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# A process-oriented model evaluation using EURECA water isotope field observations in the North Atlantic trades reveals the imprint of the atmospheric circulation at different scales

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Shallow clouds, ubiquitous in the trade-wind region, substantially contribute to the cooling of the Earth's climate through their shortwave radiative effect. Their response to climate change is unclear, contributing to a large part of the uncertainty of climate projections. The cloud fraction at cloud base, in particular, has been identified as a key parameter for the spread of modelled feedback of these clouds to climate change. Therefore, understanding the processes controlling the variability of cloudiness at cloud base is of utmost importance. Stable water vapour isotopes reflect the integral of moist atmospheric processes encountered by the vapour since evaporation from the ocean surface. This study focuses on stable water isotopes variability from aircraft observations with the French ATR research aircraft and high-resolution isotope-enabled simulations in the winter trades near Barbados at cloud base. Nested convection resolving COSMOiso simulations at 10, 5 and 1 km grid spacing during the EUREC4A field experiment period are used, which have been thoroughly evaluated using observations from different platforms. The three main findings are: (i) contrasting isotope and humidity characteristics in clear-sky versus cloudy cloud base environments emerge due to vertical transport on time scales of 12 hours, which (ii) are associated with local, convective circulations, and show a clear diel cycle; (iii) the cloud base isotope signals are, in addition, sensitive to variations in the large-scale circulation on time scales of several days, which shows on average a Hadley-type subsidence but occasionally much stronger descent related to extratropical dry intrusions. This investigation, based on stable water isotopes in high-resolution simulations in combination with trajectory analyses reveals, in a physically plausible way, how dynamical processes at different scales act in concert to produce the observed humidity variations at the cloud base of trade wind cumuli.