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Hydrodynamical and Chemical Modeling of Jupiter's Atmosphere – Updates on the Deep Water Abundance

Ali Hyder[1], Glenn Orton[1], Cheng Li[2], Nancy Chanover[3], and Gordon Bjoraker[4]
[1]NASA Jet Propulsion Laboratory, California Institute of Technology, La Cañada Flintridge, CA
[2]Department of Climate and Space Sciences and Engineering, University of Michigan, Ann Arbor, MI.
[3]Department of Astronomy, New Mexico State University, Las Cruces, NM
[4]NASA Goddard Space Flight Center, Greenbelt, MD

The Jovian deep water abundance is an important quantity in planetary formation theories that serves as a proxy for Jupiter's evolution during the early Solar System. The *in-situ* measurement of this quantity made by the *Galileo* probe showed that Jupiter's atmosphere was significantly depleted in oxygen than previously expected (Seiff et al., 1996). However, it is believed that the measurement was made in a Jovian "hot spot" (Orton et al., 1998), which is a region where there is a lack of water clouds (Wong et al., 2004). As a result, the *Galileo* probe's measurement of ~0.3x Solar oxygen enrichment has remained contested. Subsequent estimates of the water content made using the Microwave Radiometer (MWR) instrument on-board the *Juno* spacecraft, particularly in the equatorial region of the planet showed that the planet is enriched in oxygen (Li et al., 2024)., in contrast to the subsolar enrichment obtained by its predecessor spacecraft.

Measurements of disequilibrium chemical species, such as carbon monoxide (CO), phosphine (PH_3), and germane (GeH_4) have been tied to Jupiter's deep water abundance as they serve as tracers for the compositional make-up of the deeper troposphere (e.g., Wang et al., 2015, 2016). Conventionally, 1D chemical-diffusion models have been employed to simulate the behavior of these trace chemical species in hydrogen-rich atmospheres to constrain the deep water abundance using tropospheric measurements. However, such models are limited in their treatment of the atmosphere as all dynamical behavior is assumed to be constrained via the eddy mixing coefficient, K_{zz} (Zhang & Showman, 2018).

Here, we present the results of our hydrodynamical cloud-resolving model with simplified thermochemistry to showcase the effects of hydrodynamical and microphysical processes on the abundances of these disequilibrium trace species (Hyder et al., 2025). Using updated chemical timescales, we demonstrate that a deep water abundance of ~2.5x Solar is needed to match the CO observations made near the lifting condensation level. We also find that PH_3 and GeH_4 can be used to place upper bounds on the water content, limiting it to a range of 2.5-5.0x Solar. Our results show that this coupled approach can explain the observations made by the *Juno* MWR instrument near the equatorial region, supporting the case for a supersolar abundance oxygen in the Jovian troposphere.

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