ATMOSPHERIC STUDIES WITH THE ENVISION MISSION. T. Widemann[1], R.C. Ghail[2], C. F. Wilson[3], D.V. Titov[4], [1]Paris Observatory, Meudon, France (thomas.widemann@obspm.fr); [2]Royal Holloway, University of London, UK; [3]University of Oxford, UK; [4]ESA-ESTEC, Noordwijk, Netherlands.

Introduction: On June 10, 2021, the European Space Agency (ESA) announced the selection of EnVision as its newest medium-class science mission. EnVision [1, 2, 3] 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; and it will 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 the Synthetic Aperture Radar, VenSAR.

EnVision science payload: EnVision's science payload will consist of VenSAR, a dual polarization S-band radar also operating as microwave radiometer, three spectrometers VenSpec-M, VenSpec-U and VenSpec-H designed to observe the surface and atmosphere of Venus and their couplings, and the Subsurface Radar Sounder (SRS), a High Frequency (HF) sounding radar to probe the subsurface. They are complemented by a radio science investigation which achieves gravity mapping and radio occultation of the atmosphere.

Tropospheric trace gases spatial and temporal variability: Variable trace atmospheric species on Venus - SO_2, SO, H_2O, CO, COS, H_2SO_4 - are often associated with volcanic activity. The goal of EnVision is to understand the intrinsic atmospheric variability, and to establish to what extent it can be associated with surface activity. Several key gases have been studied & mapped below the cloud deck, at 0-50 km altitude, such as water vapour (H_2O and HDO) [4], sulphur compounds (SO_2, COS) and carbon monoxide (CO) [5, 6]; these are all potential volcanic volatile gases. In particular, spatial variability of the D/H ratio – whether associated with volcanic plumes or other fractionating processes – would be fundamental for understanding the history of the water on Venus.

H_2SO_4 in the clouds, in both vapour and liquid form, and related species: The main constituent of the clouds, H_2SO_4, in both vapour and liquid form, can be monitored near the cloud base, yielding clues as to cloud formation and convection processes. Surface activity can affect clouds in several ways: (1) volcanic ash can contribute to cloud and haze layers; (2) volcanic sulphur dioxide emissions can contribute to formation of sulphate cloud & haze layers and to the as-yet unidentified UV absorber seen at cloud-tops; (3) volcanically emitted volatiles can form condensate layers; (4) heat from volcanic activity can cause changes in atmospheric circulation [7]; (5) near-surface winds in Venus' dense atmosphere can lift dust & other particulates from the surface into airborne suspension, influenced by topography [8]. Understanding the dependence of the cloud layer on outgassed mantle volatiles is critical for understanding the long-term climate. All of these effects can be studied by monitoring the spatial and temporal variations of clouds and hazes. Characteristic timescales of cloud formation and dissipation have been measured to be of the order of hours to days. Multi-temporal and detailed atmospheric characterisation carried out by the VenSpec suite and the radio-occultation measurements, will provide better understanding of Venusian volatile cycles, including the potential link to volcanism.

EnVision payload instruments and experiment for atmospheric studies - The Venus Spectrometer suite P/L instruments, VenSpec-H & VenSpec-U, will measure variations of SO_2, 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 measure spatial and temporal variations of H_2SO_4 liquid and vapor at 55-45 km.

VenSpec-H: VenSpec-H will focus on the volcanic and cloud forming gases and search for composition anomalies potentially related to the volcanic activity. VenSpec-H will include four spectral bands: 1.165 - 1.180 µm (B#1), 2.34 - 2.48 µm (B#2), 1.72 - 1.75 µm (B#3) and 1.37 - 1.39 µm (B#4) that cover the infrared spectral transparency "windows". In order to reduce the instrument complexity, B#2 will be further subdivided in two ranges: 2.34 -2.42 µm (2a) and 2.45 - 2.48 µm (2b). Bands 1, 2a, 2b and 3 will be observed on the night side, bands 2a, 2b and 4 on the dayside. In the IR range, the high spectral resolution ($R \sim 8000$) along with the high sensitivity of the instrument will allow to clearly identify the absorption features of the targeted species.

VenSpec-U: VenSpec-U will investigate the upper atmosphere using the following wavelength ranges and resolutions: (1) 205-235 nm at 0.2 nm spectral resolution (SO_2 and SO separately at 70-80 km); (2) 190-380 nm at 2 nm spectral resolution (UV absorber, total SO+SO_2 at 70-80 km); (3) 1.36–1.409 µm (H_2O, HDO at 70-90 km); (4) 2.29–2.48 µm (H_2O, HDO, CO, COS, SO_2 at 70–90 km).

Radio-occultation: The radio-occultation experiment will derive vertical profiles of neutral mass density, temperature, and pressure as a function of local time and season, with a vertical resolution of few hundred of metres and an accuracy of 0.1 K at 45 km. Thanks to the use of the dual X-Ka band, the content in liquid phase of the sulfuric acid will be estimated for the first time. The spatial and temporal behavior of the H_2SO_4 absorbing layer (gaseous & liquid) below the cloud deck will be also investigated at 45-55 km, with an accuracy of 1 ppm for the gaseous phase and 1 mg/m^3 for the liquid one with a vertical resolution of ~100 m**.**

EnVision B/L mission scenario: The mission will launch in 2031 on Ariane 62. Following orbit insertion and periapsis walk-down, orbit circularisation will be achieved by aerobraking over a period of several months, followed by a nominal science phase lasting at least 6 Venus sidereal days (4 Earth years).

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