Diagnostic and verification of low frequency phenomena

How we assess the ensemble predictions at extended ranges

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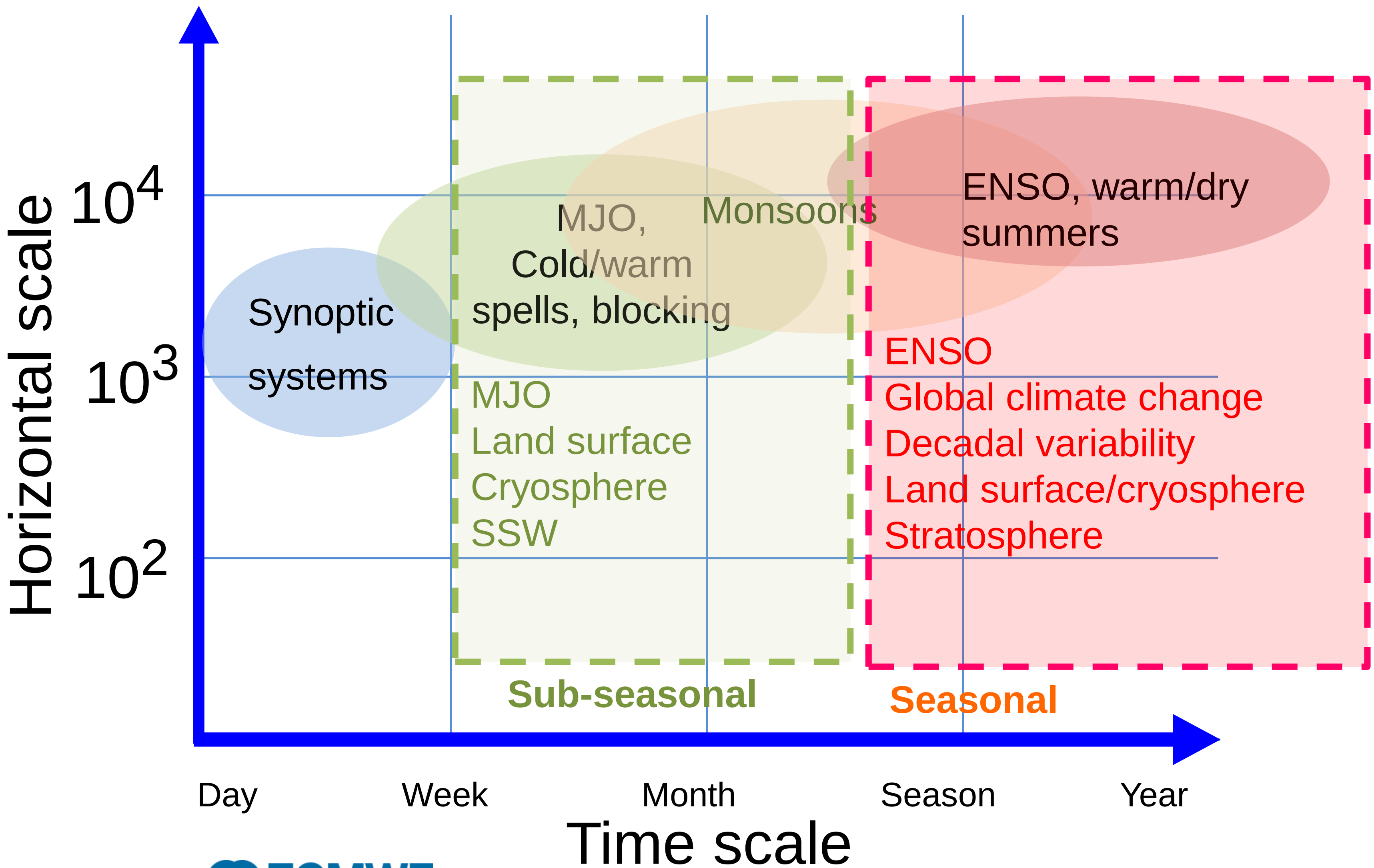
Frederic Vitart, Linus Magnusson

Sources of predictability at extended range :



Seasonal predictions :   **ENSO**

Skill is mainly conditioned by ENSO

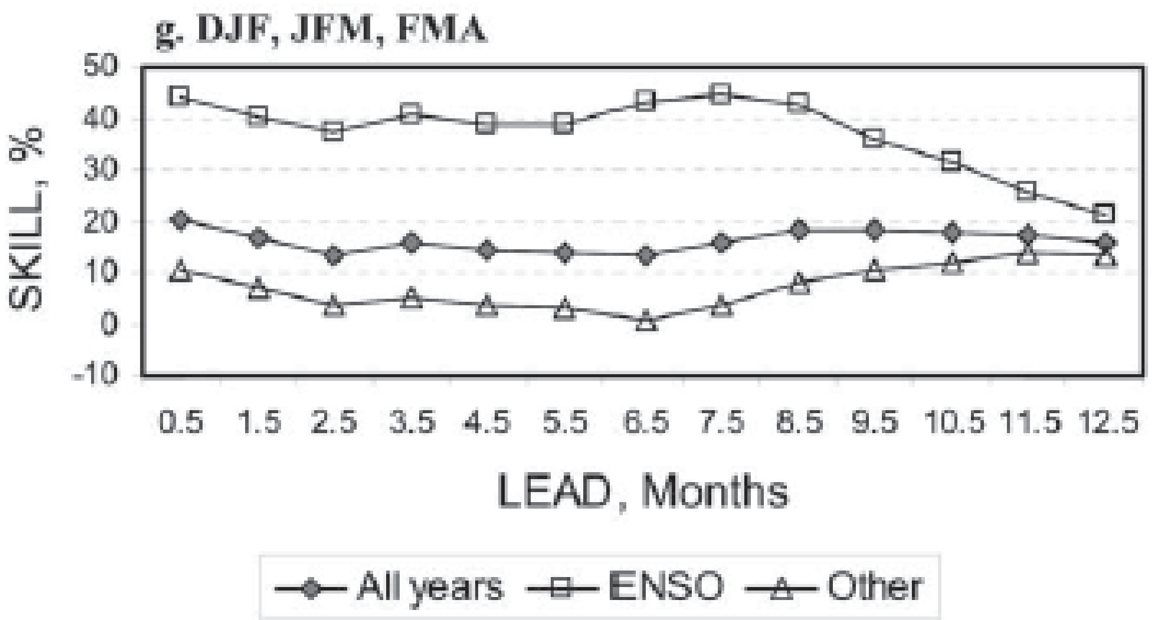
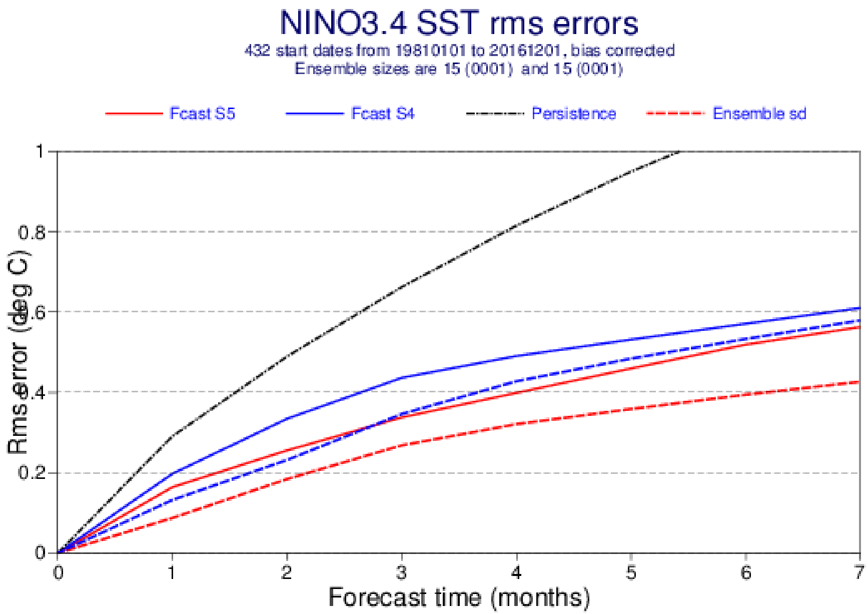


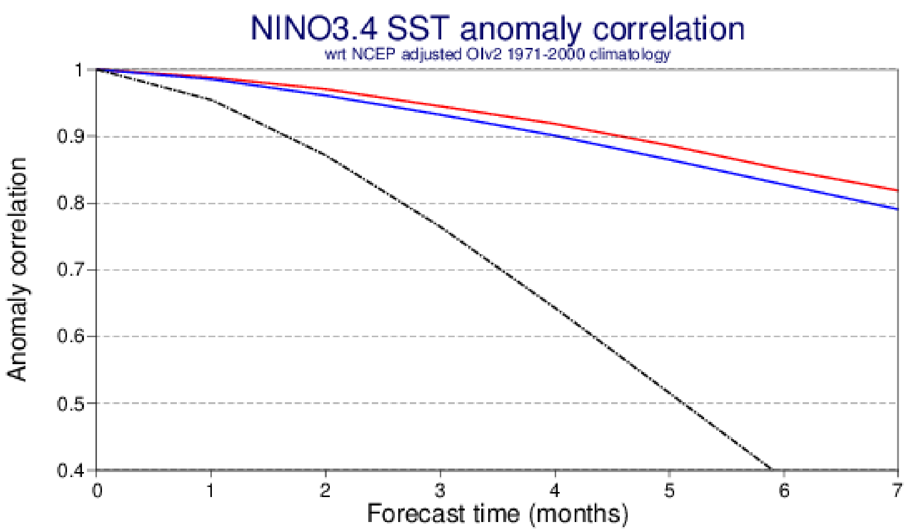
Fig. 1. Skill (times 100) of official 3-month U.S. temperature forecasts vs lead time (die-aways) for all 10 yr, 3 yr with strong ENSO episodes, and the 7 Other years.

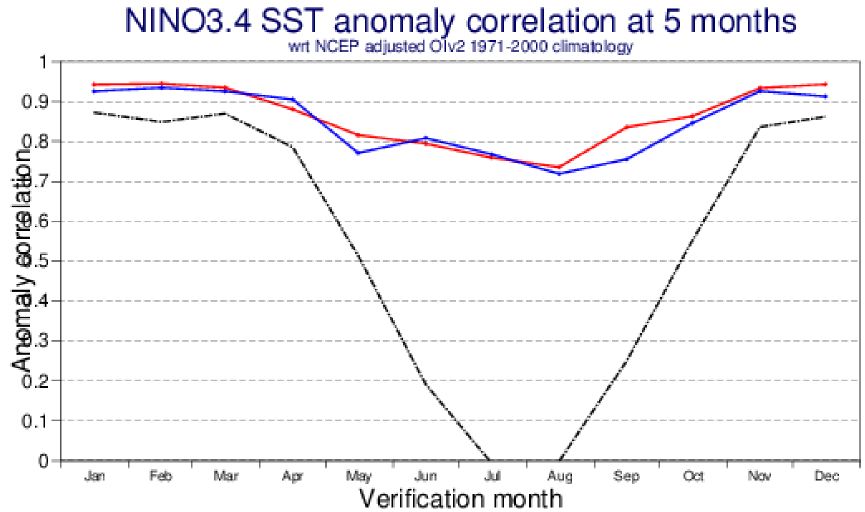
From Livezey and Timofeyeva 2008

Seasonal predictions : **ENSO**



We monitor the skill and the representation of the uncertainties .



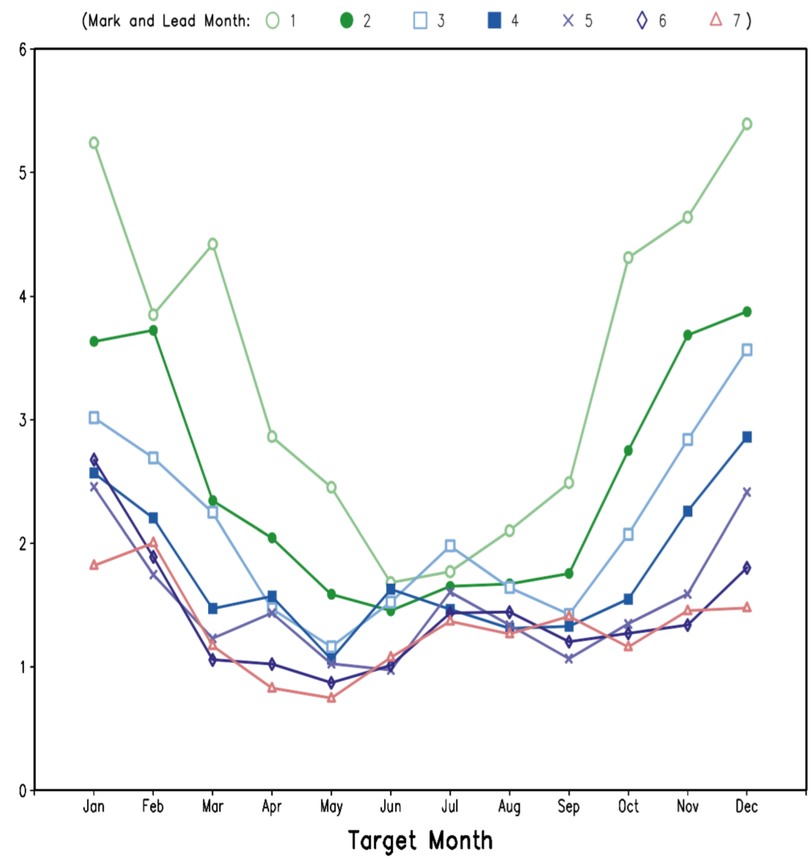


Tim Stockdale

Seasonal predictions: Predictability estimates for ENSO

Studies in a **perfect model framework** suggested that ENSO events might be predictable by some measures up to 2 years ahead [Collins et al., 2002; Chen et al., 2004; Luo et al., 2008; Wittenberg et al., 2014; Larson and Kirtman, 2017].

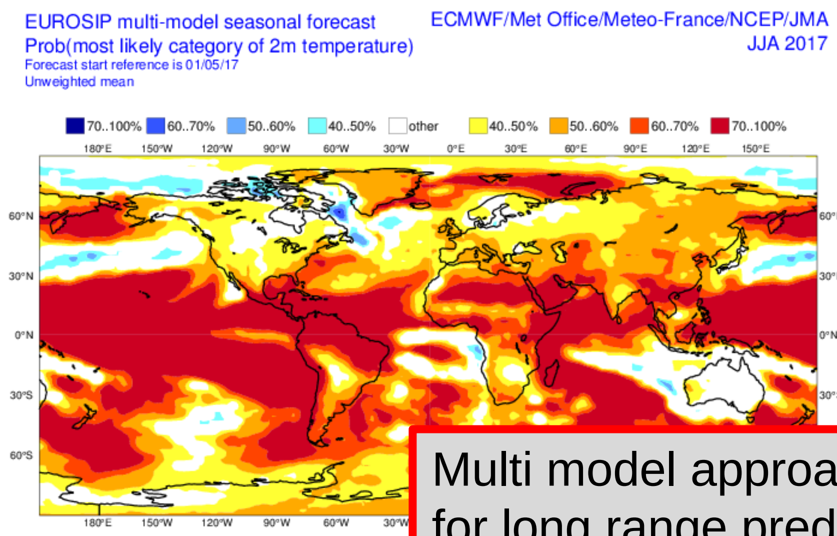
Some recent studies used multimodel ensembles to **identify predictable signals with the ensemble mean forecasts and unpredictable noise with the ensemble spread** [Chen et al., 2015; Kumar et al., 2016].

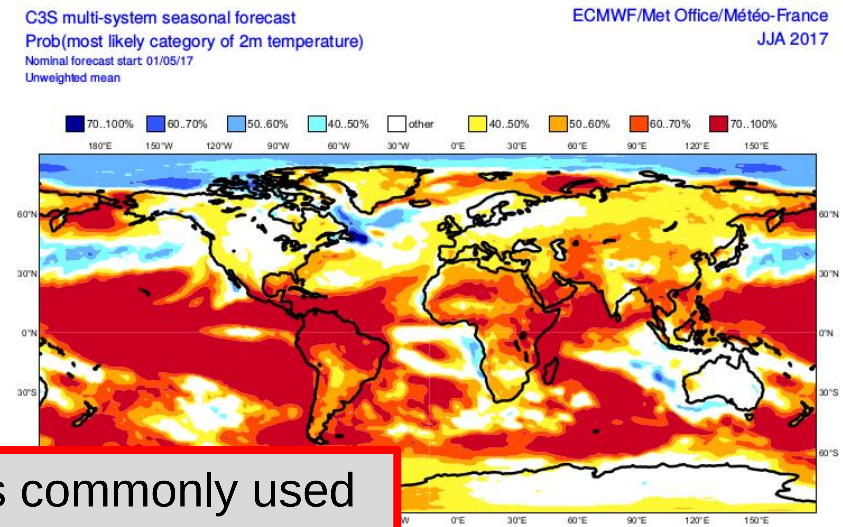


SNR of Nino3.4 index
From Kumar et al. 2016

All such predictability estimates are model dependent, limited by the CGCMs' ability to realistically represent not only the predictable signals but also the unpredictable noise.

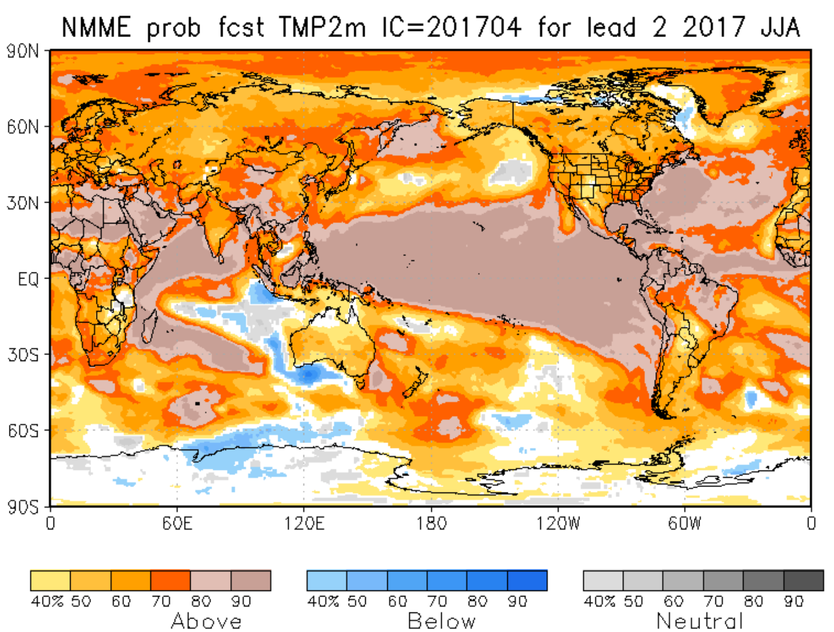
Seasonal predictions : **Multi-model approach**

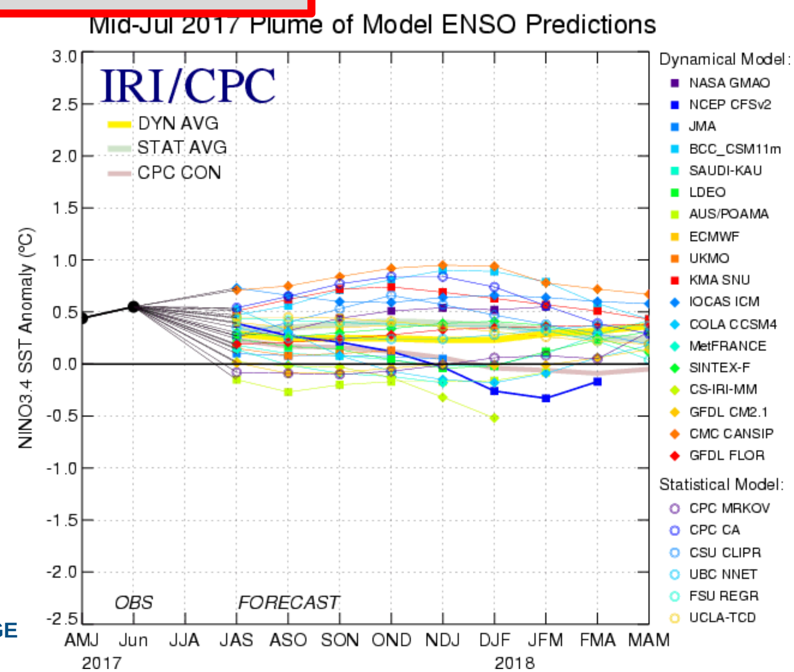




Multi model approach is commonly used for long range predictions

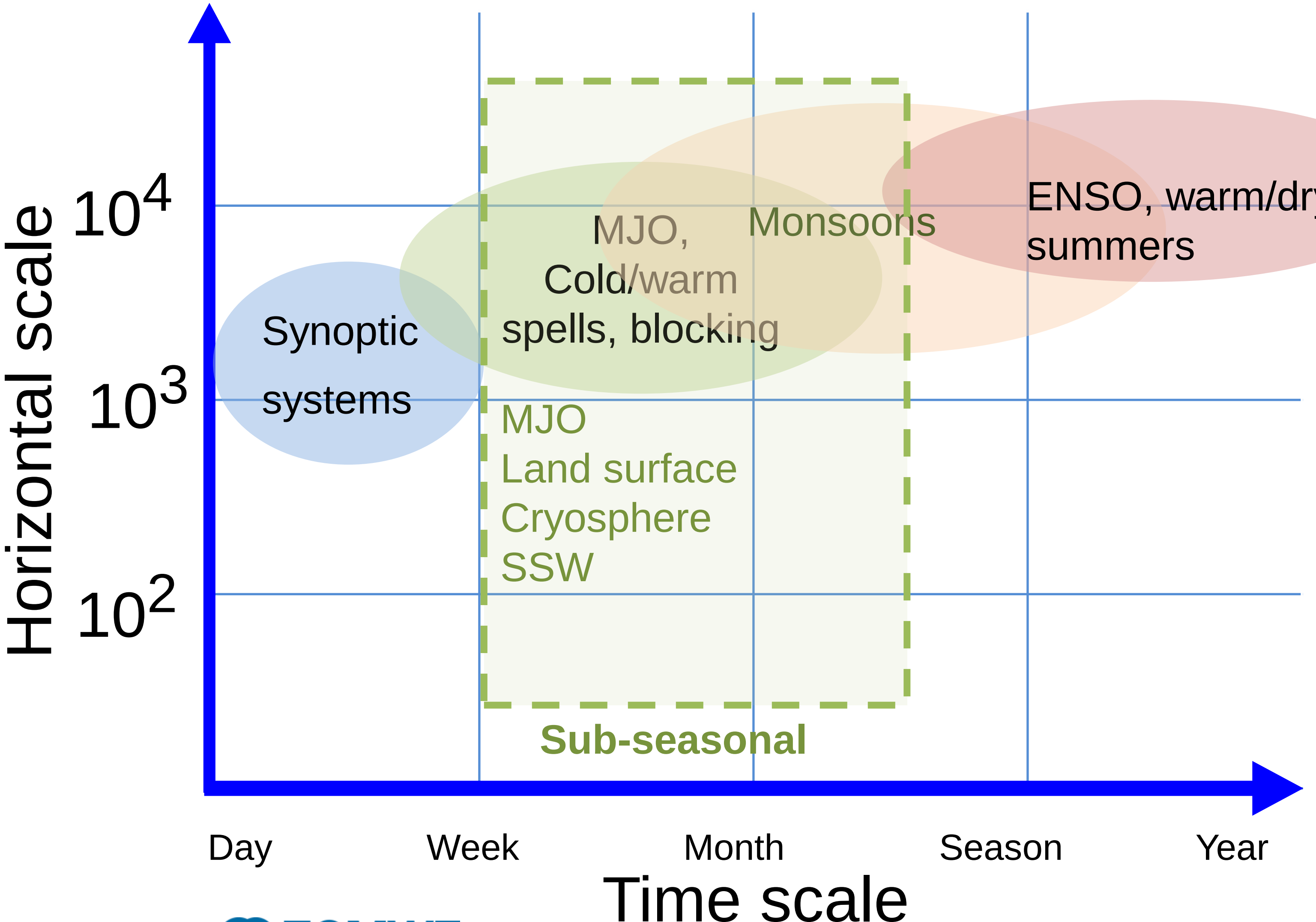
North American Multi-Model Ensemble



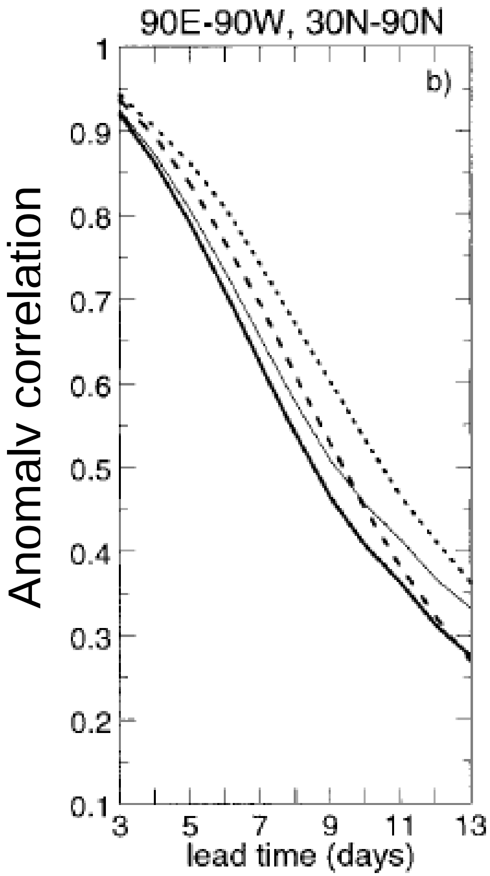


EDIUM-RANGE

Sub-seasonal range :



MJO role in modulating forecast skill over the extra-tropics:



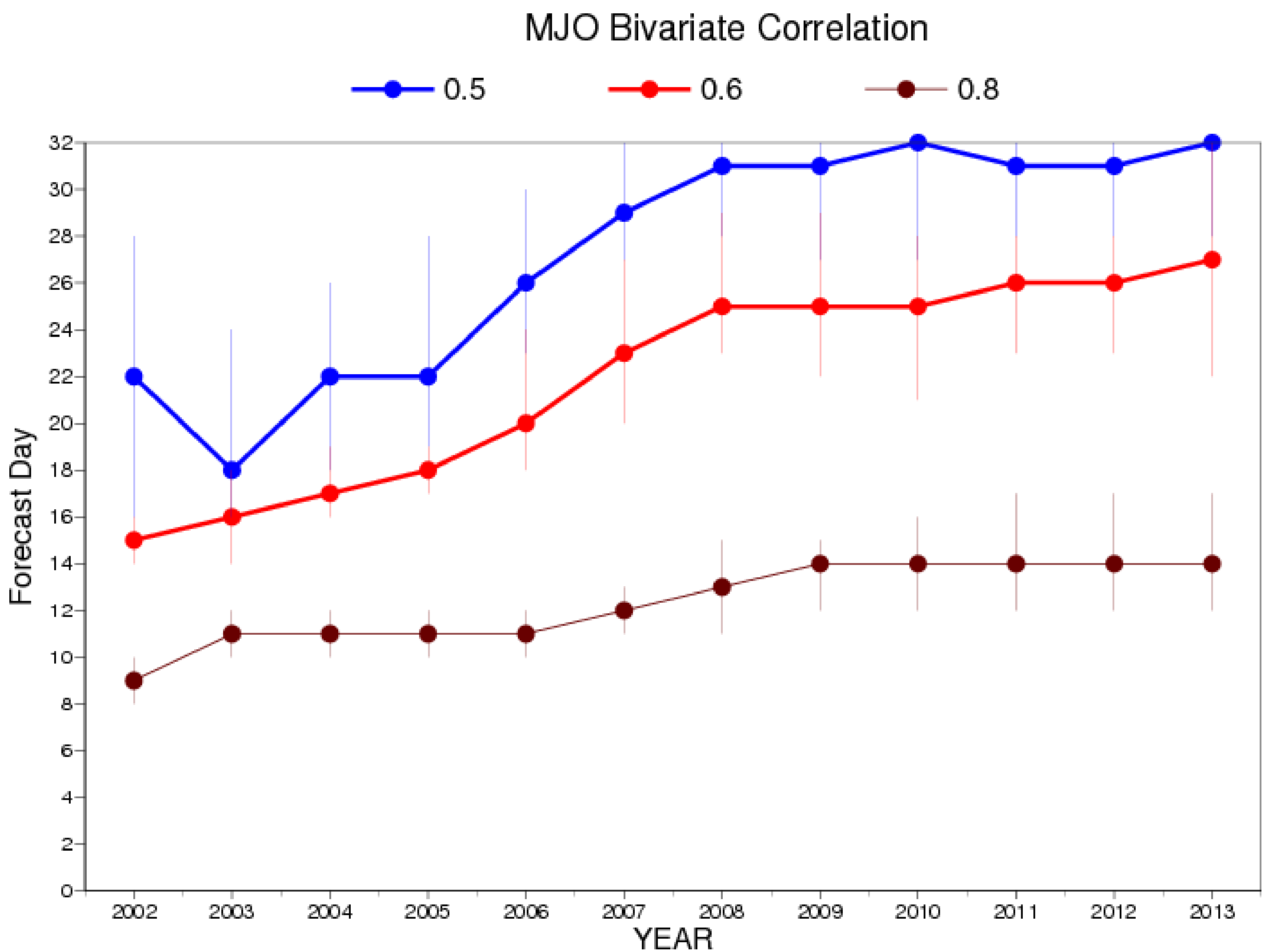
The atmospheric predictability in midlatitudes depends on internal dynamics of midlatitudes variability and modulation by tropical forcing.

Less skill for forecast with an MJO events was attributed to the inability of the model to sustain the MJO beyond 7 days which contributes to erroneous Rossby wave sources.

Reduction of errors in the tropics
Good representation of the MJO
Realistic teleconnections

From Hendon et al. (2000)

MJO skill scores improvement:



Vitart 2012

Sub-seasonal predictions :
Subesasonal to seasonal S2S

S2S (WWRP/THORPEX/ WCRP joint research project)

http://wwww.s2sprediction.net

Bridging the gap between weather and climate

MISSION: to improve forecast skill and understanding on the subseasonal to seasonal timescale, and promote its uptake by operational centres and exploitation by the applications community.

Specific attention will be paid to the risk of extreme weather, including tropical cyclones, droughts, floods, heat waves and the waxing and waning of monsoon precipitation.

MJO predictions from S2S:

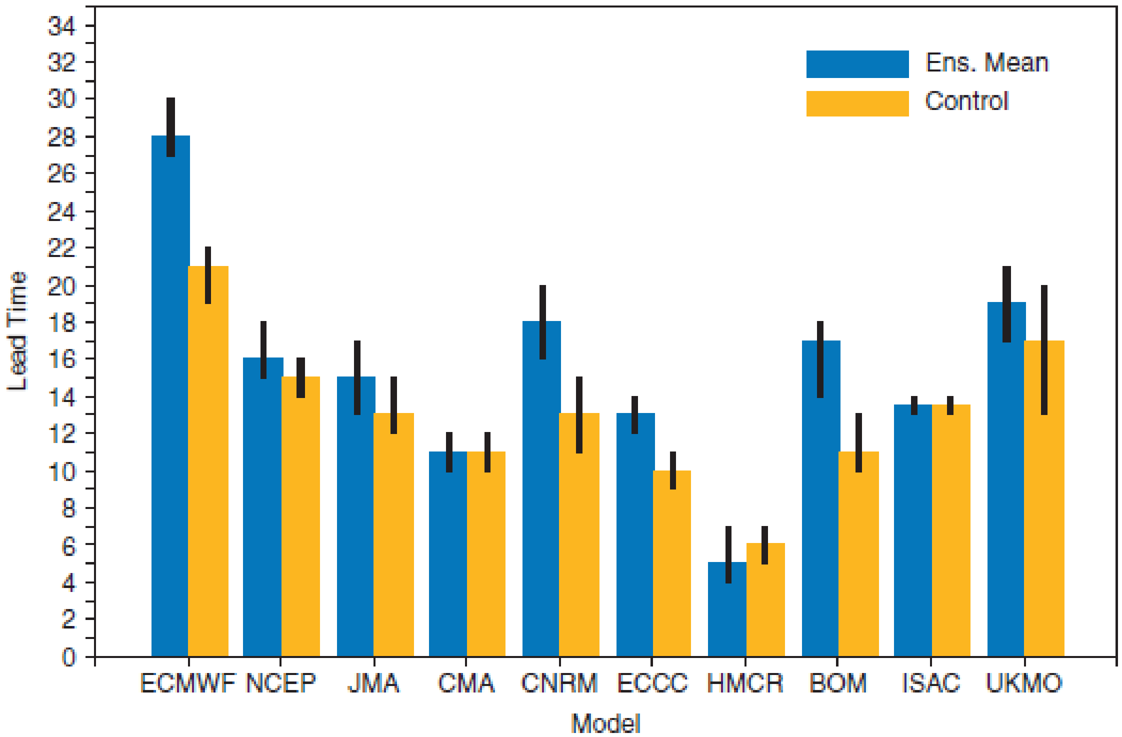


Figure 2. Forecast lead time (in days) when the MJO bivariate correlation between the model ensemble means and control run reaches 0.6. The vertical black bars represent the 95% level of confidence computed from a 10 000 bootstrap re-sampling procedure. [Colour figure can be viewed at wileyonlinelibrary.com].

Vitart 2017 QJRMS

MJO teleconnection from S2S

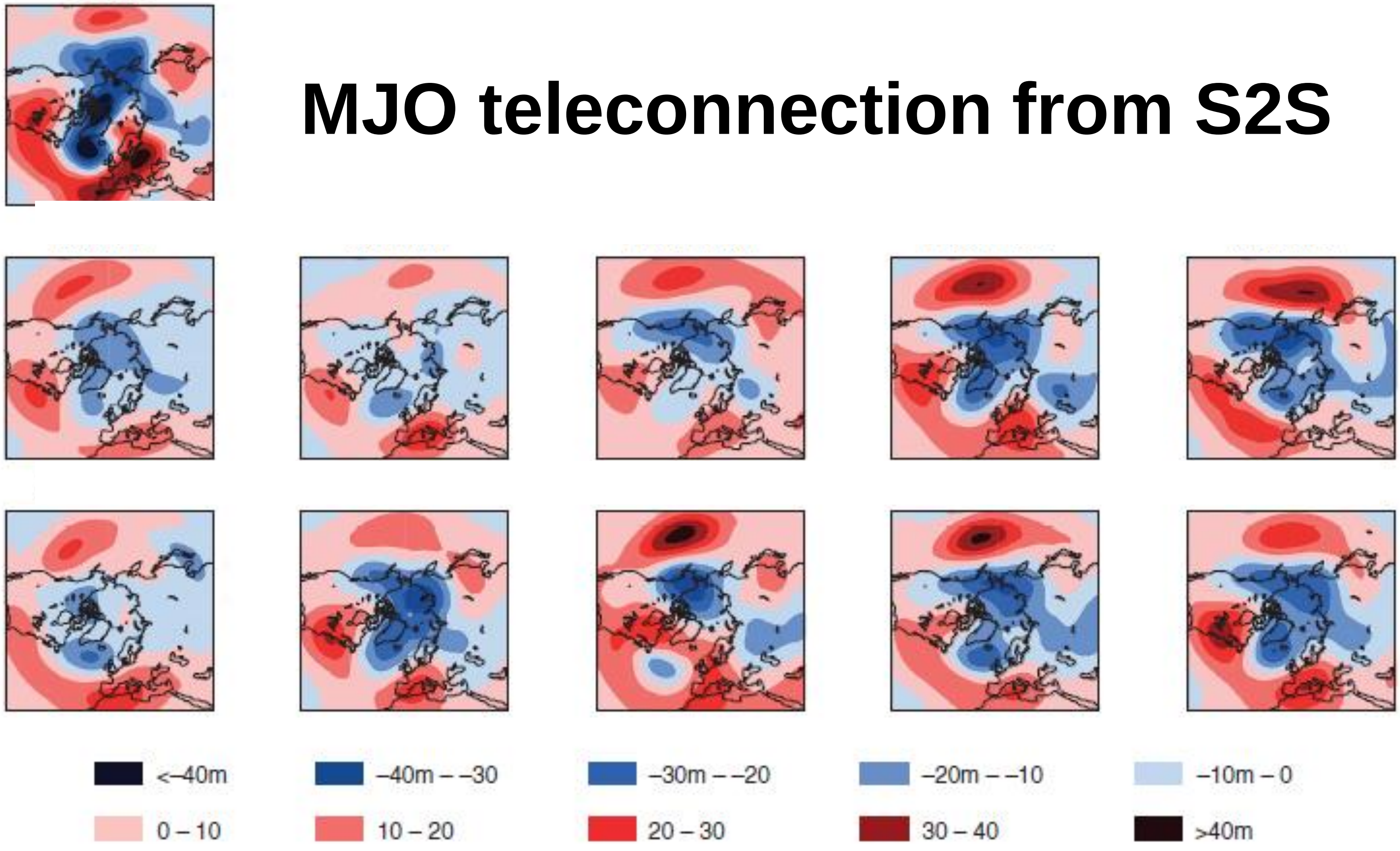


Figure 7. Composites of 500 hPa geopotential height anomalies 11 – 15 days (third pentad) after a strong MJO (amplitude larger than 1) in Phase 3 (active phase of the MJO over the east Indian Ocean). Blue (red) colours indicate negative (positive) anomalies for ERA-Interim (top left panel) and ten S2S models. The composites have been calculated over the common reforecast period 1999 – 2010 (1999 – 2009 for UKMO) for the extended winter period (November – March). All the MJO events present during the first 20 days of model integrations were taken into account to produce the composites.

Vitart 2017

Can we predict, weeks ahead, the changes in large scale flow leading to cold conditions over Europe?

Although forecasts at the extended range are not expected to have skill to predict the day to day variability, they can predict cold/warm spells that persist for longer than a week.

Cold/warm spells are generally associated with persistent high pressure systems (e.g. European Blocking, Greenland Blocking (NAO-)).

Those systems are sometime associated with global teleconnections linked to tropical organized convection (MJO) (Cassou 2005).

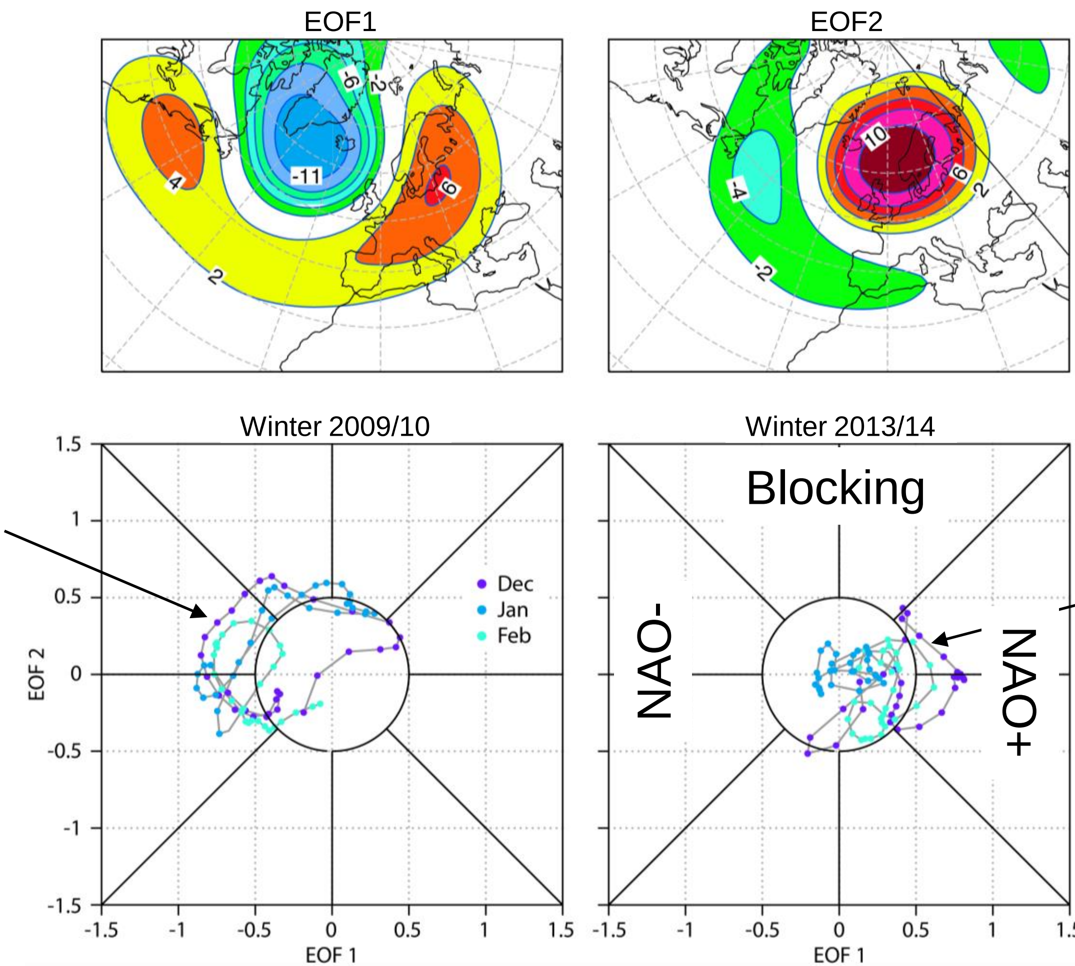
We explore the ability of the S2S systems to predict the winter circulation patterns that are generally associated with cold spells over Europe.

Can we predict weeks ahead the changes in large scale flow leading to severe cold conditions over Europe?

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

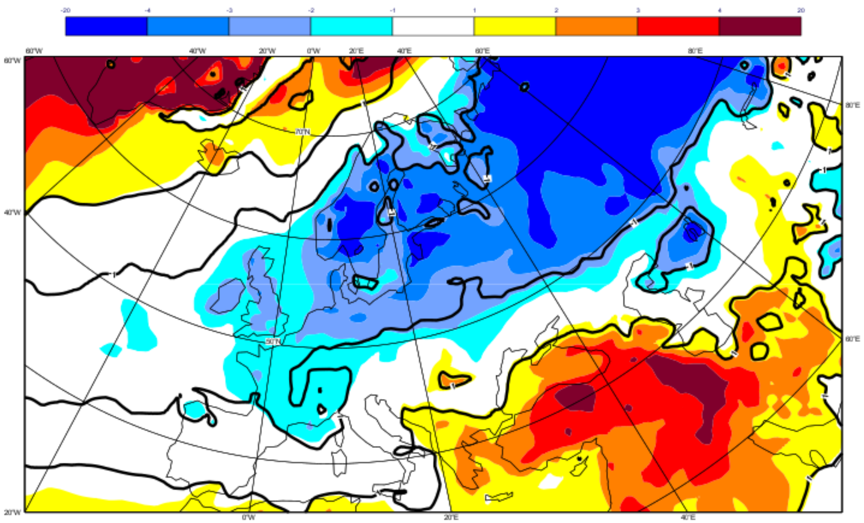


+NAO: exceptional storminess, but mild temperatures over Europe

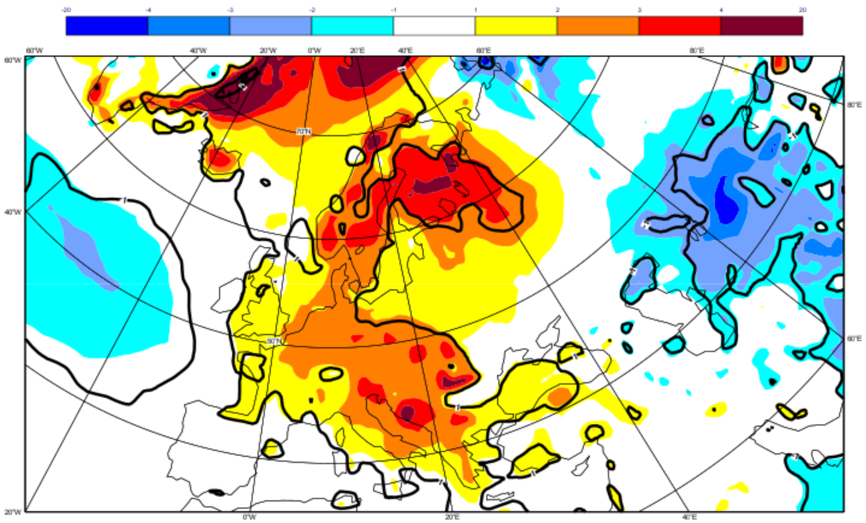
Based on 5-day running means

2m temperature anomalies (era-interim)

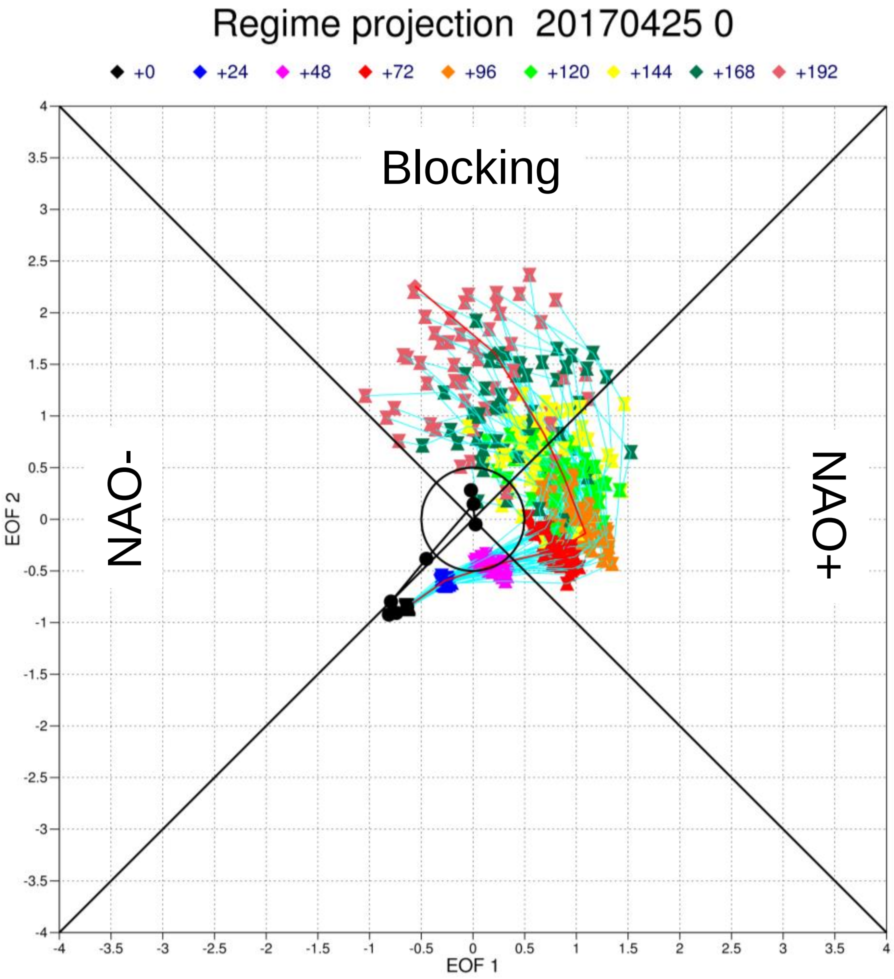
DJF 2009/10

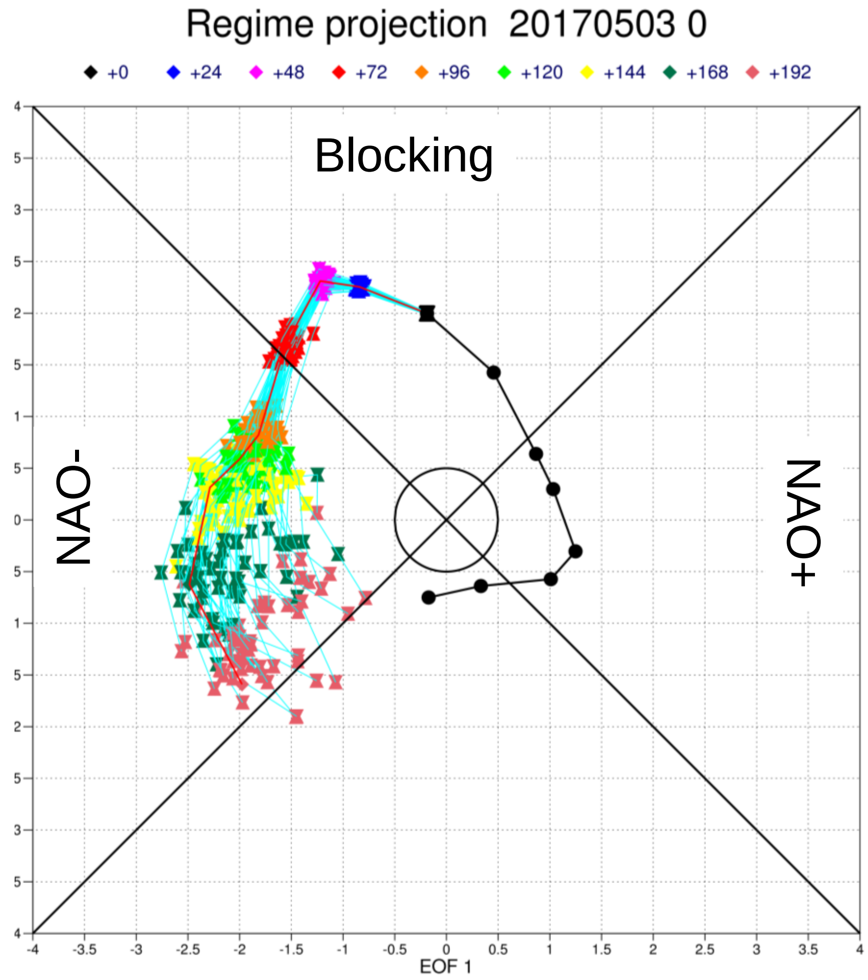


DJF 2013/14

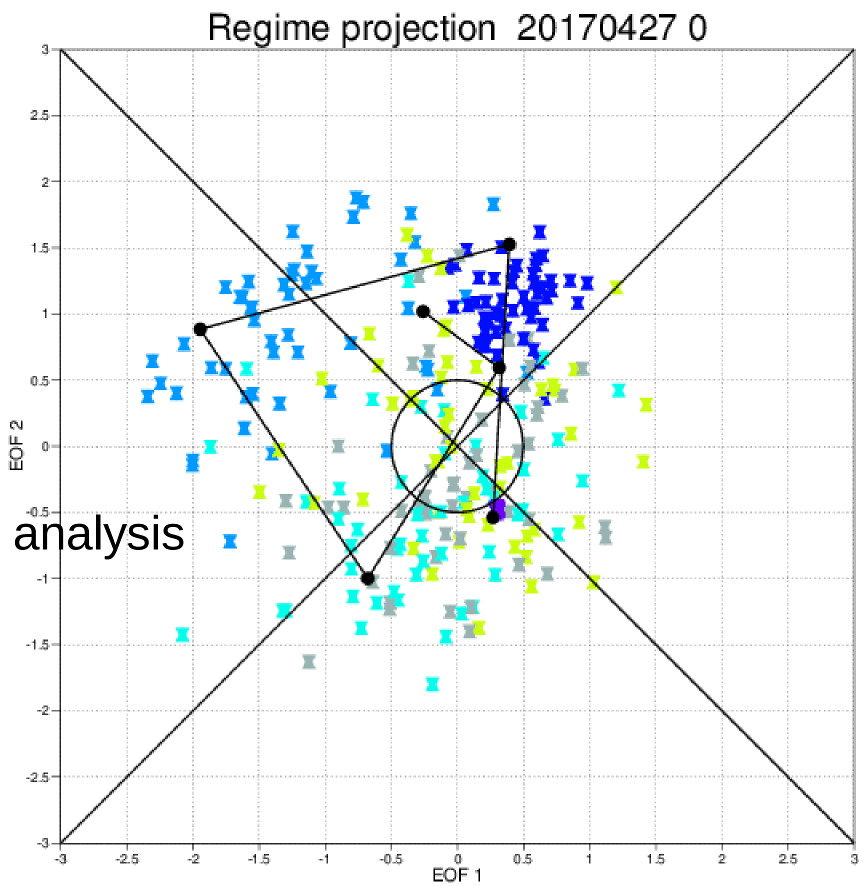


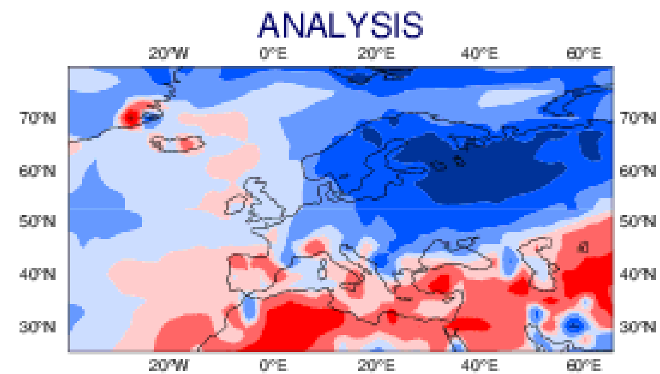
ECMWF ensemble predictions at medium range:

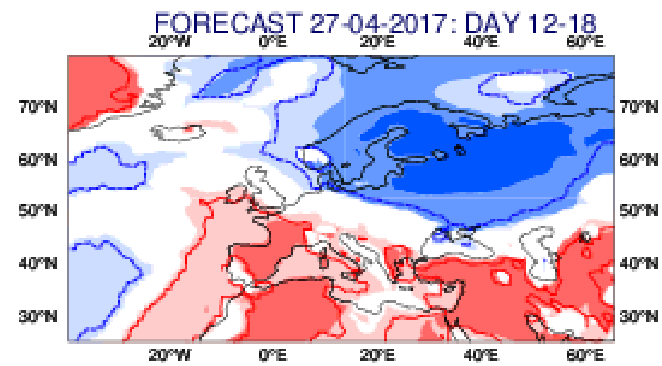




ECMWF Ensemble prediction at subseasonal range:







Verifying analysis

Day 0

Day+5

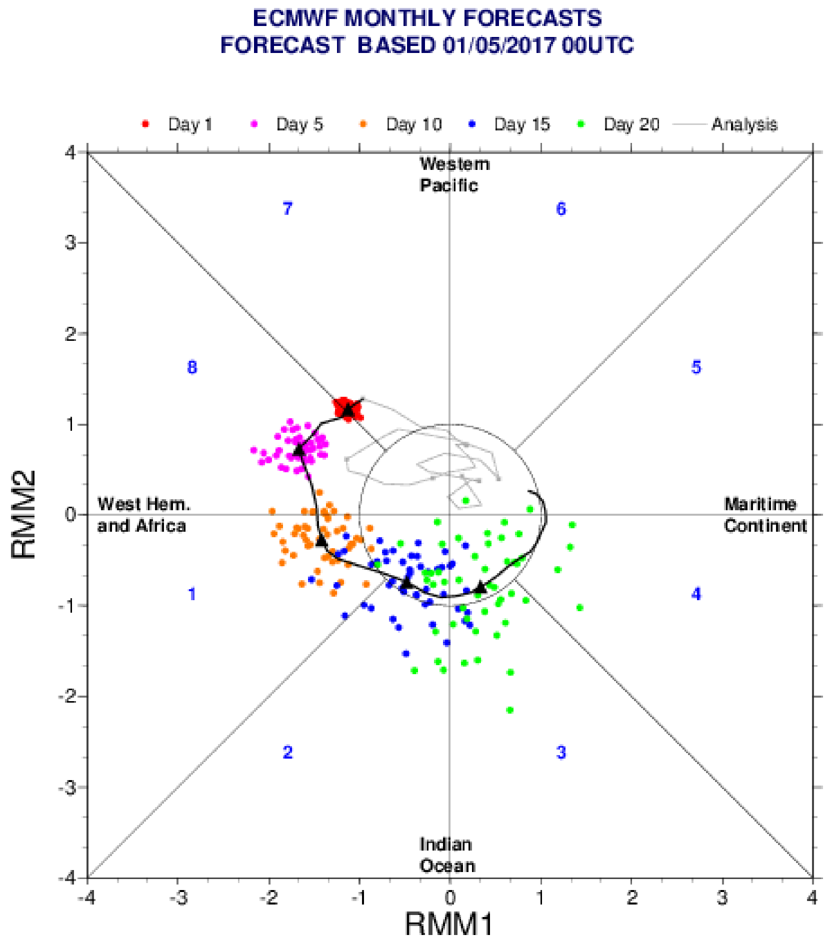
Day+10

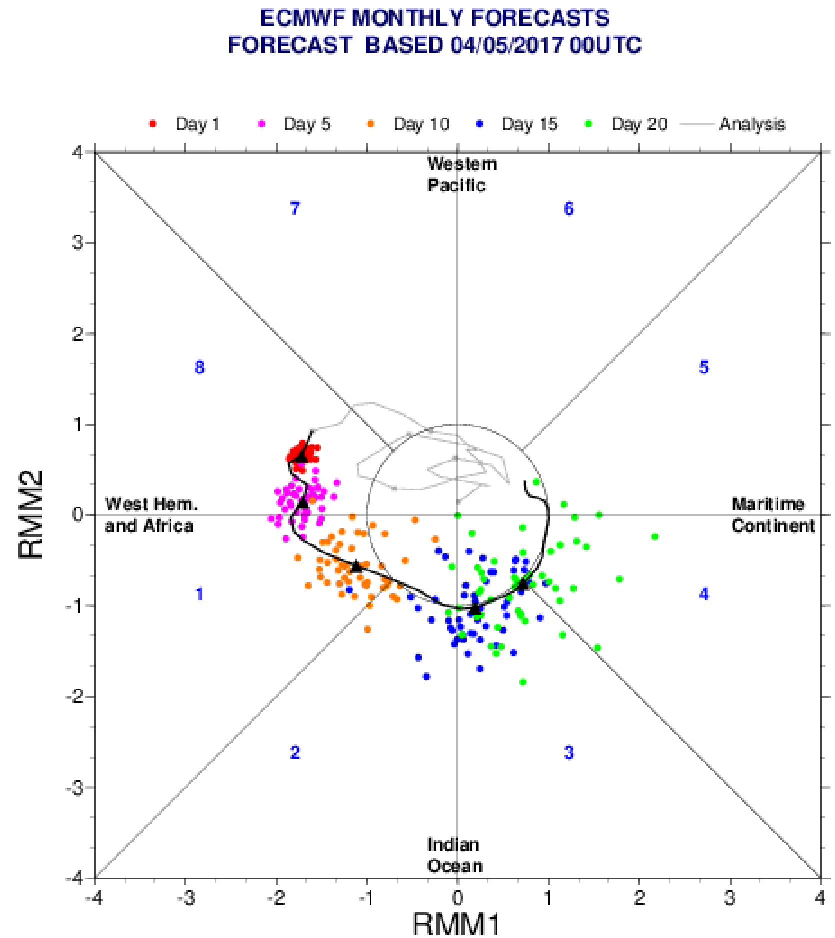
Day+15

Day+20

Day+25

ECMWF


ECMWF MONTHLY FORECASTS
FORECAST BASED 01/05/2017 00UTC
Day 1
Day 5
Day 10
Day 15
Day 20
Analysis
Western Pacific
West Hem. and Africa
Maritime Continent
Indian Ocean
1
2
3
4
5
6
7
8
RMM1
RMM2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8
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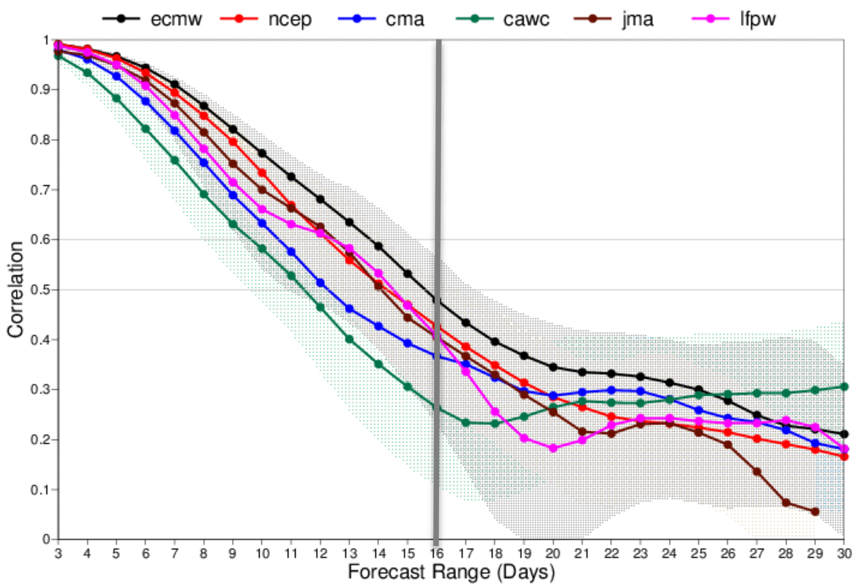
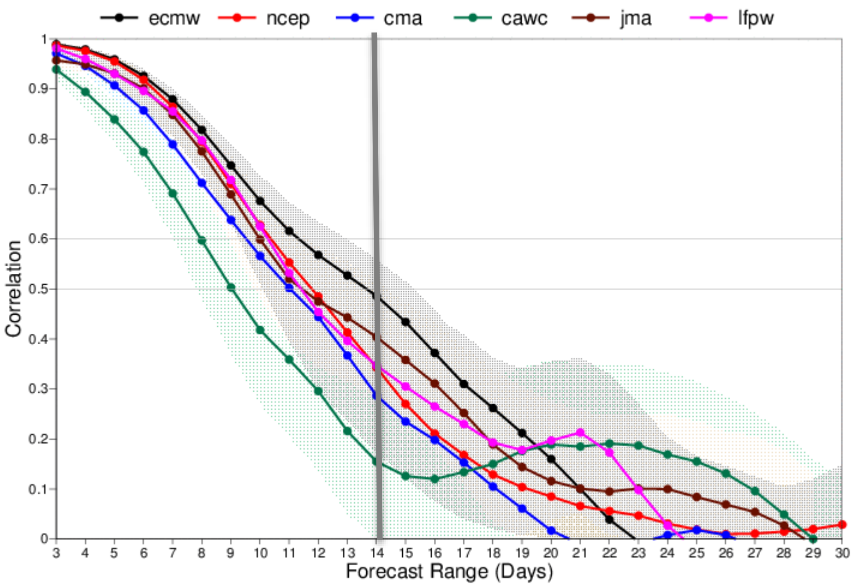
ECMWF

Anomaly correlation

EOF1

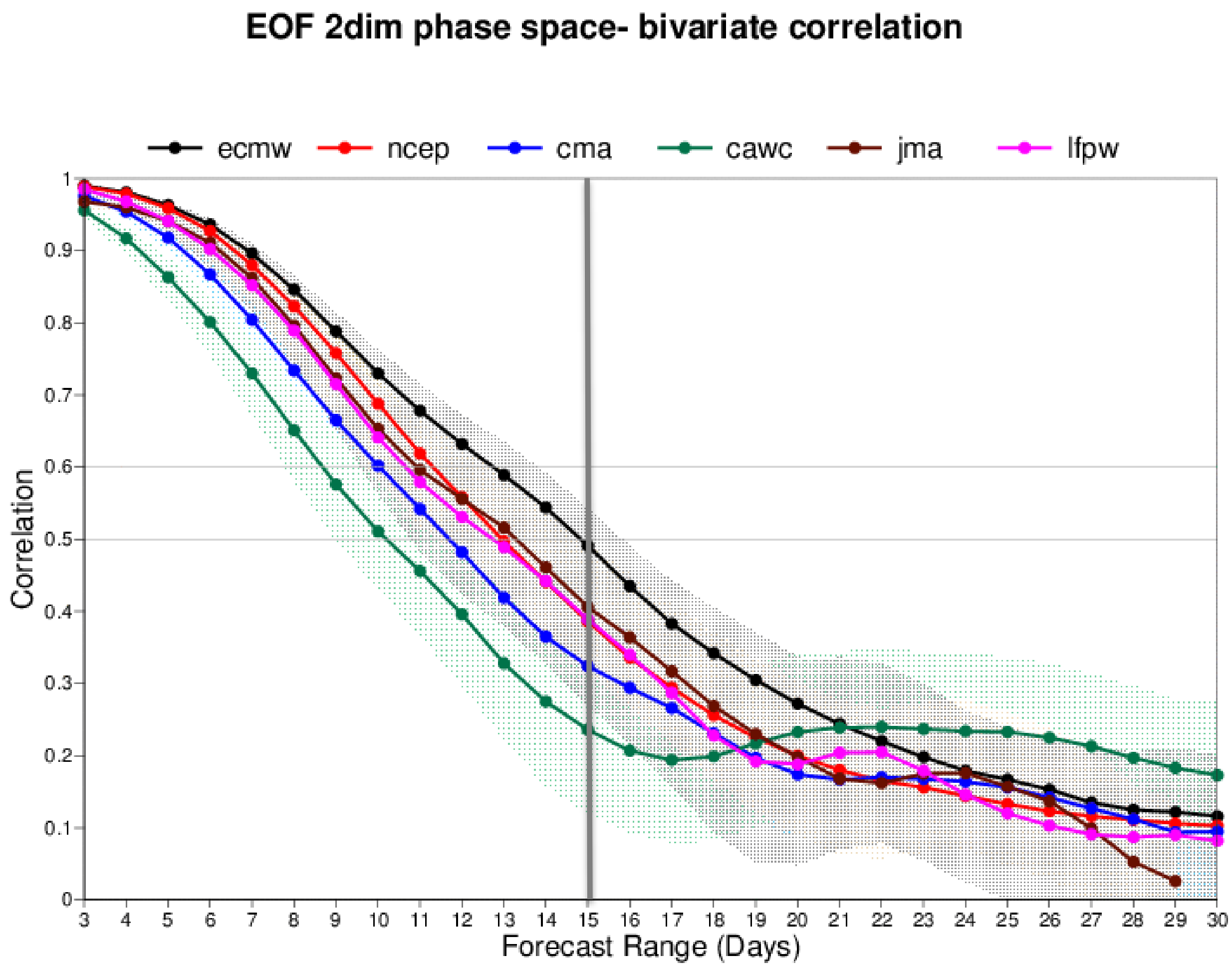


EOF2



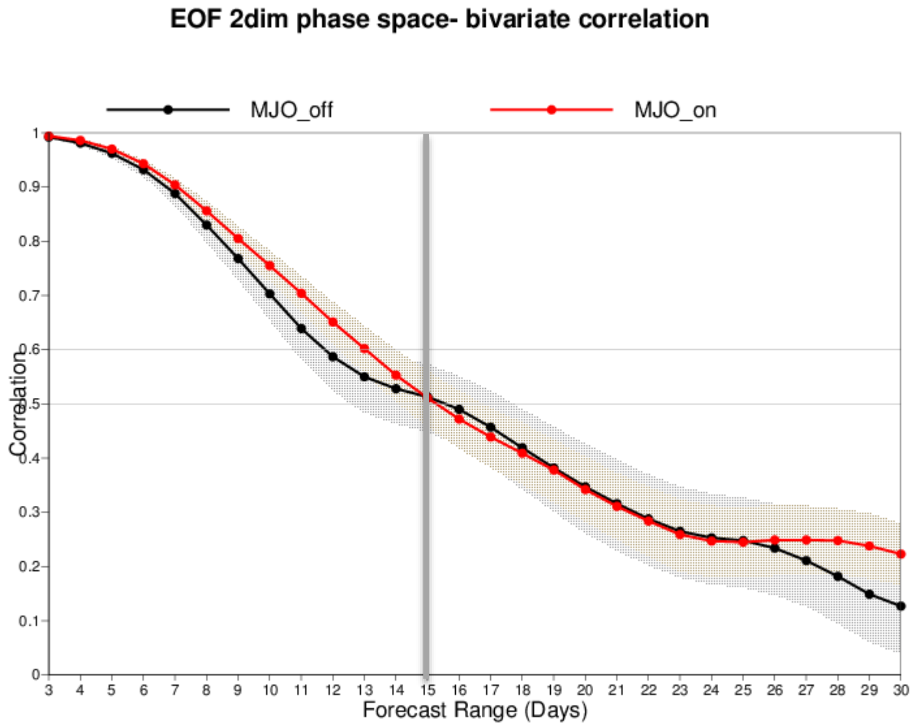
The NAO predictions (EOF1) are skillful up to 16 days ahead
The Blocking predictions (EOF2) up to 14 days

Regime transitions:

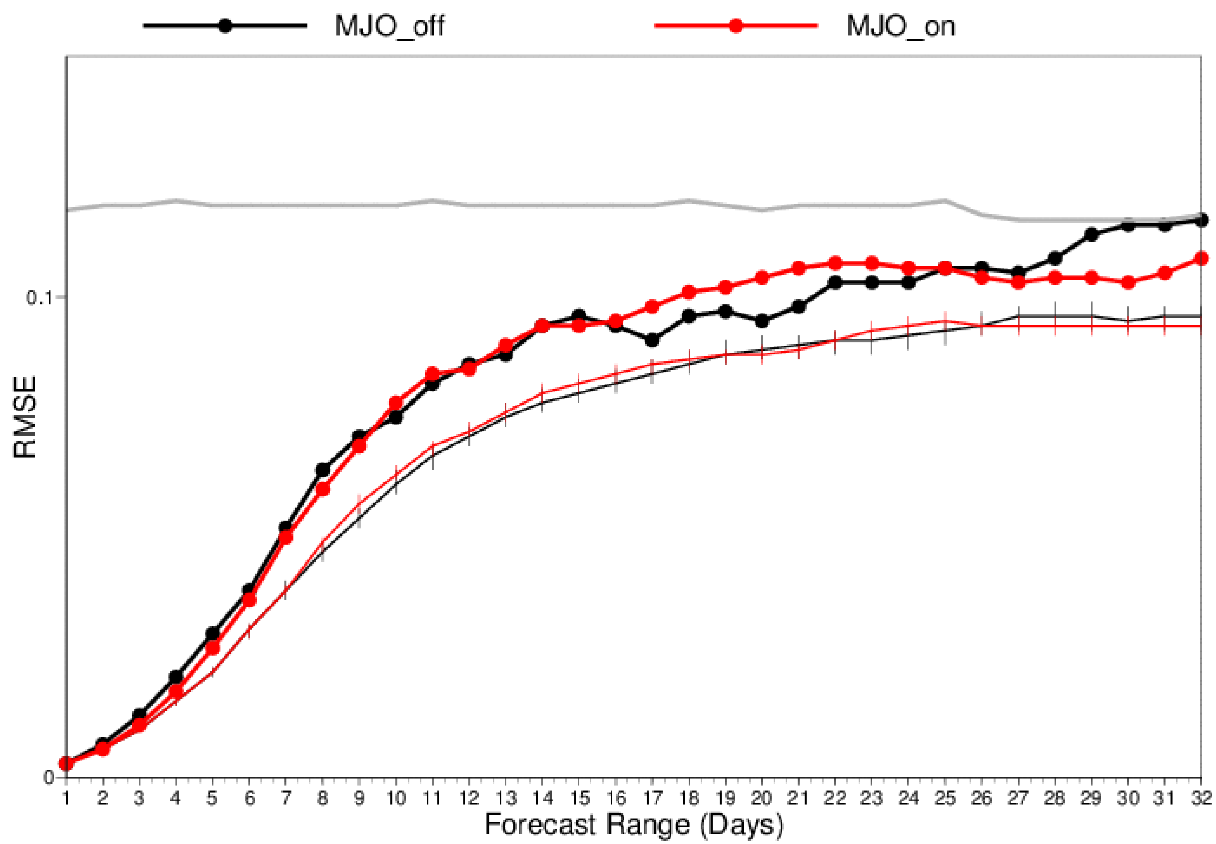


Lin et al. (2008)

Deterministic skill associated with MJO at I.C.



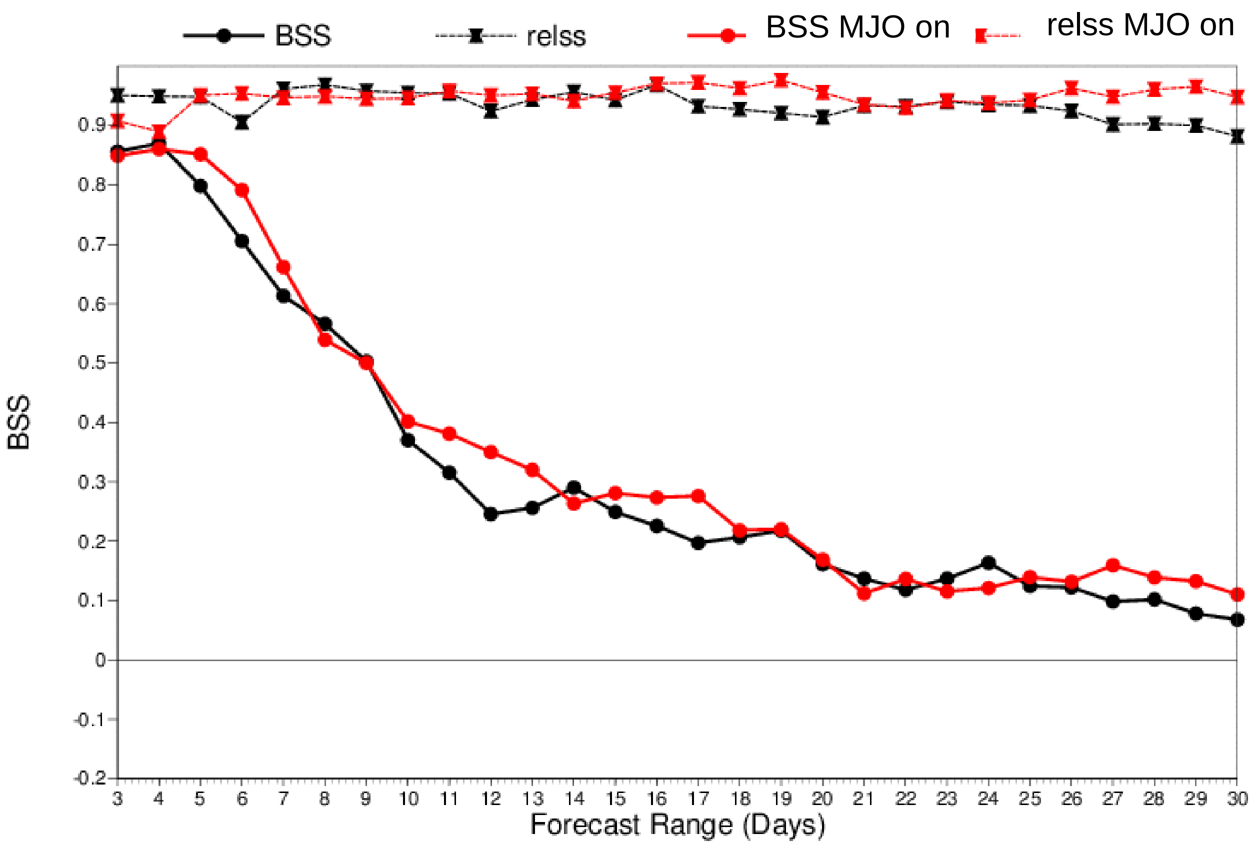
Spread/error for EOF1 (NAO)



ECMWF

Brier Skill Scores associated with MJO at IC :

Positive NAO

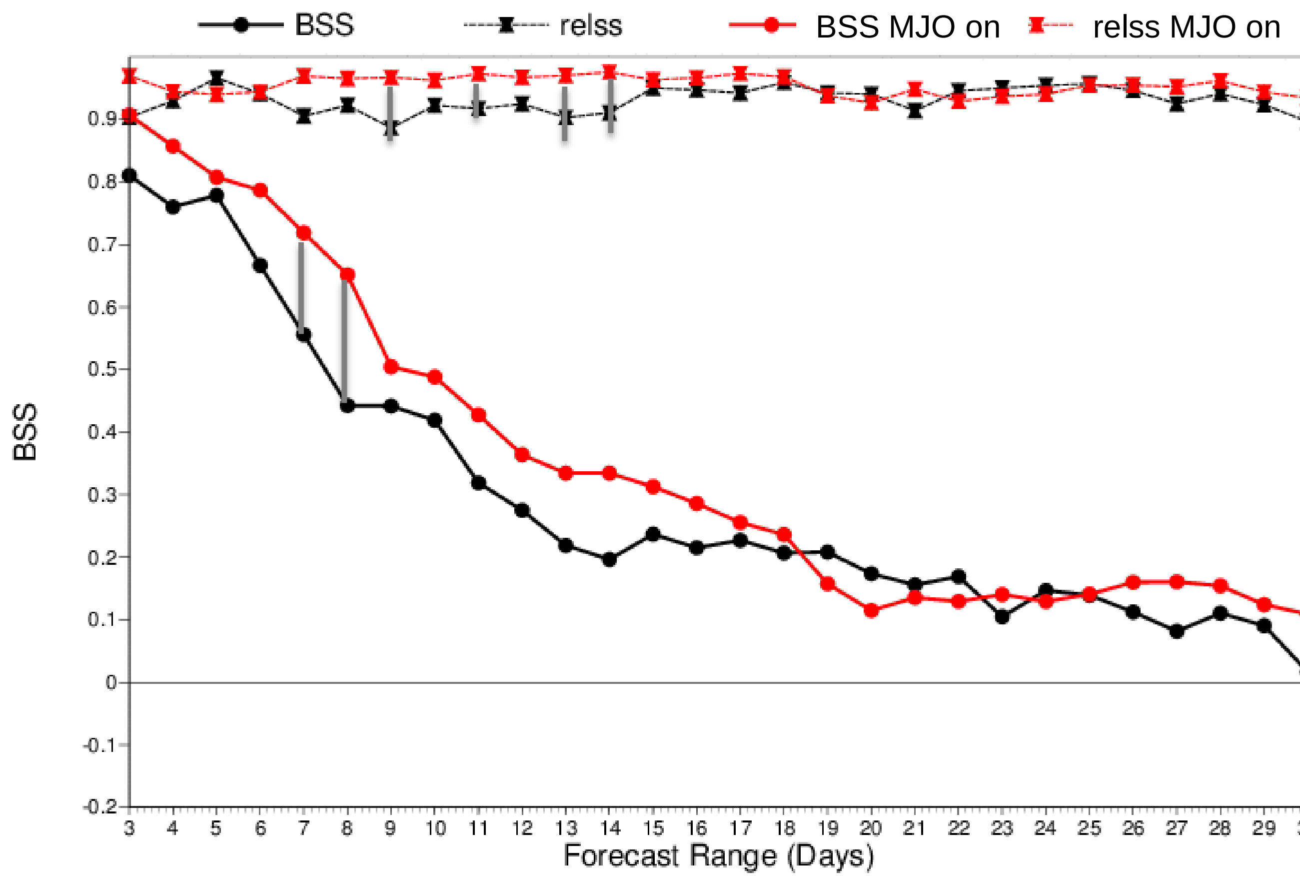


For the NAO+ predictions the skill sensitivity to MJO is small and not significant

ECMWF

Brier Skill Scores associated with MJO at IC :

Negative NAO



Forecasts with MJO in IC show higher skill in predicting NAO- up to day 18

Summary

Multi-model approach is widely used for seasonal predictions.

Despite the possibility of calibrating we aim to improve the reliability of the seasonal ensemble.

Using the S2S archive we can evaluate the skill in predicting regimes and regime transitions, from medium to extended range.

Transitions between regimes associated with high-impact temperature anomalies over Europe are evaluated using a simple 2-dim diagram based on the leading 2 EOFs.

Some S2S systems show skill beyond 10 days.

Forecasts initiated with an MJO show higher skill in predicting NAO- but not in predicting NAO+.

Sub-seasonal predictions : S2S partners

	Time-range	Resol.	Ens. Size	Freq.	Hcsts	Hcst length	Hcst Freq	Hcst Size
ECMWF	D 0-46	T639/319L91	51	2/week	On the fly	Past 20y	2/weekly	11
UKMO	D 0-60	N216L85	4	daily	On the fly	1996-2009	4/month	3
NCEP	D 0-44	N126L64	4	4/daily	Fix	1999-2010	4/daily	1
EC	D 0-32	0.6x0.6L40	21	weekly	On the fly	1995-2014	weekly	4
CAWCR	D 0-60	T47L17	33	weekly	Fix	1981-2013	6/month	33
JMA	D 0-34	T319L60	25	2/weekly	Fix	1981-2010	3/month	5
KMA	D 0-60	N216L85	4	daily	On the fly	1996-2009	4/month	3
CMA	D 0-45	T106L40	4	daily	Fix	1886-2014	daily	4
CNRM	D 0-32	T255L91	51	Weekly	Fix	1993-2014	2/monthly	15
CNR-ISAC	D 0-32	0.75x0.56 L54	40	weekly	Fix	1981-2010	6/month	1
HMCR	D 0-63	1.1x1.4 L28	20	weekly	Fix	1981-2010	weekly	10