SPICAV-UV on board Venus Express: SO_2, O_3 and UV absorber

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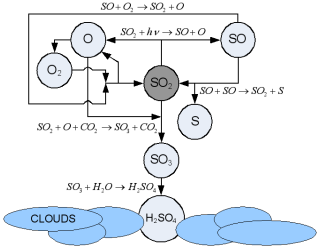
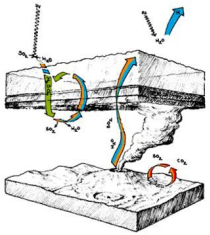
LATMOS

- SO_2 linked to:
  - **Geological activity**
    Long-term ($\sim 10^7$ yr) source for SO_2 assumed to be volcanic outgassing.
  - **Cloud formation & energy deposition**
    SO_2 is a precursor species to H_2SO_4 (and UV absorber?) through photo-oxidization
  - **Vertical mixing & General circulation**
    Short-term source for SO_2 above the clouds located in lower atmosphere (150 ppmv).

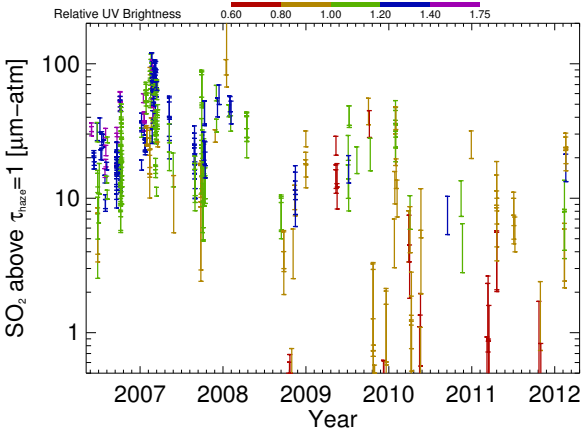


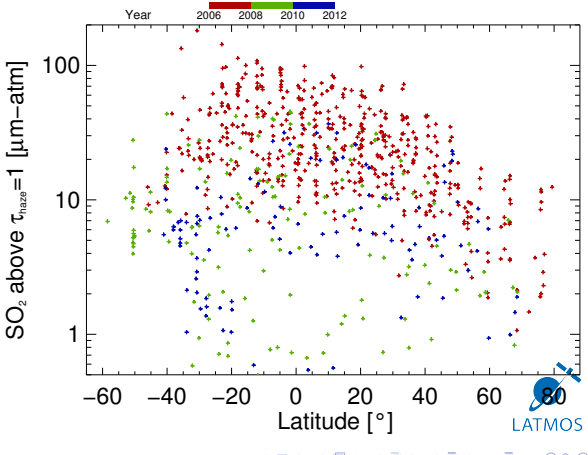


LATMOS

Marcq et al. (2011, 2013)

- Evidence for **short term** variability of SO_2
- **Rapid increases** followed by **slower, chaotic decreases**.
- Typical **latitudinal patterns** associated with rich/poor SO_2 epochs.





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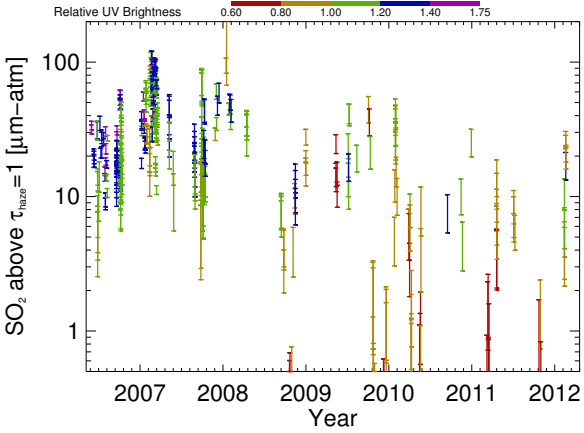

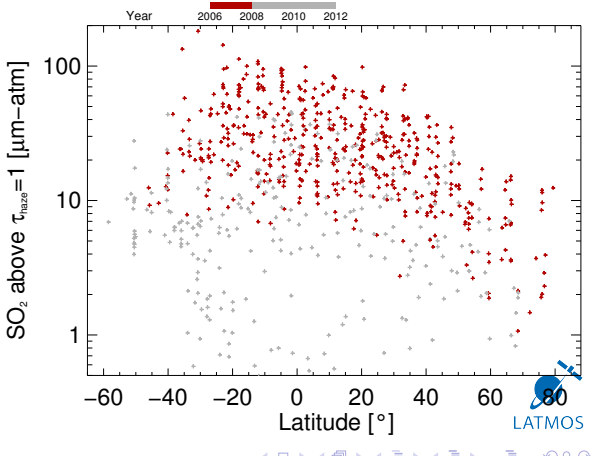

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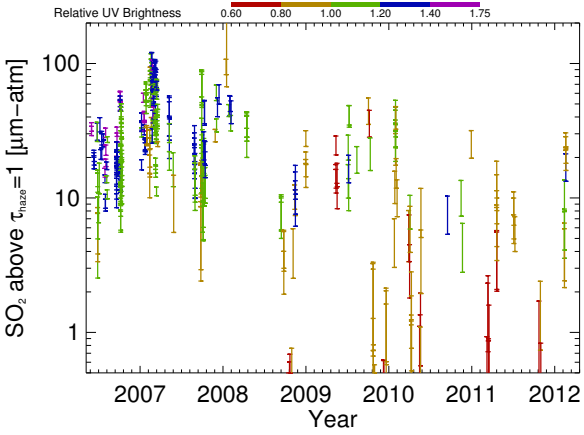
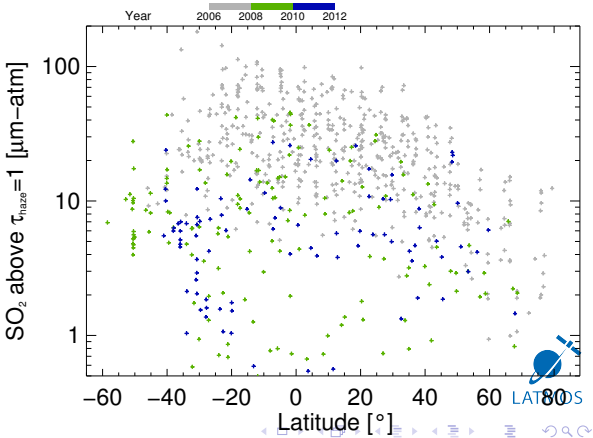
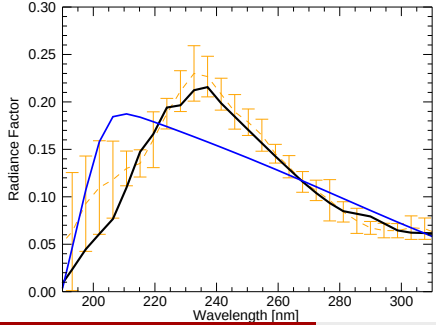


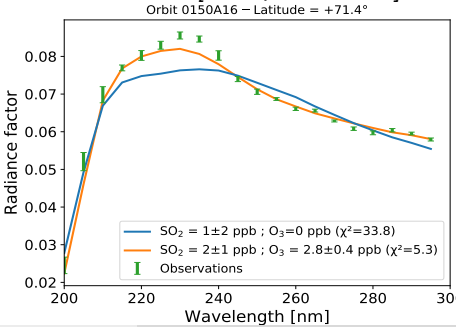


- Latest published nadir SPICAV-UV retrievals from 2012
  $\Rightarrow$ **Data from 2012-2014** yet to publish.
- **Better aerosol profiles** available (*Venus III*, ISSI, etc.)
- **Delivery** of products to ESA requires peer-review
- Improvements of SPICAV-UV radiance factors at shorter wavelengths enable a better processing and require **forward model improvements**

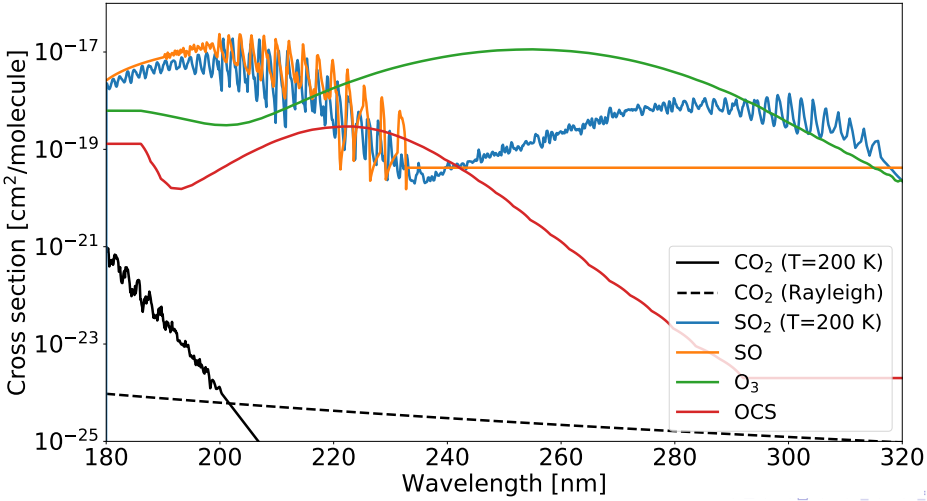
Old version *[Marcq et al., 2013]*



New version *[Marcq et al., 2019]*



- Already included CO_2, SO_2, SO
- New species O_3, OCS



LATMOS

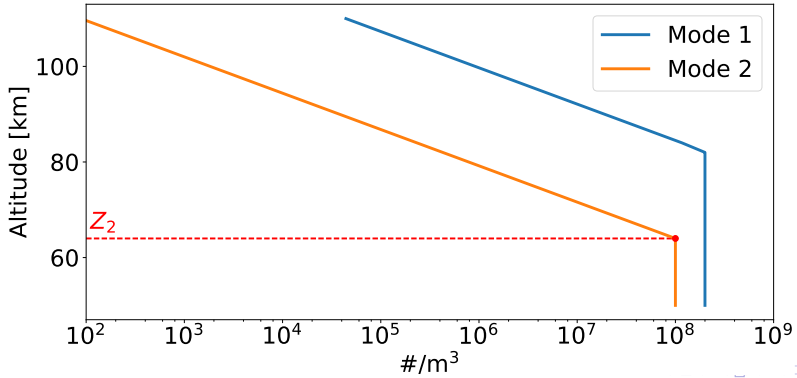
- Gases

(P, T) VIRA-2, fixed
SO_2 $\propto e^{-z/H}$ with $H = 3$ km
150 ppmv cap
SO tied to 10%$\times$ SO_2
O_3 uniform (55-70 km)
OCS fixed, follows *Haus et al. (2015)*

- Clouds & Hazes
  - Bimodal distribution

1 $r_{\text{eff}} = 0.12\,\mu\text{m}$, $\nu_{\text{eff}} = 0.15$
2 $r_{\text{eff}} = 0.8\,\mu\text{m}$, $\nu_{\text{eff}} = 0.15$

  - From *Luginin et al. (2016)*
  - Z_2 tunable parameter



LATMOS

- Refractive index

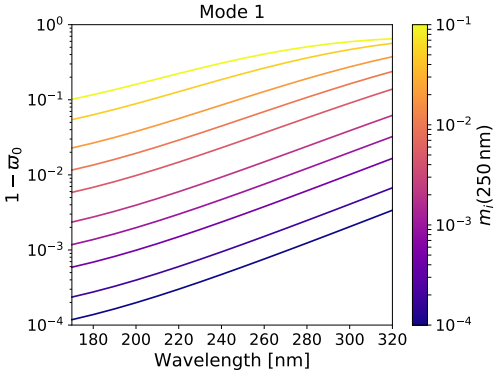
  Real Assuming 75% H_2SO_4 - 25% H_2O

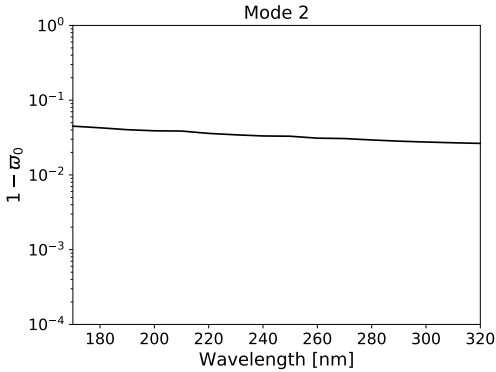
  $$m_r = 1.526 - 3.05 \cdot 10^{-4} (\lambda - 200\,\text{nm})$$

  Imaginary Need for darker mode 1 particles at longer wavelengths

  Mode 1 $$m_i = m_i(250\,\text{nm}) \times \exp\left(\frac{\lambda - 250\,\text{nm}}{40\,\text{nm}}\right)$$

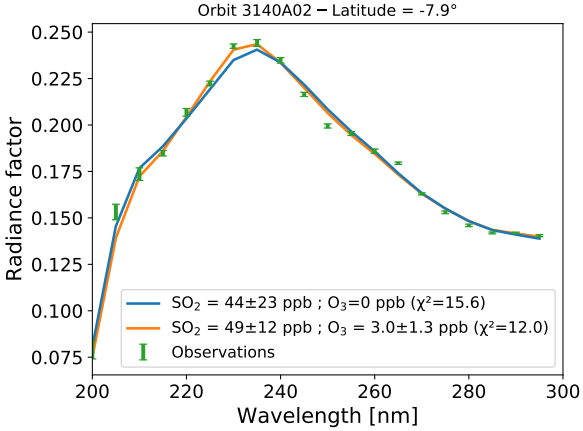
  Mode 2 $$m_i = 10^{-3}$$

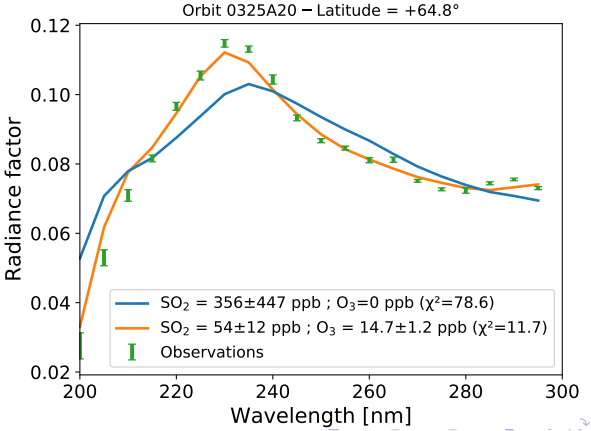




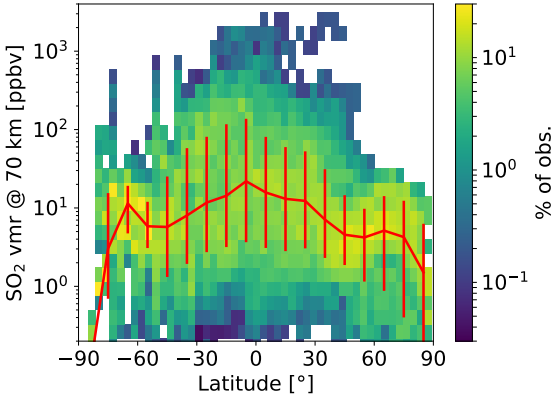
LATMOS

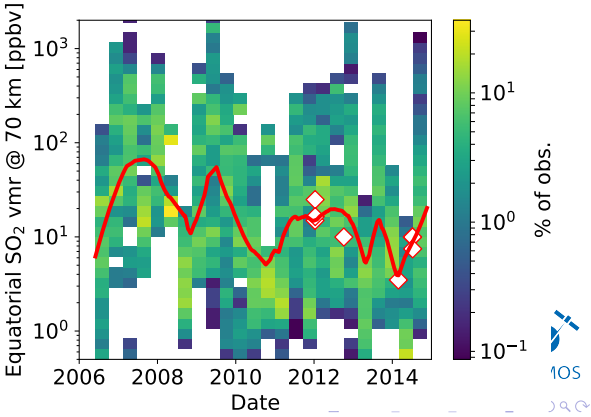
- SPS-DISORT, 16 streams
- Levenberg-Marquardt fit
- 4 fitted parameters: SO_2 @ 70 km, O_3 @ 65 km, m_i(250 nm), Z_2
  - O_3 detection threshold: 5.5× reduction in χ^2





- **Highly variable**, especially at lower latitudes
- Overall **secular decrease** over 2006-2014
- **Peaks** ($\sim$ 1 ppmv) take place **at lower latitudes**
- Depletion near subsolar point also seen by TEXES/IRTF.
- Possible increase over western edge of *Aphrodite Terra*





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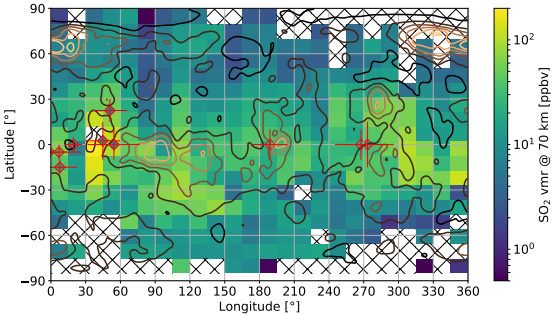
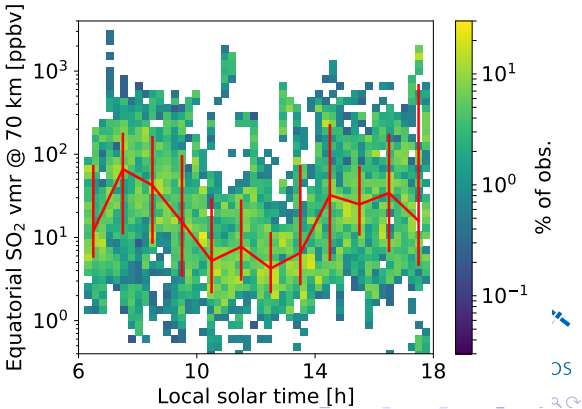
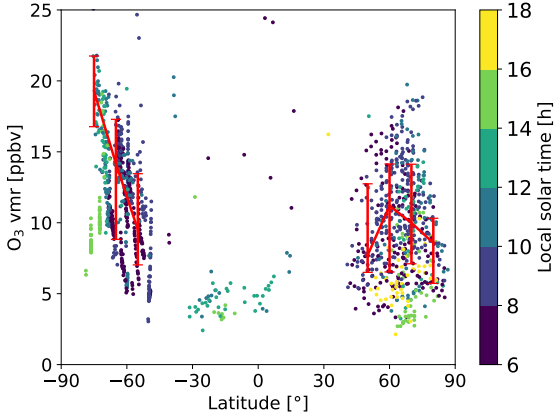
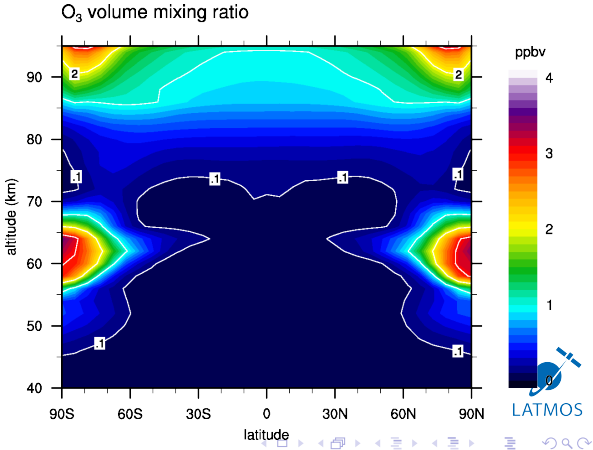


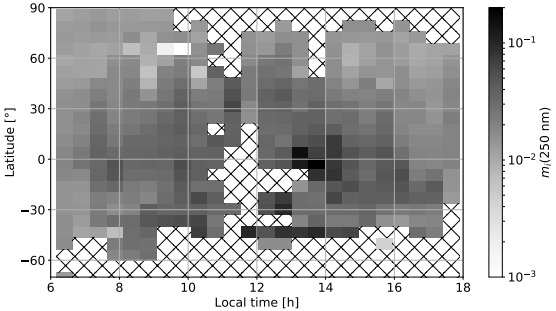


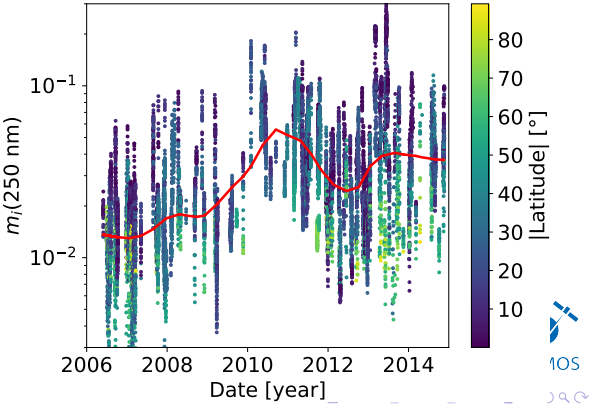
- **Detection of cloud top O_3** polewards of $\pm 50^\circ$
- Typical range: 1-10 ppbv
- Consistent with F. Lefèvre's **3D photochemical model**





- Latitudinal pattern **consistent with known features**
  - Large variability
  - Relatively dark lower latitudes
  - Sub-solar darkening
- Possible secular increase of UV absorption in 2006-2012
  - Consistent with VMC, STIS, MASCS trends





- **Complete rewriting** and major improvements to the whole SPICAV-UV nadir pipeline.
- Main results *[Marcq et al., 2019; under review]*
  - SO_2 Distribution mostly consistent with previous observations, except for a previously undetected early 2009 peak.
  - O_3 **Routinely detected** at cloud top level (1-10 ppbv) northwards of 50°N.
  - Clouds Confirmation of previously known trends.
    - **No need for any OSSO absorption**
- Next steps
  - Publication of data sets on ESA PSA
  - Providing science heritage for proposed **VenSpec-U/VeSUV** spectrometer on board *EnVision*

VeSUV Science Specs

FOV 22.5°
HR 210-240 nm @ 0.2 nm, SNR $>$ 100
LR 190-380 nm @ 2 nm, SNR $>$ 200