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Sensitivity of extratropical cyclones water balance to climate models' resolution

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This paper investigates the systematic changes of extratropical cyclones (ETCs) and their associated water balance in coupled models when the horizontal resolution of the atmospheric component is increased. To do so, we analyse the results of six CGCMs involved in the EU-PRIMAVERA project (HadGEM3-GC31, EC-Earth3, MPI-ESM, CNRM-CM6-1, CMCC-CM2, ECMWF-IFS), spanning a range of resolutions from 200 km to 20 km. In each simulation, the cyclone tracking is achieved by applying the TRACK algorithm (Hodges, 1994) to six-hourly vorticity at 850 hPa.

Changes in the characteristics of ETC with resolution are first evaluated by compositing ETCs centred on their maximum vorticity and categorised according their minimum sea level pressure. We also assess the evolution of the water balance of the moving ETCs during their lifecycle.

Our results show that the sensitivity to resolution of precipitation for strongest ETCs (i.e. with minimum sea level pressure less than 960 mb) is primarily associated with a change in number of cyclones in that category rather than in the amount of precipitation per cyclone. Although there is little change of the amount of precipitation per cyclone at a given time of the lifecycle, we observe a redistribution of precipitation within the frame of reference of the storm, with an increase of 10% of precipitation associated with the cold front and a decrease of the same magnitude of precipitation associated with the warm front when resolution increases. Those changes arise from a complex balance between stronger vertical velocity and lower relative humidity at higher resolution.