Evaluation of global nonhydrostatic simulations for the recent field campaigns over the tropical Indian Ocean

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In order to gain our understanding of the interactions between local phenomena and the large-scale intraseasonal variability (e.g., Madden-Julian Oscillation; MJO) over the tropical warm pool region, field programs were conducted in recent years, such as the CINDY2011/DYNAMO (October 2011-January 2012) and Pre-YMC (November-December 2015). Currently, the Years of the Maritime Continent (YMC) project (2017-2019) is launching. Global nonhydrostatic simulations are useful to the project goal and to the field operation. In this study, we evaluate the overall performance of the near real-time forecasts using Nonhydrostatic Icosahedral Atmospheric Model (NICAM; Satoh et al. 2014) for the field campaigns (Nasuno et al. 2017, in revision).
In the CINDY2011/DYNAMO campaign, week-long forecasts were daily conducted using the regionally stretched NICAM (Tomita 2008), with the finest horizontal mesh size of ˜14 km. The moist convection was explicitly represented without using the cumulus parameterization. The forecasts fairly simulated the two prominent and one marginal MJO events; the real-time multivariate MJO index (Wheeler and Hendon 2004) skill score ˜0.8 for the week-long integrations (Nasuno 2013). On average, the precipitation amount was overpredicted by 30% than in TRMM 3B42v7, with overprediction of strong (> 40 mm day^{-1}) precipitation and underprediction of weak precipitation. This suggests that the excessive occurrence of the very strong precipitation events was the major source of the overprediction of the total precipitation amount. The evaluation of atmospheric soundings using the radiosonde data revealed growth of lower to middle tropospheric dry (˜1 g kg^{-1}) warm (˜1 K) biases. The moisture and energy budgets during the CINDY2011/DYNAMO period were investigated using the 6-hourly (unfiltered) and 7-day mean (low-pass filtered) forecast outputs. The 7-day mean diagnosis well represent the observed profiles of the apparent moisture sink and apparent heat source, and the variation in the moisture budgets associated with the MJO phase. As a merit of using the high-resolution forecast outputs, the high-frequency effects were directly quantified as the difference between the 6-hourly and 7-day mean diagnosis. A significant amount of upward transport of moisture was found in the NICAM forecasts, which accounted for the excessive condensation in the upper troposphere and the resultant heavy precipitation events, as well as the dry and warm biases in the lower troposphere due to the compensating subsidence. Thus, the high-frequency effects were rather diffusive to the growth of the MJO on average, and more pronounced in the active phases of the MJO events then in the inactive phases. During the pre-conditioning phases, both the low-frequency and high-frequency advections had a tendency to enhance the moistening in the lower to middle troposphere.
In the Pre-YMC campaign, the forecasts were conducted using the global 7-km and 14-km mesh NICAM on the Earth Simulator. During the campaign, a MJO was intensified around the observational site (southwest Sumatra). The RMM skill score in 14-km mesh month-long forecasts was ˜0.6 at the three-week lead time. The budget analysis and high-frequency effects in these forecasts, and the plans for the YMC campaign will be also discussed.

References:

Nasuno, T., 2013: Forecast Skill of Madden-Julian Oscillation Events in a Global Nonhydrostatic Model

during the CINDY2011/DYNAMO Observation Period. SOLA, 9, 69–73, doi: 10.2151/sola.2013-016.
Nasuno, T., K. Kikuchi, M. Nakano, Y. Yamada, M. Ikeda, and H. Taniguchi, 2017: Evaluation of the Near real-time Forecasts Using a Global Nonhydrostatic Model during the CINDY2011/DYNAMO, J. Meteorol. Soc. Japan, in revision.
Satoh, M., and others, 2014: The Non-hydrostatic Icosahedral Atmospheric Model: Description and Development. Progress in Earth and Planetary Science, 1, 18. doi:10.1186/s40645-014-0018-1.
Tomita, H., 2008: A stretched grid on a sphere by new grid transformation, J. Meteor. Soc. Japan, 86A, 107–119.

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