

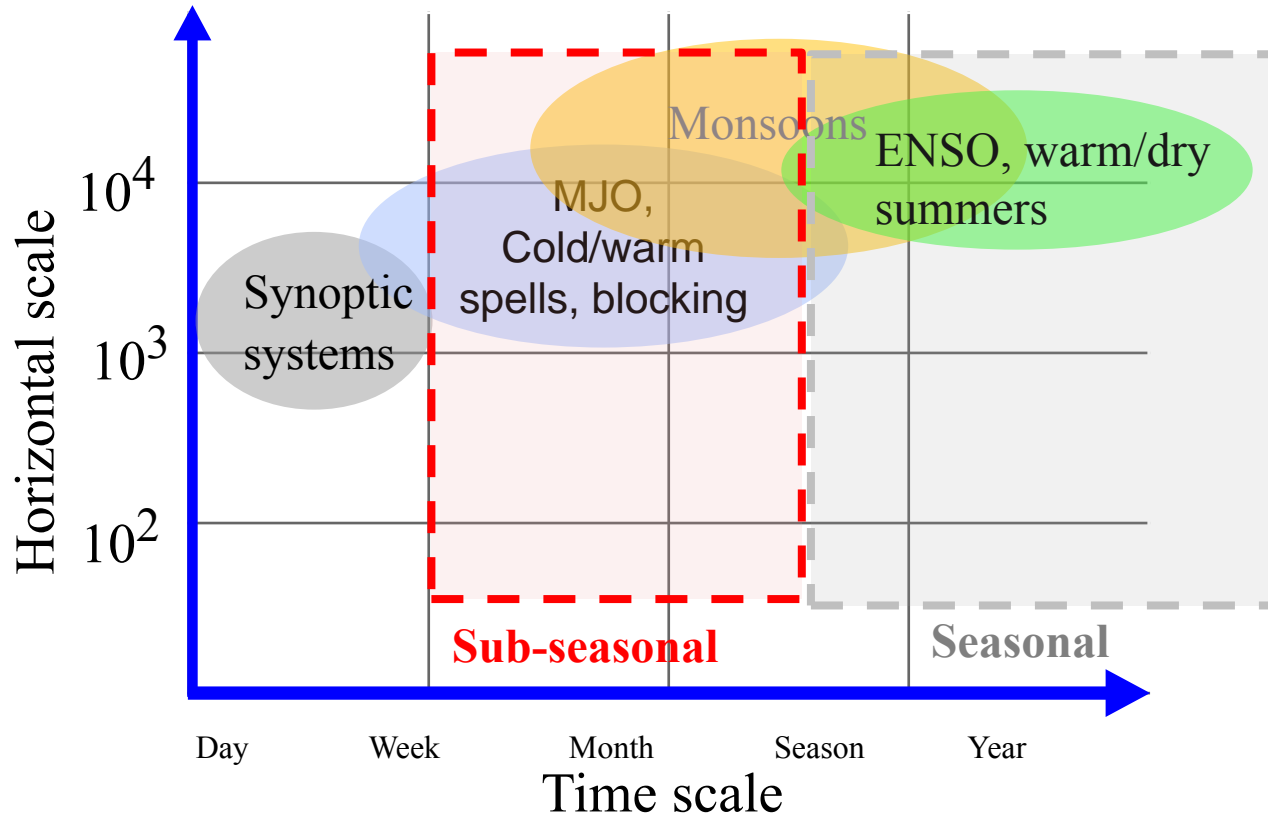
The ECMWF sub-seasonal forecasts (extended range)

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ECMWF, Reading, U.K.

Subseasonal time scale: longer than 2 weeks but shorter than a season

Sources of predictability at extended range :



2

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, ~36 km 91 levels,
to 7 months ahead

Extended range forecast / ENS extension

Ens. m. range twice daily

Tco639 (18Km)

ENS Extended range Mon/Thu

Tco319 (36Km)



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

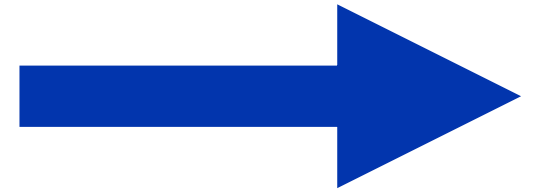
The ECMWF extended forecasts consists of 2 elements:

Real time forecasts

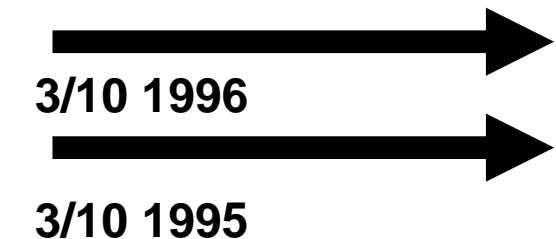
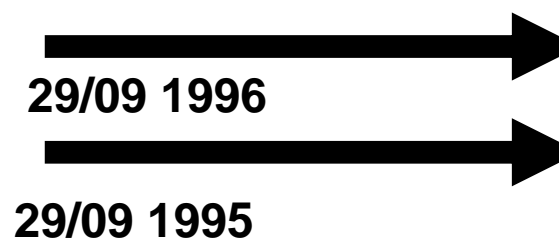
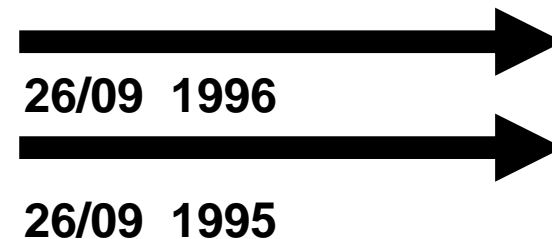
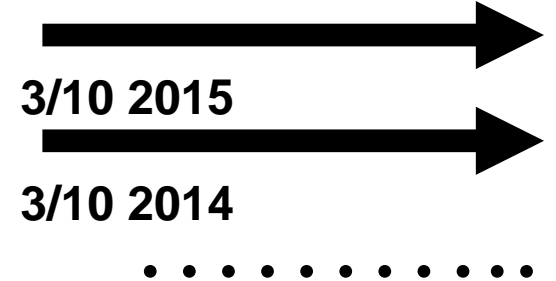
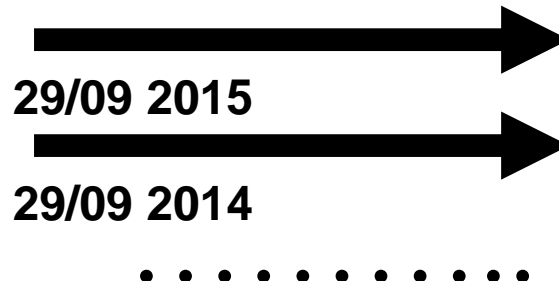
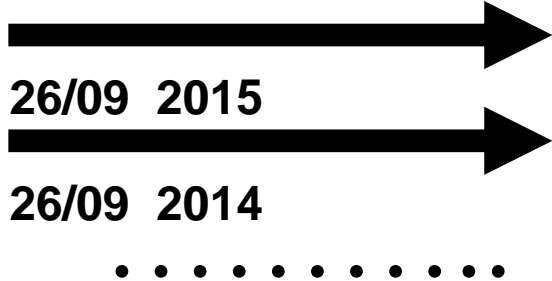
26/09/16 Monday

29/09/16 Thursday

3/10/16 Monday



Set of reforecasts



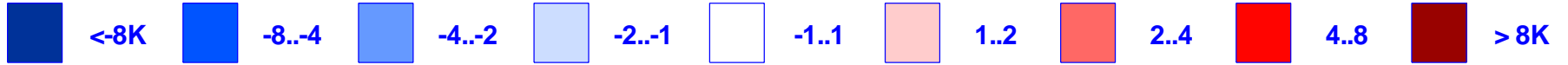
ECMWF Monthly Forecasting System

MODEL BIAS: 2m Temperature

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

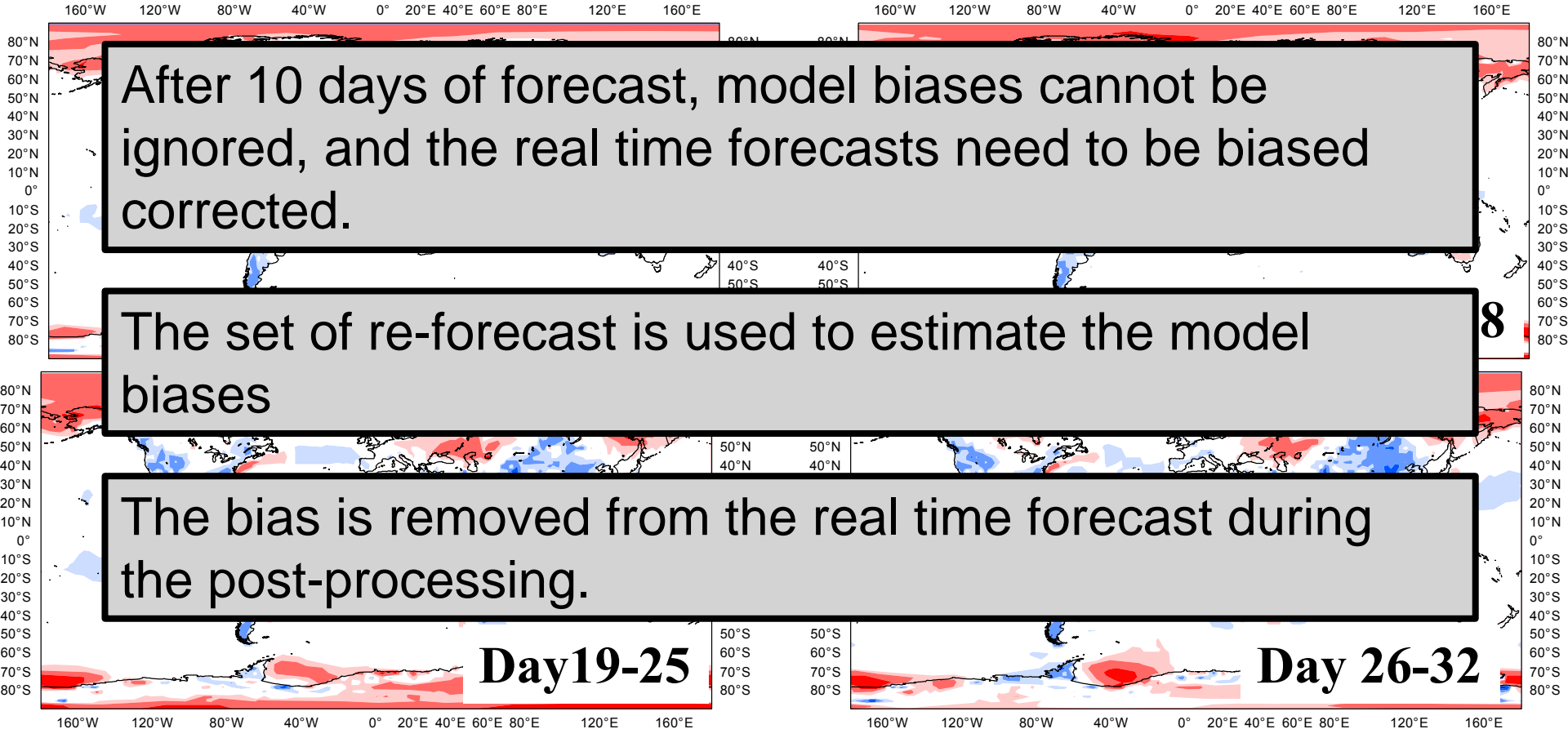
Model Bias:

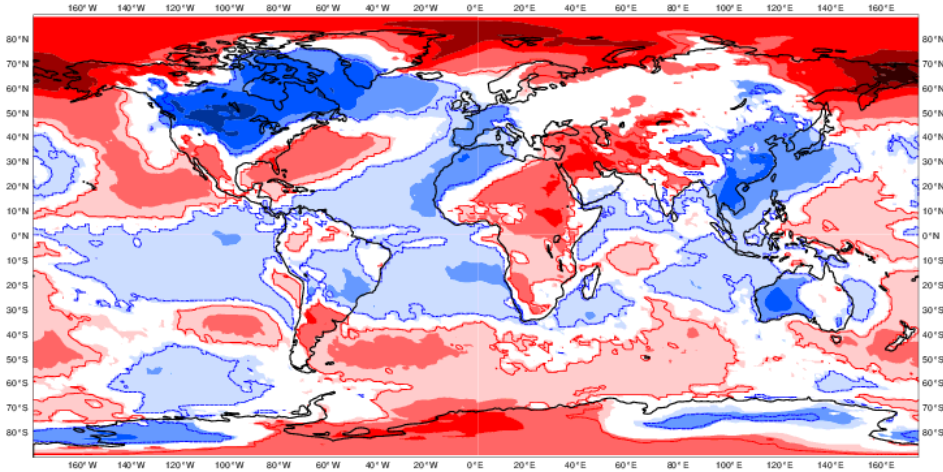
WEEK1-4



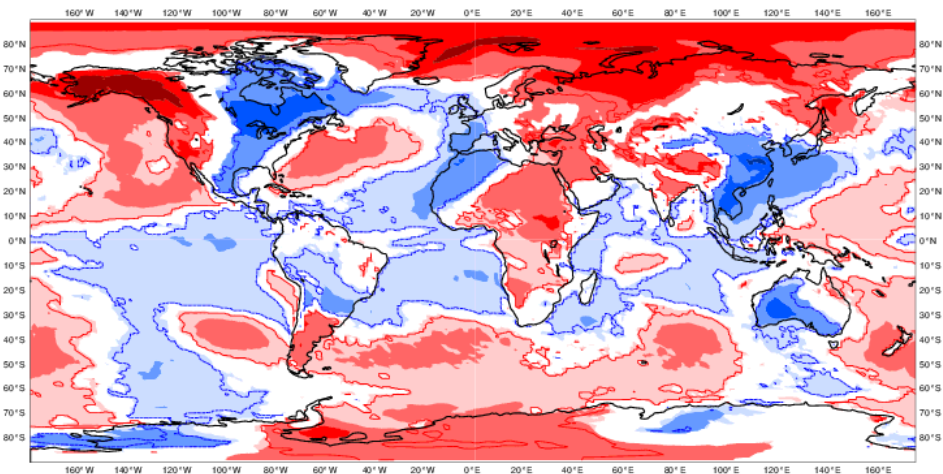
WEEK1: DAY 5 TO 11

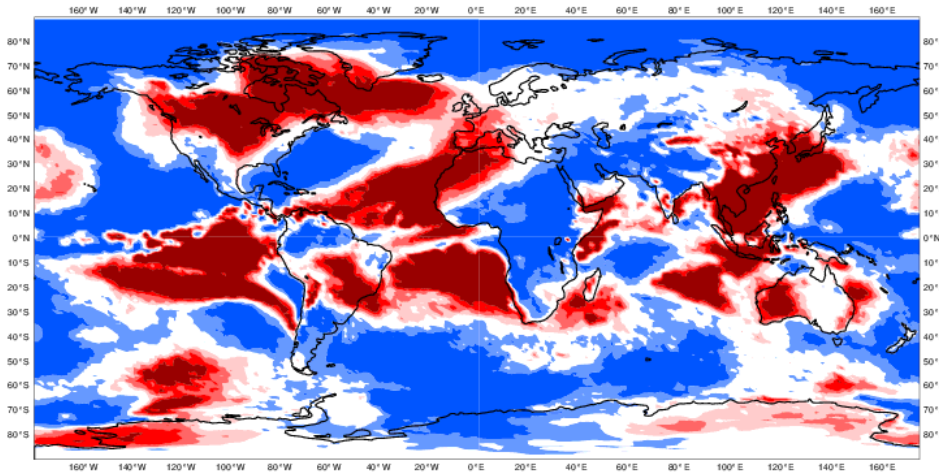
WEEK2: DAY 12 TO 18



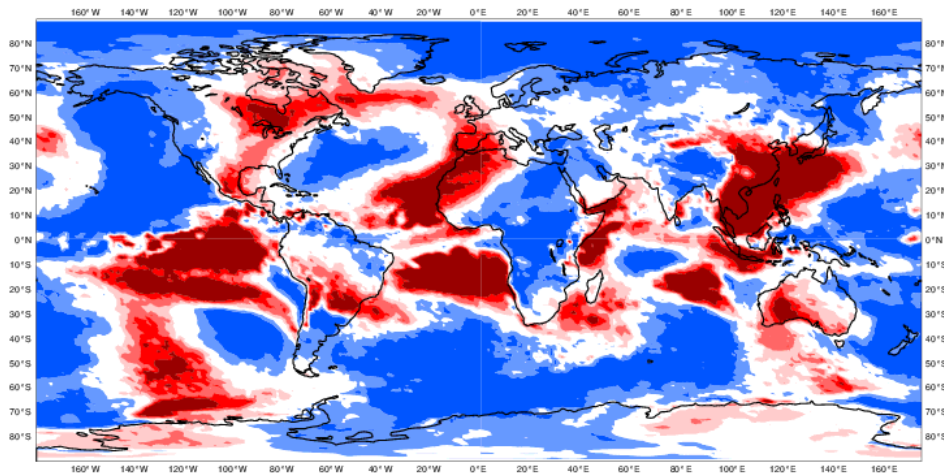


Ens. mean weekly anomalies :





Probabilities for weekly mean anomalies:



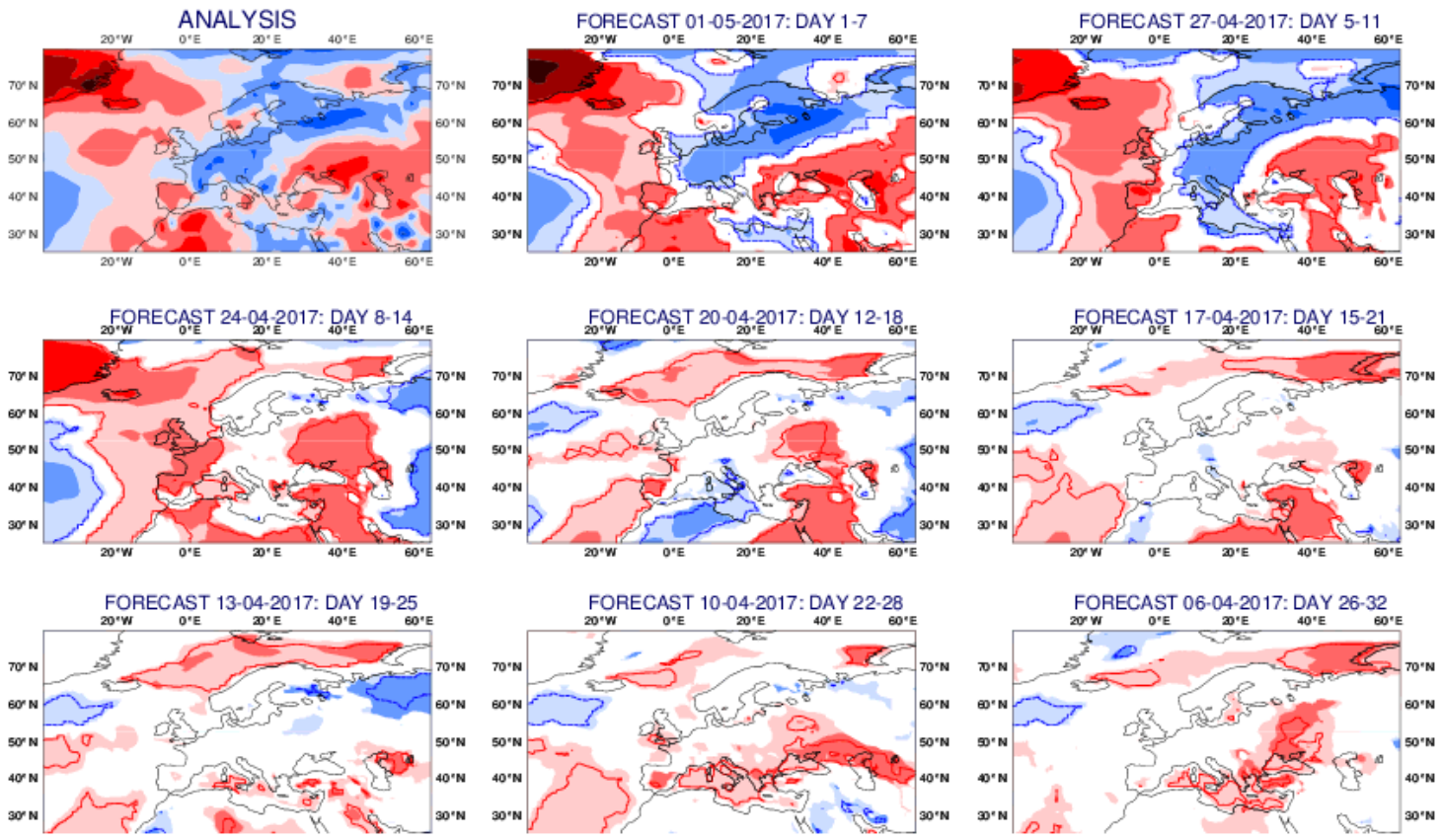
Analysis and ECMWF ENS Forecasting System

2-metre Temperature anomaly

Verification period: 01-05-2017/TO:07-05-2017

ensemble size = 51 , climate size = 660

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



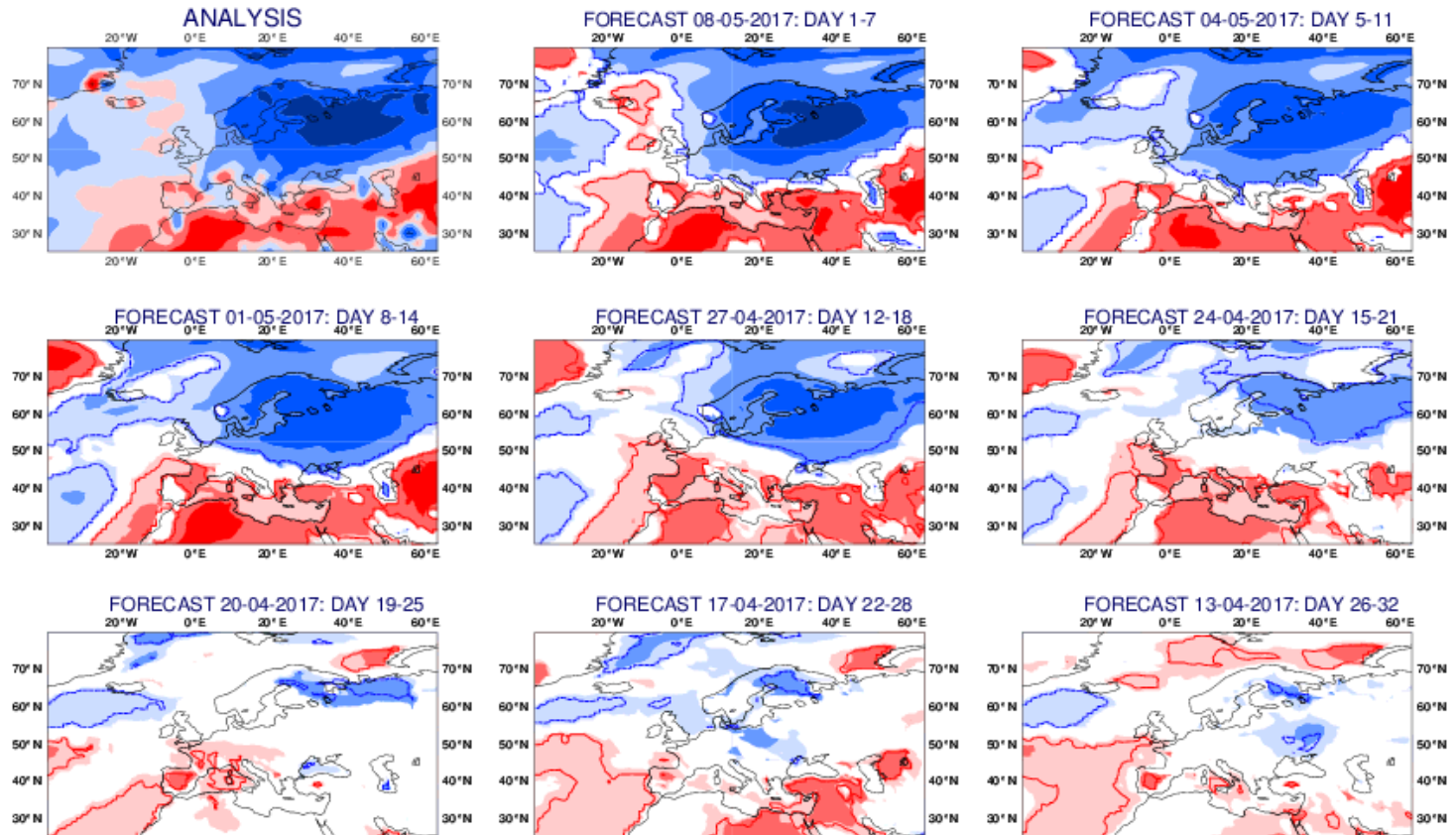
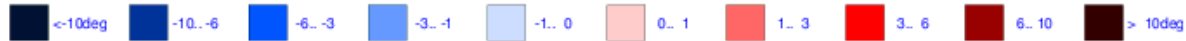
Analysis and ECMWF ENS Forecasting System

2-metre Temperature anomaly

Verification period: 08-05-2017/TO/14-05-2017

ensemble size = 51 , climate size = 660

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



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, low frequency modes, weather regimes...)**

Cold spell over Europe Nov-Dec 2012

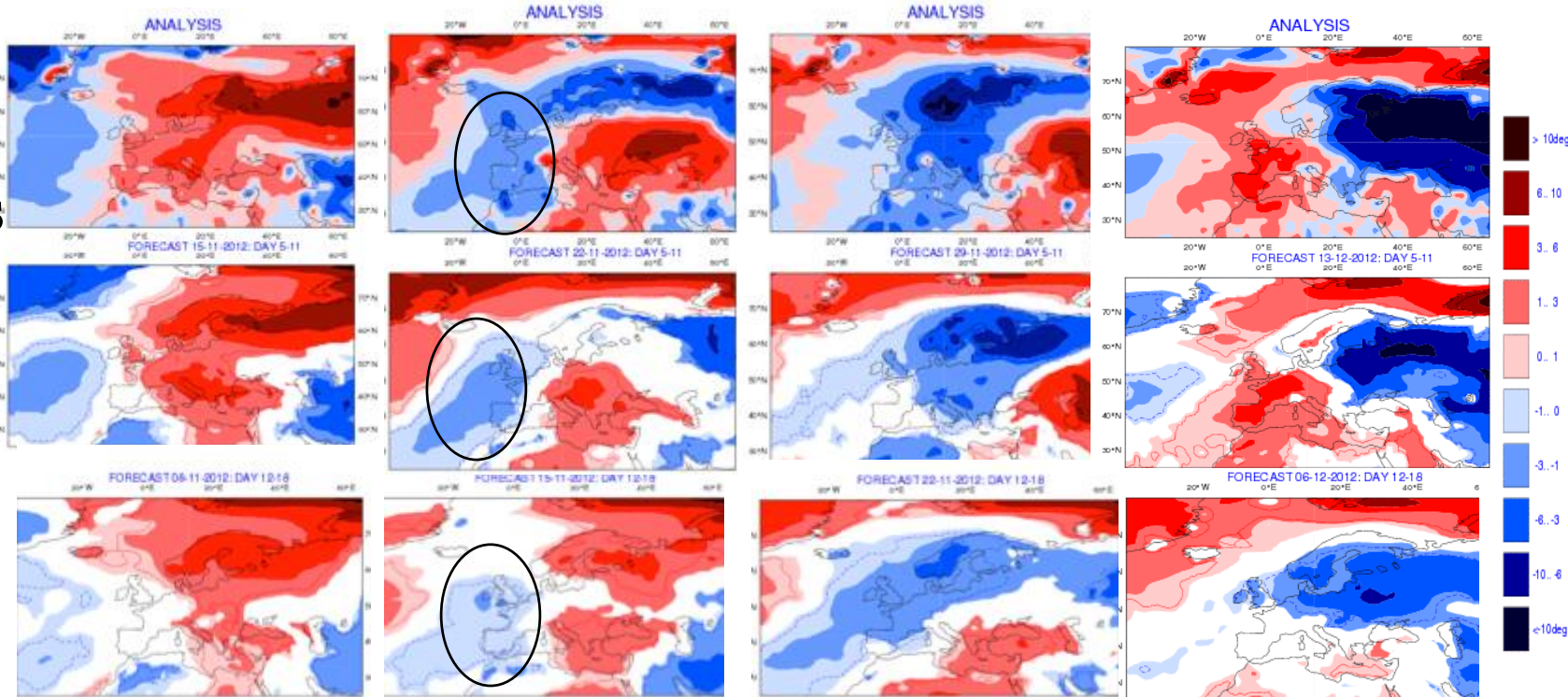
19 -25 /11/2012

26 /11 -2/12 2012

3-9/ 12 /2012

17 -12 12 2012

analysis



5-11d

12-18 d



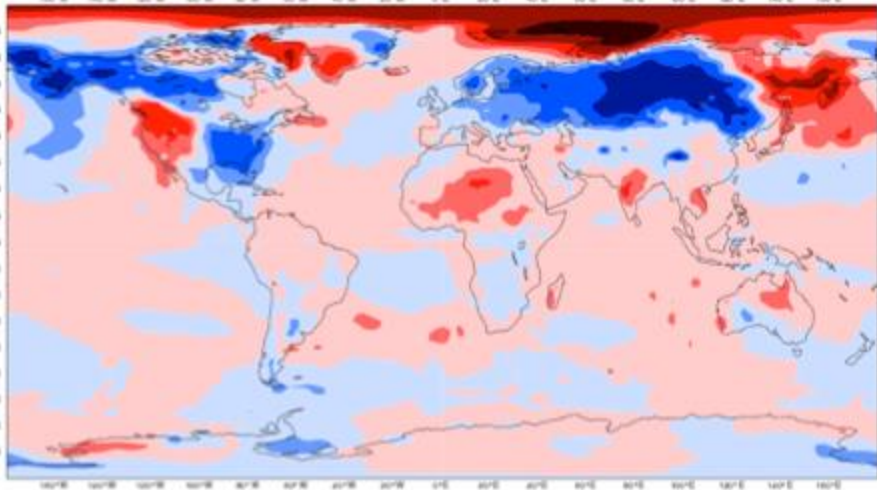
Cold Weather over Europe

SSW Index - Forecast starting on 22/11/2012

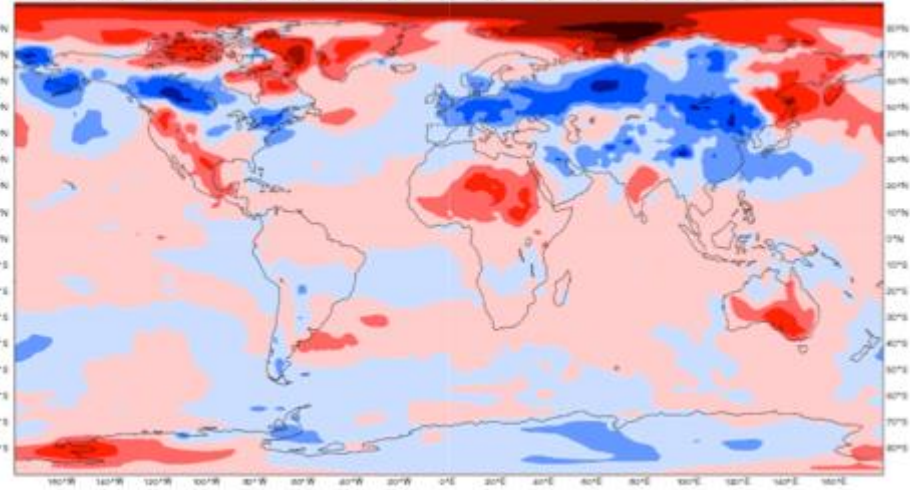
Strong SSW

Weak SSW

■ 6.4 ■ 4.4 ■ 4.2 ■ 2.1 ■ 1.0 ■ 0.1 ■ 1.2 ■ 2.4 ■ 4.8 ■ 6.8 ■ 8.0

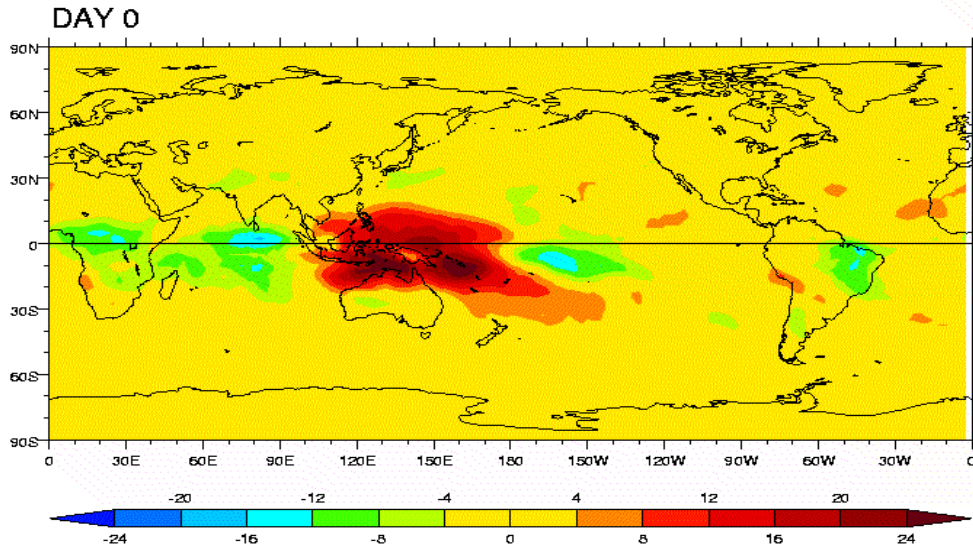


■ 6.4 ■ 4.4 ■ 4.2 ■ 2.1 ■ 1.0 ■ 0.1 ■ 1.2 ■ 2.4 ■ 4.8 ■ 6.8 ■ 8.0

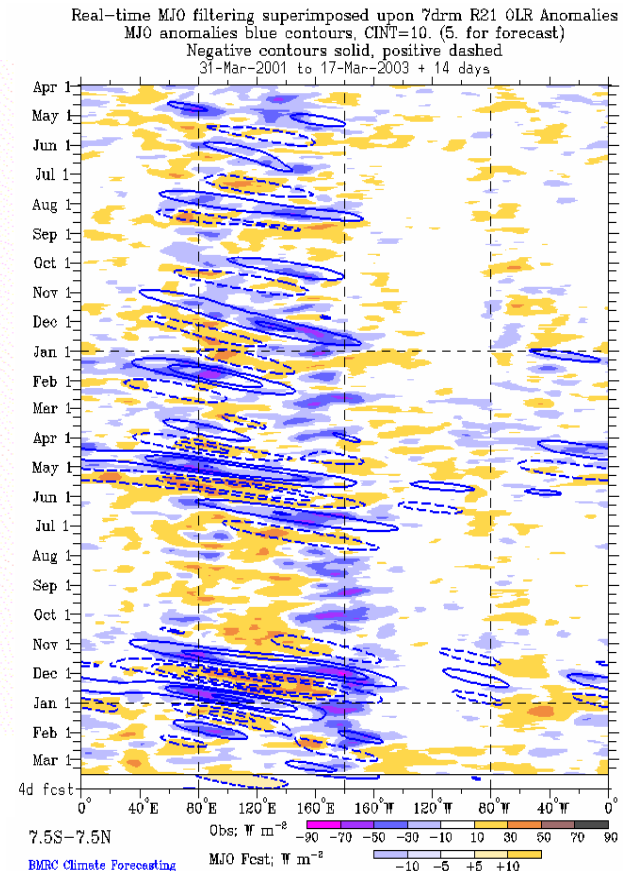


The Madden Julian Oscillation (MJO)

MJO life cycle



(From NASA)



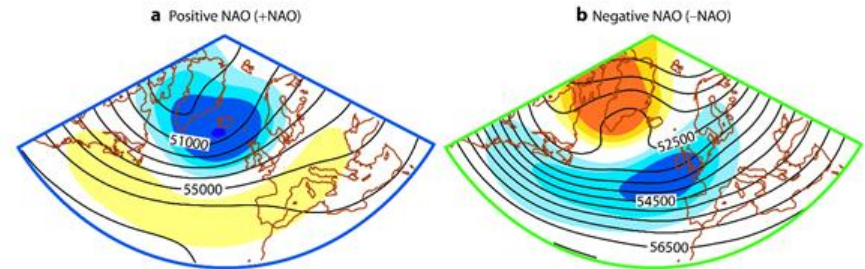
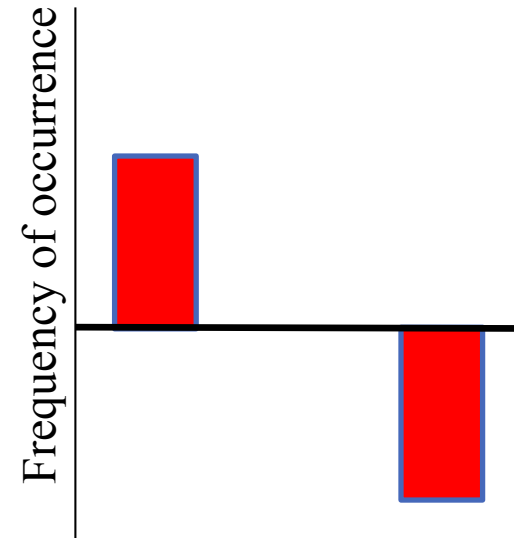
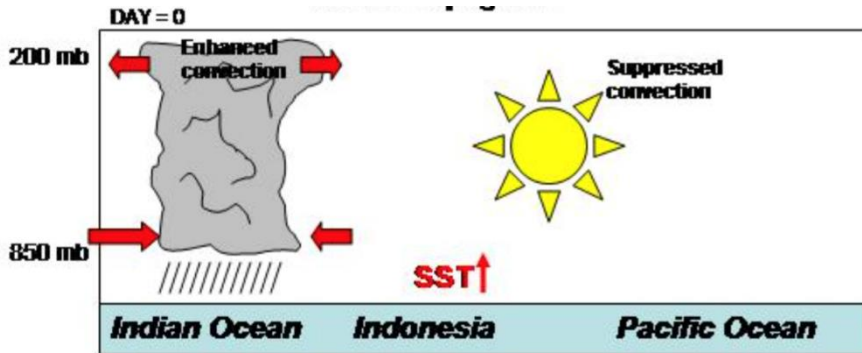
From

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

About 10-12 days after enhanced convection over Indian Ocean the NAO+ is the most probable pattern while the NAO- is less likely to occur

Enhanced convection over Indian Ocean

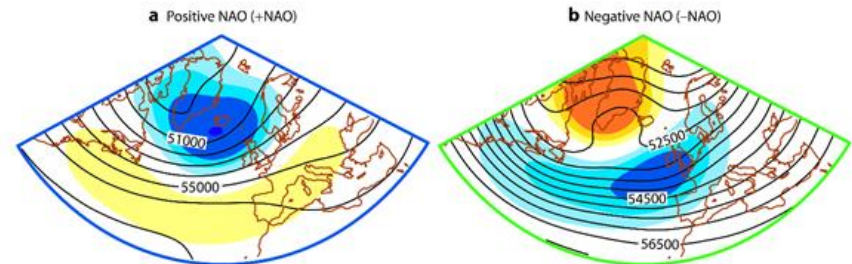
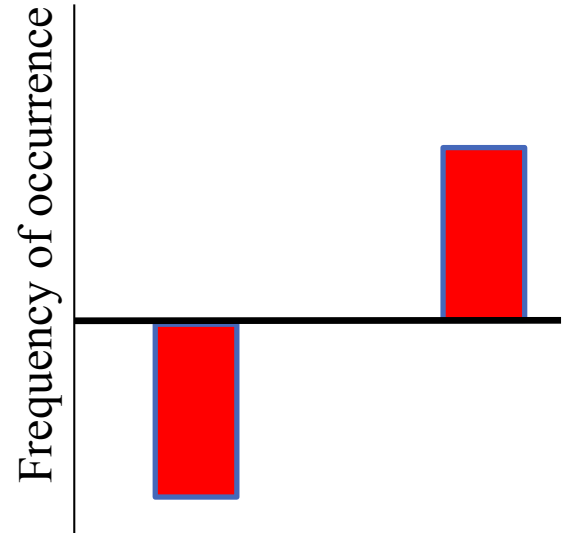
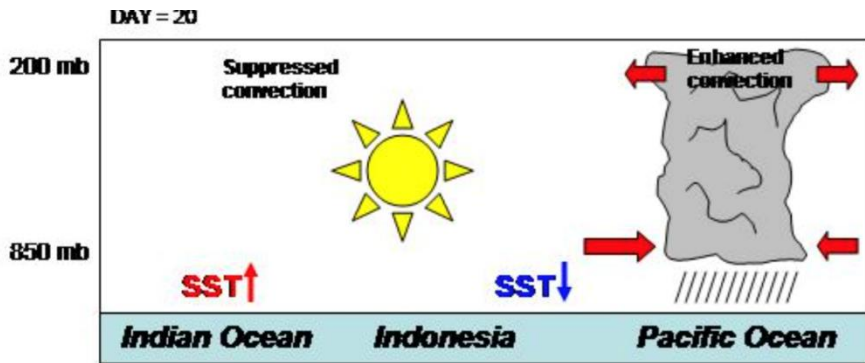
MJO phase 2-3



Cassou (2008) Lin et al (2008)

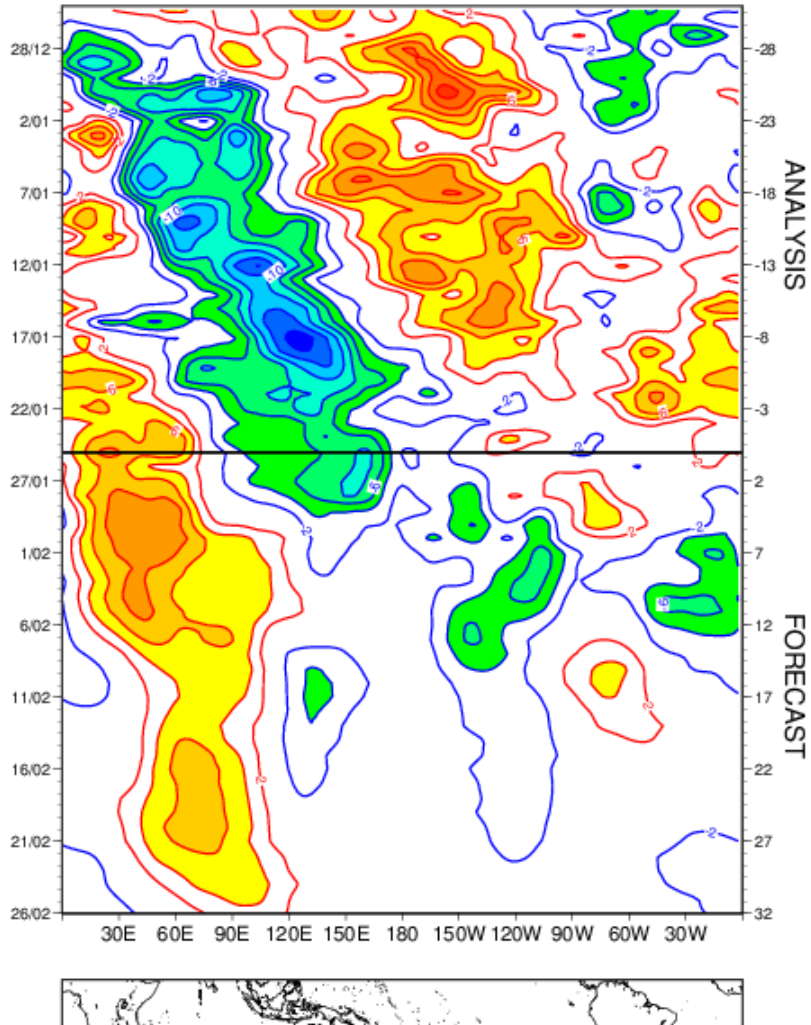
About 10-15 days after enhanced convection over Western Pacific, the NAO- is the most probable pattern while the NAO+ is less likely to occur

MJO phase 6-7

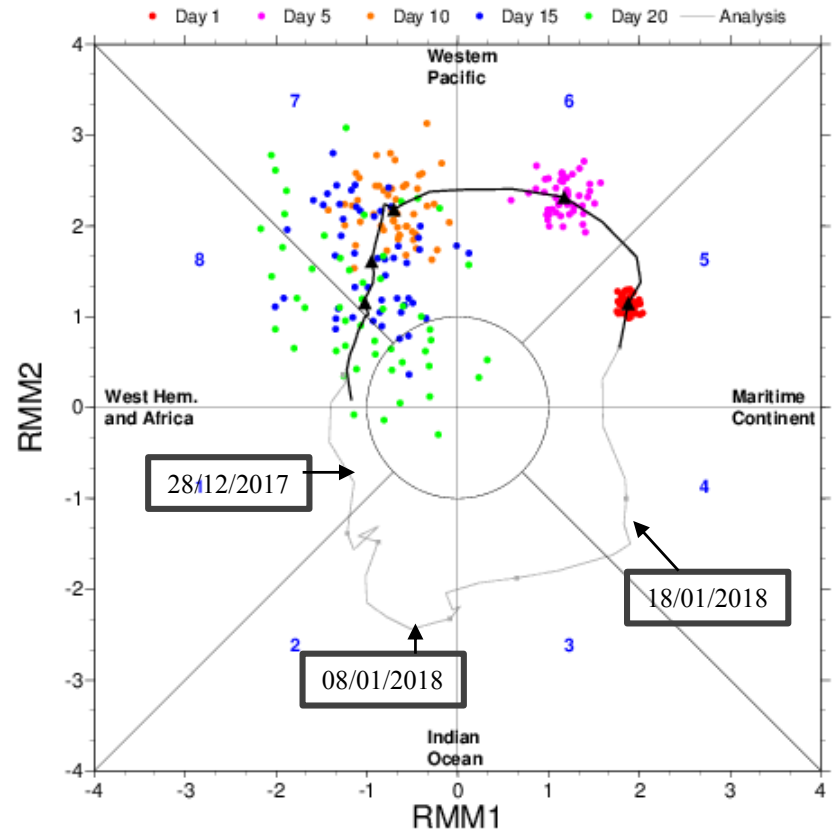


Cassou (2008) Lin et al (2008)

VELOCITY POTENTIAL AT 200 HPA
 Ensemble mean between Lat 15S and 15N
 FORECAST BASED 25/01/2018 00UTC



ECMWF MONTHLY FORECASTS
 FORECAST BASED 25/01/2018 00UTC

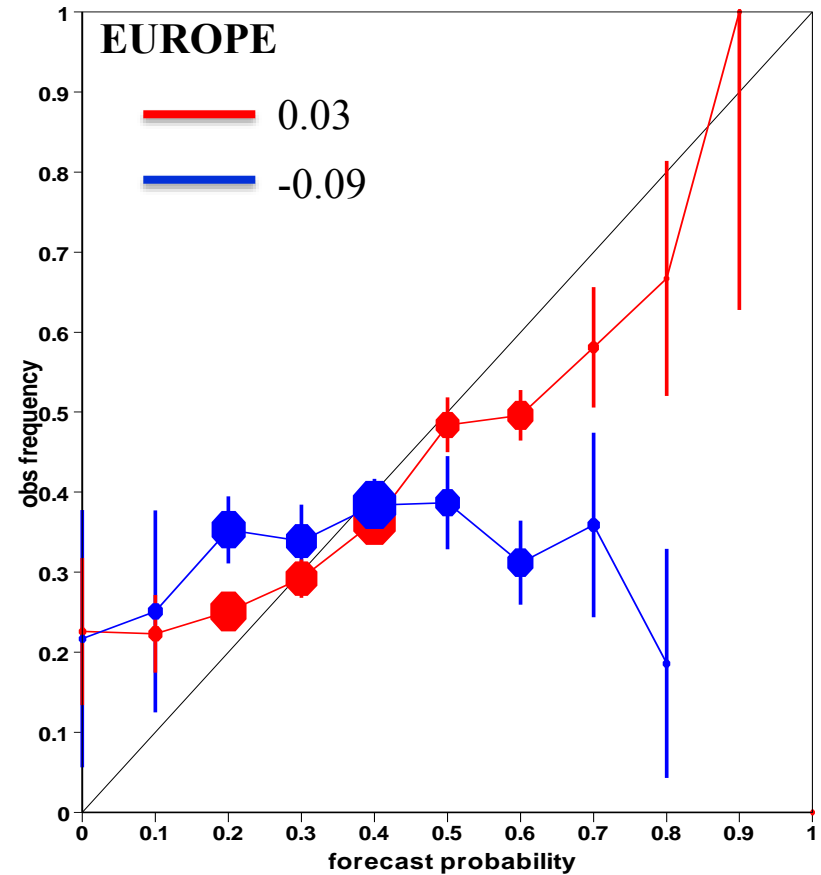
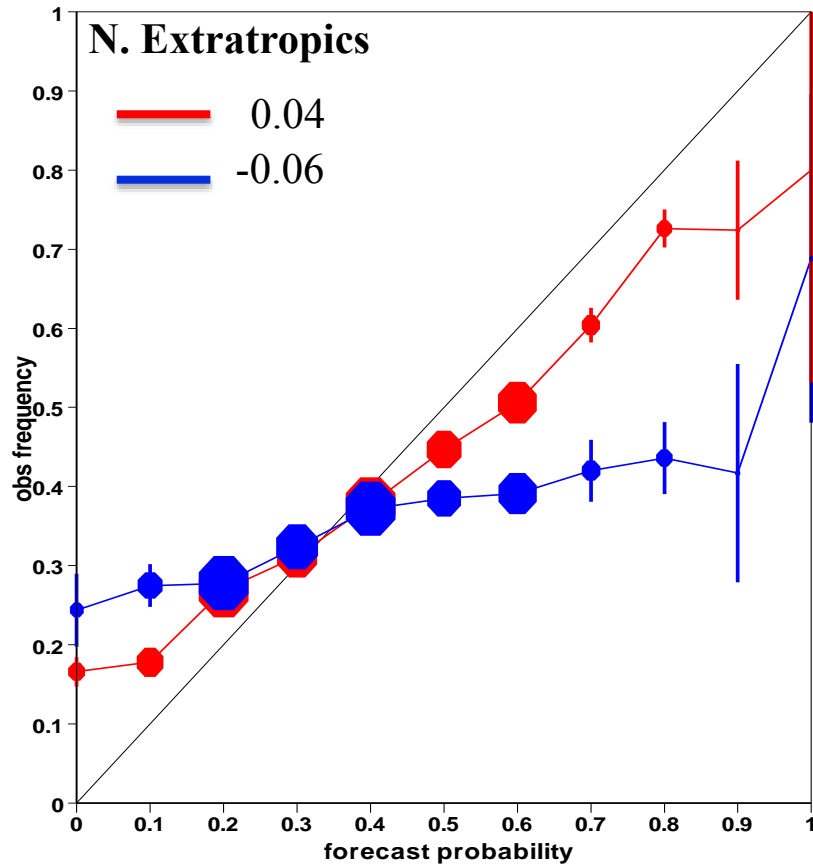


Probabilistic skill scores – NDJFMA 1989-2008

Reliability Diagram

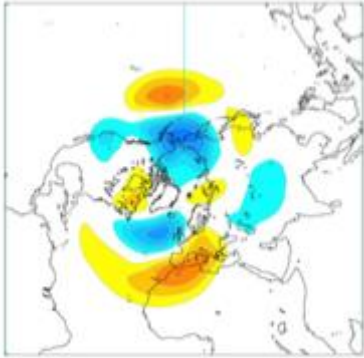
Probability of 2-m temperature in the upper tercile

Day 19-25

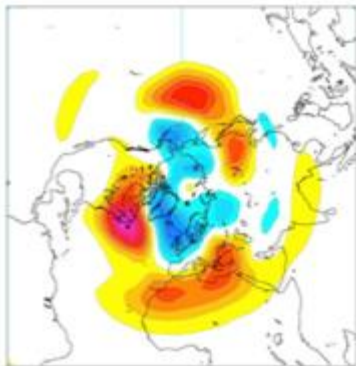


— MJO in IC — NO MJO in IC

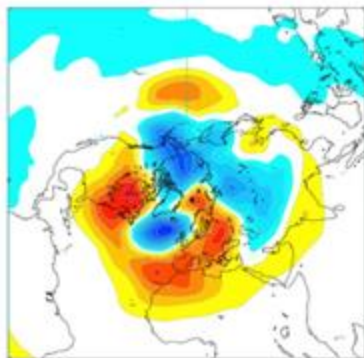
2002 MOFC hindcasts



2013 MOFC hindcasts



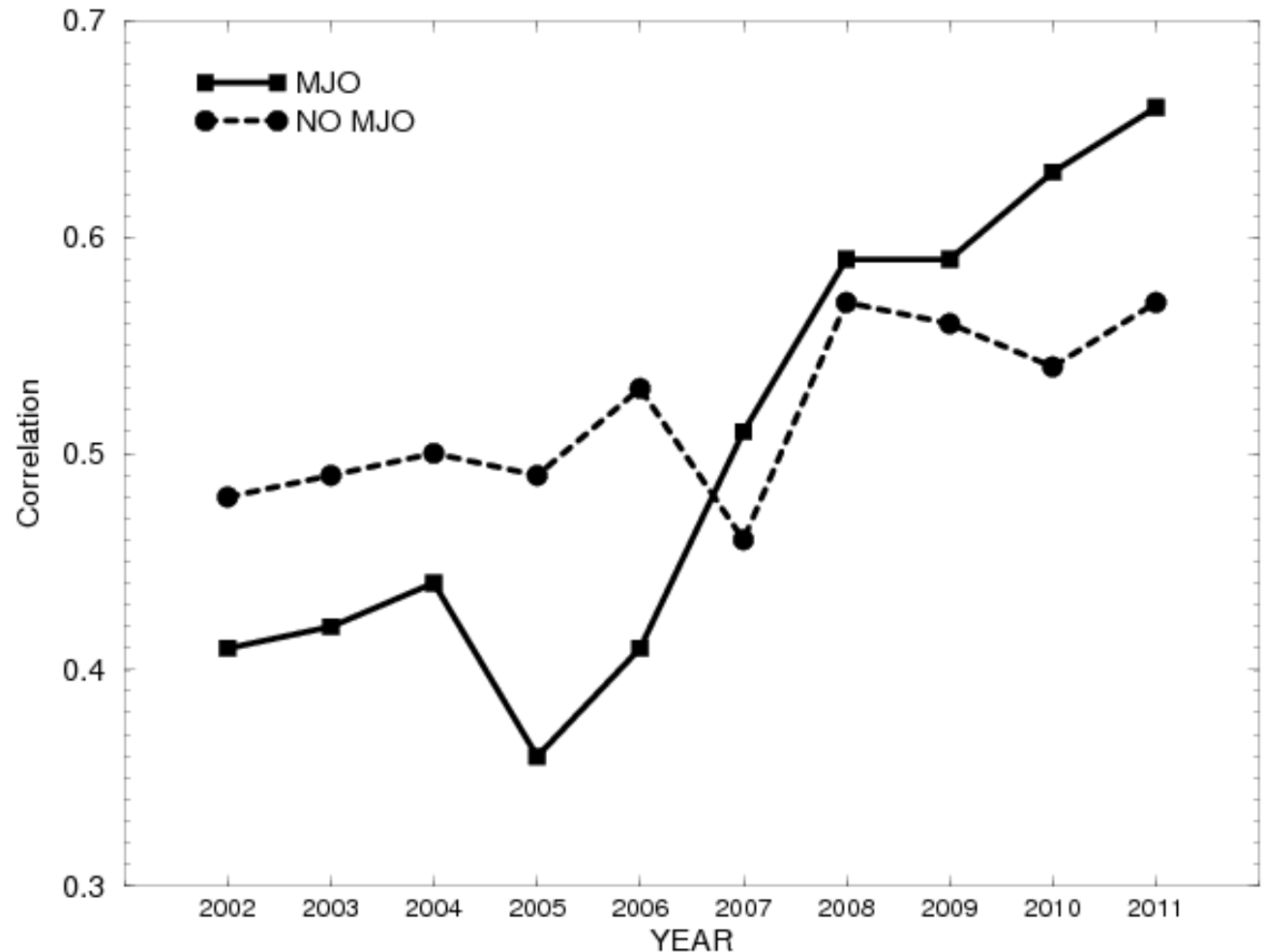
ERA Interim



MJO Teleconnections

Evolution of NAO skill scores day 19-25

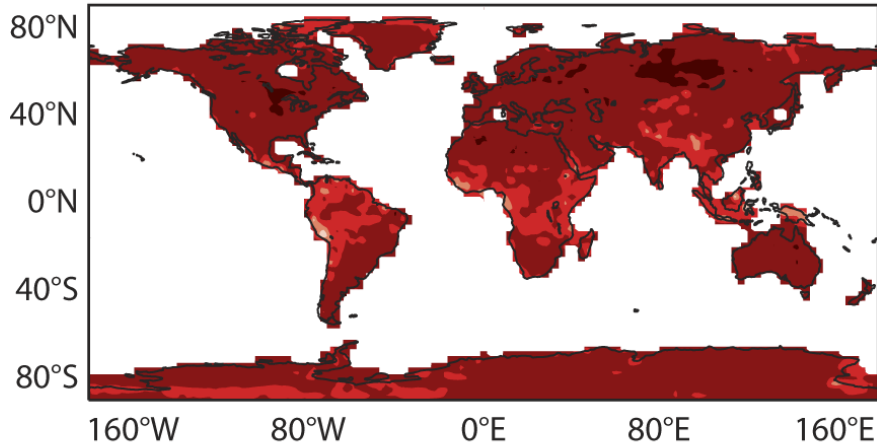
NAO index is computed as projection onto a reference pattern



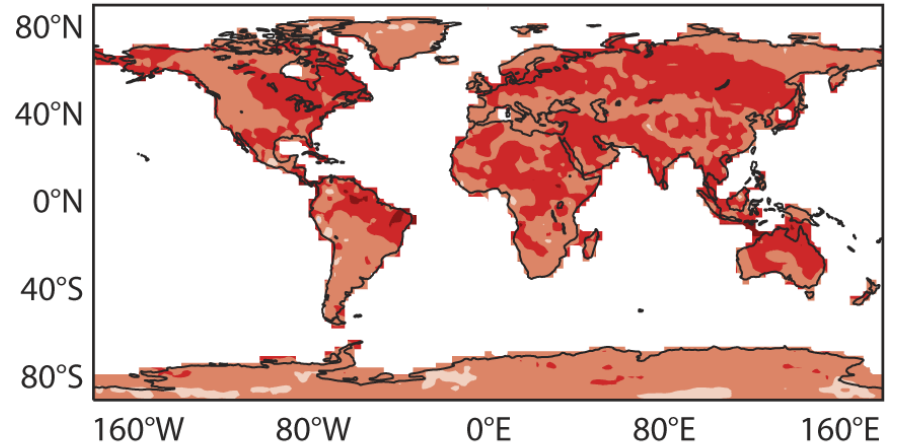
ROC for 2mt in the upper tercile

since Oct 2004

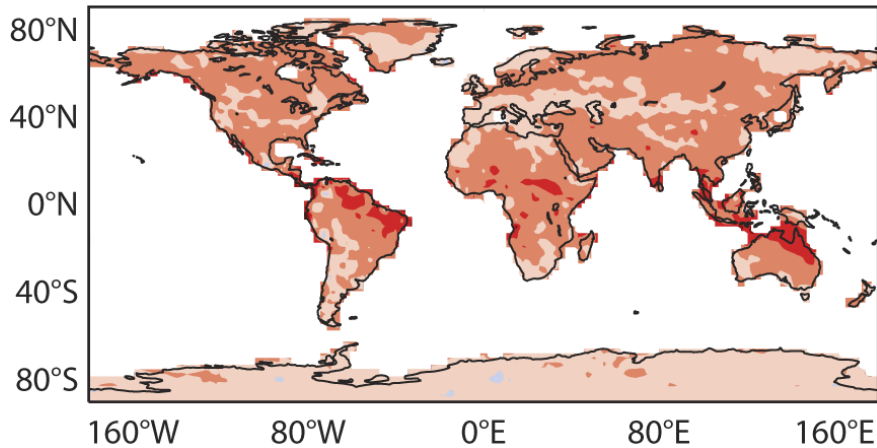
a Day 5–11



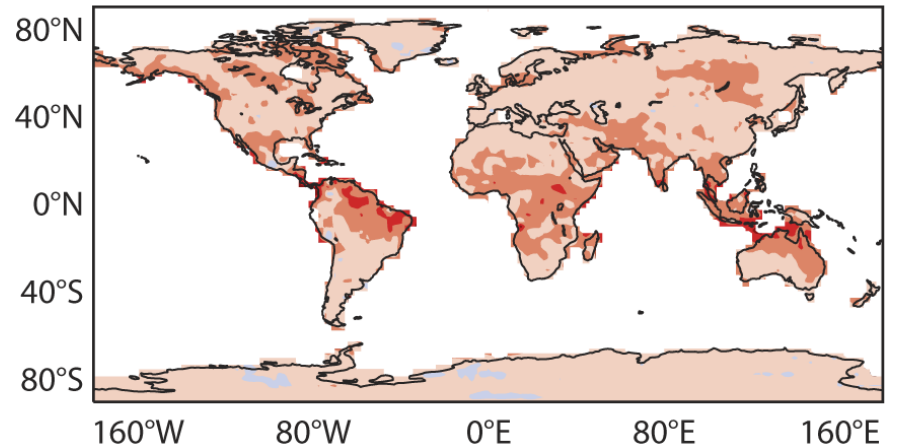
b Day 12–18



c Day 19–25



d Day 25–32

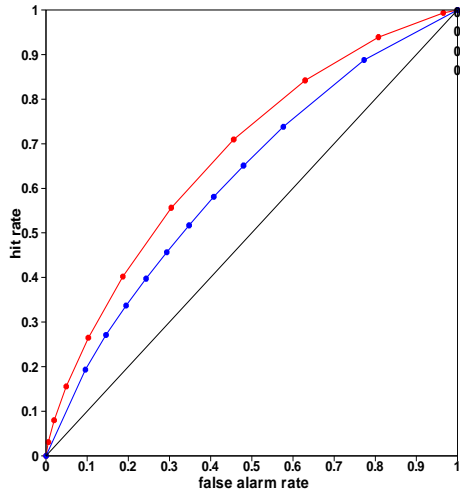


Skill of the ECMWF Monthly Forecasting System

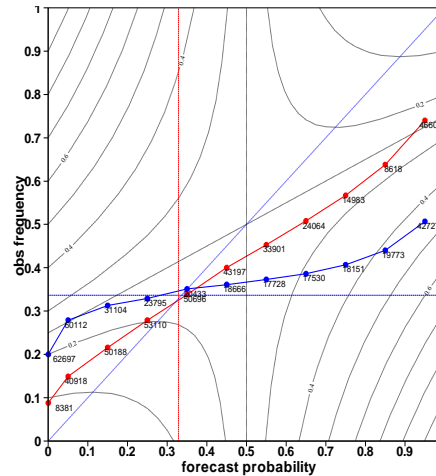
2-meter temperature in upper tercile - Day 12-18

Day
12-18

ROC score



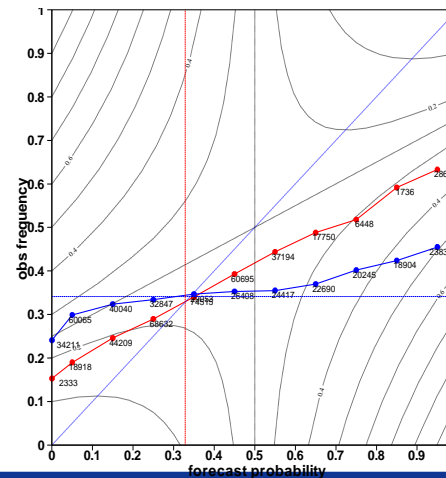
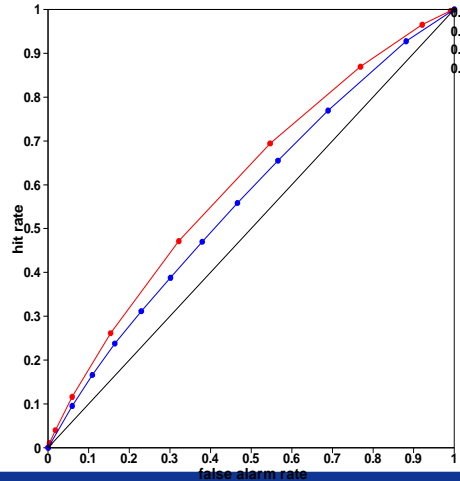
Reliability diagram



— Persistence
of day 5-11

— Monthly forecast
day 12-18

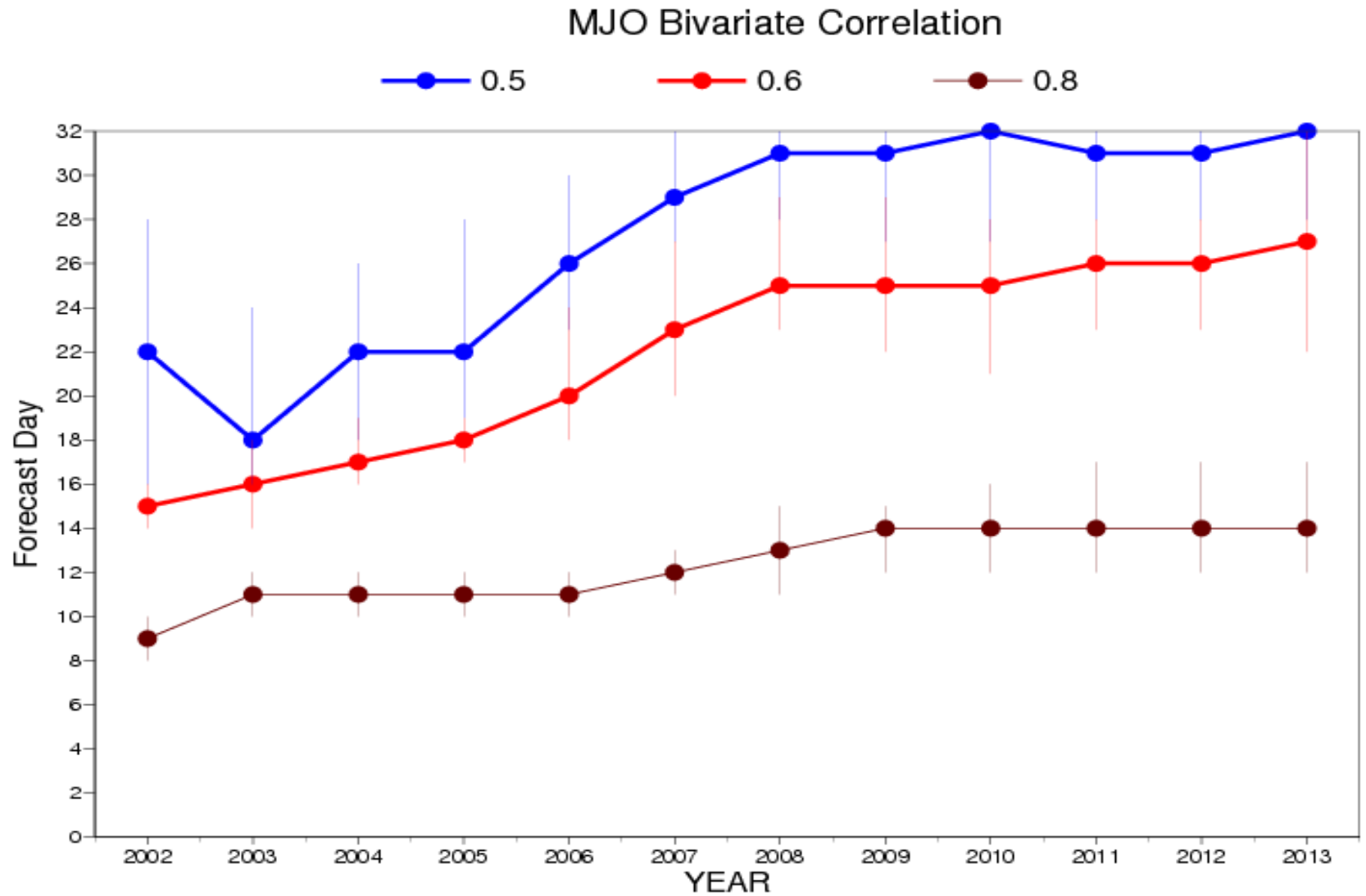
Day
19-25



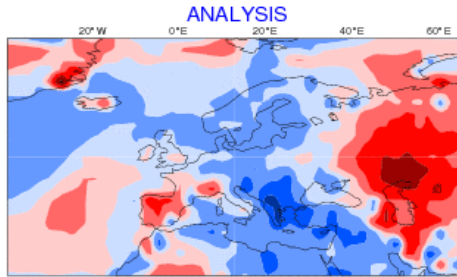
— Persistence
of day 5-18

— Monthly forecast
day 19-32

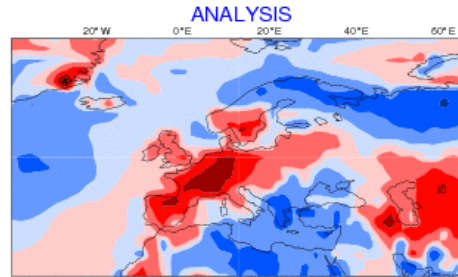
MJO skill scores



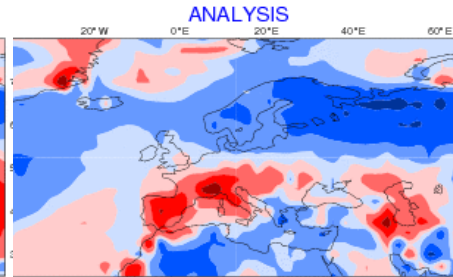
Heat wave over Central-southern Europe: 2mt weekly mean anomalies



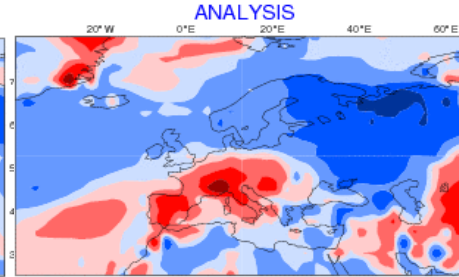
22-28 Jun



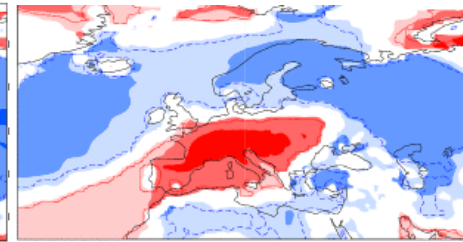
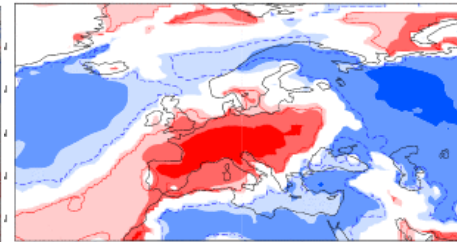
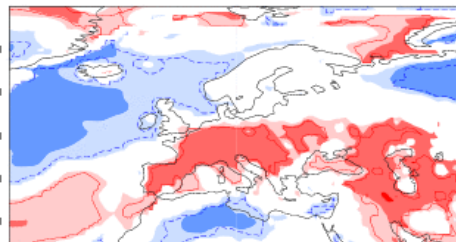
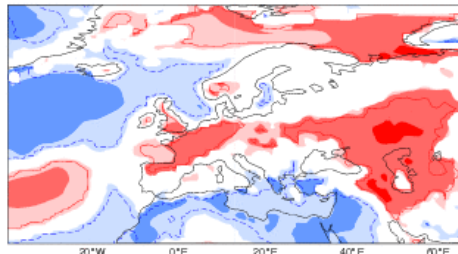
29-5 Jul



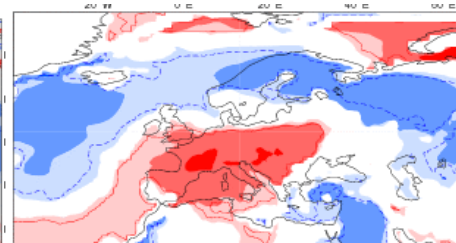
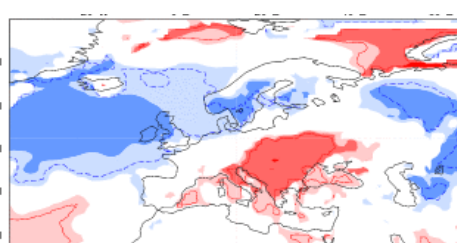
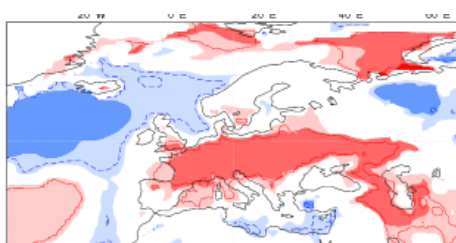
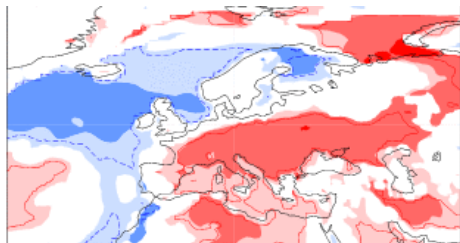
6-12 Jul



13-19 Jul



Forecasts: 12-18 days

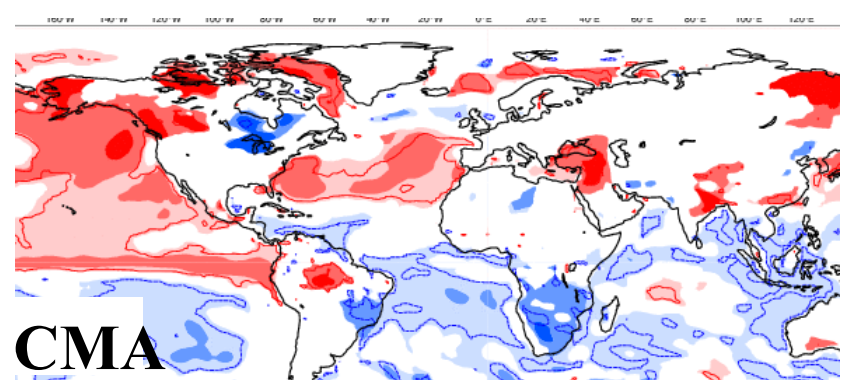
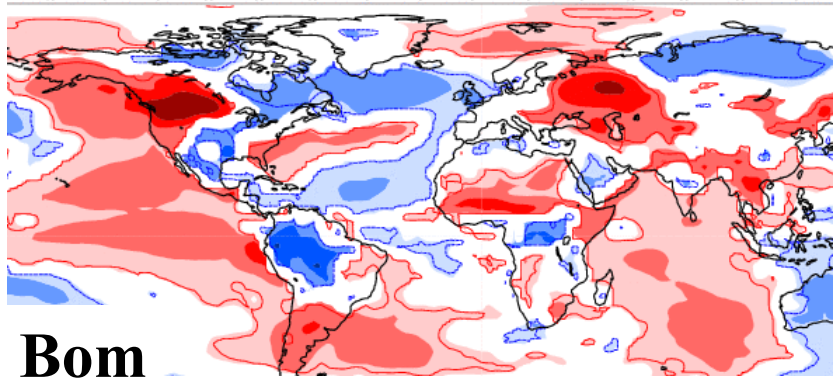
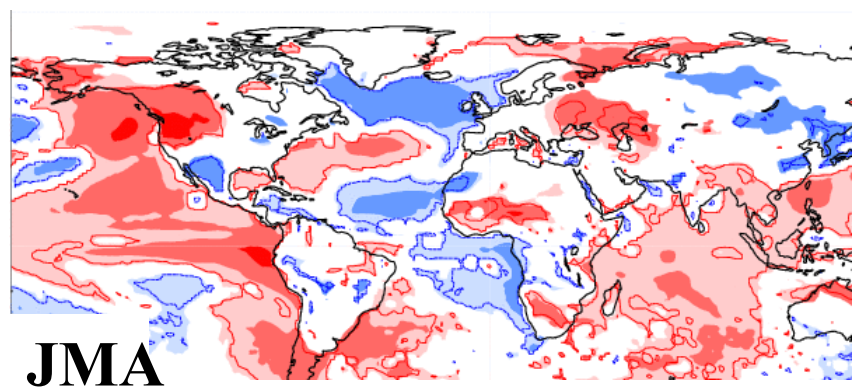
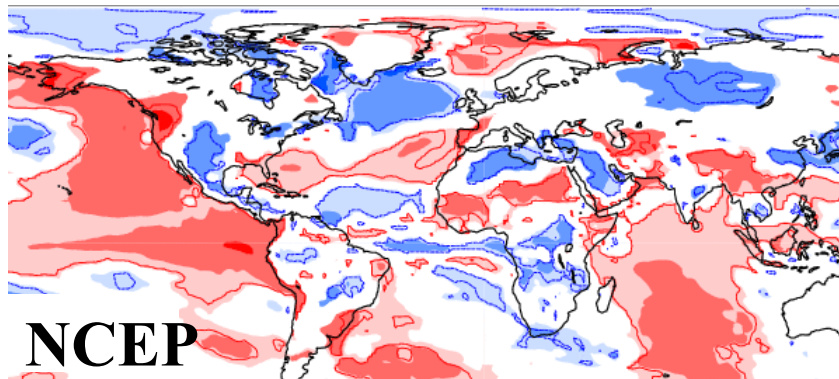
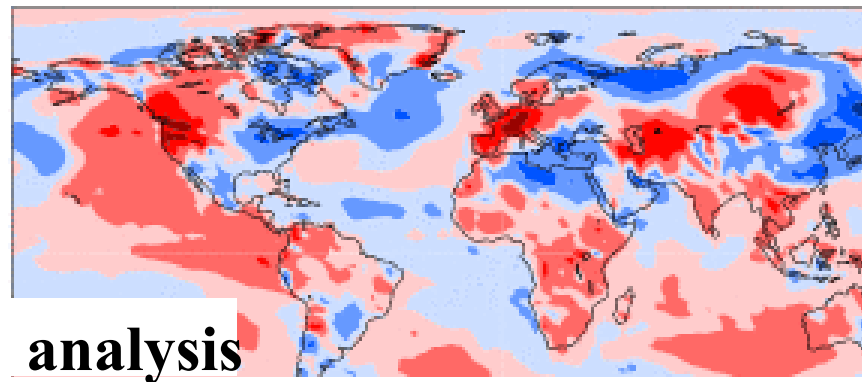
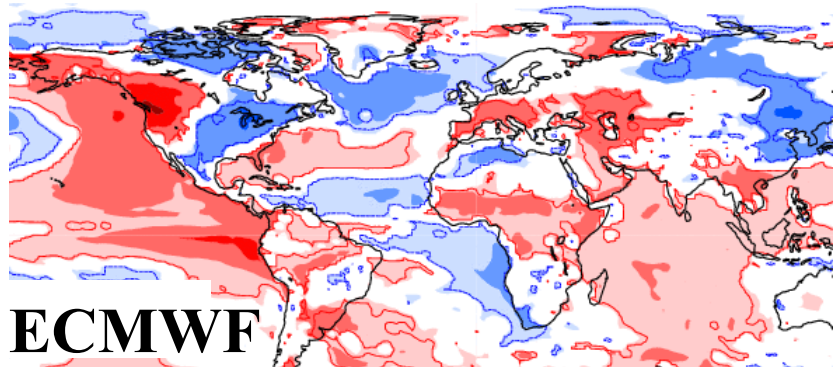


Forecasts: 19-25 days

S2S 2mt anomalies:

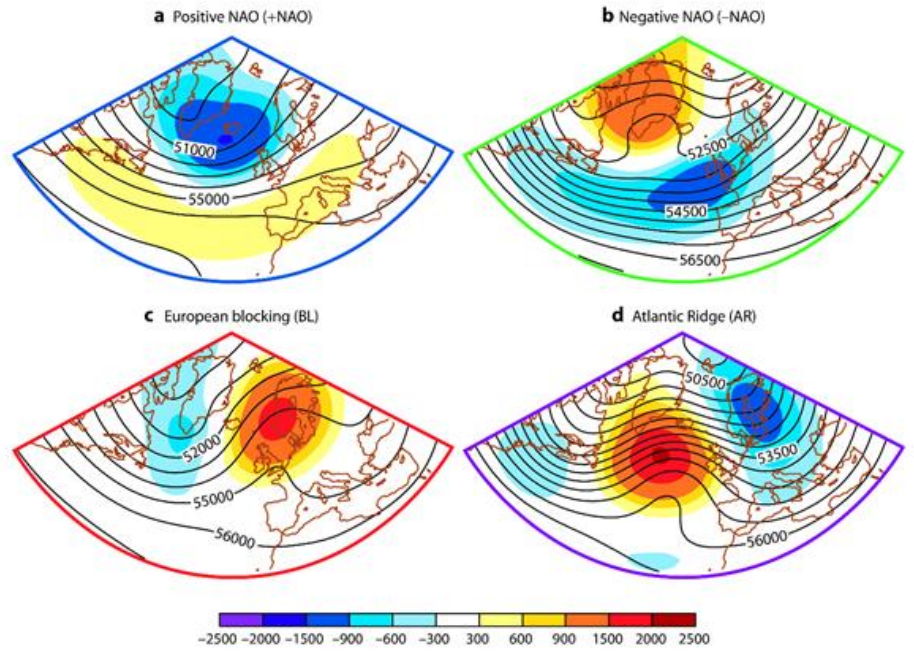
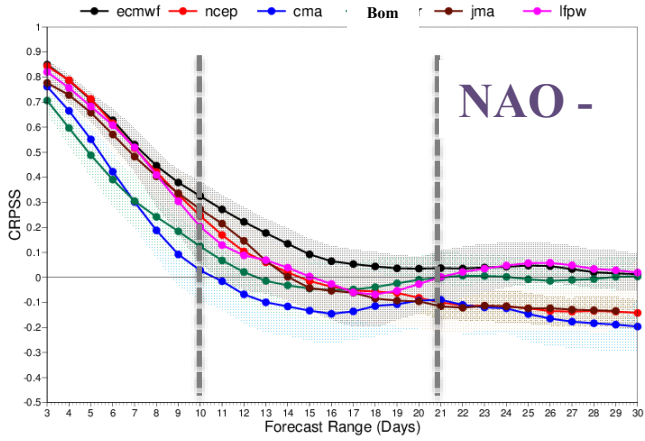
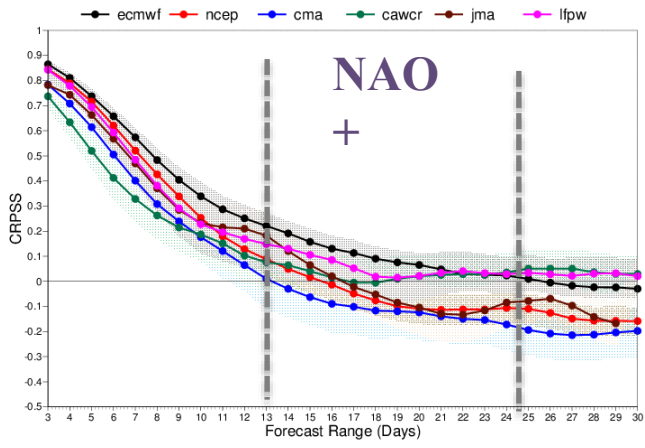


days 12-18 - verifying 29-06 to 05-07 2015

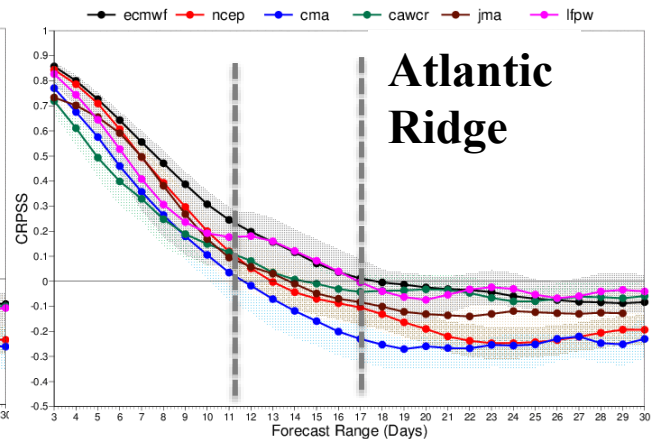
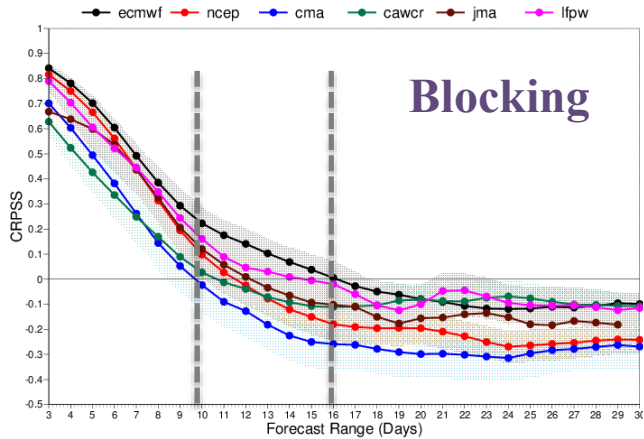


The Sub-seasonal to Seasonal (S2S) Prediction Project

- 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>



Predicting skill associated with the Euro-Atlantic Regimes:



Challenges on subseasonal predictions:

- **What are the sources of predictability at the sub-seasonal time scale?**
- **What is the main target of the sub-seasonal predictions?**
- **Why these forecasts are generally calibrated?**
- **Why these forecasts are expressed in terms of weekly averages?**
- **Why these forecasts are expressed in terms of anomalies?**
- **The subseasonal forecast skill is usually compared with?**

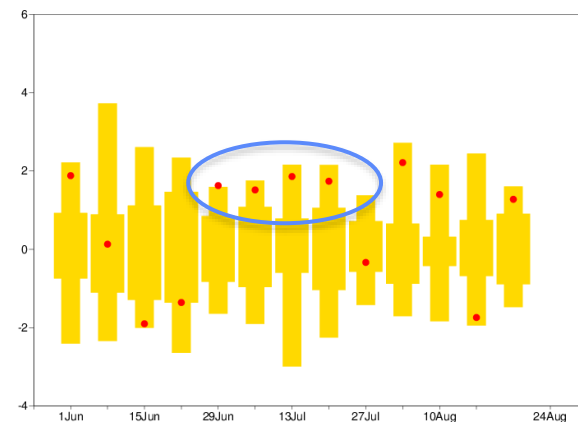
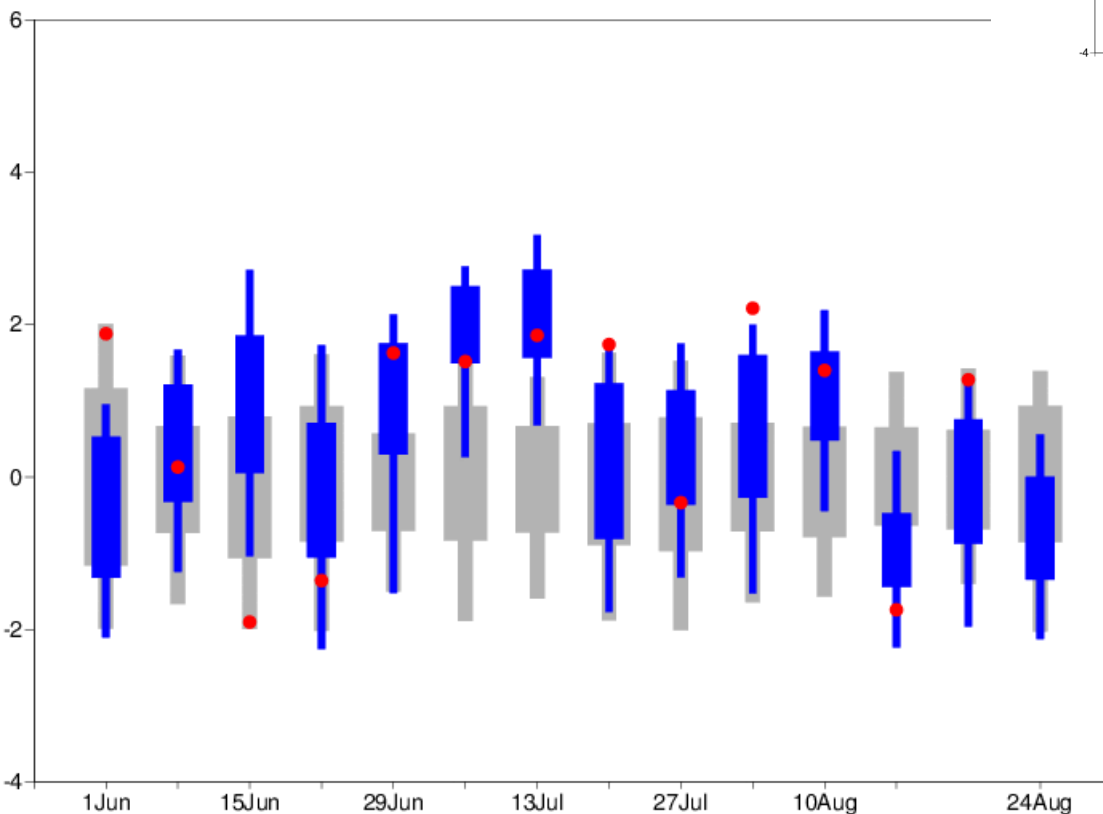
More specific to ECMWF:

- **How often the extended range ens. forecast is issued ?**
- **How long is the reforecast?**
- **What is the ensemble size of the real-time ensemble and reforecast?**

Conclusion

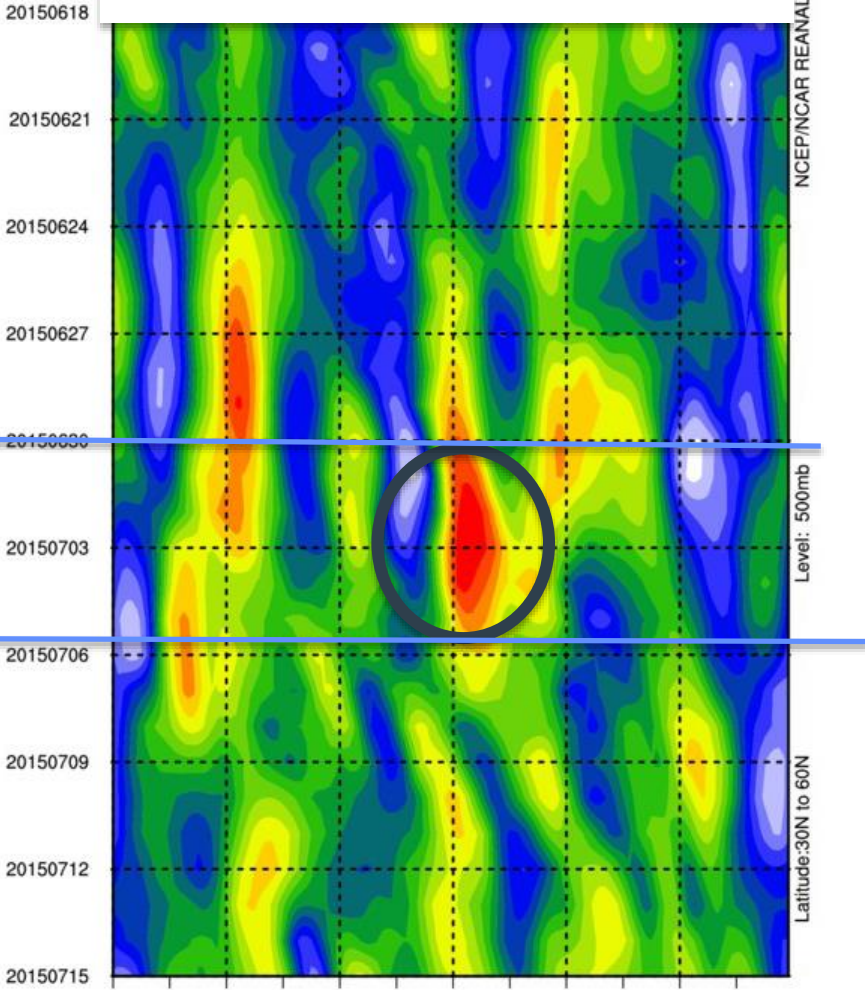
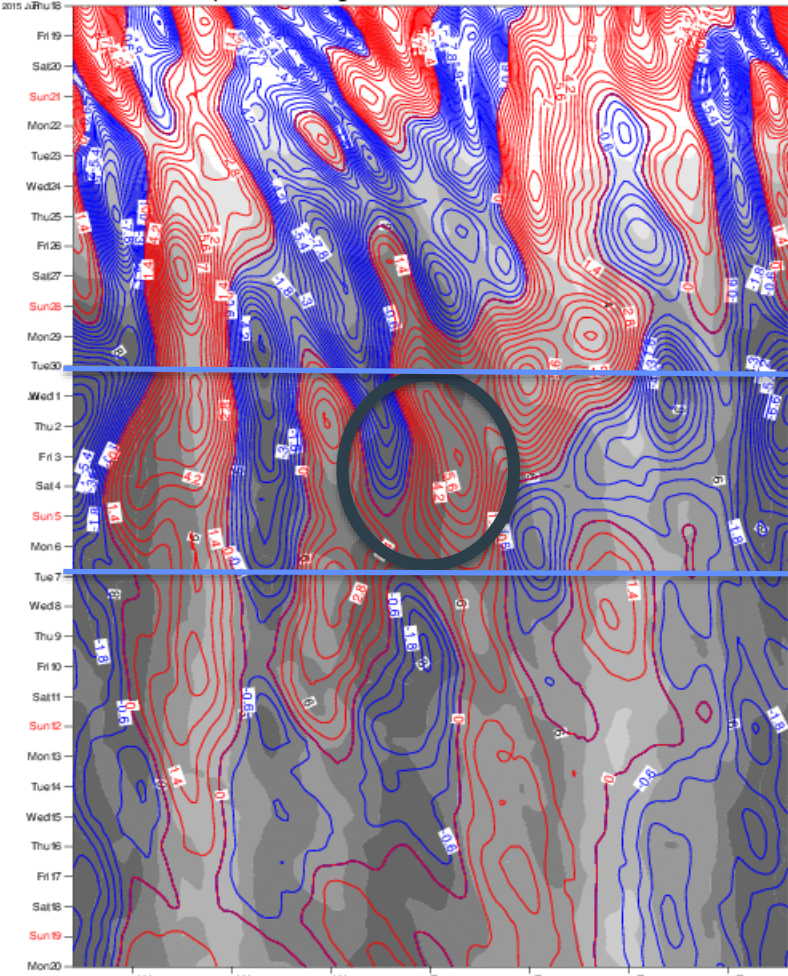
- SSTs, Soil moisture, stratospheric initial conditions and MJO are source of predictability at the intra-seasonal time scale. In particular the MJO has a significant impact on the forecast skill scores beyond day 20.
- The ENS produces forecasts for days 12-18 that are generally better than climatology 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



180 120W 60W 0 60E 120E
Longitude

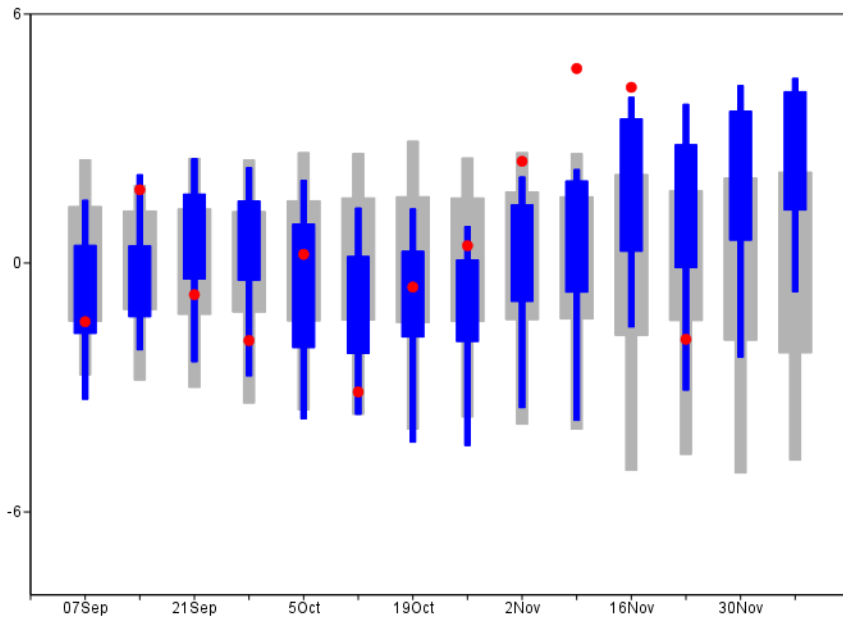


September to December 2015

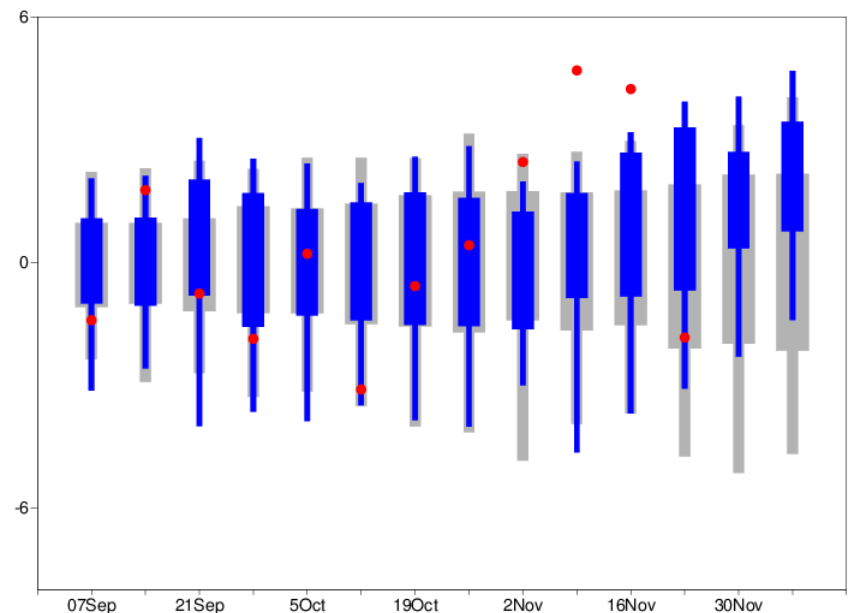
2m temp weekly anomalies

(55-45N 5-15E):

For. range 12-18 days
days



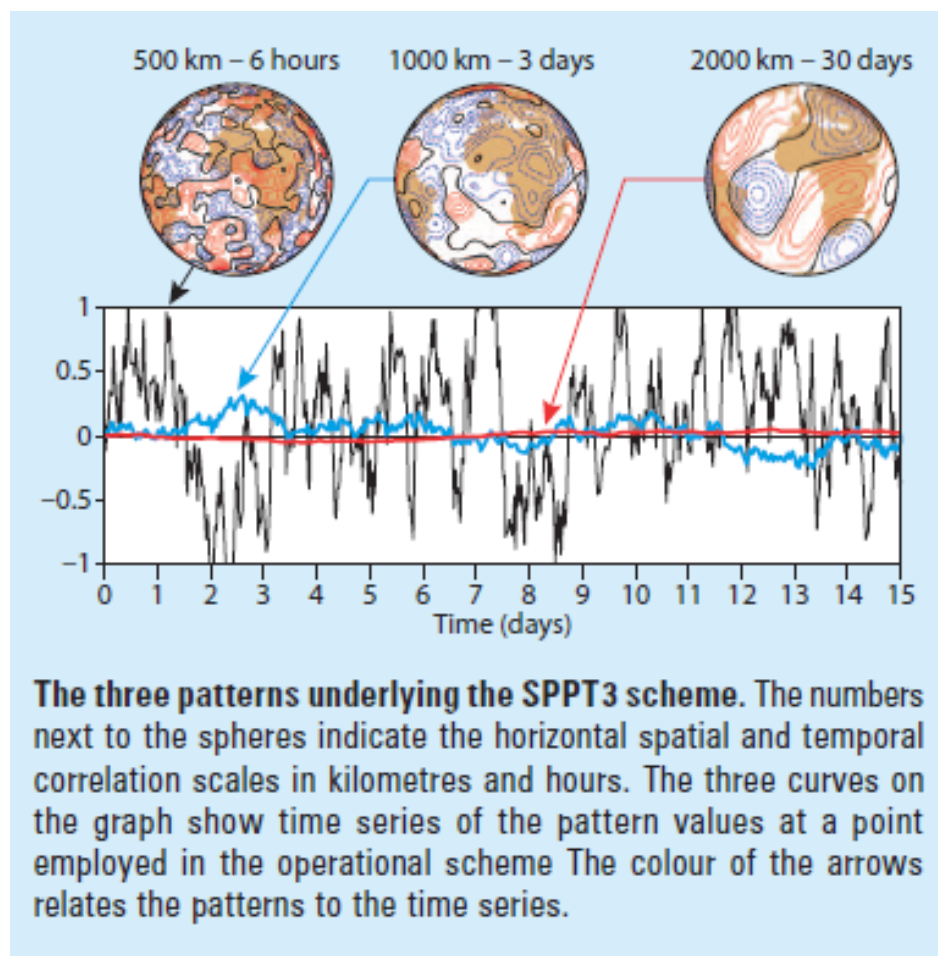
For. range 19-25
days



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



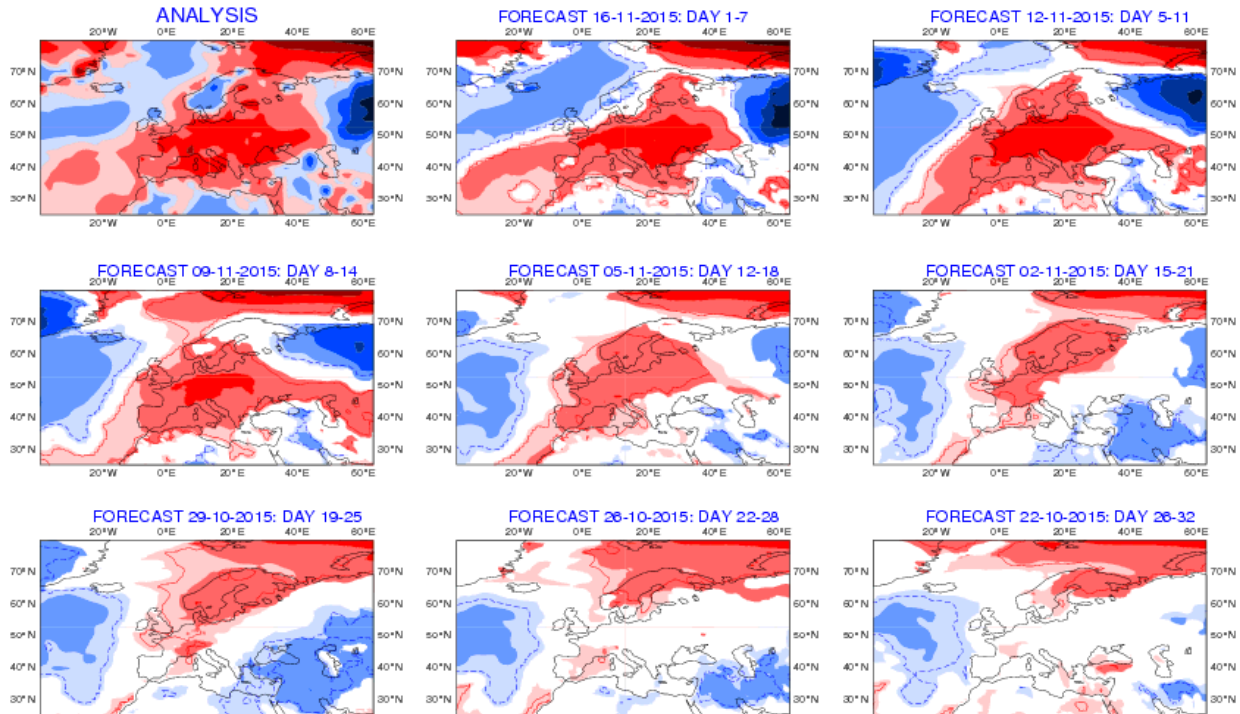
Analysis and ECMWF EPS-Monthly Forecasting System

2-metre Temperature anomaly

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

ensemble size = 51 , climate size = 660

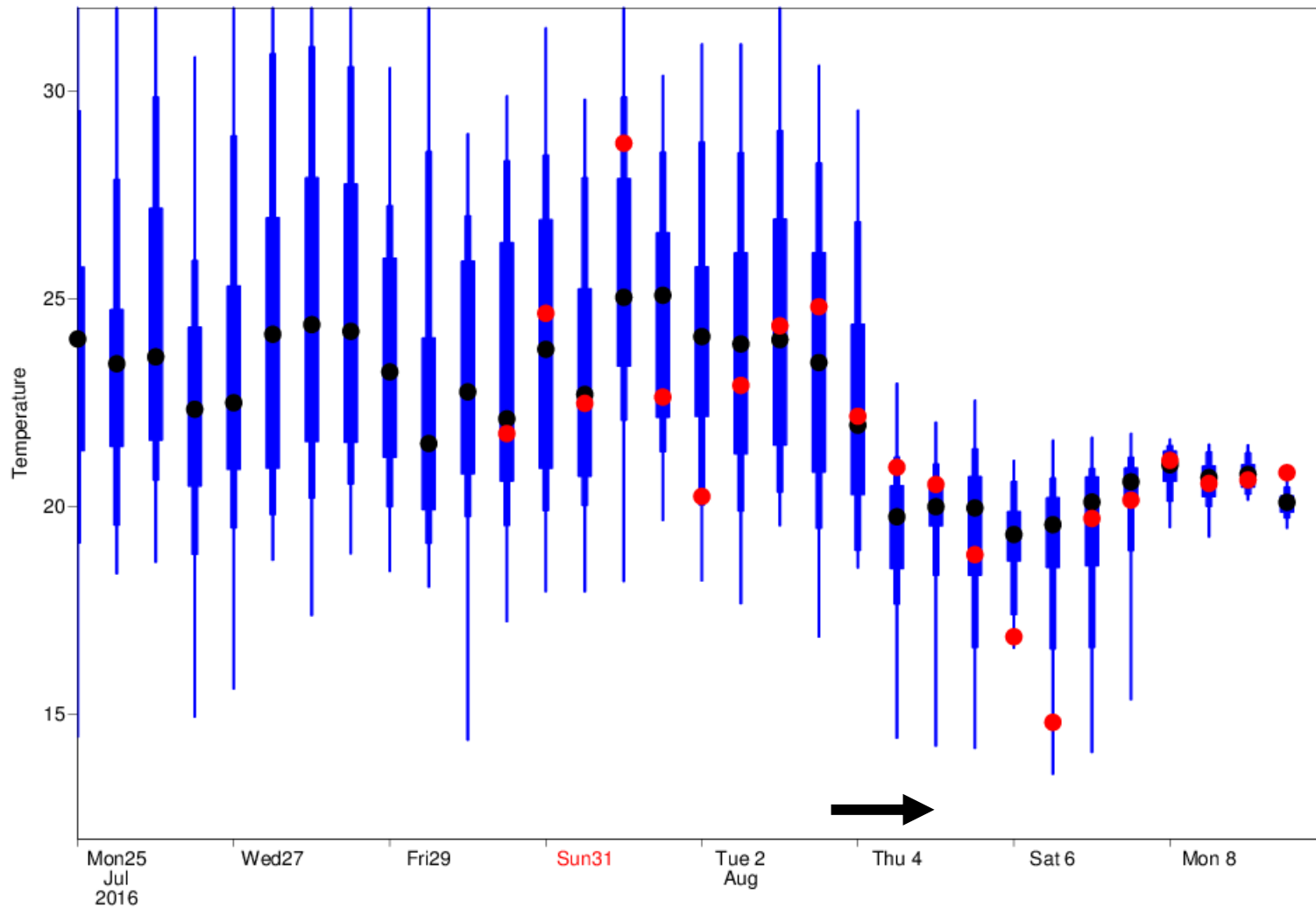
Shaded areas significant at 10% level, Contours at 1% level



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

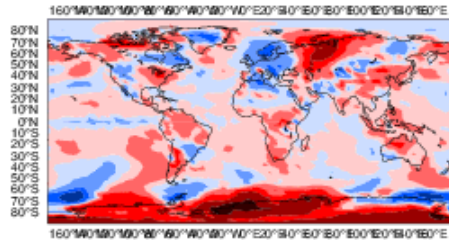
Verification period: 08-08-2016/TO/14-08-2016

ensemble size = 51 , climate size = 660

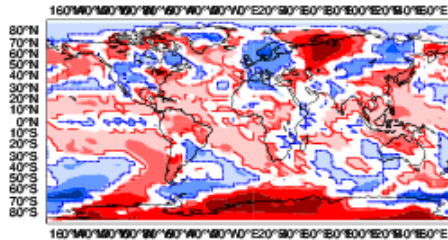
Shaded areas significant at 10% level, Contours at 1% level



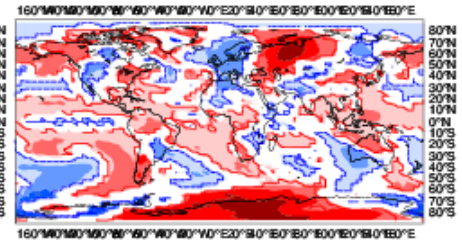
ANALYSIS



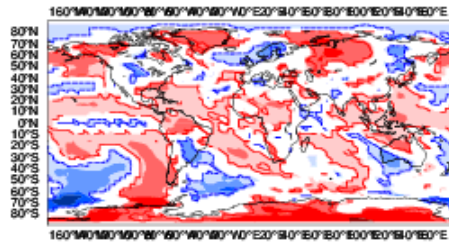
FORECAST 08-08-2016: DAY 1-7



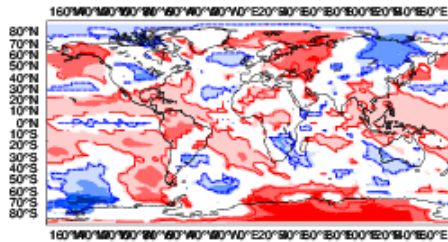
FORECAST 04-08-2016: DAY 5-11



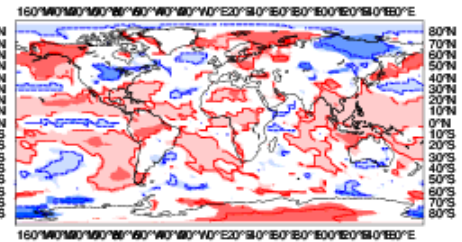
FORECAST 01-08-2016: DAY 8-14



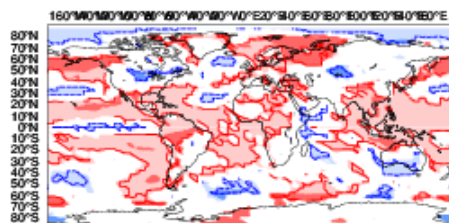
FORECAST 28-07-2016: DAY 12-18



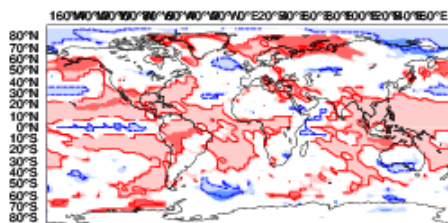
FORECAST 25-07-2016: DAY 15-21



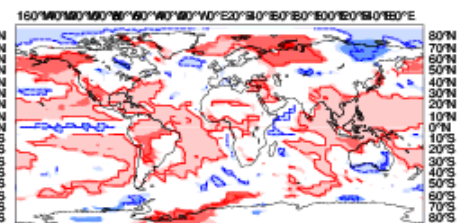
FORECAST 21-07-2016: DAY 19-25



FORECAST 18-07-2016: DAY 22-28



FORECAST 14-07-2016: DAY 26-32



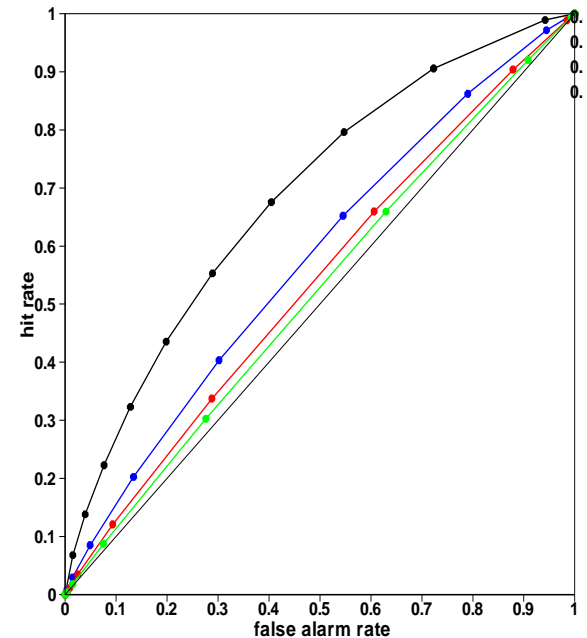
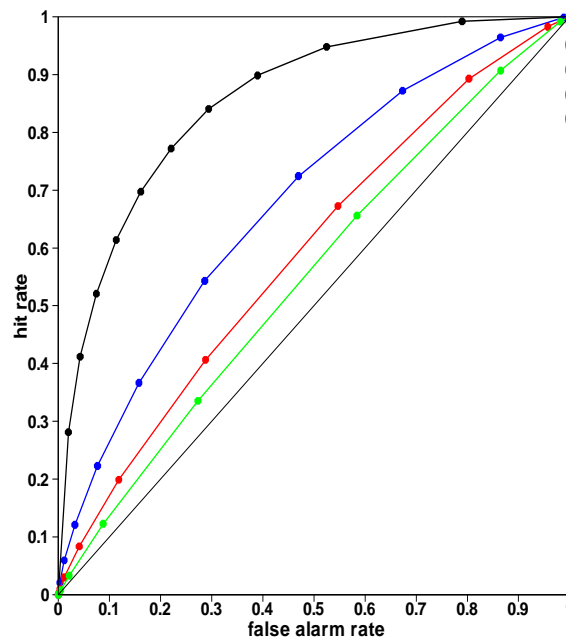
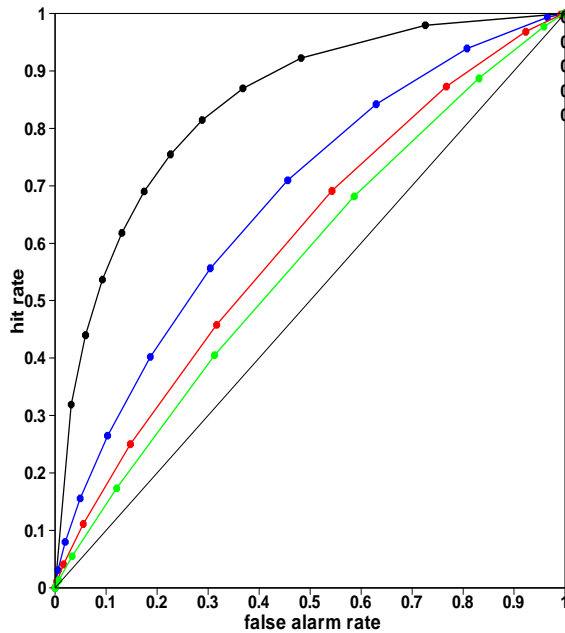
Skill of the ECMWF Monthly Forecasting System

ROC scores over the Northern extratropics

2-metre
temperature

Mean sea-level
pressure

Precipitation



Day 5-11

Day 12-18

Day 19-25

Day 26-32