Simulating and Visualising the Earth as a Dynamic System

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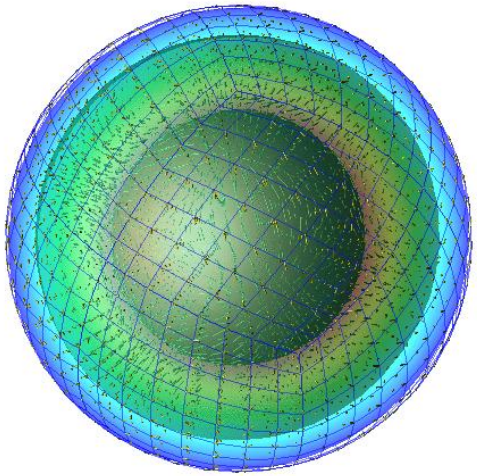
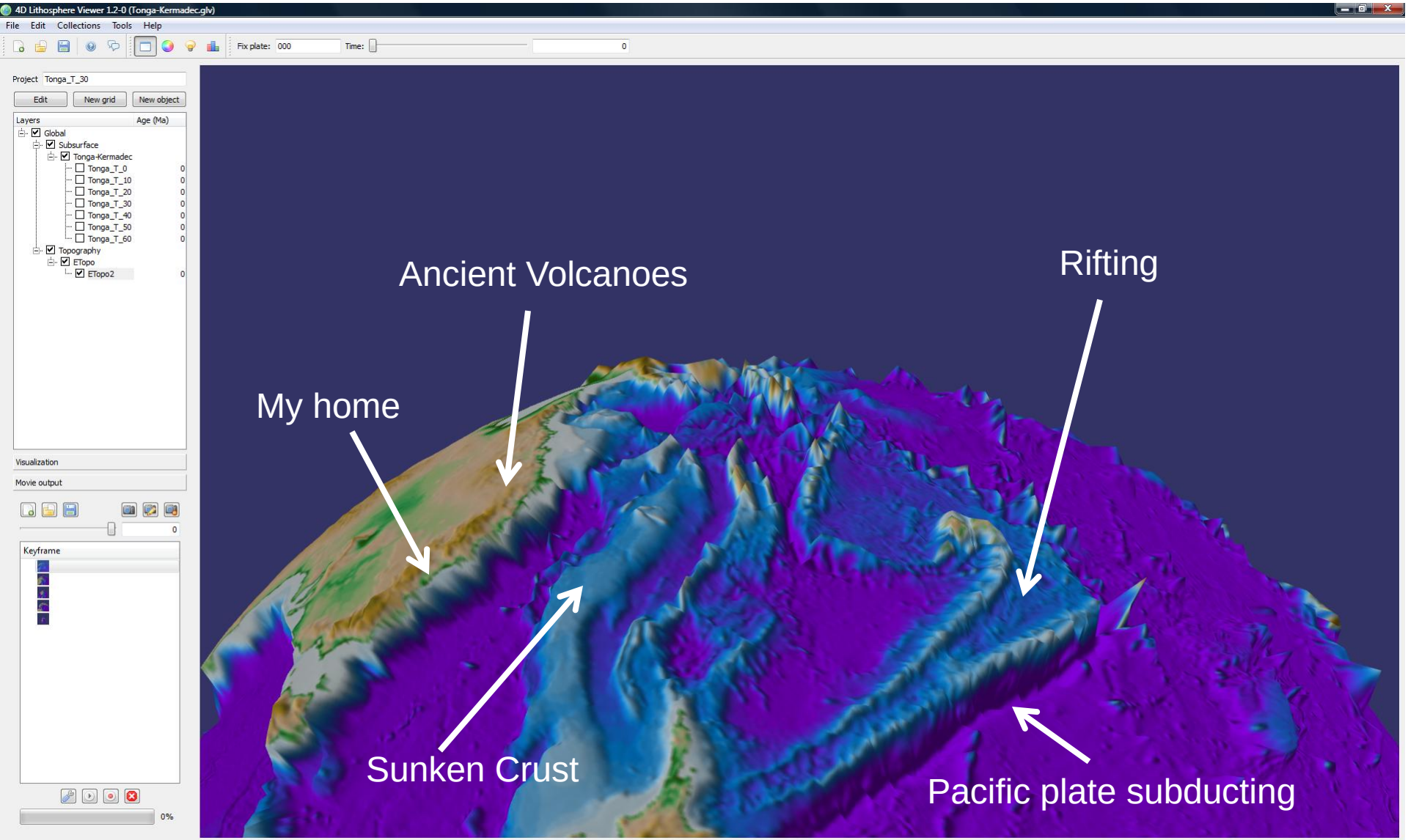


The dynamic history of the Earth is represented on its surface



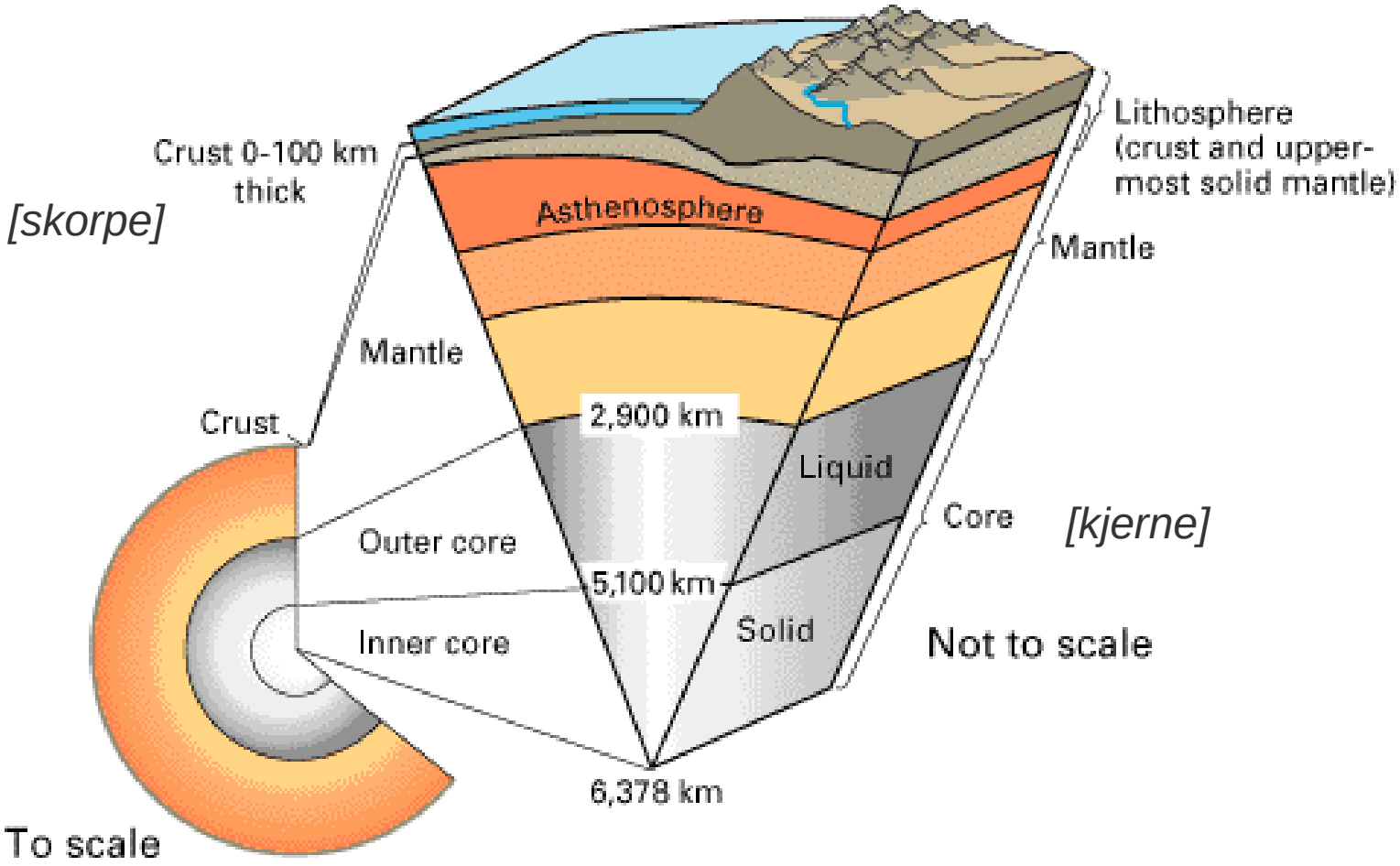
The objective of my talk is for you to see the connections between High School Science and Geodynamics

Newton's second law of motion <-> Fluid Dynamics

Newton's law of cooling <-> Mantle Convection & Erosion

Geophysics is a Visually Stimulating Science!

The surface is mostly shaped by plate tectonics, driven by the mantle, driven by the core



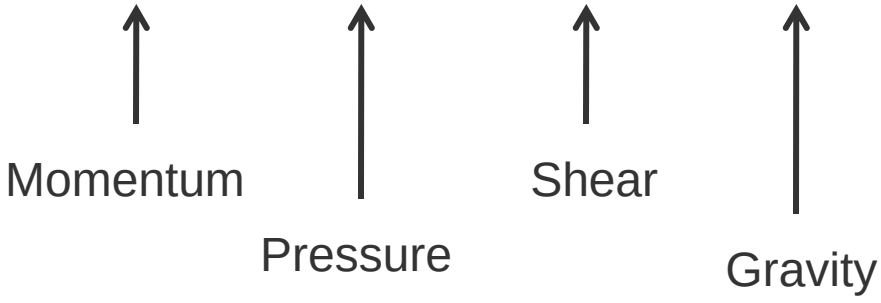
A little physics goes a long way...

Newton's Second law of motion

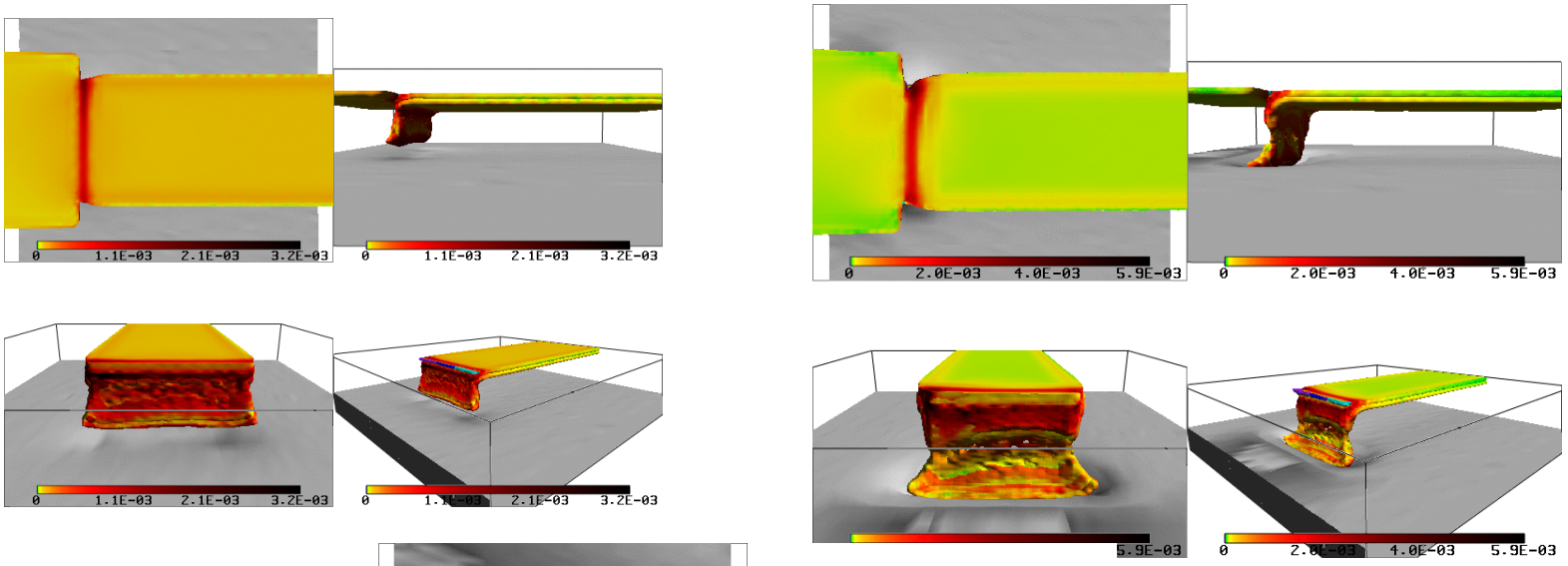
$$m\frac{d\boldsymbol{v}}{dt} = F_{net}$$

Leads to the Navier-Stokes Equation

$$\rho\frac{Dv}{Dt} = -\nabla p + \nabla \cdot \tau_{ij} + \Delta\rho g\hat{\boldsymbol{z}}$$



Subduction is an interplay between plates, their interfaces and the mantle



Top

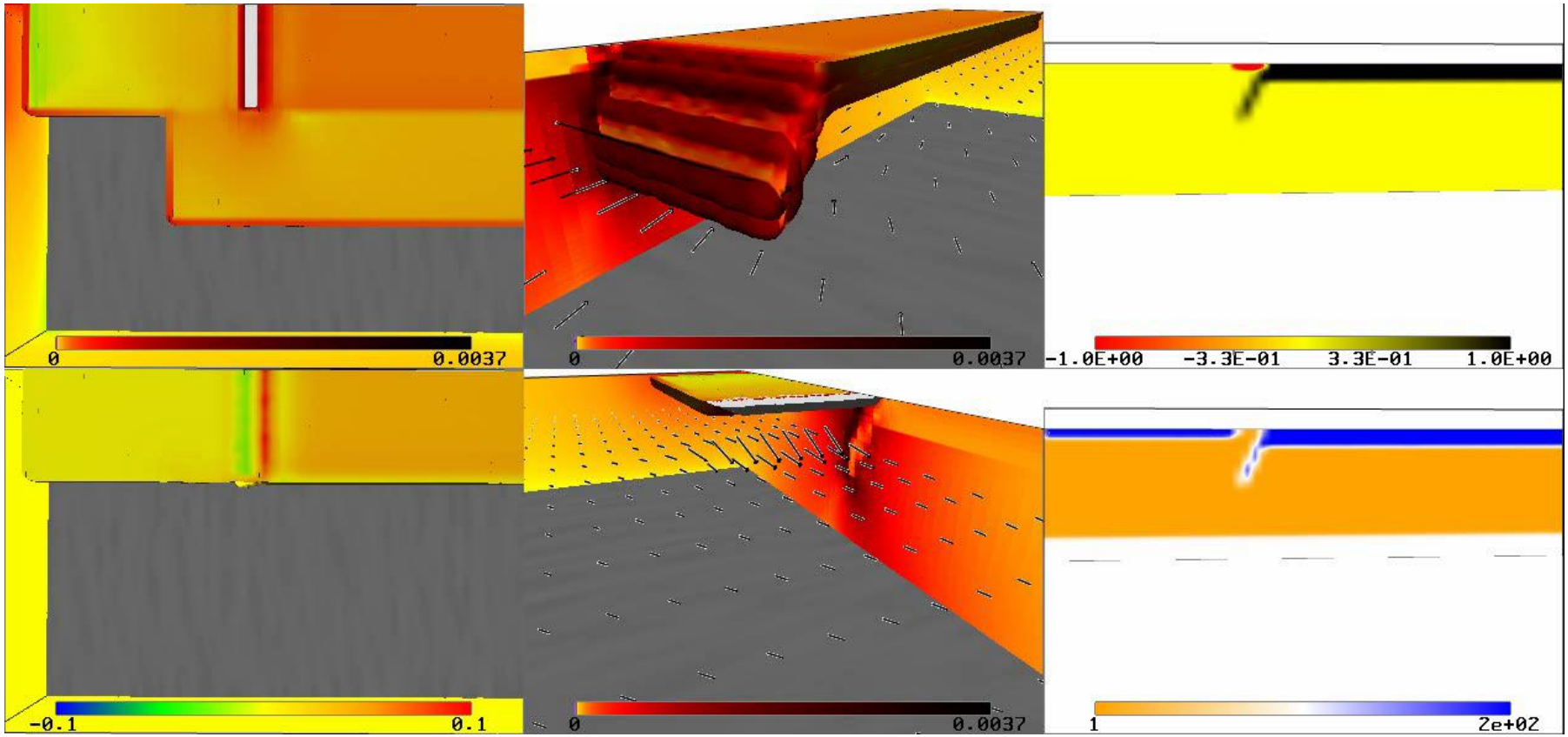
Side

Subducting plate

Perspective

Views [utsikt]

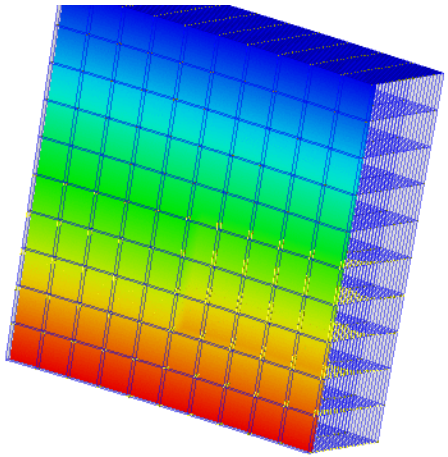
A slice through the subducting slab shows its development



Temperature in the Mantle controlled by advection-diffusion

Advection [*ta med*]

$$\frac{\partial T}{\partial t} = -\vec{u} \cdot \nabla T + \nabla^2 T$$

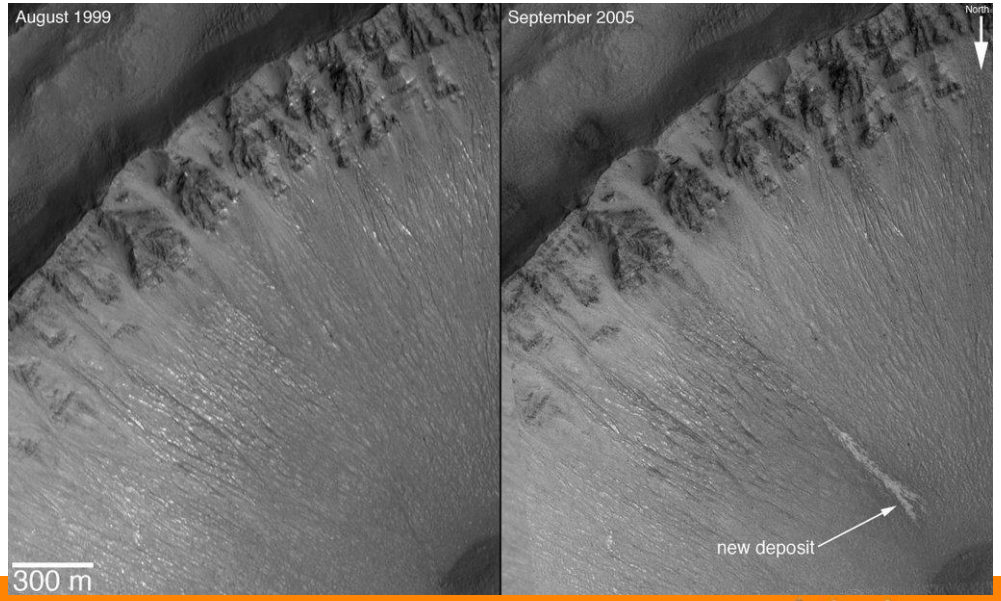


Temperature

Diffusion [*sive ut*]

Badlands, Mojave National Preserve (courtesy USGS)

Endurance Crater, Mars



Mars' Centauri Montes crater (courtesy NASA/JPL/Malin Space Science Systems)

Erosion is also modelled by diffusion, using the "heat equation"

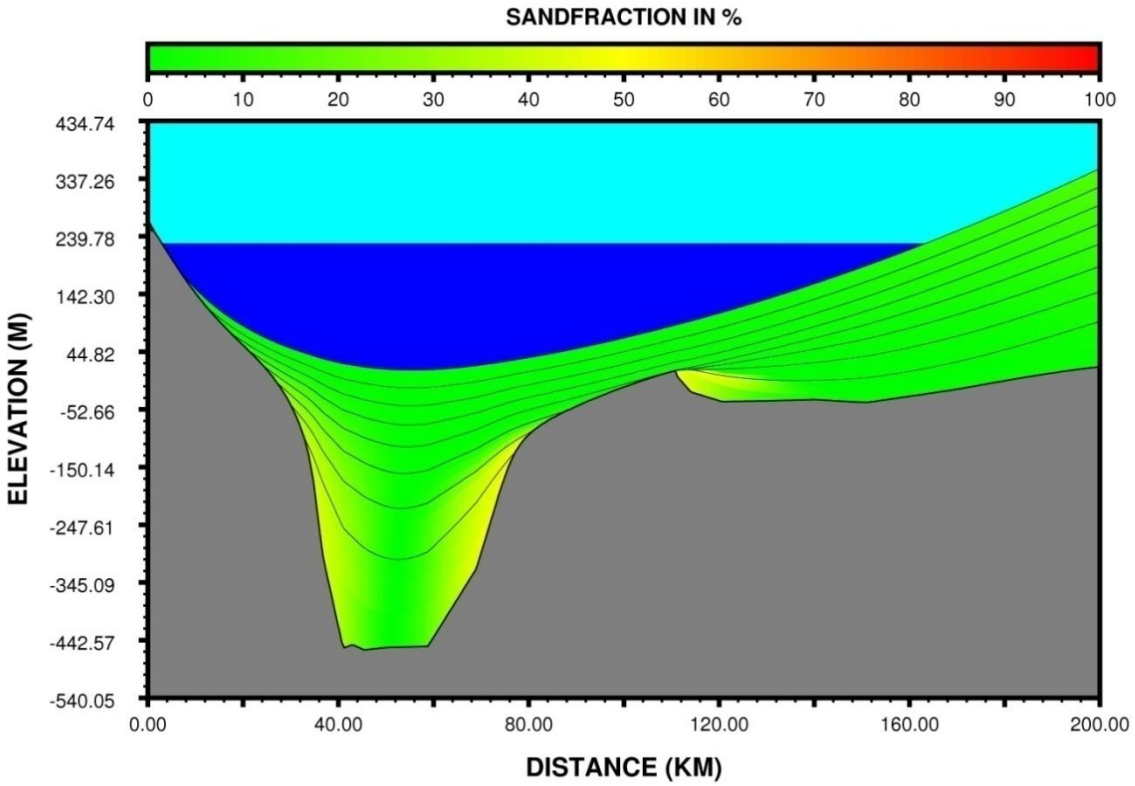
$$\frac{\partial \boldsymbol{h}}{\partial t} = \nabla \cdot (K \nabla \boldsymbol{h})$$

Potential driving the equation is the gradient

Height

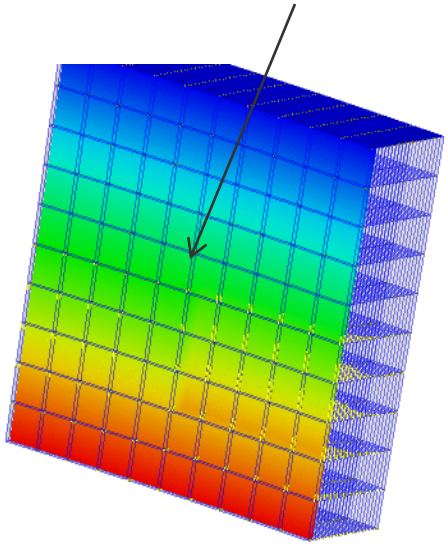
Coefficient

Speed of transport

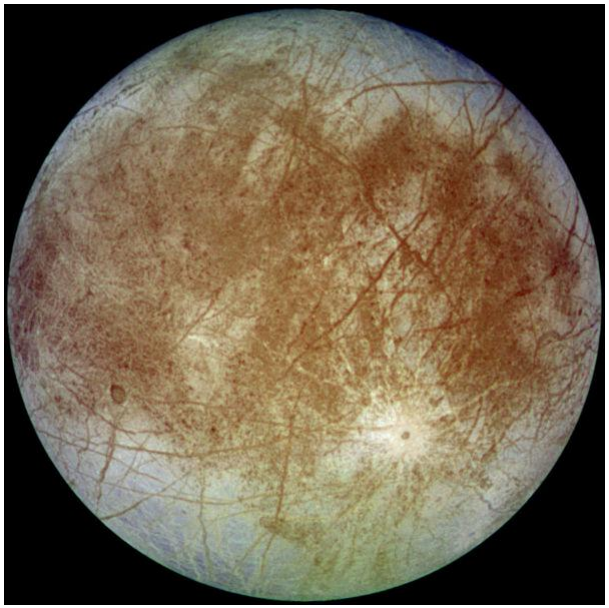


Surface structures on Europa may be predominately caused by convection of a ice shell

Lineament developing

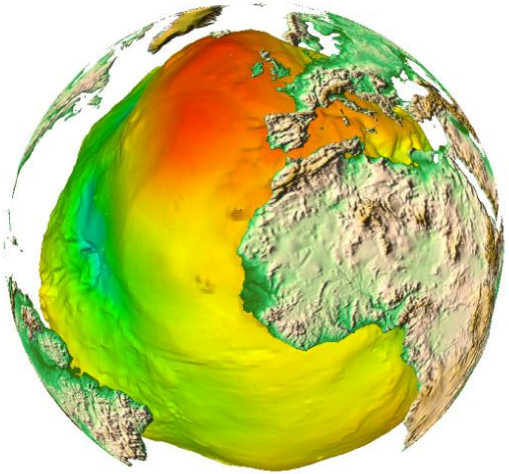


Ice convection

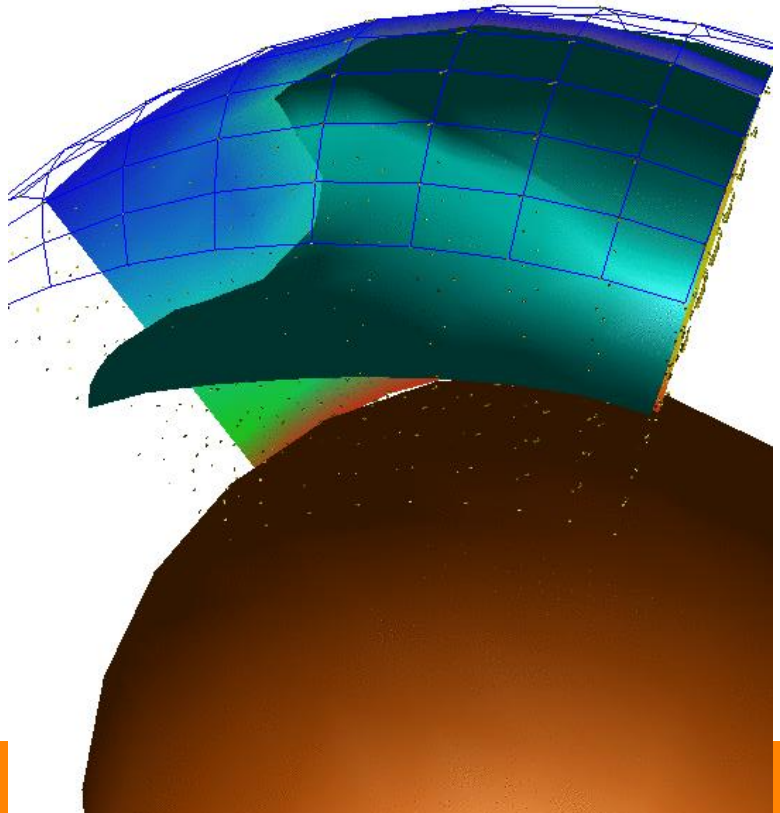


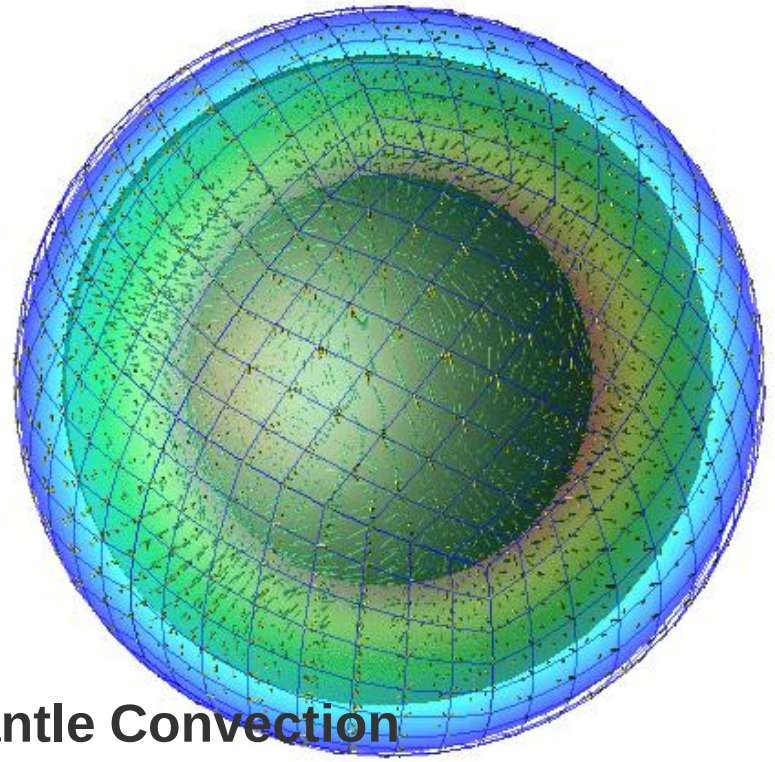
Europa, one of Jupiter's Moons

Plumes arising from the core impact the surface as long-lived features



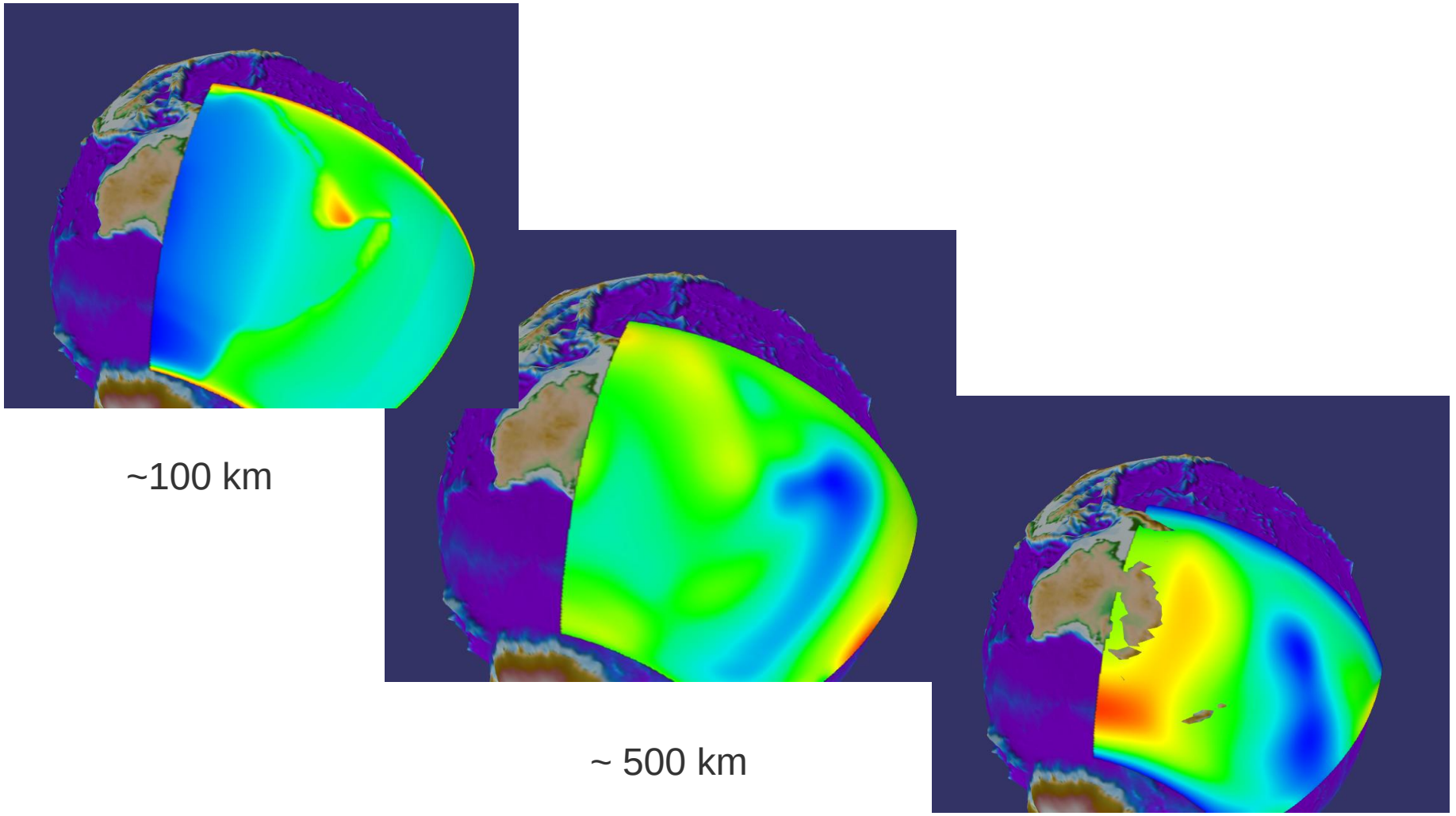
Geoid height





Mantle Convection

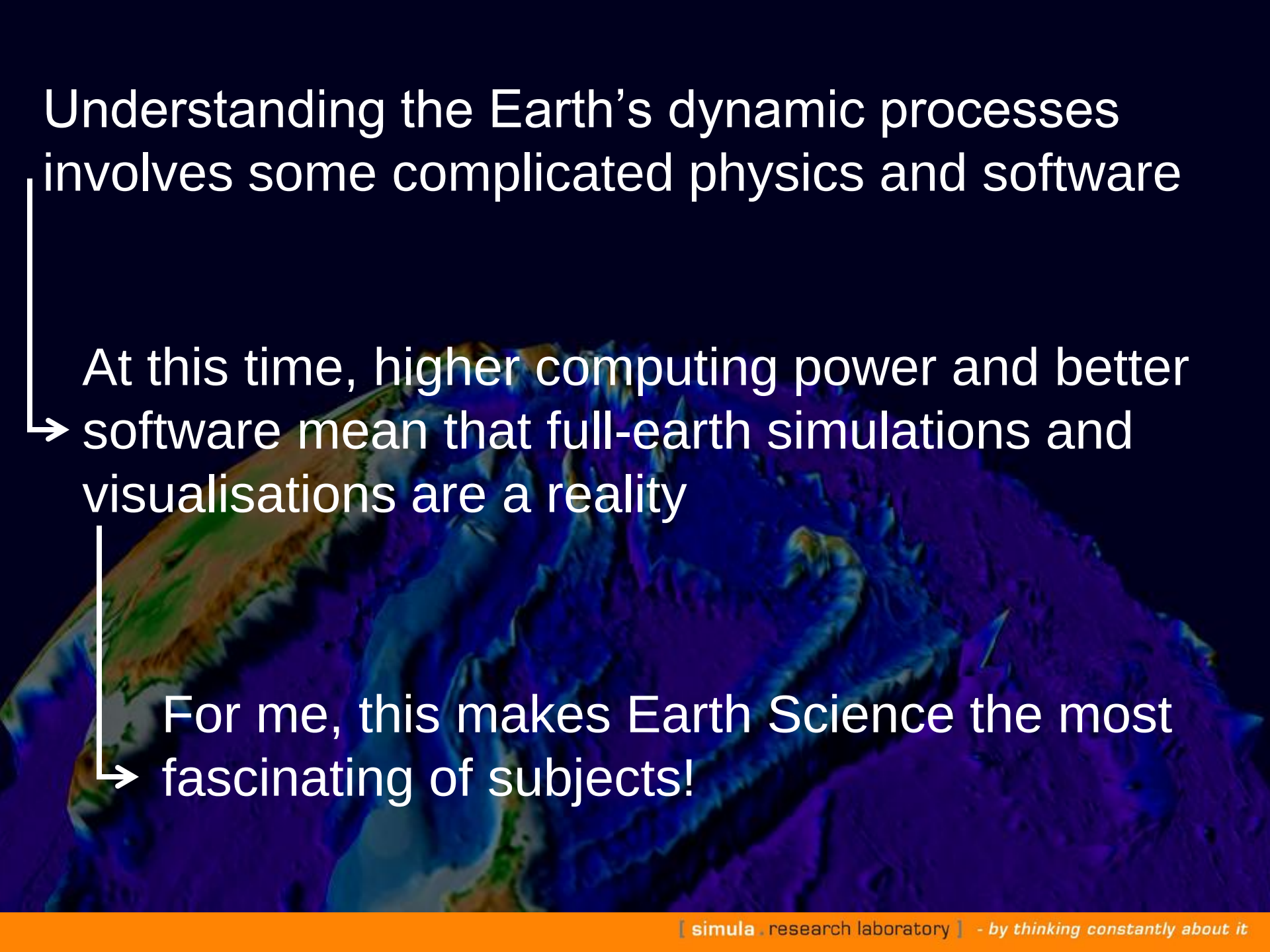
Flow in the mantle can cause subsidence [*nedtrykt*] or uplift [*oppstå*]



~100 km

~ 500 km

~ 1000 km



Understanding the Earth's dynamic processes involves some complicated physics and software

- At this time, higher computing power and better software mean that full-earth simulations and visualisations are a reality
  - For me, this makes Earth Science the most fascinating of subjects!