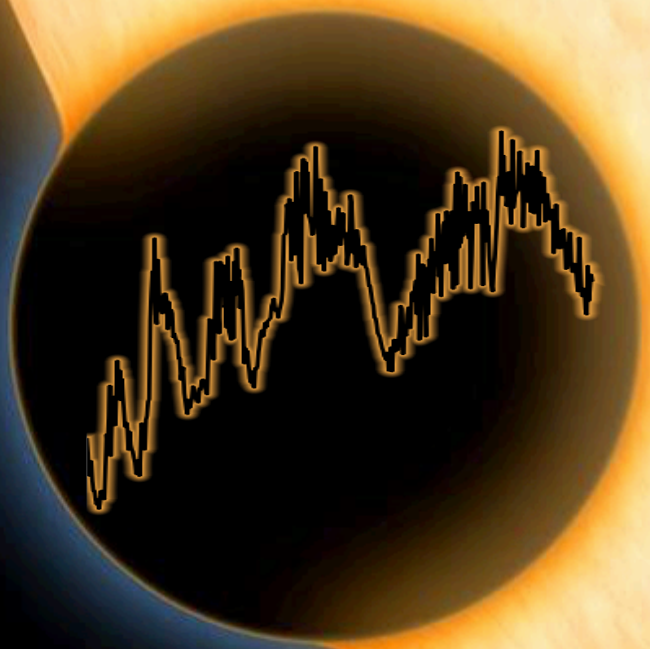
UCL

Atmospheric composition of transiting extrasolar planets

with HST/WFC3 spatial scanning



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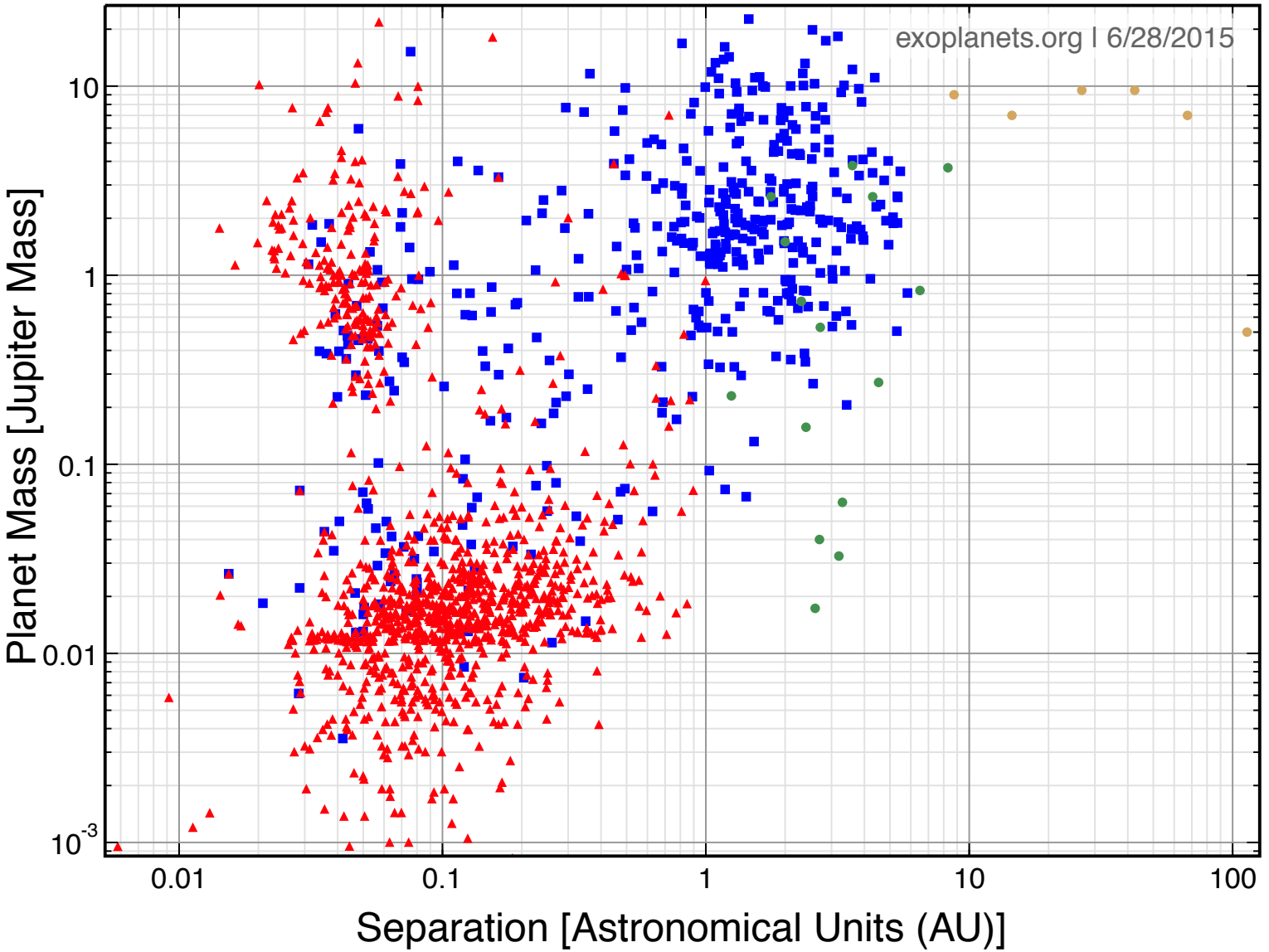
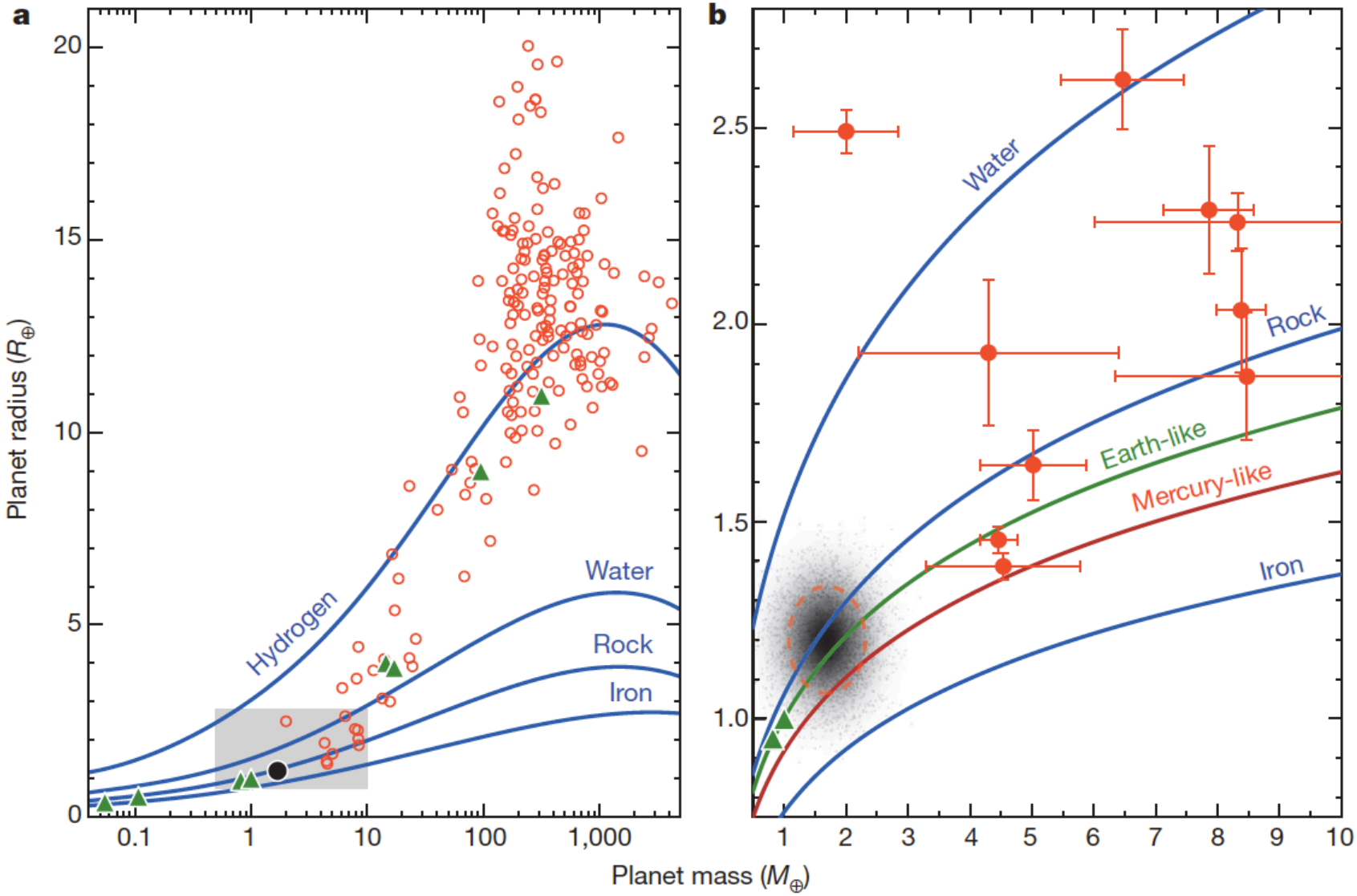
12th Hellenic Astronomical Conference

Thessaloniki, 2nd July 2015

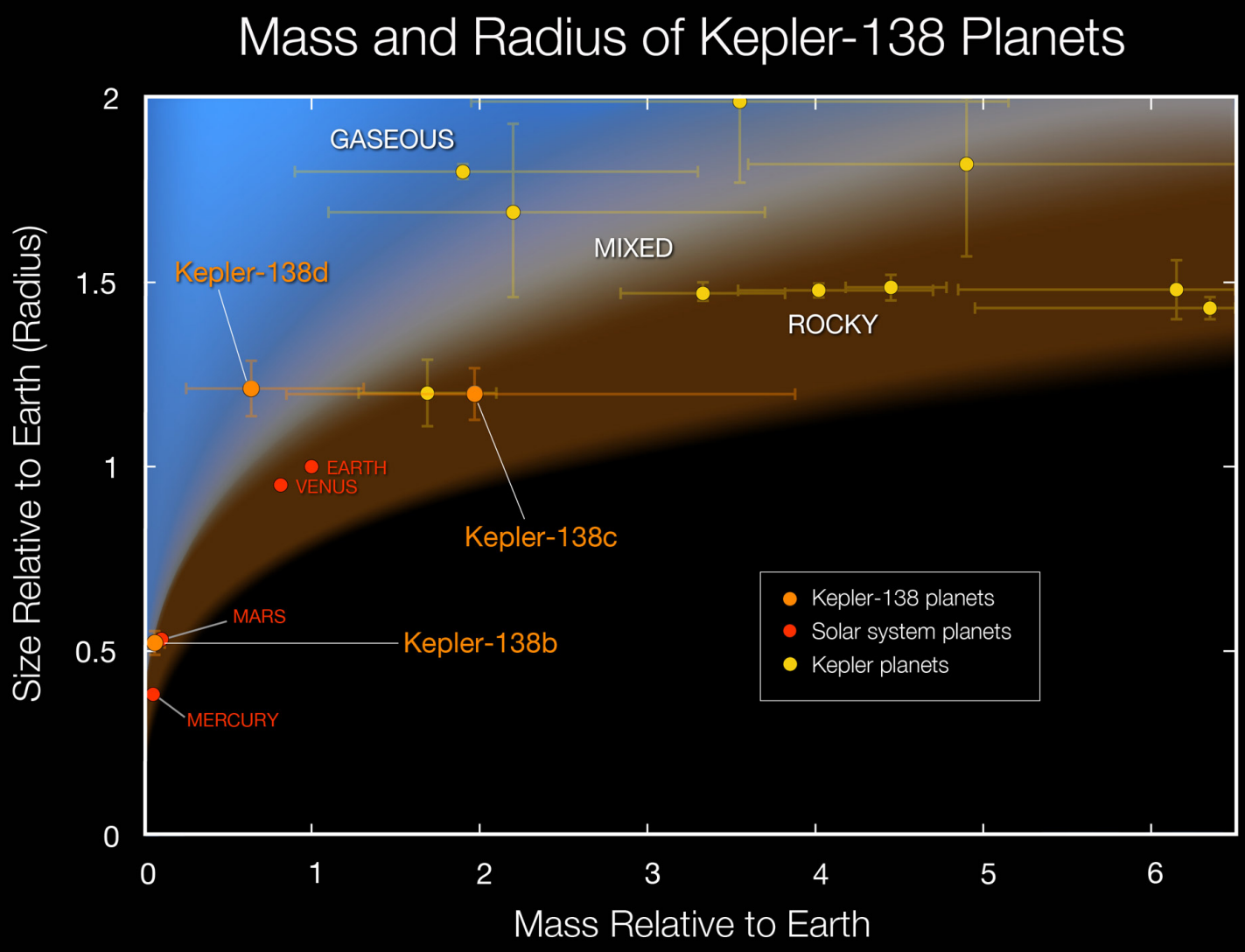
Detection overview



Composition

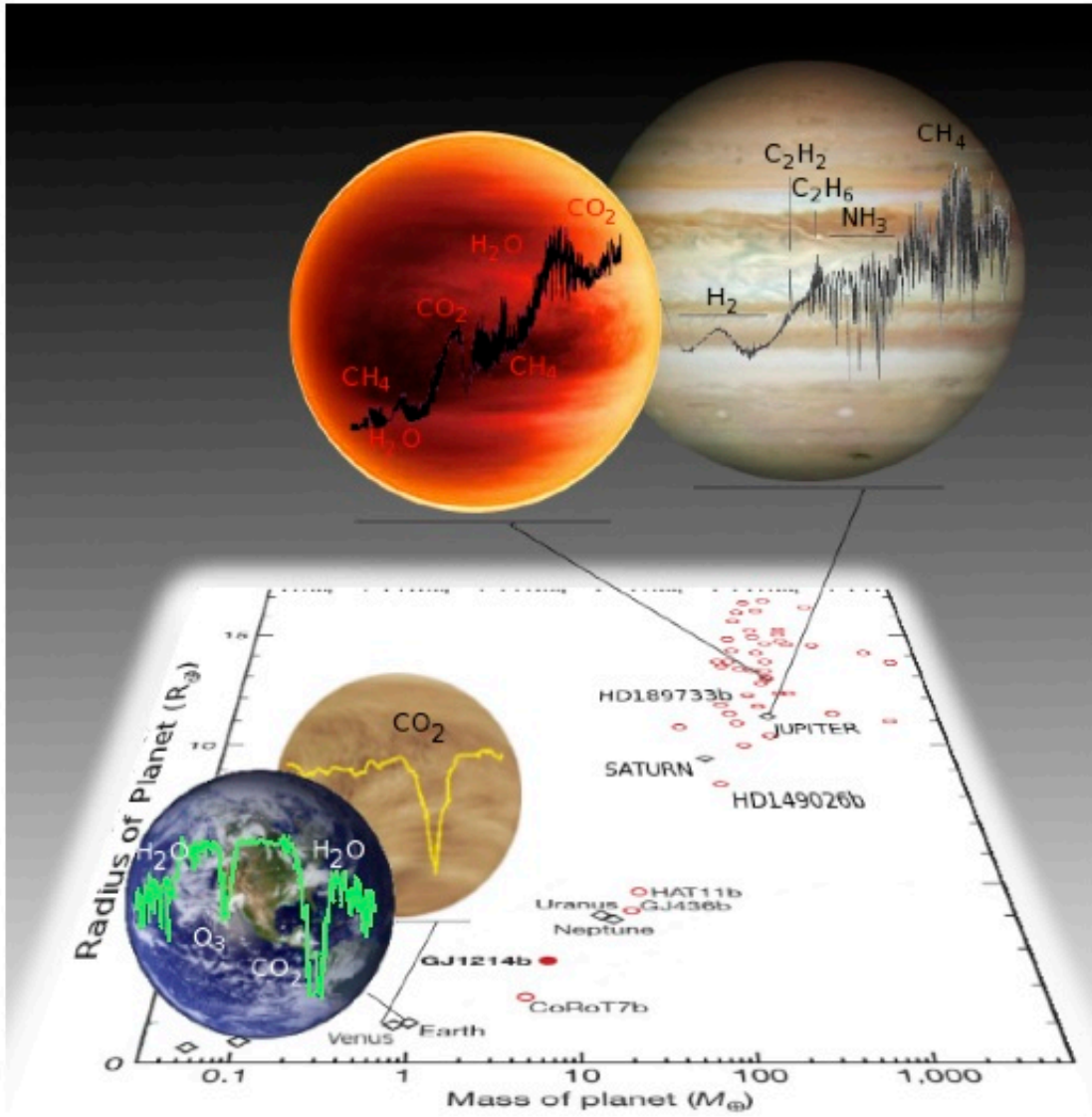


Composition

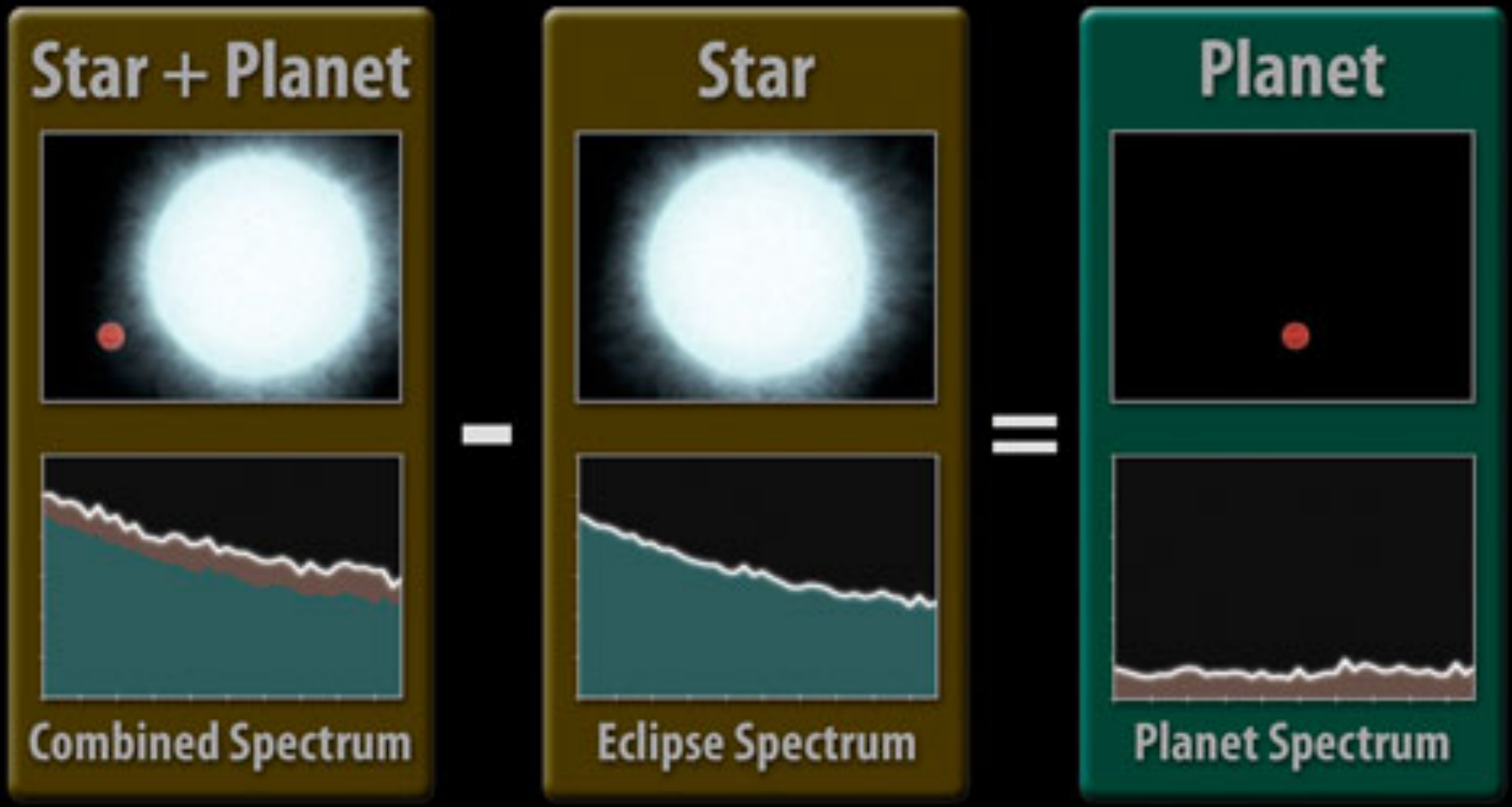


Conditions on exoplanets

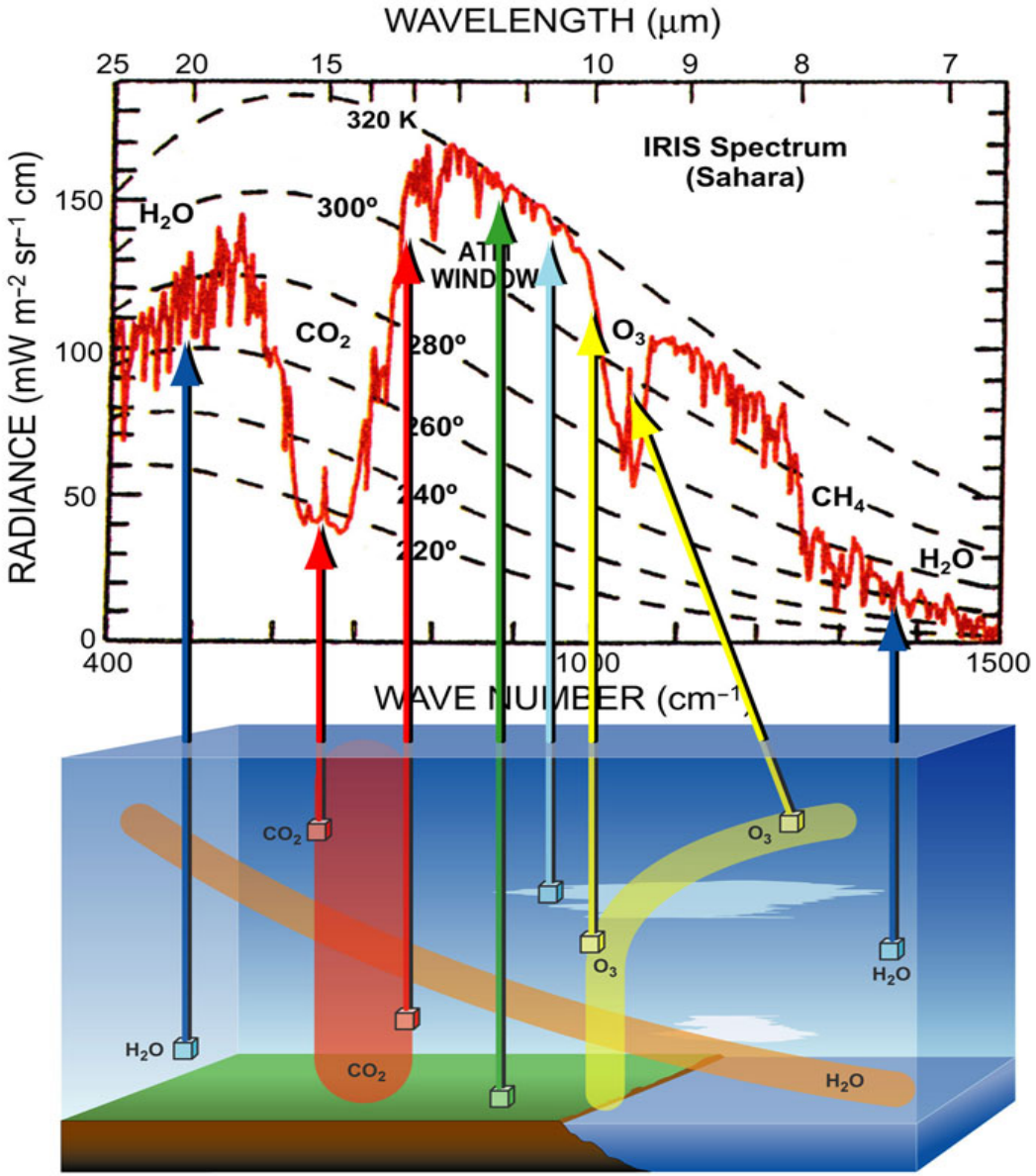
- Density alone does not fully characterise a planet.
- Atmosphere is the one, key component, that affects mostly the conditions on a planet (Earth - Venus).
- We need spectroscopy of to constrain molecular abundances in the exoplanetary atmospheres.



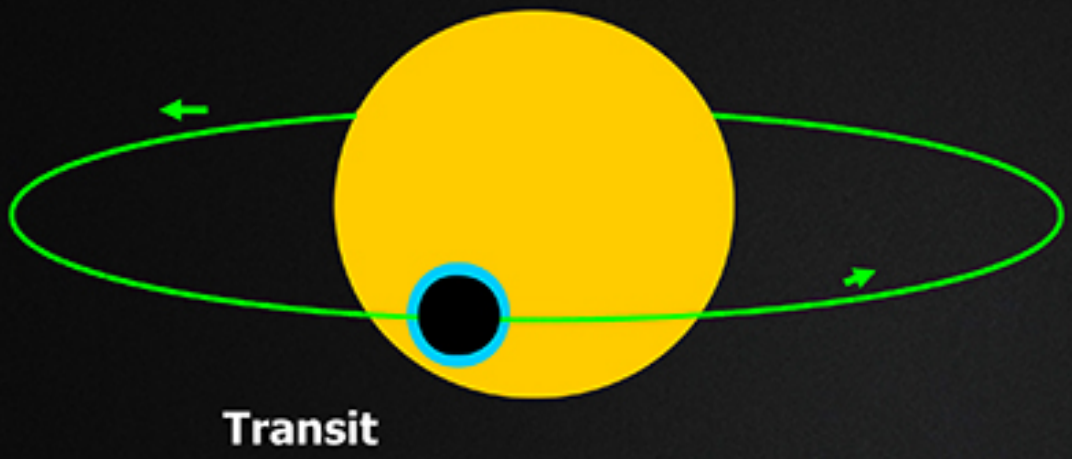
Emission spectrum



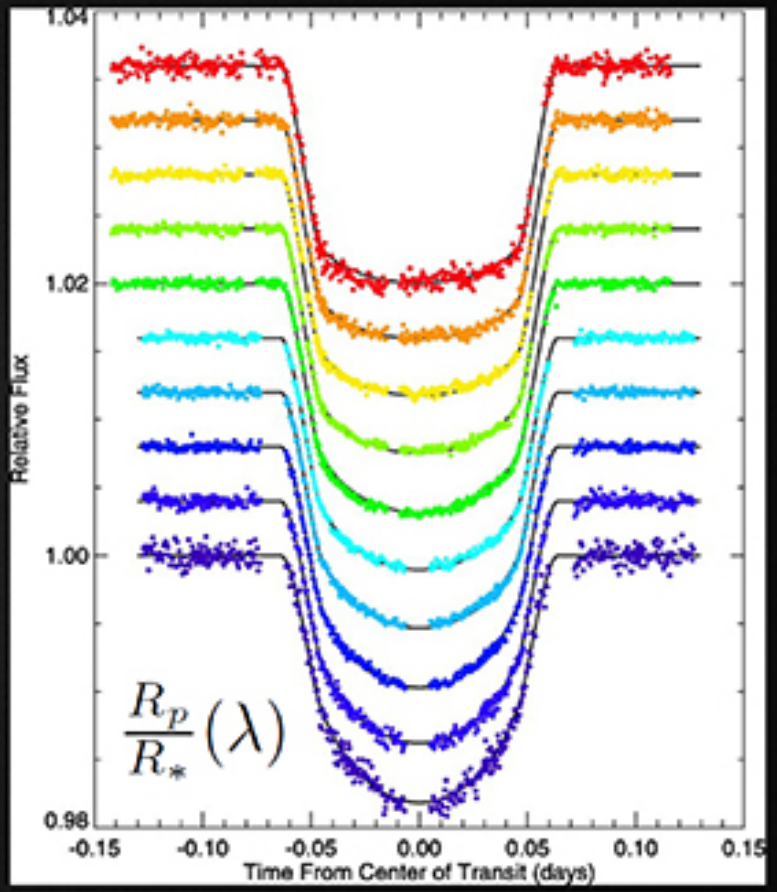
Emission spectrum



Transmission spectrum

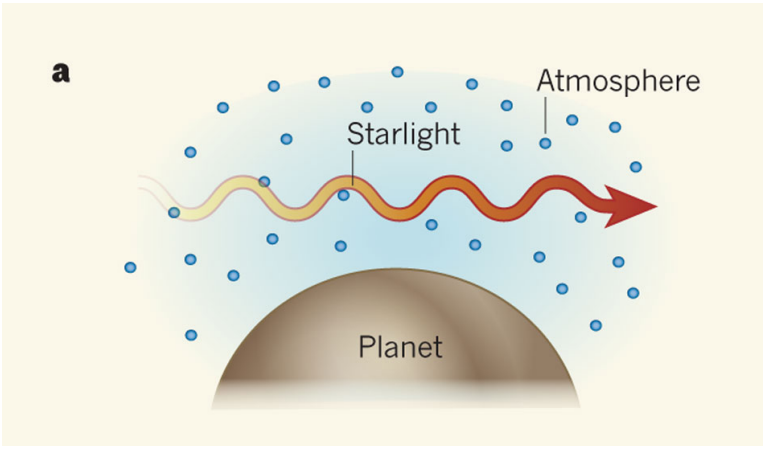


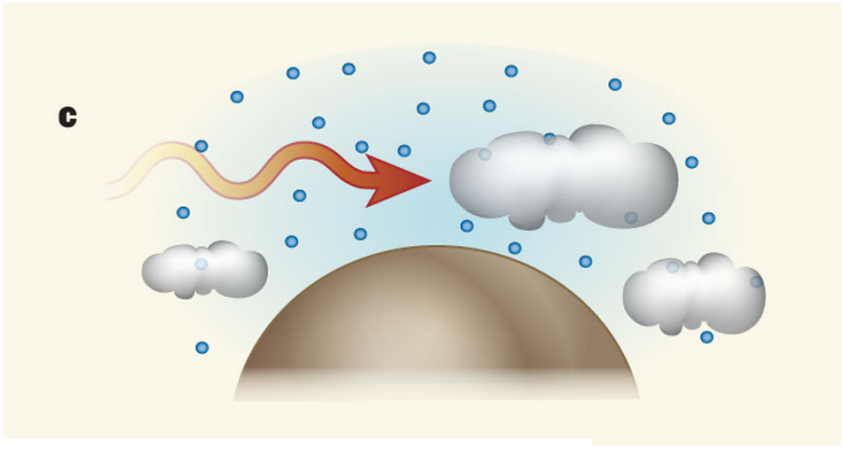
$$\frac{\Delta f}{f} = \left(\frac{R_p}{R_*}\right)^2$$

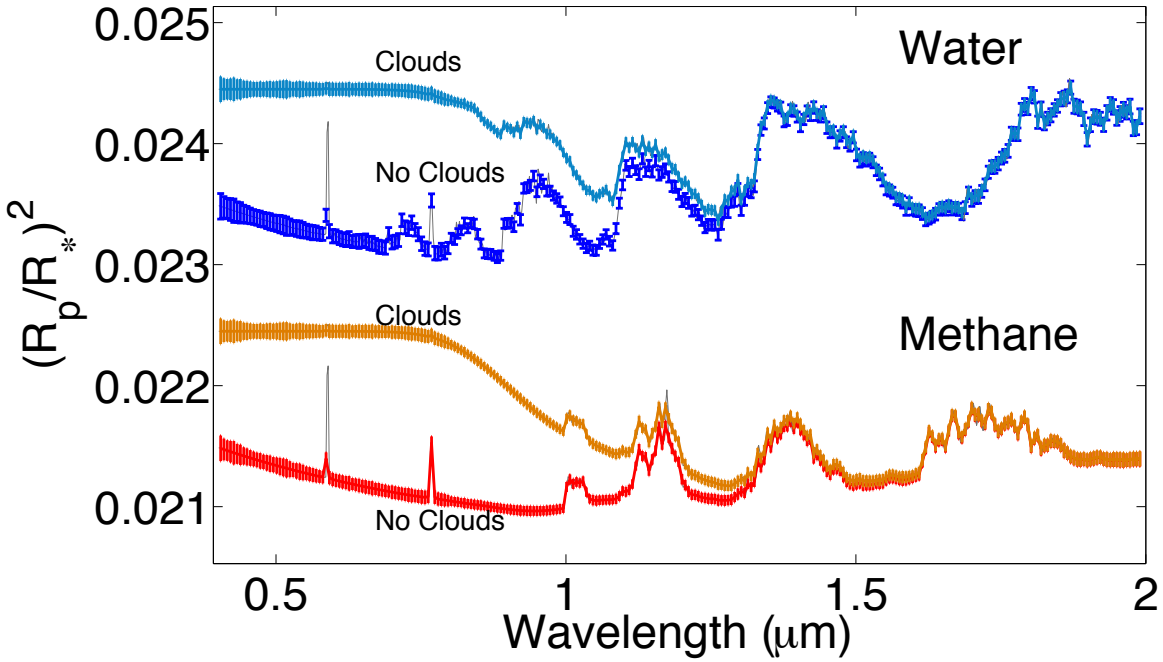


HD 209458b from 290–1030 nm (Knutson et al. 2007)

Transmission spectrum

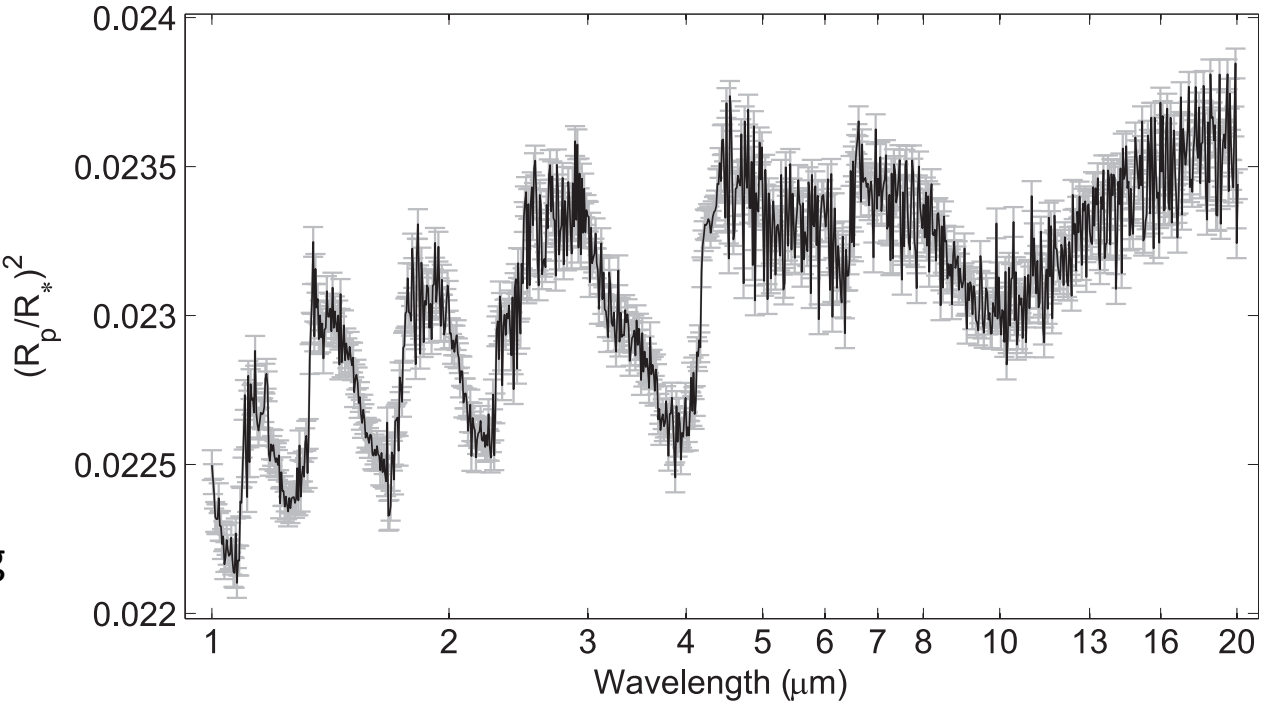




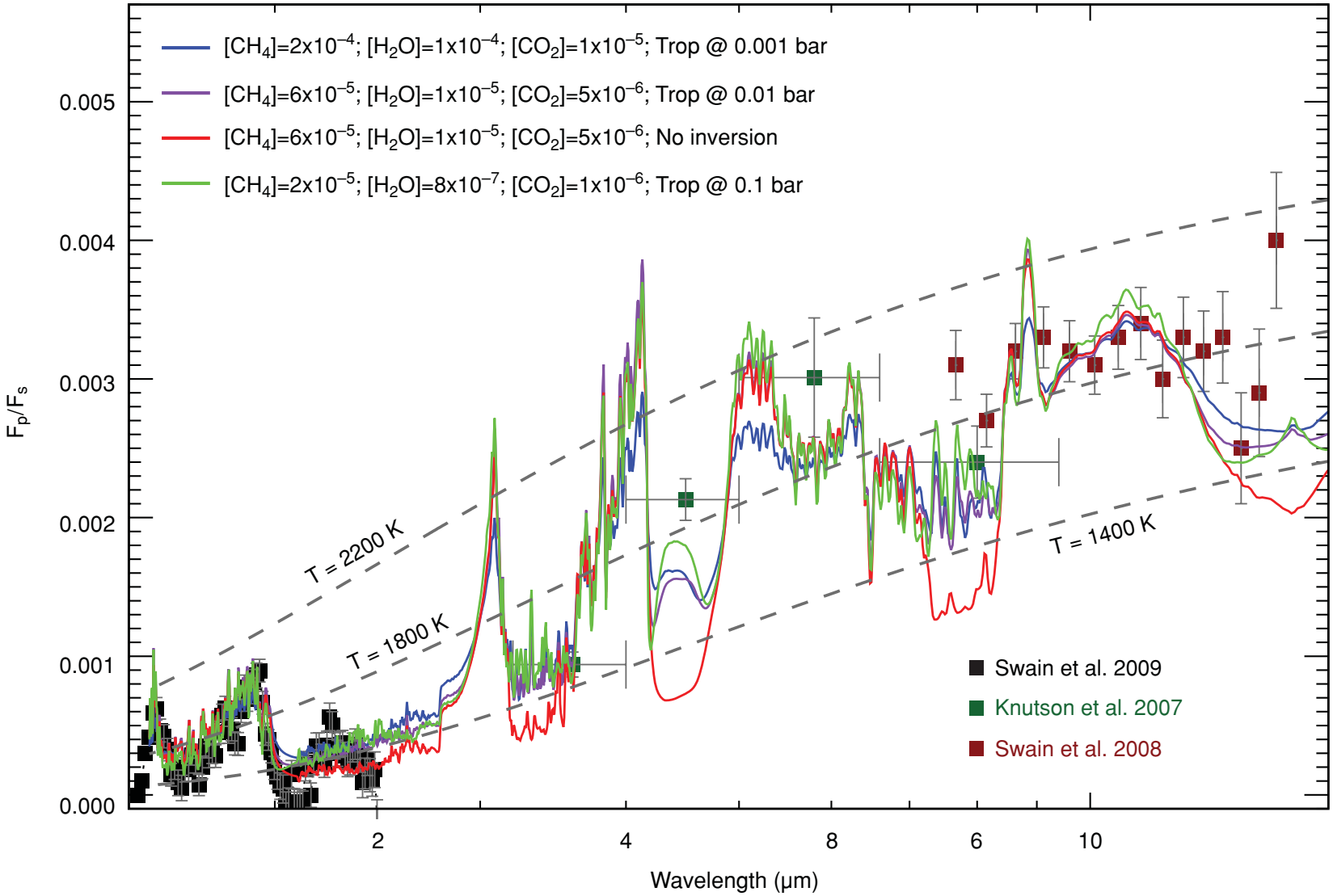


Observational requirements

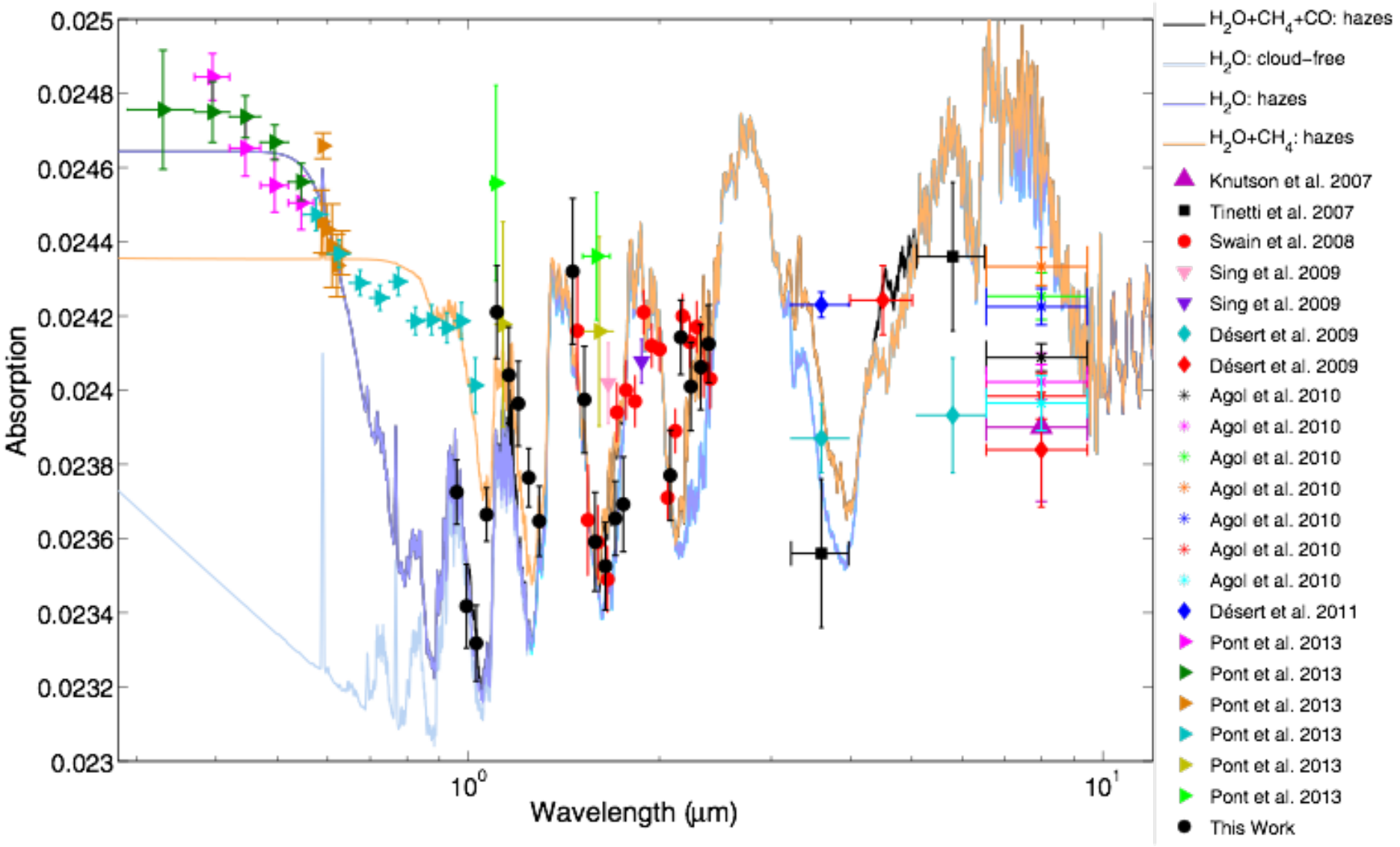
- **Precision of ~ 10^{-4}**
- **High SNR**
  - Bright star
  - Large planet
  - Hot planet
- **Infrared spectrometer:**
  - More absorption lines from molecules
  - Low Rayleigh scattering
  - Less stellar activity
- **Large wavelength range**
- **Reliable IR detectors**



HD209458b - emission



HD189733b - transmission

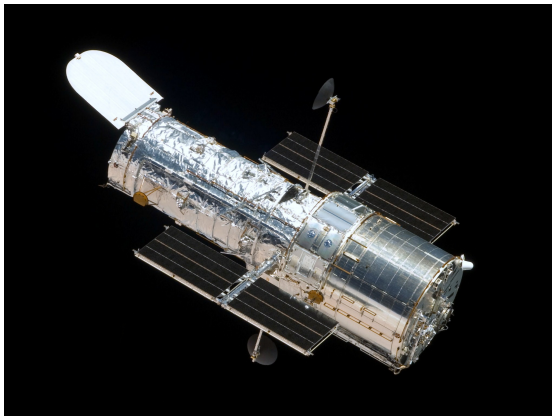


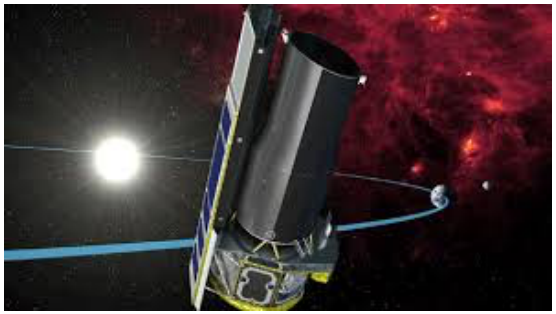
Atmospheric characterisation process

DATA → SPECTRUM

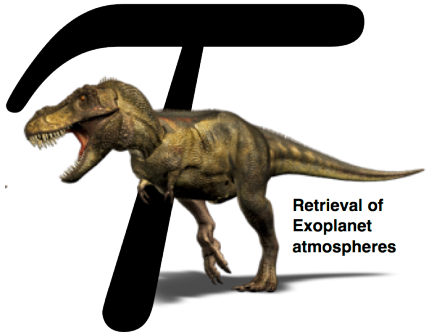
LINE-LISTS

ExoMol



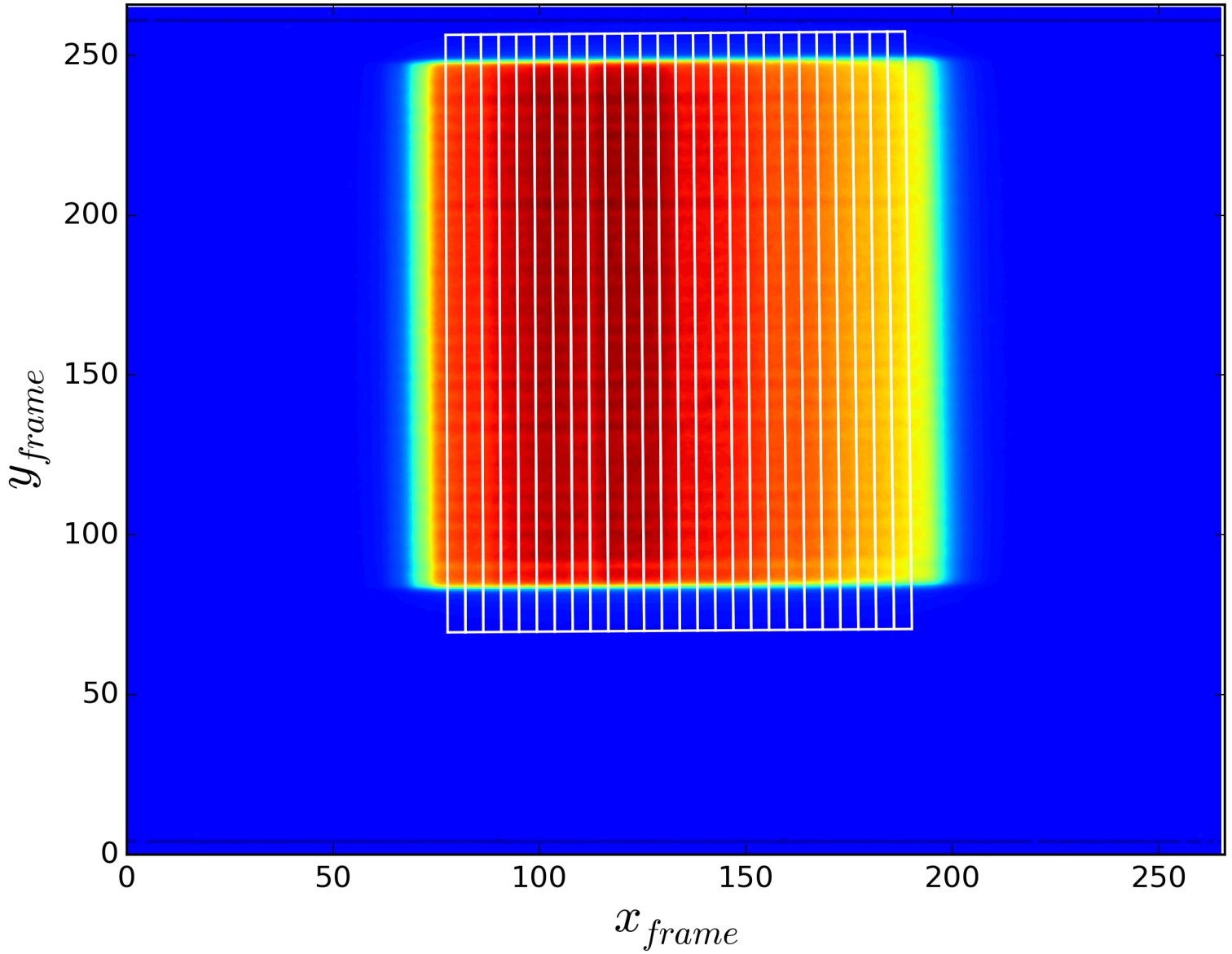


RETRIEVAL

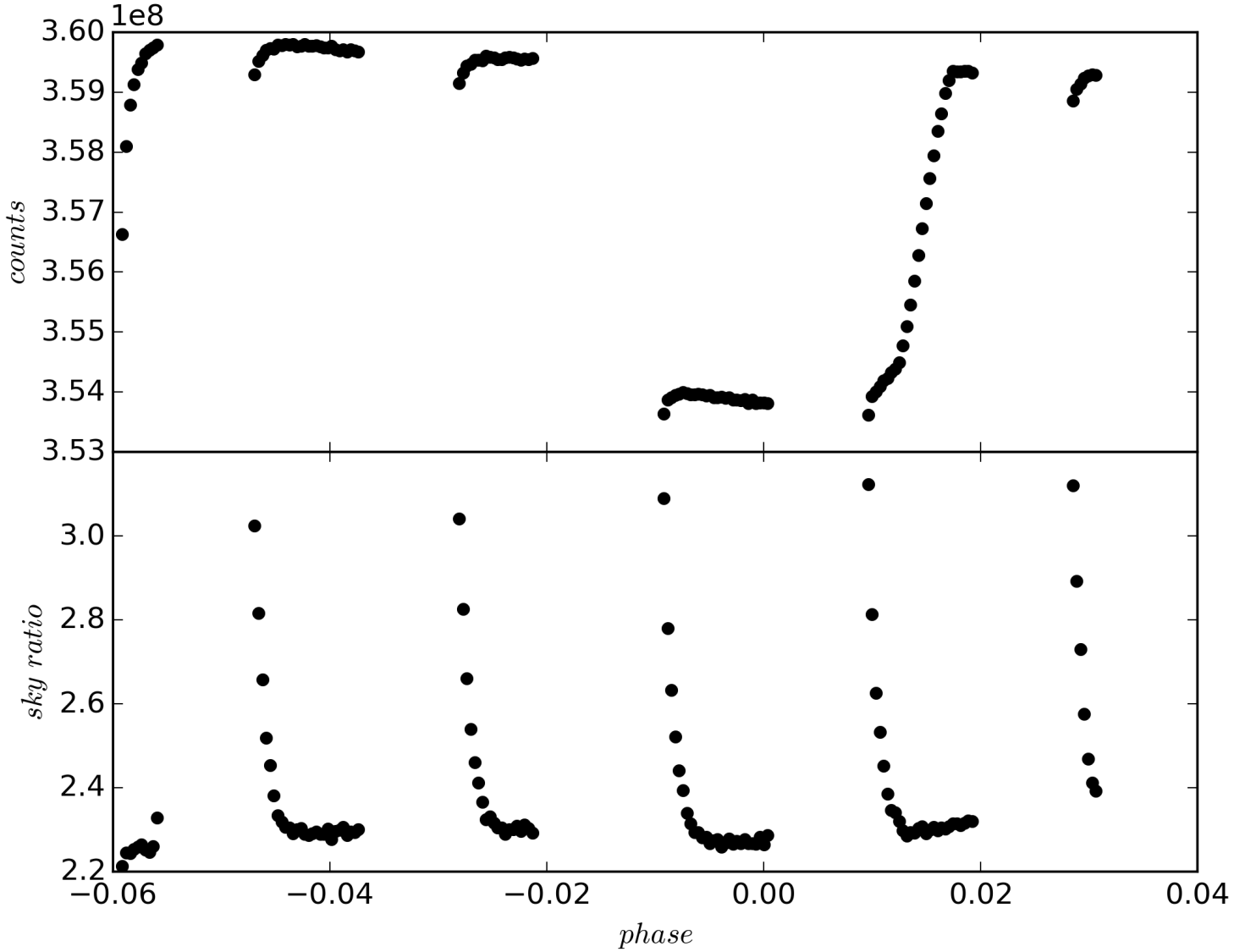


COMPOSITION

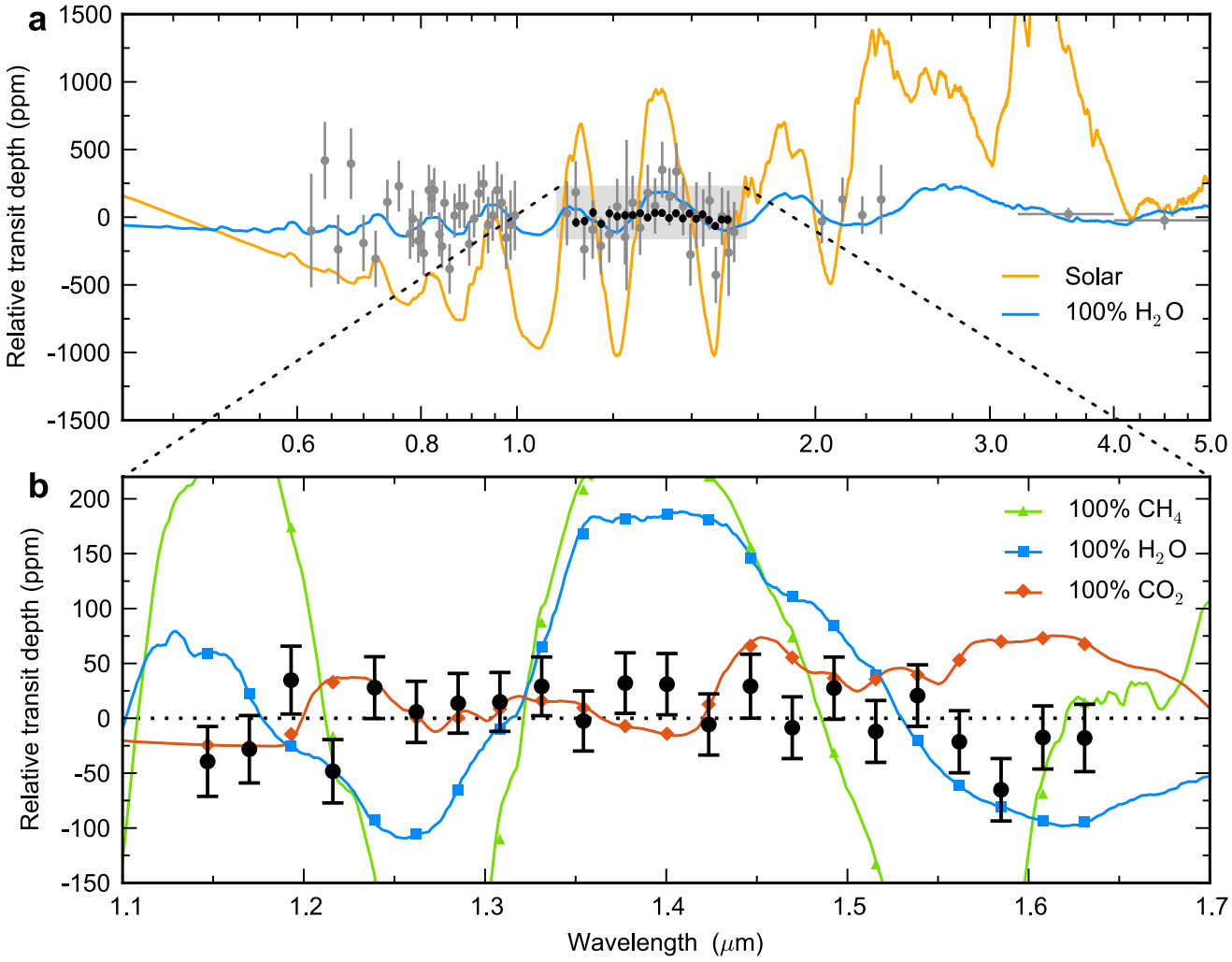
HST Spatial scanning



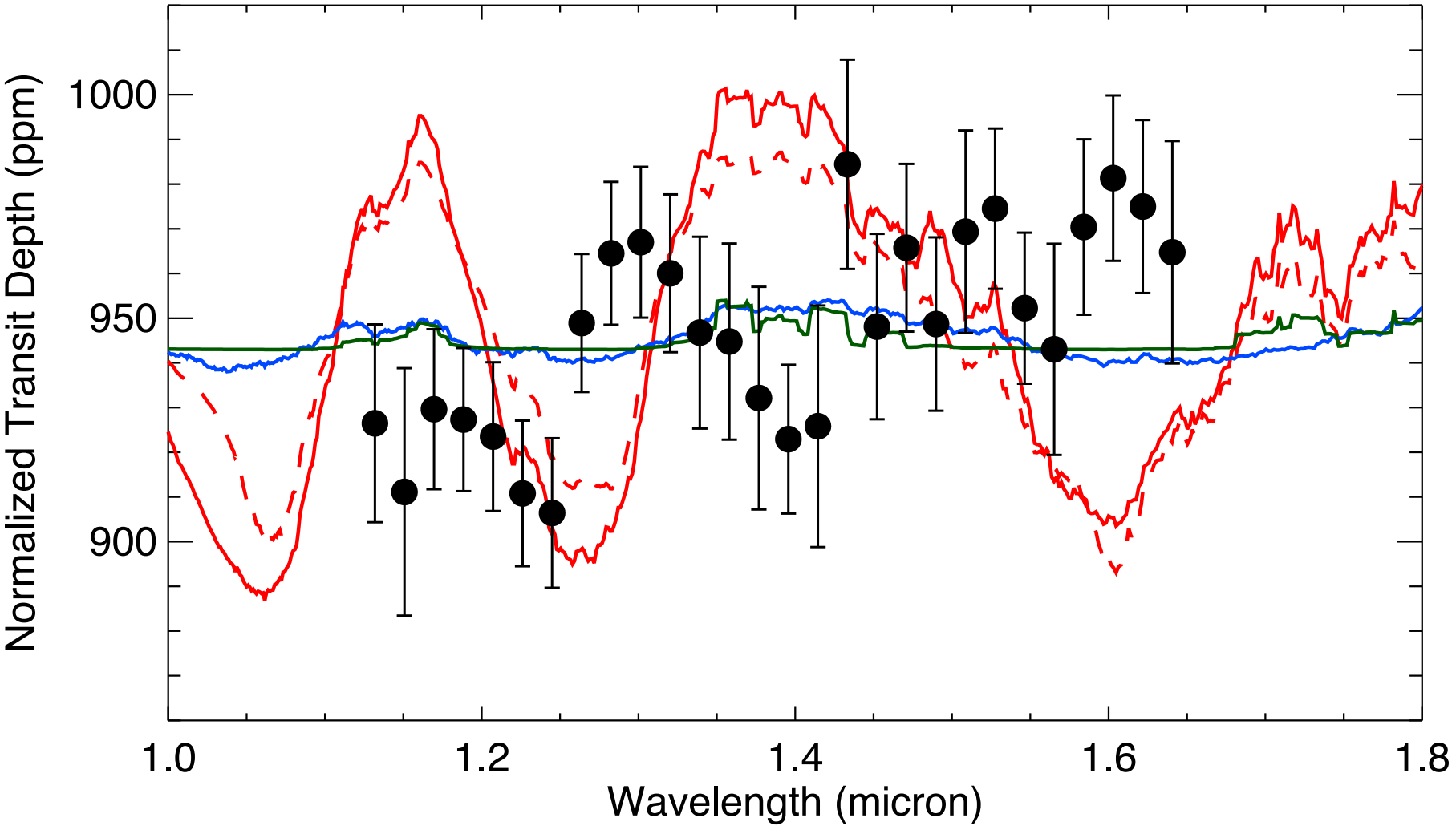
Instrumental systematics



GJ1214b - transmission



HD97658b - transmission



De-trending techniques

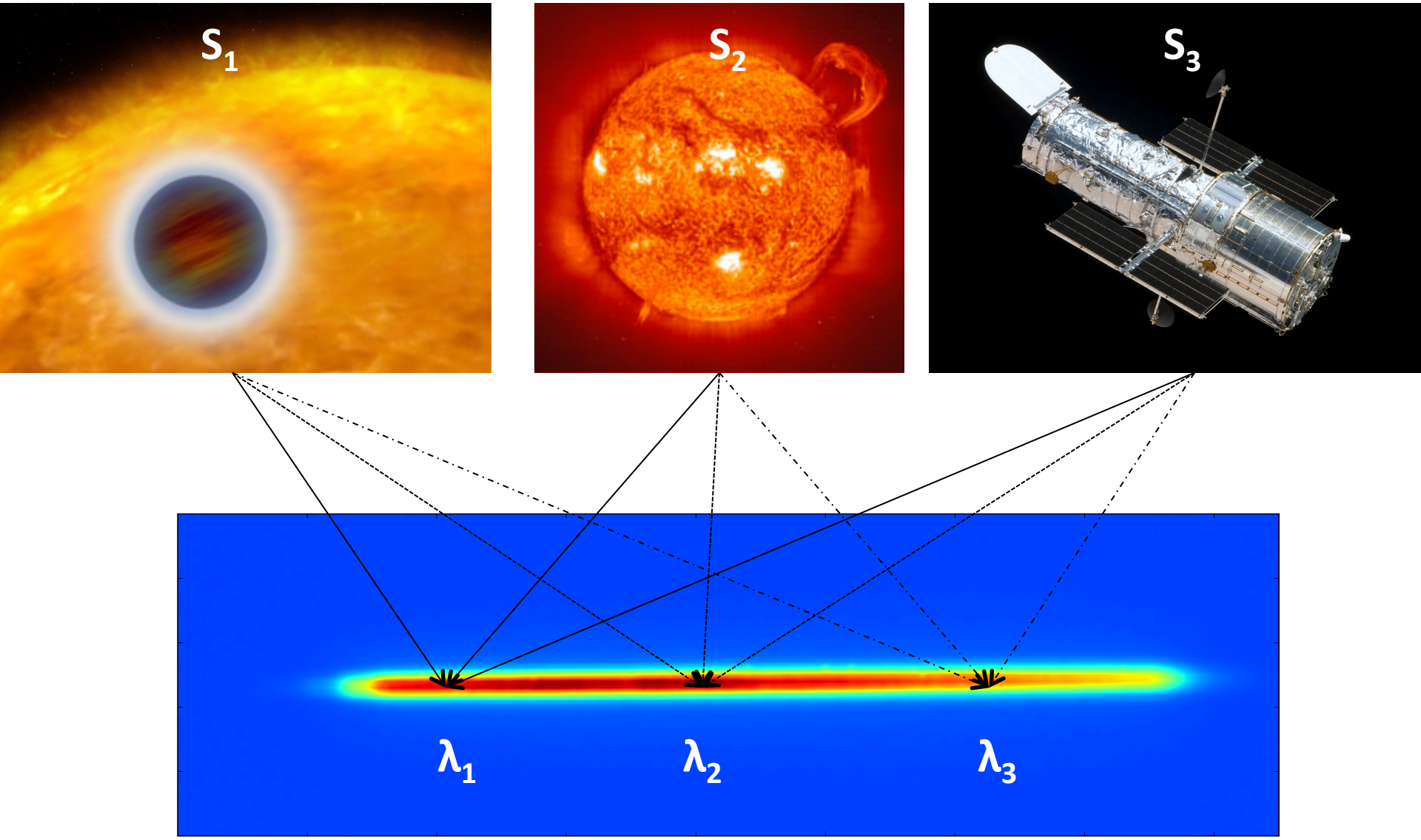
Supervised learning

- E.g. gaussian processes, neural networks.
- No functional form for the instrument systematics.
- Requires information about the instrument to learn the data properties.

Unsupervised learning

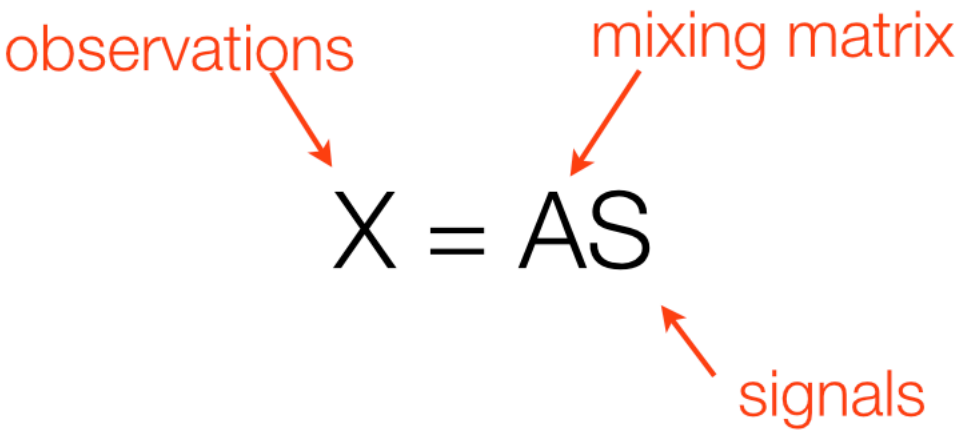
- No prior knowledge.

Independent Component Analysis



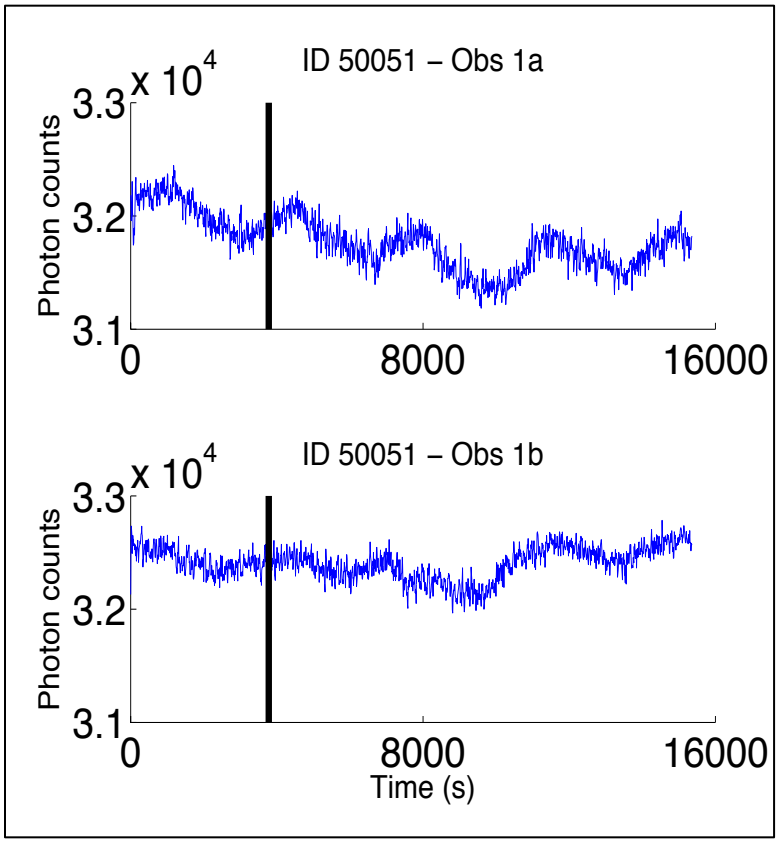
Independent Component Analysis

$$x_{\lambda_1} = A_{11}s_1 + A_{12}s_2 + A_{13}s_3$$
$$x_{\lambda_2} = A_{21}s_1 + A_{22}s_2 + A_{23}s_3$$
$$x_{\lambda_3} = A_{31}s_1 + A_{32}s_2 + A_{33}s_3$$

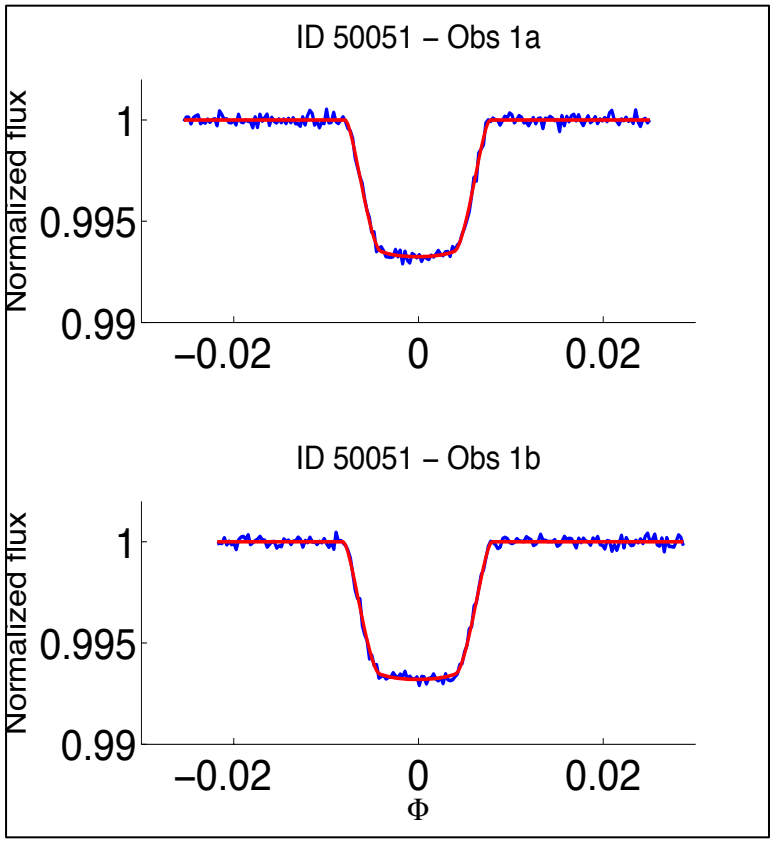


Spitzer/IRAC observations at 3.6 mm of GJ436b

- Raw lightcurves
- Detrended lightcurves + models

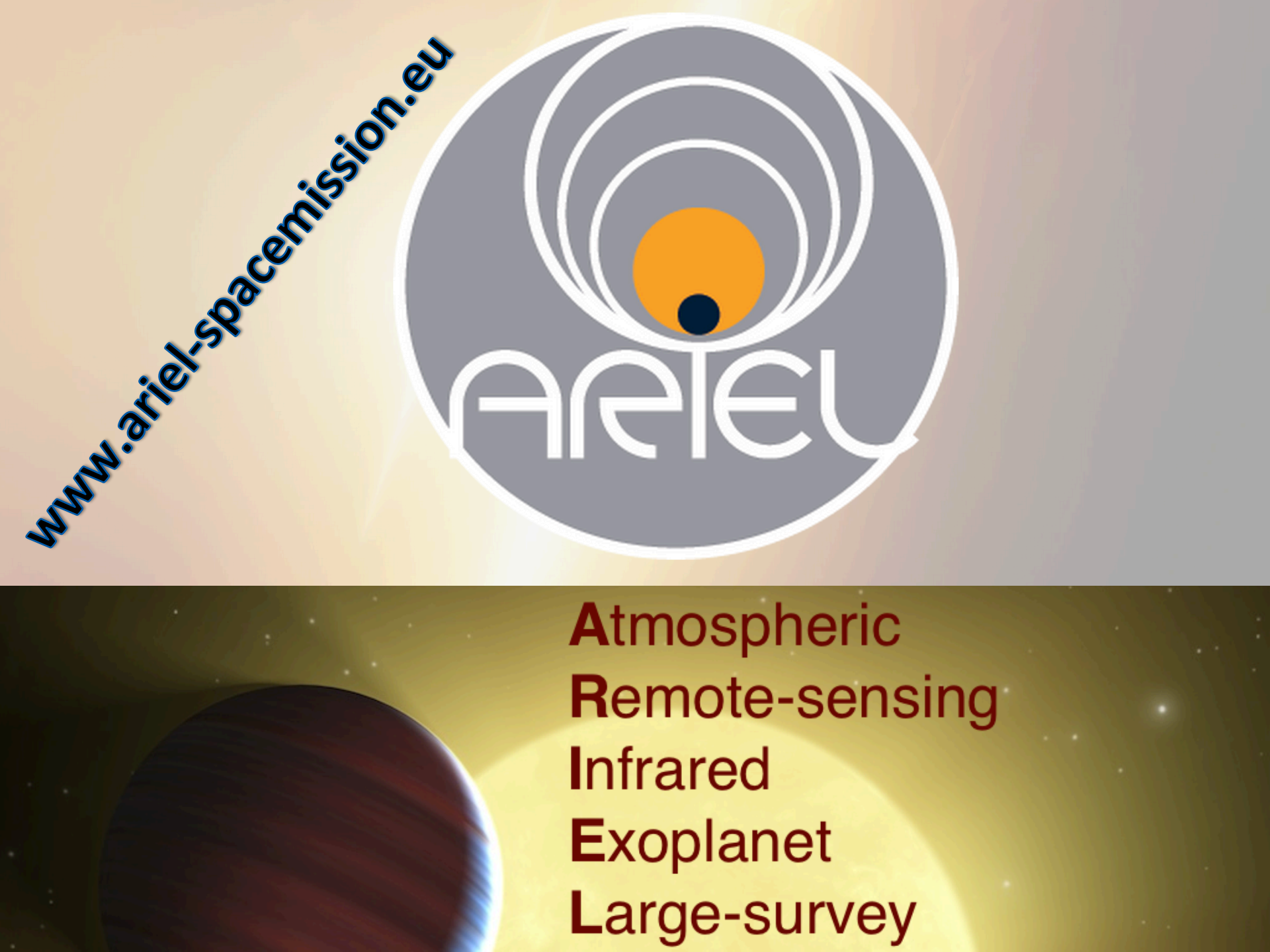


ICA



Morello et al. 2015, ApJ, 802, 117

www.ariel-spacemission.eu



ARIEL – Example spectrum