The VERITAS gravity science investigation

See also Mazarico et al., **tomorrow** @ 10:25 AM

G. Cascioli[1,2], E. Mazarico[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], A. Gülcher[6], D. Breuer[4], S. Smrekar[7], S. Hensley[7]

VERITAS

Introduction

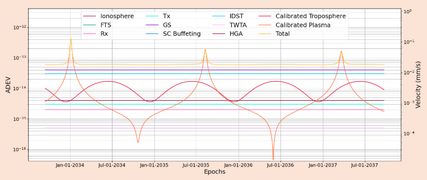
The NASA Discovery-class mission VERITAS (Venus Emissivity, Radio Science, InSAR, Topography, and Spectroscopy) will acquire science data for 2.7 years in Venus orbit (nominal mission duration). The goal of its gravity science investigation is to understand the Venus lithosphere, crustal evolution, and interior structure by measuring the planet's gravity field and orientation to an unprecedented level of accuracy, creating a foundational dataset for fundamental geophysical investigations of Venus.

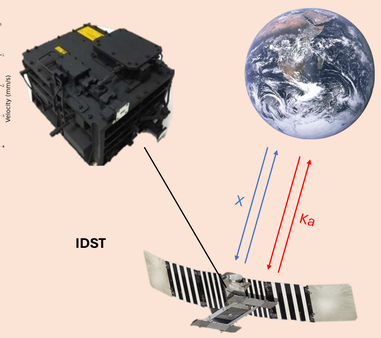
Hardware and gravity data

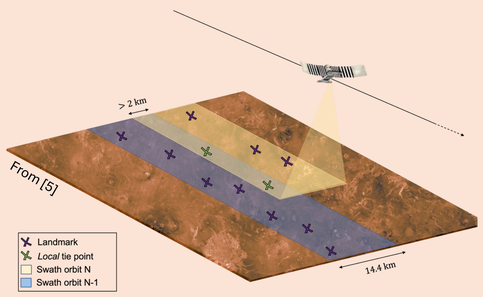
Gravity science data will be acquired using **two coherent radio links in X- and Ka-band** (first mission ever to baseline and use Ka-band uplink from all the DSN complexes) [1].
The key hardware element onboard enabling the investigation is the **Integrated Deep Space Transponder** (**IDST**, built by Thales Alenia Space, under contract with Italy's ASI).

Radio tracking system. It enables two extremely precise measurement types:

- **Doppler tracking: Noise floor 0.018 mm/s (@10s)**
- **PN Ranging: 24 Mcps, noise floor 1-4 cm (@4s) [2]**



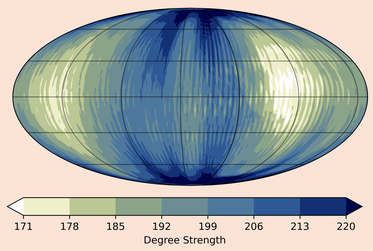




Radar Tie Points.
Additionally, the gravity investigation will take advantage of the **repeated observations of surface features made by the VERITAS interferometric radar instrument VISAR** (tie points) to improve the ties between the spacecraft inertial position and the Venus body fixed frame.

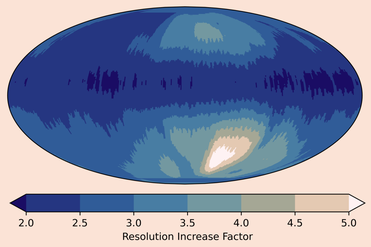
Main measurement products

STATIC GRAVITY FIELD (see [3])
Resolution: simulated to be better than degree 180 over 90% of Venus (degree strength). This corresponds to a lateral resolution of 106 km.
Amplitude: Significantly lower noise with respect to Magellan. When gridded at 200 km, the gravity anomaly RMS noise is 0.5 mGal (compared to ~10 mGal for Magellan)



TIDAL RESPONSE (see [4])
Tidal Love number k_2 and its phase lag

Parameter	Uncertainty (3σ)
k_2	4.6×10^{-4} (0.2%)
ϕk_2	0.045 deg



MOMENT OF INERTIA (see [4])
Precise measurement of spin pole precession, directly related to the MOIF

Parameter	Uncertainty (3σ)
MOIF	5×10^{-3} (0.3%)
Ω	$0.004\ \mathrm{deg}\cdot\mathrm{cy}^{-1}$

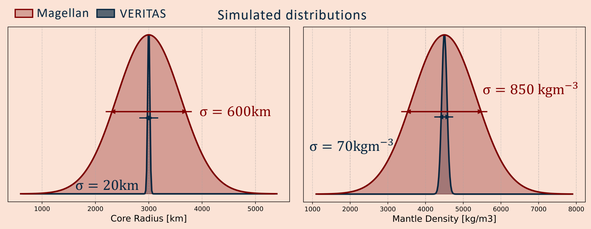
Explore the VERITAS science!

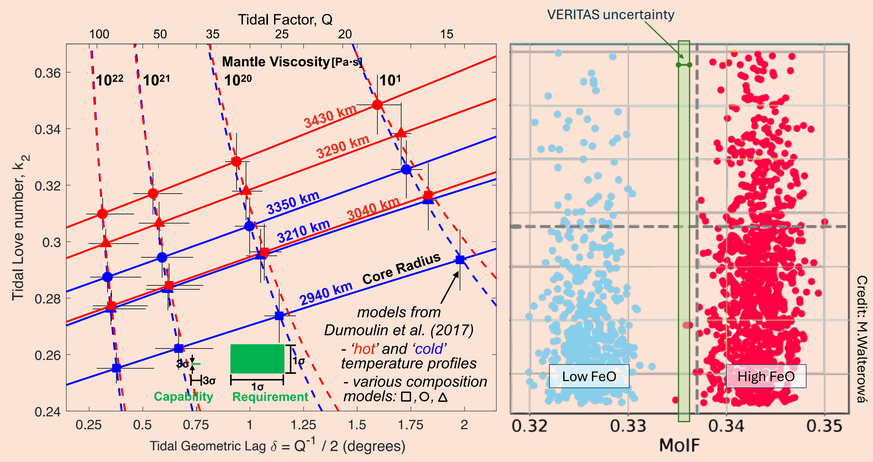
Smrekar & the VERITAS science team (#1763, Tomorrow 2.20 PM)
Nakaya et al . (#2583), Li et al. (#2617)
VISAR: Mendoza et al . (#1770)
VEM: Alemanno et al . (#1824), Garland et al . (#1029), Plesa et al . (#2079)
Gravity Science: Gülcher et al . (#1936), Baccarin et al . (#1903), Mazarico et al . (#1771)
Iceland 2023 Field Campaign: Hong et al . (#1844), Matsko et al . (#1549), Adeli et al . (#2484), Cascioli et al . (#1893), Whitten et al . (#2220), Nunes et al . (#1591), Hensley et al . (#1440), Raguso et al . (#2037)

Deep interior

A refined estimate of the MOI and k_2 , together with the first measurement of the tidal phase lag, will provide fundamental constraints to investigate interior of Venus.

Notably, these quantities will inform on the state of the core (solid/liquid), its size, and the viscosity and composition of the mantle.

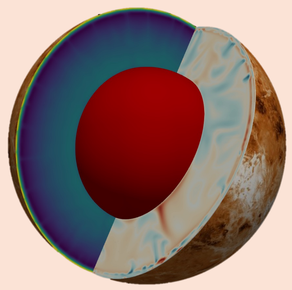


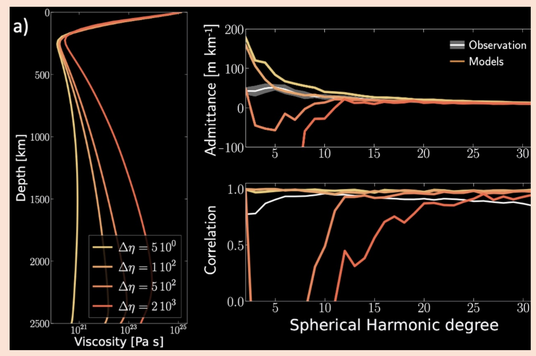


Mantle dynamics

The low degrees (long wavelengths) of the gravity field are sensitive to deep density structures in the mantle. The improved sensitivity of VERITAS (noise lower by orders of magnitude with respect to Magellan) will enable refined modelling and model-to-data comparison to investigate mantle convection, viscosity and viscosity structure.

See Plesa et al., **tomorrow** @ 4:20 PM

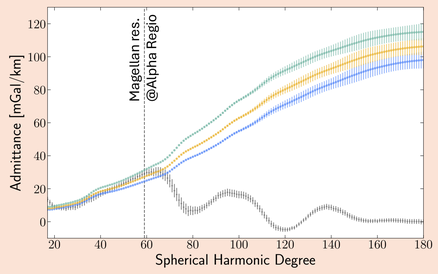




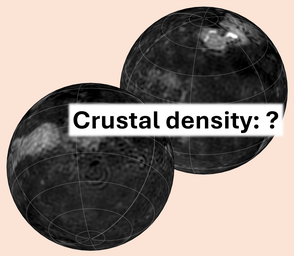
Surface geophysics

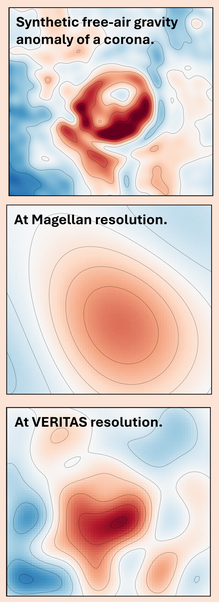
The high-resolution low-noise static gravity field that VERITAS will measure will be used to investigate the heterogeneities in the crustal thickness and density. These products will improve our understanding of Venus' heat flow, thermal evolution, and resurfacing history.

Moreover, such short spatial scales will enable the investigation in great detail of individual features. The combined analysis of high-resolution gravity (ant topography) will facilitate the study of the origin and activity stage of volcanic and tectonic features, providing fundamental insights into Venus geodynamics.

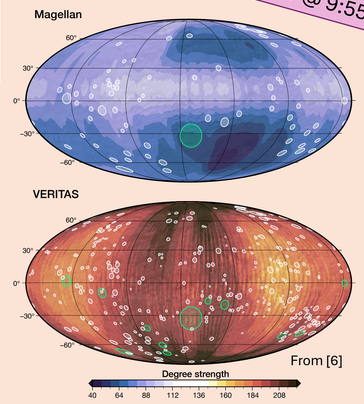


See Maia et al., **tomorrow** @ 9:45 AM





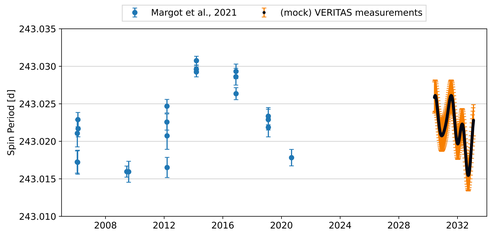
See Gülcher et al., **tomorrow** @ 9:55 AM

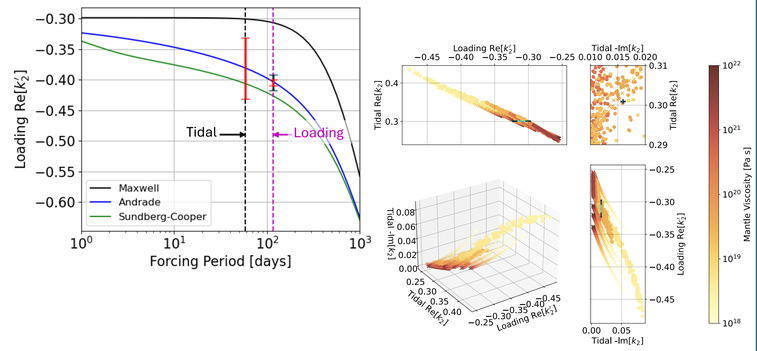


Additional measurements

Besides the gravity field, tidal response, and MOIF, the gravity science experiment onboard VERITAS will deliver additional measurements:

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





References

[1] S. Smrekar *et al.*, *2022 IEEE Aerospace Conference (AERO*. doi: 10.1109/AERO53065.2022.9843269.
[2] P. Cappuccio *et al.*,2020 *IEEE Transactions on Aerospace and Electronic Systems*. doi: 10.1109/TAES.2020.3008577.
[3] F. Giuliani *et al.*, 2025 *Planetary Science Journal*, doi: 10.3847/PSJ/ad991a.
[4] G. Cascioli *et al.*, 2021, *Planetary Science Journal*, doi: 10.3847/PSJ/ac26c0.
[5] G. Cascioli, *et al.*, 2023, *Journal of Spacecraft and Rockets*, doi: 10.2514/1.A35499.
[6] G. Cascioli and A. Gülcher et al., (under review) *Science Advances*

Acknowledgements

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

(1) UMBC (2) NASA Goddard Space Flight Center (3) Sapienza Università di Roma (4) DLR (5) Charles University (6) Universität Bern (7) NASA Jet Propulsion Laboratory, California Institute of Technology