Complete transmission spectrum of an exoplanet from UV to IR

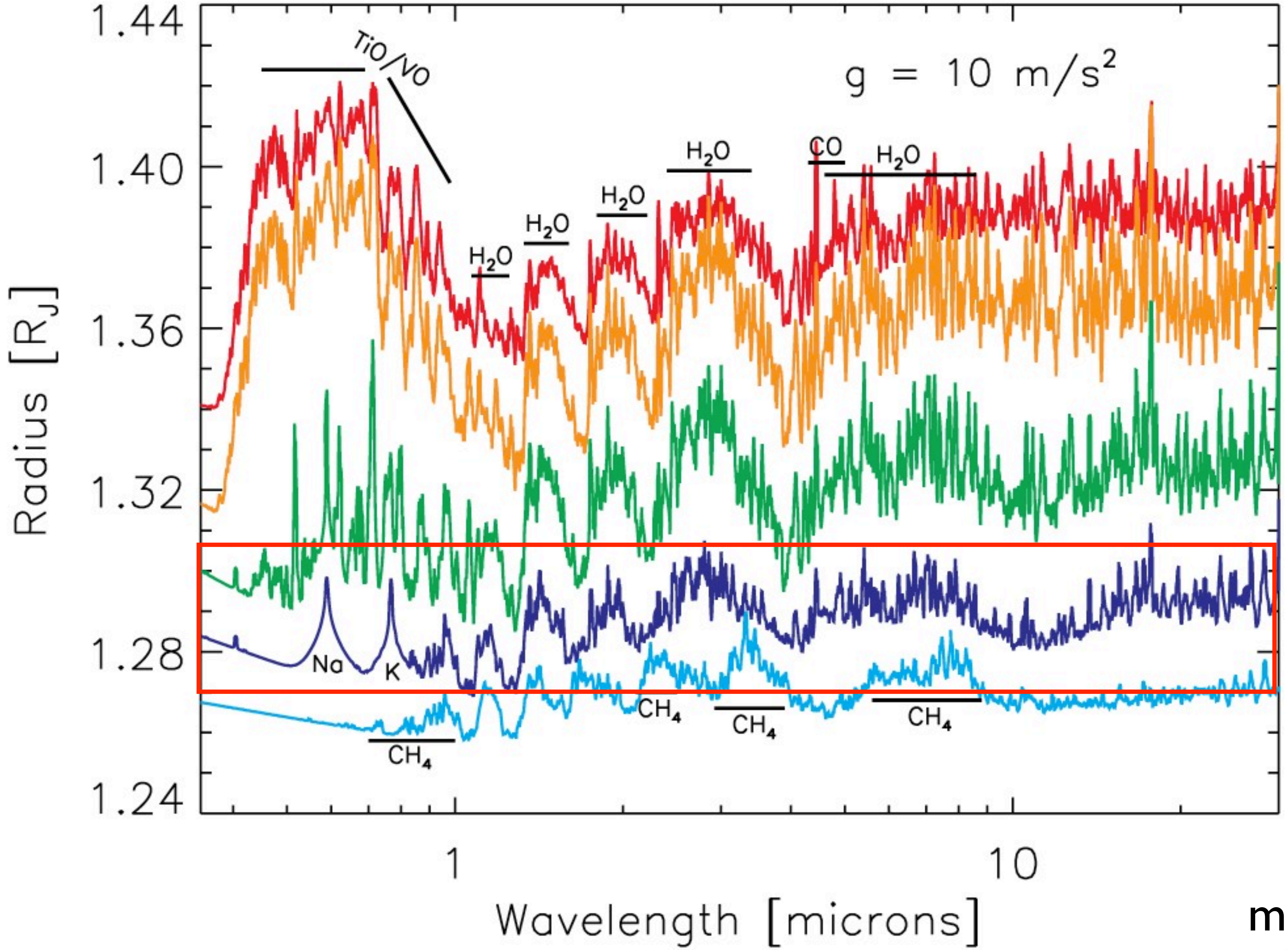
F. Pont, D. Sing, R. Gilliland, D. Charbonneau, H. Knutson, J.-M. Désert, A. Lecavelier, N. Gibson, S. Aigrain

HST programmes

STIS low-res UV/visible
STIS mid-res visible
ACS low-res visible
NICMOS low-res IR
NICMOS filters IR
WFC3 low-res IR

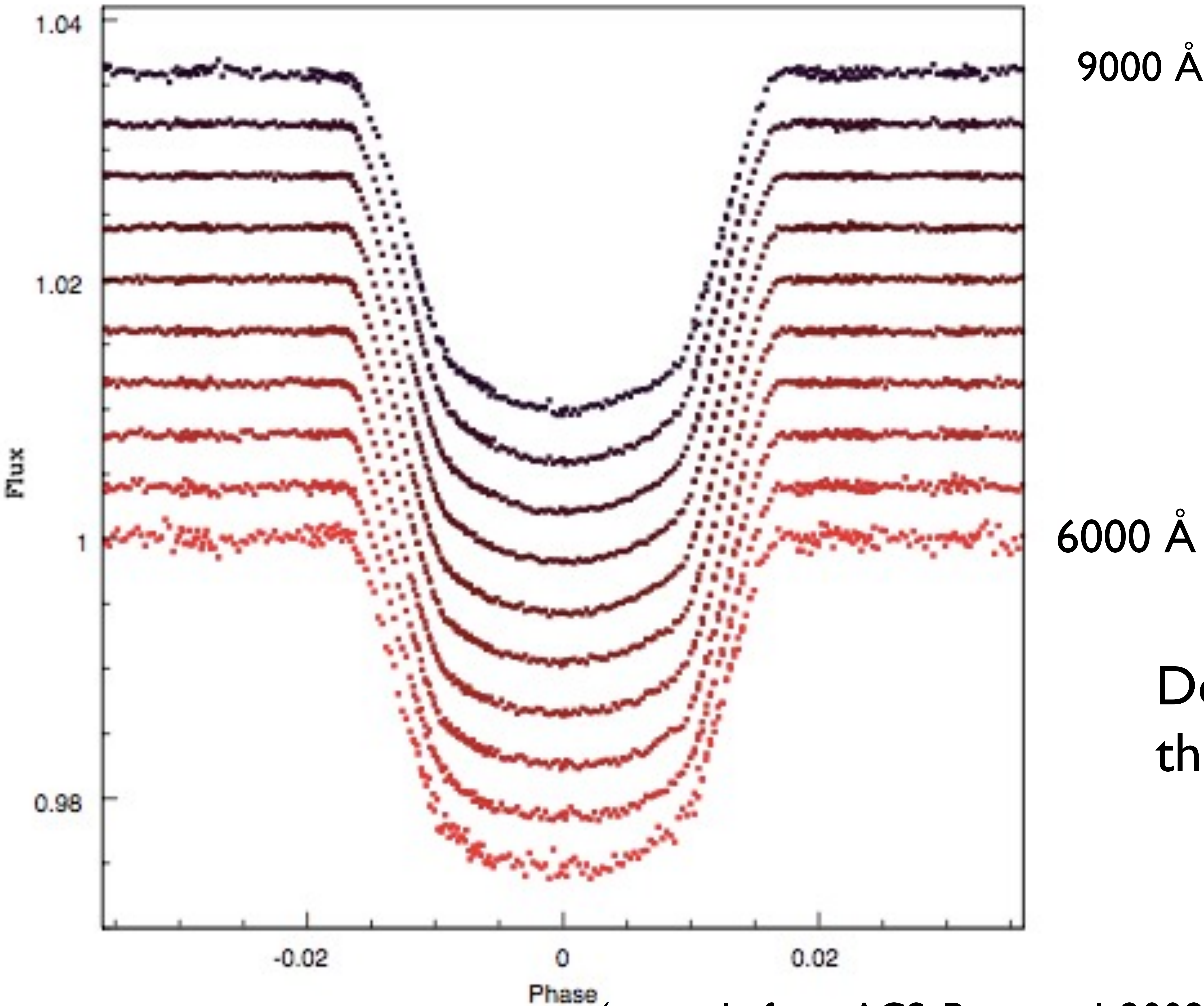
HD 189733b
prototype non-inflated hot gas giant

Transmission spectra: models



models by J. Fortney

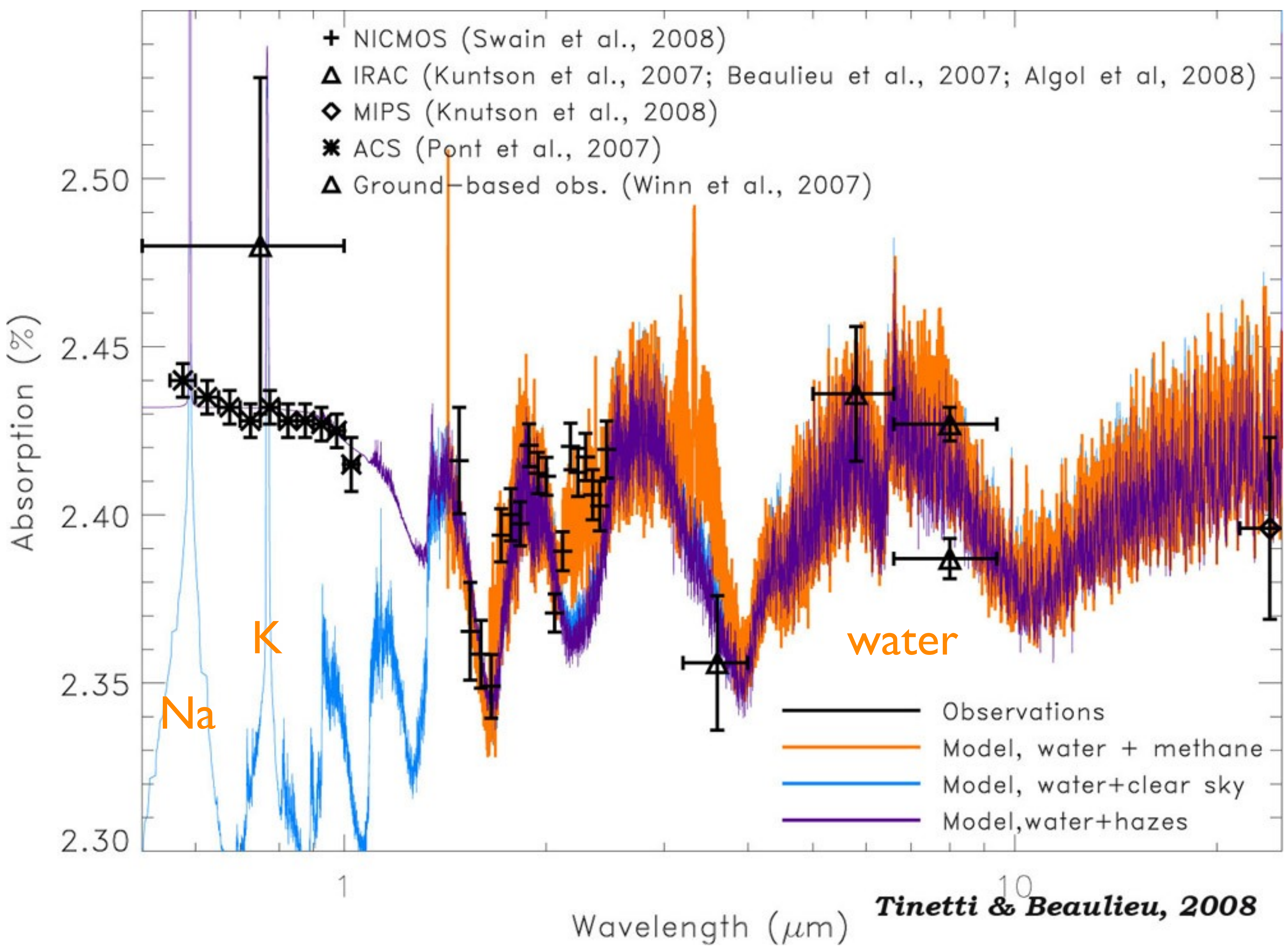
Transit spectroscopy



Deriving $R_{planet}(\lambda)$ by measuring the transit depth at many λ

(example from ACS, Pont et al. 2008)

TRANSMISSION SPECTRUM OF HD 189733b



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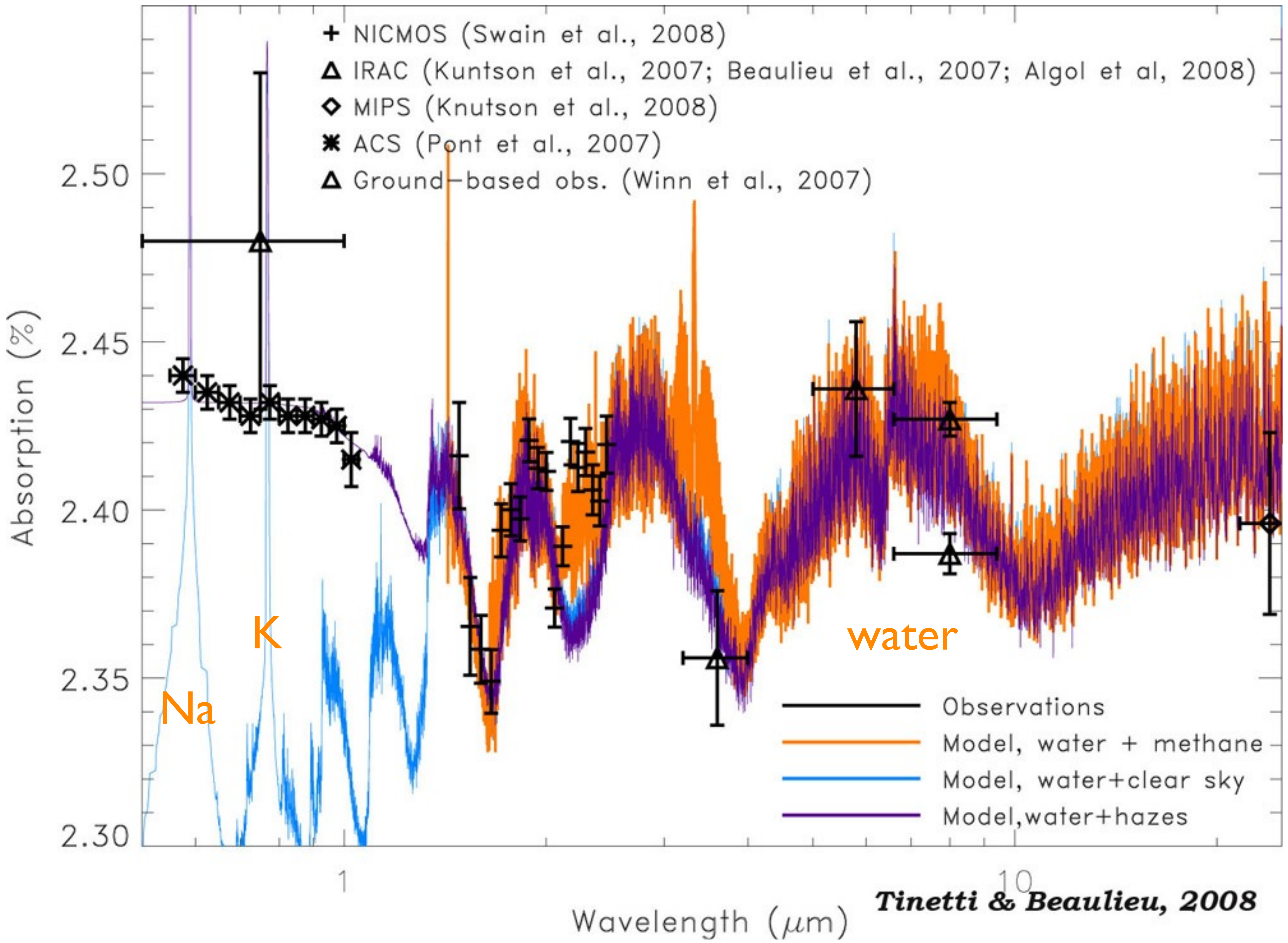

Challenges:

Infrared : complex instrumental systematics

Visible: star spots

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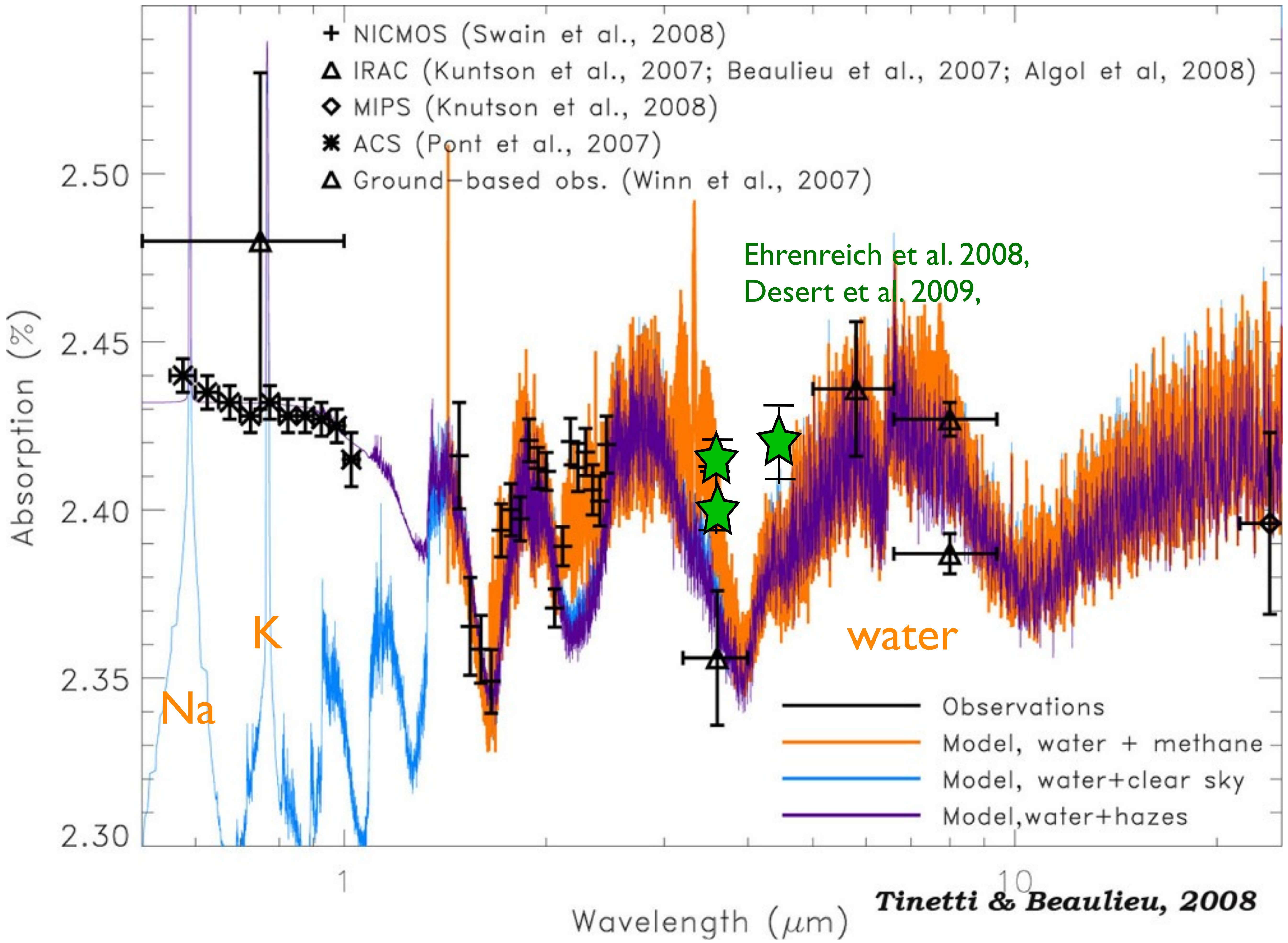

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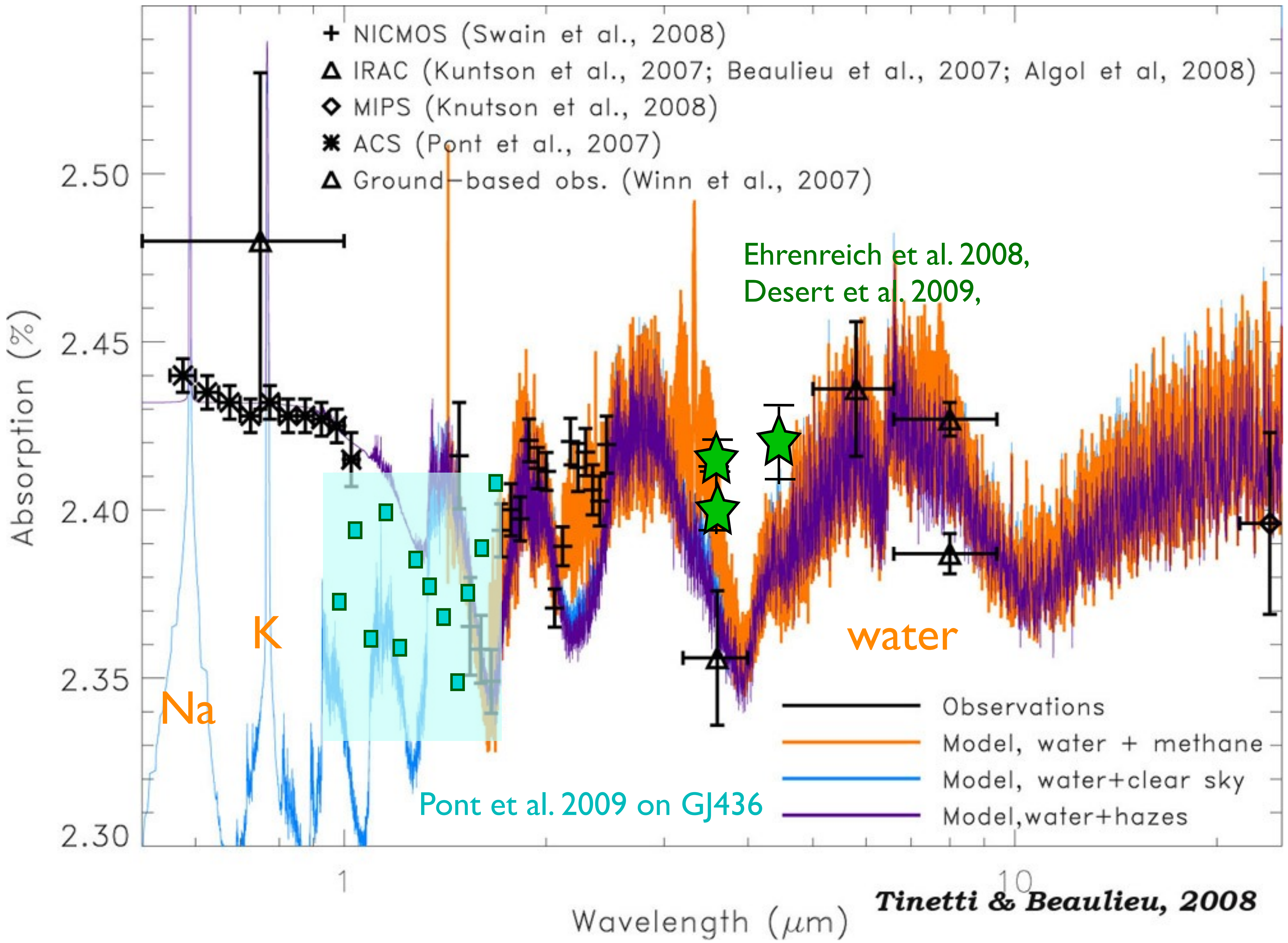


Challenges:

Infrared : complex instrumental systematics

Visible: star spots

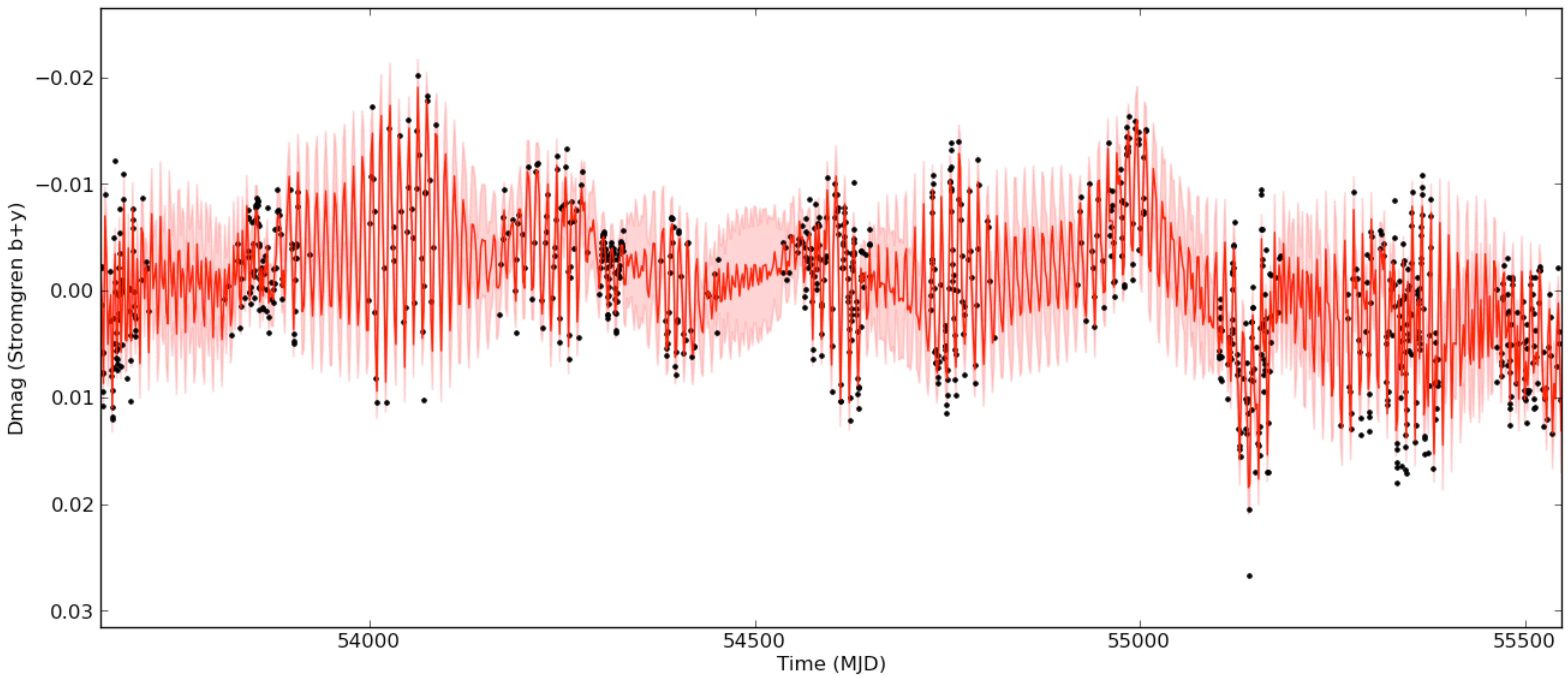
Our runs on HD189733 after *Servicing Mission 5* on the HST:

GO-11740 (16 orbits)
STIS 3000-5500 Å (Sing et al. 2011)
WFC 1-2 μ (Gibson et al. 2011)

GO-11572 (16 orbits)
STIS 5893 Å Na (Huitson et al. 2011)

+ re-analysis of NICMOS data
(Gibson et al. 2010)

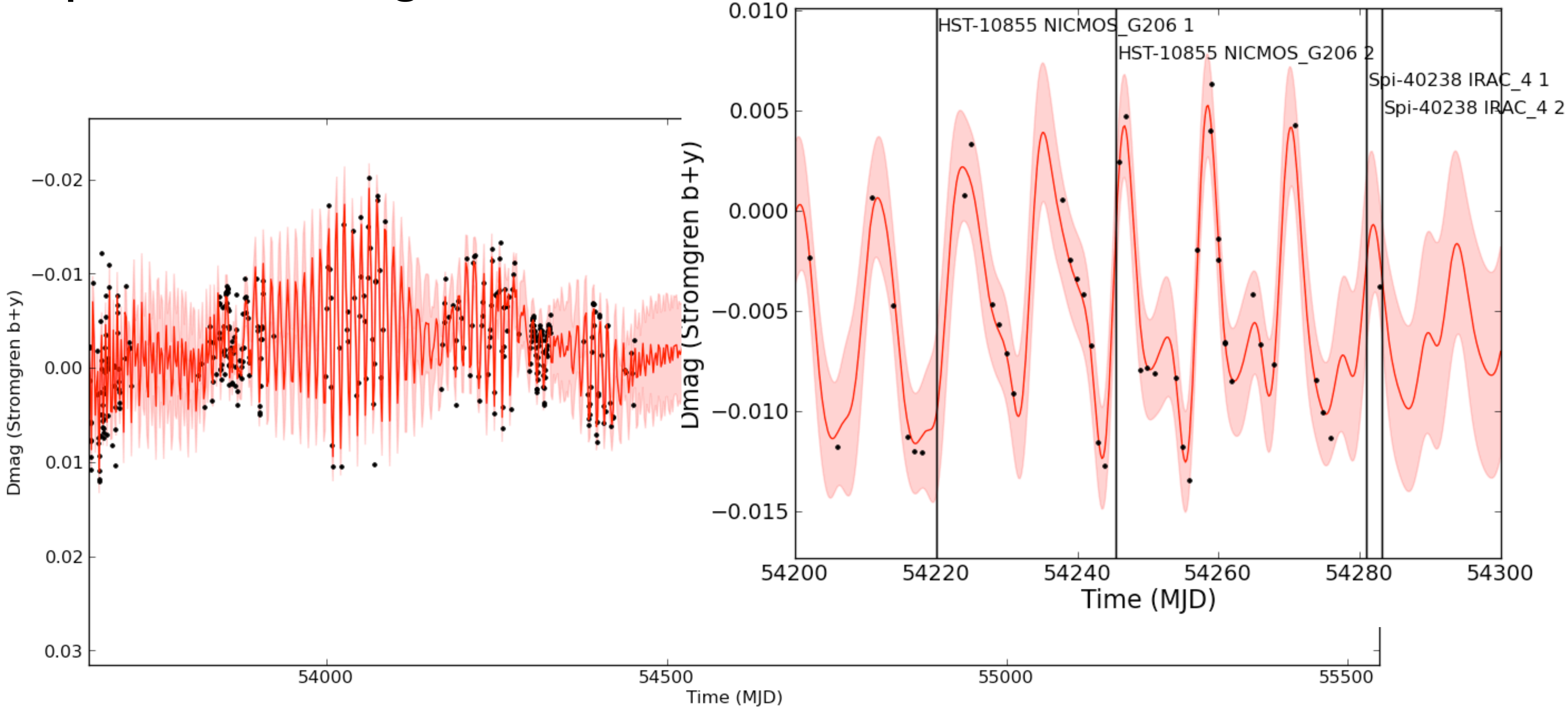
Star spot monitoring



Monitoring of HD189733 over 6 years by G. Henry with APT

Gaussian process analysis (see talk by S. Aigrain)

Star spot monitoring



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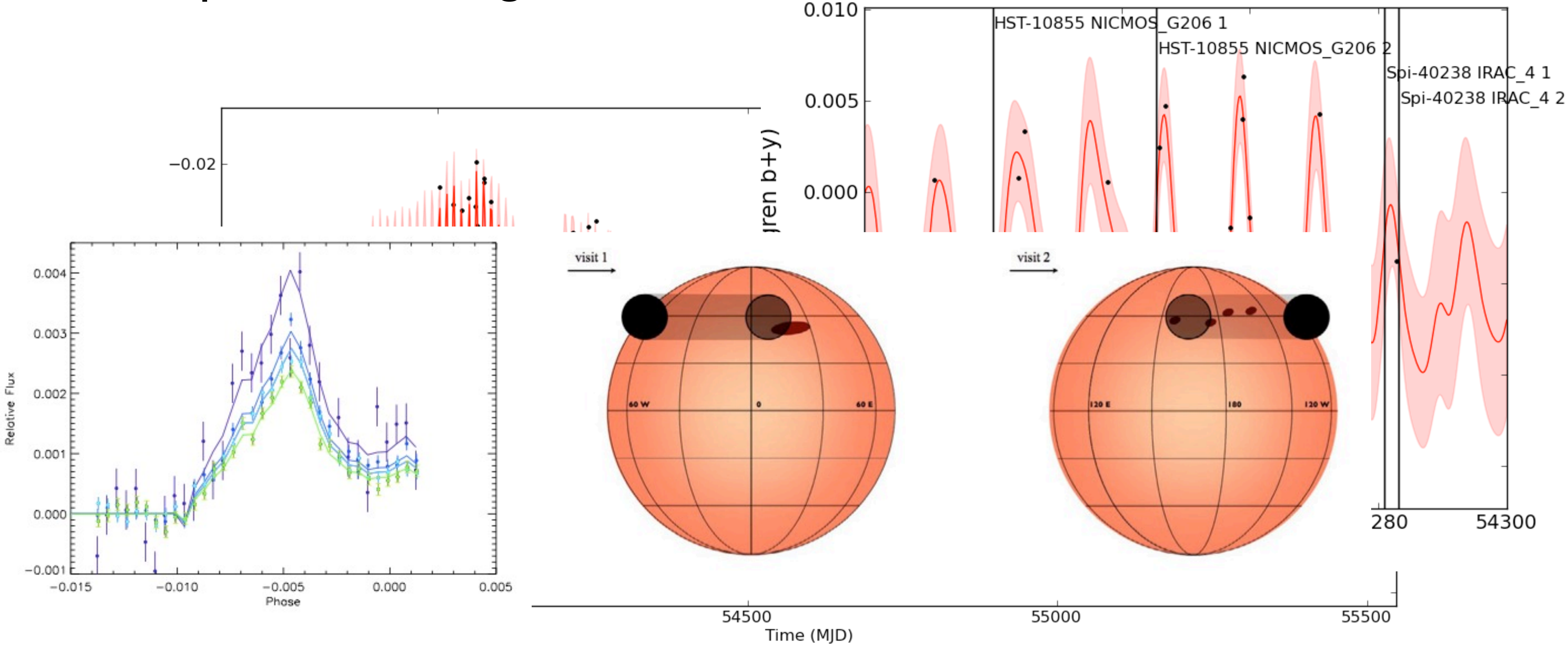

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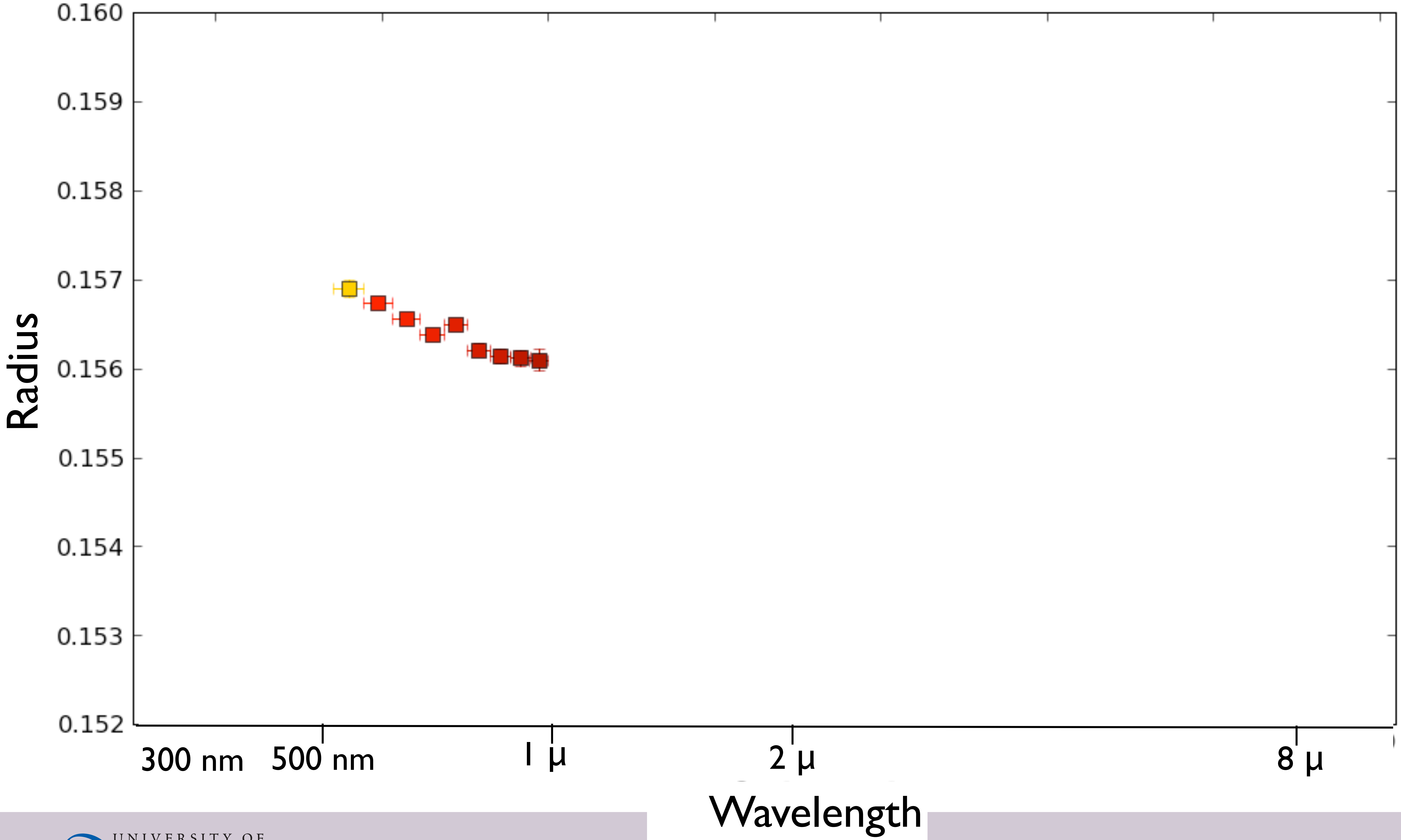
\+ many spot crossings during HST measurements

TRANSMISSION SPECTRUM OF HD 189733b

new results with refurbished HST



ACS 600nm-1μ (Pont et al. 2008)

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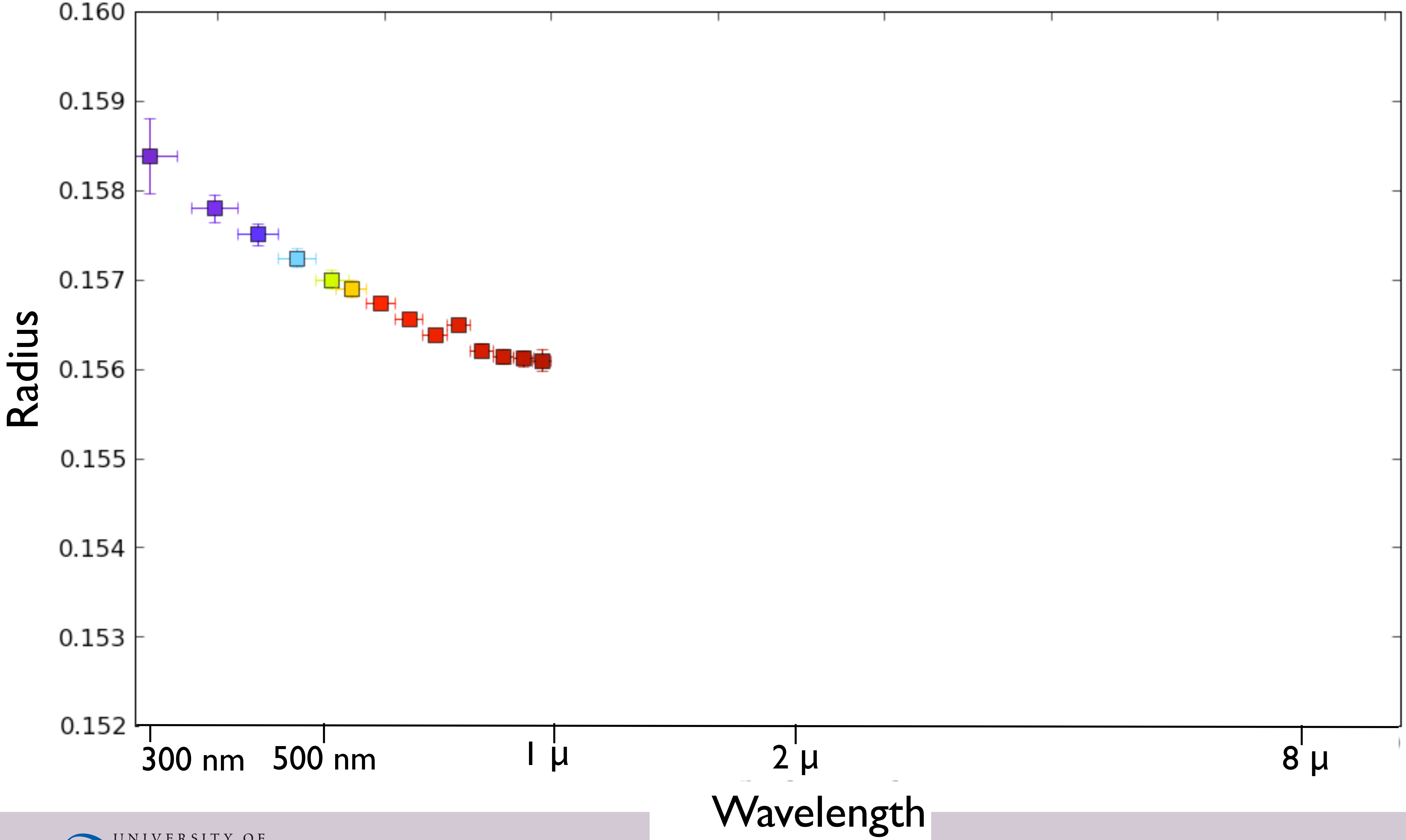

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STIS 300-600 nm (Sing et al. 2011)

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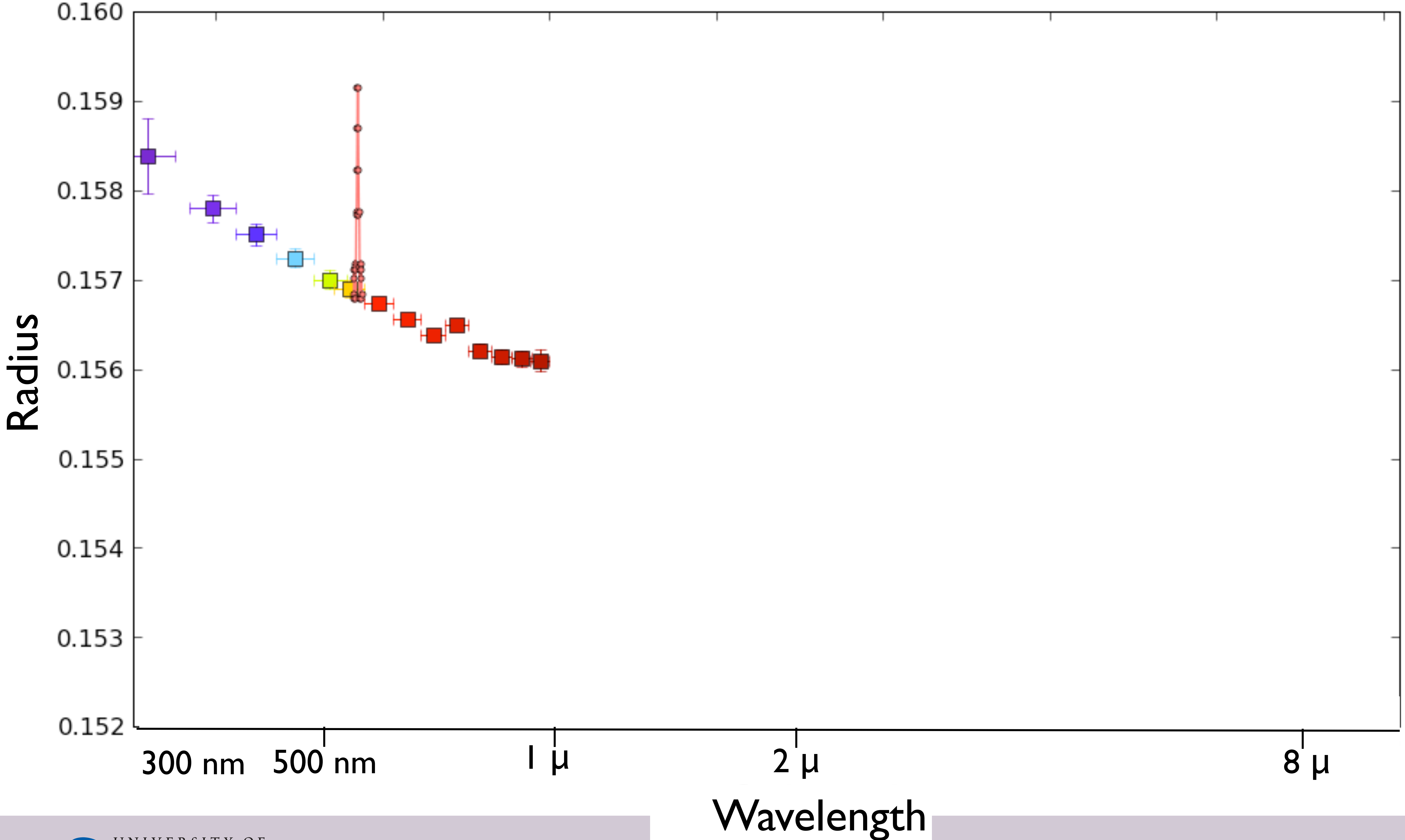

ACS 600nm-1μ (Pont et al. 2008)

STIS 300-600nm (Sing et al. 2011)

STIS Na-D line (Huitson et al. 2011)
Poster
Ground (Redfield et al. 2008)

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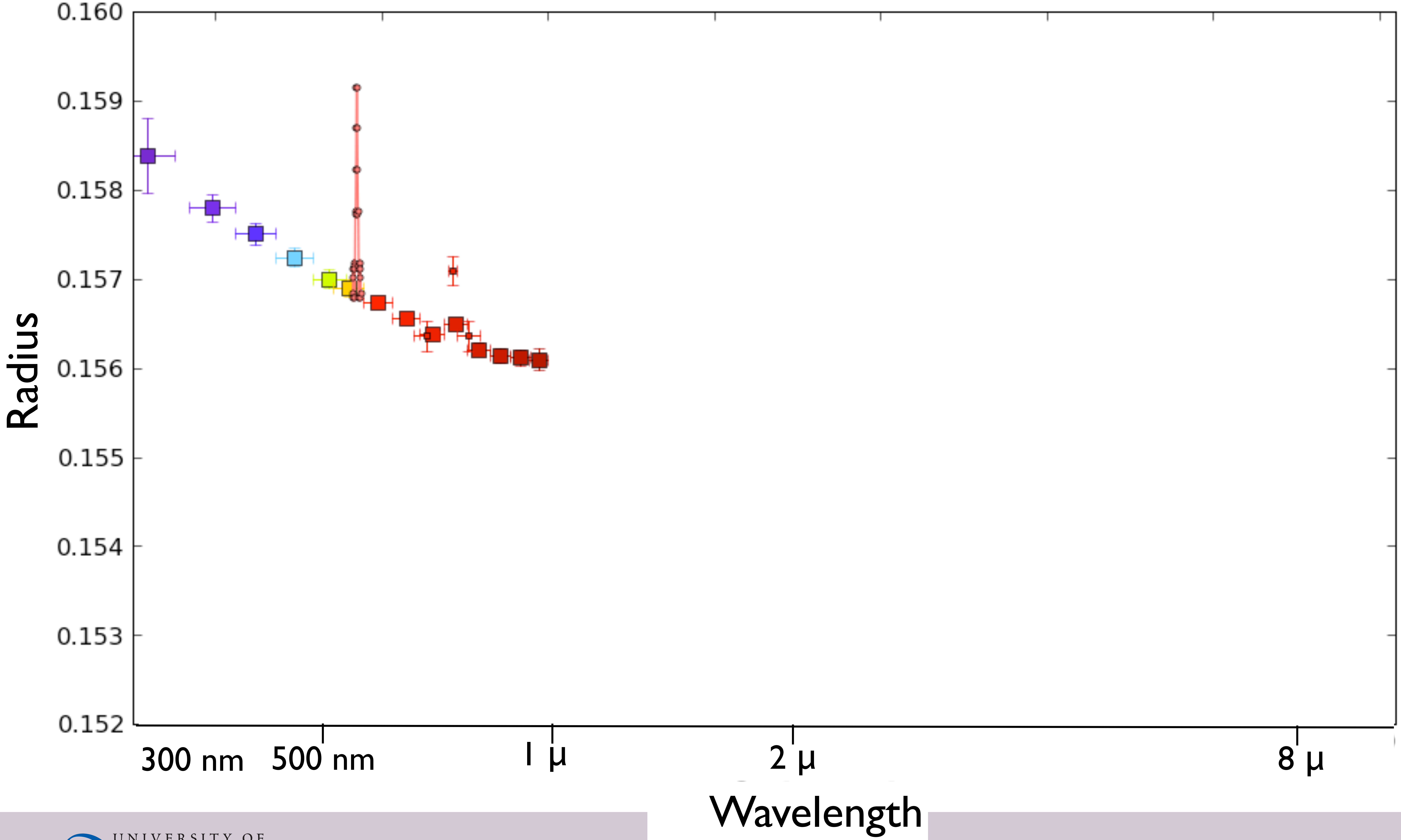

ACS 600nm-1μ (Pont et al. 2008)

potassium line

STIS 300-600nm (Sing et al. 2011)

STIS Na-D line (Huitson et al. 2011)
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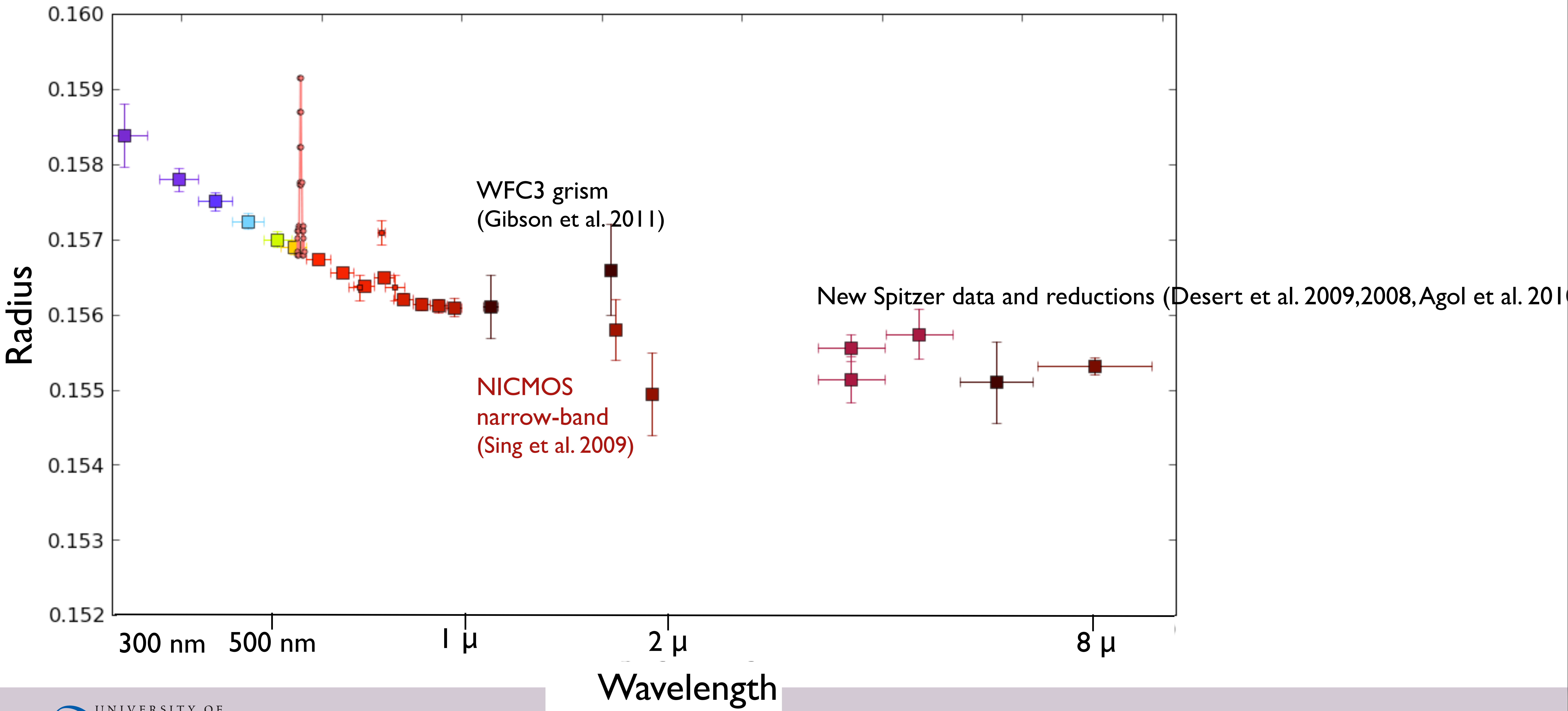

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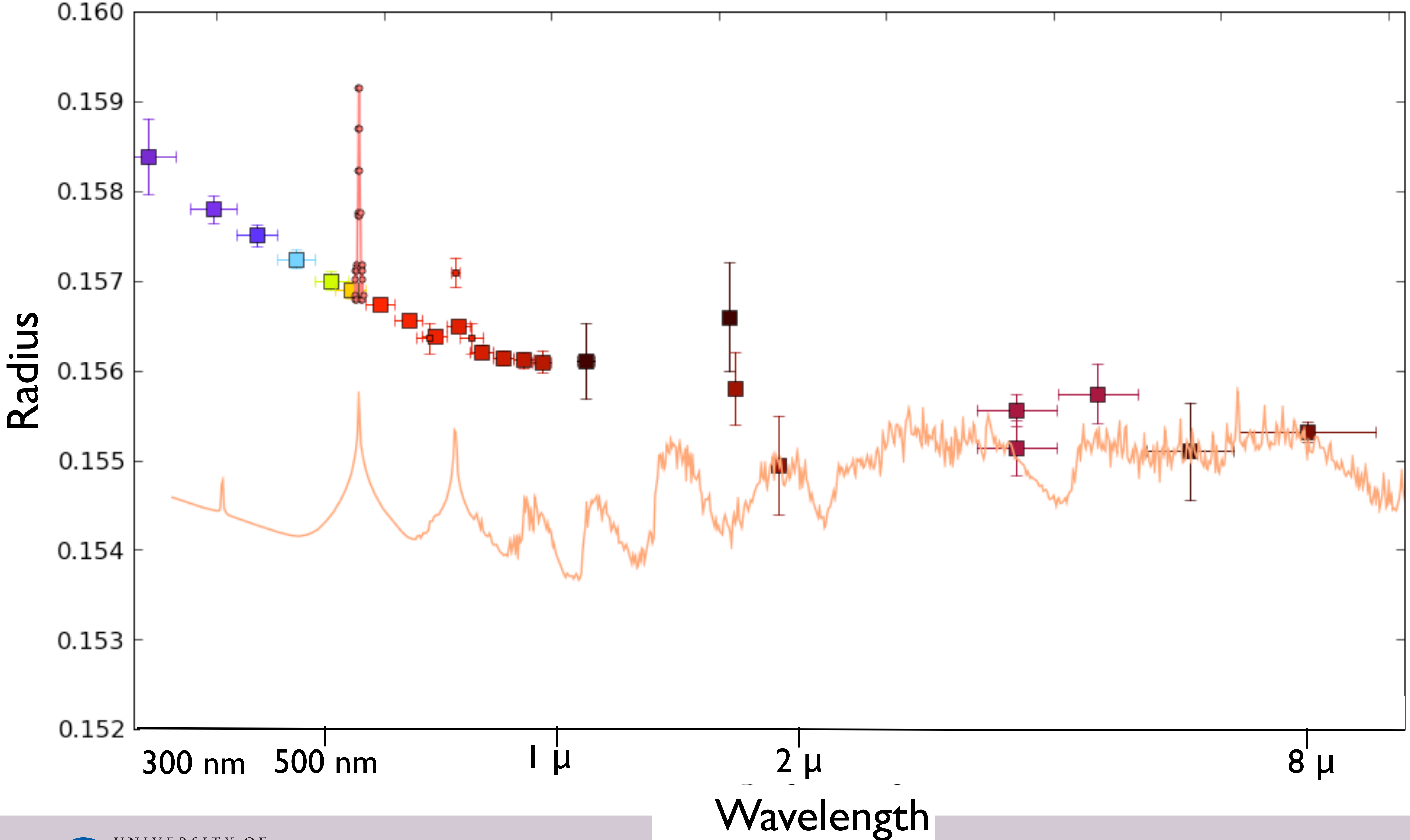

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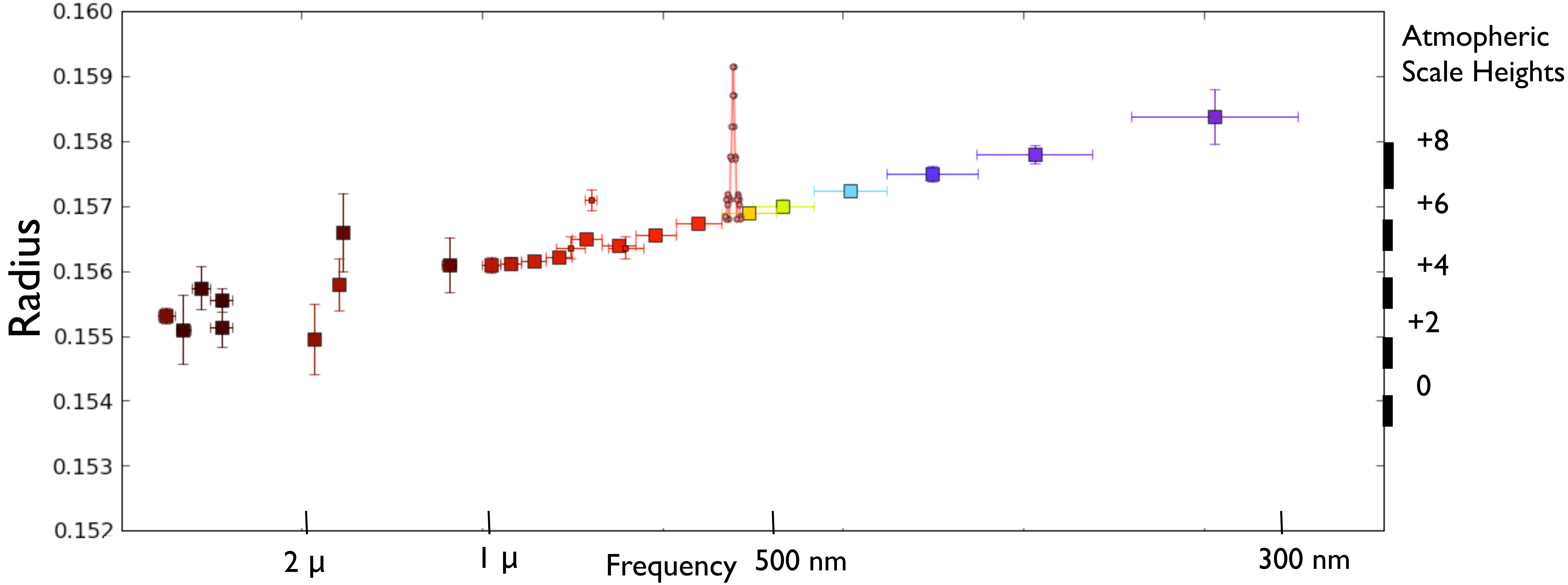

Rayleigh scattering: slope gives scale height, temperatures

Haze with mixture of silicate grains shows correct behaviour Over >5 scale heights

Visible opacity determines the deposition of stellar energy (Heng, Hayek, Pont, Sing 2011)

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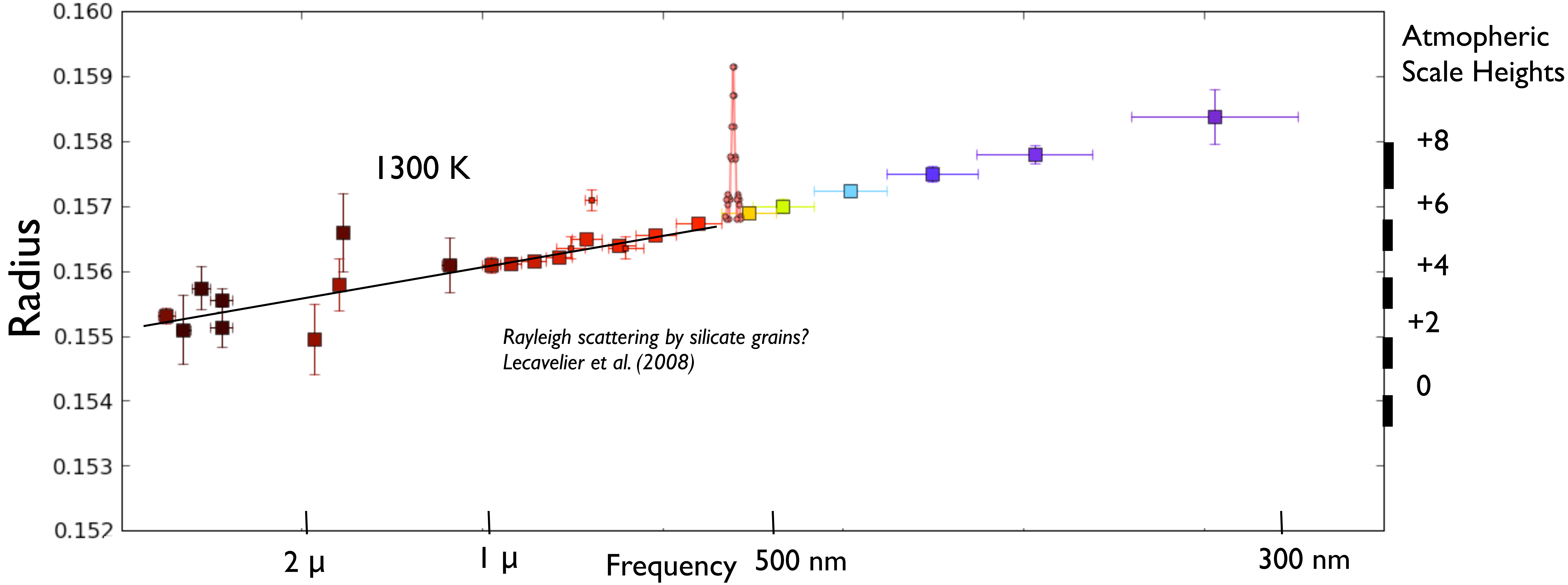

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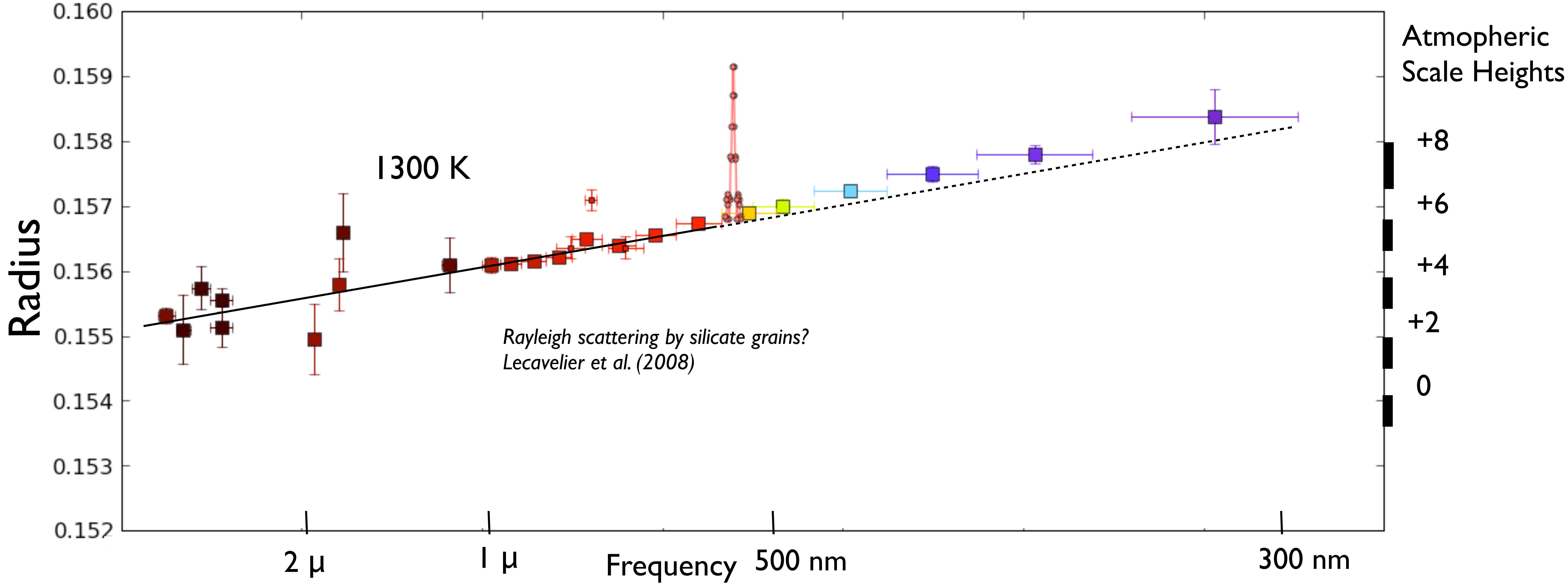

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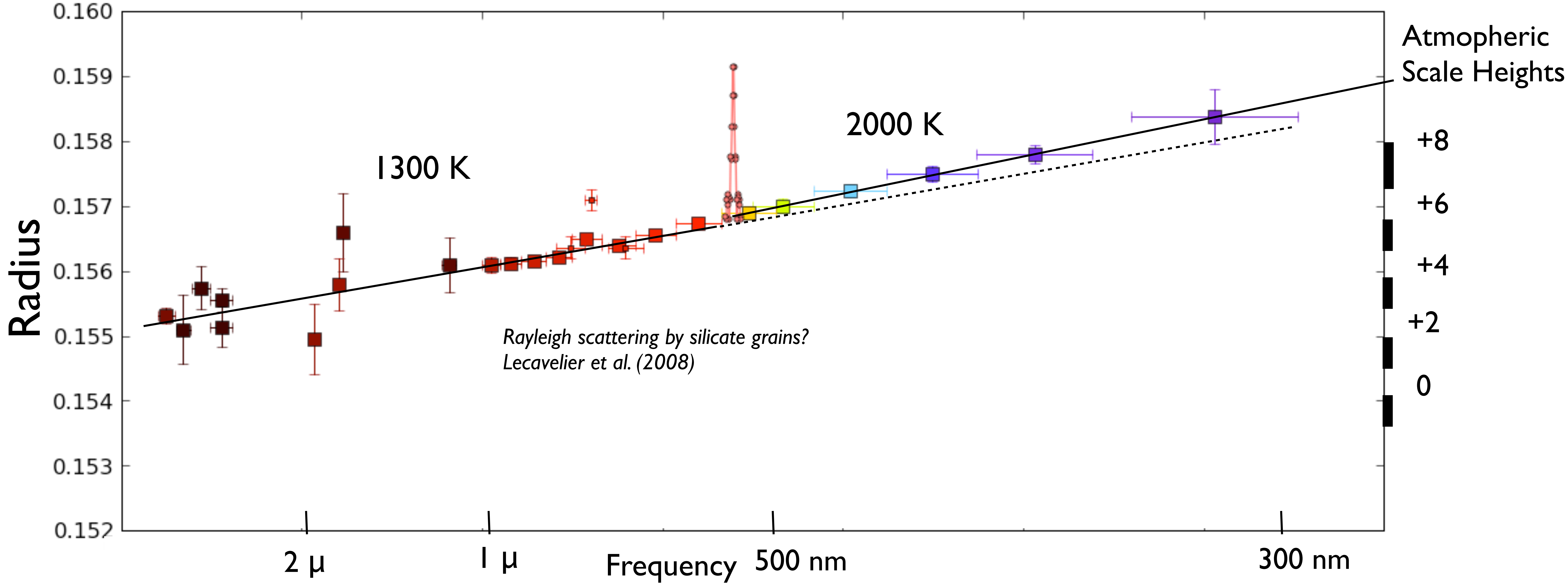

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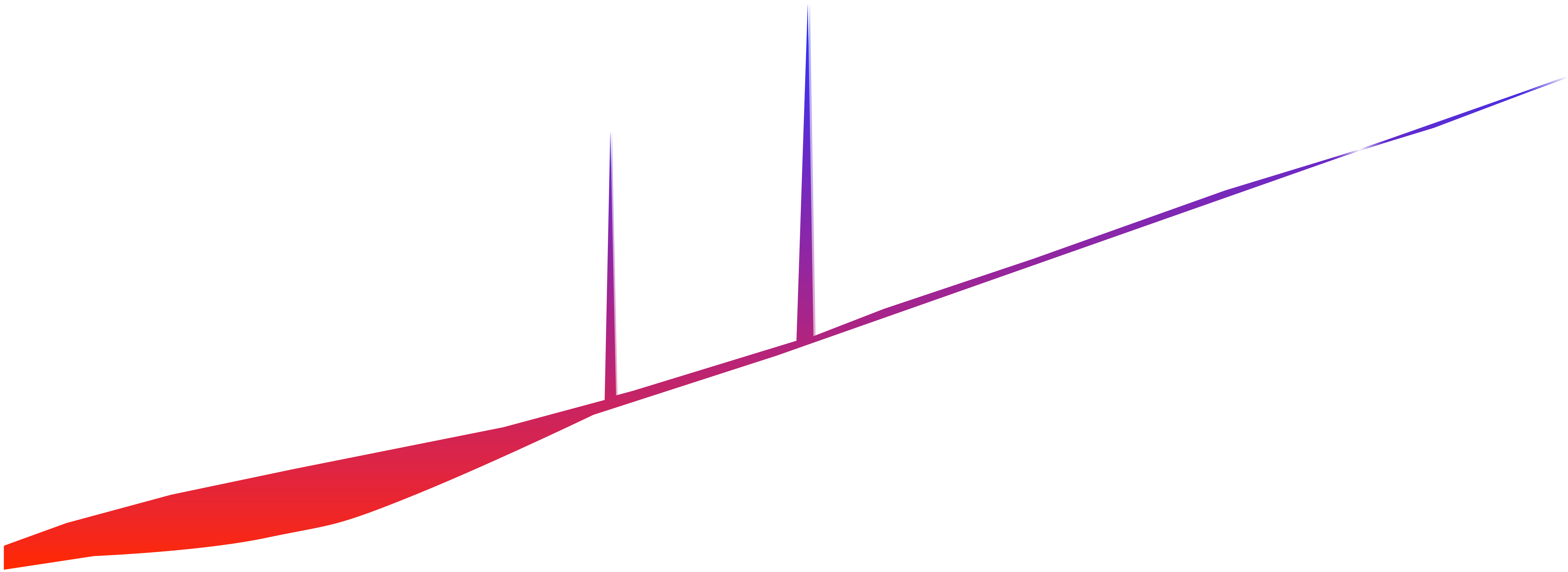
Conclusions



Conclusions

A “best-guess” picture of the atmosphere of HD189733b near the limb from HST transit spectroscopy:

Dominated by haze scattering, possibly by silicate grains

Temperature rising above photosphere to ~2000 K thermosphere

Alkali metal abundances far above solar

Photosphere and deposition of heat high in the atmosphere (10-100 mbars)

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HST Large Programme - 124 orbits ! - to collect STIS transit spectroscopy for ten hot Jupiters

Conclusions

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see you in Aspen!