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Evaluation of the interplay between deep convective parameterization and large-scale condensation using measurements of water isotopic composition profiles

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A major purpose of a deep convective parameterization in an atmospheric general circulation model is to simulate the effect of deep convection on large-scale environmental properties, including temperature, humidity and chemical tracers. How convection affects the environment depends on the deep convective parameterization itself, but also on the interplay with other parameterizations, especially shallow convection and large-scale condensation. The proportion of the precipitation that is produced by the different parameterizations is somewhat arbitrary (e.g. it is not clear which parameterization should produce anvils). However, this proportion has important consequences on heating profiles and on moisture and chemical tracer transport.
Here we explore the possibility of using profile measurements of water isotopic composition to add some constrain on the interplay between convective parameterization and large-scale condensation, and on the effect of these parameterizations on environmental humidity. This is based on the fact that the isotopic composition of water vapor is affected by fractionation during phase changes and is then conserved during transport. Using the isotope-enabled general circulation model LMDZ, we analyze the sensitivity of simulated isotopic profiles to parameters in the deep convection and large-scale condensation schemes. This sensitivity study is then extended in single-column simulations, after checking the relevance of single-column simulations to interpret three-dimensional simulations. Results are compared with the Aura TES measurements of water isotopic composition profiles. We show that for a given set of large-scale atmospheric conditions, the water vapor becomes more depleted in the mid and upper troposphere when large-scale condensation plays a larger role in producing the precipitation relatively to deep convection. In addition, for a given deep convective mass flux, the water vapor becomes more enriched when convections moistens the environment more strongly through detraiment of condensate. A framework is proposed to use joint humidity and isotopic measurements in a parameterization evaluation perspective.