

The ECMWF Extended range forecasts

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The operational forecasting system

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

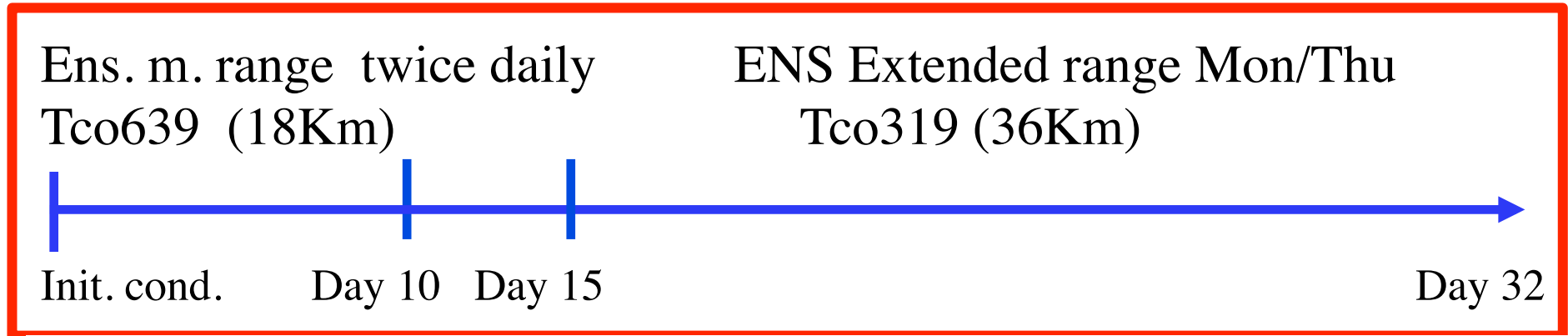
Coupled atmosphere-ocean system

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 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
 - 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

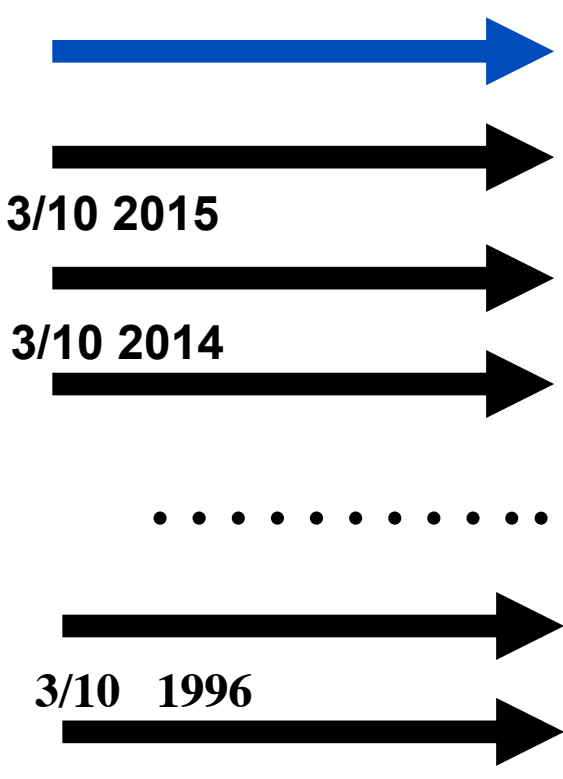
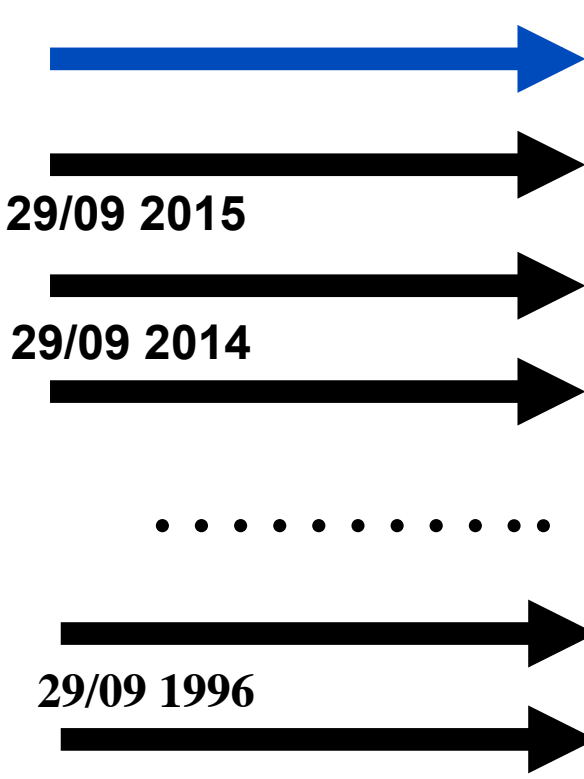
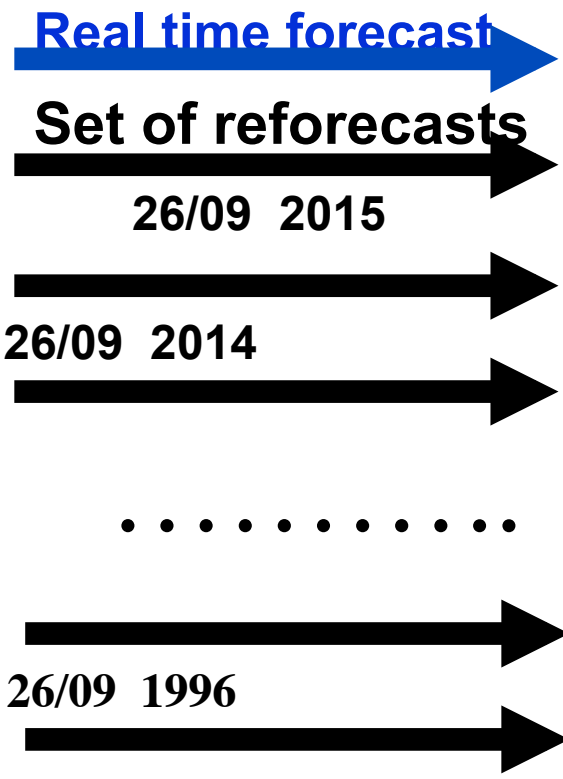


The ECMWF extended forecasts consists of 2 elements:

26/09/16 Monday

29/09/16 Thursday

3/10/16 Monday



MODEL BIAS: 2m Temperature

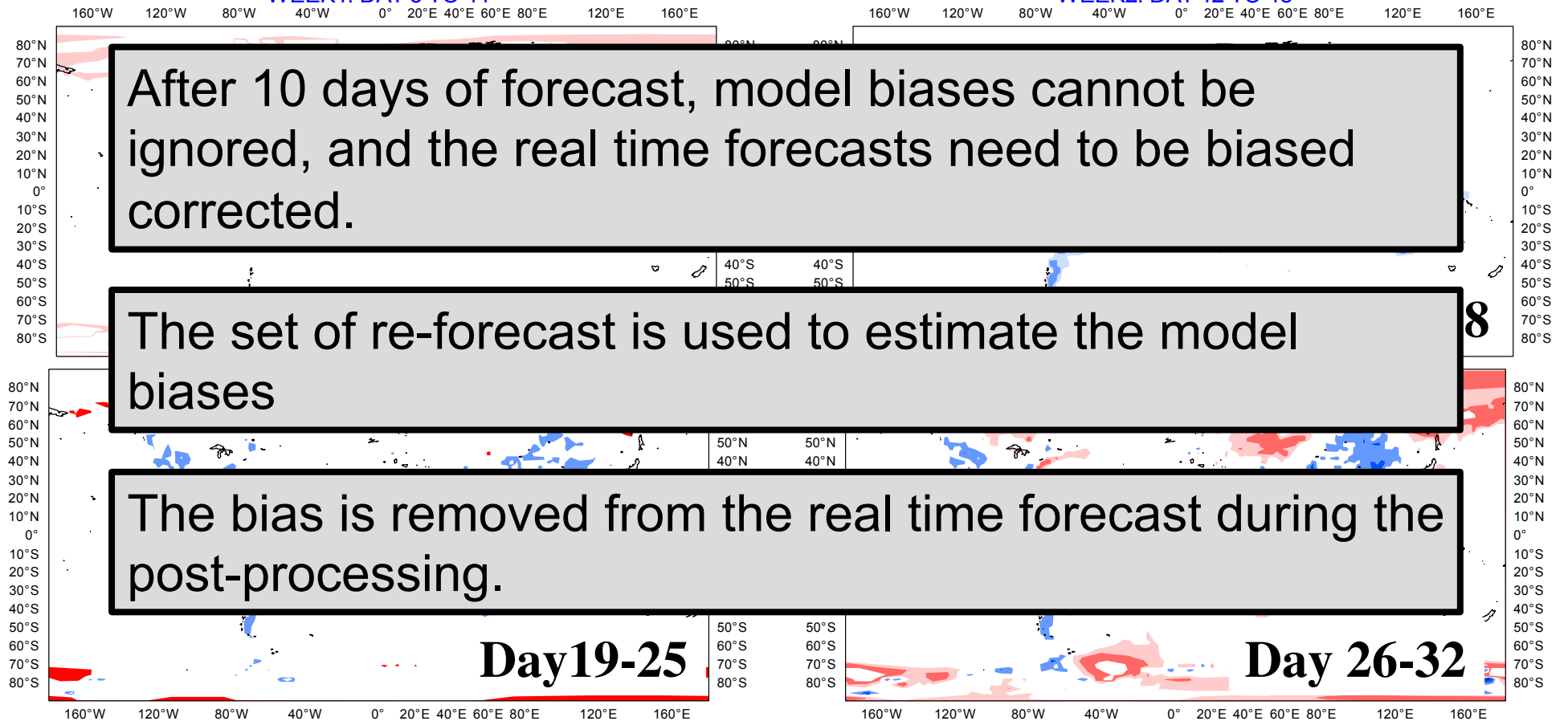
Forecast start reference is 05/03/1991-2008

ensemble size = 5



WEEK1: DAY 5 TO 11

WEEK2: DAY 12 TO 18



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.

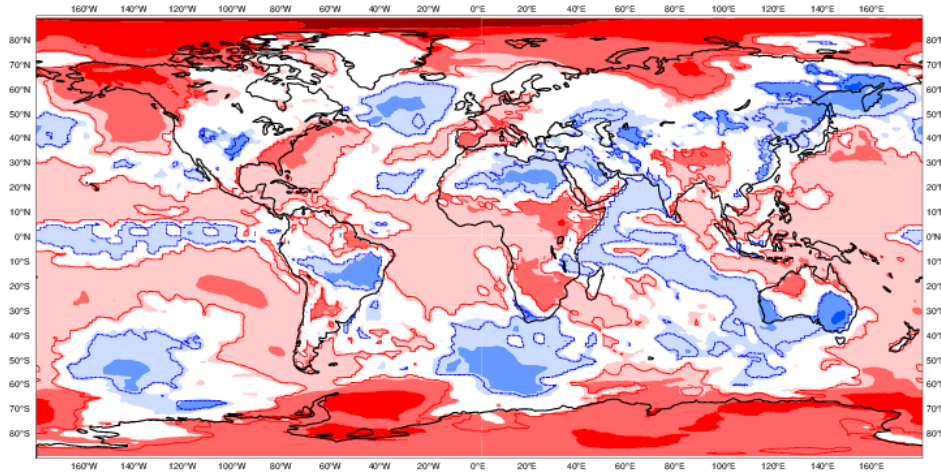
Day 19-25

Day 26-32

ECMWF EPS-Monthly Forecasting System
2-meter Temperature anomaly
Forecast start reference is 28-09-2016
ensemble size = 51 , climate size = 660

Day 15-21
10-10-2016/TO/16-10-2016
Shaded areas significant at 10% level
Contours at 1% level

<-10deg -10.. -6 -6.. -3 -3.. -1 -1.. 0 0.. 1 1.. 3 3.. 6 6.. 10 > 10deg

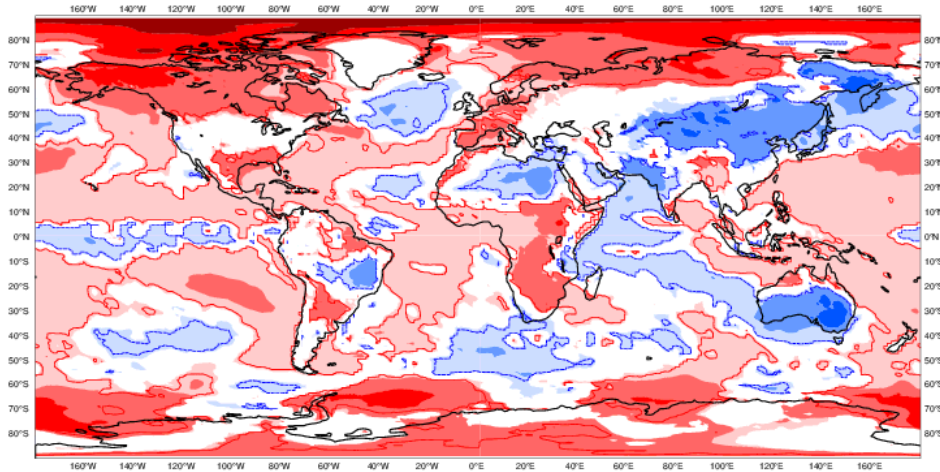


Ens. mean weekly anomalies :

ECMWF EPS-Monthly Forecasting System
2-meter Temperature anomaly
Forecast start reference is 29-09-2016
ensemble size = 51 , climate size = 660

Day 12-18
10-10-2016/TO/16-10-2016
Shaded areas significant at 10% level
Contours at 1% level

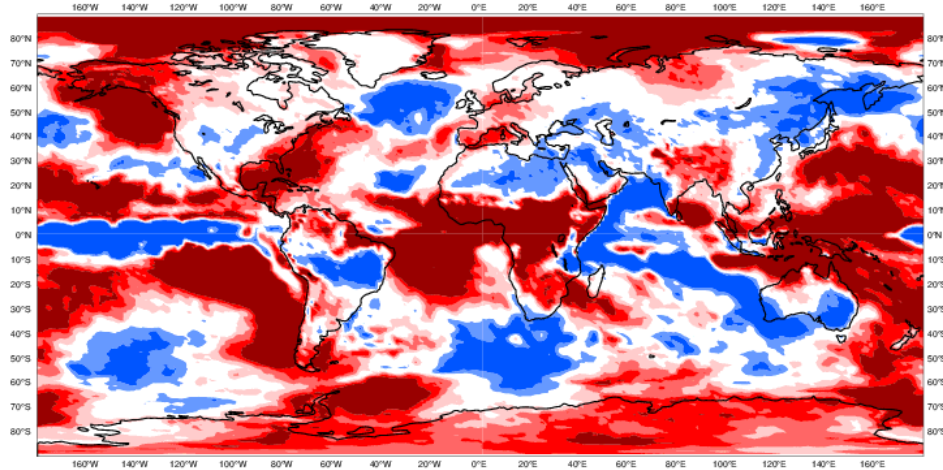
<-10deg -10.. -6 -6.. -3 -3.. -1 -1.. 0 0.. 1 1.. 3 3.. 6 6.. 10 > 10deg



ECMWF EPS-Monthly Forecasting System
(Prob 2m Temp. anom above 66%)
Forecast start reference is 28-09-2016
ensemble size = 51 ,climate size = 660

Day 15-21
10-10-2016/TO/16-10-2016

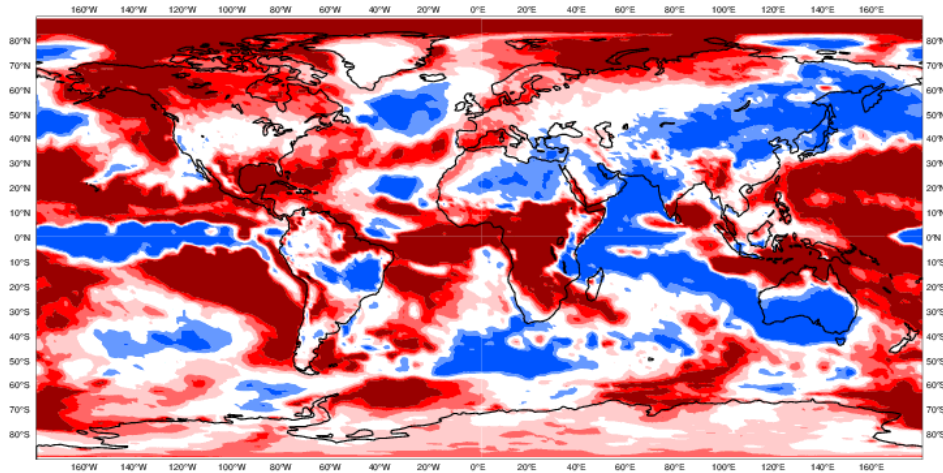
< 10% 10..20 20..40 40..50 50..60 60..70 > 70%



ECMWF EPS-Monthly Forecasting System
(Prob 2m Temp. anom above 66%)
Forecast start reference is 29-09-2016
ensemble size = 51 ,climate size = 660

Day 12-18
10-10-2016/TO/16-10-2016

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

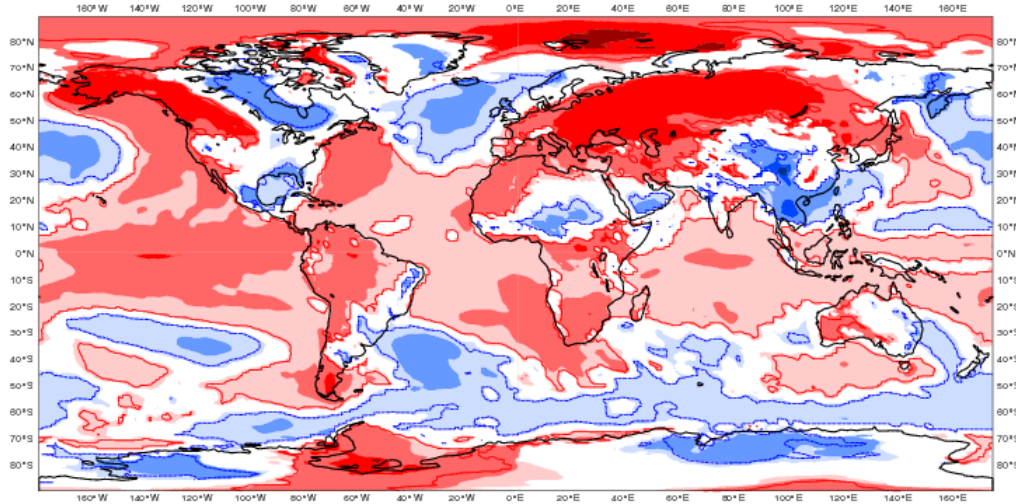


ECMWF EPS-Monthly Forecasting System
2-meter Temperature anomaly
Forecast start reference is 28-01-2016
ensemble size = 51 , climate size = 660

Day 12-18
08-02-2016/TO/14-02-2016
Shaded areas significant at 10% level
Contours at 1% level

Weekly mean anomalies

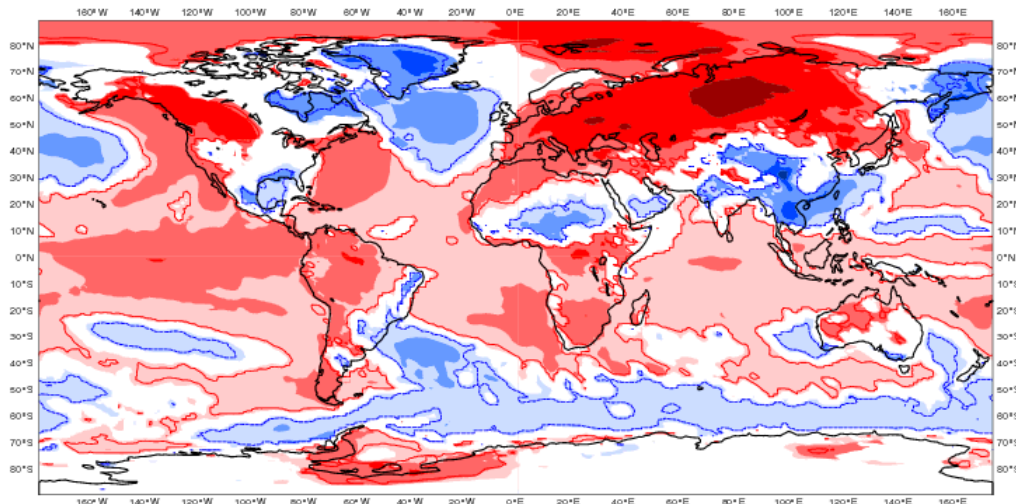
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ECMWF EPS-Monthly Forecasting System
2-meter Temperature anomaly
Forecast start reference is 25-01-2016
ensemble size = 51 , climate size = 660

Day 15-21
08-02-2016/TO/14-02-2016
Shaded areas significant at 10% level
Contours at 1% level

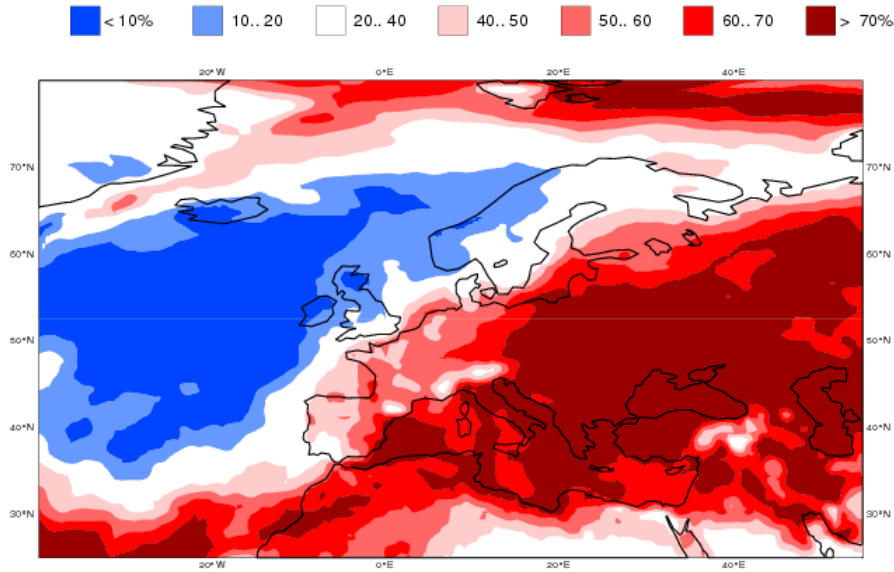
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ECMWF EPS-Monthly Forecasting System
(Prob 2m Temp. anom above 66%)
Forecast start reference is 25-01-2016
ensemble size = 51 , climate size = 060

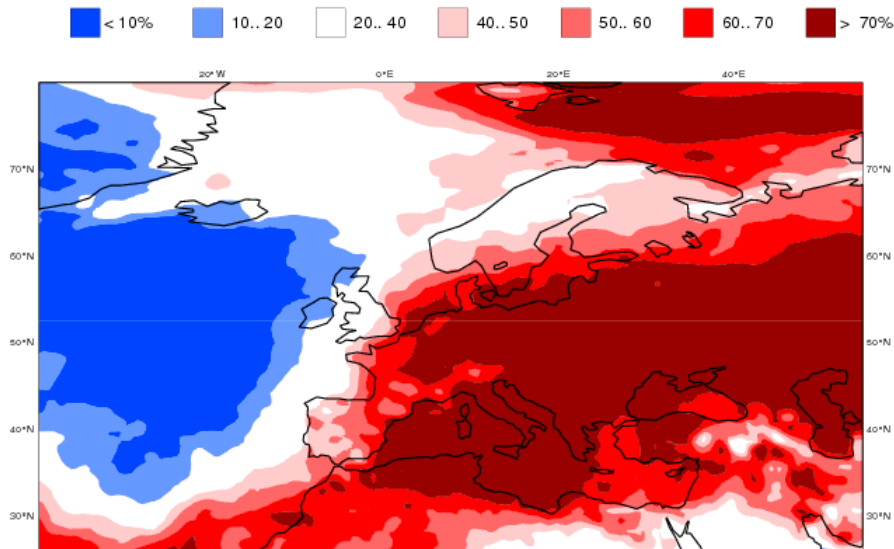
Day 12-18
08-02-2016/TO/14-02-2016

Probabilities for weekly mean anomalies:



ECMWF EPS-Monthly Forecasting System
(Prob 2m Temp. anom above 66%)
Forecast start reference is 25-01-2016
ensemble size = 51 , climate size = 060

Day 15-21
08-02-2016/TO/14-02-2016



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

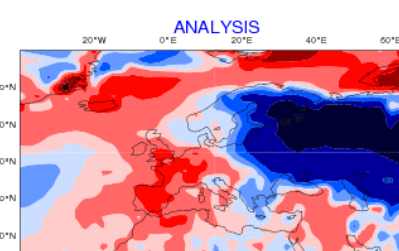
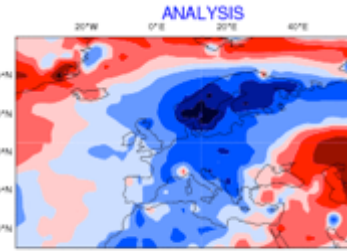
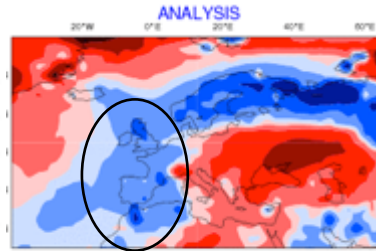
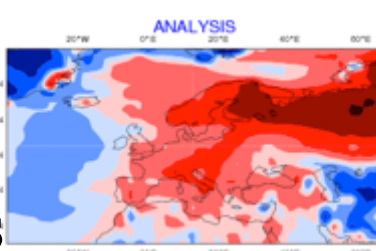
19 -25 /11/2012

26 /11 -2/12 2012

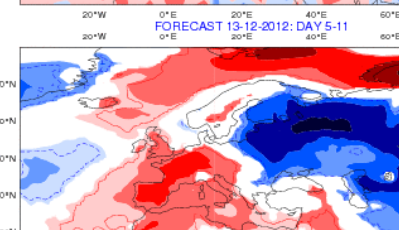
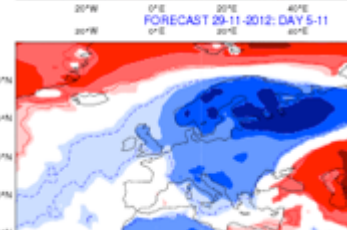
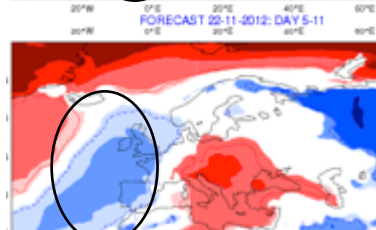
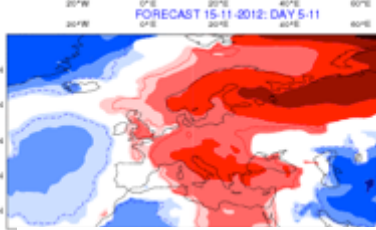
3-9/ 12 /2012

17 -12 12 2012

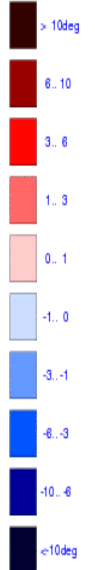
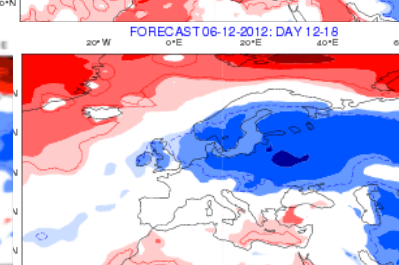
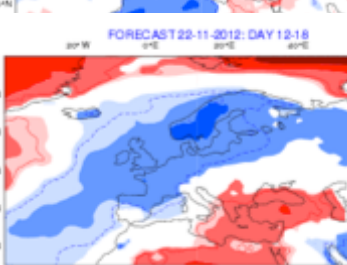
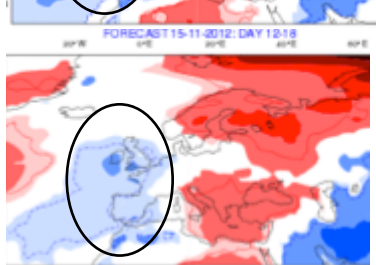
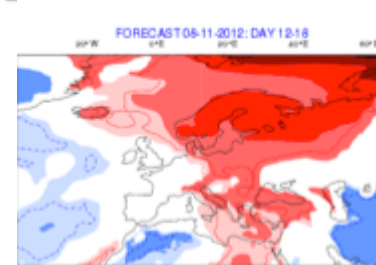
analysis



5-11d



12-18 d

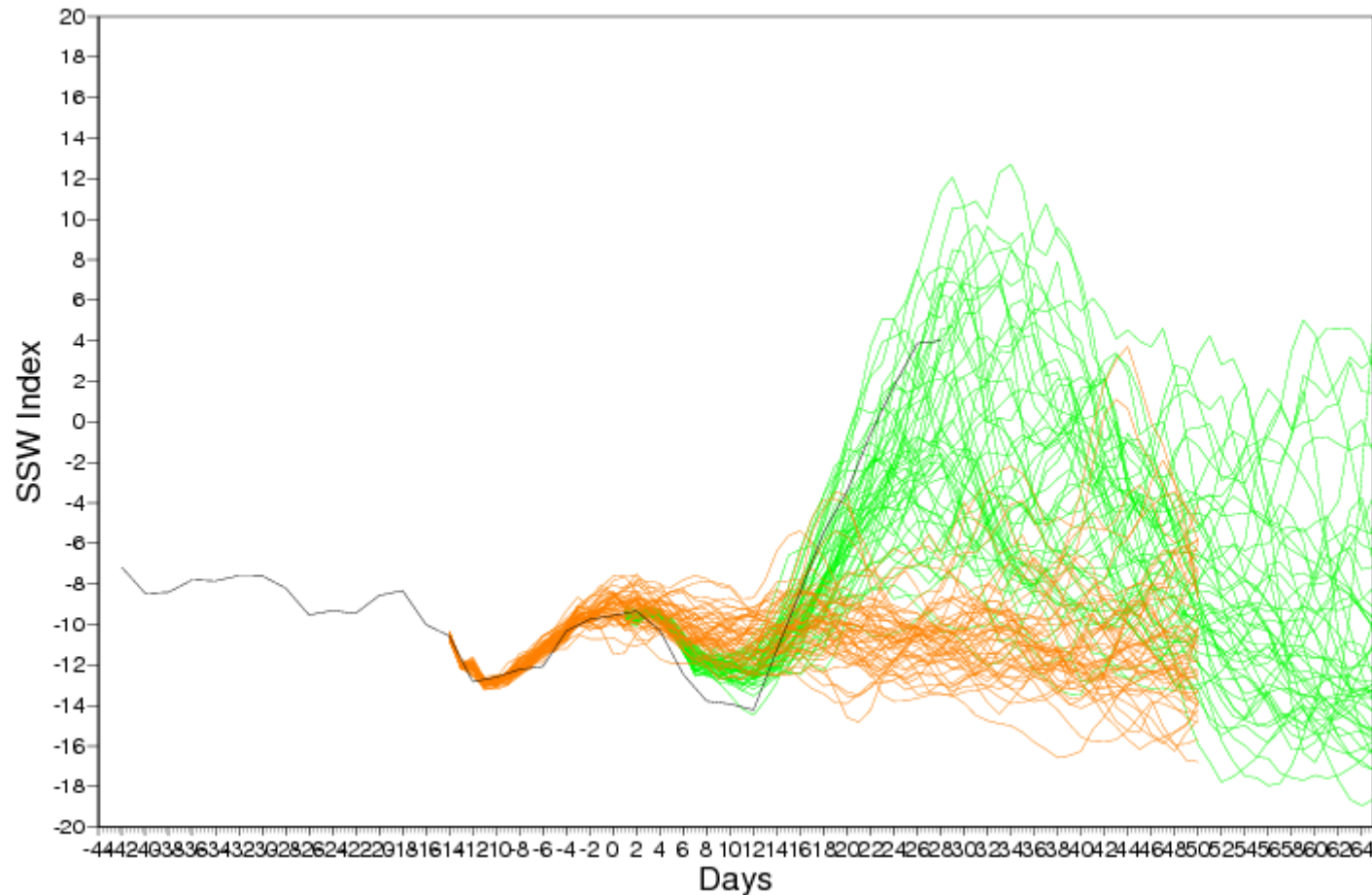


Cold Weather over Europe: SSW Index

Forecast starting on :

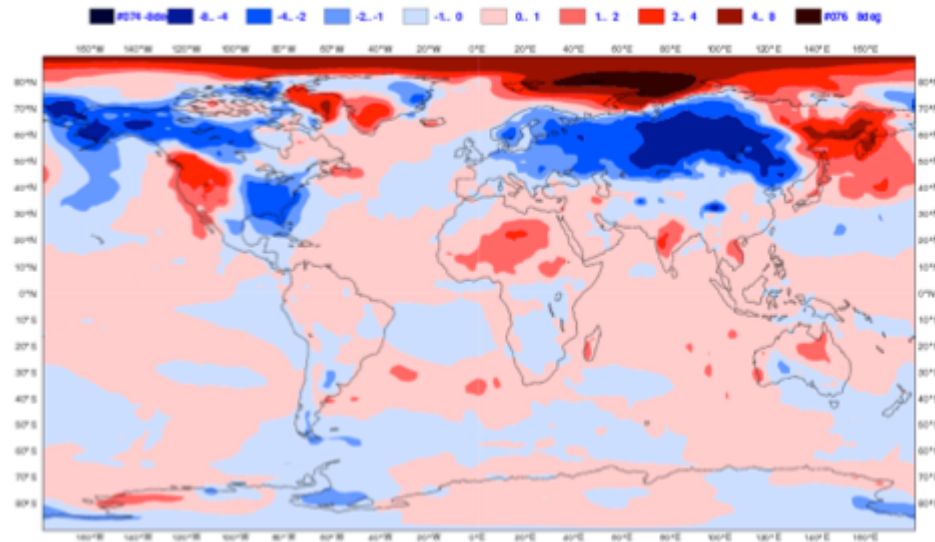
22/11/2012 —————

15/11/2012 —————

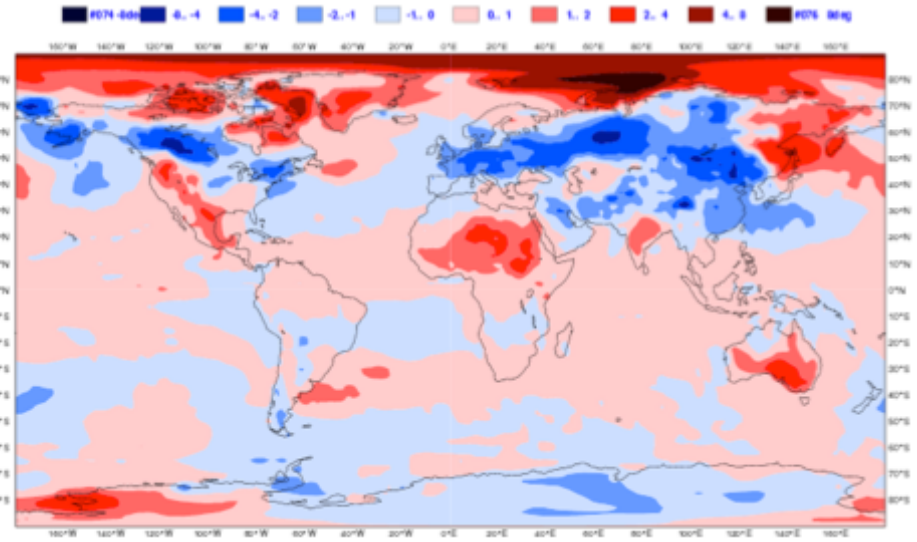


Cold Weather over Europe SSW Index - Forecast starting on 22/11/2012

Strong SSW

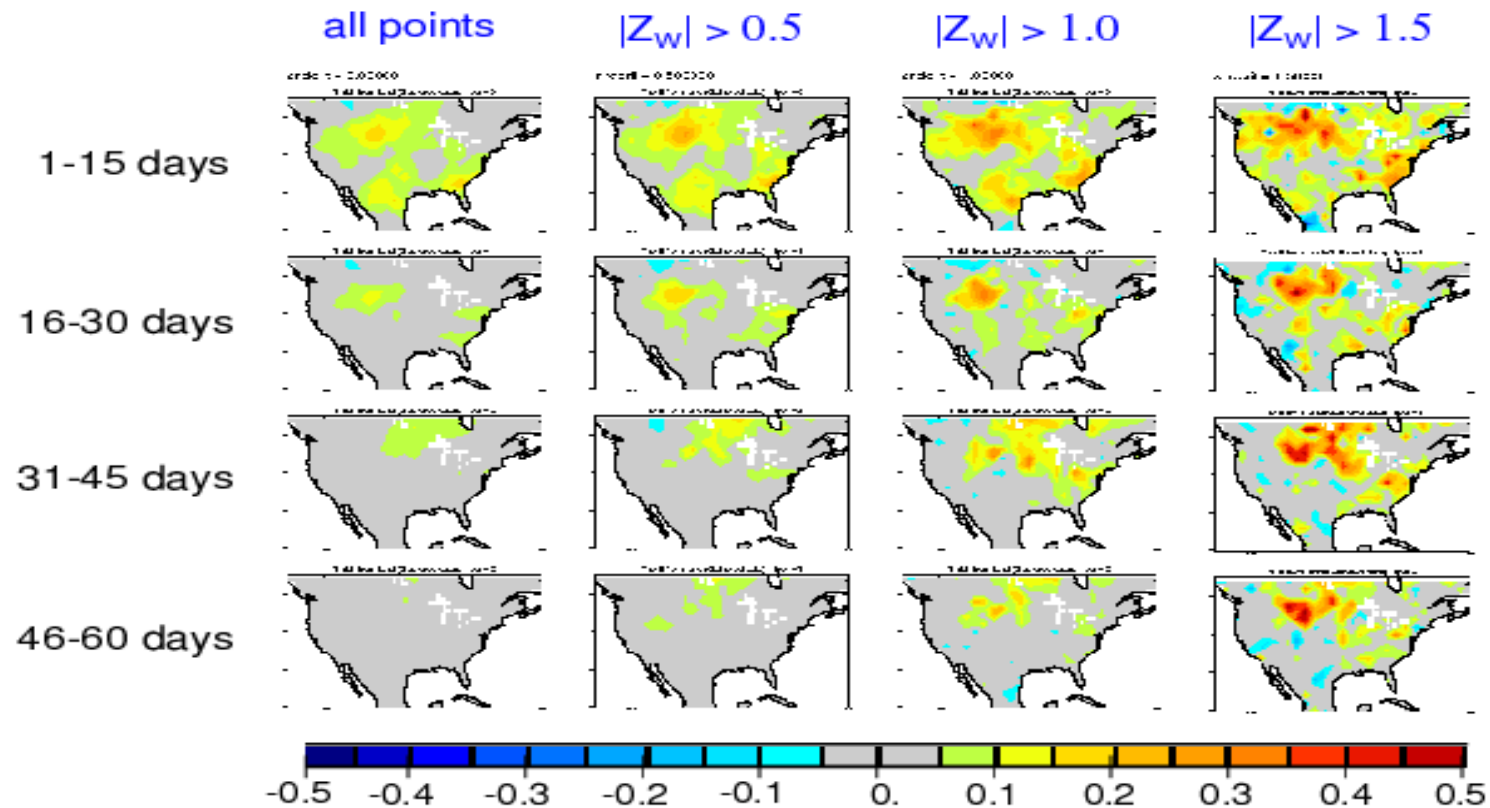


Weak SSW



Impact of soil moisture:

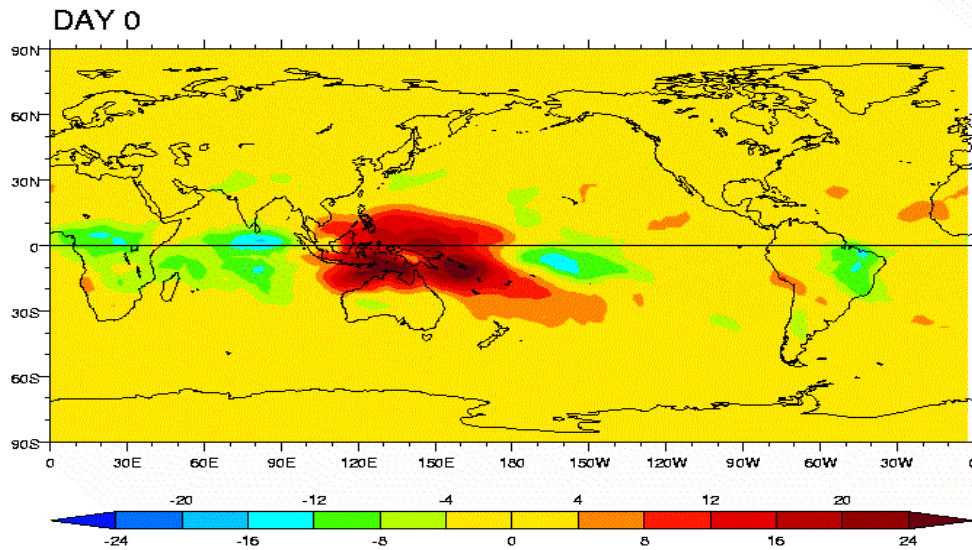
Temperature forecasts: Increase in skill due to land initialization (JJA) (conditioned on Z-score of initial soil moisture anomaly)



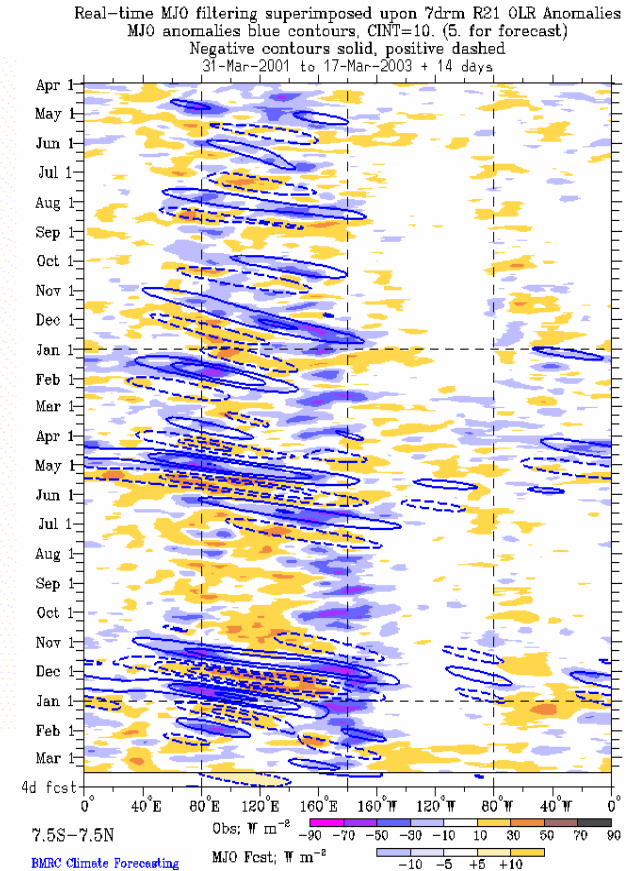
Koster et al, GRL 2010

The Madden Julian Oscillation (MJO)

MJO life cycle



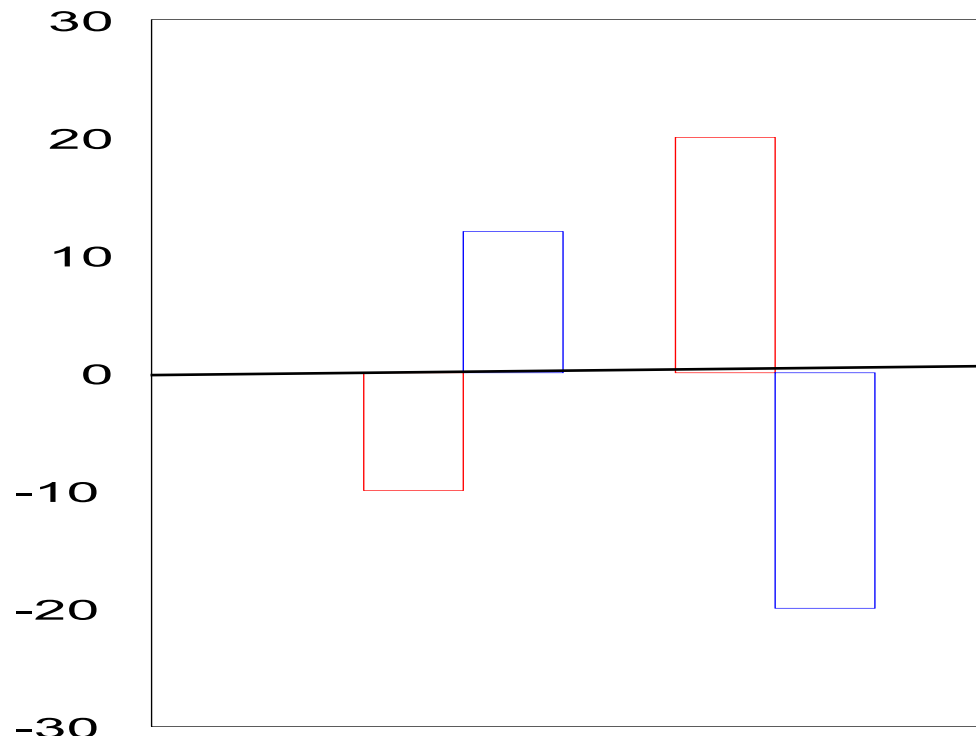
(From NASA)



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



MJO impact on European weather:



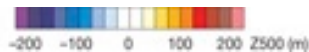
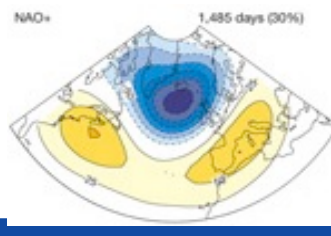
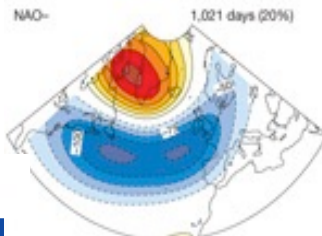
The MJO impact is the strongest about 10 days after the MJO is in the phase with:

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

Cassou (2008) Lin et al (2008)

NAO-

NAO+

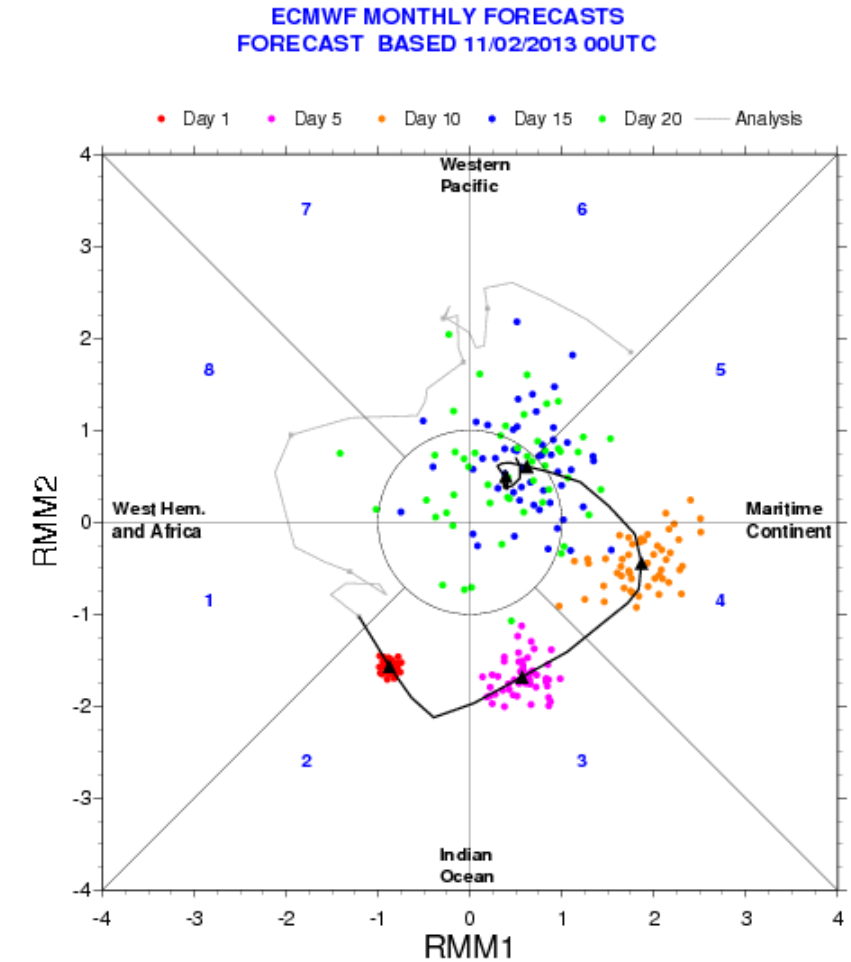
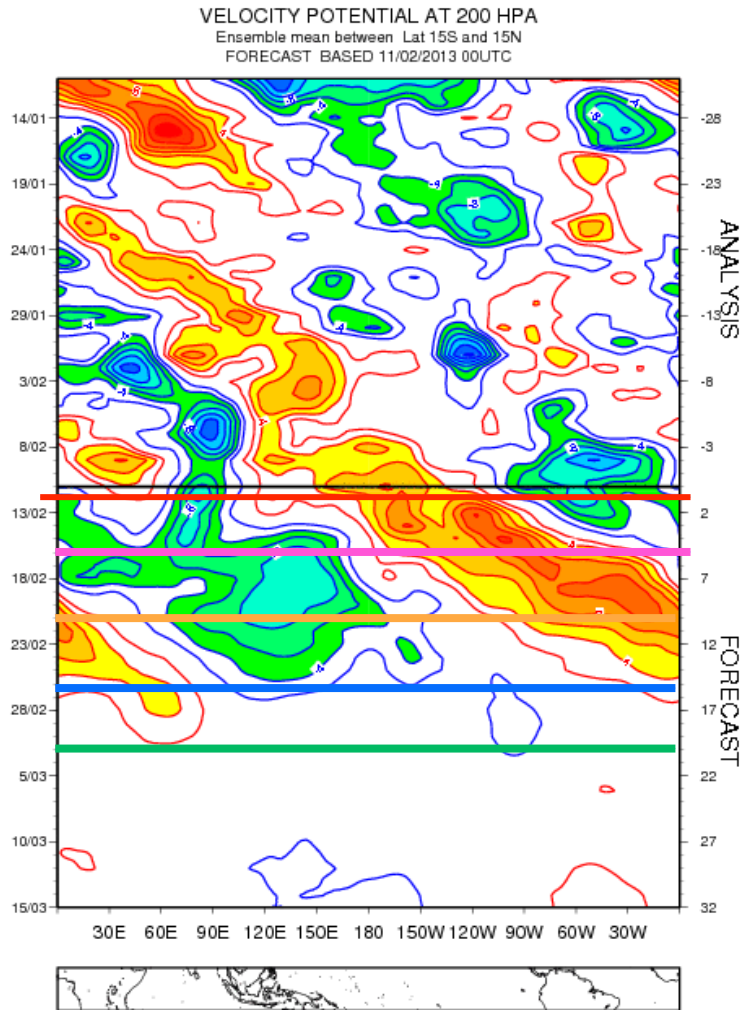


Conv. Over Indian Ocean +10 days

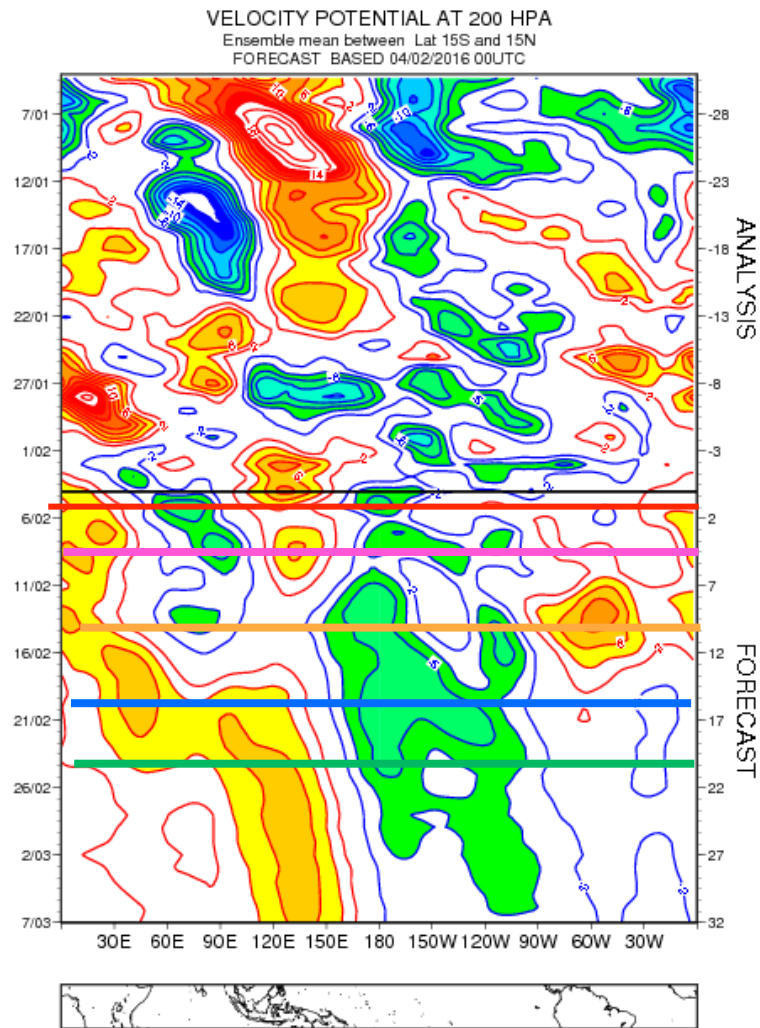


Conv. Over Western Pacific +10 days

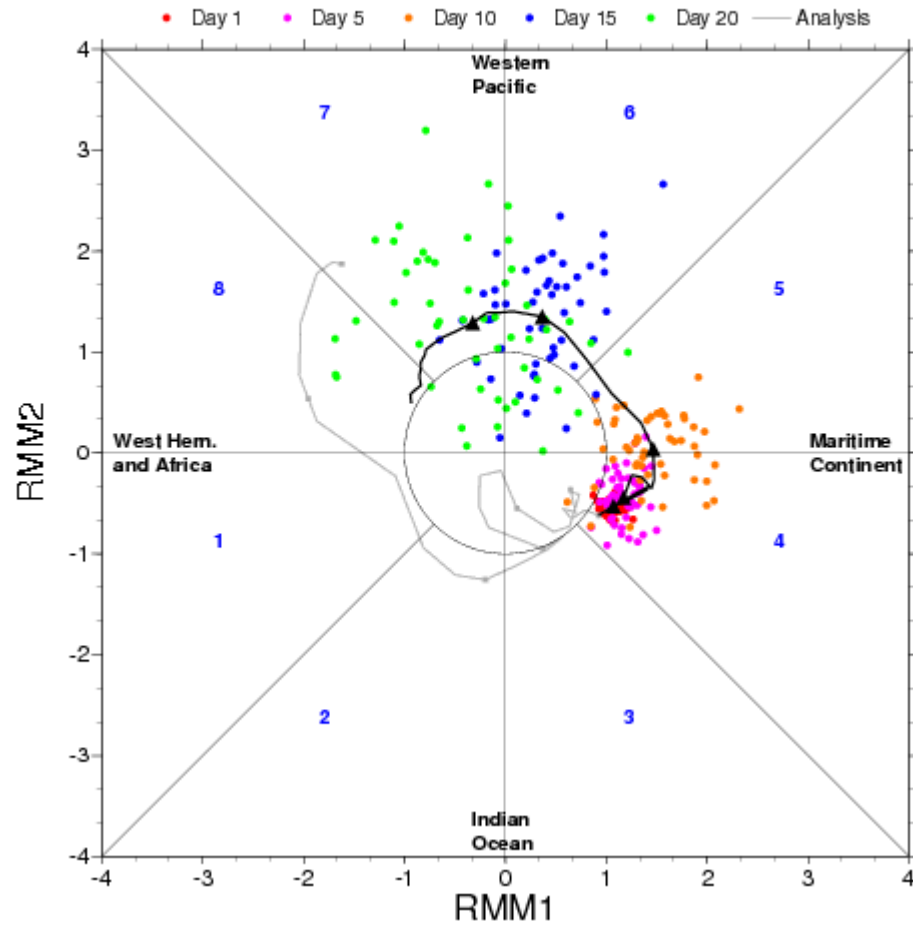
MJO forecast:



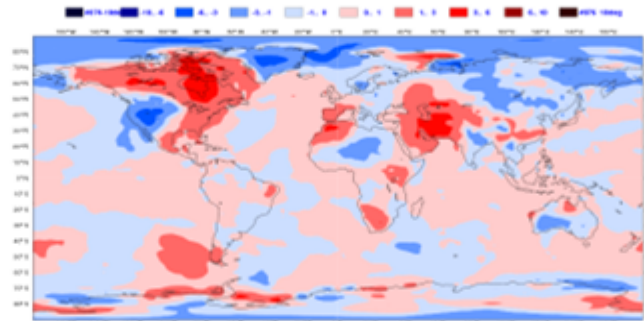
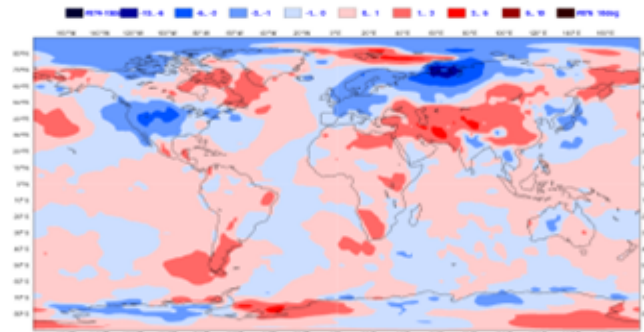
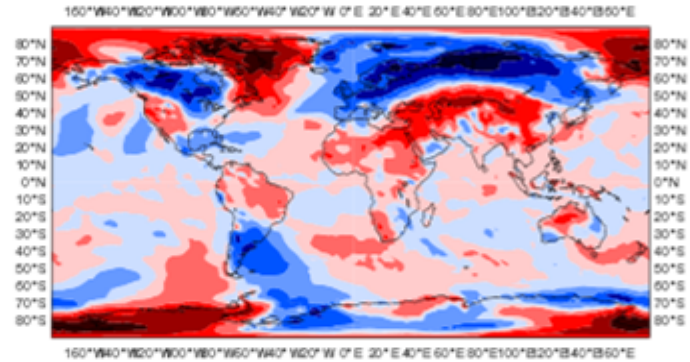
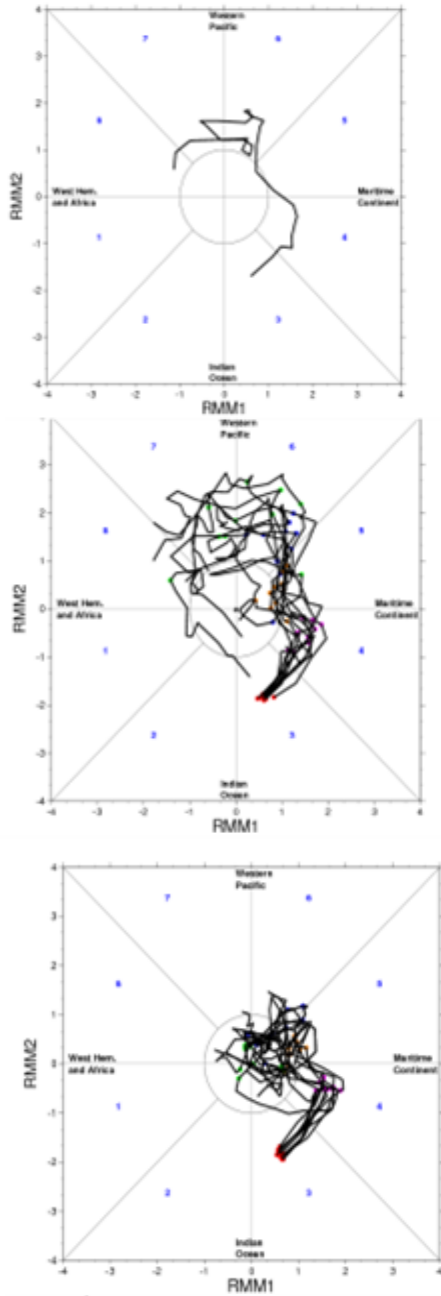
MJO forecast:



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



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

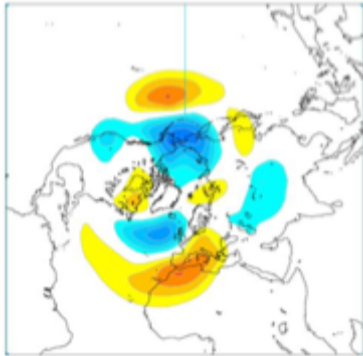


Analysis

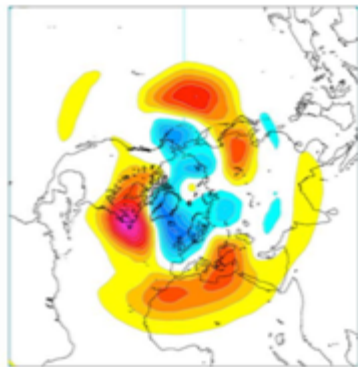
**10 best
MJO
forecasts**

**10 worse
MJO
forecasts**

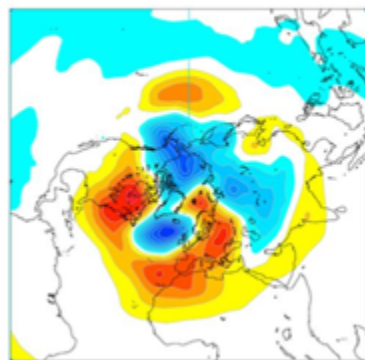
2002 MOFC hindcasts



2013 MOFC hindcasts



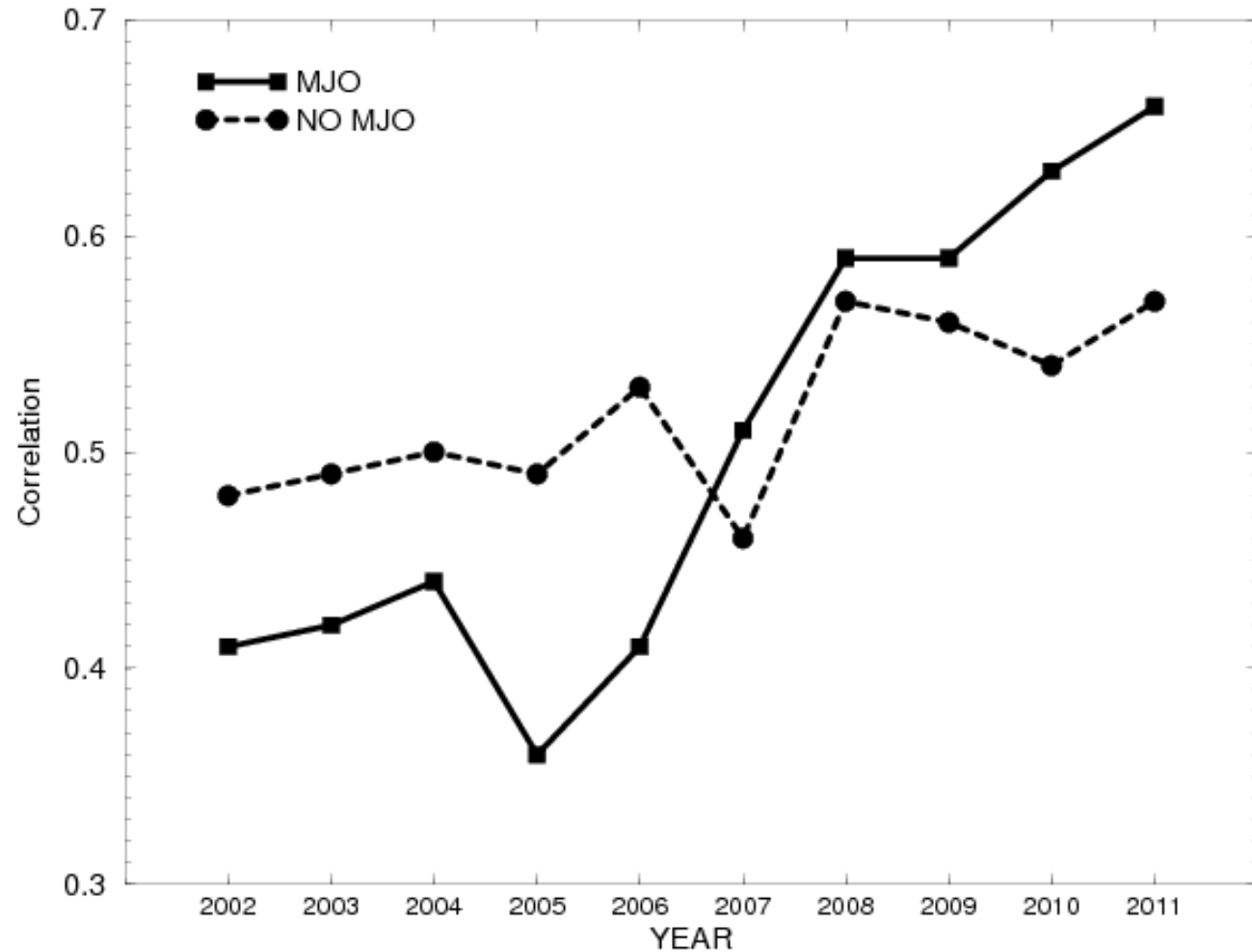
ERA Interim



MJO Teleconnections

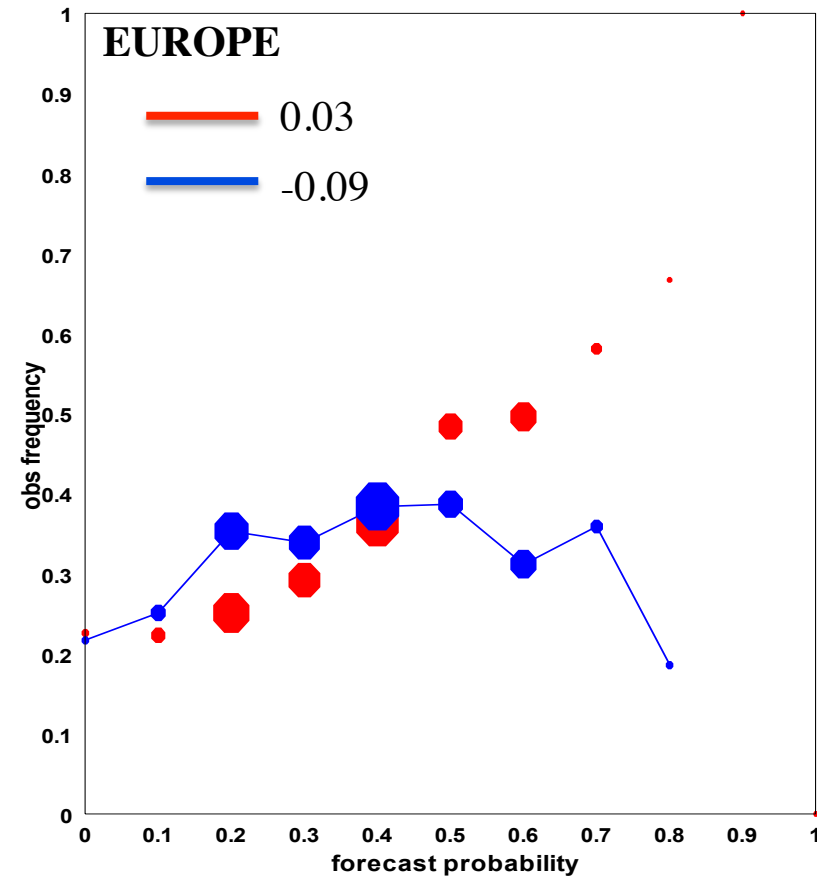
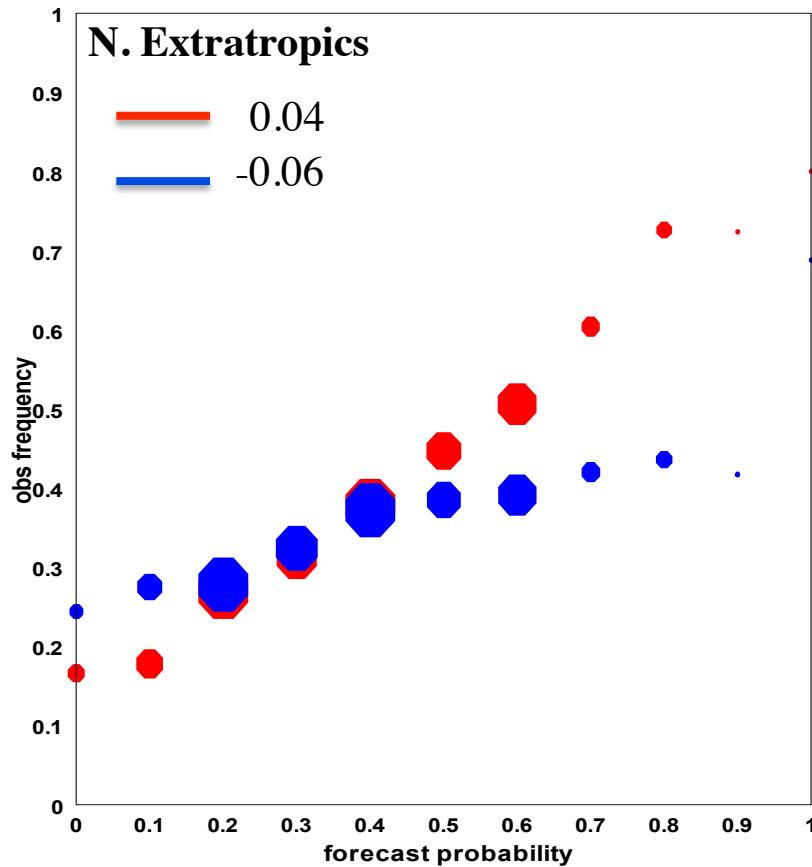
Evolution of NAO skill scores day 19-25

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

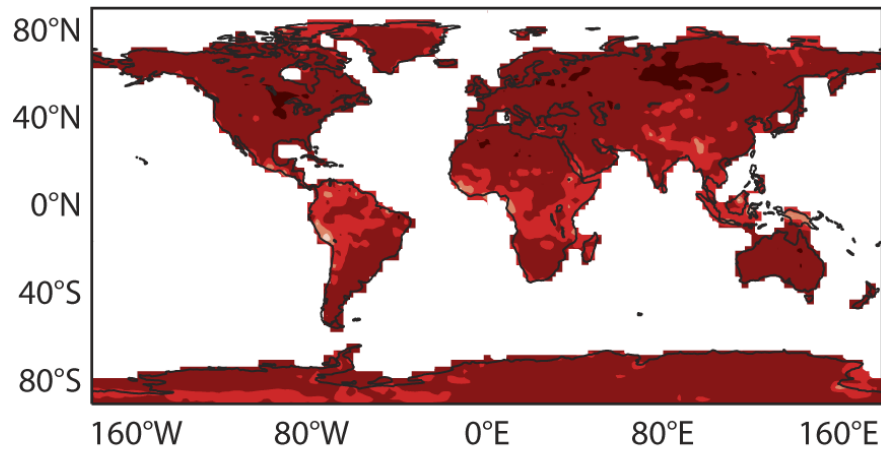


MJO in IC NO MJO in IC

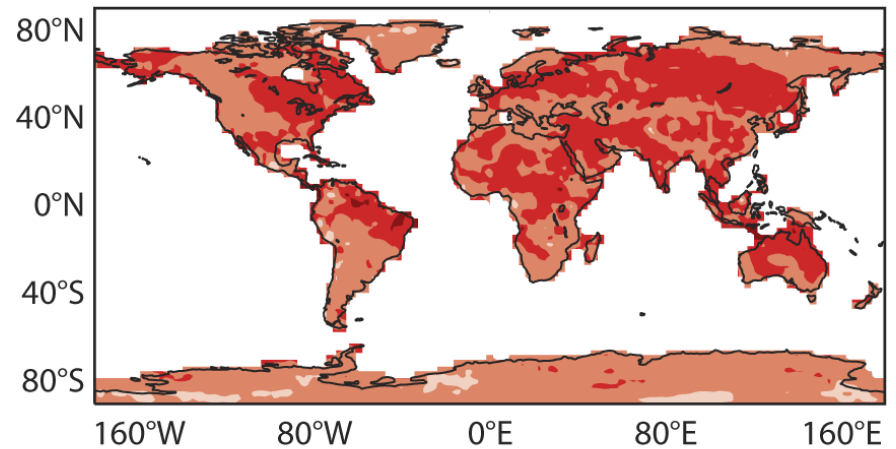
ROC for 2mt in the upper tercile

since Oct 2004

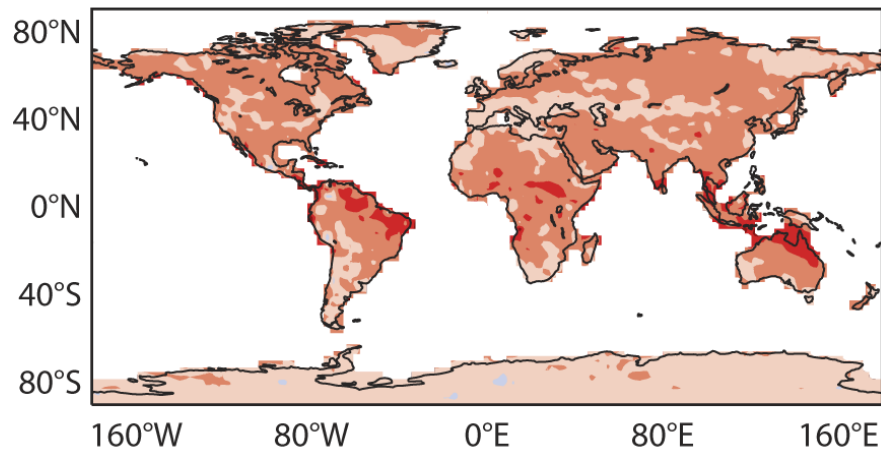
a Day 5–11



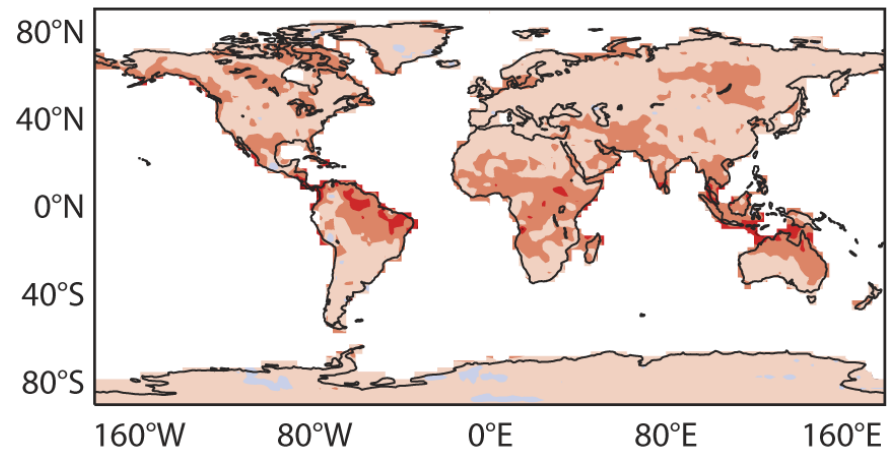
b Day 12–18



c Day 19–25



d Day 25–32

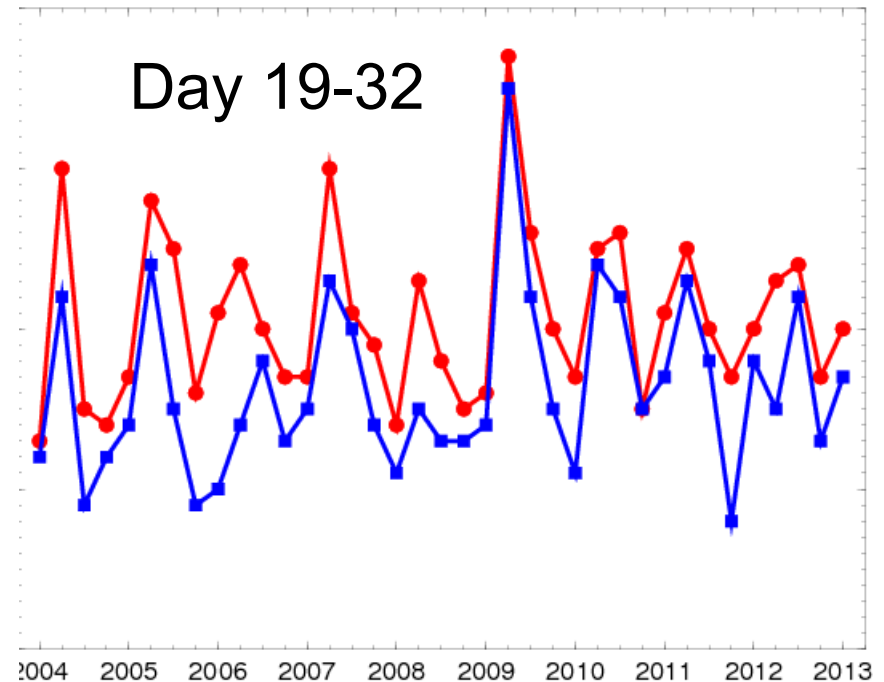
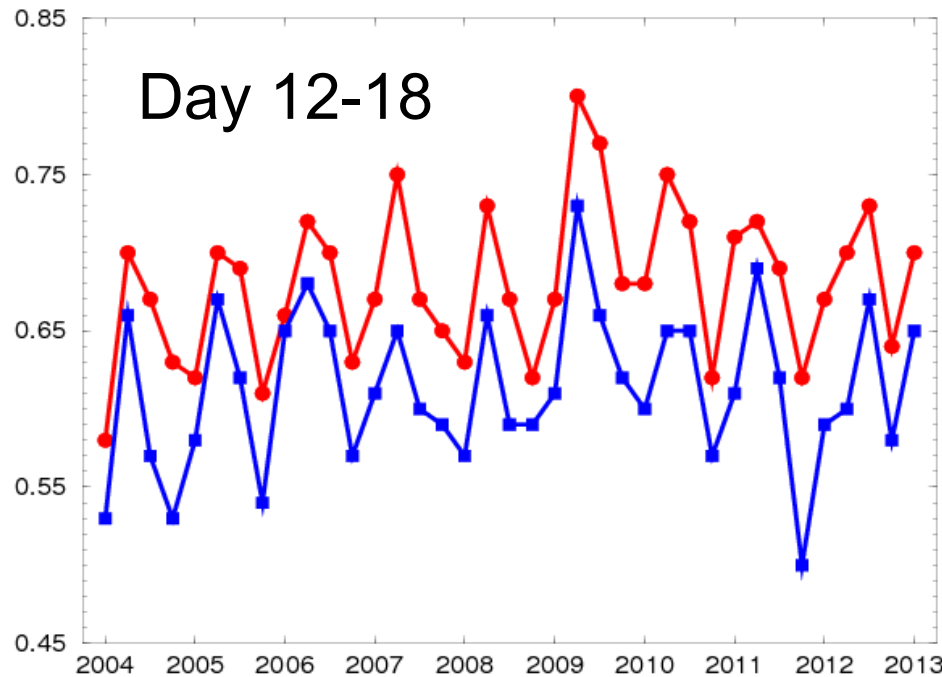


Monthly Forecast: Northern extratropics

ROC score: 2-metre temperature in the upper tercile

— Monthly Forecast
— Persistence of day 5-11

— Monthly Forecast
— Persistence of day 5-18

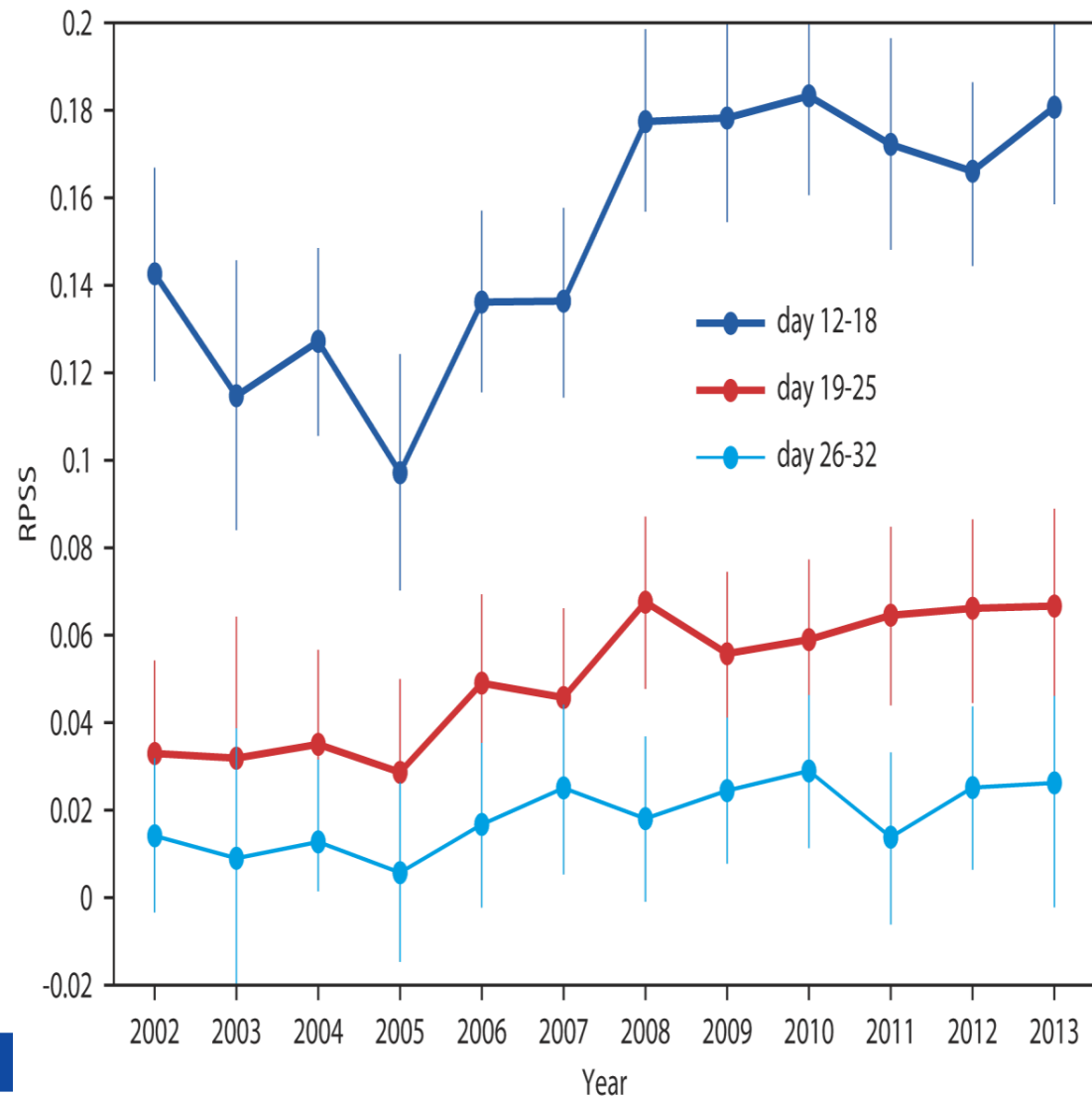


Evolution of skill scores based on the re-forecasts

RPSS – Probability of 2mt in upper tercile NDJFM

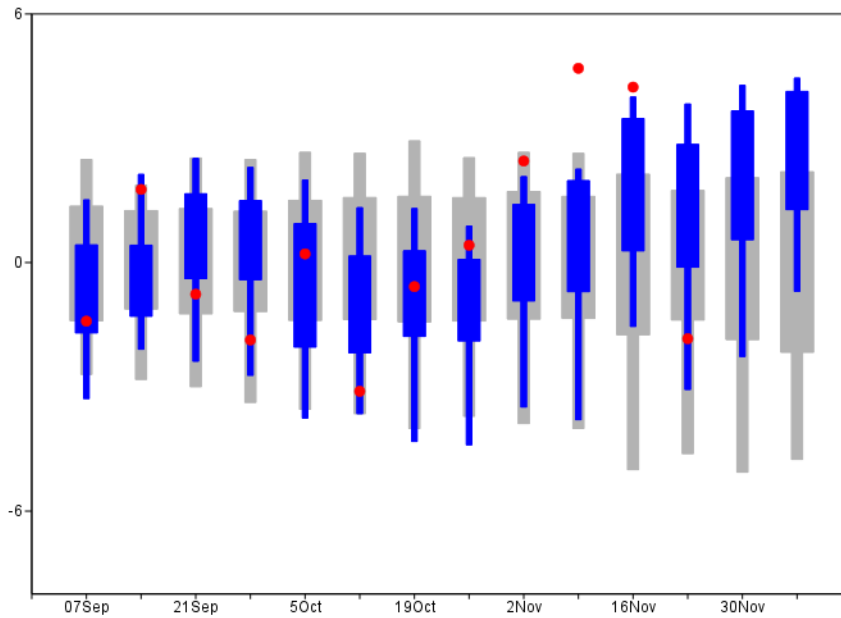
All the re-forecasts produced since 2002 have the period 1995-2001 in common.

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).

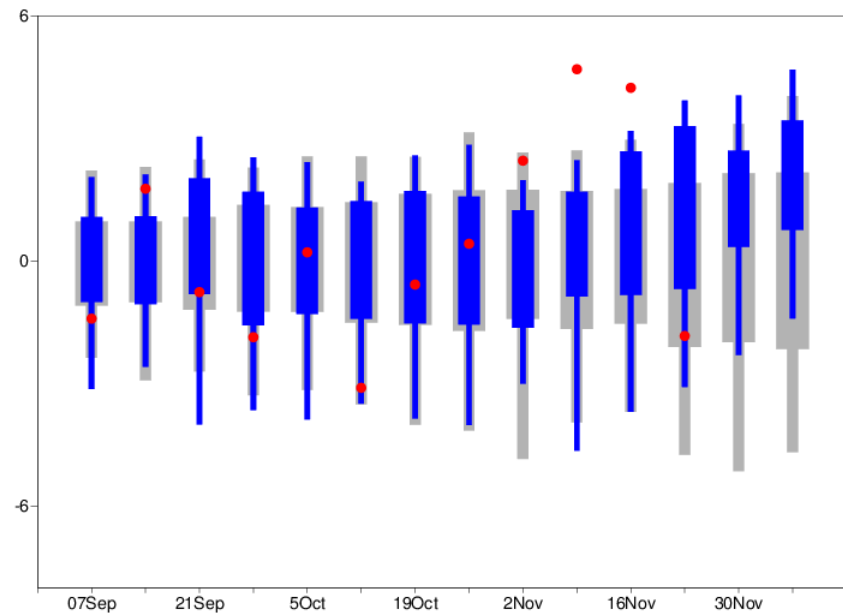


September to December 2015 2m temp weekly anomalies (55-45N 5-15E):

For. range 12-18 days
days



For. range 19-25
days



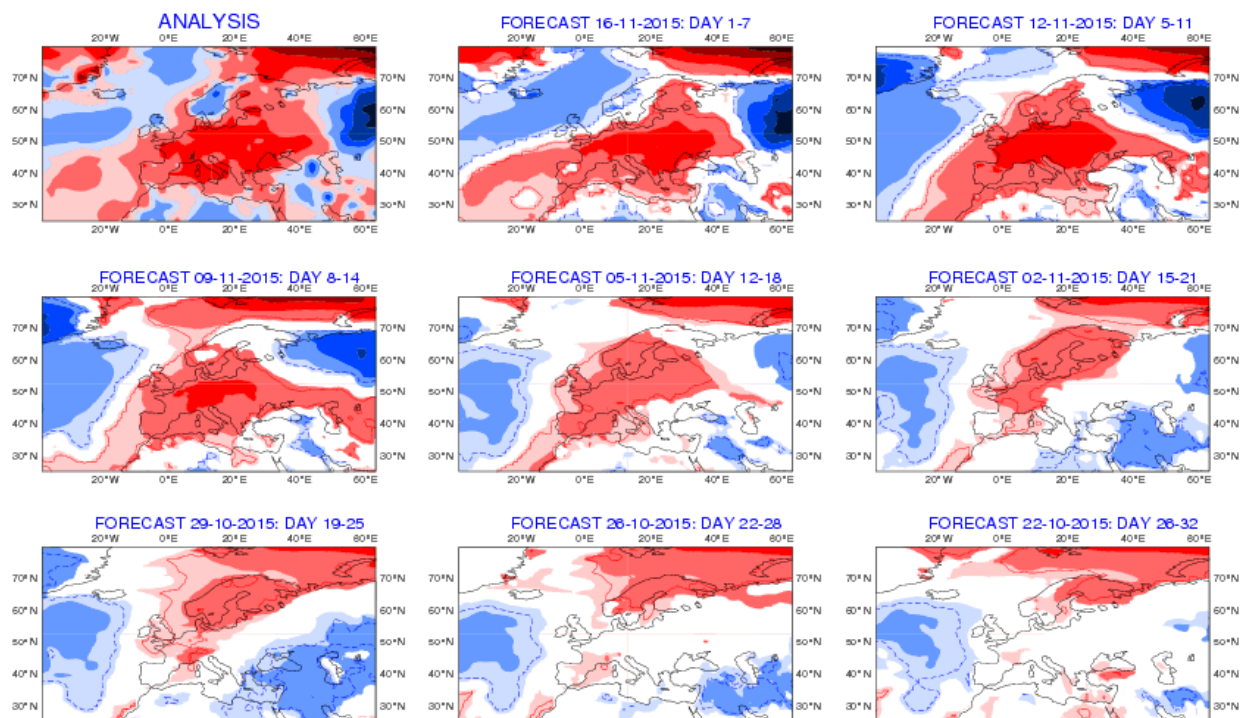
Analysis and ECMWF EPS-Monthly Forecasting System

2-metre Temperature anomaly

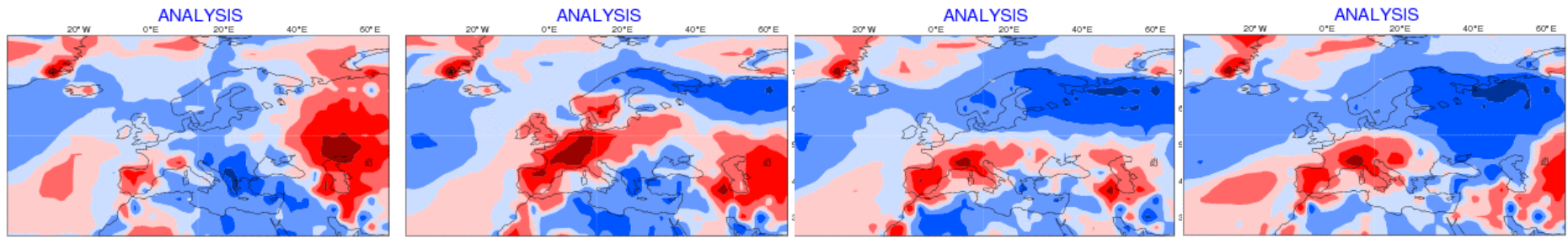
Verification period: 16-11-2015/TO/22-11-2015

ensemble size = 51, climate size = 660

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



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

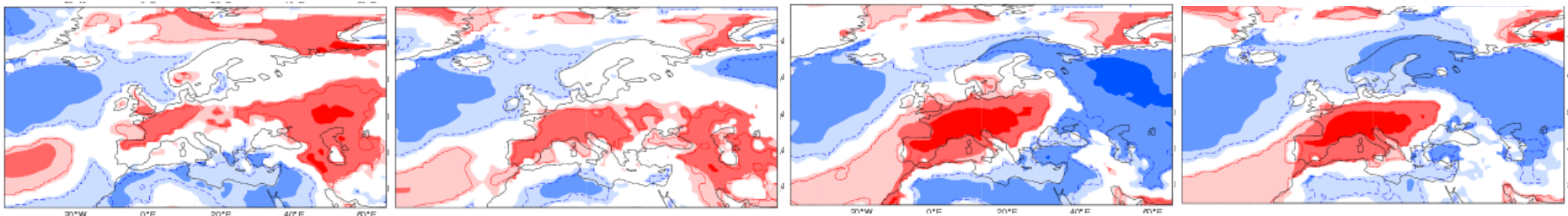


22-28 Jun

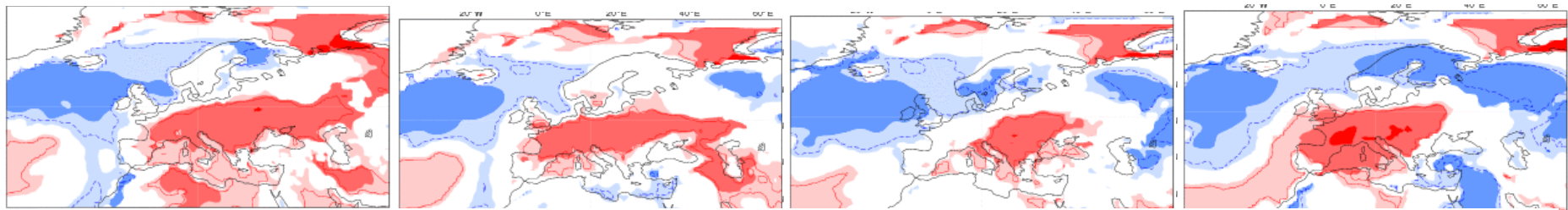
29-5 Jul

6-12 Jul

13-19 Jul



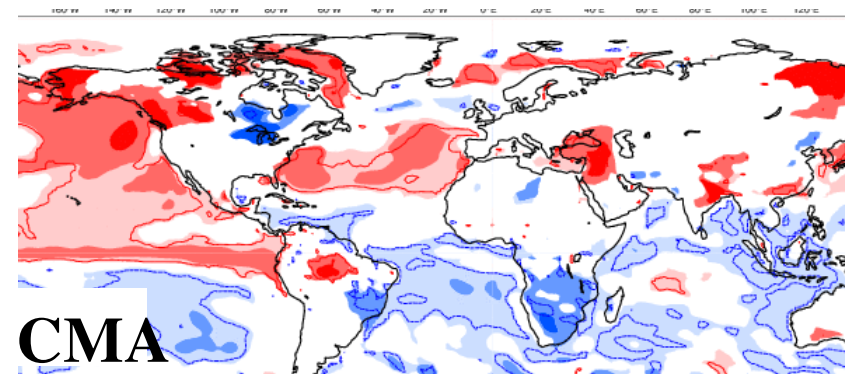
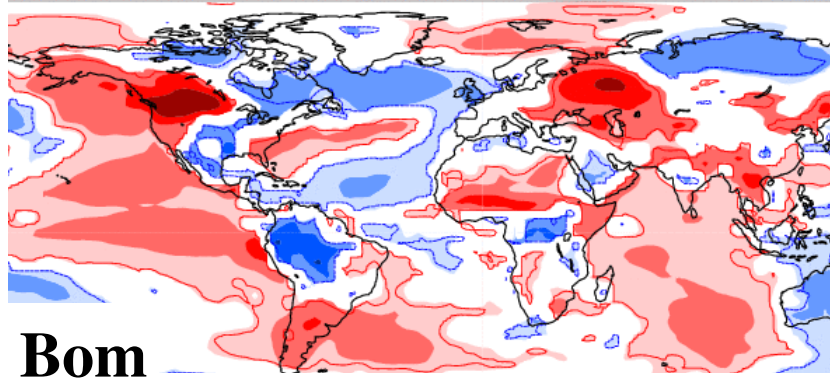
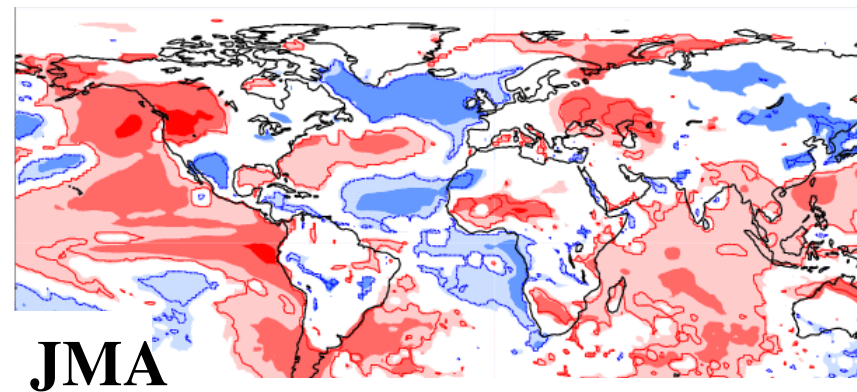
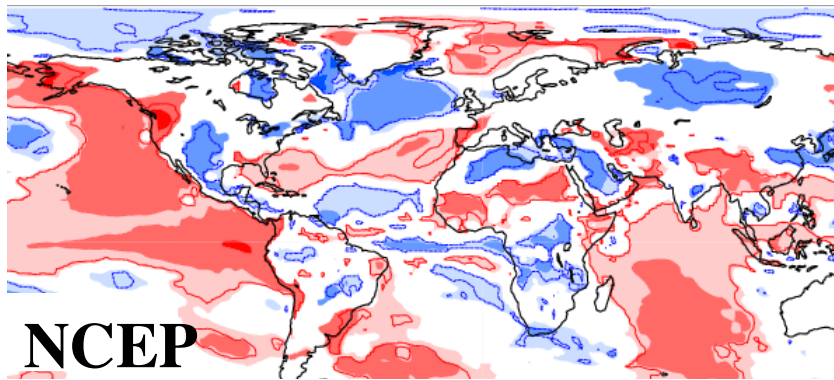
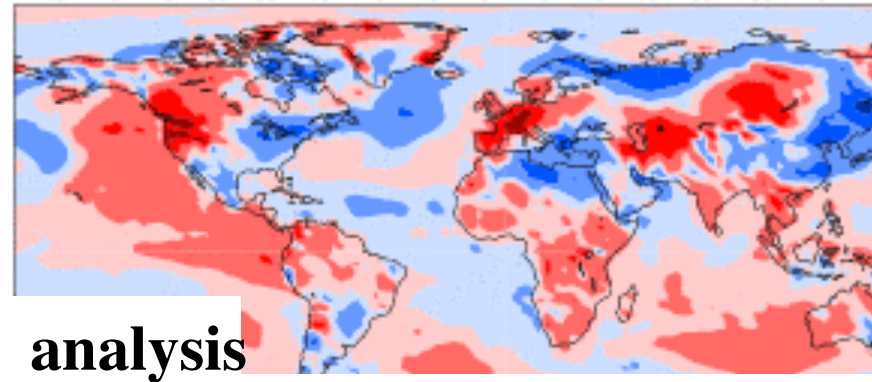
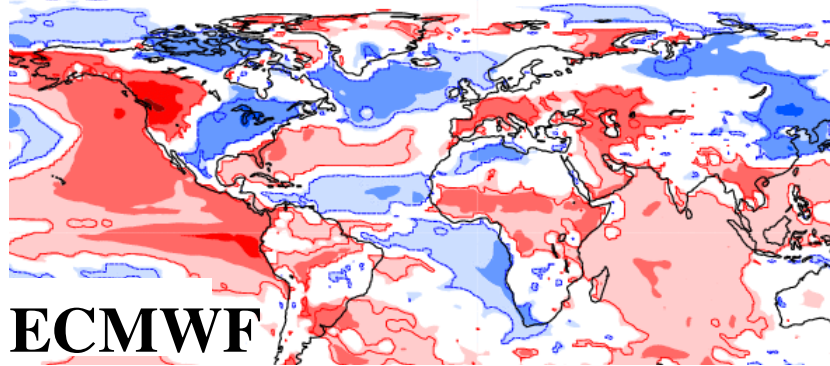
Forecasts: 12-18 days



Forecasts: 19-25 days

S2S 2mt anomalies:

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



Analysis and ECMWF ENS Forecasting System

2-metre Temperature anomaly

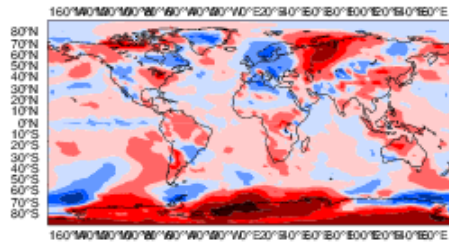
Verification period: 08-08-2016/TO/14-08-2016

ensemble size = 51 , climate size = 660

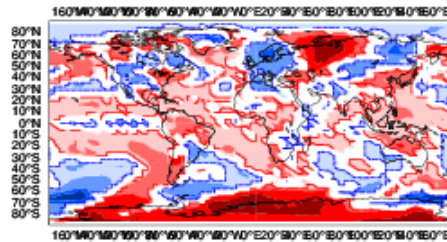
Shaded areas significant at 10% level, Contours at 1% level



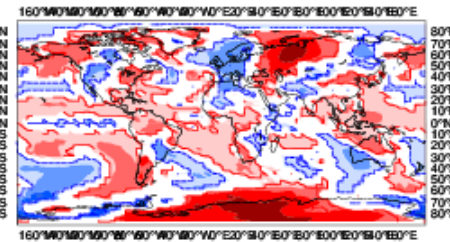
ANALYSIS



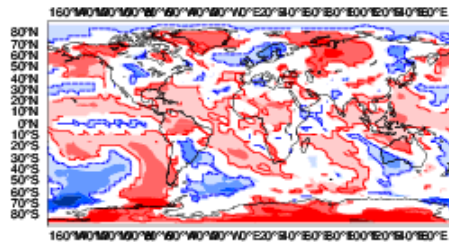
FORECAST 08-08-2016: DAY 1-7



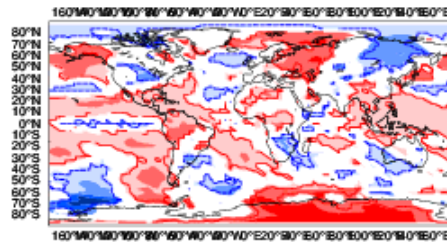
FORECAST 04-08-2016: DAY 5-11



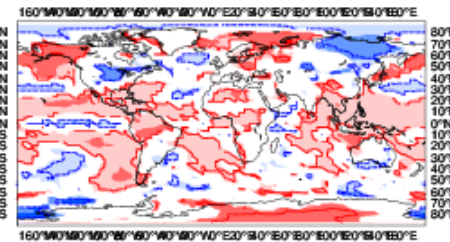
FORECAST 01-08-2016: DAY 8-14



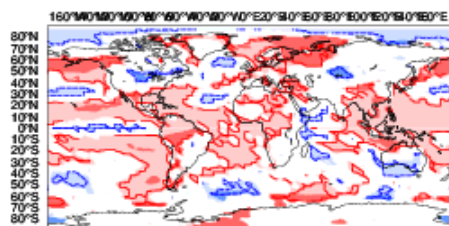
FORECAST 28-07-2016: DAY 12-18



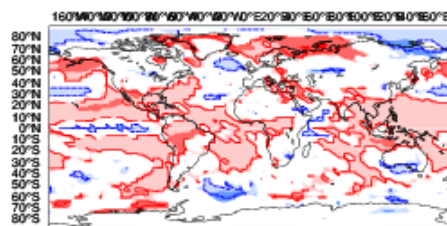
FORECAST 25-07-2016: DAY 15-21



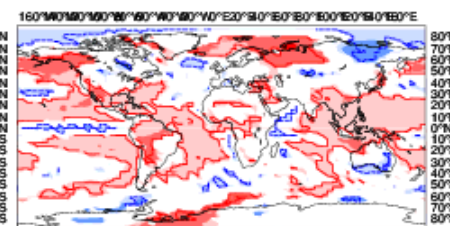
FORECAST 21-07-2016: DAY 19-25



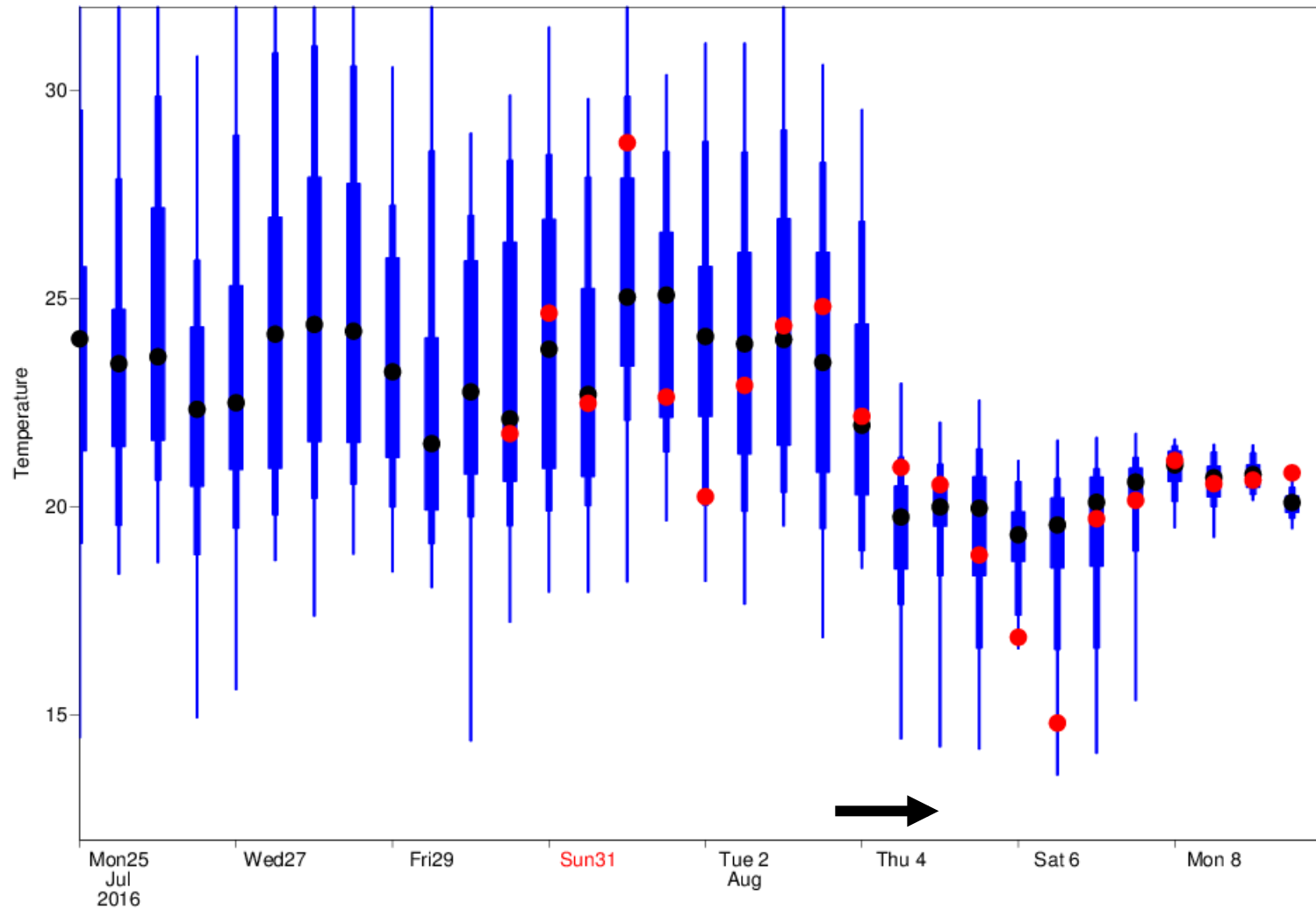
FORECAST 18-07-2016: DAY 22-28



FORECAST 14-07-2016: DAY 26-32



2-metre temperature Paris 9 August 12z



From Linus 's weather discussion 2016-08-12





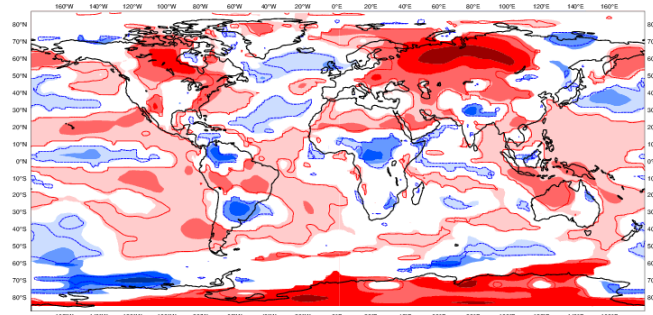
The Sub-seasonal to Seasonal (S2S) Prediction Project

- 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:

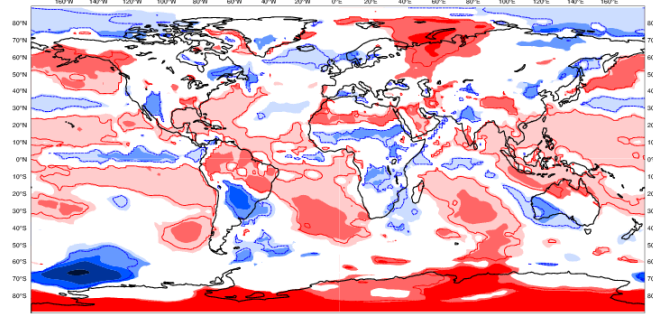
Ens. Forecasting System: cawc
2-meter Temperature anomaly
Forecast start reference is 28-07-2016
ensemble size = 33 ,climate size = 395
Day 12-18
08-08-2016 TO 14-08-2016
Shaded areas significant at 10% level
Contours at 1% level

<-10deg -10..-6 -6..-3 -3..-1 -1..0 0..1 1..3 3..6 6..10 >10deg



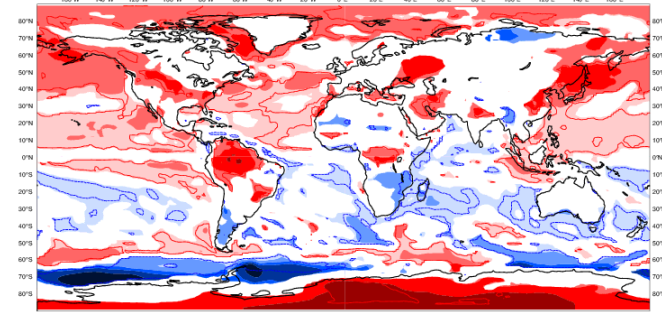
Ens. Forecasting System: ncep
2-meter Temperature anomaly
Forecast start reference is 28-07-2016
ensemble size = 16 ,climate size = 48
Day 12-18
08-08-2016 TO 14-08-2016
Shaded areas significant at 10% level
Contours at 1% level

<-10deg -10..-6 -6..-3 -3..-1 -1..0 0..1 1..3 3..6 6..10 >10deg



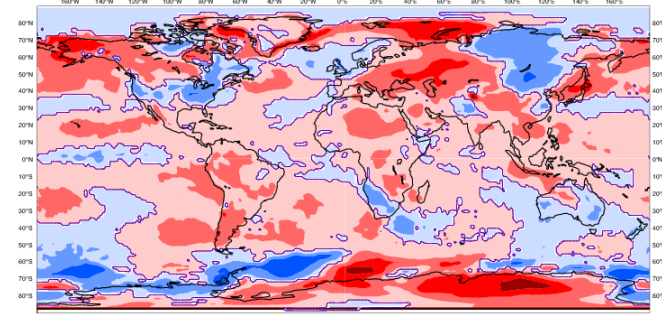
Ens. Forecasting System: cma
2-meter Temperature anomaly
Forecast start reference is 28-07-2016
ensemble size = 4 ,climate size = 48
Day 12-18
08-08-2016 TO 14-08-2016
Shaded areas significant at 10% level
Contours at 1% level

<-10deg -10..-6 -6..-3 -3..-1 -1..0 0..1 1..3 3..6 6..10 >10deg



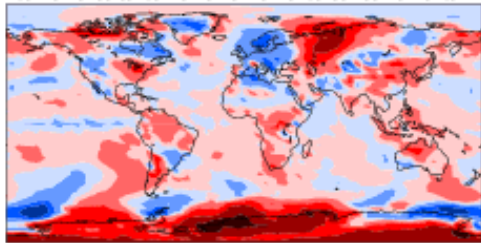
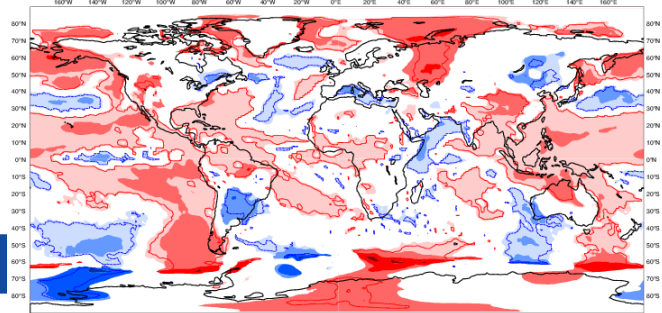
Ens. Forecasting System: ukmo
2-meter Temperature anomaly
Forecast start reference is 28-07-2016
ensemble size = 4 ,climate size = 33
Day 12-18
08-08-2016 TO 14-08-2016
Shaded areas significant at 10% level
Contours at 1% level

<-10deg -10..-6 -6..-3 -3..-1 -1..0 0..1 1..3 3..6 6..10 >10deg

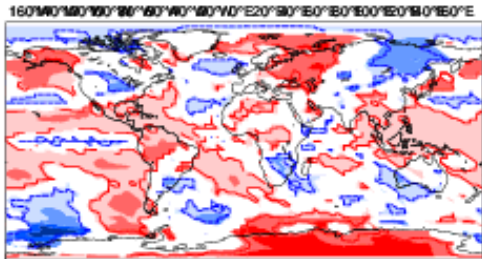


Ens. Forecasting System: jma
2-meter Temperature anomaly
Forecast start reference is 28-07-2016
ensemble size = 25 ,climate size = 60
Day 12-18
08-08-2016 TO 14-08-2016
Shaded areas significant at 10% level
Contours at 1% level

<-10deg -10..-6 -6..-3 -3..-1 -1..0 0..1 1..3 3..6 6..10 >10deg



FORECAST 28-07-2016: DAY 12-18



TIGGE-S2S database

Sub-seasonal real-time Operational Forecasts

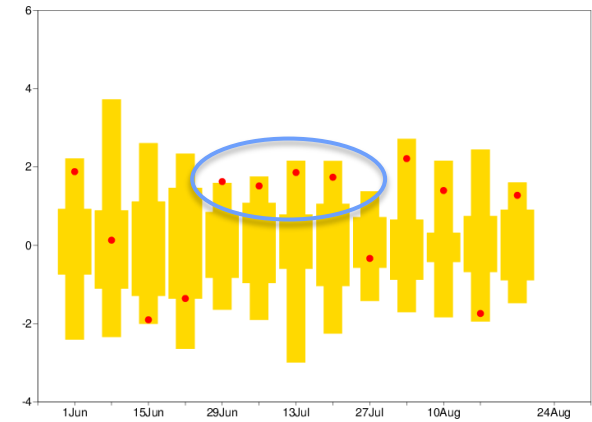
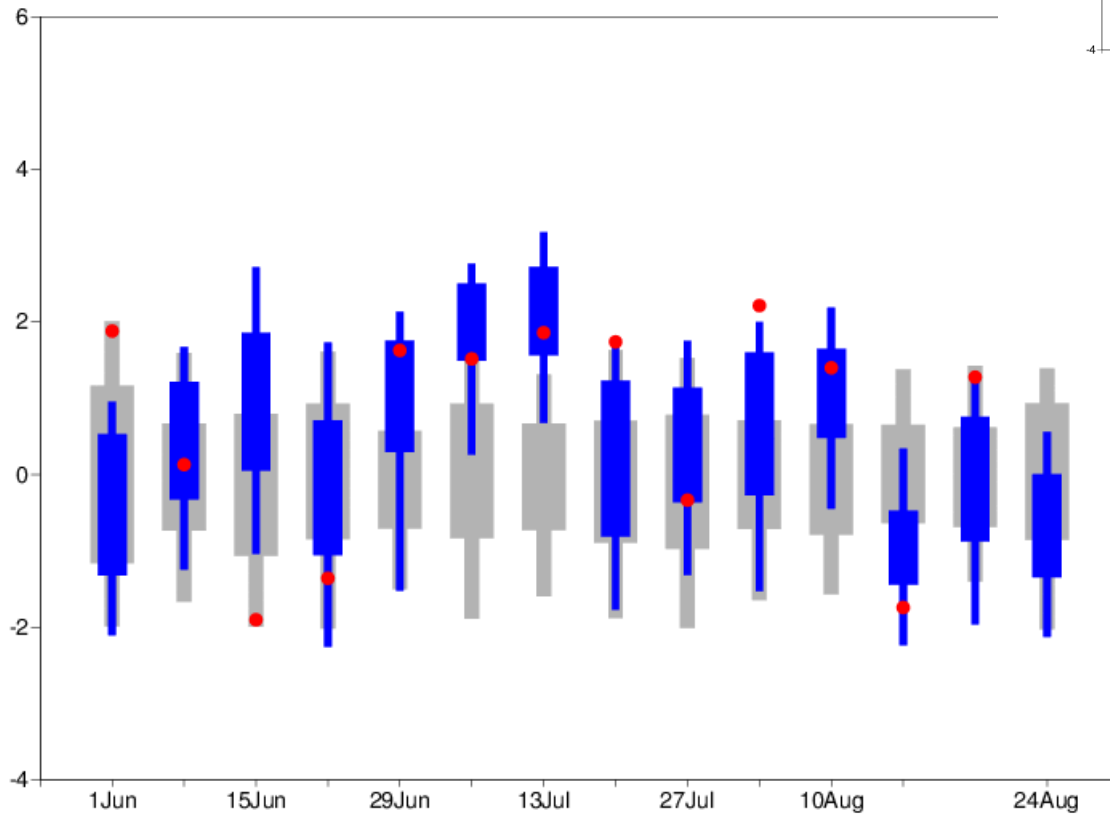
	Time-range	Resol.	Ens. Size	Freq.	Hcsts	Hcst length	Hcst Freq	Hcst Size
ECMWF	D 0-32	T639/319L62	51	2/week	On the fly	Past 18y	weekly	5
UKMO	D 0-60	N96L85	4	daily	On the fly	1989-2003	4/month	3
NCEP	D 0-60	N126L64	16	daily	Fix	1999-2010	daily	4
EC	D 0-35	0.6x0.6L40	21	weekly	On the fly	Past 15y	weekly	4
CAWCR	D 0-120	T47L17	33	weekly	Fix	1989-2010	3/month	33
JMA	D 0-34	T159L60	50	weekly	Fix	1979-2009	3/month	5
KMA	D 0-30	T106L21	20	3/month	Fix	1979-2010	3/month	10
CMA	D 0-45	T63L16	40	6/month	Fix	1982-now	monthly	48
Met.Fr	D 0-60	T63L91	41	monthly	Fix	1981-2005	monthly	11
SAWS	D 0-60	T42L19	6	monthly	Fix	1981-2001	monthly	6
HMCR	D 0-60	1.1x1.4 L28	10	monthly	Fix	1979-2003	monthly	10

Conclusion

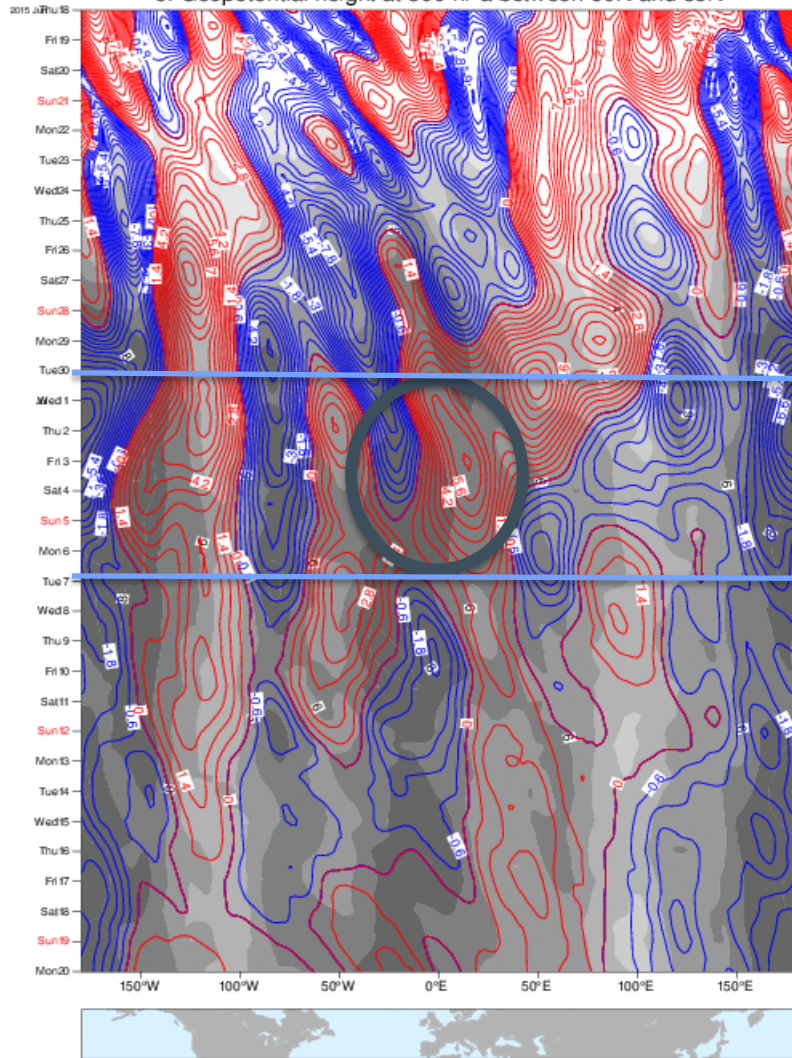
- SSTs, Soil moisture, stratospheric initial conditions and MJO are source of predictability at the intra-seasonal time scale. In particular the MJO has a significant impact on the forecast skill scores beyond day 20.
- The ENS produces forecasts for days 12-18 that are generally better than climatology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



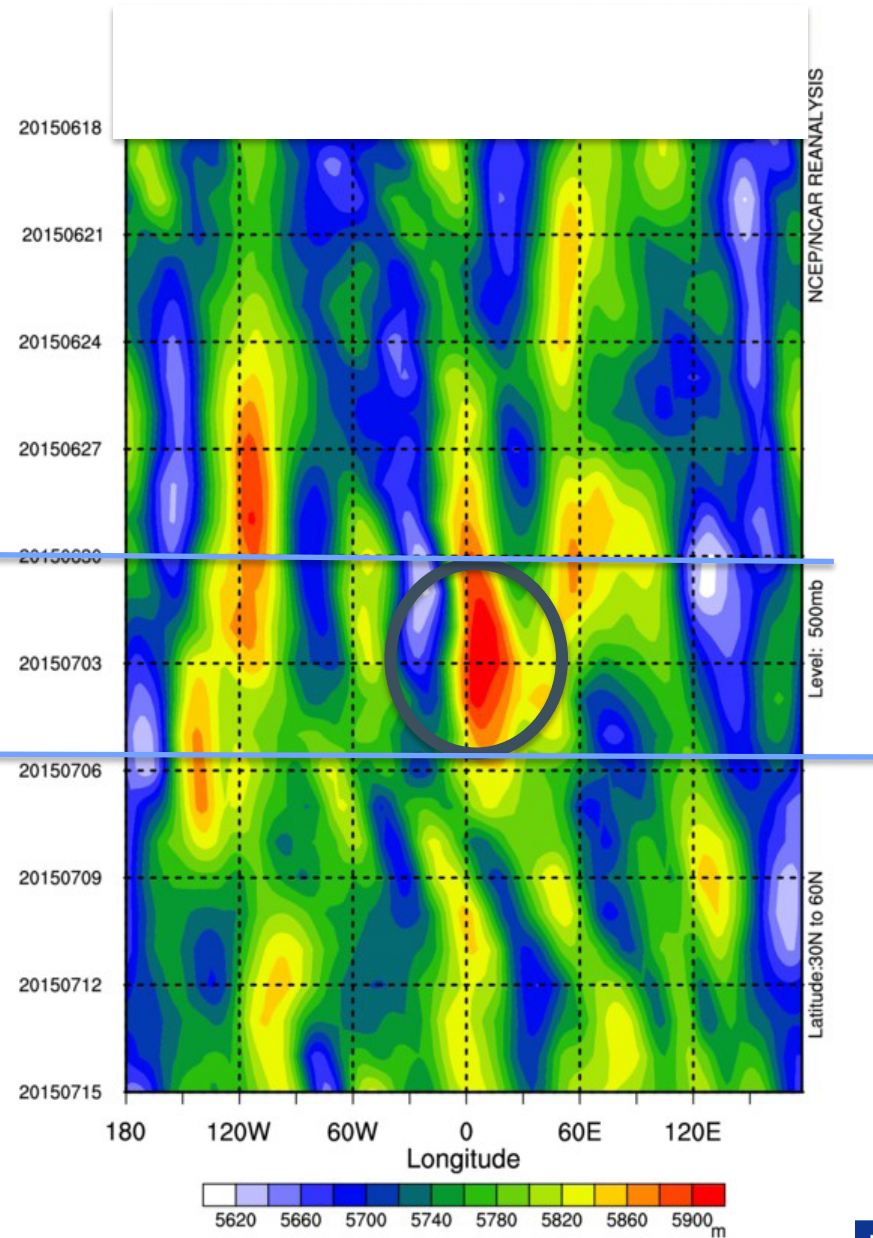
weekly mean anomalies over Southern Europe: 2mt forecast 12-18



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



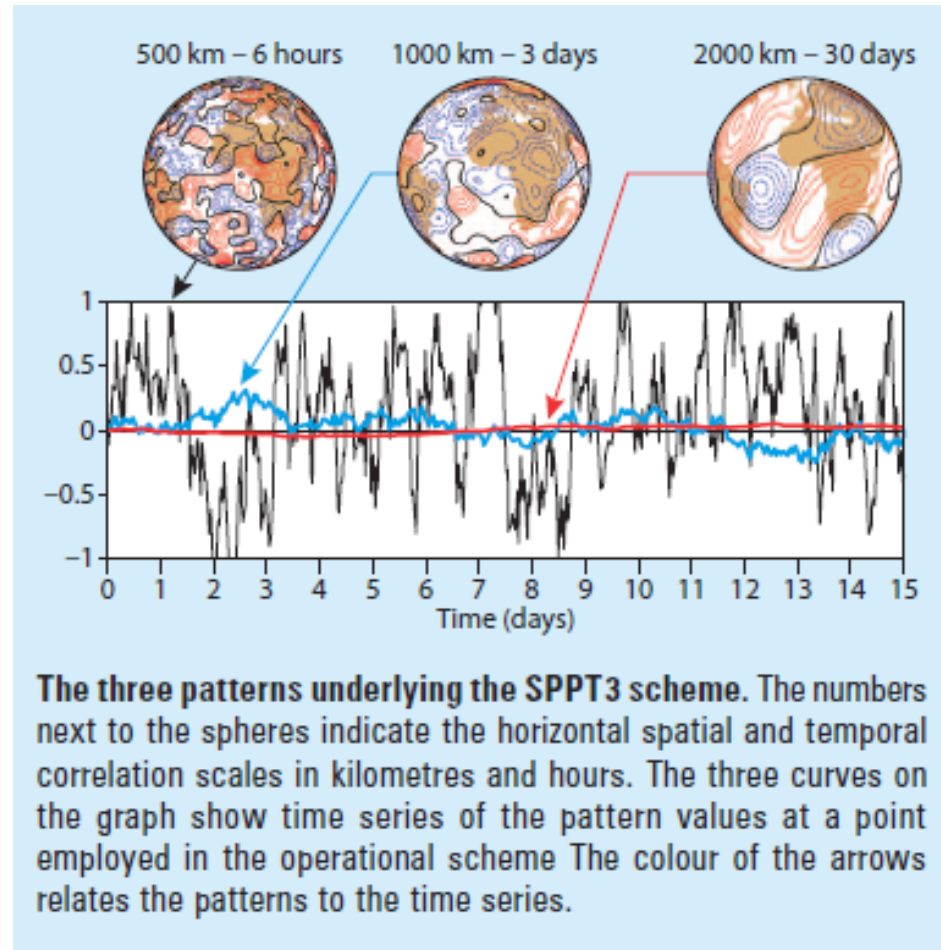
Geopotential height



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

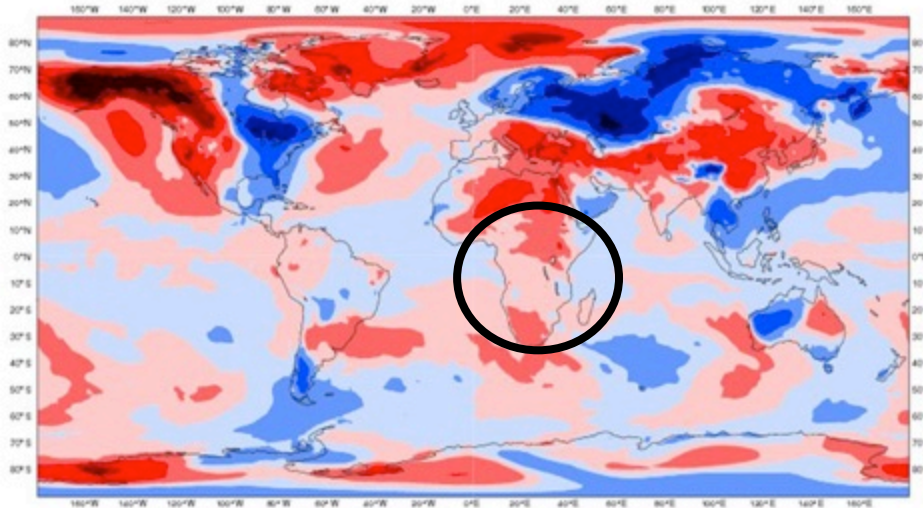


Stochastic backscatter scheme (SKEB)

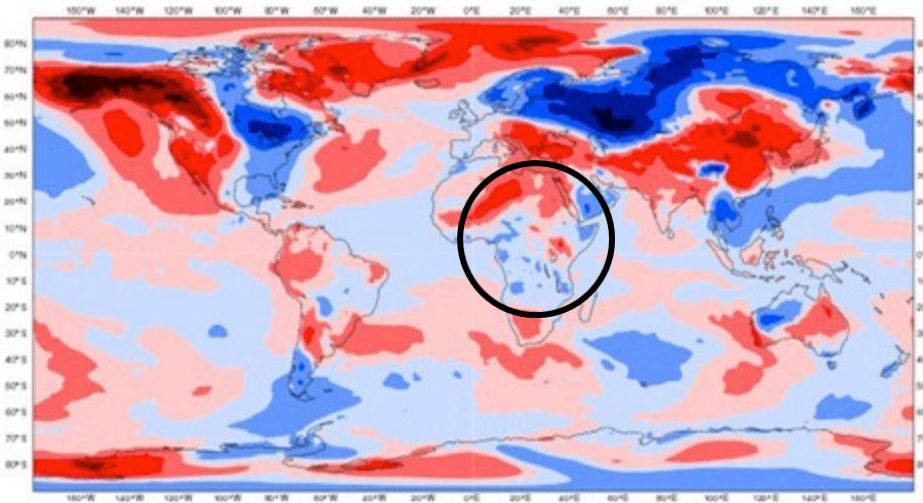
It compensate for the loss of energy in the model due to the Mis-representation of processes at sub-gridscale.

New re-forecast twice a week 11 members

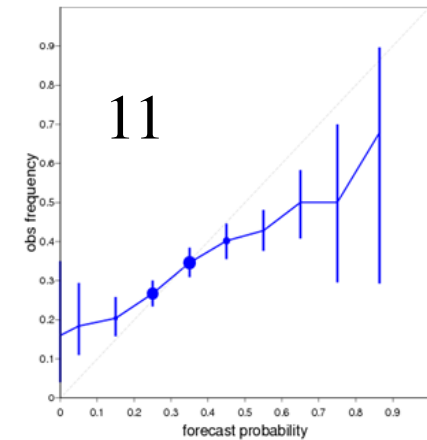
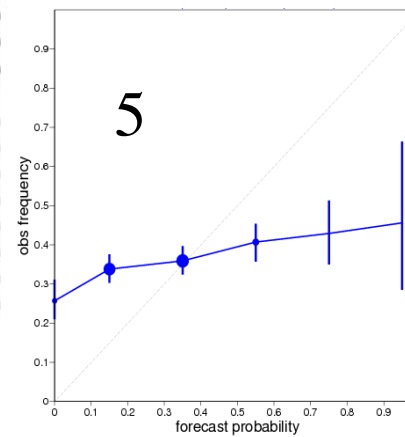
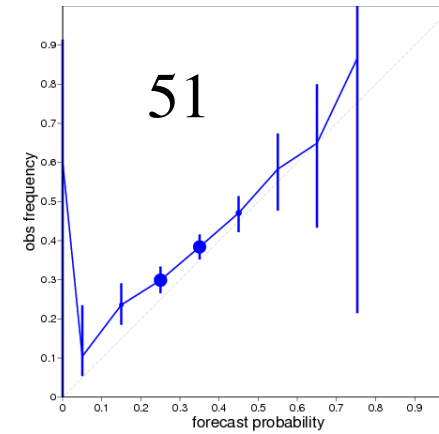
a) Current Re-forecast configuration



b) New Re-forecast configuration

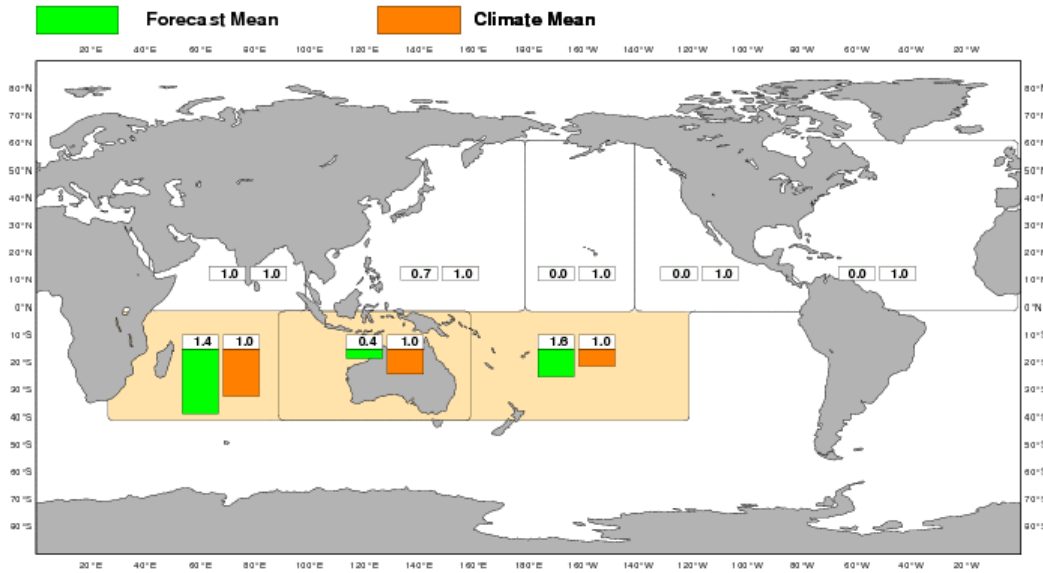


Impact on verification
T850- Upper terciles – Week 4



ECMWF Monthly Forecast
 Accumulated Cyclone Energy
 Forecast start reference is 24/01/2013
 Ensemble size = 51, climate size = 100

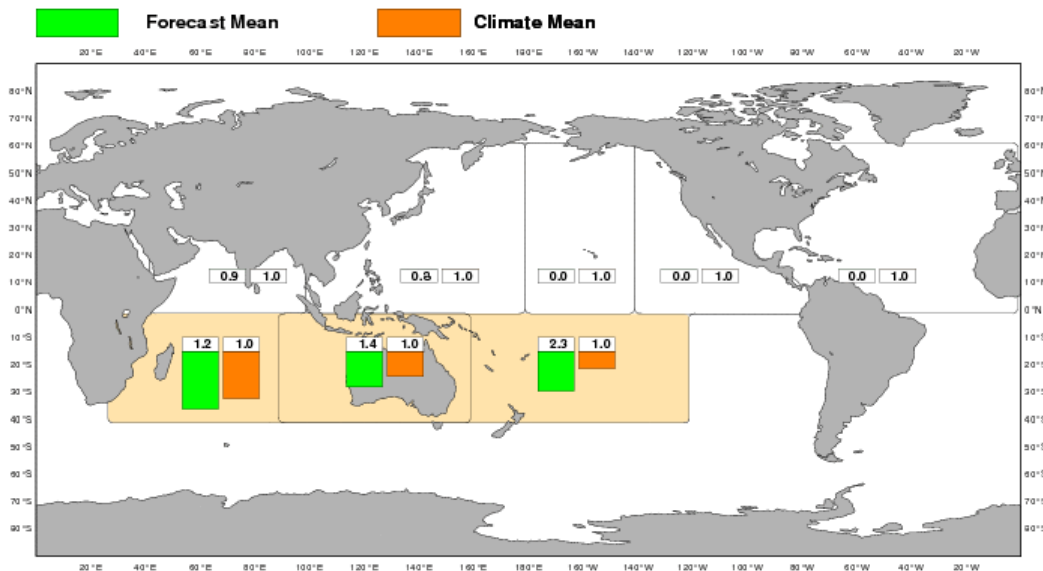
DAY 05-11
 28/01-03/02/2013
 Climate = 1993-2012



Weekly mean Accumulated Cyclone Energy (ACE)

ECMWF Monthly Forecast
 Accumulated Cyclone Energy
 Forecast start reference is 17/01/2013
 Ensemble size = 51, climate size = 100

DAY 12-18
 28/01-03/02/2013
 Climate = 1993-2012



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

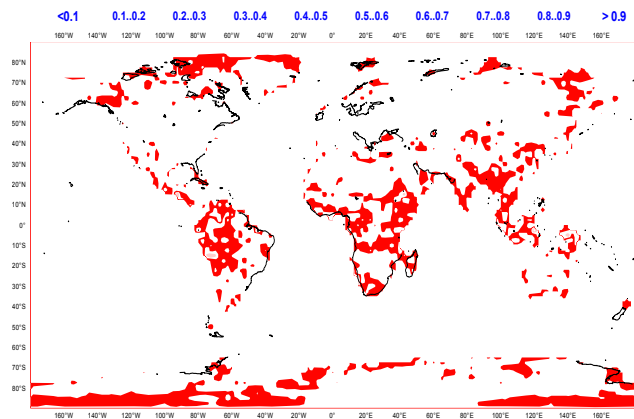
- **Atmospheric initial conditions:** ECMWF operational analysis
- **Oceanic initial conditions:** “Accelerated” ocean analysis
- **Perturbations:**
 - **Atmosphere:** Singular vectors + stochastic physics
 - **Ocean:** Wind stress perturbations during the data assimilation



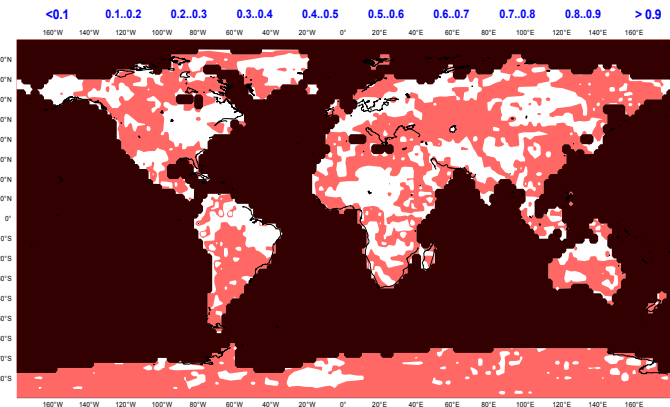
Skill of the ECMWF Monthly Forecasting System

ROC score: 2-meter temperature in the upper tercile

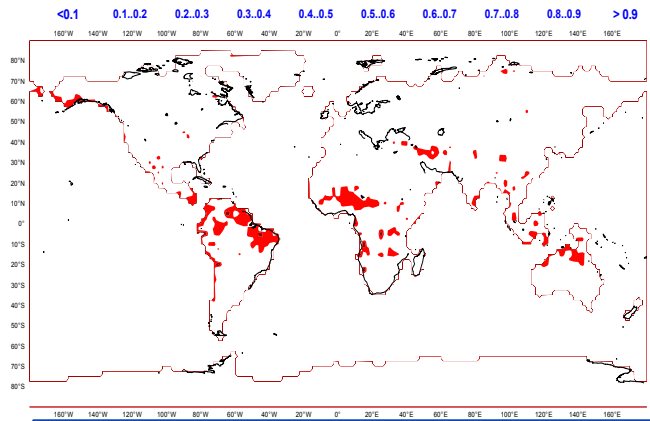
Day 5-11



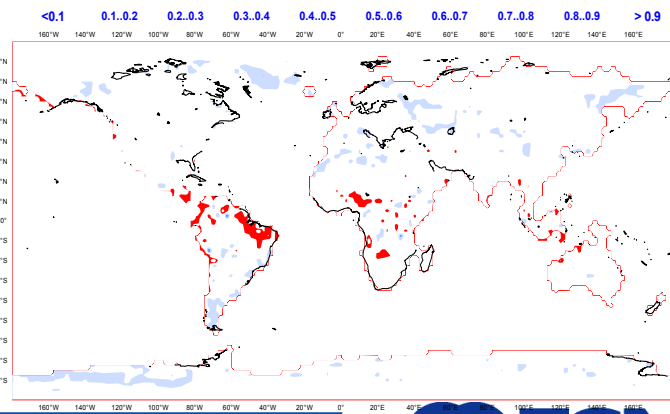
Day 12-18



Day 19-25

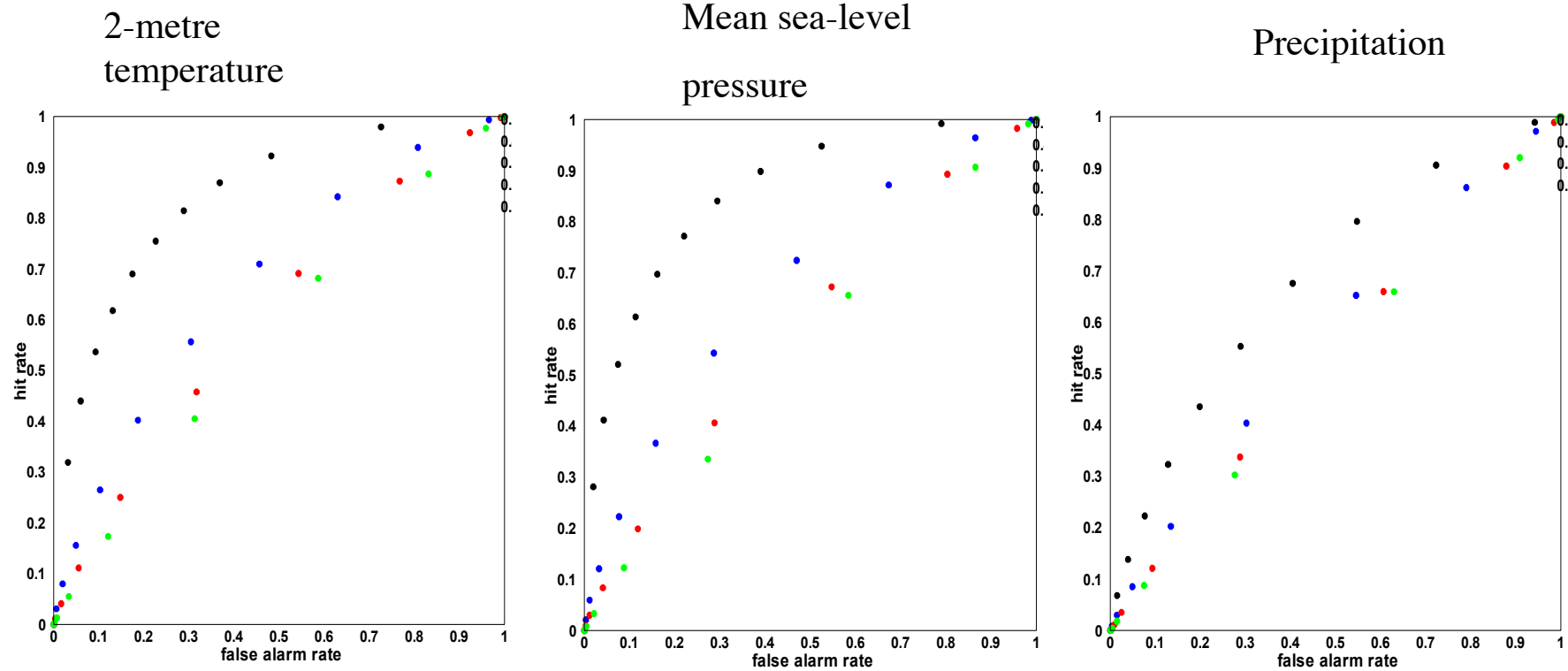


Day 26-32



Skill of the ECMWF Monthly Forecasting System

ROC scores over the Northern extratropics



Day 5-11

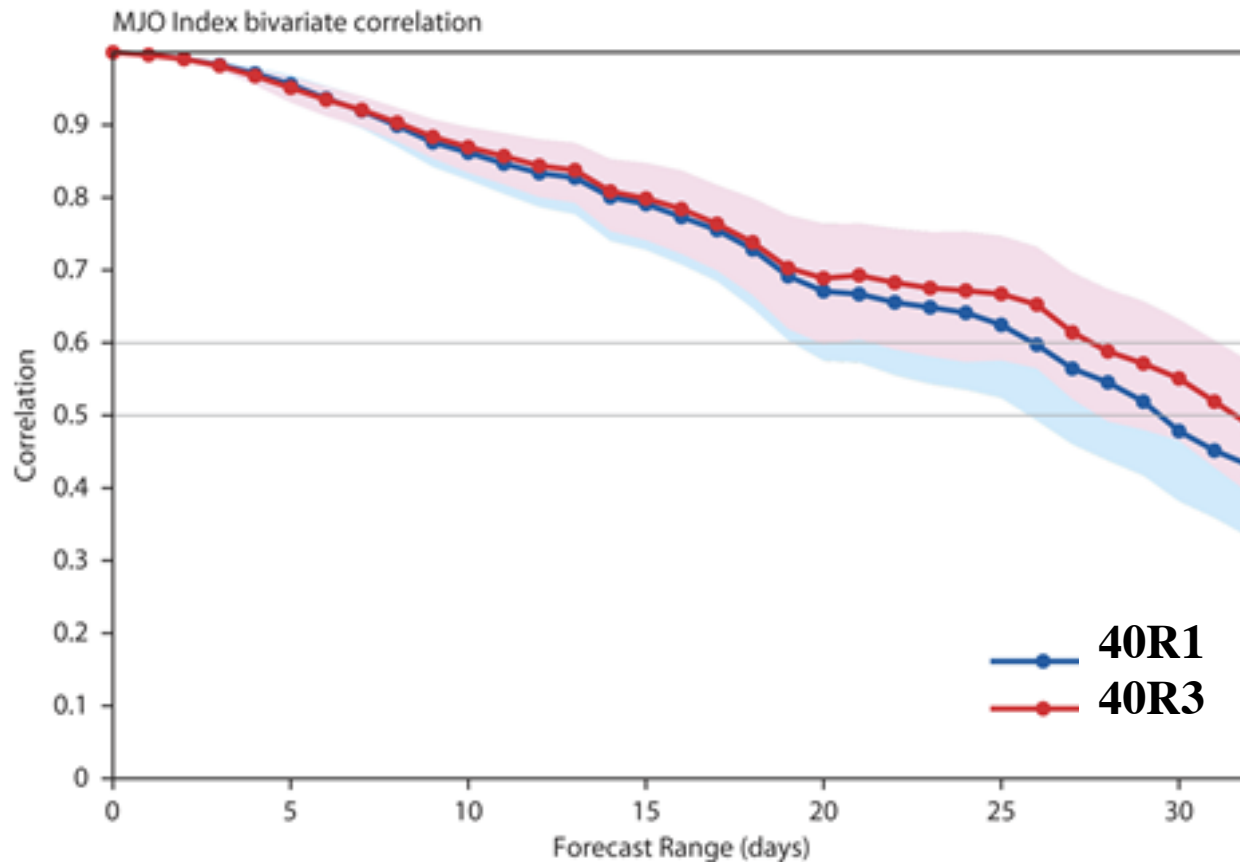
Day 12-18

Day 19-25

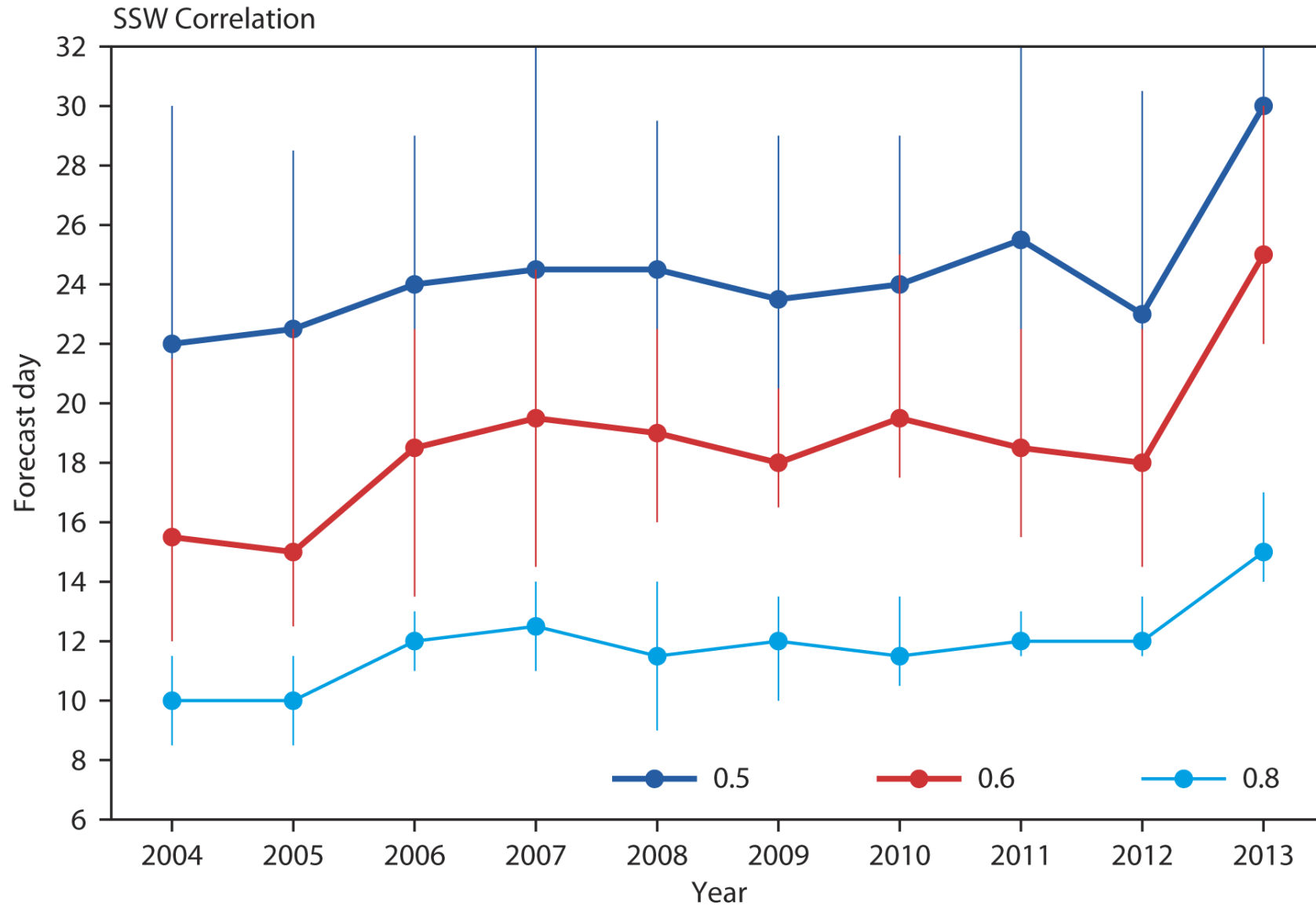
Day 26-32



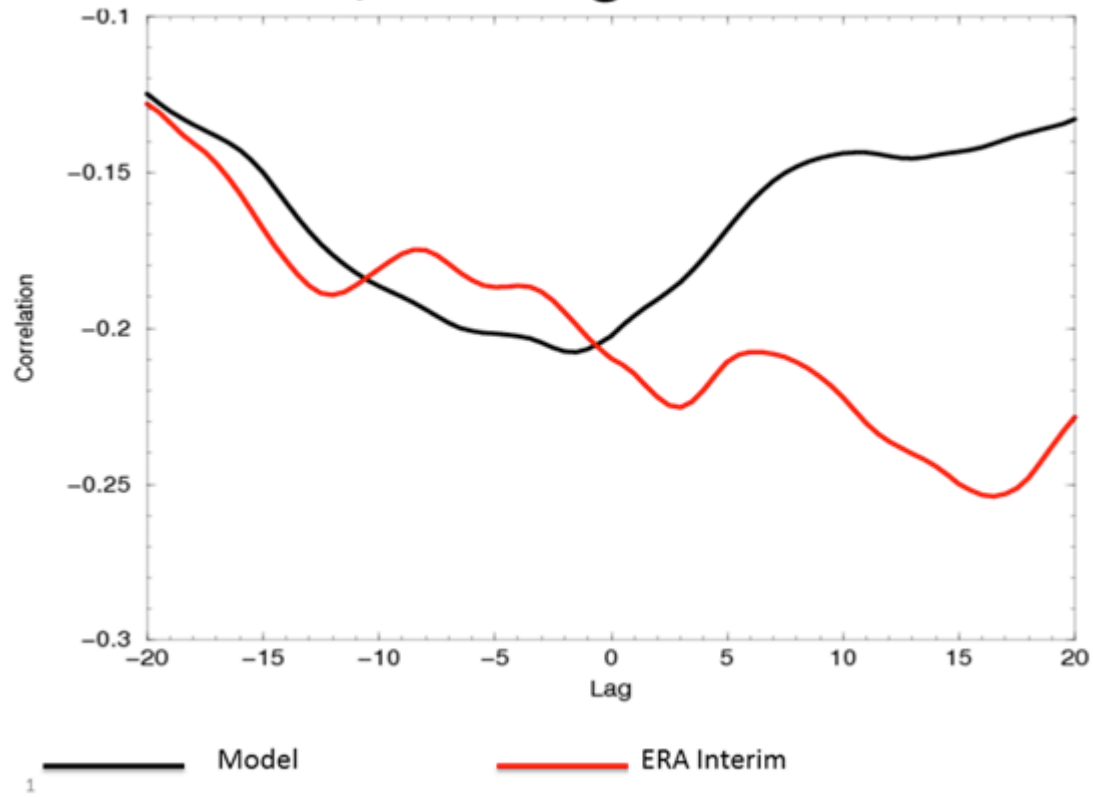
Madden Julian Oscillation

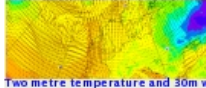


Improvement due to revised organised convective detrainment term and the revised convective momentum transport.



NAO/SSW lag-correlation





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Weekly terciles

Parameter

precipitation
temperature
2m temperature
mean sea level
pressure

Valid calendar week

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

Tercile

lower
upper

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](#)

Your Room

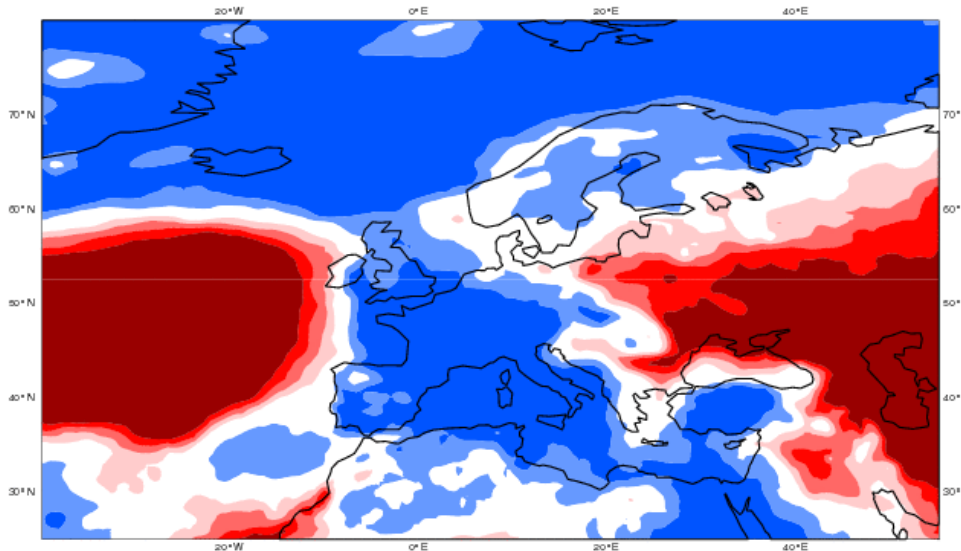
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Probabilities (temperature)

ECMWF EPS-Monthly Forecasting System
(Prob 2m Temp. anom below 33%)
Forecast start reference is 27-01-2014
ensemble size = 51 climate size = 100

Day 8-14

03-02-2014/TO/09-02-2014



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)

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

<-10deg -10.. -6 -6.. -3 -3.. -1 -1.. 0 0.. 1 1.. 3 3.. 6 6.. 10 > 10deg

70°N 60°N 50°N 40°N 30°N
 20°W 0°E 20°E 40°E

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 Valid calendar week
 Area
 Date

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

Tropical storm density

