What can we learn about processes controlling tropospheric humidity using water stable isotopes observed from satellites?

Analysis using water tagging experiments with the LMDZ-iso GCM

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In the recent years, several satellite datasets measuring atmospheric water vapor isotopes have been developped and yield the isotopic distribution of the tropical tropospheric water vapor with an unprecedented temporal resolution and spatial coverage. It has been suggested that water vapor isotopes may be useful to better understand processes controlling atmospheric humidity and its variations. However, an assessment of what can really be learnt from water isotopes is still missing. One reason for that is that a consistent framework to interpret the isotopic distribution and variability in the tropospheric water vapor still needs to be established. Therefore, our goal here is to use water tagging experiments with the isotope-enabled general circulation model LMDZ-iso to better understand what controls the isotopic distribution in the lower and middle tropical troposphere and its variations at different time scales. In turn, this would help evaluate the potential of water isotopes observed from satellites to quantify the contribution of different processes to humidity variations.

First, we carefully evaluate LMDZ-iso using the TES and SCIAMACHY satellite data.

Second, we perform a water tagging experiment in which we tag the last saturation specific humidity, in a method analog to Galewsky et al 2005 who had shown the success of such a method to explain the subtropical humidity distribution. Three additional tags represent remoistening processes: (1) surface evaporation, (2) condensate detrainement and subsequent evaporation, (3) precipitation evaporation. We use this tagging framework to diagnose the relative contribution of the different dehydrating and moistening processes to the simulated distribution in humidity and water isotopes, as well as its seasonal and intra-seasonal variations.

Third, this tagging framework is applied to climate change experiments to investigate processes involved in humidity changes, and the associated isotopic signature that would be observed from satellites. Using sensitivity tests to the microphysics, we investigate the possible contribution to humidity changes of microphysical processes versus dynamical processes, and the potential of water isotope observations to quantify this contribution.