ULTRAVIOLET ASTRONOMY IN THE XXI CENTURY

e-Workshop 2020 – October 27-29

JcUVa

UV-SCOPE

Ultraviolet Spectroscopic Characterization Of Planets and their Environments

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ASU School of Earth and Space Exploration
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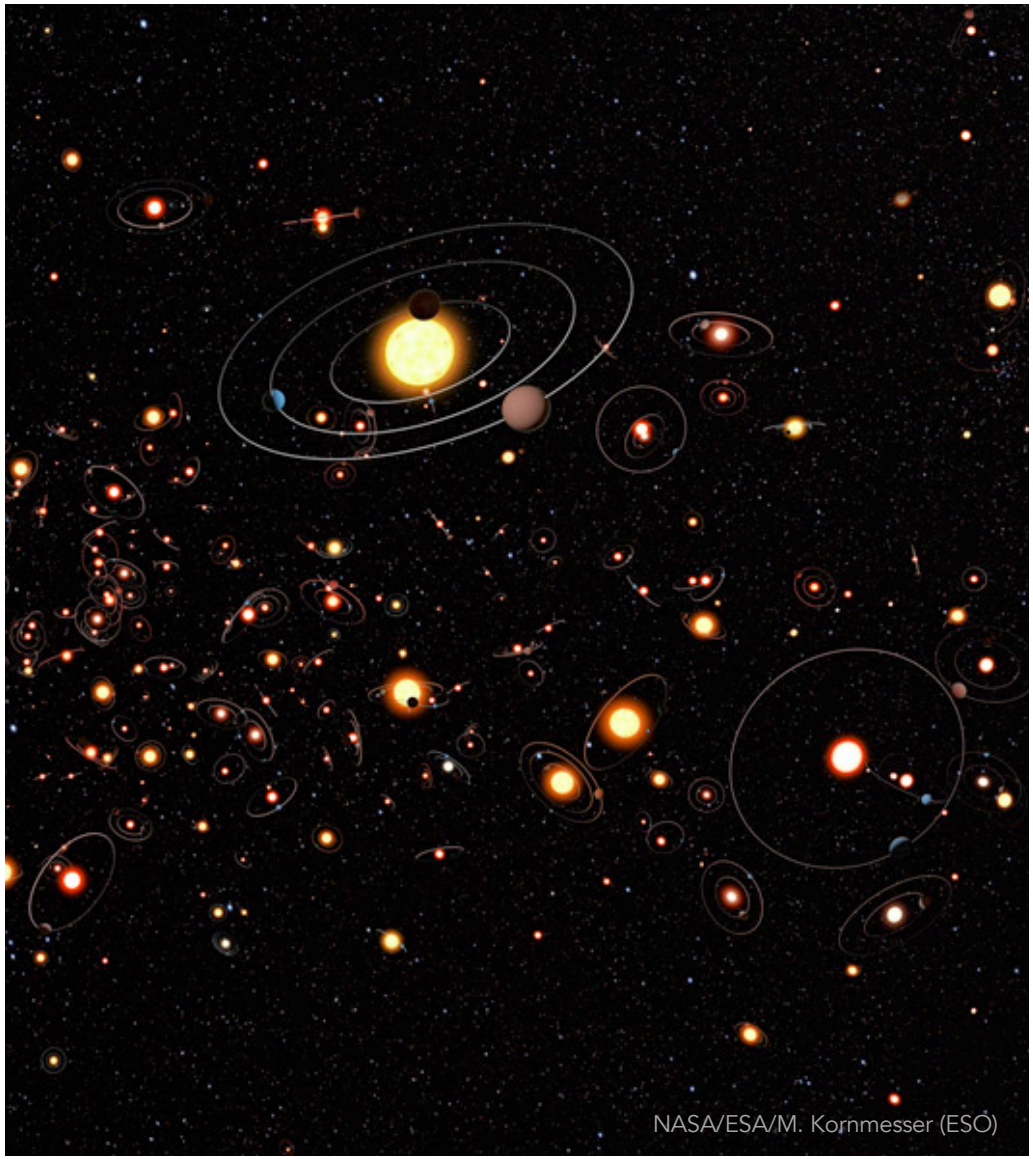
R. Dragushan



Today,
the Biggest Questions in
Exoplanet Science are:

How do planets form?
How do planets evolve?
What are they made of?
Are we alone?

UV-SCOPE will provide
critical information needed
to answer all these
questions, studying the
cause and effect of the UV.

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University of Arizona

Courtney Dressing
UC-Berkeley

Michael Line
Arizona State University

Josh Lothringer
Johns Hopkins University

R. Parke Loyd
Arizona State University

Victoria Meadows
University of Washington

Ruth Murray-Clay
UC-Santa Cruz

Shouleh Nikzad
Jet Propulsion Laboratory

James Owen
Imperial College London

Sarah Peacock
NASA-Goddard

Evgenya Shkolnik
Arizona State University

David Sing
Johns Hopkins University

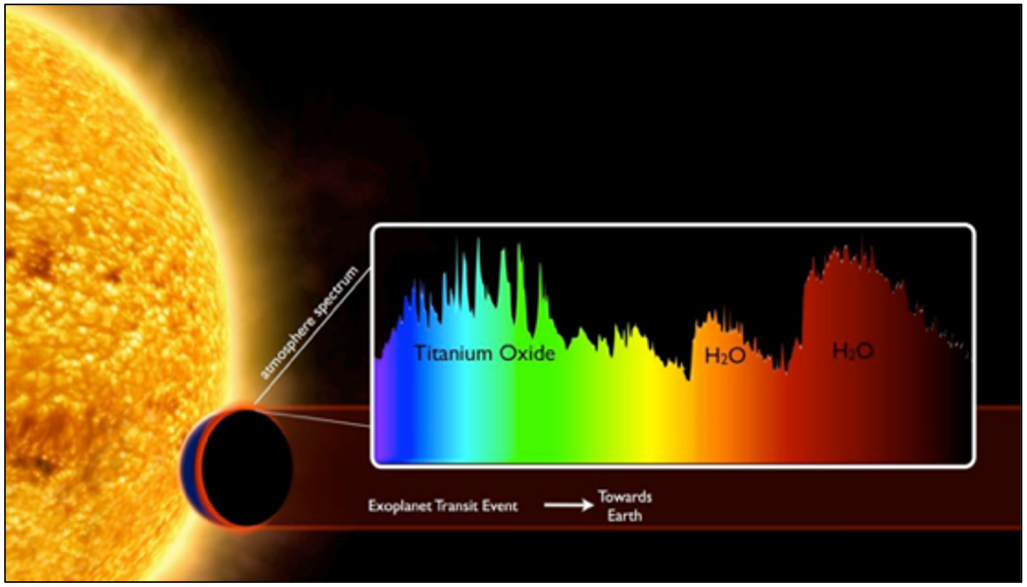
Kevin Stevenson
Applied Physics Lab

Mark Swain
Jet Propulsion Laboratory

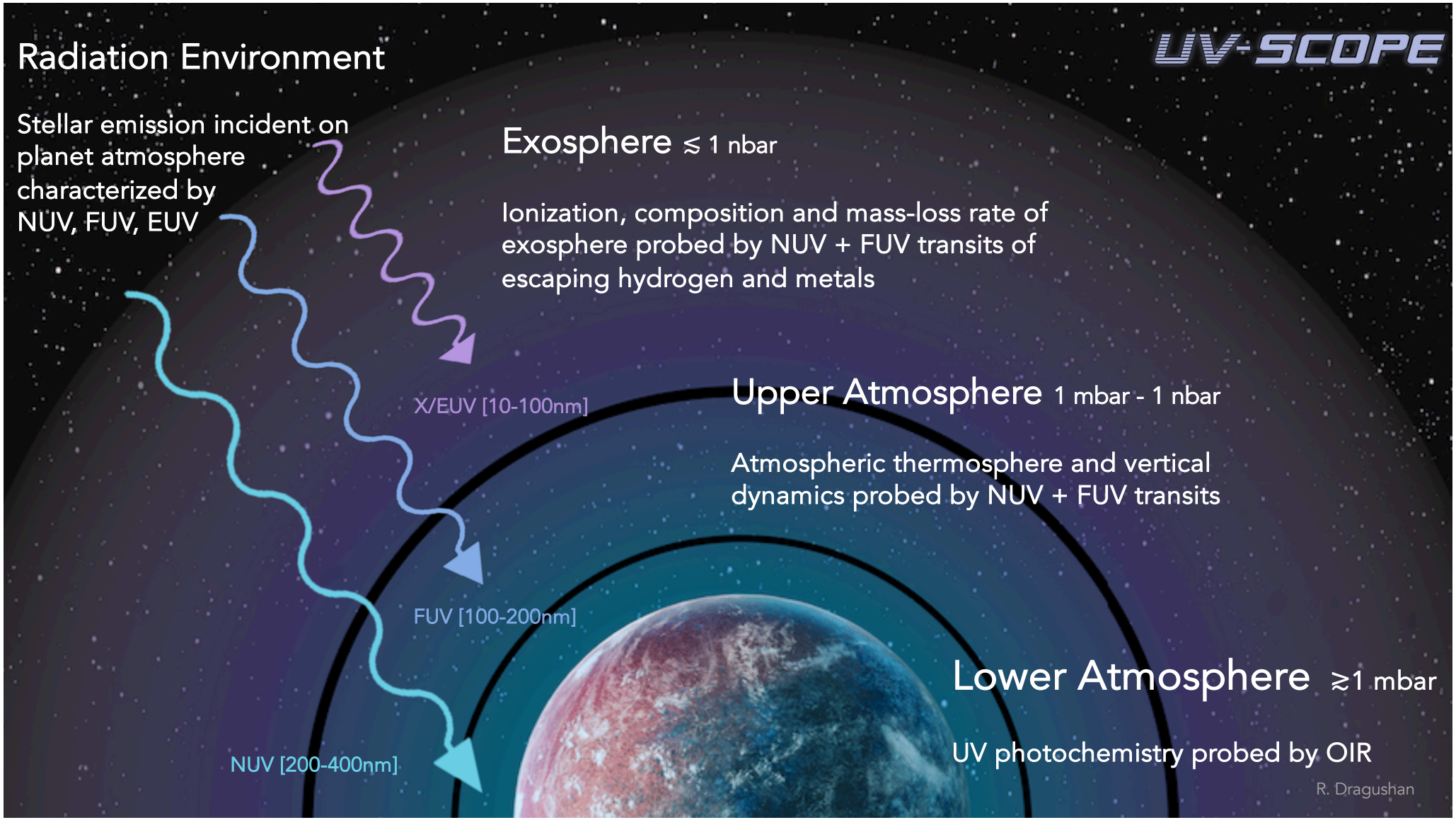
Directly probing planet atmospheres

Known transiting and new TESS planets will be UV-SCOPE targets; both small and large planets around AFGKM.

Transmission spectroscopy of transiting planets is the leading way to study the conditions and chemistry of exoplanet atmospheres.



NASA/D. Sing


Radiation Environment
UV-SCOPE
Stellar emission incident on planet atmosphere characterized by NUV, FUV, EUV
Exosphere ≲ 1 nbar
Ionization, composition and mass-loss rate of exosphere probed by NUV + FUV transits of escaping hydrogen and metals
X/EUV [10-100nm]
Upper Atmosphere 1 mbar - 1 nbar
Atmospheric thermosphere and vertical dynamics probed by NUV + FUV transits
FUV [100-200nm]
Lower Atmosphere ≳1 mbar
UV photochemistry probed by OIR
NUV [200-400nm]
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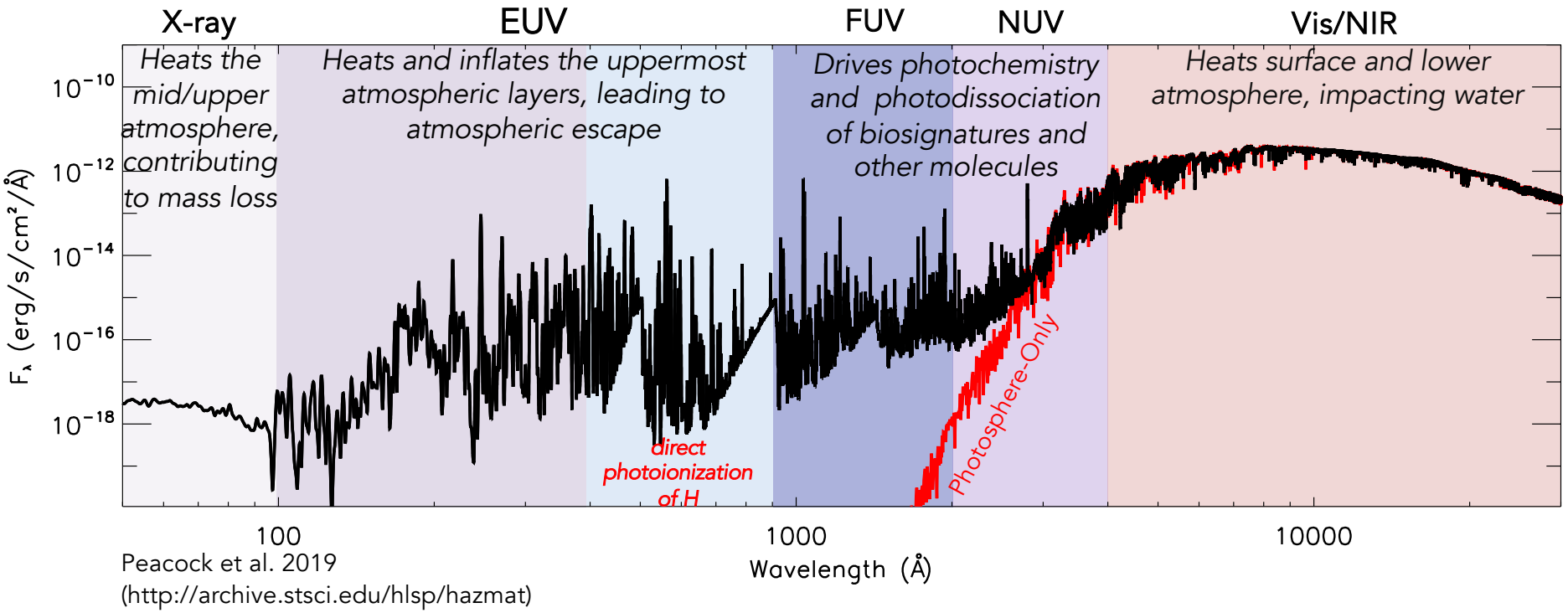
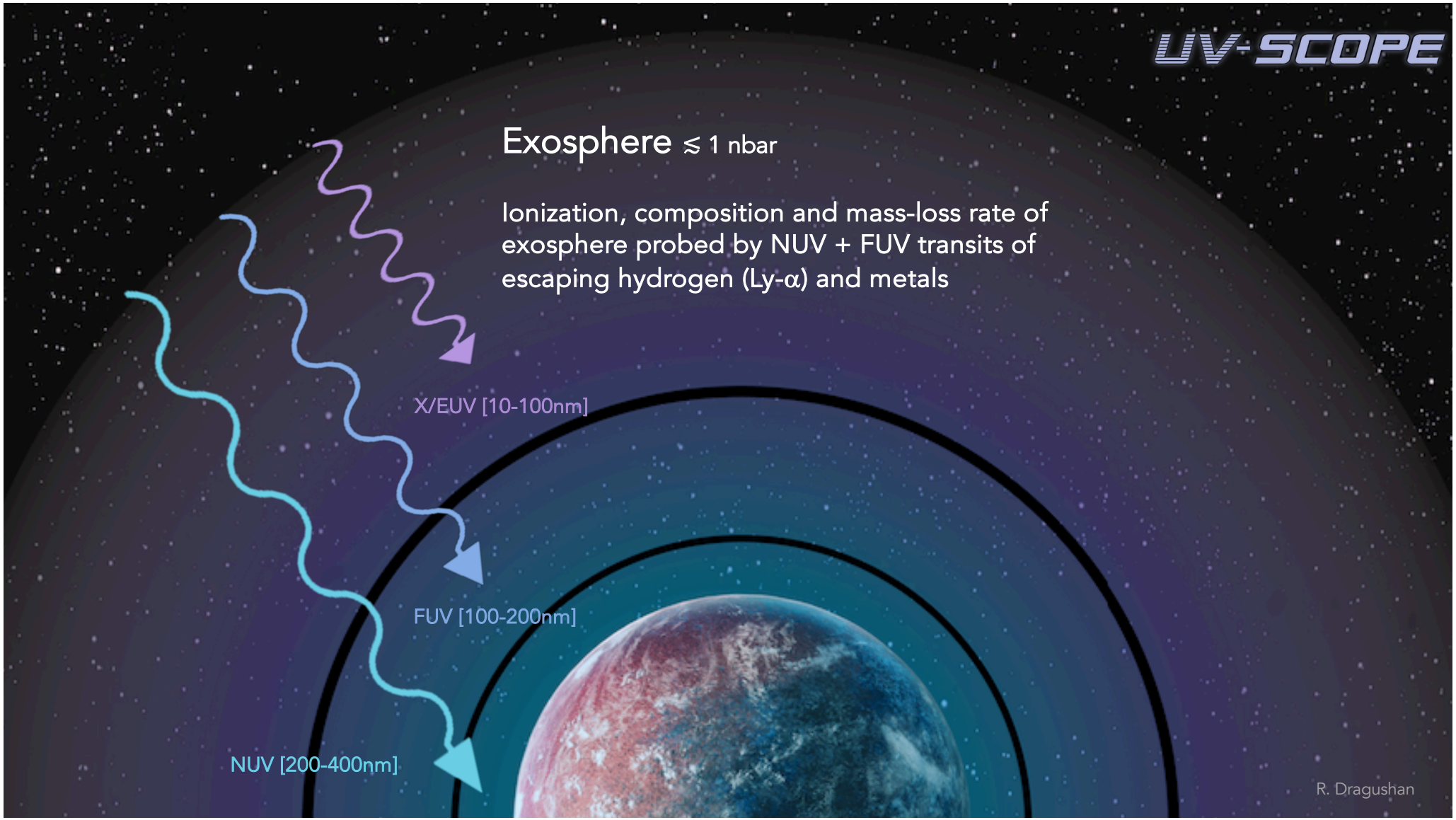
Predicting the EUV for all targets for escape

Model spectra of M dwarf planet host GJ 832



Peacock et al. 2019
(http://archive.stsci.edu/hlsp/hazmat)


UV-SCOPE
Exosphere ≲ 1 nbar
Ionization, composition and mass-loss rate of exosphere probed by NUV + FUV transits of escaping hydrogen (Ly-α) and metals
X/EUV [10-100nm]
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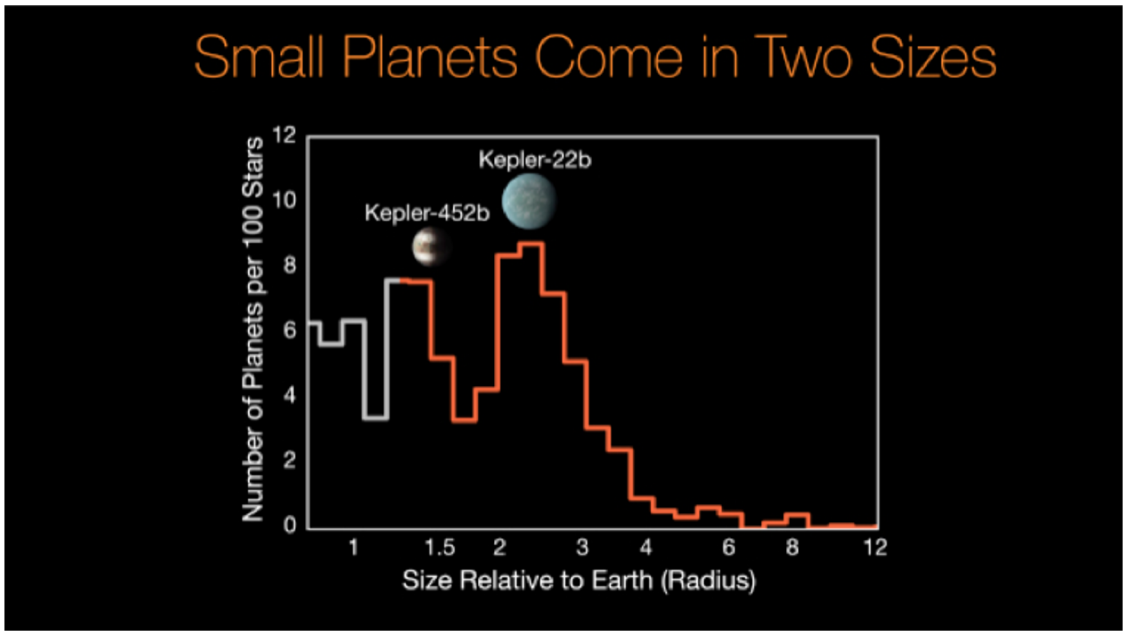
UV-SCOPE

Directly measuring escape

Do planets form or evolve into these two populations?

How much mass is being lost to space?

What is the range in mass loss rates and atomic fractionation across the diverse planet population?



Owen & Wu, 2017
Fulton et al. 2017, 2018

Directly measuring escape

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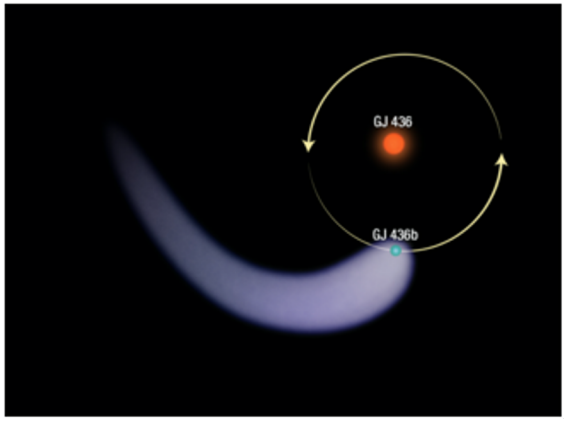
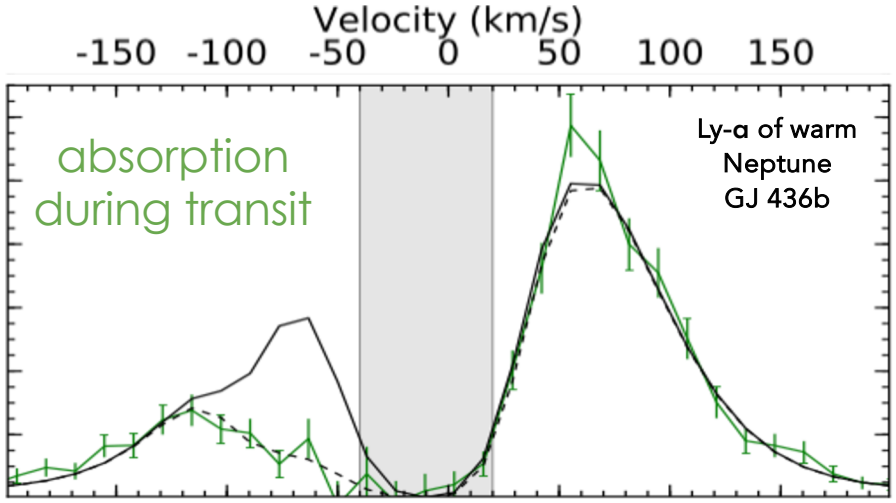
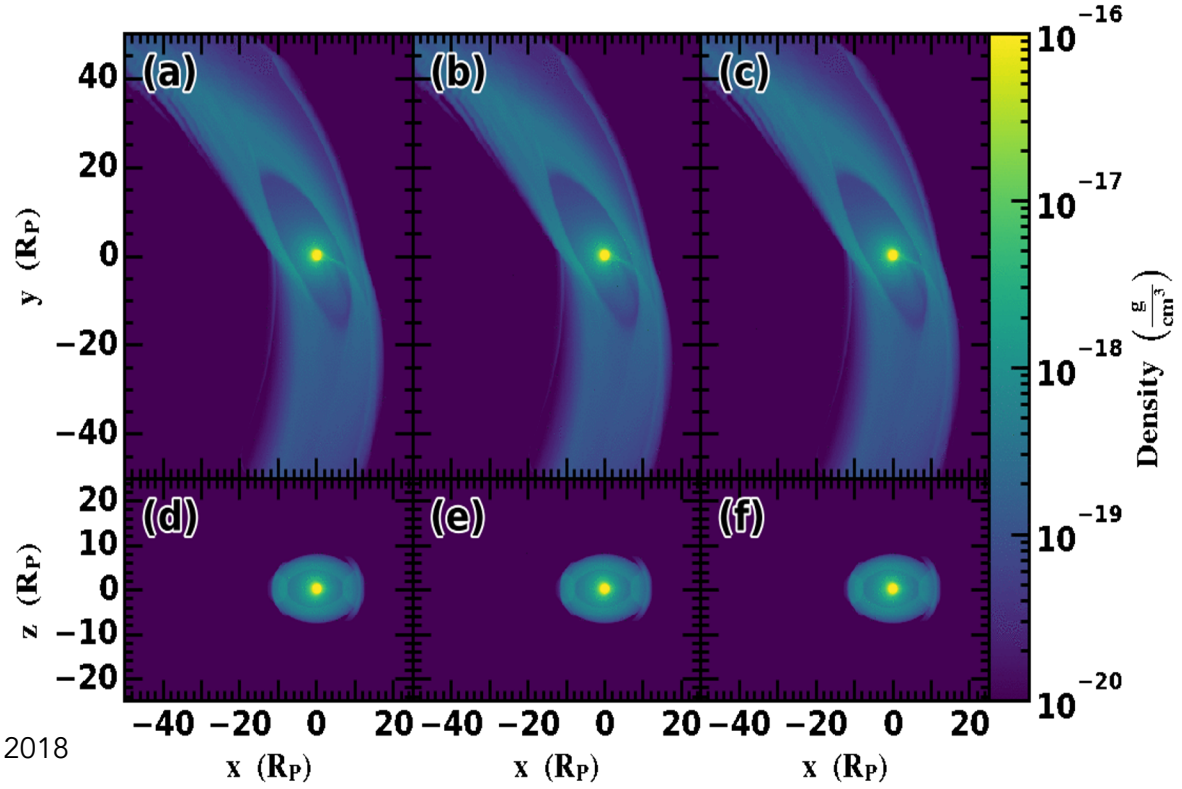




Bourrier et al. 2016

Directly measuring escape

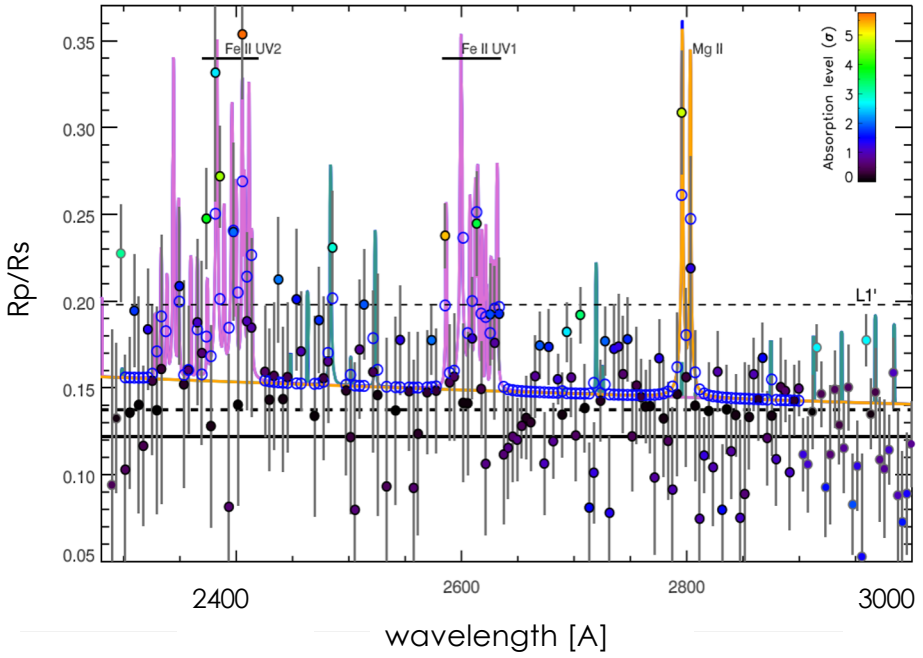
Evaporating gas can be sculpted into a tail by stellar radiation pressure and/or the stellar wind.



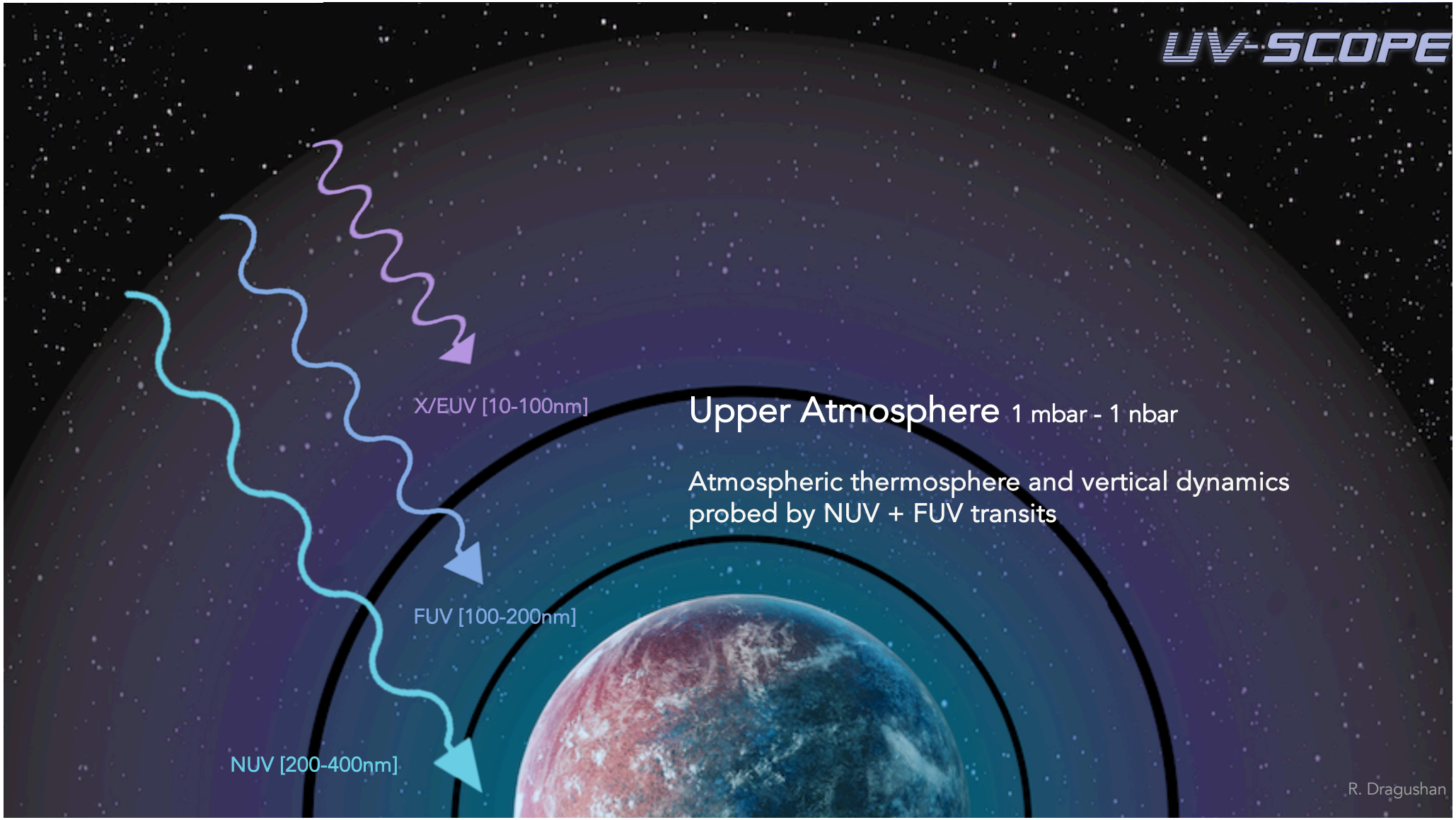
McCann, Murray-Clay, et al. 2018

Metals can be present in escaping gas

- Broad wavelength (FUV+NUV) coverage useful in constraining continuum level features (Wakeford+2020)
- Deeper atmosphere can influence composition of upper atmosphere (Sing+2020)



HST exoplanet transit of WAST 121b by Sing et al. 2019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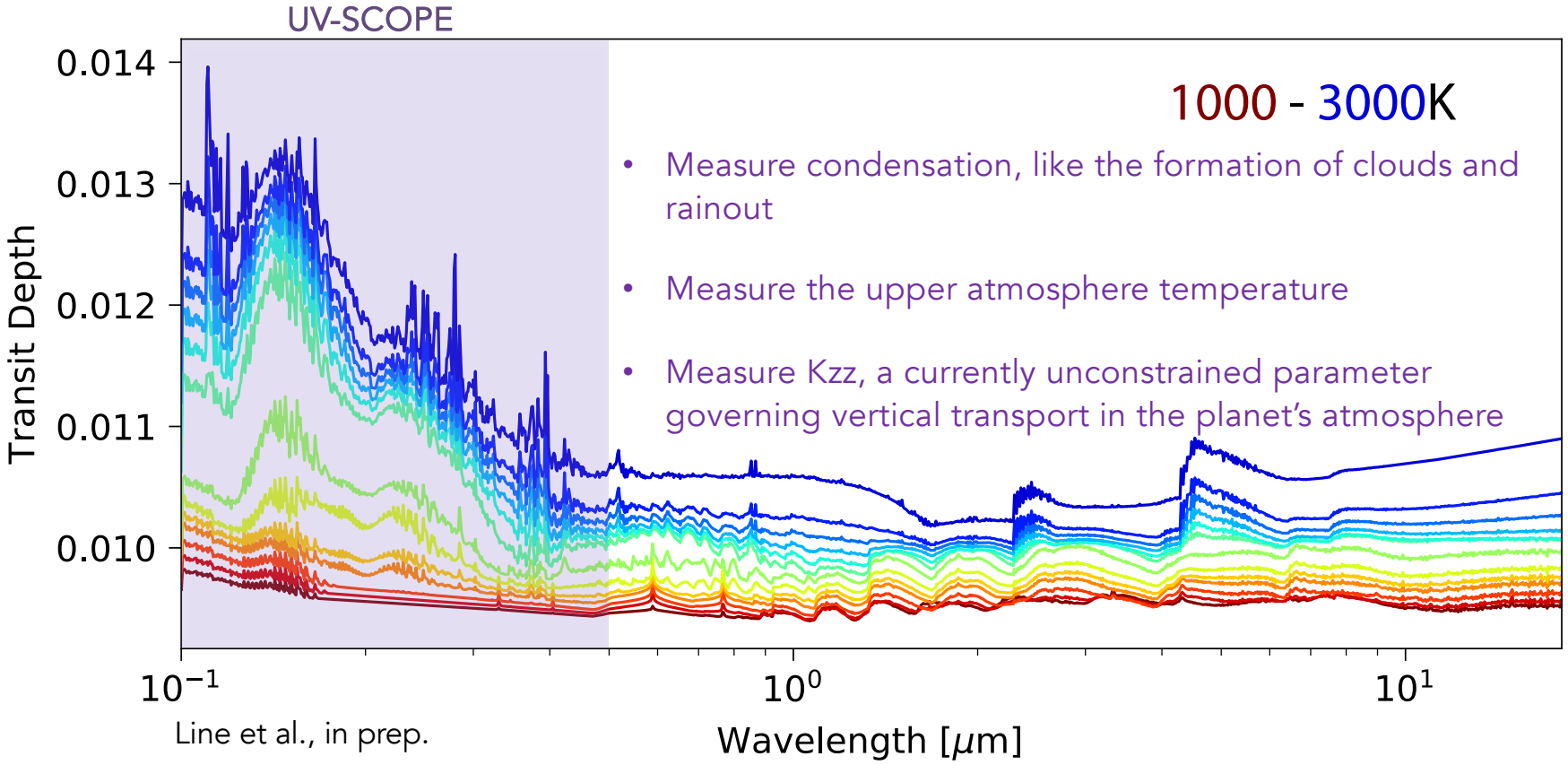
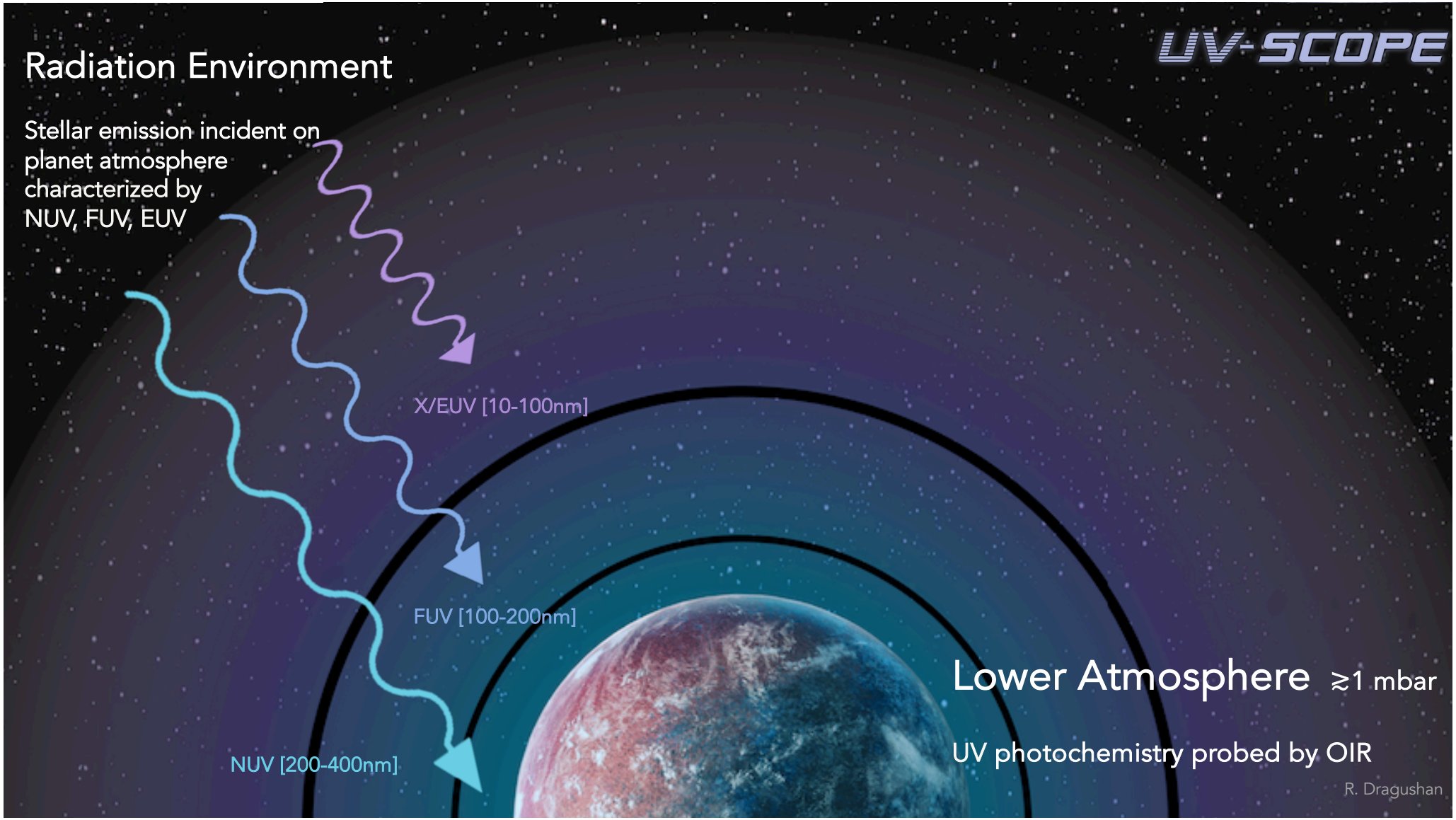
UV-SCOPE

UV transmission spectra of hot Jupiters



Line et al., in prep.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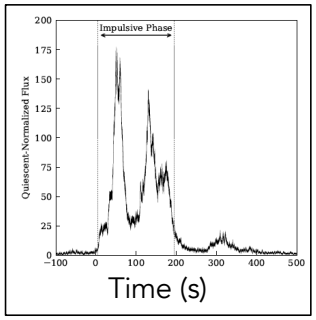
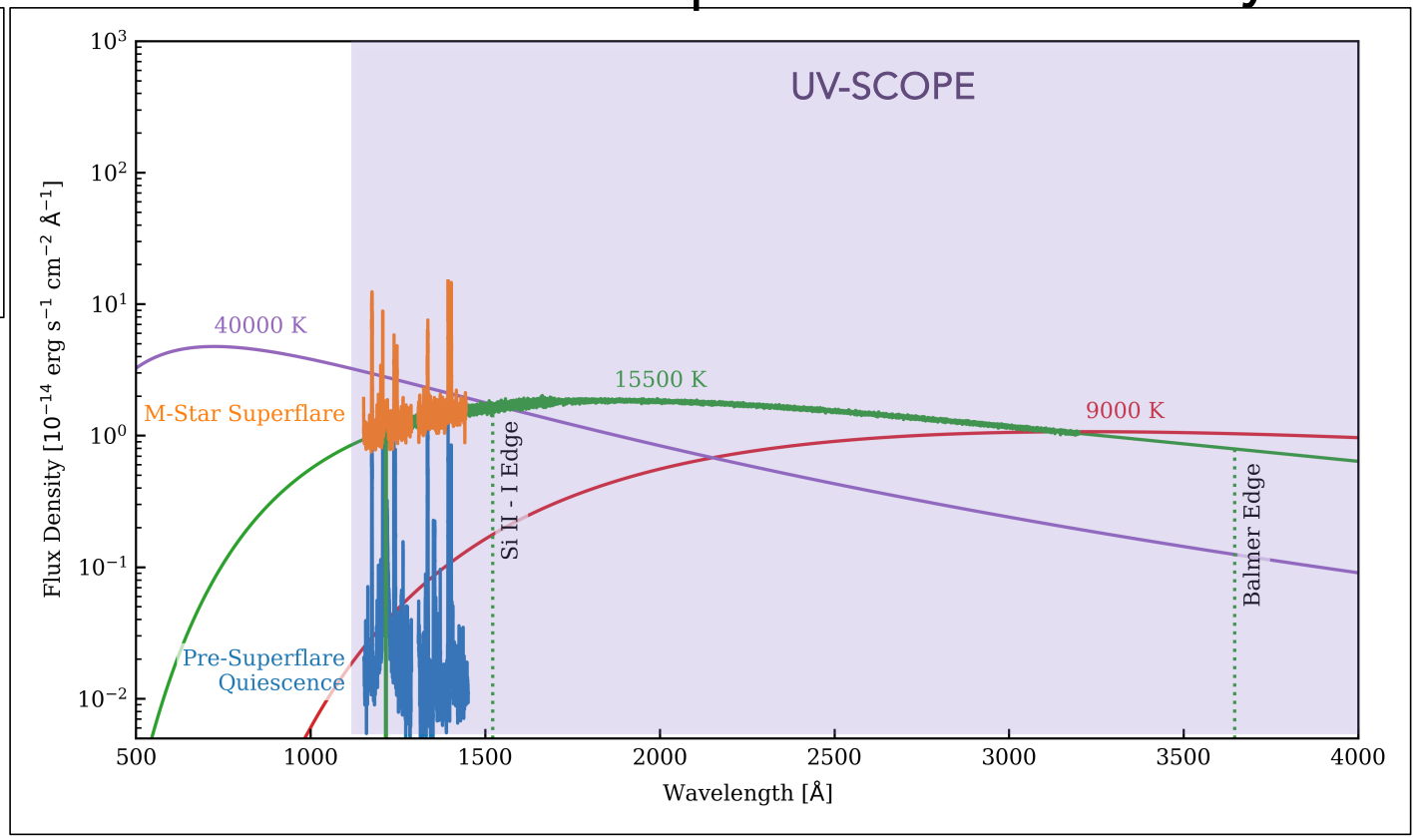
How much UV is emitted? Superflares + blackbody emission



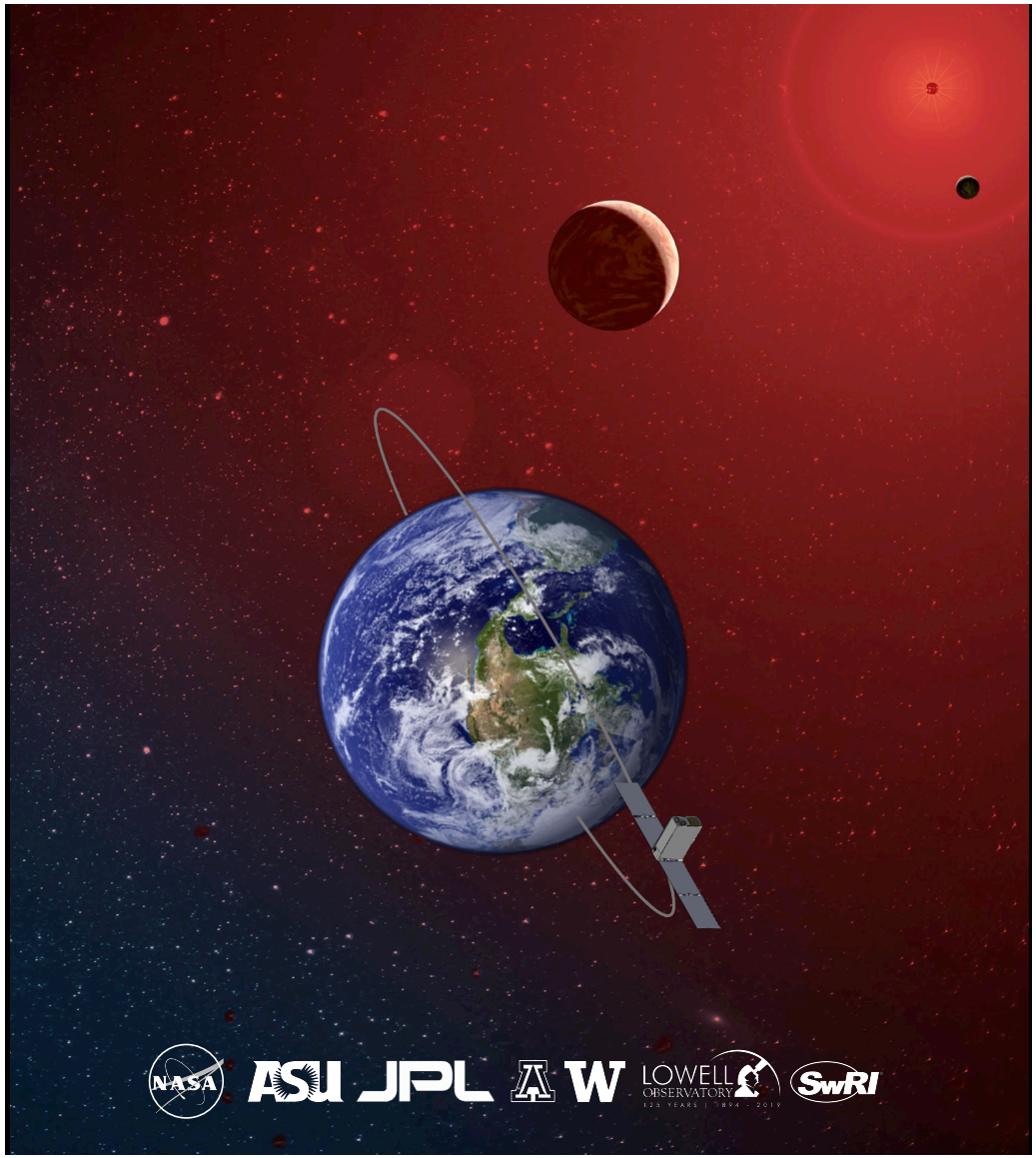


Kowalski et al. 2013
Froning et al. 2019

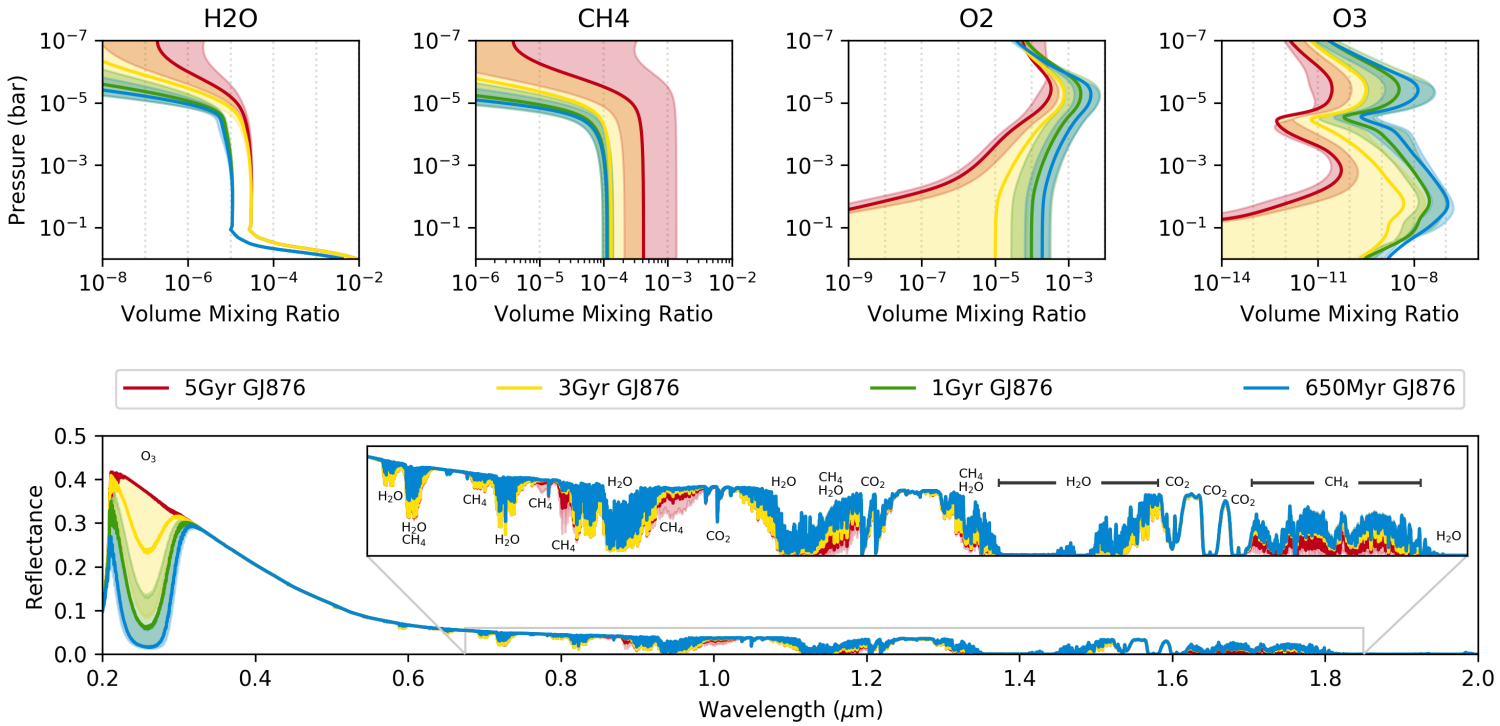
HAZMAT IV, Loyd et al. 2018

Star-Planet Activity Research CubeSat

Scowen et al. 2018
Jewell et al. 2018
Ardila et al. 2018



Example: Photochemical impacts on Earth-like atmospheres



The Virtual Planetary Laboratory will apply *UV-Scope* time-series to their continually improving planetary atmospheric modeling suite to assess the effects of stellar variability and the robustness of abiotic biosignature production.

Davis et al., in prep.

UV-SCOPE

- Simultaneous FUV (R=6000) & NUV (R=100) time-domain spectra
  - A capability sorely needed for all sorts of science!
- A large sample of AFGKM stars, *all with transiting planets*
- UV transmission spectroscopy of exoplanets super-Earths to hot Jupiters
- Stellar host characterization, e.g. UV emission, variability and flares

By observing both the star and its planet, UV-SCOPE will be able to simultaneously study the **"cause and effect"** of UV radiation in exoplanet systems.

R. Dragushan