Hydro-JULES

Project 2 - Characterising sub-seasonal to seasonal variability in extreme thunderstorms over India

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Across India, large thunderstorm clusters – so-called Mesoscale Convective Systems (MCSs) - are a major component of the water cycle during the Indian Summer Monsoon (ISM), when they contribute between 50 to 70% of the total rainfall. Their sub-seasonal to seasonal (S2S; 1 to 6 week) variability can thus have a profound impact on agriculture, socio-economic status and water security across the nation, impacting the lives of over a billion people. Extreme thunderstorms in particular are associated with life threatening hazards such as flash-flooding and lightning. Accurate forecasts of increased MCS activity are hence critical for planning and hazard mitigation, yet due to the complexity of the earth system, S2S forecast skill remains low. In addition, identifying S2S drivers of extreme MCSs will help us to better benchmark climate models and their ability to capture important drivers of future rainfall extremes, for which estimates are needed to inform longer-term hydraulic infrastructure scaling.

This project will utilise a new global storm track dataset and state-of-the-art satellite and reanalysis products to analyse S2S variability of MCSs, and investigate the key environmental drivers to storm variability. In particular, the project will investigate links between large-scale atmospheric sub-seasonal variability and the likelihood of extreme thunderstorms as defined by their precipitation and flash rates. Through this project, we will identify opportunities for improved forecasts of these extreme hydro-meteorological events across India.

The ISM is characterised by sub-seasonal wet and dry periods. Sub-seasonal rainfall variability throughout the ISM is partly modulated by the Madden–Julian Oscillation (MJO), an atmospheric wave which modulates tropical weather on S2S timescales. The MJO controls large-scale atmospheric conditions including wind shear, humidity, and atmospheric instability, which, alongside land surface characteristics, modulate the likelihood of convective initiation and subsequent convective storm development. Observations of individual storms and atmospheric reanalysis will be used to identify the relative roles of these environmental conditions in MJO-modulated convection. Understanding how the MJO affects storm characteristics will provide valuable information for forecast development.

The project aligns well with international efforts to understand the links between S2S atmospheric variability and local weather characteristics. Through collaborative partnerships with U.K. universities and Indian forecasting institutions, such as the University of Leeds and Indian Meteorological Department, the scientific research will support national and international efforts.

During this six-week internship, the student will:

- Identify S2S variability in storm characteristics from storm tracks and satellite products
- Investigate the possible relationship between sub-seasonal atmospheric variability and the likelihood of extreme storms
- Use satellite and reanalysis products to investigate environmental drivers of storm variability

Skillset Required:

- Essential – Interest in extreme weather and atmospheric dynamics
- Essential – Ability with a scientific programming language (preferably Python)
- Essential – Very good numeracy / statistical ability
- Desirable – Experience with remote-sensing or reanalysis datasets