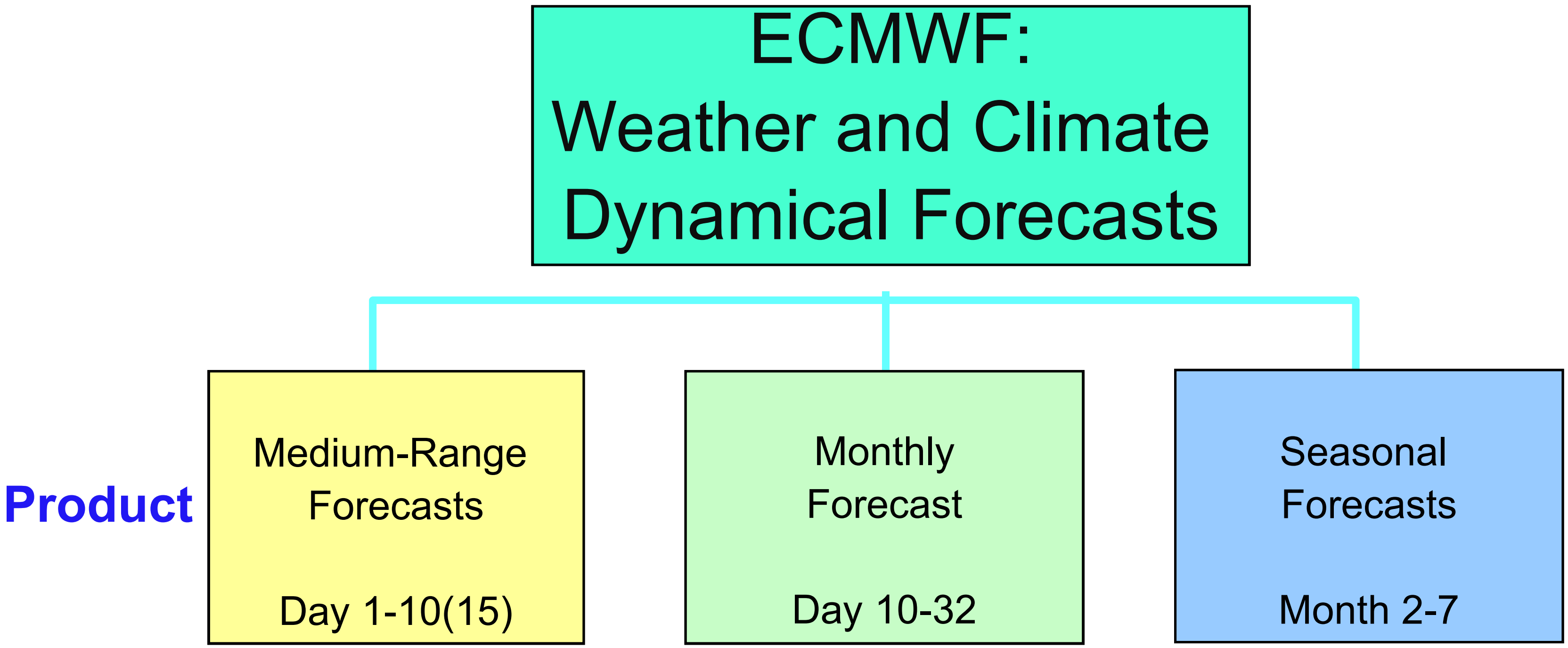
Monthly Forecasting at ECMWF

Frédéric Vitart

European Centre for Medium-Range Weather Forecasts

Forecasting systems at ECMWF



Index

Use of monthly forecasts in applications

Main sources of predictability on the monthly time-scale

- Madden Julian Oscillation
- Soil Moisture
- Stratospheric Initial conditions

The ECMWF monthly forecast system

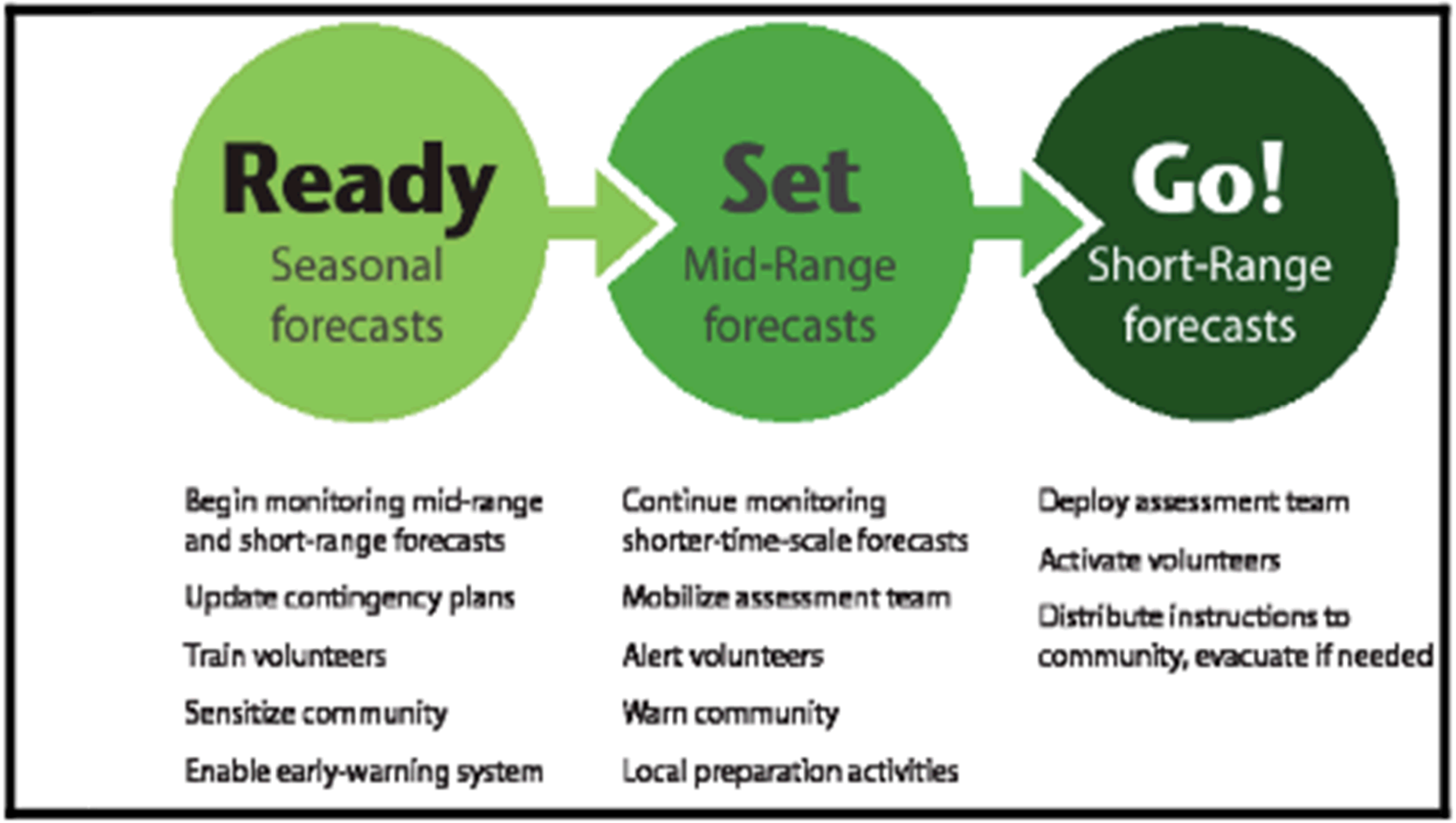
- Description
- Some examples of forecasts
- Skill

Use of sub-seasonal forecasts in applications

Growing, and urgent, requirement for the employment of sub-seasonal predictions for a wide range of societal and economic applications which include:

- Warnings of the likelihood of severe high impact weather (droughts, flooding, wind storms etc.) to help protect life and property
- Humanitarian Planning and Response to disasters
- Agriculture particularly in developing countries — e.g. wheat and rice production
- Disease planning/control — e.g. malaria, dengue and meningitis
- River-flow — for flood prediction, hydroelectric power generation and reservoir management for example

Opportunity to use information on *multiple* time scales



Red Cross - IRI example

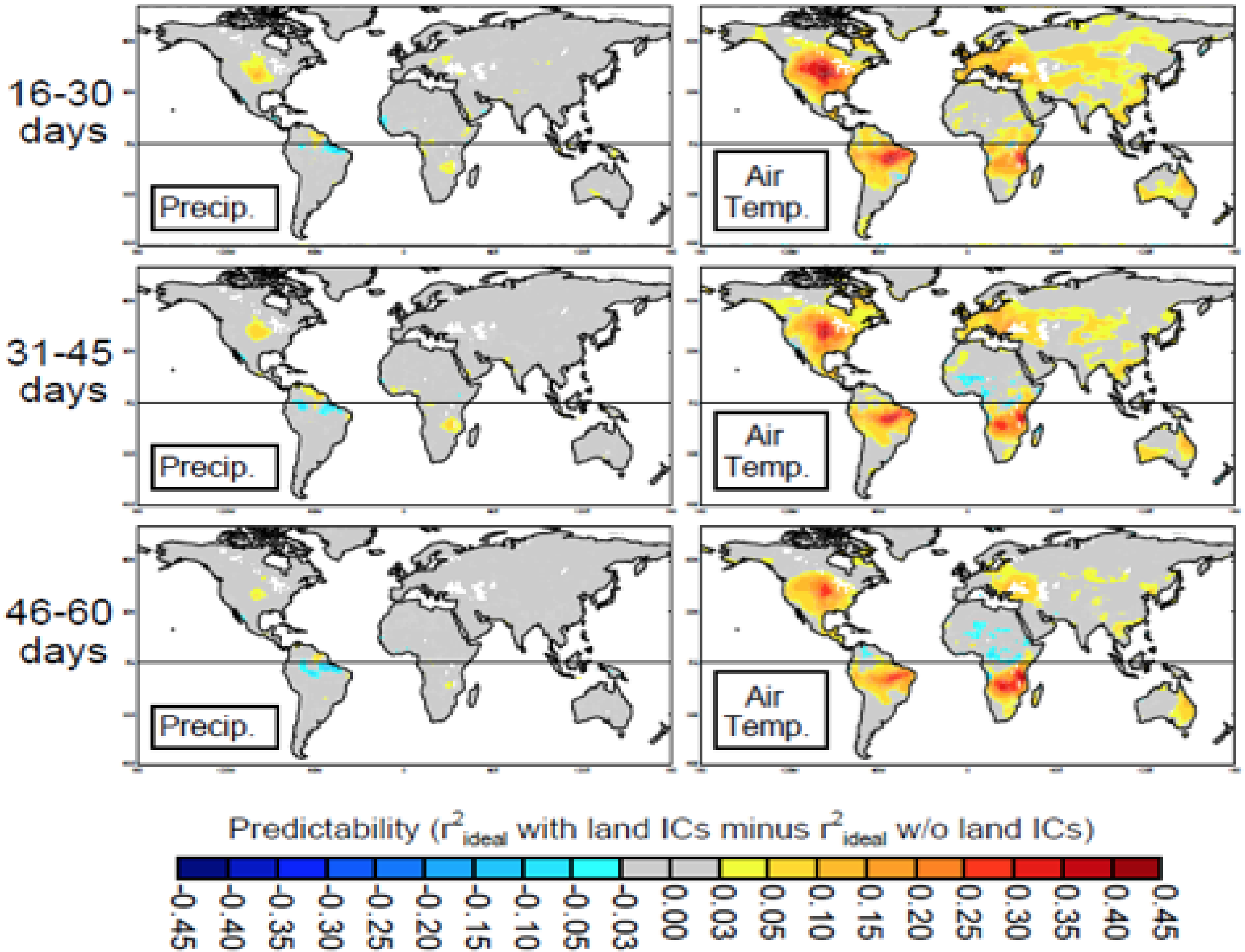
Bridging the gap between Climate and weather prediction

A particularly difficult time range: Is it an atmospheric initial condition problem as medium-range forecasting or is it a boundary condition problem as seasonal forecasting?

Some sources of predictability :

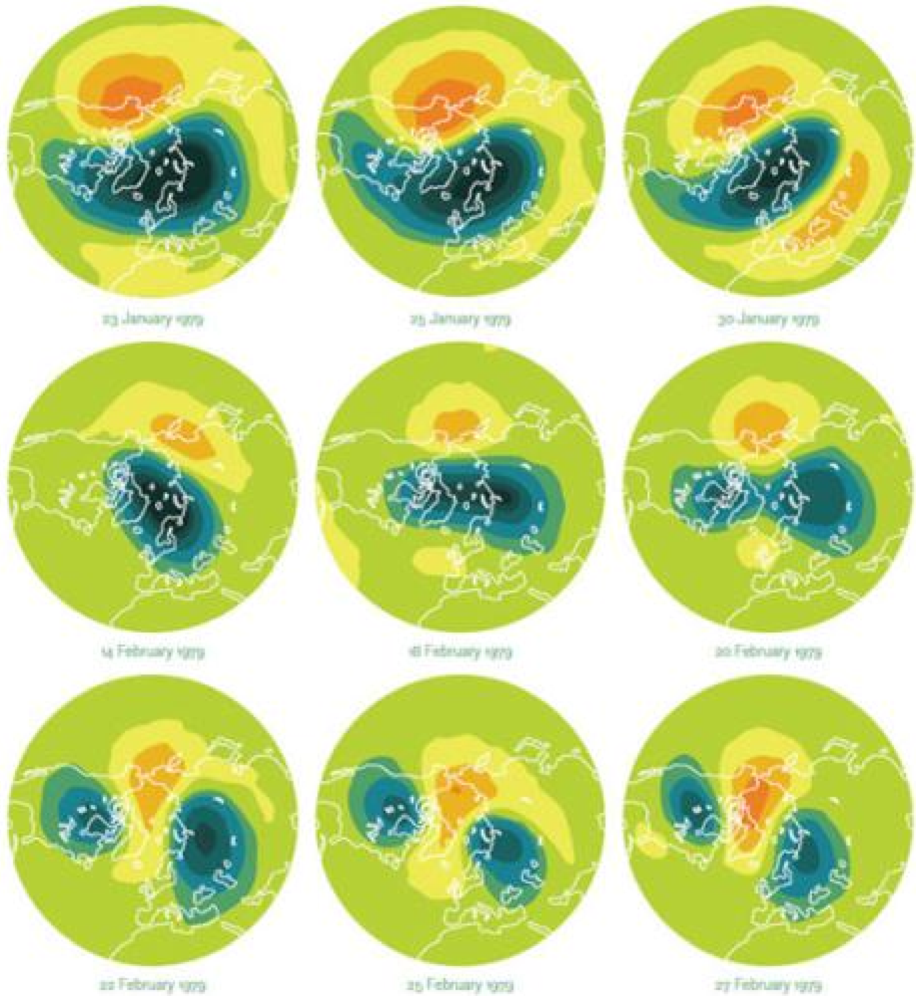
- Sea surface temperatures
- Land surface conditions: snow-soil moisture
- The Madden Julian Oscillation
- Stratospheric variability
- Atmospheric dynamical processes
  (Rossby wave propagations, weather regimes…)
- Sea ice cover –thickness ?

Impact of soil moisture



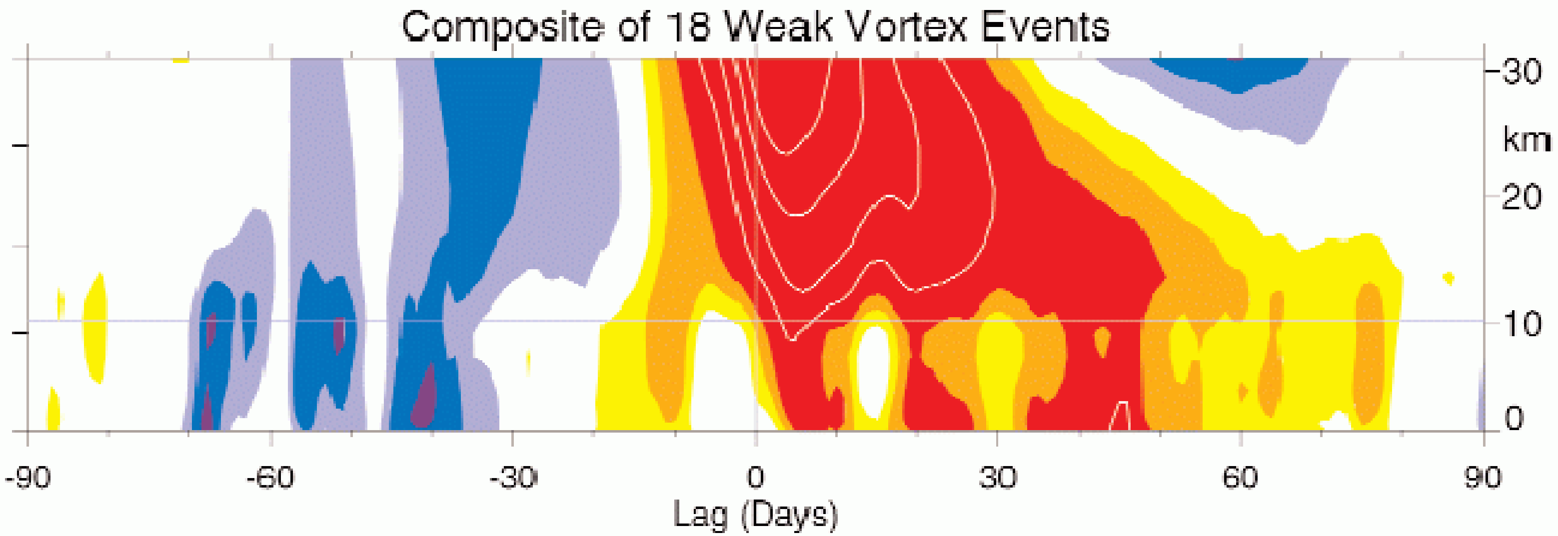
Koster et al, GRL 2011

Sudden Stratospheric Warmings



Chui and Kunz, 2009

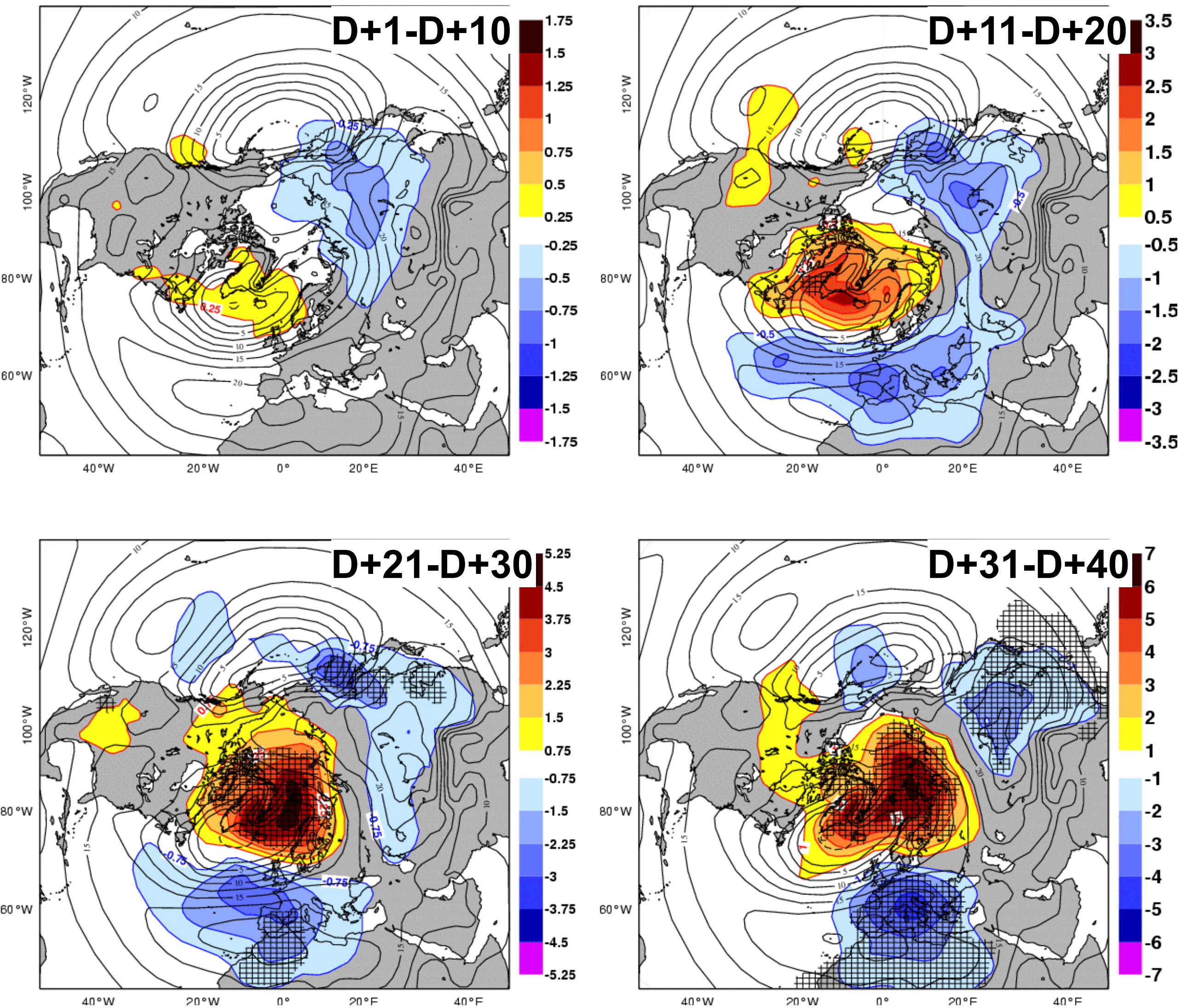
Stratospheric influence on the troposphere?



Weather from above. A weakening stratospheric vortex (red) can alter circulation down to the surface, bringing storms and cold weather farther south than usual.

Baldwin and Dunkerton, 2001

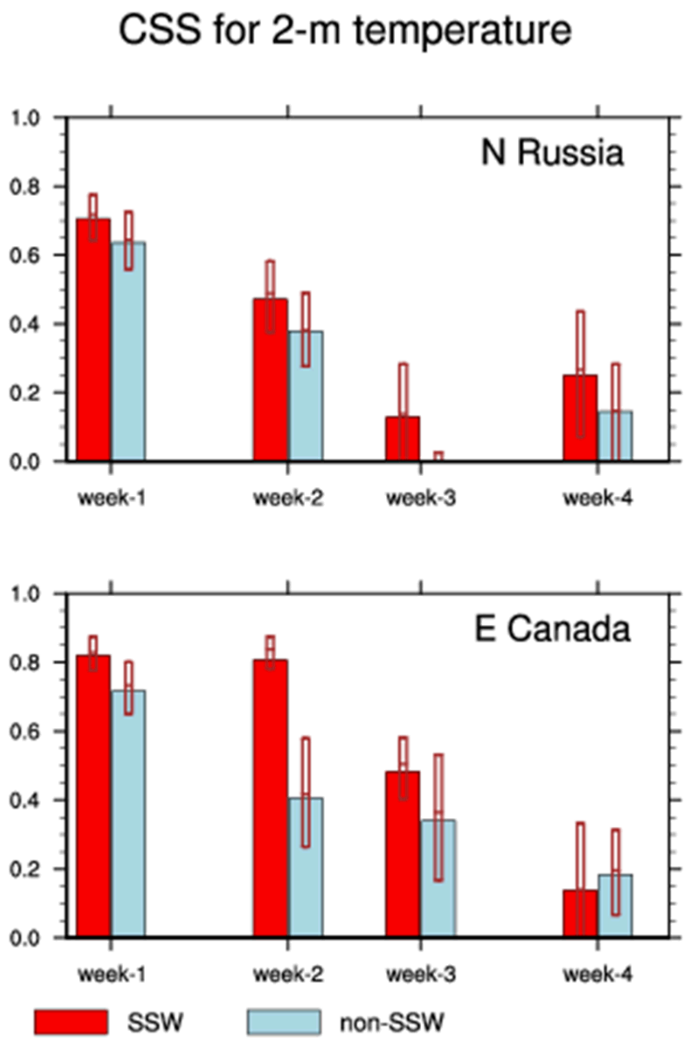
Stratospheric influence on the troposphere?



Z1000 Response
(Weak vortex-CTL)

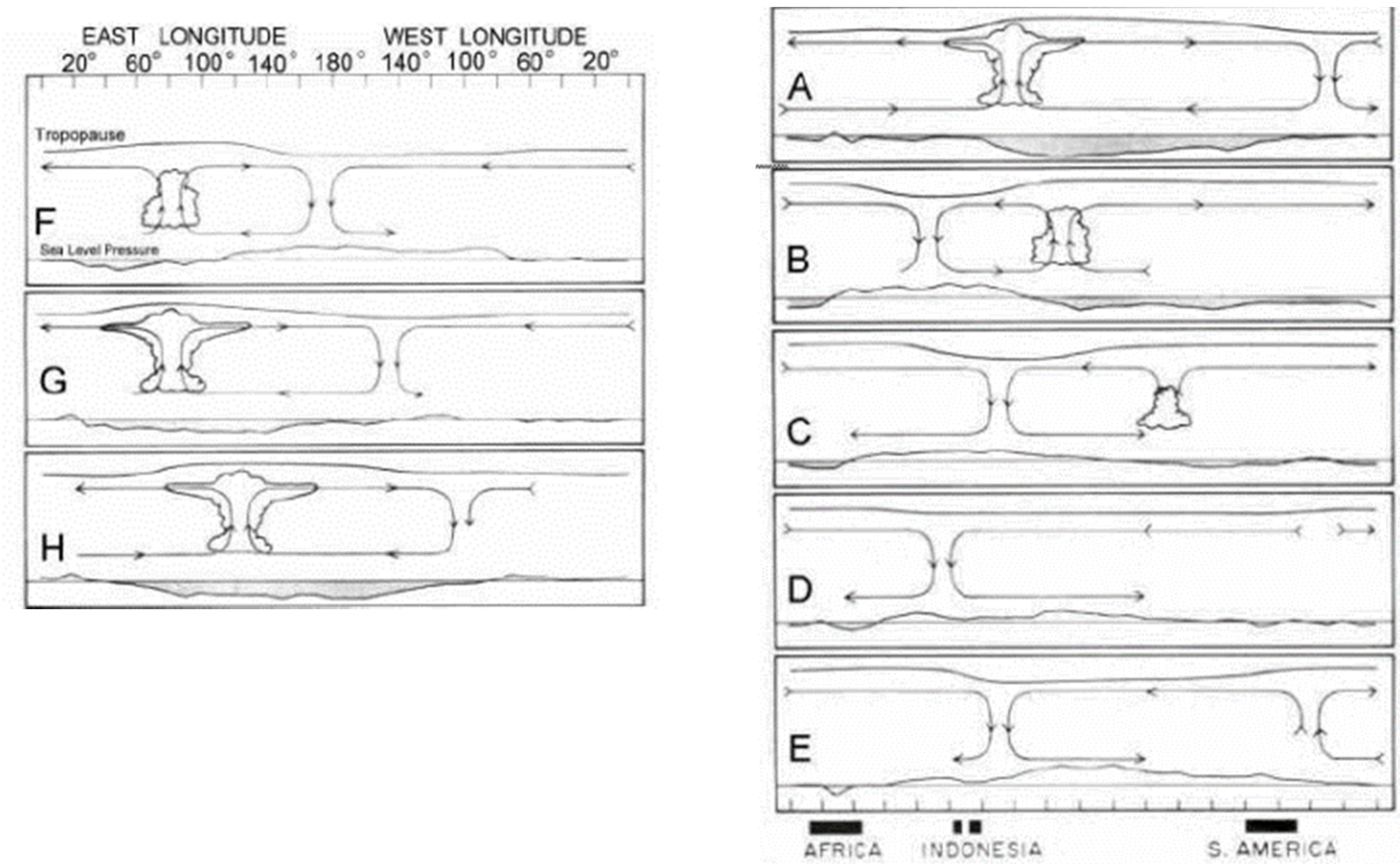
From T. Jung et al 2005

Impact of SSWs on skill scores



From Om Tripathi (2015)

The Madden-Julian Oscillation (MJO)



From Madden and Julian (1972)

The Madden Julian Oscillation (MJO)

Why is the MJO so important?

- Impact on the Indian and Australian summer monsoons (Yasunari 1979), Hendon and Liebman (1990)

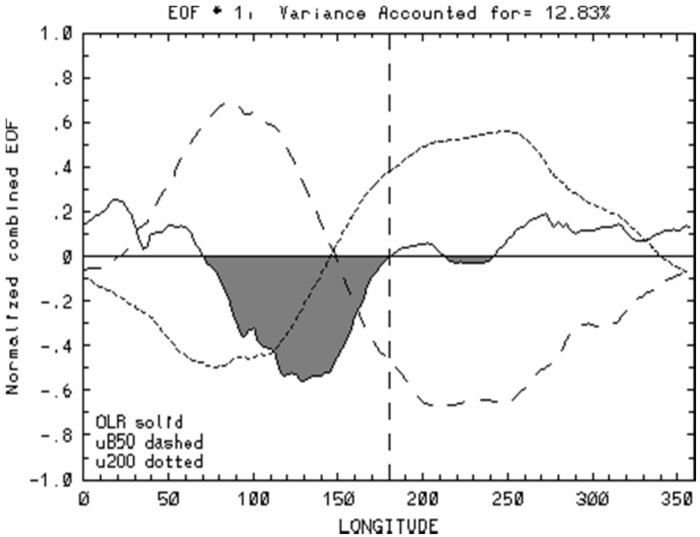
- Impact on ENSO. Westerly wind bursts produce equatorial trapped Kelvin waves, which have a significant impact on the onset and development of an El-Niňo event. Kessler and McPhaden (1995)

- Impact on tropical storms (Maloney et al, 2000; Mo, 2000)

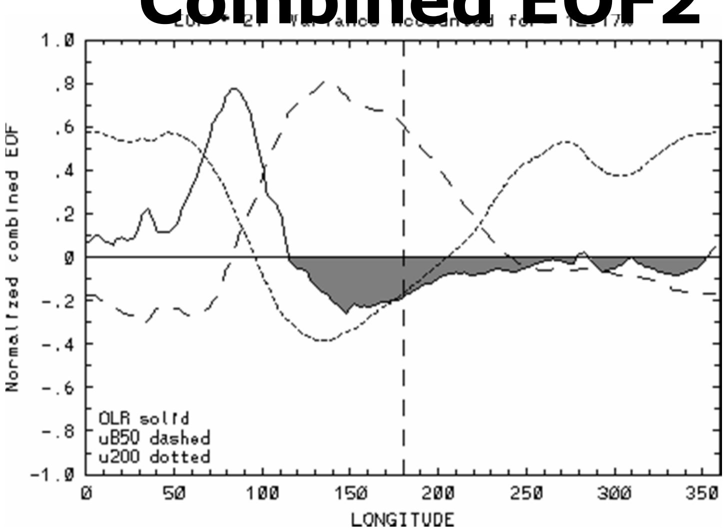
- Impact on Northern Hemisphere weather

MJO Prediction

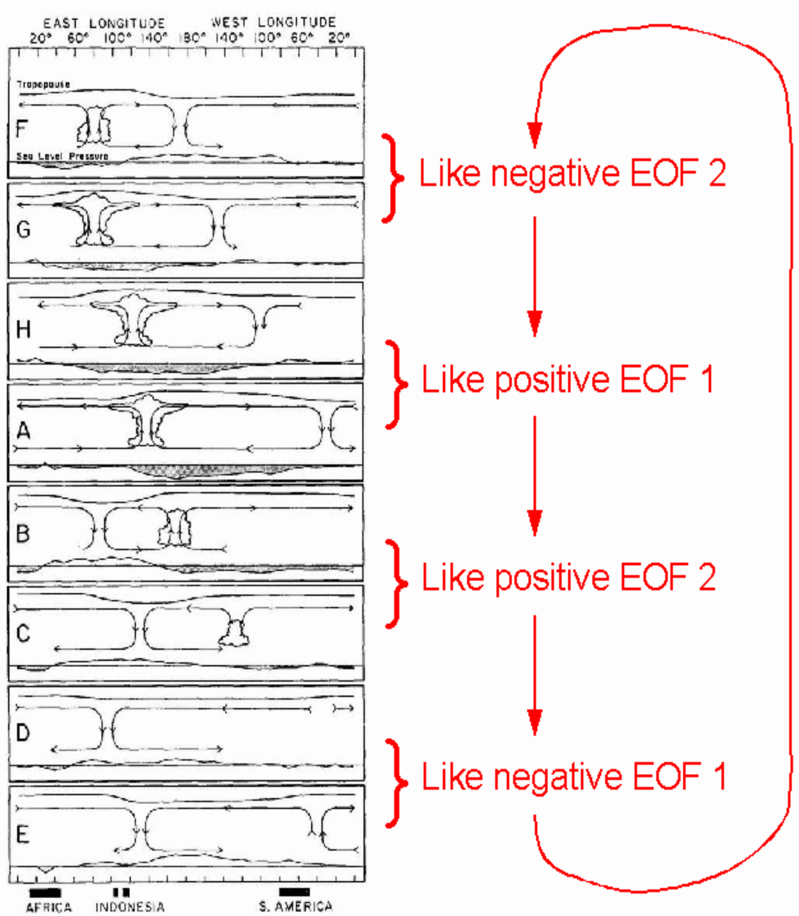
Combined EOF1



Combined EOF2

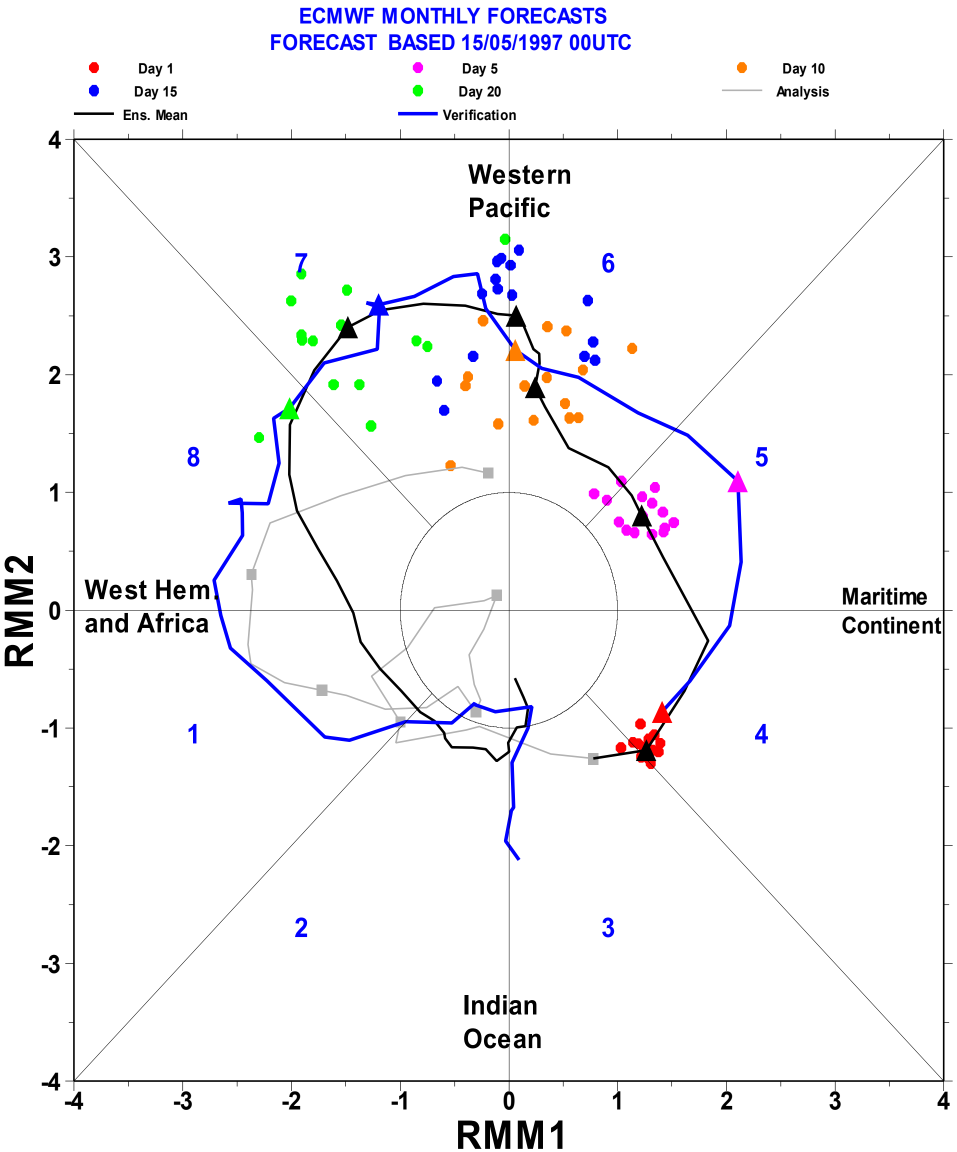


Madden and Julian's (1972) schematic



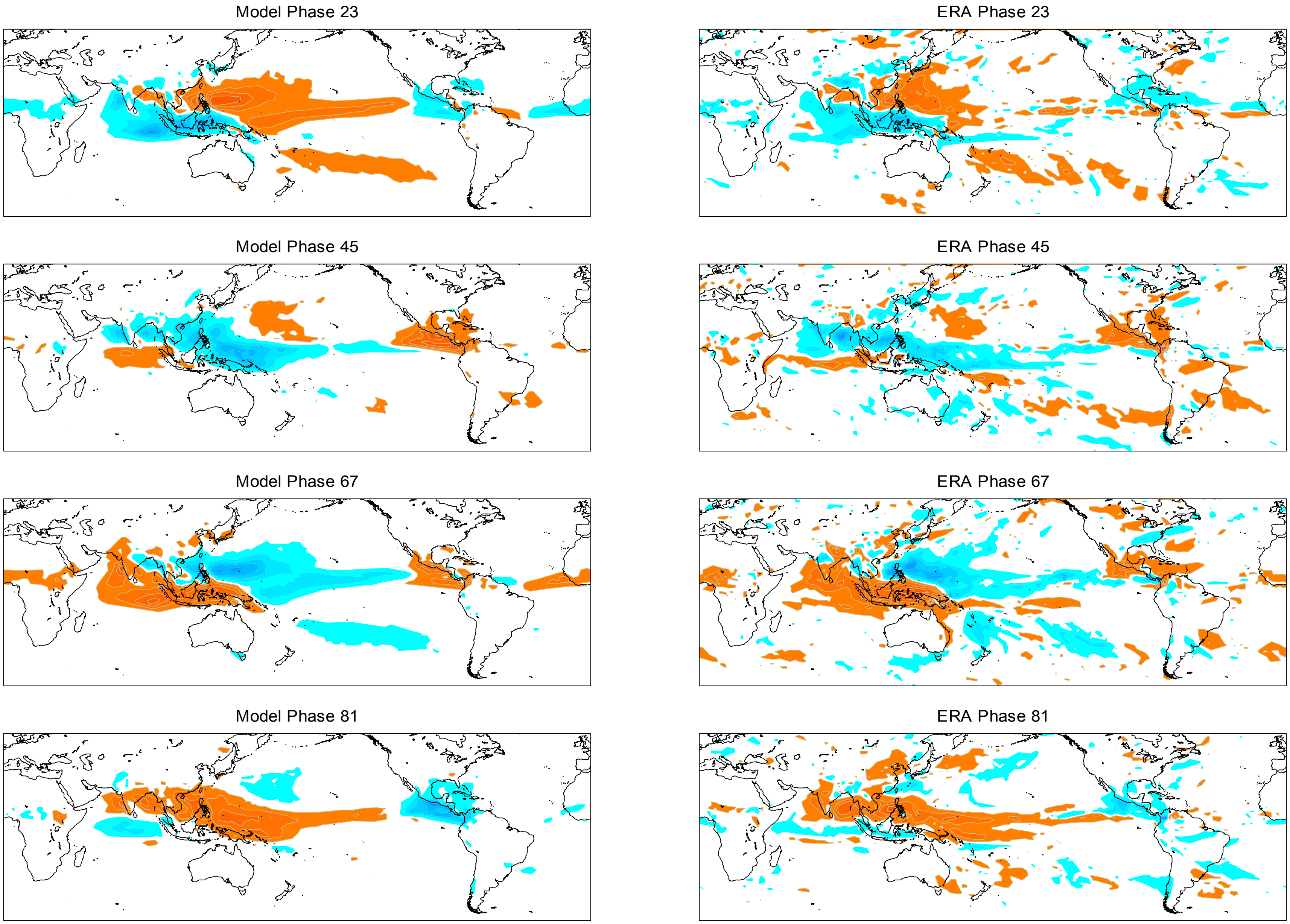
From Wheeler and Hendon, BMRC

MJO FORECAST

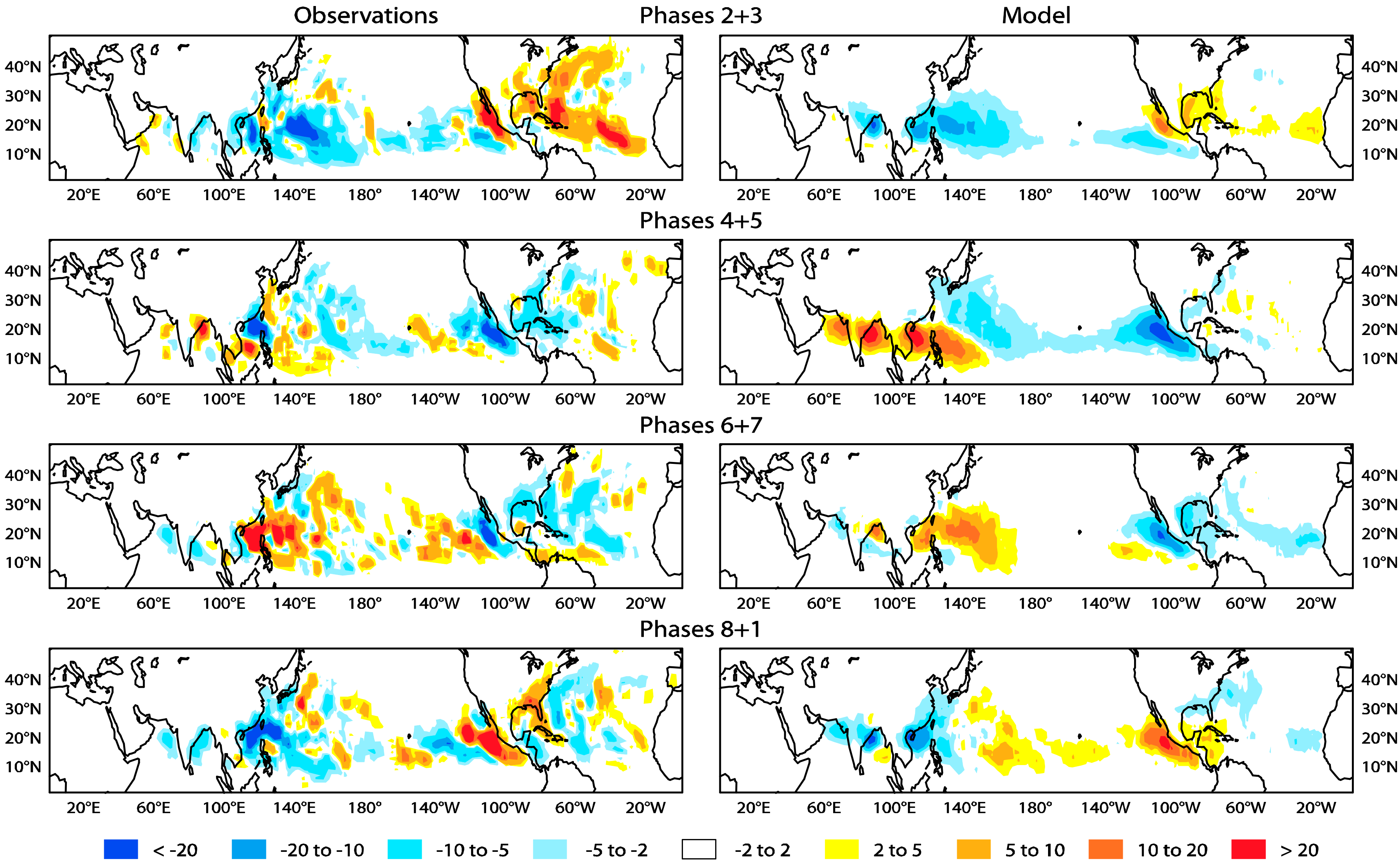


Impact of the MJO on precipitation

JJA

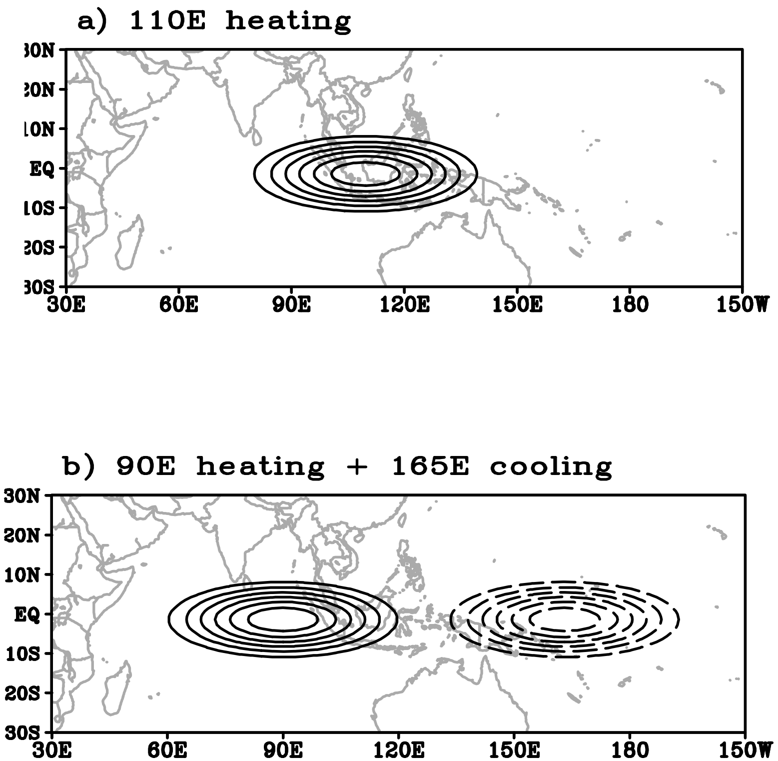


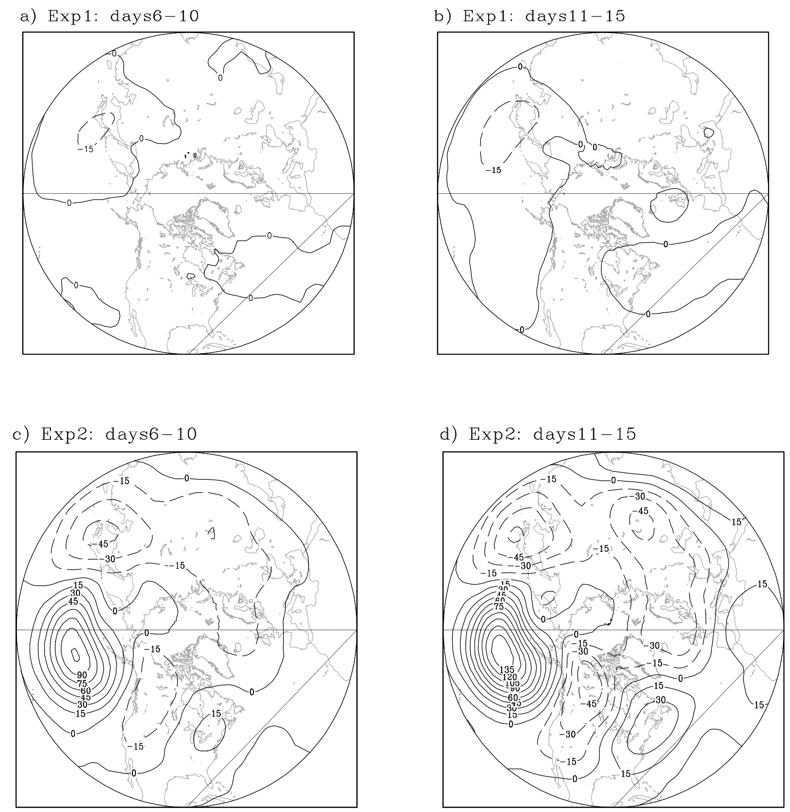
Impact on Tropical Cyclone Density (Summer)



Vitart, GRL 2009

Impact of the MJO on Extratropics





Lin et al, MWR 2010

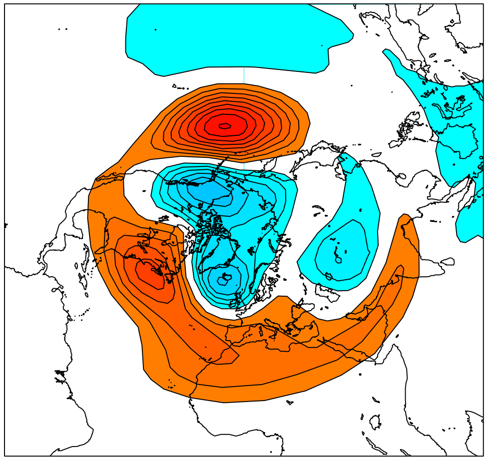
See also

Simmons et al JAS 1983

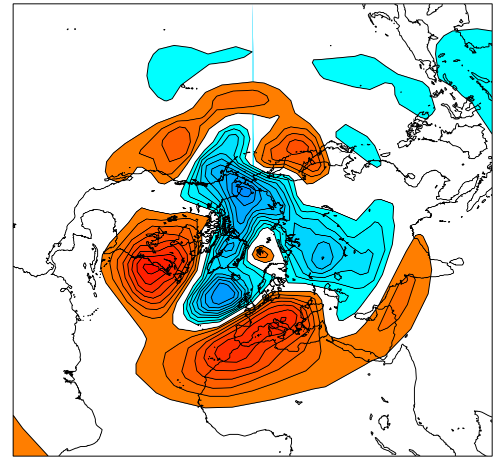
Ting and Sardeshmukh JAS 1993

Impact on the Extratropics- Z500 anomalies

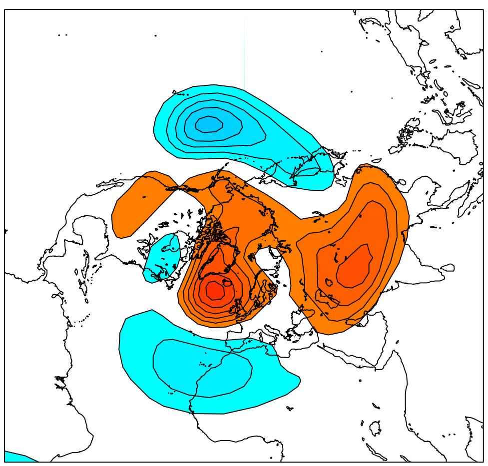
MODEL Phase 3 + 10 days



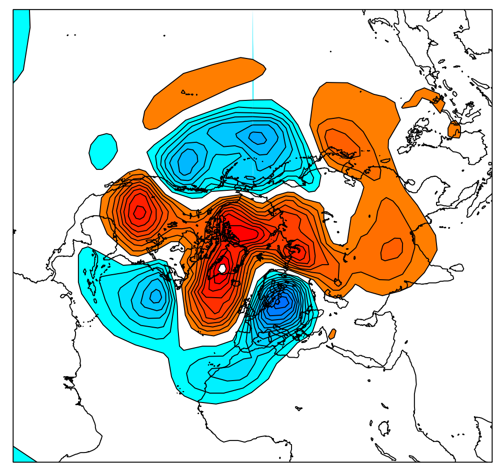
ERA Phase 3 + 10 days



MODEL Phase 6 + 10 days

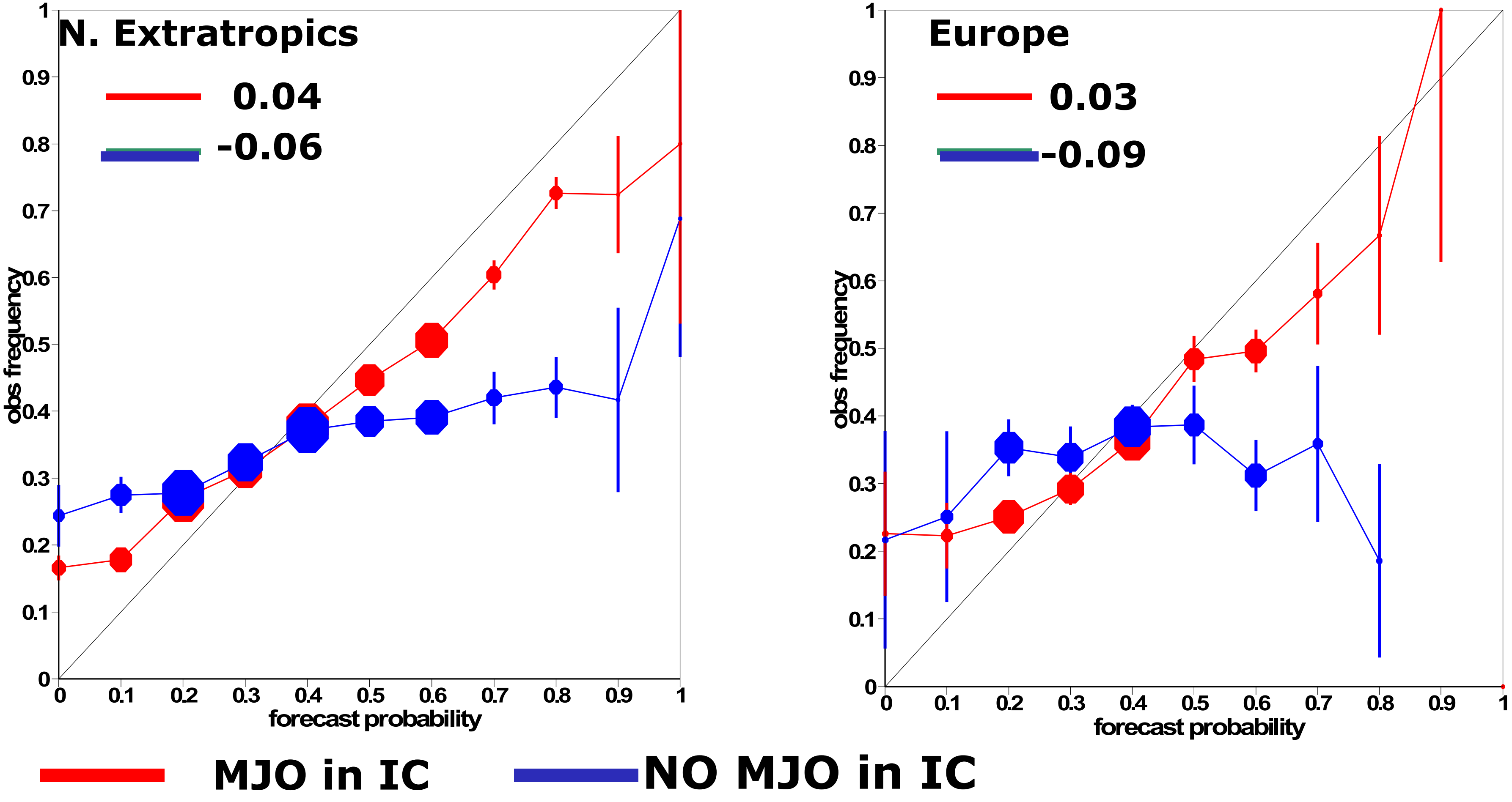


ERA Phase 6 + 10 days



Probabilistic skill scores – NDJFMA 1989-2008

Reliability Diagram
Probability of 2-m temperature in the upper tercile
Day 19-25



ECMWF monthly forecasts

- A 51-member ensemble is integrated for 32 days twice a week (Mondays and Thursdays at 00Z)
- Atmospheric component: IFS with the latest operational cycle and with a T639L91 resolution up to day 10 and T319L91 after day 10.
- Ocean-atmosphere coupling from day 0 to NEMO (about 1 degree) every 3 hours.

Initial conditions:

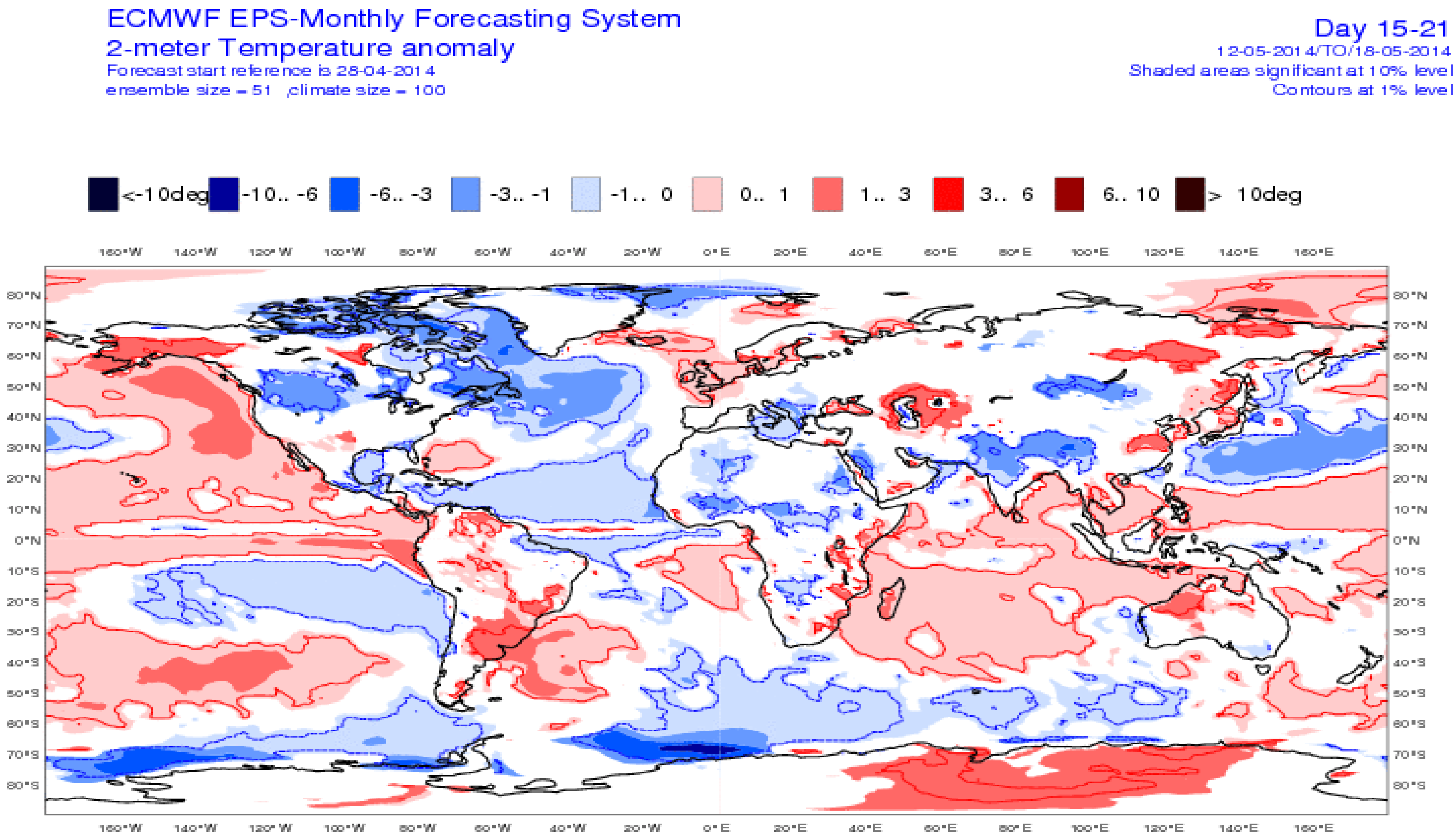
- Atmosphere: Operational 4-D var analysis + SVs+ EDA perturbations
- Ocean: 3D-Var analysis (NEMOVAR) + wind stress perturbations

Background statistics:

5-member ensemble integrated at the same day and same month as the real-time time forecast over the past 20 years (a total of 100 member ensemble). Initial conditions: ERA Interim. Produced once a week (to be extended later this year with Cycle 40r3 to 11 members, twice a week)

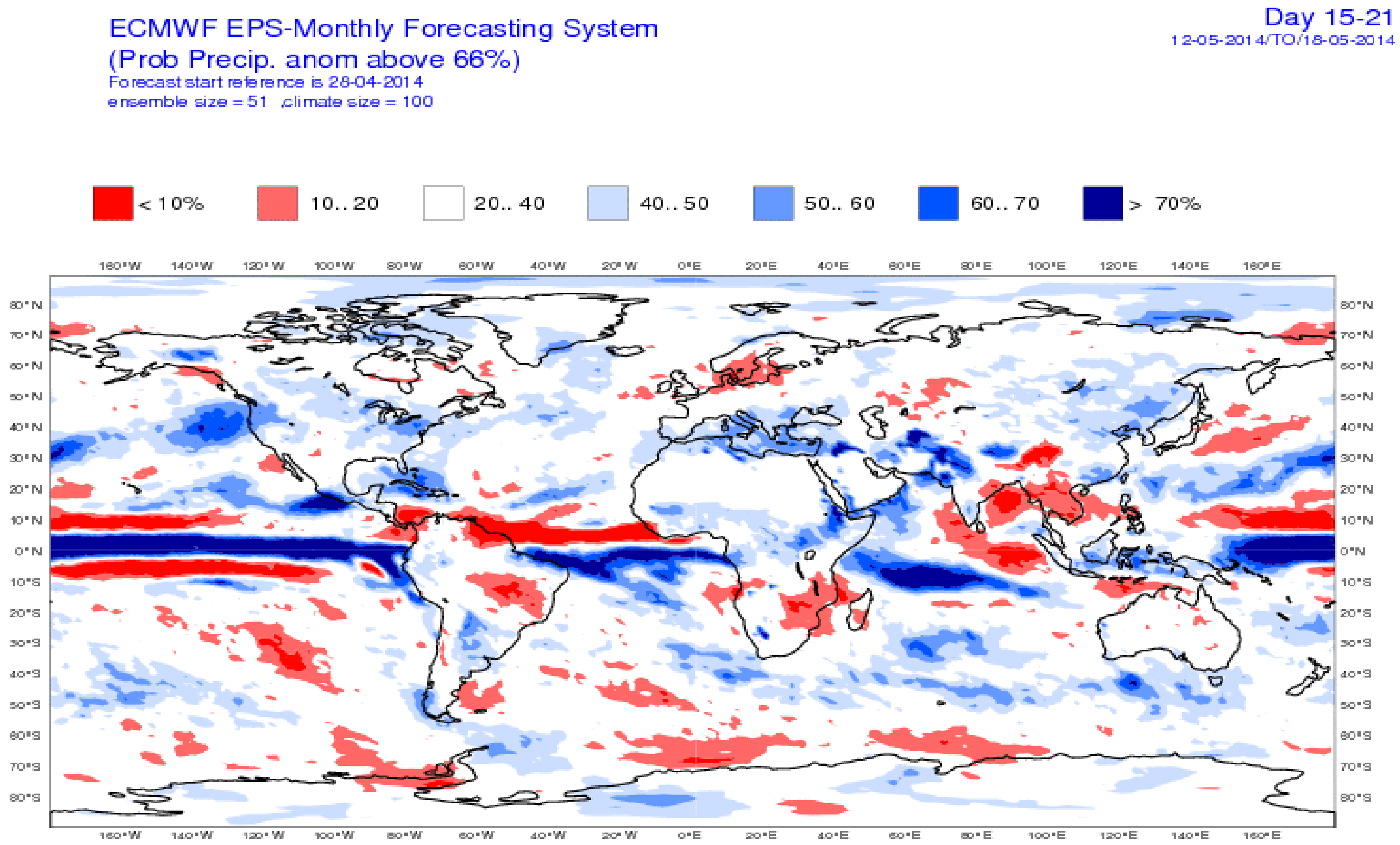
The ECMWF monthly forecasts

Anomalies (temperature, precipitation..)



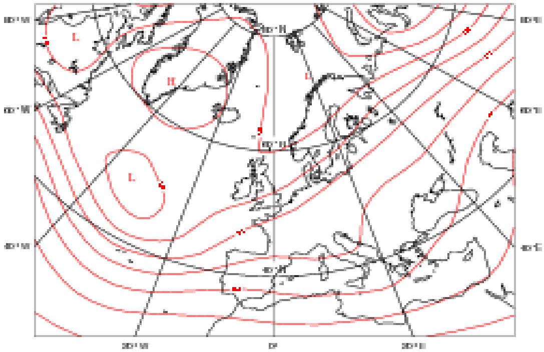
The ECMWF monthly forecasts

Probabilities (temperature, precipitation..)

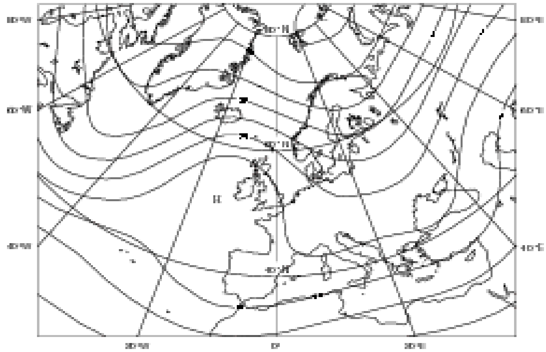


The ECMWF monthly forecasts

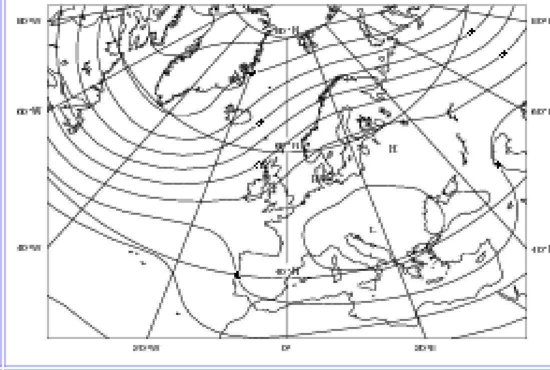
28-04-2014 week3 : step 336-504
Reg 1 ** Sub-cluster mean (2)



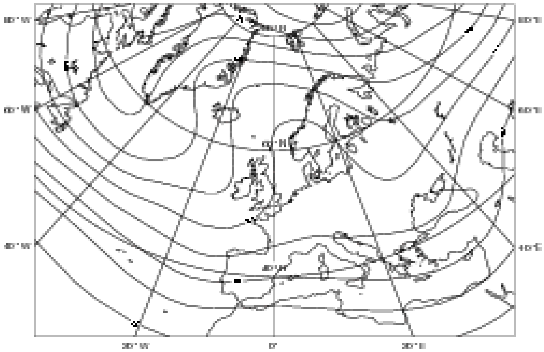
28-04-2014 week3 : step 336-504
Reg 2 ** Cluster mean (13) - CTR



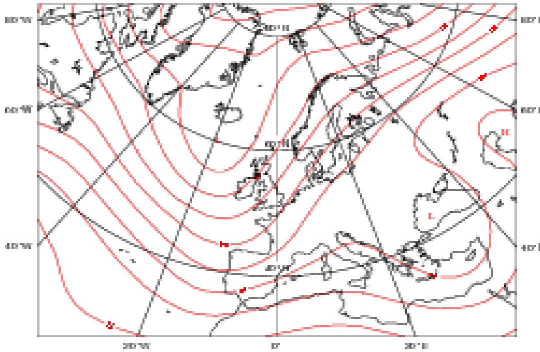
28-04-2014 week3 : step 336-504
Reg 3 ** Cluster mean (11)



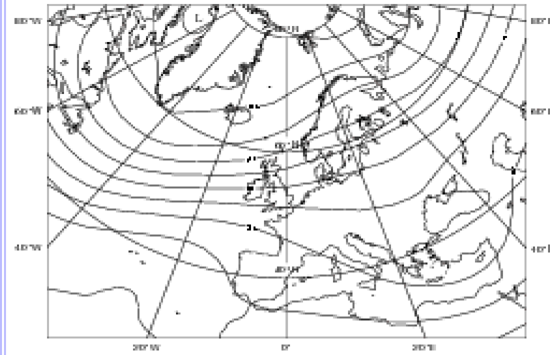
28-04-2014 week3 : step 336-504
Reg 4 ** Cluster mean (11)



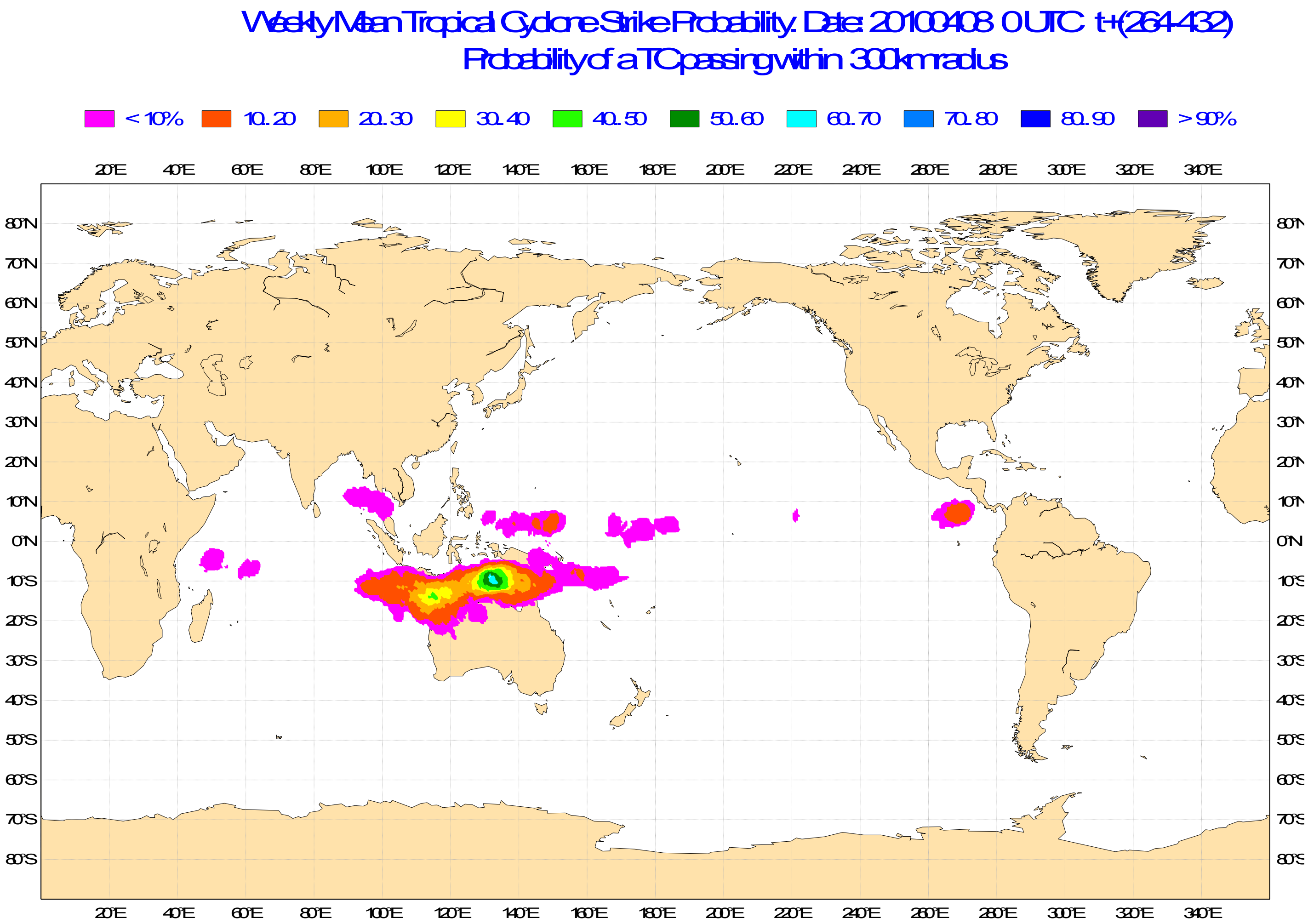
28-04-2014 week3 : step 336-504
Reg 5 ** Sub-cluster mean (4)



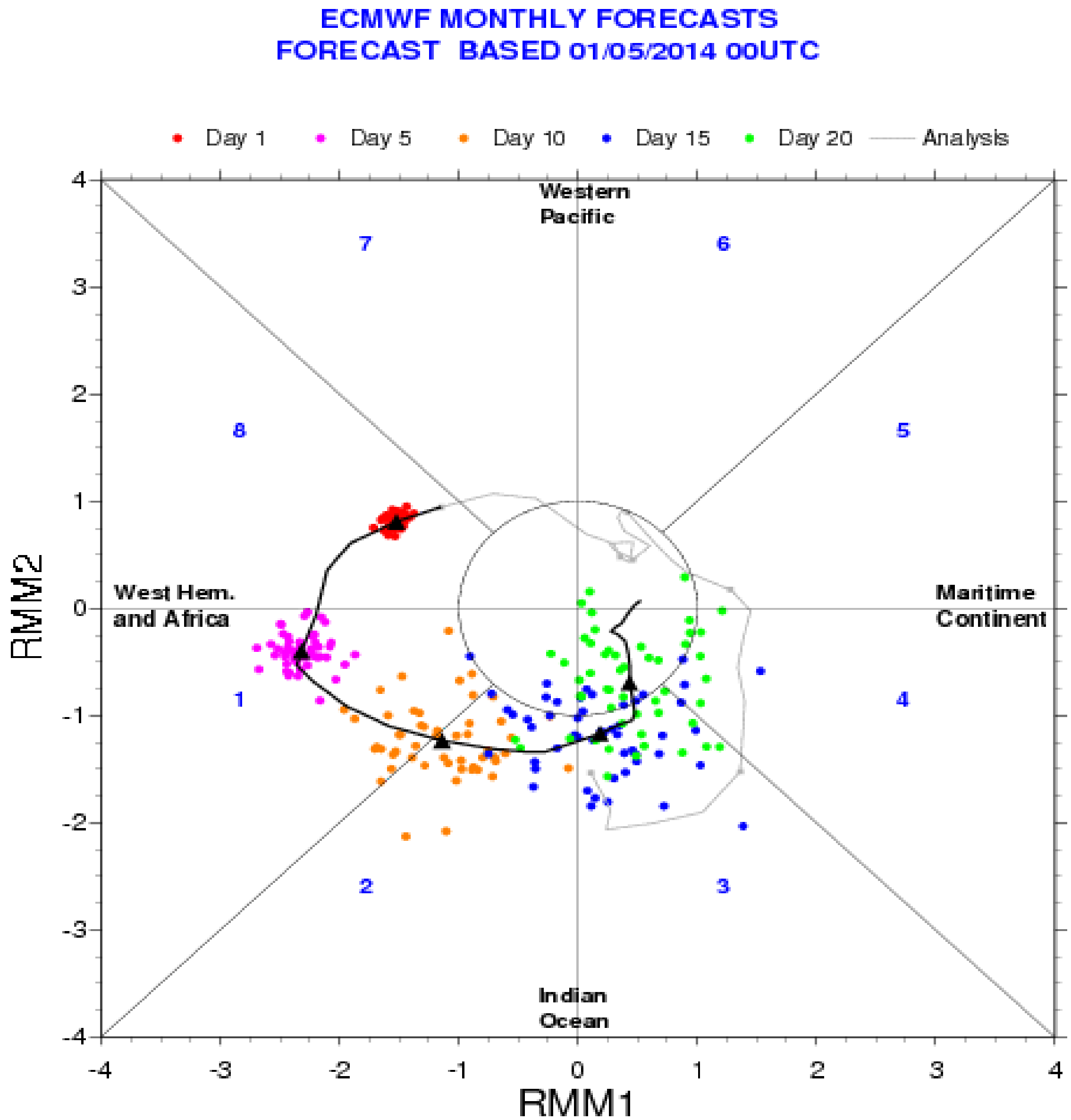
28-04-2014 week3 : step 336-504
Reg 6 ** Cluster mean (9)



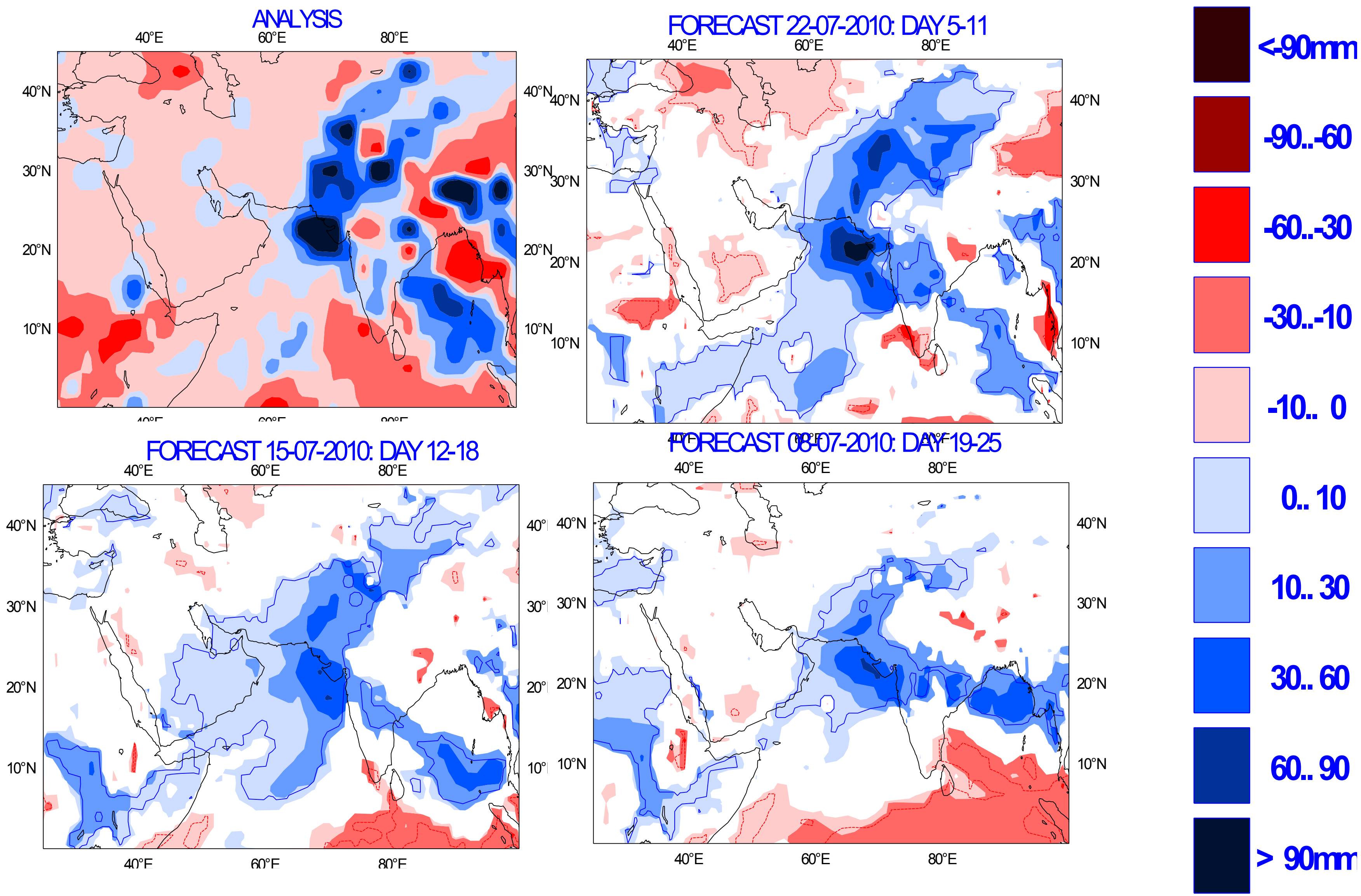
Tropical cyclone activity



MJO Forecasts



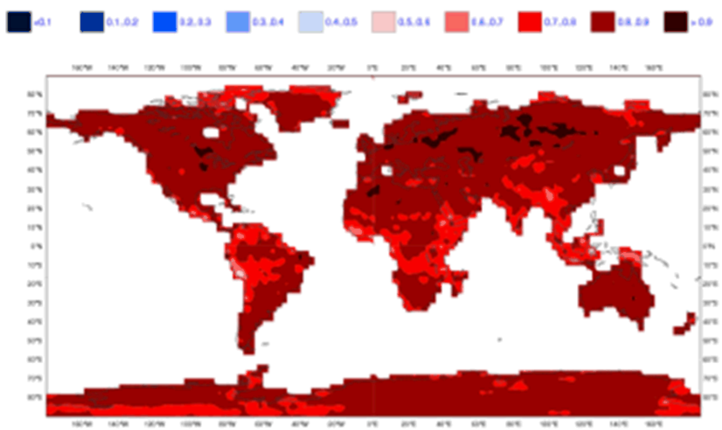
Precip anomalies : 26 July 2010 – 01 August 2010



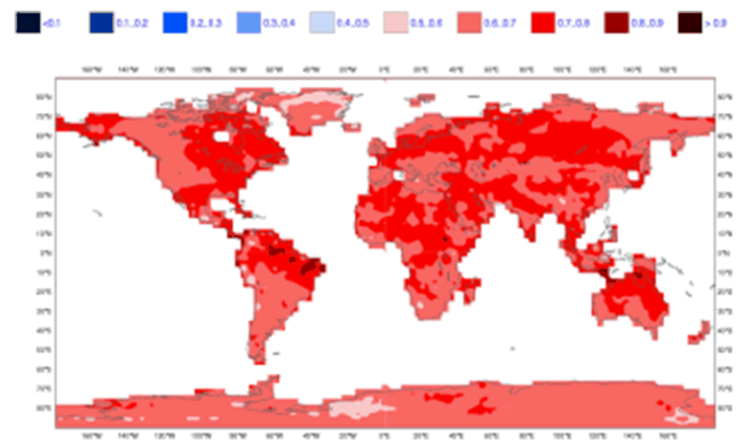
Skill of the ECMWF Monthly Forecasting System

ROC score: 2-meter temperature in the upper tercile

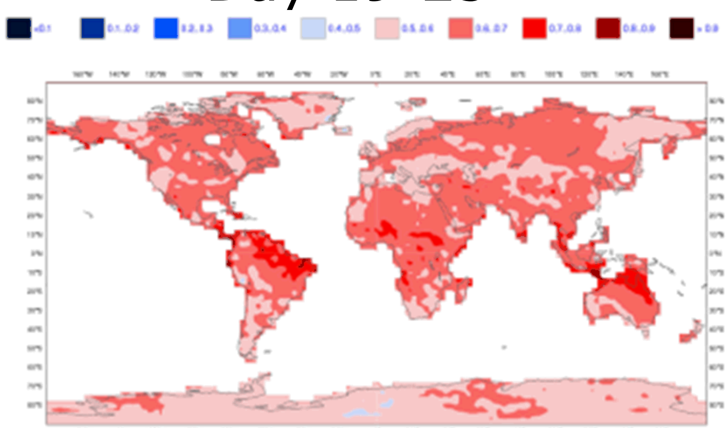
Day 5-11



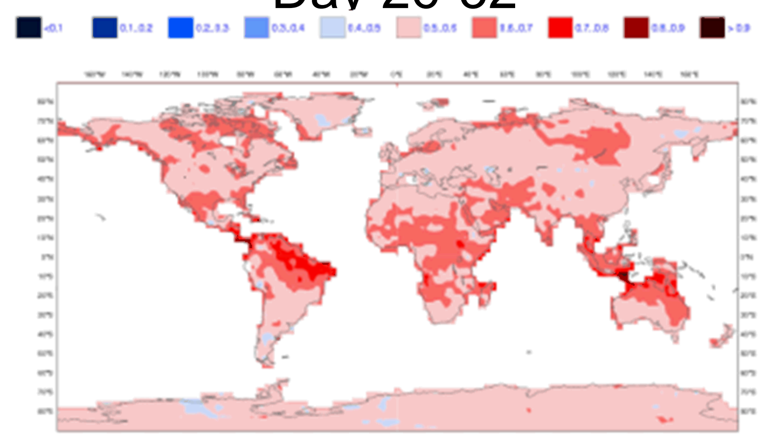
Day 12-18



Day 19-25



Day 26-32

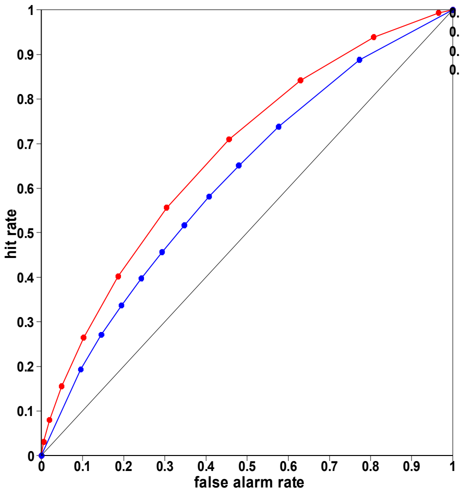


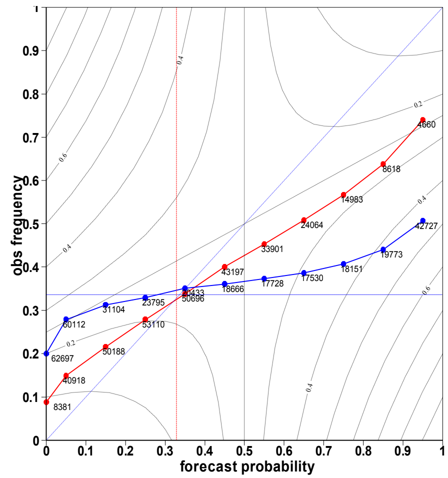
Skill of the ECMWF Monthly Forecasting System

2-meter temperature in upper tercile - Day 12-18

ROC score

Day 12-18

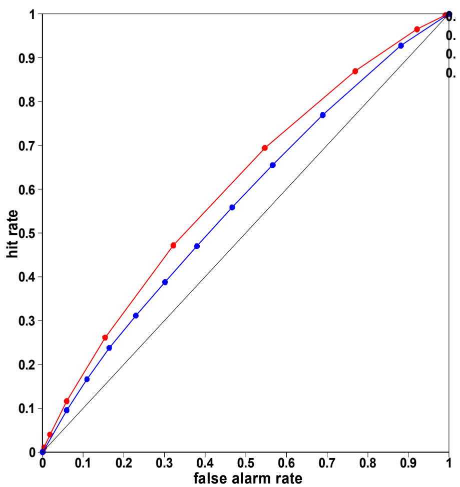


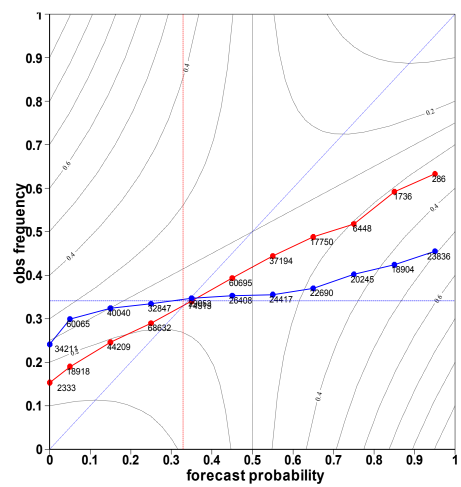


Persistence of day 5-11

Monthly forecast day 12-18

Day 19-25

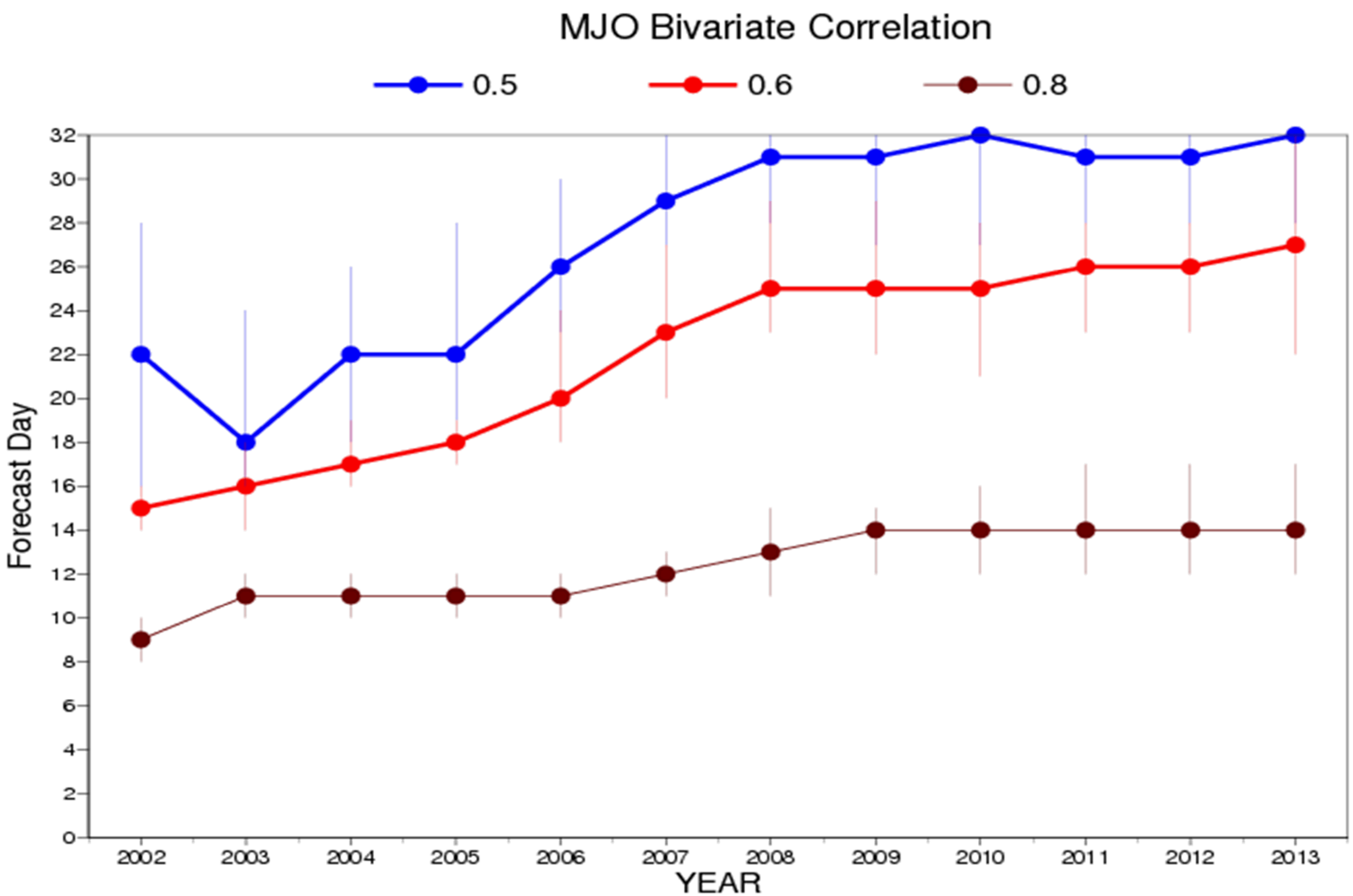




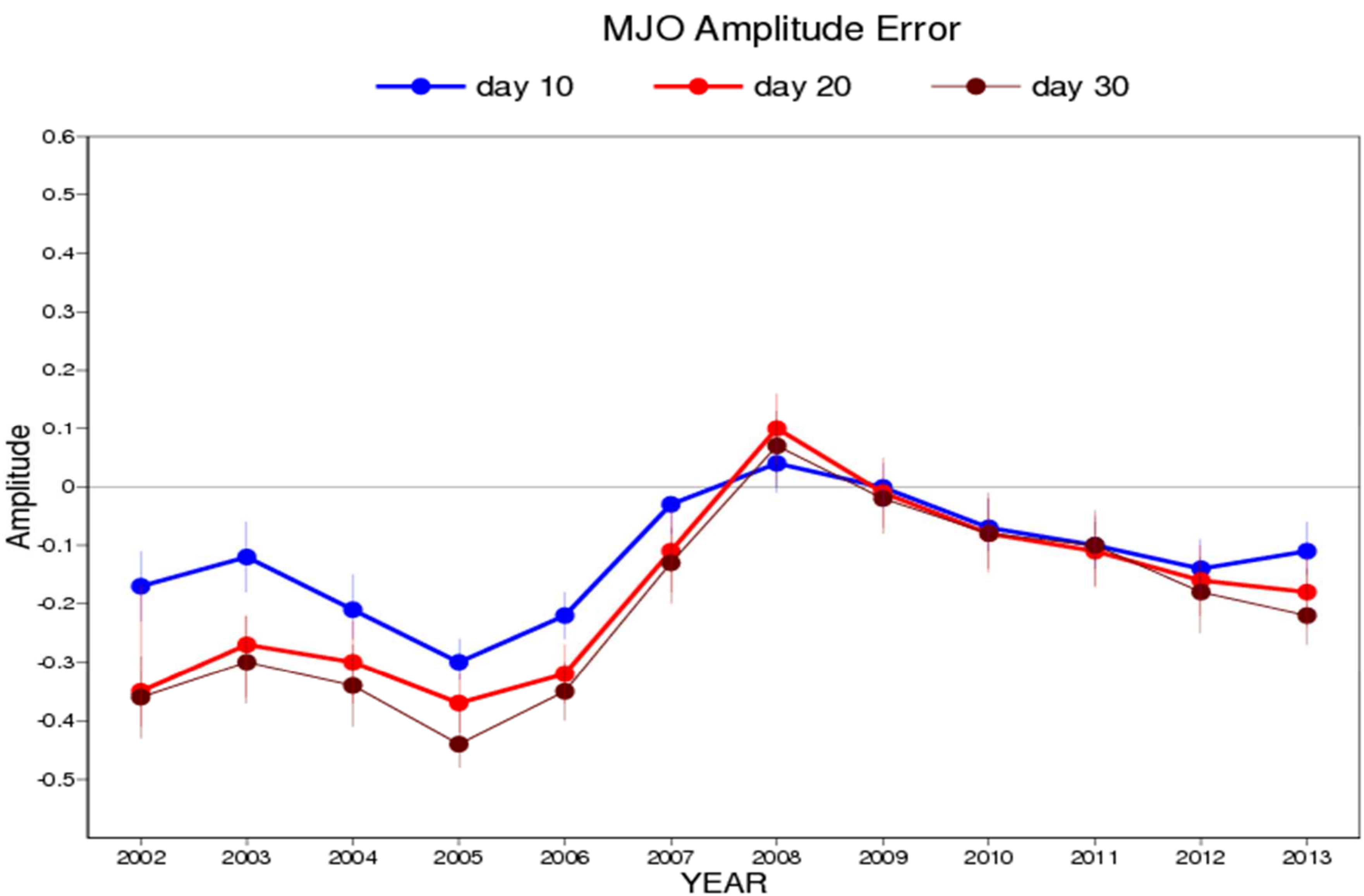
Persistence of day 5-18

Monthly forecast day 19-32

MJO skill scores

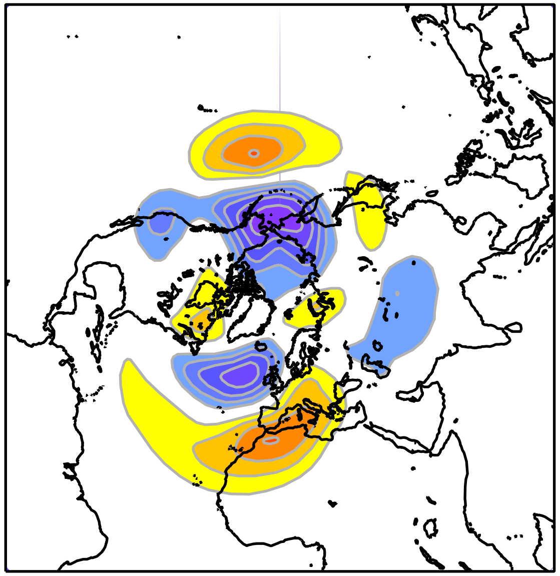


MJO amplitude

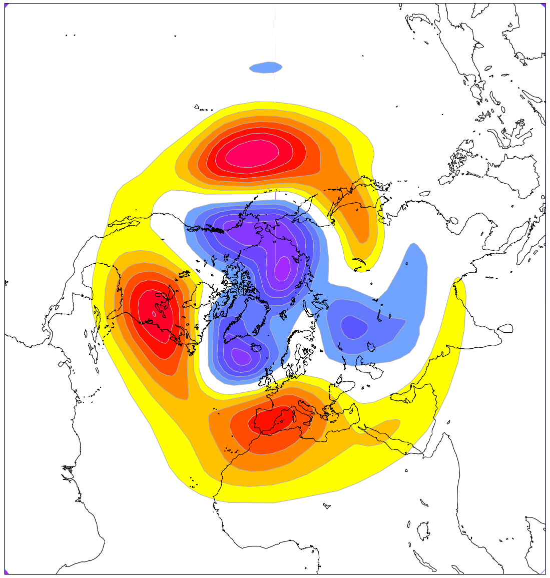


Impact of the MJO on the N. Extratropics

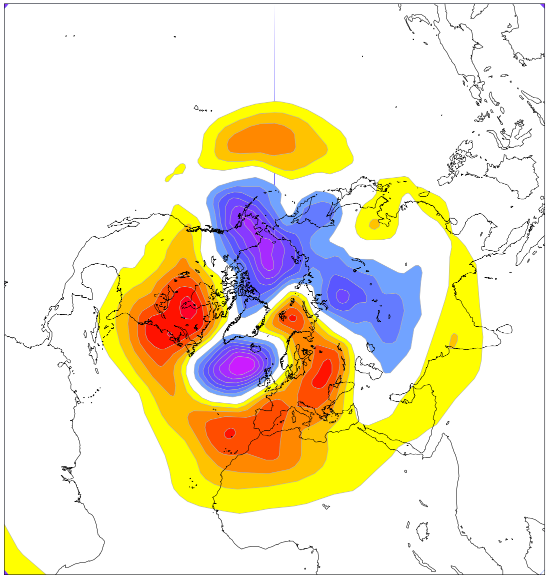
2002 MOFC hindcasts



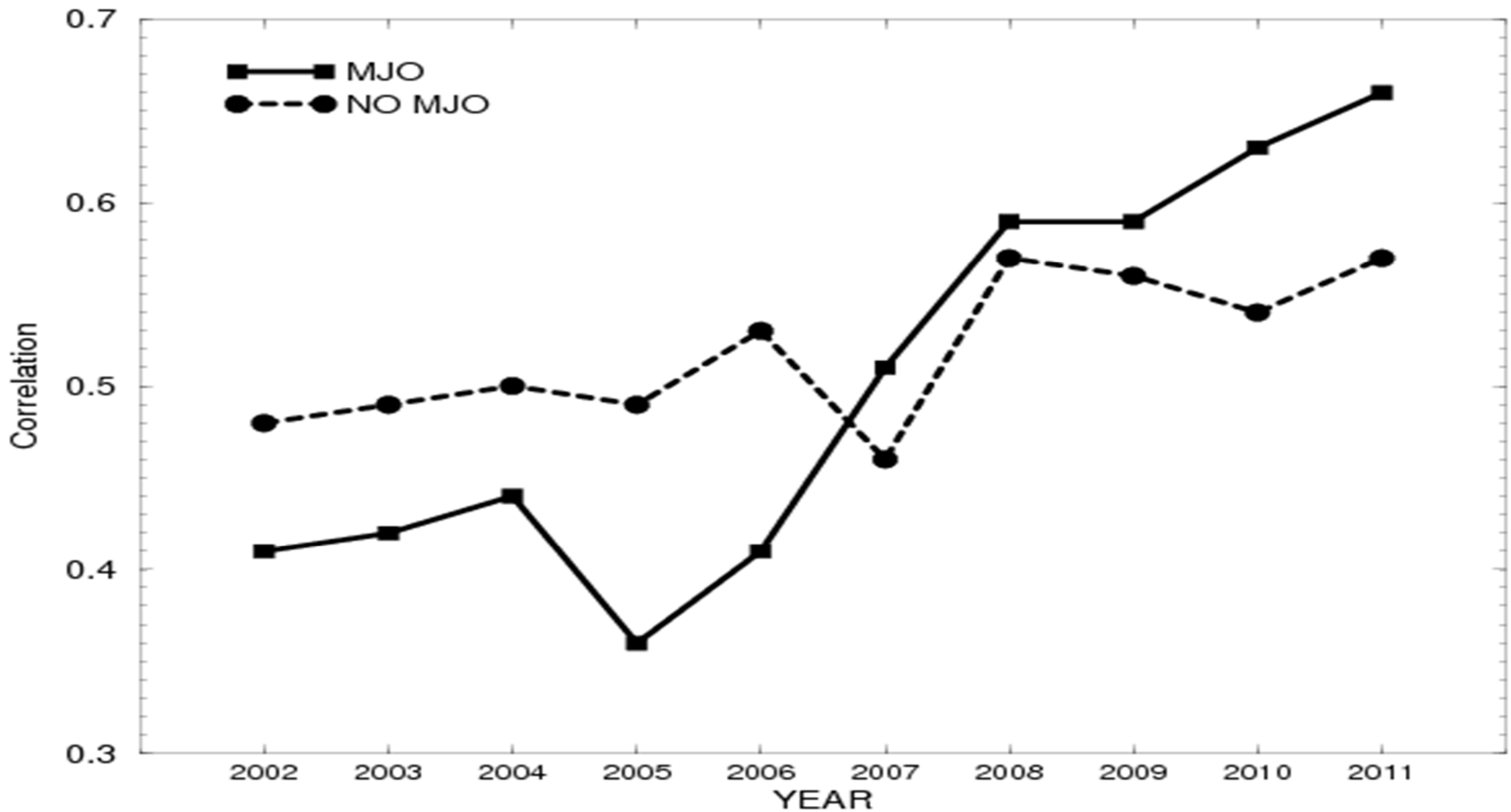
2012 MOFC hindcasts



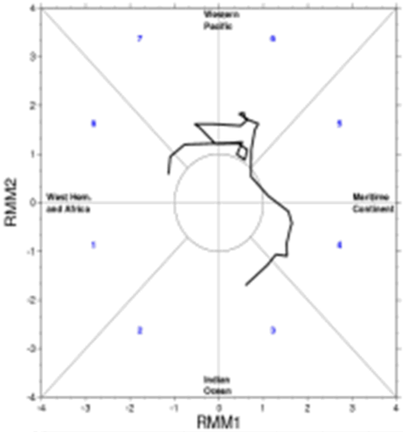
ERA Interim

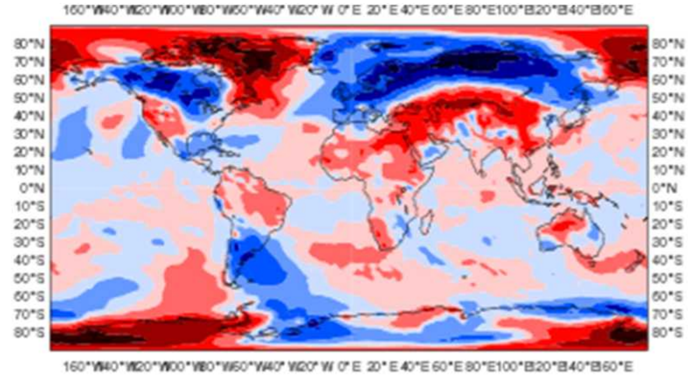


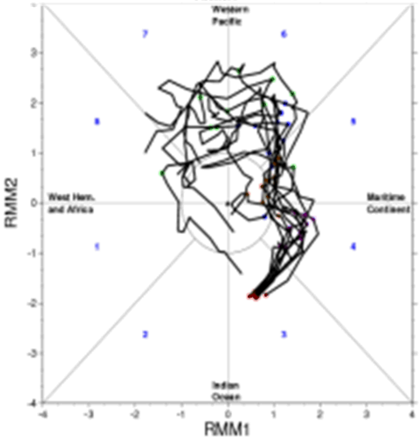
NAO skill scores – Day 19-25

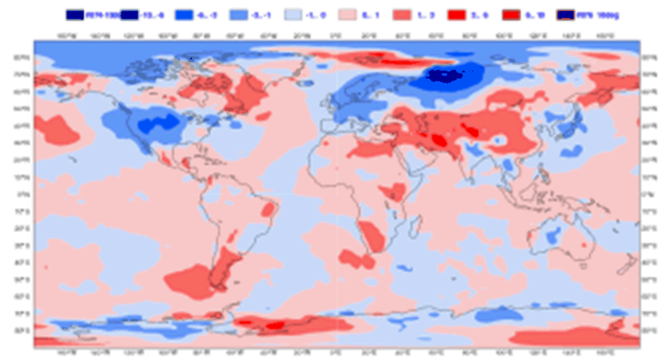


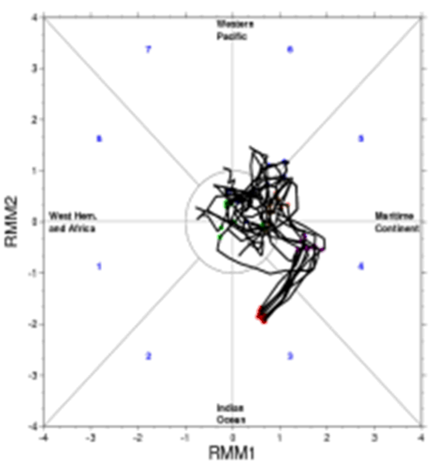
14 Feb 2013 -Day 26-32

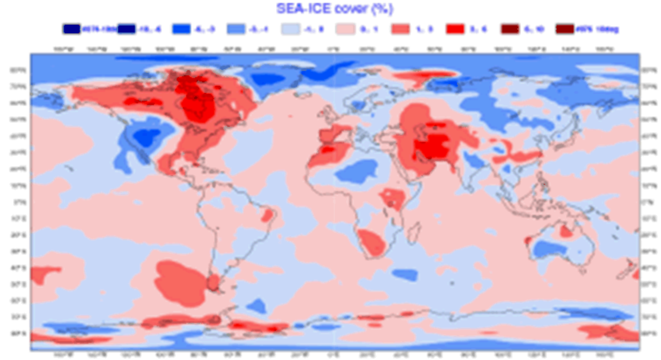




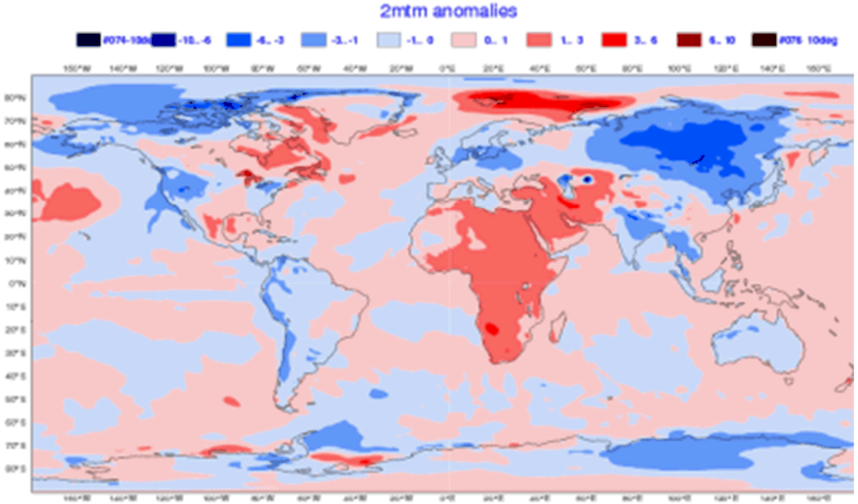




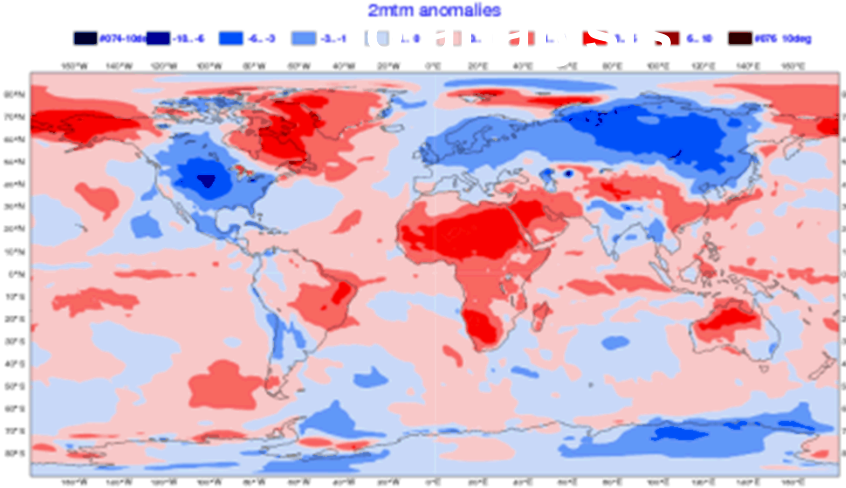




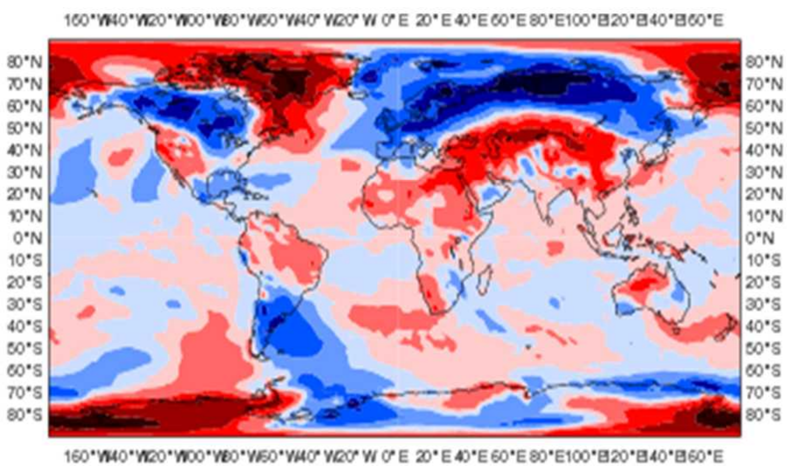
Control



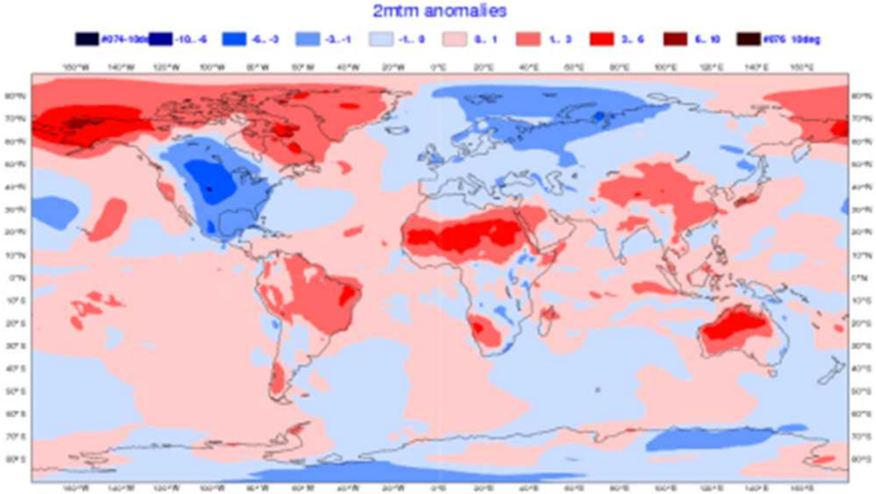
Tropics relaxed



Analysis

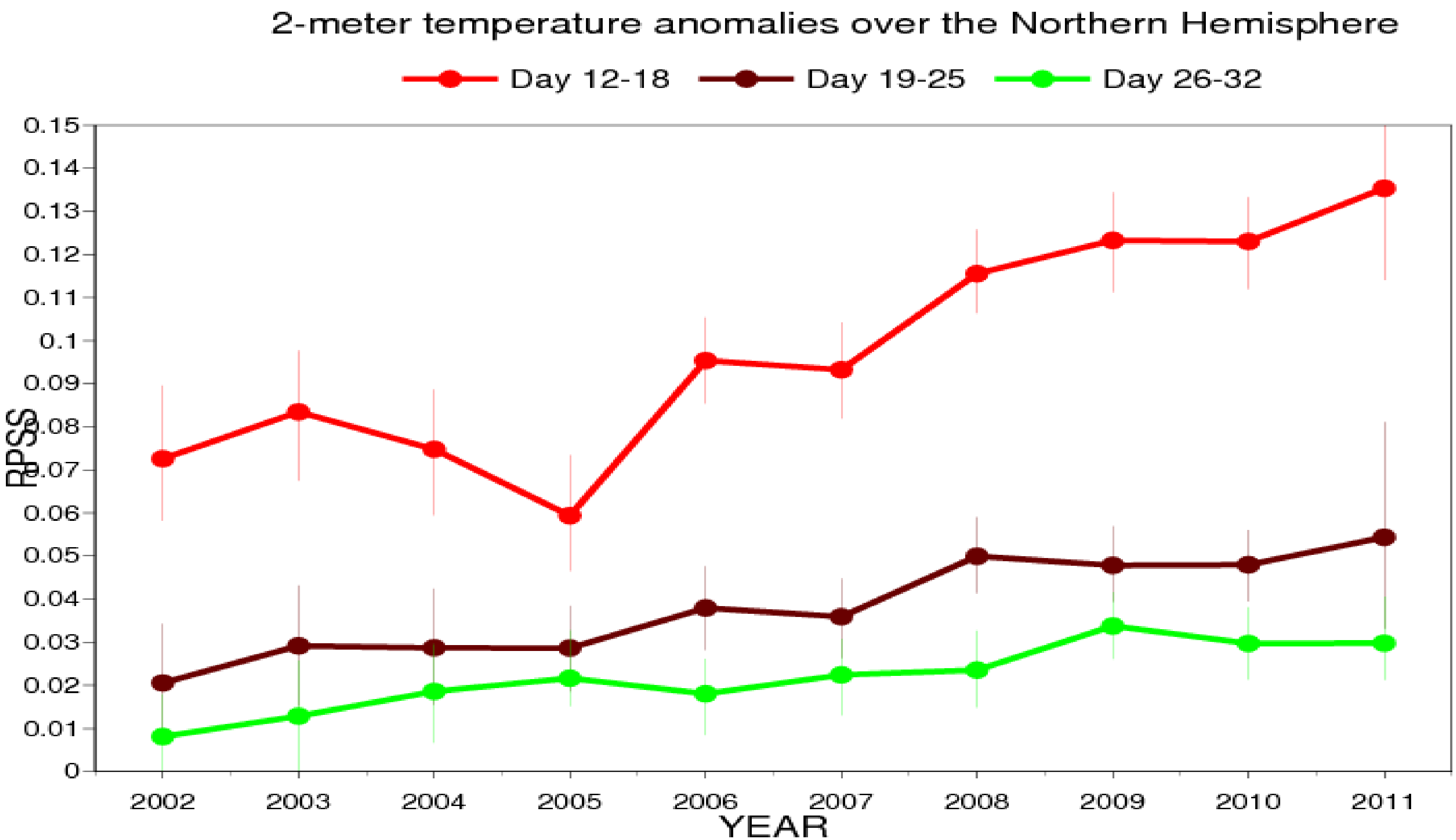


Relax-Control



Performance of the monthly Forecasts

2-metre temperature ROC area over Northern Extratropics



Future model changes

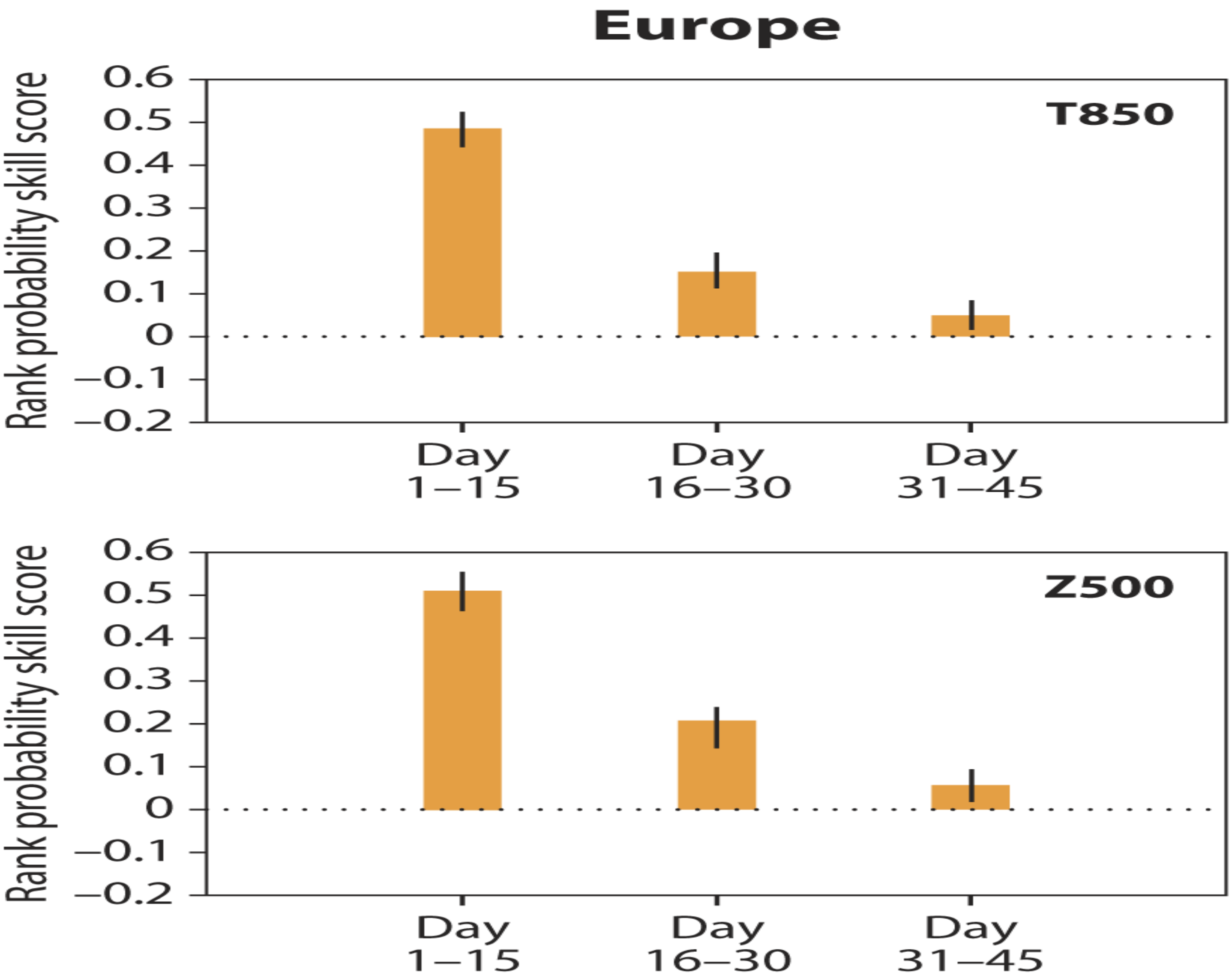
- *Re-forecast extension (twice a week, 11 members)*
(MAY 2015)

- *Extension to 46 days*
(May 2015)

- *Increased atmospheric resolution*
(2015/2016)

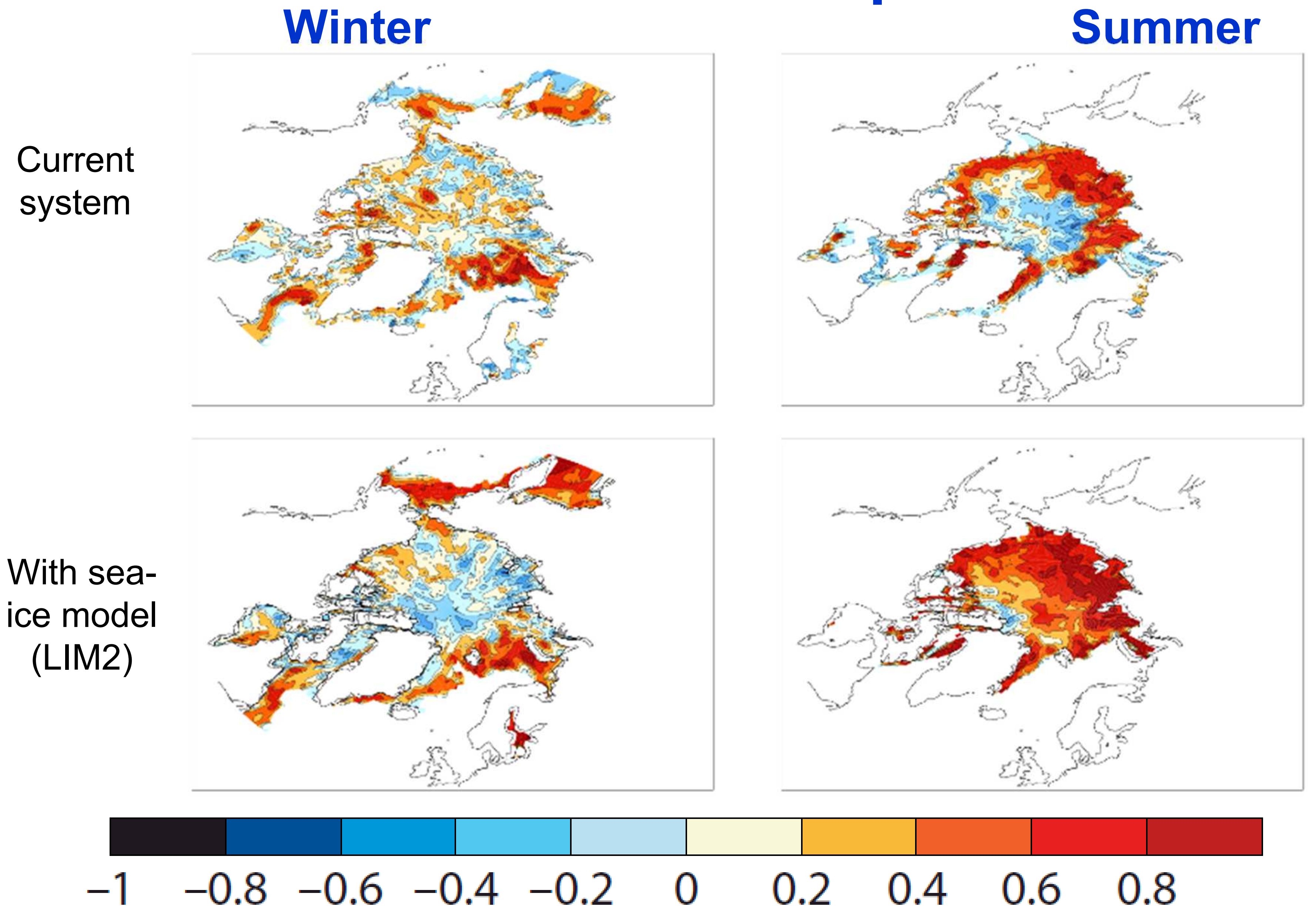
- *Sea-ice – NEMO ¼ degree*
(2016/2017)

Extension to 46 days

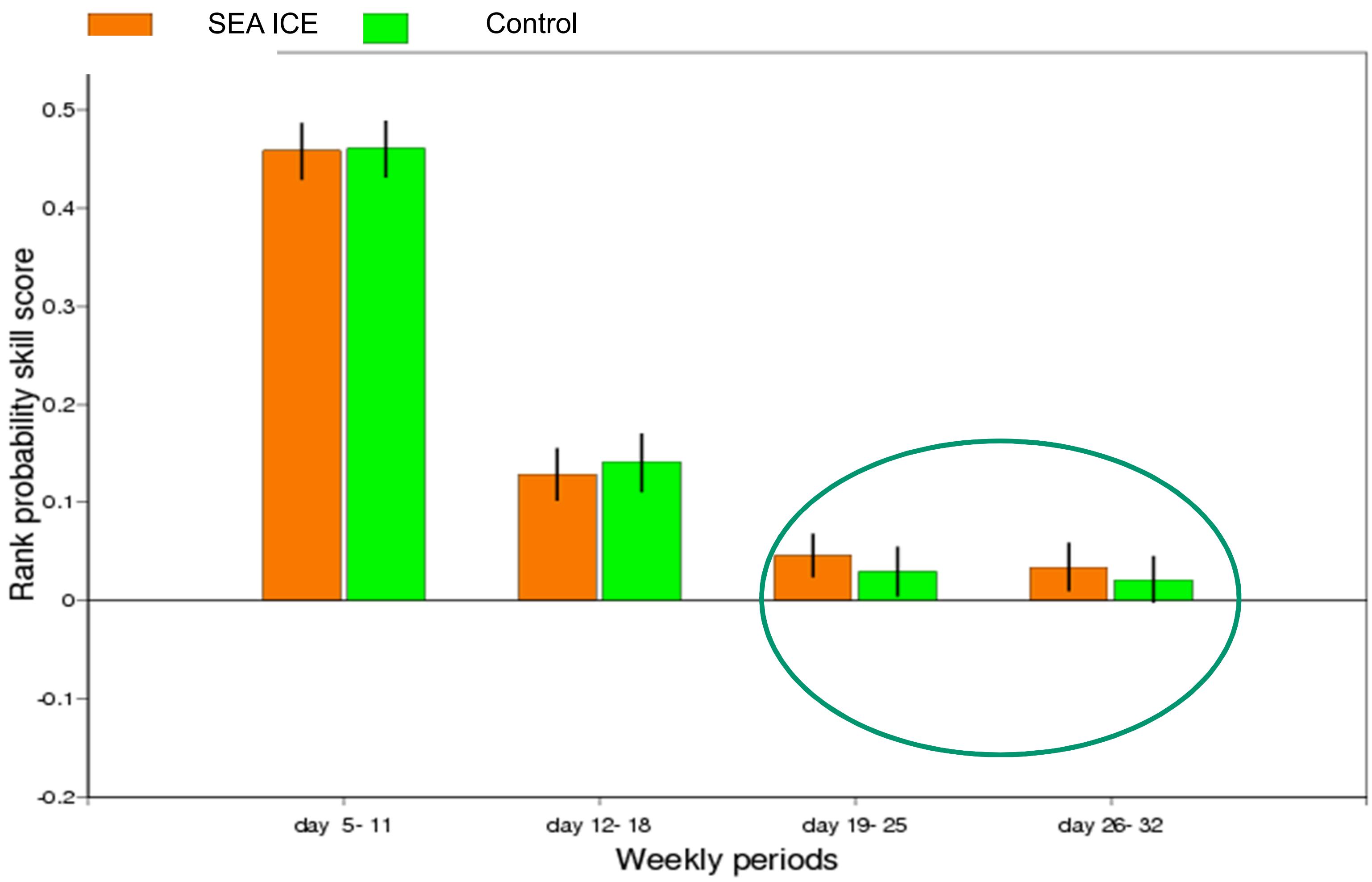


80 case, starting on 1st Feb/May/Aug/Nov 1989-2008

Correlations for week 4 Northern Hemisphere



Active sea ice model: Z500 Forecast Skill (weeks 1-4)



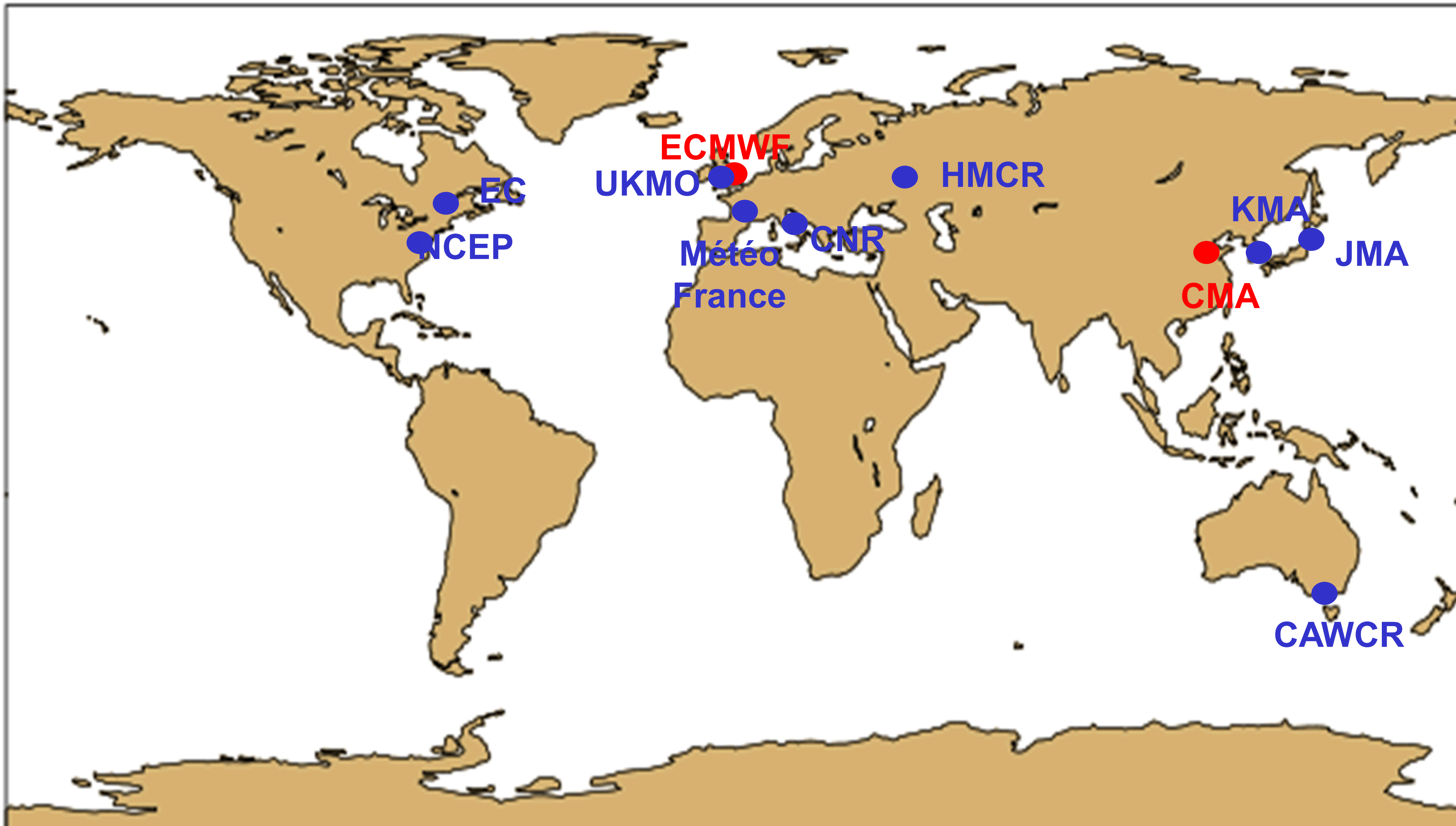
WWRP/WCRP Sub-seasonal to Seasonal Prediction (S2S) database

- Daily real-time forecasts + re-forecasts
- 3 weeks behind real-time
- Common grid (1.5x1.5 degree)
- Variables archived: about 80 variables including ocean variables, stratospheric levels and soil moisture/temperature
- Archived in GRIB2 – NETCDF conversion available

TIGGE-S2S Database

11 data providers and 2 archiving centres

● Data provider ● Archiving centre

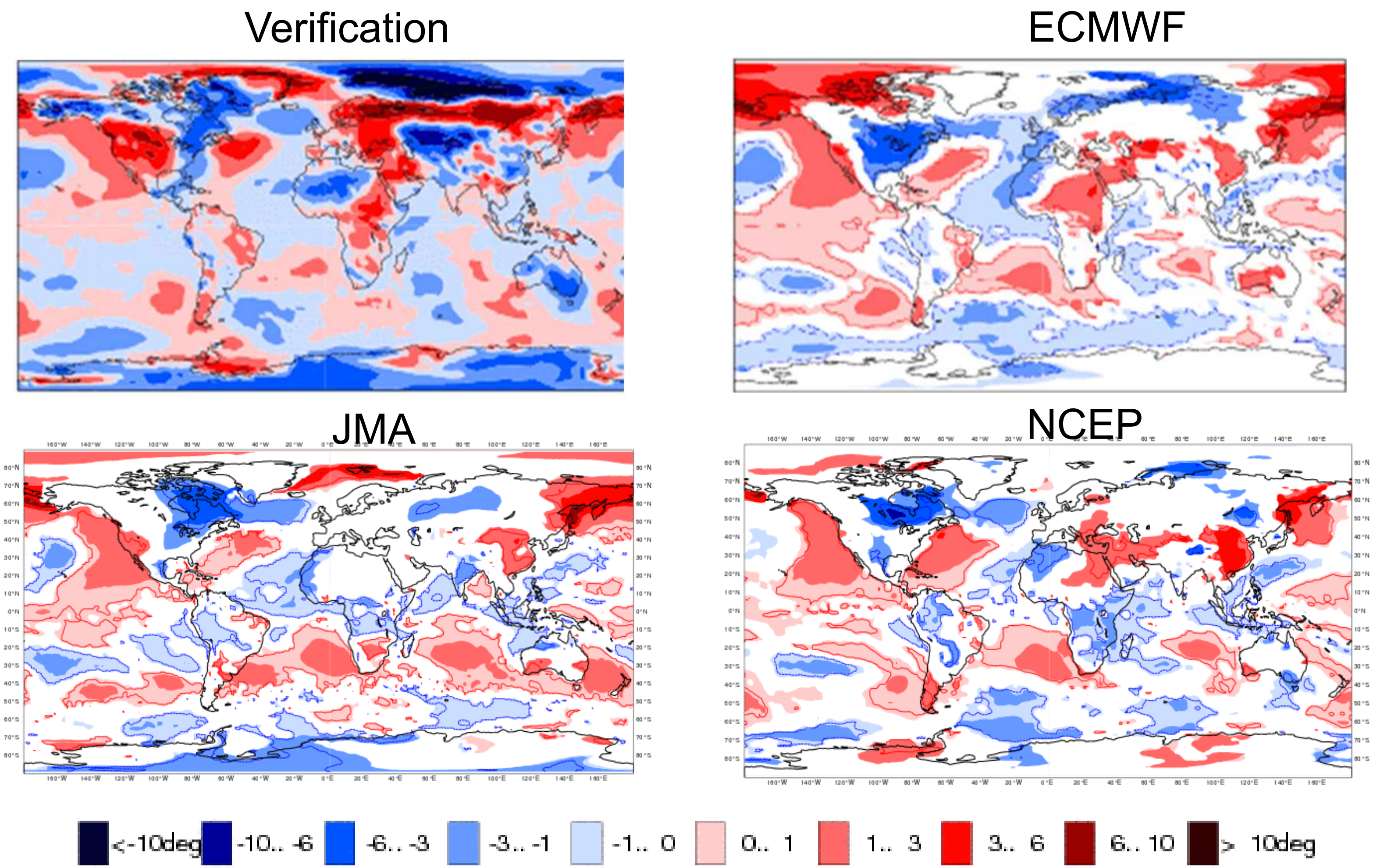


S2S partners

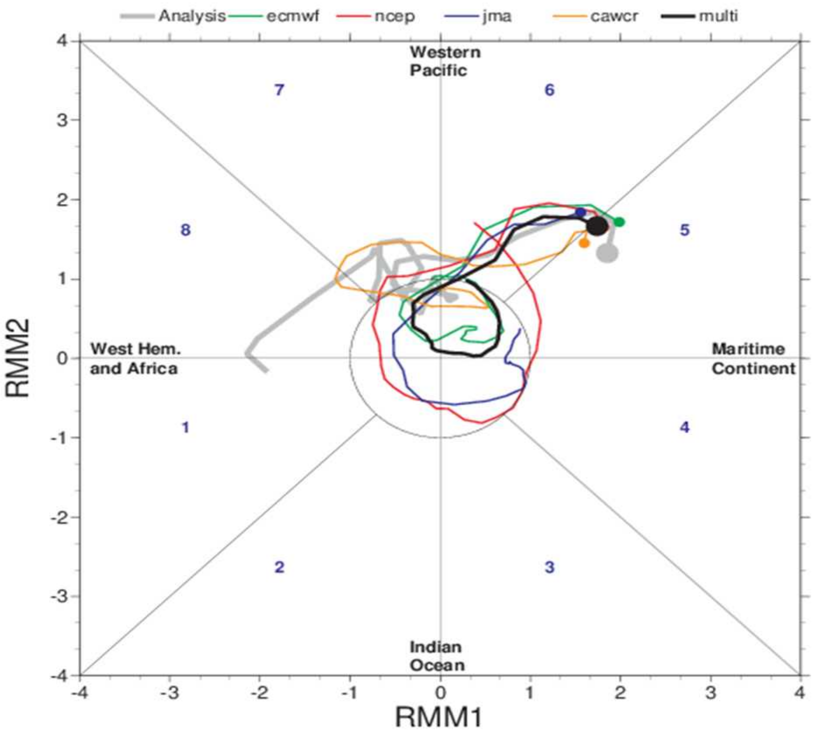
	Time-range	Resol.	Ens. Size	Freq.	Hcsts	Hcst length	Hcst Freq	Hcst Size
ECMWF	D 0-32	T639/319L91	51	2/week	On the fly	Past 18y	2/weekly	11
UKMO	D 0-60	N96L85	4	daily	On the fly	1989-2003	4/month	3
NCEP	D 0-45	N126L64	4	4/daily	Fix	1999-2010	4/daily	1
EC	D 0-35	0.6x0.6L40	21	weekly	On the fly	Past 15y	weekly	4
CAWCR	D 0-60	T47L17	33	weekly	Fix	1981-2013	6/month	33
JMA	D 0-34	T159L60	50	weekly	Fix	1979-2009	3/month	5
KMA	D 0-60	N216L85	4	daily	On the fly	1996-2009	4/month	3
CMA	D 0-45	T106L40	4	daily	Fix	1992-now	daily	4
Met.Fr	D 0-60	T127L31	51	monthly	Fix	1981-2005	monthly	11
CNR	D 0-32	0.75x0.56 L54	40	weekly	Fix	1981-2010	6/month	1
HMCR	D 0-63	1.1x1.4 L28	20	weekly	Fix	1981-2010	weekly	10

S2S Multi-model prediction

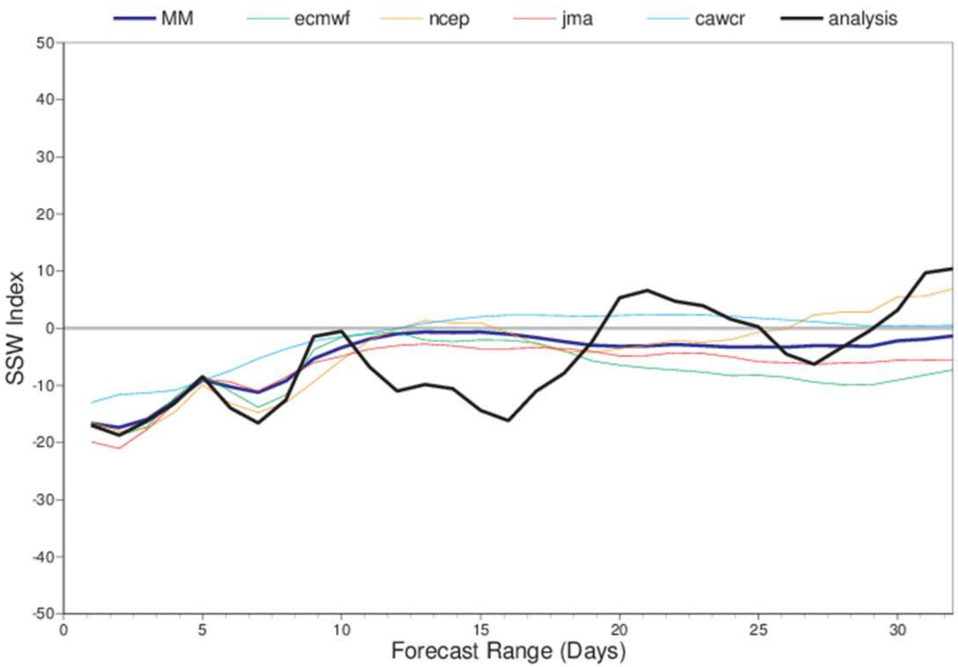
Day 12-18 2-m temp anomalies - Forecasts starting on 15/01



MJO 1/1/2015



SSWs 1/1/2015



Conclusion

- SSTs, Soil moisture, stratospheric initial conditions and MJO are sources of predictability at the intra-seasonal time scale. The MJO has a significant impact on the forecast skill scores beyond day 20.

- The monthly forecasting system produces forecasts for days 12-18 that are generally better than climatology and persistence of day 5-11. Beyond day 20, the monthly forecast is marginally skilful. For some applications and some regions, these forecasts could however be of some interest.

- There has been a clear improvement in the monthly forecast skill scores since 2002. This improvement is likely to be related to improved prediction in the Tropics and most especially improved MJO prediction.