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Vortex streets to the lee of Madeira in a km-resolution regional climate model

Qinggang Gao[1], Christian Zeman[3], Jesus Vergara Temprado[3], Peter Molnar[2], and Christoph Schär[3]
[1]Department of Civil, Environmental and Geomatic Engineering, ETH Zürich, Zürich, Switzerland
[2]Institute of Environmental Engineering, ETH Zürich, Zürich, Switzerland
[3]Institute for Atmospheric and Climate Science, ETH Zürich, Zürich, Switzerland

Atmospheric vortex streets are one of the widely studied dynamical effects of isolated islands. However, the study of vortex shedding is still limited by the availability of observational wind fields of high spatial and temporal resolutions. Although the geometry, kinematics, and dynamics of vortex streets have been intensively investigated in numerous theoretical, numerical, and observational studies, our understanding of vortex shedding in the real atmosphere and atmospheric models is still insufficient.

Using the non-hydrostatic limited-area COSMO model driven by the ERA-Interim reanalysis, we simulated a mesoscale domain in high spatial (grid spacing 1 km) and temporal resolutions over one decade. This enabled us to investigate vortex streets within the planetary boundary layer despite limited observations. The basic properties of vortex streets are analyzed and validated through a 6-day-long case study in the lee of the Madeira island. The simulation compares well with satellite and aerial observations, and with the existing literature on idealized simulations.

Our results show a strong dependency of vortex shedding on local and synoptic flow conditions, which are to a large extent governed by the location, shape, and magnitude of the Azores high, which represents one pole of the North Atlantic Oscillation. As part of the case study, we have developed a vortex identification algorithm, consisting of a wavelet analysis using a set of objective criteria. The algorithm shows good performance in terms of false-positive rate and enables us to develop a climatology of vortex shedding in this region for the 10-year simulation period. Based on the long term analysis, we can identify an increasing vortex shedding rate from April to August and a sudden decrease in September, which can be well explained by the large-scale wind conditions.