

How do you like it?

OR

investigate how the spectral shape changes as a function of temperature
and assumed composition

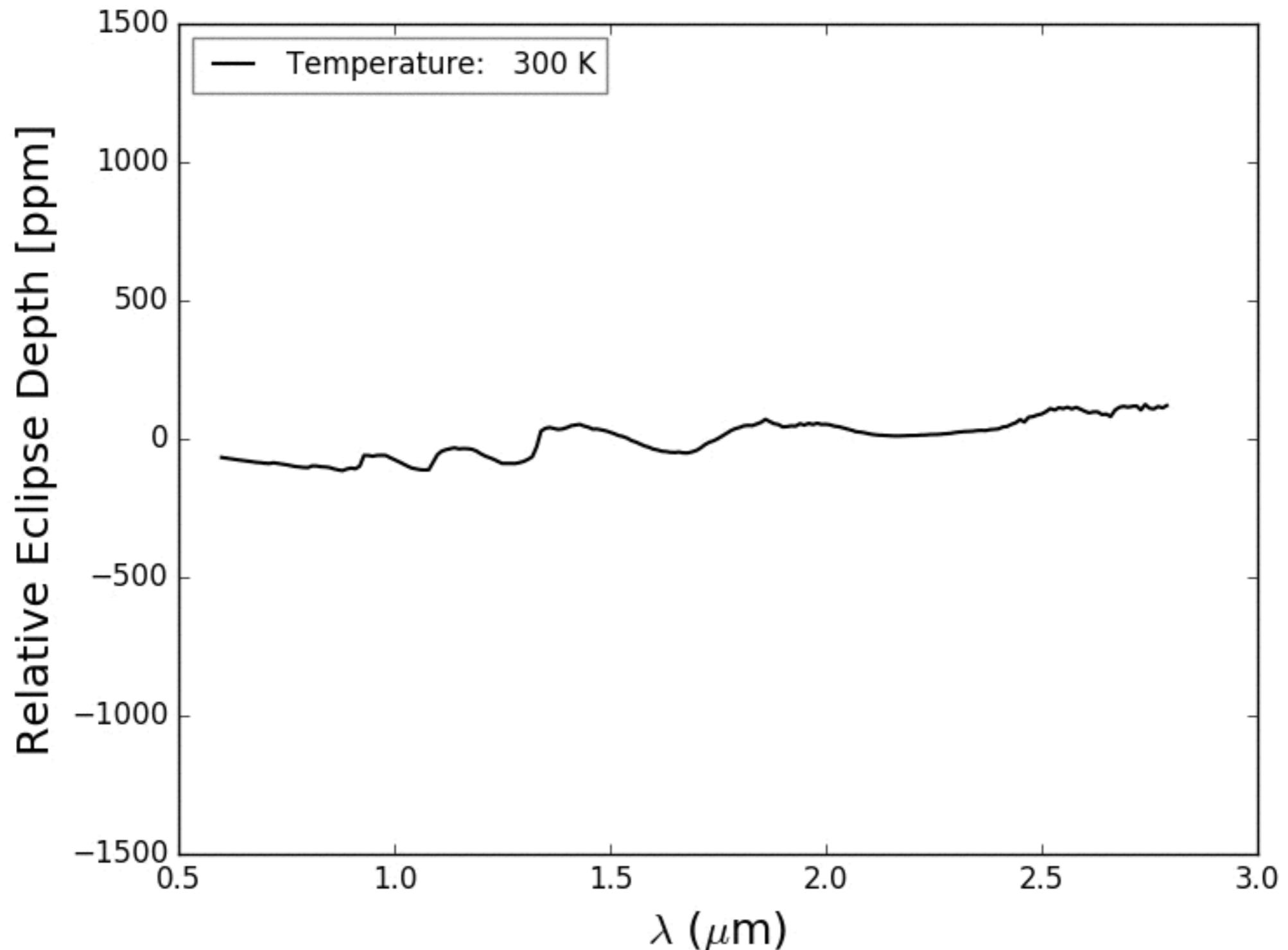
How do you like it?

- Temperature
- Water
- Molecules

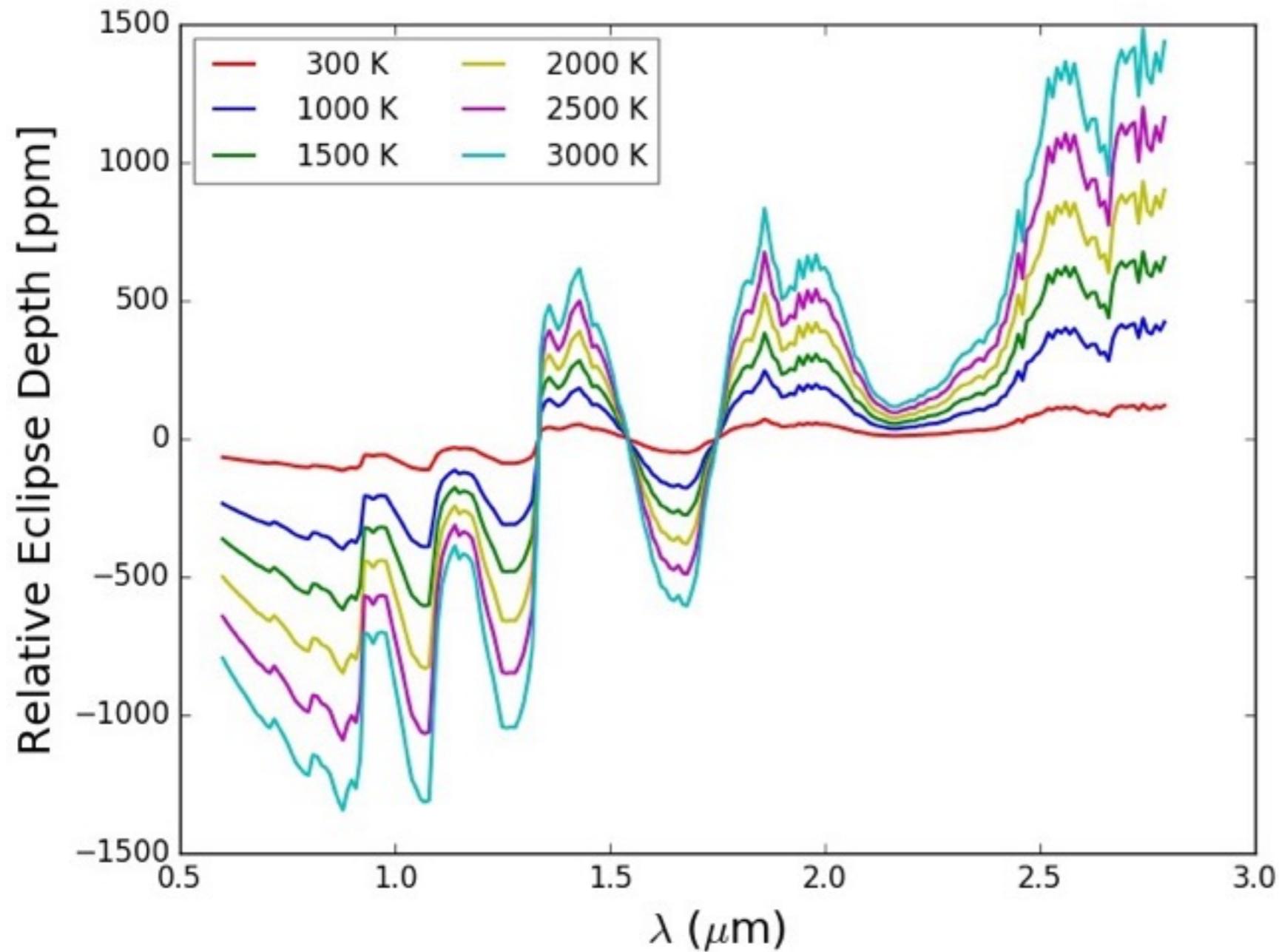
Dream Team

- Bin Ren - **Johns Hopkins**
- Clara Sousa-Silva - **UCL/MIT**
- Jesse Lopez - **CSUN**
- Lorenzo Pino - **University of Padova**
- Pinghui Huang - **Chinese Academy of Science**
- Jessica Roberts - **University of Colorado**
- Kyle Sheppard - **University of Maryland**

Spectra like it hot



Temperature dependence



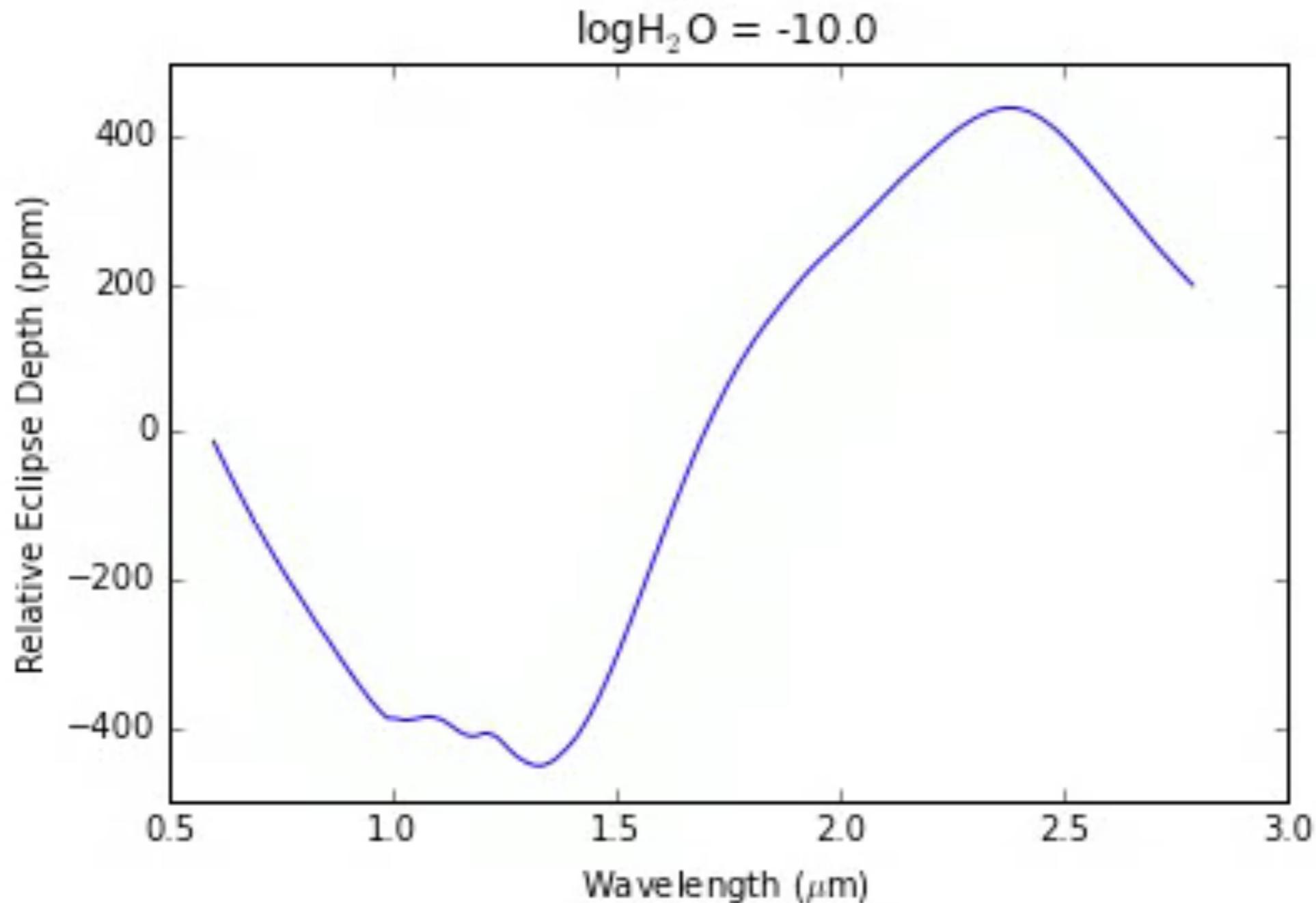
Absorption During Transit (%):

$$\frac{10R_p}{R_*^2} \left(\frac{kT_p}{\mu g} \right)$$

$$H = \frac{k_b T}{\mu g}$$

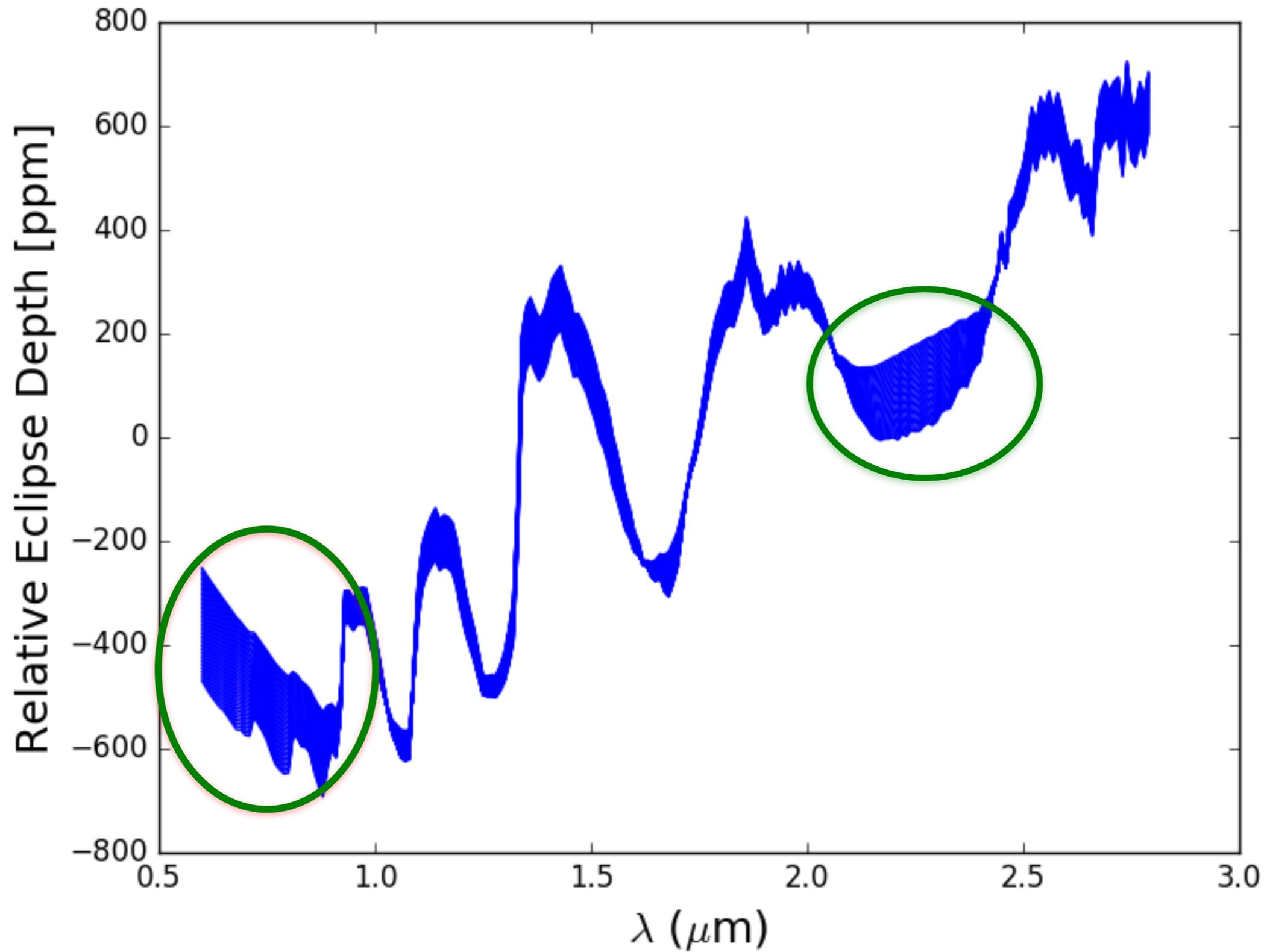
H.E: $n(z) = n_0 e^{-z/H}$

Spectra like it wet

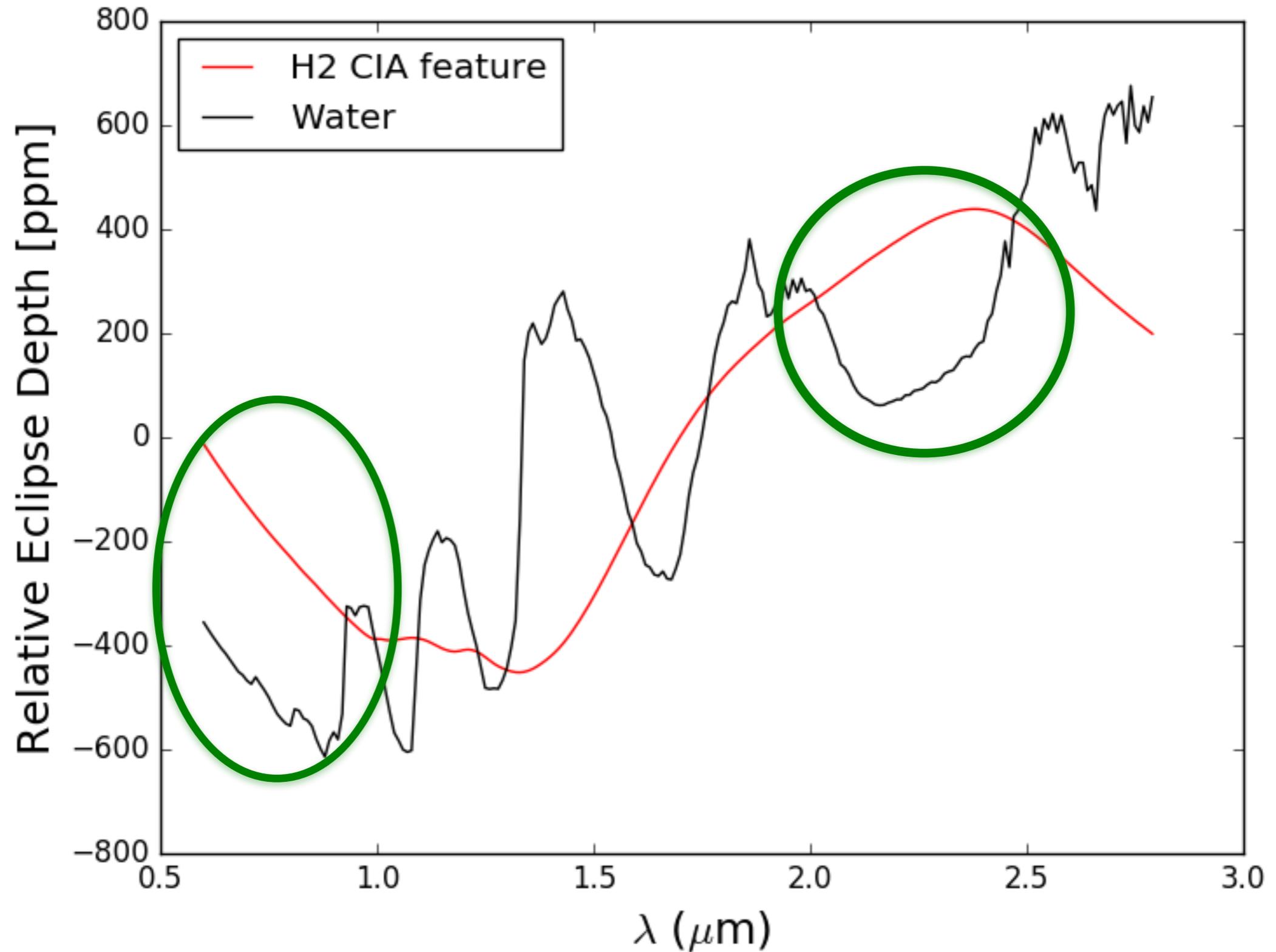


$$H = \frac{k_b T}{\mu g}$$

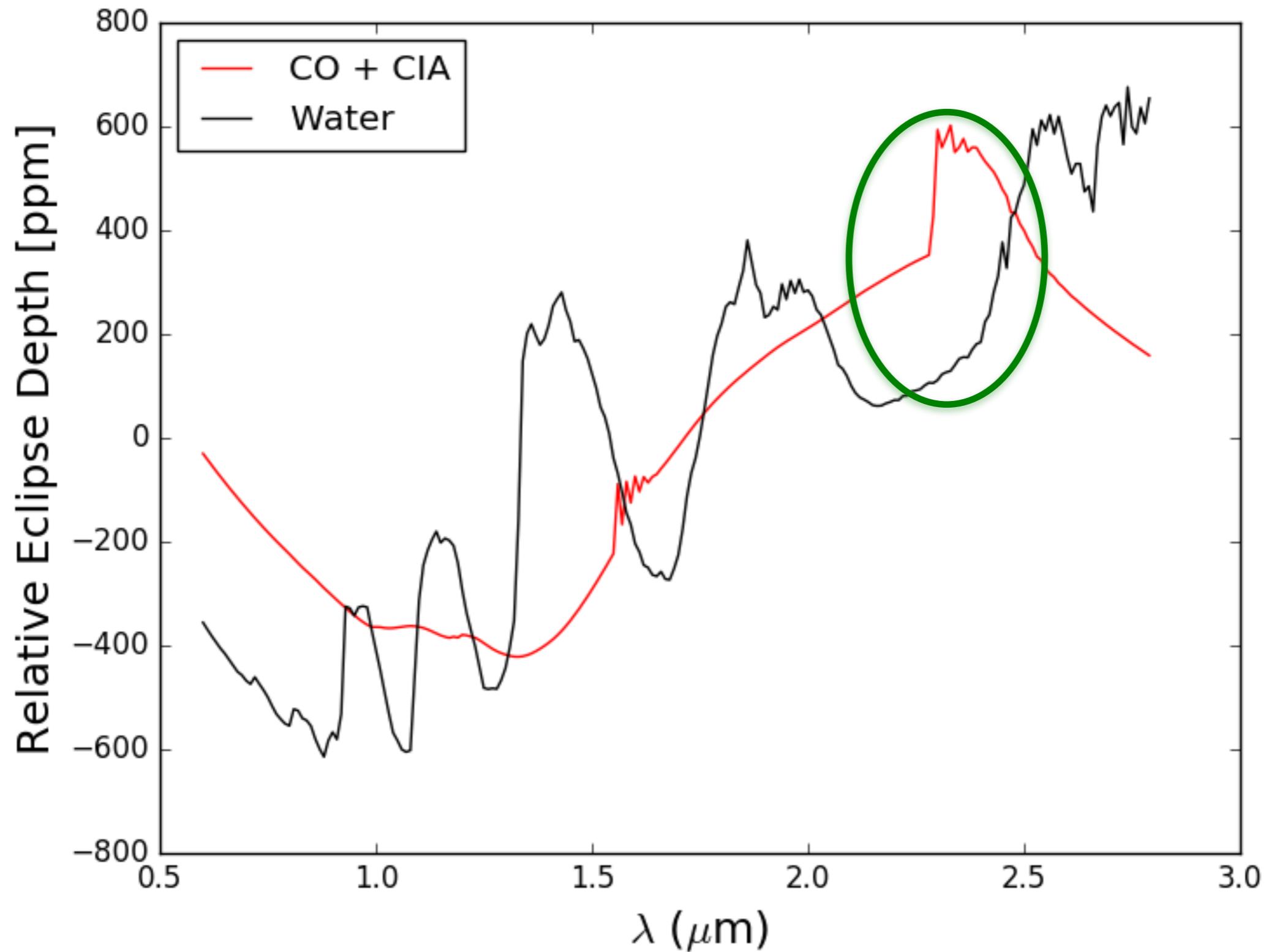
Sensitivity to H₂O Abundance



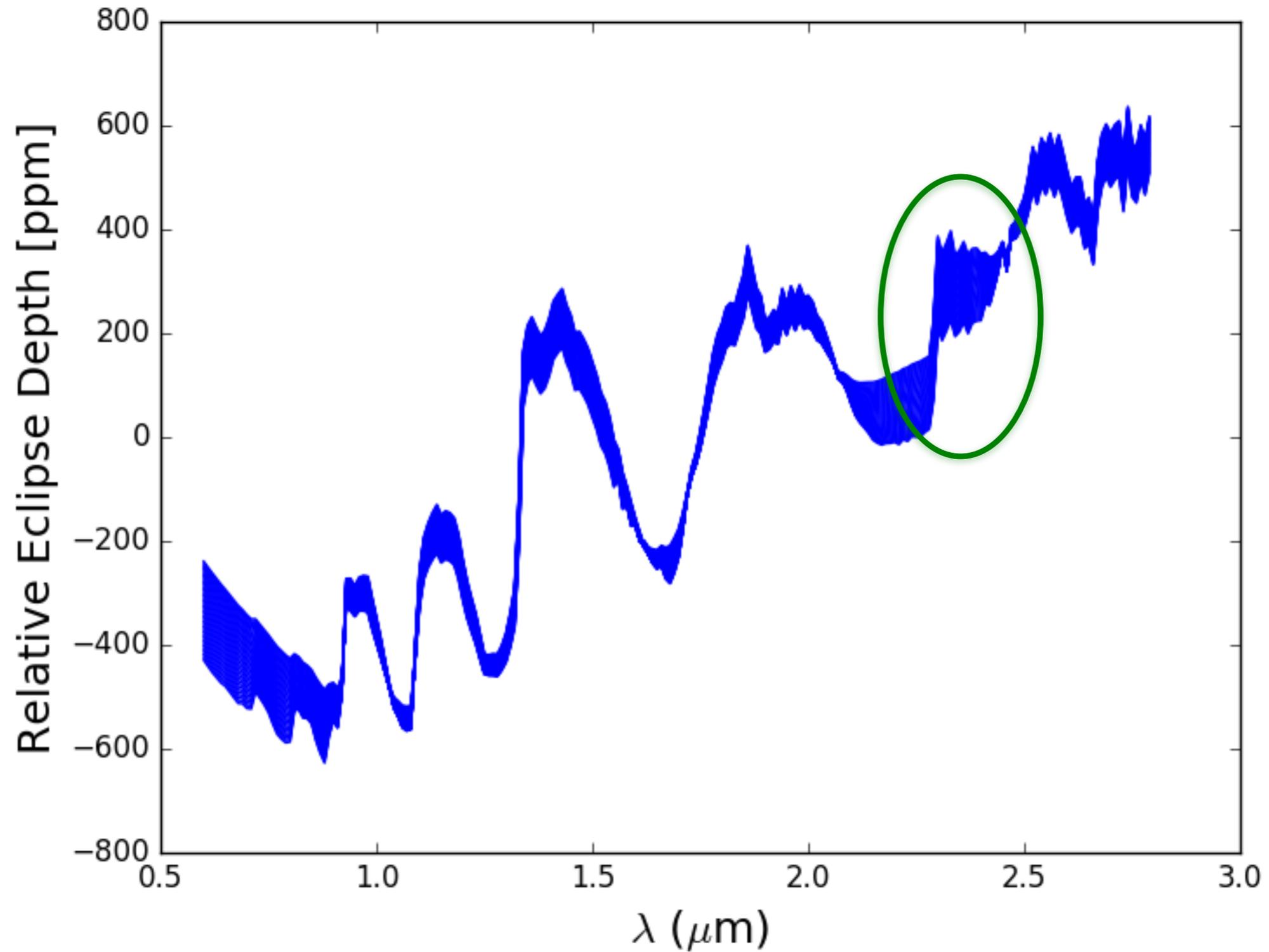
Sensitivity to H₂O Abundance



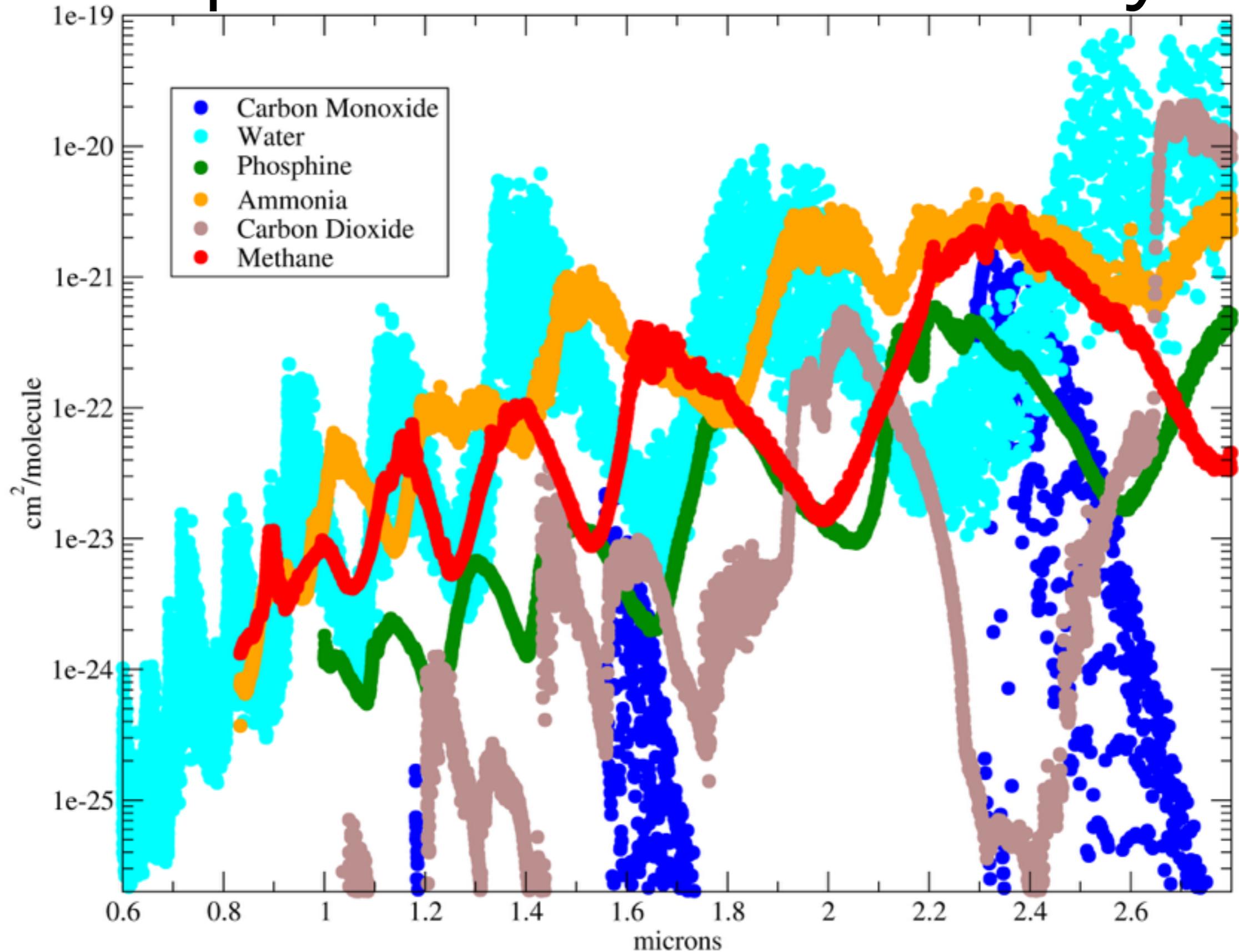
Sensitivity to H₂O Abundance



Sensitivity to H₂O Abundance



Spectra like it messy



www.exomol.com

The screenshot shows a web browser window with the URL www.exomol.com. The browser's address bar and tabs are visible at the top. The website header features the ExoMol logo and the tagline "High temperature molecular line lists for modelling exoplanet atmospheres". A search bar is located on the right side of the header. Below the header is a navigation menu with options: Data, About, Activities, Outreach, Contact, and Group Pages. A dropdown menu is open under "Data", showing options: "By Molecule", "By Data Type", and "Bibliography".

The main content area includes a welcome message: "Welcome to the new ExoMol website!". Below this, there is a paragraph: "The new ExoMol format is described in our open-access article, [The ExoMol database: Molecular line lists for exoplanet and other hot atmospheres](#). The database can be navigated from the [data page](#)." Another paragraph states: "ExoMol is a database of molecular line lists that can be used for spectral characterisation and simulation, and as input to atmospheric models of exoplanets, brown dwarfs and cool stars, and other models including those for combustion and sunspots."

A large image of a glowing, fiery planet is displayed below the text. To the right of the main content is a "Recent Tweets" section. It features two tweets:

- A tweet by Sergey Yurchenko (@TroveMaster) mentioning a paper on black holes published by Andrei Patrascu (former @ExoMol) with a link: <https://t.co/D341oheroF>, posted 1 day, 7 hours ago.
- A tweet by E J Barton (@EJ_astrogeo) presenting "Hot Molecular Line Lists for Extrasolar Planets and Industry" with the hashtag #PhDelphi and a link: <https://t.co/apPZvPjsnX>, posted 2 days, 9 hours ago.

The browser's taskbar at the bottom shows several open files: PairsPlot_CLEAR.pdf, Knutson_Sagan.pdf, Temperature.jpg, Tem.gif, and Line_Sagan.pdf. A "Show All" button is also visible in the taskbar.



Data / By Data Type

[By Molecule](#)

[By Data Type](#)

[Bibliography](#)

ExoMol: Molecules with Absorption cross sections

triatomic molecules

H₂O

CO₂

HCN

other diatomics

CS

other hydrides

OH

metal oxides

TiO

SiO

CaO

metal hydrides

TiH

larger molecules

CH₄

NH₃

H₂CO

PH₃

ions

H₃⁺

other oxides

CO

NO

Cross section data for $^{31}\text{P}^1\text{H}_3$

Reminder: the cross sections provided by this page are calculated at **zero-pressure** (*i.e.* Doppler-broadened lines only). If you enter your email address below it will only be used to inform you of fixes to the service in case it fails. Alternatively, please email christian.hill@ucl.ac.uk.

The default format of the .sigma data file is a single column of cross section points (in cm^2/molec), one for each wavenumber bin selected, starting at ν_{min} and spaced by $\Delta\nu$. Select two-column output below if you want each cross section point preceded explicitly by the wavenumber at the centre of the bin it applies to.

$\Delta\nu$:

ν_{min} (0 - 10000 cm^{-1}):

ν_{max} (0 - 10000 cm^{-1}):

T (296 - 1500 K):

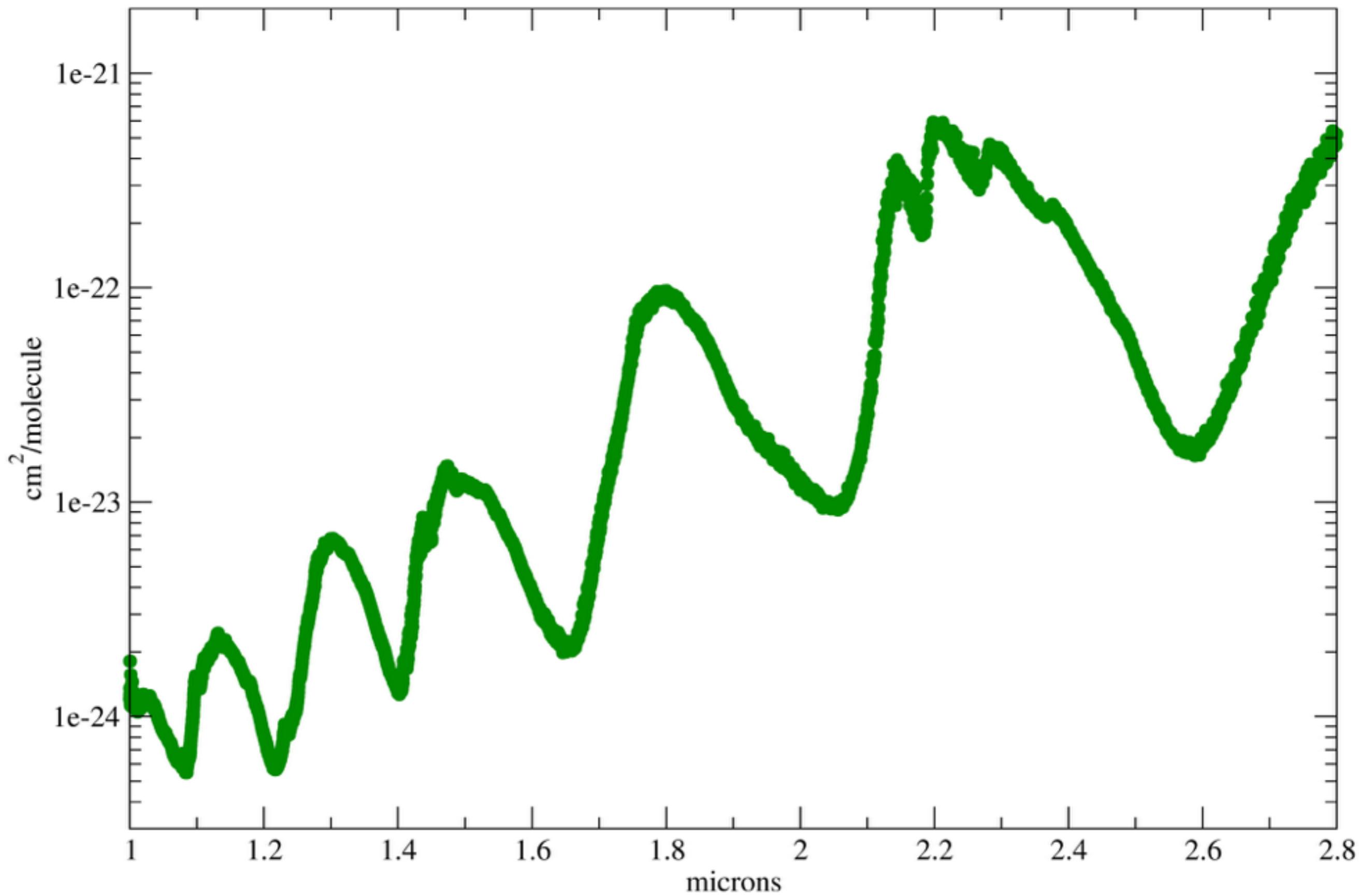
Two-column output: ν and σ :

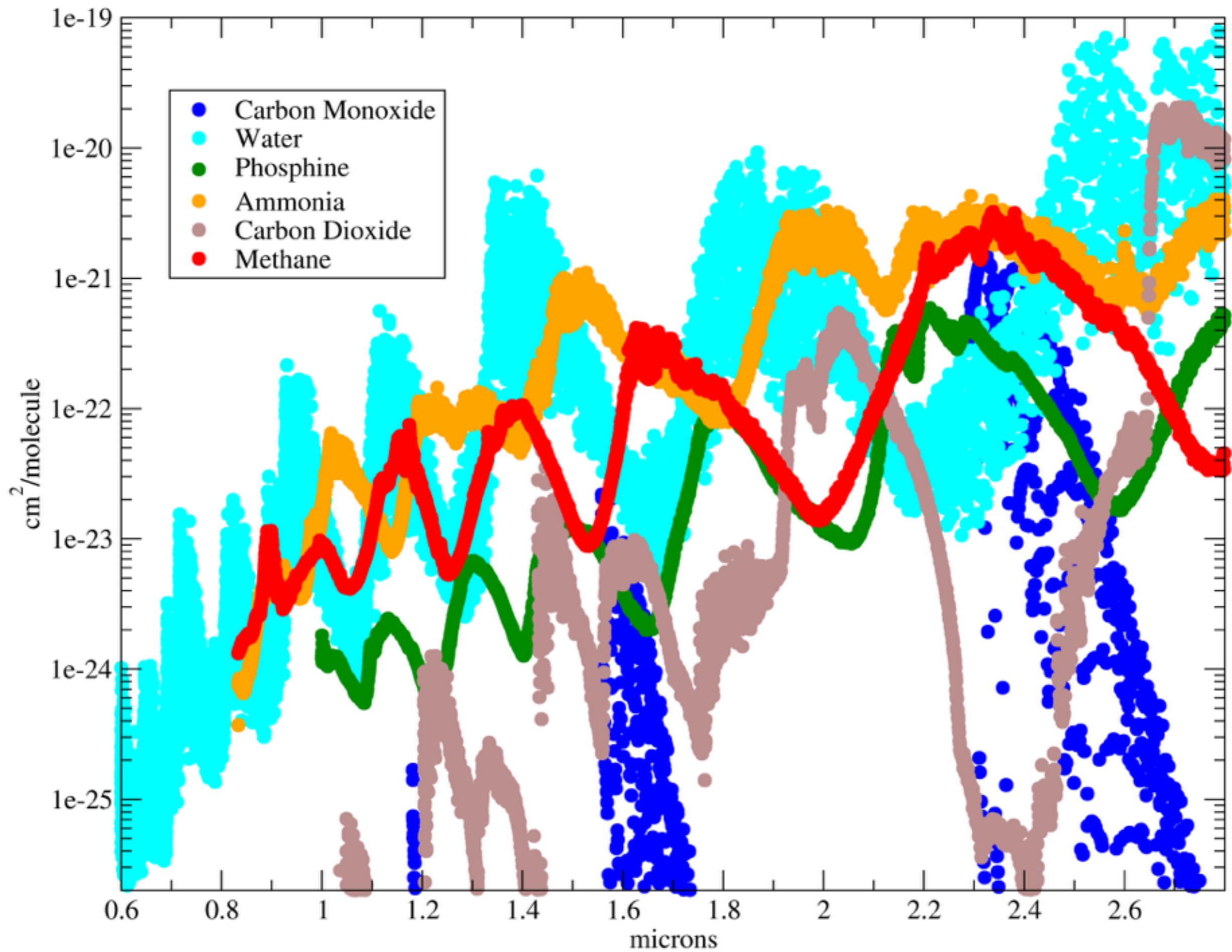
Submit

Online absorption cross section service: this cross section has been generated from data in the SAITY PH_3 calculated line list [Sousa-Silva *et al.* (2015)] for the ExoMol project [Tennyson and Yurchenko (2012)] using the procedure described in [Hill *et al.* (2013)].

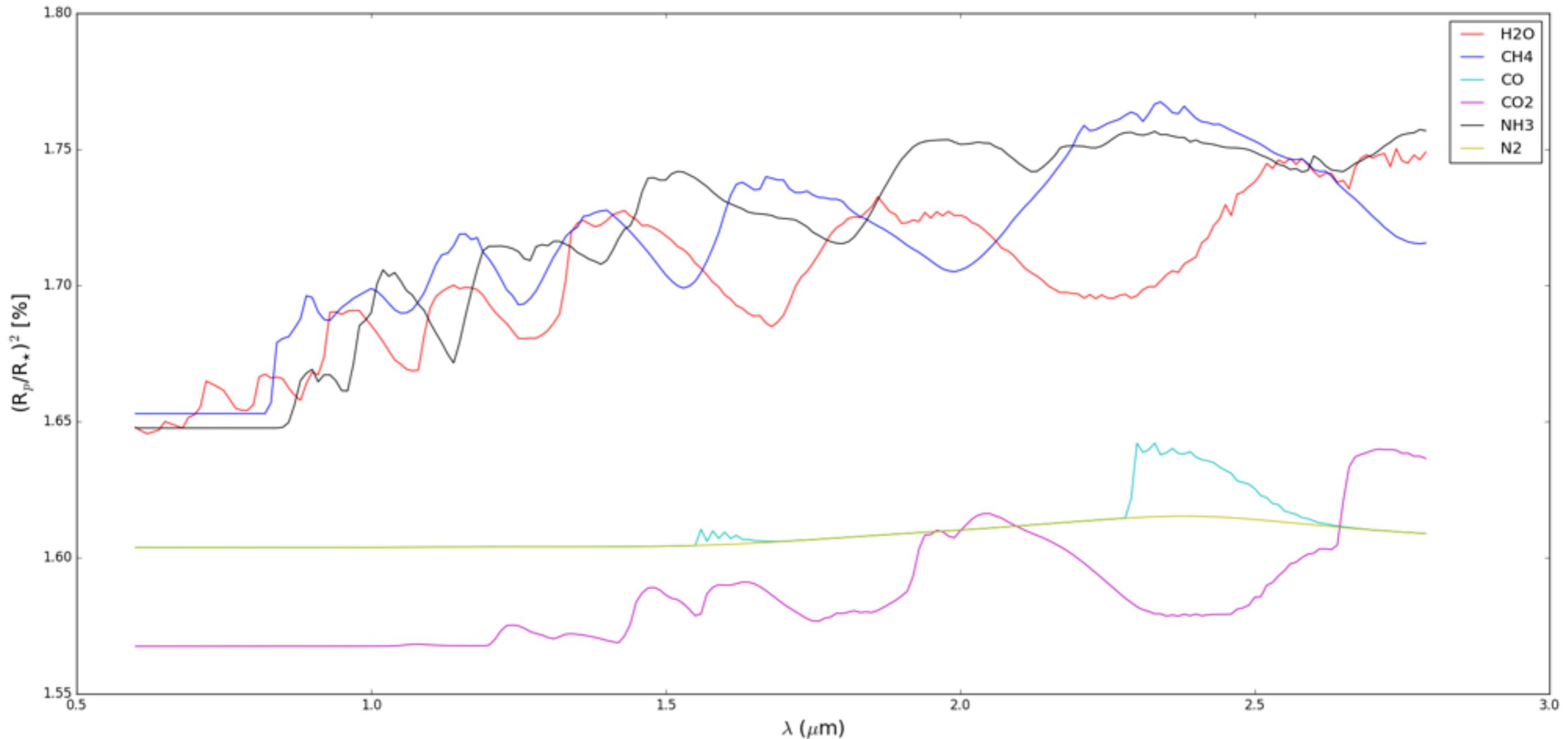
References

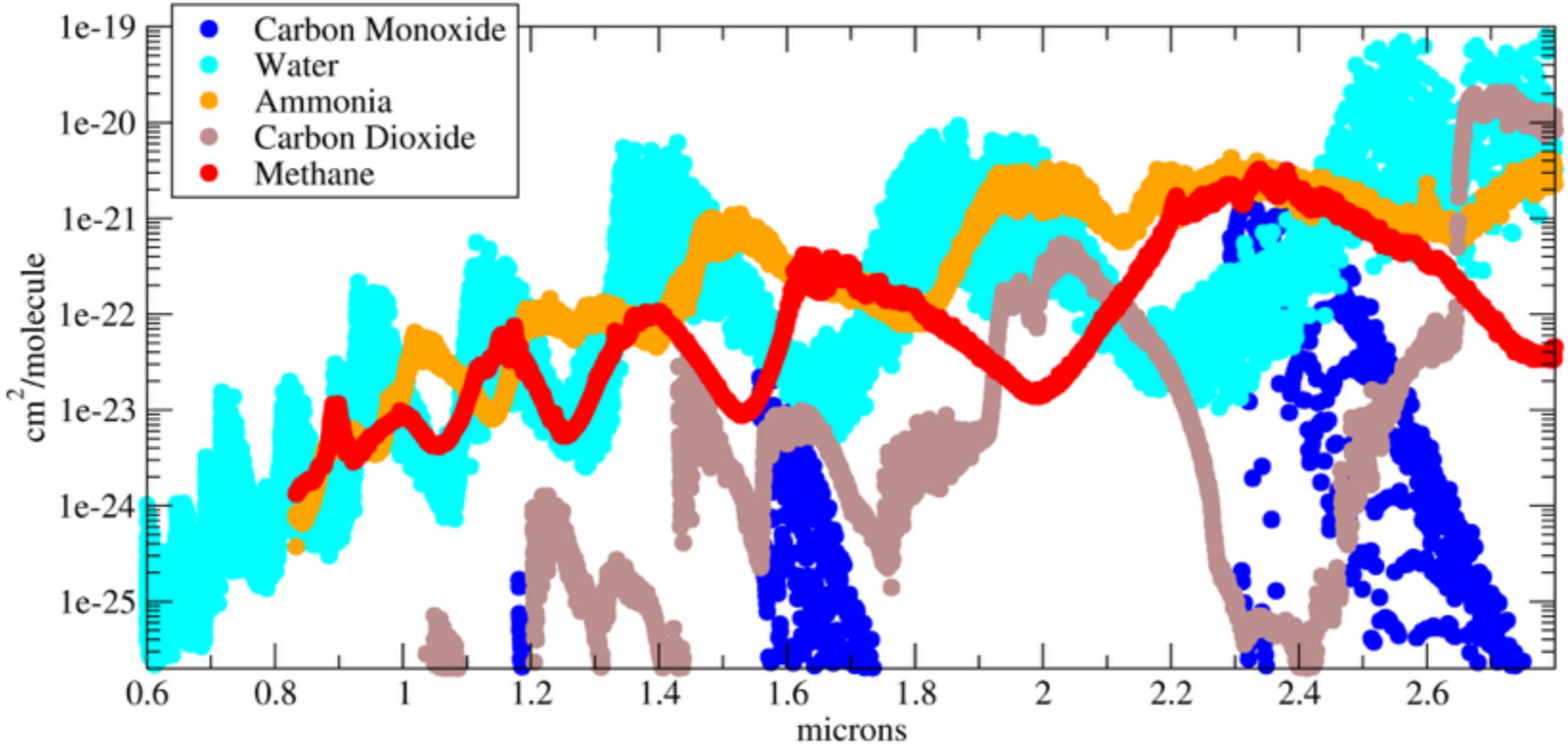
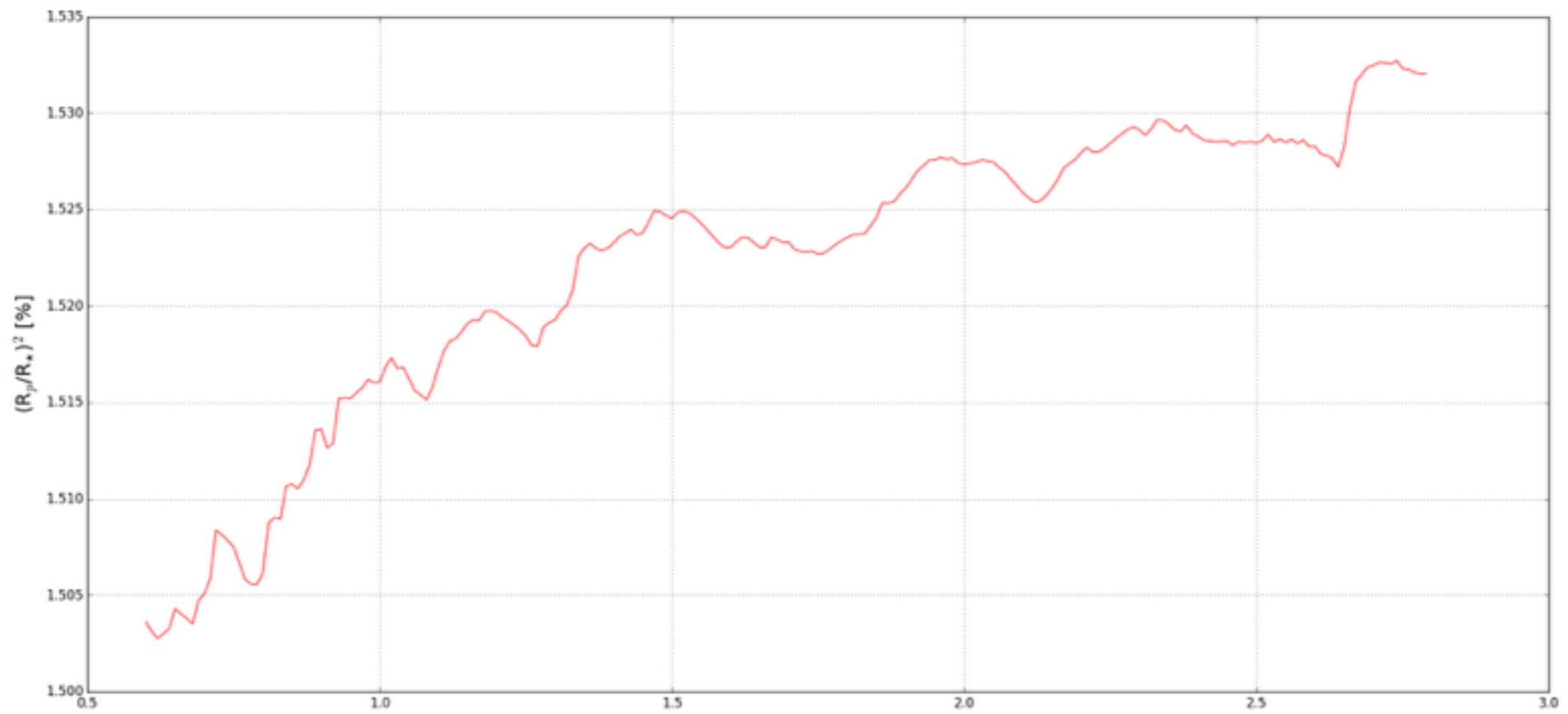
1. C. Hill, S. N. Yurchenko, J. Tennyson, "Temperature-dependent molecular absorption cross sections for exoplanets and other atmospheres", *Icarus* **226**, 1673-1677 (2013). [[link to article](#)]
2. C. Sousa-Silva, A. F. Al-Refaie, J. Tennyson and S. N. Yurchenko, "ExoMol line lists VII: The rotation-vibration spectrum of phosphine up to 1500 K", *Monthly Notices of the Royal Astronomical Society* **446**, 2337-2347 (2014). [[link to article](#)]





Atmospheric Composition - Extremes





We hope you liked it

Take Home Points

- Spectral features are temperature dependent.
- Higher temperatures -> bigger features (assuming constant composition).
- More water means more water features, but there are negative trade-offs with increasing mean molecular weight.
- Most significant spectral features depend on ratio of molecular abundances.
- Use good molecular data or your model will be wrong.

We hope you liked it



2016 Sagan Summer Workshop, July 18 – 22, Pasadena