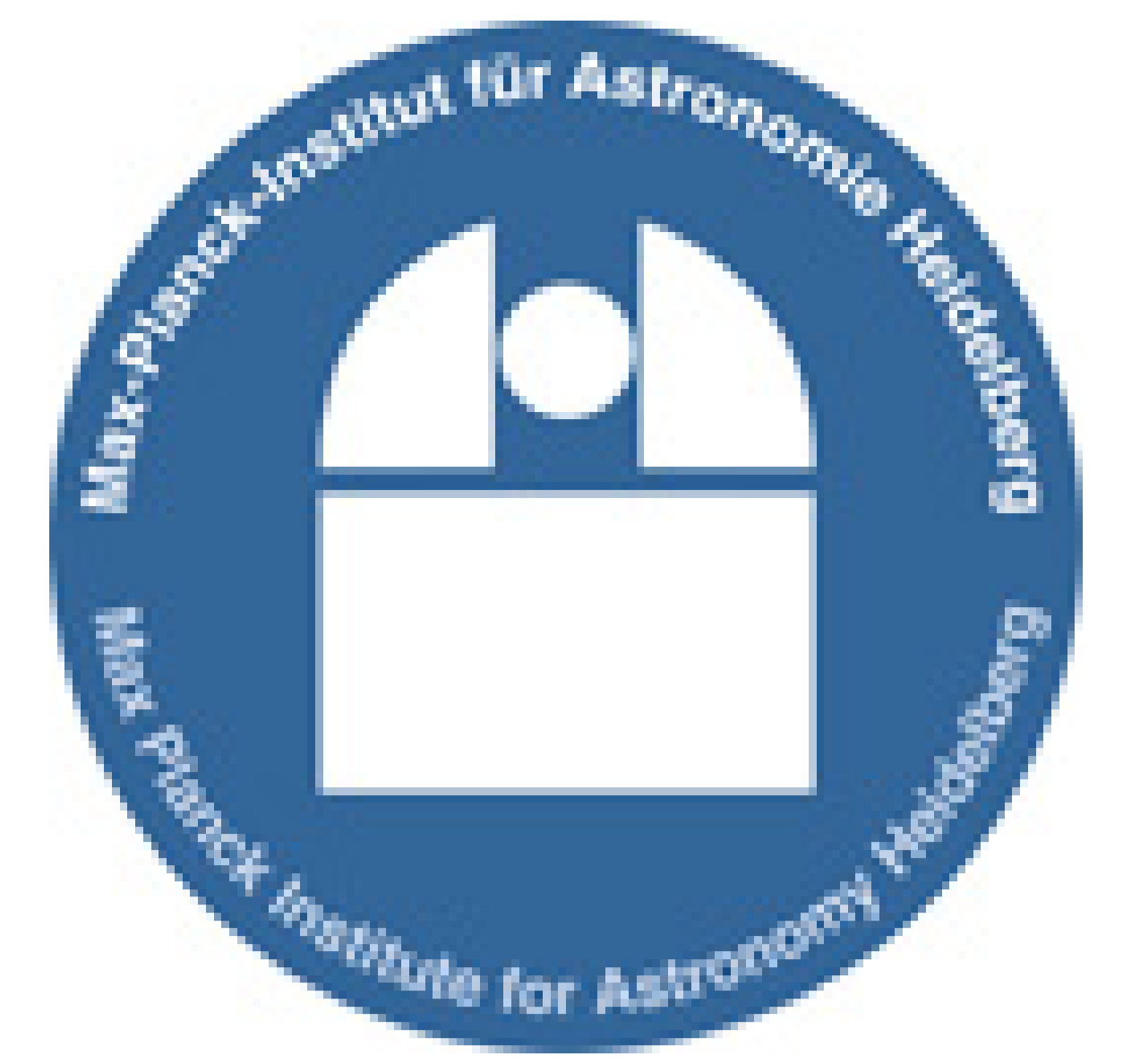


# EARTH AS AN EXOPLANET:

## EARTH'S TRANSIT SPECTRUM FROM THE ULTRAVIOLET TO THE NEAR-INFRARED



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For more details, see [Bétrémieux & Kaltenegger 2013, ApJL, in press, arXiv:astro-ph/1307.0416](#)

### ABSTRACT:

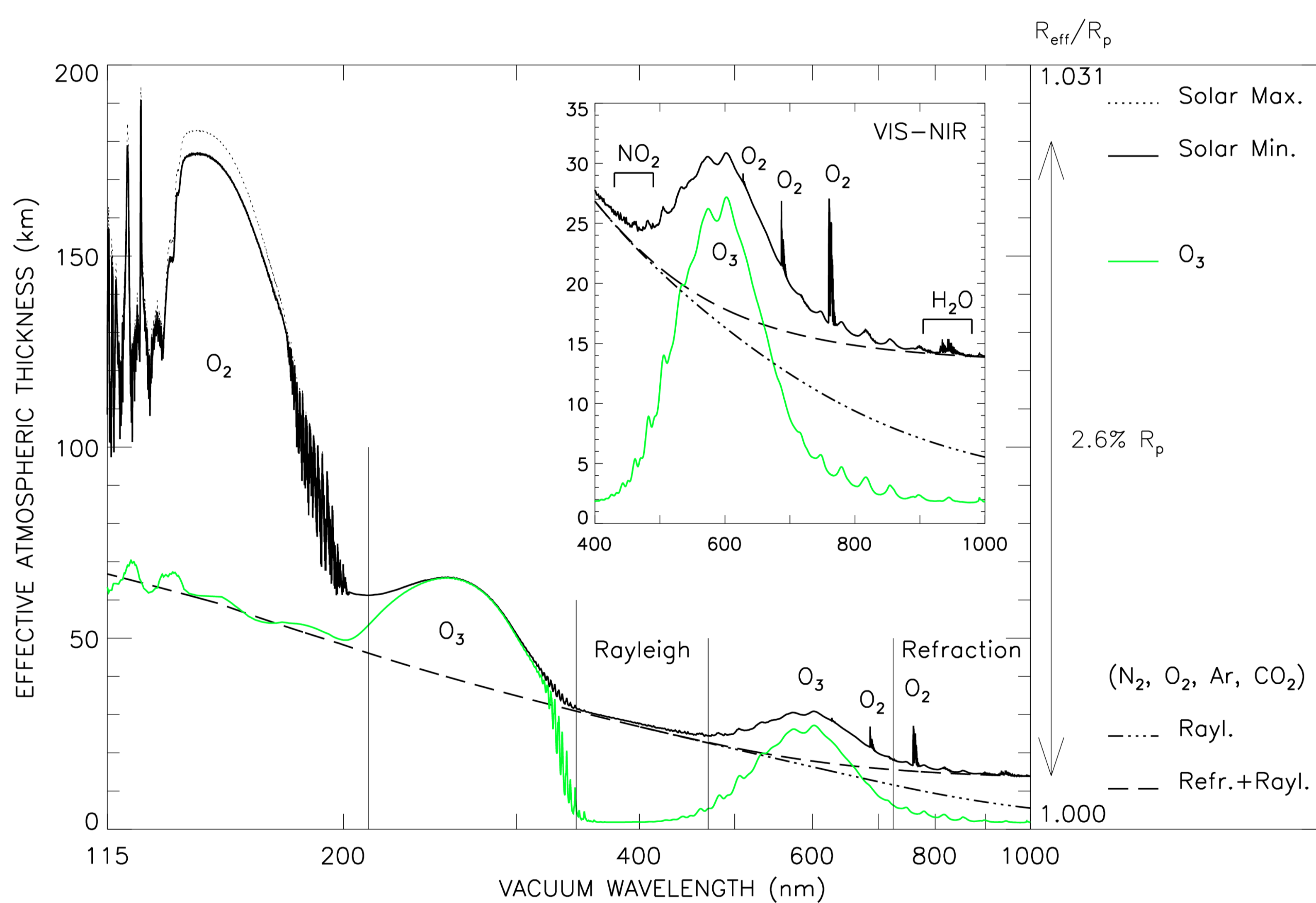
We present the transit spectrum of Earth seen as an exoplanet in primary eclipse from 115 to 1000 nm, and the detectable features, including biosignatures. The effective observable planetary radius for Earth increases by 14 to 180 km, about 3% of the Earth's radius, towards the shorter wavelengths. Our model shows the individual chemical as well as scattering components that contribute to the spectrum and present a view of Earth as a transiting exoplanet in the UV-NIR spectral region to guide instrument studies for future mission concepts.

EXTENSIVE UPGRADES TO SAO98 RADIATIVE TRANSFER CODE (SEE KALTENEGGER & TRAUB (2009, ApJ, 698,519) AND REFERENCES THEREIN FOR DESCRIPTION OF ORIGINAL CODE) INCLUDING:

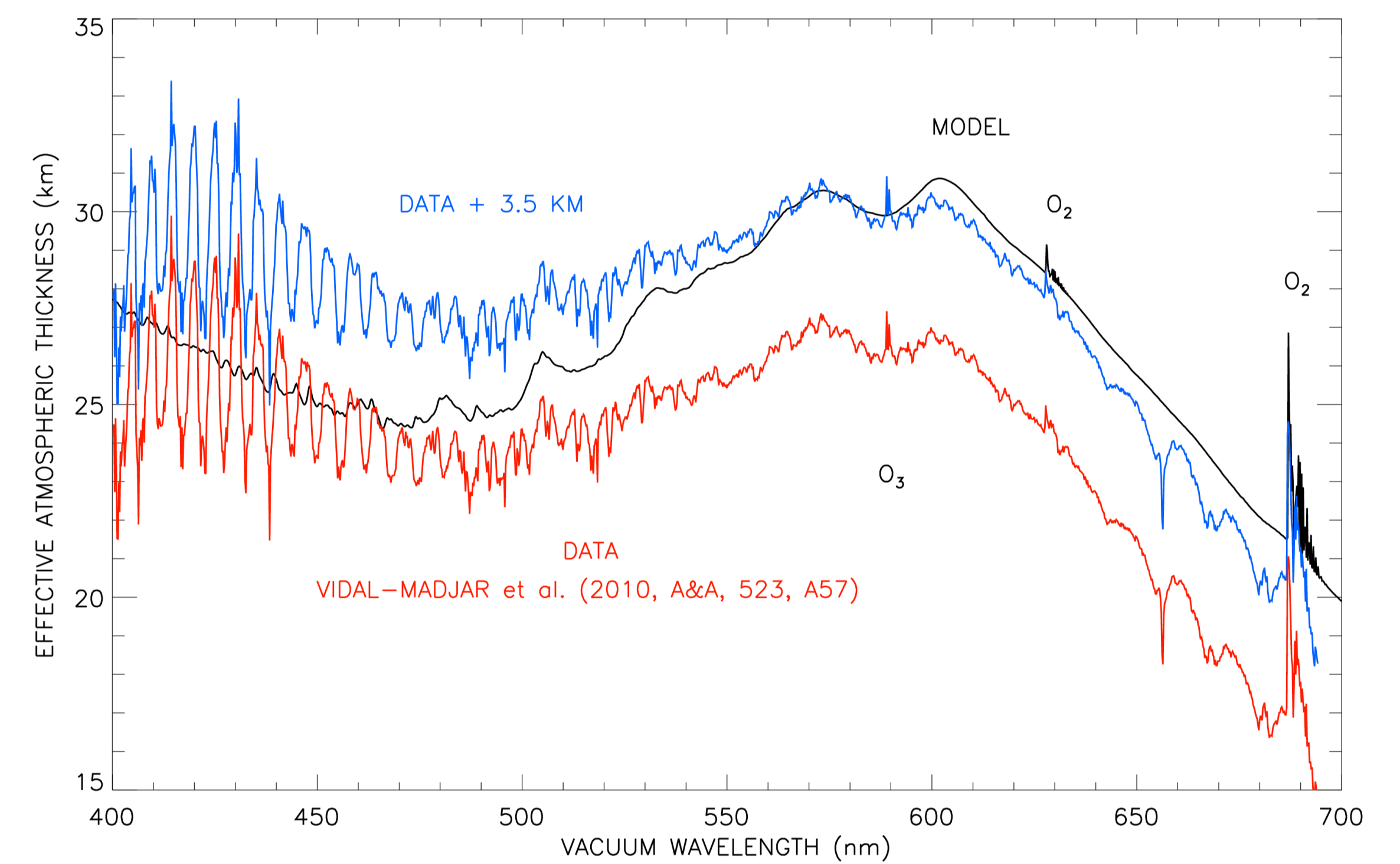
- NEW UV-NIR CROSS SECTIONS FOR CONTINUOUS ABSORBERS
- NEW N<sub>2</sub>, O<sub>2</sub>, Ar, & CO<sub>2</sub> RAYLEIGH SCATTERING CROSS SECTIONS
- EFFECTS OF REFRACTION BY N<sub>2</sub>, O<sub>2</sub>, Ar, & CO<sub>2</sub> FOR EXOPLANET TRANSIT GEOMETRY: **ATMOSPHERIC REGIONS BELOW 12.75 KM ALTITUDE CAN NOT BE OBSERVED FOR EARTH-SUN ANALOGS**

EFFECTIVE ATMOSPHERIC THICKNESS = APPARENT INCREASE IN PLANETARY RADIUS FROM ATMOSPHERIC ABSORPTION AND SCATTERING

### IDENTIFICATION OF MAIN SPECTRAL FEATURES



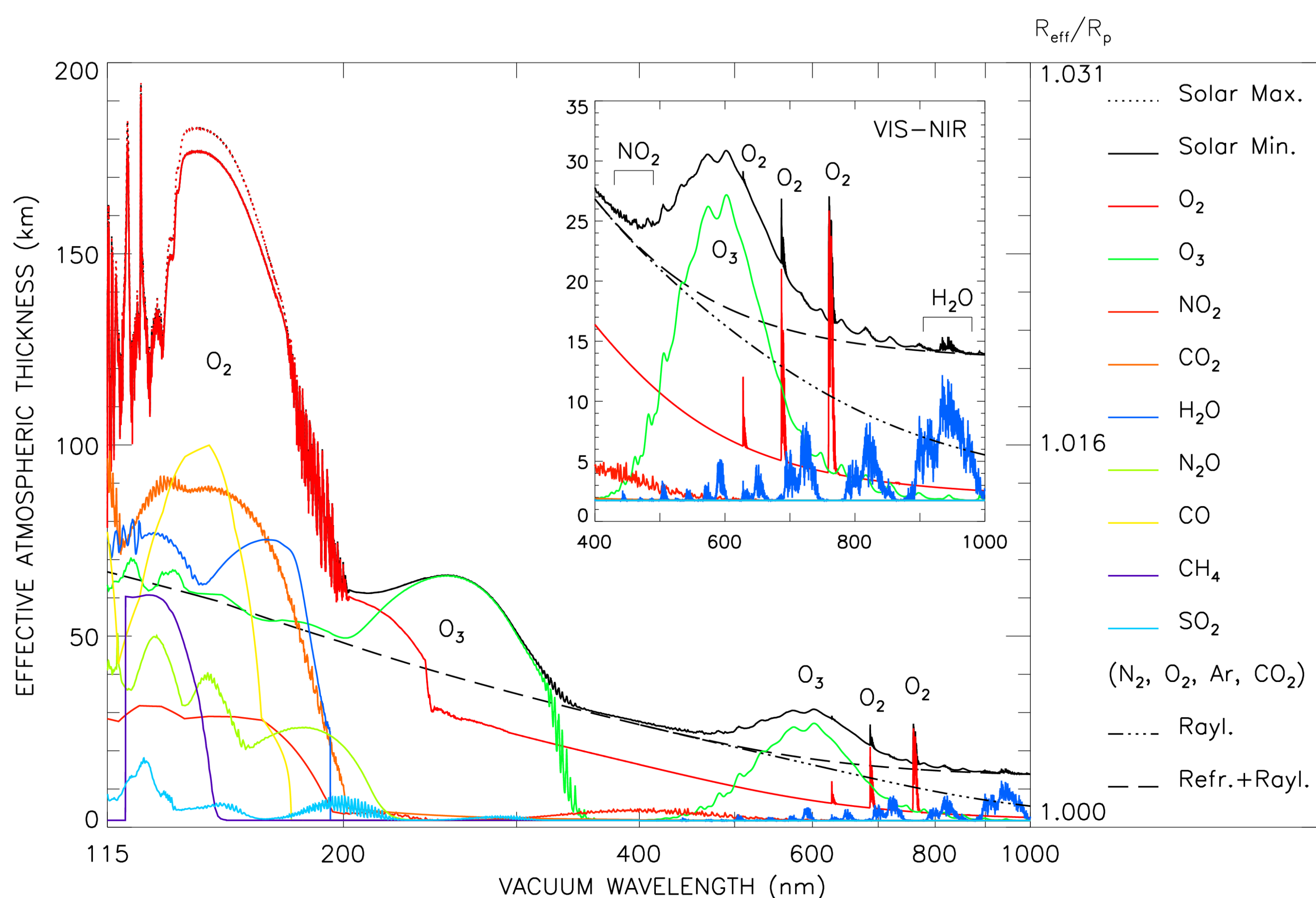
### COMPARISON WITH PENUMBRAL LUNAR ECLIPSE OBSERVATIONS



### REMARKS ABOUT COMPARISON WITH THE ABOVE DATA:

- The oscillatory features on the short wavelength side of the data are due to uncorrected echelle spectrograph cross-order contamination and should be ignored.
- Data absolute values are not known better than  $\pm 2.5$  km.
- Our model does not include limb darkening. However, the Earth's atmosphere does not occult the same region of the Sun in Lunar eclipses and exoplanetary transits, so limb darkening effects would be different anyway.

### INDIVIDUAL CONTRIBUTION OF EACH SPECIES OR EFFECTS



### EARTH'S SPECTRUM FEATURES OF NOTE:

- CLEAR SIGNATURES OF O<sub>2</sub> & O<sub>3</sub> IN THE UV-NIR
- BROAD UV O<sub>2</sub> ABSORPTION PEAKS  $\approx 180$  km AND IS DEPENDENT ON SOLAR ACTIVITY
- REFRACTION EFFECT MASKS MOST NIR H<sub>2</sub>O FEATURES
- EFFECTIVE PLANETARY RADIUS CHANGES BY  $\approx 2.6\%$  EARTH'S RADIUS FROM UV TO NIR. **CONTRAST BETWEEN NIR AND UV IS POTENTIALLY INTERESTING TO INFER THE PRESENCE OF AN ATMOSPHERE**