The State of Venus Atmospheric Chemistry Modeling

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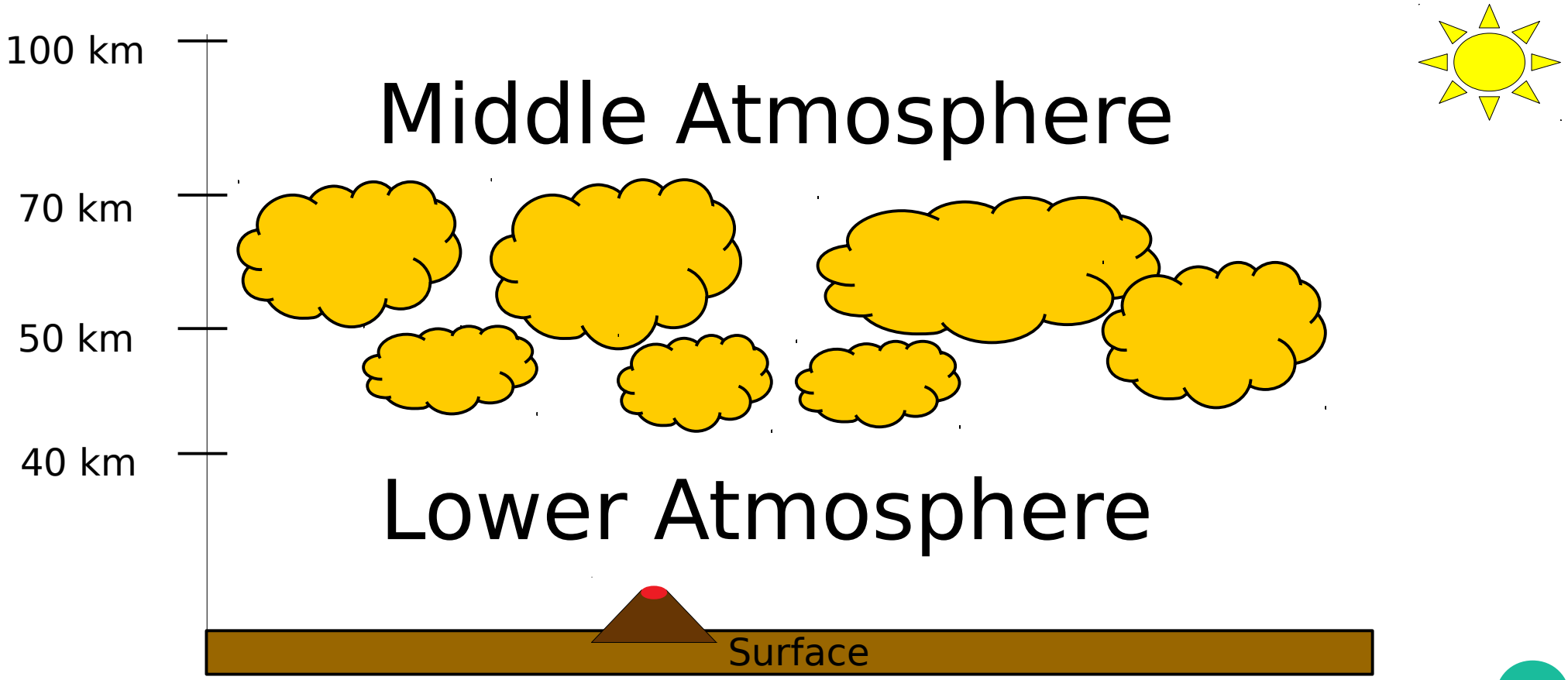
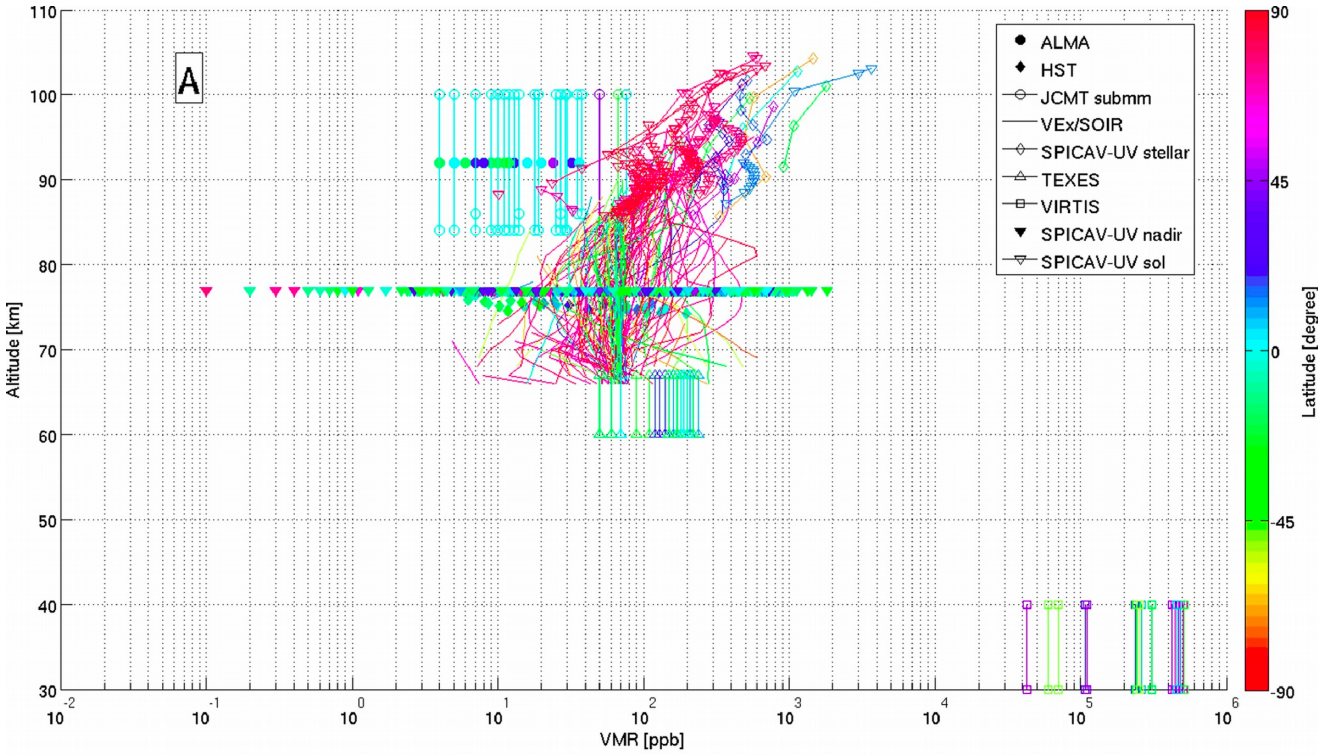
Introduction to the Venus atmosphere



Compiled SO_2 Observations (Vandaele et al. 2017)



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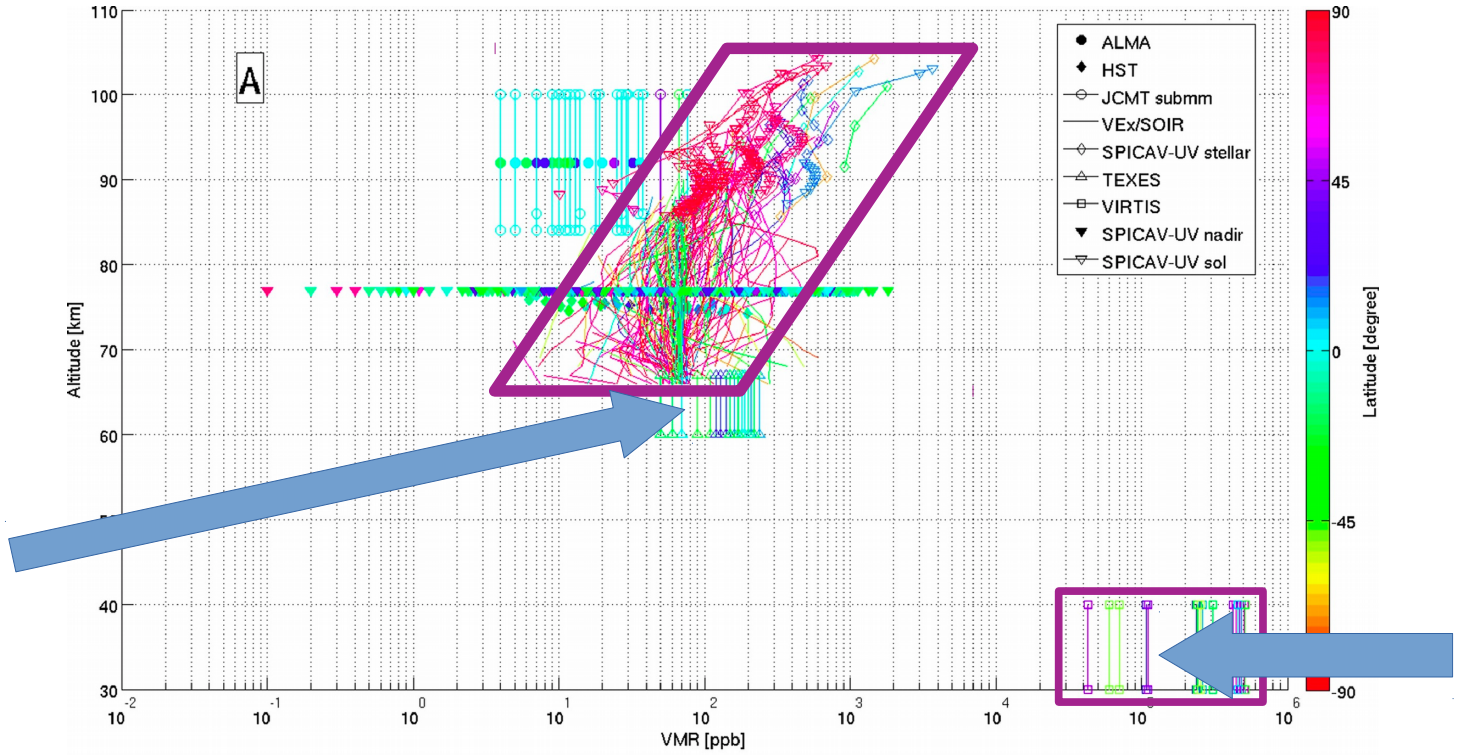
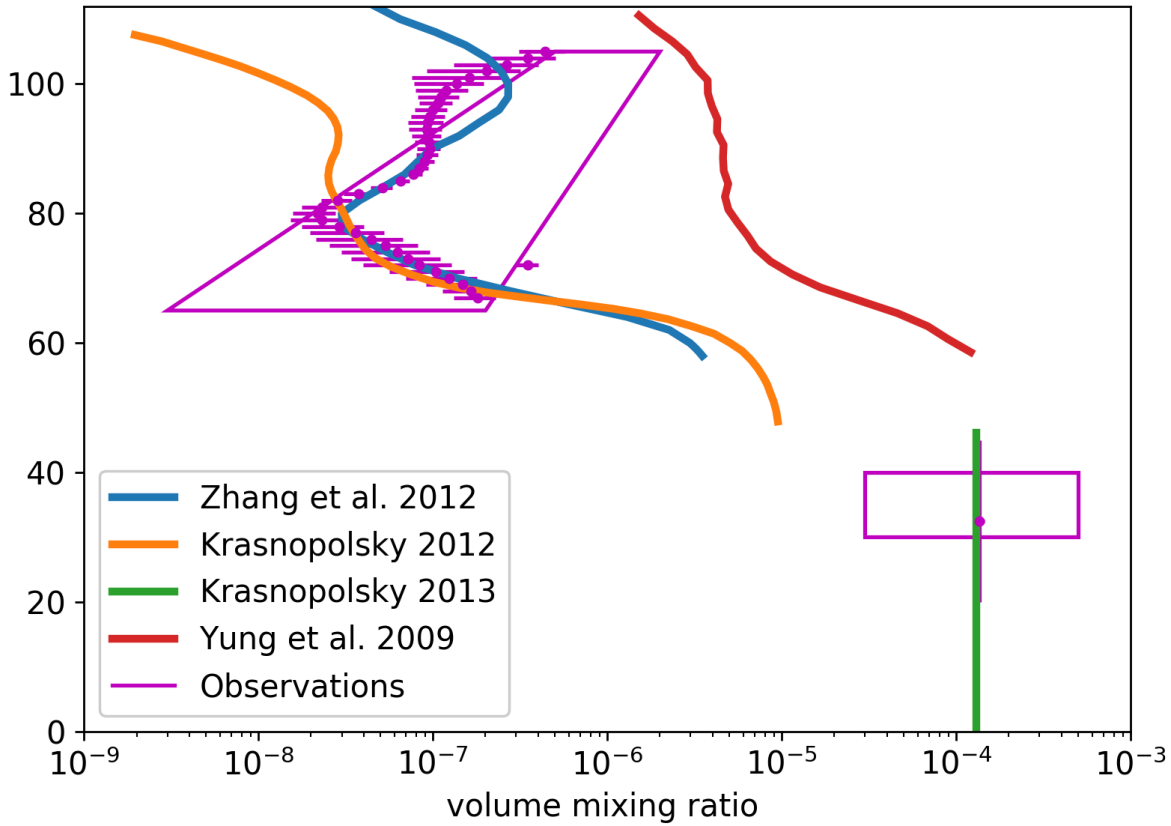


~0.1 ppm

~100 ppm

Previous Models (SO_2)

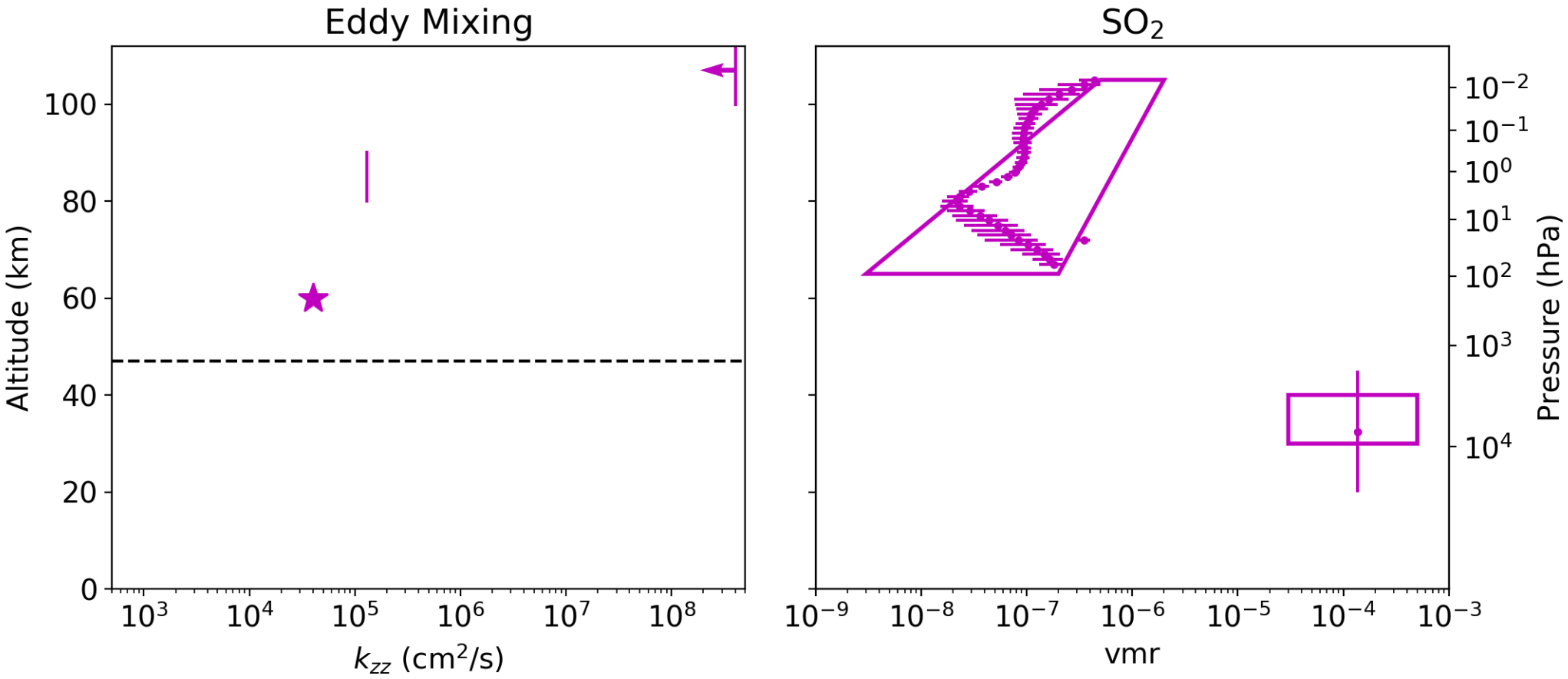


Observation Sources:
Arney et al. 2014,
Belyaev et al. 2012,
Vandaele et al. 2017

Our new model

- **1D**
- **Domain: Surface-110 km**
- **Updated chemistry from Zhang et al. 2012**
- **Includes ~50 species (SO_x, CO_x, NO_x, Cl_x, O_x)**
- **Using fixed profiles for H_2O, H_2SO_4, and N_2**
- **Published in: Chemical Cycling in the Venusian Atmosphere: A Full Photochemical Model From the Surface to 110 km, C. J. Bierson and X. Zhang (2020)**

SO2 Profile



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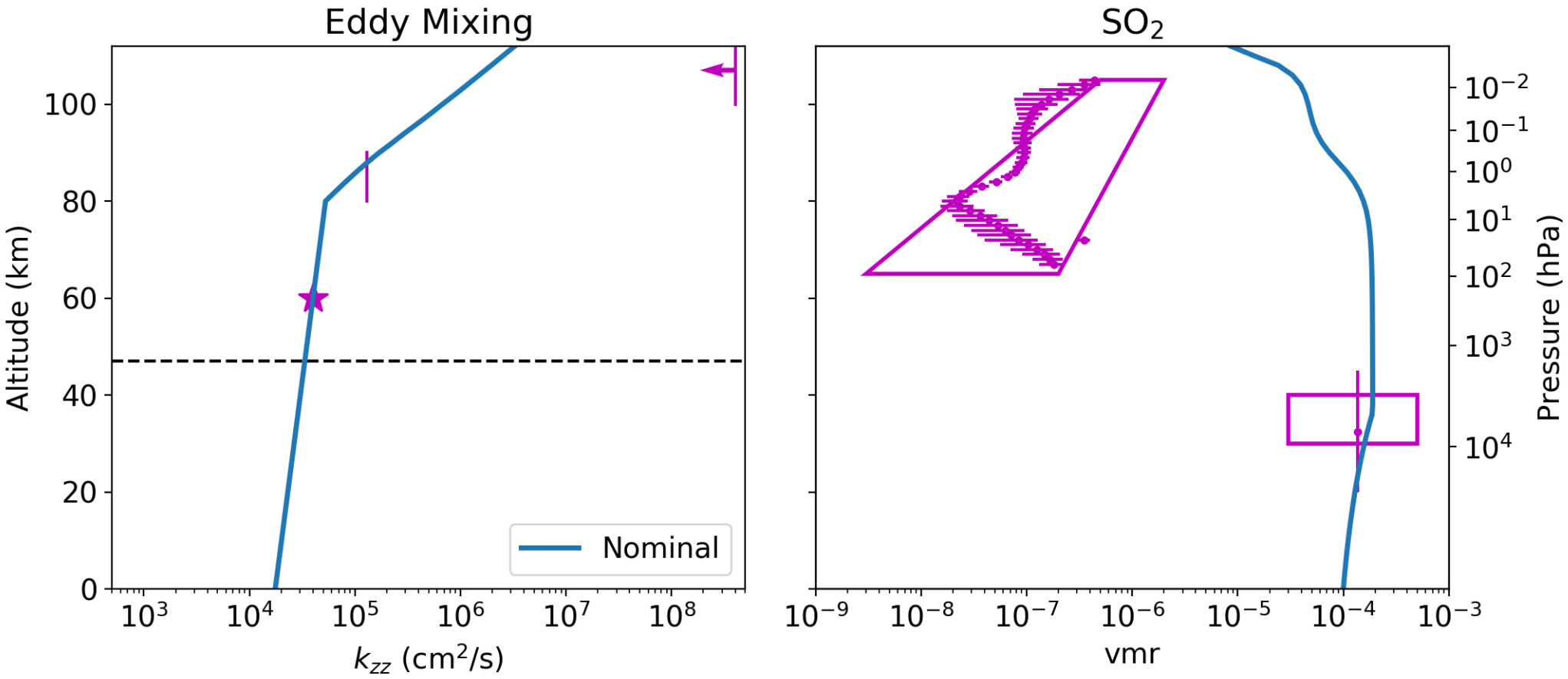

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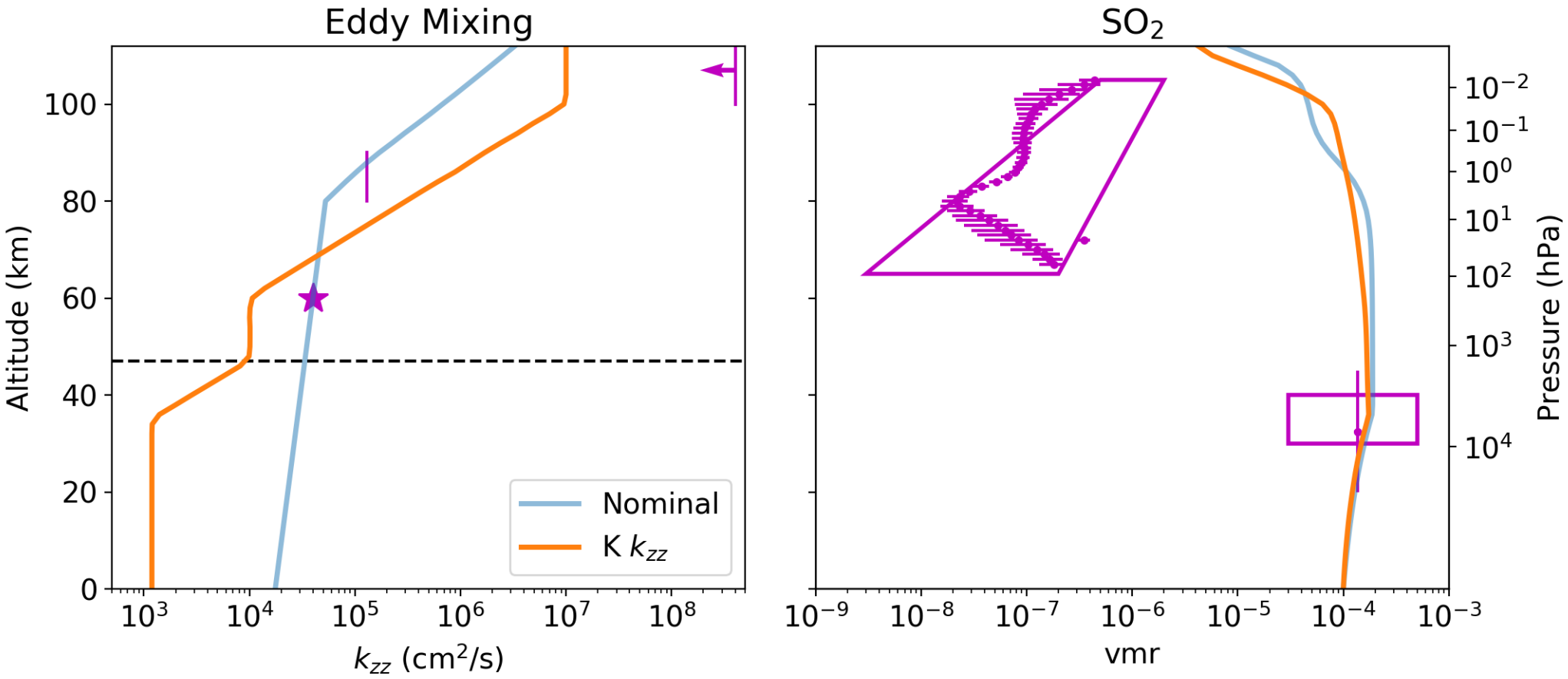

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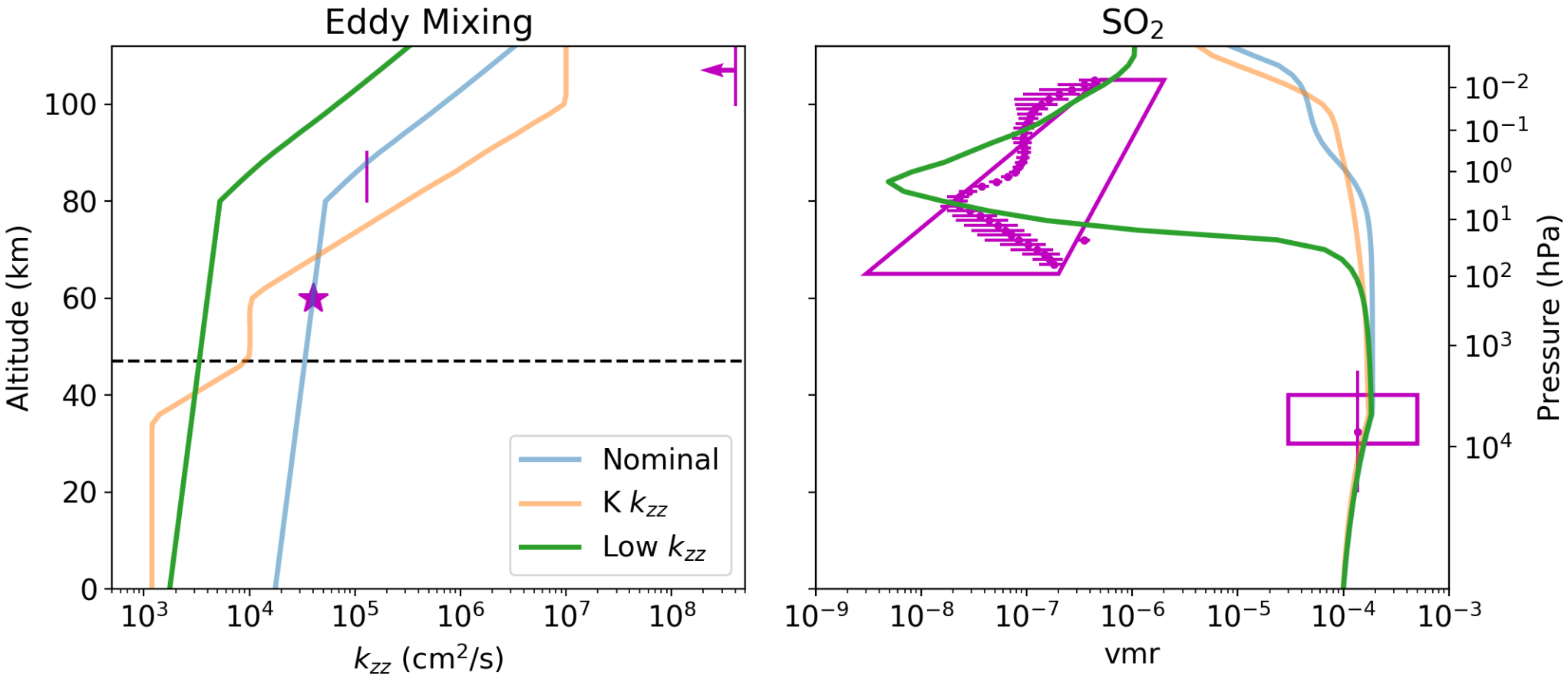

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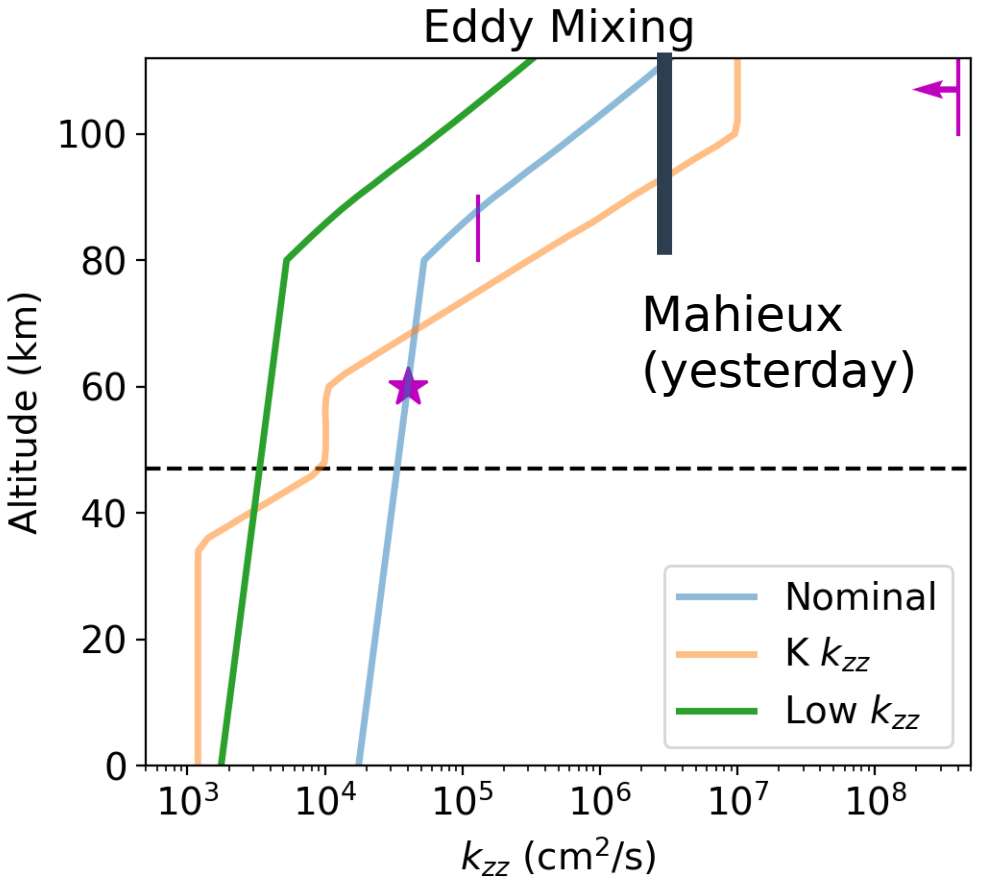

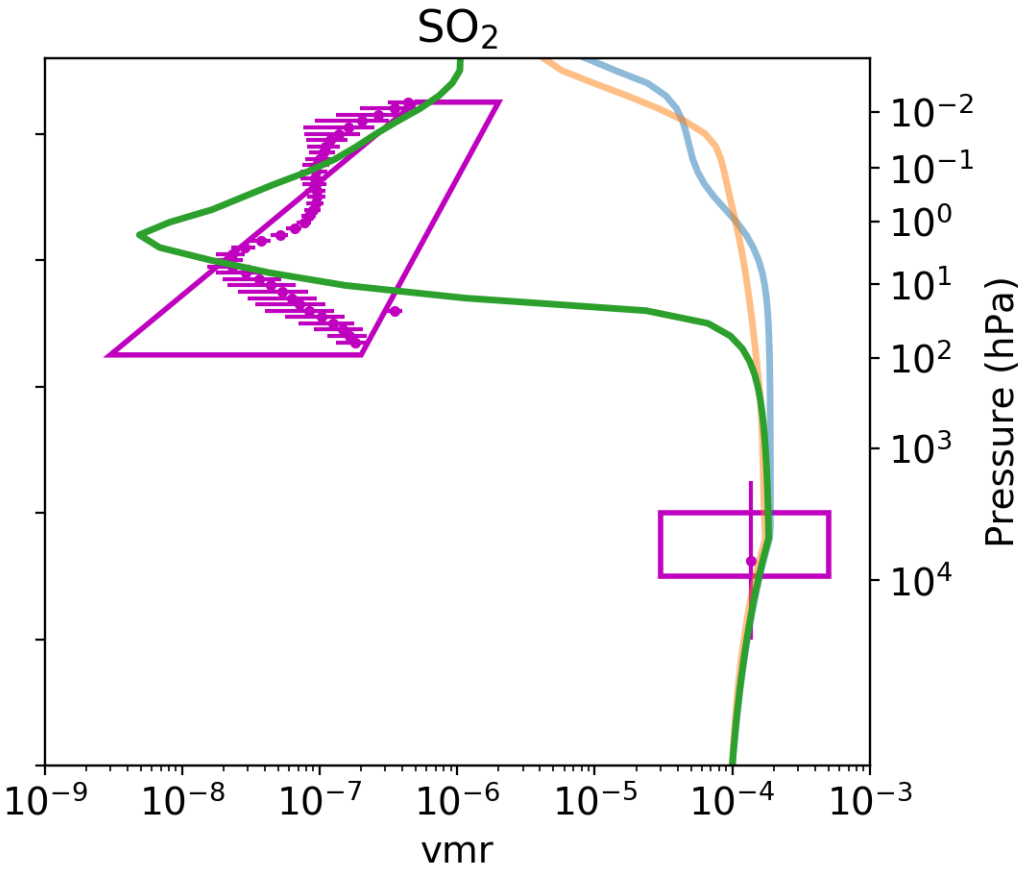

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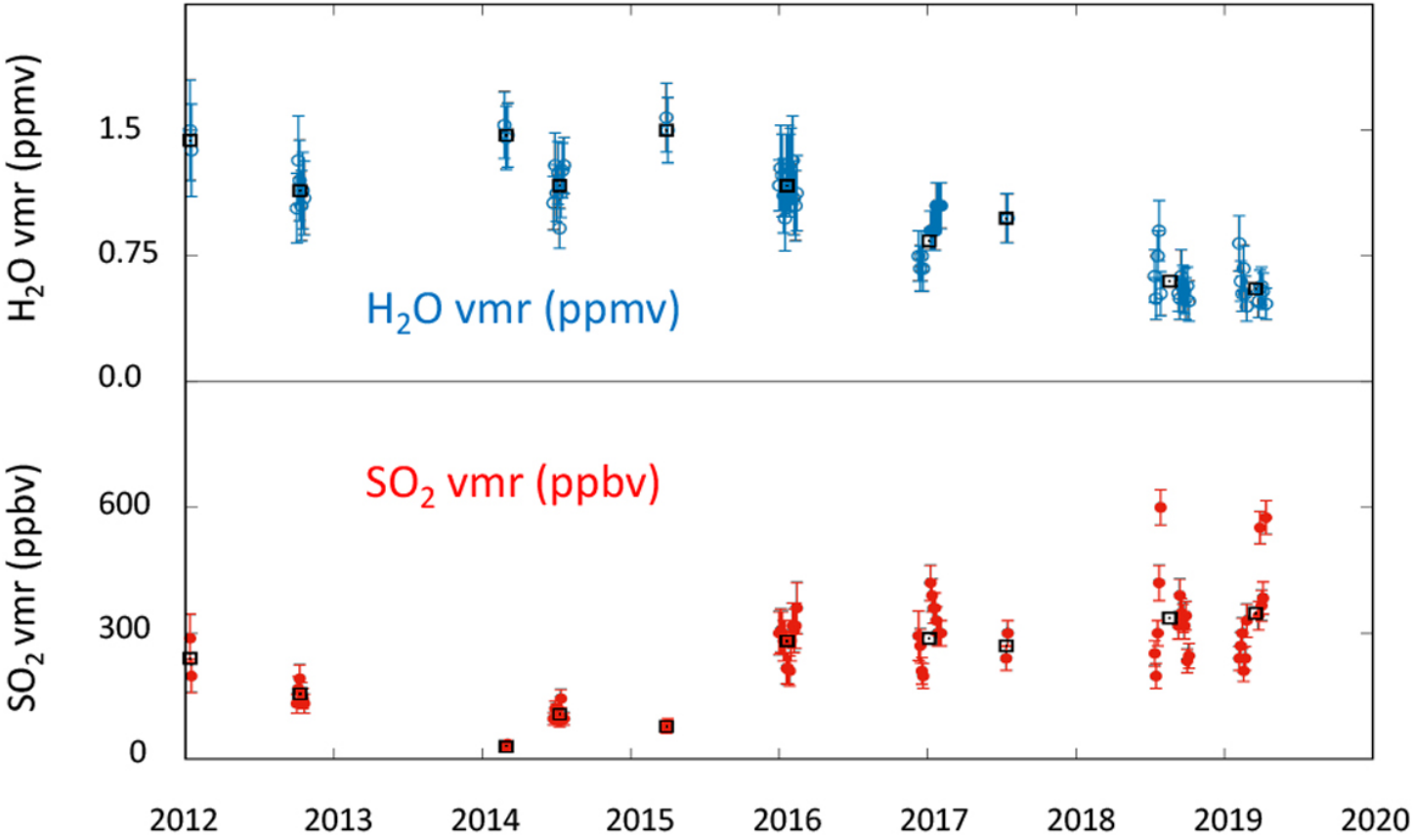
Key point #1

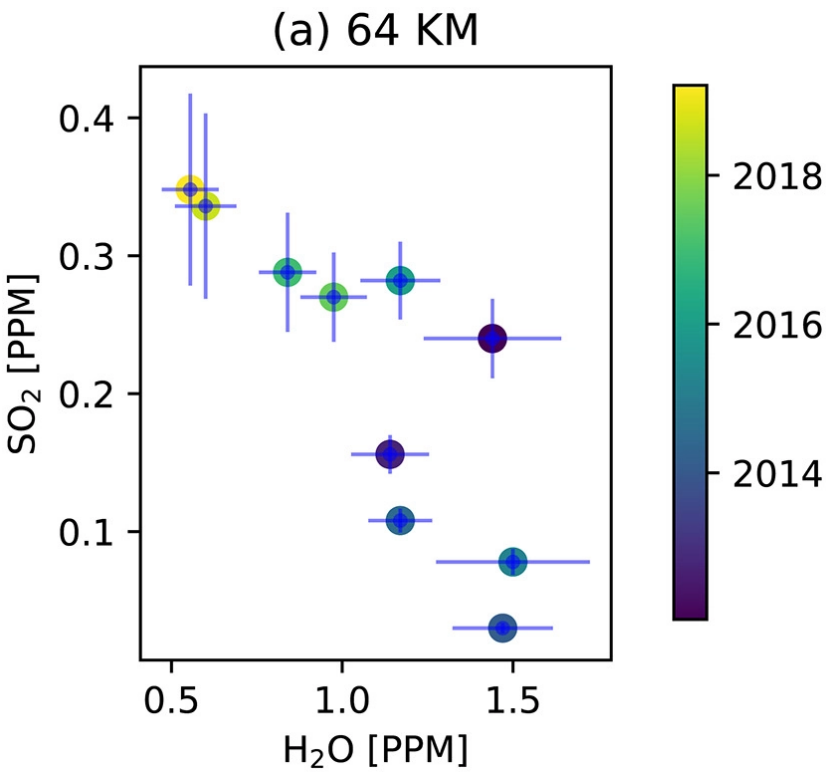
We are still missing a first order process in the Venusian SO_2 cycle

Co-variability with water



Encrenaz et al. 2020

SO_2 and H_2O are anti-correlated

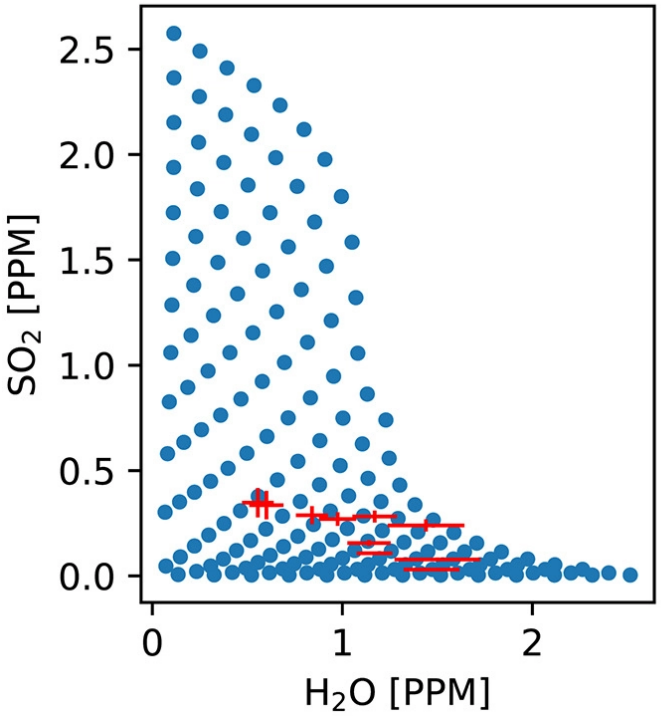


- **Use middle atmosphere model (58 km-110 km)**
- **Randomly vary mixing ratio at 58 km for SO2 (0-2.6 ppm) and H2O (0-10 ppm)**

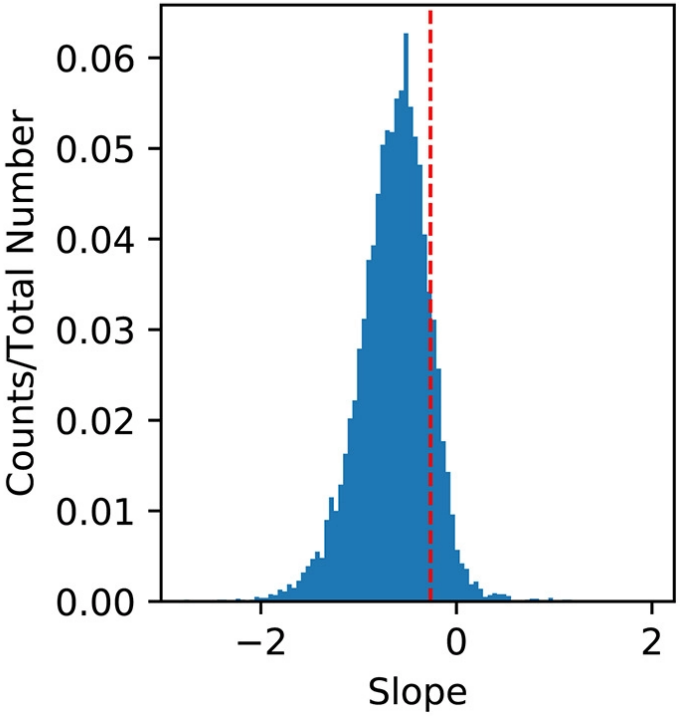
Shao et al. 2020

SO_2 and H_2O are anti-correlated

Resulting values at 64 km

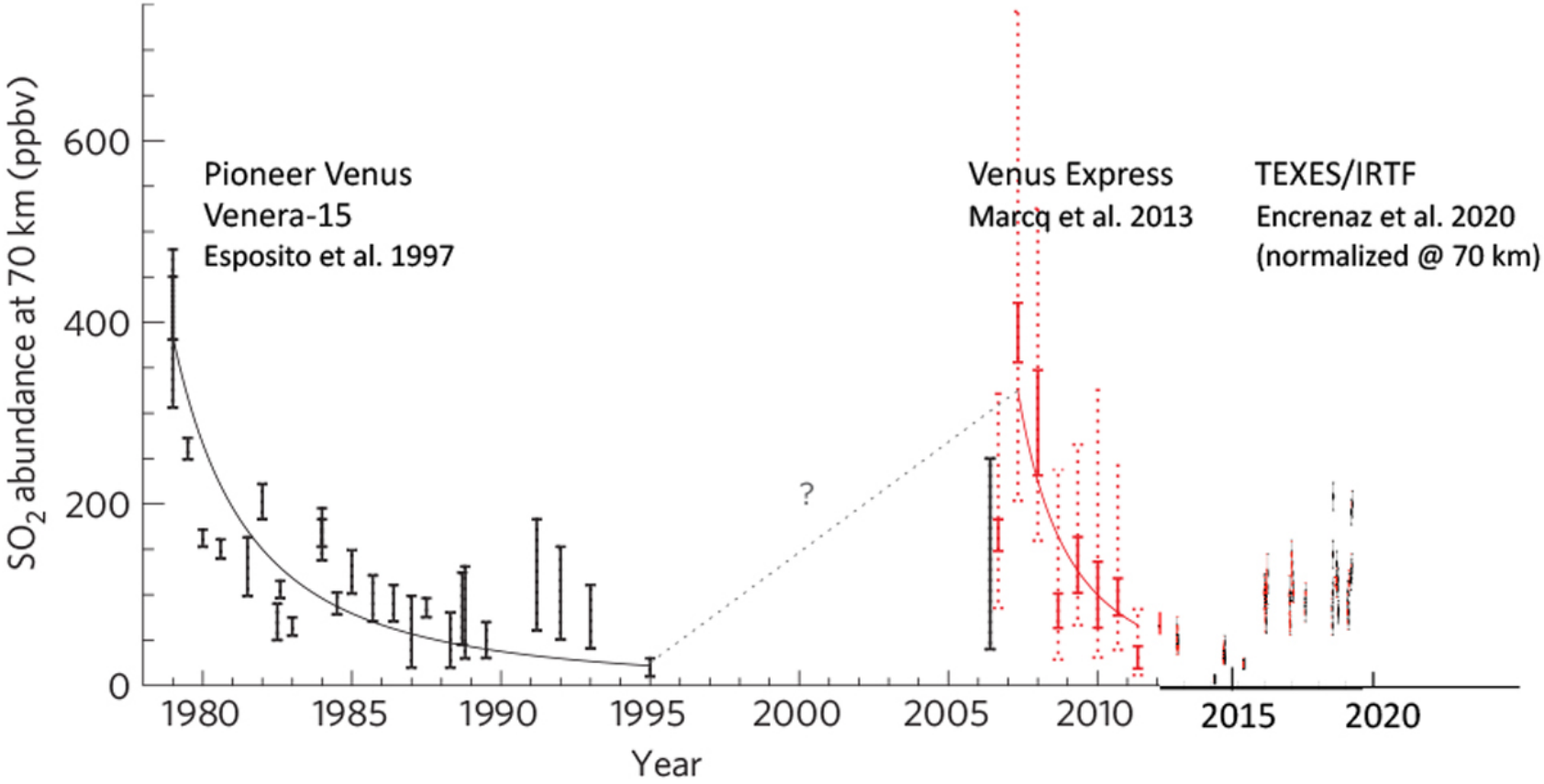


Resulting slope distribution



Shao et al. 2020

Temporal Variability

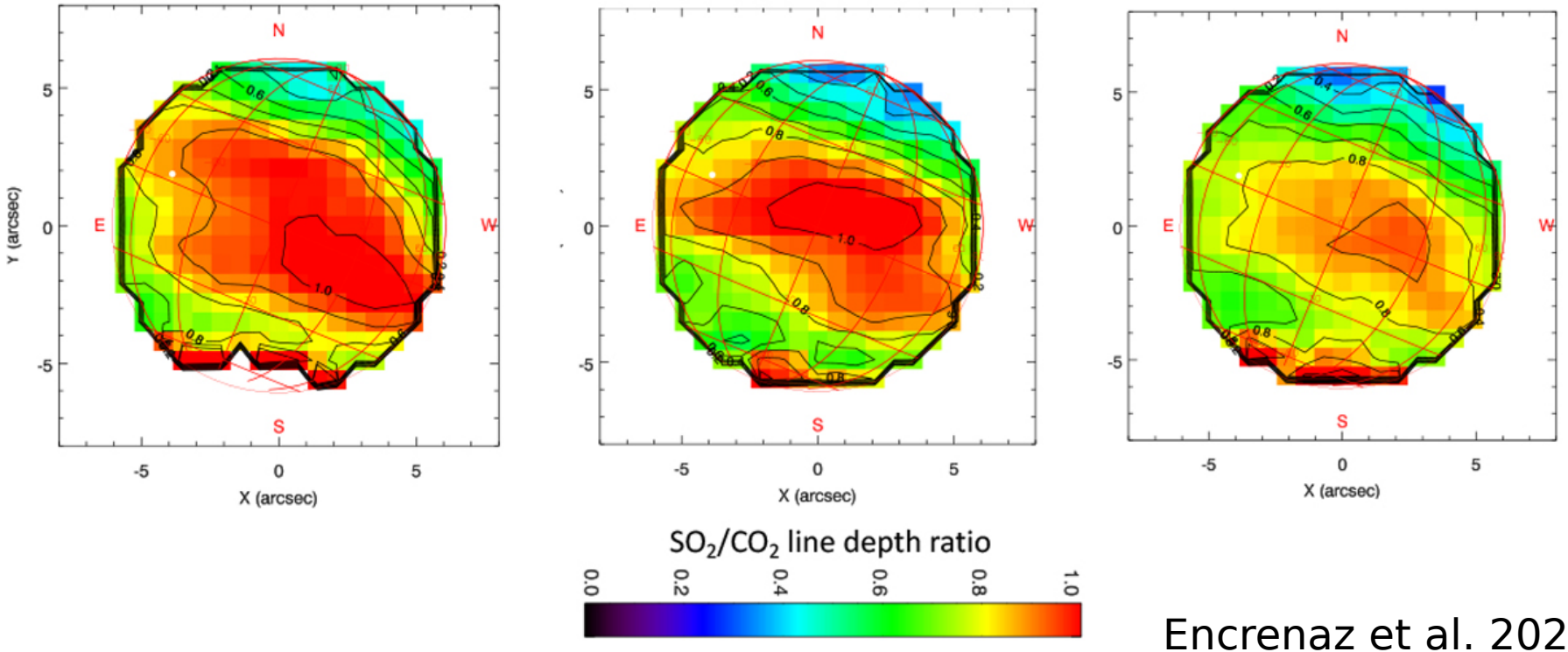


Encrenaz et al. 2020

Spatial Variability

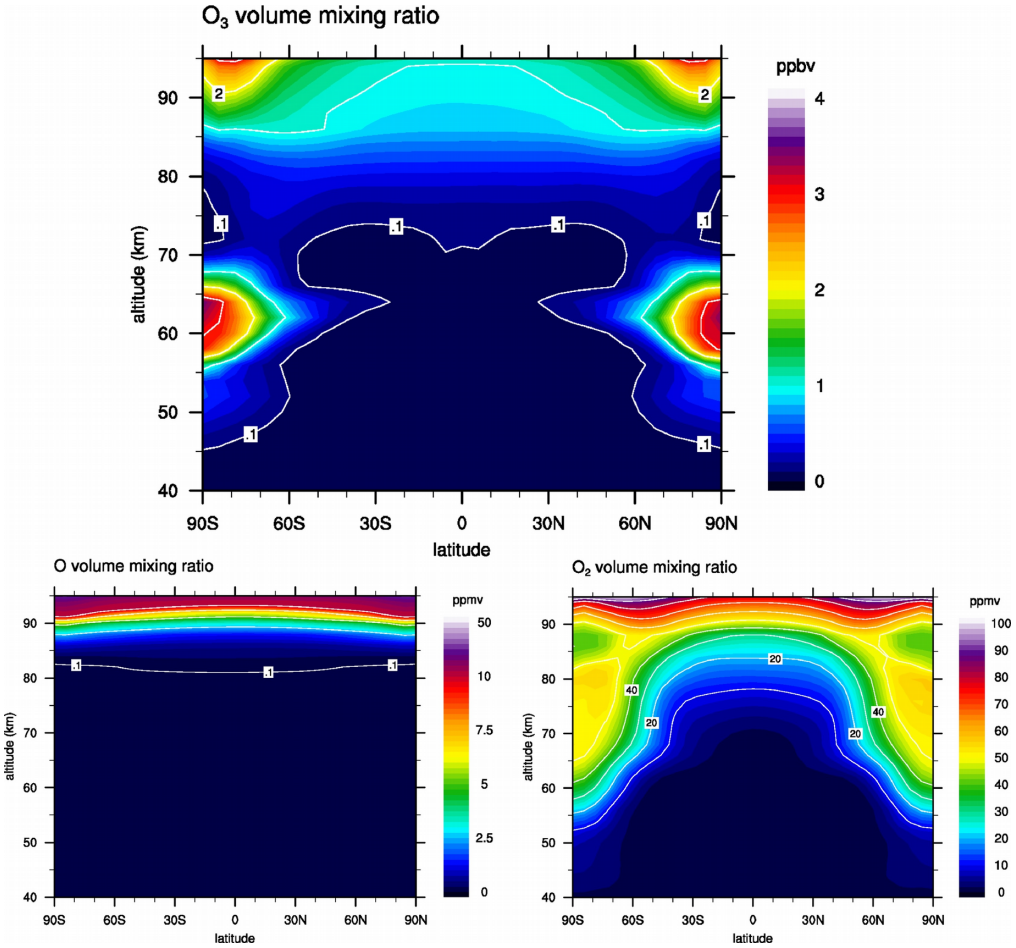
16 April 2019

a (18:23 UT) b (19:22 UT) c (20:25 UT)



Encrenaz et al. 2020

3D Models



Marcq et al, 2019

Questions

- **What is causing the large drop in SO2 in the clouds?**
- **How much interaction is there between the sulfur and carbon chemical systems?**
- **Can we reconcile the surface fluxes used by atmospheric chemistry models with surface reactions?**

Bierson and Zhang (2020) *Chemical Cycling in the Venusian Atmosphere: A Full Photochemical Model From the Surface to 110 km*, Icarus

Where do we go, from here….

- **Models**
  - Incorporate H_2O and H_2SO_4 condensation
  - Testing new reactions within the cloud region
- **Measurements**
  - S_x (S, S_2, S_3, S_4, …)
  - SO_3
  - SO_2 (and other speices) in the cloud region
- **Laboratory reaction rates/Quantum chemistry calculations**
  - S_x chemistry
  - SO_3 + OCS -> ?
  - SO_3 + CO -> SO_2 + CO_2