Impact of deep convection parameterization of a global atmospheric model on the warm conveyor belts and the jet stream

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Résumé

The impact of numerical representation of deep convection on the jet stream structure and the warm conveyor belt (WCB) of an explosive extratropical cyclone is investigated with the global numerical weather prediction model, ARPEGE, operational at Météo-France. Three hindcasts simulations differing in their deep convection numerical representation are

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analyzed : two hindcast simulations are run with two distinct deep convection schemes while the third one is without any parameterized deep convection scheme. These simulations are compared with (re)-analysis datasets and aircraft observations from the NAWDEX field campaign. A large variety of airborne observations from the NAWDEX field campaign (Doppler radar, Doppler lidar, dropsondes) are used to assess the skills of the three hincasts.

Without any deep convection parameterization, the release of convective instability at the resolved scale of the model generates localized cells marked by strong heating with few degrees extent in longitude and latitude along the front. In runs with activated parameterized deep convection scheme, the heating rate is more homogeneously distributed along fronts as the instability release happens at sub-grid scale. This difference leads to more rapid and abrupt ascents in the WCB without parameterized deep convection, and more moderate but more sustained ascents with parameterized deep convection.

The consequences of these differences in the heating rates and WCB characteristics in the jet stream structure and intensity are analyzed using potential vorticity (PV) diagnostics and WCB Lagrangian trajectories computing. One key result is that the WCB trajectories for the simulation with the less active deep convection scheme undergo a sooner PV destruction due to a stronger heating occurring in the lower and middle troposphere. This accelerates the jet in the mid-troposphere. In contrast, in the simulation with the most active deep convection scheme, both the heating and the PV destruction extend further up in the upper troposphere that more deeply impact the jet stream at higher altitude.
Finally, differences in the jet stream structure between 10 distinct simulations using 10 different combinations of physical parameterization schemes (turbulence, surface oceanic fluxes, shallow and deep convection schemes) are analyzed. The main differences are found to originate from the type of closure used in the deep convection scheme (namely CAPE or moisture convergence).