The role of post-tropical cyclones for European extreme weather

Lead Supervisor:
Reinhard Schiemann, National Centre for Atmospheric Science (NCAS), University of Reading, Email: r.k.schiemann@reading.ac.uk

Co-supervisors: Kevin Hodges, Len Shaffrey, Alexander Baker (NCAS/Department of Meteorology, University of Reading)

North Atlantic tropical cyclones typically form at low latitudes off the African coast, then track west and northwestward, and some of them make landfall over Central and North America. Europe is not directly affected by tropical cyclones, yet some tropical cyclones recurve over the North Atlantic, transform into midlatitude storms during extratropical transition, and then reach Europe as so-called post-tropical cyclones. One such storm, Ophelia (see figure), made landfall over Ireland in October 2017 and caused loss of life as well as widespread damage and shutdown of economic activity. The reinsurance sector are now becoming aware of the risk from such storms and the risk modelling community are starting to incorporate these types of storms into their models.

Post-tropical cyclone Ophelia making landfall over Ireland on 16 October 2017. By NOAA - NOAA EVL, Public Domain, https://commons.wikimedia.org/w/index.php?curid=63495813

While individual storms such as Ophelia have received considerable attention, much remains unknown about the climatological role of post-tropical cyclones for Europe in the historical period, and how this role might change with global warming. There is tentative evidence from single climate model simulations, for example, that more post-tropical cyclones will affect Europe in the next century due to a warmer sea surface in the northeast Atlantic in particular (e.g., Haarsma et al. 2013).

In this PhD project, the following questions will be addressed

- How special are post-tropical cyclones for Europe, i.e. how different are they from the entire population of midlatitude storms reaching Europe in terms of where and when they occur, what their structure is, and how strong the associated surface impacts (wind/waves, precipitation) are?
- How do the properties of post-tropical cyclones depend on (i) the properties of the original tropical cyclone, (ii) on the midlatitude westerly flow as the tropical cyclones develops into a midlatitude storm, and (iii) on the sea-surface temperature field? For example, do particularly strong post-tropical cyclones originate from particularly strong tropical cyclones?
- How does the latest generation of high-resolution global climate models represent these post-tropical cyclones, and how are they predicted to change over the next century? Will more of them affect Europe, and more strongly so? Do different models agree on predicted post-tropical cyclone changes, including across different storylines of atmospheric circulation change (Zappa et al. 2017)?

The student will work closely with the High Resolution Global Climate Modelling Group at NCAS and the Met

Office, and thereby gain access to a recent set of high-resolution climate simulations, for example those currently prepared in the PRIMAVERA[1] project. PRIMAVERA simulations have resolutions of down to 25km grid spacing in the atmosphere and ¼° in the ocean. This corresponds to a four to five-fold increase in resolution over typical climate models in the Fifth Coupled Model Intercomparison Project (CMIP5). Model resolution has been shown to be important for representing tropical cyclones (e.g., Roberts et al. 2015) and also the North Atlantic storm track (Zappa et al. 2013), one initial aim for this project will be to evaluate the role of model resolution for representing extratropical transition and post-tropical cyclones. Having improved insights into storms undergoing extratropical transition and their impact on western Europe will lead to improvements in how well they are represented in the reinsurance risk models.

Training opportunities:
The student will be in a good position to apply for attending the NCAS Climate Modelling Summer School, organized biennially by NCAS at the University of Cambridge (entry competitive). In addition to training through SCENARIO and the Department of Meteorology, NCAS also conducts short courses that may be beneficial (https://preview.tinyurl.com/NCAS-training).

Student profile:
We are looking for an enthusiastic student with a natural science background from subjects like meteorology, physics, environmental/earth science, or mathematics, with demonstrated strong analytical skills and a keen interest to study the physics of post-tropical cyclones as well as the statistics of their occurrence and impacts. The student will also need to have or acquire the necessary programming and data analysis skills required for the quantitative analysis of big climate data sets.

References

Haarsma, R. J., Hazeleger, W., Severijns, C., De Vries, H., Sterl, A., Bintanja, R., … Van Den Brink, H. W. (2013). More hurricanes to hit western Europe due to global warming. *Geophysical Research Letters*, 40(9), 1783–1788. https://doi.org/10.1002/grl.50360

Roberts, M. J., Vidale, P. L., Mizielinski, M. S., Demory, M.-E., Schiemann, R., Strachan, J., … Camp, J. (2015). Tropical Cyclones in the UPSCALE Ensemble of High-Resolution Global Climate Models*. Journal of Climate, 28(2), 574–596. https://doi.org/10.1175/JCLI-D-14-00131.1

Zappa, G., Shaffrey, L. C., & Hodges, K. I. (2013). The Ability of CMIP5 Models to Simulate North Atlantic Extratropical Cyclones*. Journal of Climate, 26(15), 5379–5396. https://doi.org/10.1175/JCLI-D-12-00501.1

Zappa, G., & Shepherd, T. G. (2017). Storylines of atmospheric circulation change for European regional climate impact assessment. *Journal of Climate*, 30(16), 6561–6577. https://doi.org/10.1175/JCLI-D-16-0807.1

http://www.reading.ac.uk/nercdtp

[1] **PR**ocess-based climate s**IM**ulation: **A**d**V**ances in high resolution modelling and **E**uropean climate **R**isk **A**ssessment, EU Horizon 2020 project (https://www.primavera-h2020.eu)