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The Effect of the Mean Bias Removal on MJO Forecast Skill

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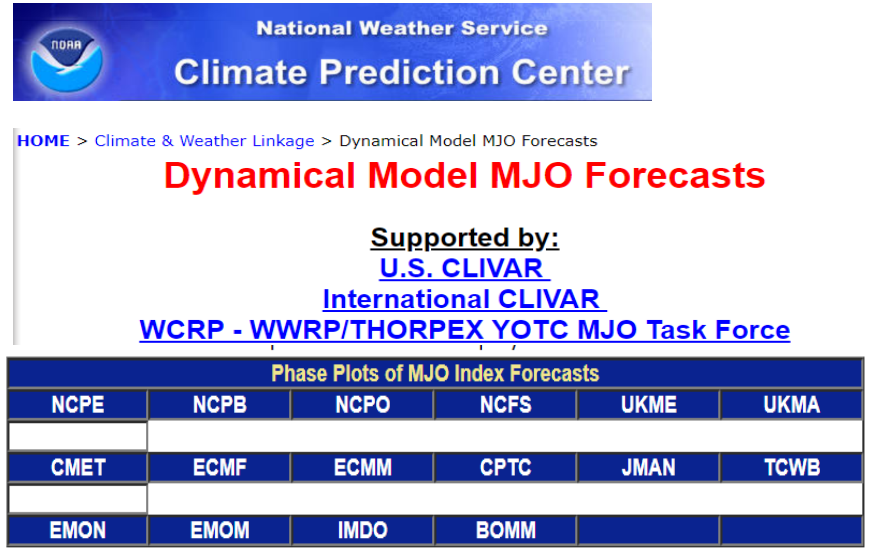
Motivated by
using the operational MJO forecasts



Acknowledgement : CPC Monsoon Desk Program

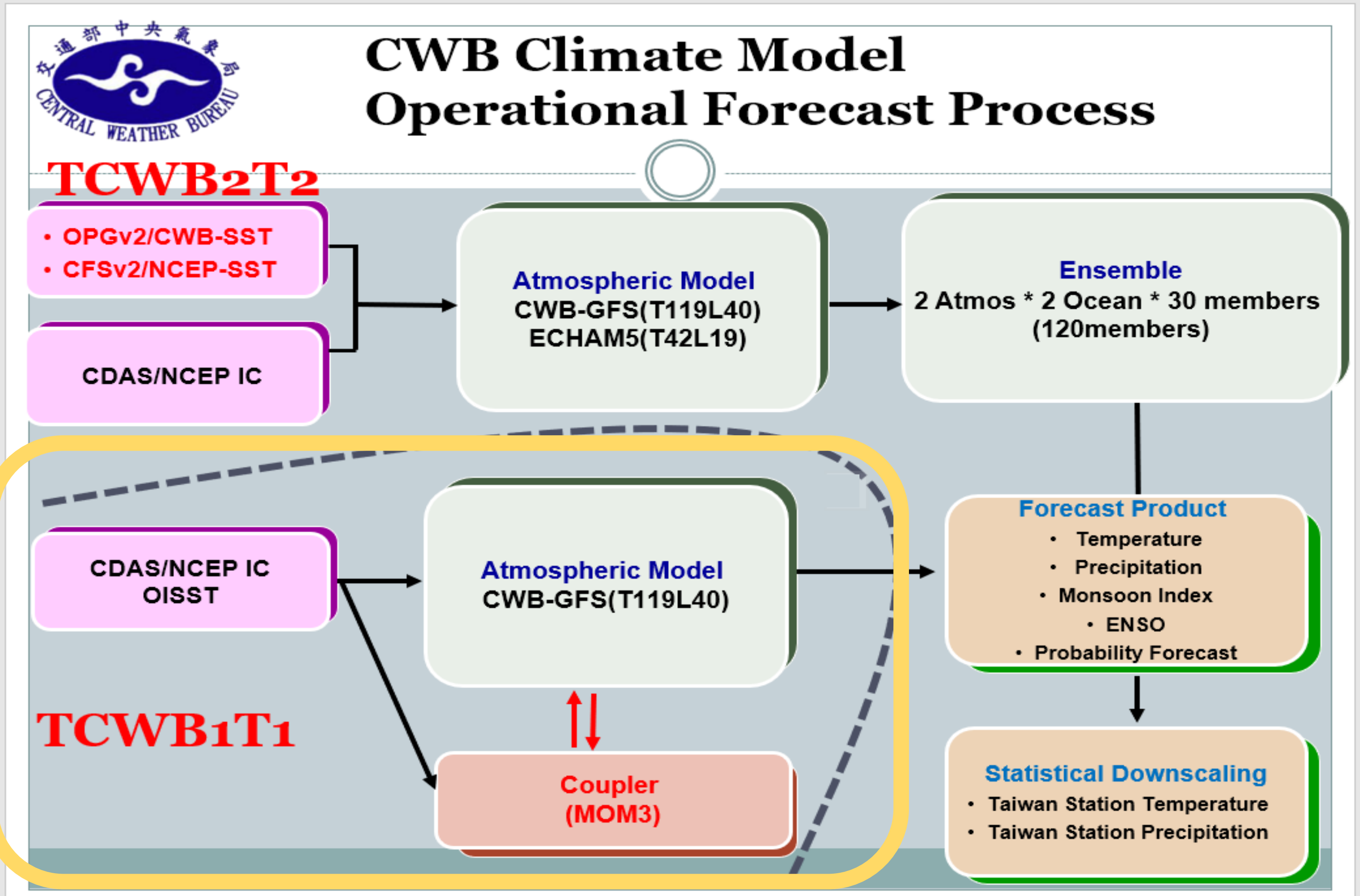
Taiwan Weather Bureau has coupled models for S2S forecasts

This work used CWB 1-tier model to discuss the effect of the bias removal on MJO forecasts.

CWB 2-Tier model
(CWBT2)

CWB 1-Tier model
(CWBT1)

A : CWBGFS
O : MOM3



(Provided by Dr. C. T. Lee,CWB)

CWB short-term climate models have provided guides for supporting Taiwan month/seasonal forecasts services for years.

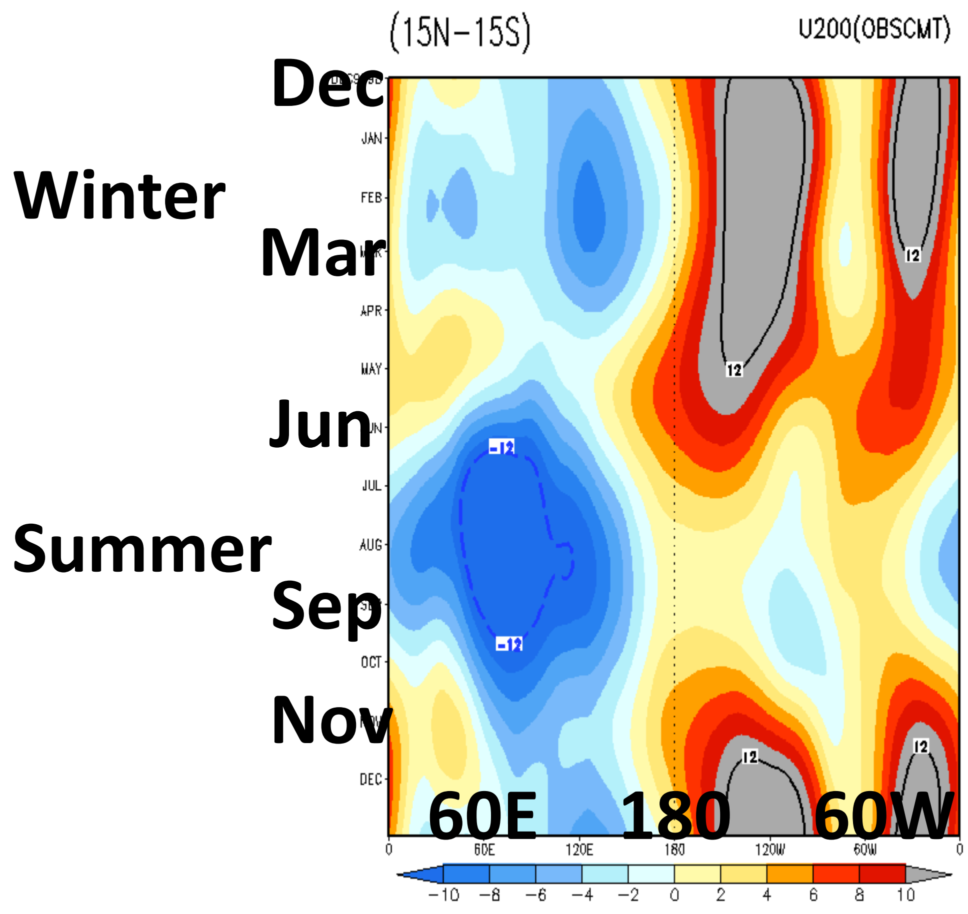
More about CWBT1 : Poster #60 : Wu et al. Taiwan CWB 1-Tier model : Hindcast Analysis and Forecast Verification

Take **U200(15N-15S)** for example :

A look at CWB1T model climatology

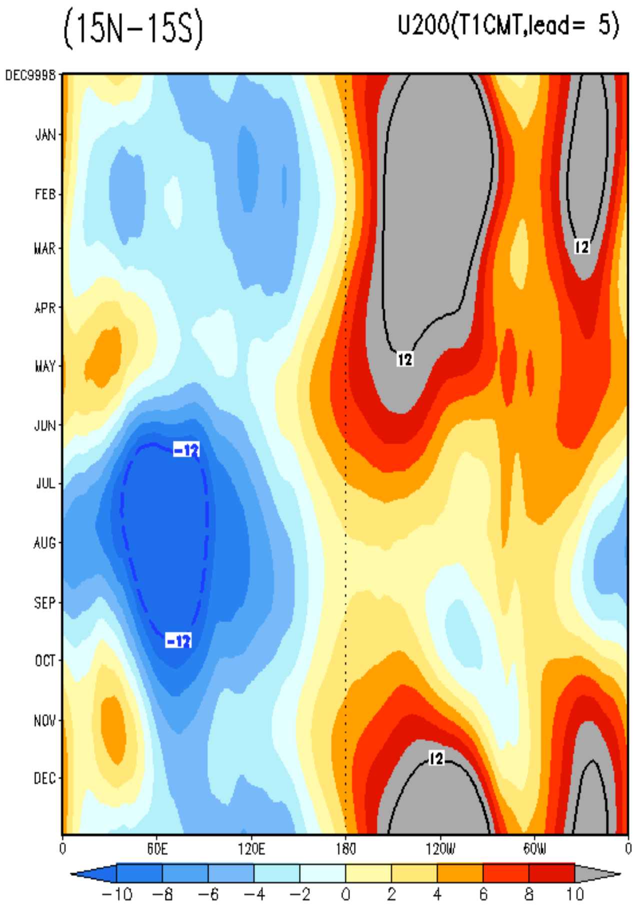
Based on 2001-2017

O_climatology(t)

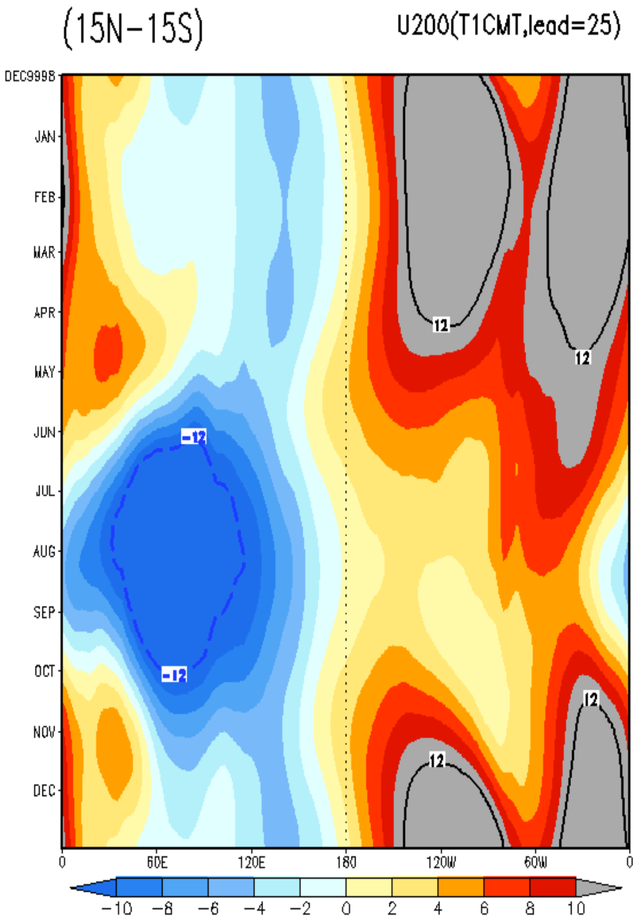


M_climatology (t, lead)

Lead = 5day



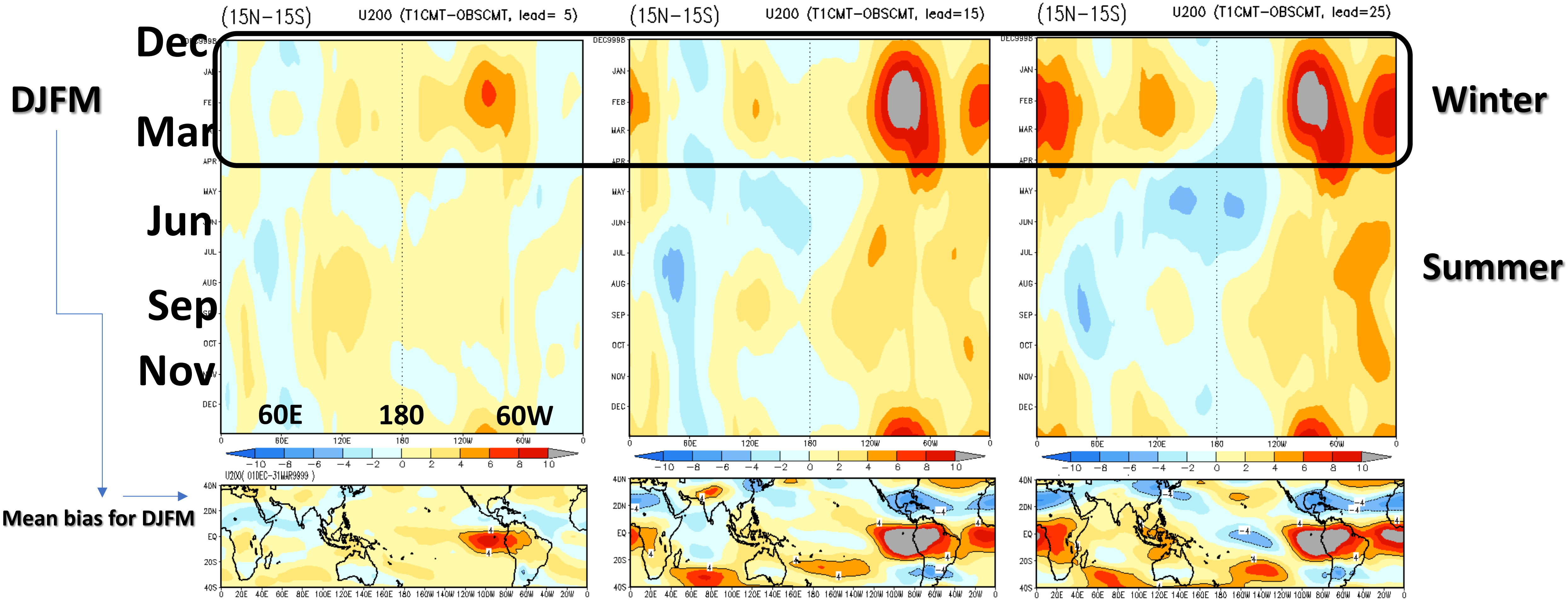
Lead = 25day



Model : CWB 1-Tier

Model bias(t, lead) = M_climatology(t,lead) – O_climatology(t)

Lead = 5d **Lead = 15d** **Lead = 25d**



Model mean bias could change with season and grow with the lead time

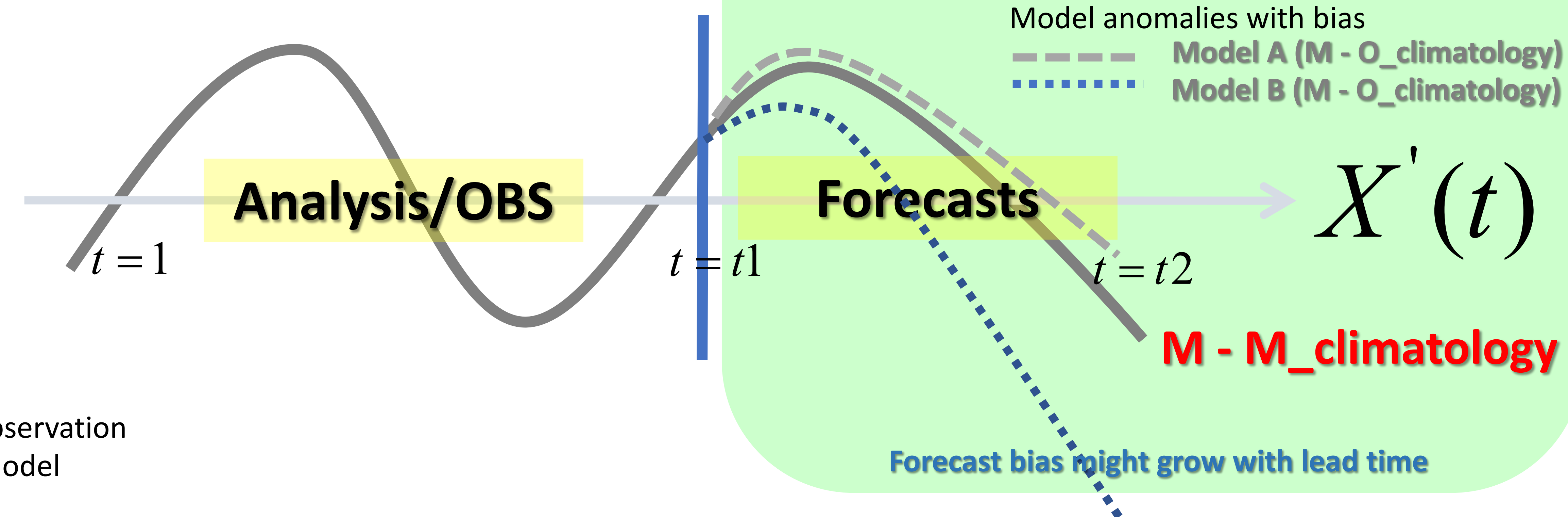
It's about the anomalies when comes to model forecasts.

O_anomaly

= O - O_climatology(t)

M_anomaly with bias removal

= M(t,lead) - M_climatology(t,lead)



O : observation
M : model

Bias removal needs model climatology.

But sometime we just have the forecasts but without the model climatology…….

http://www.cpc.ncep.noaa.gov/products/precip/CWlink/MJO/CLIVAR/clivar_wh.shtml

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Climate Prediction Center

HOME > Climate & Weather Linkage > Dynamical Model MJO Forecasts

Dynamical Model MJO Forecasts

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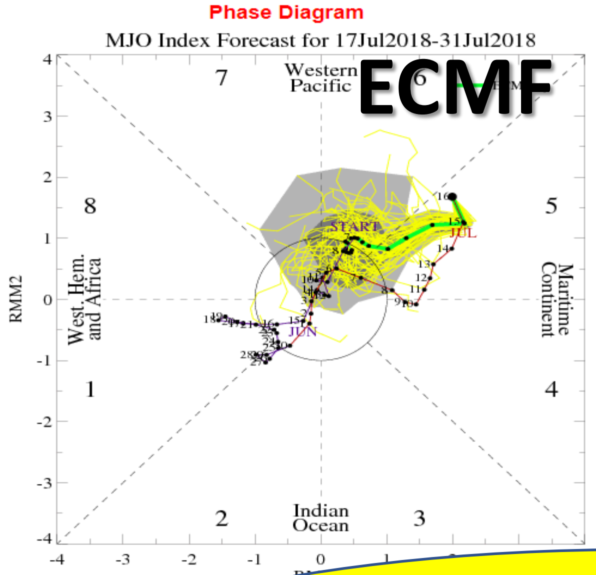
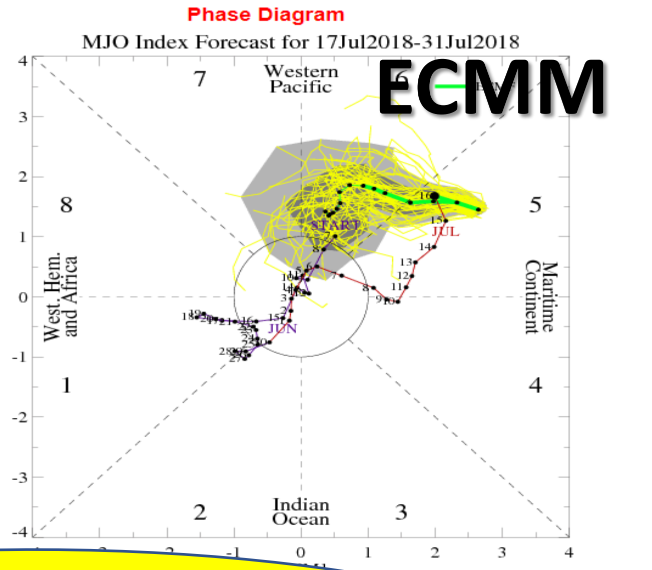
Phase Plots of MJO Index Forecasts					
NCPE	NCPB	NCPO	NCFS	UKME	UKMA
CMET	ECMF	ECMM	CPTC	JMAN	TCWB
EMON	EMOM	IMDO	BOMM		

M_Anomaly = **M – O_climatology**
(with model bias)

M_Anomaly = **M – M_climatology**





: **Bias corrected forecasts**
NCPB/ECMM/EMOM/BOMM

Others : No bias corrected forecasts
NCPE, ECMF,CMET,JMAN, TCWB…

How to interpret properly
the biased and unbiased MJO forecasts?
How different they are?

Q1 : How is the effect of the model mean bias on RMM forecast performance ? Why we need bias removal ?

No bias removal **M_Anomaly = M(iy, t, lead) – O_climatology(t)**

With bias removal **M_Anomaly = M(iy, t, lead) – M_climatology(t, lead)**

Q2 : Model climatology (or mean bias) is usually got by a long period of hindcast data(eq. 30yrs or 20yrs). What can we do if we only have few years data ?

Can we work from O_climatology and mean bias?

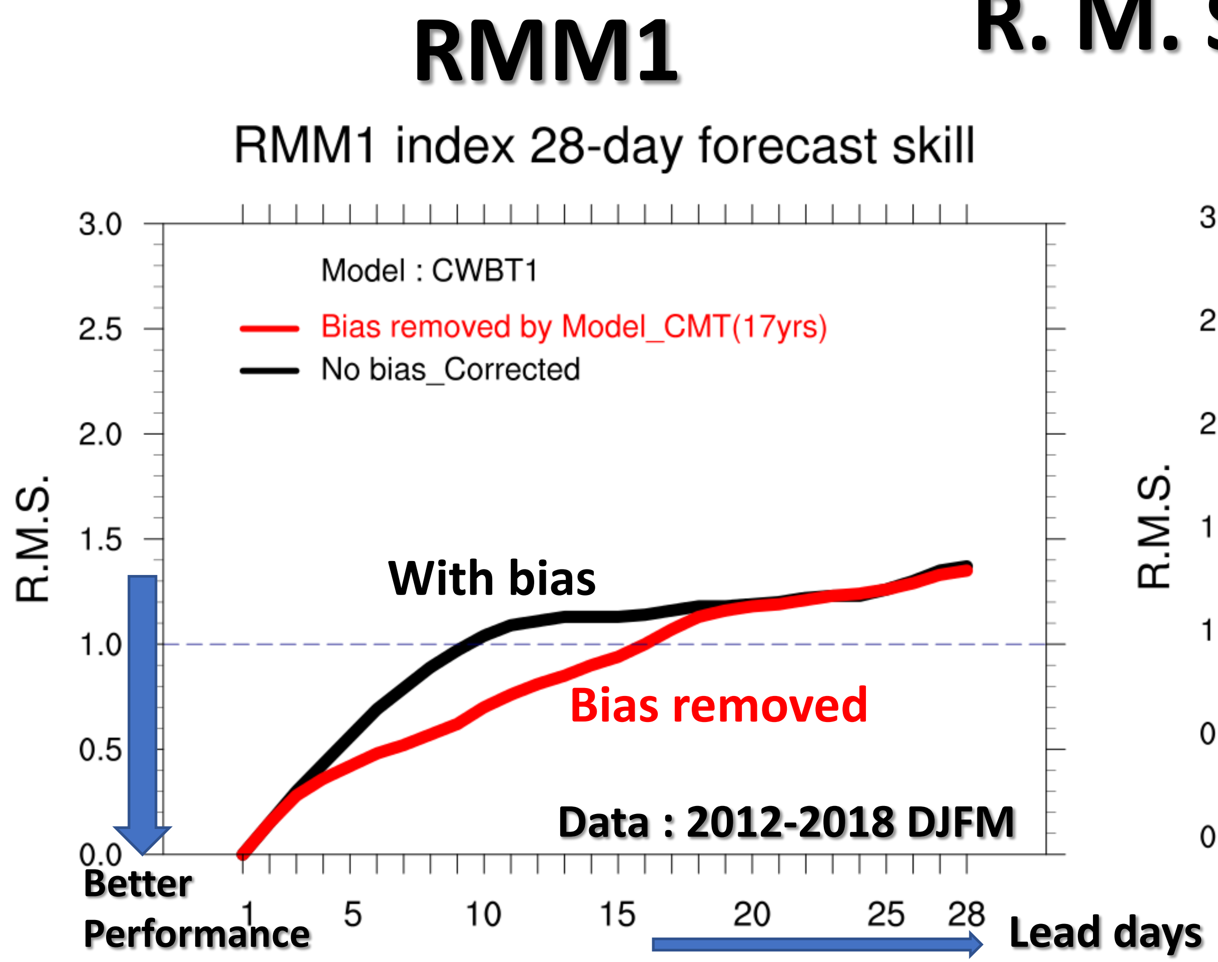
M_Anomaly = M(iy,t,lead) – (O_climatology(t) + Mean bias(t,lead))

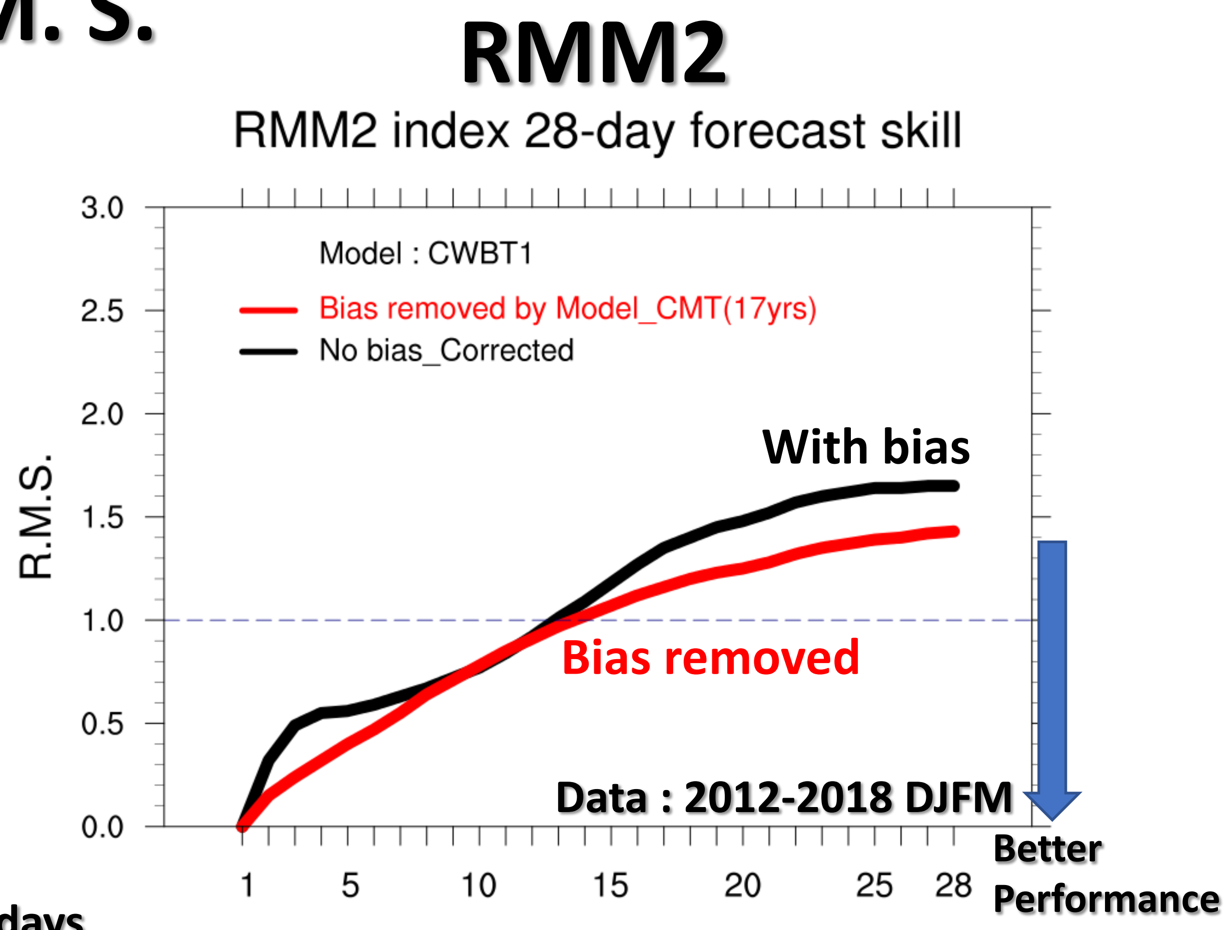
Can we work out a reasonable approach to estimate the model mean bias?

Q1 : How is the effect of the model mean bias on RMM forecast performance ?

Model : CWB 1-Tier

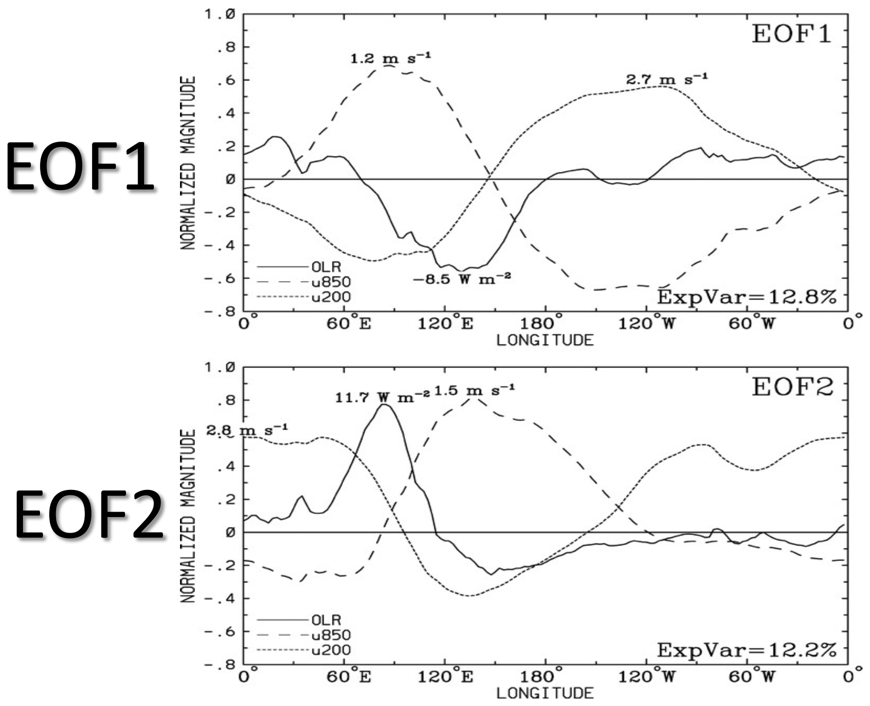
R. M. S.



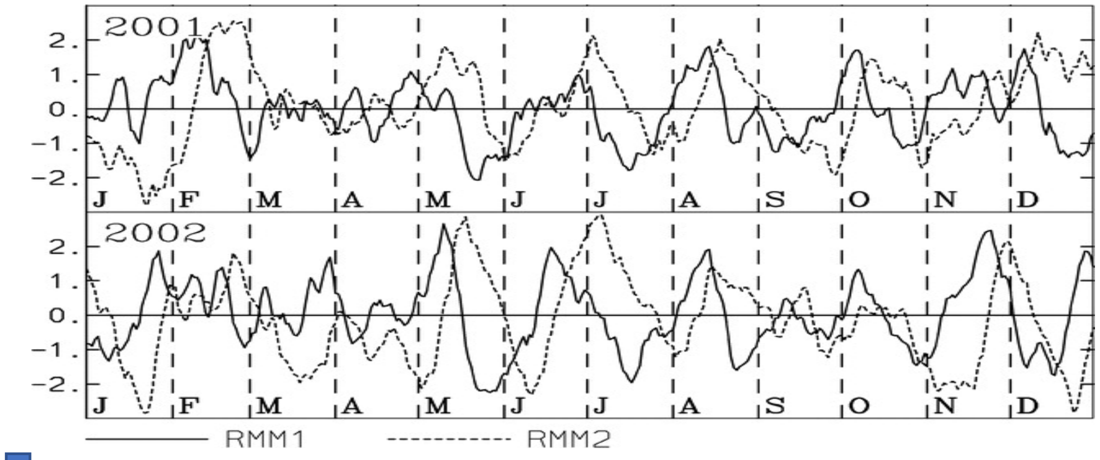


RMM index
: the 2 leading PCs of the combined EOF from 3 variables(U200/U850/OLR)

(Wheeler and Hendon, 2004)



RMM1 = PC1 (t)
= sum {
EOF1(ig1) * **OLR'' (t, ig)**
+ EOF1(ig2) * **U850'' (t, ig)**
+ EOF1(ig3) * **U200'' (t, ig)** }
RMM2 = PC2 (t) same as above, but with EOF2

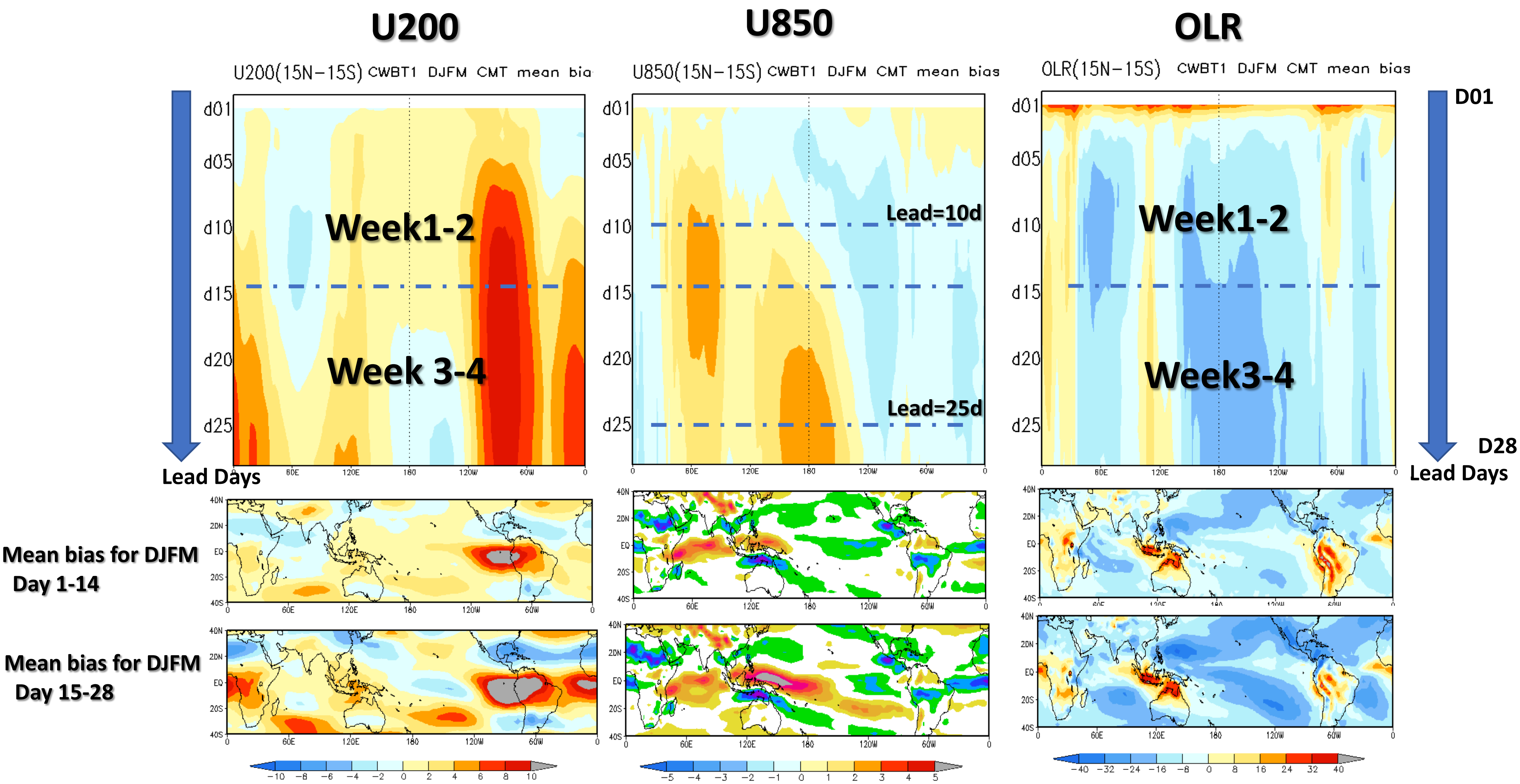


The contribution of mean bias on RMM can be estimated by :

RMM_BiasEffect = sum { EOF*OLR_bias + EOF*U850_bias + EOF*U200_bias } EOF : Fixed weighting function

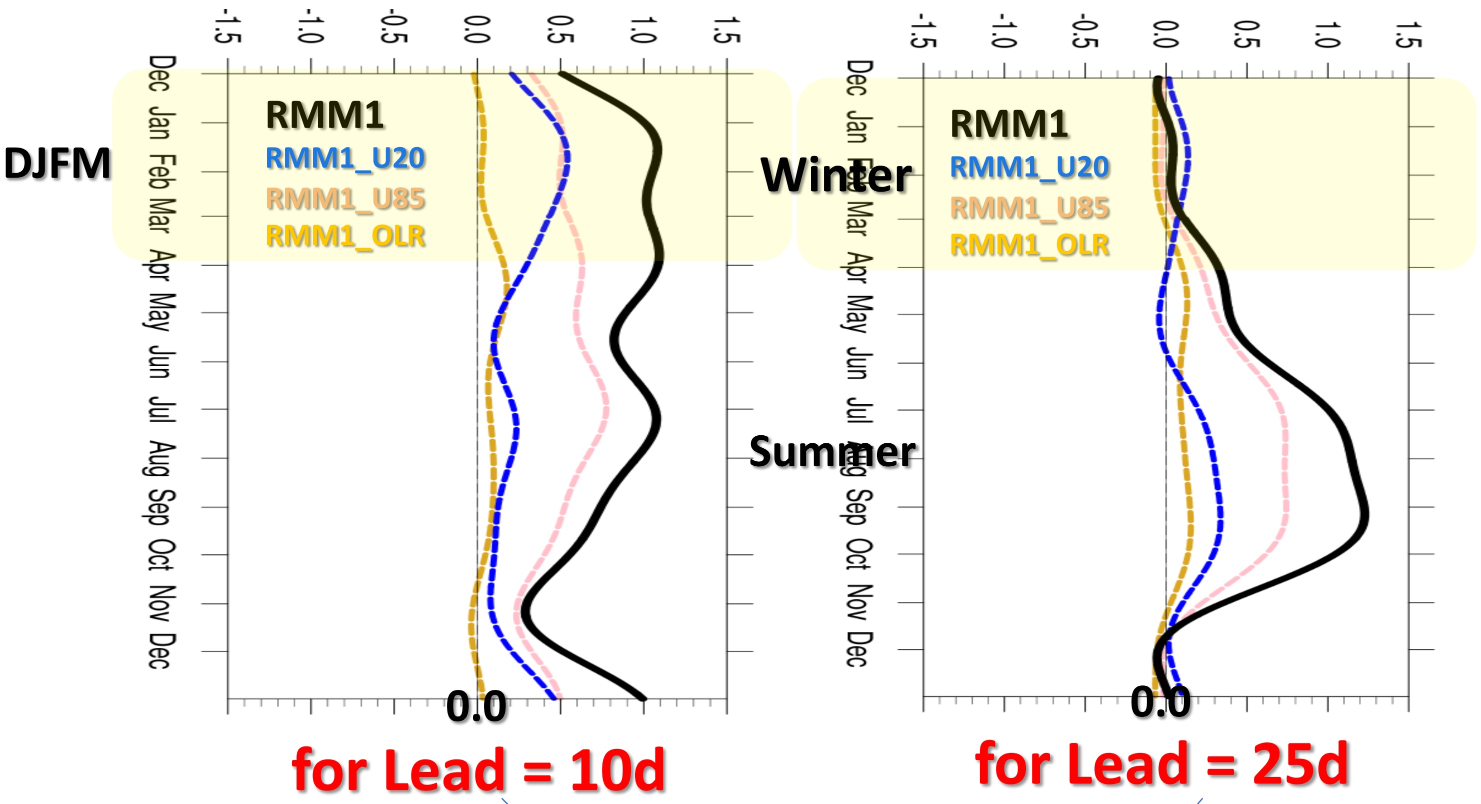
➔ If model bias behavior changes with lead time, the bias effect would also do.

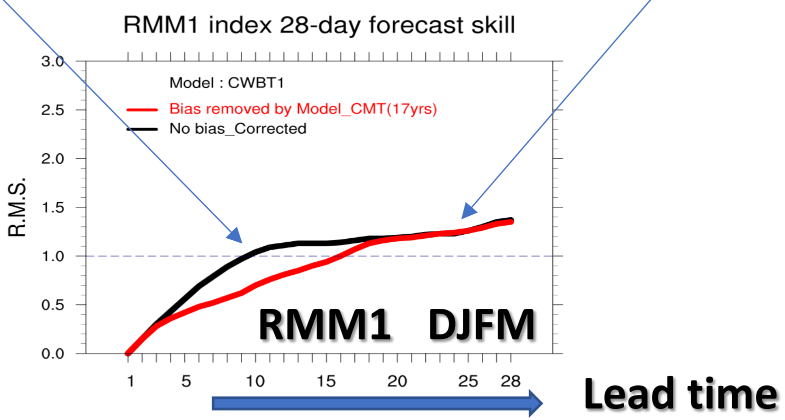
A Look at CWBT1 model mean bias Season : DJFM



Mean bias contribution on RMM1

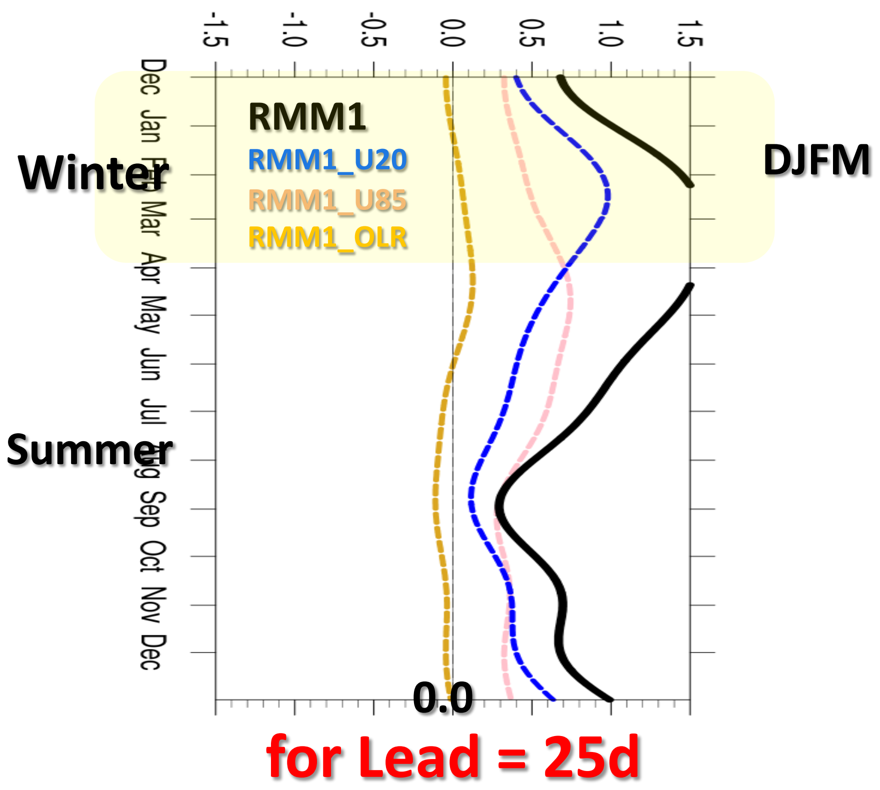
sum { **EOF1***OLR_bias + **EOF1***U850_bias + **EOF1***U200_bias }

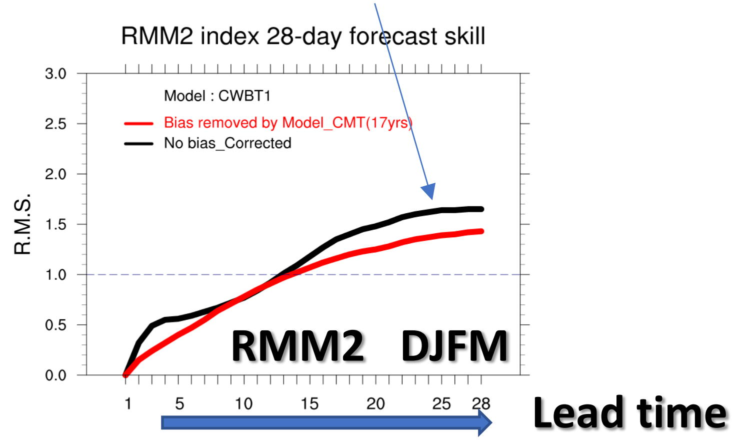




Mean bias contribution on RMM2

sum { **EOF2***OLR_bias + **EOF2***U850_bias + **EOF2***U200_bias }





The effect of mean bias in CWBT1 for DJFM

Week 2 : RMM1 positive bias

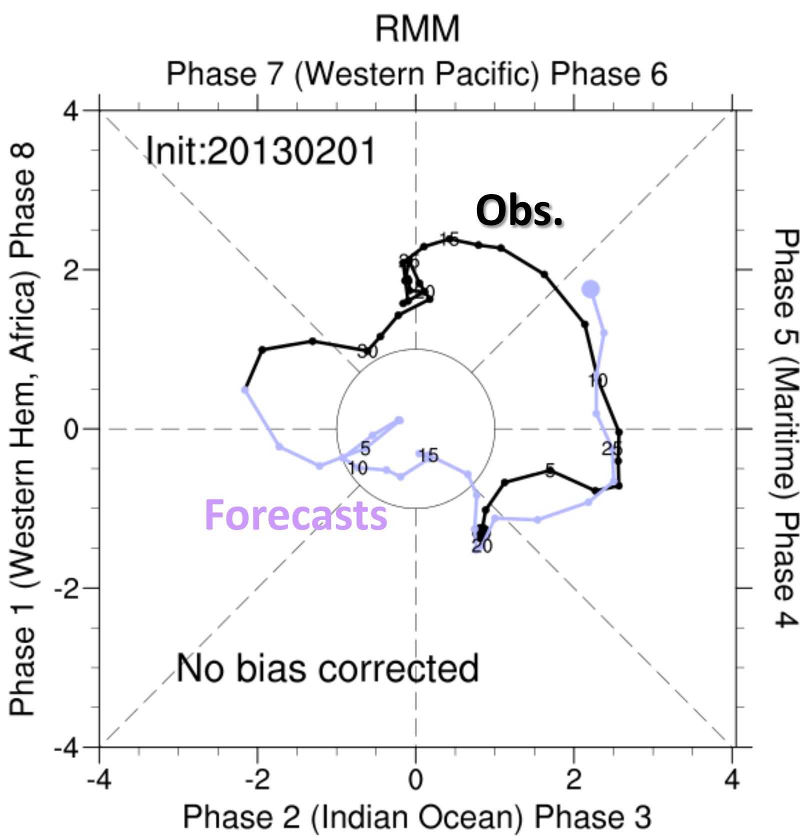
Week 3-4 : RMM2 positive bias

Model : CWB 1-Tier

An example :

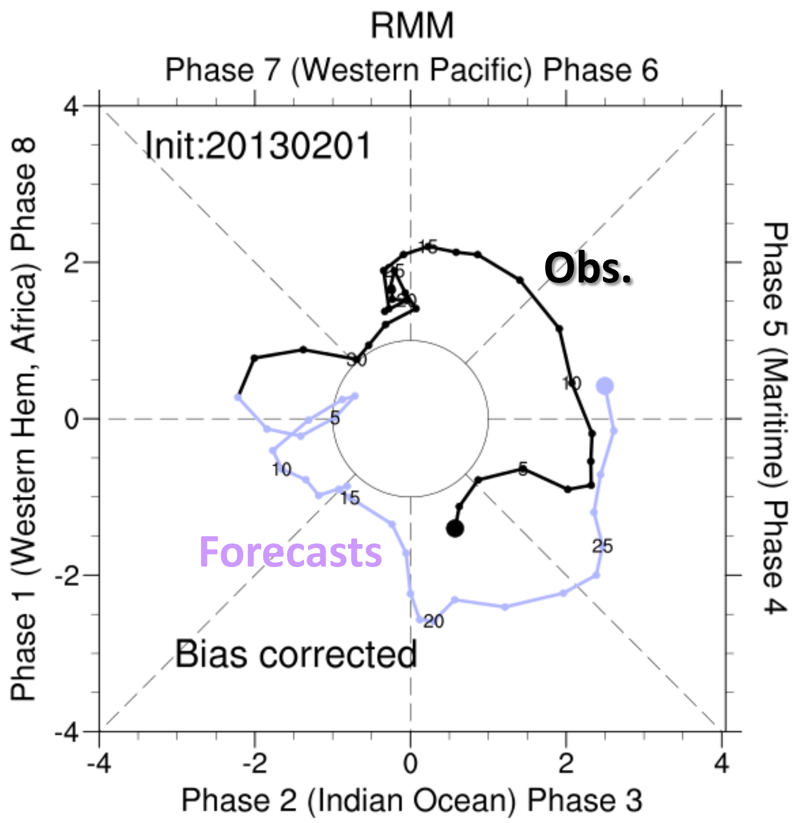
No bias correction

M_anomaly = M-O_cmt



Bias corrected

M_anomaly = M-M_cmt



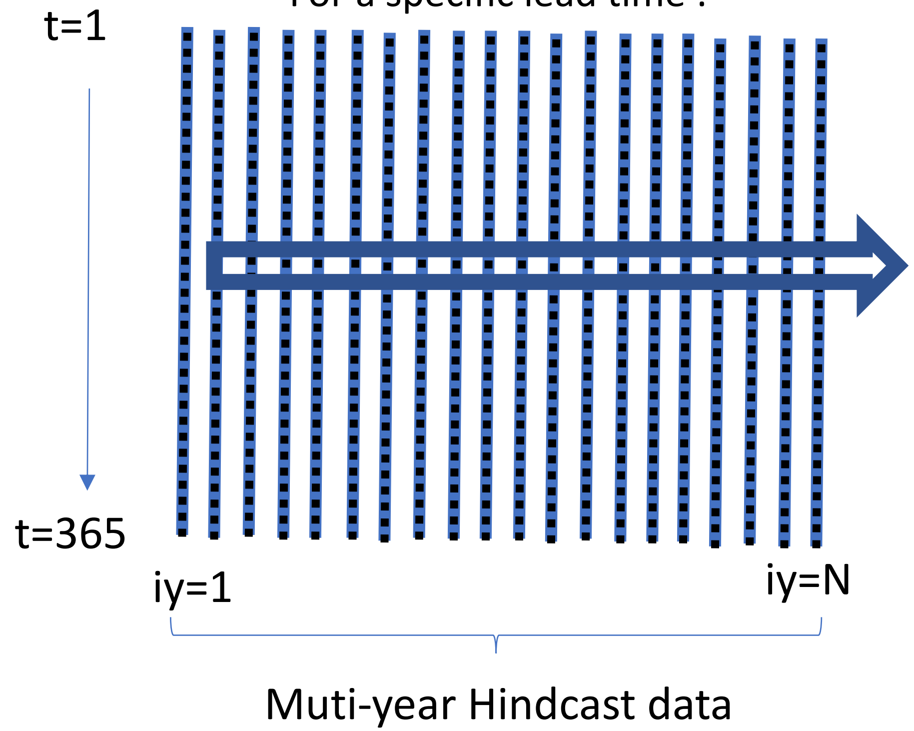
Without the model bias information, we hardly can properly interpret the forecasts.
It's better always try to pursuit bias corrected forecasts.

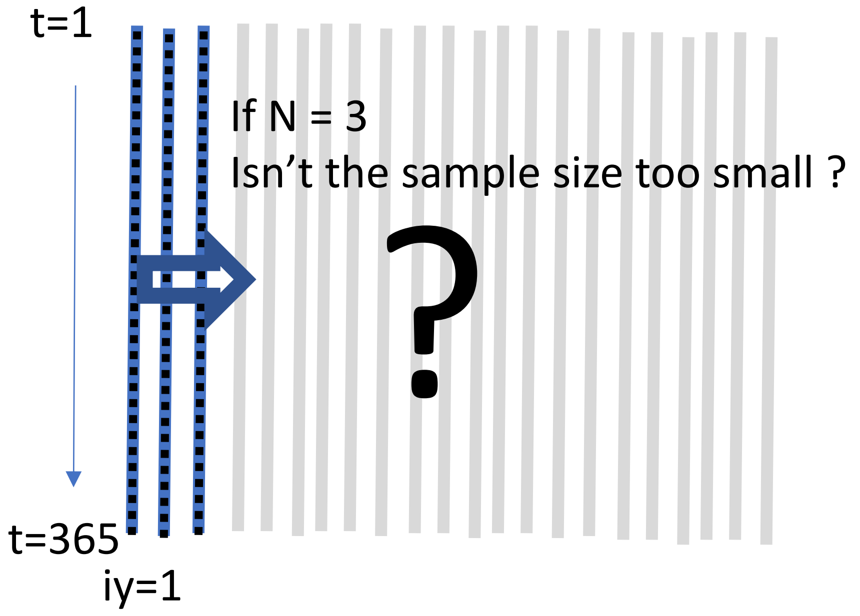
Q2 : Model climatology (or mean bias) is usually got by a long period of hindcast data(eq. 30yrs or 20yrs). What can we do if we only have few years data ?

M_climatology (t, lead) = mean(M (iy,t,lead))

M : model forecast

For a specific lead time :





Alternative approach for bias corrected M_Anomaly

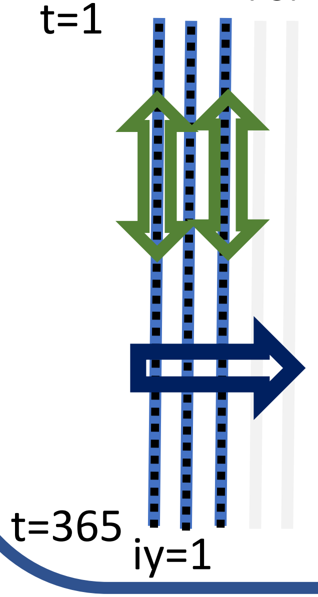
(A) Standard approach :

M_Anomaly = M(iy,t,lead) – M_climatology(t,lead)

(B) The Proposed alternative approach (**when lack of hindcast**):

M_Anomaly = M(iy,t,lead) – (O_climatology(t) + Mean bias(t,lead))

For a specific lead time :



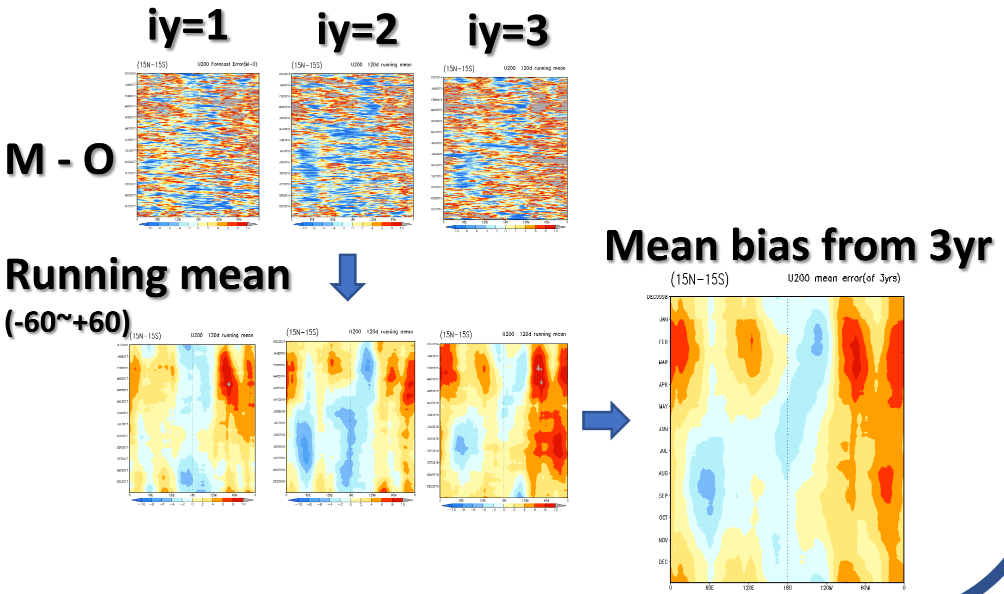
Get low frequency errors for each year :

M(iy, t, lead) – O(iy, t) = Error(iy, t, lead)

MovingAvg[(Error)] = Error_lowfreq(iy, t,lead)

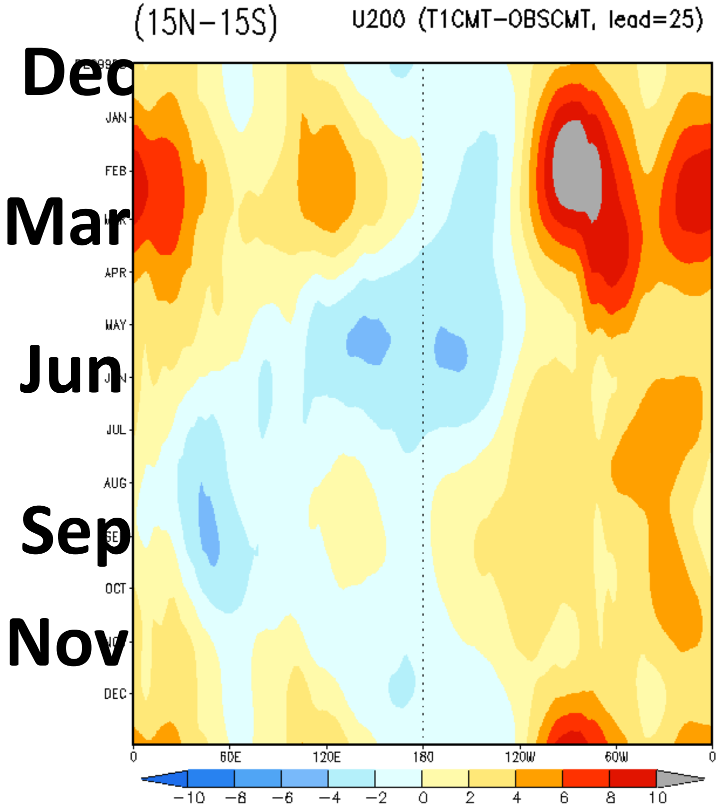
Estimate the mean bias by averaging

mean(Error_lowfreq) = Mean bias(t, lead)



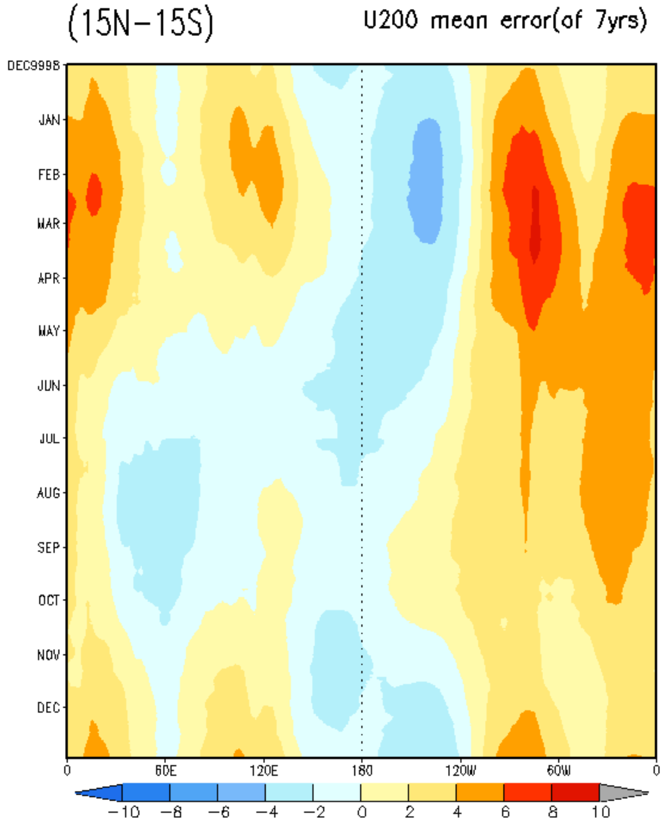
The CWBT1 mean bias (take lead 25d for example)

Standard approach (M_cmt-O_cmt)



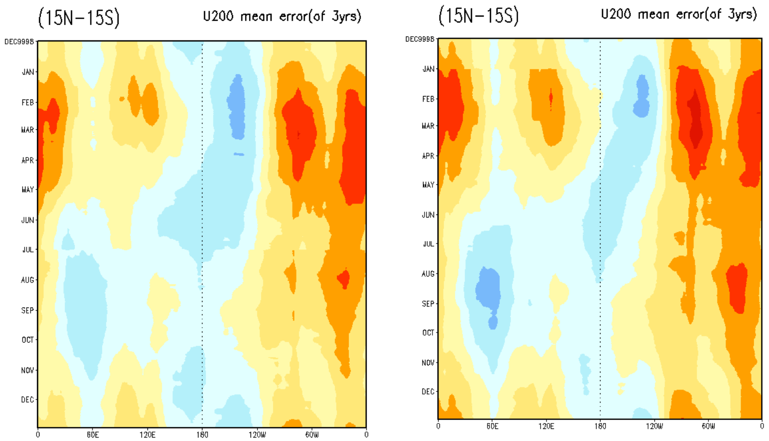
By 7yr mean

Esimate from meanErrors

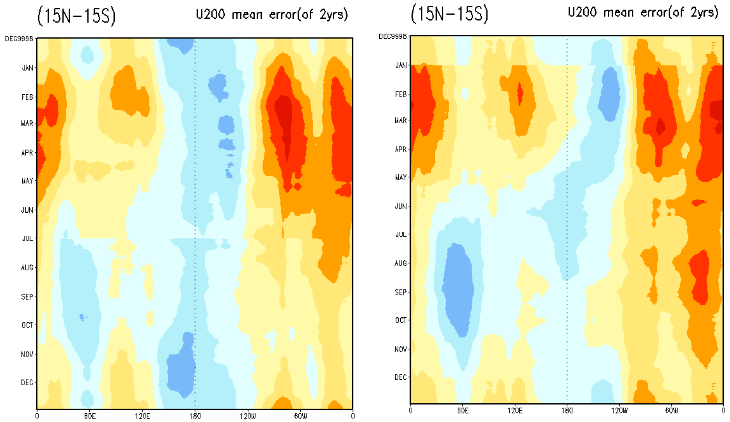


Esimate from mean Errors

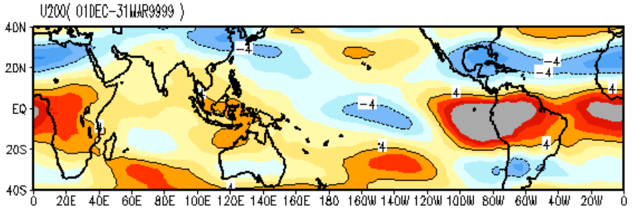
By 3yr mean



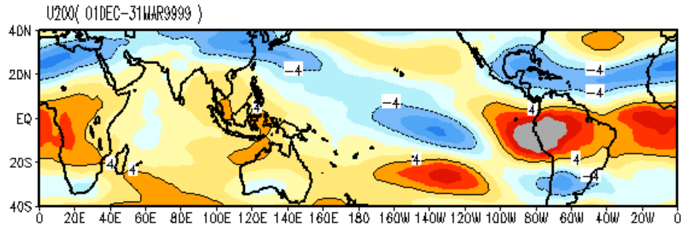
By 2yr mean



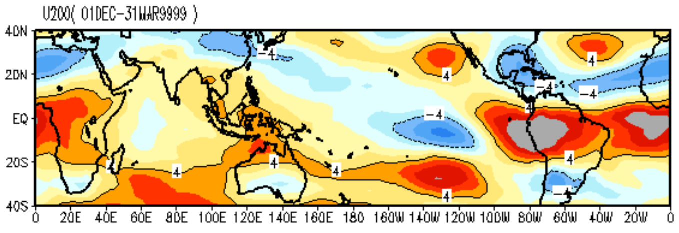
Mean bias for DJFM



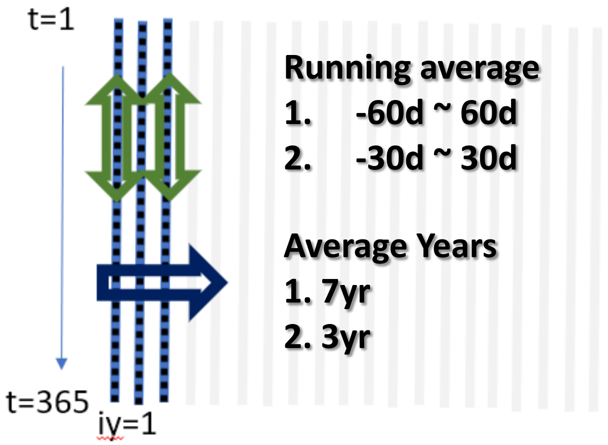
Mean bias for DJFM



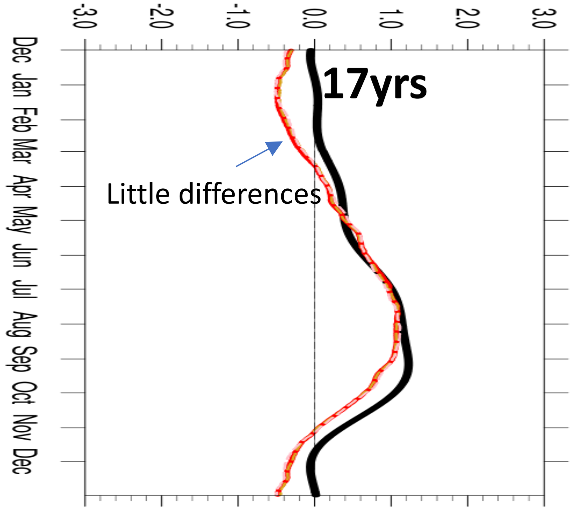
Mean bias for DJFM



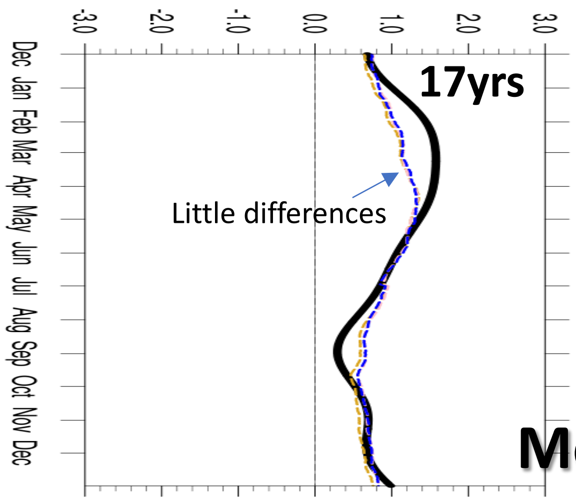
Sensitivity test on the setting



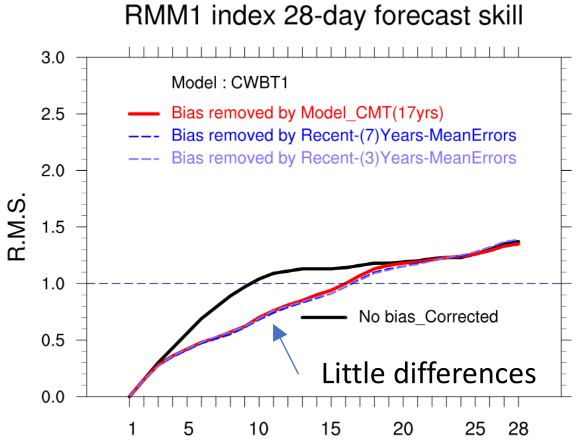
On RMM1

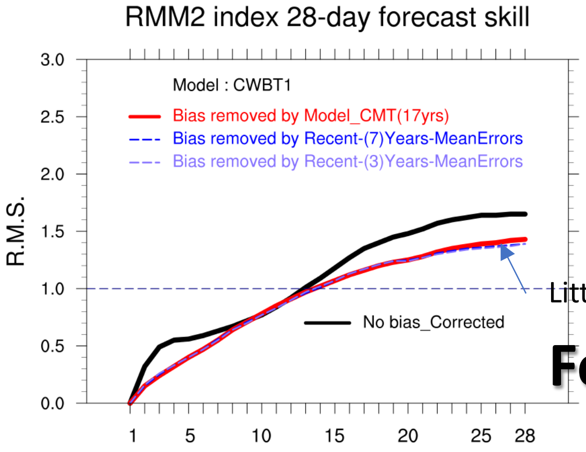


On RMM2



Mean bias contribution on RMM





Little differences

Forecast RMSE.

National Weather Service

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Dynamical Model MJO Forecasts

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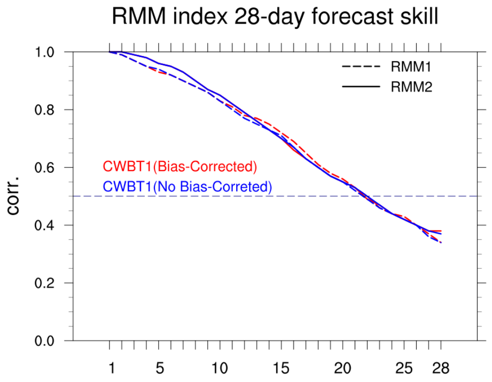
Phase Plots of MJO Index Forecasts					
NCPE	NCPB	NCPO	NCFS	UKME	UKMA
CMET	ECMF	ECMM	CPTC	JMAN	TCWB
EMON	EMOM	IMDO	BOMM	TCWBT1	

TCWB : CWB GEPS
(lack of model climatology for current, while the alternative approach proposed in this study can be applied for bias removal.)



CWB 1Tier coupled model
(with long-term hindcast, the MJO forecast skill has been shown promising.)

Summary

- This work shows the model bias removal effect on the MJO forecasts and argues a forecast guidance without bias removal would be hardly properly interpreted.
- Model mean bias in the forecast is usually removed based on the hindcast data. For forecast systems with no hindcast data, this study propose an alternative approach to estimate the model mean bias by using recent years forecast data.
- The model mean bias estimated from the proposed alternative approach resembles the results from the standard approach by using the hindcast data. The RMM forecast skill from the proposed alternative approach to removing the model bias is also comparable to the standard approach.

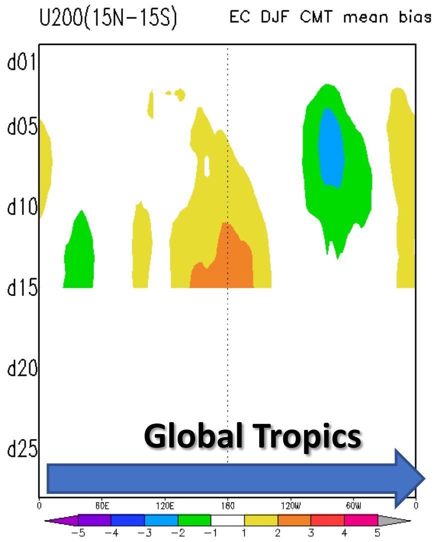
Each model has its own bias structure

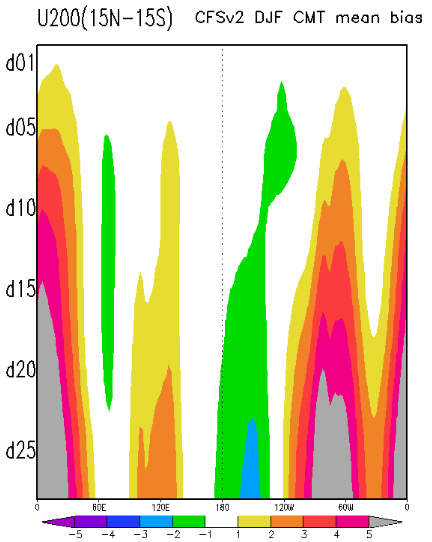
EC

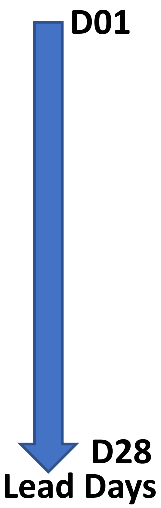
CFSv2

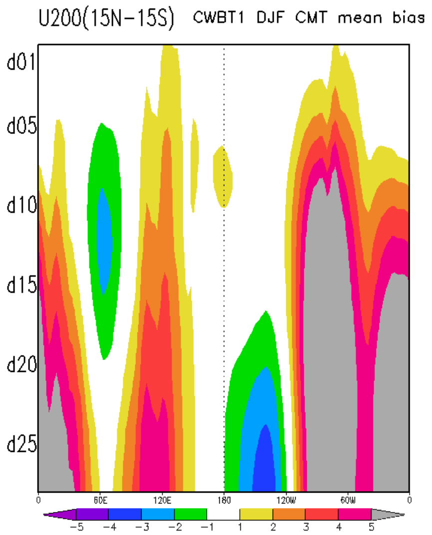
CWBT1

U200(15S-15N)
DJF

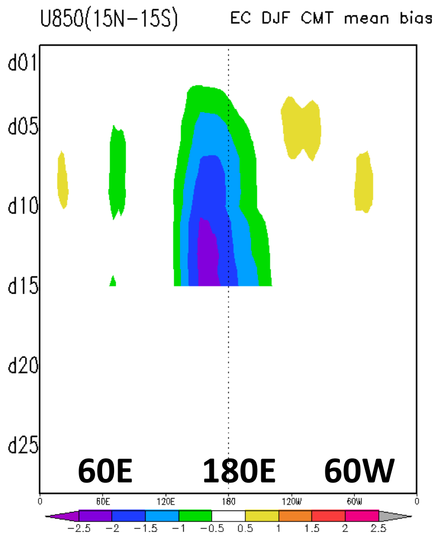


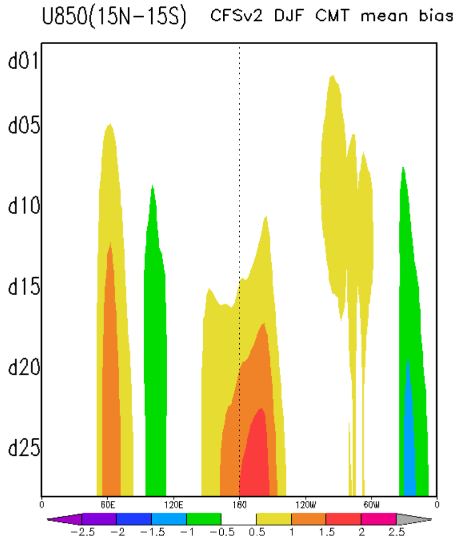


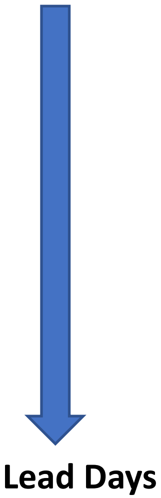


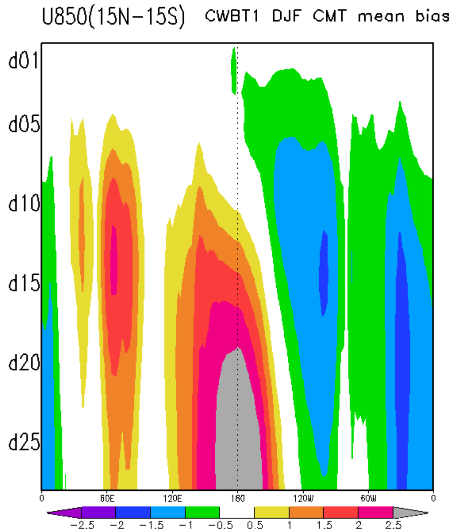


U850(15S-15N)
DJF







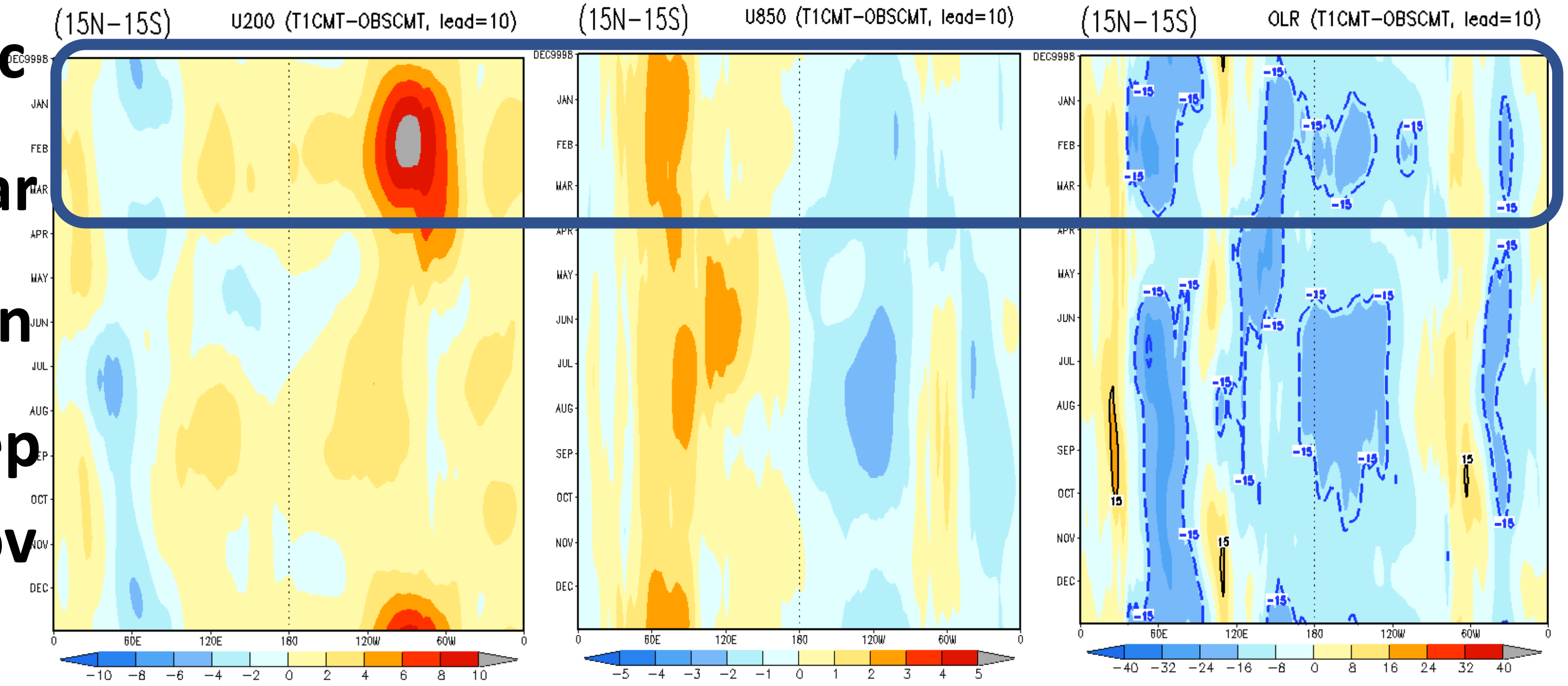


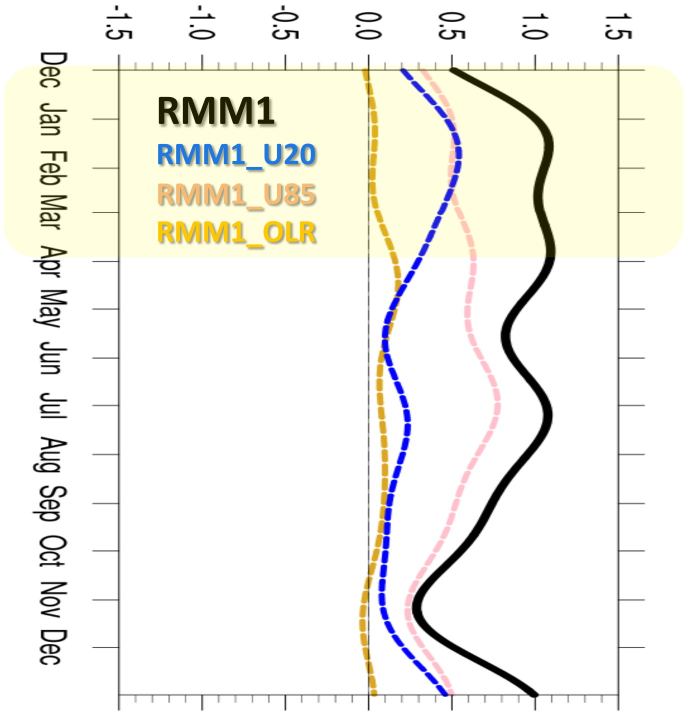
Mean bias for Lead = 10d

Mean bias contribution on RMM1

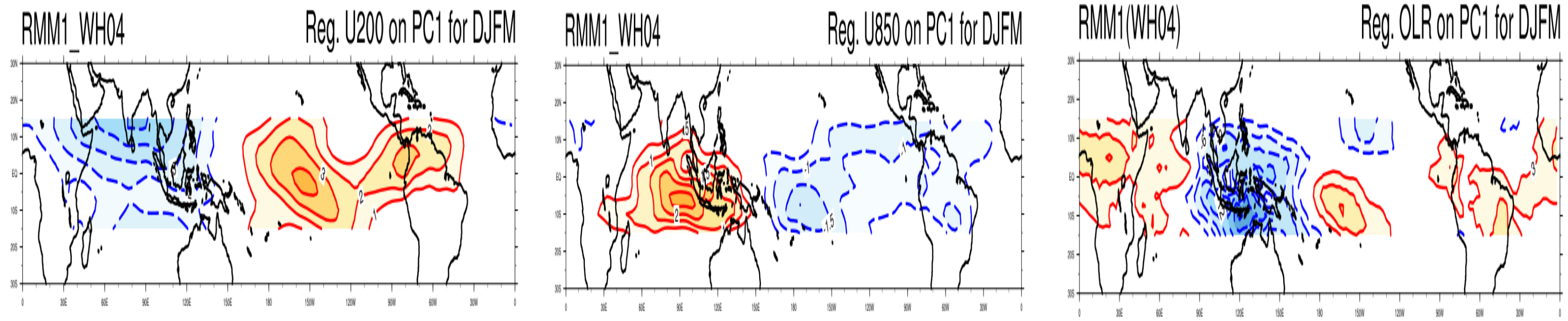
U200 U850 OLR

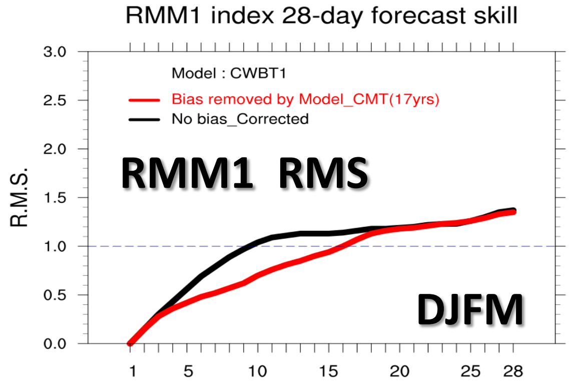
Dec
Mar
Jun
Sep
Nov





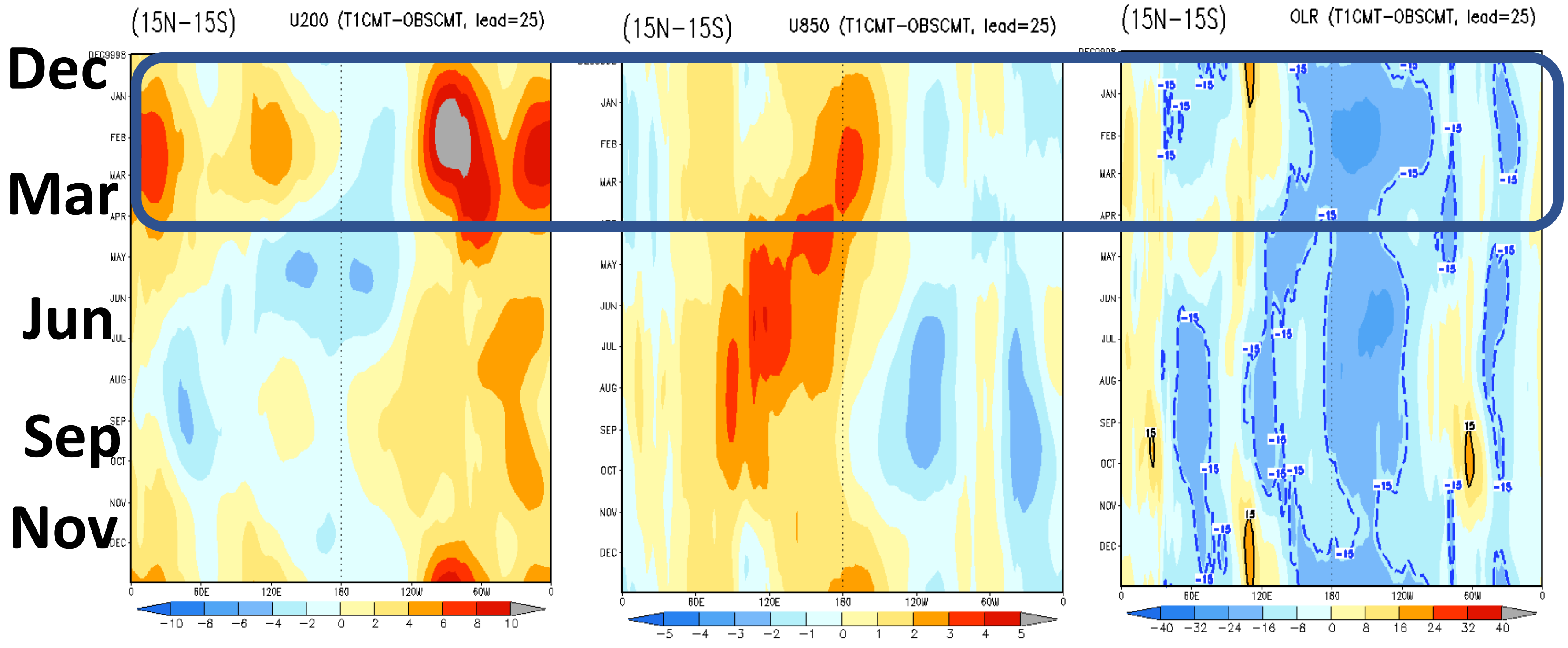
EOF1 spatial pattern



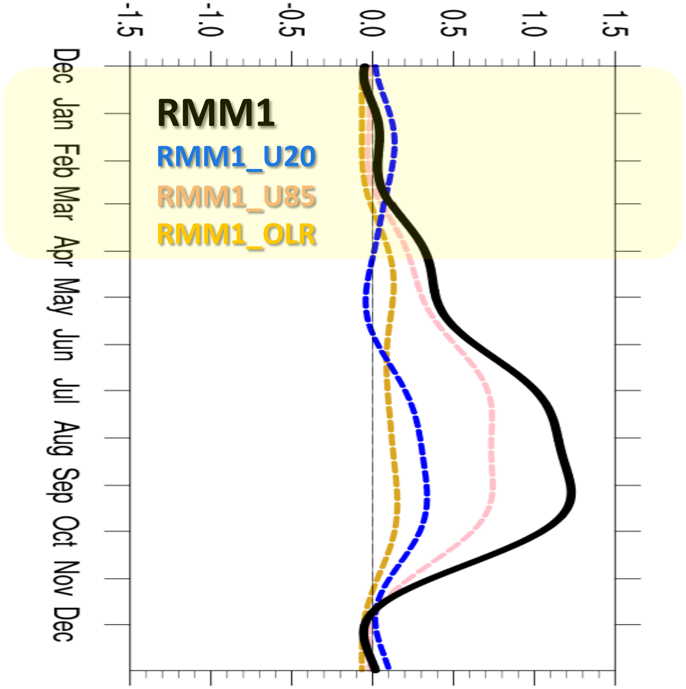


Mean bias for Lead = 25d

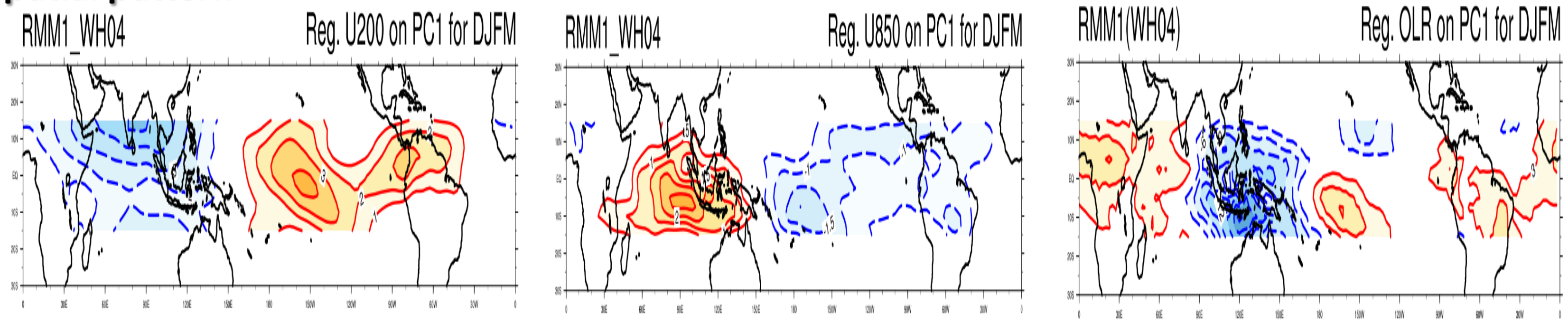
U200 U850 OLR

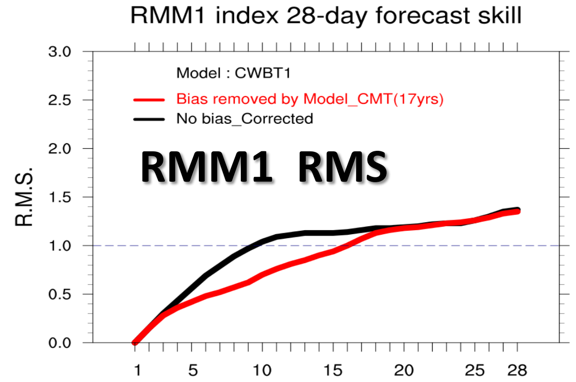


Mean bias contribution on RMM1

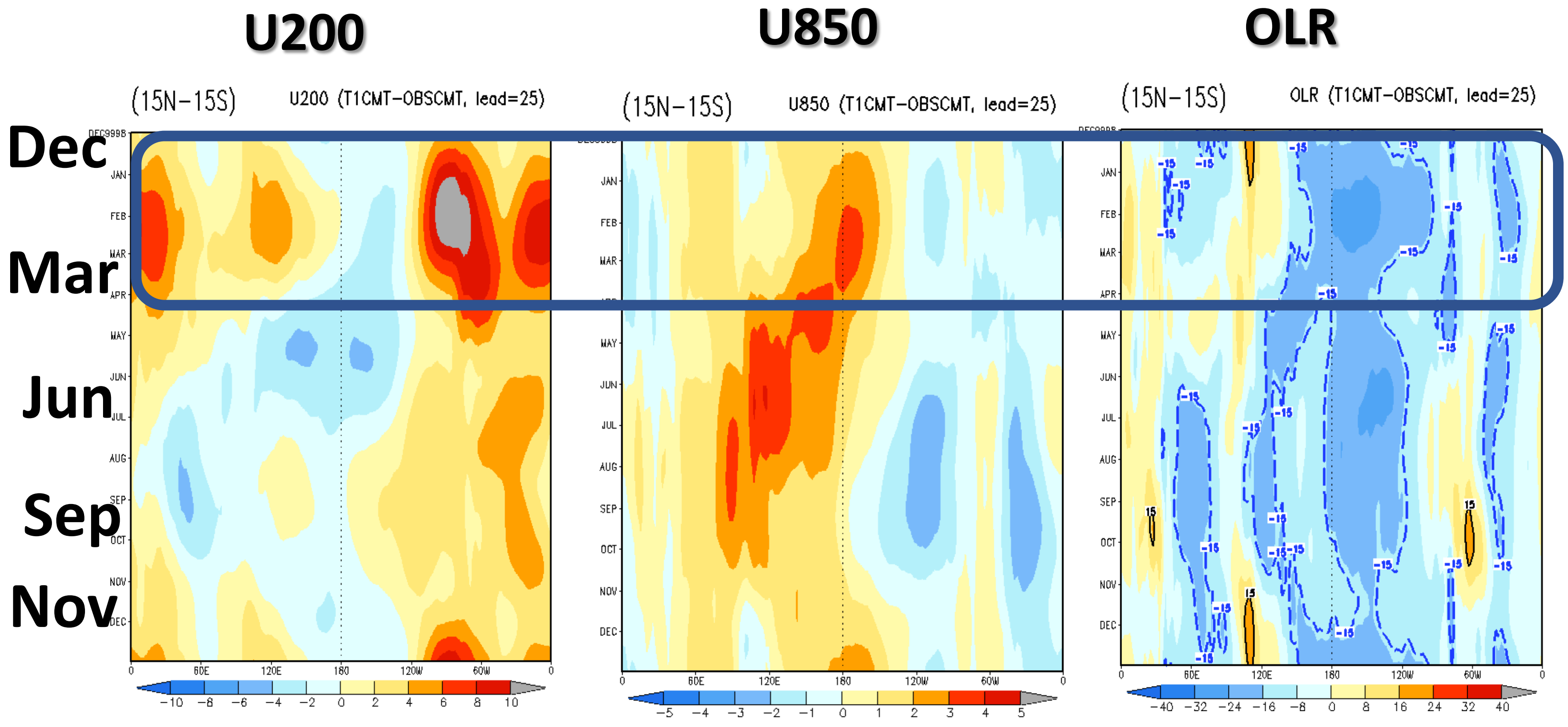


EOF1 spatial pattern

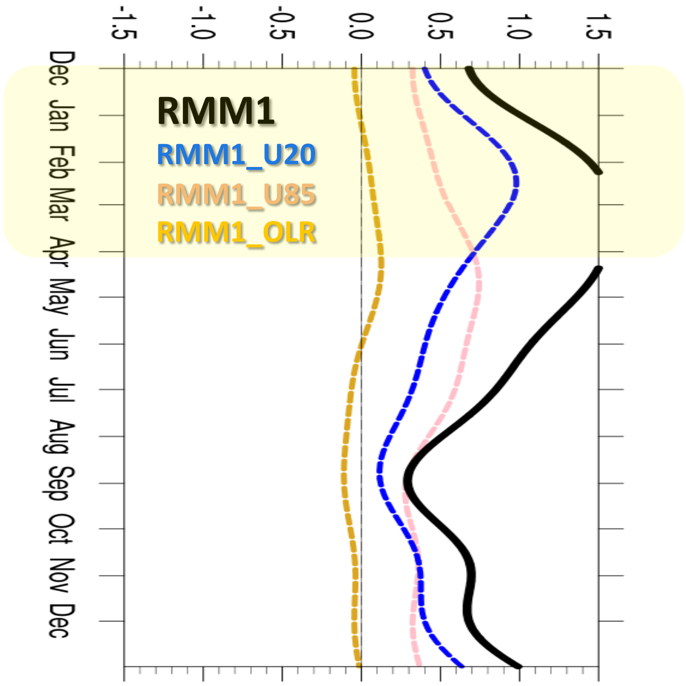




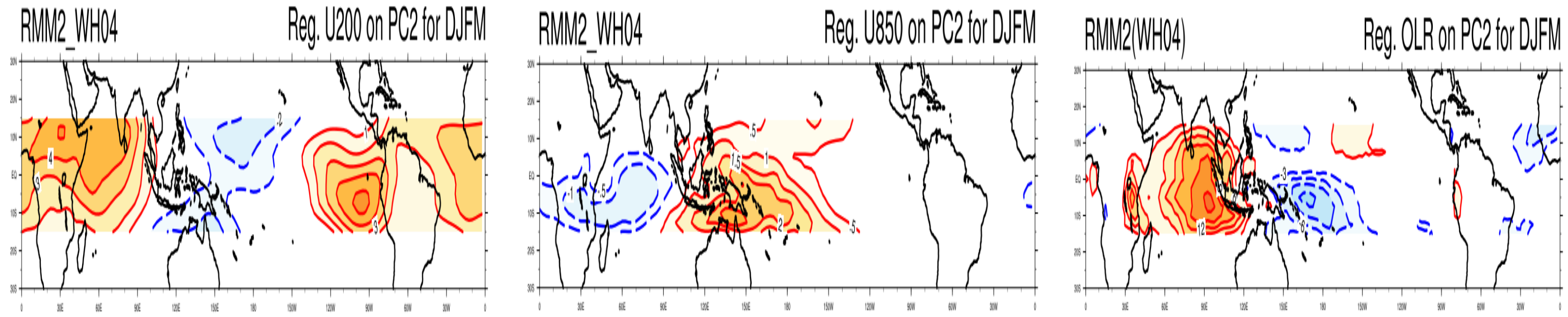
Mean bias for Lead = 25d

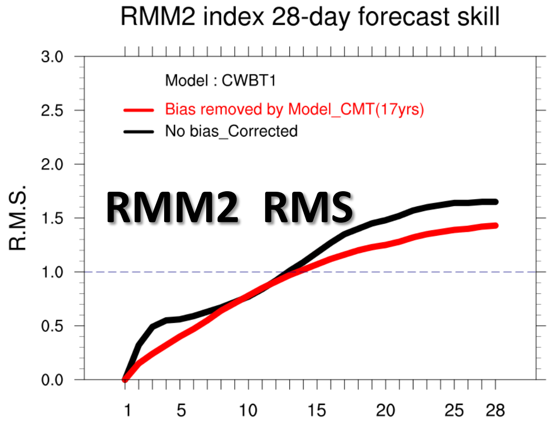


Mean bias contribution on RMM2



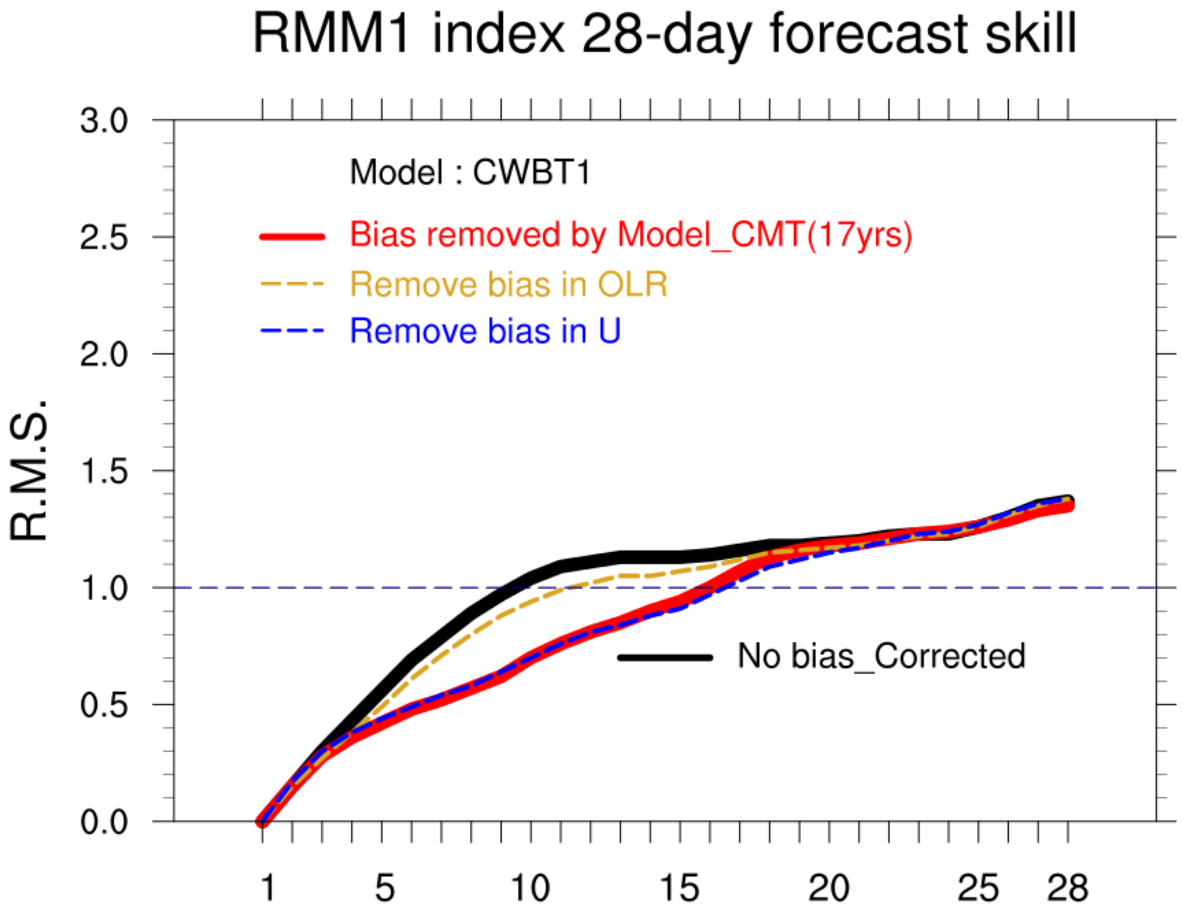
EOF2 spatial pattern



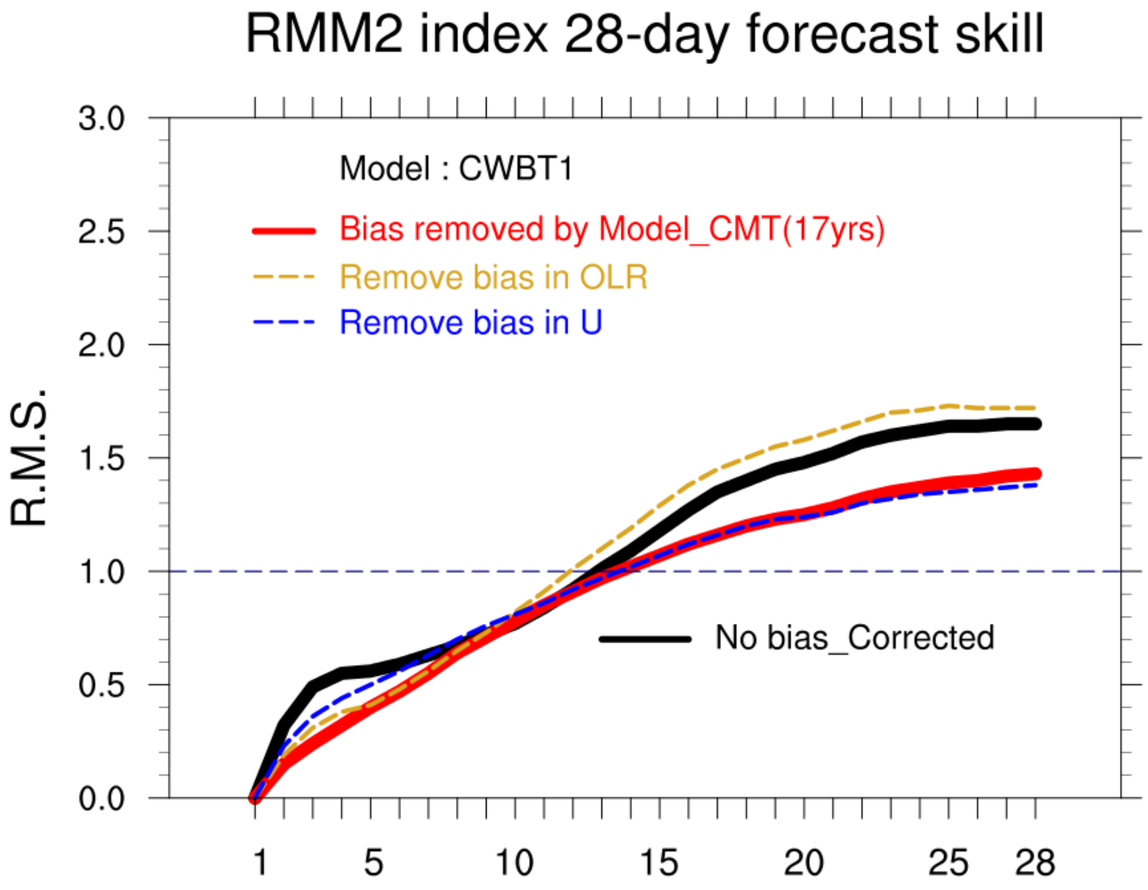


Model : CWB 1-Tier

RMM1



RMM2

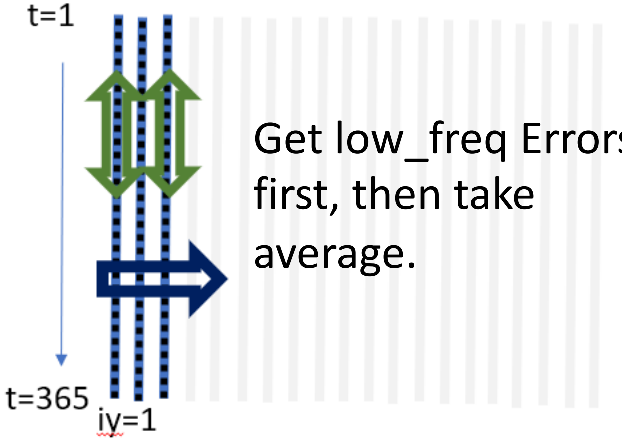


The bias removal effect is mainly from U field, the contribution from OLR is less.

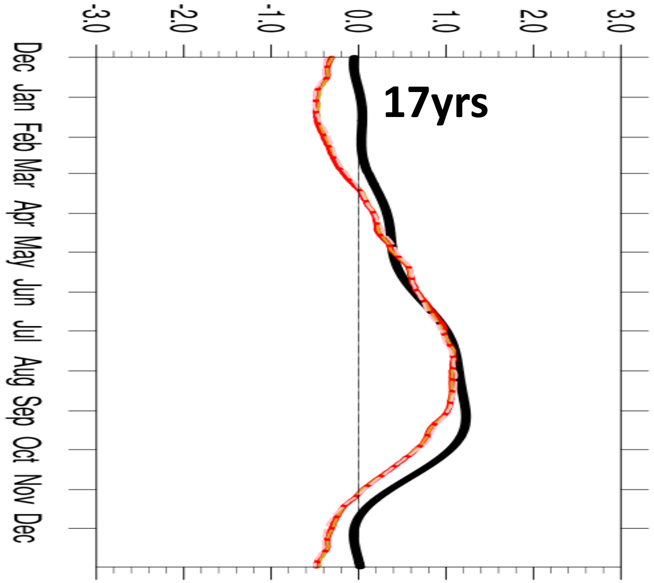
Mean bias contribution

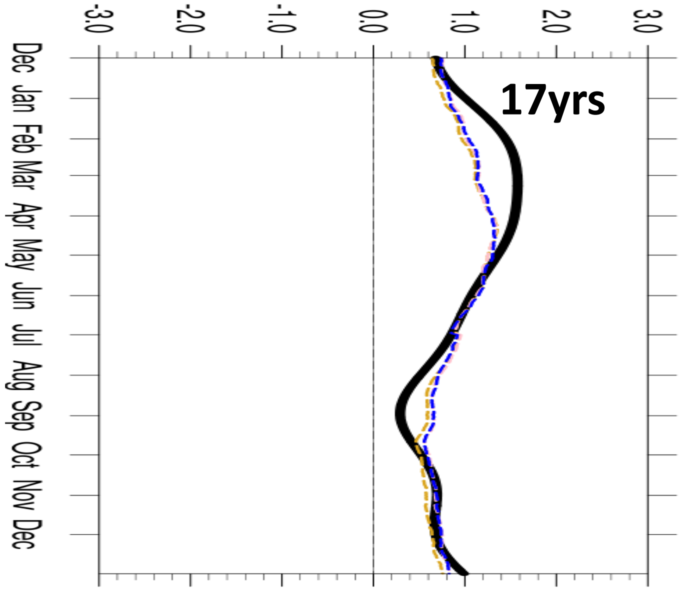
On RMM1

On RMM2



Get low_freq Errors first, then take average.

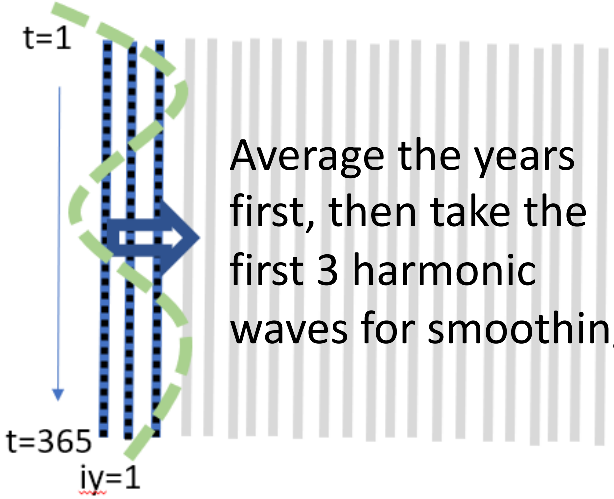




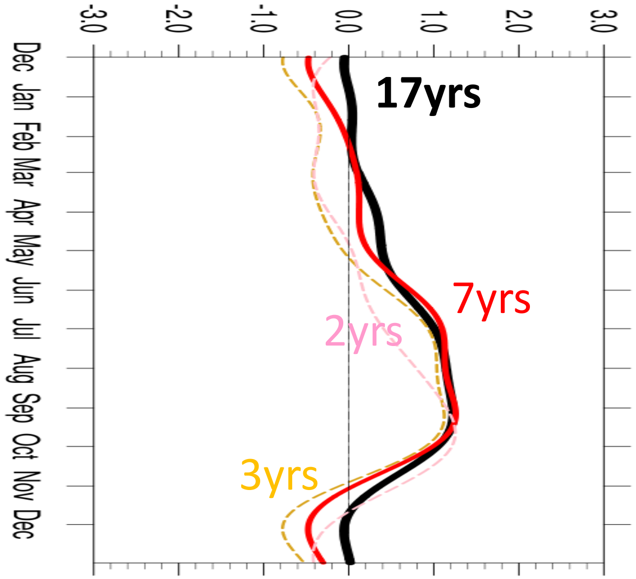
All are in agreement,not sensitive with the setting

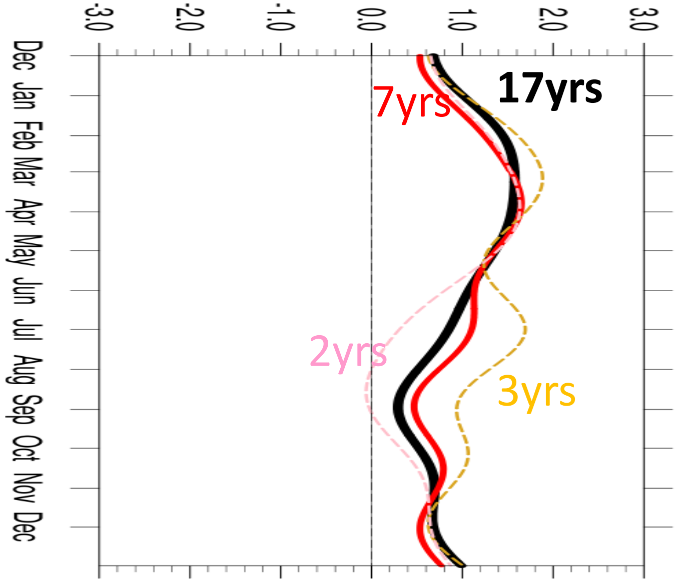
Running average
1. 120d
2. 60d

Average Years
1. 7yr
2. 3yr



Average the years first, then take the first 3 harmonic waves for smoothing.



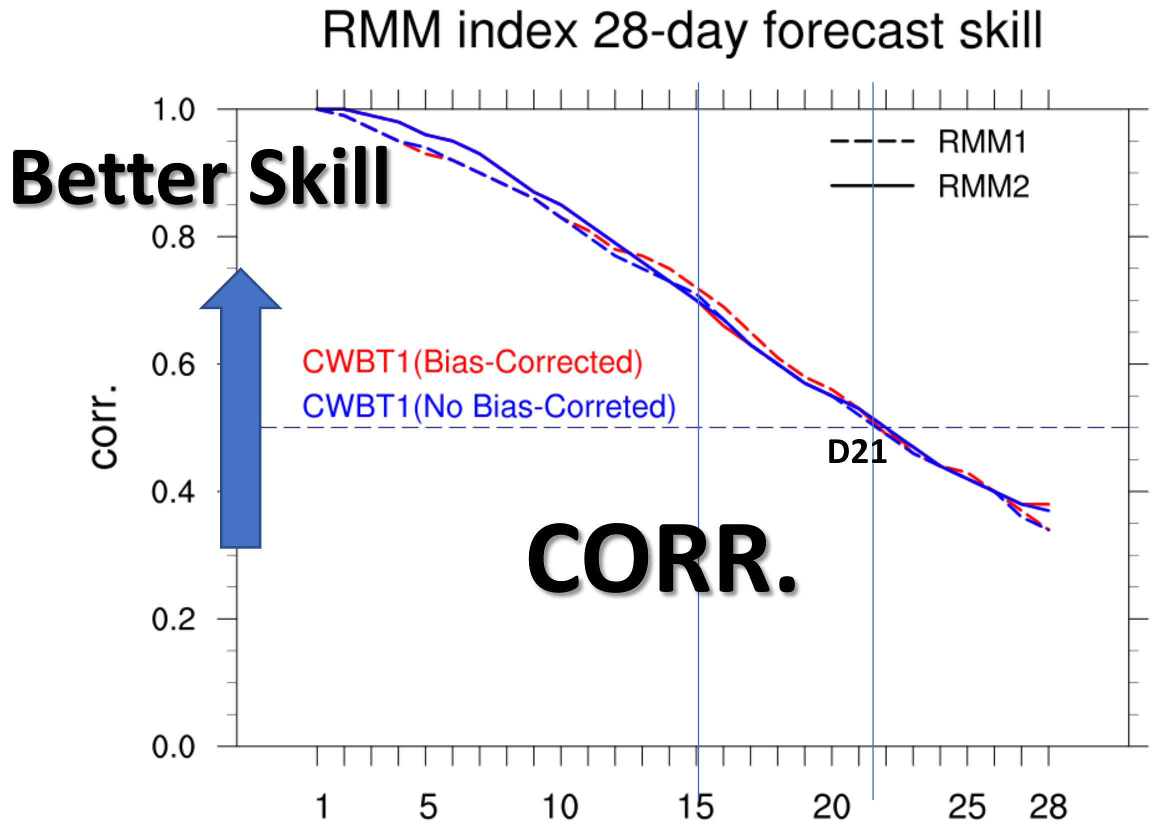


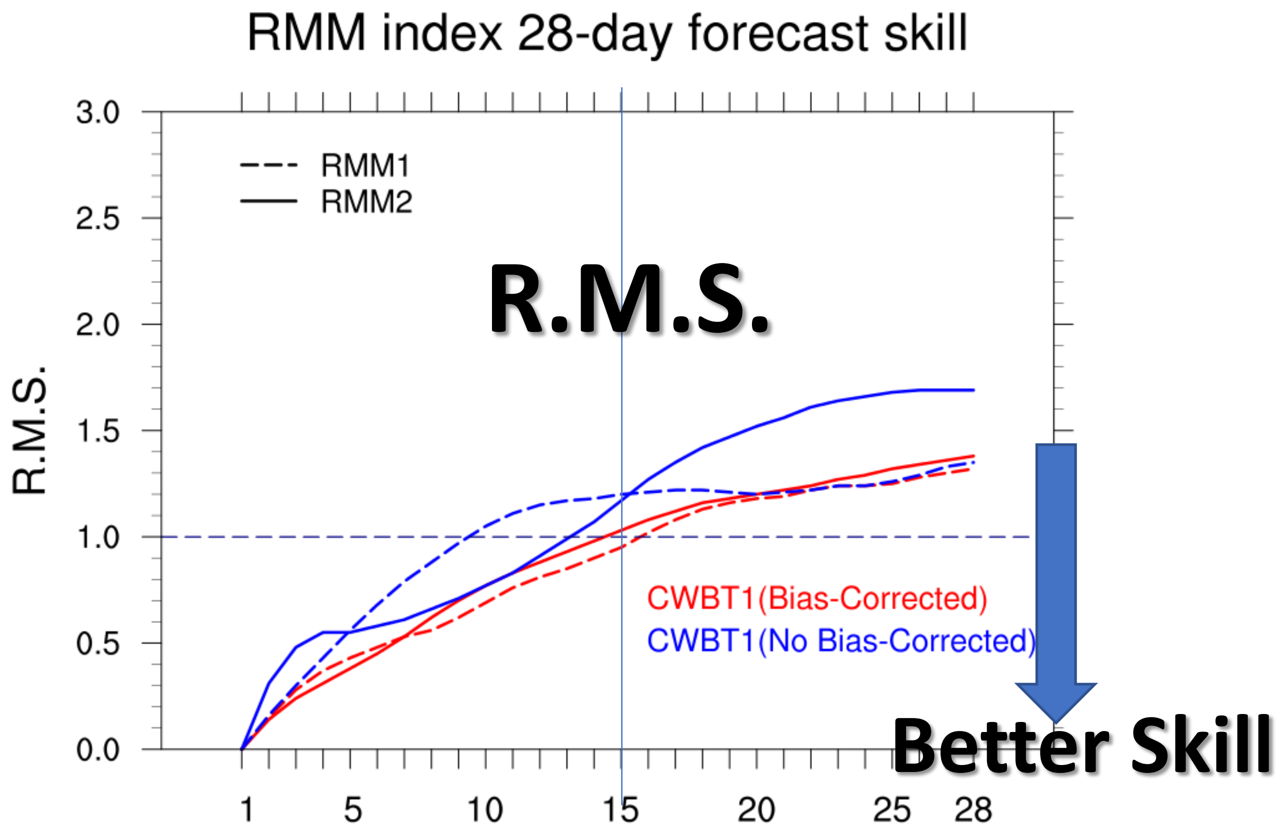
Diverse a lot

Study 1.1 : Effect of bias removal on RMM forecast skill score

Model : CWB 1-Tier seasonal forecast model (CWBT1)

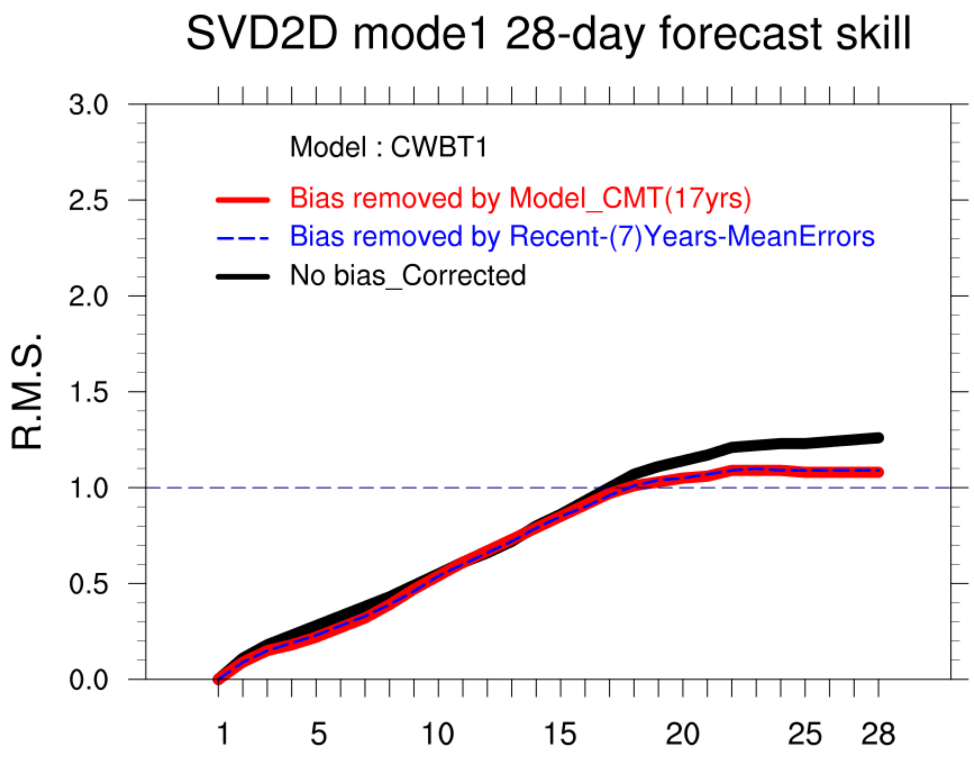
Data : 2012-2018 DJFM

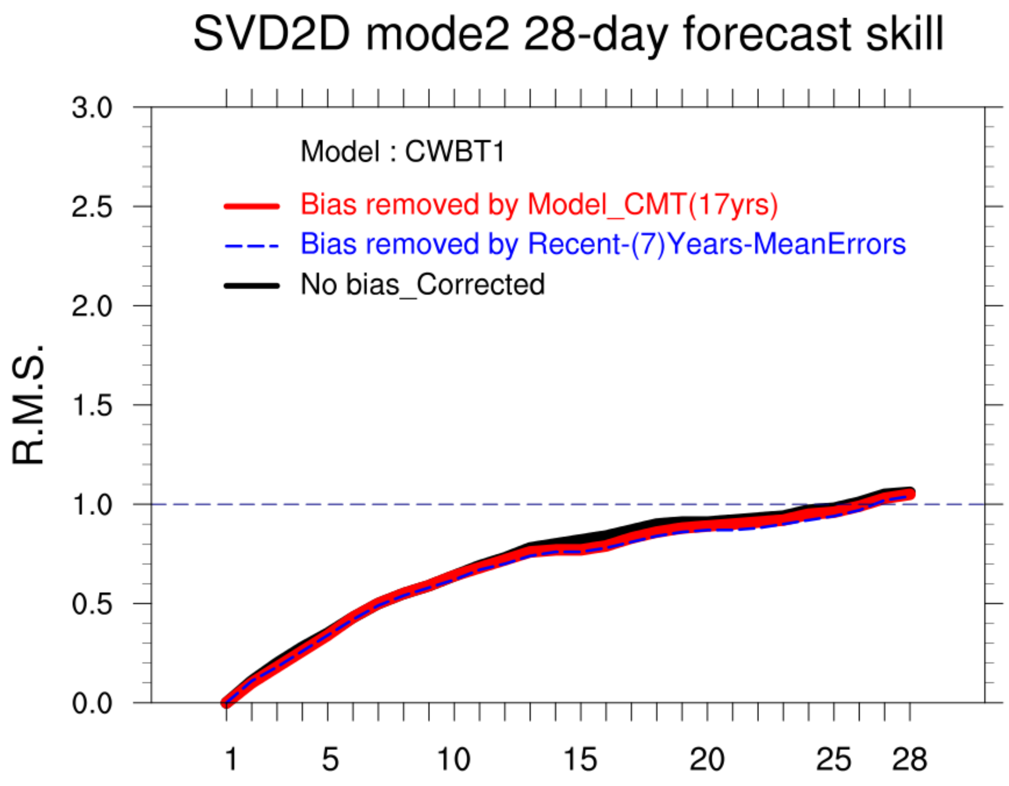




For RMS, bias corrected forecast(Red) have better skill, while comparable skill was seen from correlation measurement. This might imply no bias corrected forecasts also can catch the MJO variation tendency.

SVD


SVD2D mode1 28-day forecast skill
Model : CWBT1
Bias removed by Model_CMT(17yrs)
Bias removed by Recent-(7)Years-MeanErrors
No bias_Corrected
R.M.S.
3.0
2.5
2.0
1.5
1.0
0.5
0.0
1
5
10
15
20
25
28


SVD2D mode2 28-day forecast skill
Model : CWBT1
Bias removed by Model_CMT(17yrs)
Bias removed by Recent-(7)Years-MeanErrors
No bias_Corrected
R.M.S.
3.0
2.5
2.0
1.5
1.0
0.5
0.0
1
5
10
15
20
25
28

Simmons et al. (1983), Ferranti et al. (1990)

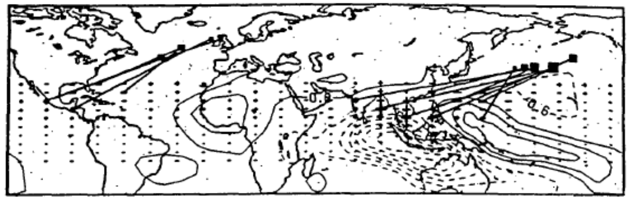


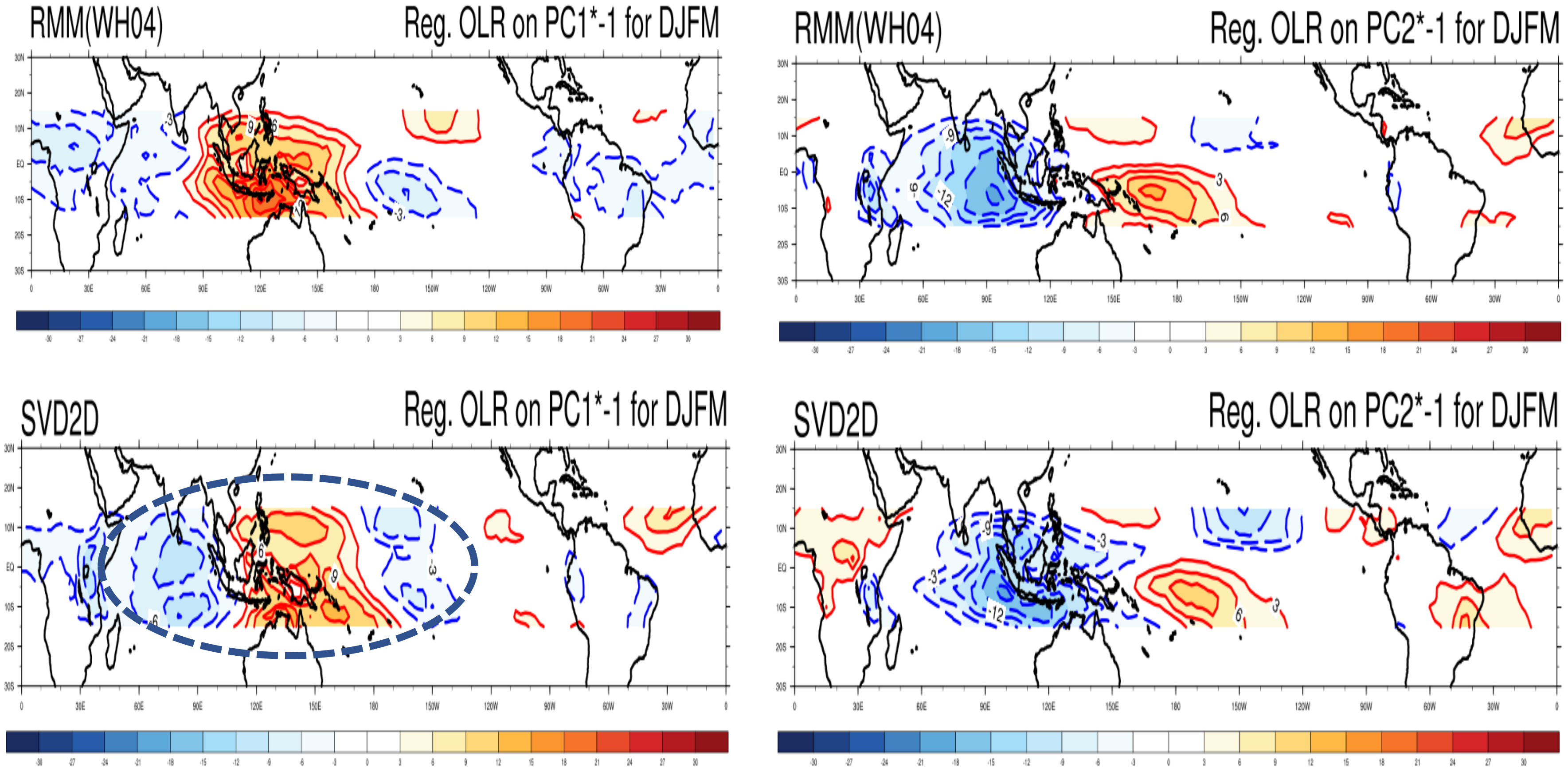
FIG. 8. Schematic illustration of the relationship between the location of the forcing region and the maximum midlatitude response excited from it. (From Simmons et al. 1983). Contours of the first EOF of OLR from the present study are superimposed.

A dipole heating structure over IO-WPC was seen from the SVD index, which is an important key feature in the tropical-extratropical interaction.

Reg (OLR , PC1) **Reg (OLR , PC2)**

(a) RMM

(b) SVD



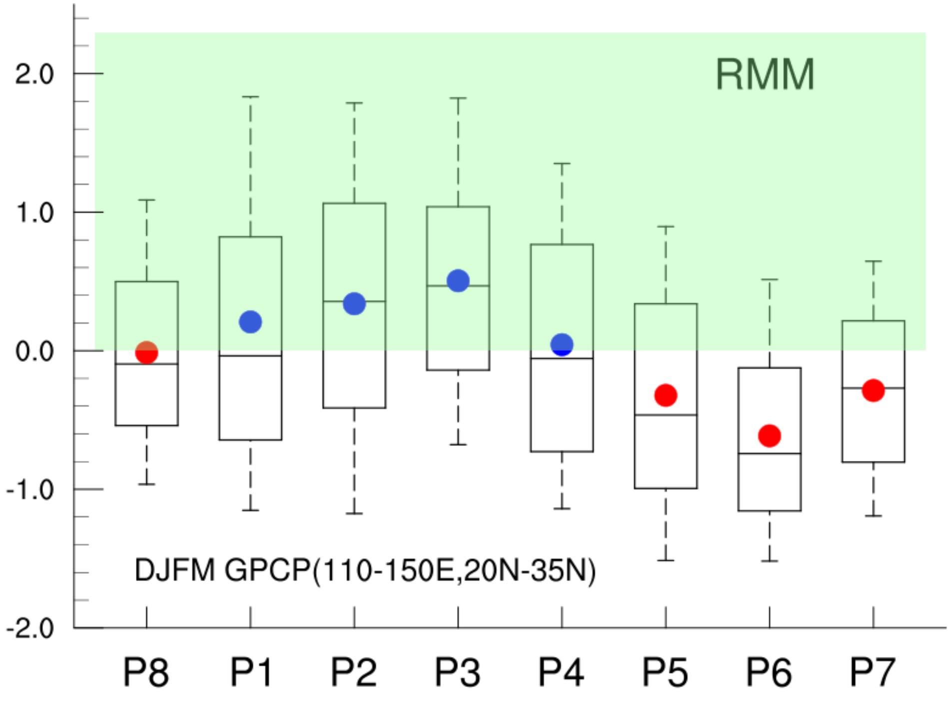
BLUE : WET **RED : DRY**

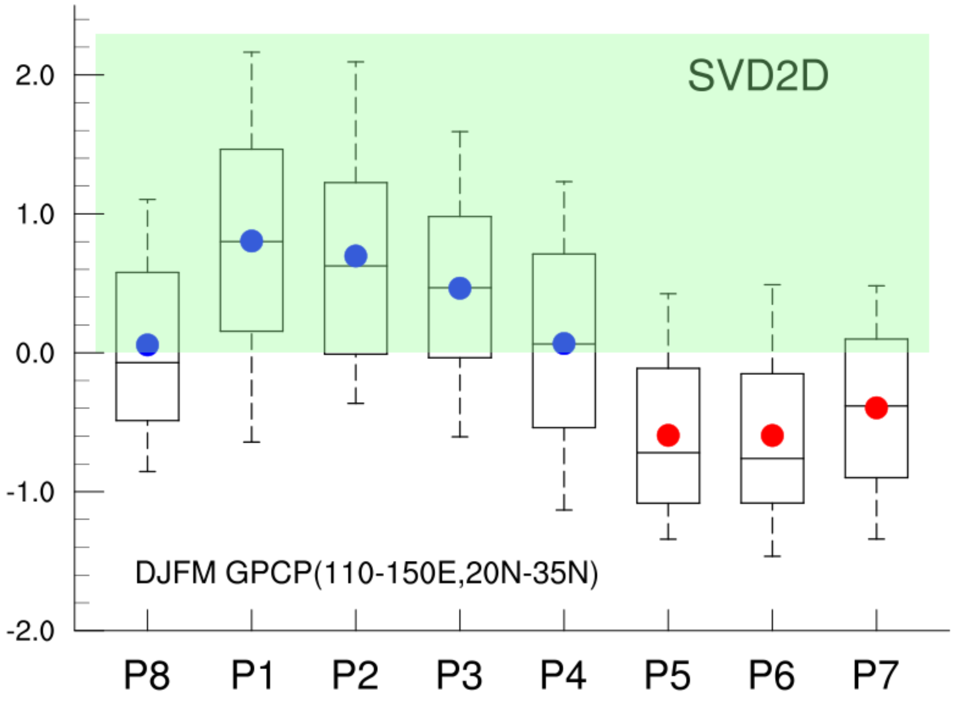
The spatial pattern of the two leading modes of OLR for (a) RMM(WH04), (b) SVD.

The rainfall anomalies distribution in terms of the 8 MJO phases : RMM & SVD

SVD composite for the complete cycle of evolution of the EA rainfall anomaly through the 8 MJO phases is more conspicuous, while the RMM composite is more ambiguous.

East Asia DJFM rainfall GPCP(110-150E,20N-35N)





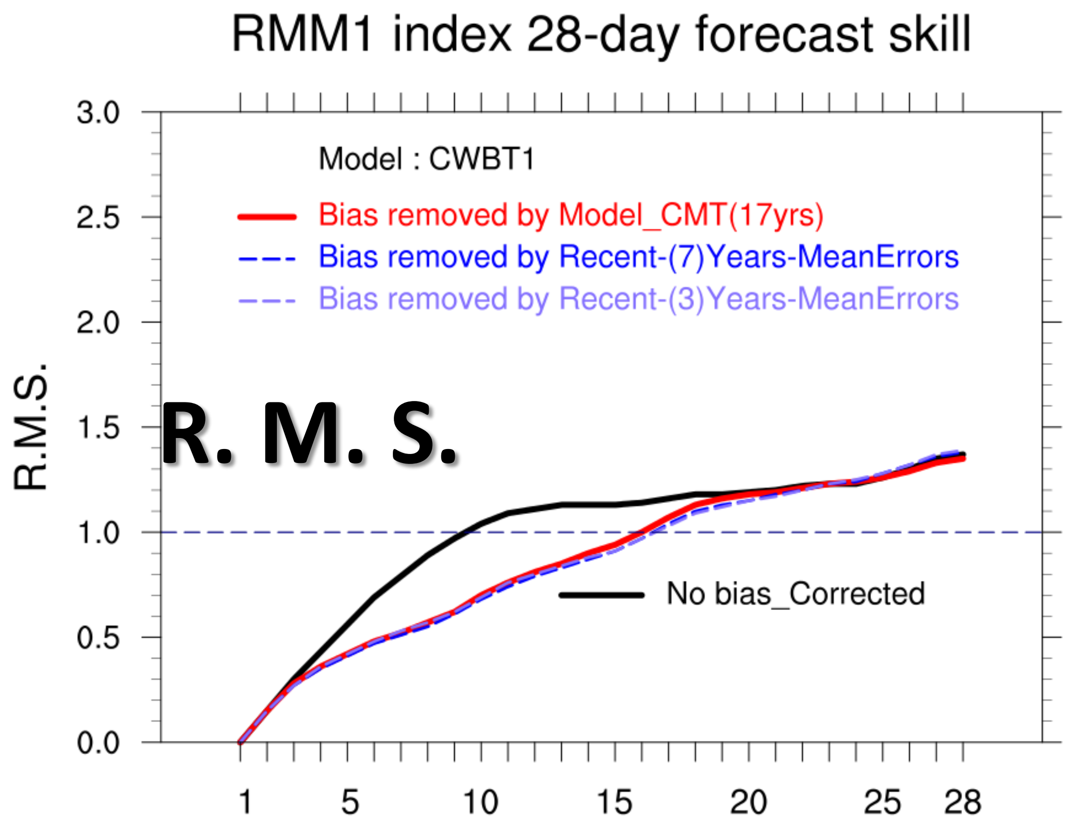
PDF of rainfall over EA jet entrance region(110-150E,20N-35N) in 8 MJO phases defined by: (a) RMM(WH04), (b) SVD. Solid dots denote the mean values.

Effect of bias removal on RMM forecast skill score

Model : CWB 1-Tier seasonal forecast model

Data : 2012-2018 DJFM

RMM1



RMM2