

# ESA EnVision : Europe's Next Medium-Class Science Mission

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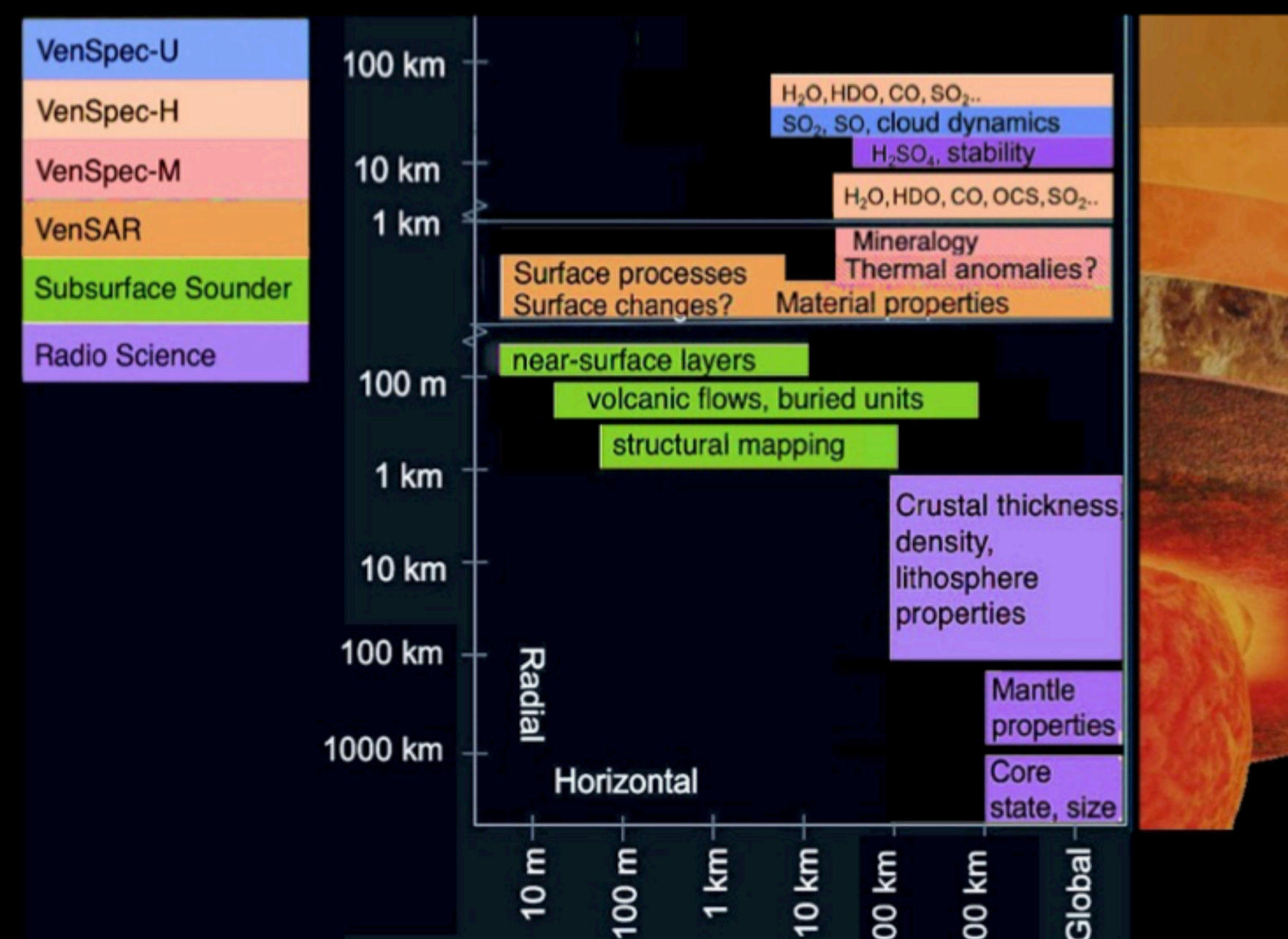
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On June 10, 2021, the European Space Agency (ESA) announced the selection of **EnVision** as its newest medium-class science mission. Solar Orbiter (M1, launched Feb. 2020), Euclid (M2, I. 2022), Plato (M3, I. 2026) and Ariel (M4, I. 2028) have been previously selected as Medium-class missions.

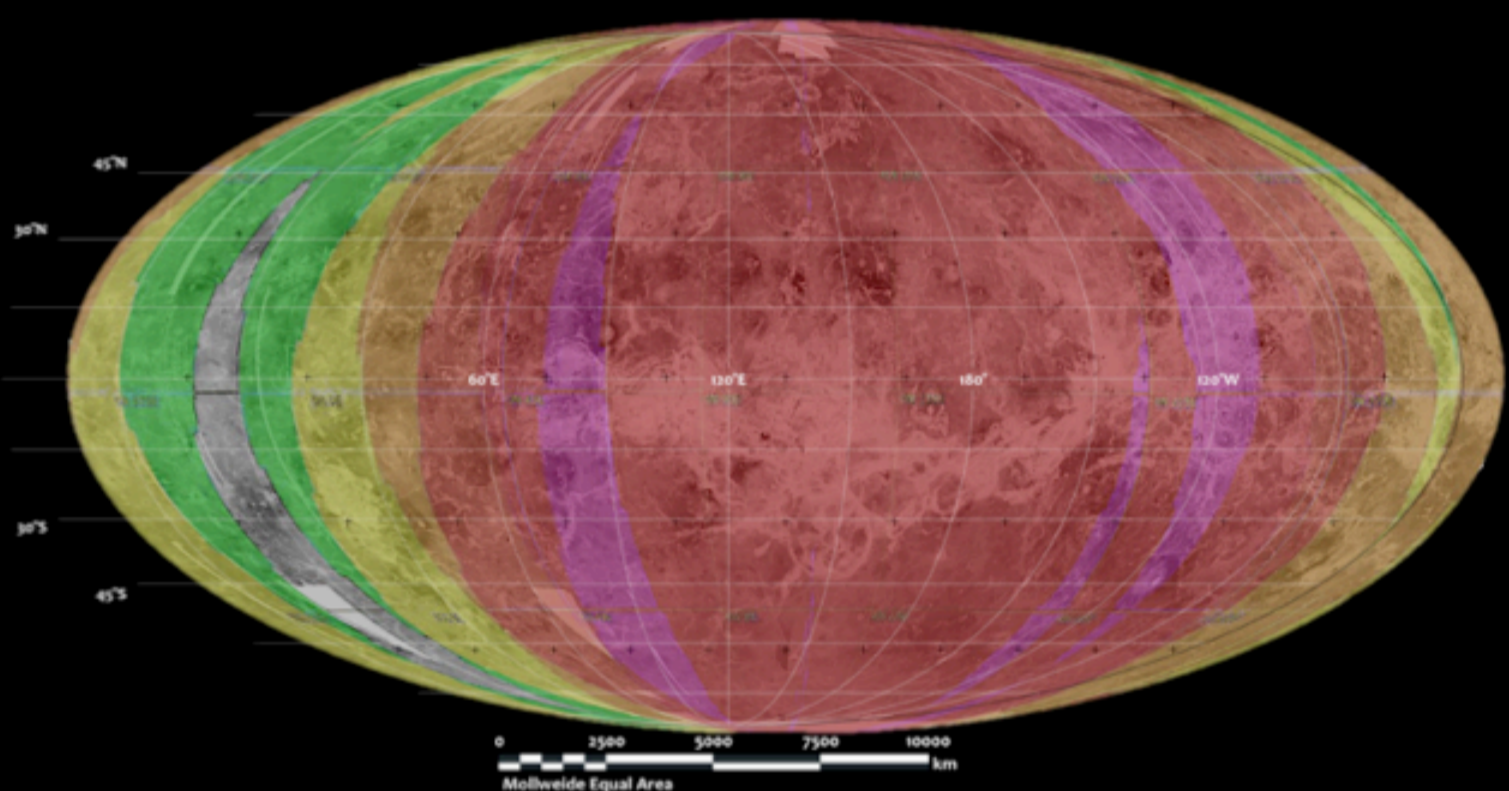
**EnVision** will deliver new insights into our neighboring planet's geological history through complementary imagery, polarimetry, radiometry and spectroscopy of the surface coupled with subsurface sounding and gravity mapping; it will

- search for thermal, morphological, and gaseous signs of volcanic and other geological activity;
- trace the fate of key volatile species from their sources and sinks at the surface through the clouds up to the mesosphere.

As a key partner in the mission, NASA provides **EnVision's** Synthetic Aperture Radar, **VenSAR**.

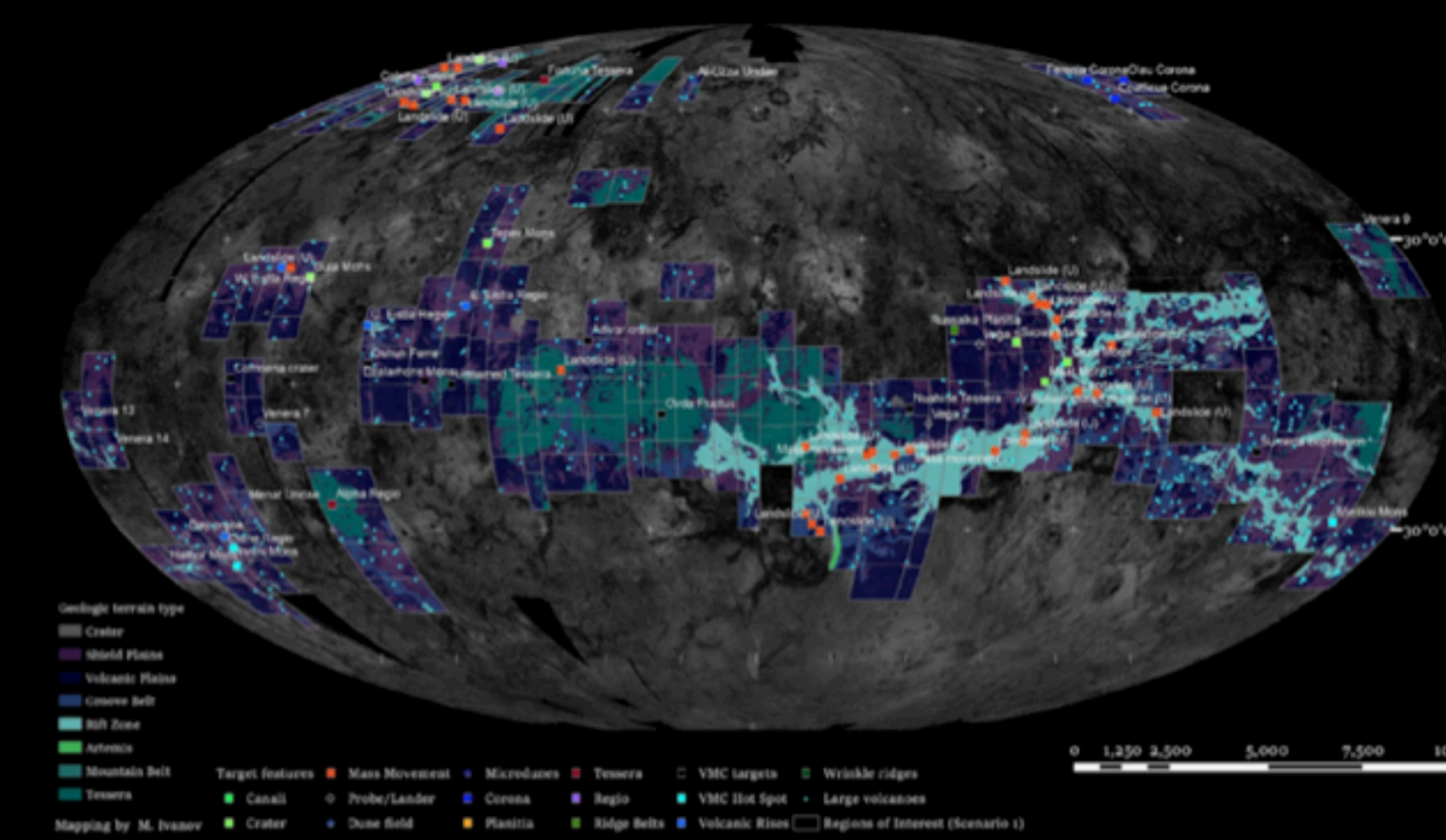


**EnVision's** synergistic investigations combine observations at wavelengths from UV to radio frequency to characterize interactions & couplings between Venus' different geophysical envelopes: its upper atmosphere, lower atmosphere, surface, subsurface and interior; it also combines *global* and *targeted* investigations over pre-defined Regions of Interest (ROIs).



**Global coverage** for altimetry, near-nadir and nadir radiometry, subsurface sounder, VenSpec suite, gravity and radio occultation;

**Targeted observations** for standard radar imaging, stereo topography, polarimetry, repeat coverage, high-resolution radar imaging and sounding



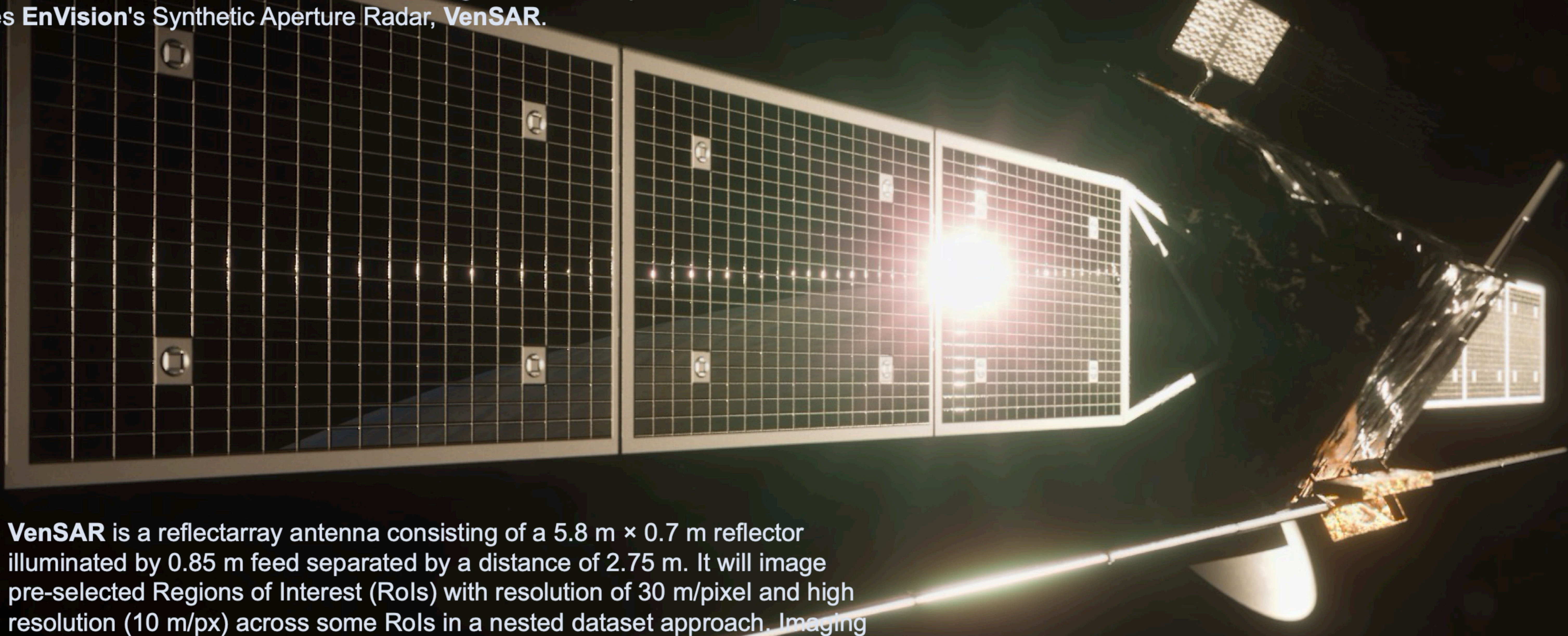
## VenSpec-M : pushbroom multispectral imager

**VenSpec-M** is a pushbroom multispectral imager operating in 14 near-infrared transparency windows at 0.86–1.18  $\mu\text{m}$  on the nightside. It will:

- (1) Map **surface composition**
- (2) Monitor current day **volcanic activity**
- (3) Map near surface **water vapour**
- (4) Measure cloud **microphysics and dynamics**

Wavelength ( $\mu\text{m}$ )	0.86	0.91	0.99	1.02	1.11	1.18	1.19	1.31	1.51	0.96	1.15
Mineralogy											
Clouds											
Water											
SM (capability)	319	595	2590	2606	2530	4400	1720	490	251	635	1120

Heritage: VEX/VIRTIS, BepiColombo/MERTIS



**VenSAR** is a reflectarray antenna consisting of a 5.8 m  $\times$  0.7 m reflector illuminated by 0.85 m feed separated by a distance of 2.75 m. It will image pre-selected Regions of Interest (ROIs) with resolution of 30 m/pixel and high resolution (10 m/px) across some ROIs in a nested dataset approach. Imaging at two incidence angles will allow reconstruction of surface topography as Digital Elevation Models (DEM) of selected terrains. Topography will also be measured globally by means of nadir altimetry. Surface emissivity and roughness will be derived from the imaging in HV and HH polarizations as well as passive radiometry. Comparison to Magellan, VERITAS and within the VenSAR data set will allow search for surface changes due to volcanic, tectonic and landscape forming processes from year to decade time scales.

**SRS** is the first sounding radar at Venus and is a fixed dipole antenna operating at 9 MHz with a 5 MHz bandwidth. It will search for subsurface material boundaries including impact craters and their infilling, buried craters, tesserae and their buried edges, plains, lava flows and their edges. It will obtain altimetry information for each track.

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

- Obtain global maps of surface emissivity in five wavelength bands in the near-infrared to constrain surface composition and inform evolution scenarios;
- Measure variations of  $\text{SO}_2$ ,  $\text{SO}$  and chemically-related gaseous species in the mesosphere and nightside troposphere, in order to link these variations to atmospheric dynamics, chemistry and volcanism.

**The Radio Science experiment will:**

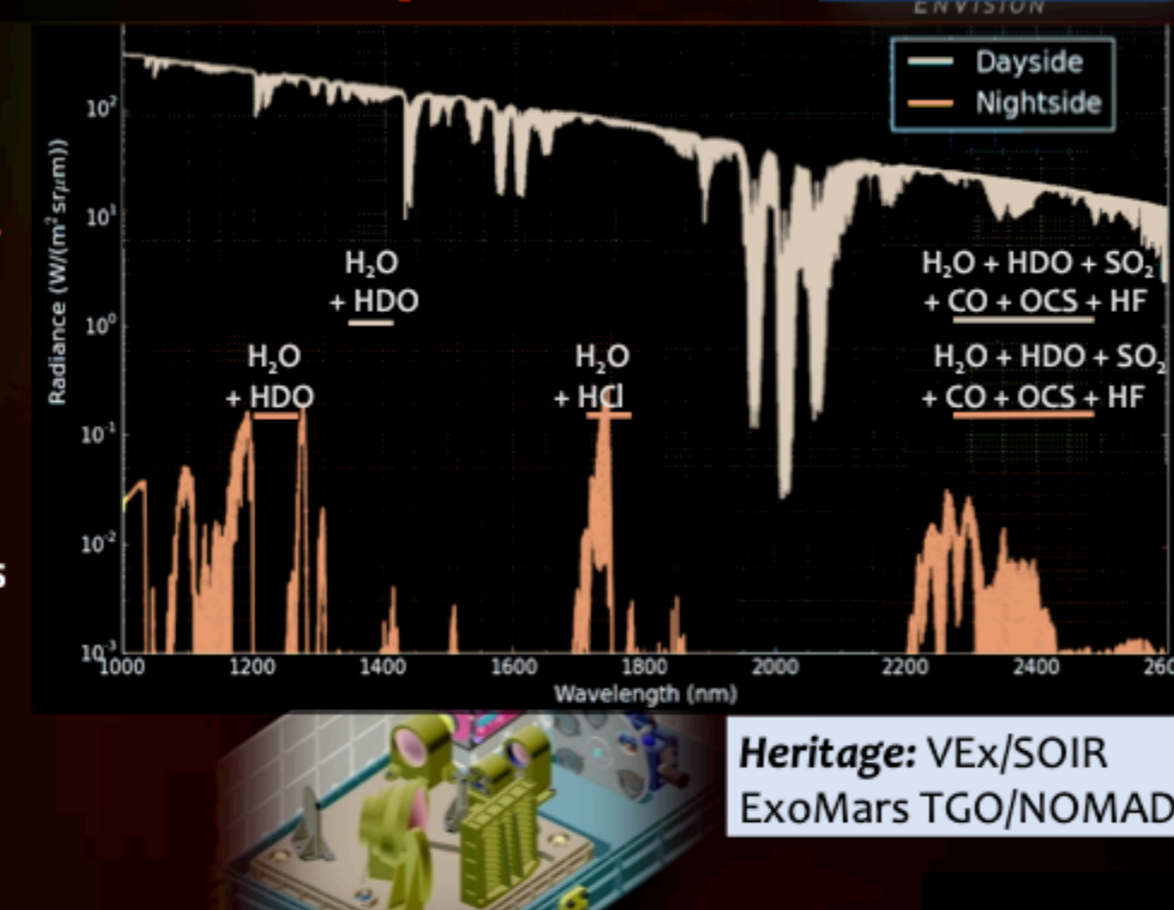
- Constrain crustal & lithospheric structure;
- Measure spin rate and spin axis variations to constrain interior structure; and
- Measure spatial and temporal variations of  $\text{H}_2\text{SO}_4$  liquid and vapor at 55–45 km.

## VenSpec-H : High Resolution Spectrometer

**VenSpec-H**, also a nadir-pointing instrument, will be dedicated to **high-resolution atmospheric measurements above and below the clouds** in the near-IR

It will detect and quantify  $\text{H}_2\text{O}$ ,  $\text{HDO}$  and  $\text{SO}_2$  in the lower atmosphere, characterising volcanic plumes and other sources of gas exchange

Mixing ratio accuracy:  
 $\text{H}_2\text{O}$ : 3%  $\text{HDO}$ : 5%  $\text{D/H}$ : 8%  
 $\text{CO}$ : 1.5%  $\text{SO}_2$ : 1%



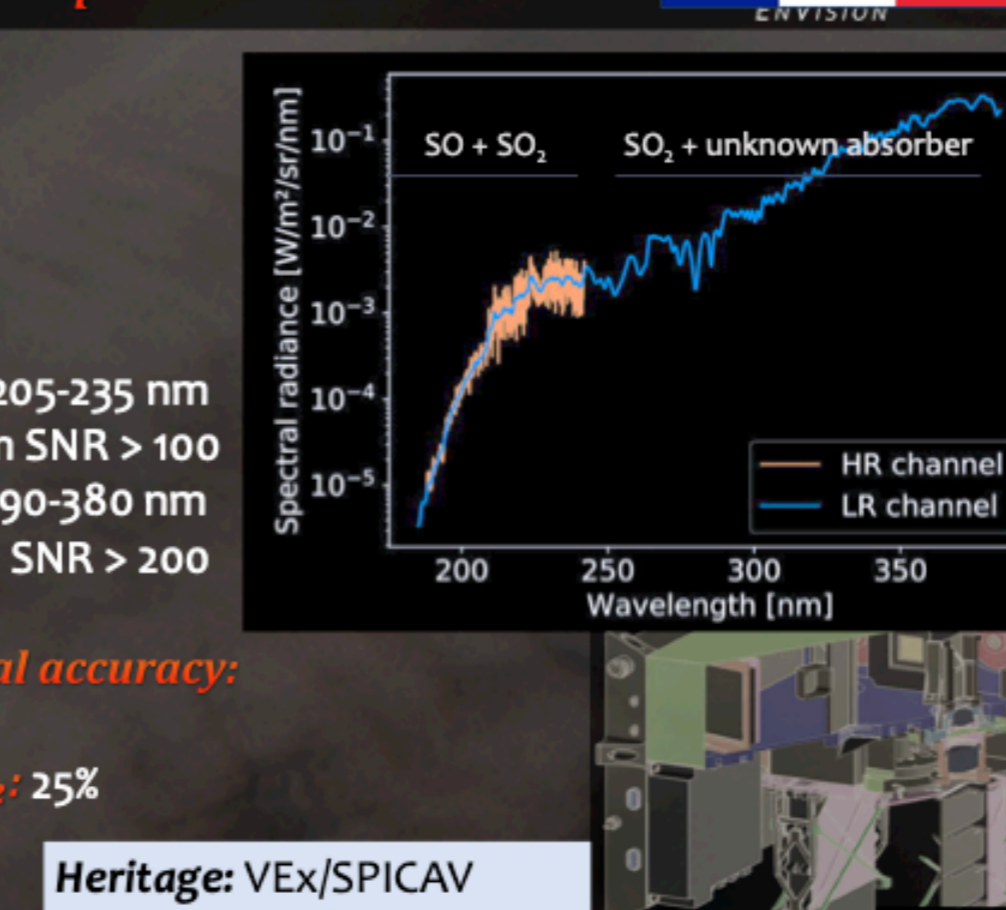
## VenSpec-U : Ultraviolet Spectrometer

**VenSpec-U**, a dual channel ultraviolet spectral imager operating between 190 and 380 nm, in low and high resolution channels, will:

- map distribution and spatial and temporal variations of sulphur bearing gases ( $\text{SO}$ ,  $\text{SO}_2$ ) supporting the search for volcanic activity
- map upper cloud and aerosols properties
- Distinguish atmospheric motion and chemical reactions from volcanic emissions

High R: 205–235 nm @ 0.2 nm SNR > 100  
 Low R: 190–380 nm @ 2 nm, SNR > 200

Retrieval accuracy:  
 $\text{SO}_2$ : 10%  
 $\text{SO} / \text{SO}_2$ : 25%



## RSE : Radio Science Experiment

The Radio Science Experiment will use the radio links between **EnVision** and Earth to:

- determine the Venus gravity field and  $k_2$  Love number to constrain the internal structure
- monitor spatial and temporal variations of  $\text{H}_2\text{SO}_4$  liquid and vapour at the base and below the clouds to understand the sulphur cycle

Parameter	Accuracy / Resolution	Altitude range
$k_2$	< 3%	45–55 km
Gravity	< 200 m	50–55 km
$\text{H}_2\text{SO}_4$ (gas)	1 ppm	45–55 km
$\text{H}_2\text{SO}_4$ (liq)	1 mg/m <sup>3</sup>	50–55 km
Temp.	0.1K to 10K	45–90 km

Heritage: Mars missions, VEX/VERA

### VenSAR : Synthetic Aperture Radar

VenSAR, a 3.2 GHz, S-band reflectarray SAR, will

- (1) **Obtain images** at a range of spatial resolutions
- (2) **Search for changes** in surface radar imagery;
- (3) **Measure surface topography** regionally by means of stereo radar imaging; and globally by means of nadir altimetry;
- (4) **Characterise surface polarimetric reflection and emission properties** using both SAR and radiometer measurements

Main Instrument Parameter	Parameter Values
Centre frequency (S-band)	3.20 GHz (9.4 cm)
Antenna Size	5.8 x 0.7 m
Bandwidth	15.5 or 60 MHz
SAR Modes	
Incidence Angles	20°–40°
Stereo Vertical Resolution	33 m
Polarizations	HH and HV
SAR Swath Width	57 and 20 km
Ground Pixel Size	30 and 10 m
Altimeter Mode	
Vertical Resolution	2.5 m
Altimeter Footprint	3 km

Heritage: NISAR, Magellan

### SRS : Subsurface Radar Sounder

SRS is the first sounding radar at Venus and is a fixed dipole antenna operating at 9 MHz with a 5 MHz bandwidth. It will search for subsurface material boundaries including

- impact craters and their infilling, **buried craters**, **tesserae** and their buried edges, plains, **lava flows** and their edges

It will obtain **altimetry information** for each track

Penetration depth will be a few hundreds of metres (depending on the target composition) at about 20 metres of vertical resolution

Main Instrument Parameter	Parameter Values
Transmitted central frequency	9 MHz
Transmitted Bandwidth	5 MHz
Antenna type	Dipole (deployable)
Antenna Dimension	$\leq 16$ m
Peak radiated power	200 W
Along Track Resolution	1.9–2.9 km
Across Track Resolution	7.2–11.2 km
Vertical resolution in $\epsilon = 6$	20 m
Data Rate	3.25–6.47 Mbit/s
Mass with contingency (w/o antenna)	13.48 kg
Pointing Requirements	Nadir ( $\pm 5$ degrees)

Heritage: JUICE/RIME, MEX/MARSIS – MRO/SARAD