Improving S2S precipitation forecasts in UFS through Tropical Nudging and Explainable Machine Learning

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Abstract

Due to the coupled nature of the earth system, precipitation forecast errors at S2S lead times are caused by a combination of errors/biases from the atmosphere, ocean, ice and land across a range of spatial and temporal scales. We show that UFS precipitation errors over the U.S. at Weeks 3-4 can be directly related to biases in simulating tropical dynamics. In particular, the inability of the UFS to realistically simulate the Madden-Julian oscillation (MJO) leads to biases in the teleconnection to North America that produces these errors. When the tropics are nudged to produce an accurate representation of the MJO and other tropical disturbances, U.S. West Coast precipitation biases are substantially reduced. A clustering analysis is used to show that the greatest forecast improvements with nudging occur during warm ENSO events when MJO convection is in the Indian Ocean and about to move into the Maritime Continent. Physical mechanisms that explain the improvement in tropical-extratropical teleconnections during certain MJO and ENSO states will be discussed. We will also present future plans to combine state-of-the-art developments in machine learning with process-based diagnostics of the tropical moisture and moist static energy (MSE) budgets to understand and correct precipitation biases in coupled UFS hindcasts. In particular, we will discuss how model biases and errors in tropical variability (e.g. MJO) and associated teleconnections to midlatitudes lead to errors in U.S. precipitation on S2S timescales, and present methods to reduce these errors via post-processing on a forecast-by-forecast basis.

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