The extratropical transition of Hurricane Ophelia (2017) as diagnosed with a generalized omega equation and vorticity equation

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Hurricane Ophelia was a category 3 hurricane which underwent an extratropical transition and made landfall in Europe as an exceptionally strong post-tropical cyclone in October 2017. In Ireland, for instance, Ophelia was the worst storm in 50 years and resulted in significant damage and loss of life.

In this study, the different physical processes affecting Ophelia’s transformation from a hurricane to a mid-latitude cyclone are studied. For this purpose, we have developed software which uses OpenIFS model output and a system consisting of a generalized omega equation and vorticity equation. By using these two equations, the atmospheric vertical motion and vorticity tendency are separated into the contributions from different physical processes: vorticity advection, thermal advection, friction, diabatic heating, and the imbalance between the temperature and vorticity tendencies.

Vorticity advection, which is often considered an important forcing for the development of mid-latitude cyclones, is shown to play a small role in the re-intensification of Ophelia as an extratropical storm. This is because the effects of divergent and non-divergent components of vorticity advection mainly cancelled each other out, resulting in a net effect close to zero. However, our results show that diabatic heating was the dominate forcing in both the tropical and extratropical phases of Ophelia.

Furthermore, we calculated in more detail the diabatic heating contributions from different model parameterizations. We find that the temperature tendency due to the convection scheme was the dominant forcing for vorticity tendency during the hurricane phase, but as Ophelia transformed into a mid-latitude cyclone, the microphysics temperature tendency gradually increased becoming the dominant forcing once the transition was complete. Temperature tendencies caused by other processes, such as radiation, surface processes, vertical diffusion and gravity wave drag, were found to be negligible in the development of the storm.