Coupling issues in monthly forecasting

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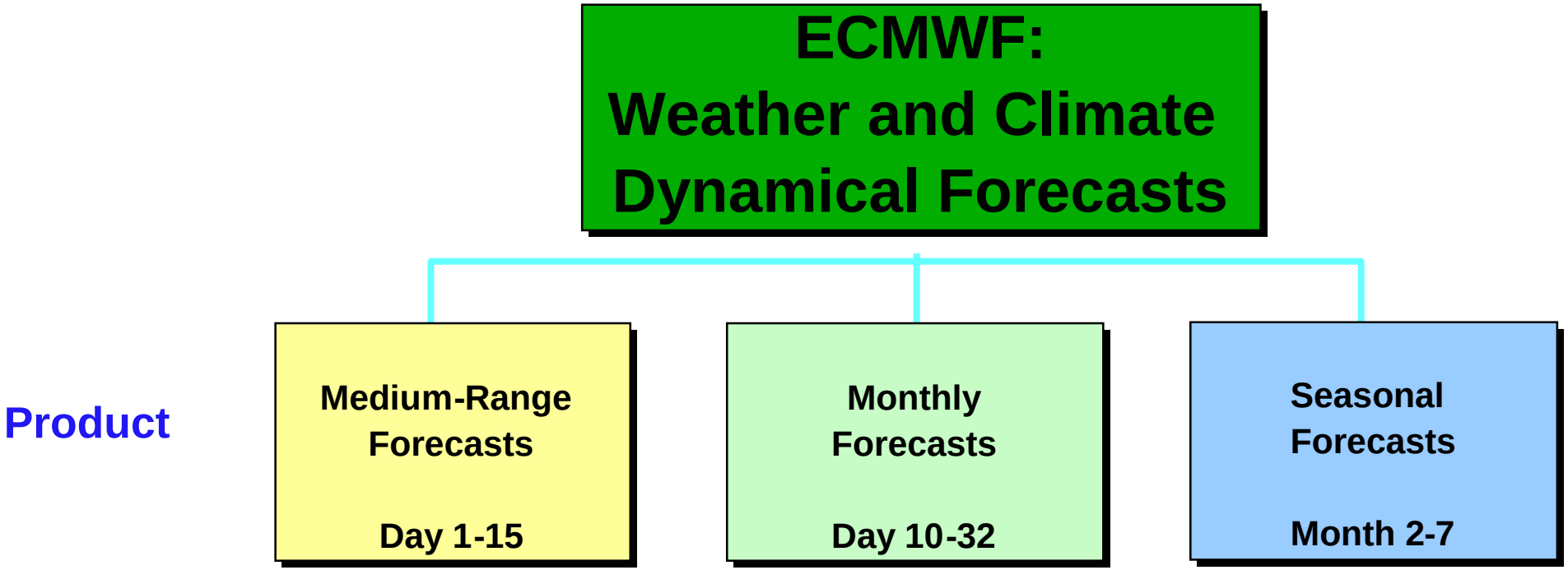
Outline

1. Monthly forecasts at ECMWF
2. Impact of coupling on MJO prediction
3. Impact of coupling on monsoon prediction
4. Impact of coupling on general scores
5. Conclusion

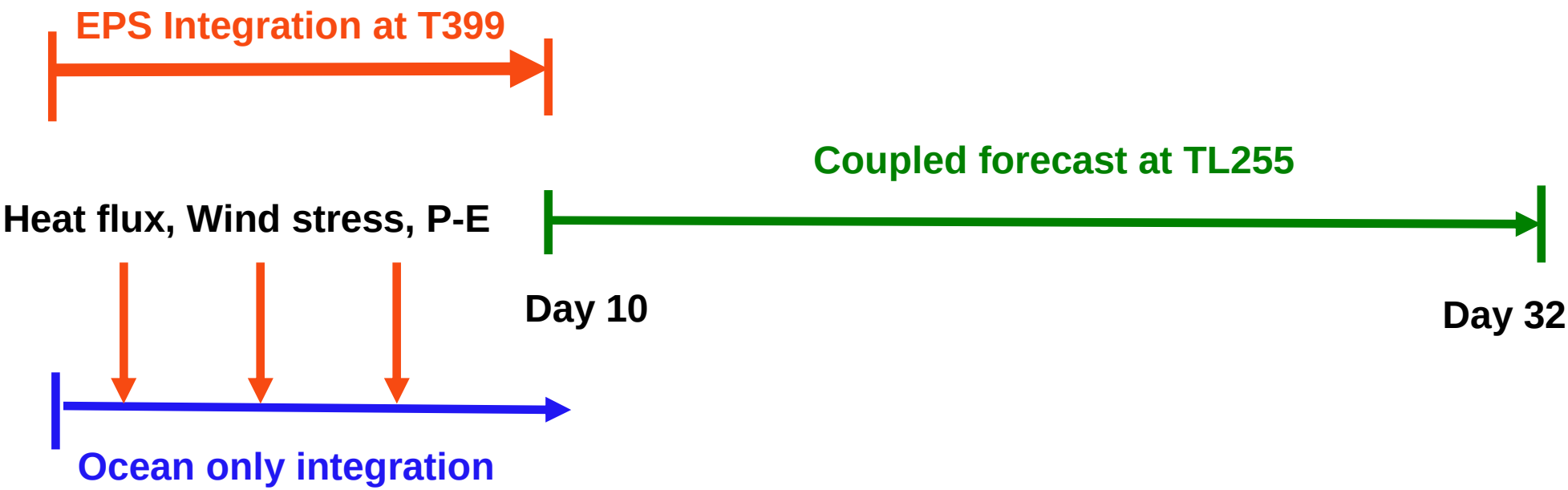
Monthly Forecasts at ECMWF



Monthly forecasts at ECMWF

- A 51-member ensemble is integrated for 32 days every week
- Atmospheric component: IFS with the latest operational cycle and with a T399L62 resolution till day 10 and T255L62 after day 10.
- Persisted SST anomalies till day 10 and ocean-atmosphere coupling from day 10 till day 32.
- Oceanic component: HOPE (from Max Plank Institute) with a zonal resolution of 1.4 degrees and 29 vertical levels
- Coupling: OASIS (CERFACS). Coupling every 3 hours

Monthly Forecasting System



Coupling Issues in Monthly Forecasting

Is the current OGCM configuration suitable for monthly forecasting?:

- What is more important for monthly forecasting: Ocean Dynamics or the mixing in the upper ocean?
- What is the impact of the oceanic vertical resolution?
- *What is the impact of oceanic horizontal resolution ?*

OGCM (HOPE)	ML (KPP, Large et al 1994)
3D Model	**1D Model**
About 1° latitude in the Extratropics,	About 1° latitude in the Extratropics
0.3° latitude in the Tropics	0.3° latitude in the Tropics
1° longitude everywhere	1° longitude everywhere
Global	44N-44S (pers. SSTs in high latitudes)
29 levels in the vertical	29 levels in the vertical
Vertical domain: to bottom of ocean	Vertical domain: to 200 meters
10m resolution in the top 100 m	16 levels in the top 30 m
Top layer is 10m thick	Top layer is 1.4 m thick
Mixing scheme:	KPP scheme
Richardson based with increased diffusivity in mixed-layer	
1 hour coupling - OASIS	1 hour coupling- OASIS
Initial conditions from EMCWF ocean analysis	Initial conditions from EMCWF ocean analysis
SST perturbations	

MJO Prediction

MJO Prediction

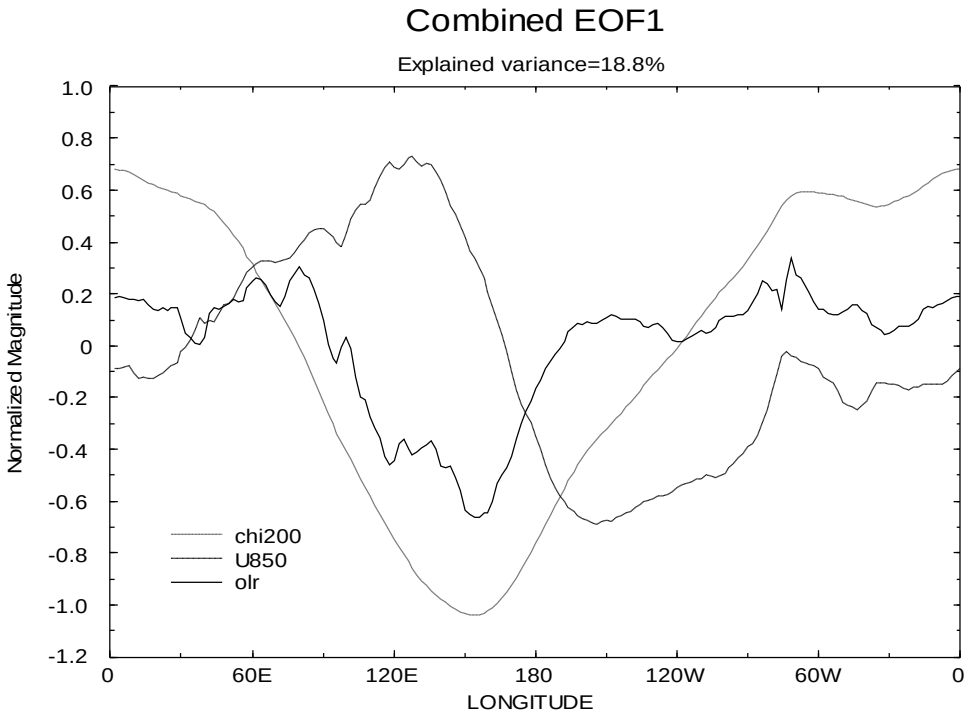
- **EXPERIMENT:** A 5-member ensemble has been run every day from 15 December 1992 to 31st January 1993.

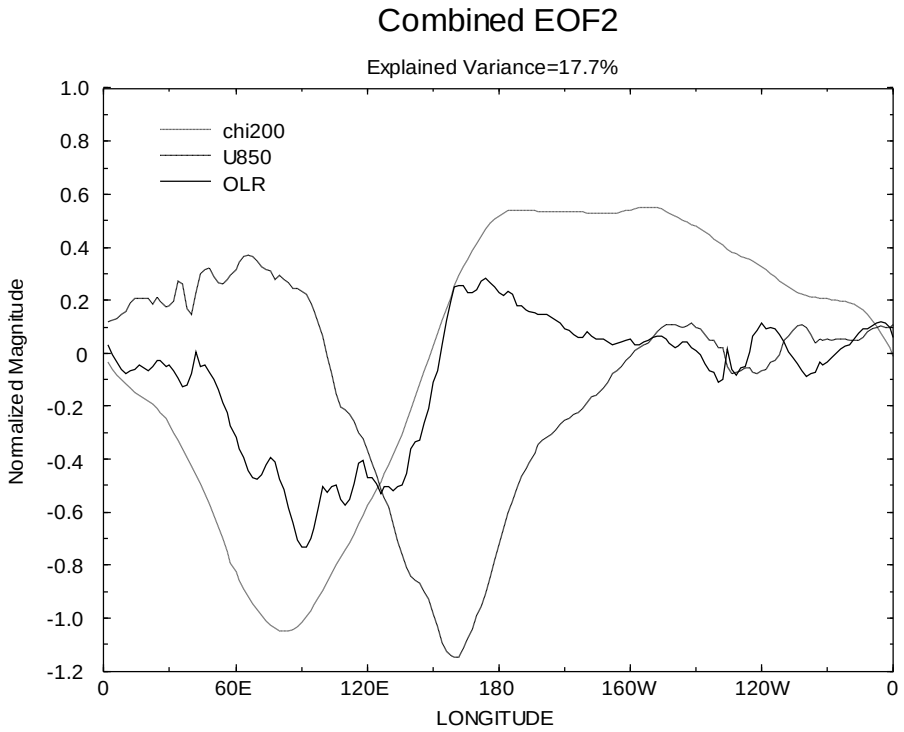
- The MJO diagnostic is based on the same method as in Wheeler and Hendon (2004). We use combined EOFs of:
  - Velocity potential anomalies at 200 hPa
  - Outgoing Long-Wave Radiations anomalies
  - Zonal wind at 850 hPa anomalies

- Anomalies are relative to the past 12 years climate. The fields have been averaged between 10N and 10S and normalized, before computing the combined EOFs.

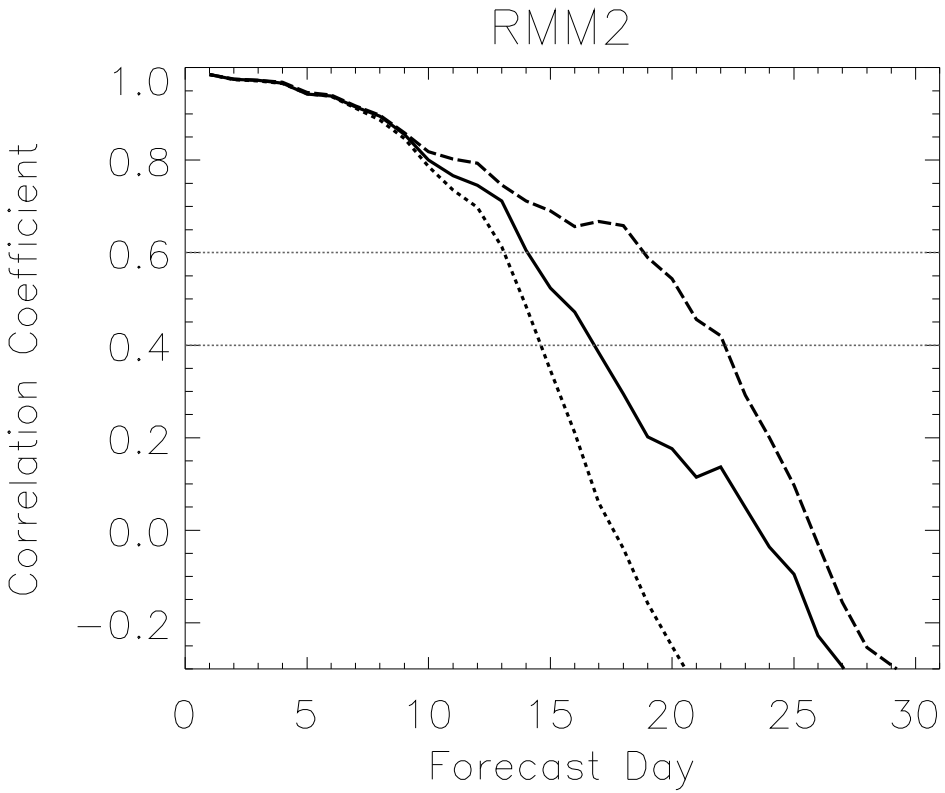
MJO Prediction

The combined EOFs have been computed on ERA40 daily data from 2002 to 2004.





MJO prediction – CY28R3



Per. SST anomalies

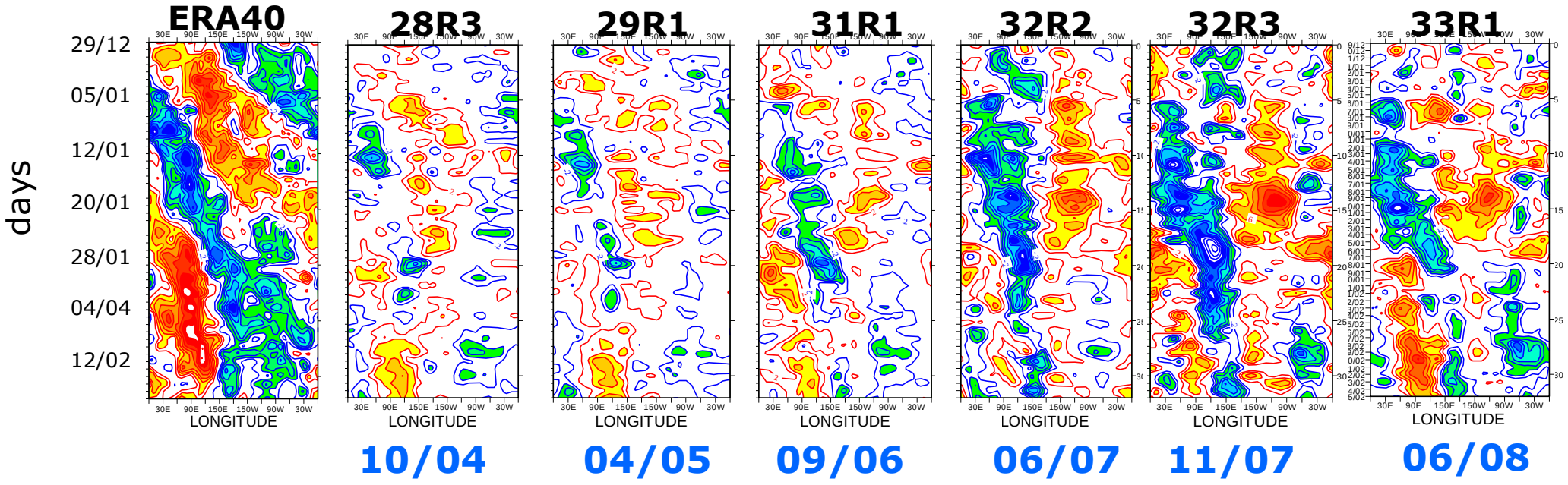
OGCM

ML

Woolnough et al, MWR, 2007

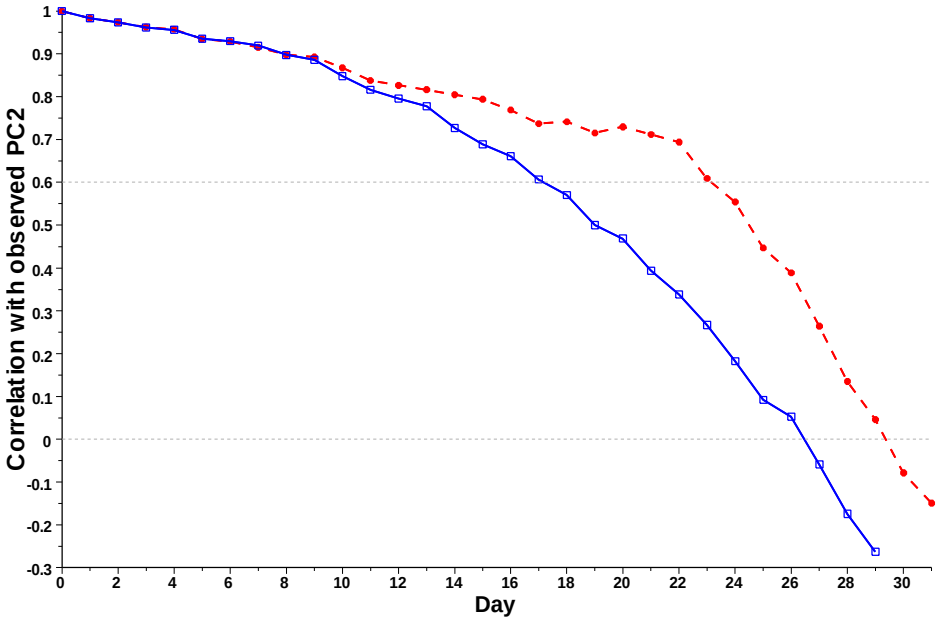
Velocity potential at 200 hPA

VP200 - Forecast range: day 15

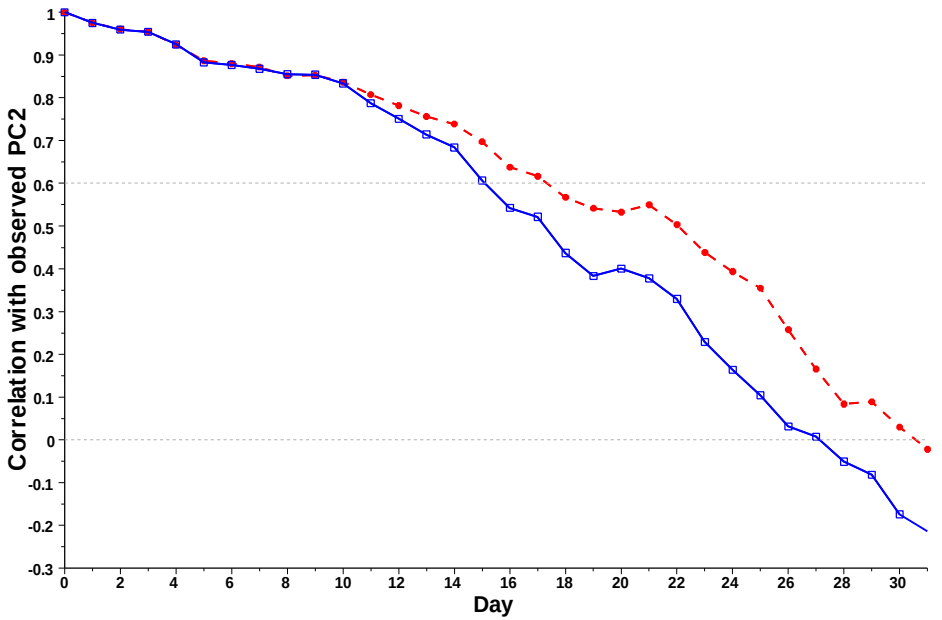


MJO Prediction. RMM2

CY30R2



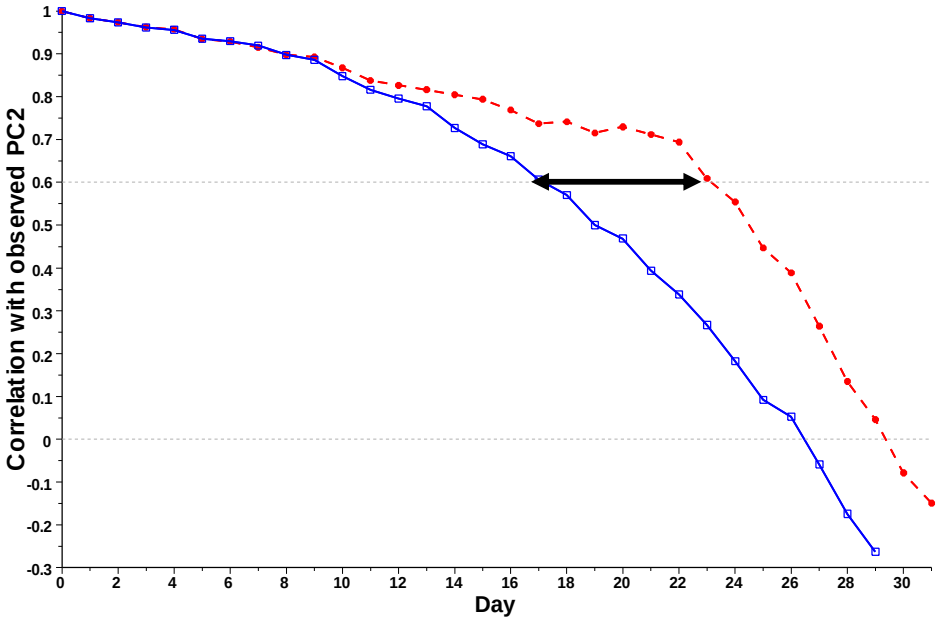
CY32R3



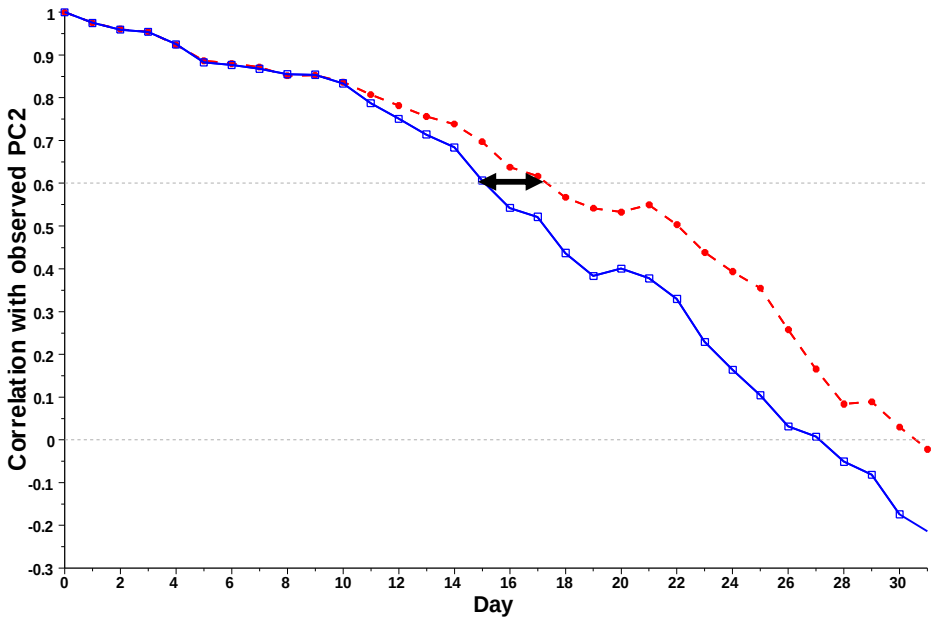
ML OGCM

MJO Prediction. RMM2

CY30R2



CY32R3



ML OGCM

Indian Monsoon Prediction

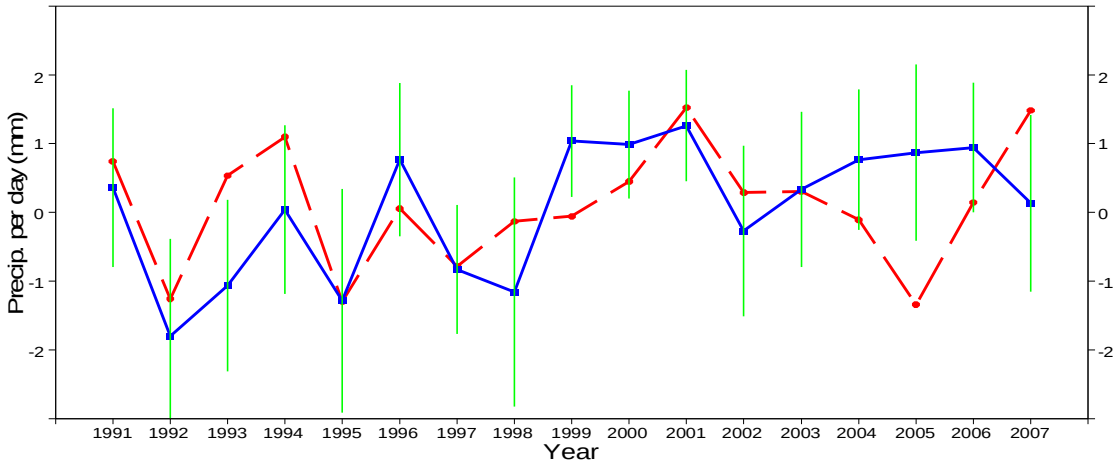
Skill to predict June Indian rainfall

Experiment's setting:

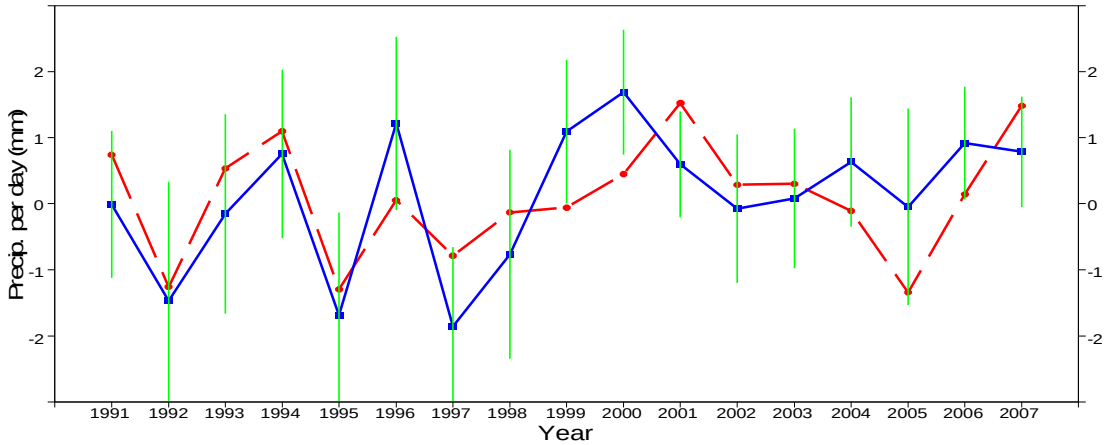
- 46 day forecasts at T159L62
- 15 members
- Starting dates: 15 May 1991-2007
- Model Cycle 31R2 (operational cycle from 12/06 to 06/07)

Interannual variability of June Indian rainfall – Day 16-45

OGCM



ML



Ens. Mean

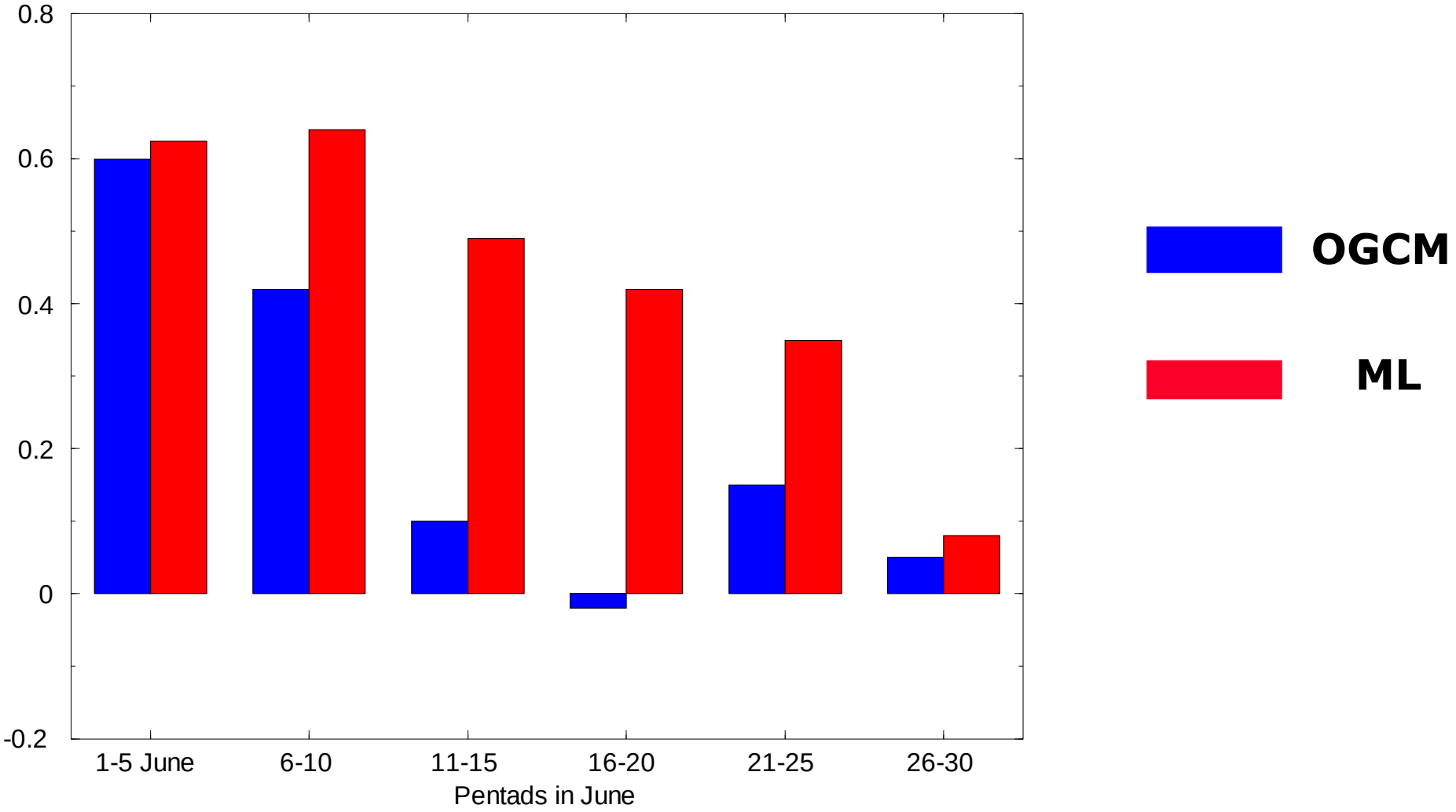
Indian Station Data

Obs. Forecast Standard Deviation

June Precipitation over India

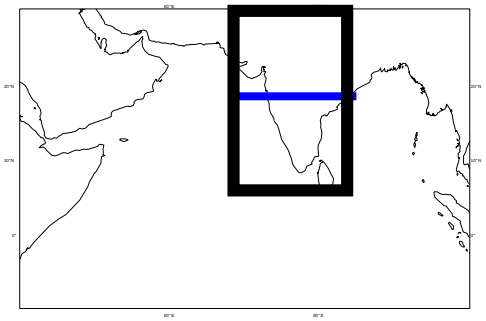
	OGCM	ML
Correlation	**0.43 (+/- 0.07)**	**0.62 (+/- 0.04)**
RMS error	**0.98**	**0.84**

Correlation with IMD station data

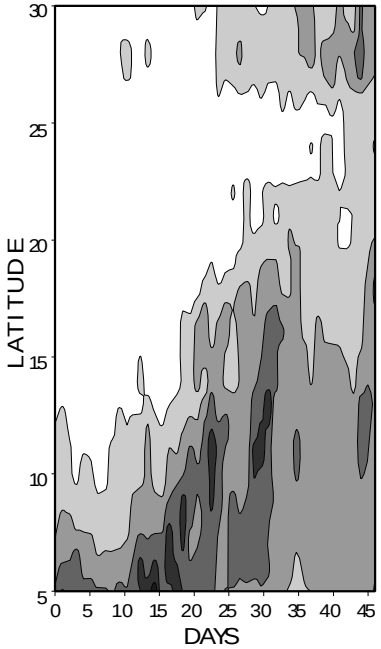


Precipitation averaged between 70E and 85E

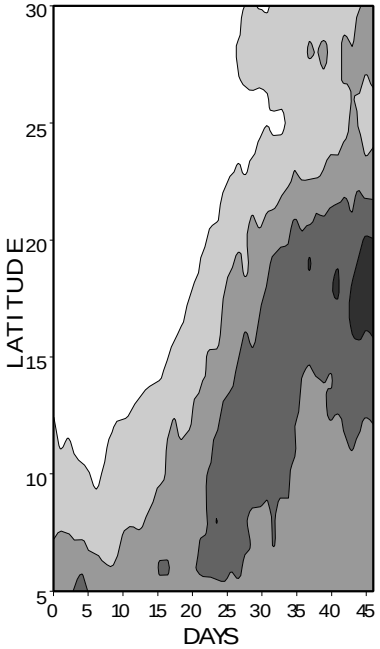
Climatology



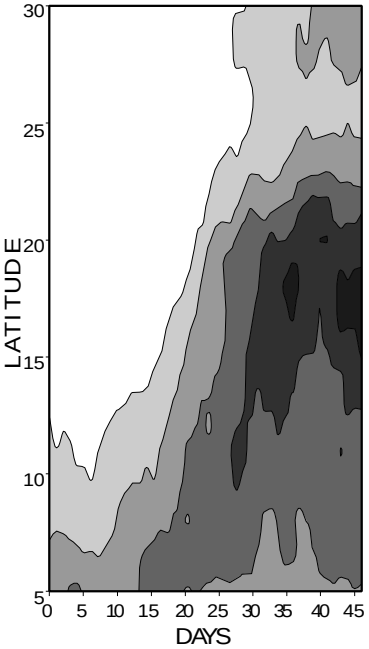
Analysis



OGCM

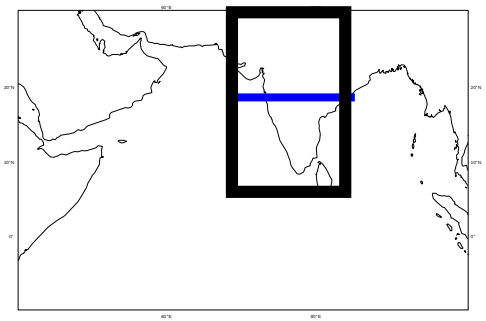


ML

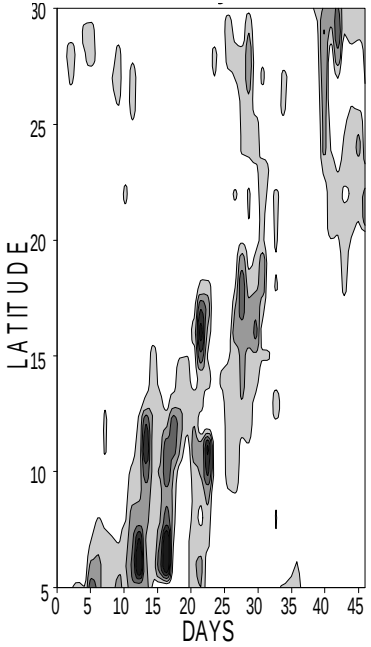


Precipitation averaged between 70E and 85E

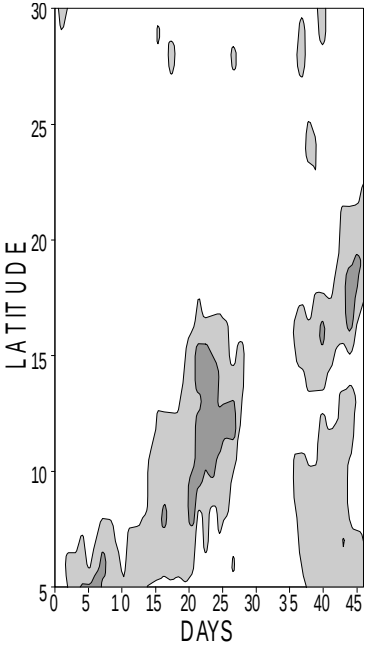
1994



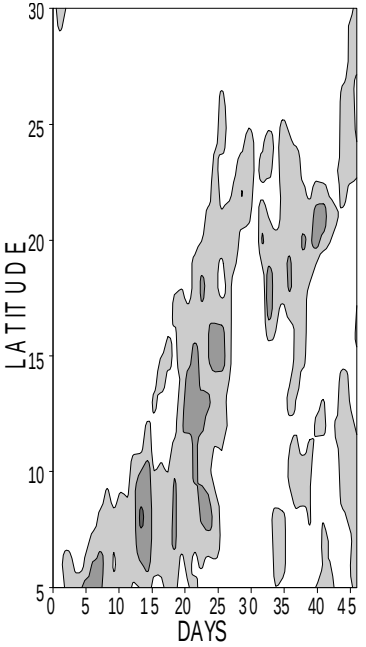
Analysis



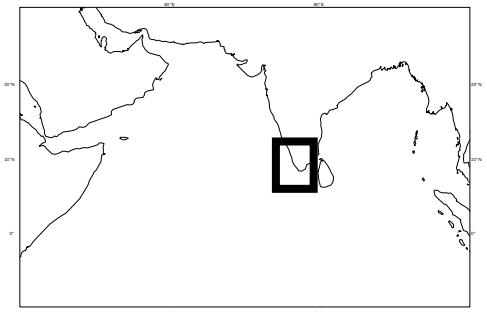
OGCM

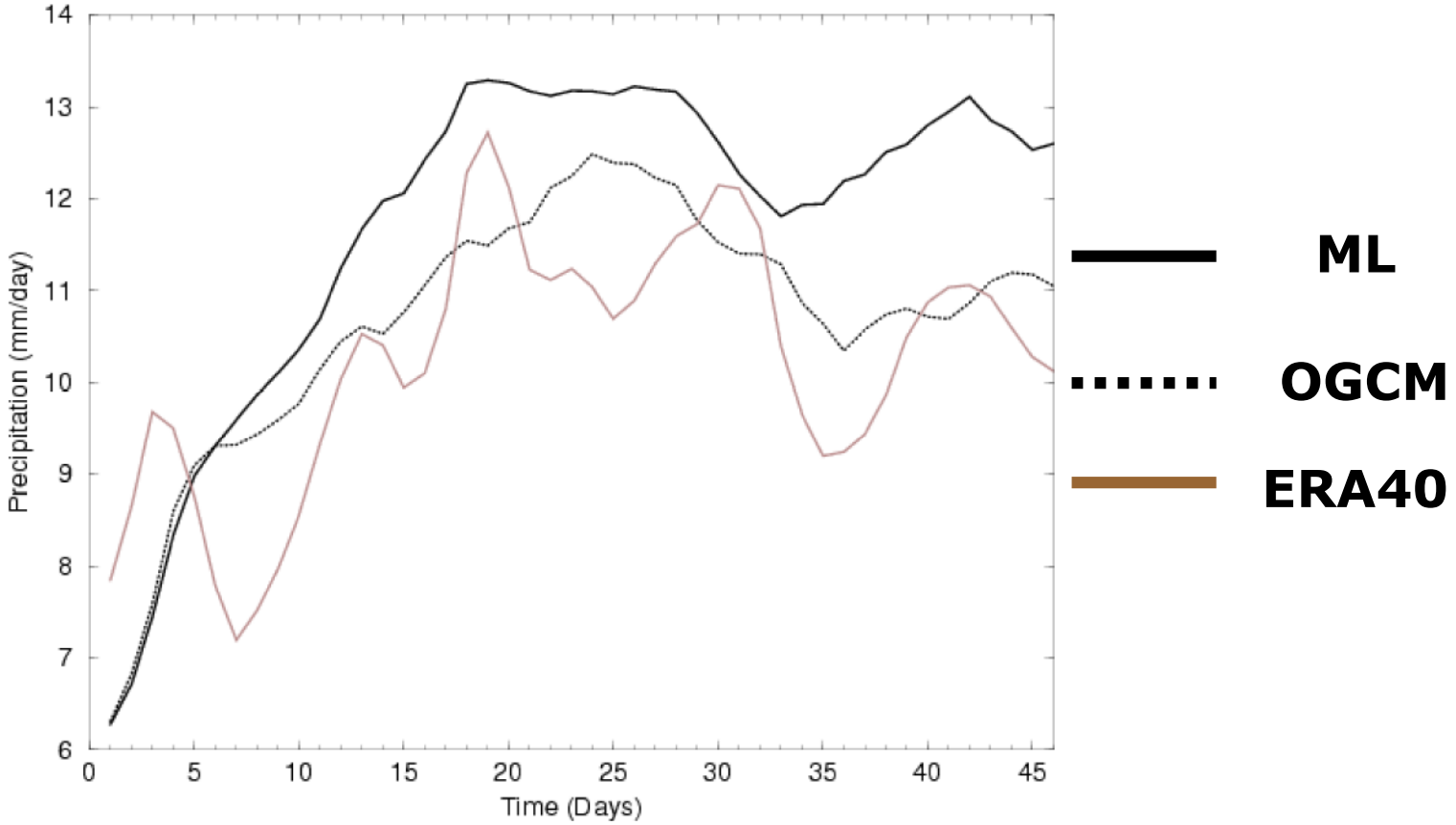


ML

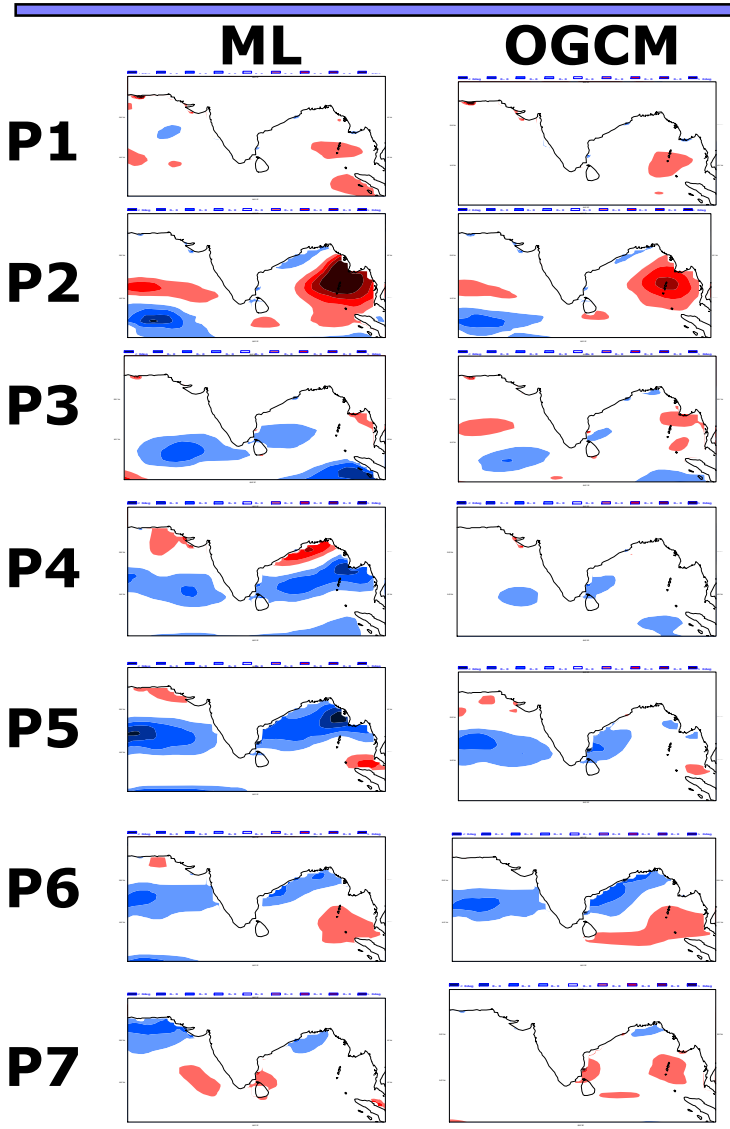


1991-2001 precipitation over the Kerala region

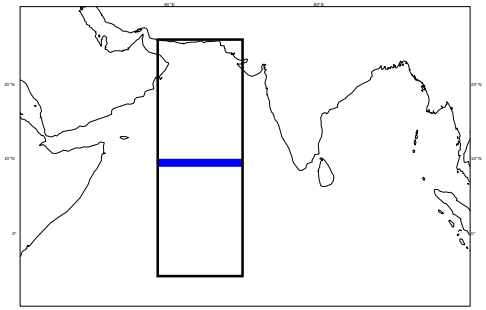


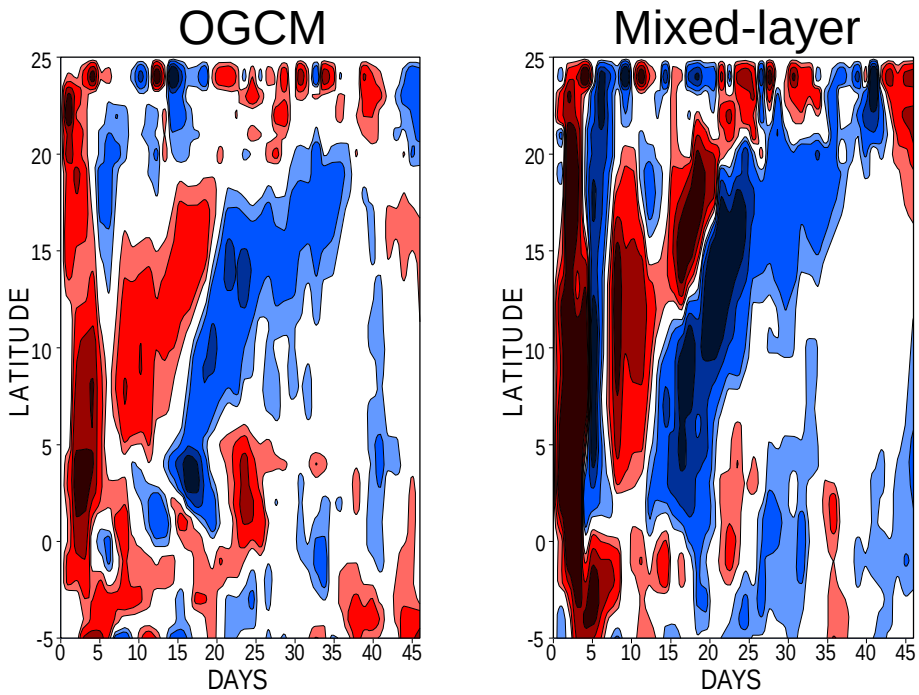


SST Evolution - 1994



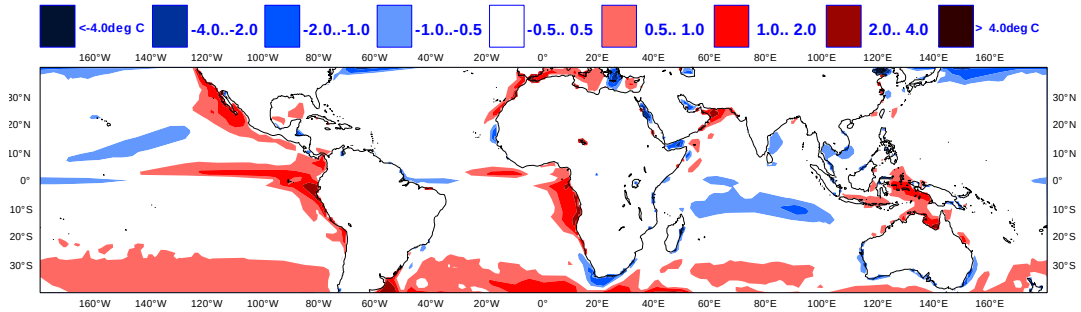
SST Tendencies



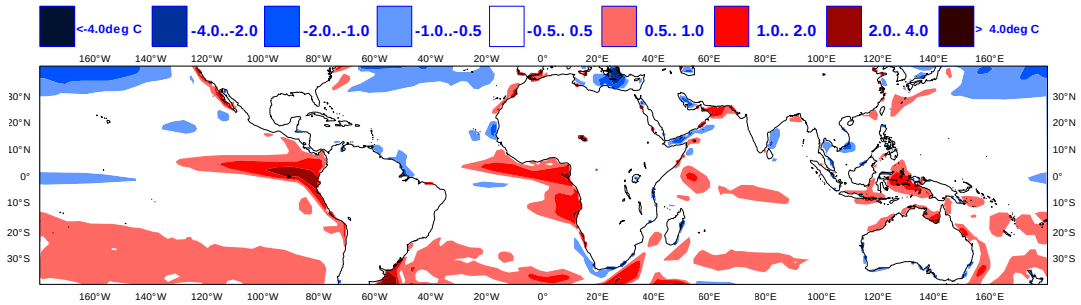


SST BIAS JJA 1991-2007 – Time range: day 16-45

ML

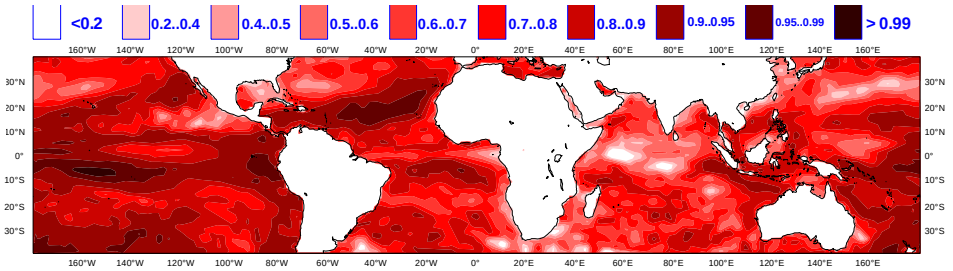


OGCM

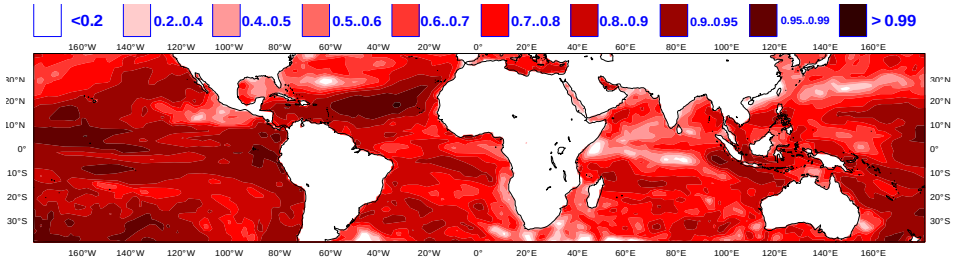


Correlation with Reynolds Oiv2 SSTs- JJA 1991-2007

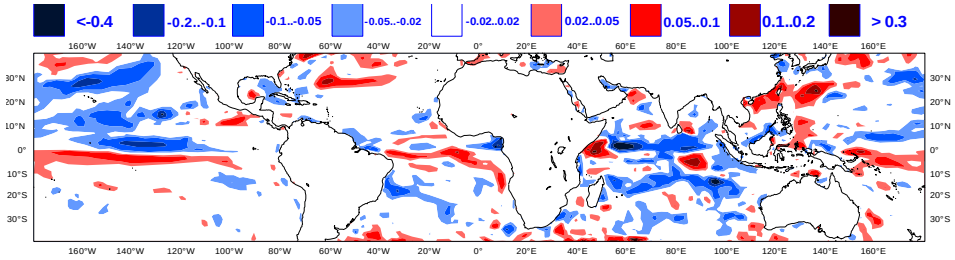
ML



OGCM

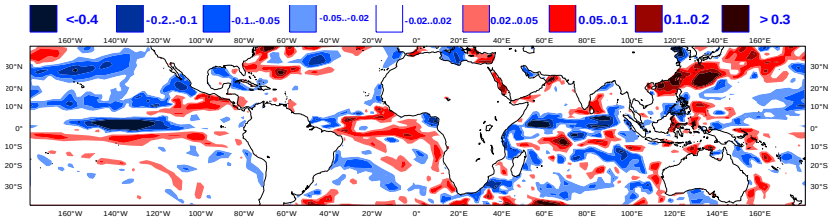


ML - OGCM

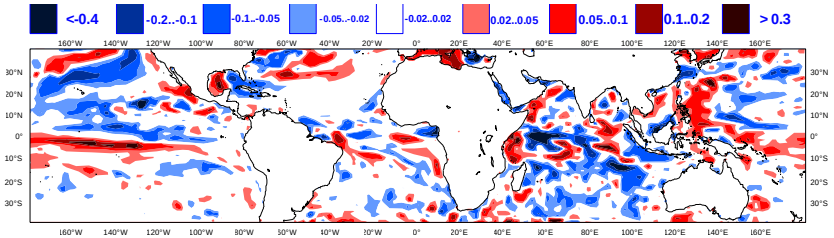


Correlation with Reynolds Oiv2 SSTs: ML - OGCM

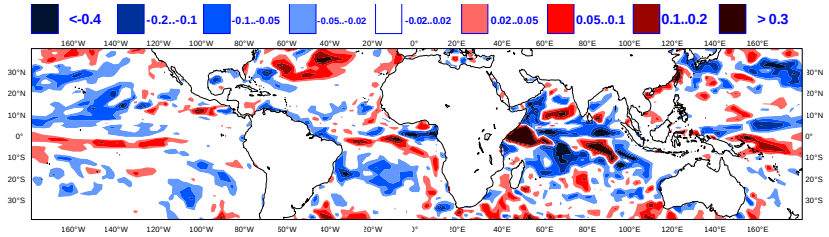
JUNE



JULY

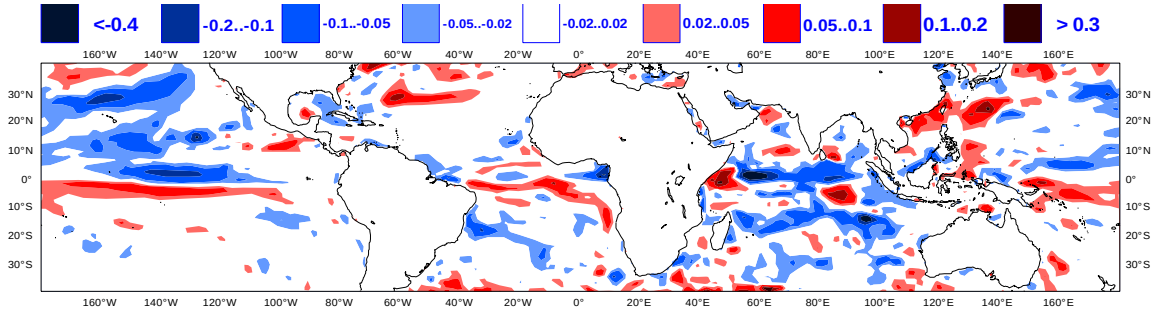


AUGUST

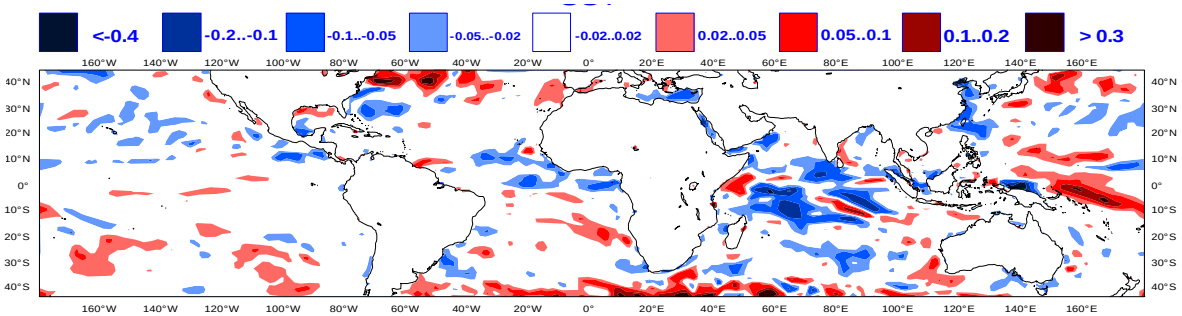


Correlation with Reynolds Oiv2 SSTs: ML - OGCM

JJA



SON



Accumulated Cyclone Energy

Correlation with observations

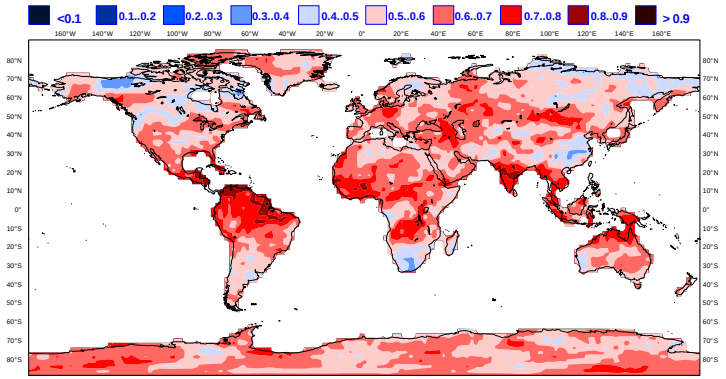
Forecast range day 16-45

	ATL	ENP	WNP
OGCM	0.72	0.63	0.47
ML	0.74	0.50	0.60

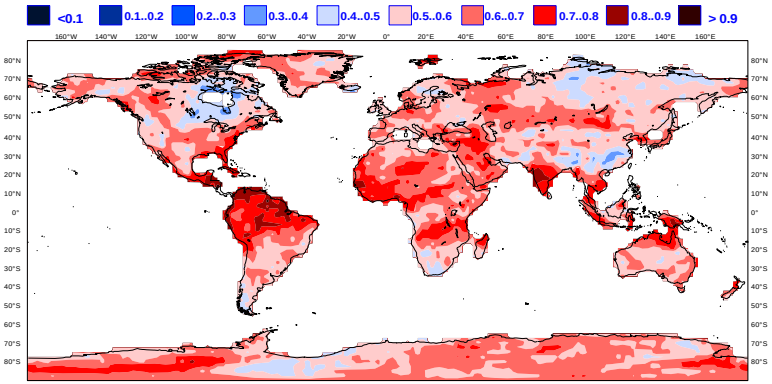
T850 ROC AREA – JJA 1991-2007

Probability of T850 in upper tercile- DAY 16-45

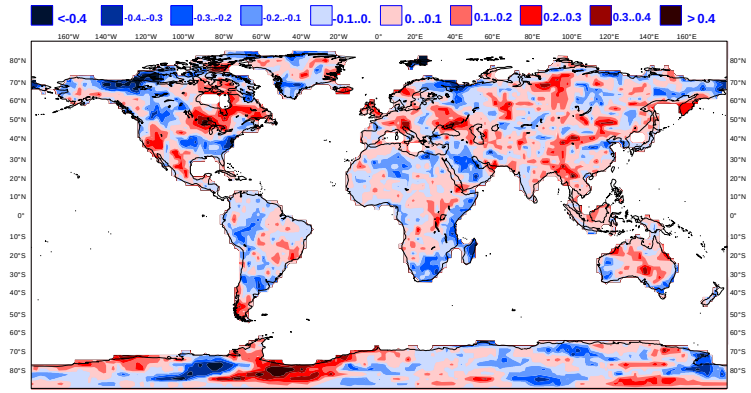
ML



OGCM



ML - OGCM



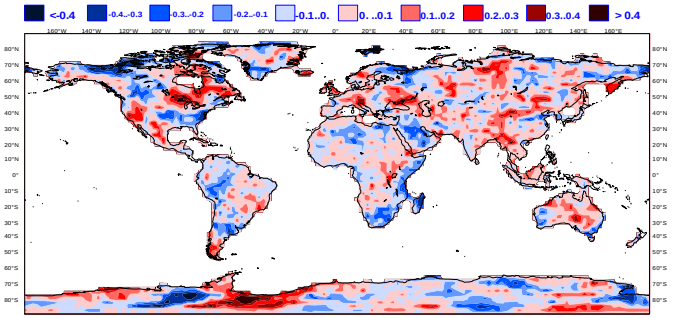
Probabilistic Skill Scores – JJA 1991-2007

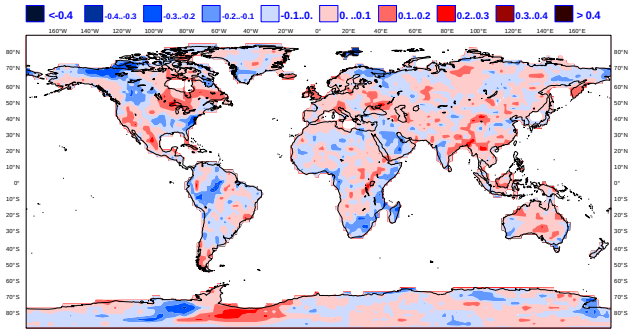
ML - OGCM

ROC Area

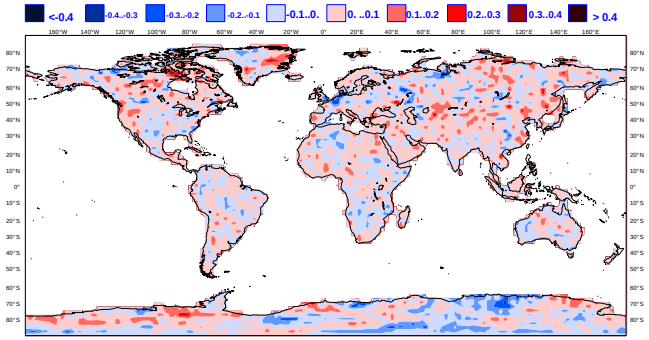
BSS

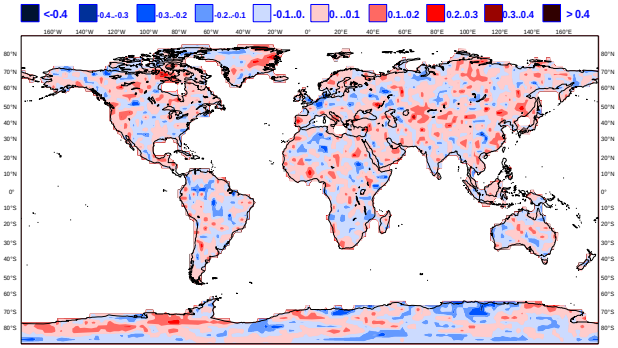
T850





Precip



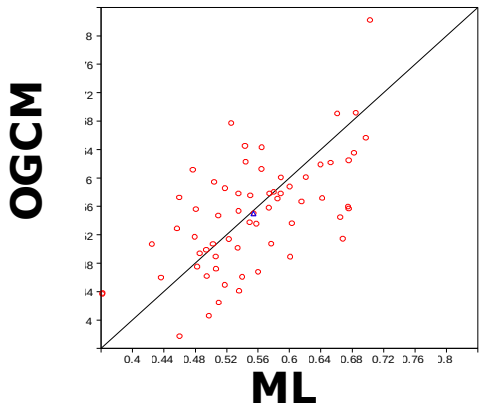


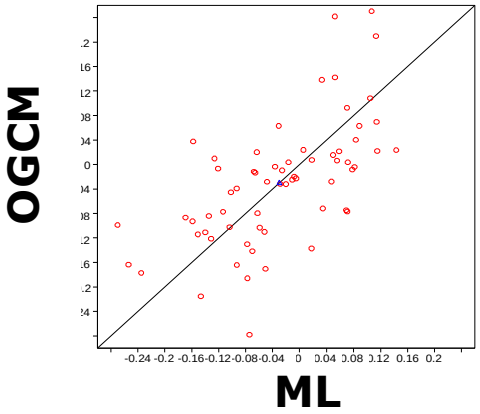
Probabilistic SCORES – Northern Extratropics-day 16-45

ROC Area

BSS

T850





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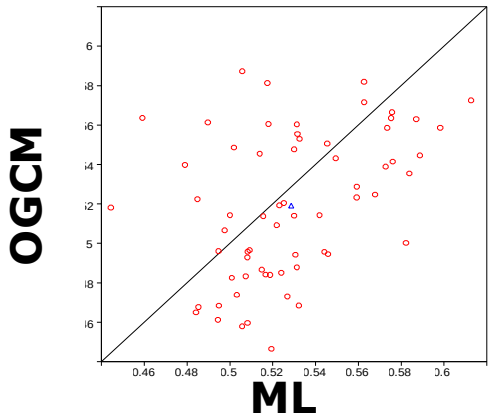
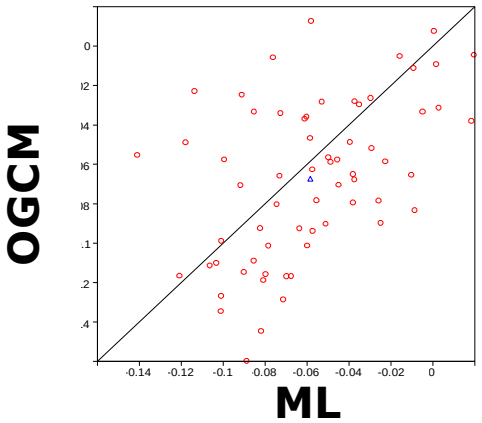


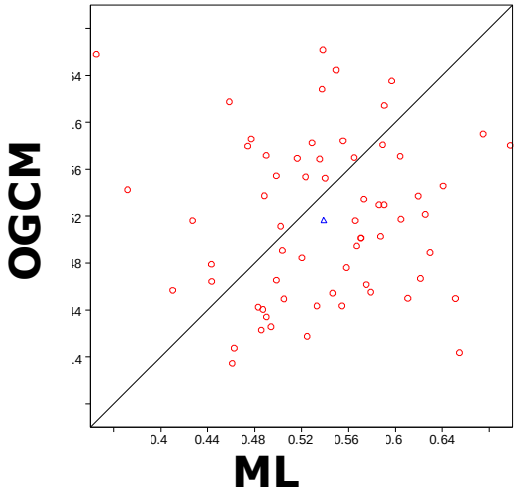


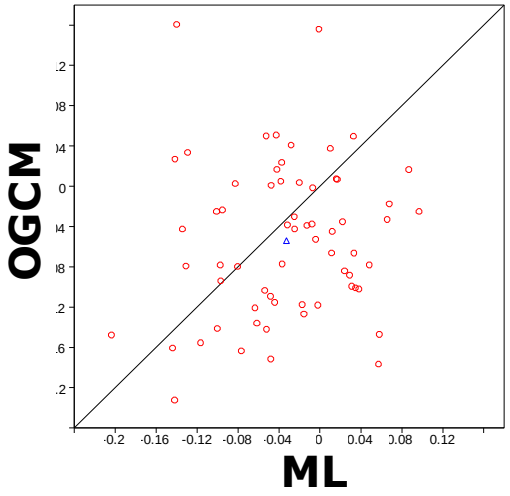
Probabilistic SCORES – Northern Extratropics-day 31-45

ROC Area

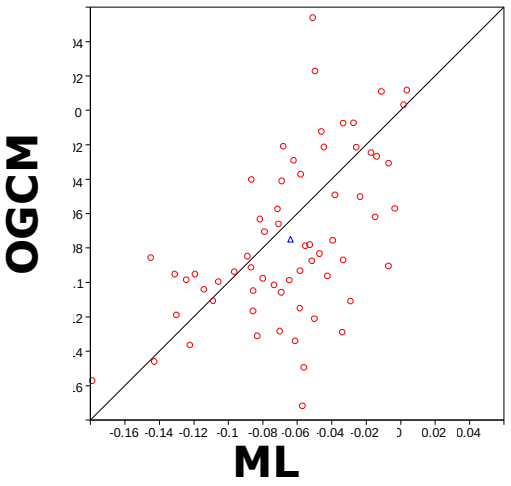
BSS

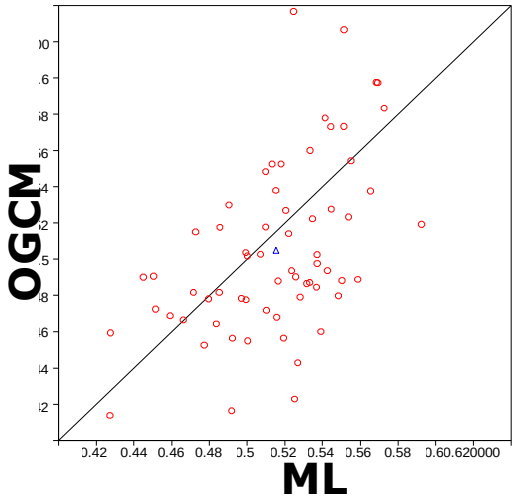
T850





Precip





Conclusion (1)

- A good representation of the mixing in the upper ocean is very important for monthly forecasting:
  - Skill to predict the MJO increased by up to 6 days
  - Skill to predict monsoon rainfall in June increased by about 2-3 pentads

- The ocean mixed layer processes seem to have a more important impact at this time range than ocean dynamics.

- The OGCM currently used in the monthly forecasting system has a configuration (low vertical resolution in the upper ocean and fine horizontal resolution near the Equator) which has not be designed for monthly forecasting. The current monthly forecasts suffer in particular from a low vertical resolution in the upper ocean.

Conclusion (2)

- An ocean mixed layer model could be an alternative to an OGCM at this time range. Work is in progress (Yuhei Takaya) to implement the KPP scheme as a subroutine of IFS. This will allow the testing of the mixed-layer model at very high horizontal resolutions.

- Remaining questions:
  - Impact of horizontal resolution has not been assessed for monthly forecasting
  - Behaviour of the mixed layer model at high latitudes
  - What configuration for medium-range, monthly, seasonal seamless systems? Variable oceanic resolution?