Forecasting local impacts of the MJO with global dynamical prediction systems

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Australian Government
Bureau of Meteorology

CSIRO

Background

- A number of global dynamical models are showing good skill at predicting the ***planetary-scale*** components of the MJO (i.e. RMM1 and RMM2).
- But how do we assess the prediction skill of MJO-related ***local weather impacts*** like rainfall (both tropical and extratropical)?
- Here I'll show an example of what we've learnt on this topic using hindcasts from the POAMA coupled prediction model.
- This is part of a larger effort we've been making in looking at intraseasonal prediction for Australia.
- Work in progress!

POAMA: Predictive Ocean-Atmosphere Model for Australia

T47 L17 atmosphere, tuned for a good MJO.

ACOM2 ocean: 0.5°(lat) x 2°(lon) resolution near equator.

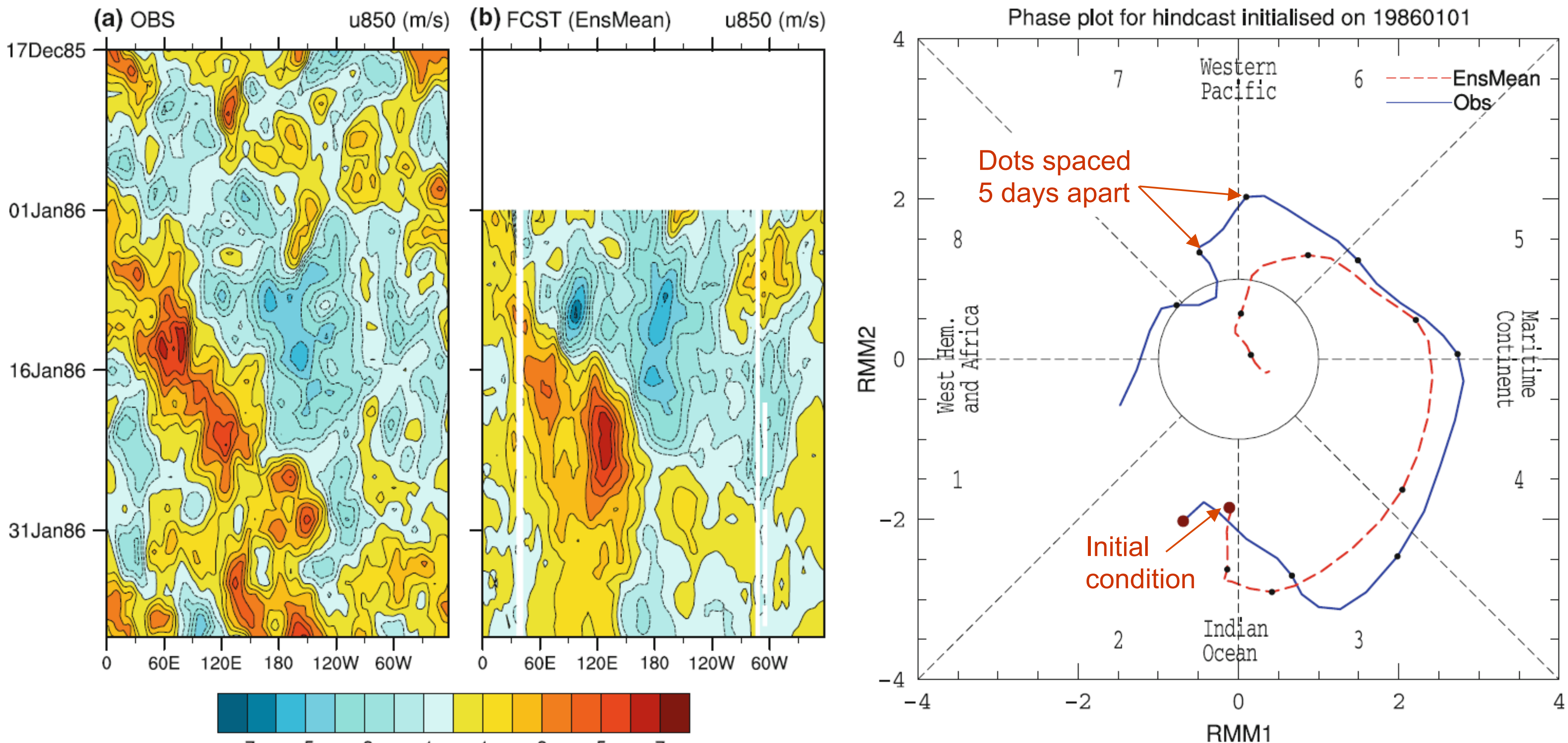
Ocean ICs from an ocean data assimilation scheme

Atmospheric ICs from an offline run of the atmosphere that is nudged towards ERA-40 reanalyses. This results in ICs that are very similar to ERA-40 but more in balance with the atmospheric model.

Hindcasts are a 10-member ensemble starting from 1^{st} of each month for 1980-2006. Ensemble is generated by having atmospheric ICs from successively 6 hours apart.

We assess the prediction skill of the ***planetary-scale components*** of the MJO using the RMM indices.

Example behaviour of the RMM indices in forecast from 1st Jan 1986

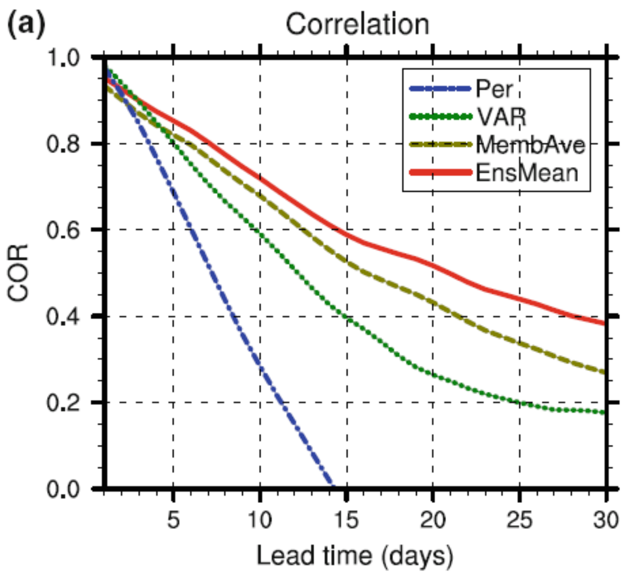


Note: Computation of RMM uses 15°S to 15°N averaged OLR, u850, and u200 (Wheeler and Hendon, 2004).

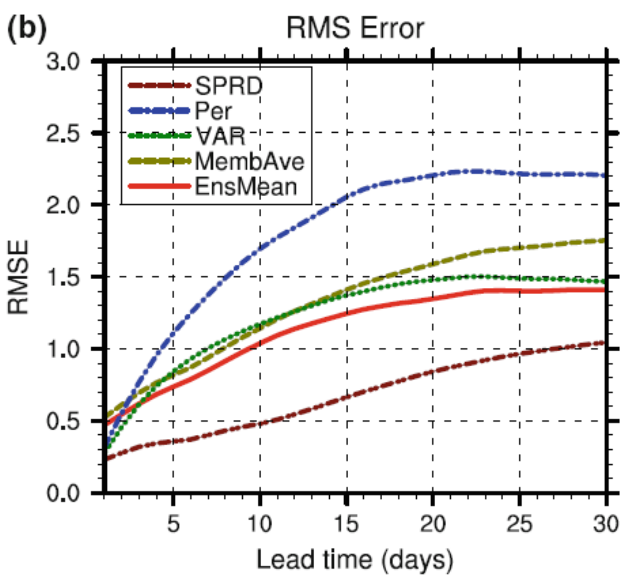
Evaluate forecasts of RMM with **bivariate correlation**, **bivariate RMSE**, **bivariate amplitude**

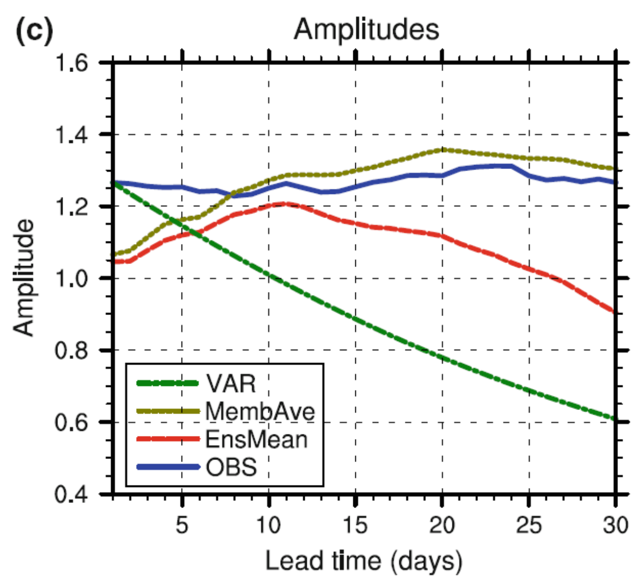
Method adapted from Hai Lin (Lin et al. 2008), and consistent with Gottschalck et al. (2010).

Refer to **HARRY'S POSTER** (or Rashid et al. 2010) for details.



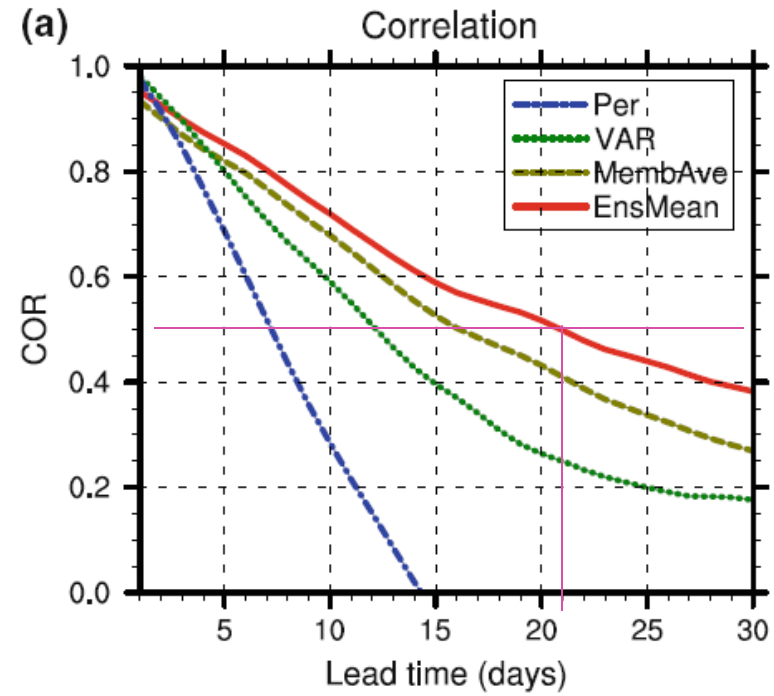
- Skill to ~21 days (for 0.5 correlation), beats the benchmark statistical scheme (vector auto-regressive model: VAR).
- Skill of ensemble mean better than mean skill of each individual member.
- Amplitude of individual members increases over first 10 days.





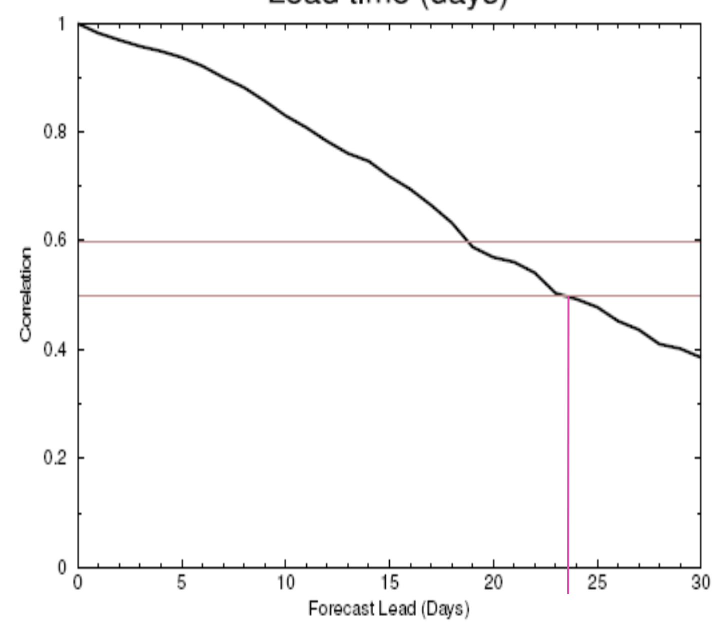
Rashid et al. (2010; *Clim. Dyn.*)

This skill for the MJO in POAMA is not much different to the ECMWF monthly system.



From Vitart et al. (2010)

T399/T255 atmospheric model



Skill to ~21 days for POAMA compared to ~24 days for ECMWF.

But does this “good” prediction of the MJO translate into improved predictions of local-scale weather impacts?

How do we assess this?

In Australia, we have been actively exploring the answers to these questions, especially in relation to **local rainfall**.

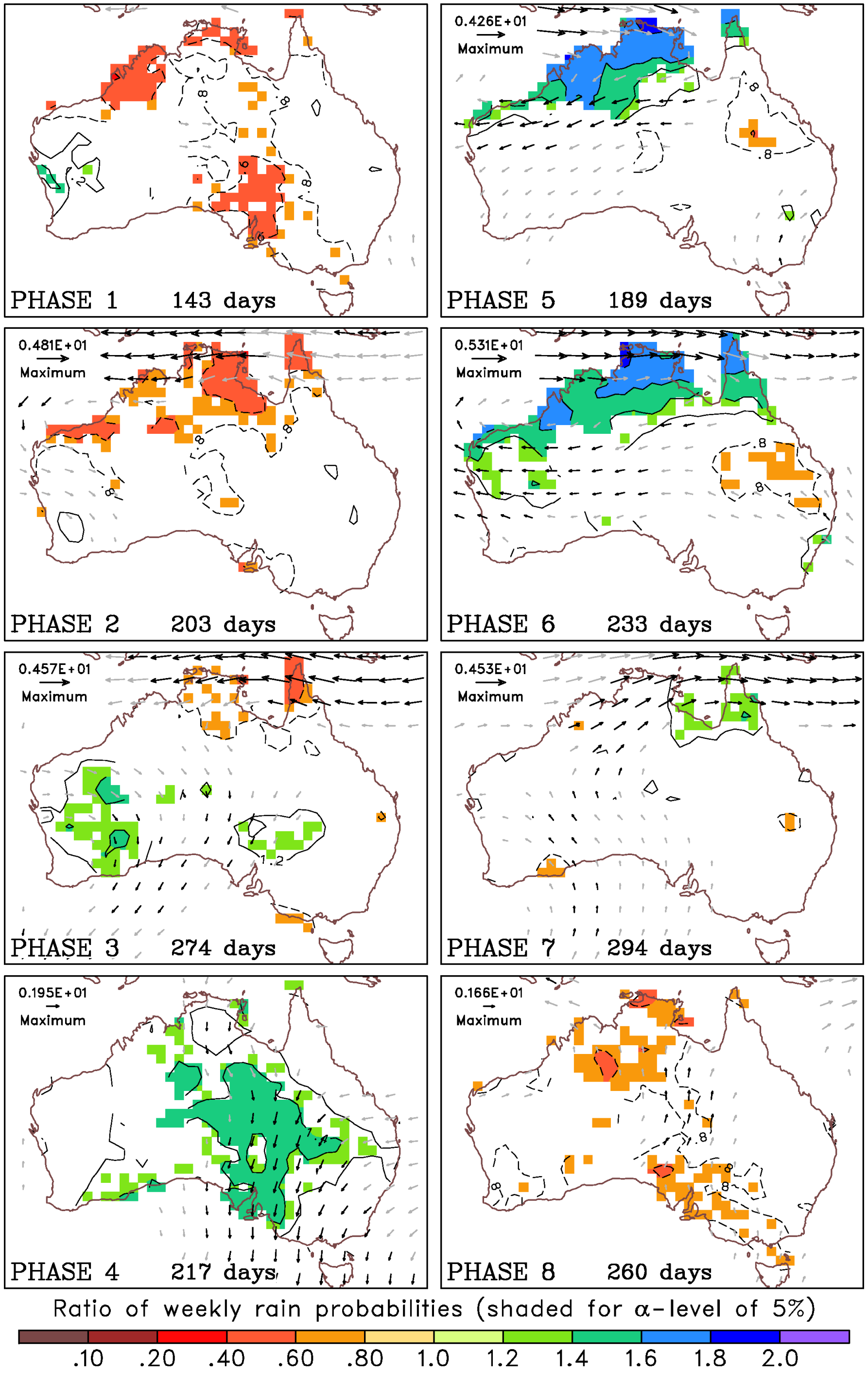
The observed MJO impact on local rainfall in Aus

Weekly rainfall probabilities conditioned on the ***RMM phase***.

The large impact in **northern Australia** is well known.

But the impact can be seen to extend into **southern Australia** as well.

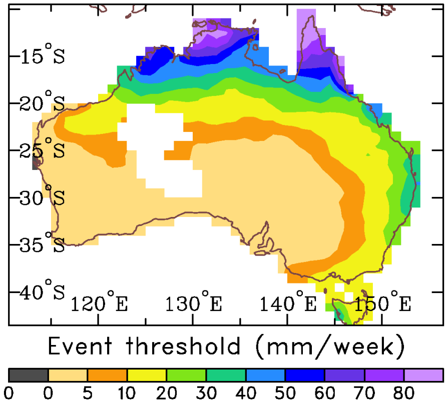
Wheeler et al. (*J. Climate*, 2009)



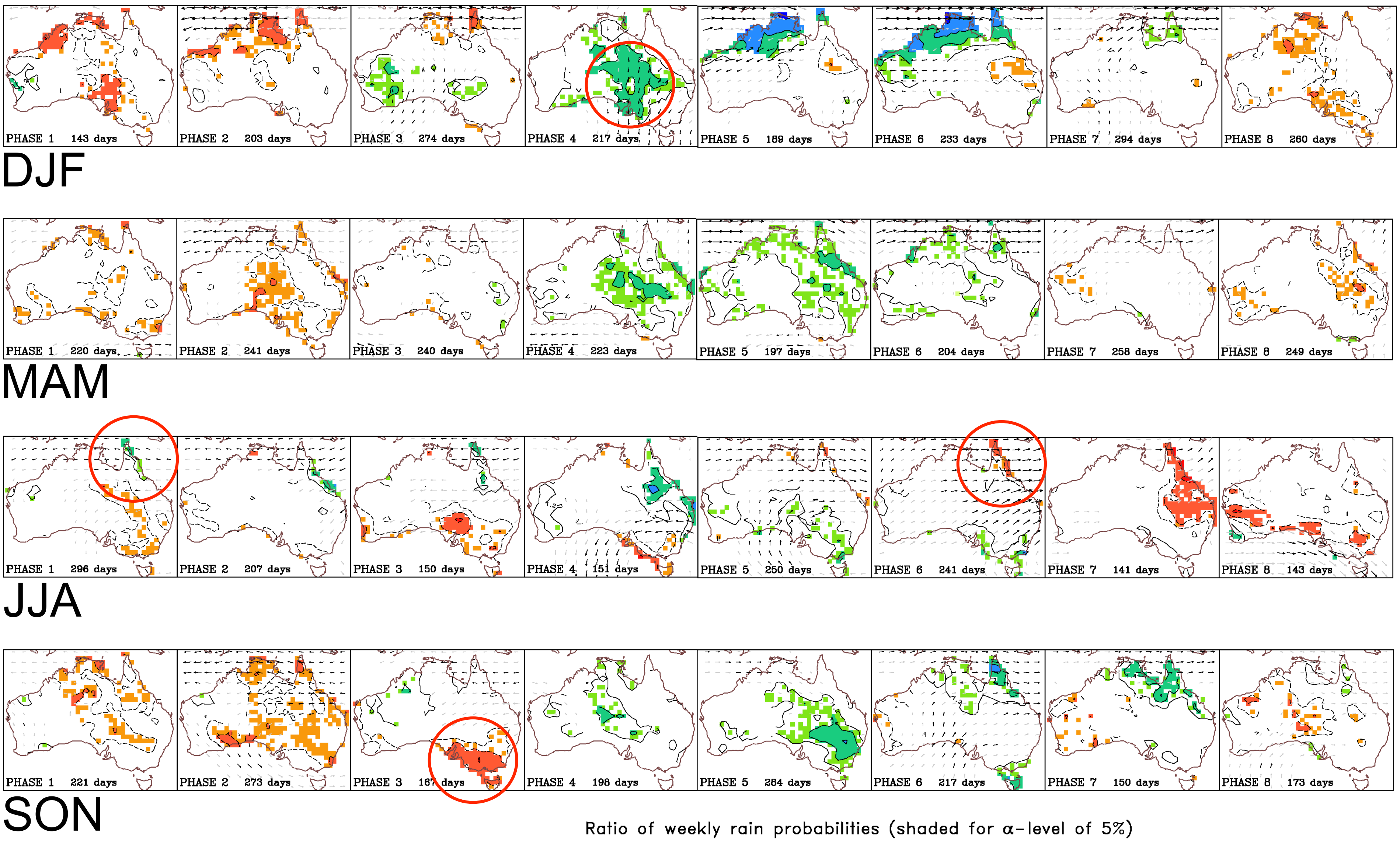
DJF

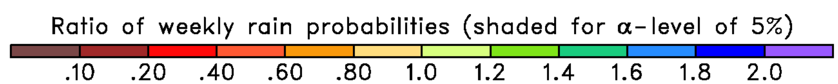
Weekly rainfall Probabilities

850 hPa winds



Extending this to all seasons: Shows complex behaviour of some local rainfall impacts. Ideally, we'd like to be able to predict these features in our dynamical models.

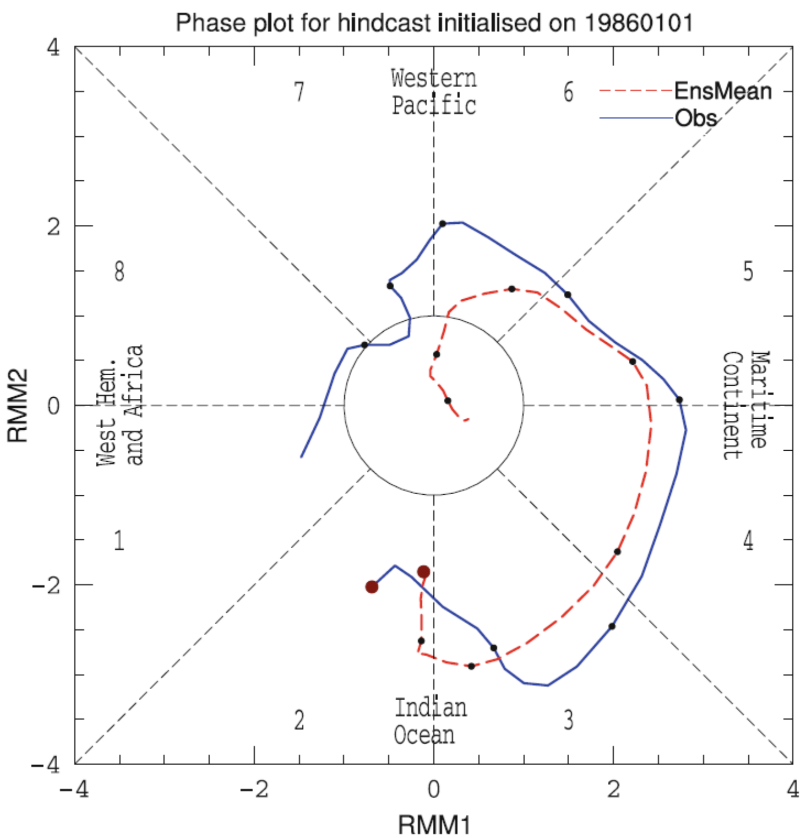




Wheeler et al. (*J. Climate*, 2009)

1st thing to check: Are the large-scale composite rainfall patterns produced by the model realistic?

Remember: RMM1 and RMM2 are functions of winds and OLR, so even with a good prediction/simulation of the RMM there is no guarantee that even the large-scale tropical rainfall patterns should look realistic.



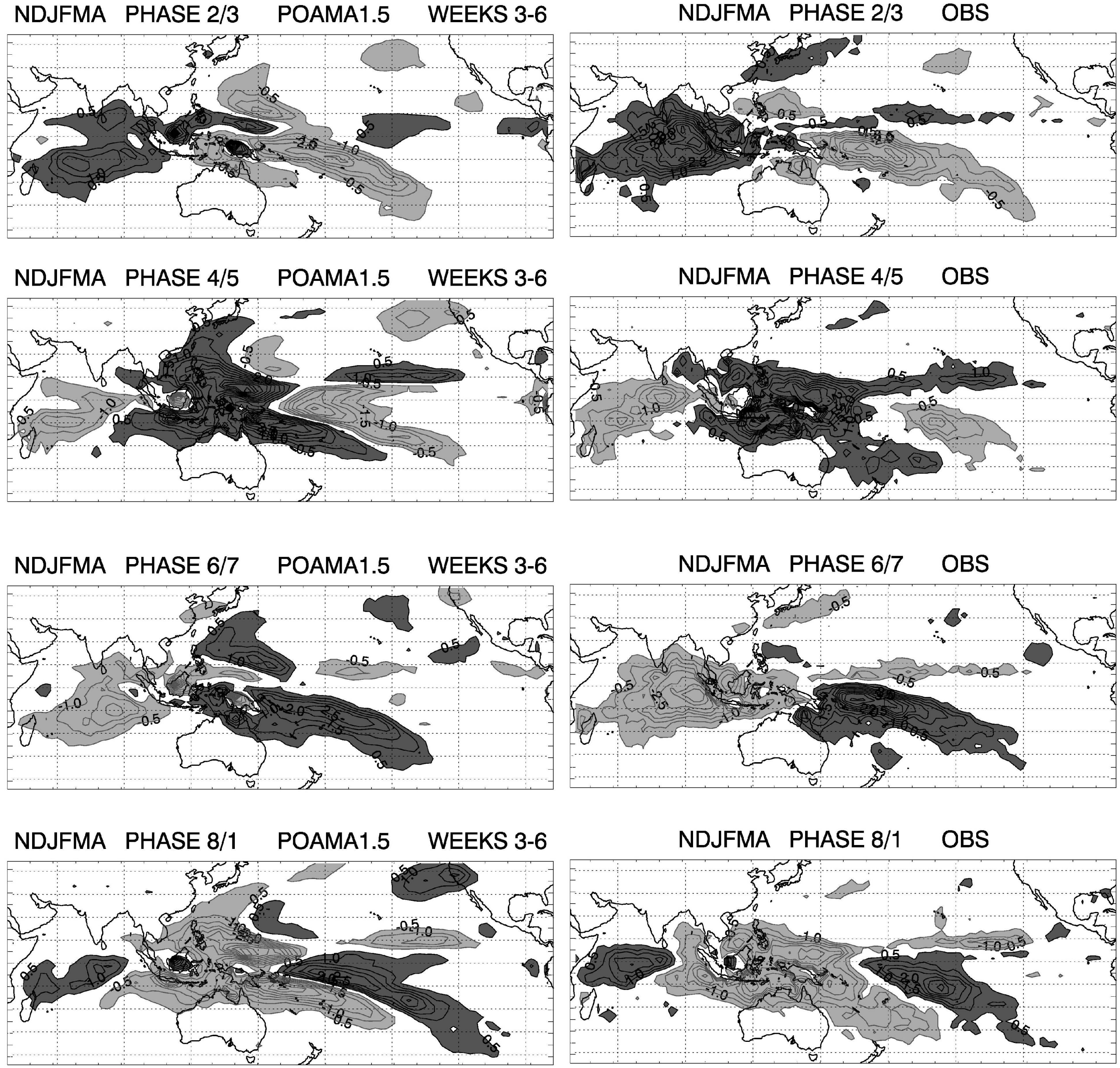
We composite the forecast rainfall as a function of the forecast RMM phase.

Initially we do this only for forecast times > 15 days.

NDJFMA
season

Yes, they look qualitatively quite good in the tropics.

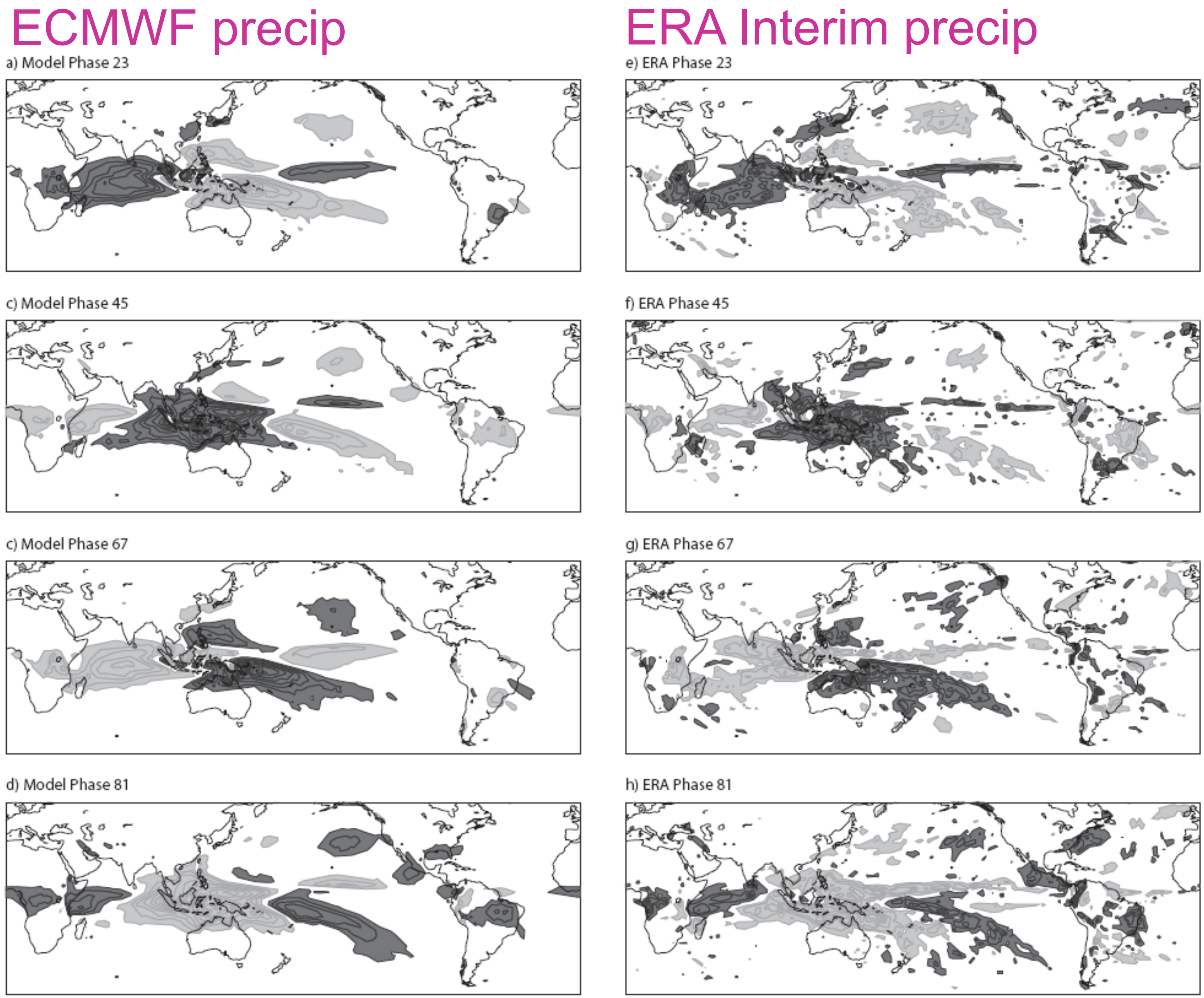
POAMA precip | CMAP observations



interval = 0.5 mm/day

This is the same thing from ECMWF (Vitart and Molteni, 2010)

Nov-Apr

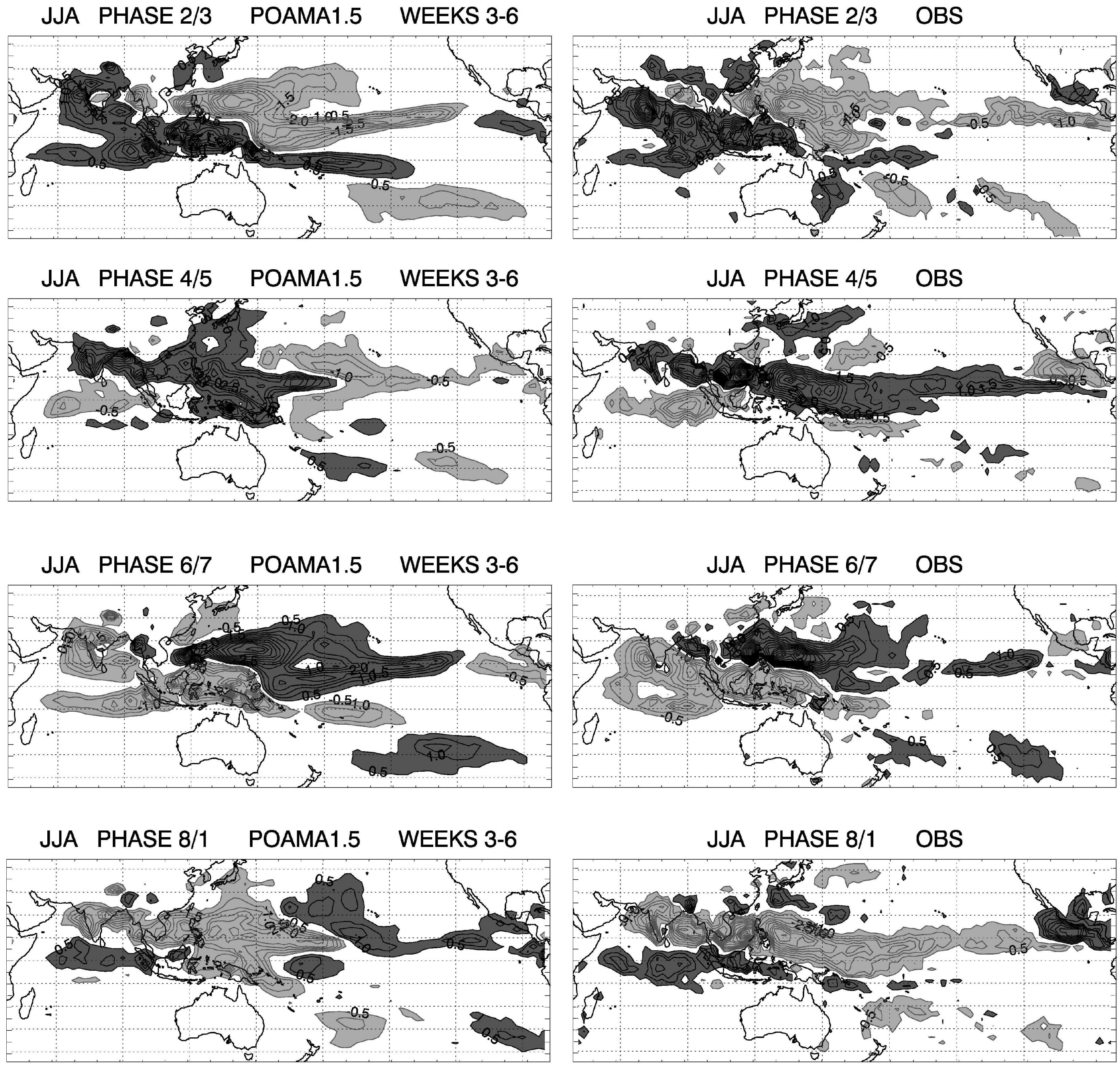


interval =
0.5 mm/day

POAMA precip   CMAP observations

Same thing for JJA season

Perhaps a bit worse.



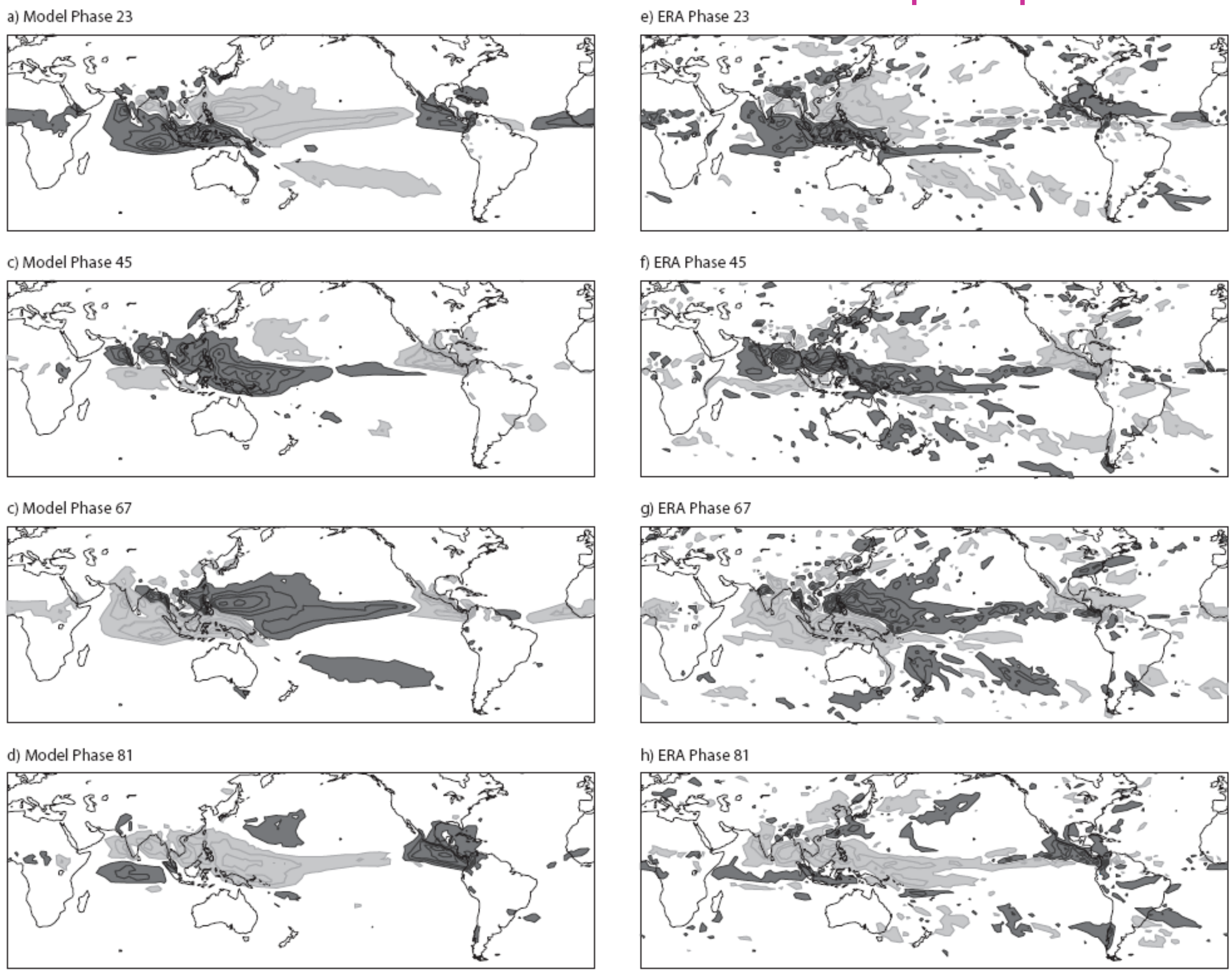
interval = 0.5 mm/day

This is the same thing from ECMWF (Vitart and Molteni, 2010)

JJA

ECMWF

ERA Interim precip

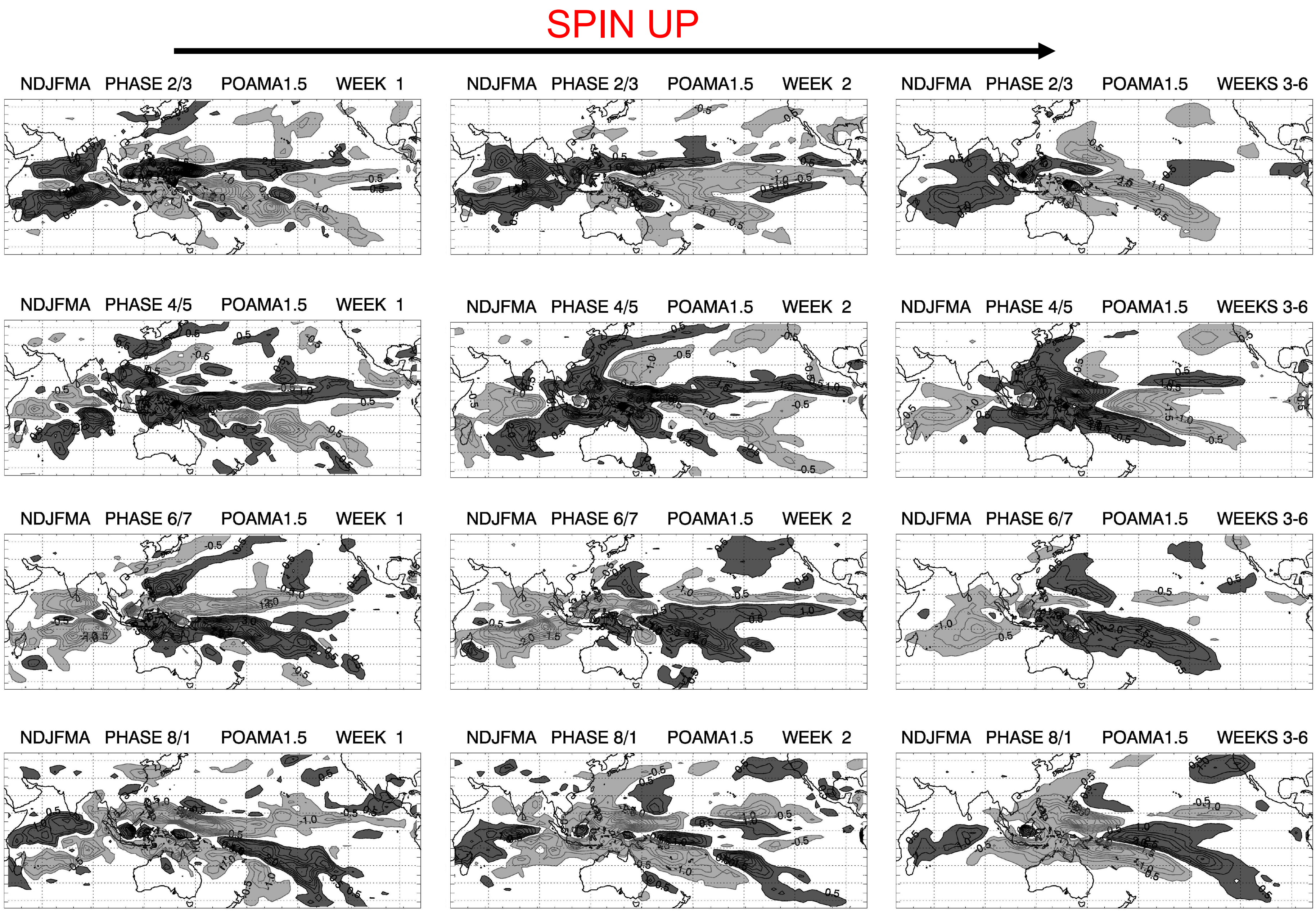


interval =
0.5 mm/day

What happens if you do this same calculation but using forecast data from nearer the initial condition?

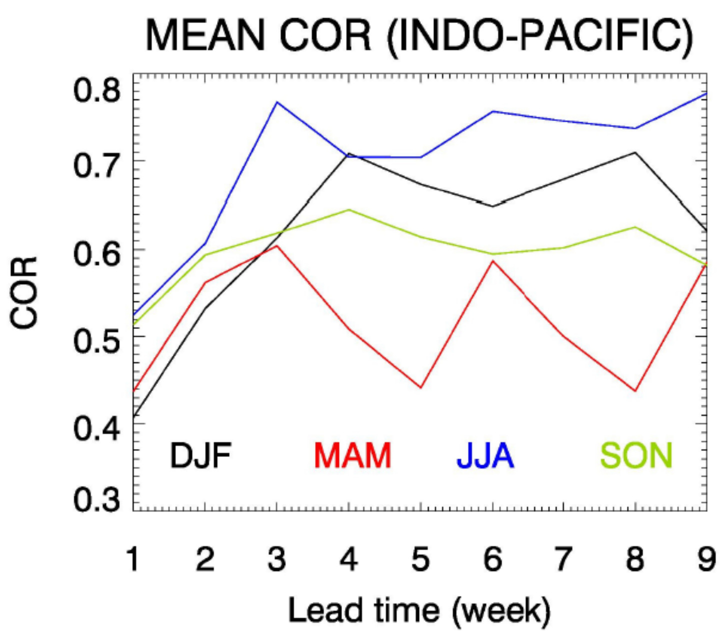
For **ECMWF** it presumably looks even better, as it is initialized with ERA initial conditions.

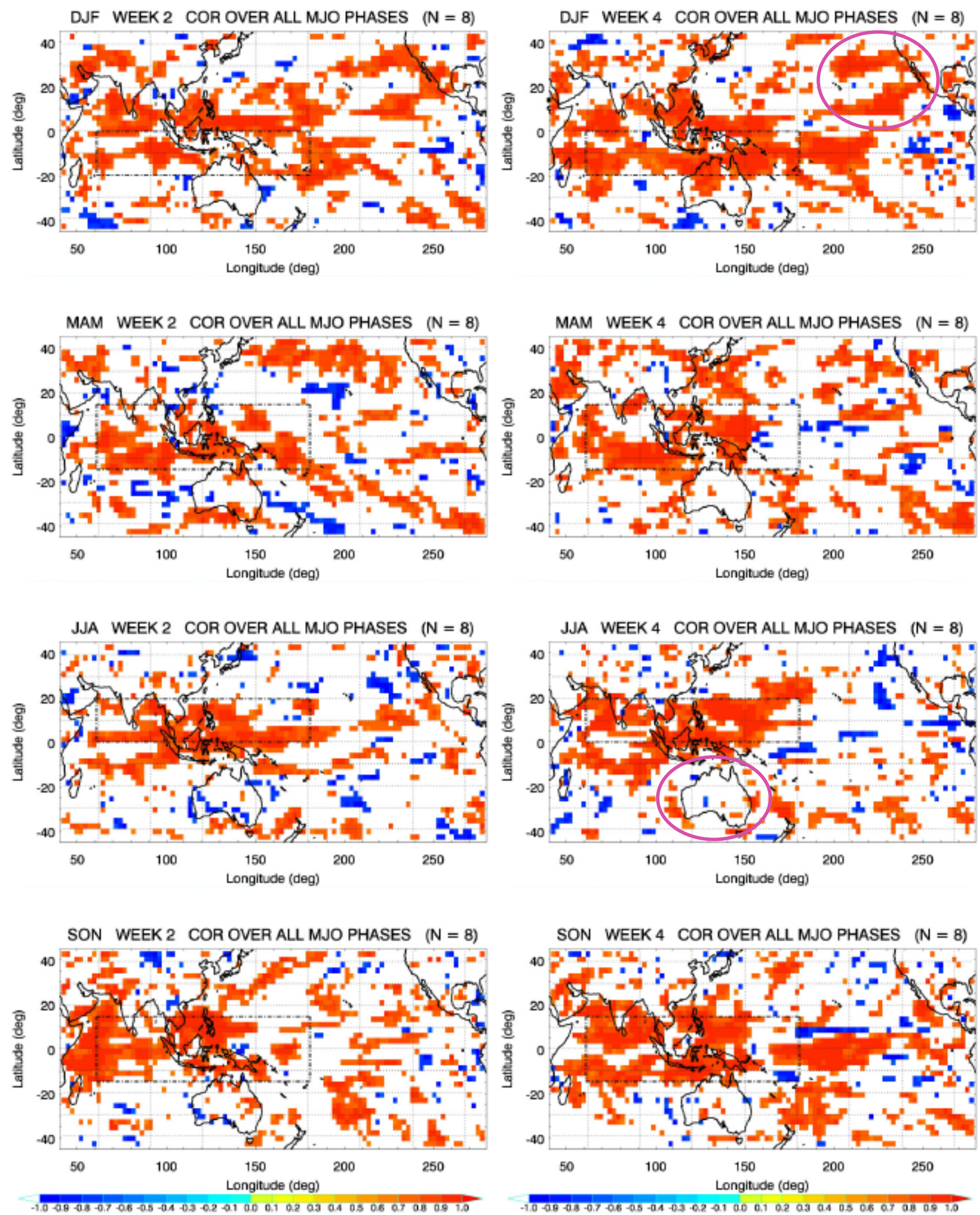
However for POAMA, the patterns actually look worse in first 2 weeks. POAMA suffers from spin-up from the ~ERA initial conditions.



We can quantify the MJO-rainfall relationship by computing the correlation of the composite observed and forecast rainfall over the 8 phases.

The correlation gets a lot better after week 2.





2nd thing to do: Is the forecast skill improved for times when the MJO is strong in the initial conditions?

Look at ROC scores for probabilistic forecasts of grid-point precip in the upper tercile

Nov-Apr

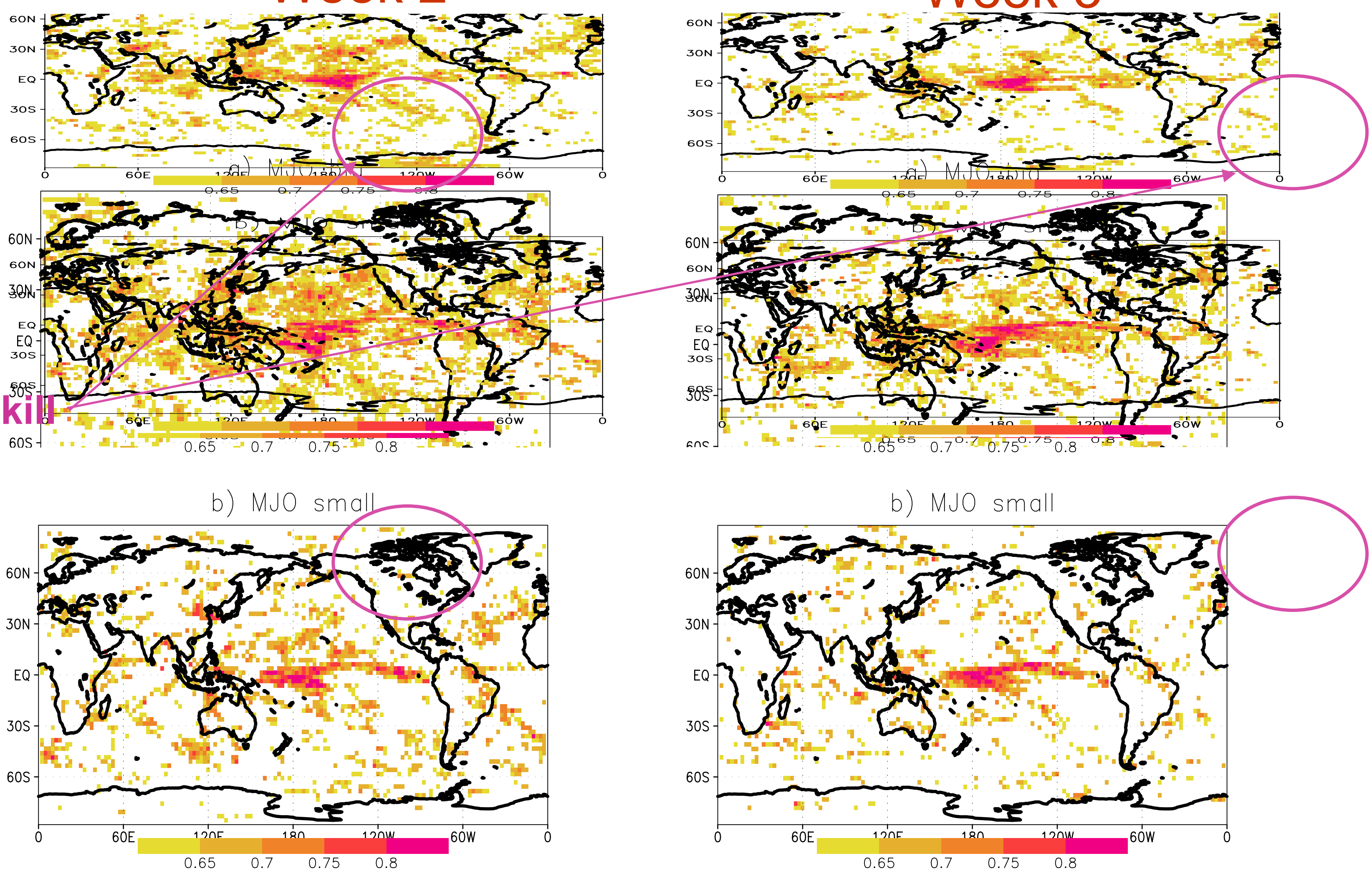
Week 2

Week 3

MJO Strong
(n=94)

Increased skill

MJO Weak
(n=62)



ROC scores significant at the 5% level are shaded

A similar result has been shown for **ECMWF** by Vitart and Molteni (2010).

ROC score averaged over land points north of 30°N.

Nov-Apr

Area-averaged ROC score is higher when an MJO is strong in the initial conditions

ECMWF is better!

precipitation

	Day 5-11	Day 12-18	Day 19-25	Day 26-32
ROC SCORE	0.72 (0.70)	0.61 (0.58)	0.55 (0.52)	0.53(0.51)
BSS	0.12 (0.08)	0.01 (-0.02)	-0.04 (-0.07)	-0.06 (-0.06)

MJO strong (MJO weak)

850 hPa temp

	Day 5-11	Day 12-18	Day 19-25	Day 26-32
ROC SCORE	0.87 (0.87)	0.70 (0.68)	0.64 (0.56)	0.57(0.52)
BSS	0.42 (0.42)	0.10 (0.07)	0.04 (-0.06)	-0.02 (-0.08)

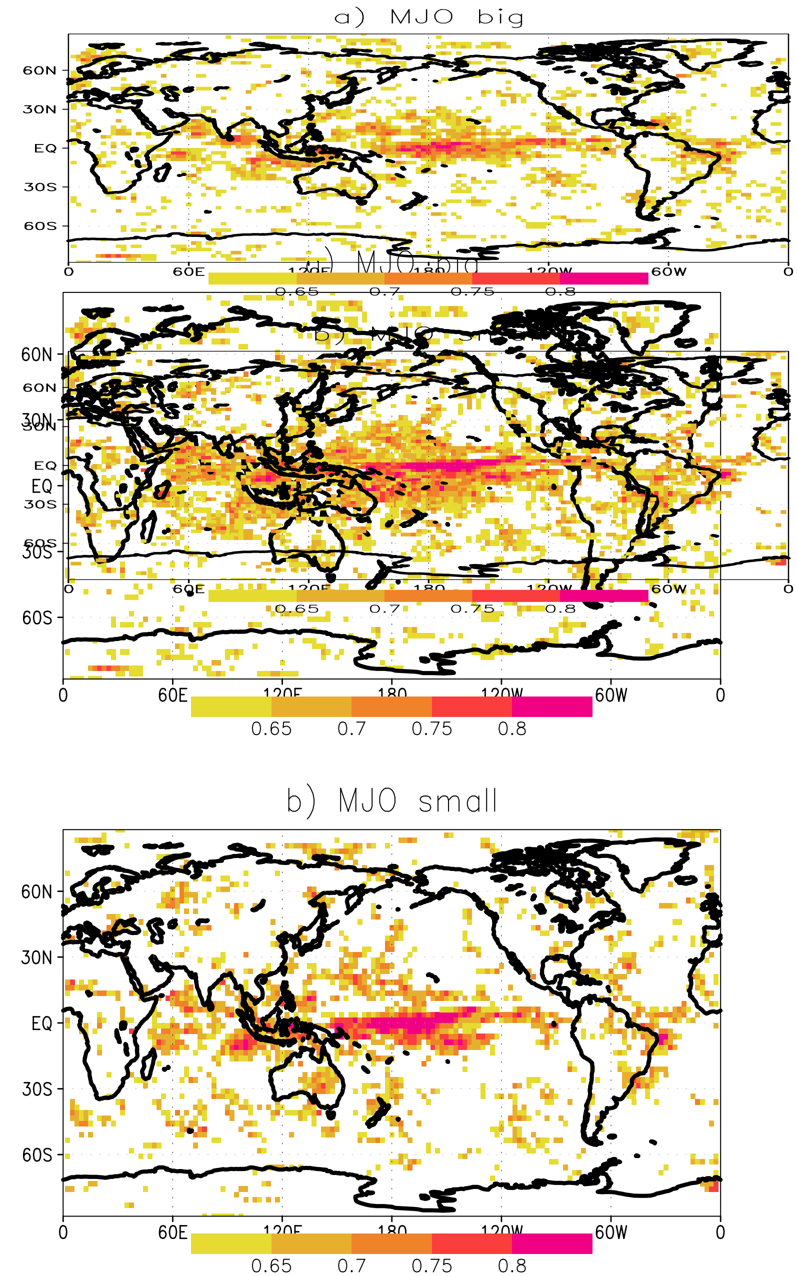
500 hPa height

	Day 5-11	Day 12-18	Day 19-25	Day 26-32
ROC SCORE	0.88 (0.87)	0.72 (0.68)	0.61 (0.55)	0.56(0.53)
BSS	0.41 (0.41)	0.14 (0.07)	0.02 (-0.07)	-0.05 (-0.06)

Table 2: ROC and Brier skill scores for the periods day 5-11, 12-18, 19-25 and 26-32 for the probability that 500 hPa geopotential height is in the upper tercile when there is an MJO in the initial conditions. Number in parentheses indicate the scores when there is no MJO in the initial conditions.

How about the opposite season? **May-Oct**

Weeks 2+3



Unfortunately, not much improvement is seen.

Perhaps other variables better?

Summary/ideas/discussion #1

1. POAMA hindcasts show quite good skill for forecasting the planterary-scale MJO (RMM1 and RMM2).

2. POAMA gets the correct grid-point rainfall relationship in much of the tropics, and perhaps in some extratropical regions as well.

3. However, there is spin-up that makes the POAMA rainfall patterns worse in the first 2 weeks.

4. For overall skill, competition exists between the prediction skill provided by the MJO, and this spin-up.

Summary/ideas/discussion #2

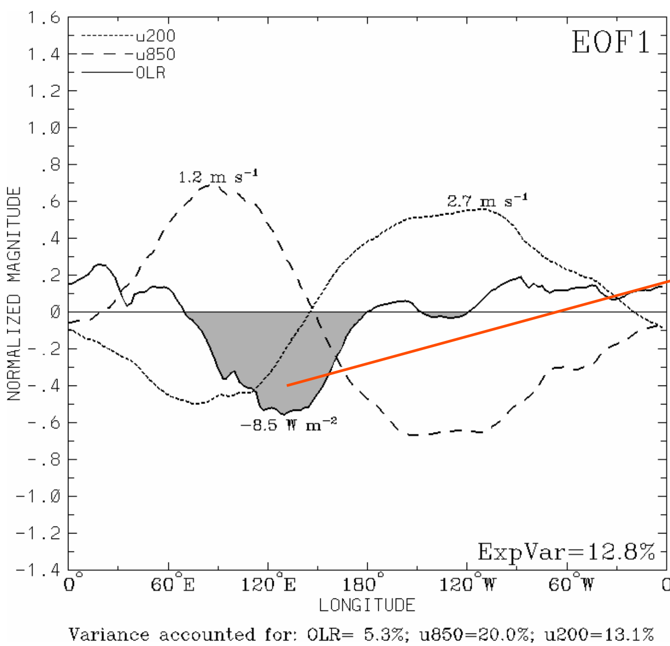
5. Skill categorized for MJO strong versus MJO weak shows some MJO-induced improvements in some locations around the globe.

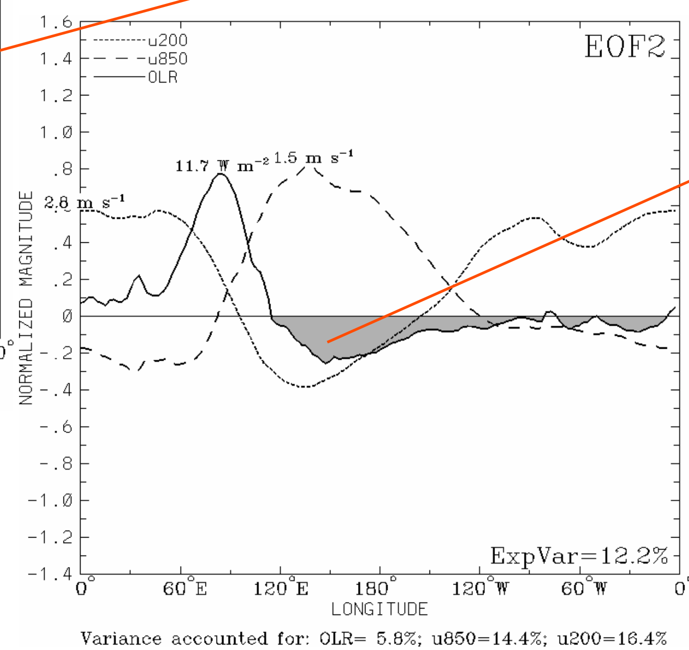
6. However, we currently don't see much of this MJO-induced improvement over Australia. Knowing the observed relationship with rainfall, this provides some hope for future improvements.

Recommendation: MJO strong versus MJO weak skill calculations should be computed for model hindcast datasets, and shown globally.

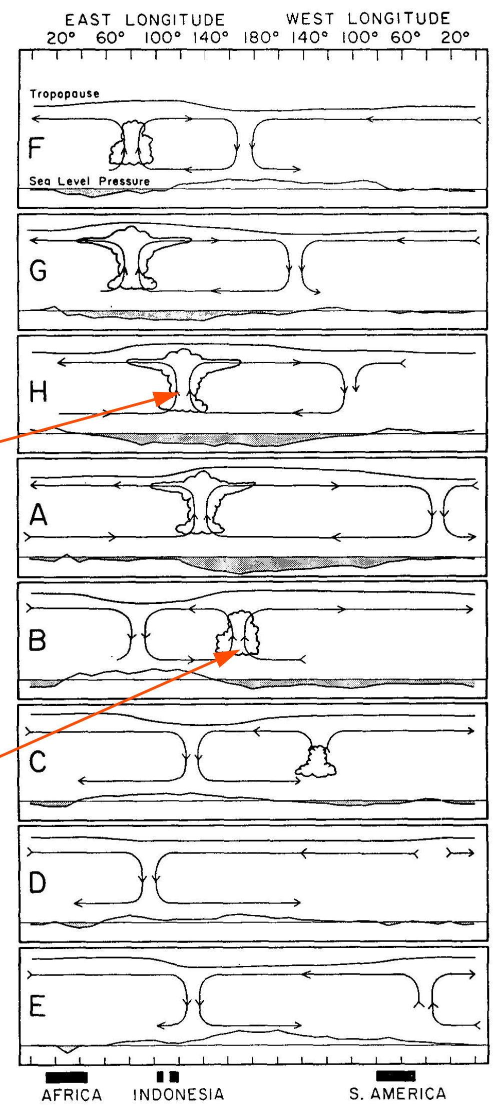
extras

The EOFs describe the convectively-coupled vertically-oriented circulation cells of the MJO that propagate eastward along the equator.





Wheeler and Hendon (2004)



Madden and Julian (1972)

Next thing to try: Is there any improvements in skill when MJO is strong in the initial conditions?

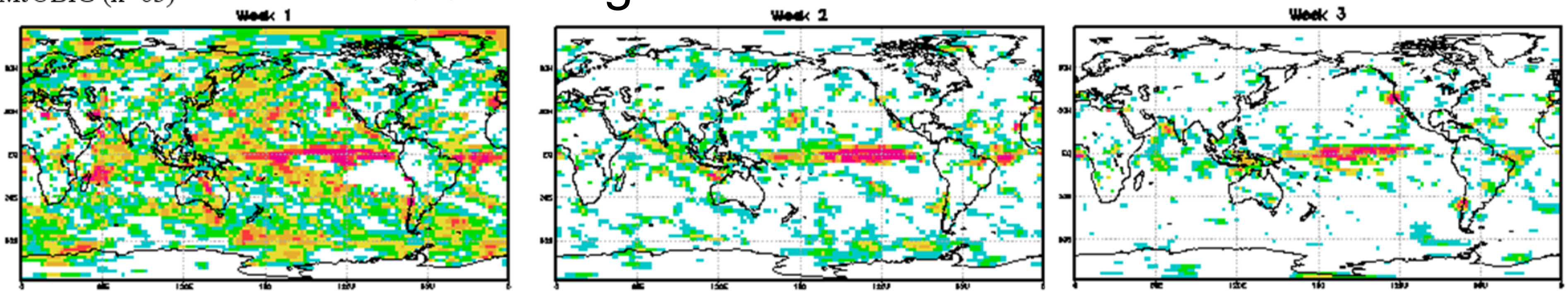
Look across the whole globe using CMAP rainfall as obs.

No great difference in skill between weak/strong MJO can be seen.

MJJASO (mean_ampl = 1.17)

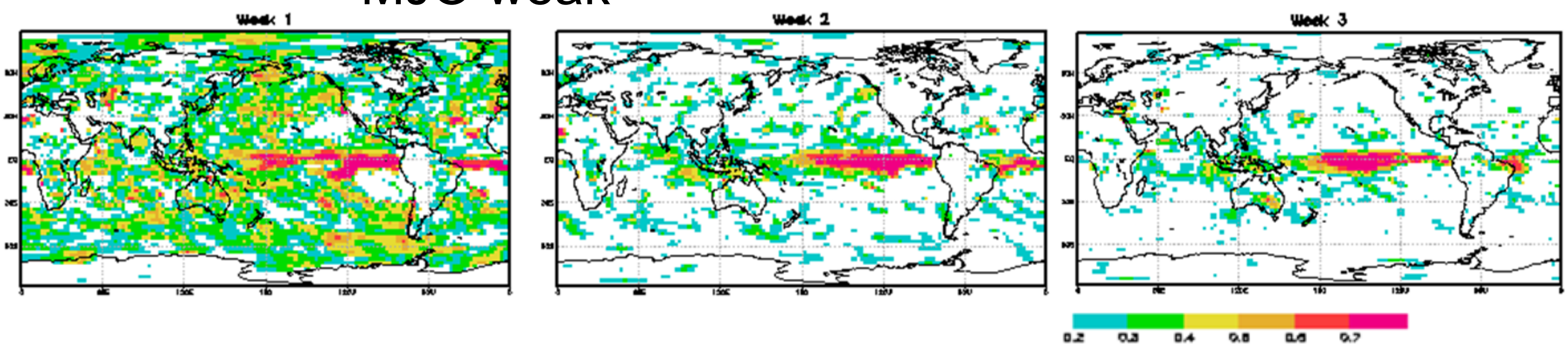
MJOBIG (n=63)

MJO strong



MJOSMALL (n=93)

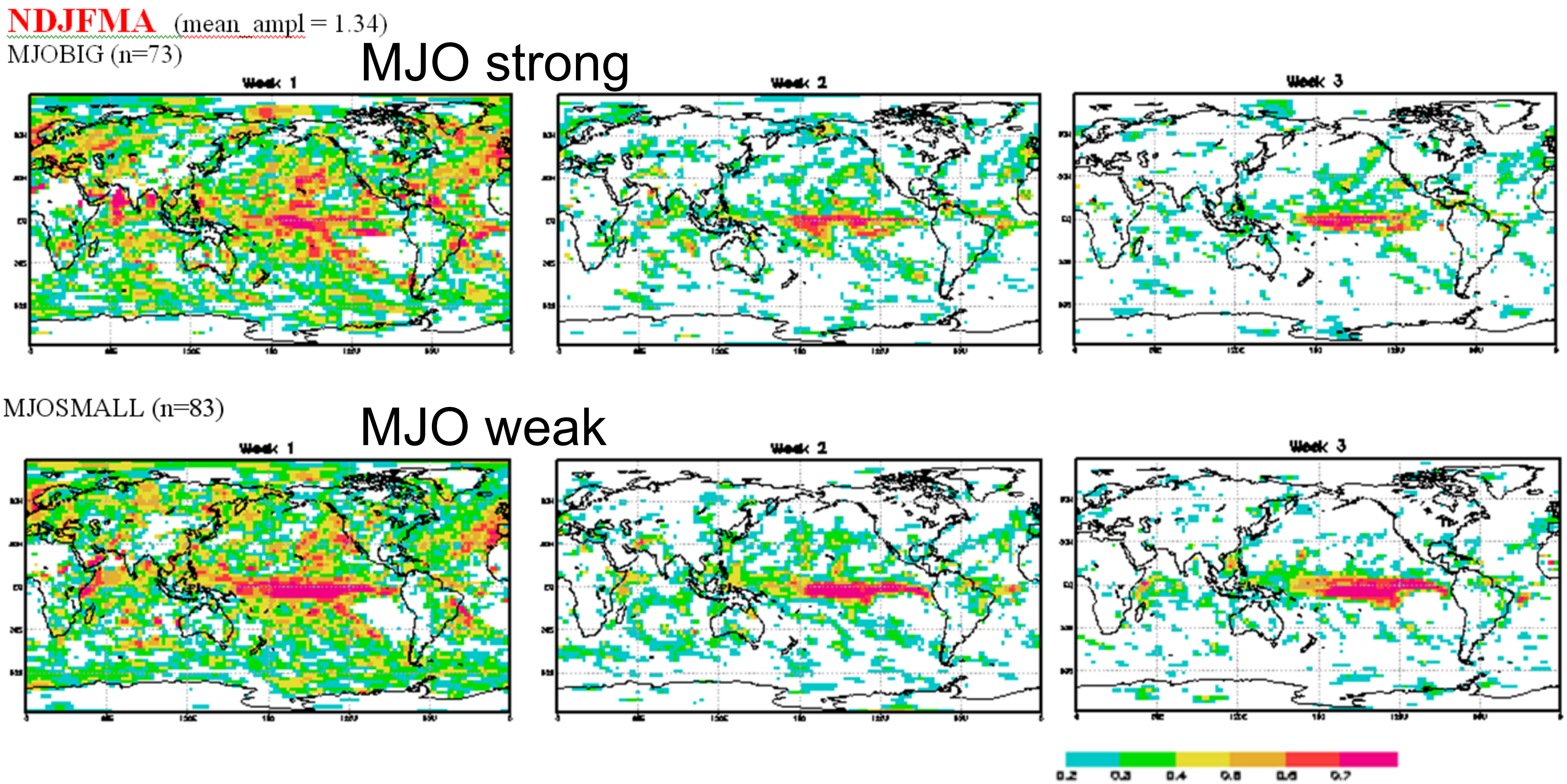
MJO weak



Same thing in opposite season.

The result is likely highly dependent on which categories the strong ENSO years end up.

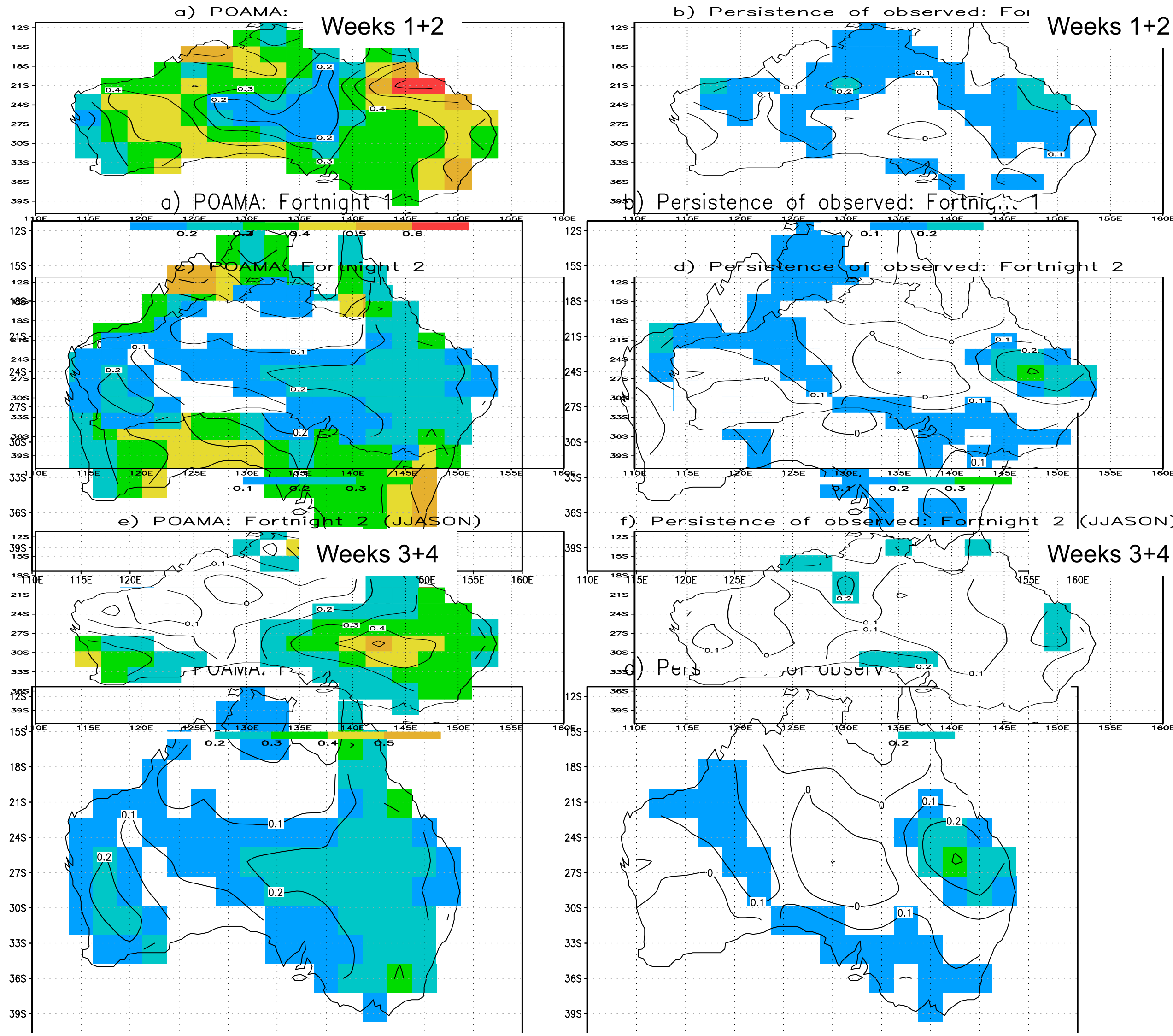
However, Frederic has reported a good result over land points north of 30N.



POAMA has skill in forecasting precipitation in weeks 1+2 and weeks 3+4

Correlation of predicted (ensemble mean) precipitation with observed for all forecast start months (n=324).

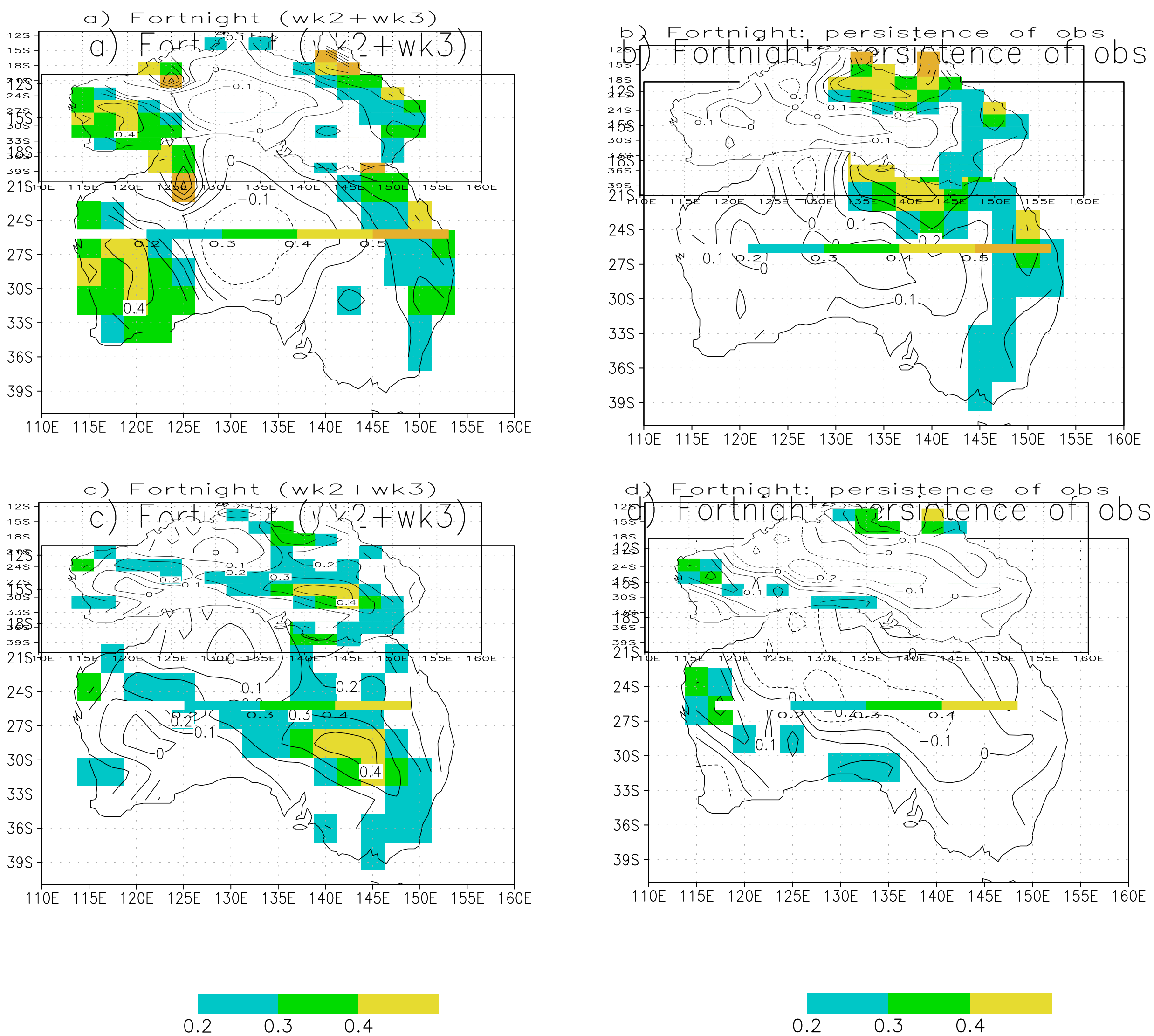
Most of this skill comes in JJASON.



Does any of this come from the MJO?

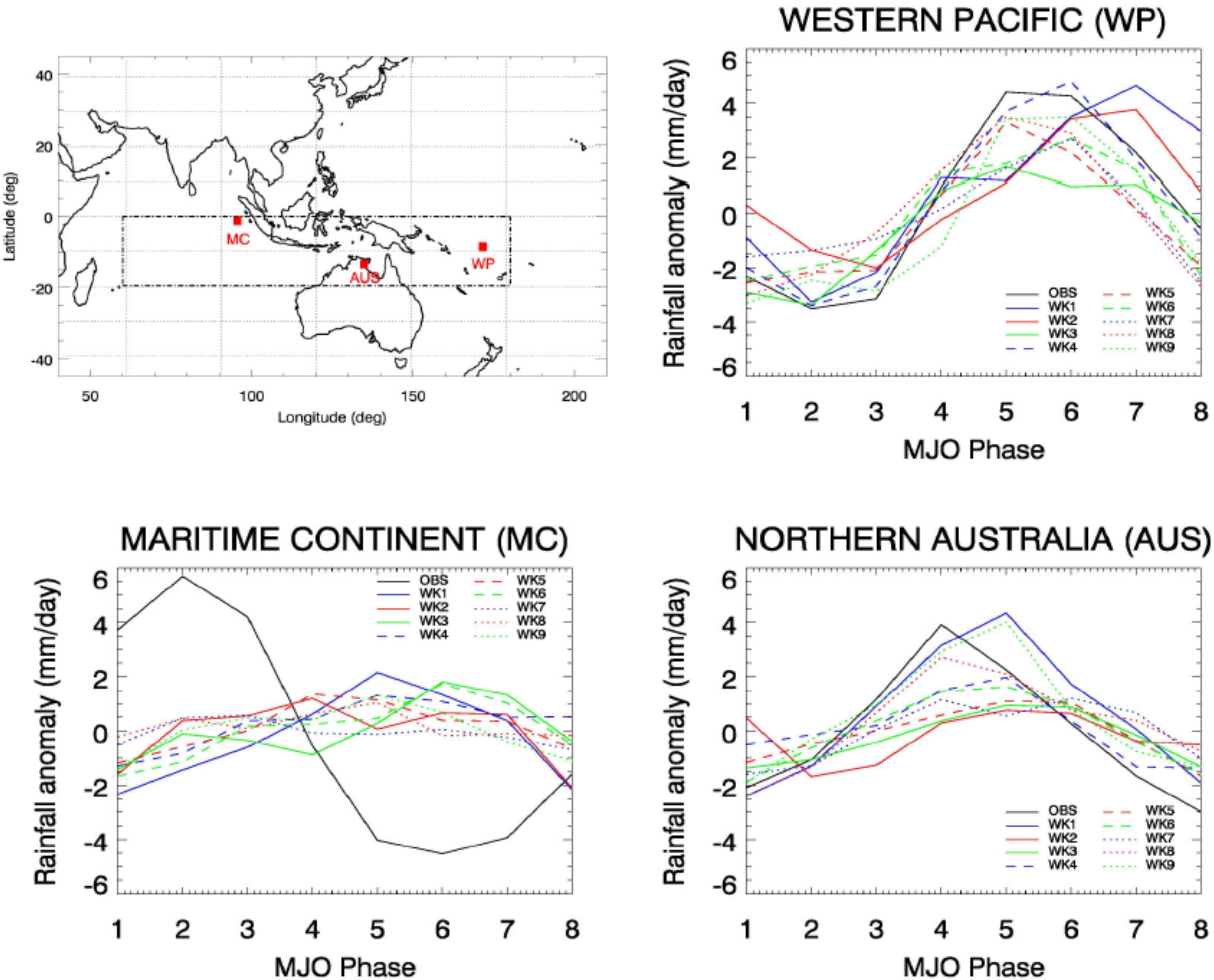
JJASON

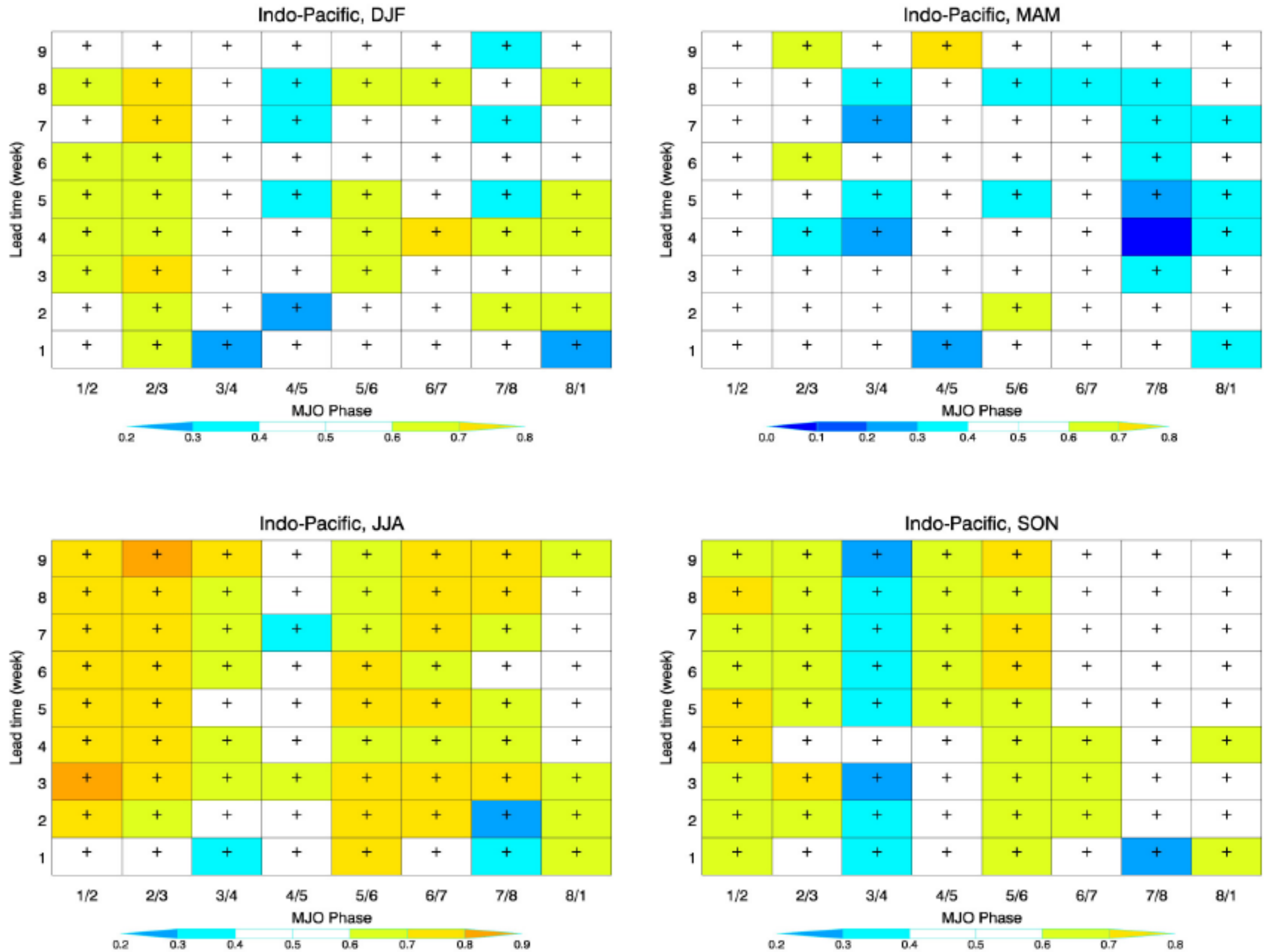
Fortnight: AVERAGING WKS 2 and 3
window = 7: average the obs MJO amplitude over the 7 day period starting on the IC date
MJO BIG: >1
MJO SMALL: <1



MJO big (n=85)

MJO small (n=77)


WESTERN PACIFIC (WP)
MARITIME CONTINENT (MC)
NORTHERN AUSTRALIA (AUS)
MC
AUS
WP
Latitude (deg)
Longitude (deg)
Rainfall anomaly (mm/day)
MJO Phase
OBS
WK1
WK2
WK3
WK4
WK5
WK6
WK7
WK8
WK9



Indo-Pacific, DJF
Indo-Pacific, MAM
Indo-Pacific, JJA
Indo-Pacific, SON
Lead time (week)
MJO Phase
1/2
2/3
3/4
4/5
5/6
6/7
7/8
8/1