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# How Rossby wave breaking modulates cold pool frequency in Barbados: A stable water isotope perspective

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Cold pools, generated by unsaturated convective downdrafts are fascinating and important mesoscale features in the tropical and subtropical North Atlantic. Through their influence on the developing cumulus cloud pattern, cold pools play a key role in the organization of shallow convection and thus in shaping the albedo over the trade wind regions of the tropical oceans. In this work, the large-scale dynamical drivers of tropical oceanic cold pool activity are studied with a combination of air parcel trajectories and stable water isotope measurements from a 25 days campaign carried out at the Barbados Cloud Observatory between 25 January and 18 February 2018. The isotope signals are used as tracers for moist diabatic processes in the atmosphere and at the air-sea interface.

Two distinct regimes in the isotope time series are found. They are associated with a differing airmass transport history towards the measurement site leading to contrasting lower free troposphere (LFT, 900-600 hPa) humidity and cloud cover properties. The first and most frequent regime ("moist LFT regime") represents the typical trade wind situation with near-surface easterlies bringing moist low-level air parcels from the eastern North Atlantic towards Barbados in a deep layer from the surface to 700 hPa. These air parcels originate from the extratropics, descend from the mid to upper troposphere within eastern Atlantic Anticyclones and experience progressive moistening by turbulent mixing with boundary layer (BL, surface to 900 hPa) air. Between 3 and 17 cold pool passages are registered in Barbados on such days. The second regime is associated with a strong drying of the LFT and the BL above Barbados ("dry LFT regime") due to the influence of air parcels descending directly from the midlatitude jet stream region in the four days prior to their arrival in Barbados. These dry airstreams are guided towards Barbados by quasi-persistent upper-level cut off lows associated with anticyclonic Rossby wave breaking in the central subtropical North Atlantic. In the "dry LFT regime" the descending dry air acts to suppress cold pool activity by continuously supplying dry upper-level extratropical air into the tropical LFT and BL over Barbados. The marine boundary layer is comparatively enriched in heavy isotopes in the "moist LFT regime" with enhanced short-term (1 min) variability induced by the frequent passage of cold pools. In the "dry LFT regime" depleted dry air from upper levels arrives into the BL and lowers the relative humidity, increases the near surface humidity gradient, and leads to intensified ocean evaporation. This induces a decrease in the amount of heavy isotopes in boundary layer vapour and an increase in the second order isotope parameter deuterium excess.

Overall, this study uses a Lagrangian approach to highlight the importance of extratropical upper-level dynamics in modulating the amount of humidity available in the tropical LFT, the isotope signals of BL moisture and the cold pool convective activity in the North Atlantic winter trades.