Observations and models : liabilities and limits

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Let's approximate the horse by a sphere

Observers' ideal: Get a spectra from a source, compare to models, with a varied range of age, mass, temperature and metallicity. Refine understanding of source.

Modelers' ideal: replace source by models and models by source in previous statement.

Only one certainty :
' The star is always right '

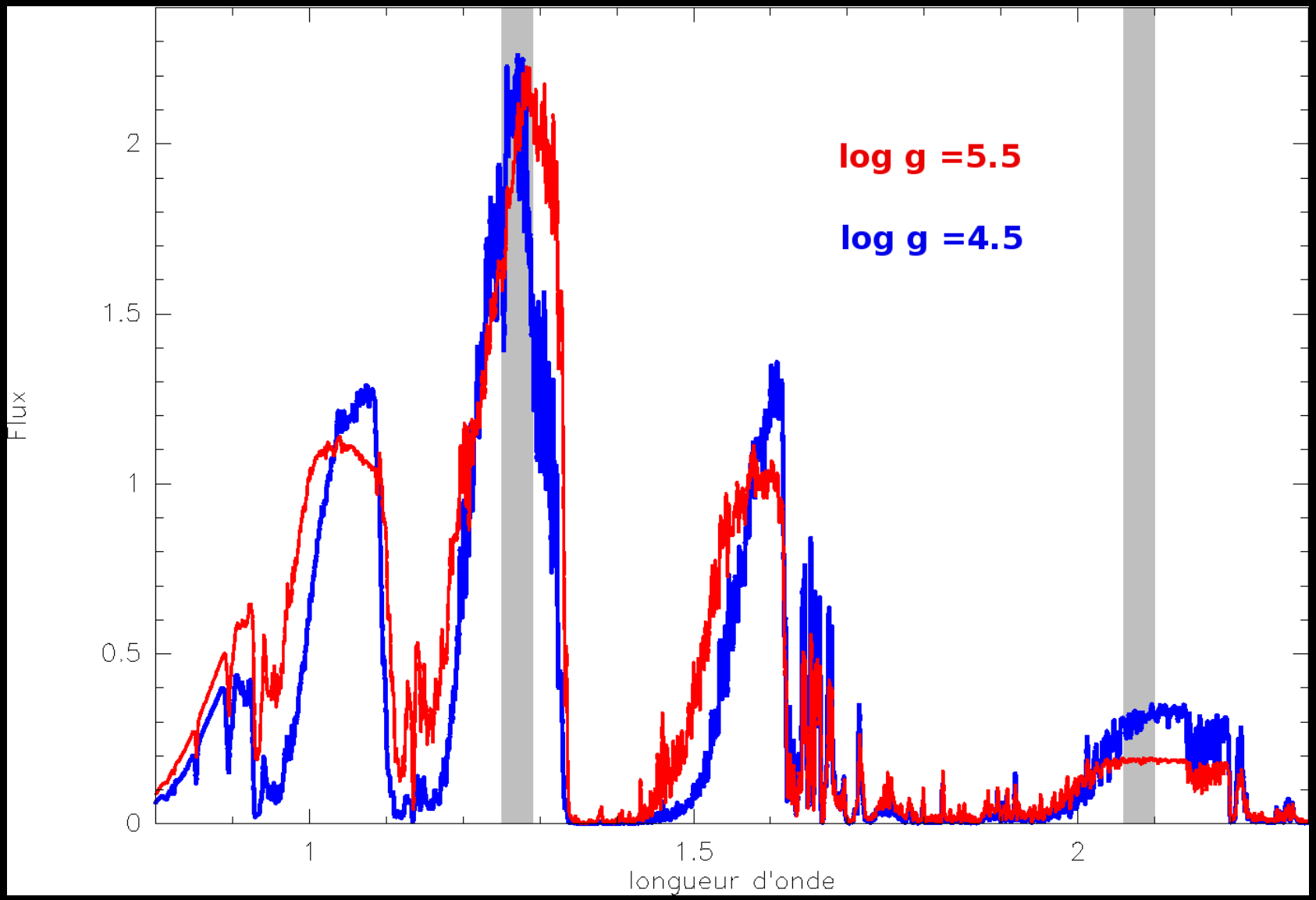
Comparison models/observations

Highlighting how well/bad cool atmosphere models reproduce the main features observed

==> *Look at spectral indices*

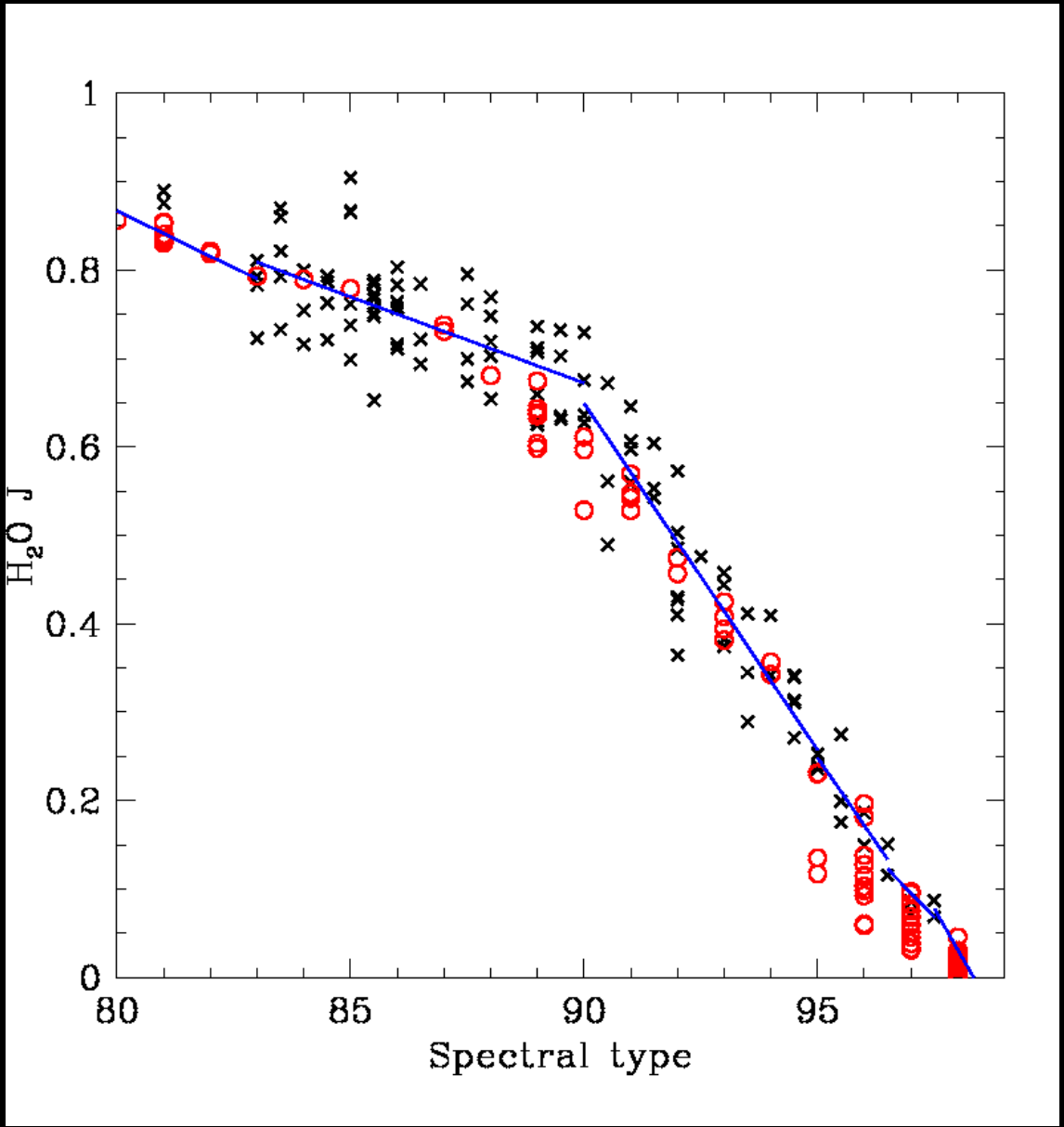
- Flux ratios targeted at specific absorption features
- Defined ~empirically on observed templates spectra
- Very valuable for determining atmospheric parameters

Spectral Indices



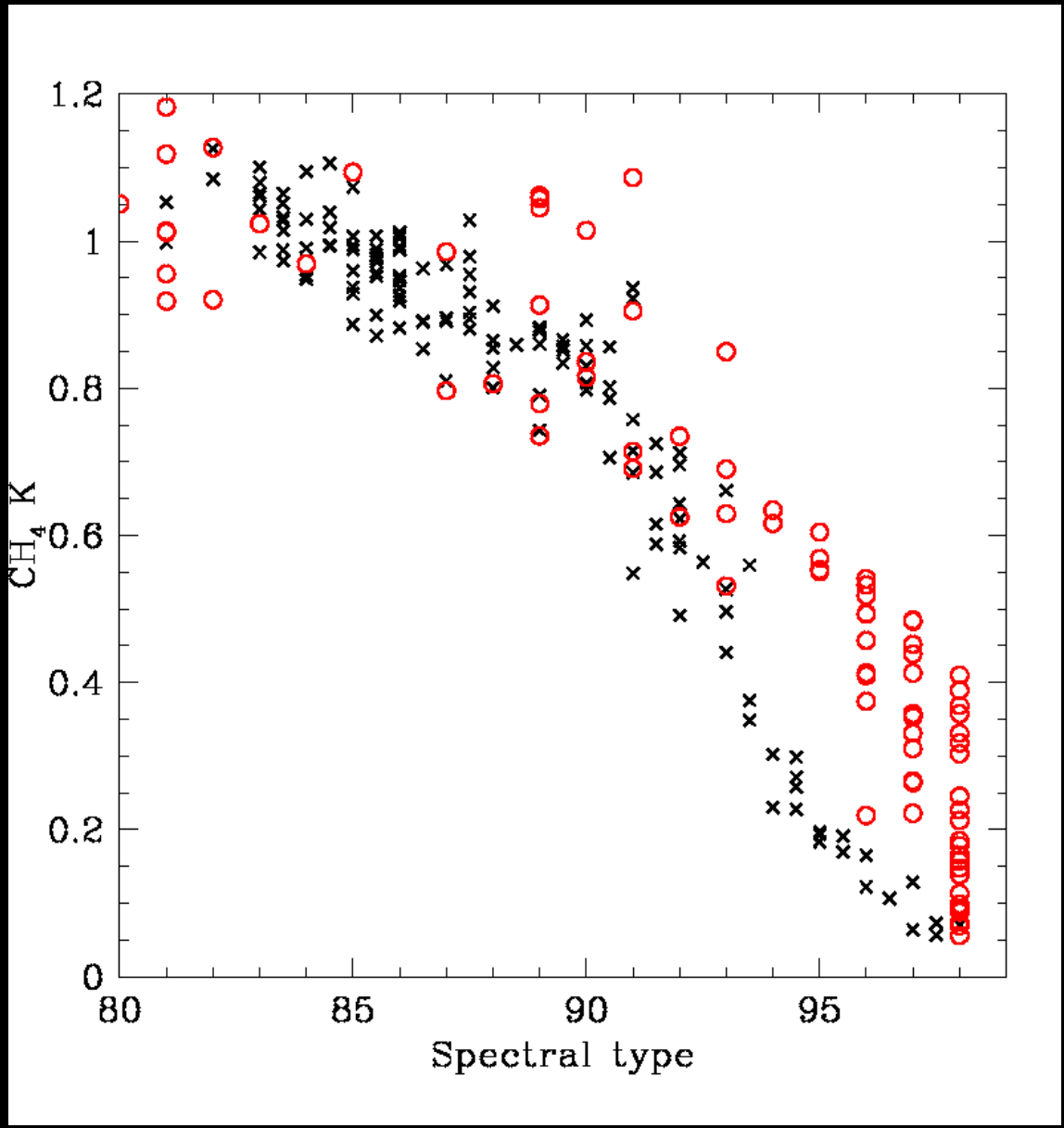
Spectral indices:models/observations(1/4)

Calibration



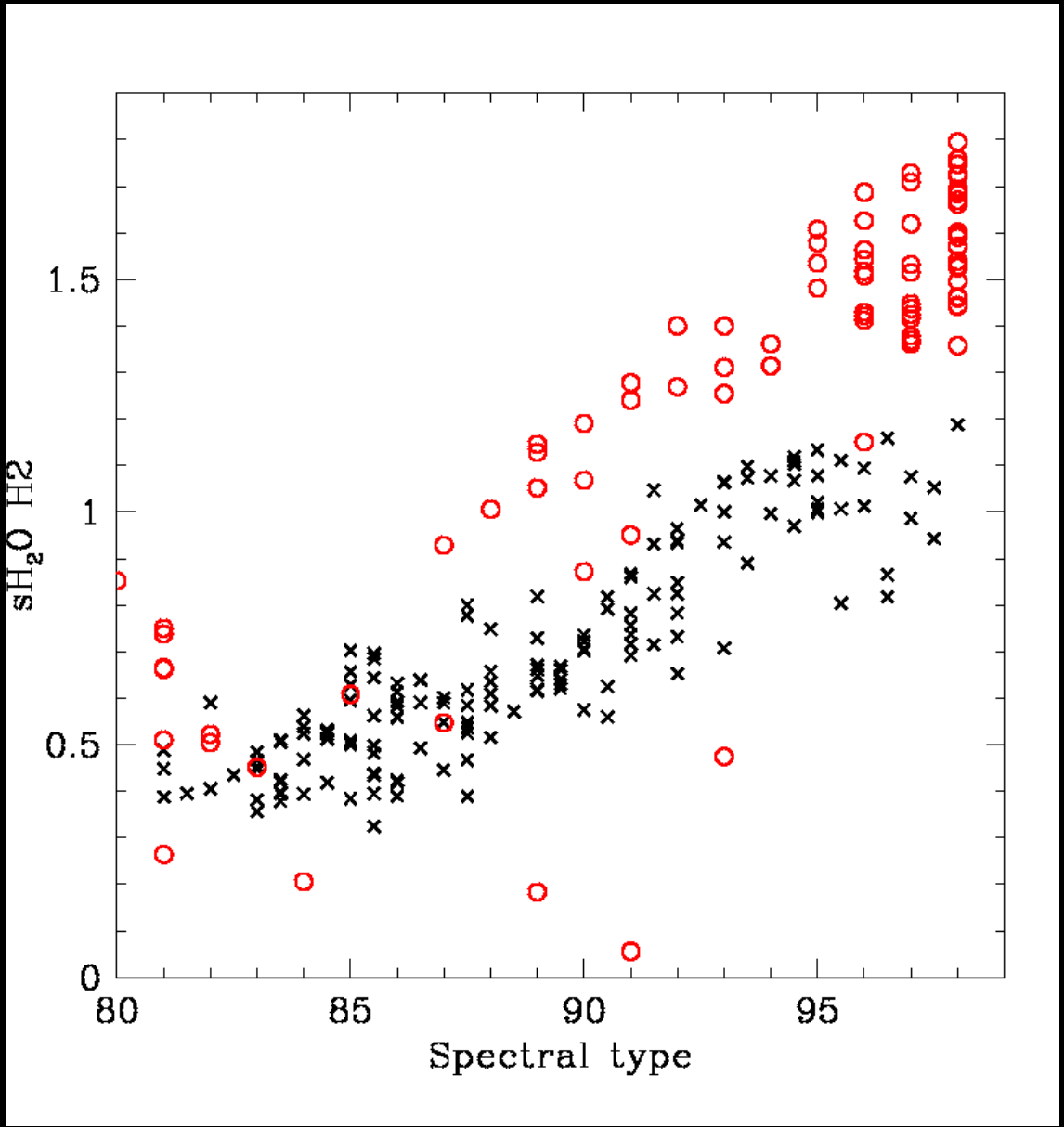
Spectral indices:models/observations(2/4)

Sometimes it ~ works



Spectral indices:models/observations(3/4)

Sometimes it only has qualitative value



Spectral indices:models/observations(4/4)

==> Models arrived to the point where they are **reliable** in a **qualitative** sense

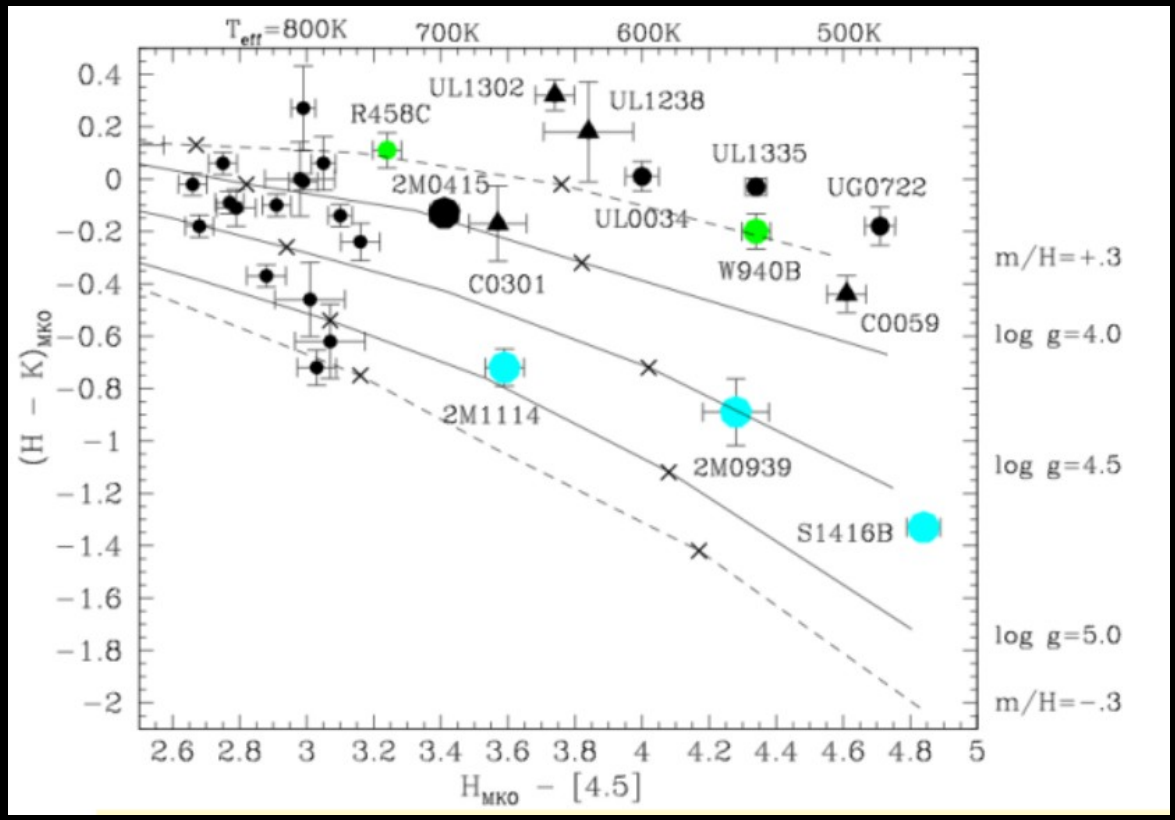
==> Models are mostly **not reliable** in a **quantitative** sense, even on a small range dominated by a single absorbing species.

==> **Absolute comparison** with models to derive parameters from photometry/spectroscopy leads to **significant, unconstrained, systematic errors**

==> **Empirical calibration** on well known sources improves accuracy, but:

- *Not available for exoplanets*
- *Is still tricky for the better known and well behaved field BDs*

Mid-Infrared

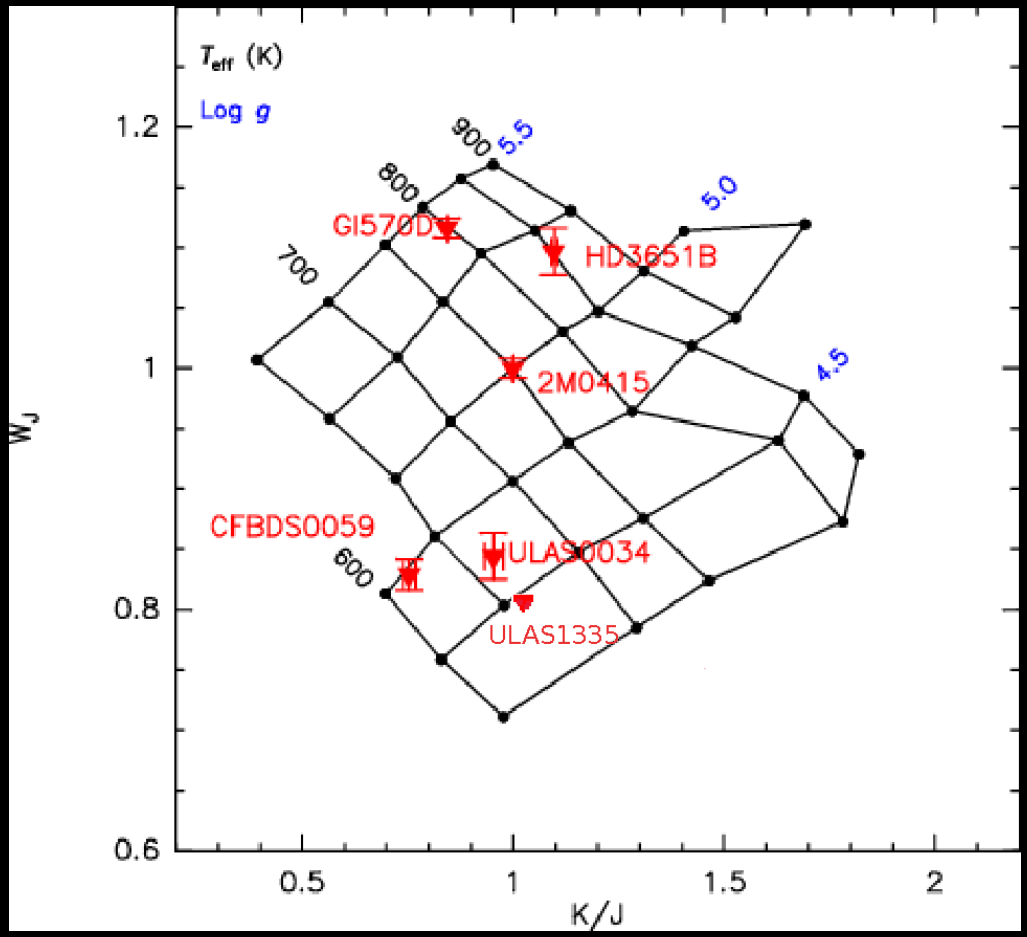


From Leggett et al 2009

	SpT	Teff	Logg
2M0415	T8	700	4.0
UL0034	T8.5	600	<4.0
UL1335	T9	550	3.5
C0059	T9	500	<4.0

Teff agree with absolute luminosity
Logg-M/H does not make sense

Near-infrared



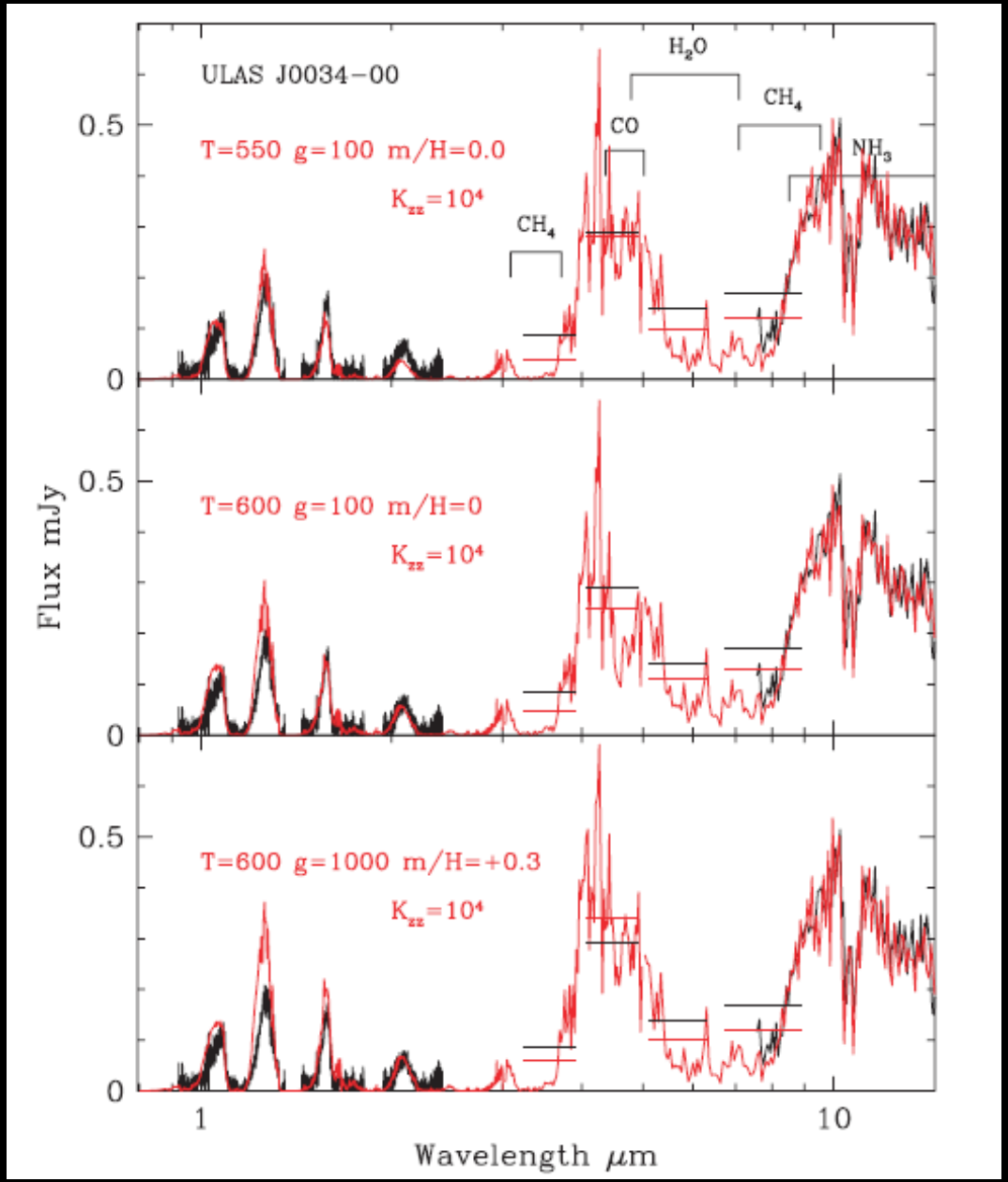
	SpT	Teff	Logg
2M0415	T8	750	5.0
UL0034	T8.5	675	4.5
UL1335	T9	650	4.5
C0059	T9	625	4.75

M/H=0

From Delorme et al 2008

Systematics of ~100K in Teff and one full order of magnitude in gravity

Fit to model spectra



From Leggett et al 2009

Decent fit to models is possible but :

- Many parameters :

Teff, Logg, M/H, Kzz, dust

- *Still some factor 2 inconsistencies at some wavelength.*

- *What do we fit ?*

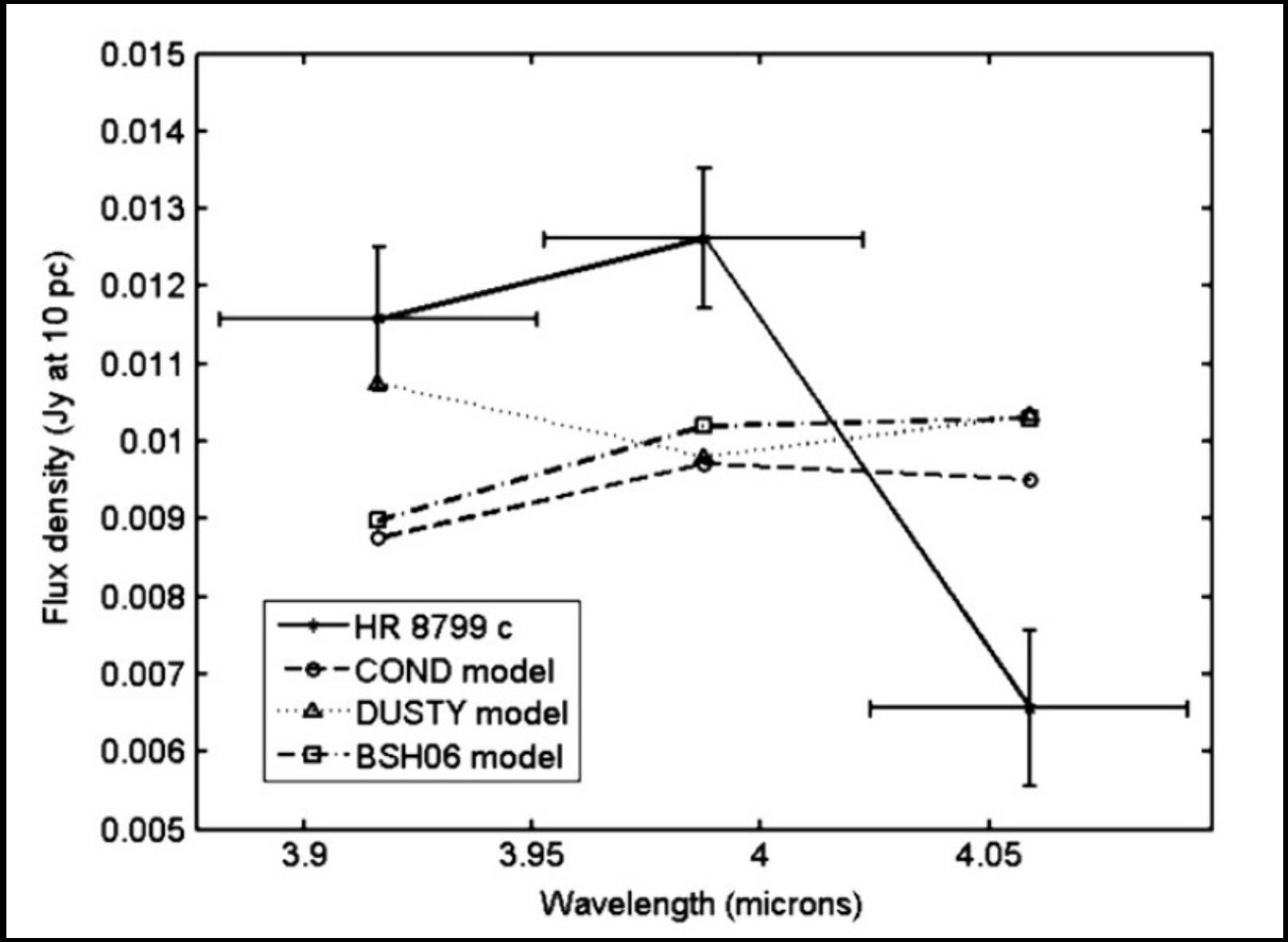
Again, this is for well behaved field objects. ***Exoplanets*** *have :*

- ***Very low gravity***

- *Strong* ***dependancy*** *to* ***evolutionary*** *Models (radius, Teff, Luminosity)*

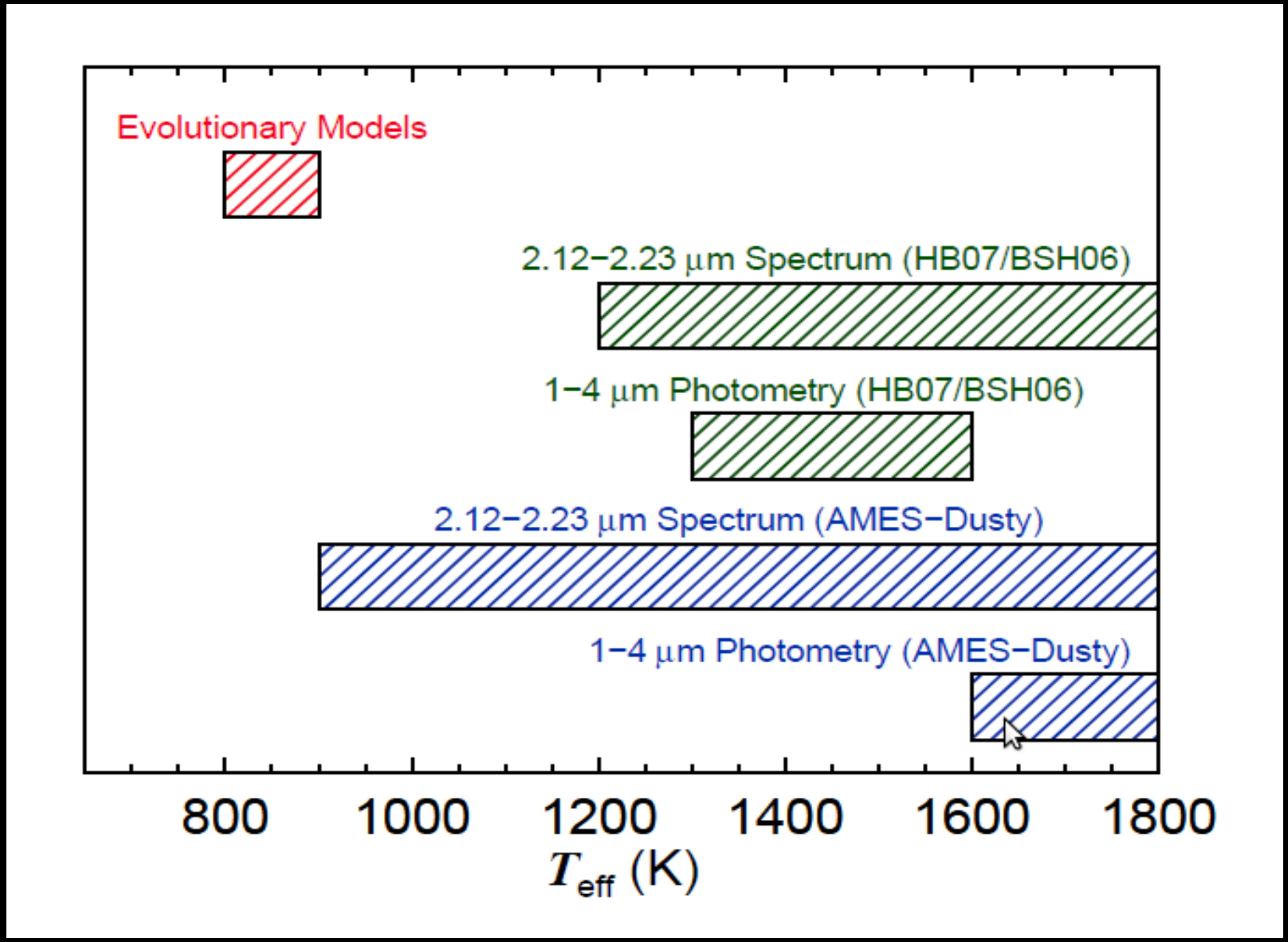
- ***Sensitivity*** *to* ***formation history***

Exoplanet spectra (1/3)



From Janson et al 2010

Exoplanet spectra(1/2)



Teff estimates for HR8799b, from Bowler et al 2010

Conclusions

• Age/low gravity messes things up a lot.
IF radius/absolute flux are reliable we can say :

• L/T transition features (CH4) at ~1000K instead of ~1300K
==> ***Low gravity delays the apparition of the usual low temperature features ?***
• ***Models*** *enable* ***relative quantitative measurements*** *of exoplanets parameters*

• **But,** at the present time, **we should not** trust spectra/models comparison to :
  • *Derive absolute parameters of the objects*
  • *Have an idea of the systematic errors on these parameters*

Thanks for your attention !

Deriving substellar parameter from spectra

(Teff, [M/H], log g) or (age, radius, mass)

Direct fit to the spectra

pro : Gives direct access to physical parameters
cons : you don't really know what you fit. Particularly bad because of cool atmosphere parameter degeneracy

Definition of spectral indices/colours :

pro : probes ~well definited absorption features
cons : Does not use all spectral information. Use/define the spectral types which do not directly carry physical information.

Each exist in 2 flavours : Vs models and Vs templates