Techniques and experiences in real-time prediction of the MJO: The BMRC perspective

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3 Approaches

Empirical

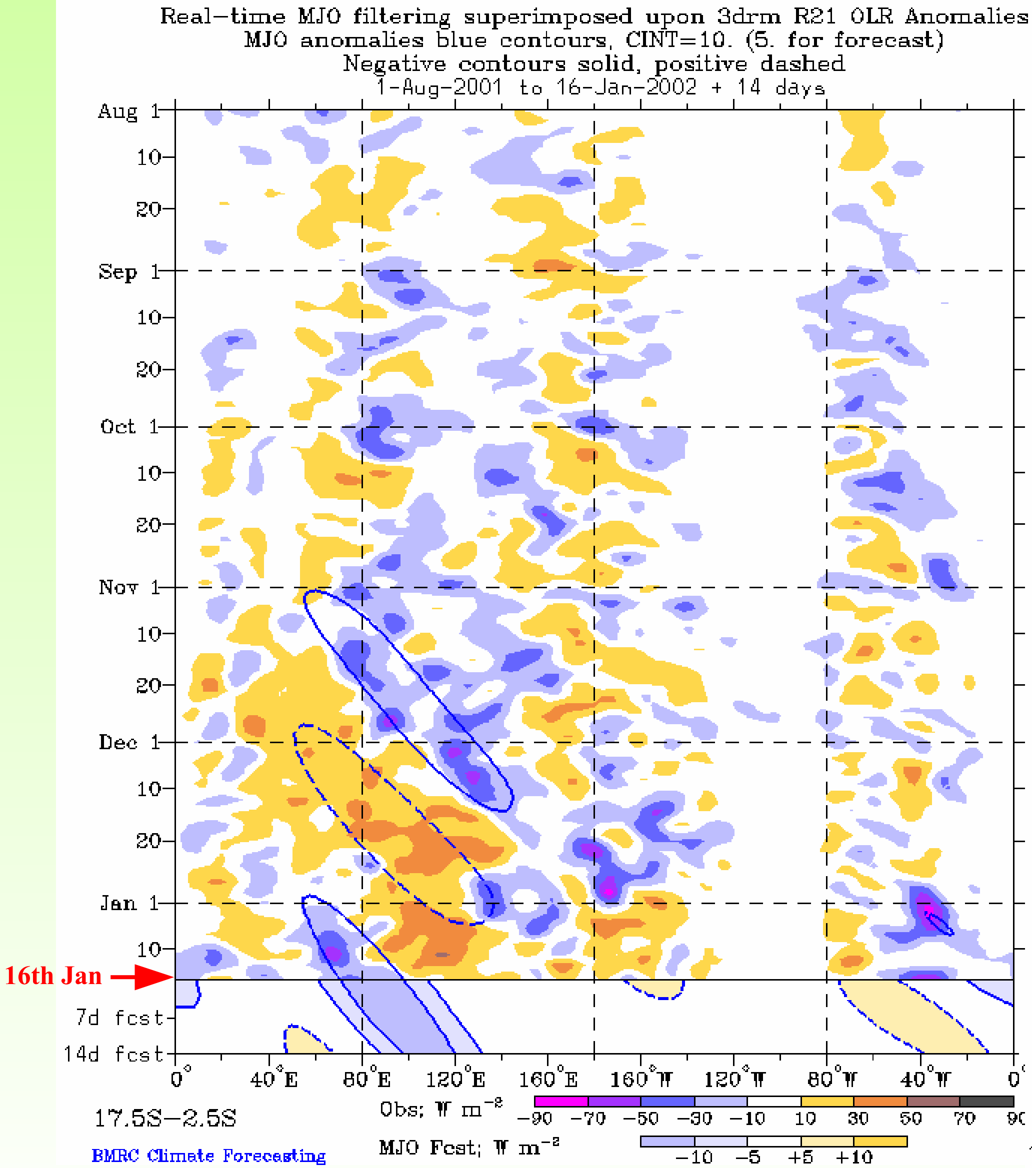
1. Wavenumber-frequency filtering *(very briefly)*
   http://www.bom.gov.au/bmrc/clfor/cfstaff/matw/maproom/OLR_modes/index.htm

2. Projection of daily observations onto combined EOFs of OLR, u850, and u200 to get two indices - what we call “Real-time Multivariate MJO” (RMM) 1 and RMM2.
   http://www.bom.gov.au/bmrc/clfor/cfstaff/matw/maproom/RMM/index.htm

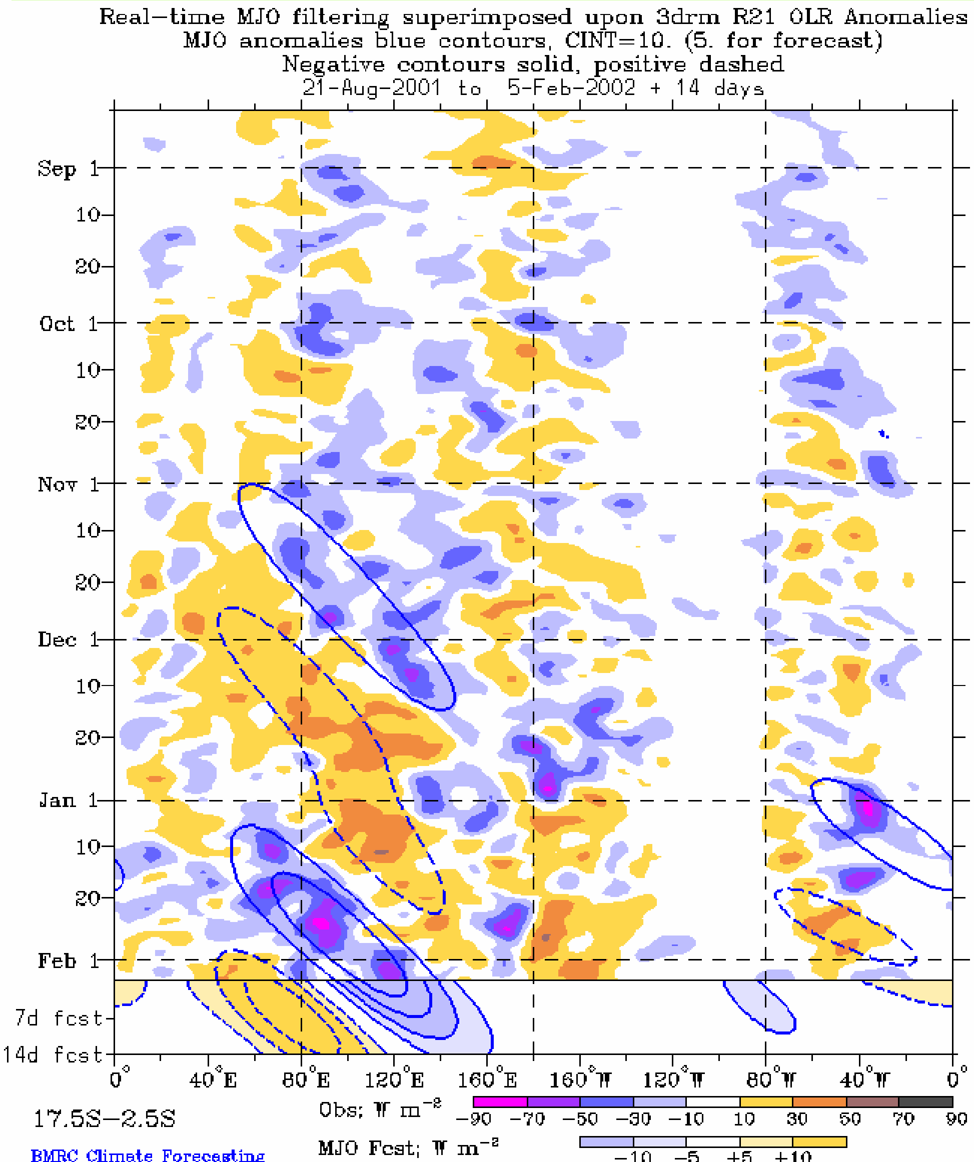
3. Coupled ocean-atmosphere forecast model - POAMA
   http://www.bom.gov.au/bmrc/ocean/JAFOOS/POAMA/

1. Wavenumber-frequency filtering of OLR

1/ Monitoring and forecast from 16th January



2/ Monitoring and forecast from 5th February (20 days later)



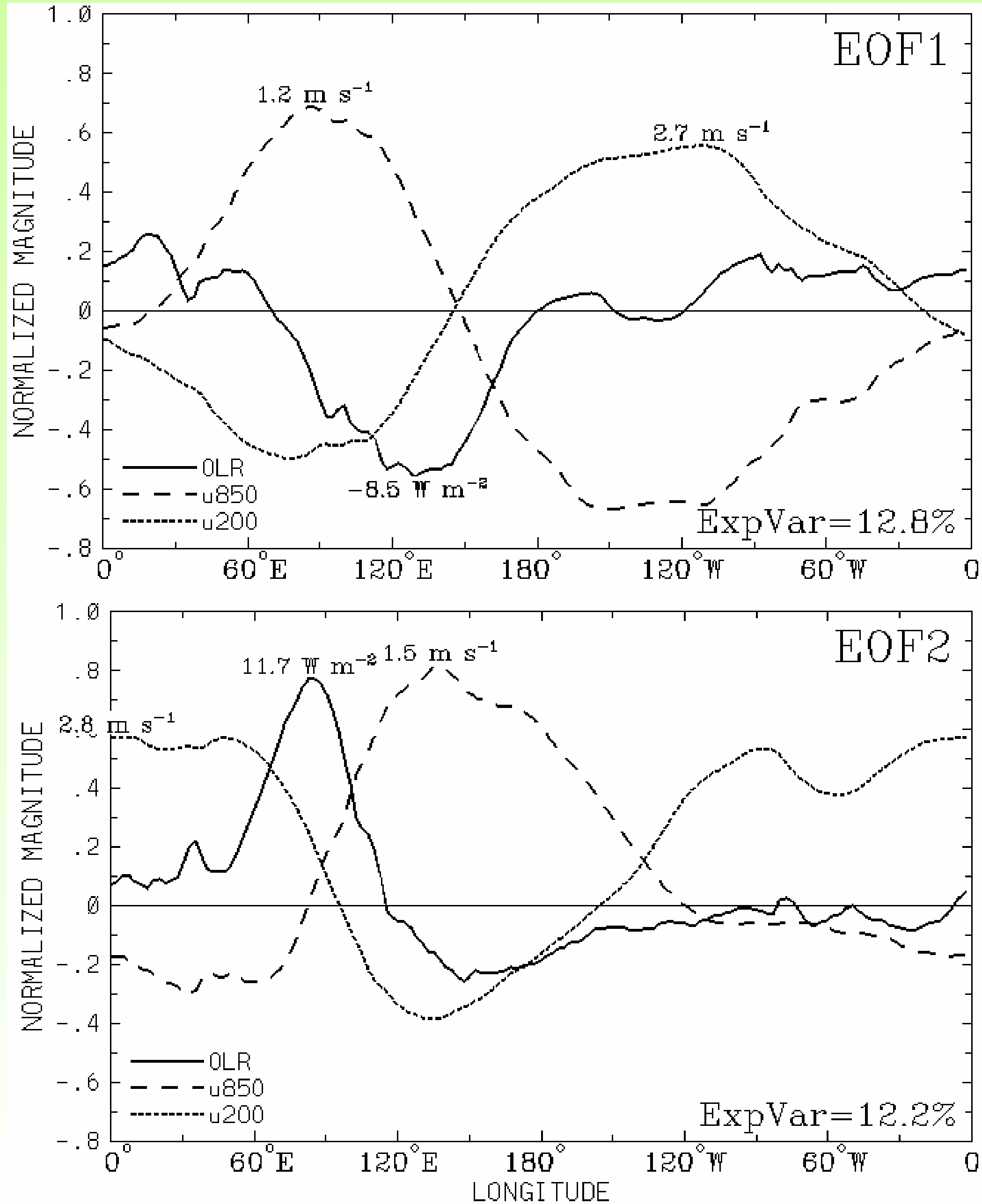
As described by Wheeler and Weickmann (MWR, 2001)

2. An All-season Real-time Multivariate MJO Index

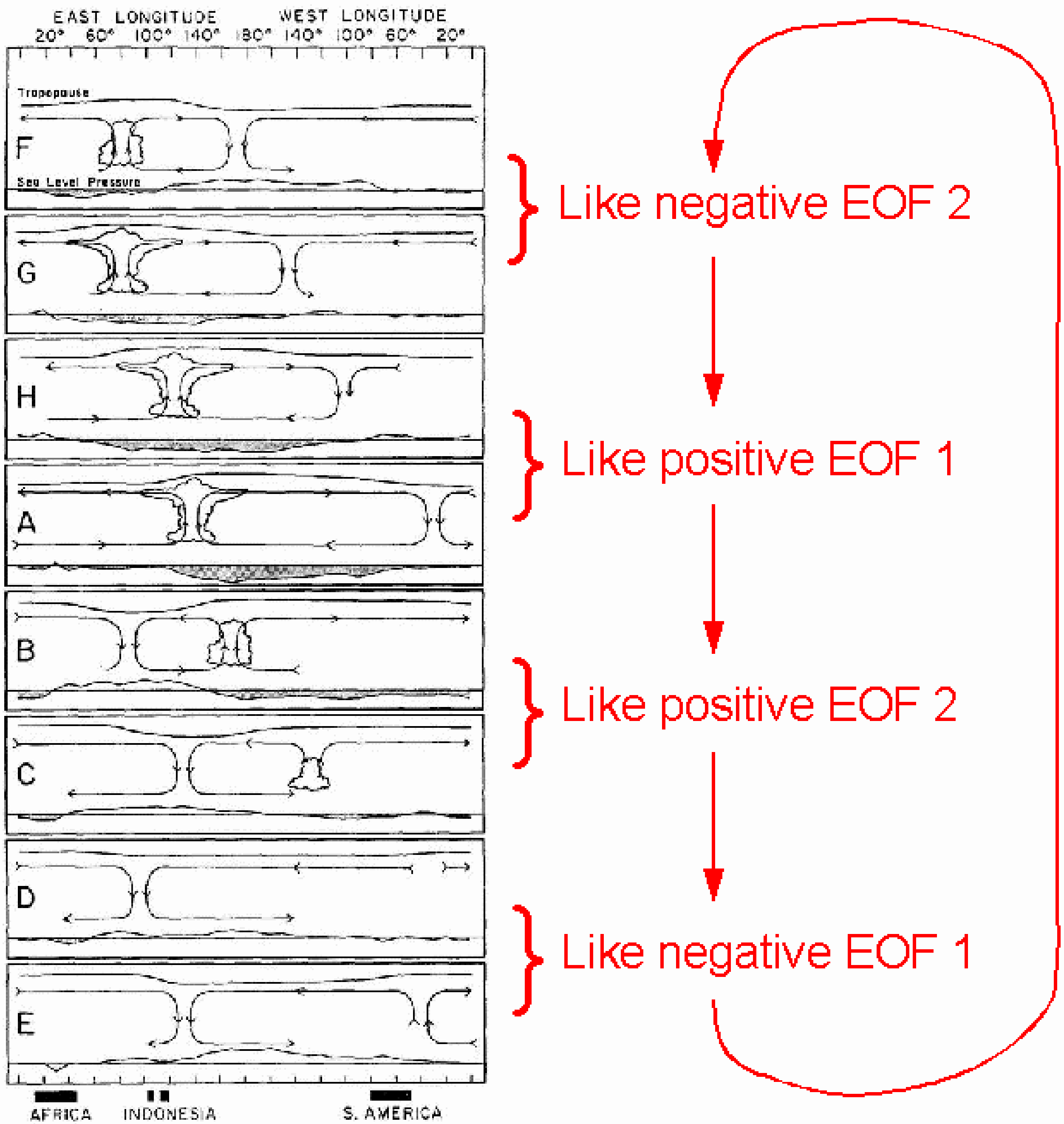
Building upon work of Lo and Hendon (2000)

The idea is that by projecting daily observed data (with long-time scale components removed) onto the MJO's spatial structure, you can isolate the signal of the MJO without the need for a band-pass time filter.

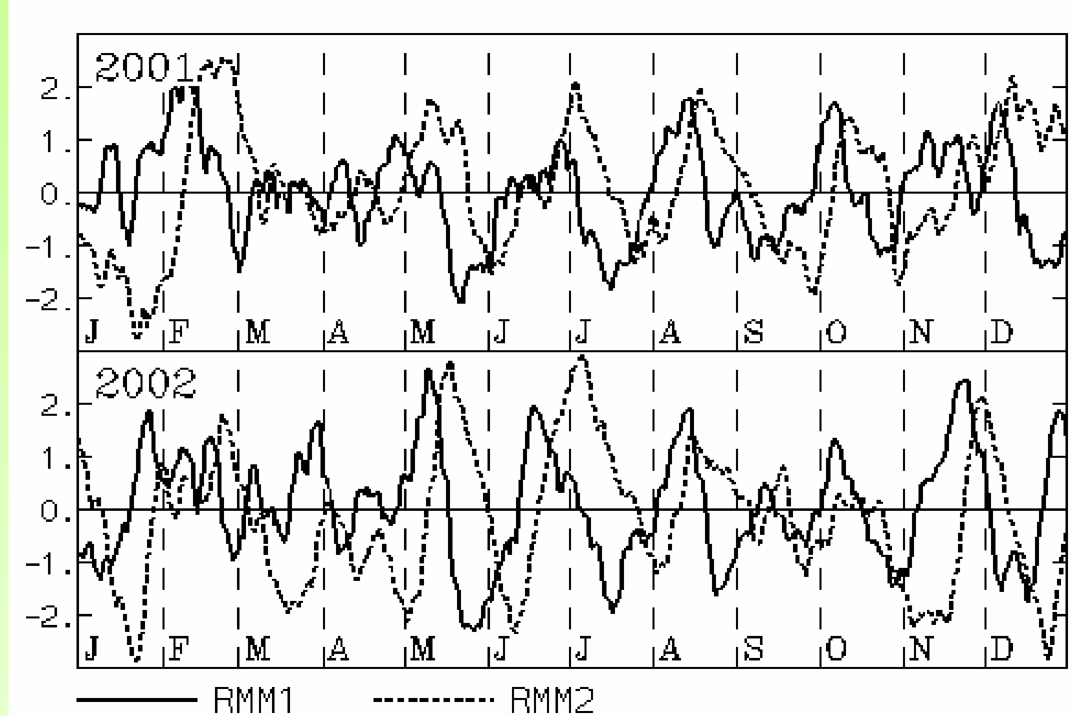
EOFs of the combined fields of 15^{o}S to 15^{o}N-averaged OLR, u850, and u200, for all seasons.



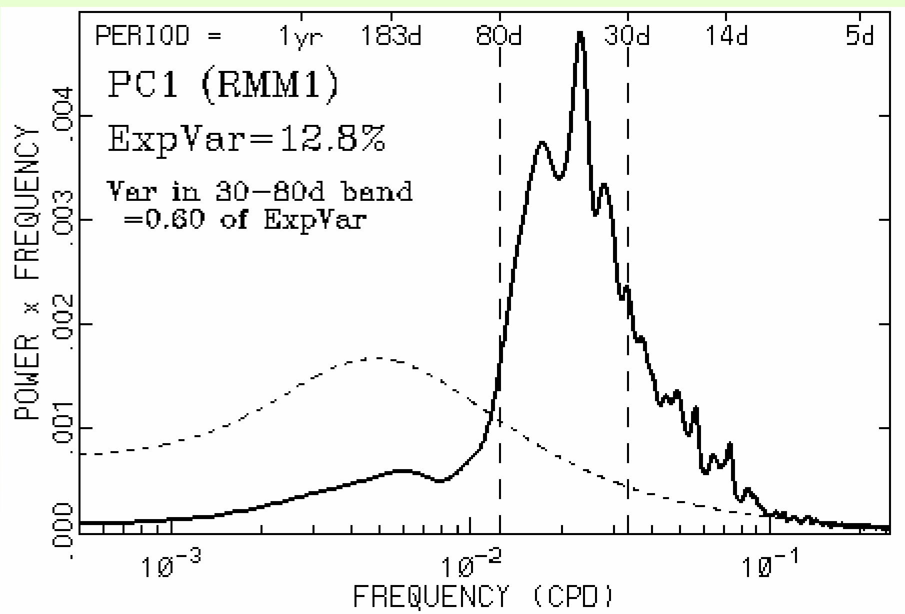
Madden and Julian's (1972) schematic

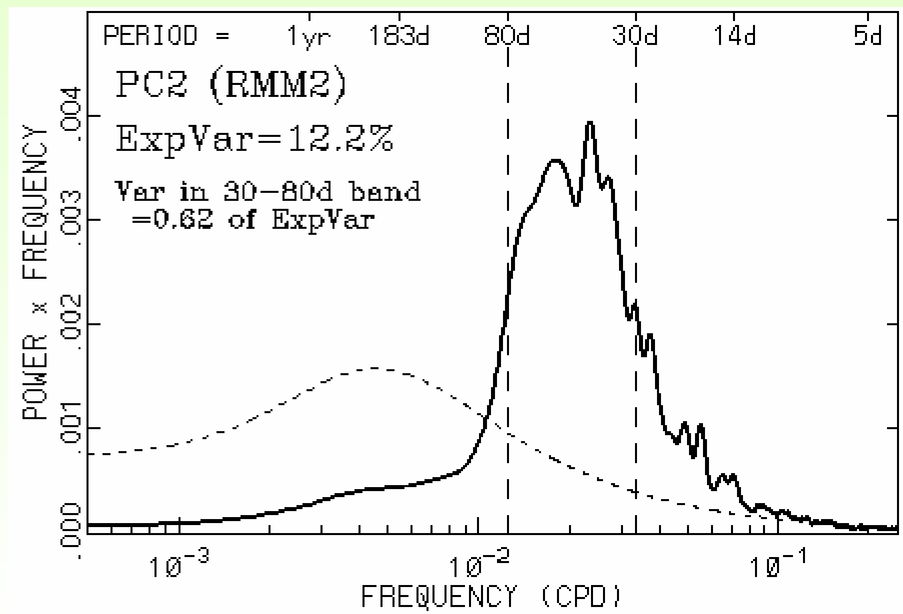


RMM1 and RMM2 values produced by projection of daily, non-filtered, observations onto the two EOFs.

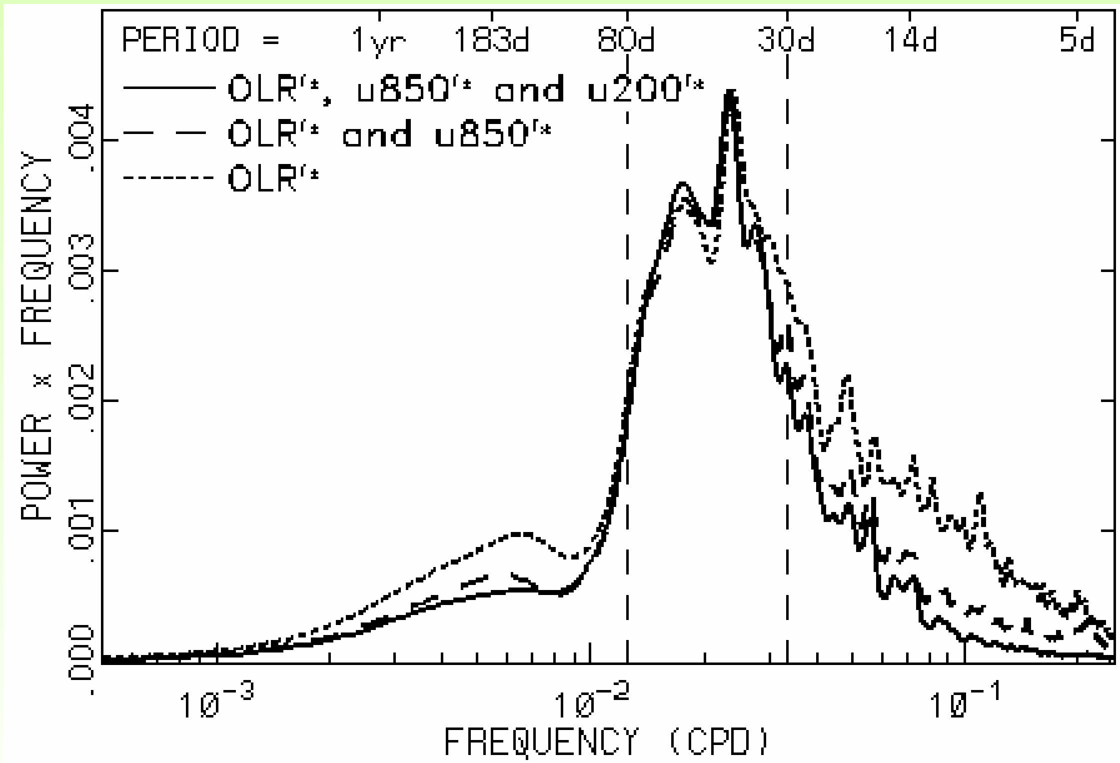


Resulting time series have majority of their variance in the 30- to 80-day range, without time filtering.

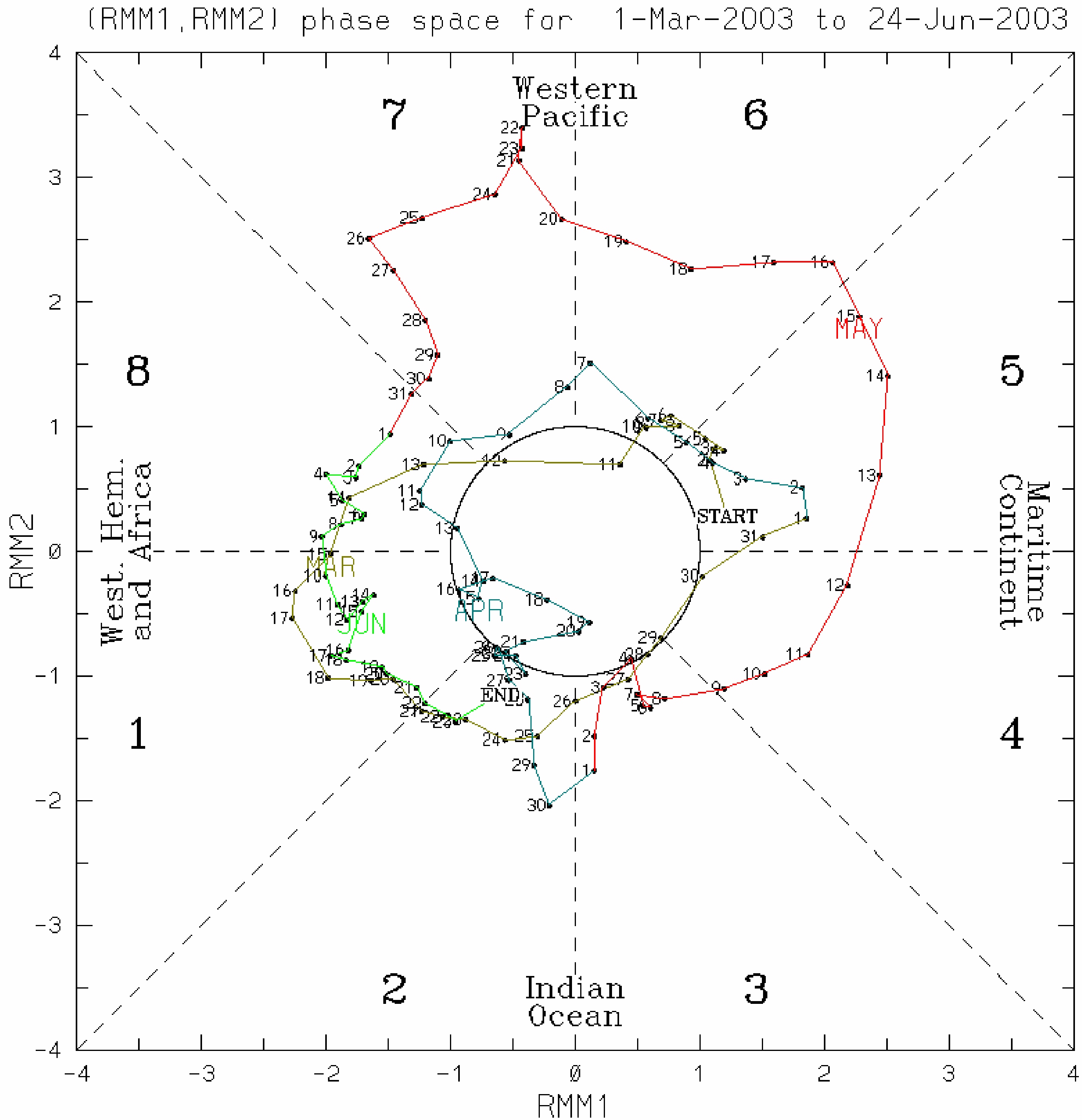




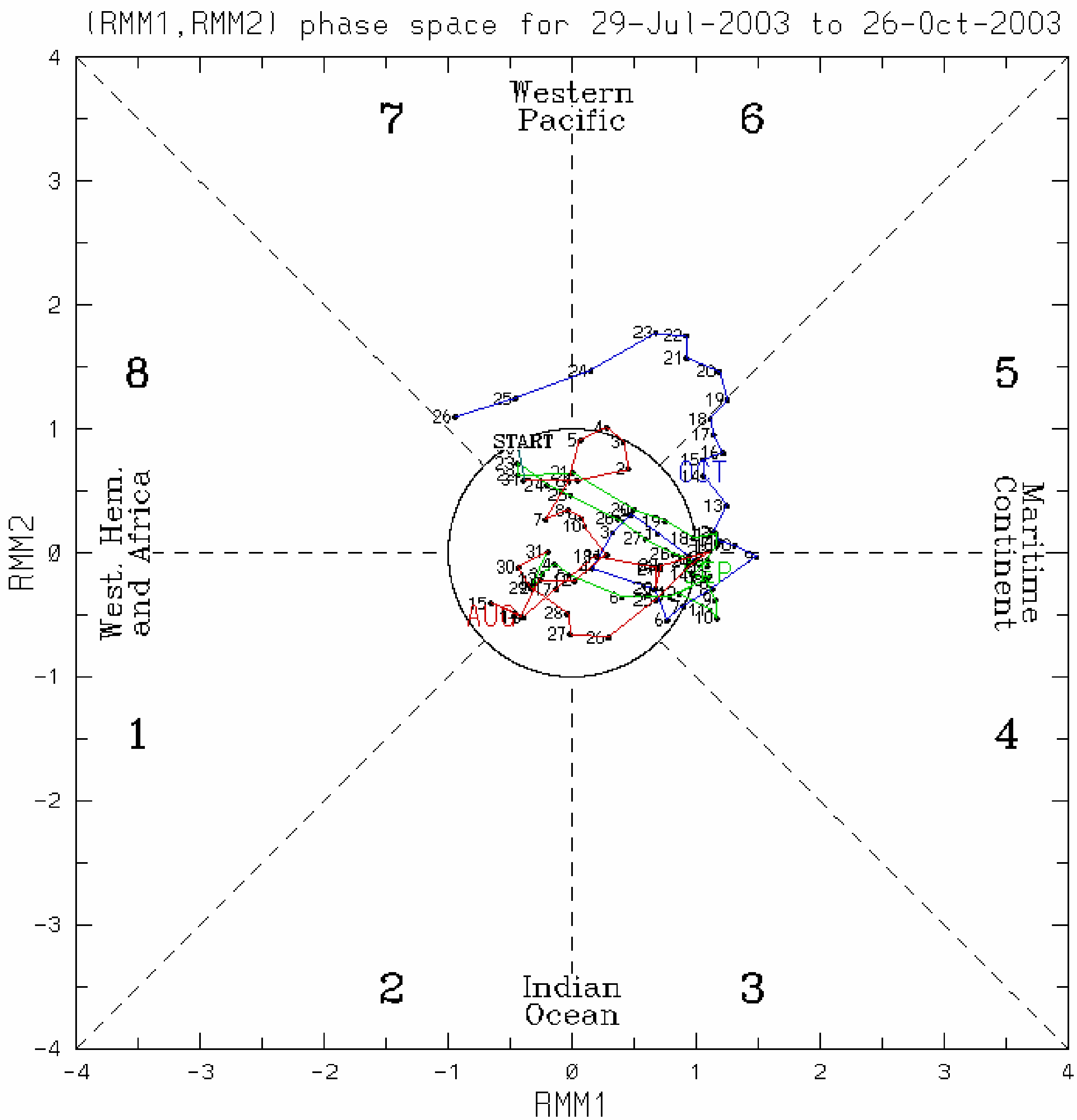
The extraction of the intraseasonal signal of the MJO is more effective when using combined EOFs of three variables compare to one or two.



Looking at resulting (RMM1,RMM2) phase space for earlier this year.



The (almost) latest 90 days.



Blue line is for Oct, green line is for Sep. Labelled dots for each day.

Can forecast RMM1 and RMM2 values using multiple linear regression.

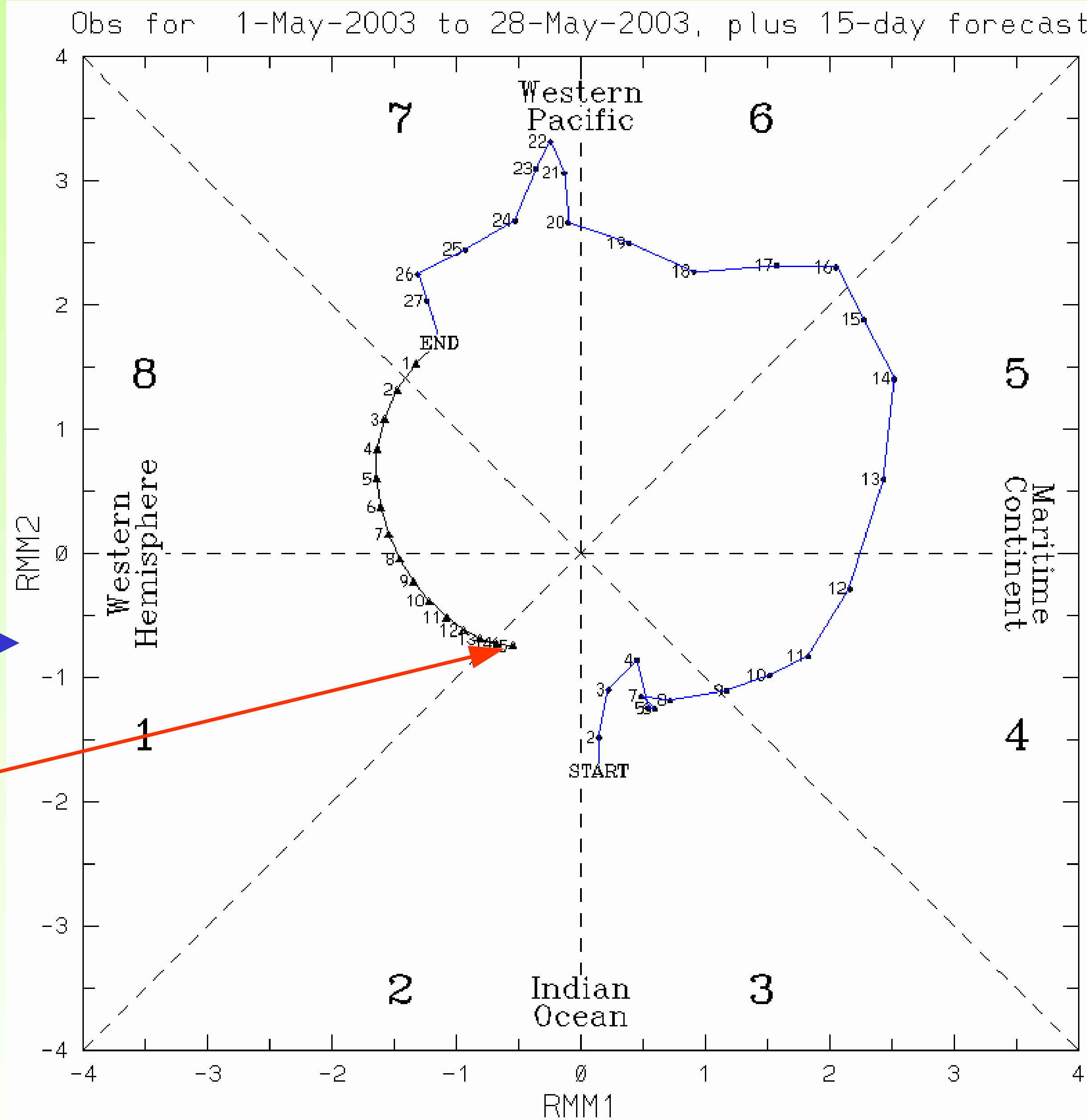
RMM1(lag)=a1+b1×RMM1(0)+c1×RMM2(0)

RMM2(lag)=a2+b2×RMM1(0)+c2×RMM2(0)

where a1,a2,b1,b2,c1, and c2 are computed independently for each lag, and are a smoothly varying function of the time of year.

Example from 28th May this year

15 day forecast (for 12th June)



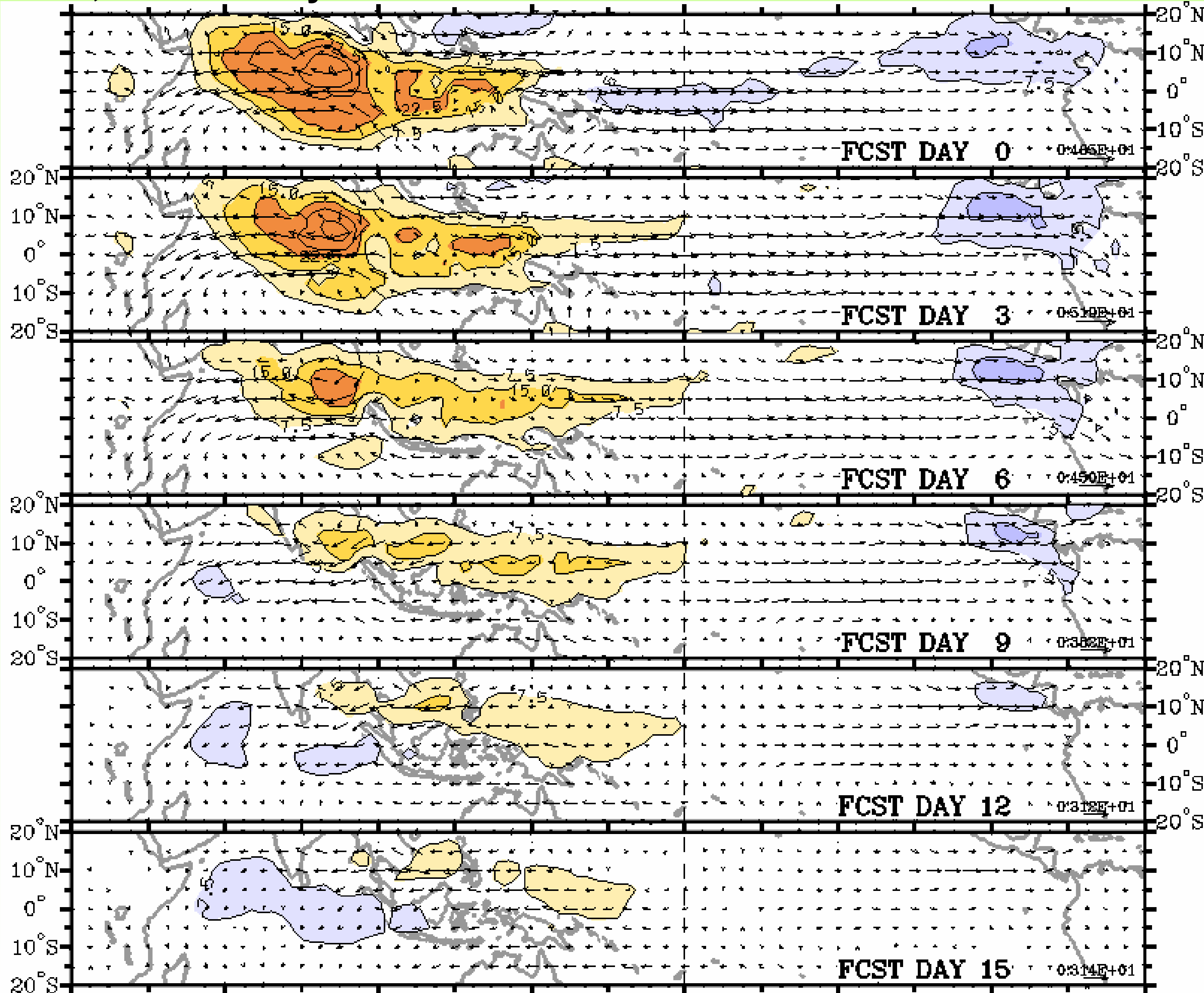
Skill as measured by the correlation coefficient ≈ 0.6 at 12-day forecast, and 0.5 for a 15-day forecast.

Similarly, can forecast any field using seasonally-varying, lagged, multiple linear regression against RMM1,RMM2 at Day 0. *OLR and 850hPa wind anoms*

28th May, 2003

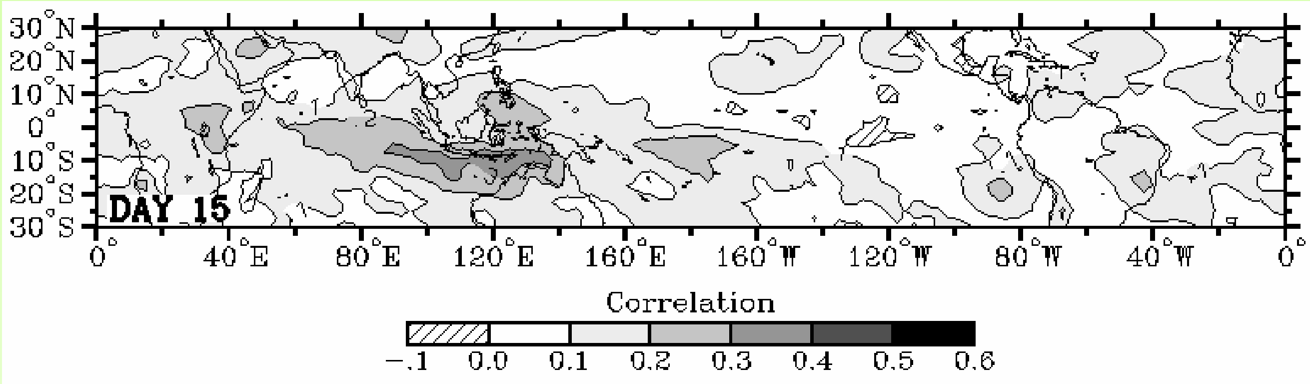
Forecast for 6th June, 2003

Forecast for 12th June, 2003

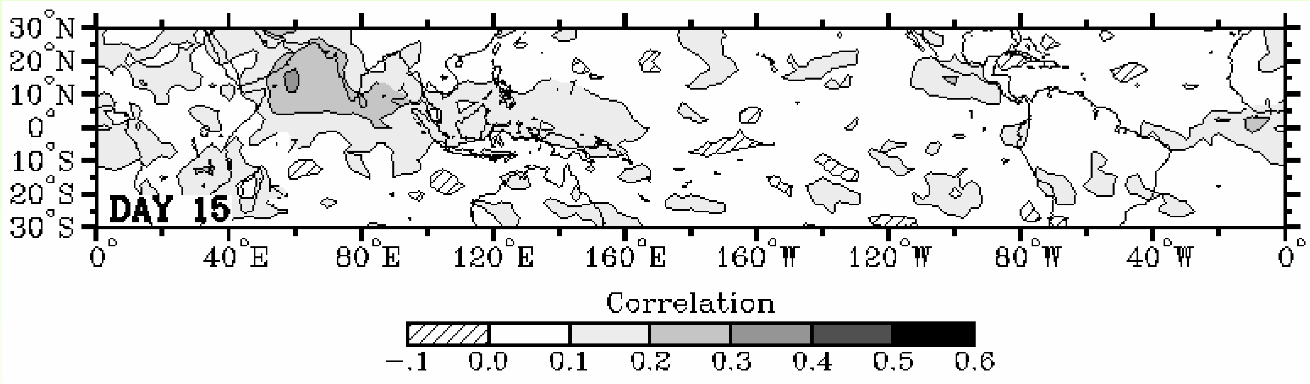


<u>Skill of RMM-based predictions:</u> Correlations of the predicted OLR anomalies with observed OLR (daily) anomalies

15-day forecasts
Southern Summer



15-day forecasts
Northern Summer

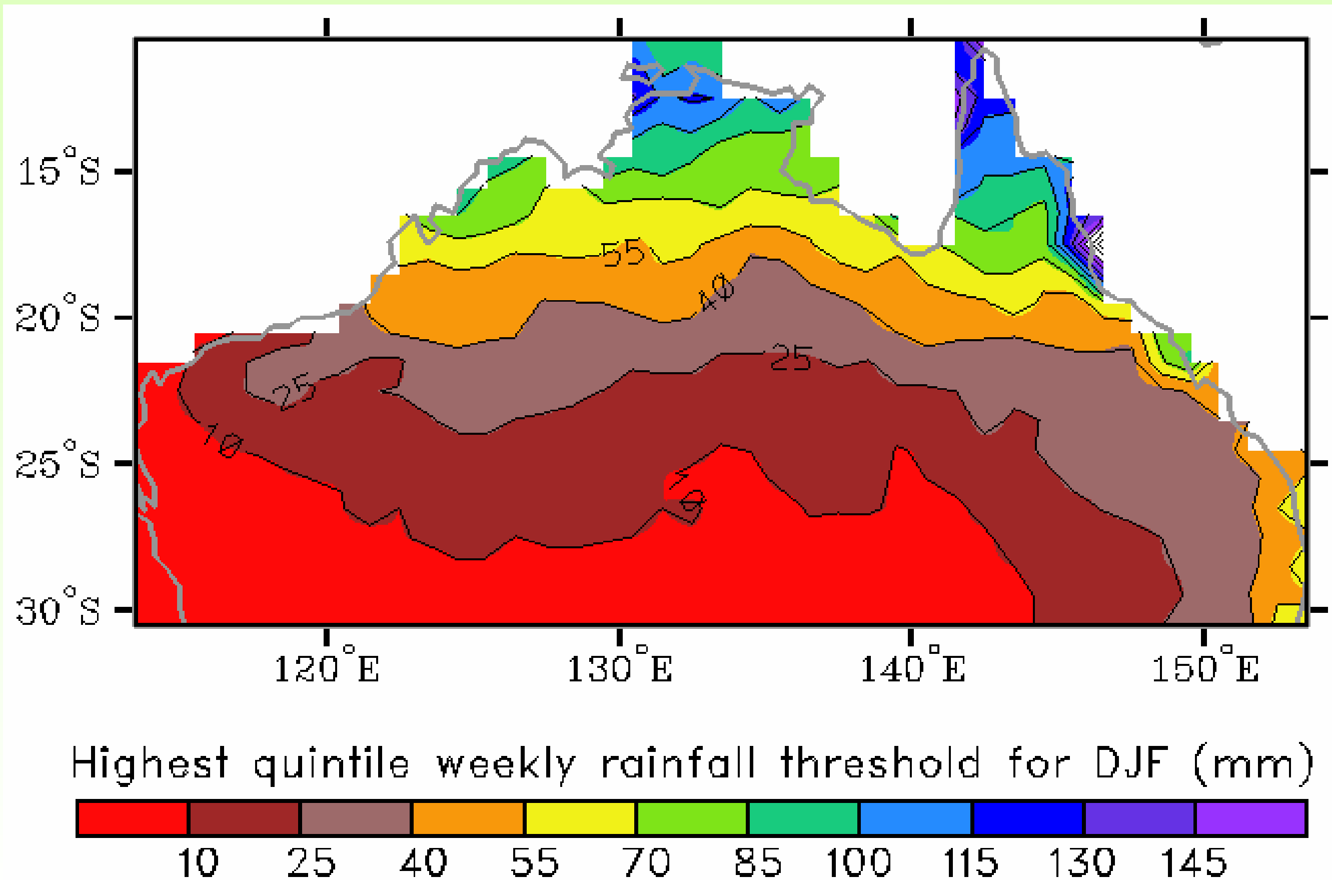


A small gain compared to the skill of previous statistical techniques……

Further applications of (RMM1, RMM2):

<u>An example:</u> Conditional probability of weekly rainfall exceeding the highest quintile

What is this highest quintile value (for DJF)?

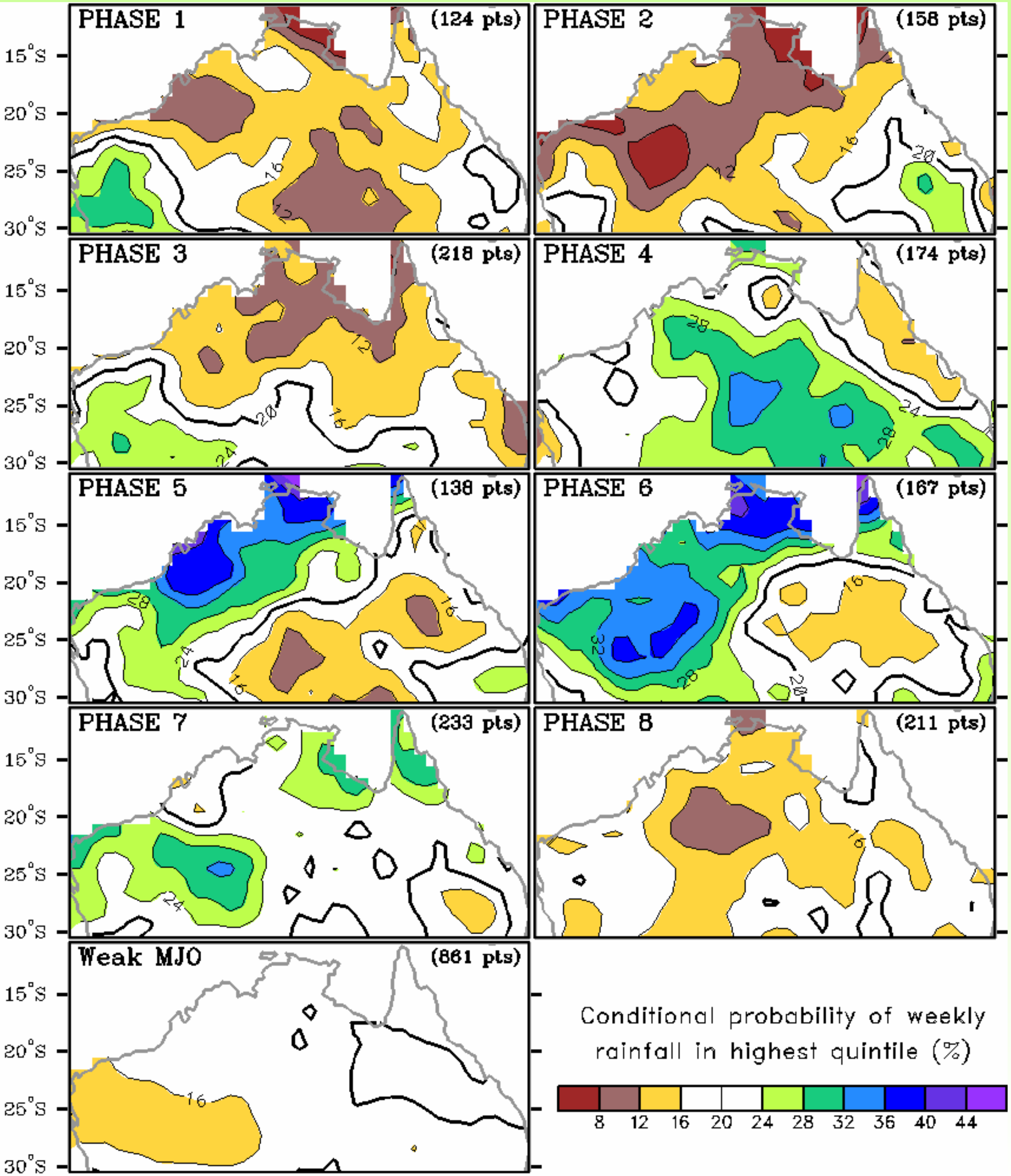


MJO modulation of probability of extreme weekly rainfall

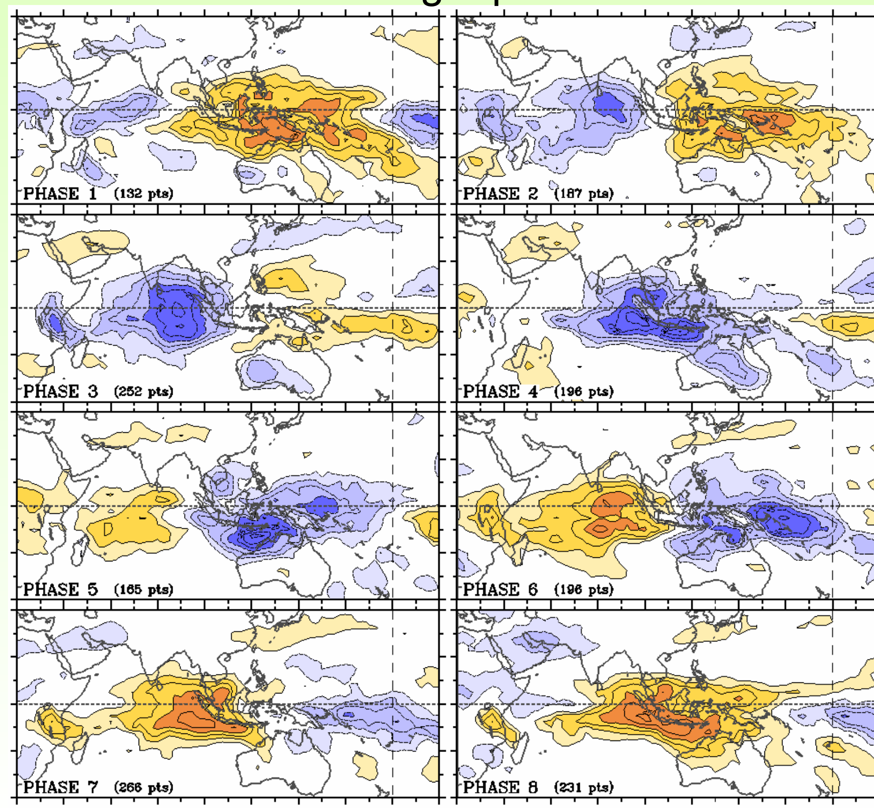
1 degree gridded rainfall

DJF

Based on 1974-1999 data



OLR during 8 phases



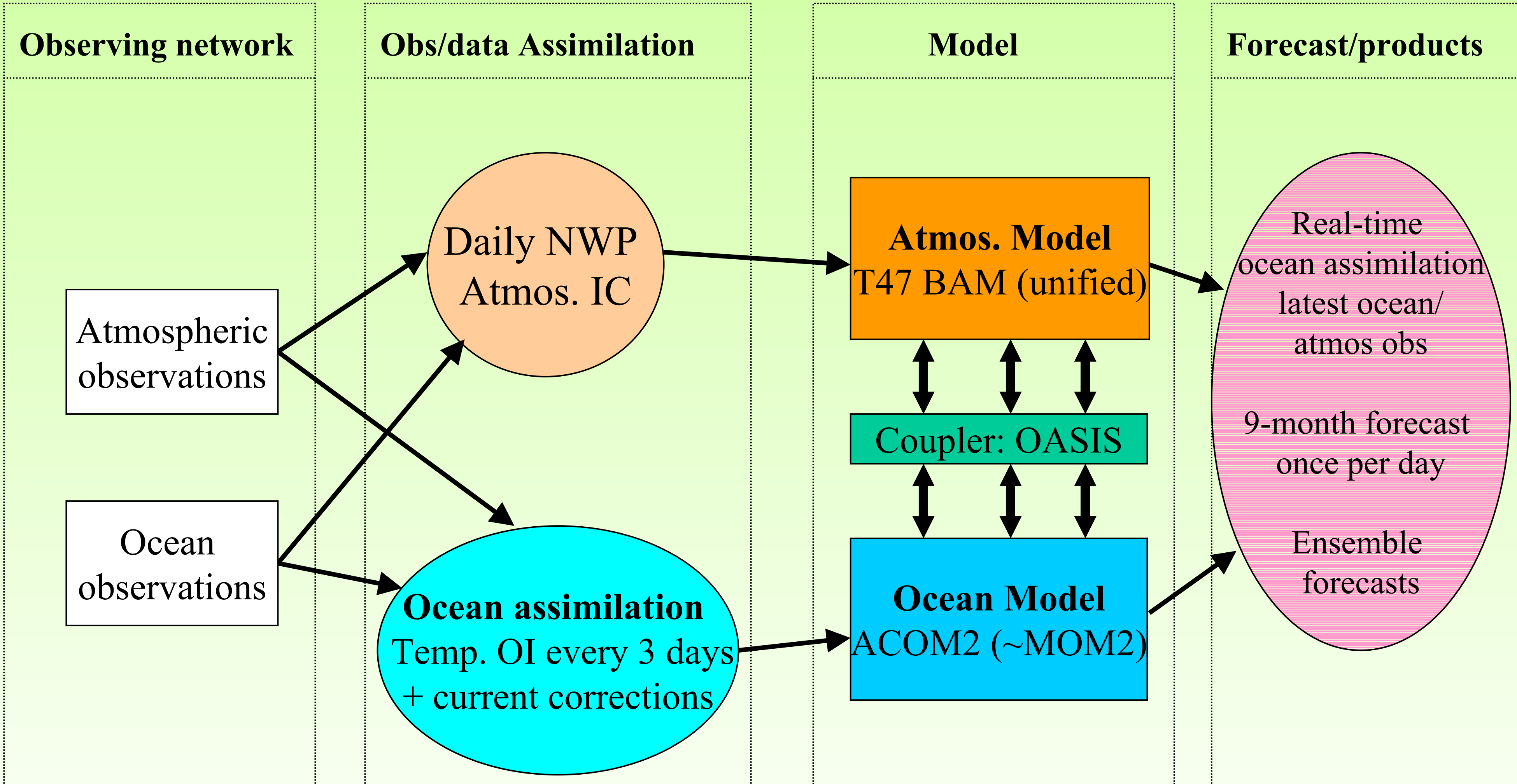
Real-time Multivariate MJO (RMM) Index - Summary

- We tackle 1st step of empirical MJO prediction problem by developing an accurate as possible index of its current state.
- New index avoids problems with conventional band-pass filters, yet is quite effective at extracting the frequency-limited signal.

- <u>Advantages include:</u>
  - MJO state reduced to two numbers (RMM1 and RMM2).
  - Diagnostic studies are easily adapted for making real predictions.
  - All-season definition

- <u>Disadvantages include:</u>
  - Only uses “MJO” signal, thus missing the rest of the existing intraseasonal variance.
  - Presumably cannot pick-up all of the MJO signal in just two numbers.
  - When MJO is not present/weak, forecast is similarly weak and of little use.

3. POAMA operational prediction system



BMRC's Atmospheric GCM

BAM3 - some particulars

Resolution: T47L17 (for climate work and POAMA)

Convection: Tiedtke (1989) mass flux scheme with either

(a) *moisture convergence closure* or (b) *CAPE relaxation closure*

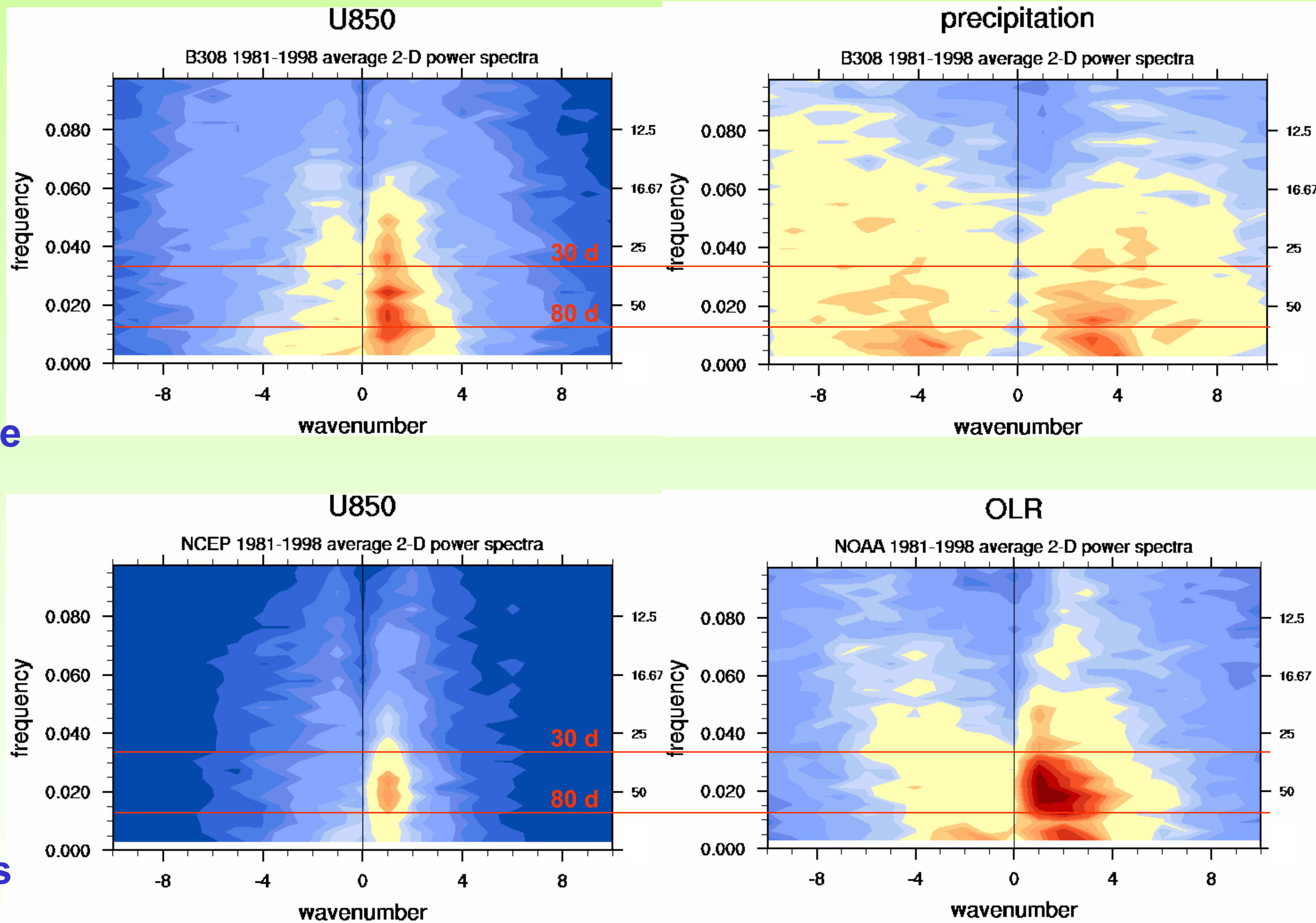
Used in GASP (global NWP model) ← (a)

Used in POAMA, v1 (coupled seasonal fcst model) ← (b)

2-D spectra of 15^{o}S-15^{o}N-averaged fields.

BAM with CAPE closure

Observations



(CAPE closure) Model "MJO" - Seasonality

Power for surface wind at MJO scales

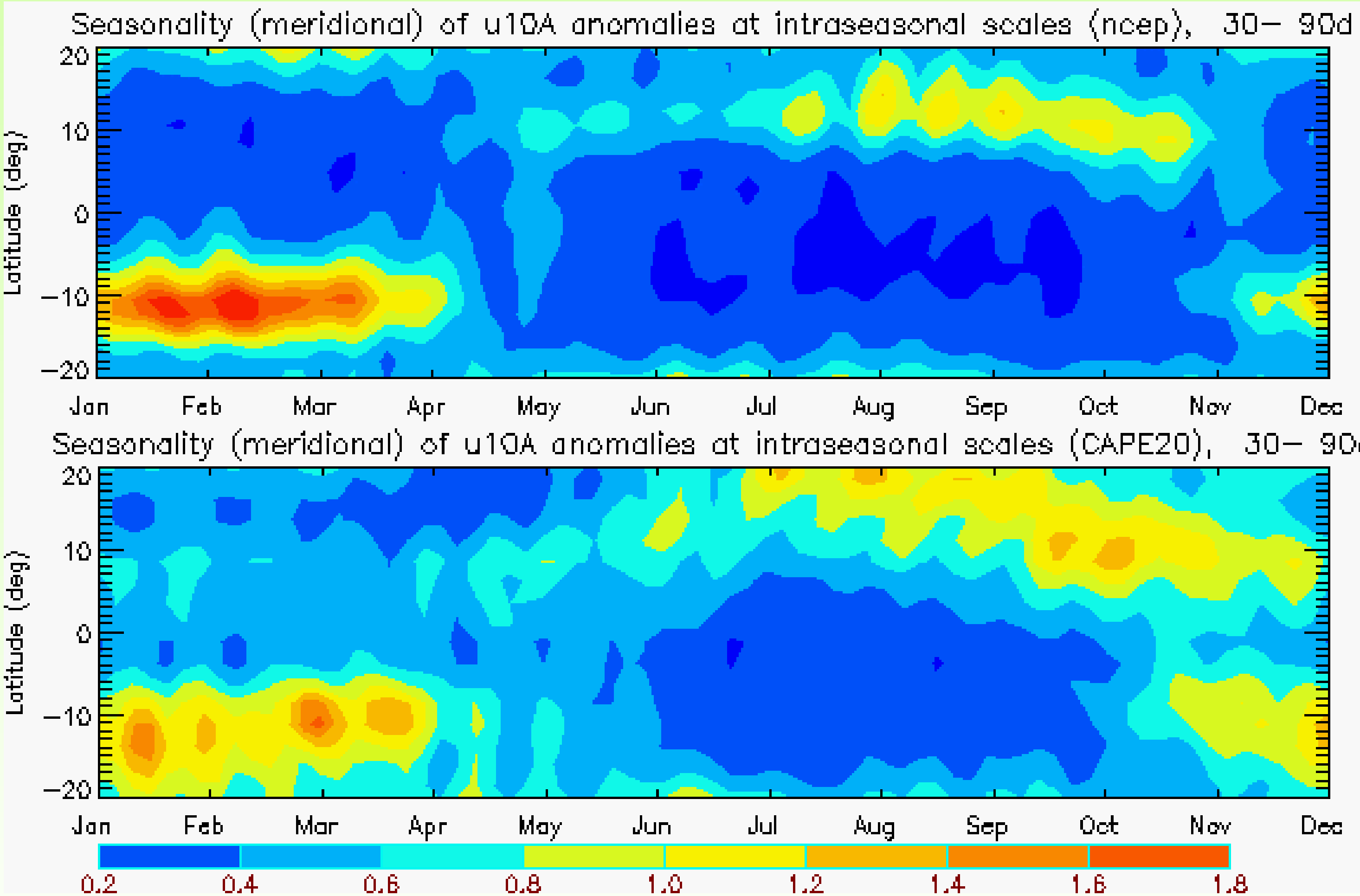
Filtered for eastward wavenumbers 1-3, periods 30-90 days

NCEP Reanalysis (20 years)

Model prescribed SST run

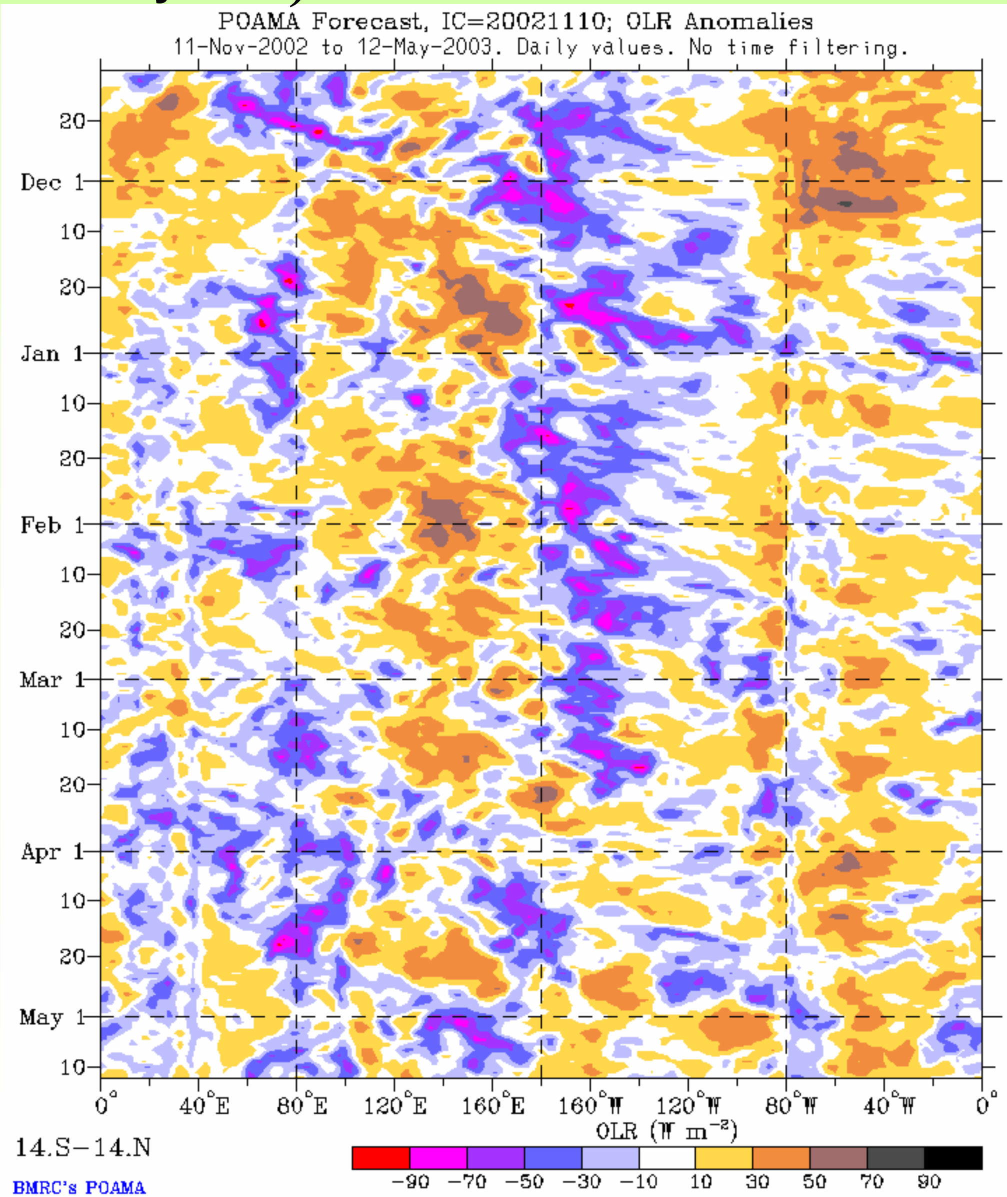
CAPE closure

(20 years)

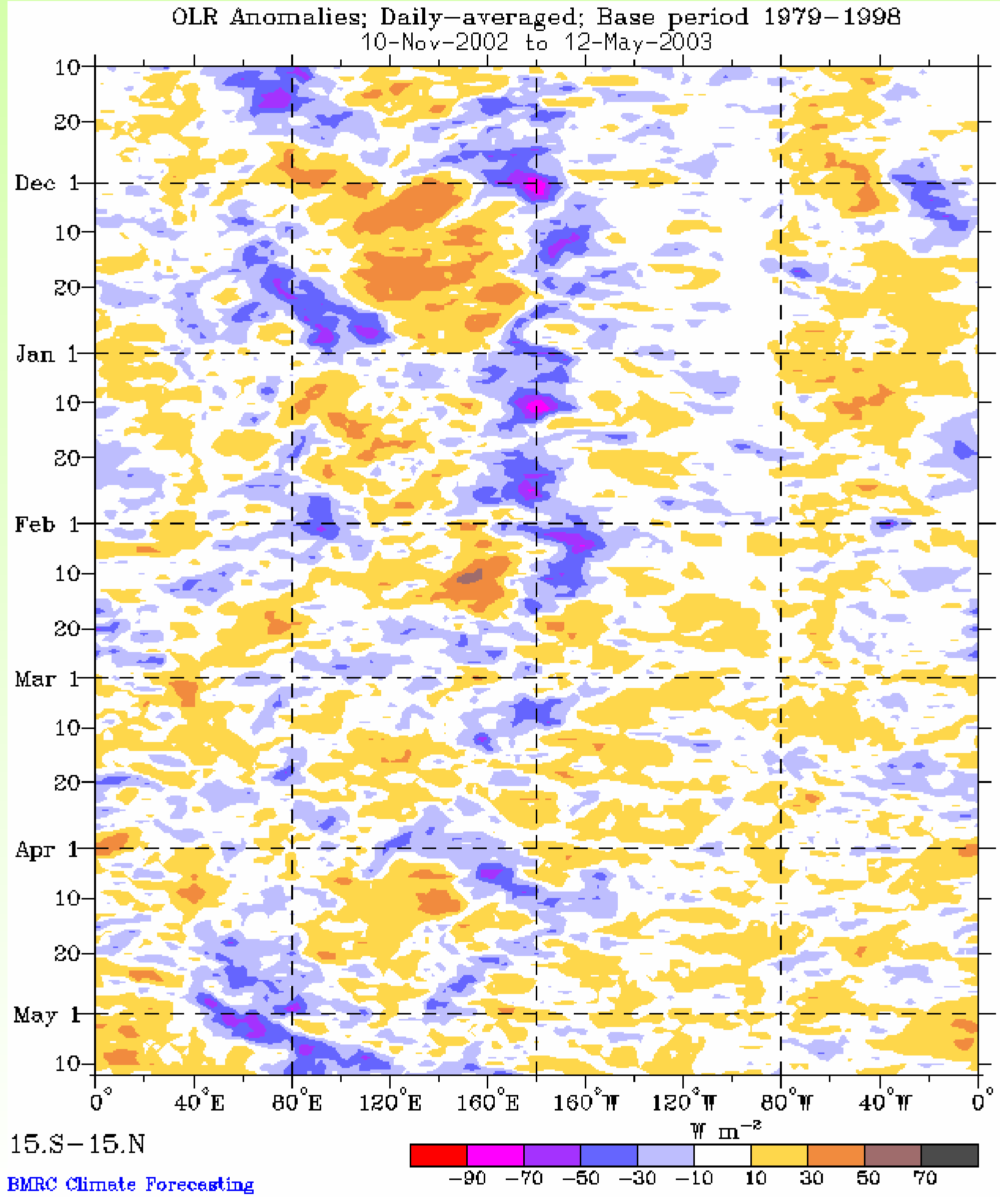


Forecast produced by POAMA coupled model on the 11th Novemeber, 2002 (IC=20021110)

(Atmospheric initial conditions from GASP NWP system.)



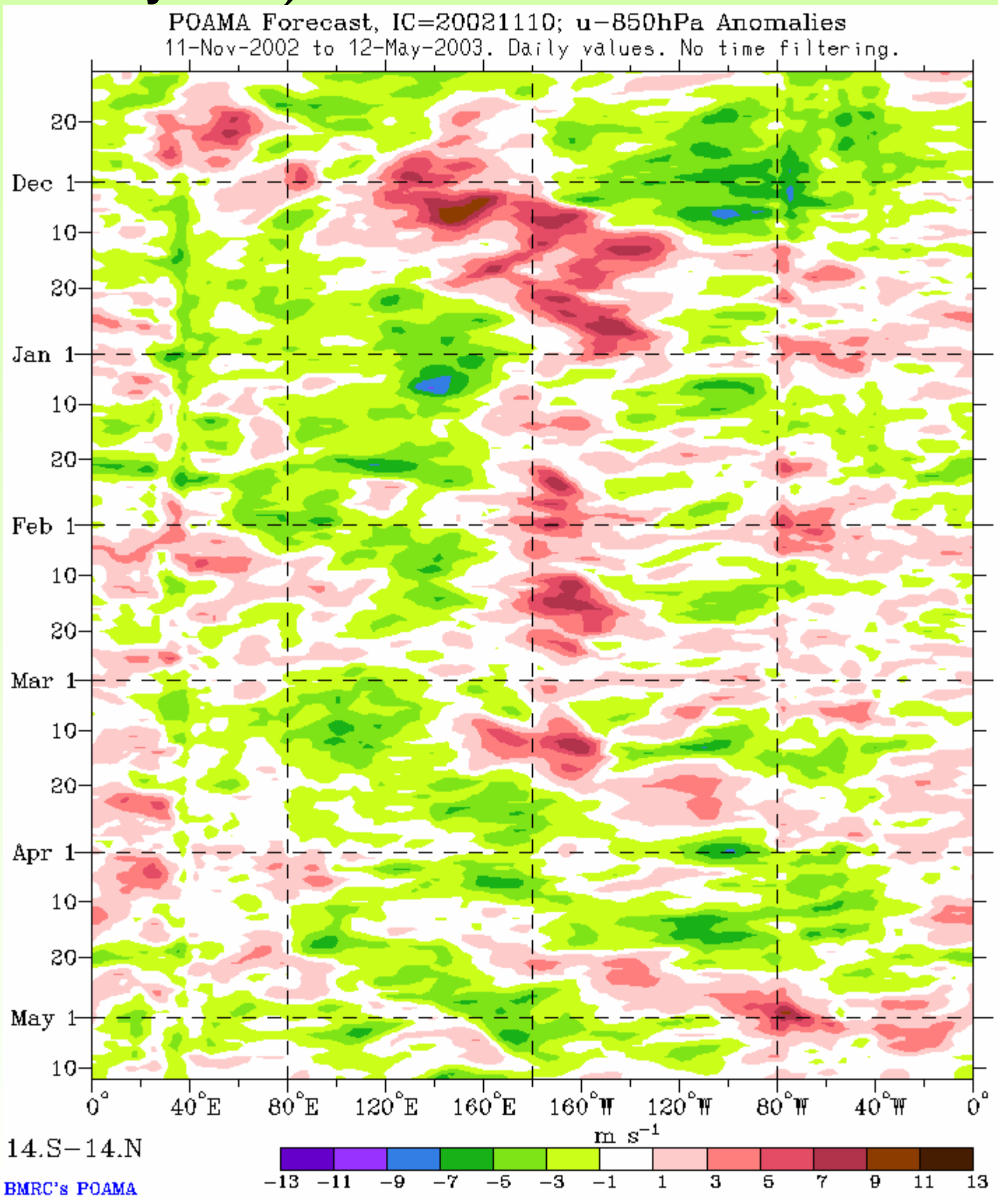
Observed OLR anomalies

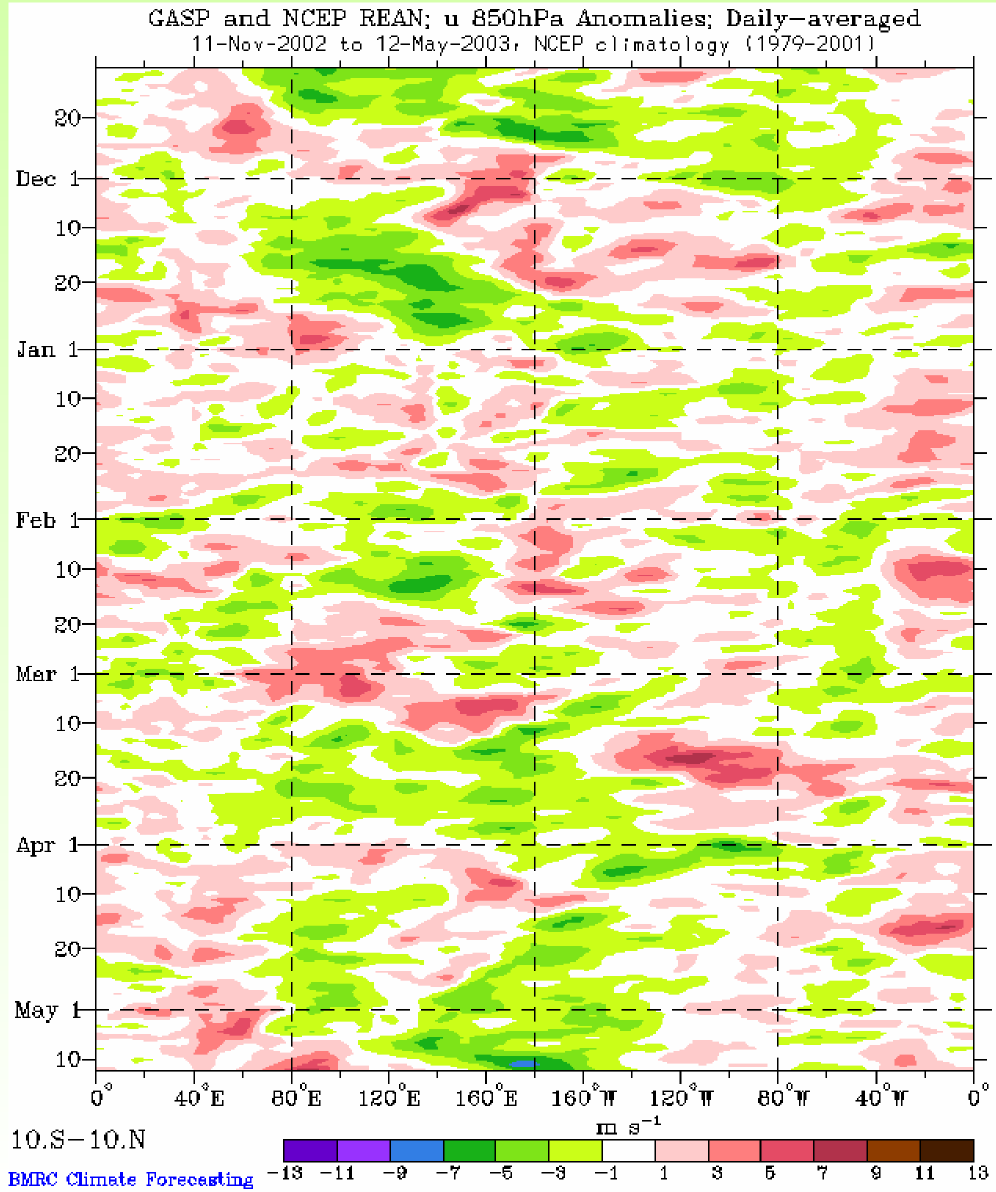


Forecast produced by POAMA coupled model on the 11th Novemeber, 2002 (IC=20021110)

(Atmospheric initial conditions from GASP NWP system.)

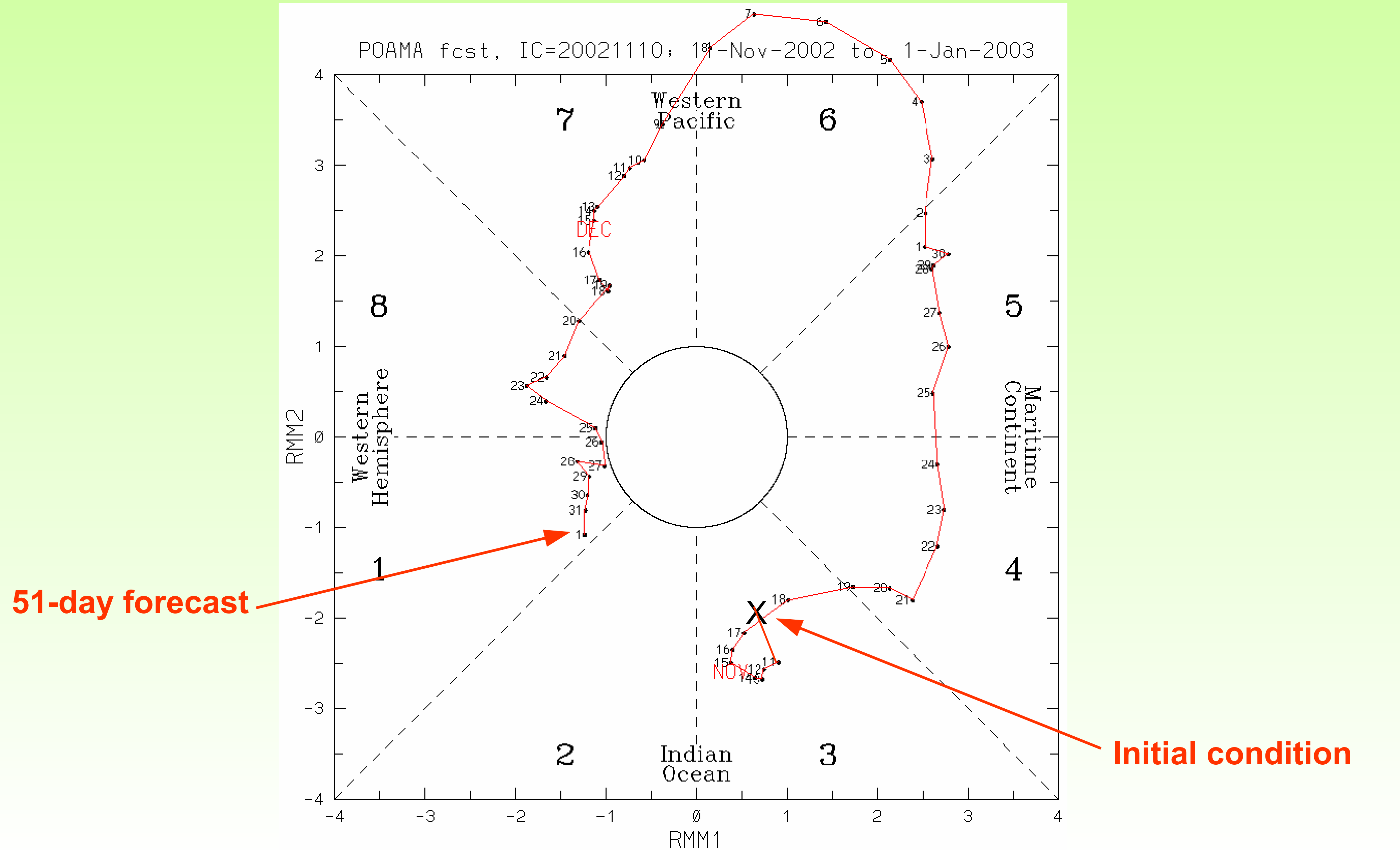
Observed u850 anomalies



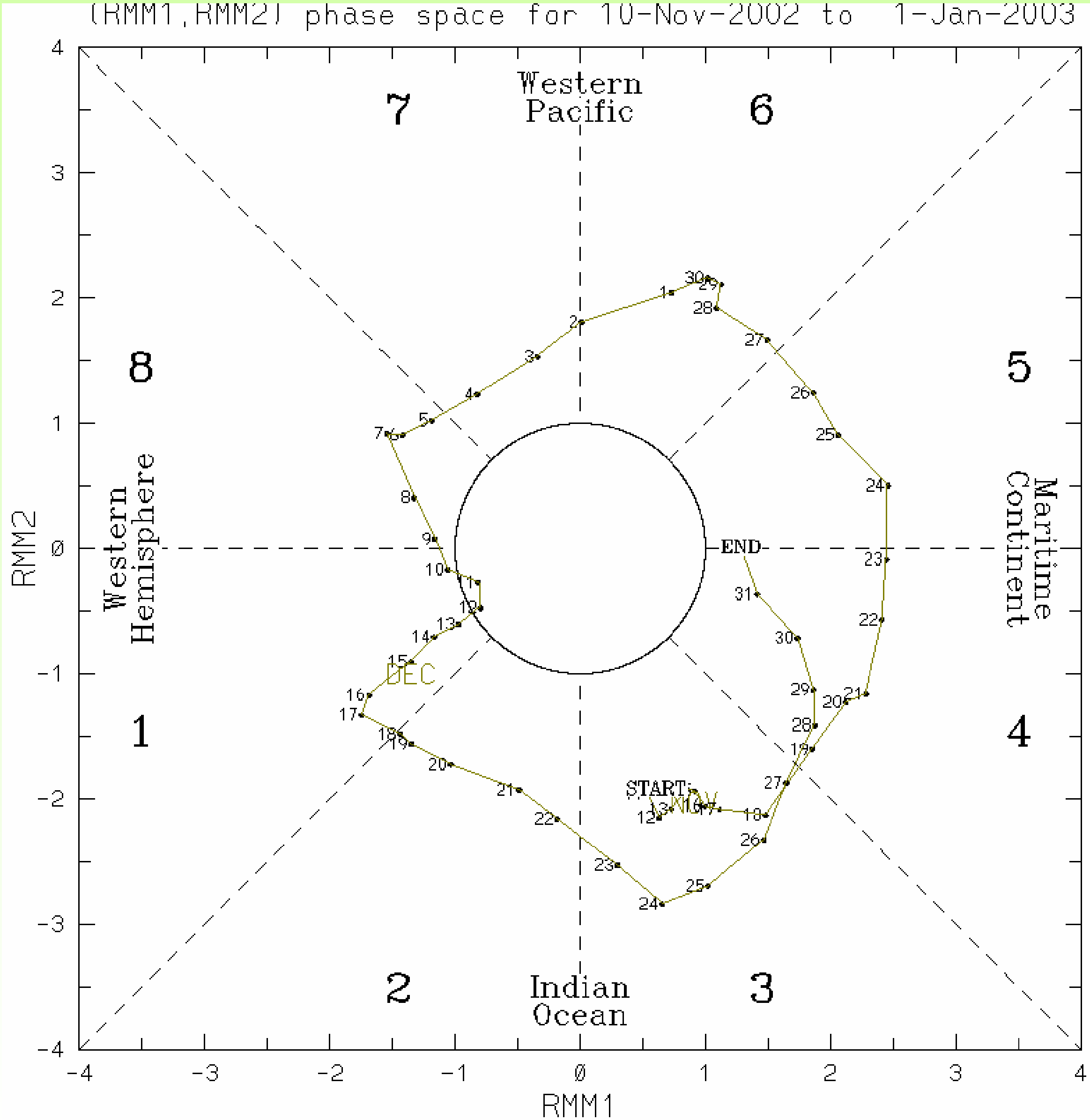


We can project the model output onto the same EOFs developed from the observations, as used to calculate the RMM indices. This is for the POAMA forecast with IC=20021110.

(NCEP climatology used near day 0, blending into model hindcast climatology at day 60.)

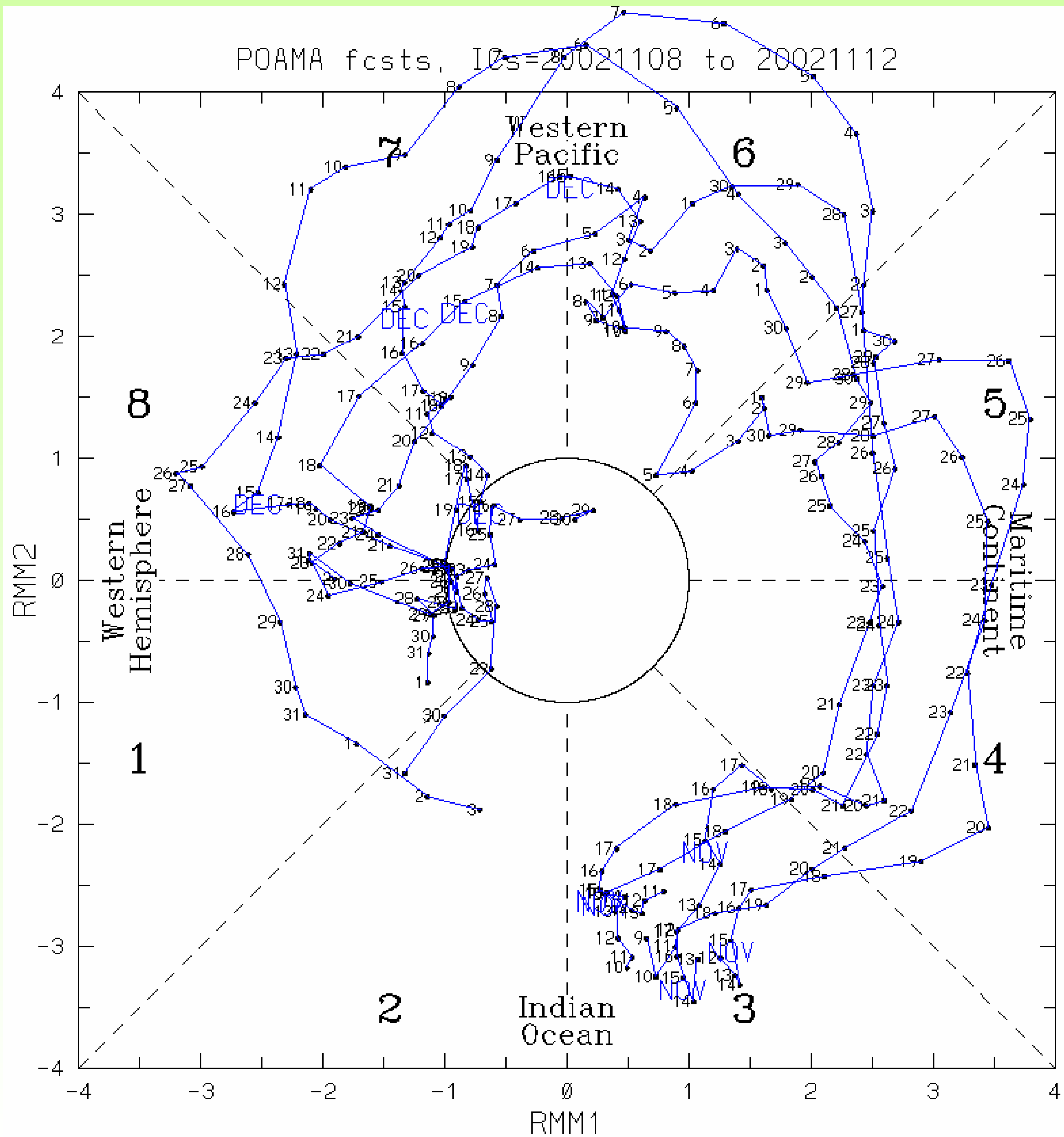


The observed MJO "trajectory" for the same period



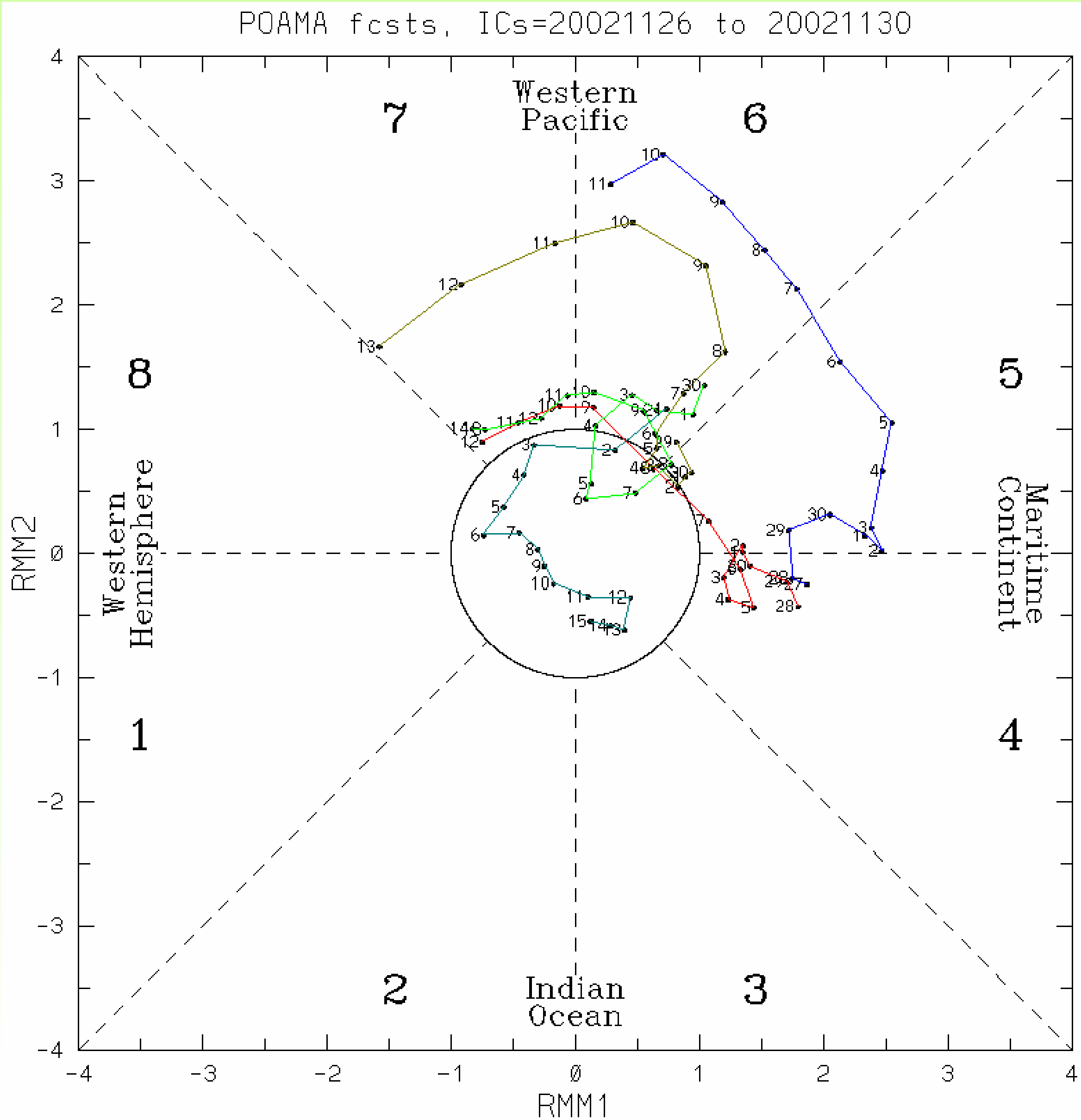
POAMA Output for forecasts initialized on consecutive days.

(Example when initial convection in Indian Ocean)



POAMA Output for forecasts initialized on consecutive days.

(Example when initial convection in Maritime Continent/W. Pacific sector)



POAMA MJO Forecasts - Summary

- As forecasts made each day from real atmospheric ICs, can be used for forecasts of the MJO - produces all fields.

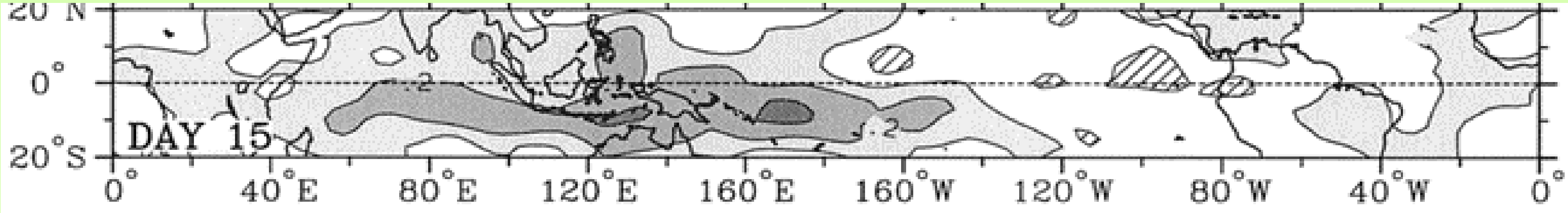
- *Still needs more diagnosis*.

- However, from limited sample of forecasts that we have available, it appears that:
  - Forecasts too strong MJOs when IC has convection in Indian Ocean, and too weak when IC has convection in W. Pacific. **Initial Shock!** Nudging of model to get MJO in ICs instead?
  - Forecasts the MJO to be systematically too slow (consistent with its ~70-day MJO spectral peak).

- Obviously, improvements in MJO simulation still required.

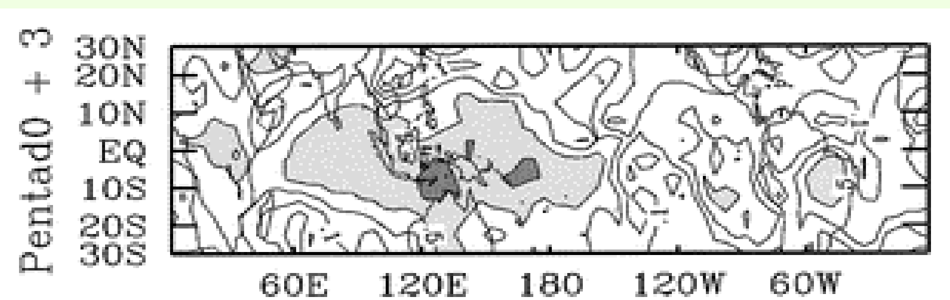
Validation and skill of 2-D filtering technique

Correlations between predicted and verifying OLR data
for hindcasts made from 1985-94. Southern Summer.

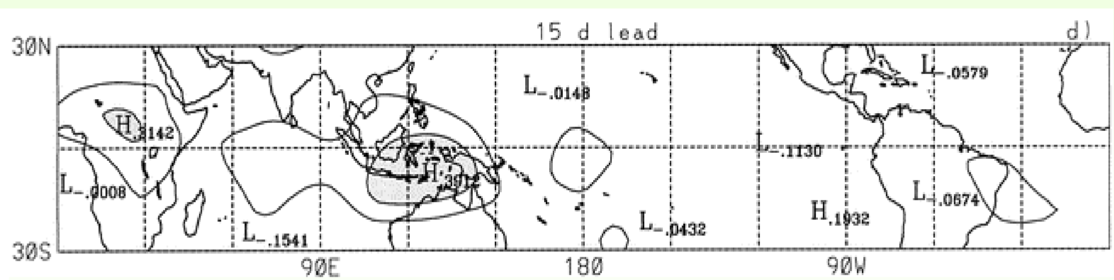


Wheeler and Weickmann (2001)

Similar (but not directly comparable) skill for other published
statistical/empirical forecast schemes.



Waliser et al. (1999)



Lo and Hendon (2000)

Periods of weak MJO activity are not uncommon.

But periods of very strong activity occur every few years.