TESS Insights into the Impact of Stellar Mass on the Exoplanet Radius Valley.

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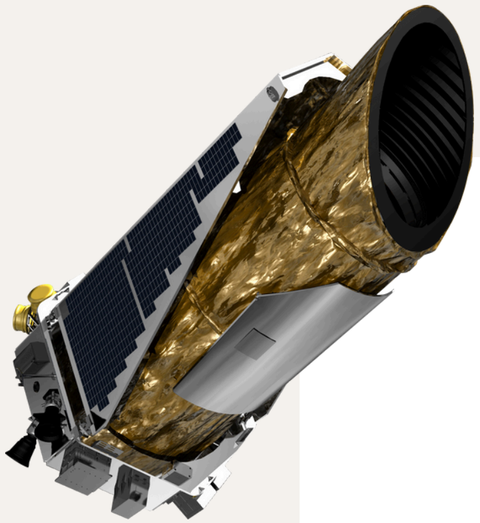
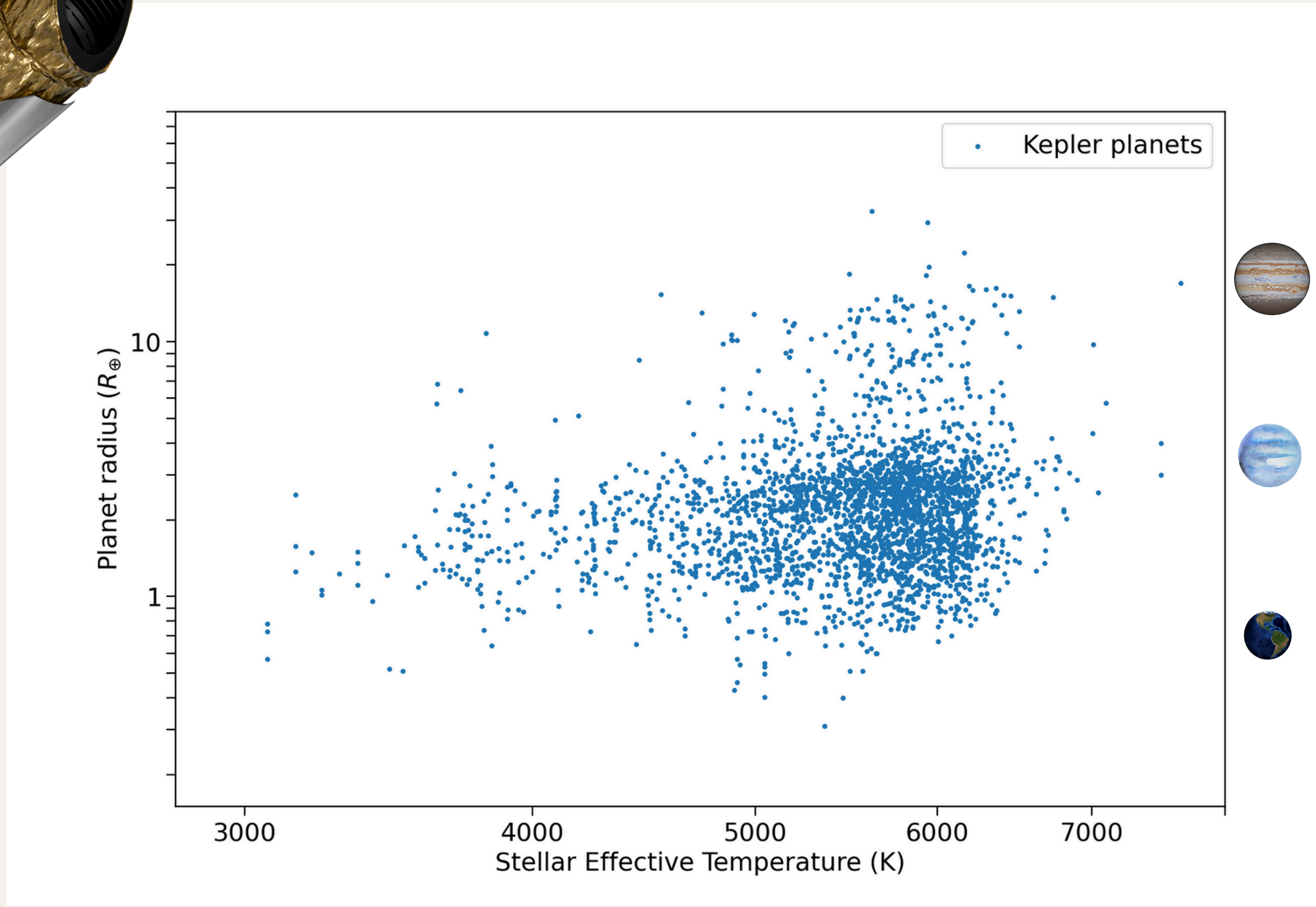
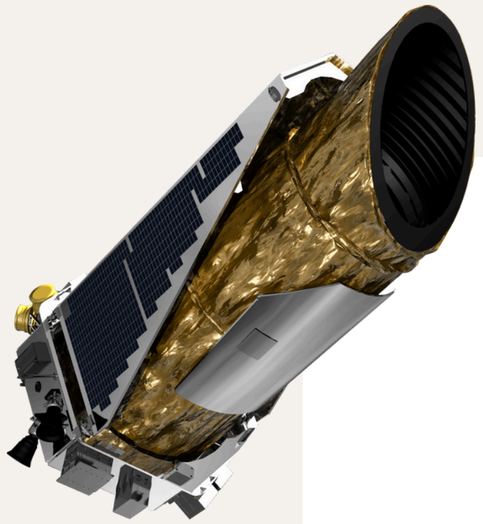
Know thy star, Know thy planet 2
February 4, 2025

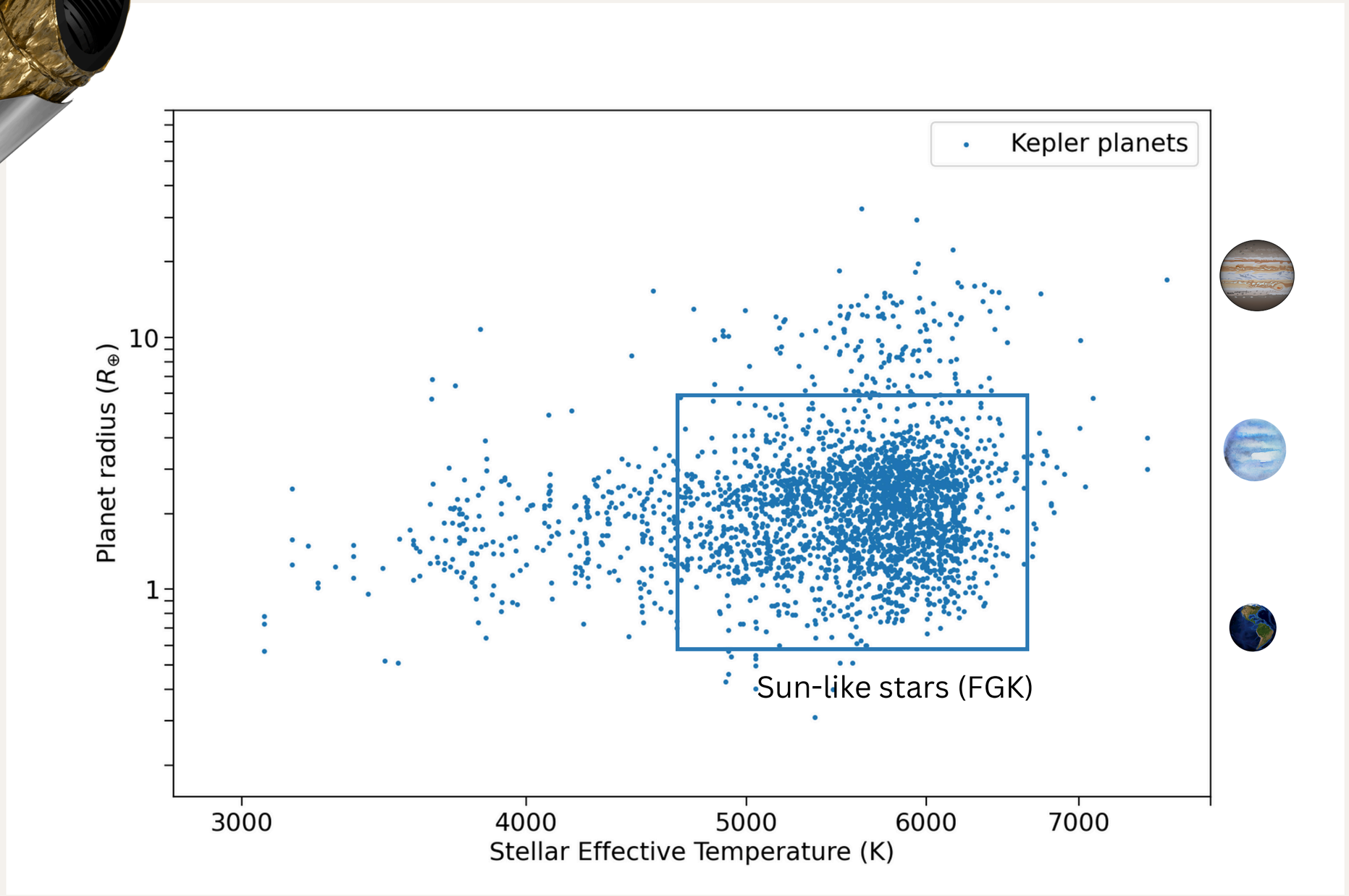


Kepler Exoplanet Discoveries





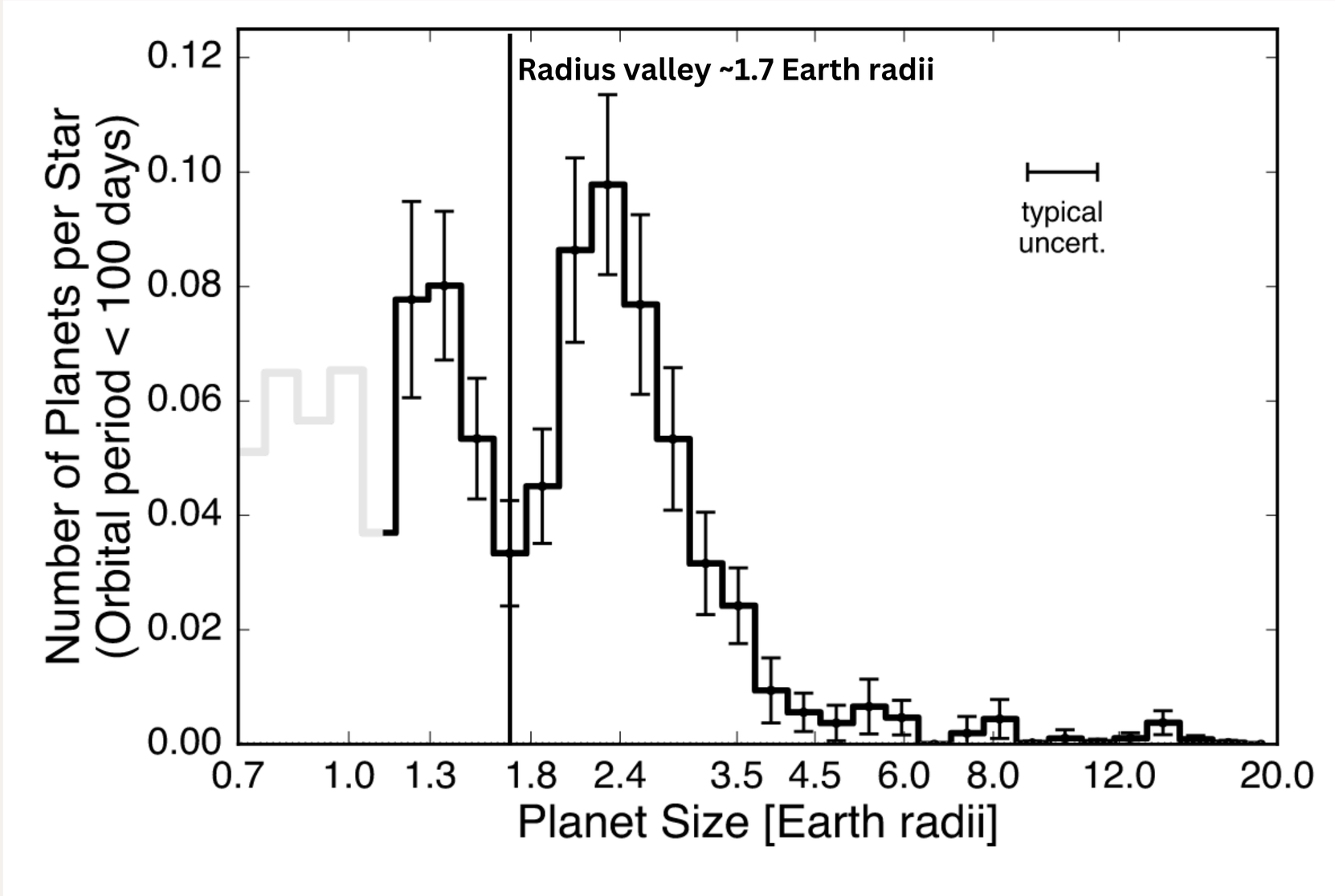
Kepler Exoplanet Discoveries



Radius Valley

A Gap in the Radius Distribution of Kepler Planets.

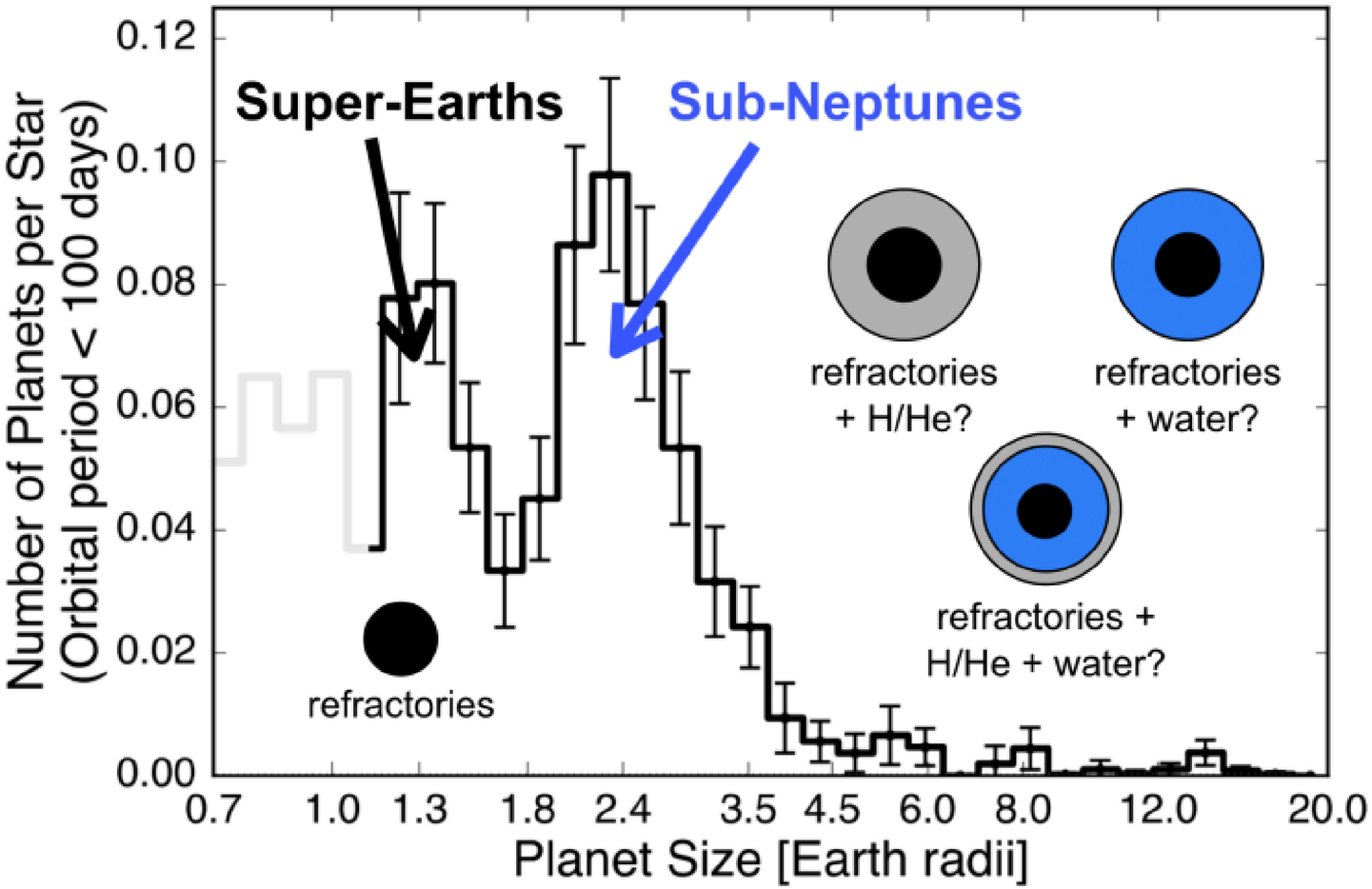
Fulton+ 2017



The radius valley was revealed, once the stellar sample was adopted from the California-Kepler Survey.

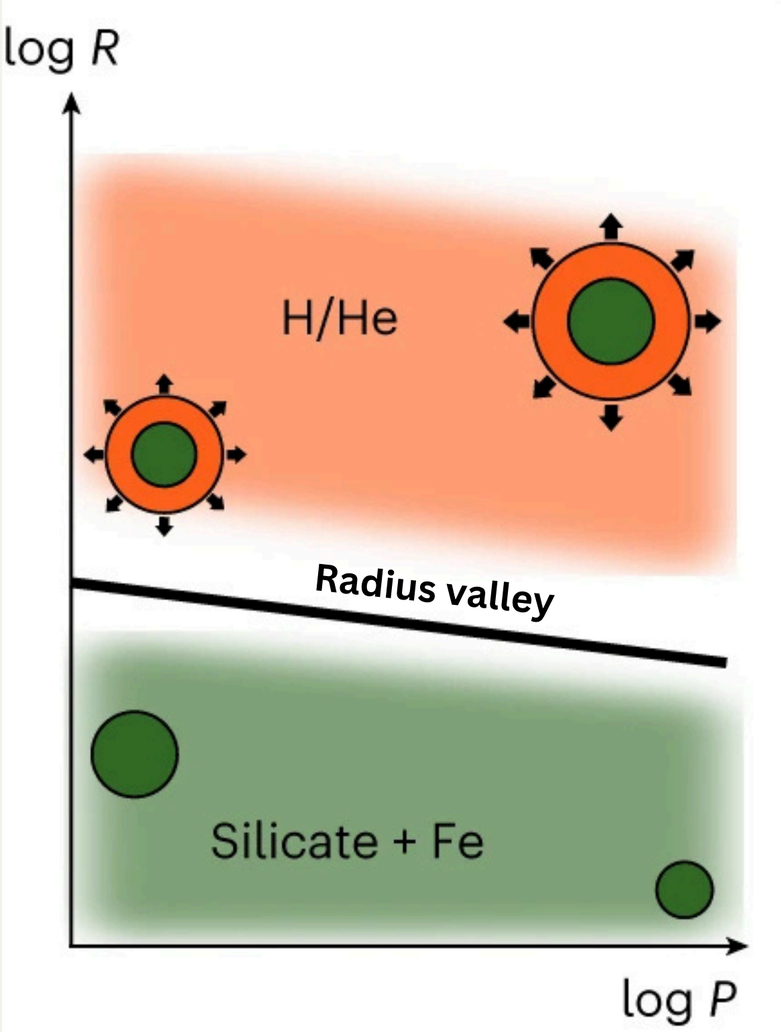
Radius Valley

A Gap in the Radius Distribution of Kepler Planets.



Cloutier 2024

Causes for Radius Valley

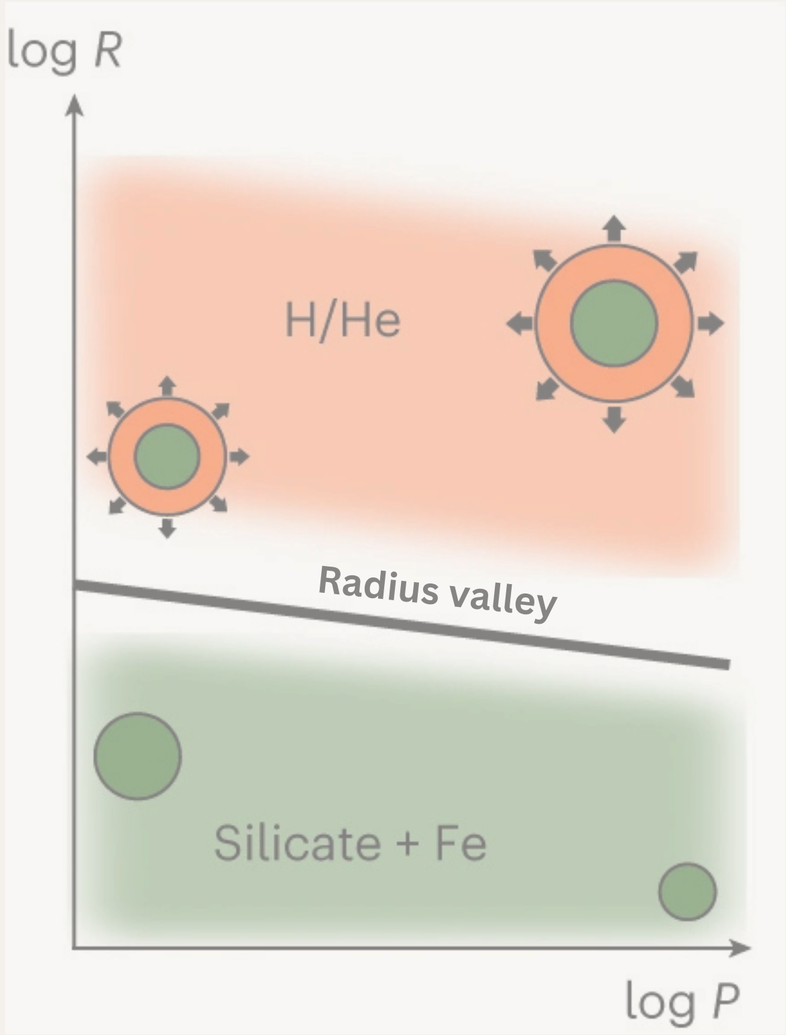


Burn et al 2024

Atmospheric mass-loss

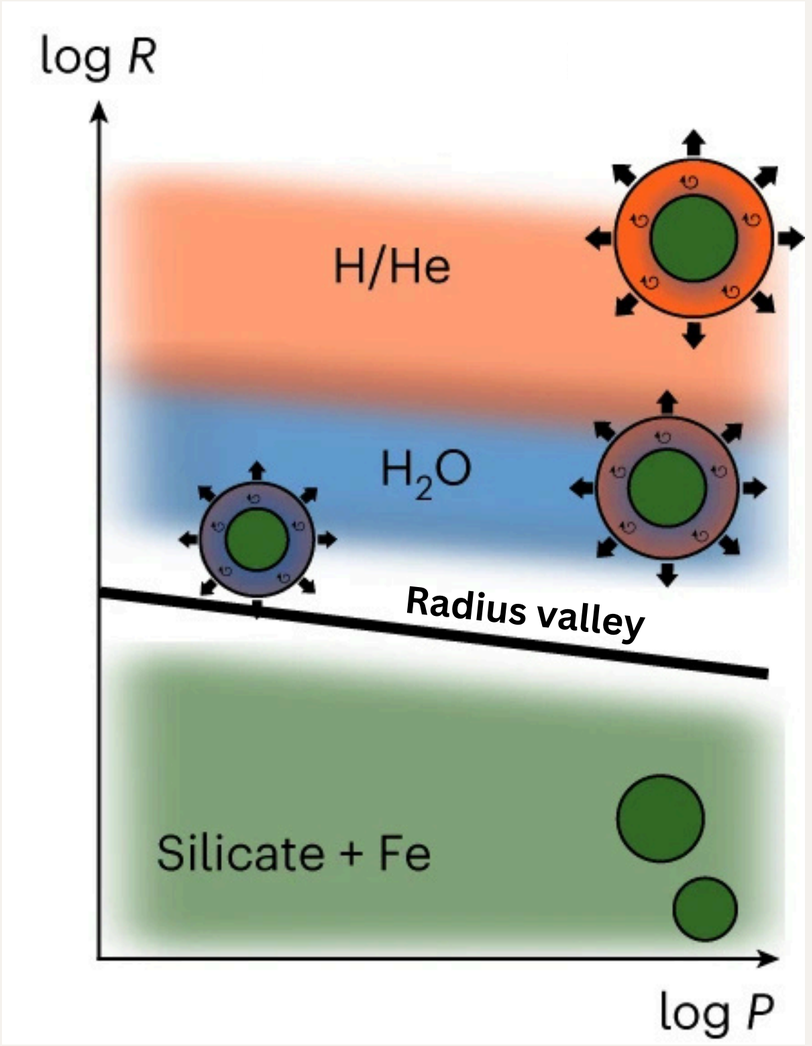
- Photoevaporation
- Core-Powered mass loss

Causes for Radius Valley



Atmospheric mass-loss models

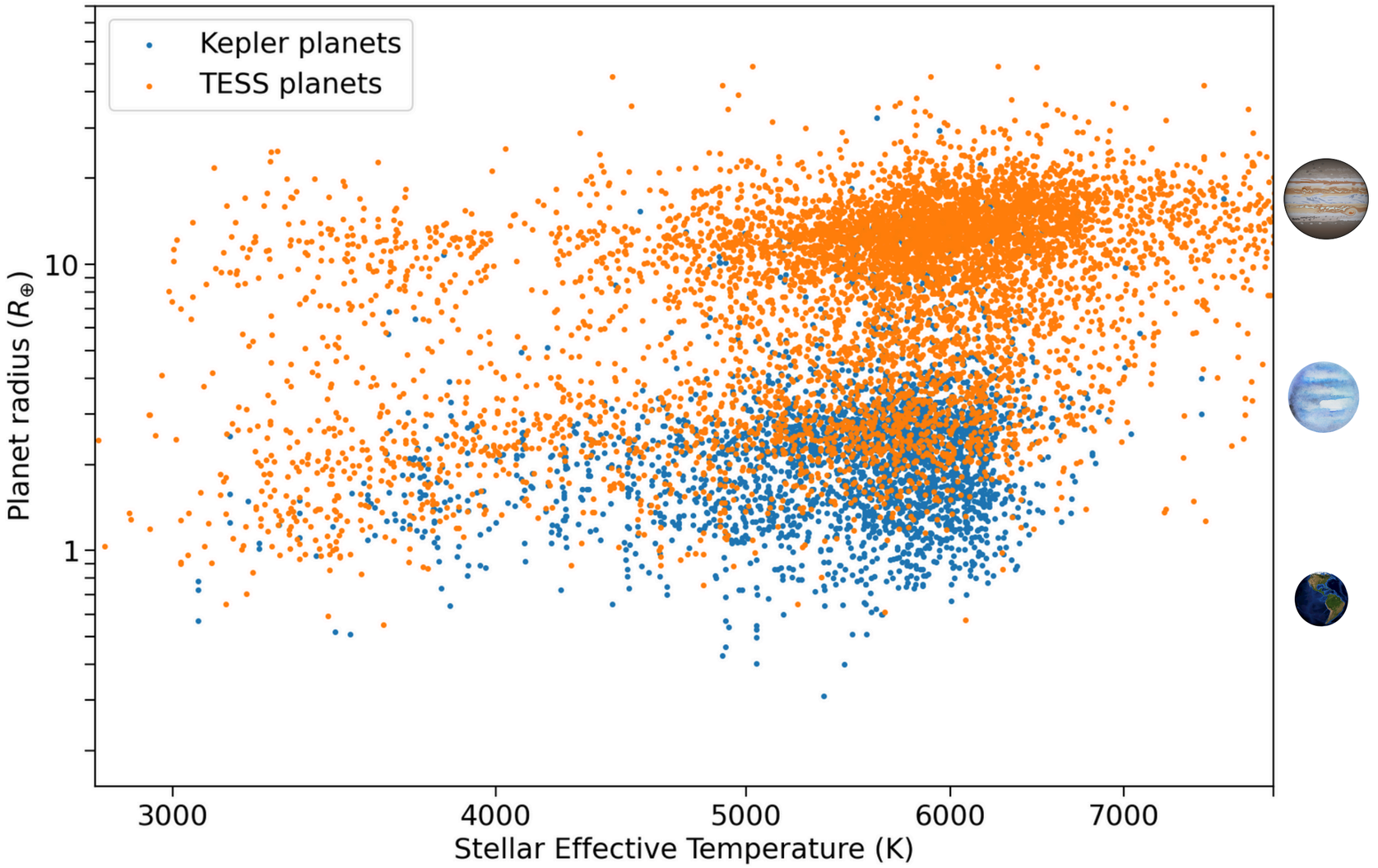
- Photoevaporation
- Core-Powered mass loss



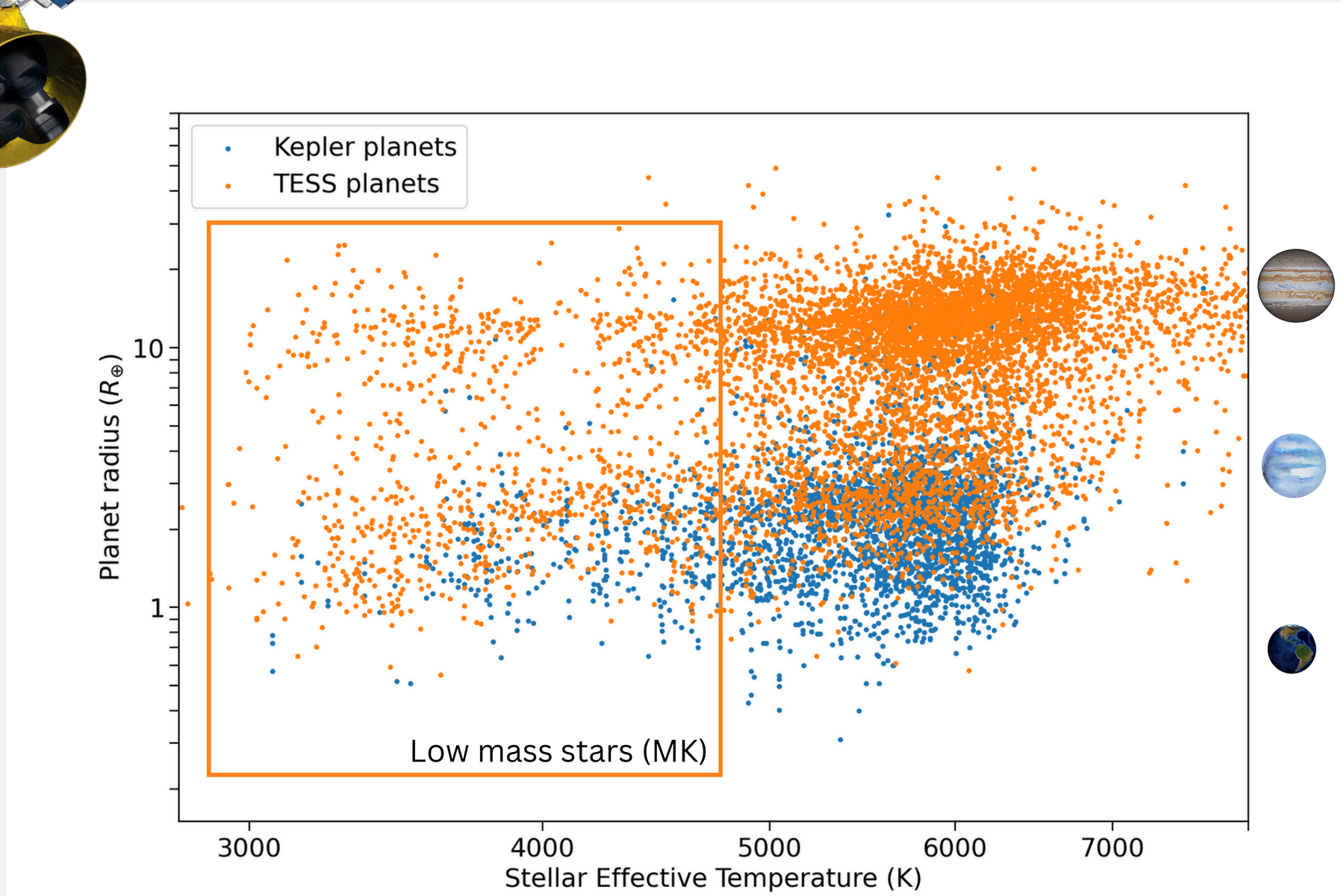
Presence of water worlds

Burn et al 2024

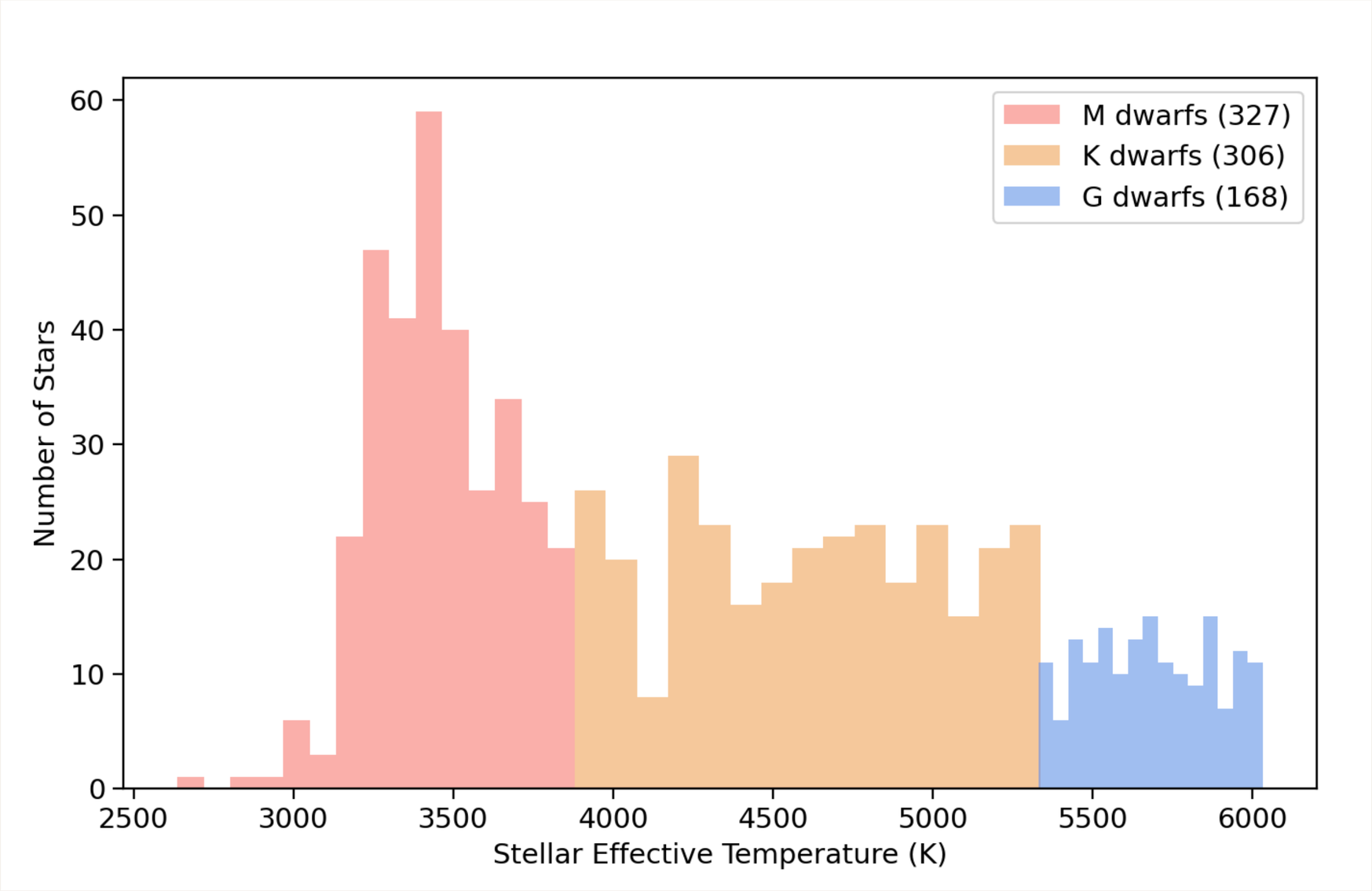
TESS Exoplanet Discoveries



TESS Exoplanet Discoveries

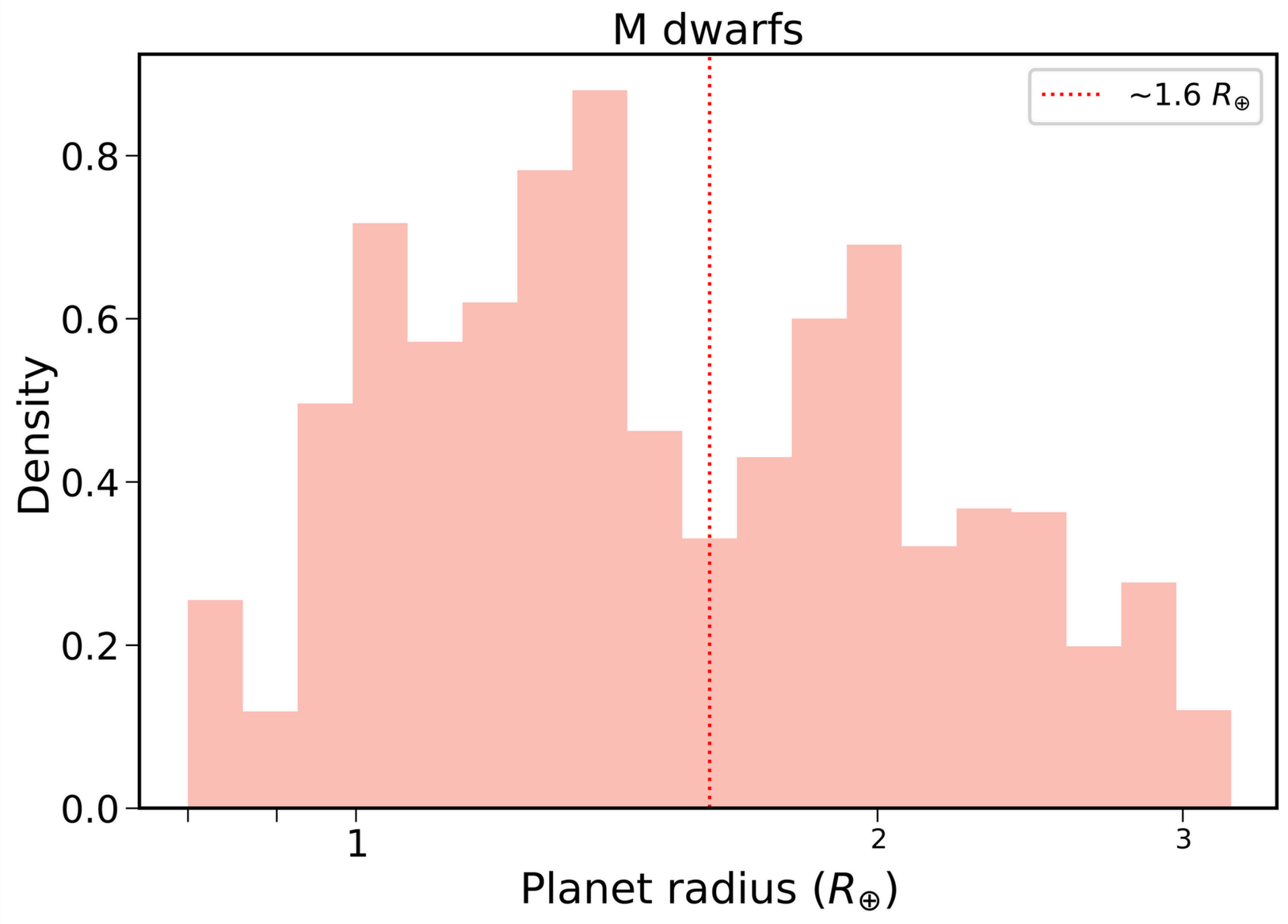


Sample of low mass stars



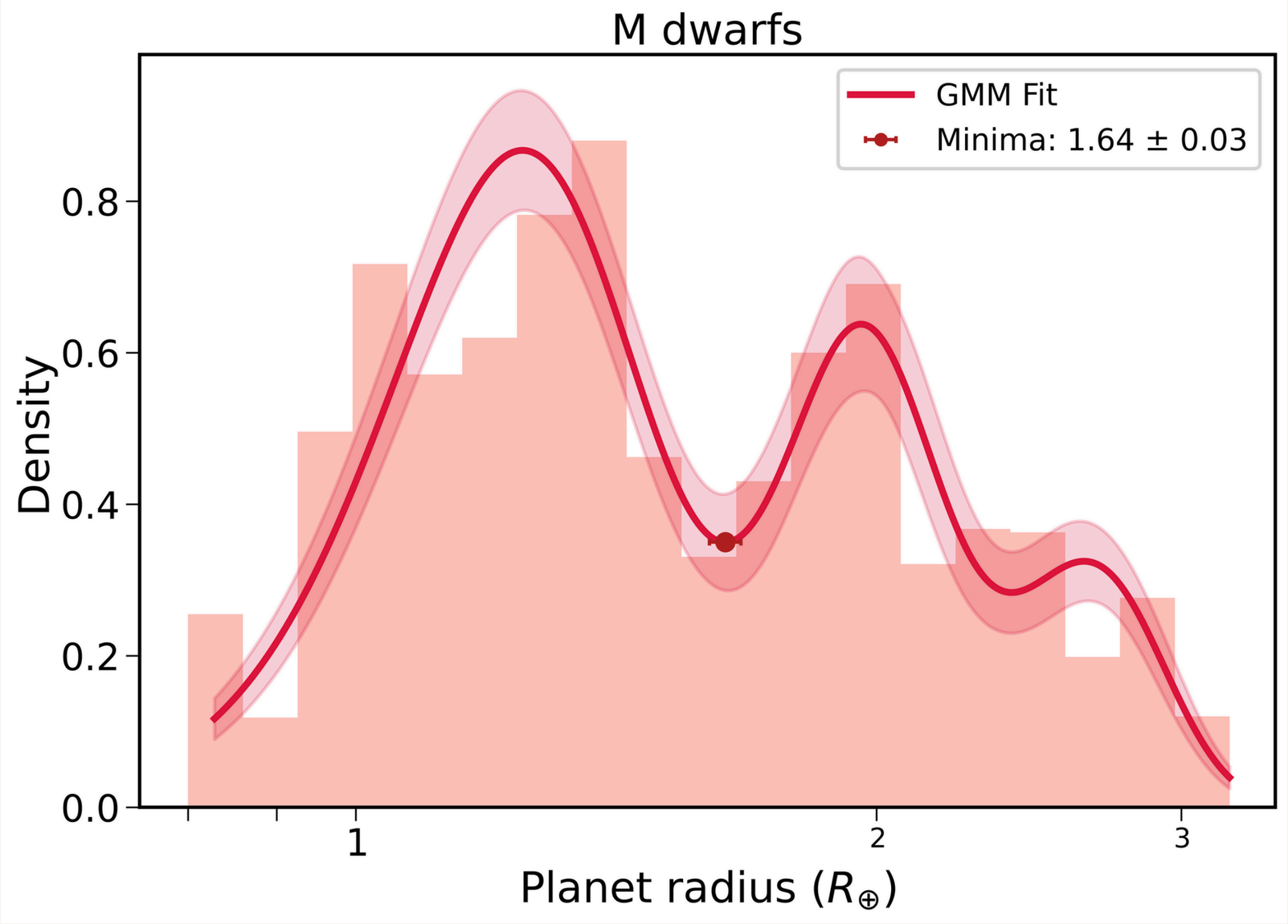
TESS candidates updated with Bioverse (Hardegree-Ullman+ 2023) GAIA DR3 stellar parameters.

Planet Radii distribution: M dwarfs



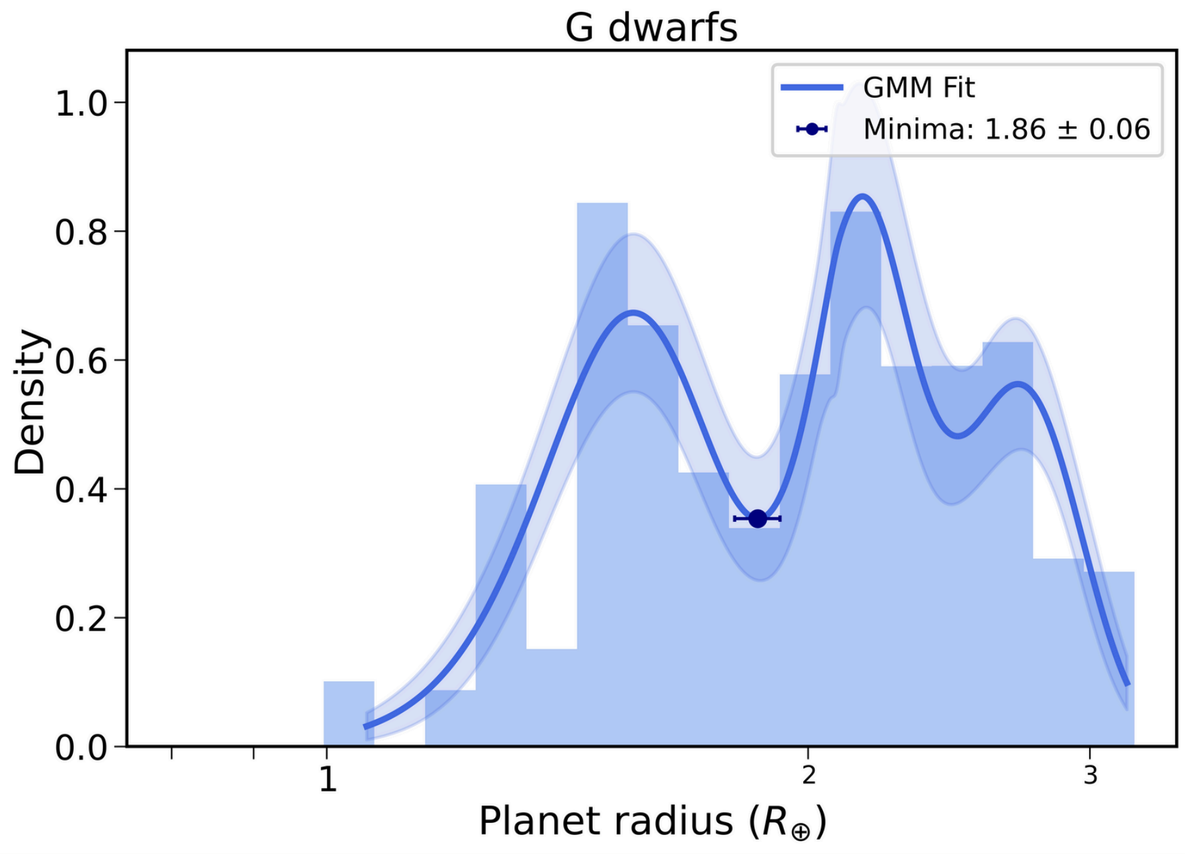
Histogram of Planet radii of TESS M dwarfs.

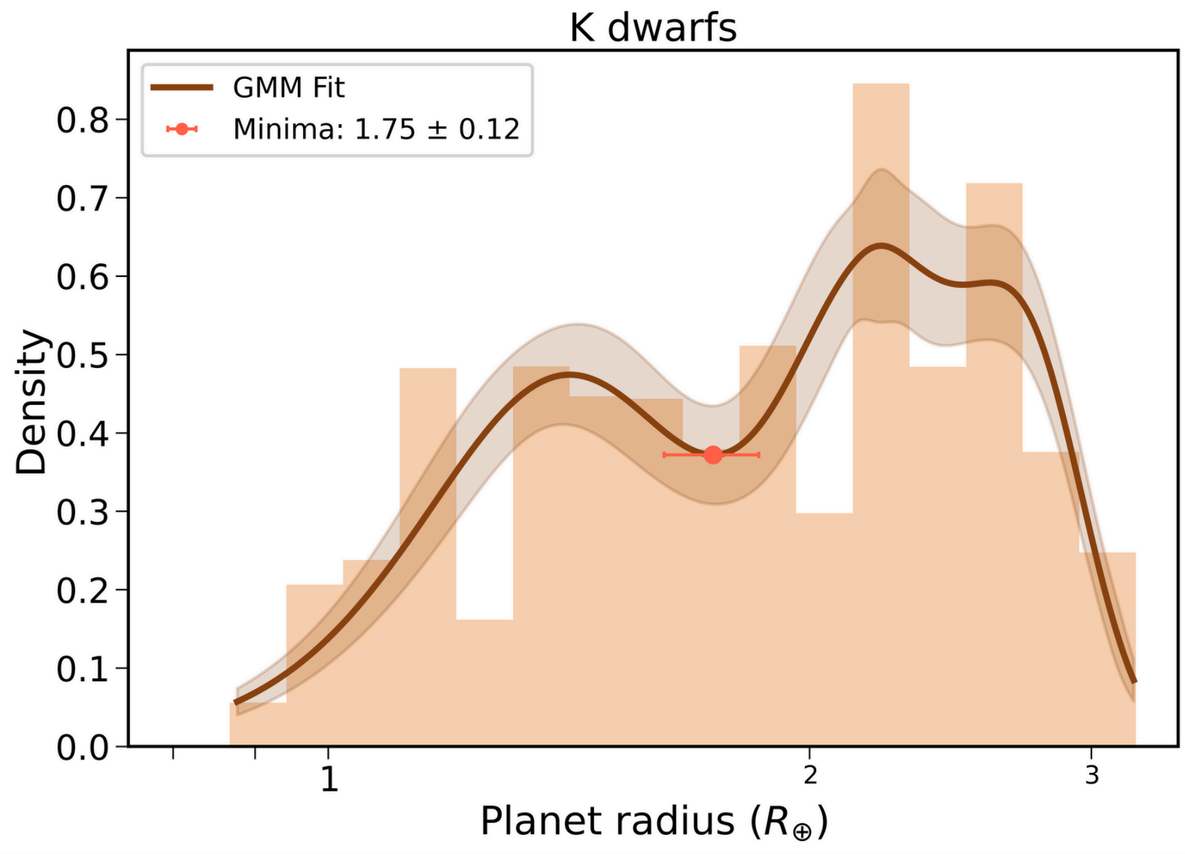
Gaussian Mixture Model (GMM)



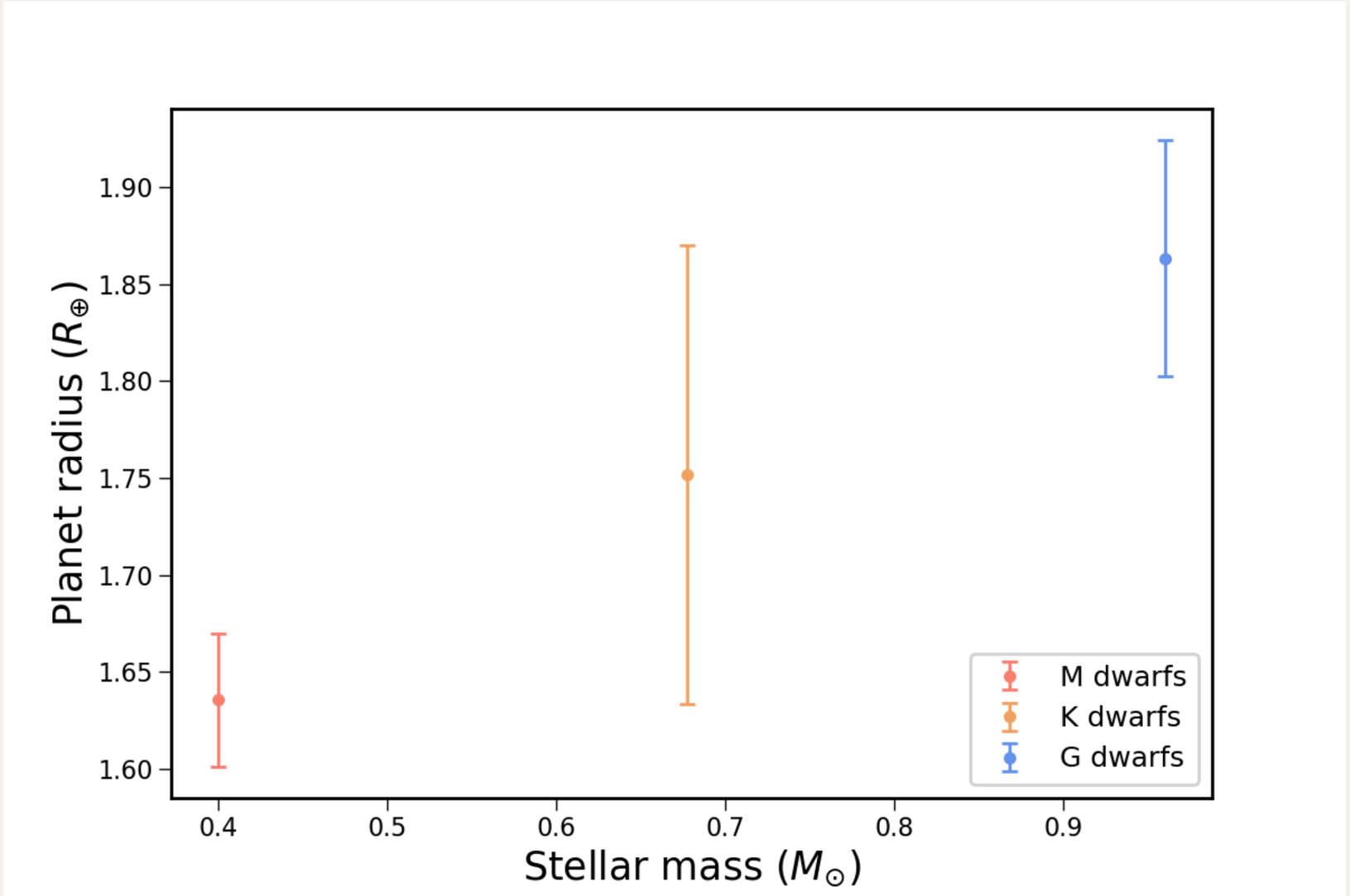
A clear radius valley is observed among the M dwarfs.

Planet Radii distribution: G & K dwarfs





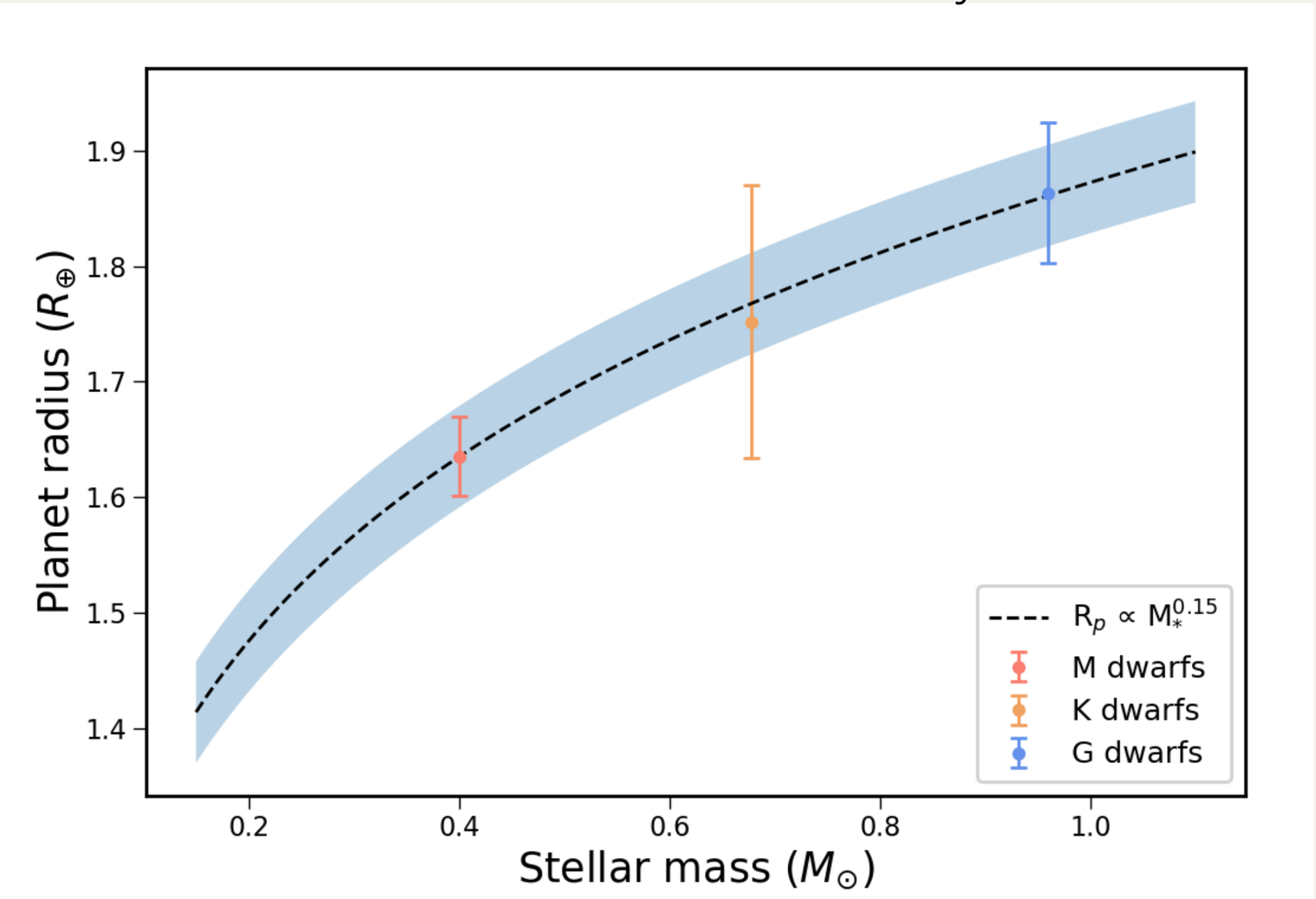
Planet size scaling with stellar mass



The value of the radius valley increases with stellar mass.

Planet size scaling with stellar mass

Parashivamurthy+ 2025 submitted



The planet size depend on the stellar mass through a power-law scaling:

$$R_{valley} = 1.87 * M_*^{\beta}$$

where, $\beta = 0.148 \pm 0.0438$.

Planet size scaling with stellar mass

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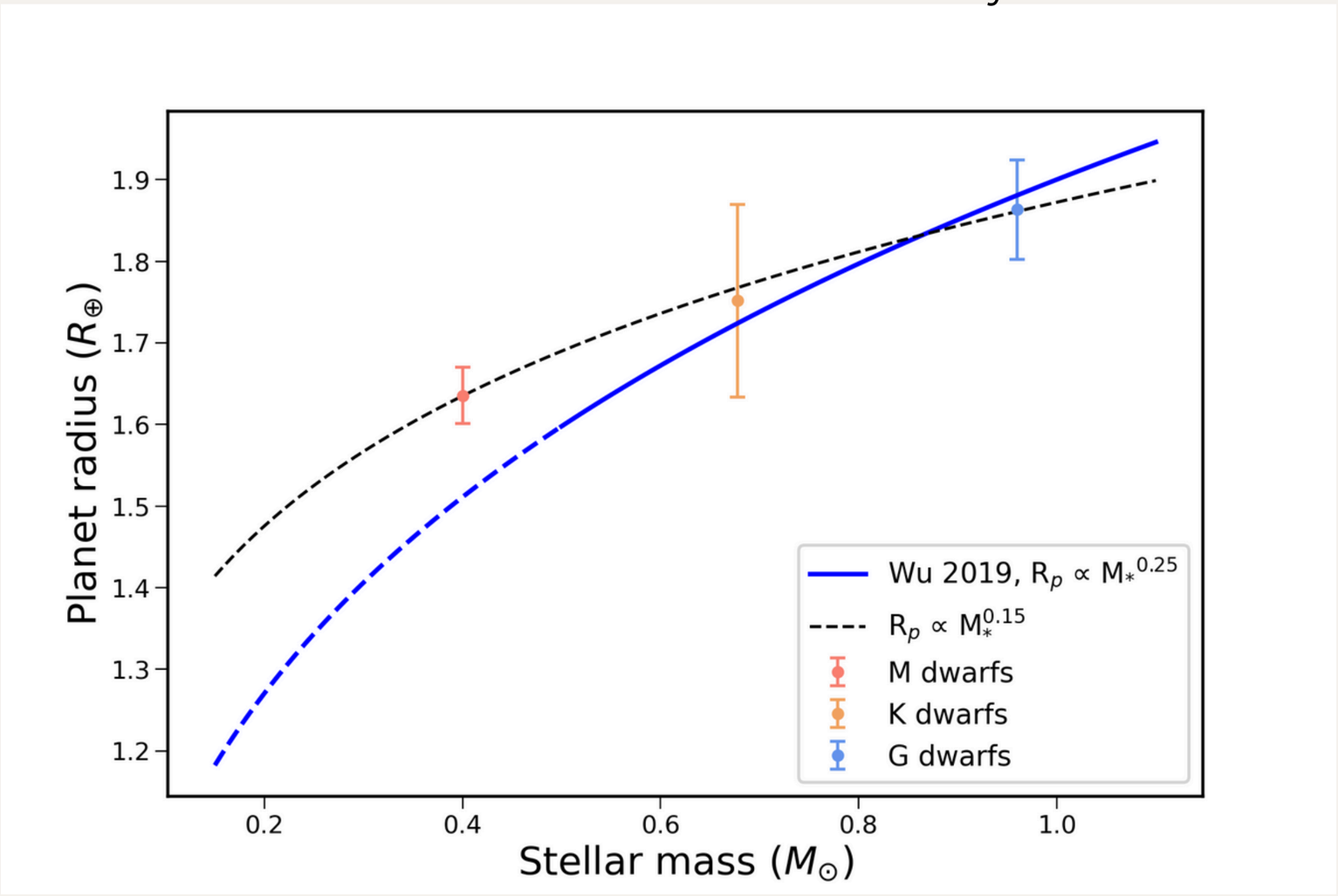

Wu 2019, explains the linear dependence through photoevaporation for FGK type stars.

Planet size scaling with stellar mass

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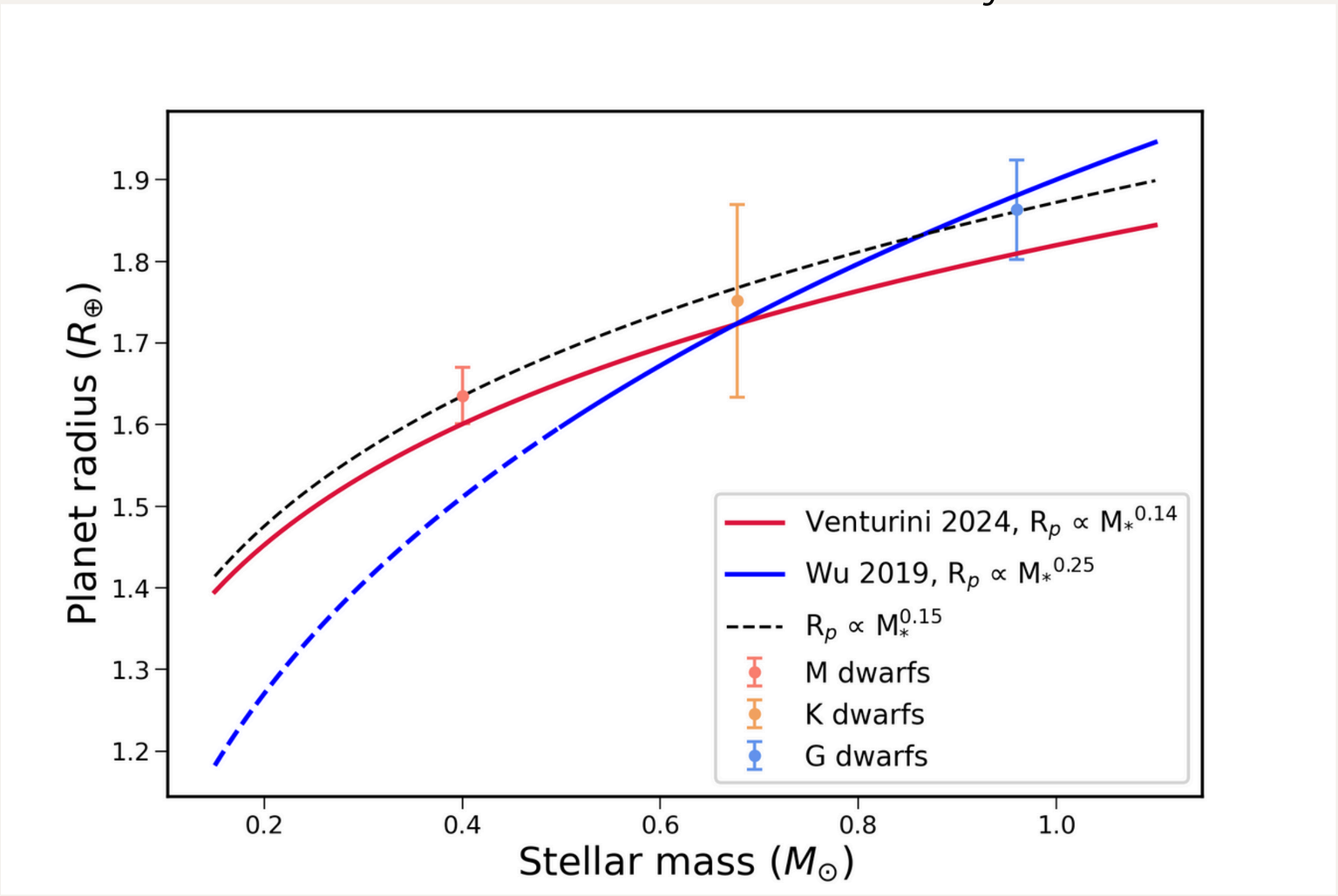
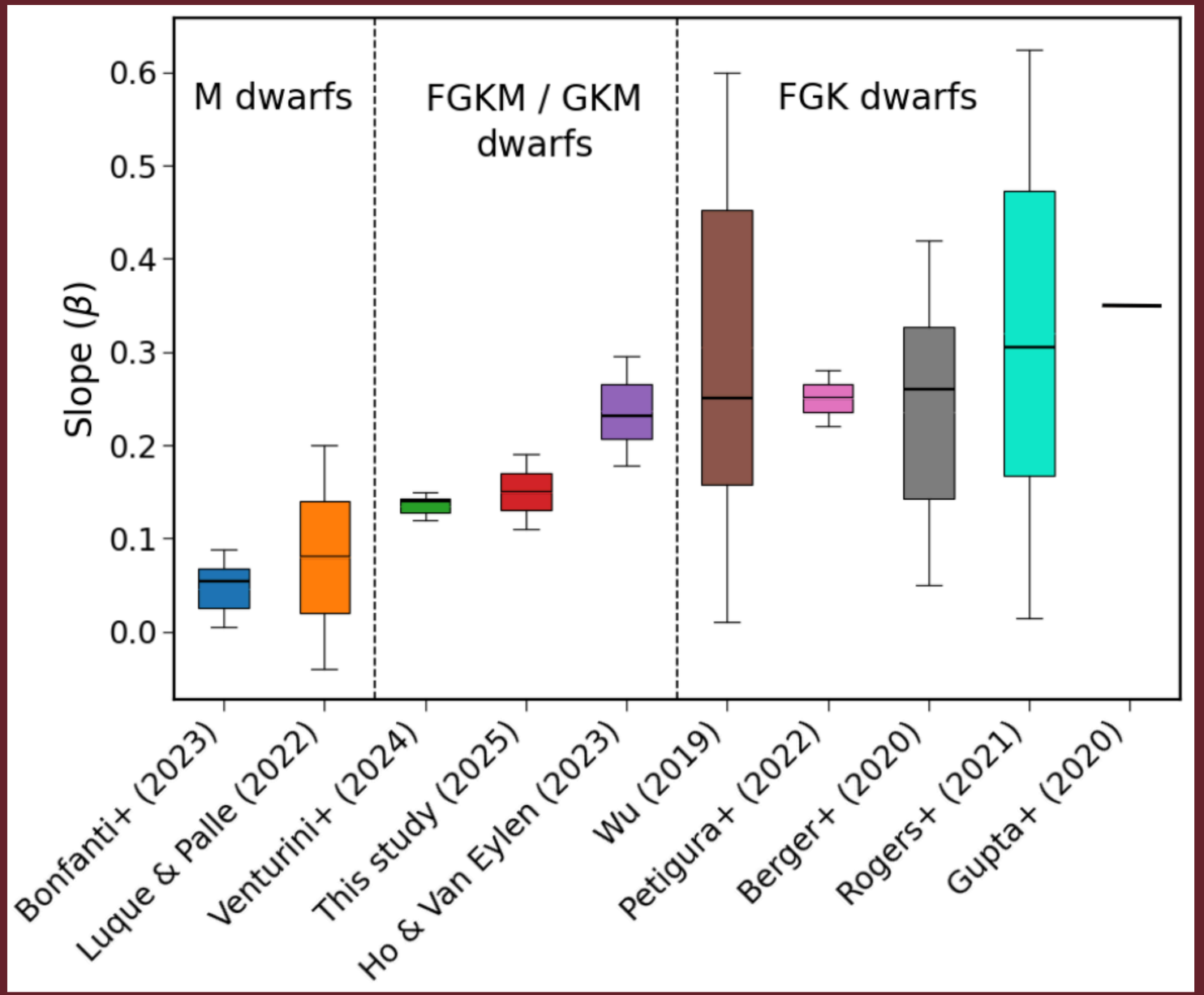


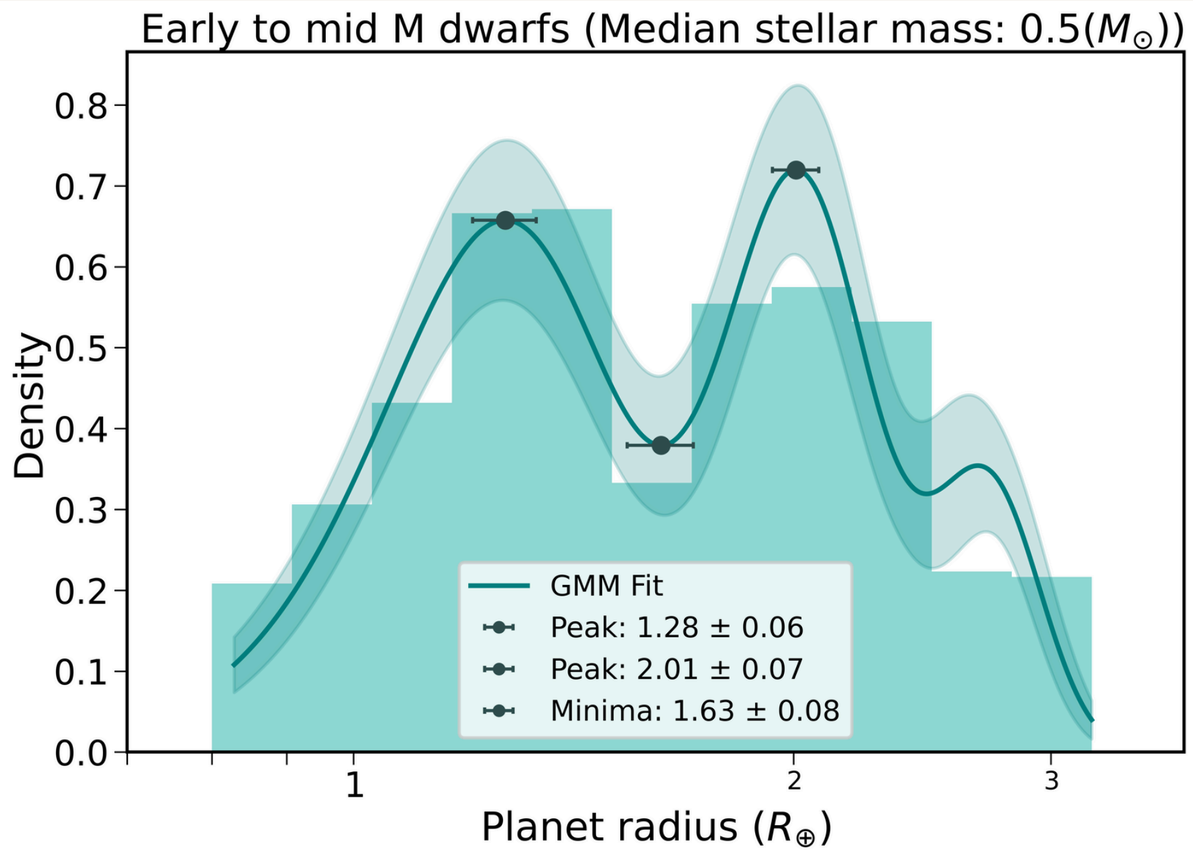
Models that include water worlds **(pebble-based planet formation models from Venturini+ 2024)** are more consistent with our observations.

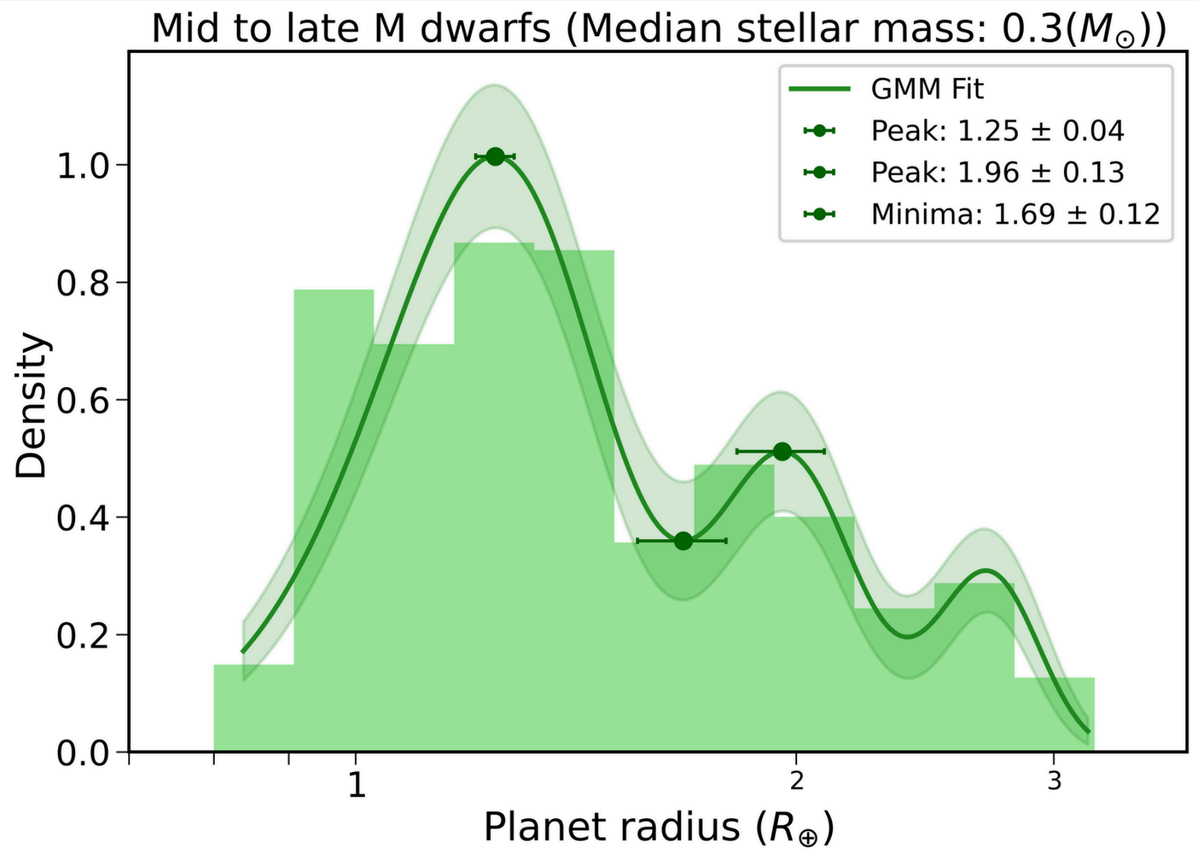
In the literature...



Slope values from various studies, grouped by stellar types.

Radius valley among M dwarfs.





Parashivamurthy+ 2025 submitted

Updated slope with all data points

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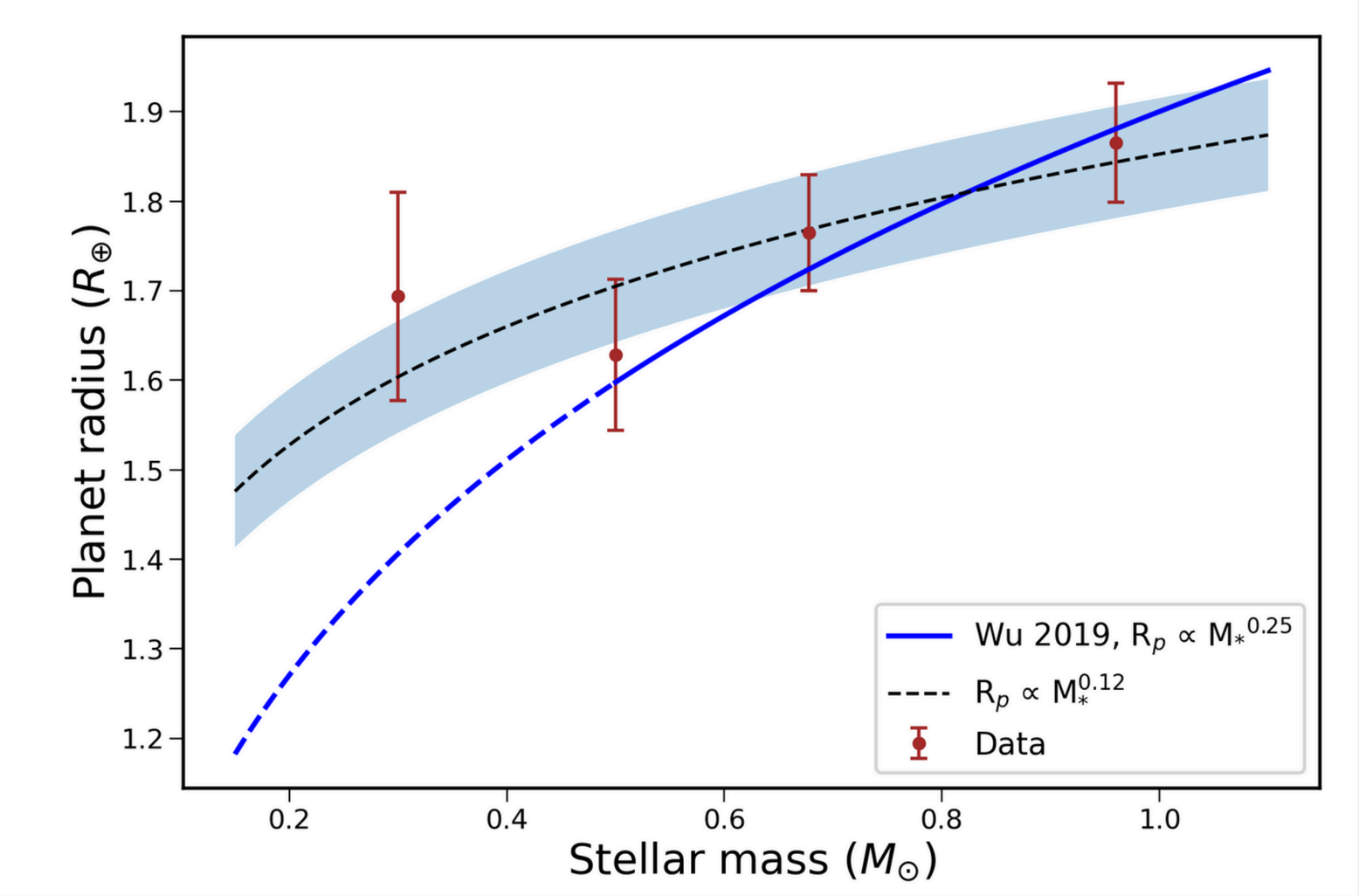

The linear dependence between the planet size and stellar mass is not seen among the M dwarfs.

SUMMARY

- We used the bioverse catalog to define a TESS low mass star sample with updated GAIA DR3 stellar parameters, to ***refine the planet radii***.
- We observe ***a clear bimodal planet radii distribution among the M dwarfs.***
- Observed a ***mass-scaling relationship between the planet size and stellar mass*** among the MKG stellar types.
- The scaling/location of the radius valley among the low mass stars might indicate ***the presence of water worlds or the need to refine planet formation and evolution models.***
- However, among the M dwarfs, the scaling is not clearly observed yet.

Thank you

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