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Editorial

Extreme Weather and Climate Events: Physical Drivers, Modeling and Impact Assessment

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1. Introduction

Extreme weather and climate events, including hurricanes [1,2], typhoons [3], cyclones [4], atmospheric rivers [5], extratropical cyclones [6] and extreme precipitation events [7], can cause tremendous economic losses. The scientific understanding of the physical drivers controlling these extreme events will thus be important for improving the predictive skill regarding extreme events across different time scales.

The publications in this Special Issue [8–11] contribute to understand the physical mechanisms underpinning the occurrence frequency of these extremes, to detect and attribute changes in extreme weather, to disentangle the physical drivers of the extreme events on multiple time scales, to improve model capabilities of simulating and predicting extreme events, and to assess their socioeconomic impacts. In this Special Issue, four papers have been published, including hurricanes and cyclones, extreme precipitation, and high-resolution simulation of extreme events using state-of-the-art climate models. Each work is discussed below.

2. Hurricanes, Cyclones and Extreme Precipitation

Gao et al. [8] examined the possible role of air–sea latent heat flux in tropical cyclone genesis over the western North Pacific using state-of-the-art satellite and analysis datasets. Particularly, they have identified developing and non-developing tropical disturbances, leading to a better understanding of tropical cyclone genesis and development in this basin with the highest number of storms among the ocean basins. A tropical depression will develop into a tropical storm when the near-surface tangential wind increases due to the continuing positive feedback between near-surface wind and latent heat flux. This work suggests an important role of wind-driven latent heat flux in shaping this type of extreme events in the western North Pacific.

In addition to dynamical understanding of tropical cyclone genesis processes [8], Zhang et al. [9] attributed an extreme event of cyclone season (i.e., 14 tropical depressions) in the North Indian Ocean. The authors found that the sea surface temperature anomaly associated with El Niño played a minor role in this extreme event. Rather, using large ensemble experiments performed by the state-of-the-art Community Earth System Model (CESM) developed by the National Center for Atmospheric Research (NCAR), they detected an important role played by anthropogenic forcing in increasing the risk of this event and a rising frequency of tropical depressions is projected to increase in the future.

Forecasting the frequency of landfalling hurricanes is still quite challenging because most climate models fall short in simulating and predicting the landfalling frequency, largely due to a complexity that involves the genesis, track, and intensity of hurricanes. Using the high-resolution Geophysical Fluid

Dynamics Laboratory 25 km grid High-Resolution Forecast-Oriented Low Ocean Resolution (HiFLOR) global climate model, Levin and Murakami [10] reported that anthropogenic forcings are tied to the long-duration major hurricane landfall droughts in the US, which implies an increase in major hurricane landfall frequency. Further, Levin and Murakami [10] documented less frequent long-duration major hurricane landfall drought events in controlled scenarios with greater anthropogenic global warming using the HiFLOR model. They have indicated that an increase in US major hurricane landfall frequencies with an increase in anthropogenic warming could pose a substantial threat to the US coast.

Tropical cyclone rainfall is the most challenging question pertaining to tropical cyclone research, with the 2017 hurricane Harvey and the 2018 hurricane Florence serving to highlight. Overall, local tropical cyclone rainfall within a ~500 km radius has been given more attention than the remote rainstorm, which occurs far away (e.g., 1000 miles) from a tropical cyclone. In this Special Issue, Yu et al. (2018) examined a remote rainstorm in the Yangtze River Delta caused by typhoon Mangkhut by diagnosing the physical and dynamical processes underlying the extreme rainfall. They combined observational data and a trajectory model to analyze the causes of this extreme rainstorm. While the coupling of the upper-level westerly jet and the low-level southerly jet contributes to the development of strong convections, the moisture associated with this rainstorm travels from the lower troposphere over the Philippine Sea, the southern South China Sea, and the sea south of the Philippines.

3. Conclusions

This Special Issue contributes to better understanding the physical drivers of extreme weather and climate events (e.g., hurricanes, cyclones and typhoons), simulating the processes of these events using state-of-the-air climate models including NCAR CESM and GFDL HiFLOR, and quantifying the risk of the events in present and future climates. In addition, this Special Issue also examines the impacts of these extremes (e.g., rainstorms), which are conducive to fluvial and riverine flooding. Moving forward, this Special Issue points to more frequent and stronger extreme events under anthropogenic forcing. If no immediate actions are taken to cut the greenhouse gas emission, we will suffer even more severely from extreme weather and climate events in the future.

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