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Venus Emissivity Mapper – Investigating the Atmospheric Structure and Dynamics of Venus’ Polar Region

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Foreword.

VEM is proposed for NASA’s Venus Origins Explorer (VOE) and the ESA MEx/EnVision mission proposals in combination with a high-resolution radar mapper. The primary mission of VEM is to study small-scale features in the Venus atmosphere near the surface with 2-band near 1150 and 660 nm. Proof of concept with VERTIS experiment on-board VEx has shown that proper correction of cloud-induced contrasts requires at least 2 dedicated bands (current design has 3). Thanks to the circular polar orbit geometry of VEx and the Planet’s spherical uniqueness to (1) better constrain the unknown microphysics of the polar lower clouds in three spectral bands at 1.19 and 1.30 and 1.5 μm at a spatial resolution of ~10 km, and (2) investigate short-timescale cloud dynamics and local wind speeds by tracking cloud features in both polar regions, as well as wave-generating dynamical instabilities.

Cloud morphology

The intensity of the right-side NE window is primarily modulated by the optically thick lower cloud deck. Various space-borne instruments, such as NIMS/SuScience, VERTIS/VEx or JIRI/MARi have already mapped and studied the morphology of these lower clouds, sometimes matching VEM ~ 10 km spatial resolution. Yet, VEM’s circular orbit will be the first to acquire a consistent climatology of these lower clouds, owing to its balanced and extended coverage in longitude, planecentric longitude and local solar time.

Observation strategy

Either NE-VOE or MEx/EnVision’s orbit will be circular, quasi-polar at an altitude of about 200 km. It will slowly precess in longitude with each passing orbit. VEM will make use of this by using a push-broom strategy, using the orbital motion to sweep the observed area onto each spectral band. This strategy also enables multiple views of the same targeted ground area during several successive orbits (about 90 min apart).

Cloud microphysics

VEM will provide images of the clouds at three different wavelengths (1150, 1300 and 1550 nm). Spatial variations in these bands will help in constraining variability in various lower cloud microphysical parameters: refractive index (related to the SO2/CO2 ratio in the part/million), altitude, size distribution (e.g. log mode 2 mode radius ratio). Although already performed with VEx and Ankara, VEM will bring (1) spatial and temporal sampling, (2) high SNR and wavelength stability as well as (3) unprecedented access to smaller scales between 200 and 20 km.

Due to the 90 min orbit and fast zonal separation of the lower cloud deck, there will be no possibility of cloud tracking between two consecutive orbits at lower latitudes. But for latitudes higher than 80°, the smaller zonal shift between orbits and the transition from super-rotation into polar vortex dynamical regime will enable cloud-tracking in this ever-changing region. Also, even though the lower cloud optical thickness is usually much higher near the poles, VEM design nonetheless warrants a very high SNR.

The Venus Emissivity Mapper instrument design

The Venus Emissivity Mapper (VEM) is focused mainly on observing the surface from a low circular polar orbit, mapping in near-IR atmospheric windows using filters with spectral characteristics optimised for the wavelengths and widths of these windows. It also observes bands necessary for correcting atmospheric effects. These bands also provide valuable scientific data on cloud thickness, cloud species variations, particle size distribution and SO2/CO2 abundance at spatial and temporal variations over ~1–4 year mission timescale. In the lowest 15 km of the Venus atmosphere.

VEM uses a push-broom, multi-spectral imaging system with a dispersive filter array and an image detector operated at ~0°. Three-channel ratio images of the same scene on the filter array are produced. In 470–750 nm, it follows with a 0.07°×0.07° FOV. In 750–1550 nm, it follows with a 0.07°×0.07° FOV. The detector is located at an intermediate focus of the Venus spectrometer. With both low and high image ratio, 40 image pairs on each channel will be acquired over a full Venus orbit.

The instrument can produce 4 image pairs on each channel with a 0.07°×0.07° FOV. The detector is located at an intermediate focus of the Venus spectrometer. With both low and high image ratio, 40 image pairs on each channel will be acquired over a full Venus orbit.

Due to the short timescale cloud dynamics and local wind speeds by tracking cloud features in both polar regions, as well as wave-generating dynamical instabilities.