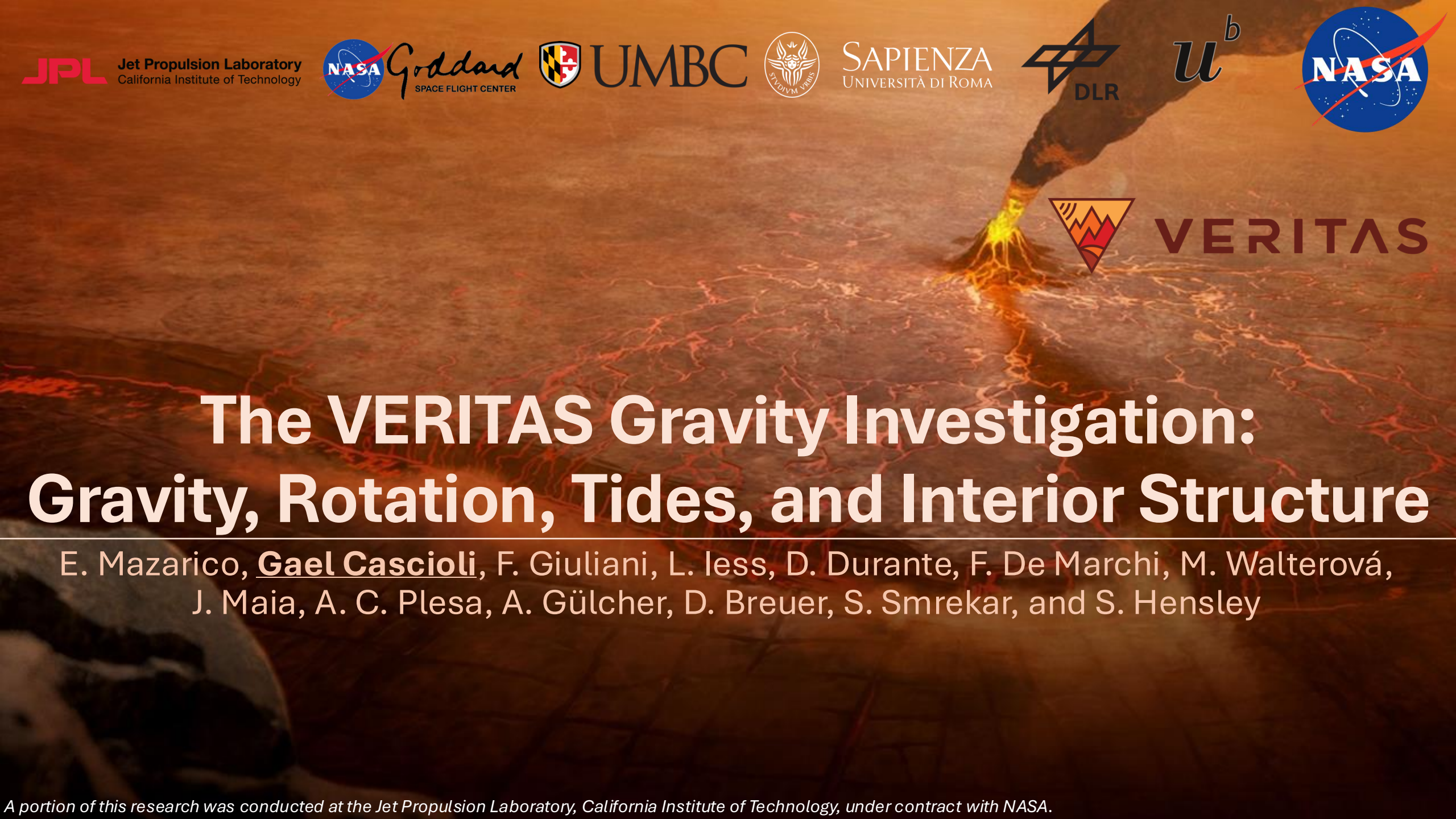
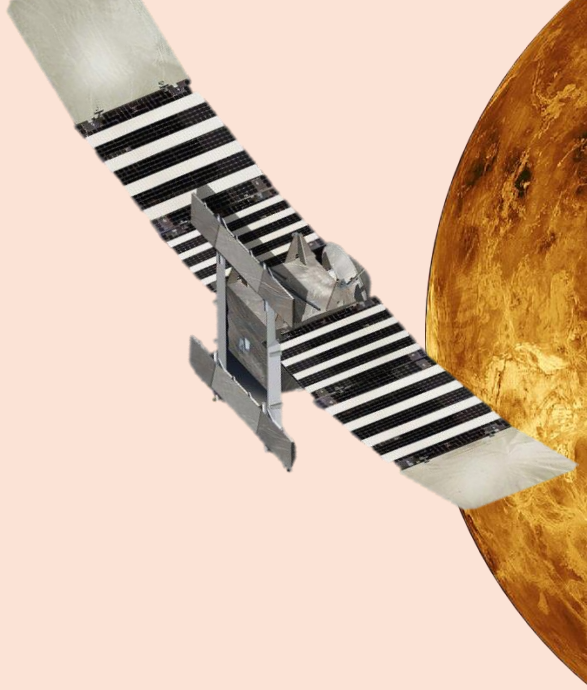


The VERITAS Gravity Investigation: Gravity, Rotation, Tides, and Interior Structure

E. Mazarico, **Gael Cascioli**, F. Giuliani, L. Iess, D. Durante, F. De Marchi, M. Walterová, J. Maia, A. C. Plesa, A. Gülcher, D. Breuer, S. Smrekar, and S. Hensley

A portion of this research was conducted at the Jet Propulsion Laboratory, California Institute of Technology, under contract with NASA.

VERITAS Gravity Science Investigation



VERITAS: **V**enus **E**missivity, **R**adio science, **I**nSAR, **T**opography **A**nd **S**pectroscopy

- 3 instruments: VISAR (interferometric SAR), VEM (emissivity mapper), Gravity science
- Global mapping of Venus from a near-circular (180x255 km) near-polar (85.4°) orbit repeating its ground track 4 times during the 2.7 years of nominal mission

Main objectives:

- Rocky planet evolution
- Active processes
- Past and present water

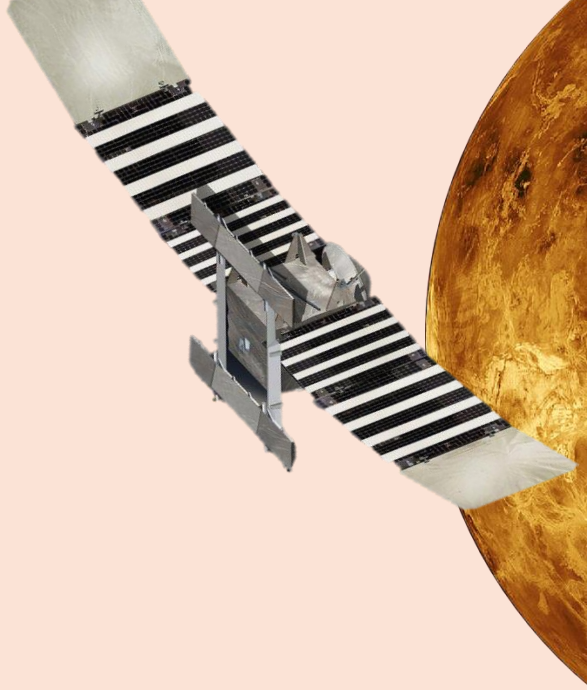
- Global rock type, terrains and tesserae
- Prior geologic regimes: buried features
- Impact and volcanic history
- What are the major tectonic processes? Is subduction active?

→ **Static Gravity Field**

- Interior structure → **Tidal deformation**, **Moment of inertia**, **Rotational state**

Geophysical parameters
Measurement capability

VERITAS Gravity Science Investigation



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- What are the major tectonic processes? Is subduction active?

→ **Static Gravity Field**

Lateral resolution < 106 km over 90% of Venus

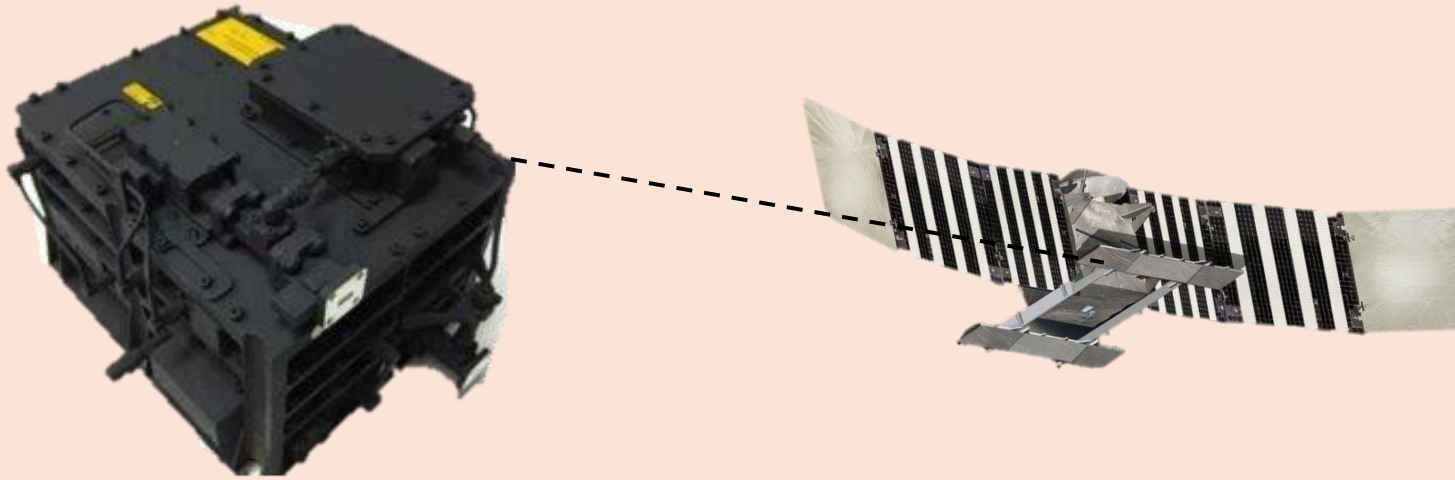
- Interior structure

Geophysical parameters	**Measurement capability**
Tidal deformation	$k_2 < 0.0005$, $\Phi k_2 < 0.045$ deg
Moment of inertia	$MOIF < 0.001$
Rotational state	$\Omega < 0.004 \text{ deg} \cdot \text{cy}^{-1}$

(3σ)

VERITAS Gravity Science Investigation

Gravity Science is enabled by the **Integrated Deep Space Transponder** (IDST) from Italy (ASI), building on BepiColombo and JUICE KaT heritage.



KaT image from Iess et al., 2021

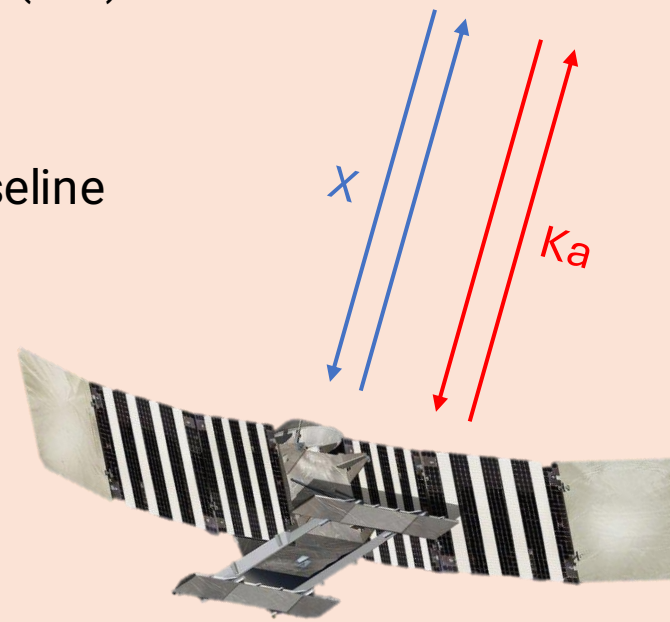
VERITAS Gravity Science Investigation

Gravity Science is enabled by the **Integrated Deep Space Transponder** (IDST) from Italy (ASI), building on BepiColombo and JUICE KaT heritage.

VERITAS will be the first mission to use DSN Ka-band *uplink* at all complexes for its baseline mission.

Fully coherent **X+Ka** radio link to DSN

Doppler accuracy: **0.000018 m/s** every 10s



VERITAS Gravity Science Investigation

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Fully coherent **X+Ka** radio link to DSN

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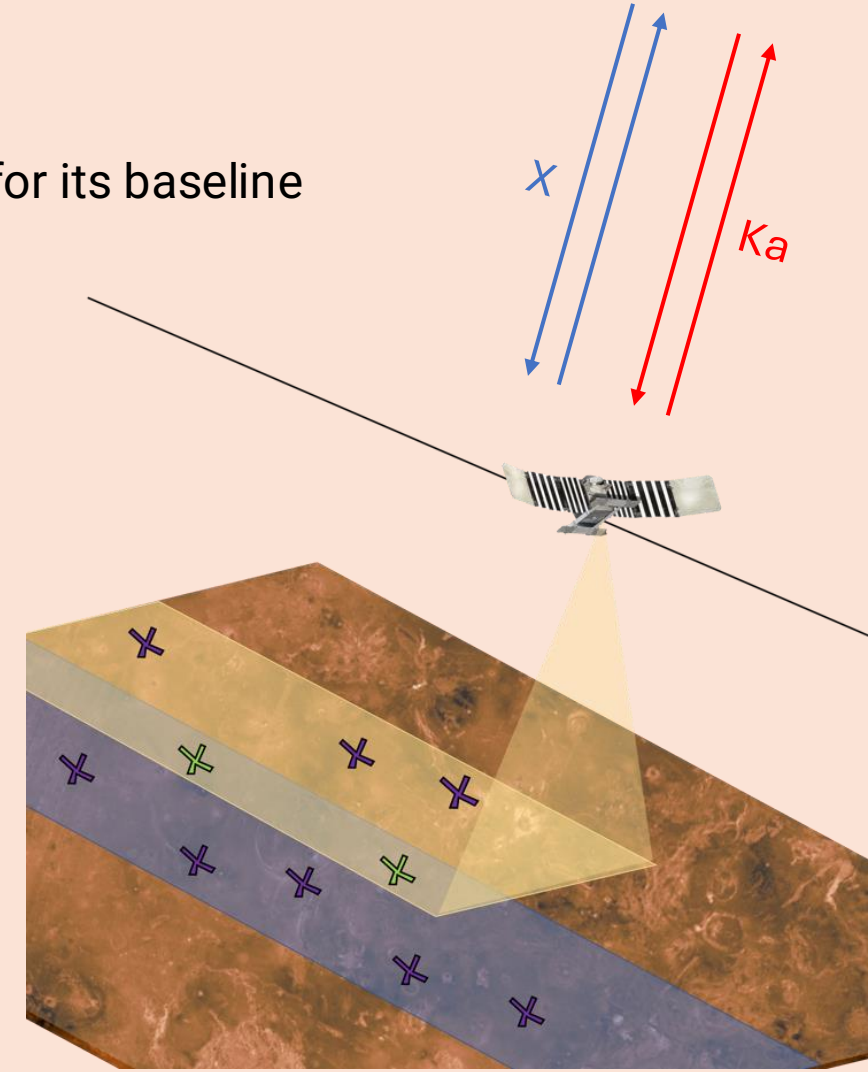
VISAR **radar tie points** provide strong repeat ties to the surface.



Interior Structure

Core state

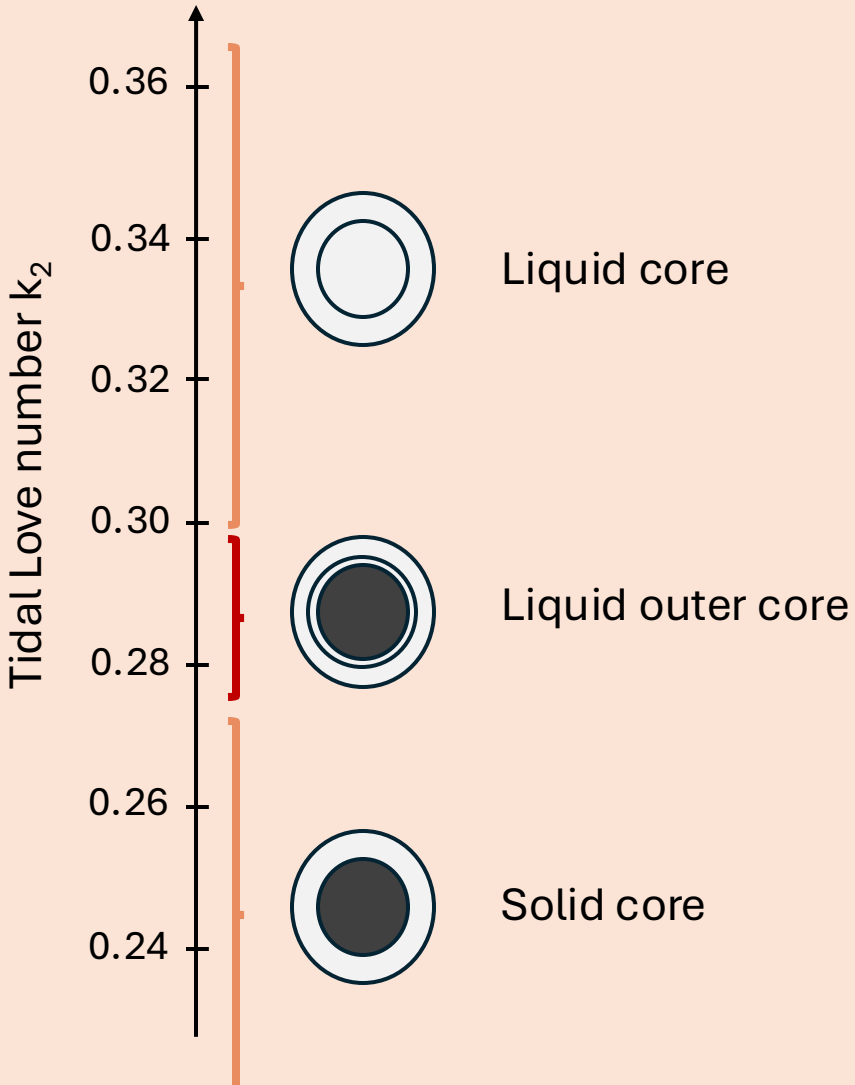
Liquid core

Liquid outer core

Solid core

Interior Structure

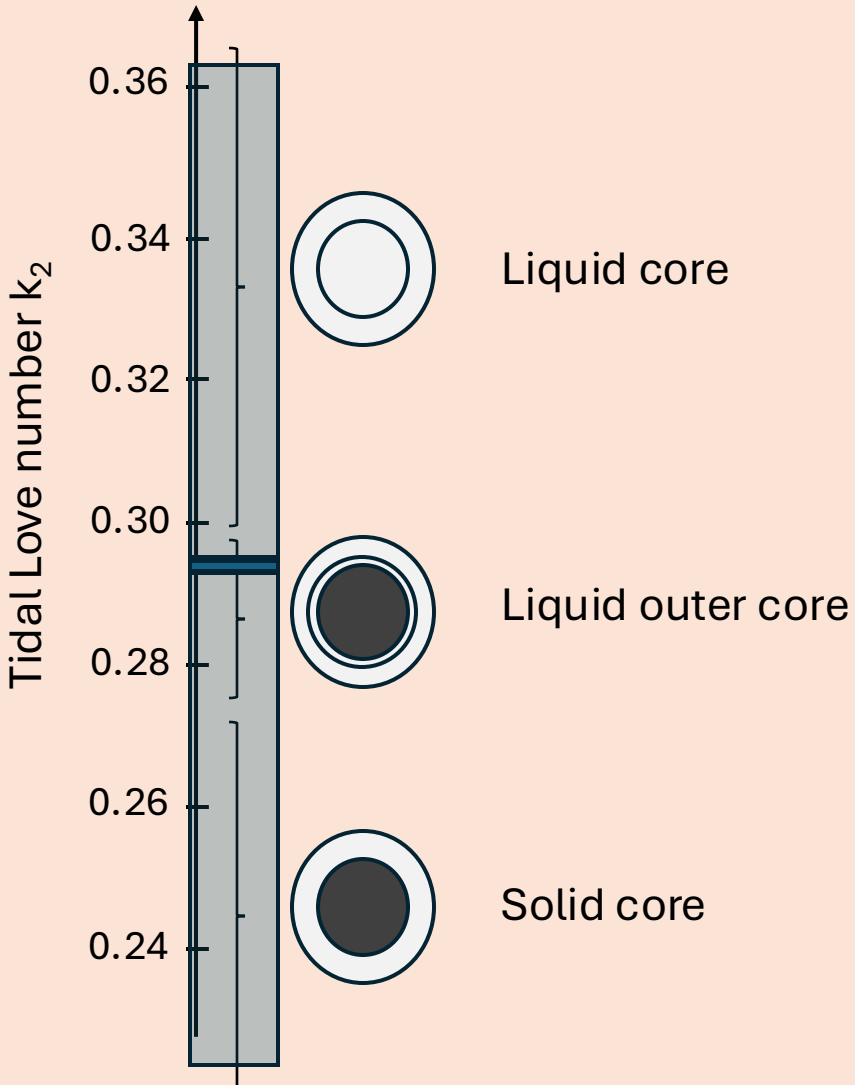
Core state



Adapted from Dumoulin et al., 2017
(assumes a mantle composition)

Interior Structure

Core state

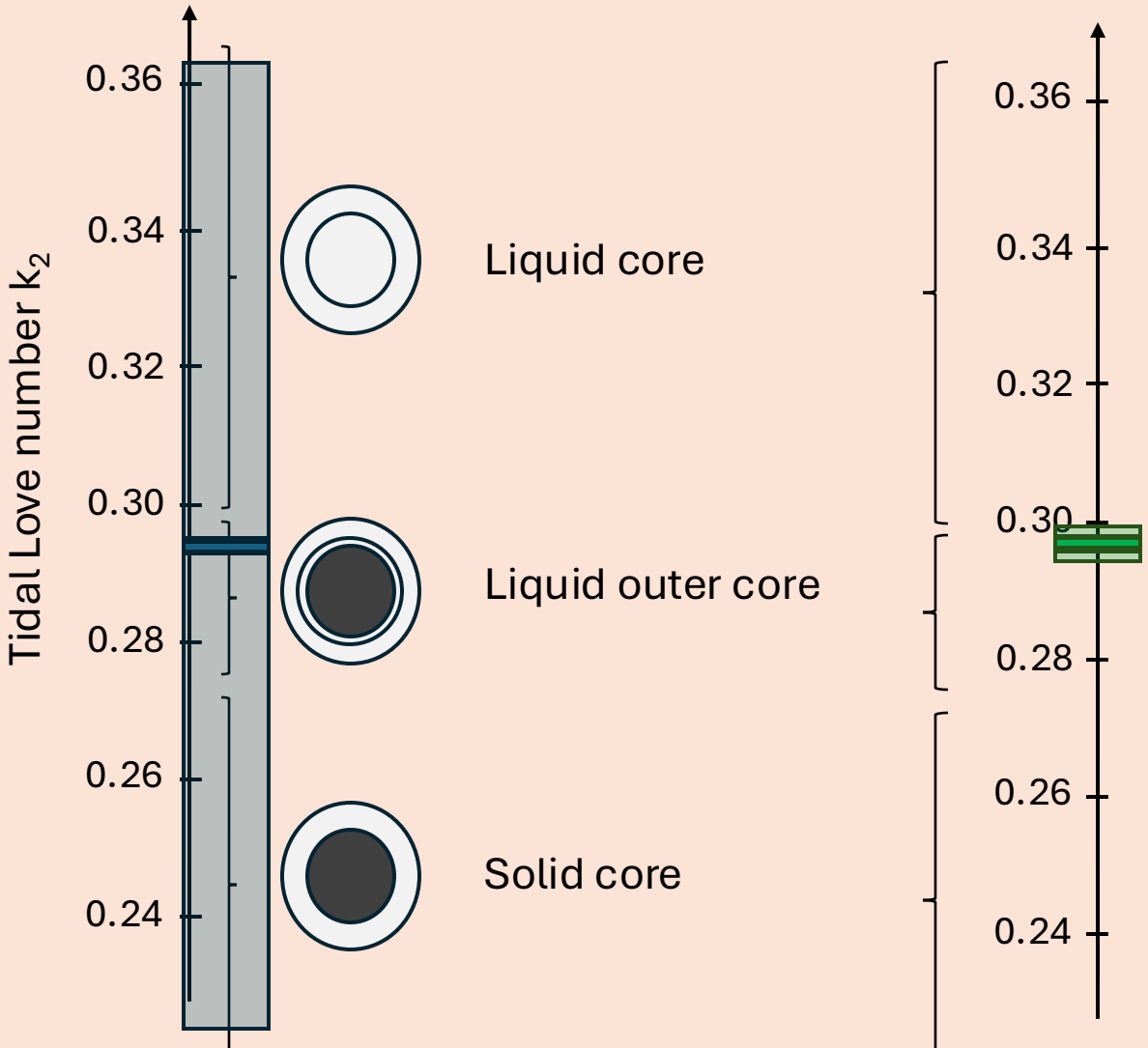


Magellan estimate
(with uncertainty)

Adapted from Dumoulin et al., 2017
(assumes a mantle composition)

Interior Structure

Core state



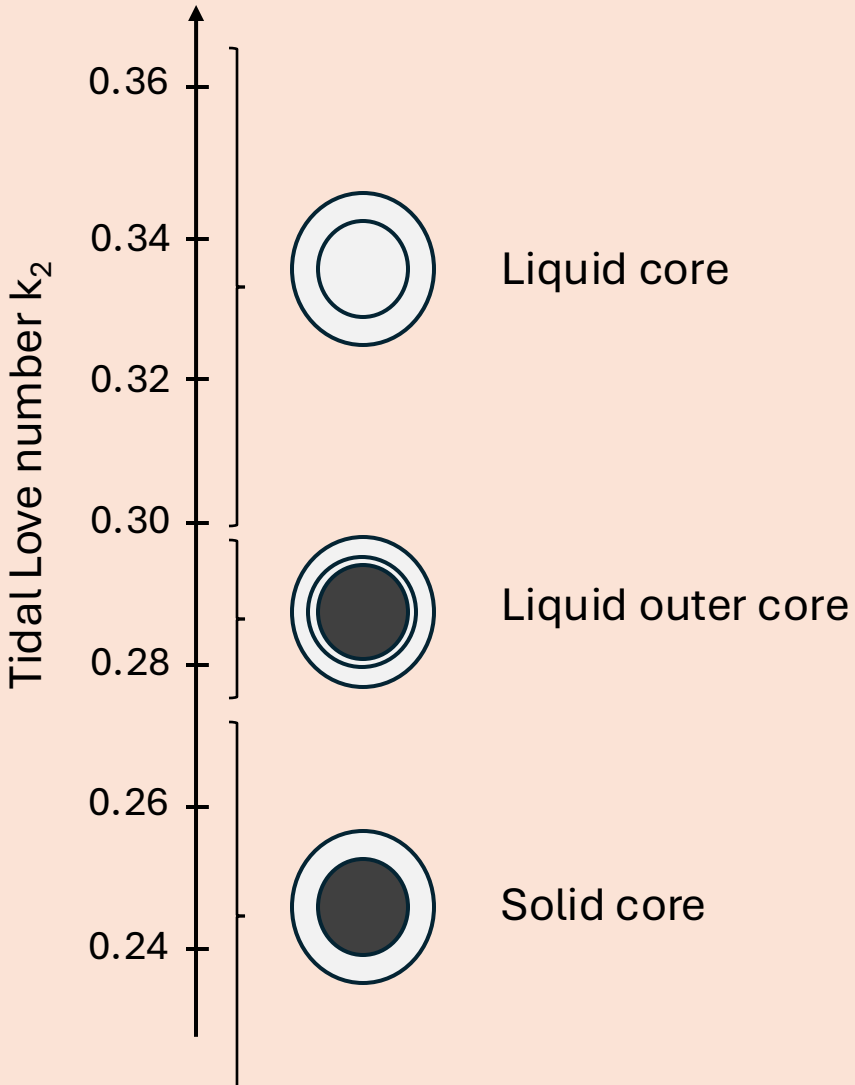
Magellan estimate (with uncertainty)

VERITAS capability (with uncertainty)

Adapted from Dumoulin et al., 2017 (assumes a mantle composition)

Interior Structure

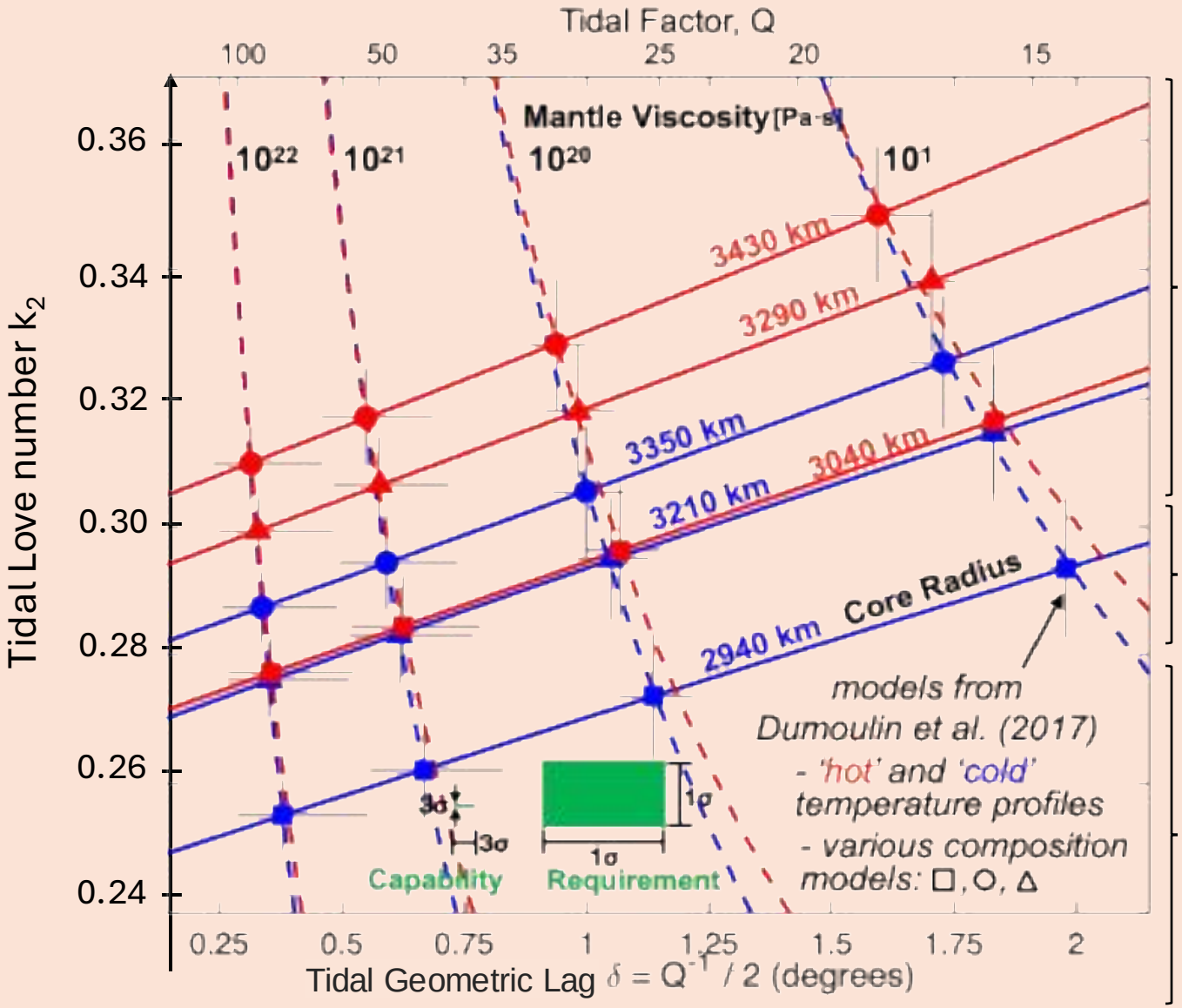
Core state

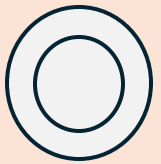


Adapted from Dumoulin et al., 2017
(assumes a mantle composition)

Interior Structure

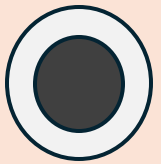
Core state | Core radius | Mantle viscosity | Mantle density





Liquid core

Liquid outer core

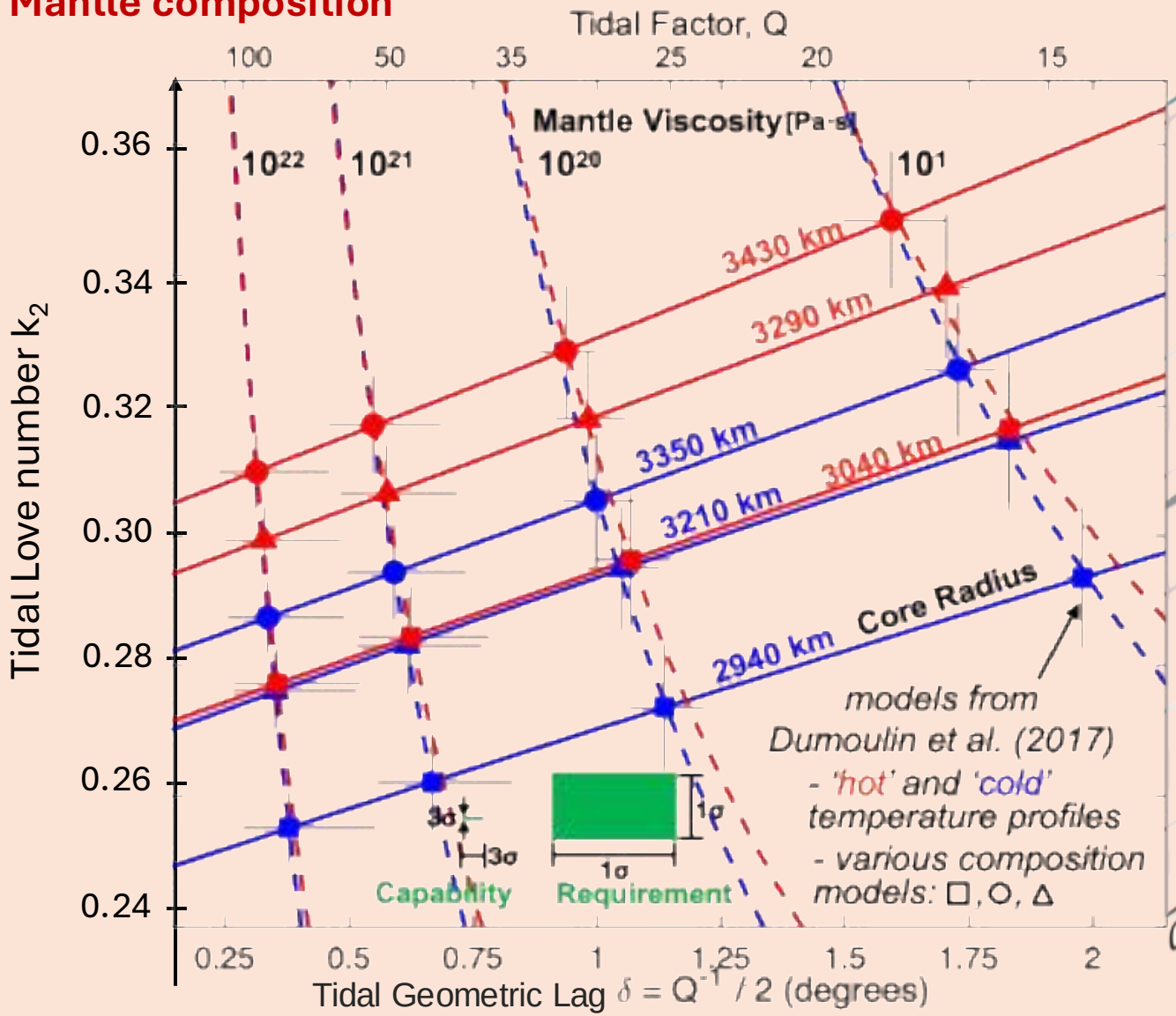


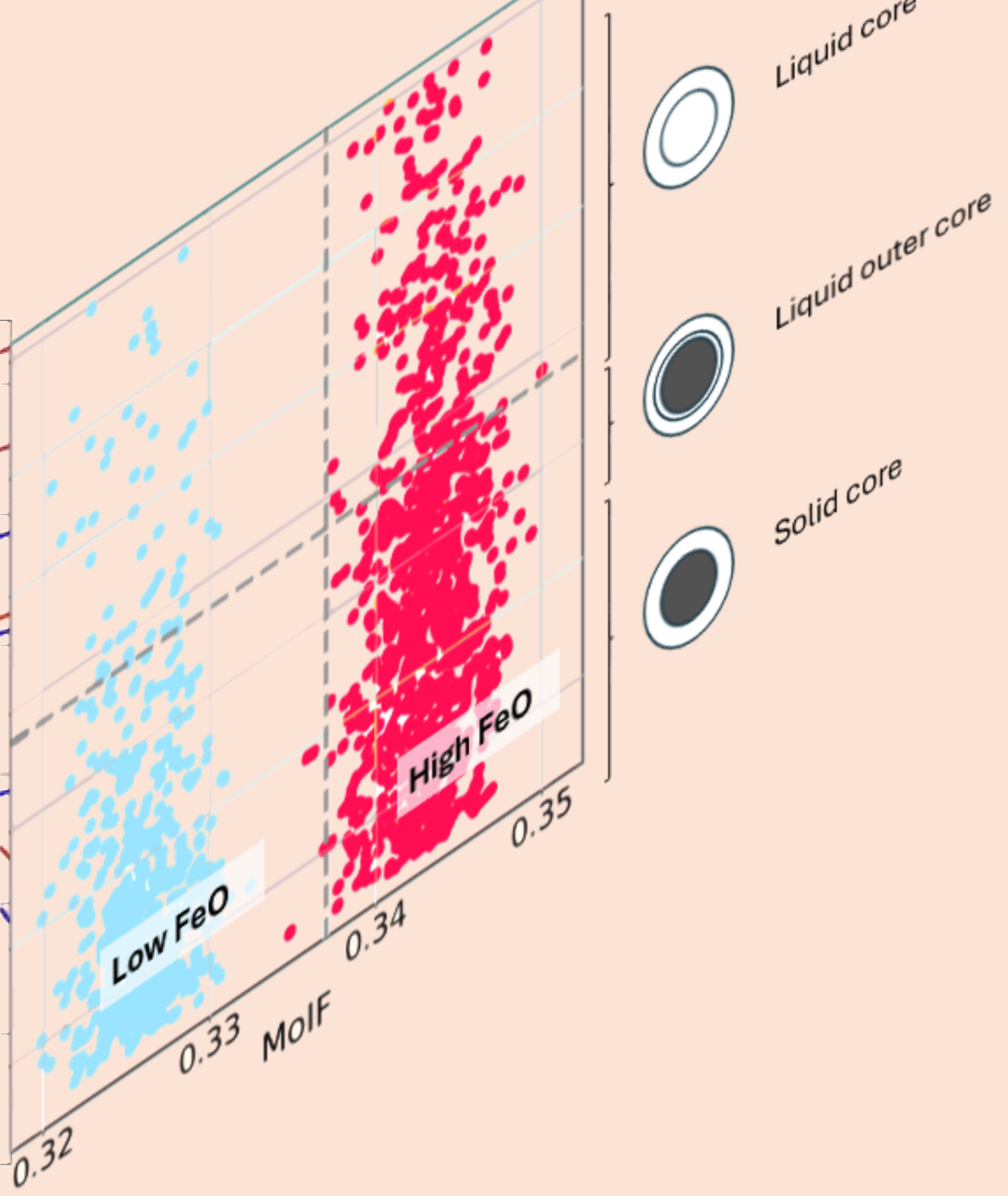
Solid core

Adapted from Dumoulin et al., 2017

Interior Structure

Core state | Core radius | Mantle viscosity | Mantle density |
Mantle composition

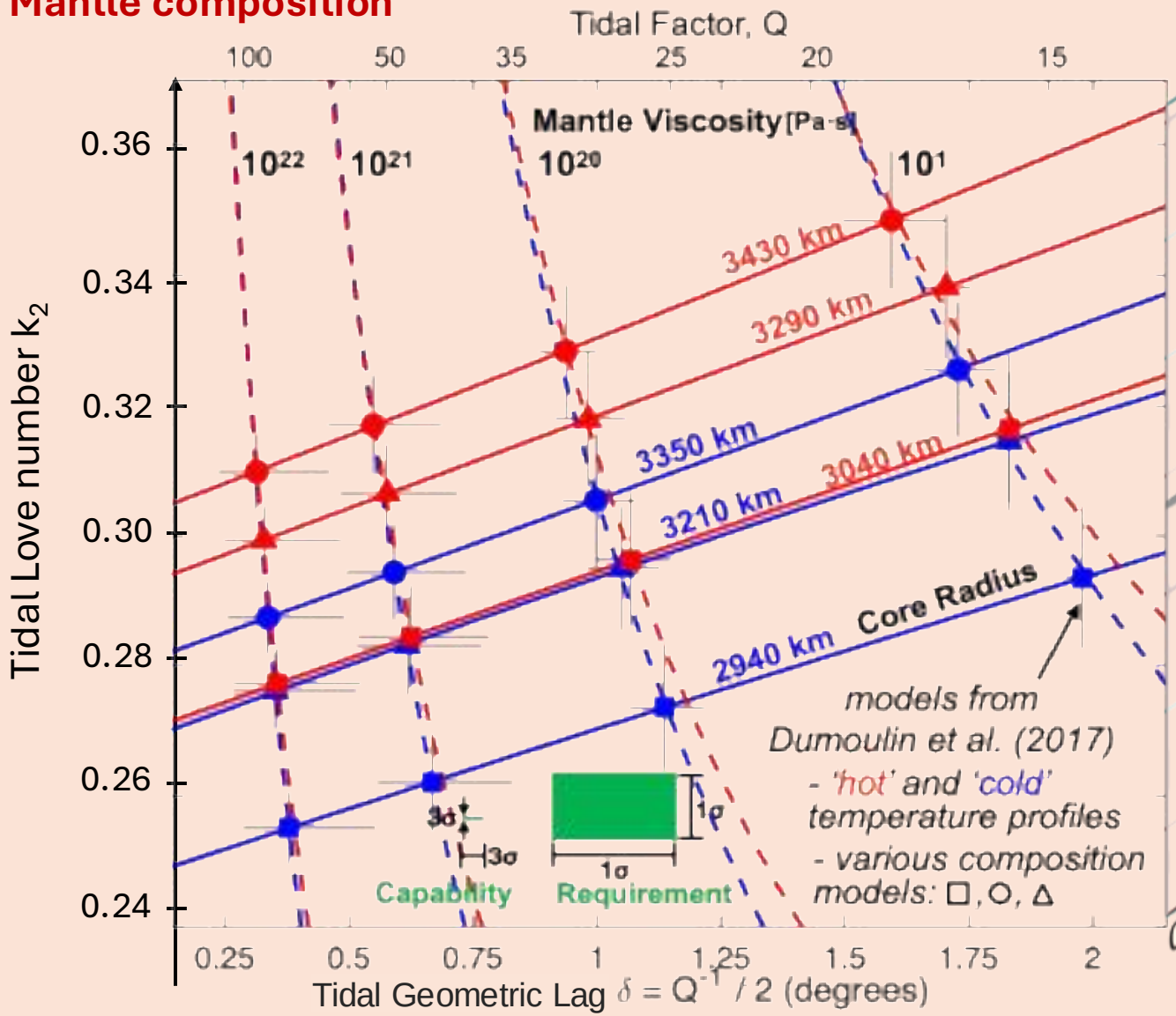


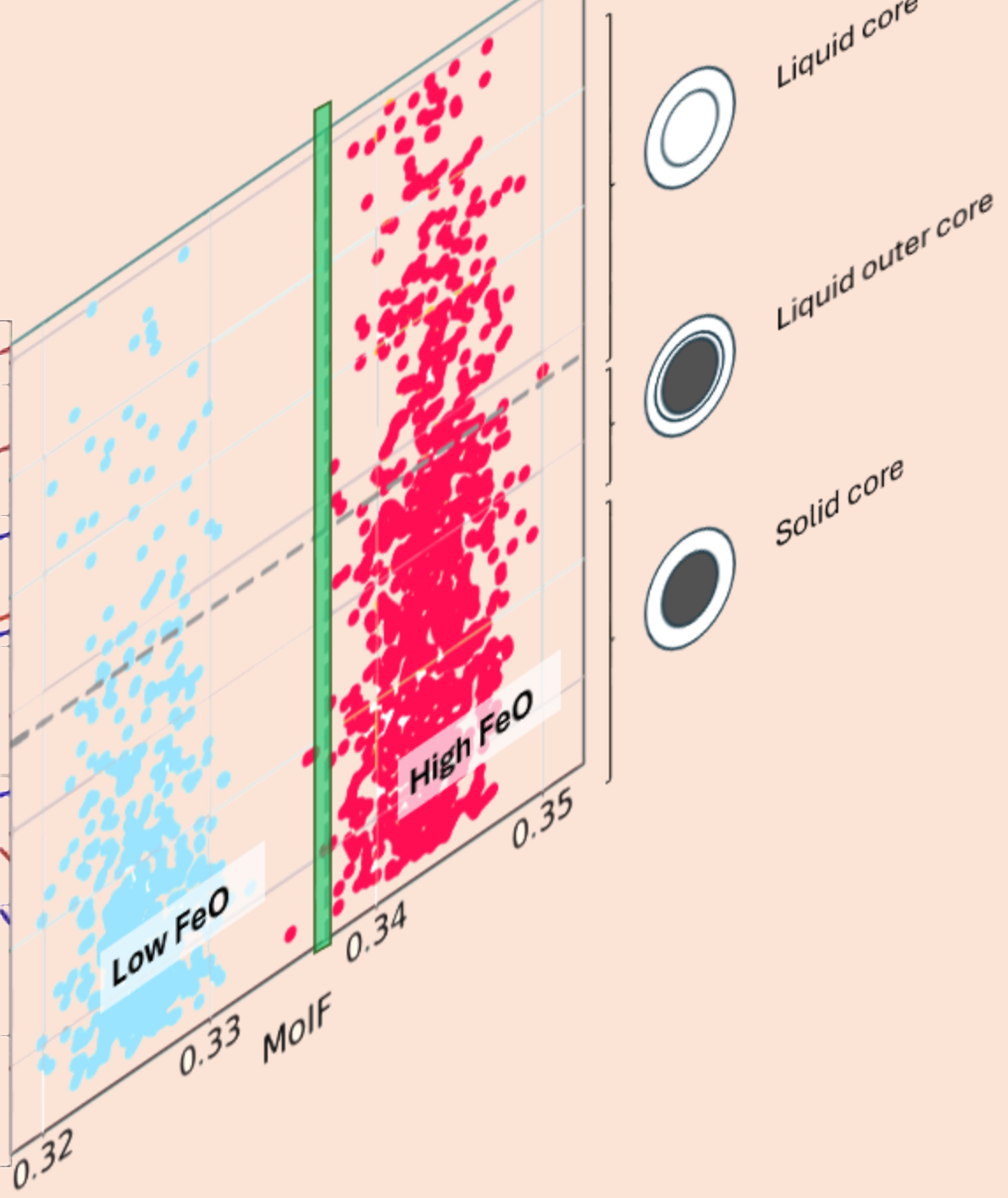


MoIF plot from Walterová et al.

Interior Structure

Core state | Core radius | Mantle viscosity | Mantle density |
Mantle composition



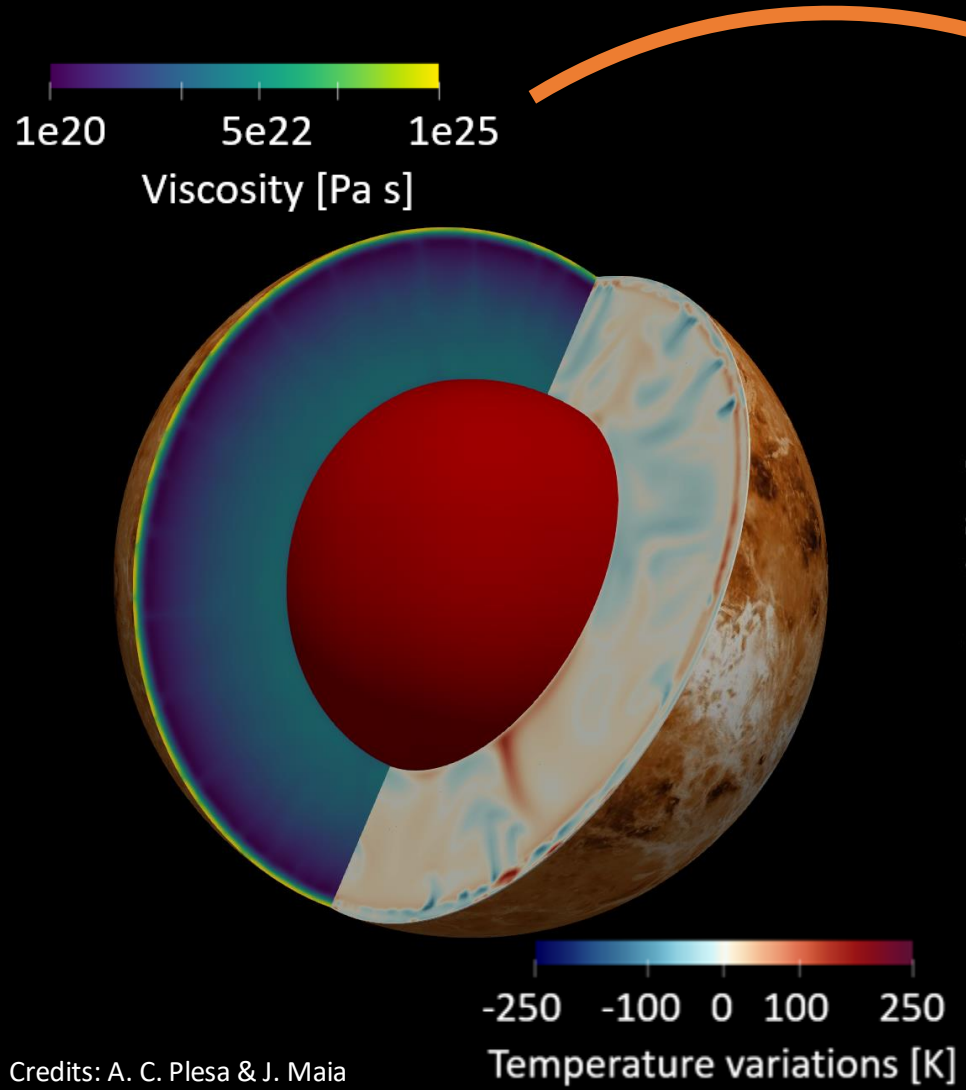


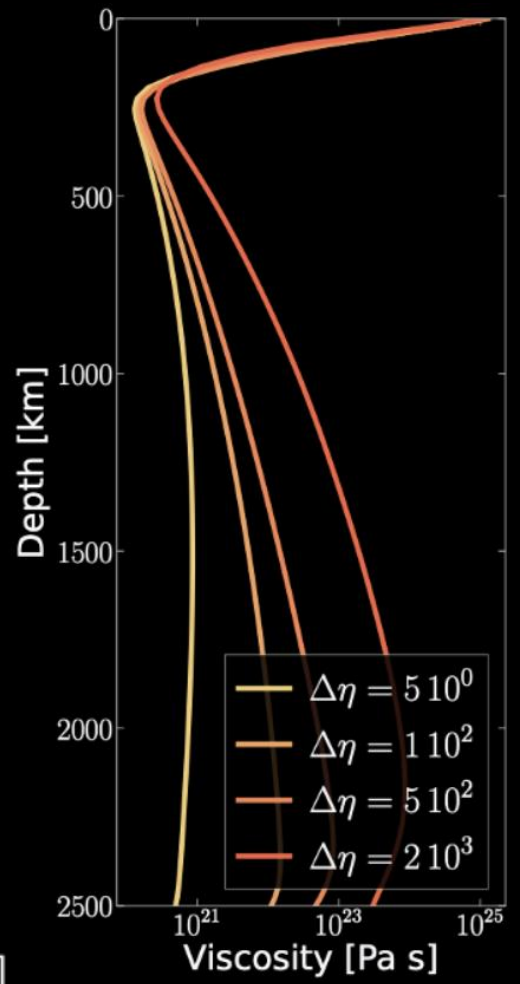
MoIF plot from Walterová et al.

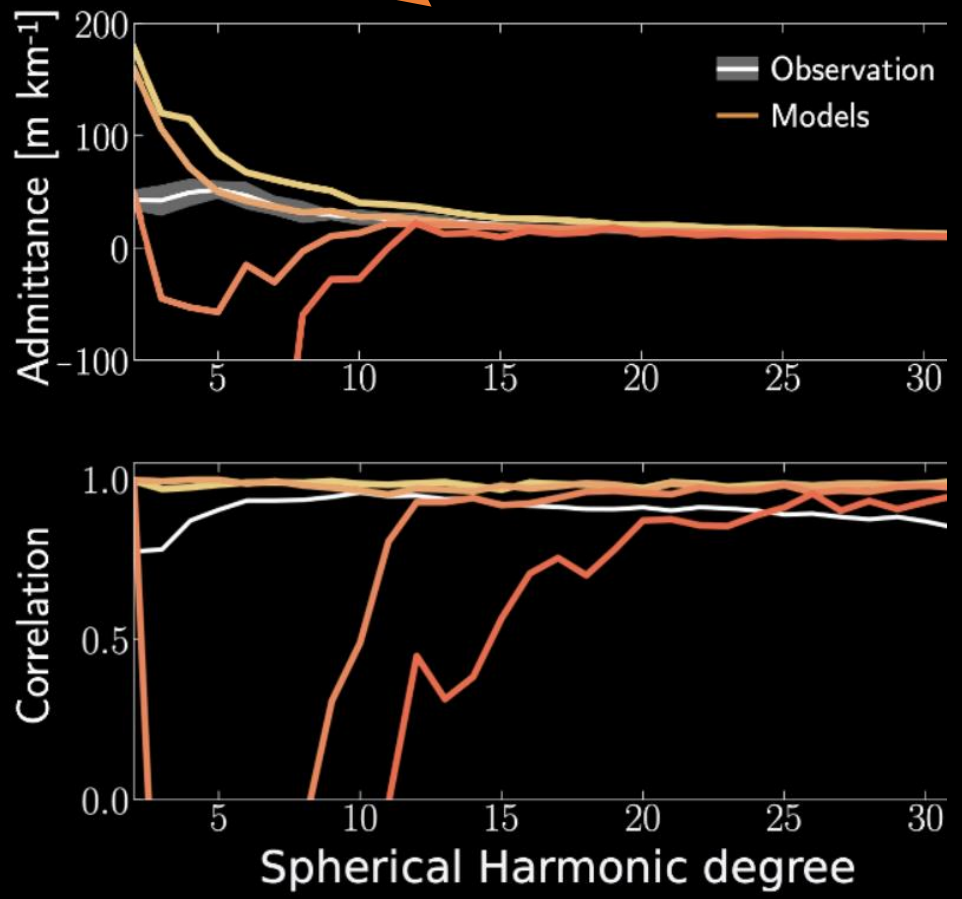
Geodynamical & Geophysical Insights

from higher gravity resolution

Global thermal evolution models combined with gravity & topography analysis will constrain the viscosity structure.



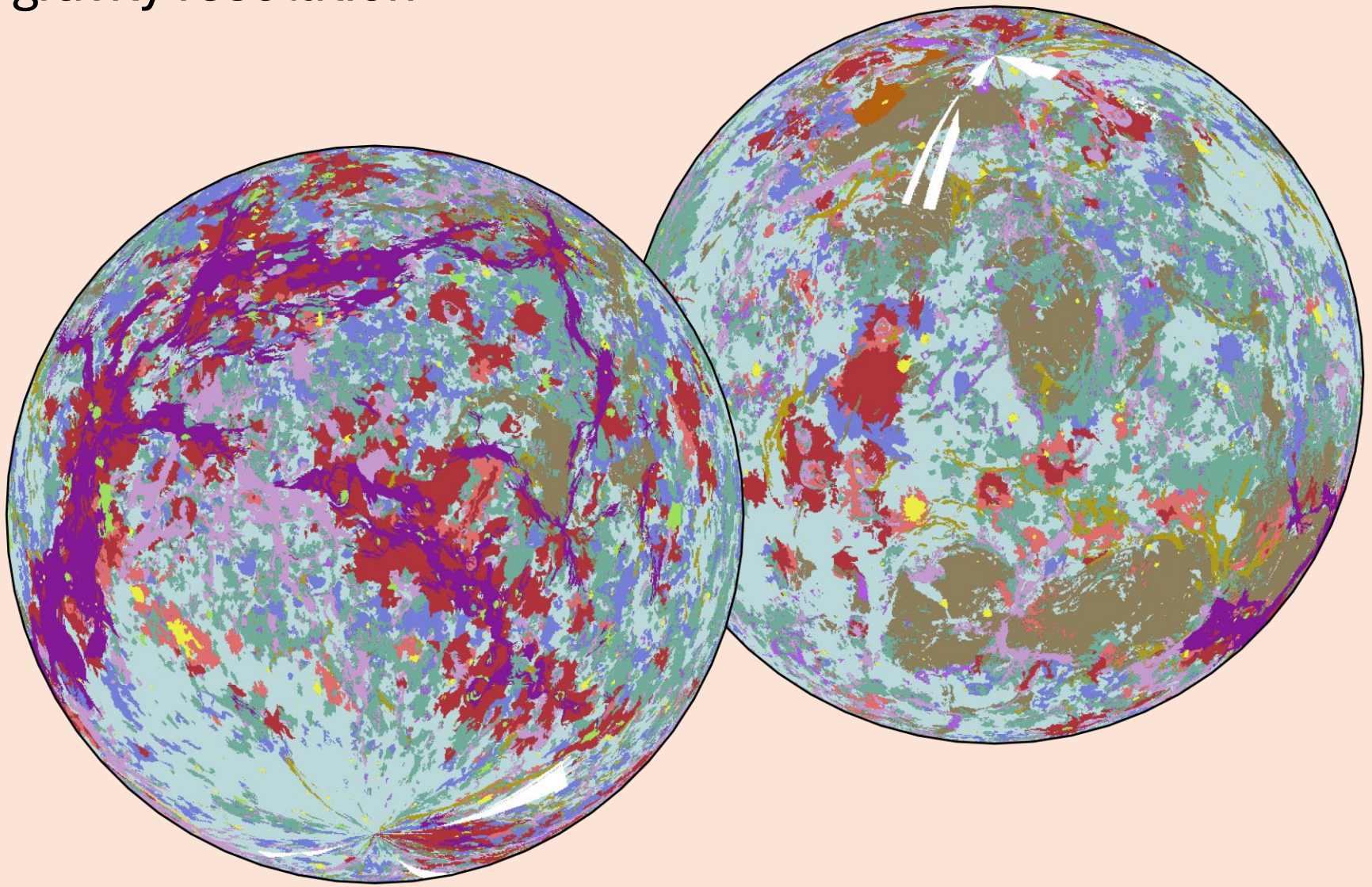




Credits: A. C. Plesa & J. Maia

Geodynamical & Geophysical Insights

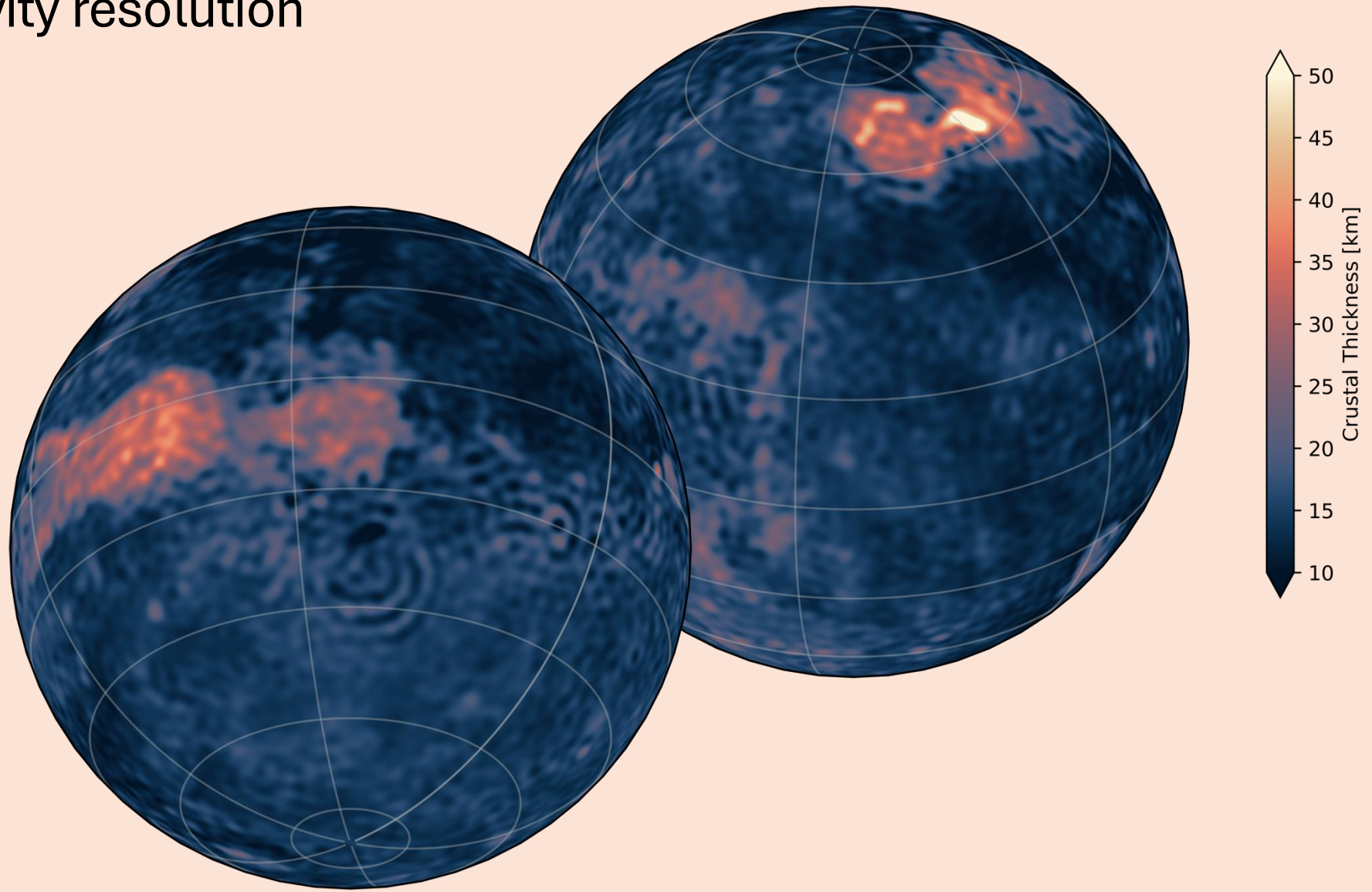
from higher gravity resolution



Geologic map: Ivanov & Head, 2011

Geodynamical & Geophysical Insights

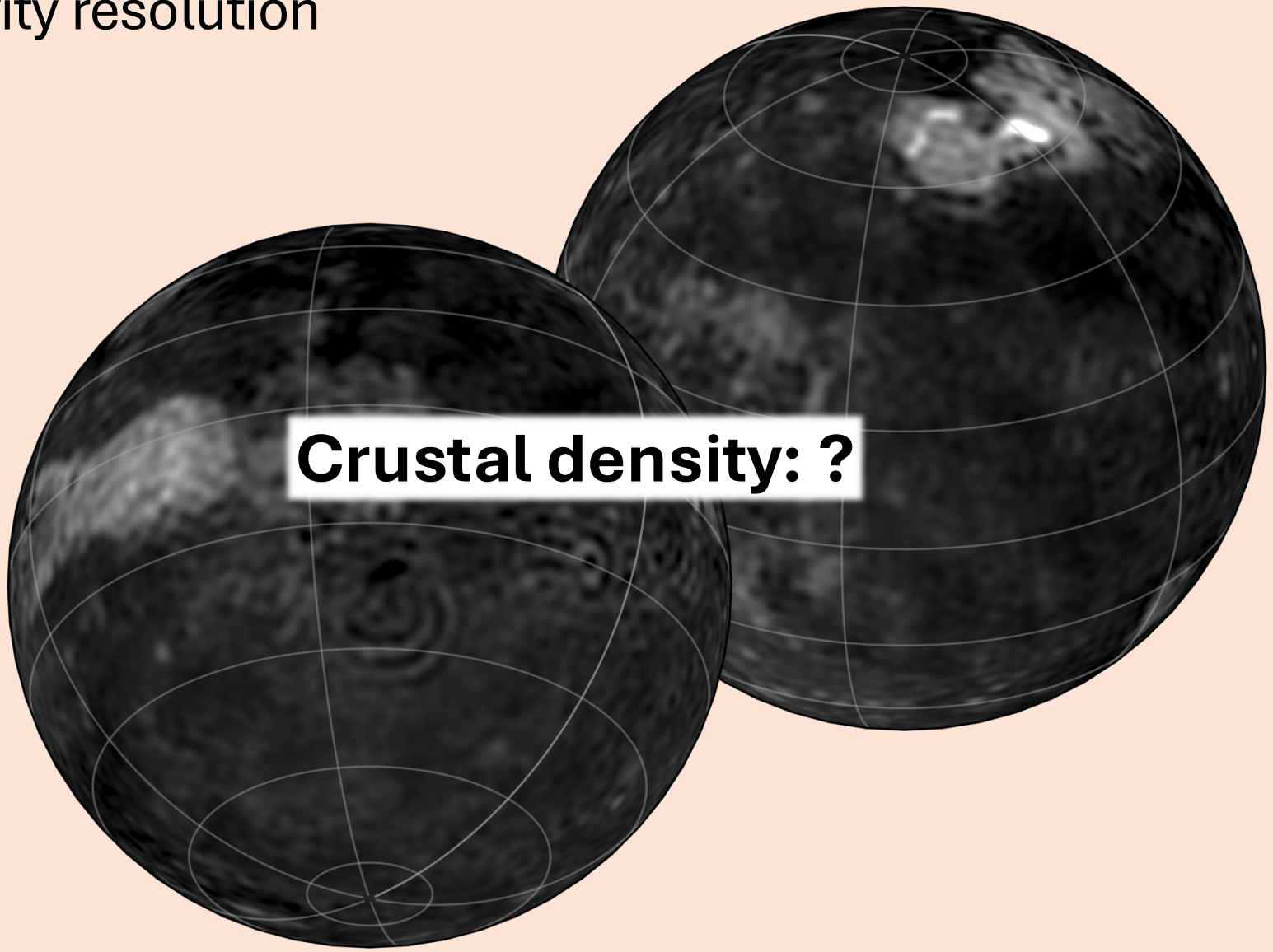
from higher gravity resolution



Crustal thickness map: James et al., 2013

Geodynamical & Geophysical Insights

from higher gravity resolution



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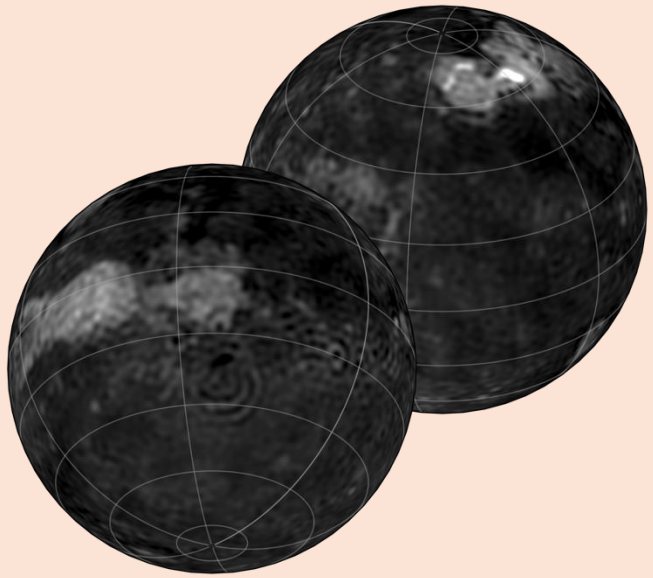
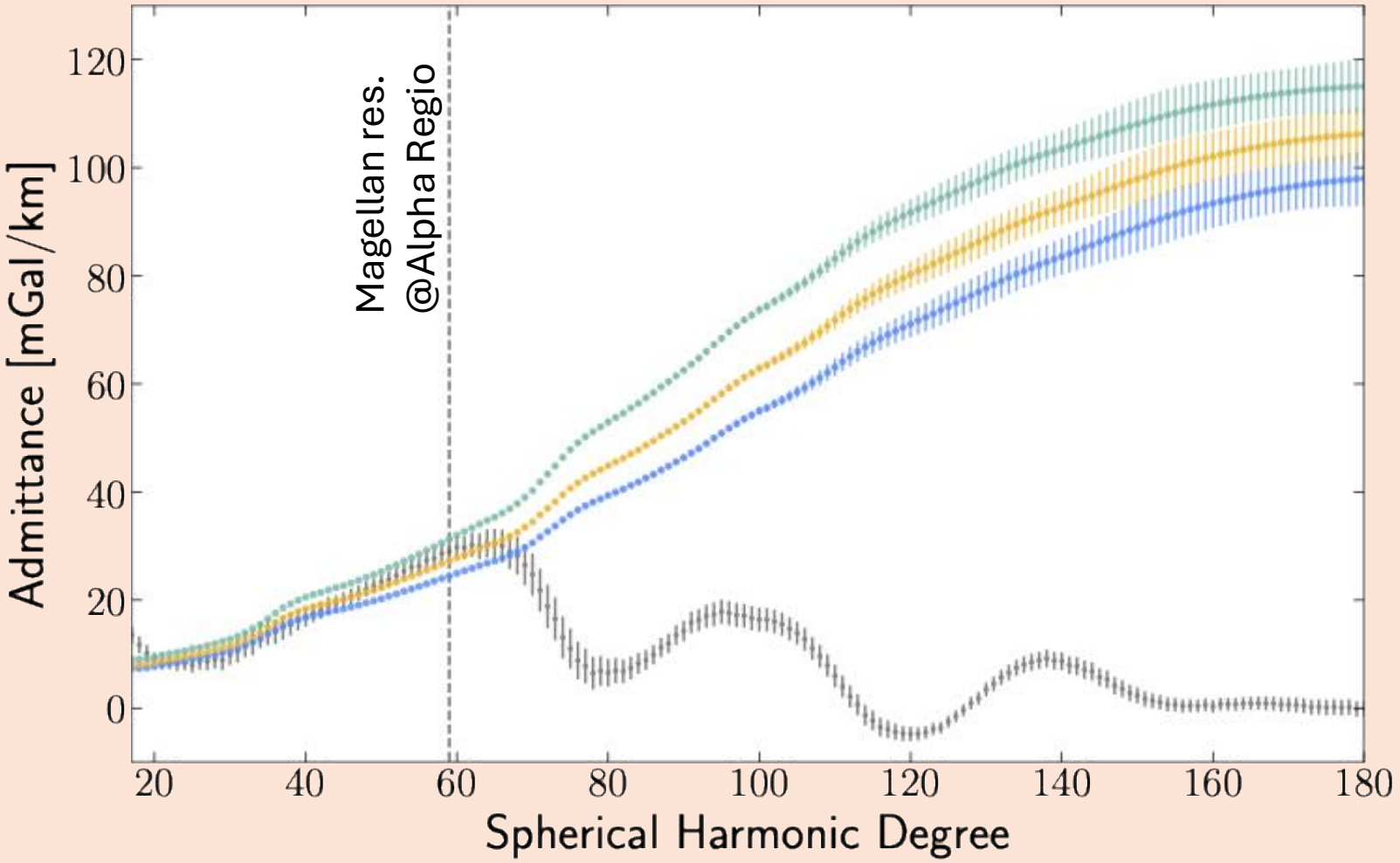
Geodynamical & Geophysical Insights
from higher gravity resolution



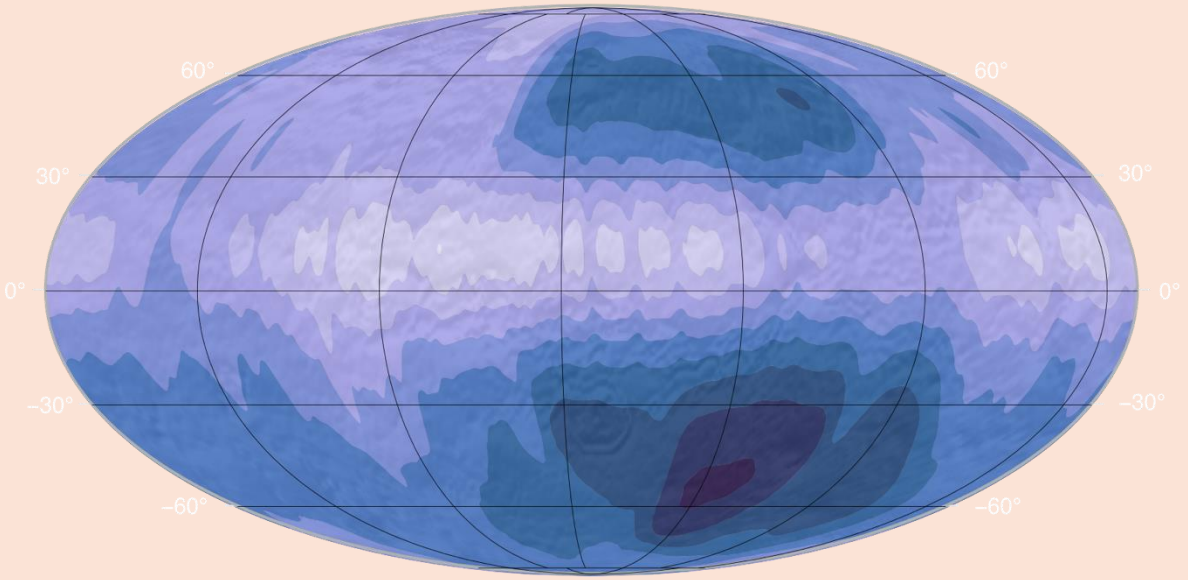


Admittance plot: Maia et al. (this session)

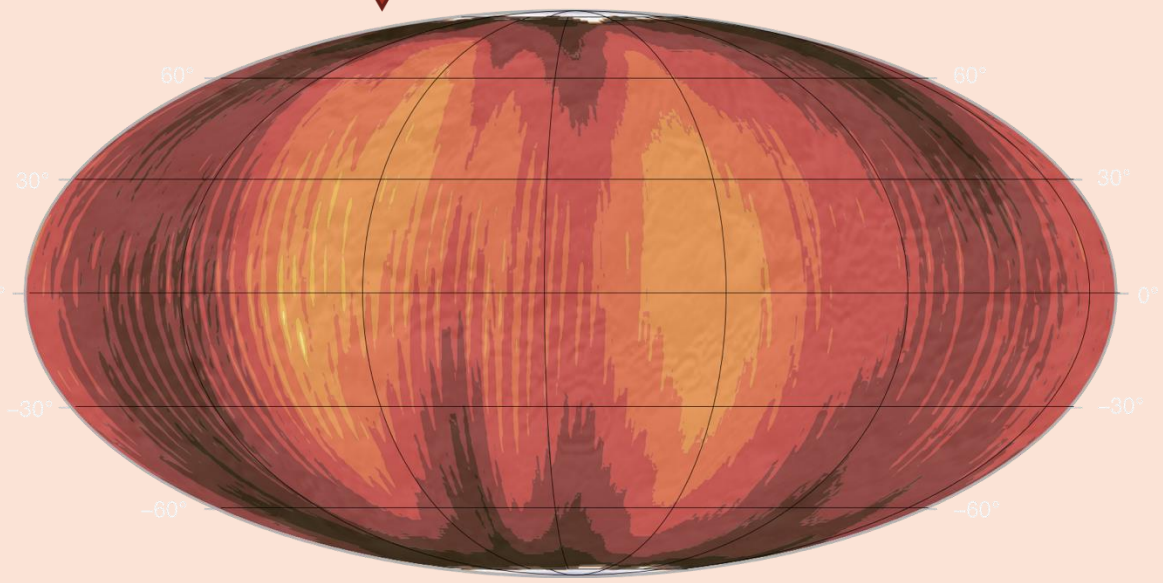
Geodynamical & Geophysical Insights

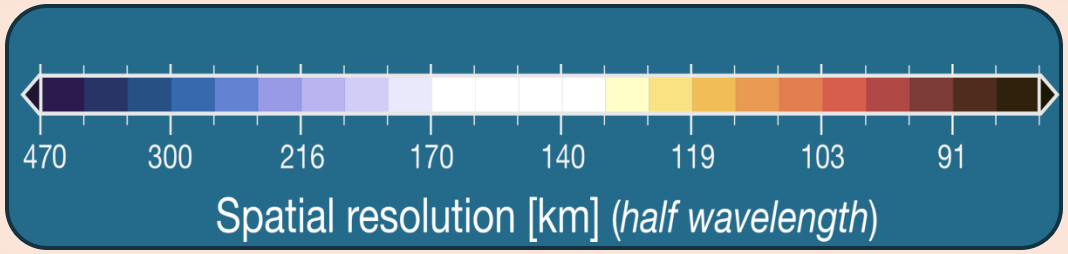
from higher gravity resolution

Magellan



VERITAS

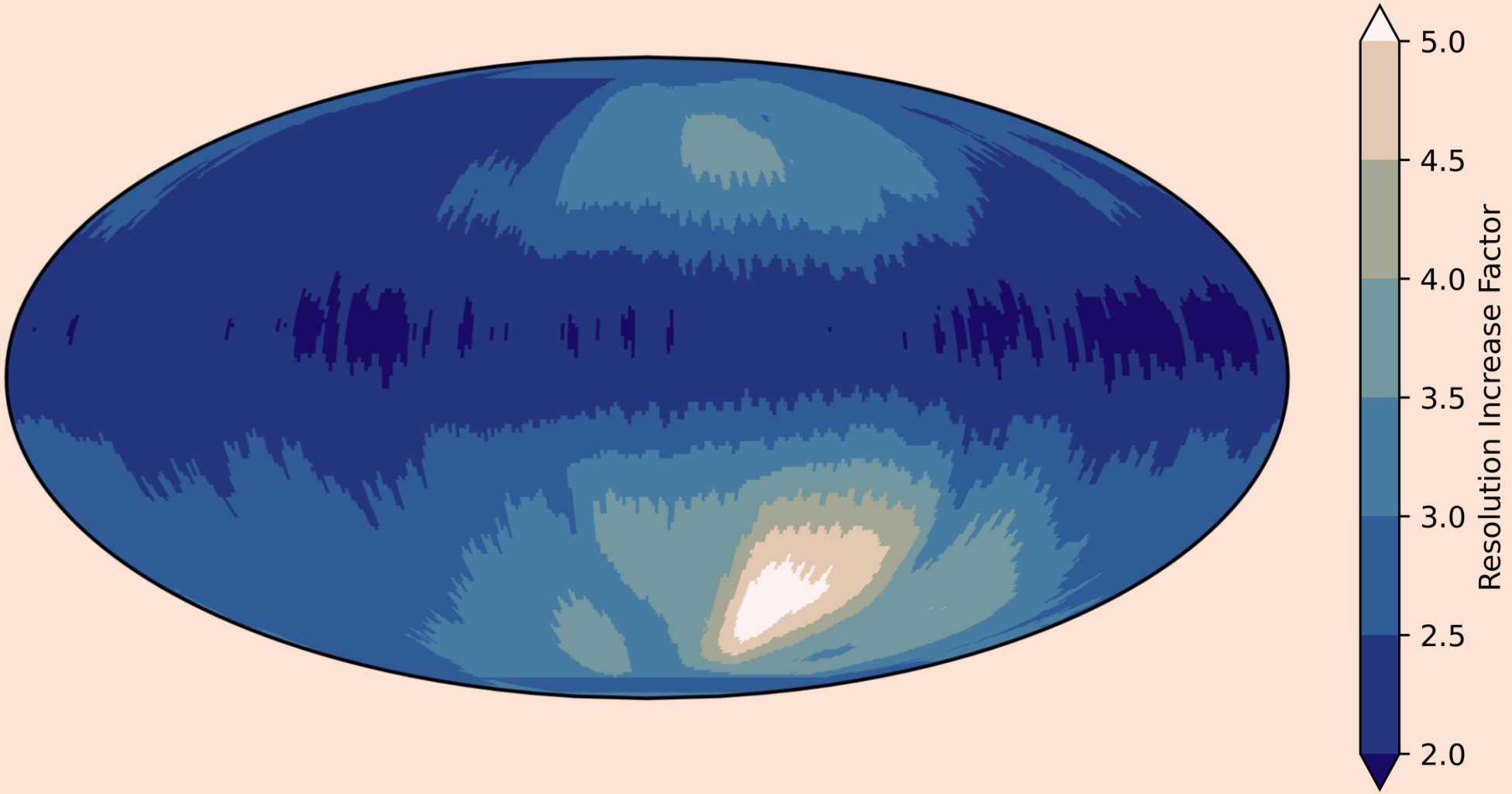




Magellan resolution : Konopliv et al., 1999 | VERITAS resolution : Giuliani et al., 2025 | plot: Cascioli & Gülcher et al. (under review)

Geodynamical & Geophysical Insights

from higher gravity resolution



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Geophysical & Geological Insights

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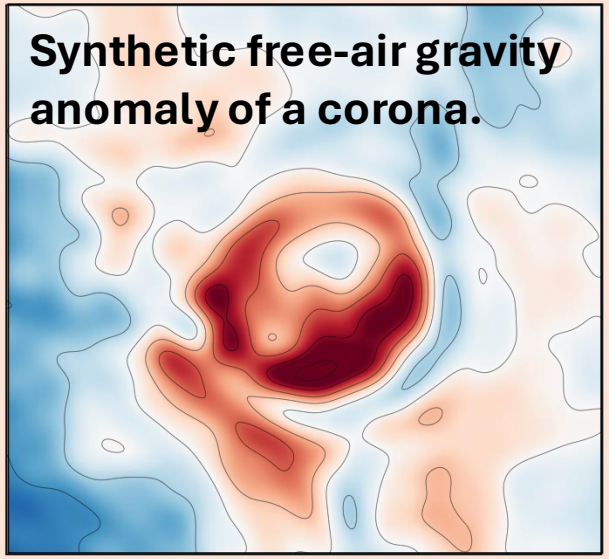
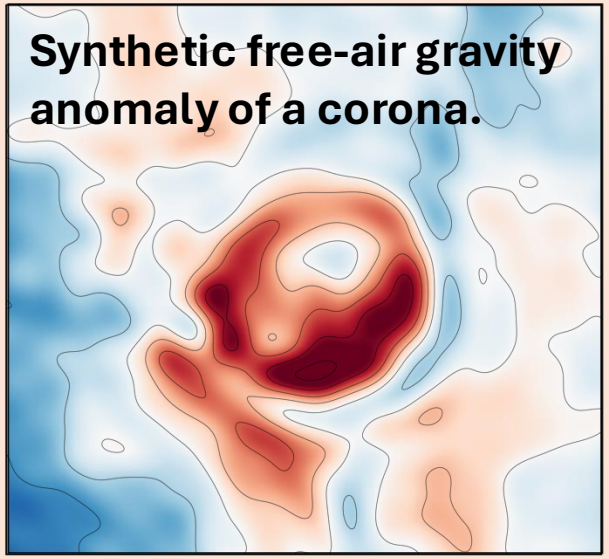
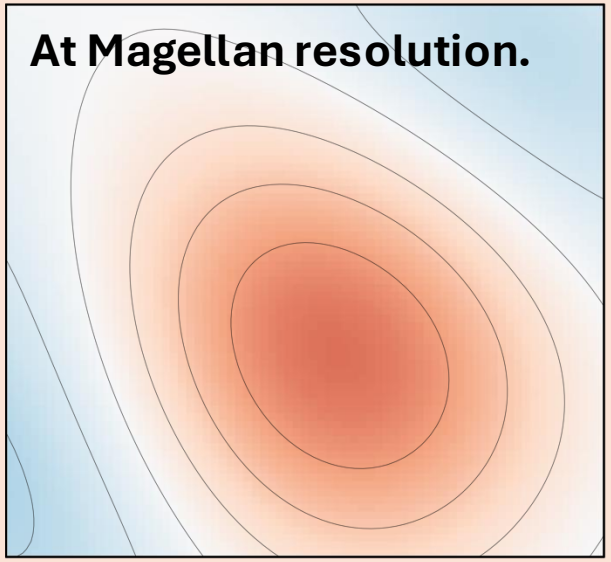


Geophysical & Geological Insights

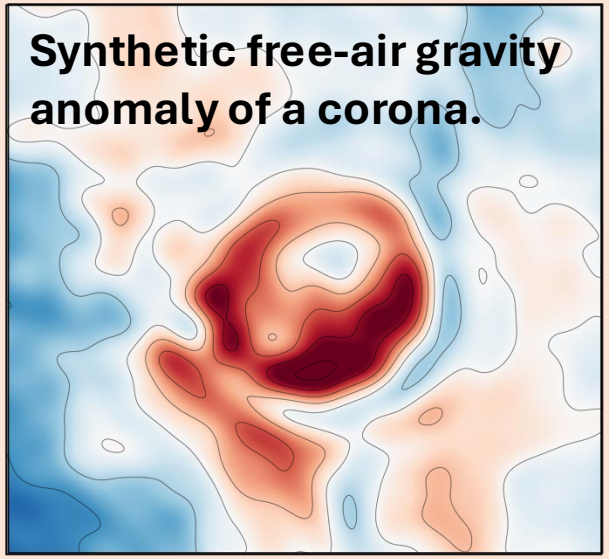
from higher gravity resolution

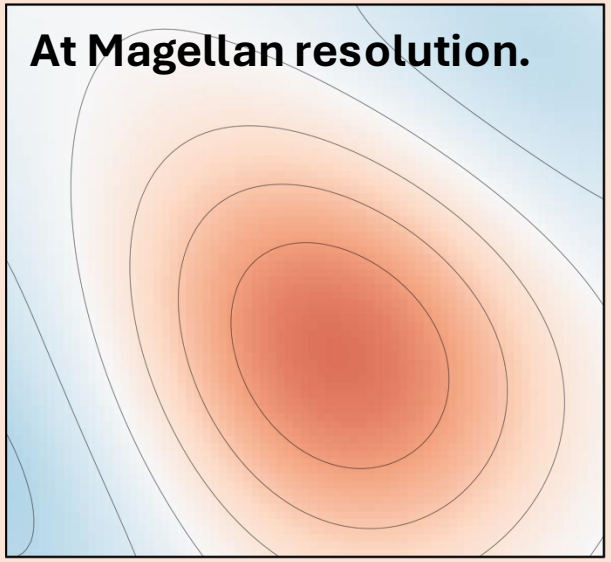


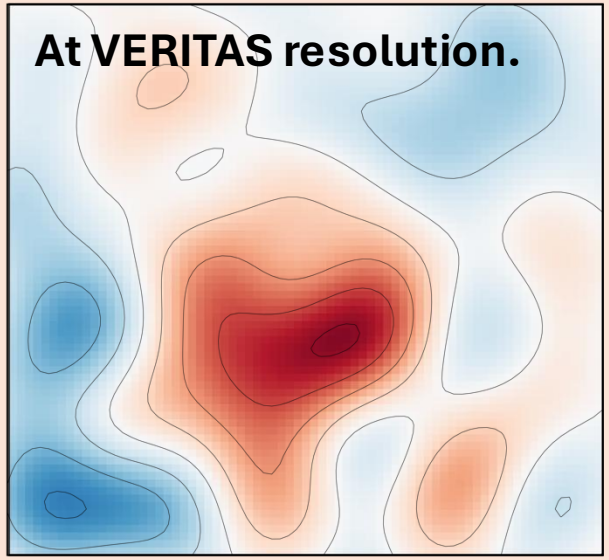


Geophysical & Geological Insights

from higher gravity resolution

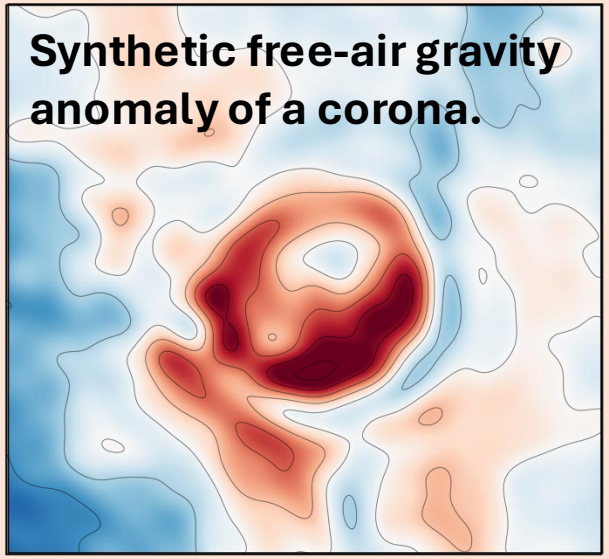


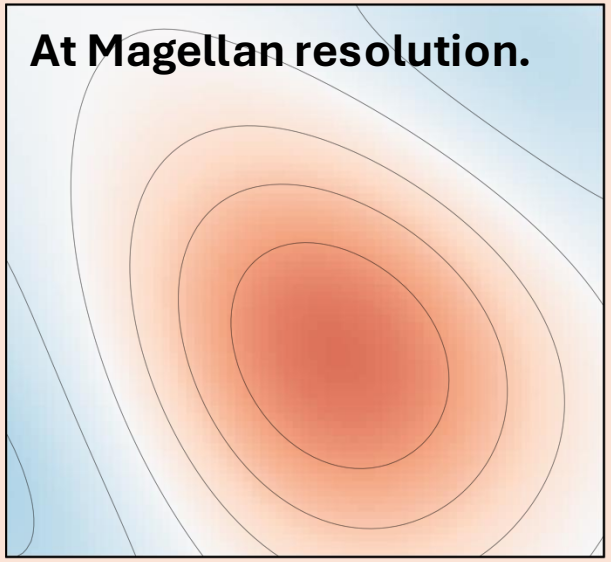


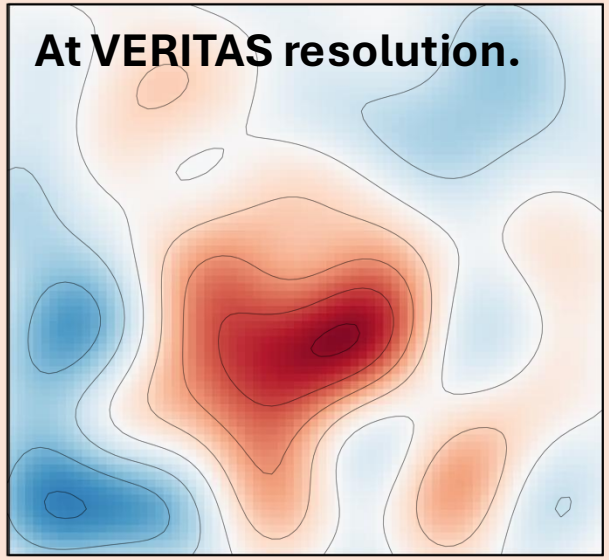


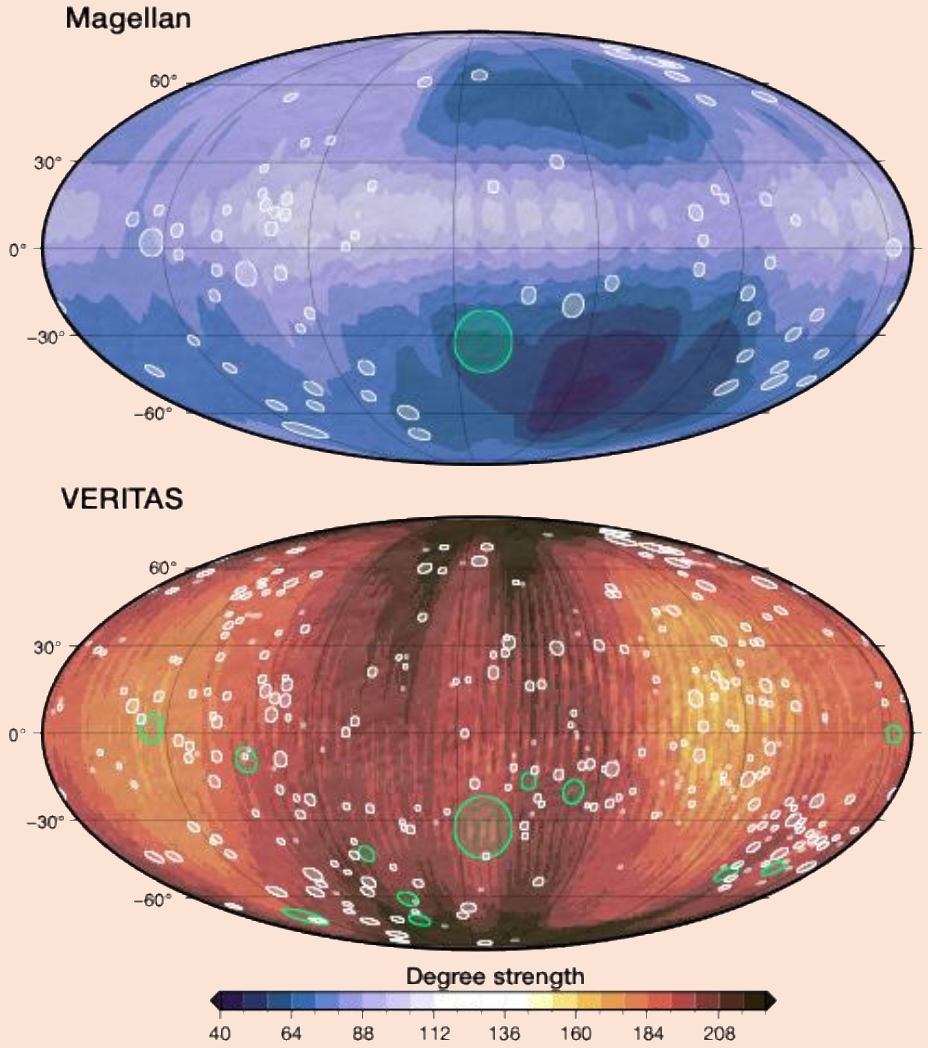
Geophysical & Geological Insights

from higher gravity resolution









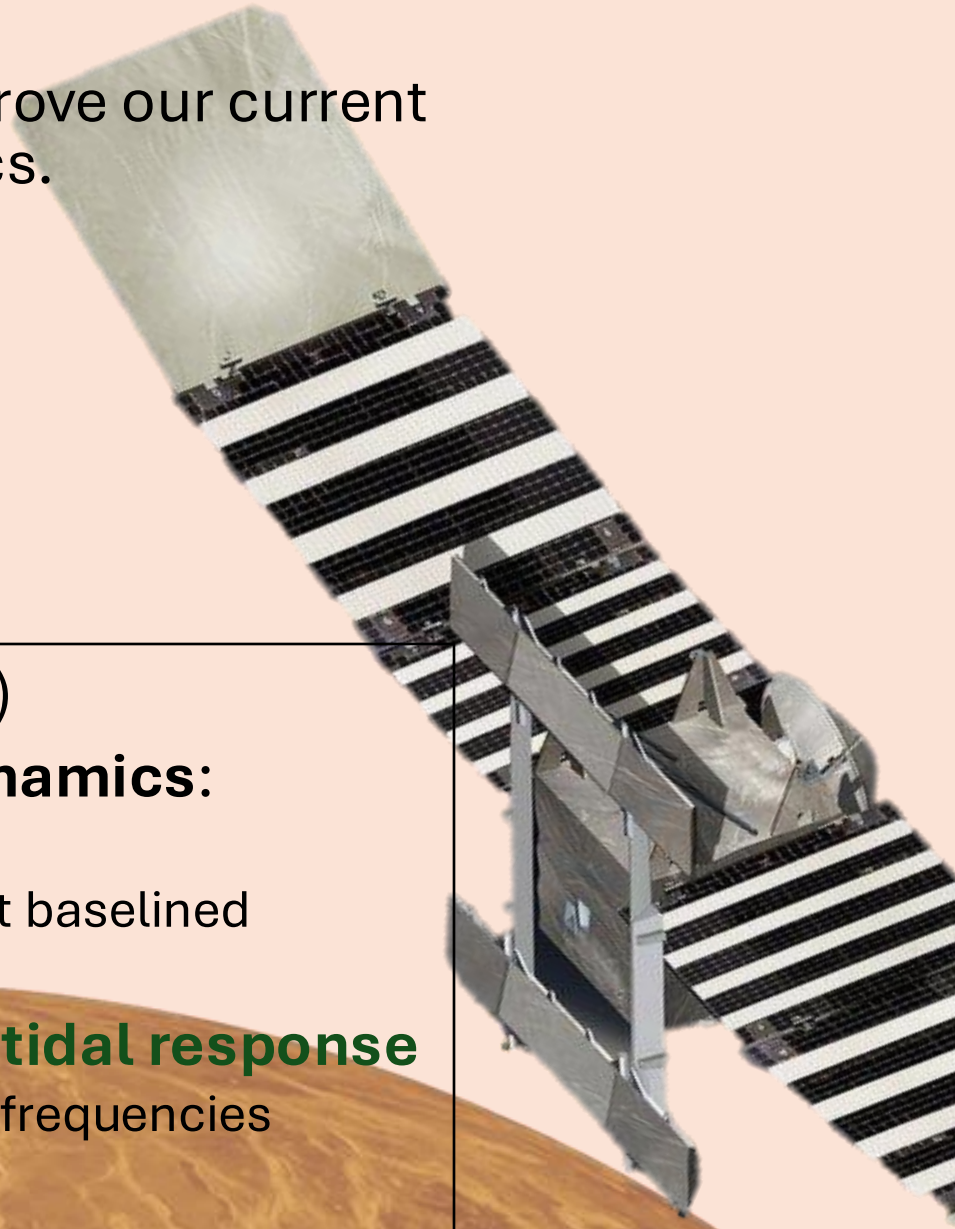
Gülcher et al. (this session), Cascioli, Gülcher et al. (under review)

Conclusion

The VERITAS gravity science investigation will greatly improve our current knowledge of Venus interior, geophysics and geodynamics.

It will produce **foundational datasets** that include:

- Static gravity field and tidal response
- Moment of inertia
- Precession



Additional insights (not discussed in the previous slides)

Angular momentum exchange with surface:

Precise spin rate monitoring over short time scales

Deep atmosphere:

Thermal tides

Atmospheric loading of the crust

Atmospheric dynamics:

Occultations

(possible, not yet baselined

Multi-frequency tidal response

Daily and semi-daily frequencies