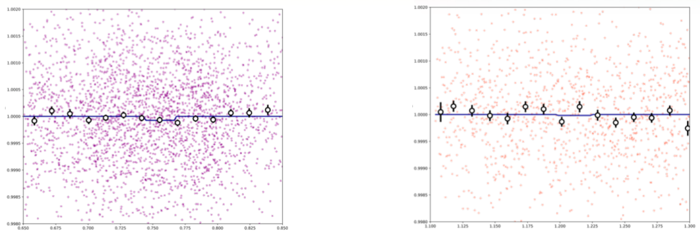
LIÈGE université Astrobiology

Elsa Ducrot[1] on behalf of the Spitzer red worlds exploration program & SPECULOOS Team

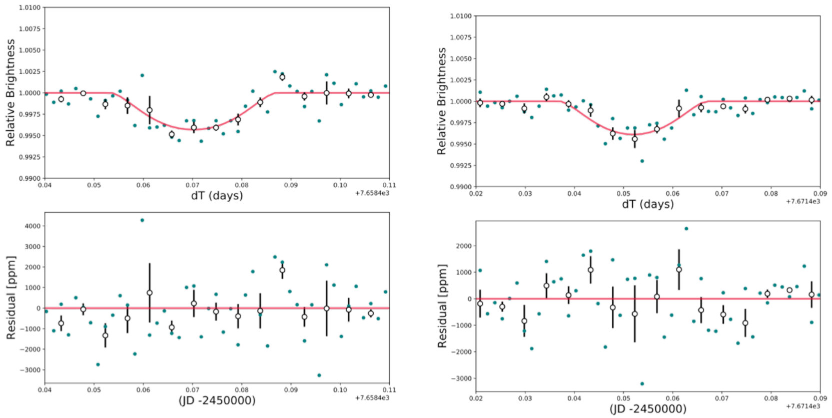
Global results of the Spitzer Exploration Science Program red worlds

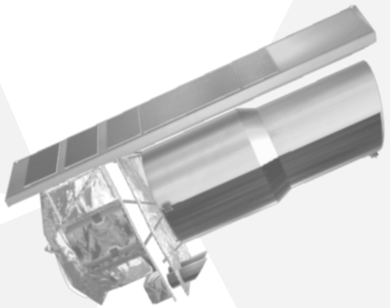
About the transiting objects



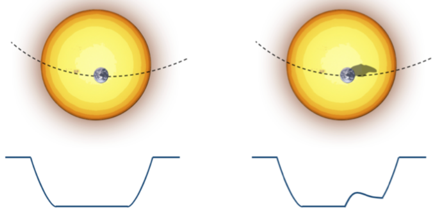
No occultation signal, but an upper limit on the brightness temperature of planet b and c

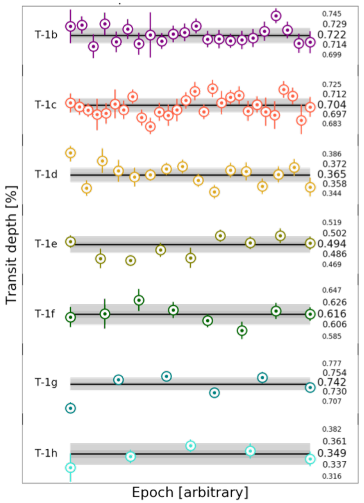
Orphans ?

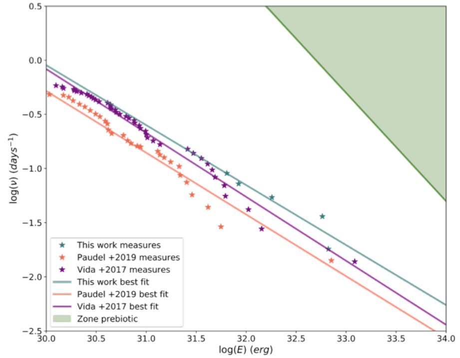


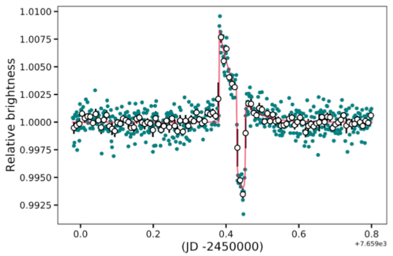


About the star







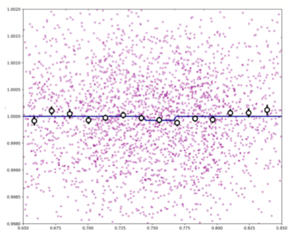


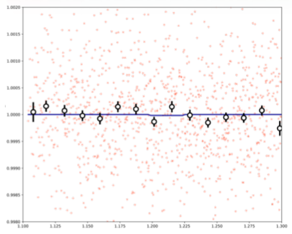
[1]UR Astrobiology, Université de Liège, 19C Allée du 6 Août, 4000 Liège, Belgium.

Elsa Ducrot[1] on behalf of the Spitzer red worlds exploration program & SPECULOOS Team

Global results of the Spitzer Exploration Science Program red worlds

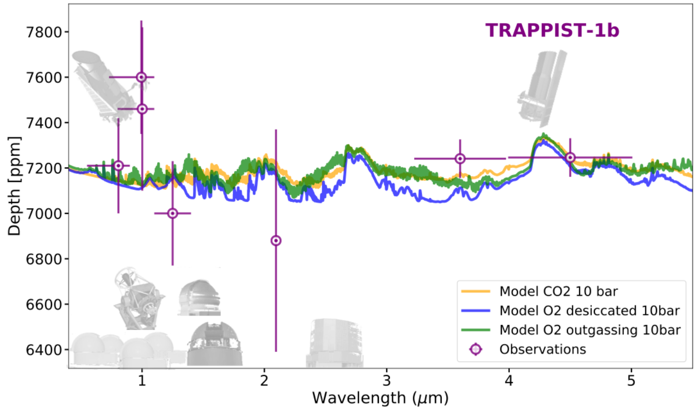
About the transiting objects

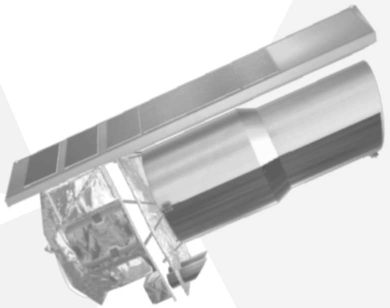




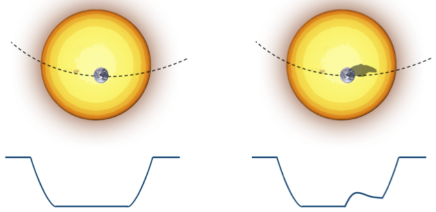
No occultation signal, but an upper limit on the brightness temperature of planet b and c

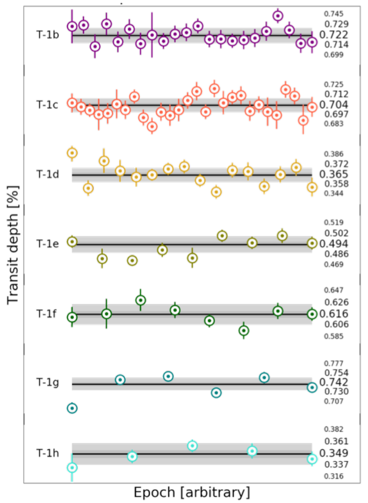
Broadband transmission spectra

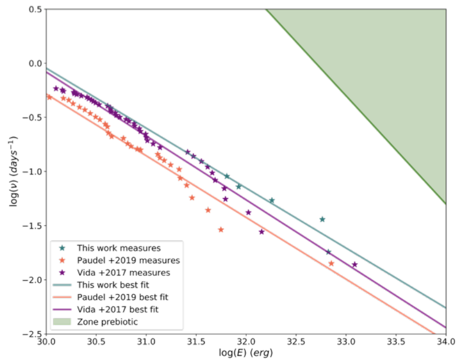


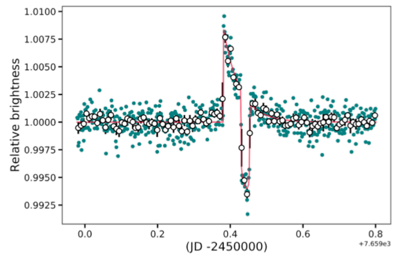


About the star



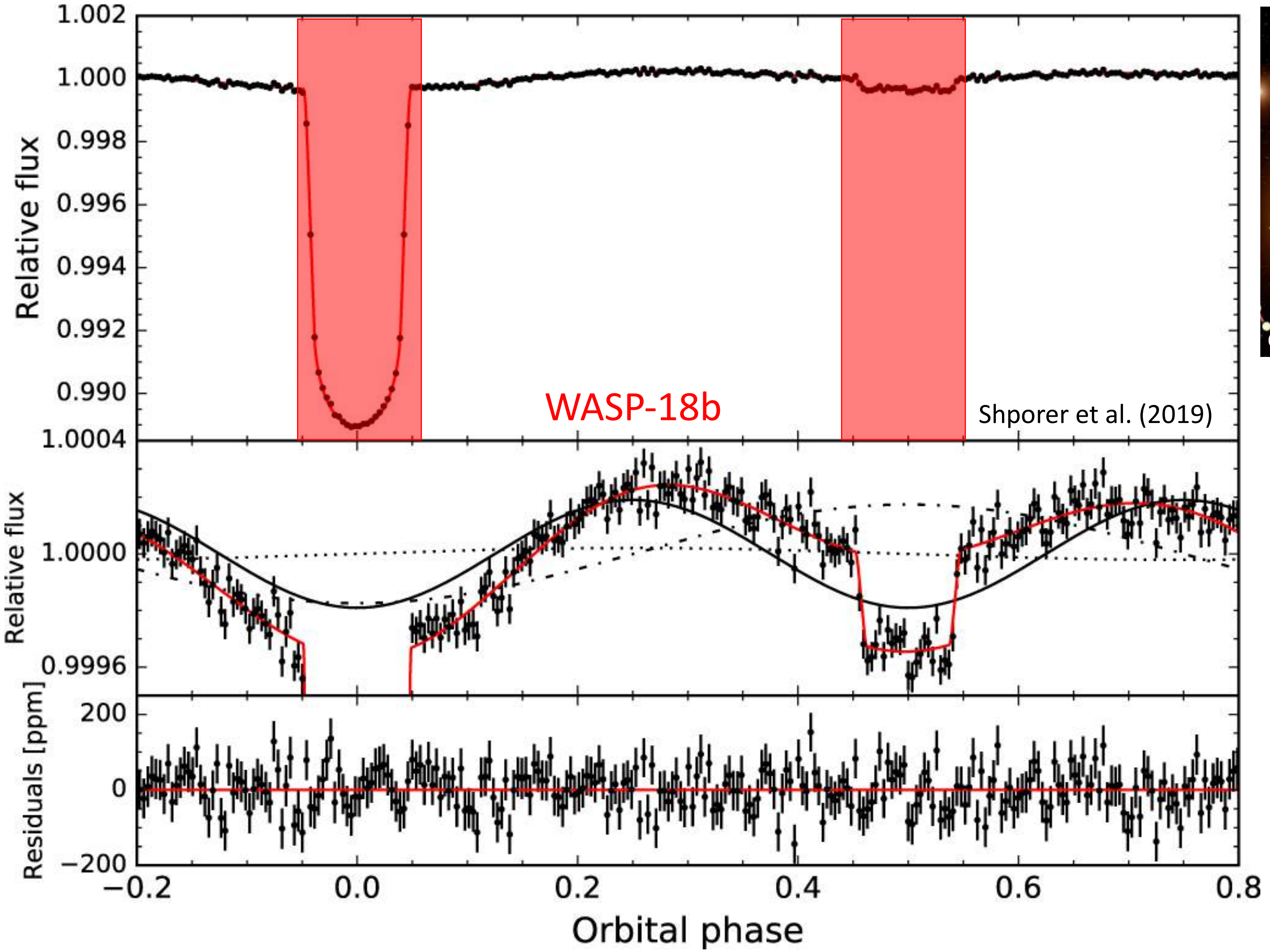


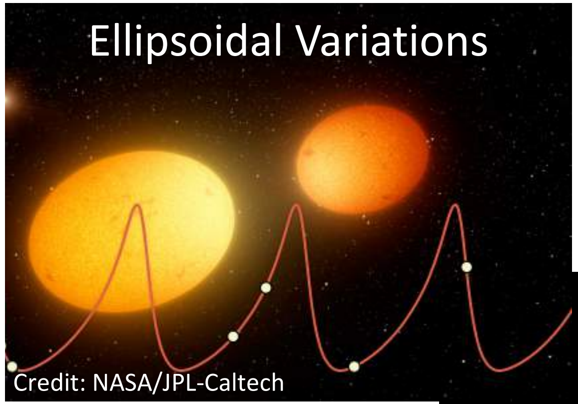


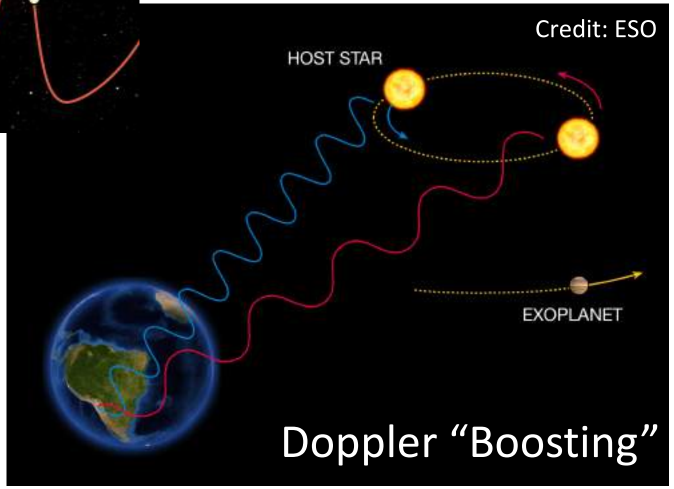


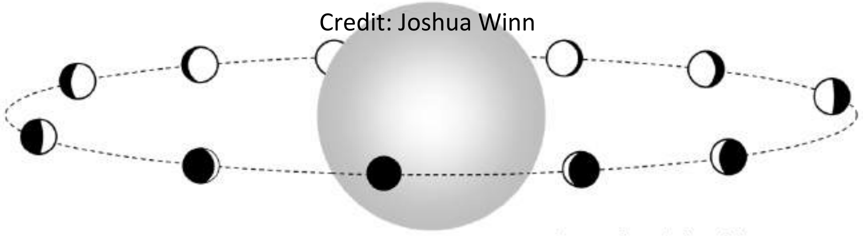
[1]UR Astrobiology, Université de Liège, 19C Allée du 6 Août, 4000 Liège, Belgium.

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







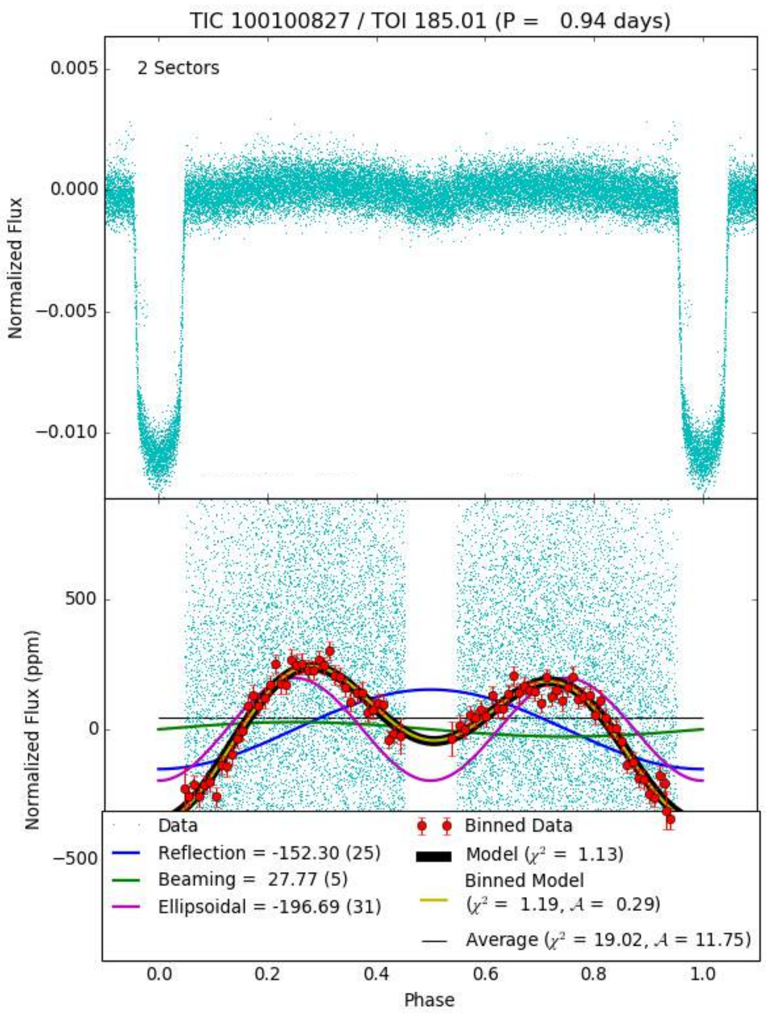


Atmospheric Reflection

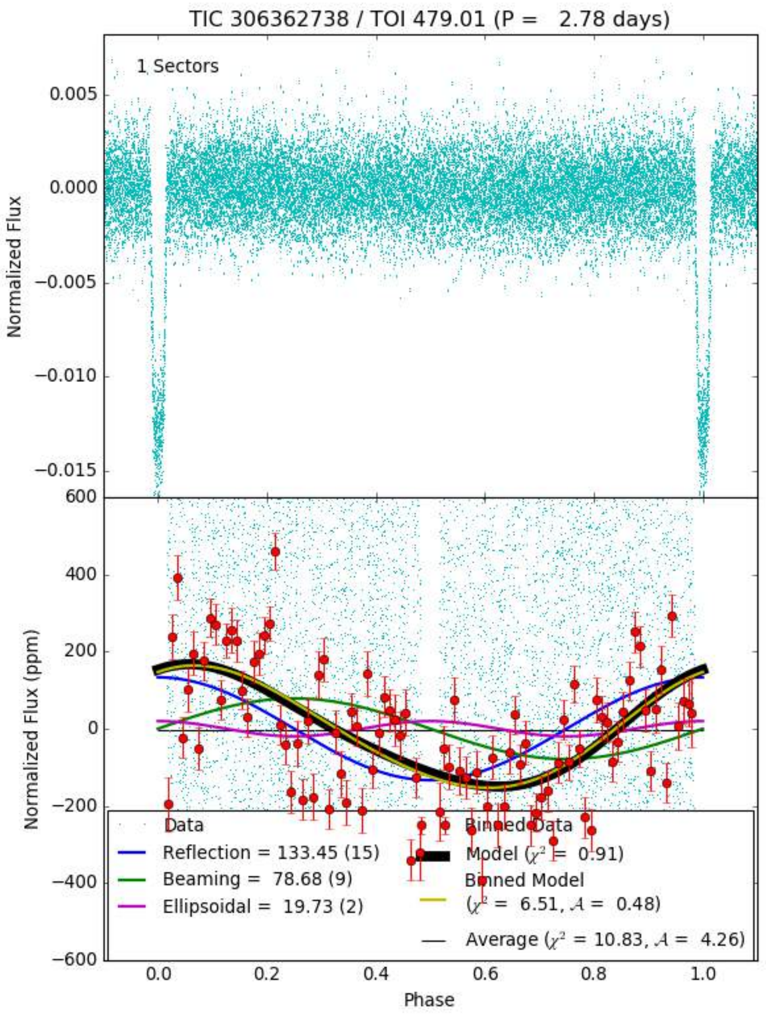
Exoplanet Characterization using Phase Variations Observed by TESS – Tara Fetherolf (UC Riverside)

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

WASP-18b

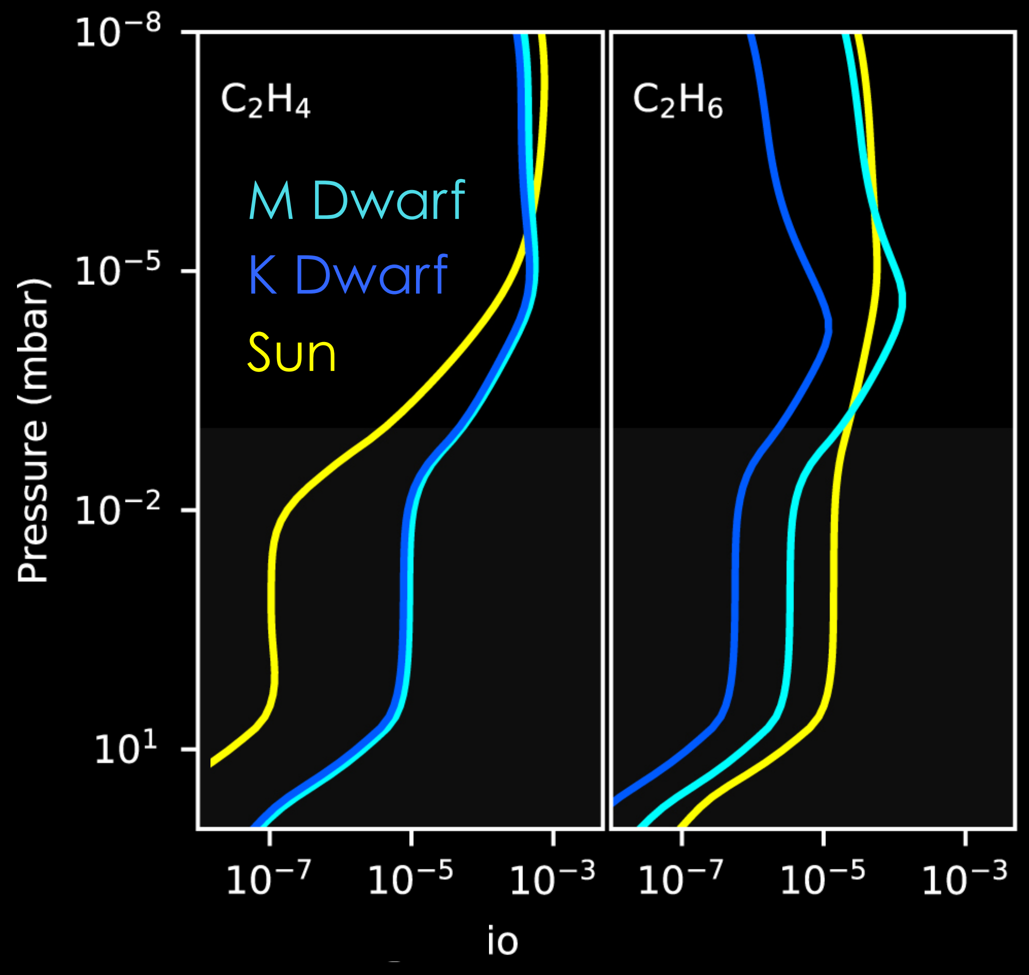


WASP-49b

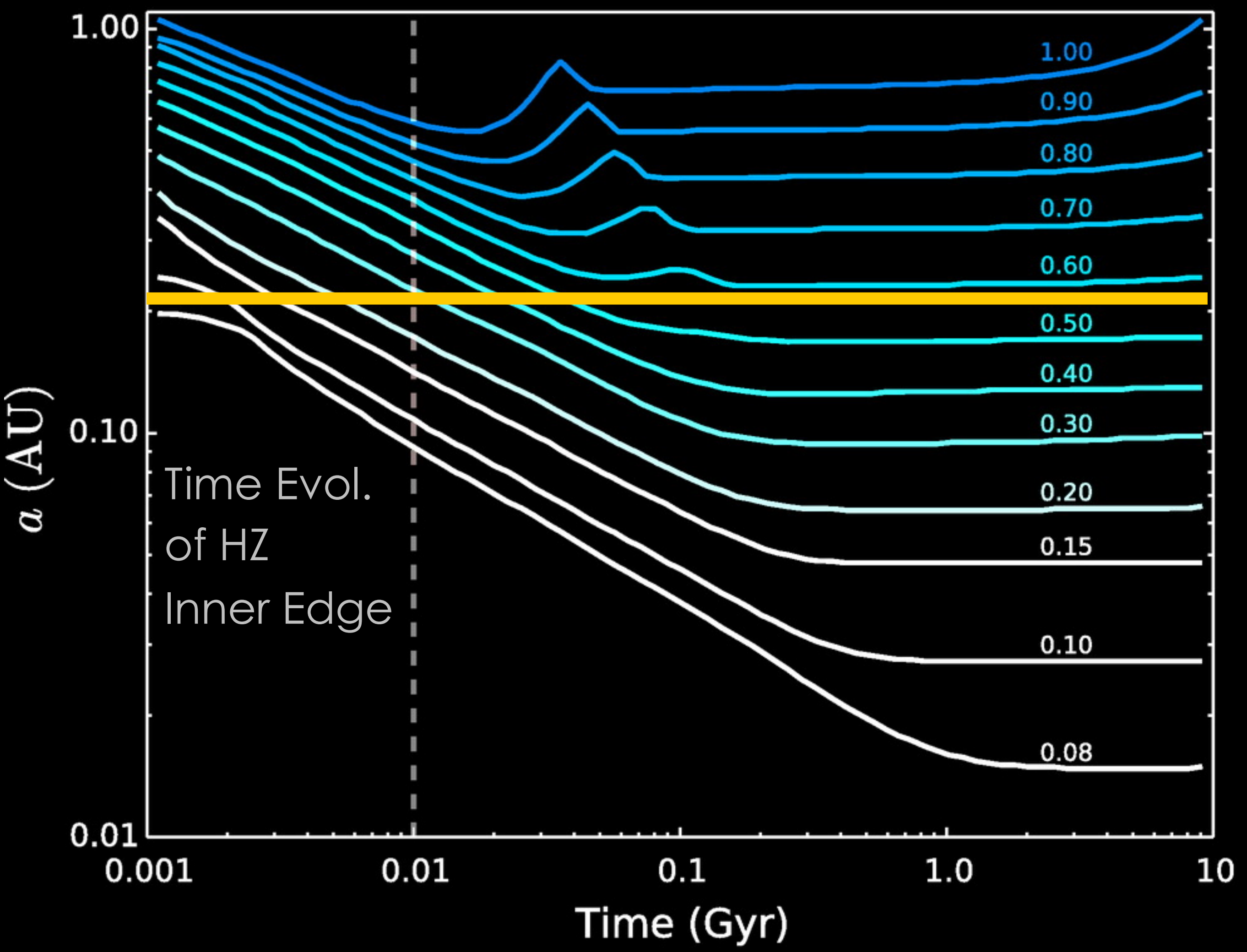


Characterizing ExoTitans with LUVOIR

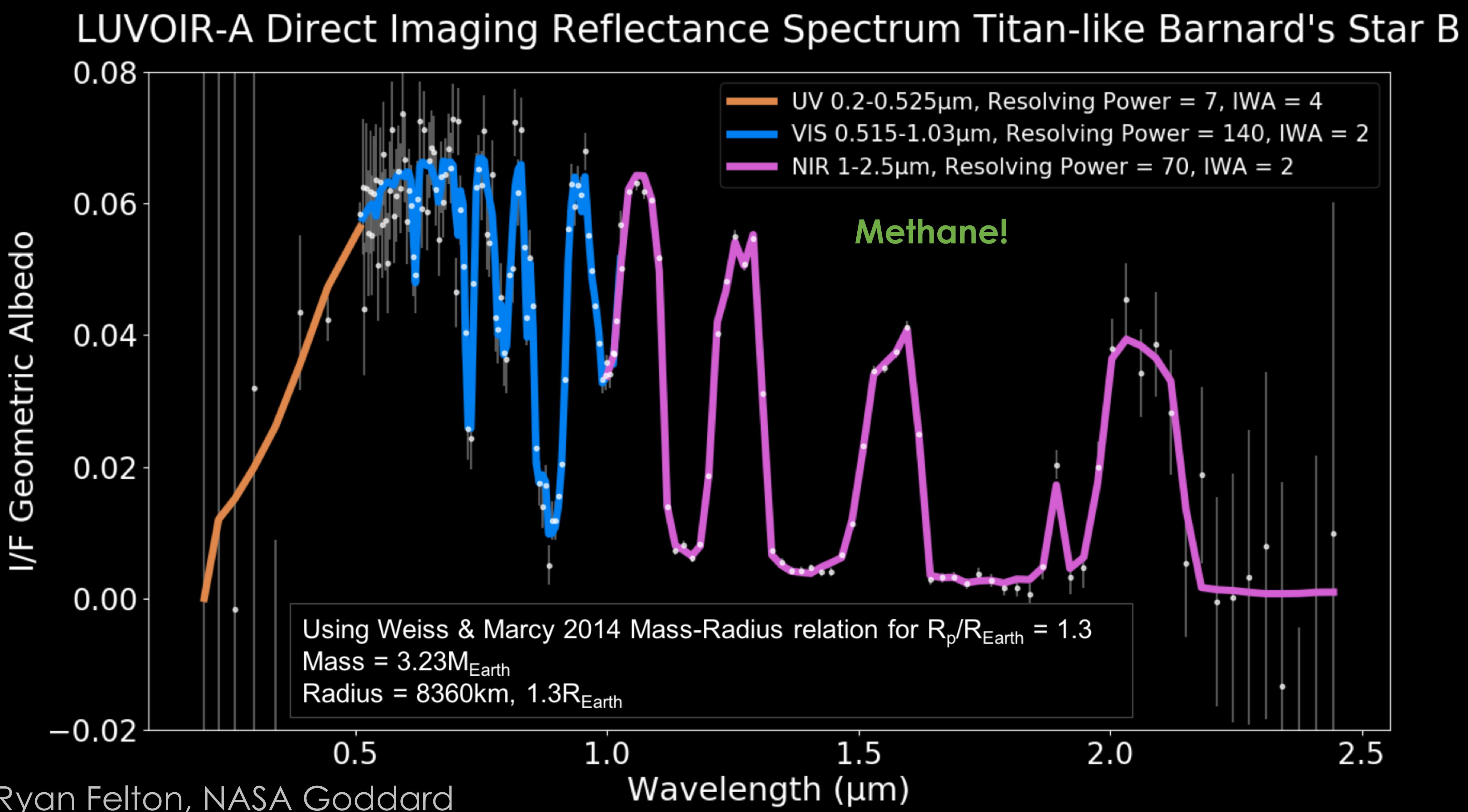
Peter Gao, Ryan Felton, Juan Lora, Tiffany Kataria, Giada Arney, Shawn Domagal-Goldman



Lora et al. (2018)



Luger & Barnes (2015)



Ryan Felton, NASA Goddard

NEID (NN-EXPLORE Exoplanet Investigations with Doppler Spectroscopy)

NEID will...

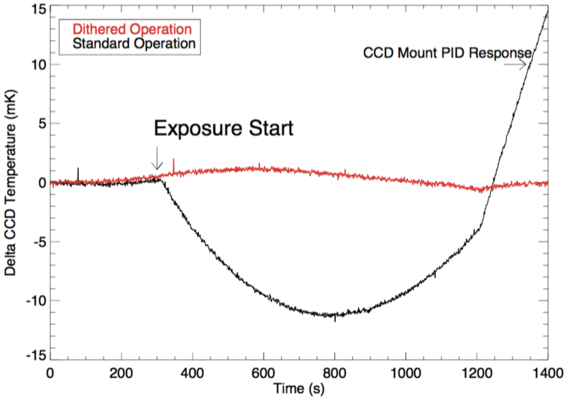
- be a fixture at WIYN (3.5m), Kitt Peak
  - observe 380-930nm
- look for Earth-like planets around Sun-like stars
- be the most sensitive spectrograph of its kind
  - $\lesssim$27cm/s level of precision
  - optimally reach ~10cm/s

For reference...

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

The WIYN Telescope

Dithering


Dithered Operation
Standard Operation
CCD Mount PID Response
Exposure Start
Delta CCD Temperature (mK)
Time (s)
15
10
5
0
-5
-10
-15
0
200
400
600
800
1000
1200
1400

Optimizing University Telescopes for TESS SG1

--Sean McCloat[1]--

UND SPACE STUDIES
UNIVERSITY OF NORTH DAKOTA

- Two 16” (0.4 m) SCTs
- FLI16803 & Apogee U9000
- 30’ x 30’ FOV, F/10
- UBVRI-RGB filters

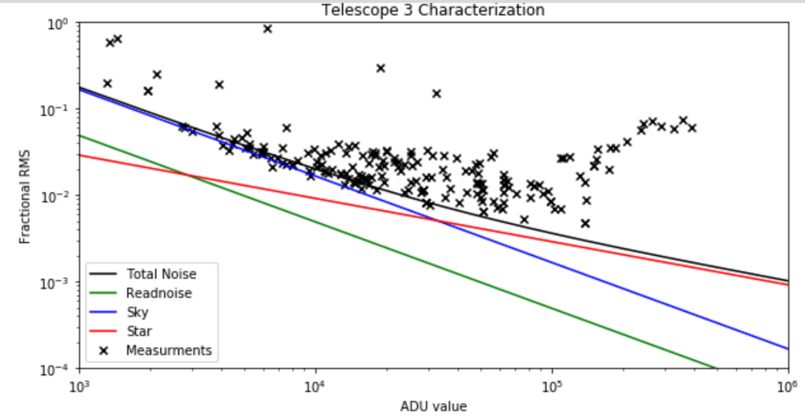
- Characterizing photometric precision

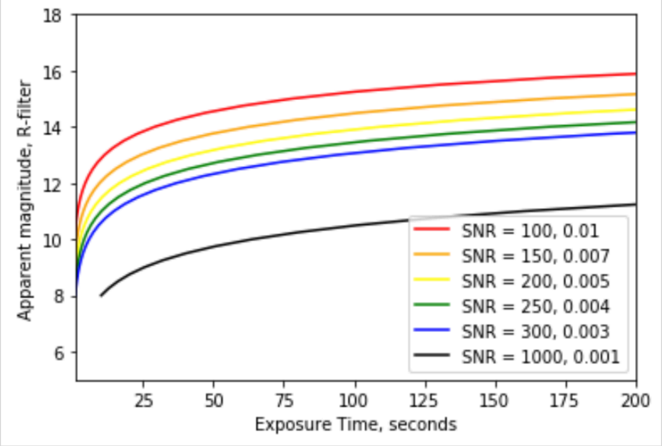
- TESS SG1 – Seeing Limited Photometry

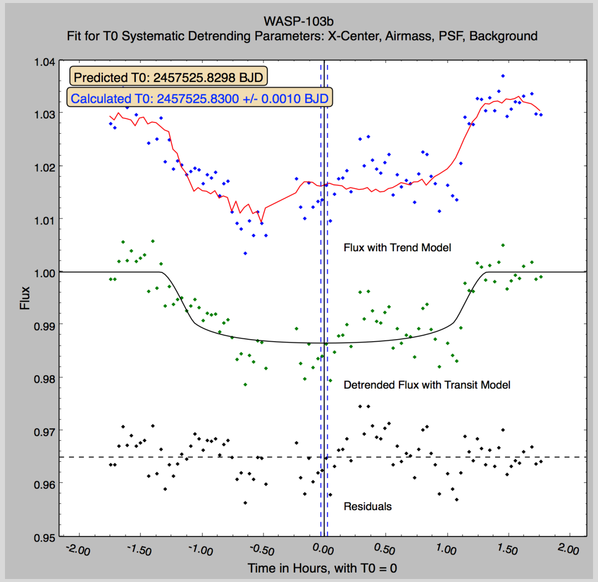
- Simulate transits, combine observations

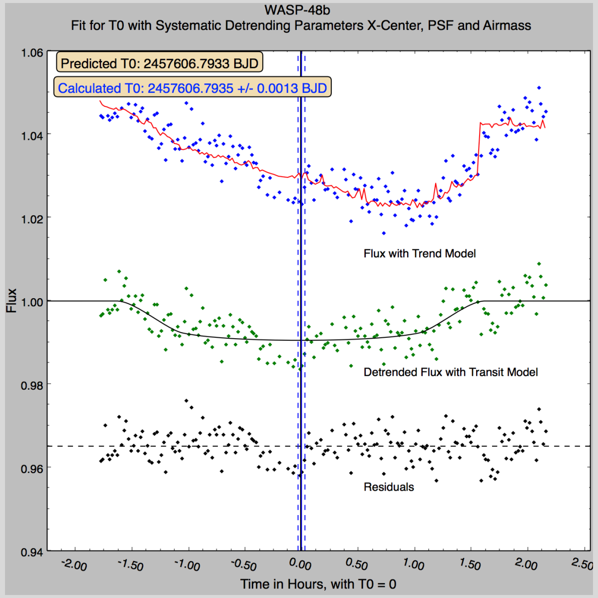
- Collaboration with Physics telescopes

- Make case for larger telescope









1 - MS Space Studies, University of North Dakota

Biosignatures in Multi-planet Systems

--Sean McCloat[1]--

UND SPACE STUDIES
UNIVERSITY OF NORTH DAKOTA

Observation

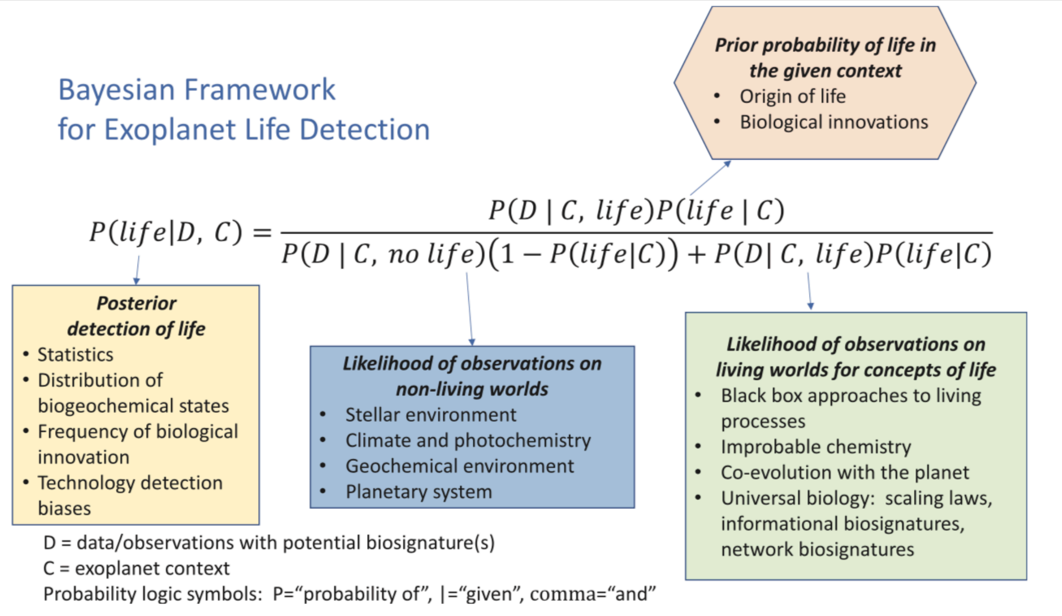
- Working with Dr. Carolina von Essen (Aarhus University) on high resolution transmission spectroscopy

Sean McCloat
spmccloat "at" gmail.com

Come talk to me!

Theory

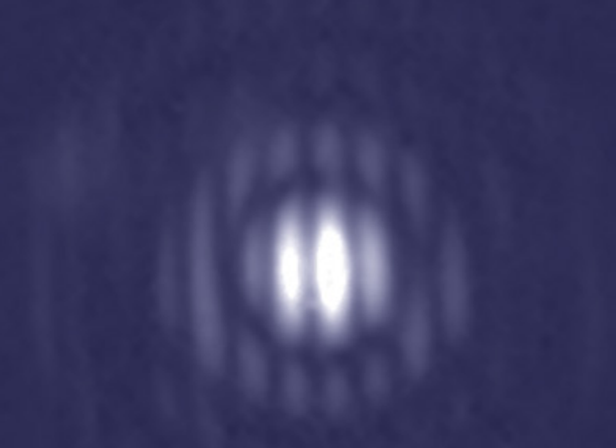
- Biosignatures in multi-planet systems!



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

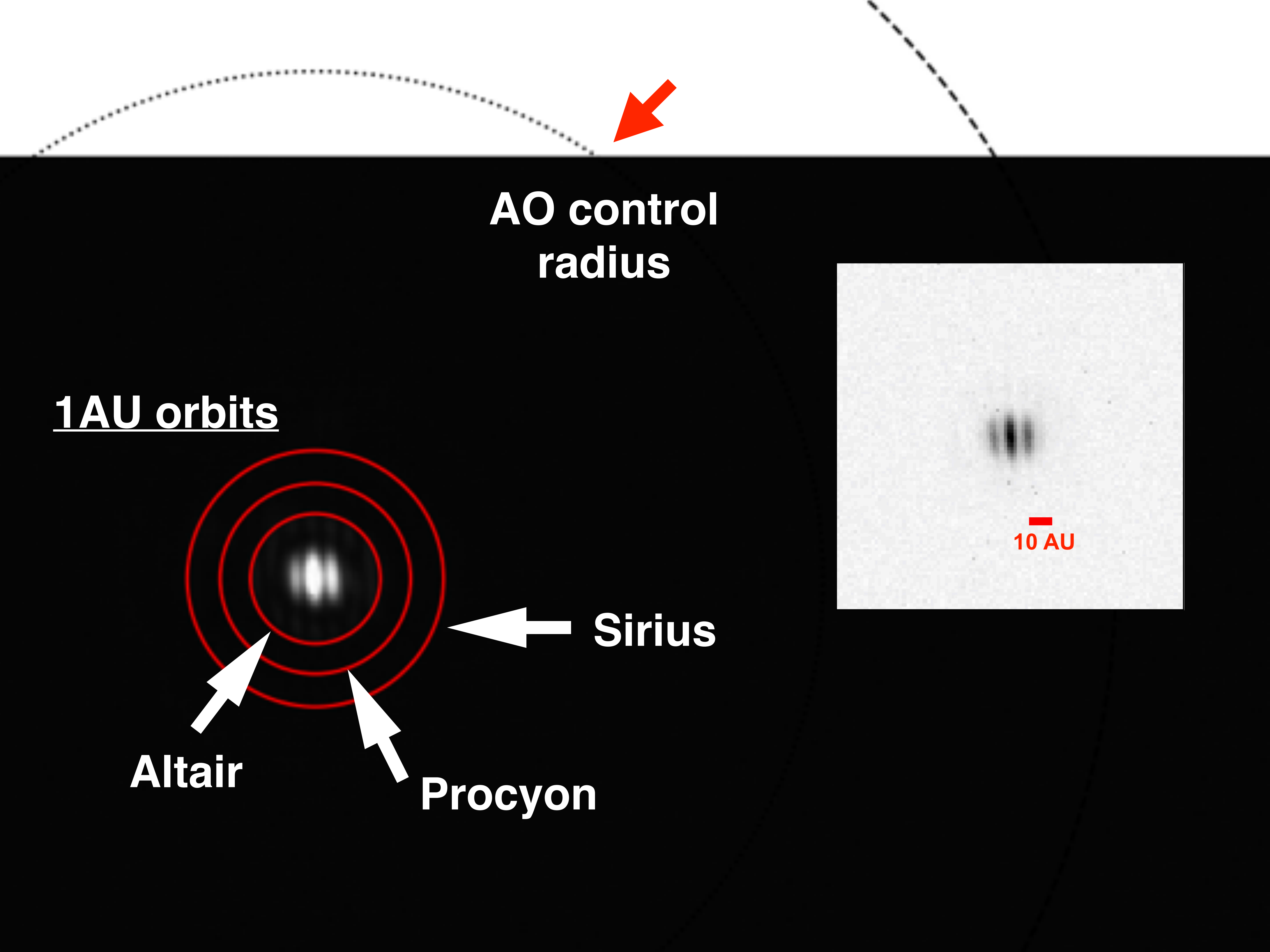
1 - MS Space Studies, University of North Dakota

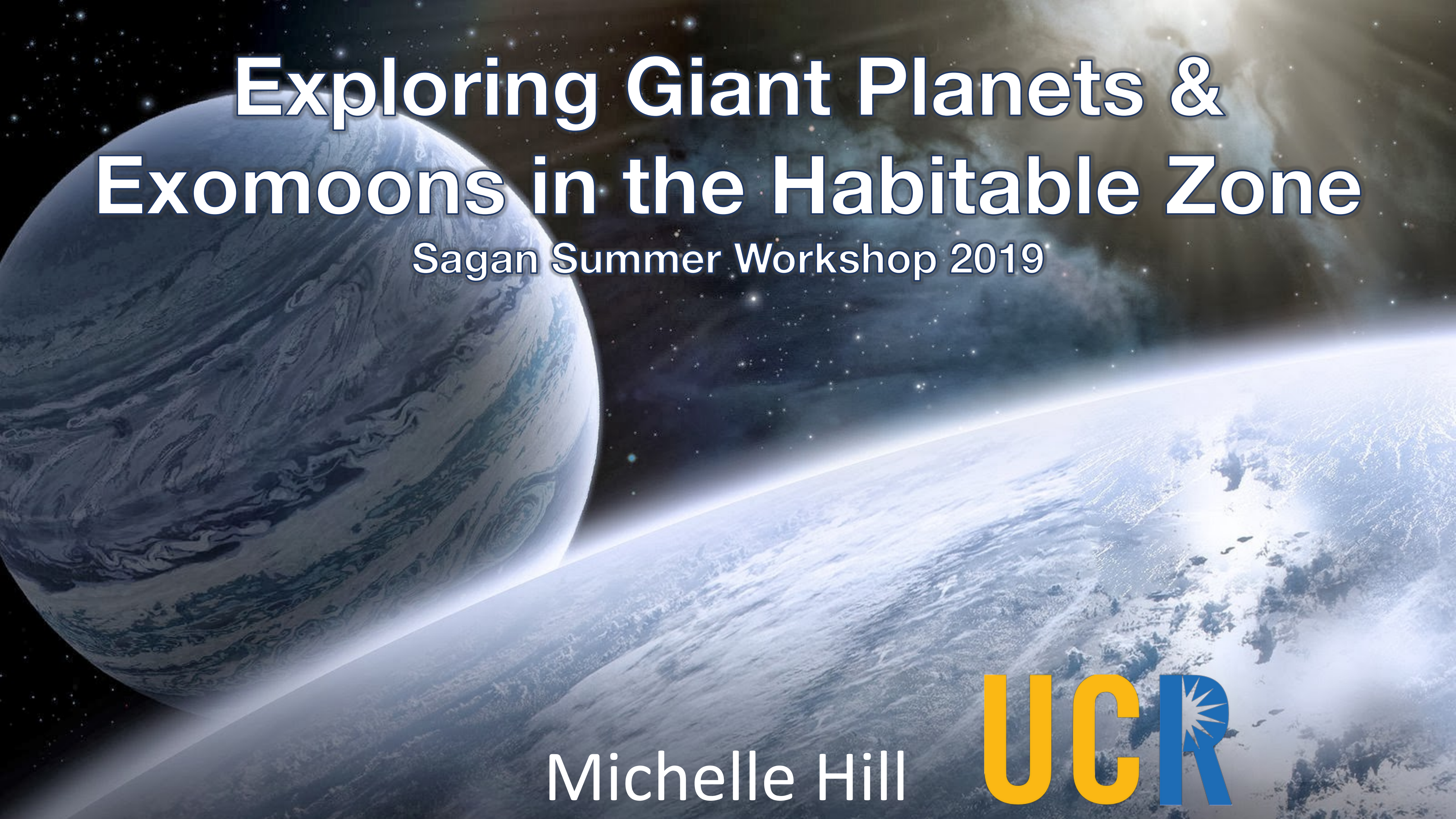
Investigating Planetary Environments with the LBT Interferometer



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
Sirius
Altair
Procyon
10 AU

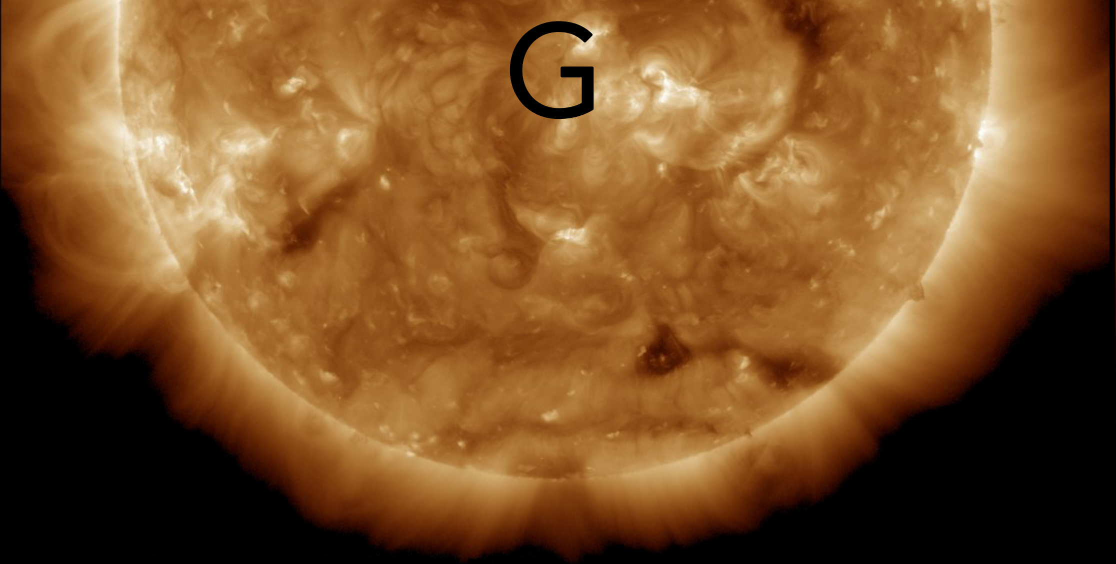


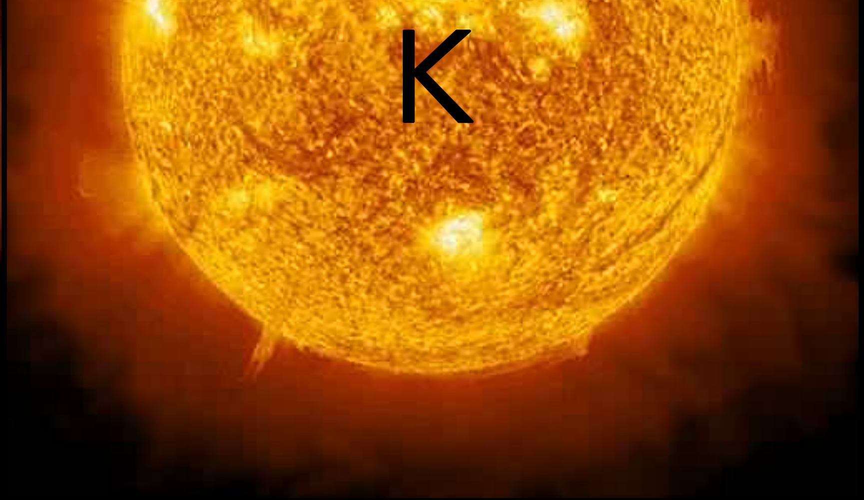
Exploring Giant Planets & Exomoons in the Habitable Zone

Sagan Summer Workshop 2019

Michelle Hill

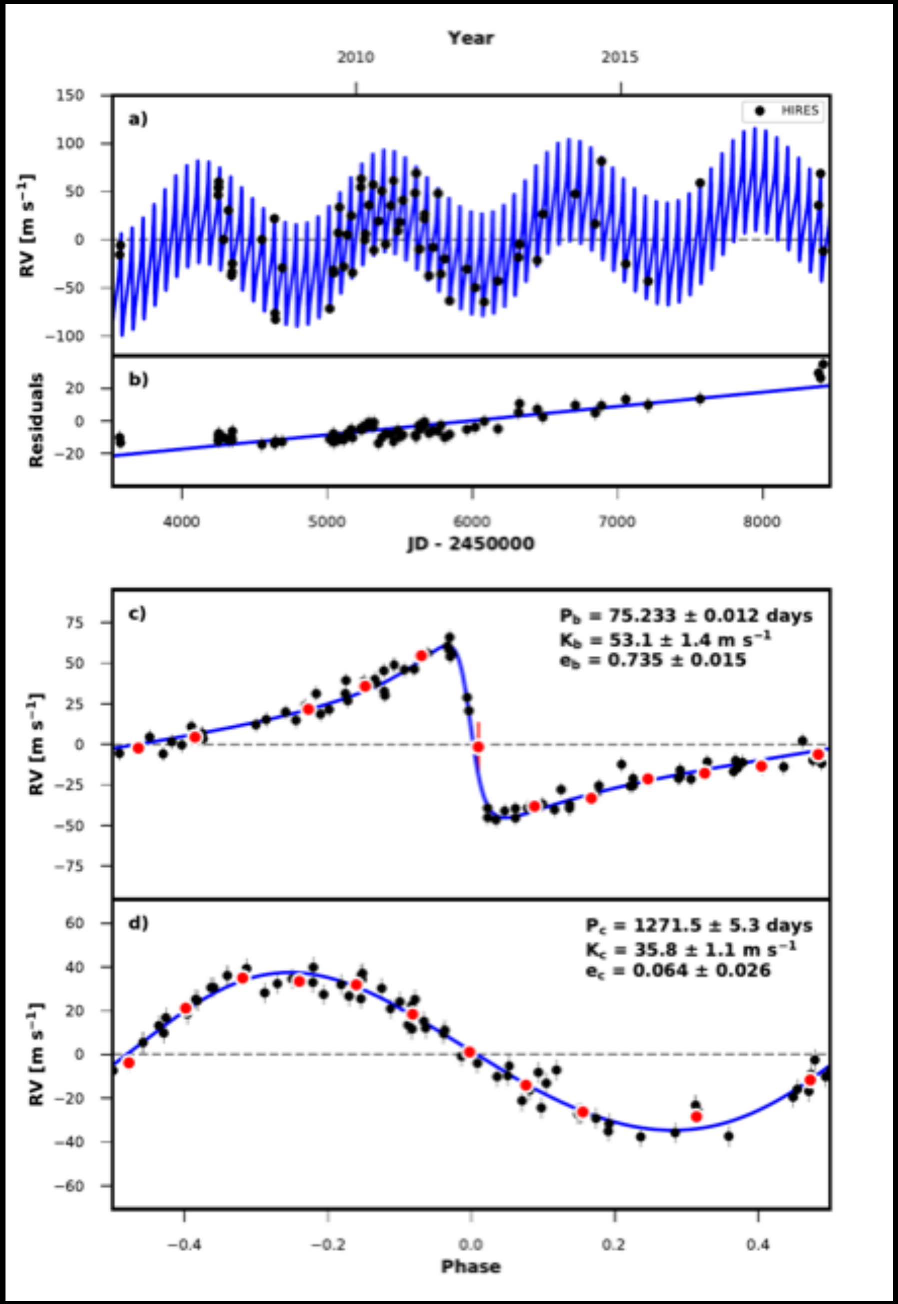
UCR





	6.5% ± 1.9	11.5% ± 3.1	6% ± 6
	2-22%	2-22%	~20%

Frequency of Giant Planets 3.0 - 25 $R_{\oplus}$ in the HZ



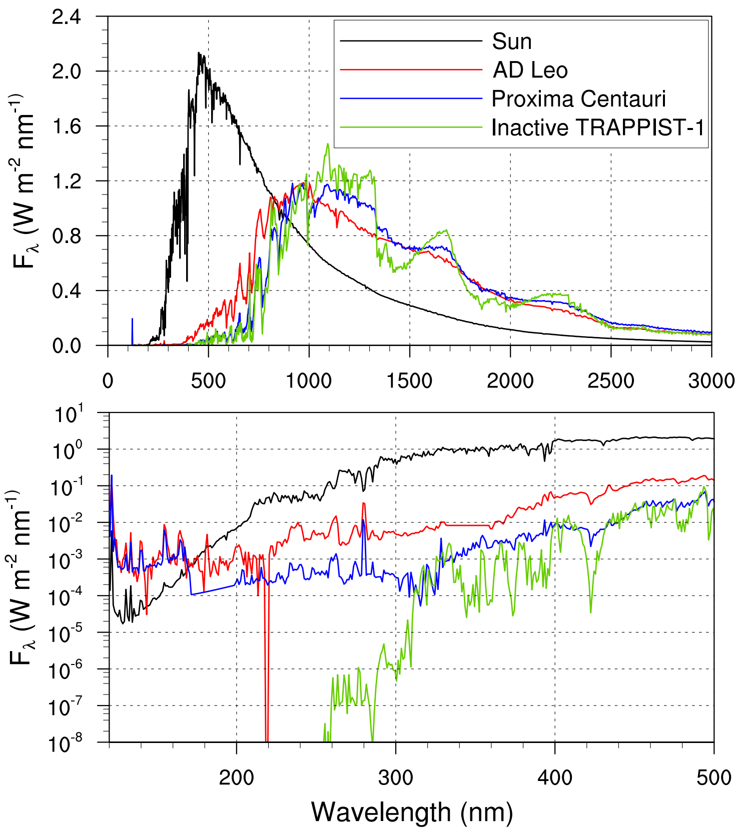
Fulton et al. 2018

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

Yangcheng Luo, Yongyun Hu, Jun Yang

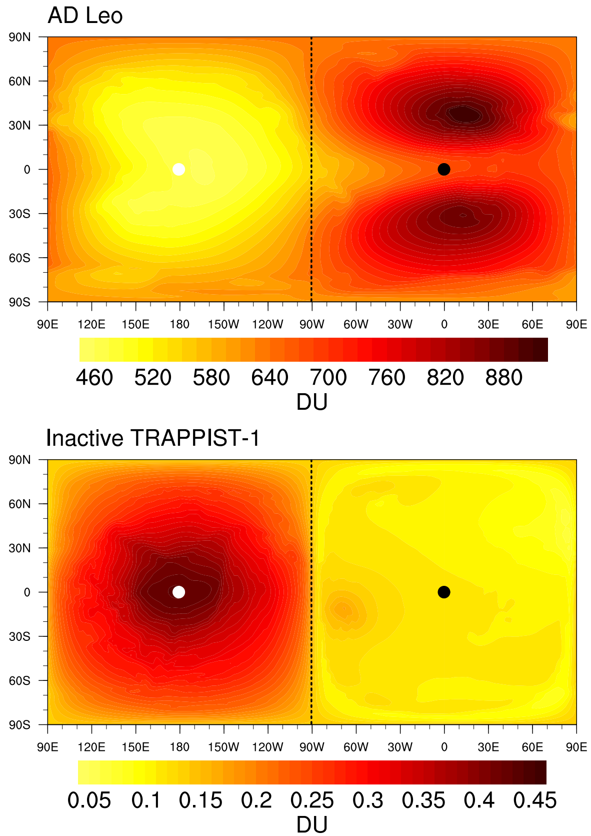
Department of Atmospheric and Oceanic Sciences, School of Physics, Peking University

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

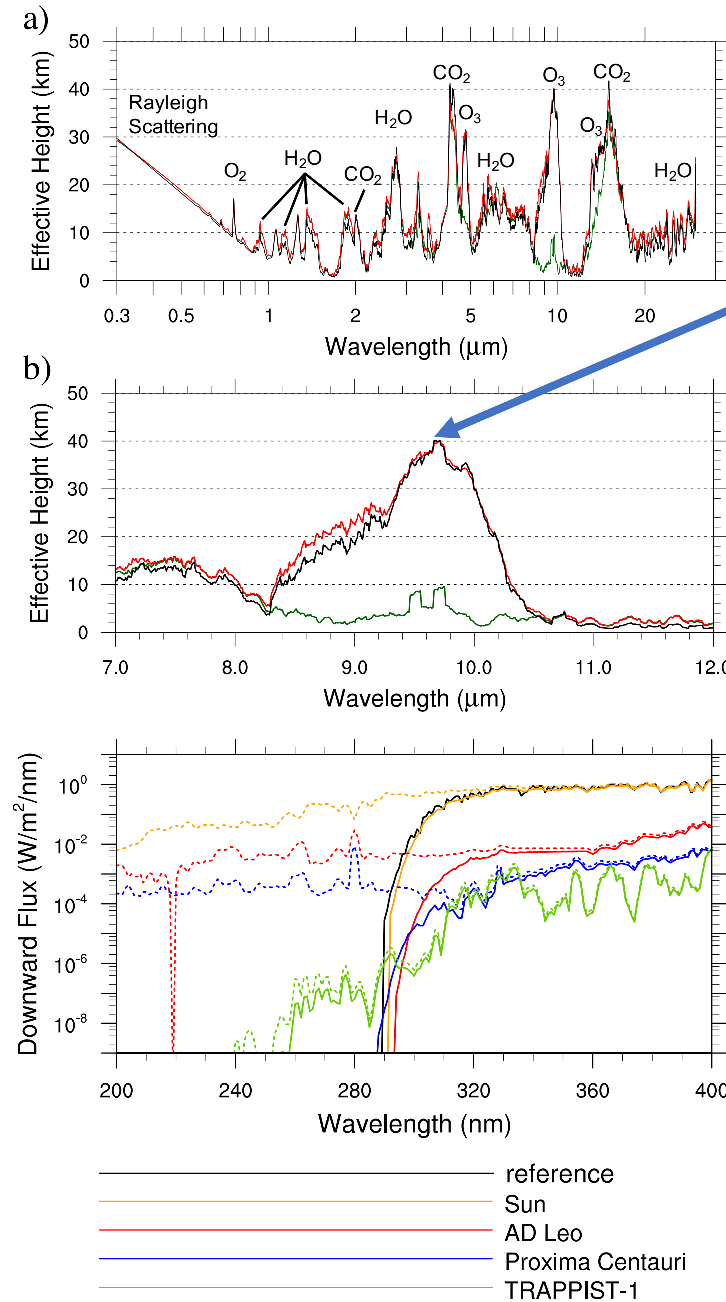


- What does an ozone layer look like on a tidally locked planet?
- Are ozone layers on exoplanets around M dwarfs detectable?
- Is the dayside exposed to a harmful UV flux?

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

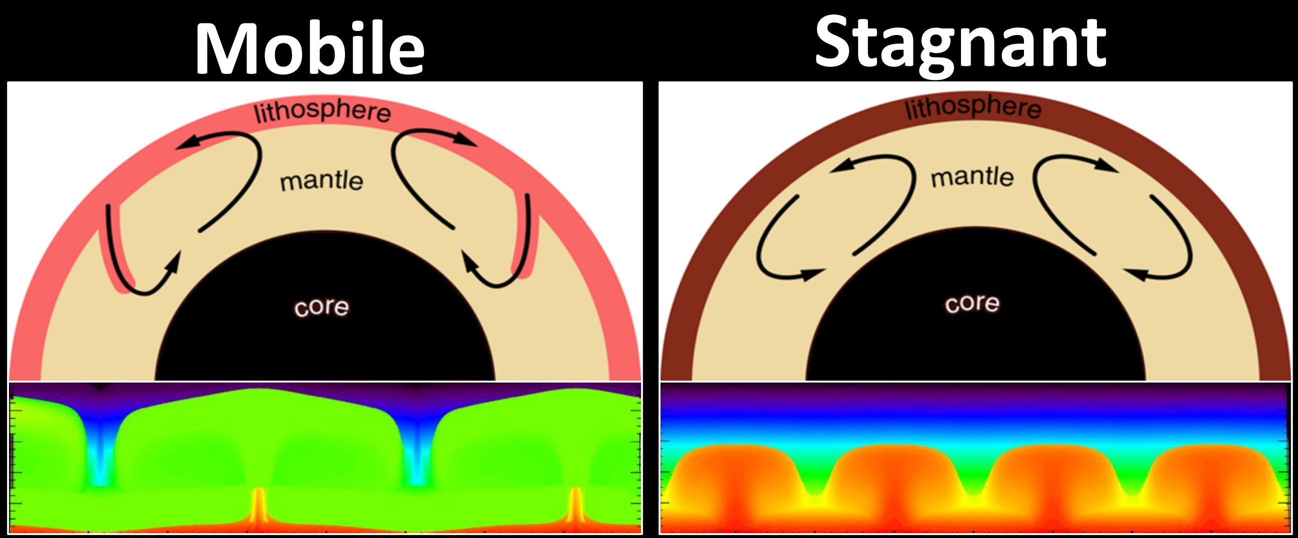


In principle, these ozone layers are detectable!

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



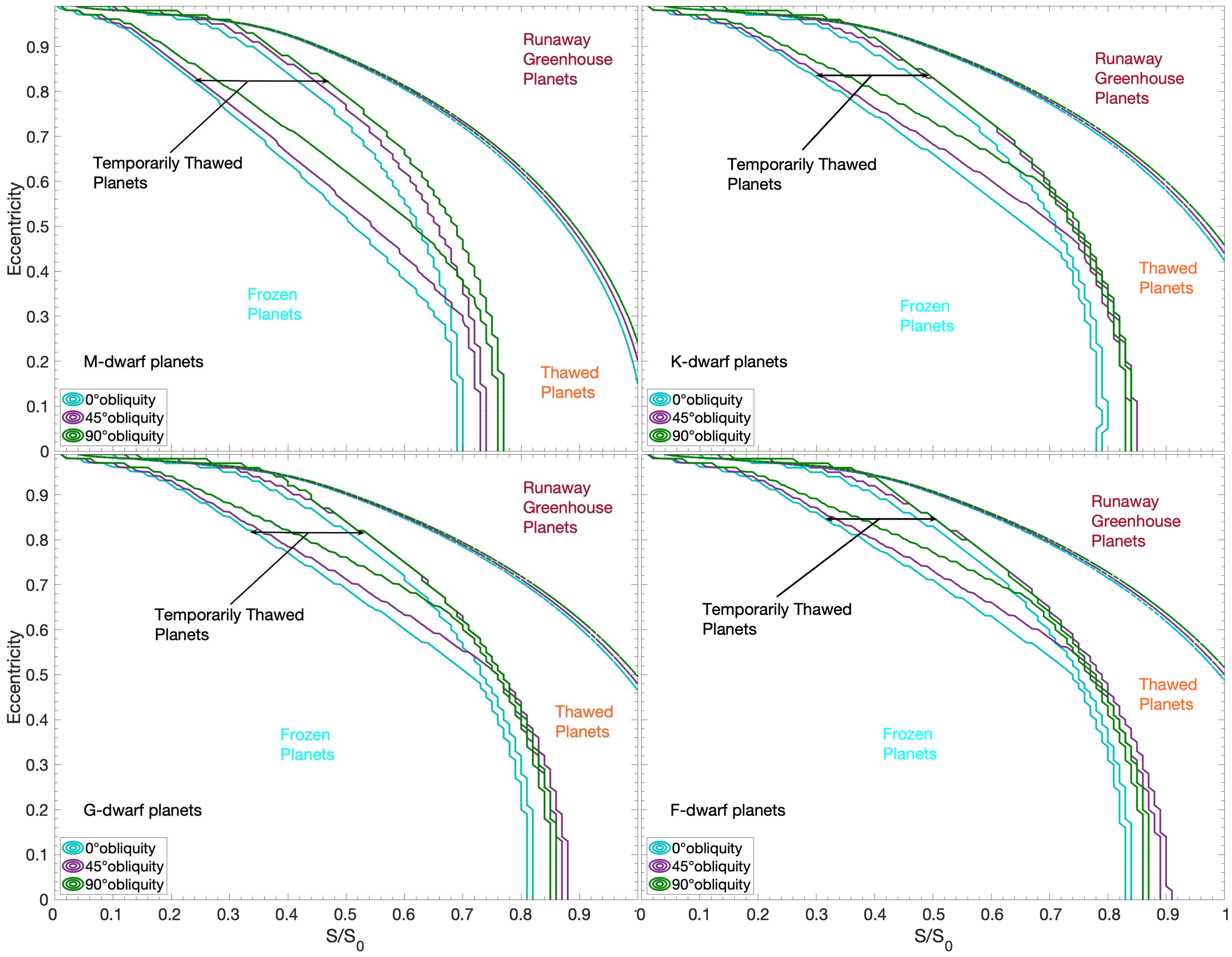
Katato & Barbot 2018

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

PENNSTATE
1855
Center for Exoplanets and Habitable Worlds
NSF

Temporal Habitability and Water Loss Limits on Eccentric Planets

Igor Z. Palubski[1] (email: ipalubsk@uci.edu), Aomawa L. Shields[1] , Russell Deitrick[2]
[1]UC Irvine, Department of Physics and Astronomy; [2]University of Bern, Center for Space and Habitability



Atmospheric Parameters and Ages of M Dwarfs in the Solar Neighborhood (Ellen C. de Almeida)

UFRJ

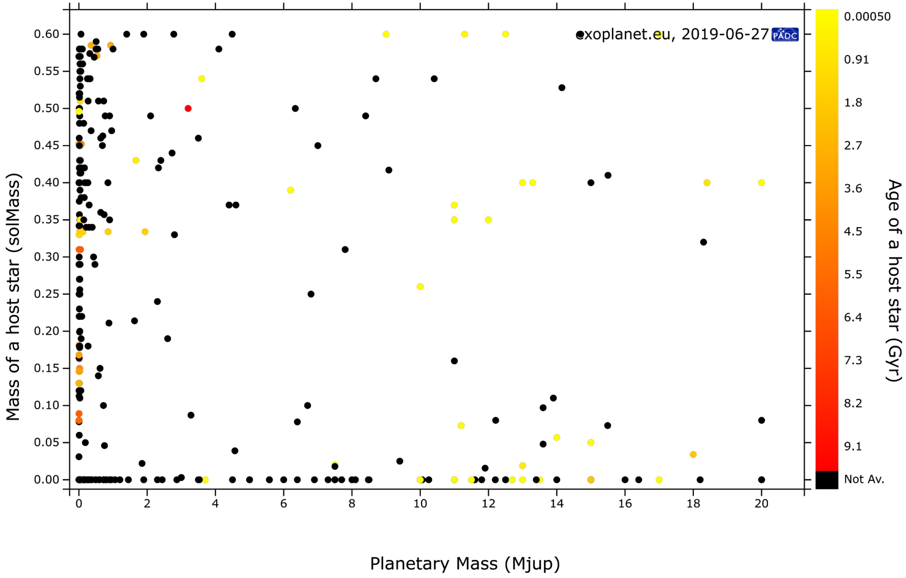
Observatório do Valongo

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 Teff 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

NASA Exoplanet Archive

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*

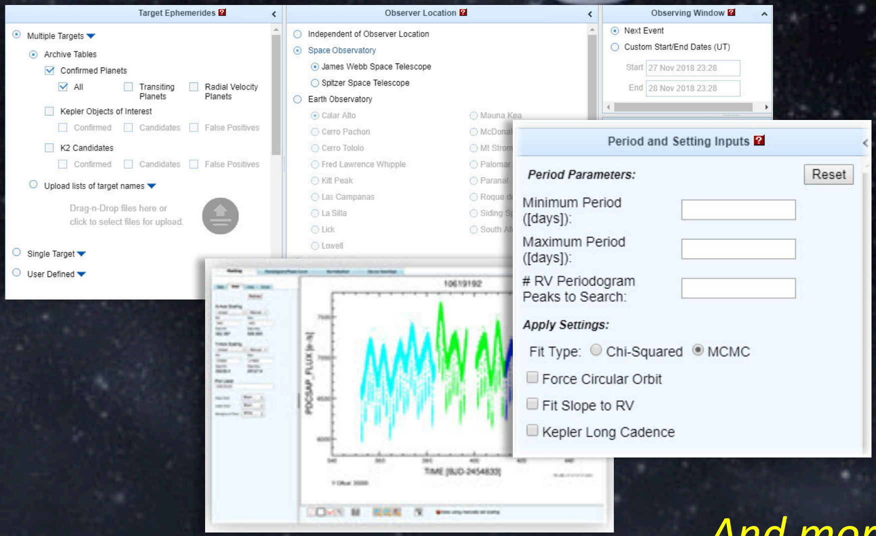
Also ***ExoFOP*** community follow-up program (Kepler/K2/TESS) https://exofop.ipac.caltech.edu/

- 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

EXOPLANETARCHIVE.IPAC.CALTECH.EDU

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*

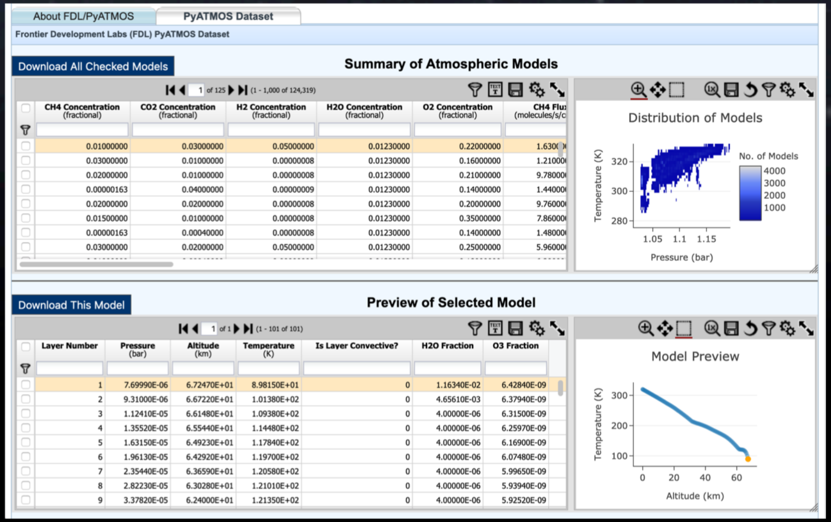


... And more!

Coming soon:

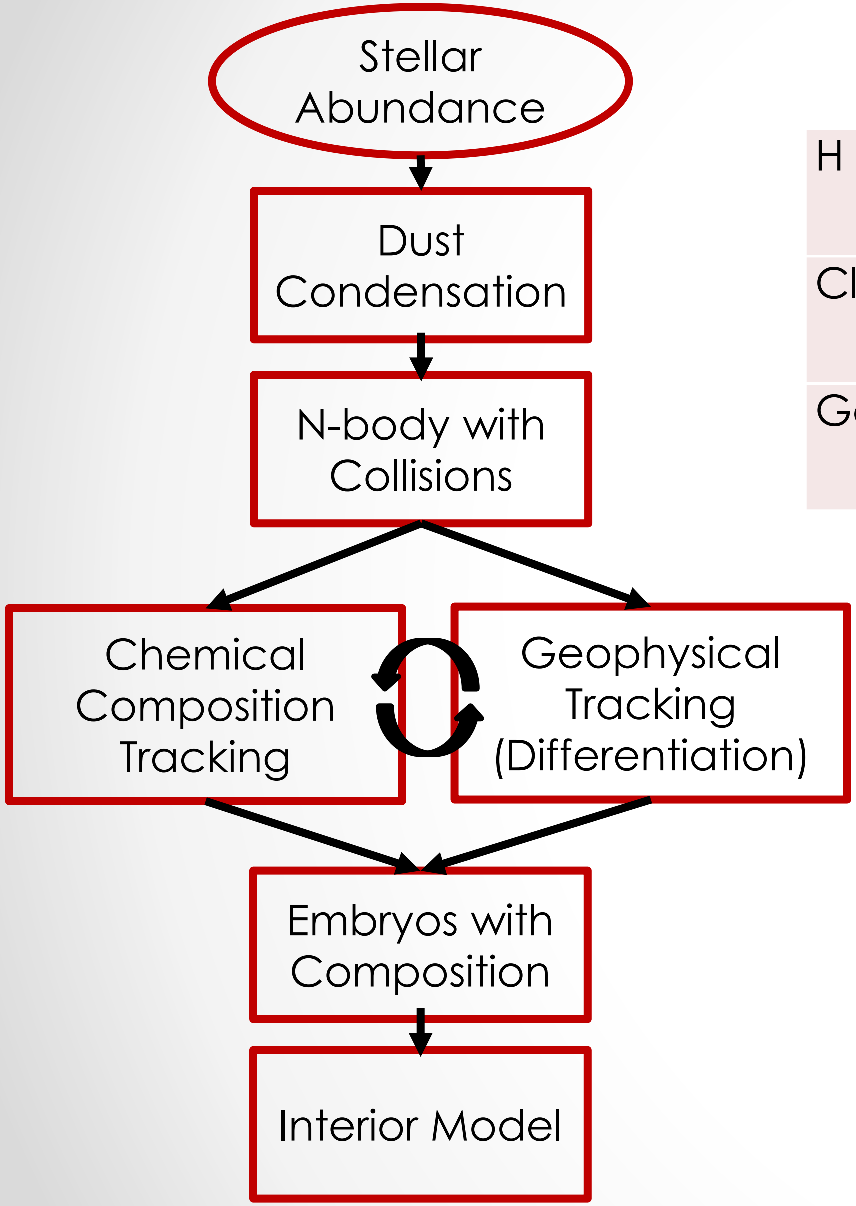
PyATMOS Dataset

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



UNLV

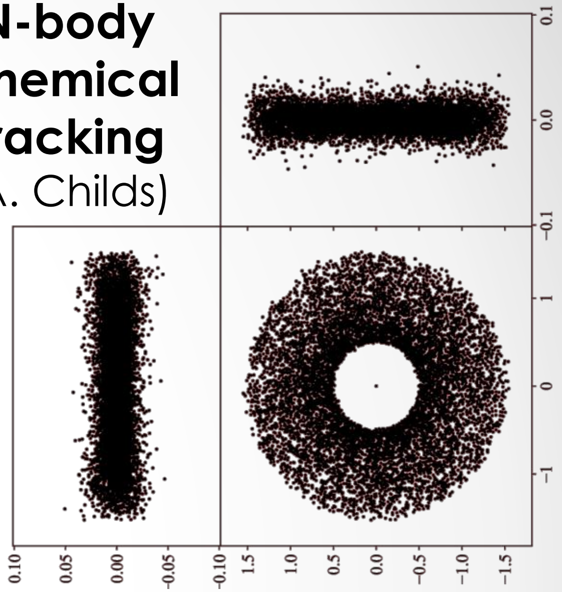
Jason H. Steffen's Research Group



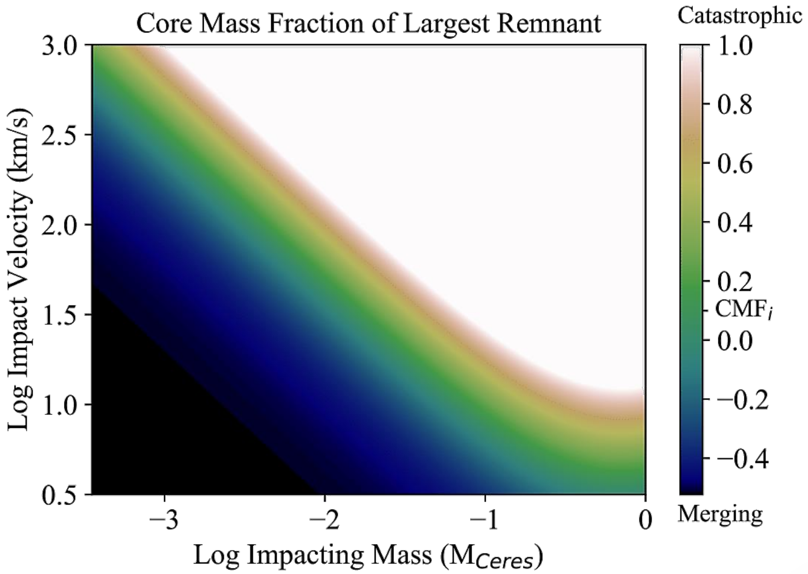
Physical-Chemical Dust Condensation (M. Li)

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

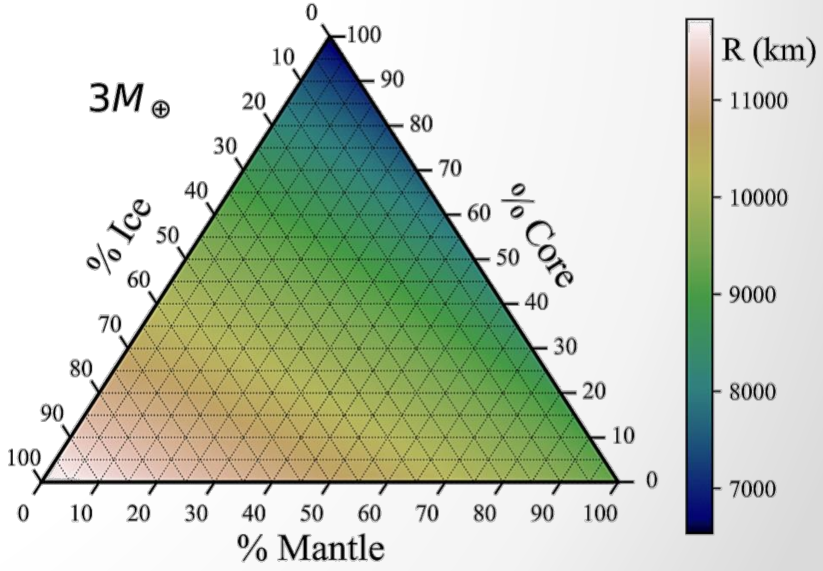
N-body Chemical Tracking (A. Childs)



Geophysical Processes (D. Rice)



Interior Structure (C. Huang)



David R. Rice | DavidRice@unlv.edu

Nitrogen Fixation on a Warm & Wet Early Mars

Danica Adams[1], Yangcheng Luo[1], Mike L. Wong[2,3], Renyu Hu[4], 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 CO_2

1-10% N_2
1-10% H_2,CH_4

NO, HCN | N, N(2D) | HNO3, HCN | NO_3^-, HCN

$CO_2 \rightarrow CO + O$
$O + N_2 \rightarrow NO + N$
$N + CO_2 \rightarrow NO + CO$

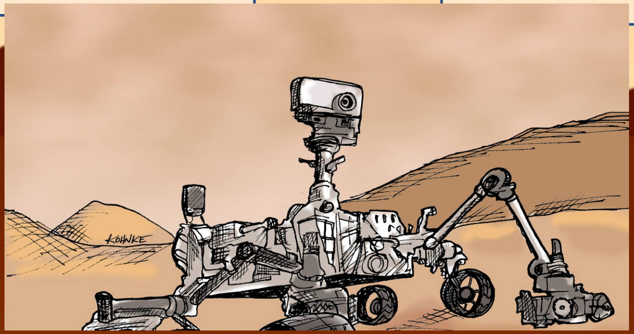
e.g.
$OH + NO_2 + M \rightarrow HNO_3 + M$
$HO_2 + NO + M \rightarrow HNO_3 + M$

$\rightarrow NO_2^-, NO_3^-$

$N_2, CH_4 \rightarrow$ N, N(2D), CH3

$\downarrow$

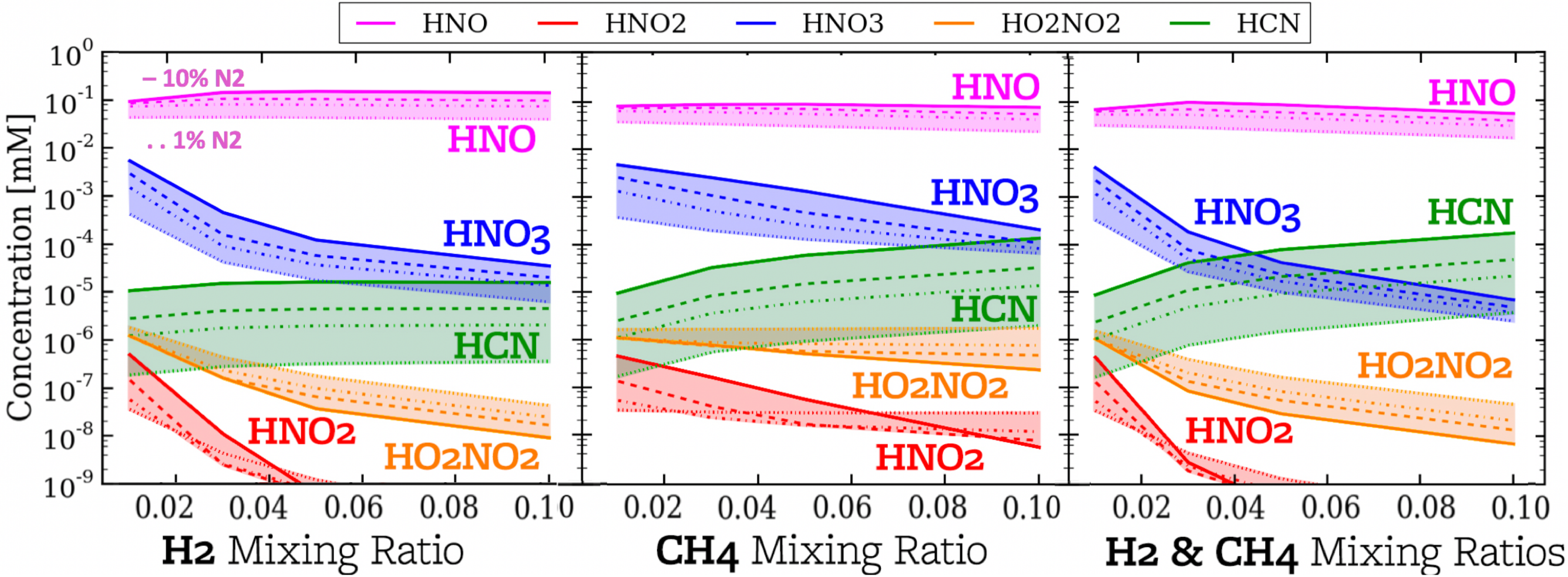
HCN



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

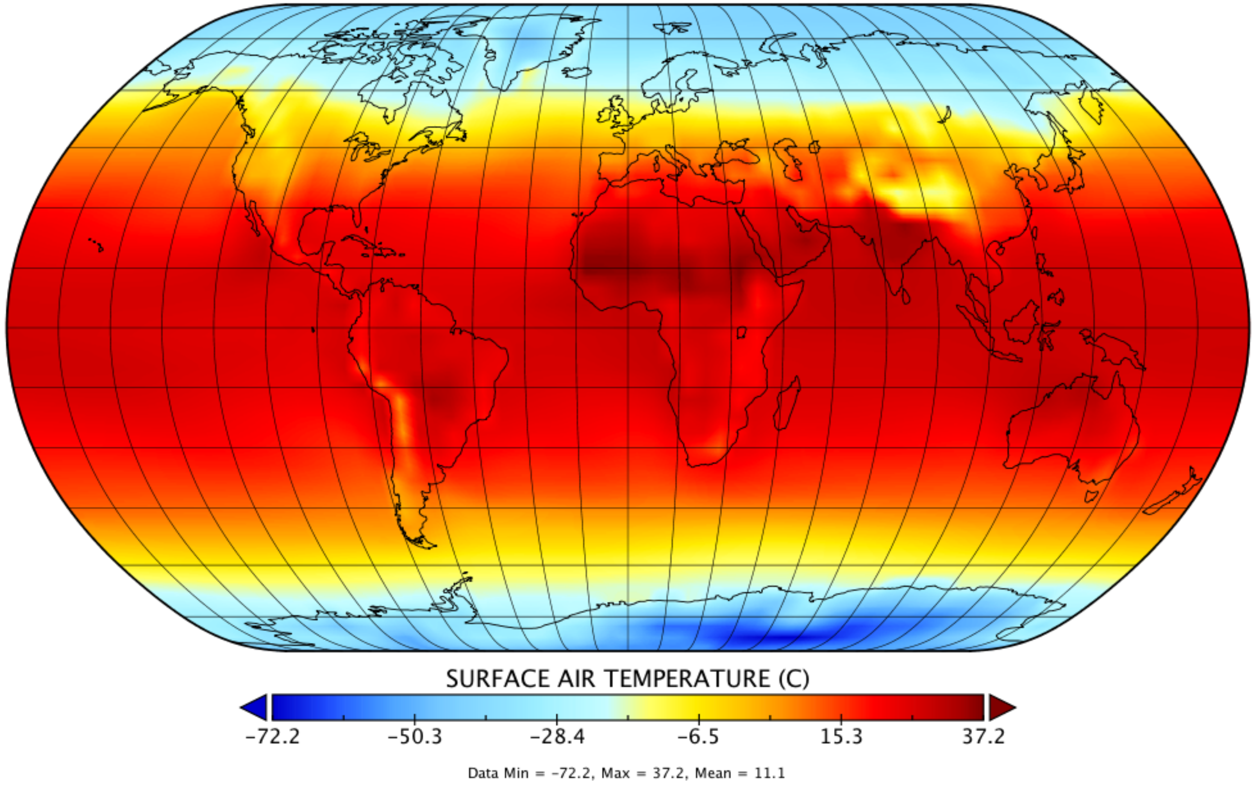
Stern et al. (2015), Sutter et al. (2017)

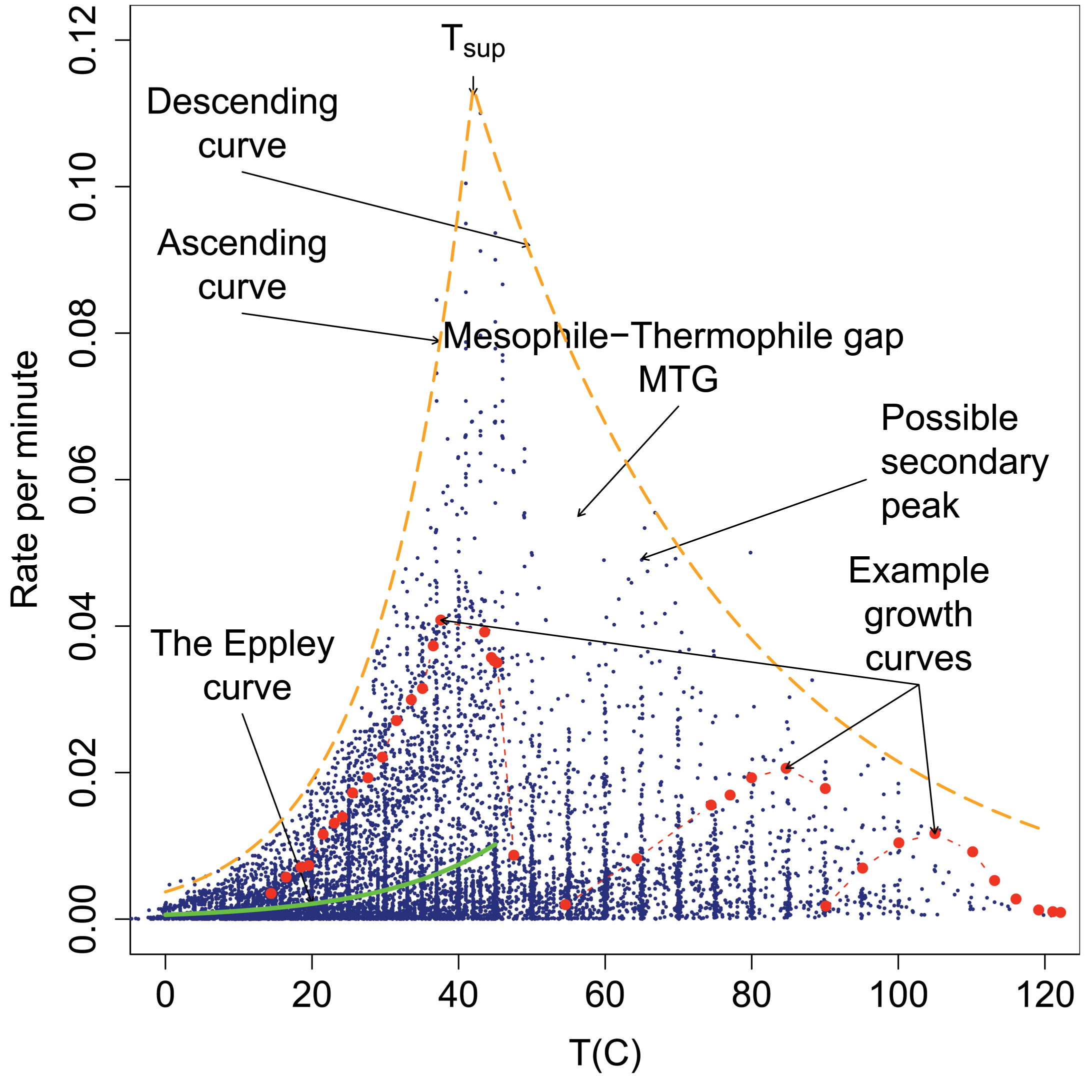
Pearce et al. (2019)
Holm & Neubeck (2009)



HNO
HNO2
HNO3
HO2NO2
HCN
Concentration [mM]
– 10% N2
. . 1% N2
HNO
HNO3
HCN
HNO2
HO2NO2
HNO
HNO3
HCN
HO2NO2
HNO2
HNO
HNO3
HCN
HO2NO2
HNO2
H2 Mixing Ratio
CH4 Mixing Ratio
H2 & CH4 Mixing Ratios

An Astroecological Model for Characterizing Exoplanet Habitability





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