1D.1 THE INITIATION OF THE MADDEN-JULIAN OSCILLATION

Pallav K Ray*
MPO/RSMAS, University of Miami, Miami, FL

1. INTRODUCTION

The mechanics of initiation of the Madden-Julian Oscillation (MJO, *Madden and Julian*, 1971) remains an open question to the atmospheric community. Most theories for the onset of the MJO fall into one of the following categories. (i) Local forcing or discharge-recharge mechanism (e.g., *Hu and Randall*, 1994), (ii) Extratropical triggers (e.g., *Lau and Peng*, 1987; *Matthews and Kiladis*, 1999), (iii) Initiation by circumnavigating waves (e.g., *Lau and Peng*, 1987), and the (iv) Stochastic forcing (e.g., *Neelin and Yu*, 1994). A review of these studies can be found in *Zhang* (2005).

The objective of this study is to explore the dynamics of the MJO in relation to its initiation and organization of convection. Previously, no modeling effort has been made in differentiating the forcings which are thought to be responsible for the MJO initiation. We will use a mesoscale model for this purpose. In a recent study, *Gustafson and Weare* (2004a,b) introduced for the first time the idea of using a regional model in studying the MJO. In a regional model, any feedbacks with the rest of the globe are controlled through the boundary conditions, which allows for several MJO-related experiments that would not be possible using GCMs (*Gustafson and Weare*, 2004a,b). For example, any signal related to prior MJOs can be filtered from the boundary conditions to see how the circumnavigating features affect the MJO. The other advantage of using a regional model is the potential increase in resolution, and the flexibility in choosing the model physics.

2. MODEL AND DATA

The model used is the fifth-generation Pennsylvania State University (PSU)-National Center for Atmospheric Research (NCAR) Mesoscale Model (MM5; *Dudhia*, 1993). The east-west boundaries of the standard MM5 join with a small overlap (5 grid points), which eliminates the need for a lateral boundary condition in the zonal direction. We call this the tropical MM5 (TMM5, D1 in figure 1). This set up of the model is necessary to isolate the boundary effects that arrive solely from the extratropics. A standard regional domain mixes up the boundary effects from the zonal and the meridional directions. Also, the TMM5 would be a great tool to investigate the circumnavigating features associated with the MJO, which would not be possible using a regular regional model. Figure 1 shows the two domains considered for the numerical simulations. The latitudinal extent in the model is a compromise between the width needed to properly capture the MJO dynamics, and the in-house computational power.

The control simulation (CS) was conducted from 1 March to 30 June 2002. To document the extratropical effect, fixed boundary simulations (FS, using boundary conditions of the initial time) were conducted for the second experiment. NCEP global tropospheric analyses (final or FNL data, $1°$x$1°$, 6 hourly) datasets were used to provide initial and boundary conditions of the model. The simulations were compared to NCEP-NCAR reanalysis ($2.5°$x$2.5°$) datasets.

3. DISCUSSIONS

The primary MJO region, i.e., the area covered by D2 domain will be considered for the results. The best agreements were found for the nested domain with higher resolution. Two factors with potential to significantly affect the simulation are the initial conditions, and the sea surface temperature (SST). Thus, we conducted several simulations by changing the initial time of the model integration (by moving the initial time of the simulation by 5 days before and after the initial time of the control simulation. There is no apparent time lag in the MJO initiation between the two simulations with different initial conditions (not shown). Figure 2 shows the anomalies of the 850 mb zonal wind (U850) with varying and constant SSTs. There is no apparent time lag in the MJO initiation, and no systematic difference in the anomalies between the two sim-

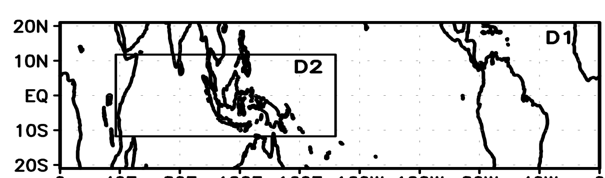

Figure 1: Domain size for the tropical MM5 (D1, $0°$-$360°$, $21°$S-$21°$N), and the nested domain (D2, $37°$E-$183°$E, $11°$S-$11°$N). The domains D1 and D2 have resolutions of 111 km, and 37 km respectively.

*Corresponding author address: MPO, RSMAS, University of Miami, 4600 Rickenbacker Causeway, Miami, FL 33149, e-mail pray@rsmas.miami.edu

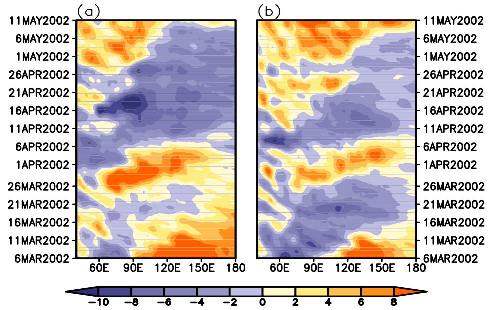

Figure 2: U850 anomaly from (a) simulation with varying SST, and (b) constant SST using only the TMM5 domain with a resolution of 111 km. The values were averaged over 10°S to 10°N.

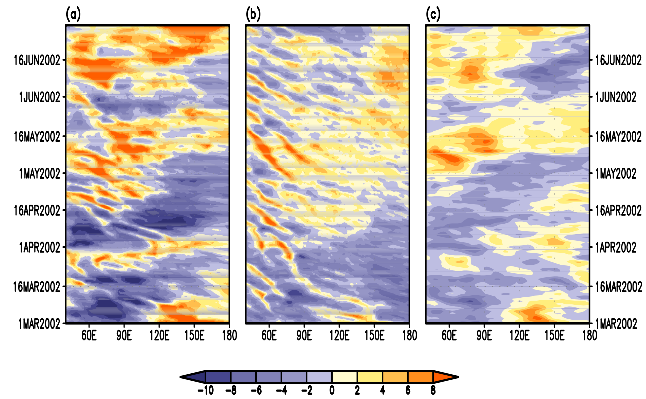

Figure 3: U850 anomaly from (a) the control simulation, (b) fixed boundary condition, and (c) NCEP-NCAR reanalysis. For (a) and (b), only the output from D2 domain was used. The values were averaged over 10°S to 10°N.

ulations. The simulations captured the mean conditions of the atmosphere quite well (not shown). This gives some confidence on the models ability to capture the robust MJO signal in absence of intraseasonally varying SST. Since, the simulation is not sensitive to the SST perturbations, the difference in the resulting simulations between CS and FS, will entirely be due to lateral boundary forcing. Figure 3 shows the U850 anomaly from the nested domain simulations. The strength of the model anomalies are somewhat stronger than the observations, but the location and the timing of the large anomalies are represented well by the CS. The eastward phase speed from the CS is estimated to be about 5 m/s (same as the observation), whereas, the eastward propagation is not quite visible from the FS. Similar tendencies were found from other variables (such as OLR, U200) as well. The wind direction from the CS also agrees well with the observations (not shown).

It is interesting to note that the model was able to initiate the MJO even after two months, from the beginning of the simulation. This shows that the models ability to simulate the MJO exceeds the predictability limit in the tropics which is thought to be about 2 to 3 weeks. This fact leads to the speculation that, somehow the provided boundary conditions are constraining the model to resemble the observations. On the other hand, the mean conditions of the FS were quite different from the observations (not shown), which indicates that the mean background state may be important for the MJO initiation.

4. CONCLUSION AND FUTURE WORK

Numerical experiments are undergoing at present to isolate the relative effects of the different mechanisms in initiating the MJO. This is being done in combinations of the TMM5, and the regular MM5. The TMM5 provides an ideal test bed to diagnose the effect of the extratropics, whereas, the regular MM5 domain will be utilised to see the effect of the circumnavigating equatorial waves from the previous MJO event. It is not feasible to integrate the model for longer duration with very high resolution as has been done in a cloud-resolving model. Thus, there will always be effects from the poorly resolved grid-scale processes in our simulations, yet the TMM5 could be very useful for individual MJO event, and to supplement data gathered during a field experiment. Because of the large domain and the long simulation time, we do not expect the TMM5 to capture the day to day variability, but the statistics derived from an individual MJO simulation can still be very useful. A natural extension of this work is to perform a detailed analysis of the present case, and to conduct similar set of experiments to elucidate the issue of case dependence. Presently, work is being carried out in this direction.

Acknowledgments

Thanks to Chidong Zhang for his advice. The help by Joe Tenerelli with the model is greatly appreciated. This study was supported by NSF grant ATM9912297.

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