Met Office seasonal predictions of the NAO, the driver of recent extreme UK winters

A. A. Scaife, A. Arribas, E. Blockley, A. Brookshaw, R. T. Clark, N. Dunstone, R. Eade, D. Fereday, C. K. Folland, M. Gordon, L. Hermanson, J. R. Knight, D. J. Lea, C. MacLachlan, A. Maidens, M. Martin, A. K. Peterson, D. Smith, M. Vellinga, E. Wallace, J. Waters, A. Williams

1. GloSea5: Met Office Global Seasonal Prediction System 5

GloSea5 is the latest version of the Met Office's operational seasonal prediction system, producing forecasts on a weekly basis out to 6 months.

Coupled atmosphere-ocean model. (HadGEM3–UM atmosphere and NEMO ocean model, JULES land-surface, CICE model with assimilated sea ice.)

Horizontal Resolution

Atmosphere 0.83º longitude X 0.55º latitude (432X325 gridpoints), i.e. approximately 50km in mid-latitudes.

Ocean 0.25º X 0.25º

Vertical Resolution.

Atmosphere: 85 levels in the vertical, with the model lid at 85km (near the mesopause).

Ocean: 75 levels in the vertical.

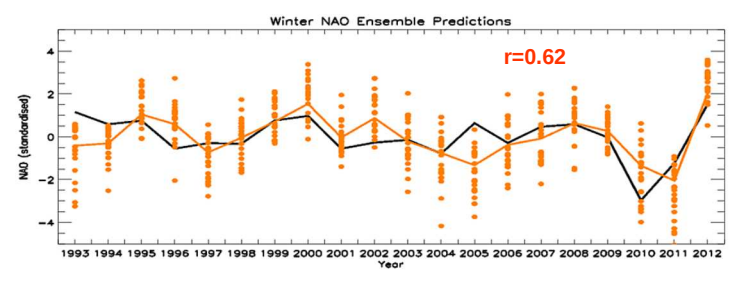
Forecasts Two forecasts per day initialised with Met Office NWP global model/FOAM short range forecasting system ocean analyses. Lagged approach combining 3 weeks of forecast initialisation dates.

Hindcasts Results shown here for winter have 24 members per year with initialisation centred on 1st November, for 1993-2012. Initialised using ERAI (atmosphere) and Met Office ocean reanalyses.

Operationally, the system runs 14 year hindcasts from 1996-2009.

Arribas et al (2012), MacLachlan et al (2014).

2. Skilful long range prediction of the winter NAO.



Hindcast set

24 members per year, 1993-2012

Winter NAO

Point index (sea level pressure difference between Iceland and the Azores)

Correlation of 0.62, statistically significant at 99% level (t-test, allowing for lagged autocorrelation).

3. Sources of predictability in forecasts and observations.

Winter (DJF) sea-level pressure response

(forecast – left column; and observed – right column)

Composites of winter differences between upper and lower terciles for each predictor in November.

ENSO

Niño 3.4 index (120-170W, 5S-5N)

Teleconnection better represented in models with resolved stratosphere (Bell et al 2009).

North Atlantic Sea Surface Temperature Anomalies

Ocean heat content in subpolar gyre. (Frankignoul 1985, Rodwell and Folland, 2002).

Sea Ice extent in the Kara Sea

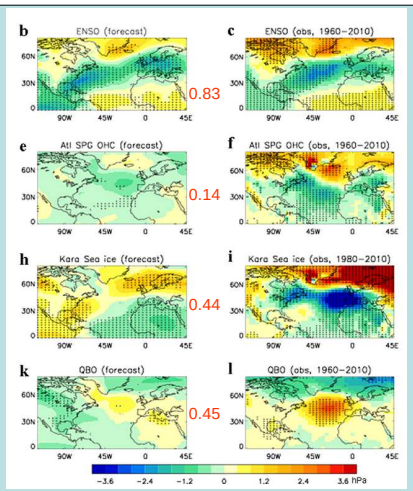
Kara sea 45-75E, 67-80N

Sea ice anomalies drive large scale circulation anomalies (Petoukhov and Semenov, 2010).

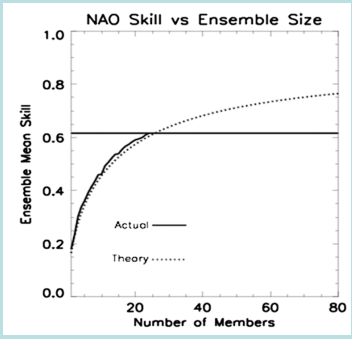
QBO

Westerly QBO associated with stronger extratropical jet (Pascoe et al., 2005).

Pattern correlations between obs. and fc. are shown in red.



4. The effect of ensemble size on prediction skill.



Increasing ensemble size (from 1 to 24 members) (solid curve). The solid horizontal line shows the full 24 member skill, and the dotted line the theoretical maximum (following Murphy 1990).

5. Long range forecast skill of weather conditions with important socio-economic impacts.

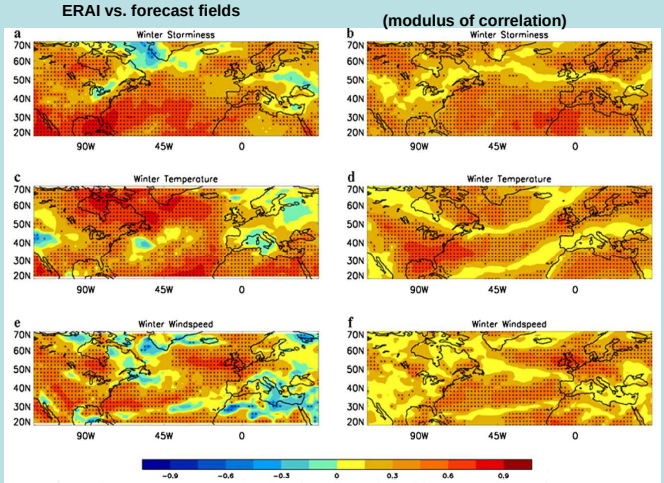
ERAI vs. forecast fields

ERAI field vs. forecast NAO (modulus of correlation)

frequency of winter storms (top decile of daily mslp minima)

mean winter temperature

mean winter wind speeds at 10m



Hatching 90% confidence (t test, allowing for autocorrelation).

6. Conclusions

GloSea5 provides useful skill in forecasting the winter NAO (correlation coefficient of 0.62).

Various aspects of the underlying forcings (teleconnections to ENSO, North Atlantic SST and Ocean Heat Content anomalies, ice extent in the Kara sea) are present in the model but weaker than observations.

This system provides skilful forecasts of weather events with high socio-economic impacts (frequencies of winter temperature, storminess and high windspeeds).

References

Arribas A., M. Glover, A. Maidens, K. Peterson, M. Gordon, C., MacLachlan, R. Graham, D. Fereday, J. Camp, A.A. Scaife, P. Xavier, P. McLean, A. Colman and S. Cusack (2011) The GloSea4 ensemble prediction system for seasonal forecasting. *Mon. Wea. Rev.*, 139, 1891-1910.

Bell C. J, Gray L.J., Charlton-Perez A.J., Joshi M. and Scaife A.A. (2009) Stratospheric communication of El Niño teleconnections to European Winter. *J. Clim.*, 22, 4083-4096.

Fereday D., A.Maidens, A.Arribas, A.A. Scaife, J.R. Knight (2012) Seasonal forecasts of Northern Hemisphere Winter 2009/10. *Env. Res. Lett.*, 7, doi:10.1088/1748-9326/7/3/034031.

Frankignoul, (1985) Sea surface temperature anomalies, planetary waves and air-sea feed-back in the middle latitudes, *Rev Geophys, 23*, 357-390.

MacLachlan, C., A Arribas, K Peterson, M Gordon, A Williams, ...(2014) The Met Office Global Seasonal Forecasting System 5 (GloSea5), *QJRMS*, DOI: 10.1002/qj.2396

Murphy J.M. (1990) Assessment of the practical utility of extended range ensemble forecasts. *Q. J. R. Meteorol. Soc.*, 116, pp. 89-125.

Pascoe et al. (2005) A GCM study of the influence of equatorial winds on the timing of sudden stratospheric warmings, *GRL*, 33, 309:10.1029/2004JD004941.

Petoukhov V. and Semenov V.A. (2010) A link between reduced Barents-Kara sea ice and cold winter extremes over northern continents. *J. Geophys. Res.*, 115:D21111.

Rodwell and Folland, (2002) Atlantic air-sea interaction and seasonal predictability, *Q. J. R. Meteorol. Soc.*, 128, 1413-1443.

Rodwell, M. J., D. P. Rowell, and C. K. Folland (1999) Oceanic forcing of the wintertime North Atlantic Oscillation and European climate, *Nature*, 398, 320–333.

A.A. Scaife, et al. (2013) Skilful Long Range Prediction of European and North American Winter Weather, *GRL*, 41, Ddoi:10.1002/2014GL059637

Met Office Hadley Centre, FitzRoy Road, Exeter, Devon, EX1 3PB United Kingdom
Tel: 01392 885680 Fax: 01392 885681
Email: anna.maidens@metoffice.gov.uk