Effects of soil moisture on a squall line in the Sahel region studied by WRF-ARW results and field observations

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During the West African Monsoon season, convective precipitation is strongly coupled to the soil moisture availability. This interaction is generally understood as a positive feedback mechanism, and it has been considered on very different spatial and temporal scales. Past research has mainly focused on studying these feedbacks in terms of their effects on general precipitation patterns. However, little attention has been paid to investigating the effects of soil moisture on a single convective system. In the current research, a single squall line, moving westward in the Sahel region, is reproduced and analyzed using the Weather Research Forecast model. Model results are compared with available surface and upper air observations.

Sensitivity analysis on the influence of soil moisture on the squall line is performed by two numerical experiments characterized by decreasing and increasing the soil moisture values with respect to a control experiment. In these sensitivity experiments, the South to North decreasing soil moisture gradient characteristic for the region is maintained constant, and consequently we solely modified the absolute soil moisture values.

It is found that in the experiment with increasing soil moisture the squall line follows a more northerly path, with a maximum deviation from the control case of around 140 km. A mechanism is proposed connecting the applied soil moisture modifications to differences in diurnal warming and, subsequently the thermal wind which determines the path of the squall line. Another relevant result is that in the three analyzed cases the precipitation intensity of the squall line declines more than 1/3 when it moves towards the lower values of the soil moisture located at the West. It is therefore concluded that a positive effect of regional soil moisture on precipitation intensity in passing the squall lines is likely on the considered length scale of 100 km. Such a mechanism was already proposed in other studies on smaller scales.