Decadal Variability of Tropical Cyclones: Natural Variability or Anthropogenic Influence?

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Tropical cyclones (TCs) are one of the most damaging storms on the planet. Understand the main environmental drivers governing their variability is key to providing trustworthy and actionable information to society. Global TC activity is known to undergo significant decadal variability both in terms of numbers and preferred paths, affecting landfall and damage (e.g. U$380bn in 2011, but >U$100bn in most years since 1990). This variability is thought to be modulated by a mixture of dynamic and thermodynamic environmental conditions and the convolution of natural variability with anthropogenic influence makes attribution a scientific challenge. Yet, existing observational records are too short and inhomogeneous to enable a full understanding of TC–climate system interactions, hence limiting our ability to assess related climate risks.

Questions:

1) can state-of-the art high-resolution GCMs (capable to resolve TCs and providing a sample size far larger than observations) simulate the decadal variability of TCs, based on credible process chains?
2) is decadal variability caused by internal climate variability alone, or is there an anthropogenic influence, particularly via radiative forcing (aerosol and GHGs)?

In this PhD output from new high resolution (25km mesh size or less) multi-decadal (10s to 100s of years, multi-ensemble member and multi-model) simulations with state of the art global coupled climate models will be used as foundations, to robustly answer those open questions. These models credibly simulate the structure and intensities of TCs, as well as their paths ("tracks") and interannual variability. This project will entail the use of existing (Horizon-2020 PRIMAVERA, HighResMIP) as well as novel simulations (performed by the student) to isolate the individual mechanisms controlling TC, now extending to decadal variability. Analysis will make use of sophisticated tools (e.g. the University of Reading "TRACK") and develop new diagnostics, in collaboration with Prof Vidale's projects, to unpick the importance of natural variability versus anthropogenic influence in controlling the variability of TCs.

The project will be in two parts:

1. *The nature of TC natural variability:* in this part of the PhD TCs will be analysed in centennial simulations with constant 1990's and 1950's forcing and contrasted with centennial transient simulations, to understand the nature of natural variability under different radiative forcing scenarios. This will be contrasted with the current observed variability and the decadal variability in pre-industrial simulations produced by the Met Office Hadley Centre and PRIMAVERA partners. How the decadal variability projects onto other modes of variability, such as ENSO and the MJO, will also be explored.

2. *The relative importance of dynamic and thermodynamic drivers:* in this part of the study the decadal variability of TCs will be studied in the context of idealised forcing, mainly sea surface temperatures (SSTs) and aerosols. Starting with high resolution multi-model coupled simulations in part 1, the student will complement with decadal simulations, using combinations of aerosol and/or SST climatologies, reflecting conditions in major known periods of TC activity and TC "lulls". Analysis will contrast with the foundations provided by the first part of the study, to explore the relative influence of dynamic versus thermodynamic processes on decadal variability.

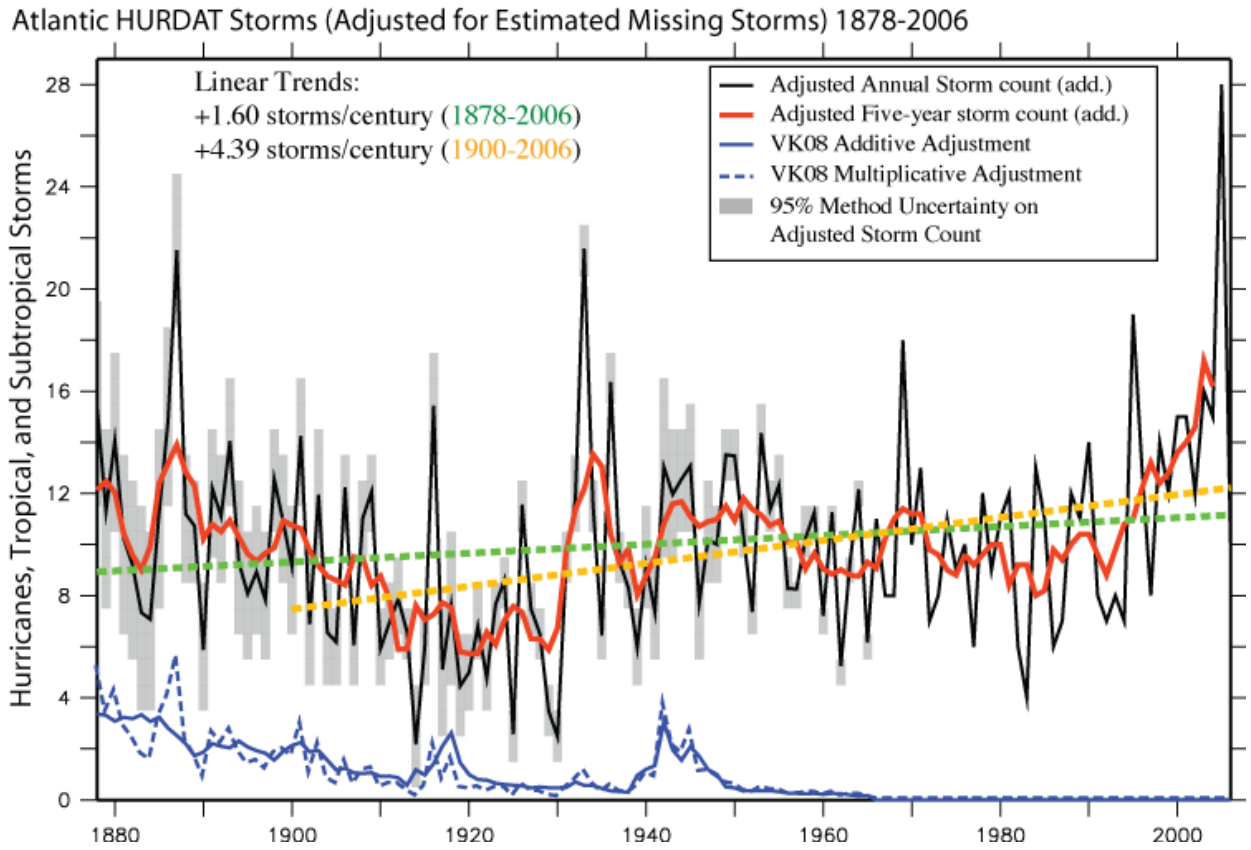

Fig. 1: the Atlantic Tropical (and sub-Tropical) Storm record, including hurricanes, 1878 to 2006. The North Atlantic record is the only one offering centennial scale and sufficient quality assurance. From HURDAT, Vecchi and Knutson 2008.

The project will provide the opportunity to study the natural variability of TCs in some of the highest resolution coupled GCM simulations available, where TCs are more credibly represented than in the lower resolution simulations used in many previous studies. These simulations are of sufficient temporal length (decadal to centennial and ensemble mode) to study decadal variability in more detail than previous studies.

The literature is still presenting the topic of dynamic vs thermodynamic influences in a polarized way, hardly ever attempting to unify the two roles. By using simulations with different levels of constant forcing the natural variability at these different levels of forcing will be explored and contrasted with transient simulations. This will provide an improved understanding of the decadal variability of TCs. Also, as part of this project, the important drivers of the variability will be explored and how these may change under different forcing scenarios hence providing a better understanding of the controls on TC variability.

Training opportunities:
The student will have the opportunity to take some masters courses and will be expected to do this if his/her background does not include meteorology. The student will also be able to attend one of the annual NCAS Climate Modeling Summer Schools to learn more about the models used to produce the data they use. As part of the industry placement the student will learn how their research can be translated into information of use to the industry partner and how it affects the decision-making process.

The student will be embedded in a large research team, international leaders in global high-resolution modelling, and will be fully exposed to the international, 19-institution research environment and opportunities provided by the PI's EU-H2020 PRIMAVERA project. In particular, the student will be immersed in work-package level discussions and activities designed specifically around Tropical Cyclone research within PRIMAVERA, including the design of process-based metrics.

The student will gain skills in the analysis of hazardous weather systems in high-resolution simulations and how this can be translated into the assessment of risk. A placement and training activities with (re-)insurance members of Risk Prediction Initiative (Bermuda) will be available at one of the partner offices in London. The student will learn how TC-related risk is managed within the (re-)insurance industry, by inserting decadal variability "conditioning" into a catastrophe model and how the research in this PhD can have an impact in the insurance/reinsurance industry.

Student profile:
This project would be suitable for students with a degree in meteorology, physics, mathematics or a closely related environmental or physical science. A specific interest in Tropical Cyclones would be desirable, albeit not essential. Skills in UNIX, Python, FORTRAN, will prove very useful, but can be instilled by the supervisory team.

Funding particulars:
This is a CASE-sponsored study, with additional funding from AXIS-Capita, Zurich

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

Key literature:

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