9th Scientific Statement

Recent Irish weather extremes and climate change

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RIA Climate Change Sciences Committee

In November 2009 Ireland experienced unusually wet weather that caused widespread flooding. It was followed by a cold spell from mid-December that culminated in exceptionally wintry conditions in the early days of 2010. Both events have led to speculation that this is a manifestation of man-made climate change, a foretaste of what is to come. Is there any substance to this view or are the events explainable in terms of natural, as opposed to anthropogenic (human-induced), variability of the Irish climate?

Climate models suggest that extreme rainfall events, such as occurred in late 2009, are likely to become more frequent in the future, with additional changes in the *average* rainfall. These changes will be projected on the natural variability of the climate system, a fundamental feature that can produce large departures from the average. It is not possible to attribute any specific weather events to either of these components. The November 2009 rainfall was likely to be part of natural variability, supplemented with a small expected increase in rainfall due to anthropogenic climate change.

Similarly, the 2009/2010 winter cold spell was consistent with the natural climate variability displayed in the climate records.

November 2009 Floods

The November floods followed a very wet period that began in mid-October and extended through most of November. Persistent and often heavy rain falling on saturated ground caused widespread flooding, exacerbated in places by changes in land use. Rainfall amounts for the month were the highest on record for most of Met Éireann's observing stations (more than 400 in number). Notable statistics for the month:

- 360mm of rainfall fell during the month at Valentia Observatory, the highest reported value since observations began in the area in 1866[1].
- More than twice the average monthly rainfall amounts were recorded at almost all stations.
- At some locations the amounts were more than three times the average.

It was also a record-breaking month for rainfall in the UK due to the same weather systems.

Record floods were noted during the month on many river catchments including the Shannon, the Suck (Co. Galway), the Fergus (Co. Clare), the Erne, the Bandon (Co. Cork), the Clare (Co. Galway), the Dunkellin (Co. Galway) and the Laune (Co. Kerry), amongst others (OPW, 2009). In many cases this type of flood event would be expected to have a return period[2] of 100 years or more.

[1] Several weeks later, on 12 January 2010, the Observatory recorded its wettest January day since records began in the area.

[2] The average recurrence interval over an extended period. For example, a 50-year flood has a 0.02 or 2% chance of being exceeded in any one year.

Other notable flooding events have occurred in Ireland in recent years. In July 2008, severe flooding was experienced in the Newcastlewest area of Co. Limerick and in August of the same year, several areas in the east of the country (e.g. Dublin and North Kildare) experienced significant flooding. These events have occurred against a backdrop of very poor (i.e. wet) summers over three consecutive years (2007-2009).

Are these events a signal that the climate is changing? Aside from the scientific interest, this is a particularly relevant issue for managing potential flood risk which may involve substantial investment by the State in flood relief schemes.

Rainfall trends

Trend analysis of rainfall data, particularly for extreme events, is notoriously difficult as rainfall displays a high degree of variability, both over space and time. Research on this topic (WMO, 2009; Frei and Schär, 2001) suggests that long records (e.g. >100 years) may be required to detect changes in the occurrence of relatively modest extreme events.

In Met Éireann, basic trend analysis has been performed on a number of high-quality rainfall stations. Some stations show an increase in the frequency of wet (>10mm) / very wet (>20mm) days over the past decades but there is large regional variation and occasionally conflicting trends from stations that are geographically relatively close.

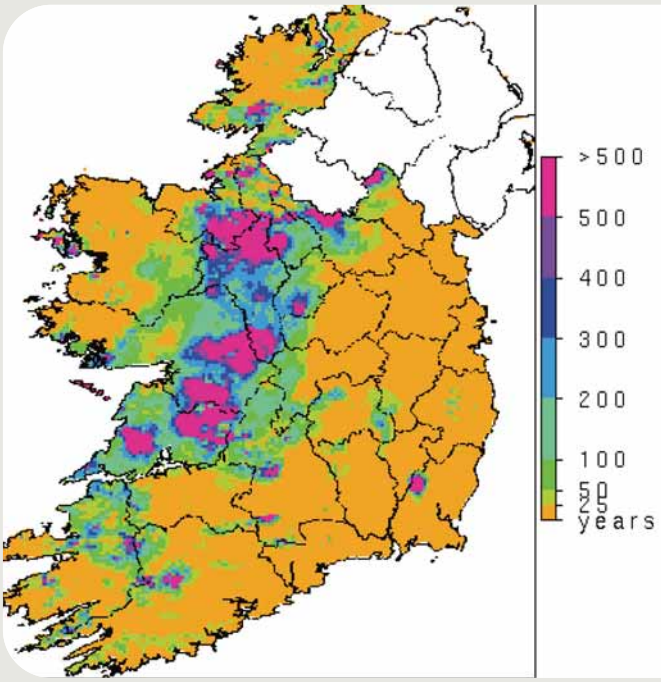


FIGURE 1.

Return period (years) estimates for 25-day rainfall ending at 0900 on 26th November 2009. Note that the analysis is referenced on rainfall data for the period 1941-2004 which are assumed to have constant statistical properties.

A major study (Fitzgerald, 2007) of Irish rainfall, based on data from 1941 to 2004, provides a statistical framework for calculating return periods of specified rainfall amounts for any station in Ireland. Applied to the November 2009 rainfall (Figure 1), it indicates that, at some sites, the return period for the observed rainfall exceeds 500 years (i.e. probability of occurring in any year is less than 1 in 500). However, such extreme figures may not be reliable. Nevertheless, the results suggest that the rainfall experienced in November 2009 was indeed extreme. A more complete description and analysis of the rainfall for this period can be found in Walsh (2010).

Technical analysis of the 1941-2009 rainfall data, detailed in the Appendix, shows that while there is evidence of a shift to increased *annual* precipitation amounts since the mid 1970s, there is no evidence of a trend in the November rainfall in recent years, although the 2009 event does stand out as extreme.

The recent cold spell

Over the winter months of 2009/2010, cold polar air moved southwards towards the lower latitudes resulting in below average temperatures being recorded throughout much of Europe and above average temperatures at more northern latitudes. This particular situation is associated with a phenomenon called the Arctic Oscillation and results from a reversal in the normal pressure distribution for the region.

The cold spell, which started in December and ran into January 2010, was particularly severe. It was the coldest December for 28 years over most of the country and the coldest of any month since February 1986 at a few stations. Air and ground frost were locally severe during the second half of December, particularly around the Christmas period when Mullingar measured its lowest December air temperature for many years (-10.0°C). In general, temperatures for the month were 2 to 3 degrees below normal. The cold spell continued into the first 10 days of January 2010; in most areas it was the coldest January since 1985, but in the Dublin area, it was the coldest since 1963.

The cold spell in historical perspective

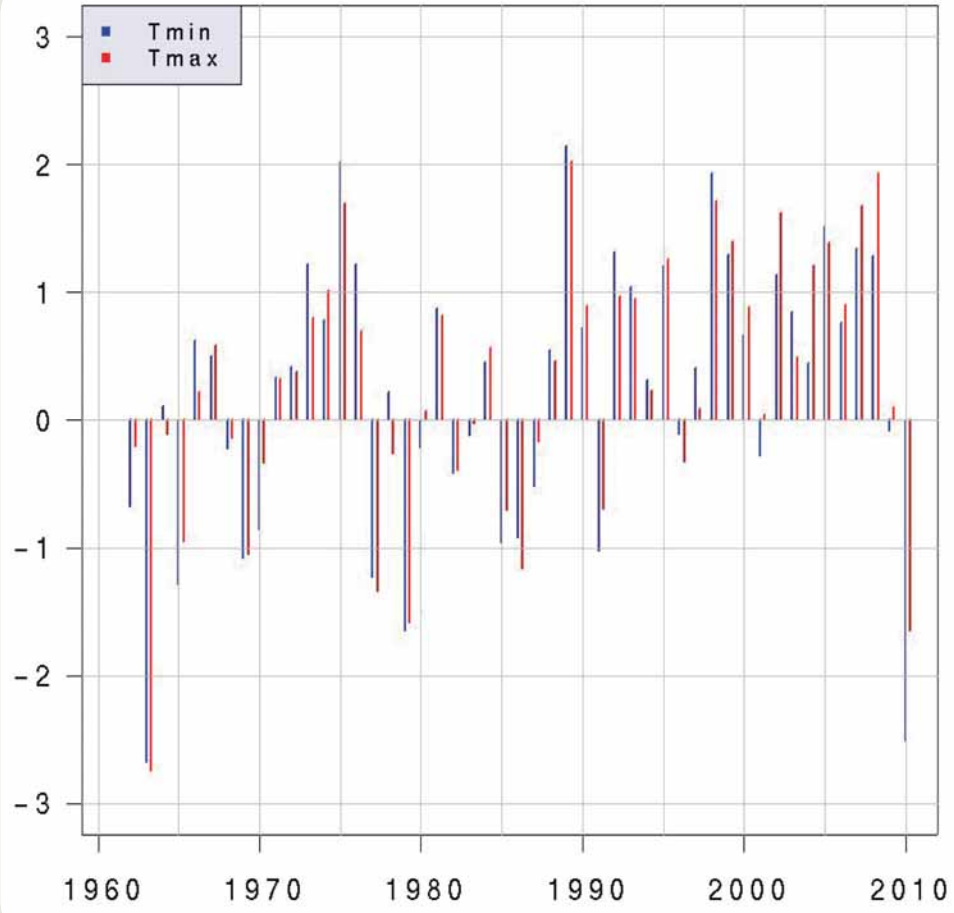
We can characterise the recent cold spell using measures that include the intensity and duration of the cold, and the quantity and persistence of the snow. The 2009-2010 spell was noteworthy for the former rather than for any particularly large quantities of snow. It was the most extreme since 1963, generally comparable in severity with cold spells in 1946/1947, 1962/1963, 1978/1979 and 1981/1982.

In summary, it was exceptionally cold, but not unprecedented in the recent past: the 1946/1947 and 1962/1963 winters, for example, were more extreme. Such cold spells may be described as recurring over a time scale of decades.

This is confirmed in Figure 2 which shows the temperature anomalies (differences relative to the baseline period), based on gridded observational data averaged over land areas for the period 1961-2010. Note that the averaging of temperatures over the three winter months does not capture the severity of short-period cold spells such as occurred in January 1982.

FIGURE 2:

Maximum (red) and minimum (blue) temperature anomalies (Celsius) 1961-2010. The data are based on average values for the winter season (December, January, February) derived from gridded observational data i.e. representative of the country as a whole.



Link with global warming?

Climate models suggest that short duration extreme events will become more frequent in the future and that we will have wetter winters and drier summers in Ireland. For example, the average forecast from the ENSEMBLES project (van der Linden and Mitchell, 2009), based on 12 climate simulations, is for an increase in the late autumn (November) rainfall over Ireland of about 8% in the period 2021-2050, rising to about 15% in the period 2071-2100 (both figures relative to the reference climate period of 1961-1990). However, compared with the expected temperature changes, there is less confidence in future projections of rainfall and this is reflected in a rather large spread, particularly at regional level, between the individual simulation forecasts. Note that these are forecasts concerning the climate over several *decades* and that natural climate variability, which may occasionally throw up a run of wet summers, will continue to play a part in the future as in the present.

Although climate models suggest that events such as the extreme rainfall in November 2009 are likely to become more frequent in the future (IPCC, 2007; Chapter 11), this single event neither confirms such forecasts nor does it set a benchmark for future rainfall. It is likely to be linked to natural climate variability, combined with a small expected increase in rainfall due to anthropogenically driven climate change. More research is needed in this area to evaluate the contributions from natural variability and anthropogenic influences; planned climate simulations by Met Éireann and ICHEC (the Irish Centre for High-End Computing) with the EC-Earth model (Hazeleger et al., 2010) will shed further light on these issues for the Irish climate.

The recent cold spell may appear to be at odds with global warming. However, while January 2010 was cooler than normal not just over Ireland but over much of Europe, on a global scale the month was the fourth warmest January on record since 1880[3]. The planet continues to warm.

The climate forecasts from the ENSEMBLES project, based on 12 climate simulations, suggest an increase in the minimum winter temperatures over Ireland of about 1°C in the period 2021-2050, rising to about 2.5°C in the period 2071-2100 (relative to the reference climate period of 1961-1990). The models also suggest that cold spells will be less intense and shorter in duration in the future. However, just as for the rainfall, these are predictions for average changes over several decades and they do not refer to individual events.

The cold spell that Ireland experienced is not inconsistent with climate model projections and is easily explained as a feature of the natural variability of the climate system superimposed on an underlying warming trend.

Acknowledgements

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Appendix

Further insight can be gained by looking at trends in the rainfall patterns using an Empirical Orthogonal Function (EOF) technique (von Storch and Zwiers, 1999). The central idea behind the method is to reduce the complexity while retaining as much as possible of the variation present in the data; it effectively describes the data in terms of products of fixed EOF patterns (or modes), and time-varying values (Principal Components – PCs). Most of the variance in the original data may be represented by a small number of modes; occasionally, the dominant, or first mode, describes the essential features with its PC revealing possible significant changes over time.

In this case, the station rainfall data for November months (1941-2009) are interpolated to a regular fine grid in a consistent manner and the monthly *anomalies* (relative to the mean of the monthly values for the period) are analysed using the EOF technique. Figure 3 shows the time variation of the PC for the dominant mode (the spatial pattern is not shown) which accounts for 71% of the total variance of the data. It shows that there is no evidence of a trend in the pattern in recent years although it does highlight the exceptional nature of the 2009 event.

If the focus is shifted to *annual* rainfall (Figure 4), a similar analysis is suggestive of a shift to wetter weather (increasing rainfall) in recent decades with the change point around 1978. This is consistent with the findings from a previous study based on data from a selected number of stations (Kiely, 1999).

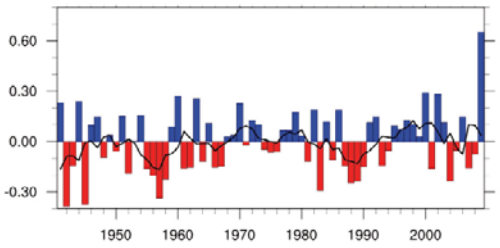

FIGURE 3:

Empirical Orthogonal Function (EOF) analysis of November monthly Irish rainfall (1941-2009). The time evolution of the Principal Component for the first mode, which accounts for 71% of the variance, is shown below together with a 5-year running trend line (black colour). The left hand scale is the relative amplitude (units: mm, red for negative, blue for positive values).The last value corresponds to November 2009.

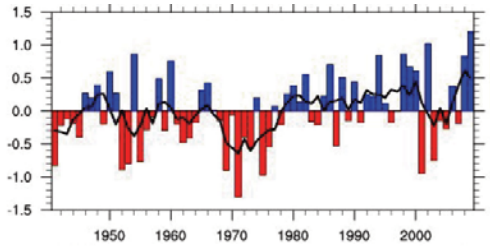

FIGURE 4:

As for Figure 3 but for annual rainfall.