

# The ECMWF Extended range forecasts

[Laura.Ferranti@ecmwf.int](mailto:Laura.Ferranti@ecmwf.int)

ECMWF, Reading, U.K.

# The operational forecasting system

High resolution forecast: twice per day Tco 1279 ~ 9km  
137-level, to 10 days ahead

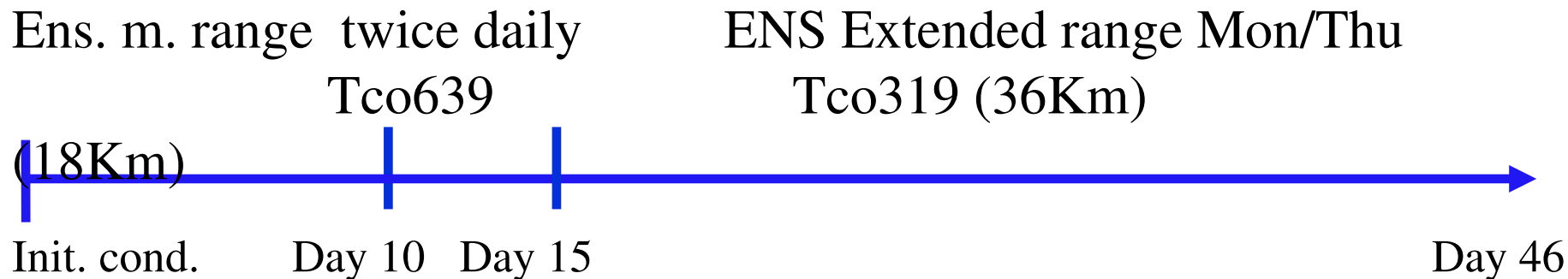
## Coupled atmosphere-ocean system

Ensemble Prediction System (ENS): twice daily TI 639/319 32/64  
km 91-level, 51 members to 15 days ahead (next update Tco639 –  
18Km)

**Extended range forecasts /ENS extension:** twice a week (Mon/Thu)  
Tco 639/319 ~ 18/36 km 91 levels, 51 members to 46 days ahead

Long range forecasts: once a month 51 members, ~80 km 91 levels,  
to 7 months ahead

# Extended range forecast / ENS extension



## Atmosphere

**Initial uncertainties** SVs+ EDA perturbations

**Model uncertainties** Stochastic physics (SPPT and SKEB schemes).

The central analysis is the Tco1279L137 4DVAR coupled to wave model (WAM) every time step

## Ocean

**NEMO** (about 0.25 degree resolution) coupled to IFS.

**Ocean initial conditions** provided by 5-member NEMOVAR analysis

# Bridging the gap between seasonal forecasting and NWP

- **Extended-range weather forecasting: Beyond 10 days and up to 30 days description of weather parameters, usually averaged over a period of 5-7 days and expressed as a departure from climate values for that period.**
- **A particularly difficult time range: In fact at this time range is generally too long for the atmosphere to keep a memory of its initial conditions, and too short for the ocean variability to have an impact on the atmospheric circulation.**

# The ECMWF extended forecasts consists of 2 elements:

- **Real time forecasts**
- **A set of re-forecasts covering the most recent 20 years period**
  - the same configuration of the real time forecasts
  - 11-member ensemble integrated at the same day and same month as the real-time time forecast
  - It runs twice every week as the real-time forecast
  - Used to estimate the model drift

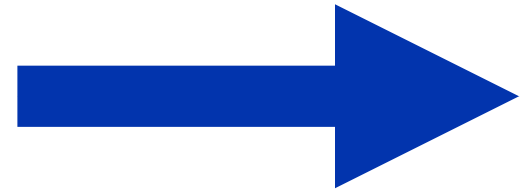
# The ECMWF extended forecasts consists of 2 elements:

## Real time forecasts

26/09/16 Monday

29/09/16 Thursday

3/10/16 Monday



## Set of reforecasts



26/09 2015



26/09 2014

.....



26/09 1996



26/09 1995



29/09 2015



29/09 2014

.....



29/09 1996



29/09 1995



3/10 2015



3/10 2014

.....



3/10 1996



3/10 1995



# ECMWF Monthly Forecasting System

## MODEL BIAS: 2m Temperature

Forecast start reference is 05/03/1991-2008  
ensemble size = 5

# Model Bias:

WEEK1-4

<-8K    -8..-4    -4..-2    -2..-1    -1..1    1..2    2..4    4..8    > 8K

WEEK1: DAY 5 TO 11

WEEK2: DAY 12 TO 18

160°W 120°W 80°W 40°W 0° 20°E 40°E 60°E 80°E 120°E 160°E      160°W 120°W 80°W 40°W 0° 20°E 40°E 60°E 80°E 120°E 160°E

After 10 days of forecast, model biases cannot be ignored, and the real time forecasts need to be biased corrected.

The set of re-forecast is used to estimate the model biases

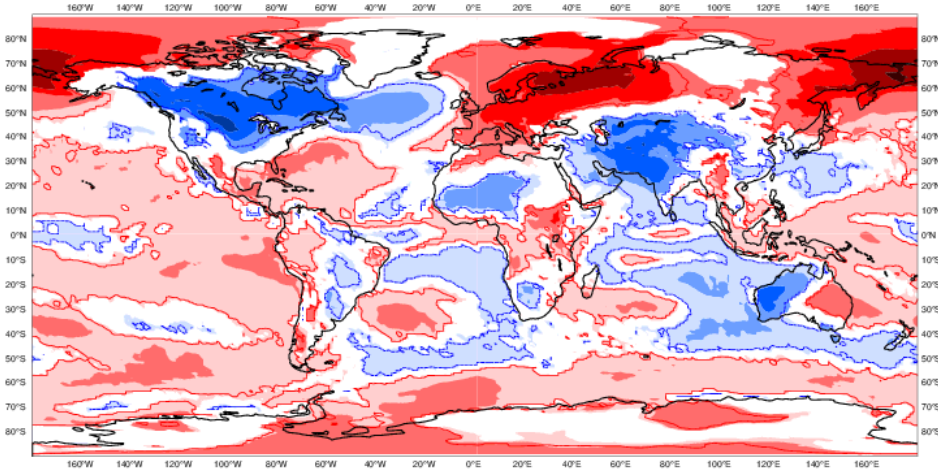
The bias is removed from the real time forecast during the post-processing.

Day 19-25

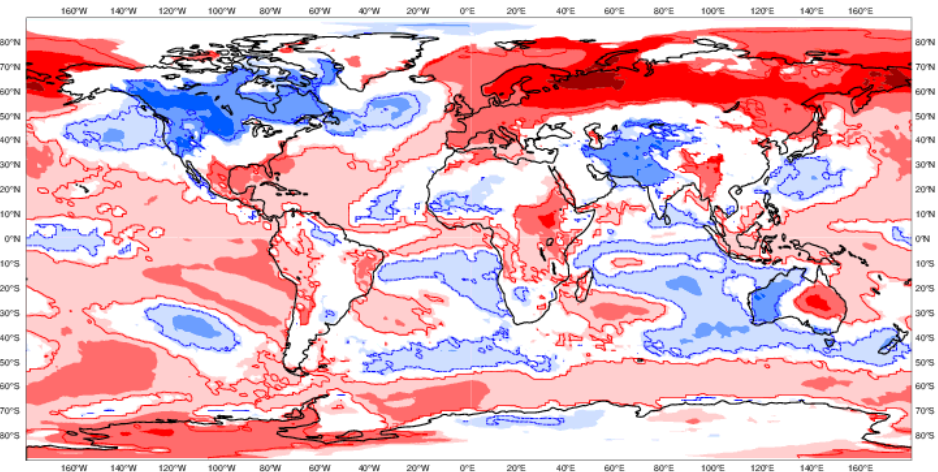
Day 26-32

160°W 120°W 80°W 40°W 0° 20°E 40°E 60°E 80°E 120°E 160°E      160°W 120°W 80°W 40°W 0° 20°E 40°E 60°E 80°E 120°E 160°E





# Ens. mean weekly anomalies :

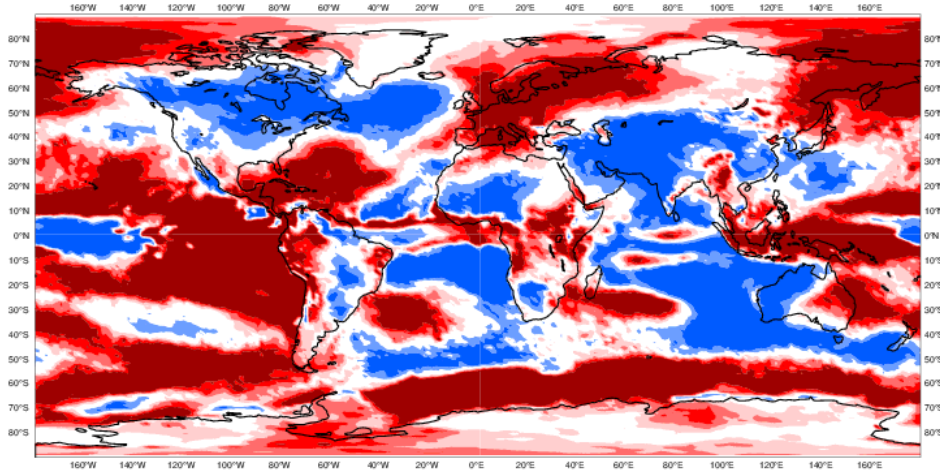




ECMWF EPS-Monthly Forecasting System  
(Prob 2m Temp. anom above 66%)  
Forecast start reference is 26-01-2017  
ensemble size = 51 ,climate size = 660

Day 12-18  
06-02-2017/TO/12-02-2017

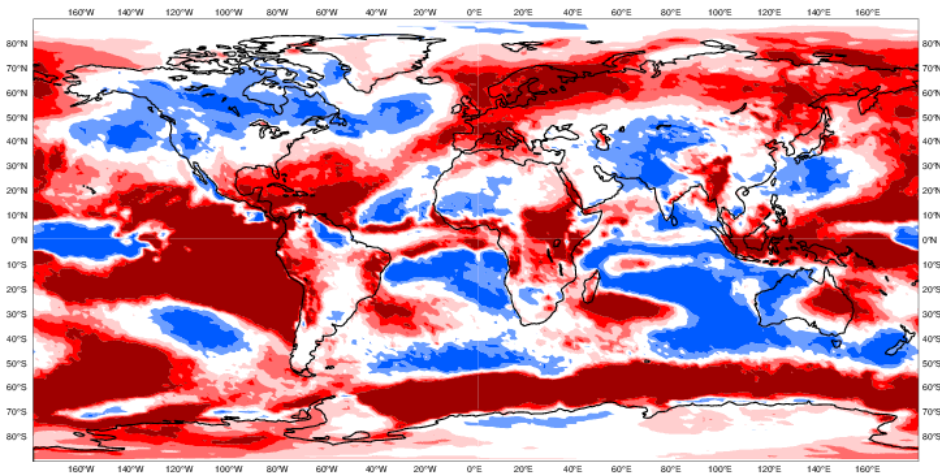
< 10% 10..20 20..40 40..50 50..60 60..70 > 70%



ECMWF EPS-Monthly Forecasting System  
(Prob 2m Temp. anom above 66%)  
Forecast start reference is 23-01-2017  
ensemble size = 51 ,climate size = 660

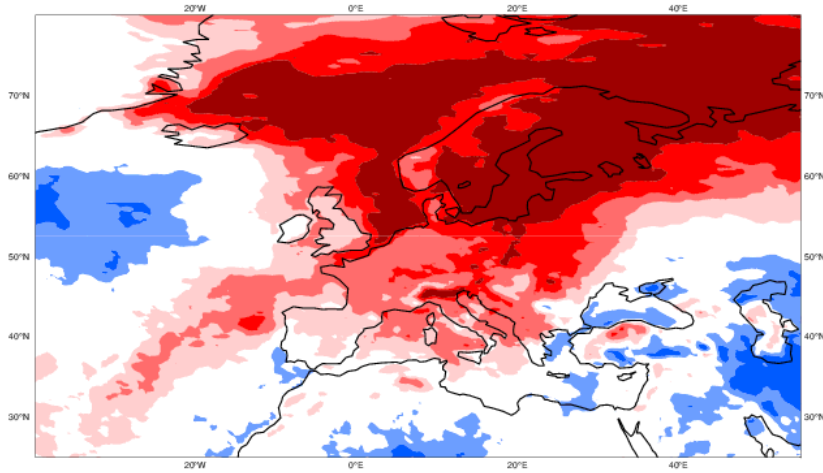
Day 15-21  
06-02-2017/TO/12-02-2017

< 10% 10..20 20..40 40..50 50..60 60..70 > 70%

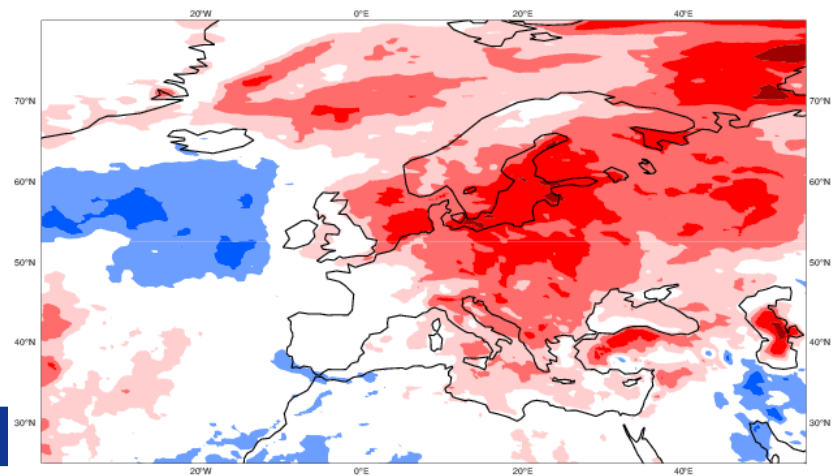


# Probabilities for weekly mean anomalies:

■ < 10% ■ 10..20 ■ 20..40 ■ 40..50 ■ 50..60 ■ 60..70 ■ > 70%

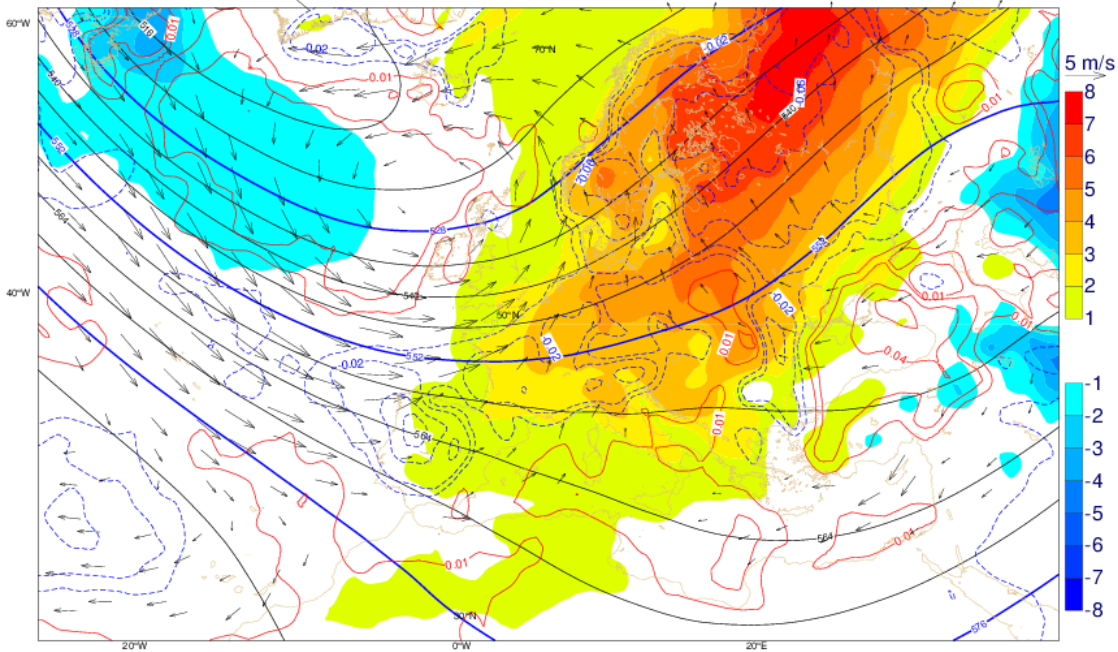


■ < 10% ■ 10..20 ■ 20..40 ■ 40..50 ■ 50..60 ■ 60..70 ■ > 70%



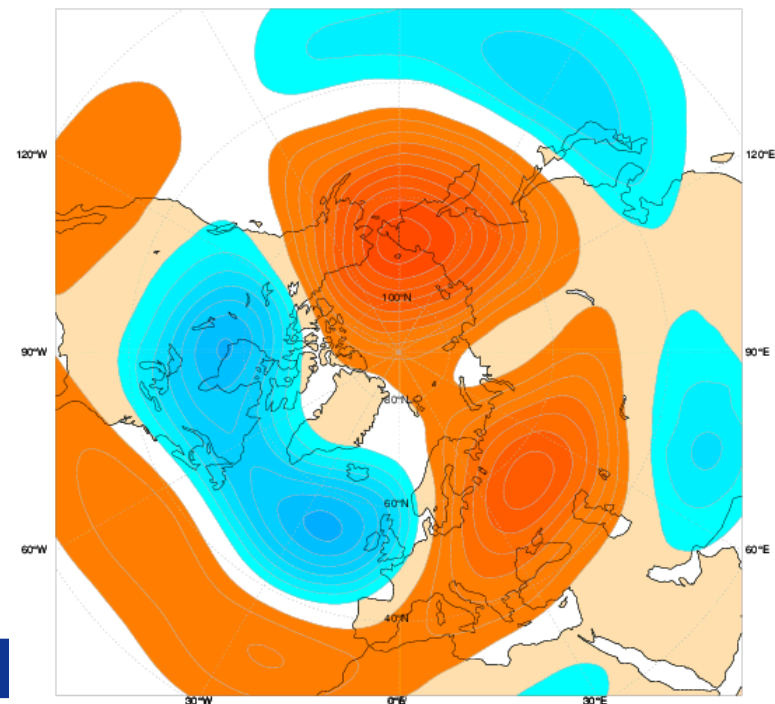
# Weekly mean multiparameter outlook:

Day 12-18 20170206 - 20170212



## Weekly mean Geop. 500

Day 12-18: Mon 20170206- Sun 20170212



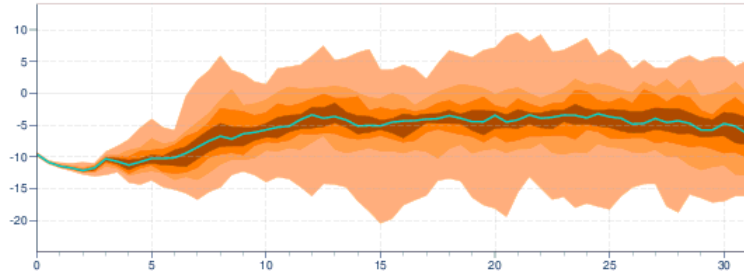
ECMWF Ensemble forecasts for FINLAND - HELSINKI

Location: 60.32°N 24.97°E

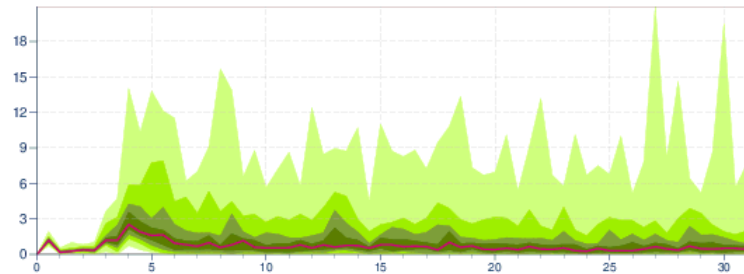
Base Time: Thursday 3 November 2016 00 UTC

Extremes 12.5-87.5% 25-75% 37.5-62.5%  
Median

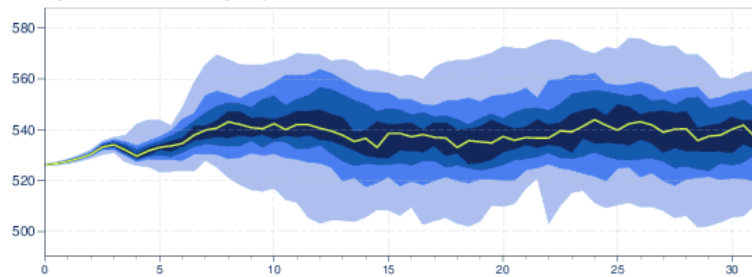
Temperature at 850 hPa (C) - Ensemble distribution



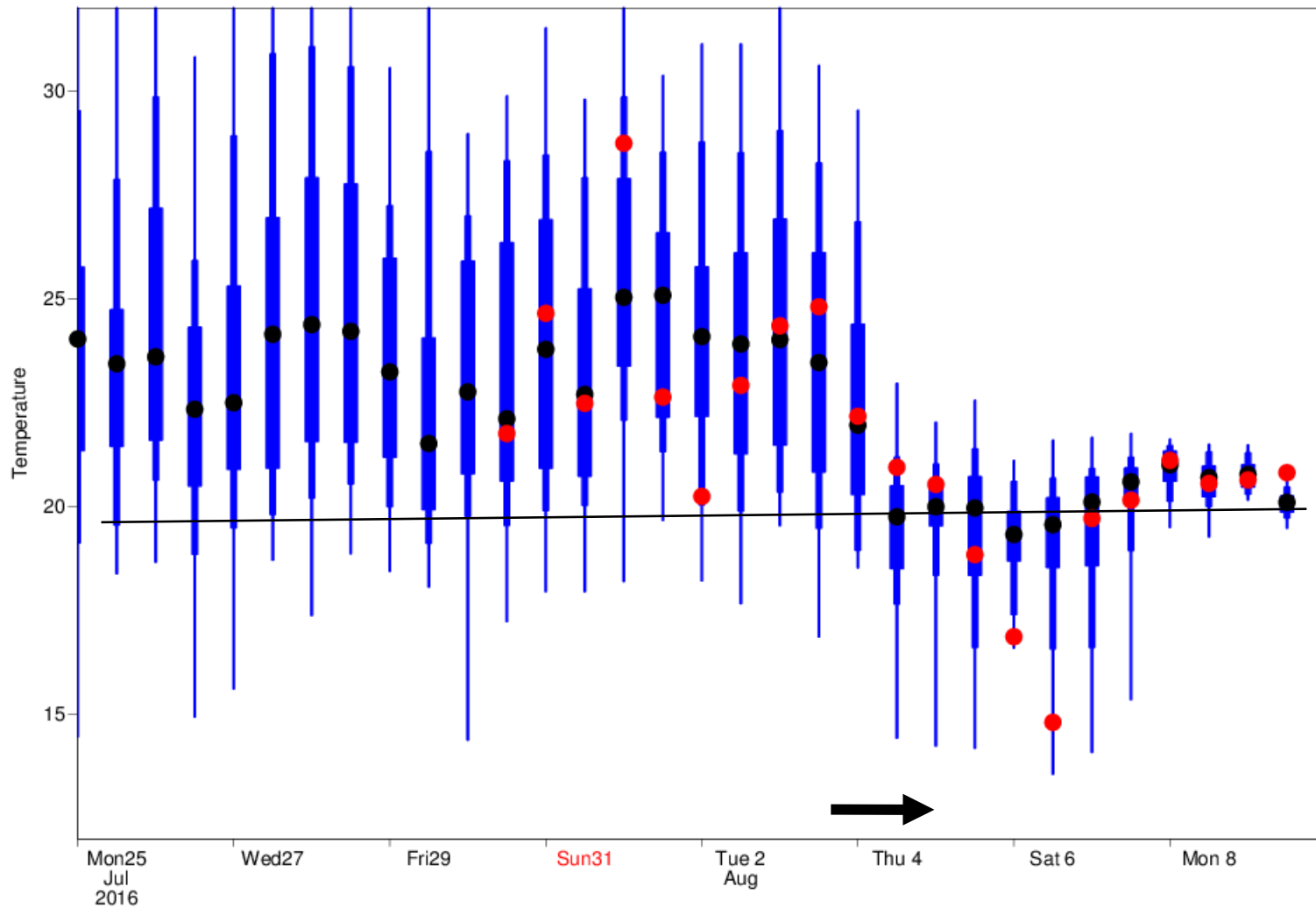
Total Precipitation (mm) - Ensemble distribution



Geopotential at 500 hPa (dam) - Ensemble distribution



# 2-metre temperature Paris 9 August 12z



From Linus 's weather discussion 2016-08-12

# Analysis and ECMWF ENS Forecasting System

2-metre Temperature anomaly

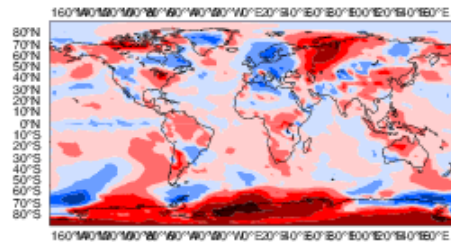
Verification period: 08-08-2016/TO/14-08-2016

ensemble size = 51 , climate size = 660

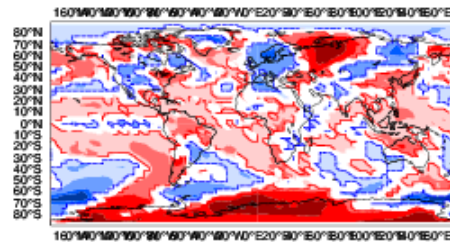
Shaded areas significant at 10% level, Contours at 1% level



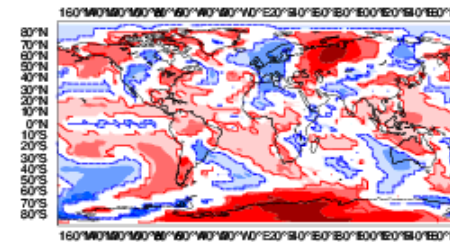
### ANALYSIS



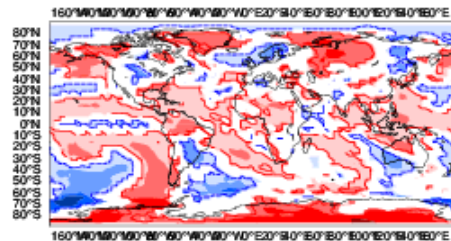
### FORECAST 08-08-2016: DAY 1-7



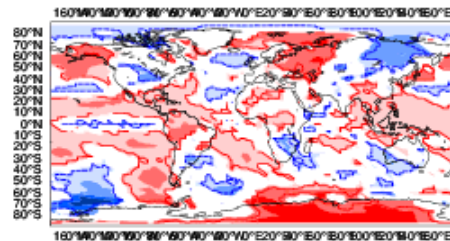
### FORECAST 04-08-2016: DAY 5-11



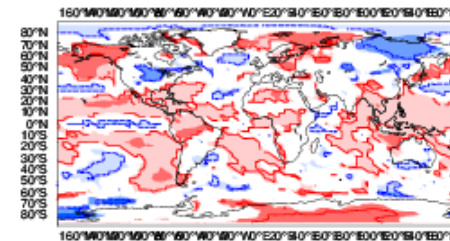
### FORECAST 01-08-2016: DAY 8-14



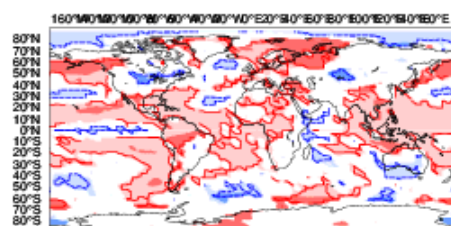
### FORECAST 28-07-2016: DAY 12-18



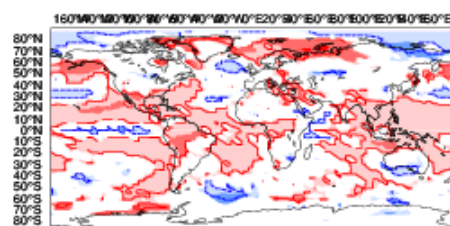
### FORECAST 25-07-2016: DAY 15-21



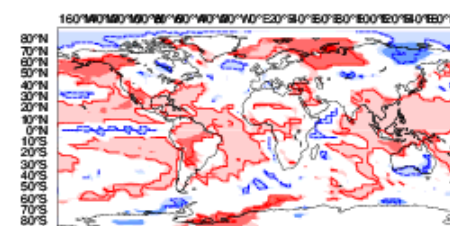
### FORECAST 21-07-2016: DAY 19-25



### FORECAST 18-07-2016: DAY 22-28



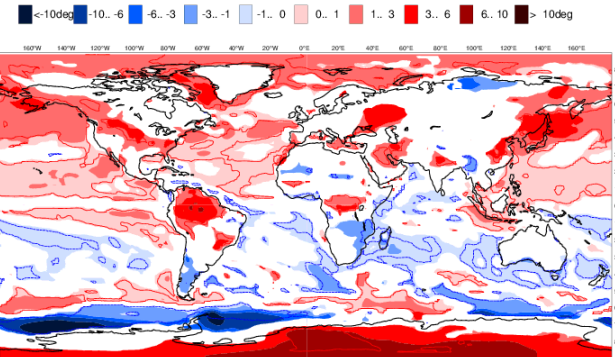
### FORECAST 14-07-2016: DAY 26-32



# S2S products:

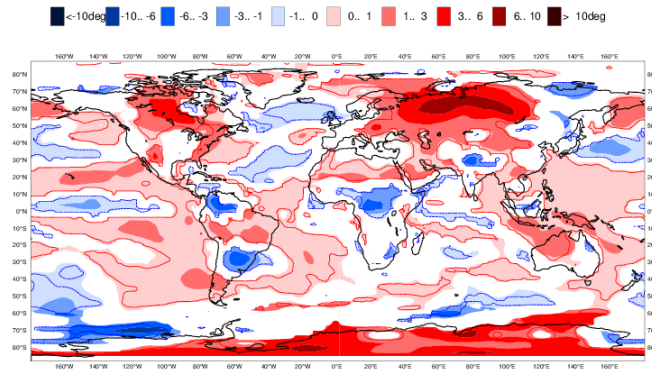
Ens. Forecasting System: cma  
2-meter Temperature anomaly  
Forecast start reference is 28-07-2016  
ensemble size = 4 ,climate size = 48

Day 12-18  
08-08-2016 TO 14-08-2016  
Shaded areas significant at 10% level  
Contours at 1% level



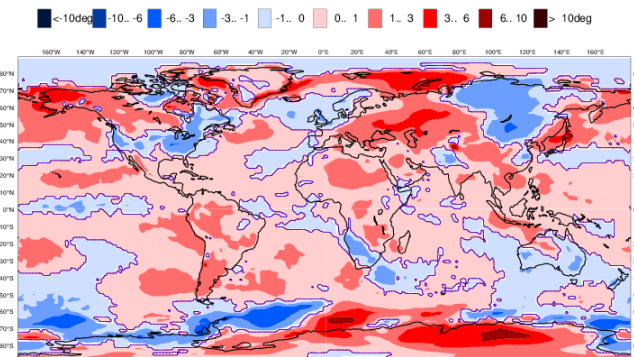
Ens. Forecasting System: cawc  
2-meter Temperature anomaly  
Forecast start reference is 28-07-2016  
ensemble size = 33 ,climate size = 396

Day 12-18  
08-08-2016 TO 14-08-2016  
Shaded areas significant at 10% level  
Contours at 1% level



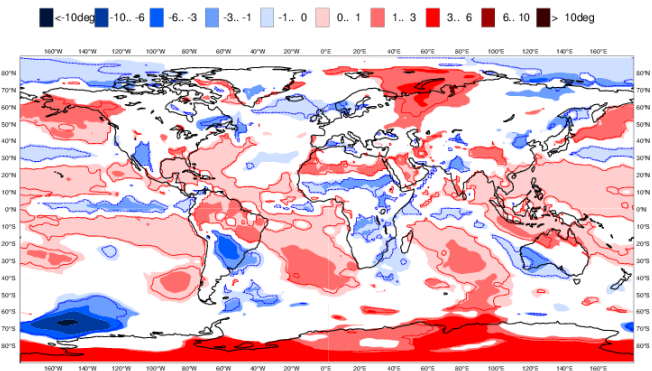
Ens. Forecasting System: ukmo  
2-meter Temperature anomaly  
Forecast start reference is 28-07-2016  
ensemble size = 4 ,climate size = 33

Day 12-18  
08-08-2016 TO 14-08-2016  
Shaded areas significant at 10% level  
Contours at 1% level



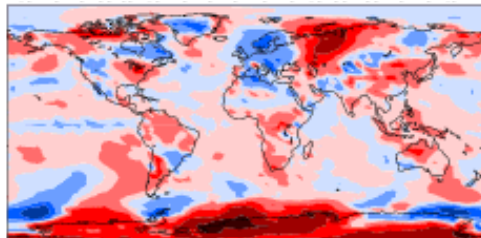
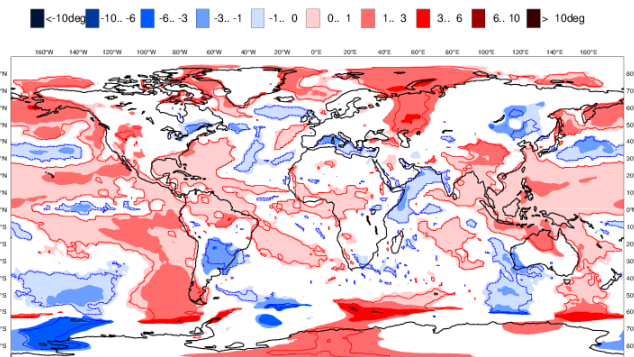
Ens. Forecasting System: ncep  
2-meter Temperature anomaly  
Forecast start reference is 28-07-2016  
ensemble size = 16 ,climate size = 48

Day 12-18  
08-08-2016 TO 14-08-2016  
Shaded areas significant at 10% level  
Contours at 1% level

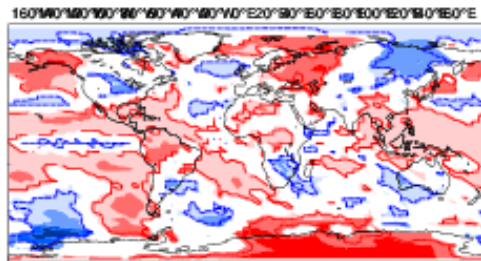


Ens. Forecasting System: jma  
2-meter Temperature anomaly  
Forecast start reference is 28-07-2016  
ensemble size = 25 ,climate size = 60

Day 12-18  
08-08-2016 TO 14-08-2016  
Shaded areas significant at 10% level  
Contours at 1% level



FORECAST 28-07-2016: DAY 12-18



# Bridging the gap between seasonal forecasting and NWP

## Sources of predictability for the extended forecasts :

- **Land Surface conditions: Snow cover, Soil Moisture**
- **Ocean conditions: Sea surface temperature, Sea ice**
- **Stratospheric Initial conditions**
- **The Madden-Julian oscillation**
- **Atmospheric dynamical processes (Rossby wave propagations, weather regimes...)**



# Cold spell over Europe Nov-Dec 2012

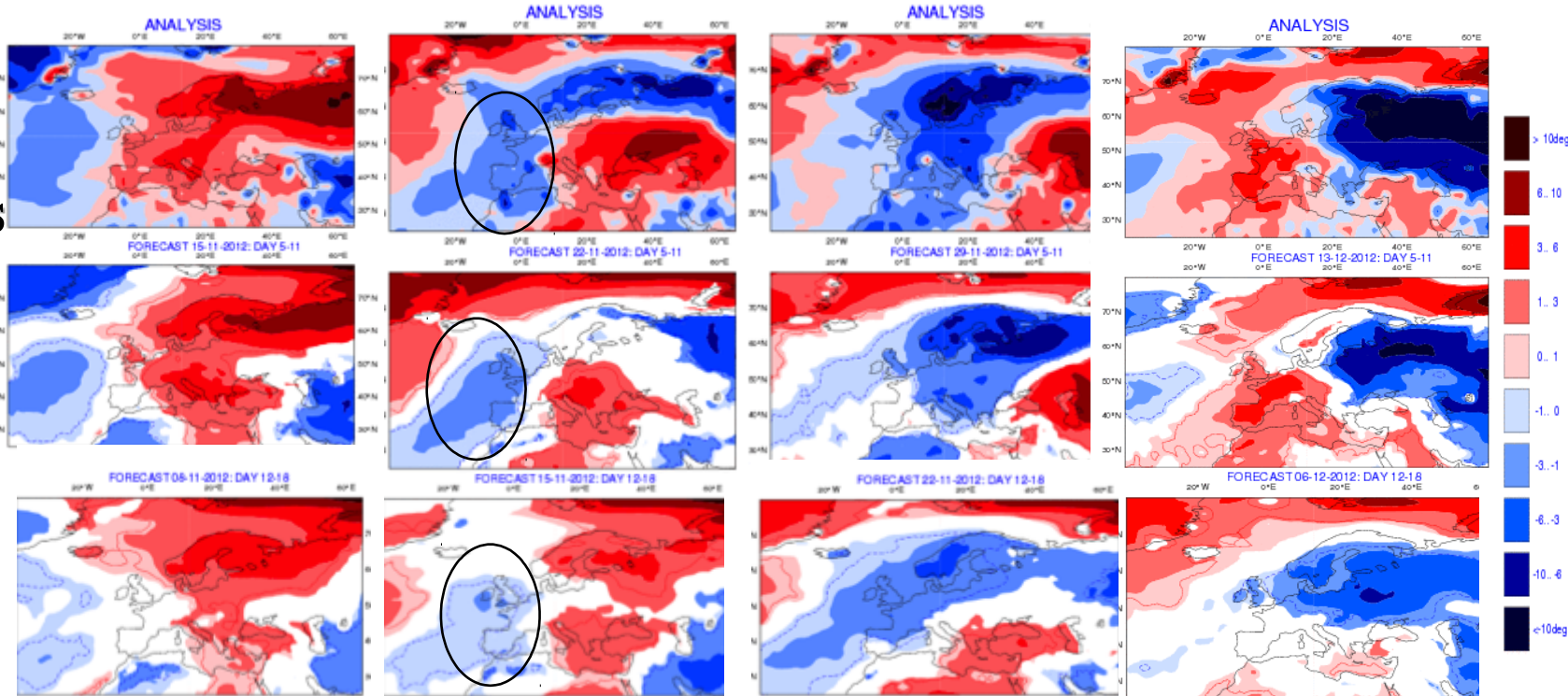
19 -25 /11/2012

26 /11 -2/12 2012

3-9/ 12 /2012

17 -12 12 2012

analysis



5-11d

12-18 d

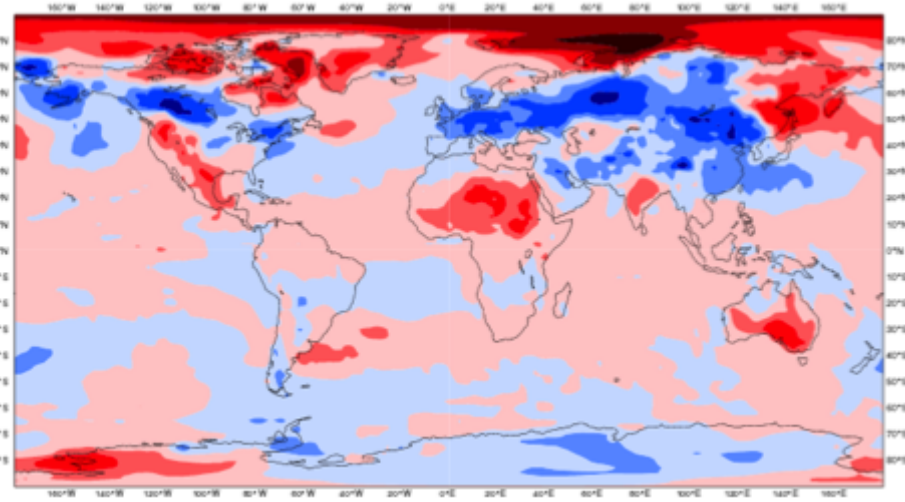
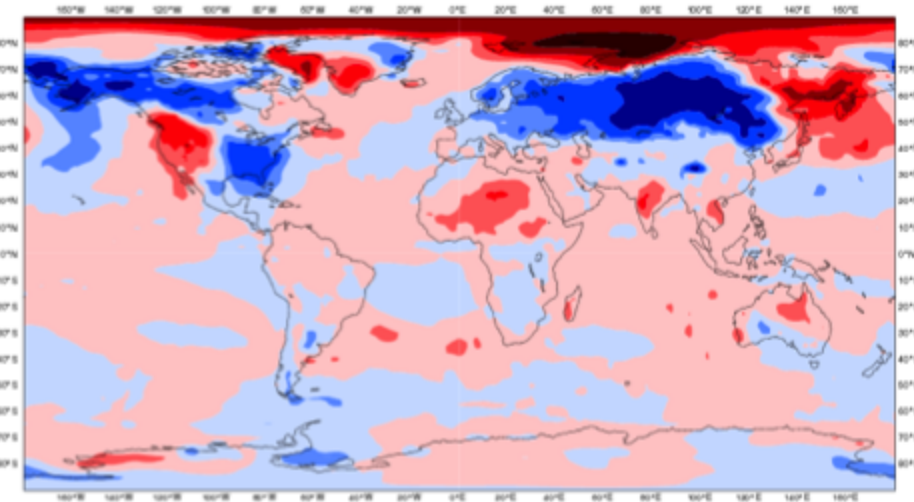
# Cold Weather over Europe SSW Index - Forecast starting on 22/11/2012

Strong SSW

Weak SSW

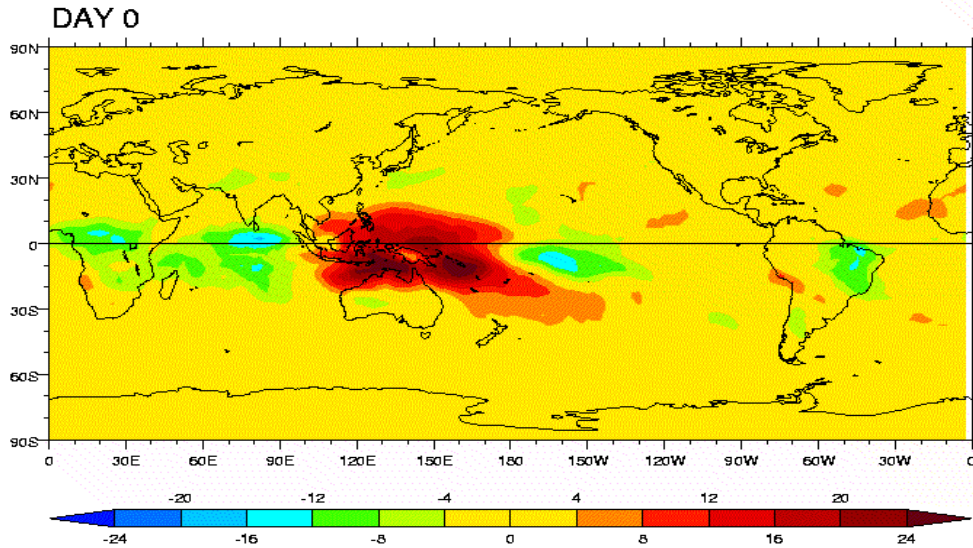
■ P0N 400 ■ 6.4 ■ 4.2 ■ 2.1 ■ -1.0 ■ 0.1 ■ 1.2 ■ 2.4 ■ 4.8 ■ P0N 800

■ P0N 400 ■ 6.4 ■ 4.2 ■ 2.1 ■ -1.0 ■ 0.1 ■ 1.2 ■ 2.4 ■ 4.8 ■ P0N 800

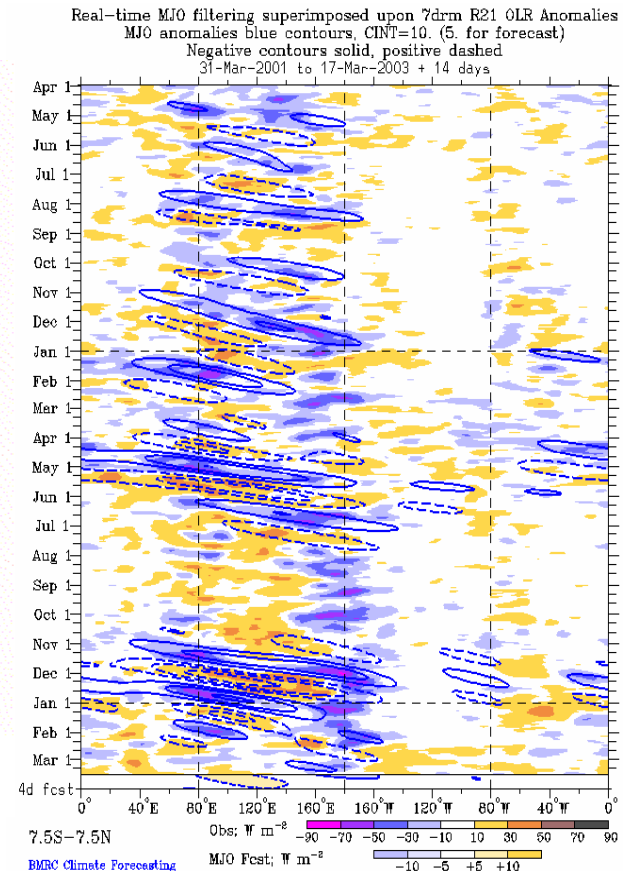


# The Madden Julian Oscillation (MJO)

## MJO life cycle



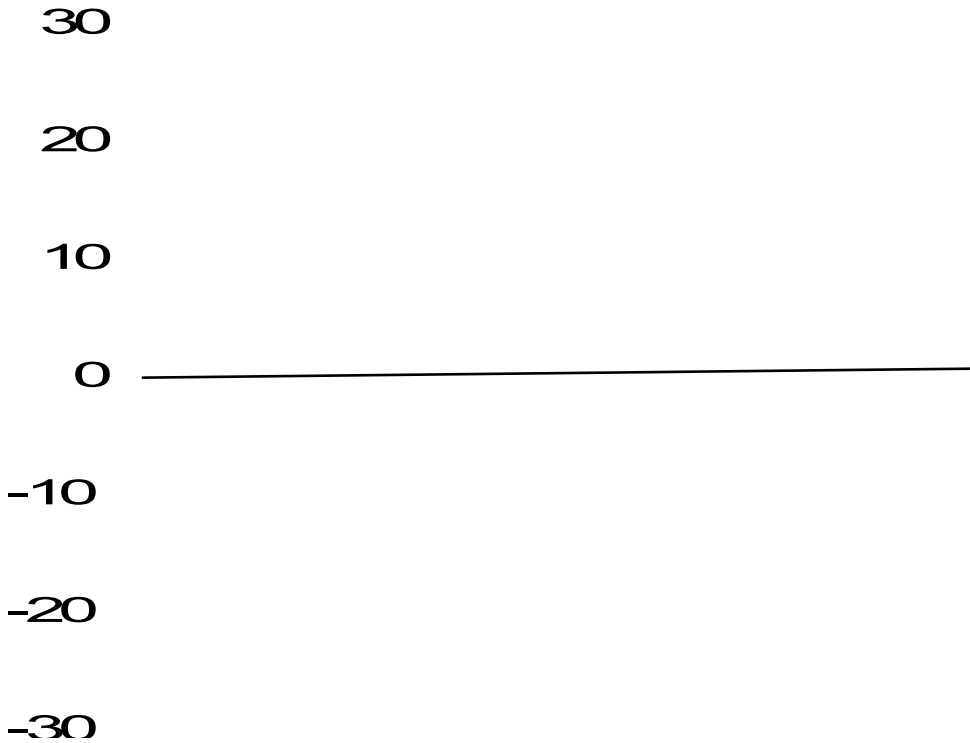
(From NASA)



From

<http://www.bom.gov.au/bmrc/clf>

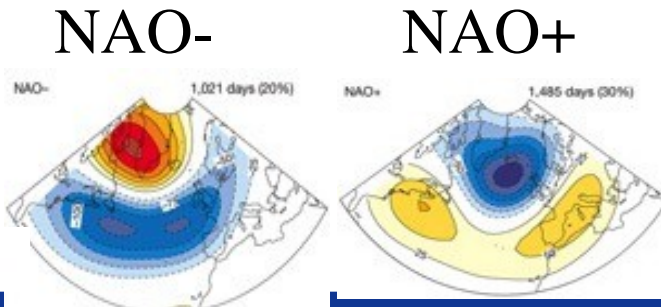
# MJO impact on European weather:





The MJO impact is the strongest about 10 days after the MJO is in the phase with:

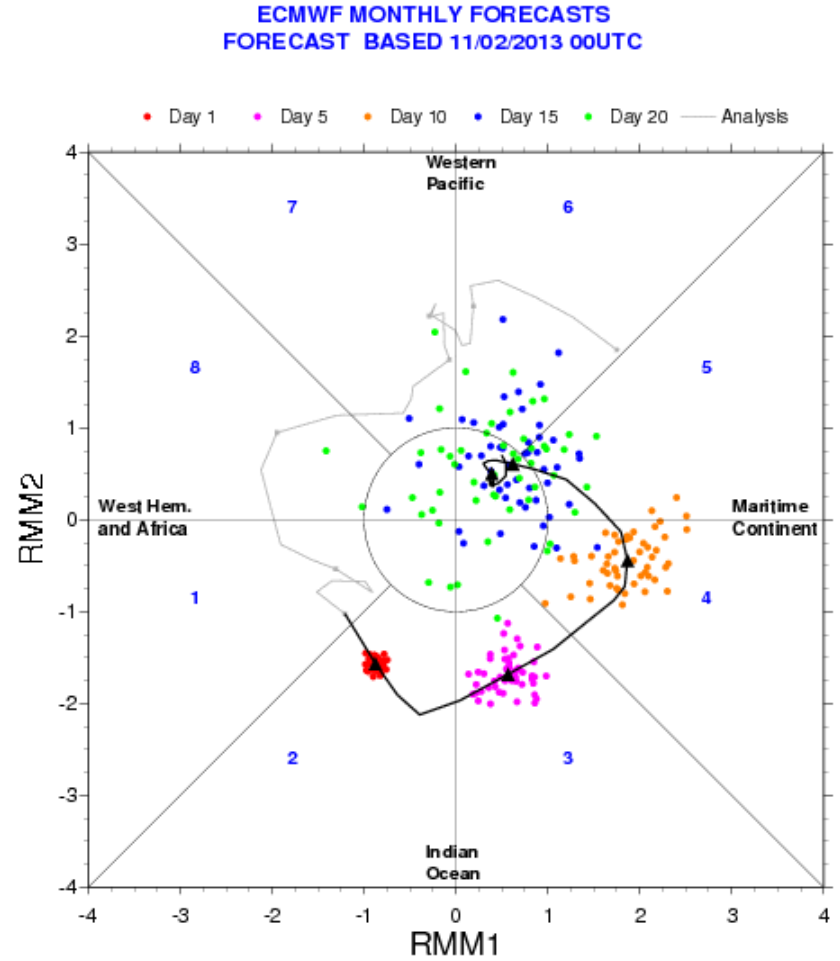
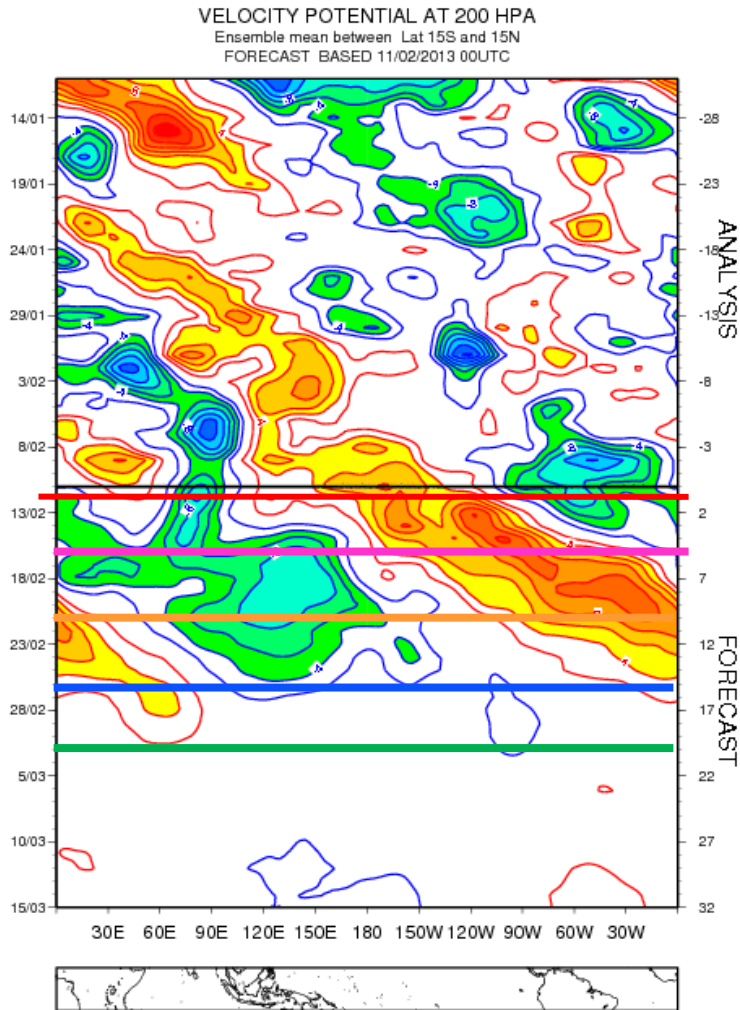
- suppressed convection over Indian Ocean
- enhanced convection over Western Pacific are conducive to negative NAO

Cassou (2008) Lin et al (2008)



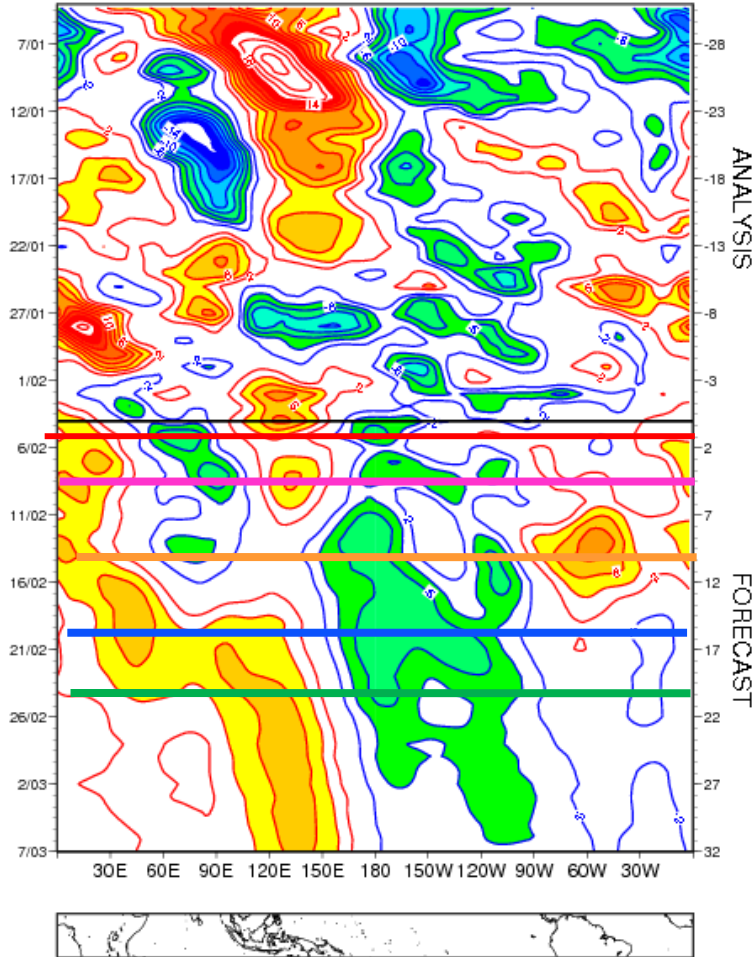
-  Conv. Over Indian Ocean +10 days
-  Conv. Over Western Pacific+10 days

# MJO forecast:

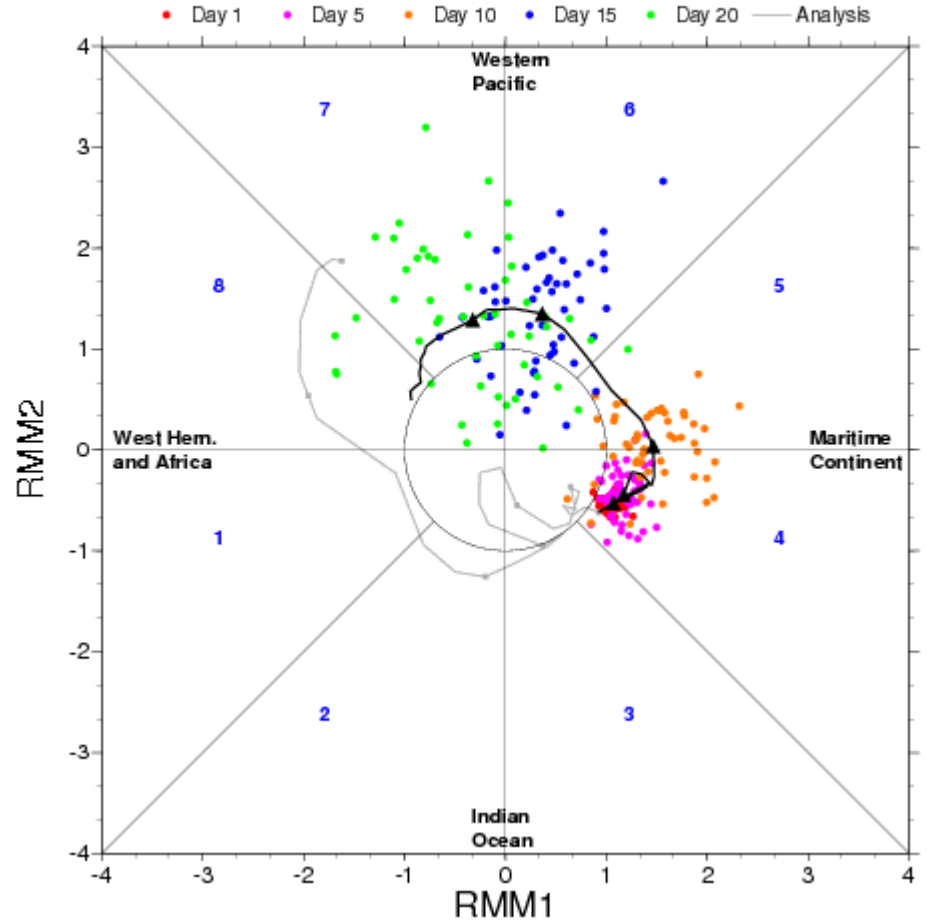


# MJO forecast:

VELOCITY POTENTIAL AT 200 HPA  
Ensemble mean between Lat. 15S and 15N  
FORECAST BASED 04/02/2016 00UTC

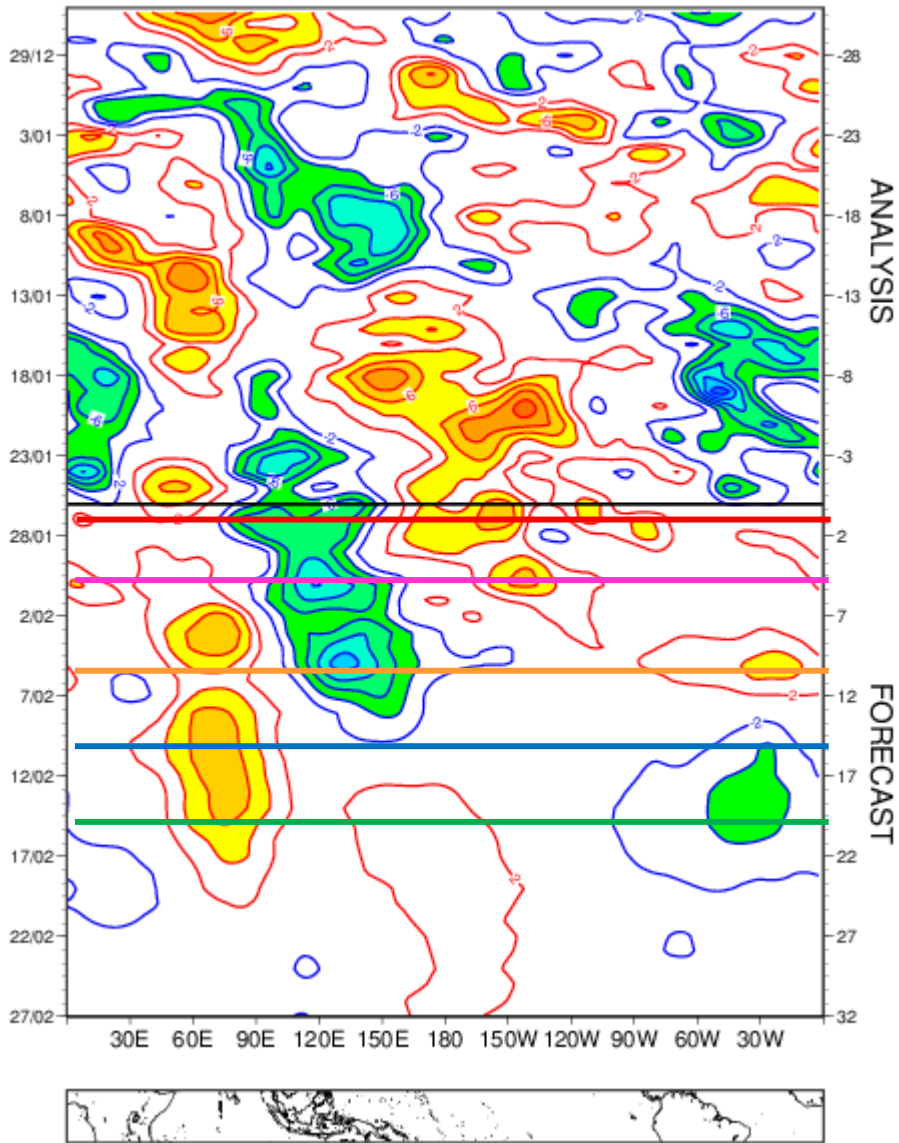


ECMWF MONTHLY FORECASTS  
FORECAST BASED 04/02/2016 00UTC

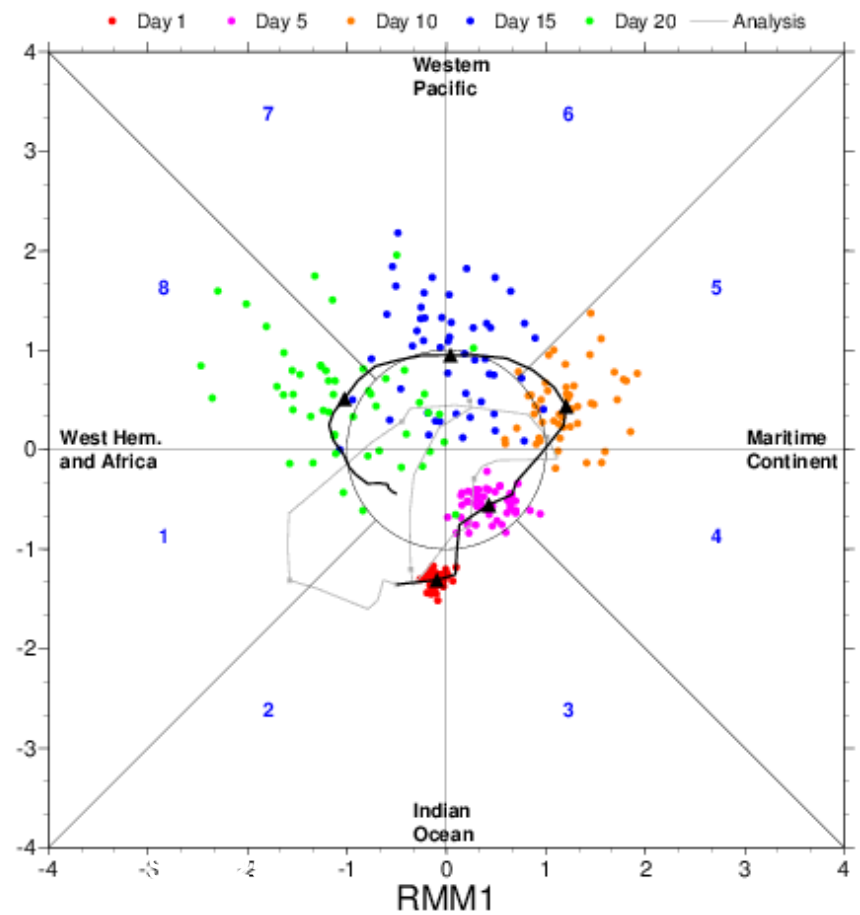


### VELOCITY POTENTIAL AT 200 HPA

Ensemble mean between Lat 15S and 15N  
FORECAST BASED 26/01/2017 00UTC

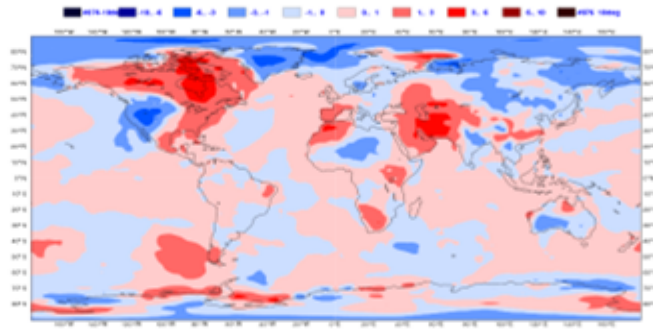
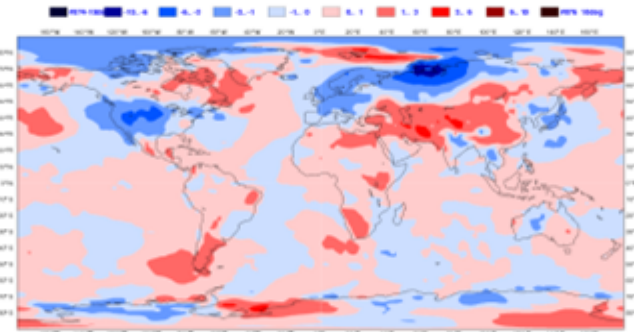
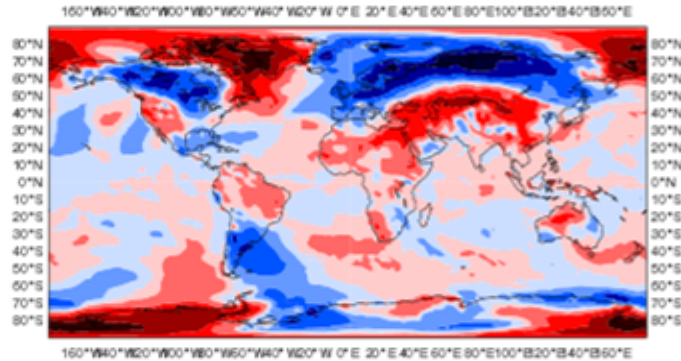
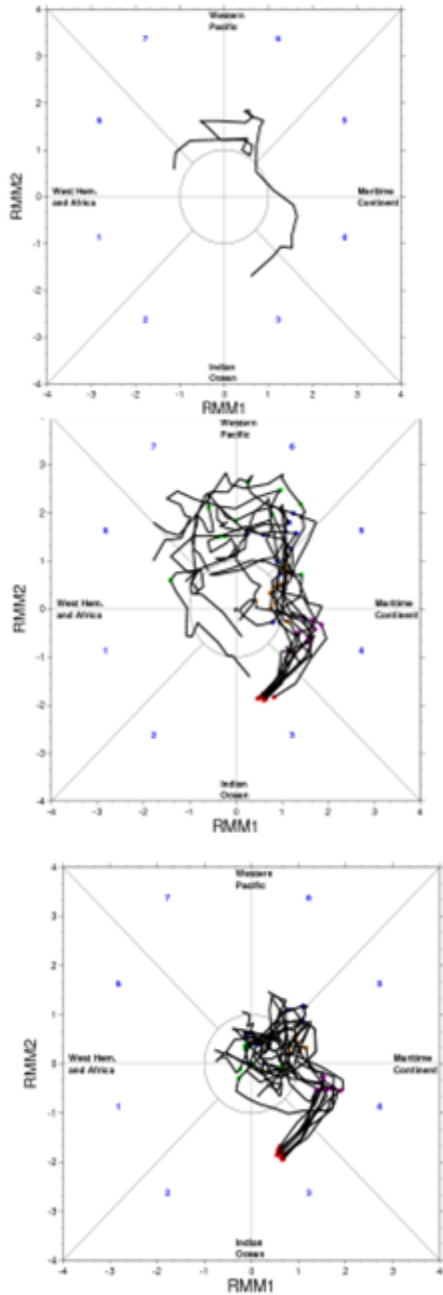


### ECMWF MONTHLY FORECASTS FORECAST BASED 26/01/2017 00UTC



# Cold March 2013 – 14 Feb 2013 -Day 26-32

## Analysis

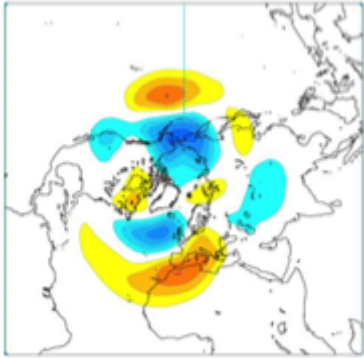


**10 best  
MJO  
forecasts**

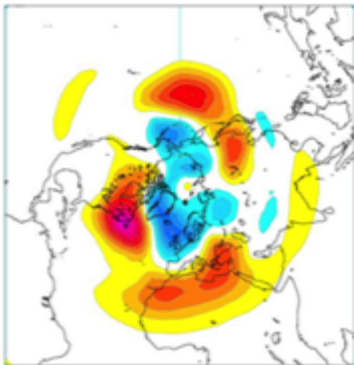
**10 worse  
MJO  
forecasts**



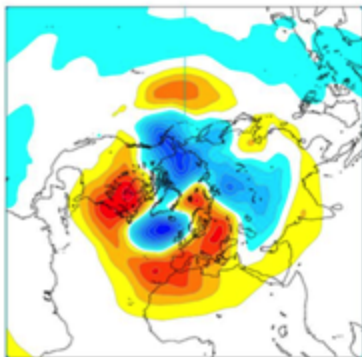
2002 MOFC hindcasts



2013 MOFC hindcasts



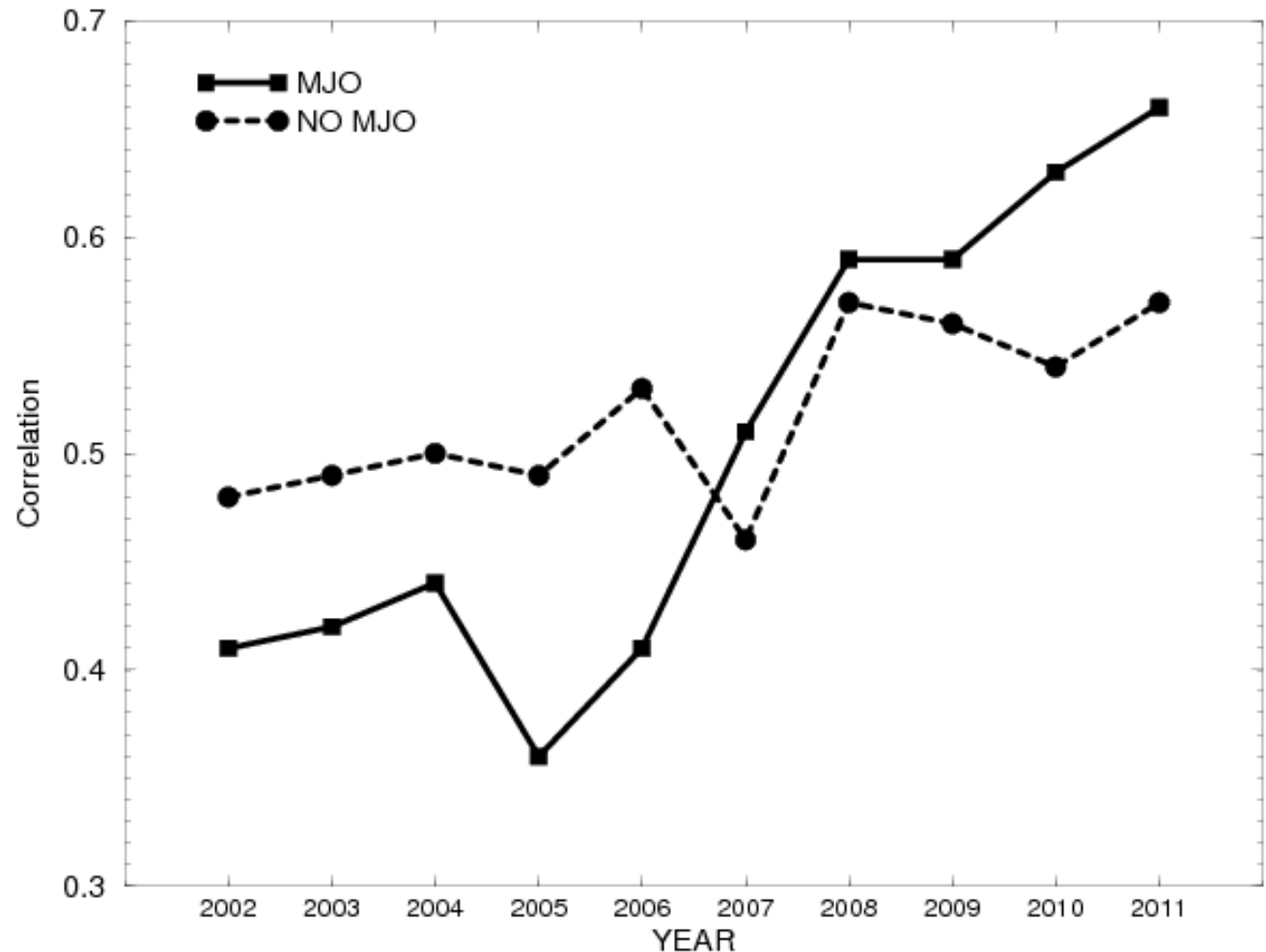
ERA Interim



# MJO Teleconnections

## Evolution of NAO skill scores day 19-25

NAO index is computed as projection onto a reference pattern

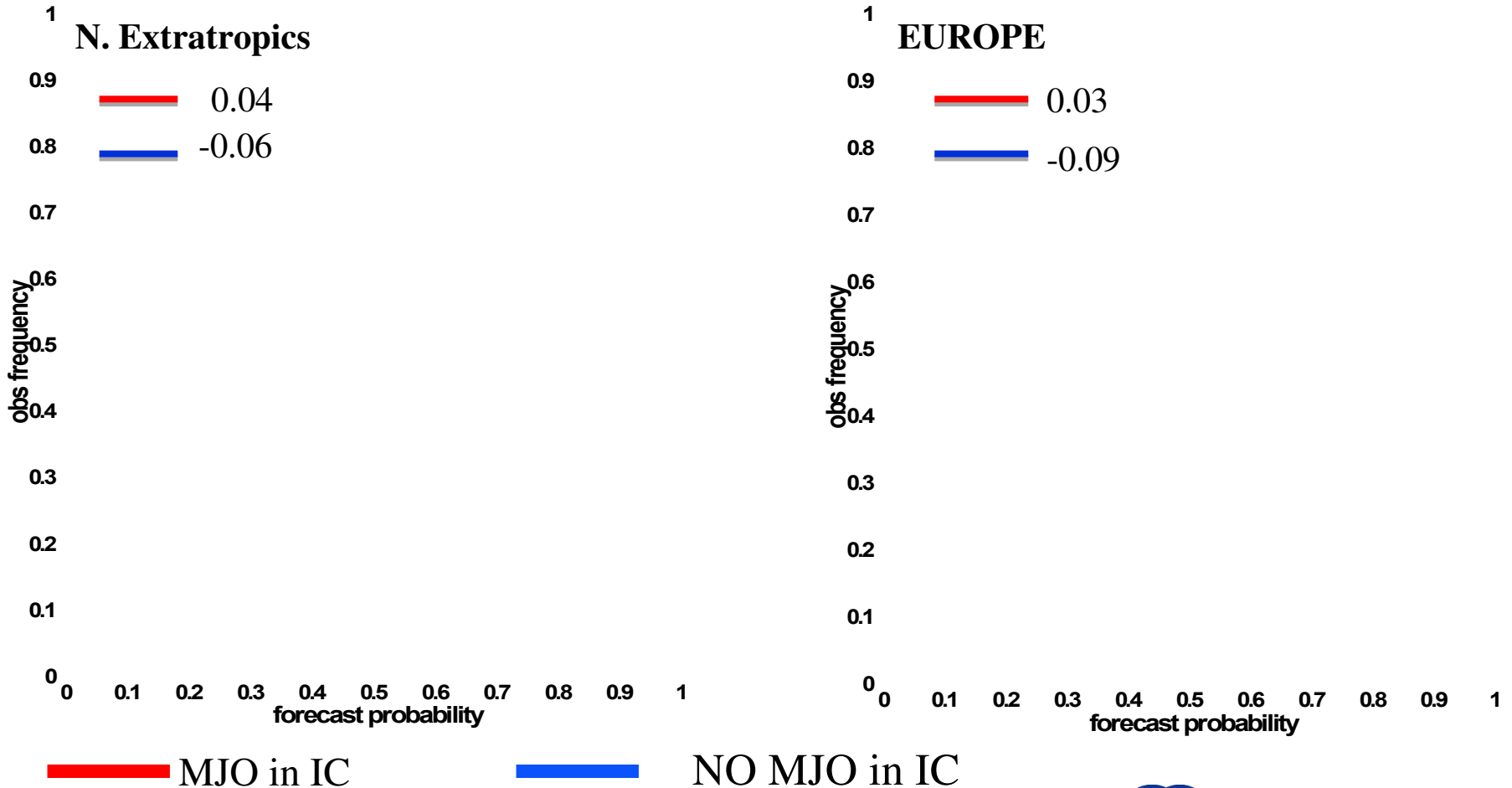


# Probabilistic skill scores – NDJFMA 1989-2008

Reliability Diagram

Probability of 2-m temperature in the upper tercile

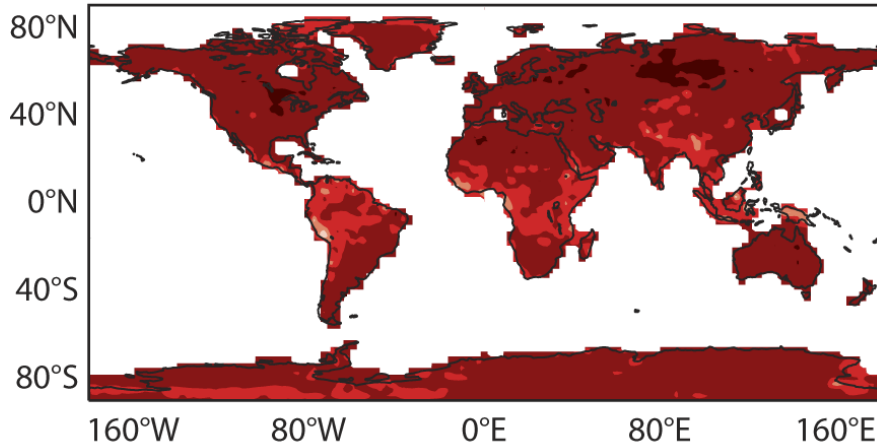
Day 19-25



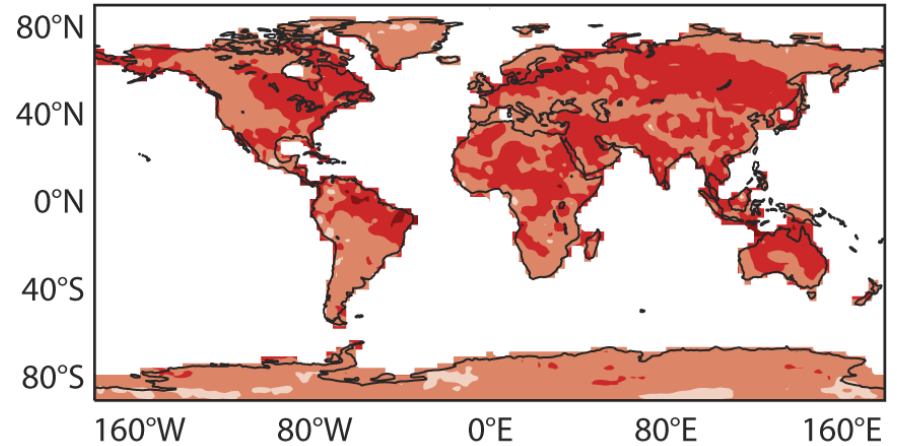
# ROC for 2mt in the upper tercile

*since Oct 2004*

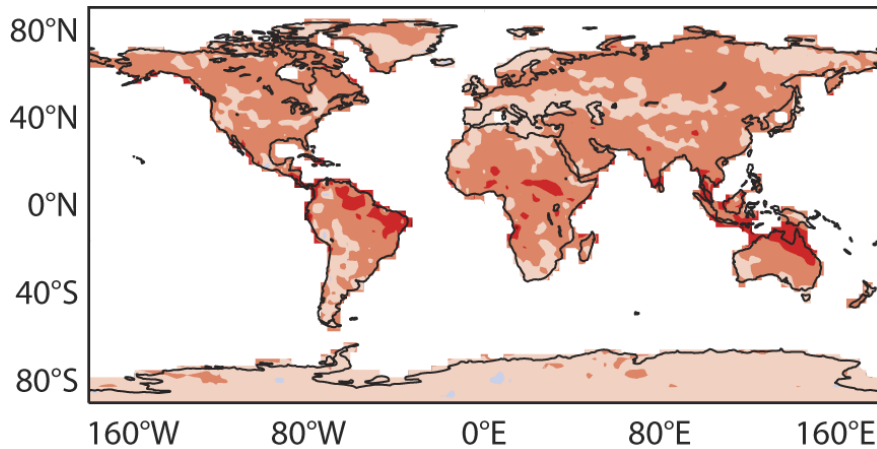
**a** Day 5–11



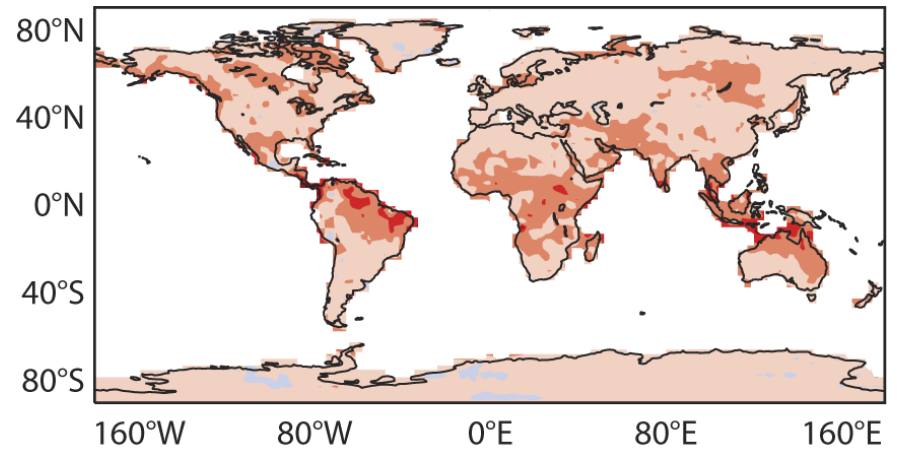
**b** Day 12–18



**c** Day 19–25



**d** Day 25–32

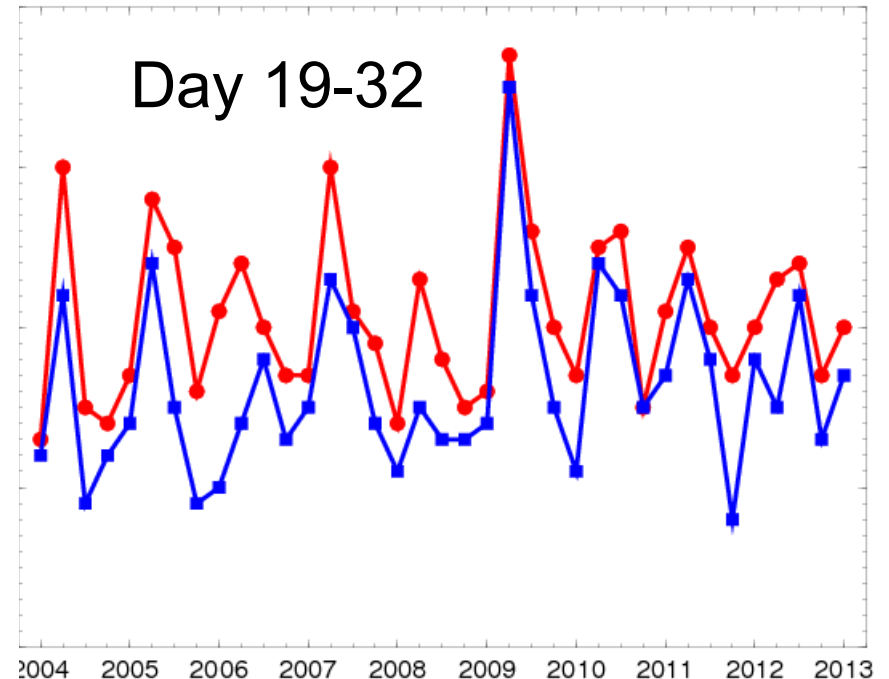
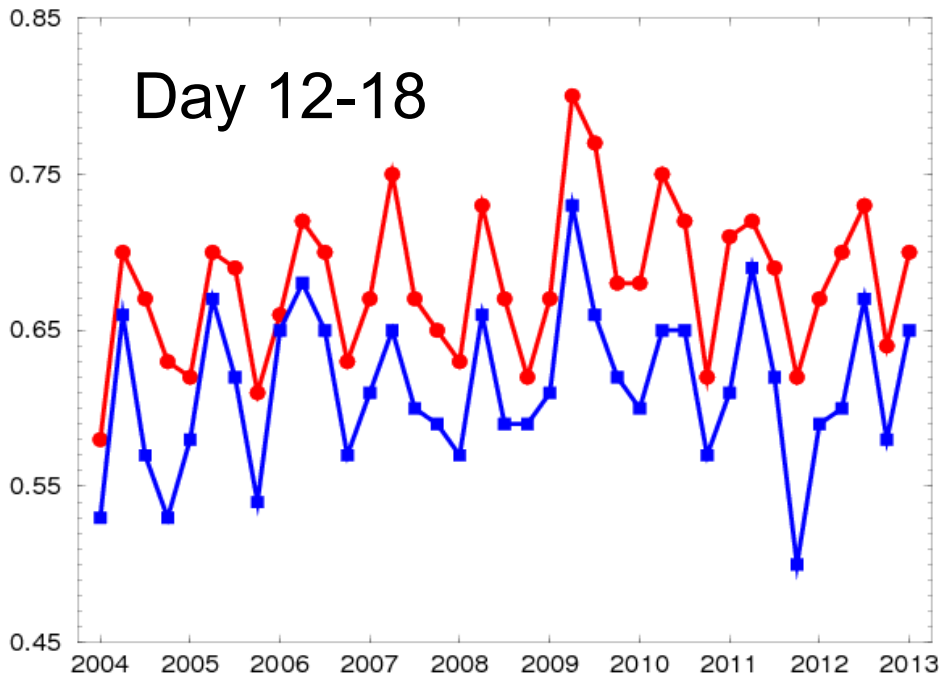


# Monthly Forecast: Northern extratropics

ROC score: 2-metre temperature in the upper tercile

— Monthly Forecast  
— Persistence of day 5-11

— Monthly Forecast  
— Persistence of day 5-18

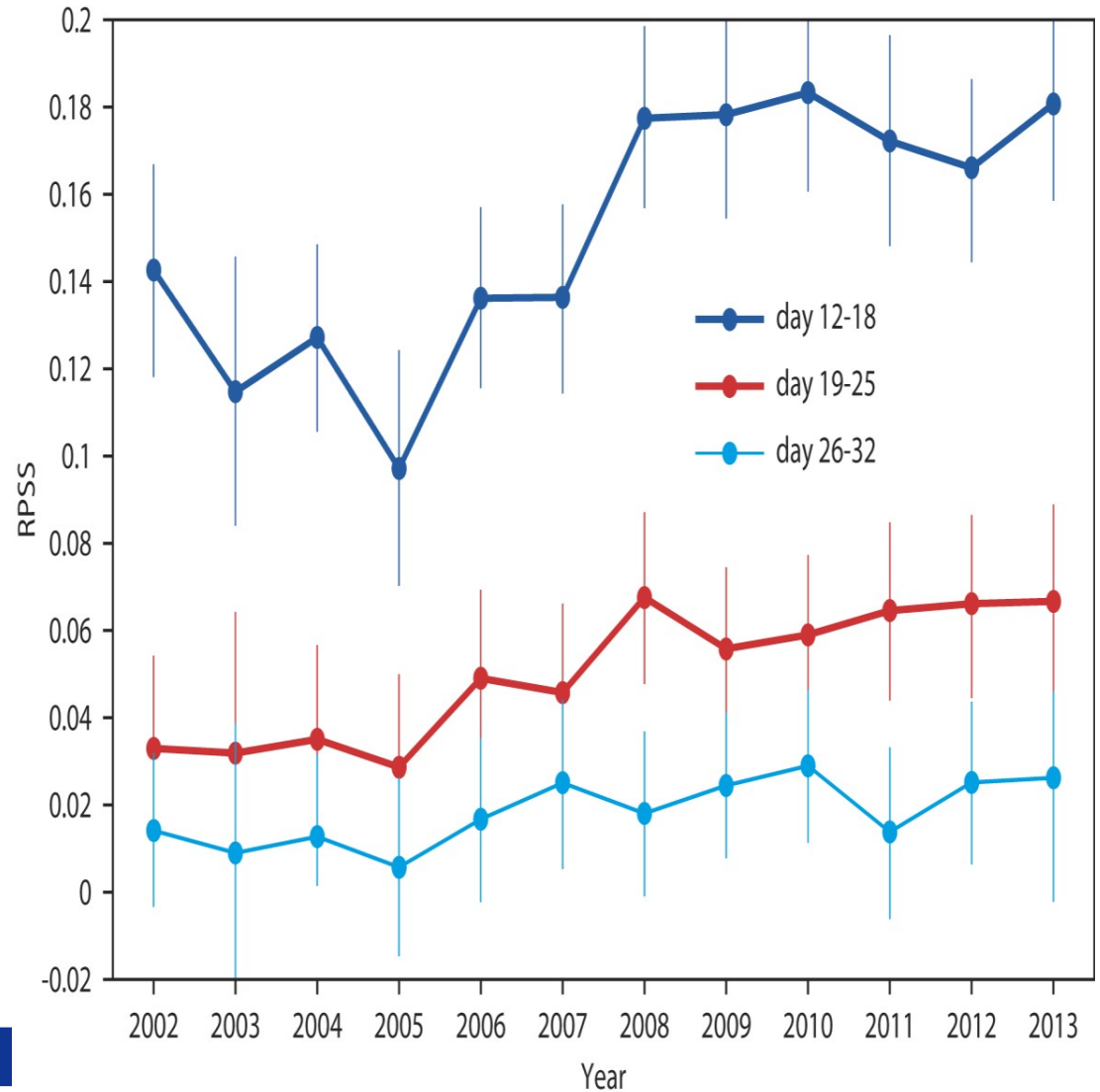


# Evolution of skill scores based on the re-forecasts

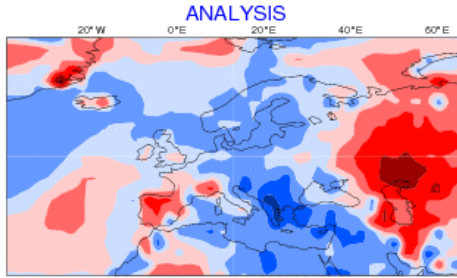
## RPSS – Probability of 2mt in upper tercile NDJFM

All the re-forecasts produced since 2002 have the period 1995-2001 in common.

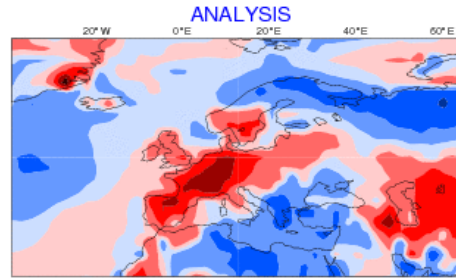
RPSS scores have been computed for all the re-forecasts produced between April of a given year and March of the following year and covering the period 1995-2001 (once a week, 5-member ensemble).



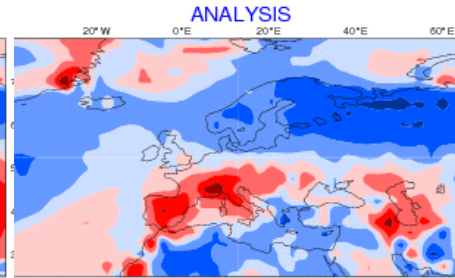
# Heat wave over Central-southern Europe: 2mt weekly mean anomalies



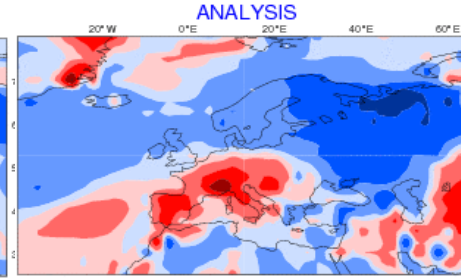
22-28 Jun



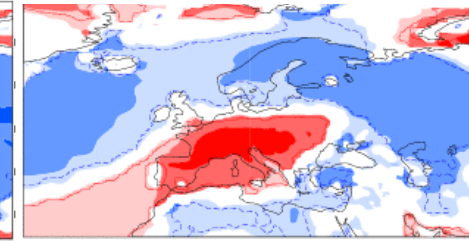
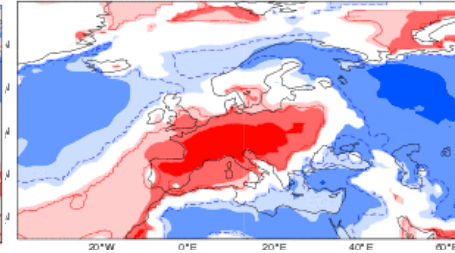
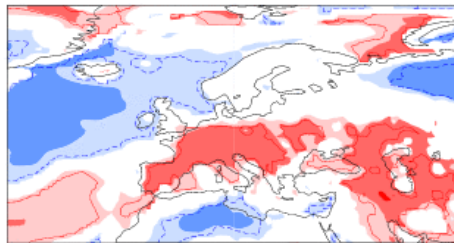
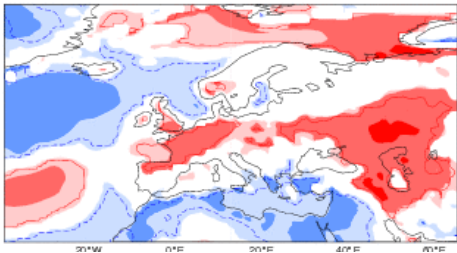
29-5 Jul



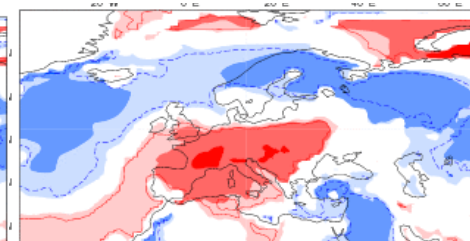
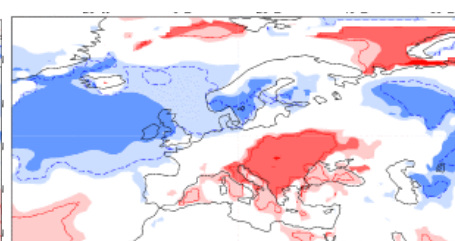
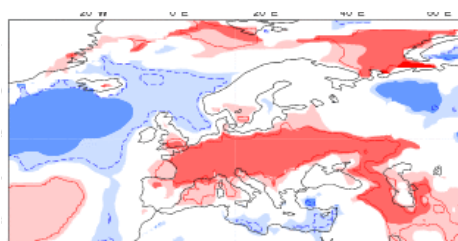
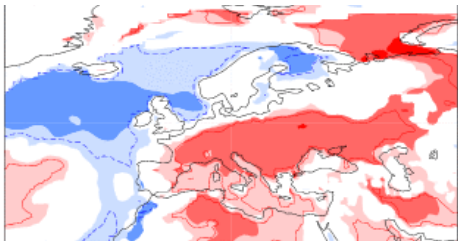
6-12 Jul



13-19 Jul

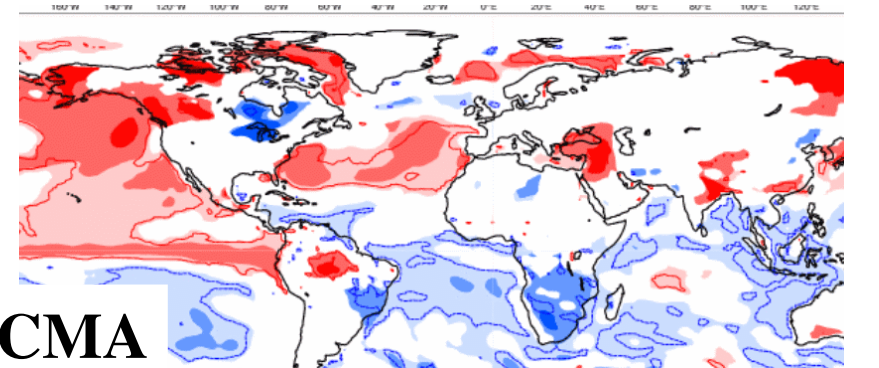
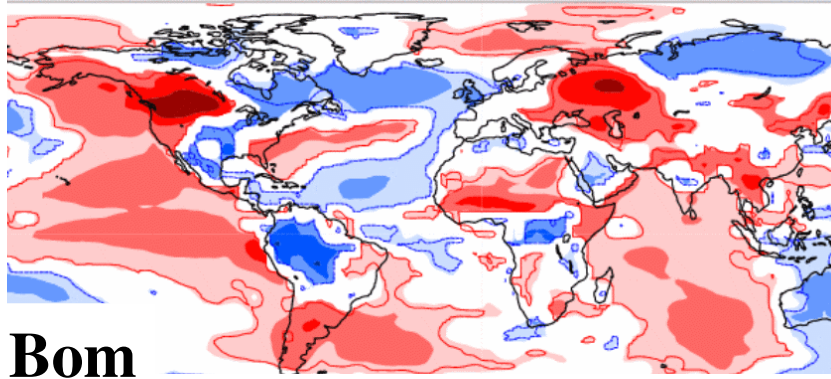
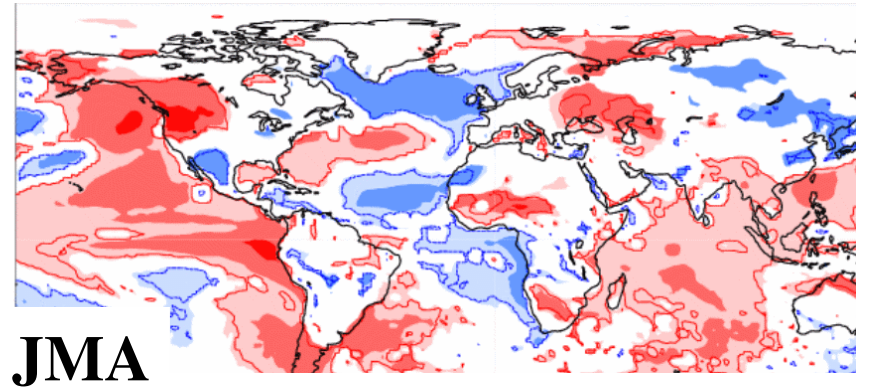
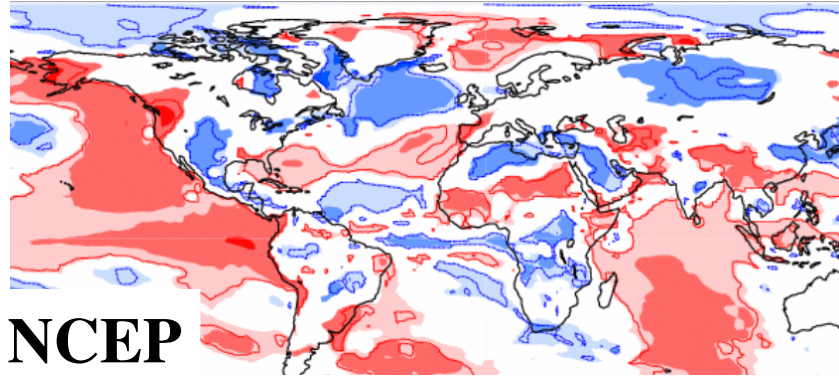
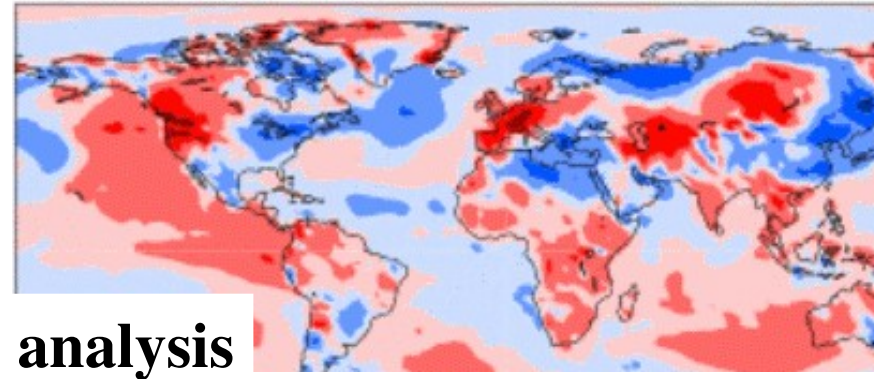
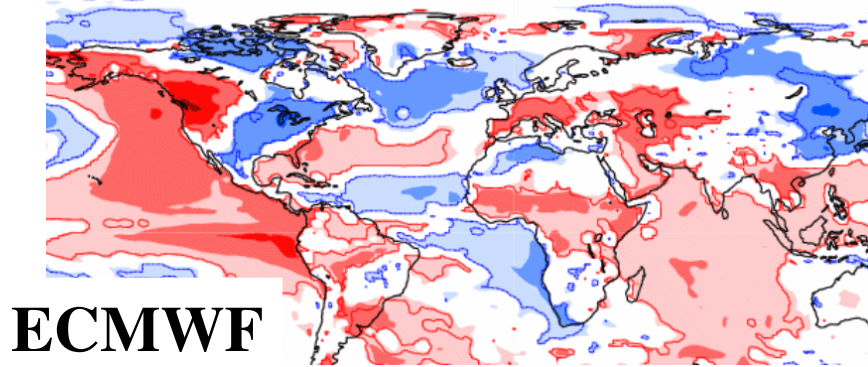


Forecasts: 12-18 days



Forecasts: 19-25 days

# S2S 2mt anomalies: days 12-18 - verifying 29-06 to 05-07 2015



## ***The Sub-seasonal to Seasonal (S2S) Prediction Project***

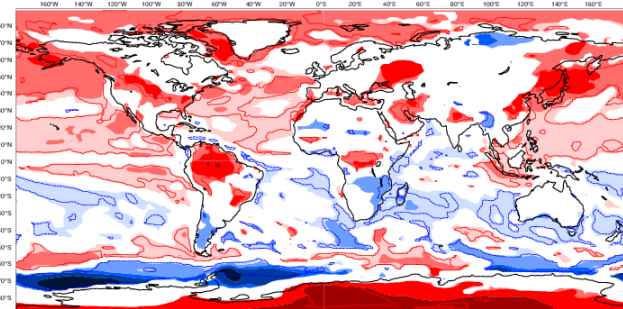
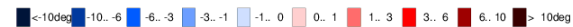
- improve forecast skill and understanding on the sub-seasonal to seasonal time scale
- promote its uptake by operational centres and exploitation by the applications community
- special emphasis on high-impact weather events
- S2S data is available to everyone  
<https://software.ecmwf.int/wiki/display/S2S/Models>



# S2S products:

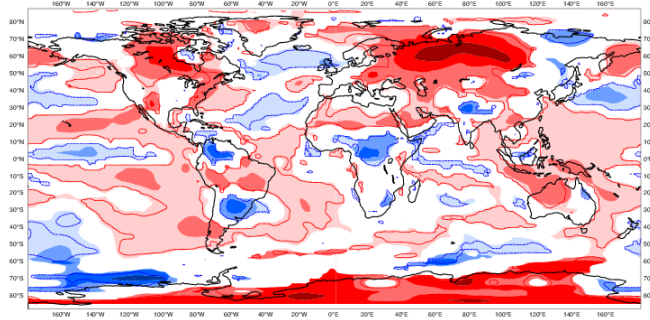
Ens. Forecasting System: cma  
2-meter Temperature anomaly  
Forecast start reference is 28-07-2016  
ensemble size = 4 ,climate size = 48

Day 12-18  
08-08-2016 TO 14-08-2016  
Shaded areas significant at 10% level  
Contours at 1% level



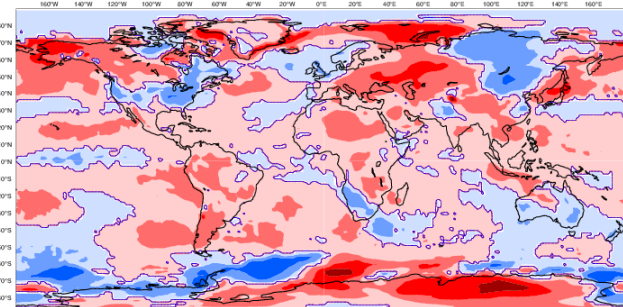
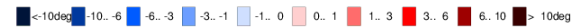
Ens. Forecasting System: cawc  
2-meter Temperature anomaly  
Forecast start reference is 28-07-2016  
ensemble size = 33 ,climate size = 396

Day 12-18  
08-08-2016 TO 14-08-2016  
Shaded areas significant at 10% level  
Contours at 1% level



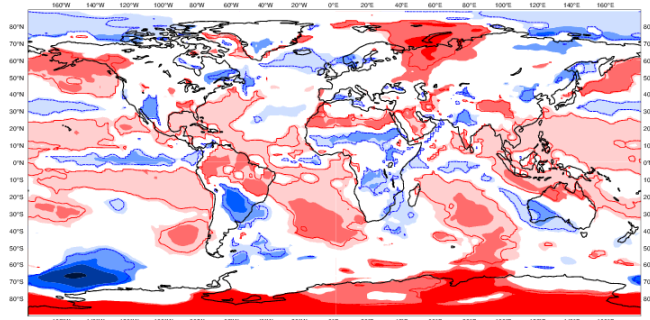
Ens. Forecasting System: ukmo  
2-meter Temperature anomaly  
Forecast start reference is 28-07-2016  
ensemble size = 4 ,climate size = 33

Day 12-18  
08-08-2016 TO 14-08-2016  
Shaded areas significant at 10% level  
Contours at 1% level



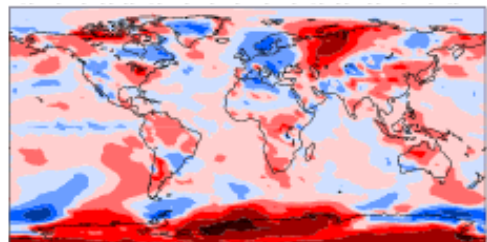
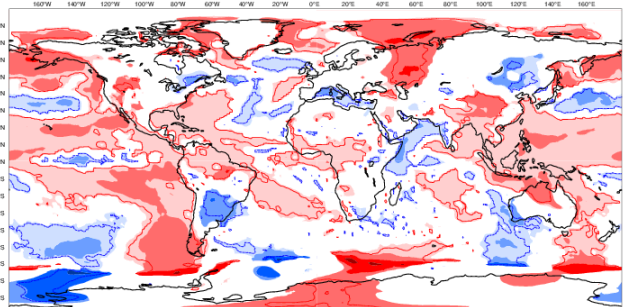
Ens. Forecasting System: ncep  
2-meter Temperature anomaly  
Forecast start reference is 28-07-2016  
ensemble size = 16 ,climate size = 48

Day 12-18  
08-08-2016 TO 14-08-2016  
Shaded areas significant at 10% level  
Contours at 1% level



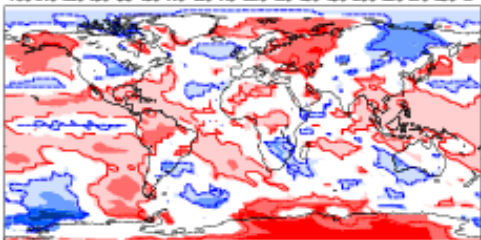
Ens. Forecasting System: jma  
2-meter Temperature anomaly  
Forecast start reference is 28-07-2016  
ensemble size = 25 ,climate size = 60

Day 12-18  
08-08-2016 TO 14-08-2016  
Shaded areas significant at 10% level  
Contours at 1% level



FORECAST 28-07-2016: DAY 12-18

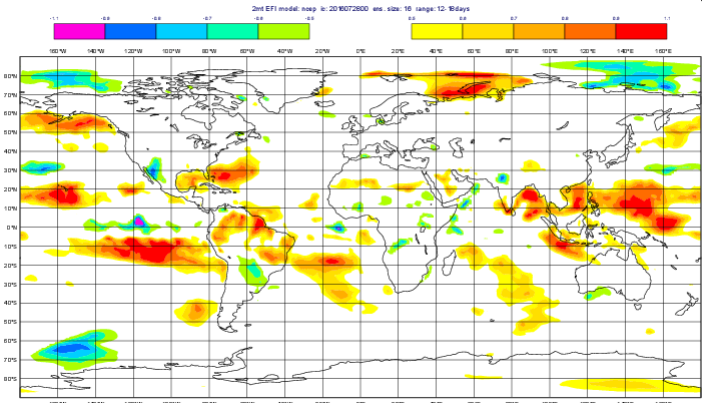
160°W 140°W 120°W 100°W 80°W 60°W 40°W 20°W 0°E 20°E 40°E 60°E 80°E 100°E 120°E 140°E 160°E



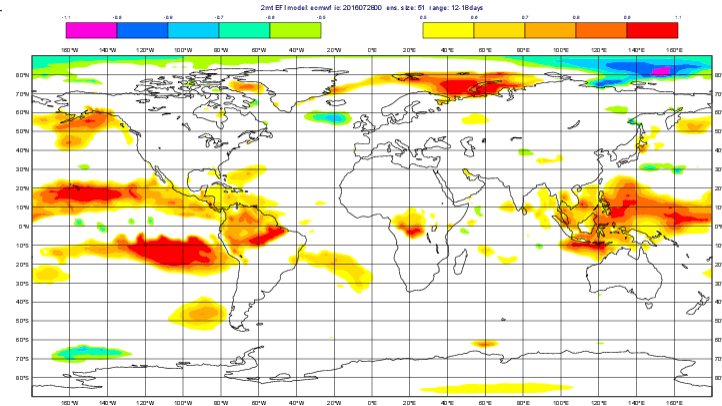
# S2S products: 2m temp EFI forecast range:12-18days verifying 8-14 August 2016

3 weeks of delay

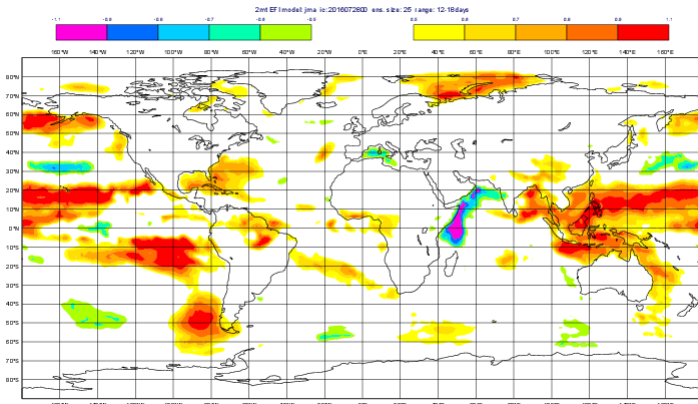
Ncep



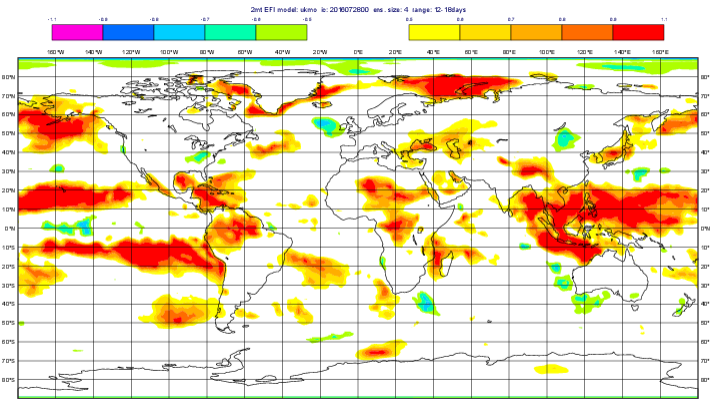
Ecmwf



Jma

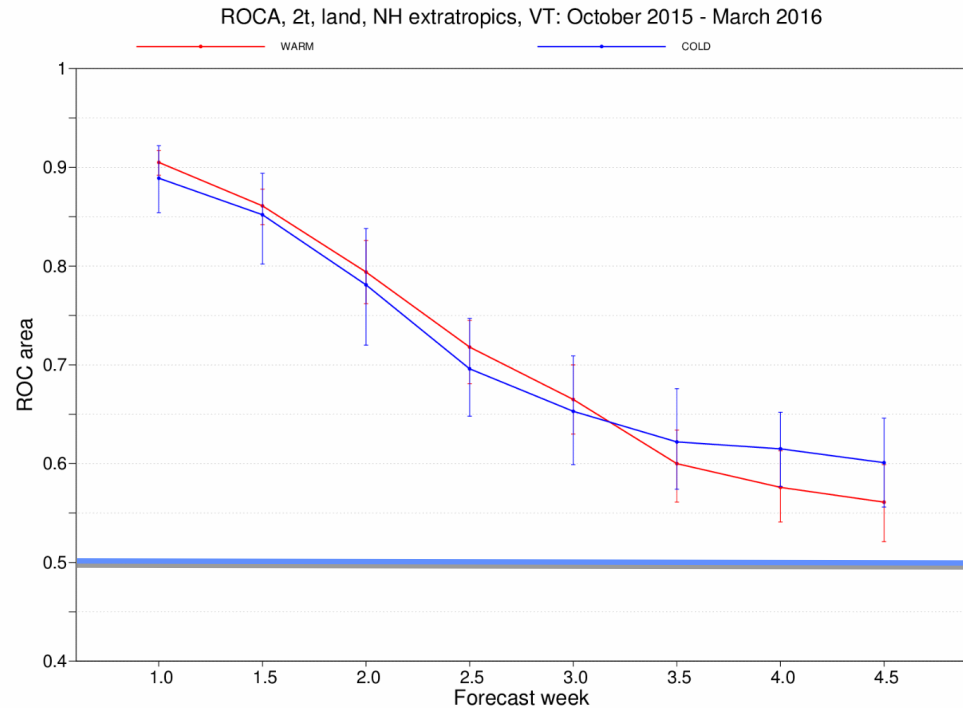


Ukmo



# EFI skill assessment

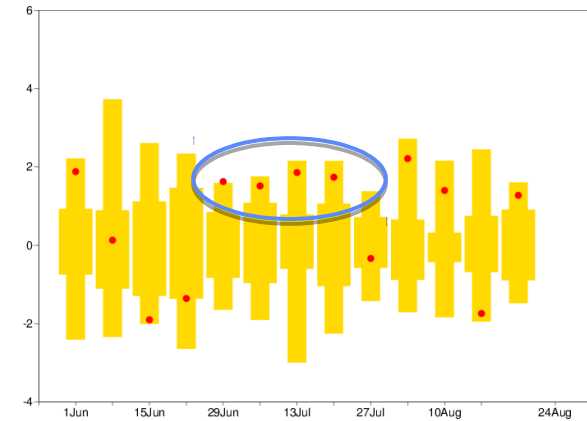
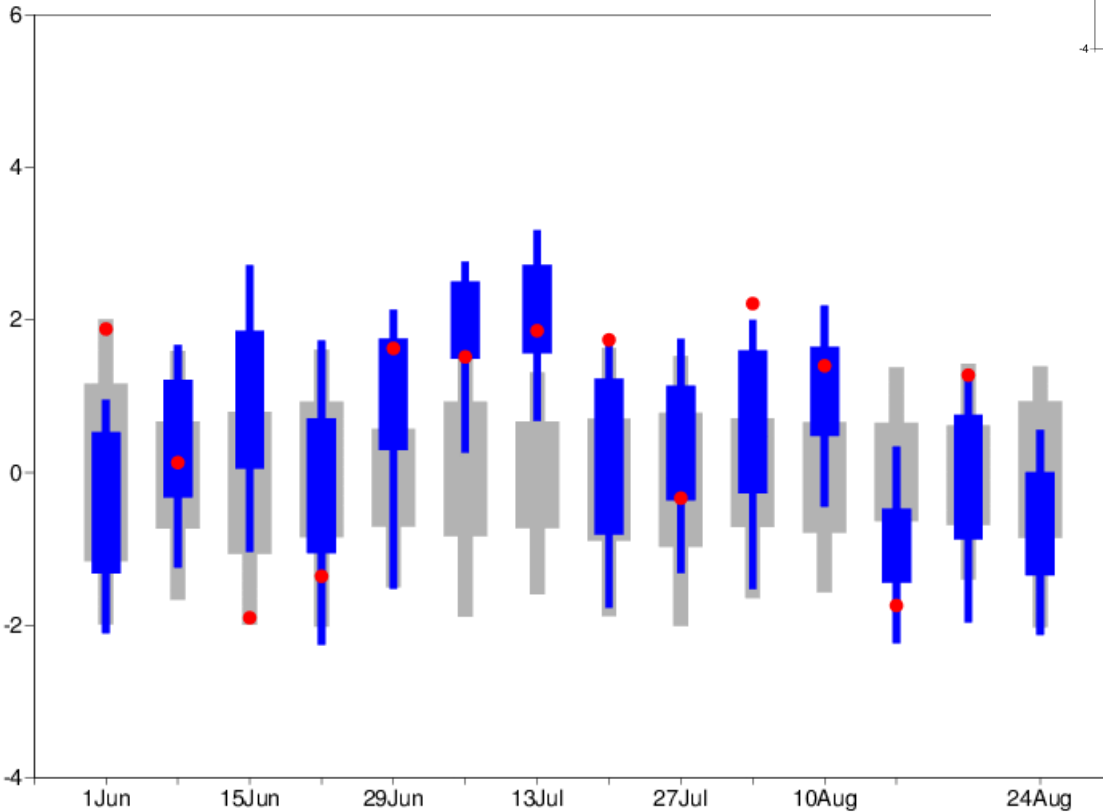
## Preliminary results based on ECMWF system:



# Conclusion

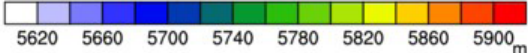
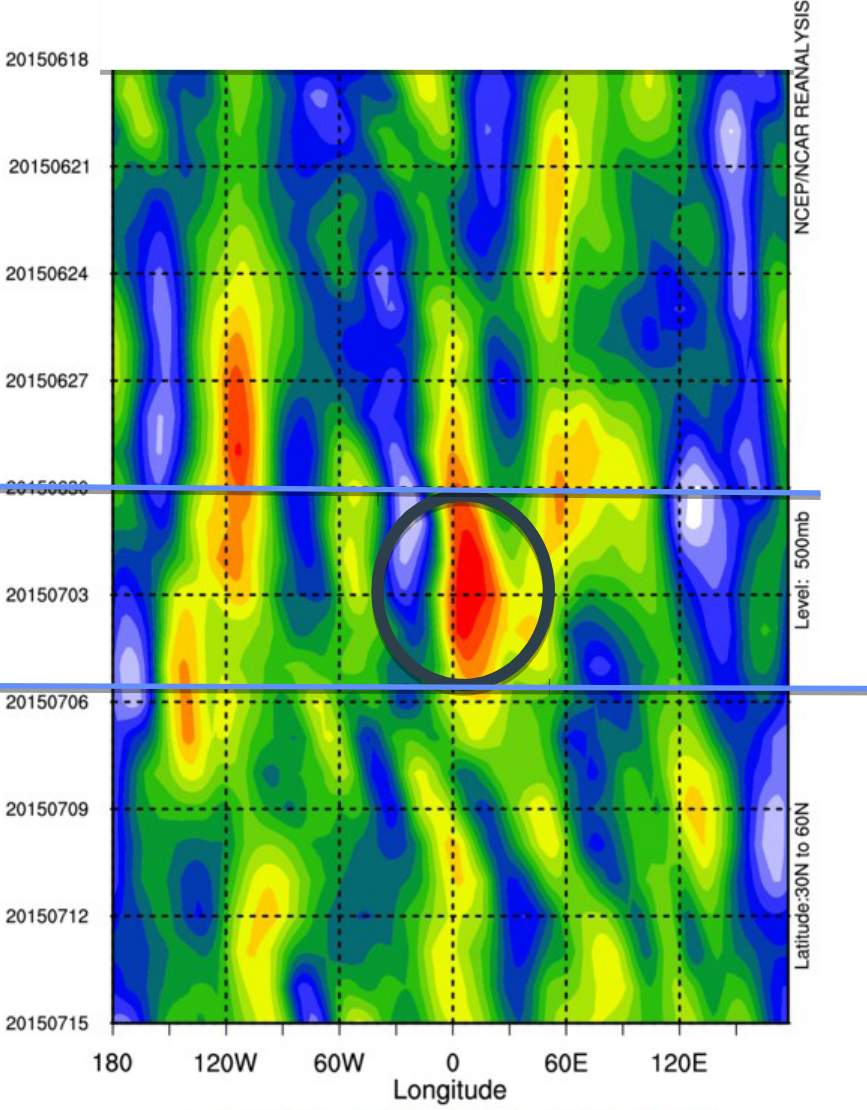
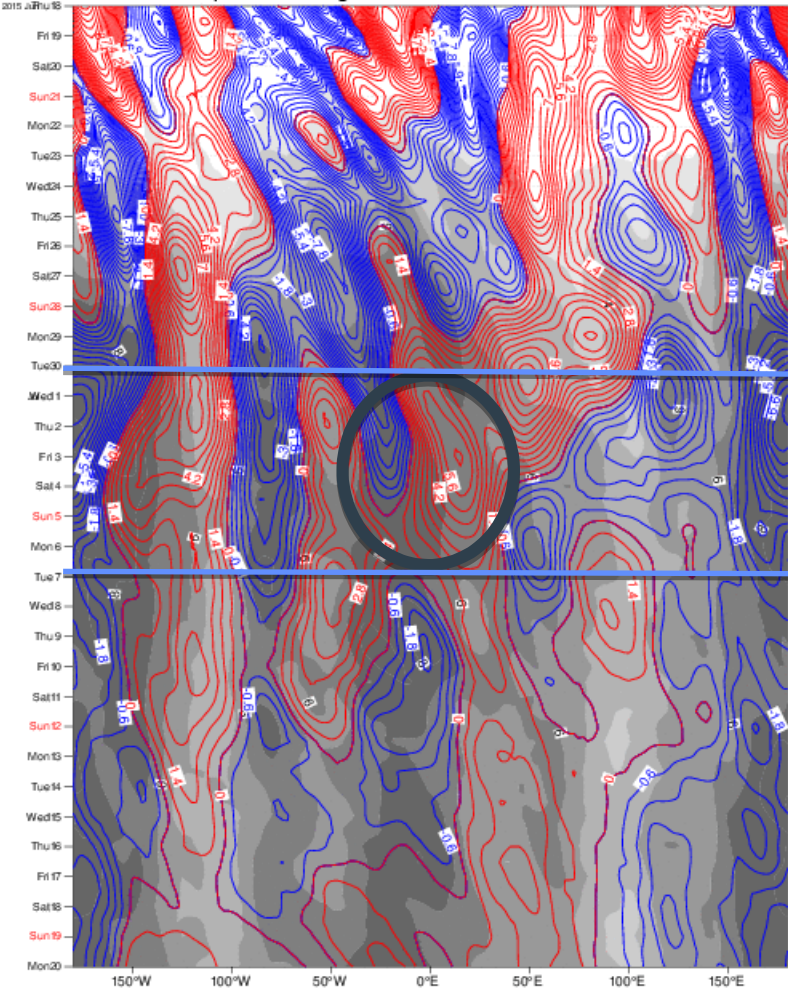
- SSTs, Soil moisture, stratospheric initial conditions and MJO are source of predictability at the intra-seasonal time scale. In particular the MJO has a significant impact on the forecast skill scores beyond day 20.
- The ENS produces forecasts for days 12-18 that are generally better than climatology and persistence of day 5-11. Beyond day 20, the skill is marginal but for some applications and some regions has some interest.
- Making improvements to sub-seasonal predictions, assessing their skill and uncertainty, and exploring ways to communicate their benefits to decision-makers are significant challenges. The S2S WWRP/THORPEX-WCRP joint project (<http://s2sprediction.net>) is embracing all these challenges and, to promote this research, has created a new database with a set of multi-model S2S reforecasts and forecasts freely available to the community.

# weekly mean anomalies over Southern Europe: 2mt forecast 12-18



Geopotential height

Time-longitude diagram of monthly forecast from 20150618:00  
Ensemble mean anomaly (contours) and spread (shading)  
of Geopotential height at 500 hPa between 60N and 35N

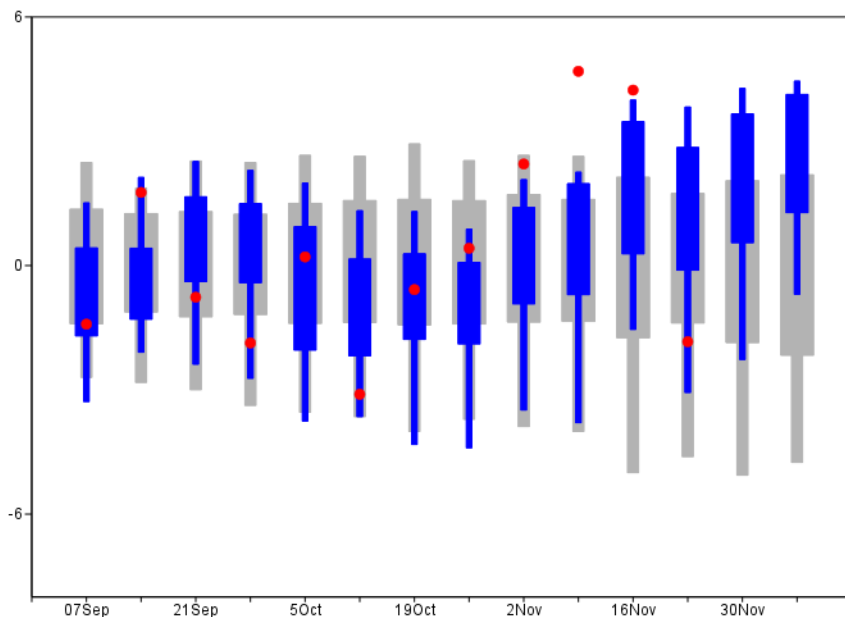


# September to December 2015

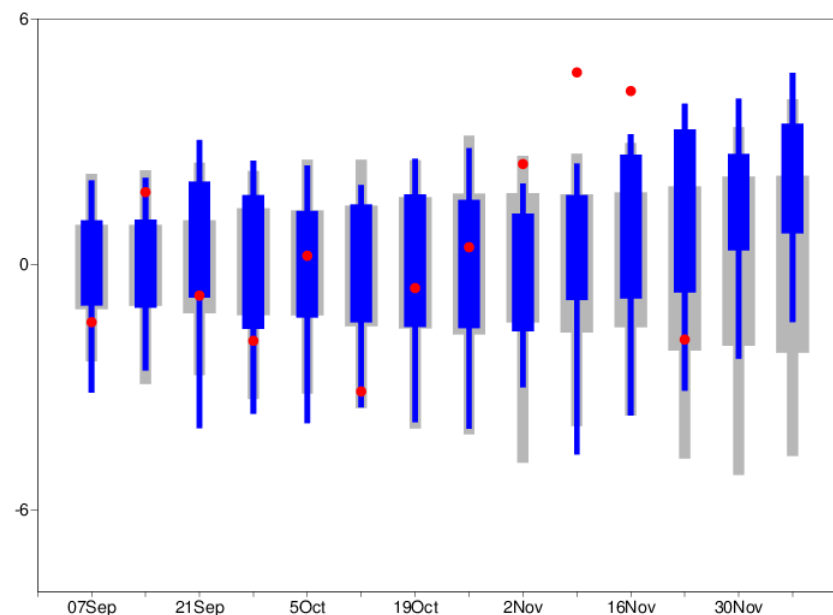
## 2m temp weekly anomalies

### (55-45N 5-15E):

For. range 12-18 days  
days



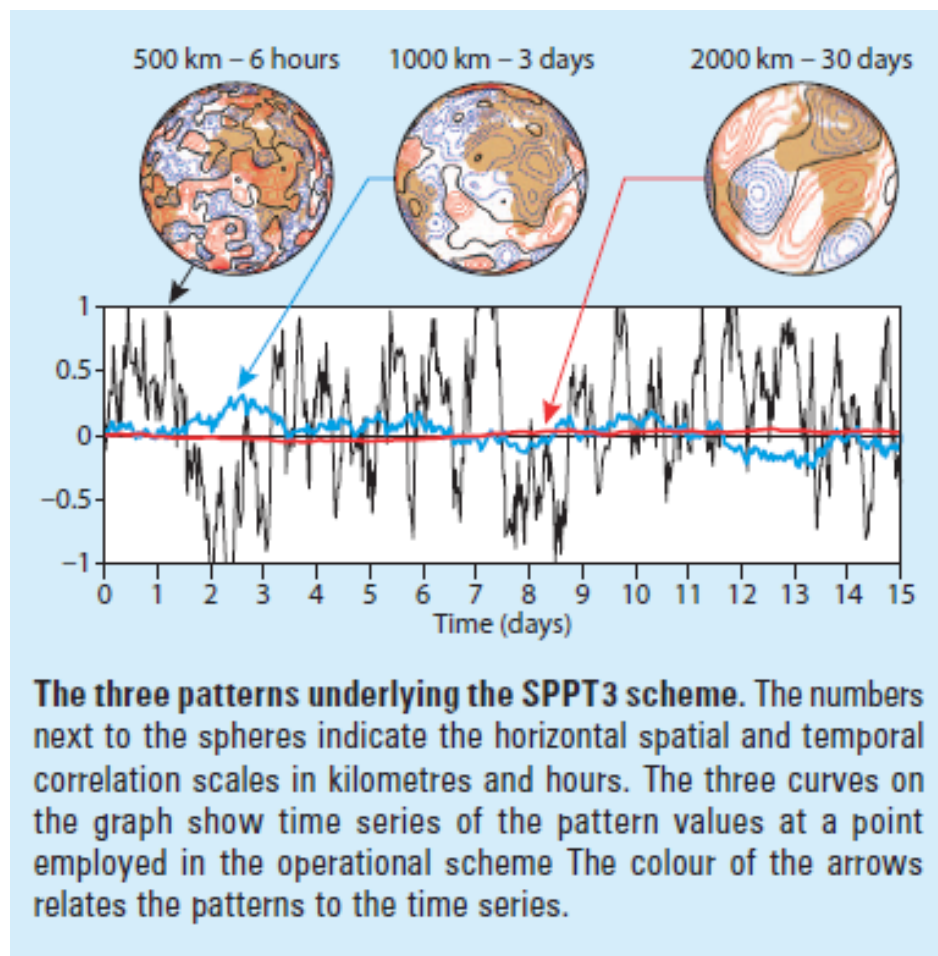
For. range 19-25  
days



# Stochastic Perturbed Parametrization Tendency (SPPT) scheme

Uncertainties in the model physical parametrizations can be a significant source of random error. This led to the development SPPT. It has been used in the since October 1998 there has been an increase in ensemble spread in the EPS and improved probability skill scores.

ECMWF Newsletter 129





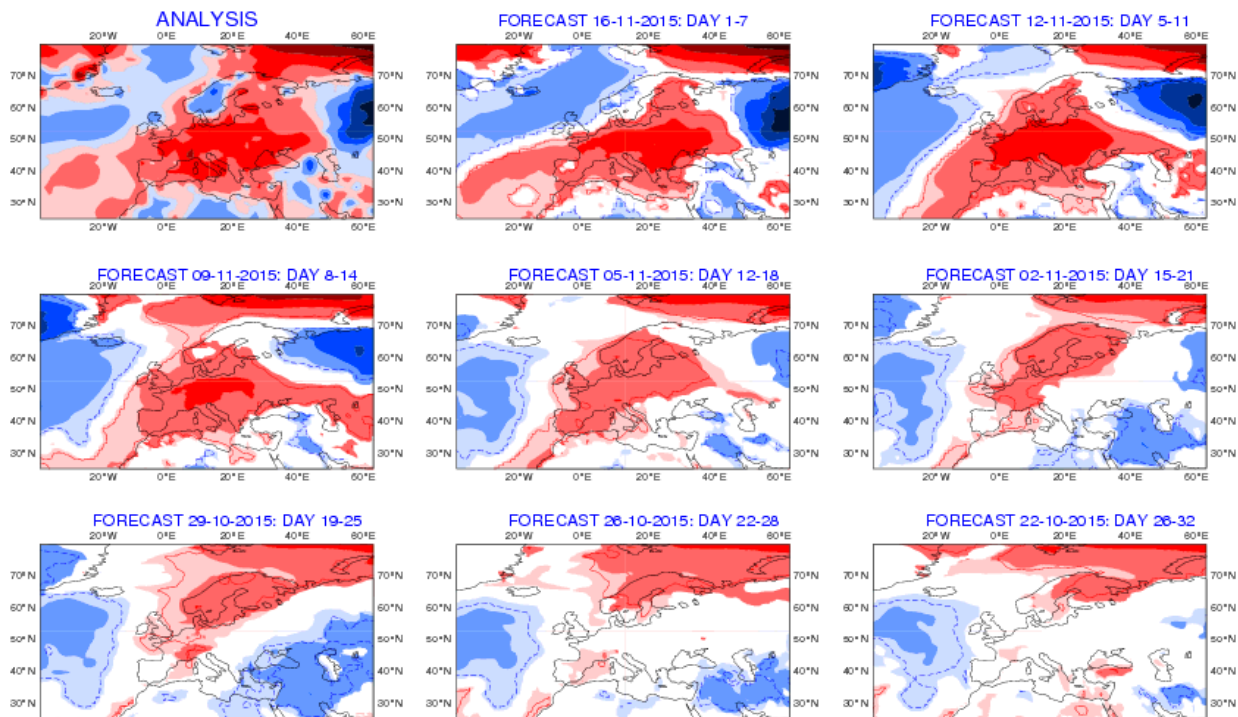
### Analysis and ECMWF EPS-Monthly Forecasting System

#### 2-metre Temperature anomaly

Verification period: 16-11-2015/TO/22-11-2015

ensemble size = 51 , climate size = 660

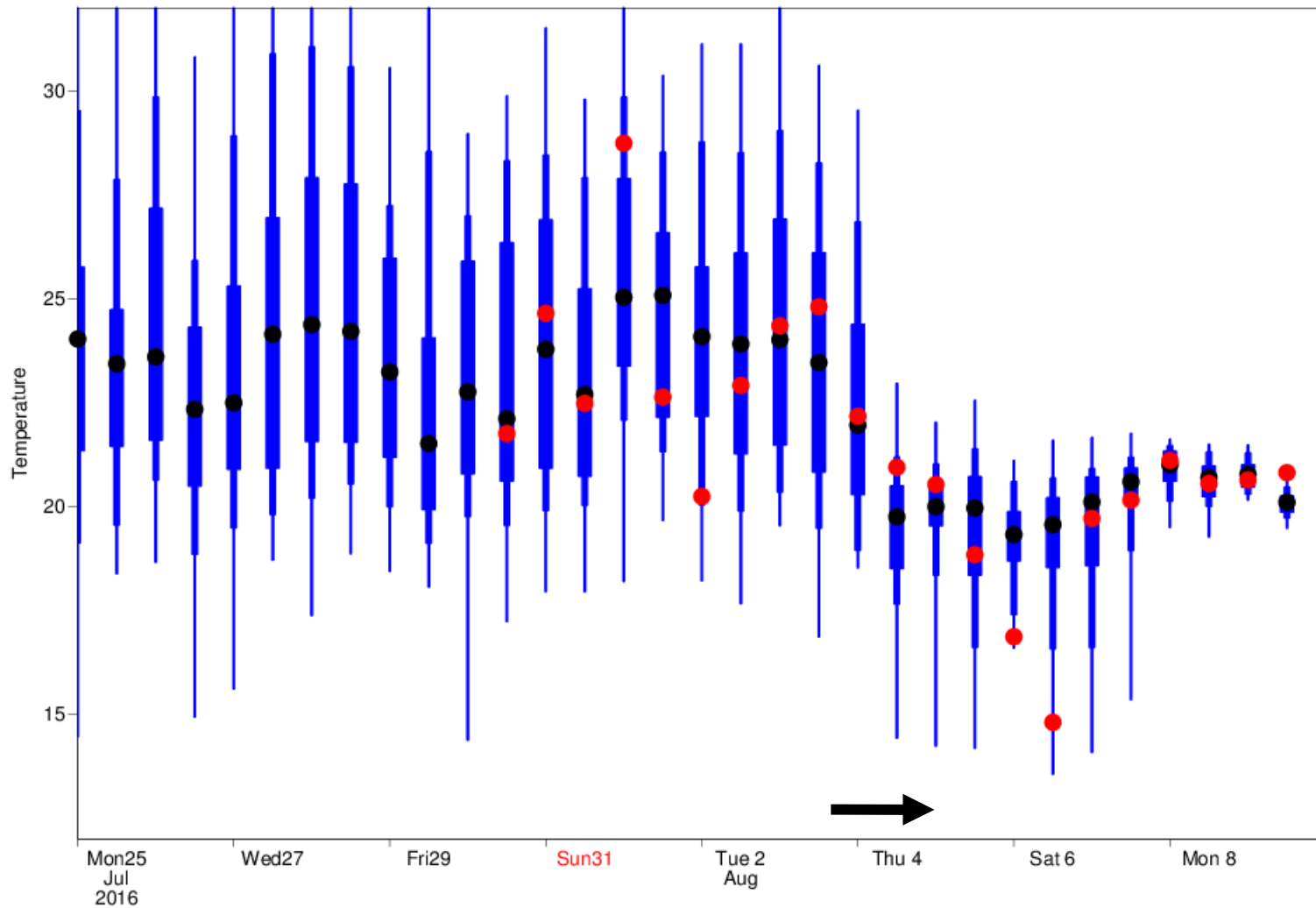
Shaded areas significant at 10% level, Contours at 1% level



# Stochastic backscatter scheme (SKEB)

It compensate for the loss of energy in the model due to the Mis-representation of processes at sub-gridscale.

# 2-metre temperature Paris 9 August 12z



# Analysis and ECMWF ENS Forecasting System

2-metre Temperature anomaly

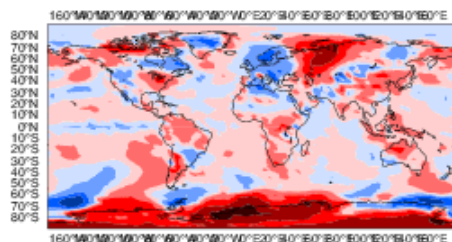
Verification period: 08-08-2016/TO/14-08-2016

ensemble size = 51 , climate size = 660

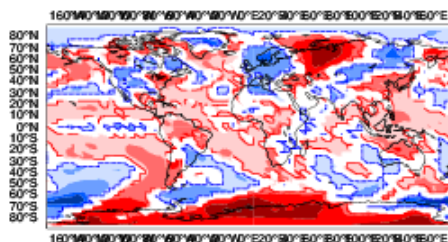
Shaded areas significant at 10% level, Contours at 1% level



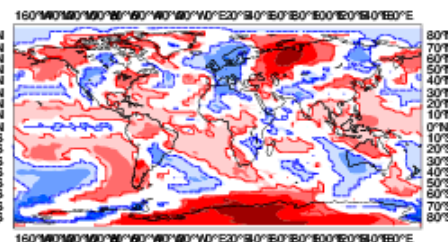
### ANALYSIS



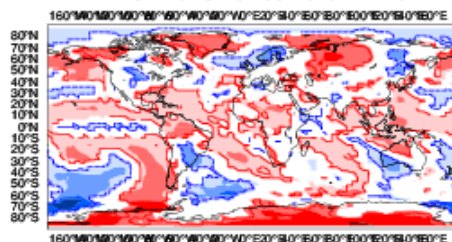
### FORECAST 08-08-2016: DAY 1-7



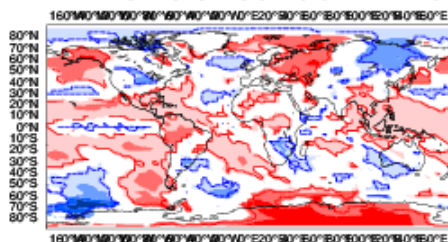
### FORECAST 04-08-2016: DAY 5-11



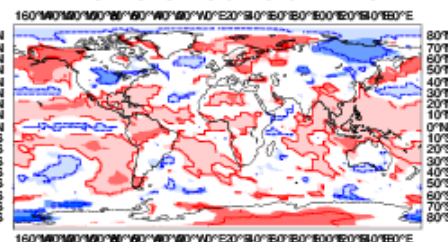
### FORECAST 01-08-2016: DAY 8-14



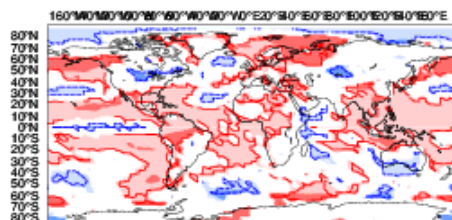
### FORECAST 28-07-2016: DAY 12-18



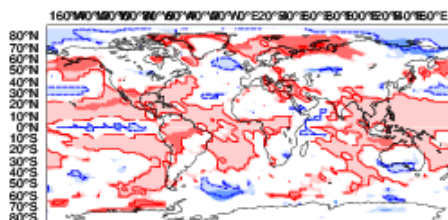
### FORECAST 25-07-2016: DAY 15-21



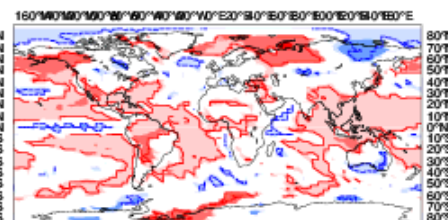
### FORECAST 21-07-2016: DAY 19-25



### FORECAST 18-07-2016: DAY 22-28



### FORECAST 14-07-2016: DAY 26-32

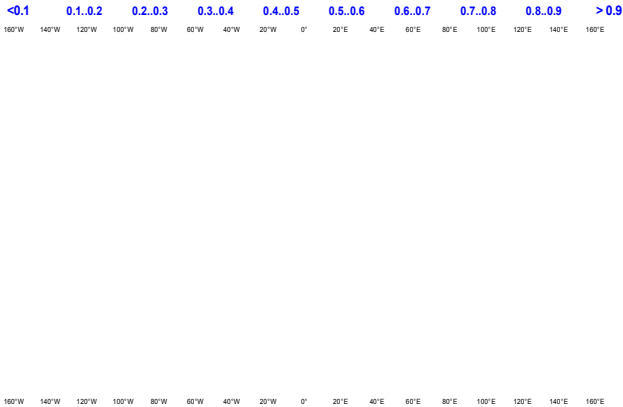
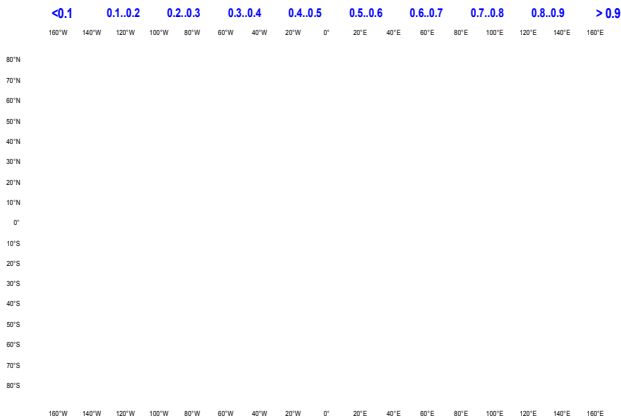


# Skill of the ECMWF Monthly Forecasting System

ROC score: 2-meter temperature in the upper tercile

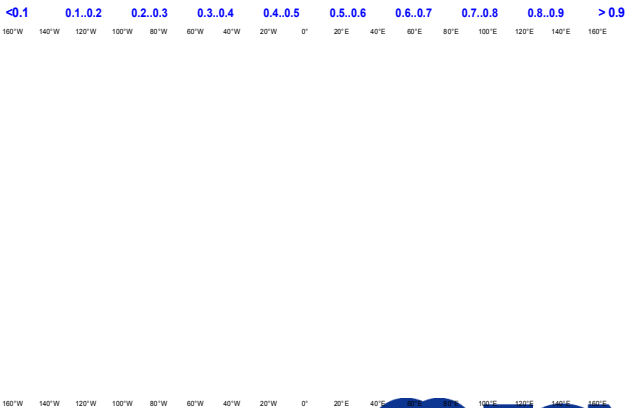
Day 5-11

Day 12-18



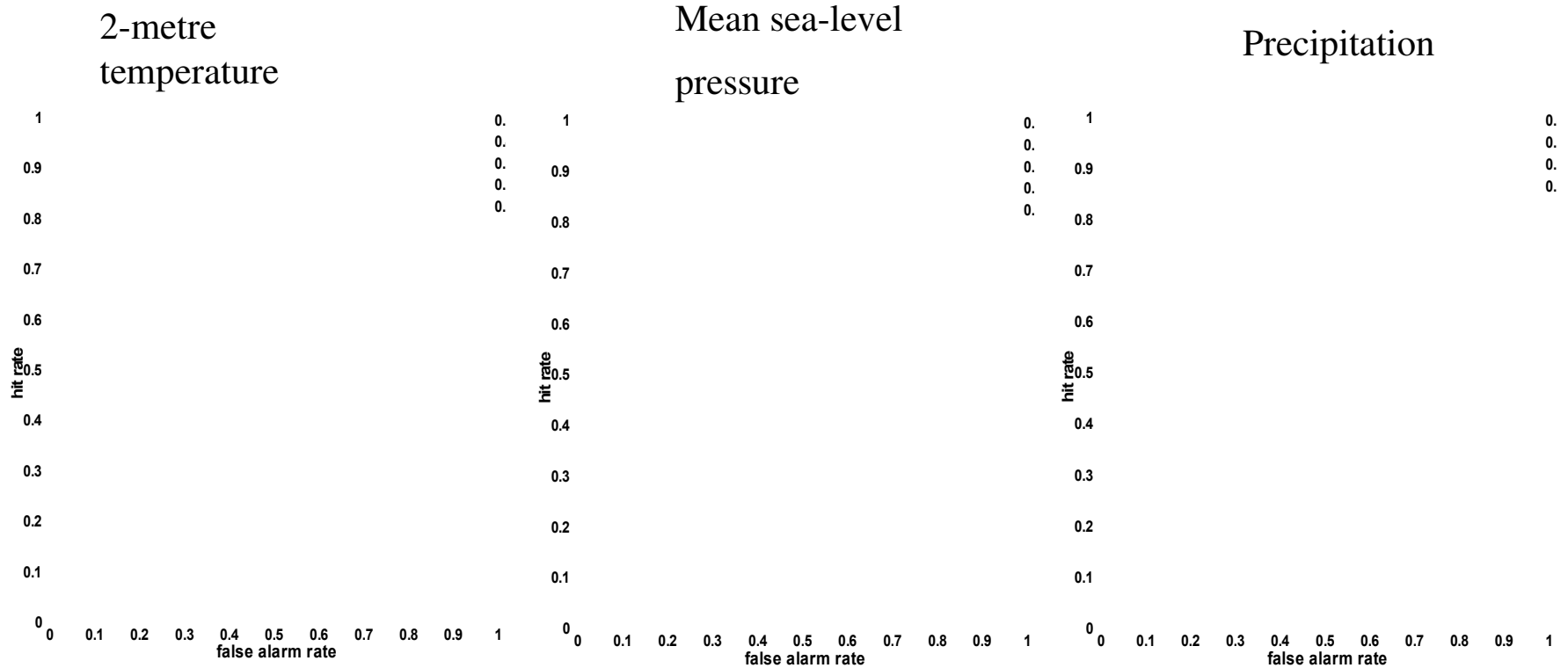
Day 19-25

Day 26-32



# Skill of the ECMWF Monthly Forecasting System

## ROC scores over the Northern extratropics



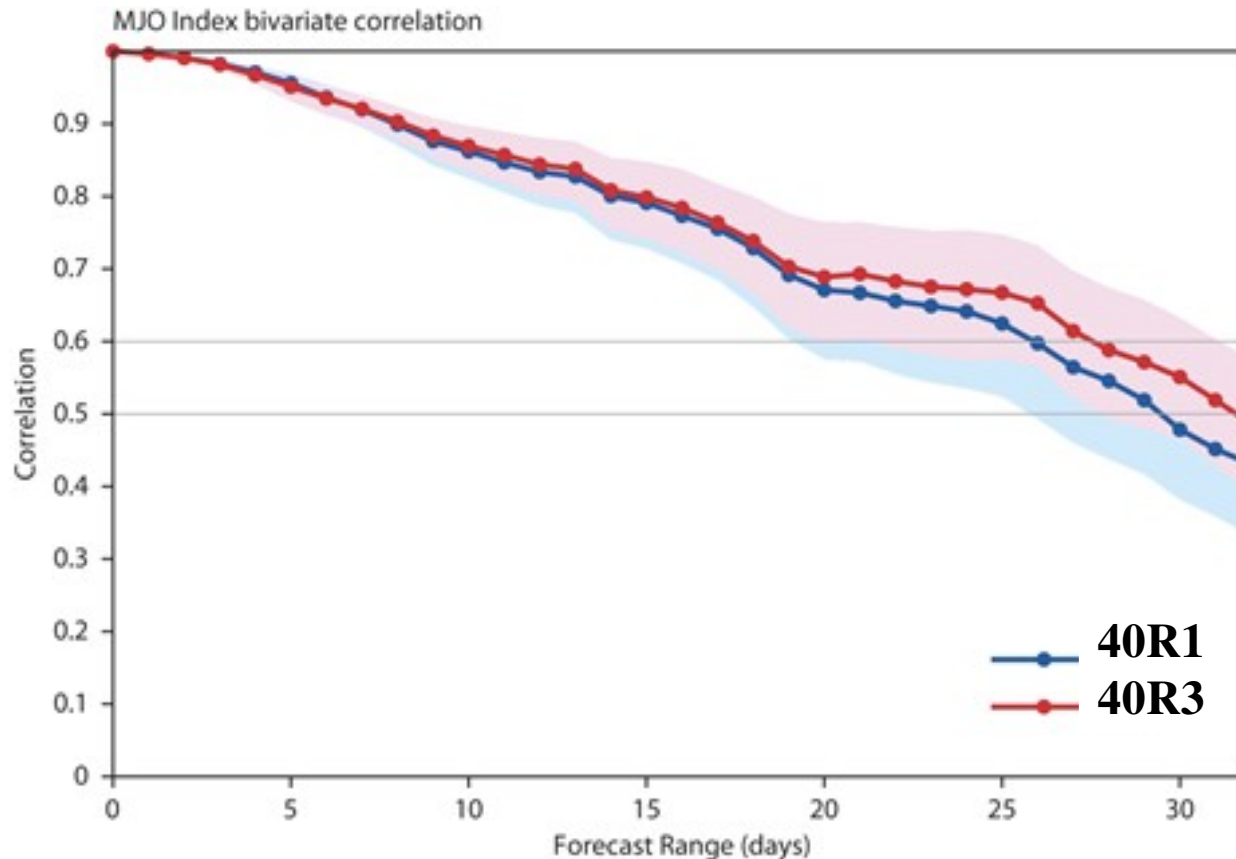
Day 5-11

Day 12-18

Day 19-25

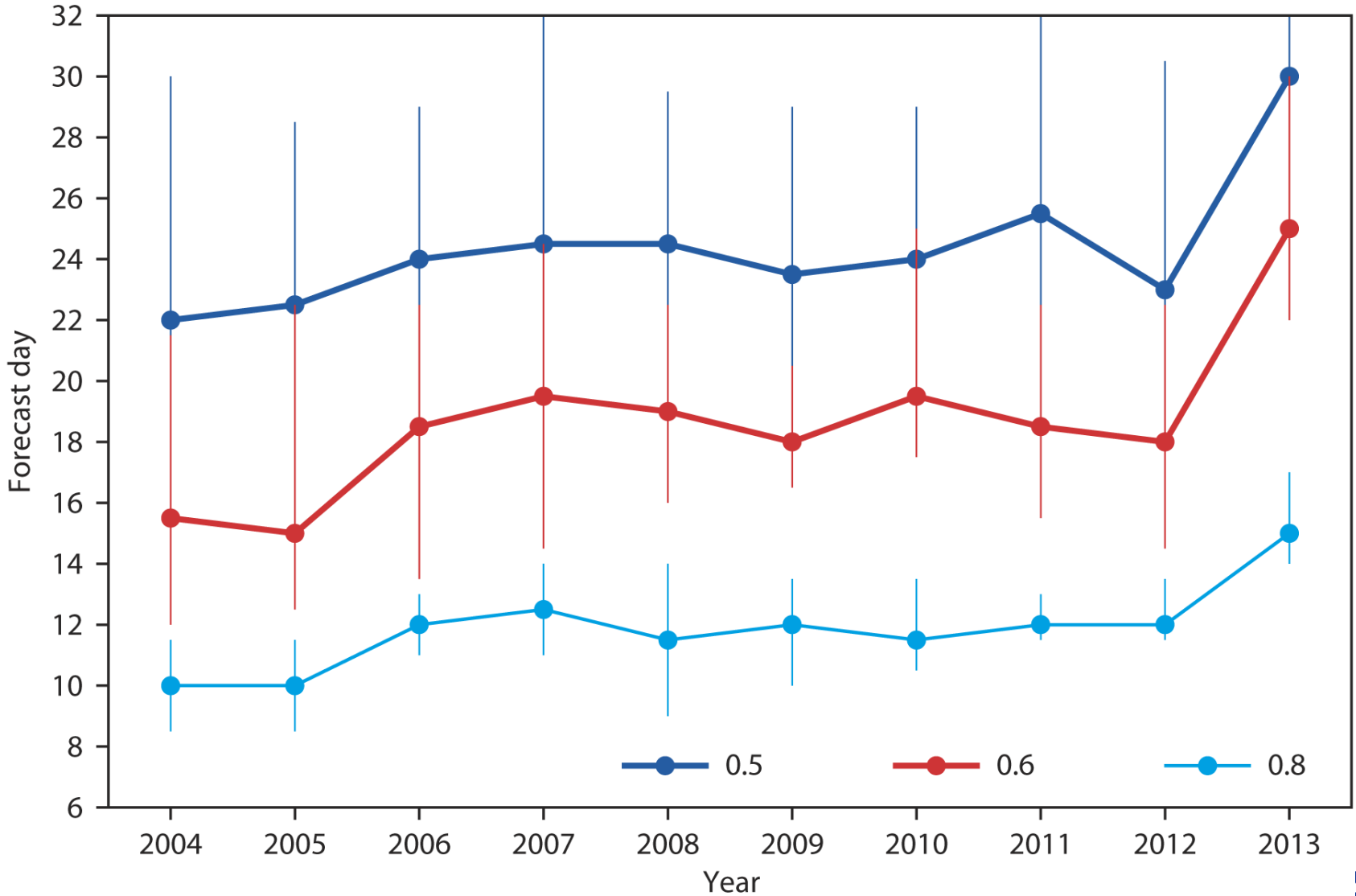
Day 26-32

# Madden Julian Oscillation



Improvement due to revised organised convective detrainment term and the revised convective momentum transport.

SSW Correlation





# NAO/SSW lag-correlation

