TITLE: Producing and Diagnosing a Regional Analysis with Data Assimilation at a Cloud-Permitting Scale to support YMC and PISTON

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Abstract

Atmospheric convection in the Maritime Continent (MC) region undergoes substantial multi-scale variability on the diurnal, synoptic, intraseasonal, and seasonal scales. The processes governing these multiscale variabilities and interactions are essential for predicting high-impact weather and climate, especially the barrier effect of the MC on the Madden-Julian Oscillation (MJO). These processes are not well understood and are key issues motivating the planned YMC and PISTON programs. Among all the challenges, uncertainties in current global analysis products and prediction regarding temporal and spatial variability of atmospheric convection, its diurnal cycle, triggering, propagation and upscale growth, and distribution over water and land in the MC are critical factors limiting the application of such analyses to understanding these processes. The available global analysis and reanalysis products cannot accurately represent the detailed features of convective systems in the MC either temporally or spatially because of their coarse resolution (~50 km to 100 km and 6 hourly) and deficiencies in cumulus parameterization schemes.

The overarching goal of this proposed project is to produce an hourly regional analysis over the MC region during the whole period of YMC at a cloud-permitting scale (~ 3 km horizontal grid spacing) using the community mesoscale Weather Research and Forecasting (WRF) model and the NCEP Gridpoint Statistical Interpolation (GSI)-based hybrid ensemble-variational data assimilation system with the assimilation of all available in-situ observations, radar data, and satellite data products during YMC, including PISTON. It is anticipated that the proposed regional analysis will reveal detailed properties of atmospheric convection and its environmental conditions that are not available from global analysis products and thus will enhance our ability to answer the following science questions:

• What are the spatial and temporal distributions and variabilities of mesoscale atmospheric convective systems, their large-scale environmental conditions, and associated physical and dynamical processes during their triggering, propagation, and upscale growth, associated with the MJO?
• What is the role of local-scale land-sea breezes and orography effects in convective system initiation, evolution, and propagation? How do these local-scale effects contribute to the diurnal cycle and the multiscale variability over the MC region? In addition, what are the major controlling factors that enhance their interactions with large-scale dynamic and thermodynamic conditions? What are the processes controlling the offshore diurnal migration of precipitating systems?
• What are the major causes of the barrier effect of the MC on the MJO? How is the MJO affected by local-scale flows and thermodynamic conditions, such as sea-land breezes, orography effects, storm outflows, etc., in the context of the MC barrier effect?
• Compared with the regional reanalysis, what are the major uncertainties and limitations of available global reanalyses in representing the physical processes of zonal propagation of the MJO and the barrier effect of the MC?
• Based on the verification and validation of the quality of regional analysis in various locations, what types of observations are the most useful for better representation of the atmospheric processes and conditions critical to MJO propagation in the MC region?

The proposed research directly responds to the NOAA Climate Variability and Predictability Programsolicitation for proposals "that aim to improve understanding of processes that affect the propagation (speed, intensity, disruption, geographic placement) of intraseasonal oscillations in the Maritime Continent and broader region by using a combination of in situ and remote observations, data analysis, modeling, and/or theoretical understanding of local and remote processes."