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)
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...*
Model version: **HadGEM3 GA3.0**

Resolution: **N216L85 O(.25)L75**
(0.83° long x 0.55° 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)


- Atmosphere & land surf: ERA-interim
- Ocean & sea-ice: seasonal ODA reanalysis
- Fixed start dates of 1\textsuperscript{st}, 9\textsuperscript{th}, 17\textsuperscript{th}, 25\textsuperscript{th} 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

Ensemble mean anomaly: mean sea level pressure: Jun/Jul/Aug
Issued May 2011
Skill information
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) prolonged spells of severe 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 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 disruption overall.

The probability that mean UK temperature for January-February will fall into the coldest of our five categories is 3-10%, whilst the probability that it will fall into one of our three categories (other than the coldest) is 93-97%.

**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 2013 (grey boxes) are as cold. Similar differences apply to the 3-month period (figure T3), right panel. So it is unlikely that the UK will see prolonged spells of severe 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 northern parts of the UK and lower-than-average pressure north of the UK. This setup would tend to greatly increase the frequency of westerly flow. Although the computer model signals are generally strong, and statistically significant, we need to be cautious: 80% levels attained over central Europe are very low, and it is possible that the mean pressure patterns forecast will not accurately reflect what actually happens.

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

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 superior-average probabilities of wet conditions, and lower-than-average probabilities of cold: on average the forecast probability curve (grey line below the grey box in figure T2) is tilted towards higher values (e.g. Figure 4) relative to the 1971-2000 climatology curve (in black). The underlying outlook—land at sea—explains the temperature of airflows reaching the UK. As present was to the west of the UK are cooler than normal, this means that the mid-levels of any westerly flow will be tempered somewhat, and the forecast reflects this.

If westerly flow prevails during the winter, northern parts of the UK will be at the mercy of any wintry weather that comes along from time to time. The transition to spring through December, which has also been a very "mean" January.

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 3-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

ROC curves
2m temp outer quintile categories
Tropics
Valid: JJA (months 2–4)
ROC scores
higher quintile: 0.71
lower quintile: 0.72
Hit Rate (%) vs False Alarm Rate (%)
Process-based assessments
Sources of predictability

- MJO (monthly)  ATLANTIC SST (seasonal)
- SSW (monthly)  SEA ICE (interannual)
- IOD (seasonal)  VOLCANOS (interannual)
- SOIL (seasonal)  SOLAR (interannual)
- SNOW (seasonal)  AEROSOL (decadal)
- ENSO (seasonal)  ATLANTIC MOC (decadal)
- QBO (seasonal)  GHG (multidecadal)
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Improving ENSO forecasts

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

Forecast

Observed

JJA

DJF

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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'

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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**
- HadSLP2r December 2009 to February 2010

**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
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