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Detecting Venus' volcanic gas plumes with VenSpec-H

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The VenSpec-H instrument is part of the EnVision payload which is currently being evaluated by ESA for mission selection. EnVision is a medium class mission to determine the nature and current state of geological activity on Venus, and its relationship with the atmosphere, to understand how Venus and Earth could have evolved so differently.

VenSpec-H is part of the VenSpec suite [1], including also an IR mapper and a UV spectrometer [2] suite. The science objectives of this suite are to search for temporal variations in surface temperatures and tropospheric concentrations of volcanically emitted gases, indicative of volcanic eruptions; and study surface-atmosphere interactions and weathering by mapping surface emissivity and tropospheric gas abundances. Recent and perhaps ongoing volcanic activity has been inferred in data from both Venus Express and Magellan. Maintenance of the clouds requires a constant input of H_2O and SO_2. A large eruption would locally alter the composition by increasing abundances of H_2O, SO_2 and CO and perhaps decreasing D/H ratio. Observations of changes in lower atmospheric SO_2, CO and H_2O vapour levels, cloud level H_2SO_4 droplet concentration, and mesospheric SO_2, are therefore required to link specific volcanic events with past and ongoing observations of the variable and dynamic mesosphere, to understand both the importance of volatiles in volcanic activity on Venus and their effect on cloud maintenance and dynamics.

To contribute to this investigation, VenSpec-H is designed to measure H_2O and HDO contents in the first scale height of Venus' atmosphere and probe H_2O, HDO, CO, OCS, SO_2 in the 30 to 40 km altitude range [3-8]. To assess the performances of our instrument at detecting volcanic eruptions, we defined a couple of scenarios of plume releases and simulated the corresponding spectra.

To simulate the vertical transport of the plume and the horizontal advection by the dynamics, the LMD Venus Mesoscale Model [9] is used, based on the WRF dynamical core and the Venus IPSL radiative transfer. The domain is focused on Imdr Regio, where VIRTIS observed a hotspot anomaly possibly linked to volcanic activity [10]. Tracers were added to the model representing H_2O, CO and SO_2. The chemistry and photodissociation sources and sinks are modelled by a linear relaxation of the tracer abundance toward a value representative of the deep atmosphere with a characteristic time. The deep atmosphere abundance is set to 130 ppm for SO_2, 30 ppm for H_2O and 20 ppm for

CO. The relaxation time is set to 100 years for SO_2, to 1000 years for CO and to 1 week, 1 month and 1 year for H_2O representing the uncertainty of the chemistry timescale in that region. Several configurations are considered for the plume, an idealised set-up where the elevation height is fixed and the outgassing abundance is constant inside the plume and in time, and a more realistic set-up where a temperature and outgassing anomalies at the surface are prescribed is ongoing testing.

The radiances of the nightside atmosphere of Venus originate from the thermal emission of the surface and atmosphere. The spectra were simulated from 1 to 2.5 microns, using ASIMUT-ALVL, a line-by-line radiative transfer code developed at BIRA-IASB [11]. CO_2, H_2O, HDO, CO, SO_2, and OCS, as well as aerosols were included.

The performances of the instrument will be described in terms of its capabilities to detect small variations in the atmosphere.

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