Simultaneous mapping of SO_2, H_2O, and CO on the night side of Venus

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Abstract

In January 2012, we have started an observing campaign to monitor the behavior of SO_2 and H_2O (through its proxy HDO) near the cloud top of Venus, using the TEXES imaging spectrometer at IRTF, Mauna Kea Observatory.

These data have shown evidence for drastic changes in the SO_2 abundance, both on the short term and the long term, the origin of which is unclear, as well as a strong spatial variability at low latitude (Encrenaz et al. A&A 703, id.A219, 2025).

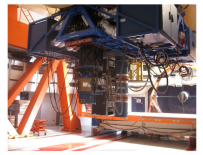
In February 2025, data have been obtained at 4.7 and 7.4 μm on the night side of Venus (49 arcsec in diameter), allowing us for the first time to map simultaneously CO, SO_2 and H_2O near the cloud top of Venus.

The TEXES data will be used in an attempt to constrain coupled dynamical-chemical GCM simulations of the Venus atmosphere (Stolzenbach et al. Icarus 395, 115447, 2023; Shao et al. AGU, December 2025).

TEXES @ IRTF, Mauna Kea Observatory, Hawaii

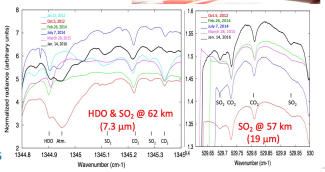
TEXAS Echelon Cross Echelle Spectrograph 5 – 25 μm, R = 8 10^4 @ 7 μm

Main question: To understand the SO_2 & H_2O cycles above and within the clouds



Observing program: Mapping of SO_2 (at 7.4, 19 & 8.6 μm) and H_2O (through HDO) at 7.4 μm

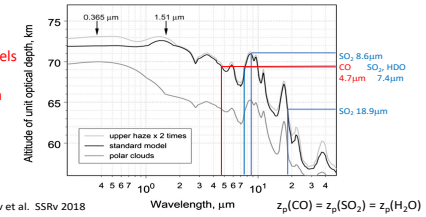
- Cloud top probed at 7.4 μm (z = 62 km, T = 235 K, P = 150 mbar)
- Within the cloud at 19 μm (z = 57 km, T = 241 K, P = 250 mbar)
- Above the clouds at 8.6 μm (z=67 km)
- 13 campaigns between January 2012 and April 2019; 14 campaigns since 2021: June, Sept. & Nov. 2021, Feb. & June 2022, March, July, Oct. & Dec. 2023, Feb. 2024; Feb, Mar, Jul, Sep 2025



CO mapping of Venus with TEXES (night side)

- Spectral cubes were recorded on Feb. 28 & Mar. 1, 2025 in 2 spectral ranges:
  - 1345 cm^{-1} (7.4 μm, high res, R = 80000) -> SO_2 and HDO mapping at 62 km (our model)
  - 2144 cm^{-1} (4.7 μm, mid res, R = 7000) -> CO mapping at the same altitude

Penetration levels are the same at 4.7 & 7.4 μm

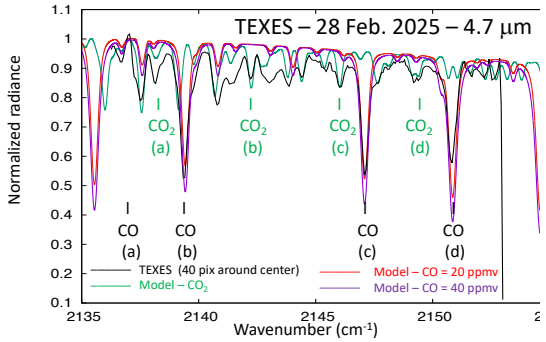


Titov et al. SSRv 2018

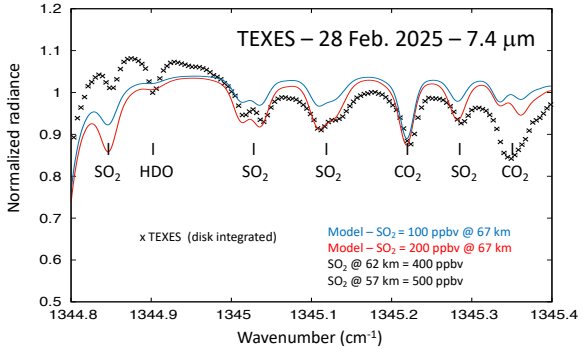
$z_p(CO) = z_p(SO_2) = z_p(H_2O)$

Spectral fit at 4.7 μm

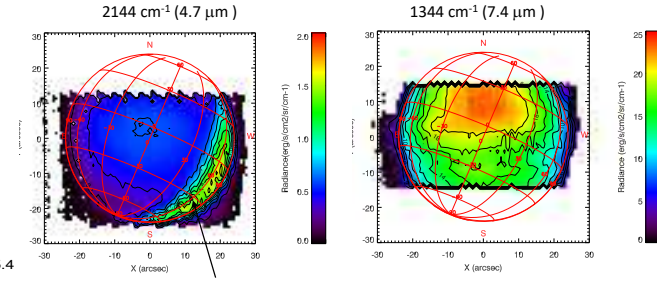
CO_2 lines are too noisy for mapp



Spectral fit at 7.4 μm

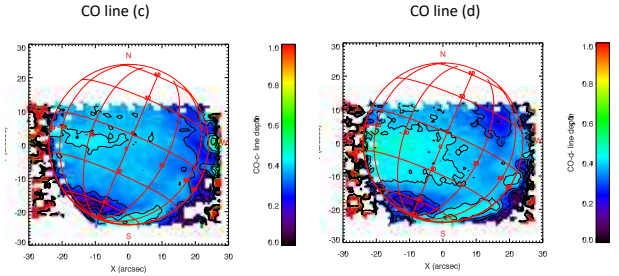


Continuum maps (February 28, 2025)

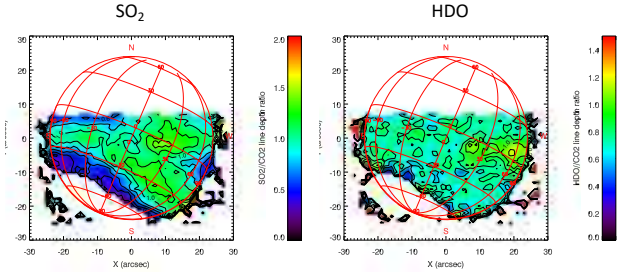


Reflected sunlight (day side)

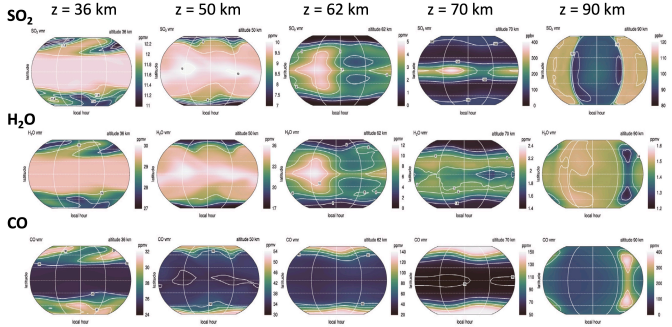
CO line depth (c & d) – 2144 cm^{-1} (4.7 μm) – Feb. 28, 2025



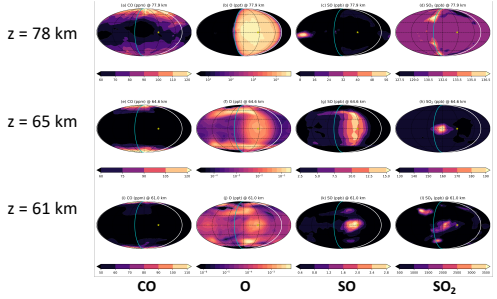
SO_2 & HDO line depth ratios – 1344 cm^{-1}(7.4 μm) – March 1, 2025



Comparison with GCM simulations (1) SO_2, H_2O, CO (Stolzenbach + 23)



(2) CO, O, SO, SO_2 (Shao +26, EPSC)



Summary and conclusions

- The TEXES data provide the first simultaneous thermal mapping of SO_2, H_2O and CO near the cloud top of Venus
- The CO distribution observed by TEXES possibly shows an enhancement at mid southern latitude around midnight
- GCM simulations predict an enhancement at high latitudes (Stolzenbach +23, Shao +25)
- SO_2, HDO and CO monitoring with TEXES will continue in 2026 to better constrain their spatial distribution and temporal variations.