Geophysical Research Abstracts
Vol. 17, EGU2015-14253, 2015
EGU General Assembly 2015

Understanding Predictability of the MJO Initiation over the Tropical Indian Ocean Using Stochastic Ensemble of a Coupled Atmosphere-Ocean Model

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One of the most challenging problems in prediction of Madden-Julian Oscillation (MJO) is the initiation of large-scale convection over the equatorial Indian Ocean. The Dynamics of MJO (DYNAMO) field campaign in 2011-12 has provided unprecedented in situ observations to advance our understanding of MJO initiation. It is evident that the complex multiscale interaction among convective cloud systems and their large-scale environment on time scales from hours to months is a key contributing factor. Two new science hypotheses on MJO initiation have emerged based on DYNAMO observations. First, dry air intrusions associated with synoptic-scale wave-like disturbances from subtropical Indian Ocean play an important role in 1) alternating deep convection from ITCZ to equatorial convection during the onset of MJO initiation and 2) favoring eastward propagation of MJO convection by entraining dry air into the equatorial region to the west by the Rossby-wave like gyres. Second, convective cloud systems and convective cold pools are sensitive to the large-scale water vapor distribution and air-sea fluxes. The boundary layer recovery time from the cold pools can affect the re-development of convection. The cold pool recovery time vary from a few hours during the convective active phases of MJO to more than 30 hrs during the suppressed phase, which indicating the upscaling effects of convective systems on MJO may be important for the evolution of MJO. The predictability of convective cloud systems and their up-scaling influence on MJO have not been studied systematically. Although the predictability of individual convective cloud systems is likely to be less than 1-2 days, the predictability of MJO initiation over the Indian Ocean should be much longer if the large-scale atmosphere and ocean processes are dominant factors.

To address the question of convective upscaling and dry air intrusions on the MJO initiation, numerical experiments using the Coupled Model (coupled WRF-UMWM-HYCOM) developed at the University of Miami are used to better understand the physical processes and multiscale interaction. This study is aimed to better understand the predictability of convective cloud systems and their variability on various spatial and time scales, model error and forecast uncertainty is investigated using a stochastic kinetic-energy backscatter scheme (SKEBS) that has been implemented and tested in the WRF and the coupled models. Perturbations of wind, temperature and water vapor fields on various spatial scales are generated using SKEBS. Systematic analysis is conducted is to examine the model error growth on different time and spatial scales that are representative of the observed multiscale interactions in the coupled atmosphere-ocean system.