

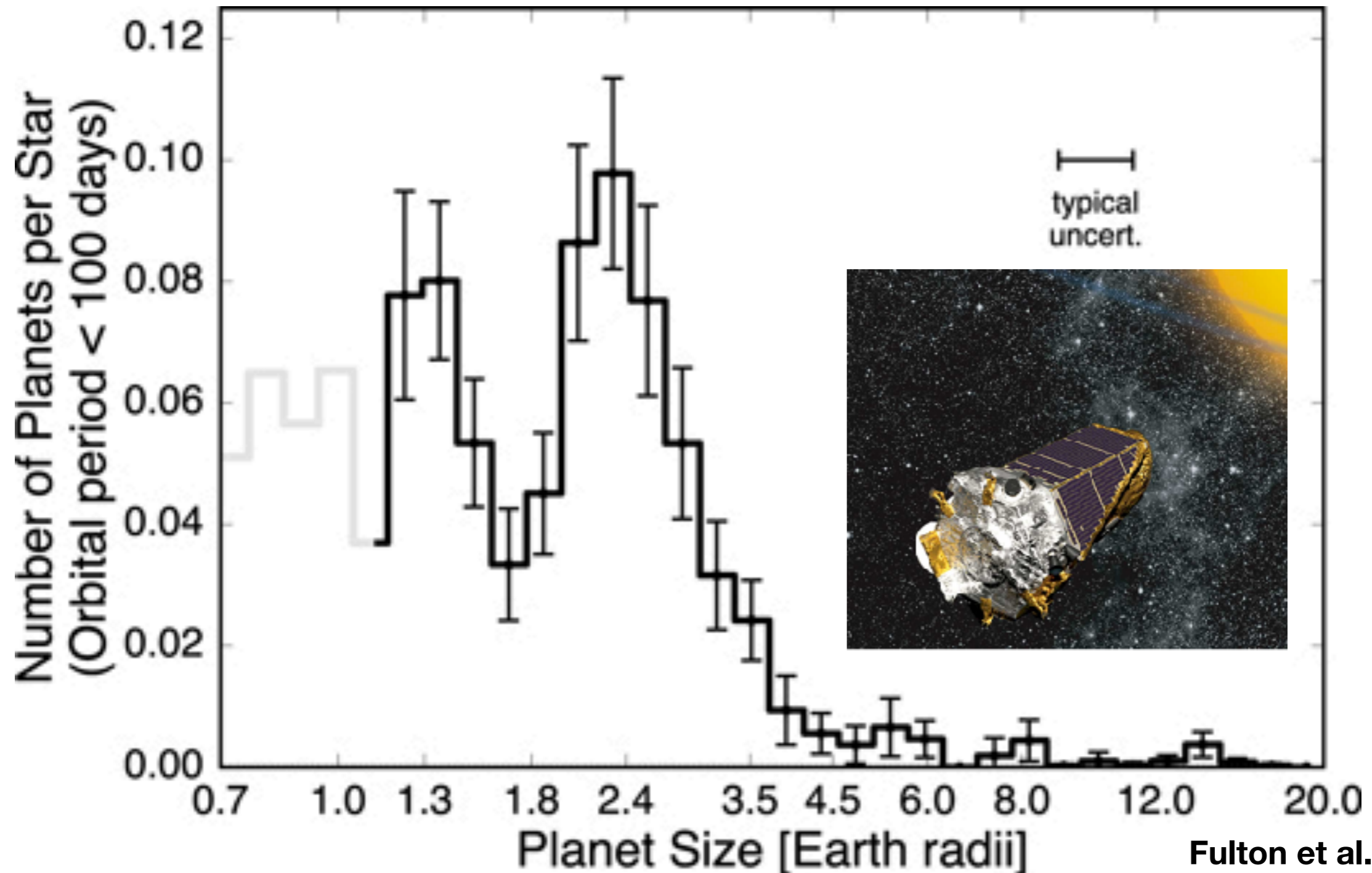
Masses of four Planets Orbiting two Bright M dwarfs

Molly Kosiarek, NSF Graduate Fellowship
University of California, Santa Cruz
ExoPAG July 29th, 2018

Advisors: Ian Crossfield + Andrew Howard

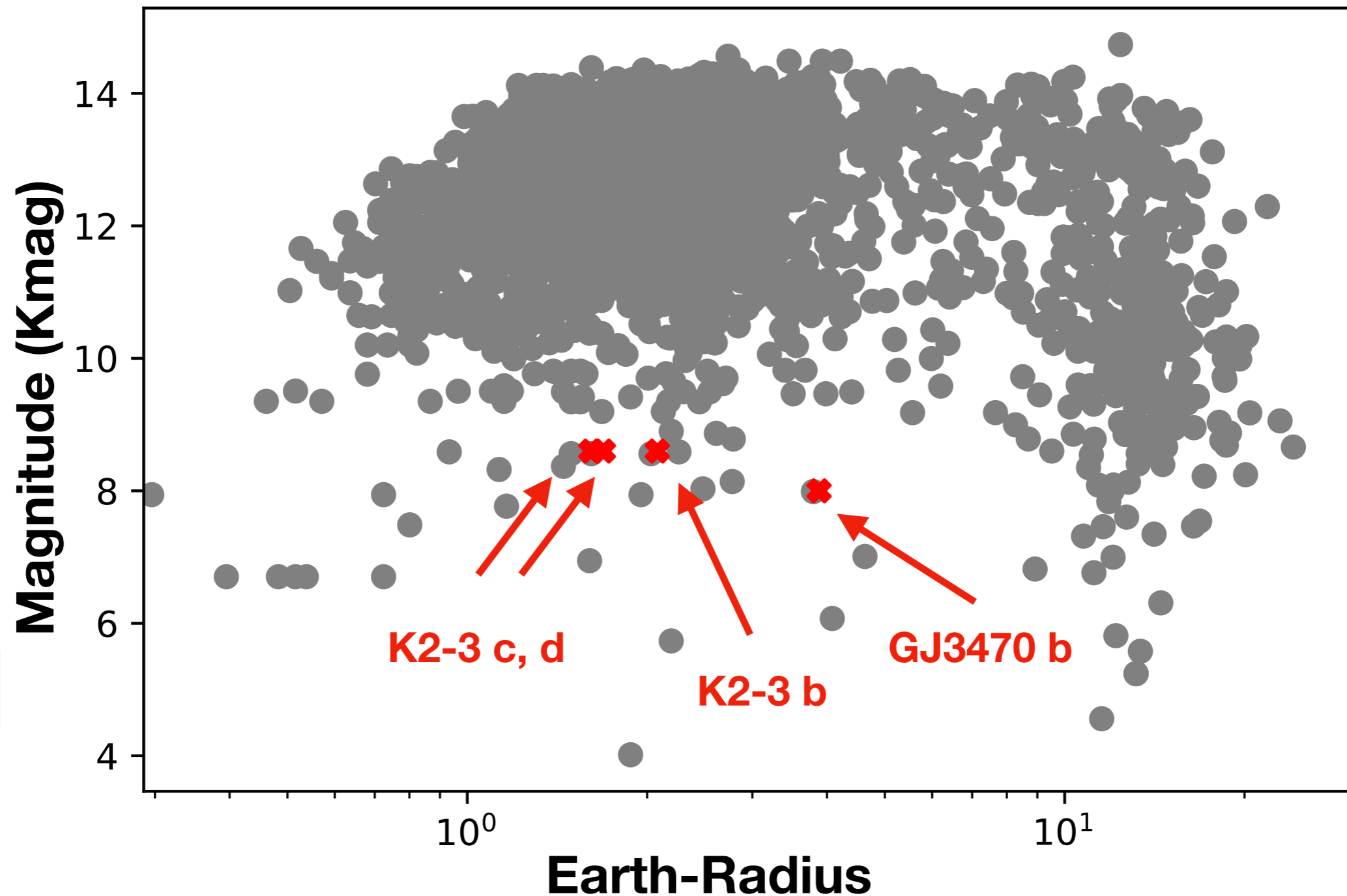
Sarah Blunt, Kevin Hardegree-Ullman, John Livingston, Gregory Henry, Ward Howard,
Bjorn Benneke, Heather Knutson, Courtney Dressing, Joshua Schlieder, and more
California Planet Search Team, HARPS Team, Evryscope Team.

Kepler showed that small planets seem to fall into two radius categories.



Fulton et al. 2017
California Kepler Survey

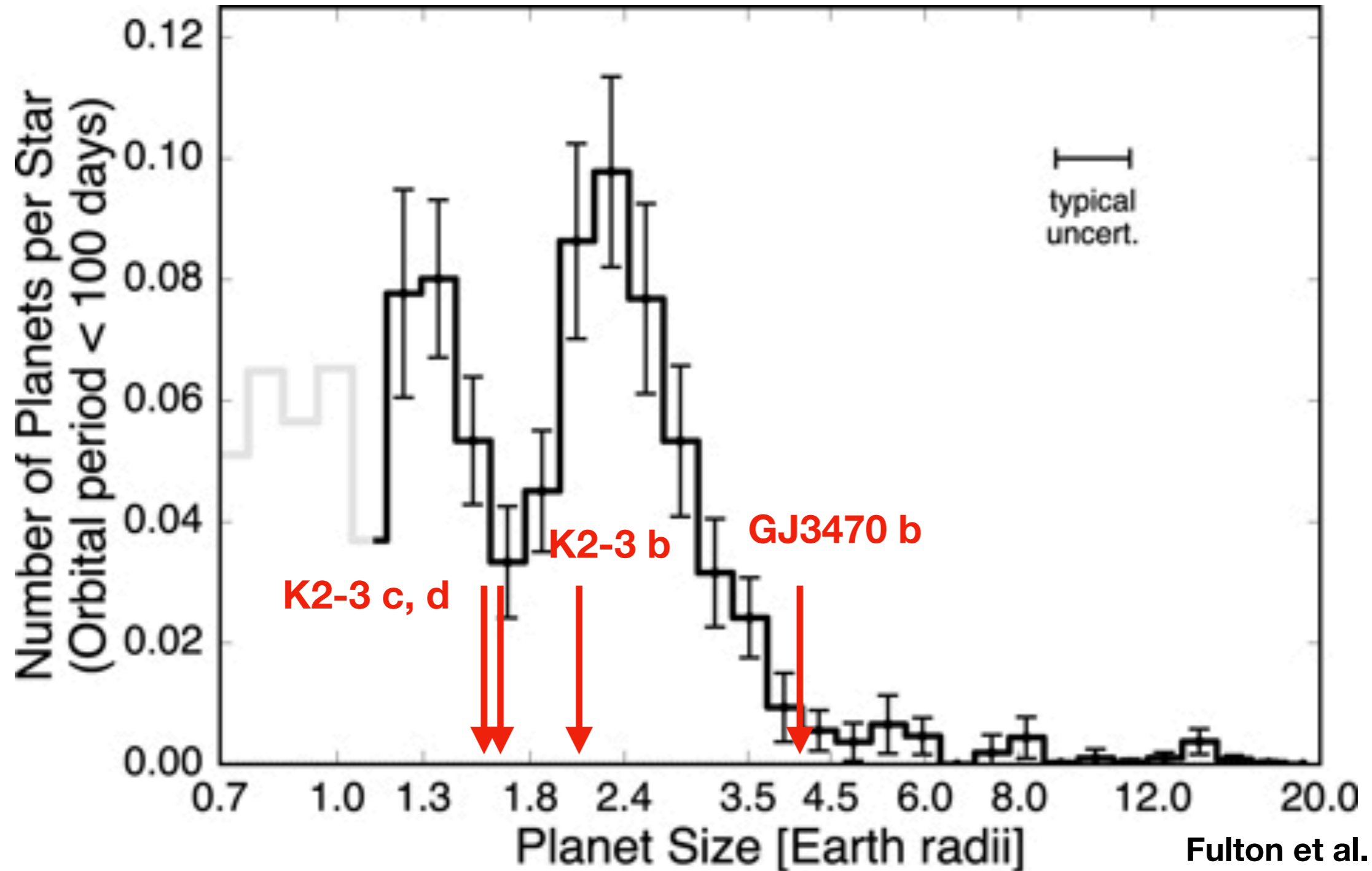
We observed GJ3470 and K2-3, two of the brightest M dwarfs hosting small planets.



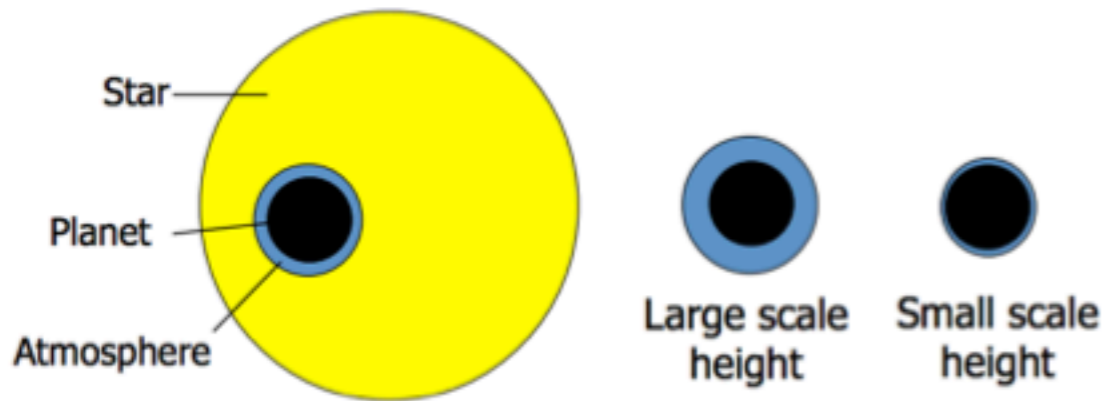
Bright

Small

Our four targets span the Fulton gap.



Planet Mass and Atmosphere Composition are Fundamentally Degenerate

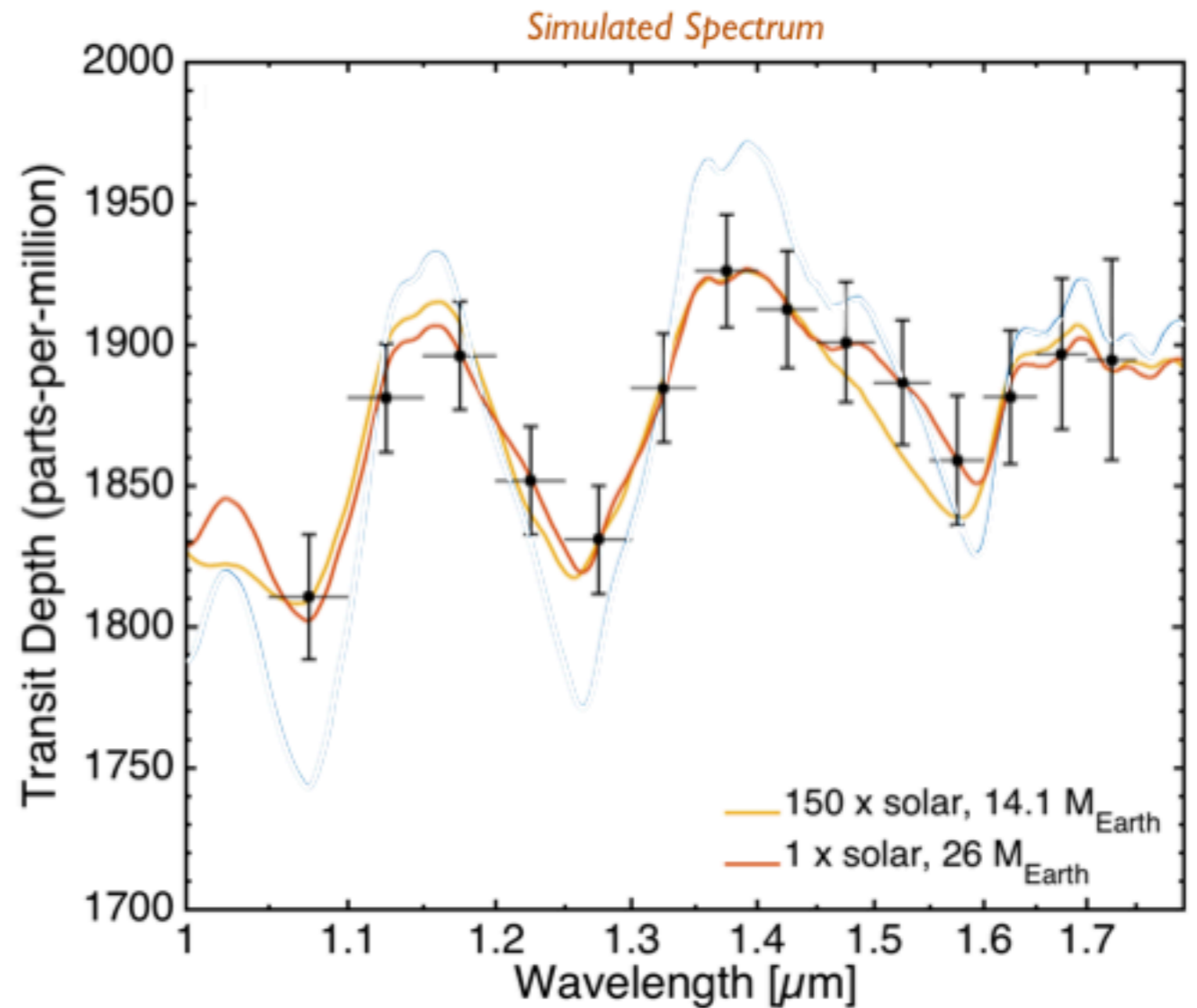


Measure Atmospheric Scale Height

$$H = \frac{kT}{\mu g} \propto \frac{1}{\mu M_{pl}}$$

Mean molecular weight

Planet Mass



**We collected new radial velocity (RV)
measurements of K2-3 and GJ3470 on
Keck and HARPS.**

K2-3

- 74 HIRES
- 31 PFS
- 132 HARPS
- 197 HARPS-N

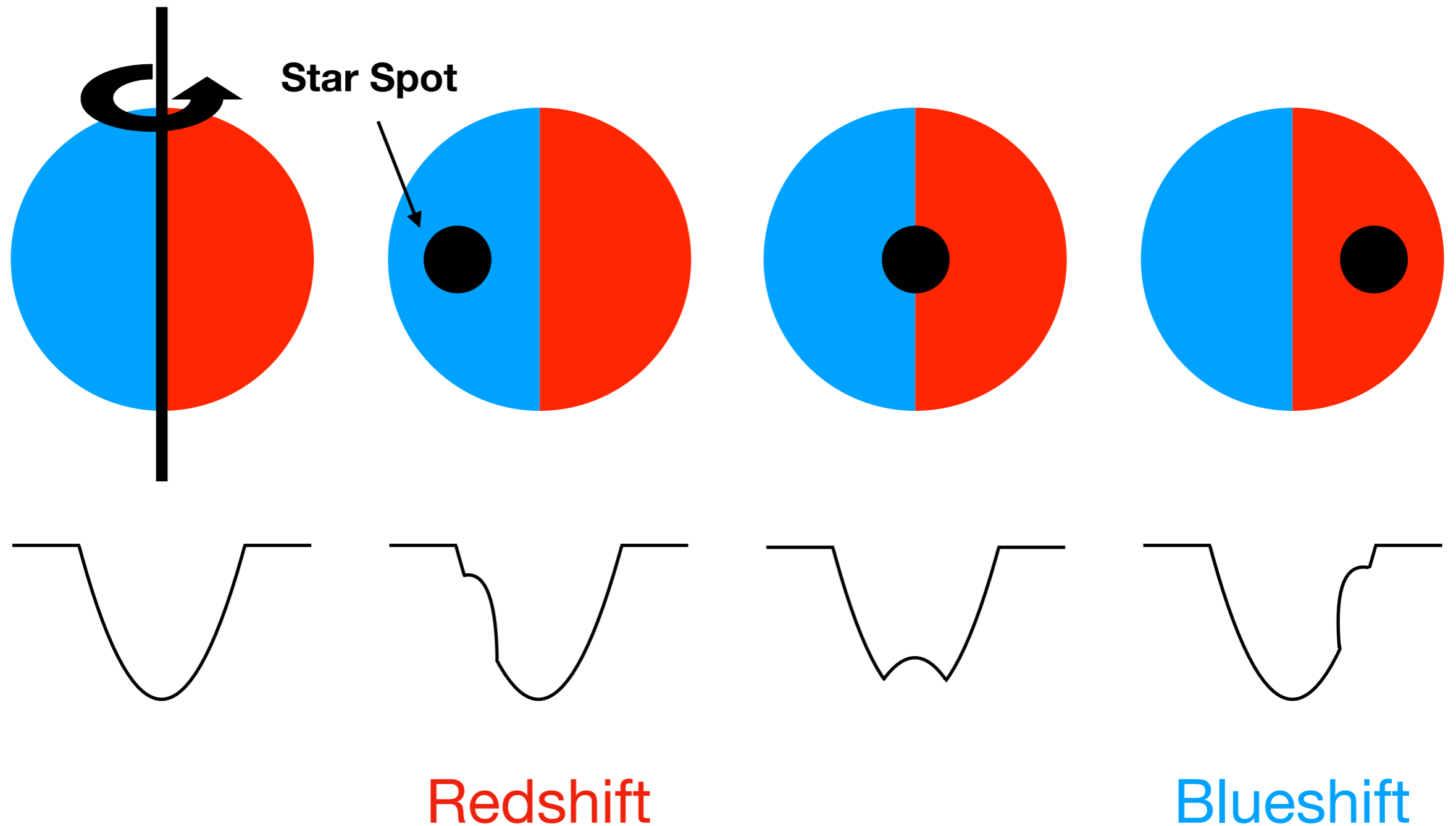
GJ3470

- 57 HIRES
- 113 HARPS

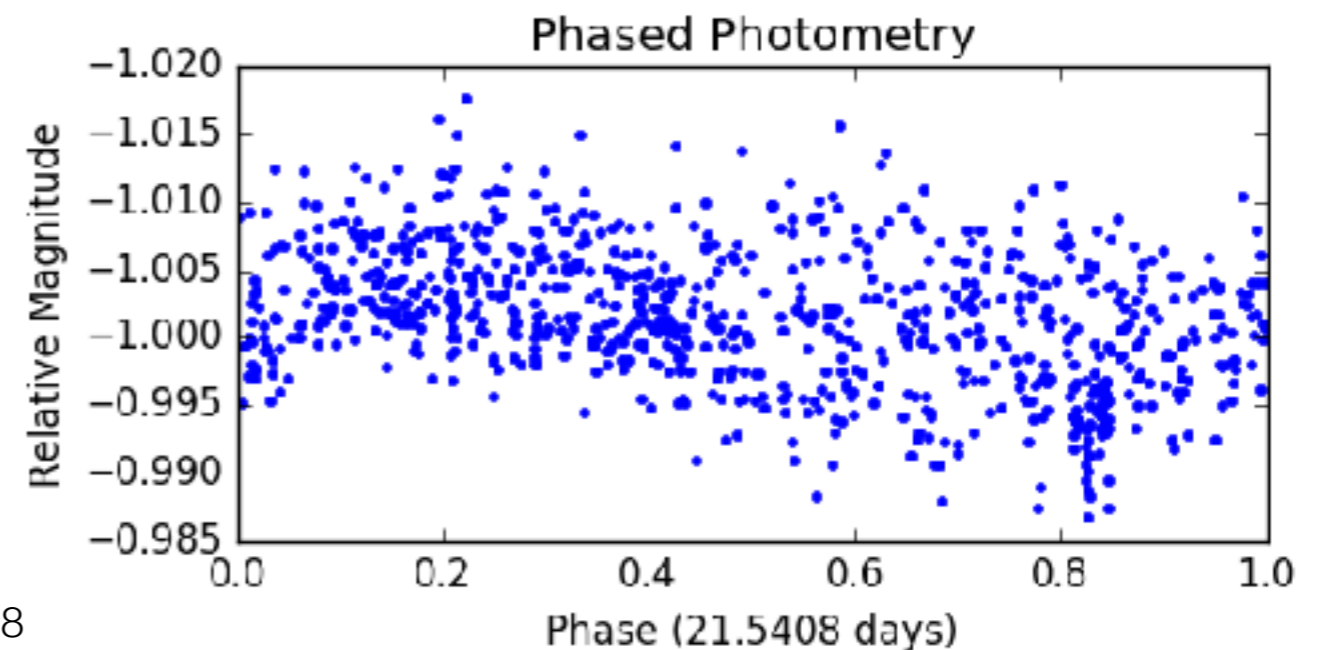
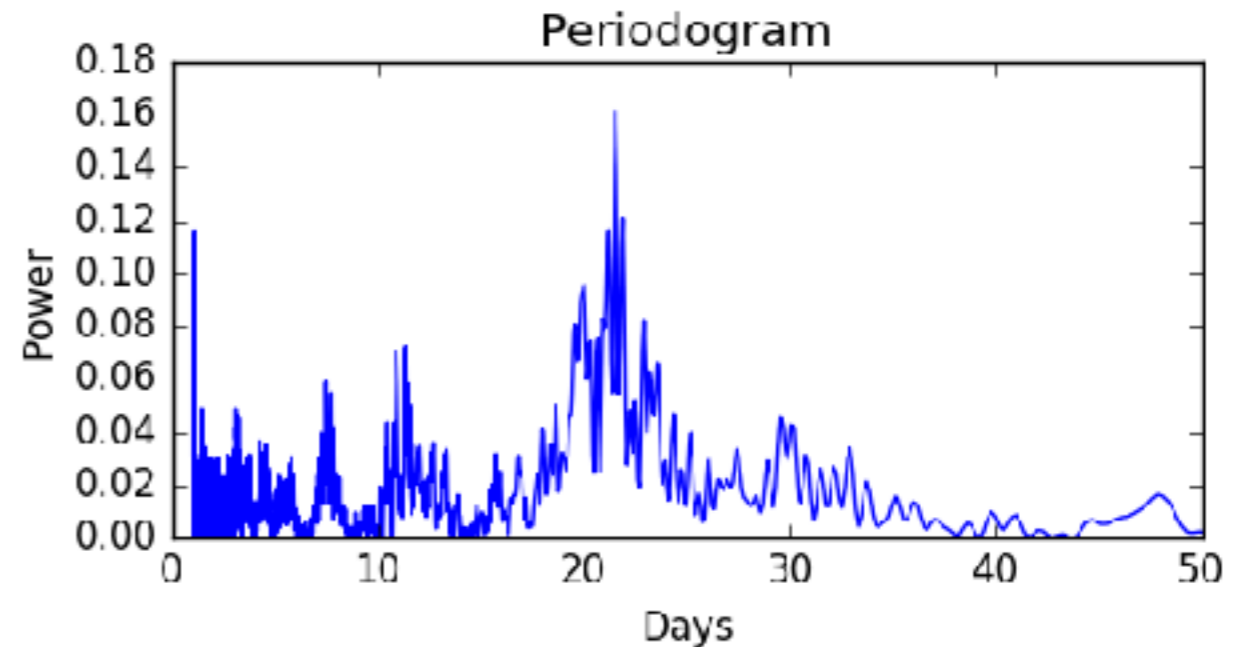
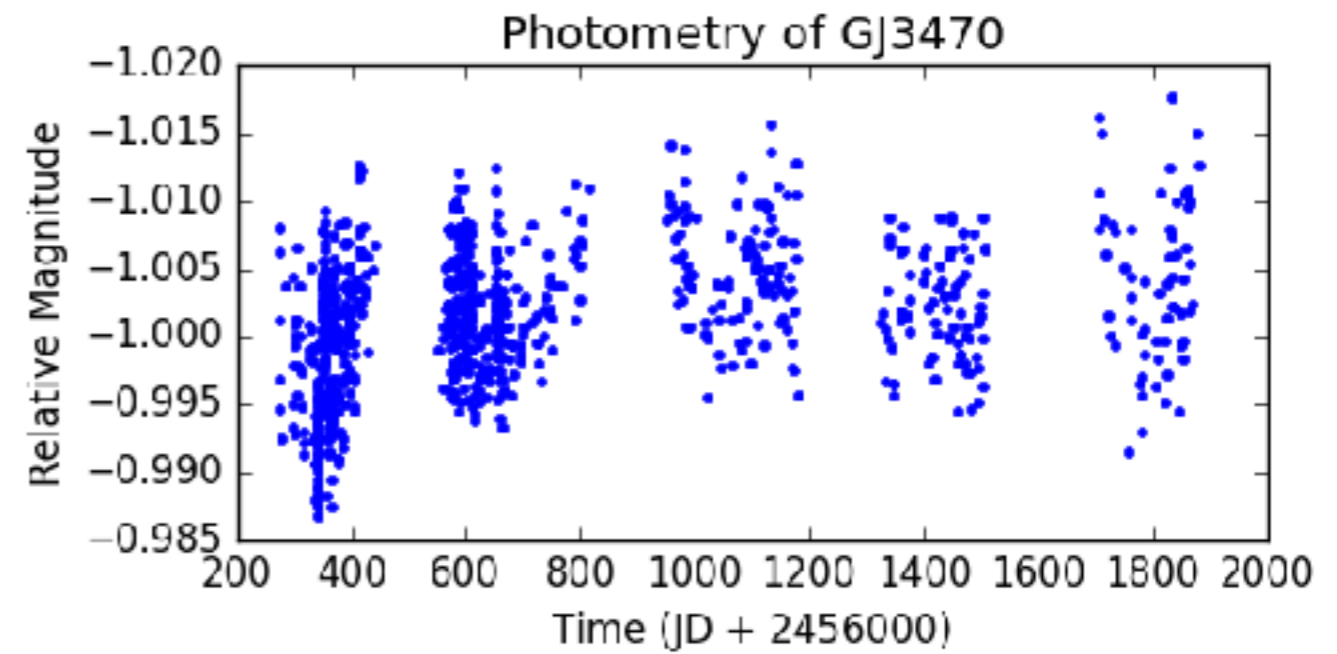


**Kosiarek et al. 2018
Dai et al. 2016
Almenara et al. 2015
Damasso et al. 2018
Bonfils et al 2012**

Magnetic activity on the stellar surface can induce planet-like signals in RV data.

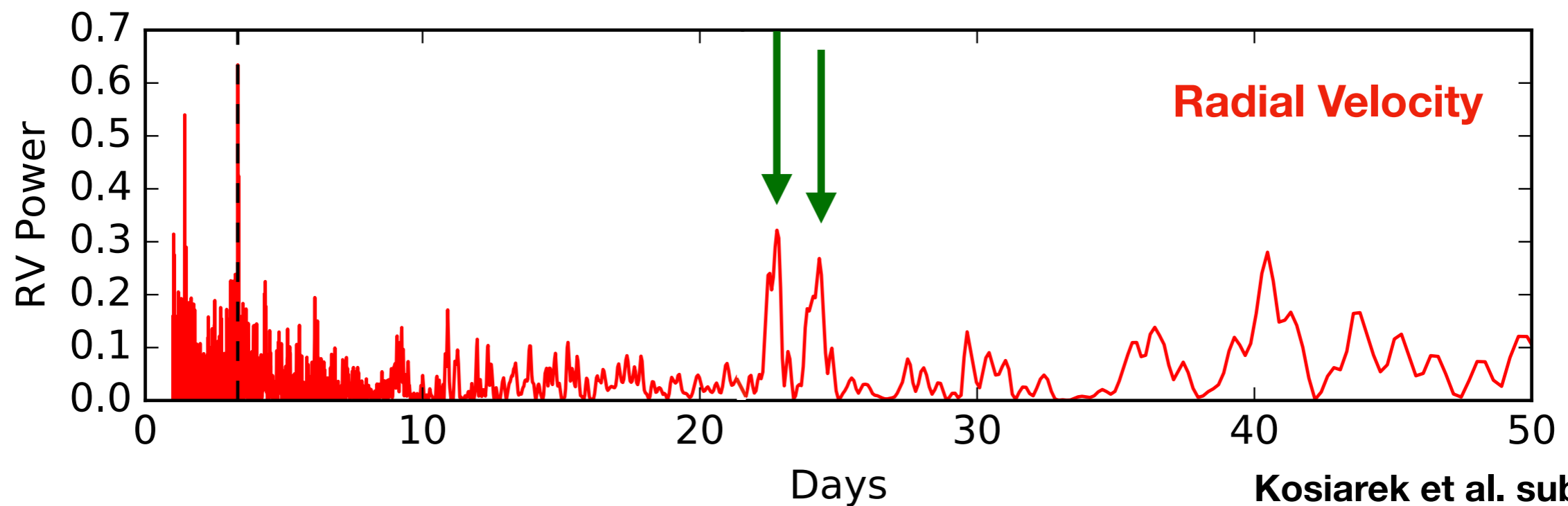
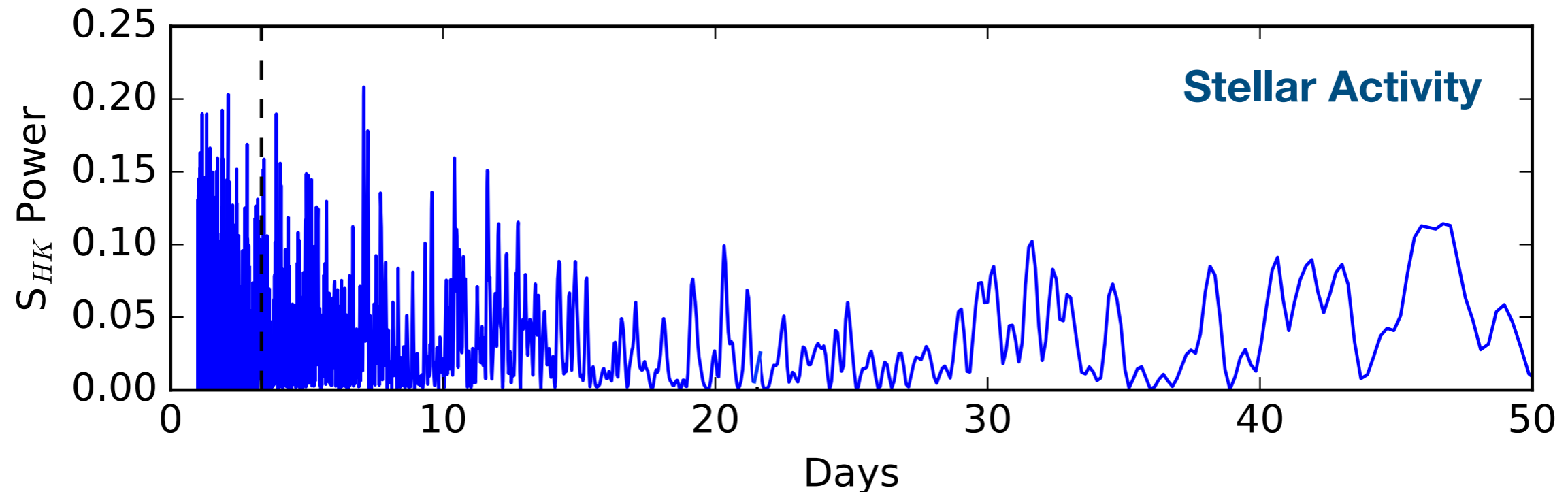


Fairborn Observatory AIT data of GJ3470 shows a stellar rotation period of 21.54 ± 0.49 days

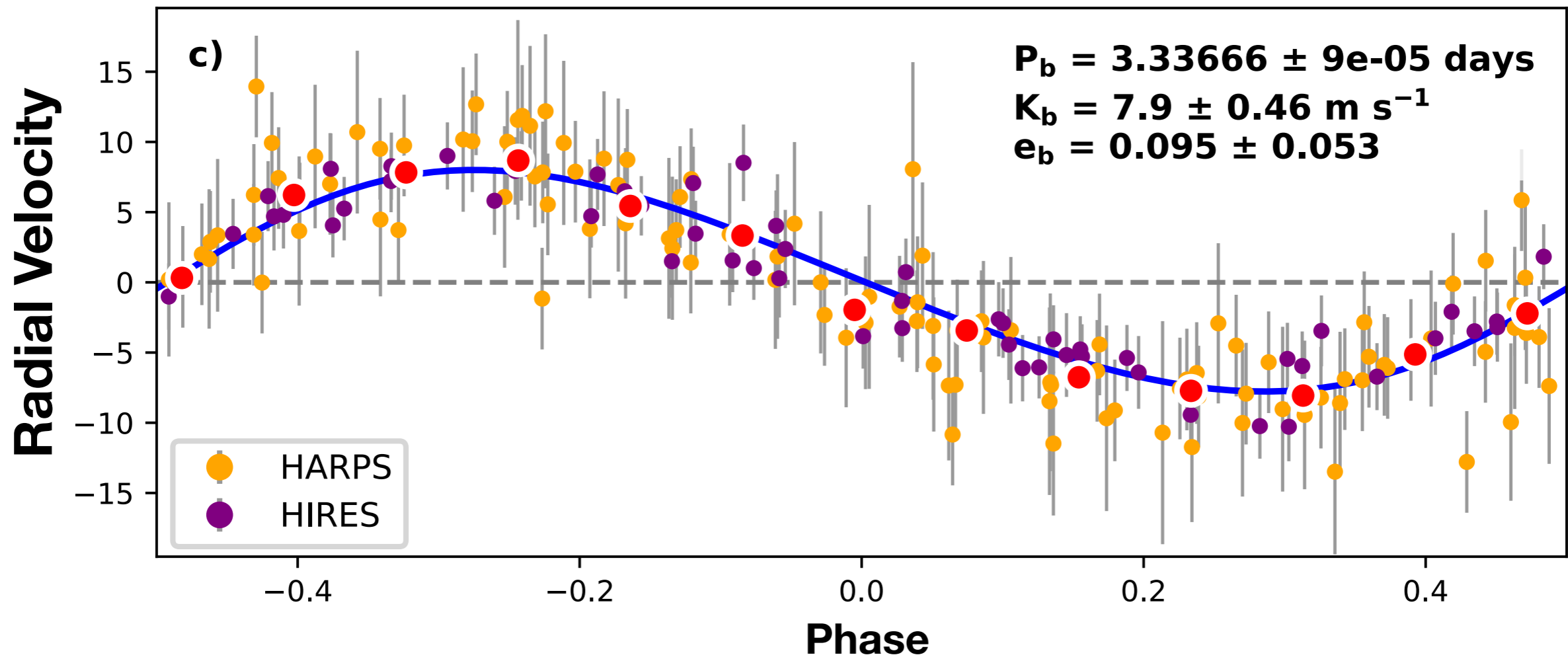


Kosiarek et al. submitted.

GJ3470: There are stellar activity signals in the RV data.



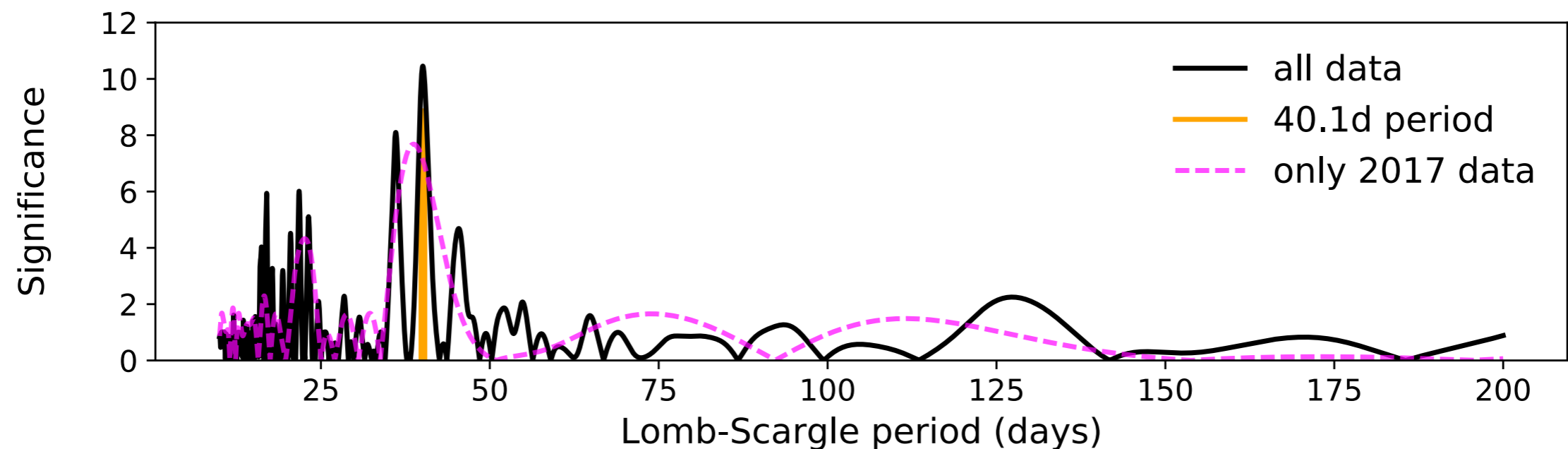
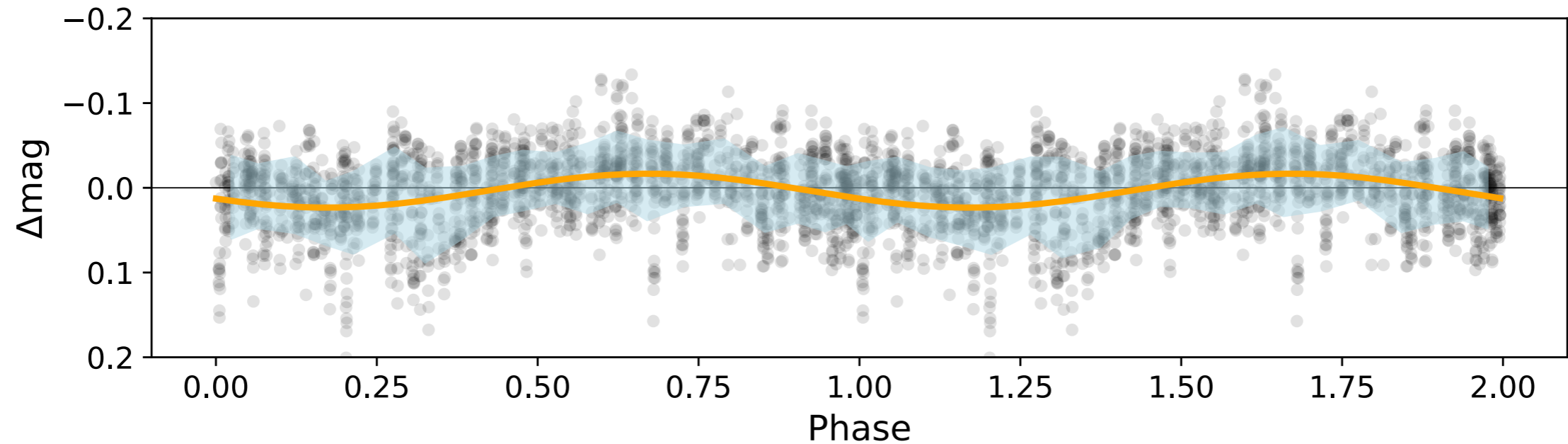
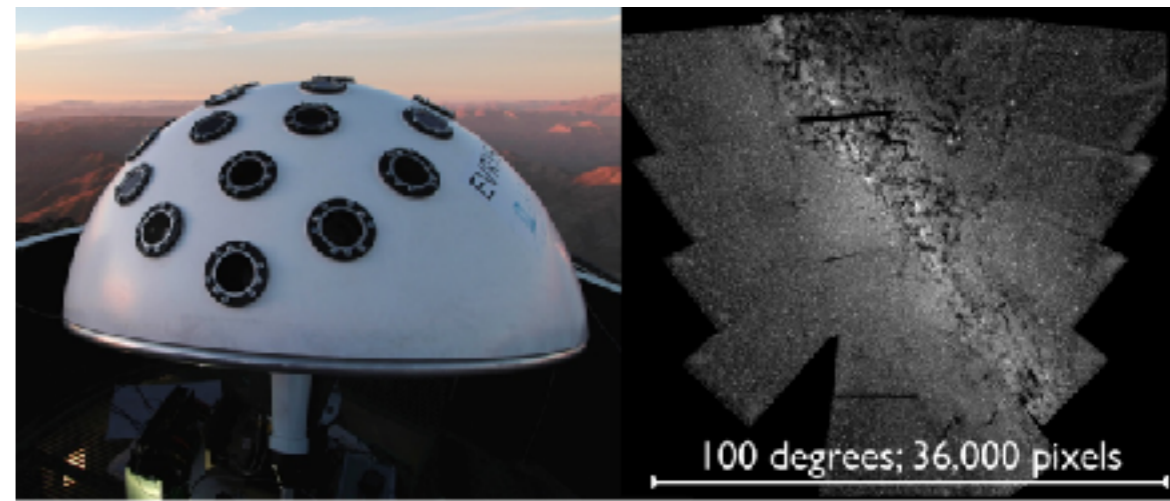
GJ3470: Radial Velocity fit including 57 HIRES and 113 HARPS measurements spanning 8 years.



Mass = $12.13 \pm 1.27 M_{\text{Earth}}$

Kosiarek et al. submitted

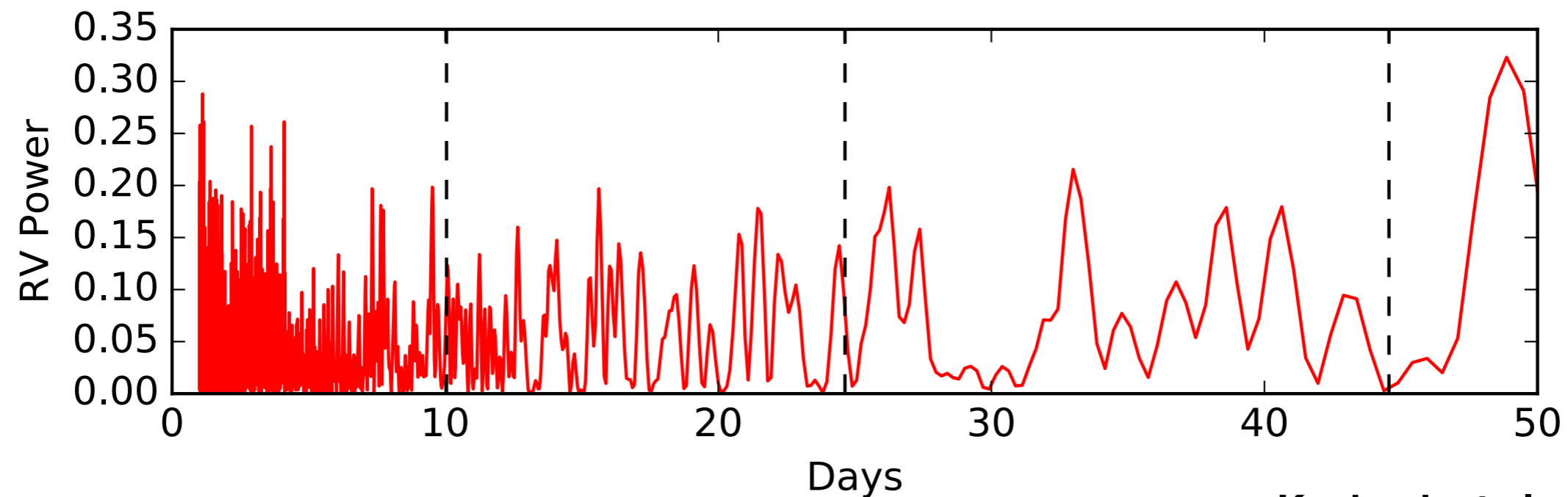
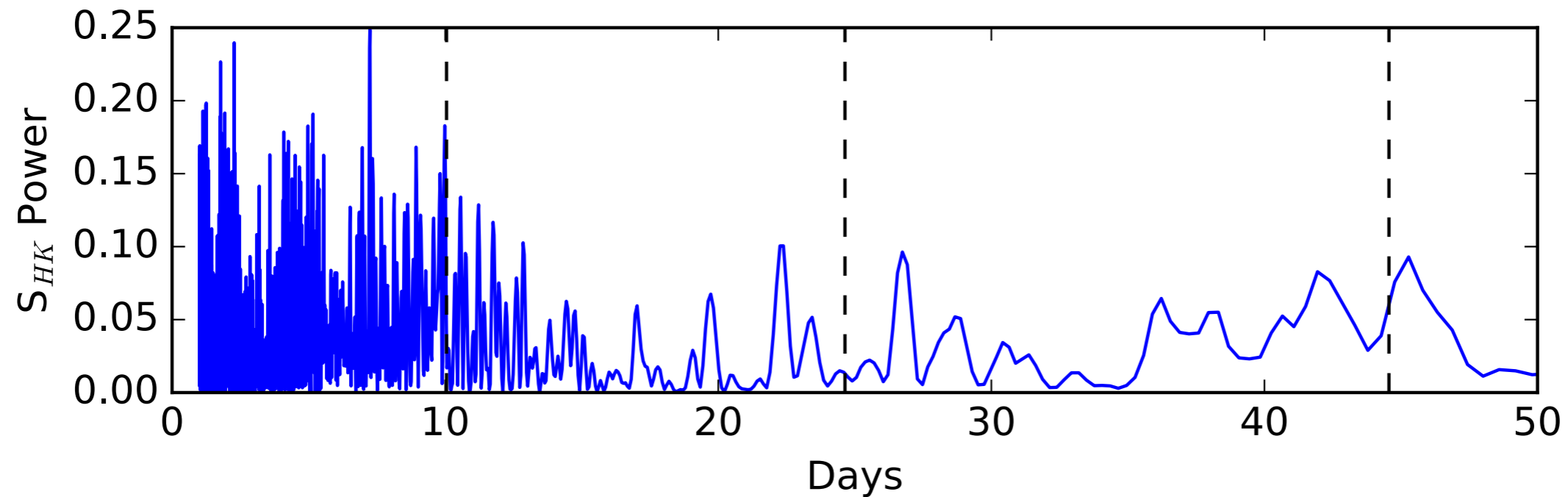
Evryscope data of K2-3 shows a stellar rotation period of 40 ± 2 days



Law et al. 2015

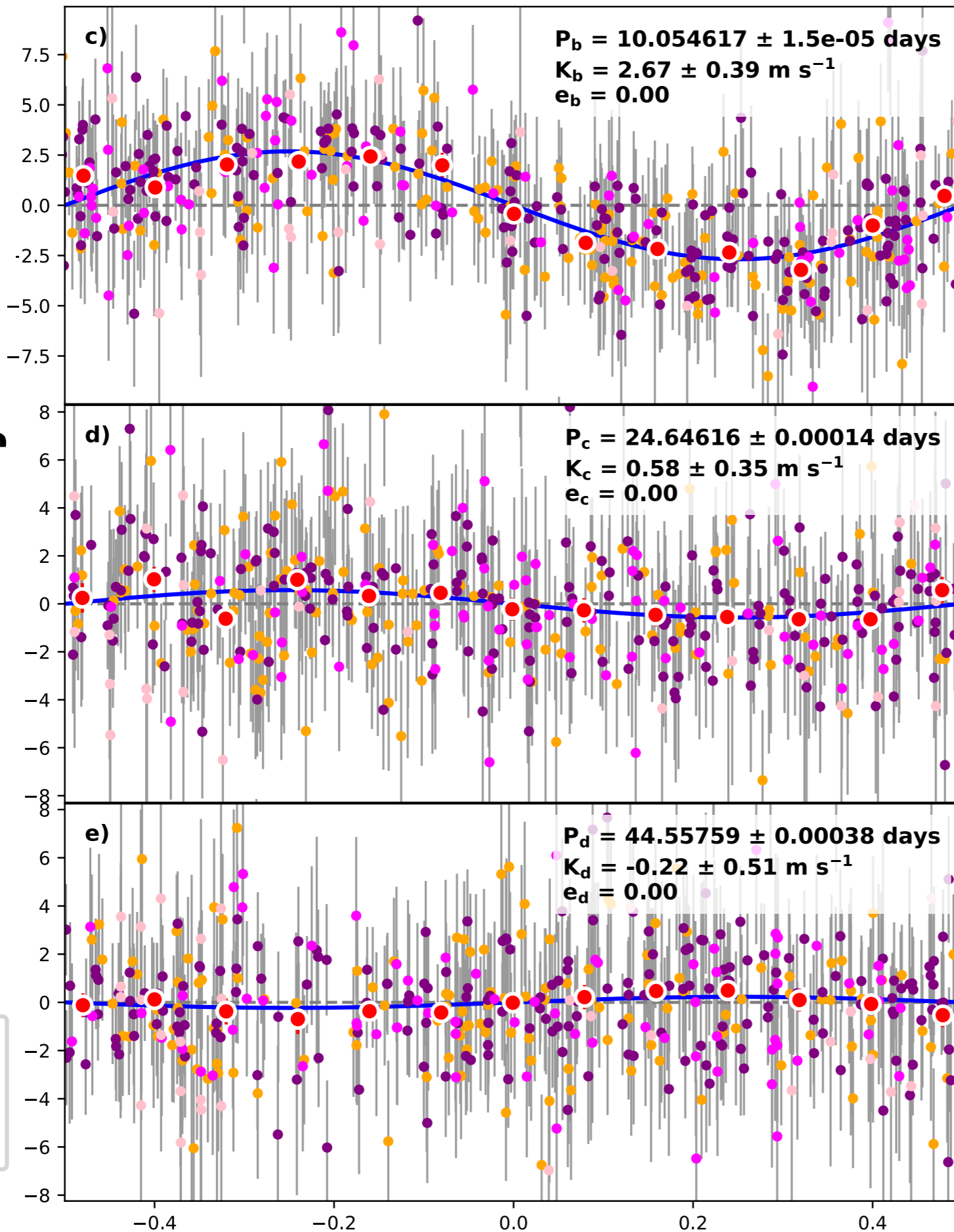
Kosiarek et al. submitted

K2-3: There are no clear stellar activity signals in the RV data or the S_{HK} data.



Kosiarek et al. submitted

Radial Velocity



6.4 ± 1.2
 M_{Earth}

1.8 ± 1.2
 M_{Earth}

1- σ upper
limit:
 $1.1 M_{\text{Earth}}$

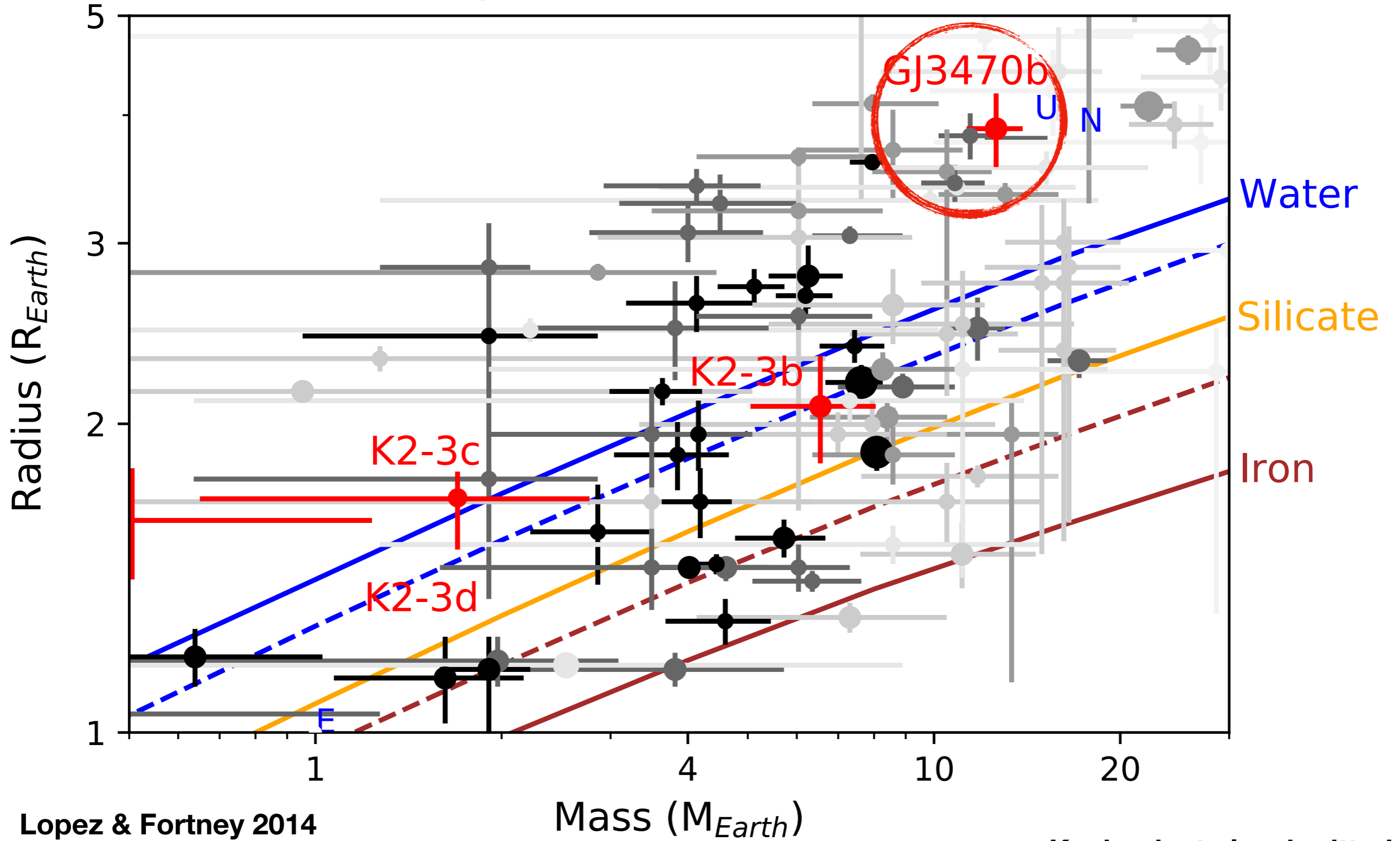
Kosiarek et al. submitted

Damasso et al. 2018

Dai et al. 2016 Almenara et al. 2015

Phase

GJ3470 has between 4% and 13% H/He depending on the core composition.

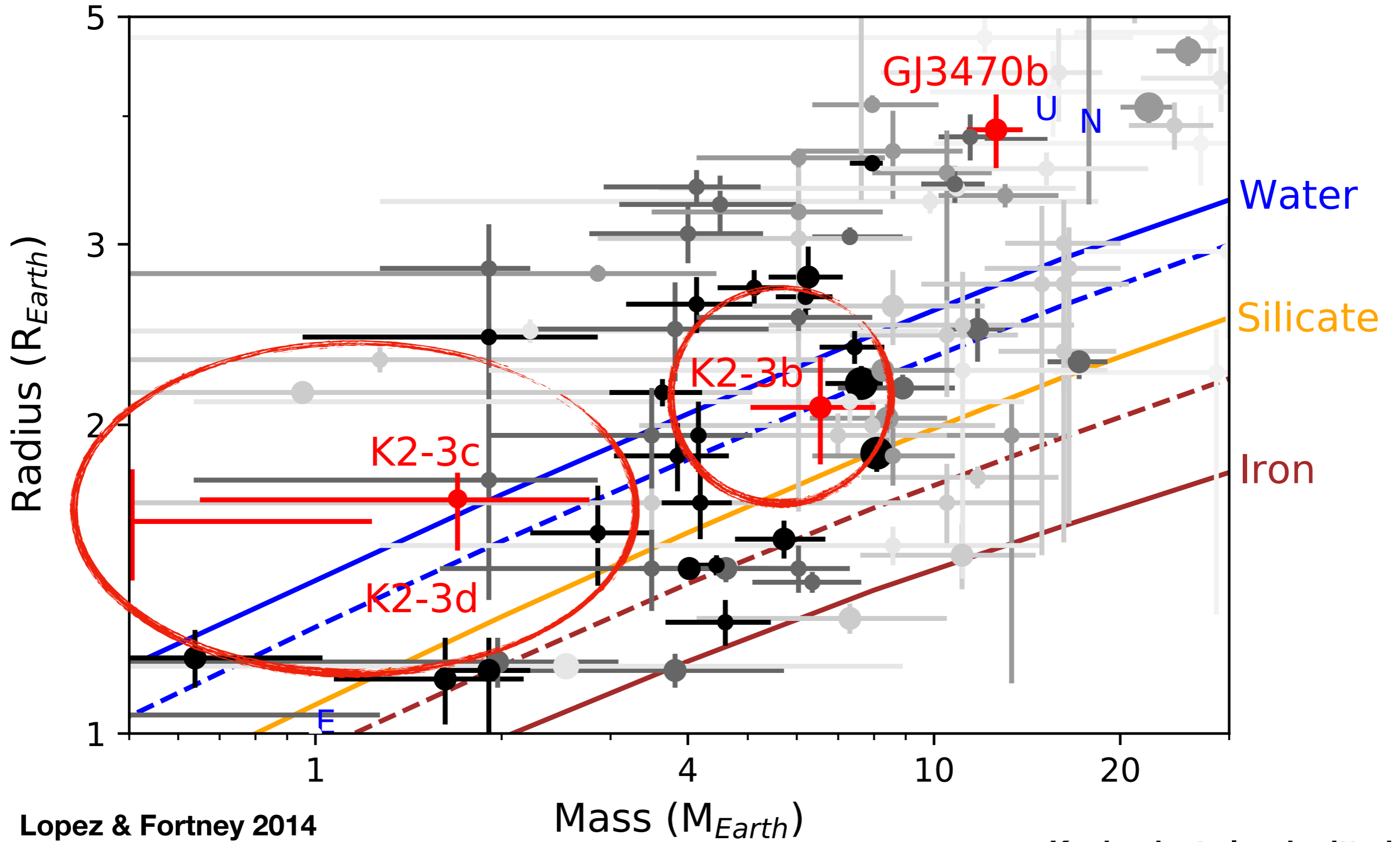


Lopez & Fortney 2014

Zeng et al. 2016

Kosiarek et al. submitted

Assuming an Earth-like core, K2-3 b and c have 0.4% and 0.8% H+He by mass.



Lopez & Fortney 2014
Zeng et al. 2016

Kosiarek et al. submitted

Key Points

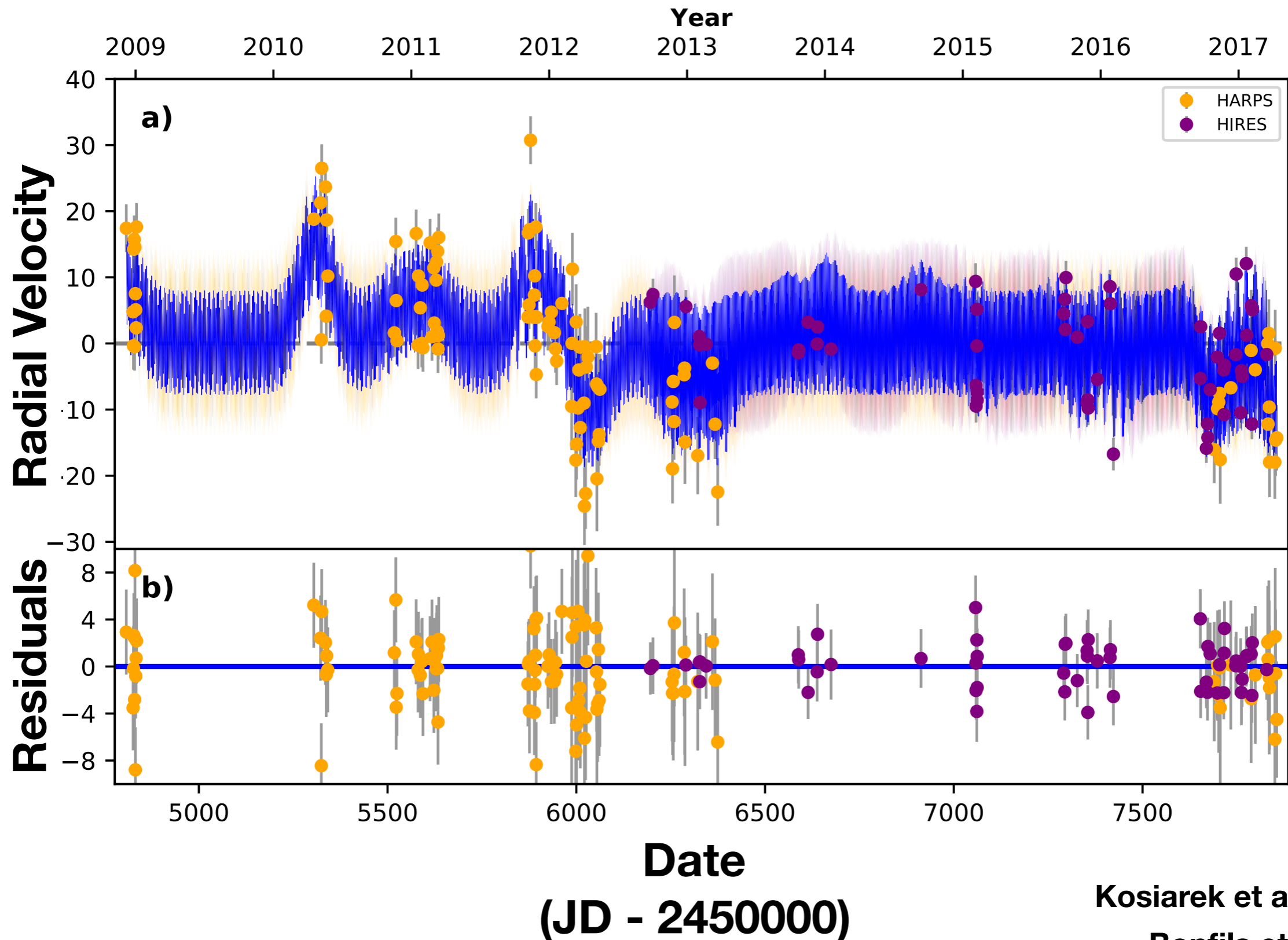
- We measured the masses of GJ3470 b and K2-3 b, c, d, crucial for transit spectroscopy measurements.
- The mass of K2-3 d is less well constrained due to the similarities in stellar rotation period and planet orbital period.
- Calcium H and K were poor indicators for stellar activity in these two M dwarf stars.
- We refined the periods and radii of K2-3 b, c, and d from Spitzer transits. This ephemeris refinement is essential for future JWST transmission spectroscopy measurements.

See Kosiarek et al. submitted. for more information.

Coming to an arxiv near you soon!

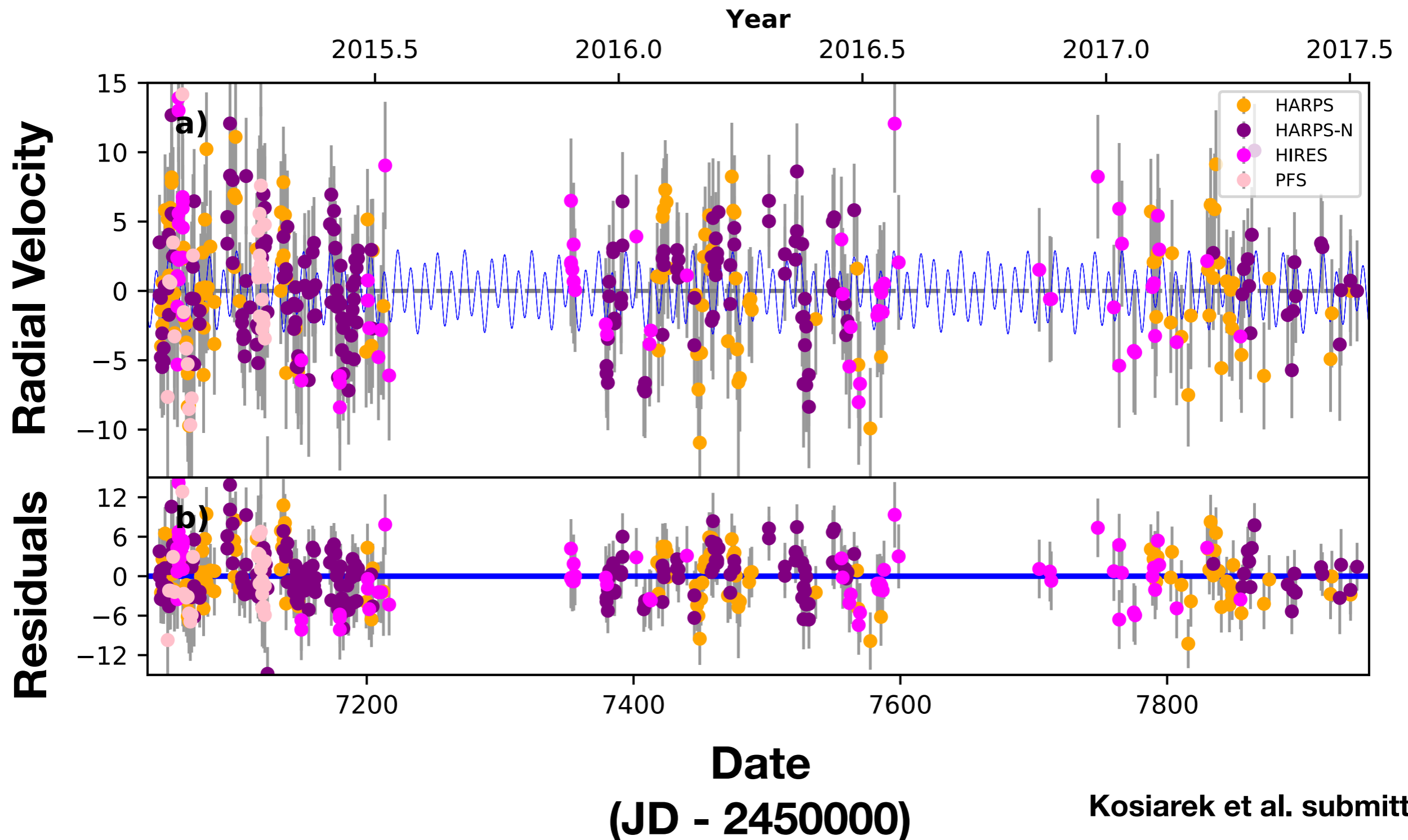
Backup Slides

GJ3470: Radial Velocity fit including 57 HIRES and 113 HARPS measurements spanning 8 years.



Kosiarek et al. submitted
Bonfils et al. 2012

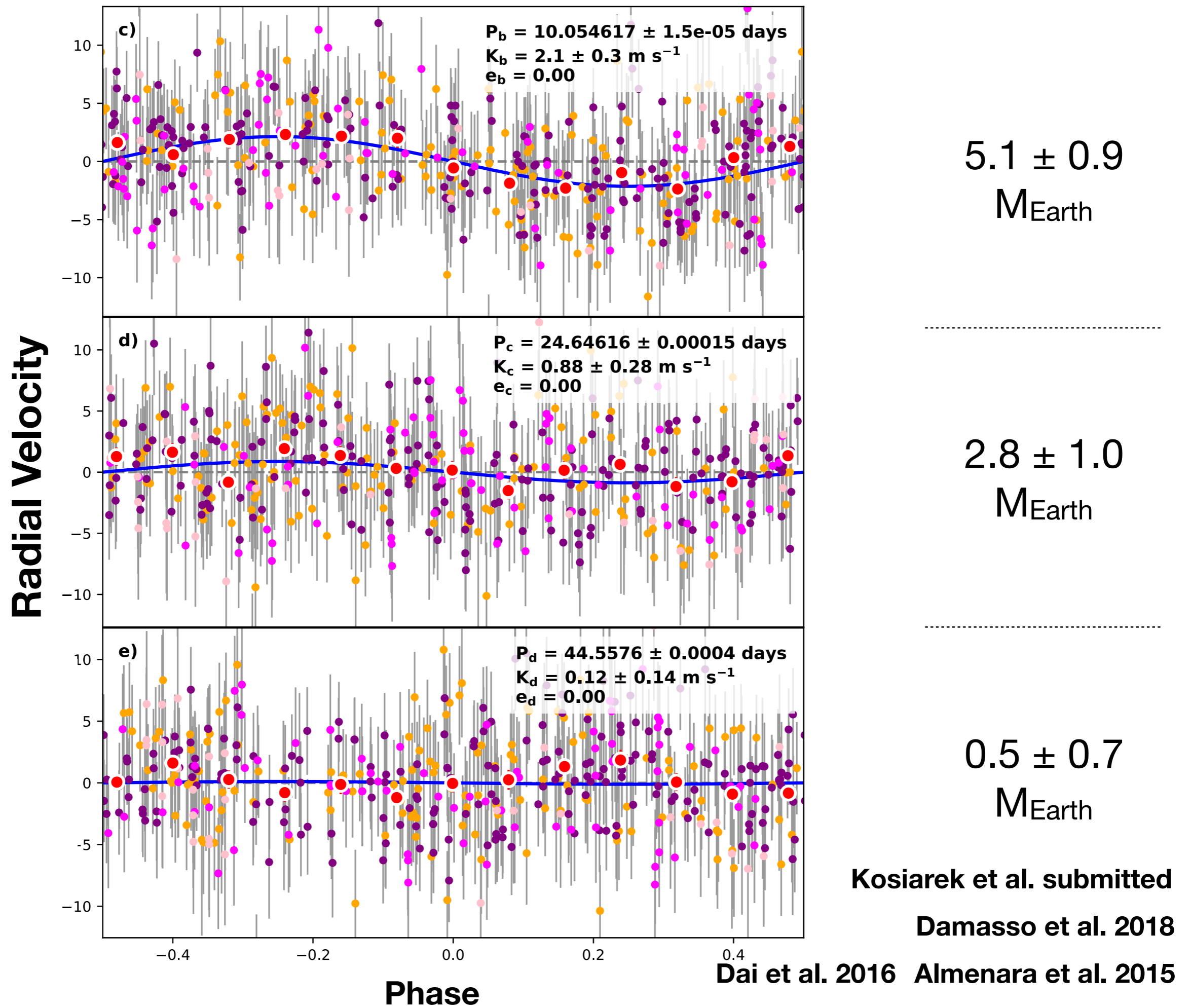
K2-3: Radial Velocity fit including 74 HIRES, 31 PFS, 132 HARPS, and 197 HARPS-N measurements spanning 3 years.



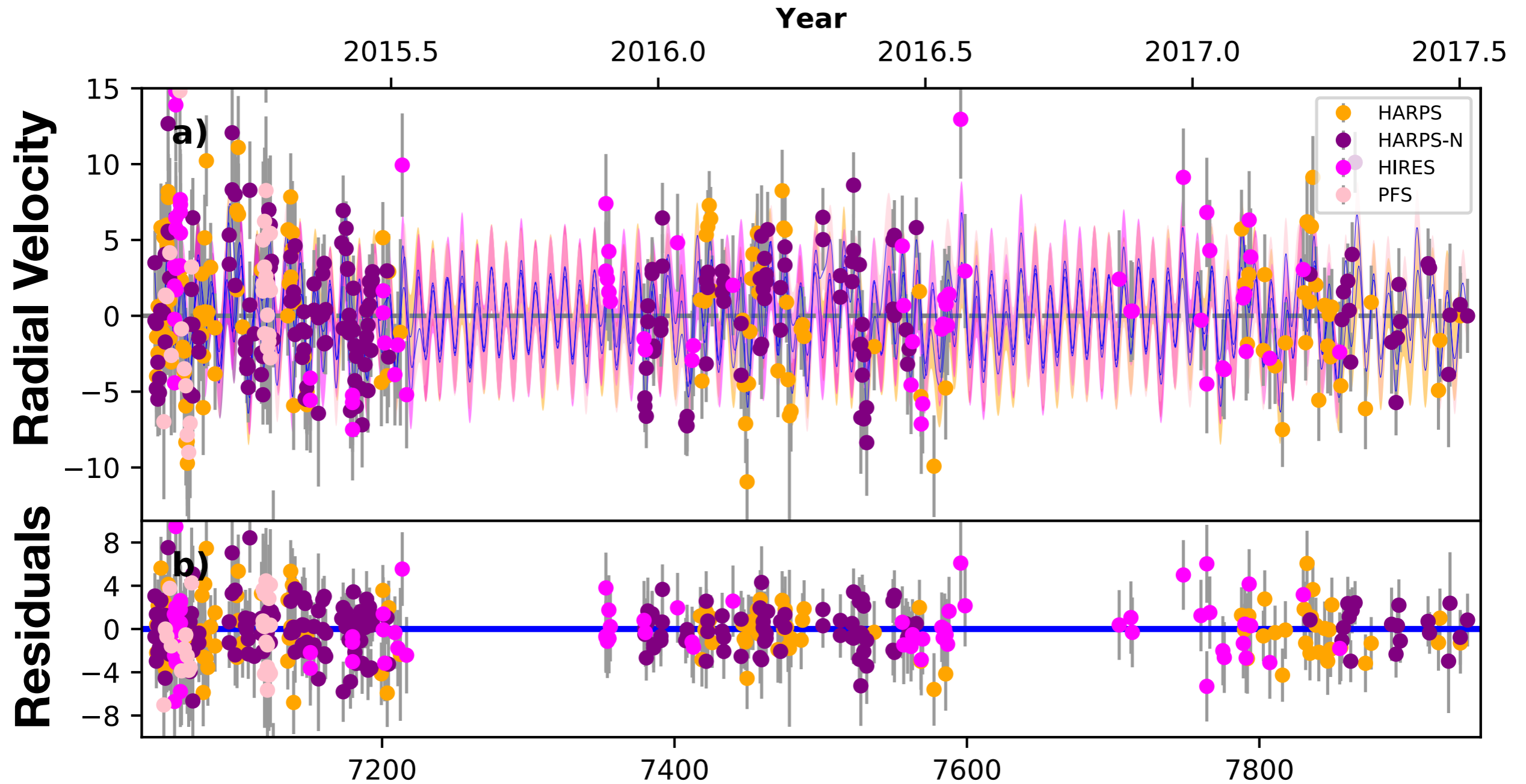
Kosiarek et al. submitted

Damasso et al. 2018

Dai et al. 2016 Almenara et al. 2015



K2-3: Radial Velocity fit with Gaussian Processes.

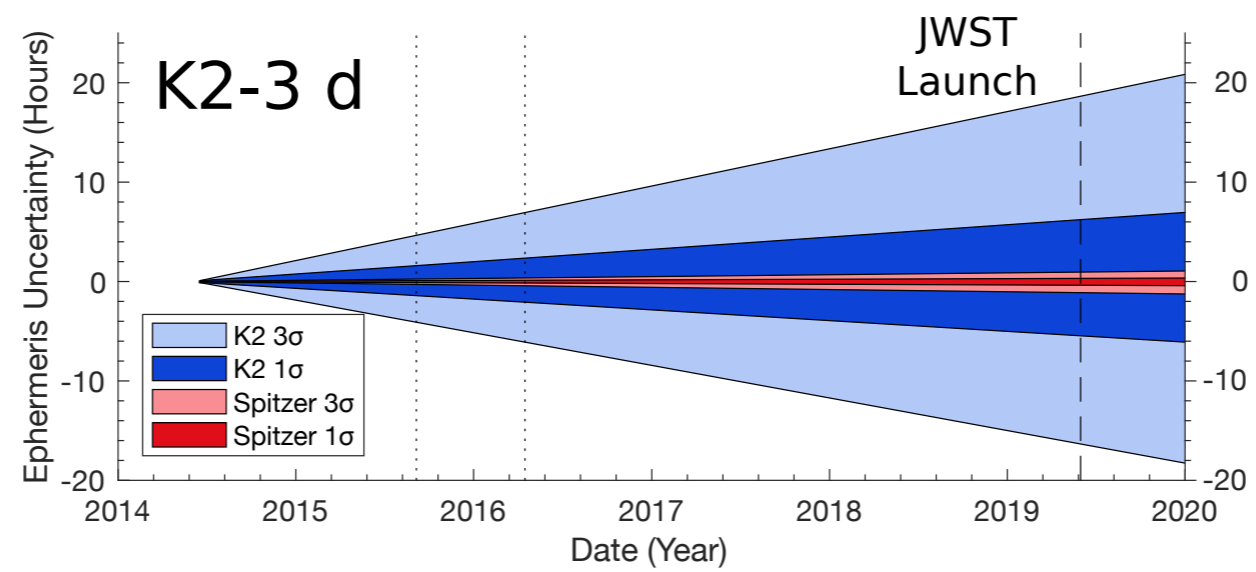
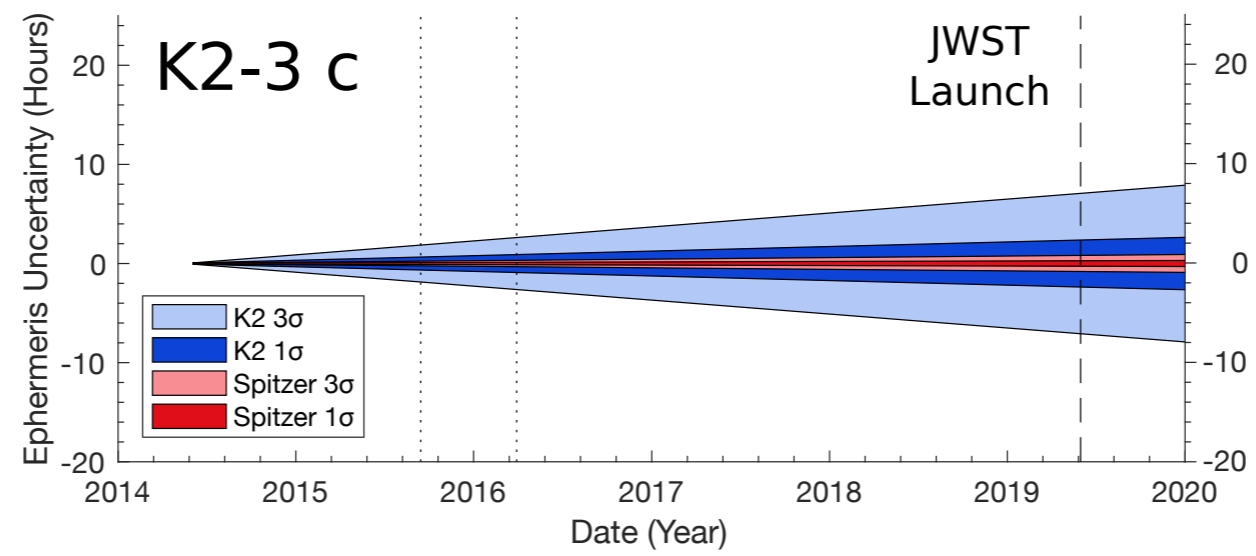
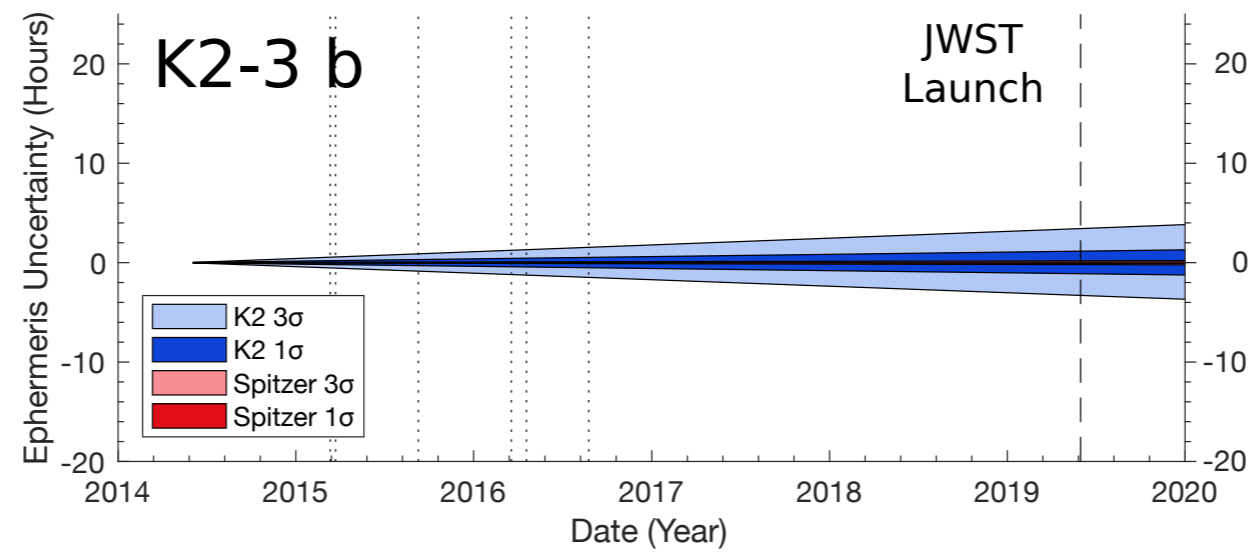


Date
(JD - 2450000)

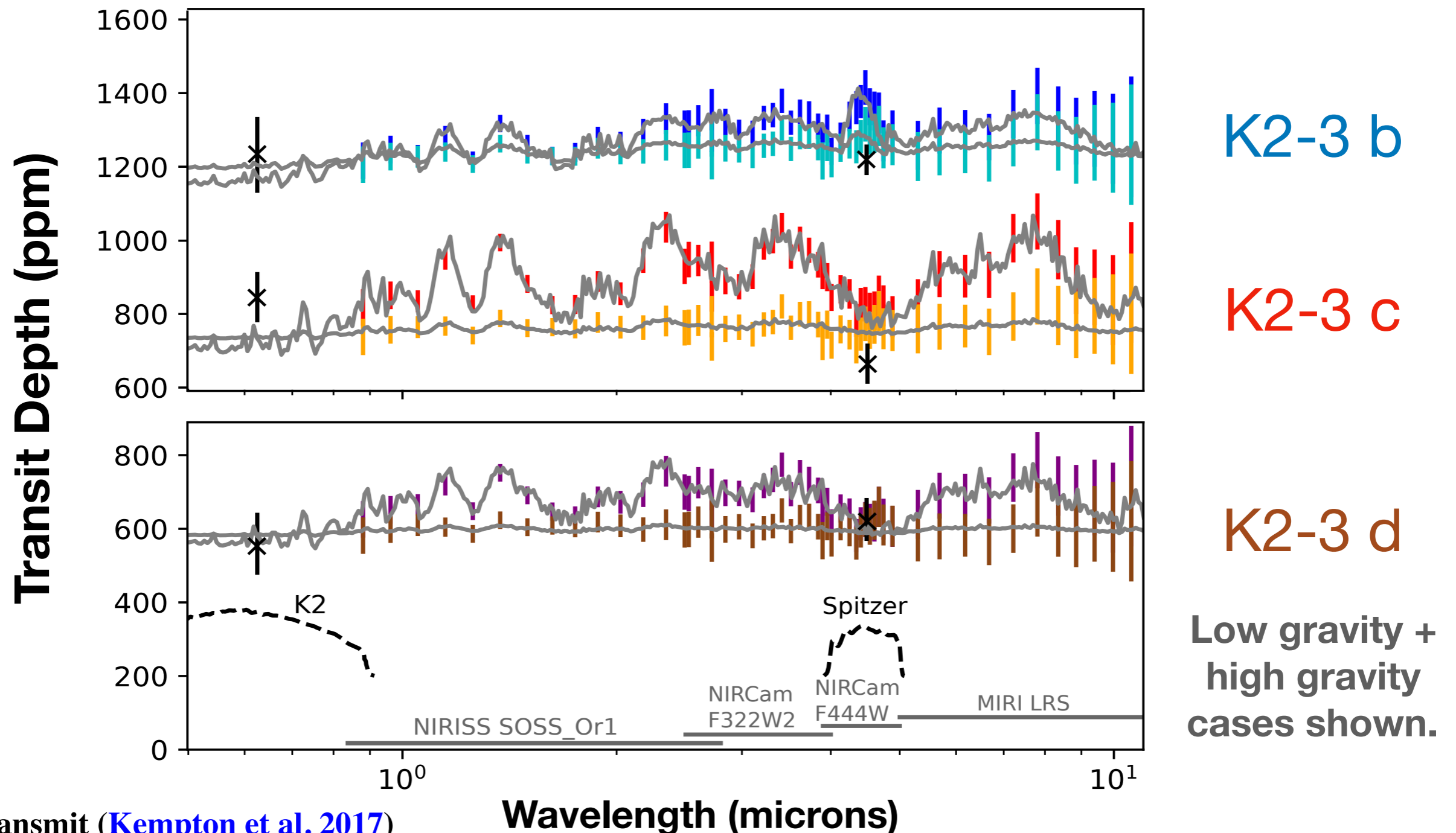
Kosiarek et al. submitted

Damasso et al. 2018

Dai et al. 2016 Almenara et al. 2015



K2-3: JWST transmission spectroscopy can determine atmospheric composition.



ExoTransmit ([Kempton et al. 2017](#))

PandExo ([Greene et al. 2016](#); [Batalha et al. 2017b](#))

Kosiarek et al. submitted.