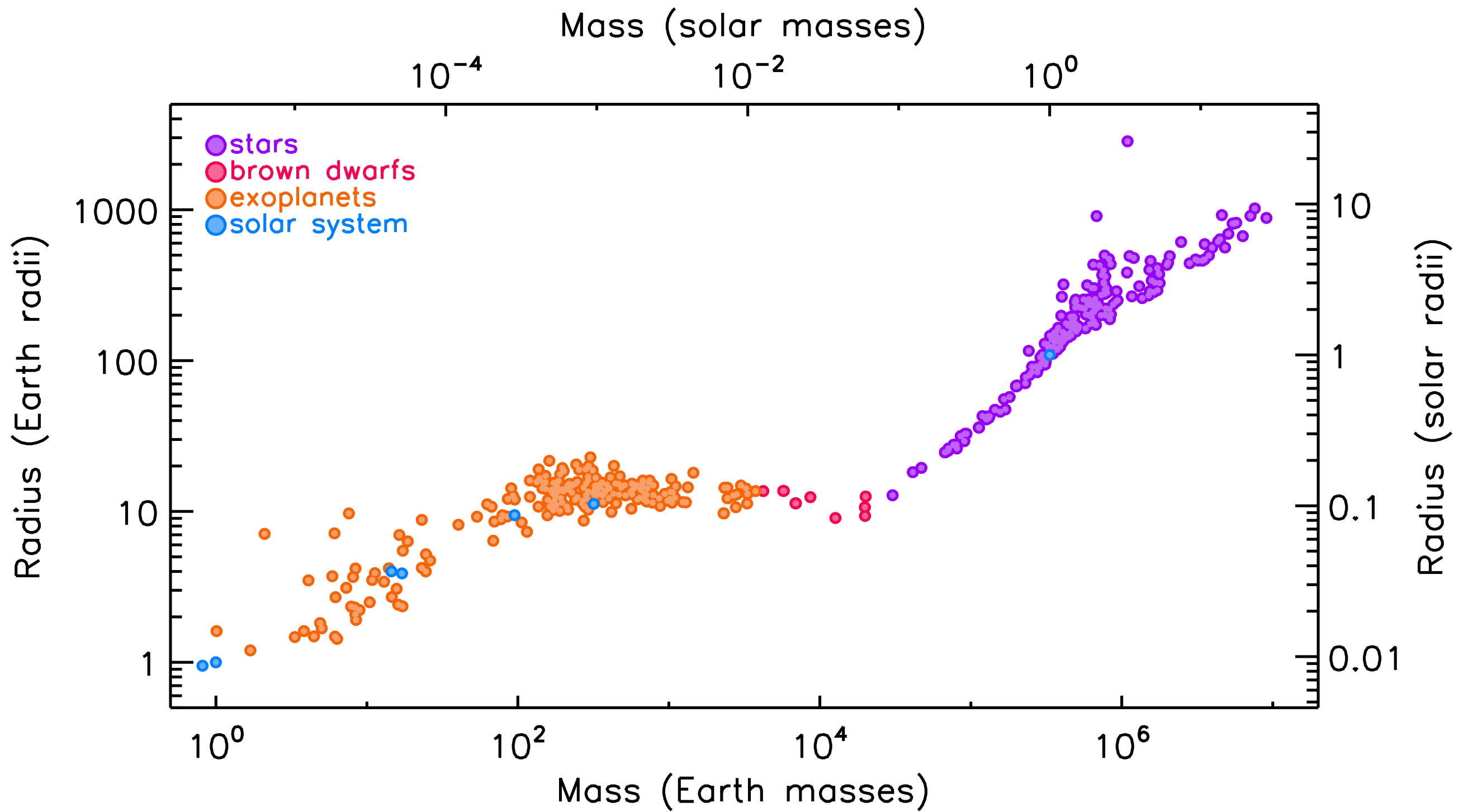


# Thick High-Altitude Clouds on an Extremely Inflated Hot Jupiter (?)

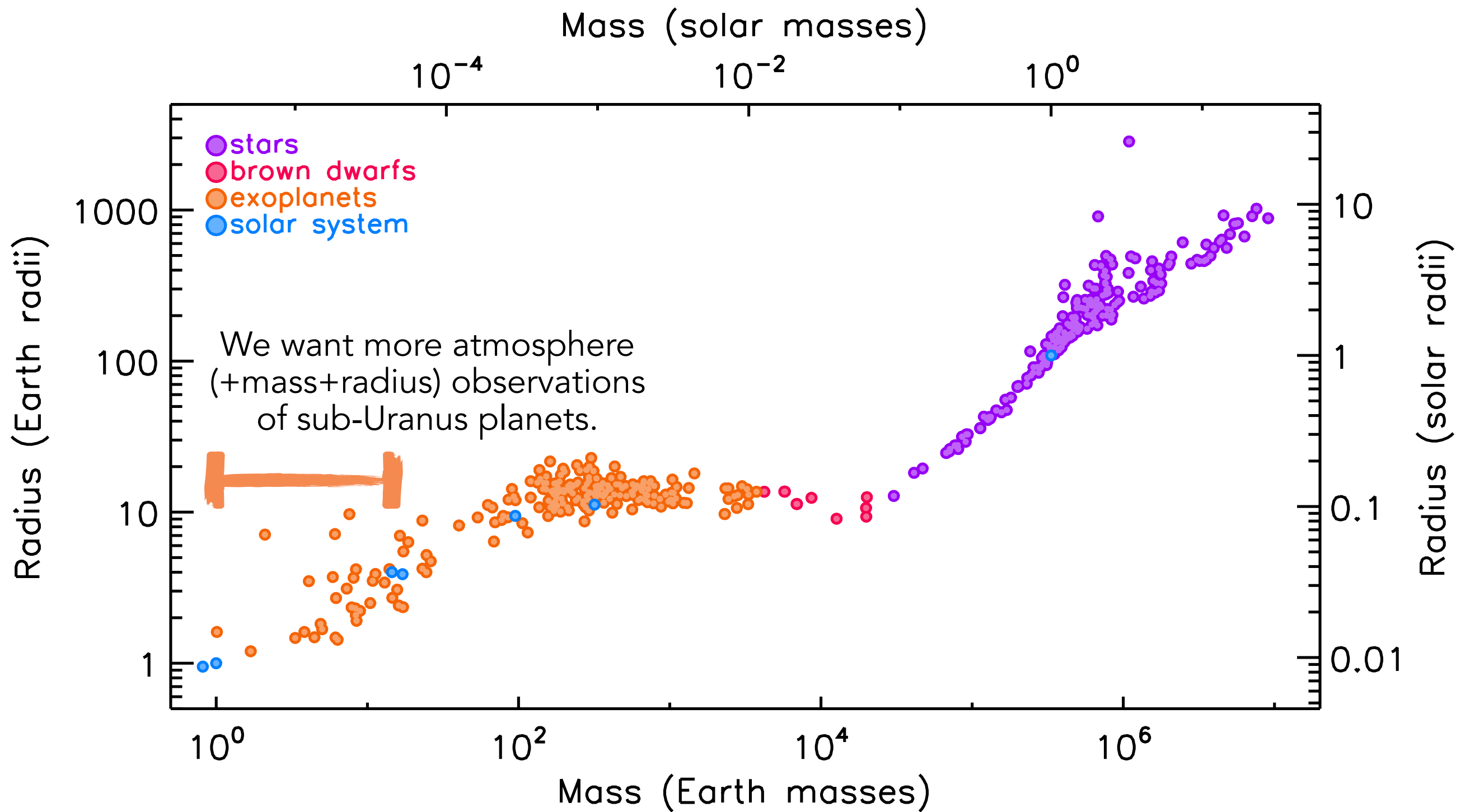
Zach Berta-Thompson  
Torres Exoplanet Fellow, MIT

with A. Triaud, C. Morley, J. Fortney, M. McDonald, D. Osip,  
M. Neveu-VanMalle, D. Queloz, C. Hellier, M. Gillon, L. Delrez



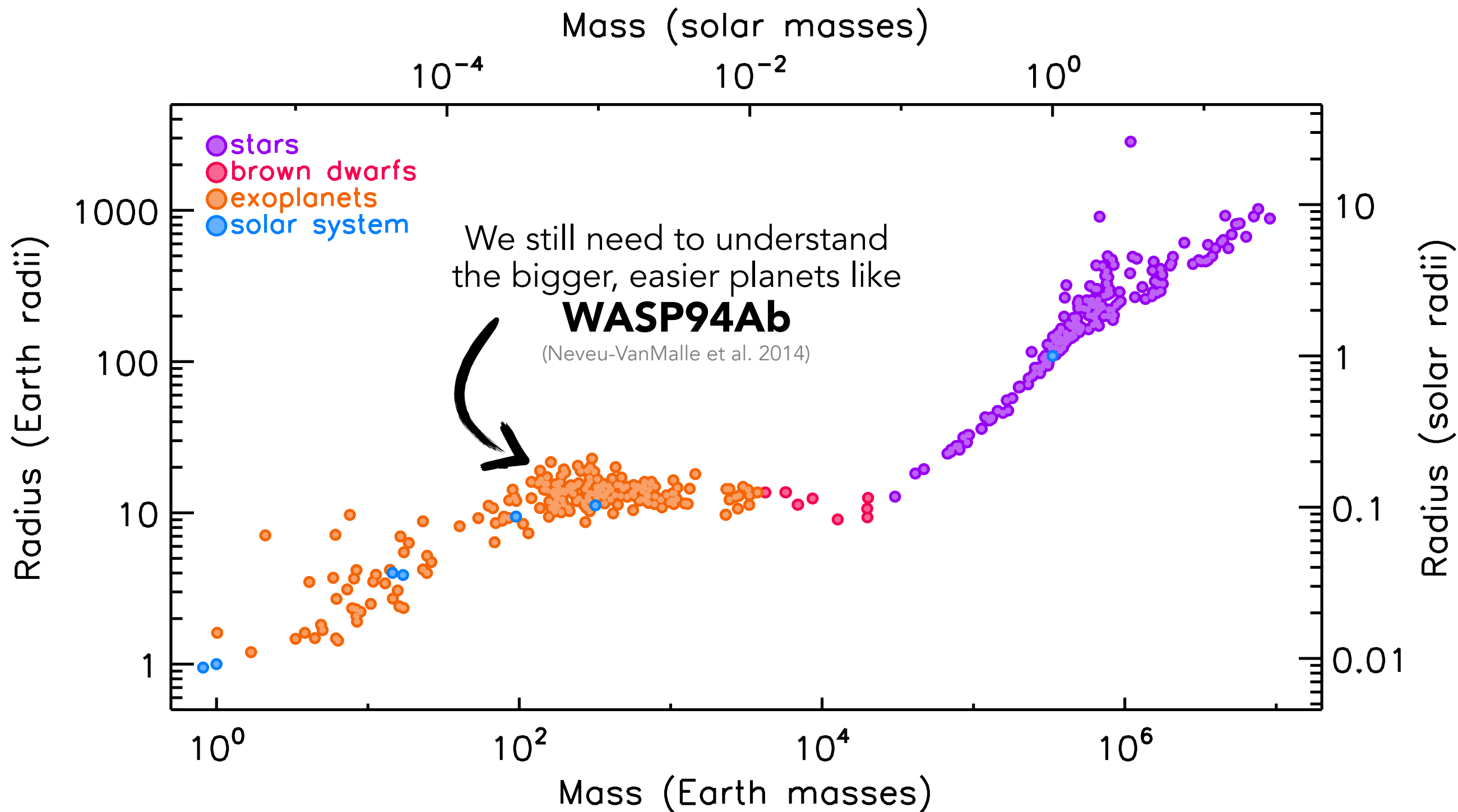




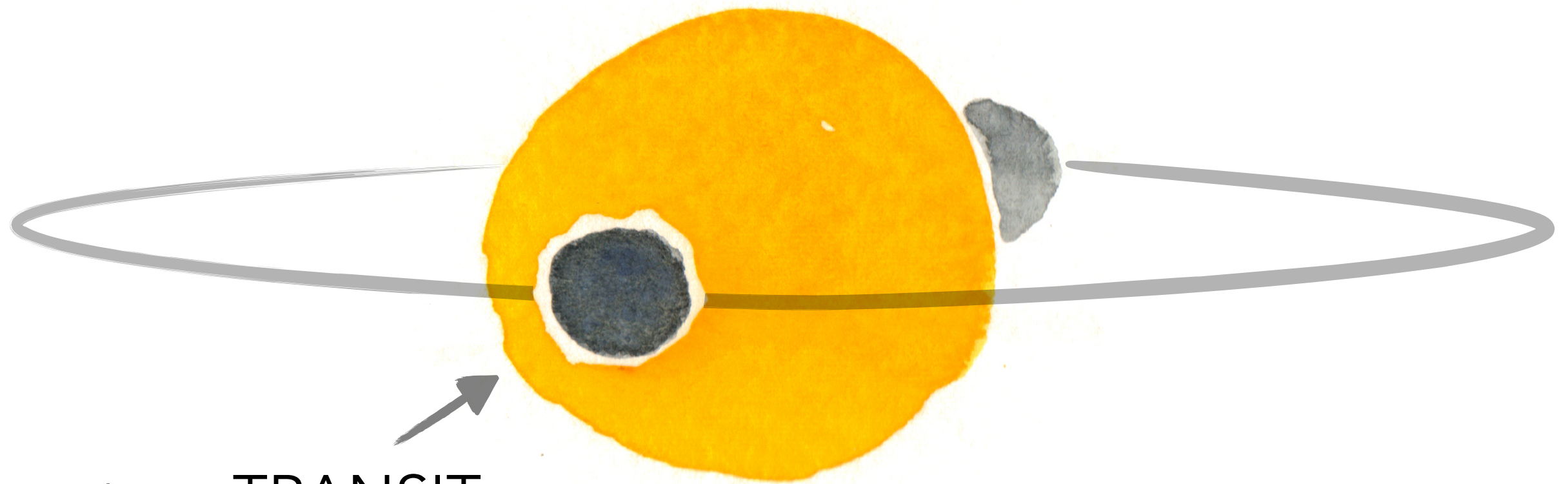




# Today's Talk:

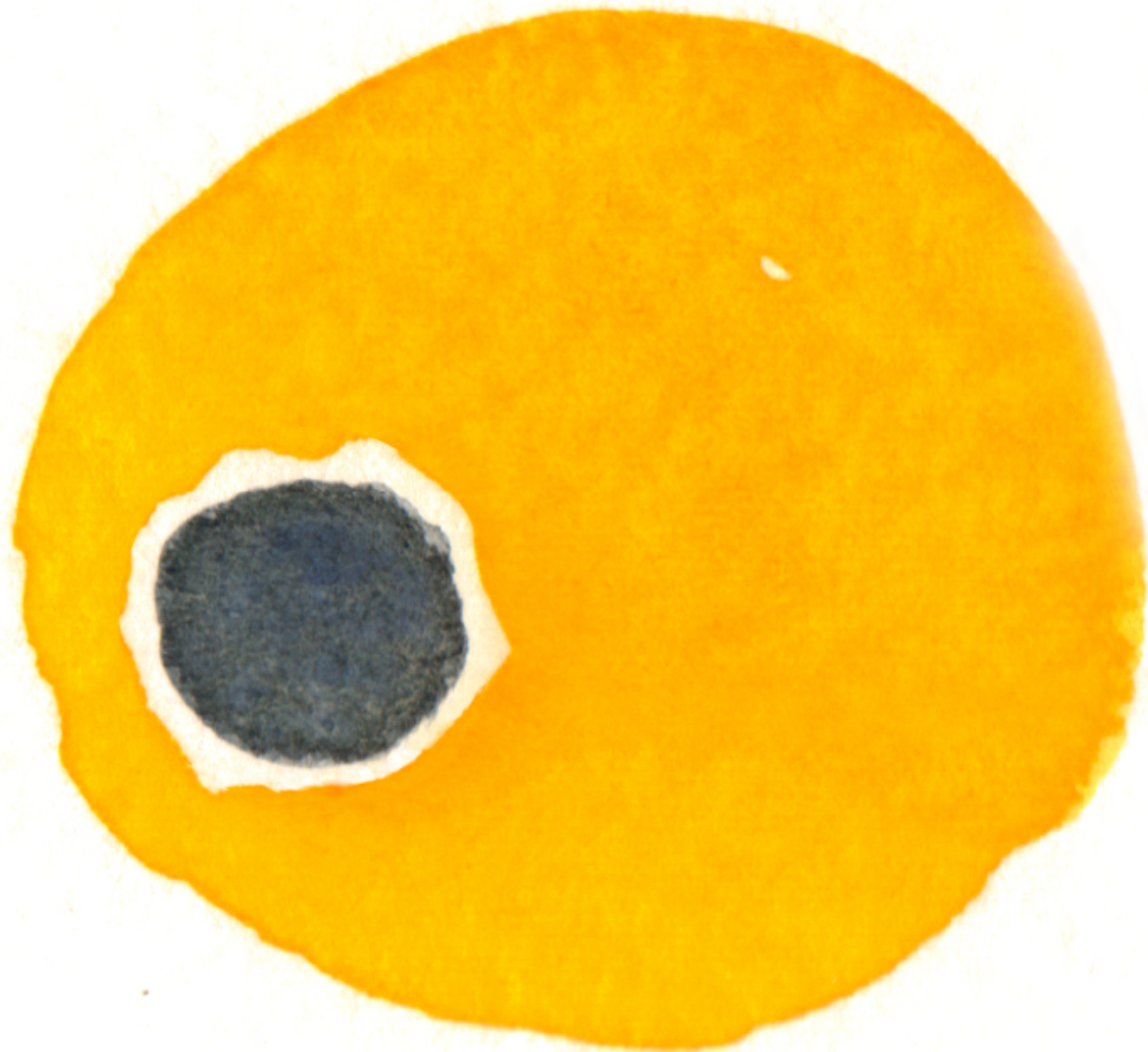




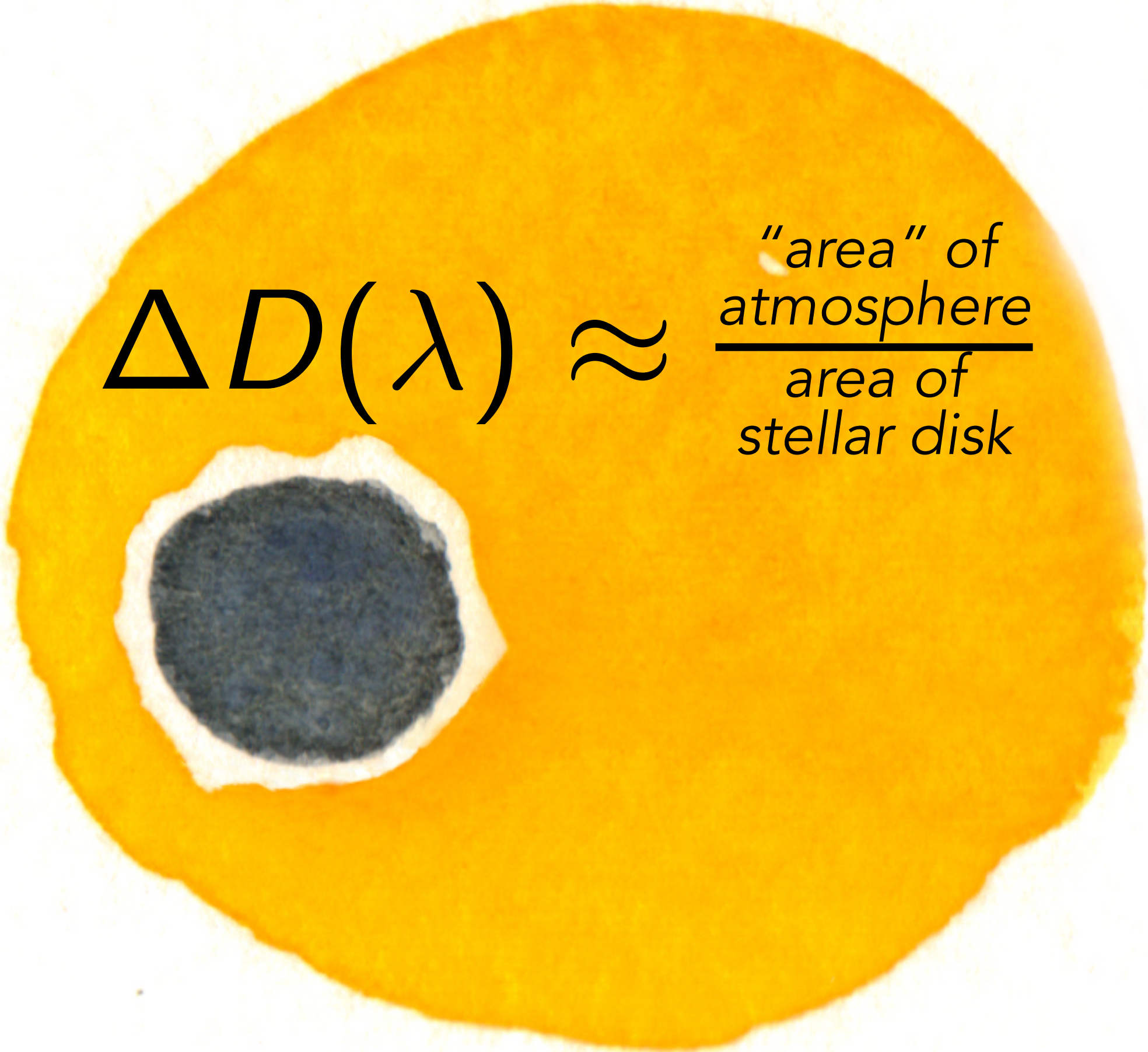


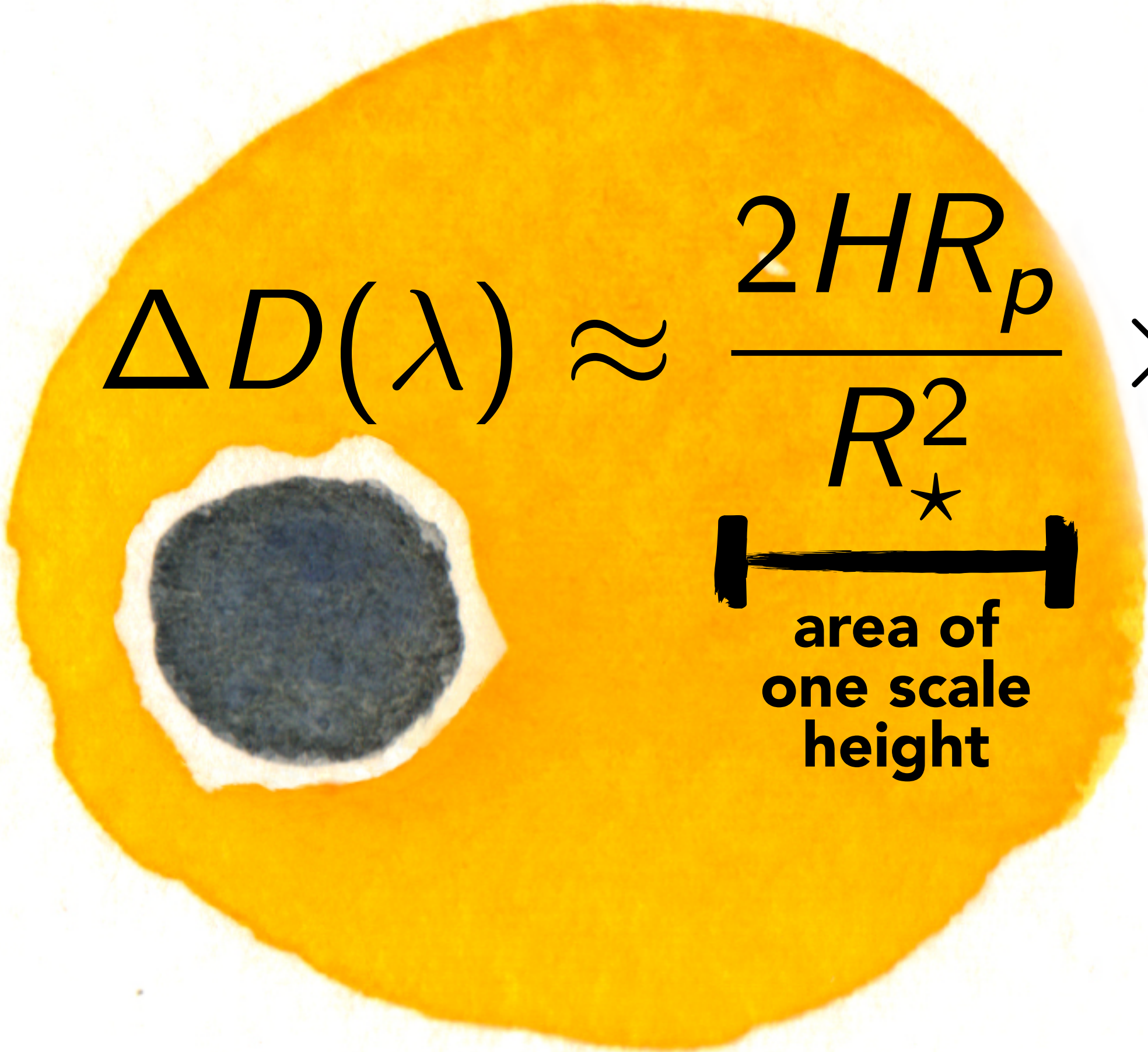
during **TRANSIT**,  
see light transmitted  
through planet's  
atmosphere








$$\Delta D(\lambda) \approx \frac{\text{"area" of atmosphere}}{\text{area of stellar disk}}$$



$$\Delta D(\lambda) \approx \frac{2HR_p}{R_\star^2} \times n(\lambda)$$

area of one scale height

# of scale heights




$$\Delta D(\lambda) \approx \frac{2HR_p}{R_\star^2} \times n(\lambda)$$

atmospheric  
scale height

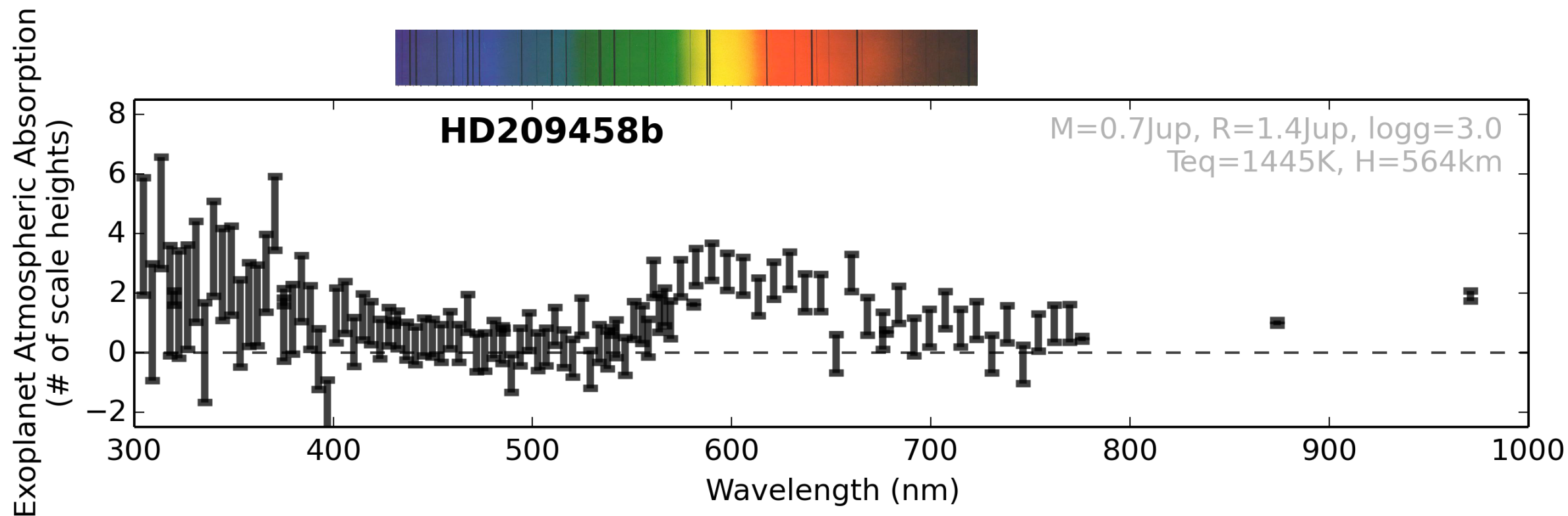
planet  
radius

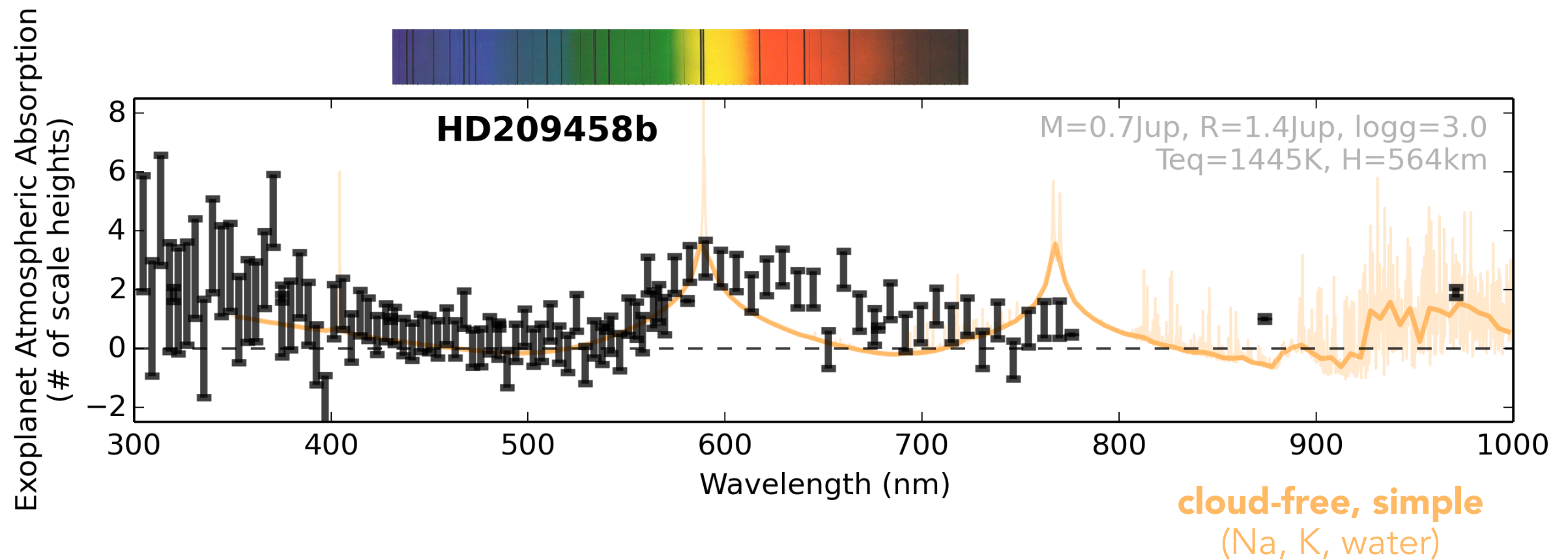
stellar  
radius


$$\Delta D(\lambda) \approx \frac{2HR_p}{R_\star^2} \times n(\lambda)$$

**radiative  
processes,  
chemistry,**  
(complicated!)

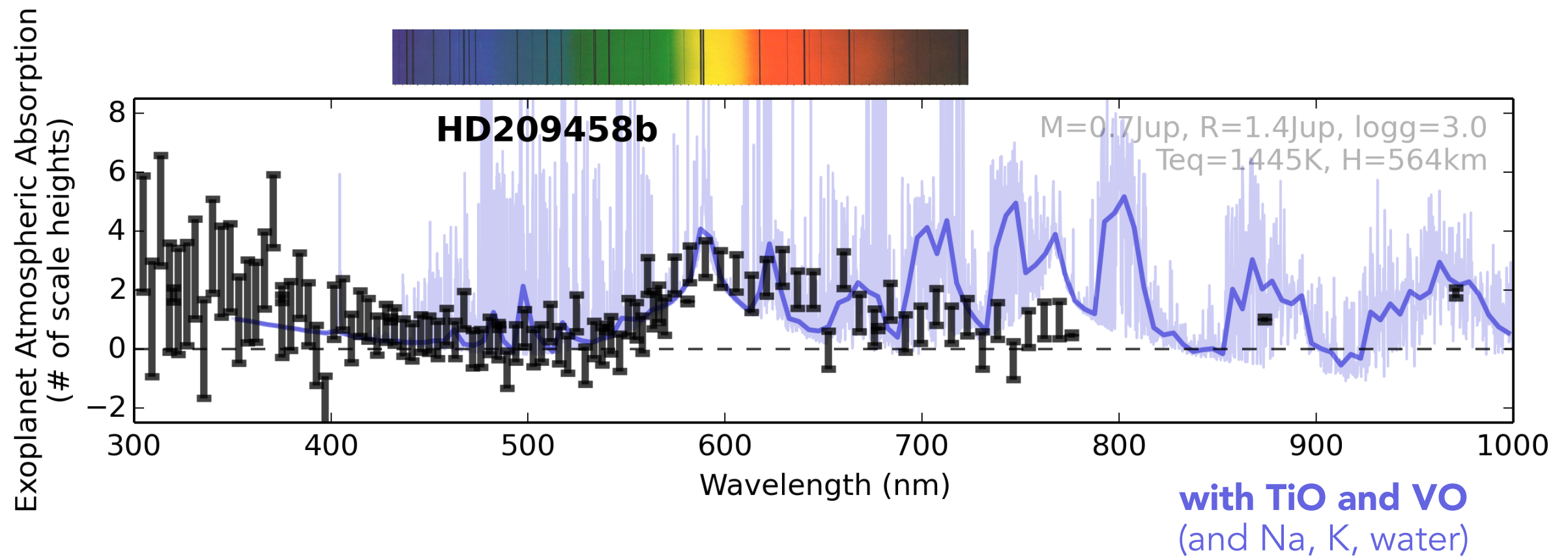




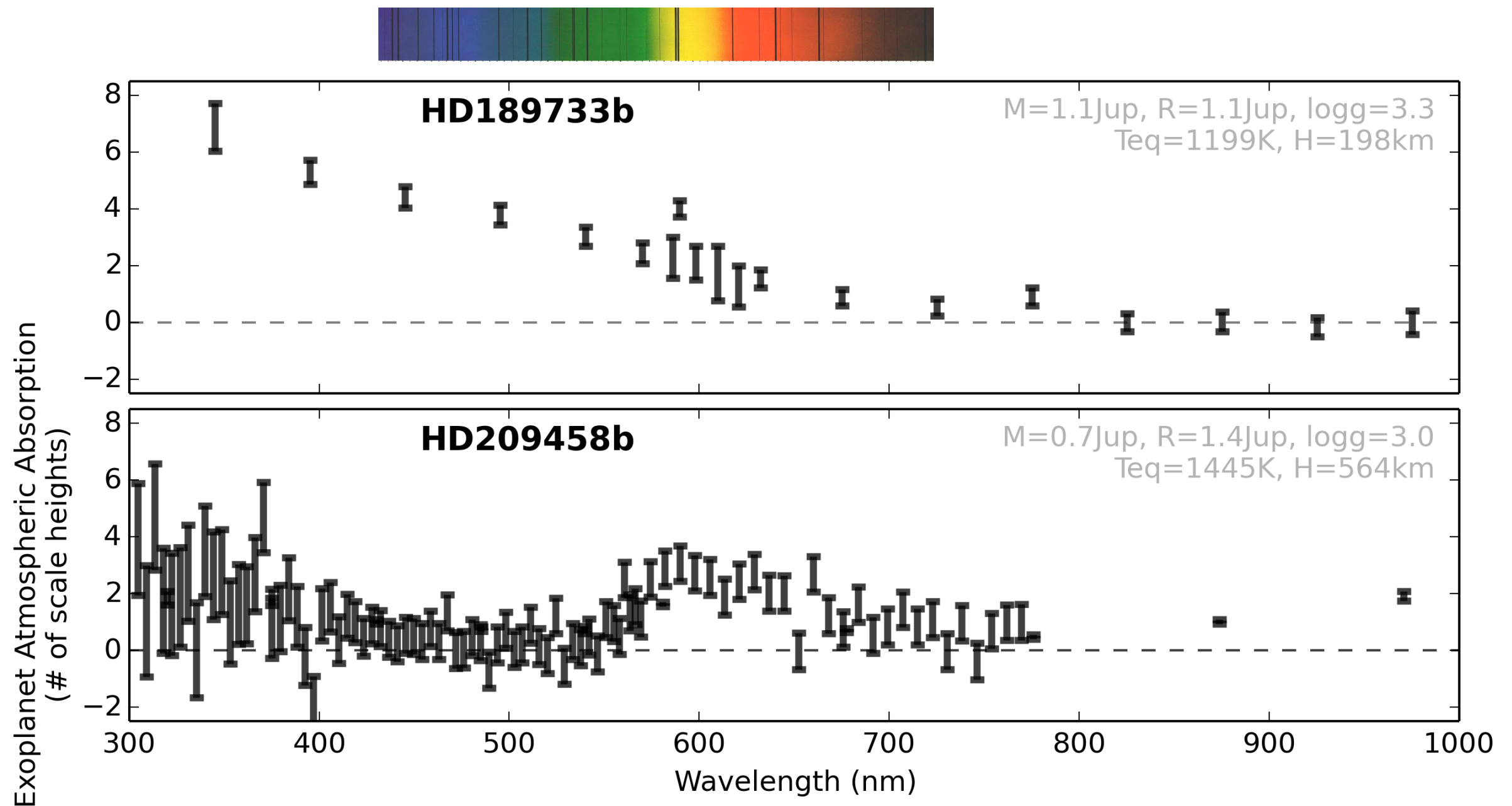


models from Fortney et al. (2010);  
HD209458b from Knutson et al. (2007), Sing et al. (2008ab), Désert et al. (2008), Lecavelier Des Etangs (2008)

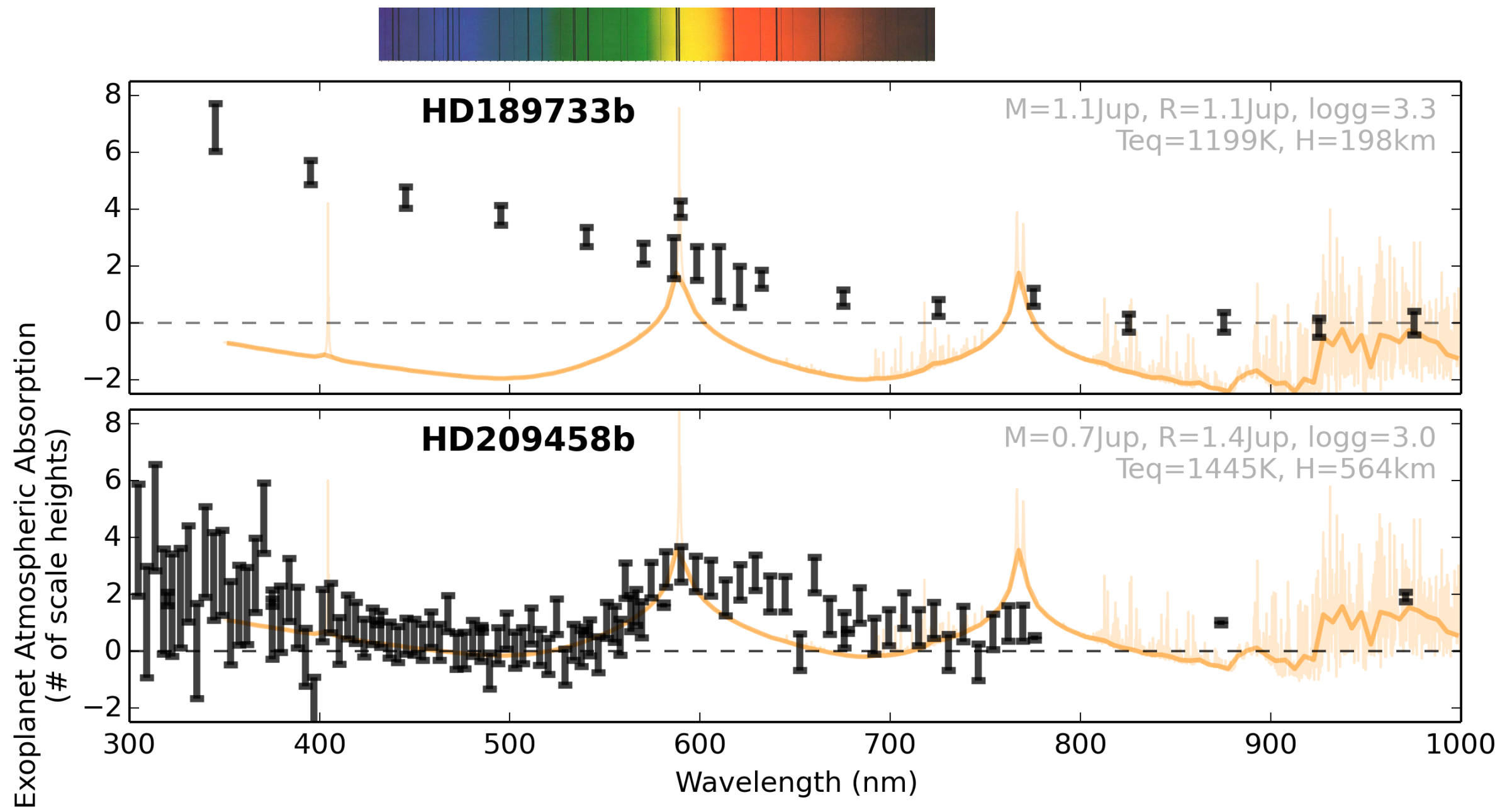




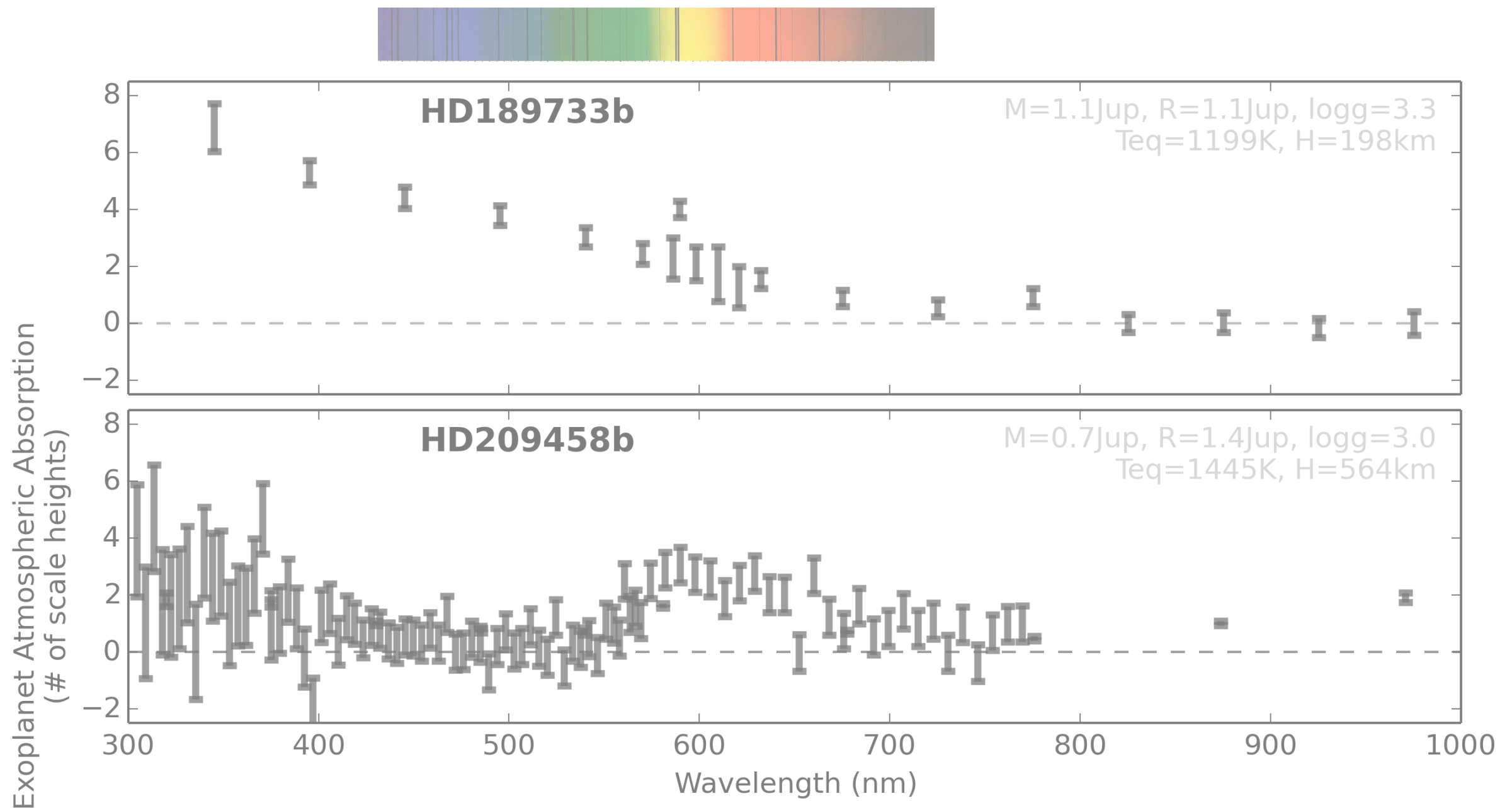
models from Fortney et al. (2010);  
HD209458b from Knutson et al. (2007), Sing et al. (2008ab), Désert et al. (2008), Lecavelier Des Etangs (2008)







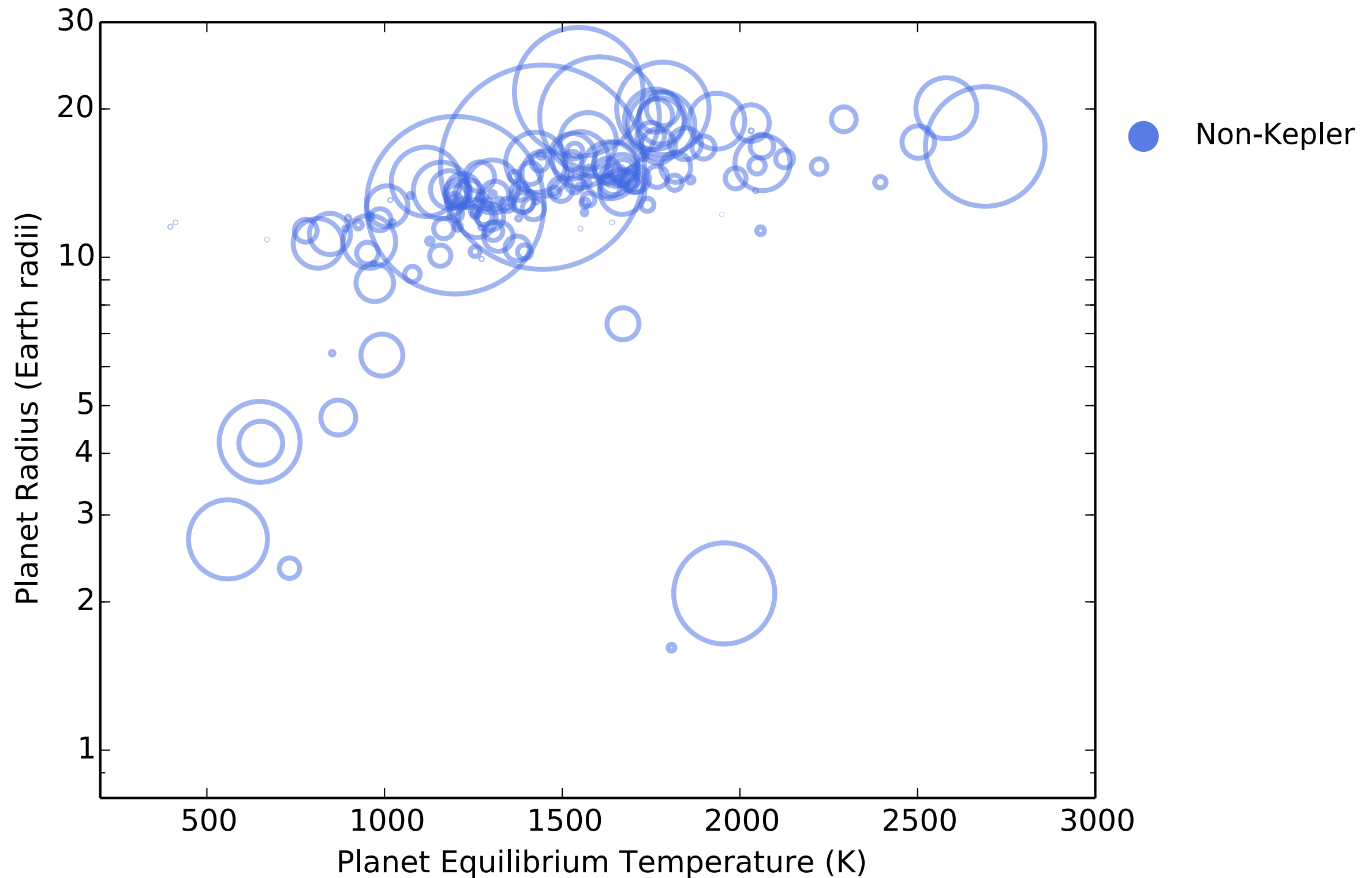
models from Fortney et al. (2010);  
HD189733b from Pont et al. (2008), Sing et al. (2011), Huitson et al. (2012)



If we observe another hot Jupiter at comparable resolution and precision, will it look like one of these two?

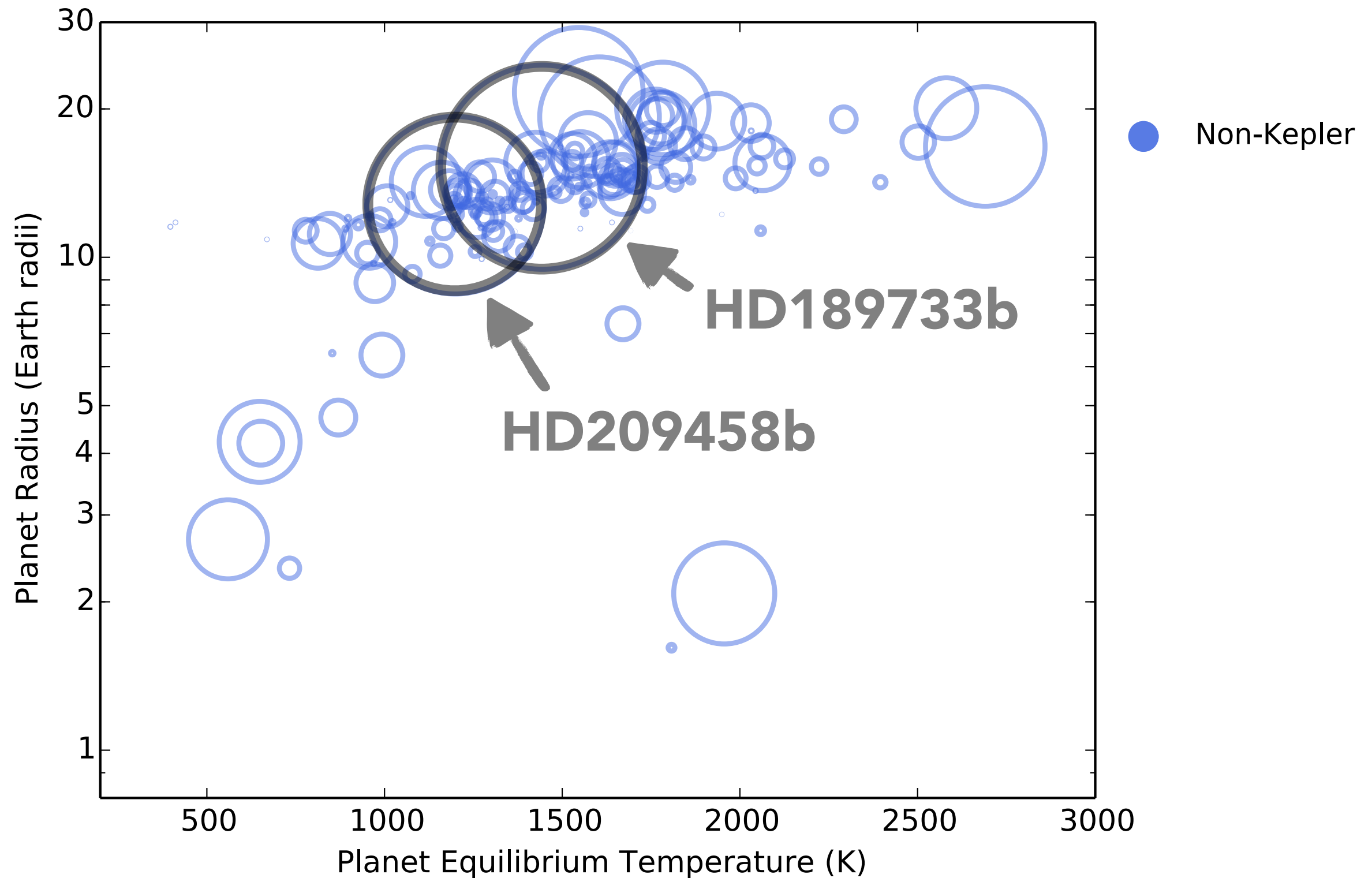


 = **S/N** for transmission spectroscopy



*(assuming H<sub>2</sub> atmosphere for all planets)*

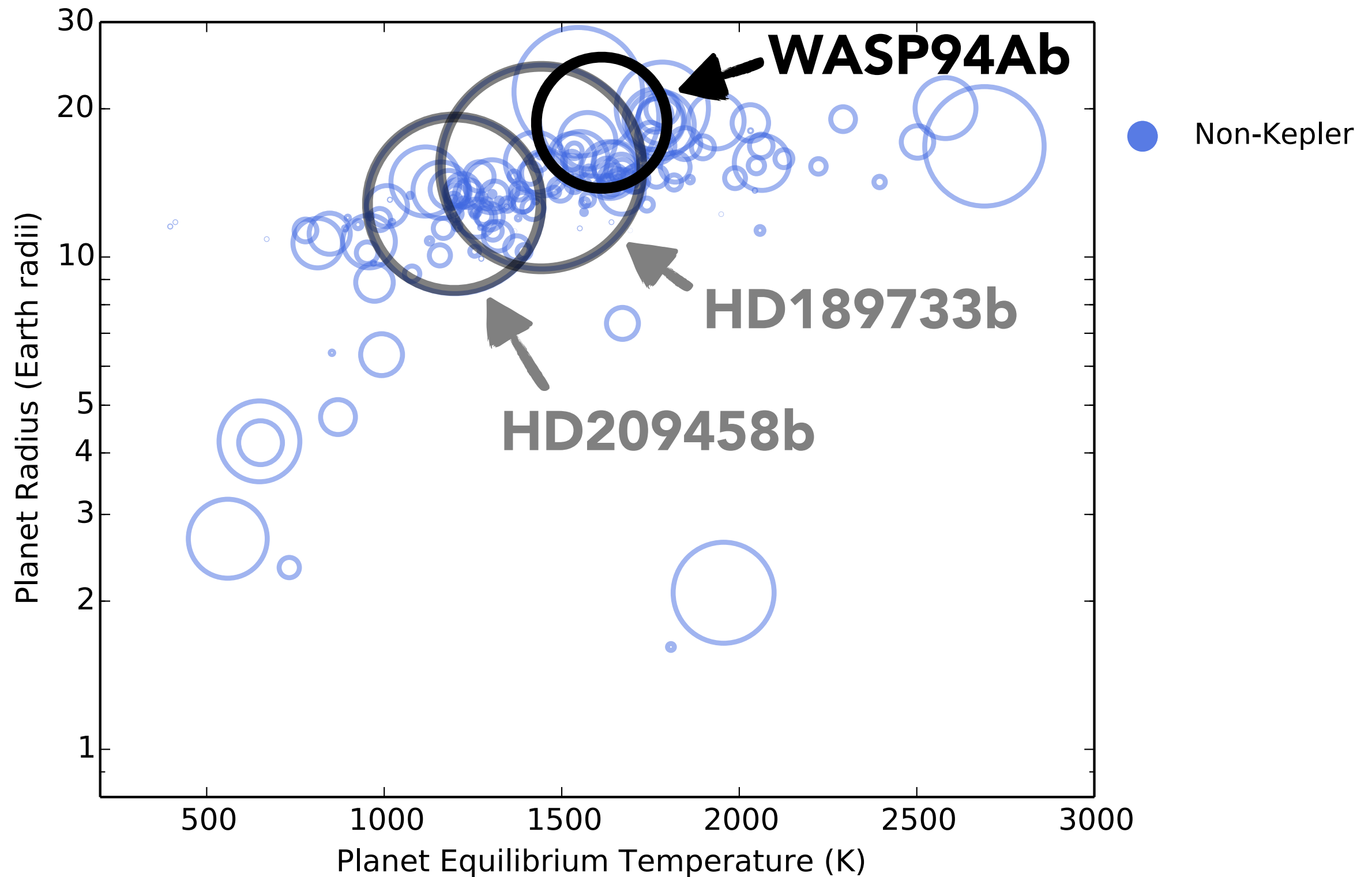
 = **S/N** for transmission spectroscopy



*(assuming  $H_2$  atmosphere for all planets)*



 = **S/N** for transmission spectroscopy



*WASP94Ab from Neveu-VanMalle et al. (2014)*

# HD209458b

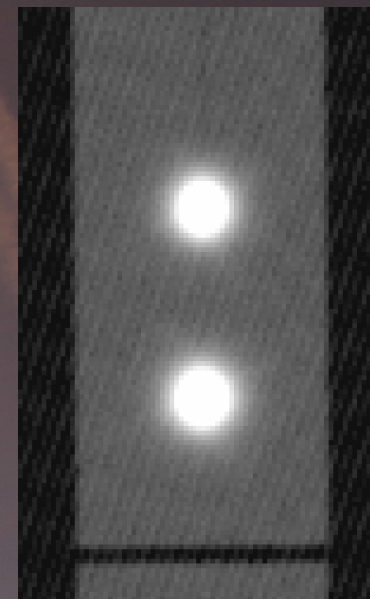
$V=7.6$

difficult to obtain  
photon-limited light curves  
except from space



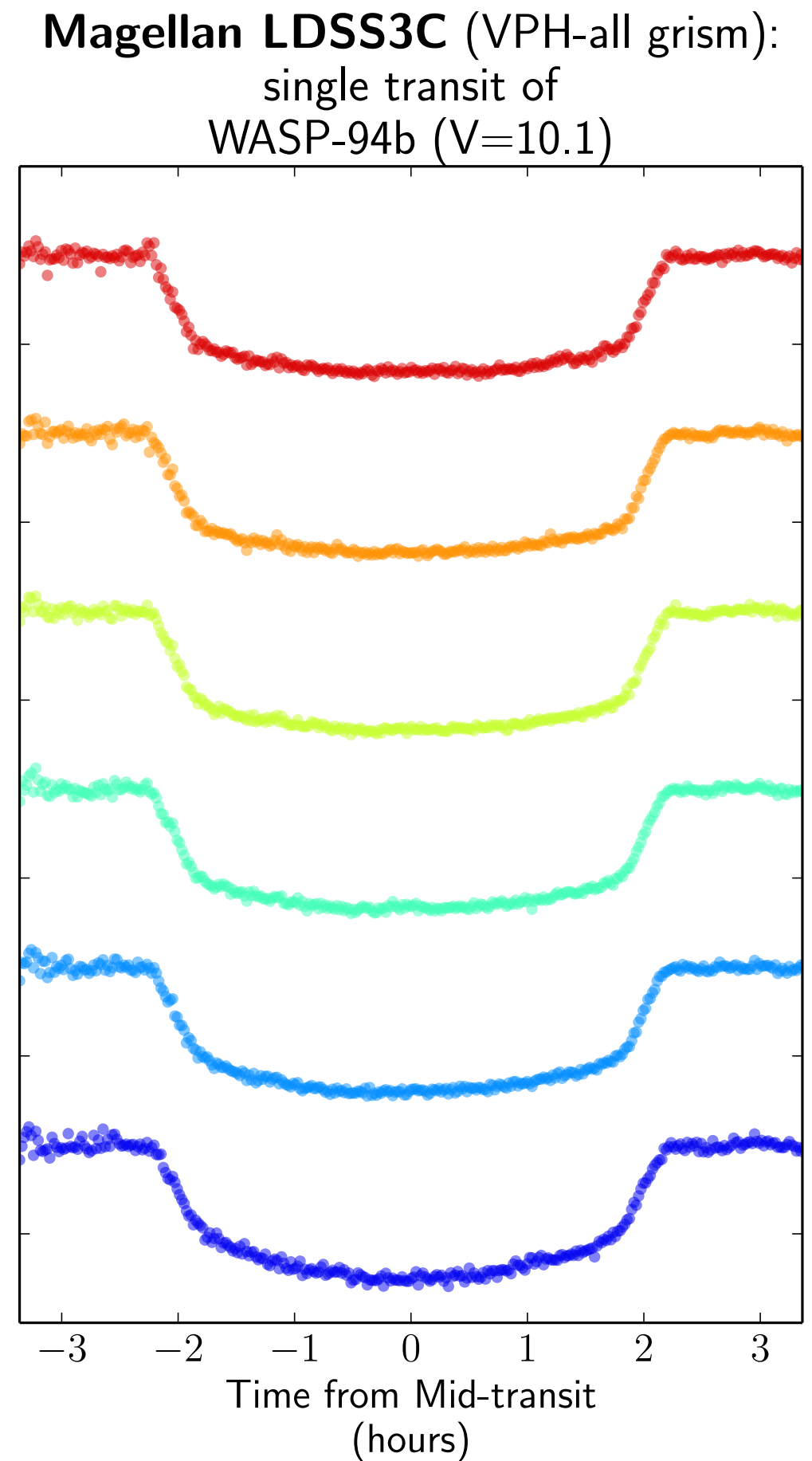
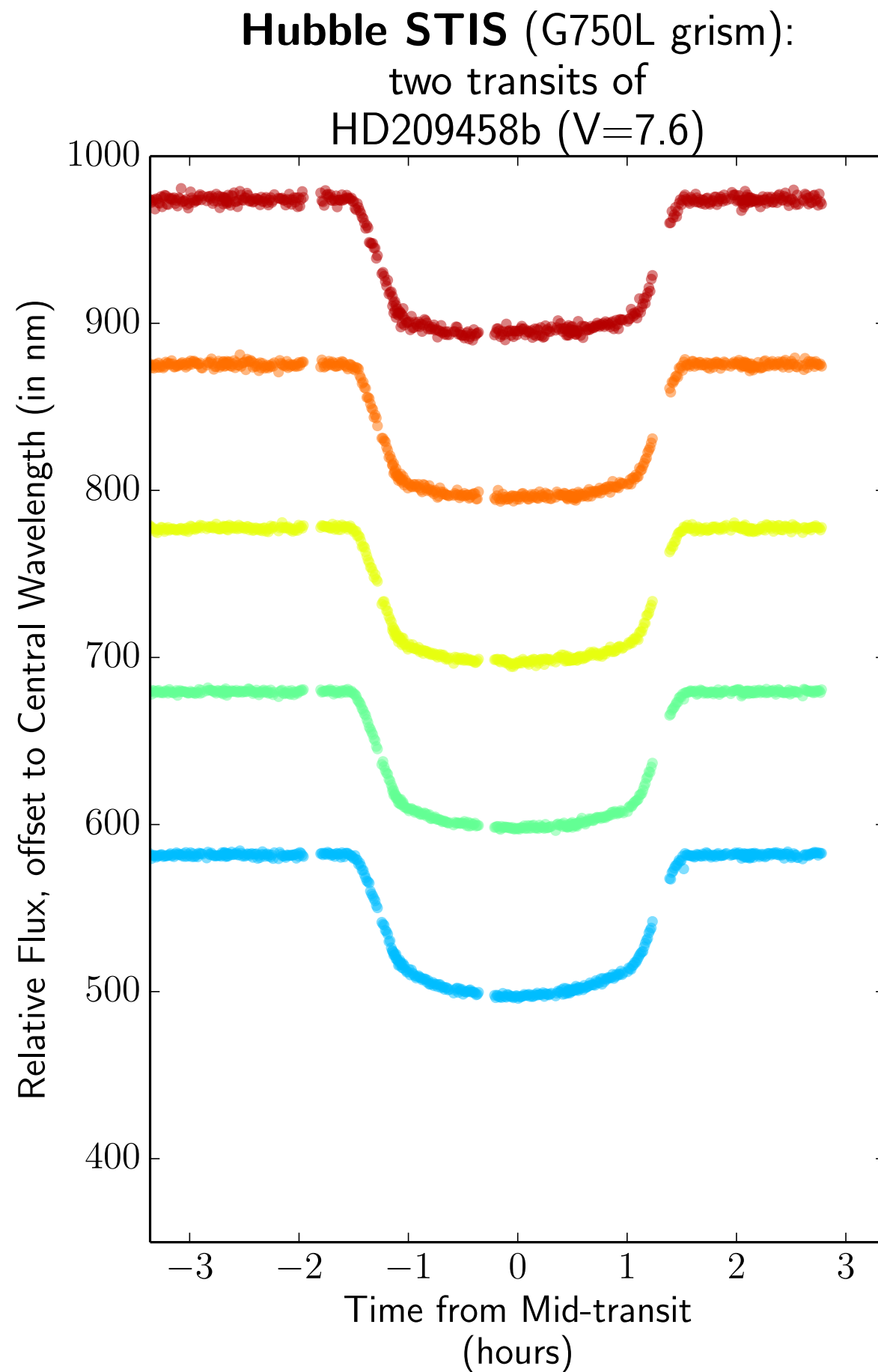
# WASP94Ab

$V=10.1$



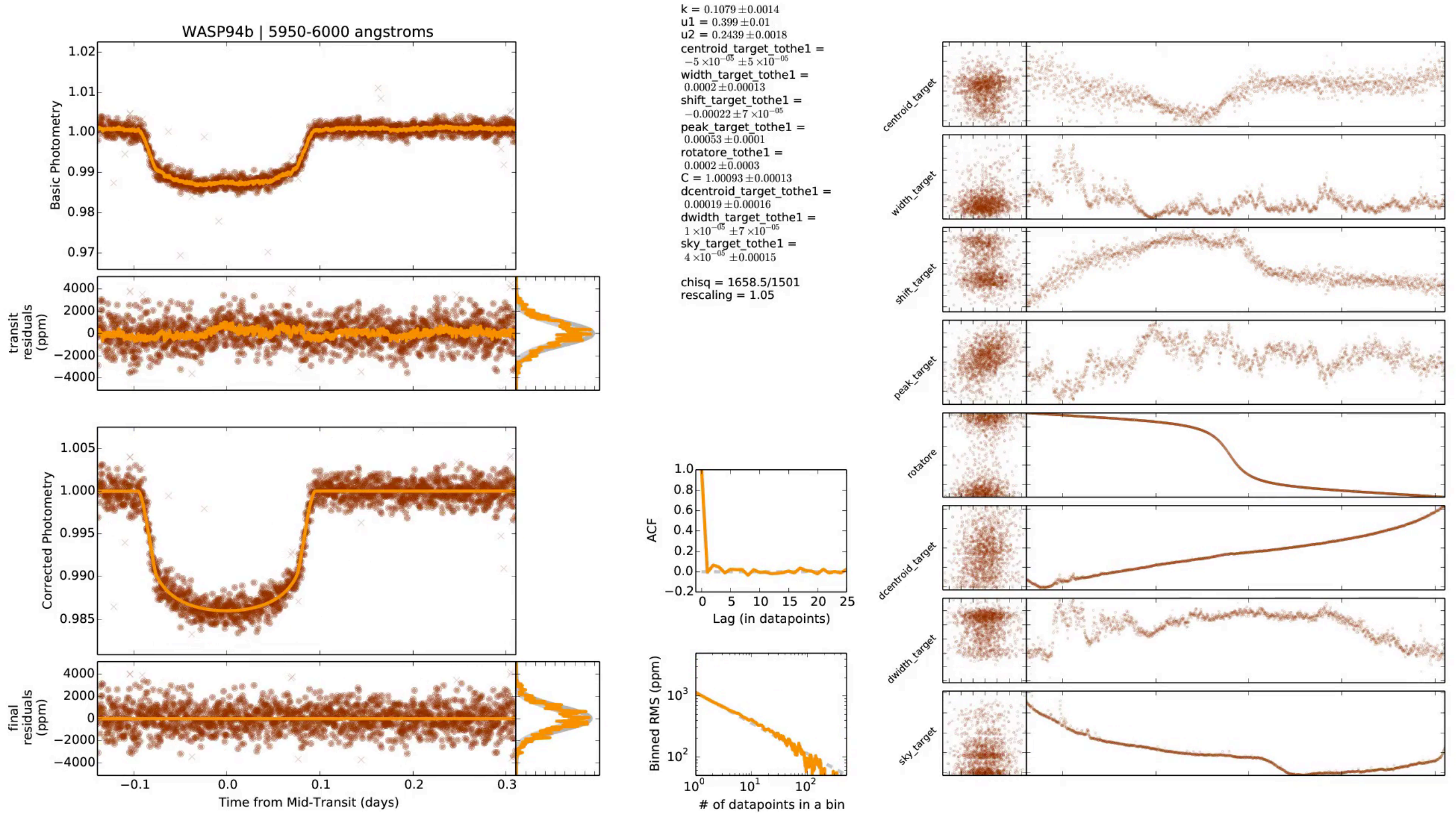
convenient to observe  
from the ground





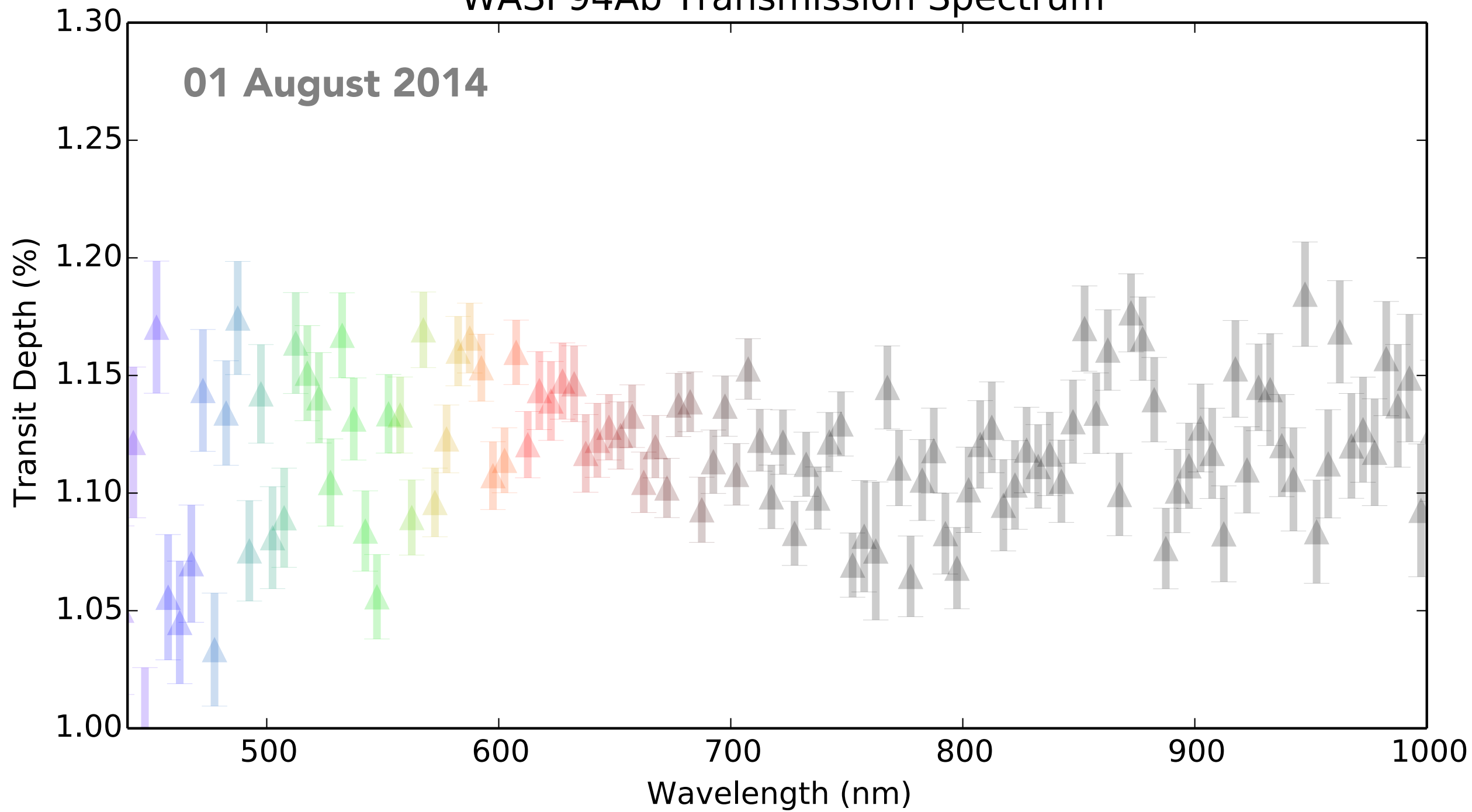
# WASP94Ab with Magellan LDSS3C

1mmag spectrophotometry, covering 450-1000nm at R=150 (5nm bins)



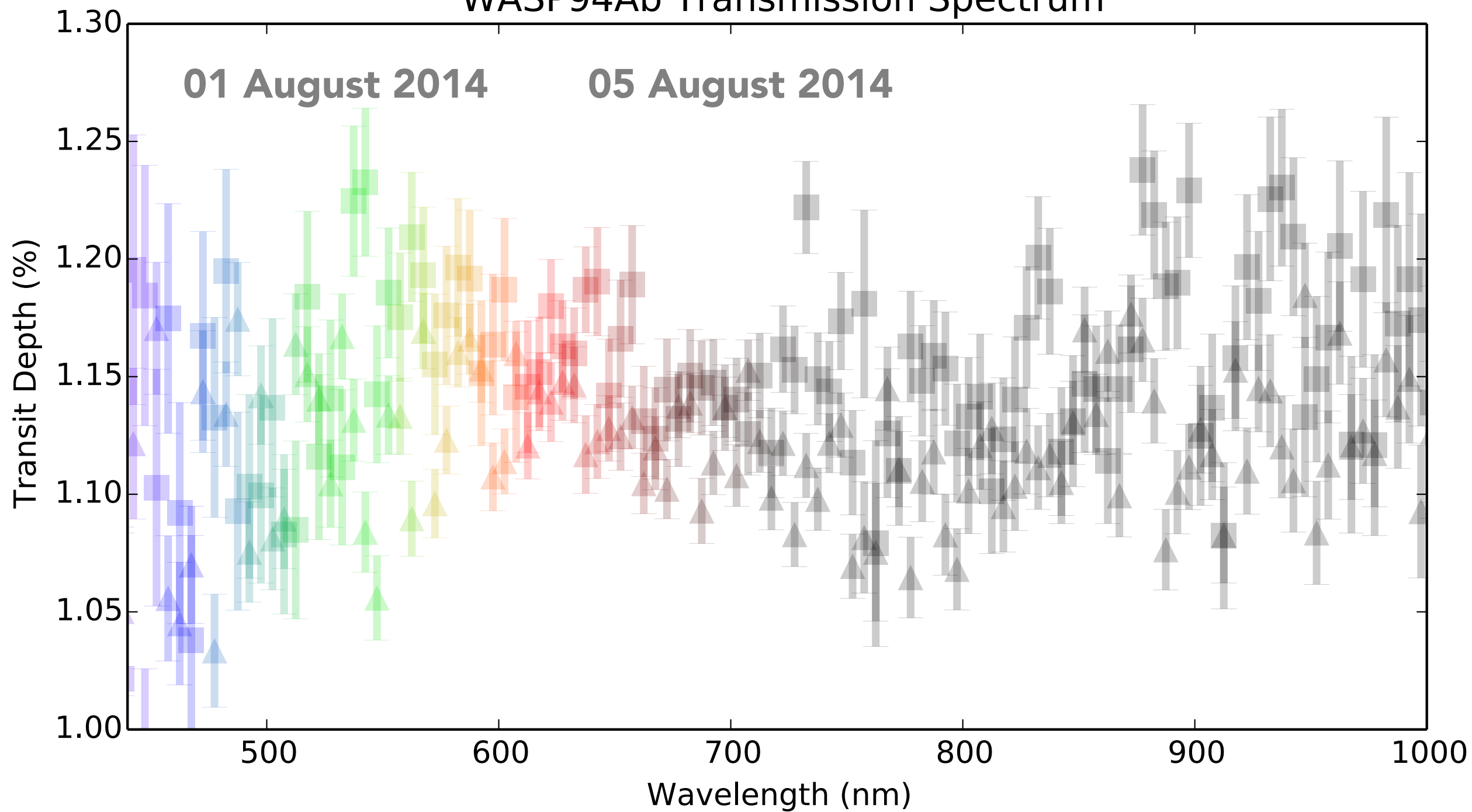
# WASP94Ab Transmission Spectrum

01 August 2014

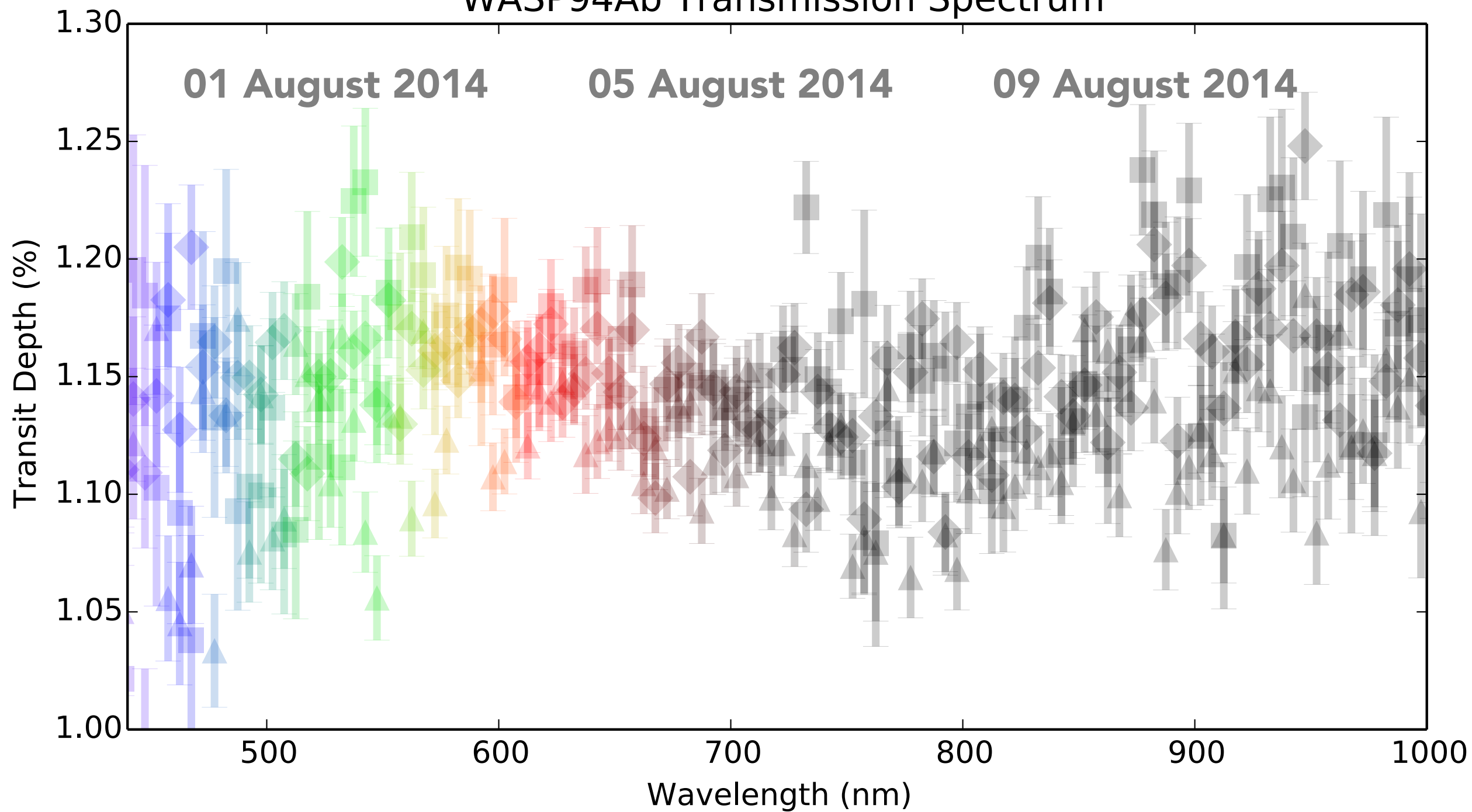




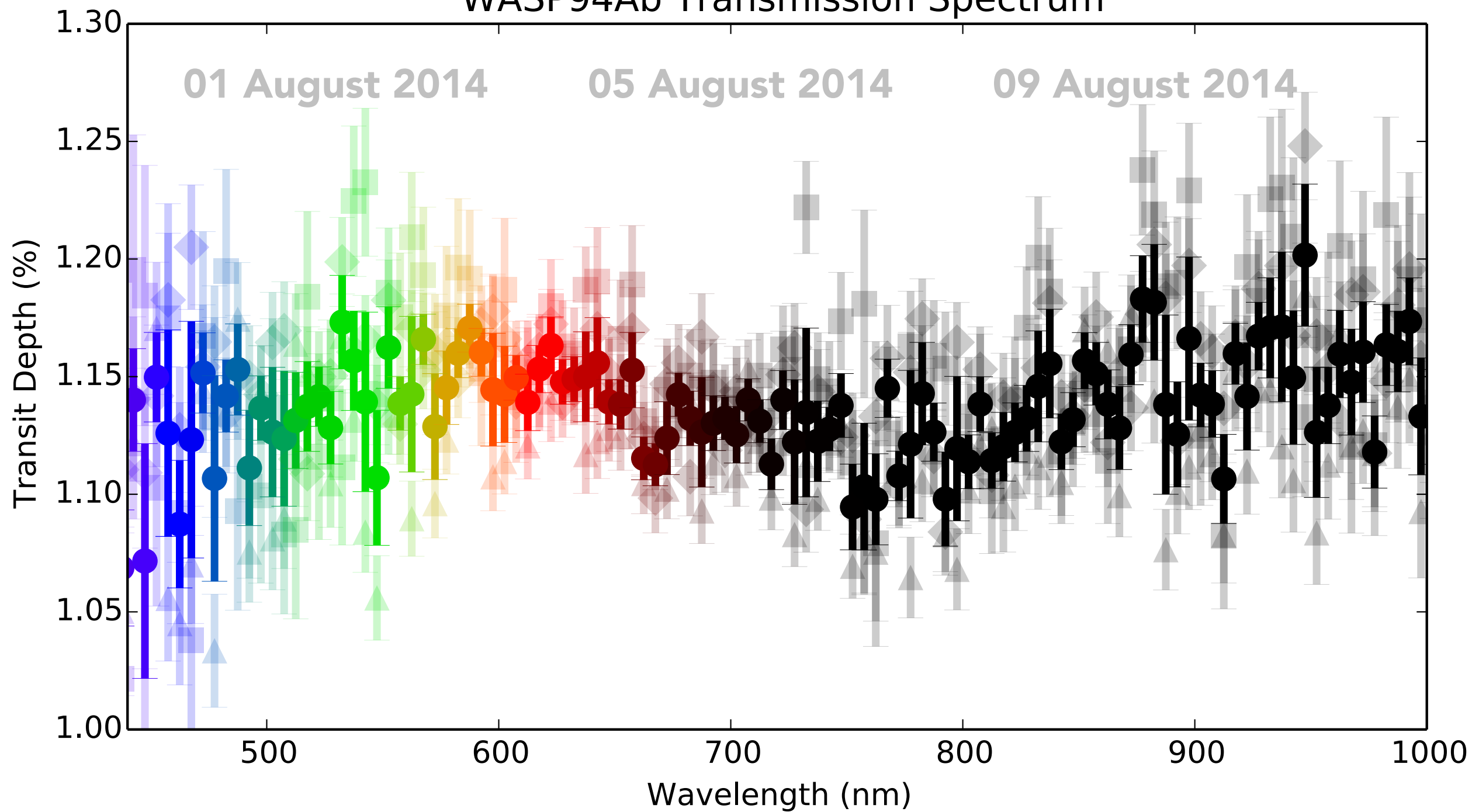
# WASP94Ab Transmission Spectrum



# WASP94Ab Transmission Spectrum

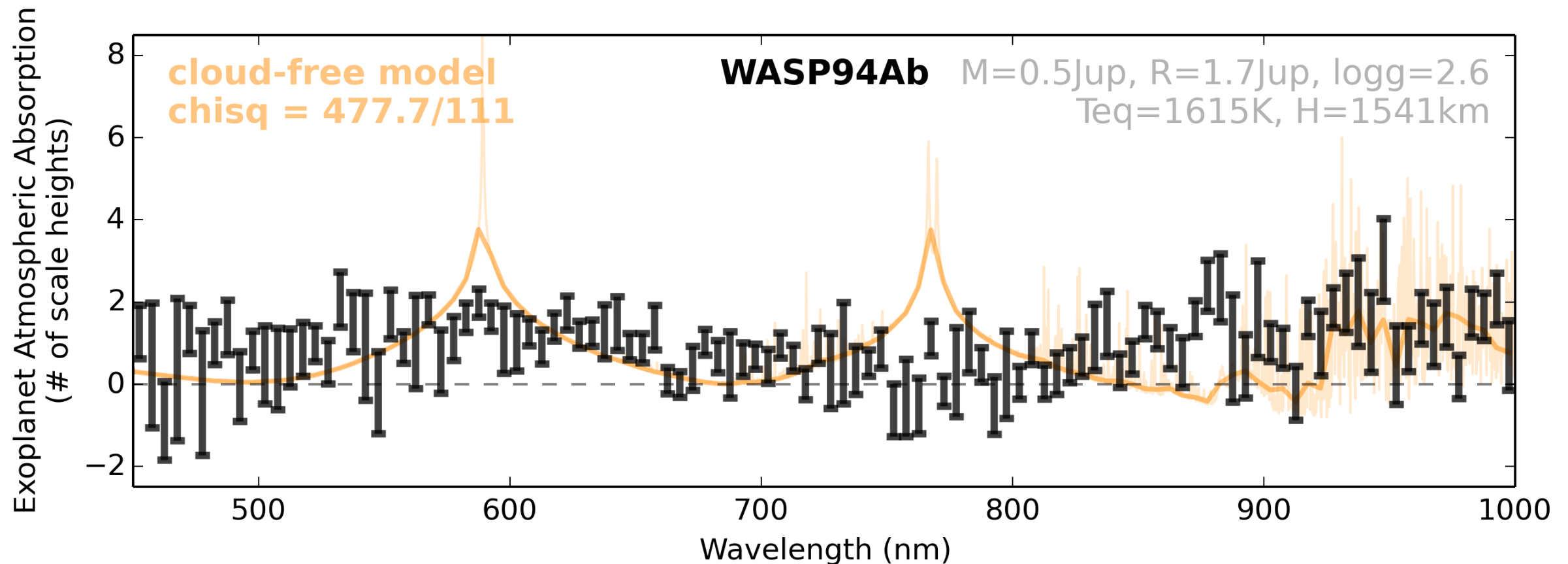


# WASP94Ab Transmission Spectrum



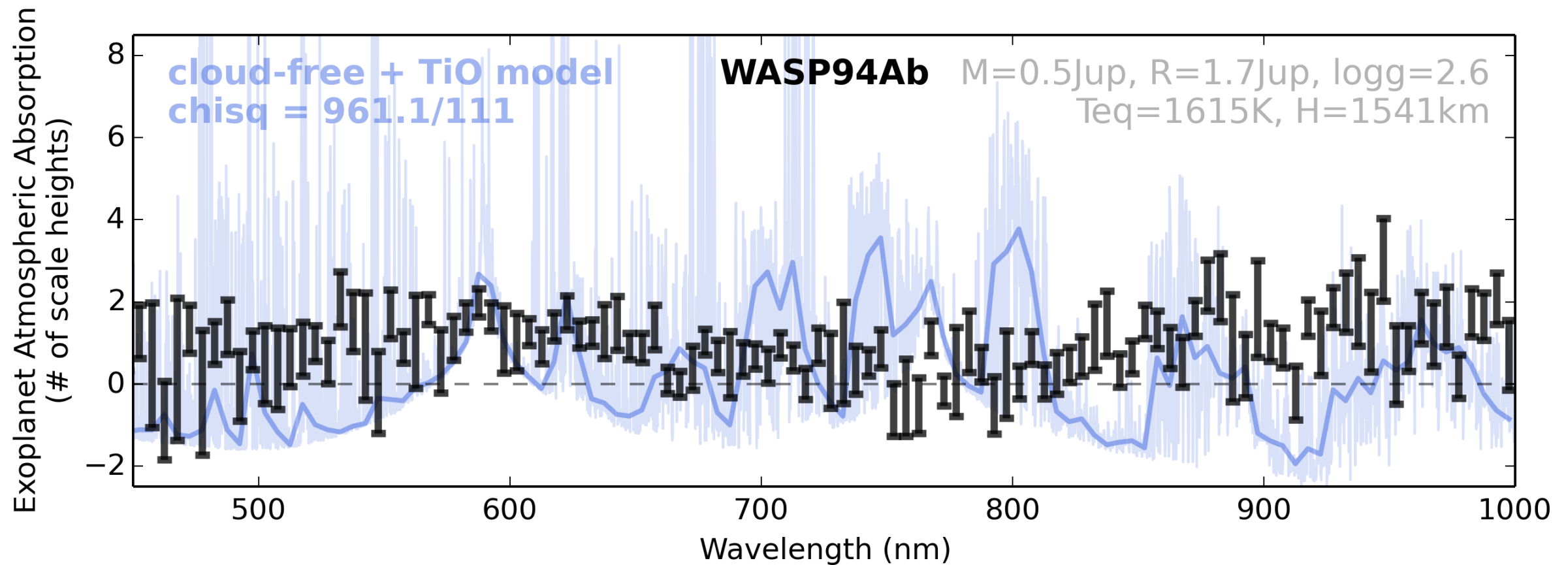


# WASP94Ab does not have a cloud-free, alkali-dominated atmosphere



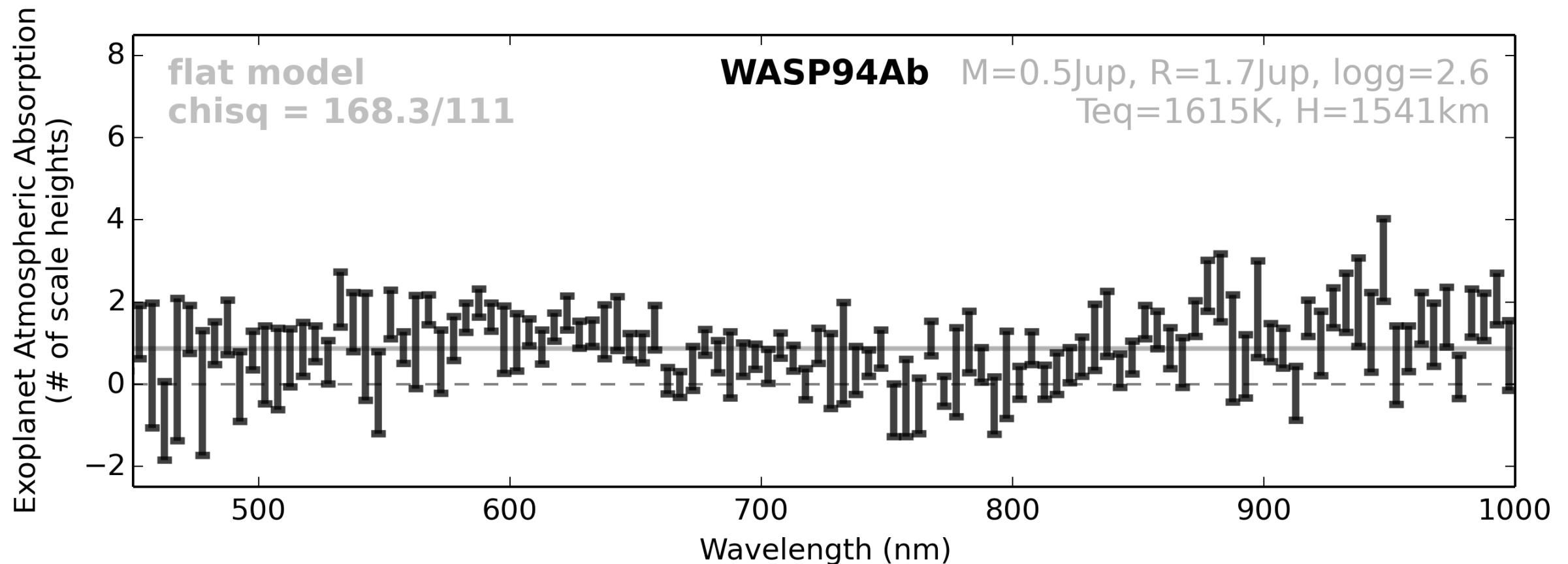
**$>10\sigma$   
excluded**

# WASP94Ab does not have cloud-free, TiO/VO-enriched atmosphere



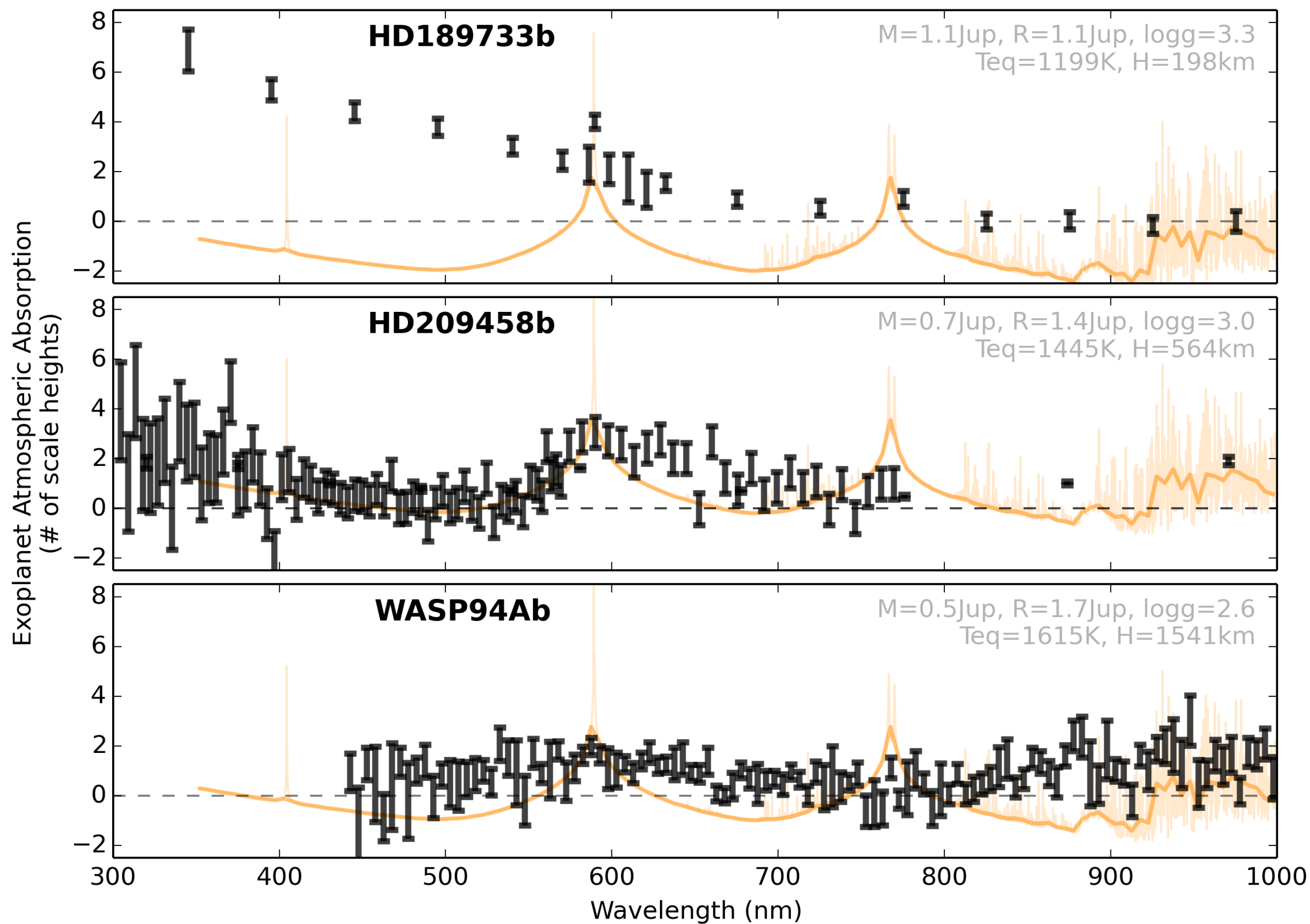
$>10\sigma$   
excluded

# WASP94Ab does not have strong features in its transmission spectrum



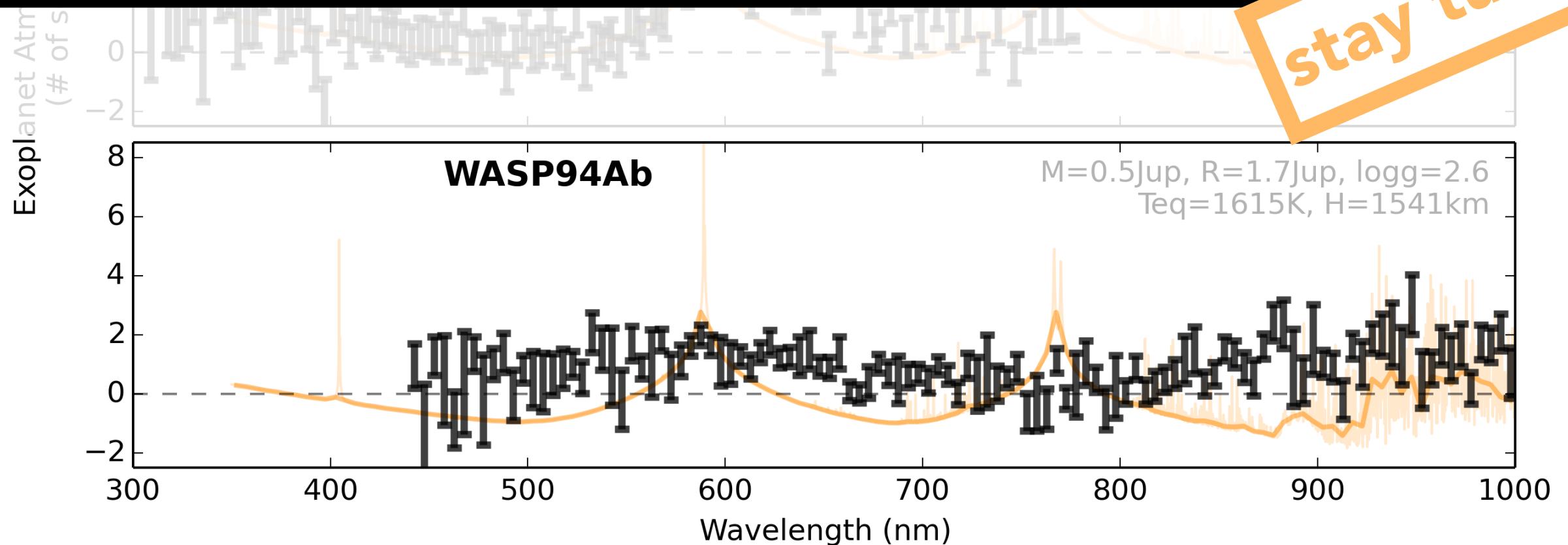
within  
 $3.6\sigma$  of  
flat

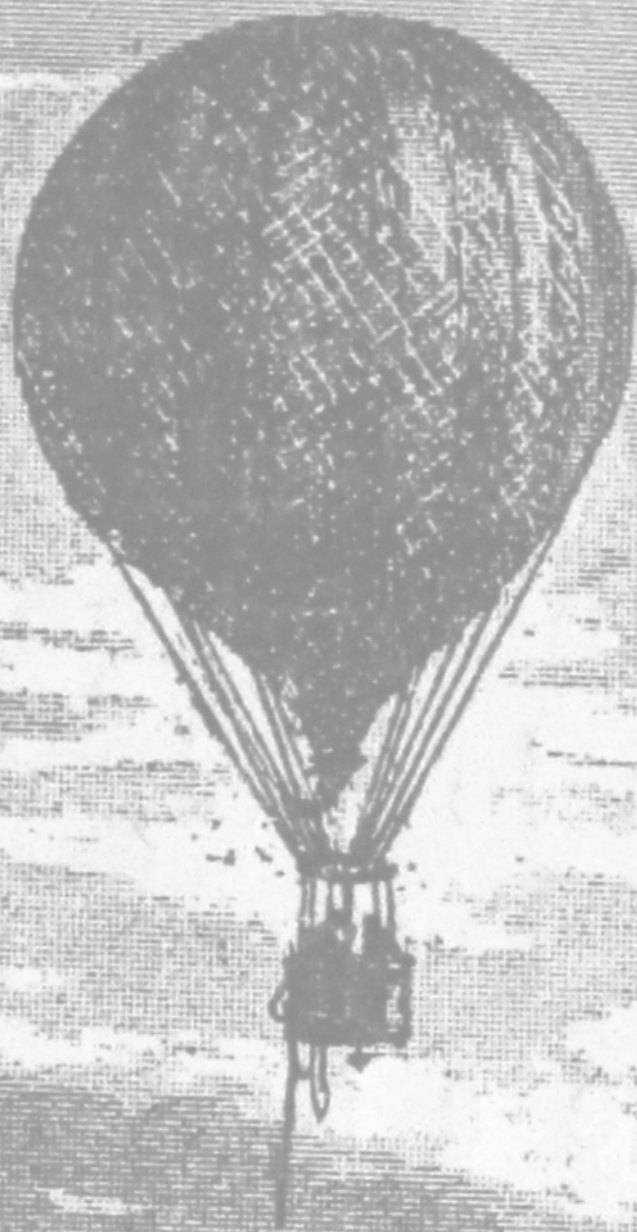




The transmission spectrum of WASP94Ab is flatter than both HD189 and HD209 (thick clouds? ionized Na? abundances?) but not *completely* flat.

stay tuned!

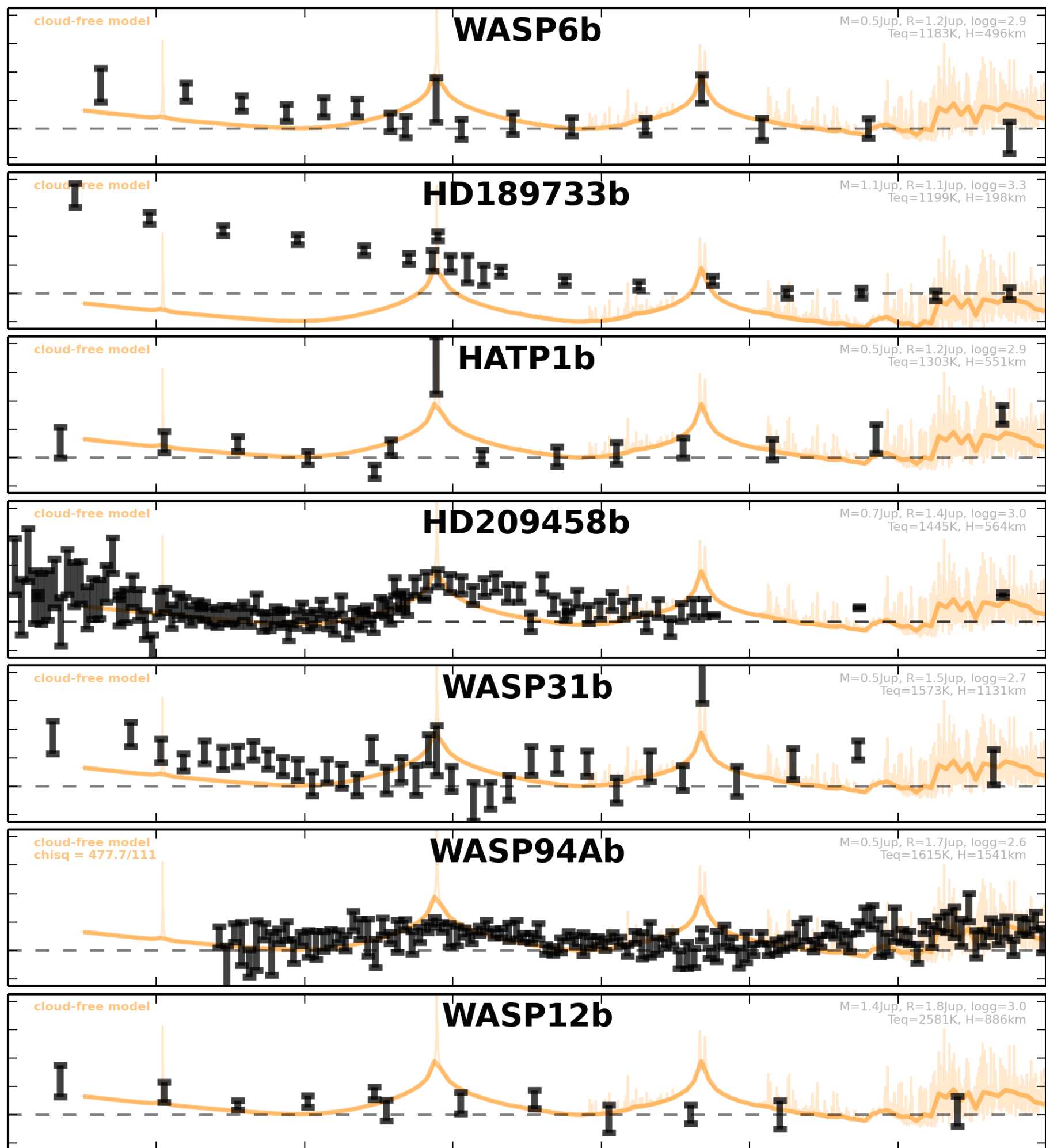




# Conclusions:

- **WASP94Ab has a mostly flat transmission spectrum.**
- **Optical ground-based spectrophotometry can be a robust tool, at least for particular targets.**





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/Users/zkbt/Cosmos/Data/Magellan/LDSS3\_2014B/working/WASP94b\_ut140805/stitched/

image 287, star 0

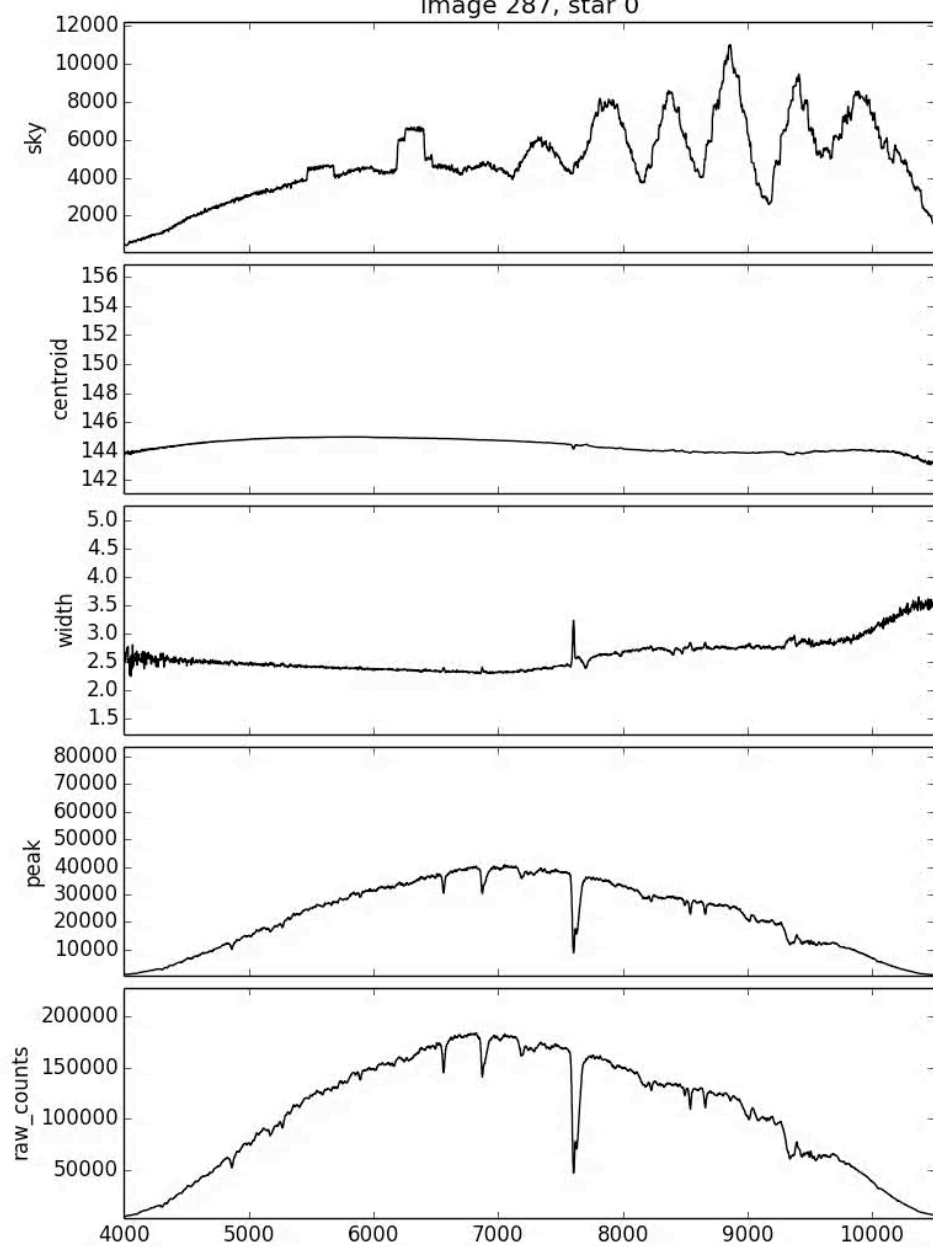
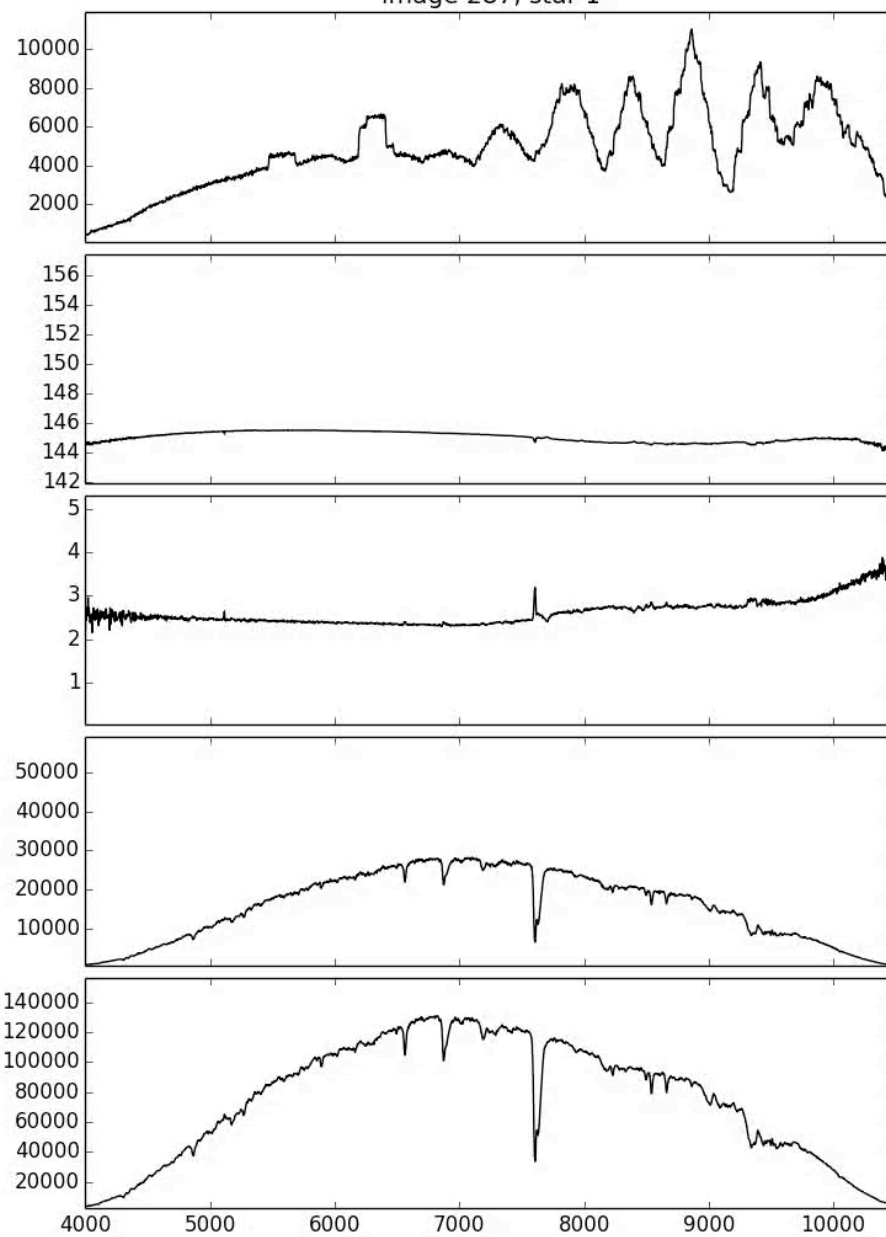
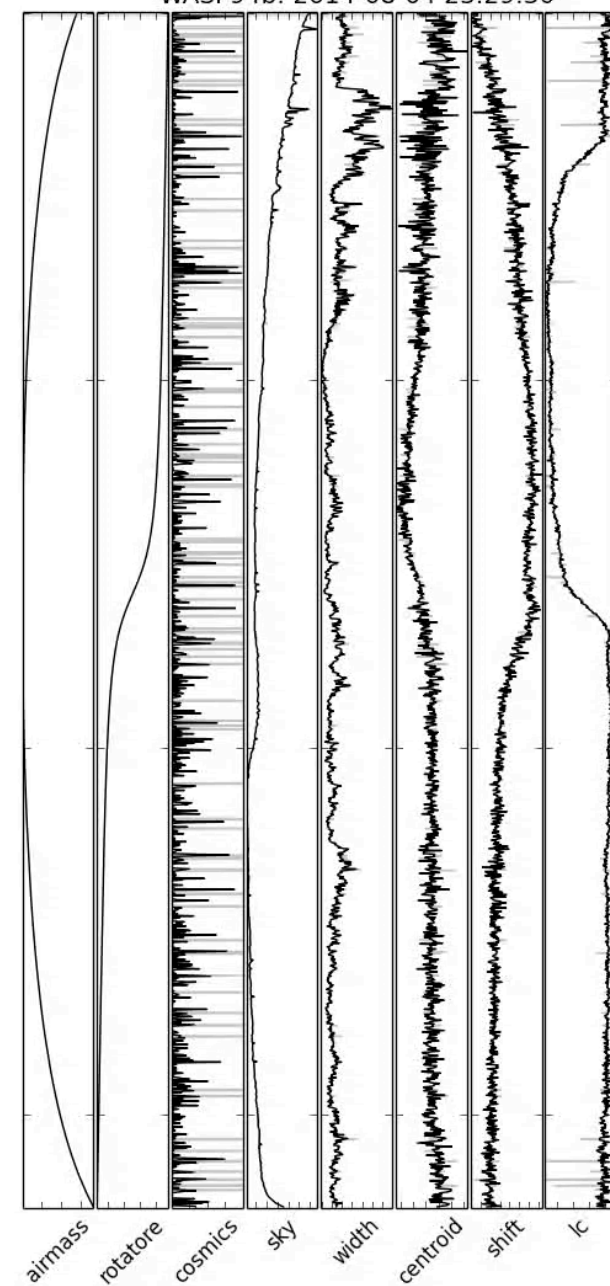


image 287, star 1



WASP94b: 2014-08-04 23:29:30





Stellar Limb-Darkening Profile  
T=6200, logg=4.5, Z=0.0  
4000-4050 angstrom

