

Using a case-study approach to improve the Madden-Julian Oscillation in the Hadley Centre model

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The Madden-Julian Oscillation (MJO) is the dominant mode of sub-seasonal variability in tropical convection and rainfall. Many climate models, including the Hadley Centre's HadGEM, have considerable deficiencies in their simulations of the MJO, including in amplitude, propagation and horizontal and vertical structure. To understand and ameliorate these errors in HadGEM, 20 sets of climate-resolution (150 km) simulations were performed for two 30-day MJO case studies during the Year of Tropical Convection (YoTC) period. In each set, a different modification was applied to the model's convective, boundary-layer or radiation scheme, spanning a range of likely causes of a deficient MJO. Two modifications improved the MJO: increasing the convective entrainment rate and switching off the convective momentum transport. These two alterations were then made, separately and together, in another 12 30-day re-forecasts for MJO cases in 2000-2009. In nearly all cases, the increased entrainment rate improved the forecasted MJO amplitude, propagation and horizontal and vertical structure. Removing the convective momentum transport further improved the MJO in one-third of cases. Finally, two 30-year atmosphere-only simulations were performed: one each with the standard and increased entrainment rates. The latter doubled the frequency of strong MJO activity, bringing HadGEM in line with observations, and again improved propagation and structure. The sensitivity of the model's convection to environmental relative humidity is therefore critical for a realistic MJO in HadGEM. More generally, this study demonstrates the value of using short, computationally inexpensive case studies to understand the causes of climate model biases.