We use Blue Waters to:

Replicate 4-D evolution of mantle dynamics

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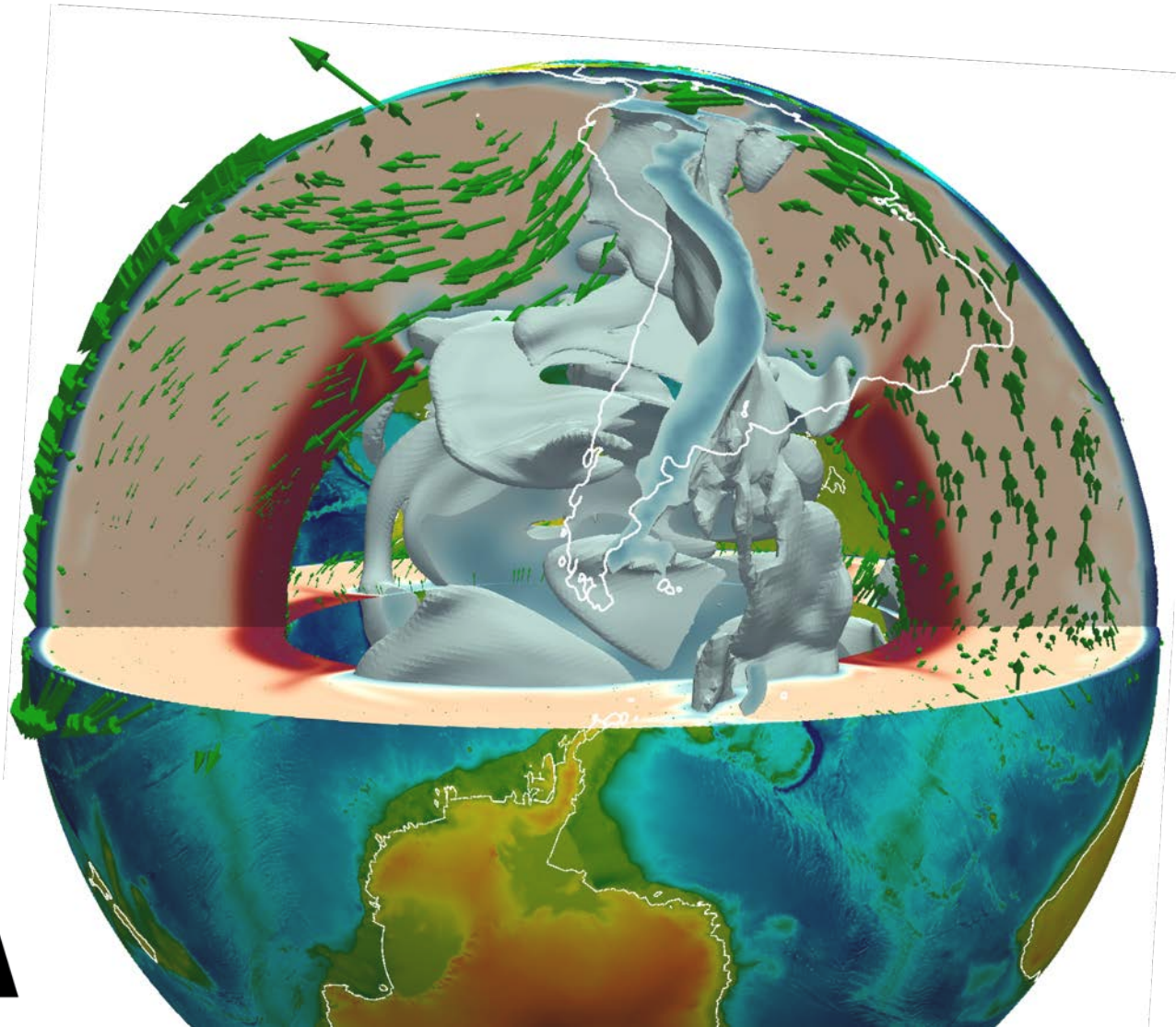

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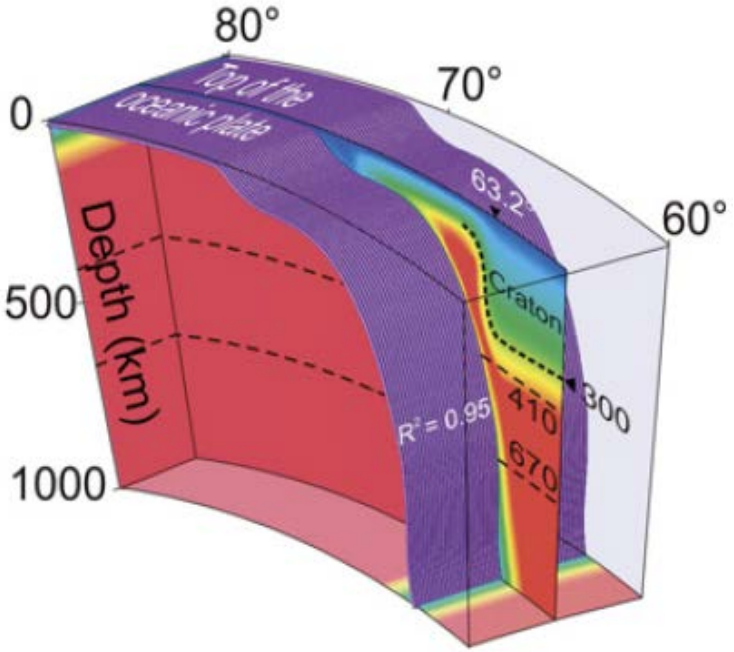
Why Blue Waters?

- **Earth's mantle is a complex system whose dynamics requires quantification of many observations (both surface and internal) simultaneously. Traditional mantle models are often simplified and thus incapable to explain various geological processes.**
- **Thus, we advocate data-oriented numerical modeling:**
  - Sophisticated numerical codes.
  - Efficient computational platform.
  - Blue Waters represents the best choice for expanding current modeling capability.

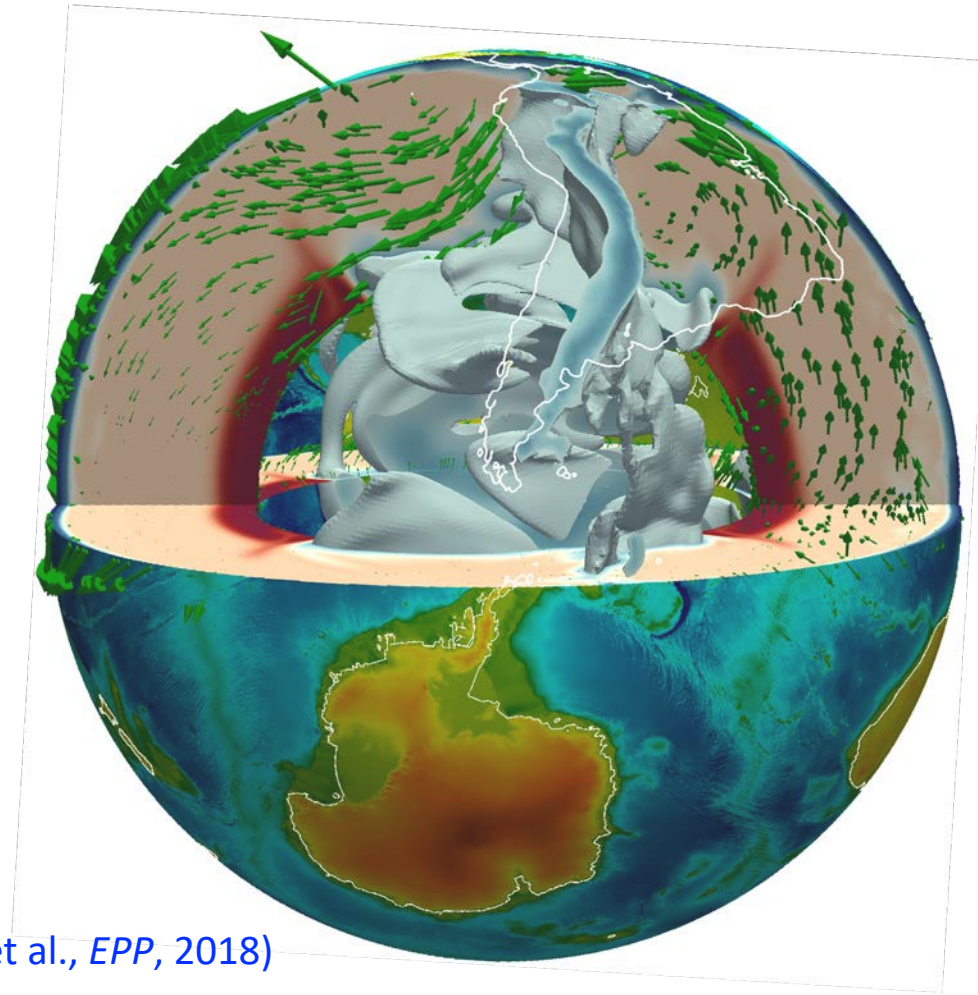
With Blue Waters

- We extend the scalability of the community mantle convection code CitcomS.
  1. Increasing total MPI cores by 10 fold, to ~10,000

Leading to increased model resolution & larger model domain.



(Manea et al., *Geology*, 2012)



(Hu et al., *EPP*, 2018)

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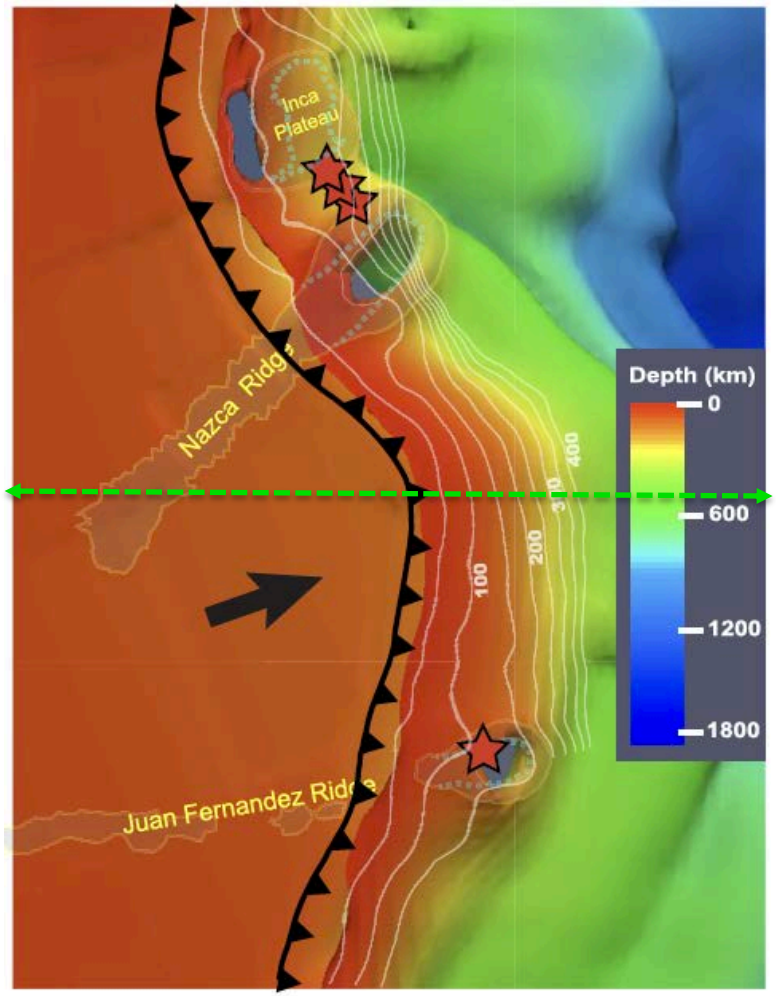
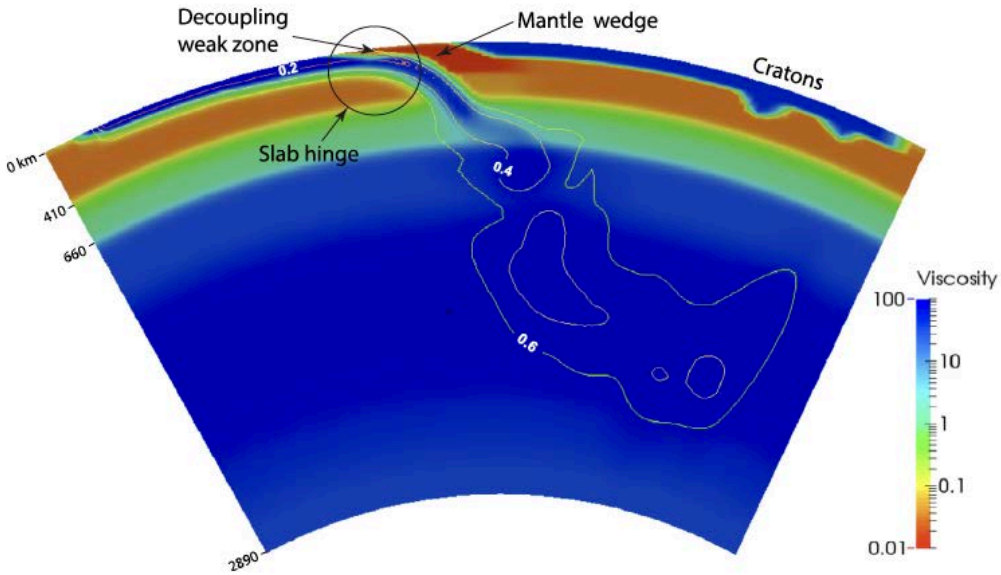
Well-reproduced South American slab



Predicted S. American slab geometry that matches multiple observational constraints:

- Steep & flat slab segments
- Geometry of seismicity distribution
- Slab tears causing abnormal volcanism



(Hu et al., *EPSL*, 2016)

With Blue Waters

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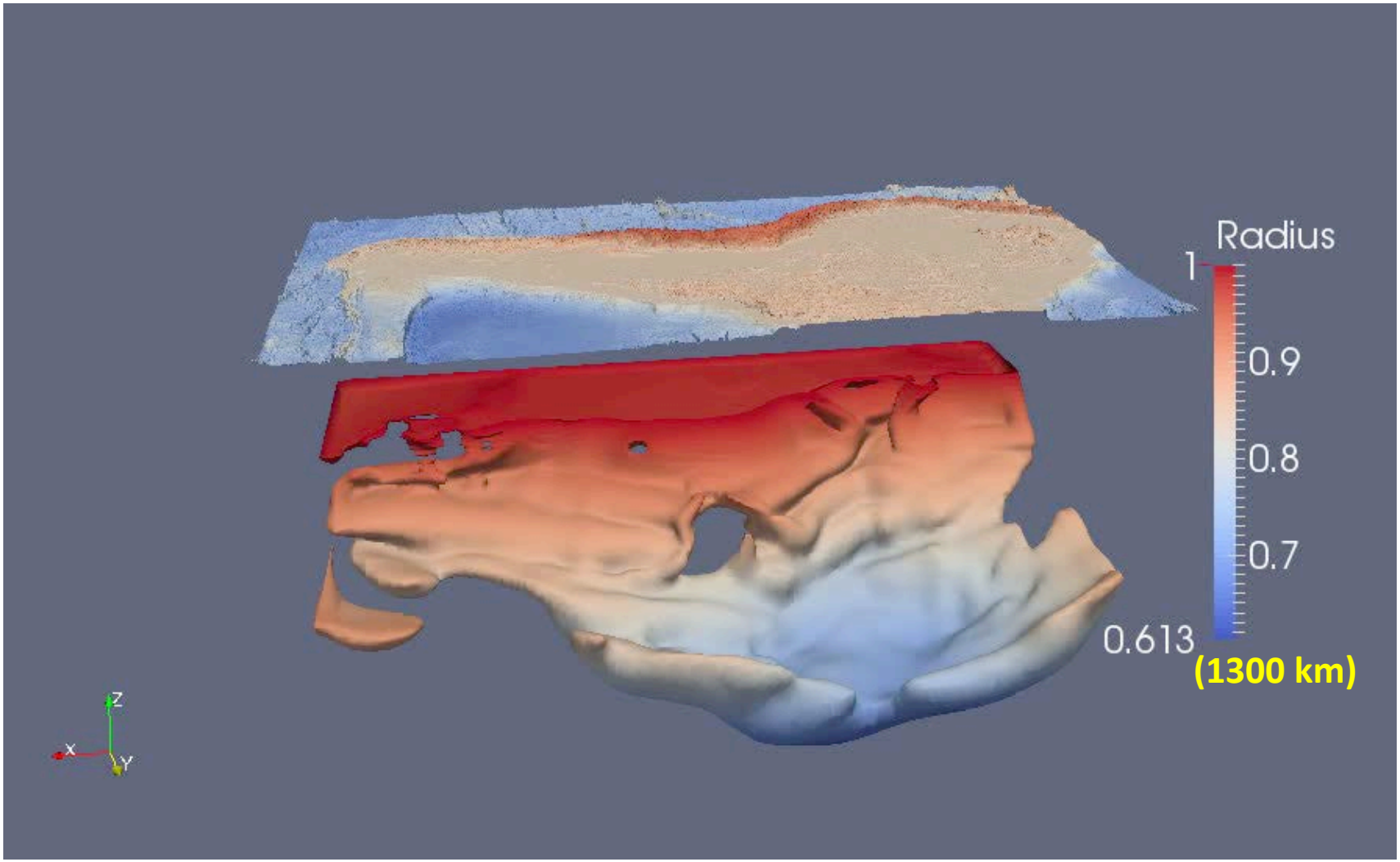
  2. Resolving fine mantle features like slabs and plumes within whole mantle-scale models.
  3. Developed realistic regional convection models for South America and North America.

Better representation of South American subduction

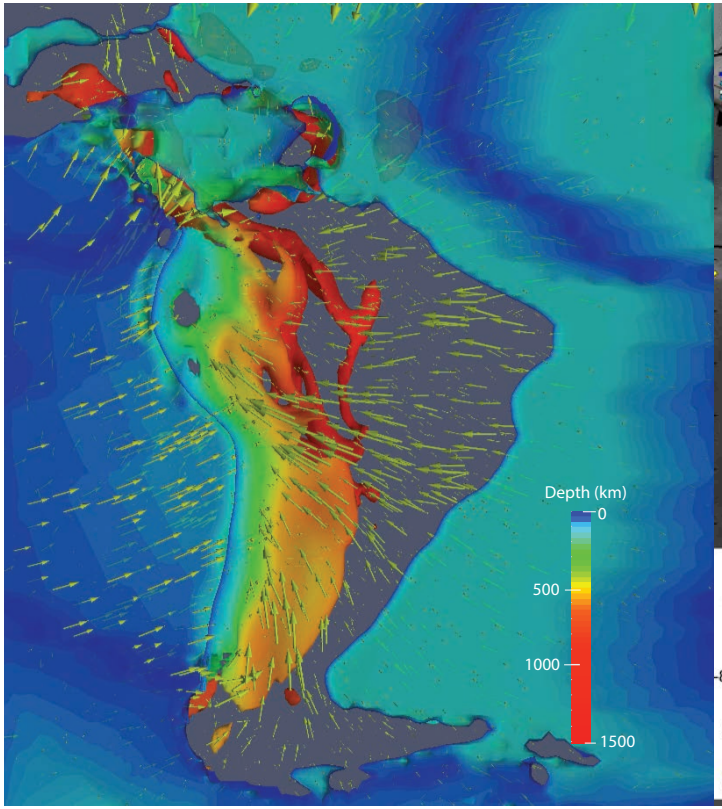


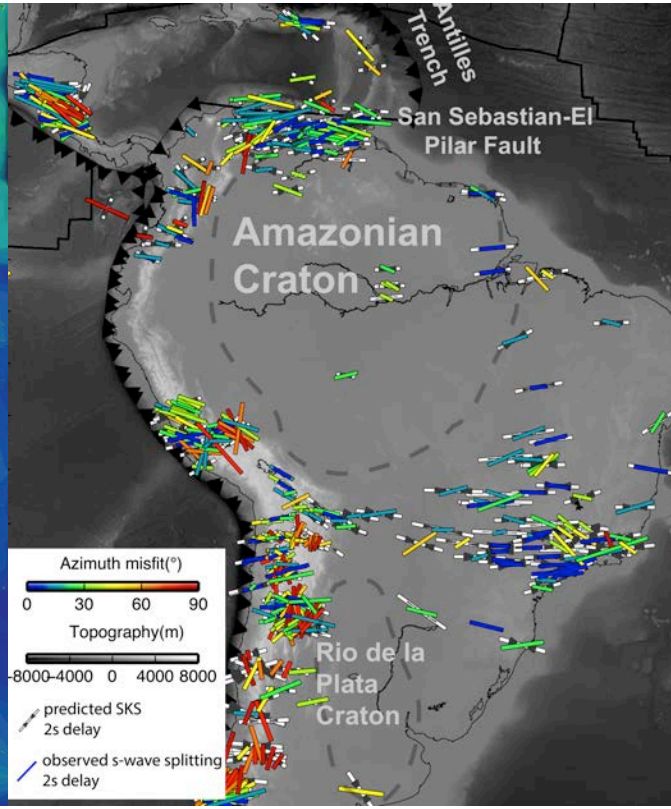
(Hu et al., *EPSL,* 2016)

Constrained mantle flow

Allowing for the quantification of mantle deformation.

(Hu et al., *EPSL*, 2017)

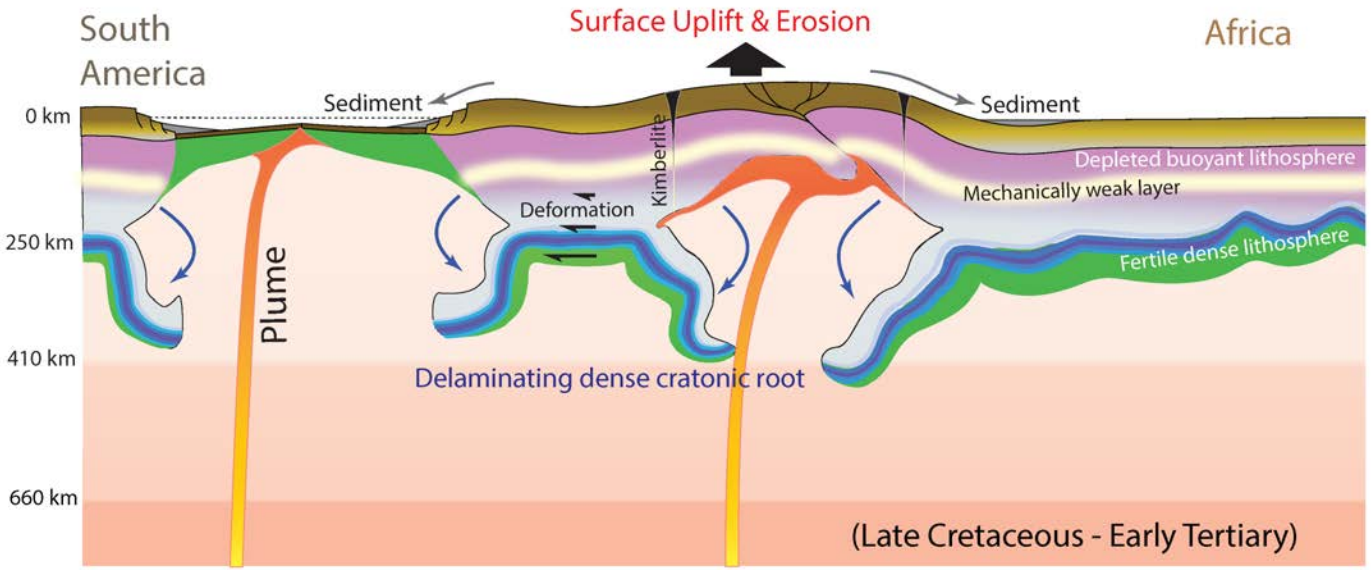




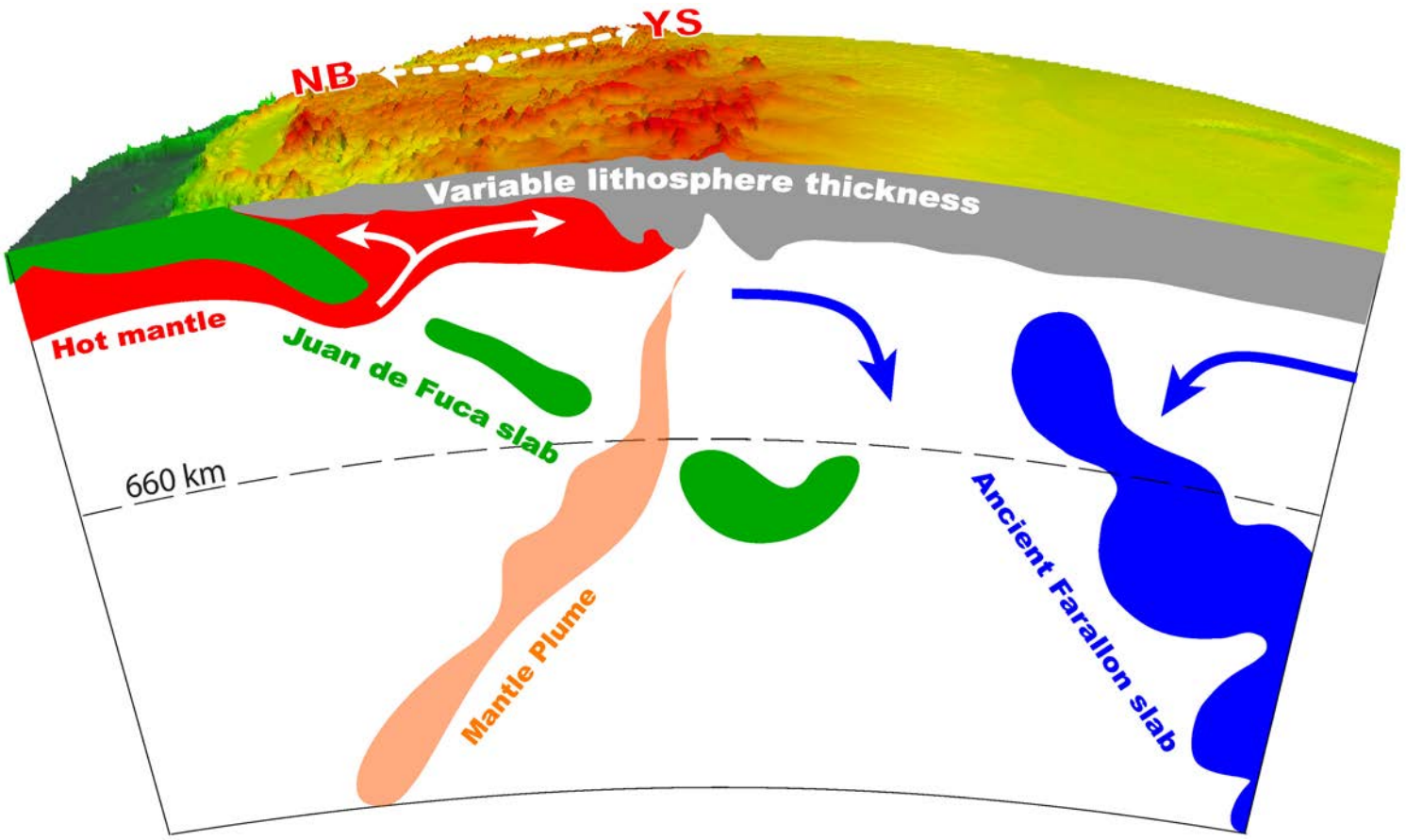
New insight on evolution of continent

Continental lithosphere has a layered density and is less stable than previously thought.

(Hu et al., *Nature Geoscience*, 2018)

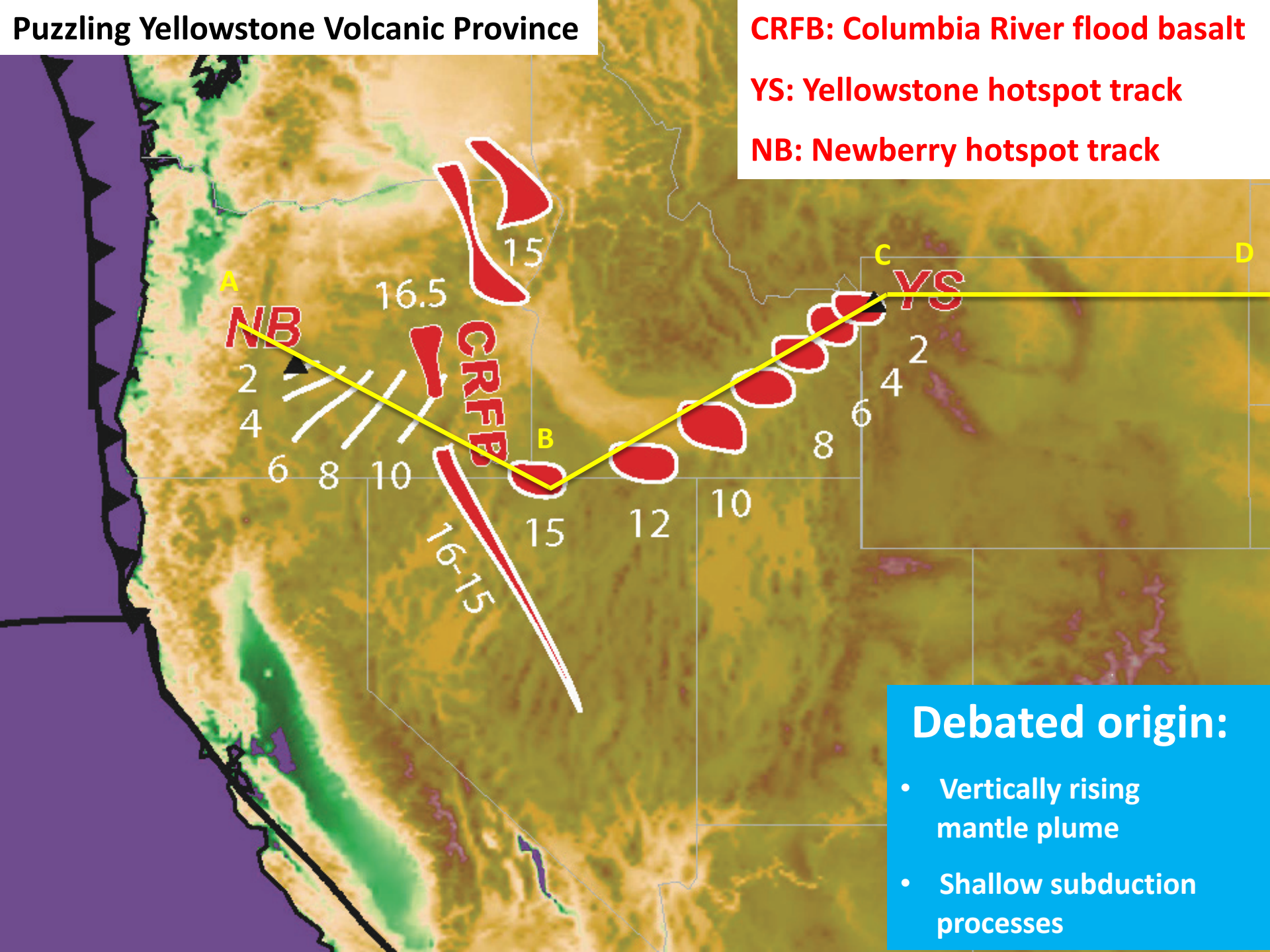


Better resolution of mantle upwelling below the western United States



(Zhou et al., *EPSL*, 2018)

Puzzling Yellowstone Volcanic Province



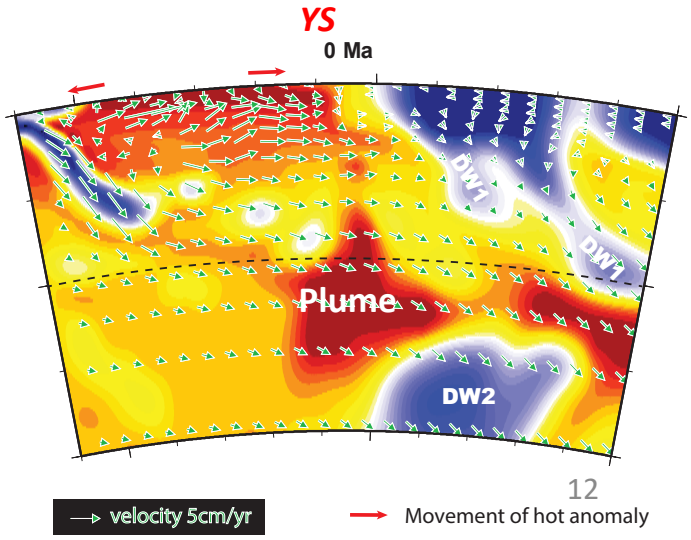
Debated origin:

- Vertically rising mantle plume
- Shallow subduction processes

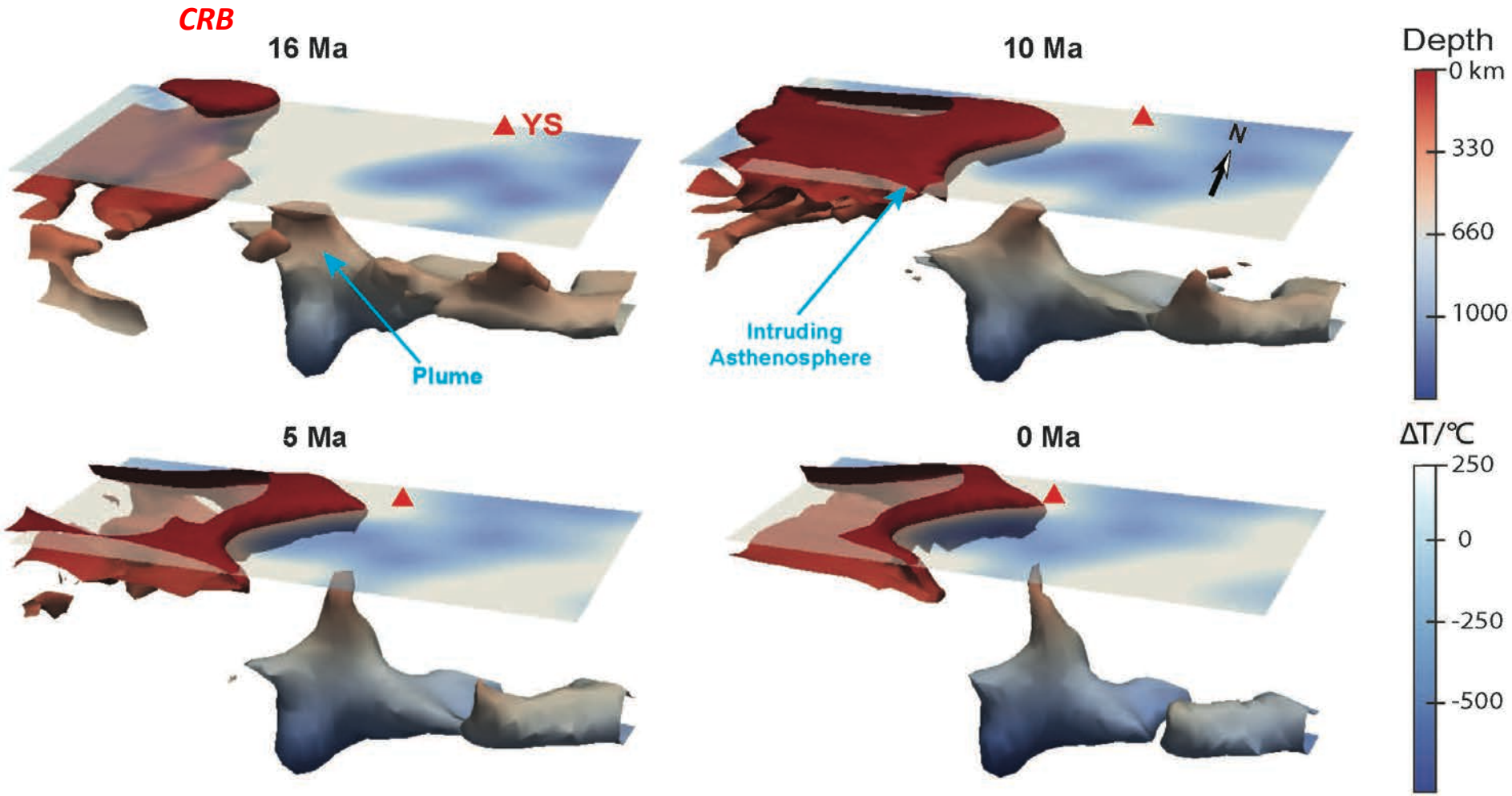
Heat below YS predominantly came from the Pacific mantle.

The mantle plume plays a minor role in generating volcanism.

(Zhou et al., *Nature Geoscience*, 2018)



Eastward intrusion of hot Pacific mantle forms YS

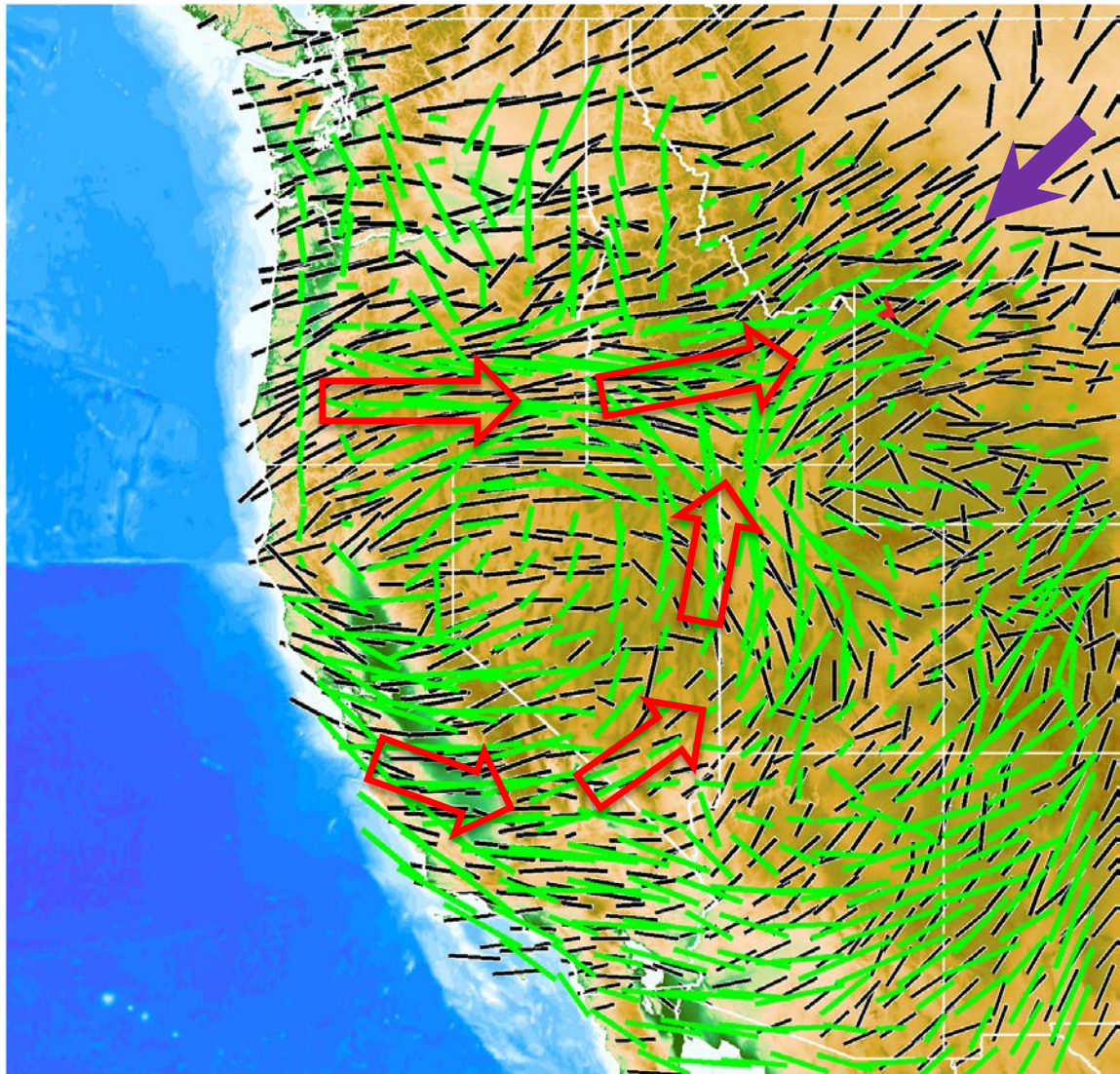


(Zhou et al., *Nature Geoscience*, 2018)

Model validation by seismic anisotropy

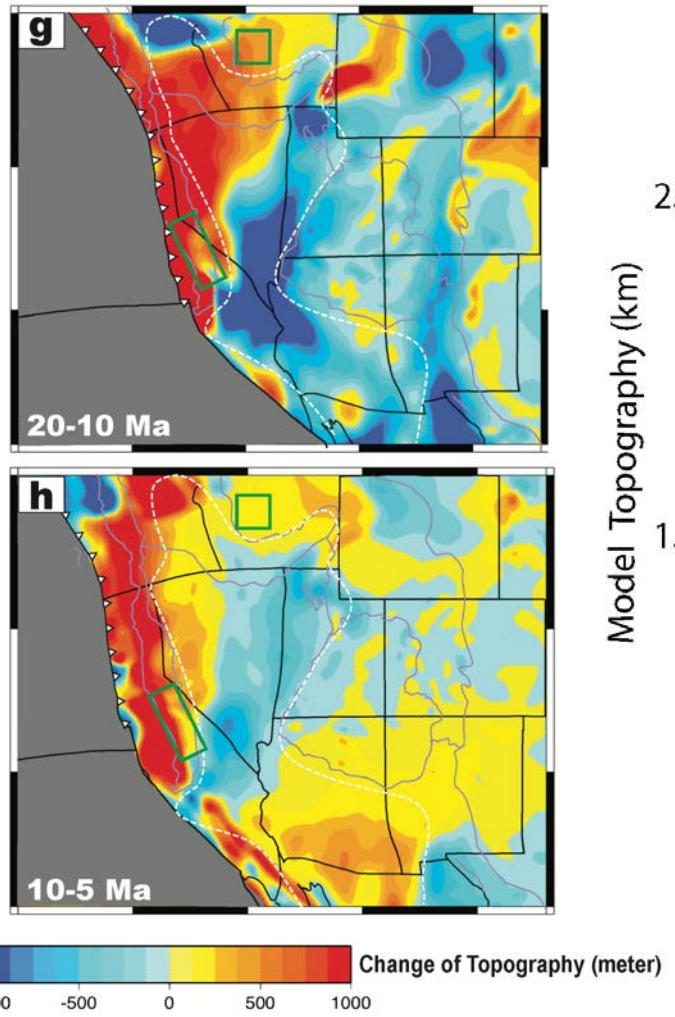
- *Rock fabric formed by mantle deformation*

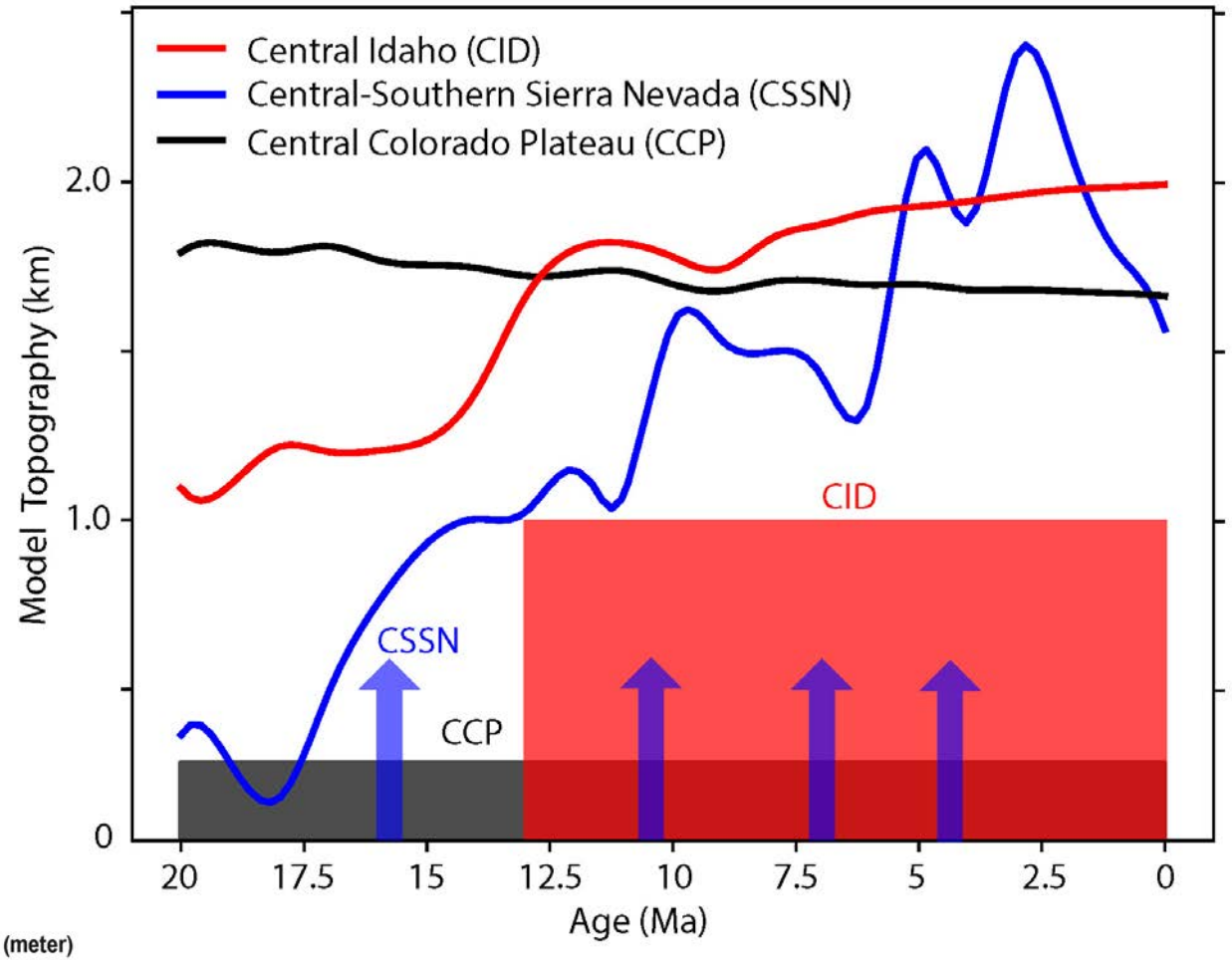
Observed (dark) and modeled (green) seismic anisotropy due to the subduction history discussed above.



(Zhou et al., *EPSL*, 2018)

Help to resolve the enigmatic topographic evolution of western U.S.





(Zhou & Liu, *EPSL*, 2019)

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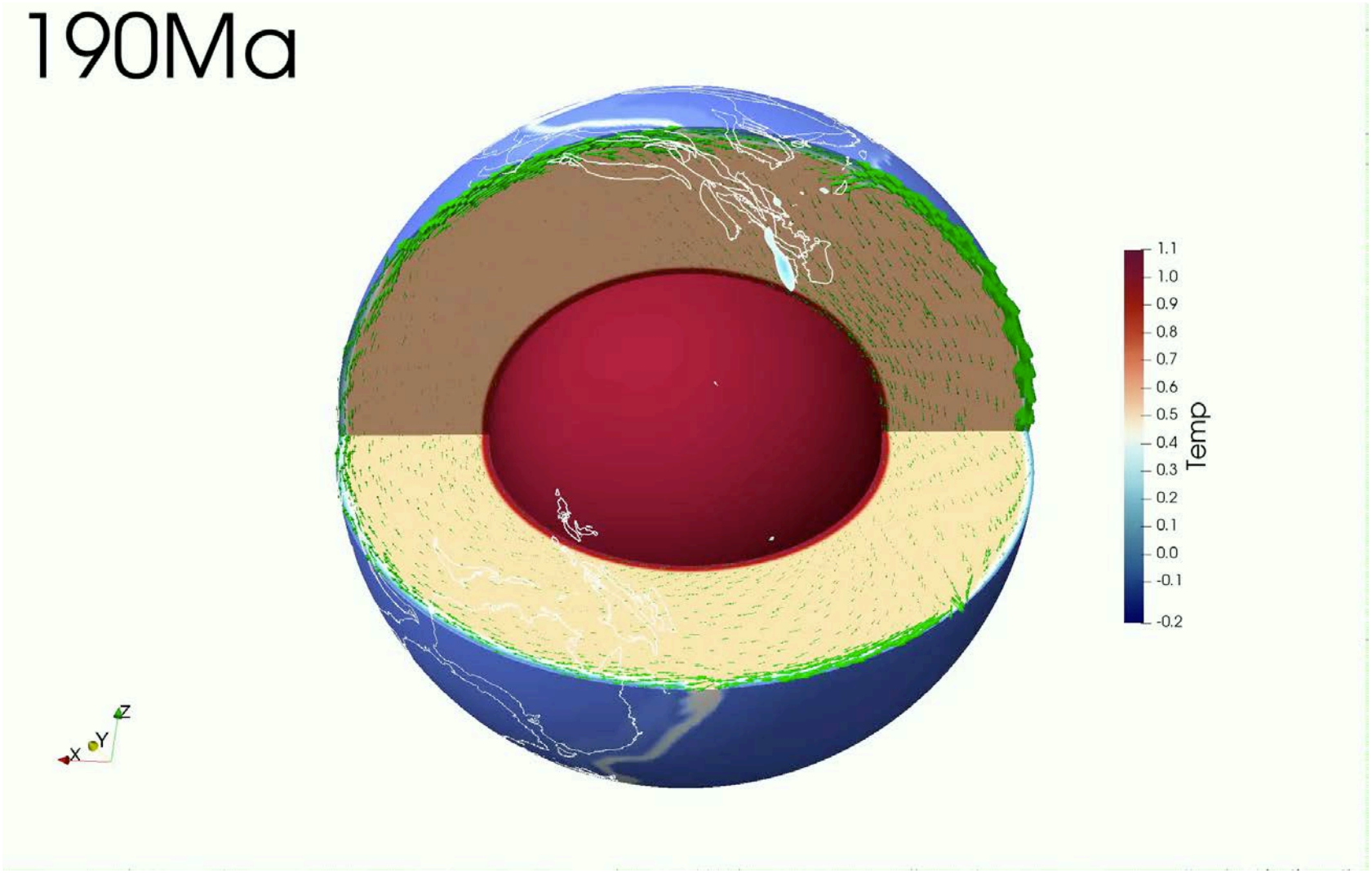
  1. Increasing total MPI cores by 10 fold, to ~10,000
  2. Resolving fine mantle features like slabs and plumes within whole mantle-scale models.
  3. Developed realistic regional convection models for North America and South America.
  4. Developing a new-generation of high-resolution global-scale subduction and convection models.

High-resolution global-scale models



Resulting publications

- Liu, L. (2015), *Rev. Geophysics*, 53.
- Liu, L. & J. Zhang (2015), *Earth & Planet. Sci. Lett*., 450, 40-51.
- Liu, L. & Q, Zhou (2015), *Geophys. Res. Lett*., 42.
- Heller, P. & L. Liu (2016), *Geol. Soc. Am. Bull*., doi:10.1130/B31431.1.
- Hu, J., et al. (2016), *Earth & Planet. Sci. Lett*., 438, 1-13.
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- Hu, J. & L. Liu (2016), *Earth & Planet. Sci. Lett*., 450, 40-51.
- Liu, L. & D. Hasterok (2016), *Science*, 353, 1515-1519.
- Chen, L. et al. (2017), *Nature Comm*., 8, doi:10.1038/ncomms15992.
- Hu, J. et al. (2017), *Earth & Planet. Sci. Lett*., 470, 13-24.
- Kalstrom, K. et al. (2017), *Desert Symp*., 145-149.
- Zhou, Q. & L. Liu (2017), *Geochem. Geoph. Geosys., Geosys*., doi: 10.1002/2017GC007116
- Zhou, Q. et al. (2018), *Nature Geosci*., doi: 10.1038/s41561-017-0035-y.
- Sun, W. et al. (2018), *Solid Earth Sci.*, doi: 10.1016/j.sesci.2017.12.003.
- Hu, J. et al. (2018), *Nature Geosci*., doi: 10.1038/s41561-018-0064-1.
- Hu, J. et al. (2018), *Earth Planet. Phys.,* 2(3), 189-207.
- Zhou, Q., et al. (2018), *Earth & Planet. Sci. Lett*., 500, 156-167.
- Zhou, Q. & L. Liu (2019), *Earth & Planet. Sci. Lett*., 514, 1-12.
- Chang, C. & L. Liu (2019), *J. Geophys. Res*., 124, doi:org/10.1029/2018JF004905.

Media exposure & outreach

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Planetarium presents new plate tectonics hypothesis

April 18, 2018 Prospectus Editor 0 Comments Greg Gancarz, Parkland College, Prospectus News, Staerkel Planetarium

Photo by gregGANCARZ | Pictured is the inside of the Staerkel Planetarium.

There's a new theory for how the Yellowstone National Park supervolcano gets its hotspot

BRETT FRENCH french@billingsgazette.com Jan 1, 2018

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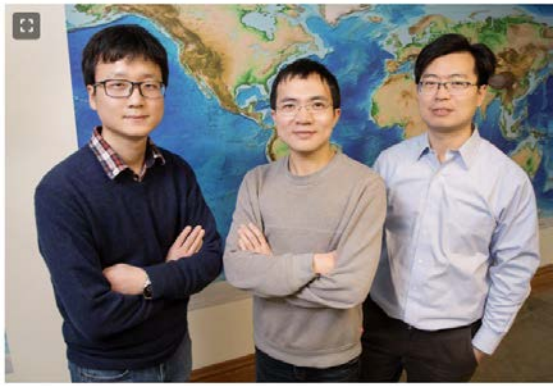

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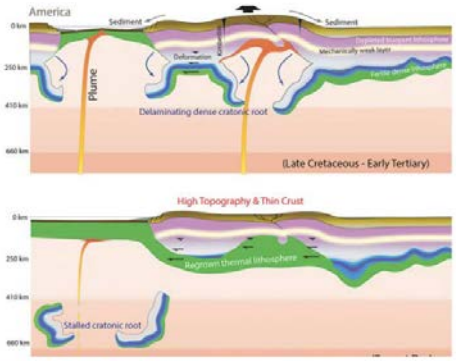
Continental interiors may not be as tectonically stable as geologists think

by Lois Yoksoulian, University of Illinois at Urbana-Champaign



ratonic lithosphere with a high-density root undergoes delamination when perturbed by mantle plumes from


Thank you