

# Early warning of severe temperature conditions over Europe

How far in advance can we predict changes in large-scale flow leading to severe cold/warm conditions over Europe?

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EUROPEAN CENTRE FOR MEDIUM-RANGE WEATHER FORECASTS

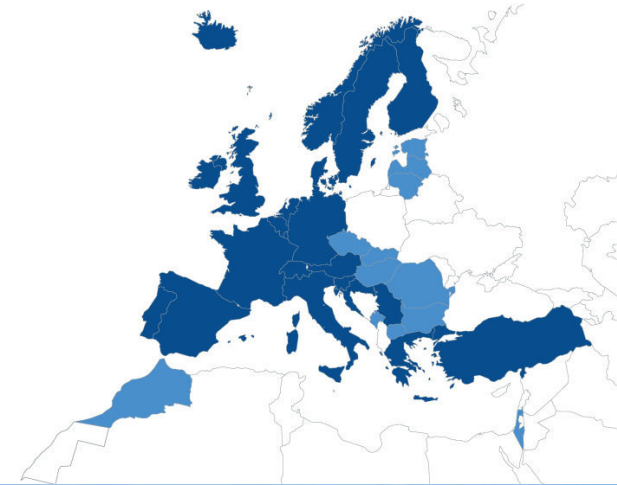
# ECMWF: European Centre for Medium-Range Weather Forecasts

Research and 24/7 operational service

Issue global numerical weather predictions to its Member and Co-operating States and the broader community.

The Centre has one of the largest supercomputer facilities and meteorological data archives in the world.

Operates the Copernicus Atmosphere Monitoring Service (CAMS) and the Copernicus Climate Change Service (C3S).



# 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 Systems (ENS): twice daily Tco 639/L91, 51  
members to 15 days ahead (~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



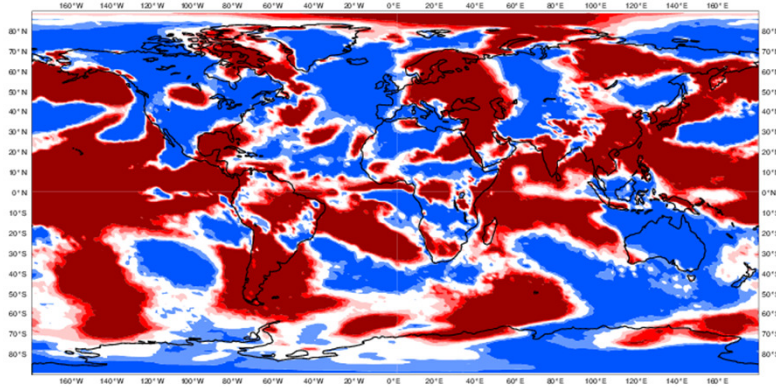
# Sub-seasonal Forecast : Probabilities for 2mt weekly anomalies exceeding the 66% of the climate distribution

ECMWF EPS-Monthly Forecasting System  
(Prob 2m Temp. anom above 66%)  
Forecast start reference is 30-05-2019  
ensemble size = 51 , climate size = 660

Day 5-11  
03-06-2019/TO/09-06-2019

30/5/2019

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

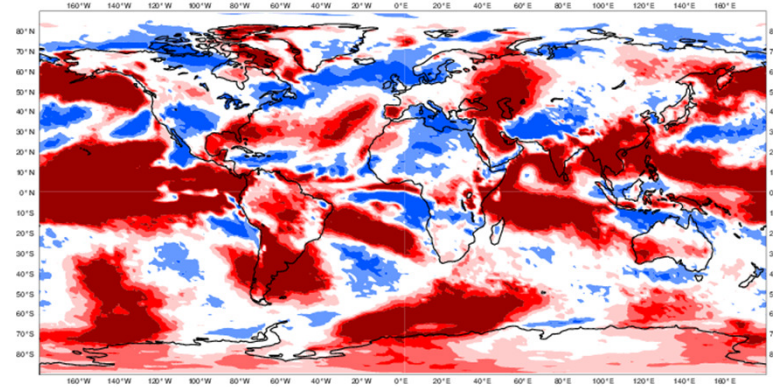


ECMWF EPS-Monthly Forecasting System  
(Prob 2m Temp. anom above 66%)  
Forecast start reference is 23-05-2019  
ensemble size = 51 , climate size = 660

Day 12-18  
03-06-2019/TO/09-06-2019

23/5/2019

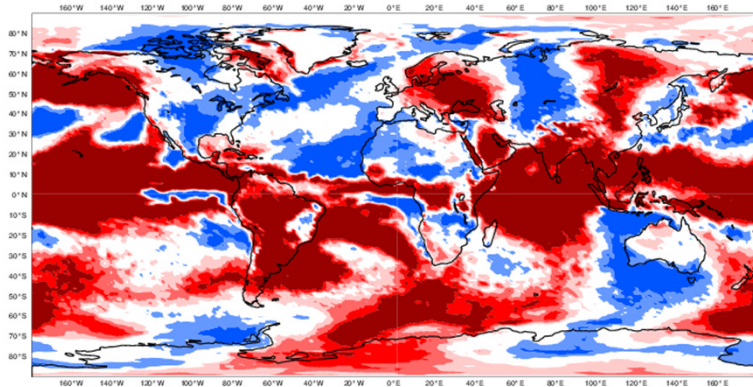
< 10% 10..20 20..40 40..50 50..60 60..70 > 70%



ECMWF EPS-Monthly Forecasting System  
(Prob 2m Temp. anom above 66%)  
Forecast start reference is 30-05-2019  
ensemble size = 51 , climate size = 660

Day 12-18  
10-06-2019/TO/16-06-2019

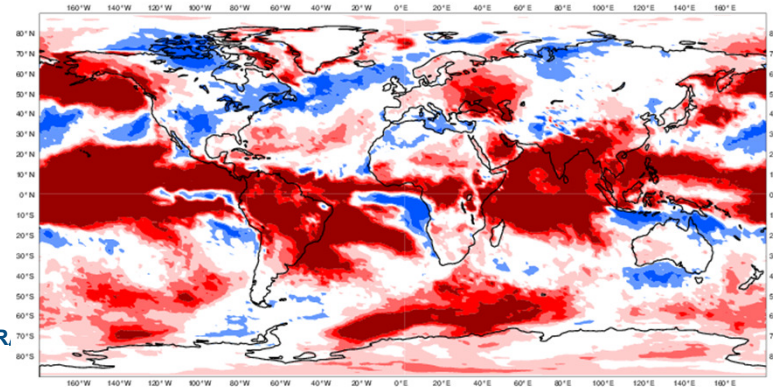
< 10% 10..20 20..40 40..50 50..60 60..70 > 70%



ECMWF EPS-Monthly Forecasting System  
(Prob 2m Temp. anom above 66%)  
Forecast start reference is 23-05-2019  
ensemble size = 51 , climate size = 660

Day 19-25  
10-06-2019/TO/16-06-2019

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



FOR MEDIUM-R

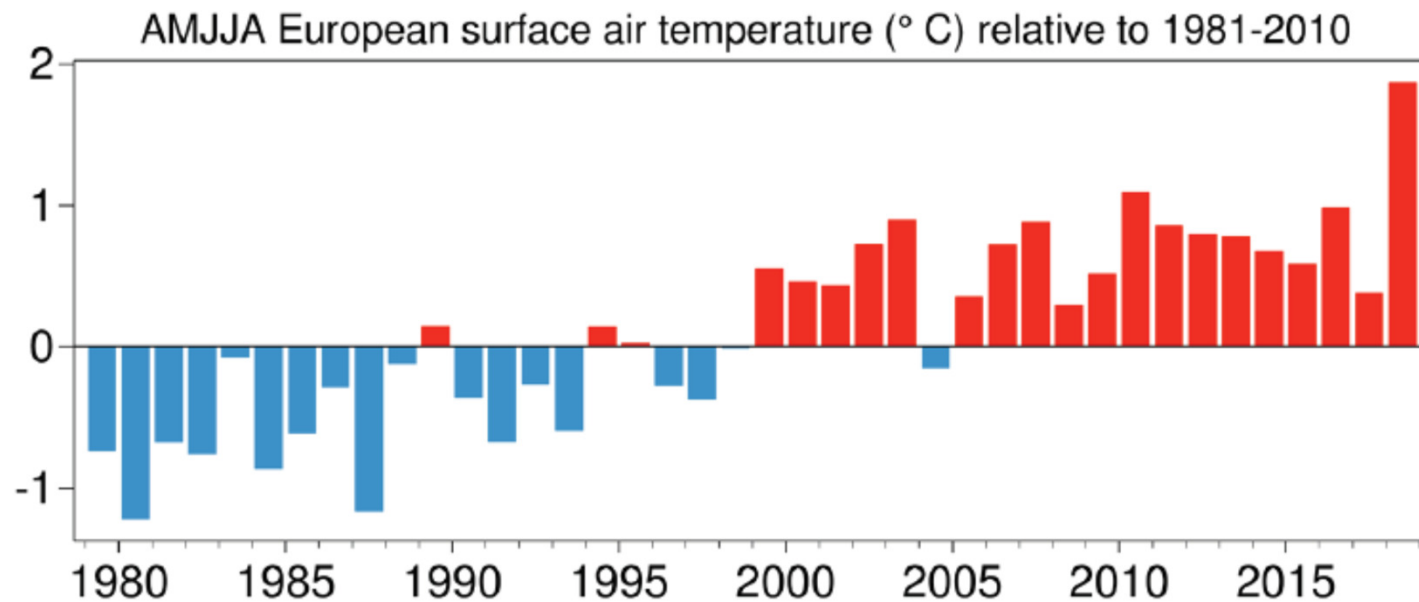


The prediction of extreme events is one of the major challenges of Sub-seasonal forecasting due to their high human and financial cost. (S2S sub-project).

Extreme events that the S2S forecast could predict are long lasting, large scale extreme weather hazards which occur on a scale of 1000 km with a lifetime ranging from a week to a few months. These events can be particularly destructive.

S2S models will probably not have skill to predict the daily variations of these extreme events, but they are expected to provide guidance on their genesis, time evolution, intensity and decay on at least a weekly basis.

## Summer of 2018 :

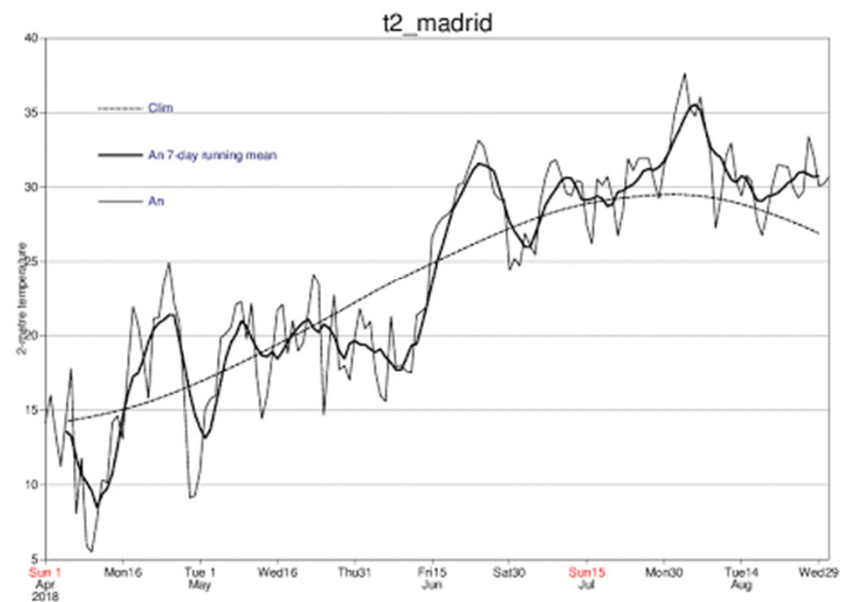
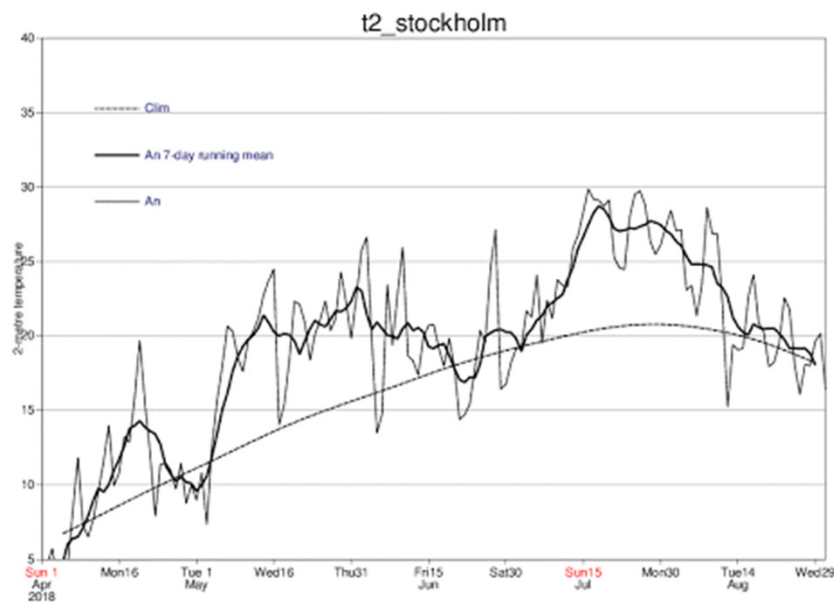
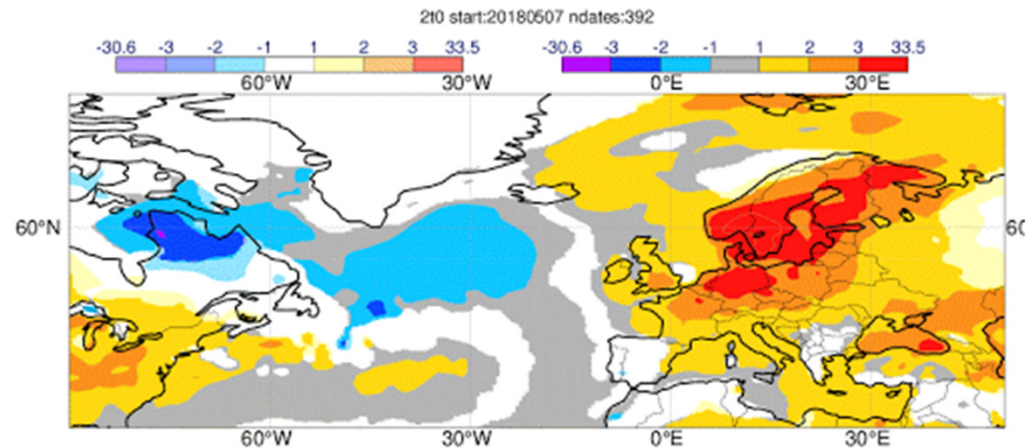


**Evolution of near-surface air temperature anomalies.** This chart produced by C3S shows that the near-surface air temperature anomaly in Europe in the period of April to August (AMJJA), calculated relative to the 1981–2010 average for those months, was much larger in 2018 than in any previous year since 1979.



EUROPEAN CENTRE FOR MEDIUM-RANGE WEATHER FORECASTS

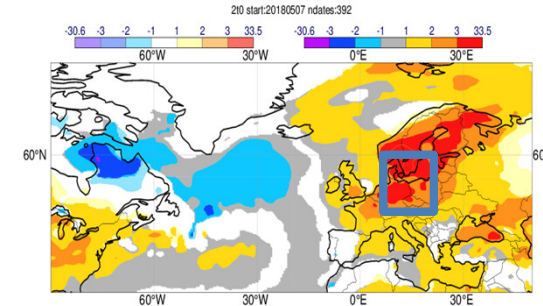
# Summer of 2018 : warmest and driest for northern Europe



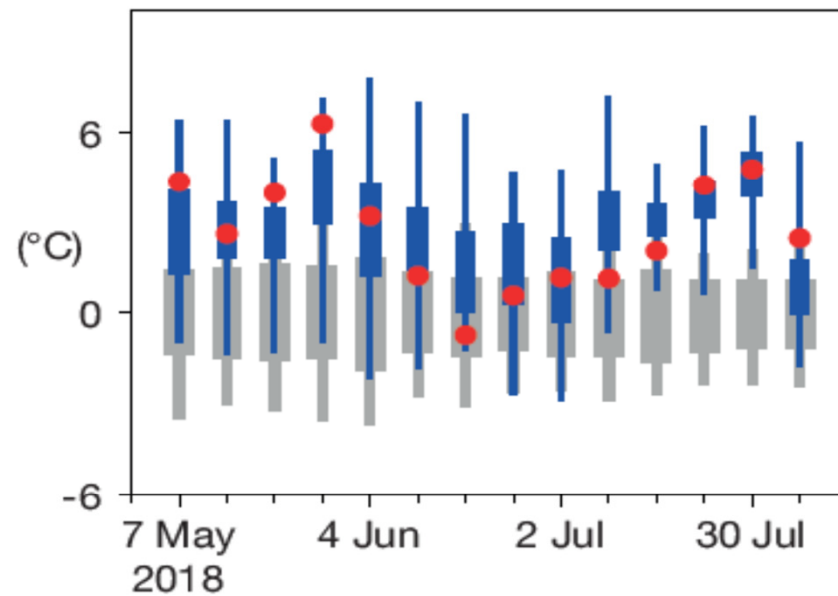
Time series of daily 12 UTC 2m temp (thin lines) 7day running mean thick lines  
Climatology (dashed lines) for St and M from the 1 of April to 31 August 2018



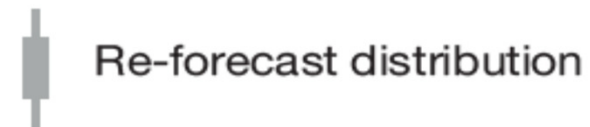
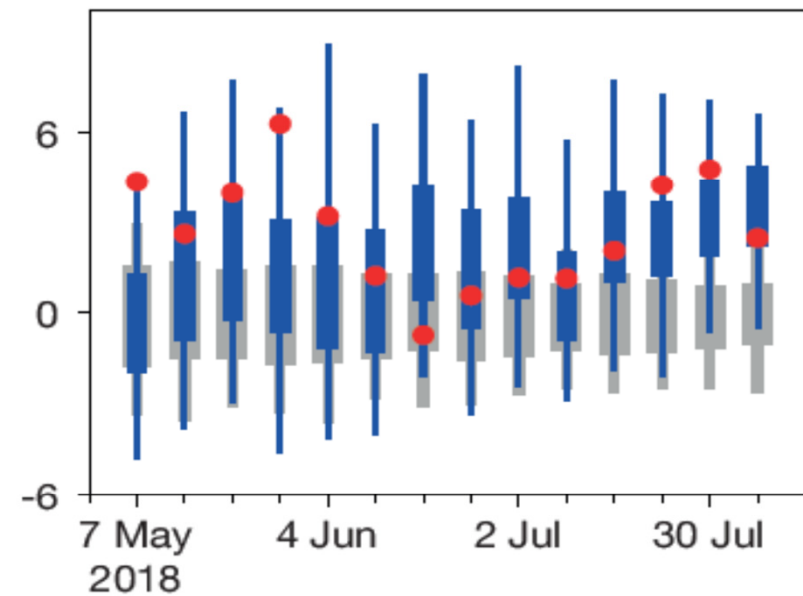
# Weekly temperature anomalies :



Week-two forecasts

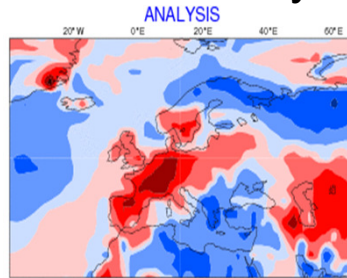


Week-three forecasts

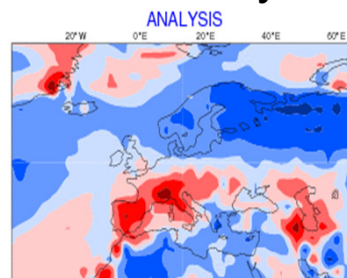


# Heat wave over Central-southern Europe in 2015: 2mt weekly mean anomalies

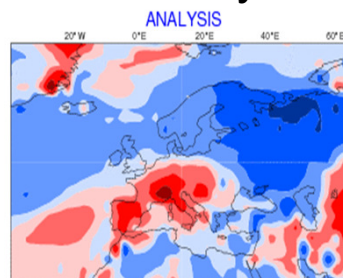
29-5July



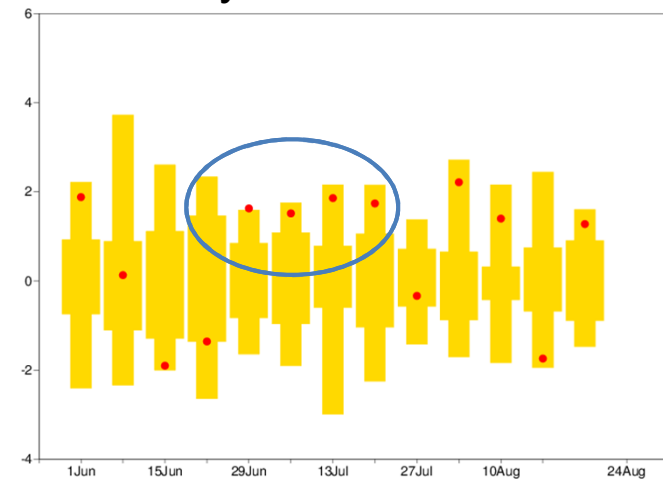
6-12 July



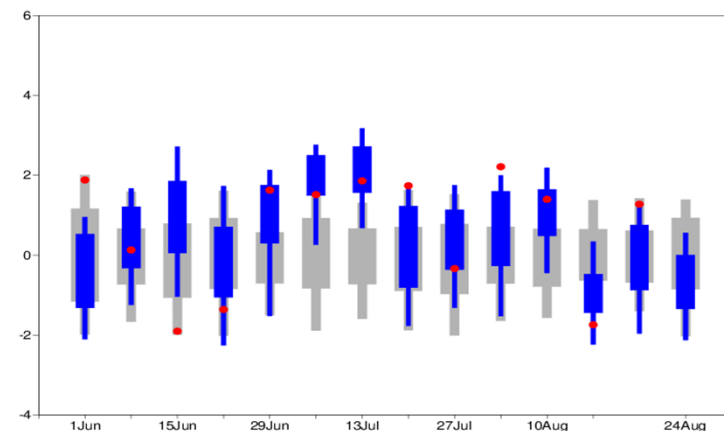
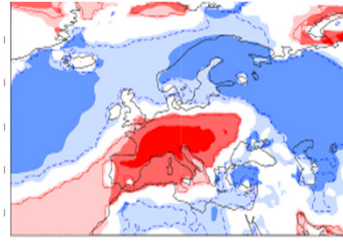
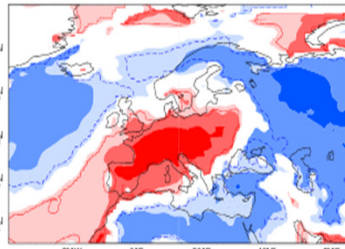
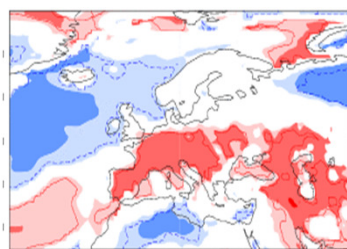
13-19 July



Analysis and era-climate



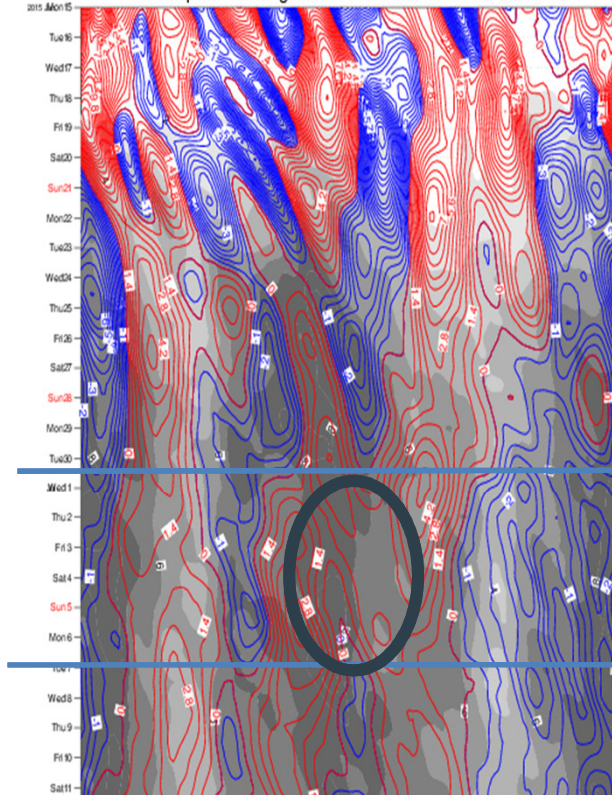
Forecasts: 12-18 days



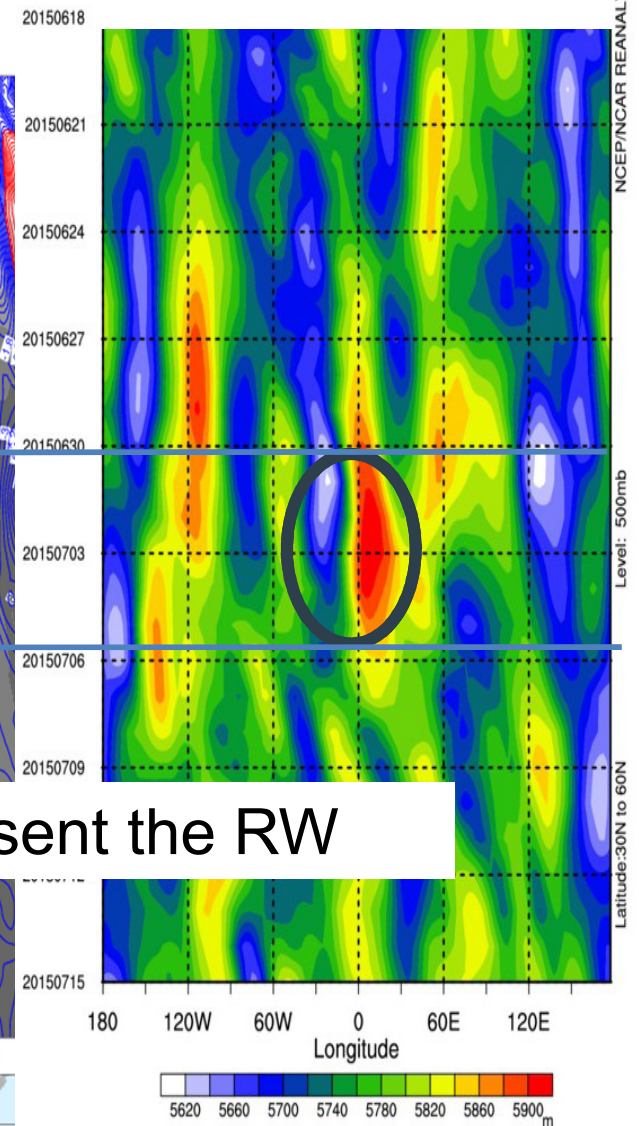
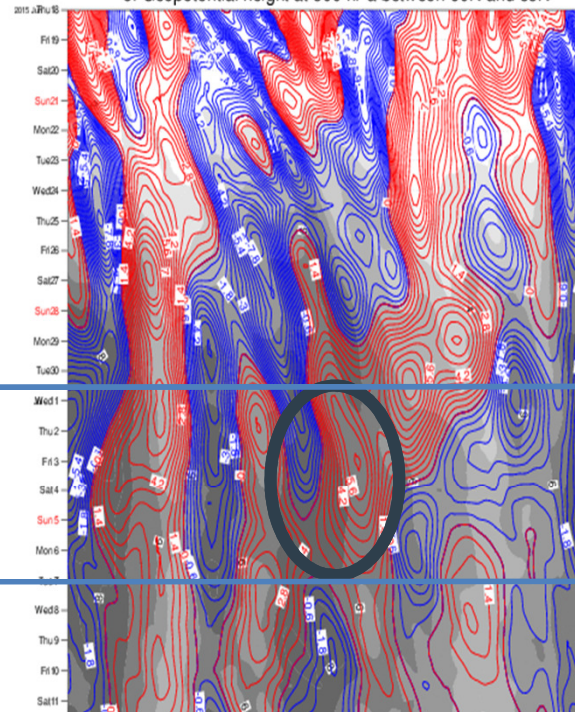


# Heat wave over Central-southern Europe in 2015: Geopotential height

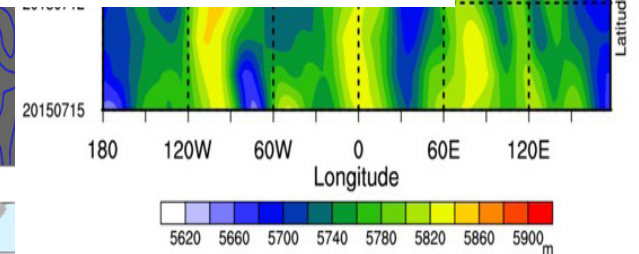
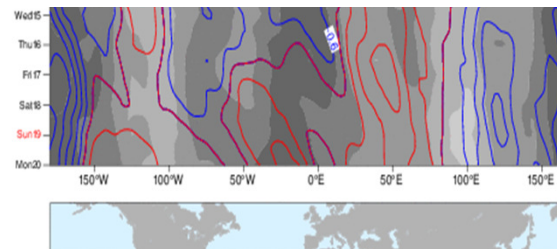
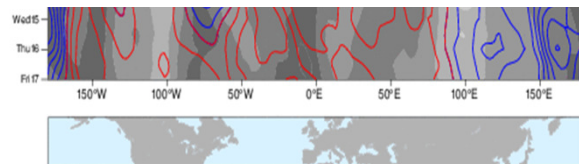
Time-longitude diagram of monthly forecast from 20150615:00  
Ensemble mean anomaly (contours) and spread (shading)  
of Geopotential height at 500 hPa between 60N and 35N



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



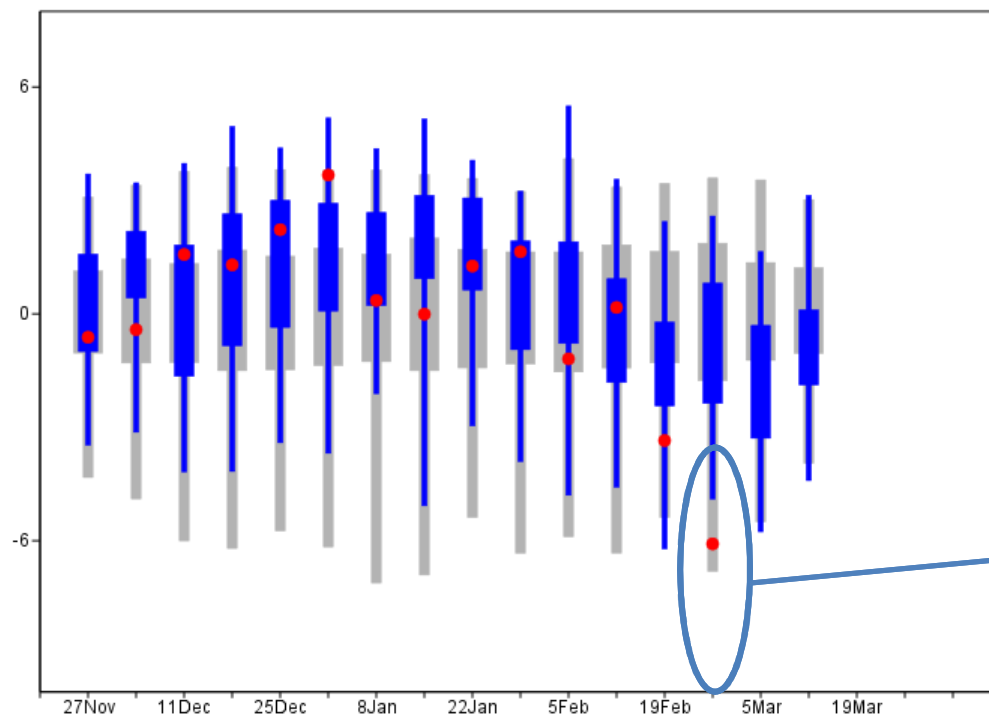
The successful forecast was able to represent the RW



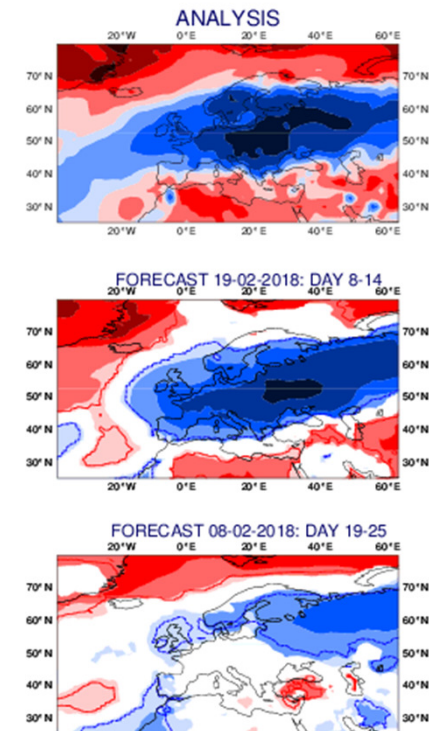


# Severe cold spell end of February 2018:

2mt over Europe  
weekly means anomalies at 19-25  
days



26/2-4/3 2018

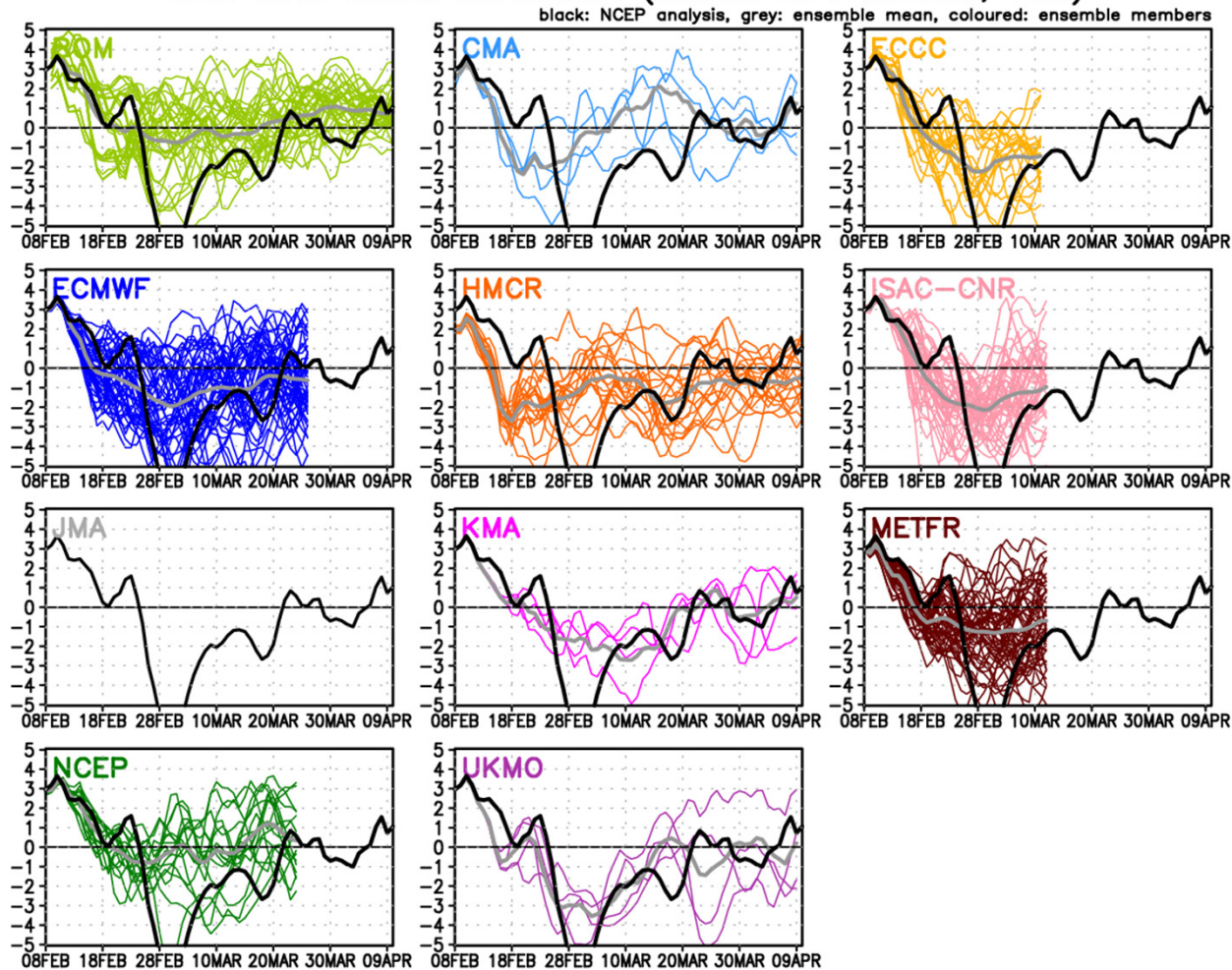


# From: the S2S Museum @University of Tsukuba, Japan

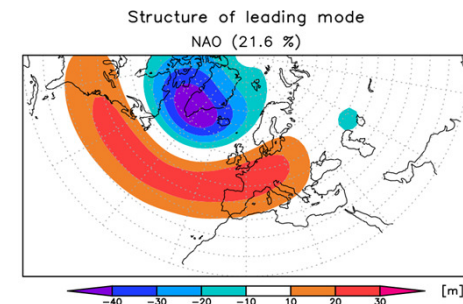
Dr. Mio Matsueda

[http://gpvjma.ccs.hpcc.jp/S2S/S2S\\_NAO.html](http://gpvjma.ccs.hpcc.jp/S2S/S2S_NAO.html)

## S2S NAO index forecasts (initial: 2018.02.08, Thu)

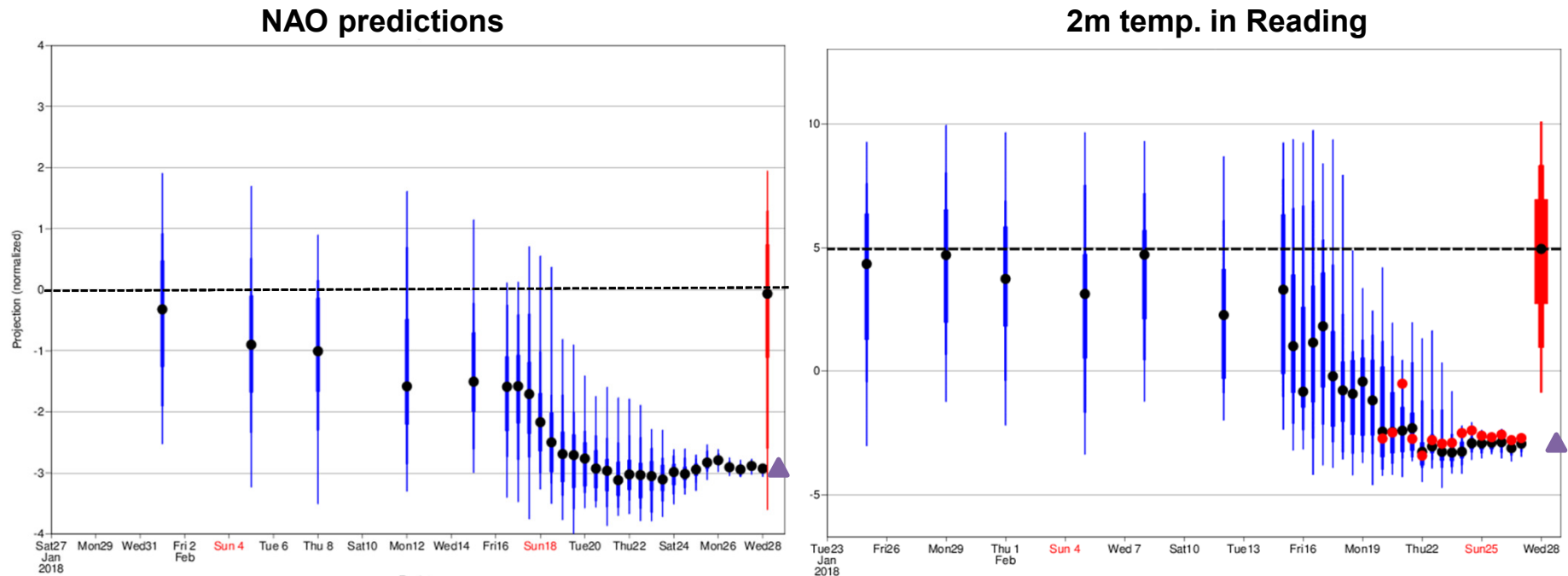


EUROPEAN CENTRE FOR MEDIUM-RANGE WEATHER FORECASTS



# How far in advance this cold event was predicted?

Predictions initialized at different time and verifying the 3-days mean (27 Feb to 1 March)

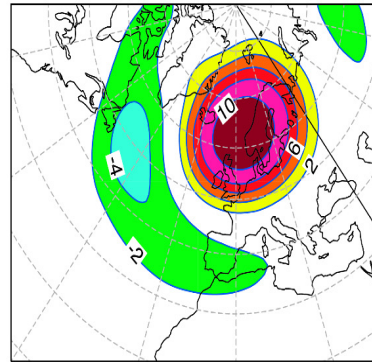


Persistent high pressure systems are associated with severe events: cold spell in winter and heat waves in summer.

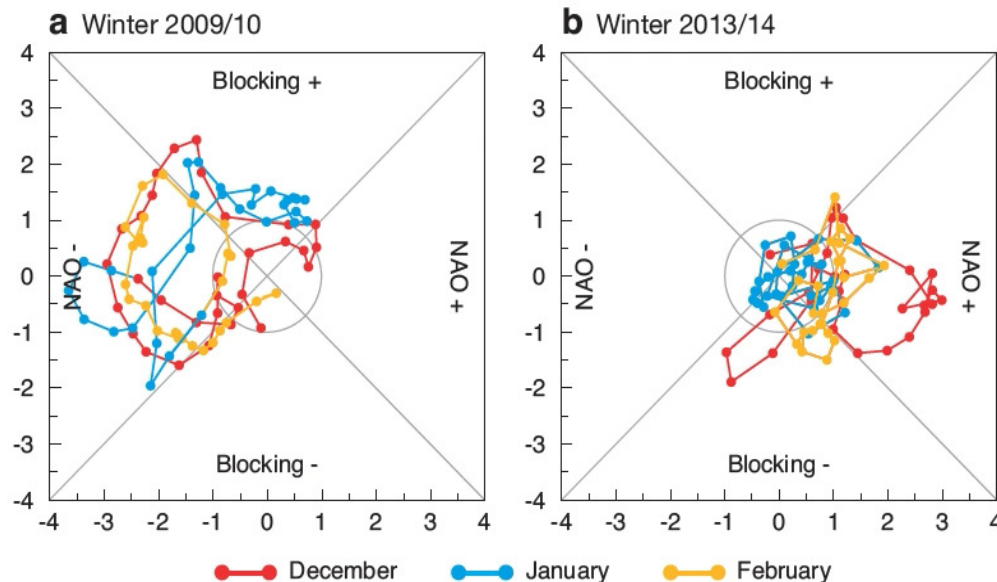
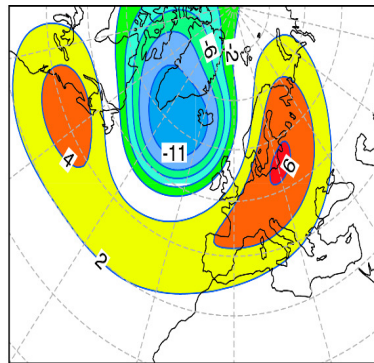
Circulation regimes, usually associated with global teleconnections, play an important role in the atmospheric predictability on sub-seasonal time scale.



# How far in advance we predict changes in large scale flow leading to sever cold spell over Europe?

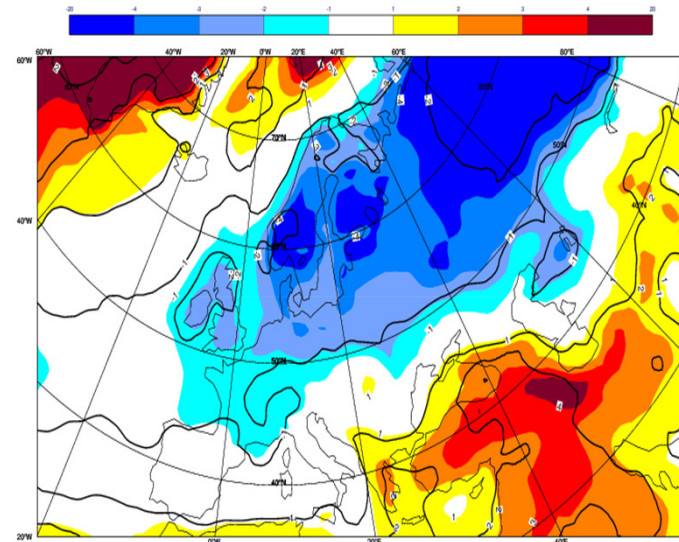
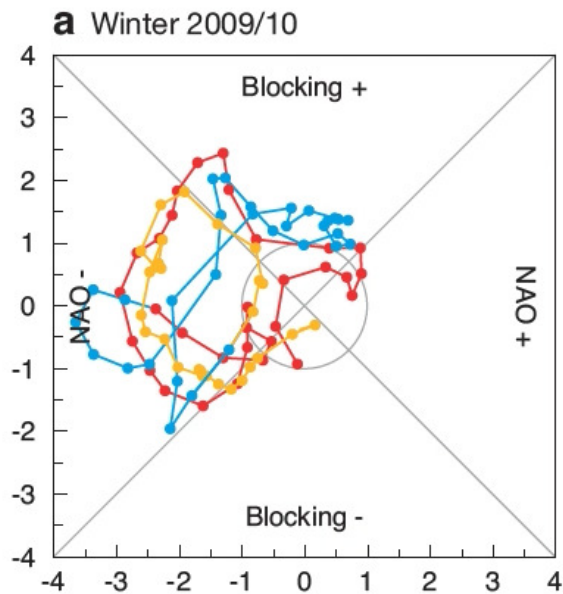


- $\pm$ EOF1 and +EOF2 represent quite well  $\pm$ NAO and BL
- Trajectories in phase space summarise regime evolution

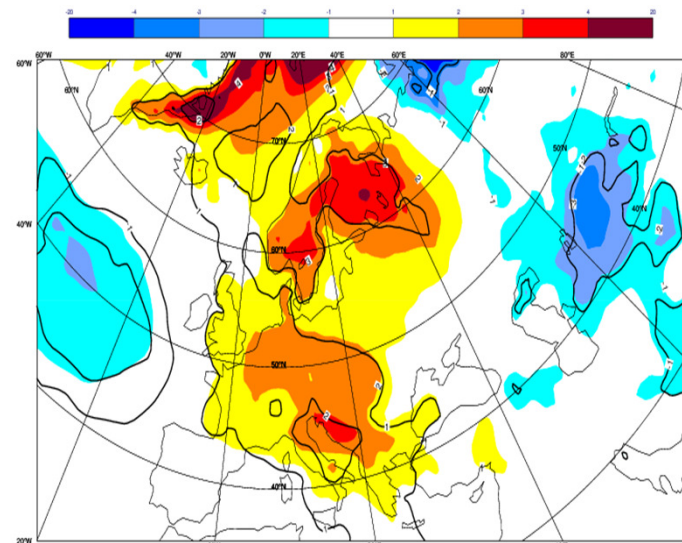
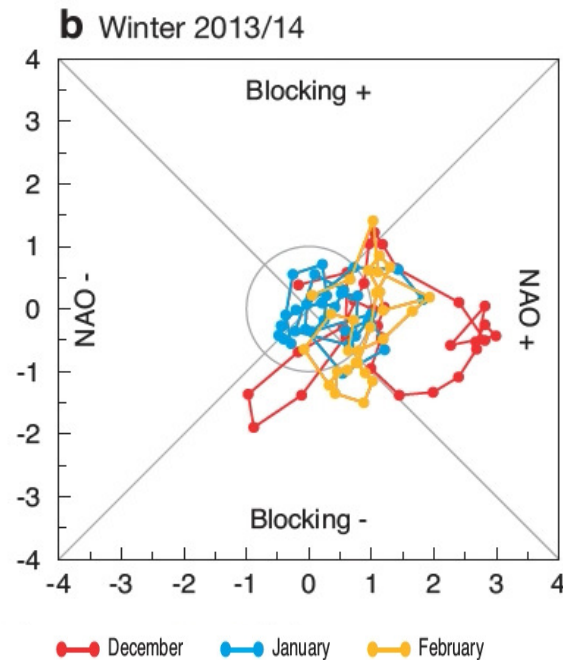


Ferranti, L. et al. 2018  
*QJRM*, **144**, 1788–1802.  
doi:10.1002/qj.3341

## 2M Temp anomalies for DJF:



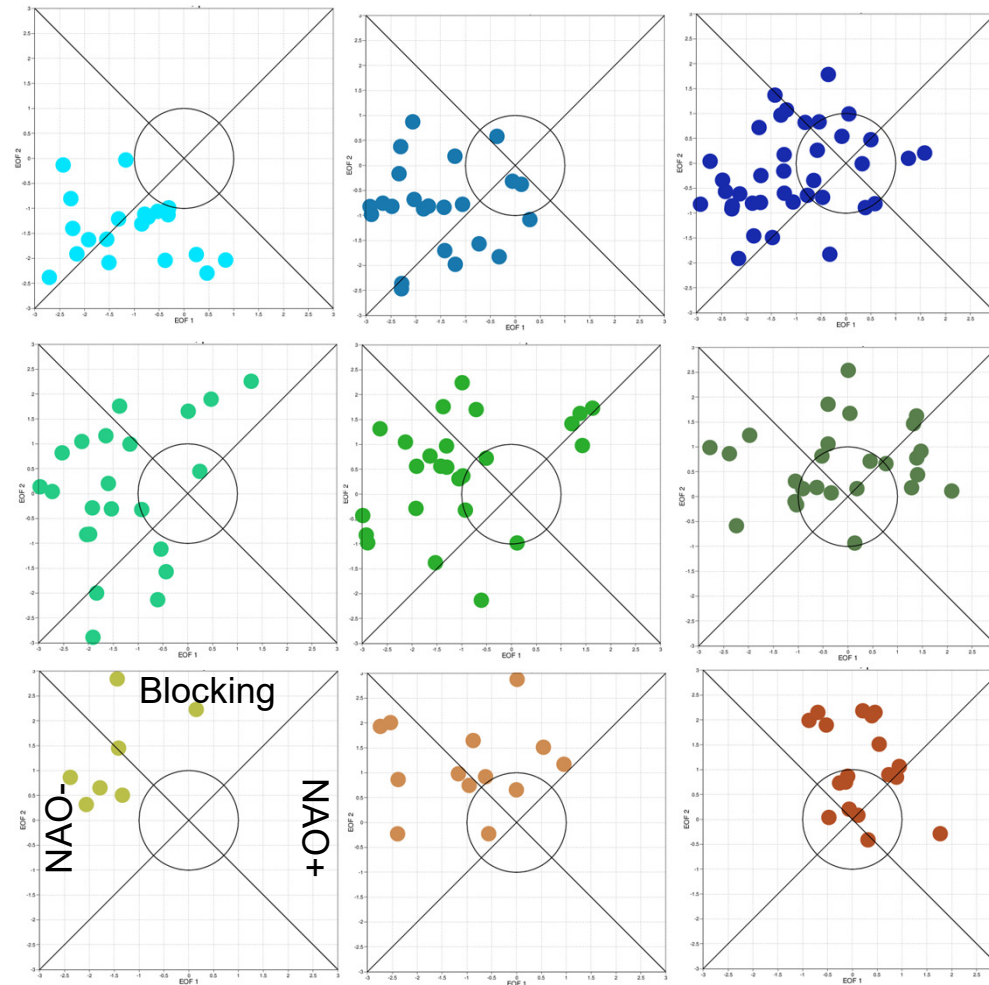
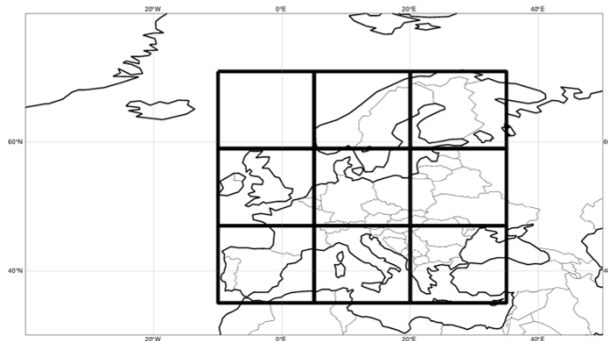
2009/2010



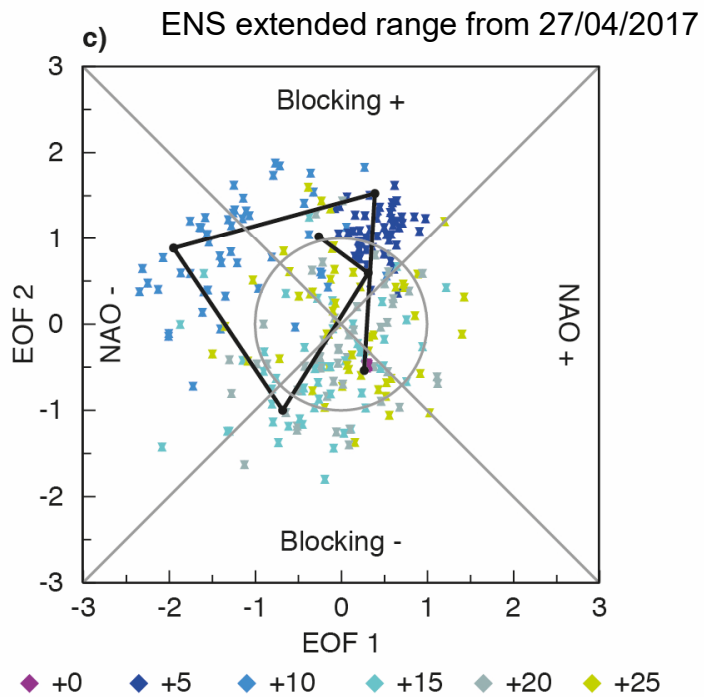
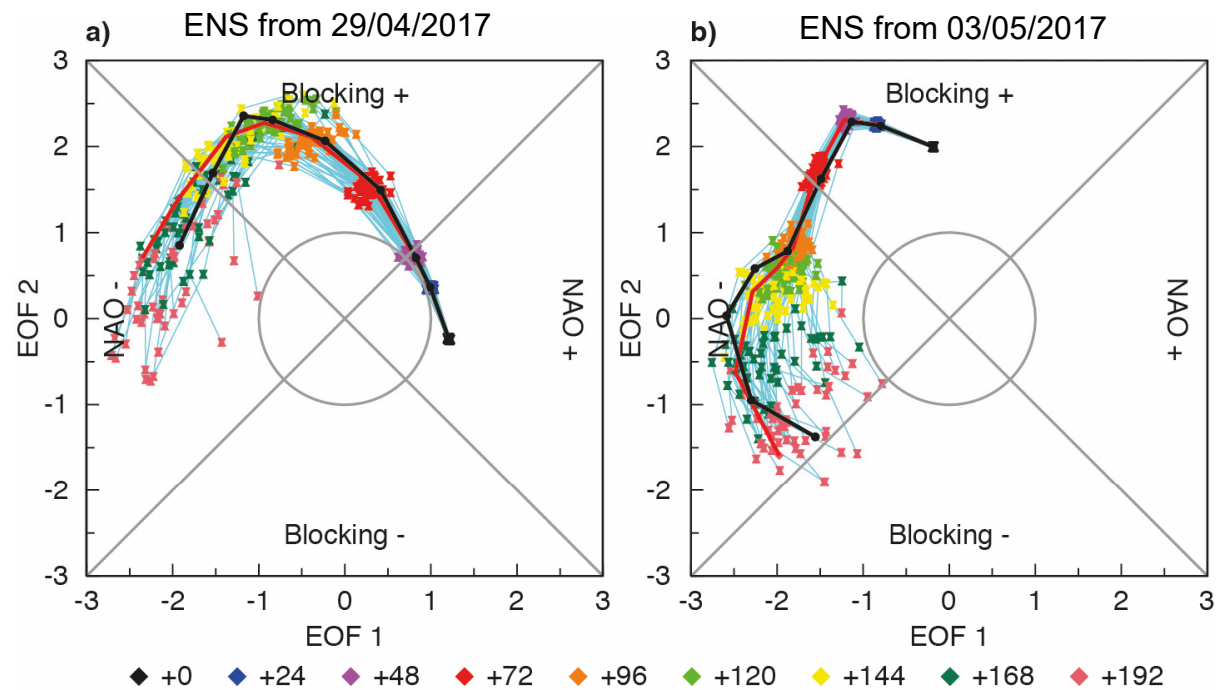
2013/2014

# Distribution of severe winter (NDJF) events in era-interim (1980-2015)

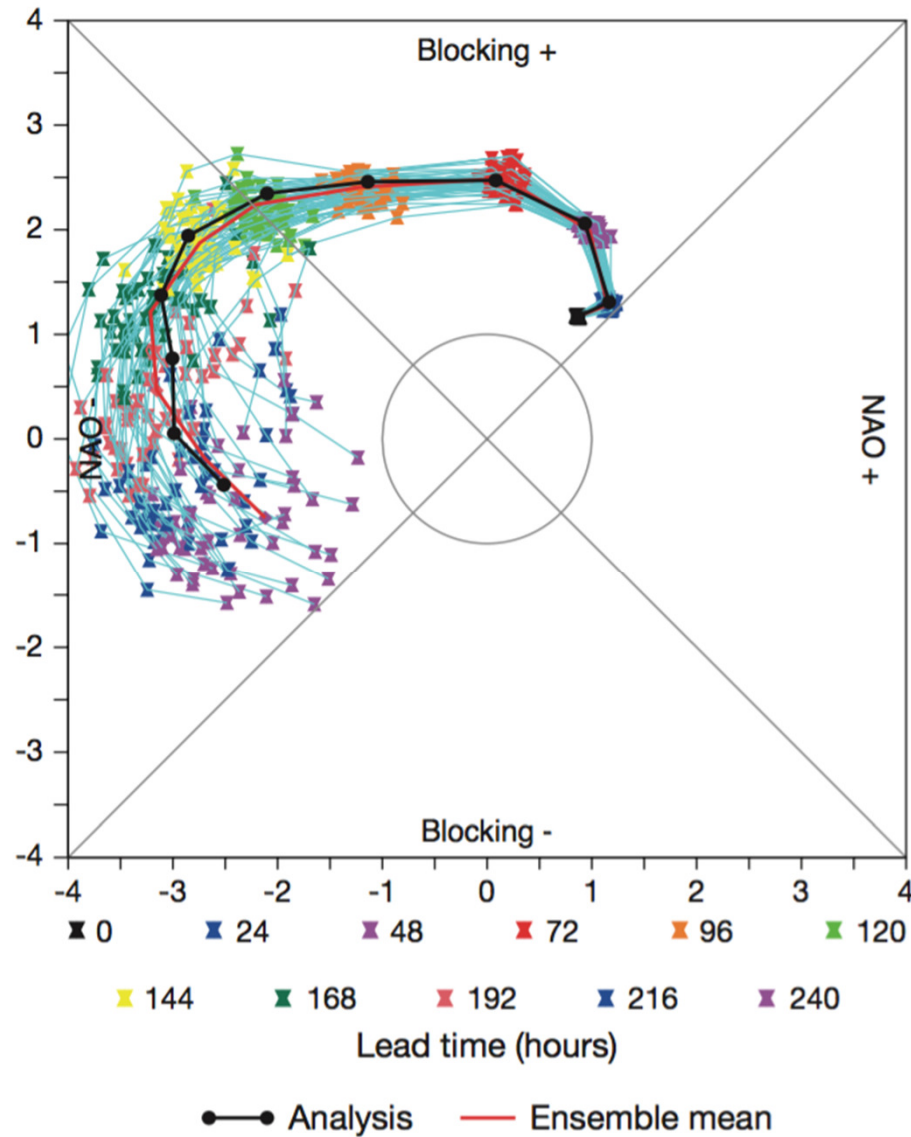
When for 60% grid points in each box the daily 2mt < 10<sup>th</sup> quantile of daily climate for at least 4 consecutive days



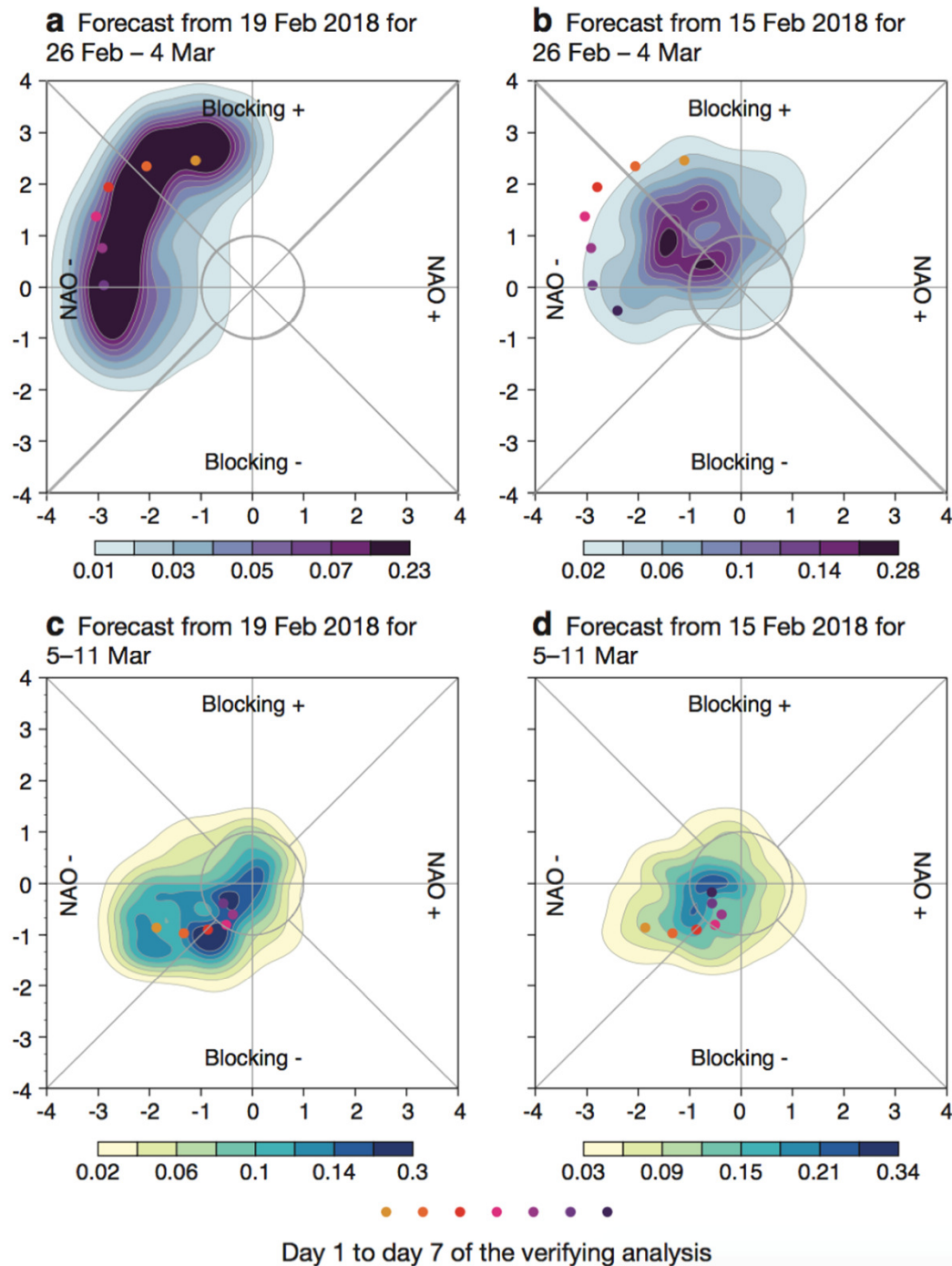




## Forecast Trajectories: 2018/02/22 at 00utc ENS



Evolution of the ensemble forecast up day 10.

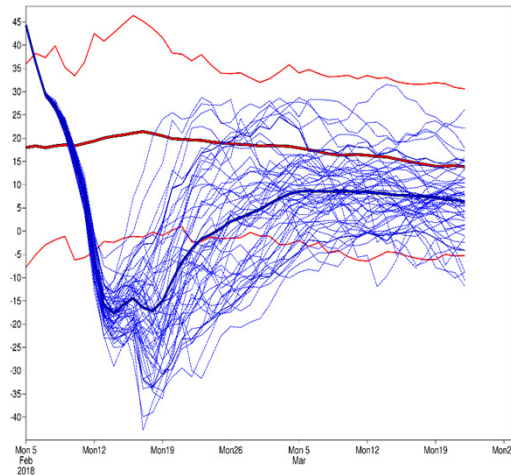
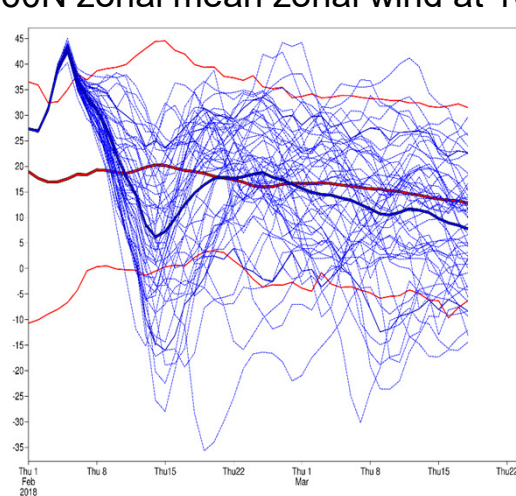


**FIGURE 5** Probability density functions for (a) an ensemble forecast starting on 19 February 2018 for the week starting on 26 February, (b) an ensemble forecast starting on 15 February 2018 for the same week, (c) an ensemble forecast starting on 19 February 2018 for the week starting on 5 March and (d) an ensemble forecast starting on 15 February 2018 for the same week. Daily values of the verifying analysis are represented by dots.

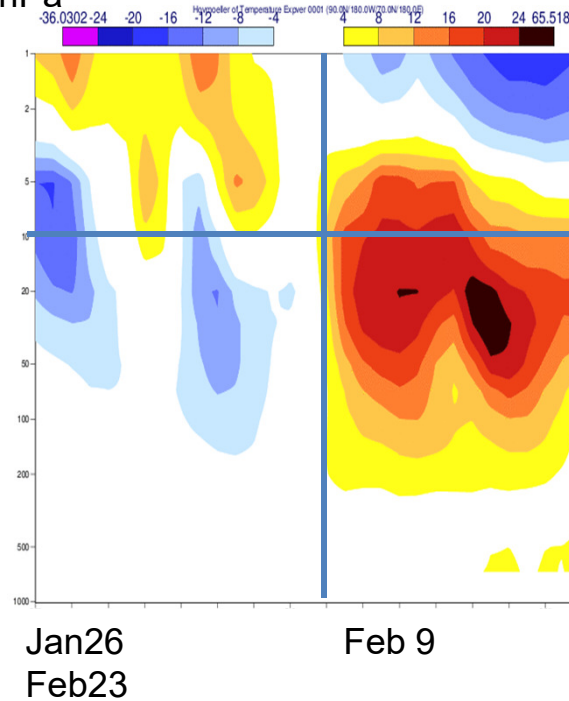
# Drivers of predictability on sub-seasonal scale

SSW:

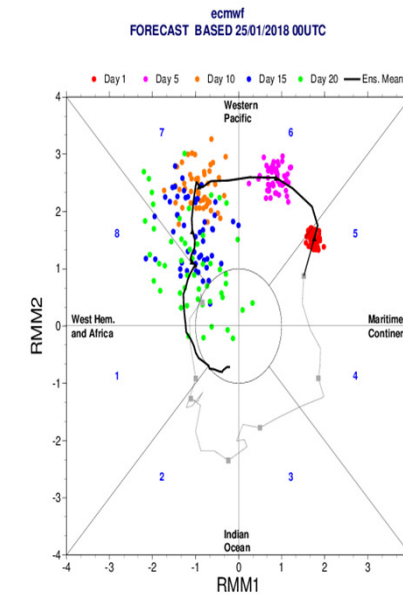
60N zonal mean zonal wind at 10hPa



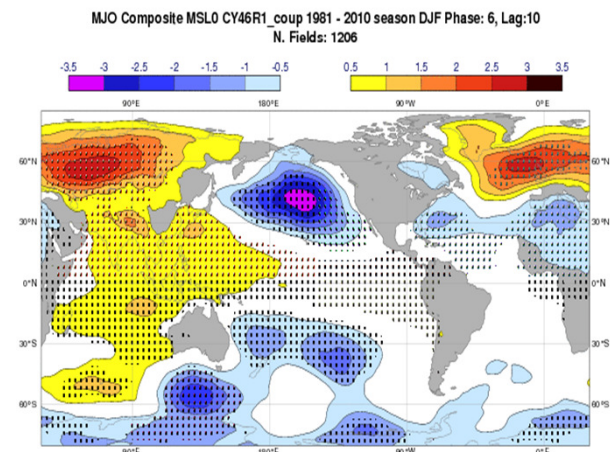
11Feb SSW onset



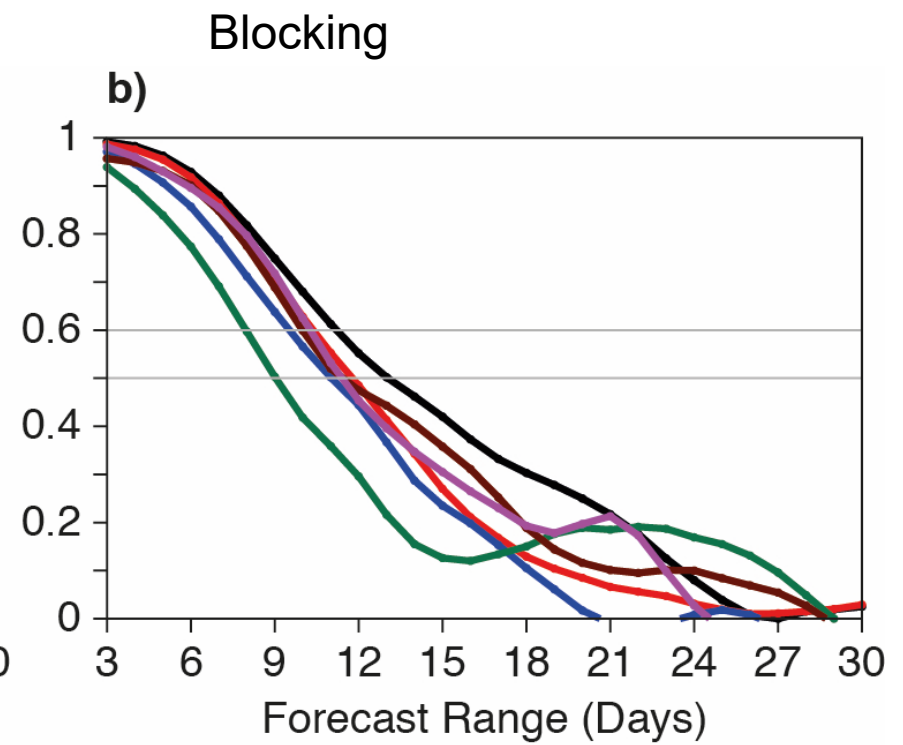
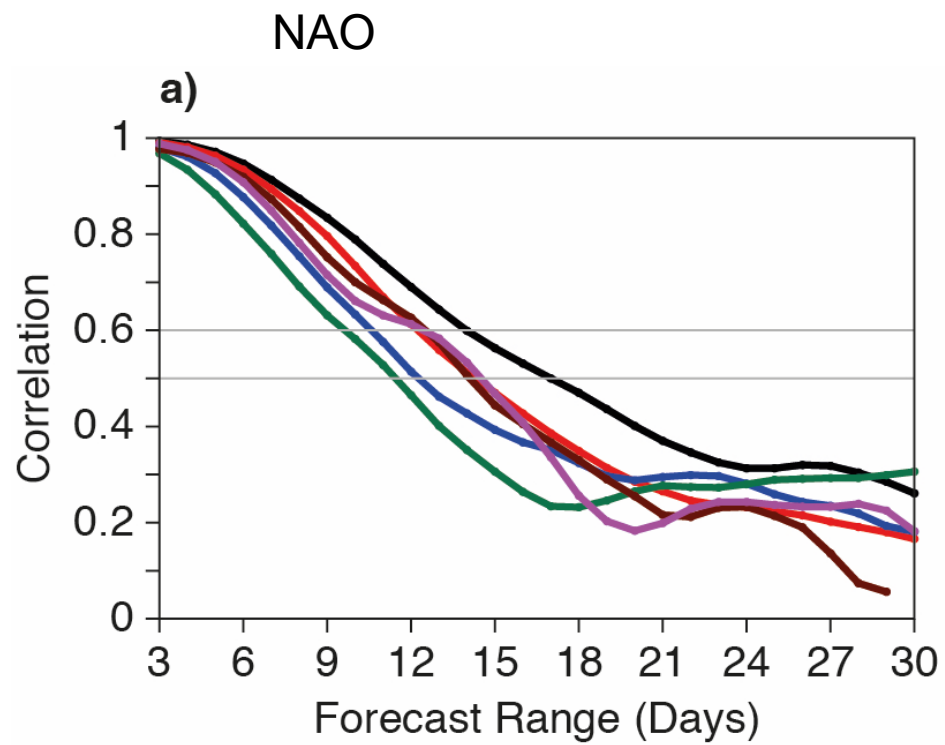
MJO:



Teleconnection from MJO phase 6 on MSLP

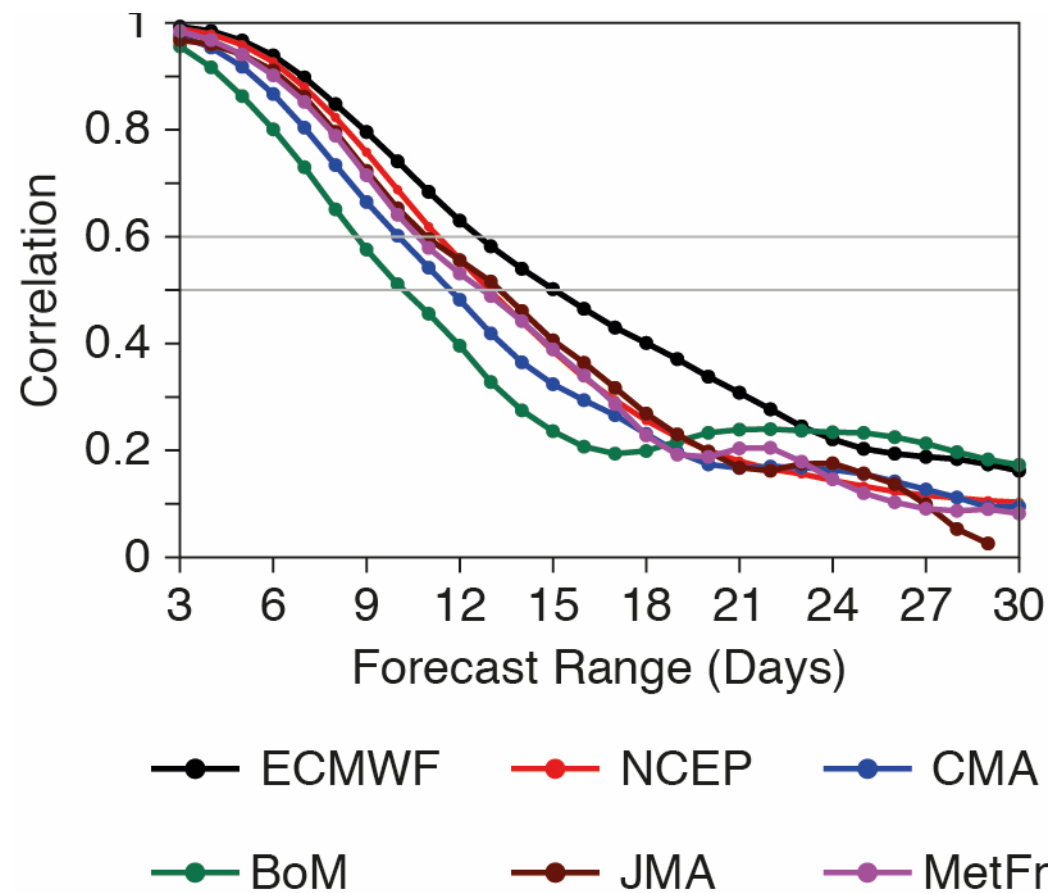






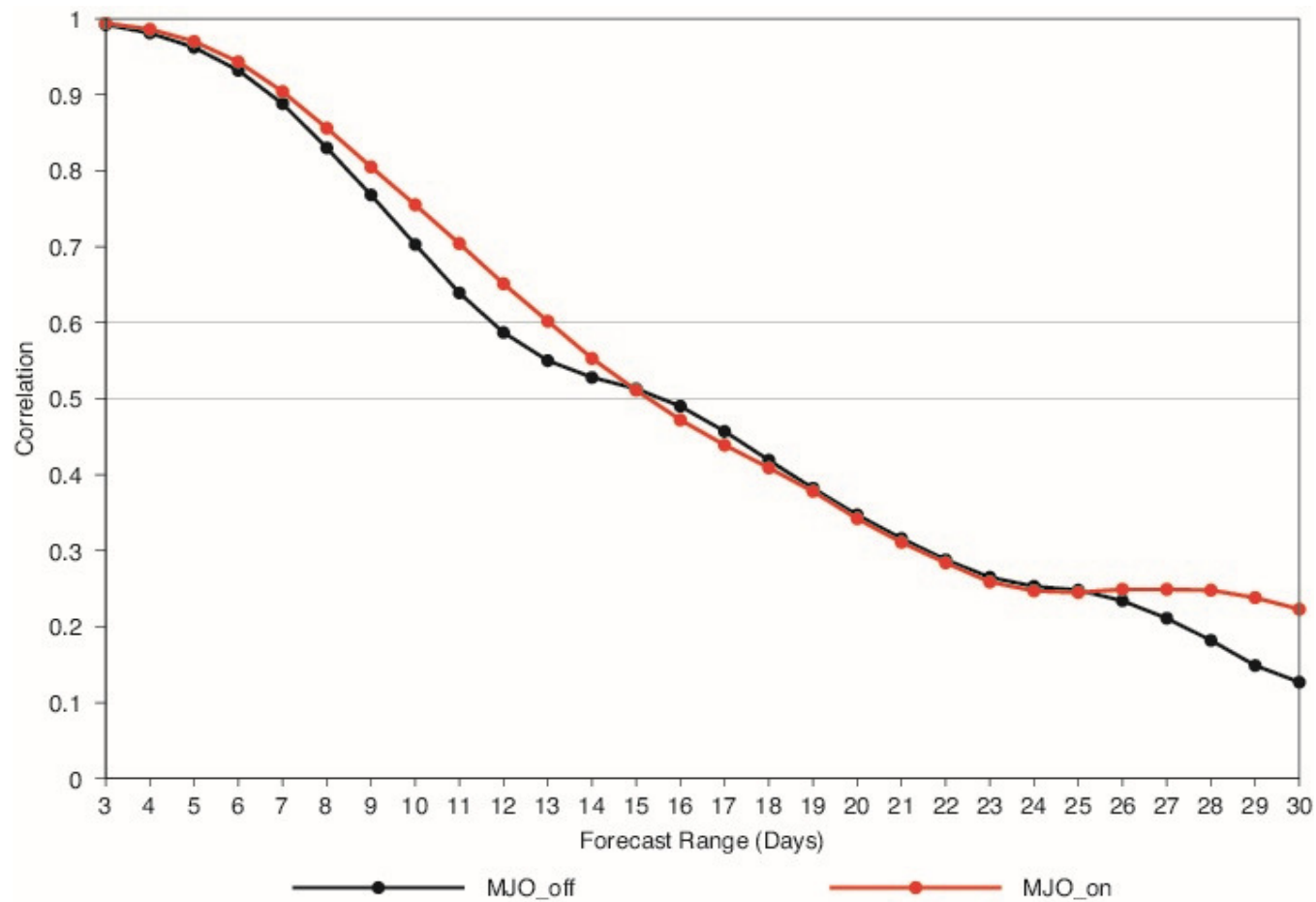
ECMWF NCEP CMA BoM JMA MetFr

## Regime transitions:



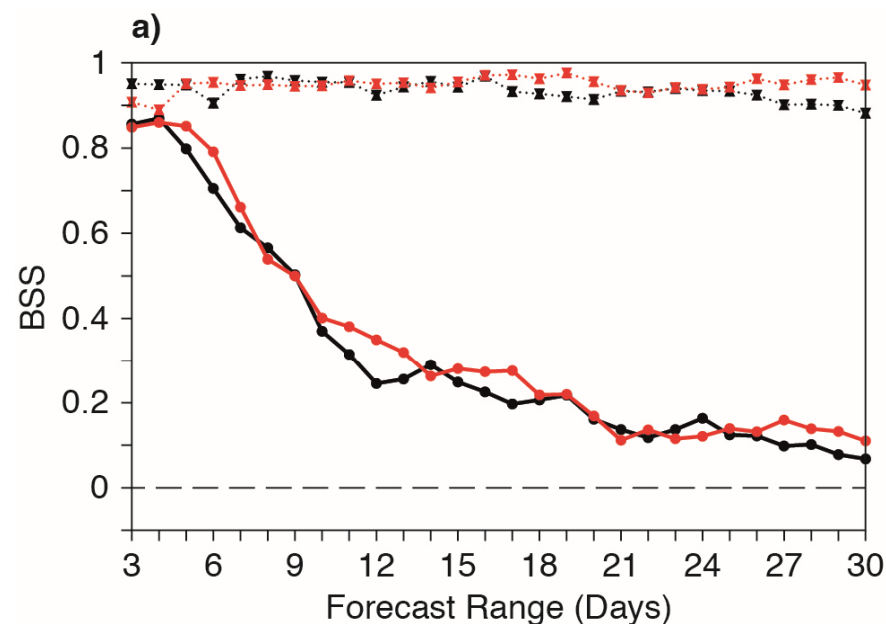
*Lin et al. (2008)*

## Conditional skill:



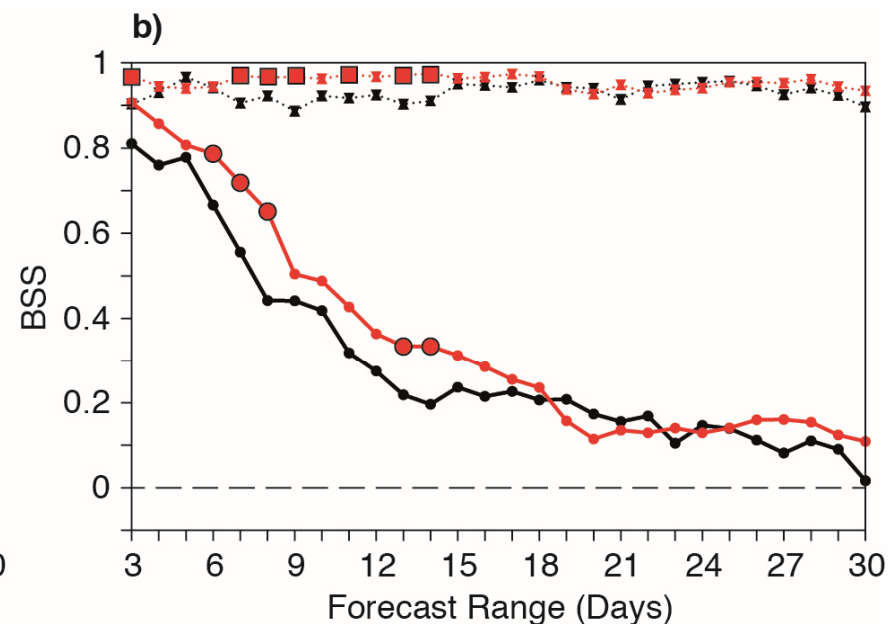
## MJO impact on probabilistic scores:

NAO+



—●— off    .....x..... off    —●— on    .....x..... on

NAO-



Small impact for NAO+ predictions  
Significantly higher skill for NAO- forecasts with and MJO in the i.c.



## Summary:

Reliable forecasts of NAO and blocking are instrumental for the extended range predictions of severe cold events over Europe.

S2S systems exhibit useful skill well beyond 10 days for NAO and Blocking predictions – strong potential for early warnings.

ECMWF forecasts, beyond 15 days, can provide reliable probabilities of cold temperatures associated with the NAO-.

Such skill can be enhanced by MJO activity (teleconnections).

Forecasting probabilities of cold spell associated with a blocking is a bigger challenge.

The accurate representation of RWP is important.

# Questions?



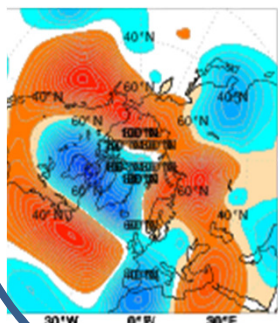
5-11/02

12-18/02

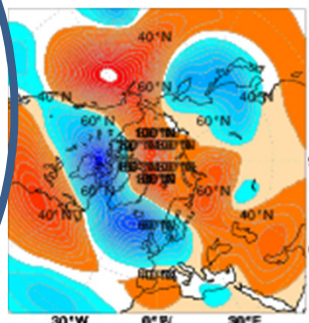
19-25/02

26-4/03

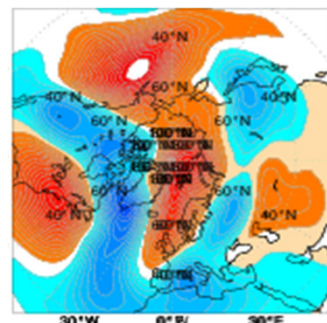
5-11/03



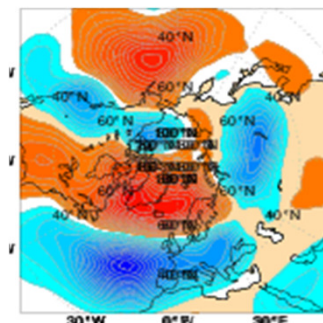
FC 20180129: Day 8-14



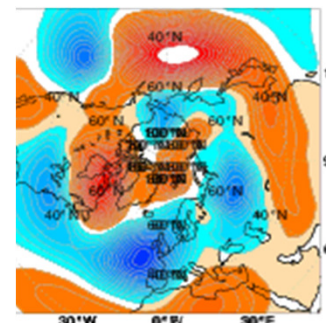
FC 20180205: Day 8-14



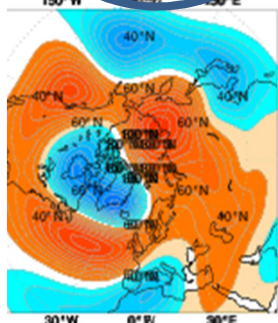
FC 20180212: Day 8-14



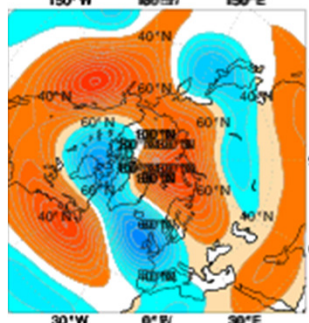
FC 20180219: Day 8-14



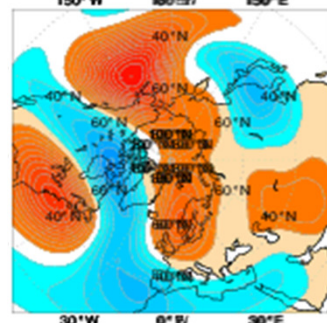
FC 20180226: Day 8-14



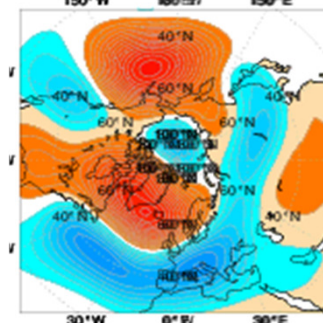
FC 20180118: Day 19-25



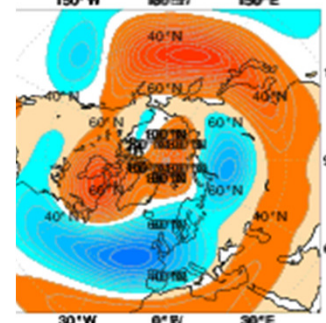
FC 20180125: Day 19-25



FC 20180201: Day 19-25



FC 20180208: Day 19-25



FC 20180215: Day 19-25

