The ECMWF Extended range forecasts

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The operational forecasting system

- High resolution forecast: twice per day
  16 km 91-level, to 10 days ahead

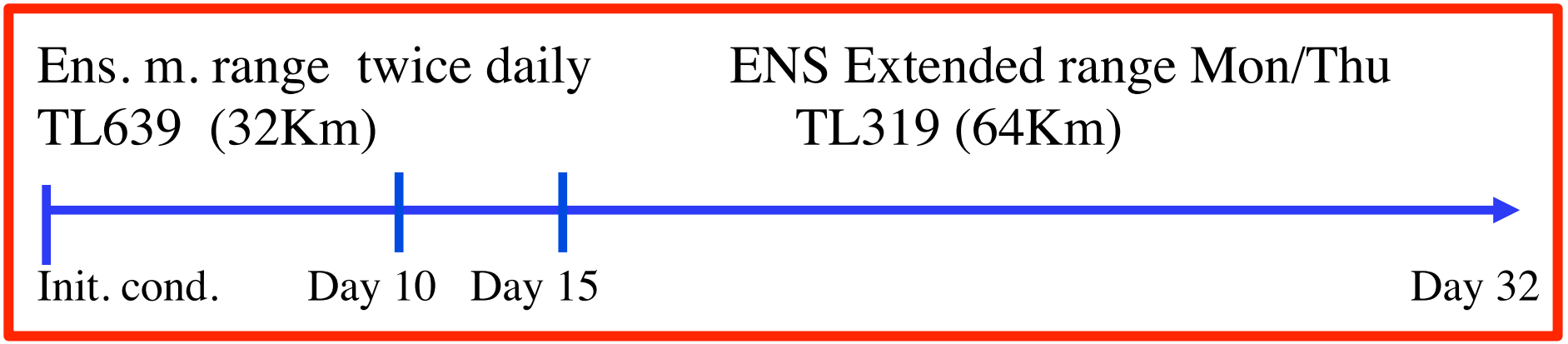
- Ensemble Prediction System (ENS): twice daily
  51 members, 30/60 km 62-level, to 15 days ahead

- **Extended range forecasts /ENS extension:**

  twice a week (Mon/Thursdays)
  51 members, 32/64 km 91 levels, to 1 month ahead

- Long range forecasts: once a month (coupled to ocean model)
  51 members, ~80 km 91 levels, to 7 months ahead

Extended range forecast /ENS extension



Atmosphere

Initial uncertainties T42L91 SVs+ T399L137 EDA perturbations

Model uncertainties Stochastic physics (SPPT and SKEB schemes).

The central analysis is the TL1279L137 4DVAR coupled to wave model (WAM) every time step

Ocean

NEMO (about 1 degree resolution) coupled to IFS every 3 hours. 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**

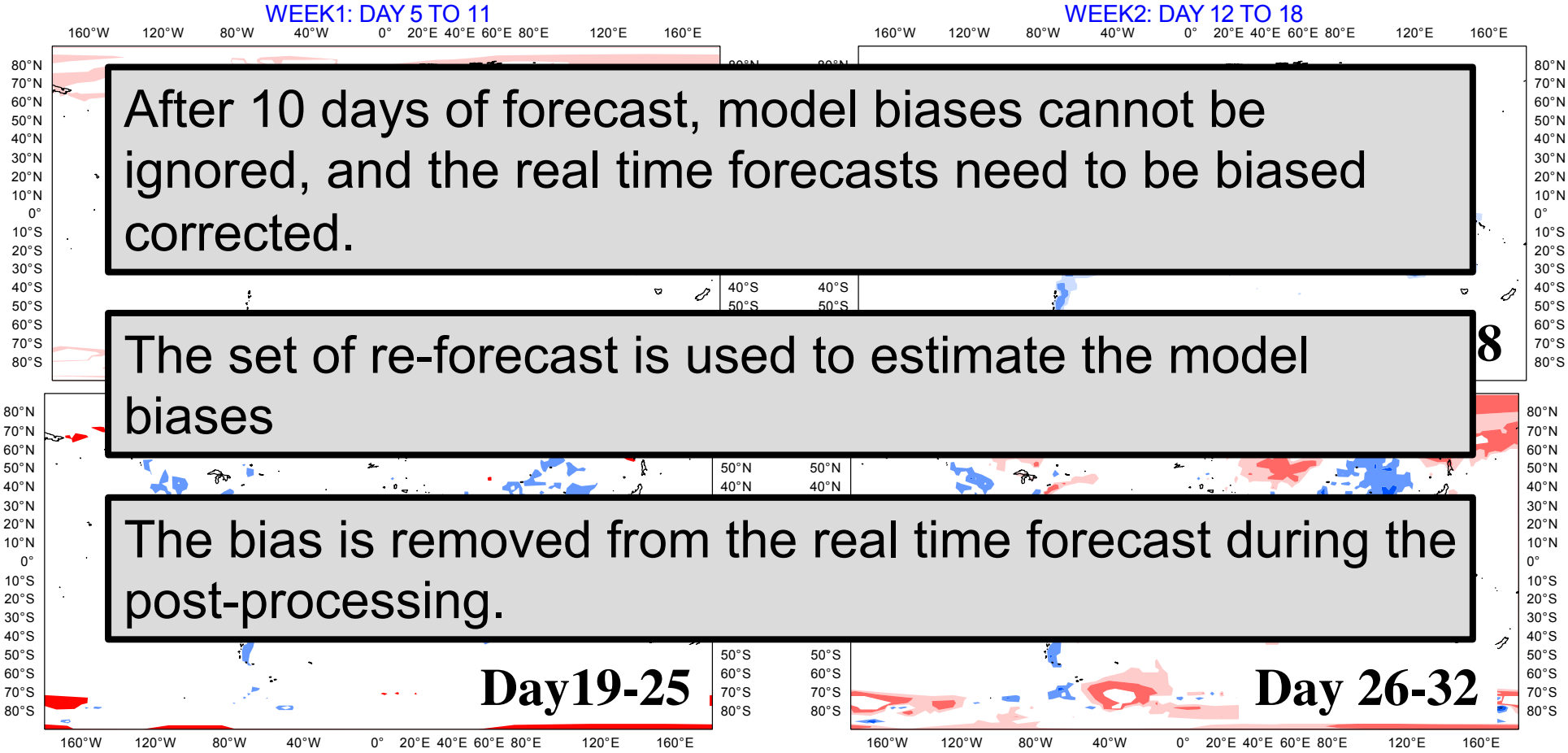
- **A set of re-forecasts covering the most recent 20 years period**
  - the same configuration of the real time forecasts
  - 5-member ensemble integrated at the same day and same month as the real-time time forecast
  - It runs once every week
  - Used to estimate the model drift

Model Bias:

ECMWF Monthly Forecasting System
MODEL BIAS: 2m Temperature
Forecast start reference is 05/03/1991-2008
ensemble size = 5

WEEK1-4

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

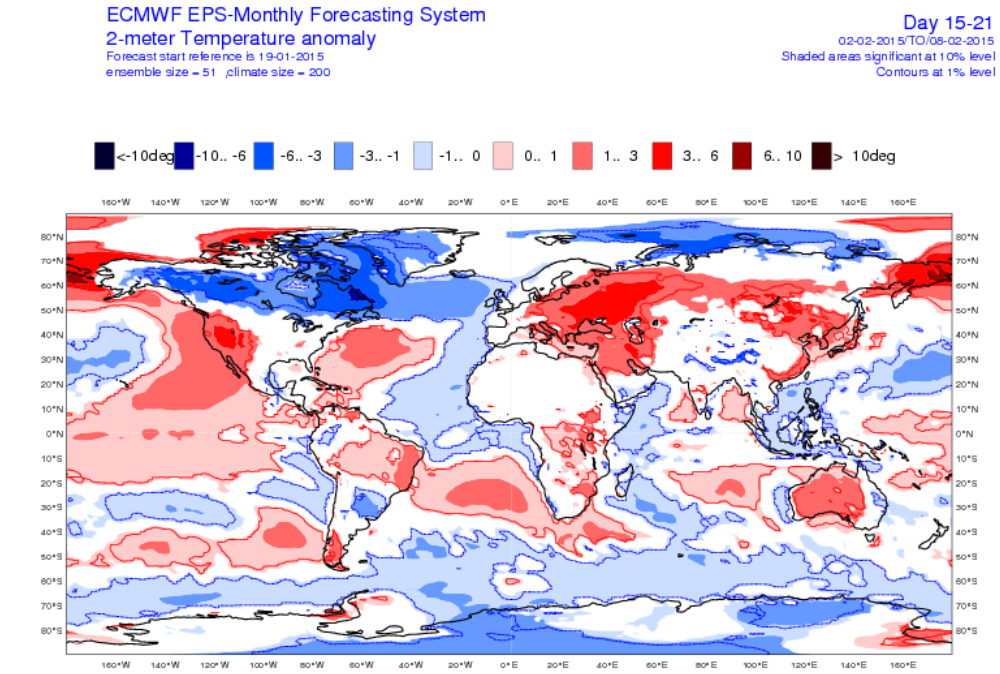


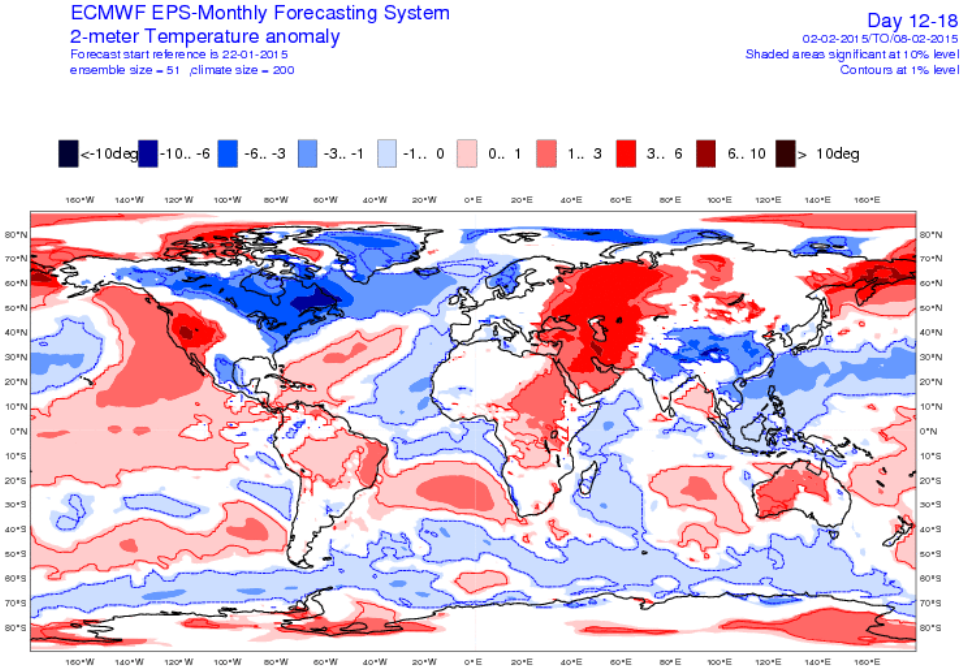
After 10 days of forecast, model biases cannot be ignored, and the real time forecasts need to be biased corrected.

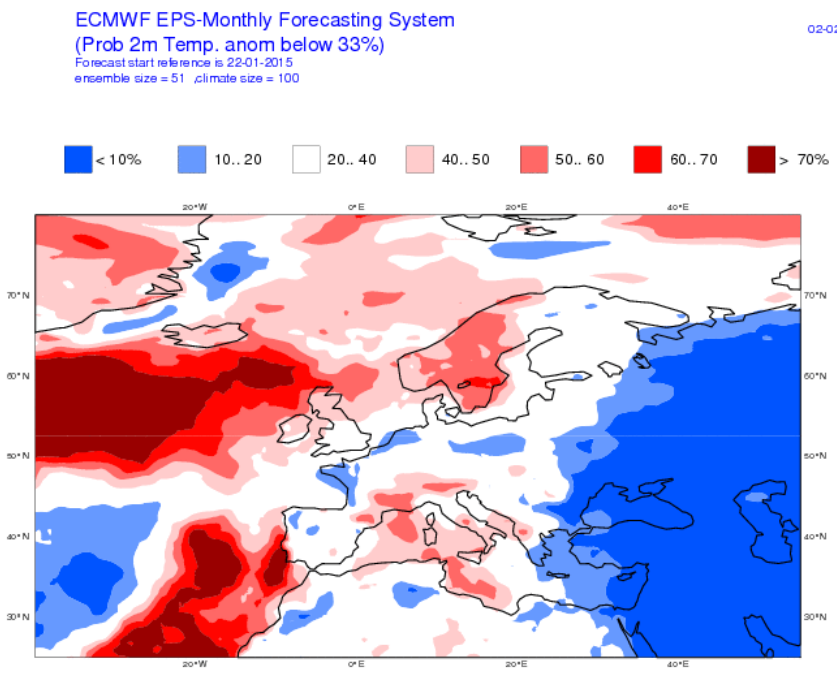
The set of re-forecast is used to estimate the model biases

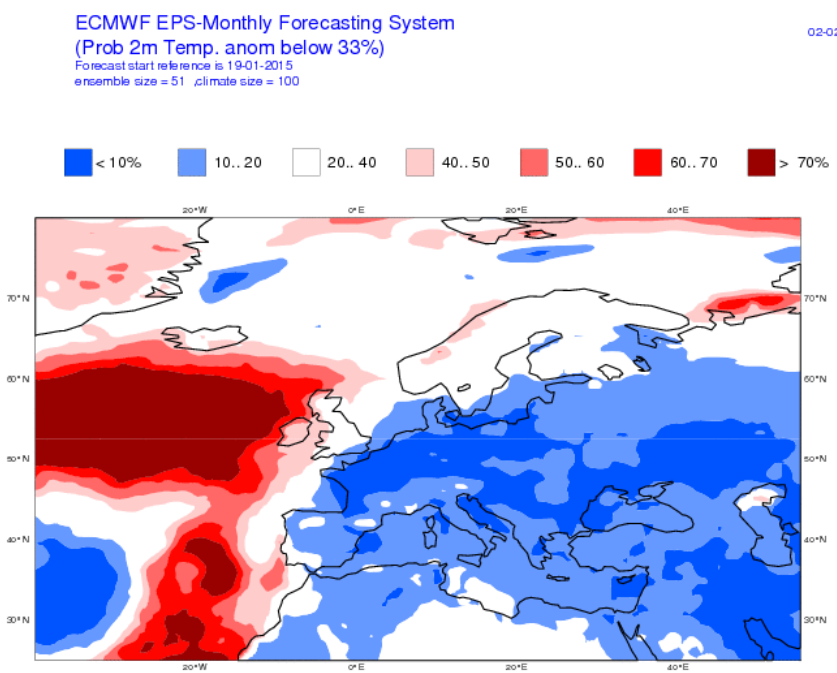
The bias is removed from the real time forecast during the post-processing.

Weekly mean anomalies





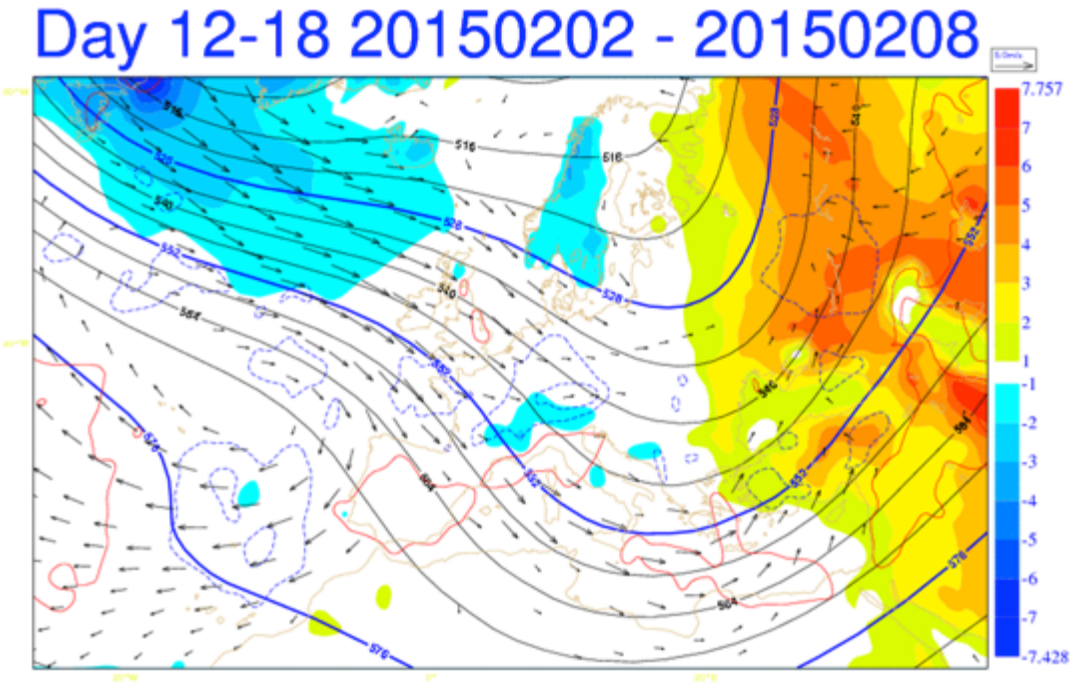


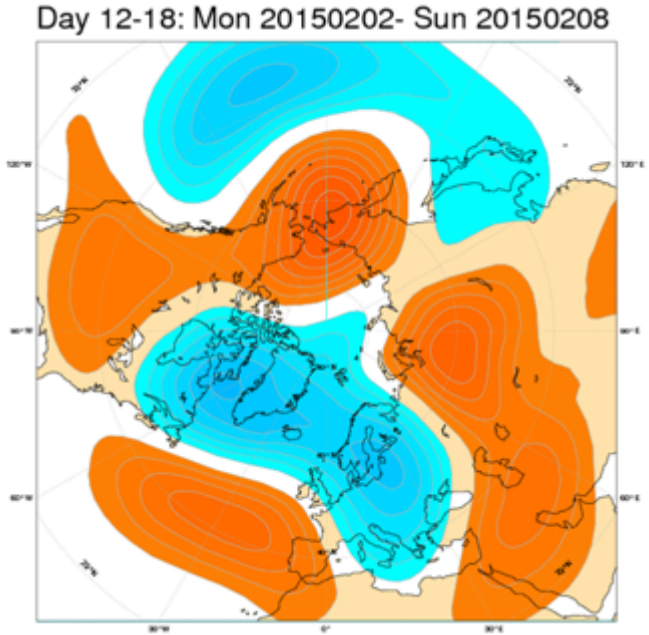


Probabilities for weekly mean anomalies:

ECMWF

Weekly mean multiparameter outlook:





Bridging the gap between seasonal forecasting and NWP

Sources of predictability for the extended forecasts :

- **Land Surface conditions: Snow cover, Soil Moisture**

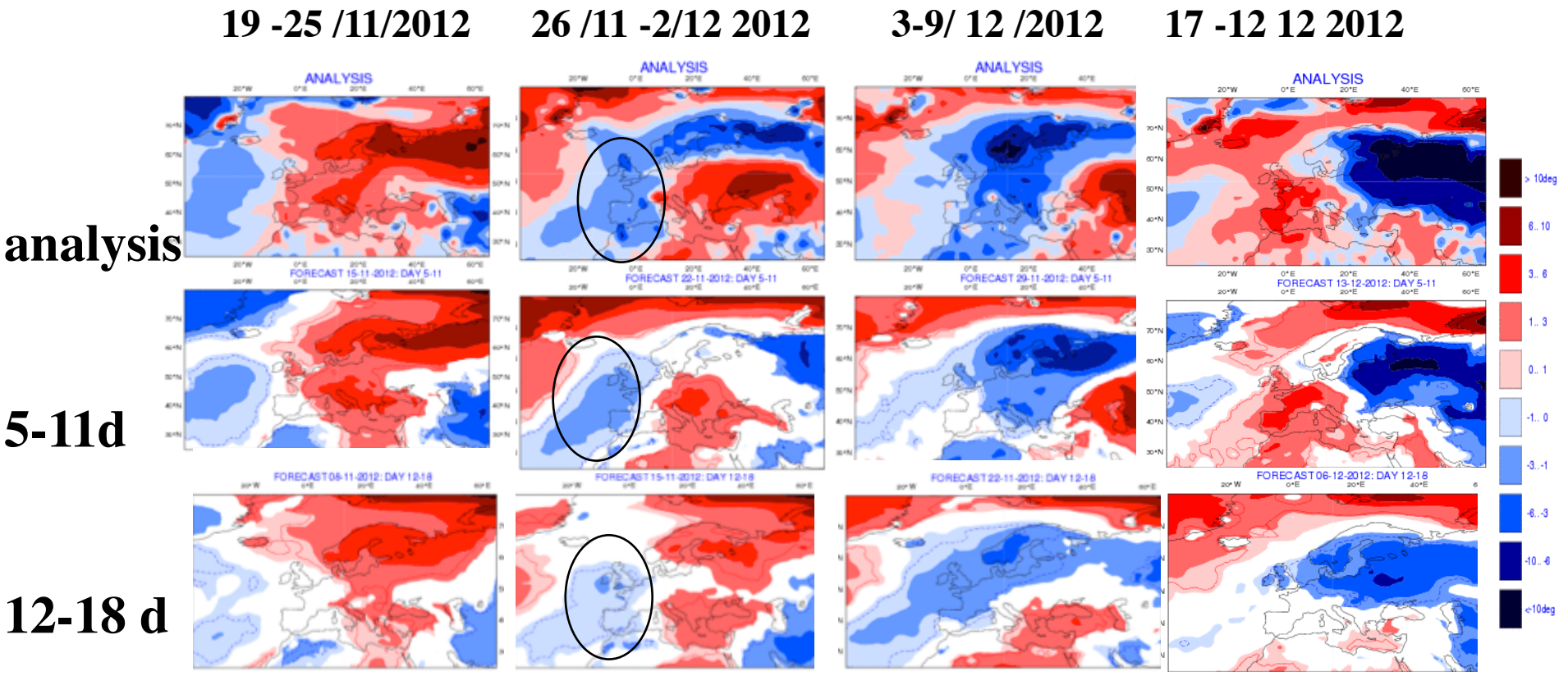
- **Ocean conditions: Sea surface temperature, Sea ice**

- **Stratospheric Initial conditions**

- **The Madden-Julian oscillation**

- **Atmospheric dynamical processes (Rossby wave propagations, weather regimes…)**

Cold spell over Europe Nov-Dec 2012

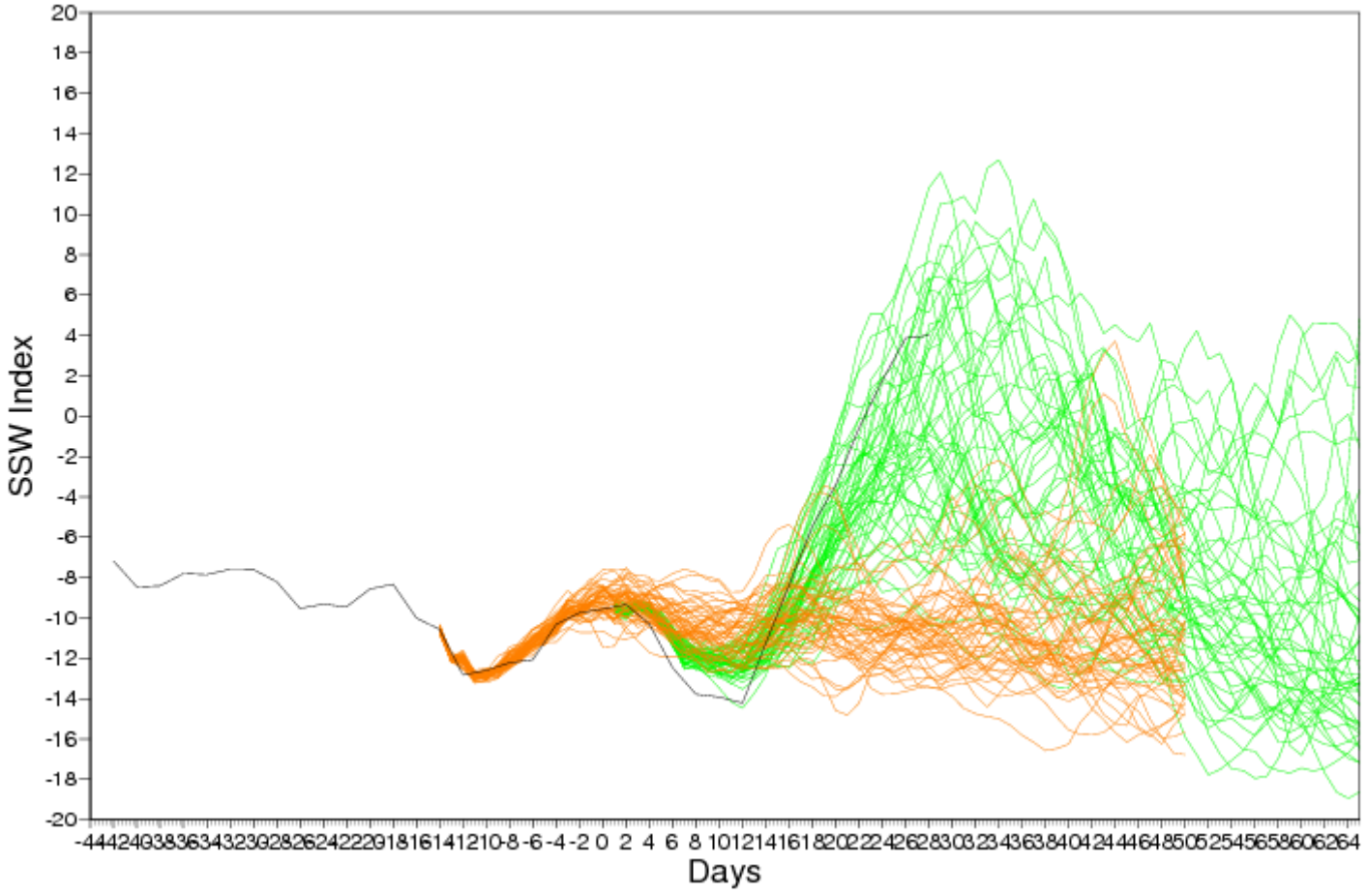


Cold Weather over Europe: SSW Index

Forecast starting on :

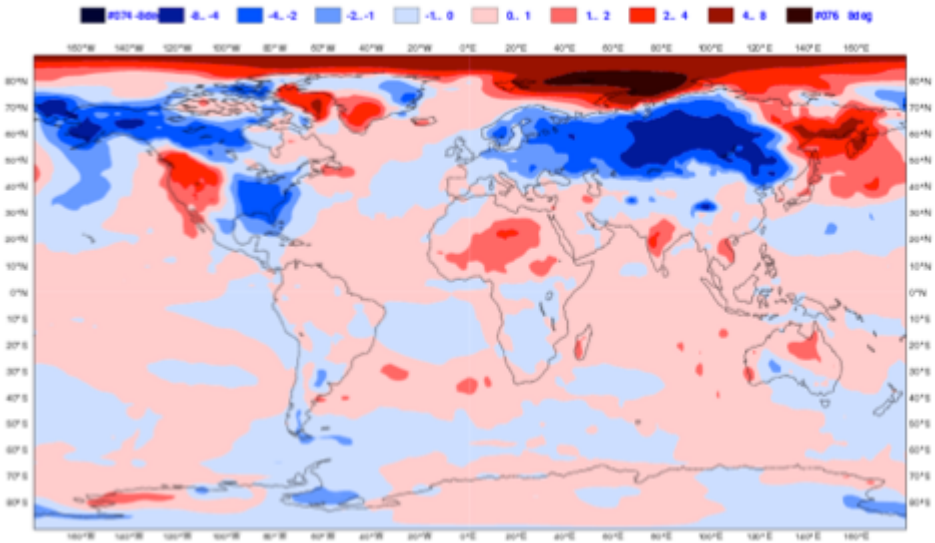
22/11/2012

15/11/2012

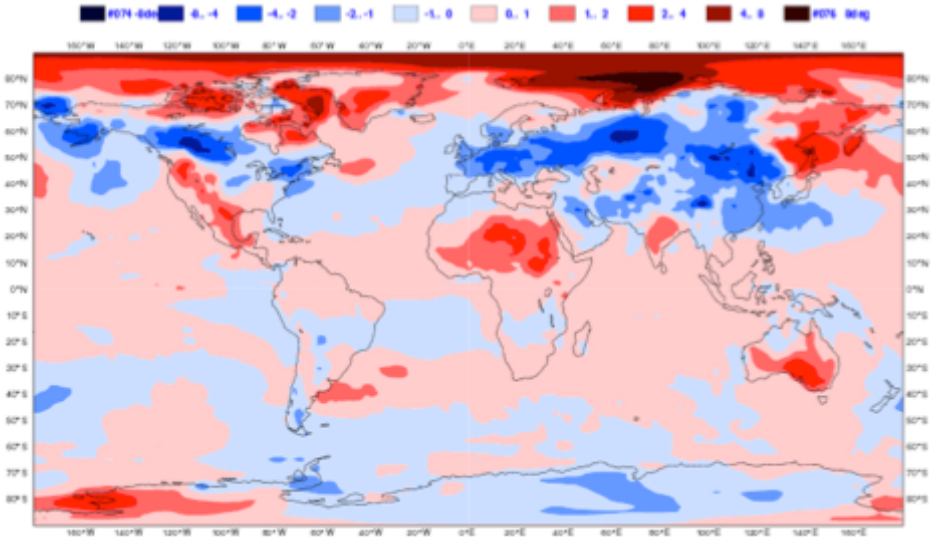


Cold Weather over Europe
SSW Index - Forecast starting on 22/11/2012

Strong SSW



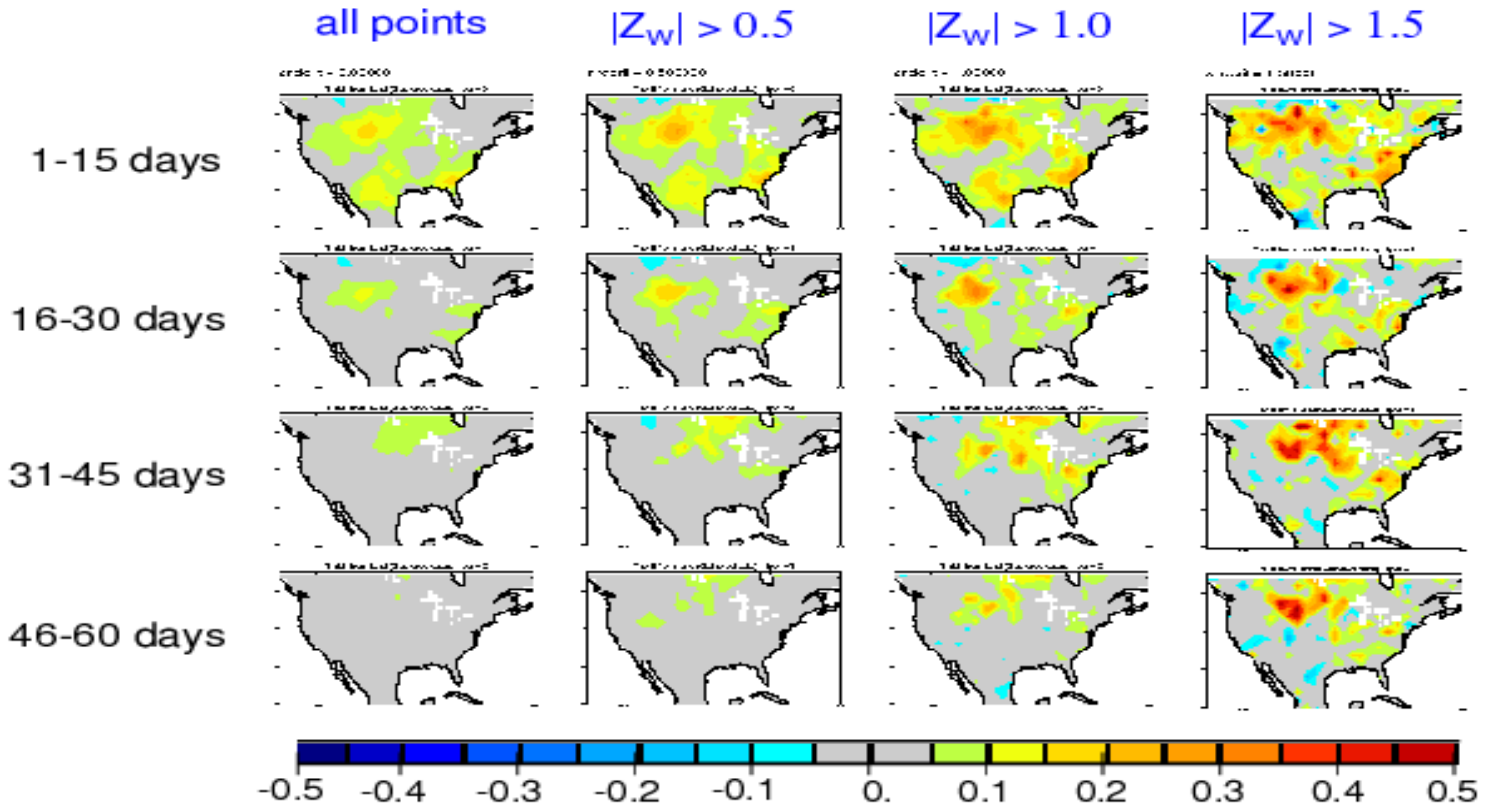
Weak SSW



ECMWF

Impact of soil moisture:

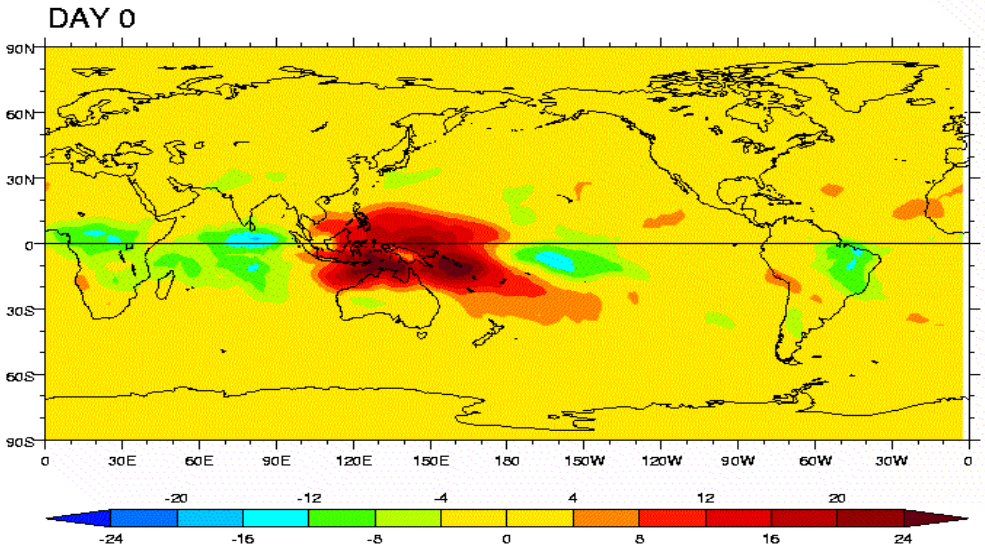
Temperature forecasts: Increase in skill due to land initialization (JJA)
(conditioned on Z-score of initial soil moisture anomaly)



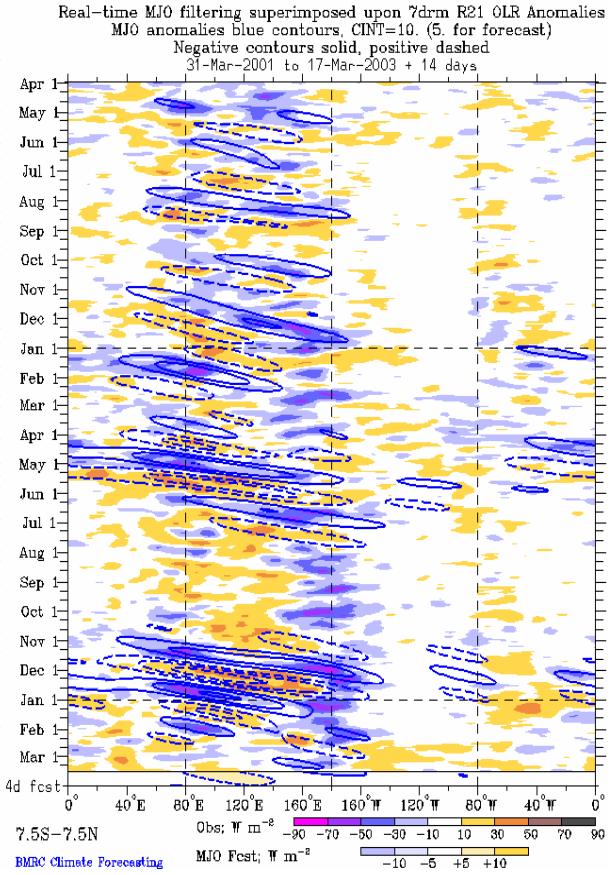
Koster et al, GRL 2010

The Madden Julian Oscillation (MJO)

MJO life cycle

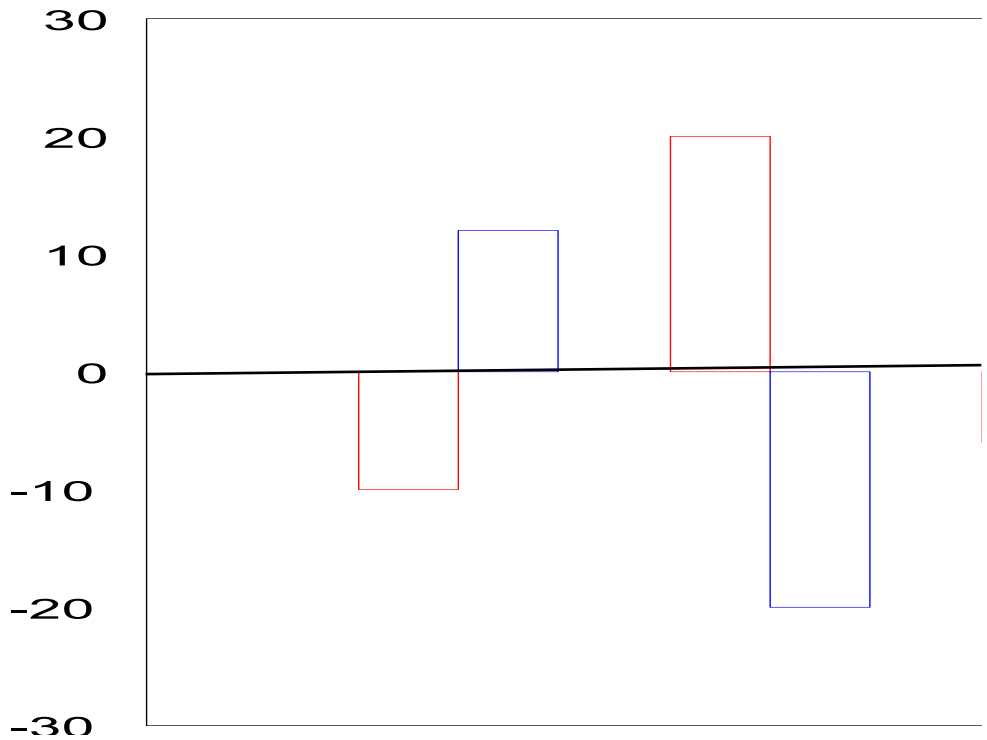


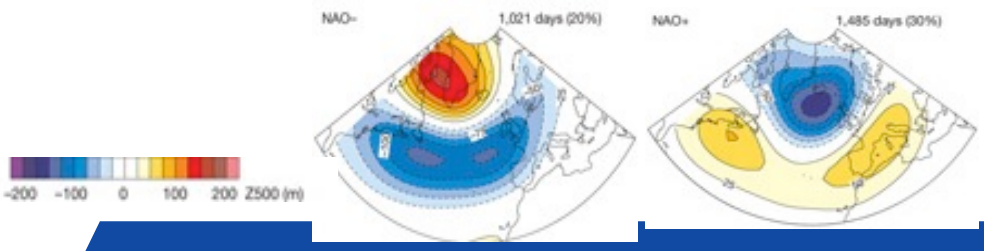
(From NASA)



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:

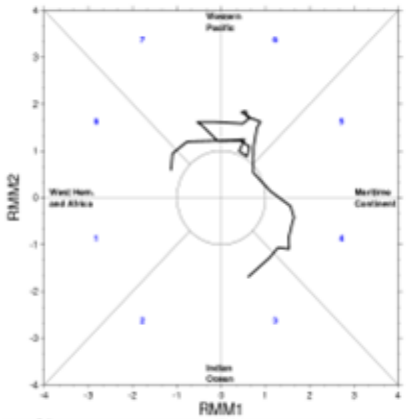
- suppressed convection over Indian Ocean
- enhanced convection over Western Pacific are conducive to negative NAO

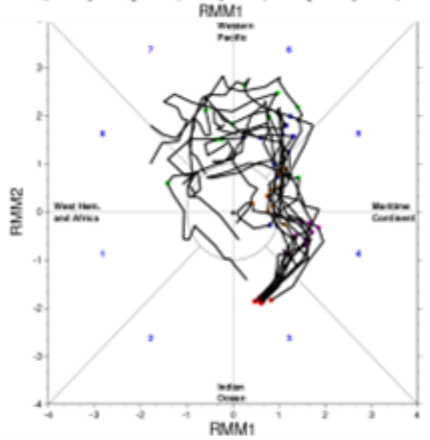
Cassou (2008) Lin et al (2008)

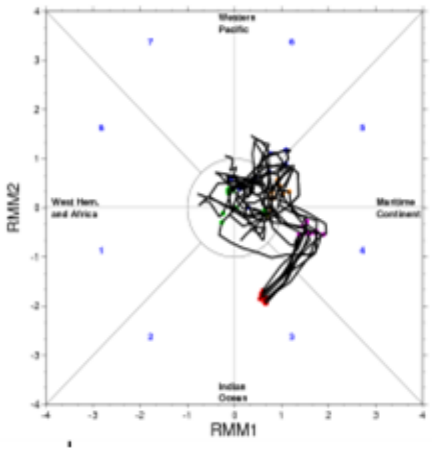
Conv. Over Indian Ocean +10 days

Conv. Over Western Pacific+10 days

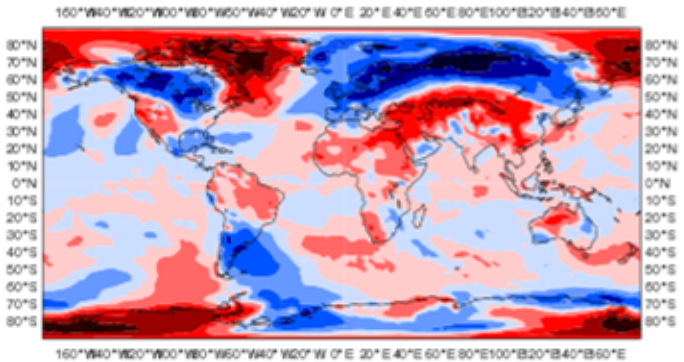
ECMWF



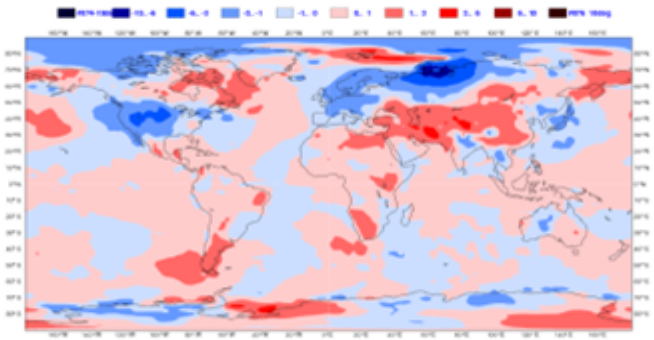




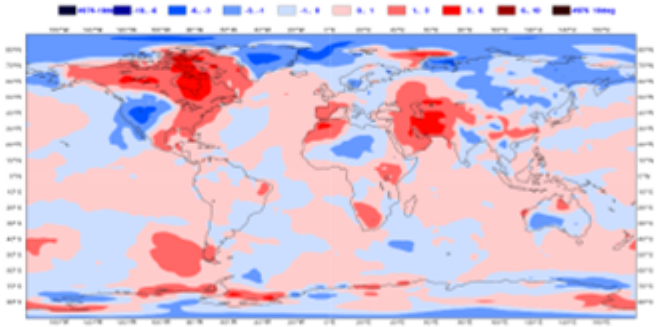
Cold March 2013 – 14 Feb 2013 -Day 26-32



Analysis

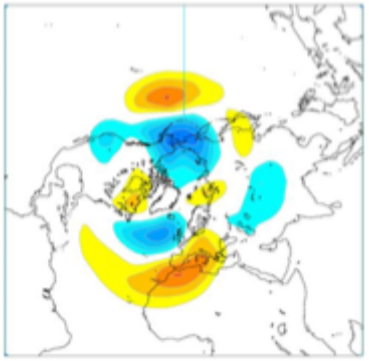


10 best MJO forecasts

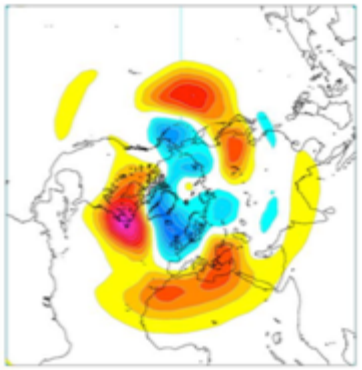


10 worse MJO forecasts

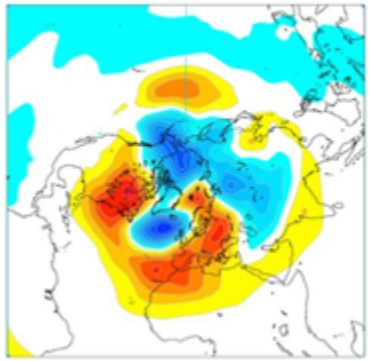
2002 MOFC hindcasts



2013 MOFC hindcasts



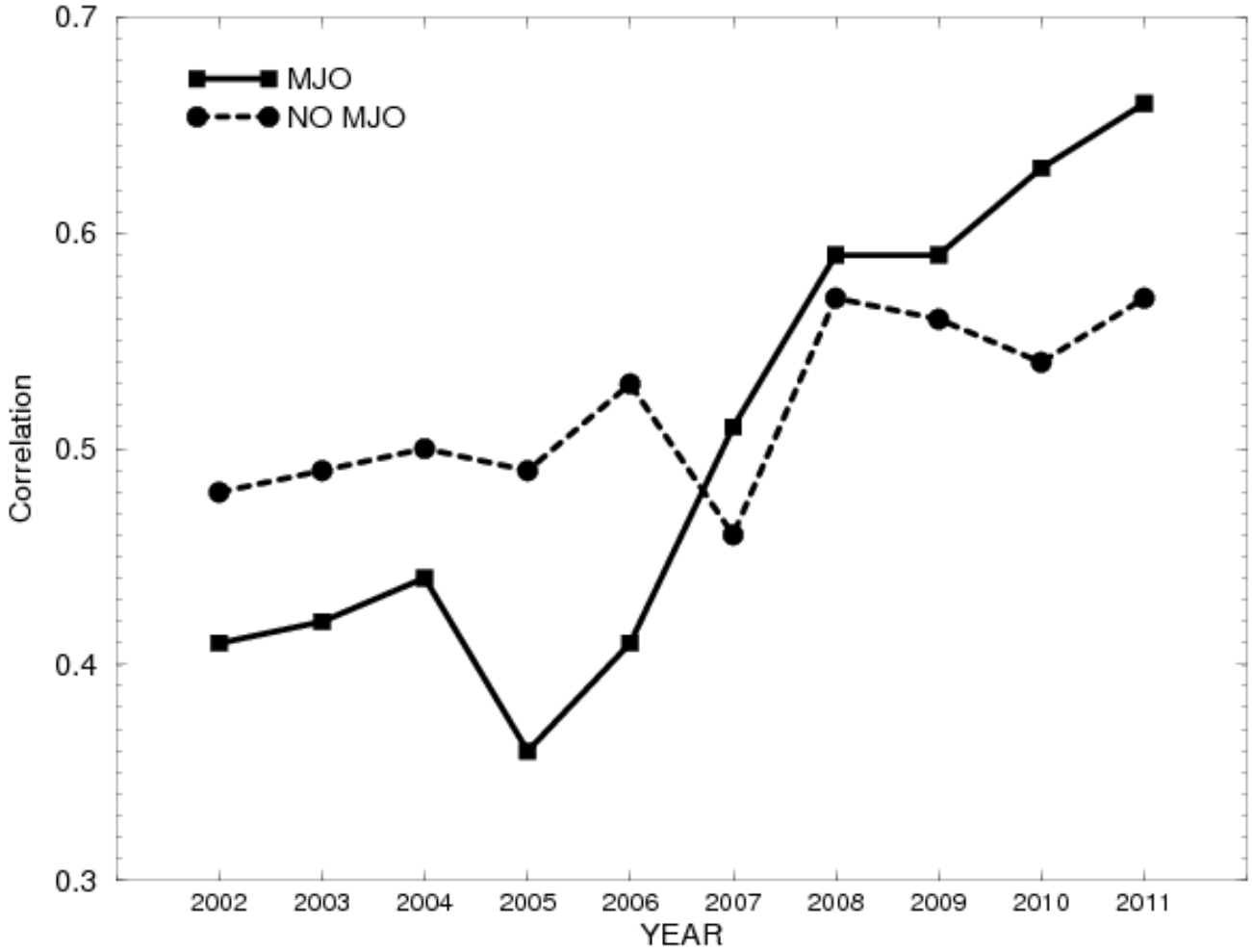
ERA Interim



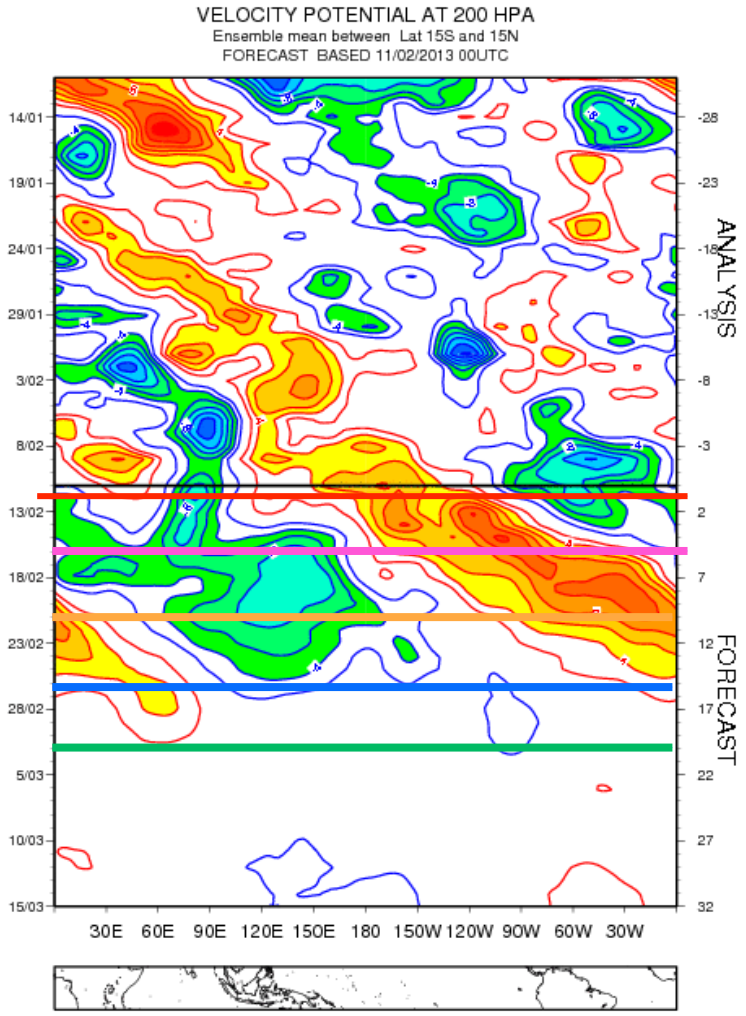
MJO Teleconnections

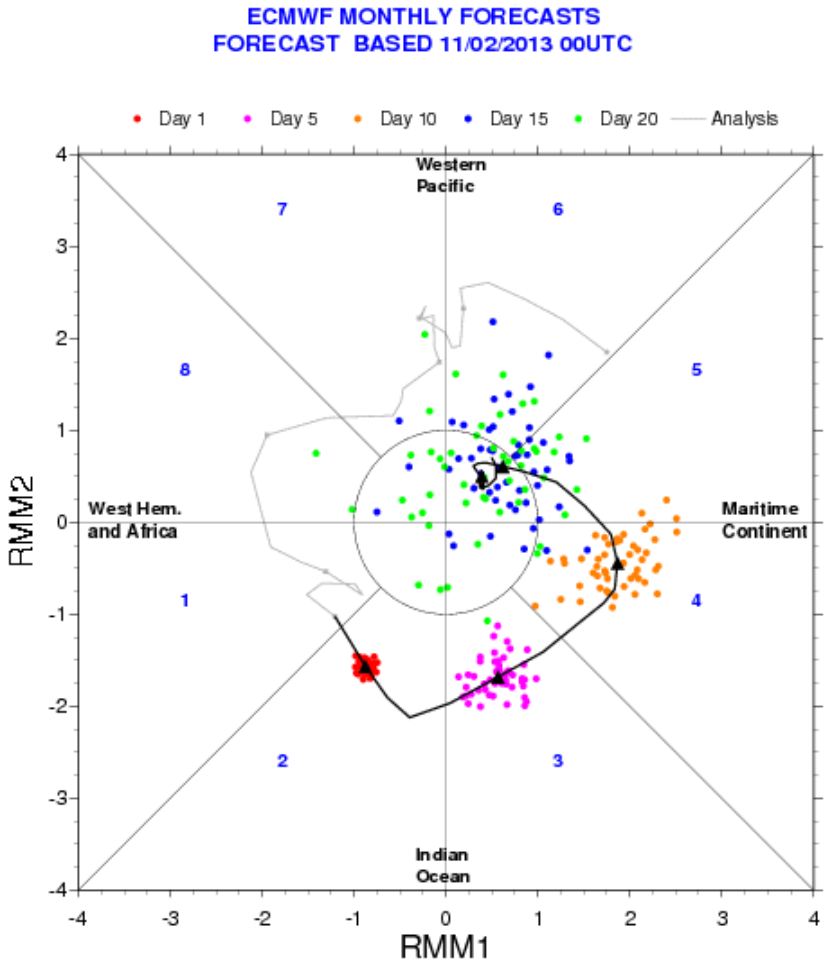
Evolution of NAO skill scores day 19-25

NAO index is computed as projection onto a reference pattern



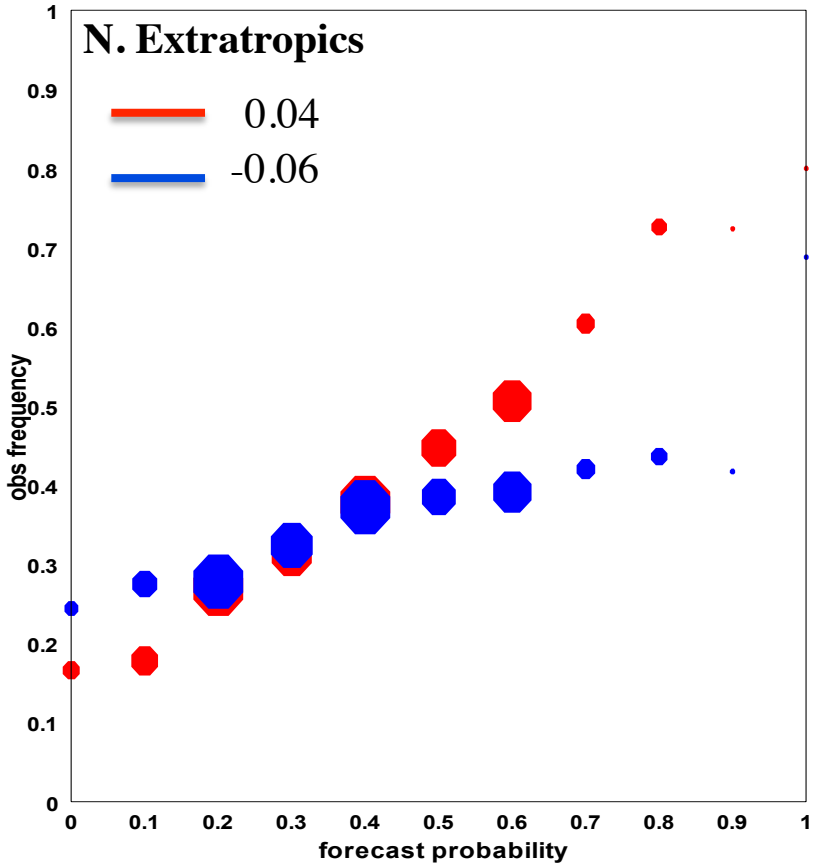
MJO forecast:

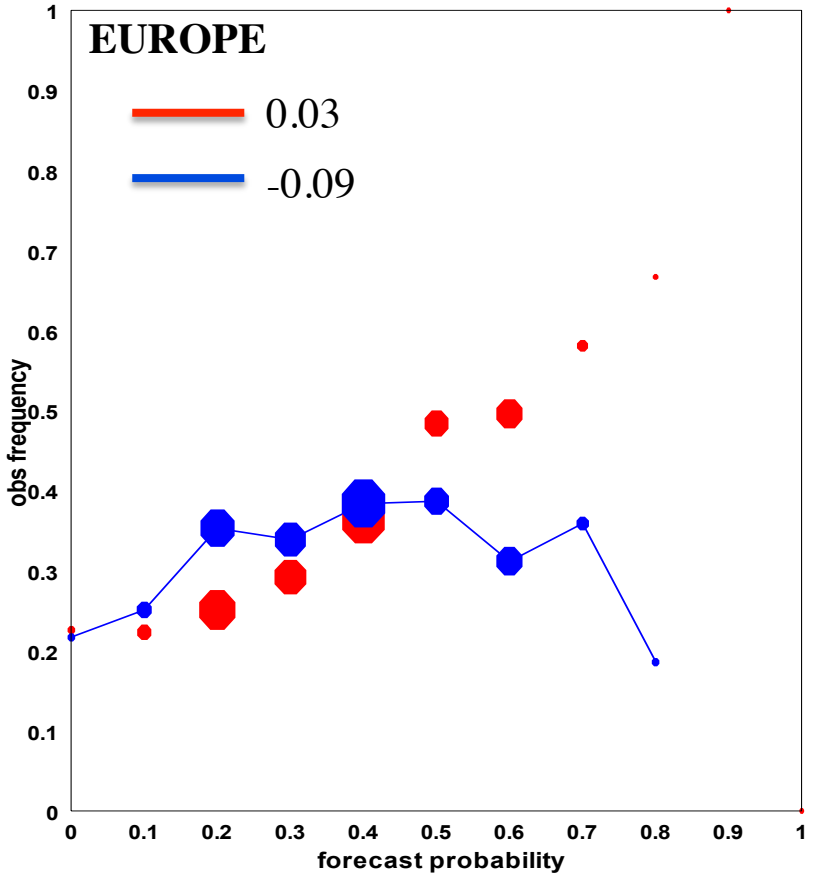




Probabilistic skill scores – NDJFMA 1989-2008

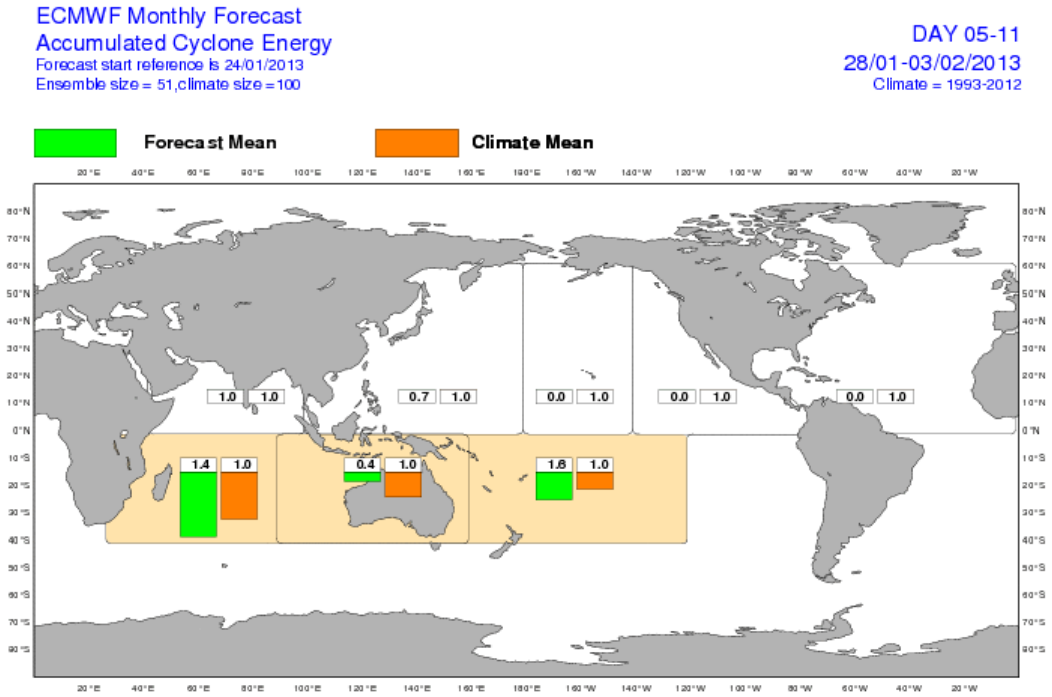
Reliability Diagram
Probability of 2-m temperature in the upper tercile
Day 19-25

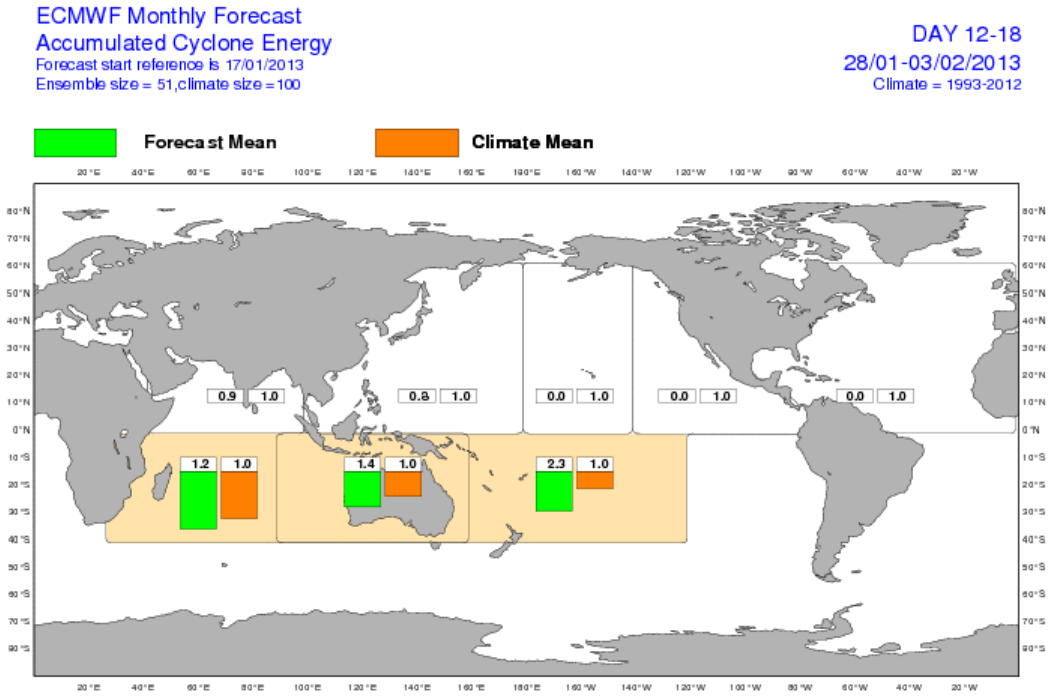




MJO in IC NO MJO in IC

ECMWF



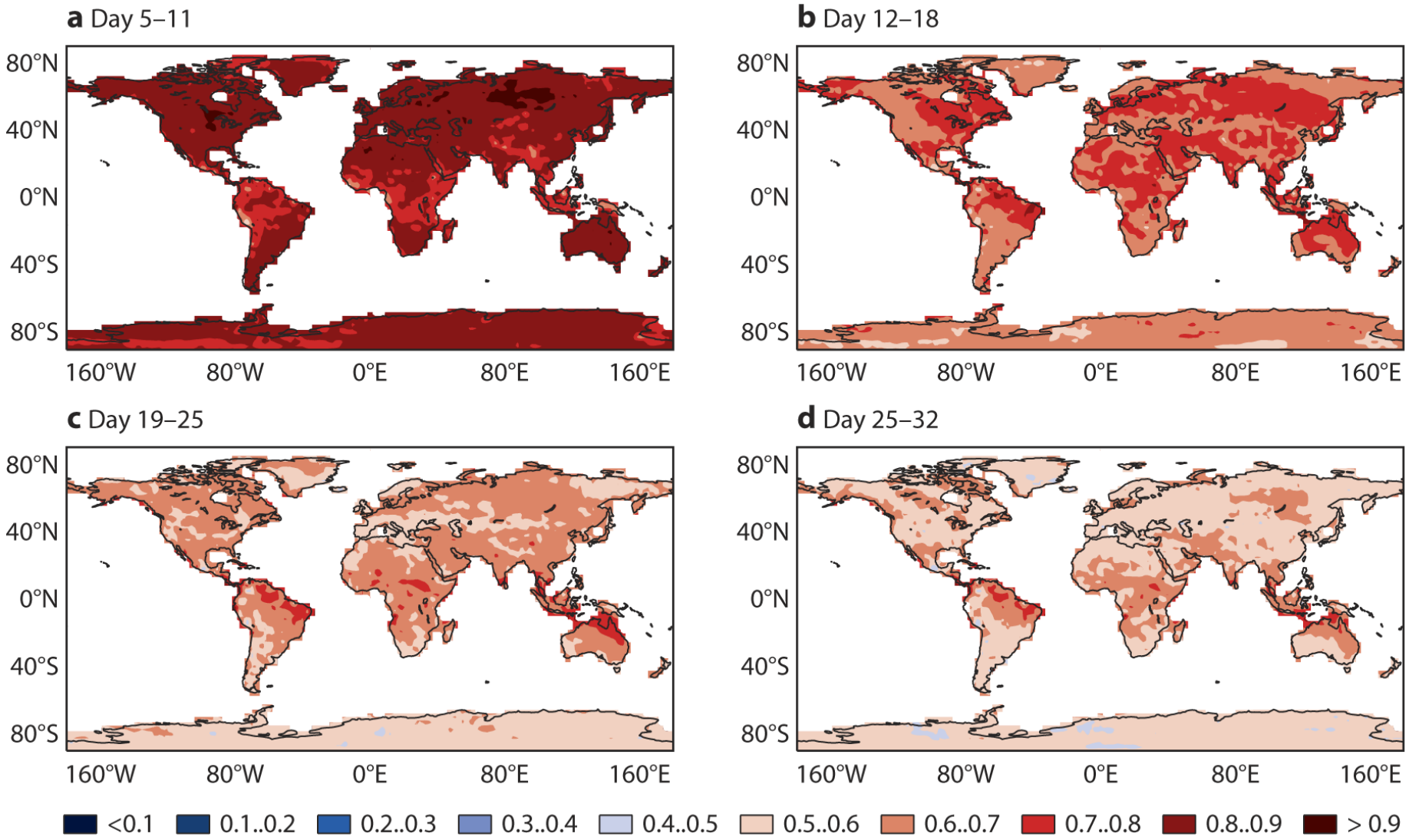


Weekly mean Accumulated Cyclone Energy (ACE)

ECMWF

ROC for 2mt in the upper tercile

since Oct 2004

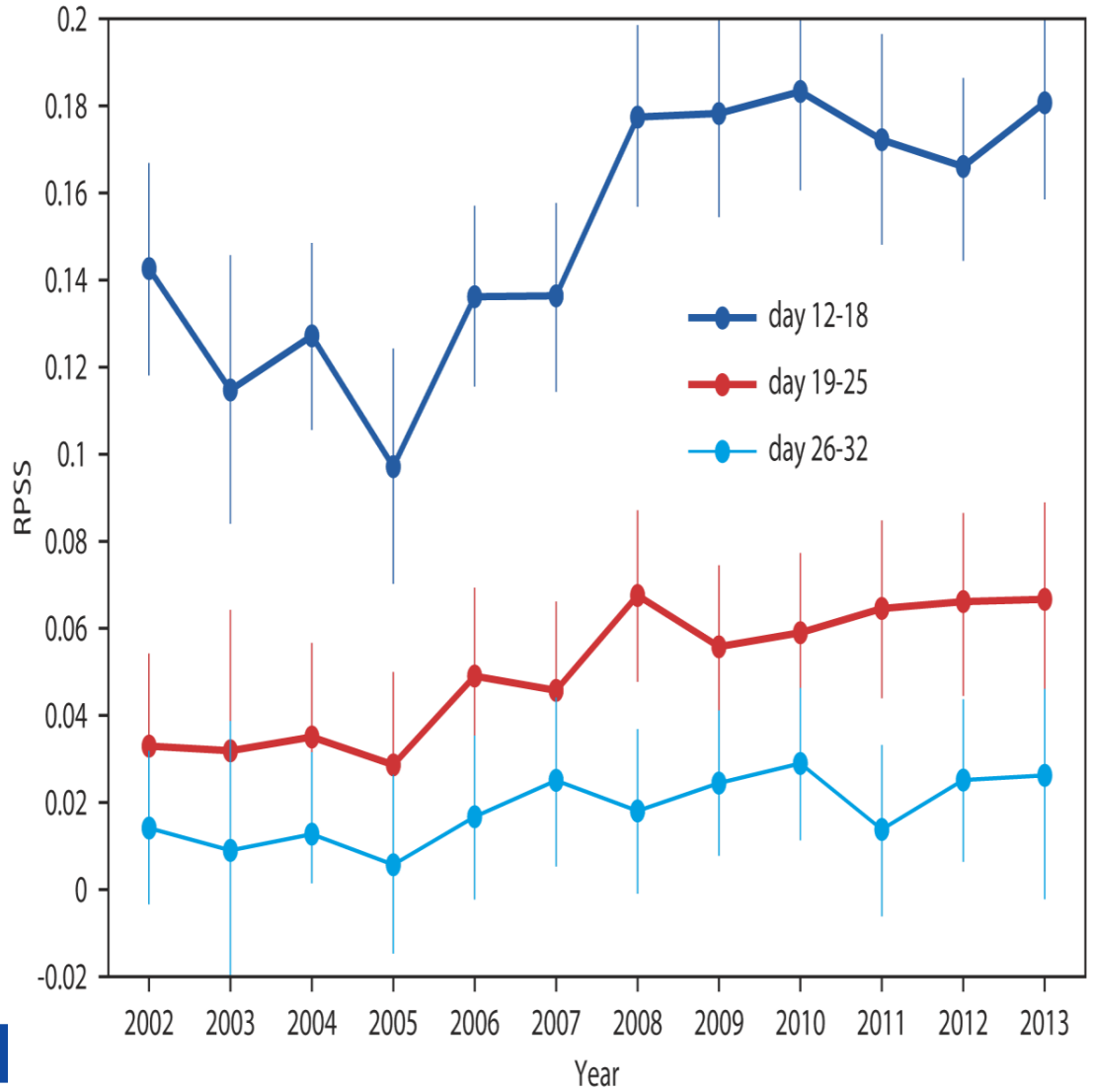


Evolution of skill scores based on the re-forecasts

RPSS – Probability of 2mt in upper tercile NDJFM

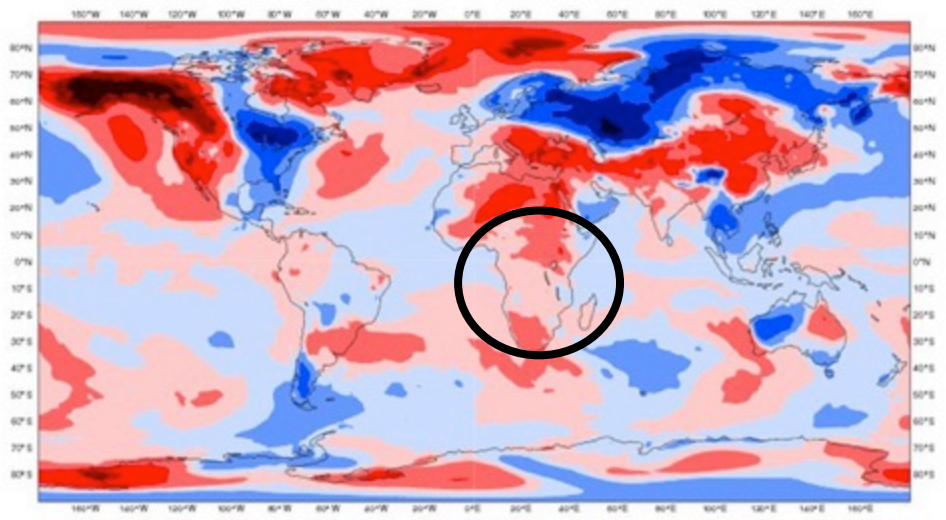
All the re-forecasts produced since 2002 have the period 1995-2001 in common.

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).

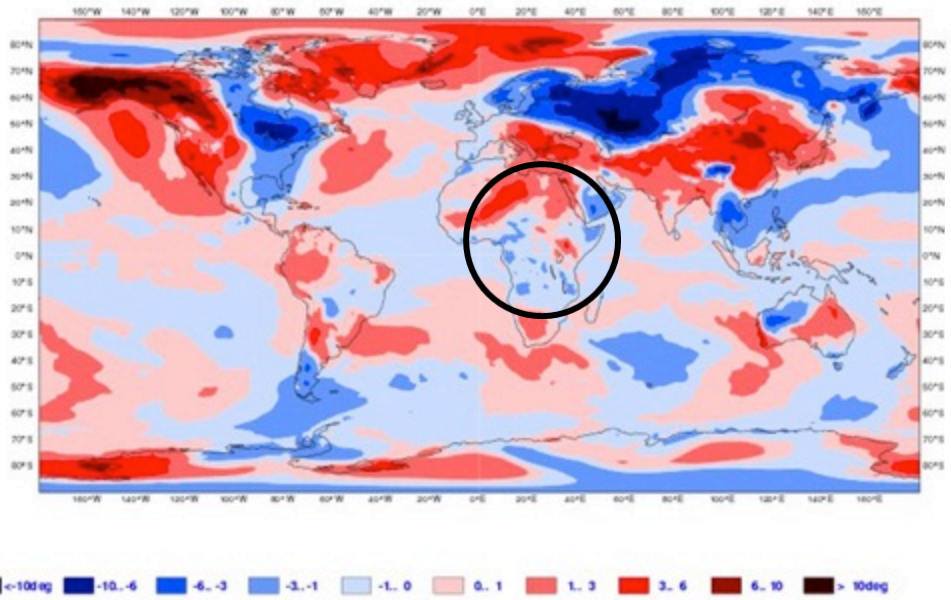


New re-forecast twice a week 11 members

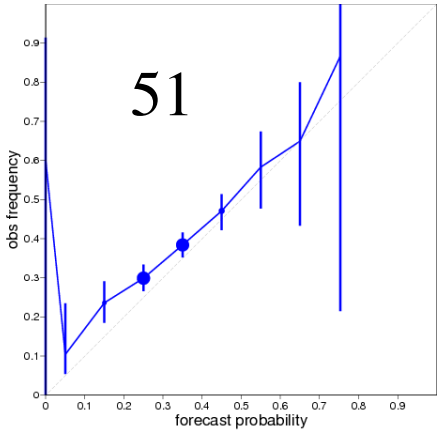
a) Current Re-forecast configuration

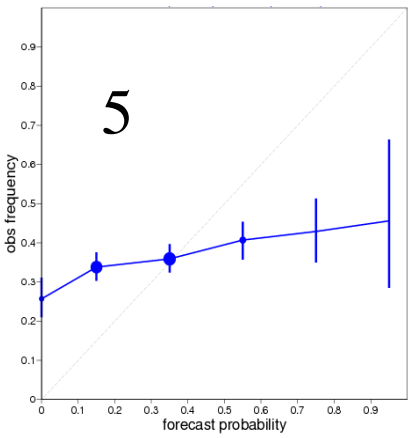


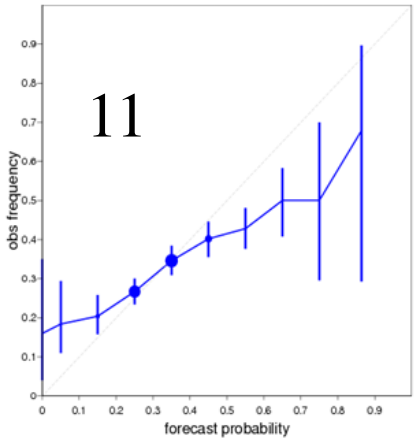
b) New Re-forecast configuration



Impact on verification
T850- Upper terciles – Week 4







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. Model improvements, particularly in simulating the MJO activity are likely to be beneficial for monthly forecasting.

- 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.

Extended range ensemble system

ENS includes 51 forecasts with resolution: TL639L91 from day 0 to 10 and TL319L91 from day 10 to 15.

Atmosphere
Initial uncertainties **T42L91 SVs+ T399L137 EDA perturbations**
Model uncertainties **Stochastic physics (SPPT and SKEB schemes). The central analysis is the TL1279L137 4DVAR. coupled to wave model (WAM) every time step**

Ocean
NEMO (about 1 degree resolution) coupled to IFS every 3 hours. Ocean initial conditions provided by 5-member NEMOVAR analysis

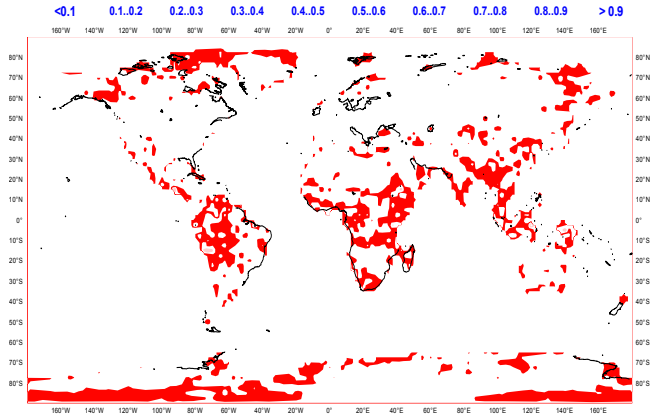
The ECMWF monthly forecasting system

- **Atmospheric initial conditions:** ECMWF operational analysis
- **Oceanic initial conditions:** "Accelerated" ocean analysis
- **Perturbations:**
  - Atmosphere: Singular vectors + stochastic physics
  - Ocean: Wind stress perturbations during the data assimilation

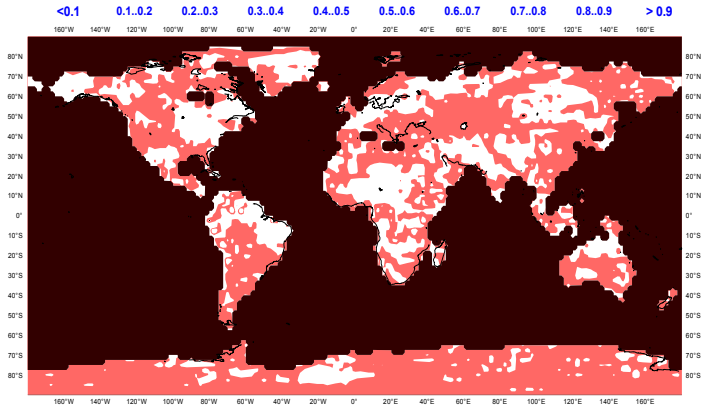
Skill of the ECMWF Monthly Forecasting System

ROC score: 2-meter temperature in the upper tercile

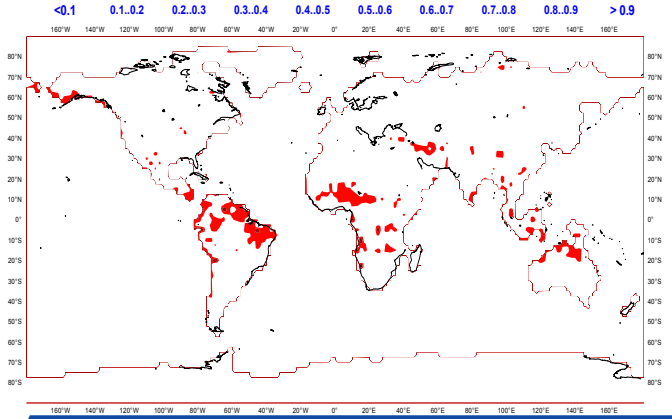
Day 5-11



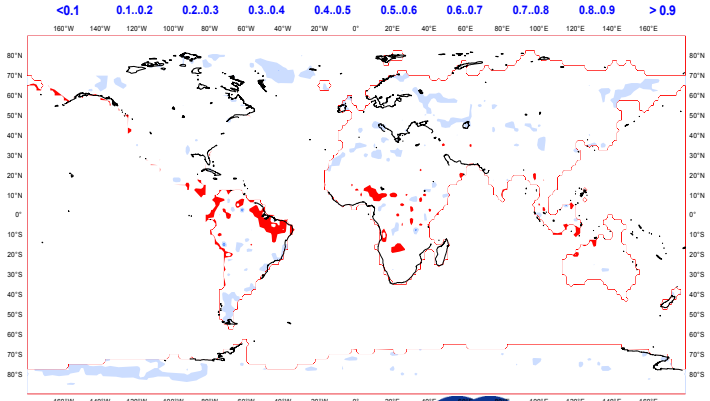
Day 12-18



Day 19-25



Day 26-32

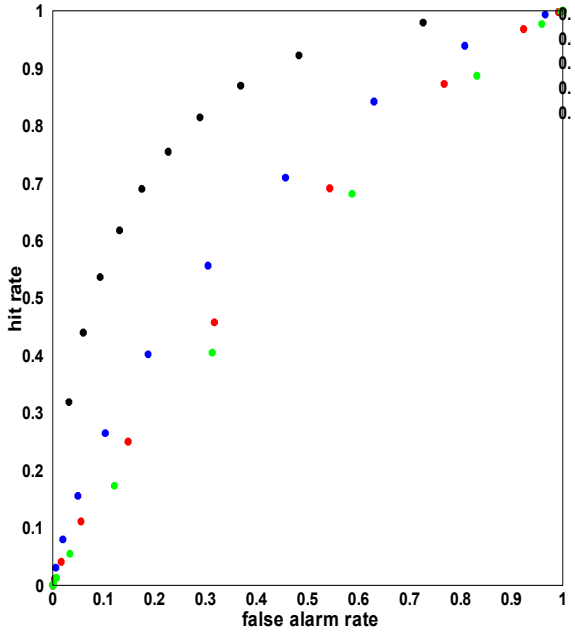


ECMWF

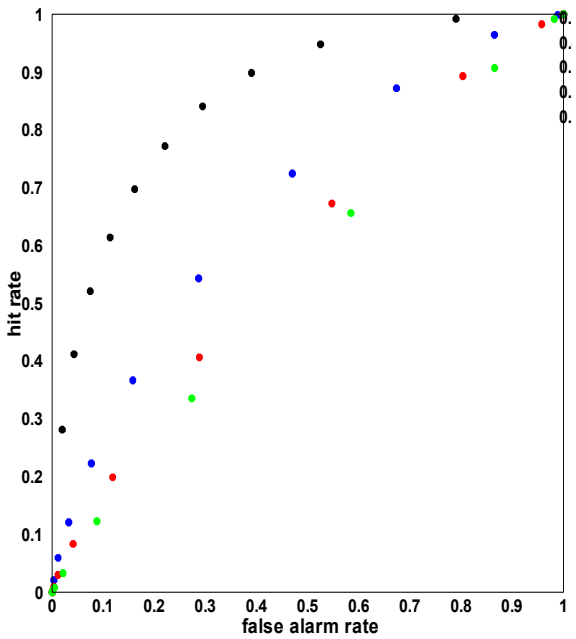
Skill of the ECMWF Monthly Forecasting System

ROC scores over the Northern extratropics

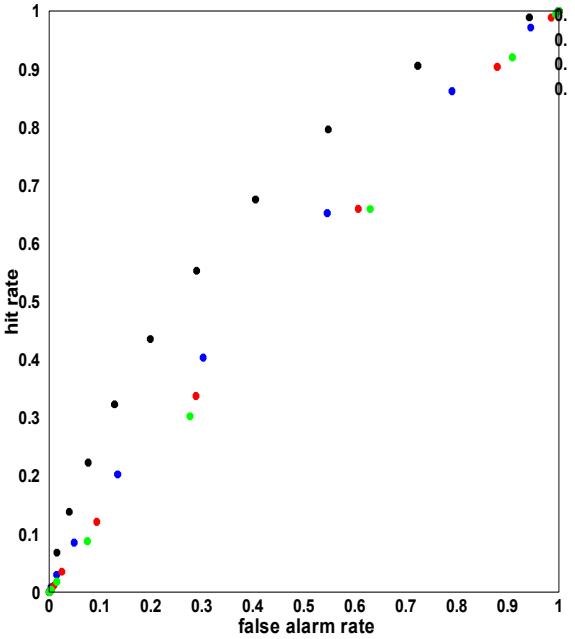
2-metre temperature



Mean sea-level pressure



Precipitation



Day 5-11 Day12-18 Day19-25 Day 26-32

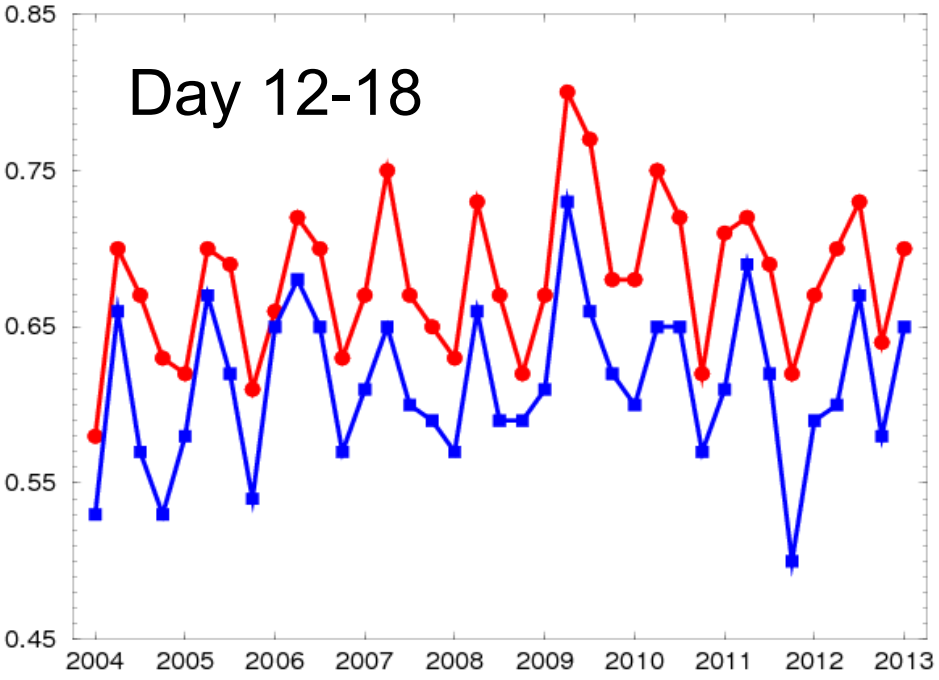
ECMWF

Monthly Forecast: Northern extratropics

ROC score: 2-metre temperature in the upper tercile

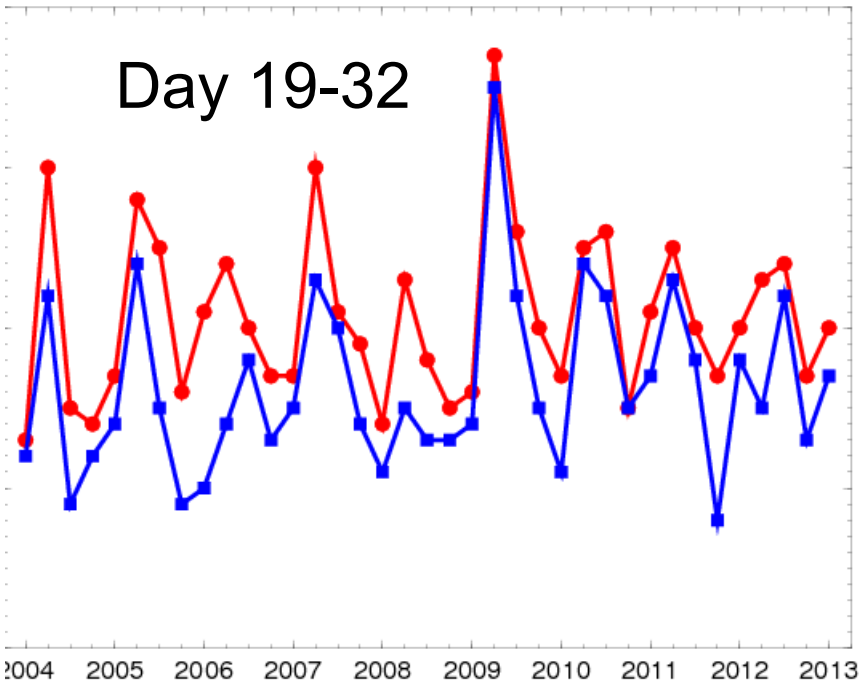
Monthly Forecast

Persistence of day 5-11



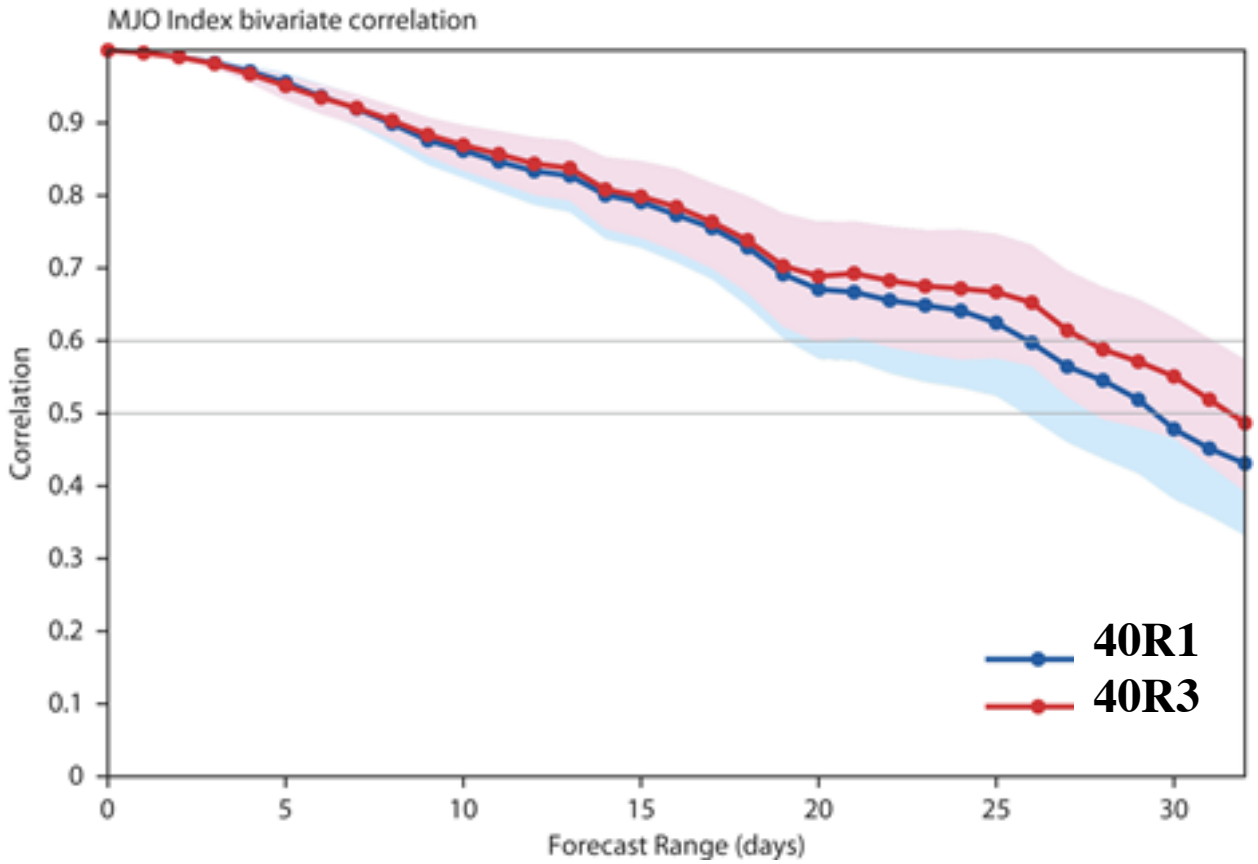
Monthly Forecast

Persistence of day 5-18

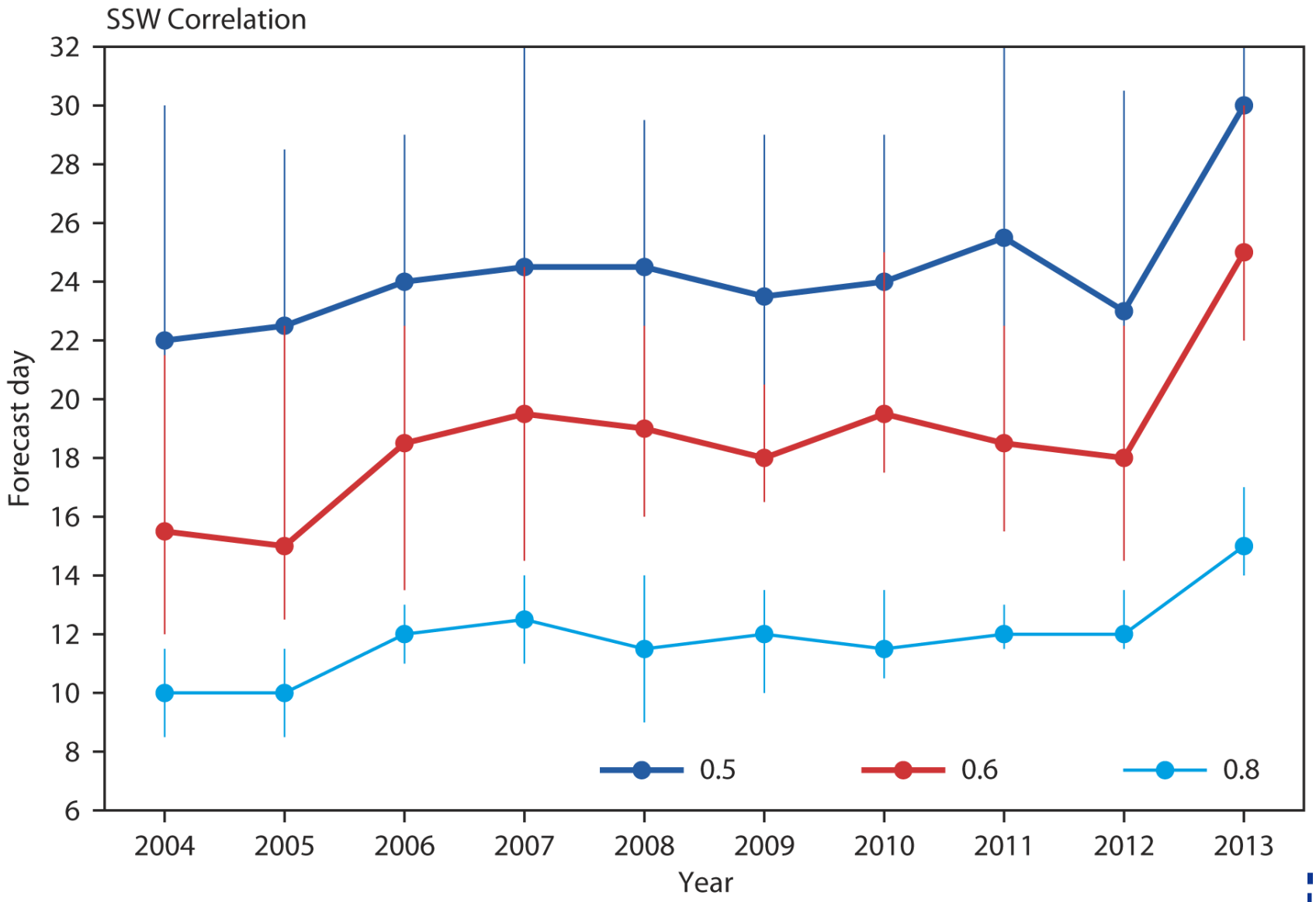


ECMWF

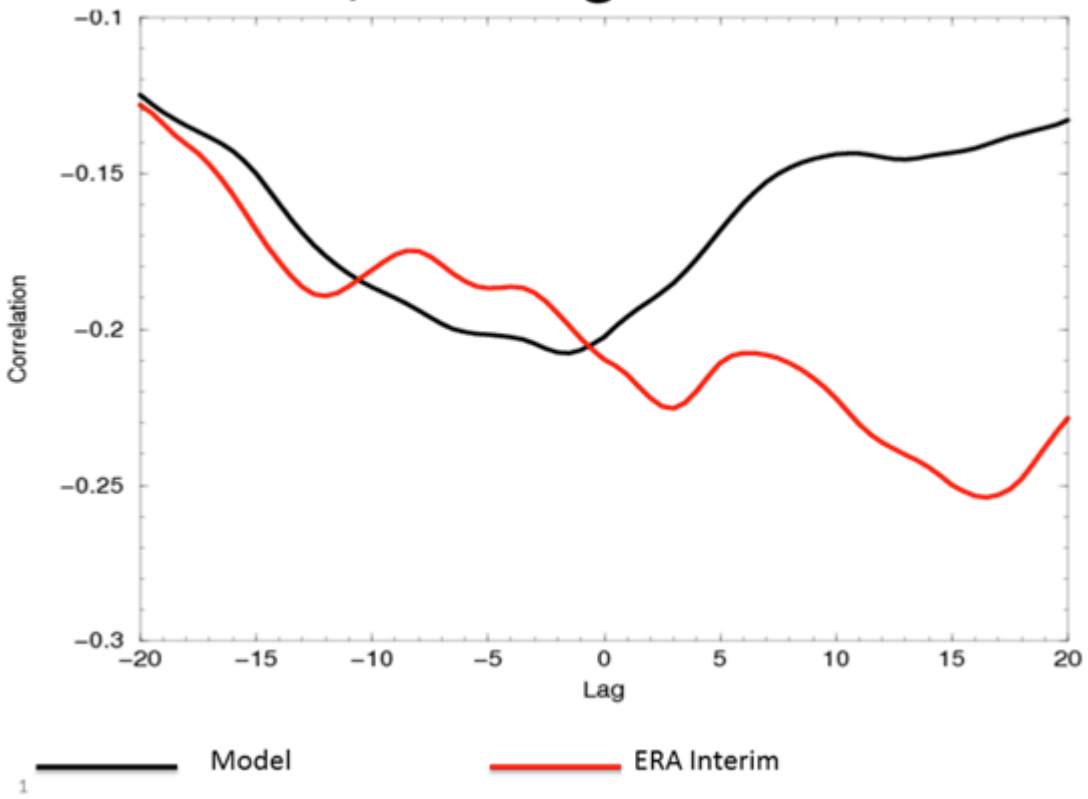
Madden Julian Oscillation



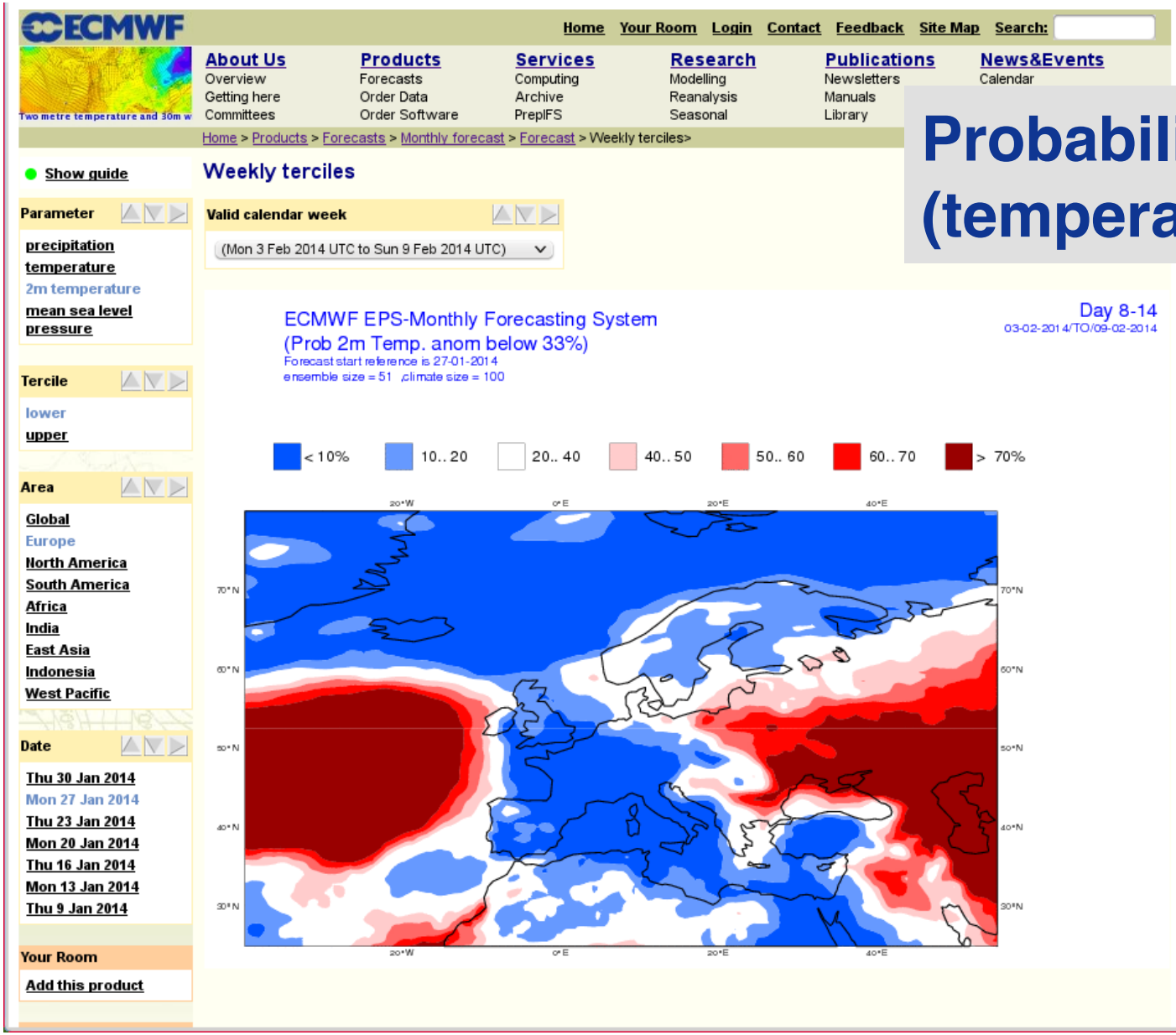
Improvement due to revised organised convective detrainment term and the revised convective momentum transport.


SSW Correlation
Forecast day
Year
32
30
28
26
24
22
20
18
16
14
12
10
8
6
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
0.5
0.6
0.8

NAO/SSW lag-correlation



Probabilities (temperature)



Weekly anomaly - Mozilla Firefox

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Weekly anomaly

Parameter

precipitation
temperature
2m temperature
mean sea level pressure

Valid calendar week

(Mon 3 Feb 2014 UTC to Sun 9 Feb 2014 UTC)

Area

Global
Europe
North America
South America
Africa
India
East Asia
Indonesia
West Pacific

Date

Thu 30 Jan 2014
Mon 27 Jan 2014
Thu 23 Jan 2014
Mon 20 Jan 2014
Thu 16 Jan 2014
Mon 13 Jan 2014
Thu 9 Jan 2014

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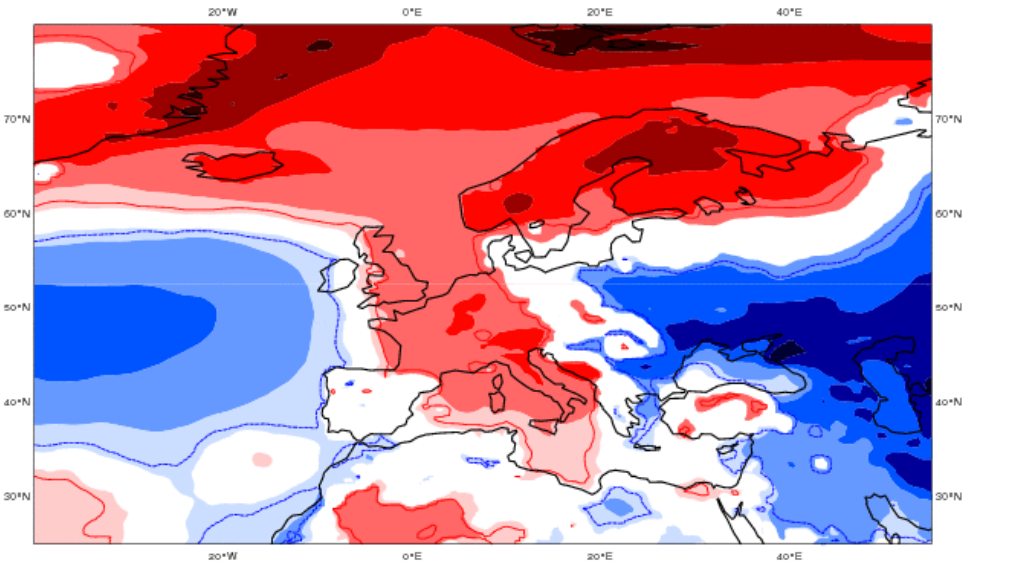
Parameter
Valid calendar week
Area
Date

ECMWF EPS-Monthly Forecasting System
2-meter Temperature anomaly
Forecast start reference is 30-01-2014
ensemble size = 51 ,climate size = 100

Day 5-11
03-02-2014/TO/09-02-2014
Shaded areas significant at 10% level
Contours at 1% level



Tropical storm density