WCRP Community-wide Consultation on Model Evaluation and Improvement

Please complete the following template by writing your answers into the boxes below the questions, sending any supplementary material such as clearly labeled figures in a separate file. Please submit your response electronically by ***15 September 2009*** to Anna Pirani at apirani@princeton.edu.

Q1: Please state your particular area of interest, e.g. global or regional climate or NWP modeling, seasonal prediction, sea-ice feedbacks, monsoons, troposphere-stratosphere exchanges, etc.
CLIVAR Asian-Australian Monsoon Panel (AAMP), interested in the modelling and prediction of the Asian-Australian monsoons at timescales from intraseasonal to decadal. The AAMP is also interested in simulation and prediction of phenomena that are important drivers of intraseasonal-interannual-decadal monsoon variability, including the MJO, ENSO, TBO, the IOD…..

Q2: Given your interest, what would you consider/identify as the KEY uncertainties/deficiencies/problems of current models? What do you think should be evaluated/improved as a priority in models in terms of parameterization and/or interactions among processes? (Give references and/or one key figure where possible)
Three key problem areas are: (1) Representation of monsoon intraseasonal oscillation (MISO, also known as boreal summer intraseasonal oscillation/BSISO) and the boreal winter MJO; (2) Systematic biases in the coupled system and (3) uncertainties in convective parameterization. Brief outlines of these are listed.
(1) Monsoon intraseasonal oscillation (MISO) and MJO: Monsoon intraseasonal variations and the MJO represent the largest variations on all timescales (eg., July 2002 monsoon break over India saw an area-mean rainfall deficiency of around 50%) and MISO prediction would be very useful for agriculture, hydroelectric/industrial uses, flood management etc., especially with a lead time of around 20 days. As shown in Fig. 1, the vast majority of coupled GCMs exhibit difficulty in representing the extension of the eastward propagating component of MISO over the western/central Pacific Ocean, though importantly they all produce eastward propagation over the Indian Ocean [e.g., Sperber and Annamalai 2008]. Though many of the models exhibit apparent northward propagation [e.g., Lin et al. 2008], in many instances it is not clearly associated with MISO as observed [e.g., Sperber and Annamalai 2008]. Phase speeds in particular are too low, and some models still show too much of a standing mode. Poor air-sea coupling may be the cause [e.g., Kemball-Cook and Wang 2001, Fu and Wang 2004] which can relate both to model horizontal resolution and to the design of the coupling mechanism itself (frequency of air-sea flux exchanges, vertical resolution in the ocean mixed layer [Bernie et al. 2005, Klingaman et al. 2008]). We note however that high model resolution alone is not a necessity for high fideility simulation of tropical intraseasonal variability [e.g., see the Sperber et al. 2008 comment on MJO simulation in NICAM].
(2) Systematic biases (particularly in coupled model mean state SST and precipitation) have a detrimental impact on mean monsoon simulation and variability. Seasonal prediction via ENSO in particular is limited via poor model simulation of the equatorial Pacific and west Pacific warm pool [e.g., Turner et al 2005]. The most severe and common bias is found in the western Pacific monsoon trough, which is an extension of the Indian monsoon trough from the northern South China Sea to the Philippine Sea, where the world's largest heat source is located during boreal summer (Kang et al. 2002, Wang et al. 2004). This bias, similar to the double ITCZ problem, has a regional as well as global impact on climate prediction. Local errors (e.g. Arabian Sea SST for the Indian monsoon) are also detrimental. There is an unrealistic relationship between Indian Ocean Dipole (IOD) and monsoon convection. Room for improvement can be found in resolution, air-sea (and land-air) coupled interactions, and in inclusion of hitherto missing processes. An improved monsoon-warm pool ocean-interaction is critical for modeling mosoon interannual variations and seasonal forecasting (Wang et al. 2005). Improved model representation of multi-scale interactions in tropical convection will help reduce some of these errors through rectification onto the mean state (e.g. of

MISO/MJO, diurnal cycle etc). The unrealistic distribution of maximum rainfall over the Maritime Continent also relates to poor representation of topography.

(3) Convective parameterization uncertainty: choice of convective parameterization leads to significant differences in mean land-ocean distribution of convection in the tropical Indo-Pacific [eg, comparison of Tiedtke and Emanuel schemes in Hourdin et al. 2006]. Excessive convection over the ocean is often a problem, although some errors may relate to coupling rather than convective parameterization. Additionally, there are wide discrepancies in the response of extremes of monsoon rainfall to anthropogenic warming according to the chosen convective parameterization [Turner and Slingo 2009] yielding Clausius-Clapeyron or super-thermodynamic responses.

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- Fu, X., B. Wang (2004) Differences of Boreal Summer Intraseasonal Oscillations Simulated in an Atmosphere–Ocean Coupled Model and an Atmosphere-Only Model**.** *J. Climate*, 17, 1263-1271.
- Kang, I.-S., K. Jin, **B.** Wang, K.-M. Lau, J. Shukla, V. Krishnamurthy, S. D. Schubert, D. E. Waliser, W. F. Stern, A. Kitoh, G. A. Meeh, M. Kanamitsu, V. Y. Galin, V. Satyan, C.-K. Park, and Y. Liu (2002) Intercomparison of the Climatological variations of Asian summer monsoon precipitation simulated by 10 GCMs. *Clim. Dyn.*, **19**, 383-395.
- Kemball-Cook S., B. Wang (2001) Equatorial waves and air–sea interaction in the Boreal Summer Intraseasonal Oscillation. J. Climate 14: 2923–2942. DOI:10.1175/1520-0442(2001)0142923:EWAASI2.0.CO;2.
- Hourdin, F., I. Musat, S. Bony, F. Codron, J.-L. Dufresne, L. Fairhead, J.-Y. Grandpeix, P. LeVan, Z.-X. Li, F. Lott (2006) The LMDZ4 general circulation model: climate performance and sensitivity to parametrized physics with emphasis on tropical convection. Clim. Dyn. 27:787–813. DOI 10.1007/s00382-006-0158-0
- Klingaman, N.P., H. Weller, S.J. Woolnough, P.M. Inness, J.M. Slingo (2009) Coupled simulations of the Indian monsoon intraseasonal oscillation using a fine-resolution mixed-layer ocean model. Proceedings of the ECMWF Workshop on Ocean-Atmosphere Interactions, 10-12 November 2008, 195-205.
- Lin J.L., K.M. Weickmann, G.N. Kiladis, B.E. Mapes, S.D. Schubert, M.J. Suarez, J.T. Bacmeister, M.I. Lee (2008) Subseasonal variability associated with Asian Summer Monsoon simulated by 14 IPCC AR4 coupled GCMs. J. Climate 21: 4541–4567. DOI:10.1175/2008JCLI1816.1.
- Sperber, K.R., H. Annamalai (2008) Coupled model simulations of boreal summer intraseasonal (30-50 day) varaibility, part 1: Systematic errors and caution on use of metrics. Clim. Dynam., 31, 345-372.
- Sperber, K.R., J.M. Slingo, D.E. Waliser, P.M. Inness (2008) Coarse-resolution models only partly cloudy. Comment on “A Madden-Julian oscillation event simulated by a global cloud-resolving model” by Miura et al. Science, 320, 612.
- Turner, A.G., P.M. Inness, J.M. Slingo (2005) The role of the basic state in the ENSO-monsoon relationship and implications for predictability. Quarterly Journal of the Royal Meteorological Society, 131, 781-804.
- Turner, A.G., J.M. Slingo (2009) Uncertainties in future projections of extreme precipitation in the Indian monsoon region. Atmos. Sci. Lett. 10. DOI:10.1002/asl.223
- Wang, B., I.-S. Kang, J.-Y. Lee (2004) Ensemble Simulations of Asian–Australian Monsoon Variability by 11 AGCMs. J. Climate*,* 17, 803–818.
- Wang, B., Q. Ding, X. Fu, I.-S. Kang, K. Jin, J. Shukla, F. Doblas-Reyes (2005) Fundamental challenges in simulation and prediction of summer monsoon rainfall. Geophys. Res. Lett., Vol. 32, No. 15, L15711,doi: 10.1029/2005GL022734 12.

Q3: Do you see a particular gap (in knowledge, in observations or in practice) that would need to be filled, or a particular connection between different modeling communities or between modeling, process studies and observations that should be made a priority?

Aside from the deficiencies outlined in Q2, a major knowledge gap lies in the field of land cover and land use change (including the large-scale irrigation in the Asian monsoon region) and their treatment in models for monsoon research. The improved land-atmosphere interaction and land surface initialization may have considerable impacts on seasonal forecast of summer precipitation, yet we do not have the knowledge regarding how much improvement can be made in terms of the current multi-model ensemble prediction. This issue is also partly related to dust and aerosol generation. Particularly with black carbon aerosols, early model results suggest that there may be a shift in seasonality of monsoon rainfall due to black carbon [Meehl et al. 2008] consisting of increased pre-monsoon rainfall due to Lau's elevated heat pump hypothesis [Lau et al. 2006] and redutions in monsoon rainfall due to the direct effect. This issue is important considering Asia's increasing population, industrial expansion etc. More work is required to examine the processes involved, ideally with links to observational activity.

- Lau, K.M., M.K. Kim, K.M. Kim (2006) Asian summer monsoon anomalies induced by aerosol direct forcing: The role of the Tibetan Plateau. Clim. Dyn. 26: 855-864.
- Meehl, G.A., J.M. Arblaster, W.D. Collins (2008) Effects of black carbon aerosols on the Indian monsoon. J. Climate 21: 2869-2882.

Q4: Do you see any particular resource or opportunity within the modeling/process study/observational/theoretical community (e.g. new results, new observations) that would be particularly useful and should be exploited to tackle this problem?

The existing Asian Monsoon Years project (AMY, 2007-2012, www.wcrp-amy.org) should provide a wealth of coordinated observational and modelling (including hindcast) opportunities on a variety of subjects in the Indian Ocean/West Pacific. Ensuring that data from these experiments can be stored and disseminated widely would enhance its usefulness to the community. Studies as part of the Year of Tropical Convection (YOTC) will also facilitate better understanding of tropical multiscale interaction [Moncrieff et al. 2009] as well as modeling studies comparing different resolutions over targeted domains [CASCADE, http://ncas-climate.nerc.ac.uk/Cascade/]. The AAMP is also promoting a Monsoon Intraseasonal Variabitiy Prediction experiment (B. Wang et al.: Multi-Model Ensemble Forecast of the MJO, a Proposal to the NOAA/Climate Program Office Climate Test Bed), which will cover some of the YOTC period and will benefit from broad community involvement (i.e. modeling groups need to contribute their extended range forecasts).

- Moncrieff, M.W., D.E. Waliser, M.A. Shapiro (2009) The multi-scale organization of tropical convection and its interaction with the global circulation: Year of Tropical Convection (YOTC). Bulletin of the American Meteorological Society, (submitted).

Q5 What would best accelerate progress on the topics raised in questions 1-4? Do you have suggestions for new initiatives (new process studies, field campaigns, or new collaborative approaches, eg international Working Groups, Climate Process Teams)?

a) AAMP supports continuation of the successful US CLIVAR MJO Working Group [see doi:10.1175/2008JCLI2731.1] with particular encouragement to include MISO/BSISO variability, design of suitable metrics for testing model perfomance, and to promote modeling workshops. The MJO Task Force needs to engage convection modelers with an interest in the MJO/MISO.

b) A repeated WGNE systematic errors workshop [http://www-pcmdi.llnl.gov/wgne2007/presentations/] with emphasis on tropical/monsoon convection would be desirable.

c) Support and community participation in the Monsoon Intraseasonal Prediction Experiment, which has been proposed as the "Multi-Model Ensemble Forecast of the MJO" to the NOAA/Climate Program Office Climate Test Bed (CTB) Research Program (PI B. Wang et al).

Q6: Any other suggestions/issues to be raised?

N/A

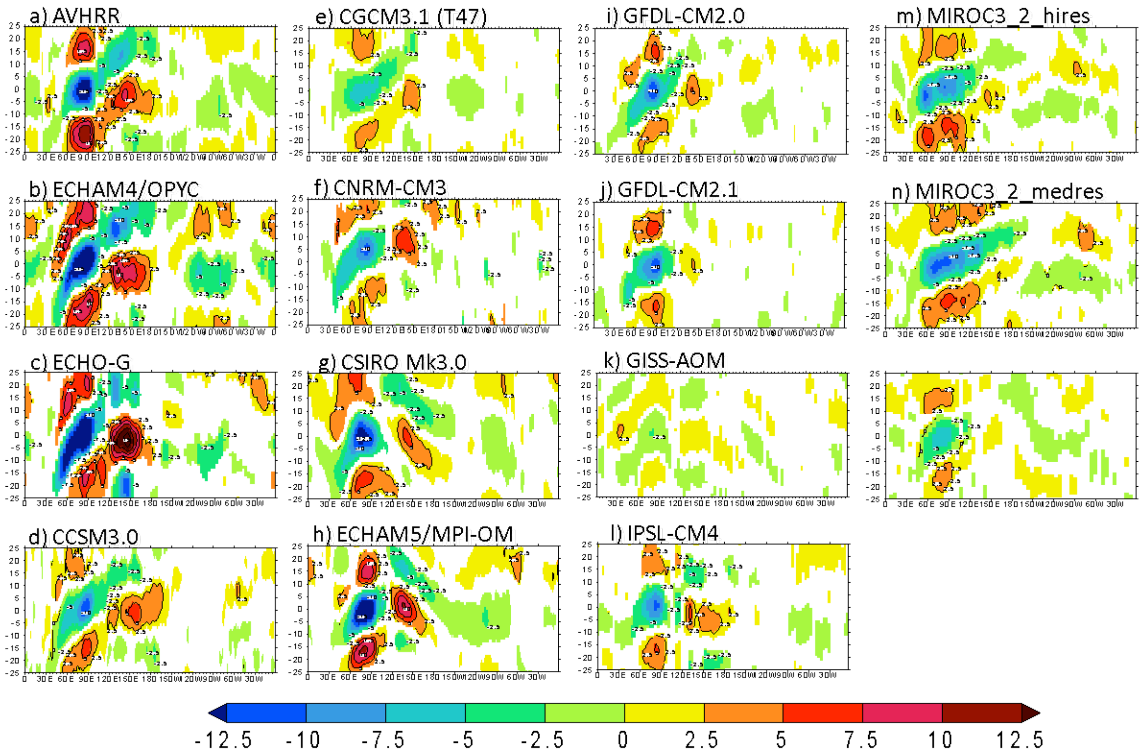

Fig. 1: Eastward propagation of 5^{o}N-5^{o}S averaged 20-100 day bandpass filtered outgoing longwave radiation anomalies for the boreal summer from observations and CMIP3 and CMIP2+ models (after Sperber and Annamalai 2008, Clim, Dyn. 31, 345-372). All models simulate eastward propagation over the Indian Ocean, with most failing to simulate its extension over the western/central Pacific Ocean.