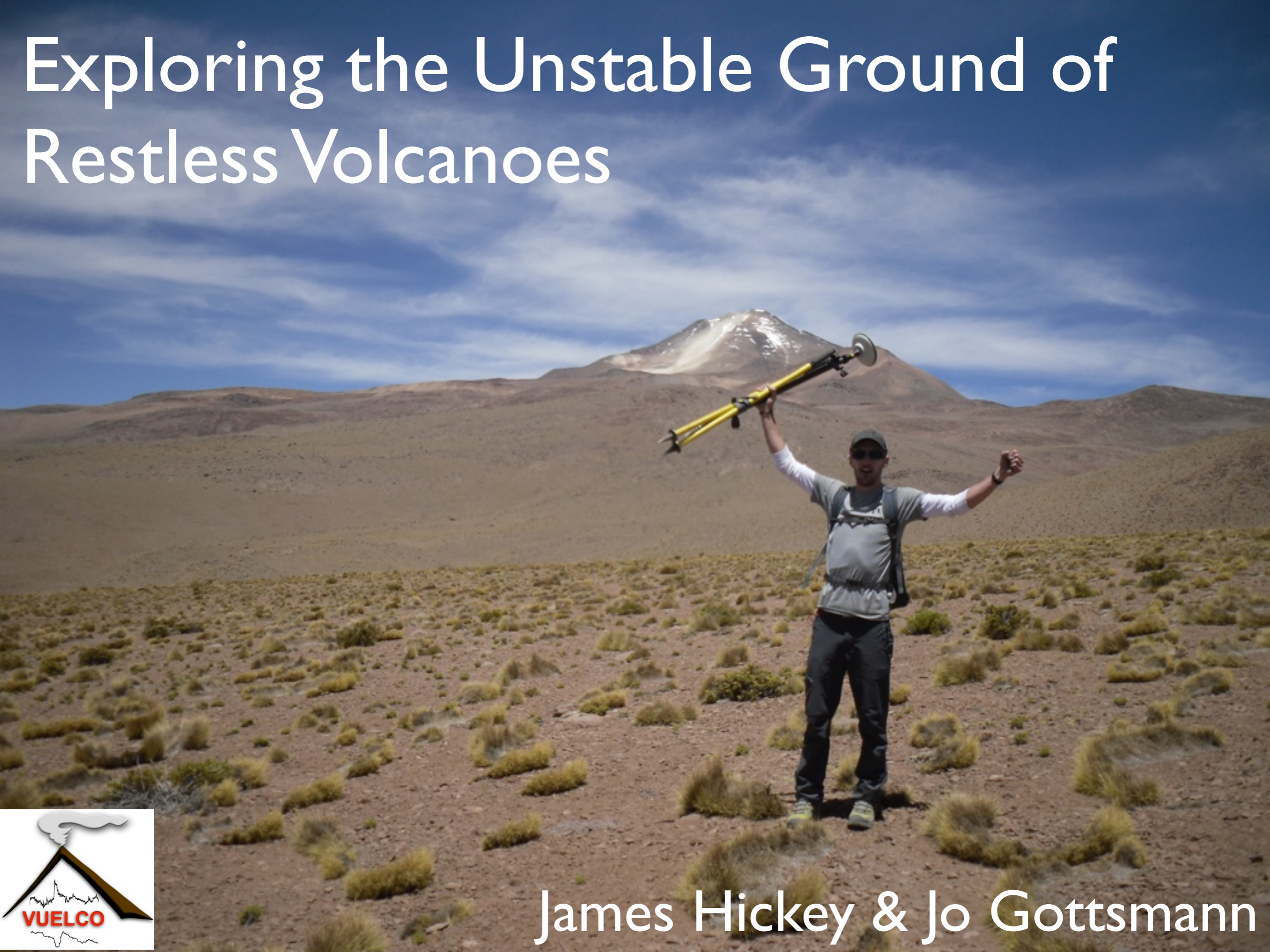


Advances In Integrated Volcanic Geodetic Modelling And Application To Deep-Seated Unrest At Uturuncu Volcano, Bolivia



James Hickey & Jo Gottsmann

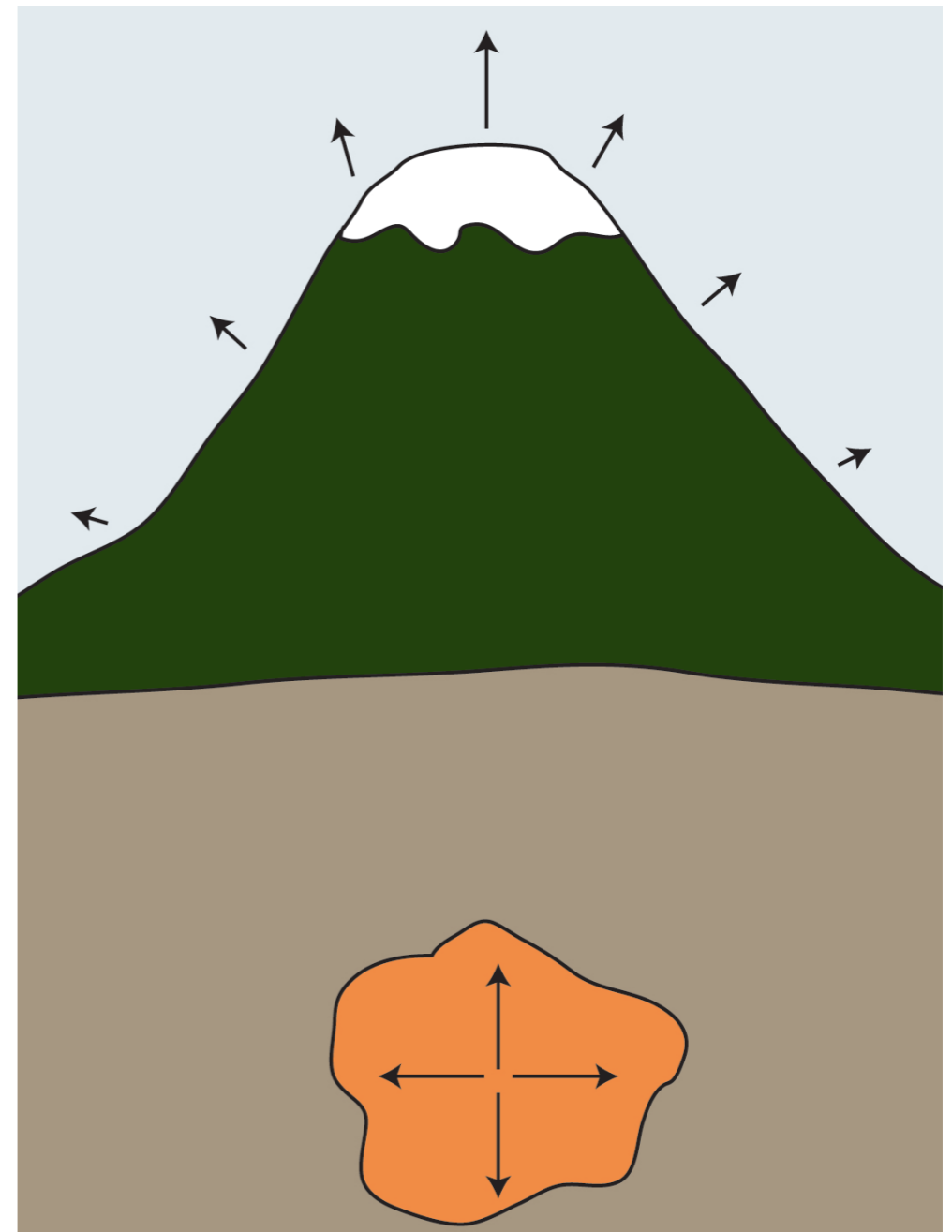
Exploring the Unstable Ground of Restless Volcanoes



James Hickey & Jo Gottsmann

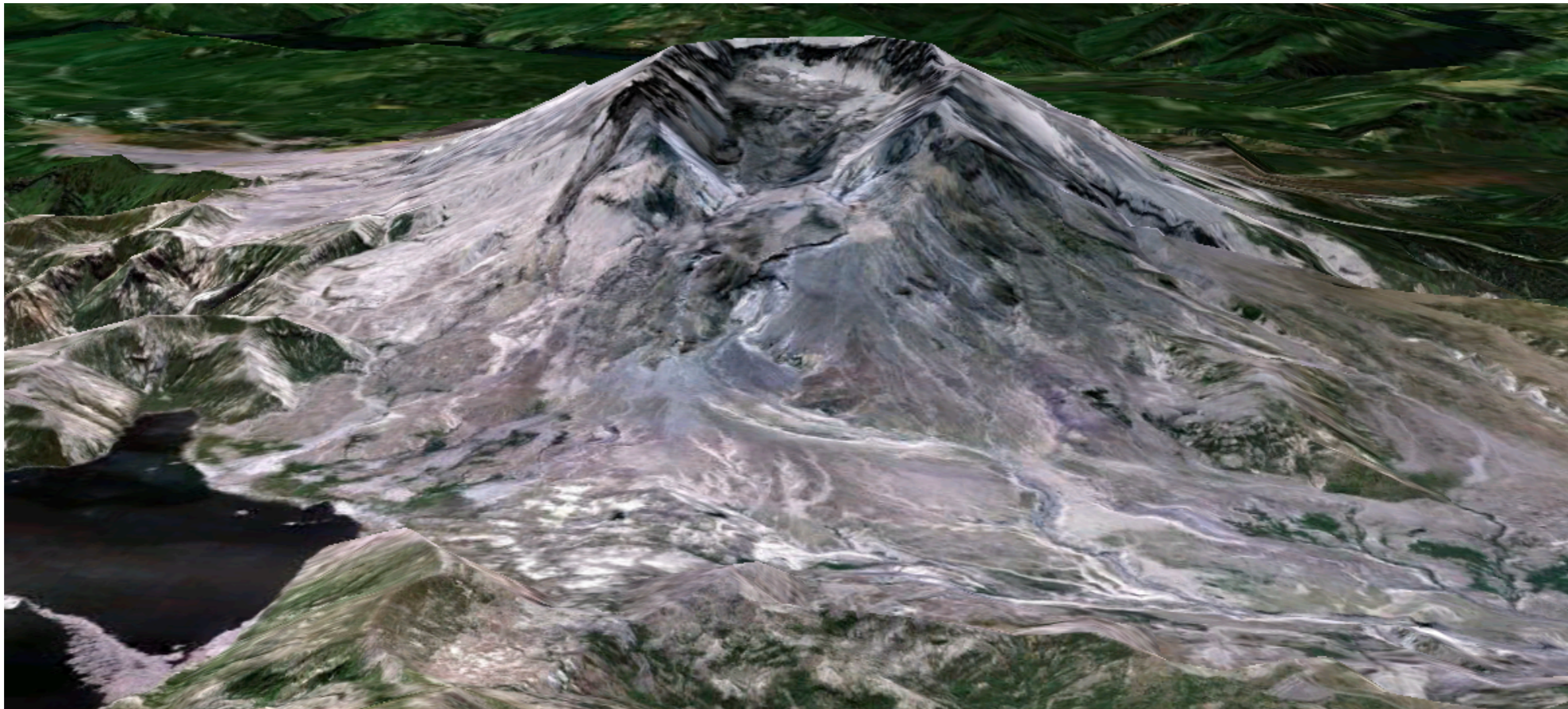
Aims of Task 3.5: Integrated geodetic modelling

- Develop advanced models
- Multi-disciplinary consistency
- Sensitivity testing
- Constrain causative sources



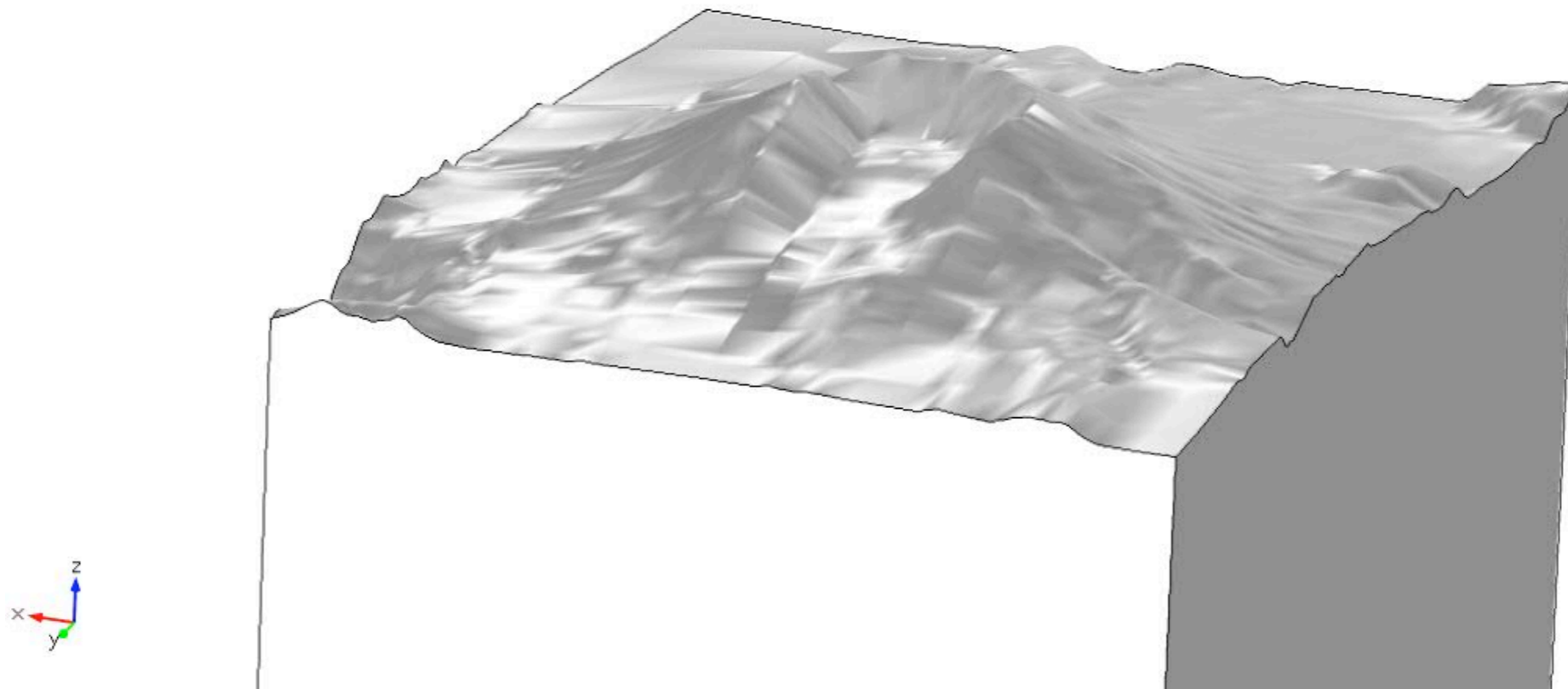
Methods

- ~~Analytical Methods~~
- Numerical Methods
- Finite Element Analysis
- COMSOL Multiphysics



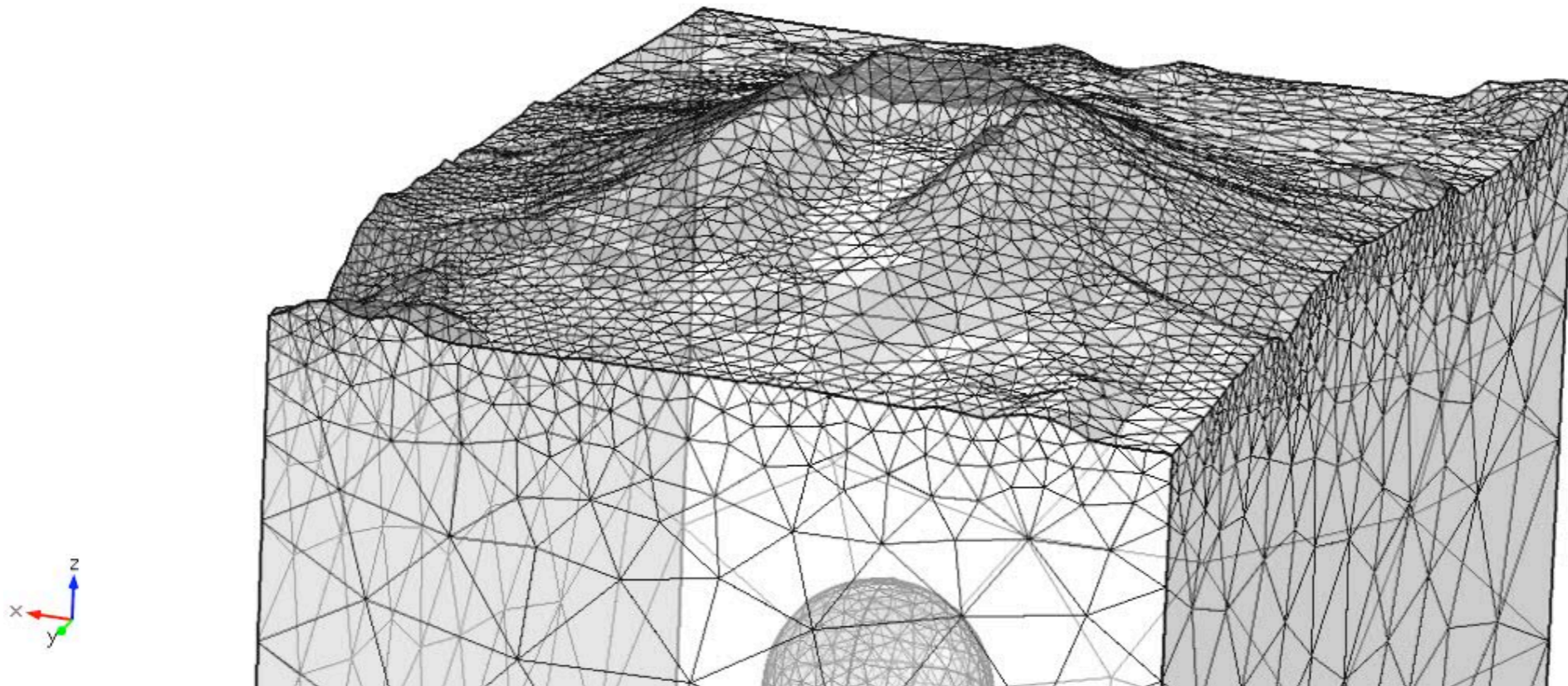
Methods

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- COMSOL Multiphysics



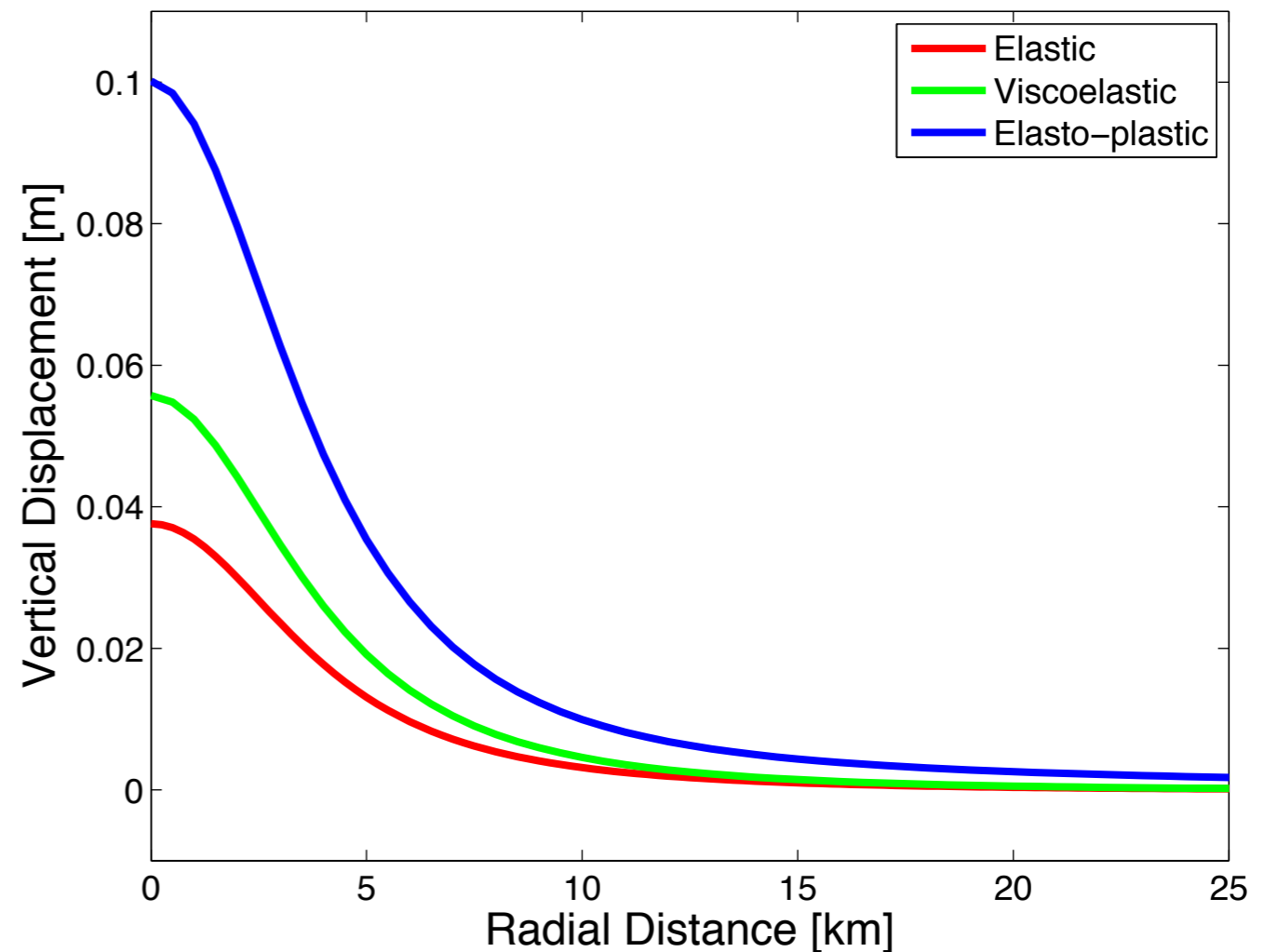
Methods

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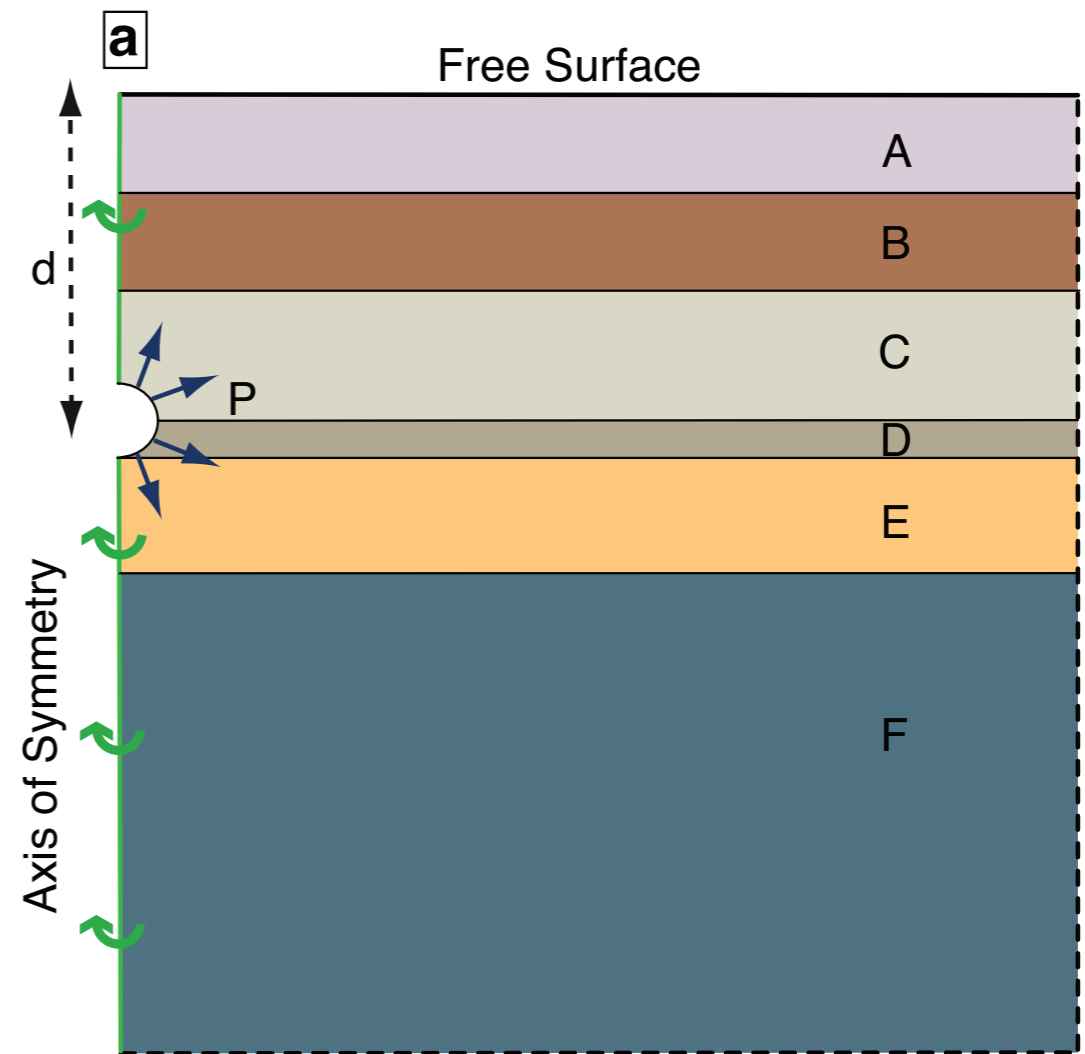
Model Advances

- Inelastic rheology
- Crustal heterogeneity
- Lateral discontinuities
- Topography
- Gravity-loading
- Multiple/irregular sources
- Temperature-dependent mechanics



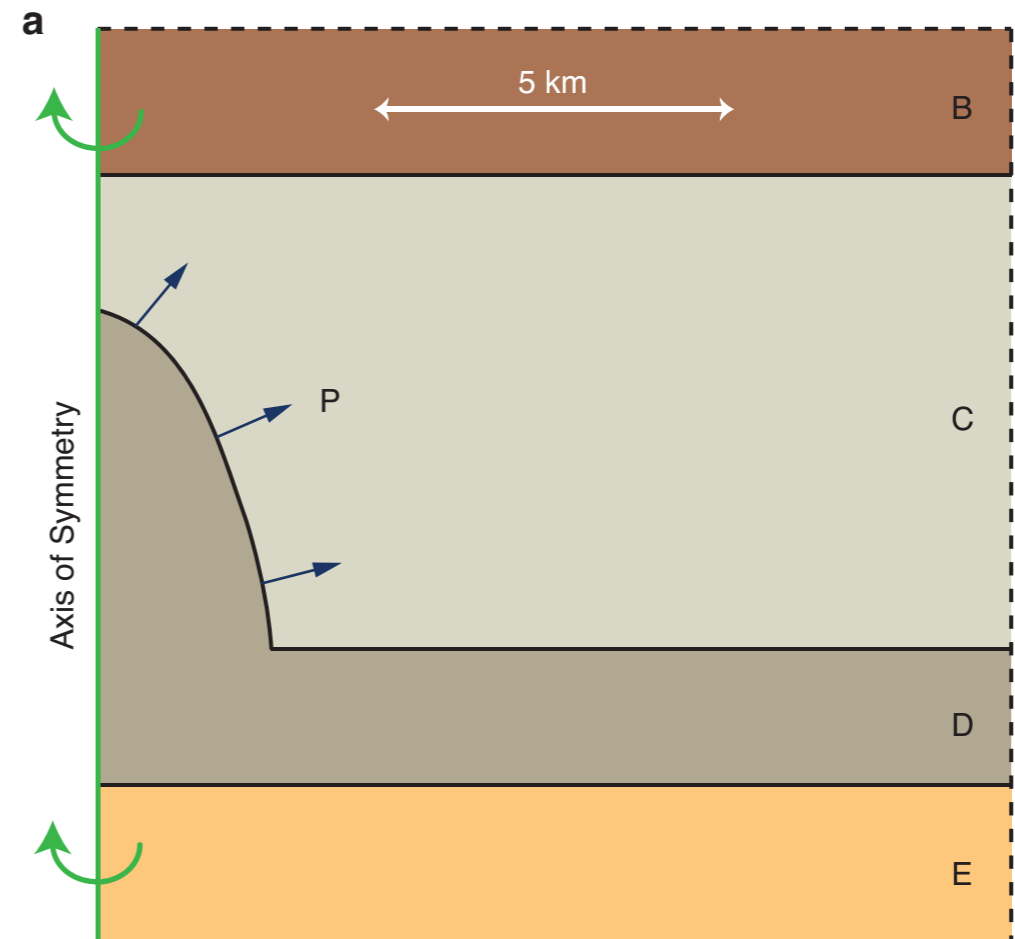
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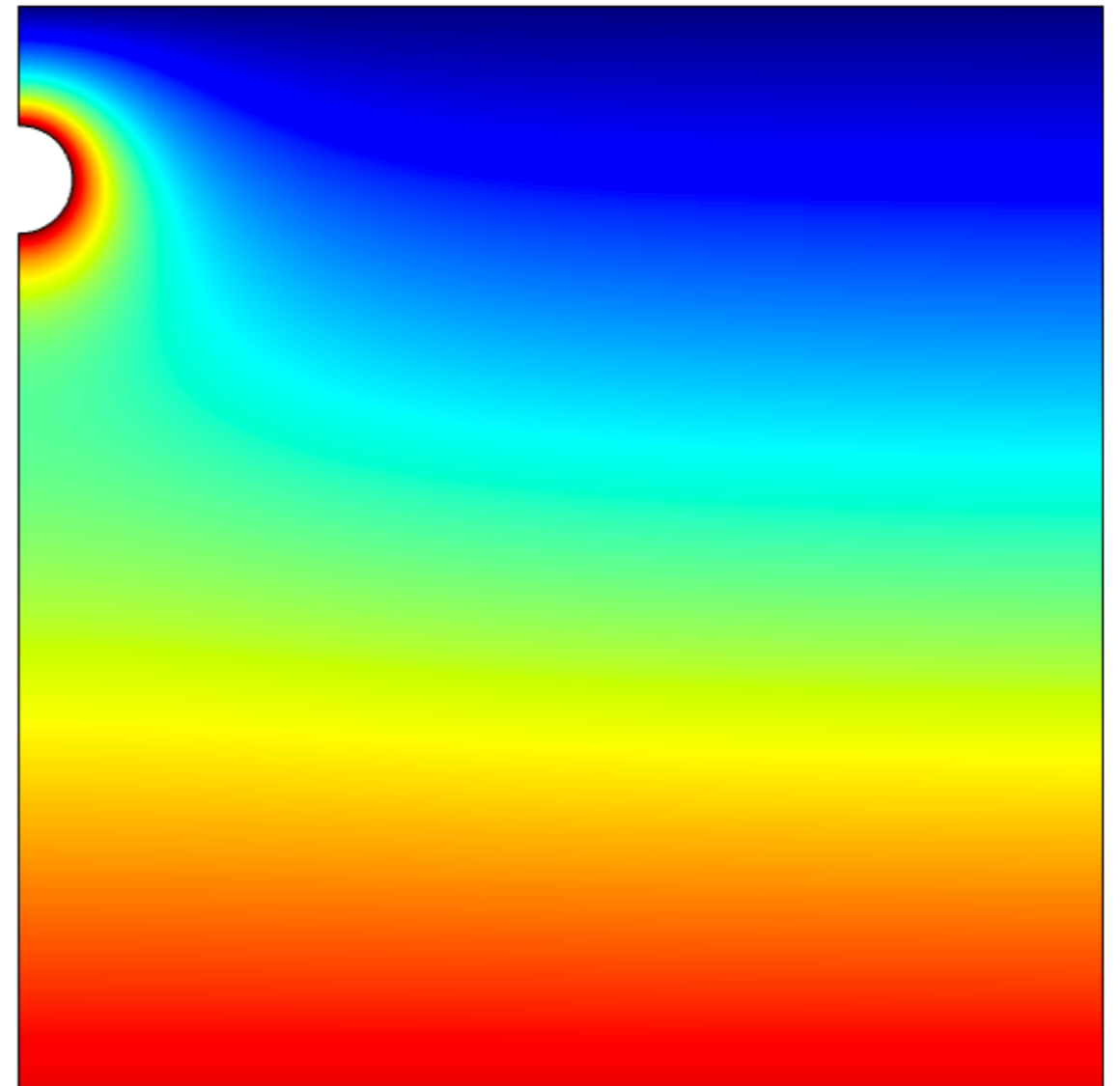
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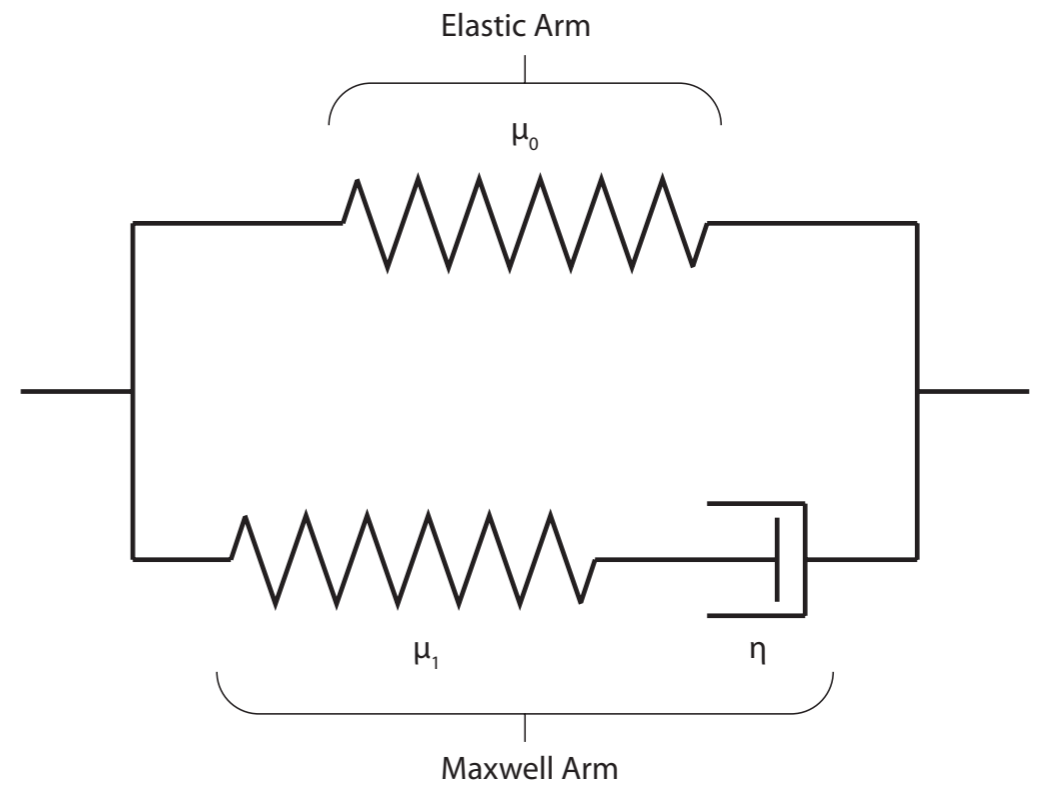
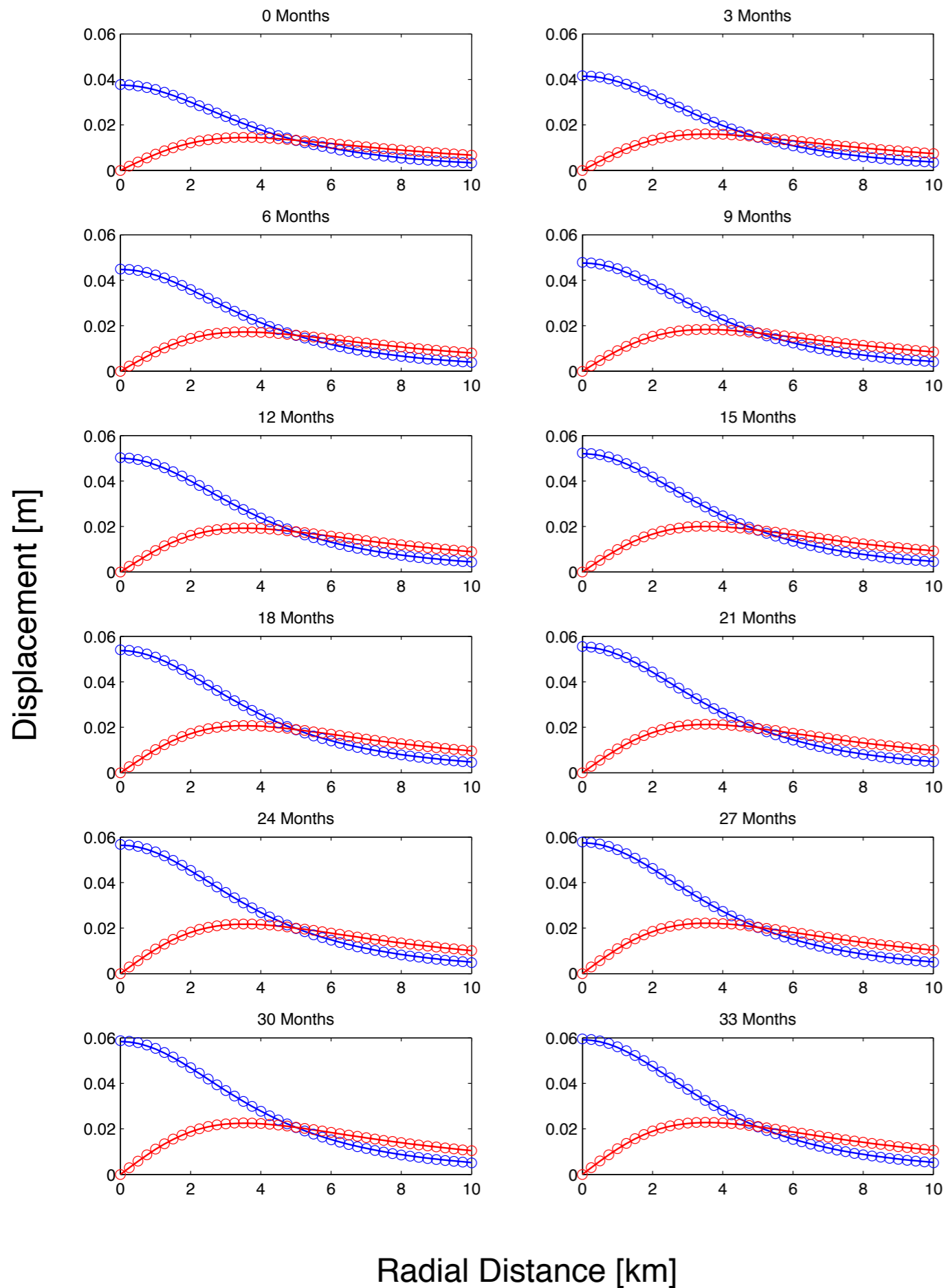
Model Advances

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- Temperature-dependent mechanics



Benchmarking

- VE analytical solution from Del Negro et al., 2009

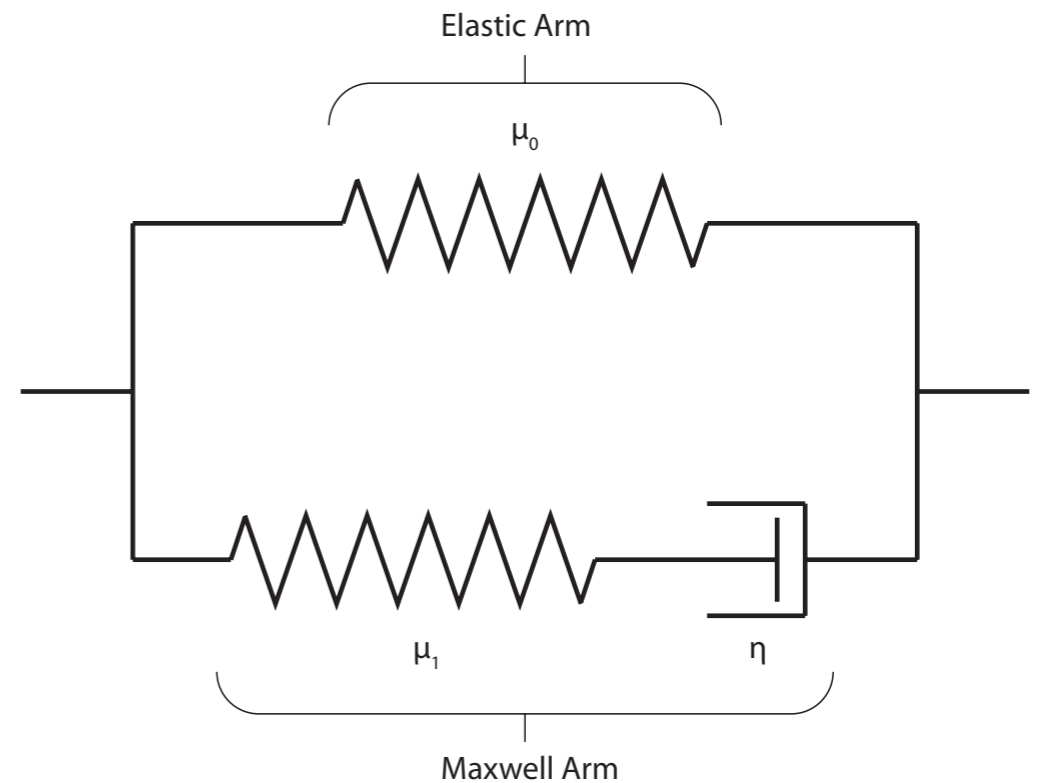
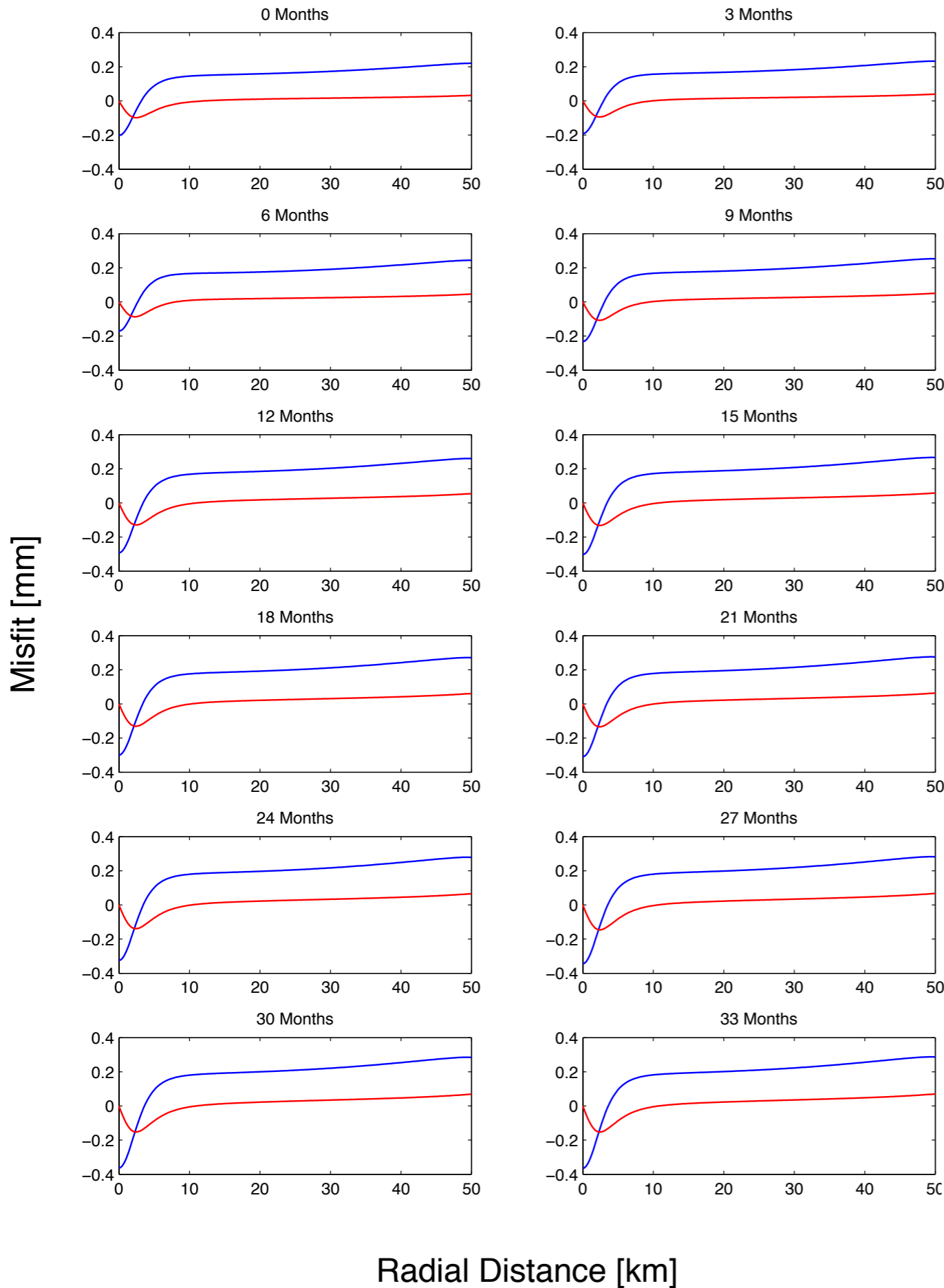


$$\begin{pmatrix} U_x \\ U_y \\ U_z \end{pmatrix} = \alpha^3 \Delta P \begin{pmatrix} \frac{x}{R^3} \\ \frac{y}{R^3} \\ \frac{d}{R^3} \end{pmatrix} A(t)$$

$$A(t) = \frac{1}{2G_0} \left[\frac{3K + 4G_0\mu_0}{\mu_0(3K + G_0\mu_0)} - 3 \frac{\eta G_0^2 e^{-\left(\frac{G_0\mu_1(3K + G_0\mu_0)}{\eta(3K + G_0\mu_0)}\right)t}}{\eta(3K + G_0\mu_0)(3K + G_0)} (1 - \mu_0) - \left(\frac{1}{\mu_0} - 1\right) e^{-\left(\frac{G_0\mu_0\mu_1}{\eta}\right)t} \right]$$

Benchmarking

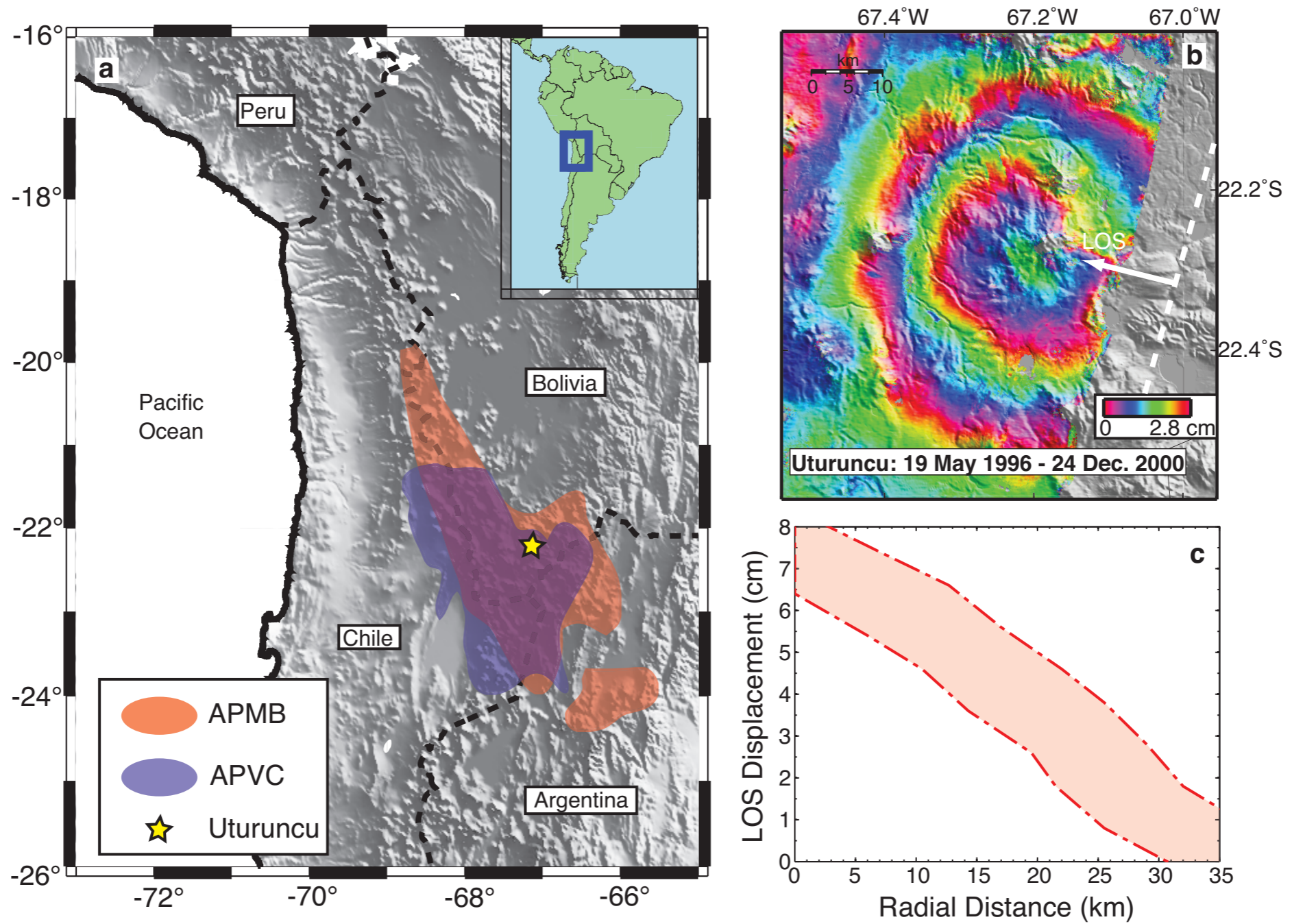
- VE analytical solution from Del Negro et al., 2009



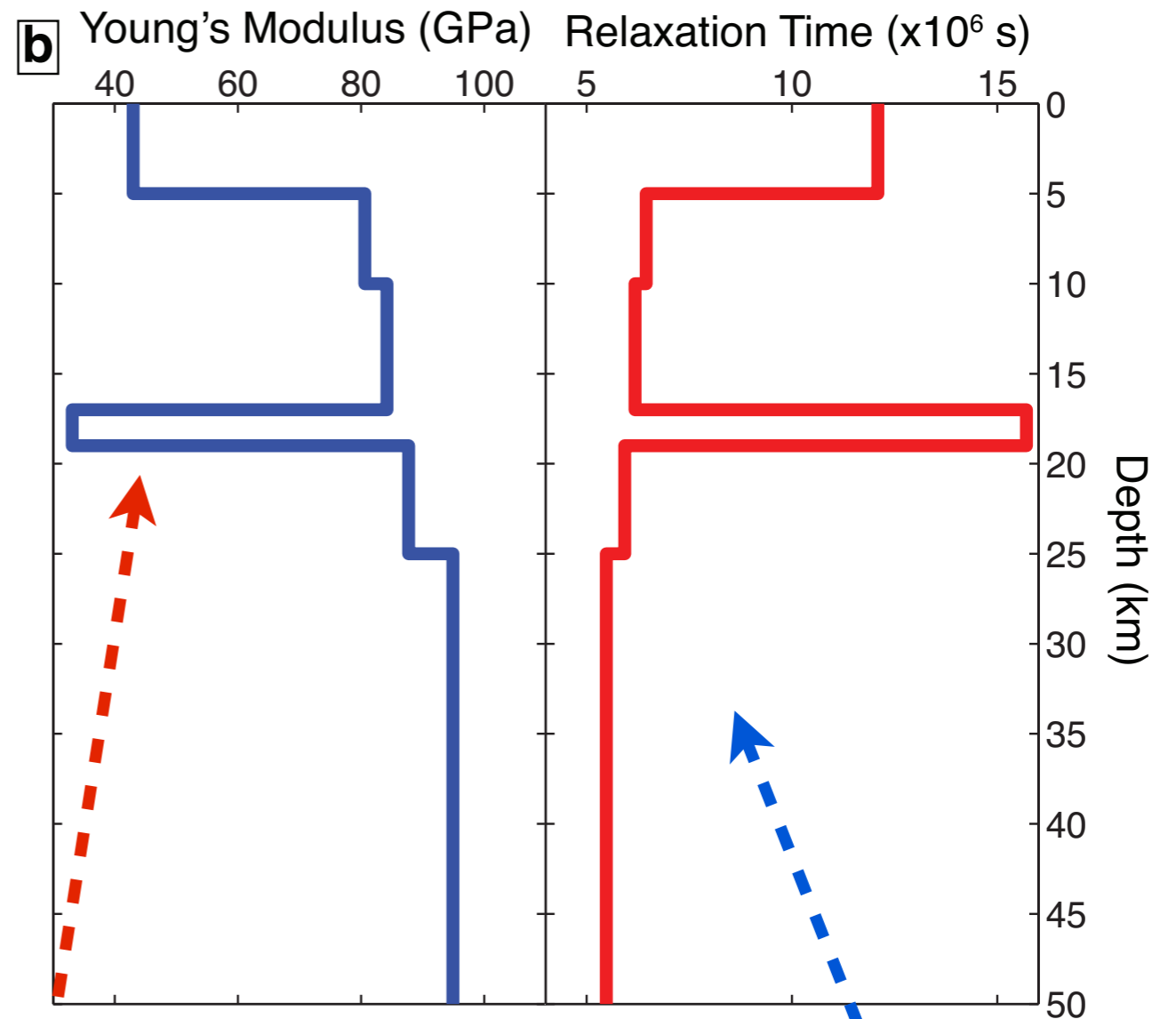
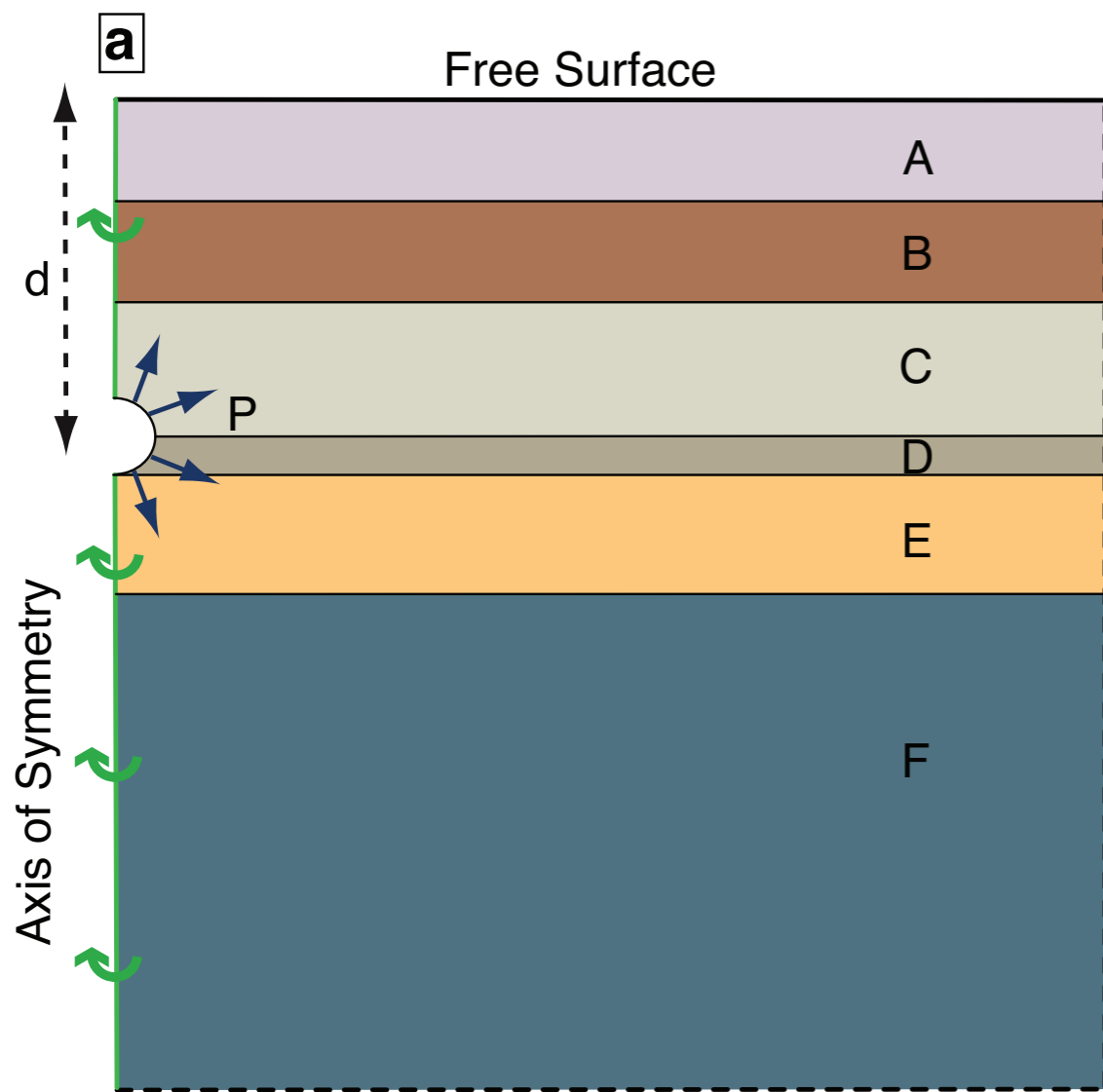
$$\begin{pmatrix} U_x \\ U_y \\ U_z \end{pmatrix} = \alpha^3 \Delta P \begin{pmatrix} \frac{x}{R^3} \\ \frac{y}{R^3} \\ \frac{z}{R^3} \end{pmatrix} A(t)$$

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Uturuncu



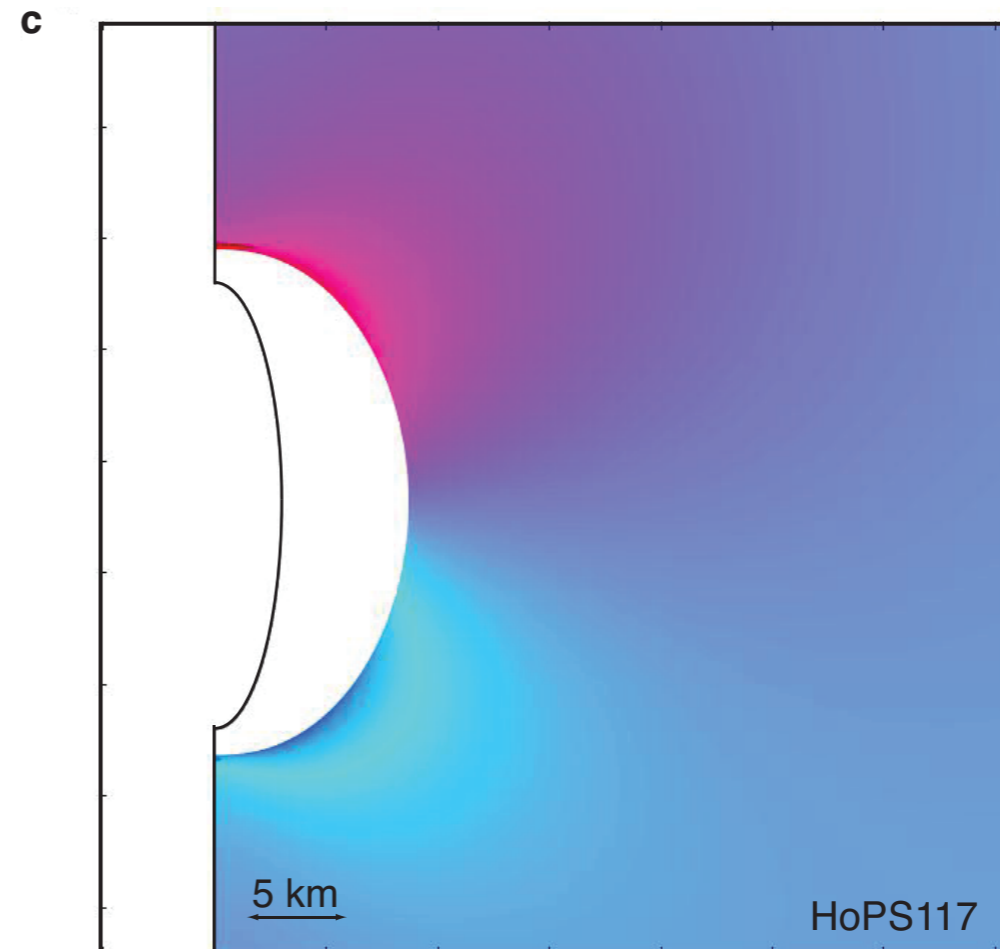
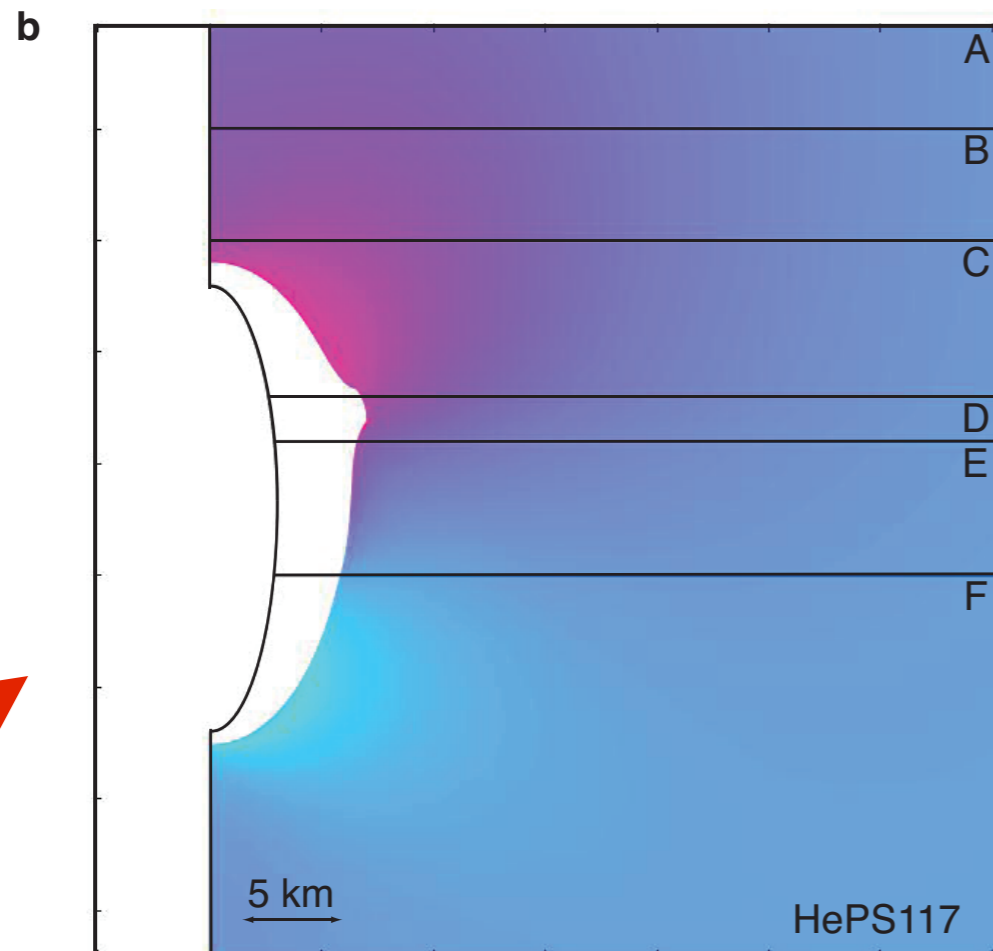
Uturuncu



Soft layer

For VE models only

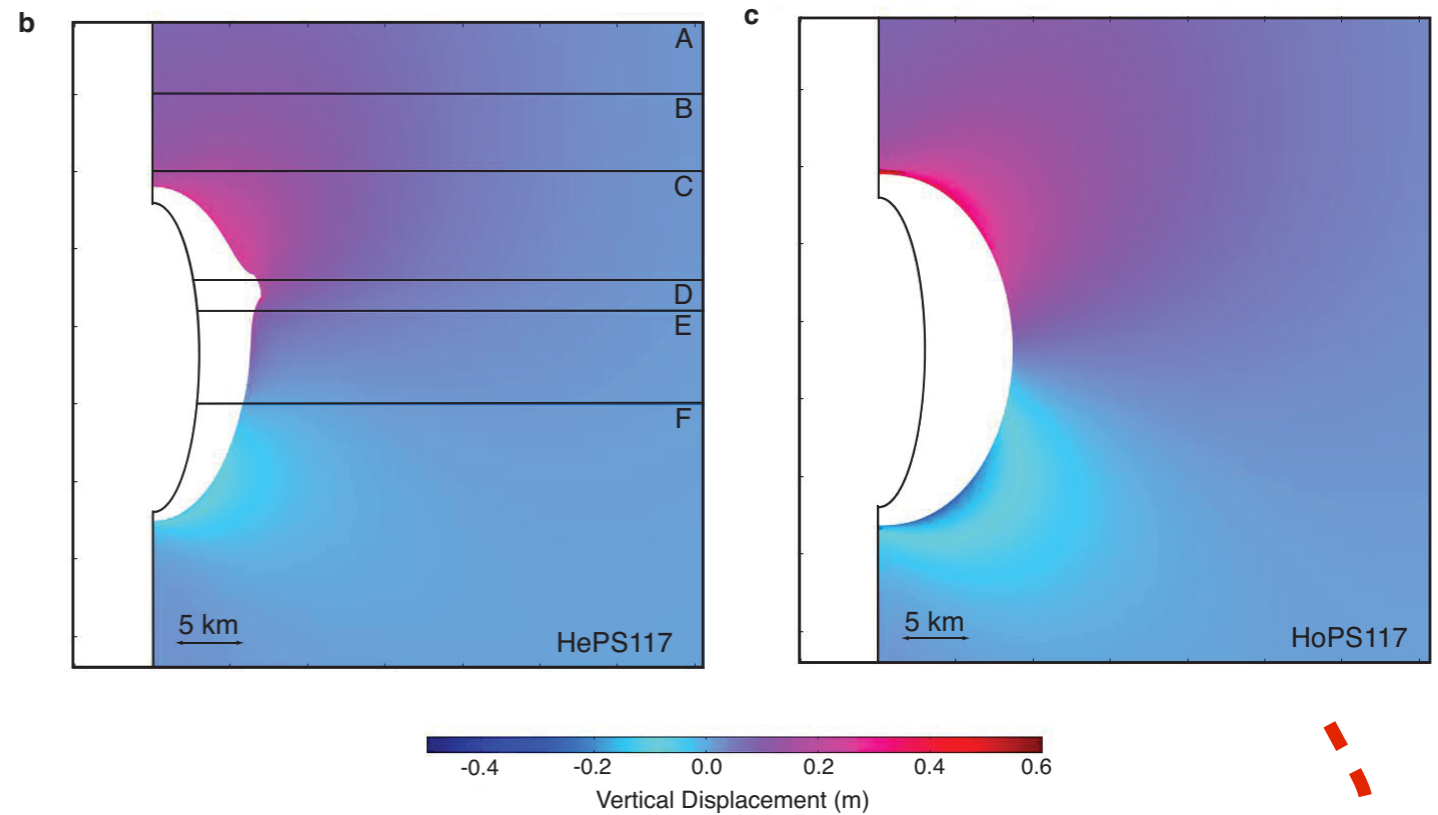
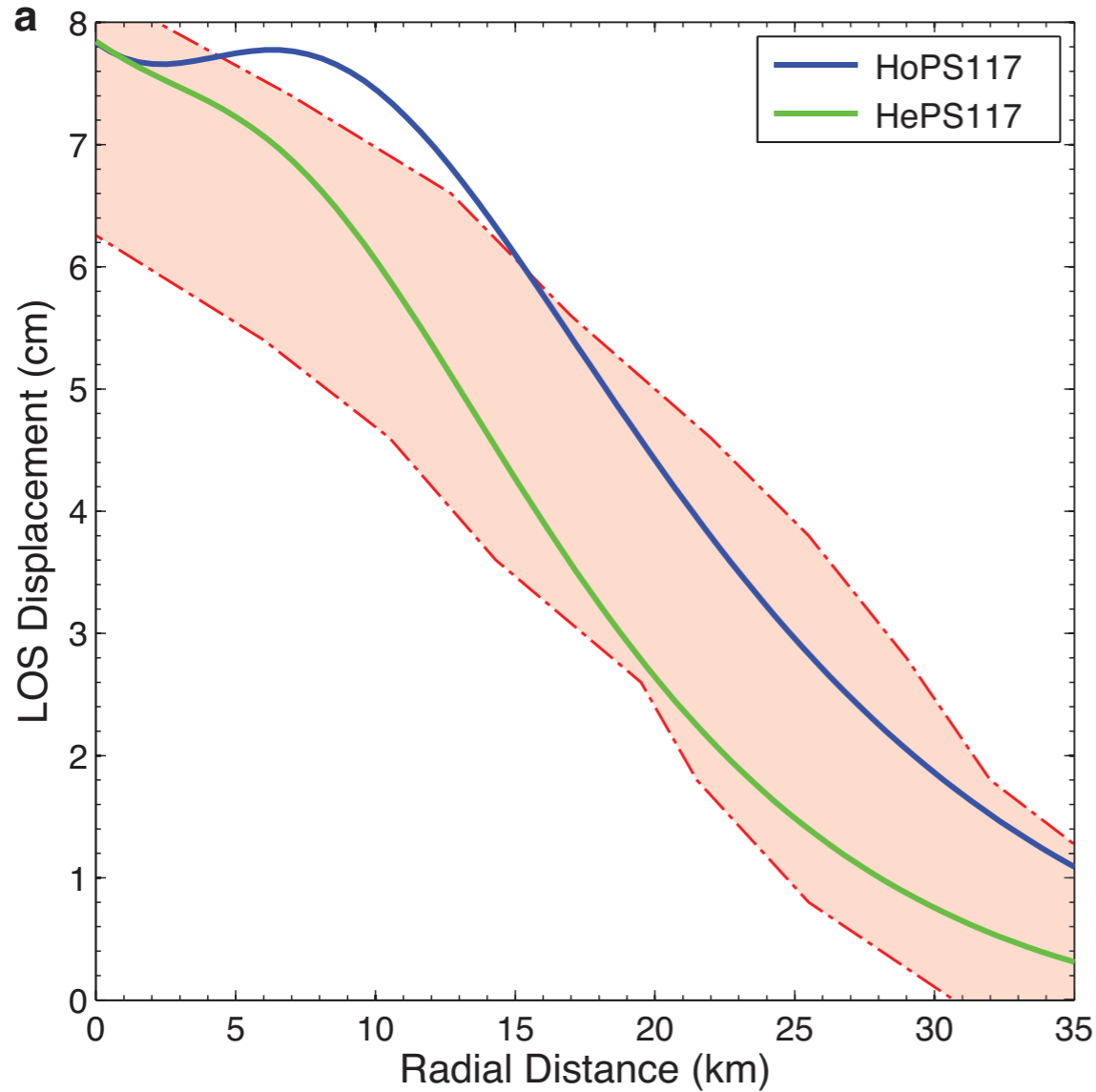
Uturuncu



Preferential
expansion into soft
layer

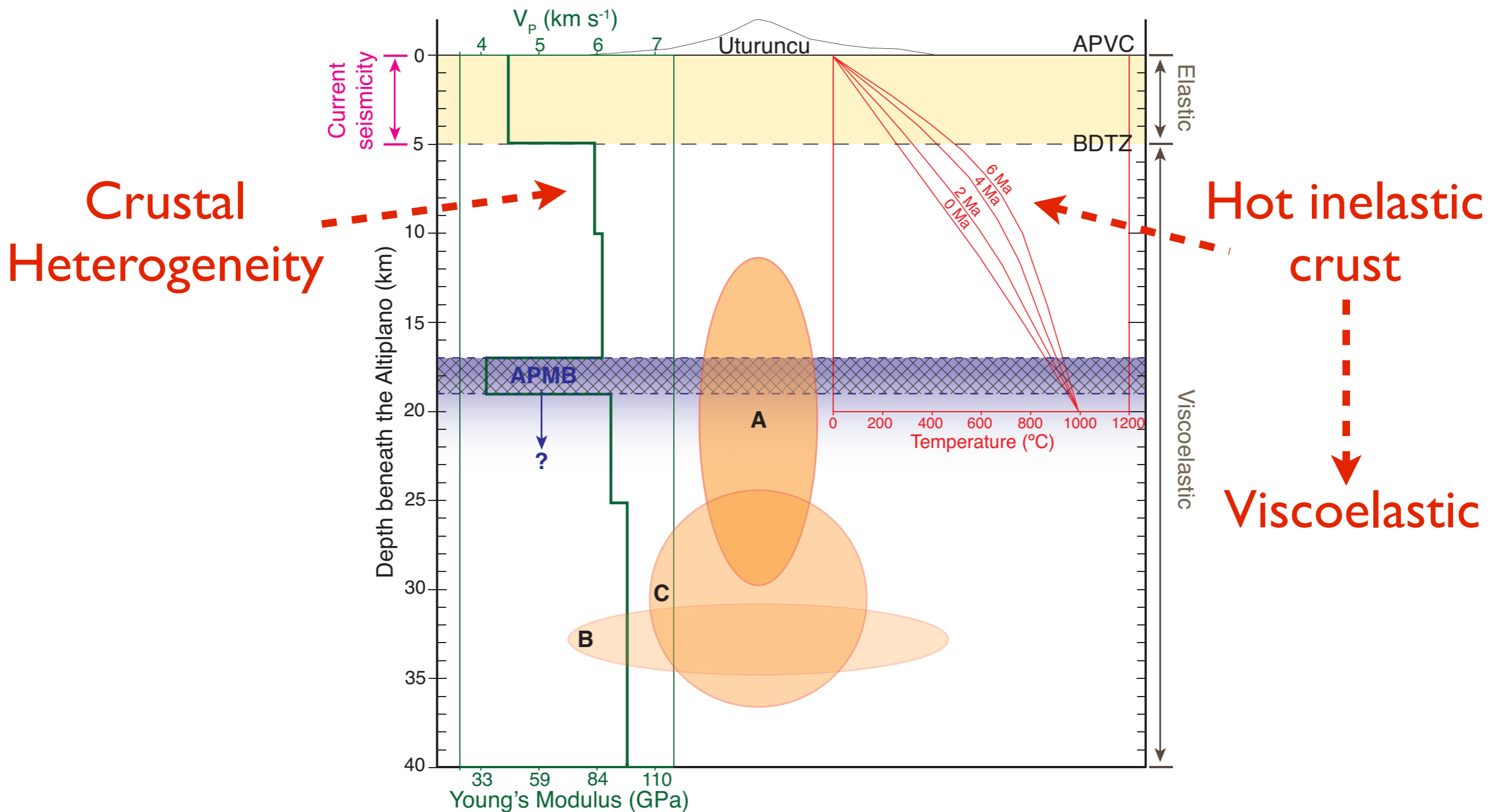
Concentric
and homogeneous
expansion

Uturuncu

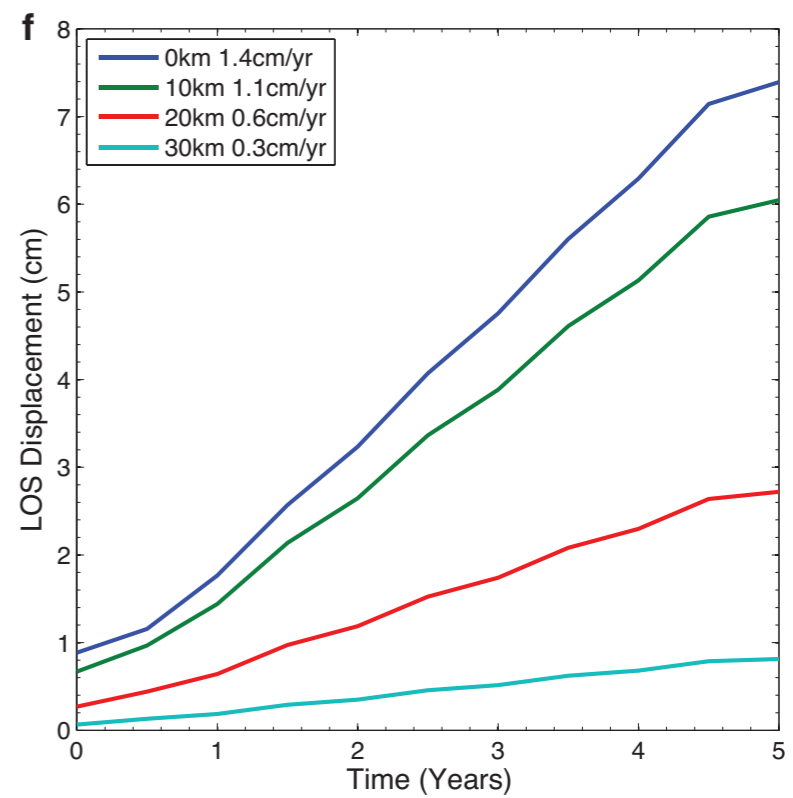
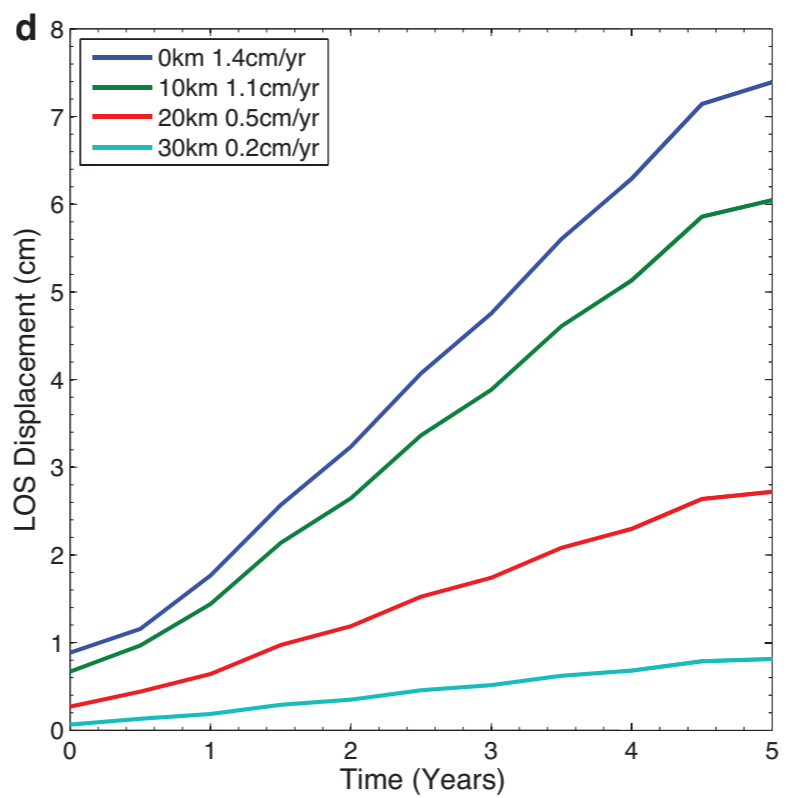
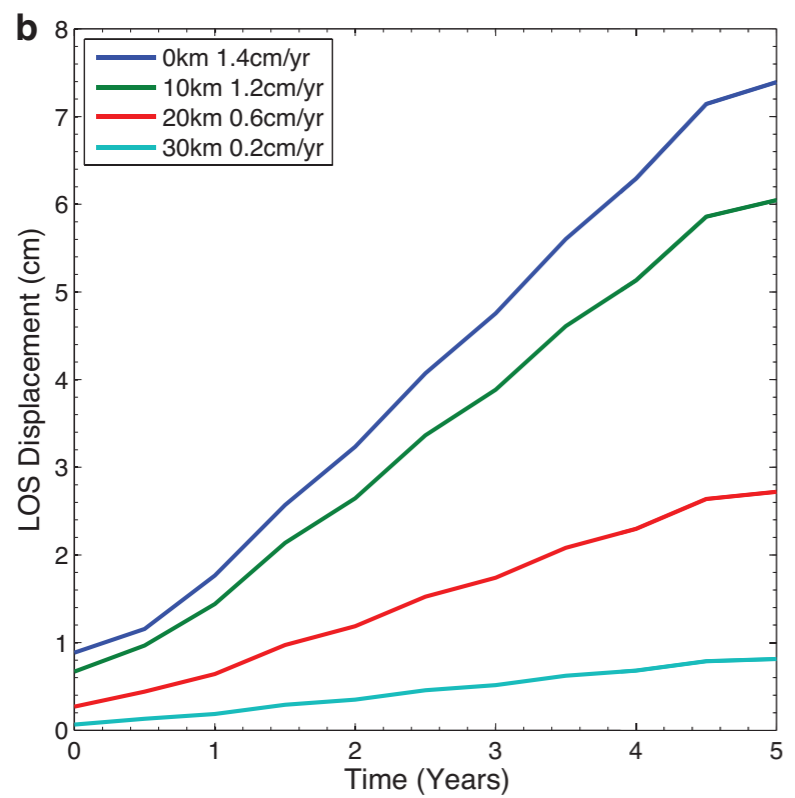
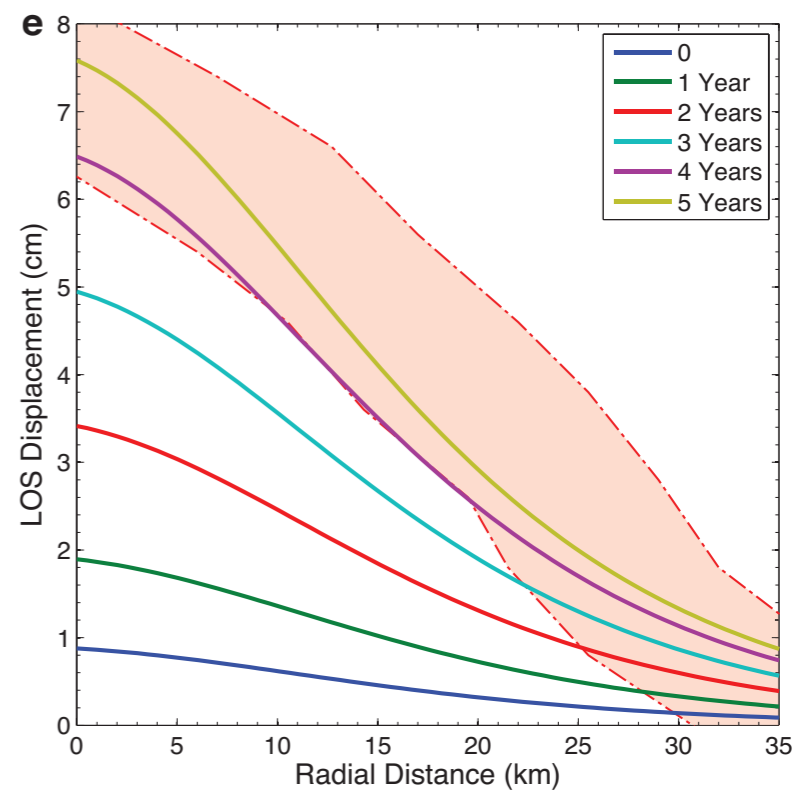
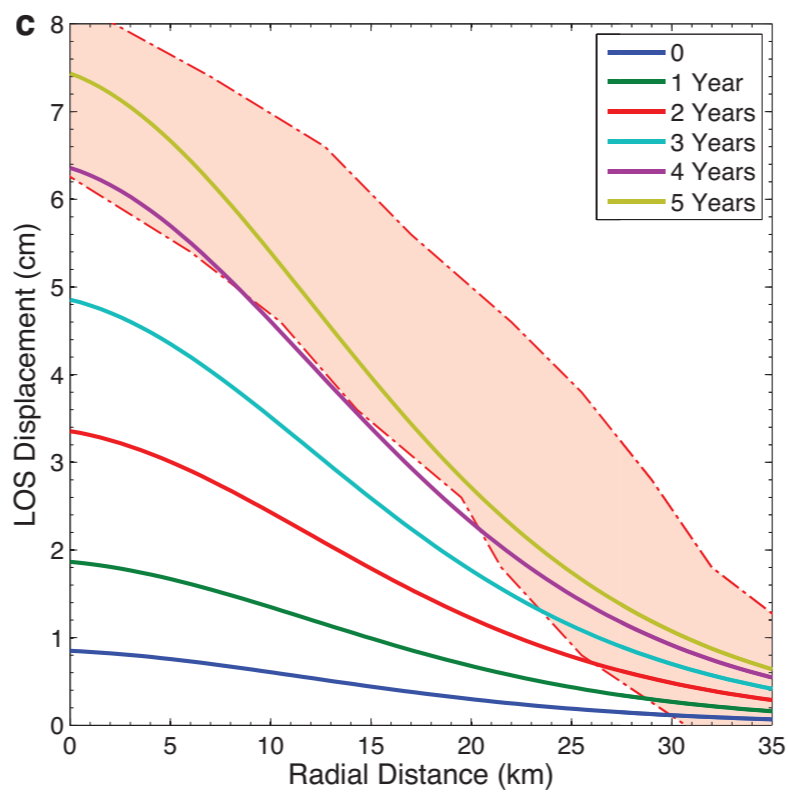
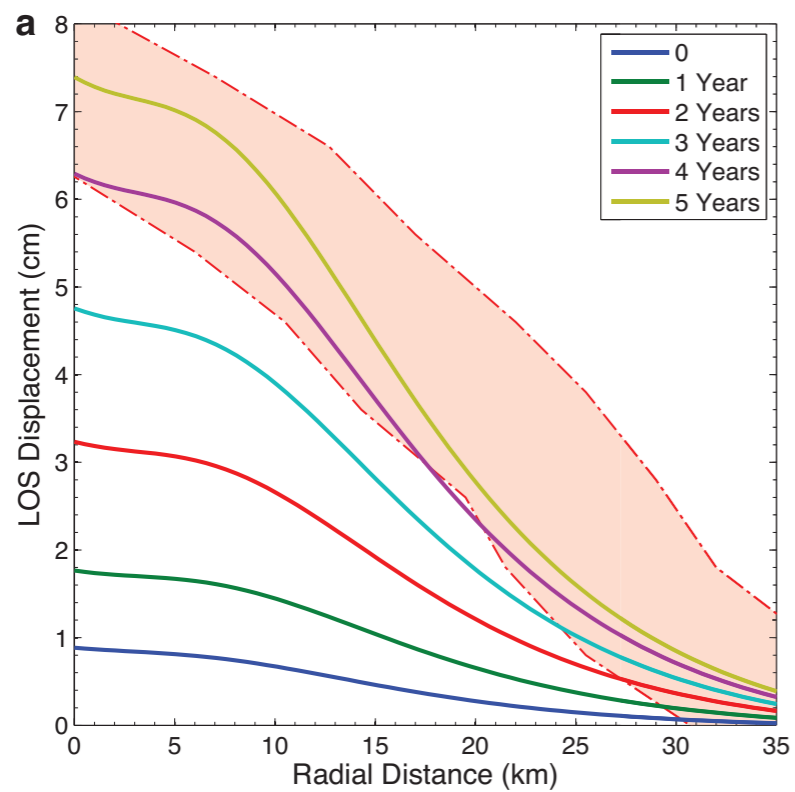


Subsurface buffering
affects surface inflation

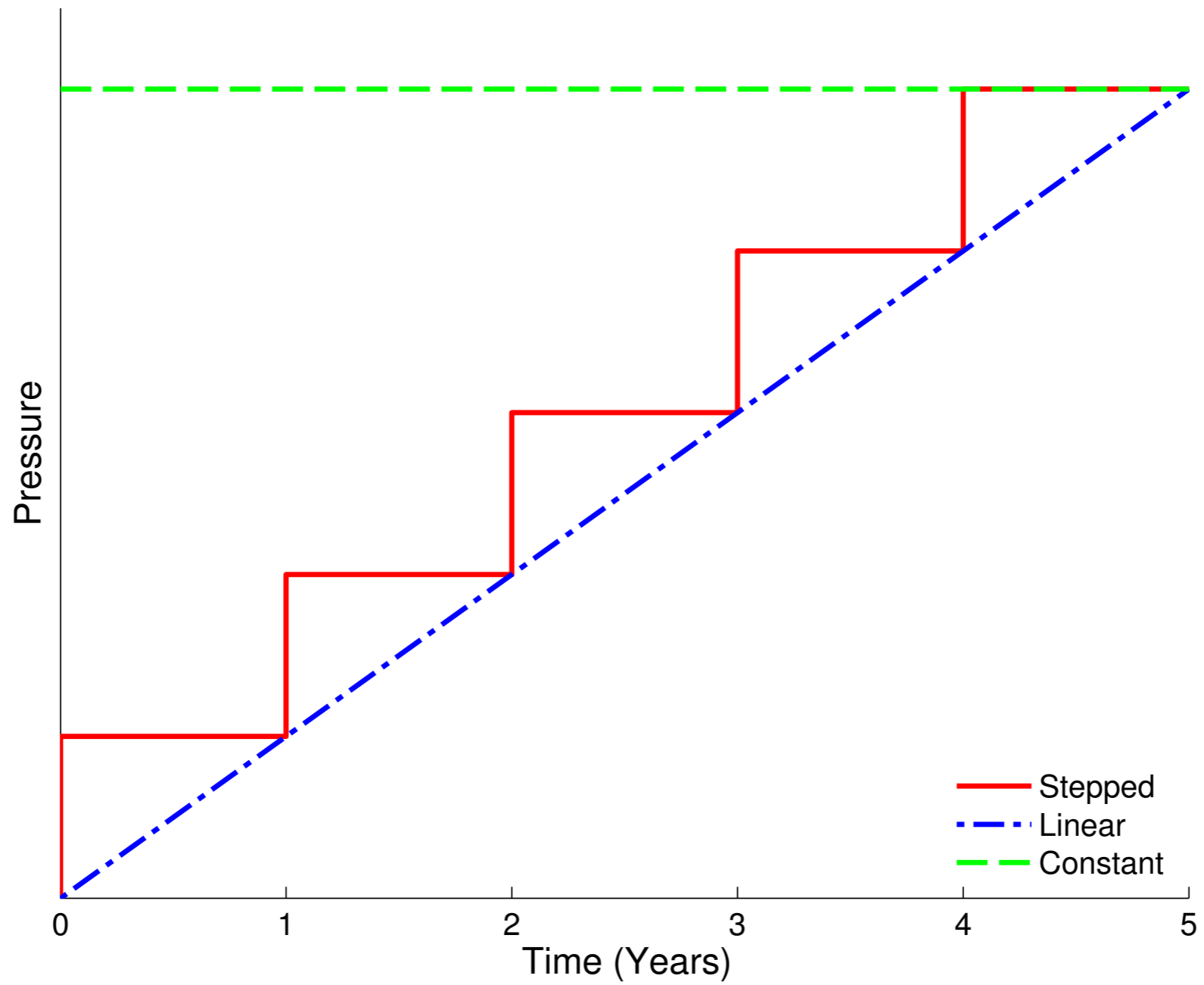
Uturuncu



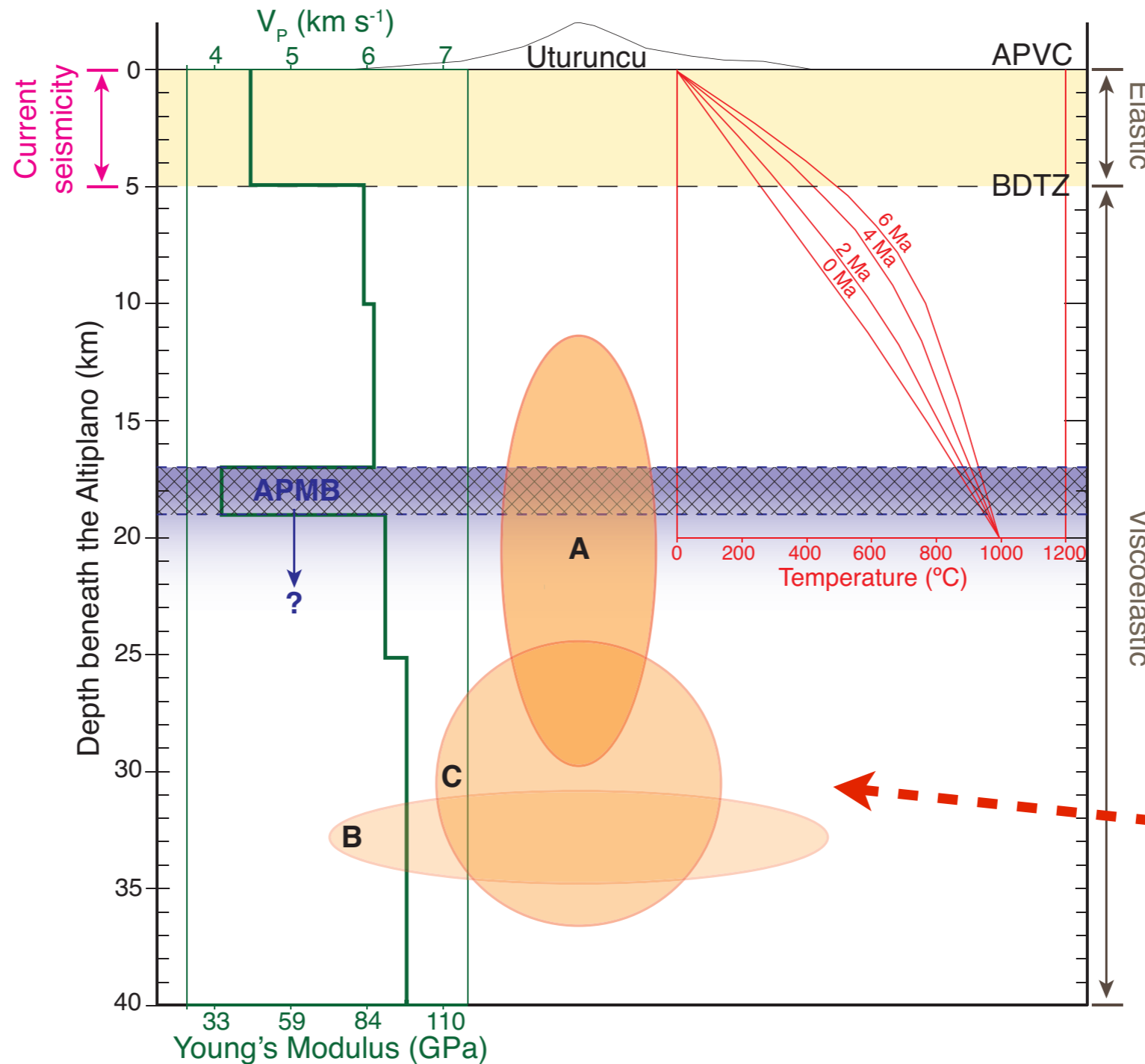
Uturuncu



Uturuncu

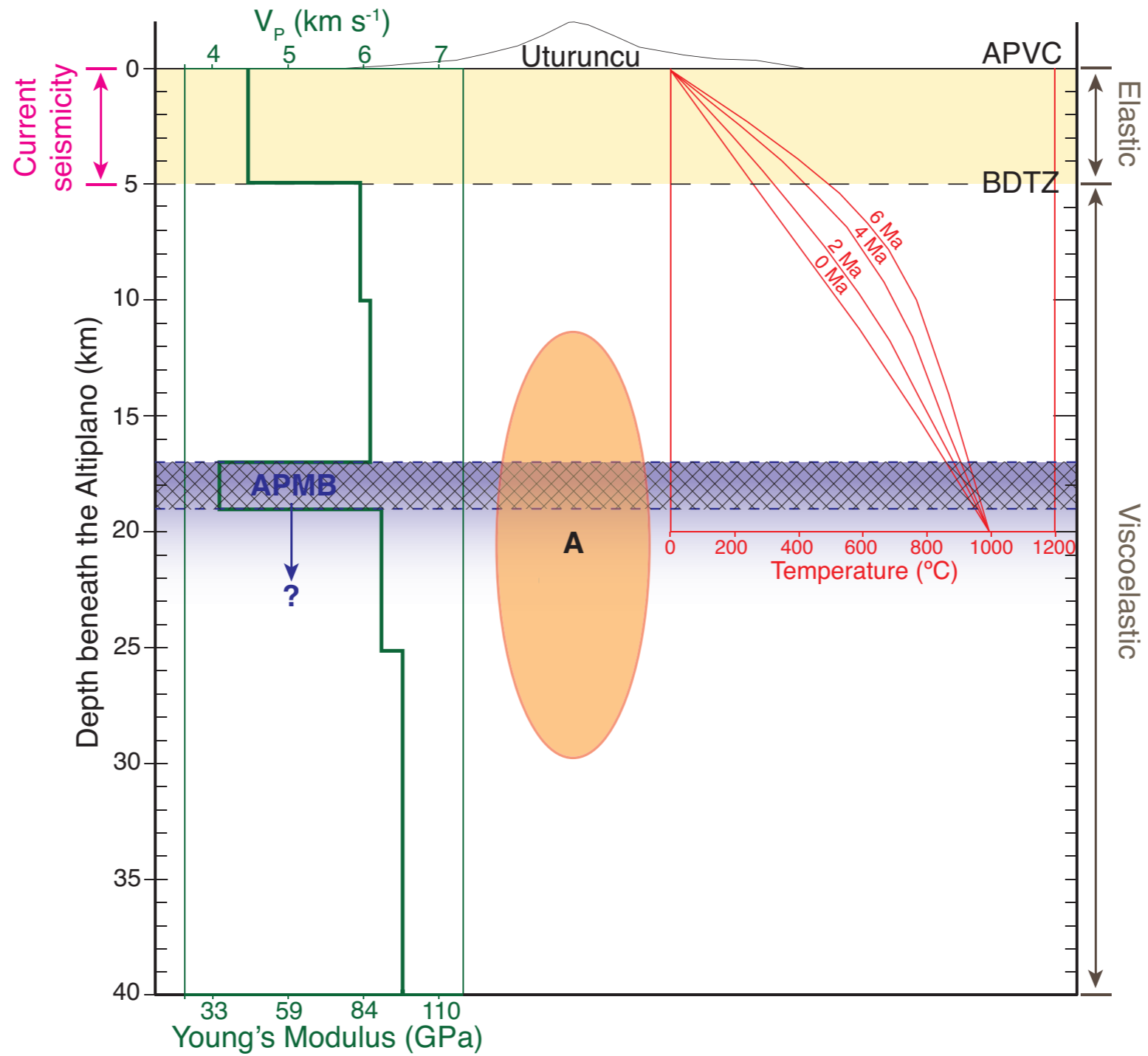


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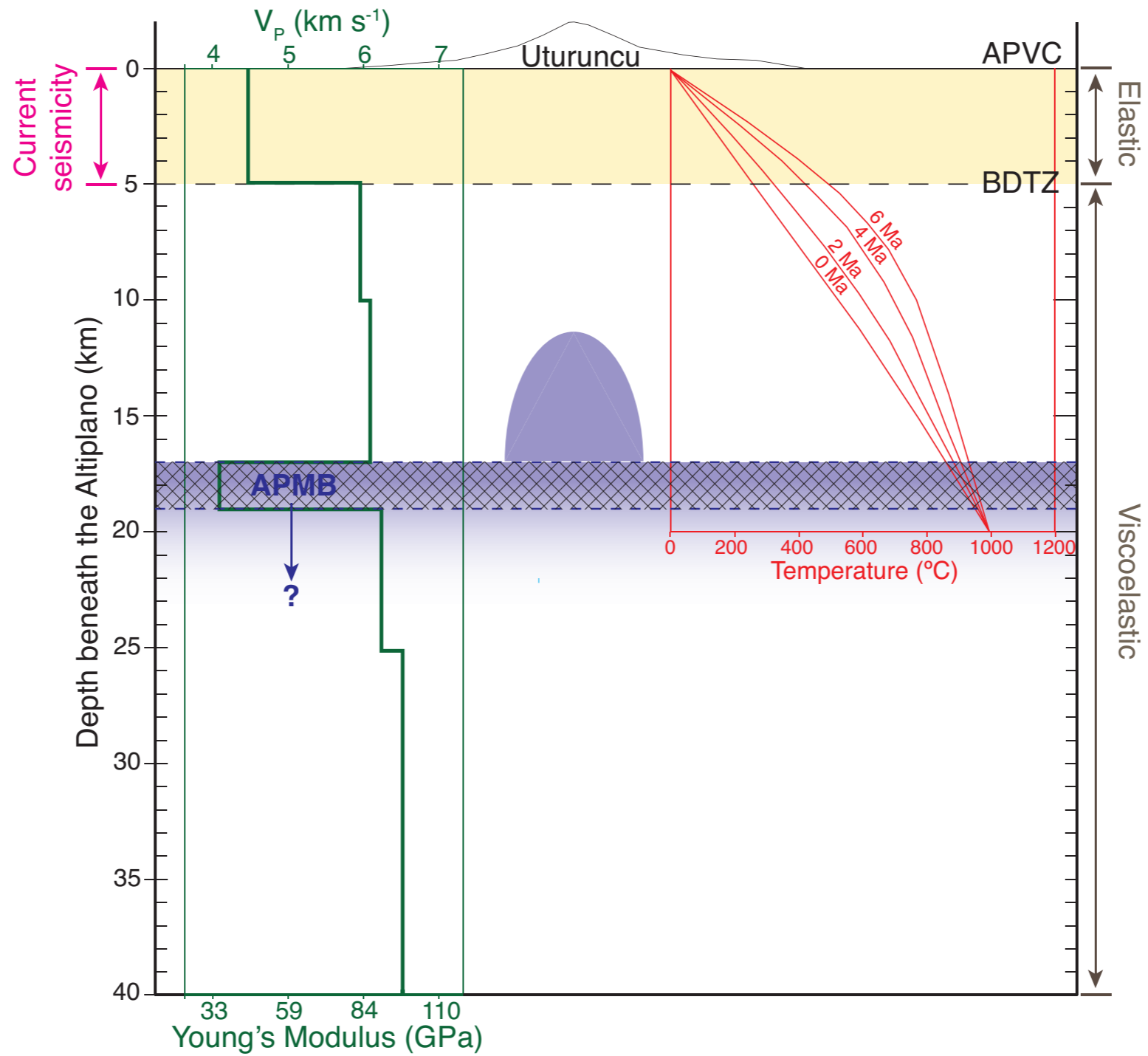


Too deep to
sustain
pressurisation

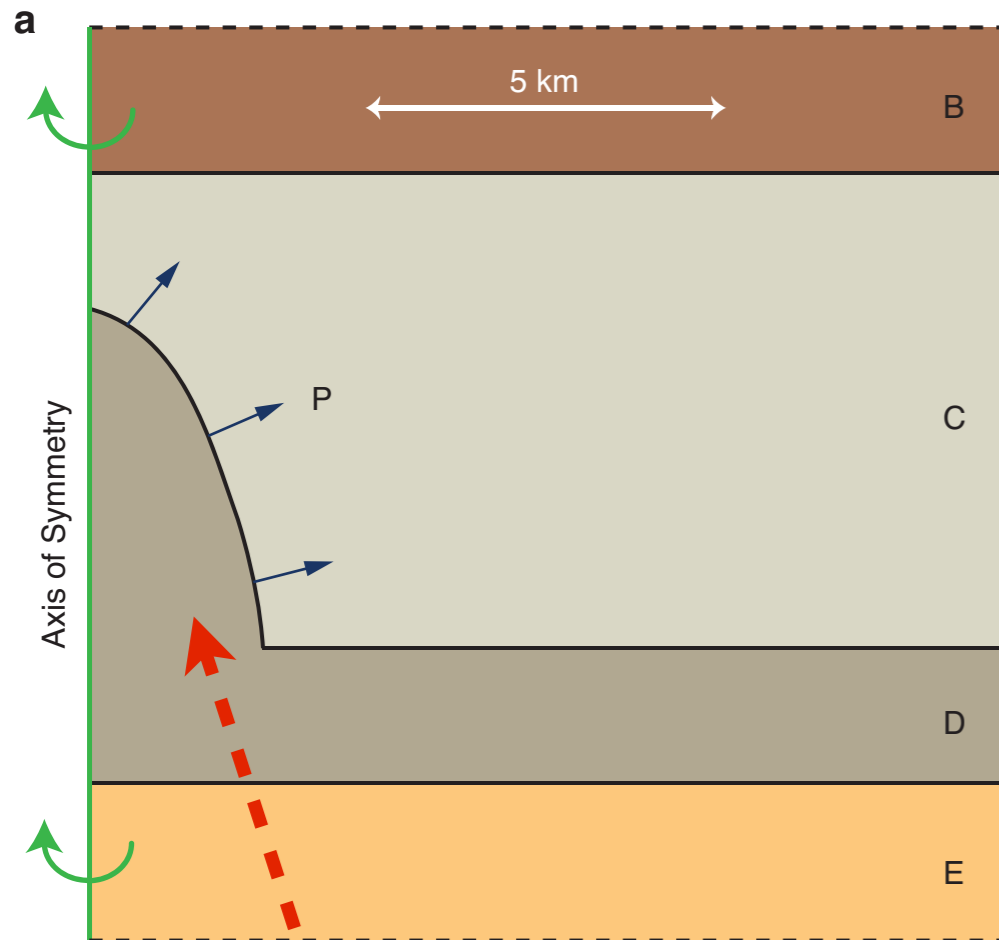
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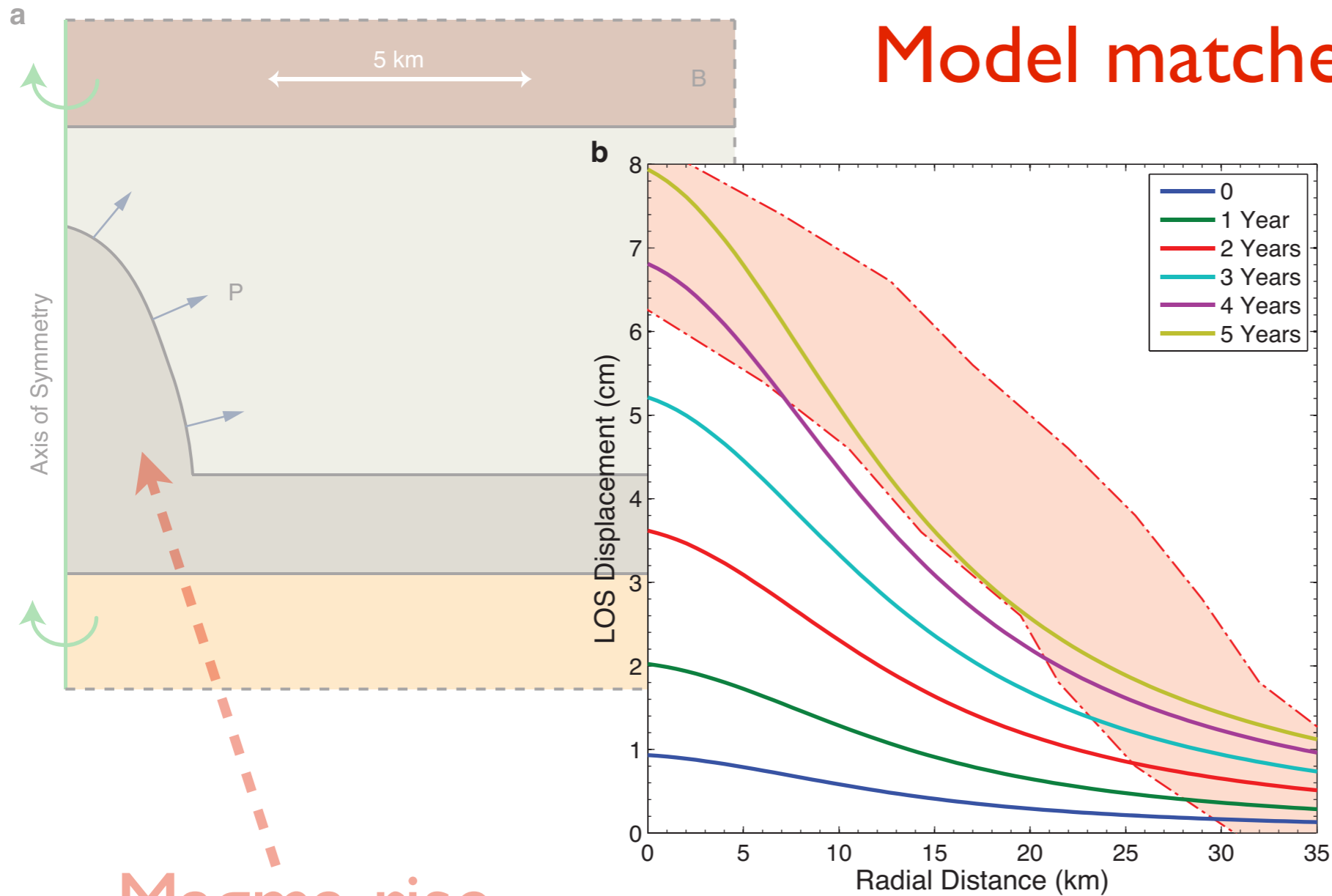
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**Magma rise
from APMB**

Uturuncu

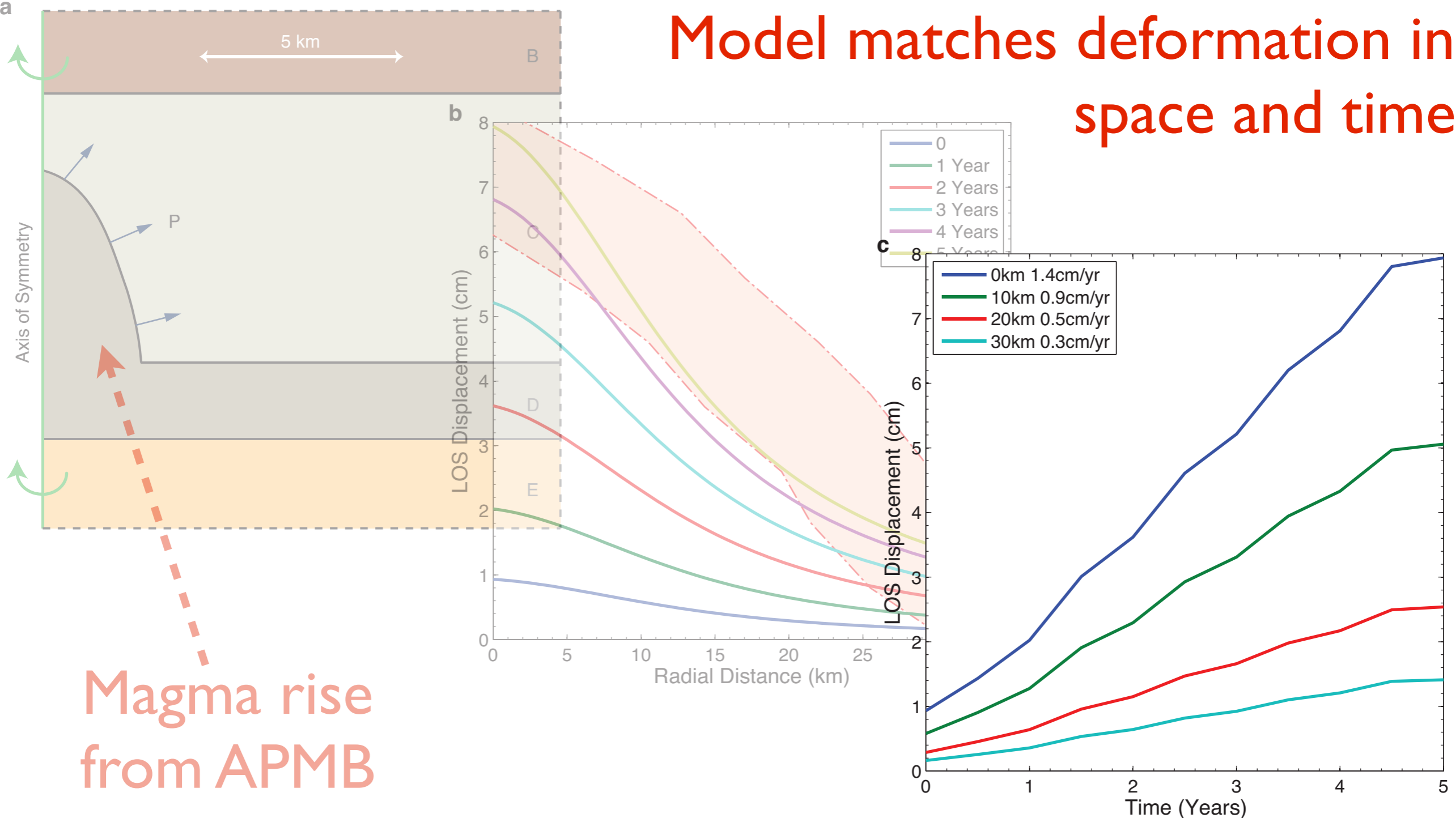
Model matches deformation in space



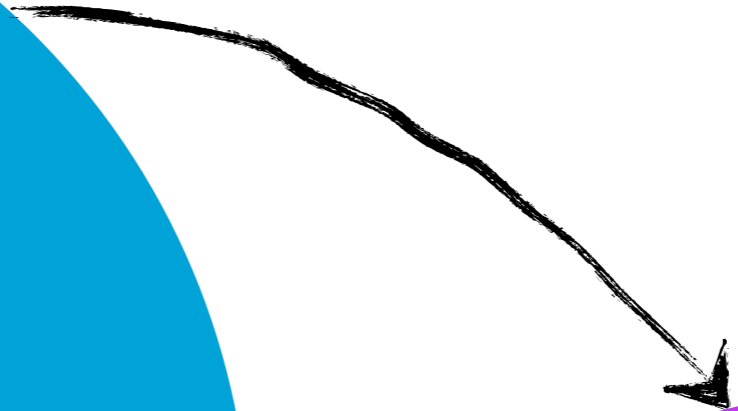
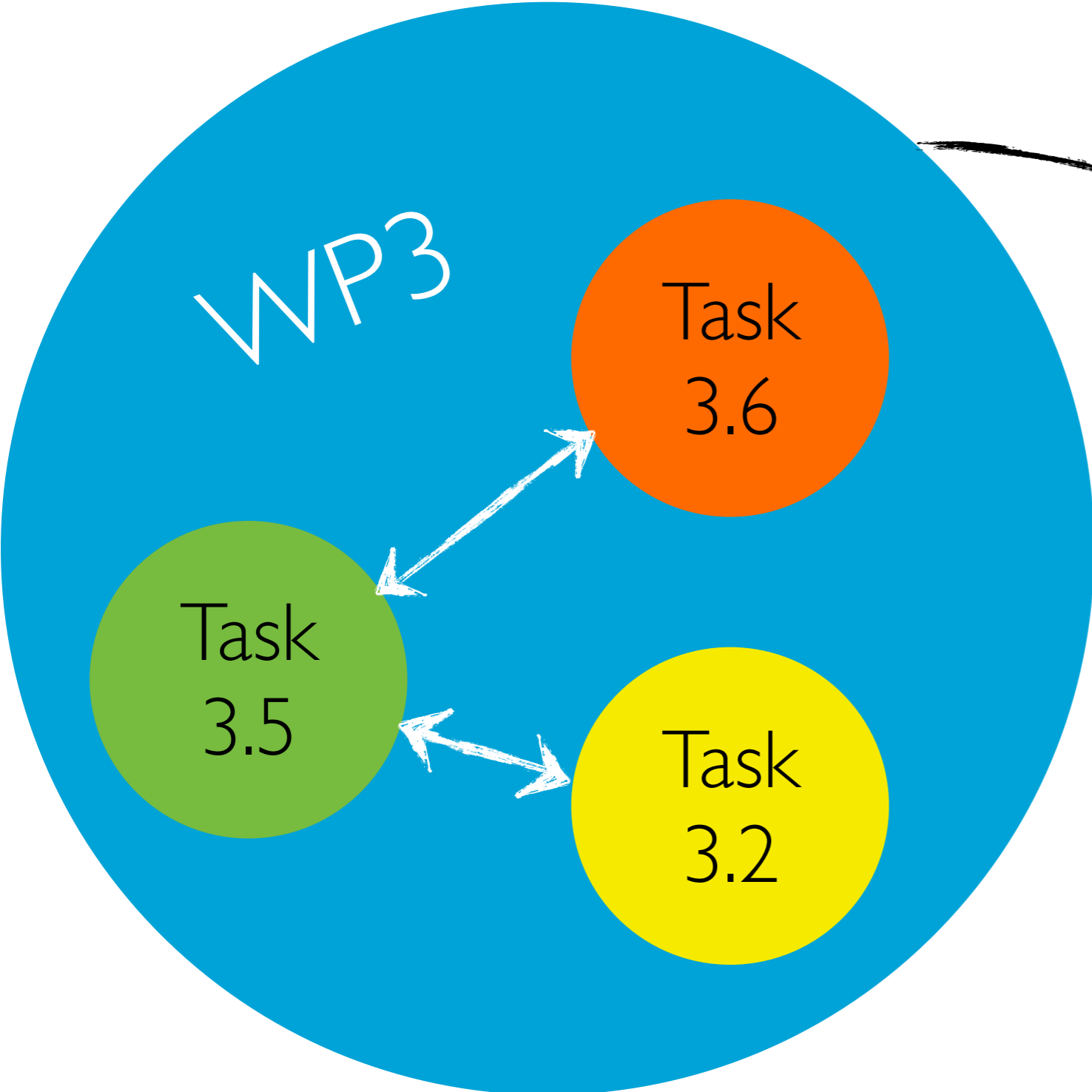
Magma rise from APMB

Uturuncu

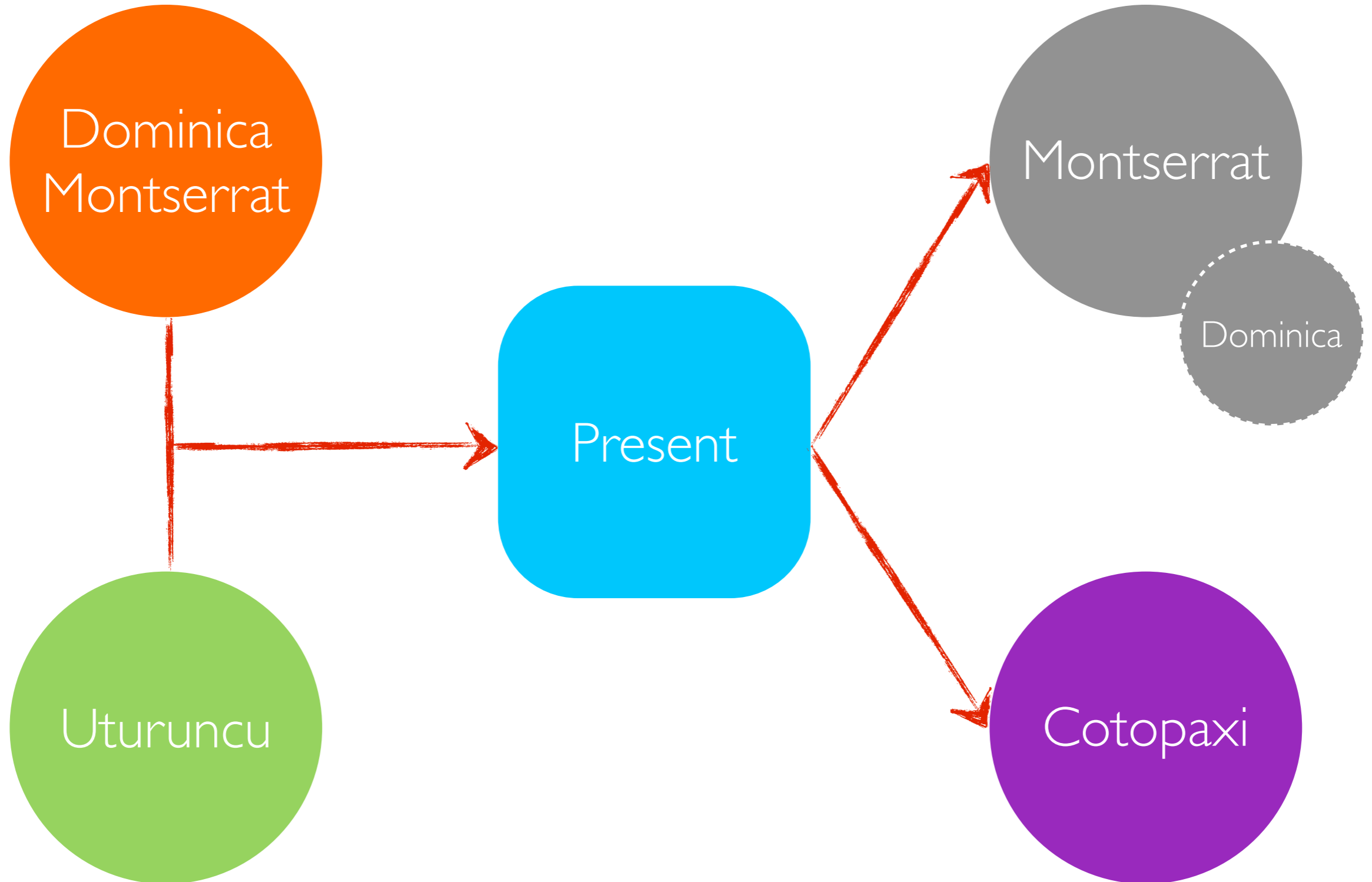
Model matches deformation in space and time



Project Links?



Outlook



Thank you!



James Hickey | james.hickey@bristol.ac.uk | [@jameshickey77](https://www.instagram.com/jameshickey77)

