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EnVision M5 Venus orbiter proposal

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Abstract

EnVision [1,2] is a Venus orbiter mission that will determine the nature and current state of geological activity on Venus, and its relationship with the atmosphere, to understand how and why Venus and Earth evolved so differently. Envision is a finalist in ESA's M5 Space Science mission selection process, and is being developed in collaboration with NASA, with the sharing of responsibilities currently under assessment. It is currently in Phase A study; final mission selection is expected in June 2021. If selected, EnVision will launch by 2032 on an Ariane 6.2 into a six month cruise to Venus, followed by aerobraking, to achieve a near-circular polar orbit for a nominal science phase lasting at least 4 Venus sidereal days (2.7 Earth years).

Figure 1: EnVision, following ESA CDF design.

1. Introduction

Why are the terrestrial planets so different? Venus and Earth were probably very similar in the past, before their evolutionary paths diverged. Understanding how and why this occurred is crucial to understanding the diversity of terrestrial planets and their habitability.

The Envision Venus orbiter will undertake science investigations in three thematic areas:

1) Is Venus **geologically active** today? How?
2) How did Venus' **surface** reach its present state?
3) How did Venus' **climate** reach its present state?

2. Payload

EnVision hosts three instruments and a radio science investigation:

The **Synthetic Aperture Radar, VenSAR**, will:

- Obtain images at a range of spatial resolutions from 30 m (regional coverage) to 1 m (images of targeted localities);
- Measure topography at <20 m resolution vertically and <100 m spatially, from stereo and InSAR observation;
- Detect cm-scale change through differential InSAR, to characterize volcanic and tectonic activity, and estimate rates of weathering and surface alteration; and
- Characterize surface mechanical properties and weathering through multi-polarisation radar, and emissivity mapping.

The **Subsurface Sounder, SRS**, will:

- Characterize the vertical structure and stratigraphy of geological units including volcanic flows;
- Determine the depths of weathering and aeolian deposits; and
- Discover as yet unknown structures buried below the surface.

The **Venus Spectrometer suite, VenSpec**, will:

- Search for temporal variations in surface temperatures, as an indicator of active volcanism;
- Obtain global maps of surface emissivity in five wavelength bands in the near-infrared, to constrain surface composition and inform evolution scenarios;
- Map tropospheric gases, searching for volcanic plumes and studying surface-atmosphere buffering processes; and
- Map variations of SO2, SO and linked gases in the mesosphere, in order to link these variations to tropospheric variations and volcanism.

The **Radio Science & Geodesy** investigation will:

- Constrain crustal & lithospheric structure at finer spatial scale than Magellan;
- Constrain interior structure through measurement of tidal response (gravitational Love number k_2) ;
- Profile the atmosphere with radio occultation, to understand volatile transport through the clouds.

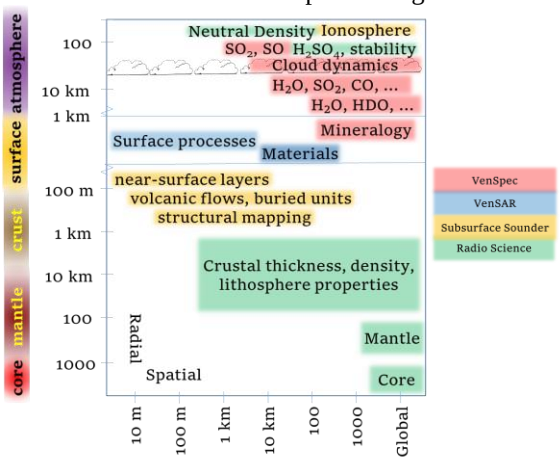

Figure 2: EnVision's payload allows study of processes from the core to the ionosphere, on a wide range of spatial scales.

3. Invitation to participate

EnVision will produce a huge dataset of geophysical data of a quality similar to that available for Earth and Mars, so will permit investigation across a large range of disciplines. Lab-based and modelling work will also be required to interpret results from the mission. We therefore invite scientists from across planetary, exoplanetary and earth science disciplines to participate in the analysis of the data.

The entire dataset obtained will be made publicly available; much of the SAR dataset will be made available in near-real-time to facilitate wide use of the data. We reiterate the opportunity for science experiments and target selection, and encourage researchers to contact the EnVision team.

References

[1] Ghail R. C. *et al.*, (2016) EnVision M5 proposal, https://arxiv.org/abs/1703.09010 .

[2] www.envisionvenus.eu

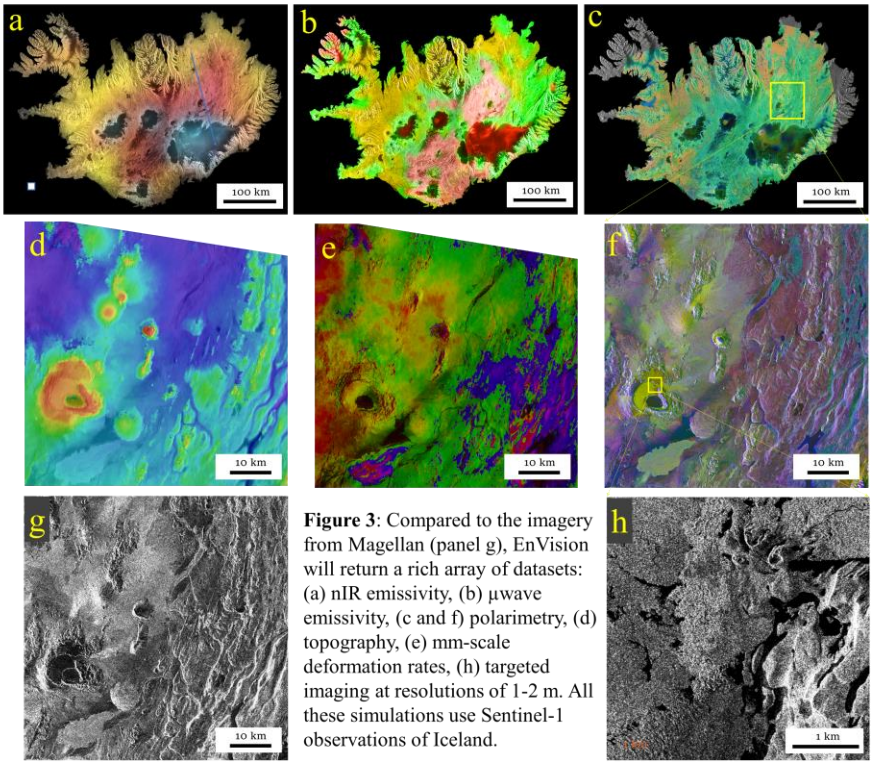

Figure 3: Compared to the imagery from Magellan (panel g), EnVision will return a rich array of datasets: (a) nIR emissivity, (b) µwave emissivity, (c and f) polarimetry, (d) topography, (e) mm-scale deformation rates, (h) targeted imaging at resolutions of 1-2 m. All these simulations use Sentinel-1 observations of Iceland.