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Towards a low-cost approach to identify sting jets in numerical models

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Sting jets (SJ) have been a research interest in the extratropical cyclone community for the last two decades. An SJ is a descending airstream that can develop in Shapiro-Keyser-type cyclones, bringing high winds to the surface. As extratropical cyclones are usually accompanied by high wind gusts and heavy precipitation, they are considered one of the most hazardous weather phenomena in Europe, especially during wintertime. While winds are often associated with the warm or cold jet (WJ and CJ, respectively), cold-frontal convection or cold-sector winds, SJs are less common but –if occurring– are often found to have caused the highest gusts.

Recently, we introduced RAMEFI (RAndom-forest-based MEsoscale wind Feature Identification), the first objective and flexible identification tool for high-wind features within cyclones, using a probabilistic random forest. RAMEFI can be applied to observational and gridded datasets independently of spatial distribution based on eight surface parameters. However, it is challenging to distinguish the SJ from the CJ in surface parameters alone, as their characteristics are similar such that the two features have been combined in RAMEFI so far. Nevertheless, the origin and potential for damage differ. While the SJ is a descending air stream originating within the cloud head, the CJ stays at low levels throughout its lifetime. With the descent, the SJ brings high momentum from mid-levels down to the top of the boundary layer or even to the surface. This commonly creates higher winds and gusts and, thus, a separate detection is desirable.

In this work, we aim to extend RAMEFI to identify potential SJs, especially focusing on output from high-resolution numerical weather prediction models. This way we want to create a suitable alternative to the data-intensive and computationally expensive computation of Lagrangian trajectories, the most established SJ identification method. Our approach is based on a simple detection of a coherent three-dimensional region of high winds. We further use relative humidity to ensure the proximity to the cloud head following previous literature and gust speeds to connect the region to actual surface impact. Initial results using model simulations and the deterministic forecast from the German weather service (ICON-EU) show promise, with a high hit and low false alarm rate. The method provides a basis for further refinement and increasing robustness, such that it can be used on different models and resolutions.