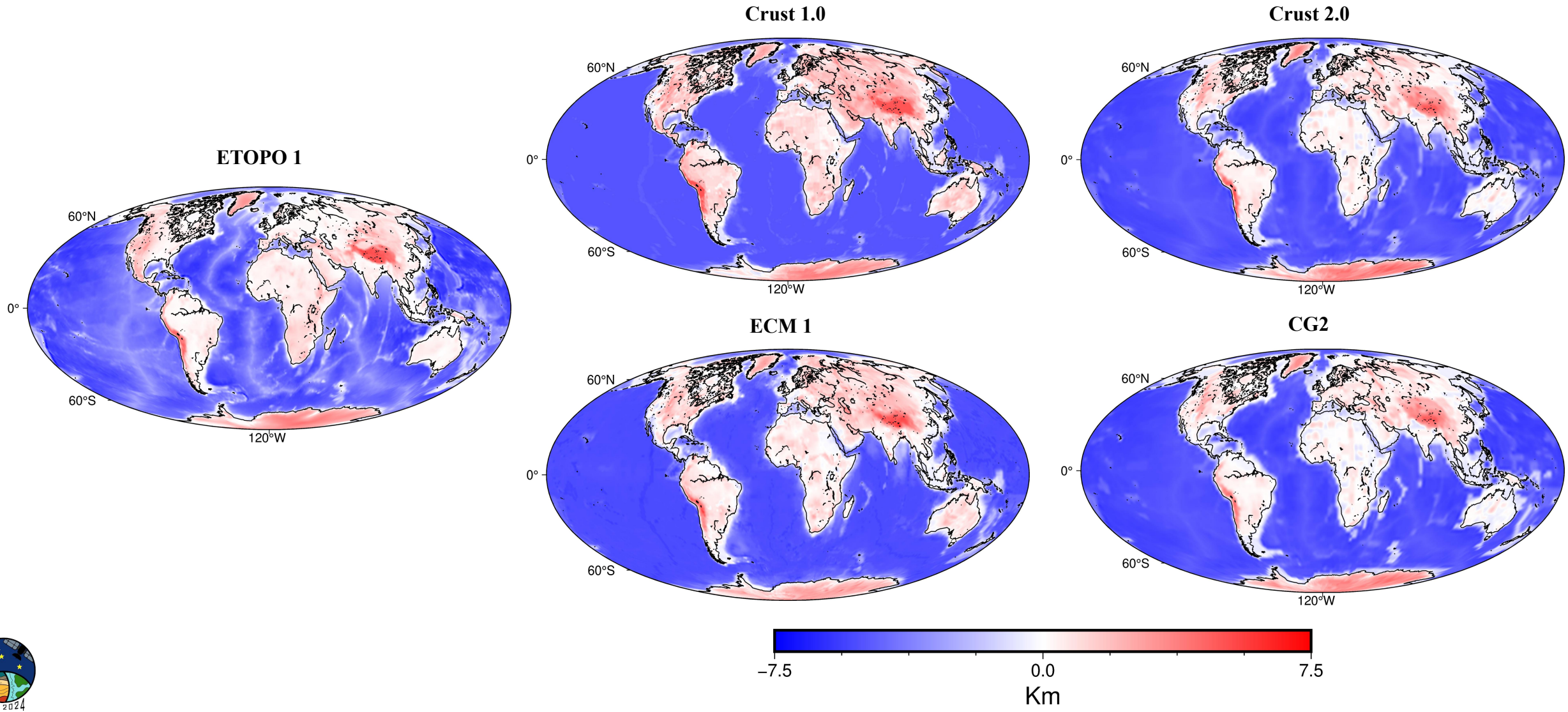

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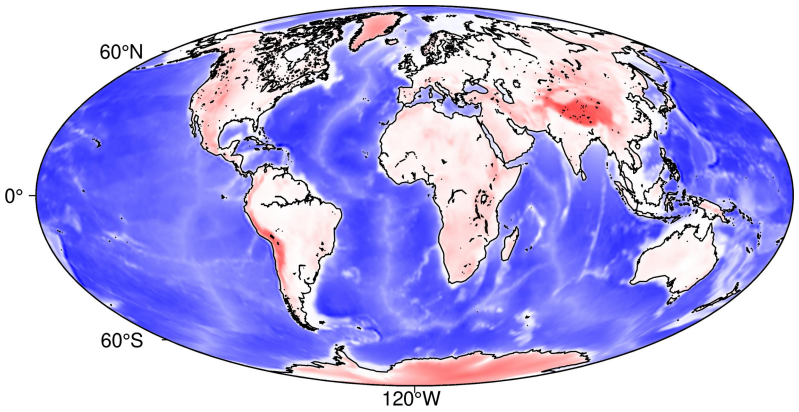
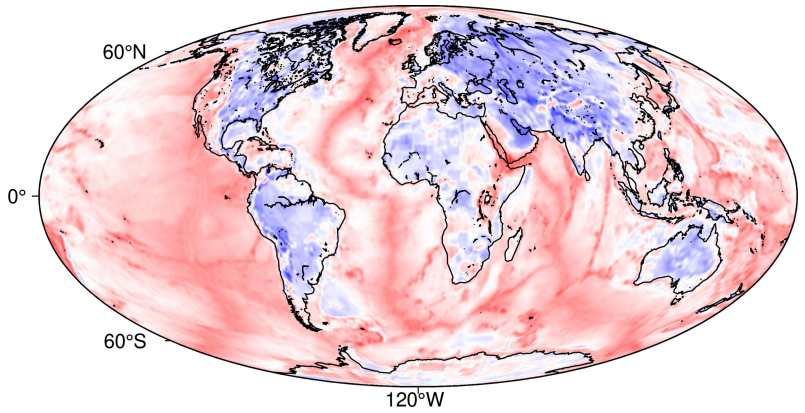
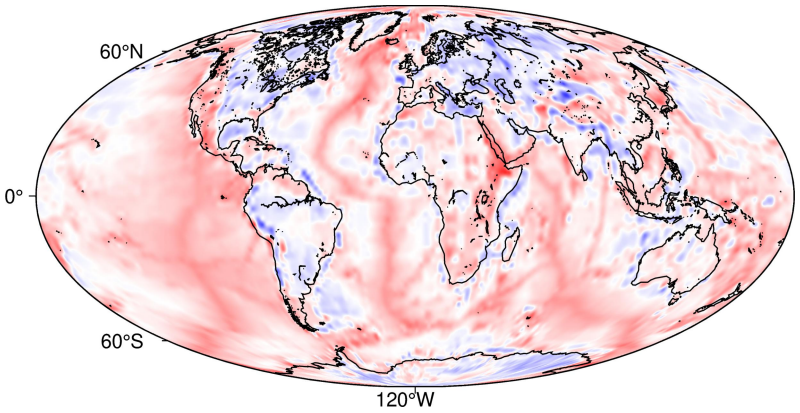
ETOPO 1



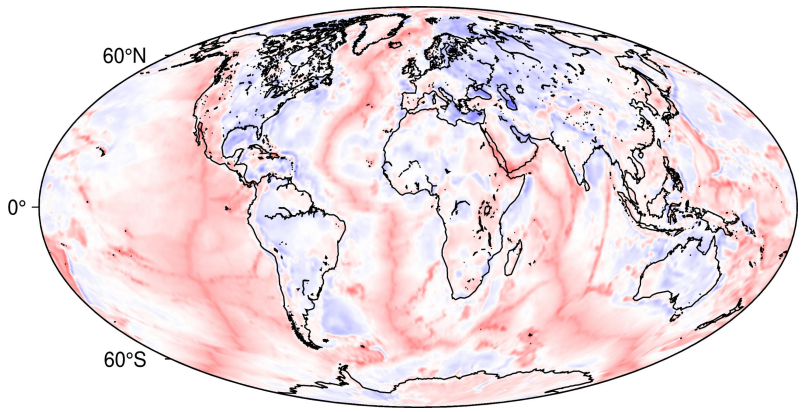
Crust 1.0



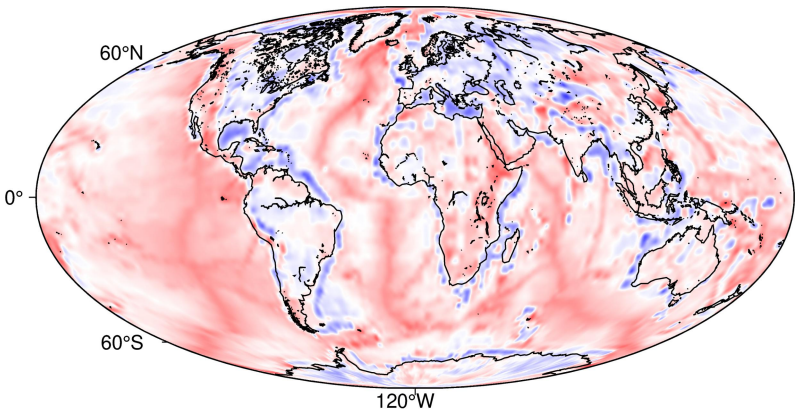
Crust 2.0

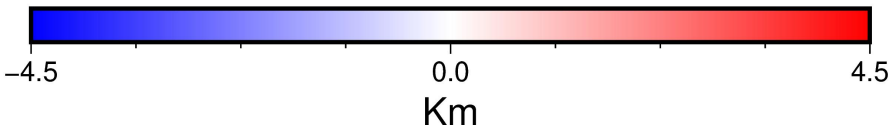


ECM 1



CG2





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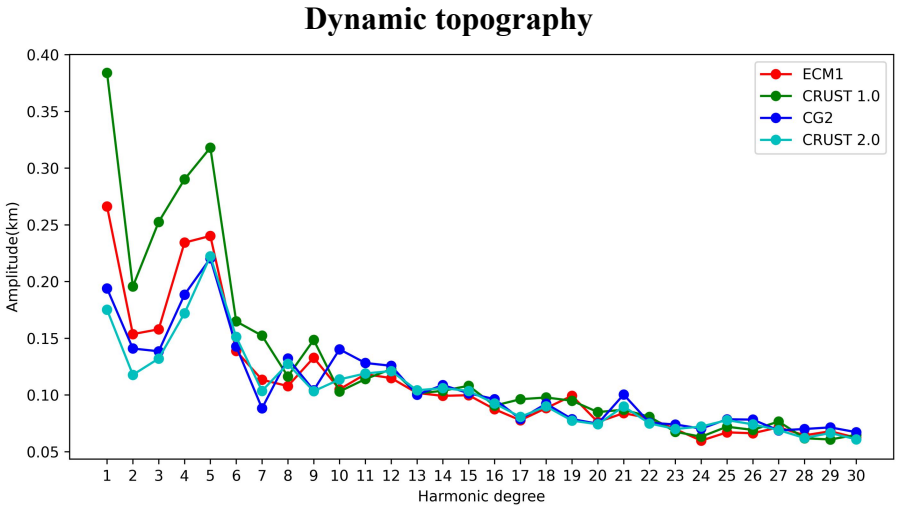

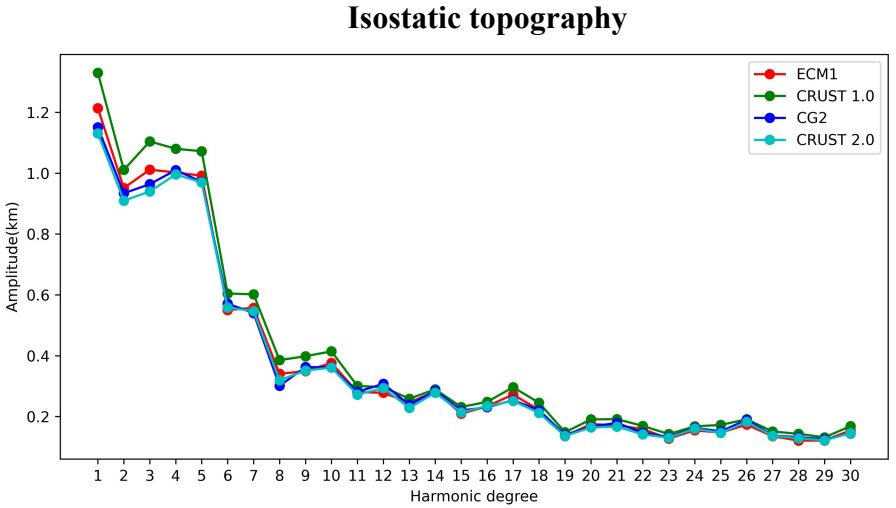

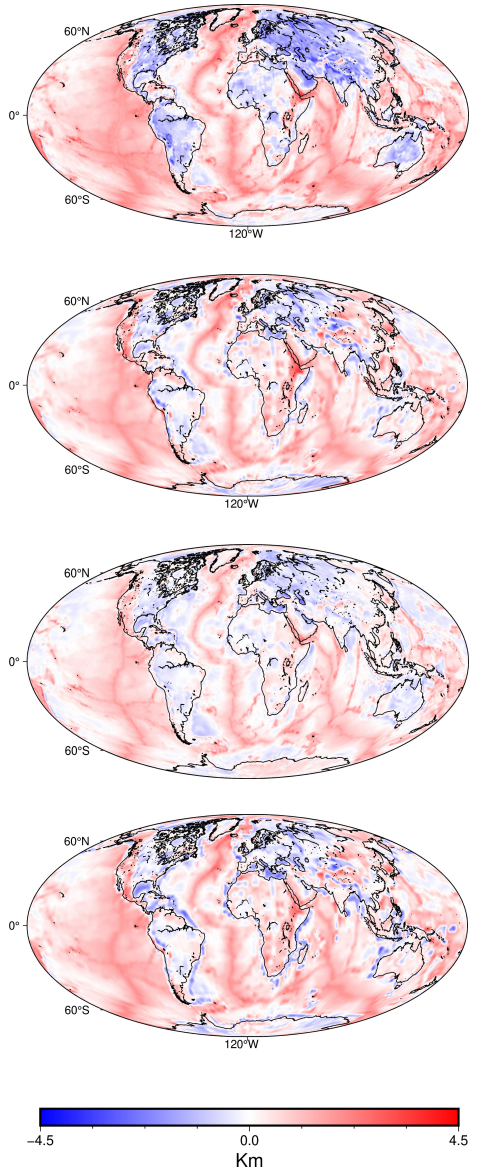

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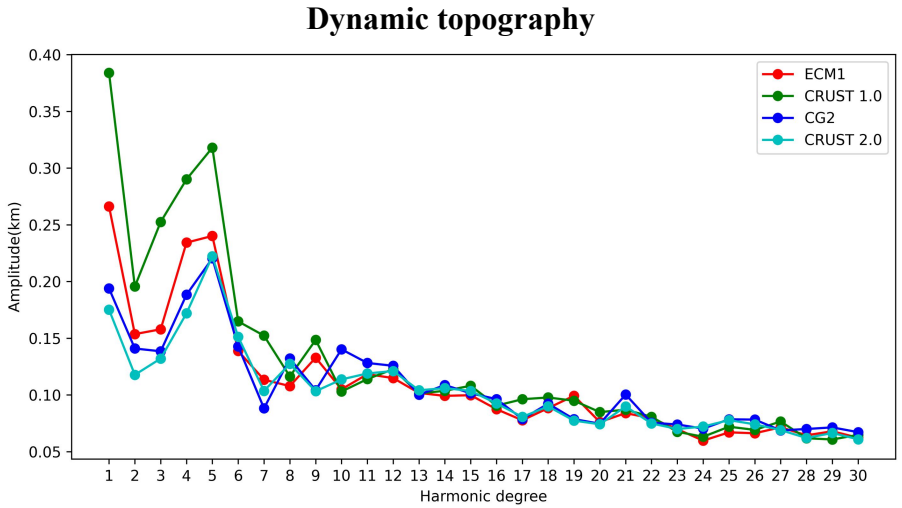

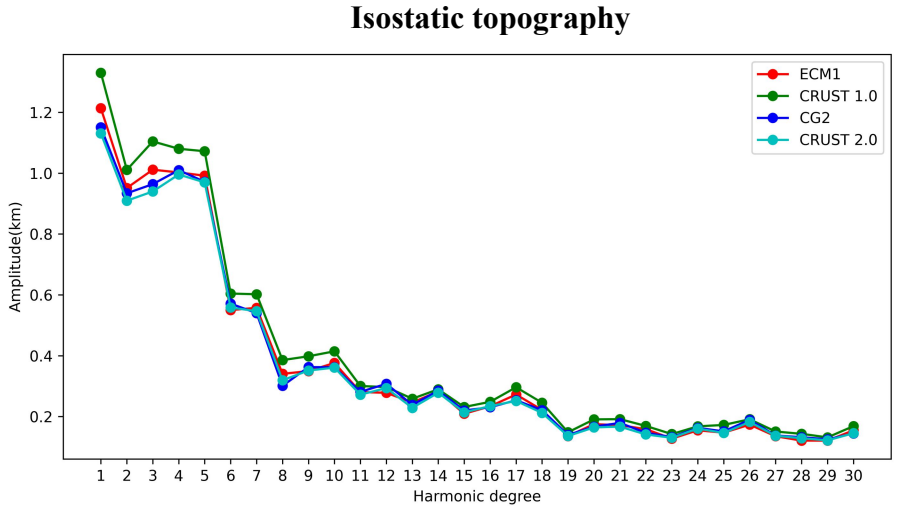

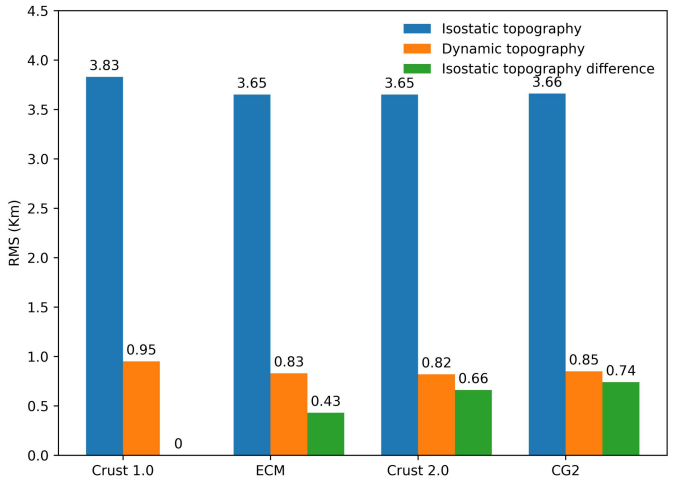

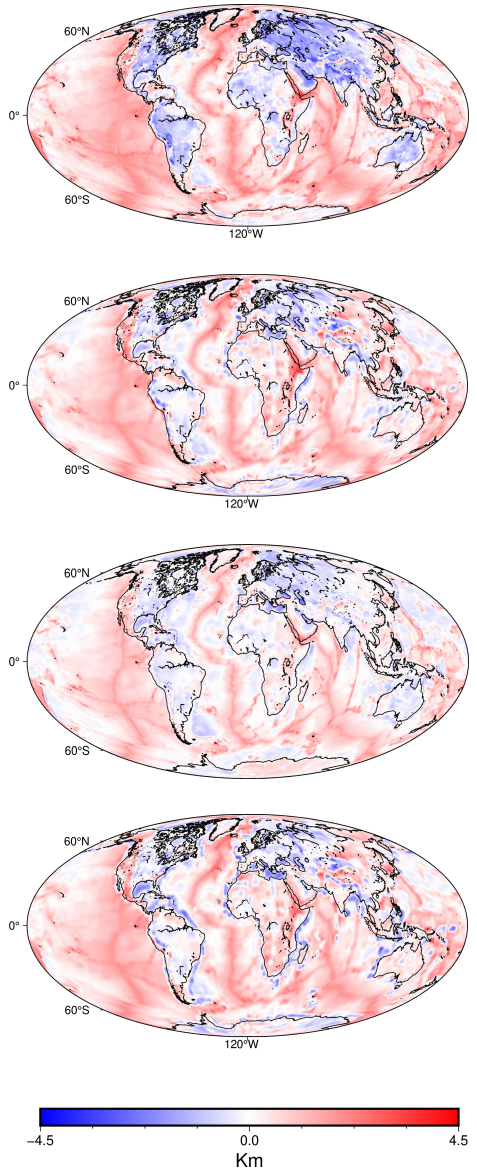

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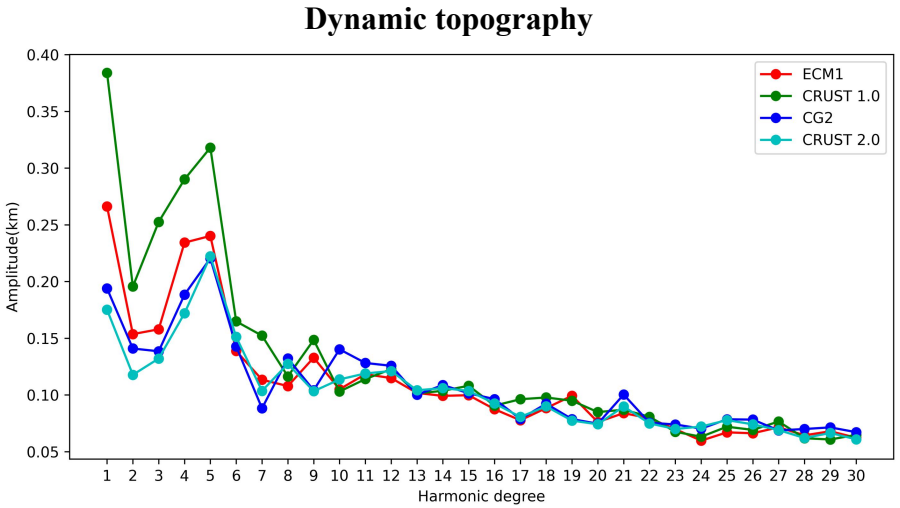

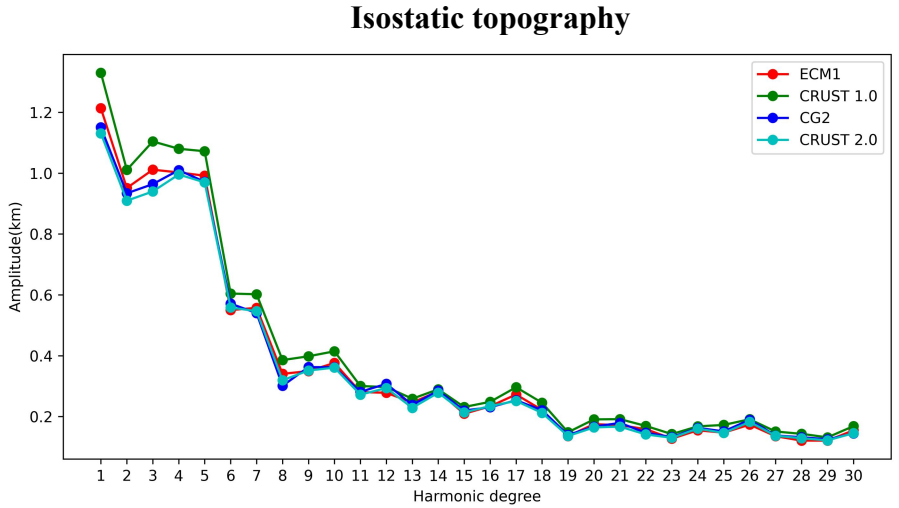

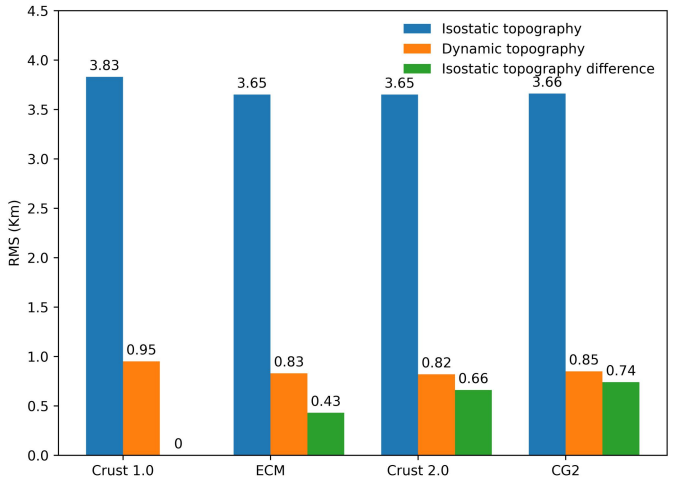

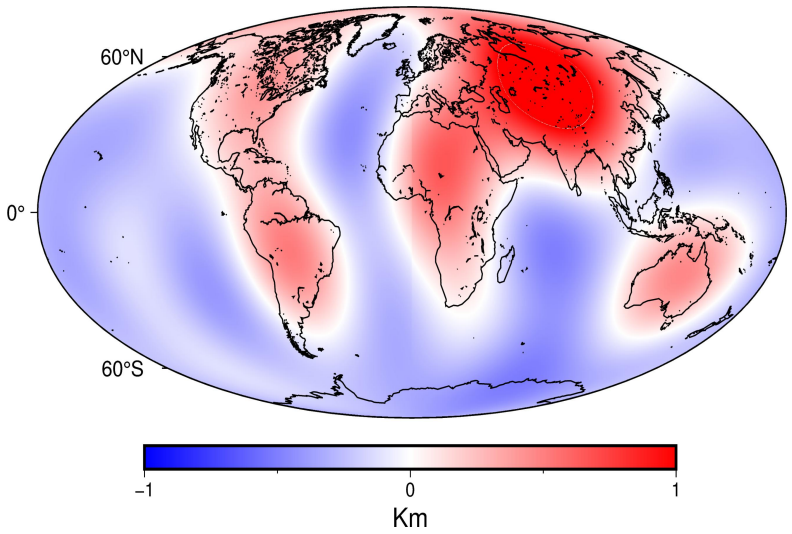

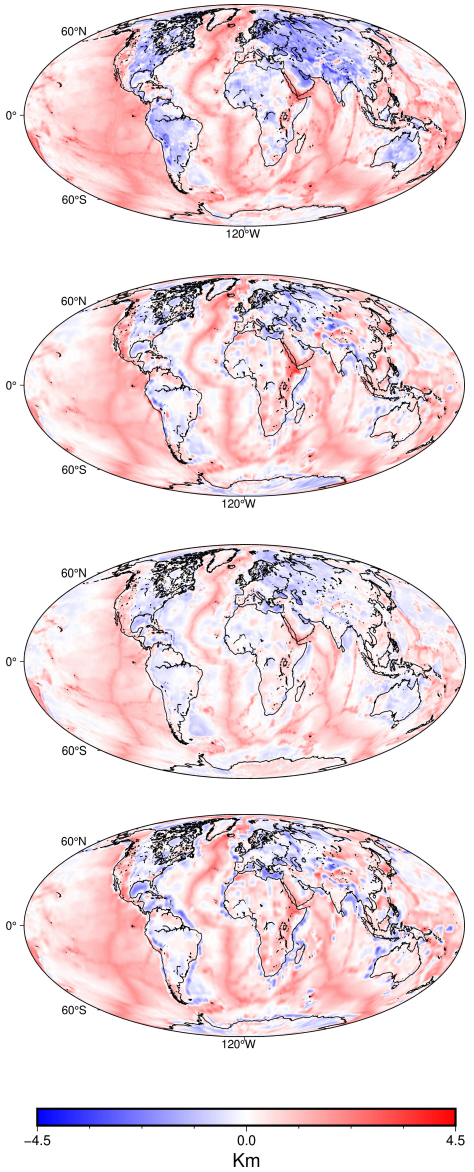

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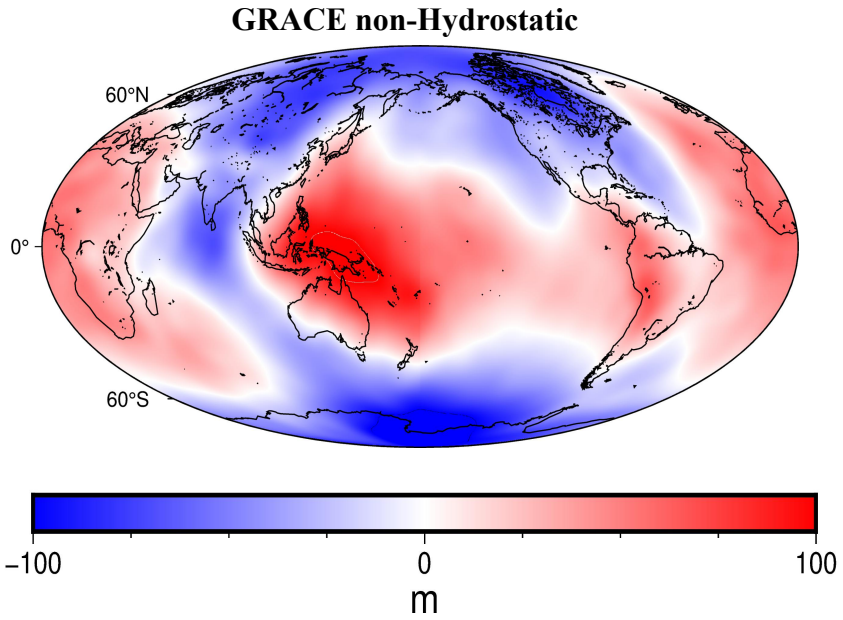

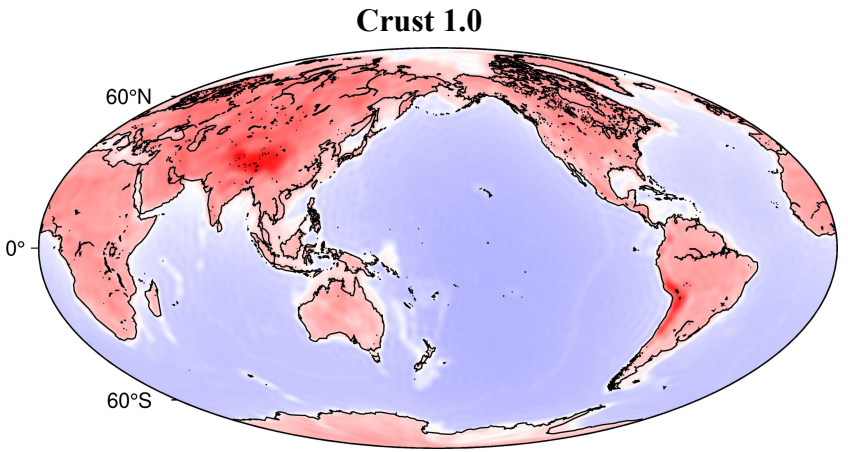

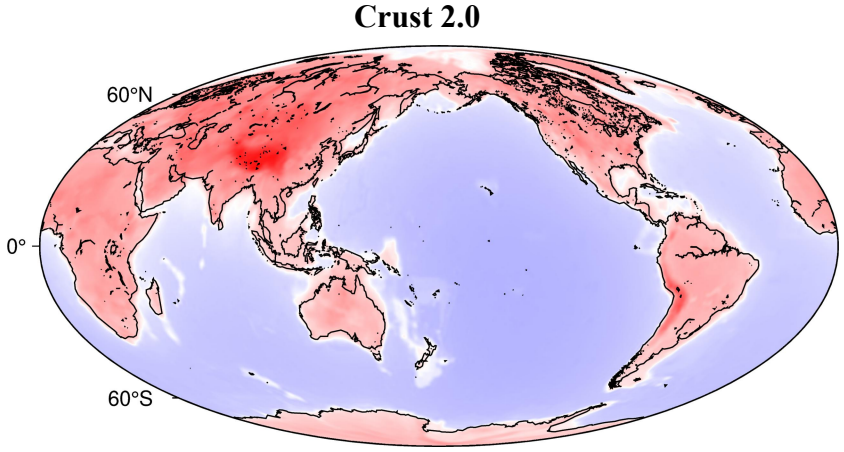

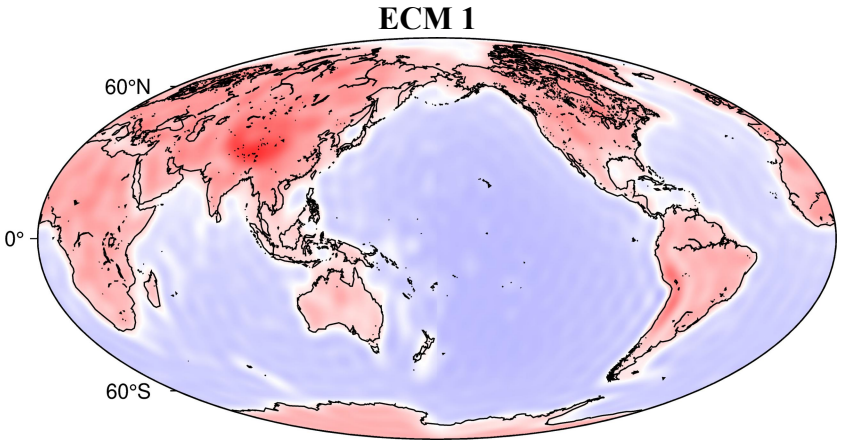

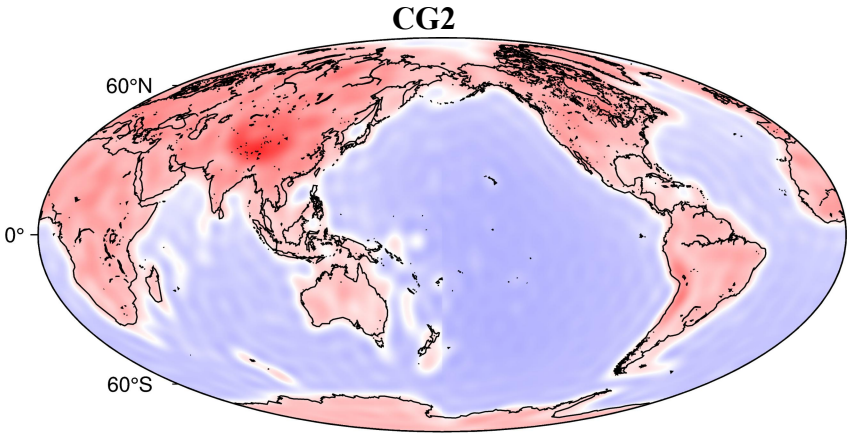

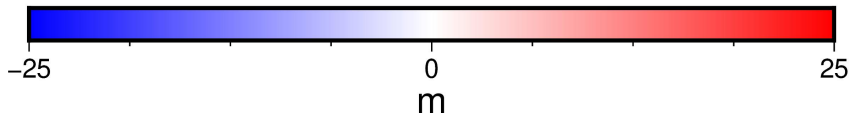

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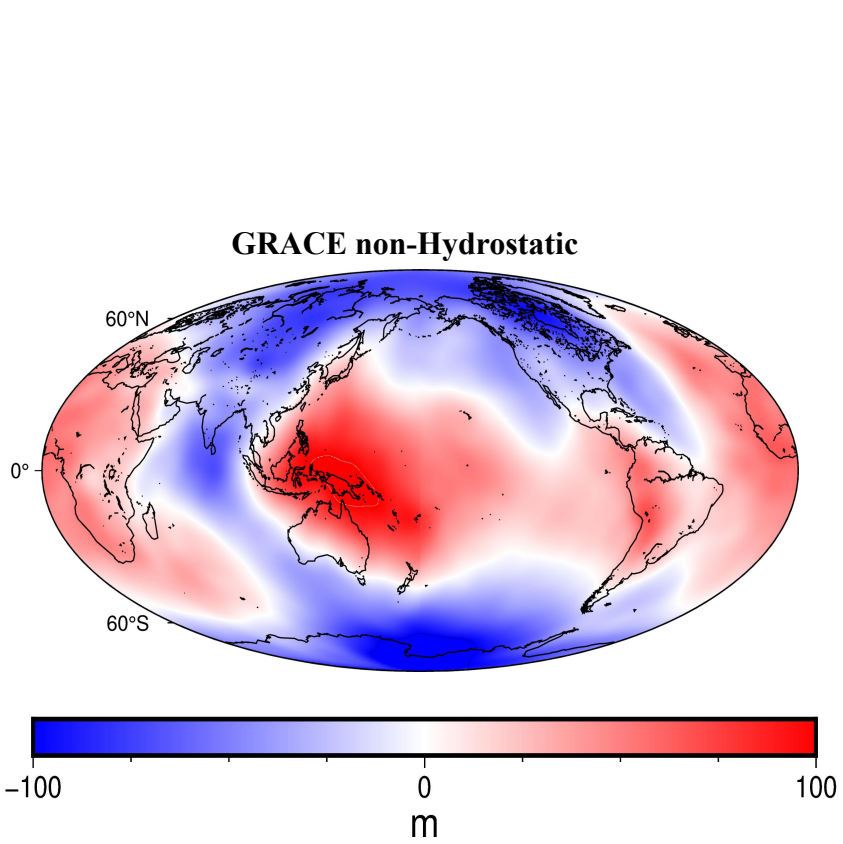

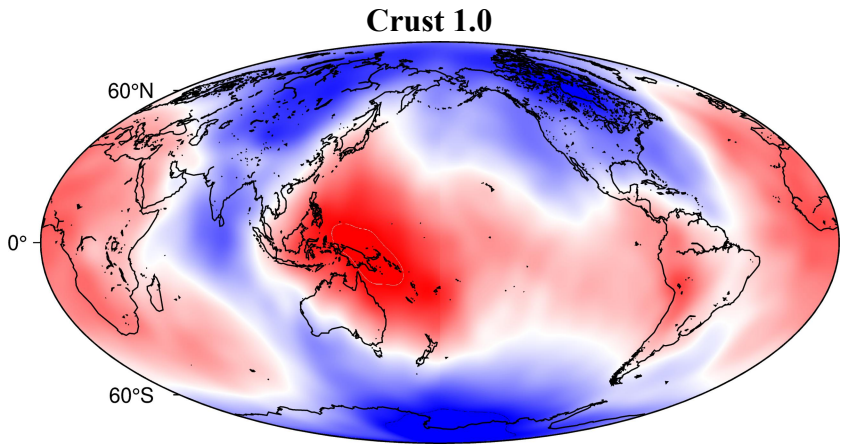

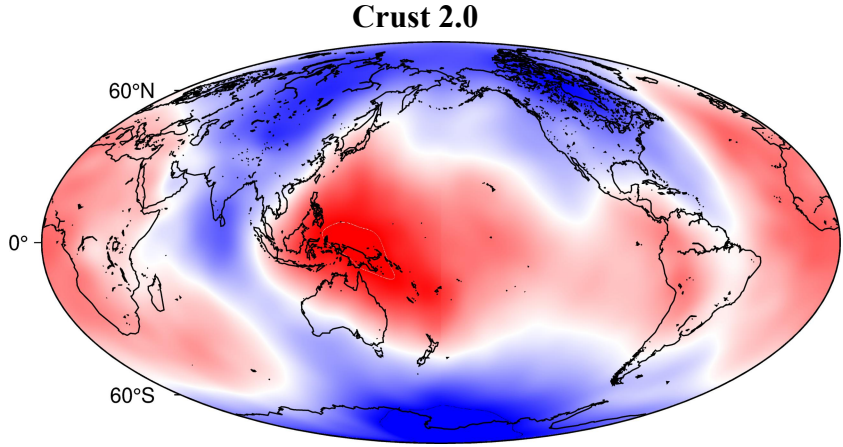

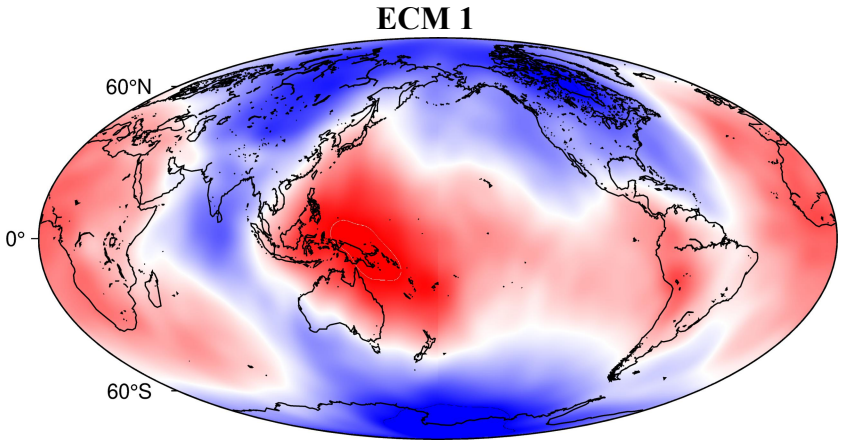

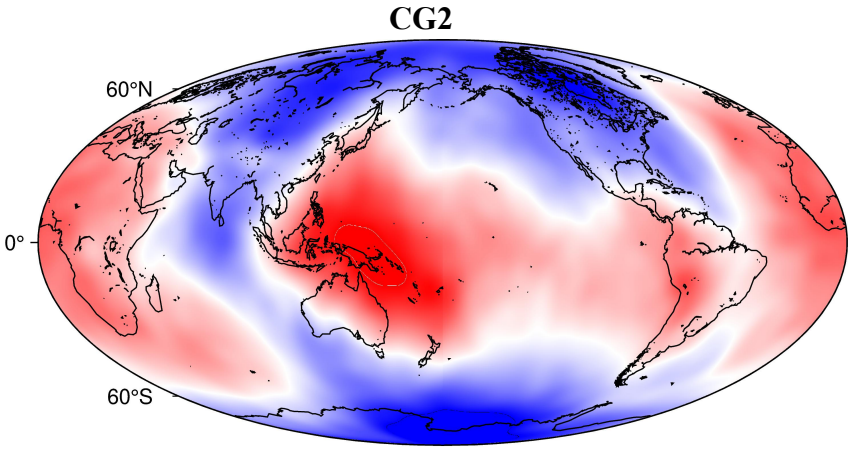

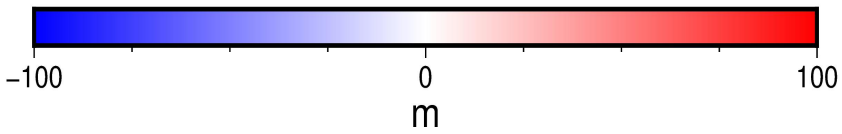

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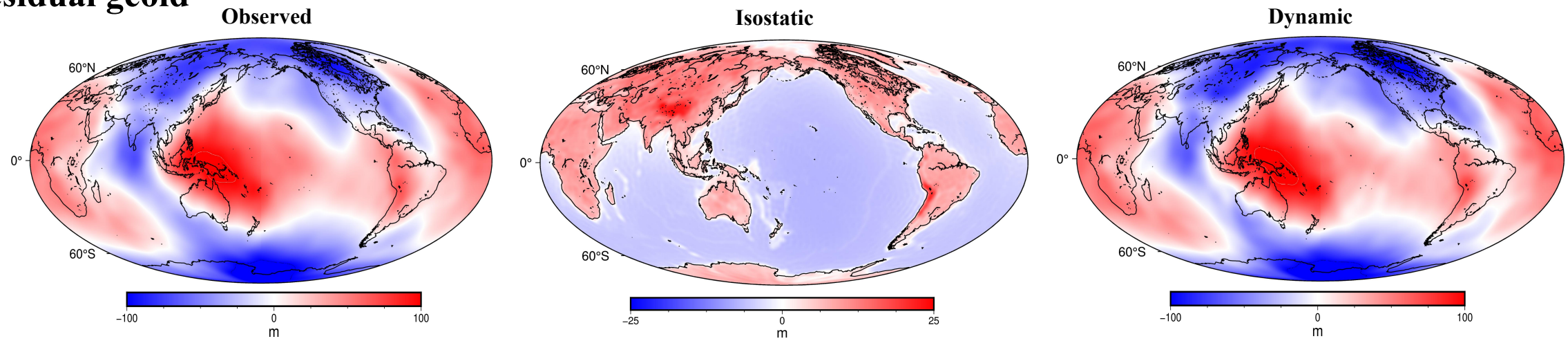

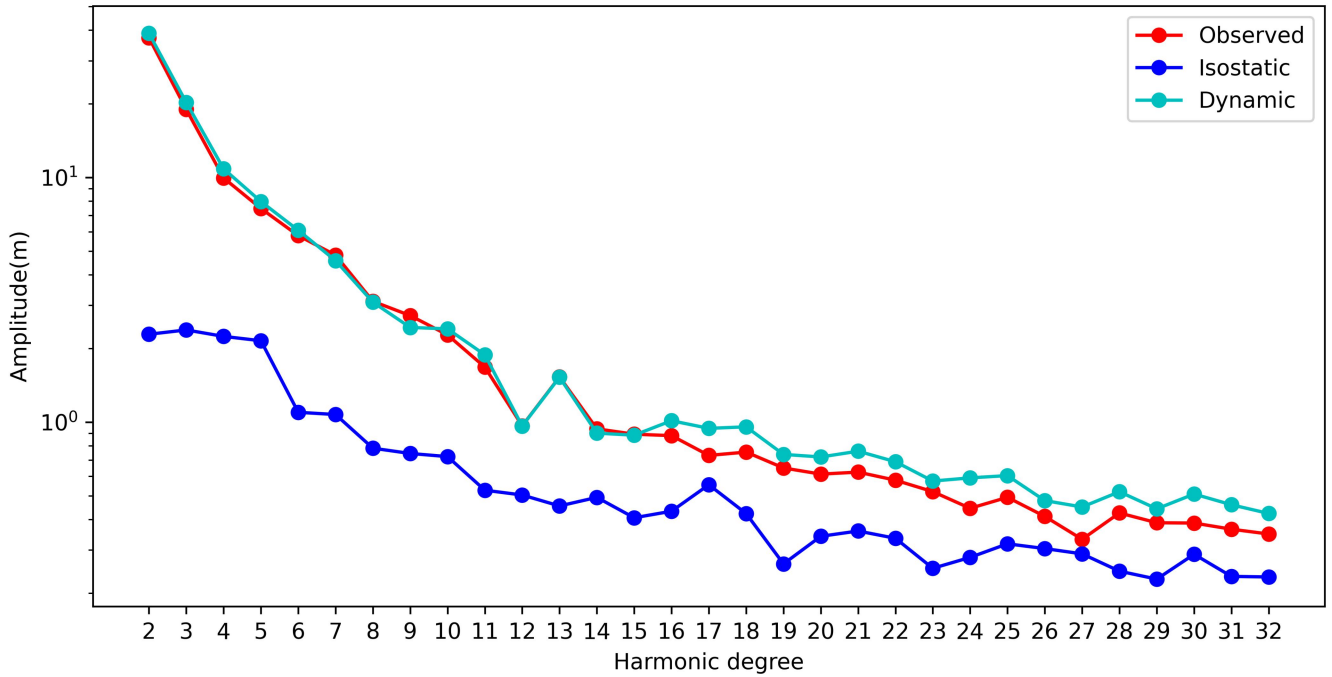

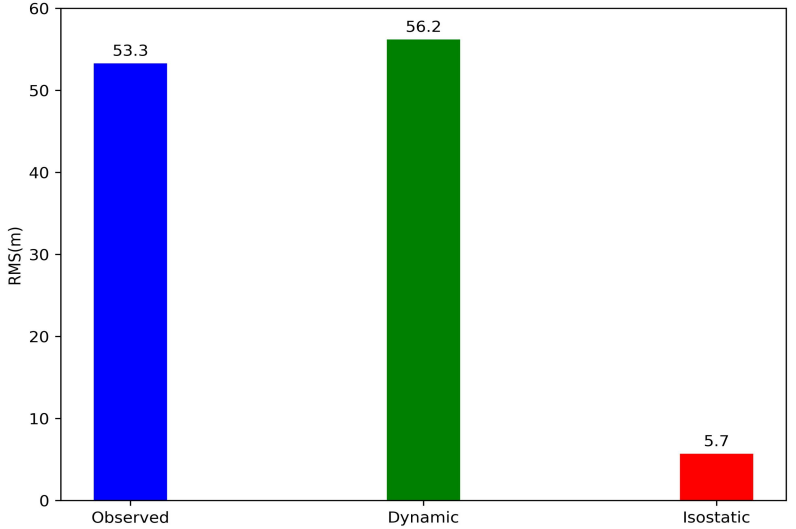

- **Geodynamically consistent approach**

Simplification

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- **Compressible**
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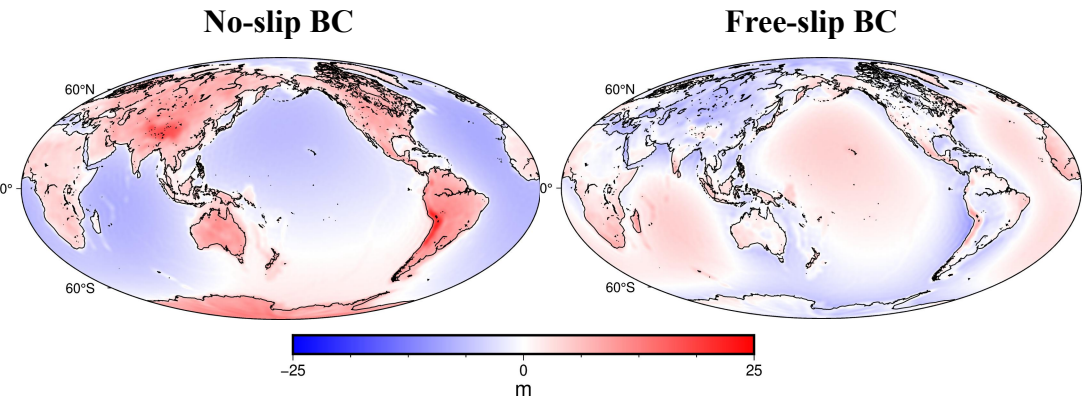

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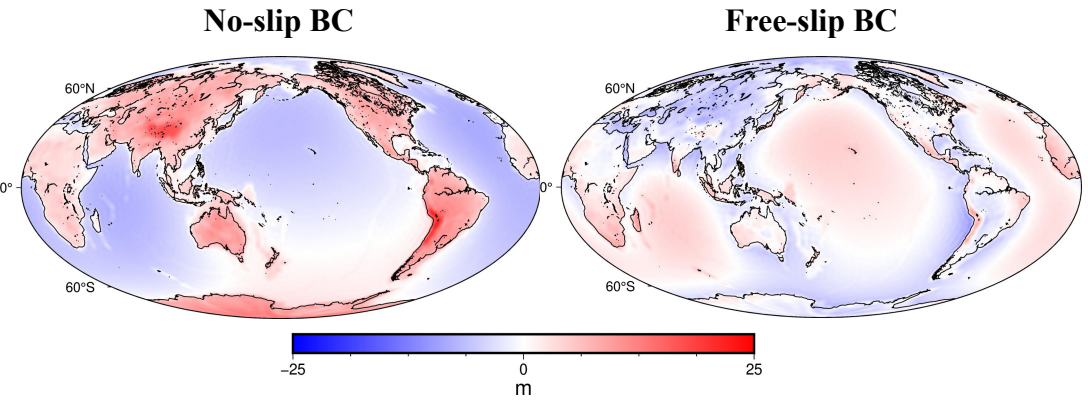

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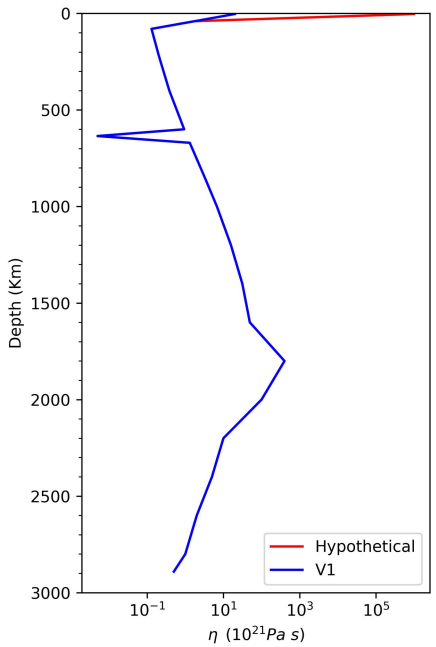

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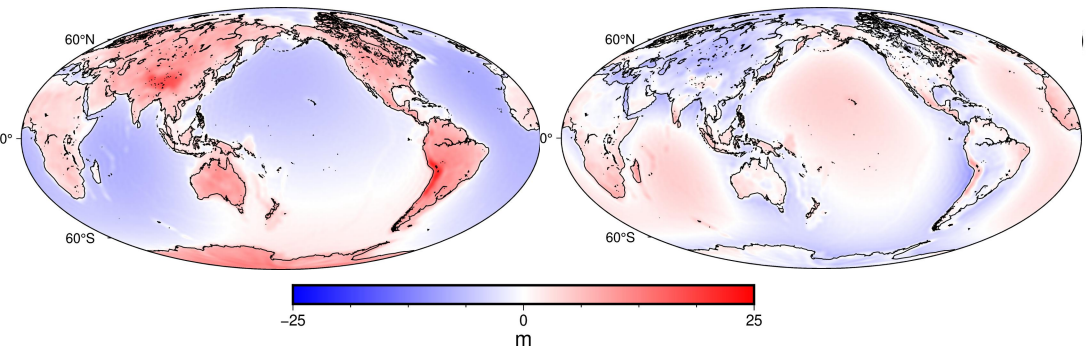
No-slip BC **Free-slip BC**



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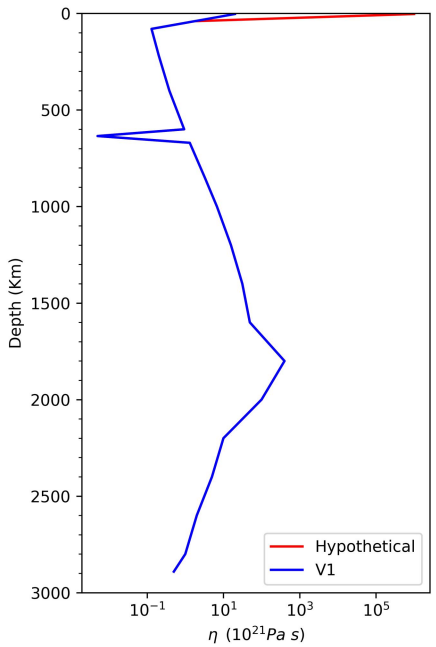
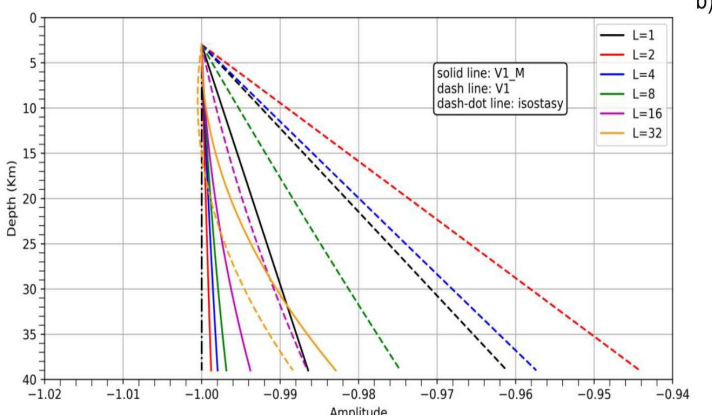
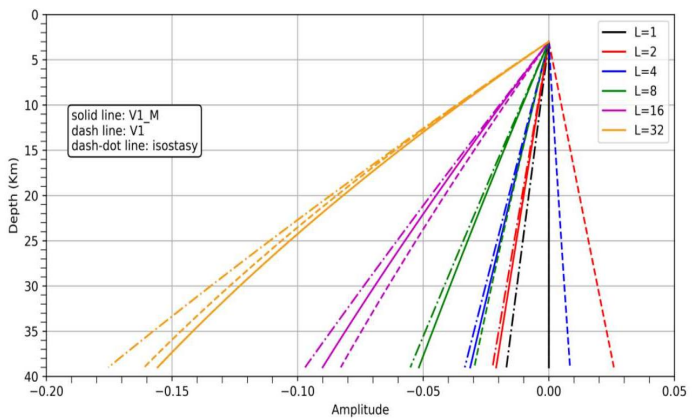


Topography kernels (Free-slip BC)

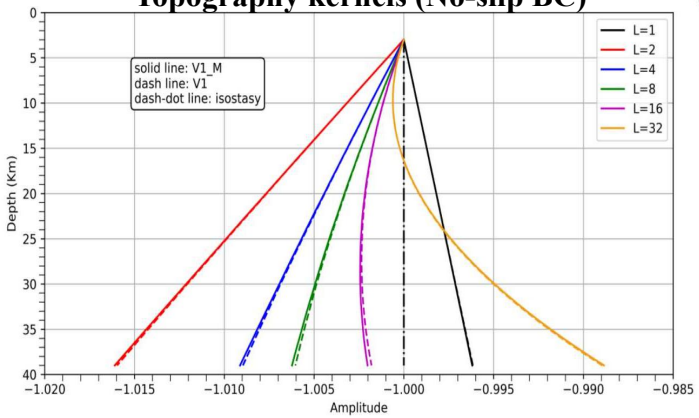


b)

Geoid kernels (Free-slip BC)

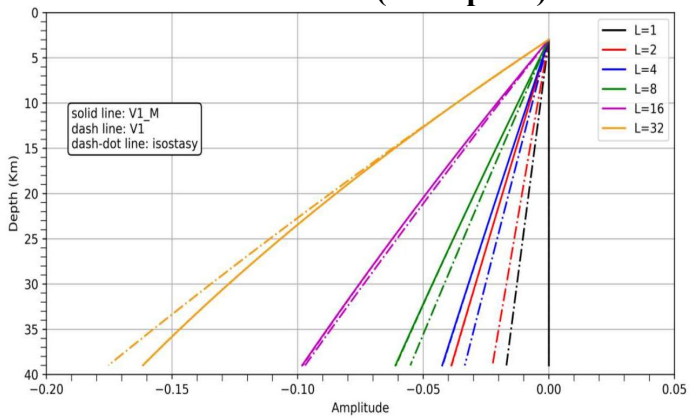


Topography kernels (No-slip BC)

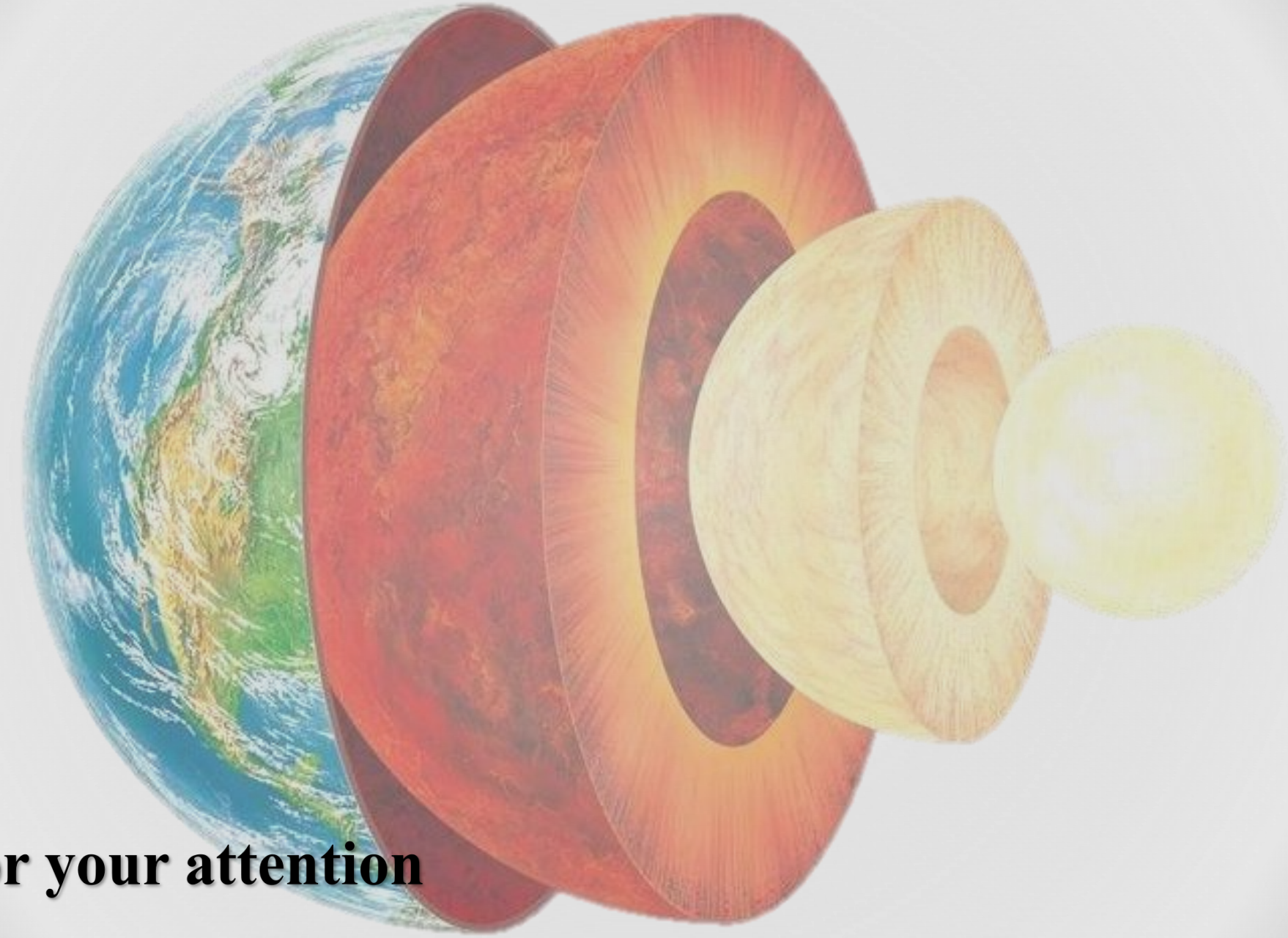


d)

Geoid kernels (No-slip BC)



- Residual topography and geoid is a consequence of dynamic processes occurring within the mantle.
- Residual geoid is not identically zero, and it must be used in combination with topography as constraint on the mantle density hetrogeneity.
- Residual topography uncertainty due to different crustal models has often been overlooked.
- Uncertainty in the multi-layer crustal models can lead to significant uncertainty (~ 50%) in the dynamic topography.
- Classic isostasy theroy is a symplified model for mantle-crust system by ignoring mantle compressibility and self-gravitating.
- Geodynamically consistant approach, derived from viscous flow model, compensates to some extent the simplifications of the classical isostasy theory.



Thanks for your attention