THE VERITAS GRAVITY INVESTIGATION: GRAVITY, ROTATION, TIDES, AND INTERIOR STRUCTURE. E. Mazarico[1], G. Cascioli[1,2], F. Giuliani[3], L. Iess[3], D. Durante[3], F. De Marchi[3], M. Walterová[4,5], J. Maia[4], A. C. Plesa[4], D. Breuer[4], S. Smrekar[6], and S. Hensley[6]. [1]NASA Goddard Space Flight Center, 8800 Greenbelt Road, Greenbelt, Maryland, USA, erwan.m.mazarico@nasa.gov; [2]University of Maryland Baltimore County, Baltimore, Maryland, USA, [3]Sapienza University of Rome, Rome, Italy, [4]Institute of Planetary Research, German Aerospace Center (DLR), Berlin, Germany, [5]Charles University, Prague, Czech Republic, [6]Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA, USA.

Introduction: VERITAS [1], the upcoming NASA Discovery mission to Venus, will be the first probe to investigate Venus's surface processes and interior structure since the Magellan mission concluded in 1994. Among its investigations, VERITAS will conduct a Gravity Science investigation, key to advance our understanding of Earth's twin planet. The dual X/Ka-band tracking system, capable of Doppler accuracy of about 18 μm/s at 10s integration time, enables a gravity field of Venus with a resolution of <106 km globally with <4 mGal RMS accuracy. Moreover, VERITAS will measure the tidal response and moment of inertia of the planet, providing an unprecedented insight on the interior structure of Venus. In this work we present the latest numerical simulations of the gravity recovery and their implications for the characterization of the interior structure and ongoing surface processes of Venus.

Geophysical Datasets: In this work we provide an overview of the expected performance of the VERITAS gravity investigation and its implication for Venus's science. Thanks to its state-of-the-art radio tracking system, VERITAS will be able to measure the gravity of Venus to an unprecedented level of detail. Figure 1 shows the results from our latest simulations in terms of expected spatial resolution of the recovered gravity field [2]. The gravity field measured by VERITAS is expected to be have a lateral resolution better than 106 km over 90% of Venus.

Besides the static gravity field, VERITAS will obtain foundational measurements of the tidal response of Venus. Namely the tidal amplitude, parametrized by the Love number k_2, will be measured with an uncertainty (3σ) equal to 0.15% of its expected value (0.295 from [3]) and the tidal phase lag will be measured, for the first time, with an uncertainty of 0.05° [4]. The VERITAS tracking system will be so sensitive that subtle effects, that were missed by Magellan, should become measurable. Notably the periodic crustal loading, imparted by the atmospheric thermal tides, will likely be measured, potentially providing new and unexpected constraints to the mantle viscosity structure [5].

The VERITAS science payload was designed with synergies between instruments in mind. Among these, the combination of gravity and synthetic radar observations (enabled by VISAR, VERITAS' SAR [6]) will enable tight constraints on the position of the spacecraft relative to the Venus body-fixed frame. Therefore, VERITAS will be able to finely monitor the rotational dynamics of Venus, particularly Venus' spin rate and pole precession. VERITAS will thus measure the moment of inertia of Venus with a precision (3σ) of 0.3%. Moreover, the spin rate will be measured at a level <0.03% or better, every few days, and bring unique perspective on the interaction between the atmosphere and the solid body [4] and shedding light on the recent, unexpected, observations of a strong variability of Venus' spin rate [7].

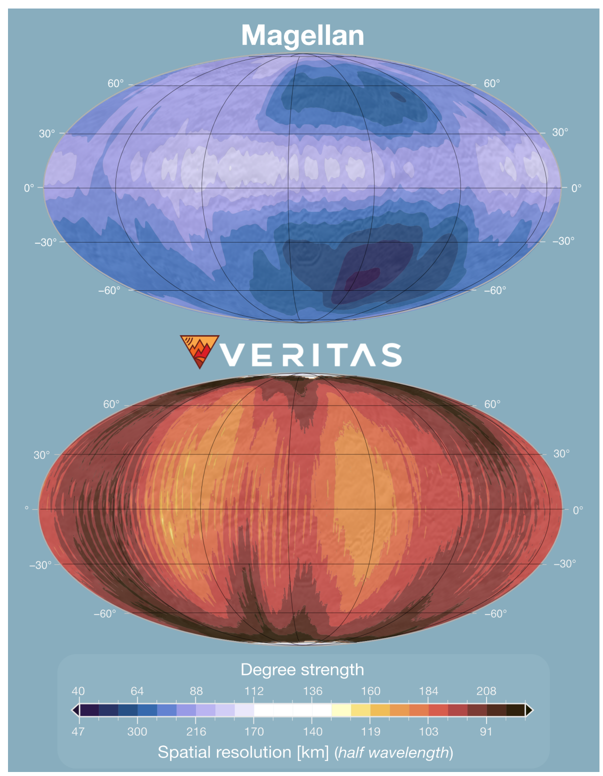

Figure 1. Gravity field spatial resolution comparison: (top) Magellan gravity field [3], (bottom) expected VERITAS gravity field [2].

Implications for the Interior Structure of Venus: The measurements VERITAS will deliver, are predicted to have a major impact on our understanding of Earth's twin planet. Such a precise measurement of the MOIF

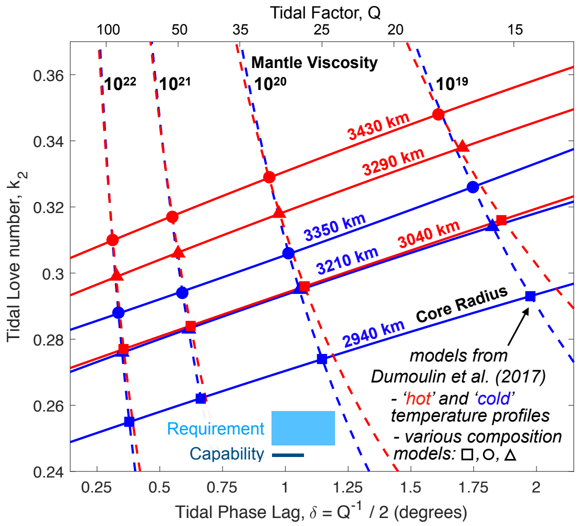

Figure 2. The size of the core and the thermal state of the mantle can be constrained through comparison with interior models (*e.g.*, [11]) by complementary measurements, of the tidal response of Venus (above) and of the moment of inertia factor (not shown).

will allow to place tight constraints on the core size and mantle composition, the tidal response will allow us to resolve the ambiguity on the core state, discriminating between a liquid and solid core. The new measurements of the tidal deformation combined with the analysis of the dynamic gravity signature will also allow us to place tight constraints on the mantle viscosity [2,4, 9, 10, 11] (Figure 2).

The improved resolution of the gravity field will revise and push significantly further our understanding of the crustal and lithospheric properties, such as elastic thickness, mechanical thickness, and crustal density. The improved gravity field data will provide valuable constraints on the crustal thickness and its spatial variations. In addition, the high-resolution gravity field can help constrain the density of the crust enabling models to distinguish between felsic and mafic compositions [12] thereby providing a complementary constraint on the crustal composition to emissivity measurements performed by the Venus Emissivity Mapper (VEM) [13]. Furthermore, the new gravity field data will help to refine elastic thickness estimates that are closely linked to the thermal state of the lithosphere and ultimately the surface heat flow [14-15]. Substantially smaller spatial scales will be resolved, the updated gravity field will allow an in-depth characterization and investigation of surface features that until now could be only studied through their morphology, such as coronae and rifts (*e.g.*, [8, 16]).

Acknowledgments: A portion of this research was conducted at the Jet Propulsion Laboratory, California Institute of Technology, under contract 80NM0020F0035 with NASA. FG, LI, DD, and FDM acknowledge support from ASI (contract 2022-15-HH.0).

References: [1] Smrekar S.E. et al. (2022) IEEE. [2] Giuliani F. et al. (2025) PSJ (*accepted*). [3] Konopliv A.S. et al. (1999) *Icarus*. [4] Cascioli G. et al. (2021) PSJ. [5] Cascioli G. et al. (2023) PSJ. [6] Hensley S. et al. (2020) IEEE Radar Conf. [7] Margot J.-L. et al. (2021) Nat. Astron. [8] Cascioli G. et al. (2024) EPSC. [9] Walterová M. et al. (2024) EPSC. [10] Maia J. et al. (2023) GRL. [11] Dumoulin C. et al. (2017) JGR:P. [12] Baccarin et al. (2024) EPSC. [13] Plesa A.-C. et al (2025) LPSC (*this meeting*). [14] O'Rourke J.G. and Smrekar S.E. (2018), JGR:P. [15] Smrekar S.E. et al. (2023) Nat. Geosc. [16] Regorda A. et al. (2023) JGR:P.