Science and Technology Infusion Climate Bulletin
NOAA's National Weather Service
42nd NOAA Annual Climate Diagnostics and Prediction Workshop
Norman, OK, 23-26 October 2017

Skillful Empirical Subseasonal Prediction of Landfalling Atmospheric River Activity Using the Madden-Julian Oscillation and the Quasi-biennial Oscillation

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ABSTRACT

Upon landfall, atmospheric rivers (ARs)—plumes of intense water vapor transport—often trigger weather and hydrologic extremes. Presently, no guidance is available to alert decision makers to anomalous AR activity within the subseasonal time scale (~2–5 weeks). Here, we construct and evaluate an empirical prediction scheme for anomalous AR activity based solely on the initial state of two prominent modes of tropical variability: the Madden–Julian oscillation (MJO) and the quasi-biennial oscillation (QBO). The MJO—the dominant mode of intraseasonal variability in the tropical troposphere—modulates landfalling AR activity along the west coast of North America by exciting large-scale circulation anomalies over the North Pacific. In light of emerging science regarding the modulation of the MJO by the QBO—the dominant mode of interannual variability in the tropical stratosphere—we demonstrate that the MJO–AR relationship is further influenced by the QBO. Evaluating the prediction scheme over 36 boreal winter seasons, we find skillful subseasonal "forecasts of opportunity" when knowledge of the MJO and the QBO can be leveraged to predict periods of increased or decreased AR activity (Fig. 1). Certain MJO and QBO phase combinations provide empirical subseasonal predictive skill for anomalous AR activity that exceeds that of a state-of-the-art numerical weather prediction model. Given the wide-ranging impacts associated with landfalling ARs, even modest gains in the subseasonal prediction of anomalous AR activity may support decision making and benefit numerous sectors of society.

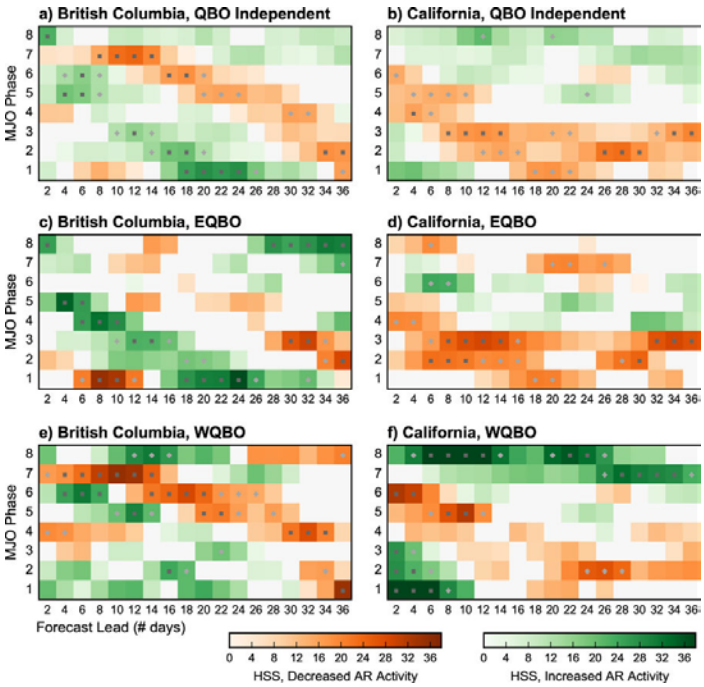

Fig. 1 Heidke skill score (HSS) values as a function of MJO phase (y axis) and forecast lead time (x axis) for the British Columbia (left column) and California (right column) landfall boundaries, (a, b) independent of the state of the QBO, as well as conditioned on (c, d) easterly QBO (EQBO) and (e, f) westerly QBO (WQBO). Only conditional combinations where the HSS is positive are shaded. The shading is based on the dominant AR activity response: decreased activity (oranges) or increased activity (greens). Statistical significance of the skill scores is denoted by the light gray diamonds (≥80th percentile) and dark gray squares (≥90th percentile), based on 1000 block bootstrap samples.

This work was published in npj Climate and Atmospheric Science in 2018.

References

Mundhenk, B., E. A. Barnes, E. Maloney, and C. F. Baggett, 2018: Skillful empirical subseasonal prediction of landfalling atmospheric river activity using the Madden-Julian Oscillation and the Quasi-biennial Oscillation. *npj Climate and Atmospheric Science*, doi: 10.1038/s41612-017-0008-2.

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