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Moisture transport over the western tropical Atlantic based on the results of COSMO-iso simulations with passive moisture tracers

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Tropical free-tropospheric humidity plays a crucial role in the Earth's radiative balance and climate sensitivity. However, the processes that control the variability of the moisture budget in tropical free-troposphere are controversal. Complementing atmospheric humidity, stable water isotopes serve as invaluable tracers that can elucidate hydrological processes such as subsidence-induced drying, turbulent mixing, and convective moistening. Here we investigate moisture pathways and their impact on the isotopic signature in the western tropical Atlantic region. We use the regional COSMO model equipped with stable water isotopes and passive water tracers to quantify the contributions of the different evaporation sources to moisture contents and their isotope signals in the free troposphere of the western tropical Atlantic. For the time period of the EUREC4A field campaign (January-February 2020), convection-resolving high-resolution (5 km) nudged simulations are performed, allowing a comparison with field data. During this period, the tropical Atlantic region is characterized by alternating large-scale circulation regimes with different moisture and isotope signatures. The moist conditions in the middle troposphere (300-650 hPa) over Barbados are associated with moisture transport from the south, east, southeast, as well as with convective moisture recycling, while the dry conditions correspond to extratropical transport from the north and west. Using a statistical model based on the specific humidity and temperature values, we were able to predict the contribution of the moisture source to the Barbados free troposphere with an R-squared (R^2) of 0.52. When we include at least one water isotope as a predictor in the model, the prediction improves (R^2 0.66). Our modeling approach, together with the unprecedented observational data from the EUREC4A campaign, offers exciting new opportunities to evaluate and ultimately improve the representation of the tropical water cycle in climate models.