

Water as a Potential Sculptor of the M Dwarf Radius Valley



https://tinyurl.com/ Bennett-Skinner-CASCA2024

Bennett Skinner, Ralph Pudritz, and Ryan Cloutier

skinnb1@mcmaster.ca

Background

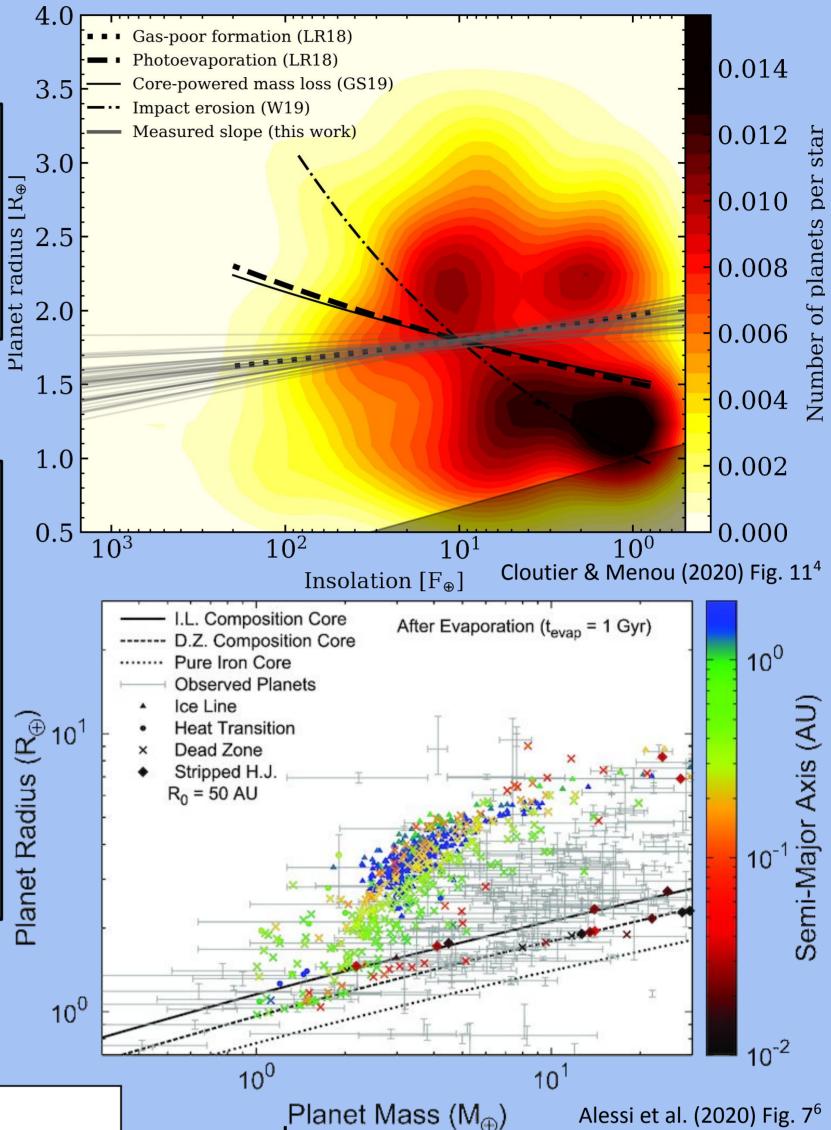
- Distribution of planetary radii is bimodal "Radius Valley"
 - Slope w/ instellation implies atmospheric escape^{2,3}
- Slope different around M v. FGK stars⁴
 - Different formation mechanism? Water worlds?⁵

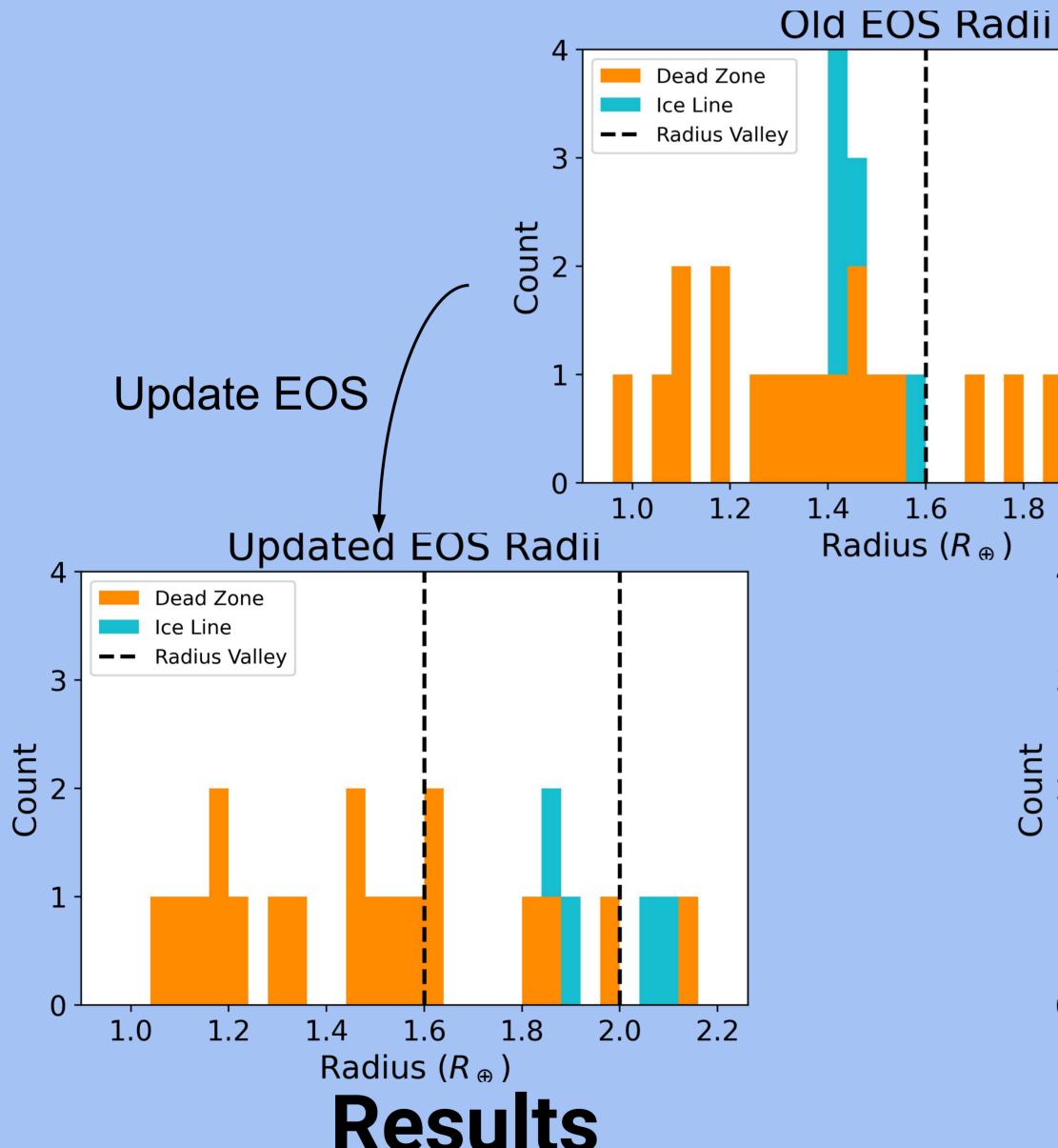
The Project

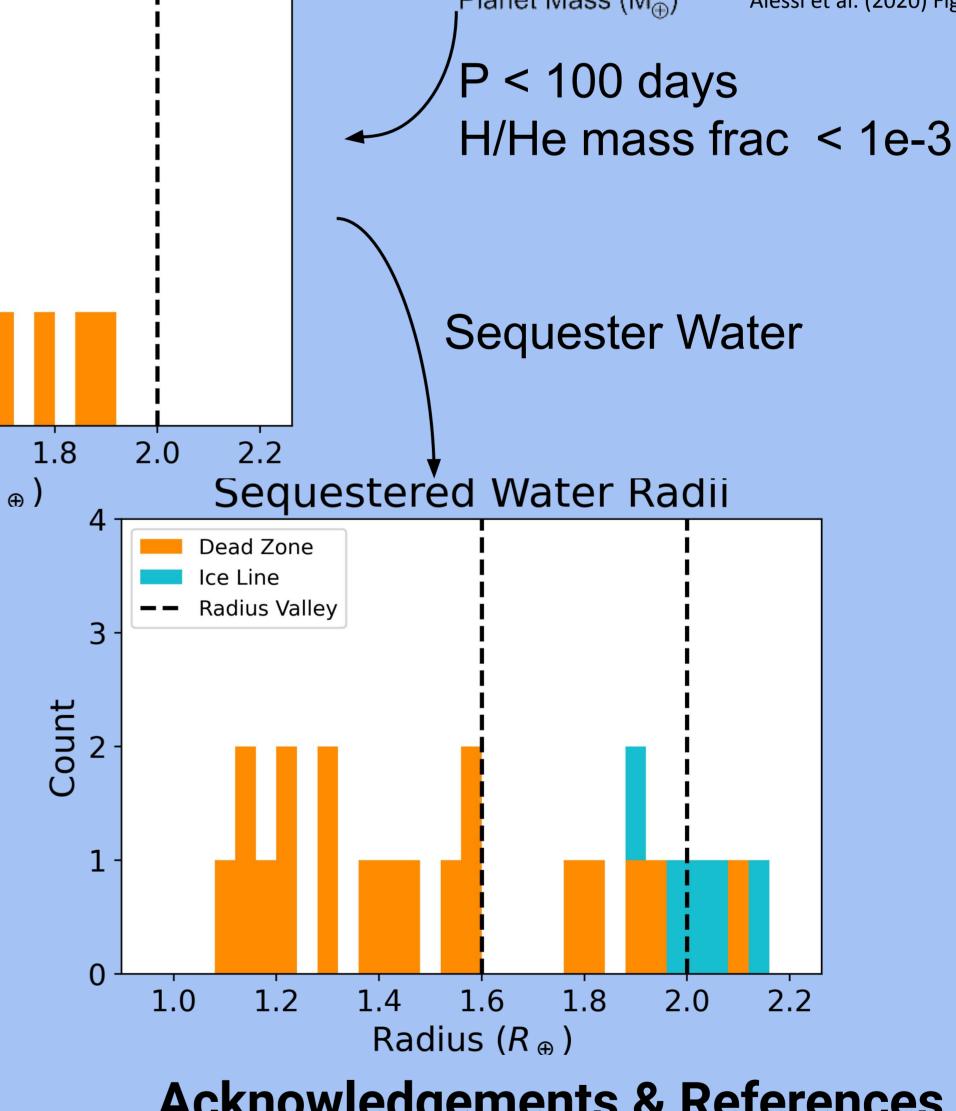
- McMaster Planet Population Synthesis model⁶
 - Planetesimal accretion in disk around FGK star
 - Planets form in planet traps at dead zone, ice line, and heat transition
 - Disks chemically evolve
- Recalculate planet radii w/ new advances
 - New Equations of State (EOS) for water⁷, iron⁸, silicates⁹, opacities¹⁰

Data

- Sequestration of water into planetary interior¹¹
- Can radius valley be replicated solely w/ water?







Updated EOS and sequestration separate water and dry worlds

- Water does NOT solely replicate radius valley, but could contribute
- Some water worlds in the valley

Future Work

- Update McMaster Planet Population Synthesis model for M stars
- Increase sample size by running more simulations
- Take advantage of disk chemistry tracking to improve mantle model

Acknowledgements & References

We would like to thank Caroline Dorn's ETH Zürich research group, particularly Komal Bali, for providing tabulated M-R relationships for planets with water sequestration.

¹Fulton, B. J., Petigura, E. A., Howard, A. W., Isaacson, H., Marcy, G. W., Cargile, P. A., Hebb, L., Weiss, L. M., Johnson, J. A., Morton, T. D., Sinukoff, E., Crossfield, I. J. M., and Hirsch, L. A. (2017) ²Lopez, E. D. and Rice, K. (2018) ³Gupta, A. and Schlichting, H. E. (2019) ⁴Cloutier, R. and Menou, K. (2020) ⁵Burn, R., Mordasini, C., Mishra, L., Haldemann, J., Venturini, J., Emsenhuber, A., and Henning, T. (2024) ⁶Alessi, M., Inglis, J., and Pudritz, R. E. (2020) ⁷Haldemann, J., Alibert, Y., Mordasini, C., and Benz, W. (2020) 8Hakim, K., Rivoldini, A., Van Hoolst, T., Cottenier, S.,

Jaeken, J., Chust, T., and Steinle-Neumann, G. (2018) ⁹Sotin, C., Grasset, O., and Mocquet, A. (2007) ¹⁰Freedman, R. S., Lustig-Yaeger, J., Fortney, J. J., Lupu, R. E., Marley, M. S., and Lodders, K. (2014) ¹¹Luo, H., Dorn, C., and Deng, J. (2024)