A white paper for the formation of an ASR Madden-Julian Oscillation Focus Group

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1. Introduction

The Madden-Julian Oscillation (MJO) is an important component of tropical intra-seasonal variability. Typically originating over the Indian Ocean, MJO is an equatorial planetary-scale envelop of complex multi-scale cloud systems that propagates eastward at a speed of about 5 m/s across the maritime continent and into the western Pacific. It has far reaching impacts on weather systems within and outside the tropics including the onset and break of the Indian and Australian summer monsoons, the formation of tropical cyclones as well as the onset and demise of some El Niño events. Decades of observational studies have documented the evolution of various fields associated with MJO propagation and several hypotheses have been proposed to explain it. However a comprehensive theory that explains all the important observed characteristics, especially its triggering and peculiar propagation characteristics, is lacking. As a result, proper parameterization of sub-grid scale dynamic and moist thermodynamic processes for a satisfactory simulation of the MJO by global climate models remains a significant challenge.

Given its societal impact, the importance of understanding the basic physics of the MJO and its accurate representation in global models has been well recognized by the scientific community, as well as US and foreign agencies. Therefore the design and implementation of various field programs aimed at addressing aspects of this problem are already underway. In particular the ARM MJO Investigation Experiment (AMIE) funded by the Department of Energy and the DYNAMO field campaign, the US component of the international Cooperative Indian Ocean Experiment on Intraseasonal Variability in Year 2011 (CINDY2011) field program, are expected to provide an unprecedented amount of data to enable the critical evaluation of various hypotheses put forward to explain the physical processes responsible for the triggering of MJO and its propagation characteristics.

There are also several ongoing global, regional and cloud scale modeling studies aimed at improving the parameterization of cumulus, boundary and radiative processes in order to ultimately improve understanding, simulation and forecasting of MJO episodes. The success of these two mutually dependent parallel efforts depends on the existence of a forum for direct communication among those implementing the field campaigns, retrieving and analyzing the data on the one hand, and those who are engaged in modeling efforts and design of physical parameterizations on the other. Therefore we propose the formation of an MJO focus group within the ASR program composed of researchers engaged in the above mentioned campaigns and the modeling community within ASR with interest in MJO simulation. The specific purpose of the focus group would be to facilitate communication and collaboration between the observations, retrievals, and modeling groups so that the ASR program would make a significant and measurable contribution to the MJO research. Additionally, in a parallel effort the DYNAMO group has a specific Modeling Working Group component comprised of modelers from the wider community outside of ASR. An ASR MJO Focus Group would serve as a mechanism for establishing collaborative efforts with the DYNAMO community, which has the same goals. The MJO Focus Group would have a projected lifetime on the order of about five years (concurrent with the field campaigns and a few years after for analysis and modeling efforts) and would have a set of task groups charged with producing specific scientific and technical deliverables that are consistent with the objectives of the ASR program.

The exact scope, objectives, tasking, and deliverables are naturally dependent on the number and collective expertise of participants of the focus group. Thus the following sections are put forth in the spirit of an example of a possible framework for the focus group, which would be amended and refined once a listing of interested participants is actually formed. We have already put in a request for an AMIE Breakout for the upcoming ASR Science Team Meeting, which given the go-ahead from the CLWG Chairs, we can and will adapt instead into an MJO Focus Group Breakout with the goal of forming the membership and refining the FG Charge document defining the details of the focus group effort.

2. Objectives

Example objectives of the focus group are;

a) Evaluate existing hypotheses on the physics of the initiation and propagation of MJO.

b) Identify critical deficiencies in current numerical models that are responsible for their low prediction skill and poor simulations of MJO initiation and propagation.

c) Provide unprecedented observations to assist the broad community effort toward improving model parameterizations.

Example hypotheses to be tested are;

a) Deep convection can be organized into an MJO convective envelope only when the moist layer has become sufficiently deep over a region of the MJO scale; the pace at which this moistening occurs determines the duration of the pre-onset state. The large-scale circulation can affect the moist layer depth through boundary-layer moisture convergence (Wang 2005; Hendon and Salby 1994), horizontal moist or dry advection (Maloney 2009; Benedict and Randall 2007), and surface evaporation (Sobel et al. 2008, 2010), which may include positive SST feedbacks to the MJO (Waliser et al. 1999). Furthermore, parameterizations that directly relate the triggering of deep convection with mid-tropospheric moisture would likely produce better simulation of MJO (Bechtold et al. 2008, Wang and Schlesinger 1999).

b) Specific convective populations at different stages are essential to MJO initiation. As the MJO progresses through different lifecycle stages, different cloud types take on greater or lesser importance, with a different predominant cloud type in each stage (Lau and Wu 2009; Chen and Del Genio 2009). The same type of convective cloud may play different roles at different stages.

c) Stratiform heating and baroclinic temperature fluctuations in MJO propagate in phase such that stratiform instability is an important source of MJO energy and organization. The absence of robust MJO in some models that depend on parameterizations (Fu and Wang 2009, Hagos et al. 2010) and the relative success of cloud resolving models (Grabowski 2001; Benedict and Randall 2007; Khairoutdinov and Randall 2008) is most likely related to deficiencies in representation of cloud populations.

3. Example Tasks

a) The focus group will collaborate to provide dynamically and thermodynamically consistent data for forcing cloud resolving models and for evaluating regional and global model experiments that will be designed to take advantage of the new observations from the AMIE/DYNAMO/CINDY2011 field campaigns, such as the "ARM Variational Analysis" data sets that are planned using the available campaign data. It is planned that the data will contain

among other things cloud statistics, moisture and temperature profiles, as well as large scale diabatic heating and moistening, and it will be formatted and processed to allow comparison with output from model simulations.

b) Development of metrics for inter-model and model-observation comparisons tailored towards testing the above hypotheses.

c) The strengths and weaknesses of the physical parameterizations in the participating models will be evaluated using a consistent set of metrics. The specific technical changes necessary to remedy the weaknesses of each participating parameterization will be documented.

d) Another set of experiments will be designed to evaluate the effects of the implementations of the changes in parameterizations guided by the above task.

e) The above two tasks will be repeated as necessary and as resources allow.

4. Example Deliverables

a) The data from the first task will be available through the ARM Archive along with its description, algorithms, error estimates etc. While it is expected that these PI value added products would to some extent be produced without the formation of an MJO Focus Group, such a focus group would serve to guide and encourage, as well as recommend the priorities for producing, these products likely resulting in a more productive and efficient overall coordinated effort.

b) A series of papers could be published as part of a special issue. The papers would describe results from tasks a), b) andc). Again, papers would likely be produced anyway, but organizing a special issue would best be accomplished within a collaborative forum such as a focus group.

c) Results from tasks d) and e) would be reported in the form of updates to the participating cumulus parameterizations for possible inclusion to the upcoming versions of the respective global and regional models.

Refinement of all the above examples would be one of first tasks as part of the formation of an MJO Focus Group.

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