Evaluating and improving high-resolution high-impact weather numerical weather forecasts

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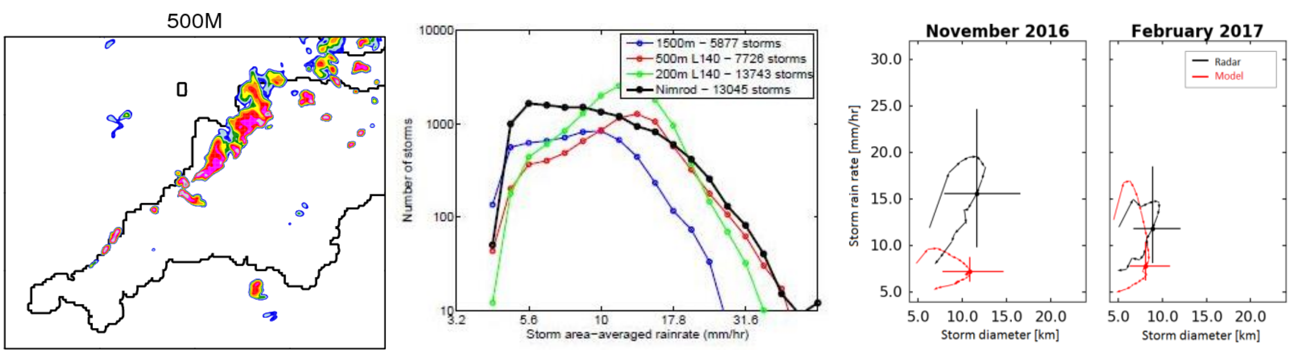
Over the past decade, high-resolution numerical weather forecasting has become practical using so-called "convection-permitting" models for lead times of 1-24 hours. Convection-permitting simulations have enabled a step change in our forecasting capacities because the individual convective storms can now be simulated directly with the numerical model. Many high-impact weather events are associated with such storms, particularly in cases of flash flooding and damaging wind gusts.

The high-resolution Met Office model have led to its use for simulation in several other regions around the world, including Australia, West Africa, South Africa, Korea and the United States. Such experiences have emphasized its benefits, but two important issues are also emerging: first that the model representations of turbulence and cloud microphysics have important uncertainties, and second that there are some concerns about how well such models capture the spatial structure and the organization of storms. A consequence is that different model settings have become preferred for practical reasons in tropical and mid-latitude regions, though without clear physical insights into how and why the associated physical processes in the model affect the storm dynamics.



Left: an example of output from a convection-permitting model showing hourly rainfall totals for a storm over Cornwall. **Centre:** an example analysis for the UK showing the numbers of storms producing particular rainfall rates, with radar data in black and different model configurations in the colours. **Right**: example anlayses for South Africa showing the average thunderstorm life cycle in radar observations and model simulations for November 2016 and February 2017. Vectors show 6-minute and 5-minute changes, respectively.

This PhD project is strongly motivated by these pressing issues. It will develop a deeper level of understanding for the behaviour of convection-permitting models and will lay a solid evidence base to guide future model developments, identifying the right model improvements for the right physical reasons. We will focus on South Africa because its meteorology can take a typical "mid-latitude" or a "tropical" character at different times of year or locations, and so it nicely exemplifies the problems.

An outline for the project is:

1. Develop and test appropriate new metrics for assessing the spatial structure and organization of convective storms.
2. Evaluate the metrics over many cases, comparing radar observations and archived forecast data.
3. Conduct modelling experiments to test the hypothesis that the quality of convective-storm forecasting over South Africa varies over the year due to the change from mid-latitude to tropical conditions.
4. Following 1-3, you will be in an excellent position to conduct a thorough assessment of what aspects of the modelling system are most important for the accurate simulation of high-impact convective storms. These issues can be addressed with detailed modelling case studies based on the events of most interest identified through 1-3.

Training opportunities:
The student will be trained in the dynamics and thermodynamics of the atmosphere, numerical modelling and data analysis. Training will include running and adapting the Met Office high-resolution forecasting model. There will also be opportunities to contribute to the international Met Office Convection Working Group, and to the model development programme of the South African Weather Service.

Student profile:
The project would be suitable for students with a 1st or upper 2nd class degree (or equivalent) in meteorology, mathematics, physics or a closely related quantitative environmental or physical science. Strong computer and programming skills are desirable.