Integrated geophysical-petrological modelling of the Eifel region

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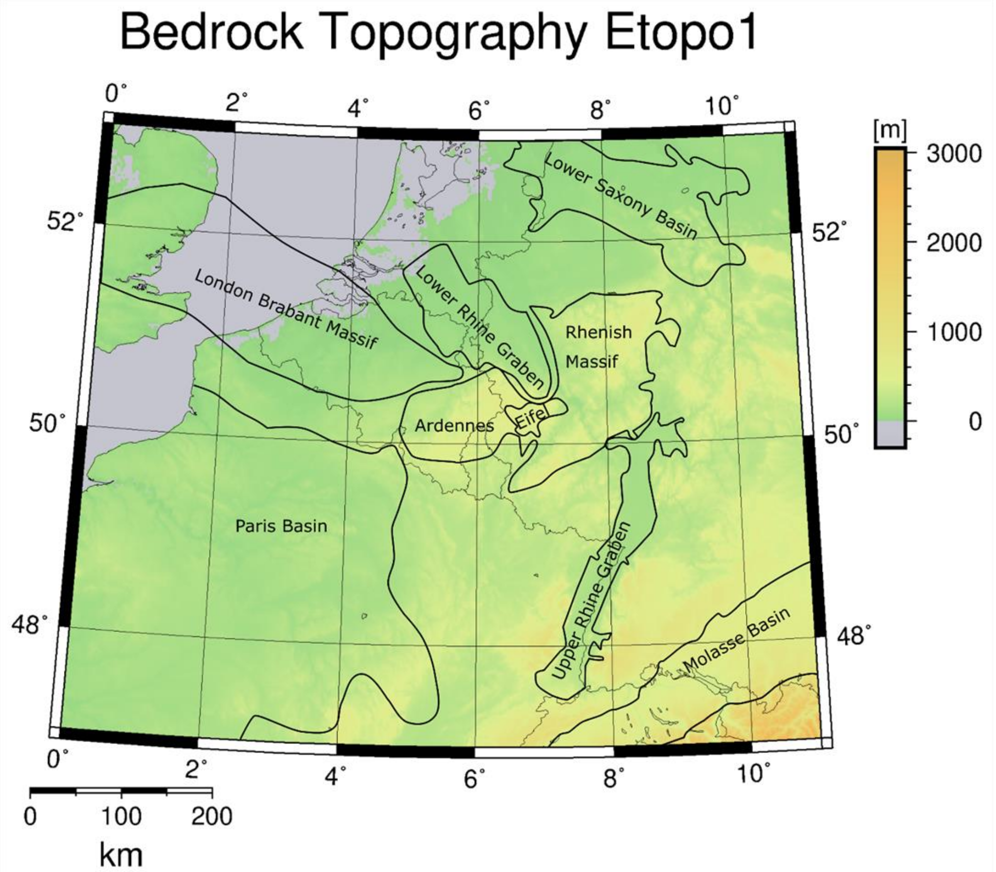
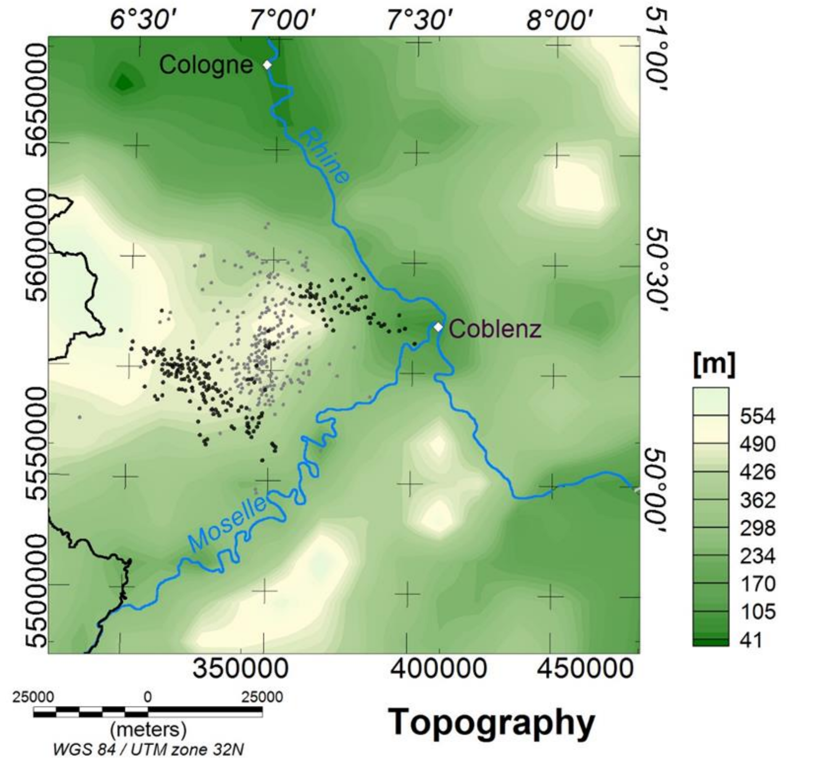
Introduction





- the Eifel is a volcanic active region in the west of Germany
- it exhibits two distinct activity phases: the Tertiary and the Quaternary phase

- 300 Tertiary eruption centres in the Hocheifel (grey dots)
- 350 Quaternary eruption centres in the West- and Easteifel (black dots)

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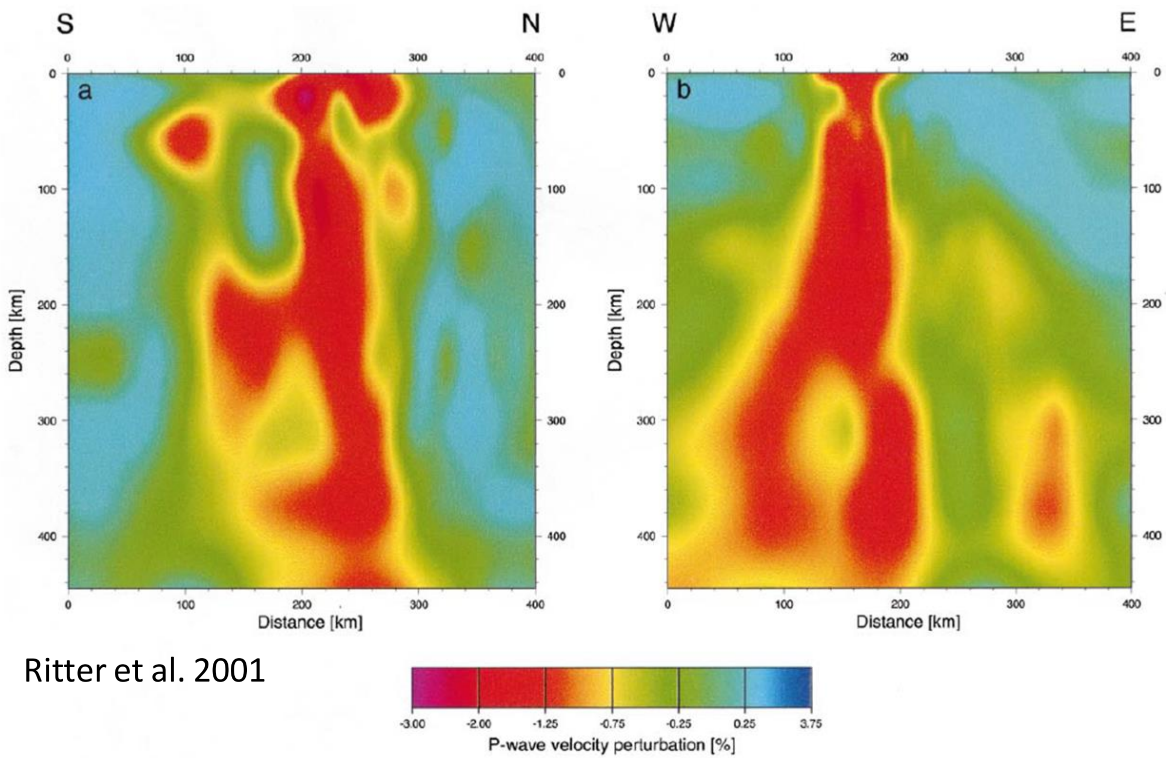
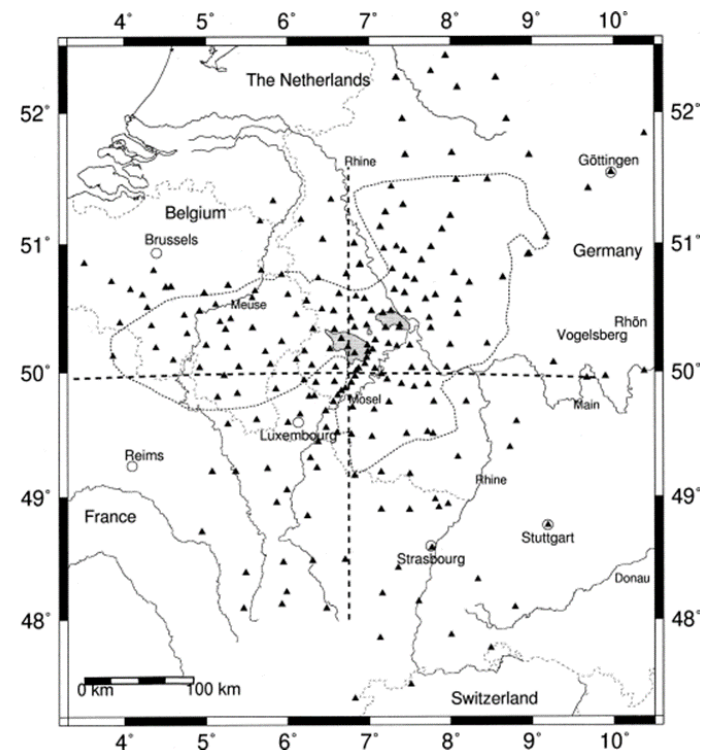
A plume?



Ritter et al. 2001



- a teleseismic traveltime tomography from Ritter et al. 2001 shows a low velocity anomaly (LVA) beneath the Eifel up to 400 km depth

- they suggest a upper mantle plume as source for the Eifel volcanism

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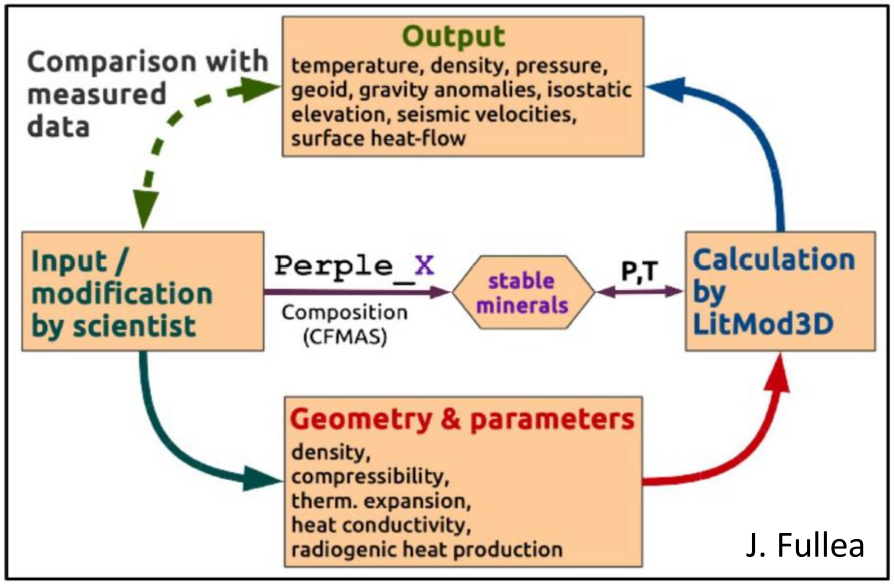
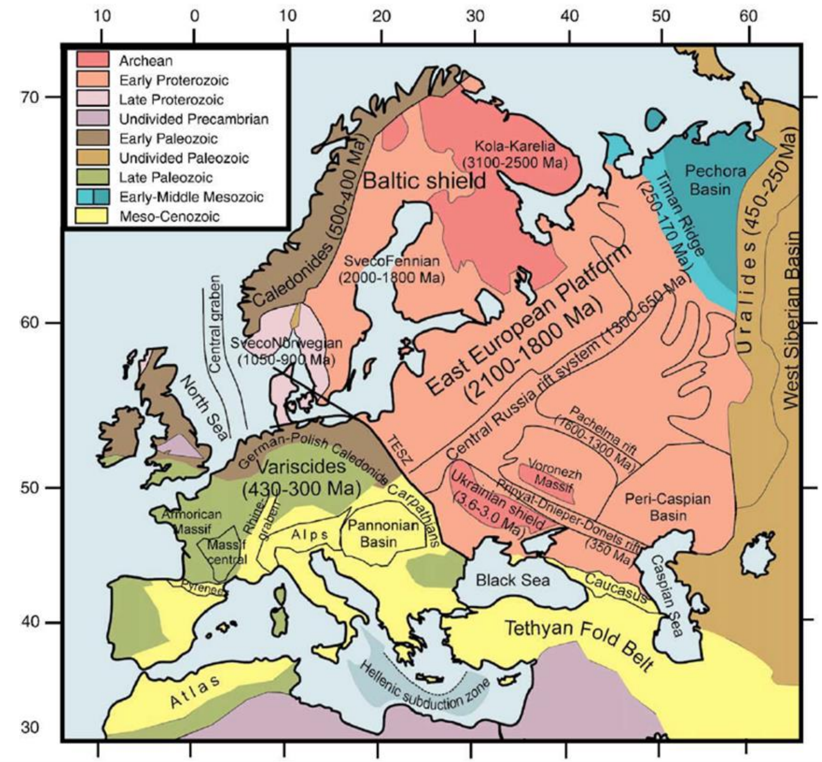
Methods

- we performed integrated geophysical-petrological lithospheric modelling with LitMod3D (Fullea et al. 2009)
- calculation of compositional files with Perple X (Conolly 2005)
- dispersion curve calculation with Mineos (Masters et al. 2011)





Artemieva et al. (2006)

- the model has a lateral resolution of 0.1° and goes down to 400 km with 2km vertical resolution

- we used a Phanerozoic composition for the subcontinental lithospheric mantle, because of the age of the overlying crust

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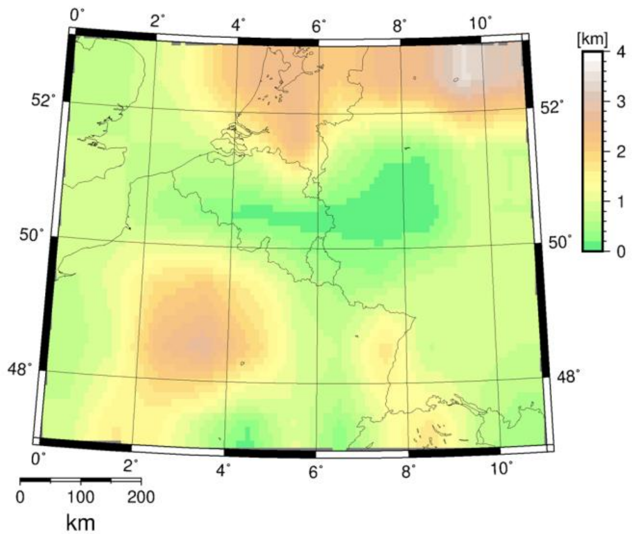
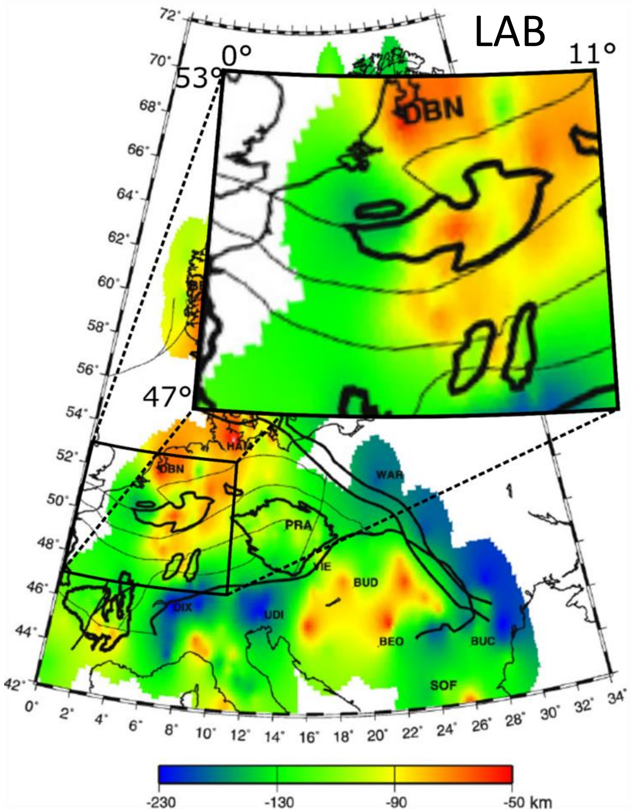
Data

Sediment thickness Crust 1.0



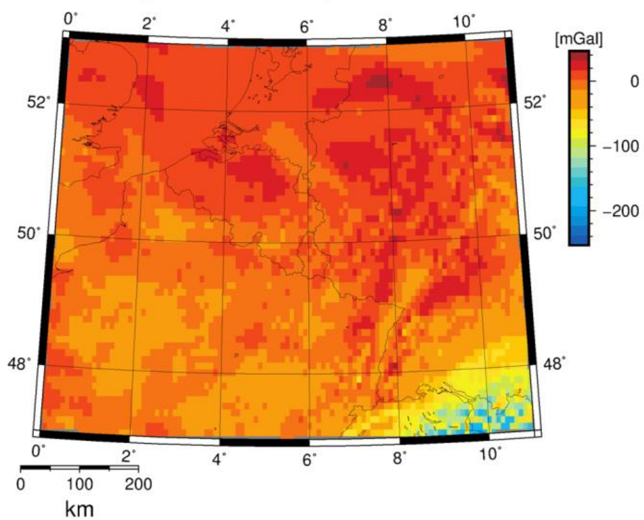
- the Moho depth is a compilation from Budweg 2002 & Grad et al. 2009

- for the Lithosphere-Astenosphere boundary (LAB) no digital dataset was available – the modelling was started with a constant LAB depth

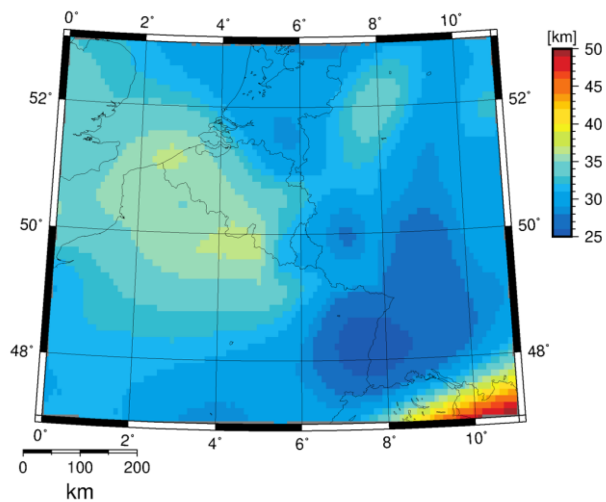


Plomerová and Babuška (2010)

Bouguer anomaly XGM2016



Moho depth Budweg & Grad et al. 2009



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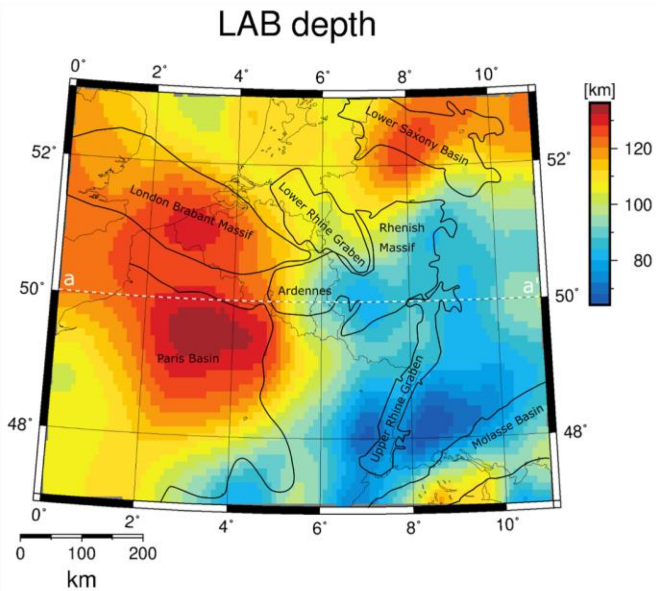
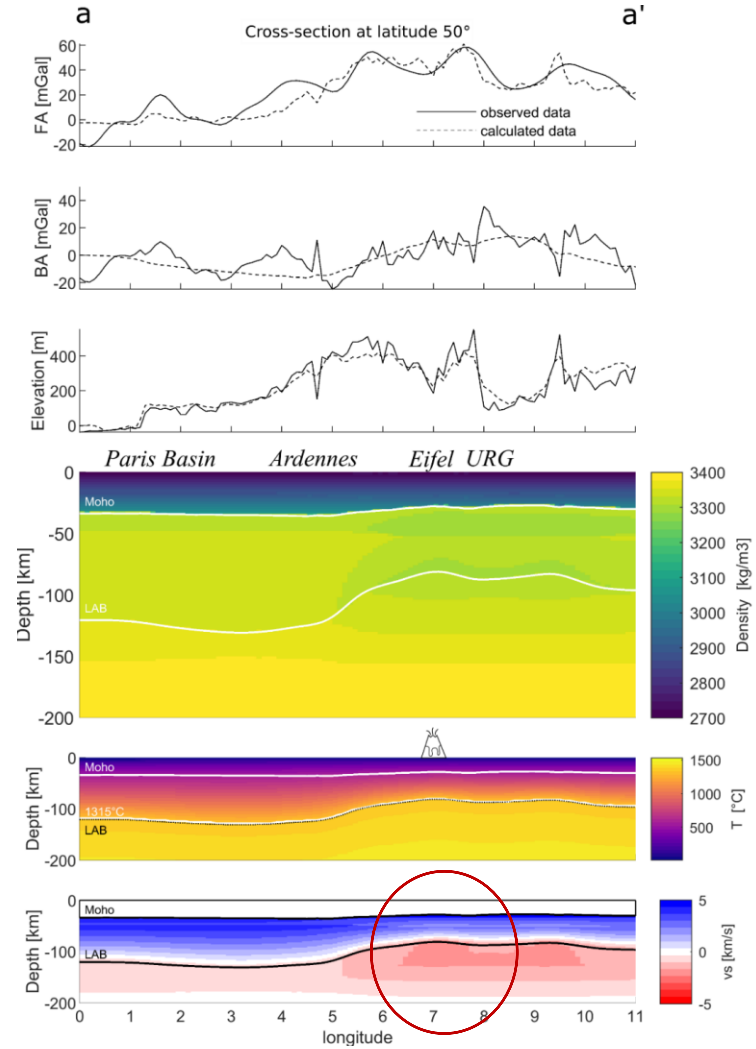
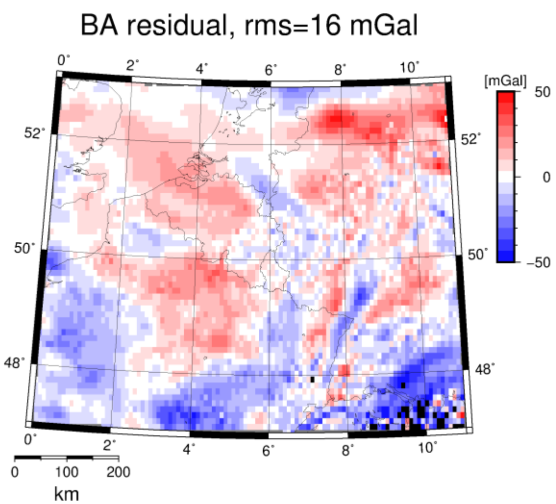
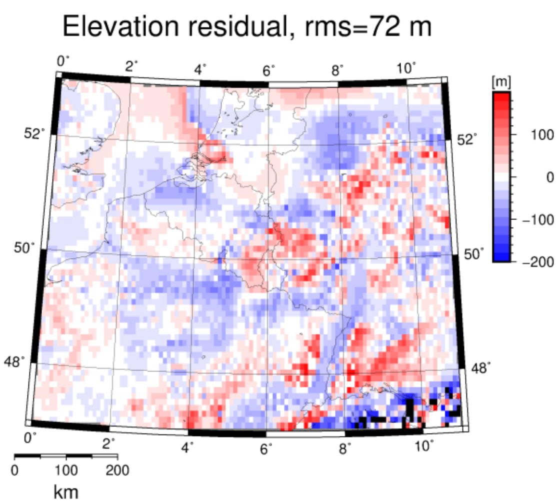
Modelling results – the homogeneous Phanerozoic model



- the modelled LAB depth
- the corresponding model residuals for the isostatic topography & the BA
- a cross section through the model at 50° latitude







- the model shows no distinct LVA

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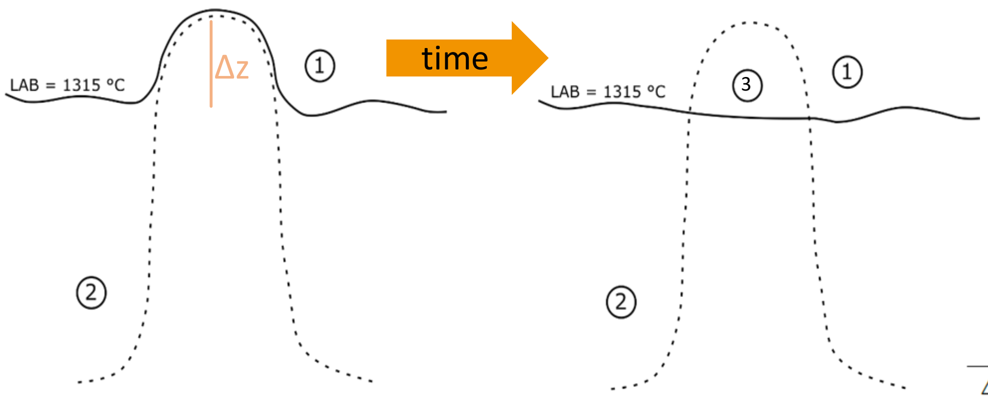
adding an ‘artificial plume’ to reproduce the LVA beneath the Eifel



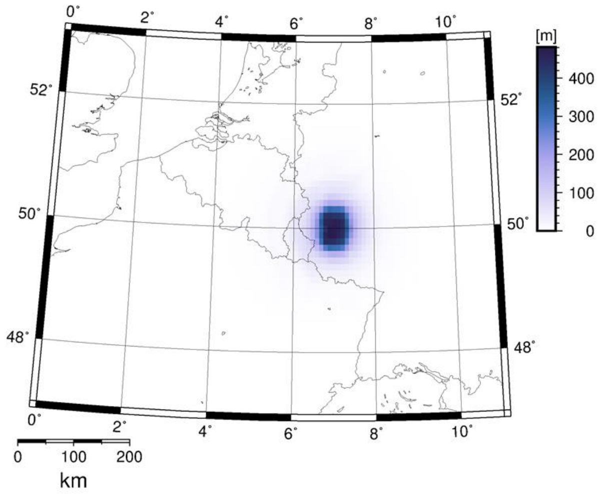
‘thermal plume’

‘compositional plume’

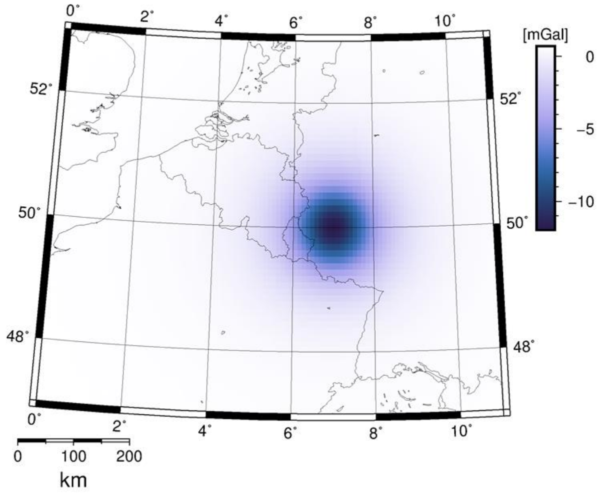
- two methods to include a LVA in the model
  - one with a thermal effect by rising the LAB
  - one with a compositional effect by adding a body with Eifel xenolith material on top of the LAB

Δz	10 km	15 km	20 km	25 km	30 km
BA signal	-5 mGal	-8 mGal	-12 mGal	-15 mGal	-20 mGal
elevation signal	210 m	320 m	480 m	600 m	730 m

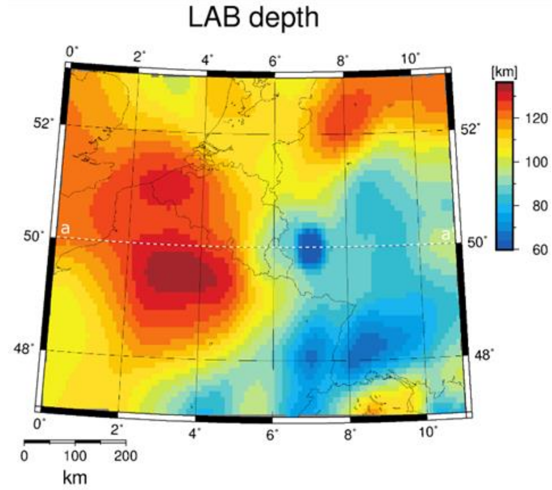
Topografic signal of plume geometry



BA signal of plume geometry



Δ z = 20 km ‘thermal plume’



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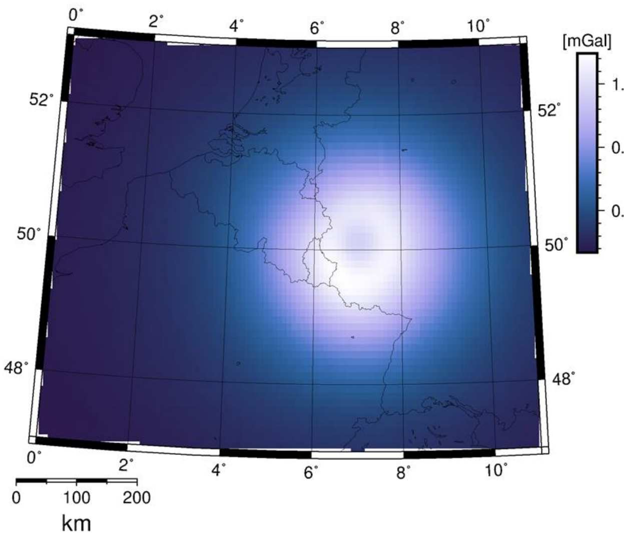
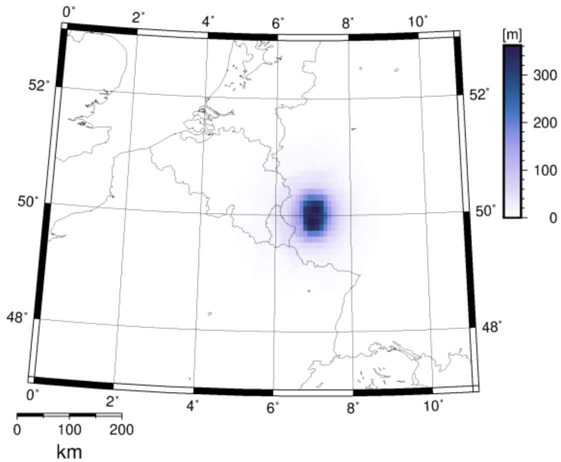
the artificial 'compositional plume' with composition from Eifel xenoliths

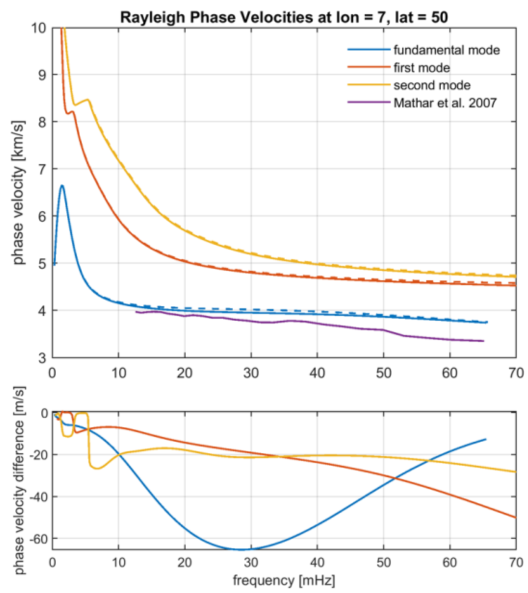
Δ z = 15 km 'compositional plume' with xenolith data composition

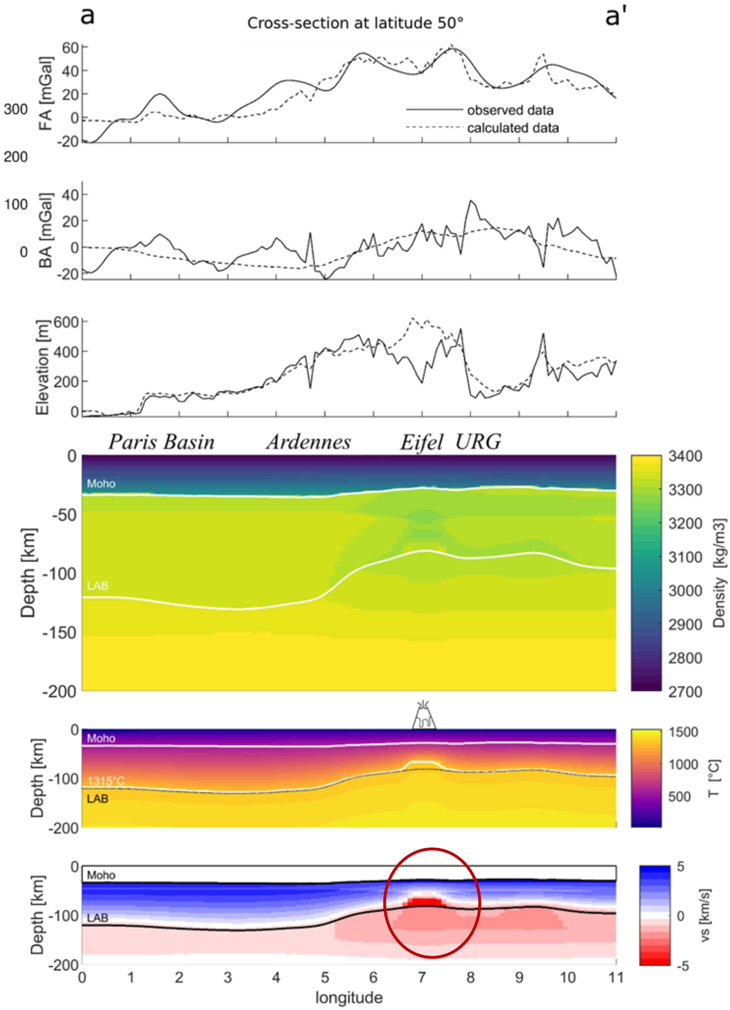
BA signal of plume geometry



Topografic signal of plume geometry







- the body produces nearly no signal in the BA
- only a small signal in the isostatic topography
- a clear signature in the calculated dispersion curves but does not reproduce the dispersion curve from Mathar et al. 2007

dashed line: homogeneous Phanerozoic model

- with this body a LVA is produced

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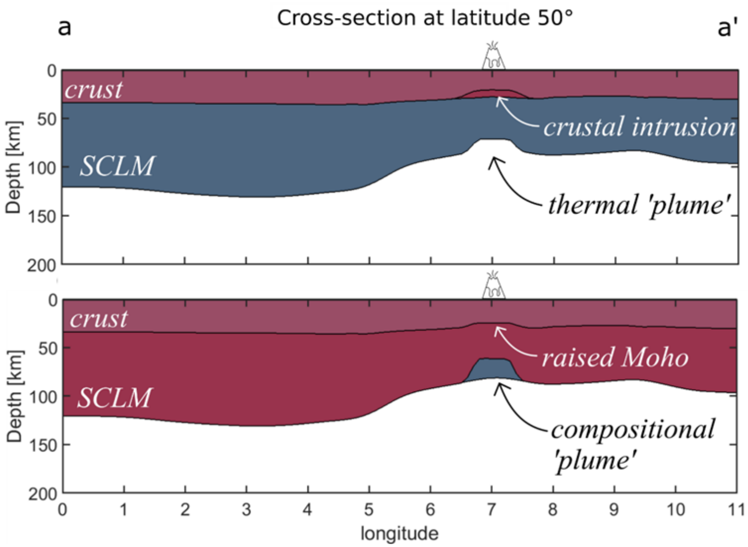
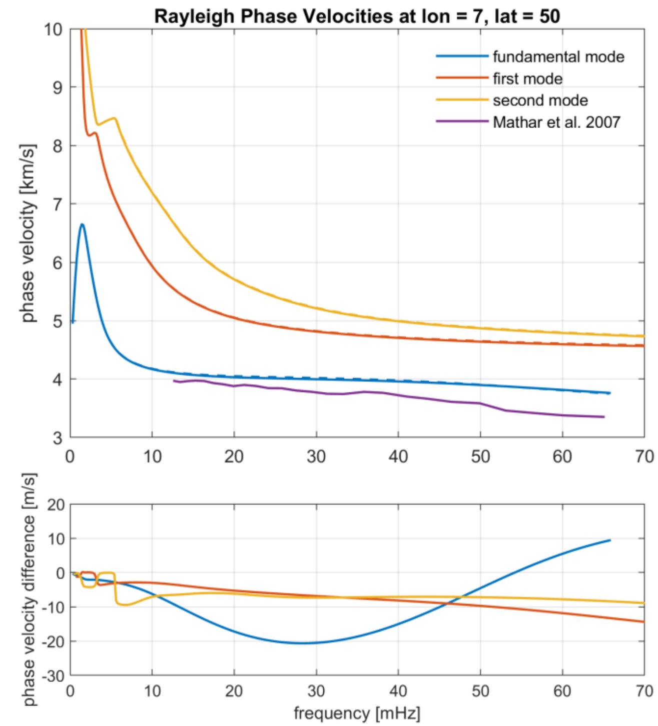
the possibility of masking the plume with crustal intrusions

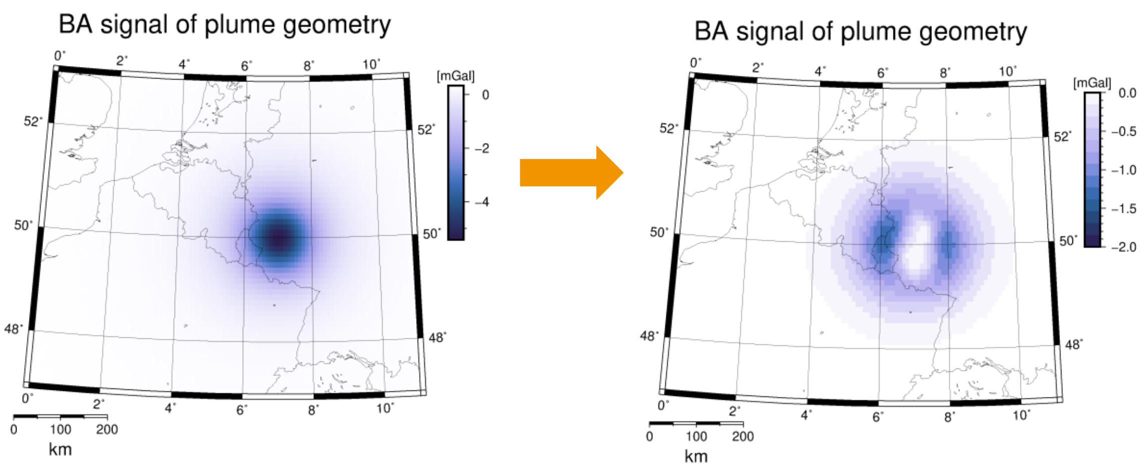


- a slightly raised Moho or a crustal intrusion could mask the topographic or gravity signal of such a small upper mantle plume
- because of the depth dependency of the gravity signal both observables can not be completely masked with the same intrusion height
- the dispersion curve of the model reveals the 'thermal plume' as well as the crustal intrusion



dashed line: homogeneous Phanerozoic model

Δ z = 10 km PUM 'thermal plume' model with a 4 km thick crustal intrusion



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Summary & conclusion

- a lithospheric model for the Eifel and Paris basin has been developed
- different plume models were calculated to test the sensitivity of various observables towards a possible plume

Following conclusions can be drawn:

- for the Eifel and Paris Basin, a Phanerozoic composition is most suited, which leads to a circular LAB rising in the Eifel with an average depth of 80 km
- the gravity signal from thermal and compositional anomalies at the LAB is slight and can be masked by crustal intrusions. Dispersion curves and the isostatic topography can reveal such small heterogeneities

- a joint inversion with seismological data would help to include a more heterogeneous composition in the SCLM, which would lead to a more complex model
- an inversion of gravity and magnetic data to study the crustal structure of the Eifel would further improve the model

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