MJO Interest Group Discussion and Planning Summary

The breakout session started out with two invited overview talks on the state of GCM MJO modeling by Tony Del-Genio and Zhiming Kuang. The talks were followed by discussions focused on the following questions;

(a) What specific processes need to be understood and/or parameterized to accurately simulate the MJO?
(b) How can we use the data collected during AMIE/DYNAMO to address these modeling challenges?

1. Overview talks

In his talk, Zhiming Kuang highlighted the growing consensus that the MJO is very likely a moisture mode and where moist static energy (MSE) for its amplitude is provided by cloud-radiation or surface flux feedback, while advection is believed to be primarily responsible for its eastward propagation. He showed some evidence to support that using MSE budget analysis and global WRF simulations that use fixed as well as temporally varying SSTs. He noted that in many of the analyses, the MSE budget does not close (large-residual exists especially in global reanalyses). Similar points were made by Tony Del-Genio, who showed that shallow convection has a relatively smaller contribution of MSE in comparison to long-wave radiation anomalies. The role of deep convection is fairly uncertain because of dependence on vertical velocity profile which is very sensitive to entrainment rate. Tony showed the sensitivity of the MJO simulation to assumed entrainment rate in the NASA GISS model. A similar result was shown by Hagos who used PNNL's global WRF. Tony also showed an example of the use of AMIE/DYNAMO data for model parameterization evaluation. He showed that convective top heights observed by KAZR are found to be sensitive to moisture during AMIE-Gan. Richard Johnson showed a surprisingly strong diurnal cycle in low-level moisture and surface fluxes from his soundings and RV Revelle measurements.

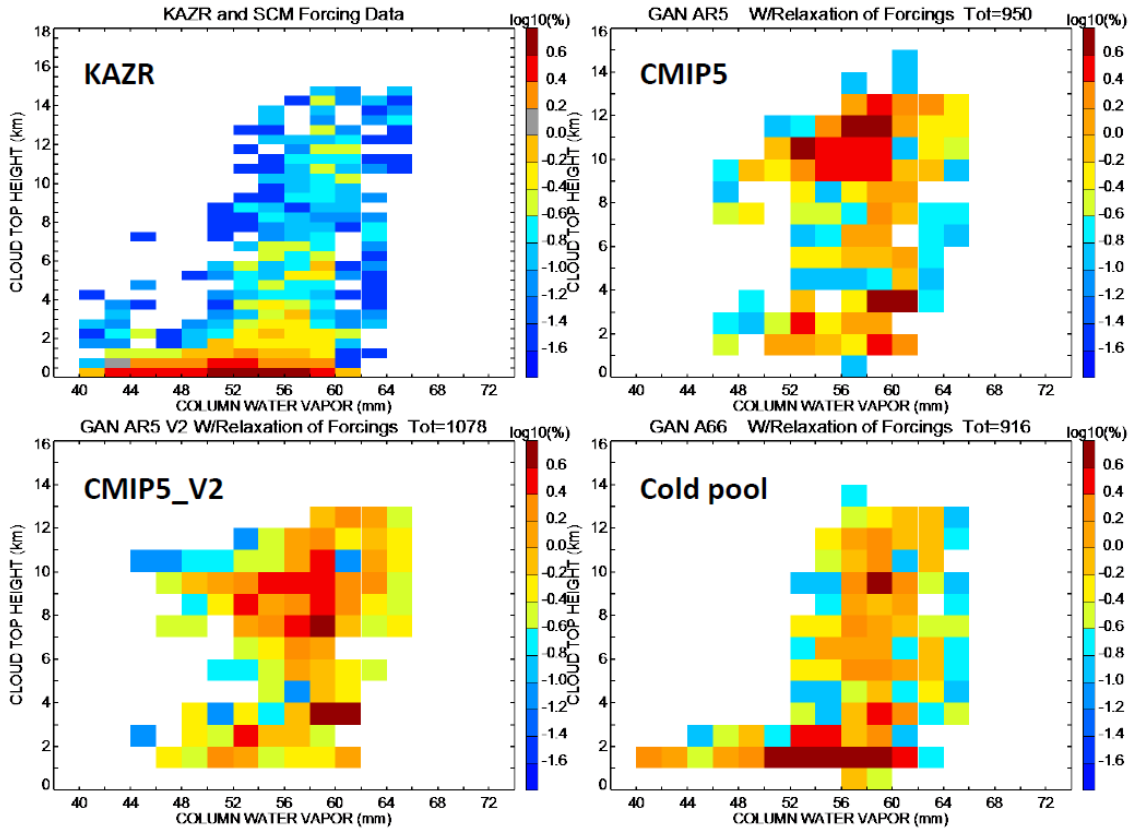
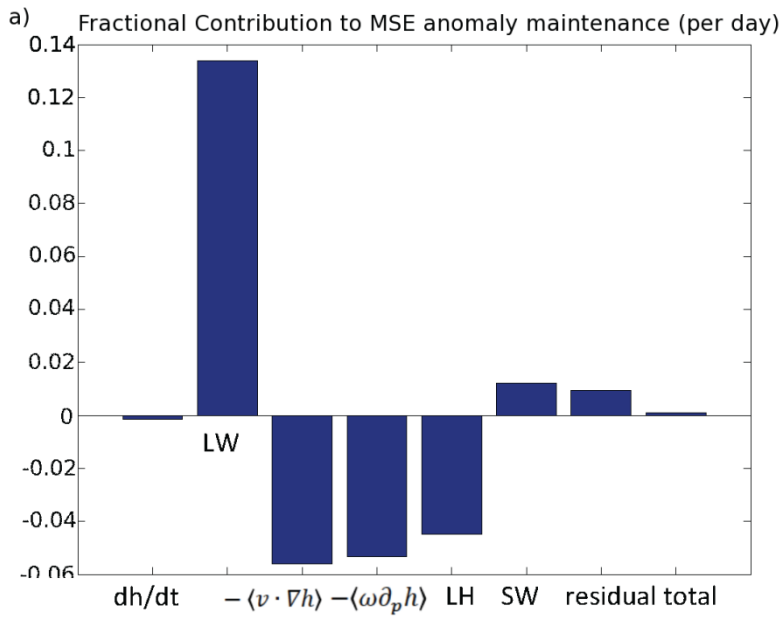


Fig. 1 Inclusion of cold pool dynamics makes the relationship between column water vapor and cloud top height in GISS model comparable to that observed in AMIE/DYNAMO (From Del-Genio's presentation).

$$\frac{\|x \cdot \langle h \rangle\|}{\|\langle h \rangle^2\|}$$



where $\|y\| = \iint_{ITCZ} y dA$ is the integral over the ITCZ

Fig. 2 An MSE budget analysis suggests MJO is primarily maintained by cloud-longwave radiation feedback (From Kuang's presentation).

2. Discussion

After the overview talks, a fairly lively discussion on the above listed two questions ensued for about an hour and half. The discussion was very fruitful in terms of the interest and engagement of many participants. While it was already expected that there would be widely different opinions on the path forward considering the large number of people involved, and the causally integrated nature of the MJO phenomenon itself, a certain degree of consensus was built around the following points.

i. Cloud resolving modeling is an indispensable bridge between the observations and GCMs.
ii. More work needs to be done on microphysics and turbulence parameterizations in CRMs to accurately reproduce observed cloud statistics and processes (relationship to environment, meso-scale organization, cold pools, shallow to deep transition, etc). Nonetheless the use of the CRMs to evaluate and improve GCM parameterizations should progress in parallel.
iii. Since the MJO is an envelope of so many processes that are also of relevance to other ASR themes (such as meso-scale organization, vertical velocity, entrainment etc.) the lessons learned from this work will be of great benefit to research over other regions and it is important to engage people working on modeling of convection from other ASR groups.
iv. A smaller group of modelers and observation experts need to immediately meet and draft specific scientific questions, design modeling protocol, analysis plan, timetable and deliverables.

3. Research Plans: ASR MJO CRM to GCPM Inter-comparison Project

As recommended at the breakout session, a small group of modeling and observation experts met to plan a path forward. The draft plan is:

1. **Objectives:** The inter-comparison project will use MJO as a context for understanding interactions of convection with the environment over a wide-range of spatial-temporal scales to guide the development of the next generation of global models with cloud-permitting and mesoscale grid spacing. These processes include entrainment, cloud-longwave feedbacks, cold pools, diurnal cycle and shallow-to-deep transitions among others.
2. **Models:** The following five models will be used in the initial trial inter-comparisons: Univ. of Miami's SAM, NASA's GCE, PNNL's WRFCRM, PNNL's GWRF and NCAR's MPAS-A.
3. **Simulation Protocol:** All simulations will start on Nov 01 and end Nov 30. Model output frequency will be 3 hours or less. CRMs will run at 500m grid-spacing. GCPMs will run at 15km grid spacing.
4. **Output variables:** 3D variables (temperature, spec humidity, zonal and meridional wind, vertical velocity, height/pressure level). 2D variables (rain rate, surface fluxes, 2m /10 m wind, specific humidity, temperature). Recommended output 3D variables if available (reflectivity, hydrometeor mixing ratio, number concentration, all components of temperature and moisture tendencies)
5. **Analysis Plan:** The inter-comparison project will examine
    a. The relationship between vertically integrated precipitable water vs convective cloud-top height (using KAZR, S-PolKa, SMART-R and soundings at Addu Atoll).
    b. Heat and moisture budget profiles (using Q1 and Q2 from the sounding arrays).
    c. Vertically integrated MSE budget (using sounding arrays).
    d. Surface fluxes, cold pools (using R/V Revelle, S-Polka). Convective/stratiform area, rain-rate statistics (using S-PolKa, C-band radars at Gan, Revelle, and Mirai).
    e. Qualitative comparisons of vertical distributions of hydrometeors (using S-PolKa).
    f. Divergence profiles (using SMART-R).

    Statistical summaries of variables and model runs will be made available online in addition to available online in addition to raw model output including their PDFs. The variable names, height levels etc will be standard for all the simulations.

6. **Responsibilities**
    a. *Simulation design and execution:* Univ. Miami SAM (Janiga), NASA-GCE (Li), NCAR-MPAS (Pilon), PNNL-WRFCRM (Hagos), PNNL-GWRF (Hagos).
    b. *Analysis:* PNNL (Hagos, Feng, Burleyson, Long), Univ. Miami (Janiga, Zhang, Zermano), Univ of Washington (Powell, Rowe, Barnes, Houze), Texas A&M (Ahmed, Schumacher)
7. **Timeline**
    a. Simulations will be done June 1, 2014.
    b. Preliminary analysis teleconference September 1, 2014.
    c. Preliminary analysis to be reported at the MJO Interest Group breakout at the ASR 2014 Fall meeting.
8. **Data-management and sharing:** The model simulation and data will be stored at NERSC. Hagos will manage the project website and the data-sharing portal.

http://portal.nersc.gov/project/cpmmjo/MJOCRM2GCPM/MJOCRM2GCPM.htm

We note that ultimately the production of a modeling best estimate (MBE) data set for the AMIE/DYNAMO campaign, similar to that assembled for TWP-ICE, will be warranted. The efforts outlined above will serve to inform the specifics of the form and format needed for these models to successfully integrate with the MBE that can be constructed. Discussions toward production of the MBE will ensue at the 2014 Fall WG meeting.