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Internal water storage capacity of terrestrial planets and the effect of hydration on the M-R relation

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The discovery of low density exoplanets in the super-Earth mass regime suggests that ocean planets could be abundant in the galaxy. Understanding the chemical interactions between water and Mg-silicates or iron is essential for constraining the interiors of water-rich planets. Hydration effects have, however, been mostly neglected by the astrophysics community so far. As such effects are unlikely to have major impacts on theoretical mass-radius relations, this is justified as long as the measurement uncertainties are large. However, upcoming missions, such as the PLATO mission (scheduled launch 2026), are envisaged to reach a precision of up to ≈ 3% and ≈ 10% for radii and masses, respectively. As a result, we may soon enter an area in exoplanetary research where various physical and chemical effects such as hydration can no longer be ignored. We have constructed interior models for planets that include reliable prescriptions for hydration of the cores and mantles. These models can be used to refine previous results for which hydration has been neglected and to guide future characterization of observed exoplanets. We have developed numerical tools to solve for the structure of multi-layered planets with variable boundary conditions and compositions. Here we have considered three types of planets: dry interiors, hydrated interiors, and dry interiors plus surface ocean, where the ocean mass fraction corresponds to the mass fraction of the H_2O equivalent in the hydrated case. We find H and OH storage capacities in the hydrated planets equivalent to 0 - 6 wt% H_2O corresponding to up to ≈800 km deep ocean layers. In the mass range $0.1 \le M/M_{\oplus} \le 3$, the effect of hydration on the total radius is found to be ≤ 2.5%, whereas the effect of separation into an isolated surface ocean is ≤ 5 %. Furthermore, we find that our results are very sensitive to the bulk composition.