Extreme Convective Storms: Tornadoes, Strong Winds, Heavy Rain, and Hail

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Introduction:

Convection is ubiquitous in the atmosphere. Although the ingredients of deep moist convection are well known (lift, instability, and moisture), how those ingredients come together to produce the observed panoply of convective storms worldwide remains an active area of research.

The advent of nationwide networks of Doppler radar networks, pan-European networks of severe convective weather reports (e.g., hail, tornadoes) and mesoscale modeling has led to tremendous leaps in our understanding of deep convective storms. Our group's research aims to better understand where convective storms occur, how convective storms work, and what factors control their formation, maintenance and decay. In particular, our previous work has focused on understanding the climatologies of convective storms and their impacts through observed climatologies (Mäkelä et al. 2011; Antonescu et al. 2013; Tuovinen et al. 2015; Mulder and Schultz 2015), case studies (Schumacher et al. 2015), numerical modeling (Norris et al. 2014; Apsley et al. 2016), and surveys of the meteorological community (Rauhala and Schultz 2009). For one example, our research has shown for the first time that tornadoes in the UK most commonly occur along lines of convection such as formed along cold fronts. For comparison, tornadoes commonly form along isolated cells in the United States. We are only just beginning to unravel the mysteries of tornado formation along such convective lines. Work continues on this topic, and you could be involved.

Our group often focuses on challenging convention wisdom, with the goal of helping forecasters, improving scientific understanding, and rewriting textbooks. A recent example is challenging the concept that tornadoes in the Central United States originate from the "clash of air masses" (Schultz et al. 2014). Earlier work examined the importance of elevated convection to producing severe weather and cumulus castellanus (Horgan et al. 2007; Corfidi et al. 2008). New work will start on understanding how convective available potential instability forms and the importance of elevated and heated terrain in creating this instability. To this end, we have produced global climatologies of the environmental conditions favourable for severe convective storms using reanalyses and observed radiosonde data. These climatologies will provide a rich source of research opportunities for our group.

Tropical convection is a result of the planetary-scale circulation patterns imposed by an unevenly heated Earth and its own rotation, yet the smaller-scale organization remains an area of active research. In such a region of strong heating, what controls its occurrence and its nonoccurrence?

Our work has received media attention such as our research on better understanding tornadoes in the British Isles, which was featured on BBC and ITV television, as well as newspapers around the UK. Our group regularly appears on the Paul Hudson BBC Weather Show talking about our research. Our team collaborates with the insurance industry through a funded research project with the Risk Prediction Initiative, to operational forecasting centers in the US, UK, and Europe, and to private-sector weather forecasting companies. We are involved in training European operational meteorologists through our connection with the European Severe Storms Laboratory, EUMETSAT, and other training programmes.

We produce daily real-time forecasts for Europe and the UK and Ireland. Check out our web-based weather forecasting portal and Apple mobile app: http://www.manunicast.com

Project Summary:

We are looking for students who want to be challenged, develop a range of skills including theory, observations and modeling, and enjoy studying the natural world. Your background can be in meteorology, atmospheric science, physics, math, or a related field.

The student has much say in the direction of this project. Potential research projects could answer the following questions.

• What are the synoptic environments that favor severe weather in the UK and Europe?

• Synoptic-scale motions are cm per second, which is too slow to result in the initiation of convective storms. How does the synoptic-scale pattern promote or inhibit convective storms?

• The most intense lightning strikes can cause the most damage. Under what conditions do these intense strikes occur, and where do they occur? What are the risks to infrastructure?

• How does tropical convection organize, and what is the role of the midlatitudes in that organization?

• How are chemicals and other conservative quantities (e.g., potential vorticity) transported by deep tropical convection?

• What is the role of mountains in creating convective storms?

• Do the Pennines weaken or strengthen convective lines passing over them?

• Is it possible to predict the downdraft strength of convective storms?

• What is the role of the elevated mixed layer in convective storms? How is it formed?

• How does convective inhibition get removed preceding convective storms?

• How good are global and regional models at forecasting and simulating convective storms?

Students are also encouraged to suggest their own research project within the broad topic of atmospheric convection and convective storms. Please contact Prof Schultz to discuss your ideas.

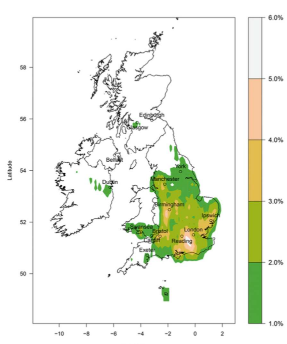

Image 1 Caption – Probability of a tornado occurring within a 10-km grid box across the British Isles per year.

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