Met Office
Hadley Centre

GLOSEA4 – the New Met Office Monthly/Seasonal Forecasting System

Tim Hewson

Thanks to: Alberto Arribas, Ann Keen, Emily Hamilton, Anna Maidens, Drew Peterson, Michael Vellinga, Anca Brookshaw, Margaret Gordon, Bernd Becker…

Layout

1. Overview of GLOSEA4
2. Performance
3. Product examples
4. New Met Office Seasonal Forecast

1. Overview of GLOSEA4

Glo-Sea-4

Global

Seasonal forecast system

Version four

Seasonal output is operational – the focus of this talk

Monthly output is not yet used operationally

GLOSEA4 Model basis:

HadGEM3 / GlobalAtmos development team

CAPTIVATE evaluation group

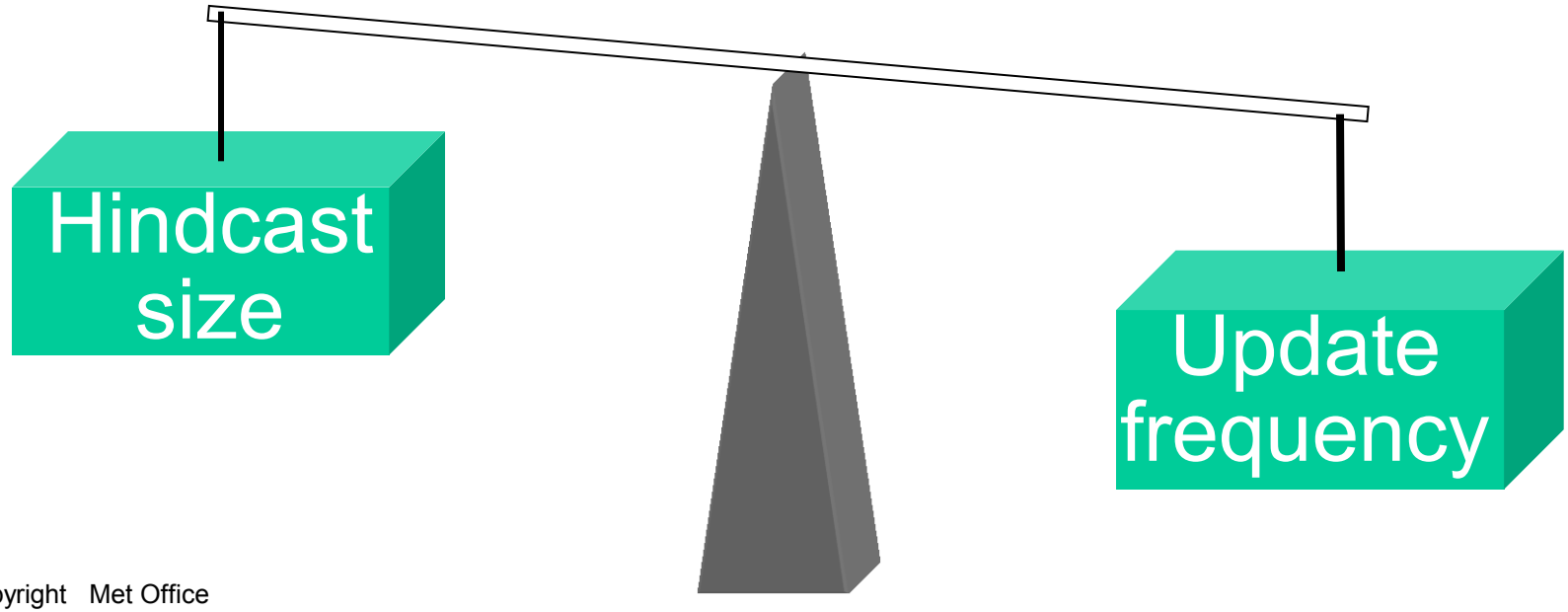
FOAM group

The GloSea4 Strategy

Frequent model upgrades (part of the Met Office GlobalAtmos development programme).

Hindcast run at the same time as the forecast.

Consequence: shorter hindcast.



GloSea4 history

Summer 2009:
GloSea4 starts

- GA 1.0
- N96L38 Orca(1)L42
- Hindcast: 1989-2002

November 2010:
Model upgrade

- GA 2.0
- N96L85 Orca(1)L75
- Sea-ice initialisation
- Hindcast: 1996-2009

March 2011:
Daily forecast

- Daily initialisation
- Monthly system

Spread derives from:
SKEB2 stochastic physics
Lagged ensemble

Why GLOSEA-4 ?

- **Generate useful information for monthly-seasonal (Climate Services agenda)**
- **Improve models (Seamless agenda)**

Forecasts produced and routinely distributed to:

Cabinet Office; Environment Agency; Insurance; Commercial Customers; WMO; DfID …

Model initialisation

Forecast (daily):

Atmosphere & land surf: NWP analysis

Ocean & sea-ice: Seasonal ODA (based on FOAM system)

Hindcast (1996-2009):

Atmosphere & land surf: ERA-interim

Ocean & sea-ice: Seasonal ODA reanalysis

Fixed start dates of 1st, 9th, 17th, 25th of each month

Ensemble

Seasonal Forecast (to 7 months):

2 members each day.

Monthly Forecast (to 2 months):

4 members, i.e. 2 *extra* members each day (seasonal runs also used).

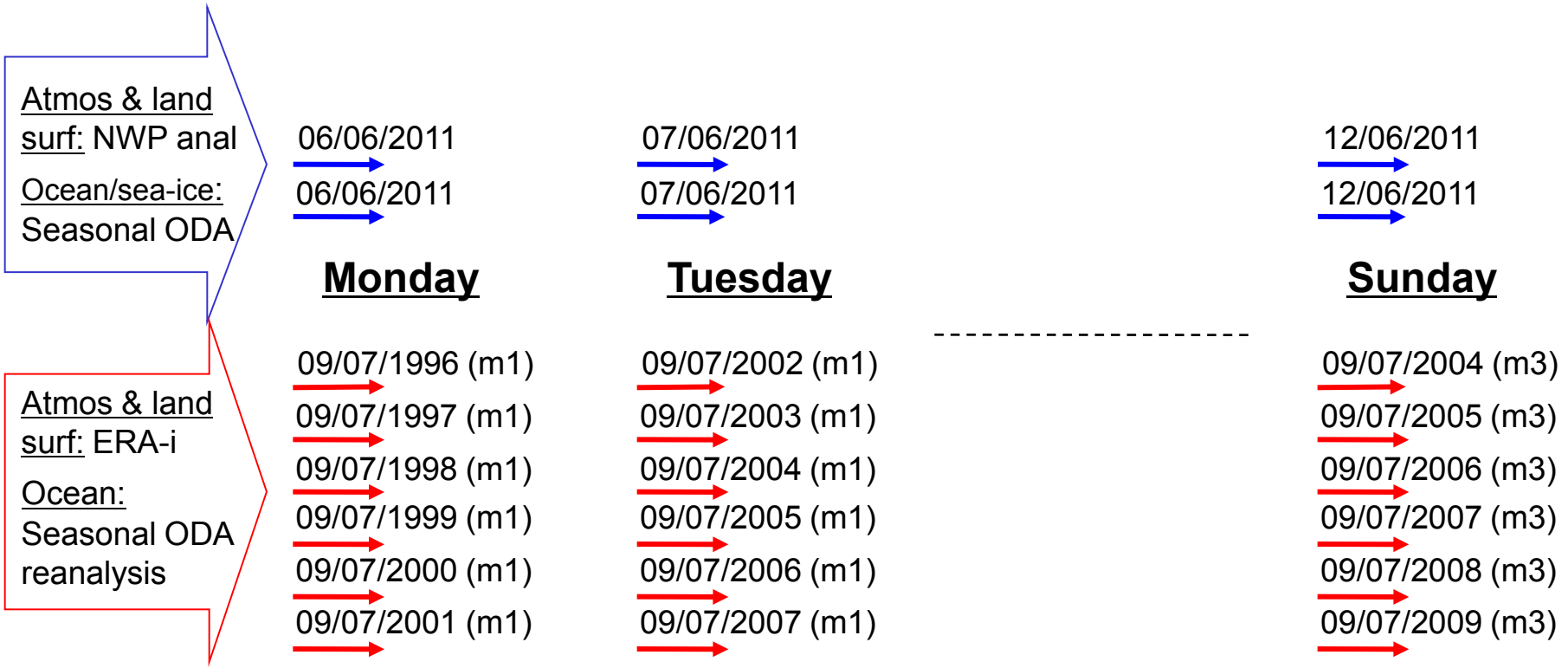
Hindcast (to 7 months):

14 year hindcast

3 members per year (per start date)

Initialised every week (42 members/week) => total of 168 used

Operational running



Each week: **14x 7-month fcst** and **42x7-m hcst** (1996-2009) …
plus **14x2-m fcst** for monthly forecast

Using the Hindcast

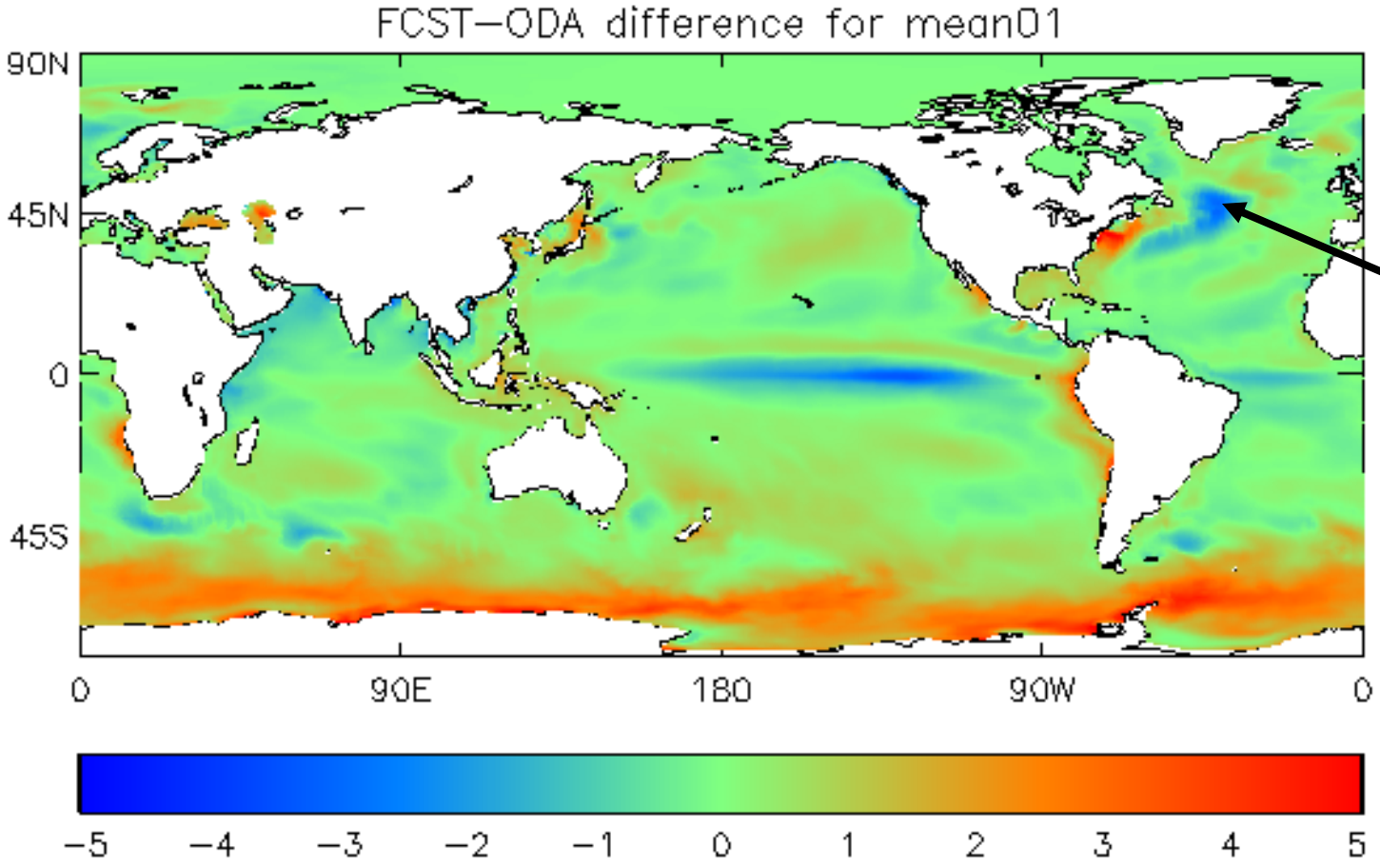
For seasonal, every Monday we do the following:

- Use a lagged approach taking all runs from the last 3 weeks to form a 42-member ensemble
- Each ensemble member is “bias corrected” using the relevant hindcast data (details in Arribas et al. 2011)
- This entails using the hindcast to define the anomaly

$$\text{Bias} = \boldsymbol{f}\,(\ \text{StartDate}, \text{LeadTime}, \text{Region}\ )$$

GLOSEA4 Bias Example

SST - Jan from Nov start



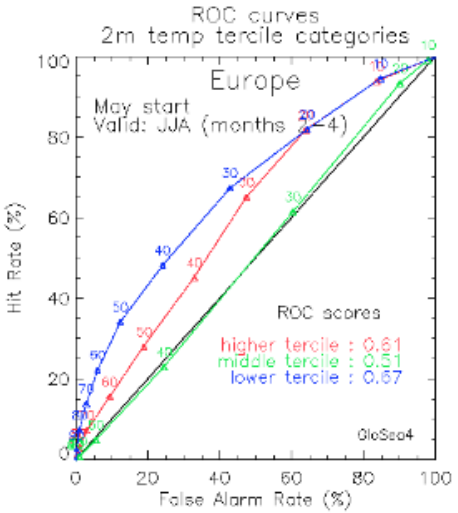
In climate runs this bias reaches ~ -7C, but can be eradicated with a high-res ocean (~0.3 deg)

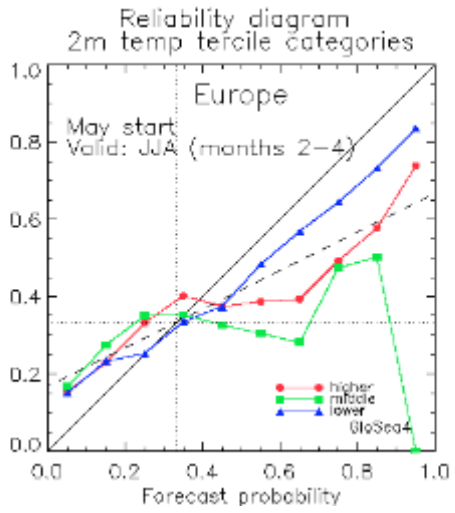
A marked improvement (increase) in blocking results

2. Performance

- some examples
- focus on:
    - memory / underlying surface
    - key weather events
    - more predictable aspects

Hindcast: skill and calibration of forecast





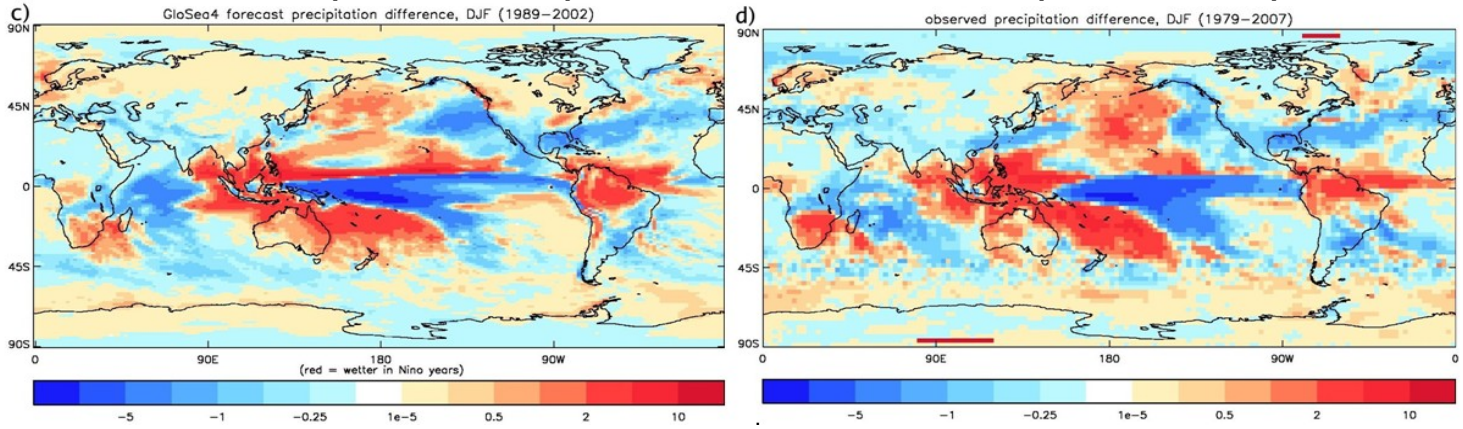
Probabilities

ENSO Teleconnections - Precipitation

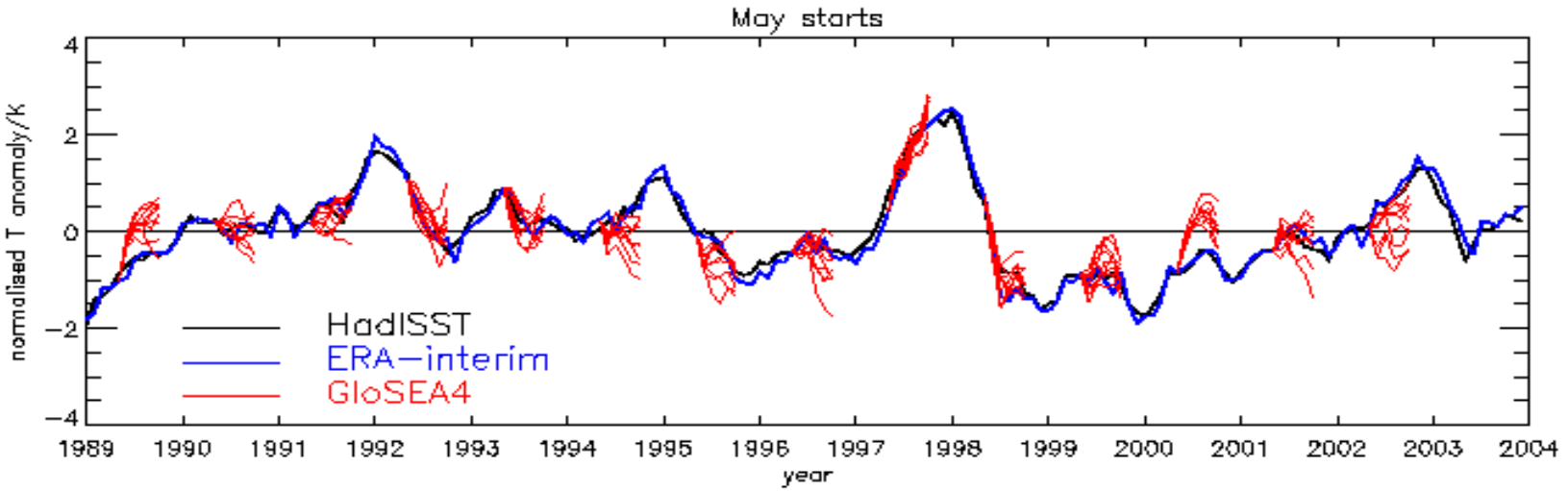
Fcst (nino – nina)

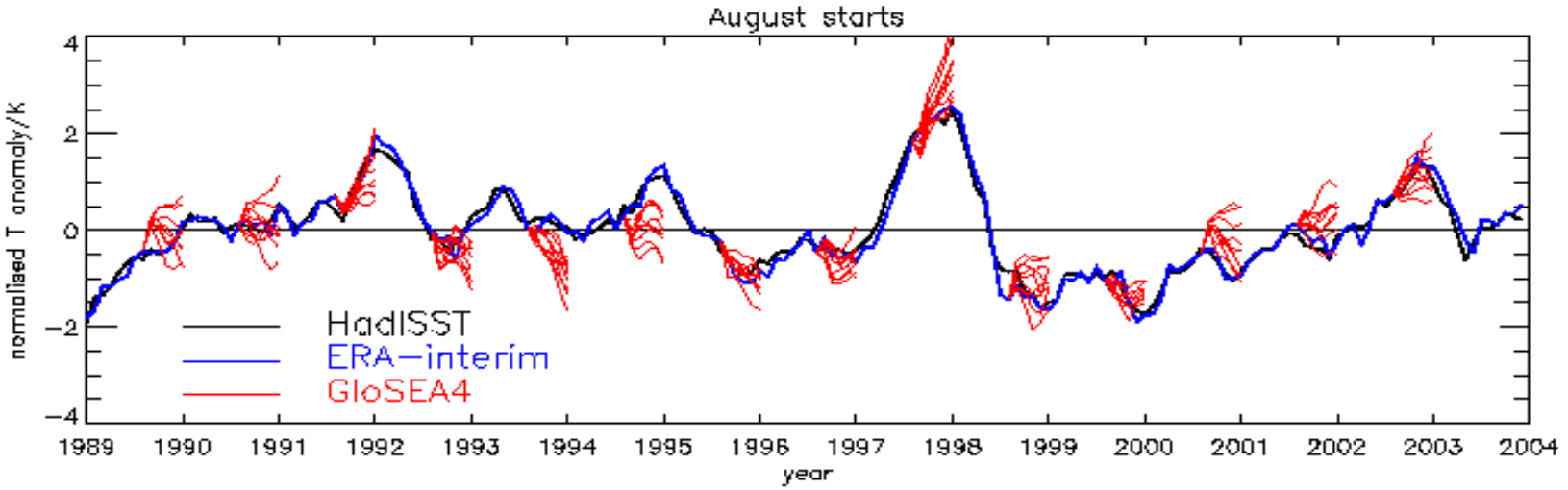
Obs (nino – nina)

DJF

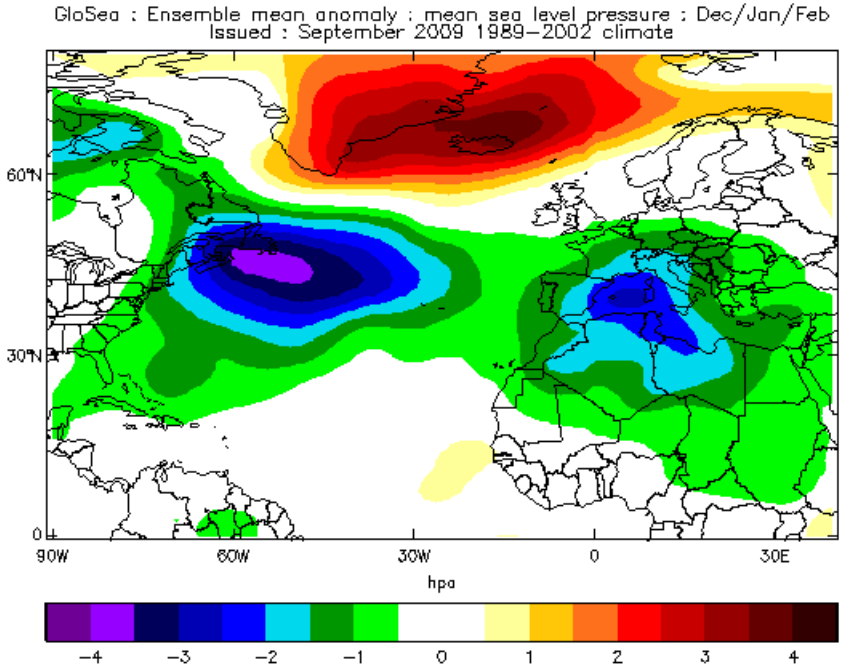


ENSO



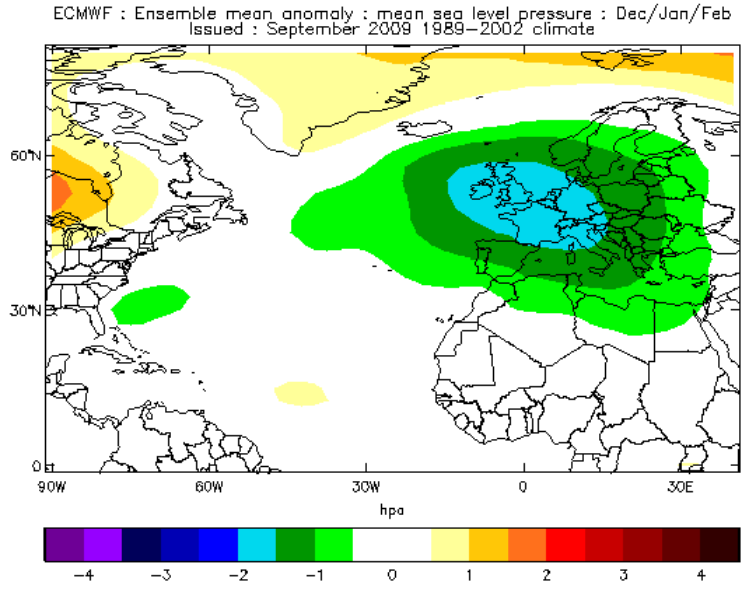


2009/10 Winter:
September run: pmsl anomalies for DJF

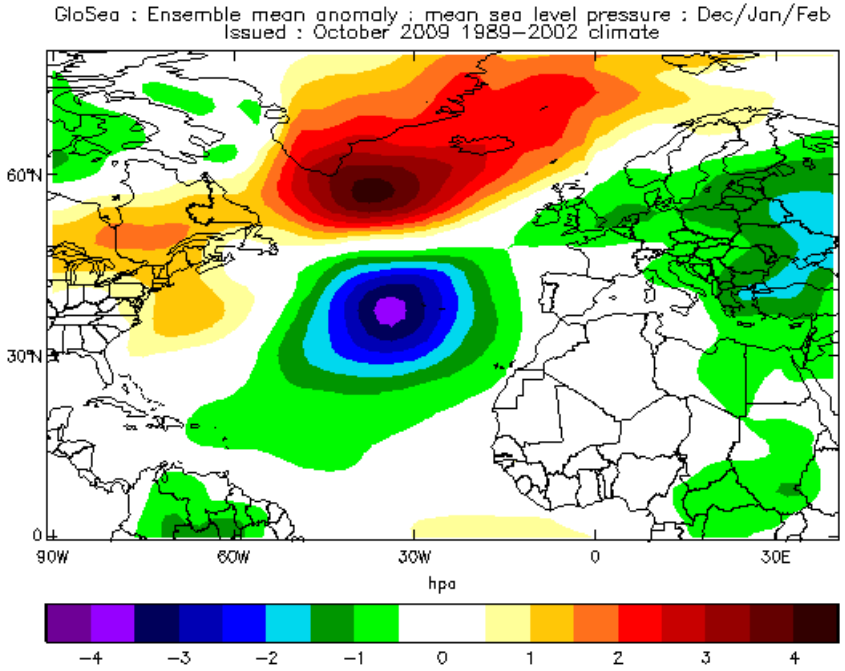


GLOSEA4

ECMWF



2009/10 Winter:
October run: pmsl anomalies for DJF



GLOSEA4

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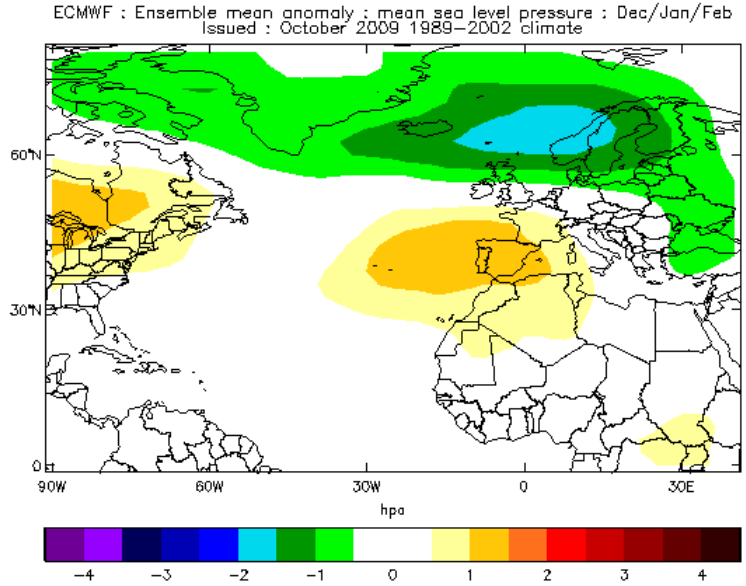
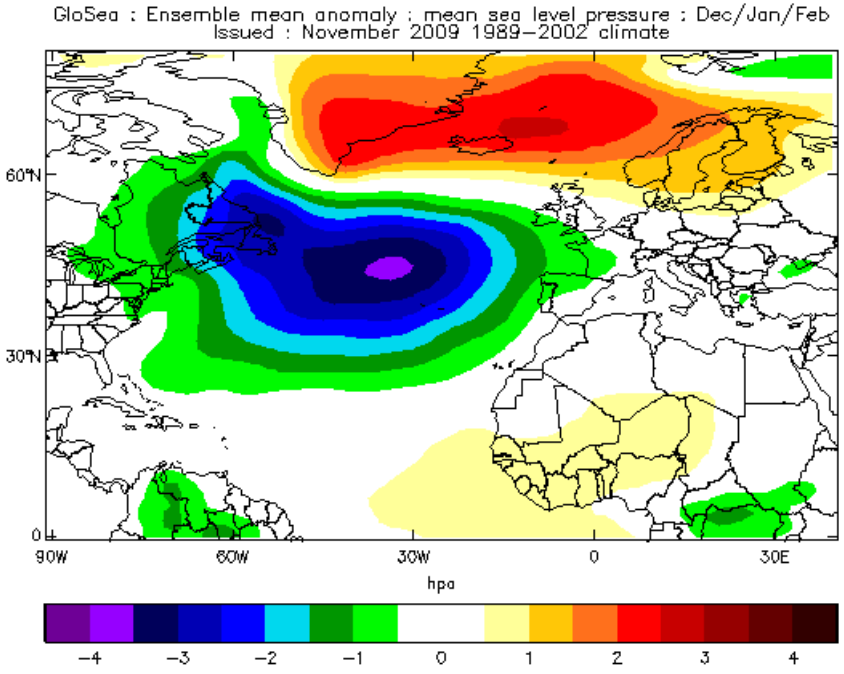


2009/10 Winter:
November run: pmsl anomalies for DJF



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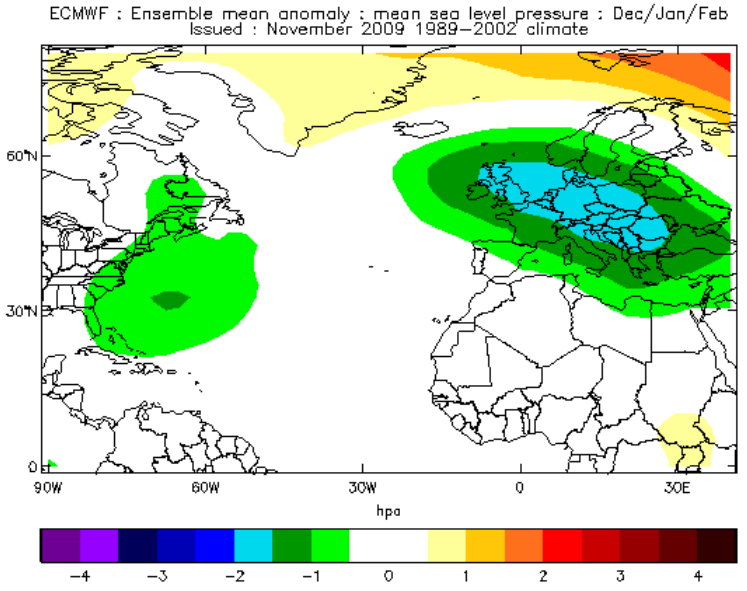
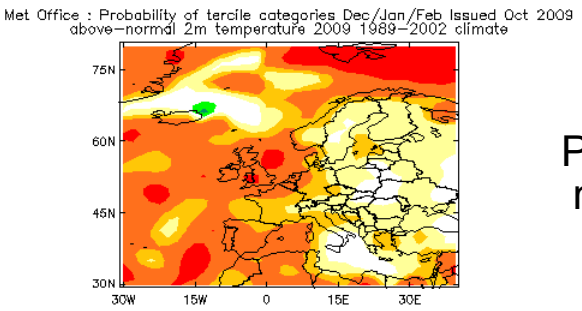
ECMWF

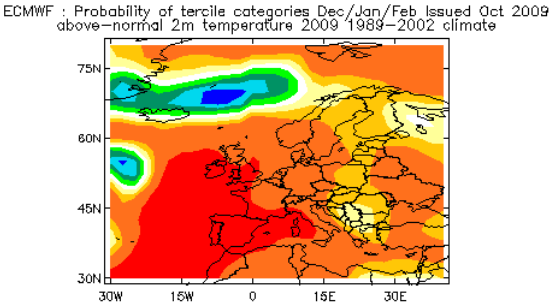


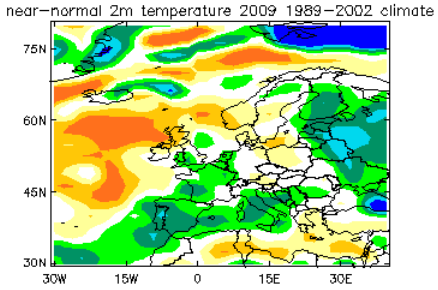
October run: t2m probs for DJF

GloSea4

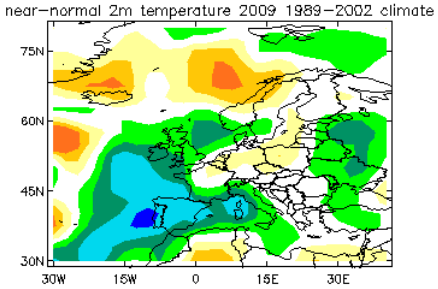


Prob. mild

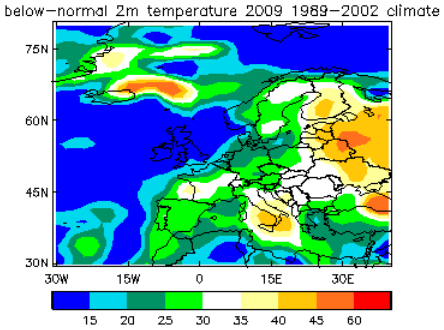




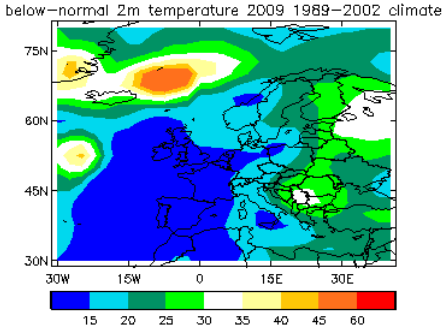
Prob. average



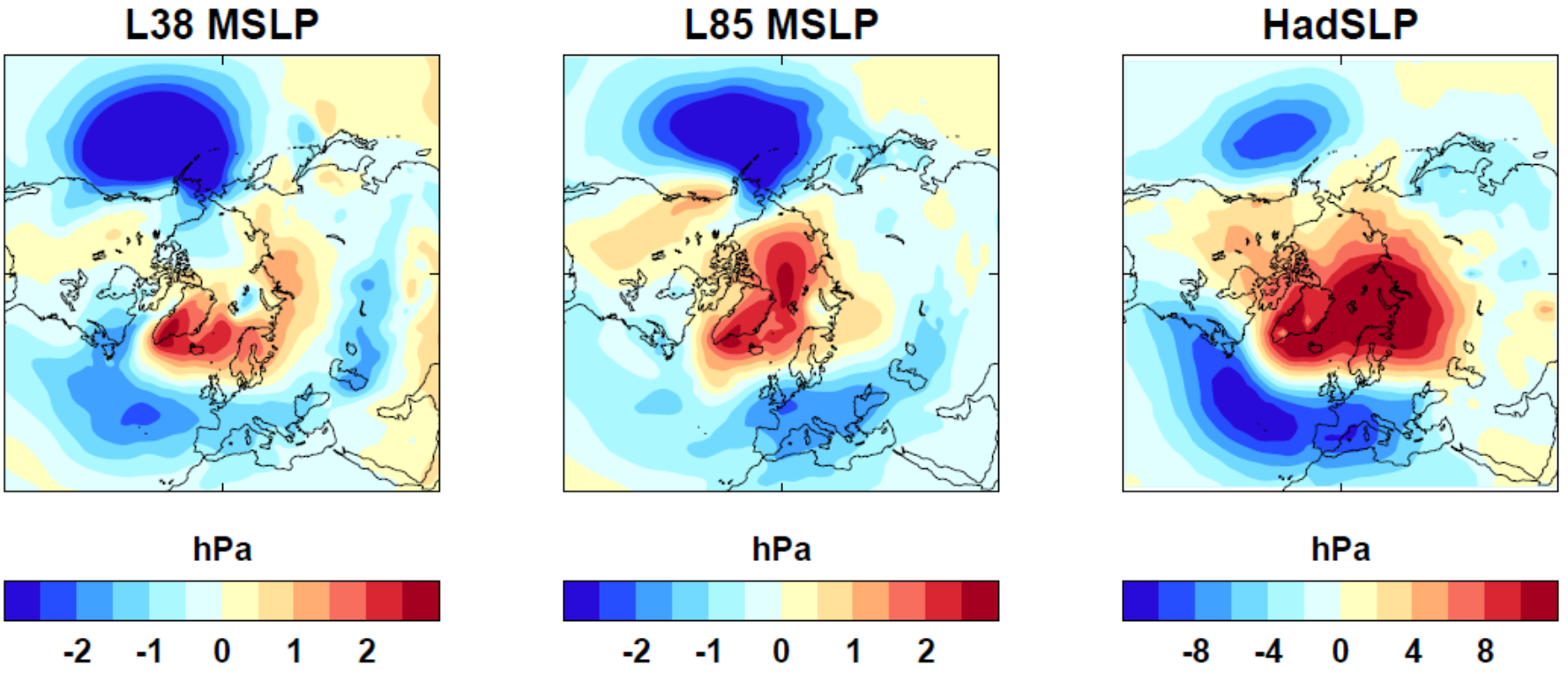
ECMWF



Prob. cold



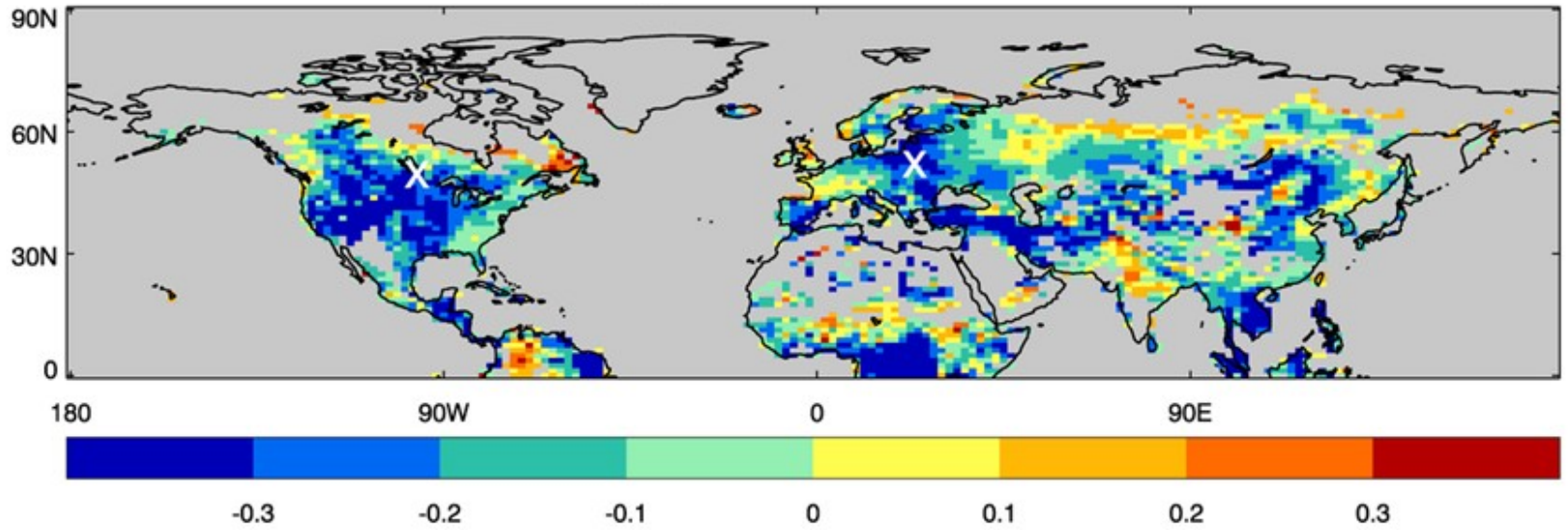
GLOSEA4 DJF 2009/10 Forecasts from Nov



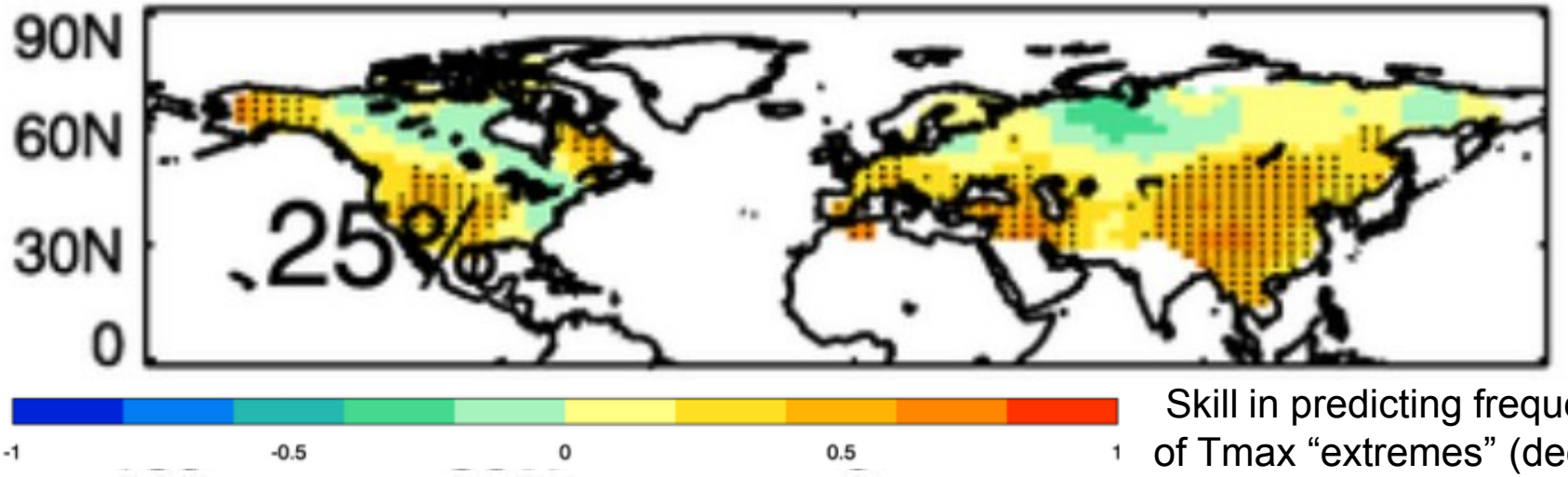
Winter 2009/10 forecasts

- NAO-minus signal consistently seen in forecasts from GLOSEA4, but not from ECMWF
- Magnitude of mslp anomaly not nearly large enough (~25% of observed)
- Synoptically, the 2m temperature forecasts looked inconsistent with the mslp anomaly
- 85-level model seems to show a *slight* improvement vs 38-level model, believed to reflect the role of the stratosphere, which is better represented in the former

Correlation coefficient for **May soil moisture anomaly** (top 2m, from **ERA-I**) vs **Forecast Mean JJA Tmax** in 21 years of GLOSEA4 May hindcasts



a) Soil removed

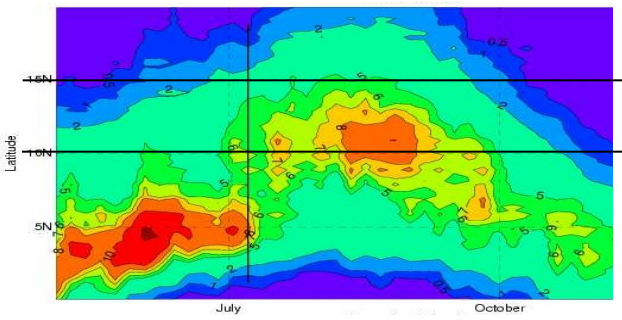


Skill in predicting frequency of Tmax "extremes" (deciles) in JJA from May (rank correlation)

West African Monsoon Onset

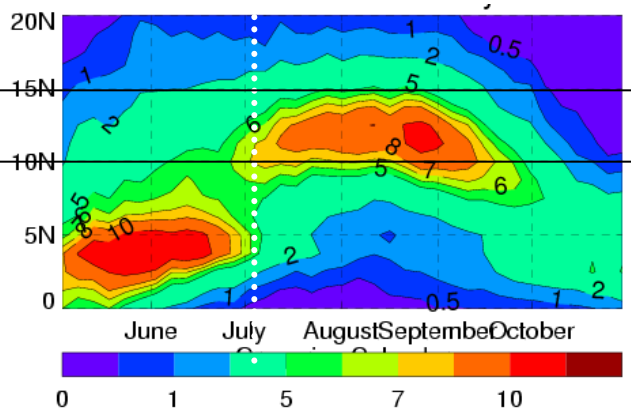
(10W-10E, May forecasts)

PPN OBSERVATIONS
(TRMM 1998-2010)



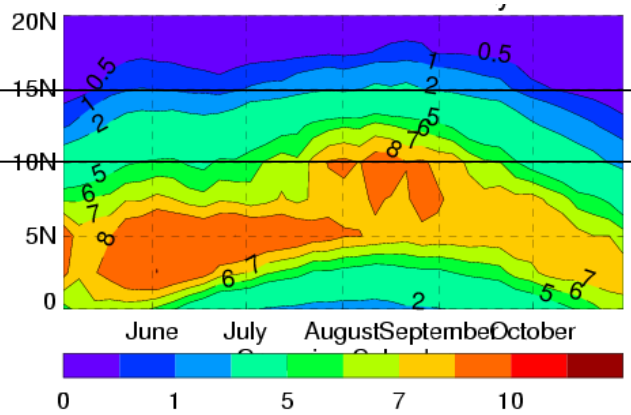
Met Office Seasonal forecast GloSea4

1996-2009 mean



ECMWF System 3

1979-2005 mean



Climatology of the monsoon onset:

- This particular GLOSEA4 version is good, but performance can deteriorate with upgrades

Interannual variability in the timing of the monsoon onset:

- Met Office seasonal forecasts beat climatology

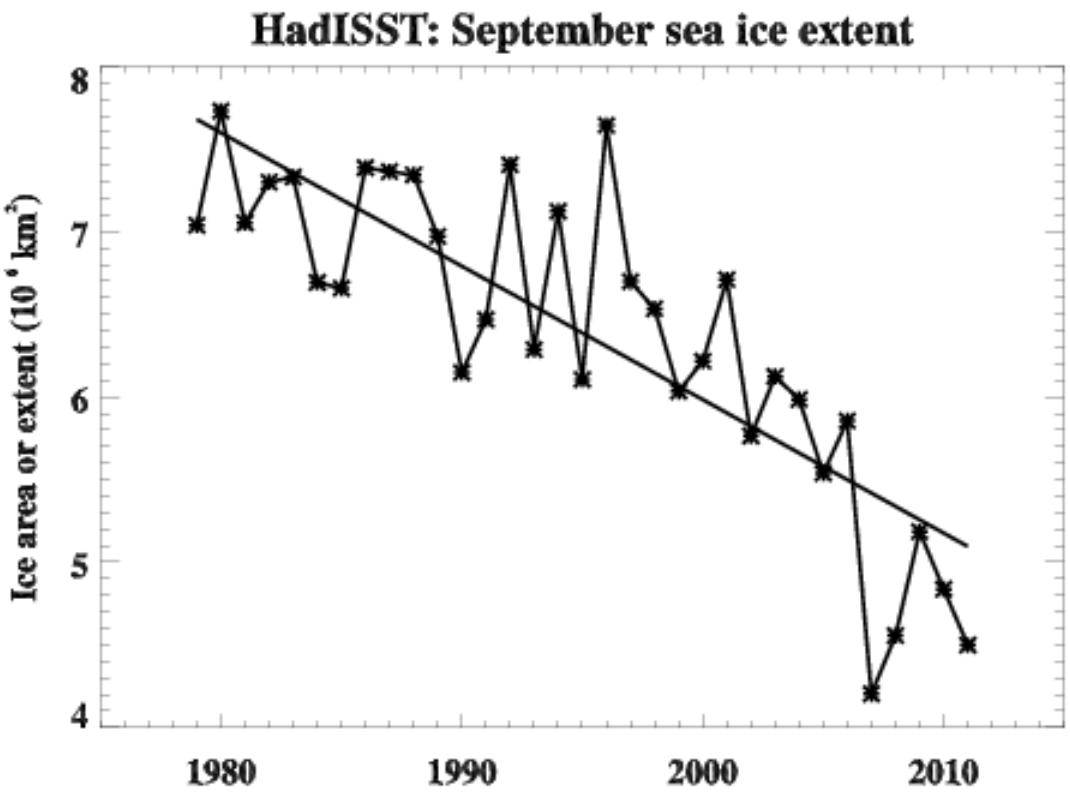
Some key factors (?), vs ECMWF:

- Capturing mslp variability in desert heat low. Capturing variability in Gulf of Guinea SST's.

Sea Ice

- Key features of GLOSEA4 are the sea ice initialisation, and the sea ice model
- Recent studies – eg Francis et al (pre-dating the last two winters) suggest sea ice depletion may enhance the likelihood of AO-minus (and NAO-minus) winters
- Rapid sea ice depletion, that we are now seeing, renders models that use climatological sea ice less relevant
- However any interactive sea ice model must be able to correctly represent the evolution….

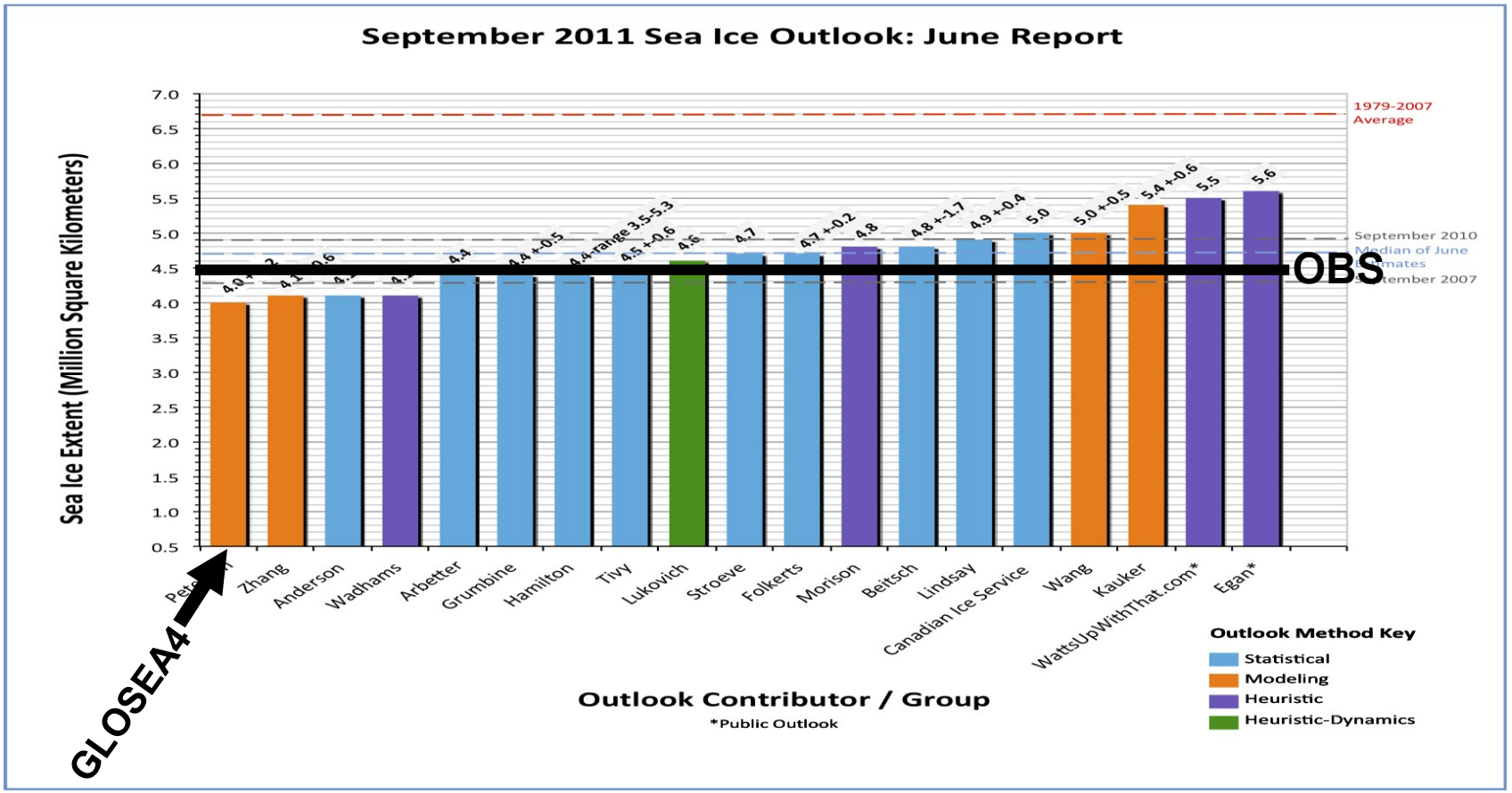
September Arctic Sea Ice



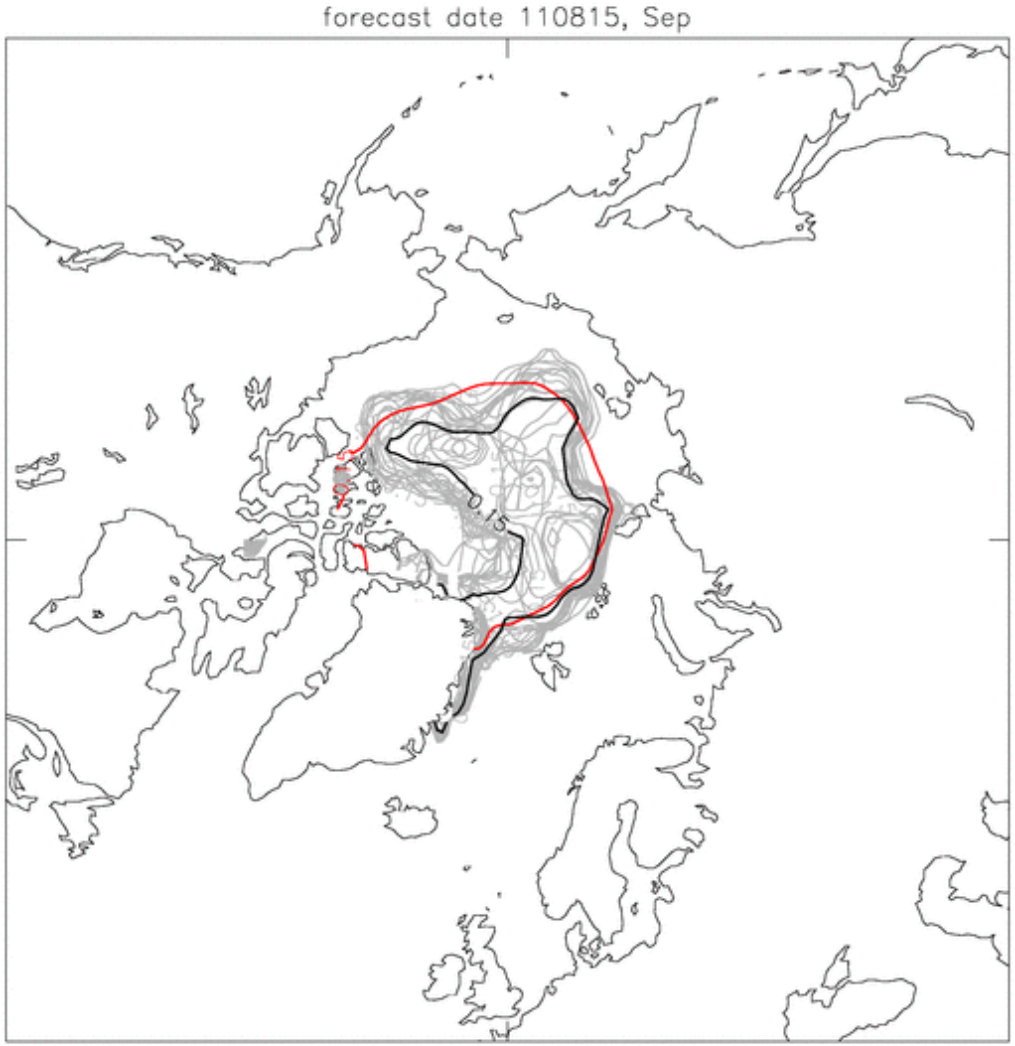
- Monthly minimum extent for September 2011 was 4.50 million sq km
- September 2011 was the 2nd lowest extent on record
- Rate of decline ~ 0.8 million square km per decade
- Last 5 years have seen the lowest 5 extents in the obs record

What was predicted to happen to Arctic sea ice in Summer 2011?

(Forecasts from June, for Sep)



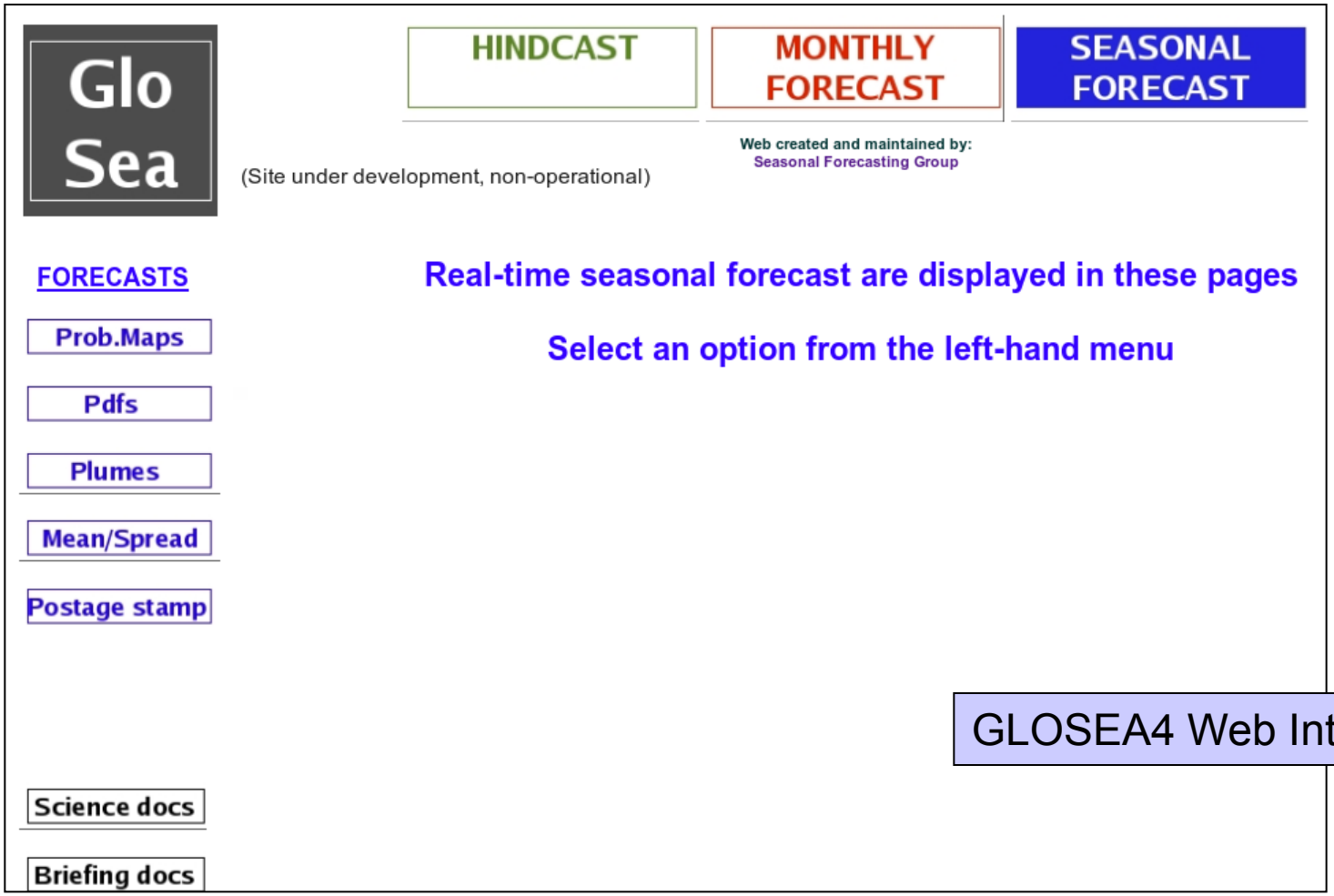
GLOSEA4 Sea Ice forecast example



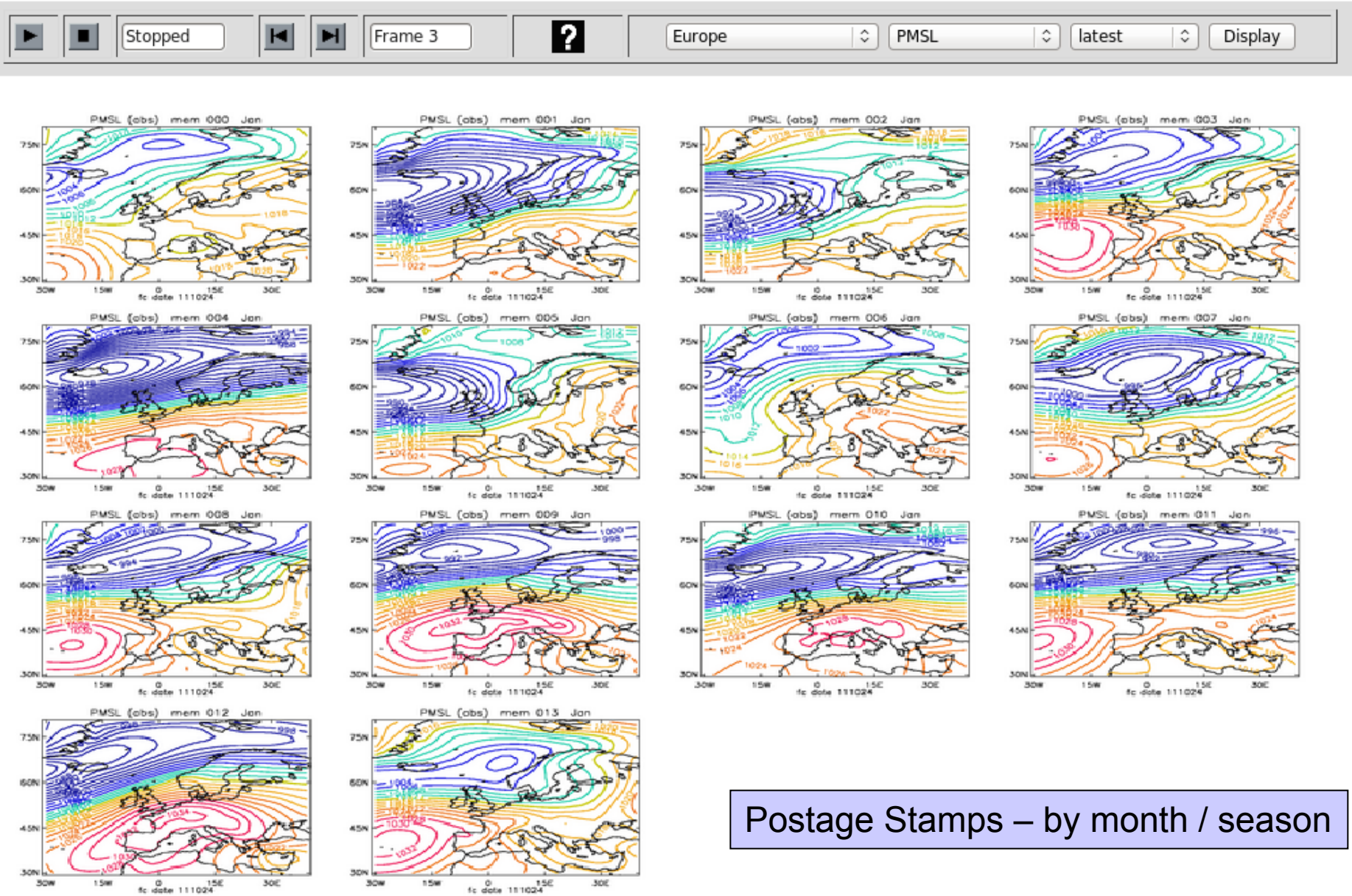
RED = Hindcast Mean
GREY = EPS member
BLACK = EPS mean

15% cover contour

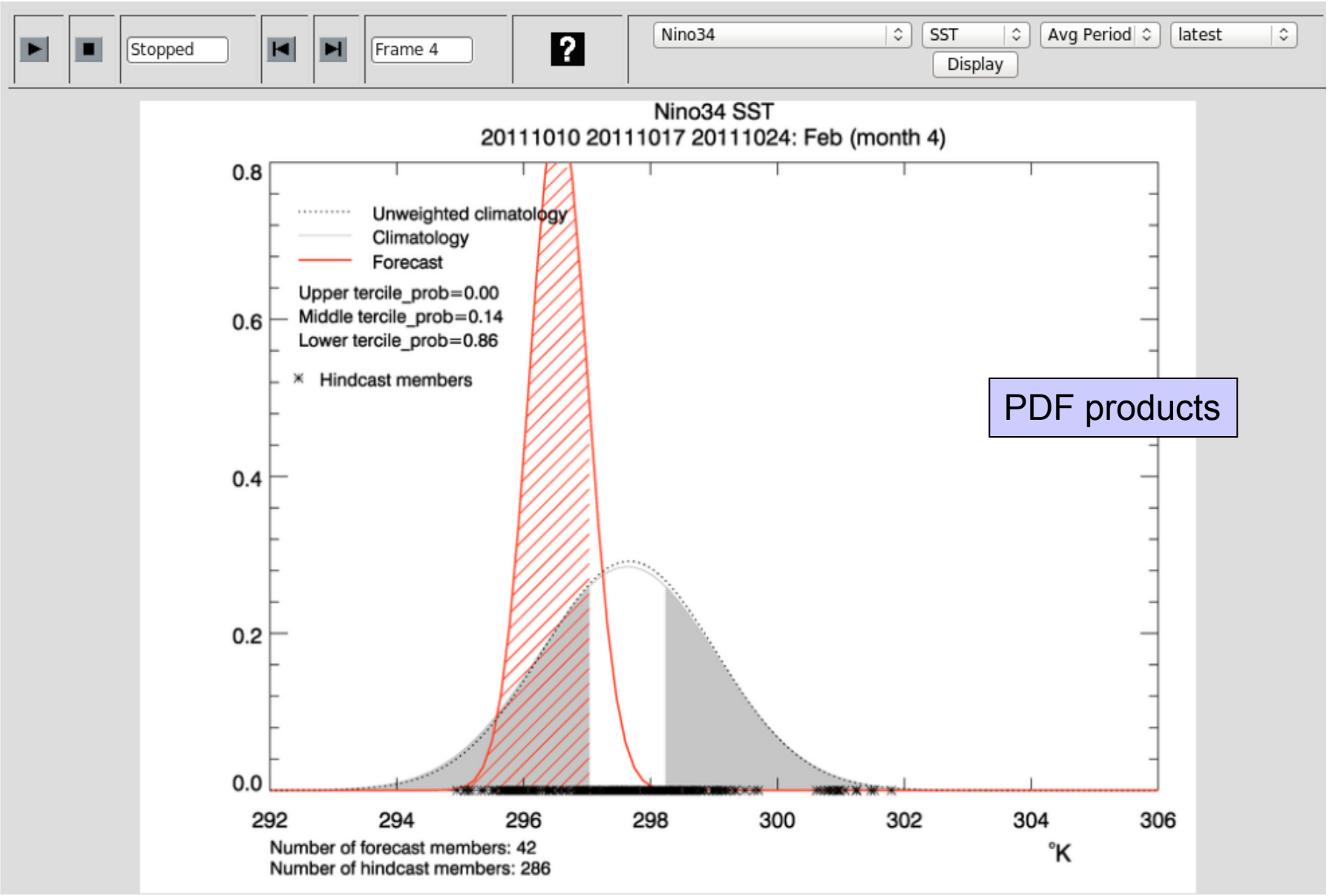
3. Products – a few examples



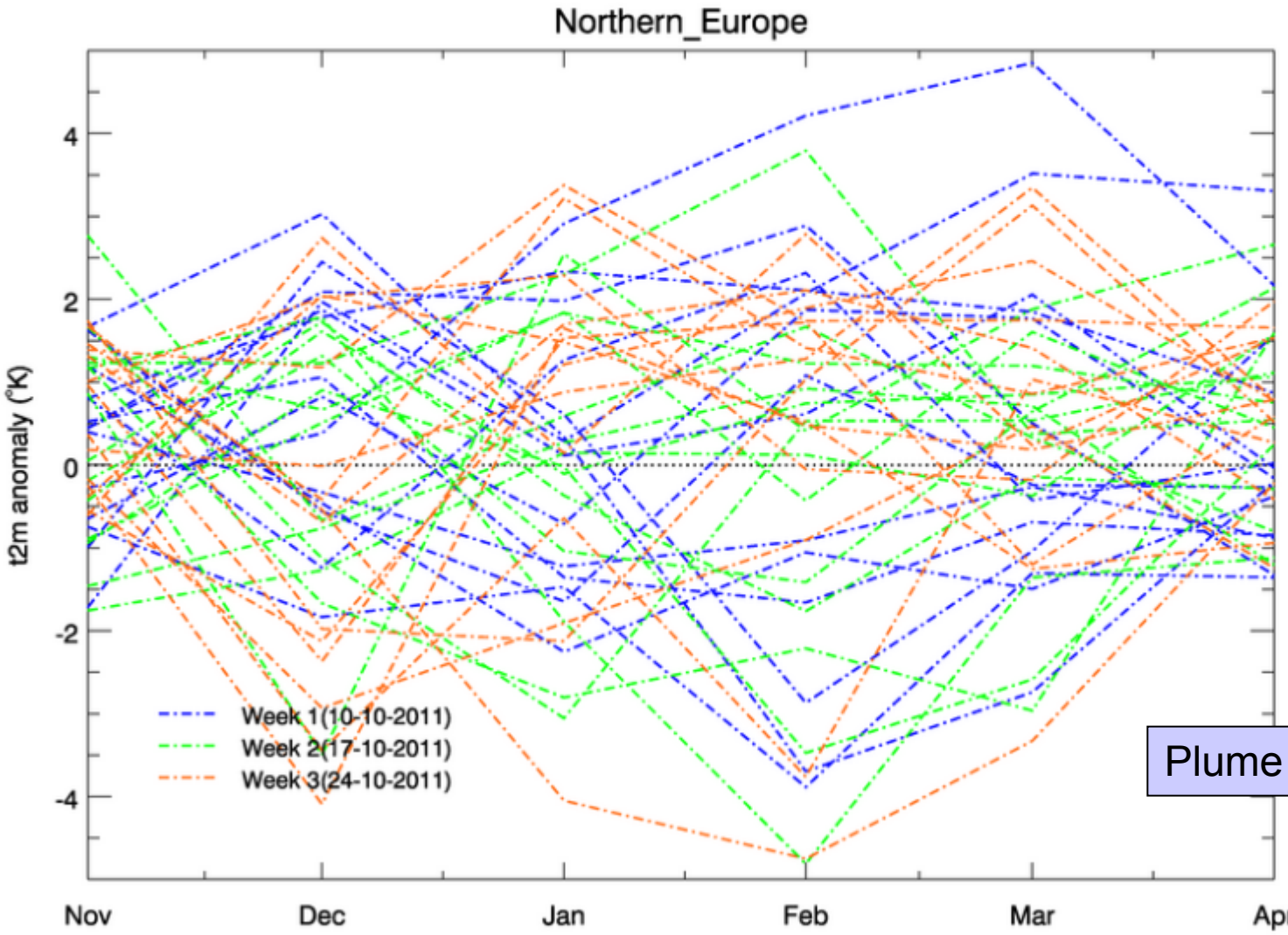
GLOSEA4 Web Interface



Postage Stamps – by month / season



Regions:	Variable:	Time of run:
Northern Europe	2m temp	latest



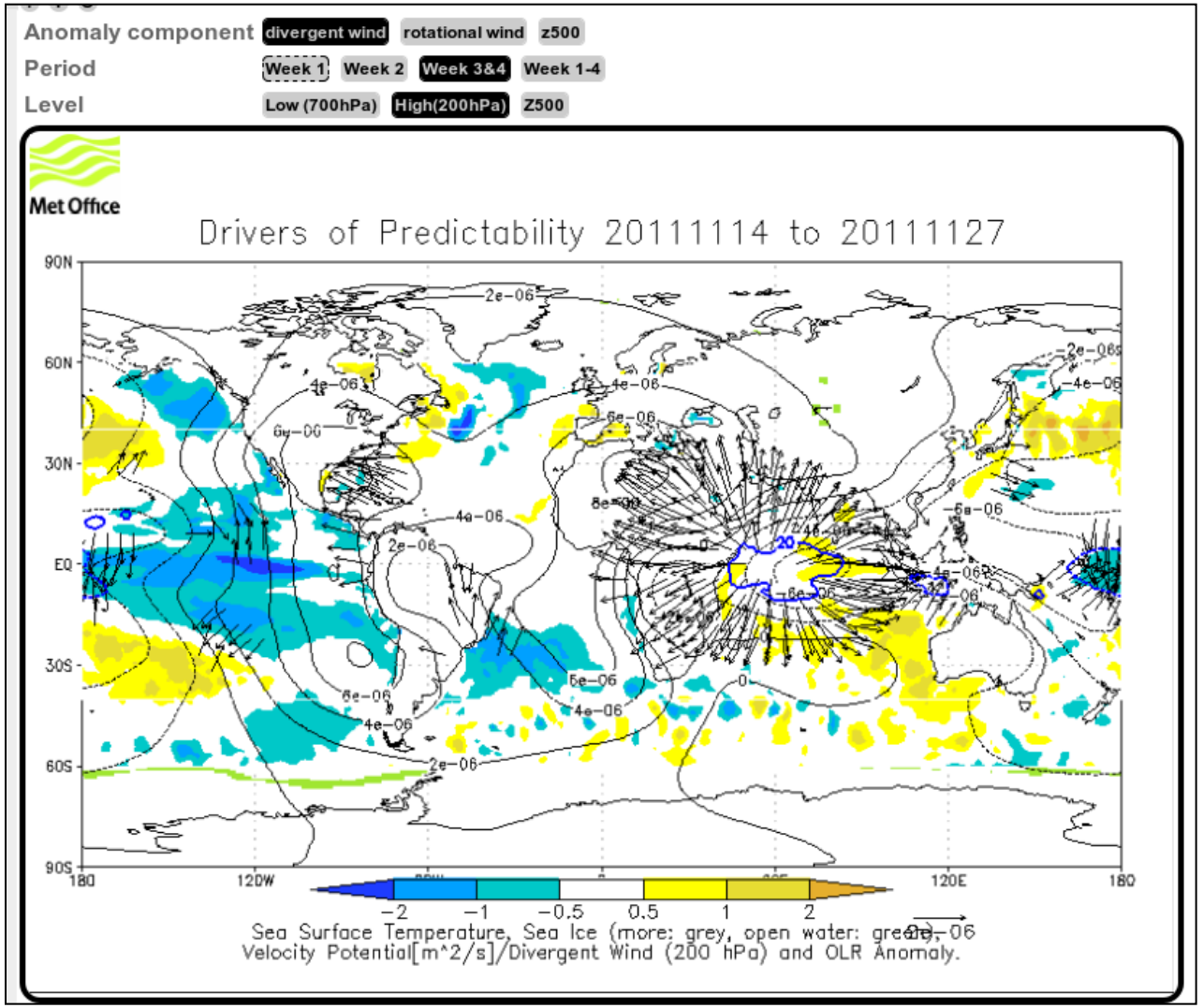
Plume diagrams

“Drivers of predictability”

Currently used with ECMWF monthly forecast.

May also be applied to GLOSEA4 Monthly component in due course.

MJO, SST, Sea Ice, …

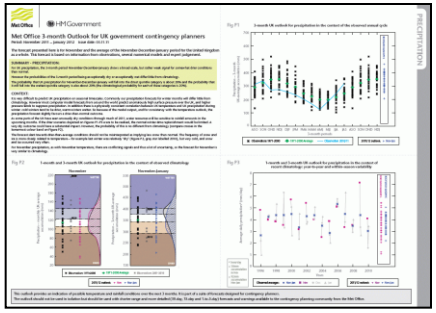


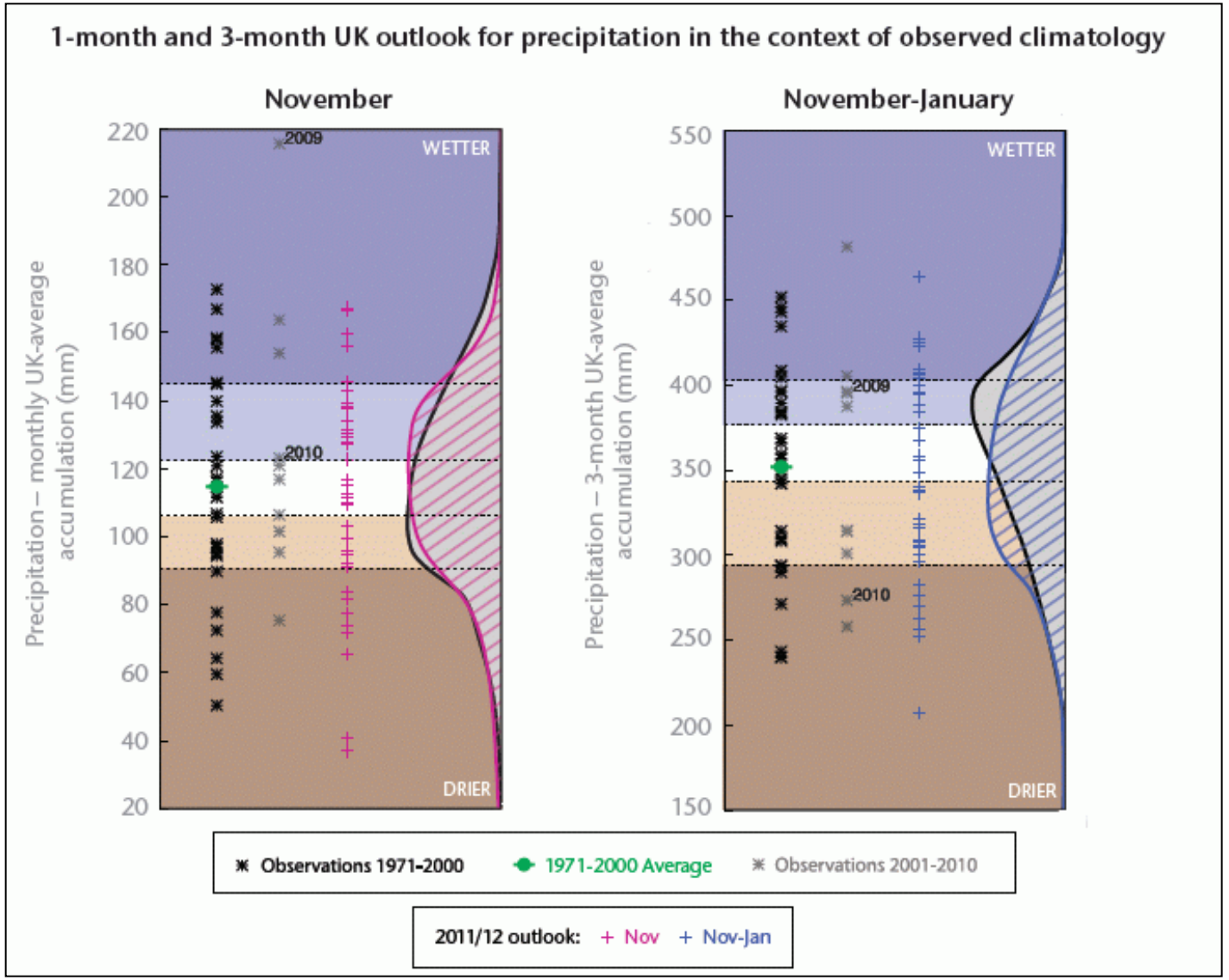
4. New Met Office Seasonal Forecast Product – the "3-month Outlook"

- Designed for contingency planners.
- But will be made available for all on the web (as of this afternoon!)
- Valid for the UK
- New structure – broadly based on GLOSEA4 runs, but incorporates every source of relevant data (forecasters will be able to make modifications to the GLOSEA4 output)
- Much more probabilistic slant, highlighting the full range of possible solutions, placing these in the context of climatology, and in particular in the context of the recent past
- Specific focus on the outer quintiles (extremes have disproportionate impacts)

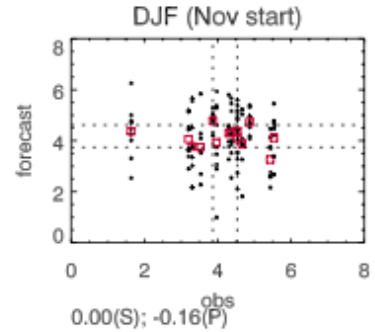
New Met Office Seasonal Forecast

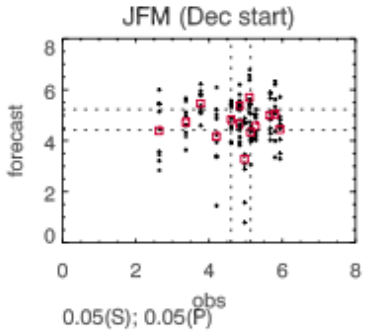
-based on GLOSEA4, but incorporates multiple runs / data sources

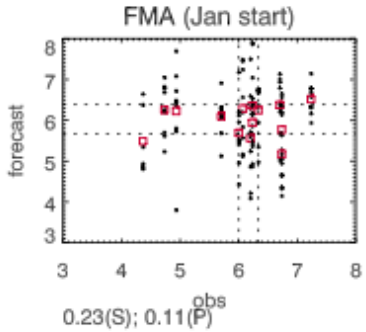


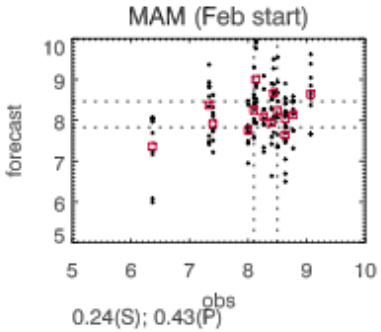


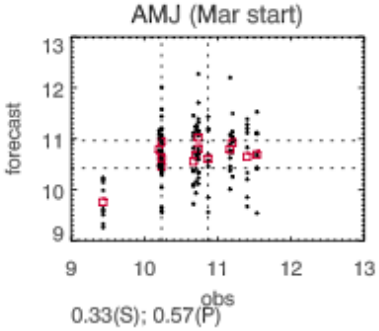
Temperature: All_points_UK_land

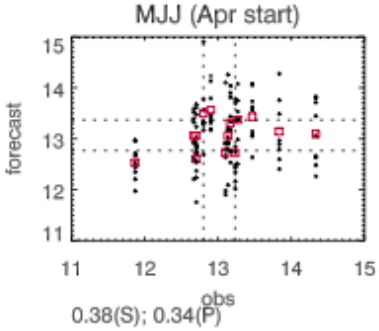


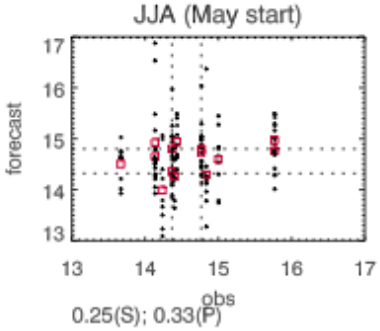


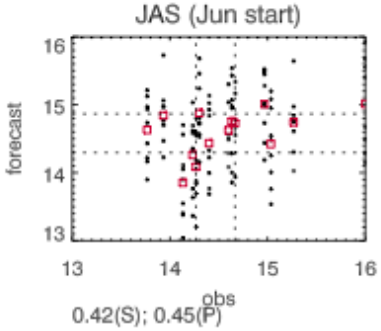


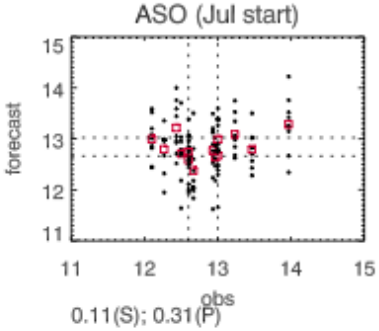


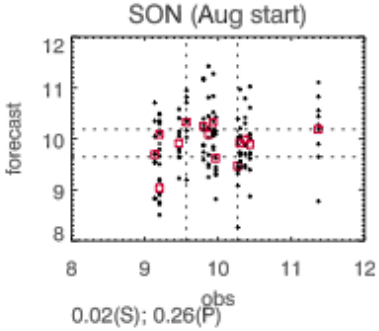


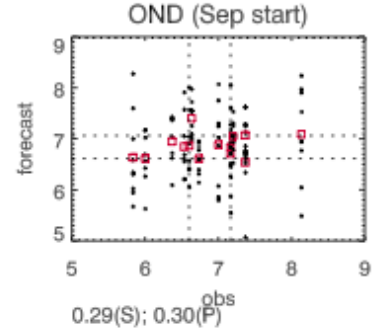


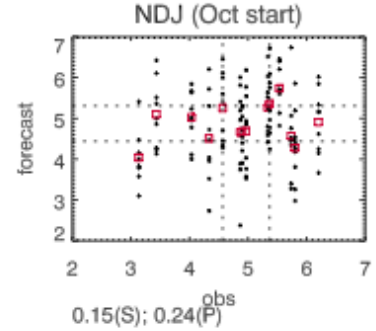












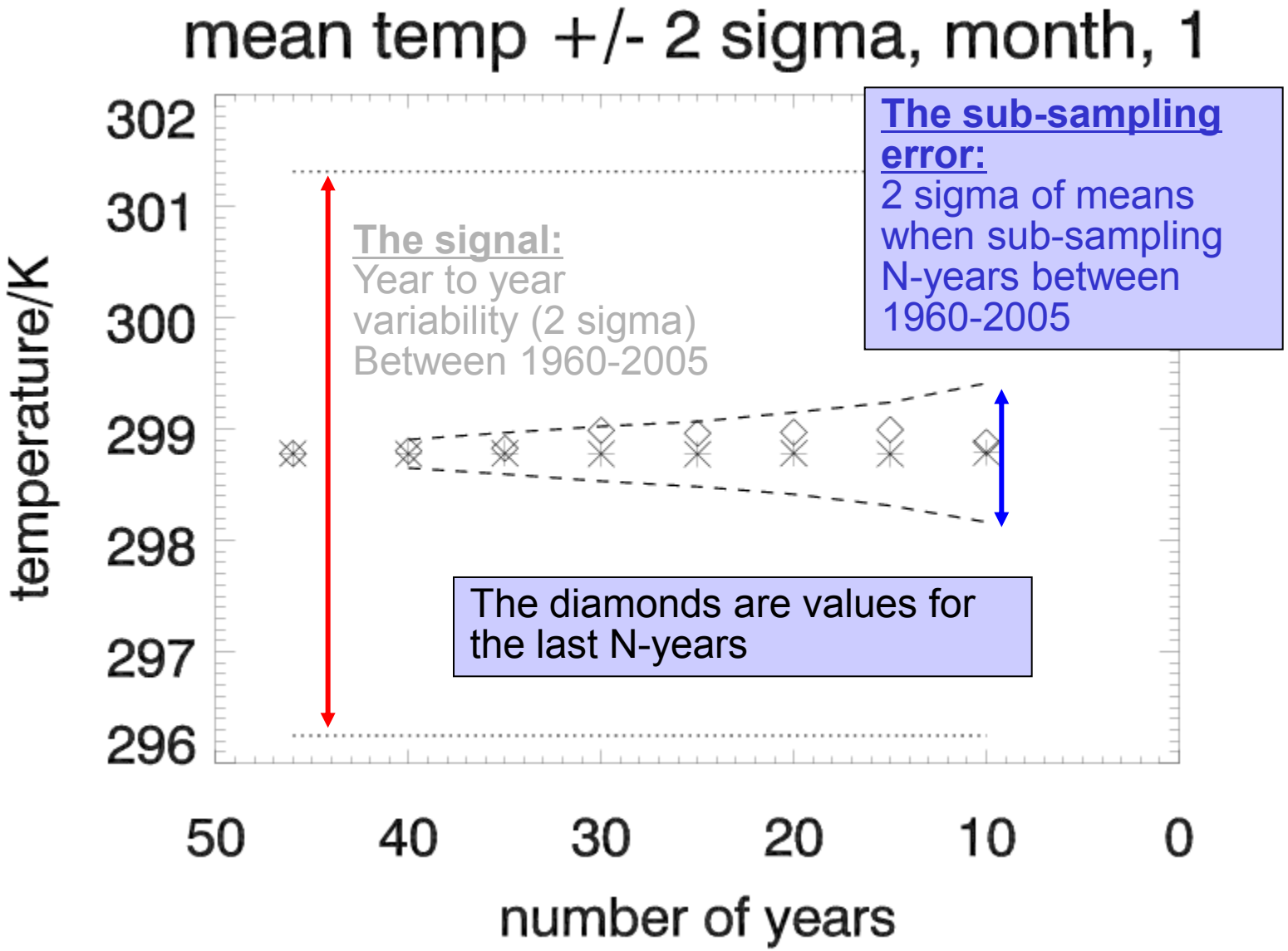
Summary

- The Met Office now runs a fully coupled seasonal and monthly forecasting system, GLOSEA4, in real time – seasonal is operational, monthly will become operational
- The system features initialised and modelled sea ice, and a 14-year hindcast run in real time
- Upgrades from 38 to 85 atmopsheric levels show hints of improved skill, but no more
- There is evidence of useful forecast skill in a number of areas, but there are also stubborn biases in key regions
- The seasonal products are now underpinning the new and greatly improved Met Office seasonal forecast
- As well as providing products for customers, the system fills a gap in the seamless modelling world, assisting in model development for both shorter range forecasting and climate prediction commitments

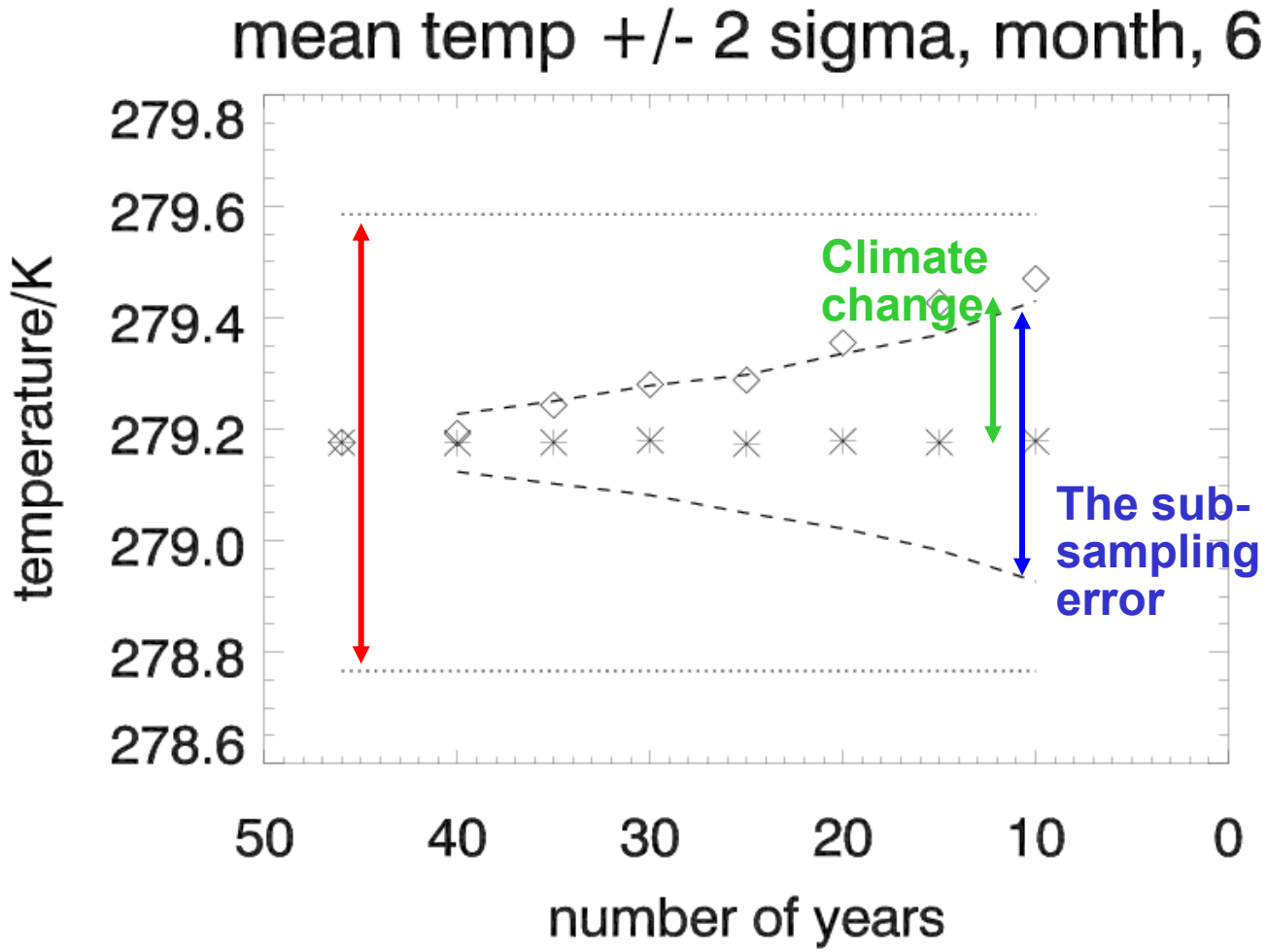
Any Questions ?

X. Hindcast Length

Nino 3.4; from Nov, lead 1



N. Europe, from Nov, 6 month lead



The length of the hindcast is not the issue:

The signal we are trying to predict (year to year variability, red line) is **larger than** the sampling error we make, regarding the mean, when having a shorter hindcast (blue line)

The issue is much more about what period we take for the hindcast as recent years are warmer (as in the Northern Europe example)

Observing systems have also changed and we have more and better observations now than we did in the past (especially relevant for the ocean)

The length of the hindcast is not the issue:

14 years is enough to estimate linear bias correction

When/where there is skill, 14 years can also be enough for calibration of terciles (e.g. Hurricanes: Vitart et al, 2007)

When/where there is no skill or when the forecast is subdivided into several categories (e.g. quintiles) 14 years may not be enough for calibration

However … there is little point in determining very accurately how low the low skill is. The challenge – and our strategy – is to improve the skill. For that, a “short” hindcast is preferable because it allows us to fully integrate the seasonal system within the model development and speeds up improvements

Using Hindcasts and Forecasts to make the Unified Model better

- Hindcasts are a very useful research database (CAPTIVATE, Willis), as are the Forecasts (4 daily coupled model runs)
- Hindcasts are critical but expensive… Ours is actually “cheap”. We follow a different (controversial) approach in the seasonal forecasting community: Short-hindcasts (14 years) run in real-time
- The reason for this is to facilitate model/system upgrades -> i.e. **improve the model faster**

Is the Strategy working?

Are we improving the model and increasing the skill of the forecasts with each upgrade?

Haven't fully answer this yet. It is challenging. Preliminary signs are positive but …

- Stubborn mean errors (e.g. Tropical Pacific cold bias)
- Difficult to understand mechanisms, even in successful forecasts: winters 09/10 and 10/11; Russian heat wave …

GloSea4 Collaboration

KMA (Rep. of Korea)

Joint seasonal forecast system

Shared workload, possibility to extend hindcast.

NCMRWF (India) – starting to use GloSea for research

DFID (Dept. For International Development)

South African weather service analysing data from GloSea4 hindcasts

Fig T2

1-month and 3-month UK outlook for temperature in the context of observed climatology