Assessing the Impact of Ocean In-situ Observations on MJO Propagation across the Maritime Continent in ECMWF Subseasonal Forecasts

OceanPredict — Advancing the science of ocean prediction

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Abstract

By analyzing the ECMWF subseasonal forecasts, we find that the ocean initialization with in-situ data assimilation does not improve the relatively low MJO forecast skill across the Maritime Continent. Moist Static Energy budget analysis further suggests that the atmospheric circulation bias is one of the major sources of the MJO prediction error, and should be a target for improving the ECMWF subseasonal forecast model.

Subseasonal Forecasts

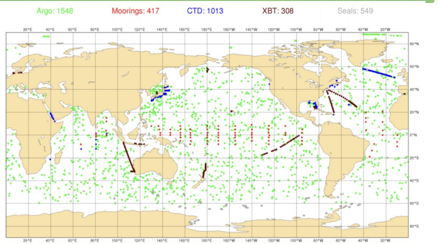
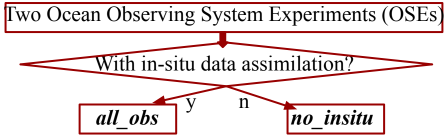


Fig 1. Ocean in-situ observations (Zuo et al., ECMWF Tech Memo., 2015)



all_obs and *no_insitu* are coupled subseasonal forecasts (model cycle 47R1).

Methods

Use RMMI-based method and OLRa-based method to compare the number of successfully forecasted MJO events that can propagate across the MC (MJO_P) in *all_obs* and *no_insitu*.

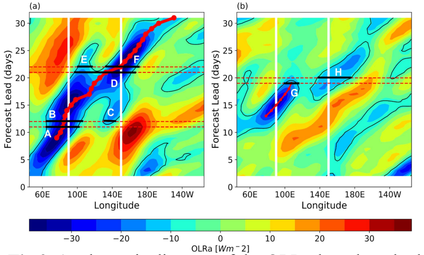


Fig 2. A schematic diagram of the OLRa-based method. (a) an MJO_P event; (b) not an MJO_P event.

Results Part 1: MJO_P events

Table 1. Results from OLRa-based method

	MJO_P	MJO_P in OBS	MJO_IO (RMMI-based)	MJO_IO_P	Passing rate
OBS	**79**	79	44	22	**0.50**
all_obs	**70**	**35**	45	12	**0.27**
	[70,65,65,69,68]	[30,25,33,27,29]	[45,45,45,44,45]	[15,7,11,10,14]	[0.25]
no_insitu	**68**	**37**	45	13	**0.29**
	[76,69,58,75,62]	[35,26,21,32,32]	[45,45,45,44,45]	[13,10,8,16,13]	[0.27]

- numbers in the bracket are for the individual ensemble members.

The passing rate is much lower in the model forecasts than in the observation; There is no improvement with ocean in-situ data assimilation; Both *all_obs* and *no_insitu* produce fake MJO_P events; RMMI-based method yields similar results.

Results Part 2: MSE budget analysis

$$\left\{\frac{\partial m}{\partial t}\right\}' = -\left\{u\frac{\partial m}{\partial x}\right\}' - \left\{v\frac{\partial m}{\partial y}\right\}' - \left\{\omega\frac{\partial m}{\partial p}\right\}' + LH' + SH' + \{LW\}' + \{SW\}'$$

$$m = C_pT + gZ + L_vq$$

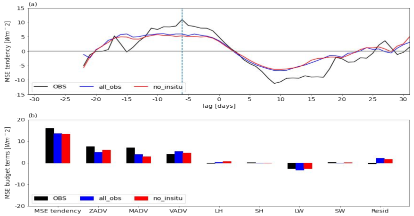


Fig 3. (a) MSE tendency over the eastern MC region (130E-150E, 15S-15N). (b) Composite mean of each individual MSE budget term.

all_obs and *no_insitu* closely follow each other in the MSE budget analysis;

The MSE tendency is positive before the arrival of MJO active convection and is negative after the arrival, consistent with moisture charge/discharge;

There exists a robust underestimation of the meridional advection in both *all_obs* and *no_insitu*.

Decompose the meridional advection term into the following format. The differences between the model forecasts and the observation are rooted in 3 terms.

$$-v_i\frac{\partial Q_i}{\partial y} = -(v_{obs}+v_i^*)\frac{\partial (Q_{obs}+Q_i^*)}{\partial y} = -v_{obs}\frac{\partial Q_{obs}}{\partial y} - v_{obs}\frac{\partial Q_i^*}{\partial y} - v_i^*\frac{\partial Q_{obs}}{\partial y} - v_i^*\frac{\partial Q_i^*}{\partial y}$$

$$T_{1i} = -v_{obs}\frac{\partial Q_i^*}{\partial y}$$

$$T_{2i} = -v_i^*\frac{\partial Q_{obs}}{\partial y}$$

$$T_{3i} = -v_i^*\frac{\partial Q_i^*}{\partial y}$$

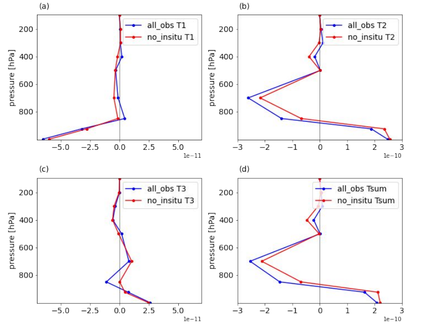


Fig 4. The vertical profile of T1, T2, T3 terms and their sum for *all_obs* and *no_insitu*. Note that the x axis for (b) and (d) is one order of magnitude greater than that for (a) and (c).

T1: observed winds advecting the moisture biases

T2: wind biases advecting the observed moisture

T3: wind biases advecting the moisture biases

Fig. 4 shows that it is **T2** that dominates the total underestimation in the meridional advection.

Why? Because the meridional wind biases are of the same magnitude of the observed meridional winds.

Summary and Conclusions

* Ocean initialization with subsurface observation assimilation does not have an impact on predicting the MJO propagation over the MC.

* The ECMWF subseasonal forecast model underestimates the meridional advection in the MSE accumulation phase. The intraseasonal wind biases are more responsible for such underestimation compared to the mean state dry biases.