Forty Years of Recording Rainfall at Kidderminster

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I suppose it might be the obvious thing for me to want to measure rainfall, after all, my work in Hydrometry, Water Resources and Flood Warning used rainfall data all the time. When we looked for a suitable person to be a rainfall observer I knew that it required someone who was available nearly every day of the year between 09:00 and 10:00am to take a measurement and carefully note it down. As well as that, the location of the gauge has strict Meteorological Office (Met. Office) rules involving overshadowing from nearby objects, and cannot be in too open a location either. A change in my situation in 1982 occurred when I got married. Suddenly we had a garden big enough to fit a gauge and very soon I was measuring rainfall myself, getting registered with the Met Office as station 438695-Kidderminster and the rest is history - 40 years of it!

What is the point you might ask, of collecting that data. The fact is that rainfall data underpins all water resources and flood warning plans, not only that, but what better way to start your day than to know how much rainfall you might be dealing with at work. The Met. Office still maintains a network of around 6000 volunteer rainfall observers in the UK and the idea is to maintain an even coverage nationally (Figure 1). The need for so many manually read stations is because, although automatic weather stations do give immediate response, these stations are far fewer and very often, as rainfall is so variable from place to place, a denser network is needed to resolve more detail. It is the data from the daily gauges that goes to build up the national rainfall archive and this data is used in climate change analysis.

Part of my role at work was to carry out the inspections of rain-gauge sites for the Met. Office to see if they were up to standard. The Met. Office inspectors often liked to surprise the observer with a visit and try to catch them out. People do things without thinking and one observer in our area was in the habit of putting a table tennis table over the

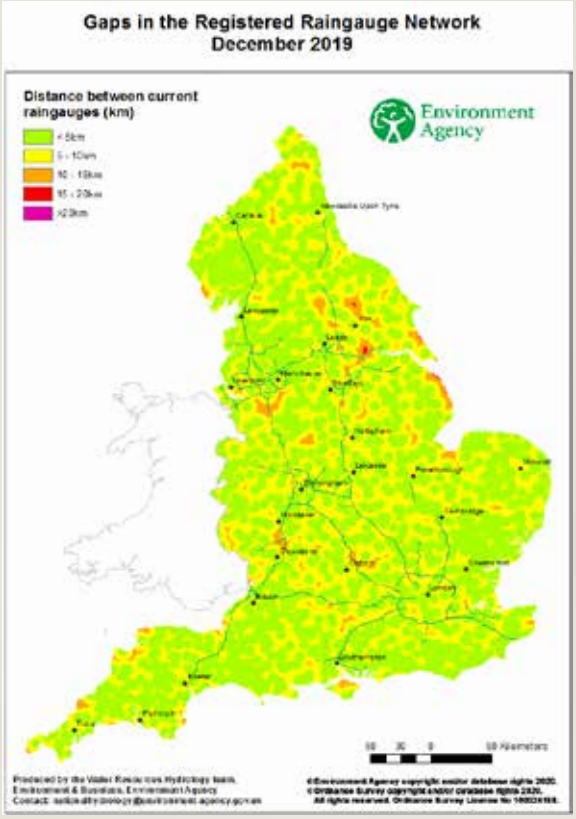

Figure 1. The UK rain-gauge network highlighting where new gauges might be needed.

gauge during games. The other classic error was hanging a washing line over the gauge. Obviously the intention would be to clear the gauge in case of rain but would they always remember? Small discrepancies you might say but an indication, perhaps, that not everyone was ready for that surprise shower. I preferred to let the observer know I was calling as I knew that some people had waited all year to have a chat about the gauge and welcomed the interest in their site. It must be remembered that observers are all voluntary so they do it for the love of the weather. Data is sent in digitally now but it used to come in on pre-stamped monthly cards. Sometimes we would know that a visit was due when we got odd comments on the return cards. One said "*Unable to measure gauge due to it being stolen*" and, yes, the gauges are all copper with a beautifully machined rim and so might make a nice umbrella stand.

Some other terrific comments can be seen

in the collection of paper entries recently digitised by Reading University where they archived 130 years' worth of handwritten rainfall observations from across the UK and Ireland (University of Reading, 2022):

> *Woolwich Eltham High Street, 1944: "Gauge destroyed by enemy action".*
>
> *West Ayton (North Riding) readings stopped in September 1949: "too old to bother now".*

Locally, the more frequent problem found amongst observers was that they would not completely empty the inner measuring bottle when quickly taking a reading and so would repeatedly have a small amount left which might then be re-measured on the next day even though that might actually be a dry day. The other most common occurrence was that mowing machines would inevitably get too close and knock the gauge out of their intended perfect level. Generally rainfall observers are sharing in their nature but they can become across as a bit pedantic for instance when someone in the local pub comments 'didn't it rain last night', they might say, 'well actually it was only 11.6mm'!. At work, when we had to find a new or replacement observer, the ideal person was someone early retired with a technical background and of course who didn't mind a gauge as the centrepiece of their lawn. By the way that's the other thing, the rain gauge's position does need to be in a patch of mown grass and wild borders with tall plants are not suitable.

A Short History of rainfall recording

During the mid-1850s, a sequence of dry years in Britain led to public concern over the possibility of permanently decreased rainfall. In 1859, the then President of the Scottish Meteorological Society, the Marquess of Tweeddale, offered a £20 prize for the best essay on '*whether the amount of rainfall in the western parts of Europe, and particularly in Scotland, is less now than it formerly was*'. This enquiry drew the attention of a young meteorologist, George James Symons, who had joined the British Meteorological Society in 1856, at the age of 17. There had been no general collection of reliable records and no thorough investigation of rainfall trends had taken place before this. Circulars were sent to observers of the British and Scottish Meteorological Societies and to all others known to keep records, hoping to gather information from all parts of the UK. In 1860, Symons started work as a clerk in the newly-established Meteorological Department of the Board of Trade, under Admiral Fitzroy. He was struck by the inadequacy of available observations of rainfall and eventually Symons, after experimenting with all sorts of designs, settled on the 5 inch diameter, 12 inch high gauge that was to be read at 09:00 each day and from the mid 1860's that is the system still used. Interestingly the millimetre has been the basic measurement unit since 1915. So Symons's great achievement was to develop a network of gauges with a general uniformity of measurement and recording which became a model for other countries. All this work was carried out under the British Rainfall Organization which was funded by various grants. It all remained for many years as a rather voluntary set up with many people doing unpaid work. Nevertheless annual books of British Rainfall were produced for many years. Eventually, the organization was merged into the Met. Office in 1919 to give the network a solid financial footing (Pedgely, 2002).

Prior to the standardization of rainfall recording, Universities, Vicars, local country estates, water undertakings, light house keepers and lock keepers all read rainfall. One of the longest records is the one at Radcliffe Observatory at Oxford University where there are records going back to 1767, but most areas only have standard recording from the 1840's.

Setting up a Rain-gauge

If you were to imagine an ideal location for a rain-gauge, think of one of the walled gardens that large country houses often had. This has

the security of a wall which also acted as a shelter from strong side winds. Inside the wall the rain would drop into a catcher without being swept away sideways. Close to the gauge, ideally nothing should be closer in distance than twice the height of that object (a 20 metre tree should be at least 40 metres away from the gauge). An approved gauge should have a 5 inch diameter funnel whose top is 12 inches above the ground. An inner bottle collects the rain which is measured with a calibrated glass tube. Those are the perfect conditions, which in reality, can be slackened for smaller gardens. There may be a tree that breaches the 22^{O} sight-line above the horizon, but if it is to the north side, that is not considered to be a major rain bearing direction and is therefore acceptable. Sometimes there is the difficult task of telling an observer that their site may be just too sheltered by trees to continue accepting measurements. In the West Midlands overexposure would be unusual but some gauges in moorland may need a sloping earth bank built up around the gauge. In this case the gauge sits down in a pit below the top of the bank. Generally most garden locations have a spot where the south and westerly direction is open to the prevailing weather.

Spaces regularly occur in the network so if you think you might like to read rainfall for the Met. Office and Environment Agency, the gaps are shown in Figure 1.

What has been found out in the last 40 years of measuring rainfall in Kidderminster?

Although it's a lifetime worth of readings for me, in the grand scheme of things my contribution has only a short time span and it is, of course, the long-term record that really begins to show us what is going on in relation to climate change. Kidderminster is located in the part of the country that is fairly average in terms of the UK extremes. It does not get the wettest Scottish annual totals of more than 3000mm a year nor the low 600mm's of Cambridgeshire; normally the average for this area is around 700mm's (Figure 2).

Adequate rainfall is essential to maintain steady plant growth and maintain a healthy environment, but when droughts or heavy downpours occur either can cause problems. Droughts are surprisingly common in the UK occurring every 5-10 years and they are de-

The photograph (left) shows a standard copper gauge with a device sitting on the top which both shows how level the top is plus an image of all the 360° surroundings. The specially machined curved metal mirror gives a perfect image of the angles of the horizon and nearby objects when viewed from directly above. Ideally there should be no objects giving an angle of more than 22° especially from the prevailing rain direction (Usually for The British Isles that is west to south east).

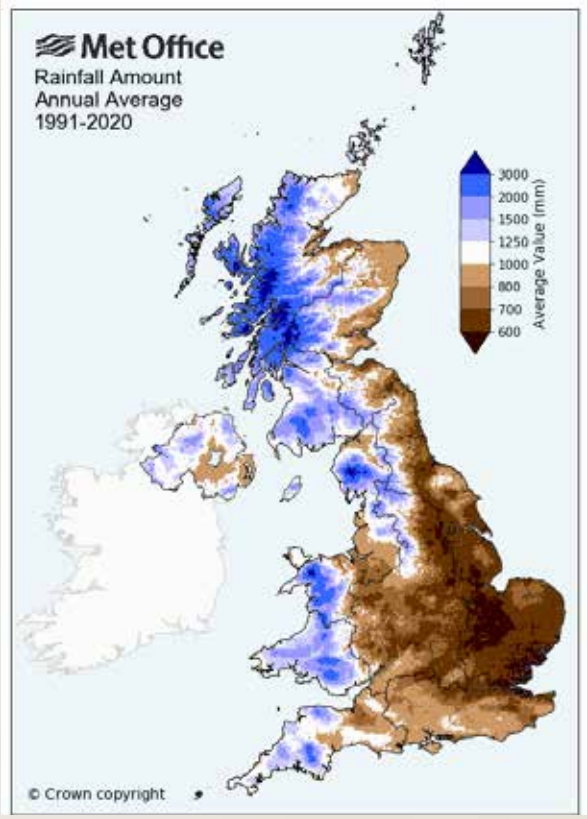

Figure 2. Met. Office UK Climate Averages - Map showing Annual Average rainfall in the UK.

fined as “a period of at least 15 consecutive days when there is less than 0.2mm (0.008 inches) of rainfall". As recently as this year (2022) we had only 62% of our summer rainfall by the end of July, with no rain at all for 17 days in mid-July. No surprise then that a drought was declared, registering 2022 as the fifth driest June-August for England & Wales in a series from 1836, joining 1976, 1995, 2006 and 2018. Even in November parts of south eastern England still had hosepipe bans.

One of the longest runs of dry weather at Kidderminster in the last 40 years was in 1995 which had 21 days with no measurable rain in August. This of course helped to make it the driest summer from April to September. The longest run though was 36 days with less than 0.2mm from 31st March to 4th June in 2011. That year was the driest April in 40 years and the rainfall stayed below average all year making it also the driest year yet. For England, in general, 2011 was the 9th driest on record.

Droughts do not just happen overnight unlike flood events which can change the picture in hours. That is the trick with understanding flood events. Knowing how long and how intense the rain has been is key to estimating the response. It can rain all day to produce 30mm and not necessarily be a problem but if that rain occurred in 1-2 hours, it may well produce local flooding. The most notable event in Kidderminster in the last 40 years has been the 61.5mm which fell on the 20th July 2007. That storm was exceptional because it was in the summer catching many people and businesses by surprise. Summer floods usually require a lot more rain because the ground has had time to dry out since wintertime year May and June had all been well above average and so the ground was already waterlogged. At work, I had been called out to the Barbourne Brook in Worcester to try to limit the floodwater entering the houses in Shelley Close by adjusting the penstock valves on the Brook. The cricket ground in Worcester was flooded and some locations that had old drainage systems were severely tested. My gauge was not the only one with record rainfall totals as that event turned out to be widespread across England leading to the wettest month for Kidderminster and many other places. Nothing had been seen like it since 1924 when a similar summer event had flooded the Pitchcroft show ground in Worcester. There was not much play on the wicket at Worcester’s Cricket ground in 2007. Locally the Severn Valley Railway was badly hit, suffering breaches in 45 separate locations between Bridgnorth and Northwood Halt. Repairs were costly and not completed until the following February, when the line was once again fully open. Tenbury was particularly unlucky in 2007 as it suffered three summer floods, one from the July event as well as two other storms that were localised in the River Teme catchment.

When you work in Water Resources you want to witness extreme events while not wanting anyone to come to harm, of course, so I was lucky to see the drought of 1975/76 and then,

just before retirement, the floods of 2007. It was with some pride that the gauge I had installed at Kidderminster to monitor the storage reservoir at Puxton, recorded just short of overtopping on 21st July 2007, saving Kidderminster Town from the terrible floods that had plagued it in the past. Puxton is the perfect project where you get flood protection, more water lying in a wetland in dry spells and all partly paid for by developers.

Extreme daily rainfall totals in excess of 50mm/day on a UK wide scale, are seen most often in the seasons of autumn and winter and have increased noticeably between 1960 and 2020. These events are significantly more likely to occur in Wales, Northern Ireland and the West Coast of Scotland and will have the largest impact there. However, examining changes in those 50mm events over all regions of the UK shows increases in the number of these events in almost all regions (Cotterill *et al.*, 2021). Storms in excess of 50mm make the news, but other than the 61.5mm in 2007, Kidderminster has not had any other 50 mm plus events but it has had 4 years when there were more than 40mm - 2004, 2007, 2012, and 2015.

Long term trends are what make the daily rain gauge archive unique, the longer the better. My comparatively short 40 year run has seen many changes. Generally rainfall averages are reached by taking 30 year snapshots, so for 1981-2010 my average was 683.2mm per year and for 1991-2020 it was 703.4mm. A rise in recent years (Table 1).

This rise is reflected in Met. Office figures for the Midlands, where there has been an annual rise of 9% from 1961 to 2004 (Met. Office, 2022). This annual figure is hiding the fact that in the spring and summer there has been a drop of between 3 and 4%, while in the winter and autumn it has risen between 19 and 22%. This is in line with the belief that in general, climate change will mean wetter winters and drier summers.

In Kidderminster only the months of January and April showed any decline in the 40 year trend. Despite a climate change forecast of longer drier summers, June and July have shown a 10-20mm increase over the 40 years. Annually though there has been a rise from around 680mm to 705mm a year (+25mm) compared to a regional change in England of 40mm from the 1961-1990 to 1991-2020 Met Office averages. Monthly averages for Kidderminster, based on a 40 year time scale, are tabulated in Table 2. The year of each month's maximum and minimum are shown.

Table 1. Comparing Kidderminster with the Midlands Average Annual Totals.

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Annual Average Rainfall - Kidderminster 1981-2010 – 683.2 mm 1991-2020 – 703.4 mm Highest day **61.5 mm** July 20th 2007 Highest month **159.5 mm** July 2007 Highest year **949.9 mm** July 2014 Lowest month **0.2 mm** April 2011 Lowest year **456.4 mm** 2011	Annual Average Rainfall - Midlands 1961-1990 - 768.0 mm 1971-2000 - 777.5 mm 1981-2010 – 792.7 mm 1991-2020 – 809.9 mm Midlands Data from https://www.metoffice.gov.uk/research/climate/maps-and-data/uk-climate-averages/gcqd2d0td

Table 2. Summary of Monthly averages and extremes for Kidderminster 1983-2022 (in mm's).

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	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Monthly 40 year Average	63.8	46.5	44.9	50.5	54.6	59.0	53.6	58.8	51.6	74.3	68.8	68.6	695.0
Cumulative Monthly Average	63.8	110.3	155.2	205.7	260.3	319.3	372.9	431.6	483.2	557.5	626.4	695.0	
Cumulative Summer Monthly Average				50.5	105.1	164.1	217.7	276.5	328.0				
Monthly Maximum	142.3	131.4	97.9	151.1	121.1	146	159.5	144.3	118.3	145.6	131	147.9	944.9
Maximum Year	2014	2020	2018	1983	2020	2007	2007	2004	1994	2013	1983	2020	2014
Monthly Minimum	11.4	6.2	13.8	0.2	3.1	11.6	15.4	7.4	9	25.4	27.7	13	456.4
Minimum Year	1997	1986	201	2011	2020	2007	1984	1995	1996	2016	1983	1988	2011

Looking at the annual totals (Figure 3) you can see that the 10 year period from 1983 was quite dry, and then by 2004 it was starting to get a bit wetter, peaking around 2014 and then dropping off again. Of course this very general fluctuation includes particularly wet years like 1992, 1999, 2000 2012 and 2014, not to mention very dry years of 1991, 1996, 2003 and 2011.

Annual totals can hide variation though. Take 2022 for instance: despite having a drought through the summer, the second wettest November helped make the annual average up to nearly normal. It is interesting to plot the accumulated rainfall total from one year to the next as in Figure 4. Because the plot is based on the 40 year average, the line starts and ends at zero so is slightly misleading, but it does show the annual fluctuations across the period. Generally we had a period of below average years which gave the accumulated deficit up to 2012 when a wetter period restored the total to near normal by 2022.

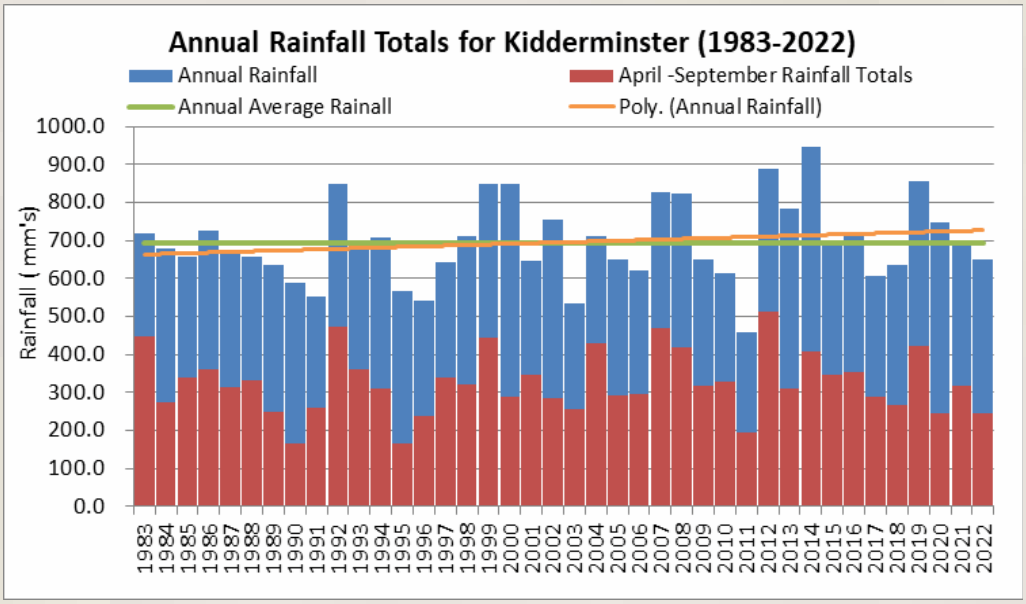

Figure 3. Showing annual totals, summer totals (Apr-Sep), and 40 year annual average (695mm) with a polynomial best curve showing the trend in annual totals.

Longer running datasets are required to really tell what is going on, such as the Met. Office Hadley England dataset (Figure 5). This is part of a dataset which includes temperature and is regarded as the reference dataset for climate change in England.

There are very few really long running rainfall datasets that go further back than the 1840's but there is one from the Radcliffe Observatory, at Oxford, which started in 1767. This is useful as it is a Midland location, like Kidderminster, and it gives the chance to see if there has been any annual trend during and since the industrial revolution (Figure 6).

Climate change is not particularly said to be giving us more or less rainfall annually, rather the tendency will be for drier summers

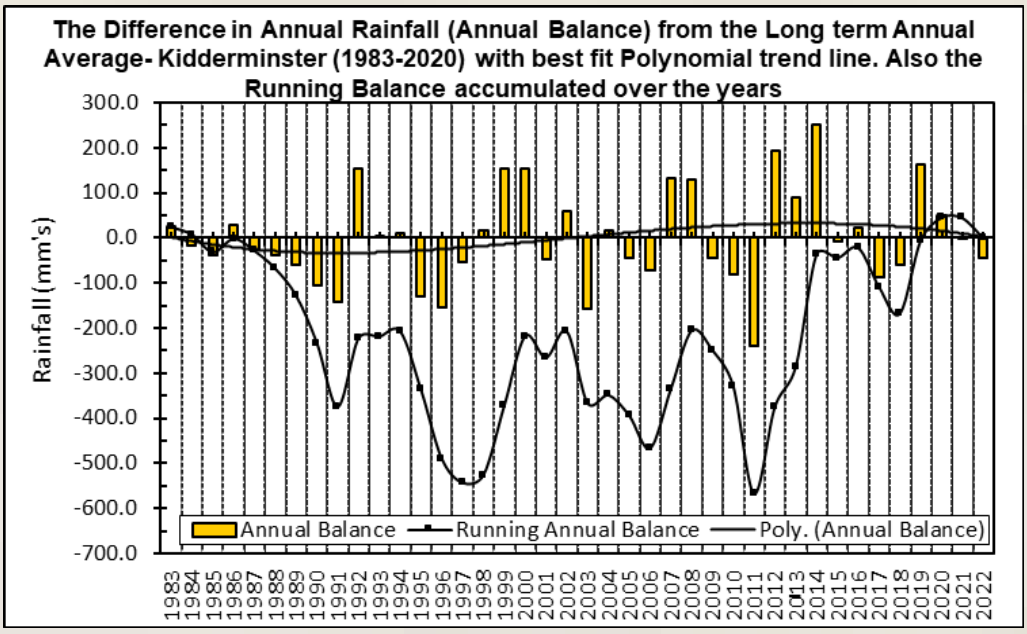

Figure 4. Showing how much each year deviates from the Long Term Average (LTA). The accumulated annual surplus or deficit (Running Balance) and the Polynomial best fit trend for the deviation from the LTA.

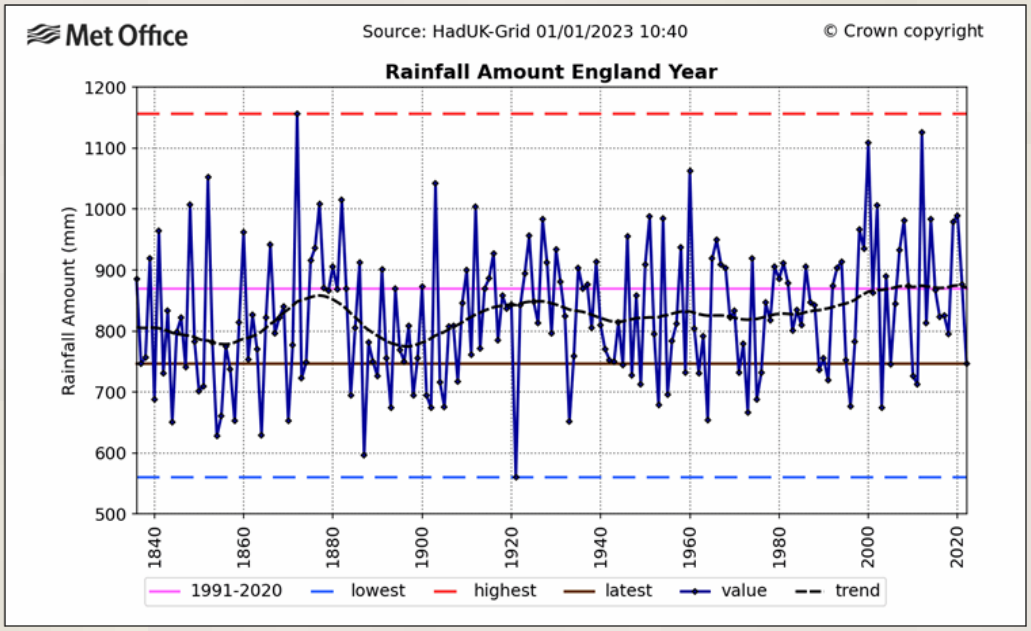

Figure 5. Annual Rainfall 1840-2020 Met. Office Haduk-Grid data.

and more extreme winters. Looking at the Radcliffe Observatory data, the running 30 year annual average has been plotted to try to see if there has been any trend over the 250 years. Here we see that there has been an increase since 1800 which is gradual and with an upturn in the last 25 years. This, more recent trend, is reflected even in Kidderminster's shorter period of records (Figure 3).

While it can be seen that the years have got wetter since 1960, does it rain more often? In the UK the number of days that we can expect rain of more than 1.0mm is 159 days a year, presumably buoyed up by Scottish totals, whereas in the Midlands of England we should expect 133 days a year. For Kidderminster over the last 25 years, rainfall days above 1.0mm have varied between 95 in 2011 and 146 in 2012 averaging at 127 days. We appear not to be getting very large storms over the Midland region unlike the odd ones seen at Boscastle (2004) and Lynton/Lynmouth (1952) but you never know. Forecasters speculate that extreme events such as convective storms could pop up anywhere, and you do not need to live by a river to get flooded nowadays. We are used to getting 4 days warning before Welsh mountain rain gets to bother Bewdley. It is the surprise local events that can catch us out.

Snowfall is classed as precipitation, along with rainfall, and its measurement is often where daily observers come in to their own. During periods of snowfall it is just as important to know how much is lying un-melted as to know how much fell each day. To do this a sample is taken using a coring tube and, with the snow depth known, the amount of water equivalent is calculated by melting the sample. This helps to inform hydrologists of the potential flood risk of a sudden thaw. Daily measurements are similarly taken but each fresh fall must be measured on a board placed on top of old snow each day.

Local storms can test drainage systems and my data was interrogated in the early 1980's when several properties in a street in Kidderminster were flooded. Insurance companies are the first to call for rainfall data when claims of flood damage are made and so data searches were called for that event. Another more unusual request was made by a company when someone claimed that they had parked on double yellow lines, unknowingly, due to the intensity of a hailstorm. A check of the data showed that there had been a storm but nothing like intense enough to obscure

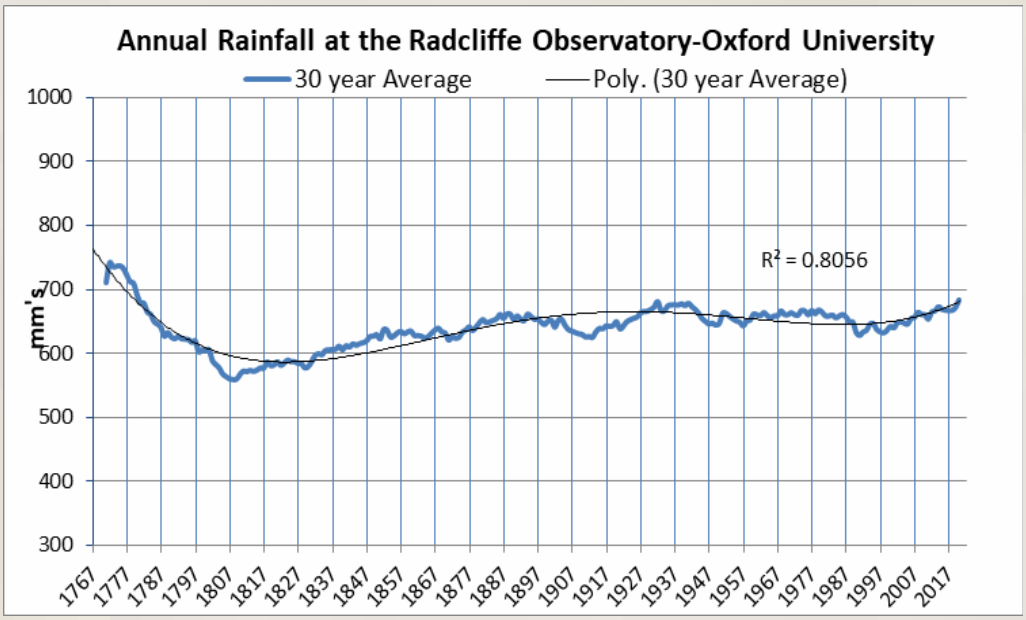

Figure 6. Plot of the 30 year running average for the Radcliffe Observatory, Oxford with Polynomial best fit trend.

the ground.

Daily precipitation in the UK has changed over the period 1961-2000, becoming on average more intense in winter and less intense in summer. Recent increases in total winter precipitation are shown to be mainly due to an increase in the amount of precipitation on wet days, with a smaller contribution in the west of the UK from a trend towards more wet days (Osborn and Hulme, 2002). This is most likely linked to anthropogenic climate change connected with human activity.

With all the technology available to weather forecasters it is good to see that basic citizen science can provide the data upon which many decisions are still made. Daily rainfall observers are still important.

Interesting as it might be, let's hope Kidderminster is not going to beat the UK 24 hourly record of 341.4mm set at Honister Pass, Cumbria on the 5 December 2015.

The Raingauge
A daily rain-gauge has a 5 inch (127mm) diameter rim, the top of which stands 12 inches (300mm) above ground level.

Ideally, in order to provide useful rainfall data:

1) you would be able to empty the rain-gauge each day (occasional 'accumulations' can be dealt with, but shouldn't go in to another month, the gauge should be read at the same time each day – recommended 09:00 GMT);

2) the rain-gauge needs to be located away from buildings, trees etc. to prevent overshadowing;

3) you would record the readings on a rainfall card and send it in every month by email or post.

Early recorders
In 1677, Richard Townley started regular measurements of the amount of rain that fell at Townley Hall, near Burnley in northern England. His measurements continued until 1704, and other interested observers subsequently took up the challenge of measuring rainfall. The equipment to record rainfall was slowly developed and, by 1820, there were a few dozen rain-gauge sites across the UK and Ireland. In 1865 George Symons developed a standard measuring gauge and procedure which was later in 1919 adopted in to the Met. Office.

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