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Process-based analysis of the MJO phase speed error in the coupled NWP model of the UK Met Office: a two-way feedback between the MJO and the diurnal warm layers

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The diurnal cycle of SST (dSST) is influenced by the development of diurnal warm layers in the upper ocean. Observations show that the dSST rectifies intraseasonal SSTs, potentially leading to changes in intraseasonal weather patterns such as the Madden-Julian Oscillation (MJO). Here we analyze 15-day forecast composites of the coupled ocean-atmosphere and the atmosphere-only configurations of the Numerical Weather Prediction (NWP) models of the UK Met Office to show that a strong dSST in the coupled model leads to a faster MJO propagation compared with the atmosphere-only version of the model. A set of experiments using the coupled model was designed to reduce the strength of the dSST by imposing instant vertical mixing in the top 5 and 10 m of the ocean model. On a 15 lead-day time scale, weakening the dSST slows the MJO phase speed in the coupled model. On a 7 lead-day time scale, all coupled model runs display an underlying 5% increase in the MJO phase speed compared to the atmosphere-only model due to the presence of thermodynamic coupling unrelated to the dSST. The MJO phase speed increase due to the dSST is linearly related to the mean tropical dSST at lead day 1 in the coupled model. An additional 4% of the MJO phase speed increase between the control coupled model and the atmosphere-only model on a 7 lead-day timescale can be attributed to the presence of the dSST in the coupled model. Over 15 lead days, the coupled model produces a two-way feedback between the MJO and the dSST. The MJO conditions set the strength of the dSST in the coupled model. Consistent with observations, the dSST in the coupled model rectifies intraseasonal anomalies of SSTs such that stronger dSST leads to positive intraseasonal SST anomalies. The MJO convection response to these SST anomalies peaks 7 days later, and subsequently feeds back onto SST anomalies. The phase relationship between MJO convection, dSST and intraseasonal SST anomalies is consistent with the relationship between dSST and MJO propagation speed. Overall, our experiments demonstrate the importance of high vertical resolution of the upper ocean in predicting the eastward propagation of the MJO in an NWP setting, potentially creating repercussions for seasonal predictions and climate projections should this feedback be unrepresented in the models.