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Decadal variability of the extratropical response to the Madden-Julian Oscillation

Daniel Skinner[1], Adrian Matthews[1,2], and David Stevens[1]
[1]University of East Anglia, Centre for Ocean and Atmospheric Sciences, School of Mathematics, Norwich, United Kingdom of Great Britain – England, Scotland, Wales
[2]University of East Anglia, Centre for Ocean and Atmospheric Sciences, School of Environmental Sciences, Norwich, United Kingdom of Great Britain – England, Scotland, Wales

It is known that the Madden-Julian Oscillation (MJO) excites a response in the behaviour of many extratropical weather regimes at lag times of one to two weeks, acting as a key predictor in weather forecasting. Less well understood, however, is the robustness of these responses over long time scales. We begin by taking a statistical approach to assess the boreal winter response of a selection of key extratropical systems (e.g. North Atlantic Oscillation (NAO), Pacific North American (PNA) pattern) to the MJO, over two non-overlapping time periods (1974-1997 and 1997-2019). It is shown that there is significant change in both the magnitude and structure of the extratropical response signal, as a function of lag, between the two periods.

This is followed by a similar analysis applied to the 1100 year pre-industrial control run of the UKESM-1-0 coupled climate model. By breaking this period into separate 20 year segments and comparing the extratropical responses to the MJO in each segment, we show that although there is a predictable mean signal, it is overwhelmed by the internal variability in the system. Repeating this methodology with segments between 10 and 40 years in length allows us to assess sampling errors and identify the key timescales for the variability. A similar mean signal is seen with every segment length, justifying the current use of the MJO as a predictor in the extratropics, although the variability in segments of 30 and 40 years (common time periods used in many historical analyses) casts doubt on the reliability of these predictors for the future.

Recent process based analysis has shown that El Niño Southern Oscillation (ENSO) can act to modulate the Rossby wave source associated with the MJO. We investigate this using our statistical approach to assess the impact of ENSO on the MJO teleconnection patterns. In addition to this, we consider lower-frequency modes, for example Atlantic Multidecadal Variability (AMV) and the Pacific Decadal Oscillation (PDO). By compositing the extratropical response to the MJO over positive and negative phases of each of these modes, we see the individual impact of each low-frequency on the MJO teleconnections. Our work suggests updating the current MJO-extratropical predictors to include consideration of the decadal atmospheric and oceanic basic state.