Some tropical issues from a forecast modellers perspective

Martin Miller, ECMWF

Acknowledge my colleagues

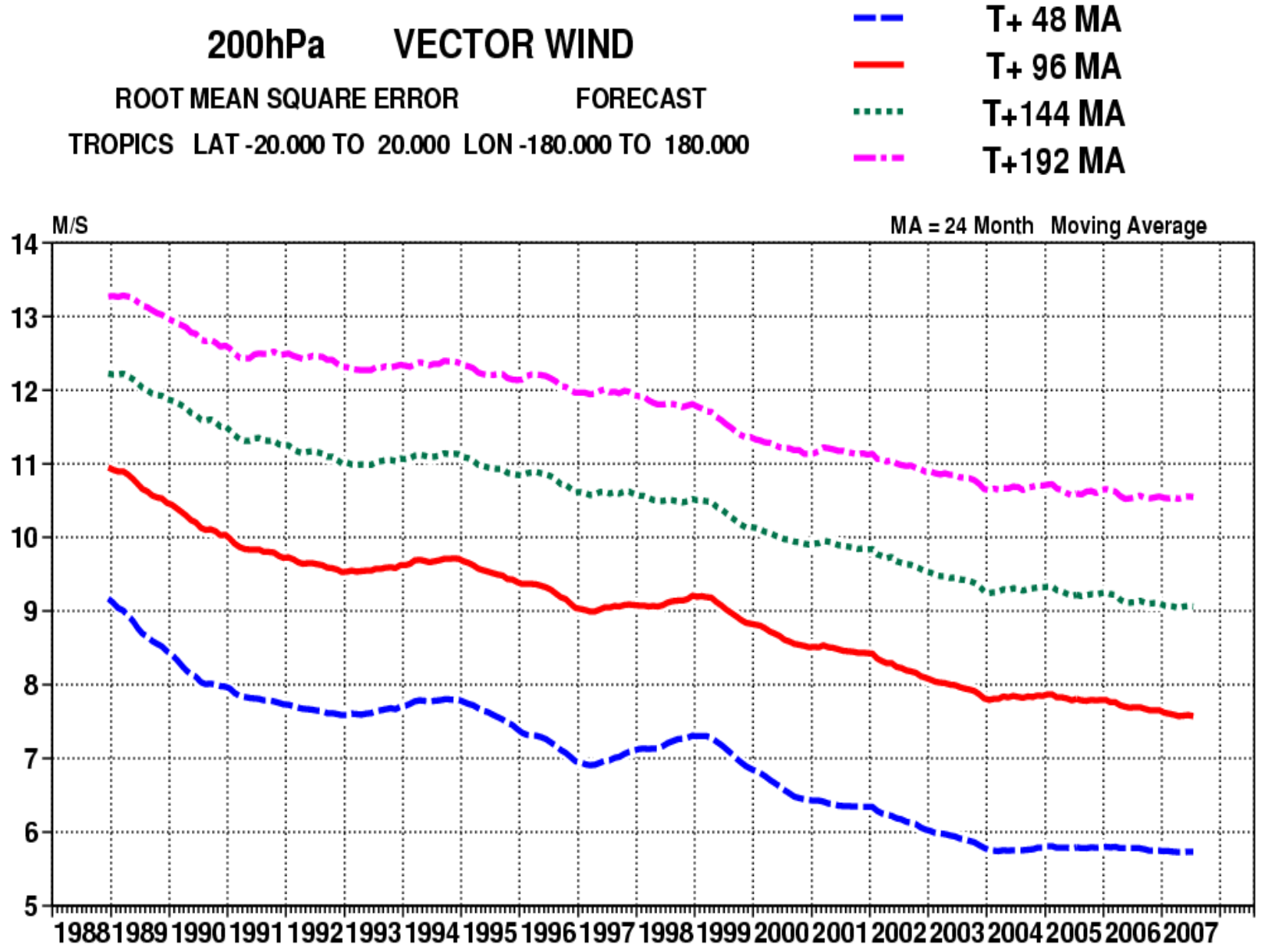
Thomas Jung, Frederic Vitart, Mark Rodwell, Peter Bechtold …….

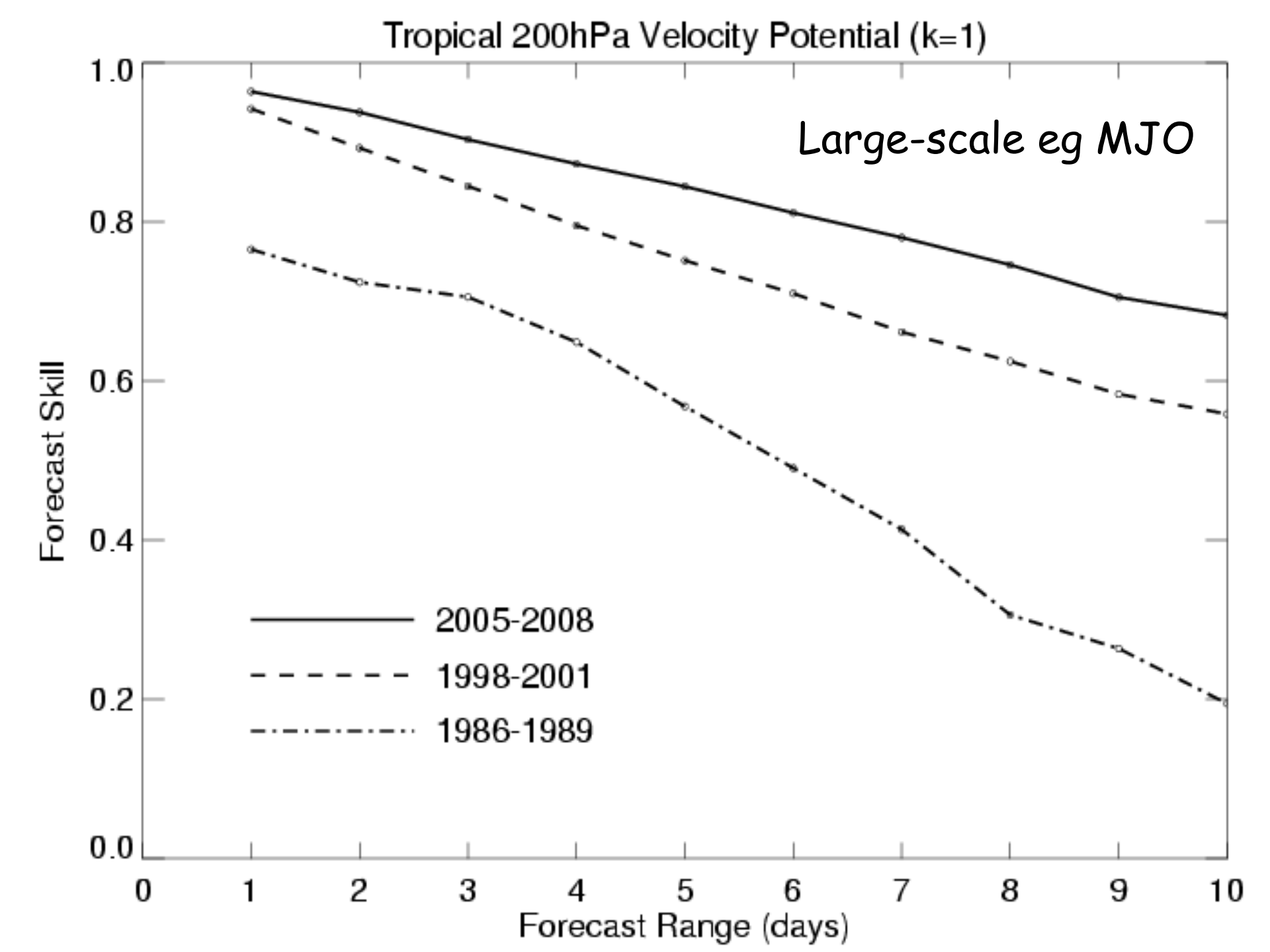
ECMWF FORECAST VERIFICATION 12UTC

200hPa VECTOR WIND

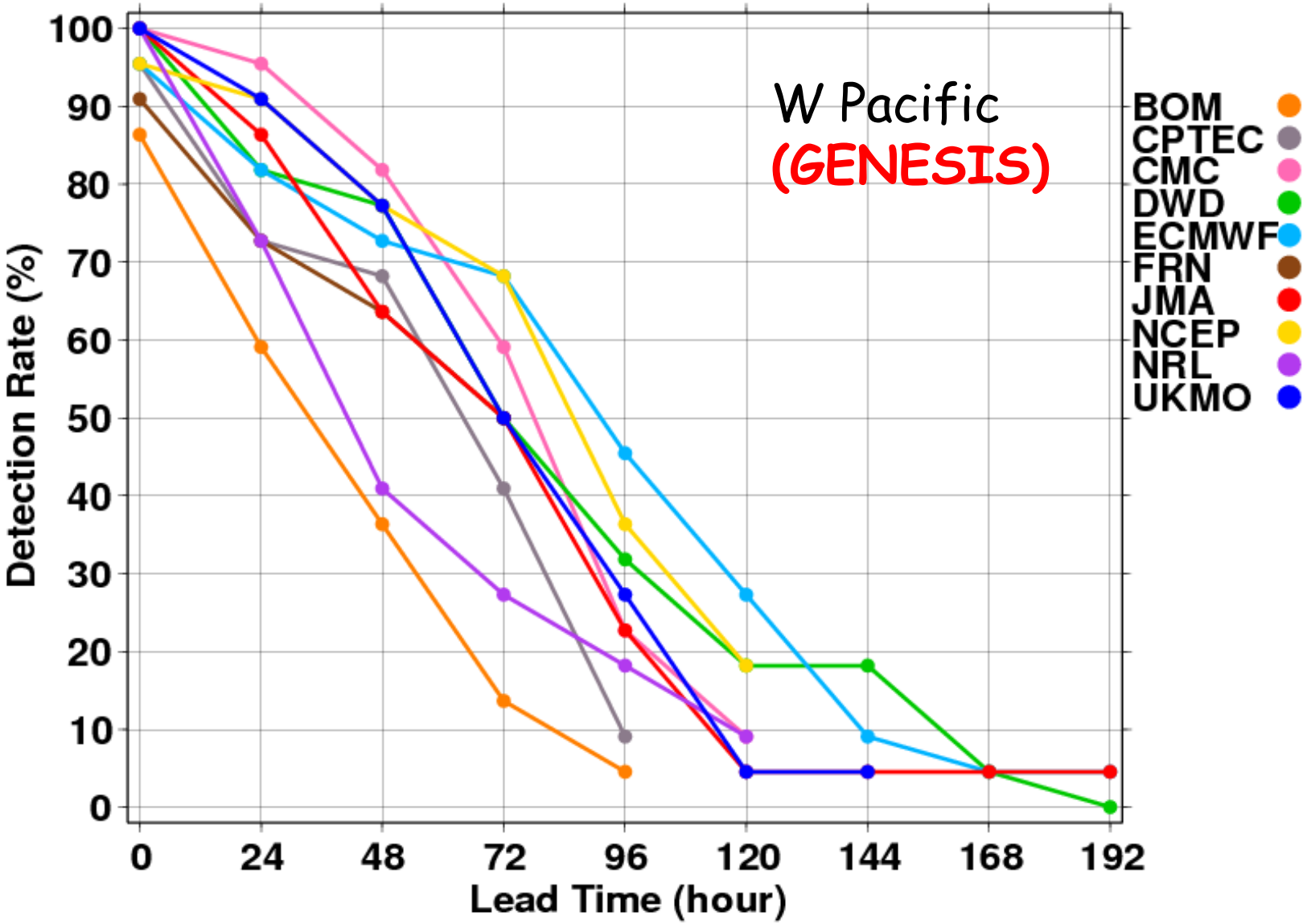
ROOT MEAN SQUARE ERROR FORECAST

TROPICS LAT -20.000 TO 20.000 LON -180.000 TO 180.000

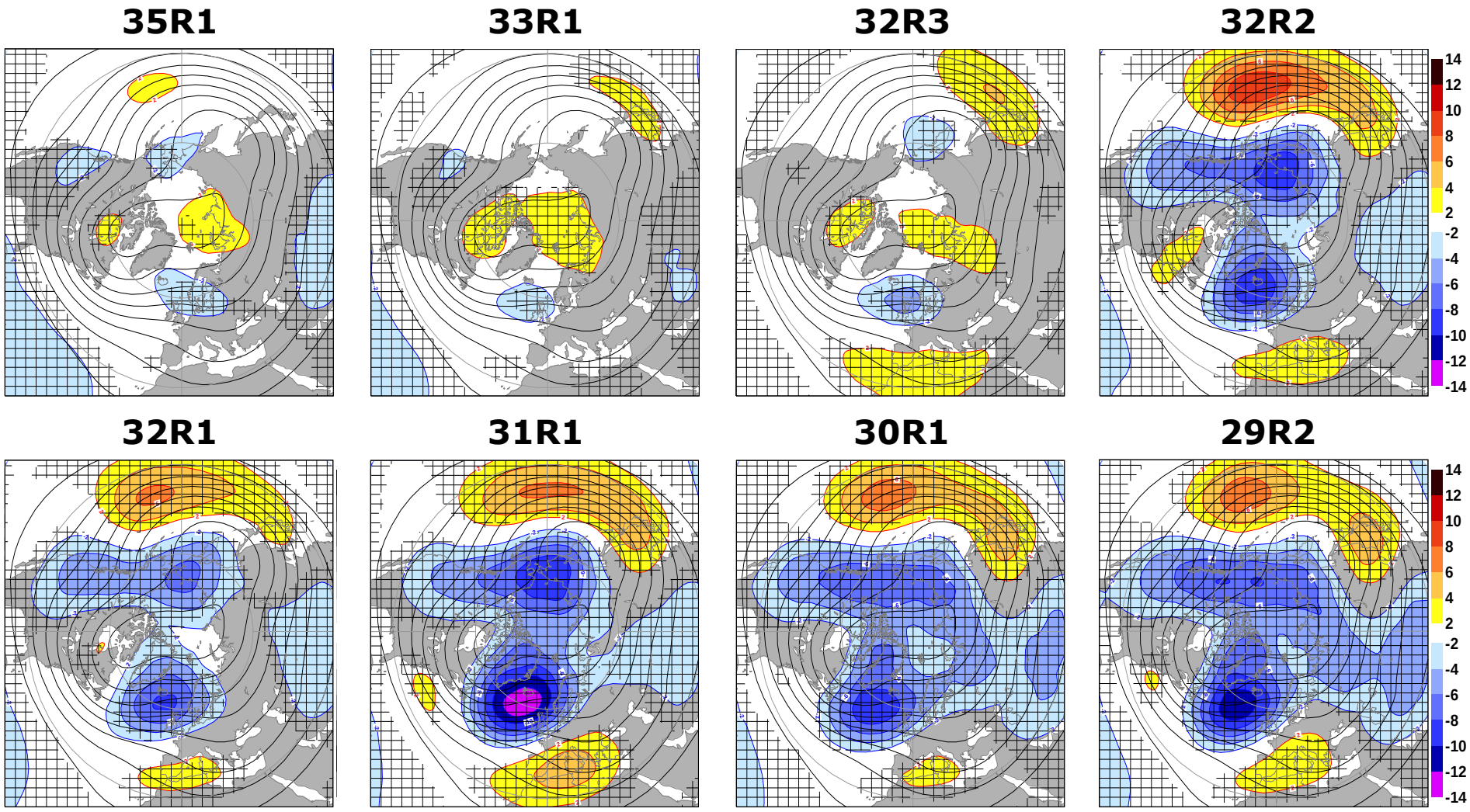



Tropical 200hPa Velocity Potential (k=1)
Large-scale eg MJO
Forecast Skill
1.0
0.8
0.6
0.4
0.2
0.0
2005-2008
1998-2001
1986-1989
0
1
2
3
4
5
6
7
8
9
10
Forecast Range (days)

WGNE/JMA for 2007



Evolution of Systematic Z500 Errors: Model Climate



Jung et al., QJ, submitted

ECMWF

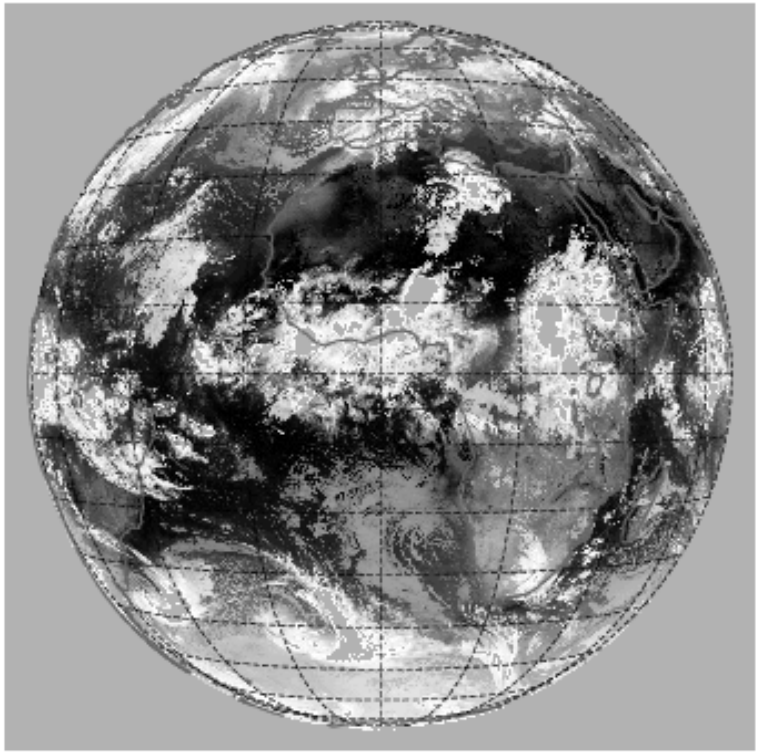
- Many aspects of the global model climate including the Tropics have been improved in the last few years, and some current problems such as with large propagating convective systems e.g. W Africa, respond to resolution
- Diurnal cycle getting better but…

Simulated Meteosat imagery

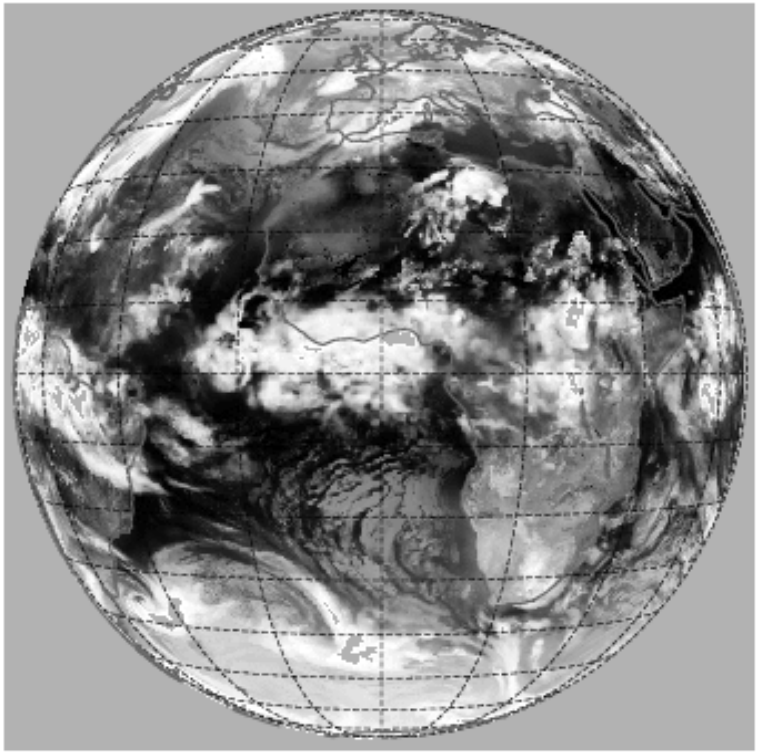
T799 36h forecast from 20080525

(Bechtold 2008)

Meteosat 9 IR10.8 20080525 0 UTC

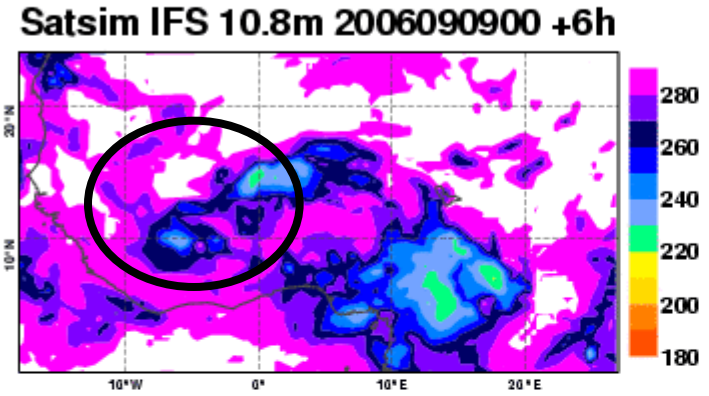


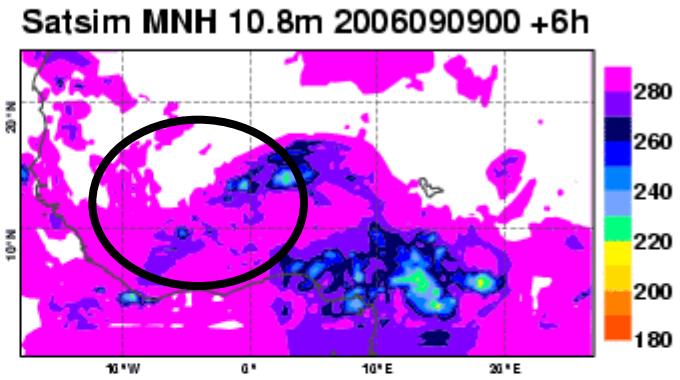
RTTOV gen. Meteosat 8 IR10.8 ECMWF Fc 20080525 00 UTC:

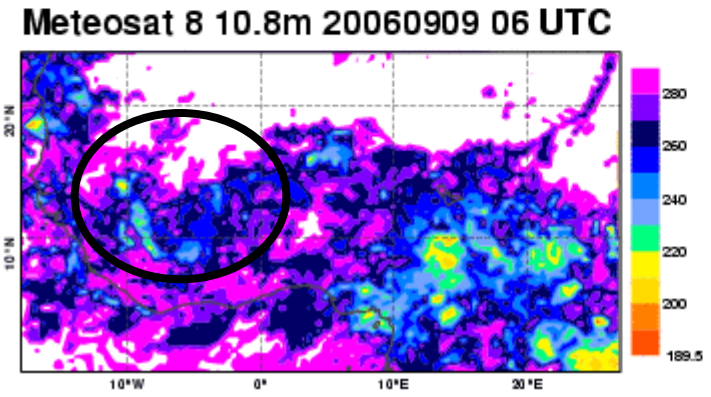


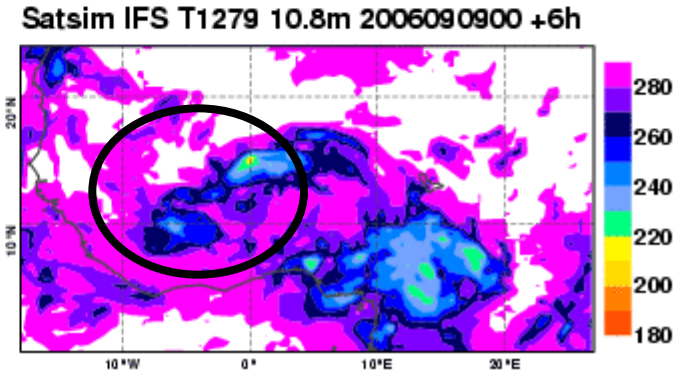
Example of AMMA easterly wave case (24h)
verification of convective systems using BTs 10.8µ

All images interpolated to T511 grid



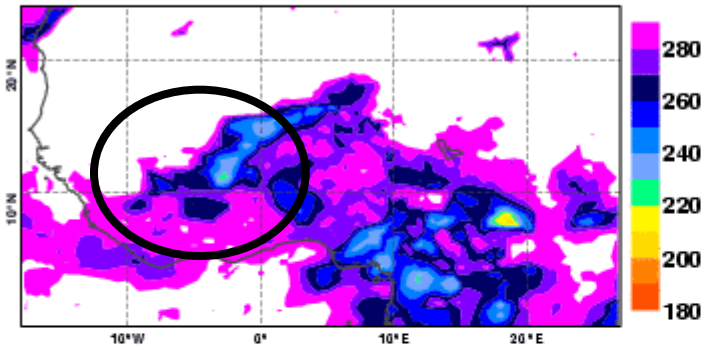




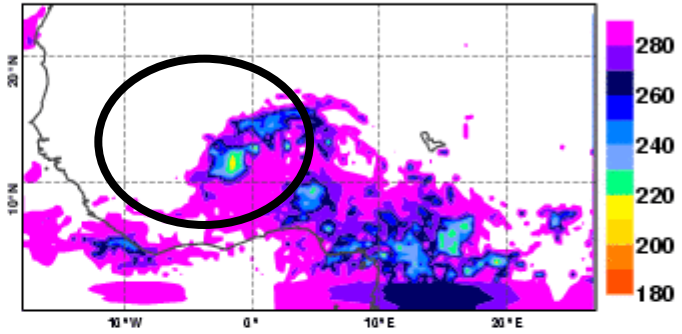


AMMA easterly wave case
verification of convective systems using BTs 10.8µ

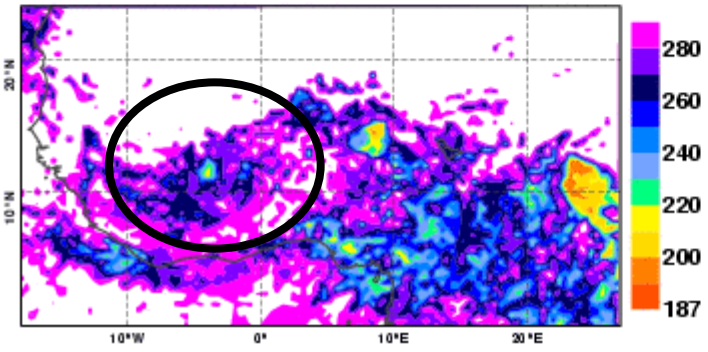
Satsim IFS 10.8m 2006090900 +12h



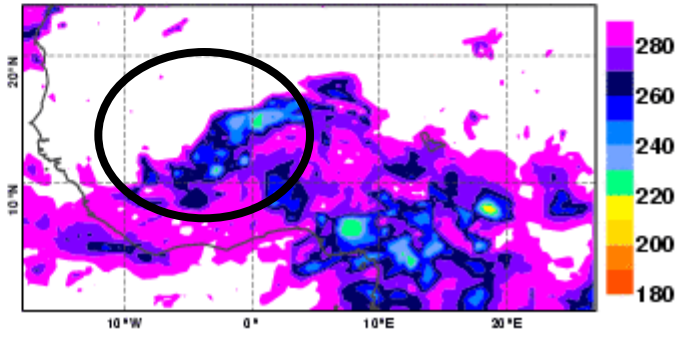
Satsim MNH 10.8m 2006090900 +12h



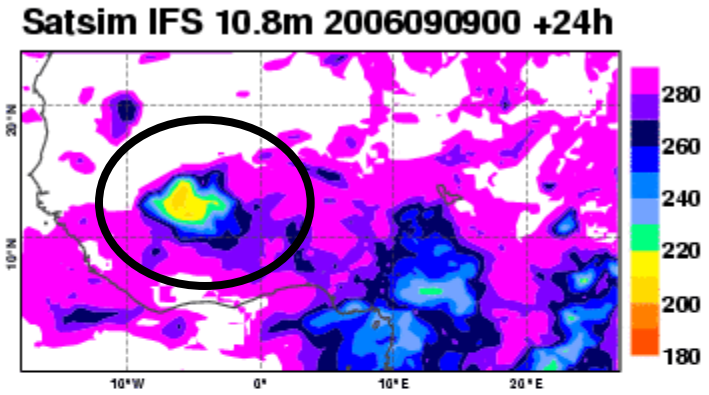
Meteosat 8 10.8m 20060909 12 UTC

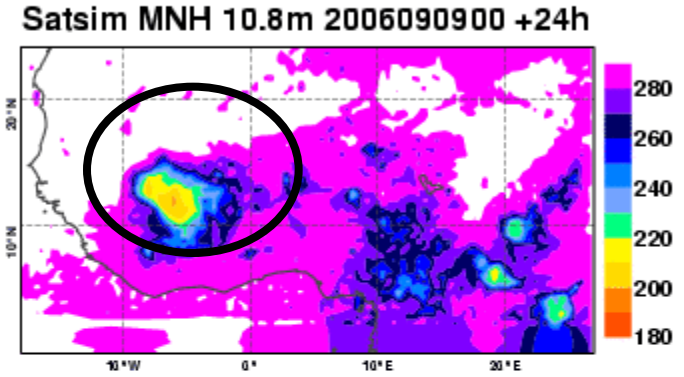


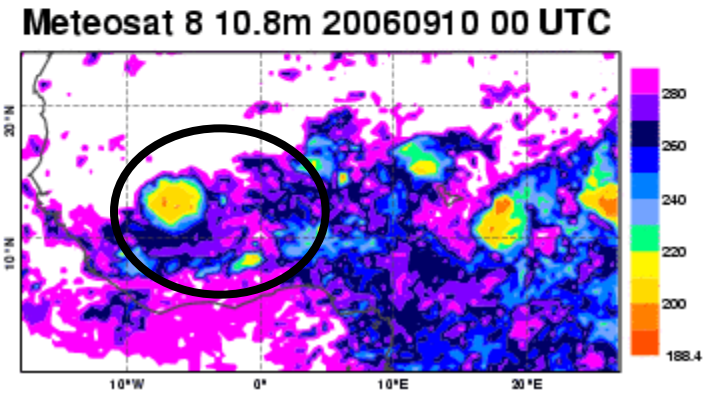
Satsim IFS T1279 10.8m 2006090900 +12h

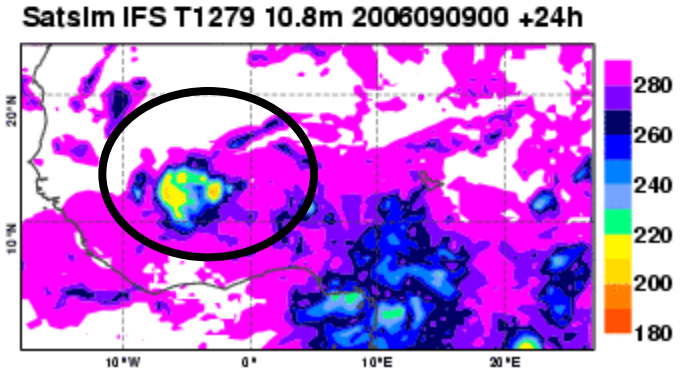


AMMA easterly wave case
verification of convective systems using BTs 10.8µ



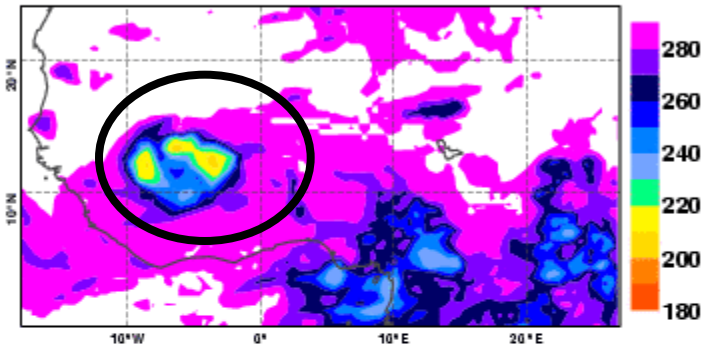






AMMA easterly wave case
verification of convective systems using BTs 10.8µ

Satsim IFS 10.8m 2006090900 +30h



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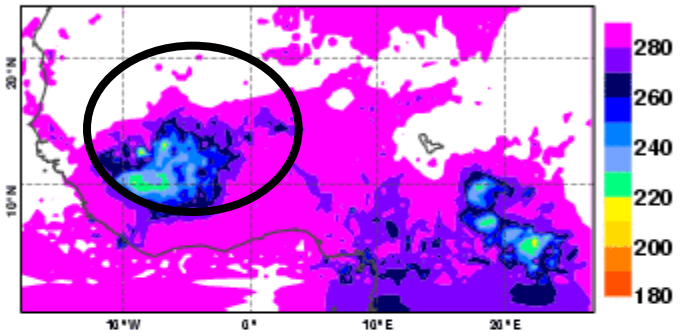
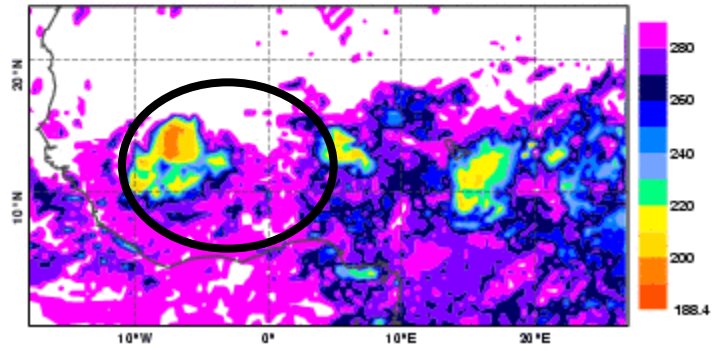


Meteosat 8 10.8m 20060910 06 UTC



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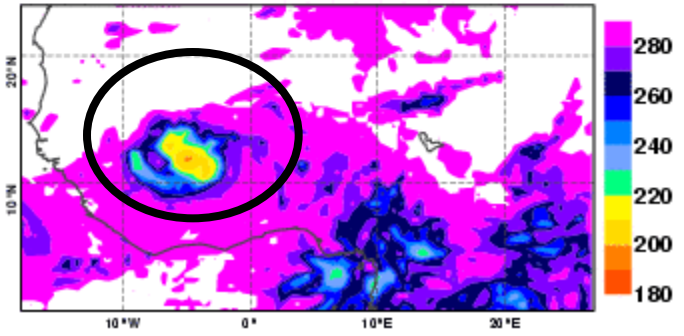
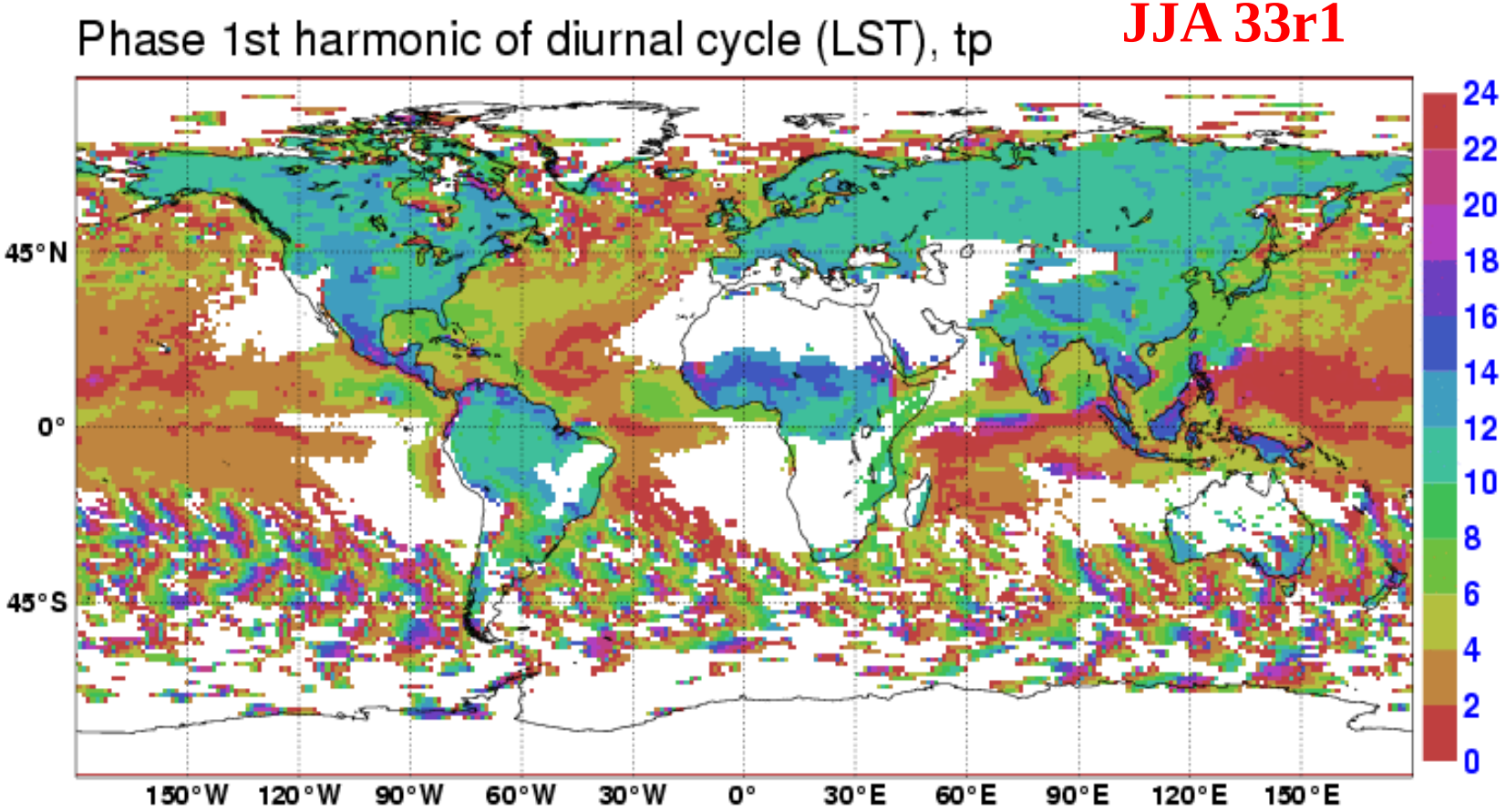


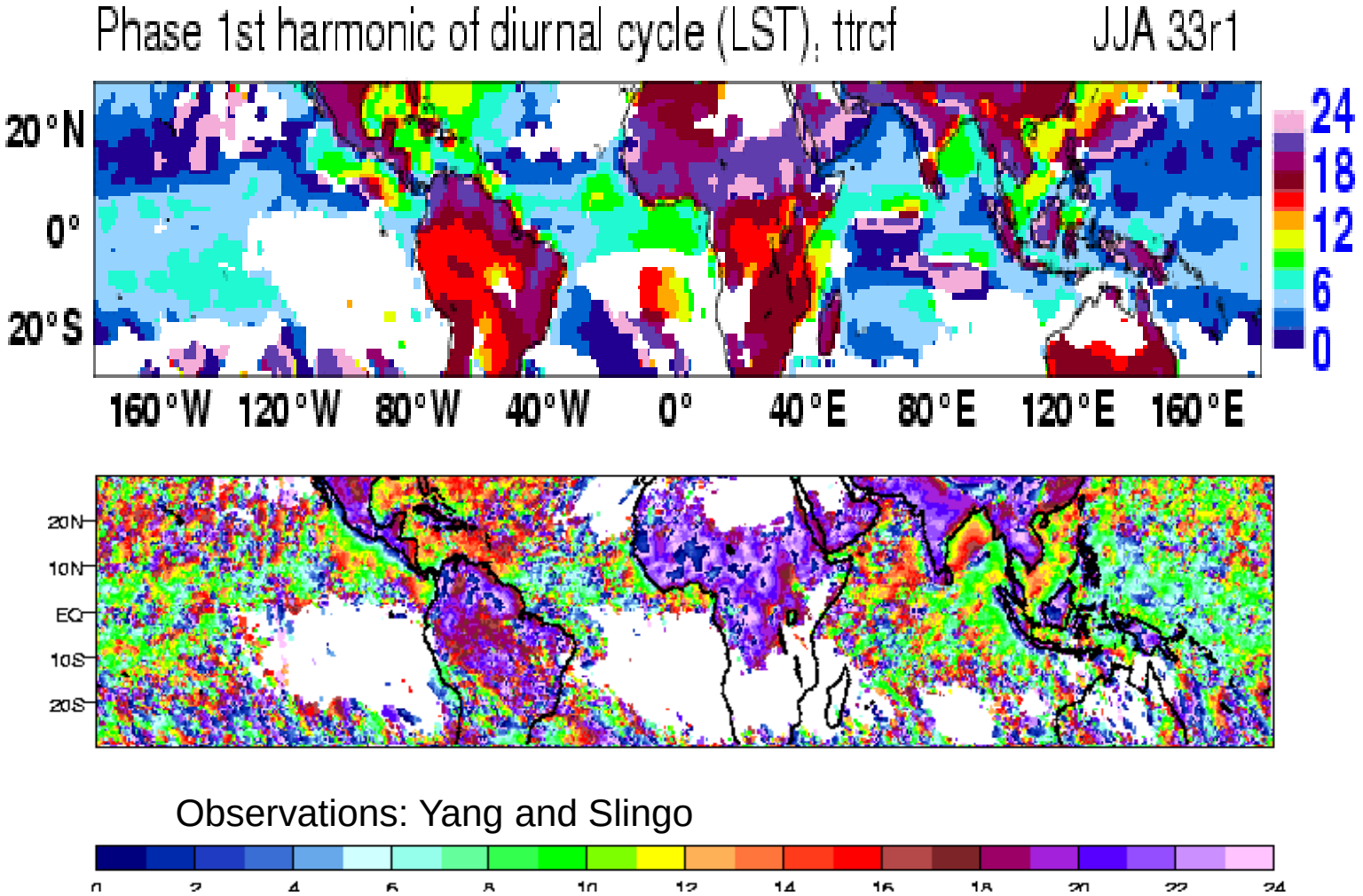
Forecast Biases

Diurnal cycle of Precipitation for JJA (all times are local)



Maximum in model precipitation occurs around 12 LST over land and around 2-4 LST over water. Compared to Obs the diurnal cycle over water is very reasonable but over land it occurs ~3h too early

The diurnal cycle of cloudy OLR (LW cloud radiative forcing) for JJA



Minimum in model OLR over land occurs several hours later than the maximum in precipitation. This time-shift is reasonable and also supported by observations

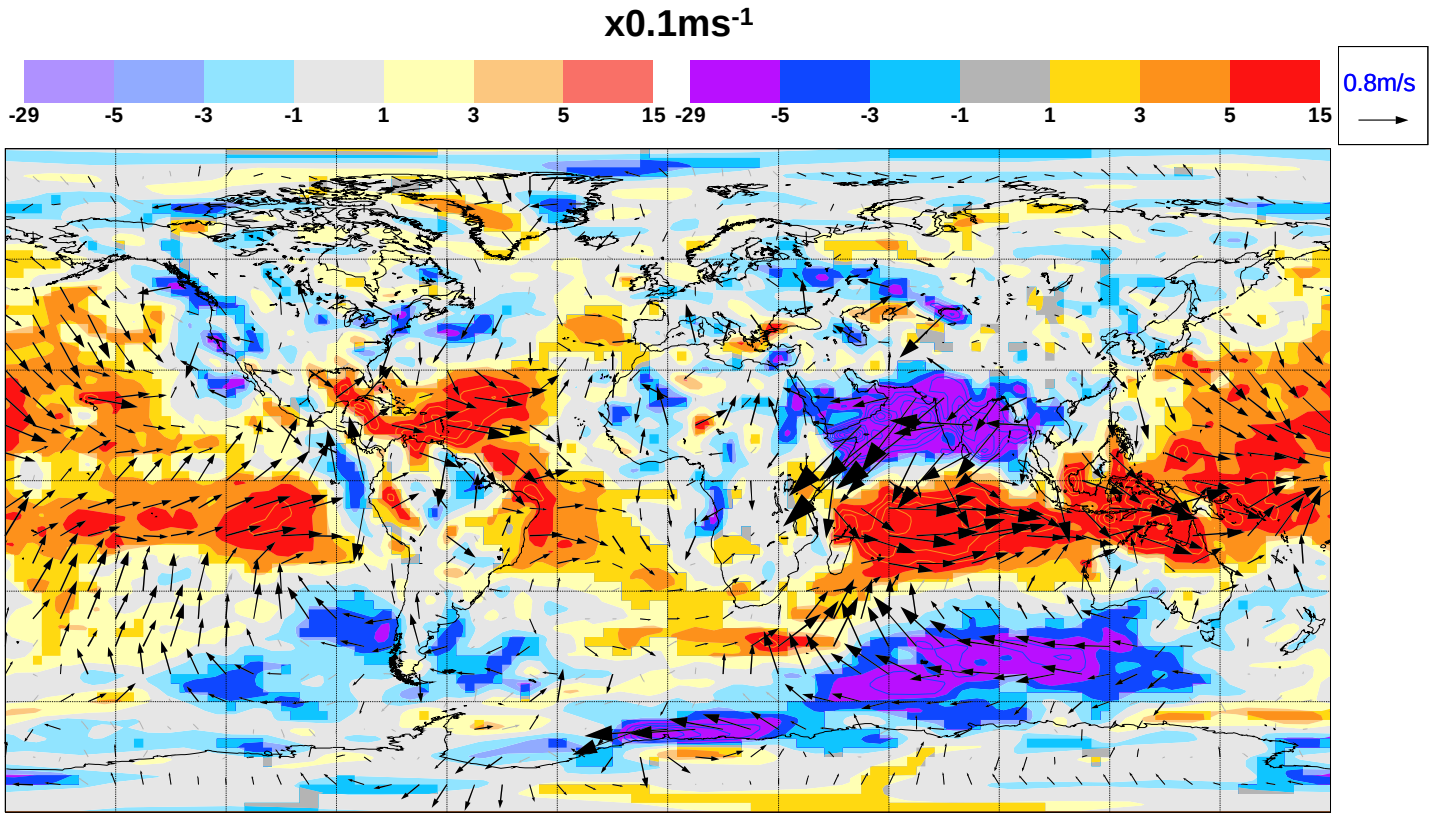
Indian Monsoon – good medium-range forecasts

(Positive feedback from Indian Met)

But monthly/seasonal circulation now too strong!

Variability not well-studied yet

JJA 2008 u and v 925hPa Analysis Increments

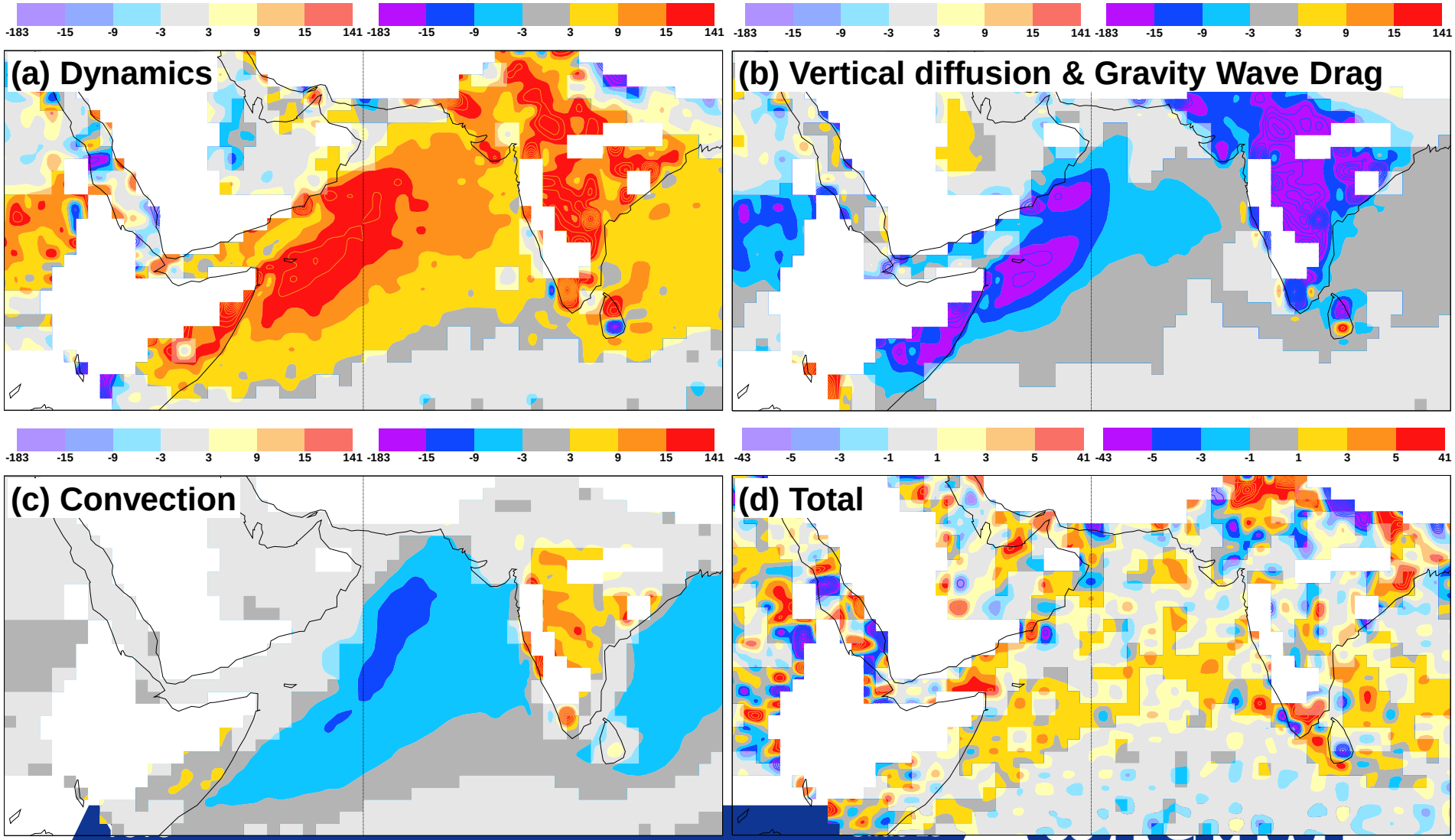


- Analysis Increments indicate that the modelled low-level flow over the Indian Ocean and Arabian Sea (and thus moisture transport into the monsoon) is too strong.
- Are these increments pointing to the root-cause for the monsoon error?

Initial Process Tendencies JJA 2008: U at 925 hPa

33R1

Unit = ms^{-1} over first 24h of forecast

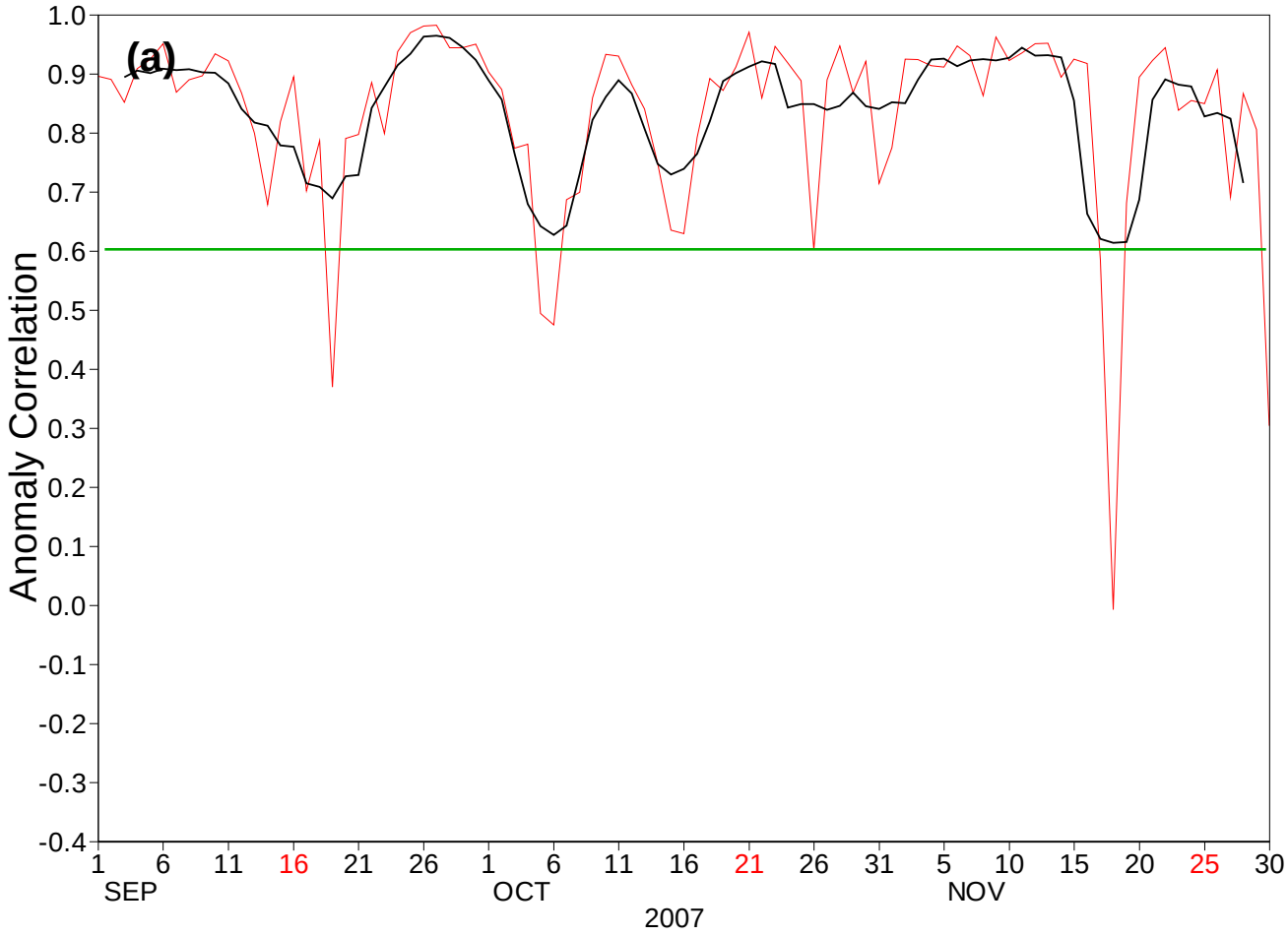


THORPEX mission to accelerate improvements in NWP etc

Importance of mid-latitude forecast 'busts' ?

Are they due to tropical-extra interactions e.g. hurricanes etc?

Time Series of D+5 European Forecast Skill

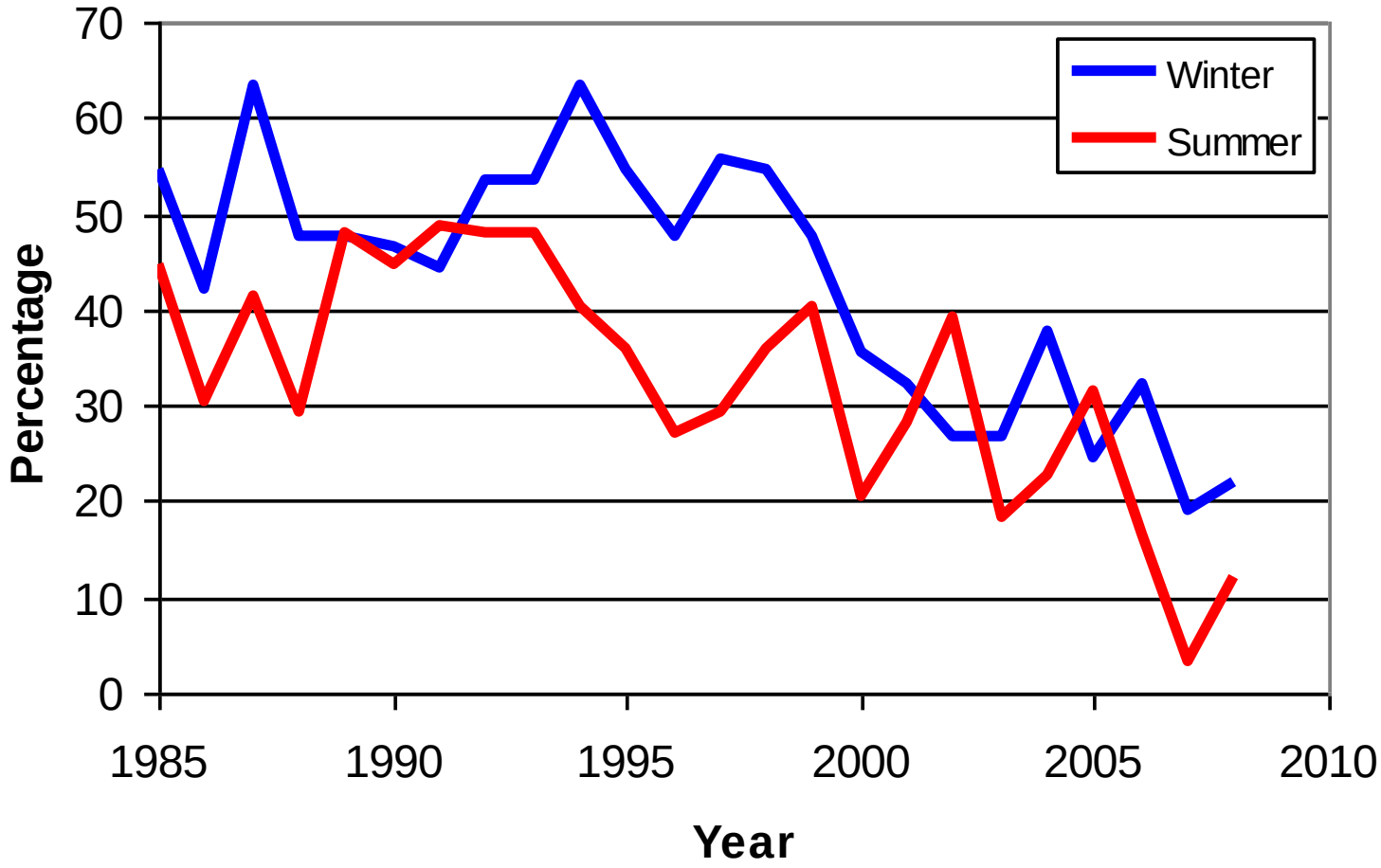


ERA-Interim Hindcasts, ACC, Z500, Europe

Busts!

Reduction in number of poor forecasts over Europe

Percentage of days for which the anomaly correlation of the day 7 forecasts of temperature at 850 hPa drops below 50%

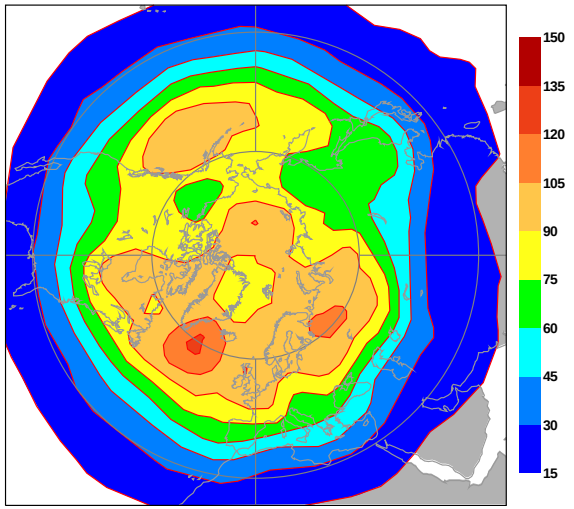


Tropical Origin of Extratropical Forecast Busts?

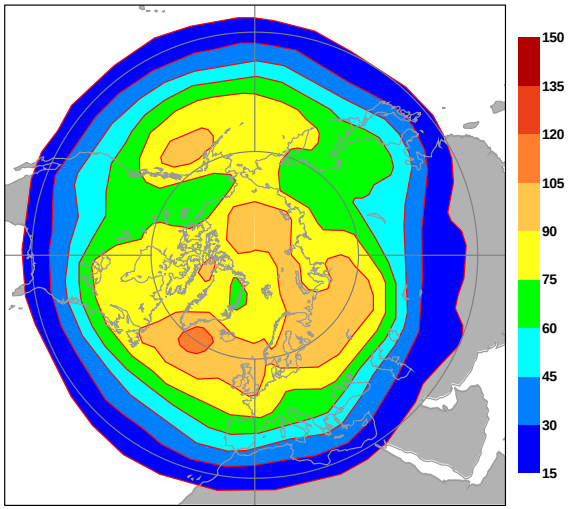
- There have been suggestions that some forecast busts over North America can be traced back to tropical error.
- Conjecture is that errors in representing the MJO are involved (→ THORPEX).
- To test this hypothesis:
  - T_L255L60
  - Relaxation towards ERA-Interim
    - Tropics (20ºS-20ºN)
    - North Pacific (10ºN-60ºN, 90ºE-140ºW)
  - 15-day forecasts every other day 1st Sep to 31st Dec 2007
    - Period of strong MJO-type variability in November and December.

Medium-Range Forecast Error: Role of the Tropics

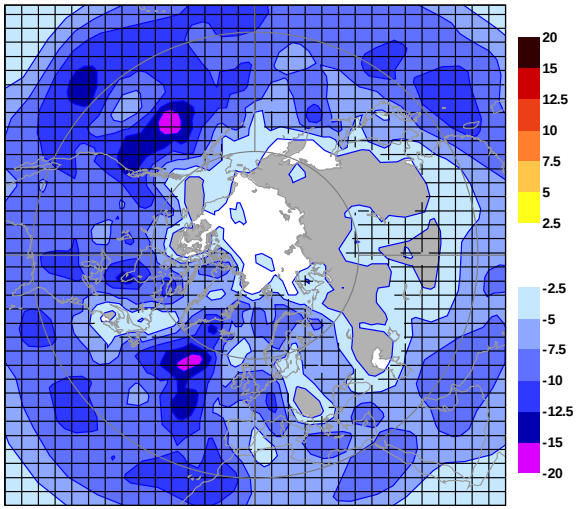
Control



Tropical Relaxation



Relaxation-Control

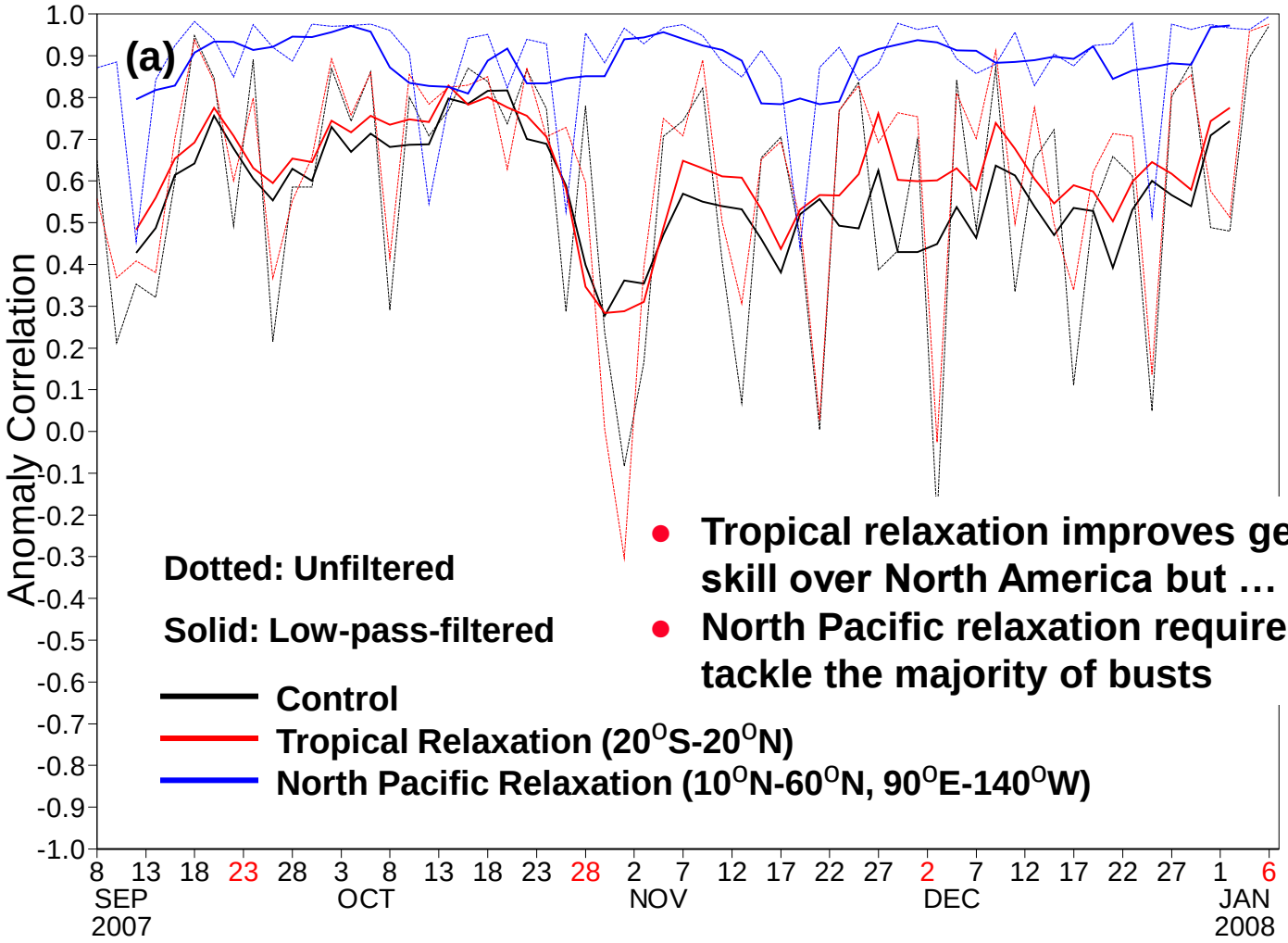


Mean Absolute Error, Z500, D+5-D+10, SON, 1980-2001

Relaxation: tropics (20S-20N), λ=0.1

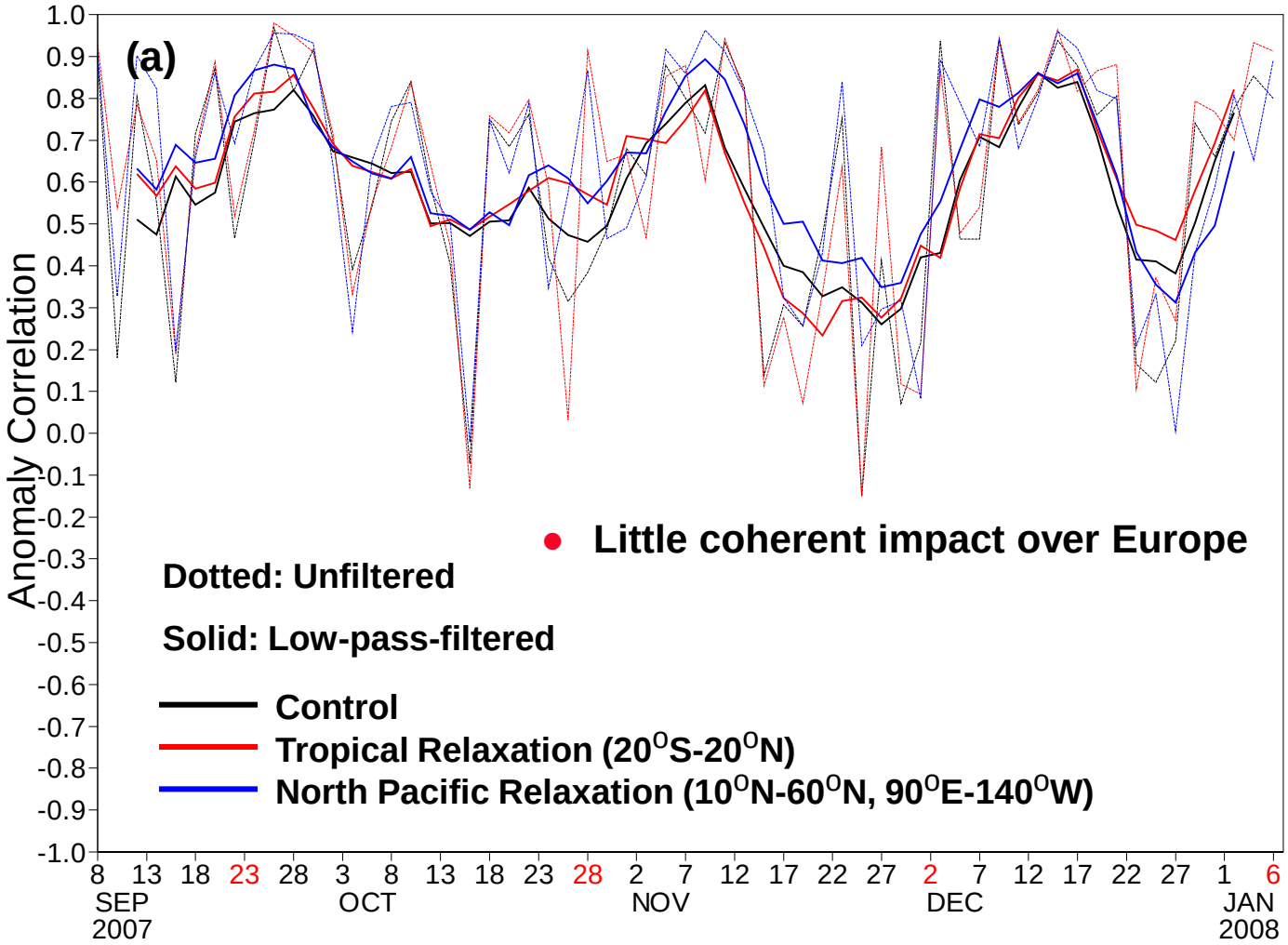
ECMWF

ACC: D+7 Z500 Forecast for North America

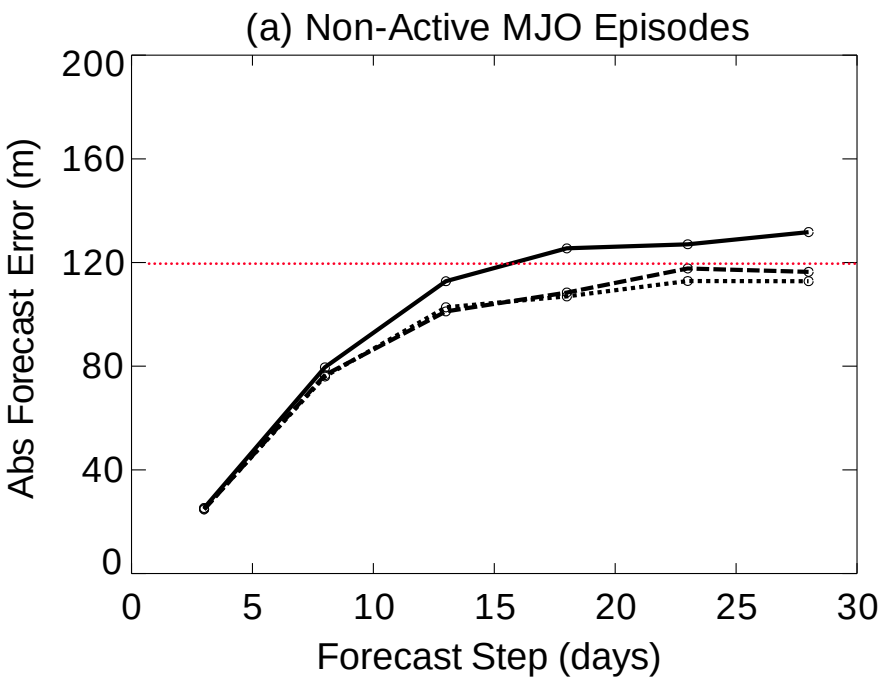


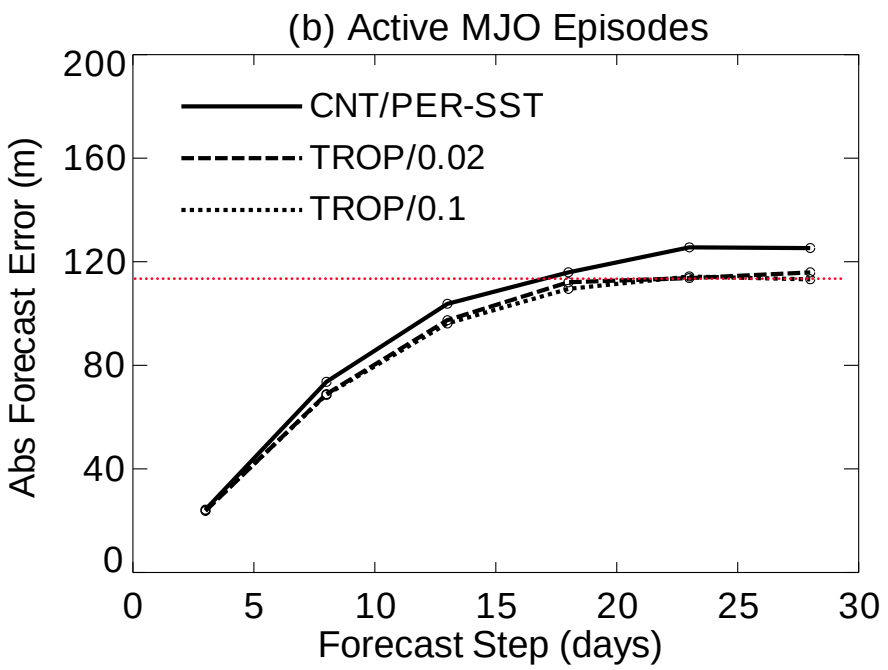
- Tropical relaxation improves general skill over North America but …
- North Pacific relaxation required to tackle the majority of busts

ACC: D+7 Z500 Forecast for Europe



Role of the MJO





Summary

- **Better representation of the tropics leads to better extratropical forecasts (North America and Europe) in the medium-range and especially beyond.**
- **In this context the MJO is of secondary importance.**
- **Better representation of the tropics leads to**
  - **a small extratropical forecast error reduction over extended periods**
  - **rather than to a reduction of forecast `drop-outs'.**

The MJO and tropical cyclones in the monthly forecast system

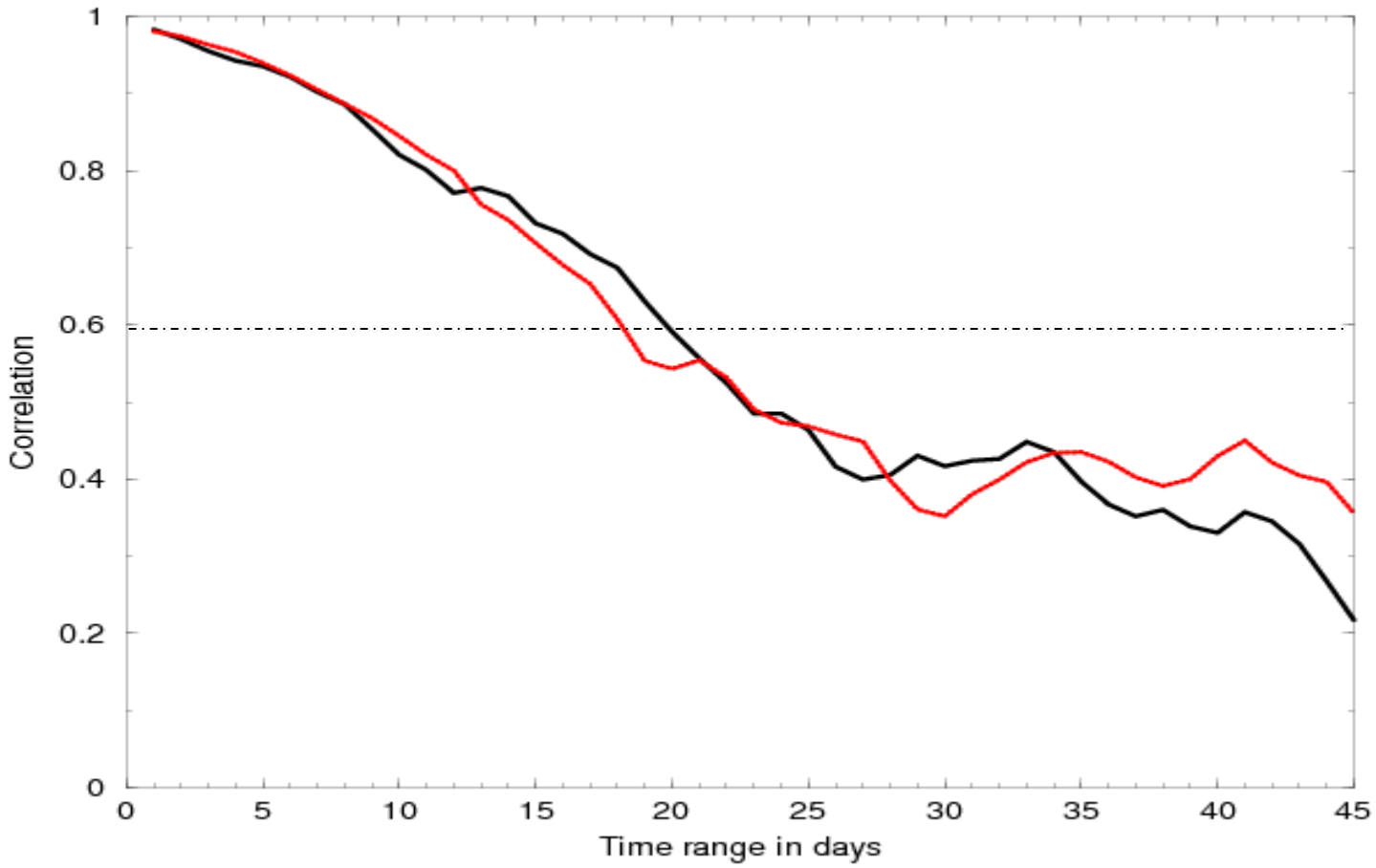
- **What is the state of play regarding the models MJO?**
- **What is the models TC climatology like?**
- **How does the MJO influence the model TC**

- **15-member ensemble forecasts starting on the 15th of each month from 1989 to 2008.**
- **46-day integrations**
- **Cycle 32R3**
- **T399 uncoupled till day 10 and T255 coupled after day 10**

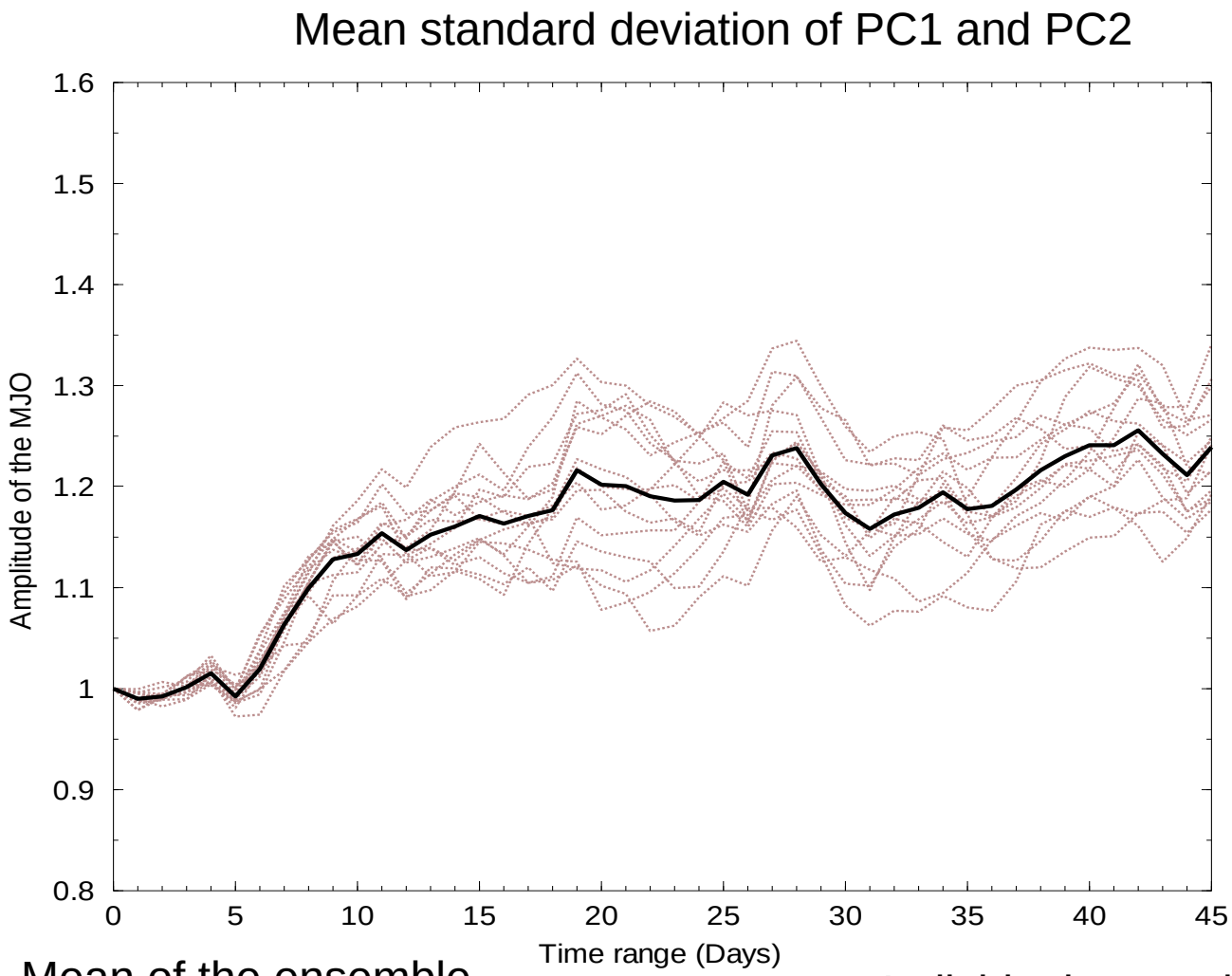
(Frederic Vitart – submitted to GRL)

Skill to predict MJO

Correlation with analysis (ERA Interim)



Amplitude of the MJO



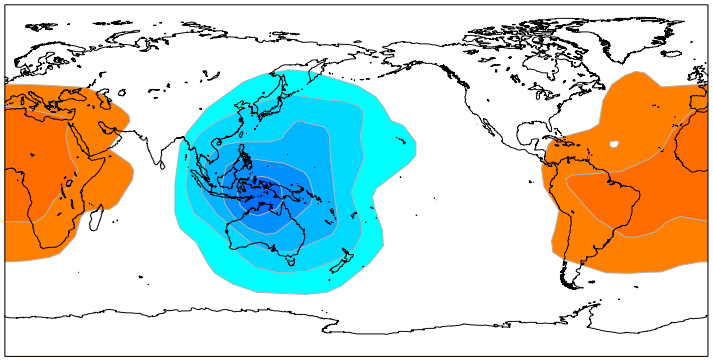
Mean of the ensemble

Individual ensemble members

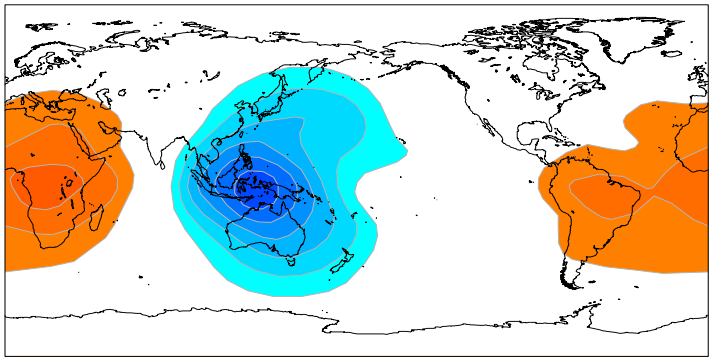
ECMWF

Amplitude of the MJO

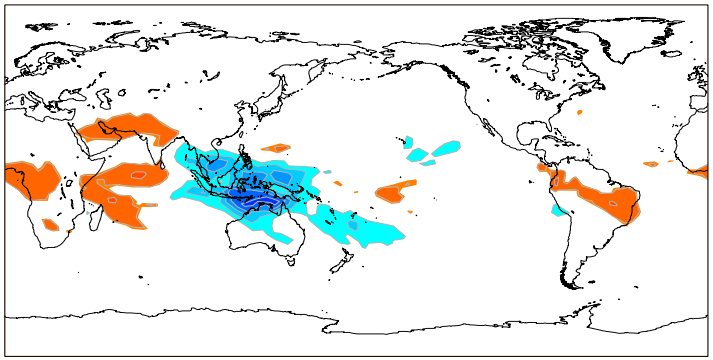
Era Interim - VP200



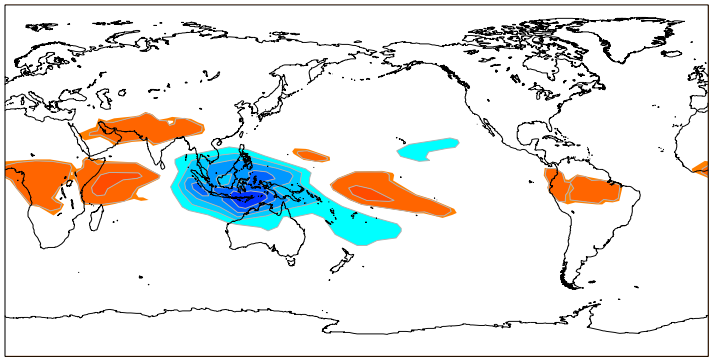
Model - VP200



Era Interim - OLR



Model - OLR

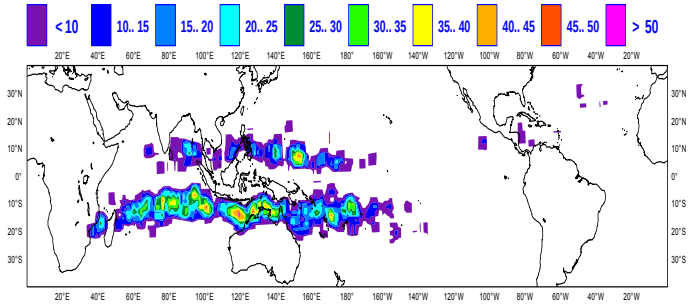


Tropical Cyclone Genesis climatology

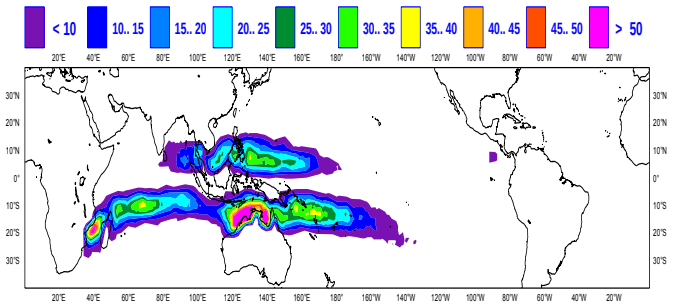
1989-2008

Observations

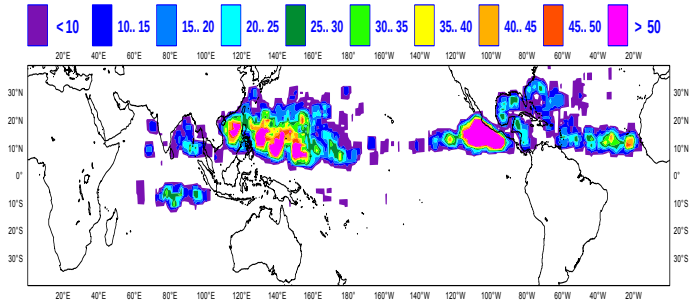
NDJFMA

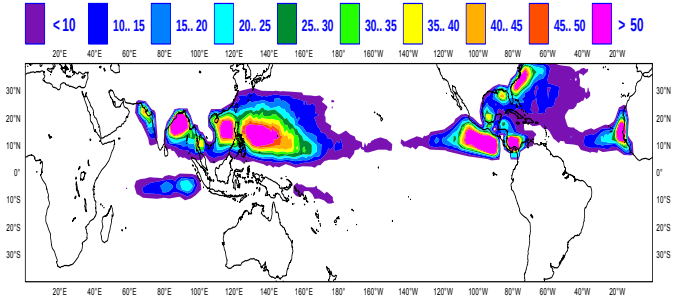


Model



JASON



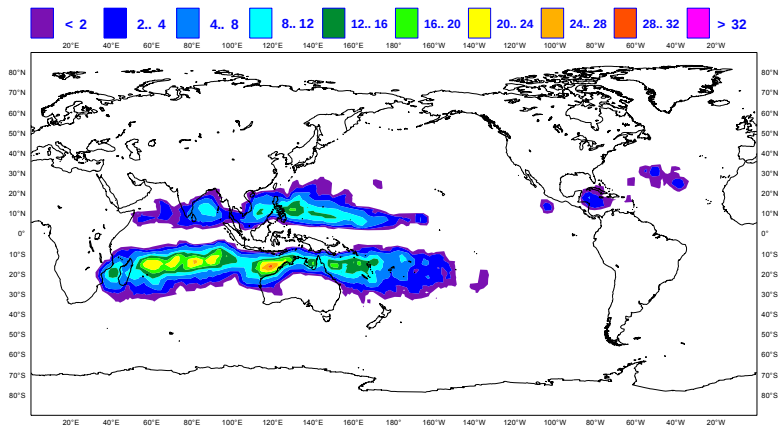


Tropical Cyclone Density climatology

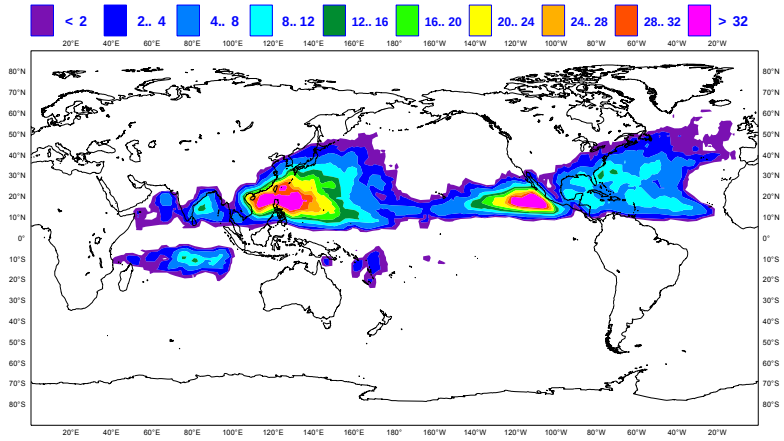
1989-2008

Observations

NDJFMA

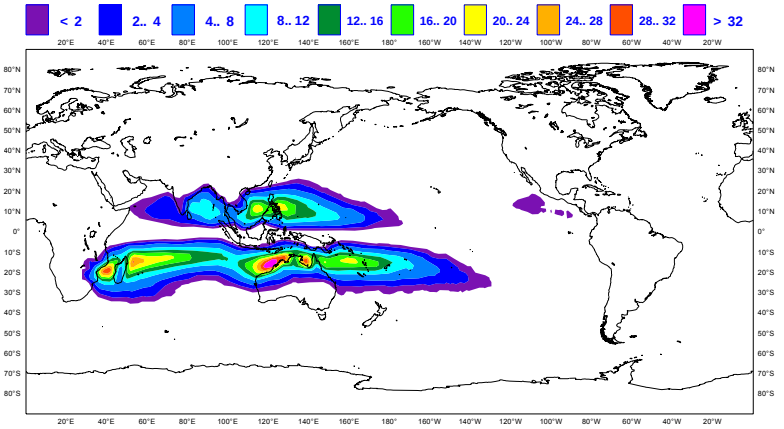


JASON

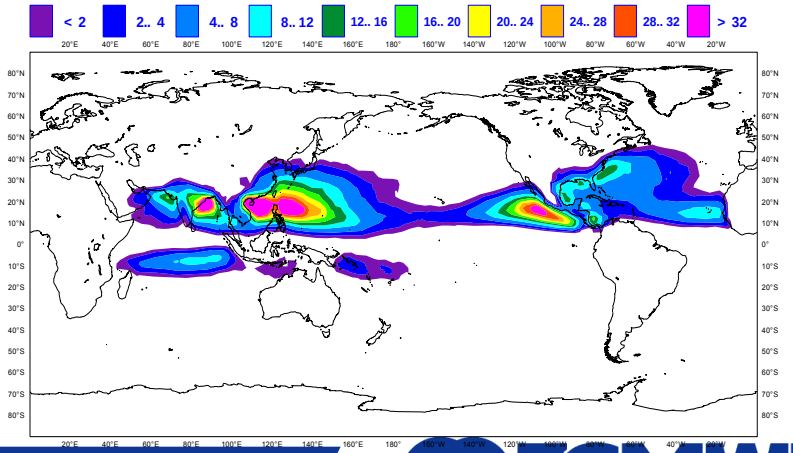


Model

NDJFMA



JASON

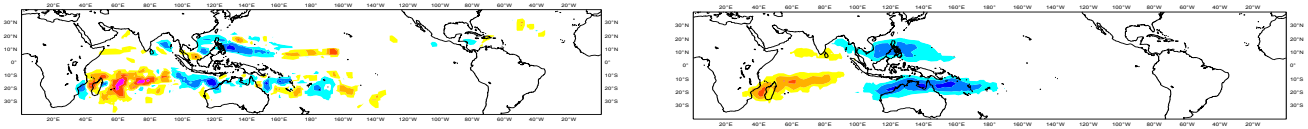


MJO Composite- NDJFMA

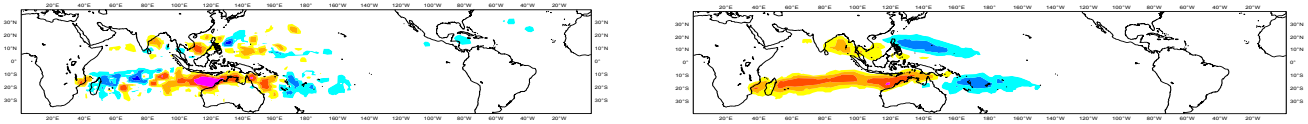
Tropical storm density anomaly

Observations **Model**

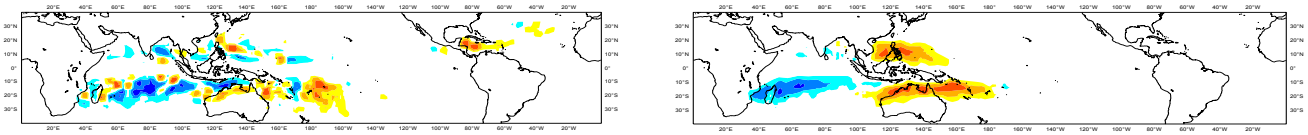
Phases 2+3



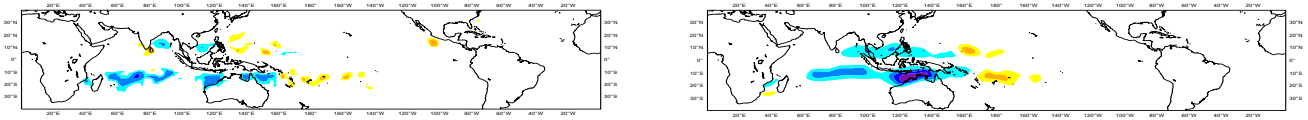
Phases 4+5



Phases 6+7



Phases 8+1

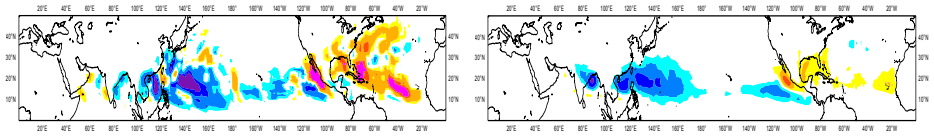


MJO Composite- ASO

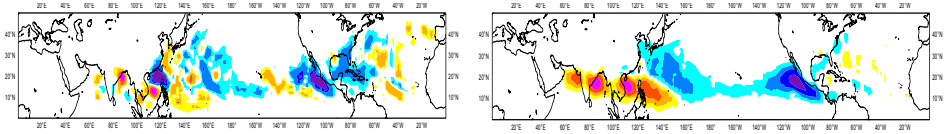
Tropical storm density anomaly

Observations **Model**

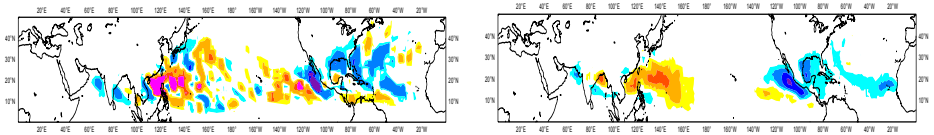
Phases 2+3



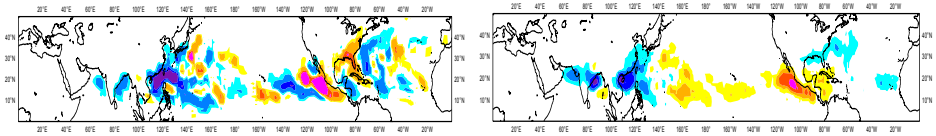
Phases 4+5



Phases 6+7



Phases 8+1



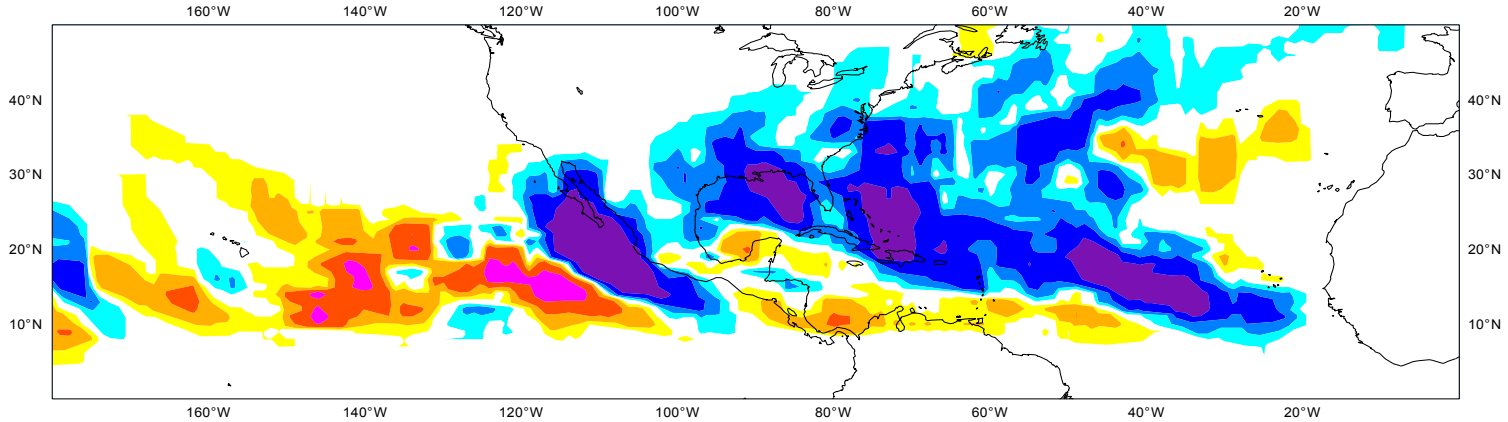
ECMWF

MJO Composite- ASO

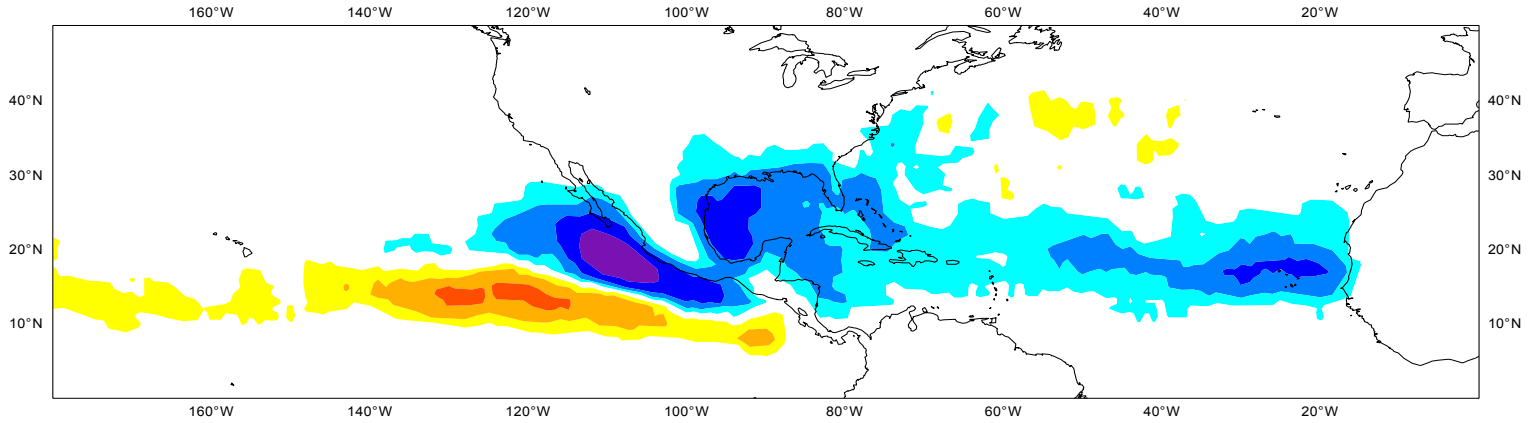
Tropical storm density anomaly

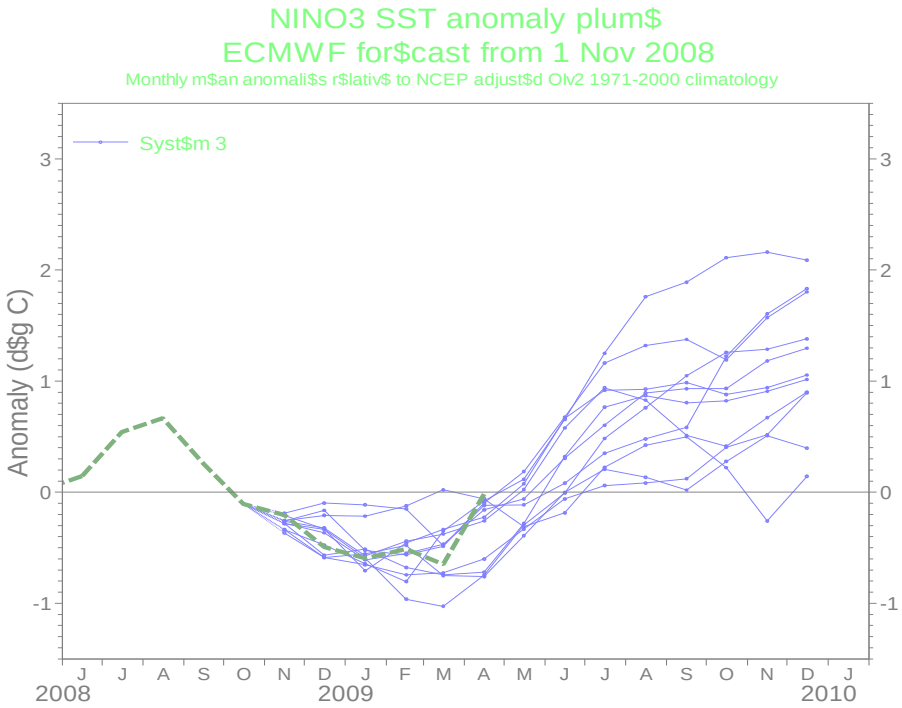
Phases 6+7 – Phase 2+3

Observations



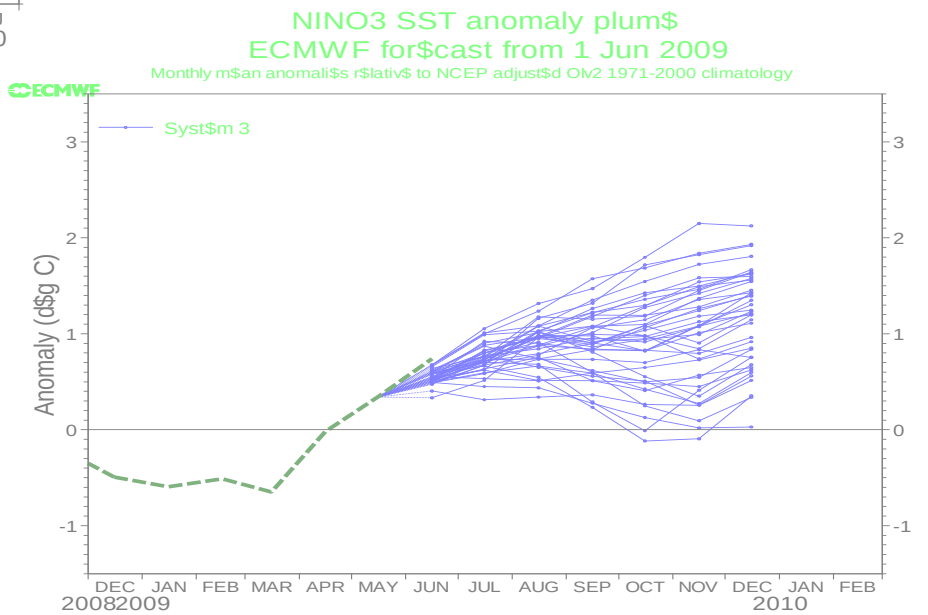
Model





For$cast issu$ dat$: 15 Nov 2008

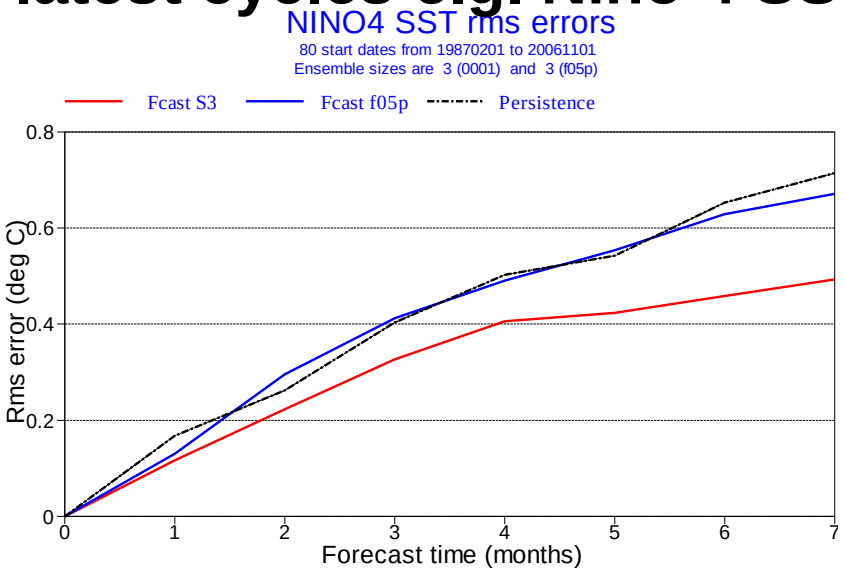
13 month f/c from Oct 2008

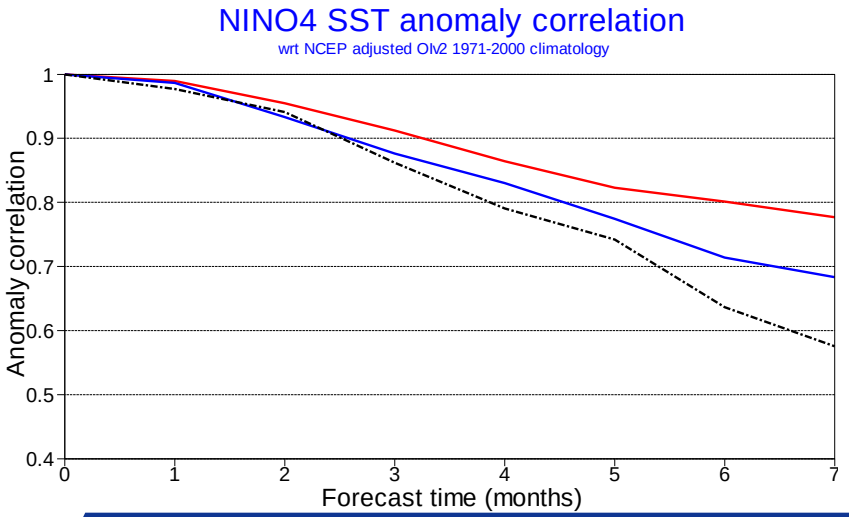


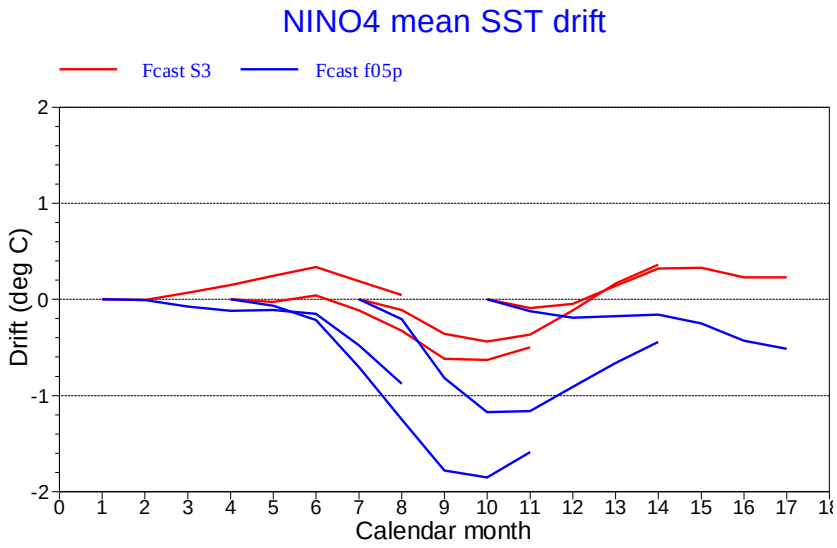
For$cast issu$ dat$: 15 Jun 2009

f/c from May 2009

Seasonal forecasting - Coupled model less good with latest cycles e.g. Nino 4 SST







CY33r1 (blue) has a strong cold bias in the second half of the year, and this results in a sharp deterioration in forecast skill in the west-central Pacific, compared to System 3 (red).