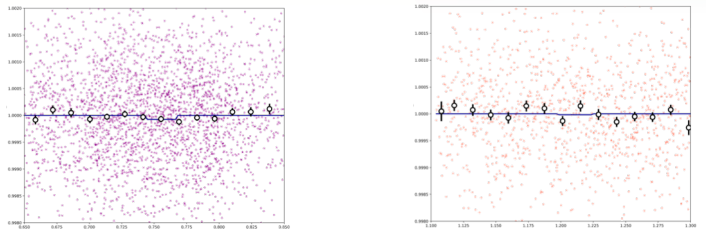


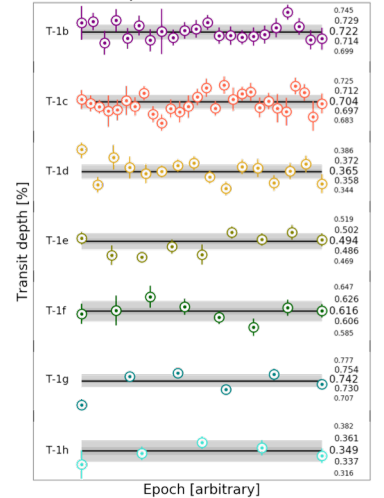
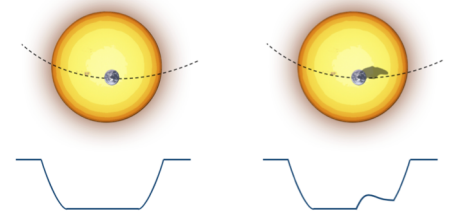
Global results of the Spitzer Exploration Science Program red worlds

About the transiting objects

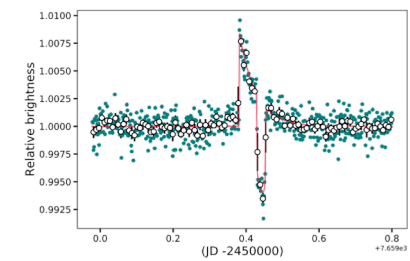
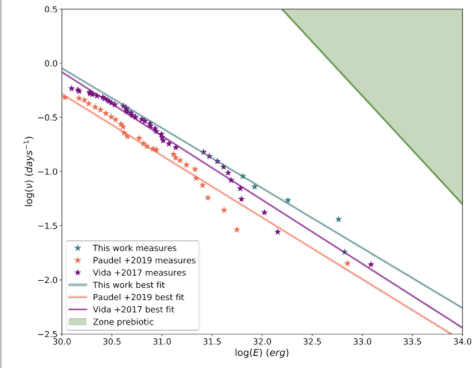
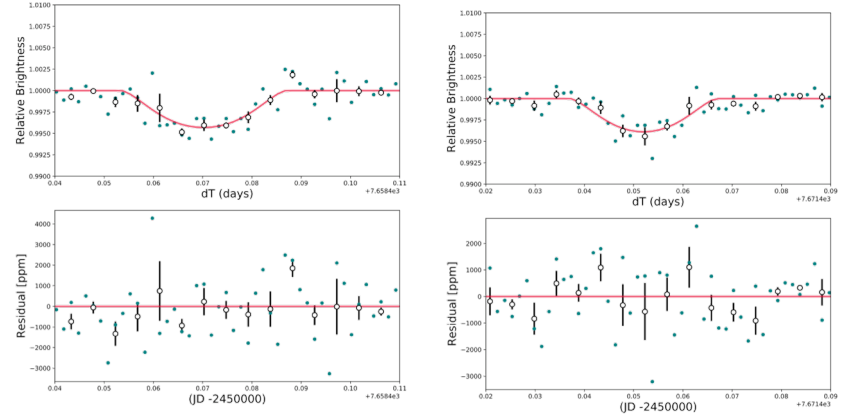


No occultation signal, but an upper limit on the brightness temperature of planet b and c

About the star

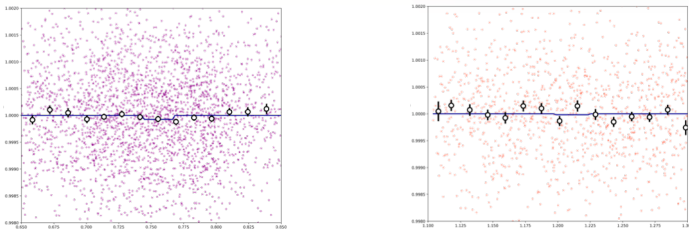


Orphans ?



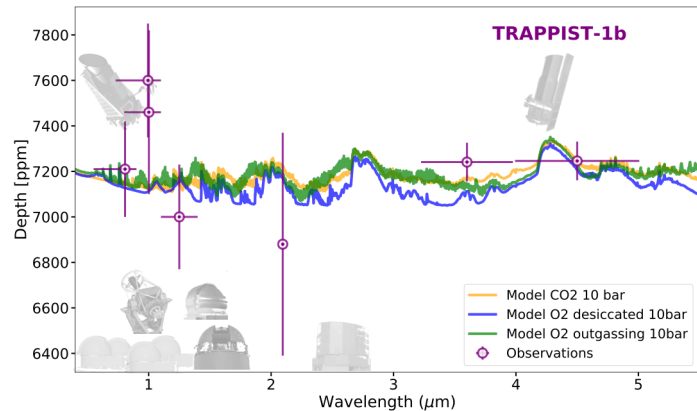
Global results of the Spitzer Exploration Science Program red worlds

About the transiting objects

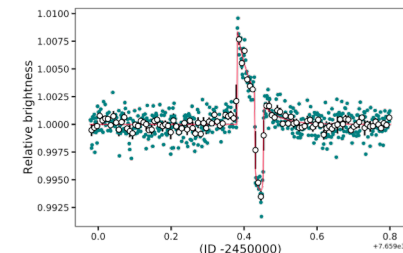
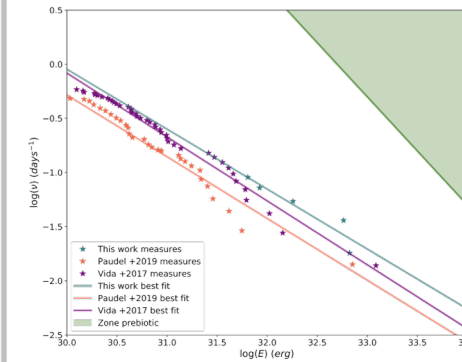
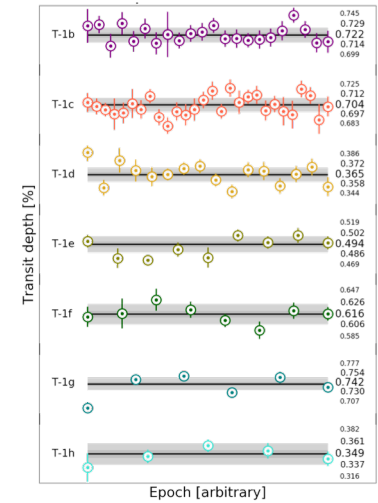
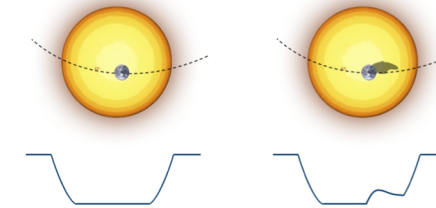


No occultation signal, but an upper limit on the brightness temperature of planet b and c

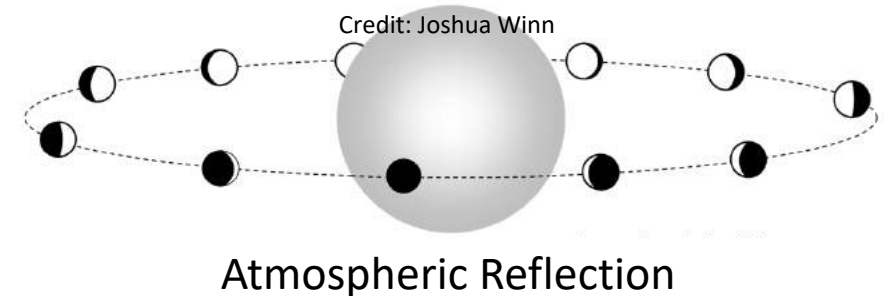
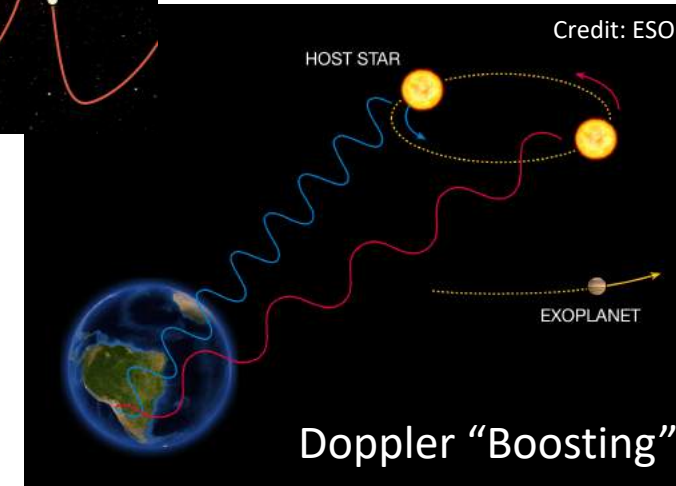
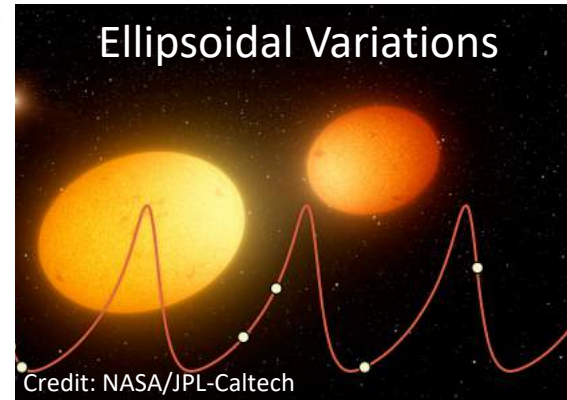
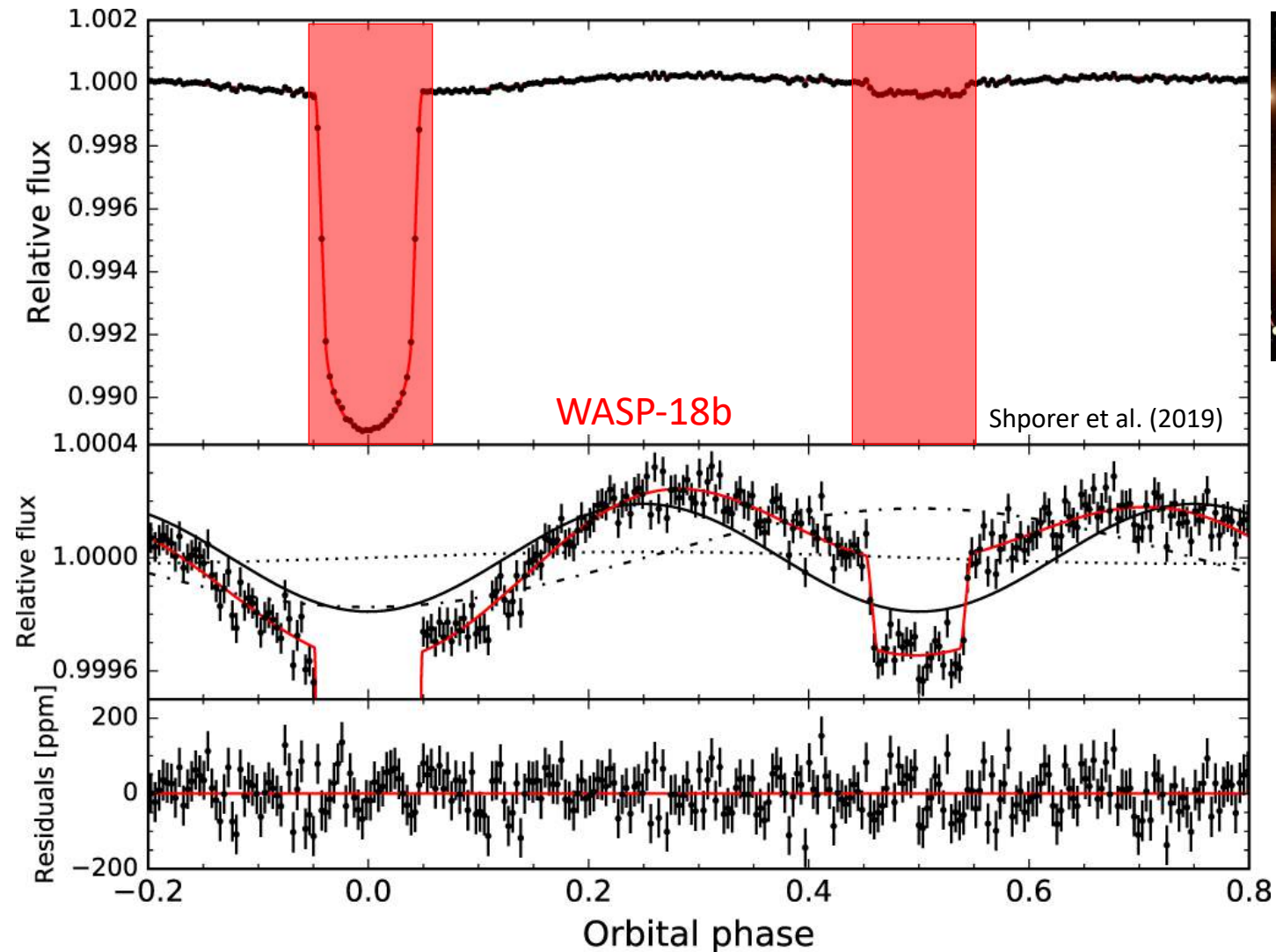
Broadband transmission spectra



About the star



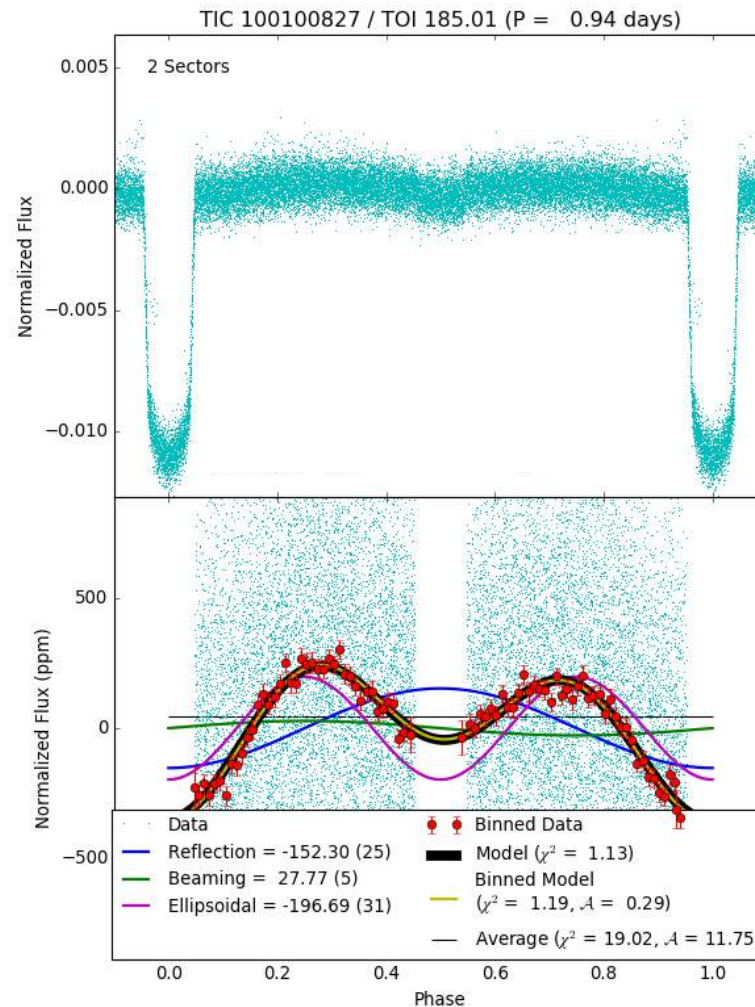
Exoplanet Characterization using Phase Variations Observed by TESS – Tara Fetherolf (UC Riverside)



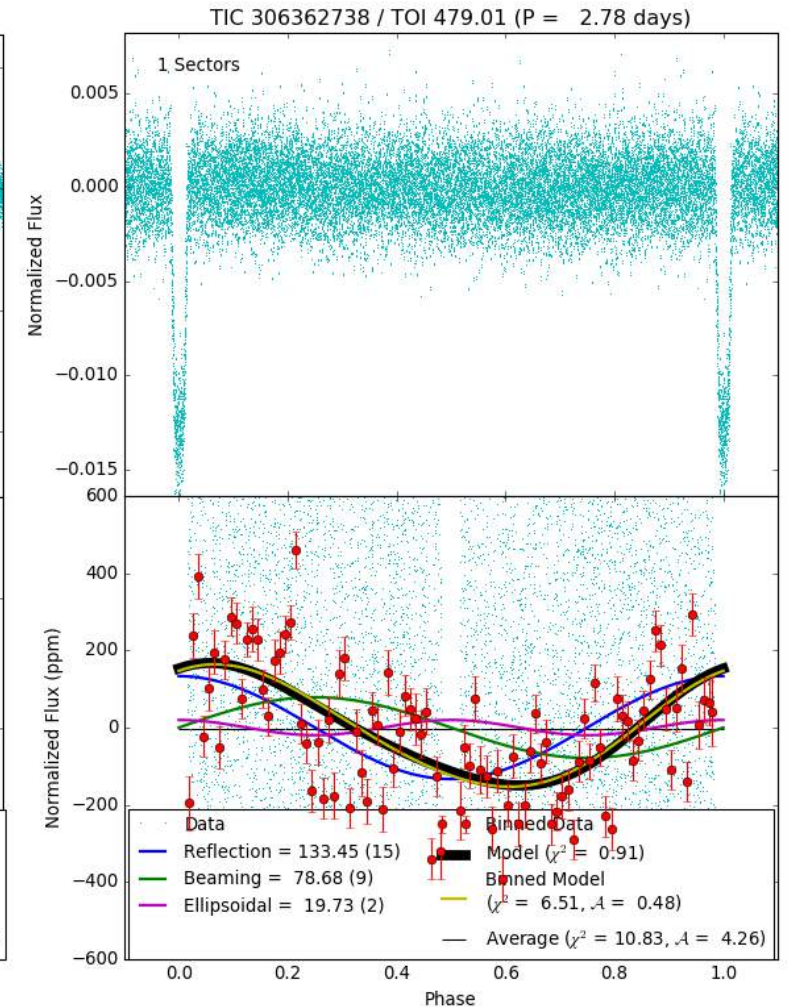
Exoplanet Characterization using Phase Variations Observed by TESS – Tara Fetherolf (UC Riverside)

- Constrain exoplanet masses and atmospheric properties
- Planet candidate vetting
- Investigate atypical phase variation signatures

WASP-18b

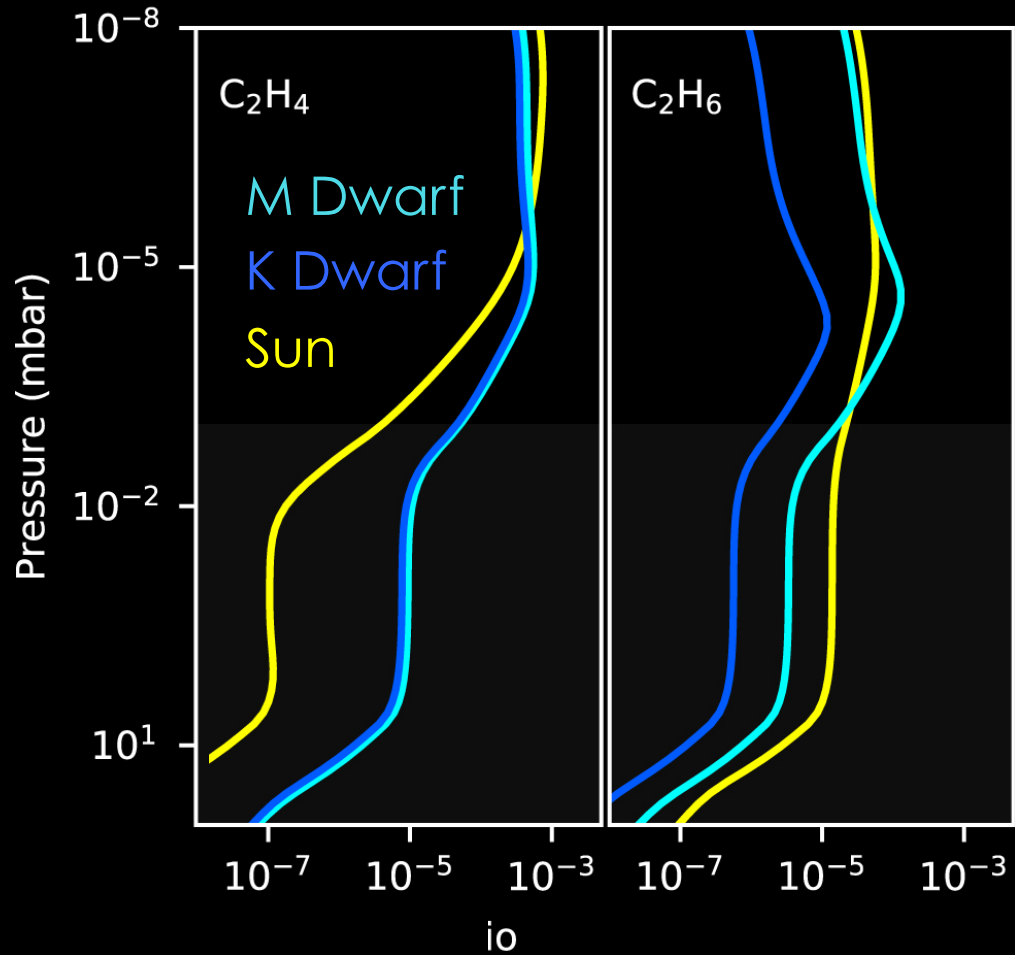


WASP-49b

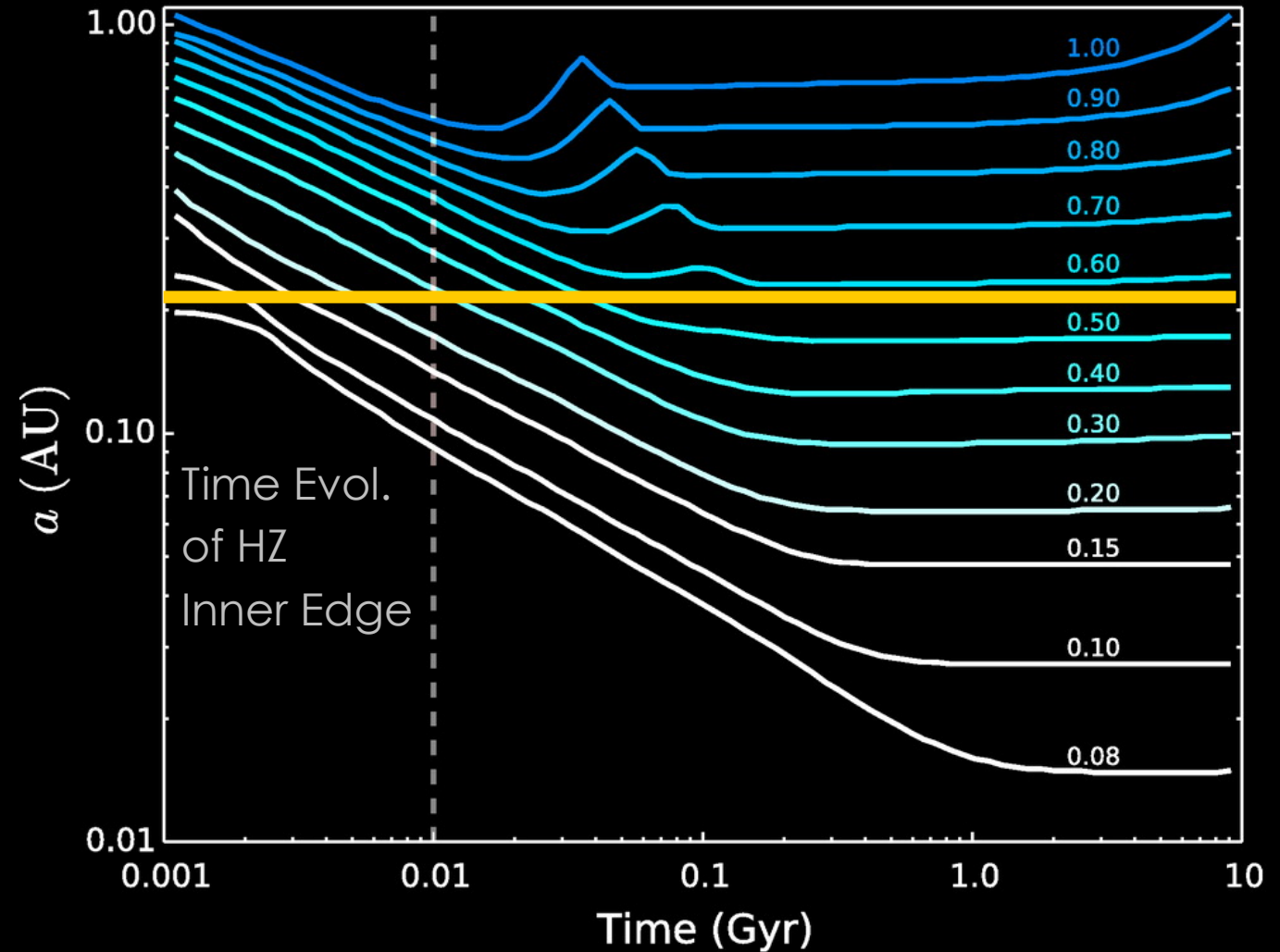


Characterizing ExoTitans with LUVVOIR

Peter Gao, Ryan Felton, Juan Lora, Tiffany Kataria, Giada Arney, Shawn Domagal-Goldman

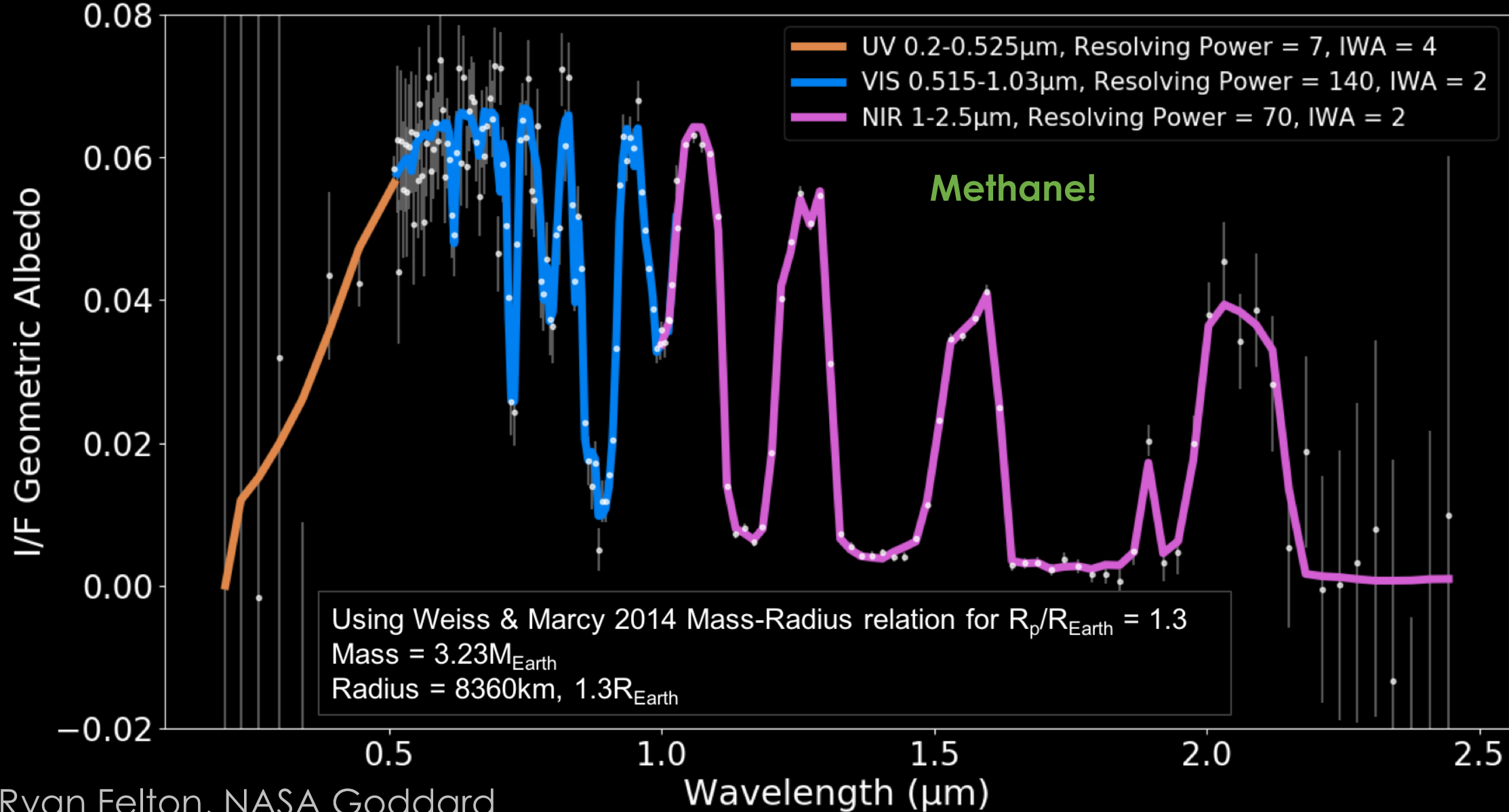


Lora et al. (2018)



Luger & Barnes (2015)

LUVOIR-A Direct Imaging Reflectance Spectrum Titan-like Barnard's Star B



NEID (NN-EXPLORE Exoplanet Investigations with Doppler Spectroscopy)

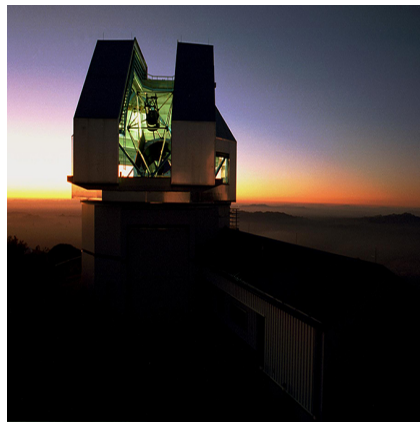
NEID will...

- be a fixture at WIYN (3.5m), Kitt Peak
 - ▶ observe 380-930nm
- look for Earth-like planets around Sun-like stars
- be the most sensitive spectrograph of its kind
 - ▶ $\lesssim 27\text{cm/s}$ level of precision
 - ▶ optimally reach $\sim 10\text{cm/s}$

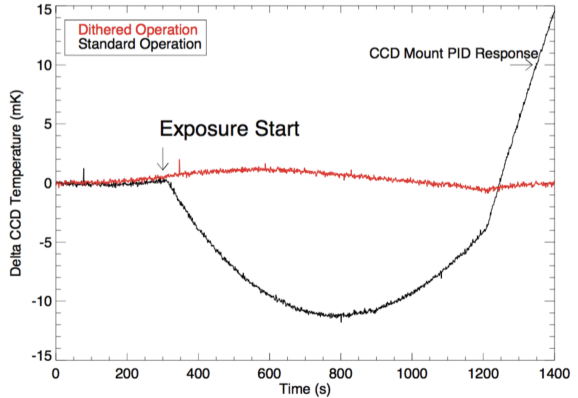
For reference...

- Jupiter induces RV of 12.4m/s
- Earth induces RV of 10cm/s

The WIYN Telescope



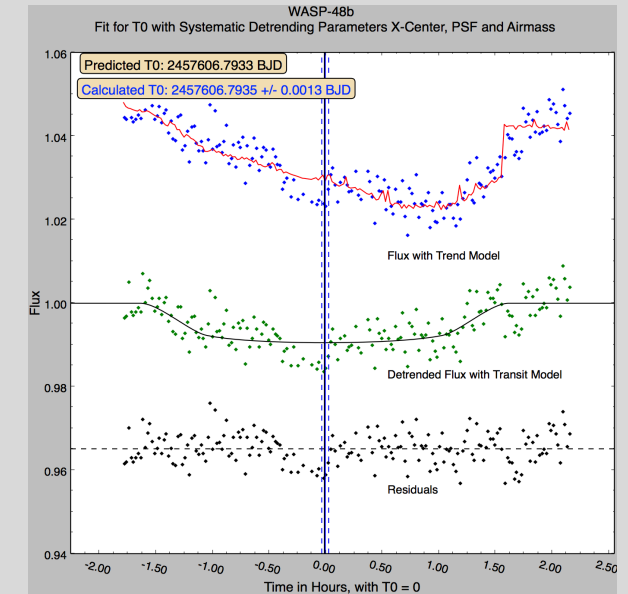
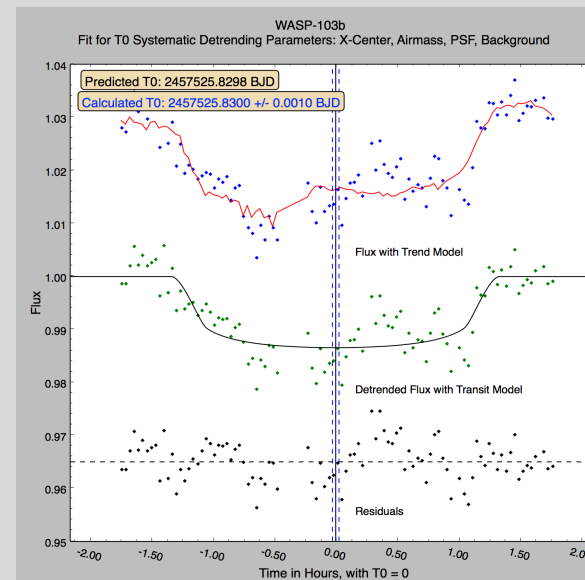
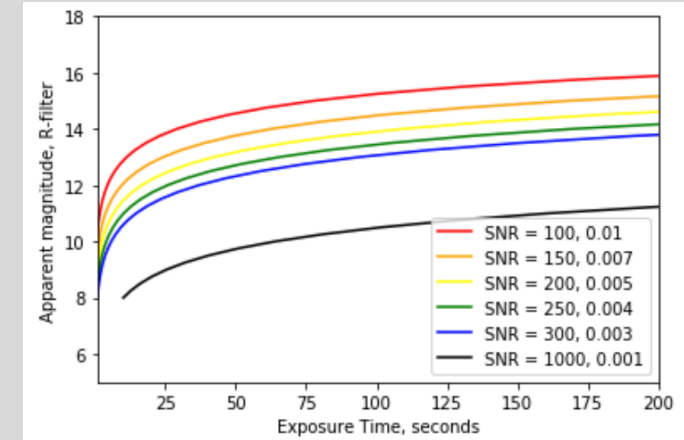
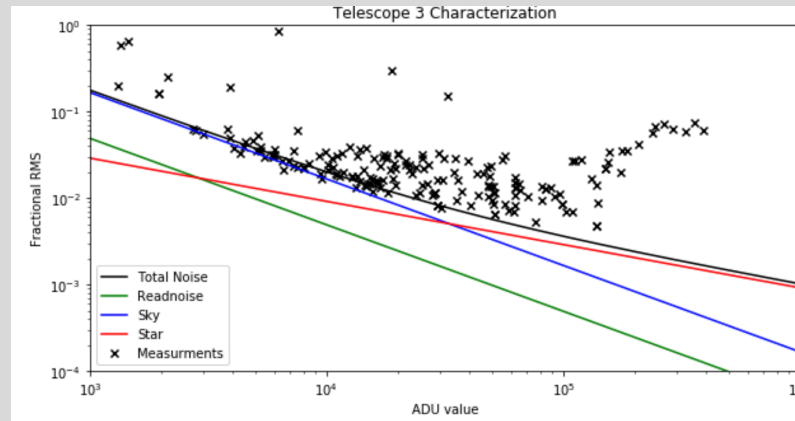
Dithering



Optimizing University Telescopes for TESS SG1

--Sean McCloat¹--

- Two 16" (0.4 m) SCTs
- FLI16803 & Apogee U9000
- 30' x 30' FOV, F/10
- UBVR-I-RGB filters
- Characterizing photometric precision
- TESS SG1 – Seeing Limited Photometry
- Simulate transits, combine observations
- Collaboration with Physics telescopes
- Make case for larger telescope



Observation

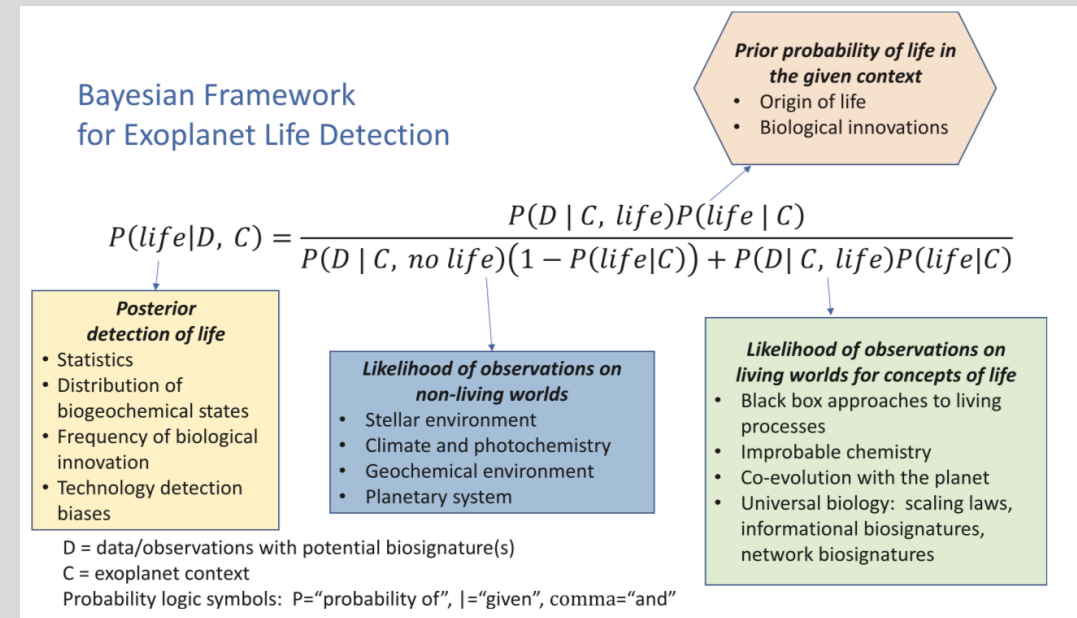
- Working with Dr. Carolina von Essen (Aarhus University) on high resolution transmission spectroscopy

Sean McCloat
spmccloat "at" gmail.com

Come talk to me!

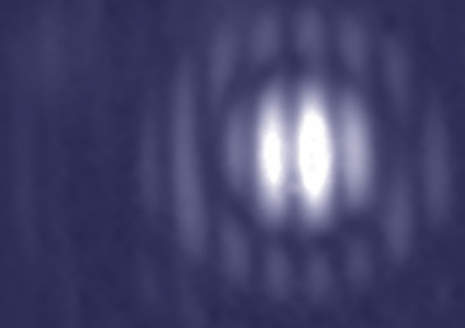
Theory

- Biosignatures in multi-planet systems!



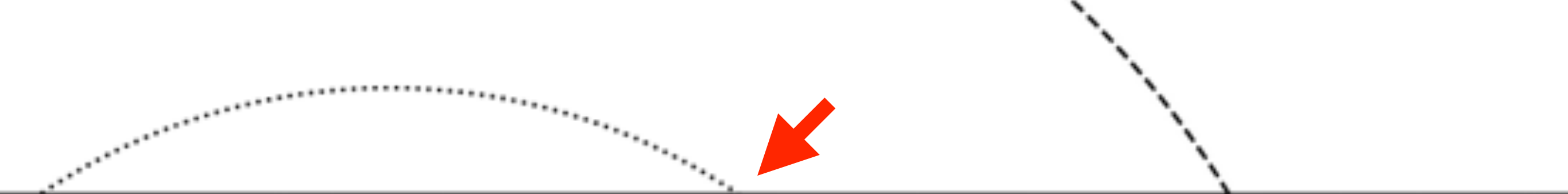
From Kiang, N. Y., et. al (2018). Exoplanet Biosignatures: At the Dawn of a New Era of Planetary Observations. *Astrobiology*.

Investigating Planetary Environments with the LBT Interferometer



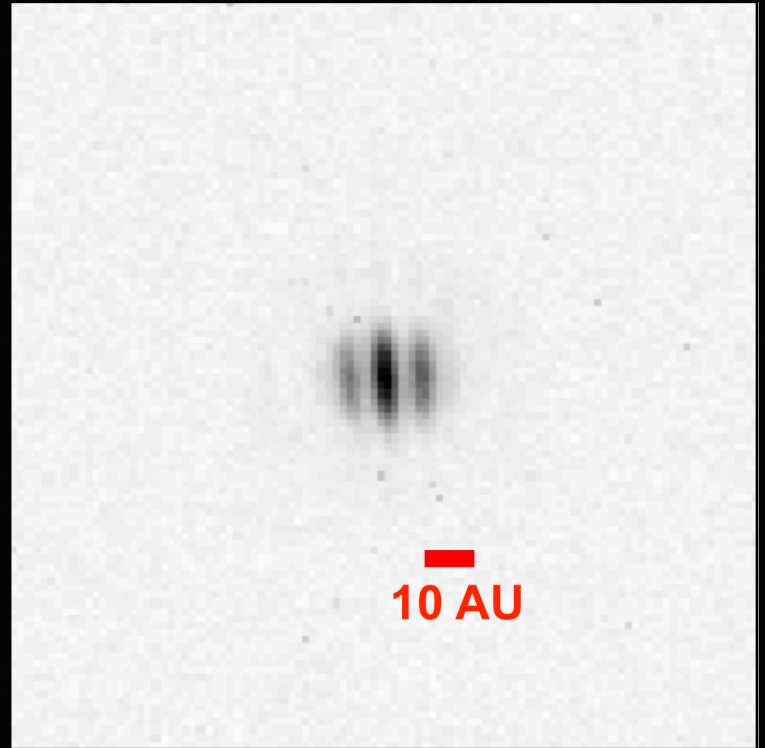
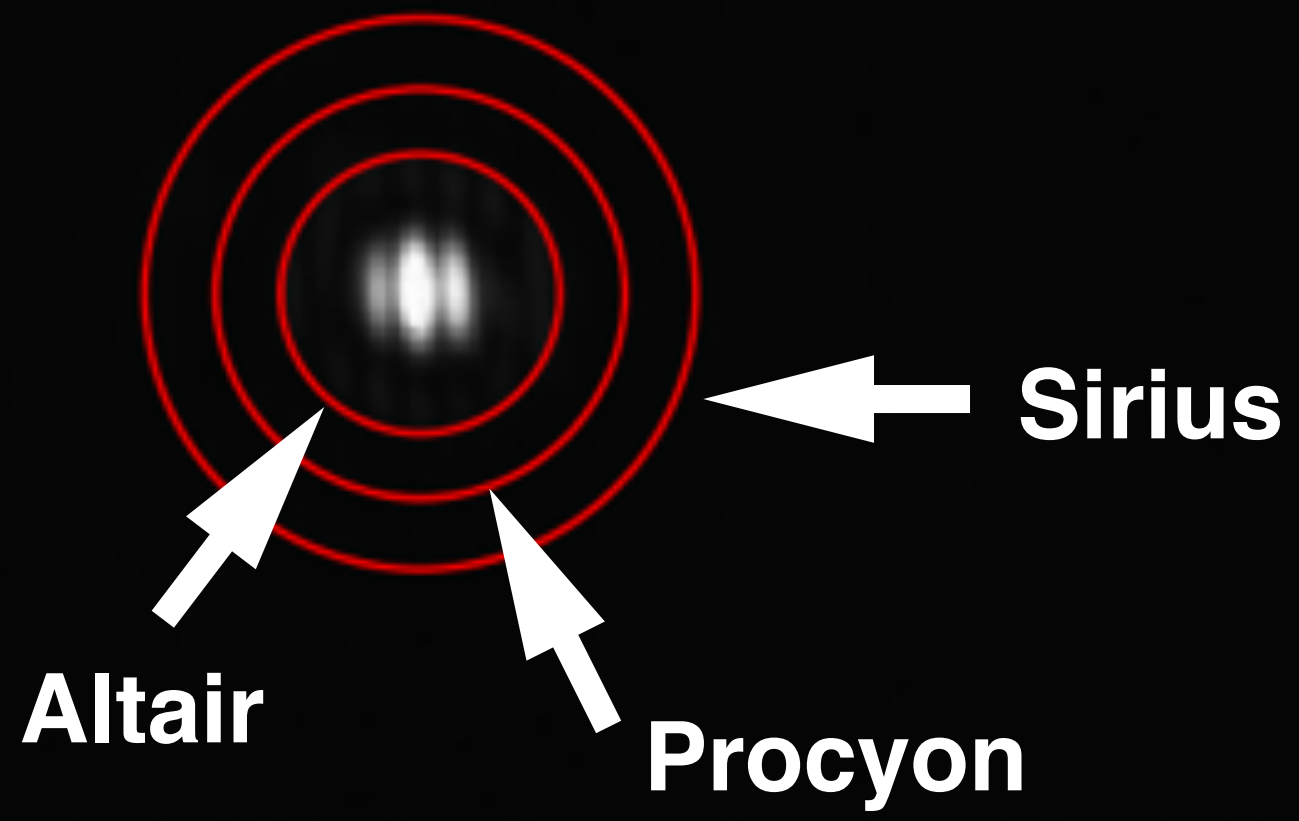
**Eckhart Spalding, 5/6th-yr grad student
University of Arizona
Sagan Exoplanet Summer Workshop, 2019**

*LBT image:
John Hill / LBTO*



AO control radius

1AU orbits

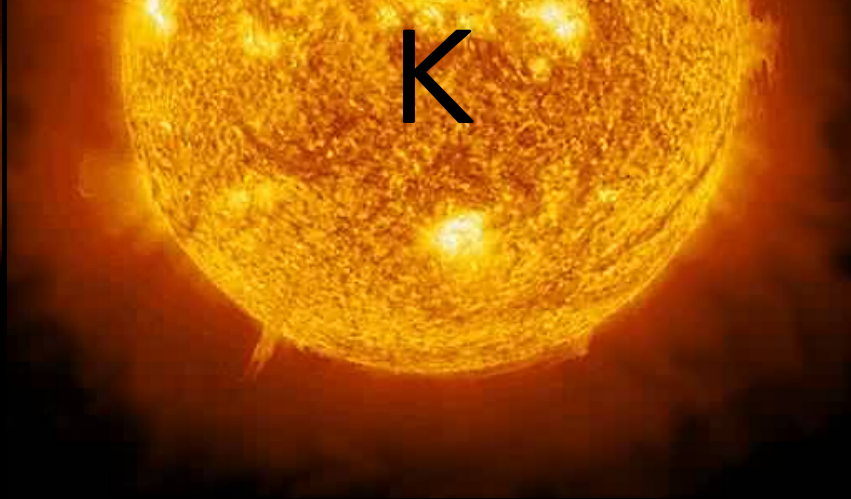
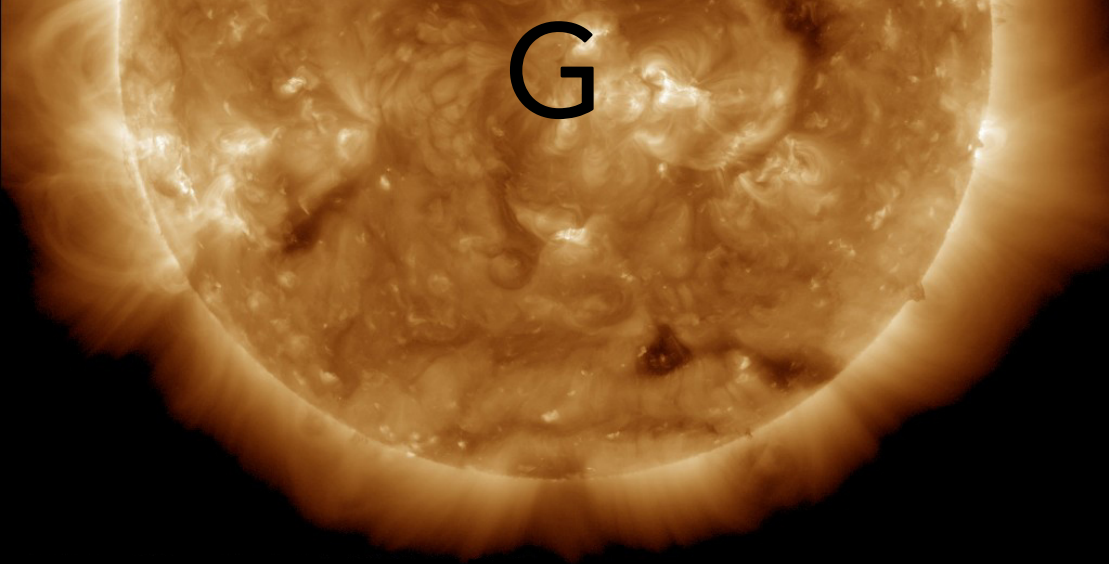


Exploring Giant Planets & Exomoons in the Habitable Zone

Sagan Summer Workshop 2019

Michelle Hill





6.5% ± 1.9

11.5% ± 3.1

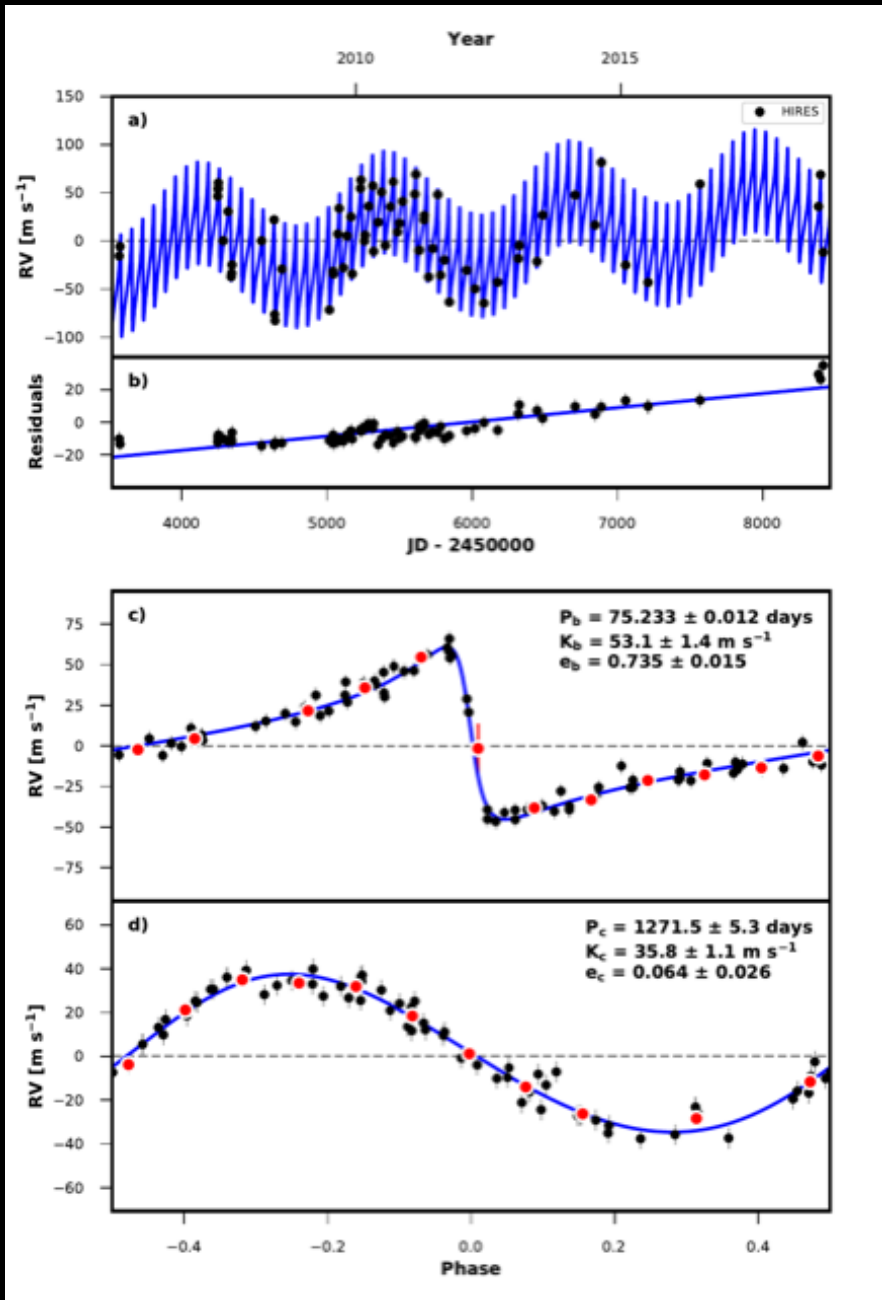
6% ± 6

2-22%

2-22%

~20%

Frequency of Giant Planets 3.0 - 25 R_⊕ in the HZ



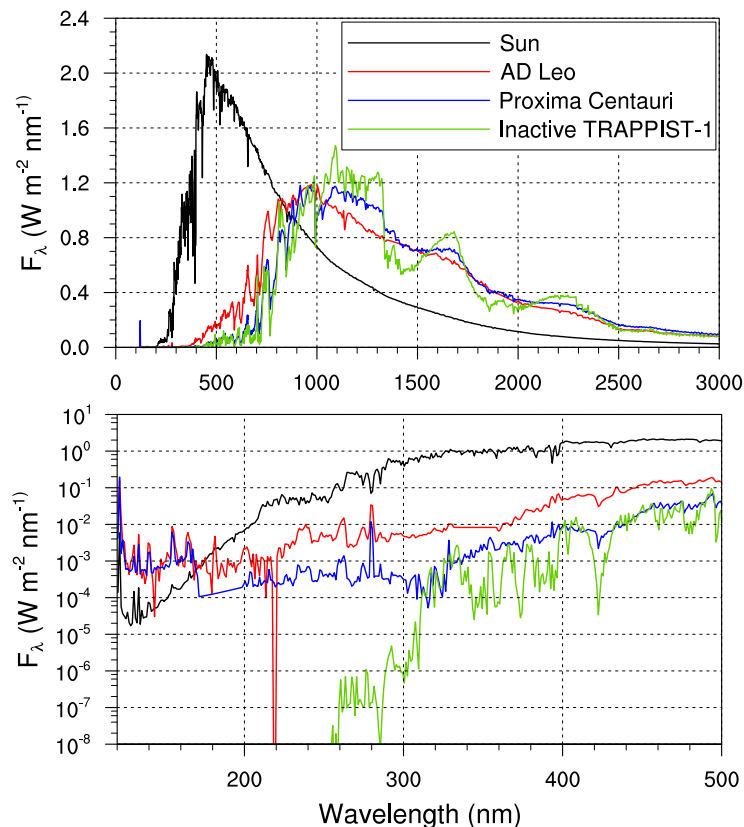
Fulton et al. 2018

Three-Dimensional Ozone Distributions on Tidally Locked Earth-Like Planets

Yangcheng Luo, Yongyun Hu, Jun Yang

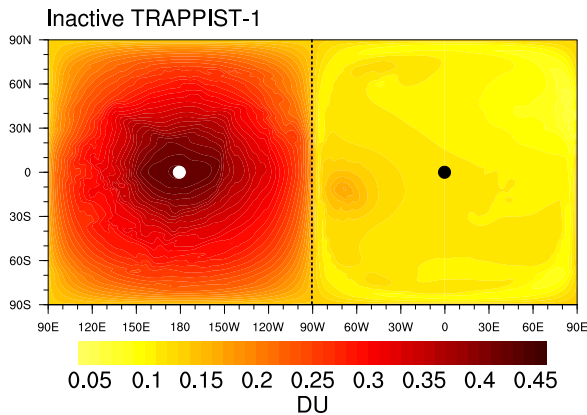
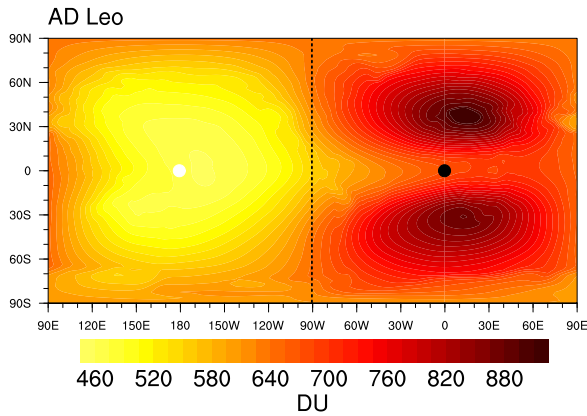
Department of Atmospheric and Oceanic Sciences, School of Physics, Peking University

- The search for extrasolar life: Ozone absorption lines indicate an oxic atmosphere
- Variability in UV activity of M dwarfs affects ozone chemistry

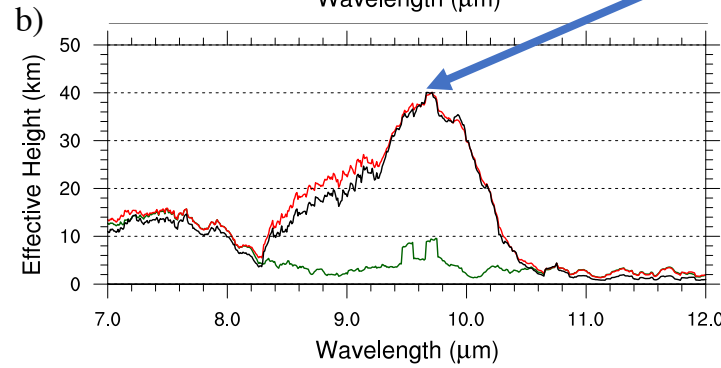
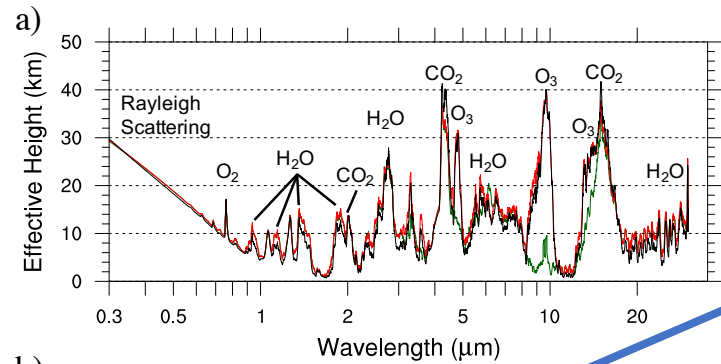


- What does an ozone layer look like on a tidally locked planet?
- Are ozone layers on exoplanets around M dwarfs detectable?
- Is the dayside exposed to a harmful UV flux?

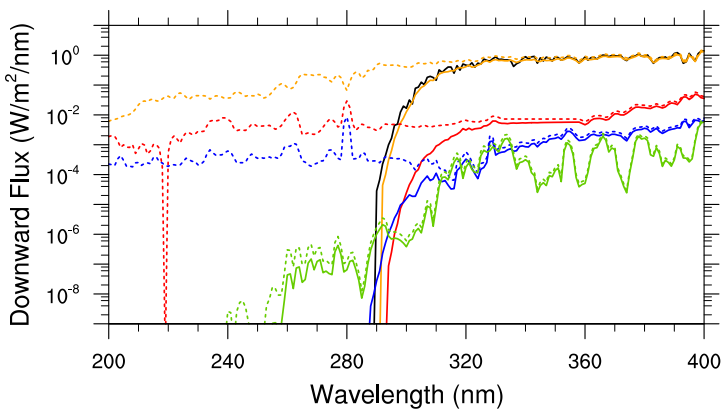
We use WACCM, a three-dimensional climate-photochemistry model, to investigate ozone layers on exoplanets.



Earth-like ozone layers are present on planets orbiting UV-active M dwarfs, but not on planets orbiting UV-inactive M dwarfs



In principle, these ozone layers are detectable!

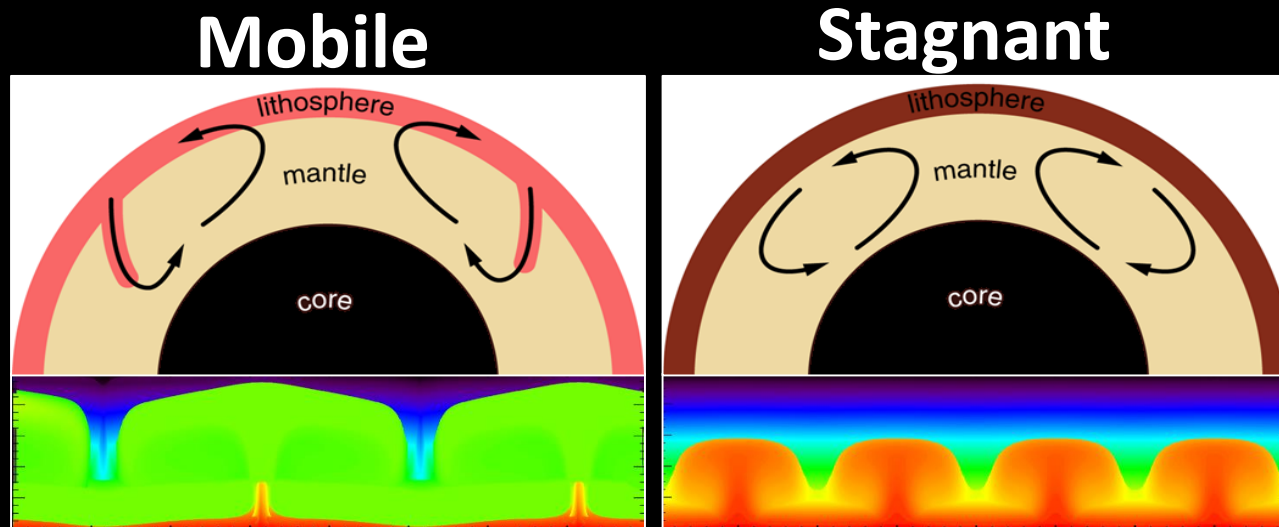


- reference
- Sun
- AD Leo
- Proxima Centauri
- TRAPPIST-1

Safe/Sterile surface UV environments, depending on the UV activity of the host stars

Exploring the Onset of Plate Tectonics on Terrestrial Planets Using Grain-Damage

Mariah MacDonald, Bradford Foley



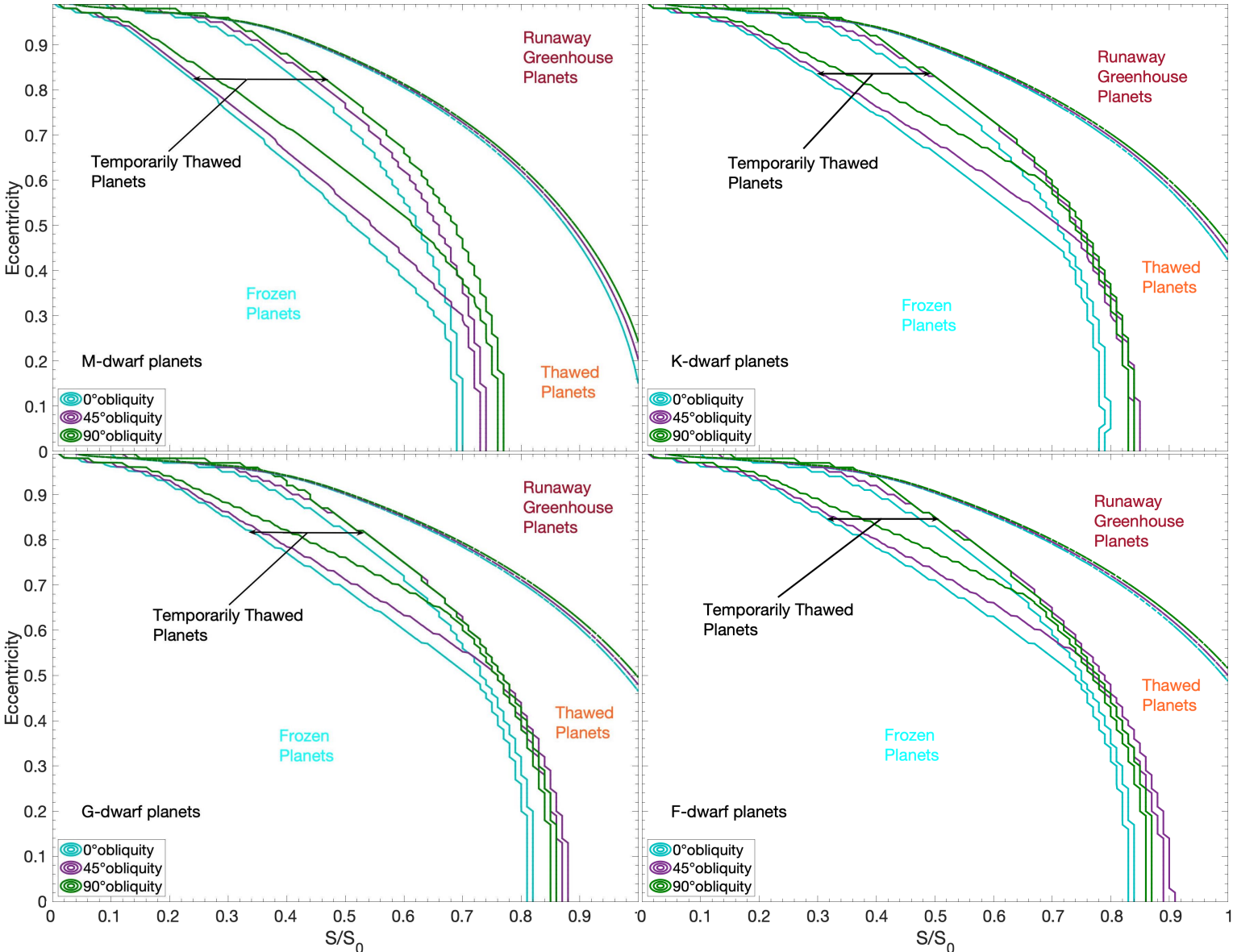
Katato & Barbot 2018

$$\frac{DA}{Dt} = D\psi \exp(\theta_v(1 - T)) A^{-m} - H \exp(-\theta_h(1 - T)) A^p$$

Temporal Habitability and Water Loss Limits on Eccentric Planets

Igor Z. Palubski¹ (email: ipalubsk@uci.edu), Aomawa L. Shields¹, Russell Deitrick²

¹UC Irvine, Department of Physics and Astronomy; ²University of Bern, Center for Space and Habitability



Atmospheric Parameters and Ages of **M Dwarfs** in the Solar Neighborhood

(Ellen C. de Almeida)



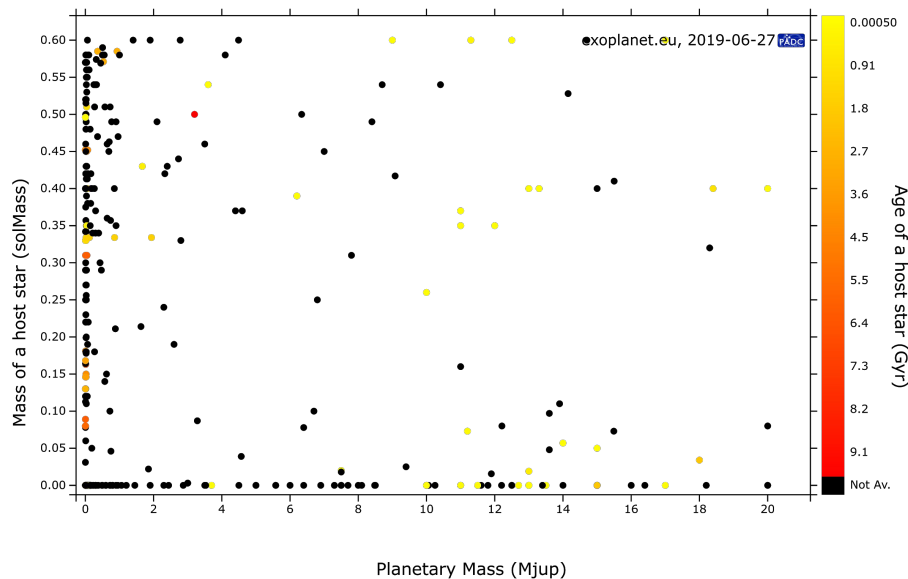
UFRJ



Brazilian 1.6m telescope, Coudé spectrograph
11 observing runs - **300 observed stars**

↳ ~80 with known parameters

NIR 8300 - 8900 Å



Methods

PCA calibration able to estimate the variation of each spectral region relative to **T_{eff}** and **[Fe/H]**

Stellar ages by measuring chromospheric fluxes of the Ca II triplet lines using an activity-age calibration

Advisor: Dr. Gustavo F. Porto de Mello

A SERVICE OF NASA EXOPLANET SCIENCE INSTITUTE

Julian van Eyken, David Ciardi, Rachel Akeson, Jessie Christiansen, Calen Henderson, and many others!

- Collates and cross-correlates data on exoplanets and their host stars
- Provides tools to work with the data

- Planet, candidate, and stellar host parameters
- *Kepler and K2 light curves*
- *Kepler pipeline products*
- *Microlensing data, inc. UKIRT light curves*
- *SuperWASP and KELT transit survey data*
- *Radial velocity data*
- *CoRoT exoplanet and asteroseismology data*
- *Transmission and emission spectra*

4,016
Confirmed Planets
07/11/2019

21
TESS Confirmed Planets
07/11/2019

804
TESS Project Candidates
07/10/2019

Row ID	Host Name	Planet Letter	Planet Name	Discovery Method	Number of Planets in System
2MASS J12073346-3932539		b	2MASS J1207334	Imaging	1
2MASS J1938				Eclipse Timing Variations	1
2MASS J2140				Imaging	1
2MASS J2236				Radial Velocity	1
30 Ari B				Radial Velocity	1
4 UMa				Radial Velocity	1
42 Dra				Radial Velocity	1
47 UMa				Radial Velocity	3
47 UMa				Radial Velocity	3
47 UMa				Radial Velocity	3
51 Eri				Imaging	1
51 Peg				Radial Velocity	1
55 Cnc		b	55 Cnc b	Radial Velocity	5
55 Cnc		c	55 Cnc c	Radial Velocity	5
55 Cnc		d	55 Cnc d	Radial Velocity	5

Also **ExoFOP** community follow-up program (Kepler/K2/TESS) <https://exofop.ipac.caltech.edu/>

- ExoFOP-TESS used by TESS project and community to share observations of TESS candidates
- Part of official TESS FOP program
- **>800** registered users, **>2800** observations, **>17000** files

Our Tools

- *Interactive data tables*
- EXOFAST fitting tool with *MCMC analysis*
- *Light curve viewer*
- Transit and Ephemeris Service *predicts transits from any location*
- Prediction of *observable exoplanet signatures*

The screenshot displays the EXOFAST software interface with several windows open:

- Target Ephemerides:** Shows options for Multiple Targets (Archive Tables, Confirmed Planets, Kepler Objects of Interest, K2 Candidates) and Single Target (User Defined).
- Observer Location:** Lists various observatories like Space Observatory, James Webb Space Telescope, Spitzer Space Telescope, Earth Observatory, etc.
- Observing Window:** Allows setting Next Event, Custom Start/End Dates (UT), and a range from Start (27 Nov 2018 23:28) to End (28 Nov 2018 23:28).
- Period and Setting Inputs:** A configuration window for search parameters:
 - Period Parameters:** Minimum Period (days), Maximum Period (days), # RV Periodogram Peaks to Search.
 - Apply Settings:** Fit Type (Chi-Squared, MCMC), Force Circular Orbit, Fit Slope to RV, Kepler Long Cadence.
- Light Curve Viewer:** A plot showing RV (m/s) vs TIME (BJD-2454833) with a green signal and a blue fit line.

... And more!

Coming soon:

PyATMOS Dataset

- *~125,000 simulated model atmospheres* from W. Fawcett, D. Angerhausen et al.

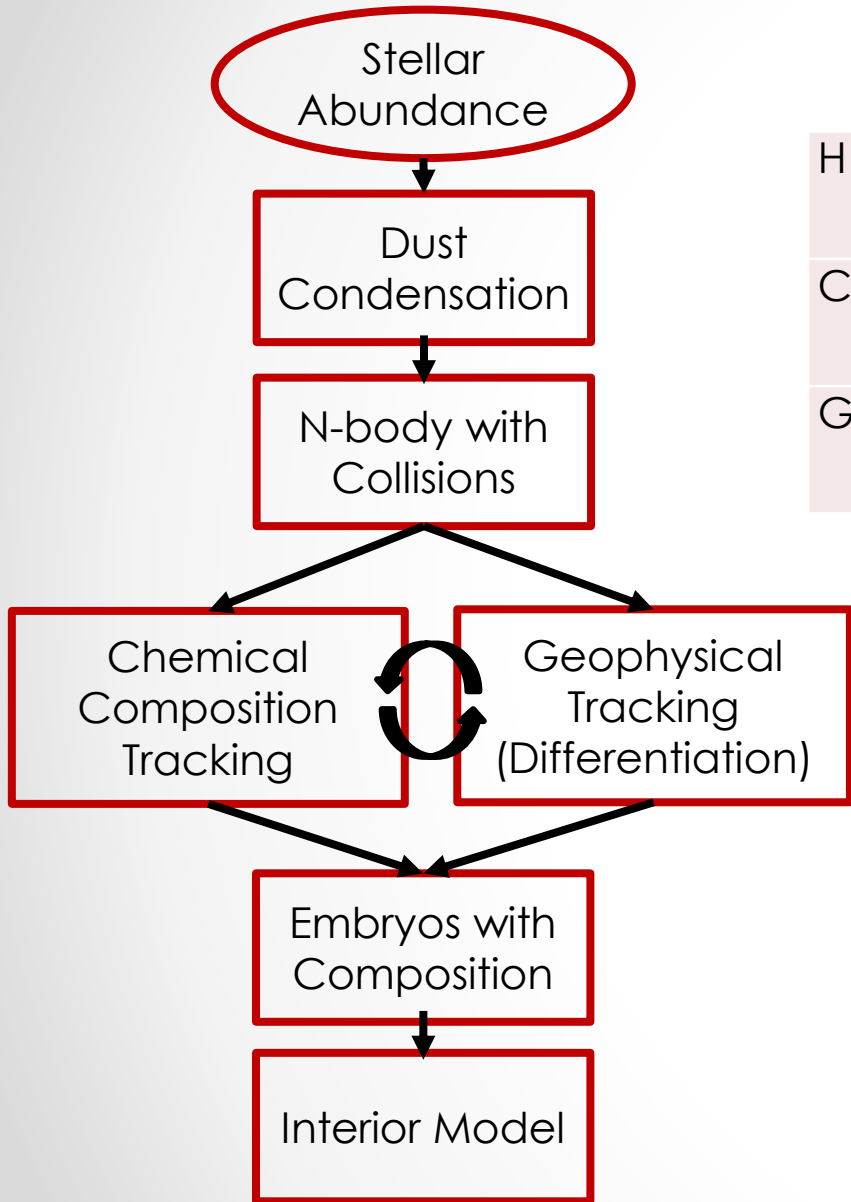
The screenshot shows the PyATMOS Dataset interface with two main sections:

Summary of Atmospheric Models

CH4 Concentration (fractional)	CO2 Concentration (fractional)	H2 Concentration (fractional)	H2O Concentration (fractional)	O2 Concentration (fractional)	CH4 Flux (molecules/ÅC)
0.01000000	0.03000000	0.05000000	0.01230000	0.22000000	1.63000000
0.03000000	0.01000000	0.00000008	0.01230000	0.16000000	1.21000000
0.02000000	0.01000000	0.00000008	0.01230000	0.21000000	9.78000000
0.00000163	0.04000000	0.00000009	0.01230000	0.14000000	1.44000000
0.02000000	0.02000000	0.00000008	0.01230000	0.20000000	9.76000000
0.01500000	0.01000000	0.00000008	0.01230000	0.35000000	7.86000000
0.00000163	0.00040000	0.00000008	0.01230000	0.14000000	1.48000000
0.03000000	0.02000000	0.05000000	0.01230000	0.25000000	5.96000000

Preview of Selected Model

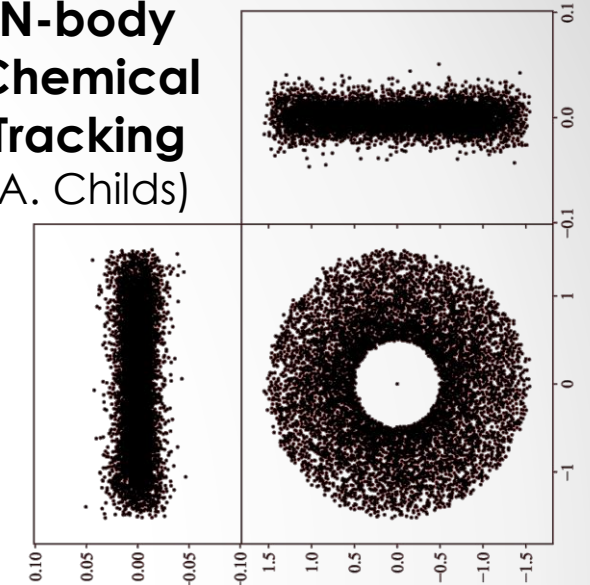
Layer Number	Pressure (bar)	Altitude (km)	Temperature (K)	Is Layer Convective?	H2O Fraction	O3 Fraction
1	7.69990E-06	6.72470E+01	8.98150E+01	0	1.16340E-02	6.42840E-09
2	9.31000E-06	6.67220E+01	1.01380E+02	0	4.65610E-03	6.37940E-09
3	1.12410E-05	6.61480E+01	1.09380E+02	0	4.00000E-06	6.31000E-09
4	1.35320E-05	6.55440E+01	1.14480E+02	0	4.00000E-06	6.25970E-09
5	1.63150E-05	6.49230E+01	1.17840E+02	0	4.00000E-06	6.16900E-09
6	1.96130E-05	6.42920E+01	1.19700E+02	0	4.00000E-06	6.07480E-09
7	2.35440E-05	6.36590E+01	1.20580E+02	0	4.00000E-06	5.99650E-09
8	2.82230E-05	6.30280E+01	1.21010E+02	0	4.00000E-06	5.93940E-09
9	3.37820E-05	6.24000E+01	1.21350E+02	0	4.00000E-06	5.92520E-09



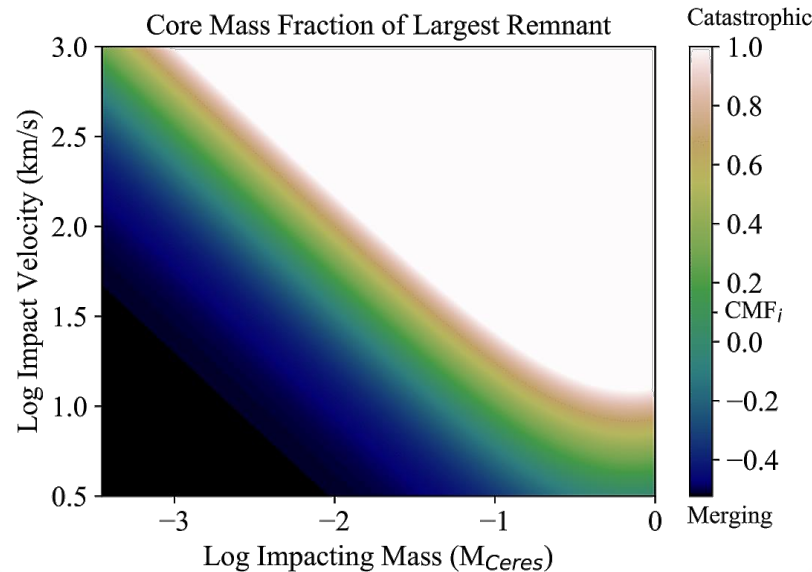
Physical-Chemical Dust Condensation (M. Li)

H	He	C	N	O	Na	Mg	Al	Si	P	S
Cl	K	Ca	Ti	Cr	Mn	Fe	Co	Ni	Cu	Ga
Ge	Mo	Ru	Pd	Hf	W	Re	Os	Ir	Pt	Au

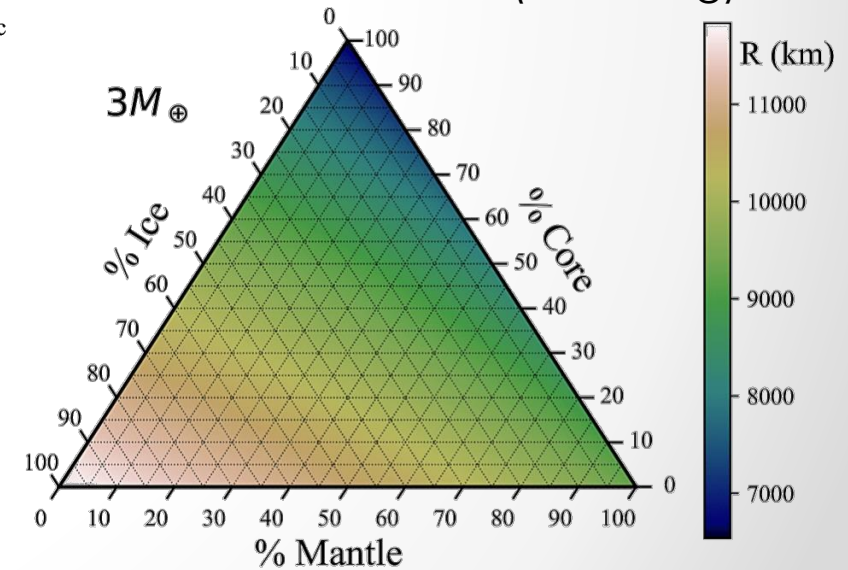
N-body Chemical Tracking (A. Childs)




Geophysical Processes (D. Rice)



Interior Structure (C. Huang)





Nitrogen Fixation on a Warm & Wet Early Mars

**Danica Adams¹, Yangcheng Luo¹, Mike L.
Wong^{2,3}, Renyu Hu⁴, Yuk Yung^{1,4}**

**1. GPS, Caltech, 2. Astronomy & Astrobiology, UW,
3. Virtual Planet Lab, 4. JPL**

**AbSciCon 2019
Bellevue, WA**

1 bar atmosphere,
background CO₂

1-10% N₂
1-10% H₂, CH₄



NO, HCN



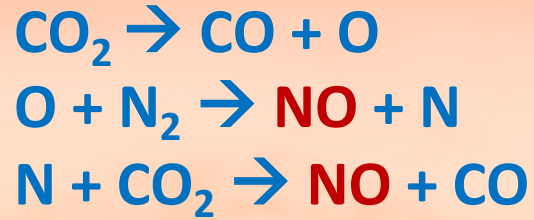
N, N(2D)



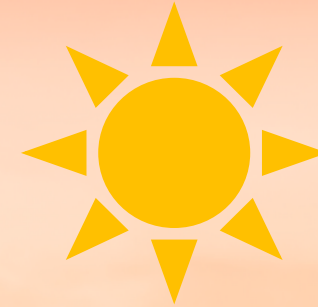
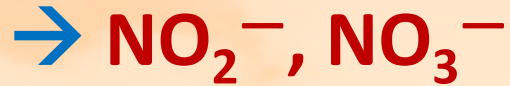
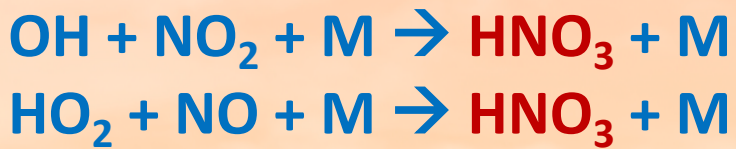
HNO₃, HCN



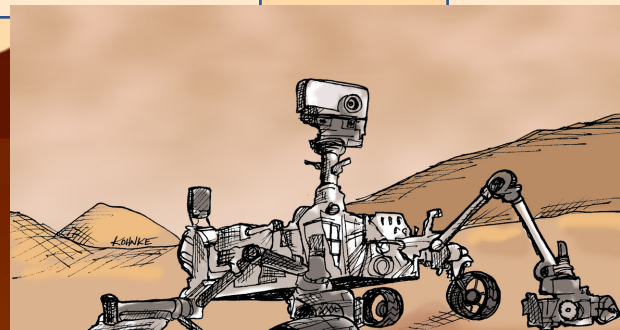
NO₃⁻, HCN



e.g.



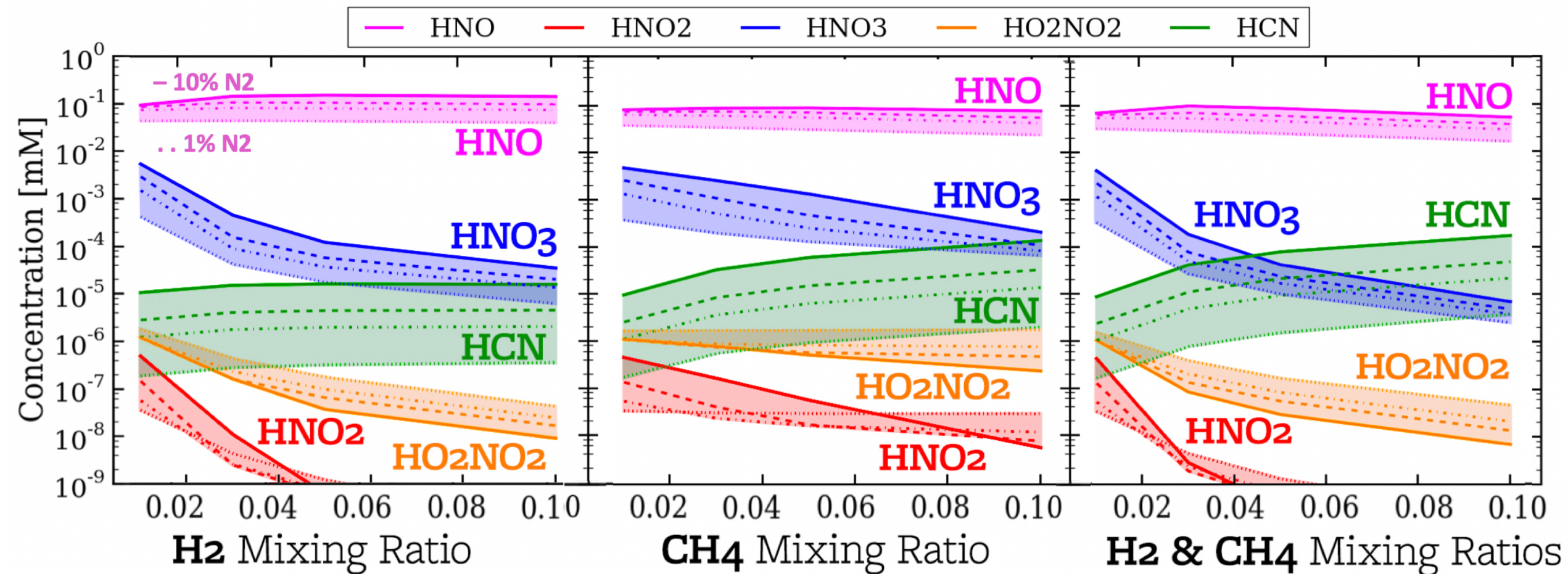
HCN



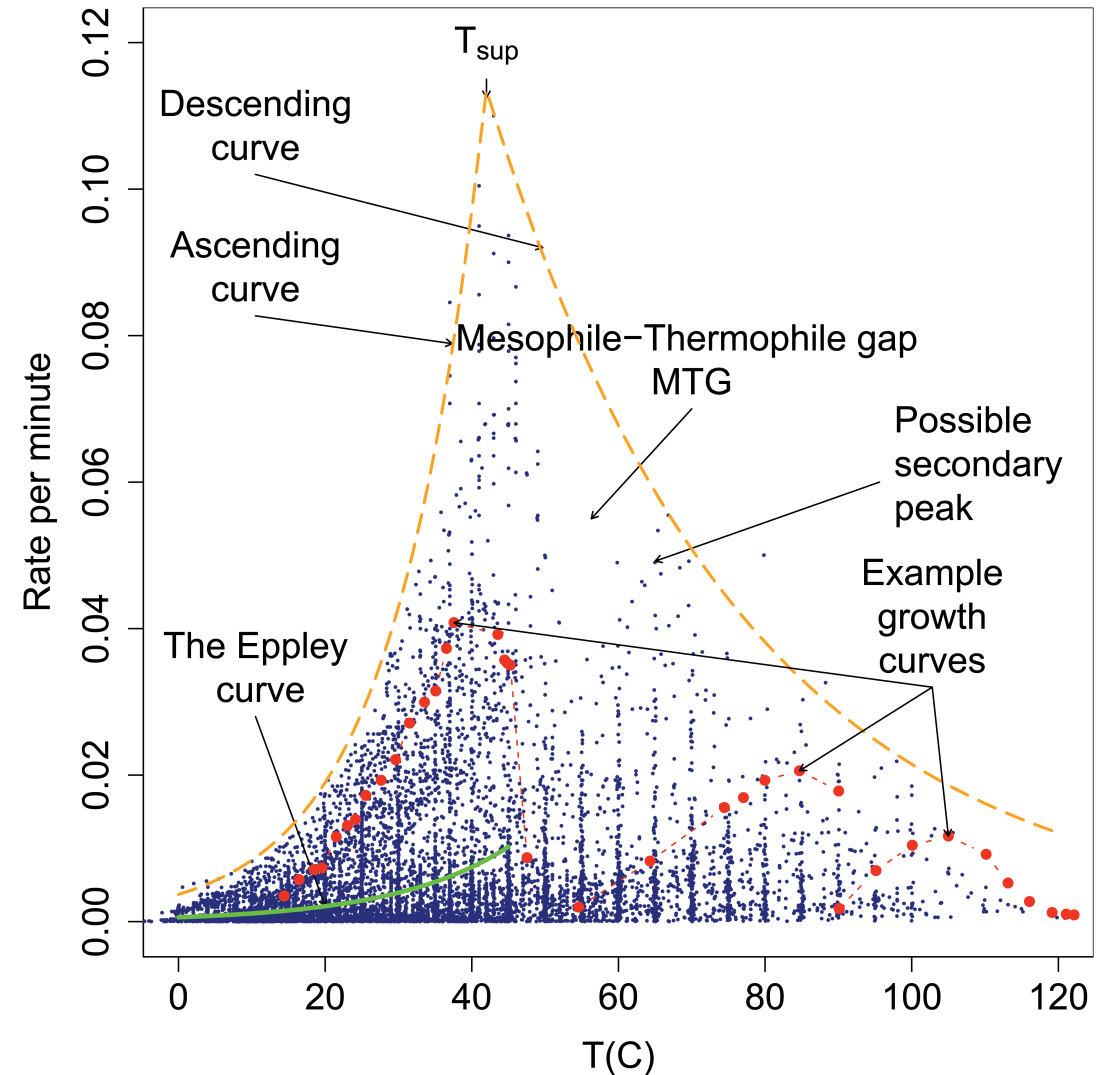
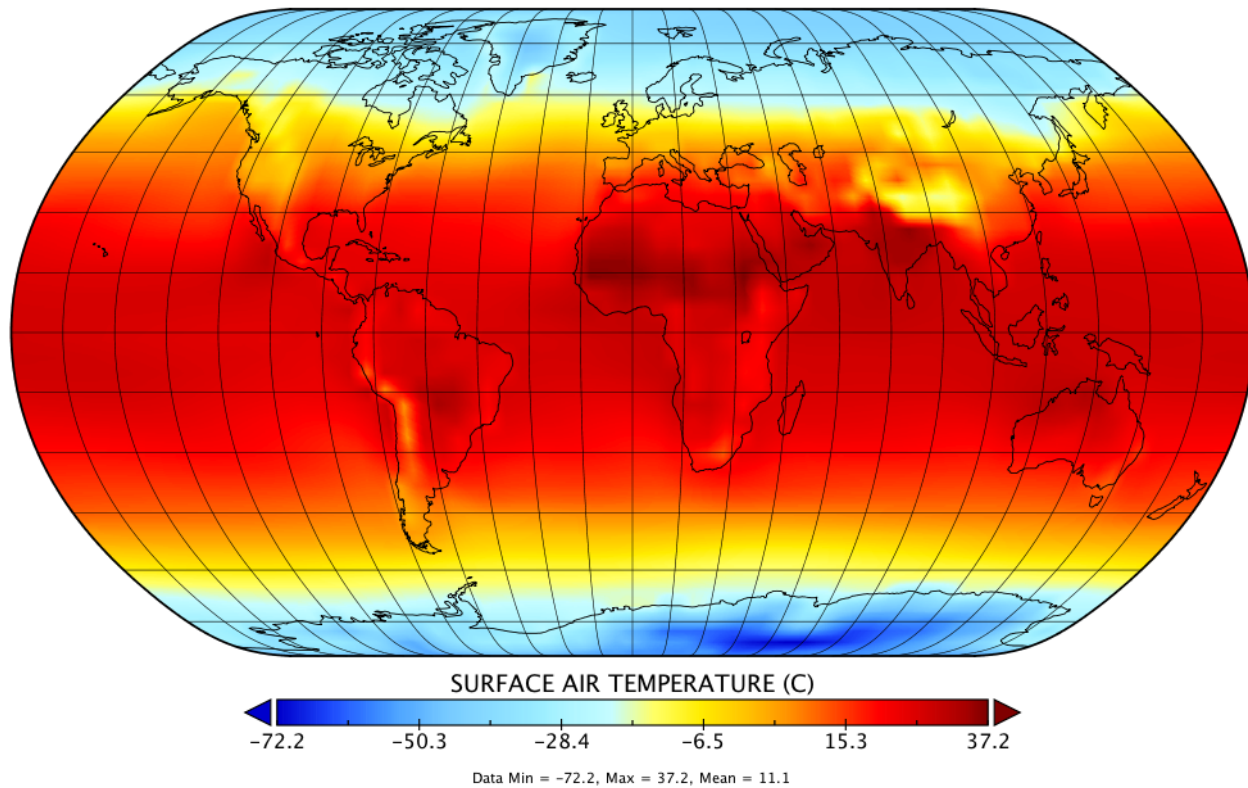
Stern et al. (2015), Sutter et al. (2017)

Wong et al. (2017)
Nitschke and Russell (2013)

Pearce et al. (2019)
Holm & Neubeck (2009)



An Astroecological Model for Characterizing Exoplanet Habitability



An Astroecological Model for Characterizing Exoplanet Habitability

