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Validation of heavy precipitation and thermodynamic relations in the regional climate model REMO

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Heavy precipitation events are expected to change their frequency and intensity in a warmer climate due to alterations in dynamic and thermodynamic processes. Because of the often regional to local scale nature of heavy precipitation events, regional climate models with a high spatial resolution are an adequate tool to investigate their climatology and future changes. In the present study we investigate the representation of heavy precipitation and related variables in the regional climate model REMO, and evaluate them against observational data over the European area. The model is run at a spatial resolution of 10km x 10km. ERA-Interim reanalyses are used as lateral boundary forcing.

In view of climate projections, it is not only important that regional climate models capture present day patterns of heavy precipitation, but also the physical processes behind such events. In particular, thermodynamic processes are expected to intensify in a warming climate. This hypothesis is based on the Clausius-Clapeyron relation, which describes the increase of the saturation vapor pressure of water with temperature. As a consequence the atmosphere is able to hold a larger amount of column-integrated water vapor, which leads to a higher potential for intense precipitation. However, on regional scales, recent studies have argued that heavy precipitation changes simulated by regional climate models scale more closely with changes in cloud liquid water than column-integrated water vapor. This study therefore aims to evaluate the connection of precipitation, water vapor, and cloud liquid water with temperature in REMO. The relation of heavy precipitation and temperature is analyzed using extreme value statistics and compared with meteorological station data. The variability of water vapor and cloud water with changing temperatures is tested against satellite data derived from optical and microwave sensors.

The model is able to capture the distribution of heavy precipitation well. Nevertheless, some difficulties are identified for regions with large orographic variability which is not resolved in the model. Regarding column-integrated water vapor and its relationship with temperature, the model compares satisfactorily with satellite observations. For cloud water the agreement is somewhat less unequivocal. Also, column-integrated water vapor and cloud luiquid water show an essentially different relation to temperature, in particular during the summer months.