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Dynamics of sting-jet storm "Egon" over continental Europe using convection-permitting simulations

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Cyclonic windstorms belong to the most destructive natural hazards in Europe. The associated strong surface wind gusts are often connected with the cold and warm conveyor belts, as well as with frontal convection. Moreover, intense Shapiro-Keyser cyclones can be accompanied by the occurrence of a so-called sting jet, which is a distinct air stream that descends from the cloud head in the mid-troposphere into the frontal-fracture region and can cause very intense near-surface gusts. There is still some debate in the community regarding what mechanisms cause or contribute to the occurrence of a sting jet. Furthermore, the existing literature is almost entirely dedicated to sting jet case studies over the North Atlantic, the British Isles, and the North Sea.

This work focuses on windstorm Egon (12-13 January 2017), which is the first documented sting jet case over continental Europe. To analyse the storm, ICON (ICOsahedral Nonhydrostatic model) in limited area mode is used for simulations with horizontal grid spacings down to 1.6 km. With such a high resolution, convective and mesoscale instabilities are explicitly resolved and the orography is well represented. Lagrangian trajectories calculated with the LAGRANTO software confirm the presence of a sting jet. They further show consistency with most of the widely accepted characteristics of sting jets, namely descent on constant wet-bulb potential temperature surfaces and acceleration during the descent. Moreover, a possible contribution of conditional symmetric instability (CSI) and evaporative cooling is detected, two processes suggested by previous studies. However, no agreement is found regarding the expected changes in relative humidity values, which do not show the typical drying

Additionally, the sensitivity of sting jet trajectories is analysed with respect to the calculation and selection of trajectories. While all combinations show a sting jet with consistent characteristics, its strength and the representation of CSI deviate significantly in some cases. This sensitivity may be a reason why some previous cases did not find a contribution of CSI release. Further sensitivity studies with flattened orography and an "aqua-Europe" configuration result in deeper cyclogenesis and, in the latter case, also strengthening of the sting jet. For example, removing the Alps leads to a cyclone track about 100 km south of the control simulations. Furthermore, simulations without orography show a slower movement across Europe. This leads to a longer impact of the sting jet in terms of near surface wind gusts in a given location. However, all parameters traced along trajectories show similar behaviour compared to the control simulations.

These results demonstrate that a sting jet storm has in fact occurred over continental Europe and that it displayed largely consistent characteristics with cases over the North Atlantic and the British Isles. Nevertheless, a marked influence of continental characteristics (orography, roughness, surface fluxes) on details of the storm evolution was found. Given the potential impacts, further potential sting jet cases over the continent should be investigated.