Colloquium

MAX PLANCK INSTITUTE
FOR DYNAMICS AND
SELF-ORGANIZATION

Modelling midlatitude cyclones across scales

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Midlatitude cyclones are essential components of the weather and climate systems but the associated windstorms are widespread natural hazards. They have been studied for more than a century and have fostered the development of meteorological research and forecasting. Since the first theoretical concepts of the Norwegian model in the early 20th Century, our understanding of midlatitude cyclones has profoundly evolved and running numerical weather predictions has become a routine task for weather centers. However, new questions relevant for both research and operations have been raised along with the emergence of new opportunities but also new challenges for numerical modelling.

Here I focus on processes governing the formation of surface gusts in midlatitude cyclones. These processes are crucial for the societal impact of cyclones but not well understood and too small scale to be explicitly represented in numerical weather prediction models. Accurately modeling windstorms requires high resolution over a large domain to represent both fine-scale structures and mesoscale dynamics, as well as advanced physical parameterizations and coupling with surface models to capture complex interactions. Running such simulations is a computational challenge, as is the analysis of the resulting deluge of data. The ANR project WINDGUST aims to better understand the formation of wind gusts through innovative numerical simulations with the Meso-NH atmospheric model.

First results are presented for the intense Mediterranean cyclone Adrian that hit Corsica on 29 October 2018 with gusts above 50 m/s and extended damages. While state-of-the-art meteorological simulations with kilometer-scale resolution are able to develop strong mesoscale winds, large-eddy simulations with hectometer-scale resolution are necessary to explicitly represent their boundary-layer organization. The latter reveal the presence of coherent structures as convective rolls aligned with the main wind direction over the warm Mediterranean sea. Lagrangian tracers computed online during the model integration highlight their crucial role in the downward transport of momentum to the surface. The characteristics of convective rolls depend on the horizontal grid spacing but are also strongly sensitive to the representation of surface fluxes over sea, which are poorly constrained under winds above 20–25 m/s. Ongoing work will extend the methodology to Atlantic cyclones involving different mesoscale features and using full atmosphere-wave-ocean coupling in order to accurately represent air-sea interactions under windstorm conditions.

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Zoom Meeting ID: 959 2774 3389, Passcode: 651129, direct link

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