Pressure sources vs. surface loads: Analyzing deformation signal composition at volcanoes – a case study at Hekla volcano, Iceland

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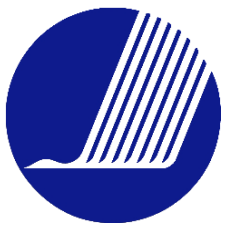
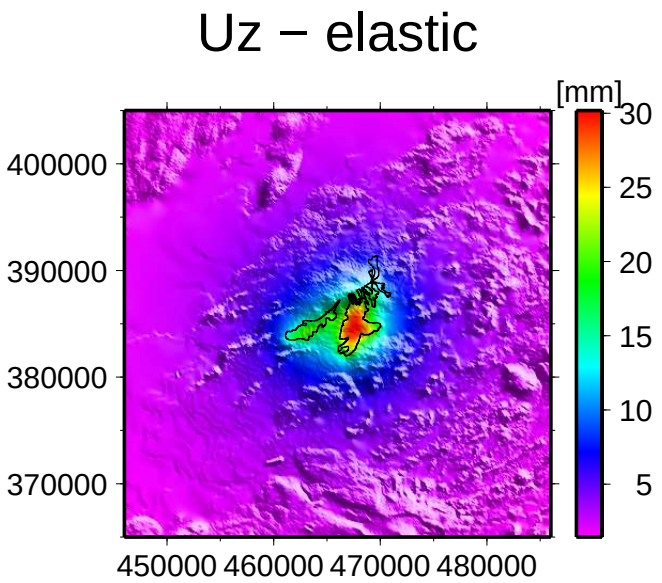
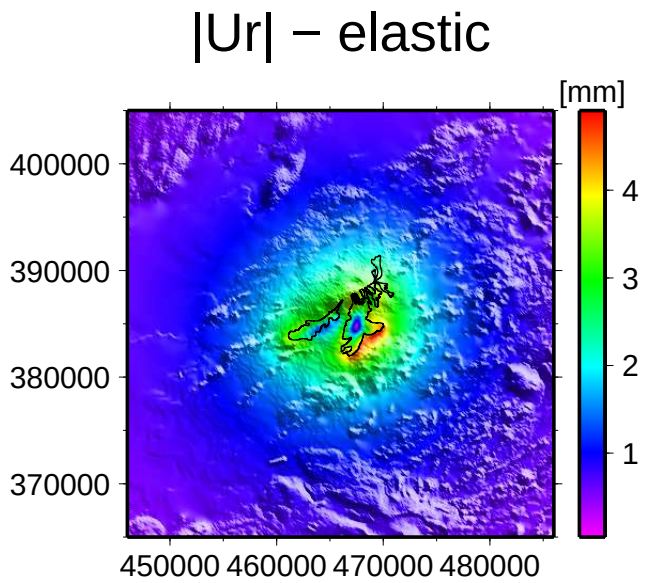


Crustal response to surface loads





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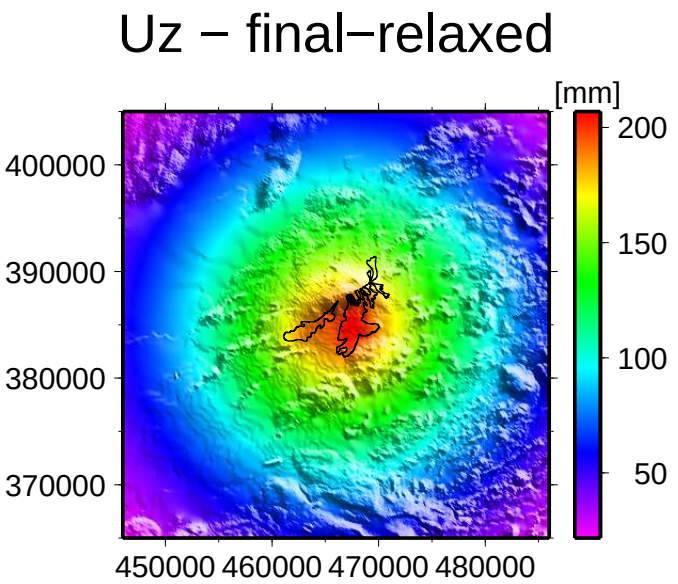

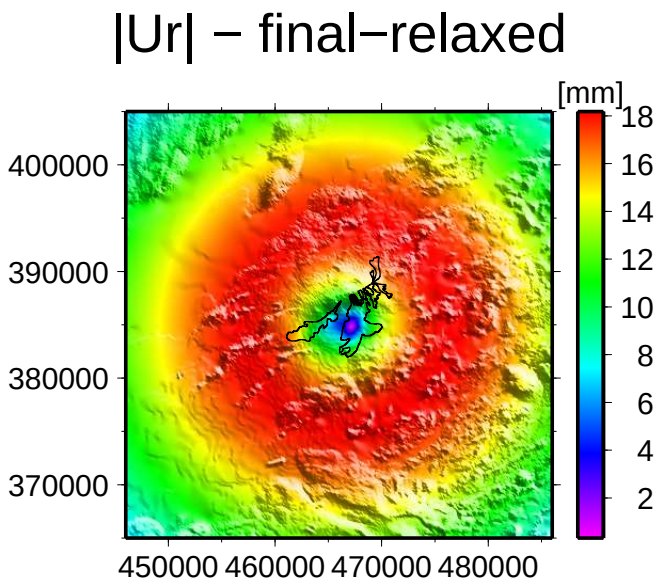

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- followed by visco-elastic response of ductile crust

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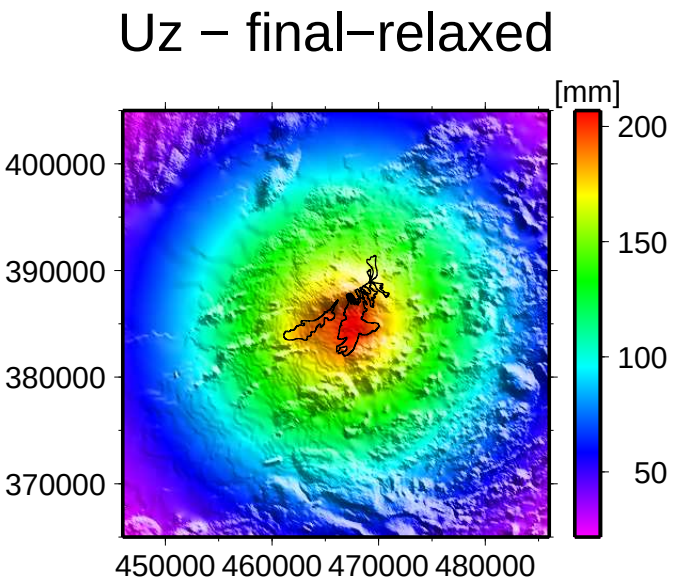

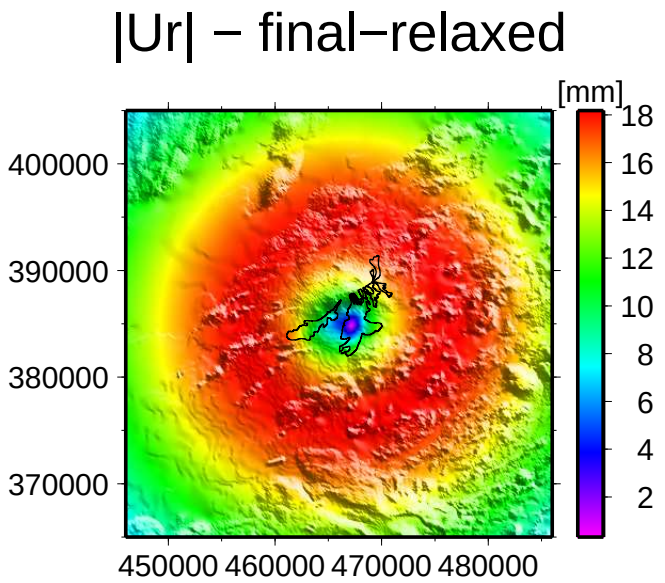

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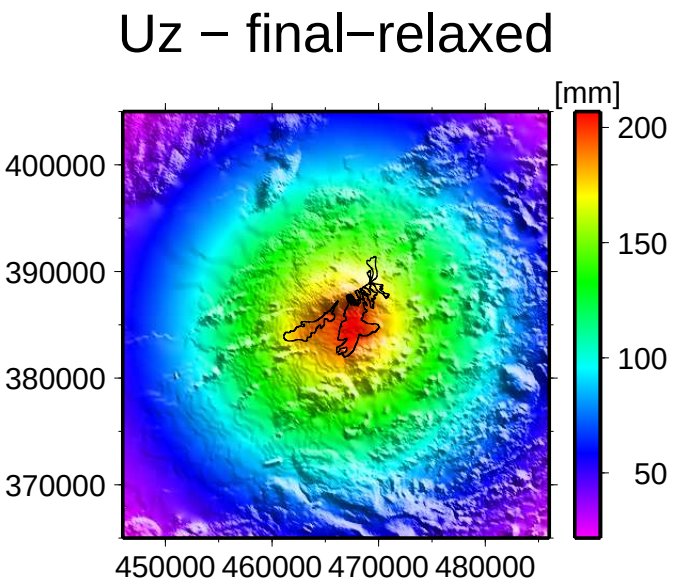
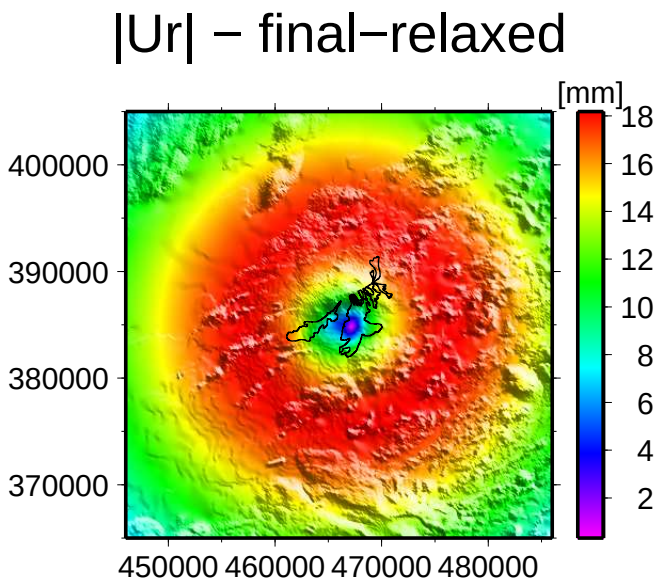
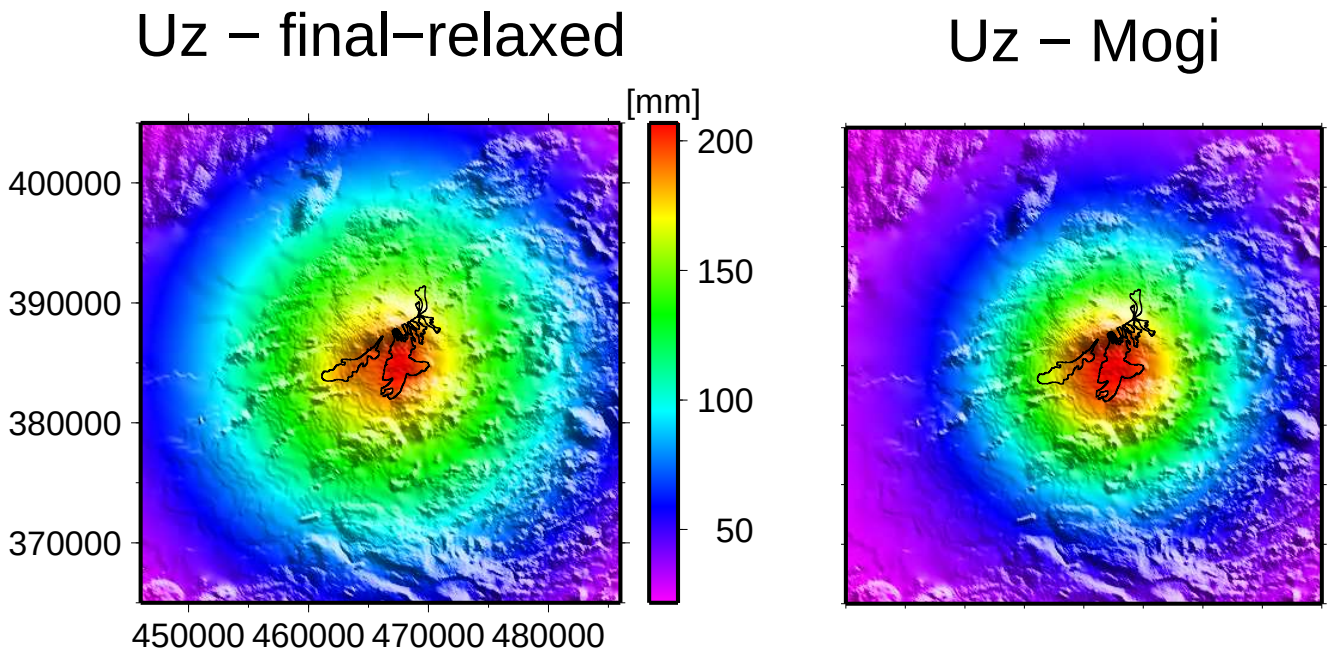




- instantaneous response of elastic layer
- followed by visco-elastic response of ductile crust
- transition for Newtonian viscosity: exponential decay
- modeled using Green's functions derived by Pinel et al. (2007)
- implemented in simulation framework CRUSDE *[Grapenthin, 2007]*

Motivation for this work



- volcano deformation often related to internal pressure sources *[Yamakawa, 1955, Mogi, 1958]*
- surface loads contribute a significant signal

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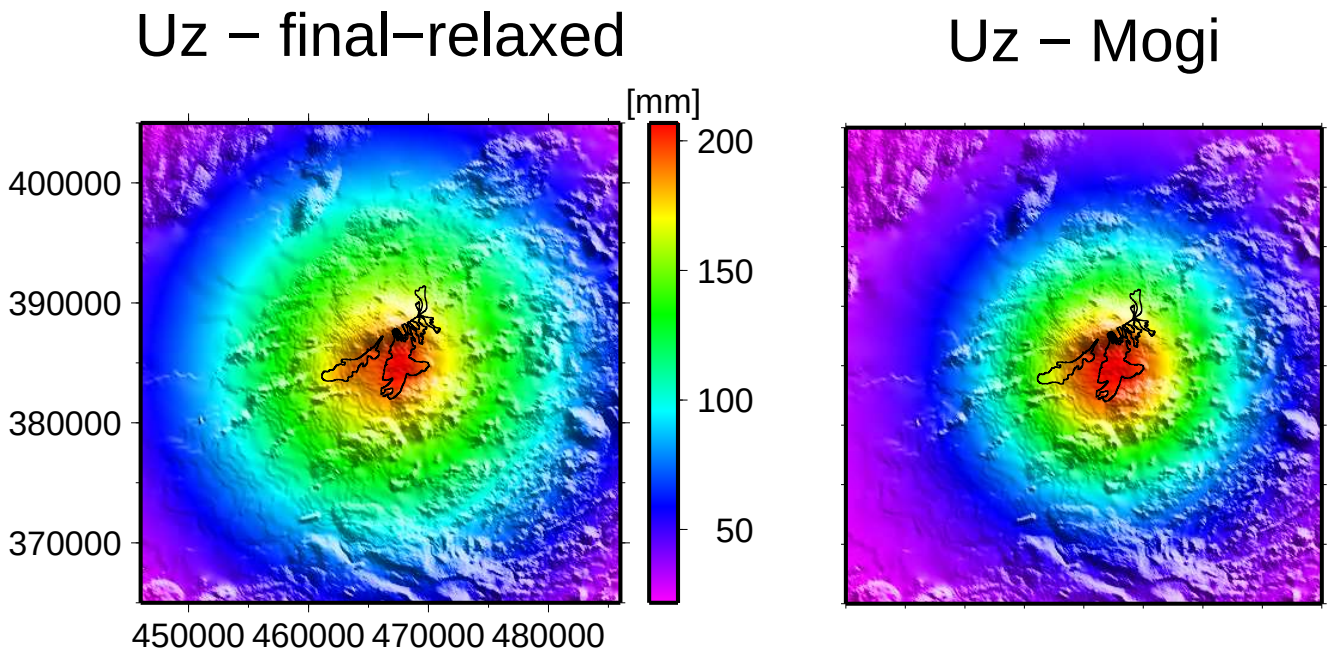

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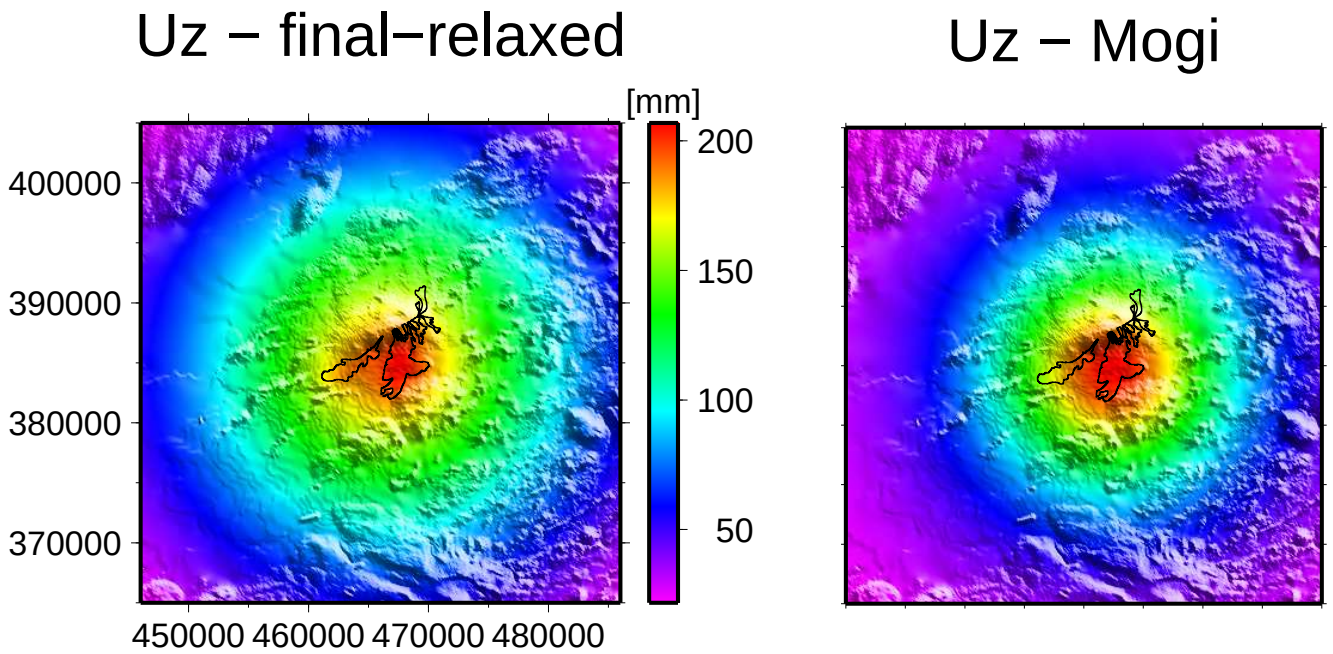

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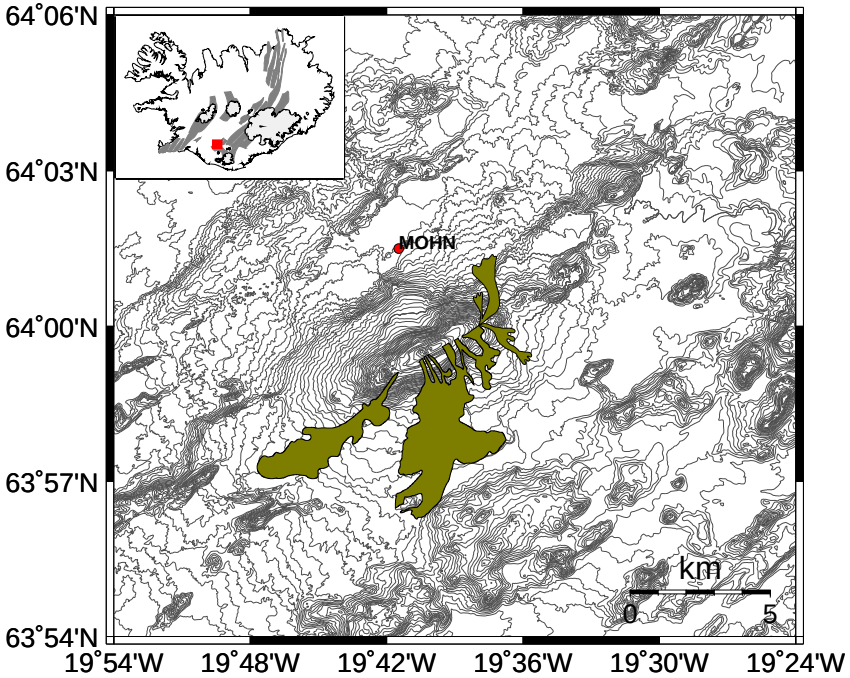
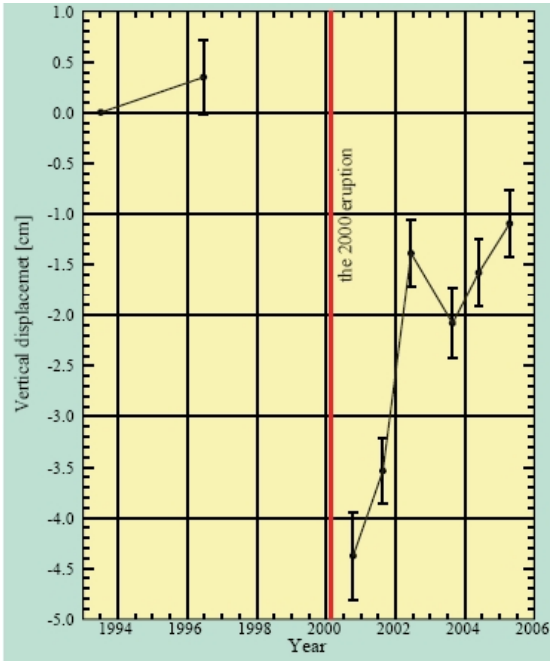
- gradual subsidence may be mistaken as source deflation – gives wrong chamber characteristics
- signal can be exploited to derive crustal parameters

Chamber depth issues (conceptual!)

Hekla 2000 lava





[Sturkell et al., 2005]

- $U_z = 45\,\text{mm}$, $V = 0.189\,\text{km}^3$ lava *[Höskuldsson et al., 2007]*

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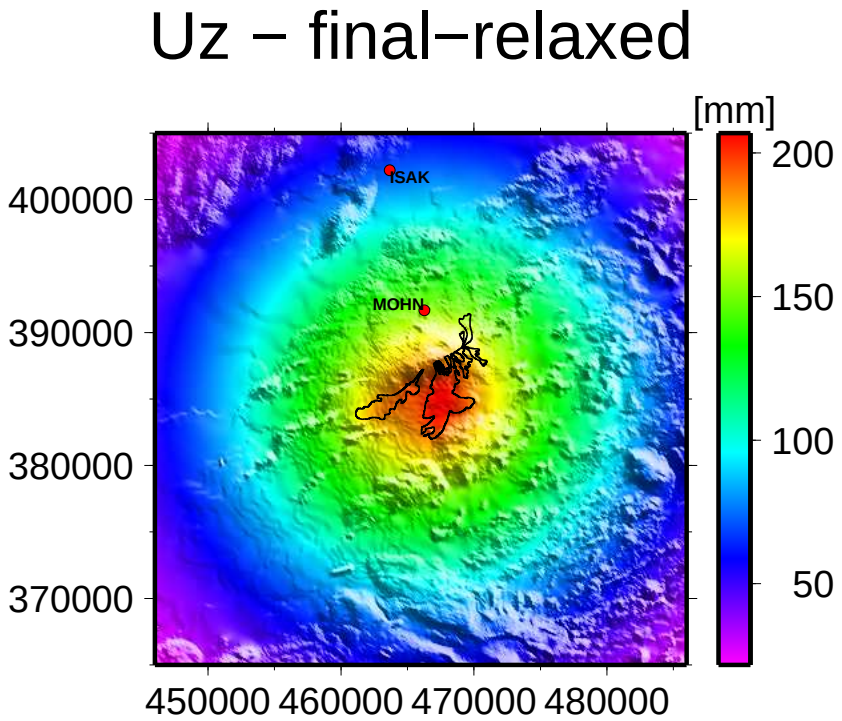

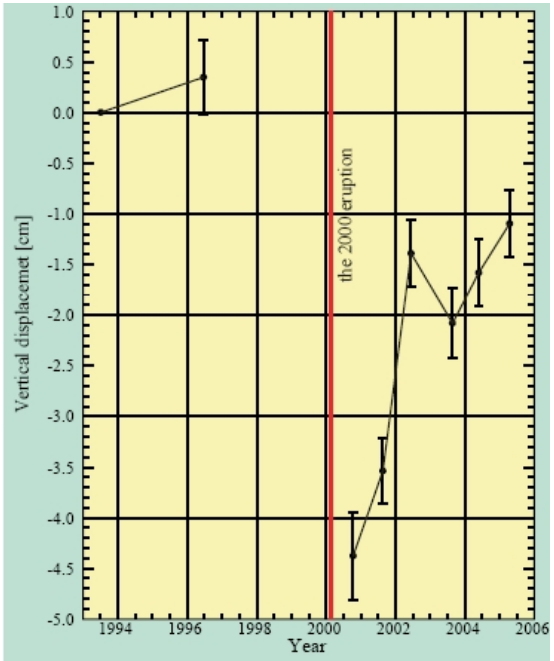

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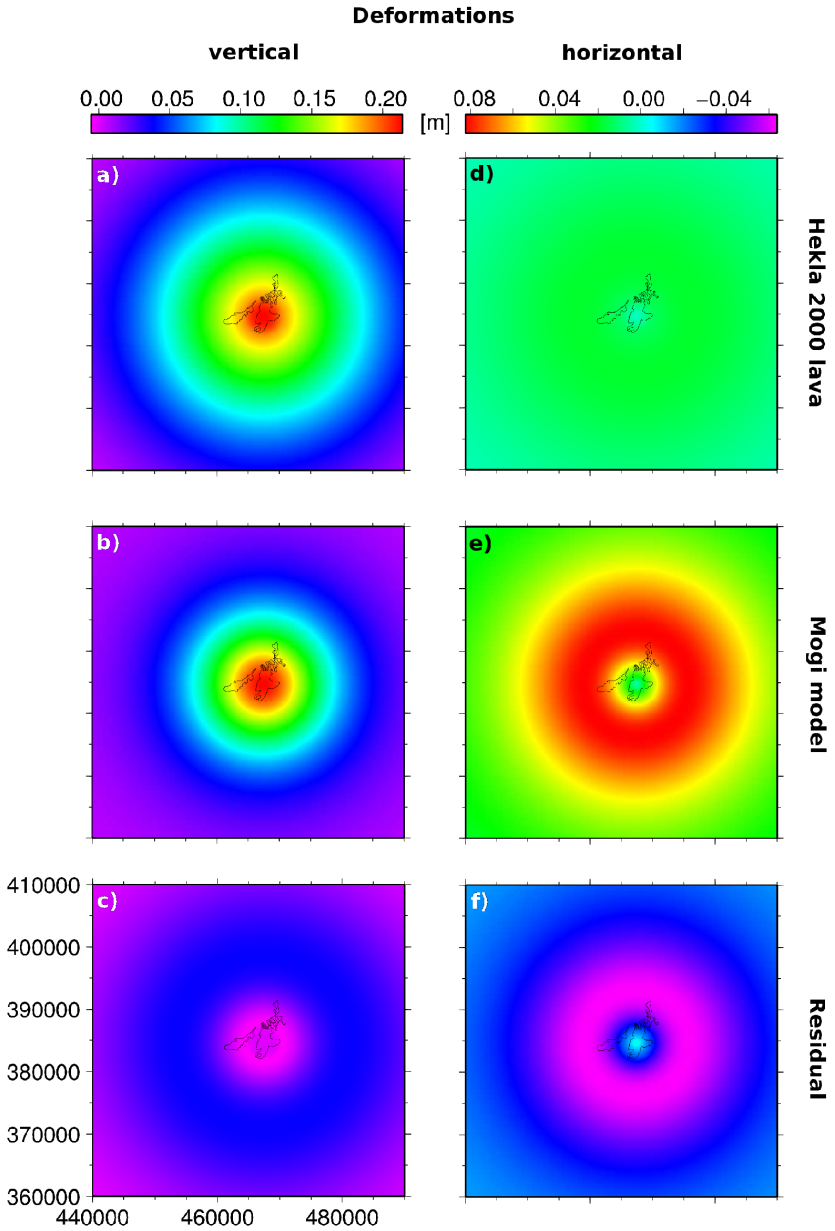
- $U_z = 45\,\text{mm}$, $V = 0.189\,\text{km}^3$ lava *[Höskuldsson et al., 2007]*
- $E = 40\,\text{GPa}$ *[Grapenthin et al., 2006]*, MOHN_{U_z}=17.5 mm:

max vertical displacement	hypothetical source depth (Mogi)
45 mm	25.8 km
27.5 mm	33.1 km

Identification of signal composition 1/2



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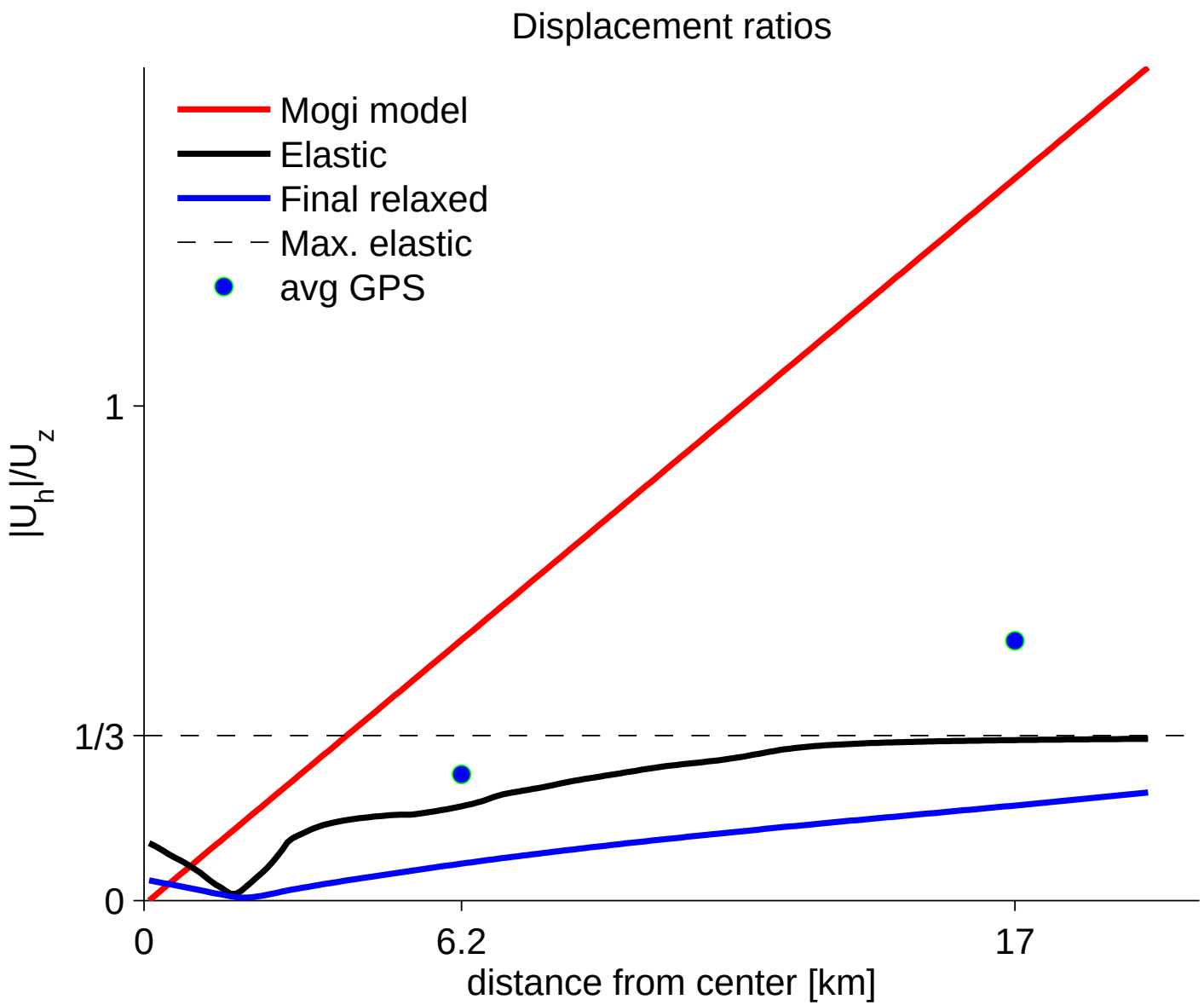
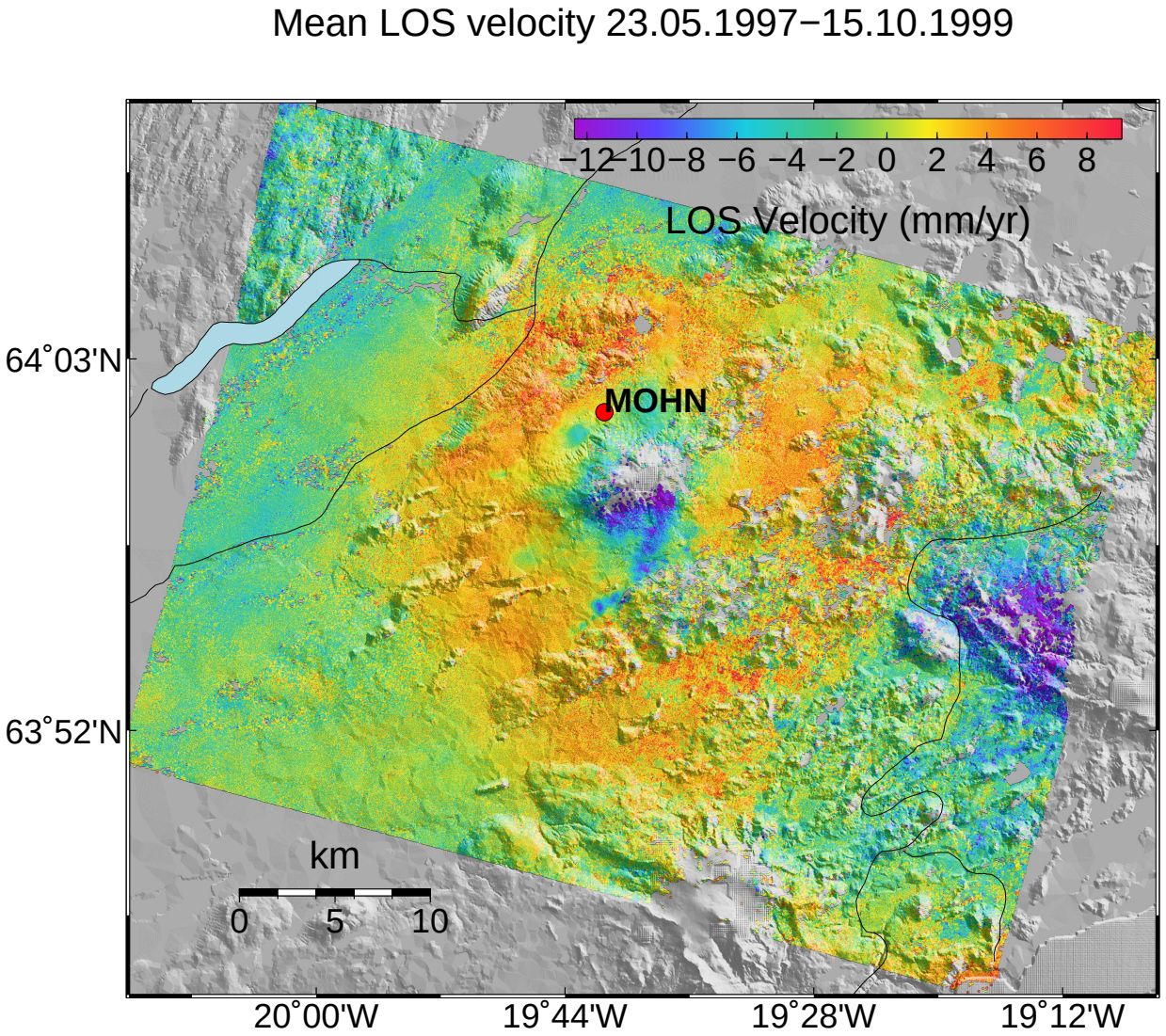


InSAR observations 1/2



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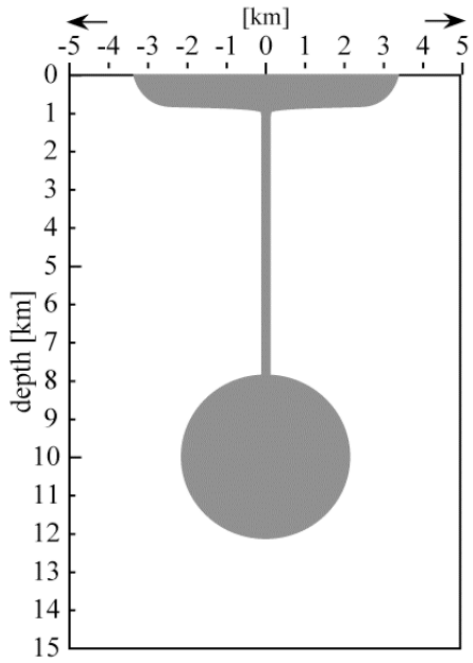

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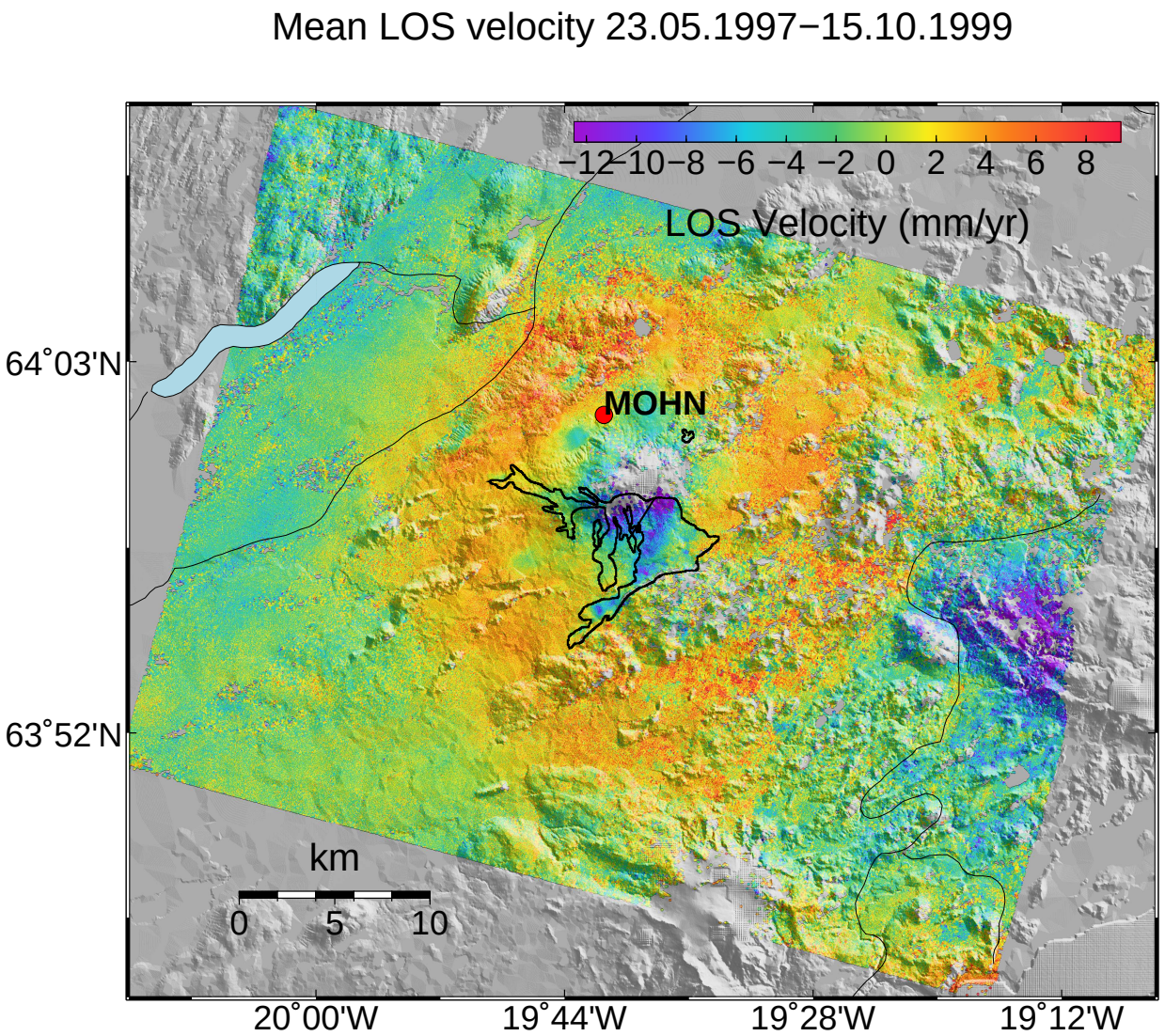

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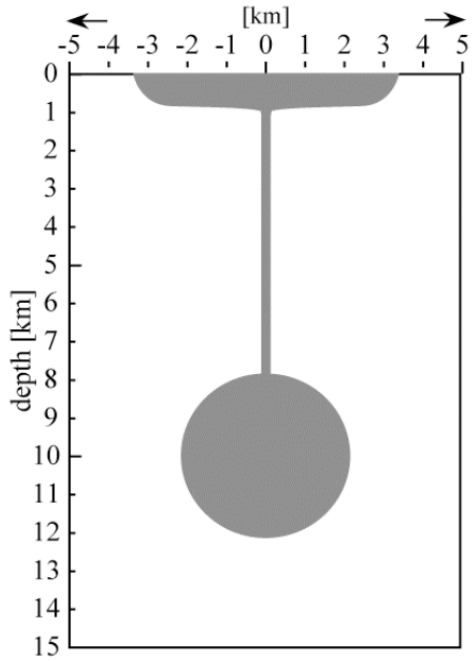

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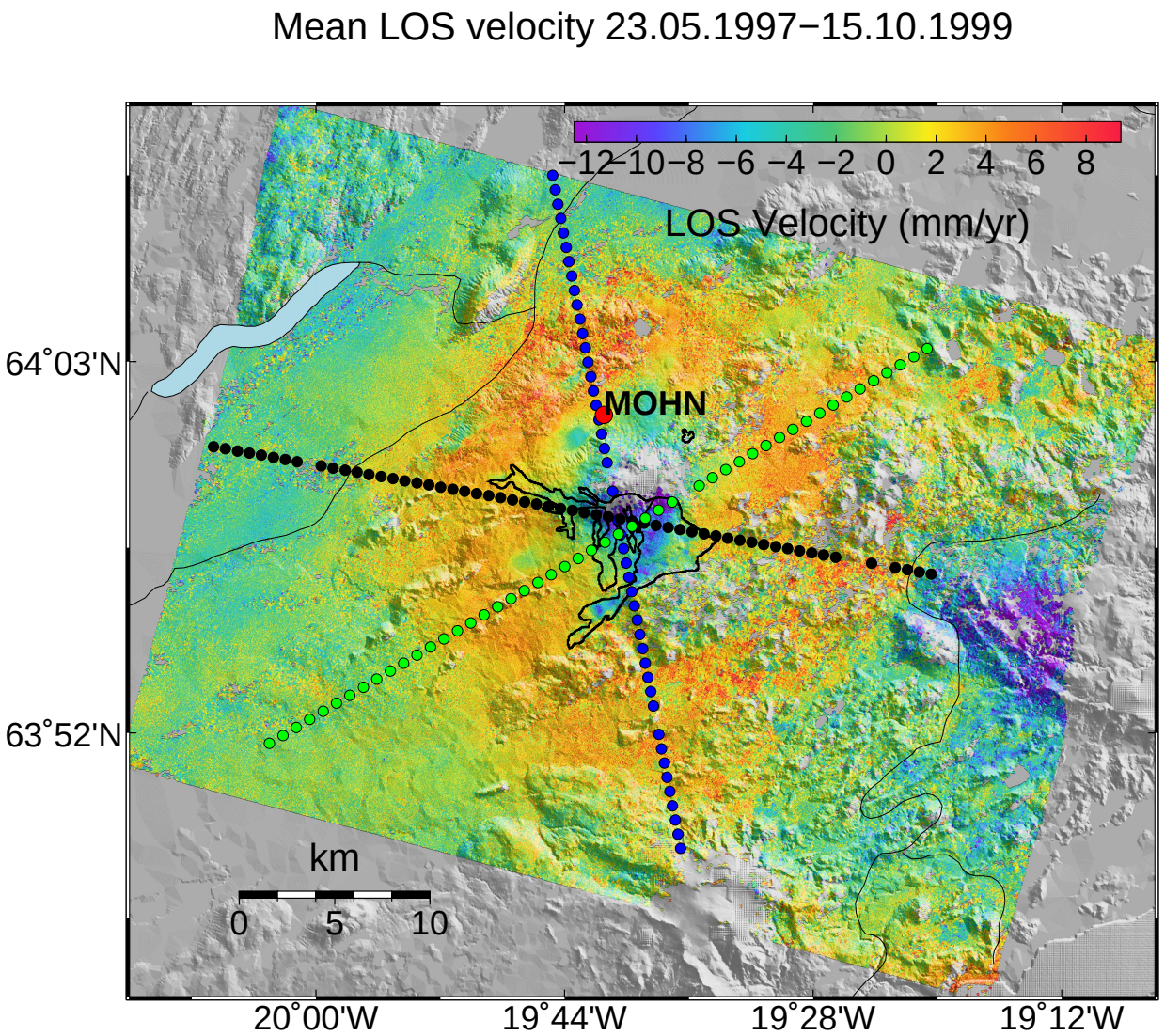

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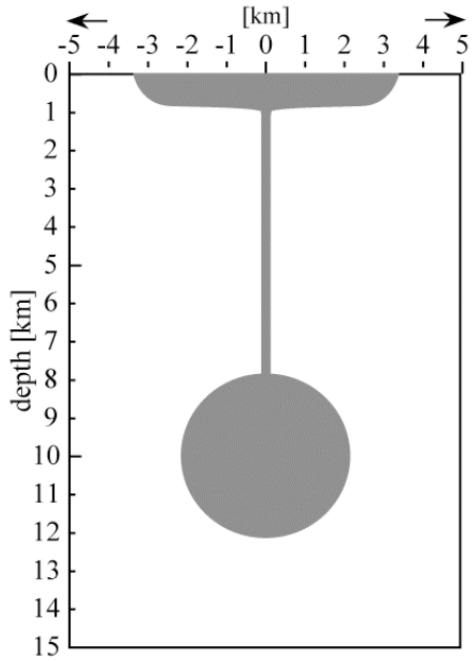

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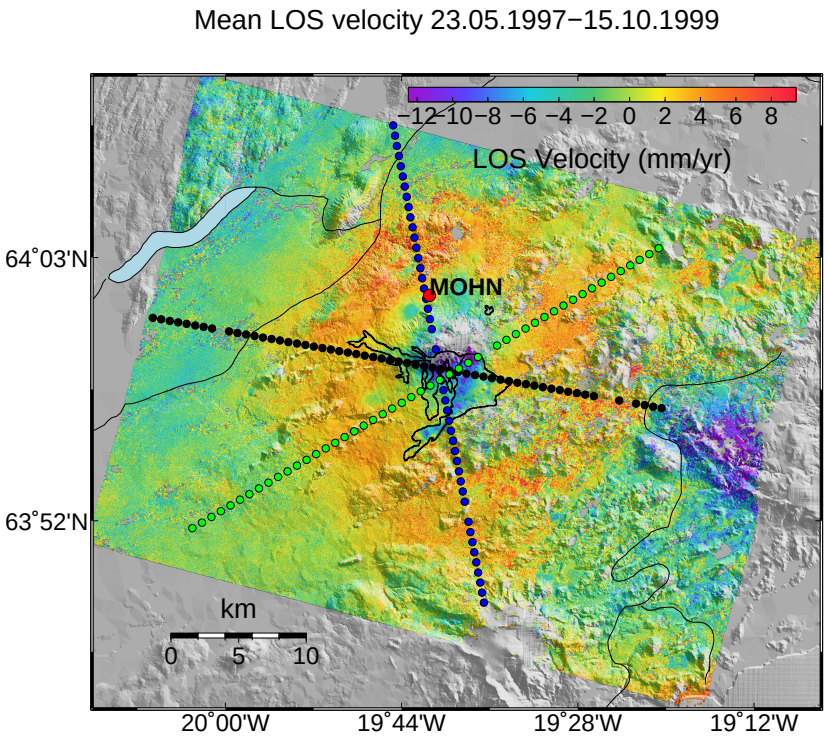

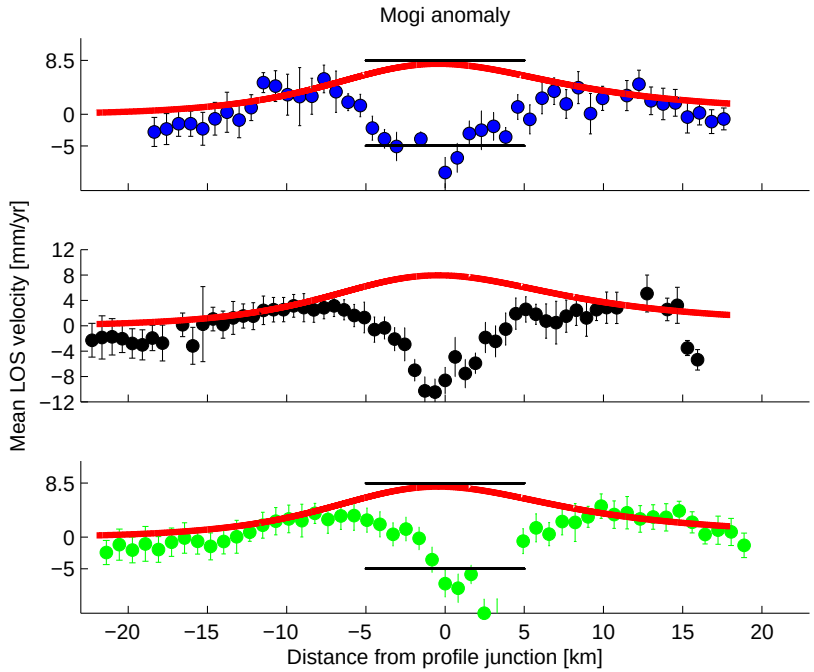

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- Mogi source depth $d = 11.6\,\mathrm{km}$, Sturkell et al. (2008, submitted) : $d = 10\,\mathrm{km}$

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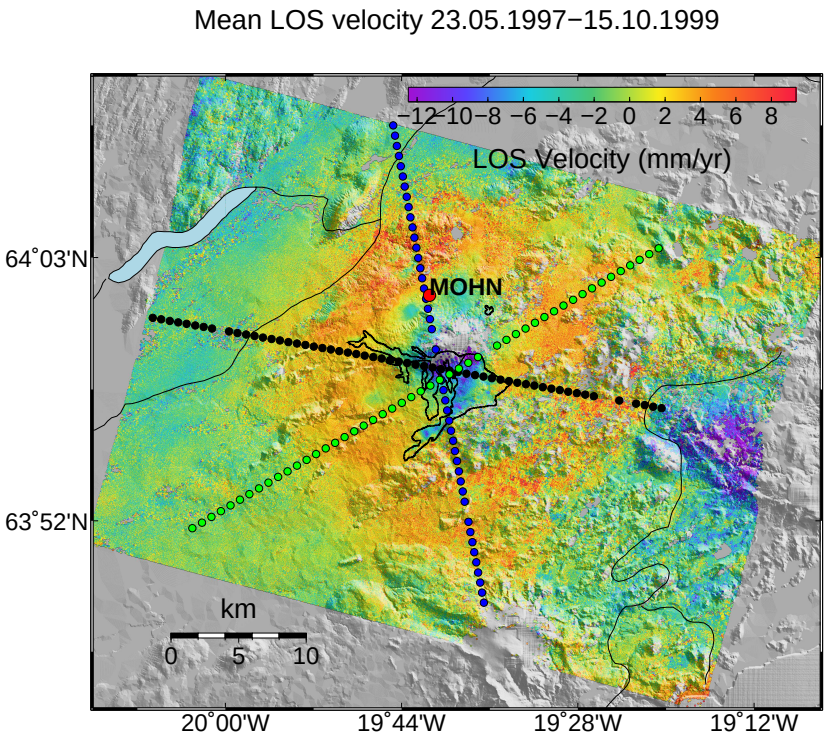

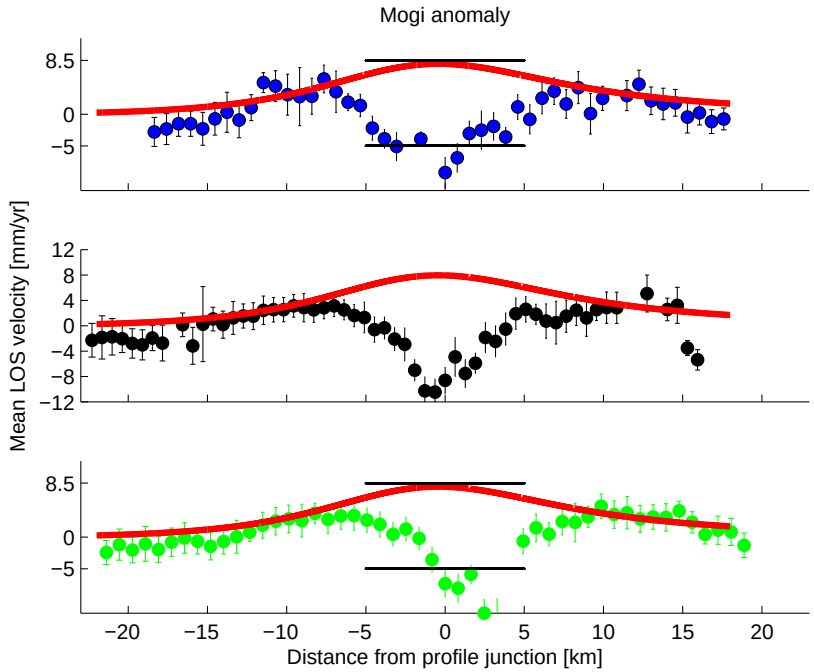

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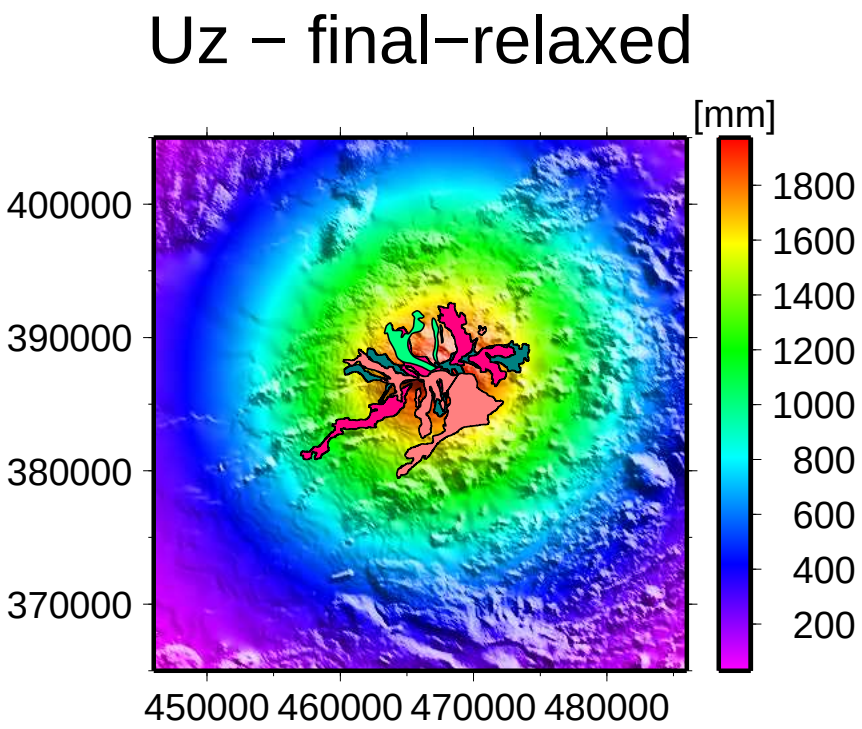
- surface loading (and/or other source) has to account for subsidence of 13.5 mm/yr

Derivation of crustal parameters (concept)



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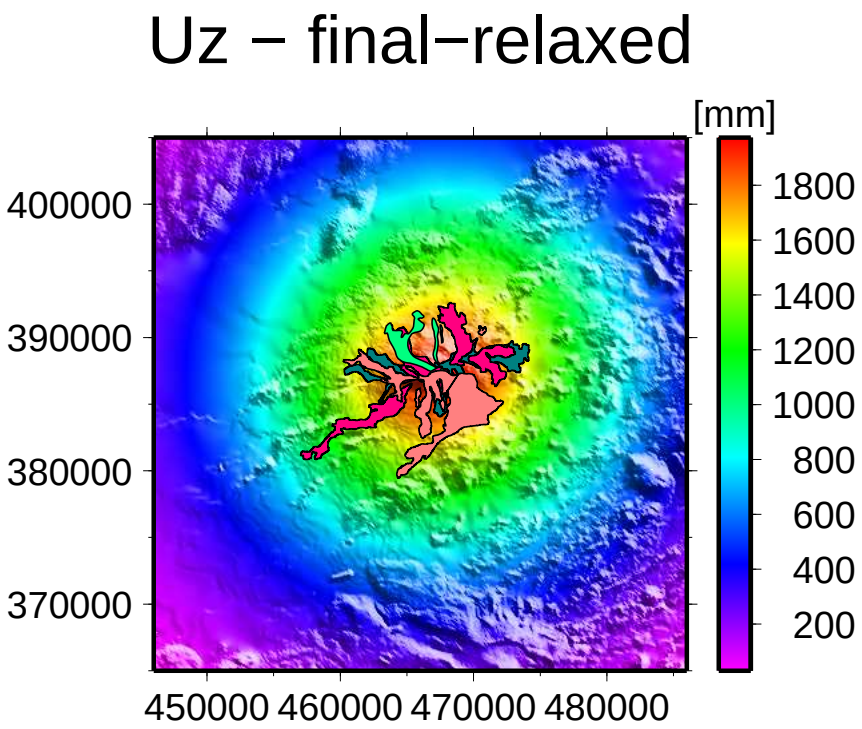

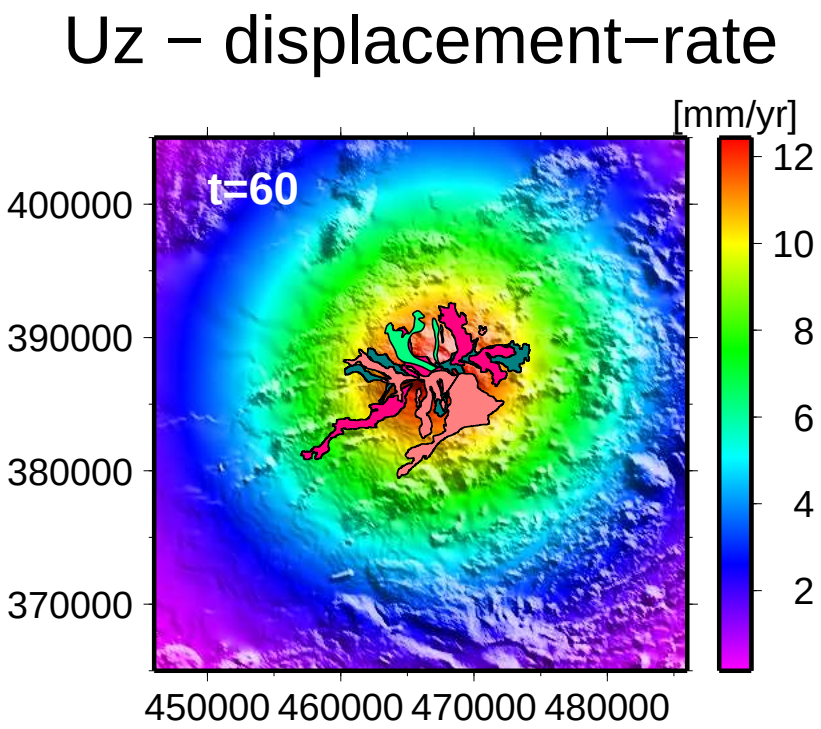

- elastic thickness: $H = 3.5\,km$ (matches 15 km subsidence diameter)
- effective relaxation time: $t_R = 100\,yrs$
- both compare well with previous results (i.e., Pinel 2007)

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  - . . . or at least has significant impact on interpretations
  - horizontal deformation field gives clues about signal source(s)
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  - we had: Young's modulus, Poisson's ratio
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- Download CRUSDE: http://www.gps.alaska.edu/ronni
- Thanks to: Jeff Freymueller, Rósa Ólafsdóttir, and Halldór Geirsson

References

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