S2S – MJOTF Joint Research Project White Paper

MJO and Maritime Continent Interactions:
Evaluating State of the Art, Characterizing Shortcomings,
Draft 3.0; January 6, 2013

Background

The MJO represents one of the high priority subprojects of the S2S. The MJO Task Force (MTF), and to some extent the CLIVAR AAMP, are seen to be the natural task team to help shepherd this subproject. Through a number of independent and collaborative discussions between the S2S and MJO Task Force (MTF) during 2013, the interaction of the Martine Continent (MC) with the MJO has been highlighted as a high priority research question that has significant bearing on shortcomings/improving operational MJO predictions. At the pan-MTF (MTF, S2S, AAMP) October 26, 2013 meeting in Macau, the collective set of questions and challenges regarding the "MJO and Maritime Continent Interaction" was adopted as a leading *candidate* for a joint activity between S2S and MTF. This brief white paper outlines the motivation underlying this consideration, highlights the principle resources that might facilitate a research activity, and poses a few science questions/objectives that might help to initiate a joint S2S – MTF research project.

Motivating Principles

Processes & Prediction: The MC is perceived to represent a natural predictability barrier for the MJO that is exacerbated by limited understanding of this natural predictability barrier and to a great extent exacerbated by limitations in model representations of the MJO and MC interactions. Addressing this topic is expected to introduce compelling questions and considerations regarding land-atmosphere and ocean-land-atmosphere interactions that garner the relevance of additional WCRP entities/objectives (e.g. GEWEX, CLIVAR).

*Practicalities and Opportunities:*There is significant interest across the participants of the MJOTF, S2S and AAMP on this topic from both research and operational perspectives. There already exists modeling resources/databases that provide the means to initiate a research activity on the MJO and MC interactions. The recent DYNAMO field activity may provide some observational inferences regarding this problem and there are strong considerations within Australia/CAWCR to conduct a field program in the MC region in a couple of years. Thus, an MJO+MC research activity could help develop/refine the science objectives of that campaign and in turn such a near-term campaign could be a timely addition to making progress in this area.

Modeling Resources

- **S2S Database**: This new modeling database will provide a comprehensive set of prospective *state-of-the-art operational forecasts for the MJO*, and in most cases associated hindcast data sets. This makes it well suited for studies of prediction

diagnostics and skill, and to a lesser degree for studies of physical processes and multi-scale interactions.

- **MJOTF-GASS Experiment**: With full vertical profiles of all physical tendency terms for climatological simulations with 6 hour output from ~30 models and higher time resolution (time step, 3 hour) output from ~12 models for 2 specific MJO cases during YOTC (boreal winter 2009-10), this is well suited for physical processes and multi-scale interactions studies.
- **ISVHE**: presently the best hindcast data set targeting the MJO and related phenomena, albeit with limited output to study physical processes.

Science Objectives/Questions

- What is the current skill of operation systems at predicting the passage of precipitating/active phases of the MJO into and across the MC, including aspects such as reliability?
- What processes determine whether individual MJOs propagate through the Maritime Continent; e.g. strength of dry anomaly (e.g. Kim et al. 2013), air-sea interactions, both in reality and in models?
- How is the simulated propagation of the MJO through the Maritime Continent related to biases in models?
- How does the partitioning of variability from diurnal to seasonal, including equatorial wave characteristics, influence the MJO and MC interaction?
- How does the ocean-atmosphere coupling in the context of the MC influence the MJO and MC interaction?
- How does topography versus land-sea contrast play a role in the MJO and MC interaction?
- How does land-atmosphere interactions (temperature, soil moisture, diurnal cycle) influence the MJO and MC interaction?
- How is forecast skill associated with the MJO over the MC influenced by the above science elements?

Potential Research Tasks

Note that the S2S database does not have any sub-daily information for anything other than max/min 2m T

- Build on existing work from the ISHVE to assess the MJO prediction skill of the current operational forecasting systems with a particular focus on the prediction of the passage of the MJO across the Maritime continent; including the development of a range of additional metrics to assess, including (depending on the number of ensemble members in the hindcast) a more comprehensive set of probabilistic skill scores for the models.
- Build on the analysis techinique of e.g. Kim et al. (2013) looking at observations, to identify additional hypothese on processes influencing the propagation of the MJO through the MC, likely candidates include

    i. Air-sea interaction however e.g. warmer SST anomalies in the West Pacific are also likely to be related to stronger suppressed phases and hence diagnosing the relative role of SST vs atmosphere only mechanisms may be difficult.
    ii. Synoptic variations in the maritime continent/west pacific related to synoptic scale moisture convergence; diurnal cycle; surface fluxes; equatorial waves (e.g. interactions between Rossby waves and Kelvin waves, c.f. YOTC 'D'); cold surges from S. China Sea, etc.

- Extend the analysis above to forecasts: Do forecasts capture the observed differences between propagating and non-propagating events; including for
    i. Propagating vs non-propagating events
    ii. Propagating bs non-propagating ensemble members for a particular event

- Analysis of the relationship between MJO prediction skill in the MC with model biases, including the mean precipitation and moisture biases; surface flux biases; land-sea contrasts; precipitation distributions; measure of veritical stability and/or GMS two particular aspects are
    i. Can we relate the difference between models to particular biases
    ii. Can we relate the lead time dependence of models predicitions to particular biases; here the focus should be on not the skill of prediction at a given lead time, but on e.g. the representation of the propagation of the MJO from day n to e.g. day n+3 where n is a given lead time (e.g. how does the propagation of the MJO at day n depend on the bias at day n)
- Can the MJO prediction skill or the relevant biases be attributed to the representation of the land-surface including land-sea mask and orography and their control on e.g. diurnal cycle and surface fluxes
- Analysis of the relationship between the MJO and diurnal cycle in models (e.g. Peatman et al. 2013) would be desirable, but not possible within the context of either the S2S project or ISVHE, the existing MJO-DH database has high frequency diagnostics but an in sufficient sample size in the initialized integrations for a properly systematic study. The climate simulations have the data, but its not clear that we are (a) sufficiently close to reality in both the models representation of the MJO, or the diurnal cycle to make this a high priority.