Hindcast Experiment for Intraseasonal Prediction

Draft Plan

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1. Introduction

The Madden-Julian Oscillation (MJO, Madden-Julian 1971, 1994) interacts with, and influences, a wide range of weather and climate phenomena (e.g., monsoons, ENSO, tropical storms, mid-latitude weather), and represents an important, and as yet unexploited, source of predictability at the subseasonal time scale (Waliser et al. 2009). The monsoon ISO (MISO), which is more complex in nature due to interaction between monsoon circulations and MJO, is one of the dominant short-term climate variability in global monsoon system (Webster et al. 1998, Lau and Waliser 2005). The wet and dry spells of the MISO strongly influence extreme hydro-meteorological events, which composed of about 80% of natural disaster, thus the socio-economic activities in the World's most populous monsoon region.

<u>Current Status of dynamical MJO Prediction</u>

About a decade ago, dynamical forecasts of MJO made using the atmospheric-only model of the NCEP reanalysis vintage had a useful skill only up to about 7 days for boreal winter season (Hendon et al. 1999). Dynamical models have improved greatly in the past decade (Sperber and Waliser 2008) and a few models have produced rather credible simulations of MJO, with evidence of useful prediction skill of the principal characteristics of MJO out to a lead-time comparable to empirical-statistical schemes (~ 2 weeks) (Kim et al. 2007; Vitart et al. 2008). Air-sea coupling can further extend the MJO predictability by up to a week (Fu et al. 2007; Woolnough et al. 2007).

The multi-model ensemble (MME) approach has proven to be one of the most effective ways to improve seasonal prediction by reducing model errors and better quantifying forecast uncertainties (Krishnamurti et al. 1999; Doblas-Reyes et al. 2000; Shukla et al. 2000; Palmer 2000, Wang et al. 2009). Give the recent growth in interest and expected benefits in MJO prediction; it is of great importance to develop the MME techniques for the ISO prediction. However, it has not been addressed to what extent the MME approach can improve the skill of MJO prediction.

The US CLIVAR MJO Working Group (hereafter MJOWG) has fostered the development of a multi-institution/model operational MJO prediction framework anchored at the National center for Environmental Prediction (NCEP). The MJOWG has also denveloped a set of diagnostics for evaluating model simulations of the MJO (Waliser et al. 2009). Despite the significant societal and environmental demands for accurate prediction of MJO/MISO and notable improvements in our ability to predict the MJO over the past decade, operational prediction of MJO is still in its infancy and its achievement seen as a great challenge faced by operational weather forecast centers.

<u>Need For a coordinated multi-model ISO hindcast experiment</u>

While the establishment of the MJO forecast metric and the coordination of operational forecast activity is a great advance, there is an outstanding challenge and urgent need to exploit these efforts to full potential and produce an MME forecast. However, underlying the development of an MME is the intrinsic need for lead-dependent model climatologies (i.e. multi-decade hindcast data sets) to properly quantify and combine the independent skill of each model as a function of lead-time and season. Thus, there is a great demand for both MME work and the associated hindcast data for its development (e.g., Sperber and Waliser 2008).

Programmatic background

Determination of ISO predictability in the current AOGCMs is a pressing need for WCRP Cross-cutting monsoon research. The MISO forecast is one of the major concerns of APEC Climate Center (APCC) and the Asian Monsoon Years (2007-2011). Launching a coordinated ISO hindcast experiment has been strongly endorsed and supported by APCC, CLIVAR/AAMP, and the SSC of AMY (2007-2011), and echoed by WCRP/International Monsoon Study (IMS).

This plan is a result of discussions among a group of scientists who have participated in APCC/ Climate Prediction and Application to Society (CliPAS) and MJOWG. The plan seeks to gain the involvement of a broad community of modeling and prediction centers in an activity to compare numerical model retrospective forecasts of the Intraseasonal Oscillation (ISO), which include both MJO and MISO.

Objectives

1) Understanding of the physical basis for intraseasonal prediction. Determine potential and practical predictability of ISO in a multi-model frame work.
2) Developing optimal strategies for multi-model ensemble (MME) ISO prediction system, including effective initialization schemes and quantification of the MME's ISO prediction skills with forecast metrics under operational conditions.
3) Revealing new physical mechanisms associated with intraseasonal variability that cannot be obtained from analyses of a single model.
4) Identifying model deficiencies in predicting ISO and finding ways to improve models' convective and other physical parameterizations relevant to the ISO through development of model process diagnostics.
5) Help to determine ISO's modulation of extreme hydrological events and its interannual variability and contribution to interannual climate variation.

2. Numerical Experiments

Two experiments are designed: Free simulation and hindcast experiment. There is no restriction as to the types of GCM. Although AOGCMs are preferable, AGCM alone is also acceptable. There is no uniform specification regarding model initialization procedures and initial conditions. The state-of-the-art empirical-statistical forecast models will be used for comparison with dynamical models' performance and skills.

Exp 1: Control simulation

The current GCMs exhibit considerable shortcomings in representing MJO, especially MISO due partly to enormous uncertainties inherent in models' physical parameterizations. Conclusions regarding a particular mechanism that is derived based on a single model are often model-dependent and inconclusive. A long simulation allows us to better understand the dependence of the prediction on initial conditions and better define metrics that measure the "drift" of the model toward their intrinsic MJO/MISO modes. For these reasons, a free run (without impacts of initial conditions) will serve as a control experiment. Free coupled runs with AOGCMs or AGCM simulation with specified boundary forcing (e.g., observed SST and Sea ice distribution) are requested for at least 20 years. The period for the forced AGCM run should be consistent with the hindcast period (see below).

Exp 2: ISO hindcast

This experiment requires a set of retrospective ISO forecasts, which covers the last 20 years from 1989 to 2008. The minimum (standard) specifications of the hindcast are: (a) Prediction is initiated every 10 days (before and up to 1^{st}, 11^{th}, and 21^{st} of each calendar month) throughout the entire 20-year period; (b) Integration length for each forecast is 45 days; (c) The ensemble size for each forecast is 5.

3. Requested output data and information

a. Model description and climatology

A concise model description includes model name, characteristics (parameterization scheme etc.), ensemble size, horizontal and vertical resolution, initial conditions and initialization scheme.

Climatological information includes (1) long-term daily mean annual cycle of precipitation, OLR, 850 hPa winds, surface winds and sea-level pressure, and (2) long-term three-hourly mean diurnal cycle of precipitation in global tropics between 30^{o}S and 30^{o}N.

b. Outputs from control simulation and hindcast experiment

The hindcast dataset provides means to determine the predictability and prediction skill of ISO and its seasonal, interannual and MJO life-cycle phase dependencies. To reach this goal, we propose the following output list for further discussion:

Standard atmospheric output variables (daily mean)**:** total precipitation rate (preferably, the convective and stratiform separately), OLR, geopotential, horizontal wind fields (u and v) at 850, 500, and 200 mb, surface (2m) air temperature, SST, mean sea level pressure, surface heat fluxes (latent, sensible, solar and longwave radiation) and surface wind stress, and humidity and temperature at standard levels.

Upper Ocean output variables (daily mean): temperature, salinity, and ocean currents (U and v), and vertical motion from surface to 300m,

c. Recommended data formats

Resolution: 2.5x2.5 degree interval over global domain (144x73 grids)
Writing order: Eastward from 0^o to 2.5^{o}W, southward from 90^{o}N to 90^{o}S
Writing format: Any readable format is OK. But, GRIB format (including data control file, such as *.ctl) is highly recommended.

4. Participating modeling Group

The following groups (with contact persons) have expressed interest to participate the coordinated hindcast at this moment and the planned experiments invite any interested modeling group or operation centers to join.

BMRC: Harry Hendon
COLA and UM: J. B. Kirtman, J. Shukla
ECMWF: F. Molteni
GFDL: W. Stern
IAP/LASG: T. Zhou, B. Wang
JAMSTEC/FRCGC: T. Yamagata, J.-J. Luo
NASA/GMAO: S. Schubert
NCEP/CPC: A. Kumar, J. E. Schemm
SNU: I.-S. Kang
UH/IPRC: B. Wang, J.-Y. Lee, X. Fu

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