EGU21-2260
https://doi.org/10.5194/egusphere-egu21-2260
EGU General Assembly 2021

Diabatic processes associated with an extratropical dry intrusion reaching into the western North Atlantic trade wind region

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Intrusions of dry upper-level extratropical air into the tropics play an important role in shaping the synoptic time-scale variability of the low-level cloud cover over the tropical oceans. In this study, we present a detailed Lagrangian analysis of an extratropical dry intrusion in the western North Atlantic, which occurred in January-February 2018. During this period, the easterly trade winds were interrupted for several days by coherent packages of rapidly descending air parcels reaching from the mid-latitude jet stream region into the sub-cloud layer close to Barbados. As those air parcels are anomalously dry and cold, they have a notable impact on diabatic processes in the vicinity of the trade wind cloud tops such as longwave cooling and cloud evaporation and sublimation. To quantify the Lagrangian heat budget along the dry intrusion, we performed a simulation with the Integrated Forecasting System (IFS, 0.4° horizontal resolution, 137 vertical levels) from the European Centre for Medium Range Weather Forecasts (ECMWF) with diabatic heating rate (DHR) output. We calculated back-trajectories based on hourly three-dimensional wind fields and analysed the DHR along the dry intrusion air parcels. In the first part of their descent from the mid-tropospheric jet stream region, the dry intrusion air parcels' heat budget is dominated by adiabatic warming. In the second part of their descent, they experience strong diabatic cooling at cloud tops, due to microphysical and radiative processes. This leads to cross-isentropic flow, which allows these air parcels to pass through the inversion and to penetrate into the boundary layer. Thereafter they experience strong diabatic warming by turbulent fluxes. The presented detailed case study thus illustrates, how the rapidly subsiding extratropical dry intrusion air interacts with the parametrised subgrid-scale processes at cloud top in the model, thereby affecting the thermodynamic conditions in the boundary layer.