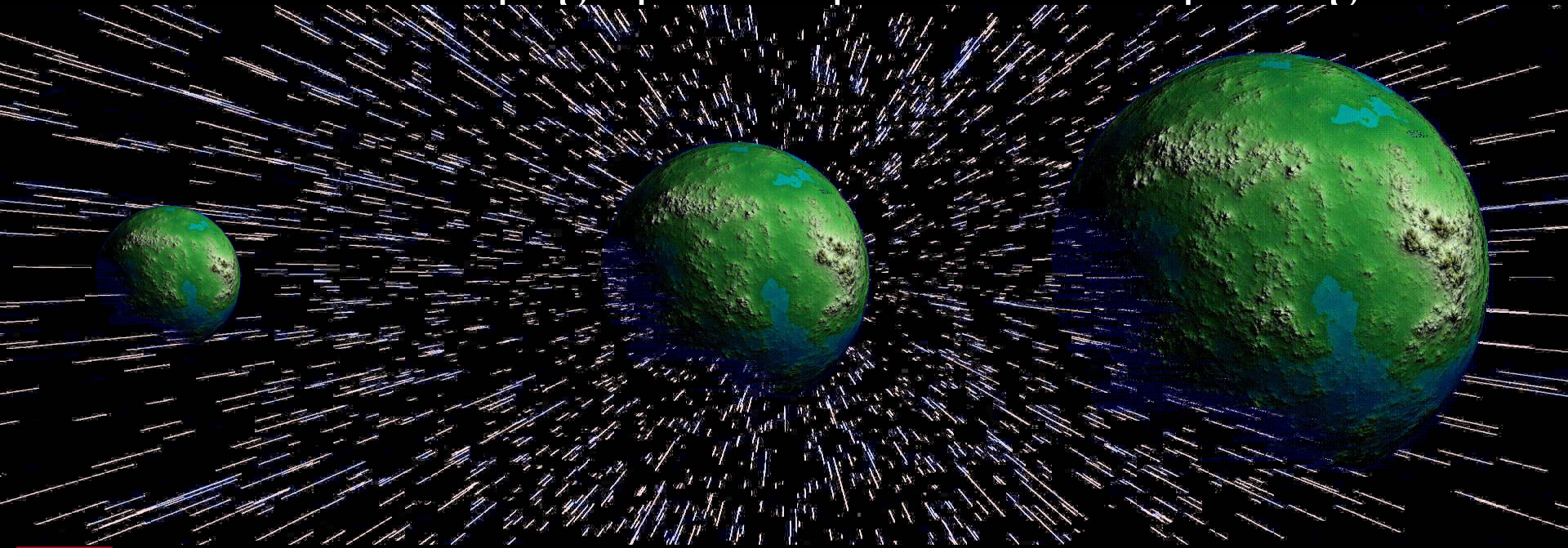
EARTH SCIENCES

UNIVERSITY OF CAMBRIDGE

Water planet thresholds:

The topographic scope for land atop a stagnant lid

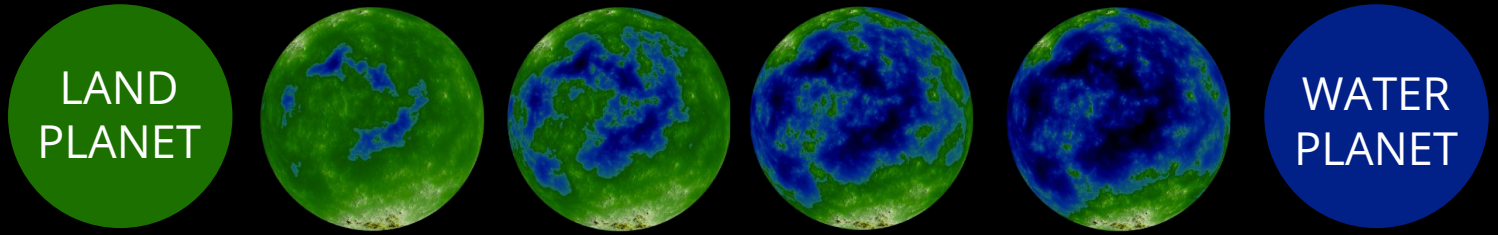


Francois Landais

Claire Marie Guimond with John Rudge & Oliver Shorttle

EGU General Assembly, 24th May 2022, Vienna

Topography might delimit marbled planets.



← higher topography
(more scope for harbouring surface water)

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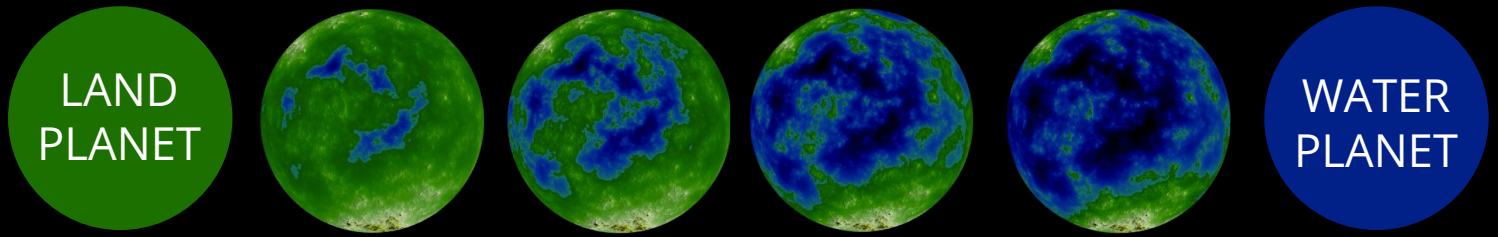

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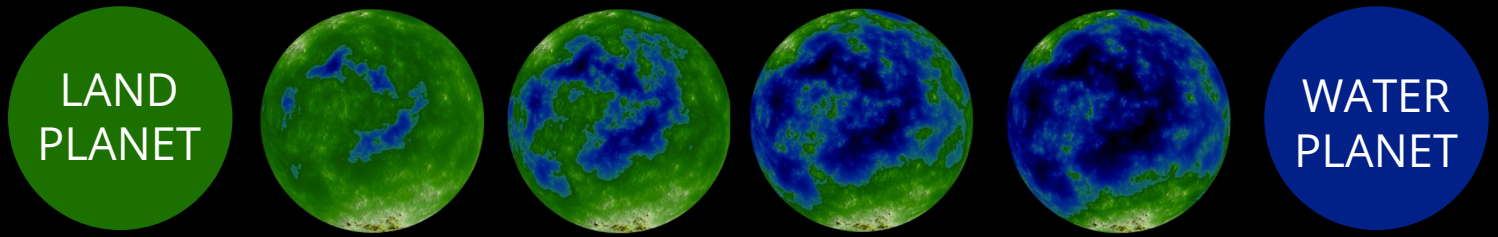

← higher topography
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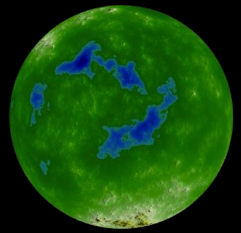
more surface water →

more tractable

less tractable?

Can we model it?



V.-P. Kostama

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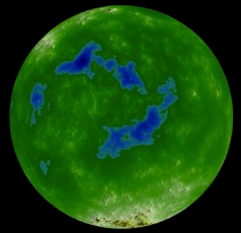
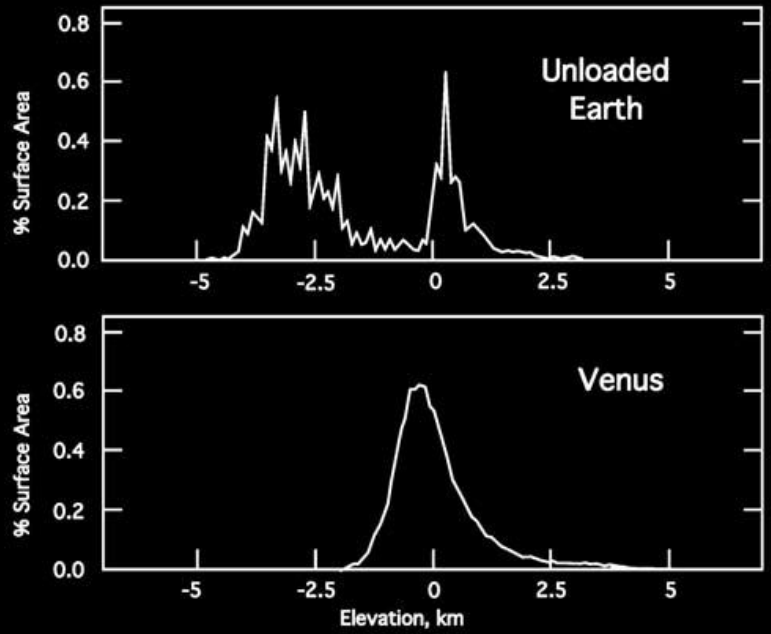


Earth-like topography—in large ways due to plate tectonics—could be rare.

Hypsometric distributions



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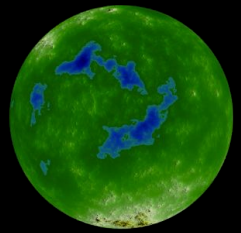

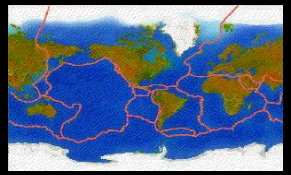

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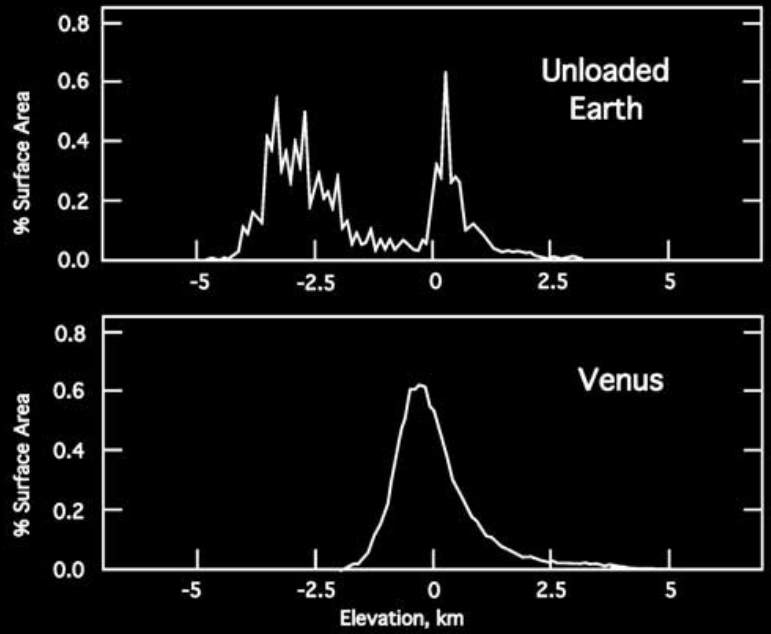

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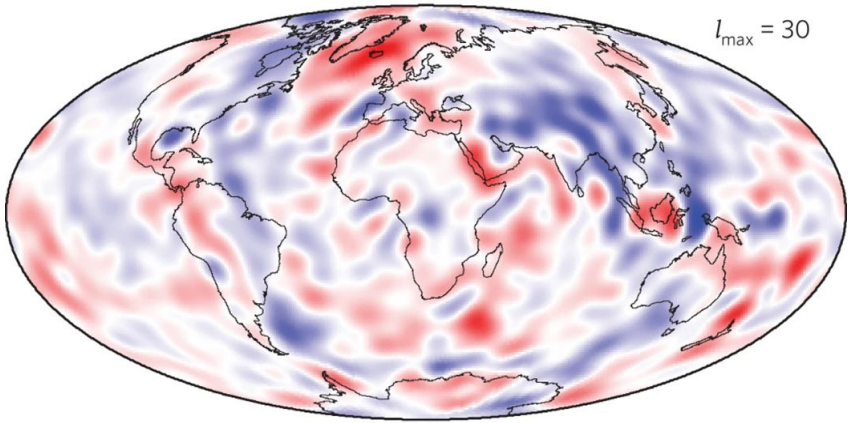
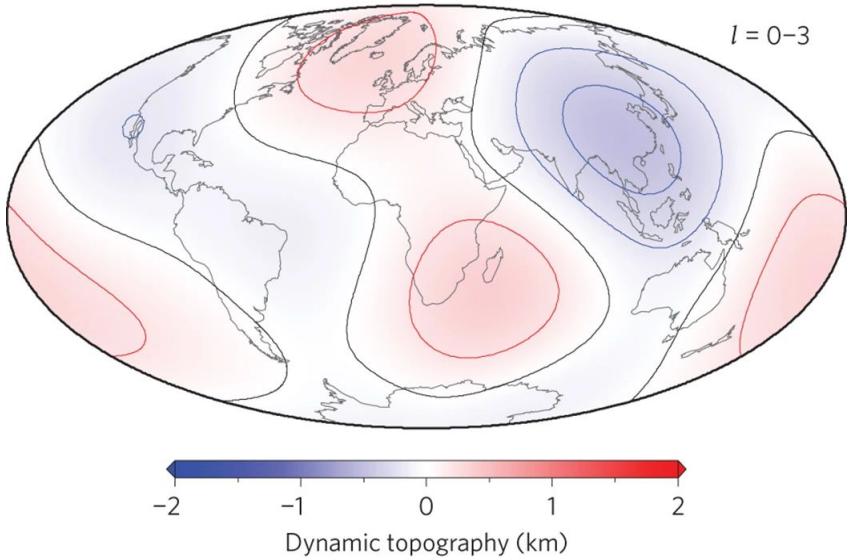


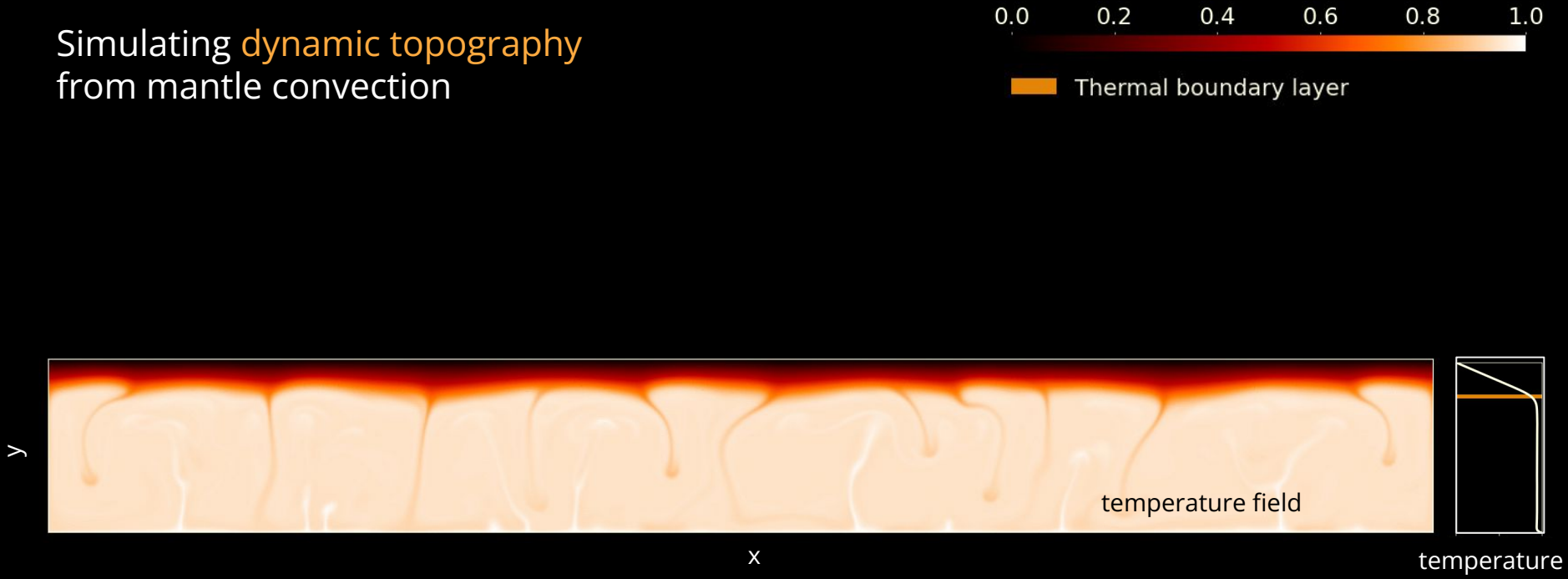
Dynamic topography occurs anyways, on the surface above mantle upwells and downwells



views of Earth's dynamic topography at different length scales

Hoggard+, 2016, *Nat. Geosci.*

Simulating dynamic topography from mantle convection



these models are already calculating the stress field of the flowing mantle!
convective stress balances hydrostatic pressure at the surface

Guimond, Rudge, & Shorttle (2022), *Planet. Sci. J.*

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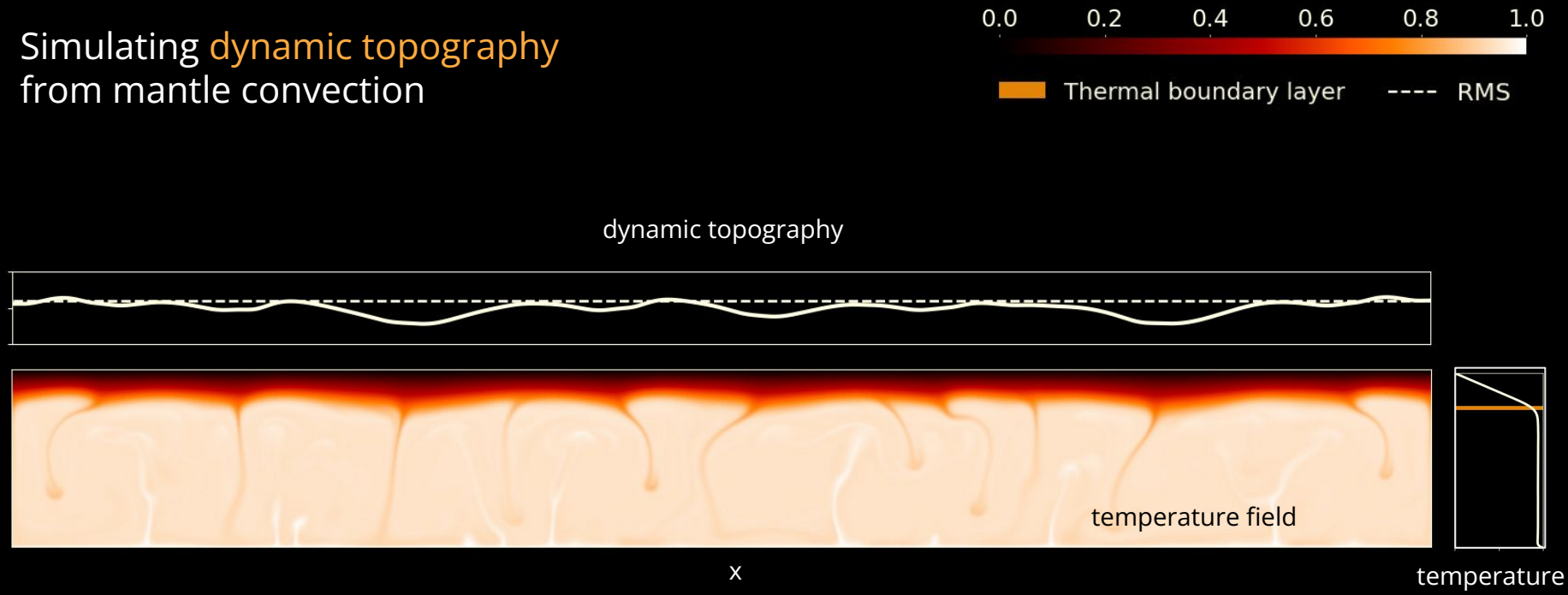

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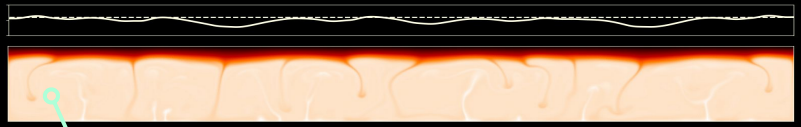
Making synthetic topography maps:

Spherical harmonic expansion of root mean square elevation



Extract scaling relationship of RMS topography for 1D thermal evolution models

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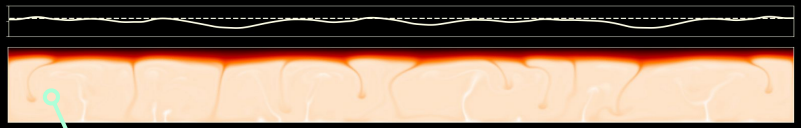

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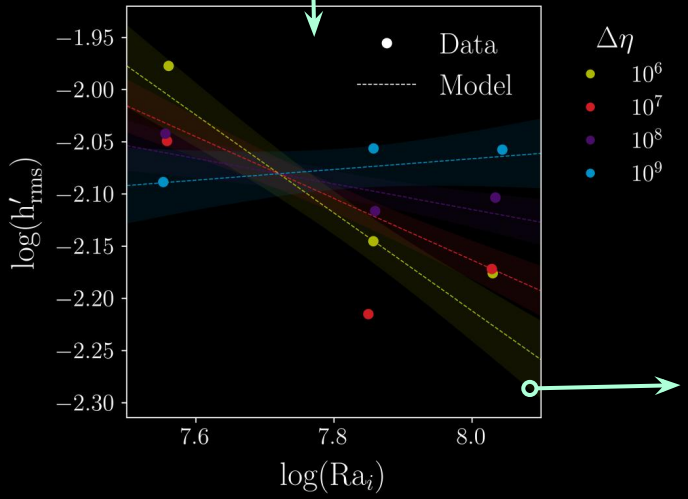

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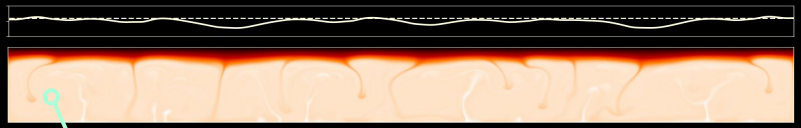

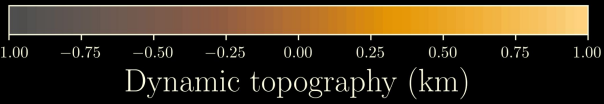

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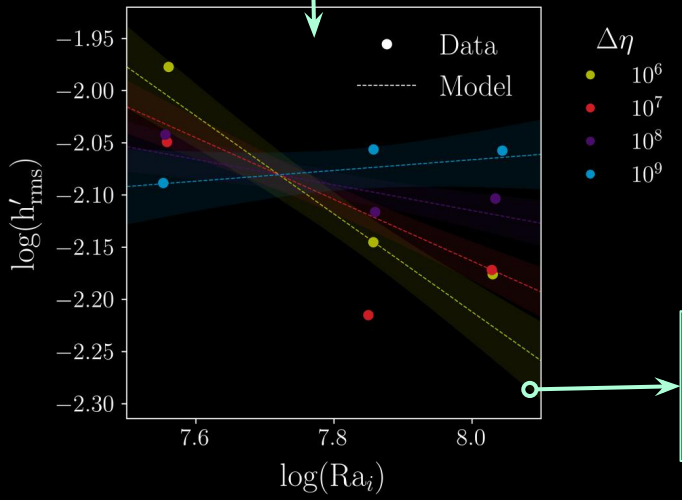
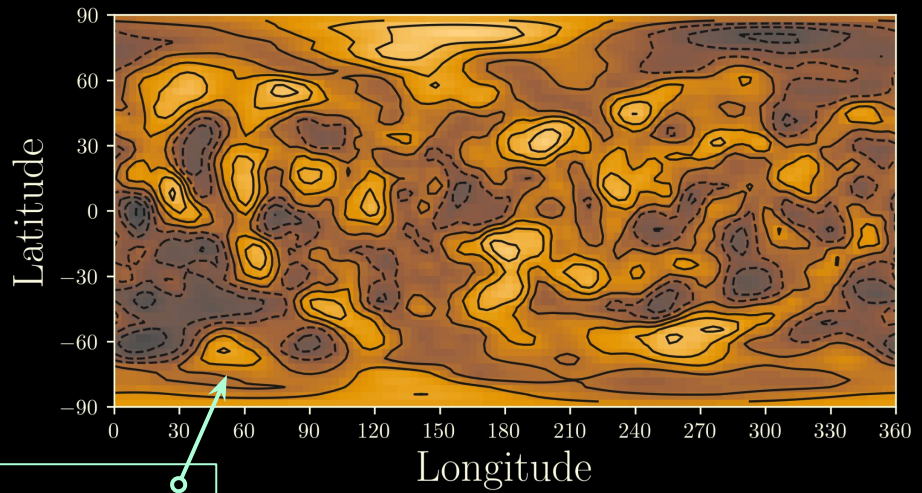


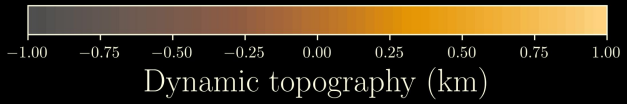
Spherical harmonics expansion

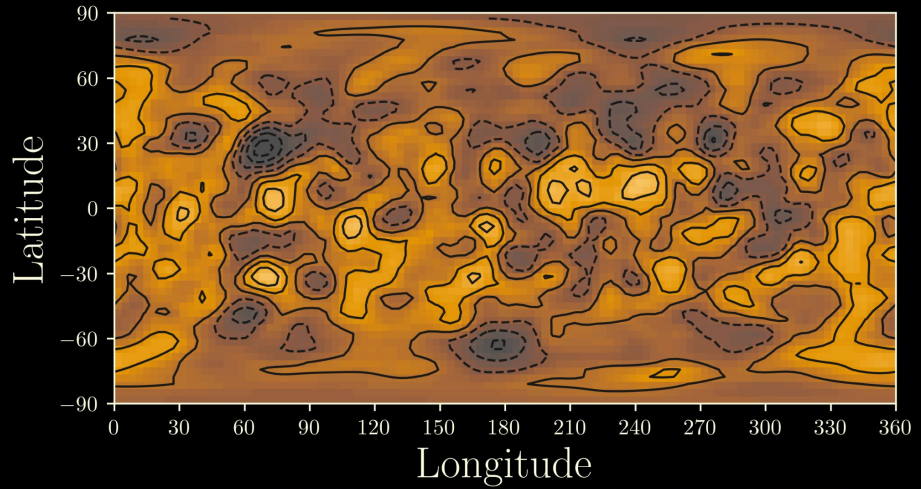


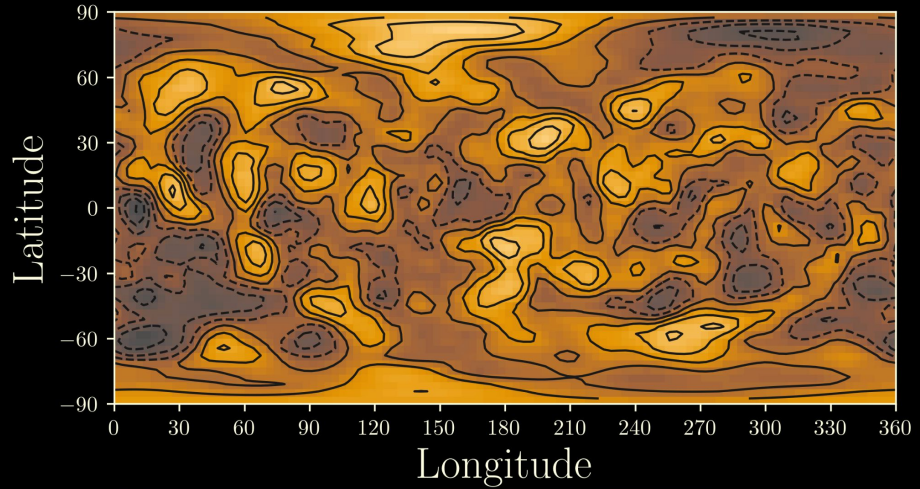
Guimond, Rudge, & Shorttle (2022), *Planet. Sci. J.*

Making synthetic topography maps:

Integrate to find the ocean basin volume







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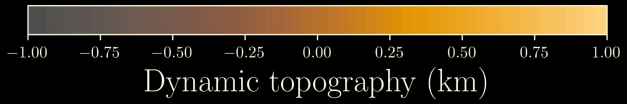

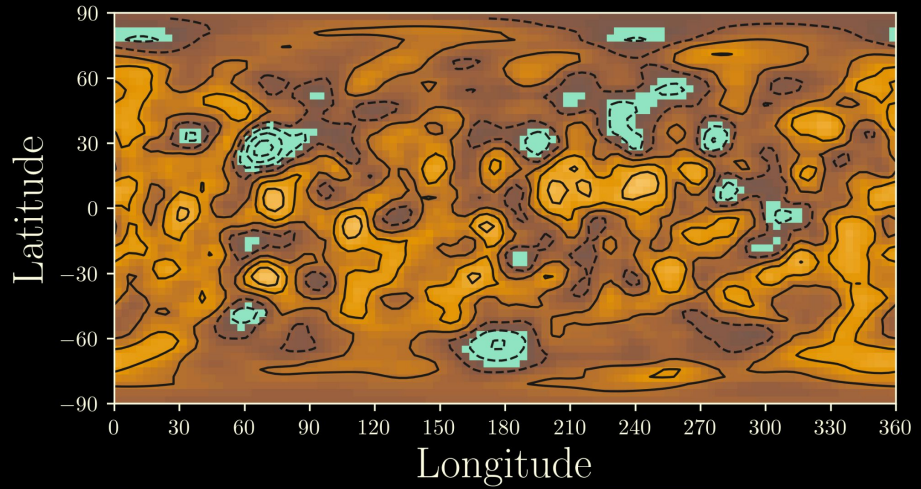

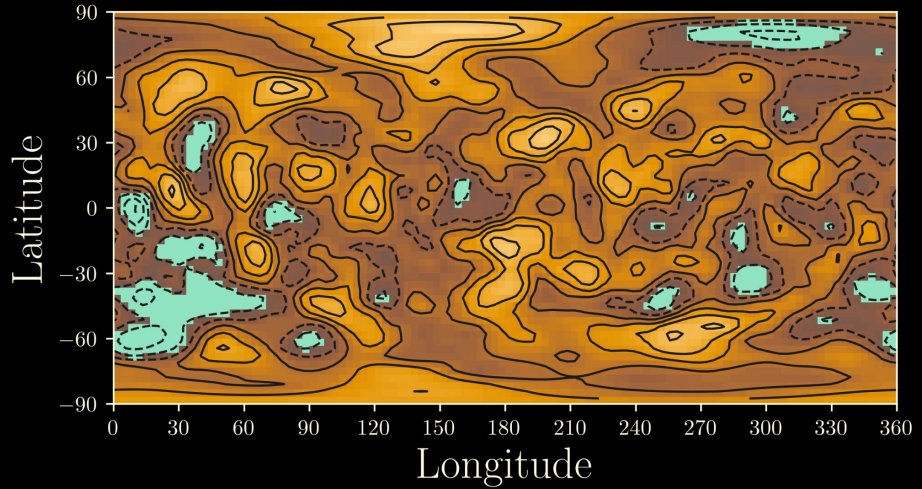

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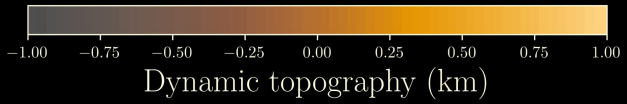

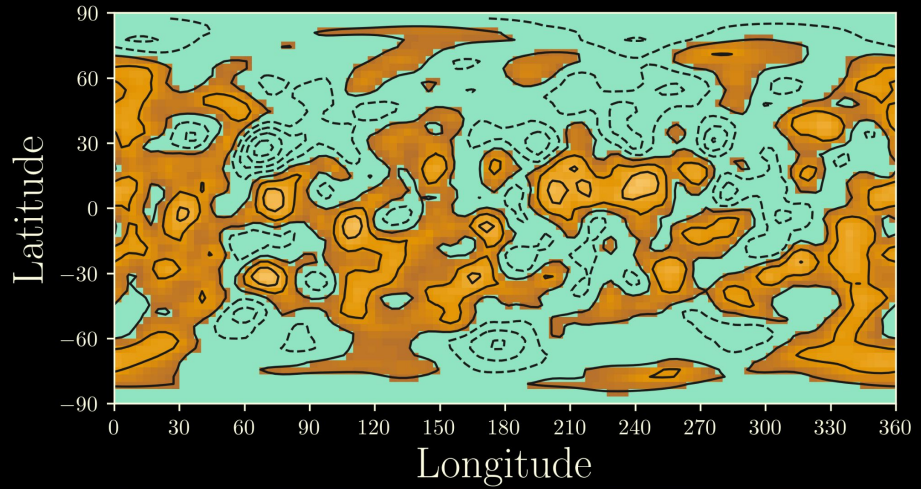

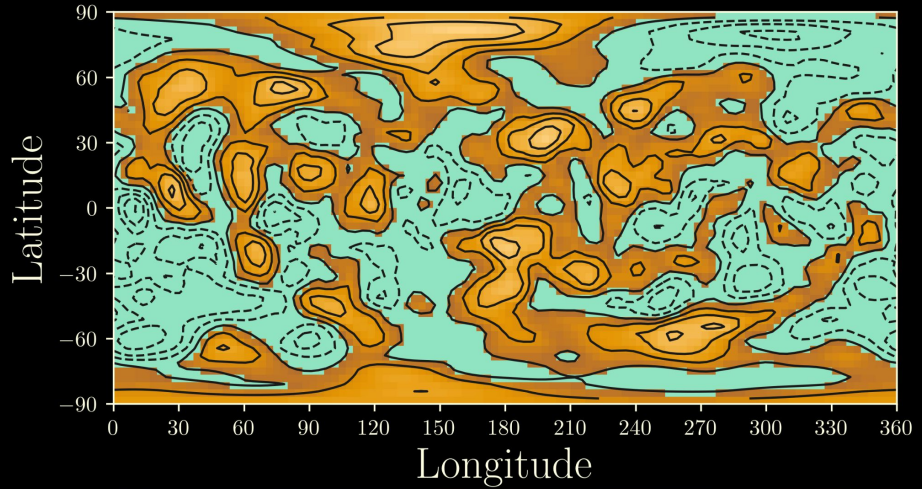

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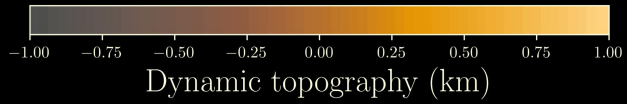

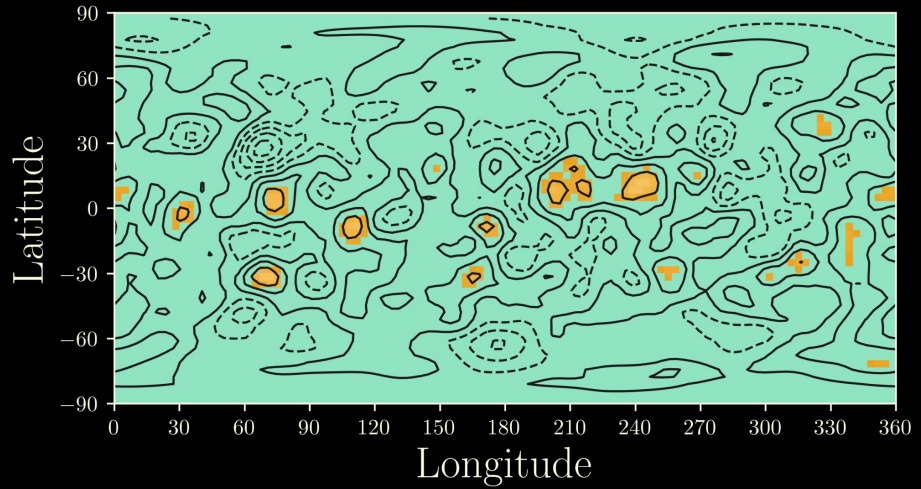

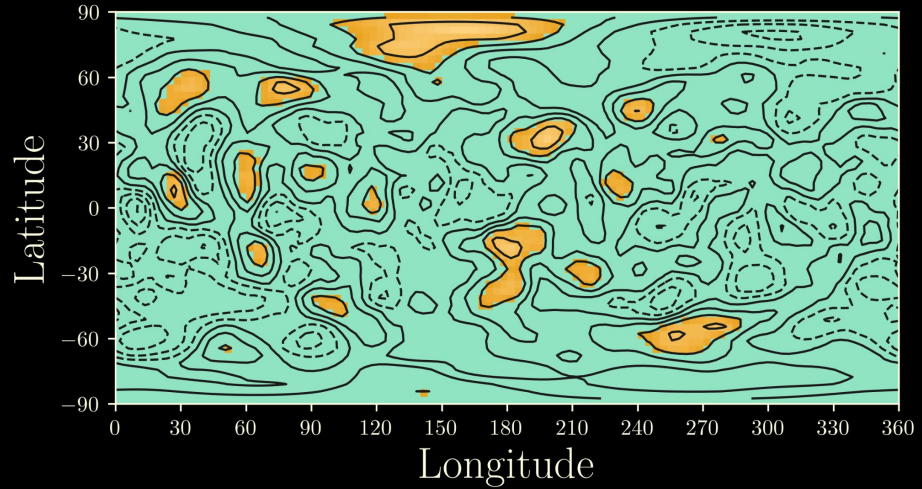

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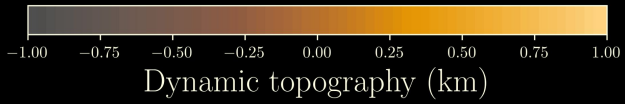

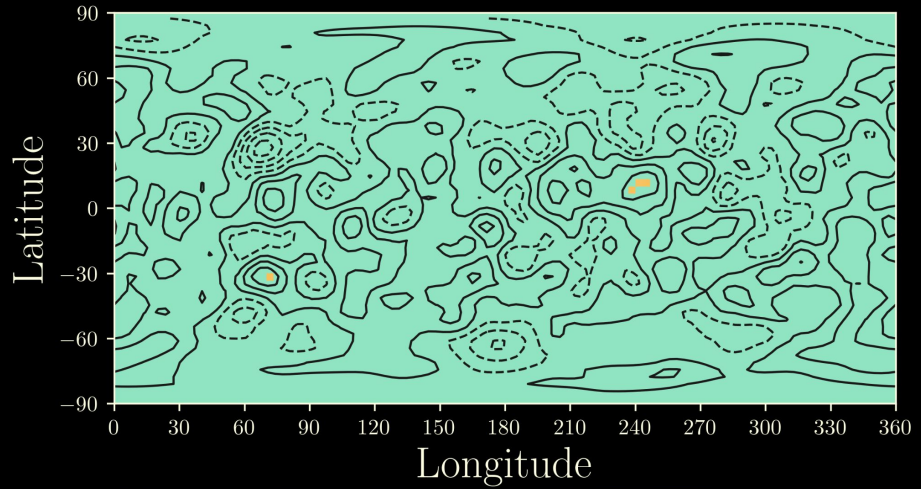

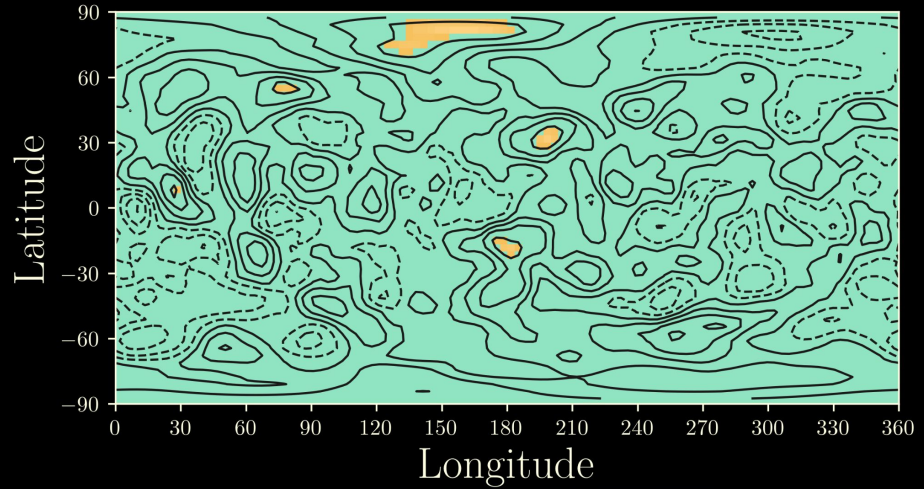

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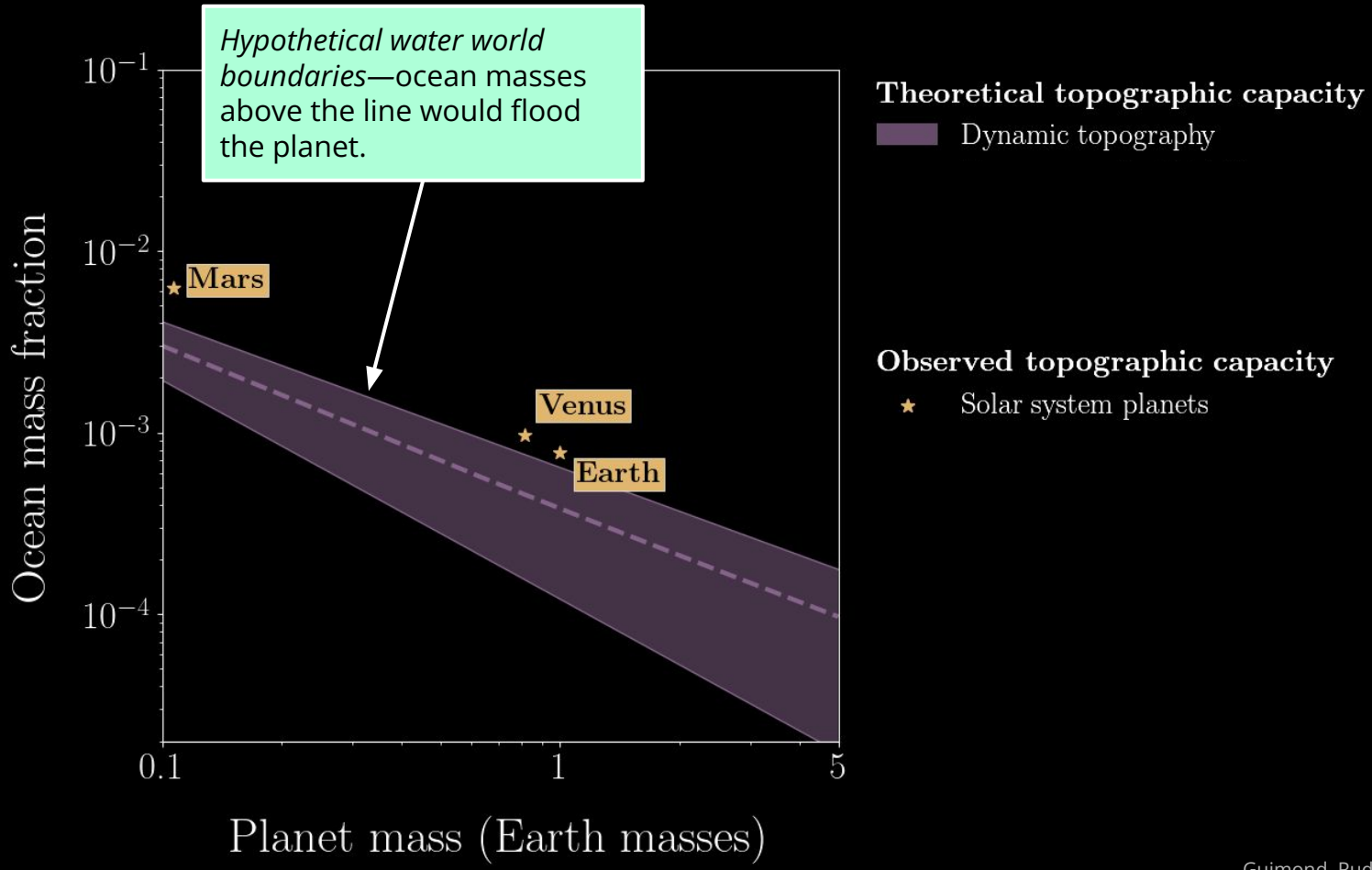

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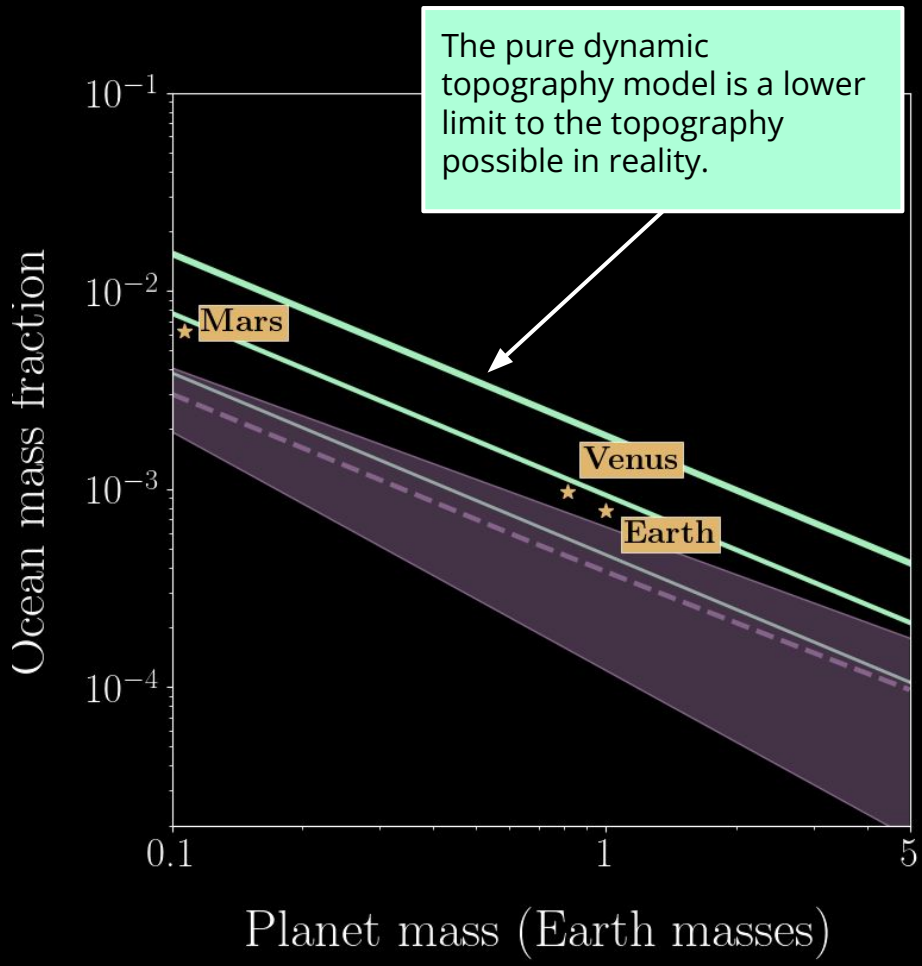

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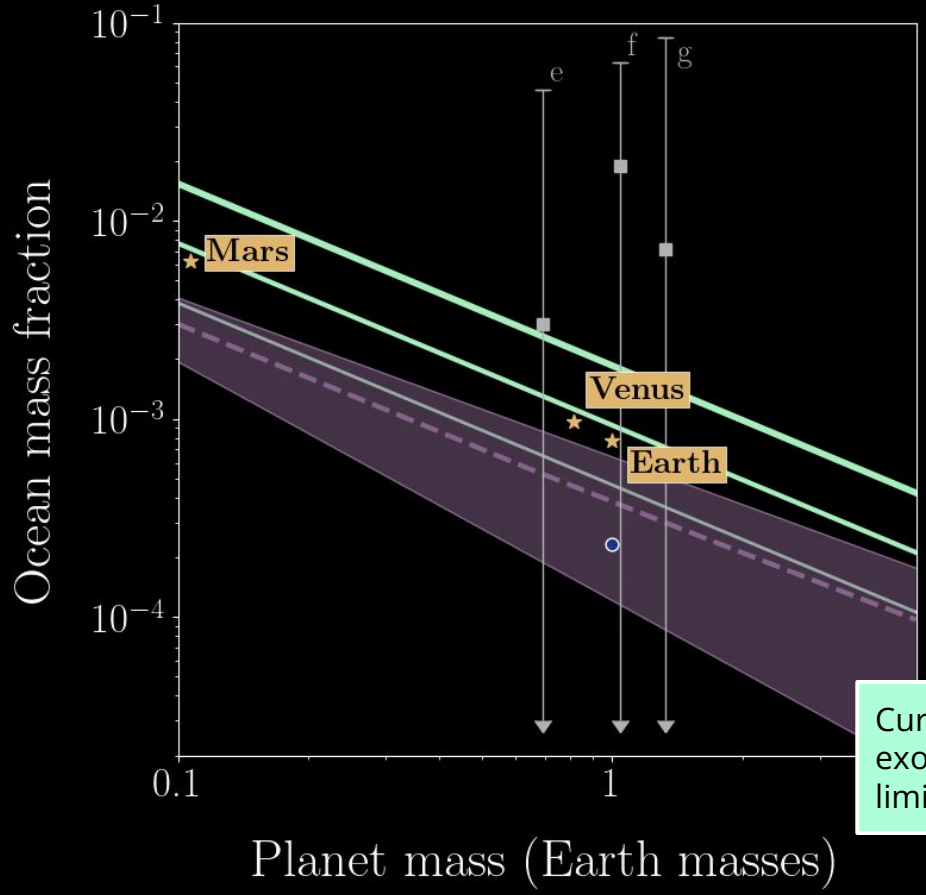

Theoretical topographic capacity

- Dynamic topography
- Crust strength, 200 MPa
- Crust strength, 100 MPa
- Crust strength, 50 MPa

maximum mountain height before being crushed by its own weight

Observed topographic capacity

- ★ Solar system planets

Observed ocean masses

- ■ TRAPPIST-1 exoplanetary system
- ● Earth, modern ocean

Agol+, 2021, *Planet. Sci. J.*

Current best guesses of water on some exoplanets could surpass purple and blue limits, but many more to come.

Guimond, Rudge, & Shorttle (2022), *Planet. Sci. J.*

CONCLUSIONS

- Simple dynamic topography alone could maintain land on planets with less than an Earth ocean's worth of water.
- The largest rocky planets are essentially smooth, featureless spheroids.
- Many Earth-sized exoplanets may **not look like Earth**.

Thanks to the Natural Sciences and Engineering Research Council of Canada, the Harding Distinguished Postgraduate Scholars Programme at the University of Cambridge, my supervisors Oli & John, the session conveners, the meeting organisers, and you!

Wyn Shaw