Seasonal Forecasting Consultation

Summary

A review has been conducted of Met Office seasonal forecasting science and use of products by responders to determine whether there is a need for a Public Weather Service (PWS) seasonal forecasting product.

The focus of the PWS has been, and will remain, on detailed short-range weather forecasts for the public and responders, with the emphasis on severe weather warnings. Nevertheless, in recent years there have been a number of seasons and extended periods which have shown persistent weather conditions associated with significant impacts. Feedback from responders is that if science permits a reliable and accurate forecast of the season there would be actions that could be taken.

Whilst the scientific consensus is that there is limited if no seasonal forecasting skill for the European summer, the Met Office has recently demonstrated useful skill in forecasting the likely winter weather patterns for northern Europe, including the UK. The mechanisms providing this skill still need to be further understood, and further research is needed to provide better understanding and improvements to seasonal forecast models.

There is, however, the potential of providing responders with useful information on the prospects for the winter season. Unfortunately, the current seasonal forecast products available to many responders are poorly used. They are considered too technical for most responders, and although the information therein is considered useful, the way it is presented is not. Dedicated seasonal forecast briefings are much better received, with examples where specific preparedness actions have been taken on the back of a winter forecast briefing. There is interest in a winter forecast product, as long as it is clear and has a consistent and authoritative message or summary, and is easily available to responders through the channels they use.

As a result, this report makes the following recommendations:

1. The PWSCG to continue sponsoring Met Office research into and production of seasonal forecasts in the next Customer-Supplier Agreement.

2. The PWSCG to ask the Met Office to develop a PWS-sponsored winter seasonal forecast product aimed at responders.

3. The PWSCG to regularly review progress in Met Office seasonal forecasting to provide assurance that anticipated improvements in scientific understanding feed through into improved products and advice for responders and Government.

1. Introduction

The focus of the Public Weather Service has been, and will remain, on detailed short-range weather forecasts for the public and responders, with the emphasis on severe weather warnings. Most responders don't take action on severe weather ahead of 48 hours before the forecast event, although longer notice is always welcome especially ahead of weekends or holiday periods. Nevertheless, the current detailed forecast period of 7 days is considered sufficient for the vast majority of responders.

The detailed short-range forecasts are complemented with outlooks up to 30 days, prepared as a text narrative describing the likelihood of possible weather types for the UK as a whole over the period. These can provide useful information on when weather types are likely to change, especially during periods of ongoing severe weather such as cold, heat, floods, storms or drought. For periods beyond 30 days, the Met Office provides a 3-Month Outlook (3MO) for contingency planners. This is available from the public website but is not aimed at the general public. Although the 3MO is not in the PWS service catalogue and so not strictly a PWS output, the PWS funds operational seasonal forecasting in the Met Office as part of the National Capability.

In recent years there have been several developments which mean the PWSCG may wish to consider the need for a PWS seasonal forecasting product. There have been a number of seasons and extended periods which have shown persistent weather conditions associated with significant impacts. Some examples are shown in Table 1. The response to the Met Office from many PWSCG representatives following these events is "was it predictable"? Furthermore, there has been considerable interest this year as to whether the El Nino that developed in the Pacific in 2015 would lead to a cold end to winter in the UK, as was seen in the last El Nino event in 2009/10. Section 2 of this report reviews the current state of seasonal forecasting capability, from interviews with Met Office scientists and meteorologists and from observing the meetings of the Met Office Science Advisory Committee (MOSAC) in 2014 and 2015. An assessment of the winter forecast for 2015/16 is included.

Section 3 of this report reviews the current Met Office seasonal forecasting products and services made available to responders and the public to determine whether these products are well used and how they are viewed by responders. Evidence was collated from the 2015 Responder Survey; discussions with participants at the Responder Workshops held in London, Durham, Glasgow and Exeter and at the Wales PWSCG; interviews with PWSCG members, including Cabinet Office and Northern Ireland, and also with the Met Office Head of Civil Contingencies. The same sources were used to identify the potential requirements for seasonal forecasts from responders outlined in Section 4. A short assessment is made of the requirement for seasonal forecasts for the public. Section 5 draws conclusions from the evidence in the previous sections and makes recommendations to the PWSCG.

Season	Climatological Summary	Observed Impacts
Summer 2007	UK rainfall of 357.8mm was 158% of the 71-00 average.	Extensive flooding across England and Wales which led to the Pitt Review.
Winter 2009/10	Coldest UK winter for 30 years, with average temperature of 1.6C, 2.0C below long-term 71-00 average. For Scotland and Northern Ireland only winter 62/63 was significantly colder, and coldest on record for northern Scotland.	Snowfall across the country from mid-December onwards, leading to widespread travel disruption. Prolonged period of cold led to pressure on road salt stocks and increased energy demand.
Winter 2010/11	Although less cold overall than the previous winter, notable for an exceptionally cold December, 4.8C below long-term average and coldest for over 100 years.	Widespread snowfall and very low temperatures in December led to widespread travel disruption and increases in energy demand.
Spring 2011	Warmest Spring since 1910 and second driest Spring for England and Wales which contributed to the impacts of the 2-year drought in England and Wales from April 2010 to March 2012.	Wildfires across UK during May. Impacts on arable crops, river flow and wildlife. Drought conditions declared across eastern counties in June.
Summer 2012	Wettest summer for 100 years with 379.2mm of rainfall for UK as a whole.	River and surface water flooding across the country during the period, with landslides leading to fatalities.
Spring 2013	Coldest Spring since 1962, with March 3.3C below long-term average and colder than any of the preceding winter months.	Disruptive snowfall in late March and early April. Severe impacts on hill farmers with the loss of several thousand sheep.
Winter 2013/14	Wettest winter on record, at 157% of 1981-2010 average for UK as a whole. Exceptionally stormy, with UEA estimating more severe gale days than in any previous winter in a series dating back to 1871.	Extensive flooding in Somerset Levels and River Thames. Coastal storm damage in South West England and Wales. Widespread power outages associated with Christmas storms.

Table 1: Examples of recent seasonal extremes for the UK. Were these seasonal extremes predictable? Source http://www.metoffice.gov.uk/climate/uk/summaries and http://www.metoffice.gov.uk/climate/uk/interesting .

2. Seasonal Forecasting Capability

2.1 Principles of Seasonal Forecasting

There are two approaches to seasonal forecasting. There is a statistical approach, by which connections are made between certain elements of the historical climate and the season in question. Where links exist, and where enough historical data can be identified, this technique can be used to provide reliable forecasts for some parts of the world. For example, there is a reliable connection between the March-May rainfall in North-East Brazil and the sea surface temperatures in the tropical Atlantic before and during the rainy season.[1]

The dynamical approach to seasonal forecasting uses numerical models of the Earth's atmosphere and ocean initialised with current observations to forecast the months ahead. There are several centres around the world which perform seasonal forecasts in this way; the leading centres, including the Met Office, have been designated by the World Meteorological Organisation (WMO) as Global Producing Centres (GPCs) for Long-range Forecasting. All the centres follow the same general approach of running an ensemble of forecasts with slightly different initial conditions and model set-ups to represent uncertainty, and then adjusting these forecasts against hindcasts, or re-forecasts, using an identical model configuration initialised with historical data to account for remaining errors.

Different centres have different approaches to their dynamic forecasts. The Met Office system, GloSea5, runs two 195 day forecasts each day initialised with current observations, and then generates its seasonal forecast based on the last three weeks of simulations, creating an ensemble of 42 members. The Met Office also run a 12 member hindcast based on 14 years worth of data.[2] The European Centre for Medium-range Weather Forecasts (ECMWF), another WMO GPC, initialises all its 51 ensemble members on the first day of the month, with variations to the initial sea surface temperatures, and compares against a 15 member hindcast based over 30 years.[3] Furthermore, the Met Office, ECMWF, Météo-France and the National Centre for Environmental Prediction in the US combine their seasonal forecasts into a multi-model ensemble called EUROSIP.[4] By using different models in this way the ensemble can represent a greater range of uncertainty as it includes variations in different models as well as in initial conditions.

Both statistical and dynamical approaches are used to produce probabilities of the average conditions for the season in question. Normally, a combination of approaches is used to develop a seasonal forecasting product. For example, the Met Office 3MO is based on "information from observations, several numerical prediction systems and expert judgement."

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[1] http://www.ecmwf.int/en/forecasts/documentation-and-support/long-range/seasonal-forecast-documentation/user-guide/introduction
[2] http://www.metoffice.gov.uk/research/modelling-systems/unified-model/climate-models/glosea5
[3] http://www.ecmwf.int/en/forecasts/documentation-and-support/long-range/seasonal-forecast-documentation/user-guide/seasonal-forecasting-system
[4] http://www.ecmwf.int/en/forecasts/documentation-and-support/long-range/seasonal-forecast-documentation/eurosip-user-guide/multi-model

2.2 Seasonal Forecasting Skill

Seasonal forecasting skill varies around the globe. Generally, skill is greater in the tropics where there is a predictable component to the seasonal conditions. For example, there are well understood correlations between tropical weather and the El Nino Southern Oscillation. In the mid-latitudes, however, the variability of weather within the season can be greater than any predictable component making it difficult to determine any useful signal from seasonal forecasts.

Even when forecast systems suggest a “most likely” outcome there is no guarantee that the favourite will win. The most infamous example of this is the Met Office’s summer forecast in 2009. On 30 April of that year, the Met Office press release stated:

> **The coming summer is 'odds on for a barbecue summer', according to long-range forecasts. Summer temperatures across the UK are likely to be warmer than average and rainfall near or below average for the three months of summer.**
>
> Chief Meteorologist at the Met Office, Ewen McCallum, said: "After two disappointingly-wet summers, the signs are much more promising this year. We can expect times when temperatures will be above 30 °C, something we hardly saw at all last year."
>
> Although the forecast is for a drier and warmer summer than average it does not rule out the chances of seeing some heavy downpours at times. However, a repeat of the wet summers of 2007 and 2008 is unlikely.

Although there was a promising start to the summer with a warm and dry June, and the 30C mark was passed at the end of the month, July turned out to be the wettest in England and Wales since 1914 and the Met Office faced derision in the press for its “BBQ summer” forecast. Whilst overall UK temperatures for the summer were notably higher than average, the rainfall was on par with 2008, making the series of three summers from 2007 to 2009 the wettest on record.[5]

As this example illustrates, even a relatively strong “most likely” outcome in the seasonal forecast does not preclude the “less likely” outcomes and it is important to get the right messaging to avoid this kind of negative response and potential loss of confidence in both seasonal and short-range forecasting.

The general scientific consensus is that there is little skill in seasonal forecasts for summer over the UK. However, there is a growing consensus that there is predictability for the winter season.

2.3 The North Atlantic Oscillation

Northern European winter weather can be ascribed to the sign of the North Atlantic Oscillation (NAO) index. The NAO index is a measure of the difference between

[5] http://www.metoffice.gov.uk/climate/uk/summaries/2009/summer

surface pressure in the Azores and that in Iceland. When the index is positive, there is a greater pressure difference between the sub-tropics and higher latitudes which implies stronger westerly flow over northern Europe. When the index is negative, the pressure difference is smaller and hence the westerly flow is weak, or easterly flow may predominate. In terms of winter weather, a positive NAO will be associated with wetter, windier and milder conditions than average for northern Europe, whilst a negative NAO will be associated with drier and colder conditions than average for northern Europe.

The NAO shows a great deal of variability, although it may persist in one phase or another for several months at a time. Because of the correlation between the NAO and winter weather for northern Europe, statistical approaches to winter seasonal forecasting has focused on trying to forecast the sign of the NAO.

2.4 Recent Advances

The Met Office has recently demonstrated potential winter seasonal forecast skill using GloSea5. Scaife et al (2014)[6] assessed seasonal predictability of winter North Atlantic climate, and demonstrated that key aspects of European winter climate and the NAO are highly predictable months ahead. Seasonal forecasts for December to February (DJF) initialised from 1 November had a correlation score of 0.62 for the NAO for the years 1993 to 2012. This represents worthwhile skill, and theory would predict this skill to increase with a greater ensemble size, although that would require additional computing resources.

Despite this positive headline result, there is still a lot to understand. For example, the amplitude of the NAO signal is weaker than observed in observations. This result has been observed in all other models that show some skill in forecasting the NAO. This low signal-to-noise ratio means it is not possible to extract useful weather information directly from the seasonal forecast model output. The exact mechanisms which are driving the predictability of the NAO are not yet understood completely, but better ocean-atmosphere coupling in the GloSea5 model is likely to be important. Understanding these mechanisms and better replicating them in models could enable an increase in skill without an increase in ensemble size.

The Met Office Scientific Advisory Committee (MOSAC) has taken great interest in these results and subjected them to rigorous scrutiny. On their request, the Met Office ran their re-forecasts over a longer historical period and reproduced the high correlation scores with the NAO. An assessment of an accurate winter forecast for 2014/15 was presented to MOSAC in 2015. MOSAC considers this research world-leading but, nevertheless, it retains some concerns over the low signal-to-noise ratio and that the increased risk of an extremely wet and stormy winter in 2013/14 would not have been identified from the NAO.

[6] Scaife, A.A. et al (2014), “Skillful long-range prediction of European and North American winters”, *Geophys. Res. Lett., 41*, 2514-2519

2.5 Forecast for Winter 2015/16

Statistical studies have shown a consistent connection between El Nino events and North Atlantic winter weather. Toniazzo and Scaife (2006)[7] showed that moderate El Nino events tended to result in a negative phase of the NAO in late winter (January and February). Strong El Nino events did not project strongly onto the NAO, but did have a consistent signal for high surface pressure anomalies in the east Atlantic, suggesting a more northerly component to the flow over western Europe. The cold winter of 2009/10 was associated with a moderate El Nino event and with the strongest El Nino since 1997/8 developing in the Pacific there is the prospect of a predictable winter signal for 2015/16.

The Met Office blog[8] for winter 2015/16 described other factors which affect the European winter weather. The direction of the stratospheric winds, which change from westerly to easterly every 27 months or so through the Quasi-Biennial Oscillation (QBO), has a bearing on the NAO. For winter 2015/16 the QBO is in its westerly phase which tends to lead to a positive NAO. Furthermore, colder than usual temperatures in the North Atlantic coupled with warmer than usual temperatures in the sub-tropics create a stronger temperature gradient that would strengthen westerly winds, leading to a positive NAO. Cold spells of winter weather are often associated with what are termed “sudden stratospheric warming” events. When these occur the polar stratospheric vortex of westerly winds breaks down, and easterly flow can propagate towards the surface. These occur on average once every two winters, and are more likely to occur later in the winter. For example, the cold spring of 2013 was associated with such an event. Disruption to the Pacific jet stream from El Nino can increase the likelihood of these events, whilst a westerly QBO tends to inhibit them.

Considering all these different factors, Met Office briefings and blogs during mid-autumn presented the following message:

- El Nino comparable with 1997/8 underway
- Increased risk of heavy rainfall and stormy conditions in late autumn/early winter
- The risk of sudden stratospheric warming events (which can bring cold weather to the UK) in late winter is raised
- Whilst risk of a cold end to winter is raised, the late autumn and early winter are likely to be mild, wet and stormy, so the risk of a very cold winter overall is much less than in 2009/10.

The 3MO for November-January (issued 22 October) noted the westerly phase of the QBO and cooler North Atlantic temperatures which would strengthen westerly winds, indicating a positive NAO and therefore a higher risk of milder and wetter weather over the period. The increased risk of cold spells at the end of the 3-month period was noted.

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[7] Toniazzo, T. and Scaife, A.A. (2006) “The Influence of ENSO on winter North Atlantic climate”, *Geophys. Res. Lett., 33*, L24704

[8] http://blog.metoffice.gov.uk/tag/sudden-stratospheric-warming/

During late autumn, the Met Office briefings presented the following messages for the winter:

- Very large El Nino set to peak in mid-winter comparable with the intense events of 1982/3 and 1997/8.
- Increased risk of heavy rainfall and stormy conditions in the early winter (December).
- Near zero chance of a stratospheric warming event in early winter, but raised to 80% by the late winter.
- Risk of cold snap highest in late winter.
- Risk of a cold winter overall much lower than in the last El Nino winter of 2009/10.

The December-February 3MO (issued 30 November) stated:

> Through the first half of the 3-month period, milder-than-average conditions are more likely than colder-than average. However later in the winter, particularly into February, several seasonal forecasting systems, including the Met Office system, are in good agreement in suggesting a shift towards more blocked weather patterns; these patterns increase the chance of cold northerly or easterly winds affecting the UK. ...In late winter the probability of colder-than-average conditions is actually higher than normal. Thus we consider the greatest risk of cold weather impacts, such as snow, to be in late winter.

The general picture of a wet, stormy end to autumn and start to winter with colder conditions at the end of winter as described in the seasonal forecast was borne out as shown in the monthly means and anomalies for temperature, precipitation and air frost for November 2015 to March 2016 shown in Table 2. However, as shown in Table 3, the winter as a whole turned out to be exceptionally mild and wet, with December 2015 being the wettest calendar month in the UK series, and the warmest December on record. Severe flooding occurred in Cumbria and southern Scotland on the 5-6 December, and parts of Lancashire and Yorkshire on 26 December. Wet weather continued into the beginning of January, with a colder interlude around mid-month. Stormy conditions returned at the end of January and continued into February. By the middle of that month the weather turned drier and colder and although there were another couple of storms at the beginning and end of March, overall both February and March were much closer to average in terms of temperature and rainfall.

Month	UK Temperature		UK Precipitation		UK Days Air Frost	
	Mean	Anomaly	Mean	Anomaly	Mean	Anomaly
November 2015	8.2˚C	+2.0˚C	176mm	145%	2.8	-2.8
December 2015	7.9˚C	+4.1˚C	230mm	191%	2.6	-8.4
January 2016	4.5˚C	+0.9˚C	185mm	152%	8.8	-2.4
February 2016	3.9˚C	+0.2˚C	114mm	129%	11.8	+0.5
March 2016	5.3˚C	-0.2˚C	87mm	91%	7.7	+0.1

Table 2: Extended winter monthly means and anomalies compared to 1981-2010 average for temperature, precipitation and air frost for the UK for 2015/16

Parameter	Mean	Anomaly (to 1981-2010 average)	Ranking
Temperature	5.5˚C	+1.8˚C	3rd warmest in the series since 1910, behind 1989 and 2007 for UK. Warmest in the series for England and Wales.
Precipitation	529mm	160%	2nd wettest in series behind 13/14 for UK. Wettest in the series for Wales, Northern Ireland and Scotland.

Table 3: Selected statistics for Winter 2015/16 (December, January and February) and relative ranking on UK series.

Overall, it could be said that the seasonal forecast gave “good guidance” in terms of the predominant weather types during the season, but not necessarily in terms of intensity and likelihood of an extreme season.

3. Review of Current Products and Services

3.1 Three-Month Outlook

The 3 Month Outlook (3MO) is a publicly available product from the Met Office available on the Contingency Planners webpage.[9] It is described as being “provided to the contingency planning community on behalf of the Cabinet Office.” It consists of two PDF documents providing “an indication of possible temperature and rainfall conditions in the next three months.” The documents are presented in a “quad chart” style with a text summary, probability distribution functions of temperature or rainfall and historical observations. The outlook is described as a “component of [Met Office] research and development” with a caveat that “the outlook should not be used in isolation but should be used with shorter range and more detailed...forecast and warnings...from the Met Office.” An example of the 3MO of Temperature for DJF 2015 is shown in Figure 1.

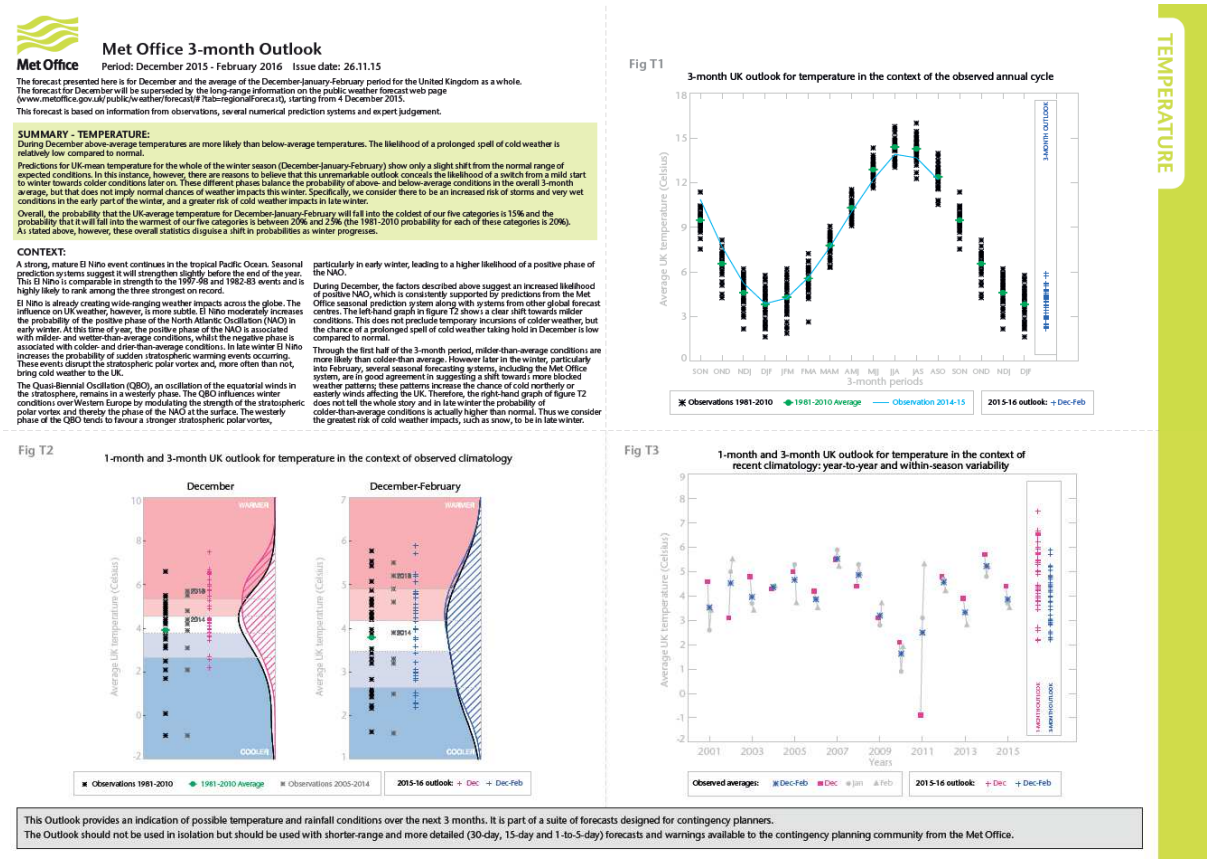

Figure 1: Example of a Three-Month Outlook PDF.

The Contingency Planners webpage received just over 15,000 views in the year from October 2014 to September 2015, with under 700 views in July and August, and nearly 3,000 in November when the winter (DJF) 3MO for 2014 was published. Figures for accessing the 3MO PDFs cannot be retrieved, so these figures should be thought of as an upper limit for web access to the 3MO.

[9] http://www.metoffice.gov.uk/publicsector/contingency-planners. Accessible from Products-> Public Sector -> Resilience -> Contingency Planners

The 2015 Responder Survey explicitly asked responders about the 3MO for contingency planners. Of the 2104 respondents, only 184, or 9%, said they used the 3MO. Of those who said they used the 3MO, only 24% (45 respondents, 2% of the total) said they took any action as a result of using it, although 73% of those taking action said that in hindsight the action they took was necessary. Note that the action taken in many cases (69%) was to brief colleagues, which indicates that the reach of the 3MO was greater than the number of respondents accessing it.

Those consulted in this report gave fairly consistent feedback on the 3MO.Typical comments included:

- Don't find it helpful.
- Quite a scientific document. The information is useful, but the way it is presented is not.
- It is necessary to summarise into two or three strategic statements to be circulated further.
- Nothing wrong with it for scientists or risk analysts but too technical for most responders.
- Too complex. If it was better understood, the language would be simpler.
- Don't always get a consistent interpretation from the Met Office.

In the 2015 Responder Survey, those who used the product and took no action cited too much uncertainty in the forecast (60%) and not enough detail to make decisions (30%) as the main reasons for not taking action.

3.2 Briefings and Advisory Services

Civil Contingency Advisors and other Met Office staff are regularly asked to brief Government and resilience forums ahead of winter. As with all advisor services, these briefings provide value over and above the standard products, tailoring the information to meet the specific needs of the user. This includes, for example, additional words around the Three-month Outlook for the Cabinet Office and Scottish Government's Forward Look documents.

Regular meetings briefed by the Met Office include the Winter Resilience Network, chaired by the Cabinet Office Civil Contingencies Secretariat, which meets fortnightly from October. Although these only tend to focus on the severe weather in hand, if it looks prolonged longer range outlooks would be provided. Winter outlook seminars are provided for transport responders.

Ad hoc briefings from advisors are also requested by Local Resilience Forums and Government departments, normally as part of a "get ready for winter" seminar or campaign, with demand increasing when there are alarmist messages in the media. This year, a proactive effort was made by the Met Office to brief Department's Chief Scientists and emergency response policy leads on what the current El Nino means for potential weather conditions in the UK and across the globe.

Outside the PWS funded advisor service, the Met Office provides bespoke seasonal forecast briefings for Government departments and industry sectors. These briefing services provide a greater level of detail, and an opportunity to interact with those providing the advice. As a result, there can be greater confidence in whether to take action as a result of the forecast. Given a briefing on the winter forecast for 2015/16, one respondent decided that the enhanced risk of a cold end to the winter made it worthwhile to invest in new snow blowers for this winter. The current snow blowers were many decades old and needed replacement, and a severe early Spring snow event was in recent memory. Had the winter forecast been for a continuation of mild conditions throughout, it is likely that the procurement would have been delayed by a further year. Replacing equipment such as snow blowers requires procurement to commence well before the onset of winter, and hence early sight of a winter forecast with a degree of confidence helped inform the decision to replace the equipment. Another decision made on the back of the forecast for a colder late winter was to maintain road salt stock throughout the winter, rather than let them run down from mid-winter onwards.

3.3 Global Long-range Forecast

As part of the Met Office's responsibilities as a WMO Global Producing Centre (GPC), the Met Office publishes raw seasonal model output on its website for use by other national meteorological services. These are global charts of temperature, precipitation and pressure anomalies and, as it states on the webpage, do not "constitute a seasonal forecast for a specific location". The requirements are set by WMO Members. It is not designed for use by the UK public or public sector.

4. Future User Requirements

Many responders have a lack of confidence in the accuracy of seasonal forecasts and would not be prepared to take any action on the back of them. But some do see a potential use for reliable seasonal forecasts, especially for winter and extremes, were it possible. Some typical comments:

- If science permits a long-range winter forecast it would be very beneficial
- Would have been great in November 2013 to have known we would have a sustained period of very stormy weather in January and February
- It's the extremes that are important
- If we could have several weeks or a few months notice and we got an accurate forecast we could prepare
- If had at least 35% probability a few months ahead that something severe was likely to occur we could start looking at resourcing and planning

One respondent, who received a dedicated winter seasonal forecast briefing, felt there was a gap for other responders who were not able to access their briefing, which was confidential. This meant that different responder organisations responsible to the same minister had access to different information and different levels of preparedness.

Requirements for a replacement or complementary product to the three-month outlook directed at responders are:

- Forecast for the winter is important, and beyond a three-month outlook where possible;
- It needs to have a quantified level of uncertainty (error bars) including whether or not there is any skill;
- Set in the context of historical and recent (memorable) events;
- Has a clear, consistent, authoritative message or summary;
- More easily accessible to responders, e.g. through Hazard Manager, or from a trusted source, e.g. Met Office Civil Contingency Advisor.

It is doubtful as to whether seasonal forecasts are useful for the general public. It is not obvious what action the public would take on the back of a seasonal forecast, and there is always the risk of over-reaction, or undermining short-range weather forecasts and warnings. Nevertheless, an authoritative voice on winter seasonal forecasts may be useful to counter any misinformation spread by eye-catching stories in the media.[10] Whilst the public could access the 3MO to get "authoritative" information it is highly unlikely that they would find it any more accessible or useful than responders.

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[10] Example headlines for the 2015/16 winter: http://www.express.co.uk/news/weather/611100/Winter-2015-Heavy-Snow-record-cold-weather-forecast-UK, http://www.mirror.co.uk/news/uk-news/britain-facing-coldest-winter-50-6431808, http://www.dailymail.co.uk/news/article-3234605/Brace-cold-winter-Forecasters-warm-recent-bad-weather-start-powerful-El-Nino-phenomenon-1950.html, http://www.telegraph.co.uk/news/weather/11983384/Three-months-of-storms-set-to-batter-UK.html, http://www.independent.co.uk/news/uk/home-news/uk-winter-weather-el-nino-phenomenon-could-plunge-country-into-long-snowy-winter-10500972.html

5. Conclusions and Recommendations

In conclusion, there is the potential of real skill available in Met Office winter seasonal forecasts, but current products do not enable clear information of the winter forecast to reach the vast majority of responders. In detail, the conclusions are:

- Seasonal forecasts are showing the promise of real skill in predicting the NAO index and hence the likely winter weather patterns for northern Europe, including the UK.
- The mechanisms providing this skill still need to be understood, and further research is needed to better understand these mechanisms and better represent them in forecast models so that seasonal forecast skill can be further increased.
- Current seasonal forecast products are poorly used by the responder community.
- Most responders find them difficult to understand, and the most frequent action taken is to brief colleagues. Although this increases the reach of the messages, there is a risk that these messages will be inconsistent with the Met Office forecasts due to poor understanding and misinterpretation of the product.
- Briefing sessions are viewed favourably and increase trust in the forecast. There are examples of preparedness actions being taken on the back of the 2015/16 winter forecast briefings.
- Whilst most responders remain doubtful as to whether the uncertainty in seasonal forecasts would enable them to take any action, some do feel that if the science would permit reliable winter forecasts they would be of value, especially if the season were likely to be extreme.
- A suitable winter forecast product for responders would need to have a quantified level of uncertainty, set in the context of historical and recent events; and have a clear, consistent, authoritative message or summary.
- A product for responders should be easily available through the channels they use, such as Hazard Manager or the Met Office advisor network.

As a result, this report makes the following recommendations:

1. The PWSCG to continue sponsoring Met Office research into and production of seasonal forecasts in the next Customer-Supplier Agreement.

2. The PWSCG to ask the Met Office to develop a PWS-sponsored winter seasonal forecast product aimed at responders.

3. The PWSCG to regularly review progress in Met Office seasonal forecasting to provide assurance that anticipated improvements in scientific understanding feed through into improved products and advice for responders and Government.