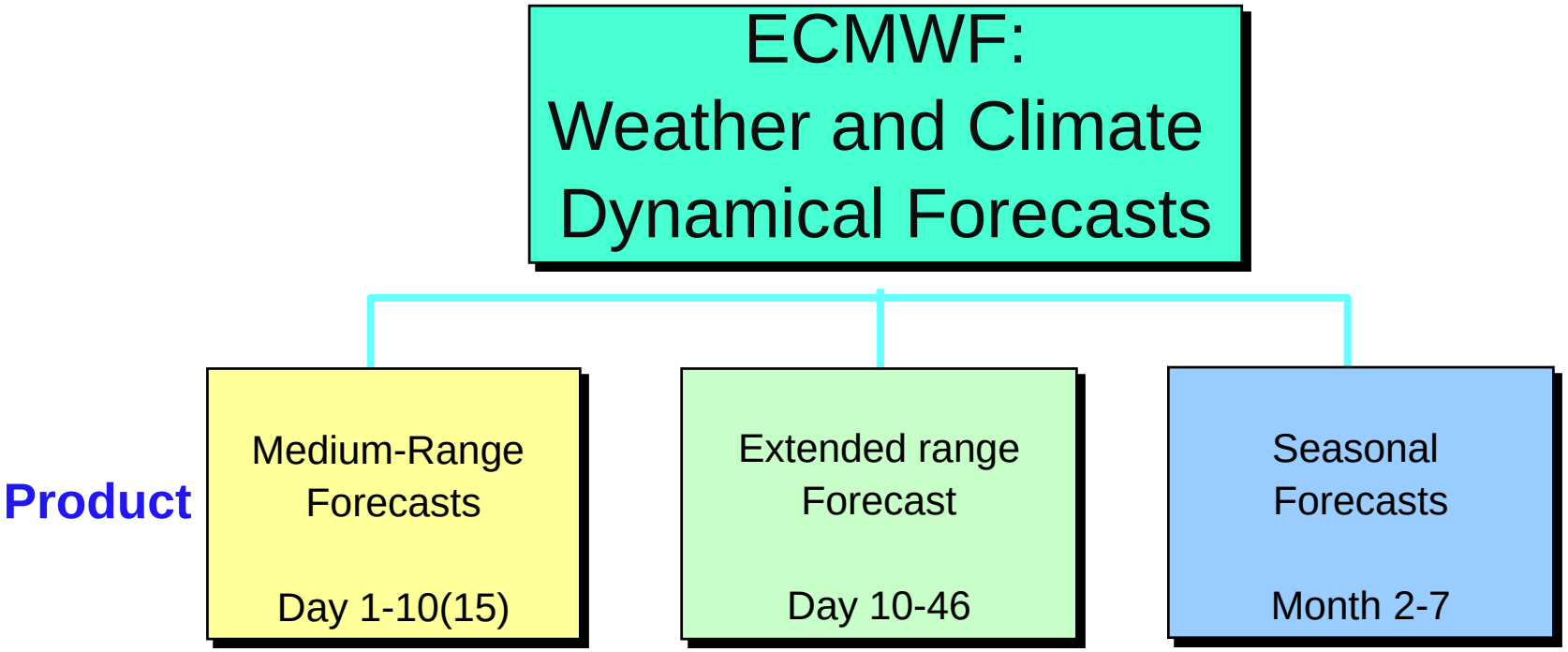
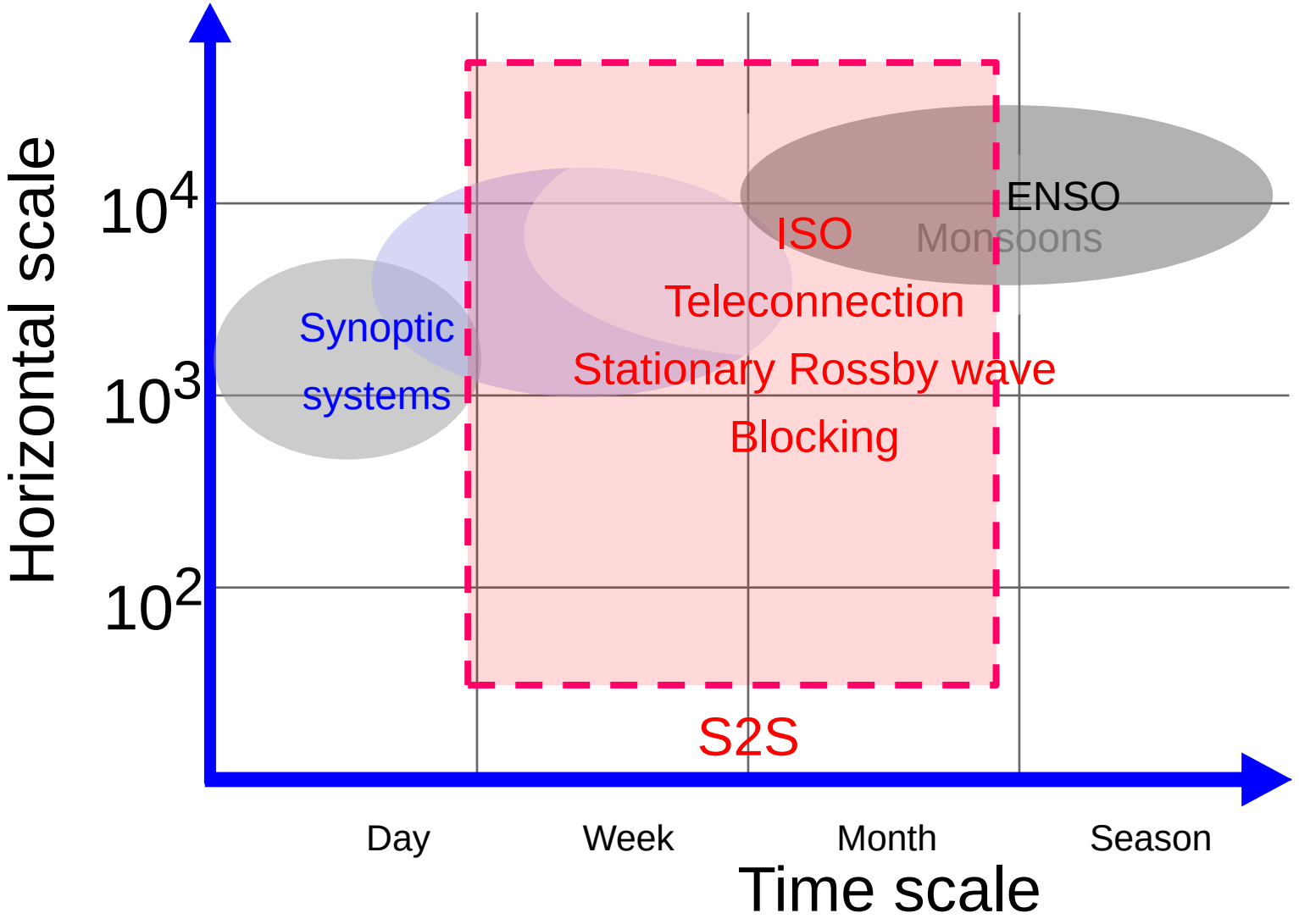
The Monthly Forecast system at ECMWF

Frédéric Vitart

European Centre for Medium-Range Weather Forecasts

Forecasting systems at ECMWF




Horizontal scale
10^4
10^3
10^2
Synoptic systems
ISO
Monsoons
ENSO
Teleconnection
Stationary Rossby wave
Blocking
S2S
Day
Week
Month
Season
Time scale

Index

Use of monthly forecasts in applications

Main sources of predictability on the monthly time-scale

- *Madden Julian Oscillation*
- Soil Moisture
- Stratospheric Initial conditions
- Rossby waves

The ECMWF extended range forecast system

- Description
- Some examples of forecasts
- Skill

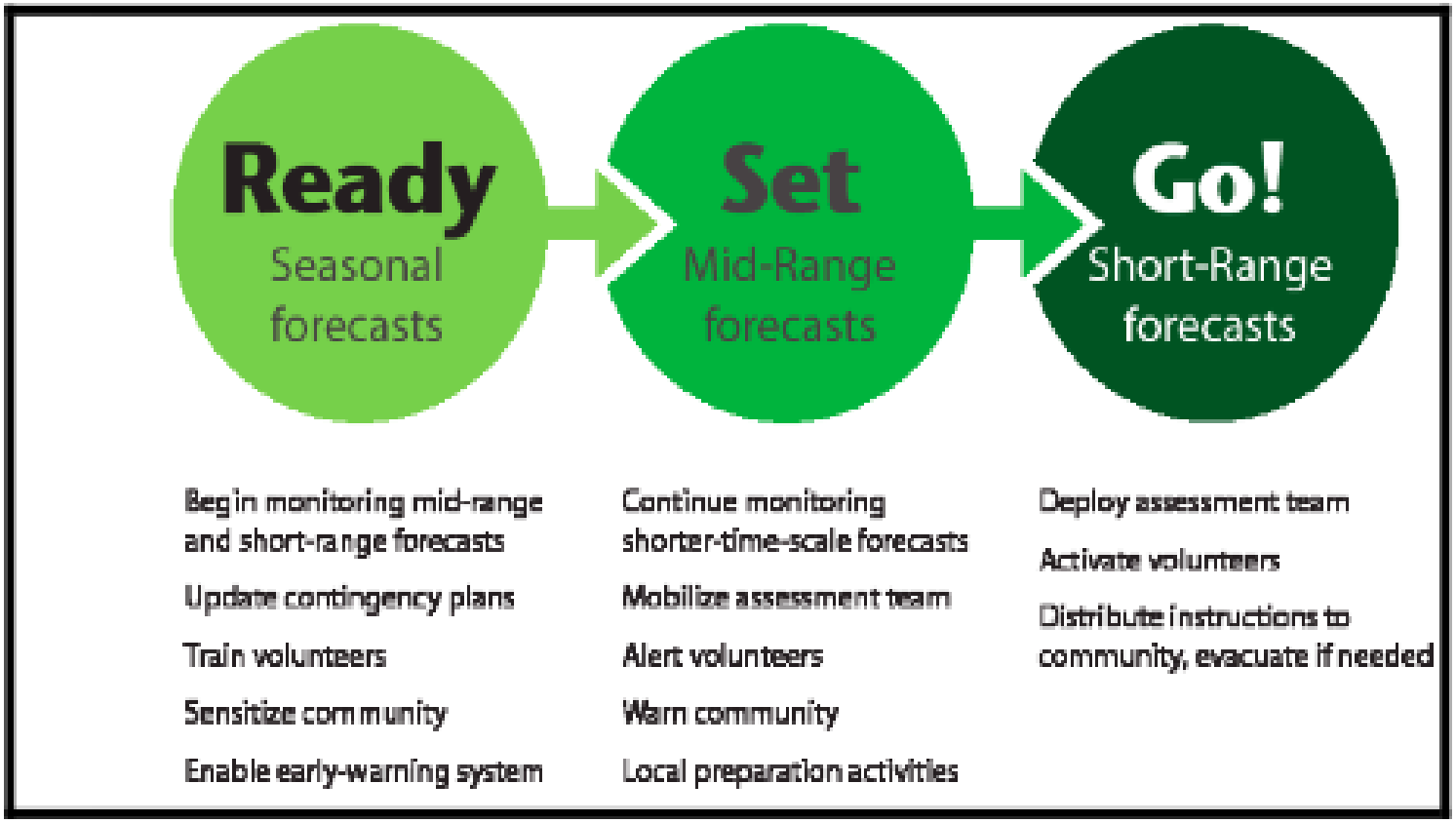
S2S database

Use of sub-seasonal forecasts in applications

Growing, and urgent, requirement for the employment of sub-seasonal predictions for a wide range of societal and economic applications which include:

- Warnings of the likelihood of severe high impact weather (droughts, flooding, wind storms etc.) to help protect life and property
- Humanitarian Planning and Response to disasters
- Agriculture particularly in developing countries — e.g. wheat and rice production
- Disease planning/control — e.g. malaria, dengue and meningitis
- River-flow — for flood prediction, hydroelectric power generation and reservoir management for example

Opportunity to use information on *multiple* time scales



Red Cross - IRI example

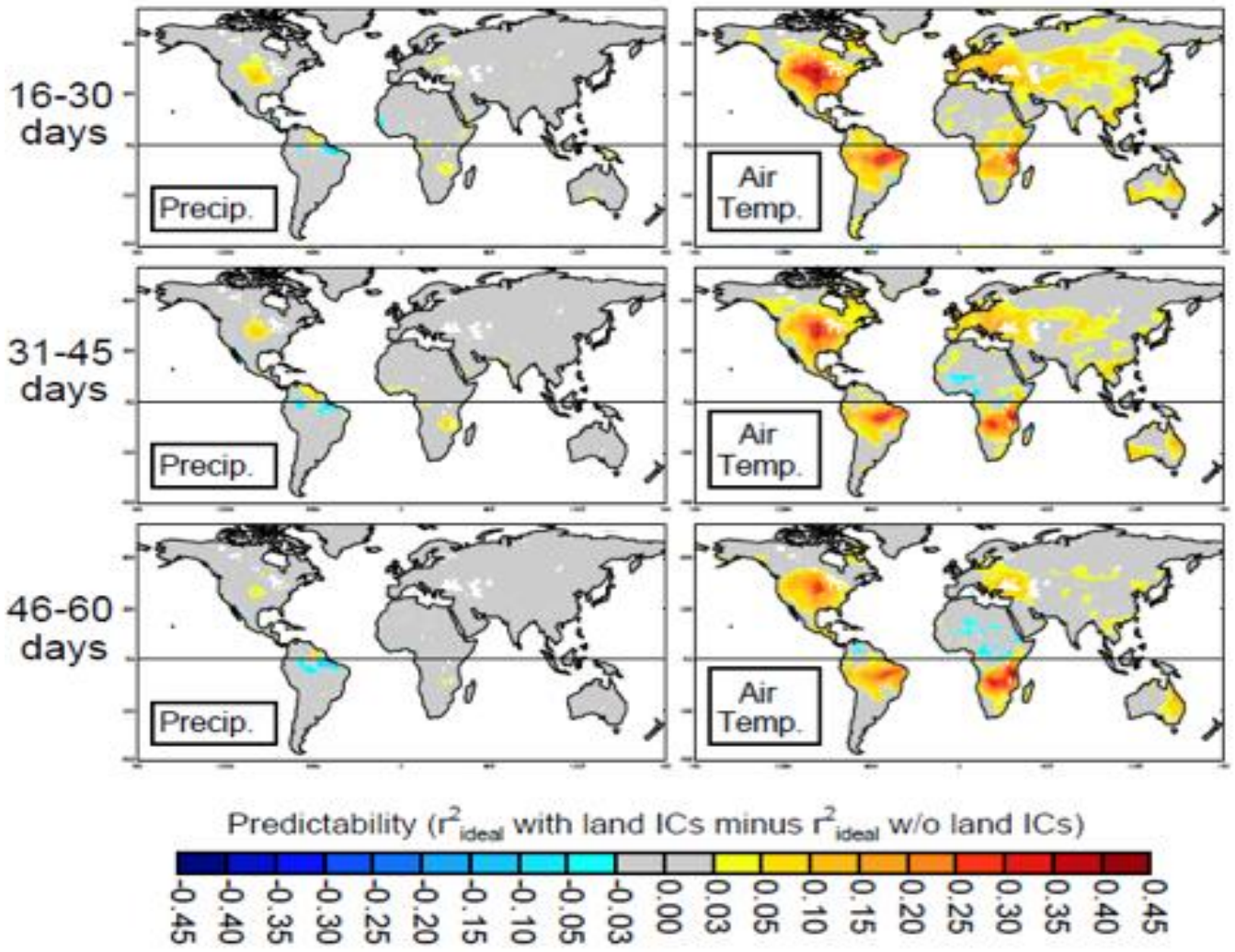
Bridging the gap between Climate and weather prediction

A particularly difficult time range: Is it an atmospheric initial condition problem as medium-range forecasting or is it a boundary condition problem as seasonal forecasting? “Predictability Desert” (D. Burridge)

Some sources of predictability :

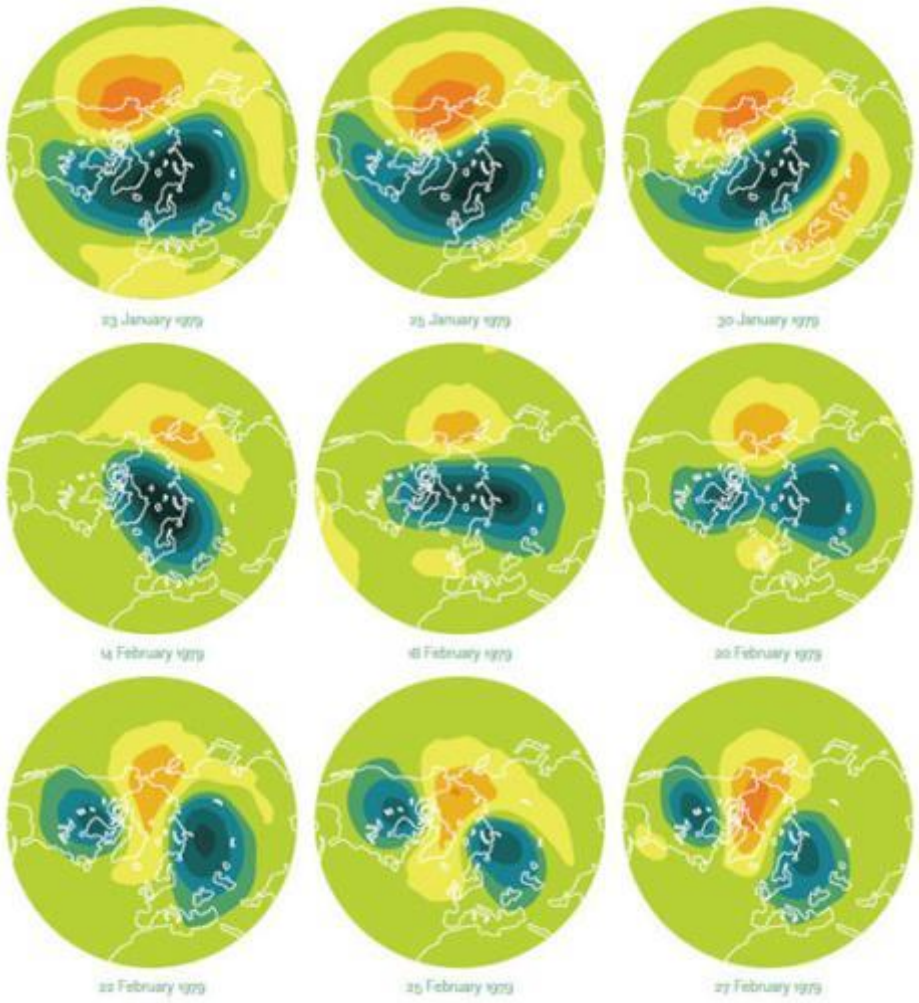
- Sea surface temperatures
- Land surface conditions: snow-soil moisture
- The Madden Julian Oscillation
- Stratospheric variability
- Atmospheric dynamical processes
  (Rossby wave propagations, weather regimes…)
- Sea ice cover –thickness ?

Impact of soil moisture



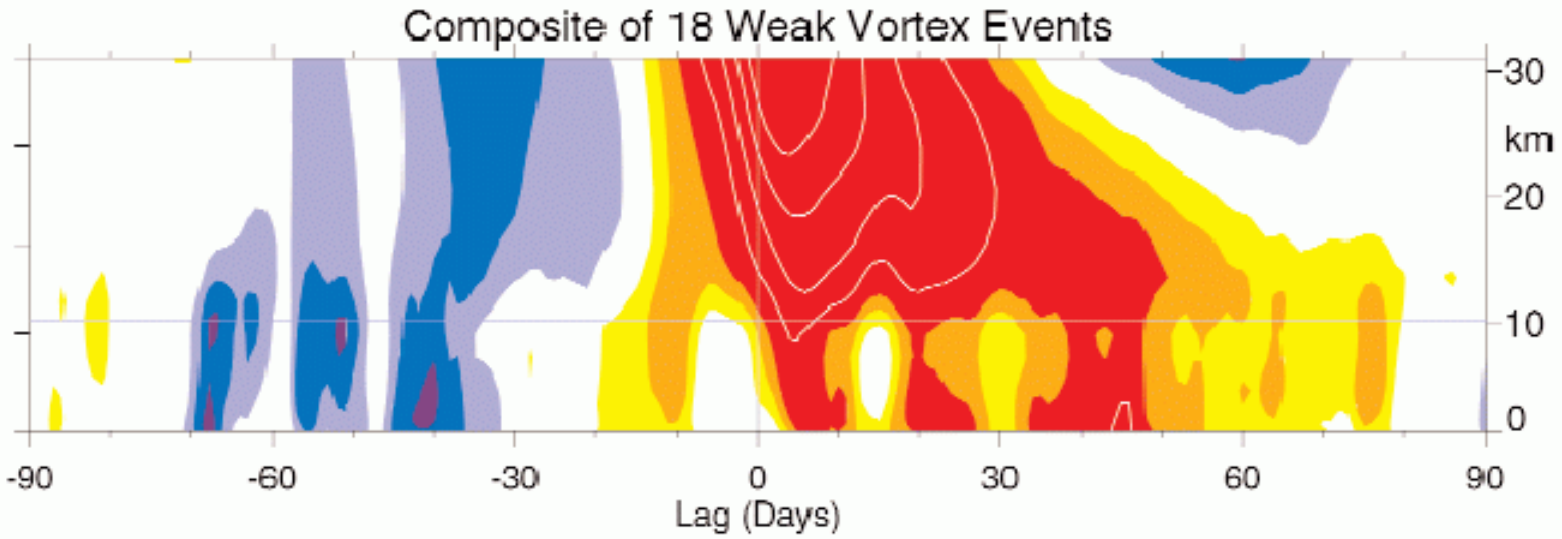
Koster et al, GRL 2011

Sudden Stratospheric Warmings



Chui and Kunz, 2009

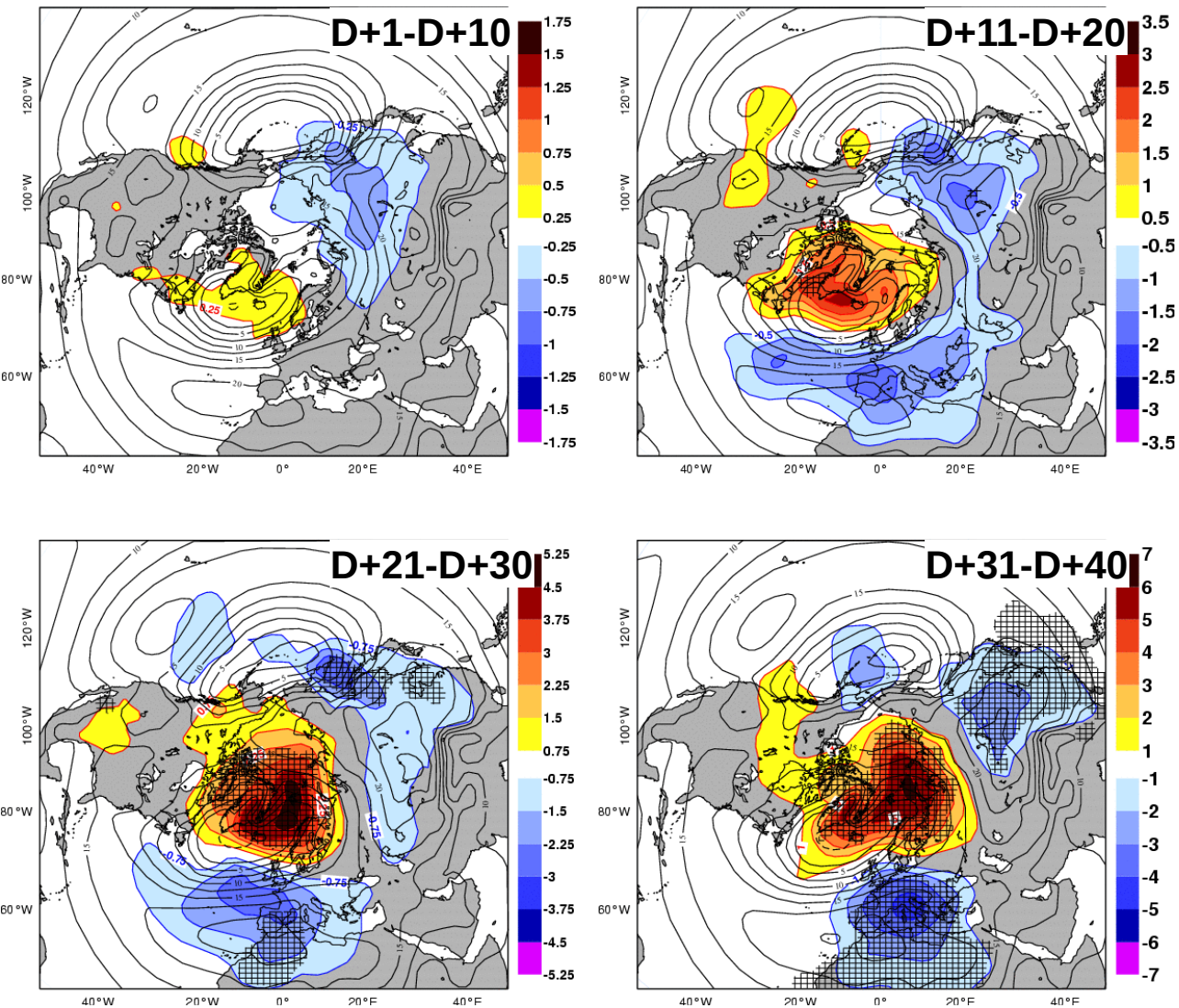
Stratospheric influence on the troposphere?



Weather from above. A weakening stratospheric vortex (red) can alter circulation down to the surface, bringing storms and cold weather farther south than usual.

Baldwin and Dunkerton, 2001

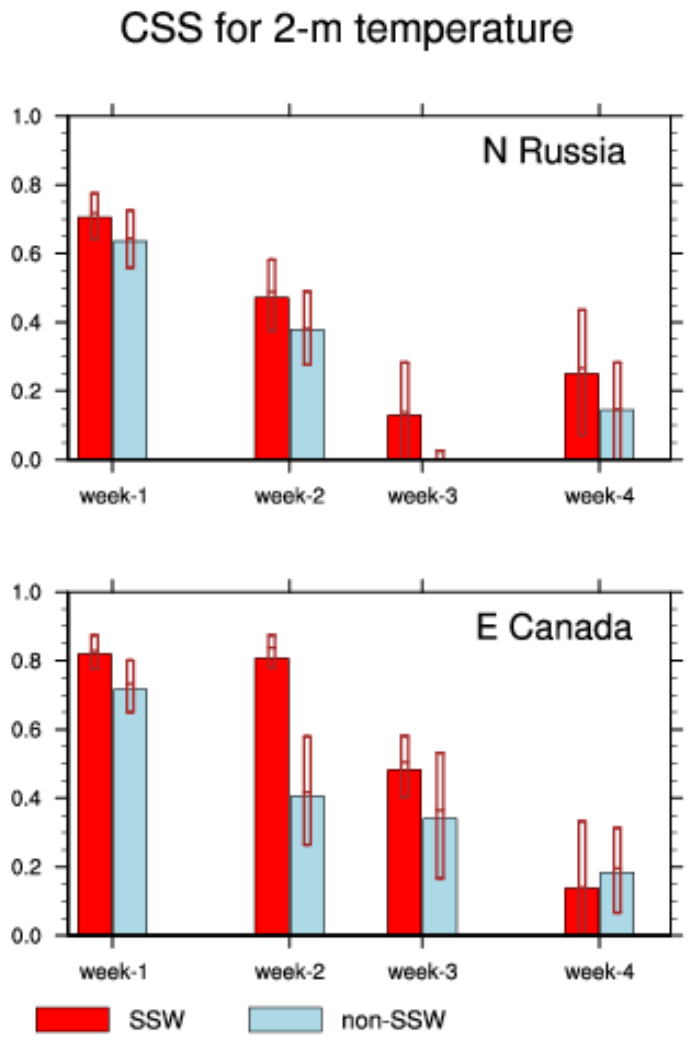
Stratospheric influence on the troposphere?



Z1000 Response (Weak vortex-CTL)

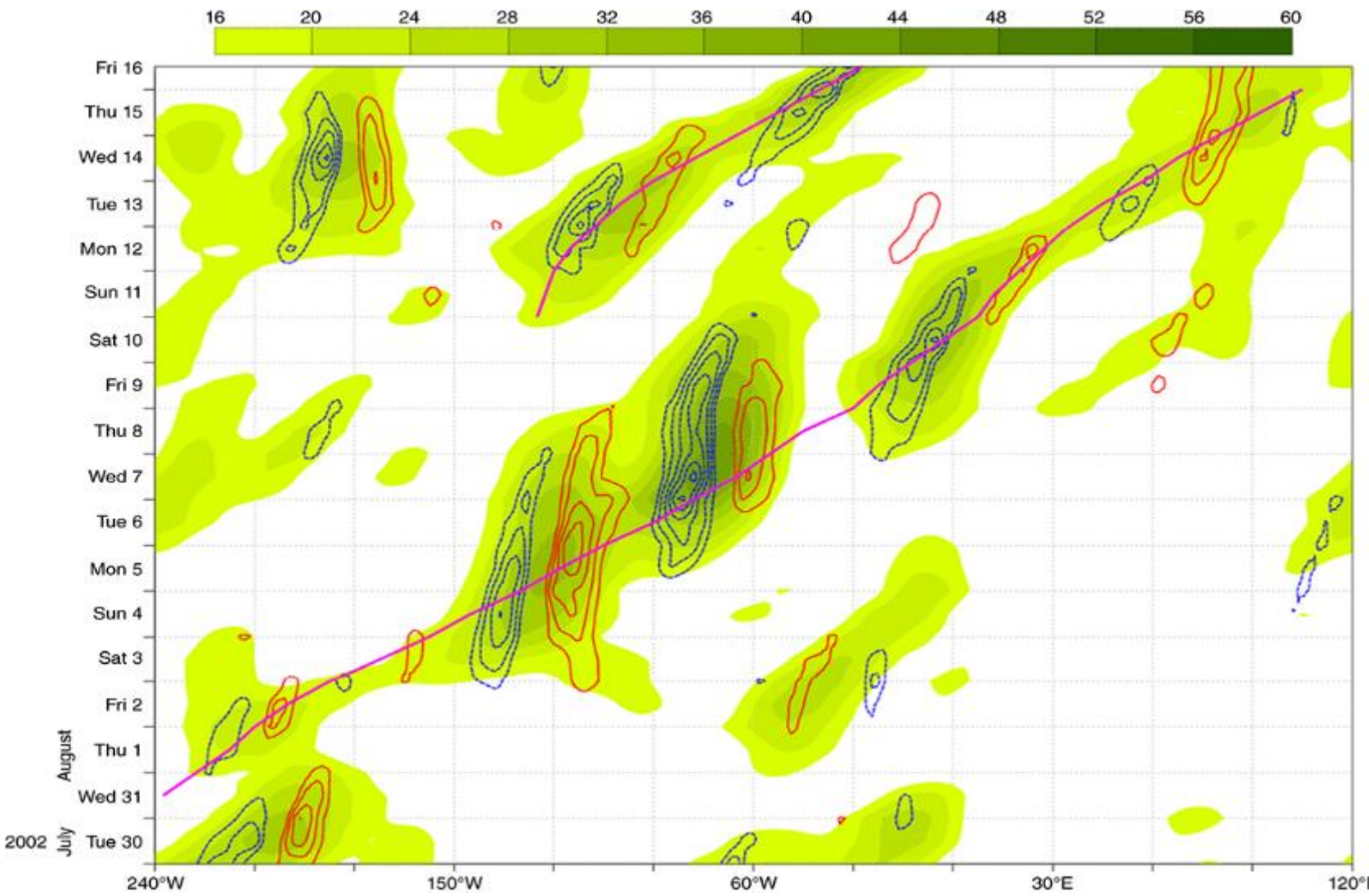
From T. Jung et al 2005

Impact of SSWs on skill scores

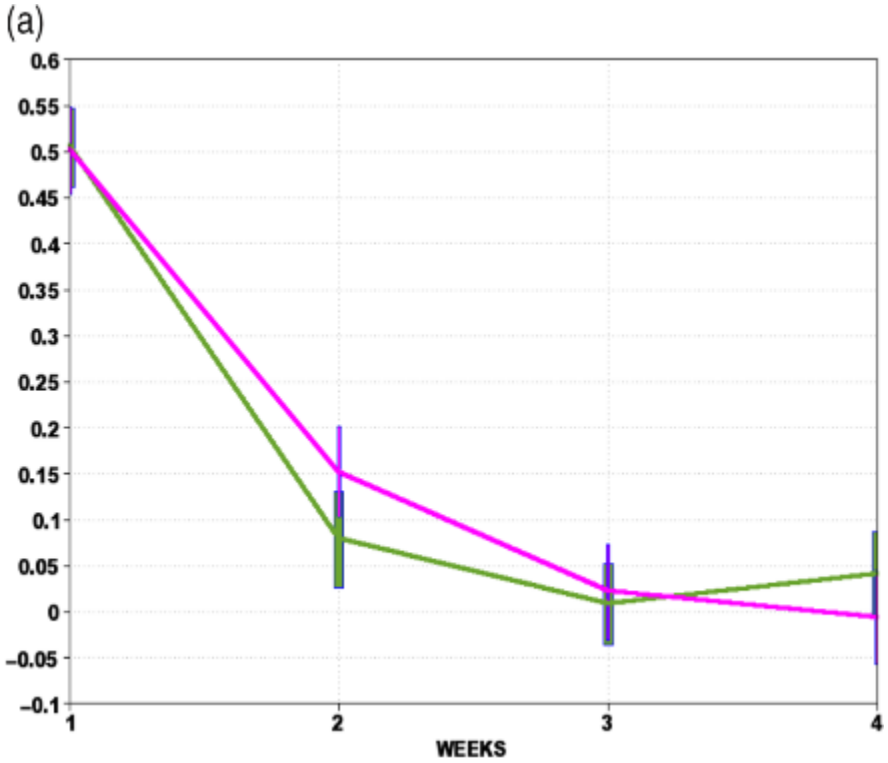


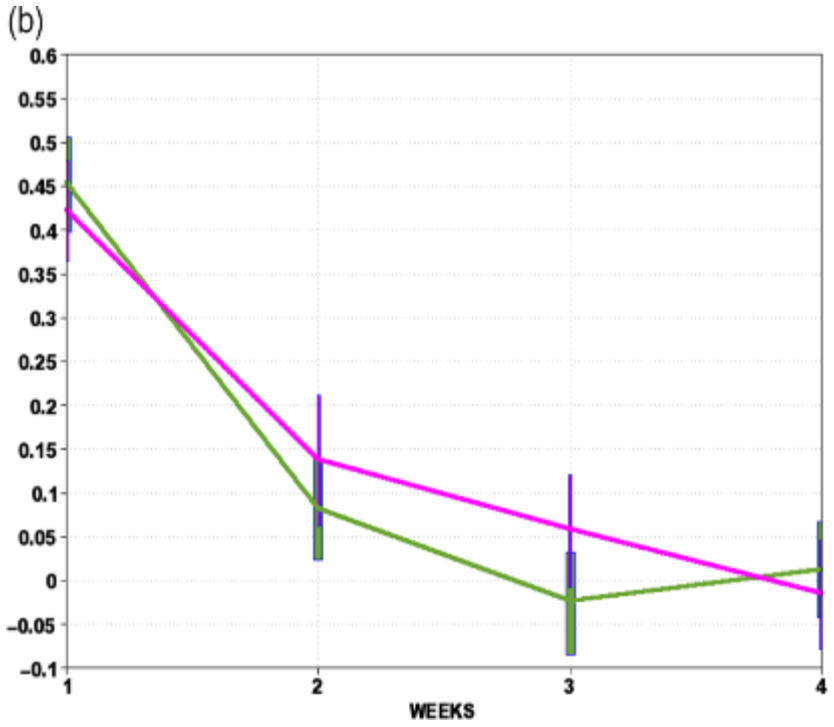
From Tripathi et al. (2015)

Rossby Wave Packets



Rossby Wave Packets





Pioneers in subseasonal predictions

Miyakoda et al. (1983), Spar et al. (1976), Shukla (1981) opened the door for subseasonal predictions.

Dr. Kikuro Miyakoda

Source: Princeton Univ. webpage

- explored the predictability at a subseasonal time-scale (beyond deterministic predictable limit),
- recognized that the subseasonal prediction can be seen as an initial value problem with external forcings (boundary value problem).

"Predictability In the Midst of Chaos" Shukla (1998), Palmer (1993)

Miyakoda et at. (1983) Simulation of a blooking event in January 1977. MWR

Spar et al. (1976) Monthly mean forecast experiments with the GISS model. MWR

Spar et al. (1978) An initial state perturbation experiment with the GISS model. MWR

Shukla (1981) Predictability of time averages. Part I. Dynamical predictability of monthly means. JAS

January 1977


Thousands in U.S. kept home by cold

Story on 2A

THE MIAMI NEWS

Miami, Florida, Wednesday afternoon, January 19, 1977 — 38 Pages

FINAL HOME EDITION

Souvenir edition:
The day that couldn't happen

Snow in Miami!

Growers fear big loss from killer freeze

Freeze warnings tonight for Dade

Picture Courtesy of Charles Trainor/Miami Herald

Source: NOAA/NWS
http://www.srh.noaa.gov/images/mfl/news/SnowSouthFlorida35th.pdf

January 1977

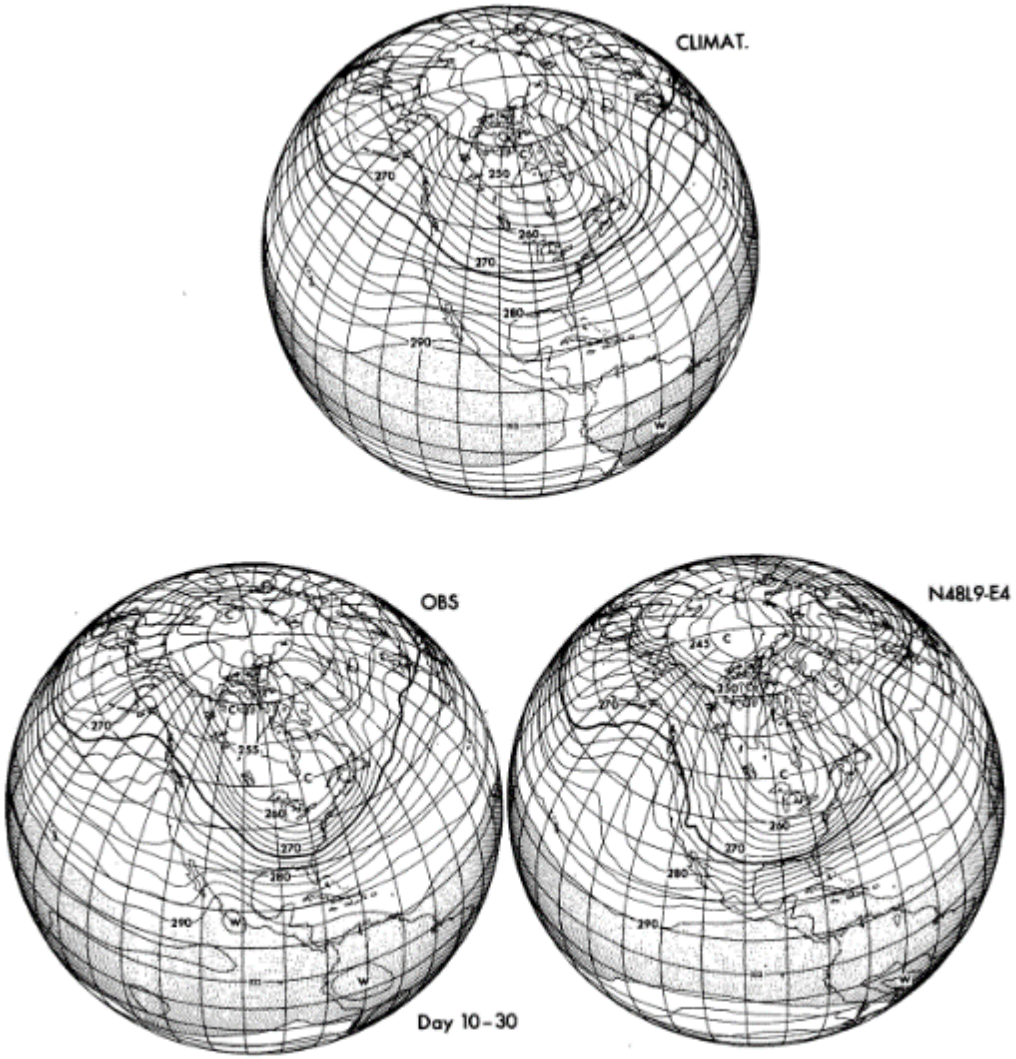


FIG. 6. The widespread record coldness over the United States for January 1977 is displayed by a 10–30 day mean temperature map at the 850 mb level. The predicted temperature shown is for the last 20 days of a one-month forecast (lower right) by the N48L9–E4 model, the observed temperature for the same period (lower left) and the January climatology (top). Units are deg. K, and the contour interval is 2.5 K.

T850 Forecast (Day10-30)

Miyakoda et al. 1983

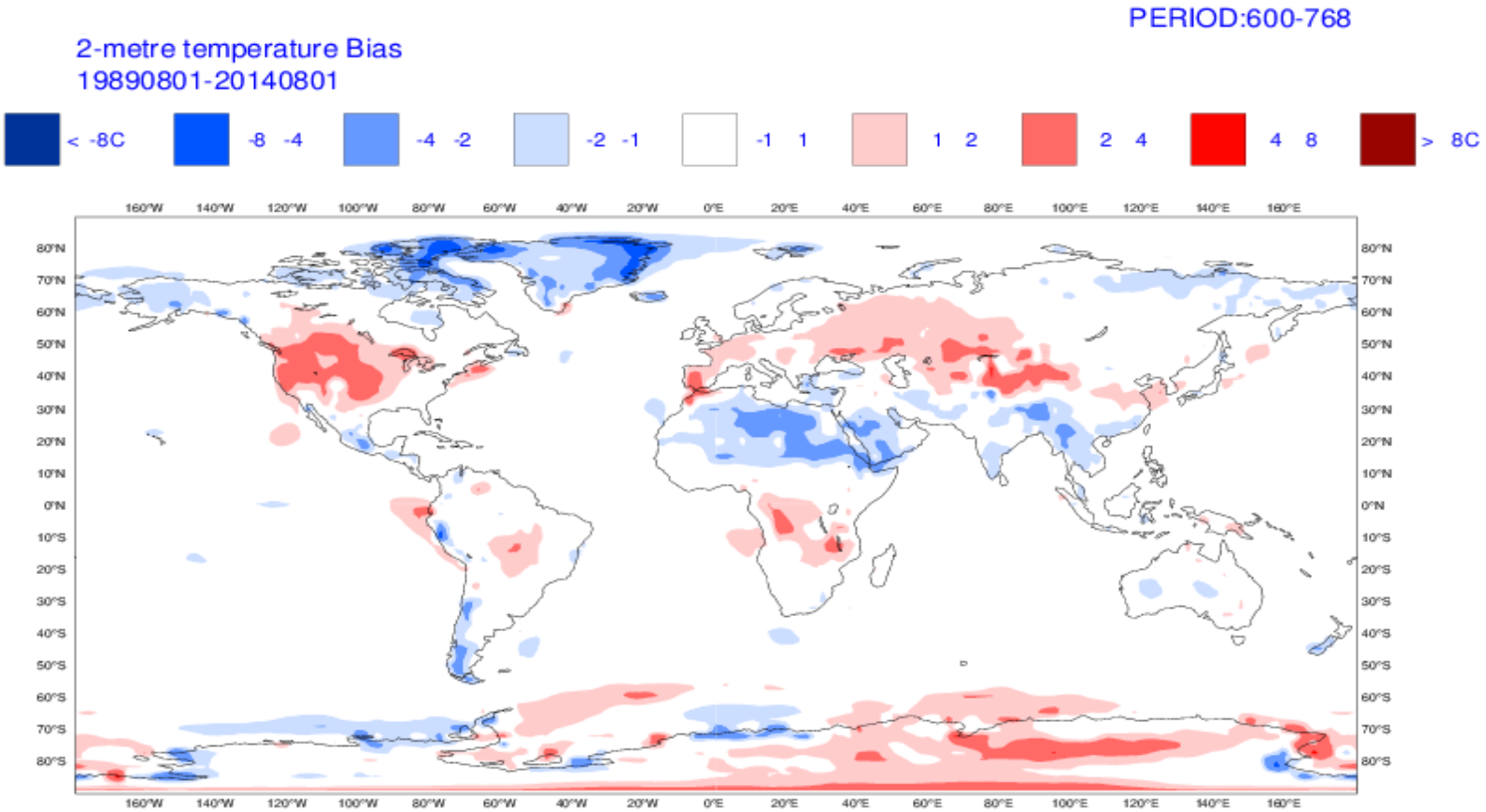
ECMWF monthly forecasts

- A 51-member ensemble is integrated for 46 days twice a week (Mondays and Thursdays at 00Z)
- Atmospheric component: IFS with the latest operational cycle and with a Tco639L91 resolution up to day 15 and Tco319L91 after day 15.
- Ocean-atmosphere coupling from day 0 to NEMO (about ¼ degree) hourly.

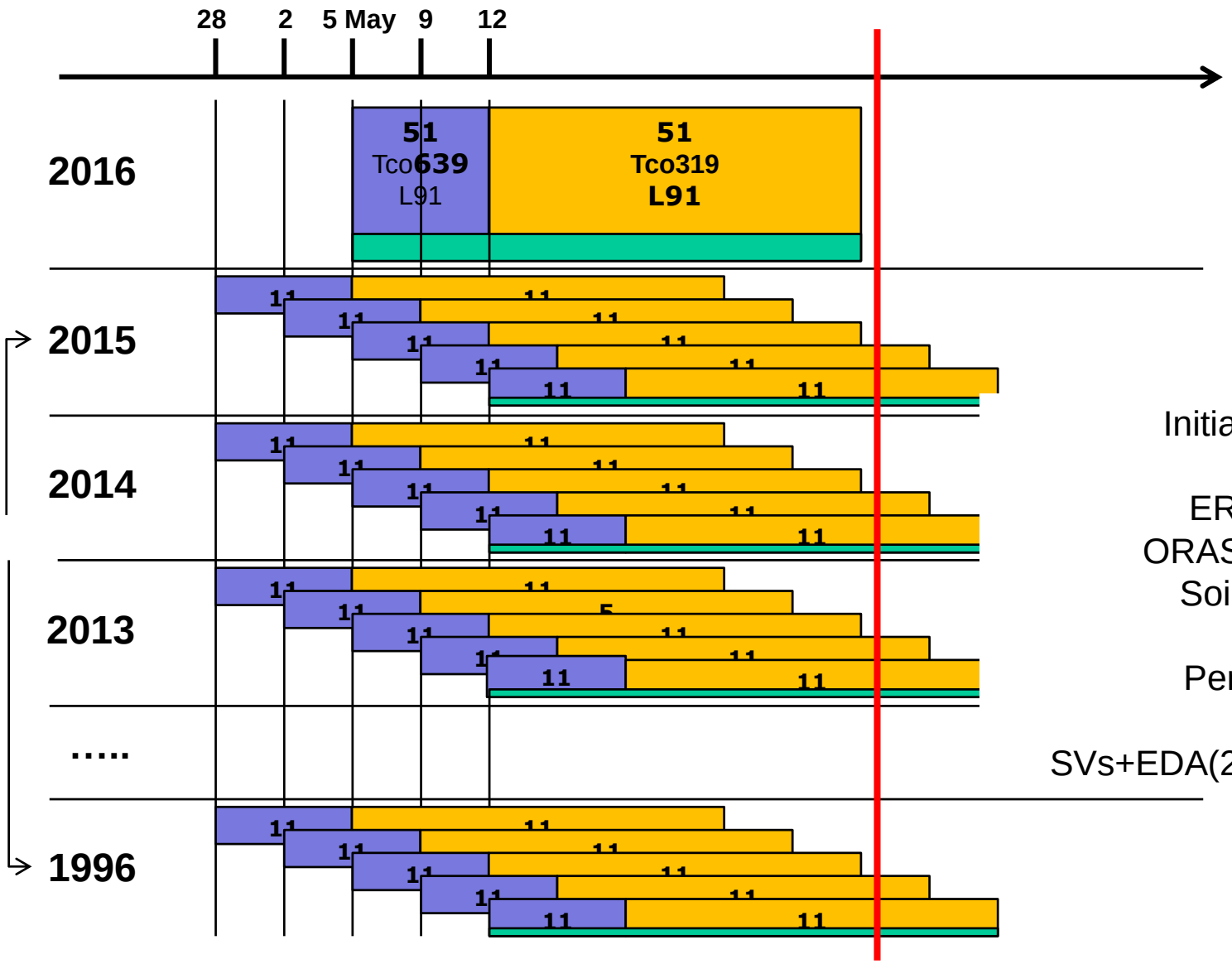
Initial conditions:

- Atmosphere: Operational 4-D var analysis + SVs+ EDA perturbations
- Ocean: 3D-Var analysis (NEMOVAR) + wind stress perturbations

Biases (eg 2mT as shown here) are often comparable in magnitude to the anomalies which we seek to predict



The ENS re-forecast suite to estimate the M-climate



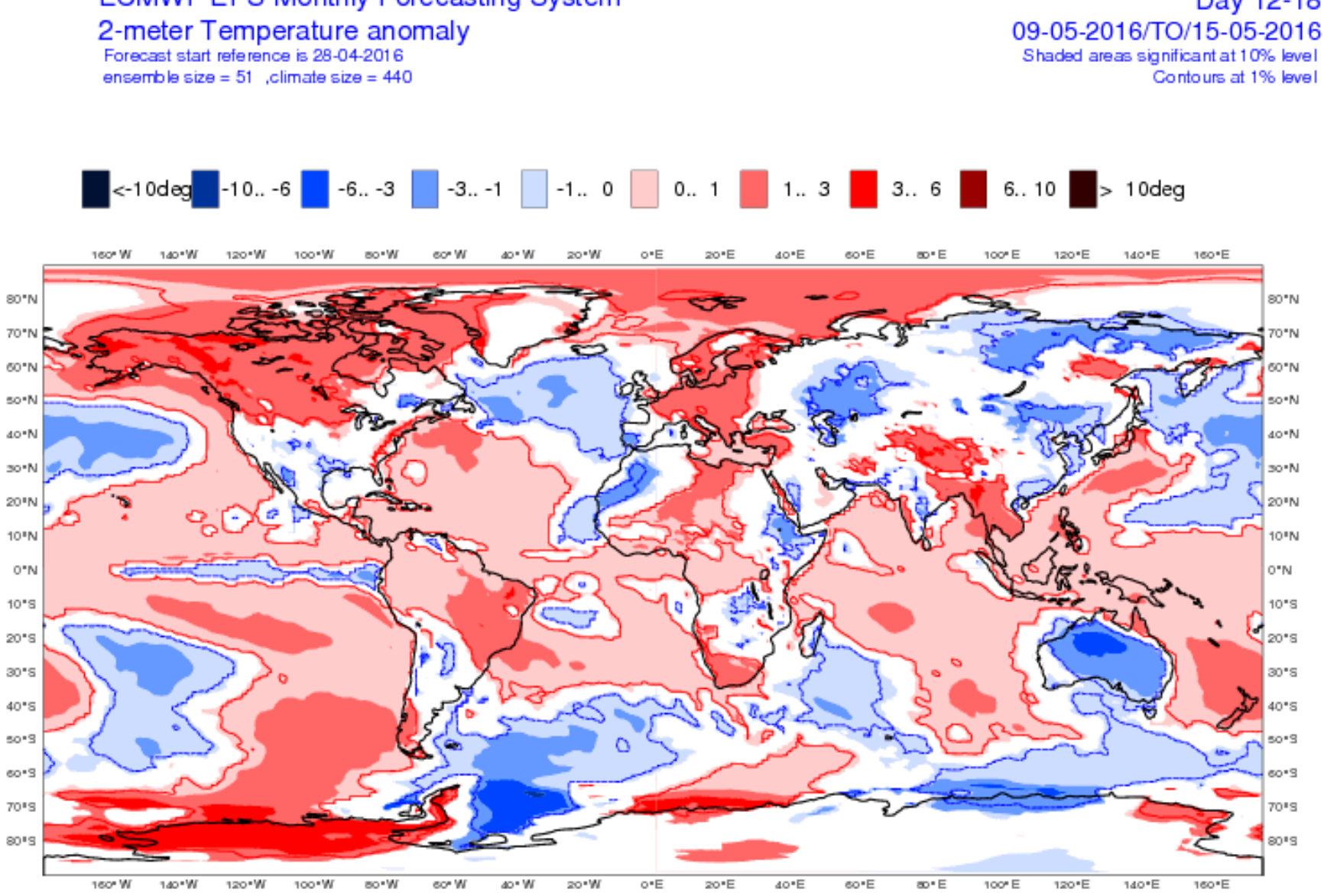
Initial conditions:

ERA Interim+
ORAS5 ocean Ics+
Soil reanalysis

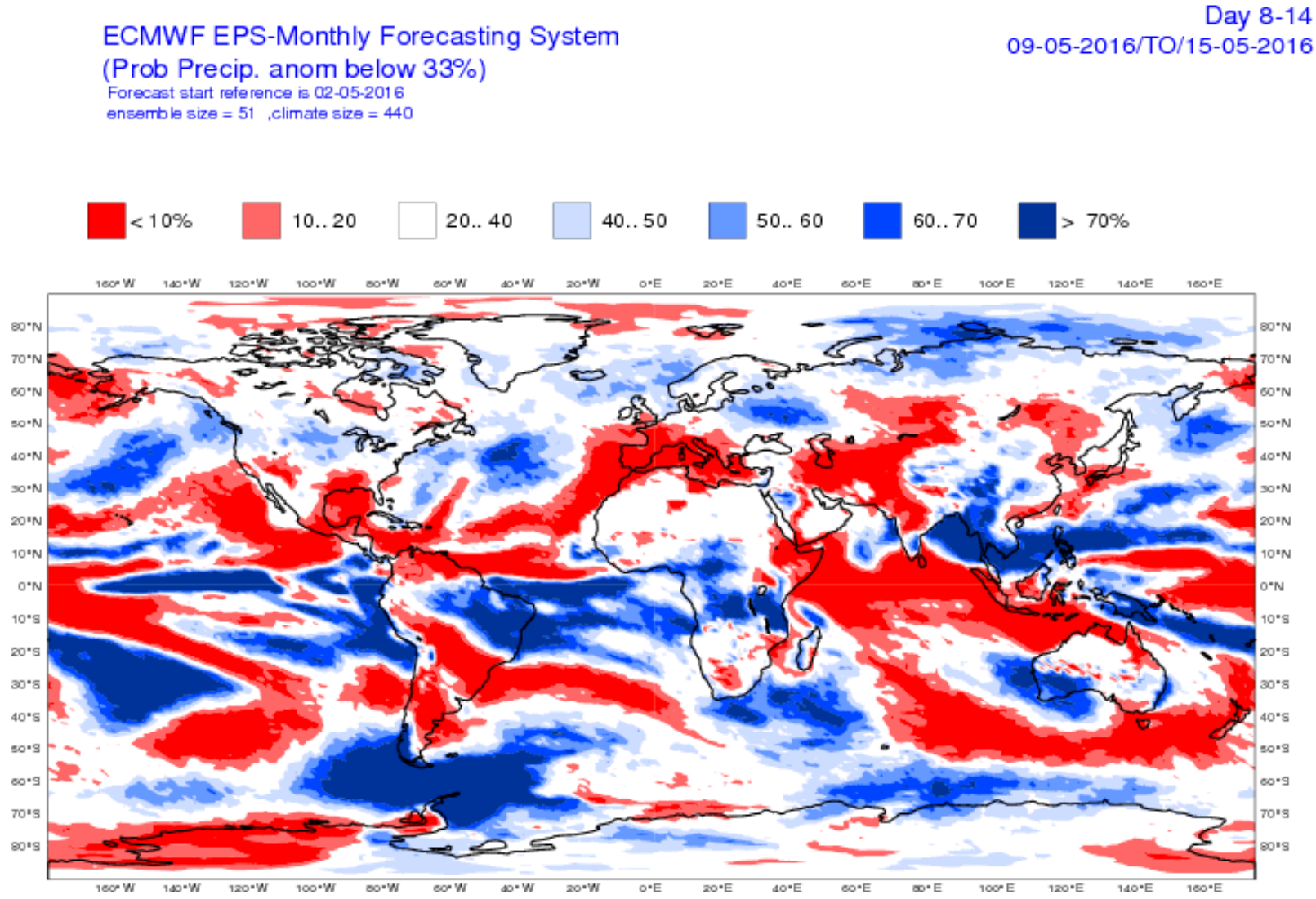
Perturbations:

SVs+EDA(2016)+SPPT+SKEB

The ECMWF monthly forecasts

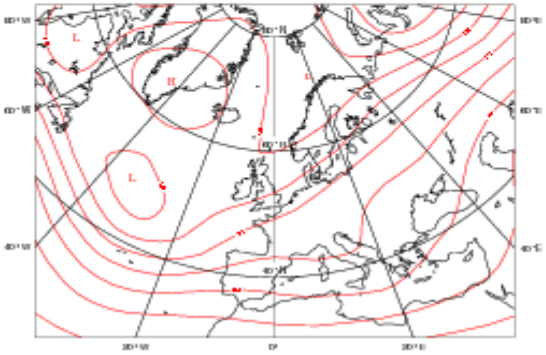


The ECMWF monthly forecasts

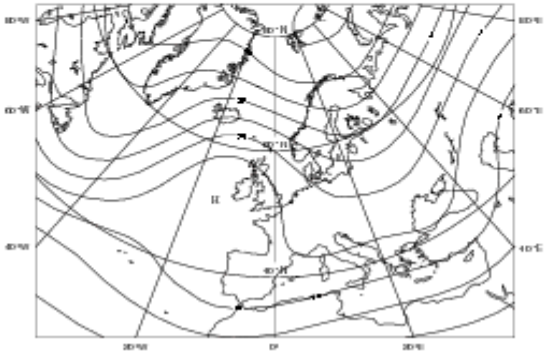


The ECMWF monthly forecasts

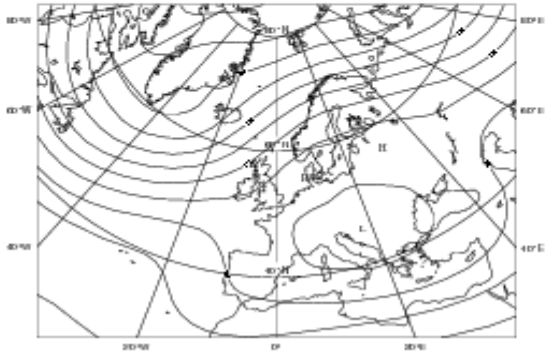
28-04-2014 week3 : step 336-504
Reg 1 ** Sub-cluster mean (2)



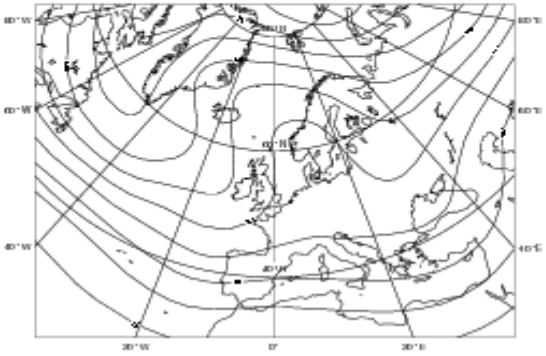
28-04-2014 week3 : step 336-504
Reg 2 ** Cluster mean (13) - CTR



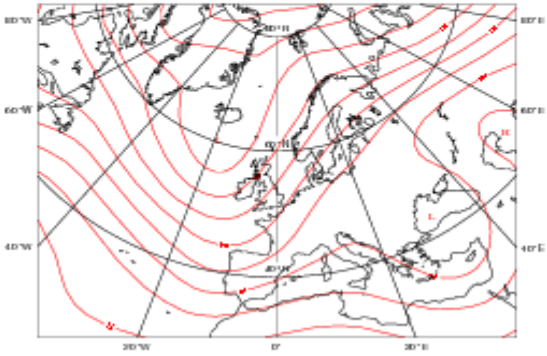
28-04-2014 week3 : step 336-504
Reg 3 ** Cluster mean (11)



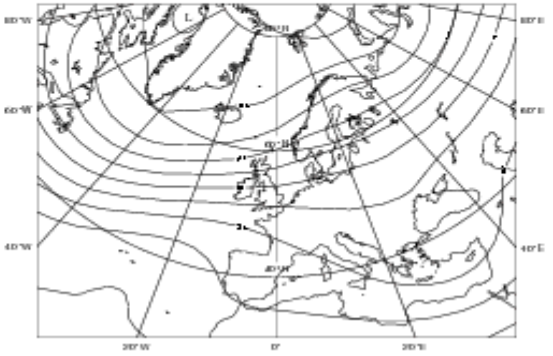
28-04-2014 week3 : step 336-504
Reg 4 ** Cluster mean (11)



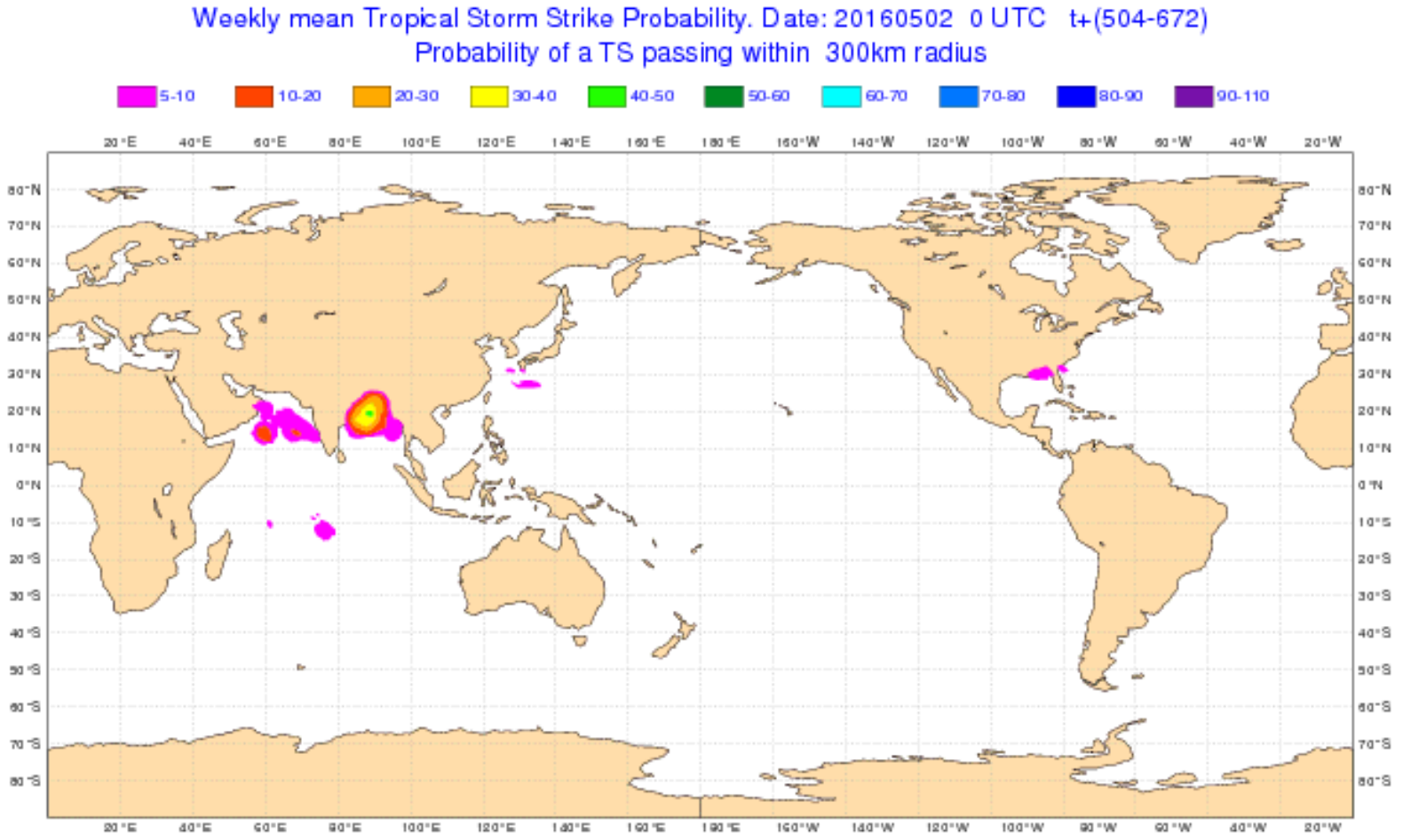
28-04-2014 week3 : step 336-504
Reg 5 ** Sub-cluster mean (4)



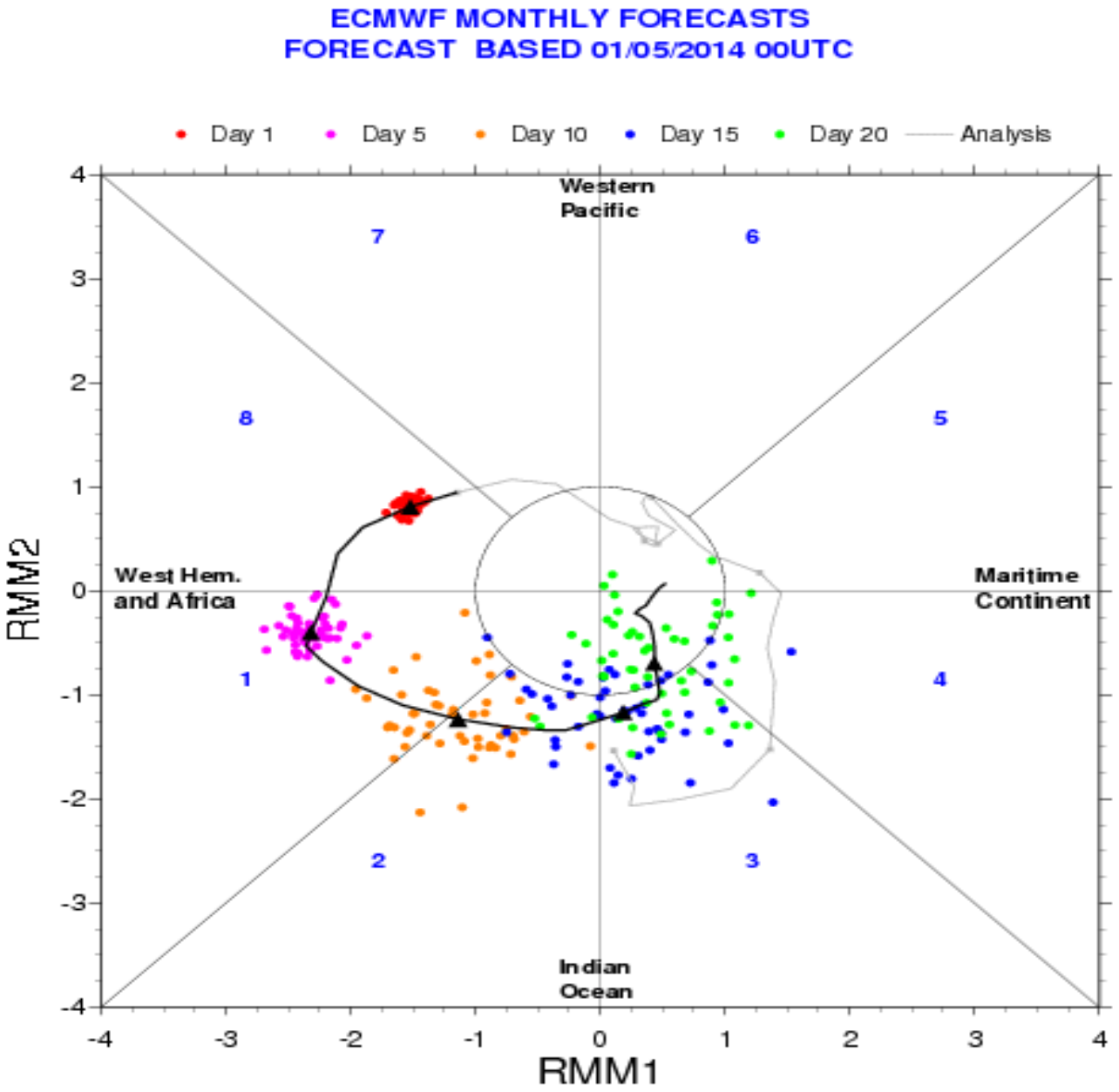
28-04-2014 week3 : step 336-504
Reg 6 ** Cluster mean (9)



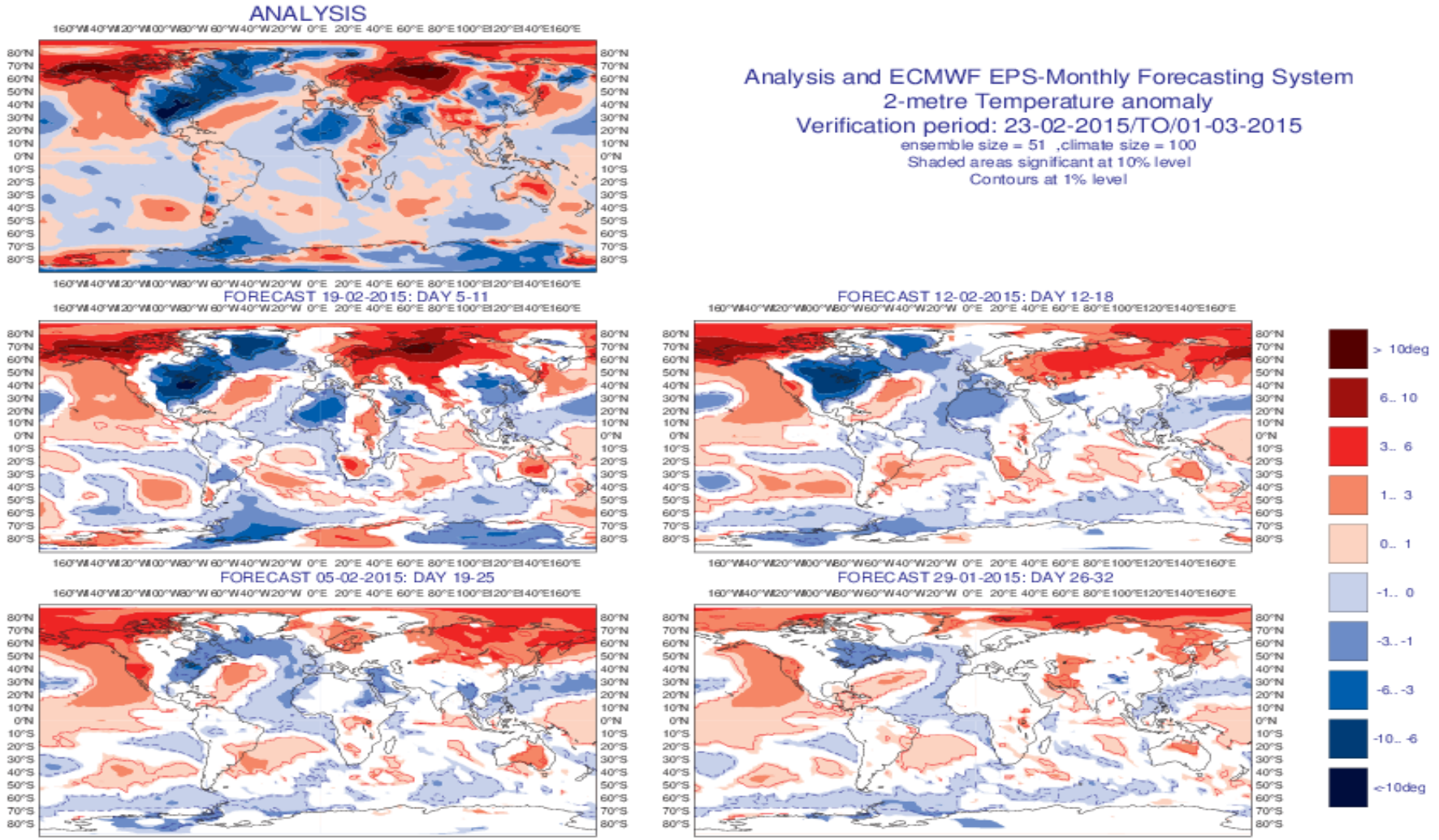
Tropical cyclone activity



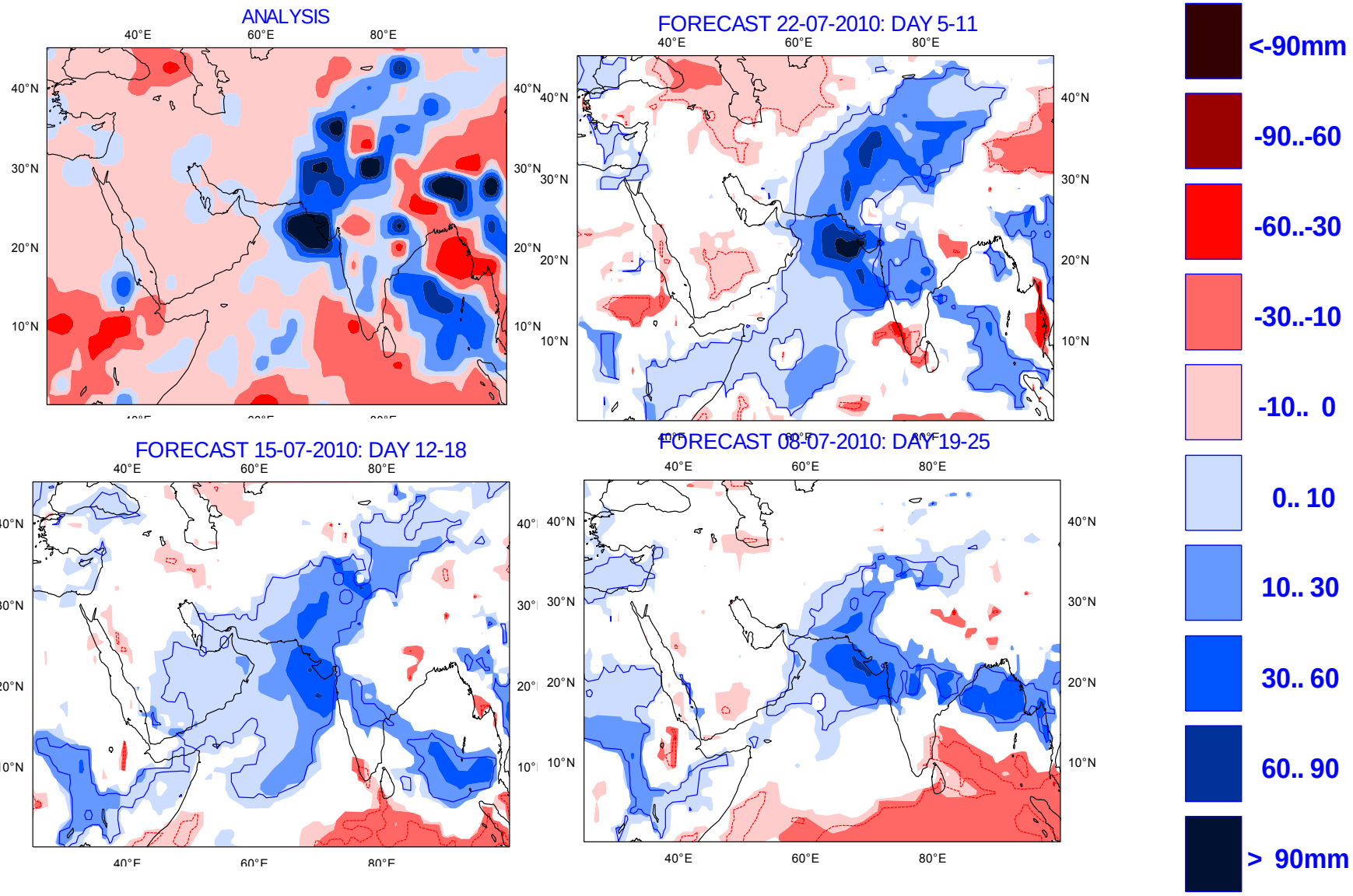
MJO Forecasts



ECMWF Extended-range forecasts



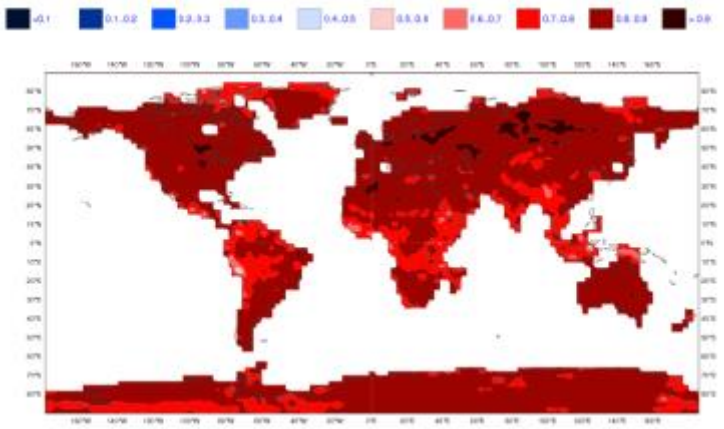
Precip anomalies : 26 July 2010 – 01 August 2010



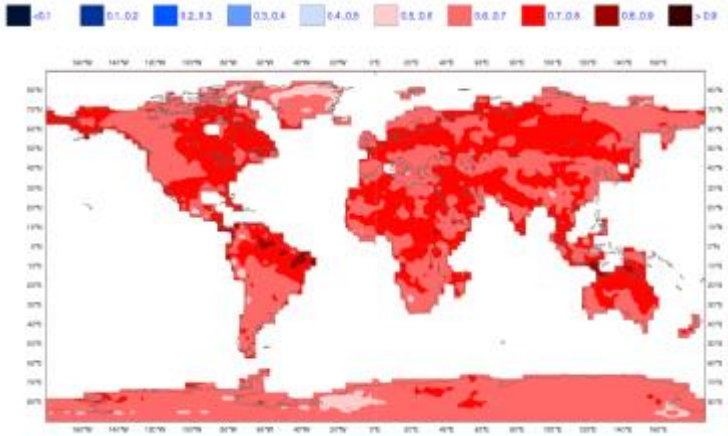
Skill of the ECMWF Monthly Forecasting System

ROC score: 2-meter temperature in the upper tercile

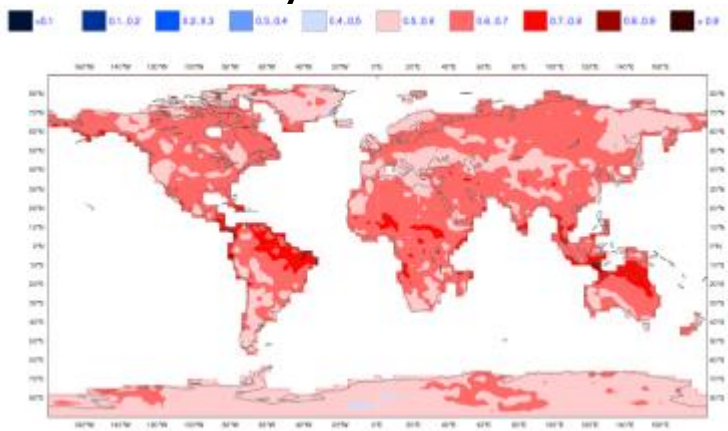
Day 5-11



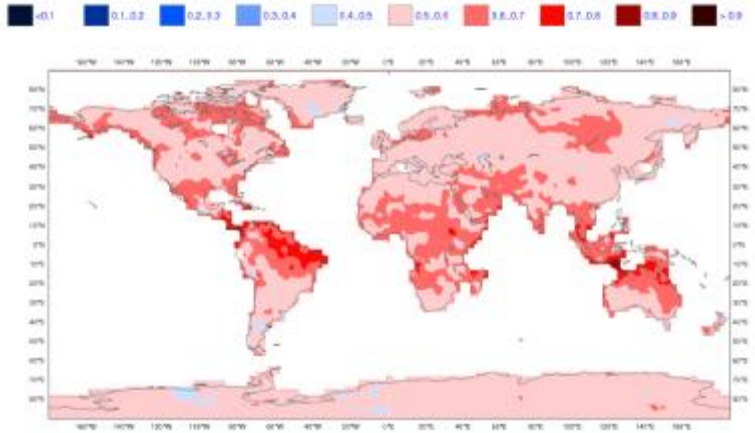
Day 12-18



Day 19-25



Day 26-32

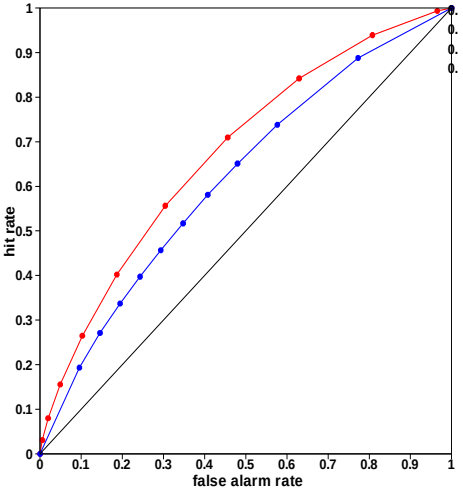


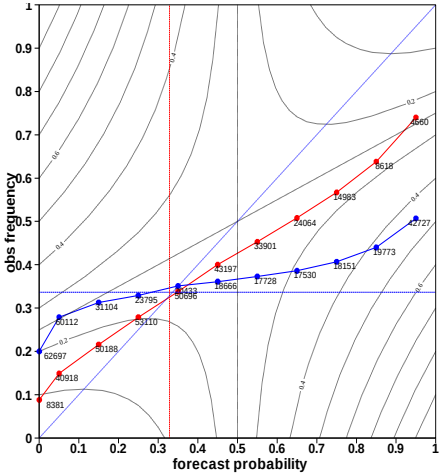
Skill of the ECMWF Monthly Forecasting System

2-meter temperature in upper tercile - Day 12-18

ROC score

Day 12-18

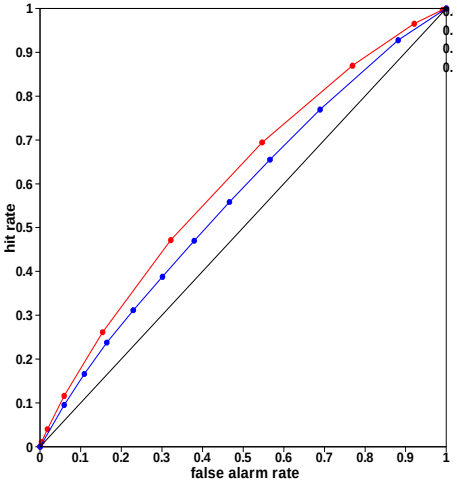


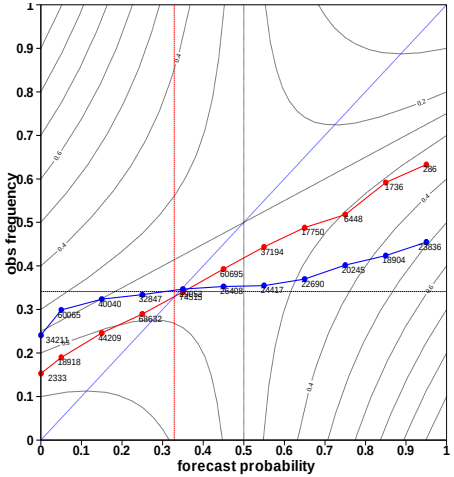


Persistence of day 5-11

Monthly forecast day 12-18

Day 19-25

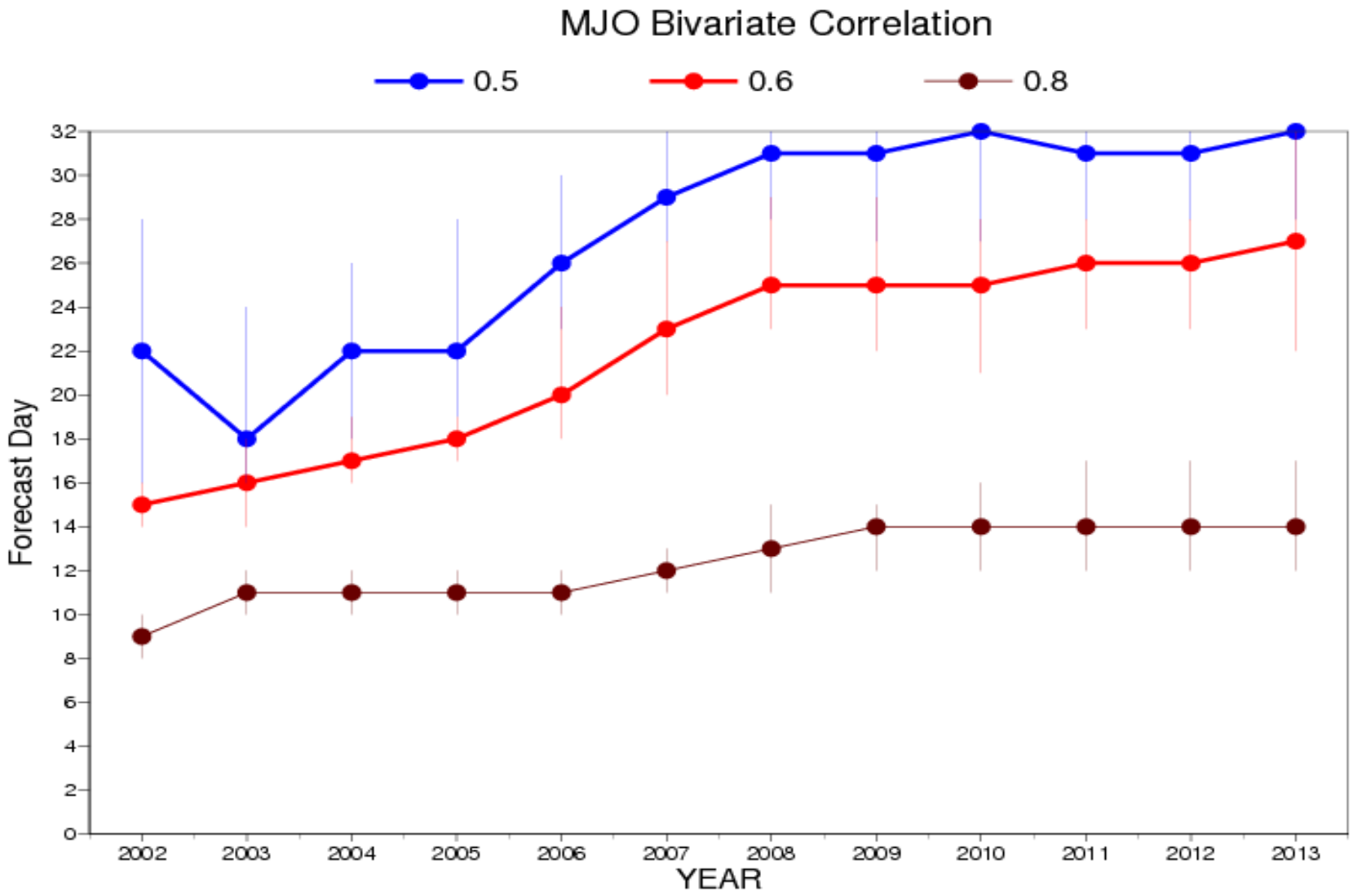




Persistence of day 5-18

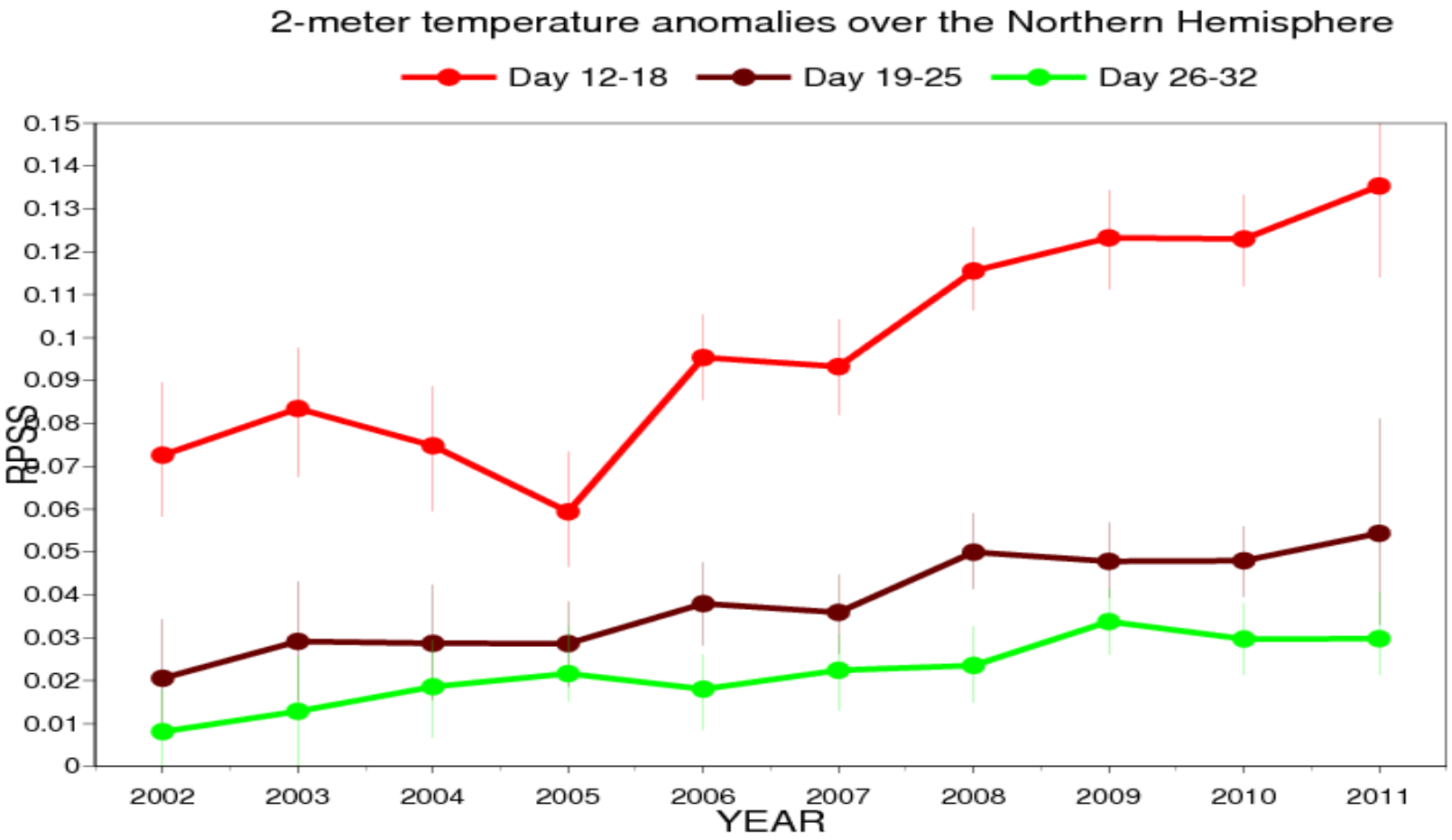
Monthly forecast day 19-32

MJO skill scores

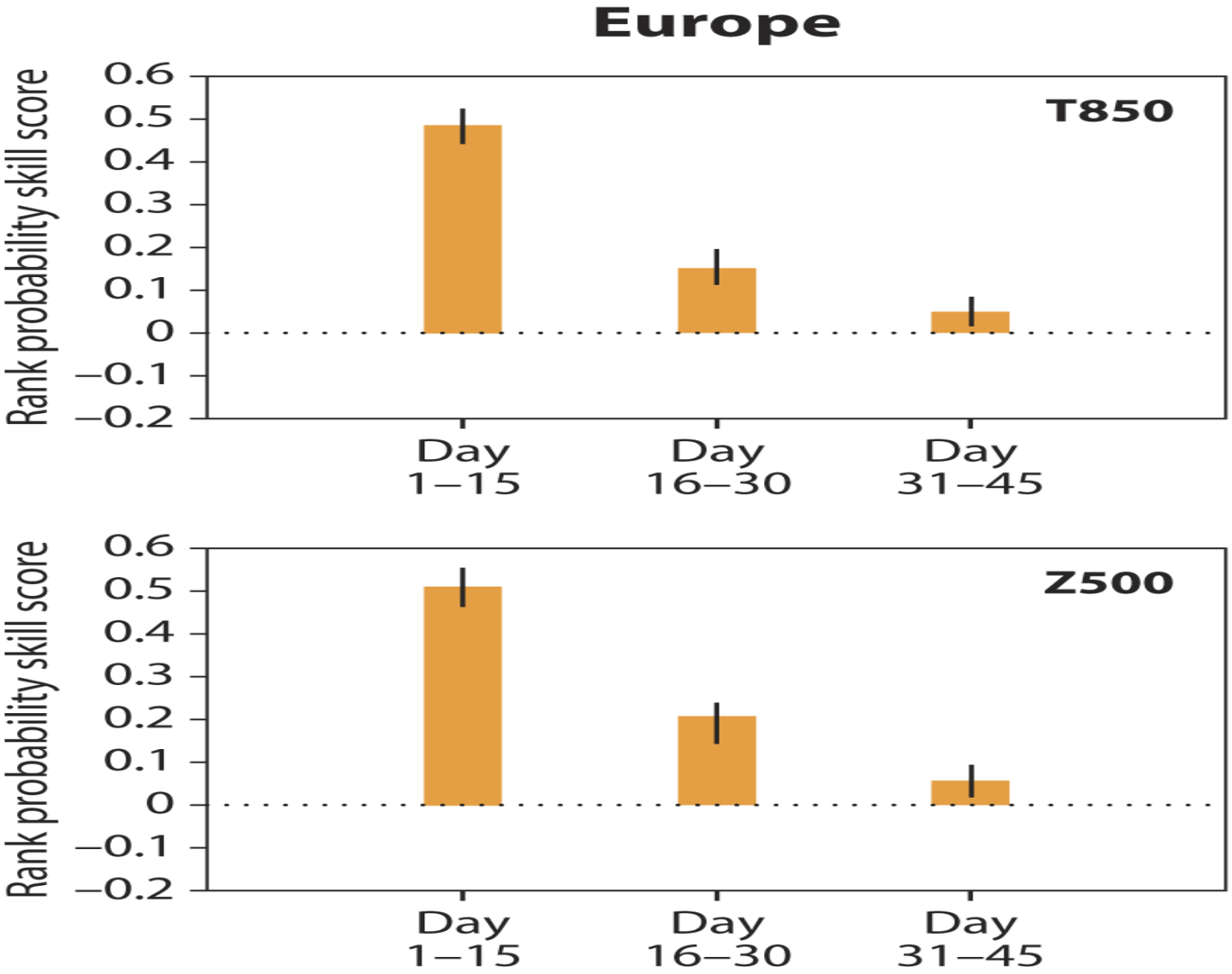


Performance of the monthly Forecasts

2-metre temperature ROC area over Northern Extratropics



Extension to 46 days



80 case, starting on 1st Feb/May/Aug/Nov 1989-2008

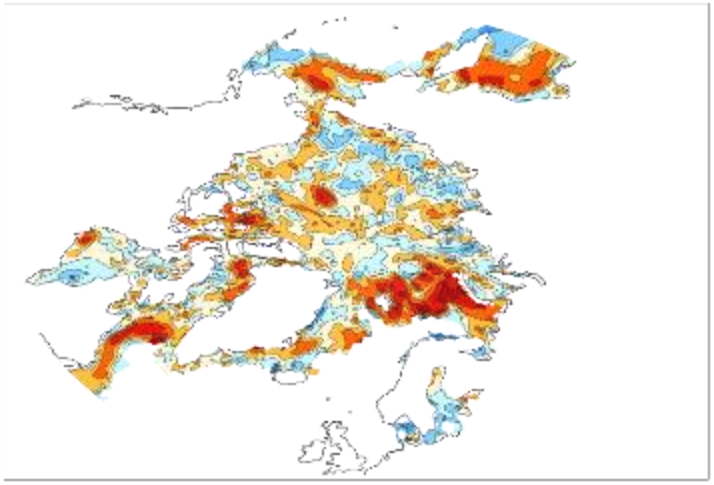
Future Model Changes

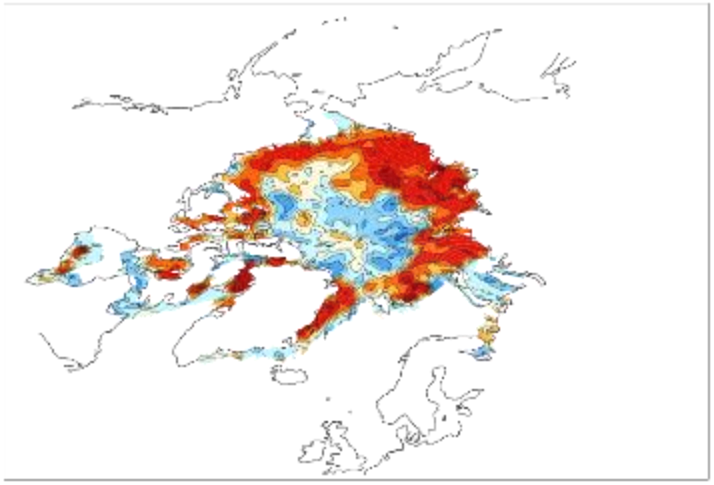
Correlations for week 4
Northern Hemisphere

Winter

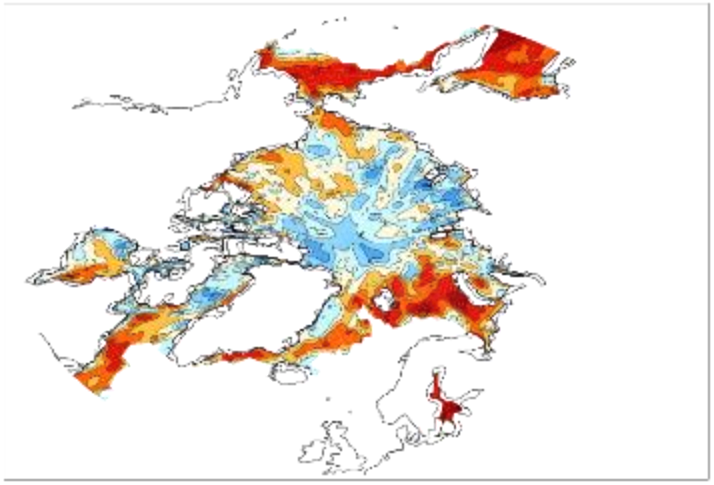
Summer

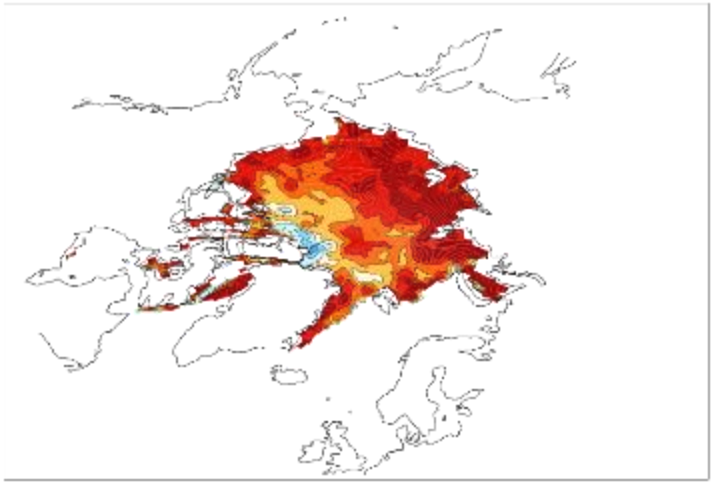
Current system

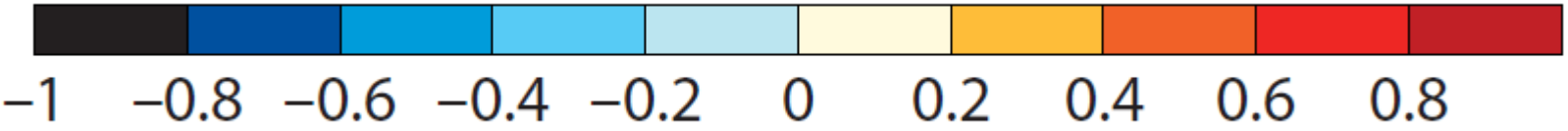




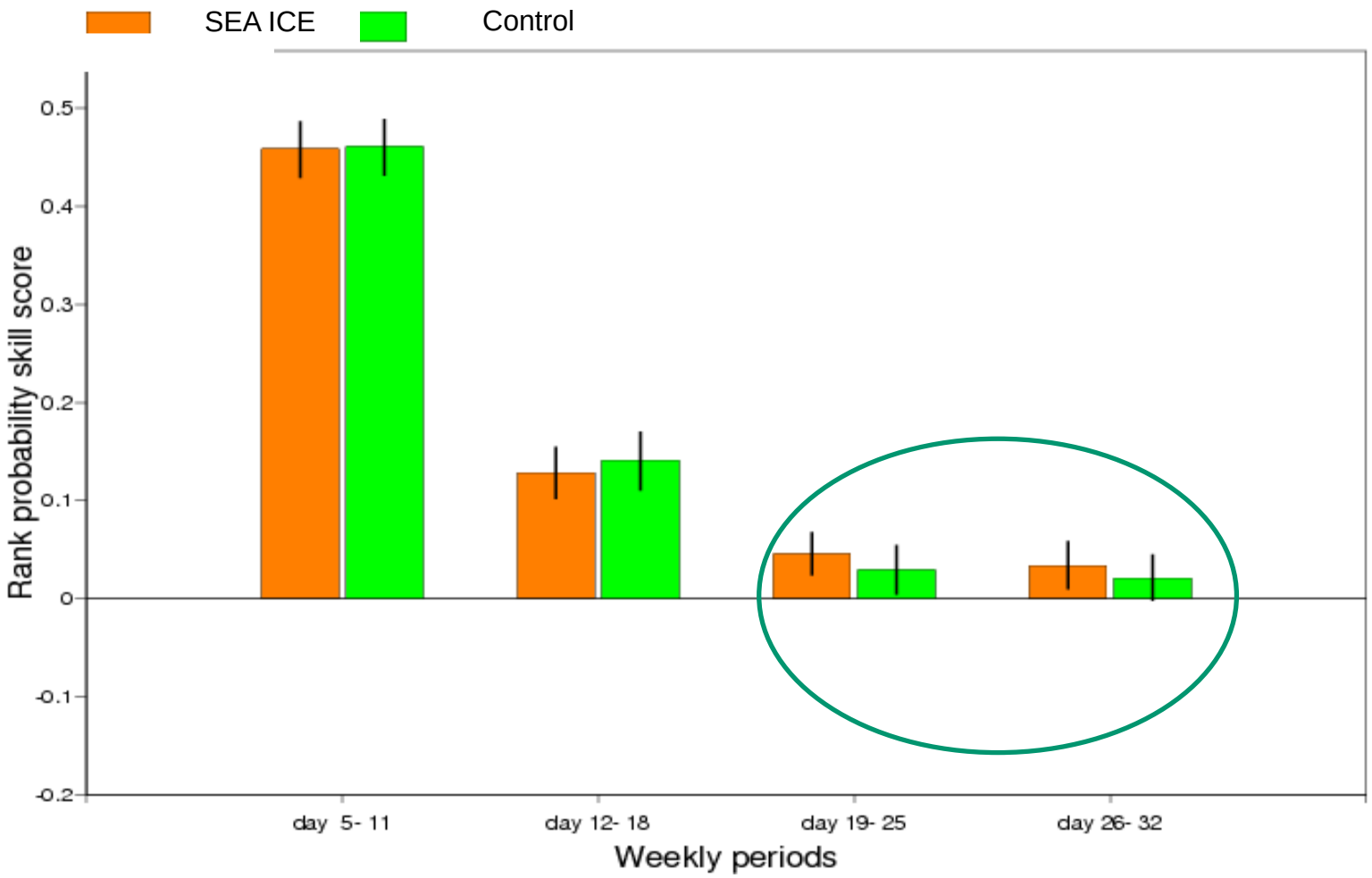
With sea-ice model (LIM2)







Active sea ice model: Z500 Forecast Skill (weeks 1-4)



WWRP-WCRP sub-seasonal to seasonal prediction Project (s2S)

- “To improve forecast skill and understanding on the sub-seasonal to seasonal timescale with special emphasis on high-impact weather events”

- “To promote the initiative’s uptake by operational centres and exploitation by the applications community”

- “To capitalize on the expertise of the weather and climate research communities to address issues of importance to the Global Framework for Climate Services”

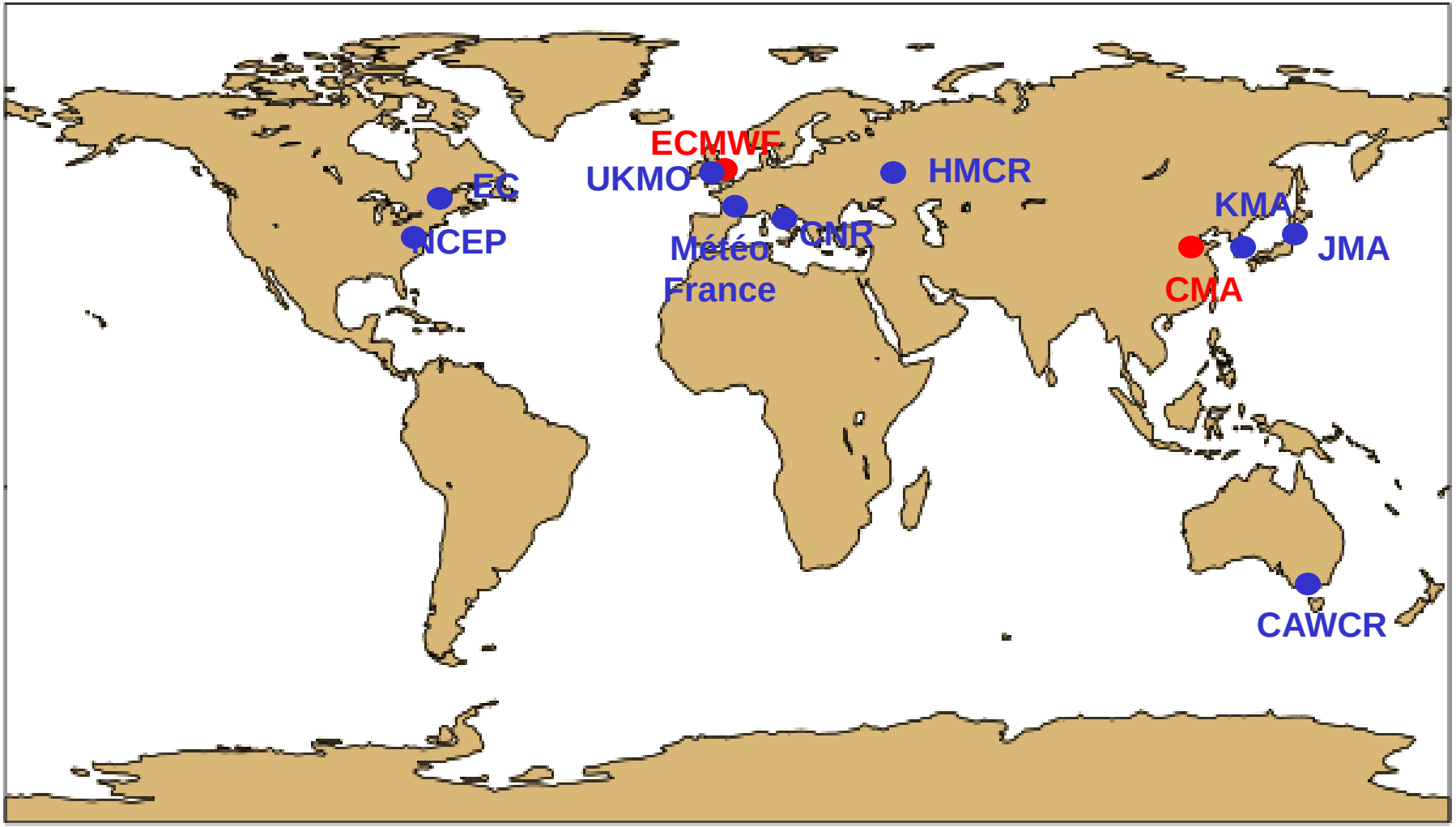
S2S database

- Daily real-time forecasts + re-forecasts
- 3 weeks behind real-time
- Common grid (1.5x1.5 degree)
- Variables archived: about 80 variables including ocean variables, stratospheric levels and soil moisture/temperature
- Archived in GRIB2 – NETCDF conversion available

S2S Database

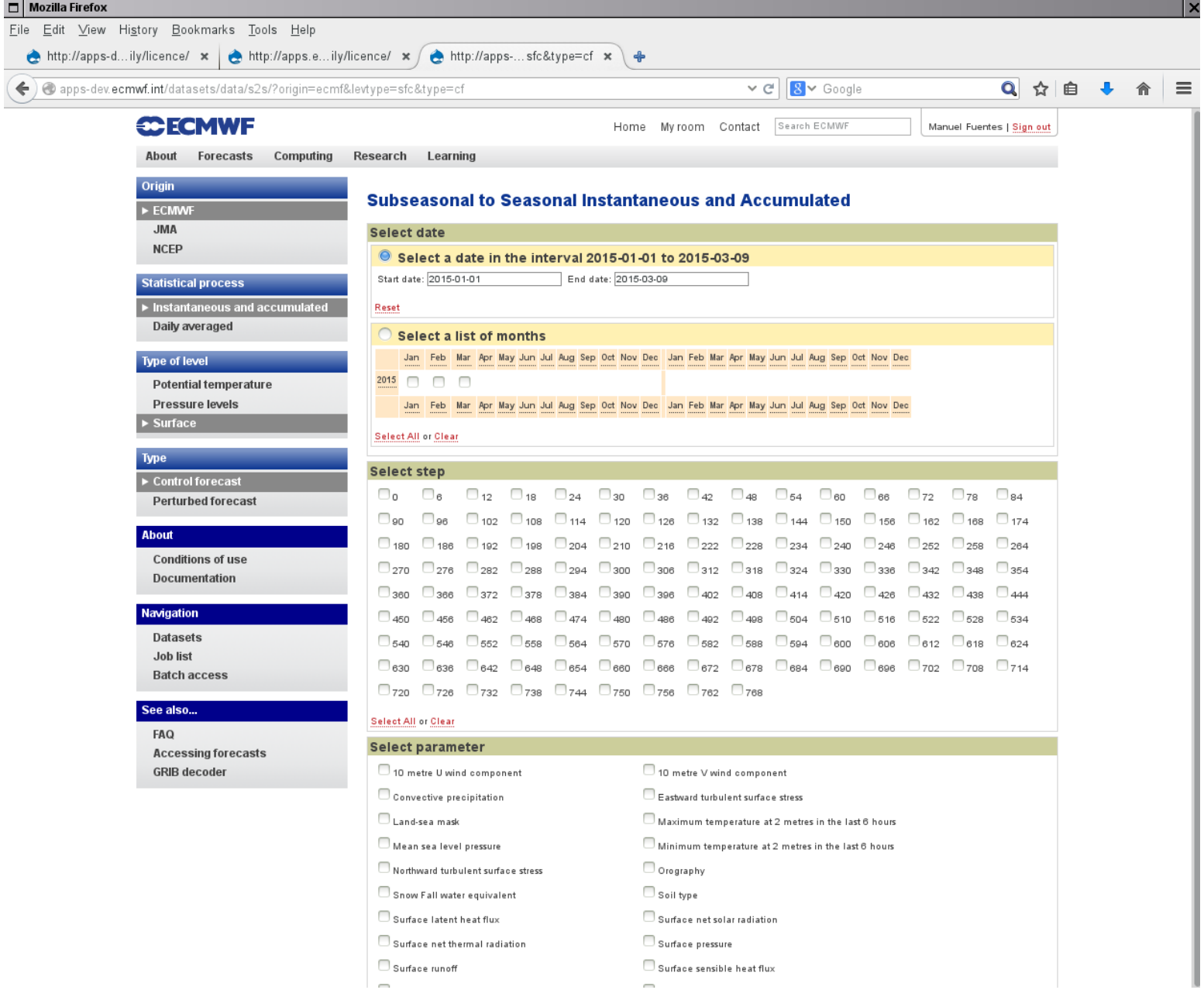
11 data providers and 2 archiving centres

● Data provider ● Archiving centre



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



http://apps.ecmwf.int/datasets/data/s2s/levtype=sfc/type=cf/

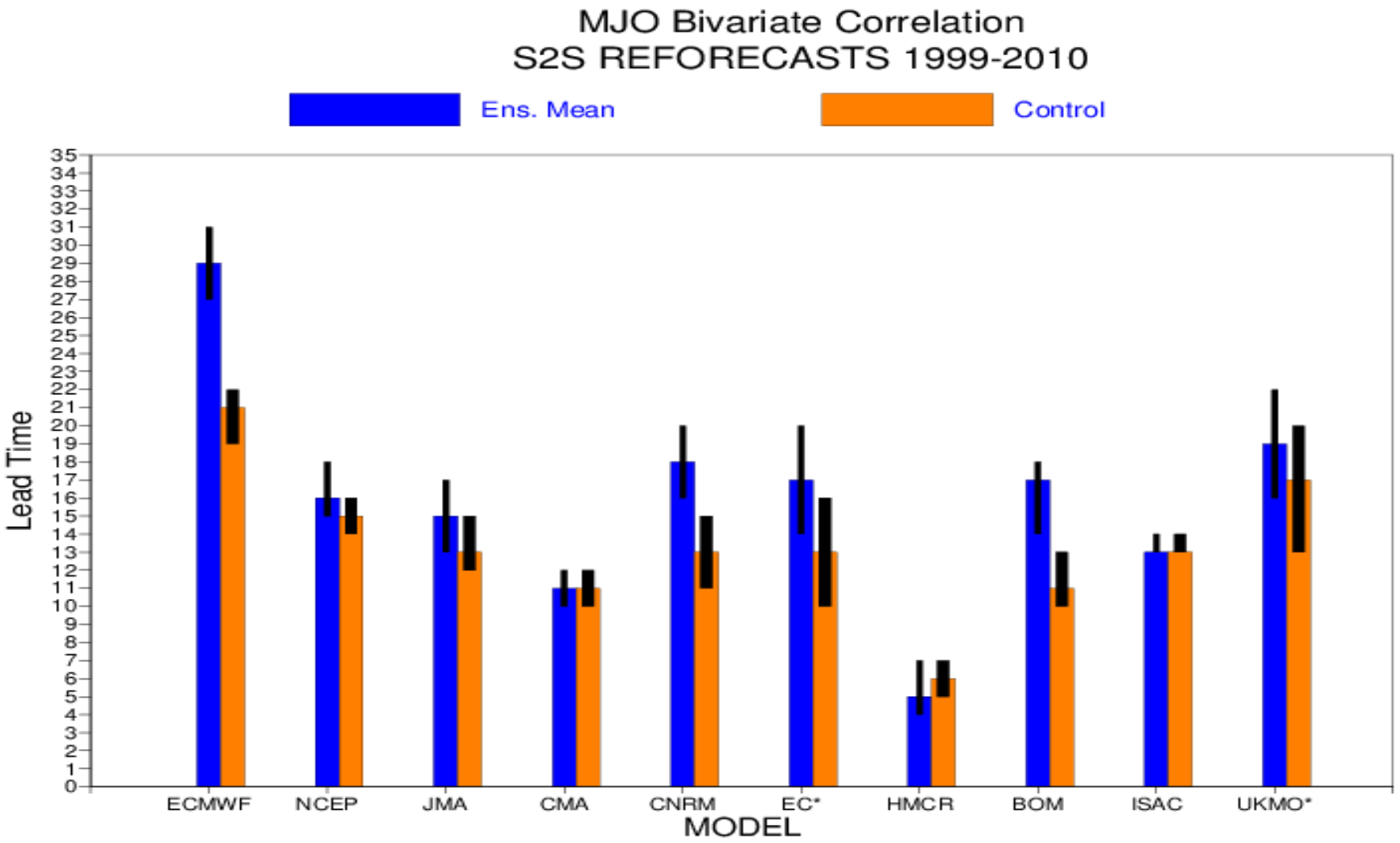
S2S Database current status

- Open access to researchers from ECMWF (since May 2015) and CMA (since Nov 2015). Subset of data also available from IRI. Data from nine data providers:
  - ECMWF, NCEP, JMA, BoM, CMA, Météo-France, HMCR, ISAC and UKMO
  - Total size of the database: 37.7 Tbytes:
    - real-time: 5 Tbytes
    - re-forecast: 32.6 Tbytes

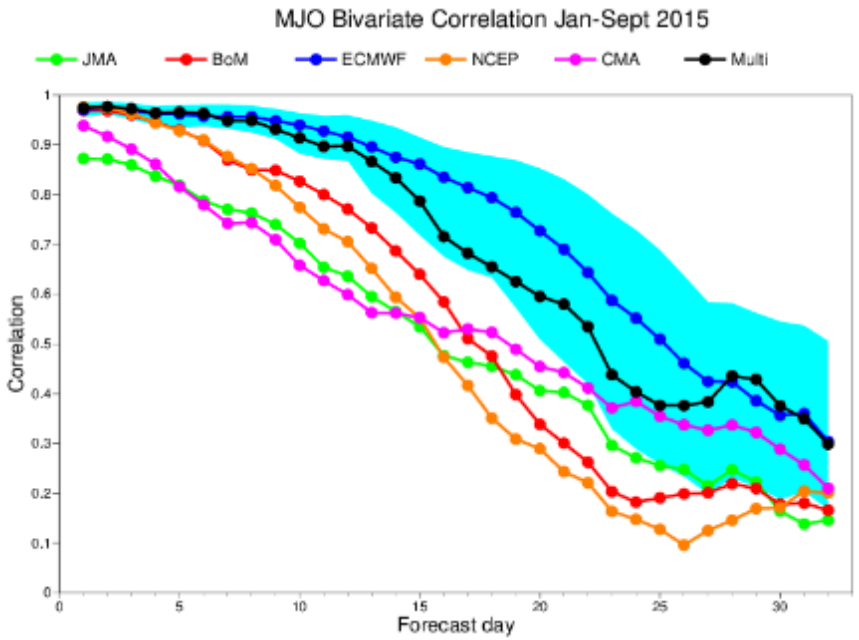
- Plans
  - End of 2016: all 11 Data Providers
  - Add new ocean sub-surface and sea-ice variables
  - Compute and archive indices such as MJO RMMS, SSW index, Weather regimes, Tropical storm tracks, Monsoon indices to be available for the research community from ECMWF and IRI servers.

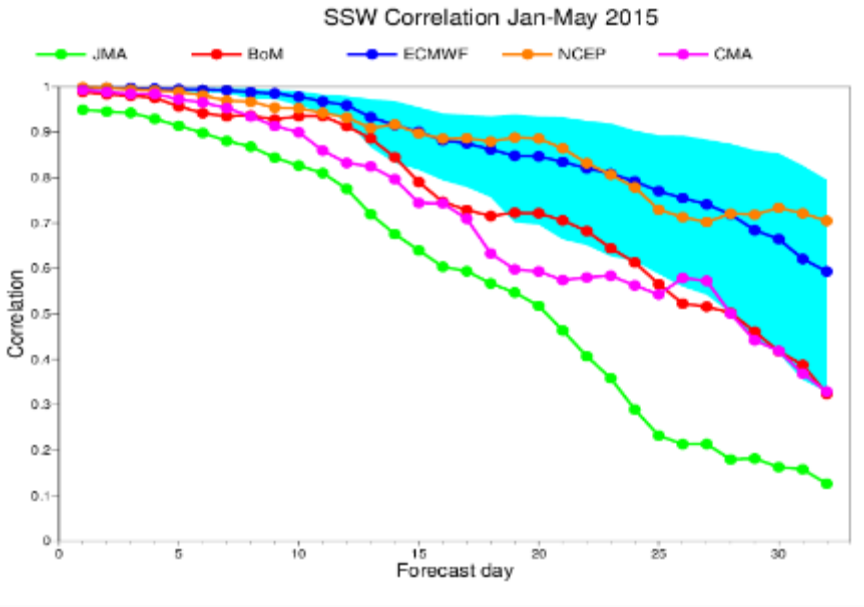
See also S2S museum http://gpvjma.ccs.hpcc.jp/S2S/

Bivariate Correlation – Ensemble

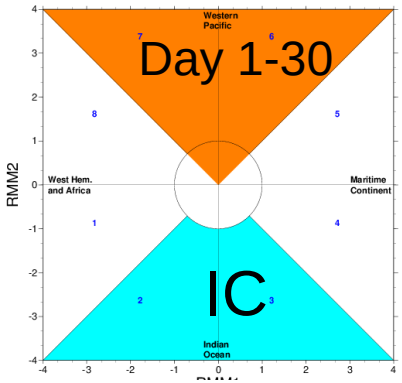


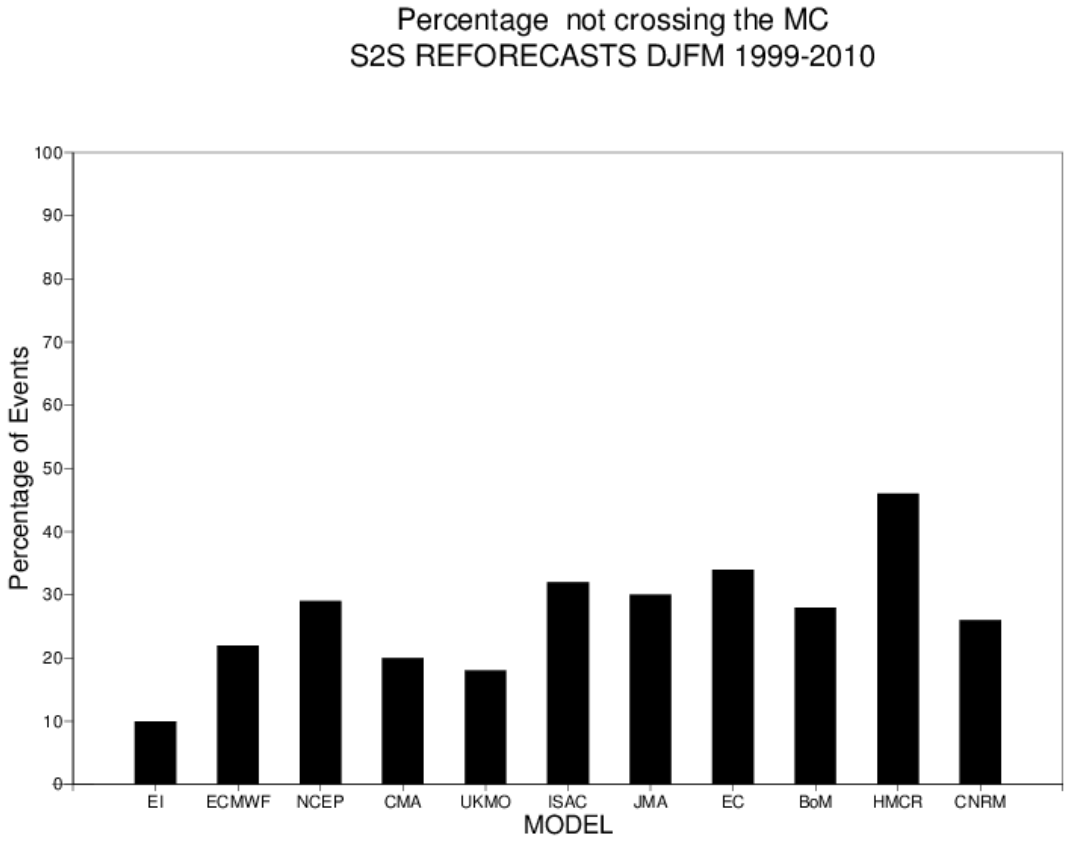
S2S verification – S2S real-time forecasts





MC crossing

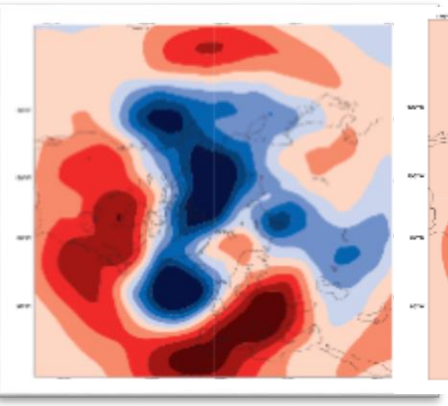

Western Pacific
Day 1-30
West Hem. and Africa
Maritime Continent
IC
Indian Ocean
RMM2


Percentage not crossing the MC
S2S REFORECASTS DJFM 1999-2010
Percentage of Events
MODEL
EI
ECMWF
NCEP
CMA
UKMO
ISAC
JMA
EC
BoM
HMCR
CNRM

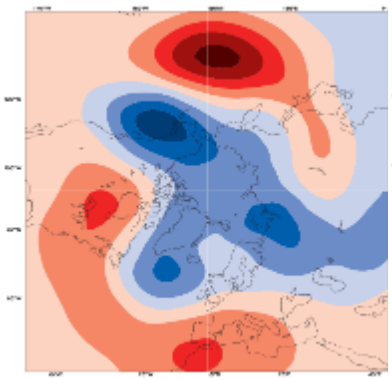
Teleconnections (S2S re-forecasts)

ONDJFM 1999-2010

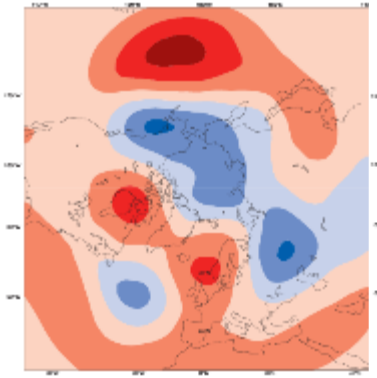
Analysis



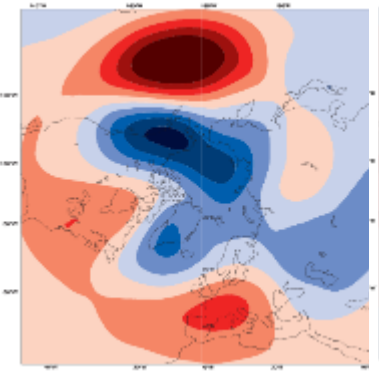
ECMWF



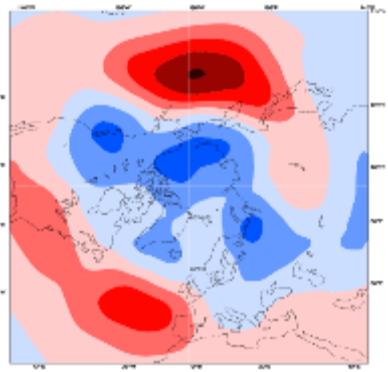
JMA



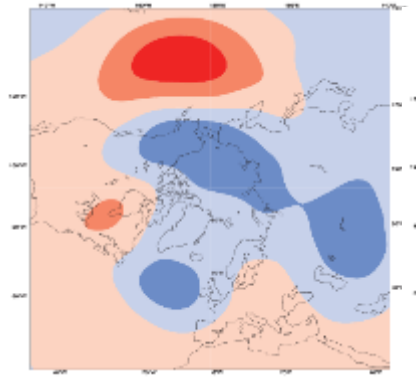
NCEP



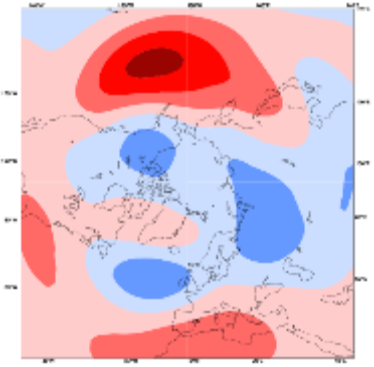
ISAC



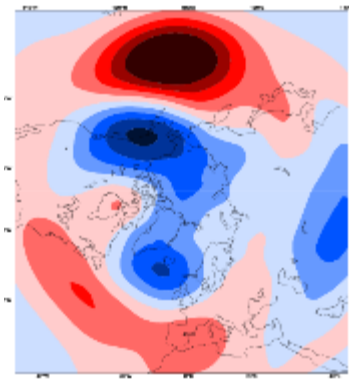
BoM



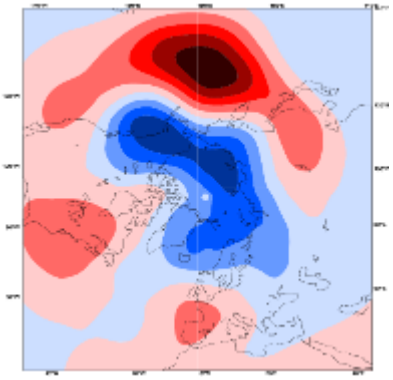
CNRM



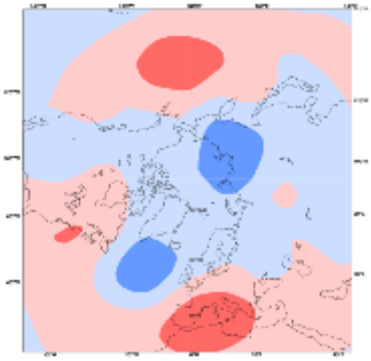
EC



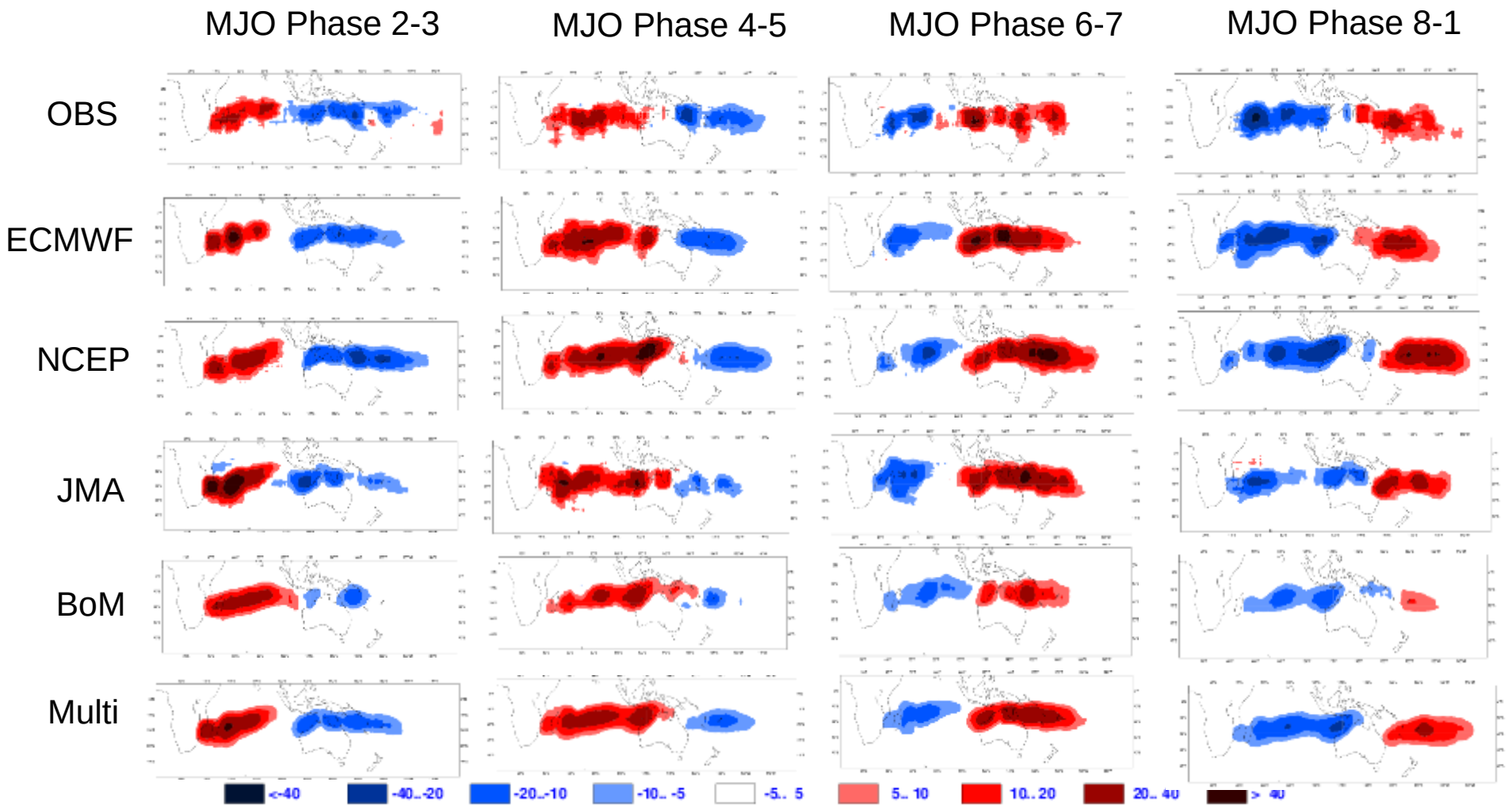
UKMO



CMA



Modulation of tropical cyclone density anomaly by MJO

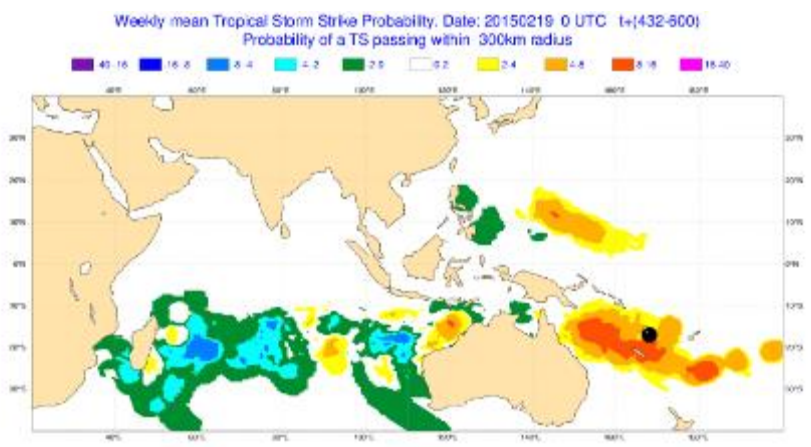


Tropical Cyclone Pam case study

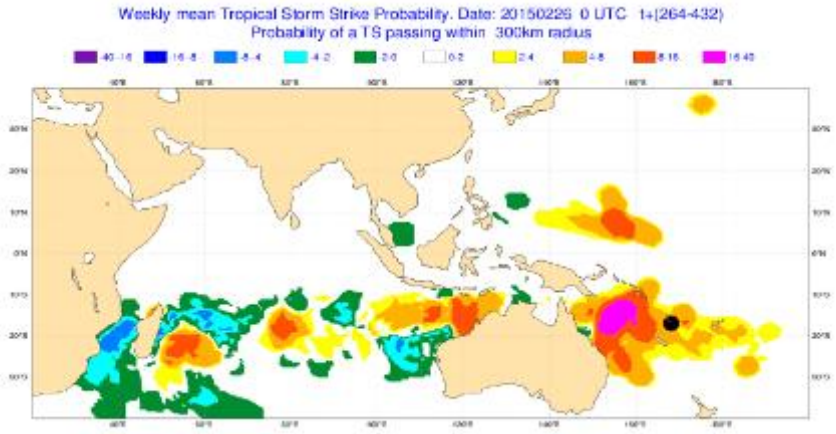
Multi-model prediction of TC strike probability anomalies- 9-15 March 2015

(NCEP/ECMWF/BoM/JMA/CMA)

2015/02/19 day 19-25



2015/02/26 day 12-18



Conclusion

- SSTs, Soil moisture, stratospheric initial conditions and MJO are sources of predictability at the intra-seasonal time scale. The MJO has a significant impact on the forecast skill scores beyond day 20.

- The monthly forecasting system produces forecasts for days 12-18 that are generally better than climatology and persistence of day 5-11. Beyond day 20, the monthly forecast is marginally skilful. For some applications and some regions, these forecasts could however be of some interest.

- There has been a clear improvement in the monthly forecast skill scores since 2002. This improvement is likely to be related to improved prediction in the Tropics and most especially improved MJO prediction.

- S2S database is now available. It is an important tool to better identify model's sources of predictability and teleconnections.