Comparing the Transit Spectra of Potential Earth-like and Venus-like Exoplanets

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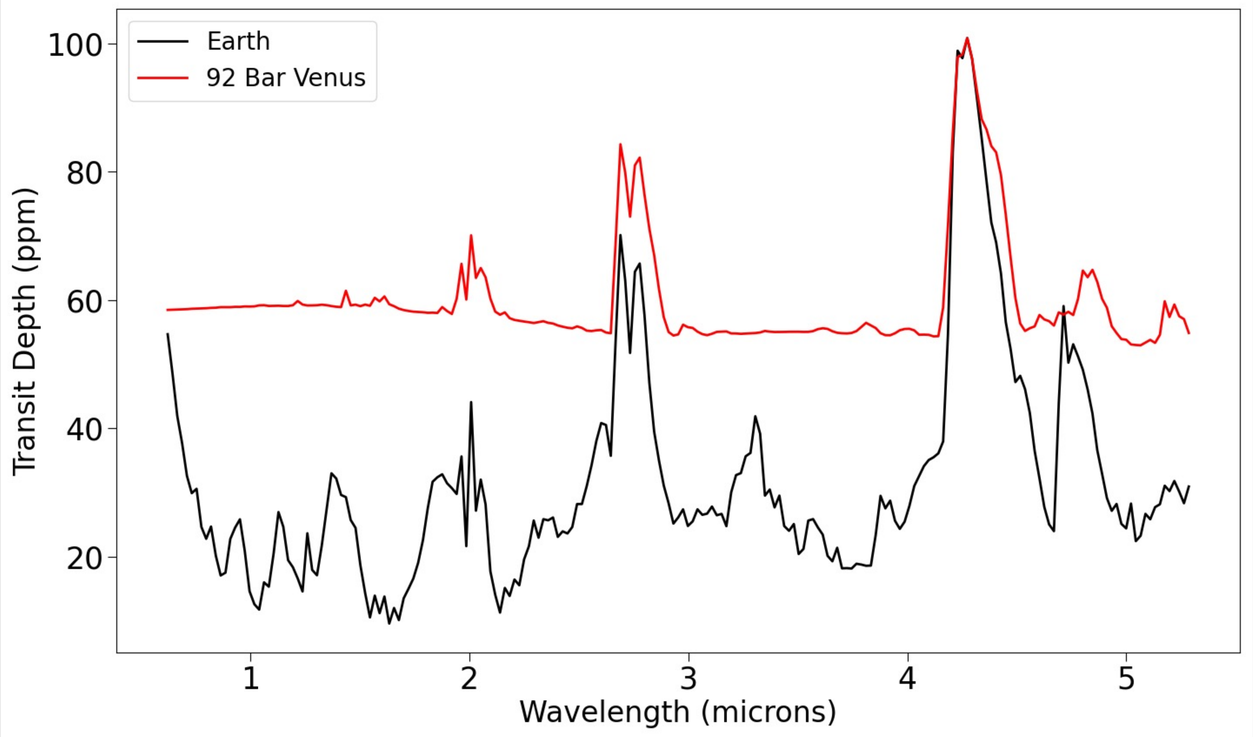
Size of CO_2 Features in the Transit Spectra of Earth and Venus

Despite the stark difference in atmospheric CO_2 between present day Earth and Venus, the transit spectra of Earth boasts larger CO_2 absorption features than that of Venus. This is caused by the global opaque haze and cloud layers on Venus which prevent the bulk of Venus' atmosphere from being probed during transit observations. The discrepancy between CO_2 abundance and absorption feature size in the two planets' transit spectra will make it difficult to differentiate an Earth-like planet from a Venus-like planet.

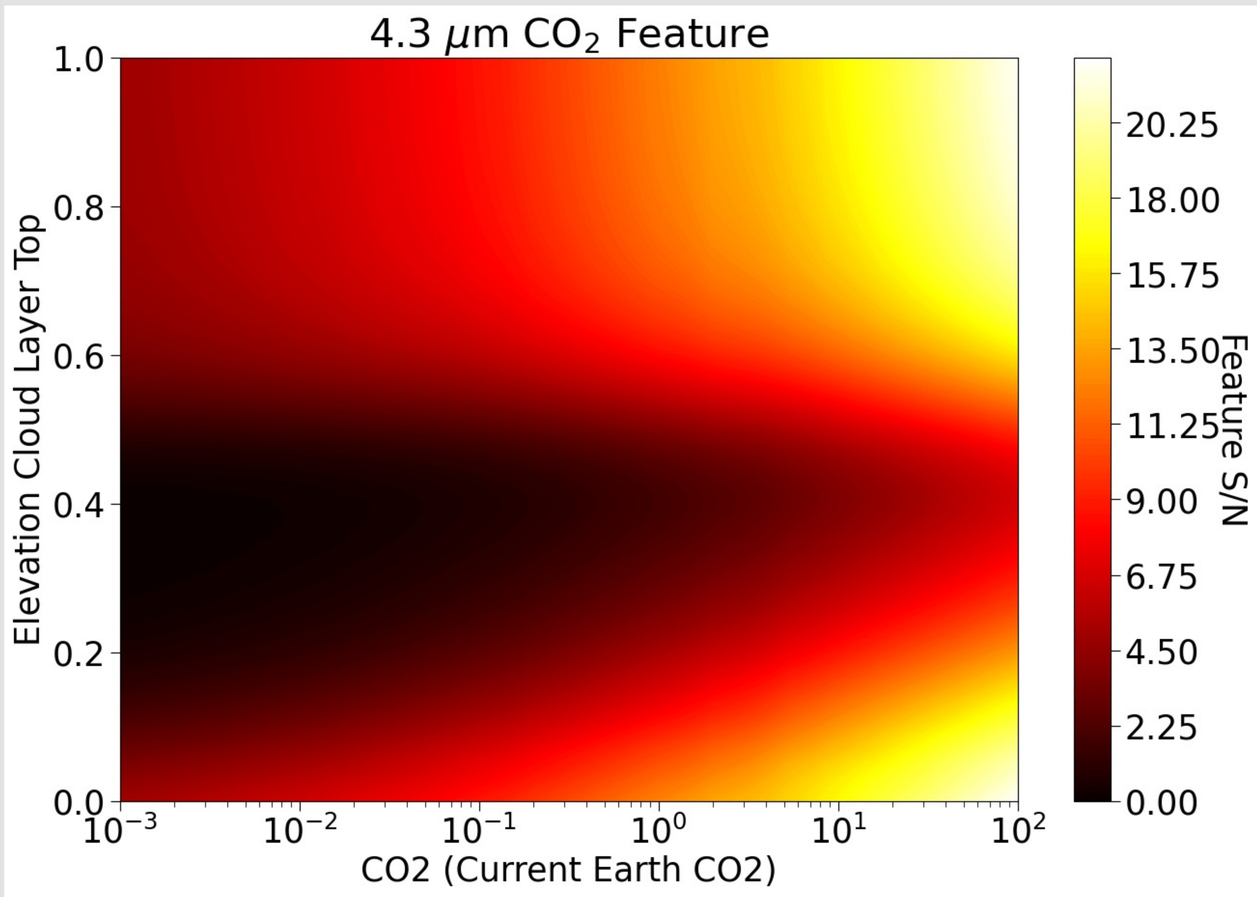
It is a possibility, however, that exoplanets discovered in the Venus Zone and Habitable Zone will have atmospheres which deviate from that of present-day Venus or present-day Earth, respectively. This work aims to explore the the differences in transit spectra between an assortment of potential exo-Earths and exo-Venuses with varying atmospheric CO_2 abundances and cloud decks. Comparing the size of respective CO_2 absorption features between the variants of each planet will reveal the scenarios where an Earth-like exoplanet would exhibit larger CO_2 features than a Venus-like exoplanet. The array of transit spectra were produced using the Planetary Spectrum Generator (PSG) developed at the NASA Goddard Space Flight Center



The figure above compares the transit spectra of present-day Earth to that of present-day Venus. To better illustrate the differences between the two, the maximum value of the Venus spectra was set equal to the maximum of the Earth spectra. It can be seen that Venus has smaller CO_2 features at 2.7 and 4.3 μm

S/N of CO2 features

The S/N of the CO_2 absorption features at 2.0, 2.7, and 4.3 μm were determined for the transit spectra of every Earth and Venus variant. The figure below illustrates how the S/N of the 4.3 μm CO_2 absorption features varies as a function of atmospheric CO_2 abundance and the height of Earth's water-ice cloud deck (the cloud deck elevation in the figure varies from 0-1, where 0 is the surface, and 1 is the top of the atmosphere). The water-ice clouds affect the S/N of the feature most when located in the bottom half of the atmosphere, and can totally conceal the feature for an exo-Earth with less CO_2 than present day Earth.



Summary

- The CO_2 features in the transit spectra of Earth can be much larger than the same features in the transit spectra of Venus.
- The array of transit spectra created in this work illustrate how the S/N of CO_2 features are dependent on atmospheric CO_2 abundance and cloud deck height.
- Future work will investigate whether the S/N obtained from the PSG modelled spectra will be obtainable with future JWST observations. Specifically, whether JWST will be able to distinguish exo-Earths from exo-Venuses.