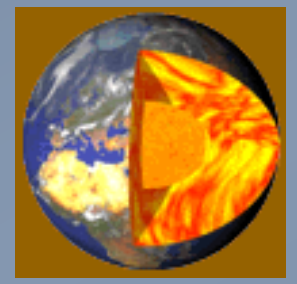
Christian-Albrechts-Universität zu Kiel



3D Earth
Towards a Digital Twin for the Geosphere

Jörg Ebbing (Kiel), Javier Fullea (Madrid),
Clint Conrad (Oslo), Bart Root (Delft)
&
3D Earth study team

LPS 22
Bonn, May 26th 2022

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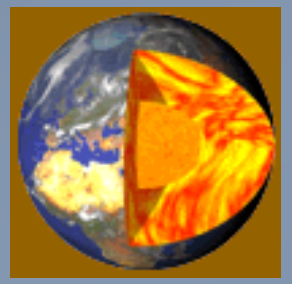
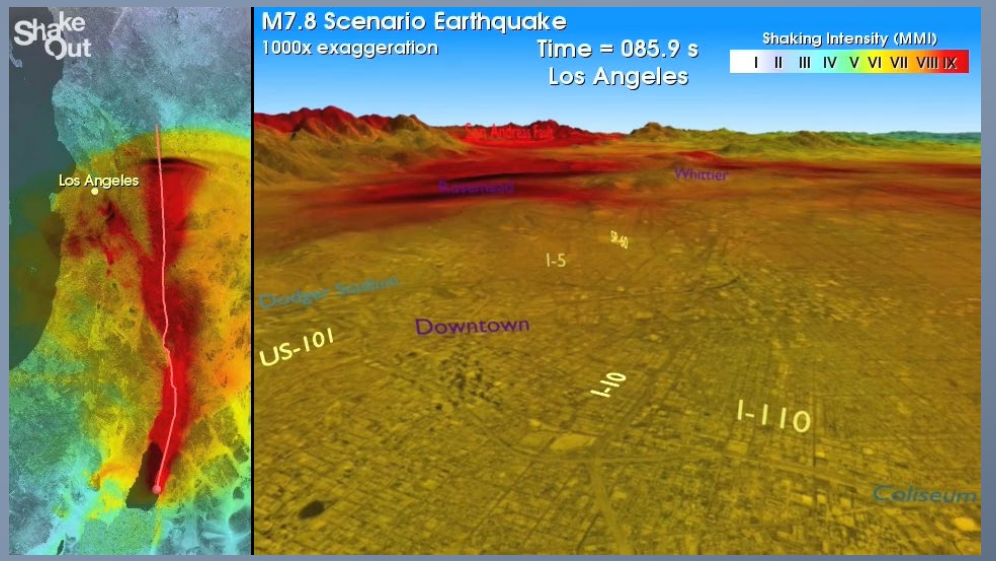
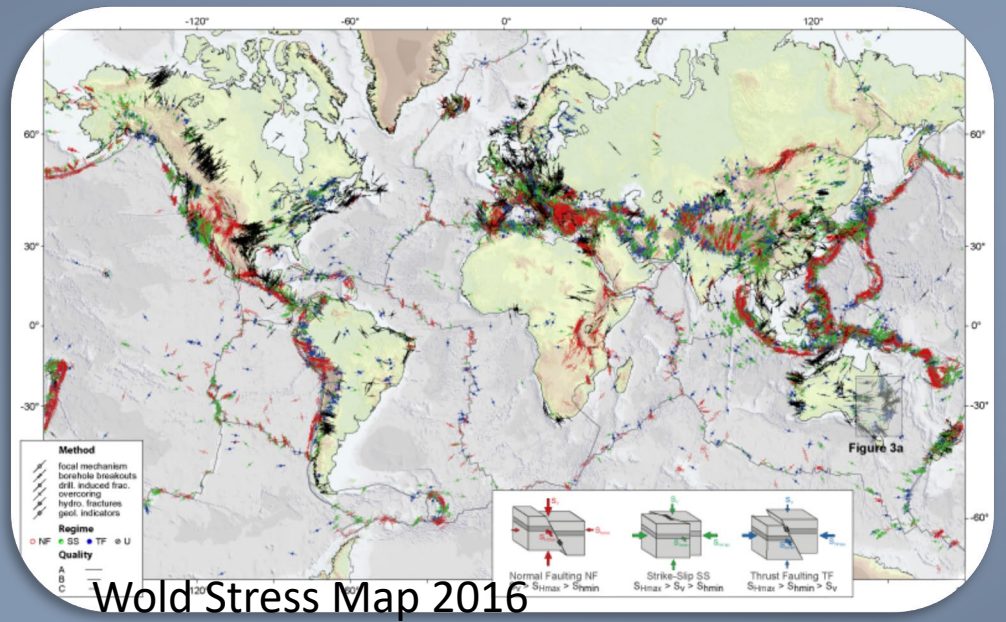
Why do we need a Digital Twin of the Geosphere?



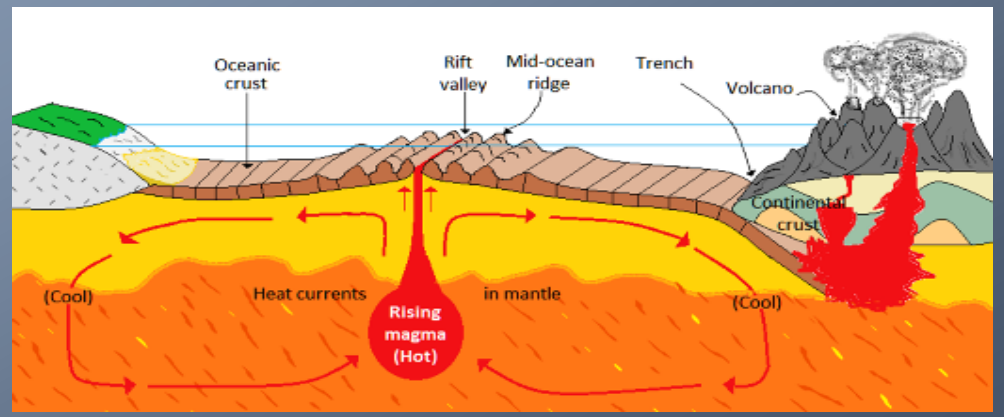
Linking surface processes to their sources in depth

Understanding the dynamic sources within the Earth

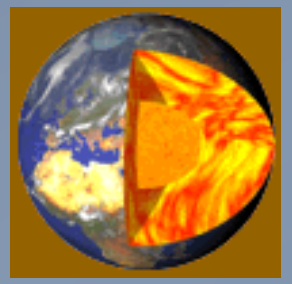




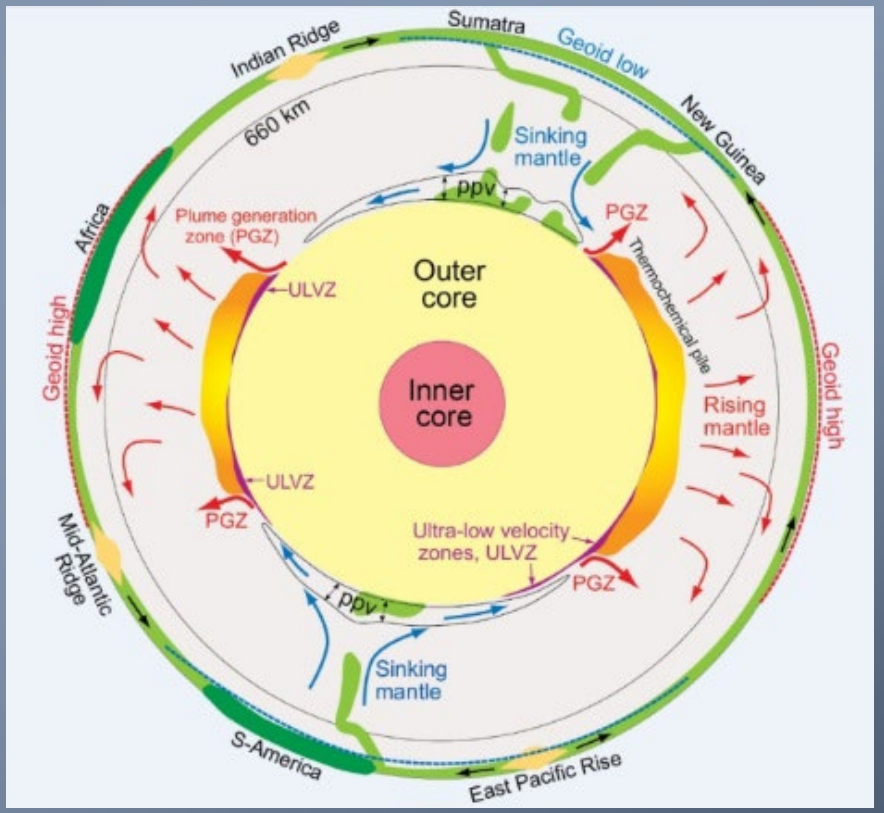
Wold Stress Map 2016



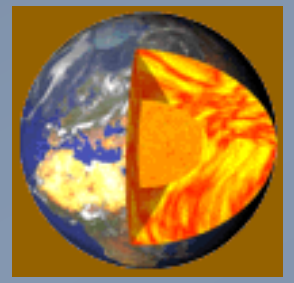
Why do we need a Digital Twin of the Geosphere?



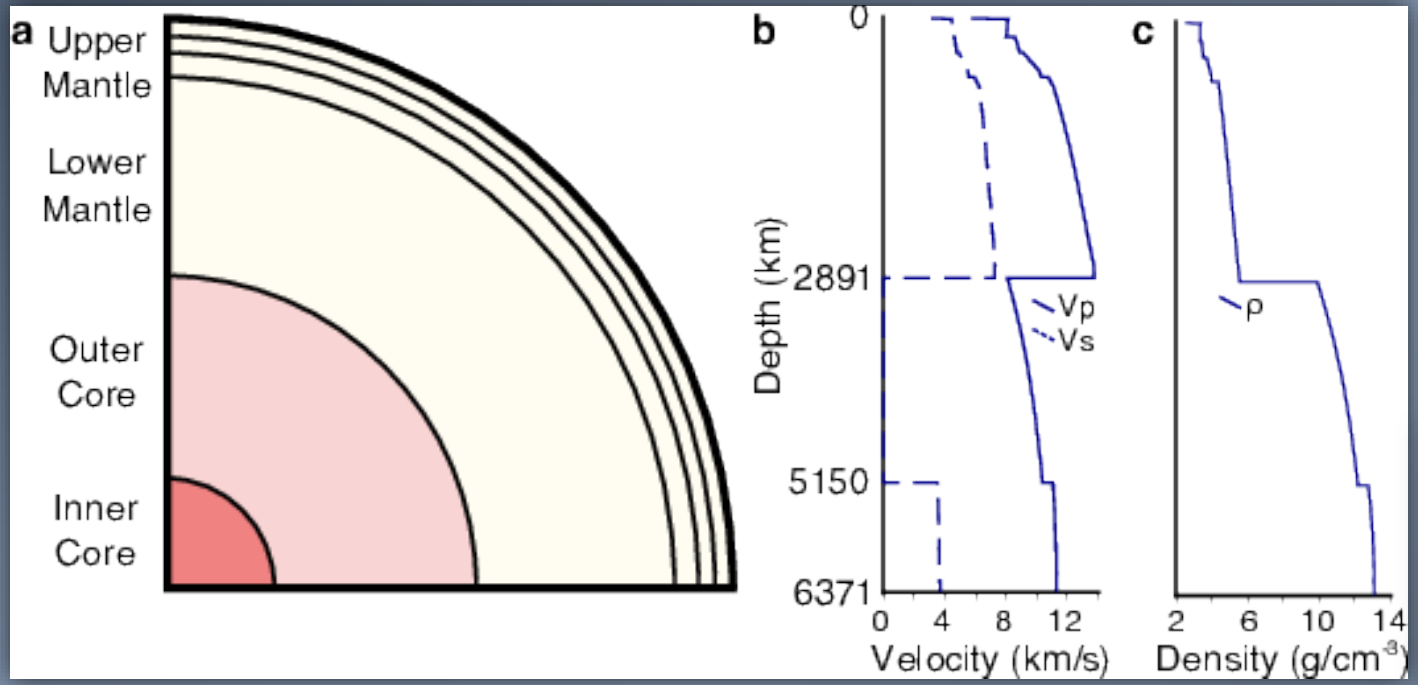
- Linking surface processes to their sources in depth
- Understanding the dynamic sources within the Earth
- What is used: simplified representation of the Earth



Digital Twin of the Geosphere

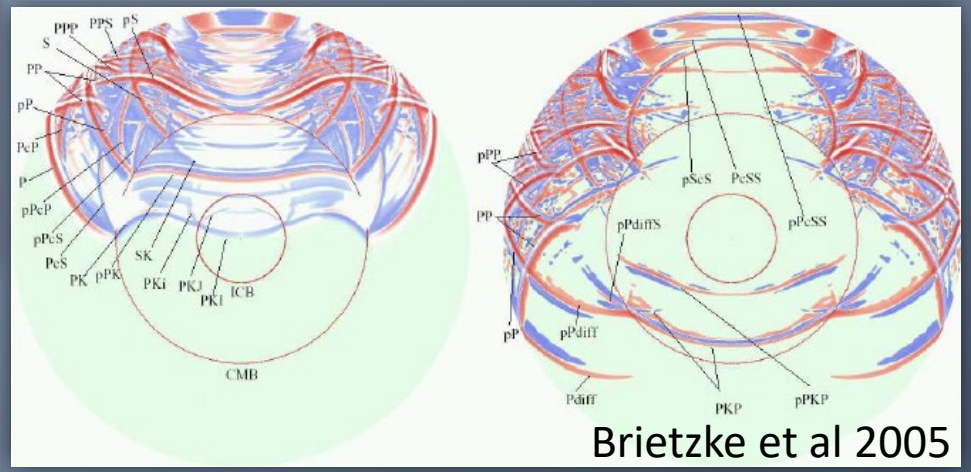


Preliminary Reference Earth Model 1981



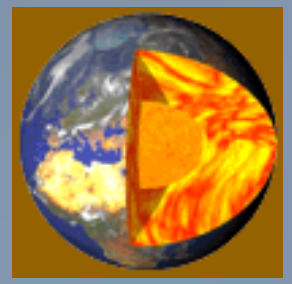
The reference model since 1981

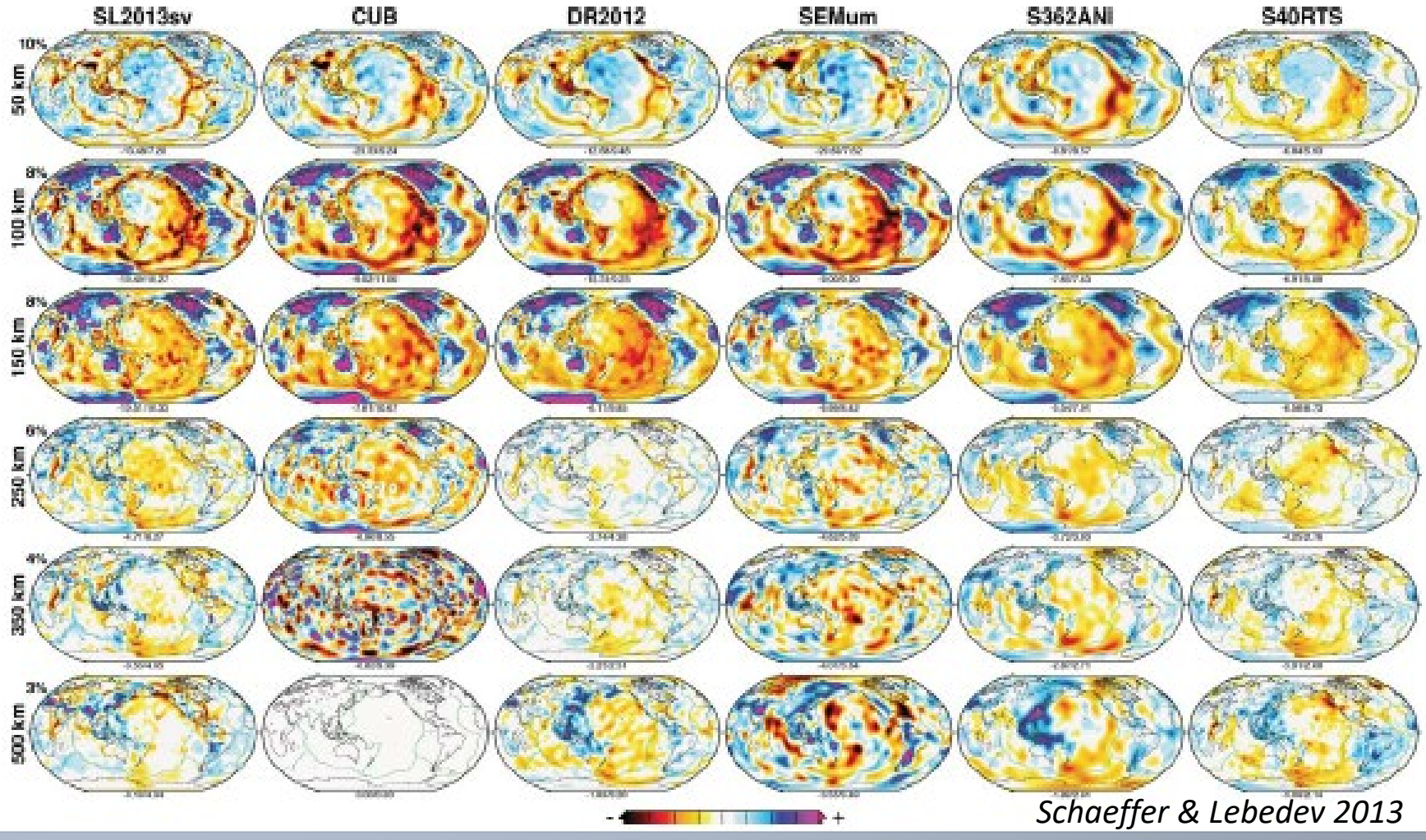
Seismic wave propagation within PREM



Brietzke et al 2005

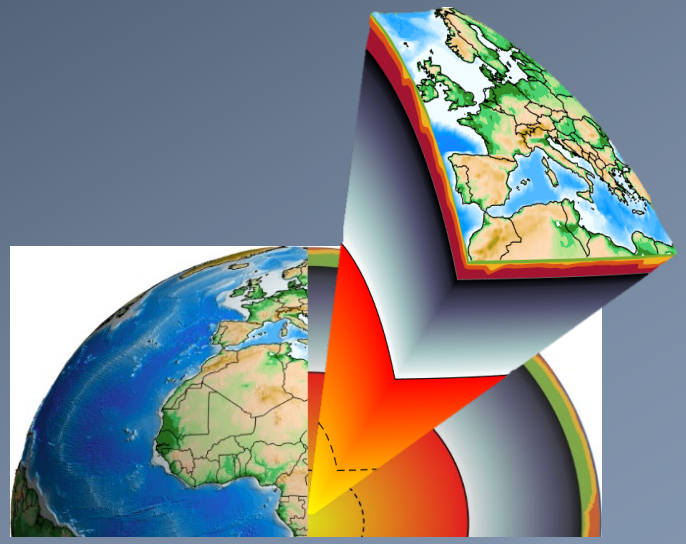
Global models from seismic tomography
- a suite of alternatives -

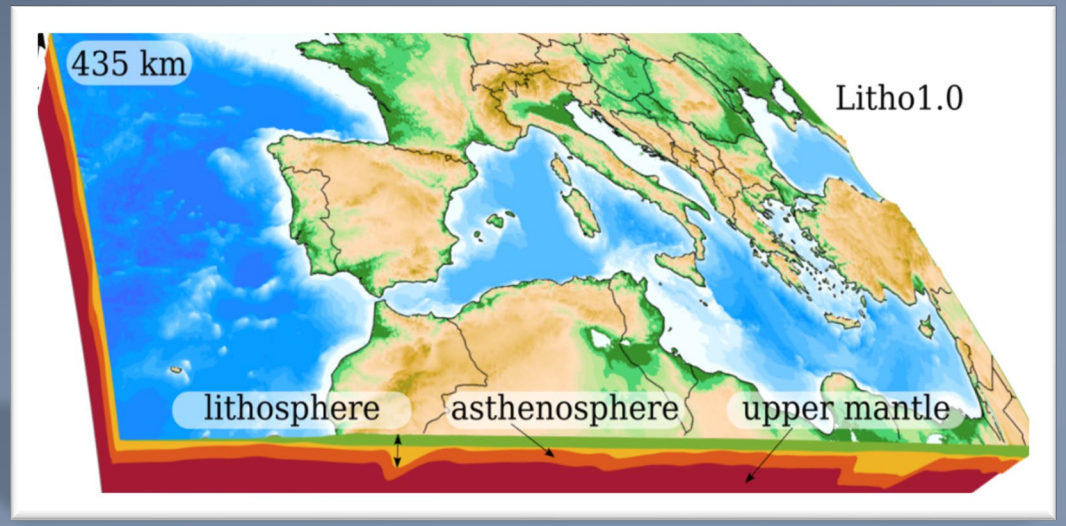


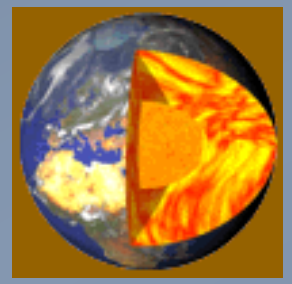


Schaeffer & Lebedev 2013

Global Earth reference model LithoRef18

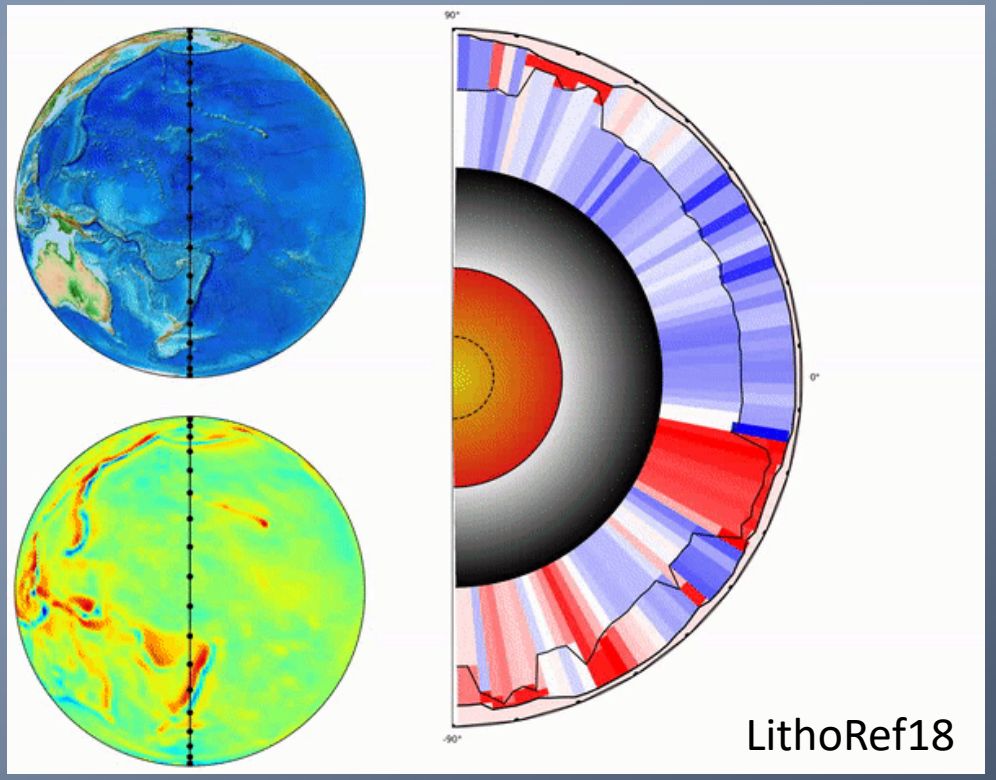




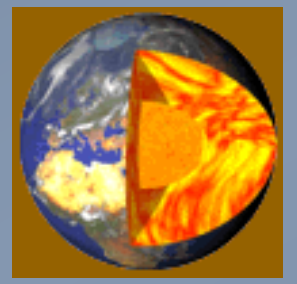


Example of a Global Solid Earth model

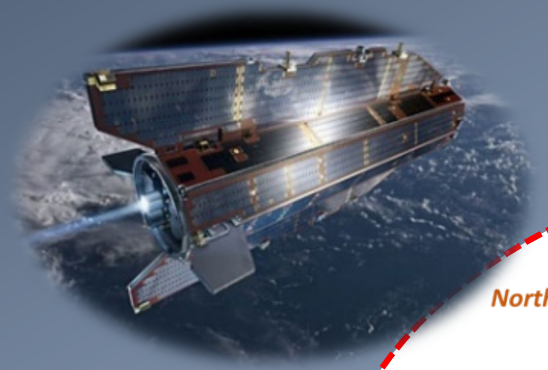
- Resolution of 2 degree
- Blocky structure due to parametrisation
- Fits purpose, not what we need for full coupling



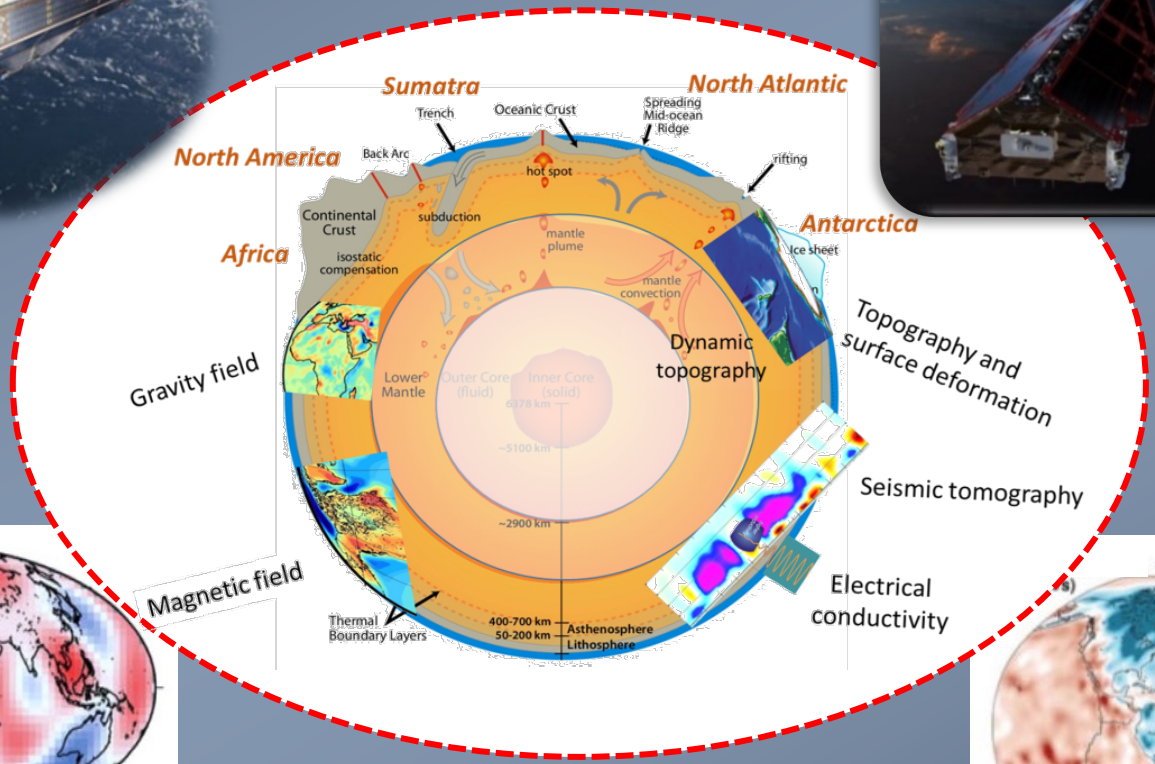
3D Earth: Integrated thermochemical imaging of the Earth…



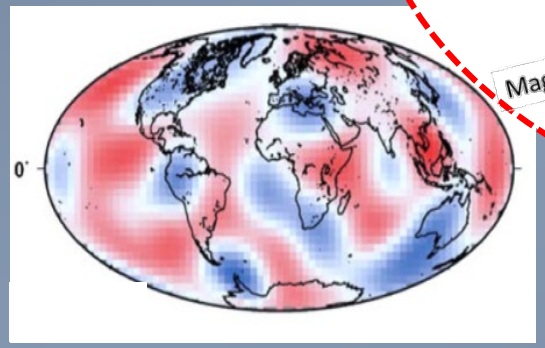
Gravity (GOCE & GRACE)



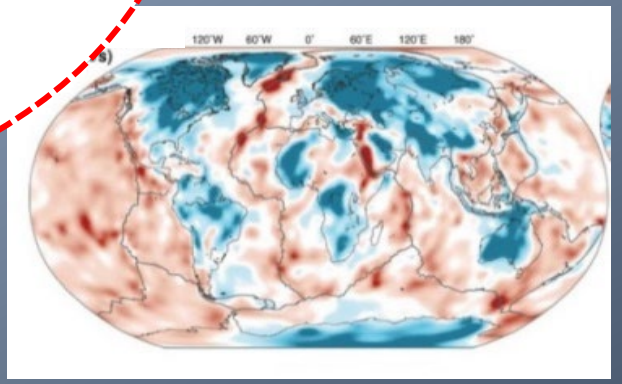
Magnetic field (Swarm)



Electromagnetics



Seismology



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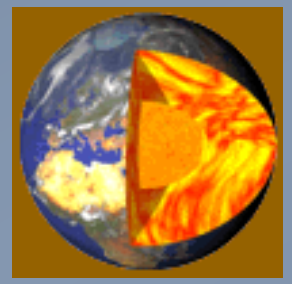
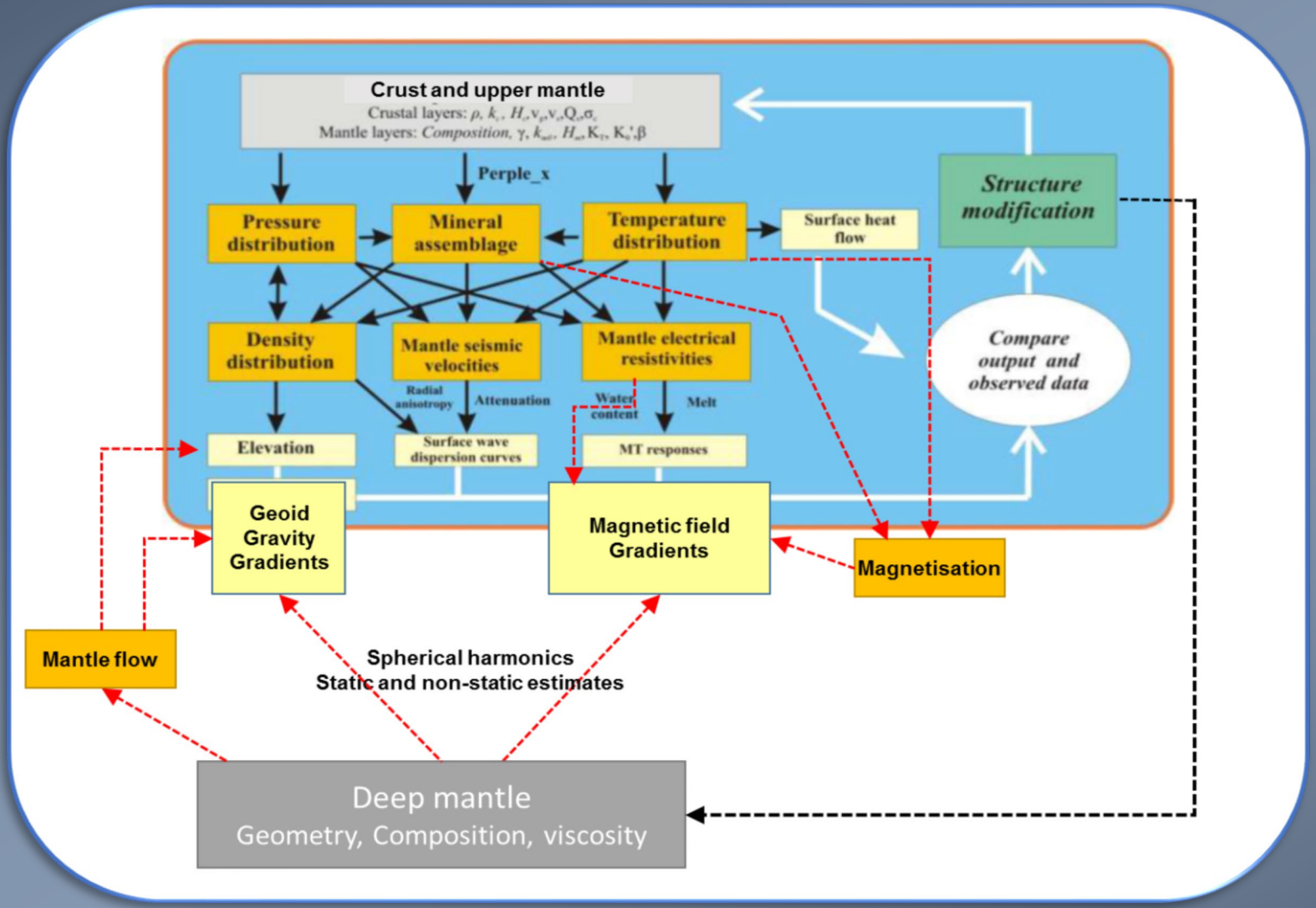
The 3D Earth simulator





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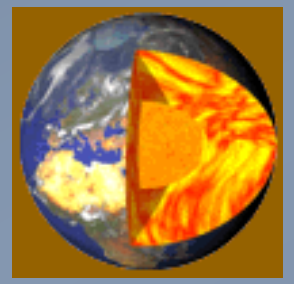
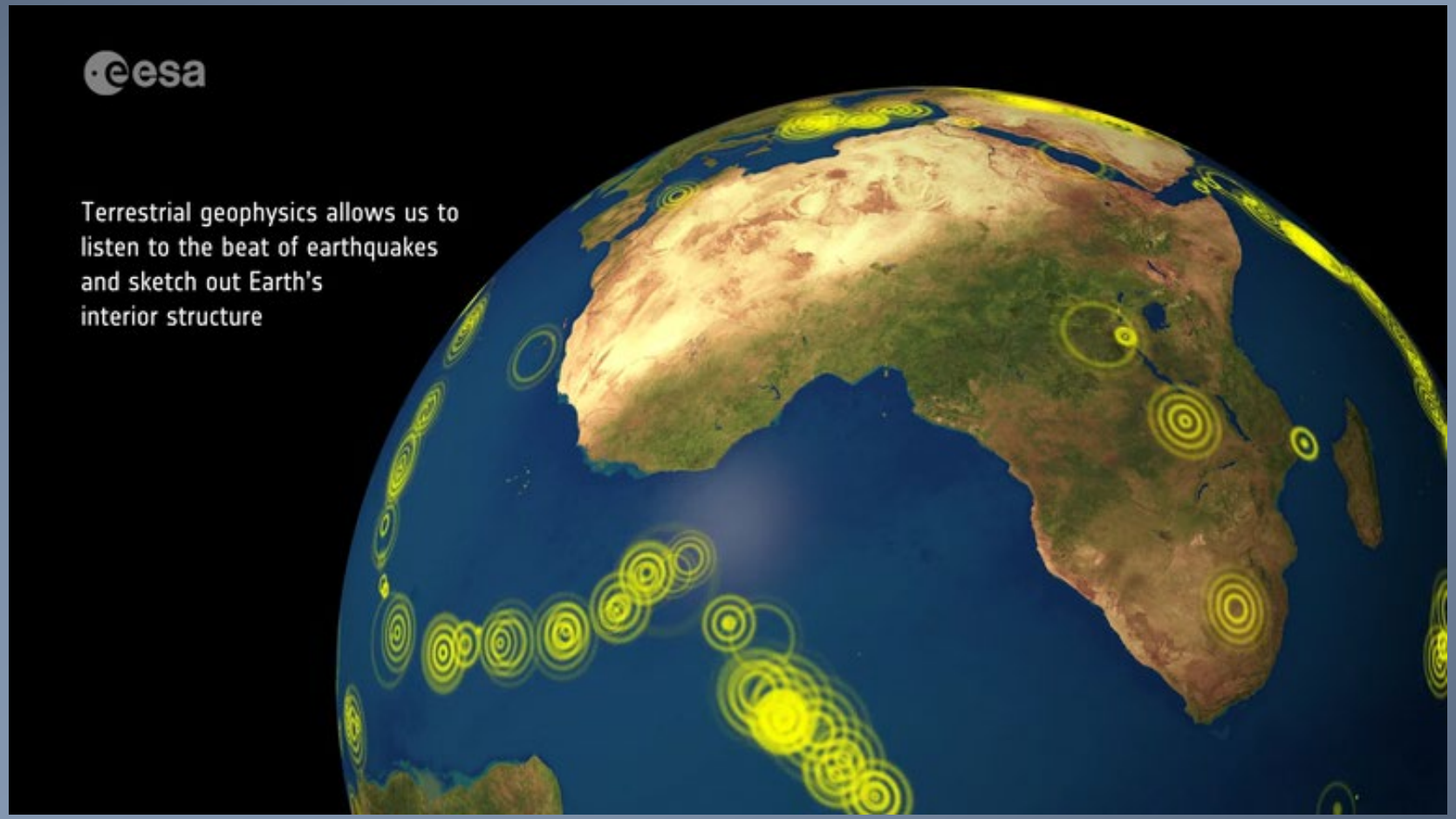
3D Earth - The first global reference model of crust and upper mantle based on joint inversion of seismology and satellite gravity





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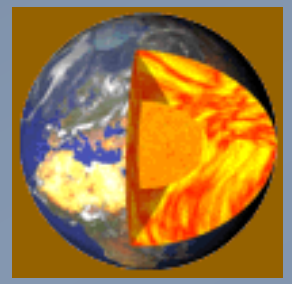

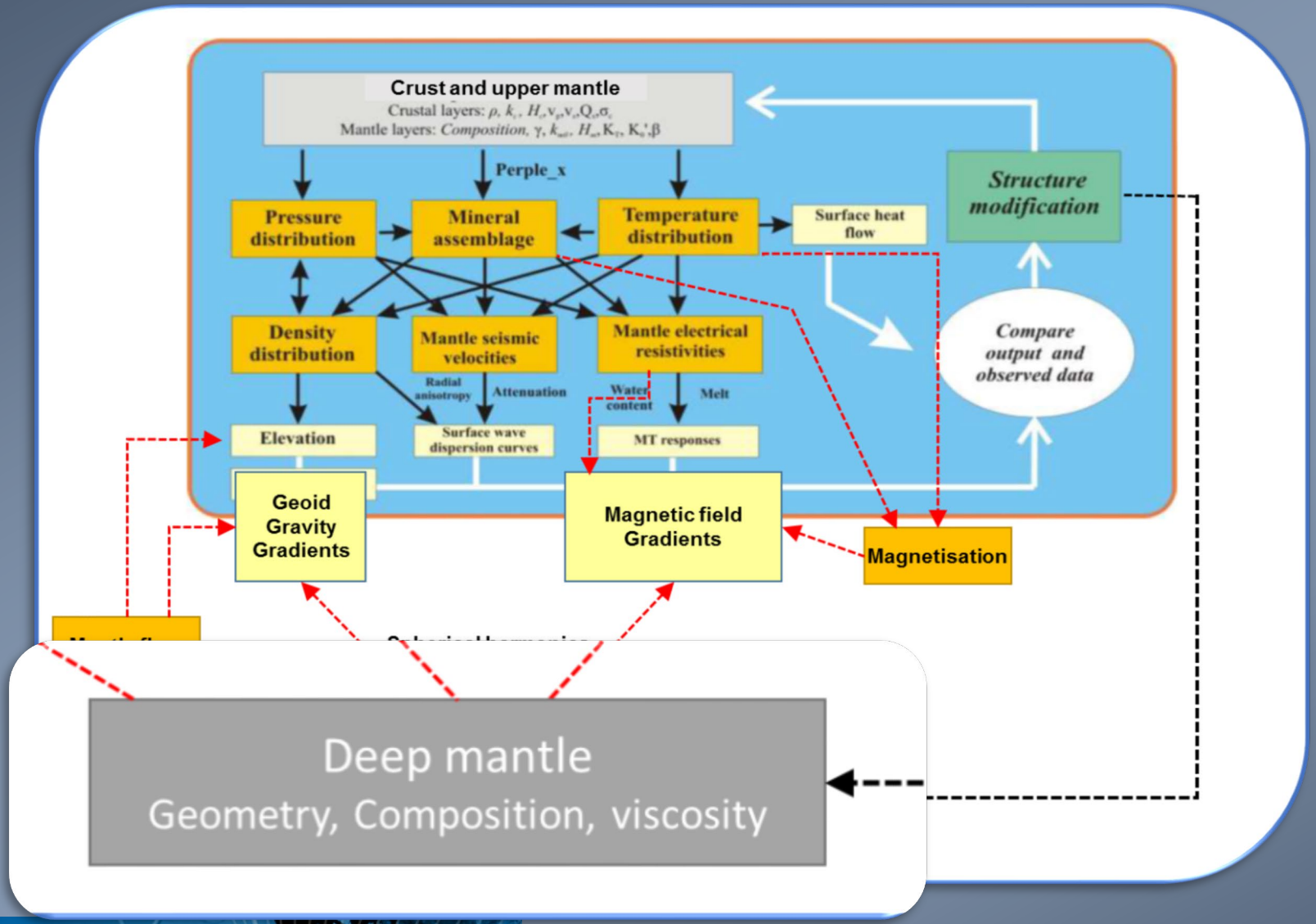

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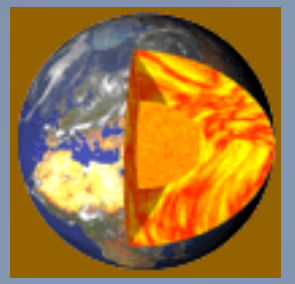
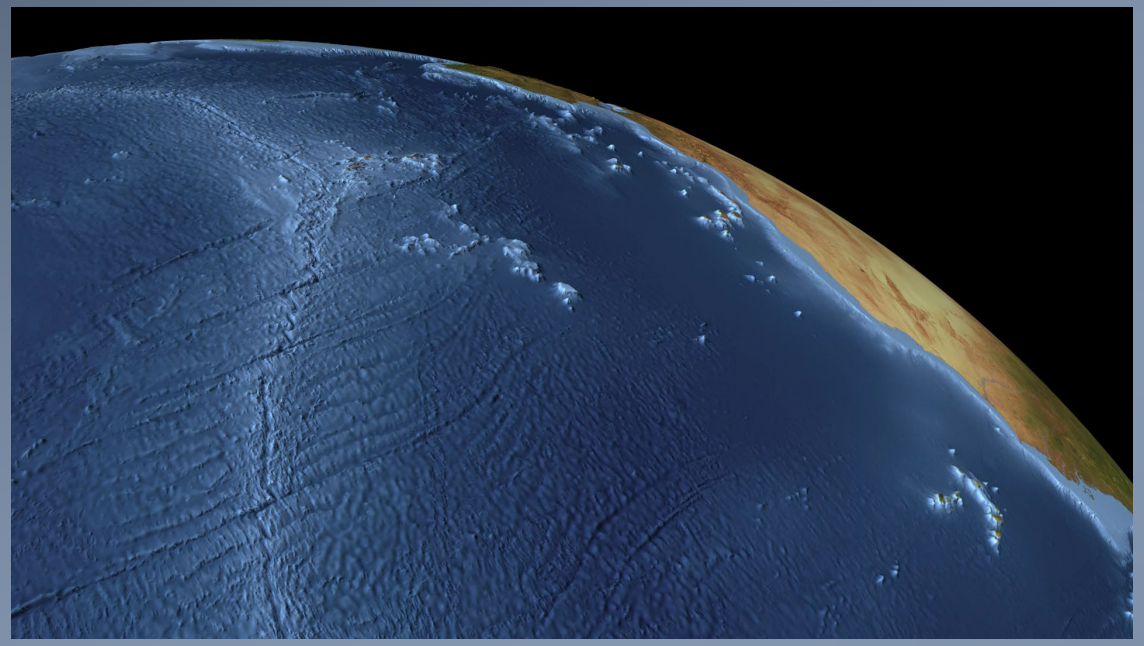
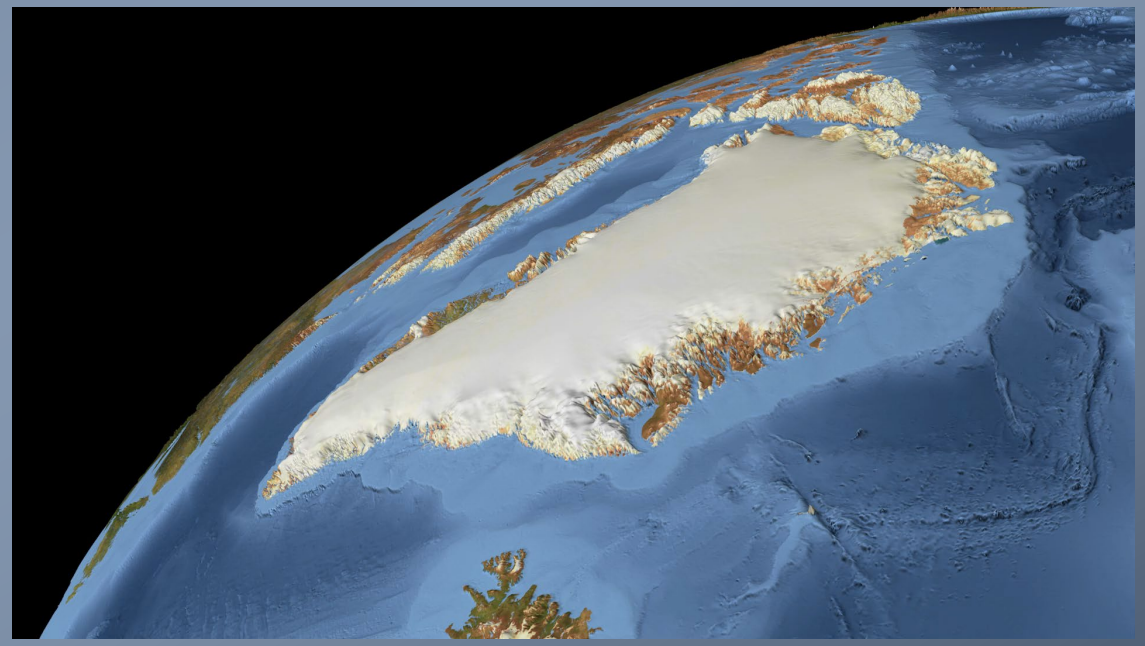
Linking the deep Earth to the surface



Tracing the source of the
La Palma eruption



Understanding geothermal heat
and basal melt in Greenland



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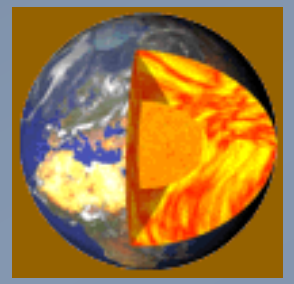
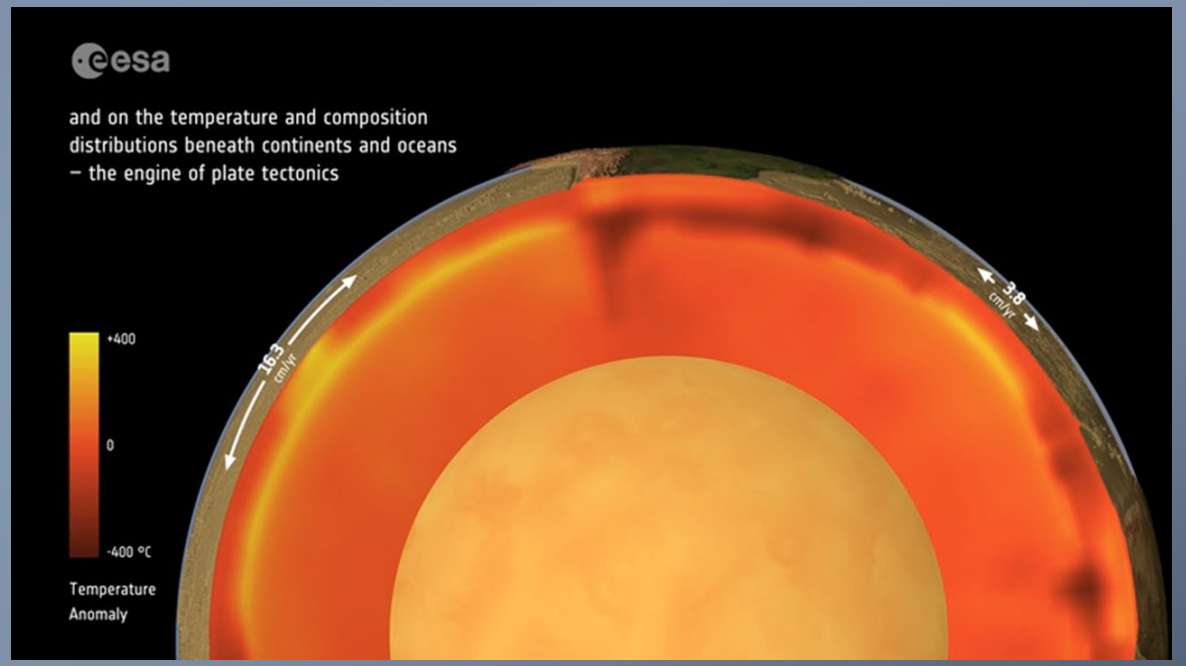
Why do we need a Digital Twin of the Geosphere?



What we have:

- **3D Earth Simulator as 1st Generation Digital Twin**
- Fully consistent global 3D model of the upper Earth structure from combining satellite mission data with other geophysical data



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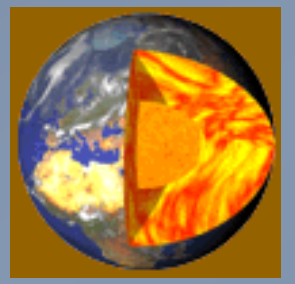
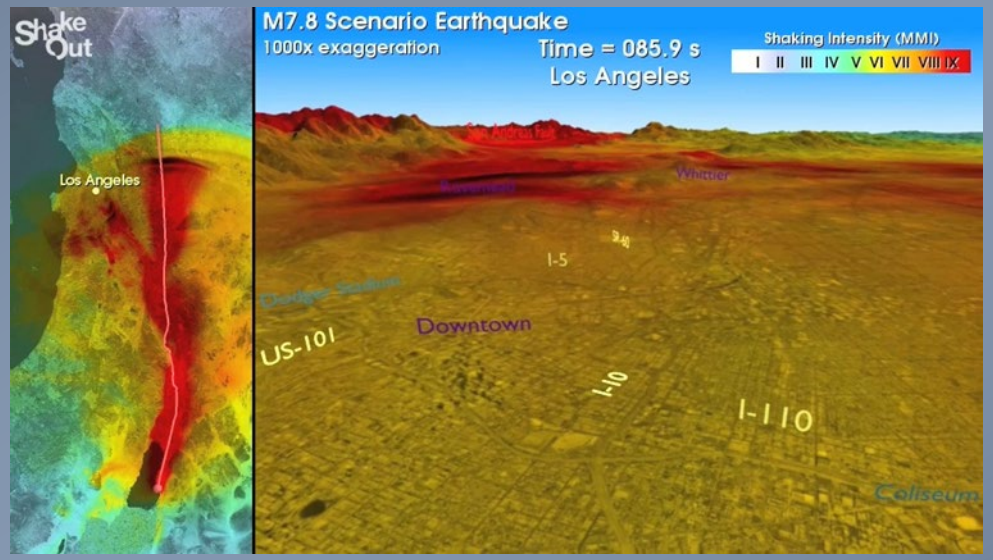
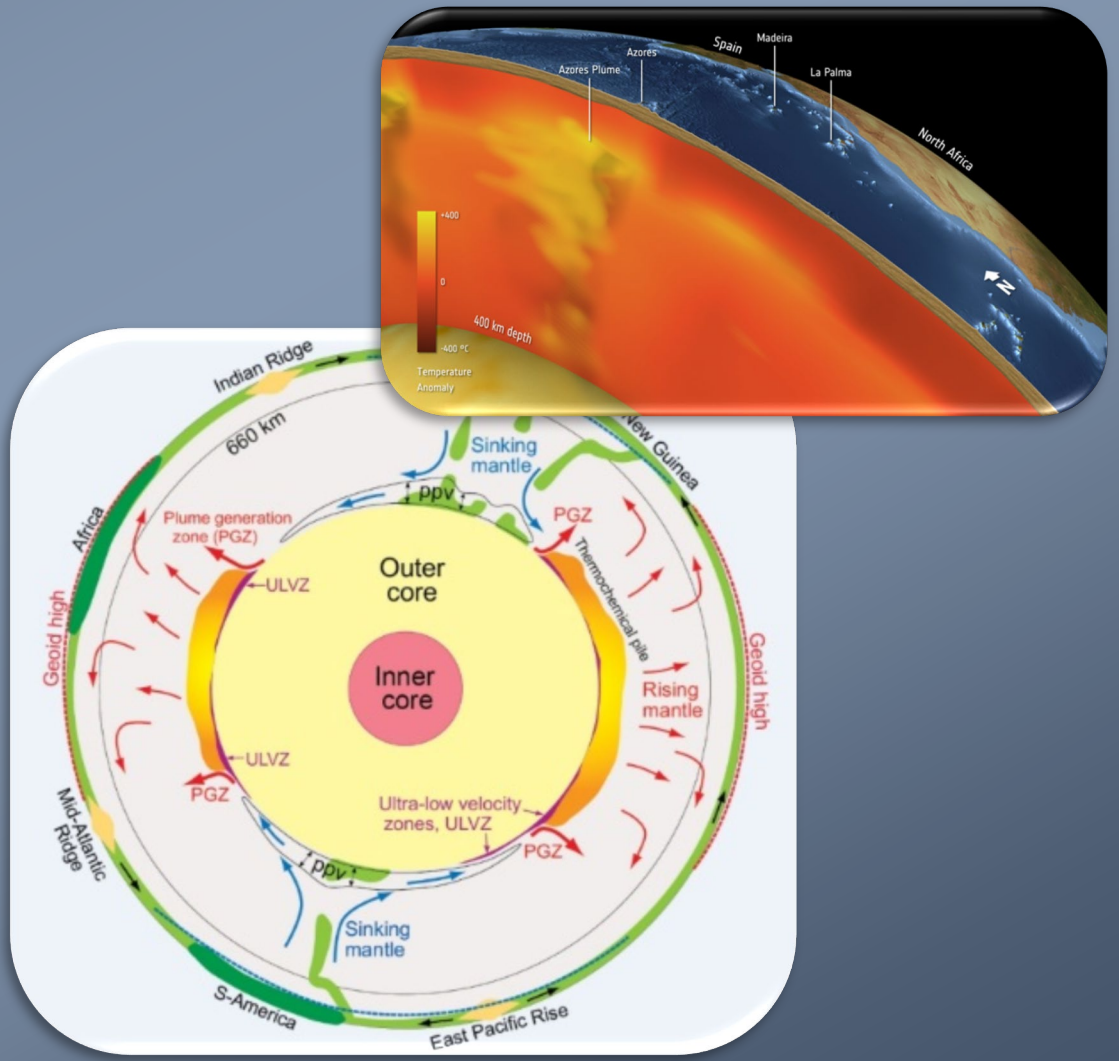


What we need:

- Fully consistent global 3D model of the entire Earth, linked to observed dynamic processes -> Scalability





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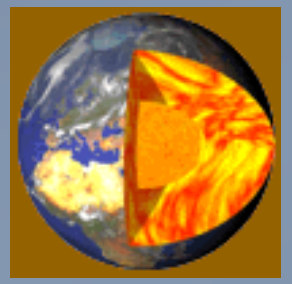
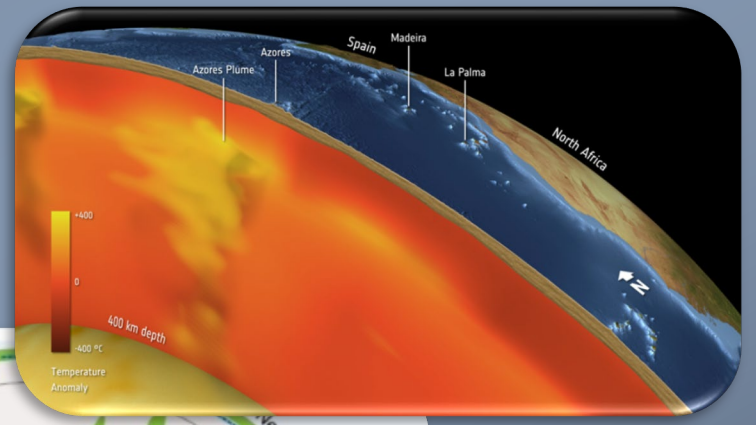
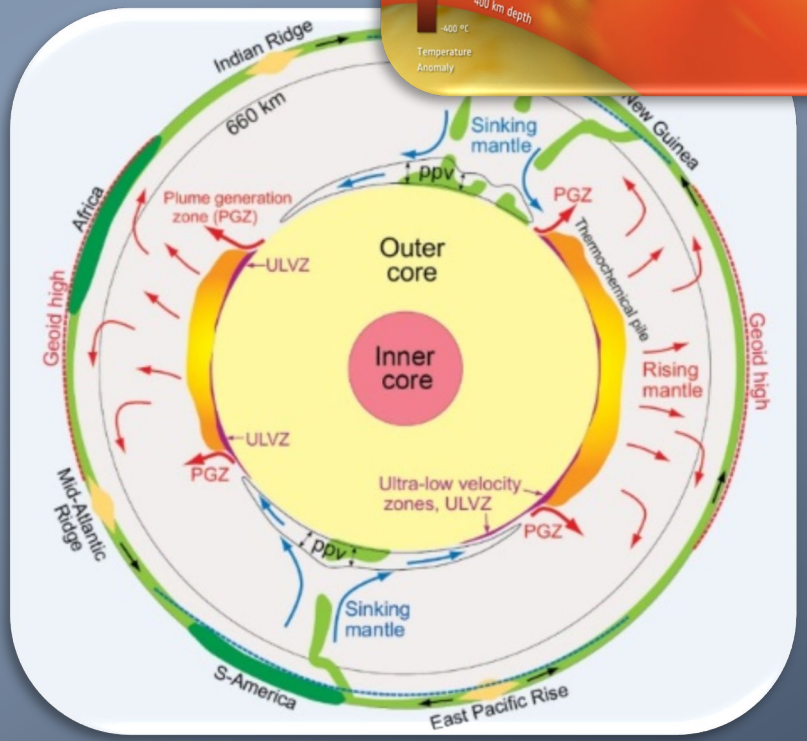


What we need:

- Fully consistent global 3D model of the entire Earth, linked to observed dynamic processes -> Scalability
- 3D viscosity model of the Earth, supporting GIA and other deformation studies -> Applications





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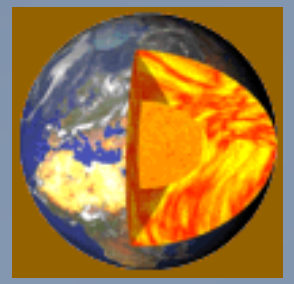
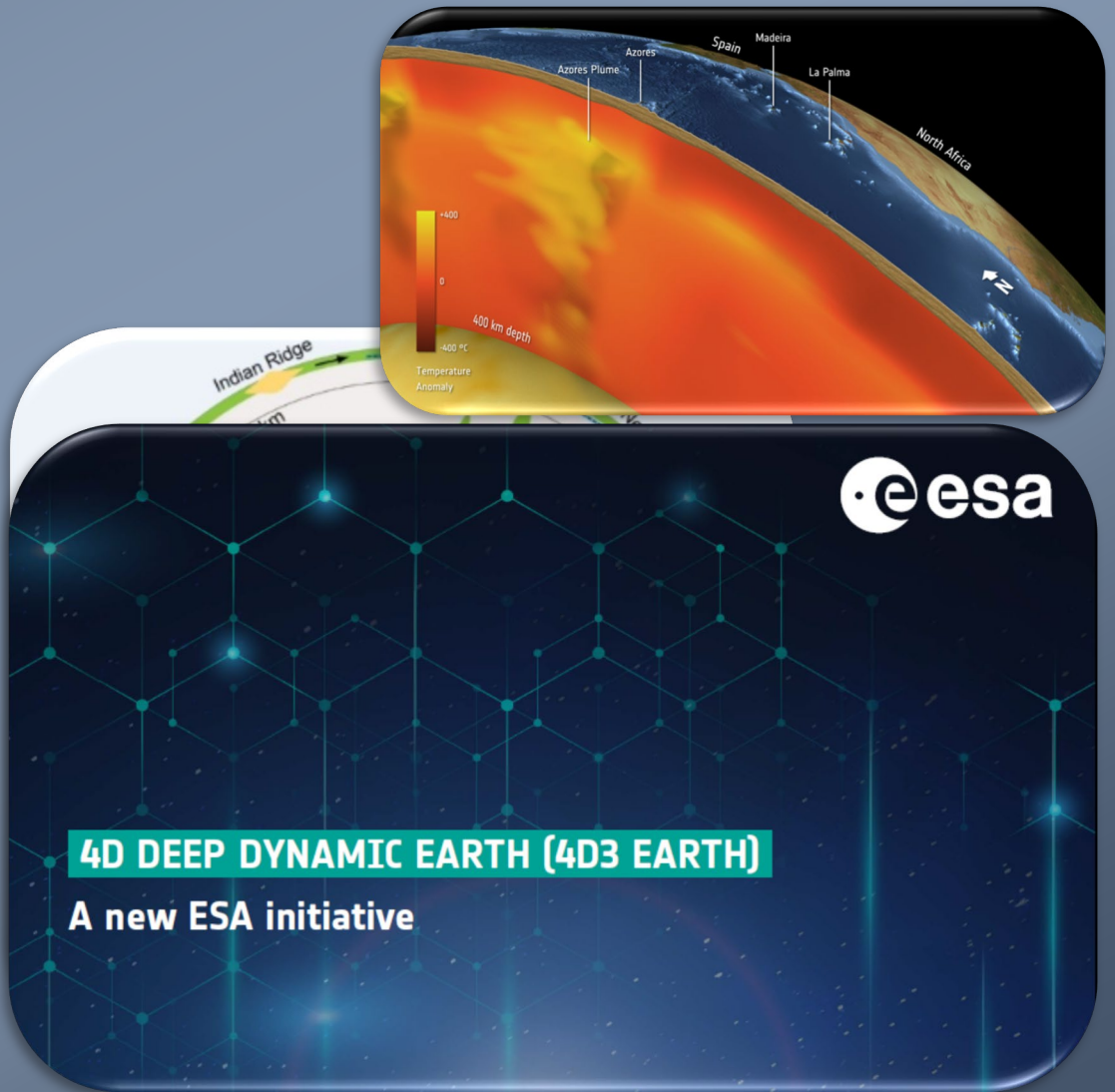
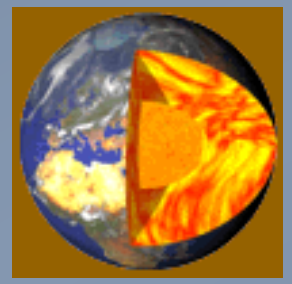


What we need:

- Fully consistent global 3D model of the entire Earth, linked to observed dynamic processes -> Scalability
- 3D viscosity model of the Earth, supporting GIA and other deformation studies -> Applications
- First order model of CMB characteristics that fit seismology, gravity, and core flow studies -> Extensions



Conclusions and outlook



3D Earth Simulator as 1st Generation Digital Twin

Current simulator is consistent with various global data sets

- Background/Reference model for local applications
- Provides outputs to study coupling of geosphere with surface, ocean and ice

4D Deep Dynamic Earth

- Extension to core-mantle boundary

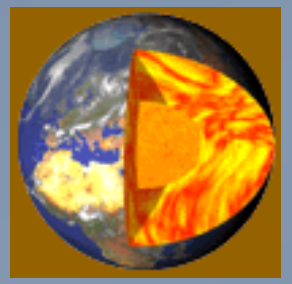
➢ 3D viscosity which must be in agreement with mantle convection and postglacial rebound

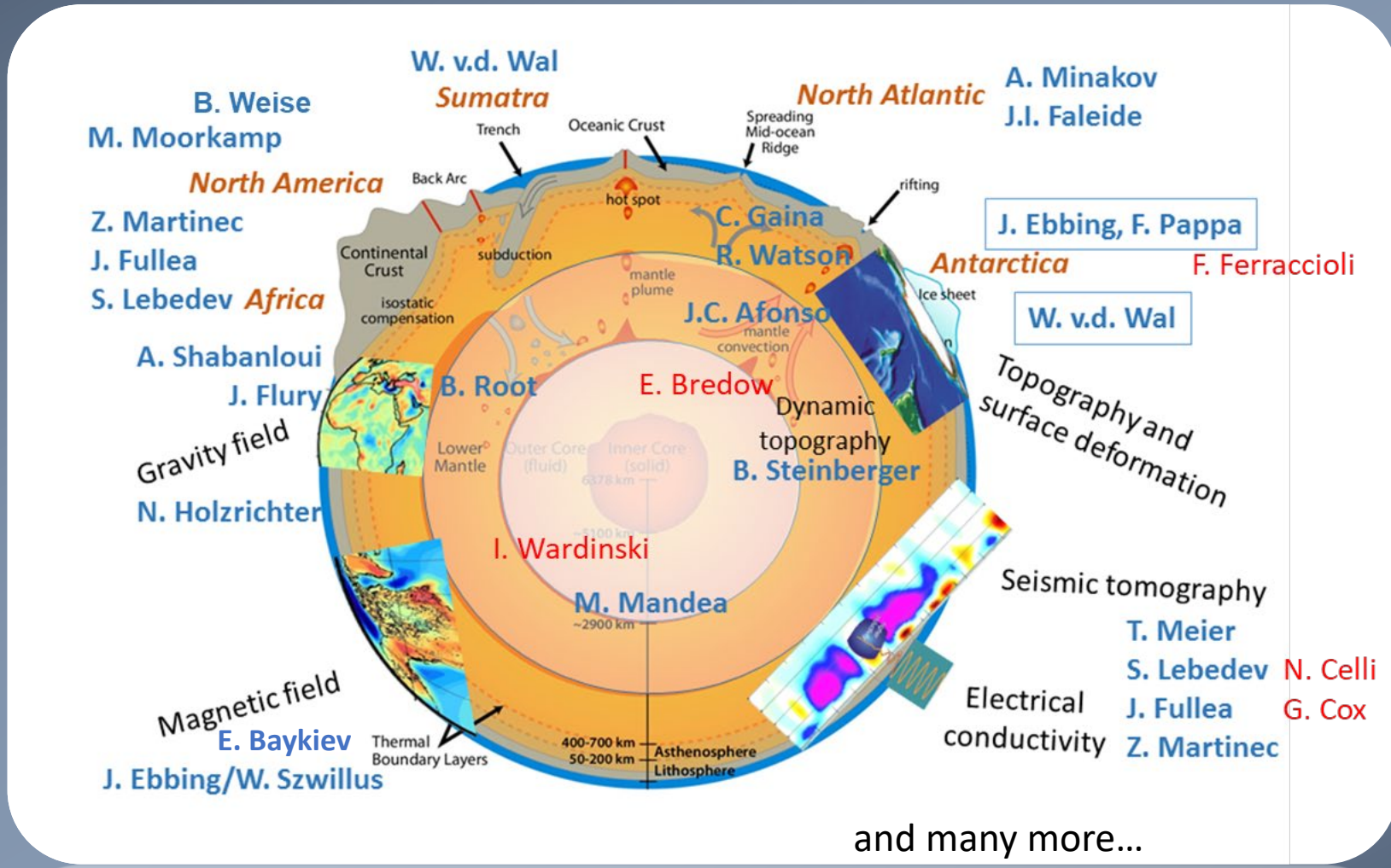
Full Digital Twin requires

- Adaptive multi-resolution mesh in line with data availability and applications

Acknowledgments

esa support to science element
European Space Agency





and many more…

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