



STScI | SPACE TELESCOPE
SCIENCE INSTITUTE

EXPANDING THE FRONTIERS OF SPACE ASTRONOMY

Transiting Exoplanet Community Early Release Science Program with *JWST*

Presented By Kevin Stevenson (STScI)
IAU - Vienna

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Co-Investigators:

Investigator	Institution	Country	Investigator	Institution	Country
M Alam	Harvard University	USA/MA	A Mandell	NASA Goddard Space Flight Center	USA/MD
N Batalha	NASA Ames Research Center	USA/CA	M Mansfield	University of Chicago	USA/IL
N Batalha	Space Telescope Science Institute	USA/MD	E May	University of Michigan	USA/MI
J Bean	University of Chicago	USA/IL	G Morello	University College London	GBR
B Benneke	Universite de Montreal	CAN	C Morley	Harvard University	USA/MA
Z Berta-Thompson	University of Colorado at Boulder	USA/CO	J Moses	Space Science Institute	USA/CO
J Blecic	New York University	USA/NY	N Nikolov	University of Exeter	GBR
G Bruno	Space Telescope Science Institute	USA/MD	V Parmentier	University of Arizona	USA/AZ
A Carter	University of Exeter	GBR	S Redfield	Wesleyan University	USA/CT
J Chapman	Jet Propulsion Laboratory	USA/CA	J Roberts	University of Colorado at Boulder	USA/CO
I Crossfield	Massachusetts Institute of Technology	USA/MA	E Schlawin	University of Arizona	USA/AZ
N Crouzet	Instituto de Astrofisica de Canarias	ESP	A Showman	University of Arizona	USA/AZ
L Decin	Katholieke Universiteit Leuven	BEL	D Sing	University of Exeter	GBR
B Demory	University of Bern	CHE	J Spake	University of Exeter	GBR
J Desert	Universiteit van Amsterdam	NLD	K Stevenson	Space Telescope Science Institute	USA/MD
D Dragomir	Massachusetts Institute of Technology	USA/MA	M Swain	Jet Propulsion Laboratory	USA/CA
T Evans	University of Exeter	GBR	K Todorov	Universiteit van Amsterdam	NLD
J Fortney	University of California - Santa Cruz	USA/CA	A Tsiaras	University College London	GBR
J Fraine	Space Telescope Science Institute	USA/MD	O Venot	Laboratoire Interuniversitaire des Systèmes Atmosphériques	FRA
P Gao	NASA Ames Research Center	USA/CA	W Waalkes	University of Colorado at Boulder	USA/CO
A Garcia Munoz	Technische Universitat Berlin	DEU	H Wakeford	Space Telescope Science Institute	USA/MD
N Gibson	The Queen's University of Belfast	GBR	P Wheatley	The University of Warwick	
J Goyal	University of Exeter	GBR	R Zellem	Jet Propulsion Laboratory	
J Harrington	University of Central Florida	USA/FL	Number of investigators: 61 SA investigators: 23 SA investigators: 1		
K Heng	University of Bern	CHE			
R Hu	Jet Propulsion Laboratory	USA/CA			
E Kempton	University of Maryland	USA/MD			
S Kendrew	ESA-European Space Astronomy Centre	ESP			
B Kilpatrick	Brown University	USA/RI			
H Knutson	California Institute of Technology	USA/CA			
L Kreidberg	Harvard University	USA/MA			
J Krick	Caltech/IPAC	USA/CA			
P Lagage	Commissariat a l'Energie Atomique (CEA)	FRA			
M Lendl	Space Research Institute, Austrian Academy of Sciences	AUT			
M Line	Arizona State University	USA/AZ			
M Lopez-Morales	Smithsonian Institution Astrophysical Observatory	USA/MA			
T Louden	The University of Warwick	GBR			
N Madhusudhan	University of Cambridge	GBR			

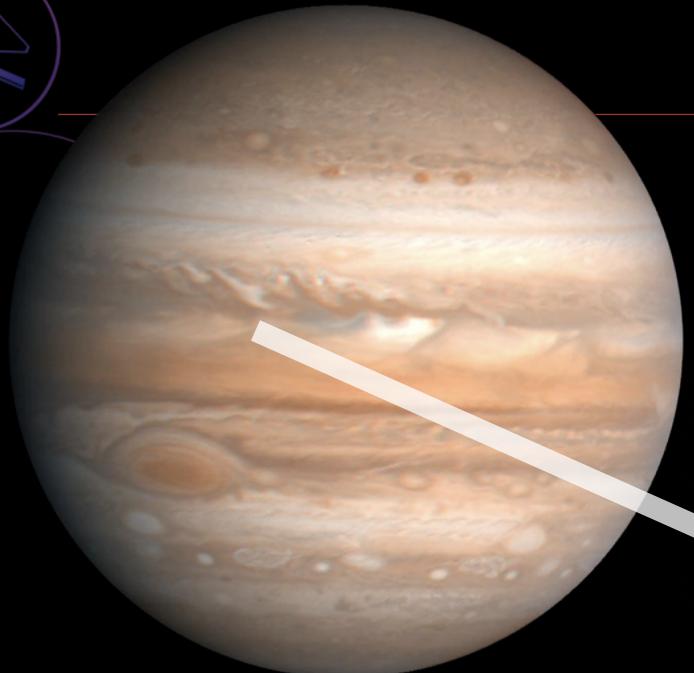
+ about 50 more
Collaborators

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The Transiting Exoplanet Community Early Release Science
Program
James Webb Space Telescope
Cycle 1 ERS Proposal

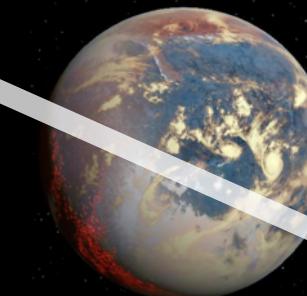
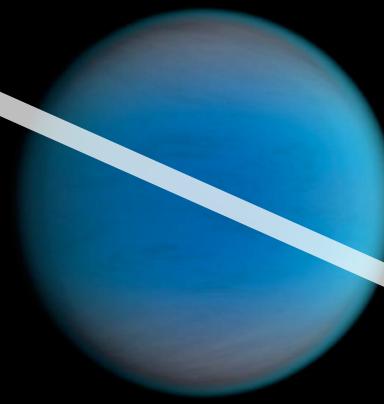
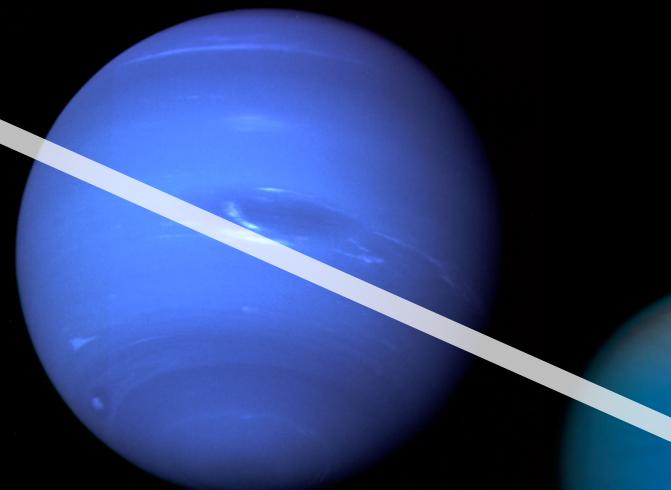
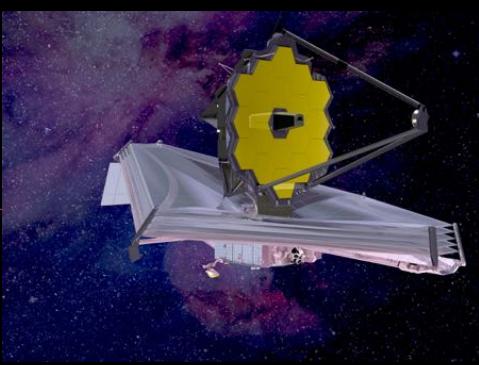
Scientific Category: Planets and Planet Formation
Scientific Keywords: Extrasolar Planets, Planetary Atmospheres, Transits
Instruments: NIRSPEC, NIRISS, MIRI, NIRCAM
Proprietary Period: 0 months

Allocation Information (in hours):
Science Time: 52.1
Charged Time: 78.1



In the era of *JWST*

Potential to characterize >300 exoplanets at high resolution and across a broad range of wavelengths



In the era of *Hubble & Spitzer*

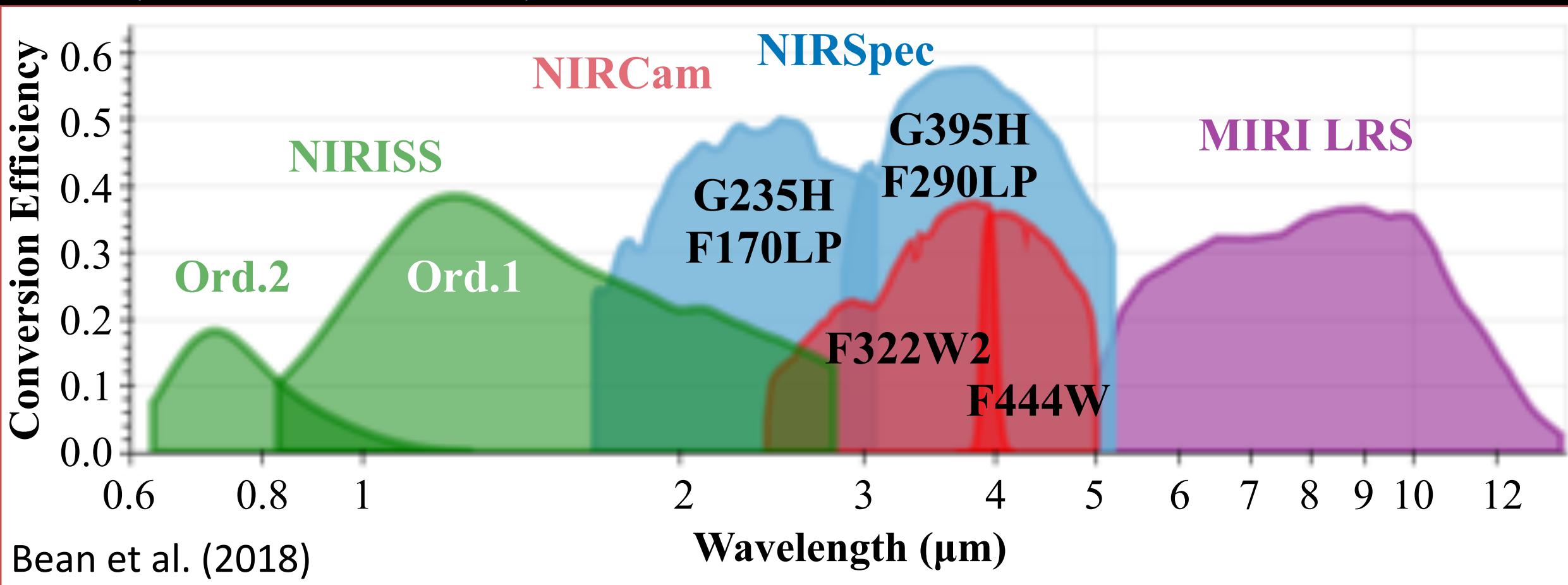
~100 exoplanets observed using low-R spectroscopy or broadband photometry



JWST's Most Anticipated Spectroscopic Modes

HST STIS+WFC3

Warm Spitzer





Infrared spectrum of Jupiter – Circa 1960's

- Danielson (1966)
 - IR reflectance spectrum of Jupiter
- Stratoscope II balloon flight
 - November 1963
 - 84,000 ft
- $0.8 - 3.1 \mu\text{m}$, $R \sim 100$
- Detect CH_4 , NH_3 , and collision-induced H_2

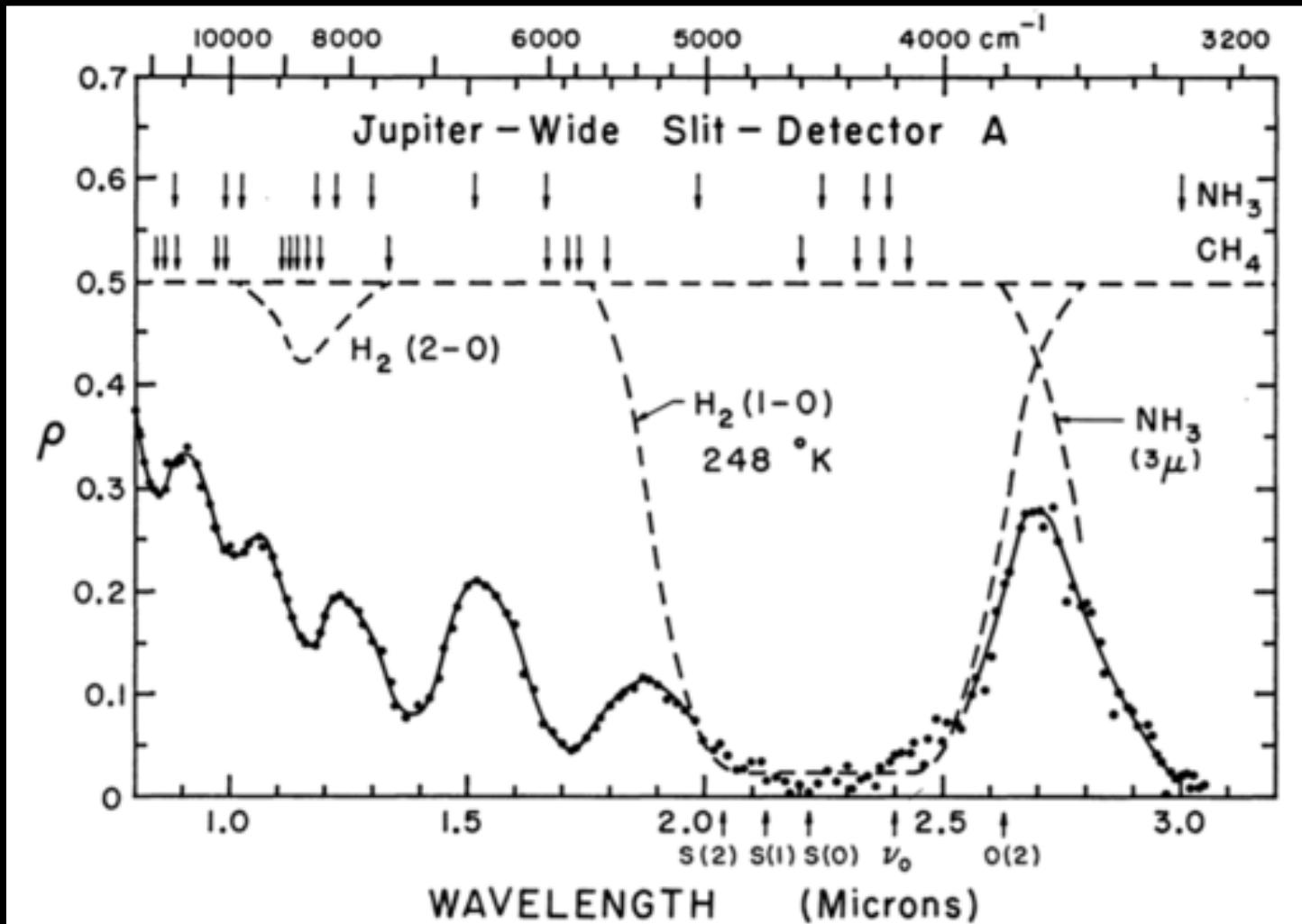
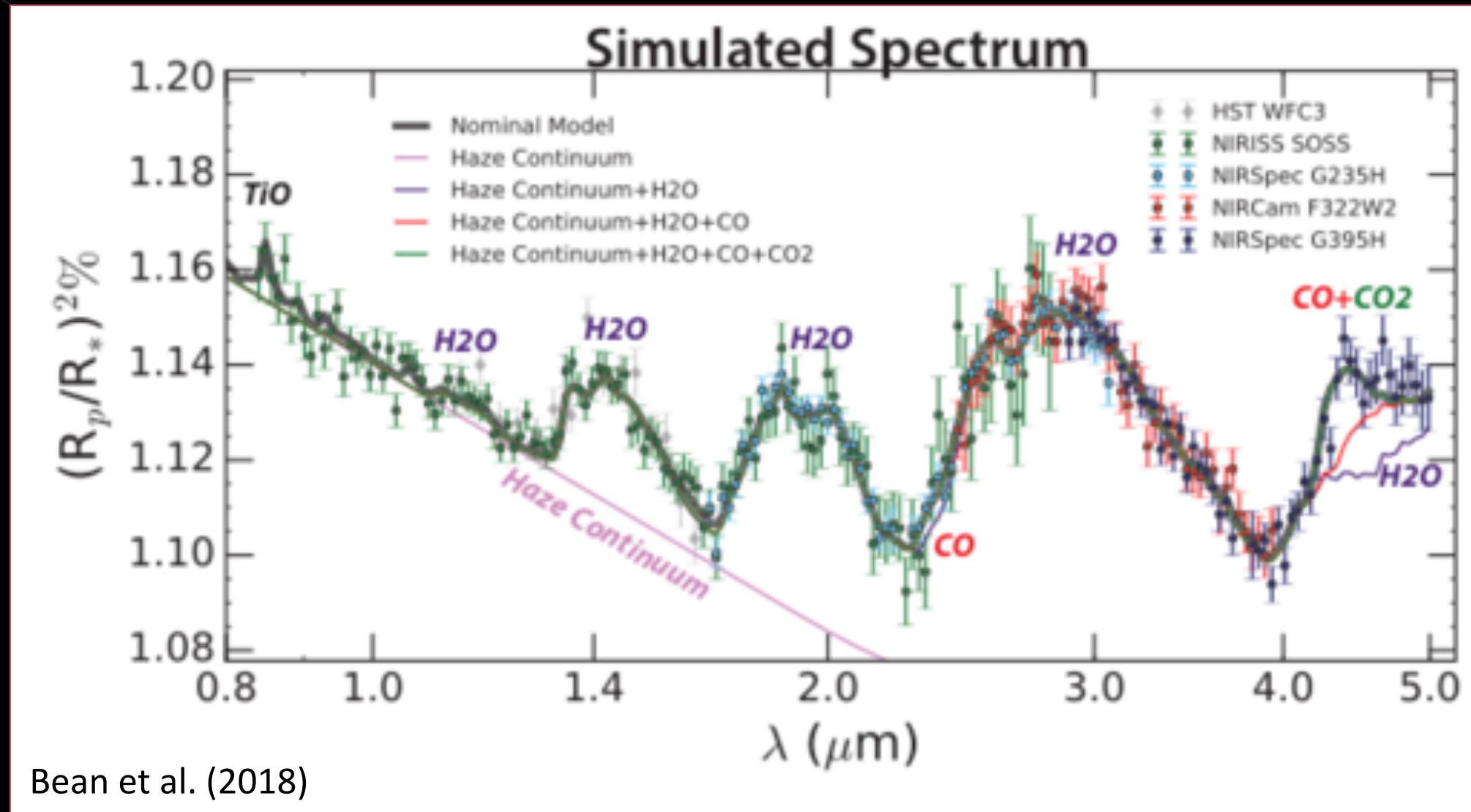


FIG. 2.—The ratio of the observed intensity of Jupiter (as derived from detector A and the wide entrance slit) to the brightness of a perfectly diffusing screen (having an albedo of unity) held normal to the Sun's radiation at Jupiter's distance. The bands of CH_4 and NH_3 which have been observed in the laboratory are shown along with the positions of the lines in the 1-0 band of H_2 .



Simulated JWST Data With Abundance Constraints





Origins of the Transiting Exoplanet Community ERS Program

- We began a transparent and inclusive process for designing this program at a STScI workshop in **November 2015**.
- With 22 months of work by $\mathcal{O}(100)$ exoplanet and instrument experts, we identified a **consensus set of high-priority observations** that
 - Exercises all four JWST instruments
 - Includes three characterization geometries
 - Focuses only on previously vetted, easy-to-observe planets



Community Targets

TABLE 1
PLANET AND OBSERVATION PROPERTIES

Stevenson et al. (2016)

Name	Period (Days)	T_{eq} (K)	log g (dex)	Tr. Depth (%)	Tr. Dur. (Hours)	Signal Size ^a (ppm/H)	Vis. Window	# Transits	Score ^b
HAT-P-3b	2.900	1160	3.26	1.23	2.1	90	Dec 11 – Jun 28	69	3
HAT-P-11b	4.888	870	3.06	0.33	2.3	60	Apr 30 – Nov 26	44	2
HAT-P-40b	4.457	1760	2.71	0.65	6.1	140	Jun 15 – Dec 31	45	1
TrES-2b	2.471	1500	3.30	1.57	1.8	100	Apr 09 – Nov 12	89	3
WASP-3b	1.847	1990	3.48	1.03	2.8	60	Mar 24 – Oct 17	112	3
WASP-62b	4.412	1430	2.86	1.23	3.8	180	Jan 01 – Dec 31	83	5
WASP-63b	4.378	1530	2.66	0.61	5.3	150	Sep 23 – Apr 05	45	4
WASP-79b	3.662	1760	2.88	1.15	3.8	170	Aug 11 – Feb 24	54	4
WASP-97b	2.073	1540	3.41	1.19	2.6	70	May 28 – Dec 20	99	4
WASP-100b	2.849	2200	3.24	0.76	3.8	60	May 22 – Jan 31	90	3
WASP-101b	3.586	1550	2.79	1.26	2.7	240	Sep 27 – Apr 08	53	5
XO-1b	3.942	1210	3.19	1.76	2.9	120	Feb 02 – Aug 21	51	4

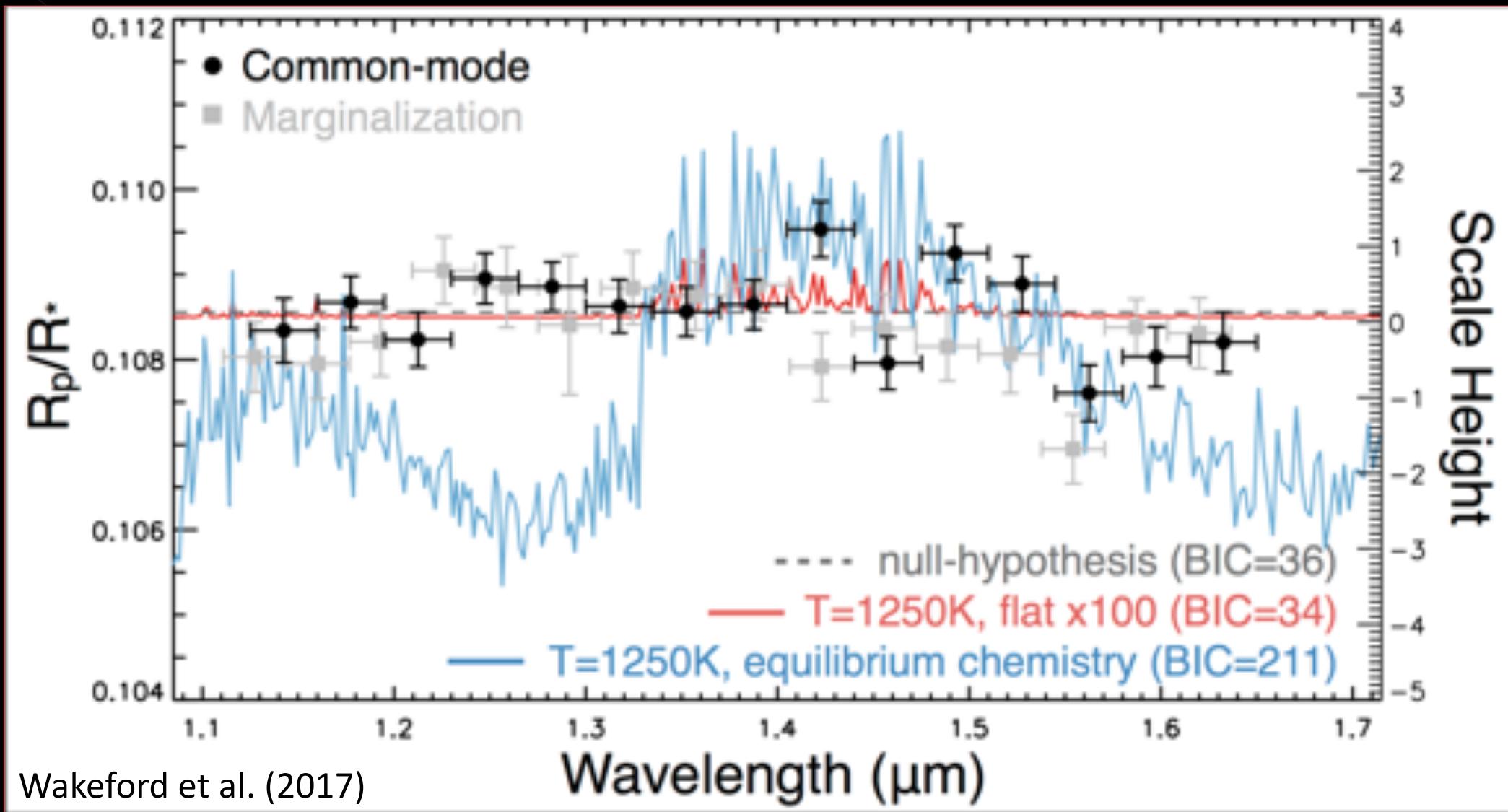
^aPredicted signal size per scale height assumes a cloud-free atmosphere at constant T_{eq} and a mean molecular weight of 2.2 u.

^bThis subjective scoring system ranges from 1 to 5, where higher values are given to targets with more favorable parameters.

- Requirements:
 - High ecliptic latitude (>45 deg)
 - Short orbital period (<10 days)
 - Known planet mass
 - Bright and quiet host star ($J < 10.5$)
 - Large spectral features (>50 ppm)
- Labeled “Community Targets” to encourage independent analyses from multiple groups
- WASP-62 is only system in *JWST*’s continuous viewing zone (CVZ)
- Identified 4 targets for atmospheric reconnaissance

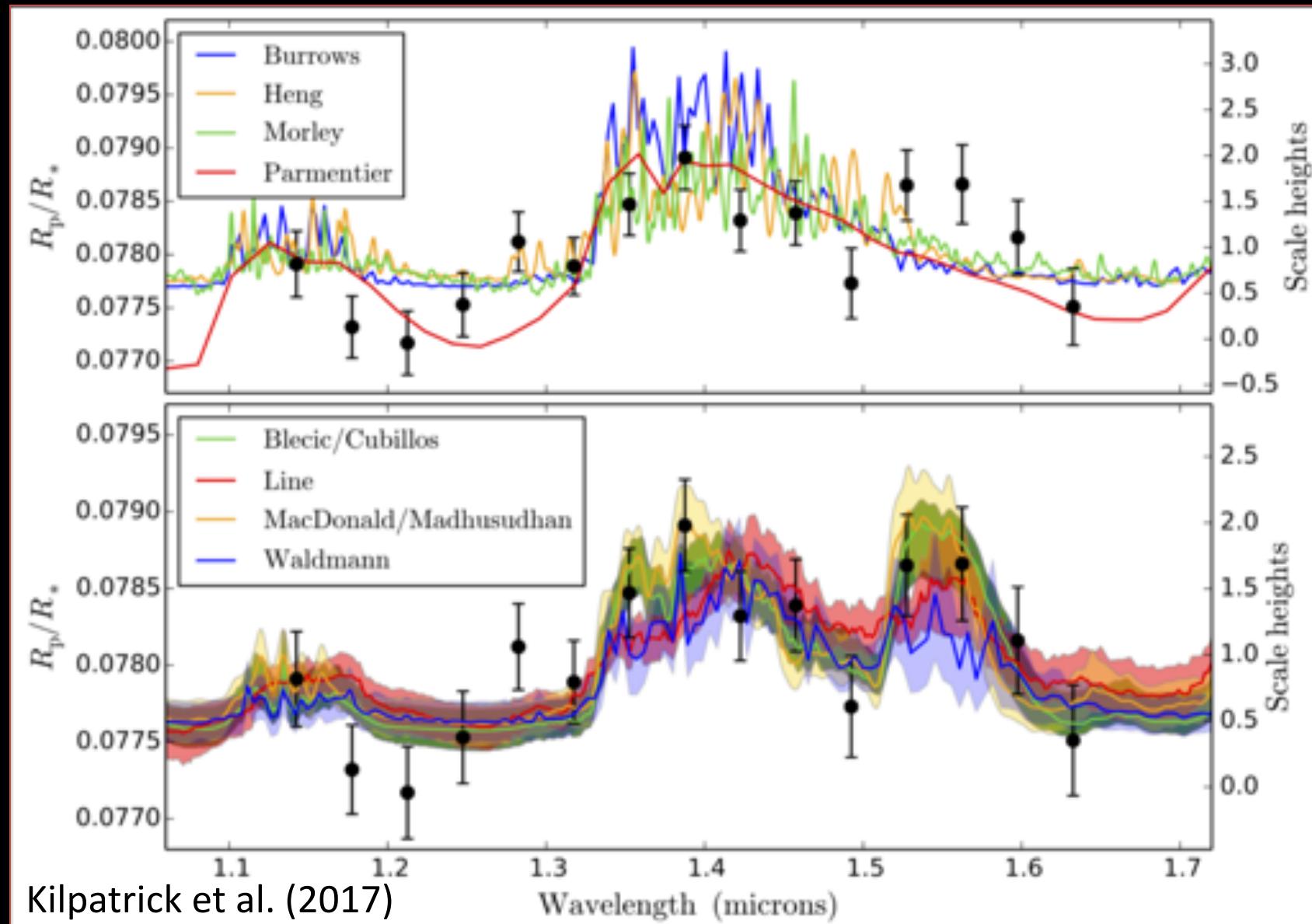


WASP-101b Observation with WFC3



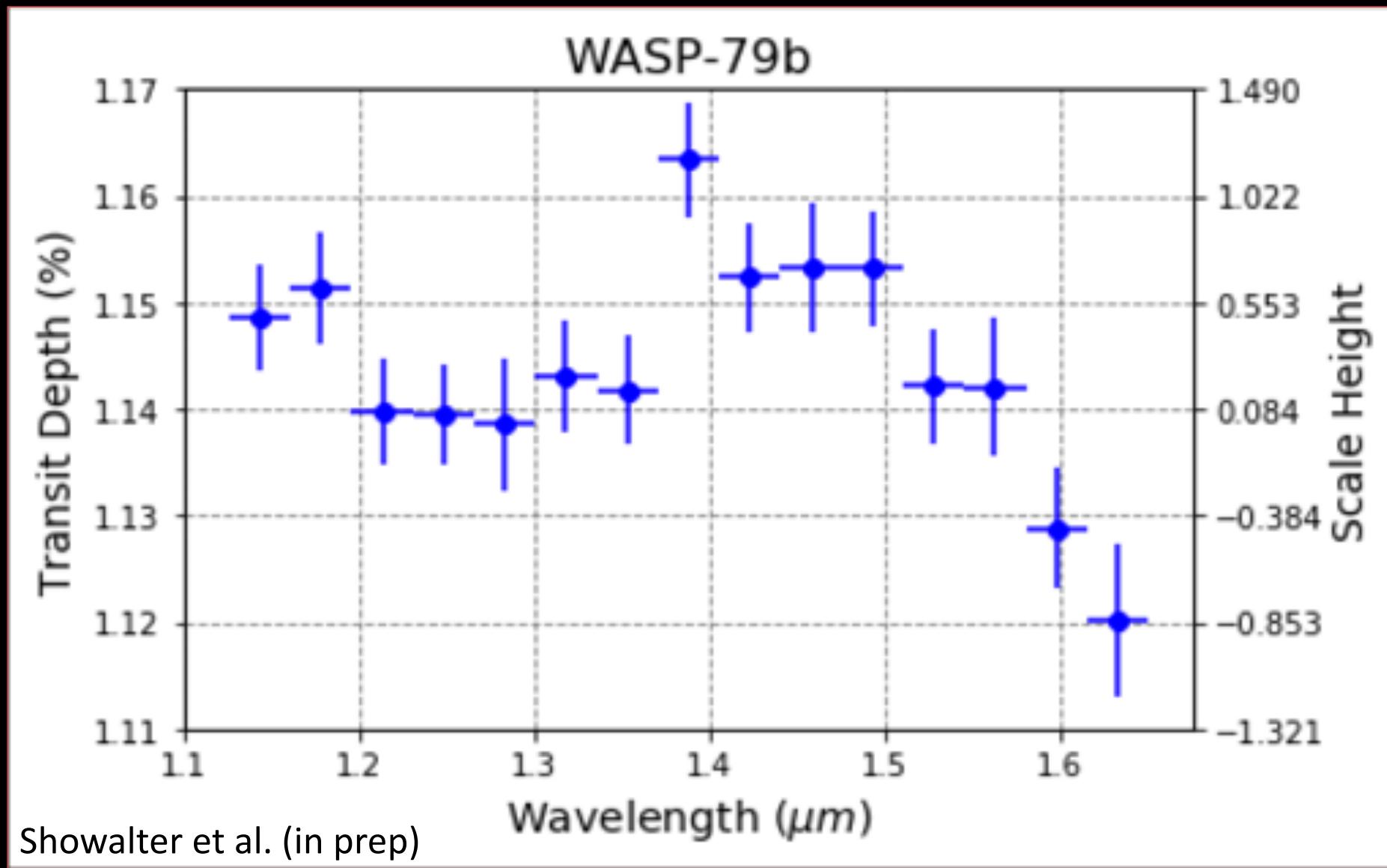


WASP-63b Observation with WFC3



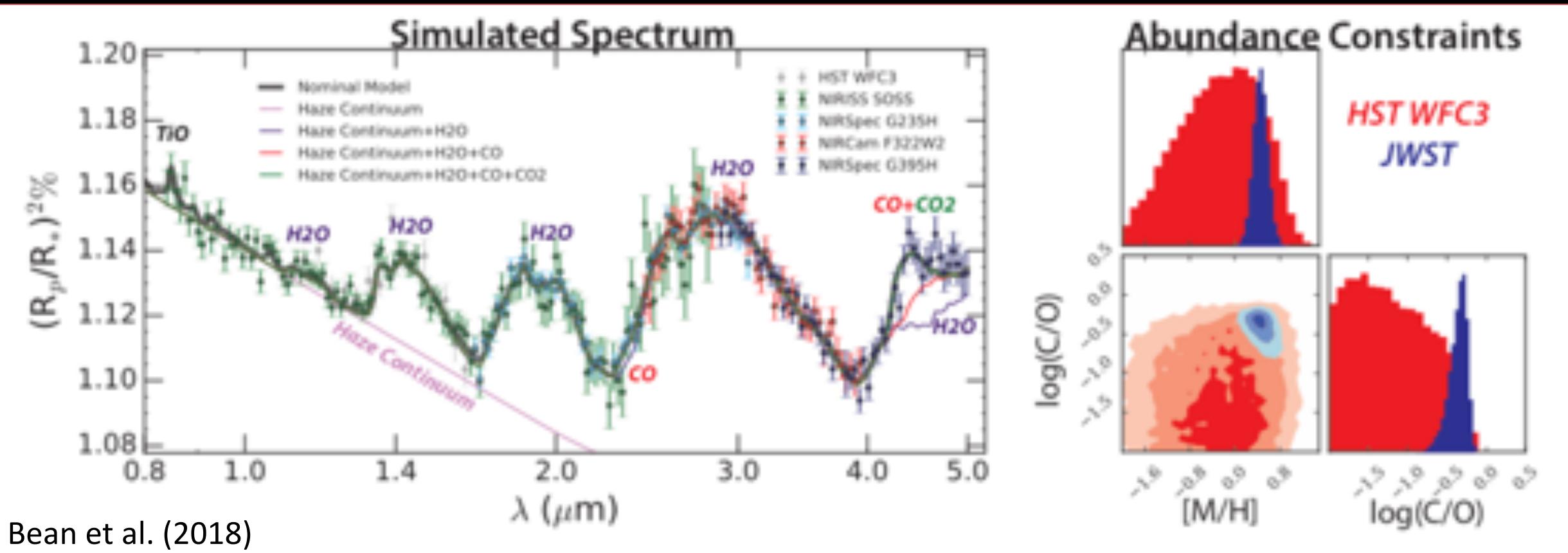


WASP-79b Observation with WFC3





Simulated WASP-79b Data With Abundance Constraints





Observing Program Summary

Transiting Exoplanet Community Early Release Science Program

Panchromatic:	39.6 hours
Phase Curve:	29.4 hours
Bright Star:	6.18 hours
Total	78.1 hours

Panchromatic Transmission

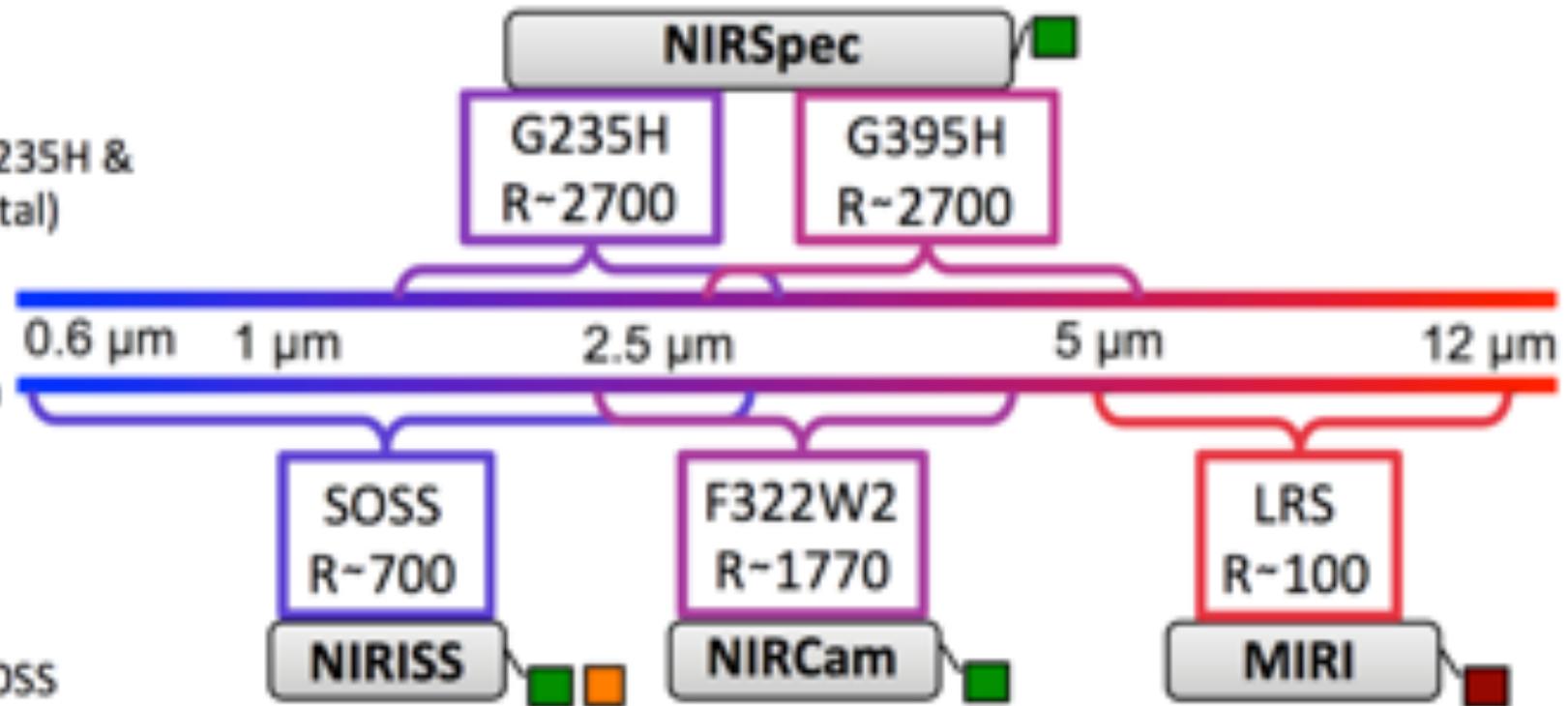
- nominal target: WASP-79b
- transits with NIRISS/SOSS, NIRSpec/G235H & G395H, and NIRCam/F322W2 (four total)

MIRI Phase Curve

- nominal target: WASP-43b
- one continuous, full-orbit observation covering two secondary eclipses and one transit with MIRI/LRS

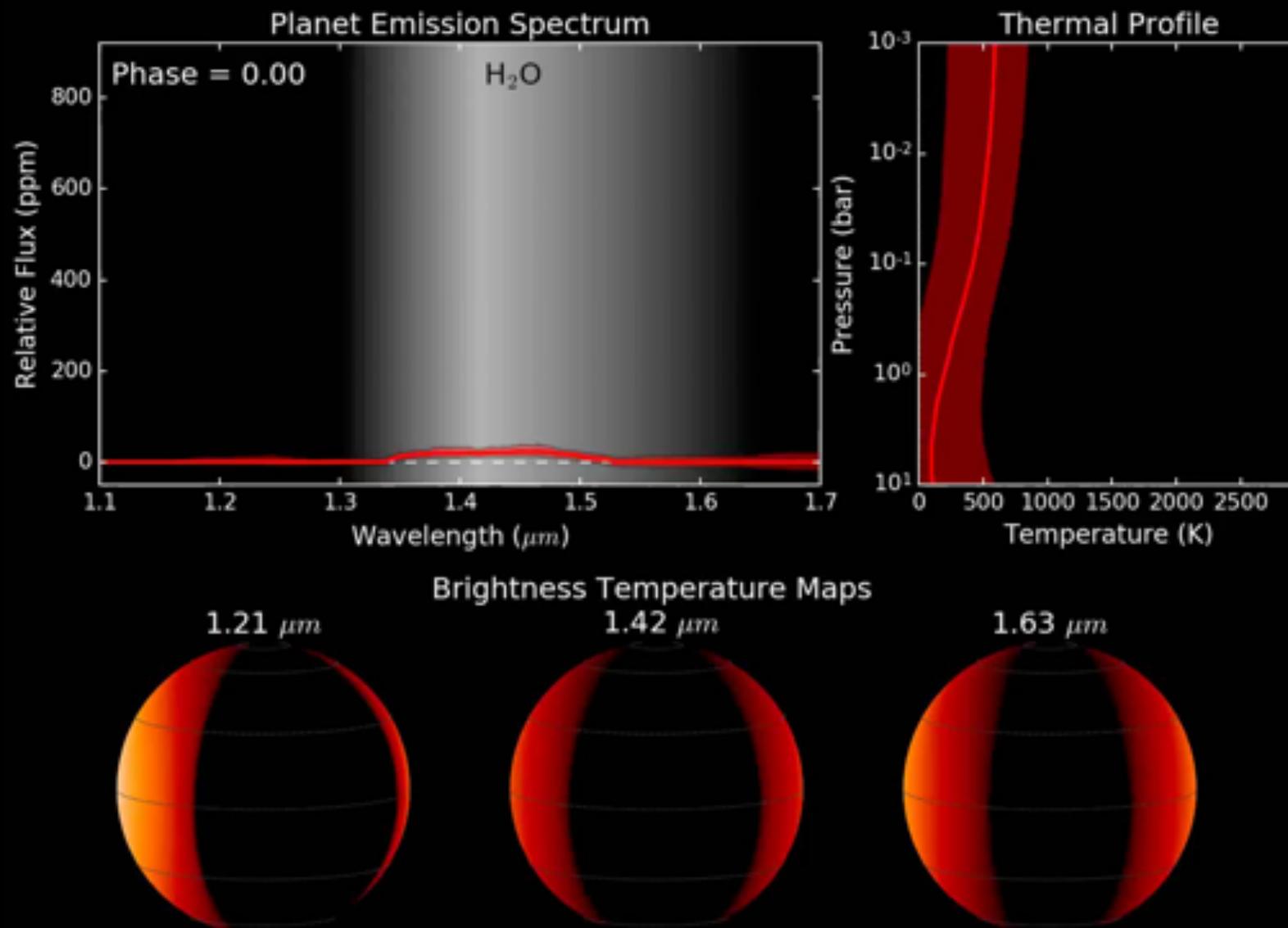
Bright Star's Planet Emission

- nominal target: WASP-18b
- one secondary eclipse using NIRISS/SOSS





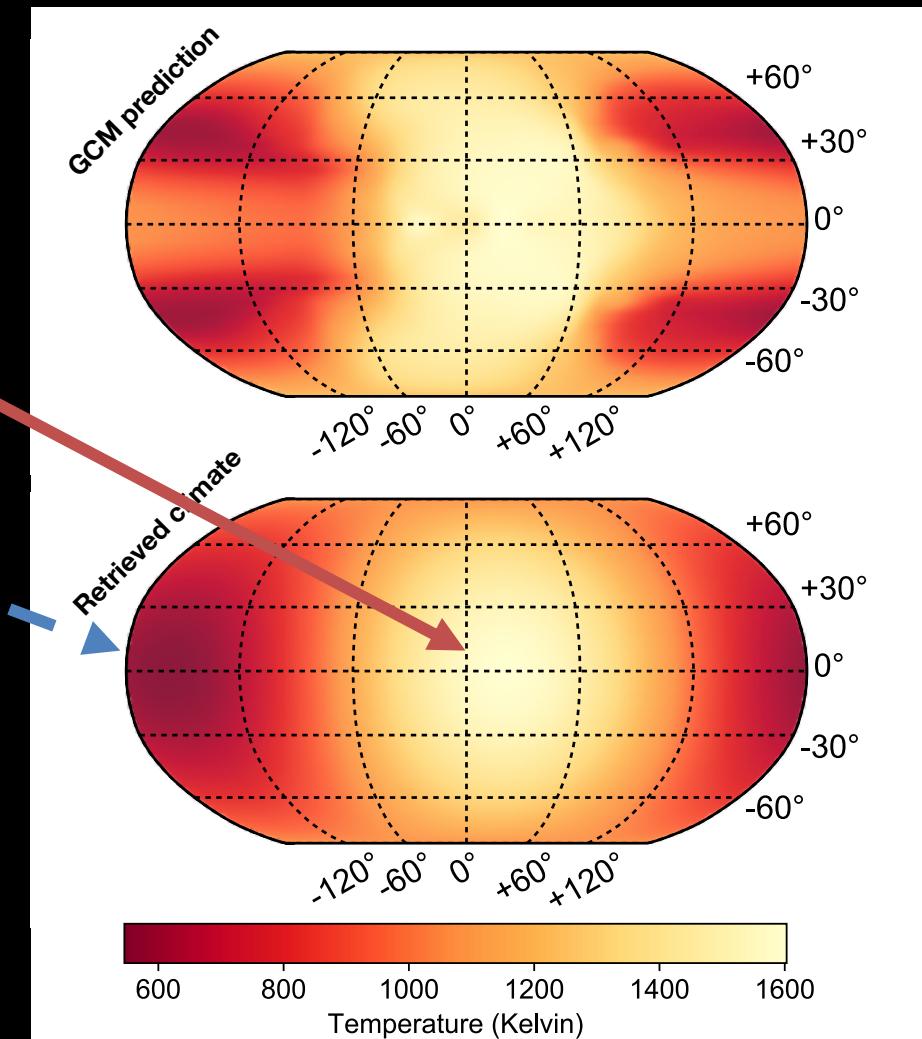
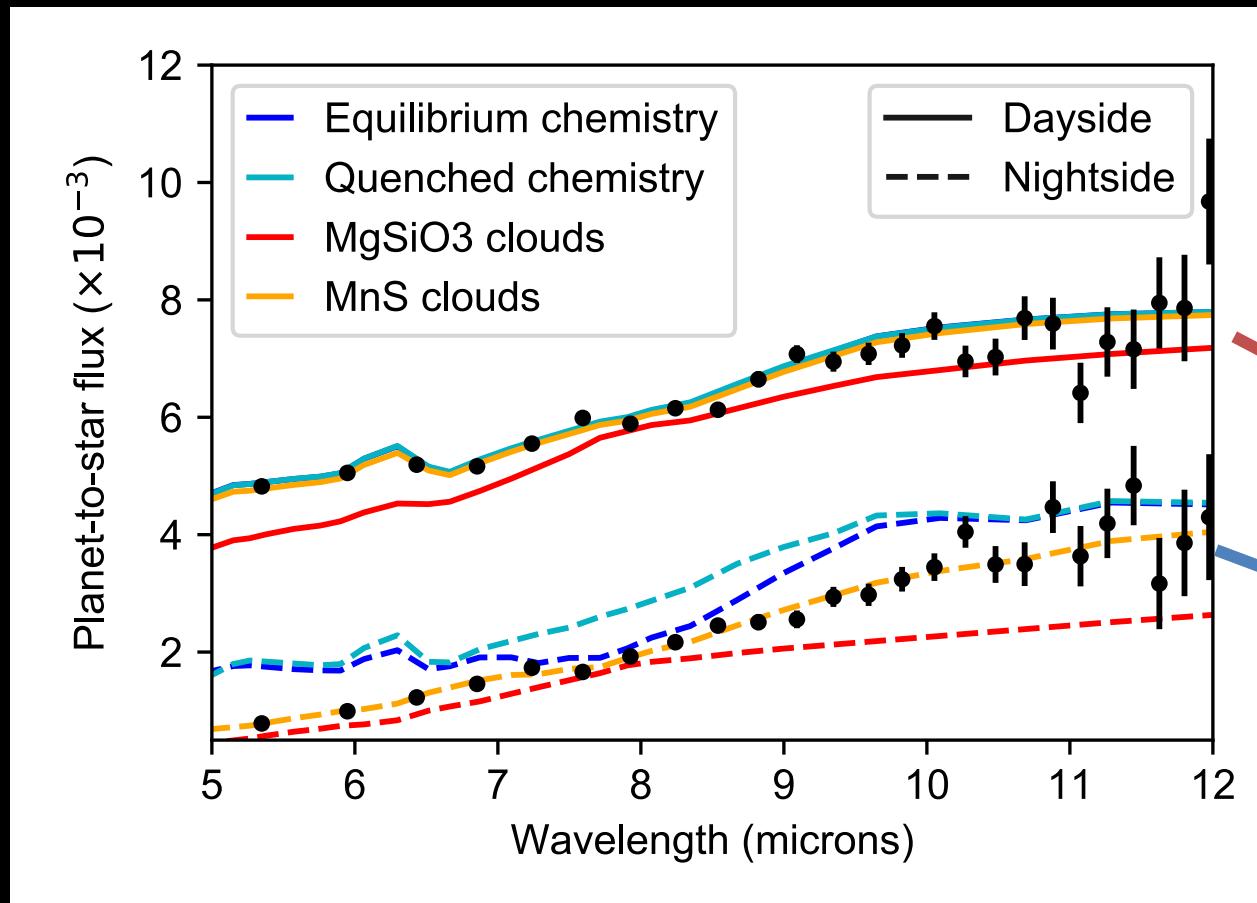
HST WFC3/IR Phase Curve of WASP-43b



K. B. Stevenson (2014)



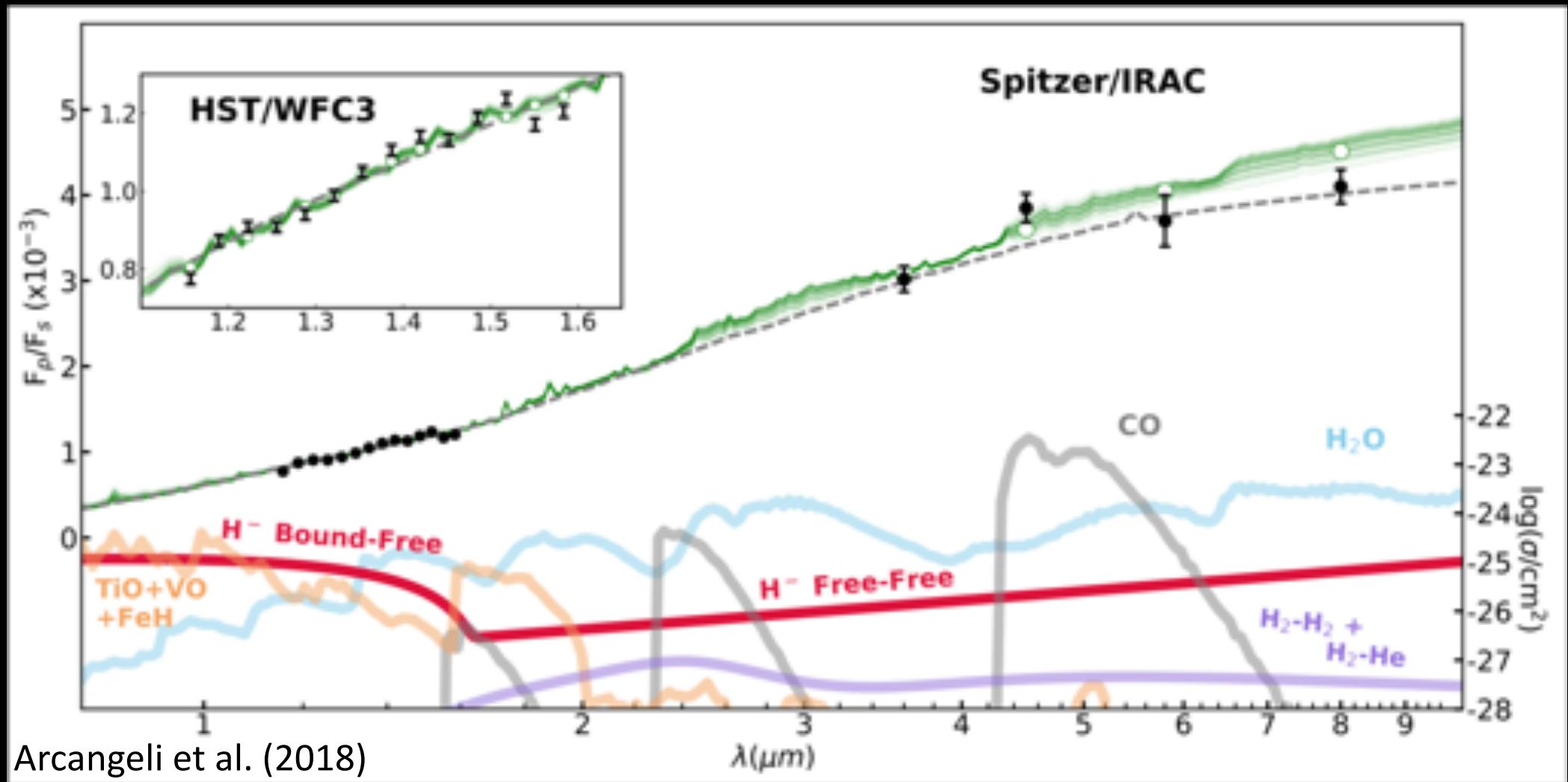
Simulated MIRI/LRS Phase Curve of WASP-43b



How do clouds and chemistry work under tidal locking and extreme irradiation?

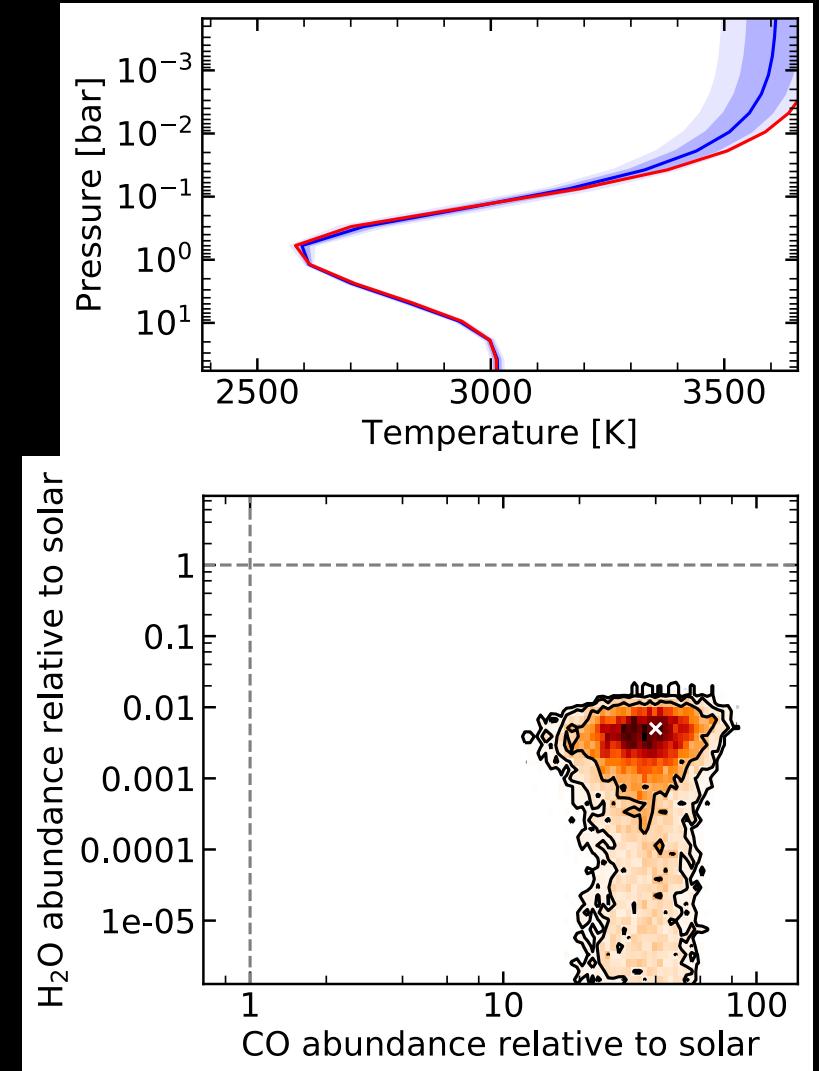
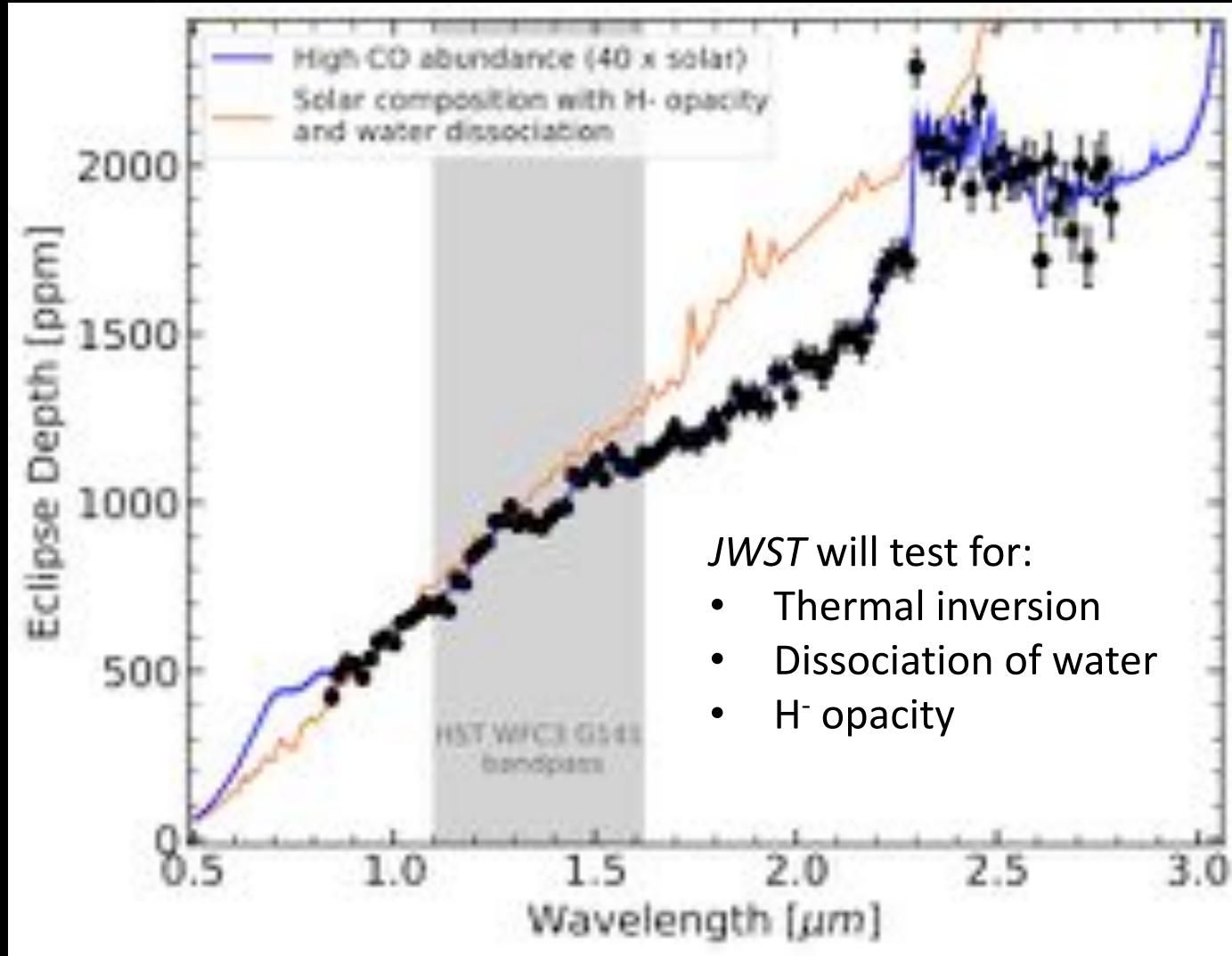


Emission Spectrum of WASP-18b





Simulated NIRISS/SOSS Emission Spectrum of WASP-18b





JWST Exoplanet Data Challenge

We will host two ERS workshops:

- **Before observations** — we will focus on simulated data, where we know the exact answers. We will meet to learn and develop analysis tools, and test the assumptions of different theoretical models and retrieval methods.
- **After observations** — we will focus on the real data, where we need cross-validation for robust results. We will meet to compare analyses and theoretical modeling frameworks, write papers, and produce science-enabling products.





Want to Learn More?



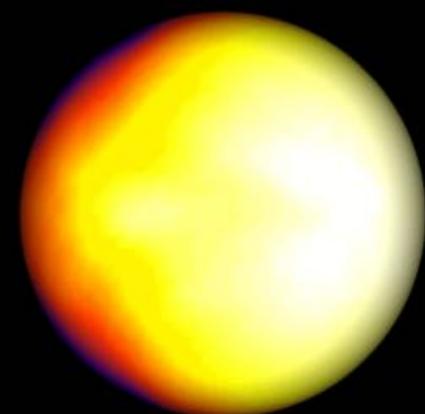
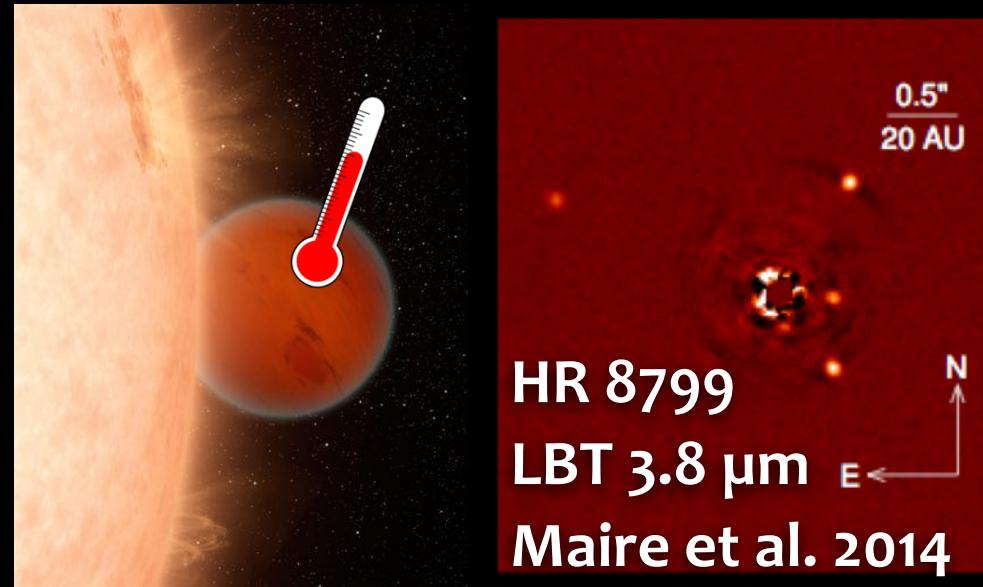
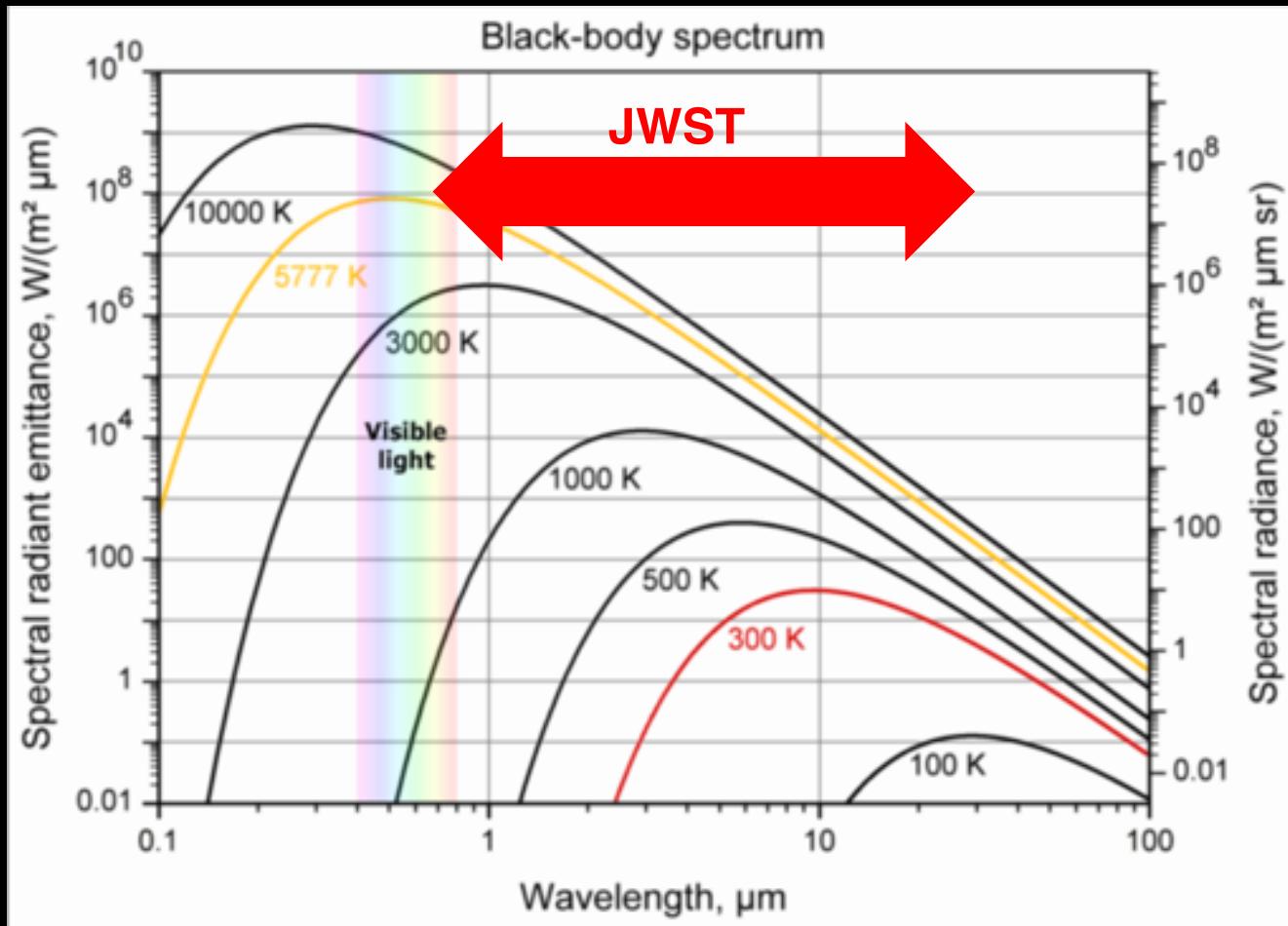
- Website: ers-transit.github.io
- Bean, Stevenson, Batalha et al, Accepted for publication in PASP



Bonus Slides

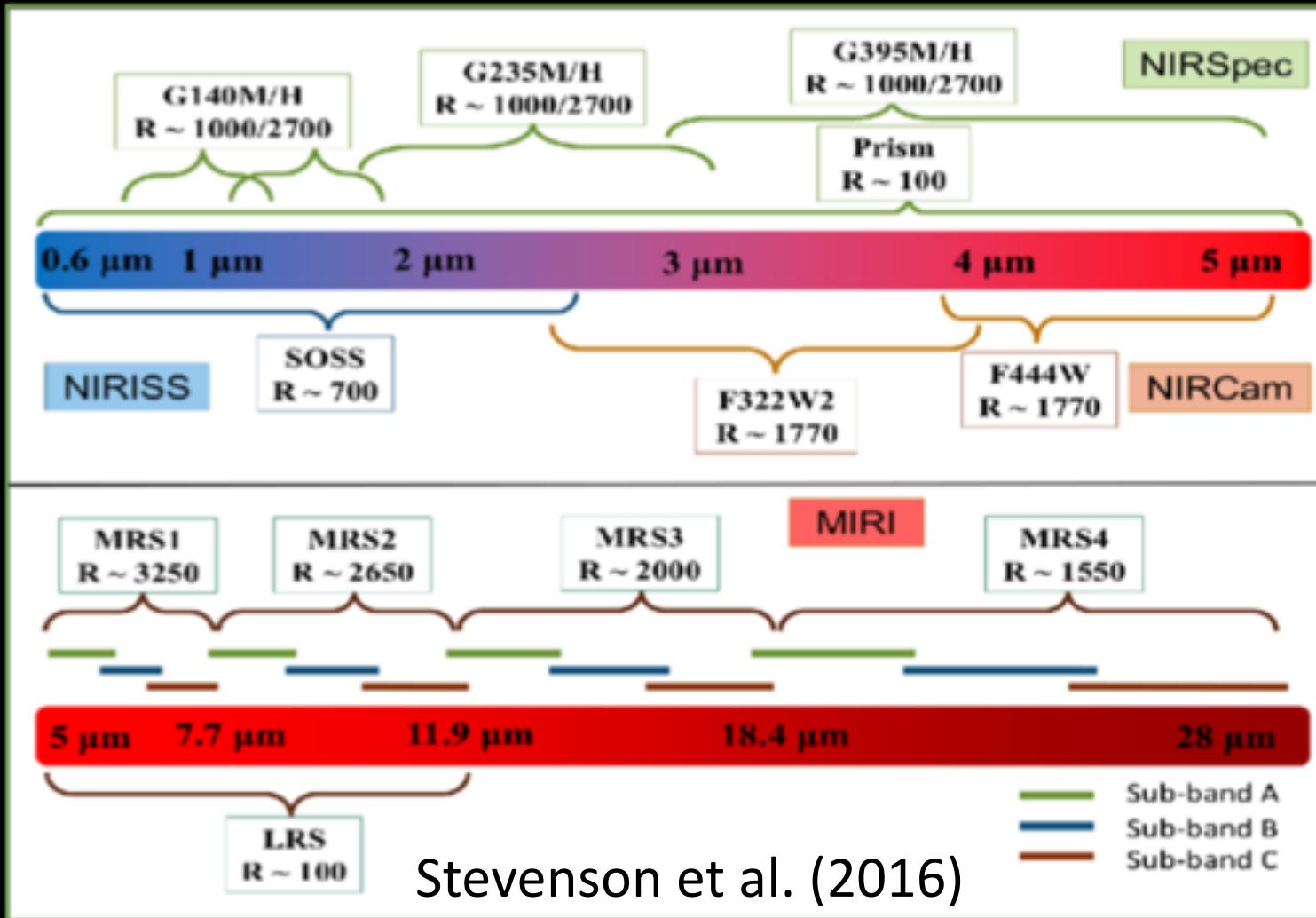


Exoplanets emit most of their light at IR wavelengths



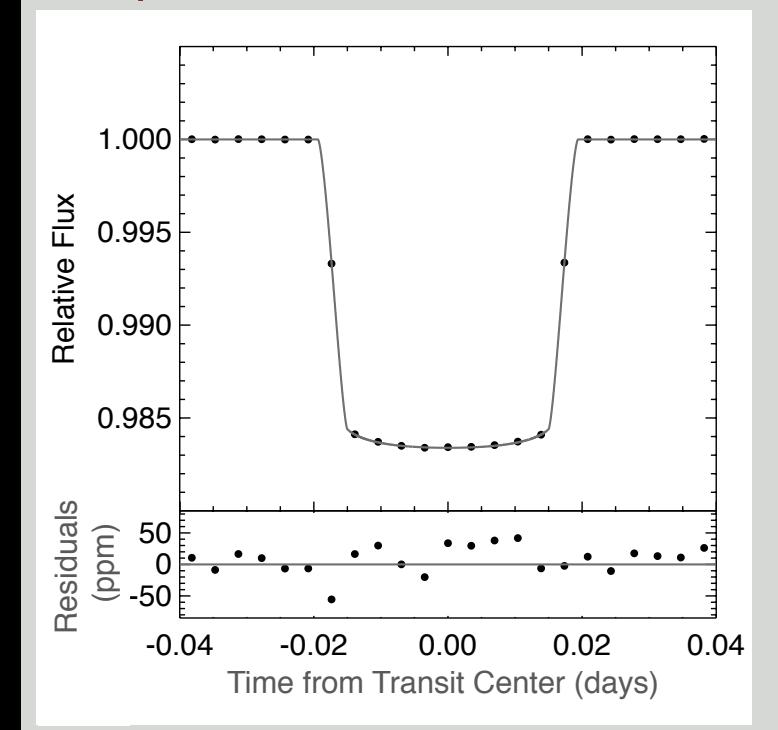


Webb High-Precision Time-Series Spectroscopic Modes



Stevenson et al. (2016)

Exoplanet Transit Time Series



Single Transit/Eclipse Precisions ~30-100 ppm