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Convective Cold Pools over the Atlas Mountains and their Influence on the Saharan Heat Low

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The West African Monsoon (WAM) and its representation in numerical models are strongly influenced by the Saharan Heat Low (SHL), a low-pressure system driven by radiative heating over the central Sahara and ventilated by the cold and moist inflow from adjacent oceans. It has recently been shown that a significant part of the southerly moisture flux into the SHL originates from convective cold pools over the Sahel. These density currents driven by evaporation of rain are largely absent in models with parameterized convection. This crucial aspect has been hypothesized to contribute to the inability of many climate models to reproduce the variability of the WAM.

In this contribution, the role of convective cold pools approaching the SHL from the north is analyzed. These events originate from the Atlas Mountains, a strong orographic trigger for deep convection in Northwest Africa. Knowledge about the frequency of these events, as well as their impact on large-scale dynamics, is required to understand their contribution to the variability of the SHL and to known model uncertainties. The first aspect is addressed through the development of an objective and automated method for the generation of multi-year climatologies not available before. The algorithm combines standard surface observations with satellite microwave data. Representativeness of stations and influence of their spatial density are addressed by comparison to a satellite-only climatology. Applying this algorithm to data from automatic weather stations and manned synoptic stations in and south of the Atlas Mountains reveals the frequent occurrence of cold pool events in this region. On the order of 6 events per month are detected from May to September when the SHL is in its northernmost position. The events tend to cluster into several- days long convectively active periods, often with strong events on consecutive days.

This study is the first to diagnose dynamical impacts of such convective periods on the SHL, based on simulations of two example cases using the Weather Research and Forecast (WRF) model at convection-permitting resolution. Sensitivity experiments with artificially removed cold pools as well as different resolutions and parameterizations are conducted. Results indicate that cold pools lead to increases in surface pressure of more than 1 hPa and to significant moisture transports into the desert over several days. This moisture affects radiative heating and thus the energy balance of the SHL. Even though cold pool events north of the SHL are less frequent when compared to cold pools of Sahelian origin, it is shown that they gain importance due to their clustering and potential relation to extratropical synoptic activity. Together with studies focusing on the Sahel, this work emphasizes the need for improved parameterization schemes for deep convection in order to produce more reliable climate projections for the WAM.