Geophysical Research Abstracts
Vol. 20, EGU2018-7881-2, 2018
EGU General Assembly 2018

Highlights on the dynamics of sting jets and associated mesoscale instability in real-case and idealised simulations

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Sting jets (SJ) occur as an additional region of low-level strong, and possibly damaging, winds present in some Shapiro-Keyser extratropical cyclones. It is now widely accepted that those winds are not part of the warm or cold conveyor belts. However, the precise mechanisms responsible for their occurrence are yet to be fully understood. Key aspects of the current research include the dependence of SJ generation and strengthening upon the release of mesoscale instabilities and upon the cyclone evolution in the frontolytic region. The present study focuses on these issues and outlines a mechanism of generation of instability along the SJ using real-case and idealised simulations run with the MetUM.

Real-case and idealised simulations of Shapiro-Keyser extratropical cyclones highlight the evolution of the SJ as a coherent airstream that descends from the cloud-head tip towards the frontal-fracture region while displaying a large acceleration (with maximum wind speed close to 60 m/s at the top of the boundary layer in the case study). Lagrangian trajectories, along with vorticity budgets and analysis of frontogenesis field, are used to gain further information on the dynamics of the SJ. In both simulations the SJ is driven by the release of mesoscale instabilities on the airstream. Combined tilting and stretching of vorticity are related to the generation of localised regions of negative potential vorticity along a narrow frontal zone, playing a major role in the local onset of symmetric instability on the SJ. This mechanism enhances the strong winds already generated by the synoptic-scale cyclone dynamics. Sensitivity runs in both frameworks show the existence of model resolution constraints for the instability to develop on the airstream.

This study thus outlines the dynamics of the SJ in Shapiro-Keyser extratropical cyclones, highlighting a mechanism of generation of mesoscale instability that can take place along the airstream, leading to an enhancement of the strong winds that the cyclone dynamics would already produce in the frontal-fracture region.