Exoplanets in the far-IR?

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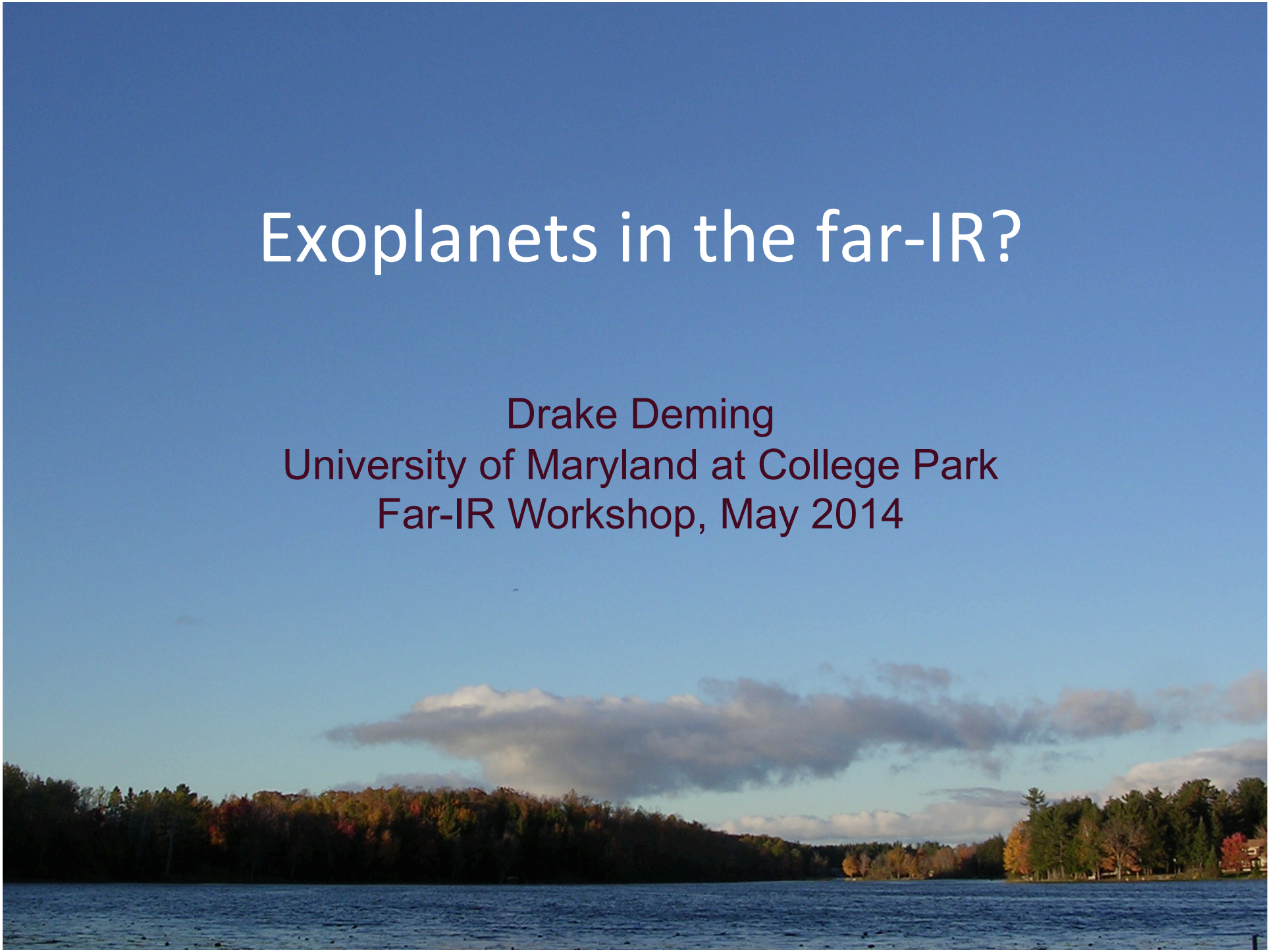
University of Maryland at College Park
Far-IR Workshop, May 2014



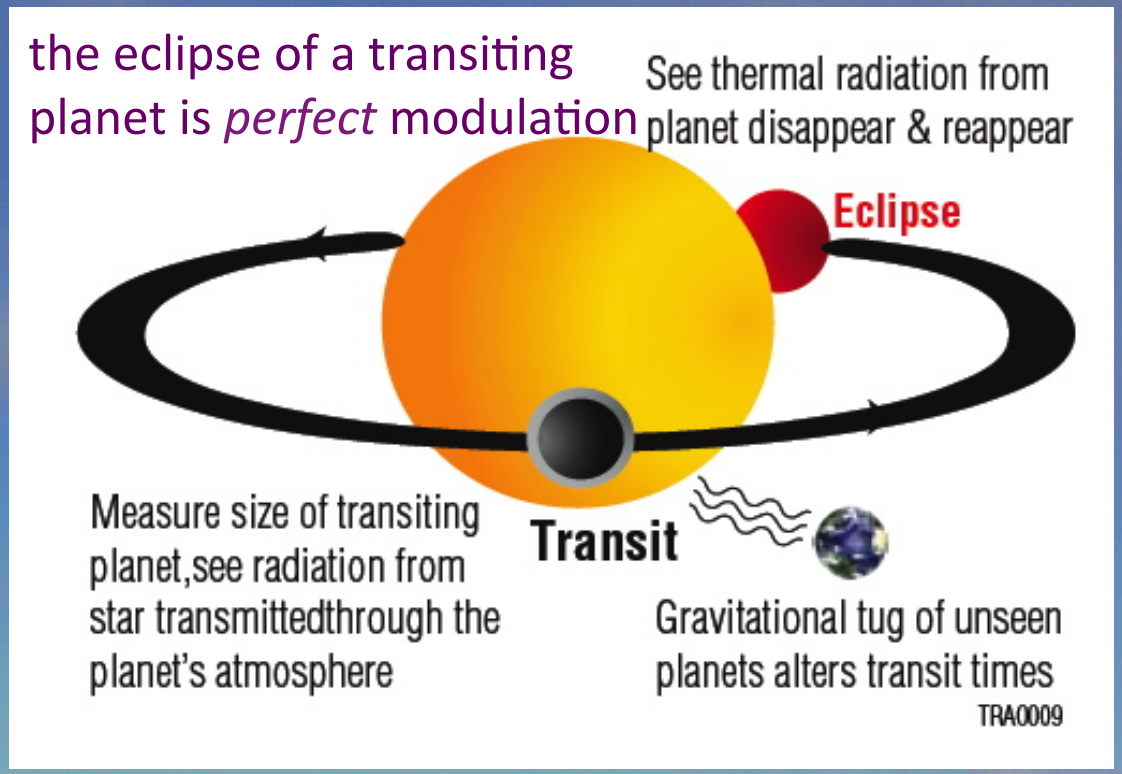
Exoplanets in the mid-infrared

a brief review....

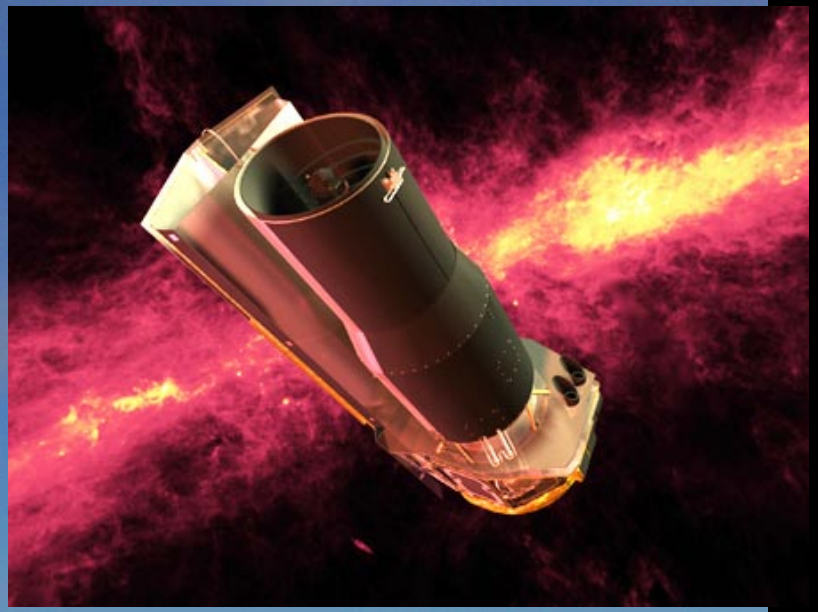
Looking forward to JWST

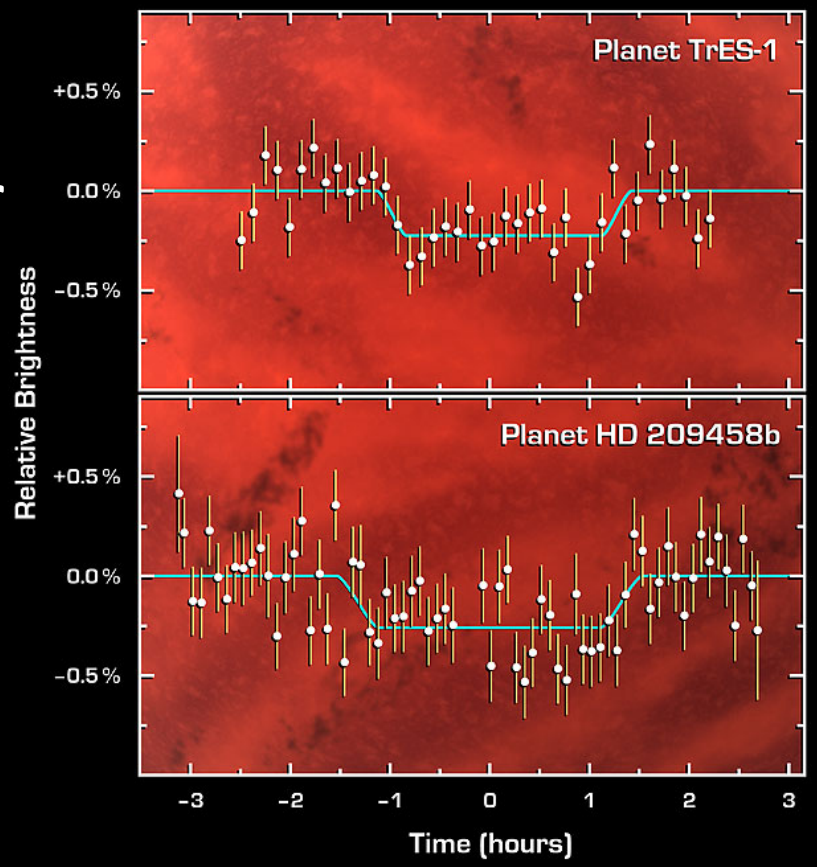
Are the longest IR wavelengths useful?

Infrared astronomy began on the ground
and required modulation techniques to detect the signal above the background



First infrared light from exoplanets was detected using Spitzer



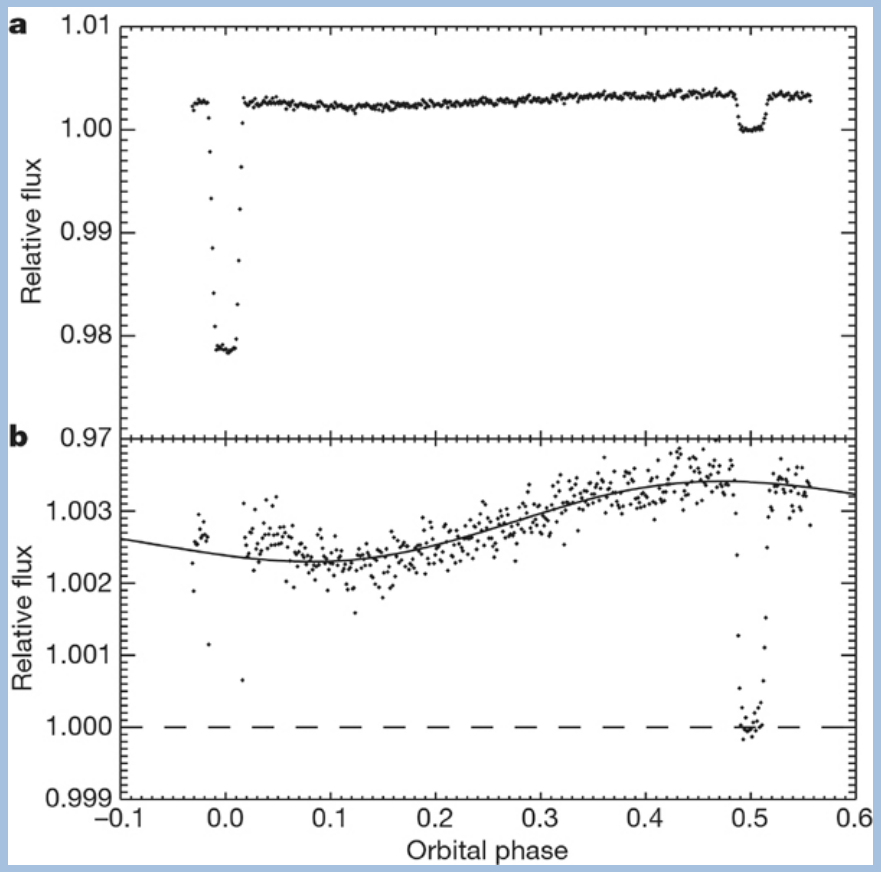


Planetary Eclipses Spitzer Space Telescope • IRAC • MIPS

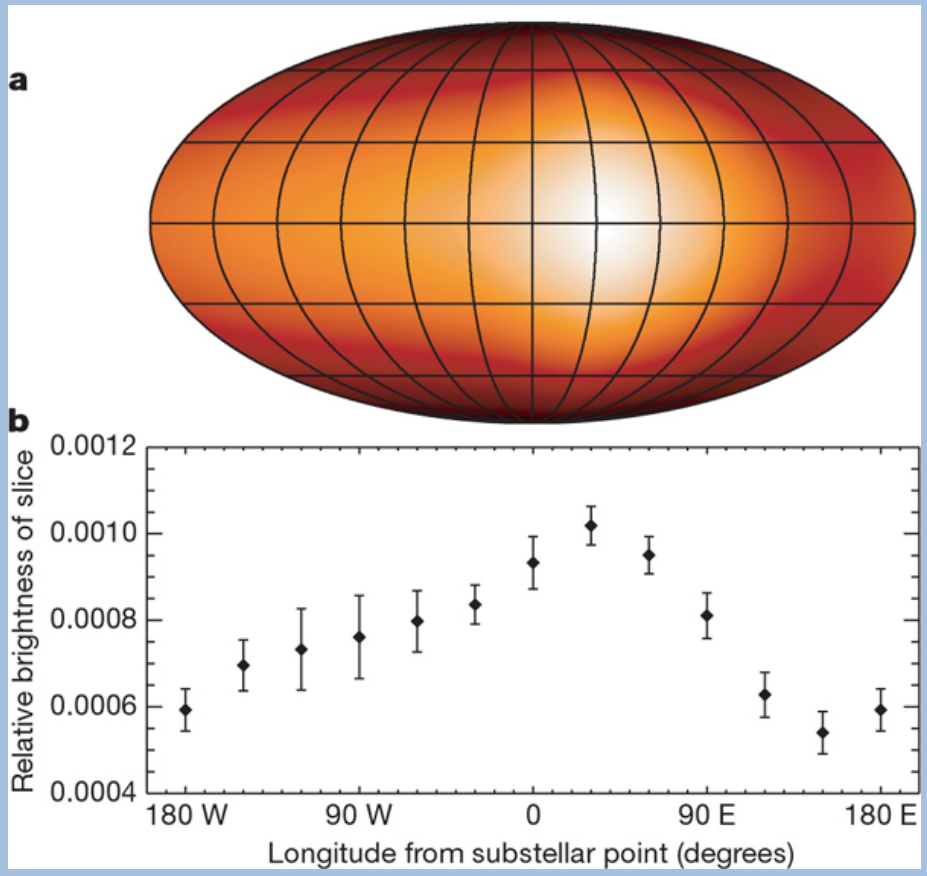
NASA / JPL-Caltech / D. Charbonneau (Harvard-Smithsonian CfA)
D. Deming (Goddard Space Flight Center)

ssc2005-09a

A Surface Emission Map of an Exoplanet



Knutson, Charbonneau, et al. (2007)



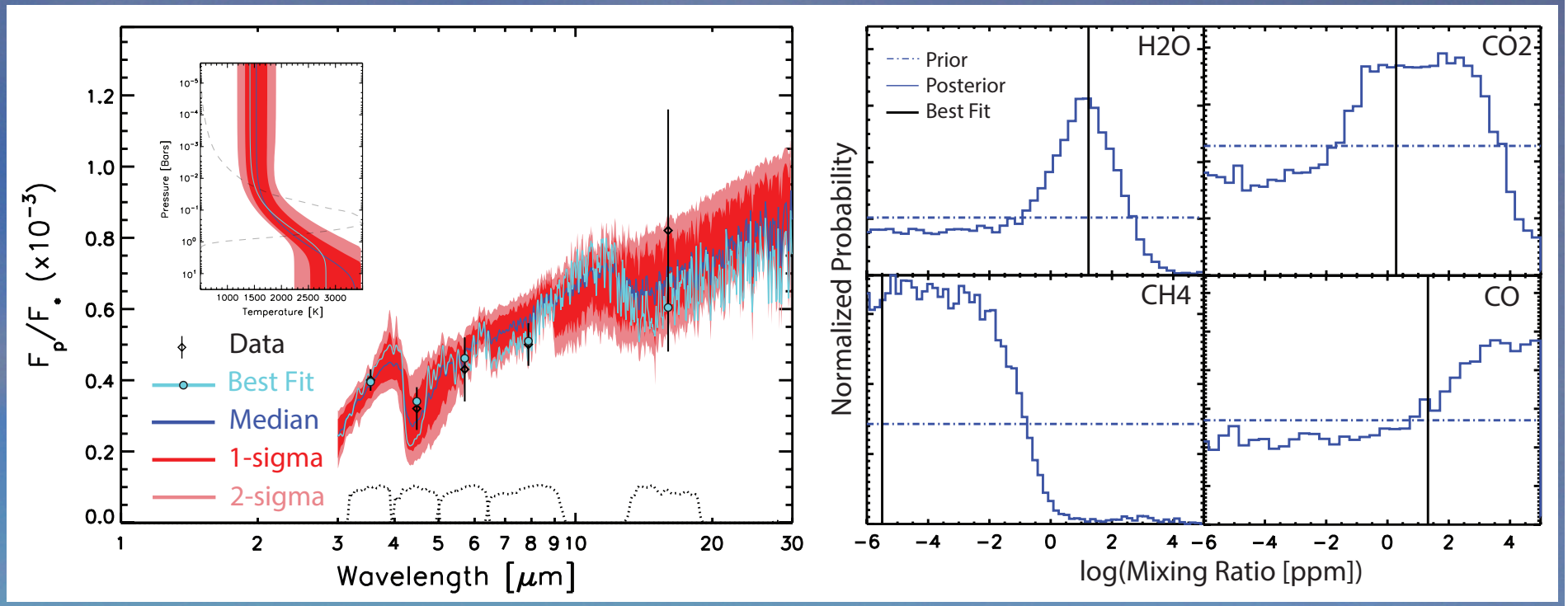
Spitzer's Legacy (not that we're done..!)

photometric-resolution spectra for about
a dozen planets in 4+ bands
(dozens more planets in the 3.6/4.5 microns bands)

temperature structure, composition

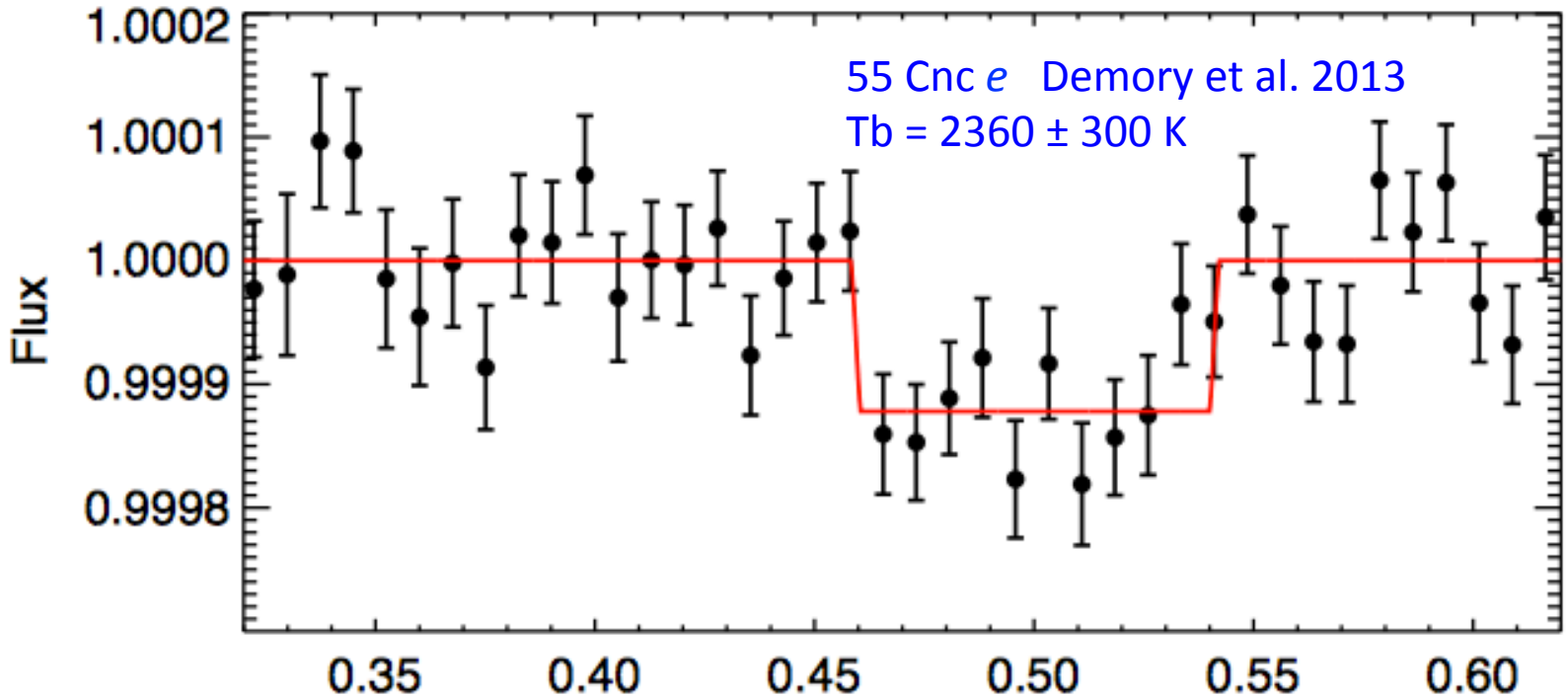
phase curves, spatial mapping, transit spectroscopy,
orbital dynamics, transit timing,
fluxes from super-Earths and more....

Spitzer results from a new analysis and Bayesian retrieval (HD149026b – a hot Saturn. Mike Line, UCSC)



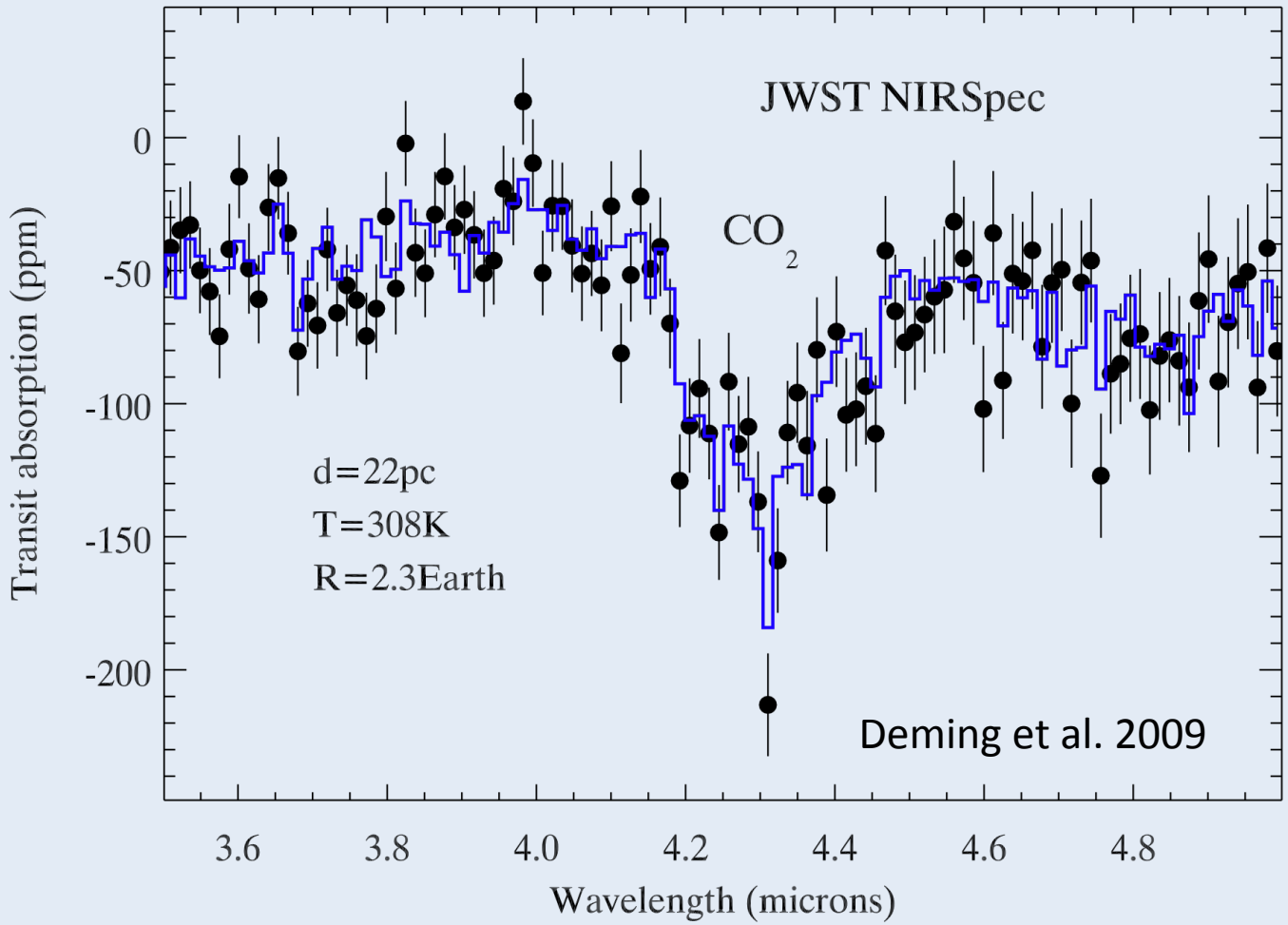
need a uniform re-analysis of all Spitzer data, with new retirevals

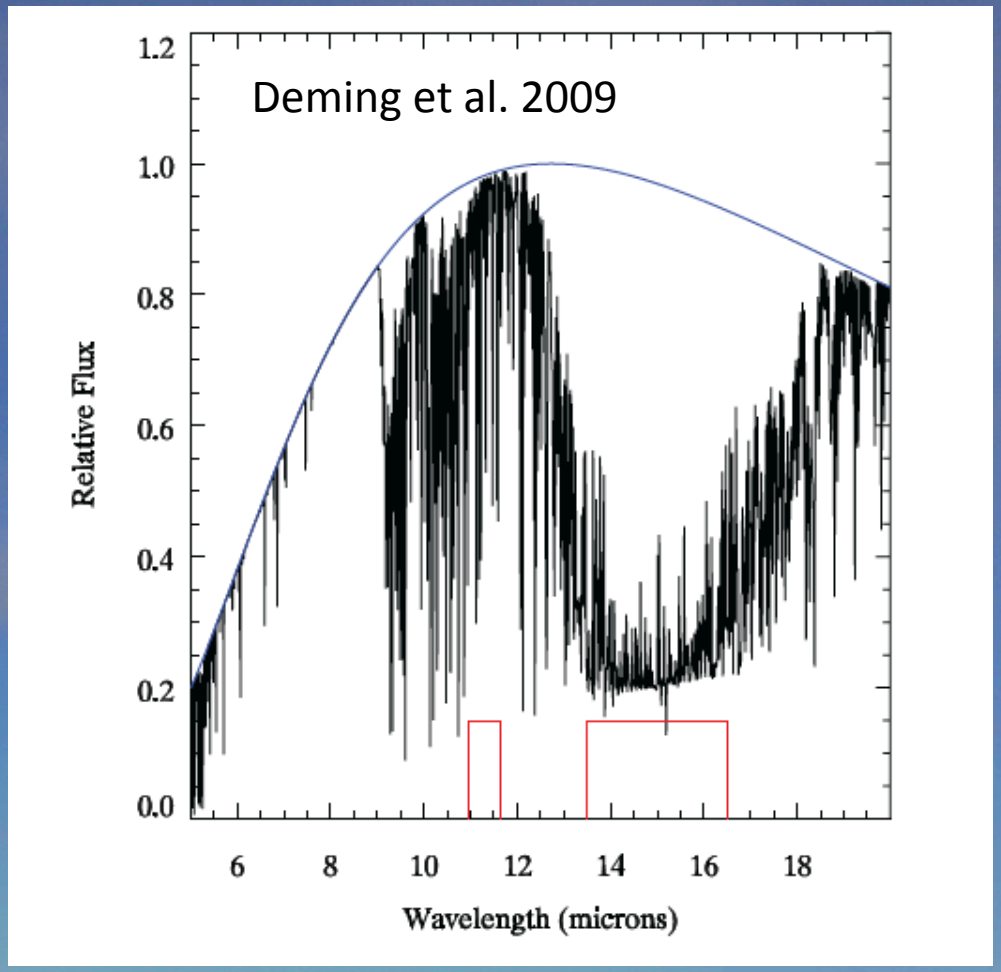
Spitzer's measurement of a super-Earth



The James Webb Space Telescope

JWST (simulated) detection of carbon dioxide in a habitable SuperEarth





JWST should be able to measure carbon dioxide *photometrically*, in the thermal infrared

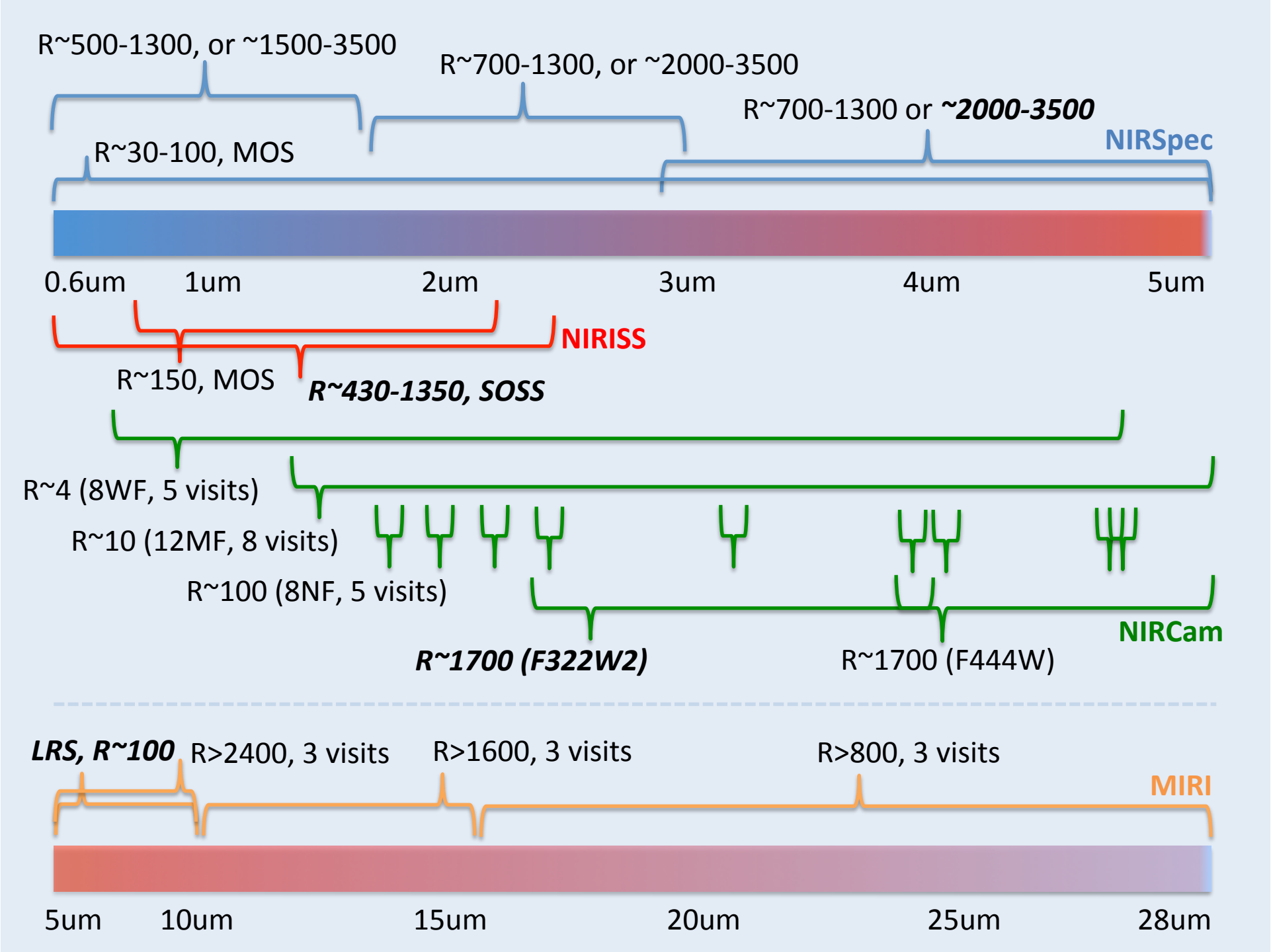
Before Spitzer, the focus was merely on detection

But hot Jupiters to super-Earths *will* be detected by JWST. Instead, the principal issues are:

what can we learn about:

- atmospheric temperature structure..?
- molecular abundances..?

what are the best observing modes...?

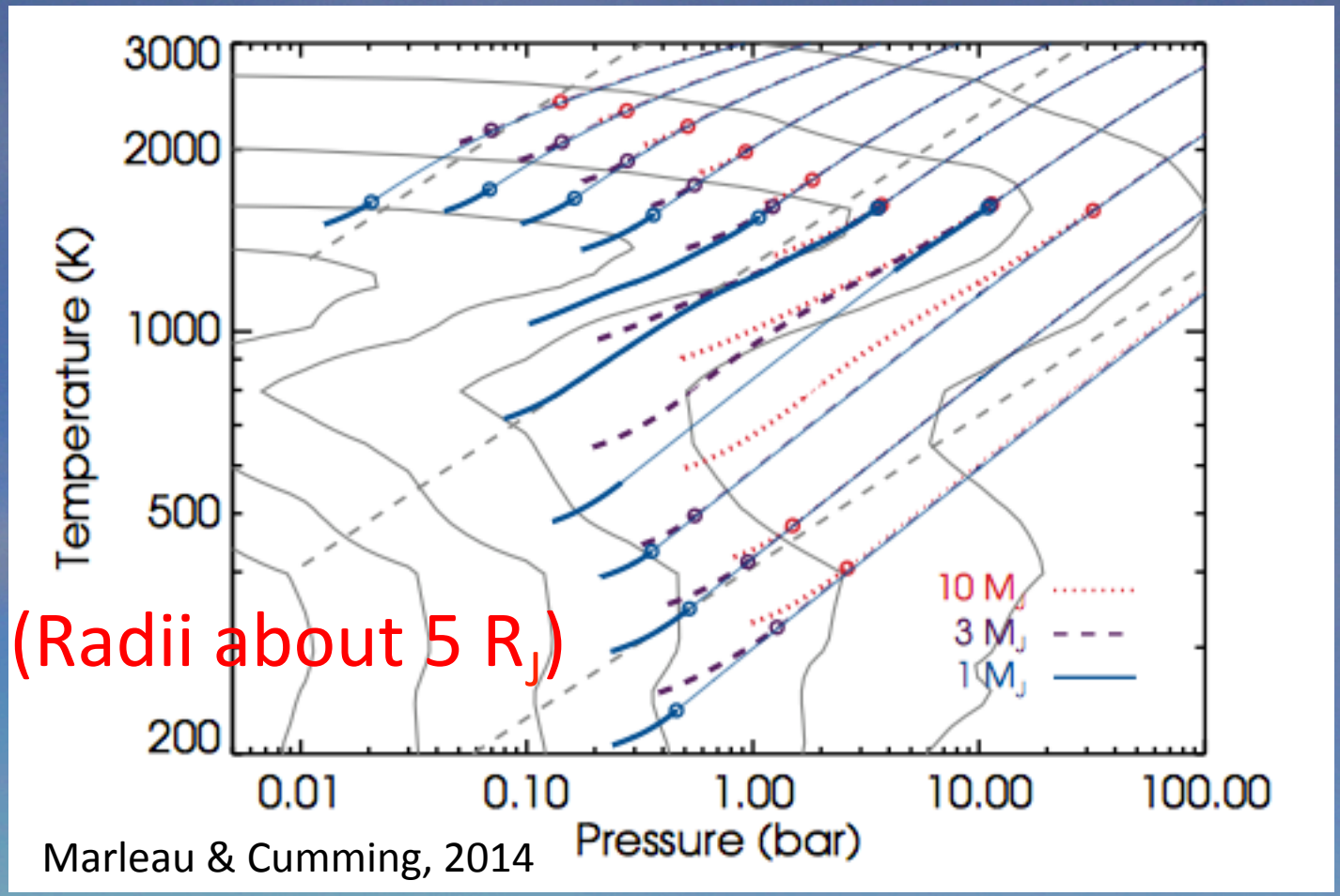

R~500-1300, or ~1500-3500
R~700-1300, or ~2000-3500
R~700-1300 or ~2000-3500
NIRSpec
R~30-100, MOS
0.6um
1um
2um
3um
4um
5um
NIRISS
R~150, MOS
R~430-1350, SOSS
R~4 (8WF, 5 visits)
R~10 (12MF, 8 visits)
R~100 (8NF, 5 visits)
R~1700 (F322W2)
R~1700 (F444W)
NIRCam
LRS, R~100
R>2400, 3 visits
R>1600, 3 visits
R>800, 3 visits
MIRI
5um
10um
15um
20um
25um
28um

Are there exoplanet applications at wavelengths longward of JWST....?

Watts m^{-2} Hz^{-1} ~ Ω B_ν

For planets, Ω is small, but:
B_ν is exponential in temperature at high frequency

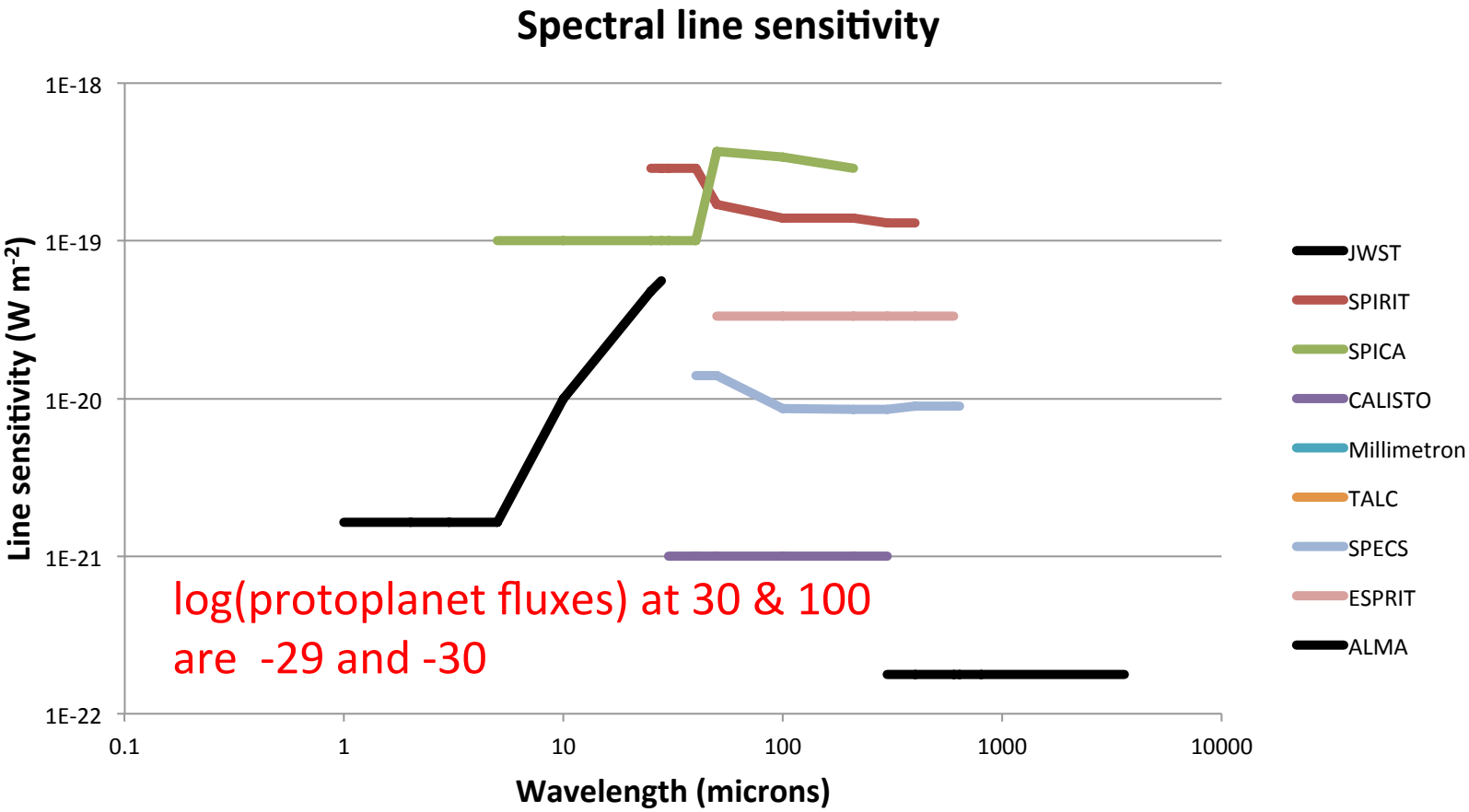
But in the far-IR B_ν is only *linear* with temperature so planet flux may be negligible



Marleau & Cumming, 2014

Sample calculation:

Protoplanet at 50 pc
2000 Kelvins and 5 R_J
30 and 100 microns
Absorption lines....


Spectral line sensitivity
Line sensitivity (W m-2)
1E-18
1E-19
1E-20
1E-21
1E-22
0.1
1
10
100
1000
10000
Wavelength (microns)
JWST
SPIRIT
SPICA
CALISTO
Millimetron
TALC
SPECS
ESPRIT
ALMA
log(protoplanet fluxes) at 30 & 100
are -29 and -30

Summary:

Spitzer leaves a rich legacy of exoplanet infrared measurements

but we need to re-analyze the data uniformly
and apply new Bayesian retrievals

JWST has myriad capabilities for exoplanet detection

but we need modeling to identify the optimal observing modes

Exoplanets *per se* are too small for true far-IR observations

unless there is unexpected physics, like masers