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The role of convectively-generated cold pools on model biases in the Sahara

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Radiosonde data from Fennec supersite-1 (Bordj Badji Mokhtar, Algeria) have been used to confront for the first time global model behaviour in the remote Sahara with regular in-situ profile observations. Convectively-generated cold pools are produced by the evaporation of precipitation and can propagate over large distances, particularly at night. These are an important component of mesoscale convective systems, which produce the majority of rainfall in the Sahel, and have been observed to ventilate the Sahara. Cold pools are, however, very poorly captured by parameterisations of convection. We assess how cold pool outflows from moist convection contribute to model biases in the Sahara and evaluate the impact of data assimilation on model analyses.

The Saharan heat low is too warm and dry in the forecast and cold pools are shown to contribute to the majority of the mean bias. Although the model does not represent dust and cold pools are an important dust uplift mechanism, the sign of the errors is inconsistent with radiative impacts of dust. These biases can therefore be directly attributed to the missing advective cooling from cold pools.

Cold pools cause 29% of the observed meridional humidity flux, but this contribution is absent both in the forecast and analysis, thus affecting the large-scale water cycle of the West African monsoon/Saharan heat low system. Assimilation of the radiosonde data reduces these errors, but significant temperature and meridional humidity-flux biases remain at night, when cold pools are most frequent and intense. This implies that significant errors remain in the analysis, and that these biases have a diurnal cycle which will in turn affect the diurnal cycle in the model.

The model biases are consistent with the larger-scale heat-low biases in the operational Unified Model. Furthermore, model analyses show significant differences in the Sahara, hampering efforts to evaluate model performance in such a data-sparse region. These issues are shown here to be linked to known deficiencies with parameterisations of convection that are used in all global weather and climate models. This study suggests that the upscale impact of the misrepresentation of moist convective processes significantly affects continental-scale biases, altering the West African monsoon circulation.