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Multi-platform observations of stable water isotopes in the North Atlantic trades as tracers for the atmospheric circulation at different scales

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Low clouds over the tropical oceans are at the heart of current uncertainties in future climate projections. These boundary layer clouds form due to a subtle interplay between the large-scale atmospheric circulation and small-scale physical processes embedded in the flow. In this presentation, we show how stable water isotopes can be used as measurable tracers of this interplay and thus serve as a tool to link different flow regimes in the North Atlantic trades with low-level cloudiness. To do so, we take advantage of a combination of multi-platform isotope observations with high-resolution numerical model simulations. In the first part of this presentation, we highlight the large synoptic-timescale variability of stable water isotope signals from ground- and satellite-based remote sensing observations (FTIR and IASI) over the Canary Islands. This observed variability can be linked with different atmospheric transport pathways and water vapour sources using air parcel backward trajectories and numerical tracers in a regional climate model simulation. We show how the Saharan heat low dynamics in summer moistens the eastern subtropical North Atlantic. Despite the strong free tropospheric moistening by the Saharan air layer, low-level cloudiness over the eastern North Atlantic is anomalously low in this flow regime. In the second part of this presentation, we use in-situ measurements of stable water isotopes from the Barbados Cloud Observatory, and from the French research aircraft ATR, downstream of the Canary Islands in the western North Atlantic trades. With these observations, we illustrate how water isotope signals in the lower troposphere are linked to different synoptic-scale flow regimes and their embedded mesoscale cloud organisation patterns with their associated cloud-relative overturning circulations. We thereby show how water isotope observations serve to evaluate climate models in a process-based way and how they can help in the future to better constrain these models in faithfully reproducing the impacts of low-level clouds on the Earth‘s energy budget.