

A Global Model Intercomparison of the Physical Processes Associated with the Madden-Julian Oscillation

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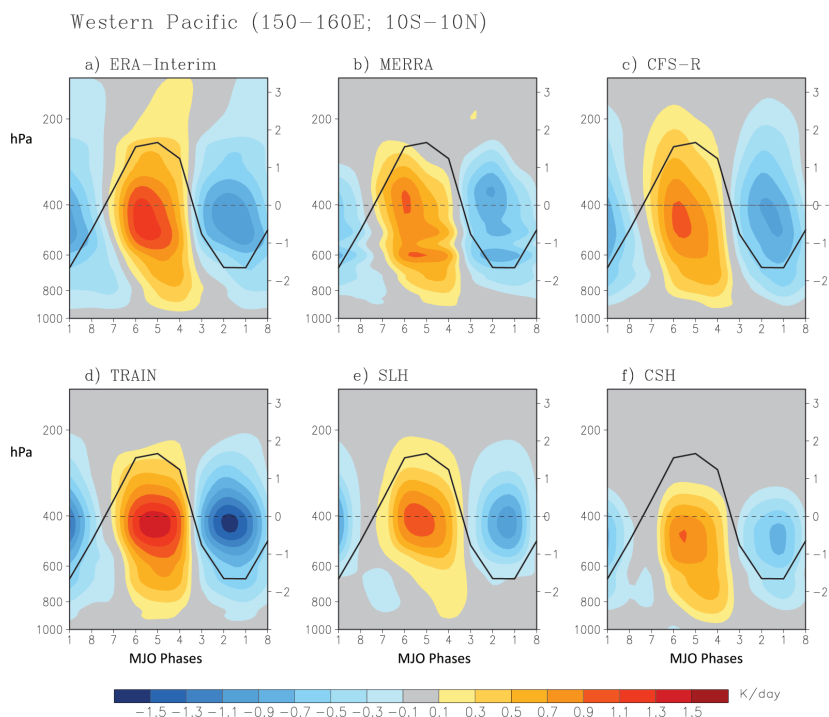
As a dominant subseasonal mode of tropical atmospheric variability, the Madden-Julian Oscillation (MJO; Madden and Julian 1971; 1994) exerts pronounced influences on global climate and weather systems (see reviews by Lau and Waliser 2005; Zhang 2005), and represents the primary source of predictability on subseasonal time scales (e.g., Waliser 2005; Gottschalck et al. 2010). Current general circulation models (GCMs), however, exhibit limited capability in representing this prominent tropical variability mode (e.g., Slingo et al. 1996; Slingo et al. 2005; Lin et al. 2006; Kim et al. 2009) and the fundamental physics of the MJO are still elusive.

A new joint project for a global model intercomparison of the physical processes associated with the MJO is being launched by the GEWEX Cloud System Study (GCSS) and the World Climate Research Programme-World Weather Research Programme/The Observing System Research and Predictability Experiment (THORPEX) MJO Task Force. The Project brings together communities that have expertise in model physics development and tropical dynamics, and will use the European

Centre for Medium-Range Weather Forecasts (ECMWF) analysis produced as a part of the Year of Tropical Convection (YOTC; <http://www.ucar.edu/yotc>), complimented by data from satellites, such as the Tropical Rain Measuring Mission (TRMM), CloudSat, the Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation (CALIPSO), and the Atmospheric Infrared Sounder (AIRS).

The goal of the Project is to provide a framework for model developers to make improvements to the physics schemes in global weather and climate models. One component of the comparison will characterize, compare and evaluate the heating, moistening and momentum mixing processes associated with the MJO by gathering profiles of physical tendencies from the model on a timestep by timestep basis over large regions influenced by the MJO. The MJO will provide a rigorous test bed of the physics in our models and their interaction with large-scale dynamics. Moreover, the Project will serve as a useful candidate for comparing model-derived diabatic profiles associated with the MJO with those from global satellite observations (e.g., Tao et al., 2006; Jiang et al. 2009, 2011; Ling and Zhang 2011).

The figure below illustrates a recent comparison of anomalous diabatic heating (Q1) profiles from three TRMM-derived products with three recent reanalyses: (1) ECMWF Reanalysis-Interim (ERA-I); (2) the National Aeronautics and Space Administration/Goddard Spaceflight Center Global Modeling and Assimilation Office Modern ERA Retrospective-Analysis for Research and Applications (MERRA); and (3) the National Oceanic and Atmospheric Administration (NOAA) National Centers for Environmental Prediction (NCEP) Climate Forecast System Reanalysis (CFS-R). Such profiles have yet to



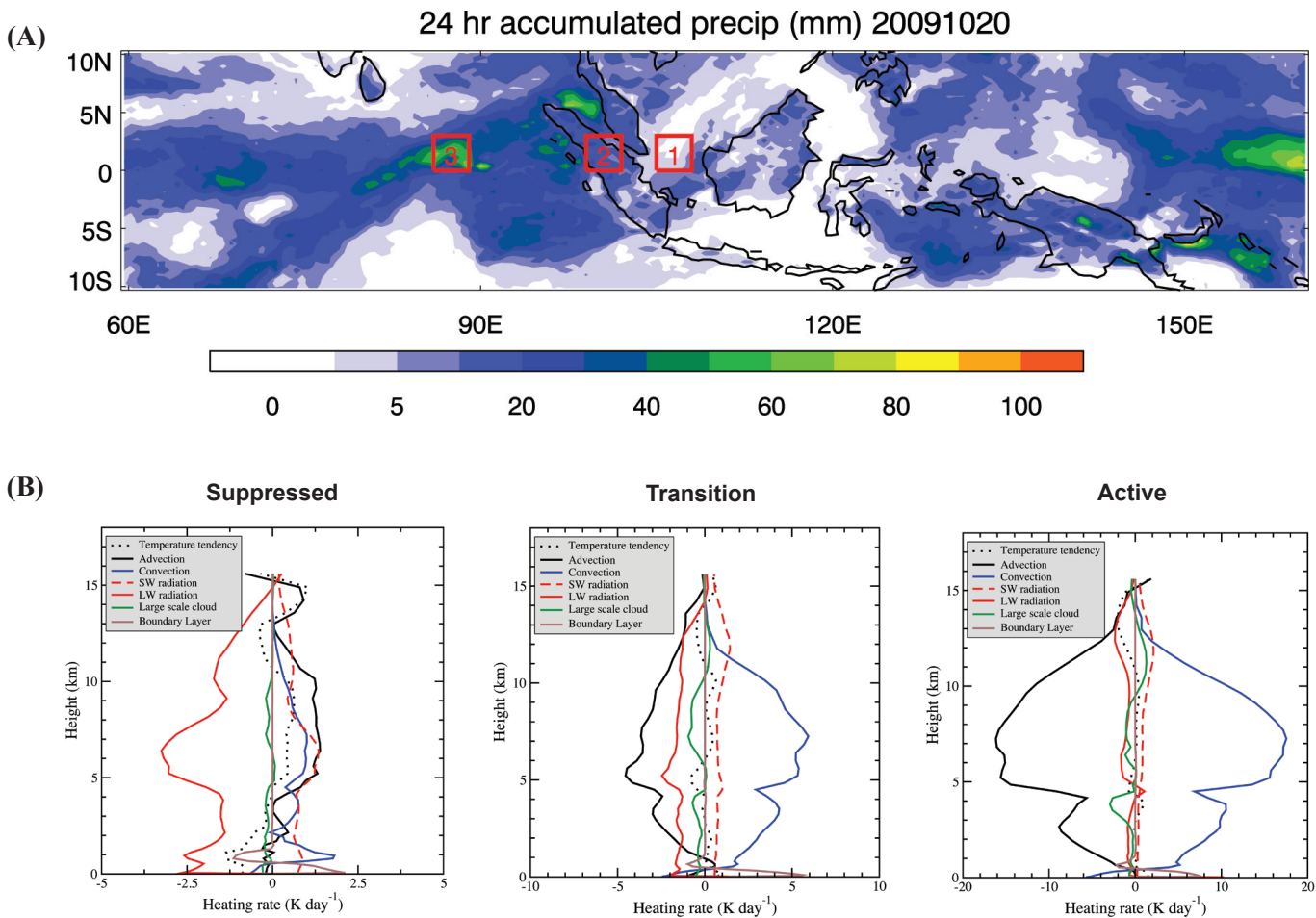
be utilized in a multi-model evaluation of the MJO despite the fact that the vertical heating structure is a core element of MJO theory and evolution. One of the objectives of this Project is to determine the utility of the satellite and reanalysis values in evaluating model simulations of the MJO and provide feedback to the satellite formulation and algorithm communities regarding strengths, shortcomings and gaps in present-day products.

The experimental framework for the Project will take advantage of the known links between biases seen in short-range forecasts and long-term climate simulations (e.g., Boyle et al. 2008), and evaluate these in the context of the MJO. It will also consider how a model's representation of the MJO changes with forecast lead-time. For this reason, the following types of simulations will be carried out:

1. Twenty-year climate simulations that provide a characterization of the models' intrinsic capabilities of representing MJO variability. Model simulations from both ocean-

coupled global models, as well as those that use specified sea-surface temperatures will be evaluated with metrics that broadly describe the models performance in terms of the MJO [e.g., U.S. Climate Variability and Predictability Project (CLIVAR) MJO Working Group, 2009; Kim et al. 2010] and the associated vertical heating and moistening structures.

2. A series of daily initialized hindcasts for two MJO events within the Year of Tropical Convection (YOTC) period—specifically the two successive MJO events during Boreal Winter 2009-2010. A principal focus of this component of the experiment is on providing highly detailed and comprehensive (e.g., every time step) model output over a select near-equatorial Indian Ocean/Western Pacific Ocean domain for the initial two days of the hindcasts.
3. Analysis of the performance of the models' MJO representation as a function of forecast lead-time from one to 20 days, differing from (2) only in the level of detailed diag-



(A) Twenty-four hour accumulated precipitation from the forecast initialized on 20 October 2009 from the Met Office Unified Model (MetUM). Three regions depicted by red boxes (each 3 x 3 degrees) are used for the heating budgets. (1) is a region of suppressed convection. (2) is a region of transition to deep convection and (3) is a deep convective region. (B) Temperature tendencies from different processes in the MetUM over the three regions indicated in (A). Total temperature tendency is plotted as black dashed line and represents the change over the 24-hour period; this is also equal to the sum of all other terms.

Key GCSS/THORPEX MJO Project Information and Dates

- The detailed case specification and model experimental framework is currently being developed and will be available at: <http://www.ucar.edu/yotc/mjodiab.html>.
- Contact Xianan Jiang (xianan.jiang@jpl.nasa.gov) and Prince Xavier (prince.xavier@metoffice.gov.uk) to express interest in participating in the Project and to sign up for Project's e-mail list.
- The deadline for submitting model results is November 2011.
- A joint YOTC/MJO Task Force and GCSS meeting is planned for late Boreal Spring 2012 to discuss the preliminary results of the experiment, with papers to be drafted by late 2012.
- GCSS is project of the Global Atmospheric System Studies Panel within GEWEX.

nosis. Hindcast components two and three will provide the framework from which analogous cases can be examined from the Dynamics of the MJO (DYNAMO)/Cooperative Indian Ocean Experiment on Intraseasonal Variability in the Year 2011 (CINDY2011) field program that is taking place in Boreal Winter 2011-2012.

Unlike previous GCSS projects, this will not include any process modeling in the beginning. Instead, it will allow the analysis of the global models to determine the most suitable follow-on process modeling studies, as well as to possibly informing needs for future field experiments and observing systems.

The figure on page 4 is an example of the types of analyses to be performed. The top figure shows the 24-hour accumulated rainfall on 20 October 2009 from a 24-hour forecast from the Met Office Unified Model (METUM). It has been initialized from the ECMWF YOTC analysis and run with a horizontal grid length of 40 km. Three regions are depicted as red boxes: Region 1 is in the suppressed phase of the MJO; Region 2 is in a transition region ahead of the propagating convection; and Region 3 is in the active phase of the MJO. The three panels at the bottom show the heating budgets averaged in these boxes with the physics terms divided according to parameterization schemes. Note that the x-axis increases by a factor of two as we go from suppressed to transition and again as we go from transition to active. Of course there is much more analysis that can be performed and close attention will be paid to the temporal variability of these terms on a timestep basis, as well as spatial variability on the grid-point basis.

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