

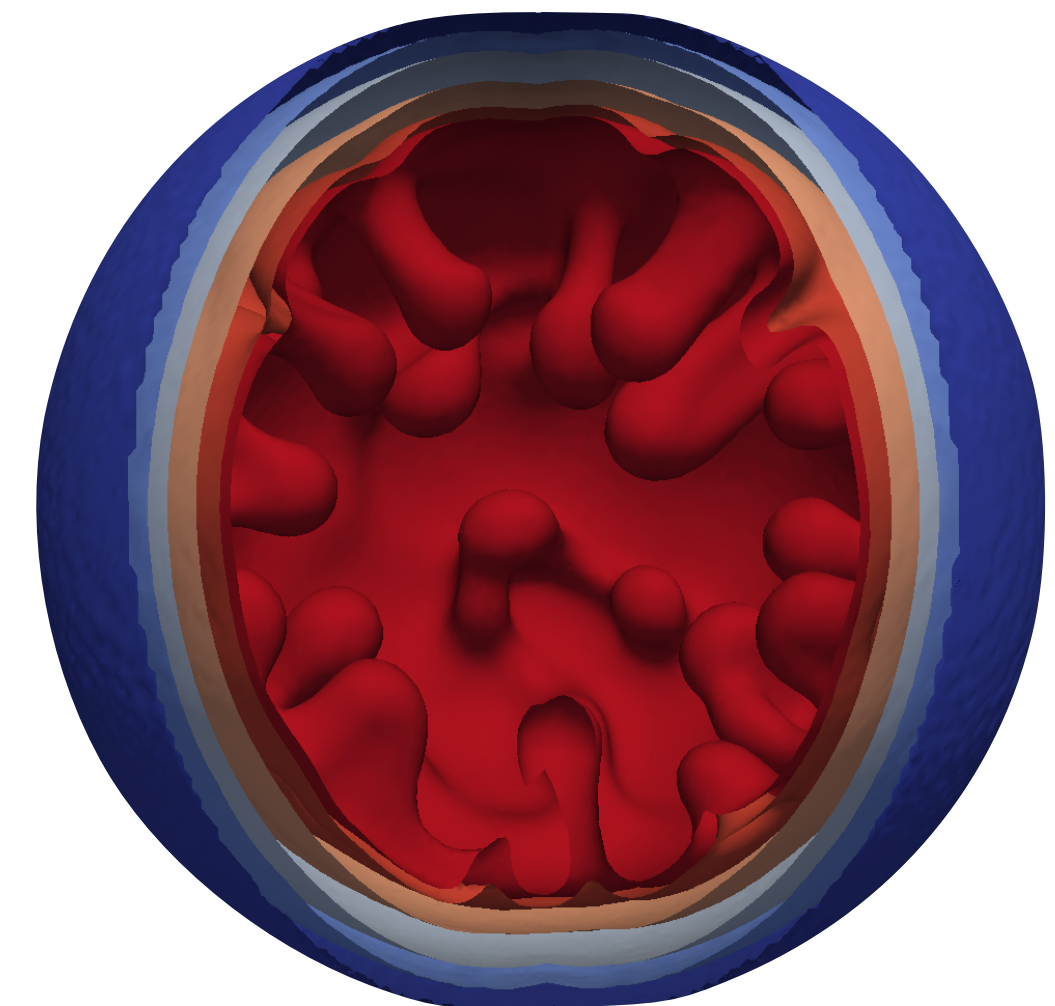
# A water budget dichotomy of rocky protoplanets from $^{26}\text{Al}$ -heating

Tim Lichtenberg

Gregor Golabek (BGI Bayreuth)  
Michael Meyer (U Michigan)  
Taras Gerya (ETH Zürich)

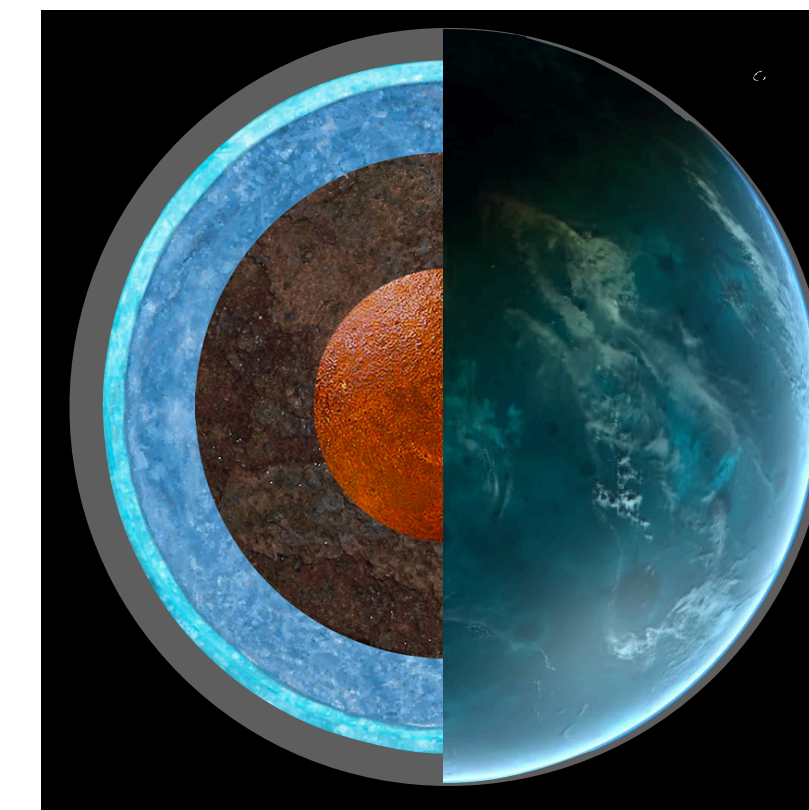
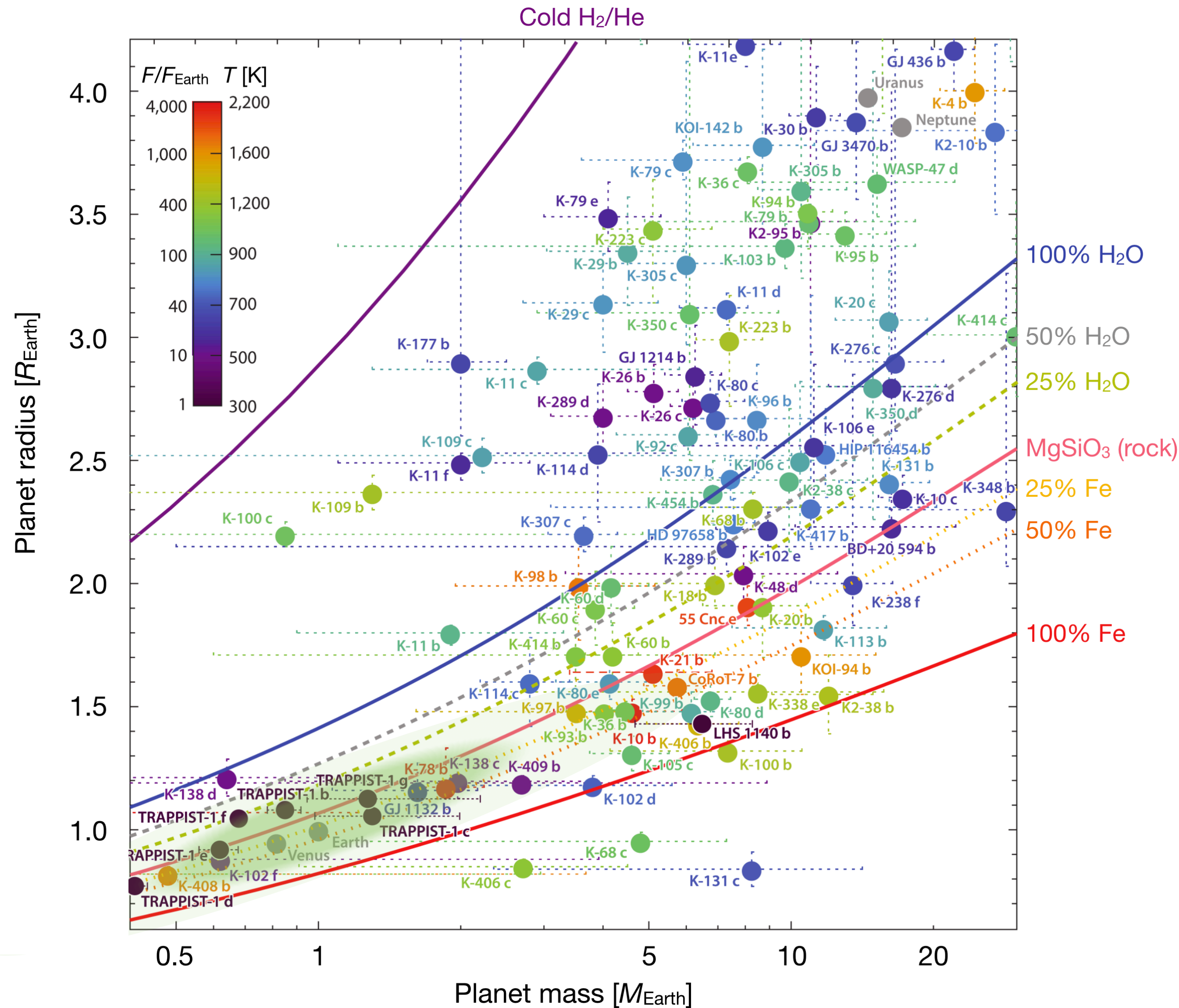
Remo Burn (U Bern)  
Yann Alibert (U Bern / CSH)  
Christoph Mordasini (U Bern / CSH)

*Nature Astronomy* 3, 307–313 (2019)  
*arXiv:1902.04026*

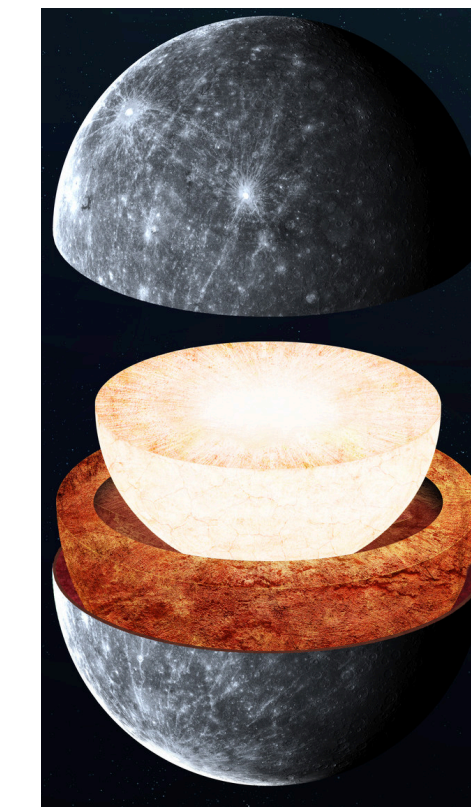




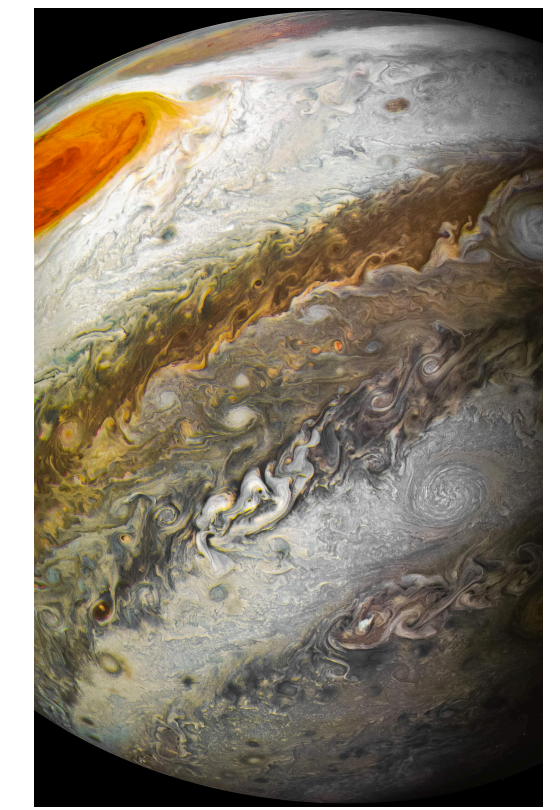
# Exoplanet diversity



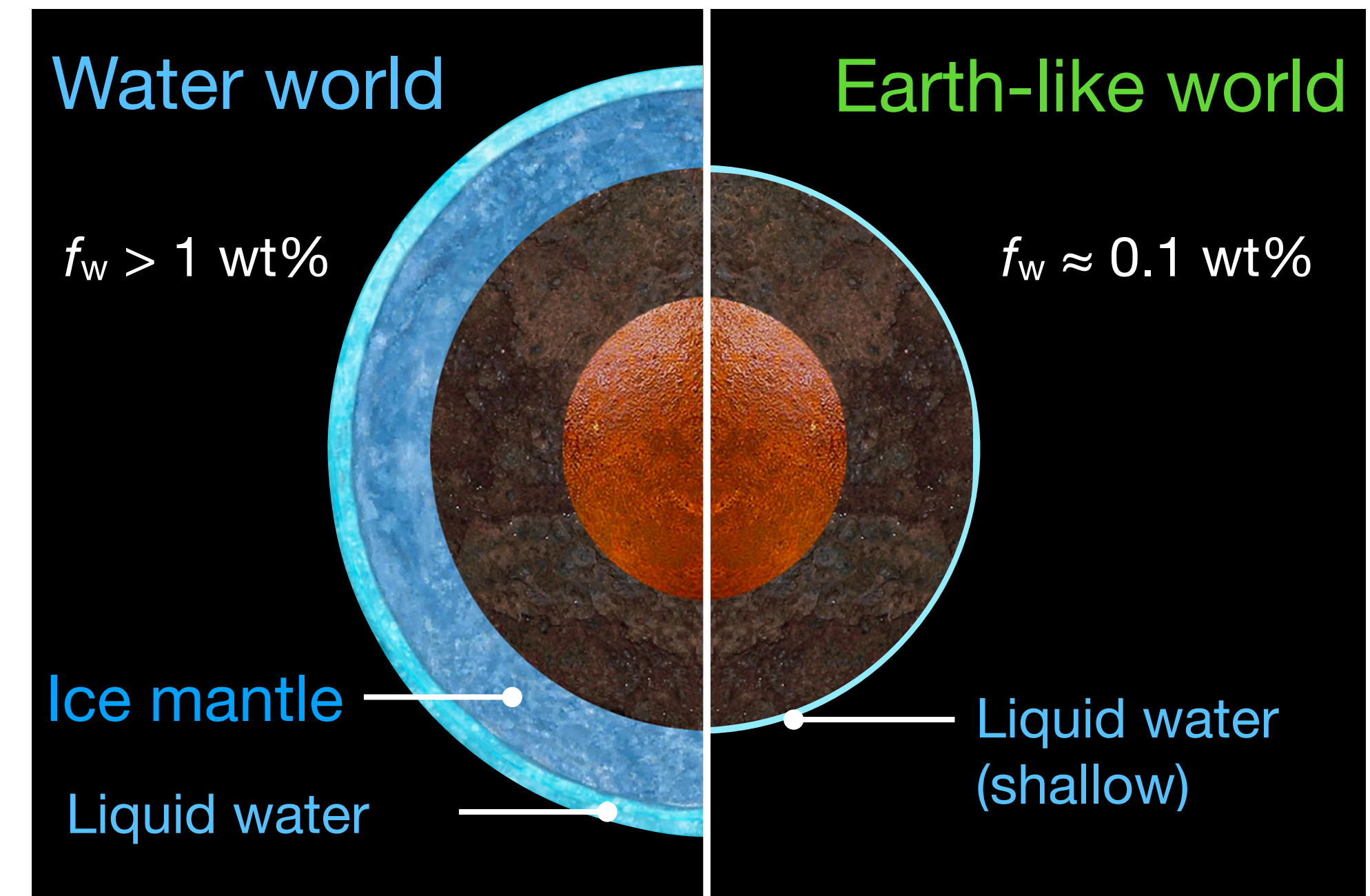
$\text{H}_2\text{O}$



Fe



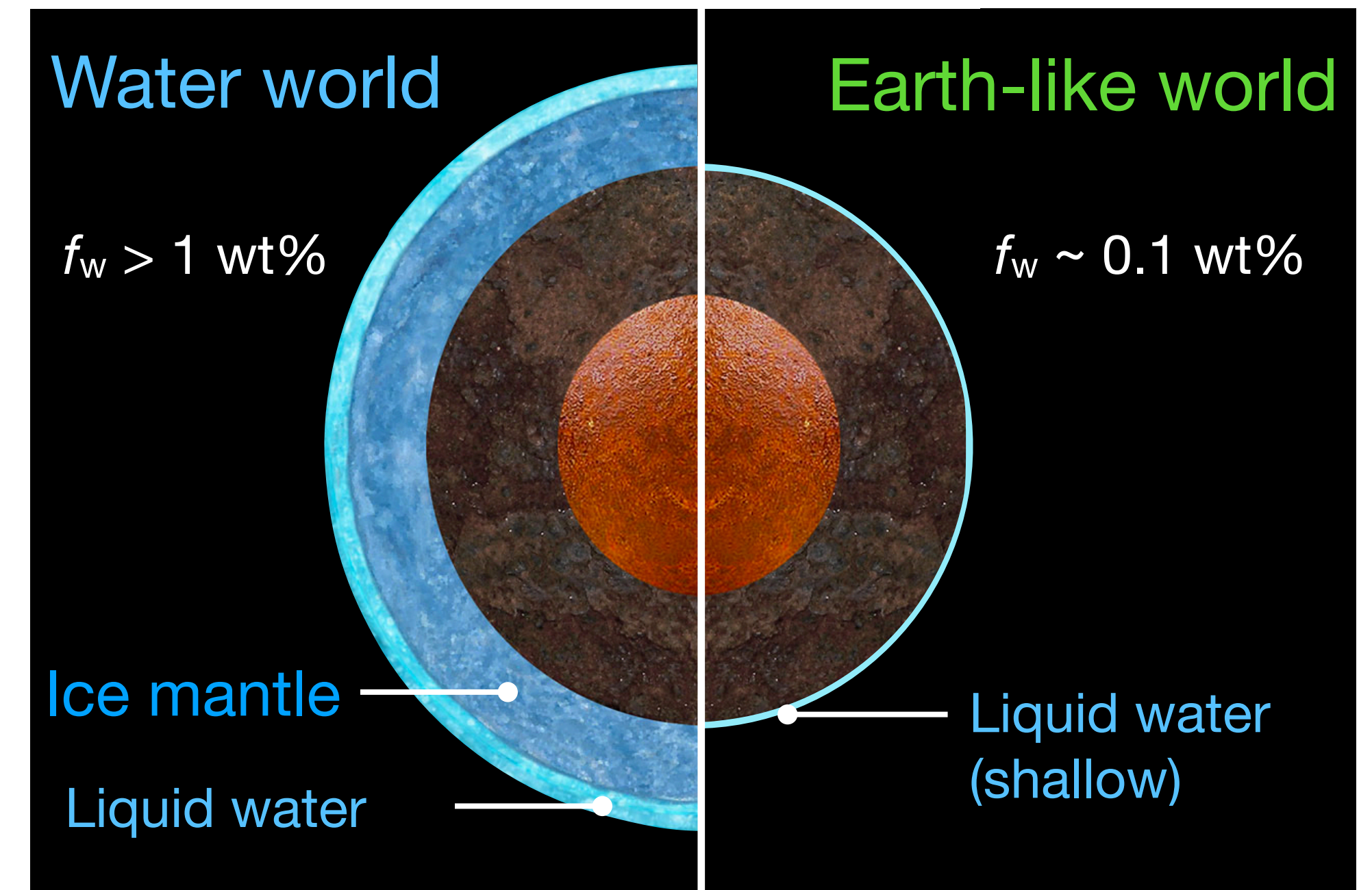
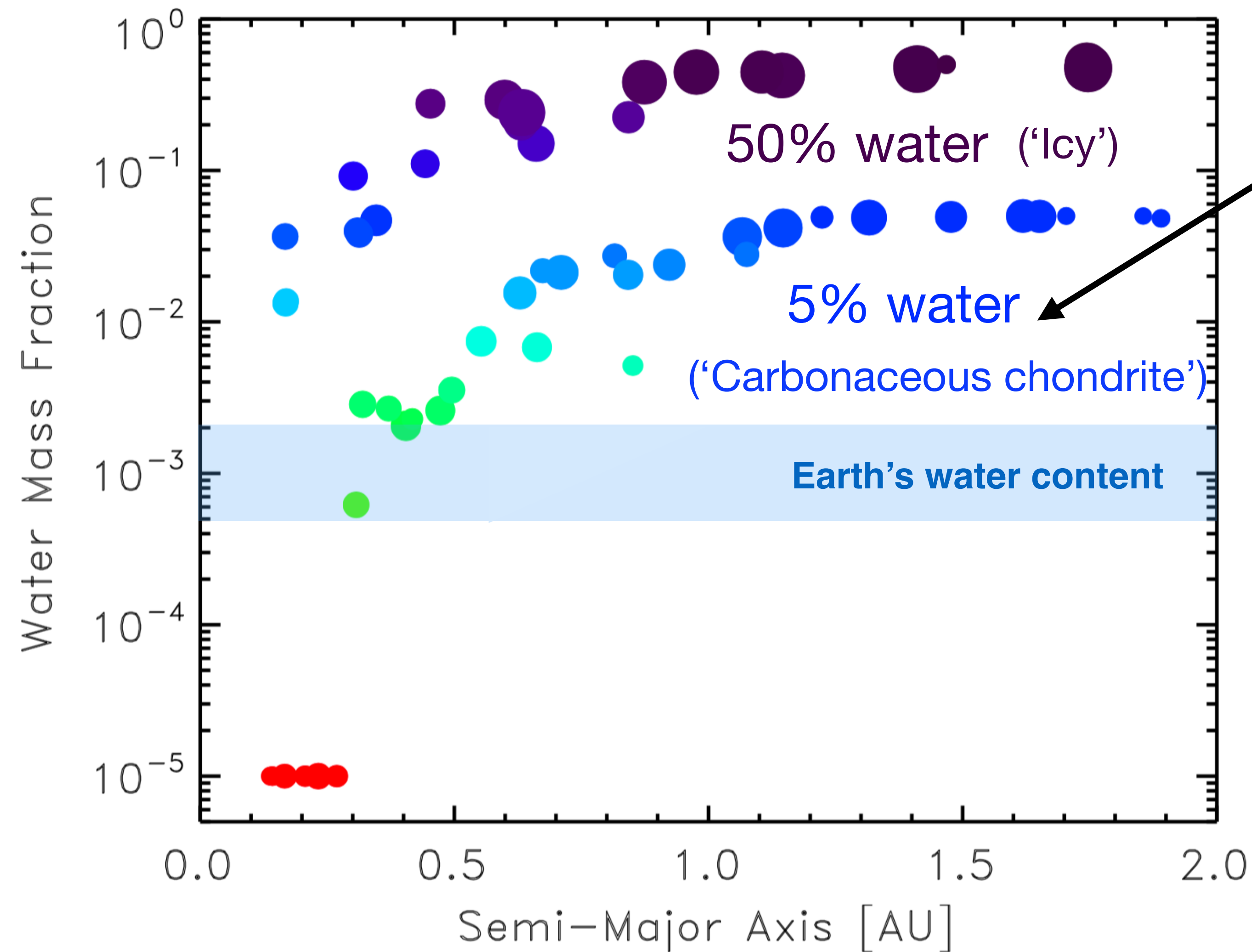
$\text{H}_2/\text{He}$



Limited storage in terrestrial core+mantle

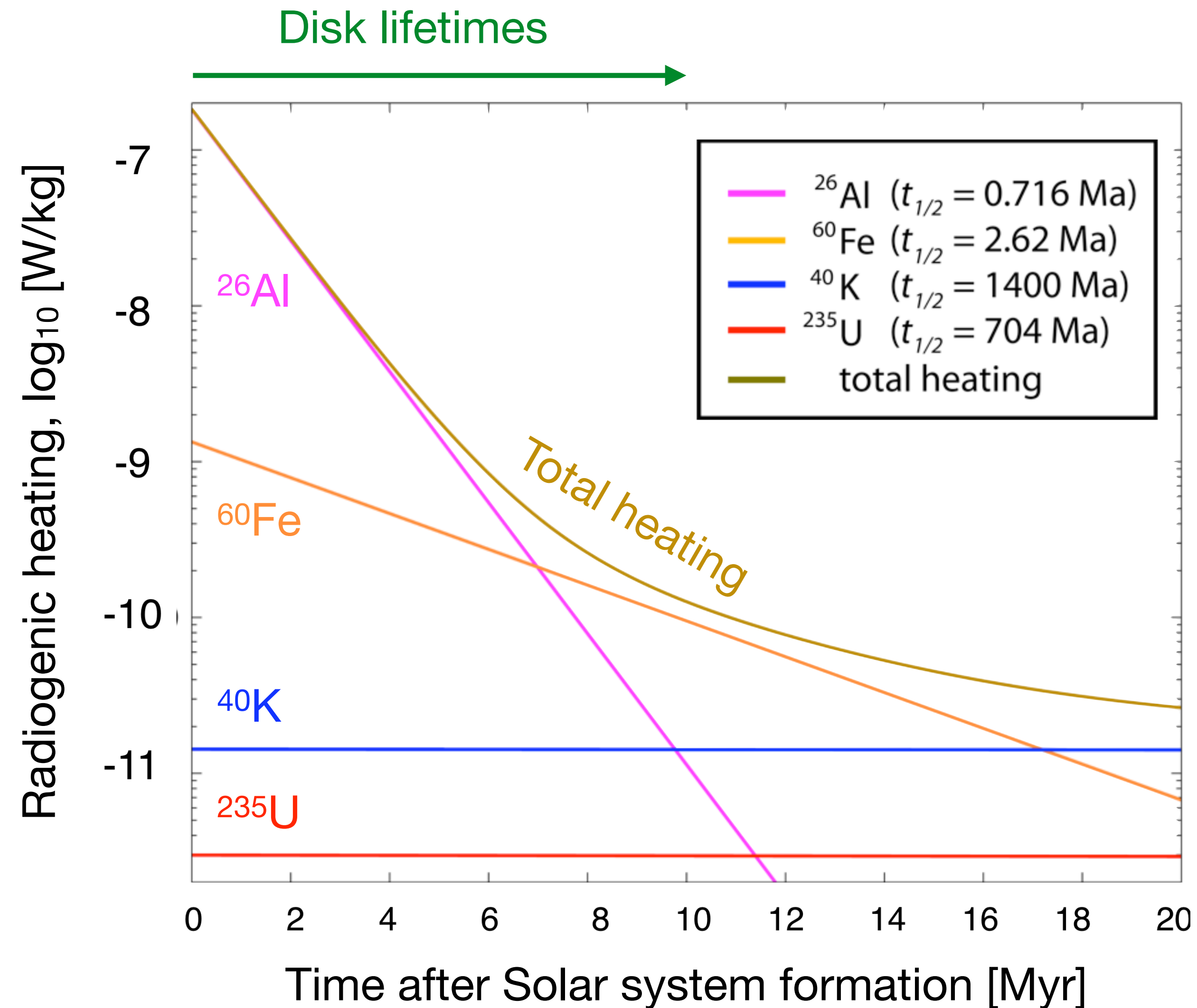


# Plethora of water worlds (?)



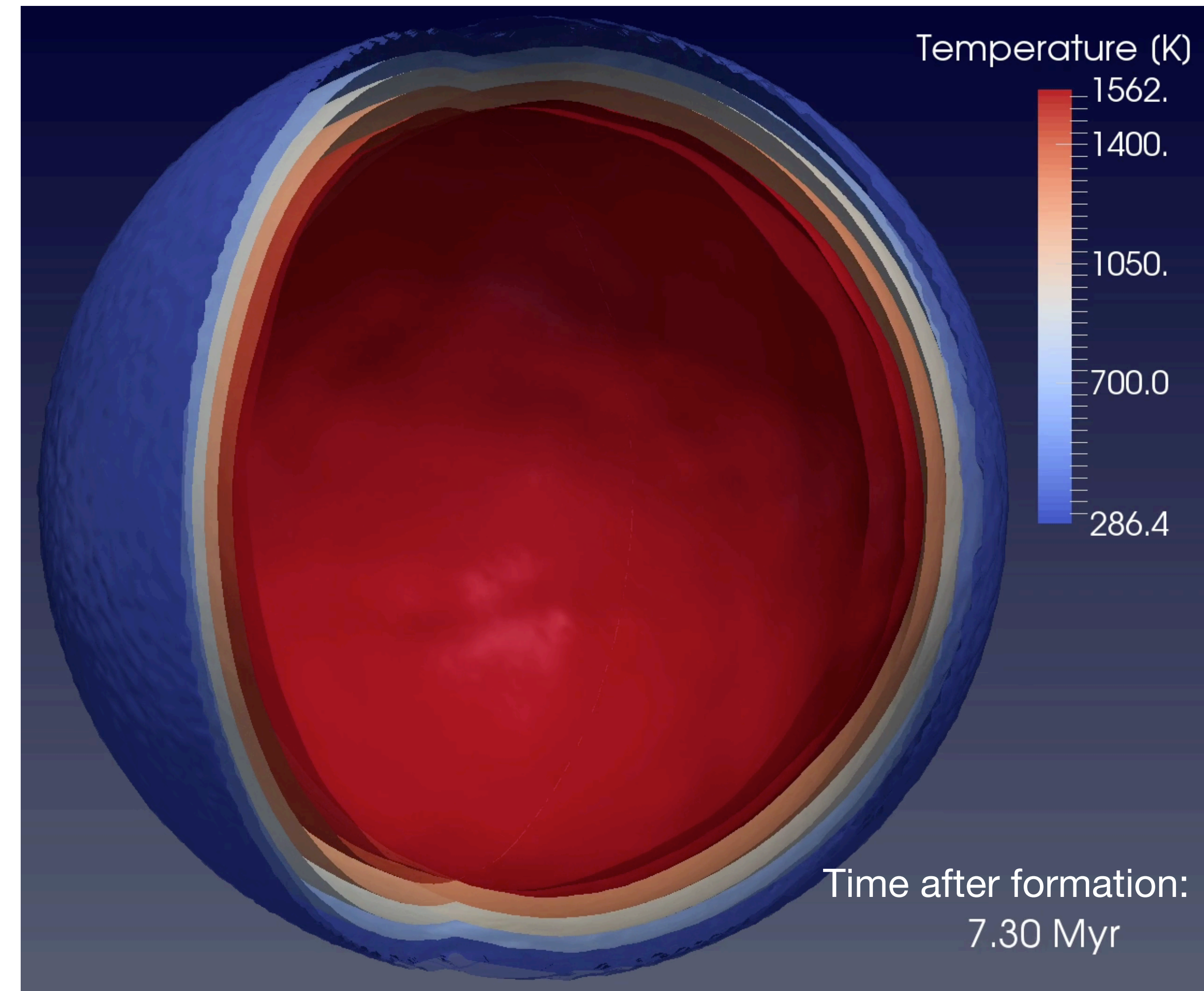
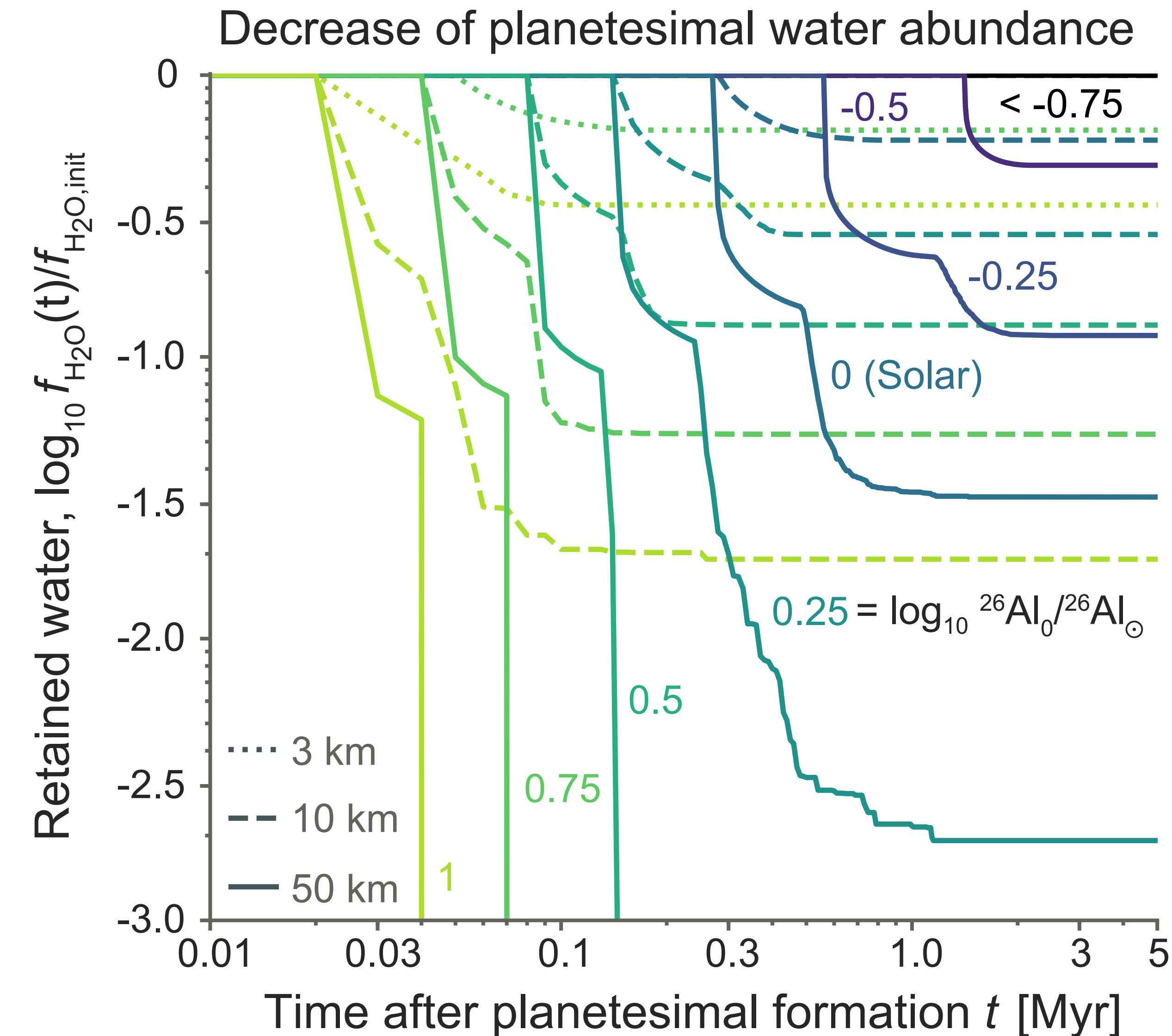


# Radiogenic heating in early Solar System



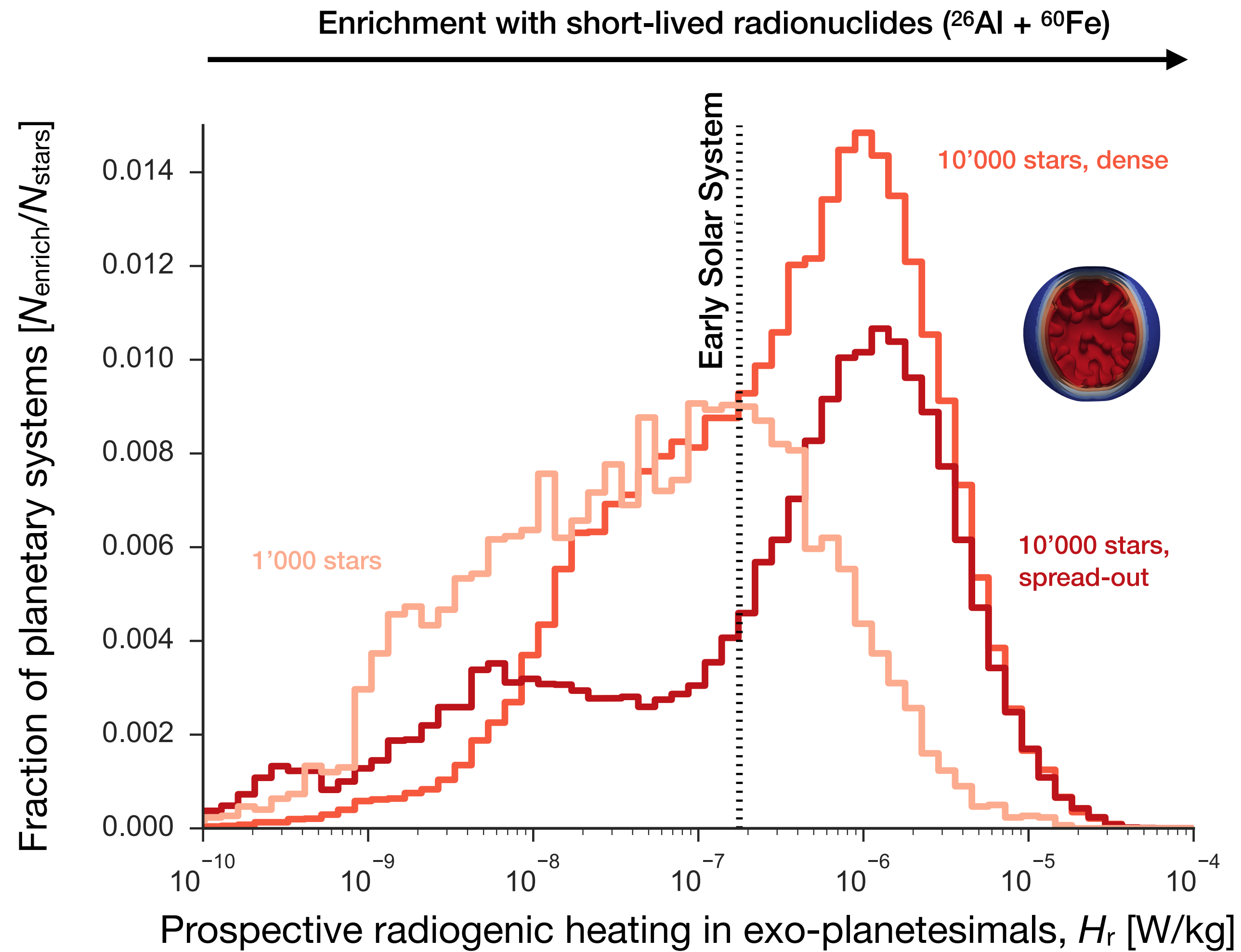


# Radiogenic heating in early Solar System



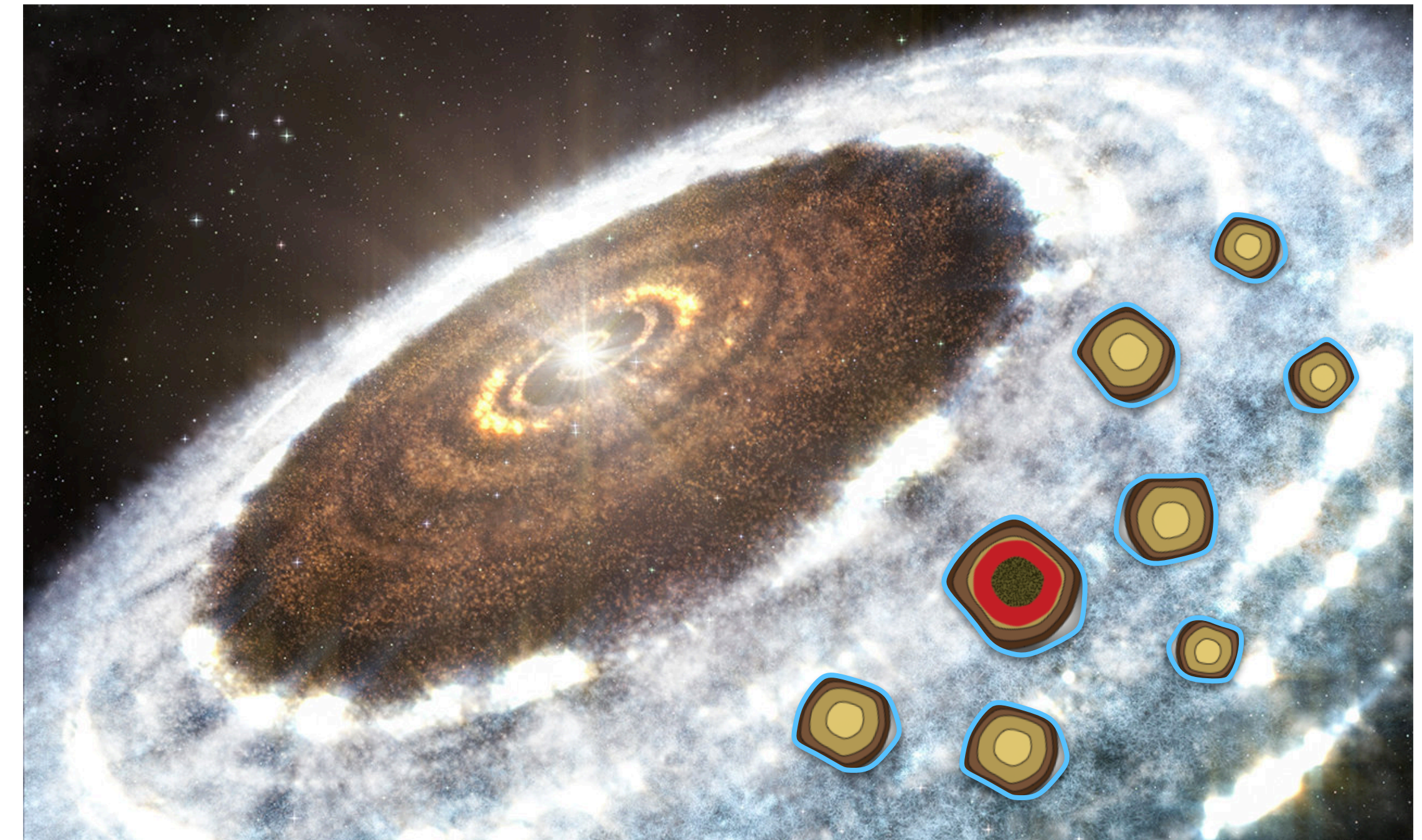


# $^{26}\text{Al}$ variability across planetary systems



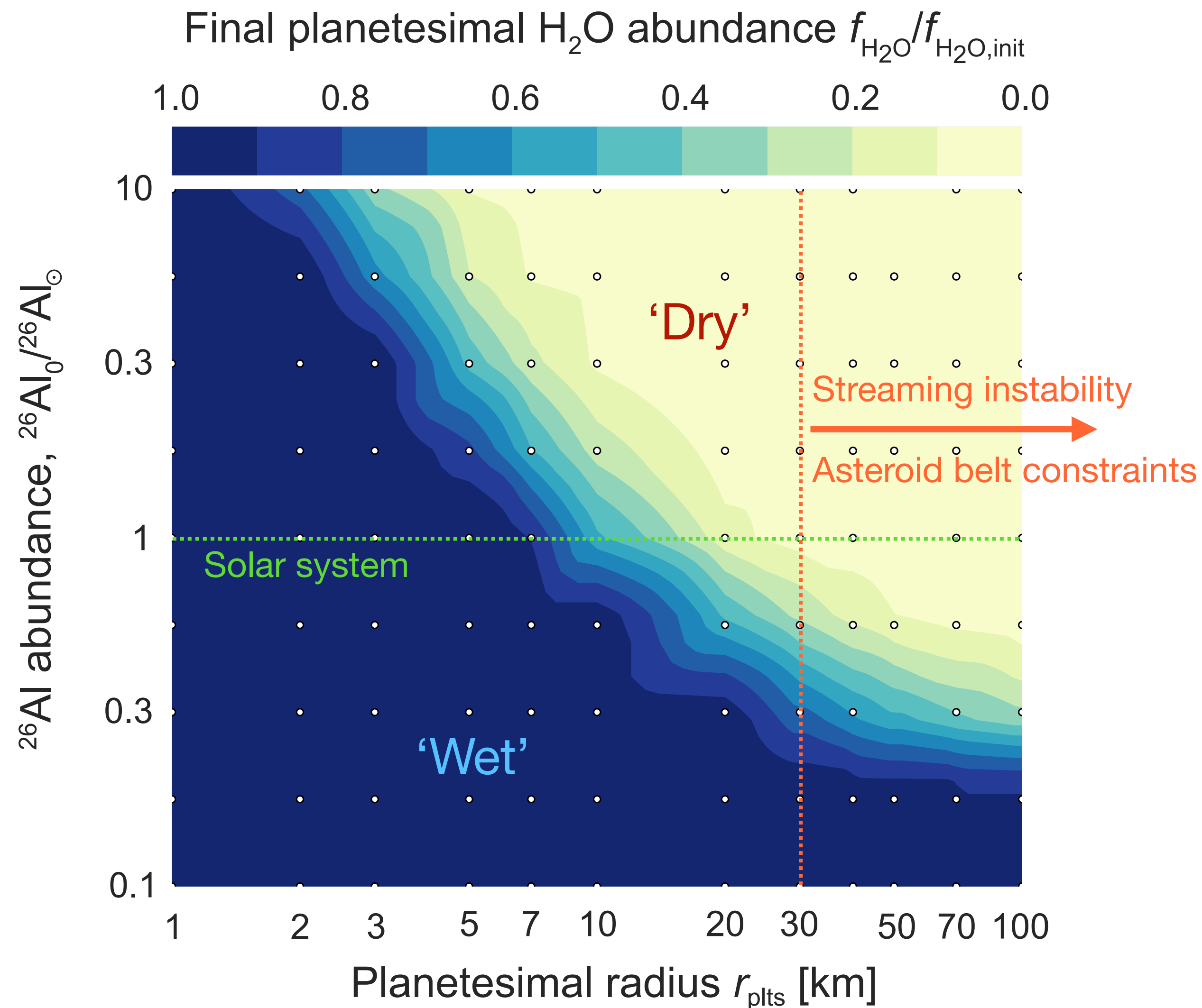
$\sim 10^2 - 10^8 \times$  Earth's present-day interior radiogenic heating

$^{26}\text{Al}$ -heated icy planetesimals forming planets

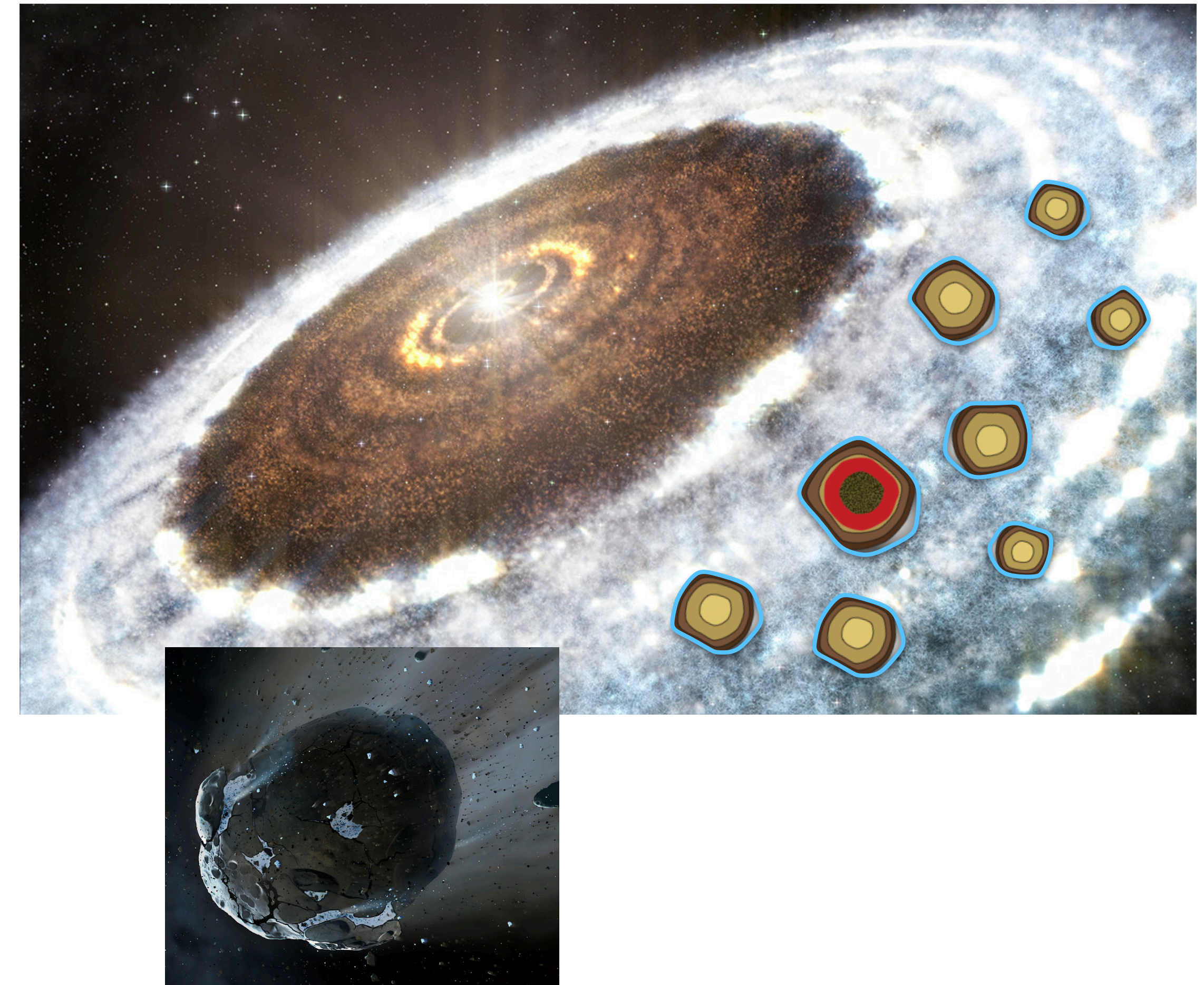




# Rapid dehydration of water-rich planetesimals

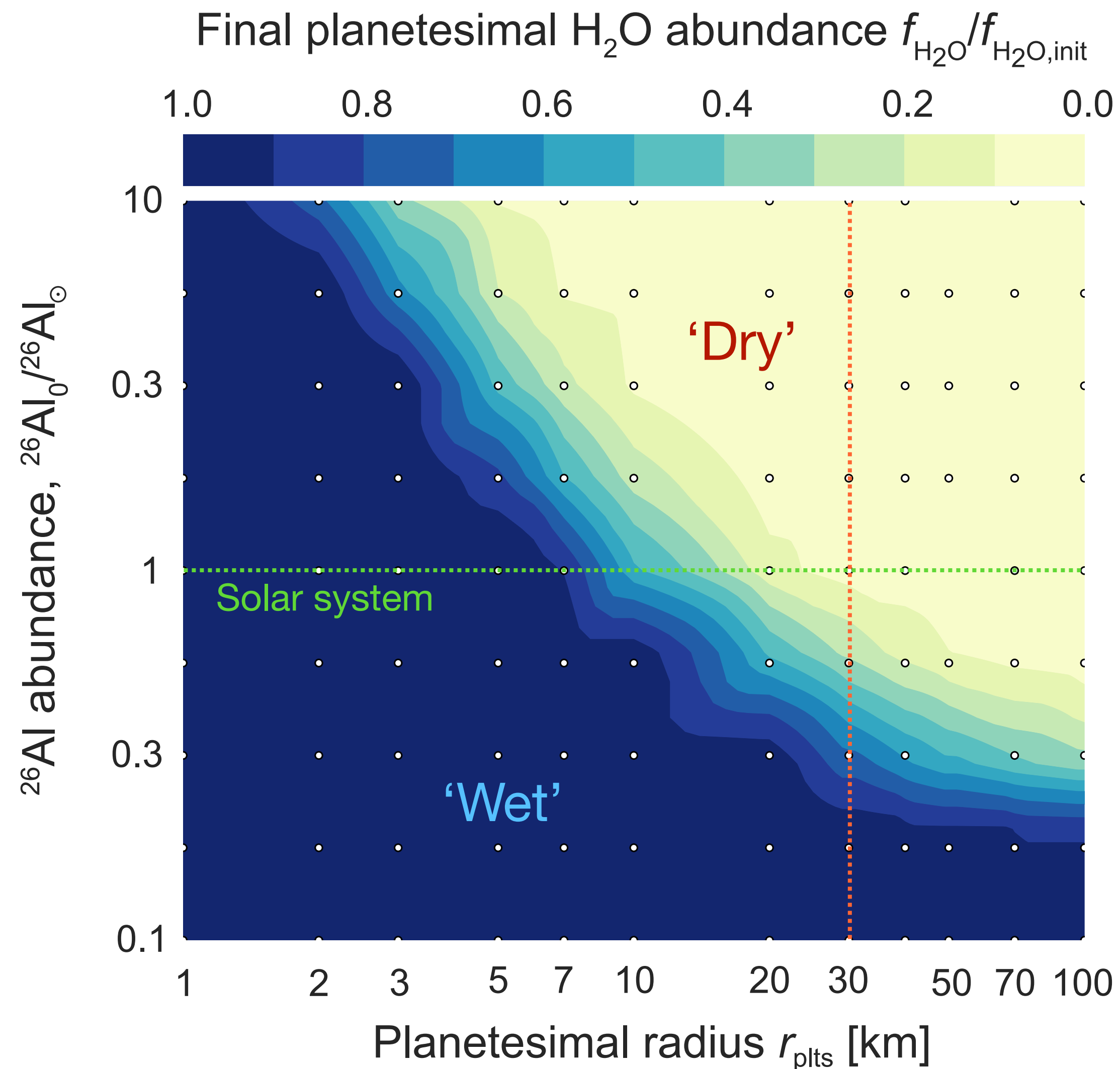


$^{26}\text{Al}$ -heated icy planetesimals forming planets

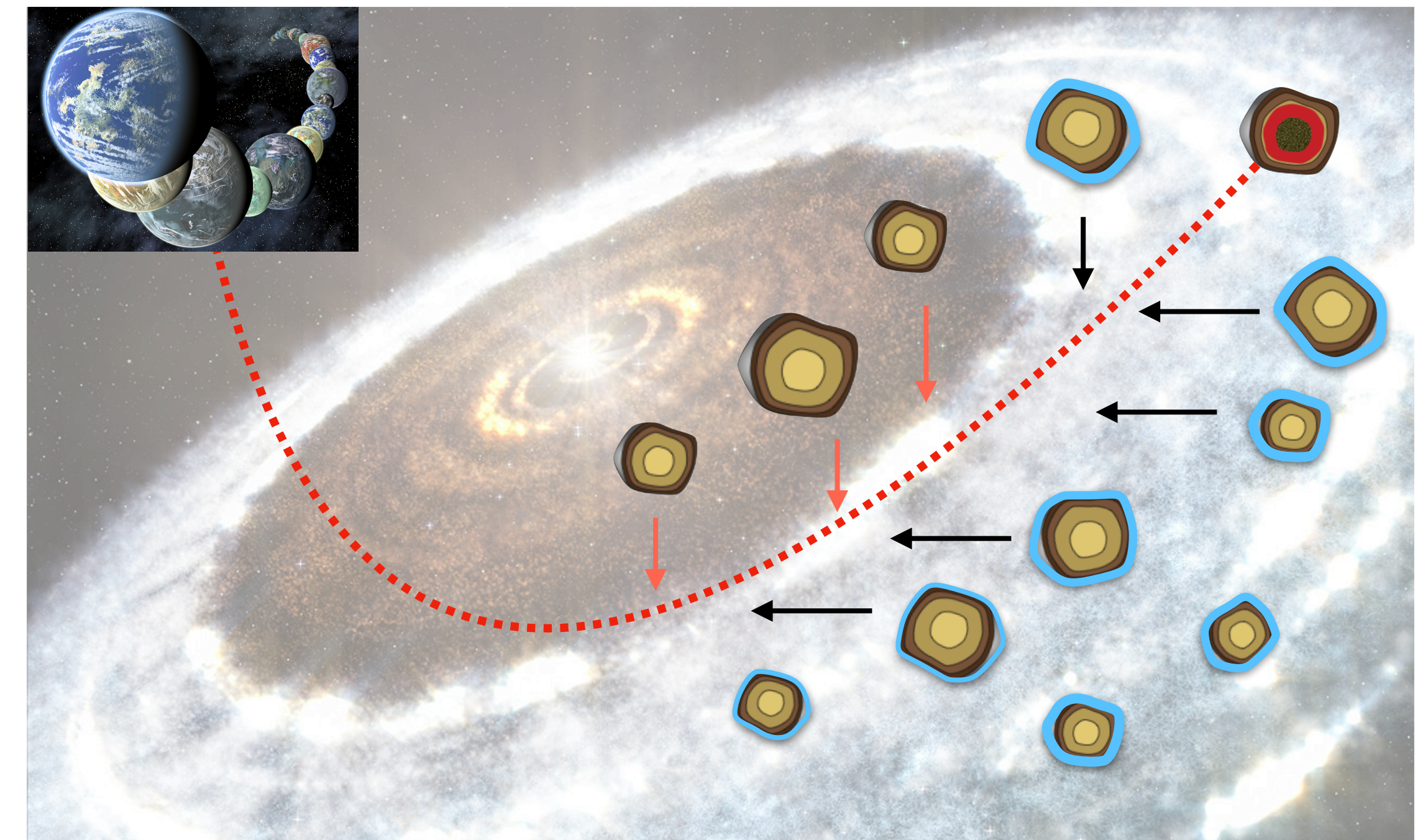




# $^{26}\text{Al}$ controls bulk water content



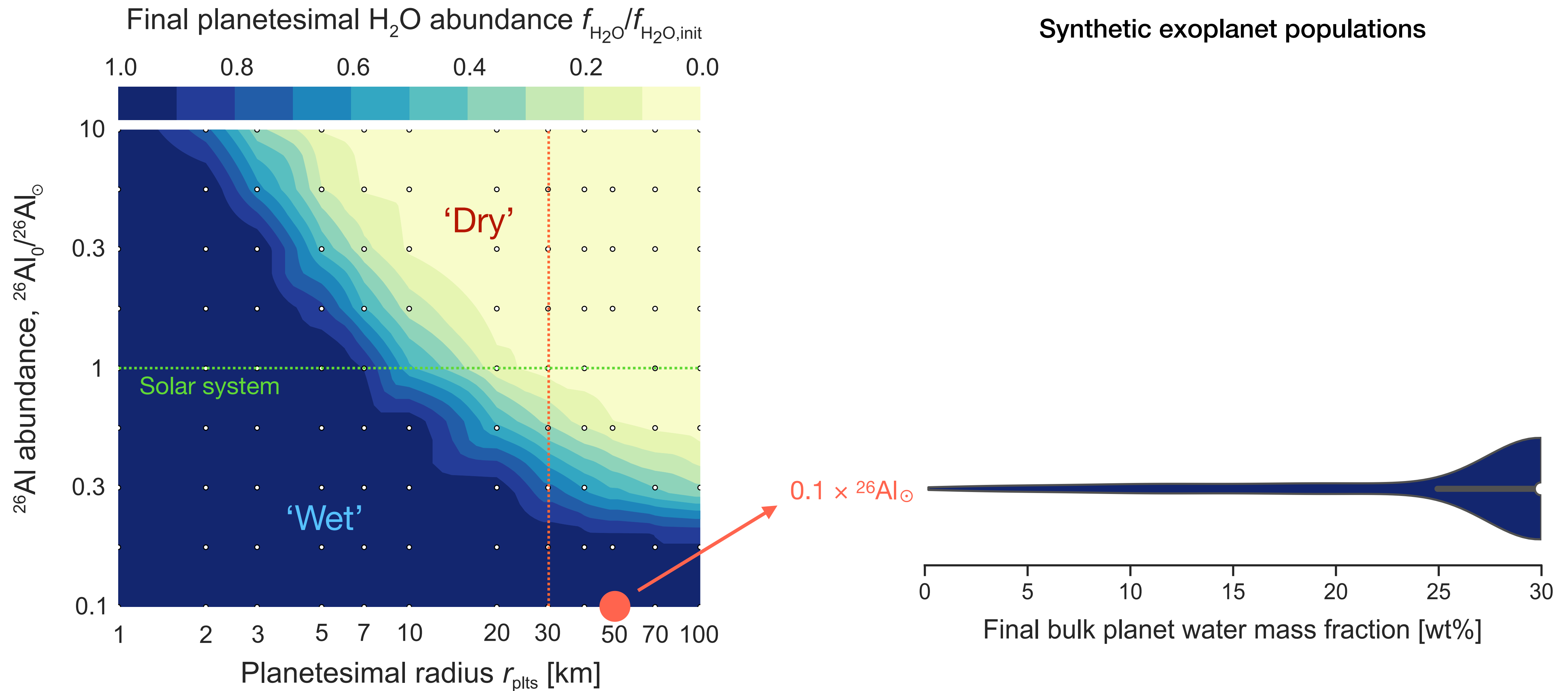
Synthetic exoplanet populations



← Accretion & decreasing water abundance in planetesimals

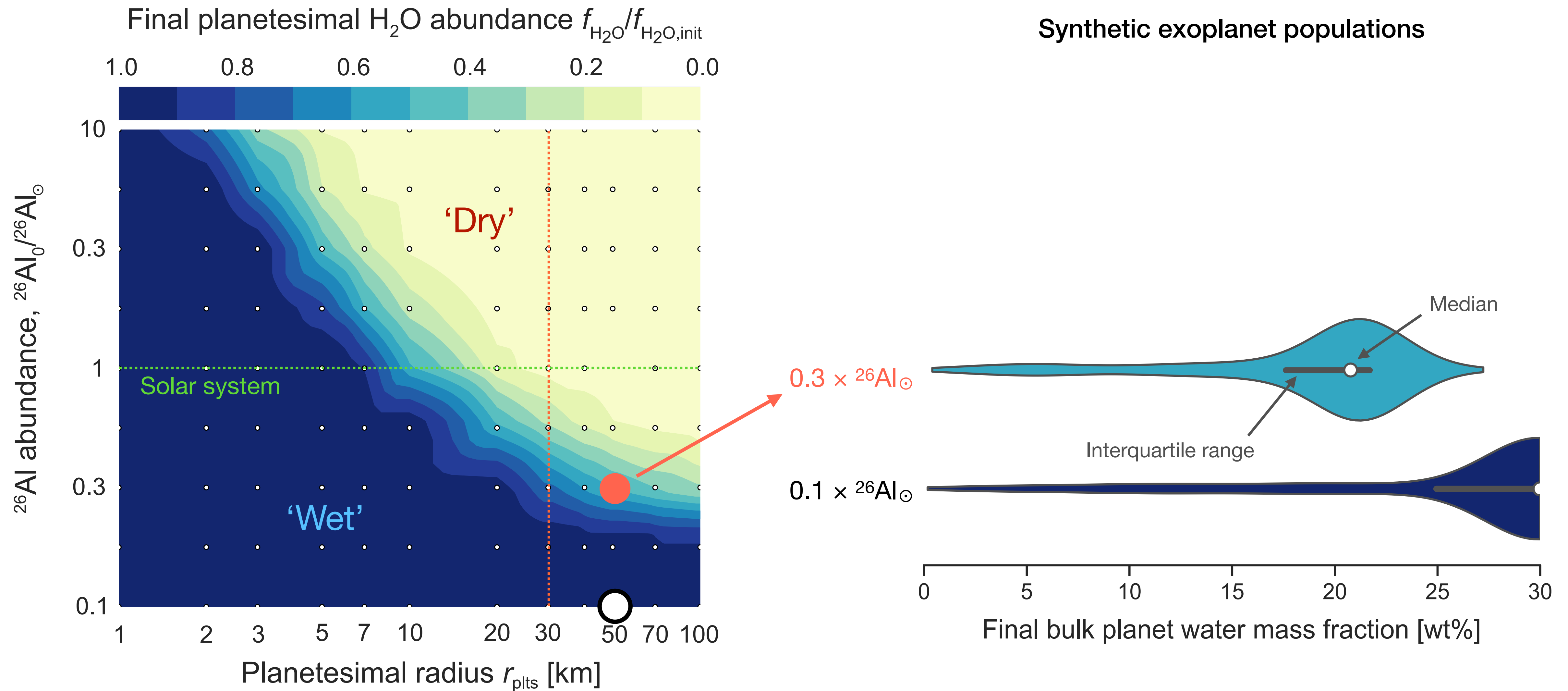


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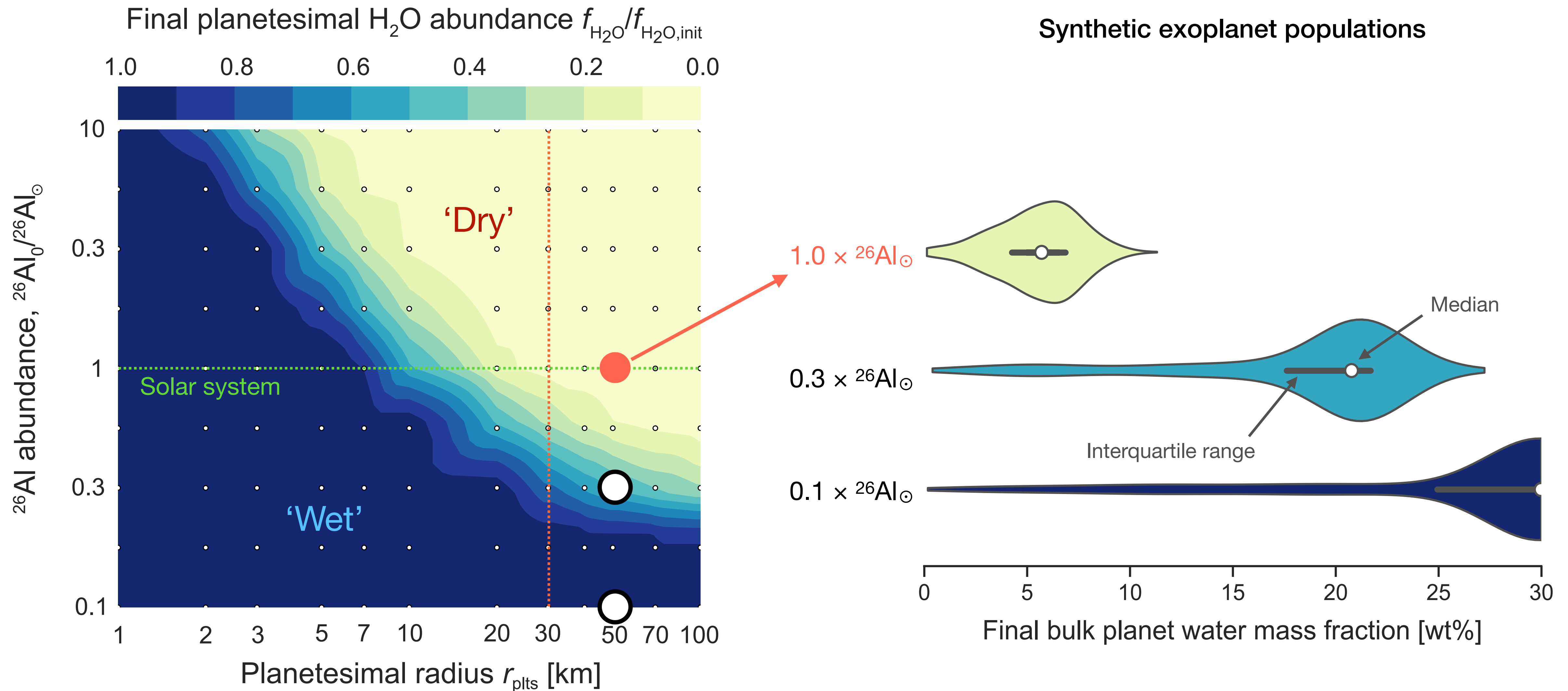


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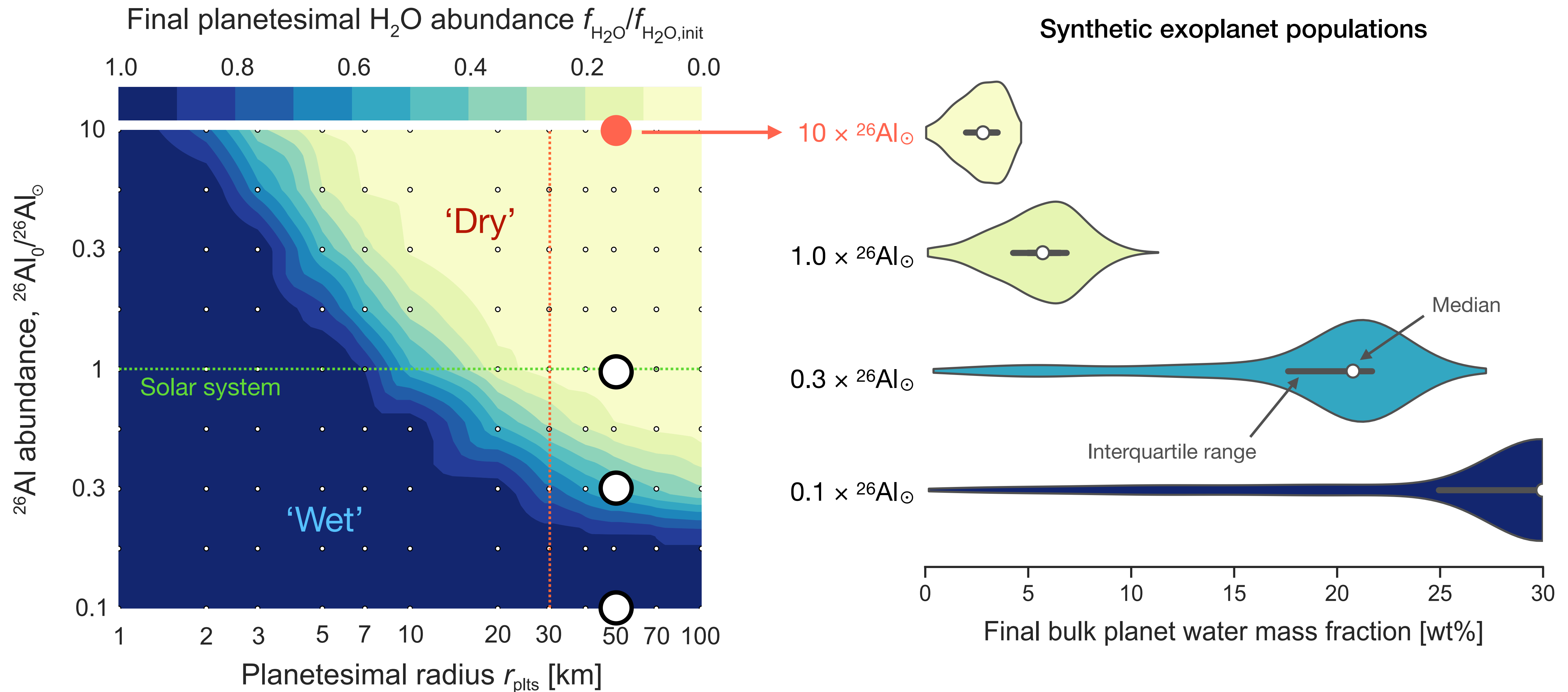


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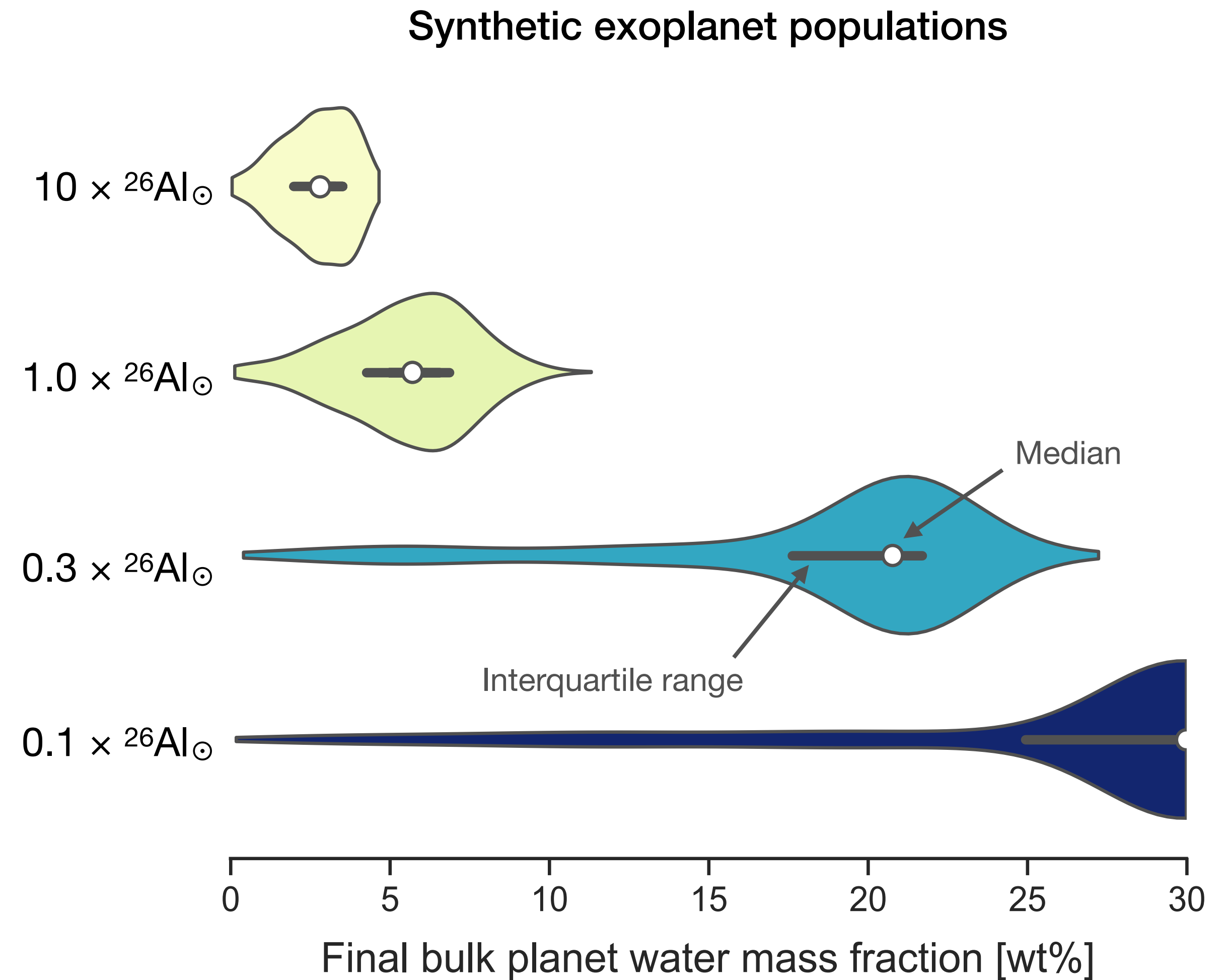
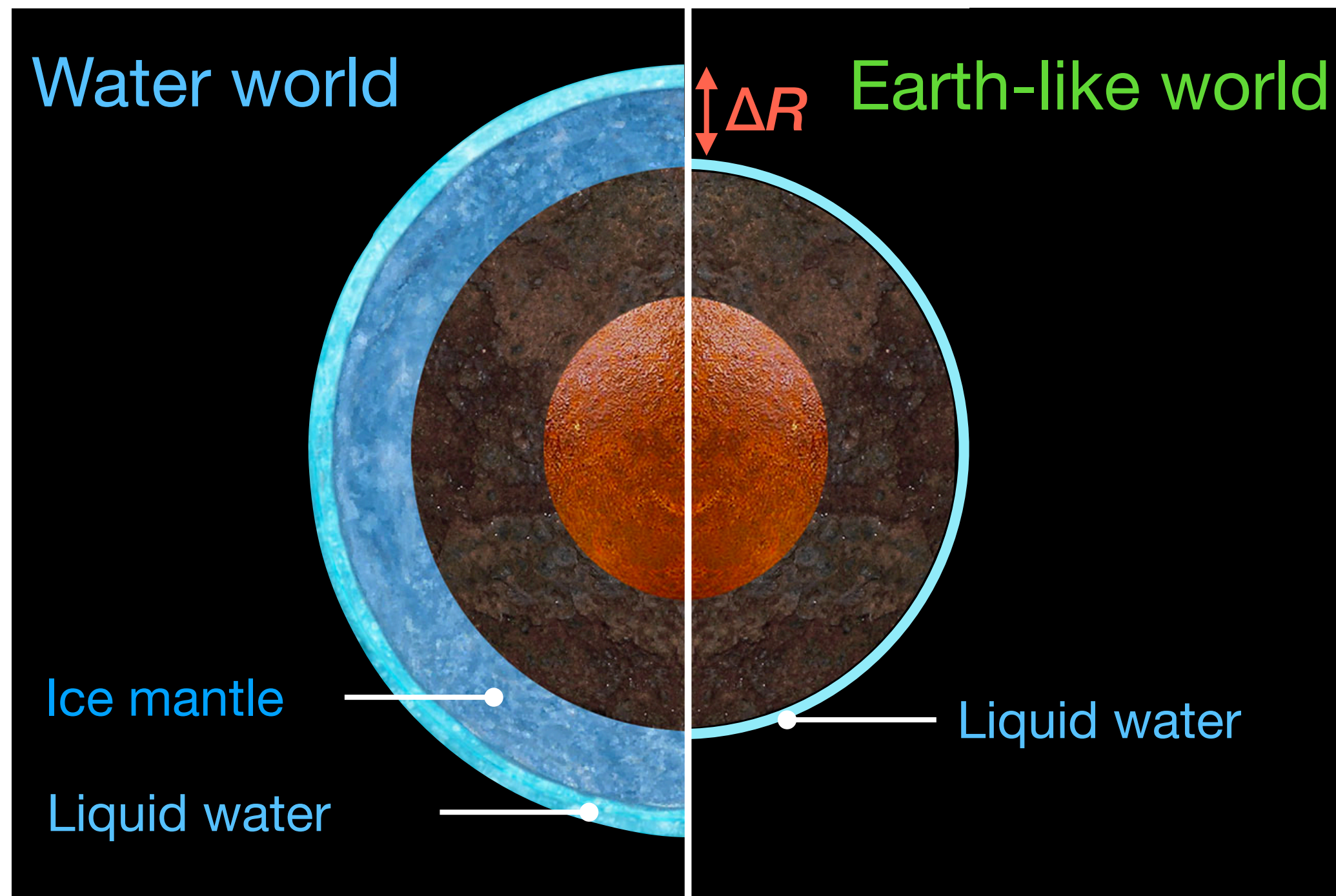


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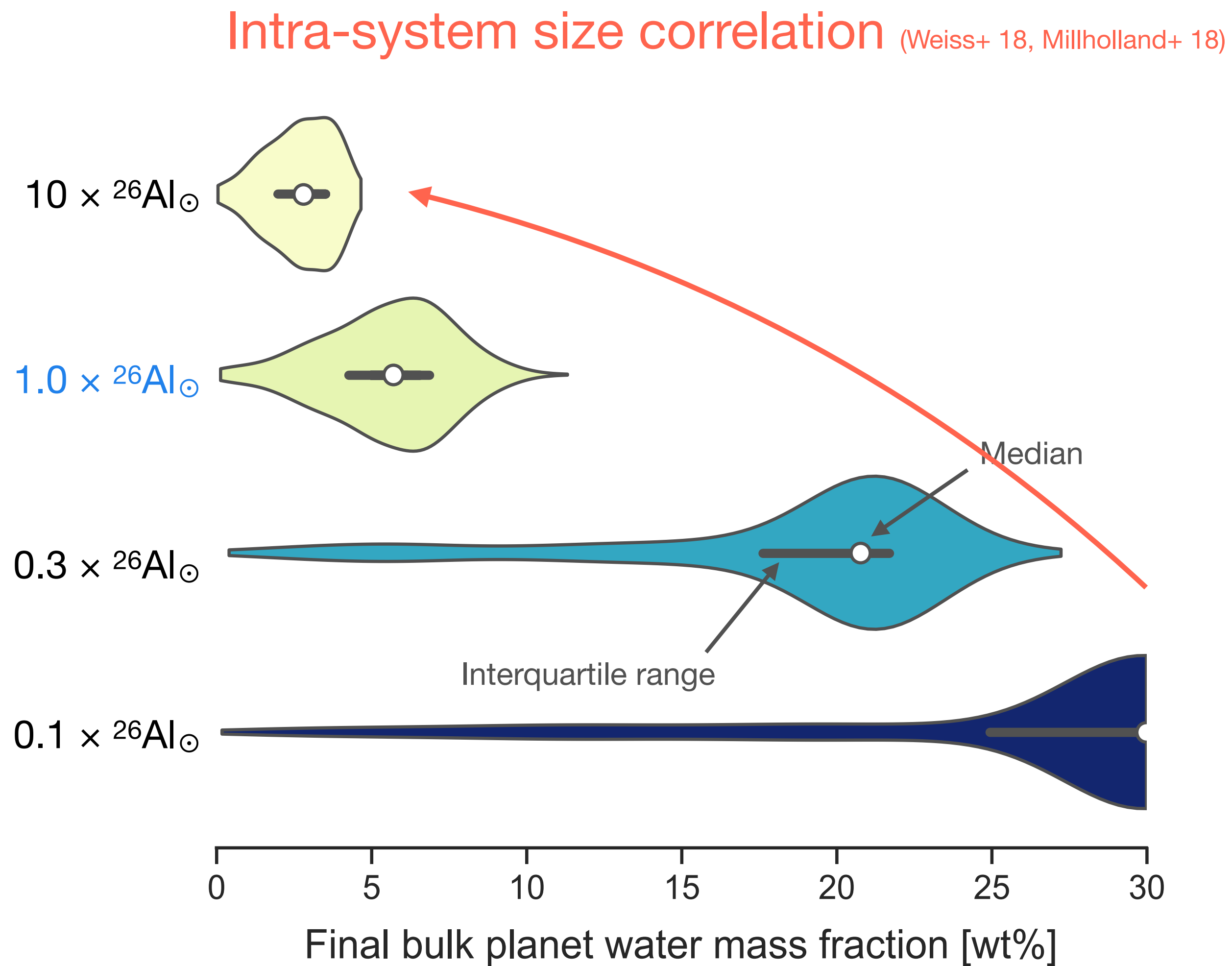
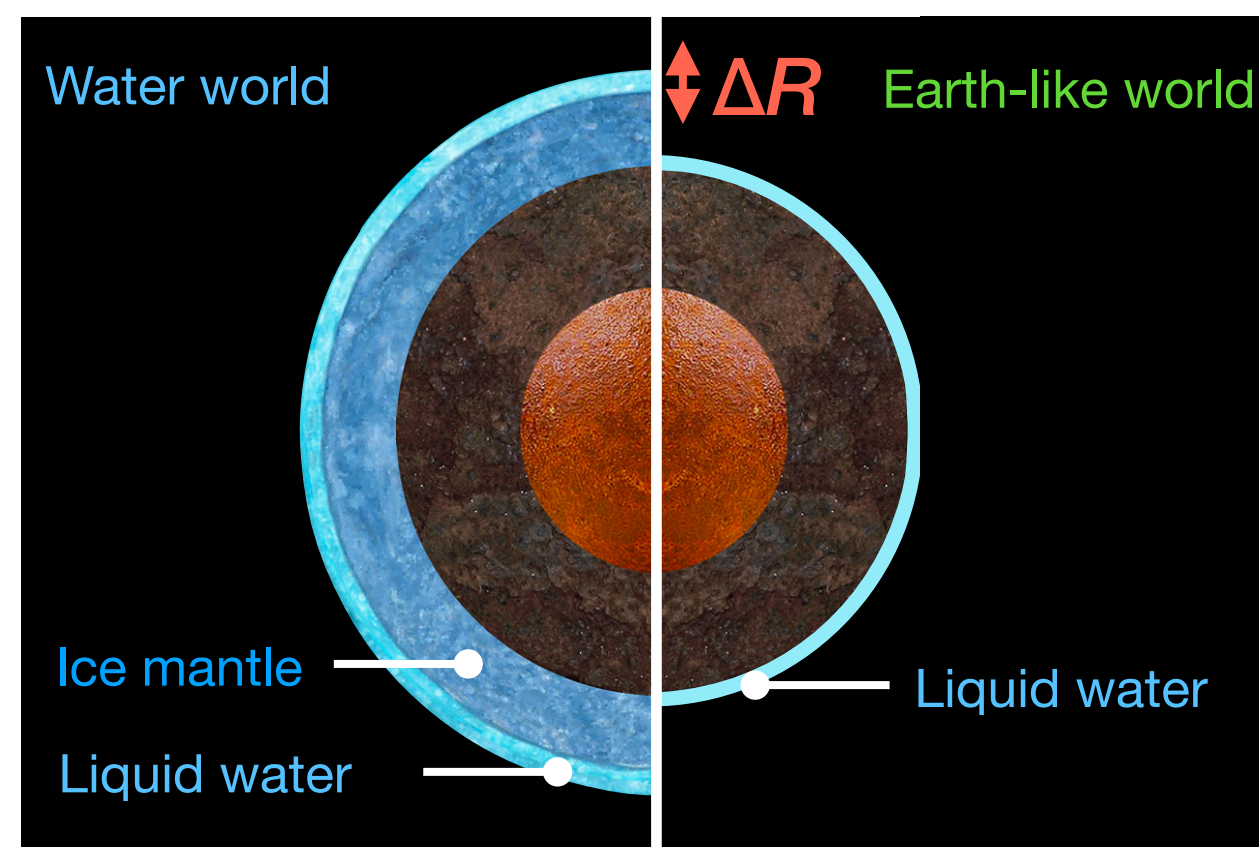
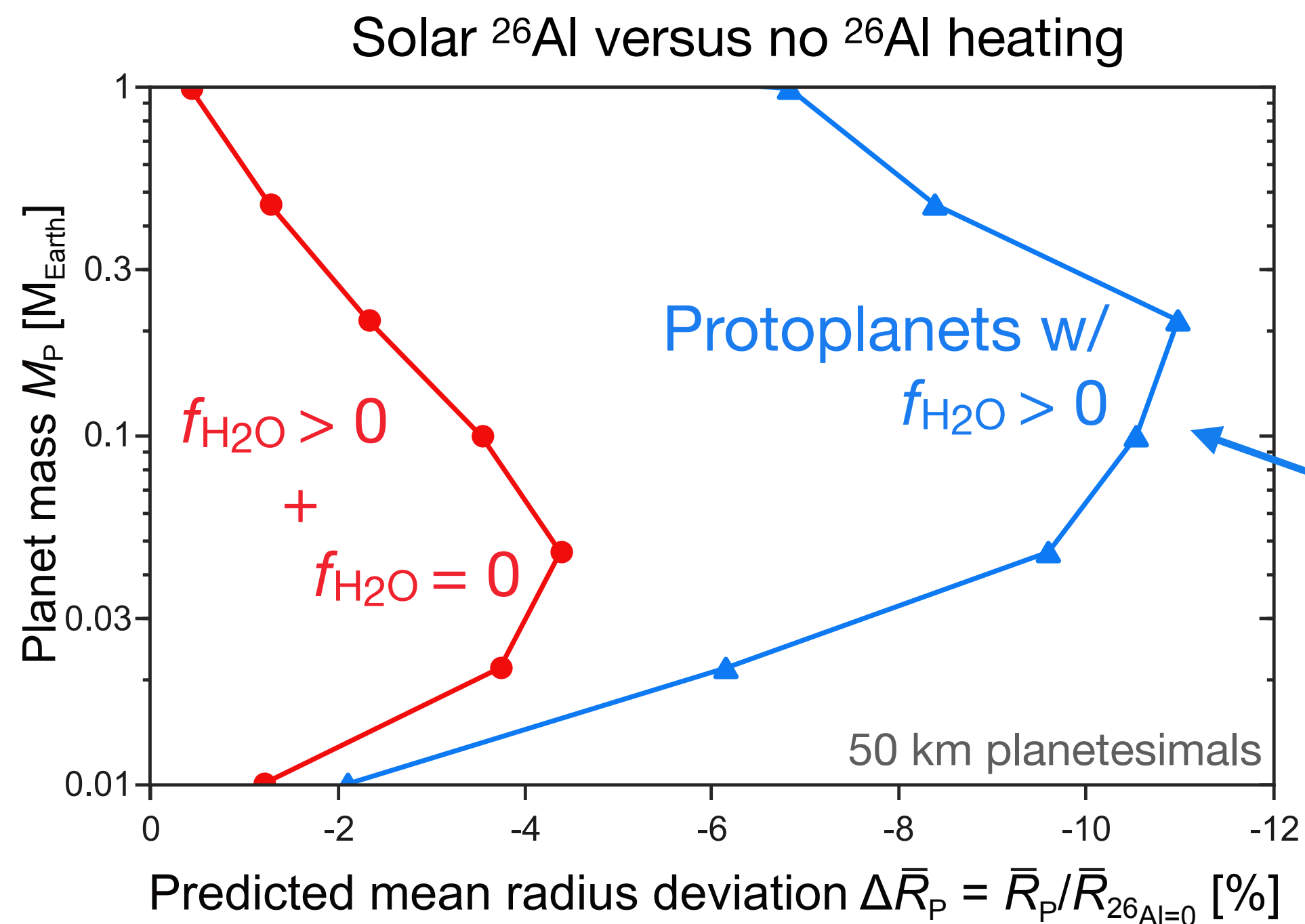


# $^{26}\text{Al}$ controls bulk water content





# $^{26}\text{Al}$ shapes exoplanet structure





# $^{26}\text{Al}$ shapes distribution systematics



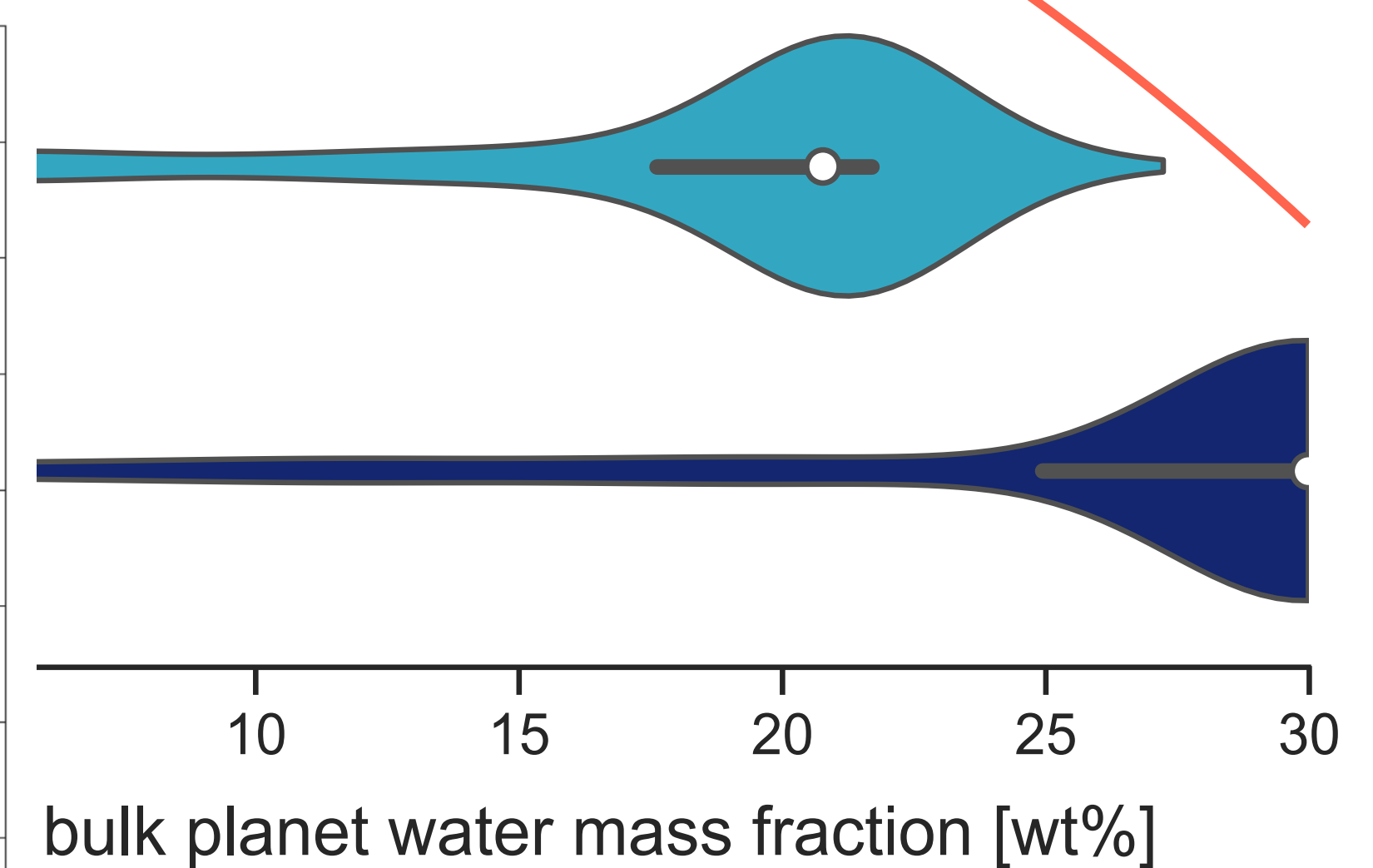
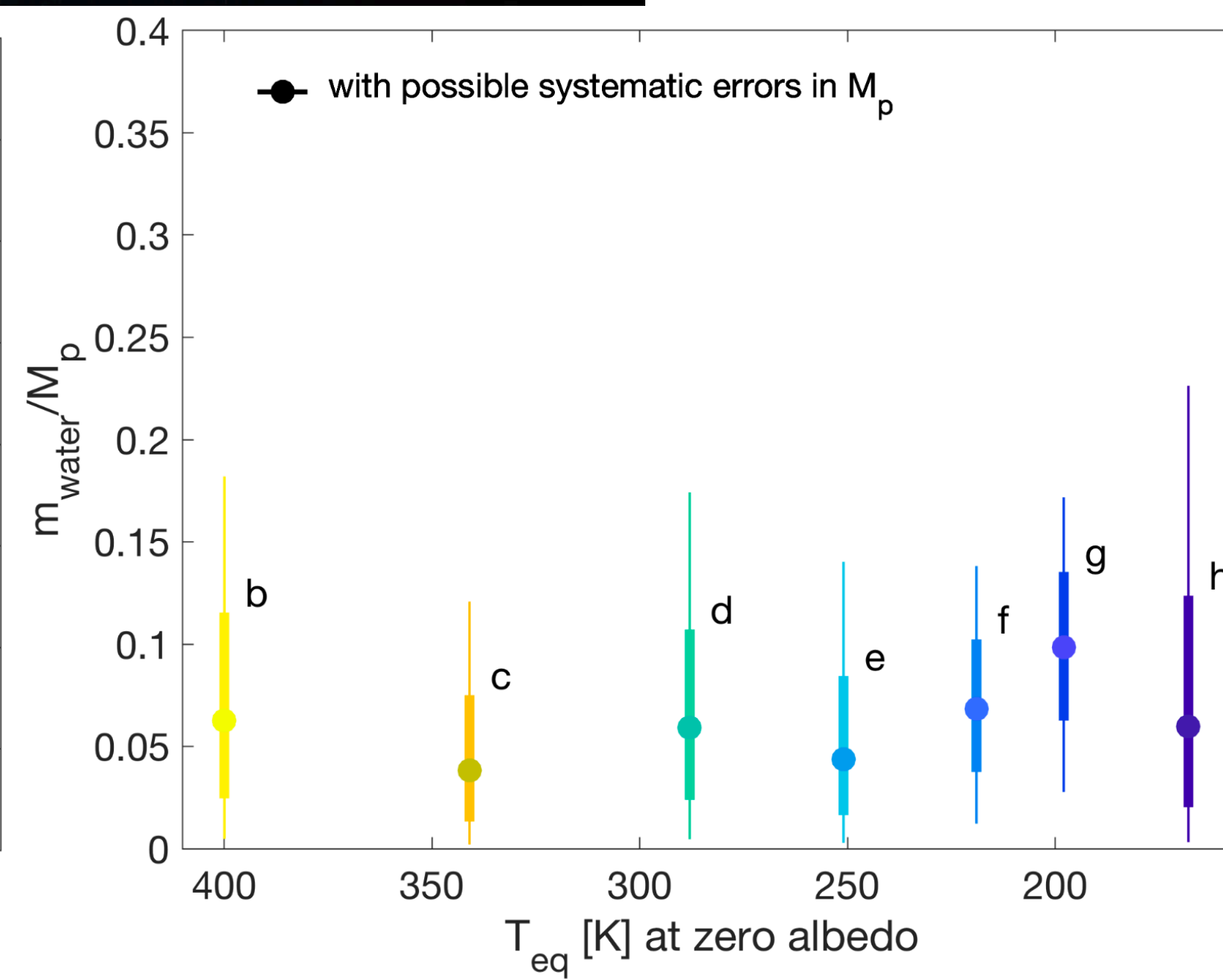
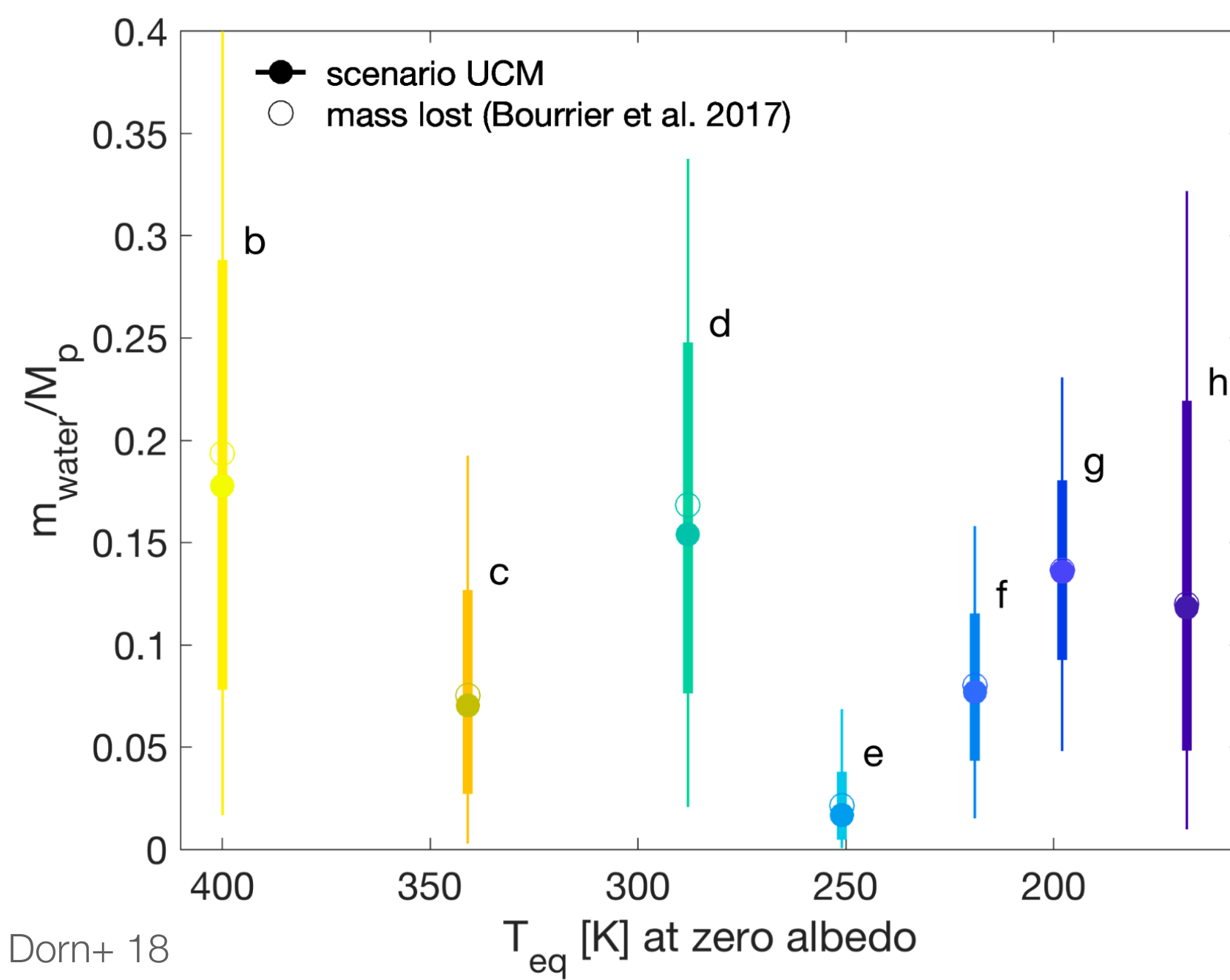
Intra-system size correlation (Weiss+ 18, Millholland+ 18)

Insensitive to orbital location

TRAPPIST-1 (Grimm+ 18, Dorn+ 18)

$10 \times ^{26}\text{Al}_\odot$

$1.0 \times ^{26}\text{Al}_\odot$



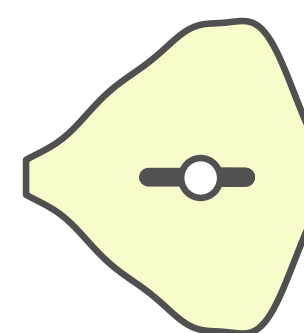


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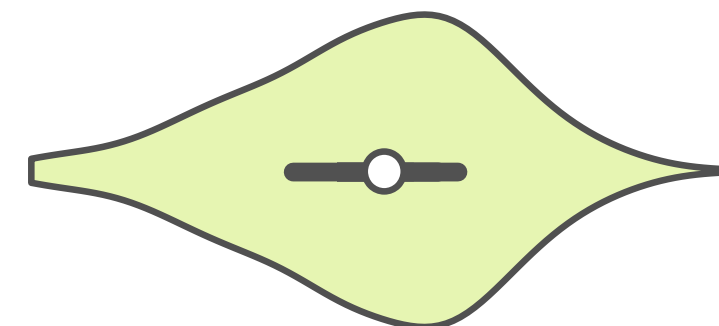


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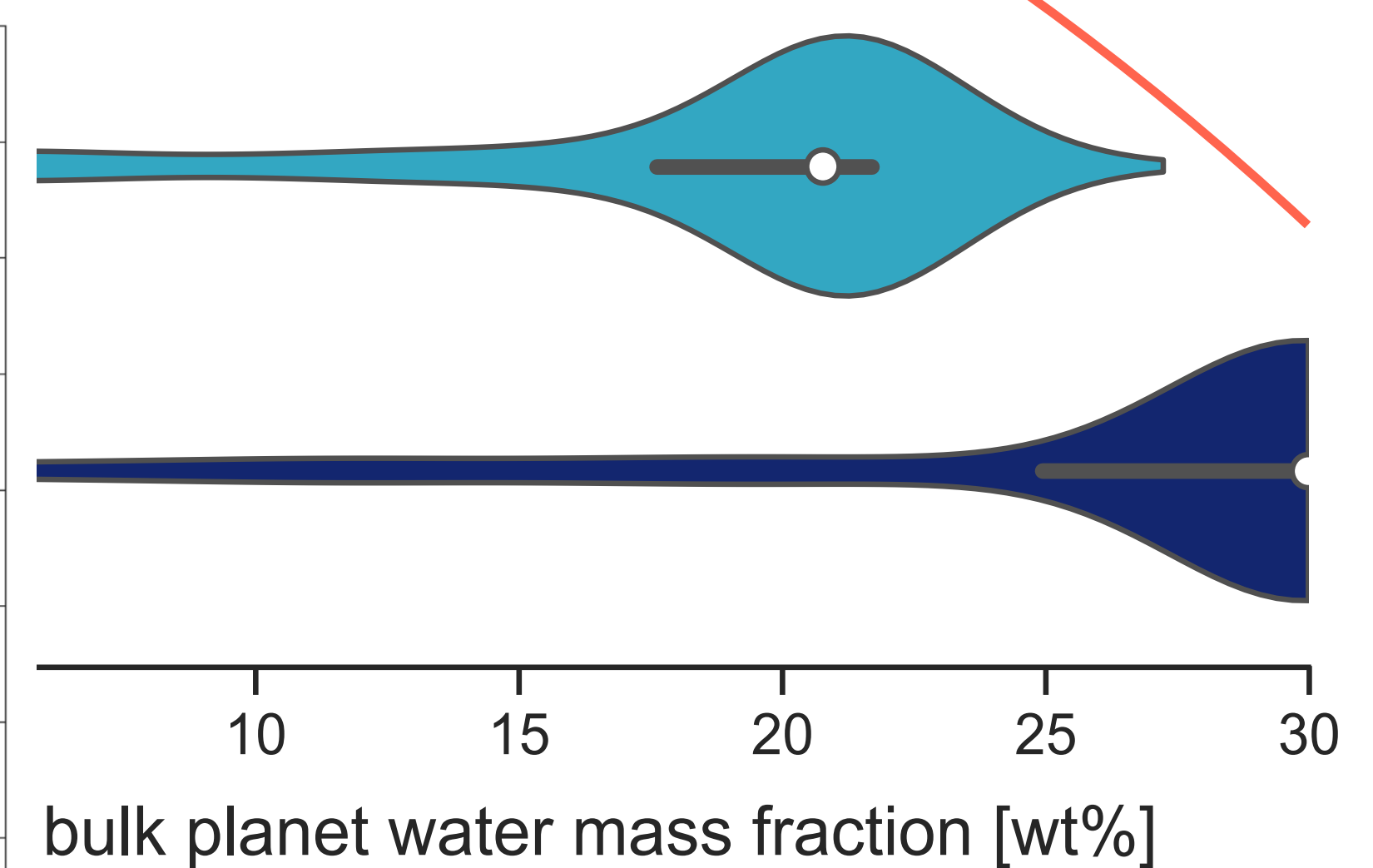
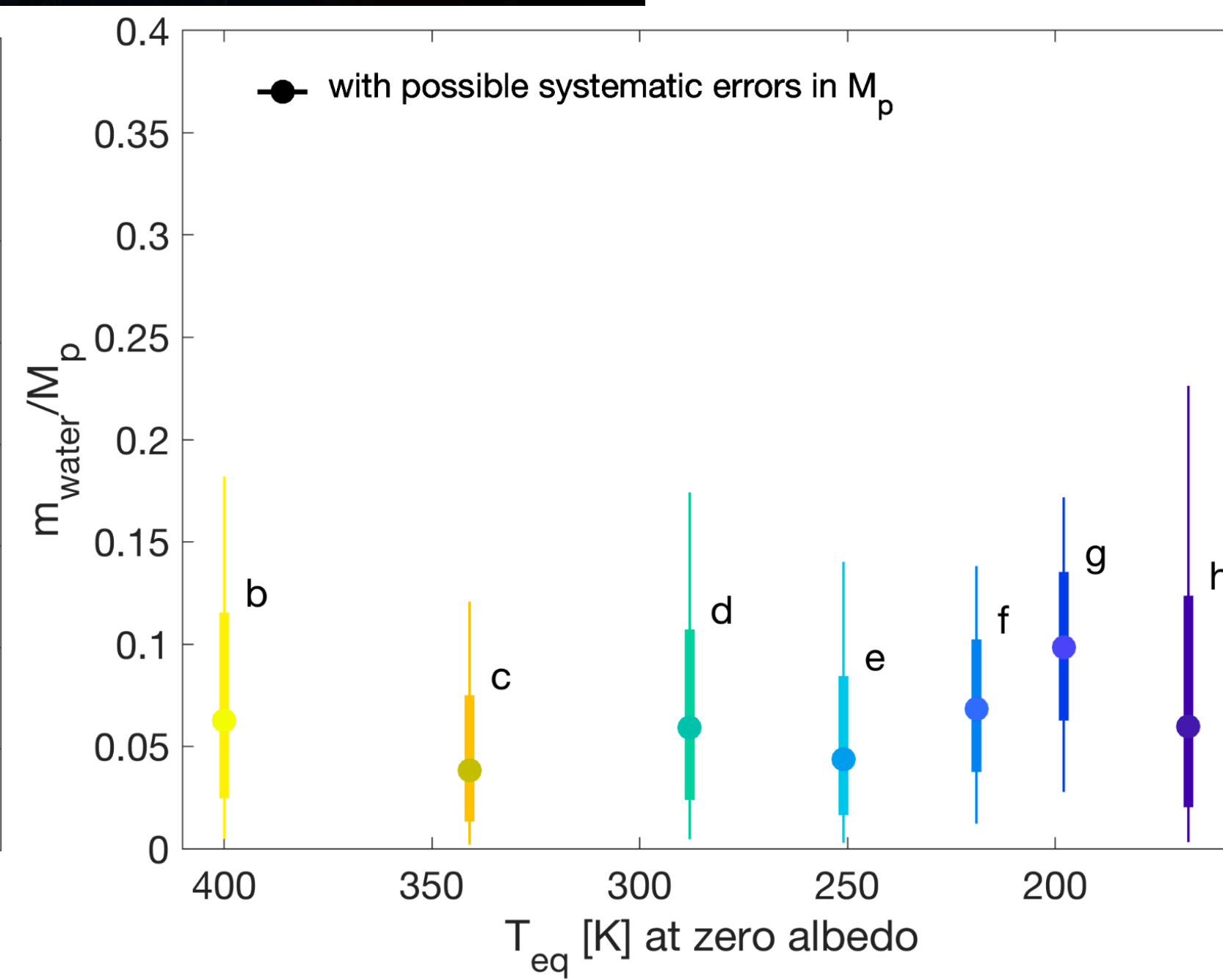
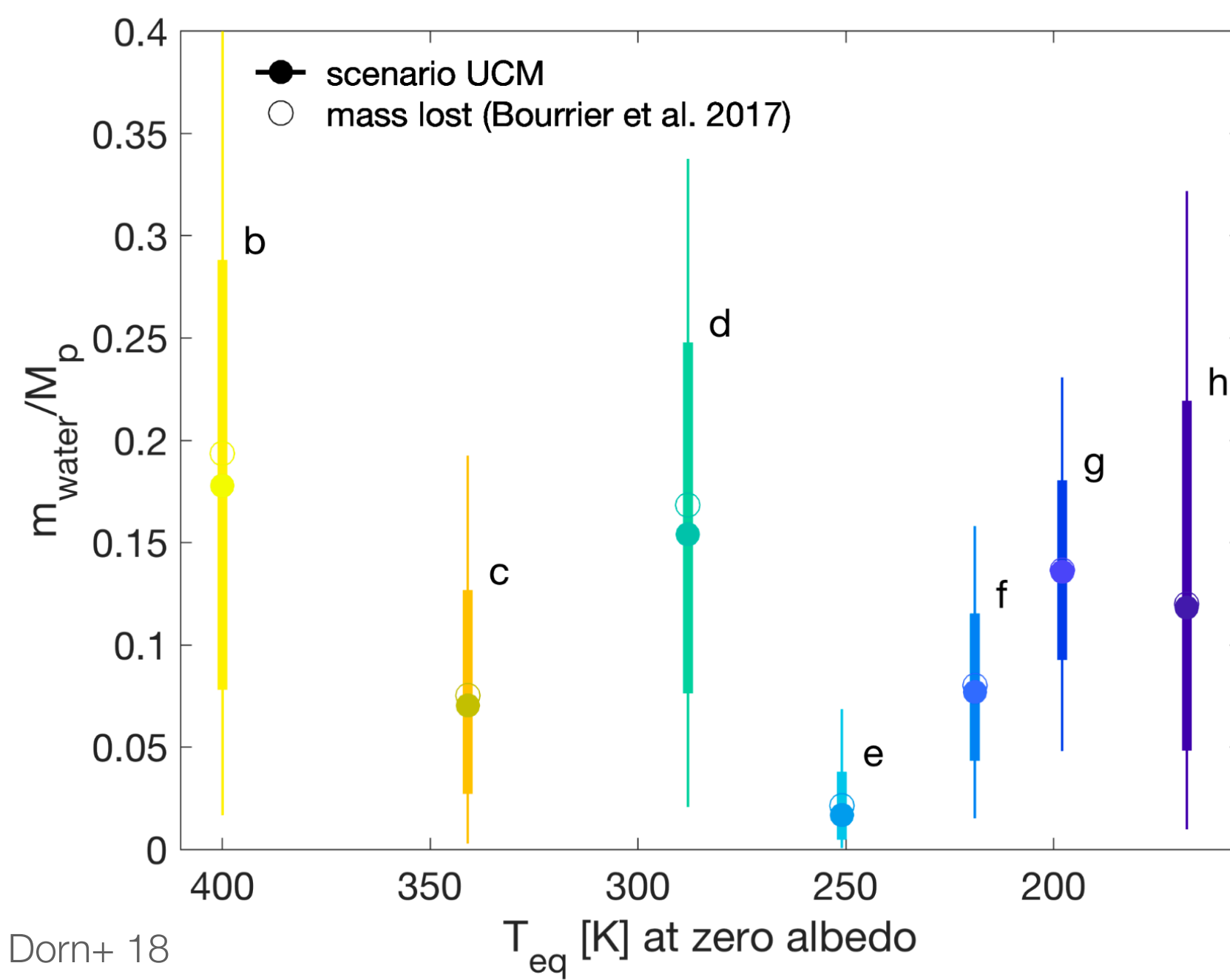
$1.0 \times ^{26}\text{Al}_\odot$



Insensitive to orbital location

TRAPPIST-1 (Grimm+ 18, Dorn+ 18)

Near-future M star statistics?  
(Ballard 19)





# $^{26}\text{Al}$ key control on rocky planet composition



- Fraction of planetary systems enriched with  $^{26}\text{Al}$ 
  - ➔ Volatile loss & differentiation in planetesimals
- Systemic dichotomy:
  - ➔ Enriched: water-poor (proto-)planets
  - ➔ Not-enriched: ocean worlds
- ◉ Statistically traceable w/ near-future data?
  - ➔ Discernible by *transit radius* alone
  - ➔ Increasing statistics on M star systems