

16D.2 - Predictability of Tropical Cyclone Formation with Large-Scale Memory Using Deep Learning Transformer



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5:00 PM - 5:15 PM

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Abstract

Predicting the formation of tropical cyclones (TC) is a challenging task in operational practice due to the complex multiscale nature of tropical cyclogenesis (TCG). While numerical weather models have progressed significantly over the last decades in predicting TCG, an inherent question of how long in advance one can predict TCG in practice is still open. The current high false alarm rate in real-time TCG forecast by numerical models for lead times of 5 days and longer strongly suggests that TCG may have limited practical predictability. In this work, we explore whether machine learning models can capture large-scale atmosphere memory and how long this memory can help detect TCs and their TCG distribution. We use a combination of highly successful deep learning models, including LSTM and Transformer, to predict the future state of atmospheric variables and use a learned nowcasting model on these future frames to detect TCs. Trained on the NCEP/FNL reanalysis from 2008-2021, we show that, with suitably designed neural networks, large-scale tropical dynamics can be meaningfully predicted for up to 3 days. TC detection based on such data can reach a probability of prediction of ~81% and a false alarm rate of <20% at 6 hrs lead time and decrease quickly after 36 hrs. By treating TCG events as mesoscale anomalies between consecutive frames of evolution, one can further extract TCG information for climate analysis or weather forecast, albeit further refinement is still needed. Our results not only present a promising way to detect TCG in global model outputs based on machine learning methods, but also suggest a limit in the machine learning approach in predicting large-scale dynamics as compared to physical-based global models.

Co-Authors

**Yadi Wei (Presenter)**

Indiana University Bloomington
Bloomington, IN
USA



Santhosh Patil
Indiana University Bloomington
Bloomington, IN
USA



Roni Khardon
Indiana University Bloomington
Bloomington, IN
USA



Chanh Q Kieu
Indiana University Bloomington
Bloomington, IN
USA
