The Technophobes Guide to Seasonal Forecasting in the 21st Century

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Weather Logistics
Seasonal Forecast

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1.1 Introduction

This short guide attempts to dispel the notion that seasonal forecasting is a feat that is only possible by a computer generation. In this short guide we describe a range of holistic forecasting methods, which are useful in compiling a long-range forecast. A forecast will only ever be a good guess, but it is essential that it is the best guess possible given the array of data available. The application of "persistence" forecasting to seasonal forecasting is clearly one of the most rigorous methods, though it must be used in conjunction with a view of "large-scale physics". By persistence we refer to recurrence of large-scale weather types in the future, that are currently affecting the general weather of today. When looking into the future it is necessary to examine larger scale features, which inherently act on longer timescales. Although the long term variability in the activity of the Sun plays a key role, its link with specific weather patterns is purely speculative. There are some powerful predicting factors including: patterns in the upper level winds (jet stream), sea surface temperature anomalies in the North Atlantic Ocean, recurrence of semi-permanent blocking patterns in the atmosphere, large-scale flow in the stratosphere and large-scale oscillations in the ocean circulation such as the Pacific oscillation (El Nino Southern Oscillation, ENSO). In general, focusing too much on the small-scale physics of the climate system increases the risk of chaos affecting the accuracy of ones forecast. Since the North American continent is far larger than the British Isles, seasonal forecasting is inherently far more difficult.

Using a set of holistic methods I was able to successfully predict both a cool and snowy Winter for 2008/2009 and showery and cool Summer for 2009 in the north and west. The forecasts were compiled by examining the current large-scale flow, which dominates the general weather patterns. My history of seasonal forecasting is one of success, forecasting weather events and extreme weather out to 14 days with reasonable confidence. In this very short document I intend to provide useful advice for any budding seasonal forecaster who wishes to pursue the field either professionally or as a past-time. The details of the current seasonal forecast can be found at: http://www.onlineweather.org.uk

1.2 How do I Compile Short-range Forecasts?

There are several free models on the internet that provide numerical forecast outputs. Numerical weather schemes predict atmospheric variables from a set of initial weather conditions using data from a diverse range of measurement sources including: Earth observation satellites, weather balloons, in-situ aircraft data and ground based readings. The output is usually on a set of vertical pressure levels, and on a fixed horizontal grid-box. There are a collection of free forecast "community" models that provide outputs of weather variables for the future. The free models are available from NCEP/NCAR are known in the forecasting community as Global Forecasting System (GFS) models.

The rainfall from the GFS informs the user by shaded contoured whether a region is prone to flooding within any reported time slot within the next few days. The duration of a numerical output is typically 3 or 6 hours. The short-range output of these models are usually consistent with the UK British Weather Service (BWS). There are limitations for any numerical model output, and the reliability of the forecast becomes poor after several days. The general large-scale components of the climate system such as temperature, rainfall, and the general flow trajectory, can be forecasted to reasonble skill up to 8 days in advance. To understand the limitations of any model it is usually necessary to undertake validation. This vastly improves the users confidence in the model.

1.3 What is Seasonal Forecasting and Why is Seasonal Forecasting Important?

Seasonal forecasting usually refers to long range weather predictions typically operating 1 to 3 months in advance, but sometimes longer. This is in contrast to short-range forecasts that typically operate up to 7 days, which focus upon specified events in the outdoor environment known as "weather". In the past such forecasts were achieved by observing patterns in the current weather patterns and by the use of "weather lores" (folklore) many of which were never proved to show any statistical significance. Modern forecasts usually rely on computer technology, and trained Meteorologists. Seasonal forecasting is a science more closely related to predictions of climate change, due to its statistical nature. By statistical, we refer to the likelihood of a particular type of weather event occurring within a specified period of time. Long-range forecasting in generally describes larger scale variability, such as the general flow trajectory prevalence of particular weather systems. The longer-term forecaster strives to make educated guesses regarding the typical weather patterns or average deviations in the weather from the "expected weather conditions" during the time of year in question. The long-term average of weather types in a region is often expressed as a "climate average". Statistics of climate are usually obtained by examination of a collection of archived weather events typically over a period of 30 years. The 30 averaging period is considered sufficient to smooth over decadel scale internal variability in the climate system. I have published the "climatological averages" for minimum and maximum temperatures during the period from 1961 - 1990. These averages can be viewed for major UK towns and cities, and can be viewed at `http://www.onlineweather.org.uk/EXPECTEMPT/11.html`. The averages were produced back in 2003 using weather data from the British Weather Service and are subject to a small error margin of $\pm 0.5\,°C$ (1.6 °F).

Seasonal forecasting has many applications including prediction of: Winter fuel payments, Flu and weather related illnesses for the National Health Service (NHS), the timing of Autumn harvest for arable farmers, water usage and drought, floods for insurance companies, flood protection agencies such as the Environment Agency, gritting or road maintenance in the Winter. Seasonal forecasts are also useful in the consumer retail markets, as they are often used to enable staff to stock the shelves of the retail stores suitably with seasonal clothes and food given advance knowledge of the expected weather.

1.4 The Origin of Weather Systems

A general understanding of what causes the observed weather in the UK, and the larger scale dynamics is crucial to make a successful forecast both for short and especially longer term weather. Weather systems form from upper level meandering in a fast-moving "ribbon" or airstream that circulates the Earth. Some of these waves are stationary due to the surface orography such as the high Greenland Plateau or the Rocky Mountains in North America. Stationary waves may also form due to contrasting temperatures between the ocean and continental mass. A transient set of waves result in the eastward passage of weather systems in the northern hemisphere, constantly evolving along their paths. Large-scale weather systems associated with these waves consist of both regions of relatively high and low pressure that is known as synoptic-scale weather. Synoptic-scale weather forecasting is important in our prediction of the day-to-day variability in atmospheric conditions such as temperature, cloud fraction and rainfall totals. In all latitudes outside of the tropics, the spinning of the Earth about its axis results in an "apparent force" known as the Coriolis force. The Coriolis force and the pressure gradients tend to oppose one-another across the constant pressure surfaces of low and high pressure systems. The magnitude of the pressure gradient at a fixed latitude is proportional the magnitude of "wind" that circulates in a gyre around the system's centre. Upper level winds are the important feature in driving the overall motion and dynamics of synoptic scale systems. The upper level winds are governed by temperature gradients between the Equator and the pole, with a maximum around 8 km above the surface known as the jet stream. The jet steam is not continuous, consisting of "streaks" or localised regions of intense wind, and regions of less intense wind. These upper level winds in general circulate the globe in the northern-hemisphere around the mid-latitudes typically centred at around 30 to 60°N. This meandering wind, known as the polar jet stream, dominates the formation and motion of weather systems that affect the weather in the United Kingdom.

1.5 What is a Good Prediction?

A prediction in weather forecasting is an educated guess regarding the state of the future atmospheric conditions by perturbation of a set of initial measurements. This is achieved by suitable representation of atmospheric fluid dynamics through computationally tiresome numerical modelling. The process involves physical representation of the atmosphere and careful parametrisation of cloud particles. Numerical calculations are usually so computational tiresome that they are undertaken by a fast multi-processor machine known as a supercomputer.

An example of an event that we might want to predict in Meteorology is a Hurricane. Hurricanes are inherently hard to predict accurately, yet it depends precisely what we mean by the term predictable. There are several variables we have to predict, and the more variables we wish to predict the harder it becomes to reach our goals. In the simplest case there are generally three main components of predictability of weather systems or developments in the weather, which include;

1. Trajectory
2. Intensity
3. Timing

It is often considered unsatisfactory in weather forecasting to predict only two of these variables well, and this means that the forecast is usually considered bad. You can probably convince yourself quite easily that the only convincing combination of two variables in this example would be (1) and (3). Indeed time and space are linked entities, which requires both to be correct to precisely locate a weather system or any event at a specified time in the future. Any other combination of two events would result in the hurricane not reaching our location. Even in the case that the forecaster is successful in predicting a storm, he / she may not be able to guarantee that the hurricane has decayed from hurricane status to a less damaging tropical storm in the period between the prediction and the event. Predicting a hurricane rather than a tropical storm may cause an unnecessary panic, a mass-evacuation and economic damage. It is therefore essential that regular updates must be made to ensure that the prediction is refined given the current observations of the atmosphere. The current observations will never exactly match the prediction undertaken from past observations, due to chaos and non-linearity in the physical equations used to describe the climate system. Many equations in Meteorology are non-linear in nature, meaning that they have no known analytical solution, requiring some form of manipulation in the form of an iteration or integration process.

In the prediction of rainfall, we need to know a lot more detail about a particular storm in order to predict the distribution and intensity of rainfall, which restricts the forecasting lead-time. In the rare case that we predict the storm's precise trajectory and timing, normally only possible with a short lead time we still need to accurately predict its intensity and other cloud components to predict the rainfall totals. The precipitation forecast is in effect a derivative of predictions, and predictions of predictions amplifies the magnitude of the chaos. The lead-time refers to the time between issuing the forecast and the occurrence of the specified event and is fairly short when predicting synoptic scale rainfall for specified regions of the UK.

1.6 The Future is a Perturbation of the Present

The role of chaos on seasonal forecasting is somewhat controlled by the forecaster. It is rather a misnomer that chaos is some fixed quantity that is fudged onto your data after you make a forecast. Forecasts are constantly improving with faster computer processing power. Due to the four dimensional grid of forecast outputs, reducing the grid size by half on a regular grid requires 16 times the processing power to compute the same number of calculations in the same period of time. Knowing the limitations and working around them is what forecasting is all about. Large-scale features are like "big magnets", which control fundamentals of the forecast, and "on average" these forcing factors will dominate forecasting process. A north-westerly flow in early Spring may seem like a normal affair, whilst projecting this to the Summer results in flash flooding from heavy thundery showers and localised severe flooding. Keeping in mind the main forcing factors of today's weather, and projecting them 3 months ahead can often prove quite profitable. In day-to-day weather forecasting it is often very accurate to say that the weather of today will be the weather of tomorrow. In seasonal forecasting the weather often strays far from the bounds of the forecast, as weather can change dramatically on a day-day basis throughout the valid forecasting period. It is however essential to keep in mind that whilst the forcing factors are in place "on average" a correctly constructed forecast will always weather well.

In general I regard the persistence forecast the best on all occasions. This can be either pessimistic or optimistic, where forecasting is based on the current weather events. There are some main differences in the "persistence" forecast when applied to seasonal forecasting. One must firstly bear in mind that the flow trajectory that affects a location possesses a seasonal dependency, and secondly that the intensity of the over-head Sun dominates the formation of showers over the land-masses. There are also some other key pointers when thinking about perturbations to the jet stream. The mid-latitude jet stream tends to strengthen in the Autumn and Spring due to stronger North-South temperature gradients and its mean latitude component will undergo a gradual drift from south to north between the mid-winter and mid-summer.

1.7 Good Predictors: Forecasting Confidence

The El Niño and La Niña are the brother and sisters extremes of oscillations known as the ENSO that dominate the global weather patterns. The El Niño Southern Oscillation is characterised by seas surface temperature (SST) patterns across the tropical Pacific ocean. Whilst it is intuitive to assume that La Niña conditions would induce a small cooling globally, the perturbation to the "normal" seasonal weather patterns in different parts of the globe expands the full spectrum from cooler to warmer than average. In the UK La Niña conditions usually result in cooler and drier conditions, whilst El Niño conditions result in warmer and wetter conditions and particularly milder winters.

It has been noted that the character of the El Niño conditions may be further complicated by the position of warmer oceanic water in the Pacific[1]. The "modified" El Niño expected to develop during the Winter of 2009/2010 is likely to be characterised by warmer water in the Central rather than East Pacific, and therefore exhibits its own unique effects upon the global weather patterns. This could spell disaster for UK weather forecasters who are hedging their bets for a warmer and wetter Winter. There is still strong evidence to support the case for a cool and wet winter, which would result

[1] http://www.nature.com/news/2009/090715/full/460317c.html

in heavy snowfall for the UK on a scale unseen since the 1980s. Good guess work would usually indicate a mild and wet winter under the influence of an El Niño. The link between the dominating Atlantic oscillation known as the North Atlantic Oscillation (NAO) and the ENSO is a positive one. Though it is dangerous to make too many assumptions by associating too many uncertain predictors in the system, as errors are sure to arise from lose logic. A stronger polar jet stream (particularly in Winter) dominates the UK's weather when the NAO is positive, and herald drier cooler Winters when the NAO is negative.

An array of seasonal or weather forecast outputs each compiled with slightly perturbed initial weather conditions are known as ensembles. The range of scenarios are derived from intensive numerical supercomputer simulations. Ensembles can also be generated by combining computer simulations of the future climate from different computer models, with slightly different representations of climate physics. In spite of the large advances in current technology and understanding of the climate system, an ensemble of weather predictions may not always provide an accurate prediction of the future course of the system. It is sometimes true that simulations may be biased towards warmer or even cooler projections, though this is often unlikely in shorter-term predictions that are constantly re-evaluated. Whilst the ensembles should statistically predict the range of possible futures associated with the current atmospheric, oceanic and solar weather; they are often subject to large errors. There is no certainty in the climate system even in occasions when the predictors all seem to point towards the warm tail of a prediction in longer term predictions. This is because some of the larger players in the climate system operate on longer time-scales, whilst synoptic weather forecasting up to a week in advance remains unaffected by such events. Many elements of the earth's system and many external forcings are unpredictable, such as volcanic activity, northern hemisphere ice coverage and ocean circulation. In seasonal forecasting the onset or continuation of either El Niño or La Niña conditions in the Pacific ocean can often give us delusions of the future, when there are other features of the system that are not often monitored on a day-to-day "weather" basis. Whilst short to medium range forecasters rely on a fundamental grounding of the physics that govern the atmosphere and ocean, longer-term features and more complex knowledge of the interactions between components of the climate system are required for long-range or seasonal forecast simulations. By such intensive modelling of the small-scale intricacies of the climate system, we then might ask the question: Are we losing insight into the larger scale physics that dominate the longer term climate?

Some general features of the climate system are predictable. We can easily generalise the migration of the ocean isotherms for instance. The sea surface temperatures in the north Atlantic ocean fluctuate between seasons, with the migration of the isotherm (lines of constant temperature) that lags the air temperature by around 2 months. The coldest sea temperatures usually occur around March, and the maximum in September in the north Atlantic. The best predictor of weather patterns is the pattern in sea temperature "anomalies". As the atmosphere and the ocean are "coupled" or linked, the chicken and the egg interactions between the general overall trend of the atmosphere and temperatures come into play. It is for instance possible for the trained eye to spot an abnormal blocking high pressure system. Whilst the westerly quadrants of a mid-latitude high pressure directs a strong southerly flow of oceanic water into the northern hemisphere the easterly limb directs flow southward. Over periods of months, the surface winds cause temperature anomalies in the ocean if the system remains a dominating or "blocking" high. These anomalies allow an experienced forecaster to track down or identify any unusual weather patterns during a season, and then project them into the future.

One further predictor is that the UK Winters are in general "getting warmer". Since the 1980's the mild and damp weather theme has dominated our picture of a typical British Winter. In general the UK temperatures averaged over day and night on a year to year basis have been in general increasing. The average day and night temperatures are now around +0.7°C (2.0°F) above those measured in the late 1970's, though natural variability and decadel variability may mean that we could see a modest cooling in the coming years. It would be a clever trick just to say, next season is going to be "slightly above average", and you would be right around 65 % of the time. This is because as the inter-monthly standard deviation in UK temperatures is almost identical to the magnitude of the mean temperature anomaly. Beware that climate change science shouldn't really be used as a tool to predict the weather, as it's very annoying both to sceptics and the very important forecasters who can successfully identify and predict a cold winter.

1.8 Physics of the Large: The Big Picture

Piers Corbyn[2] of ©WeatherAction claims to use a solar forecasting technique for his medium and long-range forecasts, the details of which he will not disclose to the public. The solar weather technique, according to Mr Corbyn, is disputably the most advanced and reliable long-range forecasting system in

[2] http://www.weatheraction.com

the world. He makes use of both particle and magnetic solar effects as the basis of his weather forecasting skill, gaining much media attention in the process. Although I am not an expert on solar weather forecasting, it stands true that Piers Corbyn is a highly gifted medium to long-range weather forecaster with a breadth of experience. In the field of meteorology his forecasting technique is much contested as he uses his innate ability to forecast extreme events as a means to disprove anthropogenic climate change. As such, Piers Corbyn is one of the most prominent climate sceptics in the world, featuring on the controversial Channel 4's documentary "Great Global Warming Swindle"[3]. Predictions on the scale of an eddy in your back-garden will take many calculations by a powerful computer, many hours of processing, and will only be ever functional out to the order of seconds. There is more to seasonal forecasting than predicting on the smallest grid-box possible, and some interesting results can arise from less computationally tiresome calculations particularly in the stratosphere where large-scale atmospheric motion dominates the weather.

1.9 Summary

There are many ways to predict the weather seasons in advance. The current state of seasonal forecasting means that making clear, logical and highly educated guesses about the future state of the climate system by making only the most essential perturbations of the current state of atmosphere is most profitable.

Once a seasonal forecast is made it is always best to stick to your guess, as the chaotic fluctuations over the months within your forecasting period should "on average" converge with your forecast, given the best set of key predictors. It is important to prioritise the forecasting process by factors that bear the largest weighting. Though this may seem subjective, it is clear that if a key predictor is missed from the seasonal forecast the outcome may never resemble the true answer irrespective of the quality of the forecaster or the model. This will result in the public or the user deciding that your forecast is "wrong". Indeed there is never a perfect forecast, but it is clear that a period of weather that is atypical to your forecast during the Christmas period or Summer holidays can warp the perception of a right or wrong forecast in the eyes of the customer.

The ENSO is clearly the strongest predictor for global weather patterns, but beware of other larger recurrent patterns on longer time-scale than an ENSO cycle, such as decadel oscillations. In the future the state of seasonal

[3] `http://www.channel4.com`

forecasting may enable us to spot the fore-coming of a climate shift. It must be recognised that the sea temperatures in North Atlantic offer some key information for predicting the seasons ahead, perhaps one of the most underestimated factors in seasonal forecasting. A common theme that appears to becoming more persistent in the current climate is an increasing frequency of blocking systems throughout the globe. That is systems that are semi-permanent, and divert or inhibit the usual cause of the prevailing weather systems. It is likely that anthropogenic greenhouse gases are causing such anomalies through interactions with the Earth's delicate radiation balance. Blocking features are often attributed to abnormal global circulation patterns that are not common to a region. Such systems are often poorly resolved in both numerical forecast schemes and in global climate models (GCMs). They can divert the usual course of the prevailing jet stream, and result in extremes of cold or heat, and extreme drought and floods associated with climate change. In the northern hemisphere a frequent disruption of the polar vortex circulating the winter pole at around 30 mb has been observed to cause extremes of winter snowfall and cold.

1.10 Contact and Further Information

For more information please contact:

`WeatherMan@OnlineWeather.org.uk`

My seasonal forecasts can usually be viewed at:
`www.OnlineWeather.org.uk`