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## SPECTROSCOPIC MEASUREMENTS OF SULFUR DIOXIDE ABOVE AND BELOW VENUS' CLOUDS: PAST AND FUTURE.

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**Introduction:** Sulfur dioxide is arguably the most variable minor species in the atmosphere of Venus, with respect to both time and location. We shall present here some recent measurements obtained from ground-based observations (iSHELL/IRTF) or orbital platforms (VIRTIS-H/Venus Express, SPICAV-UV/Venus Express). We shall also introduce the next generation of spectroscopic instruments aimed at better constraining its variability, namely the IR channel VenSpec-H and UV channel VenSpec-U part of the VenSpec suite on board ESA' planned *EnVision* mission.

### Past measurements:

*Ground-based observations.* The very high spectral resolution of iSHELL, also located at IRTF, allows for more accurate measurements of SO<sub>2</sub> in the 30-40 km altitude range on the night side using thermal radiation near 2.4 μm. Recent observations[1] found a substantially higher value for the average SO<sub>2</sub> abundance (close to 200 ppmv), as well as an increase with increasing latitude, closely correlated with CO mixing ratio – both can be interpreted as resulting from the competition between general meridional circulation and local thermochemical equilibrium profiles.

*Venus Express observations.* Below the clouds, VIRTIS-H observed Venus between 2006 and 2012 in the same wavelength range as the aforementioned iSHELL observations, albeit at a lower spectral resolution, so that only the elevated average mixing ratio of SO<sub>2</sub> could be confirmed (but not its latitudinal variability). Above the clouds, UV (190-320 nm) observations in nadir mode obtained from the SPICAV instrument were analyzed by Marcq et al. [2,3,4] to derive SO<sub>2</sub> column density above the upper cloud on the day side. They found dramatic secular variations at low latitudes, whose origin is still poorly understood. Two different regimes of SO<sub>2</sub> abundance were identified, associated with a reversal of the latitudinal gradient and caused by fluctuations of the proximal SO<sub>2</sub> source, namely lower atmospheric supply. The origin of these fluctuations is still poorly understood.

### Future instruments:

*VenSpec-H.* The high resolution IR spectrometer of the VenSpec suite onboard *EnVision* will observe SO<sub>2</sub> column density above the clouds on the day side (2.34-2.42 μm, 2.45-2.48 μm, R > 4000) and SO<sub>2</sub> mixing

ratio on the night side (2.34-2.42 μm, 2.45-2.48 μm, R > 8000) and a spatial resolution of 100 km[5].

*VenSpec-U.* The UV spectral imager of the VenSpec suite onboard *EnVision* will observe SO<sub>2</sub> column density on the day side in two spectral ranges, 205-235 nm at a spectral resolution of 0.3 nm and 190-380 nm at a spectral resolution of 2 nm. The spatial sampling will vary between 3 km and 24 km, thus resolving short scale atmospheric waves and subsolar convection cells at cloud top level[6].

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**References:** Use the brief numbered style common in many abstracts, e.g., [1], [2], etc. References should then appear in numerical order in the reference list, and should use the following abbreviated style:

[1] Marcq E. et al. (2021) *A&A*, 648. [2] Marcq E. et al. (2011) *Icarus*, 211, 58-69 [3] Marcq E. et al. (2013) *Nature Geoscience*, 6, 25-28 [4] Marcq E. et al. (2020) *Icarus*, 335 [5] Erwin, J. et al., *44th COSPAR Assembly* [6] Marcq E., et al. (2021) *Space Sci. Rev.*, 68, 275-291