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Stratospheric water vapor - progress, regress and digress

Prof. Stephan Fueglistaler

Princeton University

stf@princeton.edu

Air enters the stratospheric overworld predominantly in the tropics, and the temperatures around the tropical tropopause tightly constrain the amount of water entering the stratosphere. Improvements in numerical modeling and observations, specifically also in analysed meteorological data such as ERA-Interim and MERRA, have allowed for a much refined analysis of the governing processes, but important questions remain. Here, I argue that, in fact, progress regarding the governing processes has been remarkably slow. It's known since 20 years that large variations in water entering the stratosphere - such as the mean annual cycle, and large-amplitude interannual variability - are highly correlated with zonal mean tropopause temperature variations. However, how exactly this correlation arises remains poorly understood if we require observational evidence for model results. Specifically, I will argue that little progress has been made regarding the quantification of (i) the partitioning of water entering the stratosphere in gas and

condensed phase; (ii) the partitioning between slow ascent and direct convective injection; (iii) the role of transport pathways; (iv) the importance of the spectrum of waves perturbing the mean temperature profile, and (v) the role of cirrus cloud microphysics.

I will provide specific examples that show (i) the ambiguity of model results, (ii) uncertainty in observations preventing clear conclusions regarding the accuracy of model results, and will argue that (iii) no study to date could unambiguously attribute differences between measured water vapor and that expected from the large-scale circulation and temperature field to anomalous behaviour in any of the aforementioned processes.