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Comprehensive Chemical Models of Giant Planet Atmospheres

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Abstract

The bulk atmospheric water abundance on the giant planets is difficult to obtain by remote sensing methods because water condenses relatively deep in their cold atmospheres. Furthermore, the only *in-situ* measurements of the water abundance, by the *Galileo* probe mass spectrometer on Jupiter, pertain to an anomalous hot-spot region [1, 2]. As a result, chemical models must be used to determine the deep water abundance in giant planet atmospheres until further observations are available (e.g., with the planned *Juno* mission to Jupiter, [3]). The general approach of these models is to examine the chemical behavior of observed atmospheric constituents which are sensitive to the tropospheric water content.

We use the Caltech/JPL KINETICS code [4] to develop comprehensive one-dimensional (in altitude) photochemistry / thermochemistry / kinetics / transport models which accurately describe the transition from the thermochemical regime (where chemical equilibrium is established) in the deep troposphere to the quenched and photochemical regimes (where chemical equilibrium is disrupted) in the upper troposphere and stratosphere of the giant planets. These models are used to self-consistently calculate the abundance of important tropospheric constituents under different assumptions of bulk planetary composition and atmospheric mixing rates. In particular, we use CO observations to constrain the deep H_2O abundance on the giant planets, as done for previous estimates of the tropospheric water inventory [5, 6, 7, 8], while attempting to avoid the uncertainties associated with simple time-scale arguments. We also examine the overall chemical behavior (photochemistry, thermochemistry, kinetics, and transport) of nitrogen, phosphorus, and sulfur species to constrain the abundances of other major disequilibrium species in giant planet atmospheres.

We will discuss the implications of our results in the context of planetary formation and evolution, bulk planetary compositions, and the coupled chemical and transport processes operating in the deep atmospheres of giant planets.

References

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