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High-resolution simulations of a North Atlantic extratropical cyclone and its cloud processes

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Cloud processes within extratropical cyclones are known to be important for both the short-term weather dynamics of the cyclone, as well as the long-term radiative budget of the climate system. Here, I present high-resolution simulations of the North Atlantic cyclone Vladiana in September 2016, whose warm conveyor belt was probed by airborne measurements of cloud processes during the NAWDEX field campaign. The simulations employ the ICON atmosphere model in limited-area setup run for a range of horizontal resolutions of 2.5 to 80 km, and over a large domain of the North Atlantic that extends from 78W-40E and from 23N-80N. The 2.5 km reference simulation uses more than $8 \cdot 10^6$ grid points per layer so that the parametrizations for convection, subgrid-scale orography and gravity wave drag can be switched off. In contrast, the other simulations at coarser resolutions of 5, 10, 20, 40 and 80 km apply these paramterizations.

Increasing resolution leads to a stronger cyclone, as well as higher total cloud cover and precipitation in the region of the cyclone. Similarly, some aspects of cloud-radiative effects (CRE) are found to be sensitive to the resolution as well as the use of the convection scheme. Mean shortwave CRE at the top-of-atmosphere increases with resolution, while such a sensitivity is not found for the mean longwave CRE at the top-of-atmosphere. Mean atmosphere CRE is insensitive to resolution but strongly sensitive to the use of the convection scheme. The sensitivities appear to result mainly from low-level clouds in the cold sector of the cyclone, with little changes for clouds in the warm conveyor belt and their radiative effects.

Furthermore, I will report on work in which parts of the cyclone are simulated with ICON in large-eddy mode at resolutions of 600 and 300 m, creating an overall range of resolutions that spans more than 2 orders of magnitude. This allows for new understanding of the impact of resolution, convection and cloud micropysics on simulated cloud and radiative processes, and for a detailed comparison with the NAWDEX measurements.