Progress in seasonal prediction at the Met Office (GPC Exeter)

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Outline

- history
- methods
- products
- validation

Historical perspective

The Met Office

- was one of the first Global Producing Centres of Long-Range Forecasts (GPC Exeter)
- has been at the forefront of development of modelling and forecasting tools
  - development of coupled atmosphere – ocean general circulation models (GCMs), tested in weather forecasting and climate modelling mode
  - ensemble prediction systems for weather, seasonal, climate timescales
- has been active in engagement with users (National Met Services, RCOFs)

Met Office
Global Seasonal Forecast System 5 (GloSea5)

Model:

- high complexity (ocean, atmosphere, sea ice)
- high resolution, both in vertical and horizontal, in ocean and atmosphere

strong link of forecasting system to model development – to put model improvements into operational forecasts as soon as possible

Initialisation with observations

Ensemble of predictions, to quantify effect of uncertainties (from initial state, model formulation, internal variability)

Technically the most advanced there is…

GloSea5 operational system (since June 2013)

Model version: **HadGEM3 GA3.0**

Resolution: **N216L85 O(.25)L75**
(0.83^{o} long x 0.55 ^{o} lat; ~50 km atm.)

Simulations length: **7 months**

Model uncertainties represented by:

- SKEB2 stochastic physics (Tennant et al. 2011)

Initial conditions uncertainties represented by:

- Lagged ensemble

Initialisation of the system

Forecast (initialised daily):

- Atmosphere & land surf: Met Office NWP analysis (4d-Var) (currently running with land surface initialisation switched off)

- Ocean & sea-ice: NEMOVAR (3d-Var joint system for ocean, med-range, monthly and seasonal)

14-year 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
- 3 members per start date

Ensemble: lagged approach

Seasonal Forecast:

- 2 members run each day.

- Seasonal forecast updated weekly by pulling together last 3 weeks (i.e. 42 members)

Monthly Forecast:

- 2 additional members run each day.

- Monthly Forecast updated daily by pulling together last 7 days (i.e. 28 members)

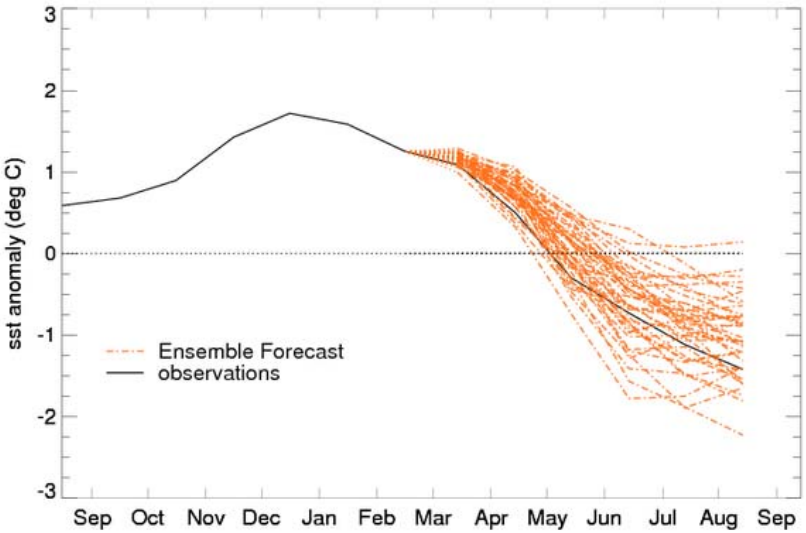
Hindcast (for monthly-seasonal):

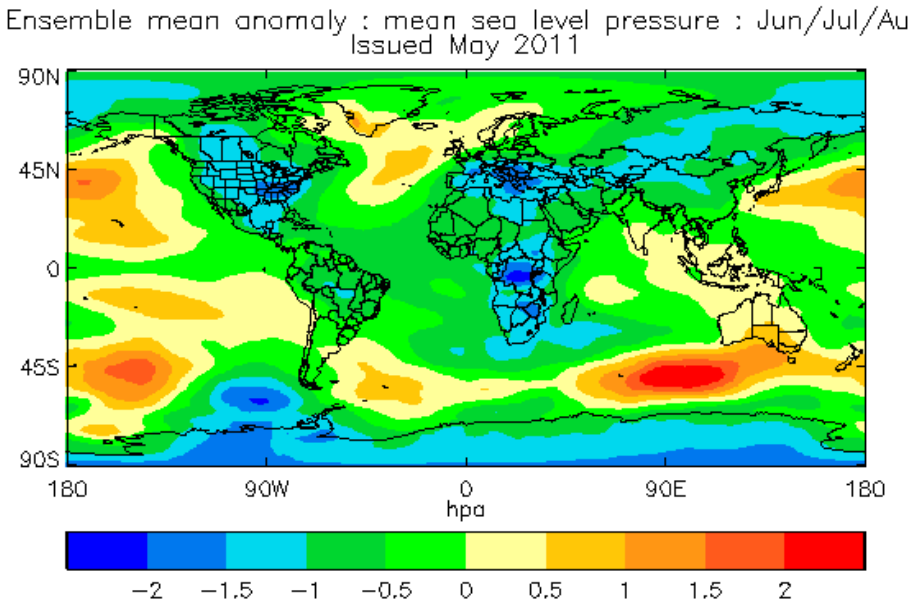
14 year hindcast *run in real time* (42 members run each week = 14 years x 3 members)

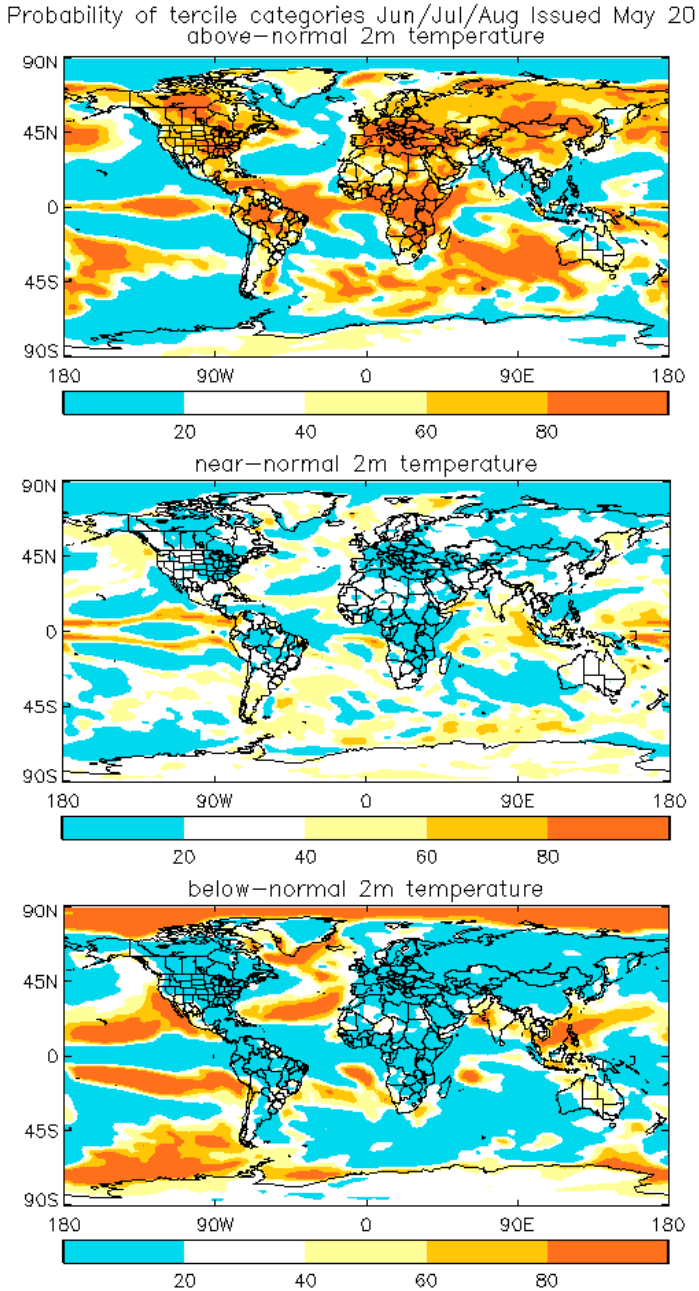
Forecast products/information

- products on Met Office website (examples on next slides)
- contribution to multi- model ensembles (EUROSIP, APCC, LC-LRFMME)
- support to RCOFs: Africa (GHACOF, PRESAO, SARCOF), Asia (FOCRAII, SASCOF), Europe, Southeast Asia

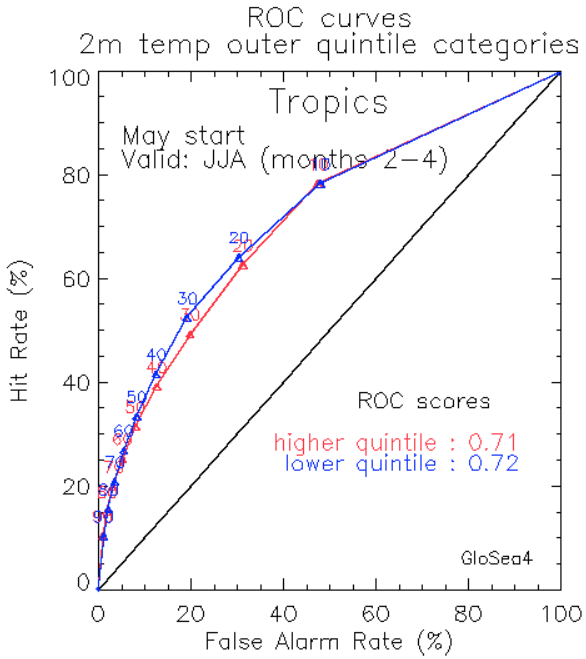
Forecast maps/graphs



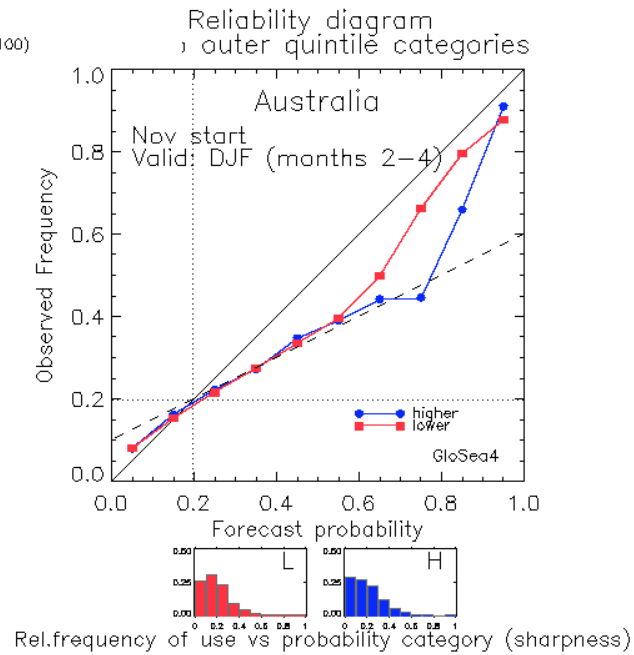


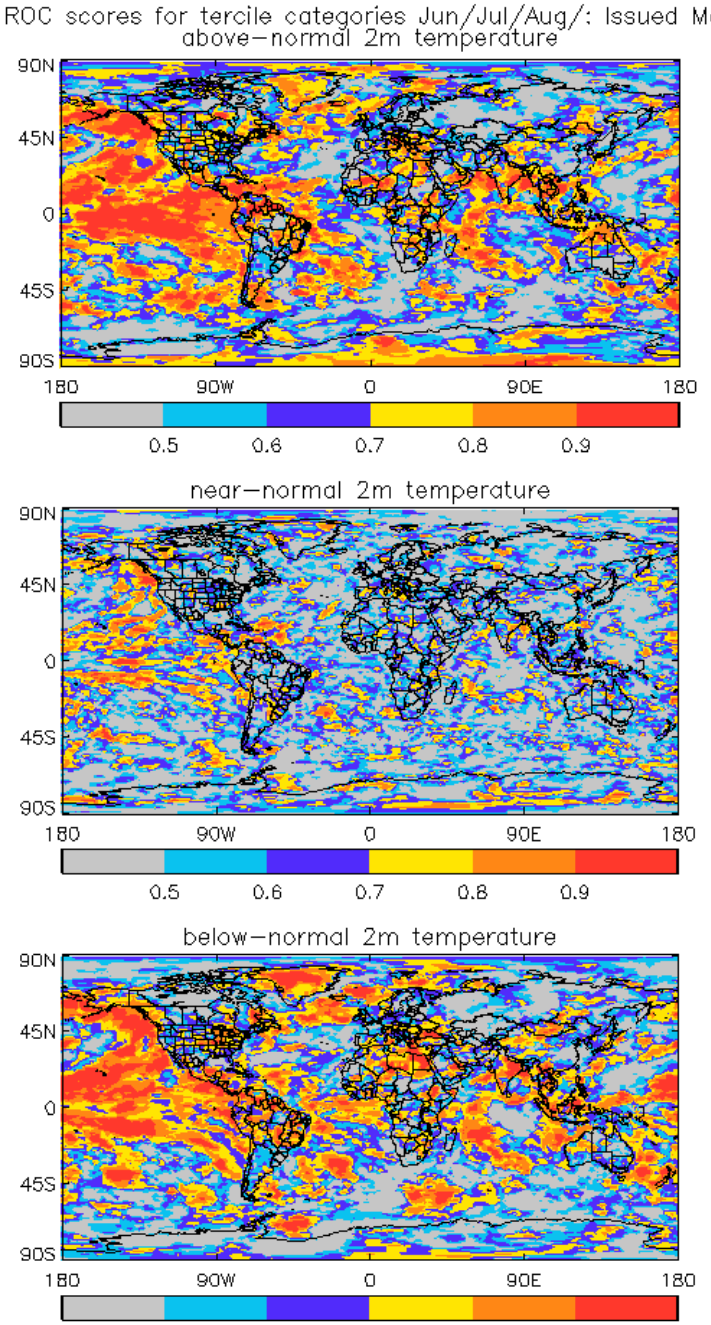


Skill information



Threshold values (%)
0.0 10.0 20.0 30.0 40.0 50.0 60.0 70.0 80.0 90.0 100.0 (>100)





Met Office 3-month Outlook

Period: January – March 2012 Issue date: 22.12.11

The forecast presented here is for December and the average of the December-January-February period for the United Kingdom as a whole. This forecast is based on information from observations, several numerical models and expert judgement.

SUMMARY - TEMPERATURE:

In the last two winters (2009-10 and 2010-11) protracted spells of severe wintry weather affected the whole of the UK and lasted several weeks. The risk of this happening again, during the current winter, is very low.

For the 3-month period January-February-March 2012, the mean UK temperature is likely to be above average, and snow and ice frequency below average. However all areas are likely to see some snow and ice, with the north of the UK at greatest risk of some disruptive snowfalls.

The probability that mean UK temperature for January-February-March will fall into the coldest of our five categories is 5-10%, whilst the probability that it will fall into the warmest of our five categories is about 30% (the climatological probability for each of these categories is 20%).

CONTEXT:

January 2010 was very cold across the UK, and between 1971 and 2000 there were 3 years when January was even colder (Figure T2). None of the predictions for January 2012 (pink crosses) are as cold. Similar inferences apply to the 3-month period (Figure T2, right panel). So it is unlikely that the UK will see prolonged spells of severe wintry weather during the remainder of the winter. The forecast also favours mild conditions across northern Europe.

Computer model forecasts from around the world are consistent in predicting higher-than-average surface pressure over southern parts of the UK and lower-than-average pressure north of the UK. This setup would lead to a greatly increased frequency of westerly flow. Although the computer model signals are unusually strong, and unusually consistent, we need to be cautious. Skill levels attained over northwest Europe are very low, and so it is possible that the mean pressure patterns forecast will not accurately reflect what actually happens.

In producing the 3-month Outlook we also evaluate the influence that external factors can have on the atmosphere. Arctic sea ice and global sea temperatures, including the persisting La Niña, are two such factors. Sometimes these factors all favour a similar meteorological outcome for the UK. However currently this is not the case, and we are therefore relying more on computer forecasts, albeit with modifications applied to reflect our understanding of their limitations.

If westerly flow is dominant, as computer models predict, temperatures across the UK are generally above average. Hence the 1- and 3-month forecasts show higher-than-average probabilities of mild conditions, and lower-than-average probabilities of cold – note how the forecast probability curves (pink and blue on Figure T2) are shifted towards higher values (upwards) relative to the 1971-2000 climatology curves (in black). The underlying surface – land or sea – modulates the temperature of airmasses reaching the UK. At present seas to the west of the UK are colder than normal; this means that the mildness of any westerly flow will be tempered somewhat, and the issued forecast reflects this.

If westerly flow prevails during the winter, northern parts of the UK will bear the brunt of any wintry weather that comes along from time to time. This is what has happened so far through December, which has also been a very 'westerly' month.

Fig T1

3-month UK outlook for temperature in the context of the observed annual cycle

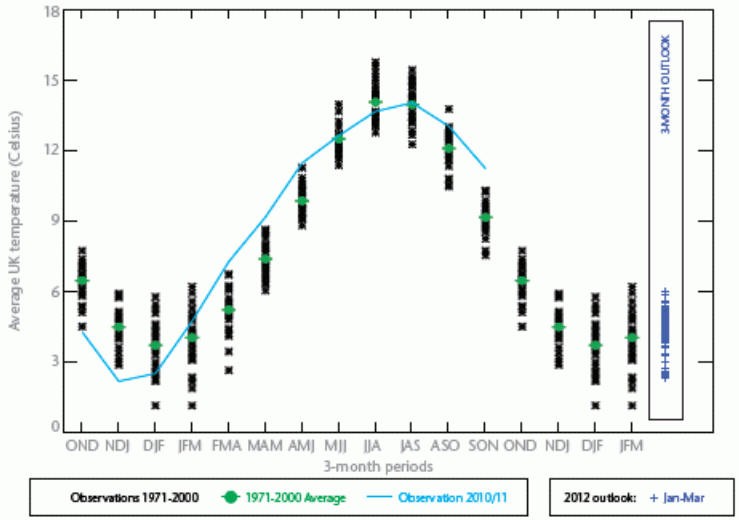


Fig T2

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

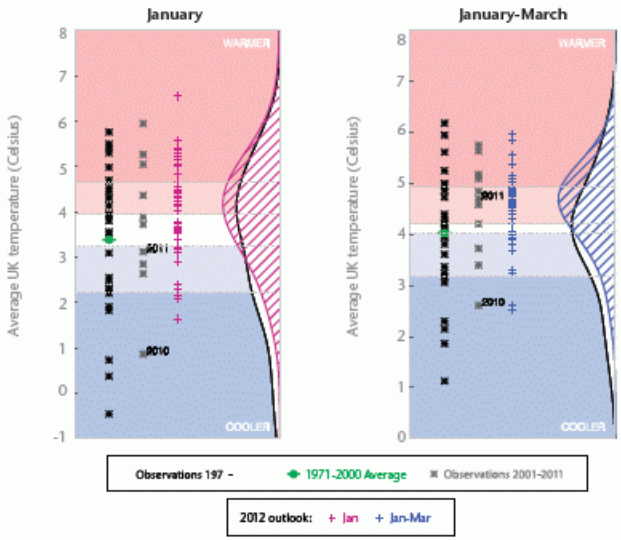
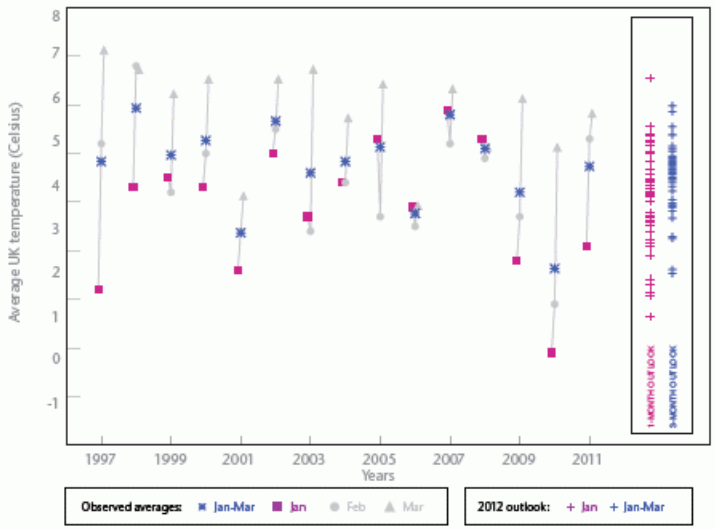


Fig T3

1-month and 3-month UK outlook for temperature in the context of recent climatology: year-to-year and within-season variability

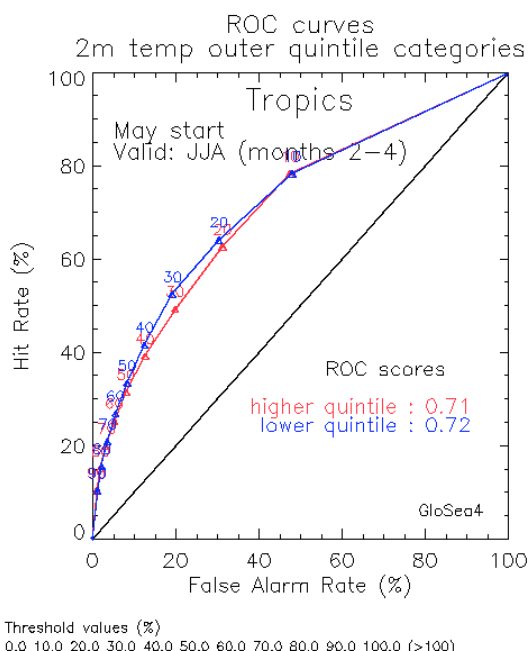


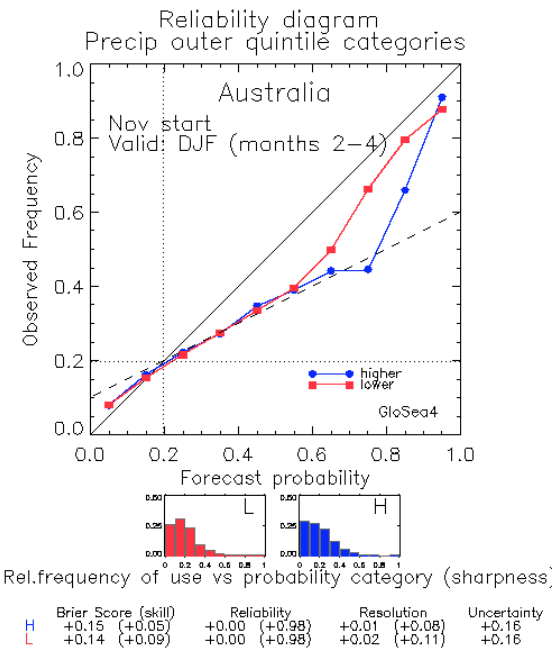
This Outlook provides an indication of possible temperature and rainfall conditions over the next 3 months. It is part of a suite of forecasts designed for contingency planners.
The Outlook should not be used in isolation but should be used with shorter-range and more detailed (30-day, 15-day and 1-to-5-day) forecasts and warnings available to the contingency planning community from the Met Office.

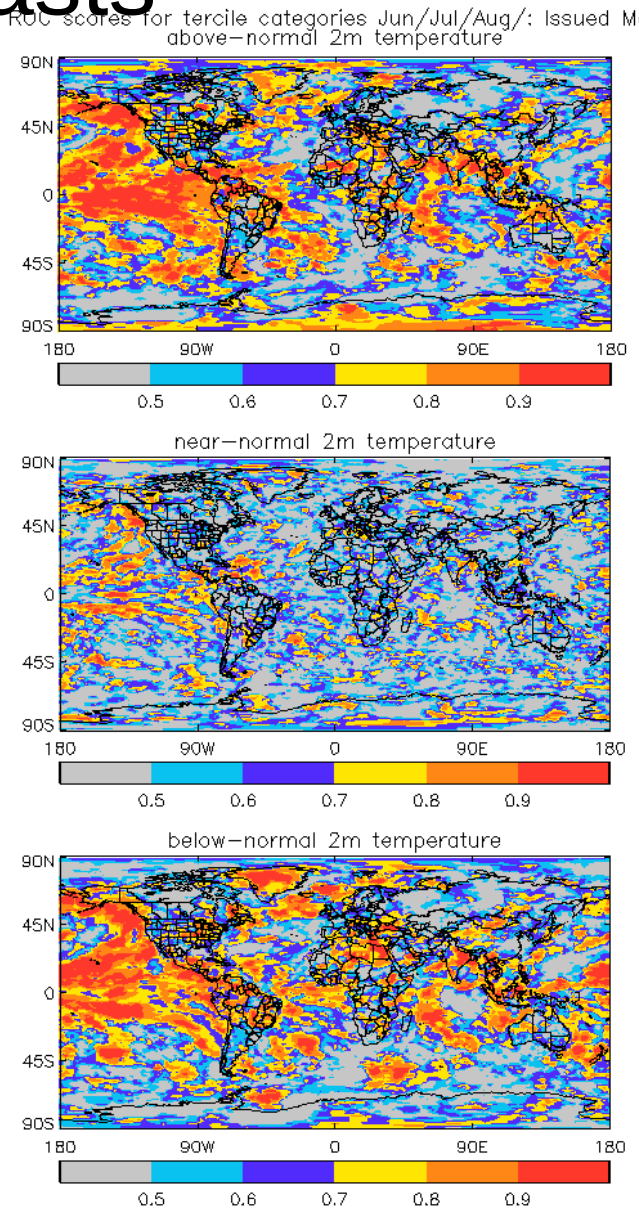
Verification/assessment

Statistical skill of forecast products, estimated from hindcasts

Skill information available alongside the forecasts







Process-based assessments

Sources of predictability

- MJO (monthly)
- SSW (monthly)
- IOD (seasonal)
- SOIL (seasonal)
- SNOW (seasonal)
- ENSO (seasonal)
- QBO (seasonal)

ATLANTIC SST (seasonal)

SEA ICE (interannual)

VOLCANOES (interannual)

SOLAR (interannual)

AEROSOL (decadal)

ATLANTIC MOC (decadal)

GHG (multidecadal)

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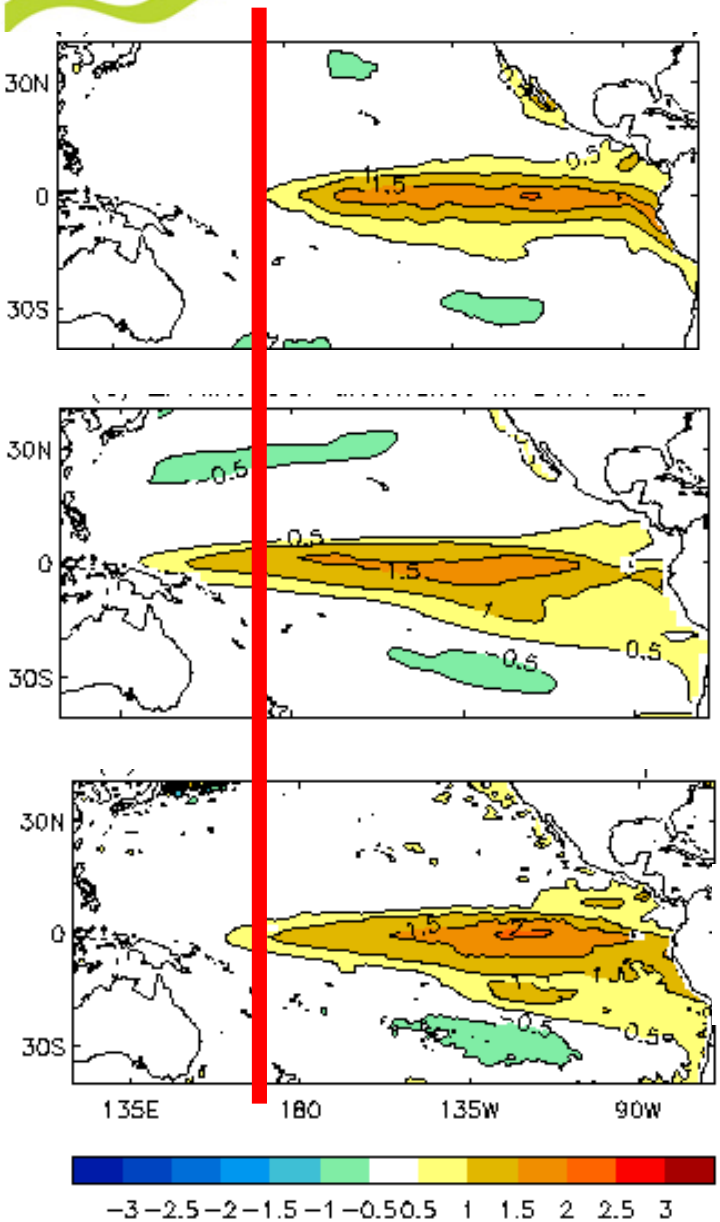
Improving ENSO forecasts



Obs

Low resolution

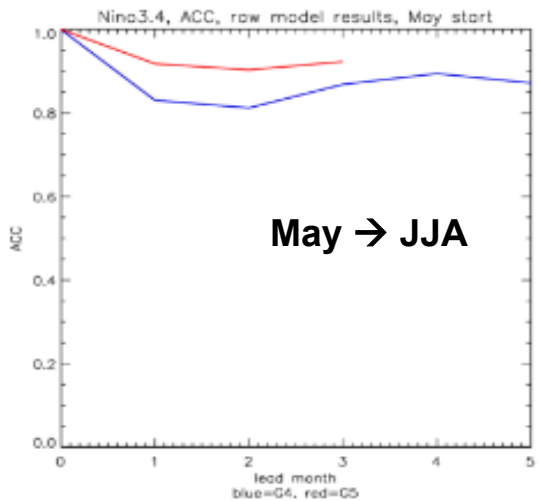
High resolution

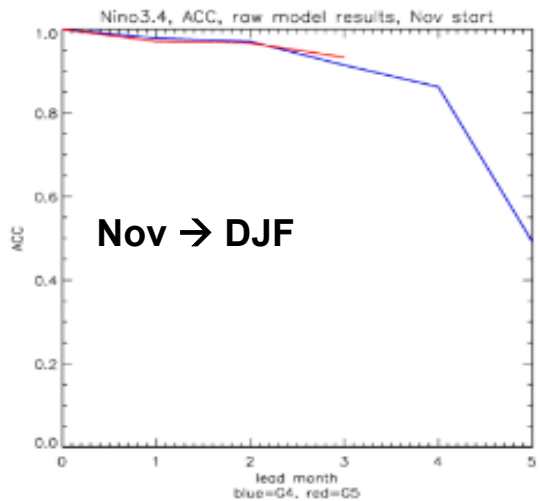
The westward extension of Nino is a common error in *many* climate models. It affects remote regions.

High-res model has better ENSO pattern and teleconnections

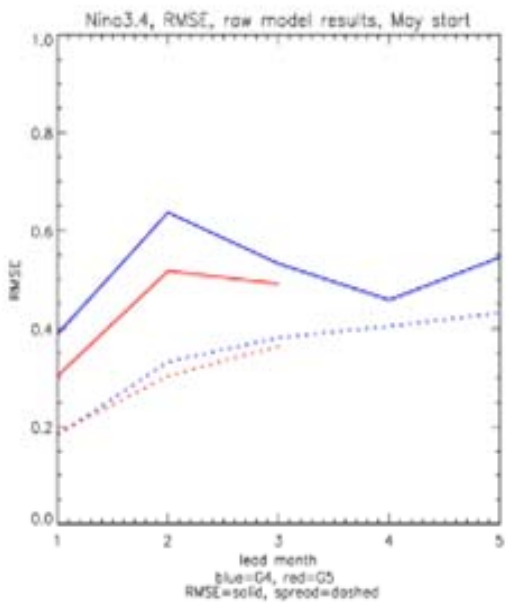
Niño3.4 SST: ACC, RMSE/spread

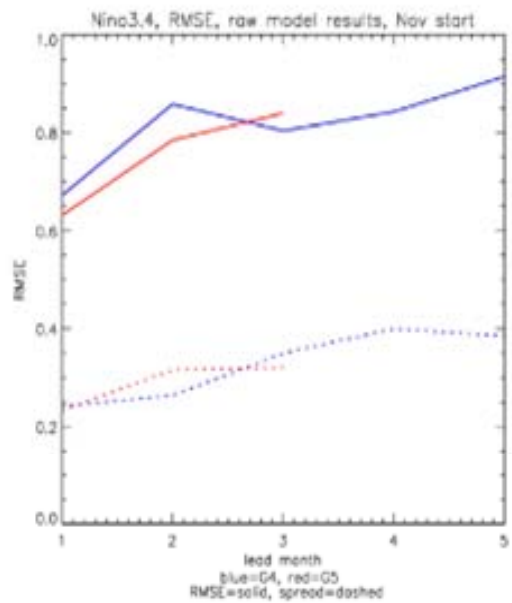
ACC higher (good)





RMSE reduced (good)

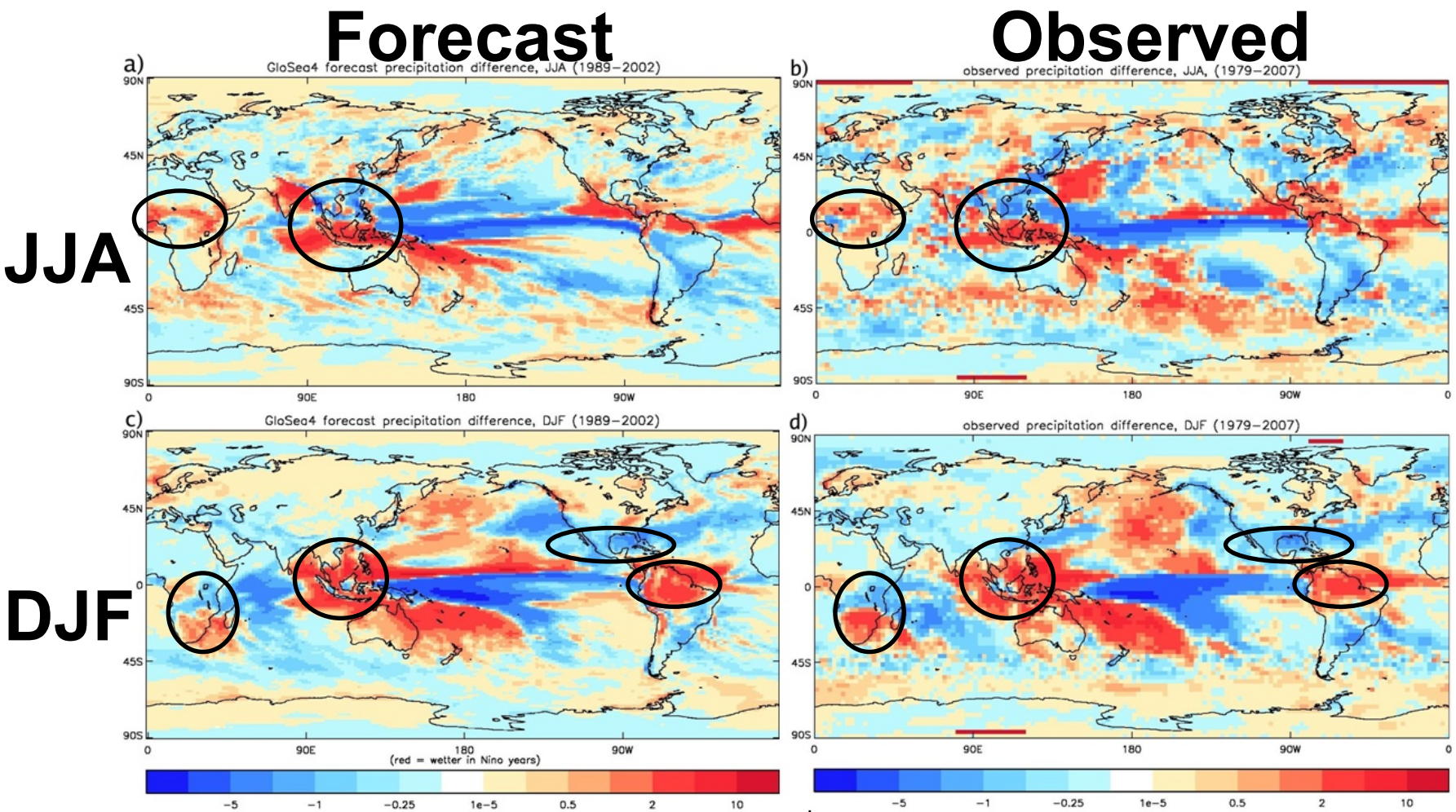




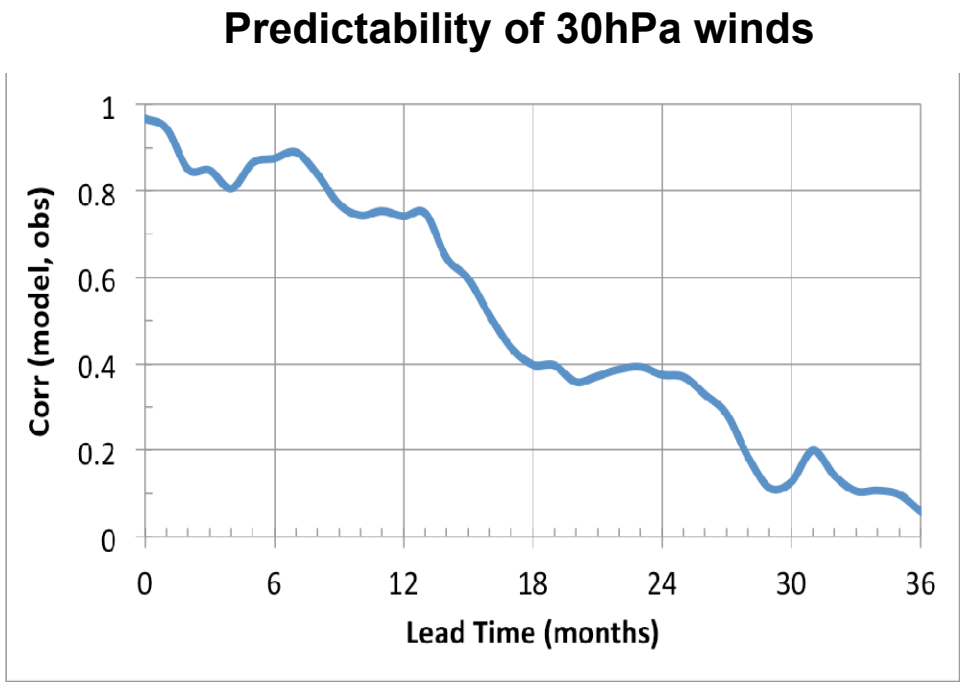
GloSea5 (red)

GloSea4 (blue)

Better ENSO teleconnections: precipitation Niño - Niña



Predictability of QBO (Quasi-Biennial Oscillation)



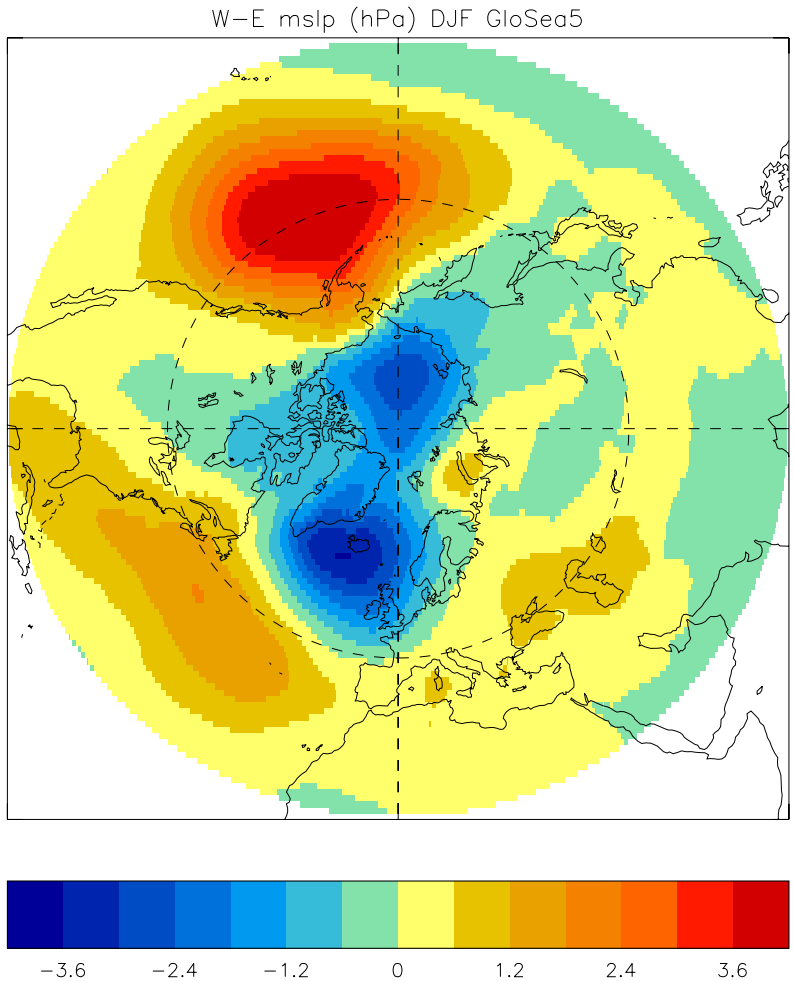
High levels of predictability

Probably the longest range predictable signal internal to the atmosphere

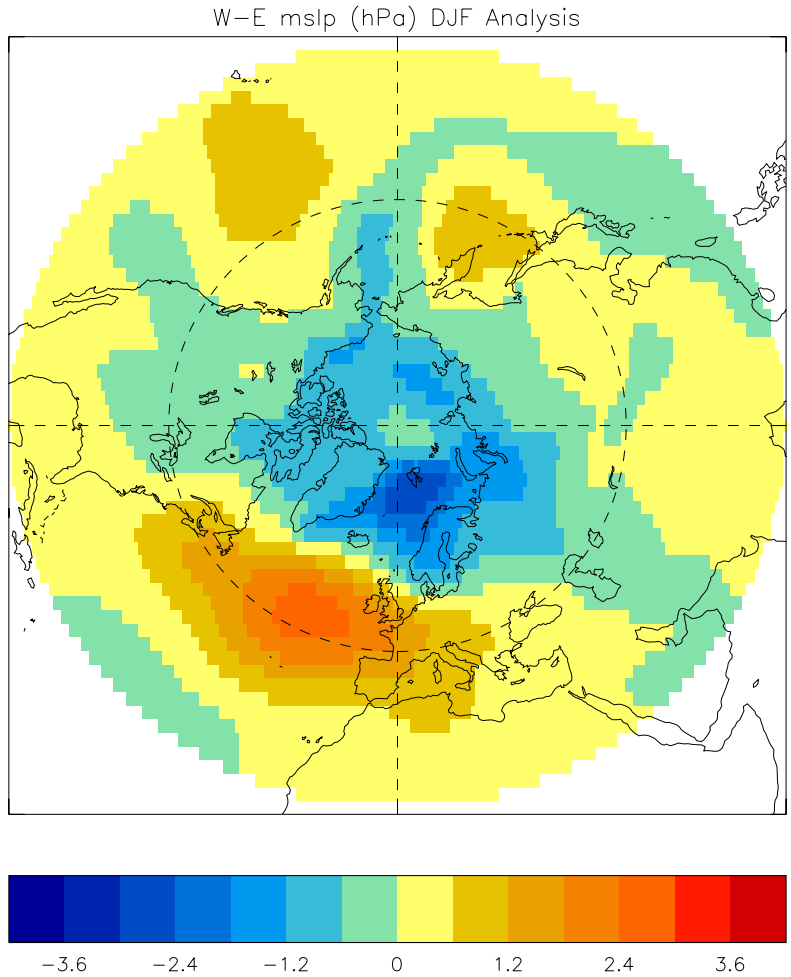
QBO effect on mean sea level pressure

westerly-easterly phase

model

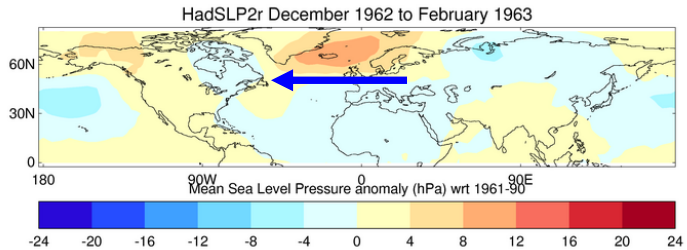


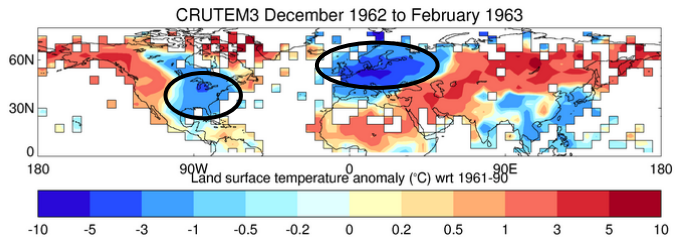
‘observations’



Winters depend on which way the wind blows

Winter 1962/63



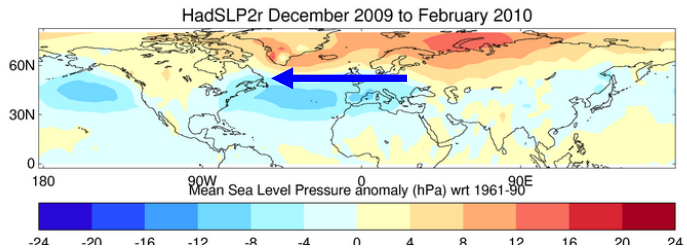


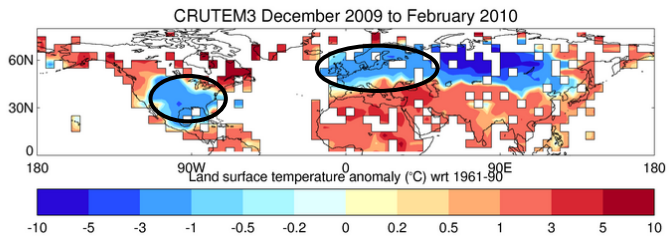
Weak P Gradient

Cold advection into Europe

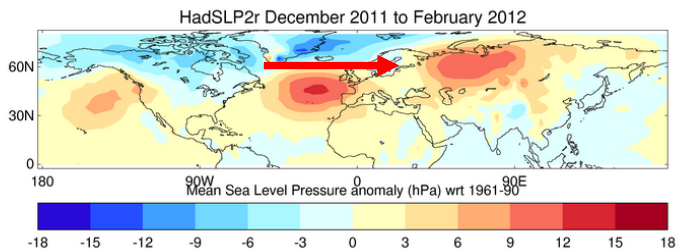
Cold, calm and dry

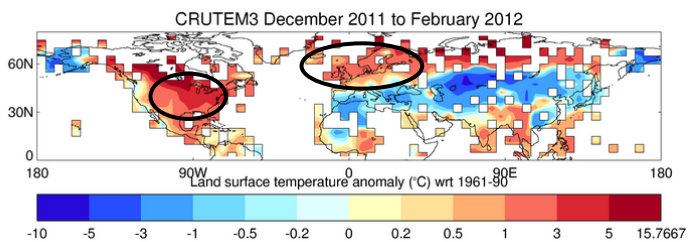
Winter 2009/10





Winter 2011/12





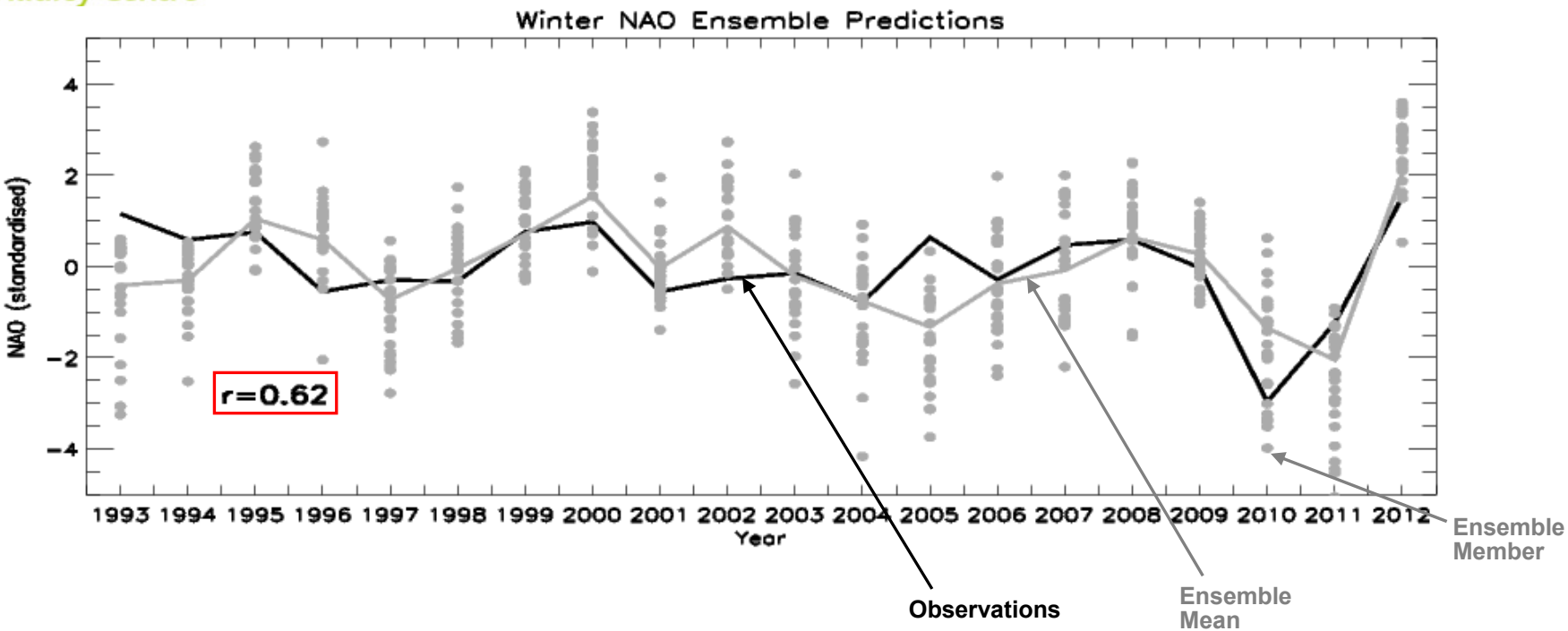
Strong P Gradient

Warm advection into Europe

Mild, stormy and wet

Predictability of the NAO

Retrospective winter forecasts from early November



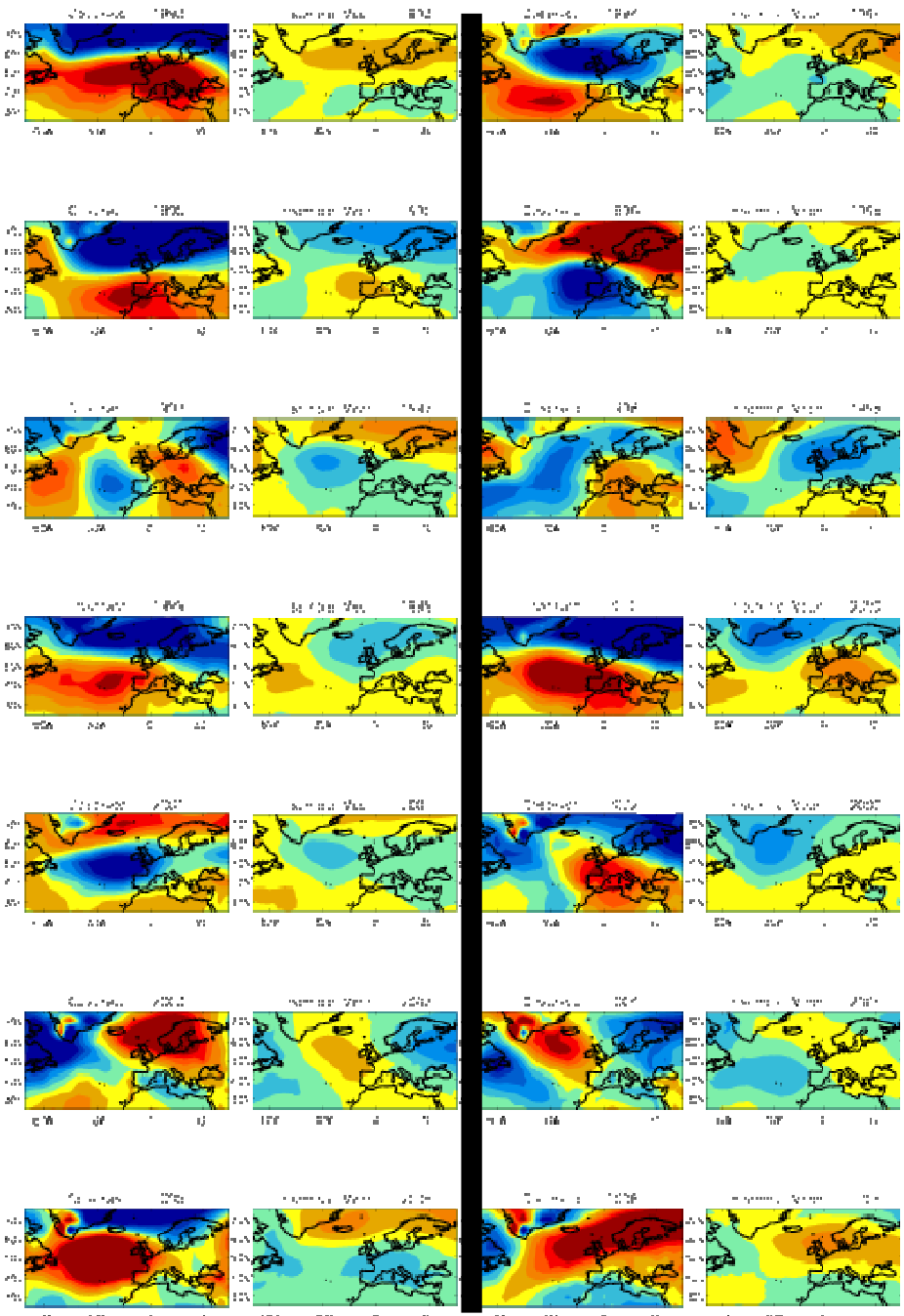
NAO skill: correlation=0.62 (c.f. ECMWF 0.16, NCEP 0.25: not significant)

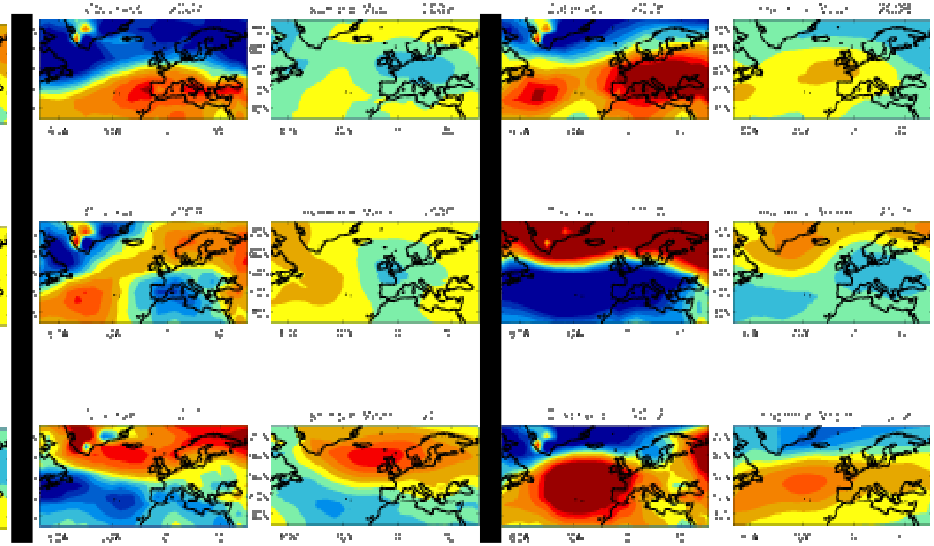
Significant at the 98% level

Similar result holds for Southern Annular Mode: correlation=0.65

Scaife et al 2013

Individual winters



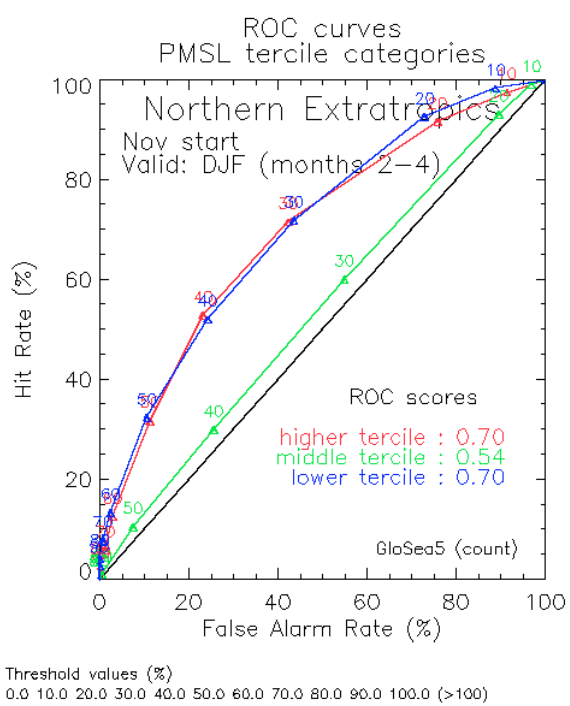


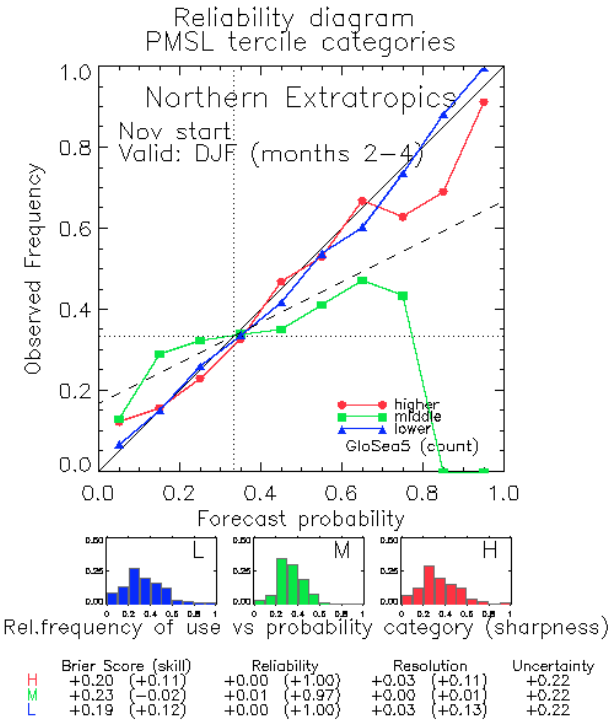
Good agreement between pressure patterns in many individual years

Especially later ones

Strength always underestimated

Probabilistic skill measures





	Brier Score (skill)	Reliability	Resolution	Uncertainty
H	+0.20 (+0.11)	+0.00 (+1.00)	+0.03 (+0.11)	+0.22
M	+0.23 (−0.02)	+0.01 (+0.97)	+0.00 (+0.01)	+0.22
L	+0.19 (+0.12)	+0.00 (+1.00)	+0.03 (+0.13)	+0.22

Skilful predictions for ‘user relevant’ variables

Skilful prediction of the NAO → skill in winter extremes

- cold days (energy, transport..)
- storms (insurance…)
- wind speed (renewables)

Skilful predictions of wintertime UK hydrology

Work has started to create forecast products

Outstanding issues

Land surface - snow and soil moisture

- plan for short reanalysis to correct bias

Aerosols

Earth System Model (ESM) components

e.g. chemistry

Seamless system across timescales

GloSea5 med-range (2013)

- Project to merge with med-range in 2013
- Aim is to have a single operational system (using coupled model at the highest possible resolution) for short-range ocean, med-range, monthly and seasonal – at the end of 2013

GloSea5 decadal (2014)

- System to be extended – in research mode - to decadal timescales in 2013
- Seamless system med-range to decadal from 2014

The end