Regime transitions associated with predictability of severe events

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L. Magnusson, F. Vitart, D. Richardson, M. Rodwell

Danube, Feb 2012

- Heat/cold waves have a strong societal impact. The prediction of such events (onset maintenance and decay) a few weeks in advance would be very valuable.

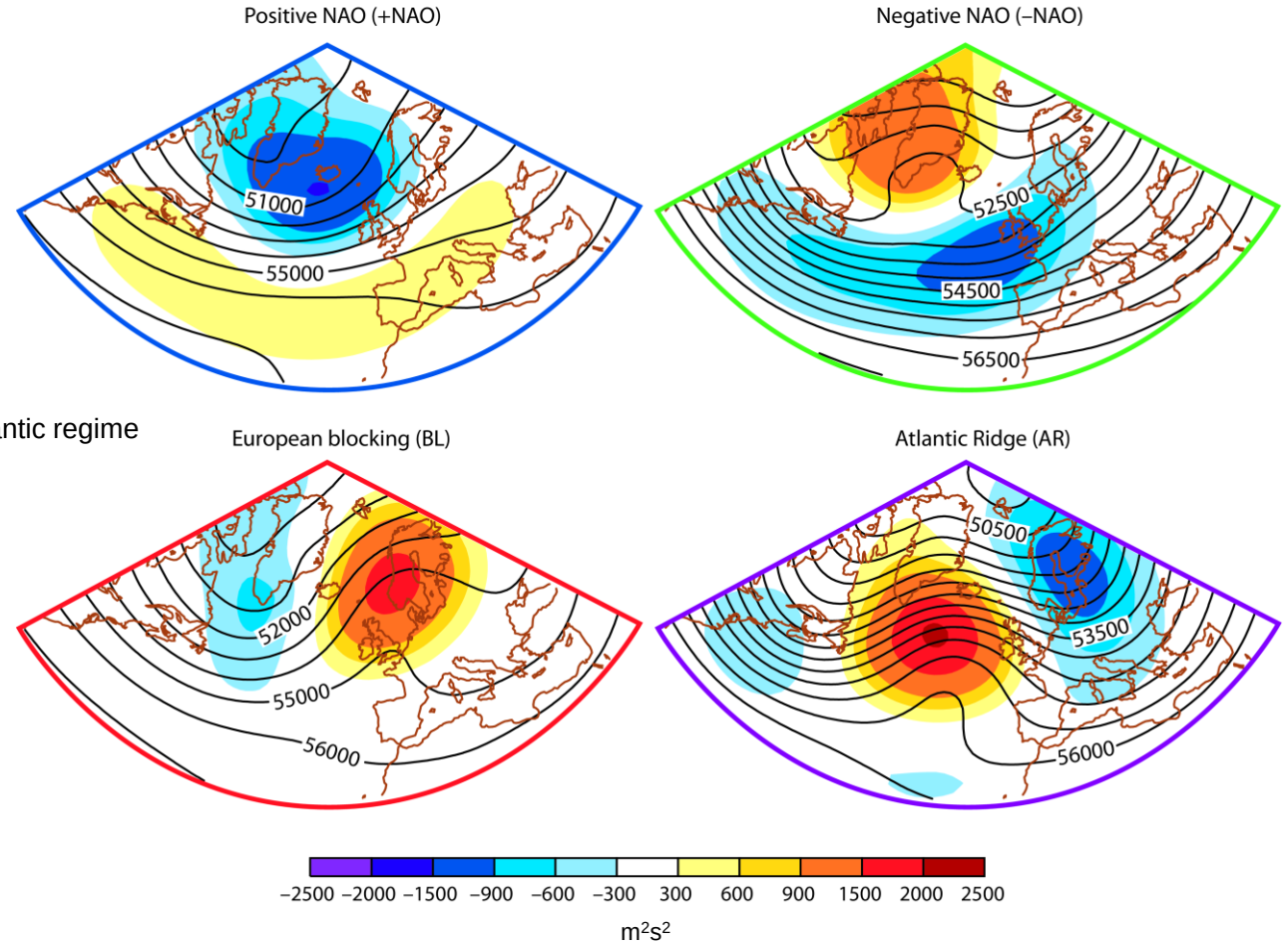
- Vitart (2005) showed that the ECMWF ensemble had some skill in predicting the maintenance of the heat wave during the 2003 summer, but that the predictions of the onset and decay were less successful.

- Strong and persistent large scale high pressure systems are often associated with dry-spells, and with heat-waves in summer and cold-spells in winter. Accurate forecasts of transition to anti-cyclonic flow regimes are therefore crucial for heat/cold wave predictions.

- Here we explore the ability of the sub-seasonal forecast systems to predict the winter large-scale circulation patterns that are generally associated with cold spells over Europe.

Regimes based on clustering of daily anomalies for 29 cold seasons (1980-2008)

500 hPa geopotential



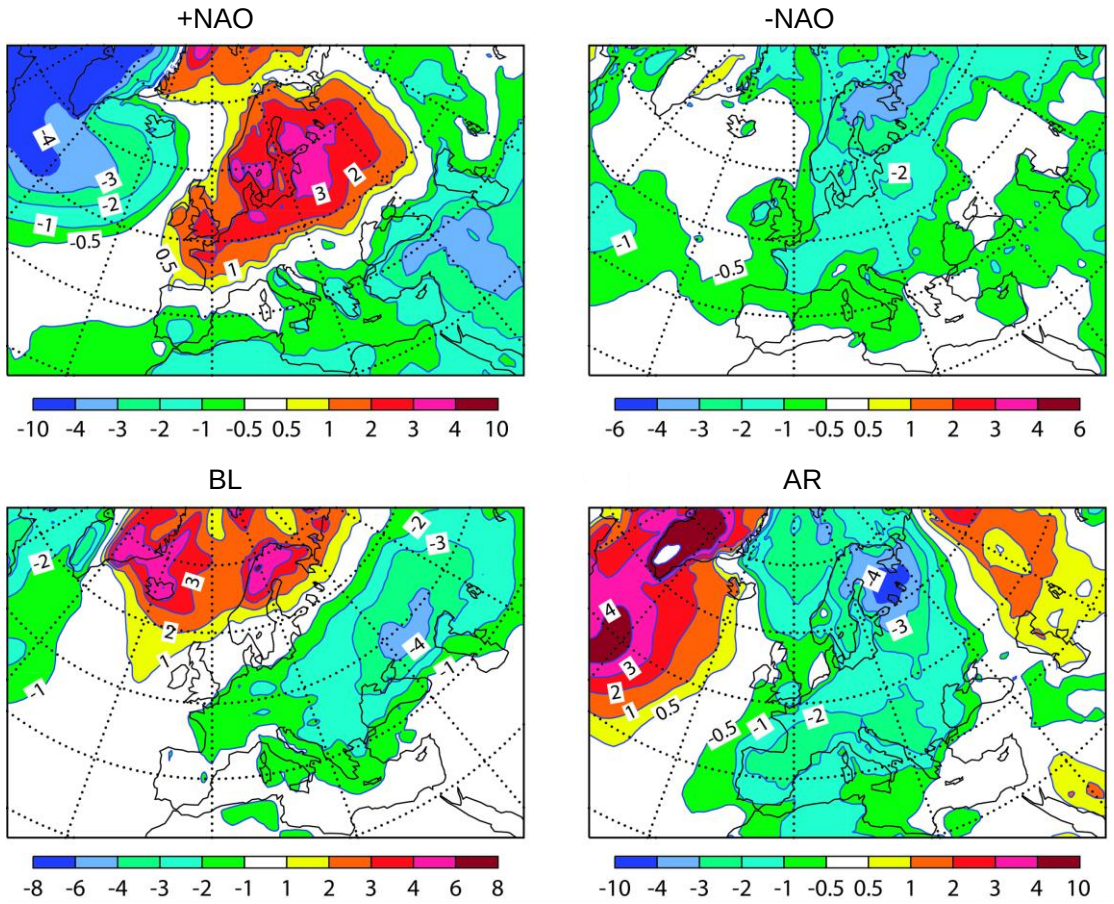
- Obtain well-known Euro-Atlantic regime patterns

'k means' clustering applied to EOF pre-filtered data (retaining 80% of variance)

2m temperature anomalies for persistent regime episodes (> 5days) in winter

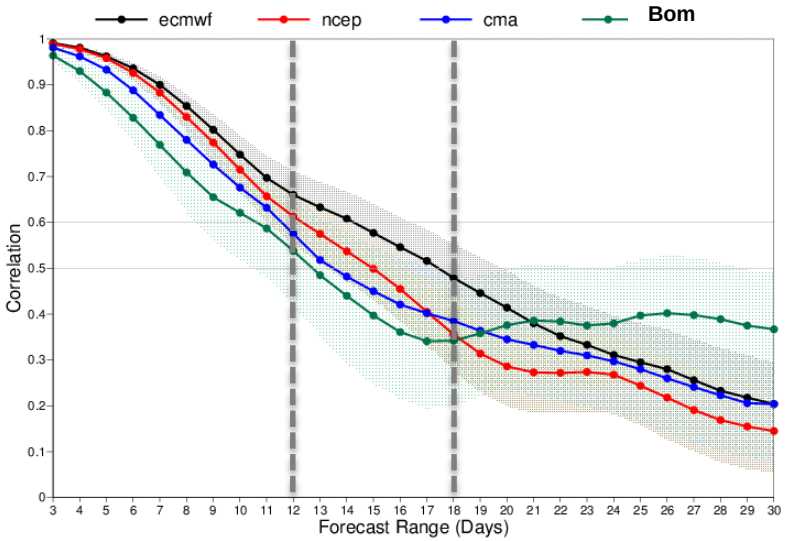
- Europe cold for 3 regimes
- BL and –NAO higher frequency of persistent events

Based on re-forecast data (20 years)

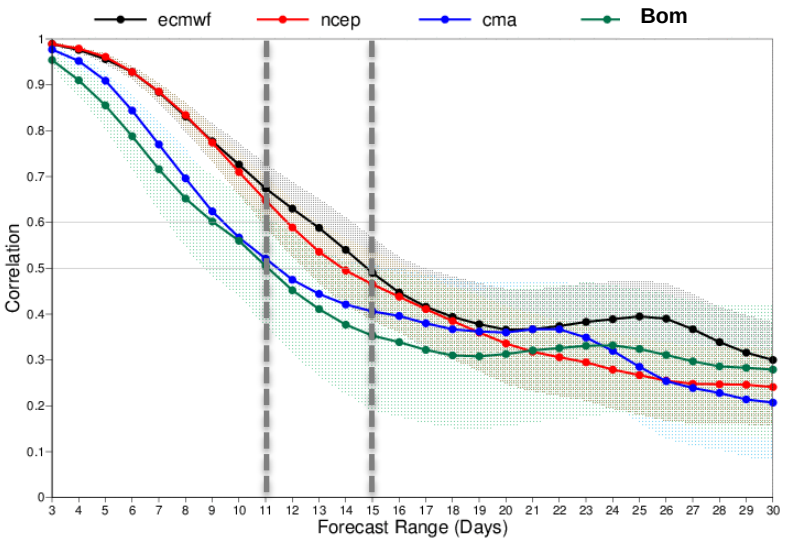


Predicting skill associated with the Euro-Atlantic Regimes:

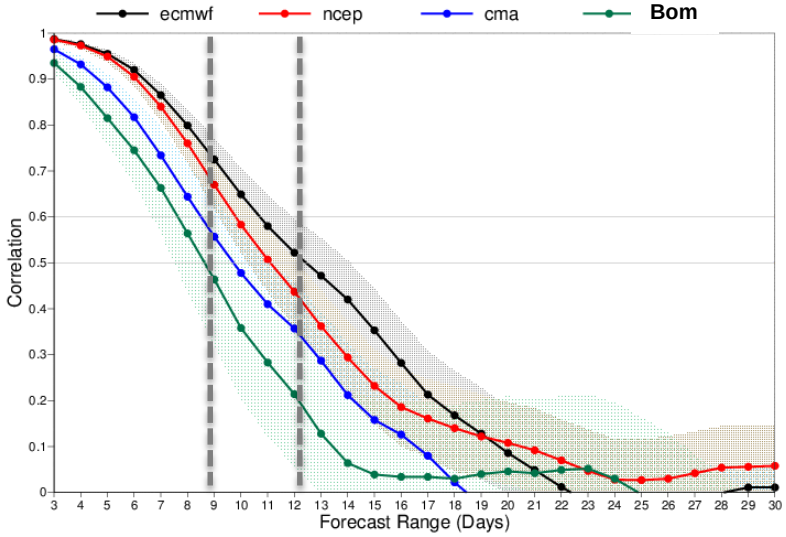
NAO +



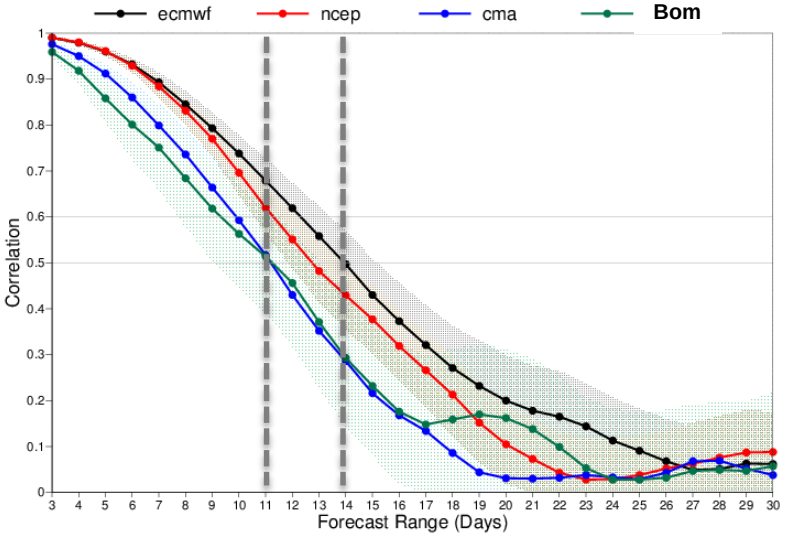
NAO -



Blocking



Atlantic Ridge



S2S reforecasts data used for the skill assessment:

model	Bom	Cma	Ecmwf	Ncep
Rfc. lenght	0-60 days	0-60days	0-46 days	0-44 days
Resol.	T47L17	T106L40	T639/319 L91	T126L64
Rfc. size	33	4	11	4
Rfc. period	1981-2013	1994-2014	1994-2014	1999-2010
Rfc. Freq.	6/months	daily	2/weekly	daily

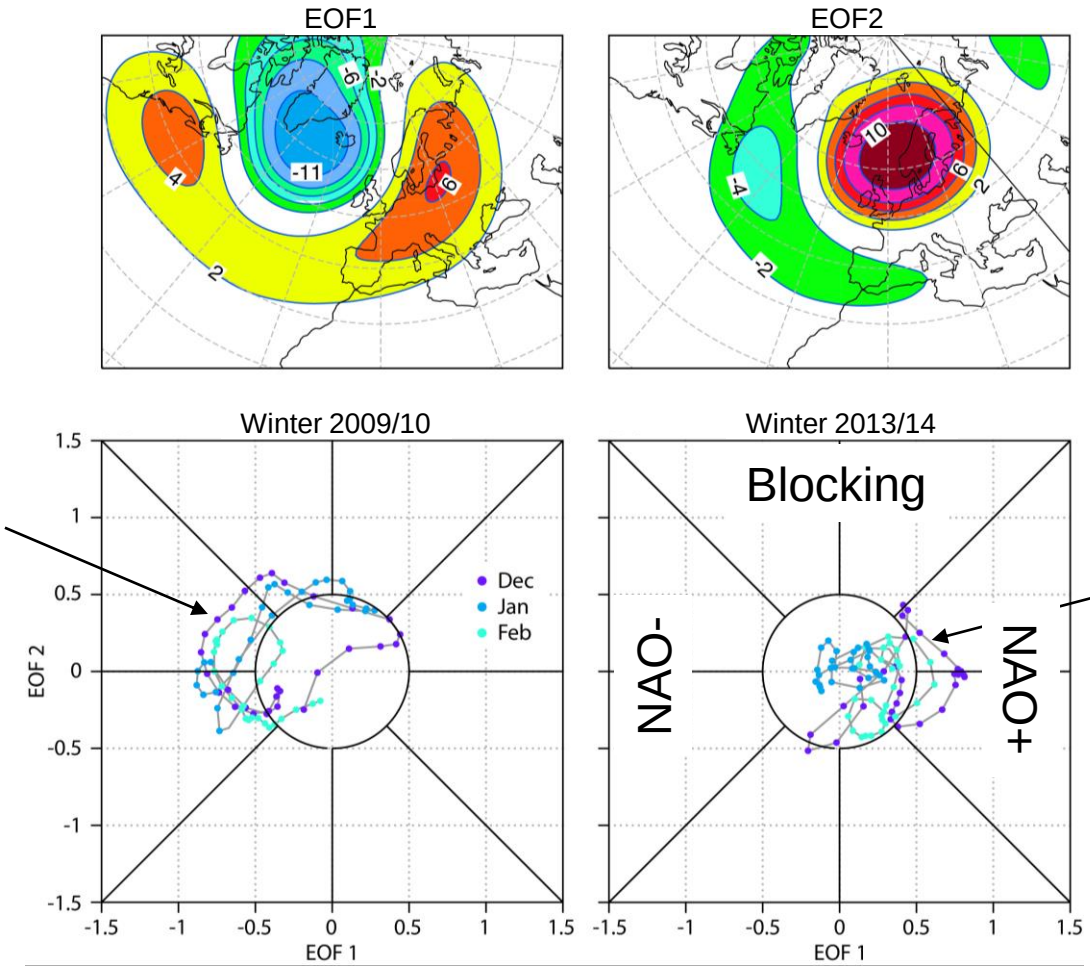
In order to increase the Cma and Ncep ensemble size, we have combined 3 ensemble forecasts (initiated on consecutive days) into a single 12-member ensemble. (We define the initial date to be that of the central sub-ensemble; this has little effect on results at extended leadtimes).

Trajectories in phase space (*c.f.* MJO propagation)

- ±EOF1 and +EOF2 represent quite well ±NAO and BL
- Trajectories in phase space summarise regime evolution
- Unlike MJO, no preferred direction

BL: record-breaking cold temperatures over Europe

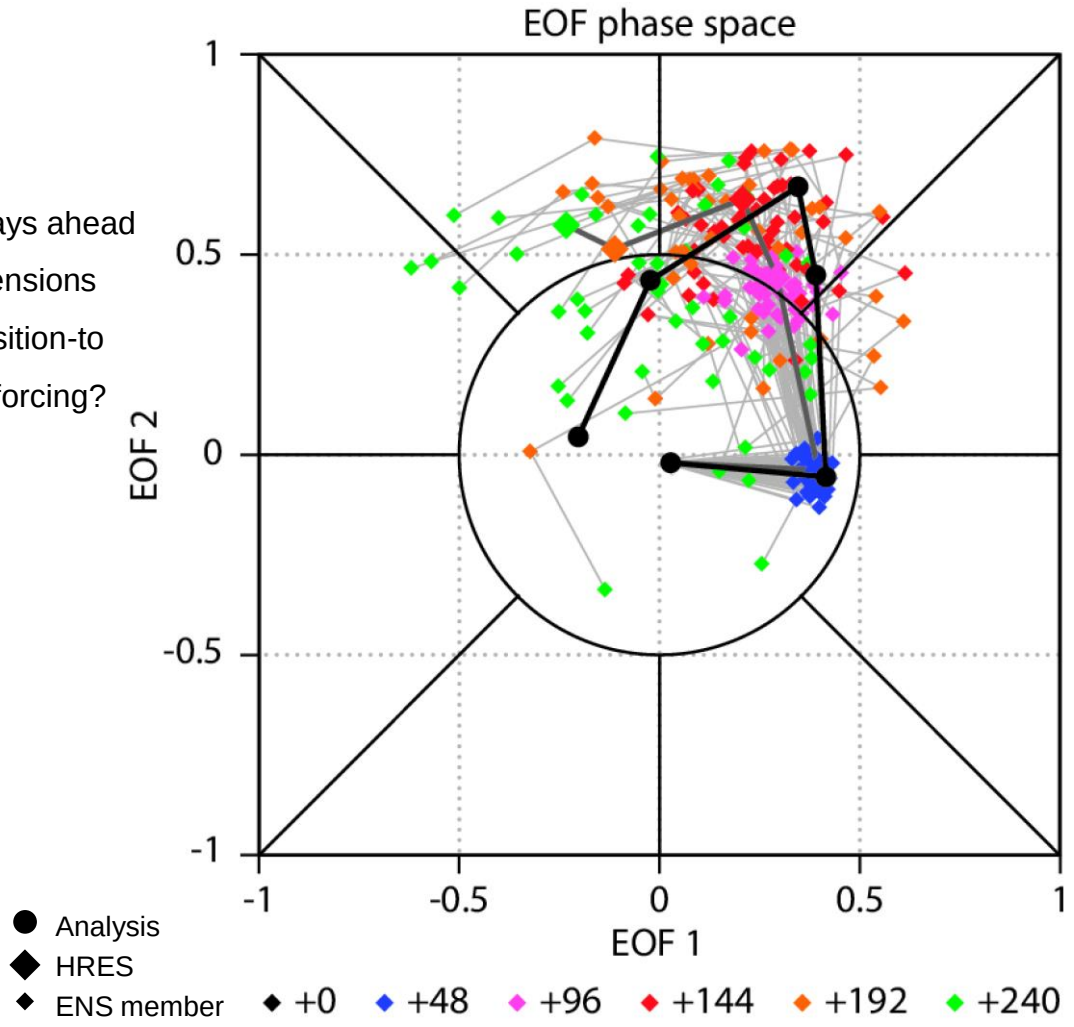
Based on 5-day running means



+NAO: exceptional storminess, but mild temperatures over Europe

Ensemble evolution in phase space

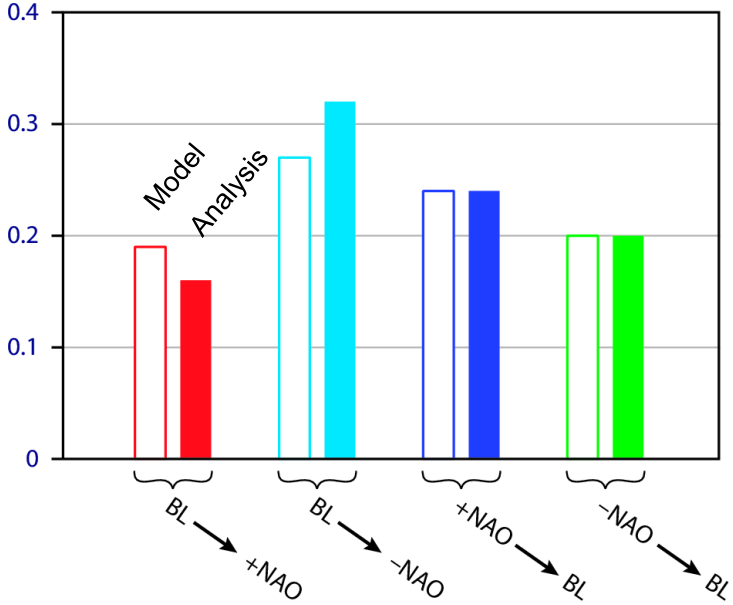
- Transition to blocking well-predicted 4 days ahead
- Nice way to summarise ENS in two dimensions
- Future: What processes involved in transition-to and maintenance-off blocking? Tropical forcing?



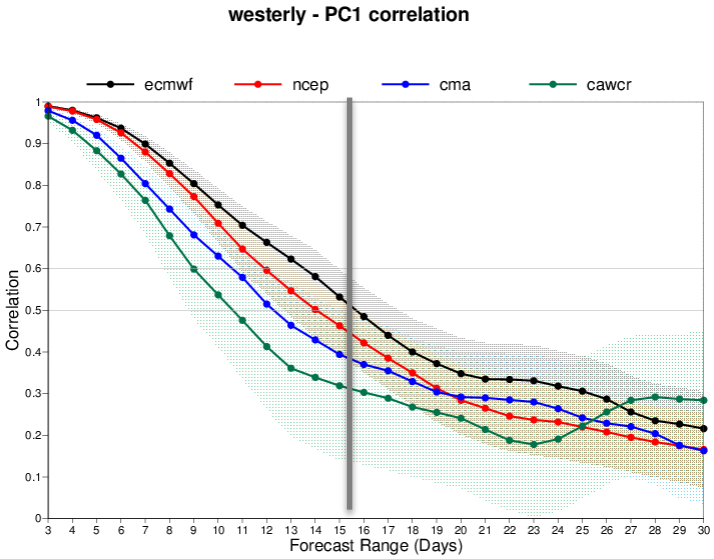
Initial date: 22 September 2015 0UTC

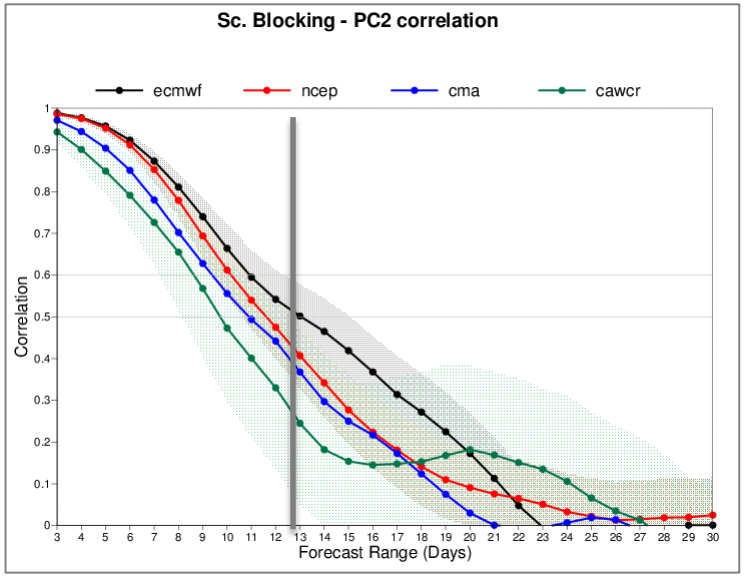
Regime transition-frequencies and predictability (*c.f.* MJO predictability)

Frequencies of transitions between persistent regimes (>5 days)



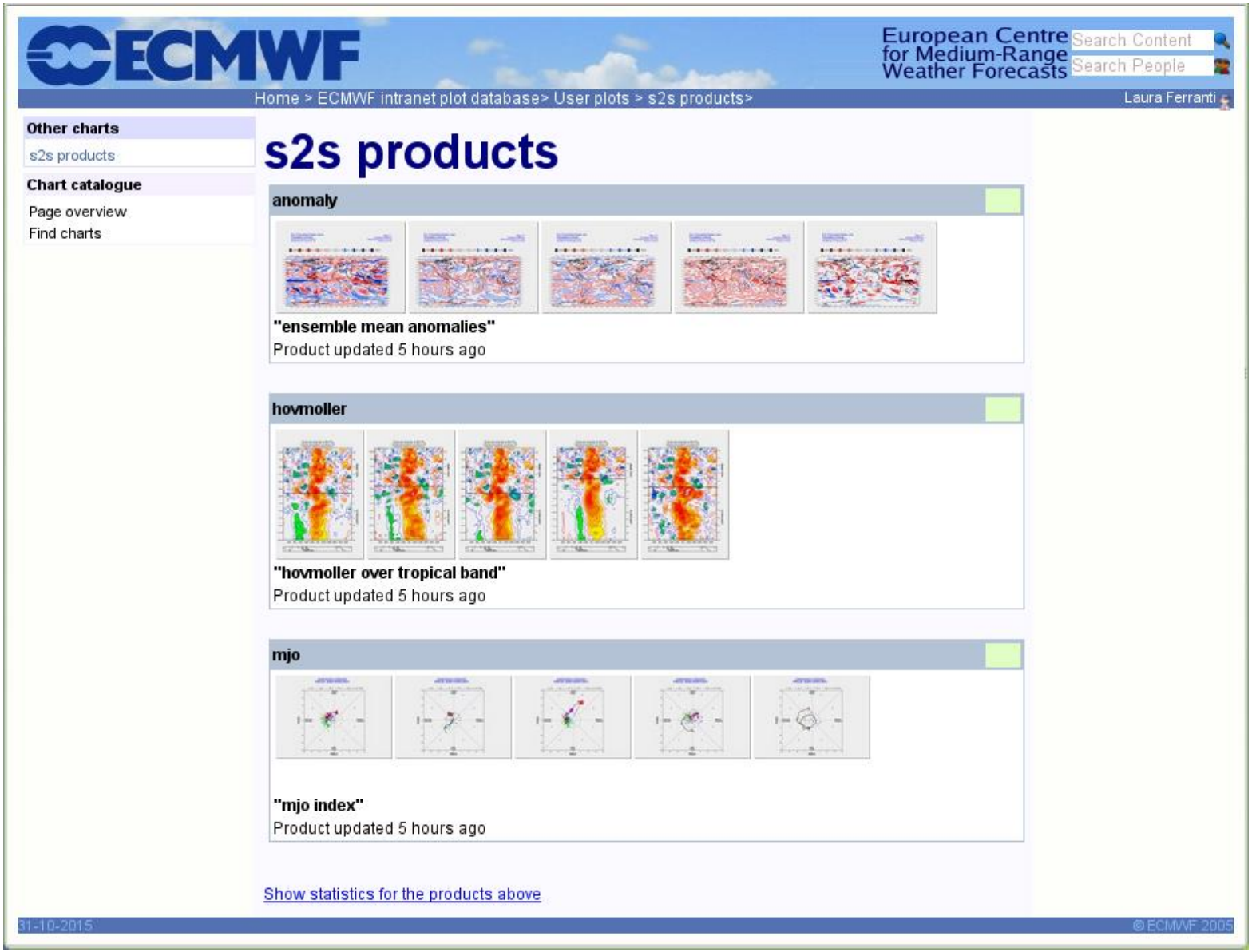
- Transition frequencies good. Slight over-preference for BL → +NAO
- ECMWF has 1-2 days better skill than NCEP
- PC1 is ~2 days better than PC2 (due to high persistence of –NAO?)



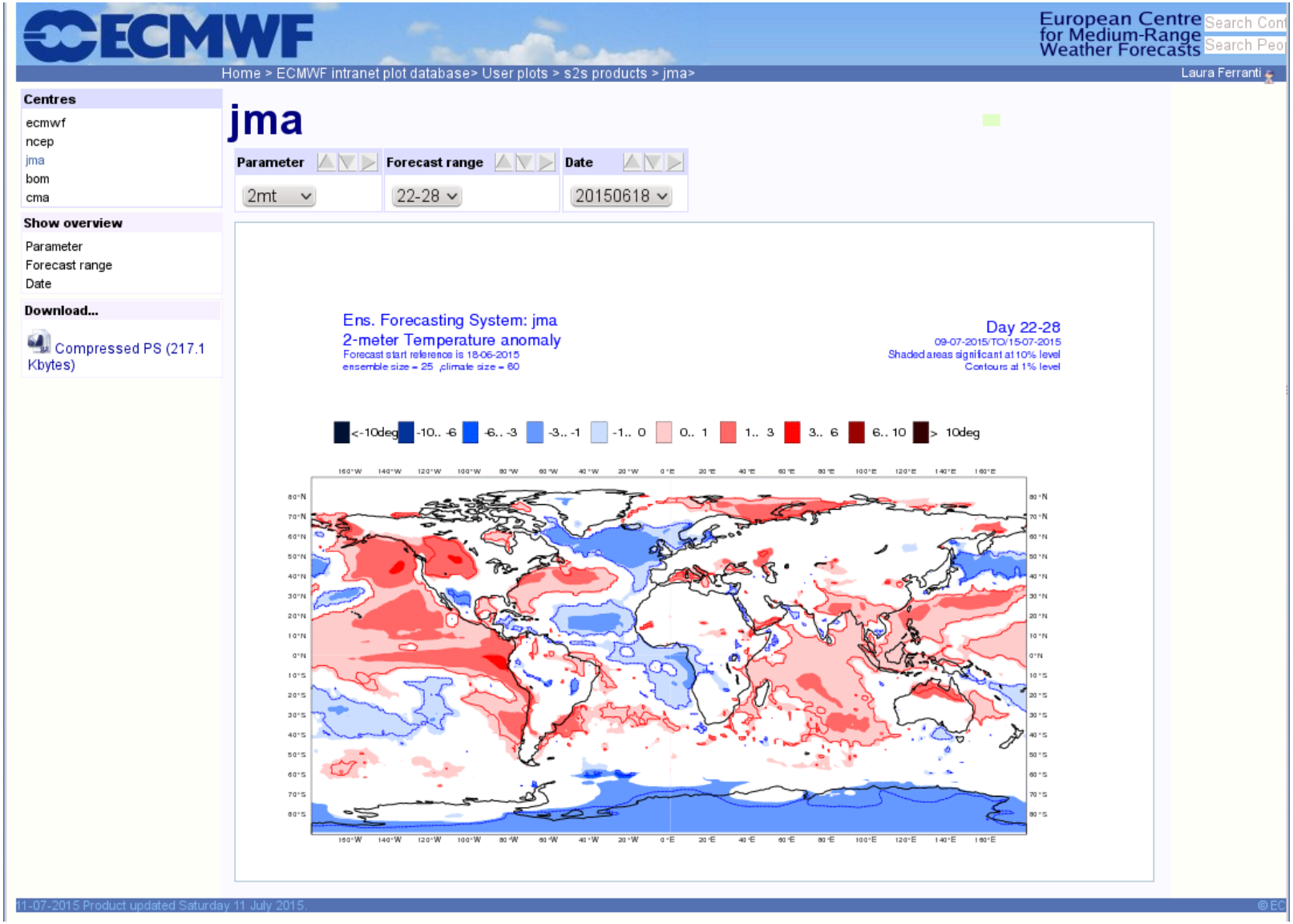


5-day running mean applied prior to correlation calculation

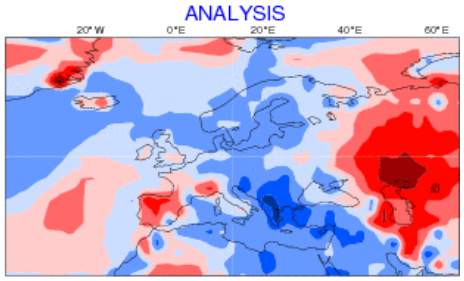
Monitoring S2S forecasts:



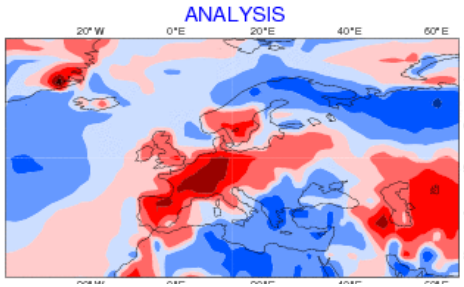
Monitoring S2S quasi real-time forecasts:



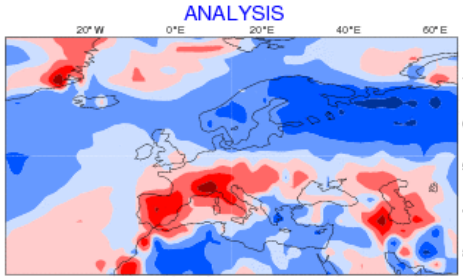
Heat wave over Central-southern Europe: 2mt weekly mean anomalies



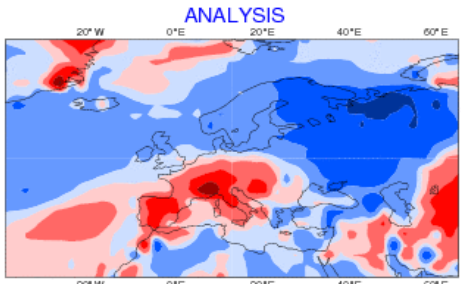
22-28 Jun



29-5Jul



6-12Jul



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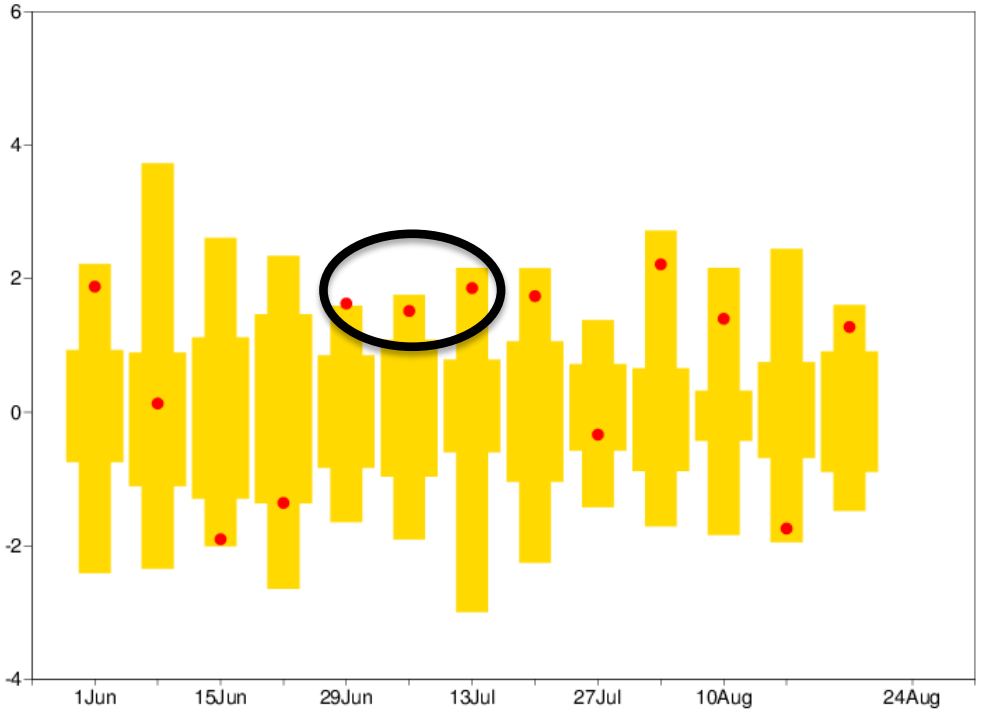
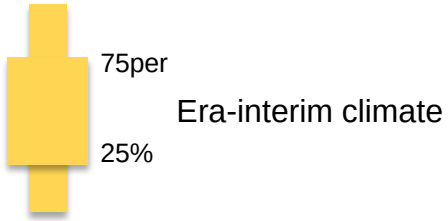
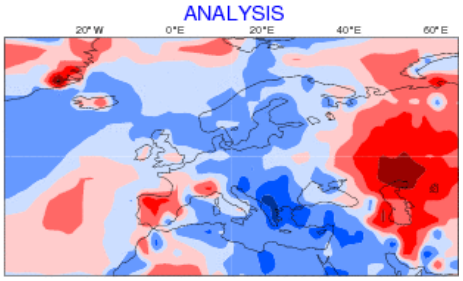




Verifying analysis

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



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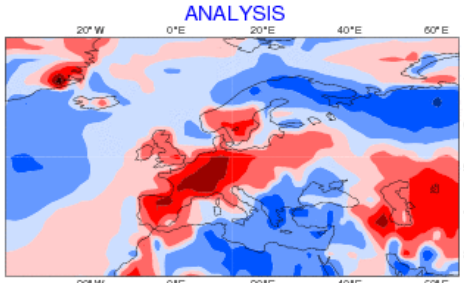

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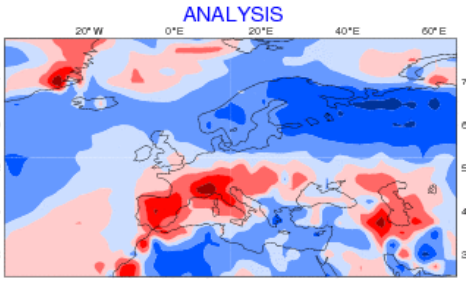

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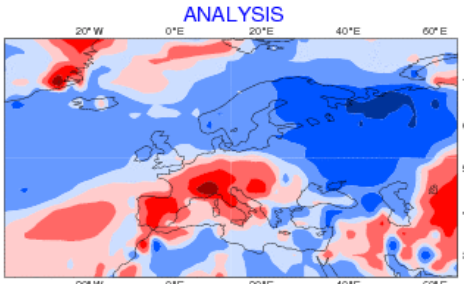

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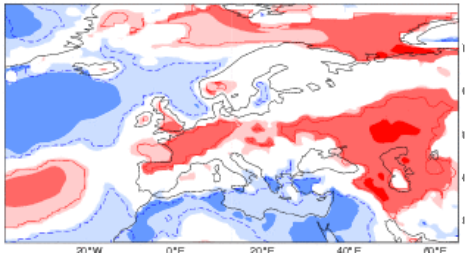
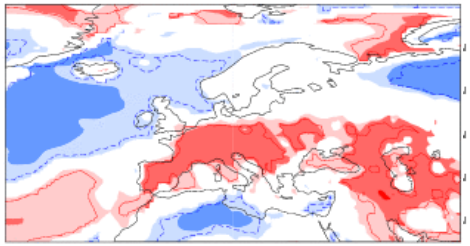
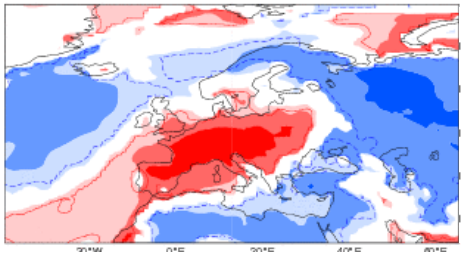
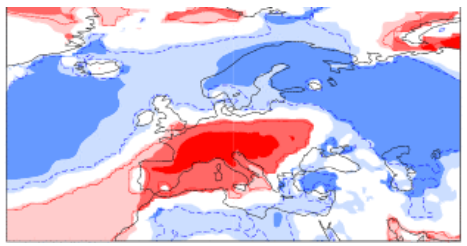




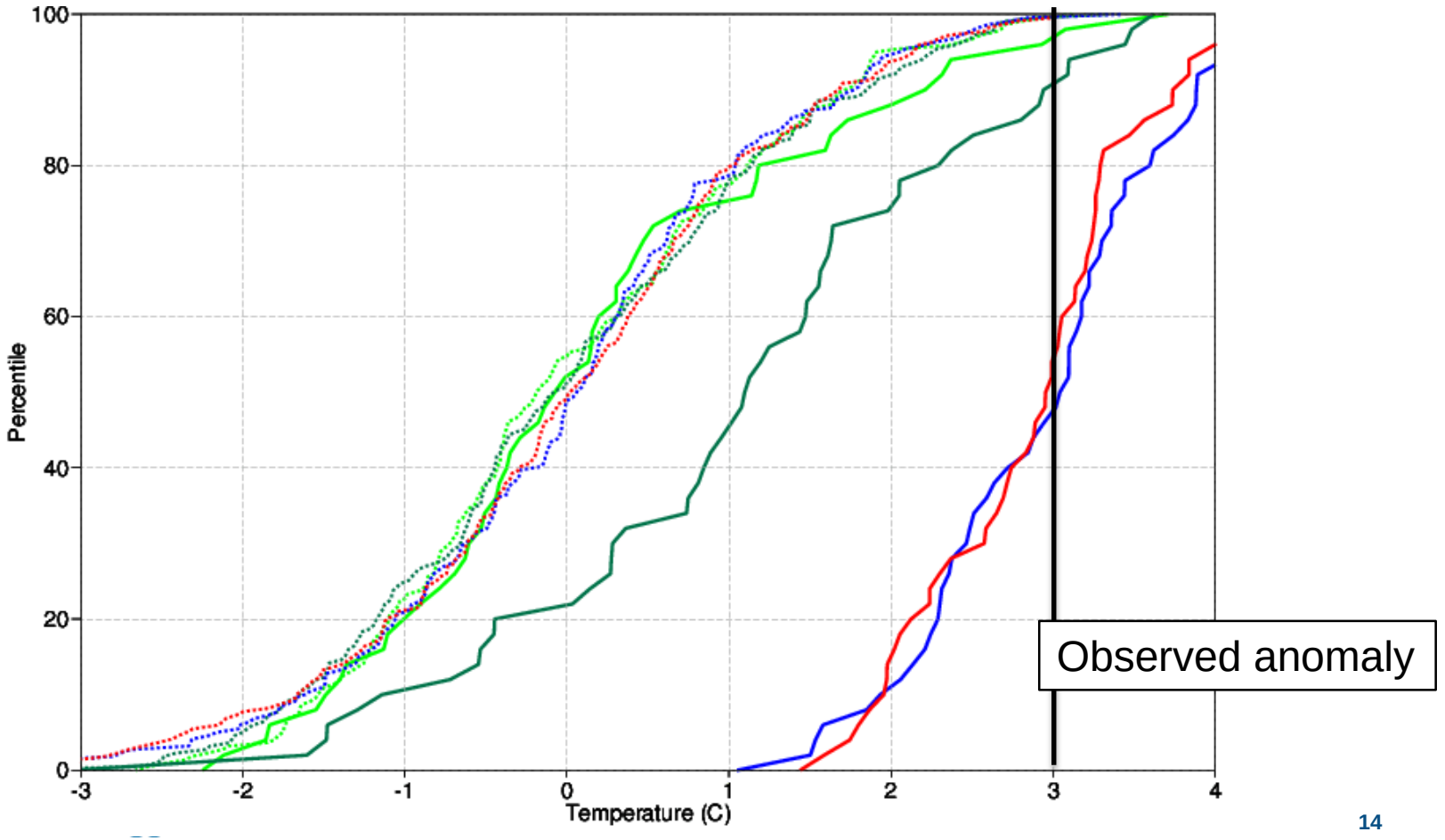


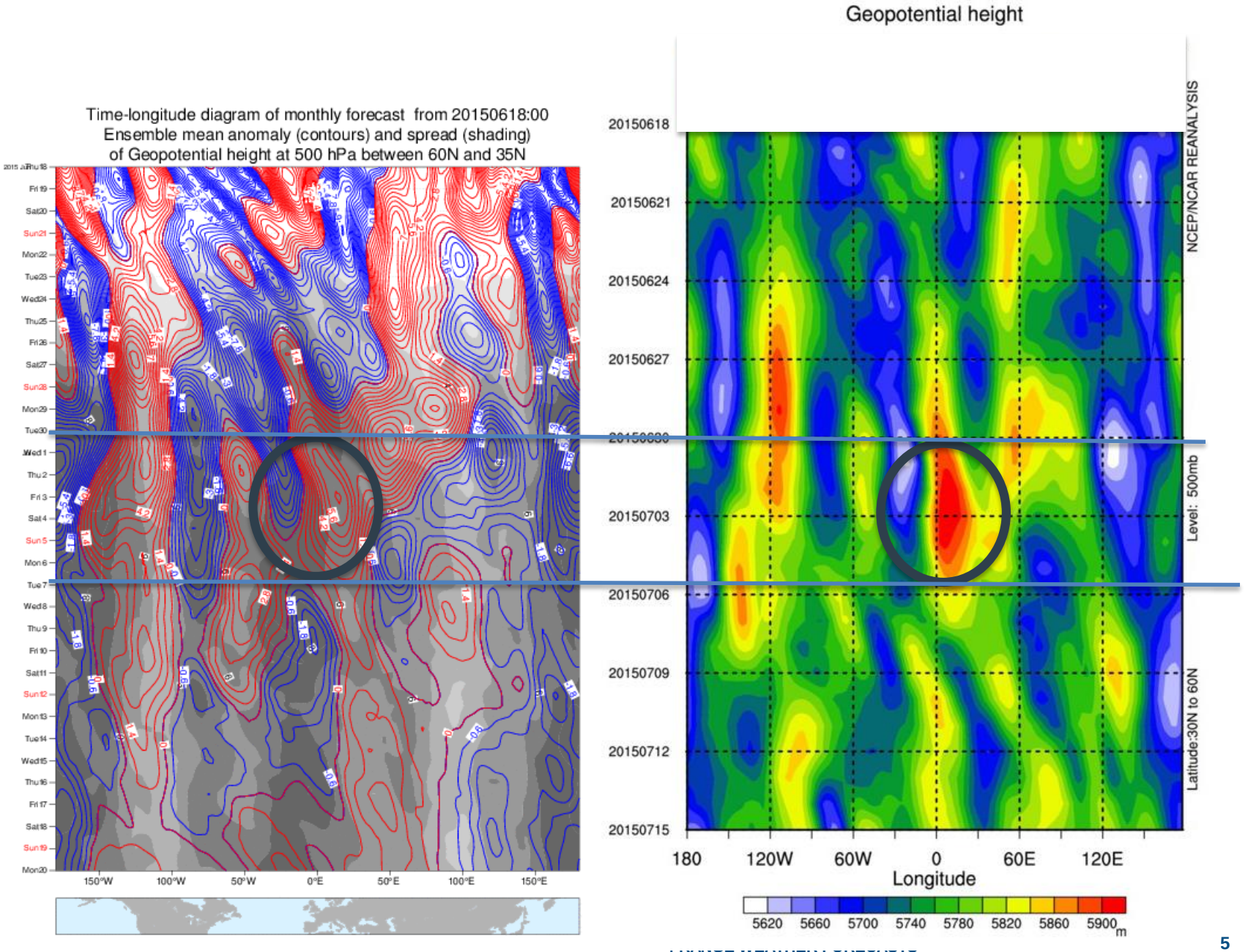


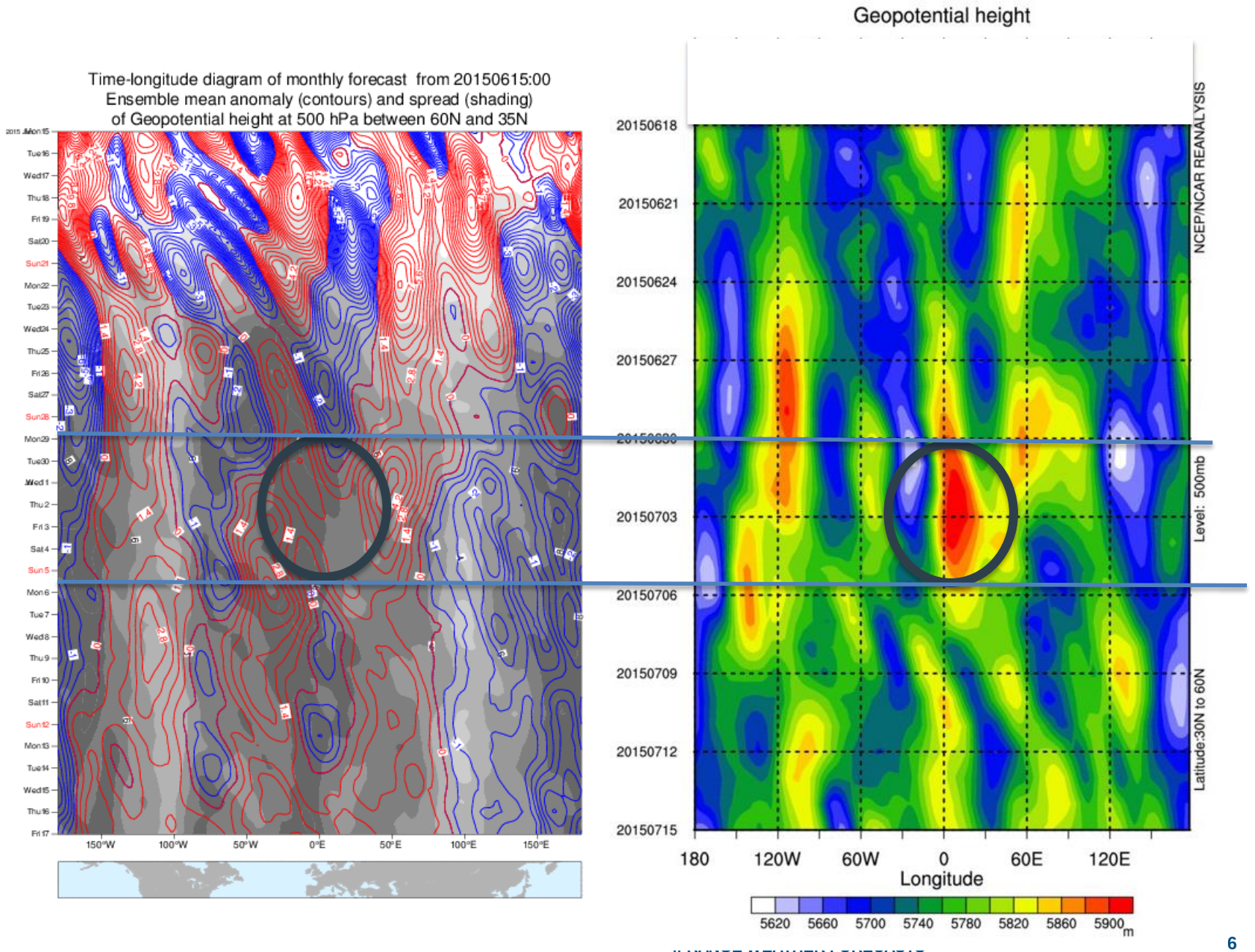
Forecasts: 12-18 days

2m temp CDF: ensemble predictions for 29 June - 5 July 2015

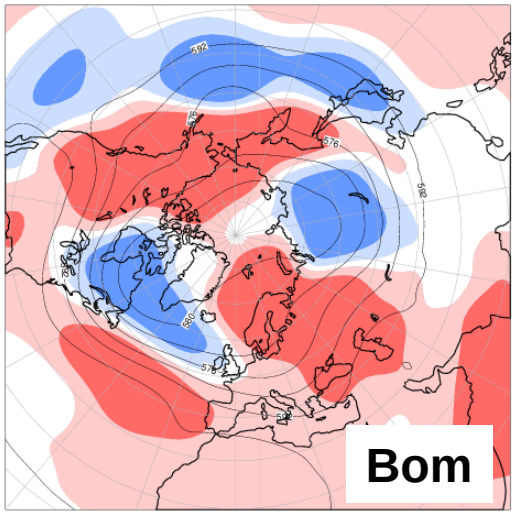
Climate | 15 June 2015 (15-21d) | 18 June 2015 (12-18d) | 22 June 2015 (8-14d) | 25 June 2015 (5-11d)

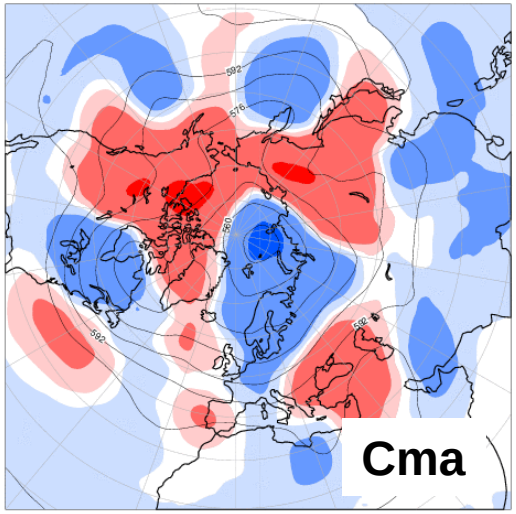


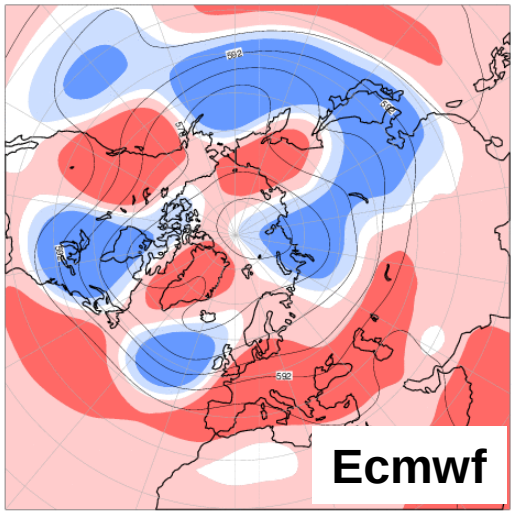

Time-longitude diagram of monthly forecast from 20150618:00
Ensemble mean anomaly (contours) and spread (shading)
of Geopotential height at 500 hPa between 60N and 35N
150°W
100°W
50°W
0°E
50°E
100°E
150°E
Geopotential height
20150618
20150621
20150624
20150627
20150703
20150706
20150709
20150712
20150715
180
120W
60W
0
60E
120E
Longitude
NCEP/NCAR REANALYSIS
Level: 500mb
Latitude:30N to 60N
5620
5660
5700
5740
5780
5820
5860
5900
m

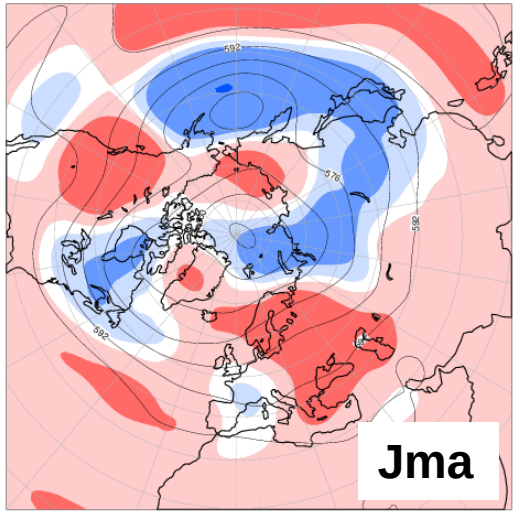

Time-longitude diagram of monthly forecast from 20150615:00
Ensemble mean anomaly (contours) and spread (shading)
of Geopotential height at 500 hPa between 60N and 35N
Mon15
Tue16
Wed17
Thu18
Fri19
Sat20
Sun21
Mon22
Tue23
Wed24
Thu25
Fri26
Sat27
Sun28
Mon29
Tue30
Wed1
Thu2
Fri3
Sat4
Sun5
Mon6
Tue7
Wed8
Thu9
Fri10
Sat11
Sun12
Mon13
Tue14
Wed15
Thu16
Fri17
150°W
100°W
50°W
0°E
50°E
100°E
150°E
Geopotential height
20150618
20150621
20150624
20150627
20150630
20150703
20150706
20150709
20150712
20150715
180
120W
60W
0
60E
120E
Longitude
NCEP/NCAR REANALYSIS
Level: 500mb
Latitude:30N to 60N
5620
5660
5700
5740
5780
5820
5860
5900
m

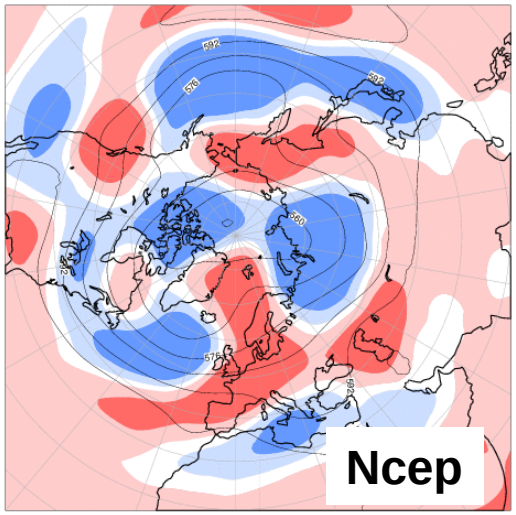
S2S Z500 anomalies: days 12-18 - verifying 29-06 to 05-07 2015

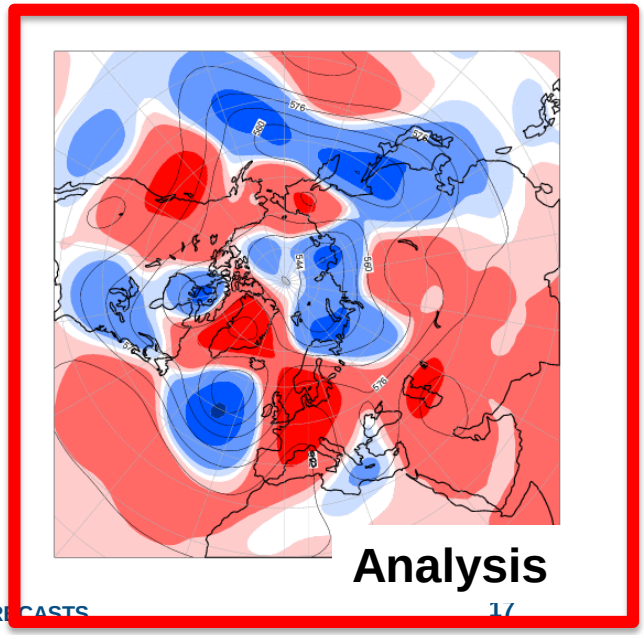




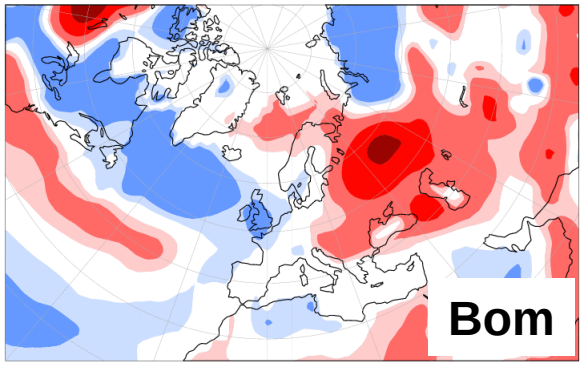


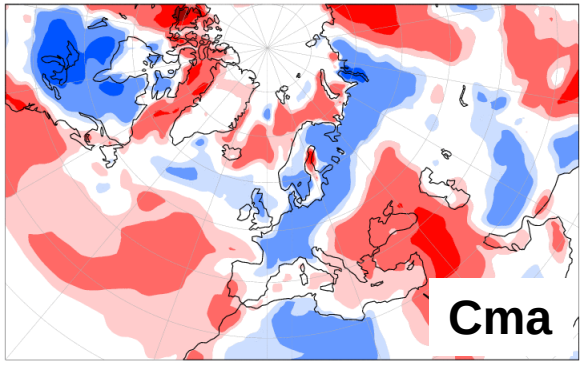


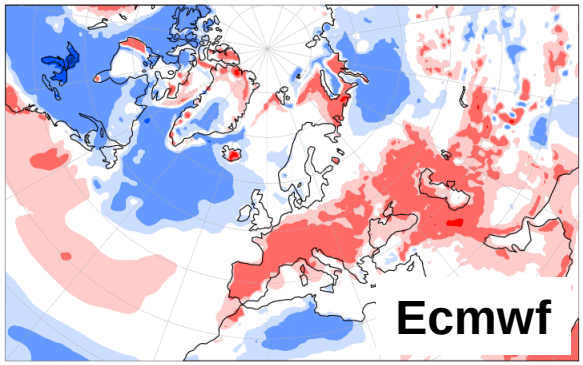


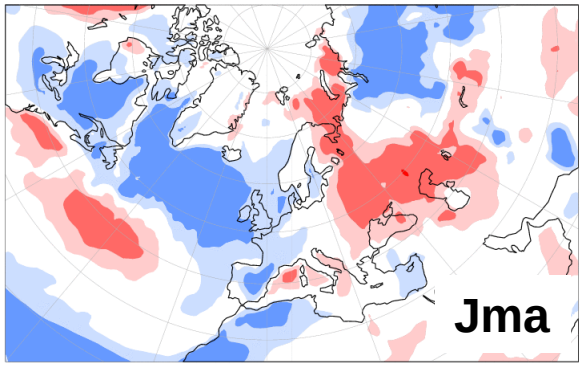


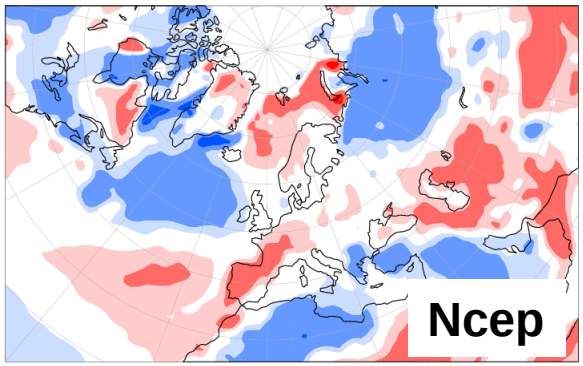
S2S 2mt anomalies: days 12-18 - verifying 29-06 to 05-07 2015

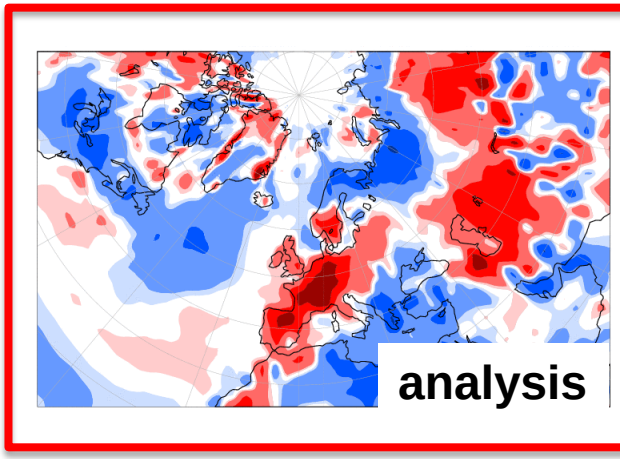












Summary and discussion:

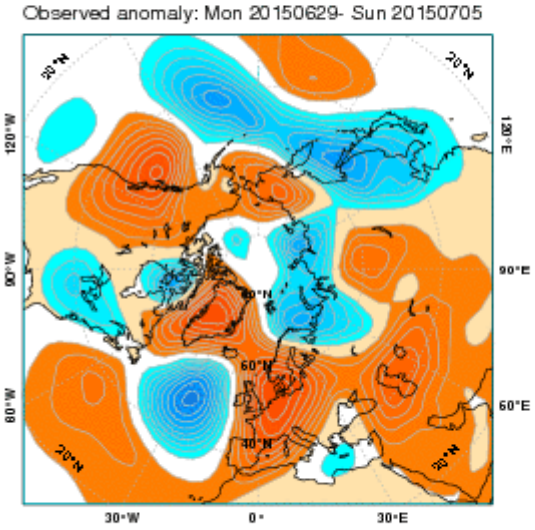
Preliminary results from the analysis on the cold events:

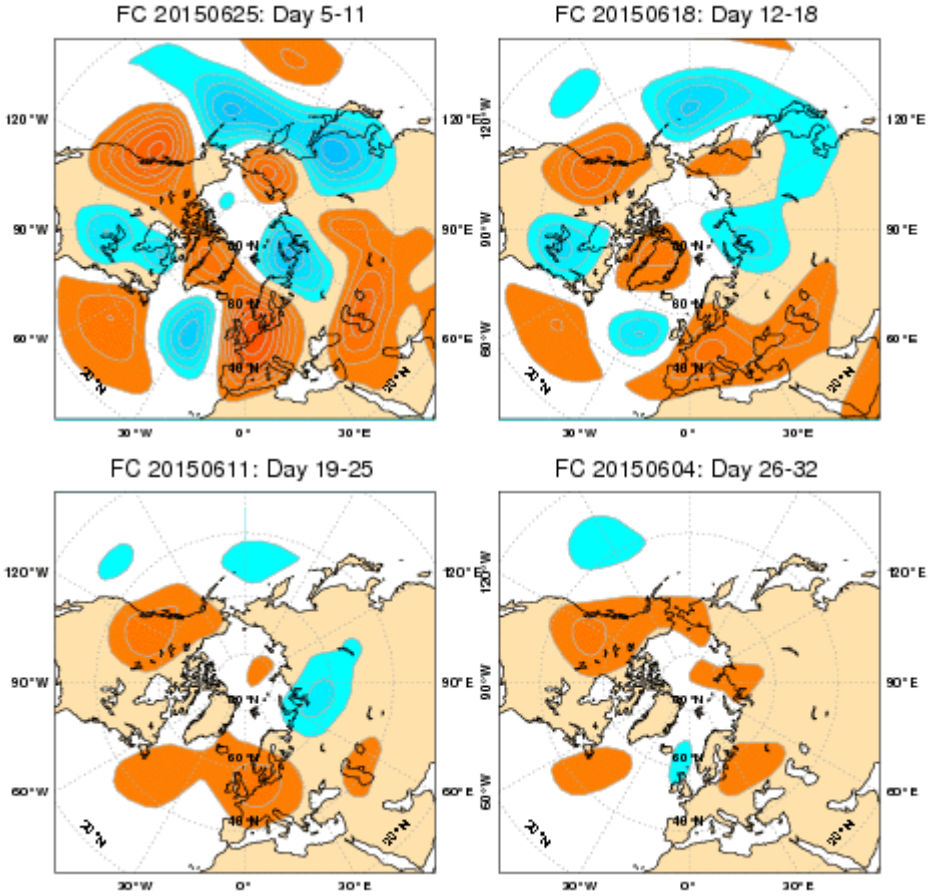
- S2S re-forecast dataset
- Assessing the predictive skill of the weather regimes associated with high impact temperature.
- Exploring a possible tool to characterize regime transitions

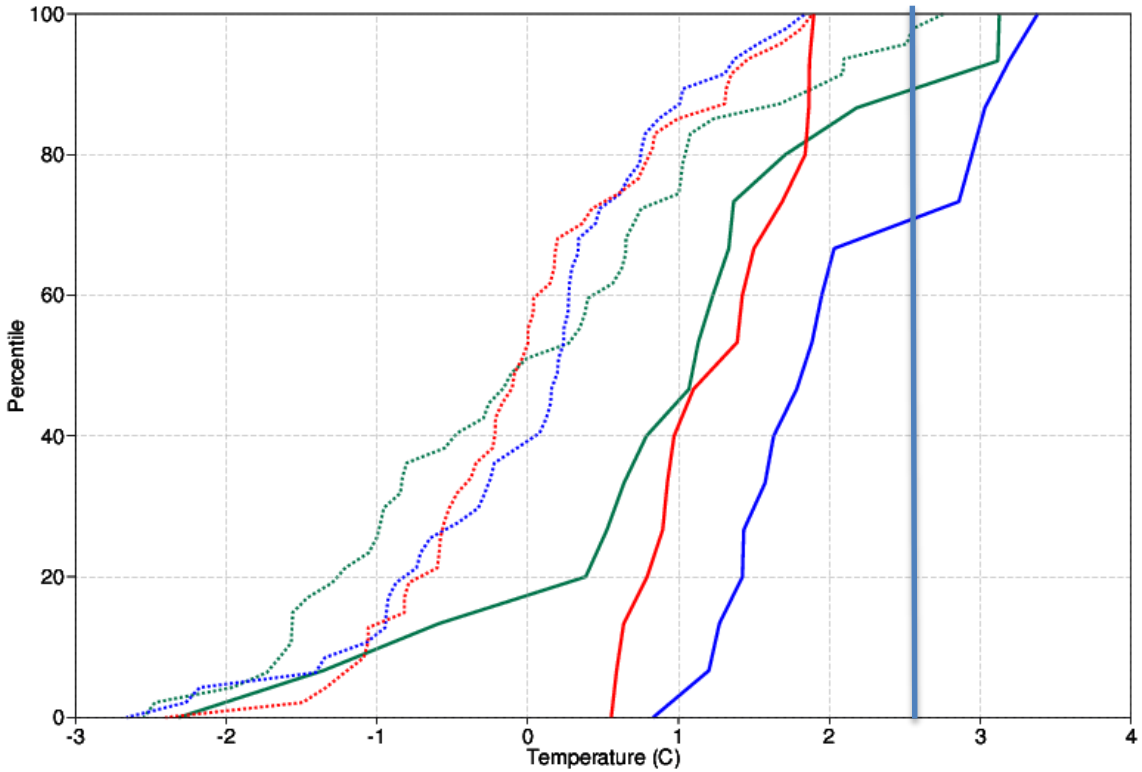
Monitoring the S2S forecasts – a small selection of basics products have been constructed.

Looking at the most recent heat wave over Europe (July 2015):

- importance of representing the transient waves
- In June the surface was very dry, a realistic surface initialization enhanced the extent of the temperature anomalies.


Observed anomaly: Mon 20150629- Sun 20150705
120°W
90°W
60°W
120°E
90°E
60°E
30°W
0°
30°E
20°N
40°N
60°N
80°N


FC 20150625: Day 5-11
FC 20150618: Day 12-18
FC 20150611: Day 19-25
FC 20150604: Day 26-32
120°W
90°W
60°W
120°E
90°E
60°E
30°W
0°
30°E
20°N
40°N
60°N
80°N


100
80
60
40
20
0
Percentile
-3
-2
-1
0
1
2
3
4
Temperature (C)