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Simulation of an extreme precipitation event in Portugal during atmospheric river – sensitivity to cloud microphysics

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Rare intense precipitation events contribute significantly to the annual total precipitation in Portugal and thus play an important role in the country's water resources. They can bring relief after the long dry periods, but on the other hand, they can cause destruction of infrastructures and take people's lives. The most extreme events affecting the Iberian coast are typically associated with atmospheric rivers. This study examines one of such events, when an atmospheric river formed during an explosive development of the Gong cyclone on January 19, 2013. The goal of this study is to better understand processes responsible for this intense precipitation event and its characteristics by means of regional climate model simulations using different horizontal resolution and cloud microphysical schemes. The study is performed using the Weather Research and Forecasting model (WRF) version 3.9. To force the model in its initial and lateral boundary conditions, ERA-Interim reanalysis fields from the European Centre for Medium-Range Weather Forecasts (ECMWF), with 0.75° x 0.75° horizontal resolution were used. The model was run in a three-nested domain, one-way configuration, centred in Portugal mainland, with horizontal resolutions of 27 km, 9 km, and 3 km. The cloud microphysical schemes employed in the simulations include the WRF Double-Moment 6-class scheme (WSM6), the new Thompson scheme, and the Morrison two-moment scheme. All these schemes predict mass mixing ratios of water vapor, cloud water, rain water, ice, graupel, and snow. Additionally, the Morrison scheme also predict number concentrations of rain water, ice, snow and graupel, and the Thompson scheme of rain water and ice.
Results of the total de-accumulated precipitation averaged over the ocean and over land show that the WSM6 scheme produces the greatest amount of precipitation among the schemes, although the differences between them are small in all domains, specially over the ocean. In the total precipitation fields, it is visible the orographic enhancement of the precipitation in high topography regions. The results for the domain averaged liquid water path (LWP) show that the Morrison scheme has the highest values during all the simulation period, followed by the Thompson and then by the WSM6 scheme. From the domain averaged ice water path (IWP) results it is possible to verify big differences in the amount of ice predicted by each scheme; the WSM6 scheme produces by far the greatest amount, followed by the Morrison scheme and then, the Thompson scheme with almost no ice predicted. To assess which microphysical scheme is better suited for the study of extreme precipitation events in Portugal, we perform an evaluation of the simulated cloud and precipitation properties using ground-based precipitation radars, as well as satellite products.