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Process-oriented diagnosis of tropical cyclones based on the moist static energy variance budget in reanalyses and high-resolution climate models

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Process-oriented diagnostics of tropical cyclones (TCs) facilitate a comparison of models to observations with respect to the physical processes relevant to TCs, informing which processes to target for model improvement. Here we use diagnostics based on the column-integrated moist static energy (MSE) variance budget, which focuses on how convection, moisture, clouds, and related processes are coupled. We use five different reanalysis datasets to provide an 'observation'-based reference against which high-resolution global climate models can be evaluated: ERA-Interim, MERRA-2, CFSR, ERA-5, and JRA-55. We calculate the budget in 10 x 10 degree boxes following tracked TCs composites over storm snapshots of the same intensity. The composites are qualitatively similar to prior work, with radiative feedbacks contributing most to MSE variance growth in the early stages of TC development and in weaker storms, and with surface flux feedbacks increasing strongly with intensity. Reanalyses that have a stronger radiative feedback, normalized by the box-mean MSE variance, in a given intensity bin exhibit a higher percentage of storms that intensify to the next bin, which emphasizes the value of the MSE variance budget as a process-oriented diagnostic for understanding model simulation of TCs. However, there is a large spread in MSE variance and the radiative and surface flux feedback contributions to MSE variance growth across reanalyses, even when considering composites over storms of the same intensity. The spread across reanalyses is comparable to the spread across the high-resolution climate models considered by Wing et al. (2019). This suggests that the data assimilation present in reanalyses does little to constrain the TC-MSE variance budget and indicates that caution must be taken when evaluating climate models against reanalysis. Ongoing work continues to evaluate climate model simulations, including those from the HighResMIP ensemble, against the reanalysis-based reference, and examine the large-scale environments associated with TC formation in reanalyses.