Potential Predictability of the Madden Julian Oscillations (MJO) in the ISVHE multi-model framework

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and Participating modeling groups

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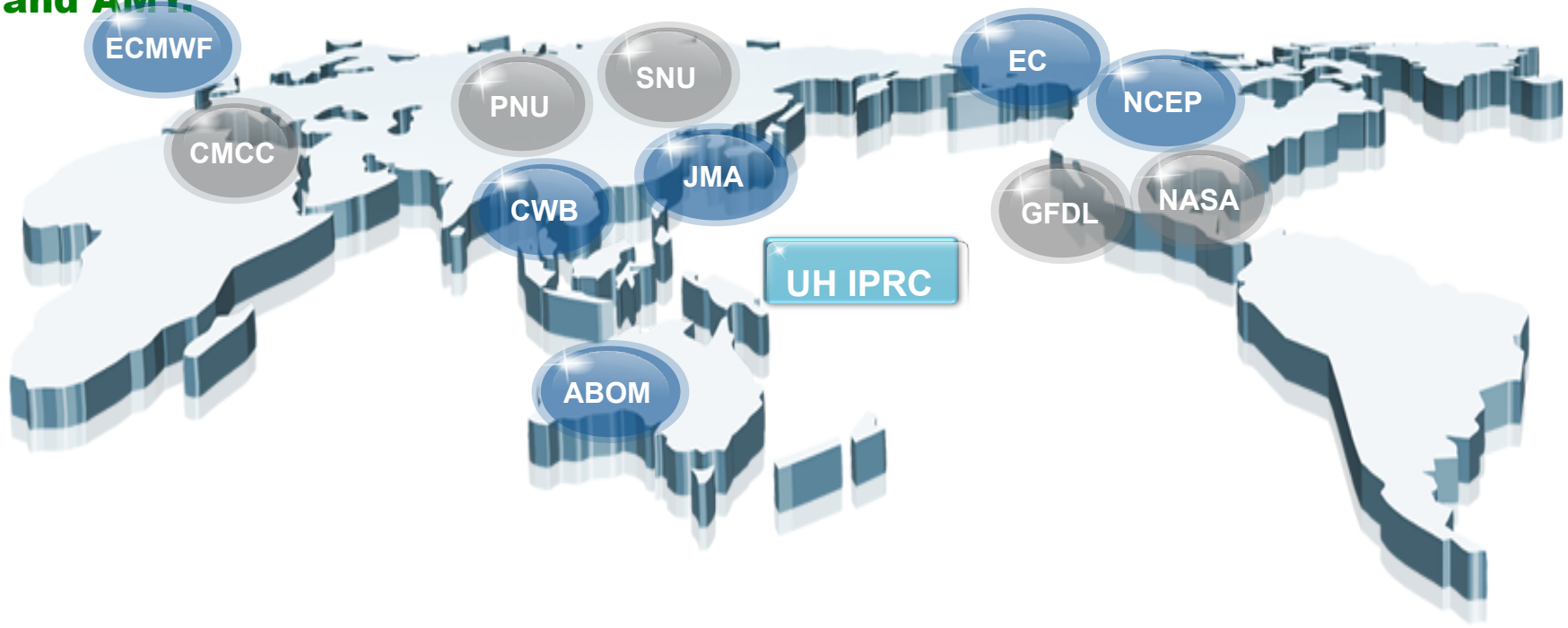
CLIVAR/ISVHE

ISVHE

Intraseasonal Variability Hindcast Experiment

The **ISVHE** is the **FIRST/BEST** coordinated multi-institutional ISV hindcast experiment supported by **APCC, NOAA CTB, CLIVAR/AAMP & MJO WG/TF, and AMY.**



Supporters

APEC Climate Center

NOAA CLIMATE TEST BED

U.S. CLIVAR Climate Variability & Predictability

Asian Monsoon Years (AMY 2007-2012)

iprc INTERNATIONAL PACIFIC RESEARCH CENTER

CTB

Additional support provided to this work by

ONR Science & Technology

Numerical Designs and Objectives

Control Run

Free coupled runs with AOGCMs or **AGCM simulation** with specified boundary forcing for at least 20 years

Daily or 6-hourly output

ISV Hindcast EXP

ISV hindcast initiated **every 10 days** on 1st, 11th, and 21st of each calendar month for at least **45 days** with more than **6 ensemble members from 1989 to 2008**

Daily or 6-hourly output

YOTC EXP

Additional ISO hindcast EXP **from May 2008 to Sep 2009**

6-hourly output

- Better understand the physical basis for ISV prediction develop optimal strategies for multi-model ensemble ISV.
- Identify model deficiencies in predicting ISV and find ways to improve models' convective and other physical parameterization.
- Determine ISV's modulation of extreme hydrological events and its contribution to seasonal and interannual climate variation.
- Determine the potential and practical predictability of MJO in a multi-model frame work.

Presentation Objectives

Primary Objective

- Present Estimates of MJO Predictability
  - ✓ *Employ better & more models*
  - ✓ *Use community standard (WH'04) MJO index*
  - ✓ *Consider ensemble as a "better" MJO model*

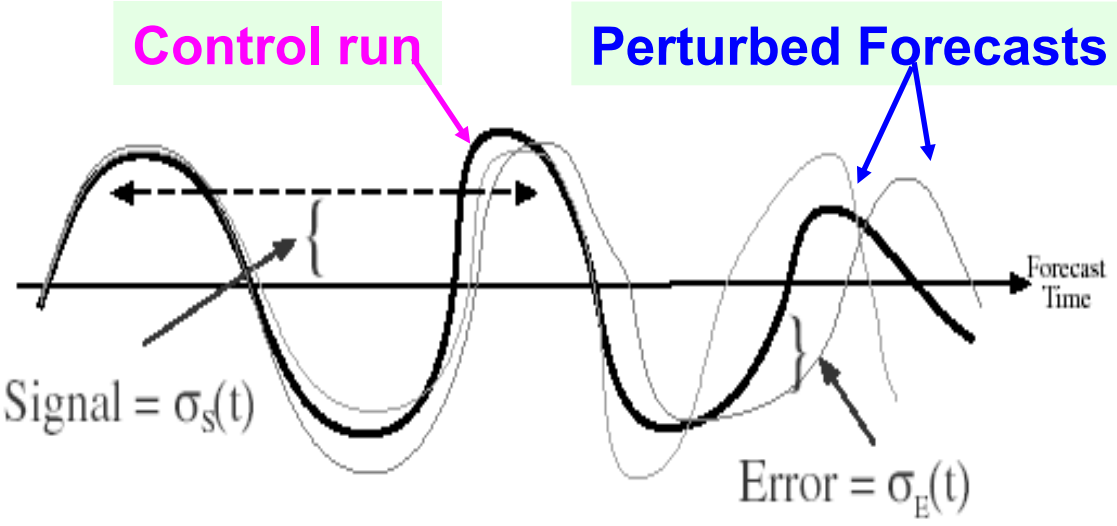
Revisit e.g.
Waliser et al. (2003),
Fu et al. (2007),
Pegion and Kirtman (2008)

Secondary Objectives

- *Quantify gap between predictability and prediction skill*
- *Examine "ensemble fidelity" on enhancement of prediction skill*

Definitions:
Predictability – characteristic of a natural phenomena – often estimated with models
Prediction skill – characteristic of a model and its forecast fidelity against observations
Ensemble - only refers to single model's ensemble of forecasts – not MME

Signal to Error ratio estimate of MJO/ISV predictability



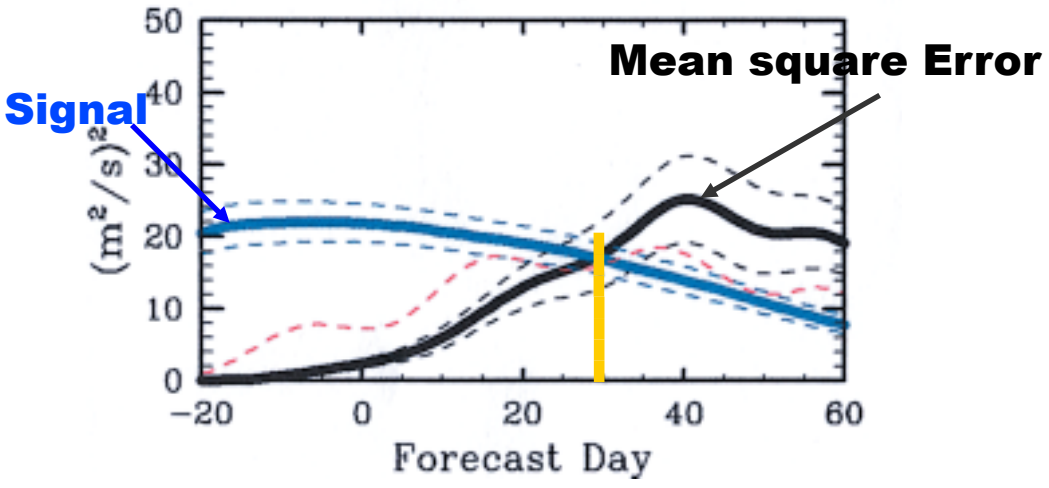
Initial Condition Differences Based On Forecasts 1 Day Apart

Signal (L=25 days)

$$\sigma^2_{S_{ij}} = \frac{1}{2L+1}\sum_{\tau=-L}^{L}(X^0_{i,j+\tau})^2$$

Error

$$\sigma^2_{E_{ijk}} = (X^k_{ij} - X^0_{ij})^2$$



As in
Waliser et al. (2003, 2004);
Liess et al. (2005); Fu et al. (2007)
Except using a combined RMM1 & RMM2 index

Bivariate estimates of Signal and Error

$$E^2_{ij} = \left(RMM1^{kl}_{ij} - RMM1^{k2}_{ij}\right)^2 + \left(RMM2^{kl}_{ij} - RMM2^{k2}_{ij}\right)^2$$

$$S^2_{ijk} = 1/51 \times \sum_{t=-L}^{L}\left(RMM1_{ikj+t}\right)^2 + \left(RMM2_{ikj+t}\right)^2$$

MJO Predictability & Prediction Skill Estimates

Single Member Approach

Error -- Difference between hindcast combined RMM1 and RMM2 values for two ensemble members.

Ensemble Mean Approach

Error -- Difference between hindcast combined RMM1 and RMM2 values for an individual ensemble member and the ensemble mean of all other members.

Comparison Provides

Prediction Skill

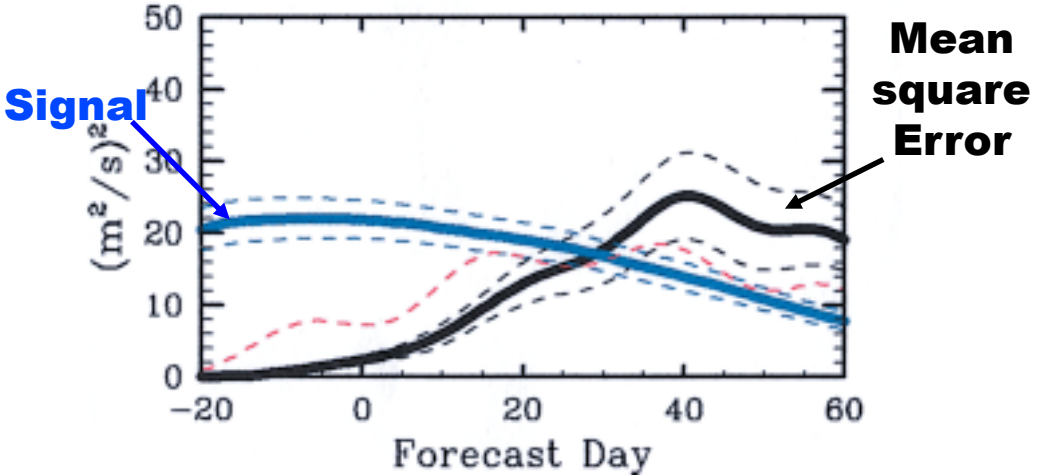
A measure of the enhanced skill provided by the given center's/model's ensemble

Predictability

An improved(?) estimate based on a "better" MJO/ISV forecast "model"

Error $\sigma^2_{E_{ijk}} = (X^k_{ij} - X^0_{ij})^2$

X^0_{ij} =
- Predictability = Model Control
- Prediction Skill = Observations

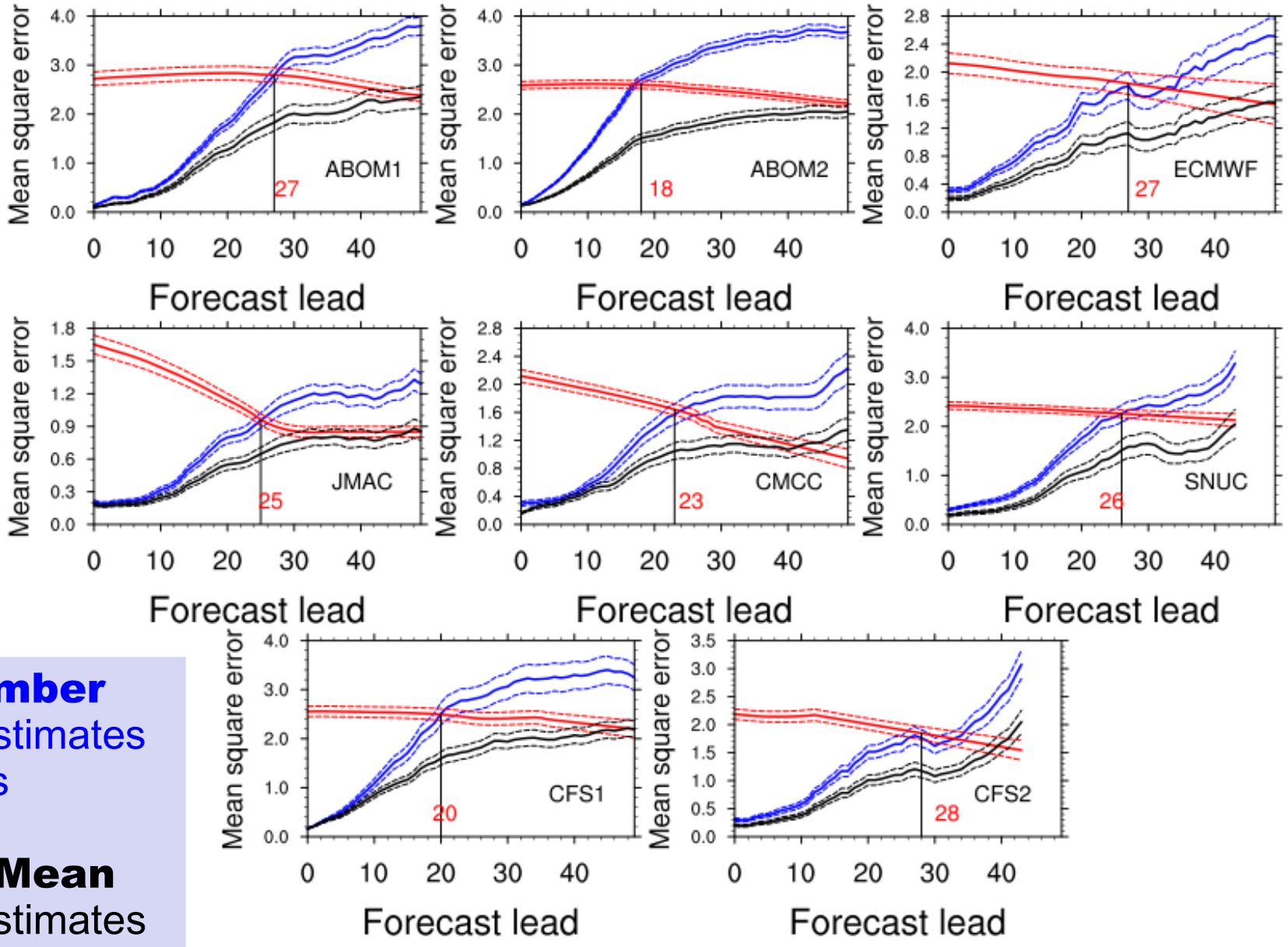


Description of Models and Experiments

One-Tier System

	Model	ISO Hindcast		
		Period	Ens No	Initial Condition
ABOM1	POAMA 1.5 & 2.4 (ACOM2+BAM3)	1980-2006	10	The first day of every month
ABOM2	POAMA 2.4 (ACOM2+BAM3)	1989-2009	11	The 1st and 11th day of every month
ECMWF	ECMWF (IFS+HOPE)	1989-2008	5	The first day of every month
CMCC	CMCC (ECHAM5+OPA8.2)	1989-2007	5	The 1st 11th and 21st day of every month
JMA	JMA CGCM	1989-2008	5	Every 15th day
NCEP/CPC	CFS v1 (GFS+MOM3)	1981-2008	5	The 2nd 12th and 22nd day of every month
NCEP/CPC	CFS v2	1999-2010	5	The 1st 11th and 21st day of every month
SNU	SNU CM (SNUAGCM+MOM3)	1990-2008	4	The 1st 11th and 21st day of every month

MJO Predictability in the ISVHE models



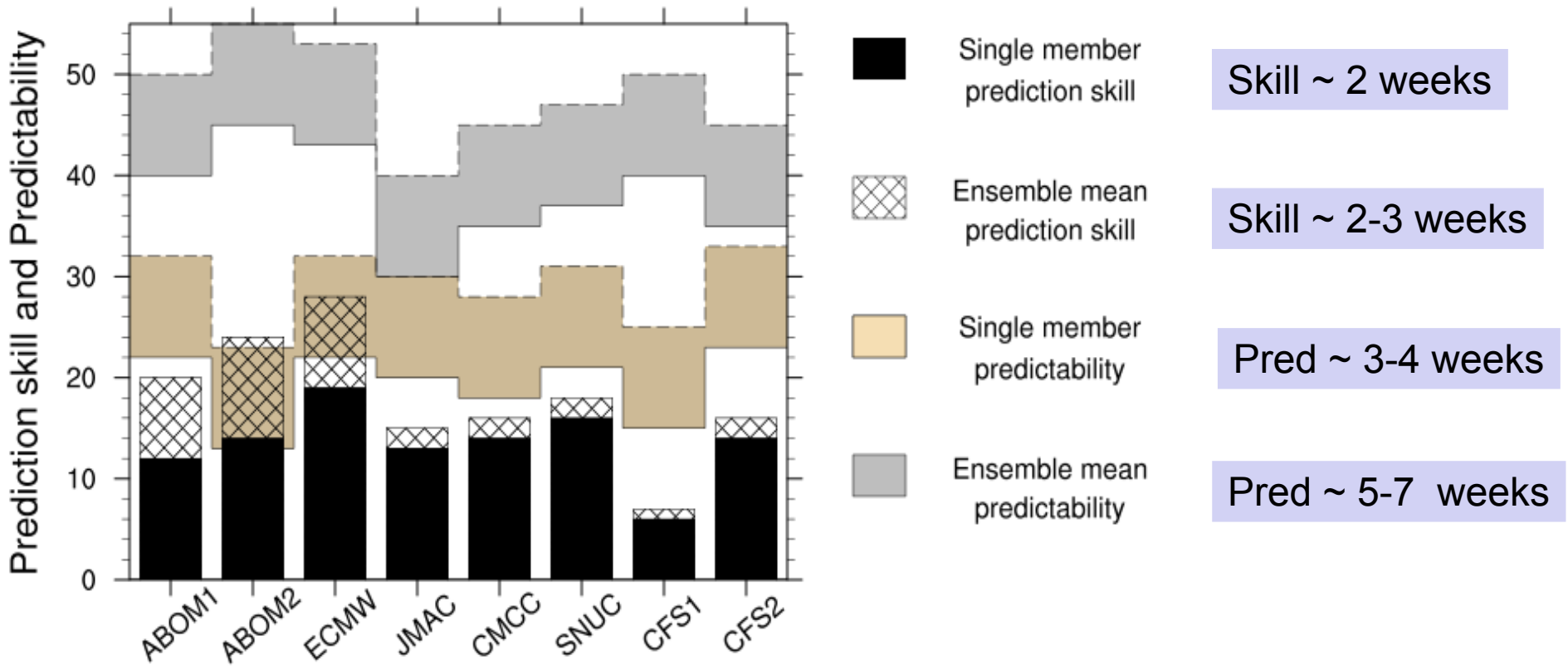
Single Member
predictability estimates
24 days

Ensemble Mean
predictability estimates
43 days

Signal- Red curve
Single member error- Blue curve
Ensemble mean error-Black

MJO prediction vs predictability----Where do we stand?

* Predictability estimates are shown as +/- 5 day range



- Significant skill remaining to be exploited by improving MJO forecast systems *(e.g. ICs, data assimilation, model fidelity)*

- High-quality ensemble prediction systems crucial for MJO forecasting.

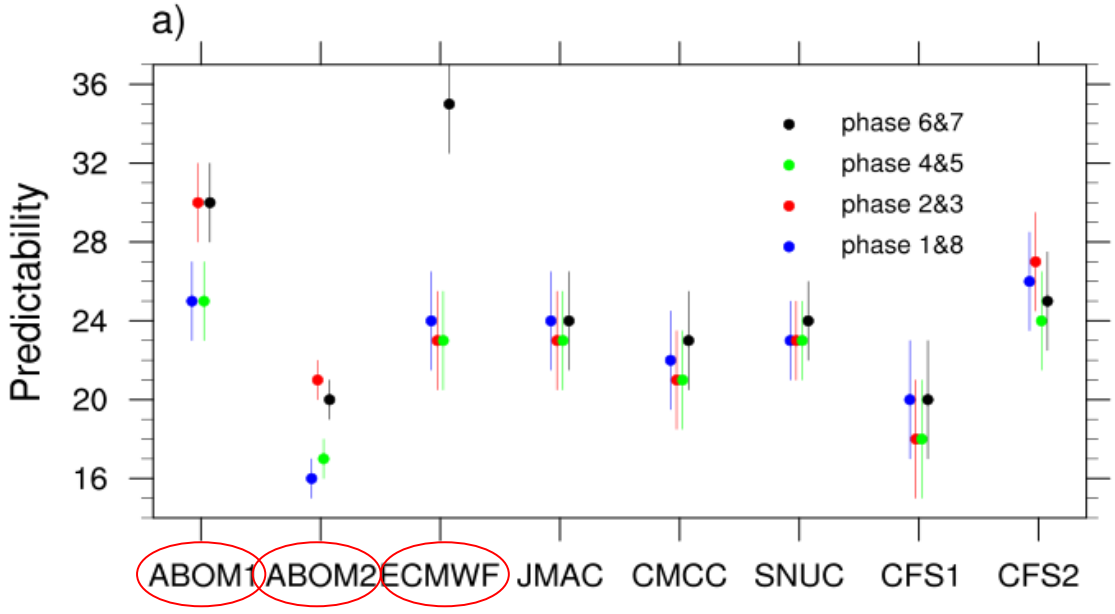
Predictability dependence on MJO phase and Primary/Secondary

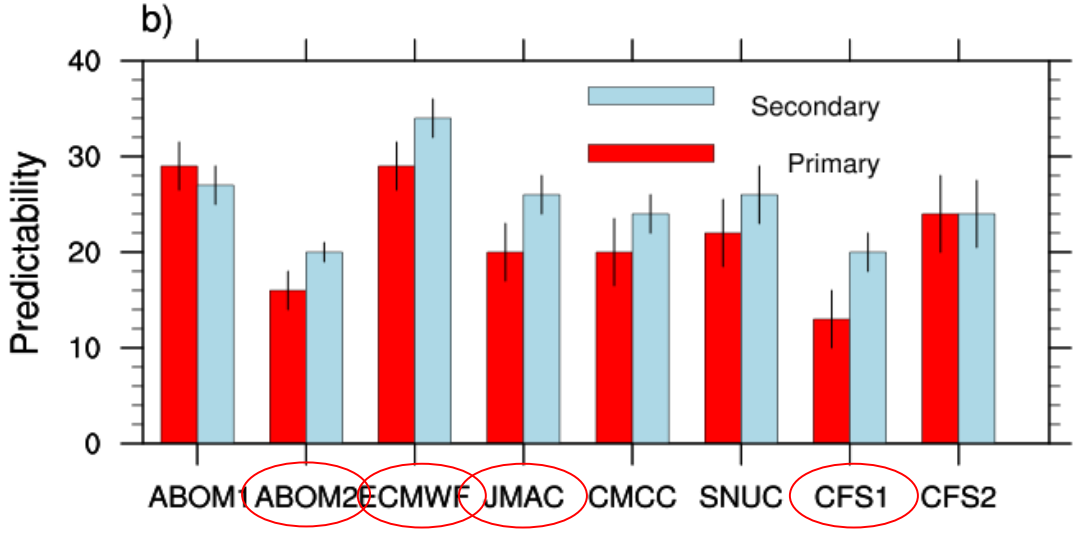
a) Hindcasts are grouped according to the RMM phase during hindcast initiation
b) Hindcasts are grouped into those associated with primary/secondary MJO events using the RMM index based classification of Straub (2012)

Only 3 (of 8) models exhibit predictability phase dependence (ABOM1, ABOM2,ECMWF)

-> E. Hemisphere convection more predictable (e.g. Phases 2,3,6,7)

Hindcasts initiated from secondary MJO events indicate (~5 days) greater predictability than those from primary events in 4 (of 8) models. (ABOM2, ECMWF, JMAC,CFS1)



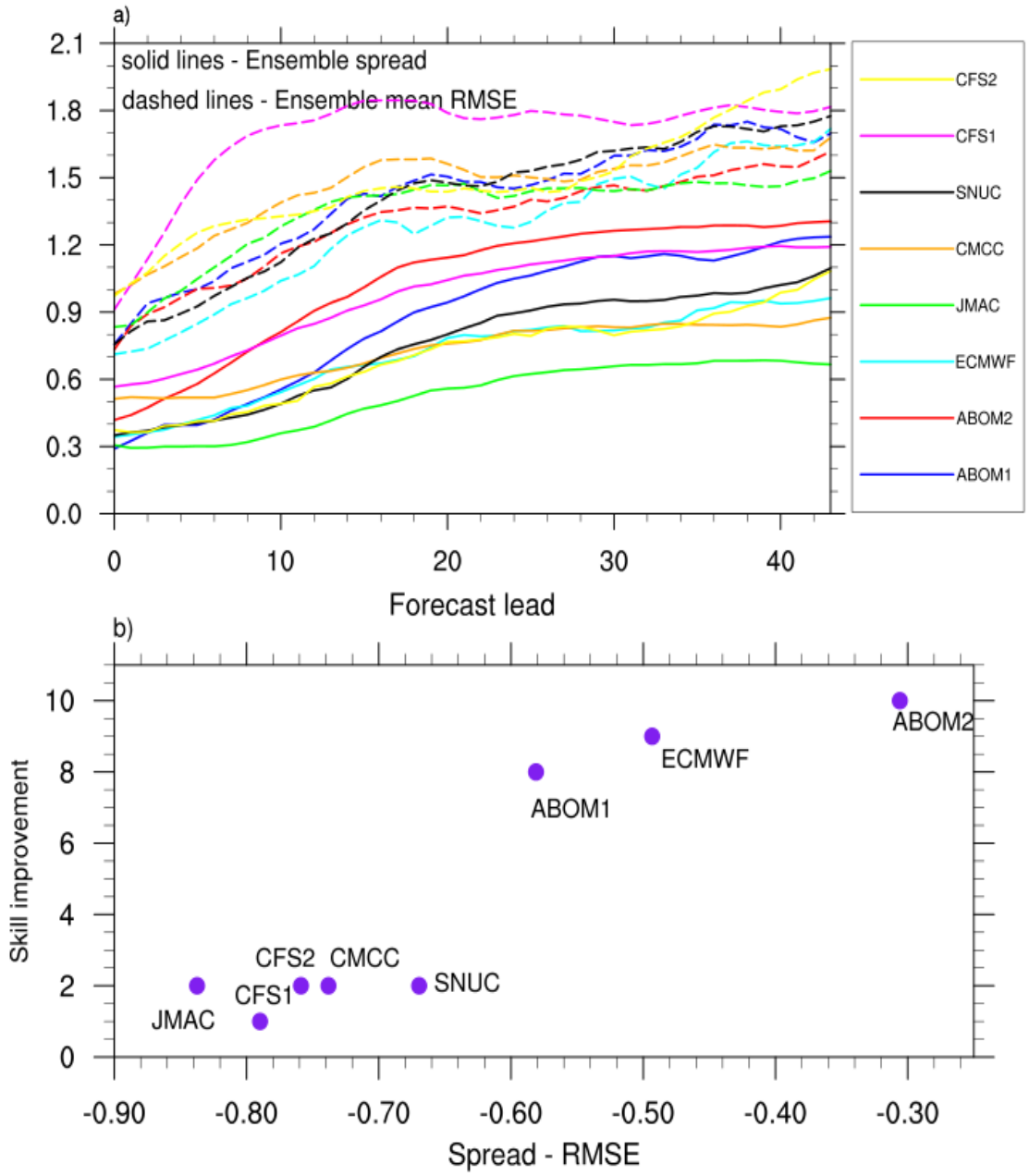


Ensemble fidelity and improvement in prediction skill for MJO

In a statistically consistent ensemble, the RMS forecast error of the ensemble mean (dashed) should match the standard deviation of the ensemble members (ensemble spread) (solid).

Ensemble Fidelity – measures the level of dispersion for MJO
-average difference between the solid and dashed curves over the first 25 days hindcast

Prediction systems with greater level of dispersion for MJO show more improvement in the ensemble mean prediction skill over the individual ensemble member hindcast skill!



Summary

The predictability of winter MJO is investigated in the ISVHE hindcasts of eight coupled models.

- Predictability estimates are made for the individual ensemble member hindcast as well as for the ensemble mean hindcasts.
- Most models show a 20-30 day predictability for indiviual ensemble member hindcasts while the ensemble mean hindcasts show a 40-50 day predictability.
- The predictability of MJO is not very sensitive on the MJO phase at the time of hindcast initiation. Three of the eight models show a higher predictability for MJO phases over the Indian Ocean and Western Pacific .
- Present day MJO prediction capabilities can be extended further by at least one week for individual ensemble forecasts in most models. Ensemble mean prediction skill improvement holds more promise.
- In addition to improving the dynamic models, devising ensemble generation approaches tailored for the MJO would have a great impact on MJO prediction.

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THANK YOU !!!