EGU23-13732, updated on 27 Apr 2024
https://doi.org/10.5194/egusphere-egu23-13732
EGU General Assembly 2023

Simulation of extreme precipitation events over south-west France: the role of large-scale atmospheric circulation and atmospheric rivers

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South-western France has witnessed some of the most devastating extreme precipitation events that eventually lead to record-breaking severe flash flooding in the region and cause losses to human lives, urban transportation, agriculture, and infrastructure. In this study, two cases of deadly flash floods that occurred/reported in the Aude watershed in south-western France during 12-13 November 1999 and 14-15 October 2018 are studied using the WRF4.3.1 model simulations, with a particular emphasis on the model ability to capture these heavy precipitation events. We performed two simulations one with parameterized convection and one without the use of convection parameterizations for each case at gray-zone resolution (~9 km horizontal grid spacing) using the ERA5 reanalysis as the lateral boundary condition. In addition, attempts have been made to investigate the role of large-scale atmospheric circulation and atmospheric rivers in the production of these heavy precipitation events. The results from model simulations are compared quantitatively with available observations and reanalysis and found that the simulations at ~9 km gray-zone resolution capture the observed spatio-temporal distribution of precipitation characteristics during both extreme cases. The added value of gray-zone resolution simulations over driving coarse-scale ERA5 reanalysis datasets is observed in the representation of the precipitation characteristics. It has also been observed that the model simulation without the use of convection parameterization yields a reasonable and realistic representation of the precipitation characteristics during both extreme cases, and this suggests that at this “gray-zone” resolution the organized mesoscale convective systems/processes can be resolved explicitly by the model dynamics. The contribution of the large-scale atmospheric circulation and the atmospheric river (i.e., moisture transport) in the production of these flood events has also been observed.