

# Repeatability and reliability of IRAC exoplanet light curves

How do we reach consensus on results?

Discussion on how we can come to a consensus on the issues of repeatability and reliability of IRAC exoplanet and BD light curves



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# Repeatability and Variability

- Repeatability and accuracy: it's one thing to be repeatable, but we also want to be accurate!
- Degree of repeatability (precision), timescales of variability (is the photometry stable over multiple years?).
- Three different “variabilities” (with 3 examples):
  - 1) Improvement of analyzing method over time (e.g., PD Deming et al. 2014, Diamond-lowe et al., 2014)
  - 2) Instrumental/observational variabilities, that can also vary over time (e.g, PCR-peakup); building-up confidence in time (analysis, but also complementary observations).
  - 3) Astrophysical variabilities.
    - Stellar variability: Transits (and phase curves) are more affected than eclipses
    - Planet's atmospheric variability: difficult to assess, but we can have some clues from complementary observations

# New Analysis Indicates No Thermal Inversion in the Atmosphere of HD 209458b

(Diamond-Lowe et al. 2014)

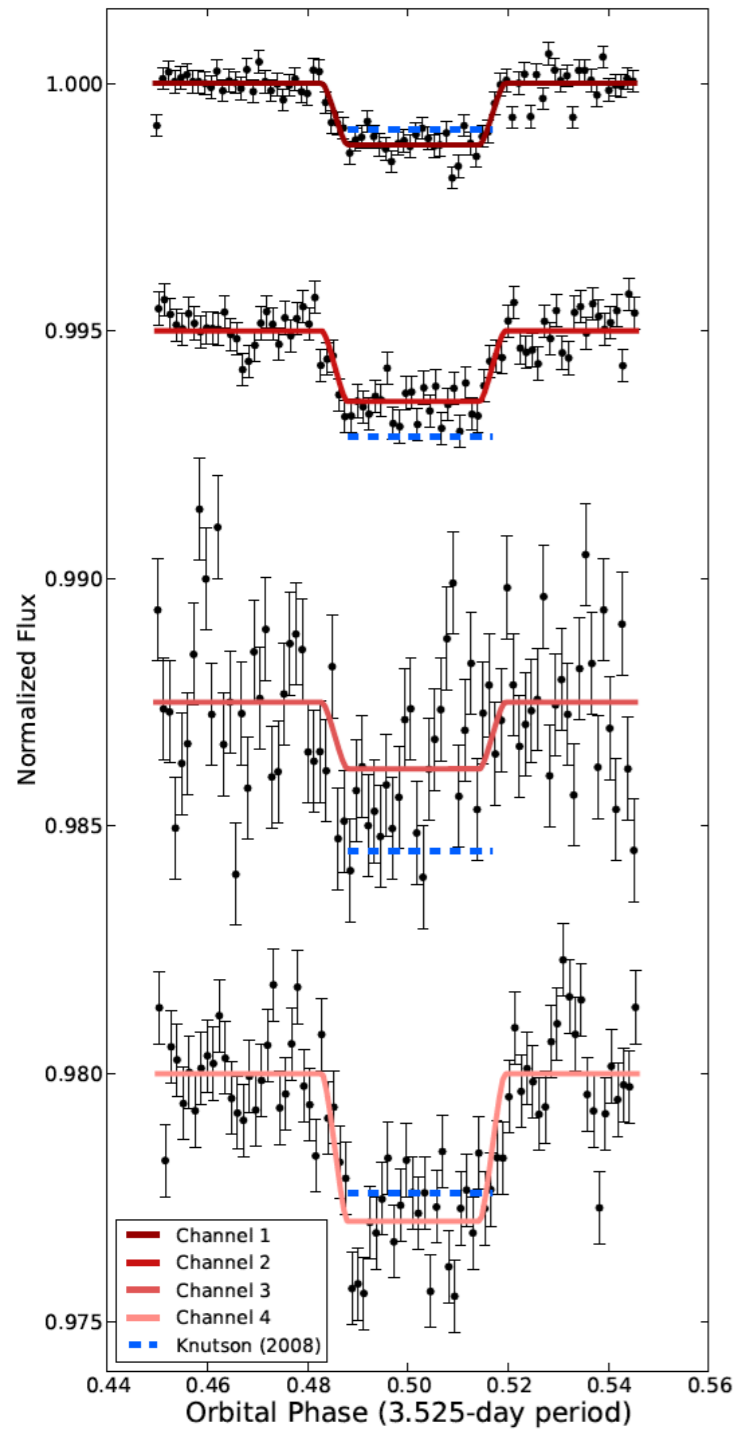


FIG. 1.— Light curves rendered from all bandpass data captured in 2005. Black points are binned data with  $1\sigma$  error bars, normalized to the system flux, and offset for ease of comparison. Colored lines in shades of red represent best fit light curves. Dashed blue lines represent eclipse depths quoted by [Knutson et al. \(2008\)](#).

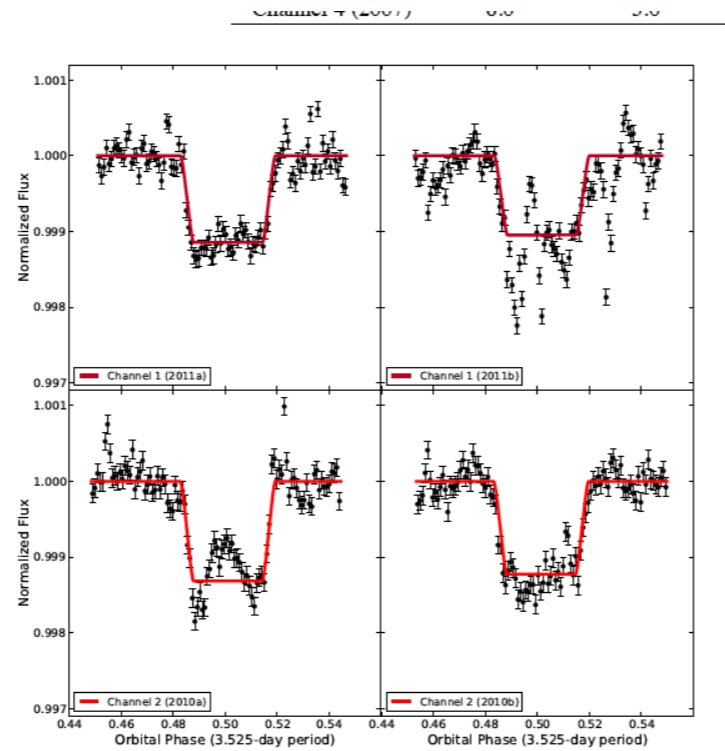
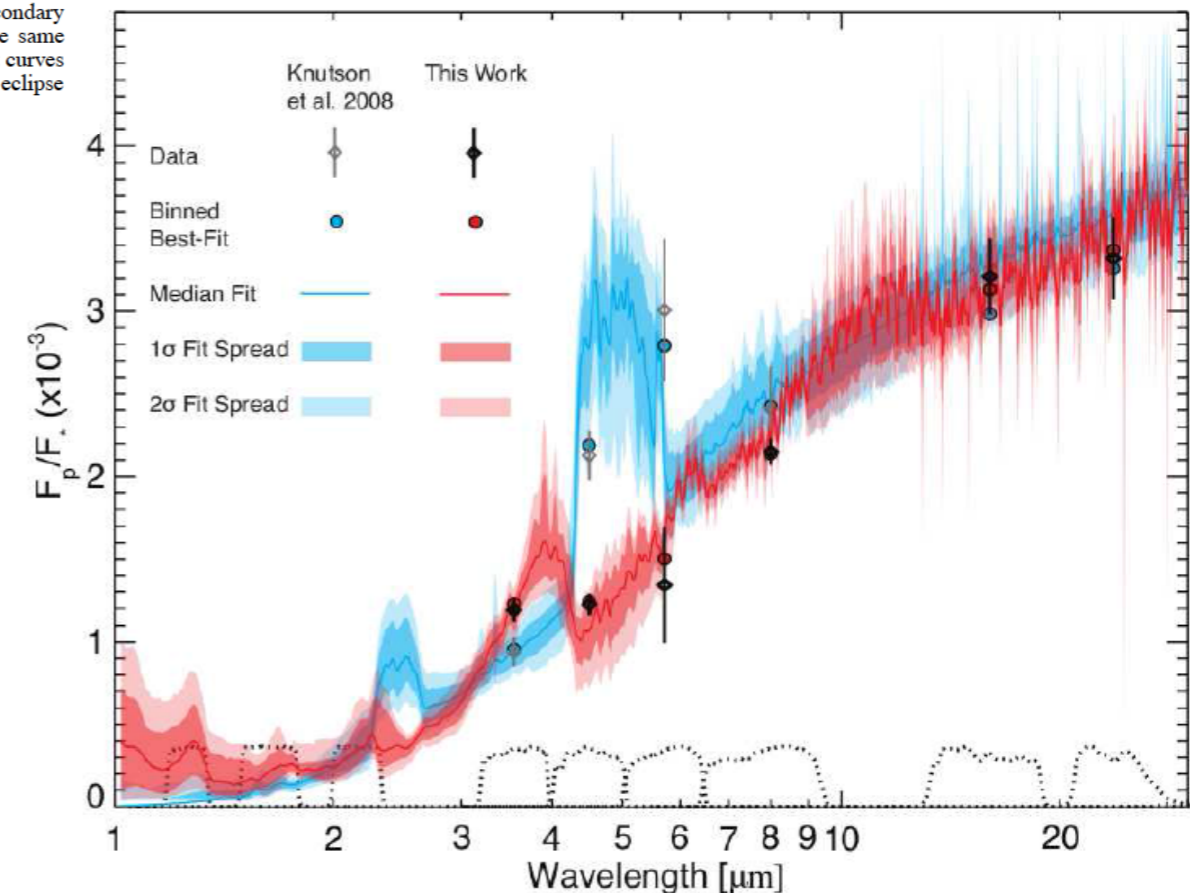


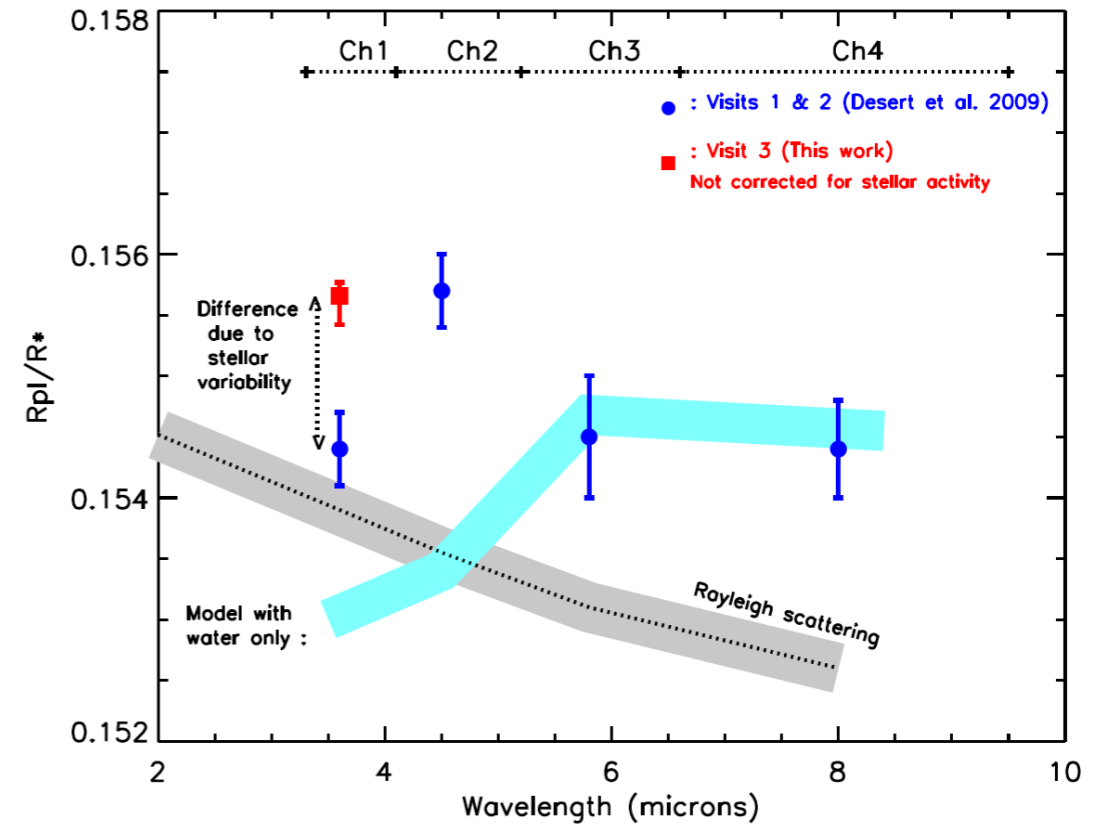
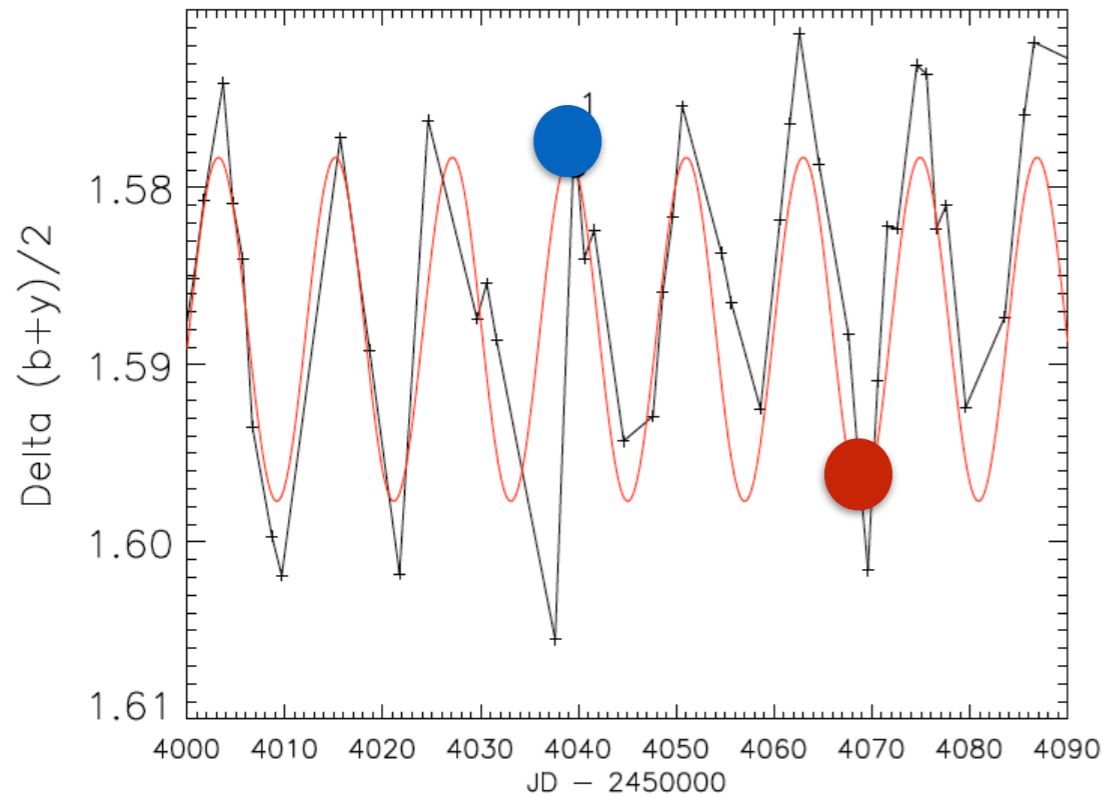
FIG. 3.— Light curves rendered from the Channel 1 (2011a), Channel 1 (2011b), Channel 2 (2010a), and Channel 2 (2010b) datasets. The secondary eclipses in each bandpass are consecutive and were obtained by the same *Spitzer* program. The Channel 1 (2011b) and Channel 2 (2010a) light curves exhibit abundant time-correlated red noise and we do not include the eclipse depths measured from these light curves in our atmospheric retrieval.

New analysis method to re-analyze old datasets previously published



# Correcting for Stellar Variability: Standard Procedure

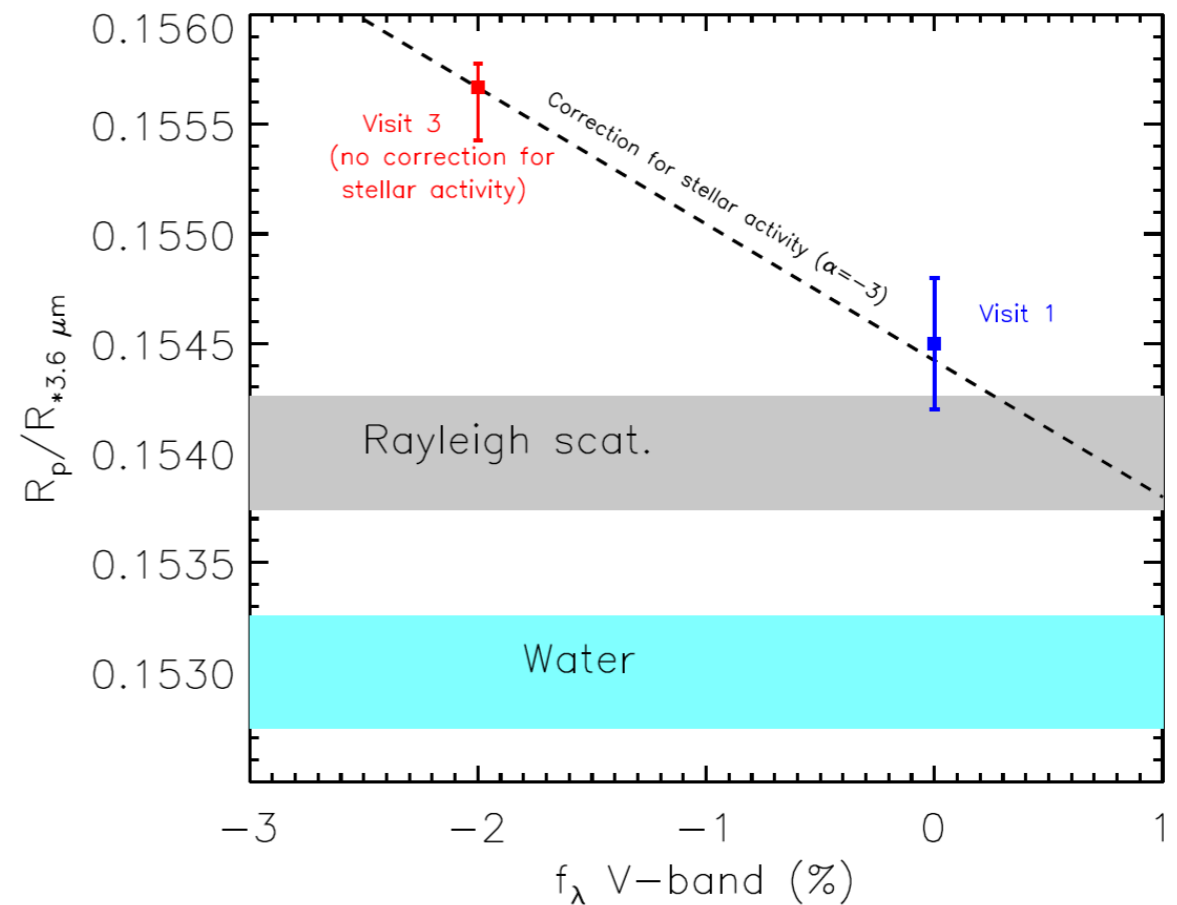
The case of HD189733b  
(Desert et al. 2011b)



$$\frac{\Delta(R_p/R_\star)}{(R_p/R_\star)_{True}} \approx \frac{\alpha f_\lambda}{2}$$

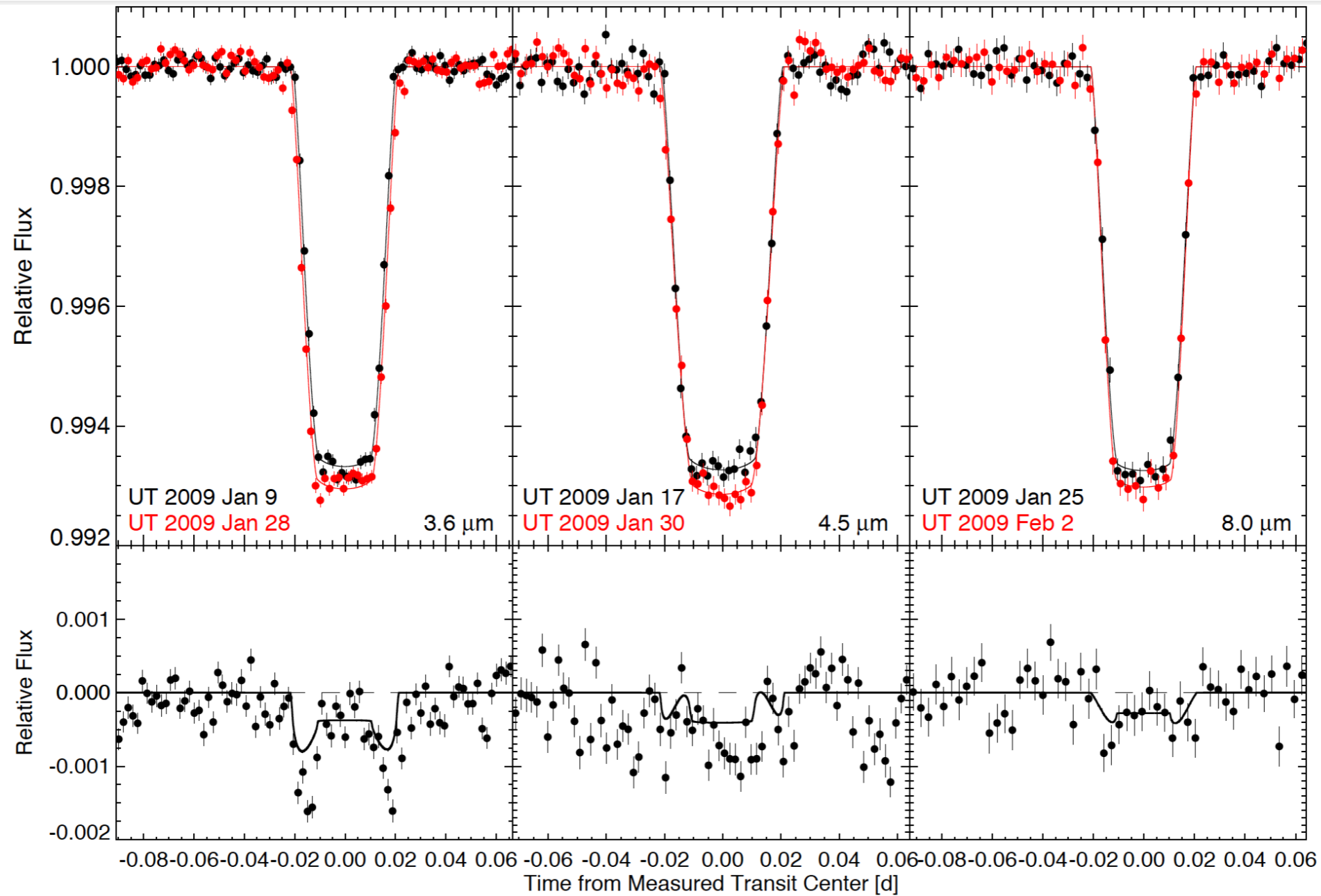
With the hypothesis that the stellar surface brightness outside the spot areas is not modified by the stellar activity, we obtained  $\alpha = -1$ .

See also: e.g., Sing et al. 2011, Berta et al. 2012



# Planetary or Stellar variability

## The case of GJ436b



Knutson et al., 2012

# Discussions

- Is the photometry stable over multiple year timescales? Can we really use one method to analyze data back in time (e.g., Pixel Level Decorrelation: Deming et al. 2014)
- IRAC pipelines are sensitive to number of parameters that need to be adjusted: the same pipeline for data taken at different epoch may not give always the most accurate results
- e.g., centroiding with 2D Gaussian fit, flux weighting, least asymmetry provide different performances for different datasets ...and for different observers.
- Some groups often publishes several results for the various methods. Shall we present all the results?