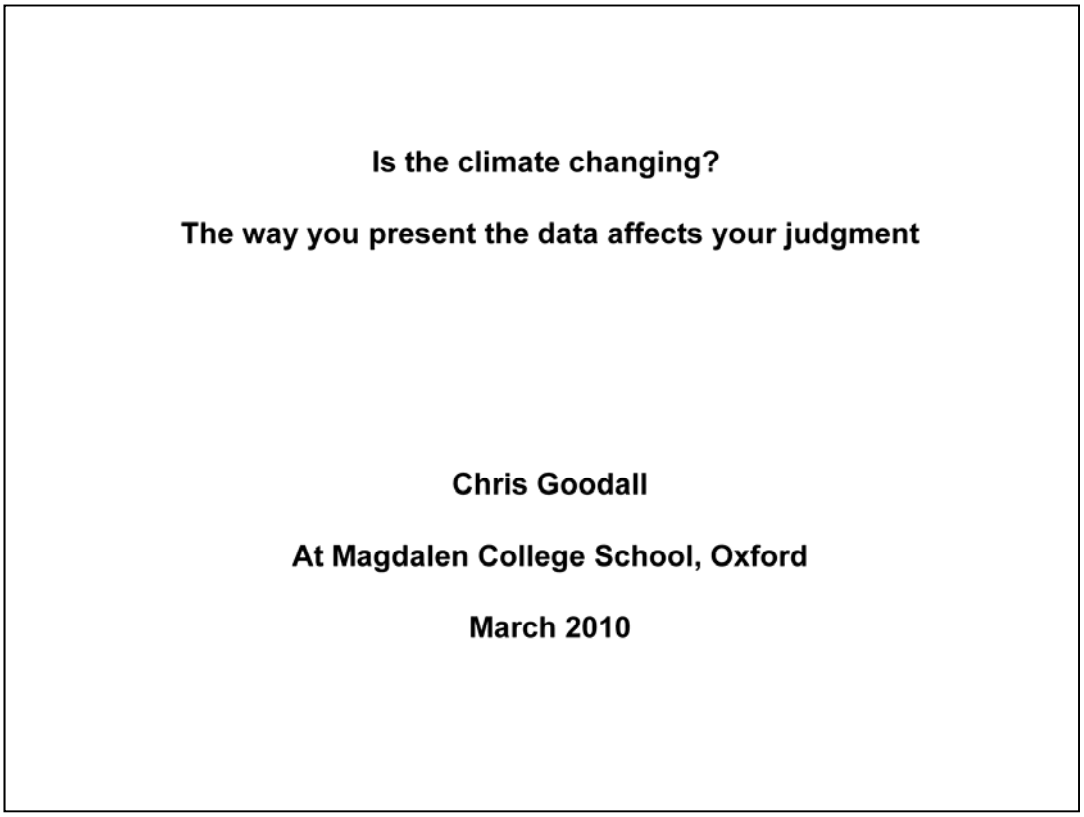



This presentation consists of 23 slides looking at climate data from the Oxford temperature recording station. This station has been recording continuously from 1853, although much older data from Oxford contributes to the 'Central England Temperature Record' which is said to be the oldest temperature series in the world. The data from Oxford was originally collected at the Radcliffe (astronomical) Observatory somewhat to the north of the original city boundary.

Myles Allen, the Oxford climate scientist, tells me that originally the temperature data was collected in the upper room at the Observatory 'with the windows open'. I guess – and it is only a guess - that the 1853 record starts at the point that the thermometer moved outside. Myles said that he thought the collector moved to the airfield at Benson – about 20km from Oxford – in the 1940s. Benson will have slightly different readings and the temperature series will have had to be normalised to adjust for this. This is exactly the problem with temperature readings like this: we can never get a perfect and unimpeachable data set.

My purpose in assembling the following slides is to show how the climate record can be used to show very different trends, depending on the data being looked at and the slant the observer places on the numbers.

Let's look first at the Metrological Office ('Met Office' for UK readers) summary of recent climate in Oxford. The figures on slide 1 are for the thirty year period from 1971-2000. Every ten years, the Met Office produces an average and updates this series. The 1971-2000 record shows the monthly average daily highs and the average daily lows. It also has the number of airfrost days, the monthly average rainfall and the typical number of days on which more than 1mm of rain fell. The wind data isn’t recorded for the city.

Average

## Oxford 1971–2000 averages

| Oxford (63 m AMSL) | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Max Temp | Min Temp | Days of Air Frost | Sunshine | Rainfall | Days of Rainfall ≥ 1mm | Wind at 10 m |
| Month | [°C] | [°C] | [days] | [hours] | [mm] | [days] | [knots] |
| **Jan** | 7.2 | 1.9 | 8.8 | 58.0 | 57.5 | 11.5 | N/A |
| **Feb** | 7.6 | 1.7 | 8.5 | 72.0 | 42.6 | 9.2 | N/A |
| **Mar** | 10.3 | 3.4 | 4.0 | 107.9 | 50.0 | 10.5 | N/A |
| **Apr** | 12.8 | 4.7 | 2.1 | 150.0 | 46.2 | 8.7 | N/A |
| **May** | 16.5 | 7.5 | 0.2 | 191.9 | 53.9 | 9.1 | N/A |
| **Jun** | 19.5 | 10.5 | 0.0 | 187.8 | 54.5 | 8.7 | N/A |
| **Jul** | 22.3 | 12.8 | 0.0 | 205.5 | 38.2 | 6.7 | N/A |
| **Aug** | 21.9 | 12.6 | 0.0 | 193.8 | 54.4 | 7.8 | N/A |
| **Sep** | 18.6 | 10.5 | 0.0 | 138.6 | 58.9 | 9.1 | N/A |
| **Oct** | 14.4 | 7.4 | 0.7 | 108.2 | 61.8 | 10.6 | N/A |
| **Nov** | 10.1 | 4.3 | 4.5 | 72.0 | 59.4 | 10.1 | N/A |
| **Dec** | 8.0 | 2.8 | 7.3 | 51.8 | 64.7 | 10.9 | N/A |
| **Year** | 14.1 | 6.7 | 36.1 | 1537.4 | 642.0 | 112.9 | N/A |

Source: Met Office

This sheet is from the Met Office web site and gives the thirty year averages for monthly average daily maxima and minima as well as information on airfrost, sunshine and rainfall.

## Source data available online

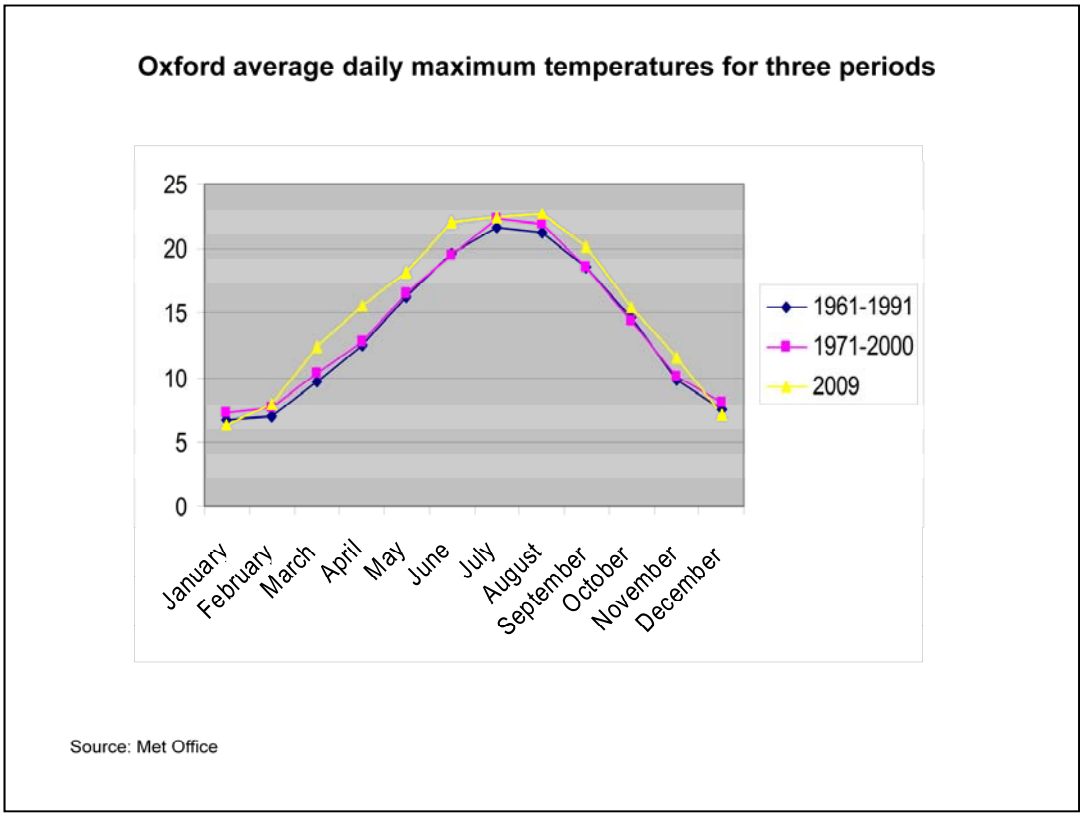
Oxford
Location: 4509E 2072N, 63 metres amsl
Estimated data is marked with a * after the value.
Missing data (more than 2 days missing in month) is marked by --

Sunshine data taken from an automatic Kipp & Zonen sensor marked with a #, otherwise sunshine data taken from a Campbell Stokes recorder.

| yyyy mm | tmax degC | tmin degC | af day | rain mm | sun hours |
|---|---|---|---|---|---|
| 1853 1 | 8.4 | 2.7 | 4 | 62.8 | --- |
| 1853 2 | 3.2 | -1.8 | 19 | 29.3 | --- |
| 1853 3 | 7.7 | -0.6 | 20 | 25.9 | --- |
| 1853 4 | 12.6 | 4.5 | 0 | 60.1 | --- |
| 1853 5 | 16.8 | 6.1 | 0 | 59.5 | --- |
| 1853 6 | 20.1 | 10.7 | 0 | 82.0 | --- |
| 1853 7 | 21.2 | 12.2 | 0 | 86.2 | --- |
| 1853 8 | 20.2 | 10.8 | 0 | 72.3 | --- |
| 1853 9 | 17.3 | 8.4 | 0 | 51.3 | --- |
| 1853 10 | 13.9 | 7.4 | 0 | 102.3 | --- |
| 1853 11 | 8.7 | 2.3 | 10 | 49.6 | --- |
| 1853 12 | 3.7 | -1.3 | 19 | 10.7 | --- |
| 1854 1 | 6.7 | 1.5 | 11 | 54.5 | --- |
| 1854 2 | 8.0 | 0.6 | 12 | 22.6 | --- |
| 1854 3 | 11.2 | 2.2 | 8 | 10.6 | --- |
| 1854 4 | 15.0 | 3.5 | 2 | 19.9 | --- |

Source: Met Office

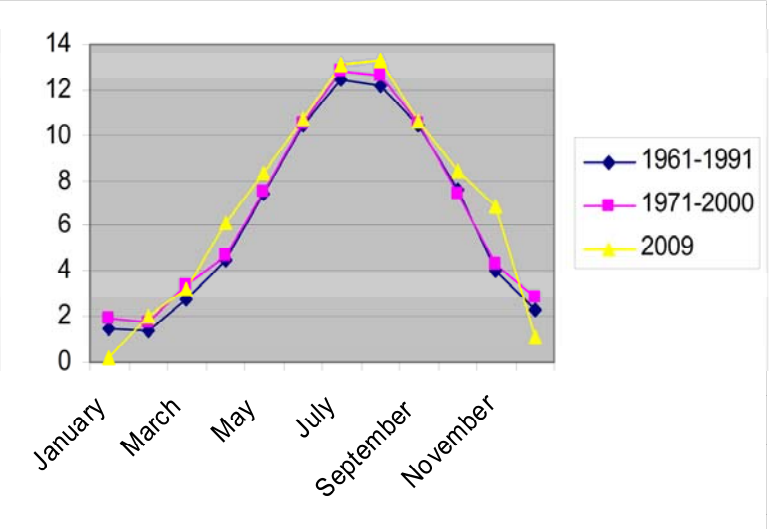
The Met Office also publishes the full record of data for most of this information back to 1853. You can find it on the Met Office web site. Slide 2 shows how the raw data looks on the page. There's information about monthly average daily highs and lows, airfrost days ('af') and some rainfall data. Anybody can put this data into a spreadsheet and look at averages and trends.




In Slide 3, I plot the monthly maximum temperature for three periods: 1961-1990, 1971-2000 and for 2009. (By the way the Met Office uses 30 year averages partly because some climate drivers, such as changes in the output of the sun, swing around in about thirty year cycles).

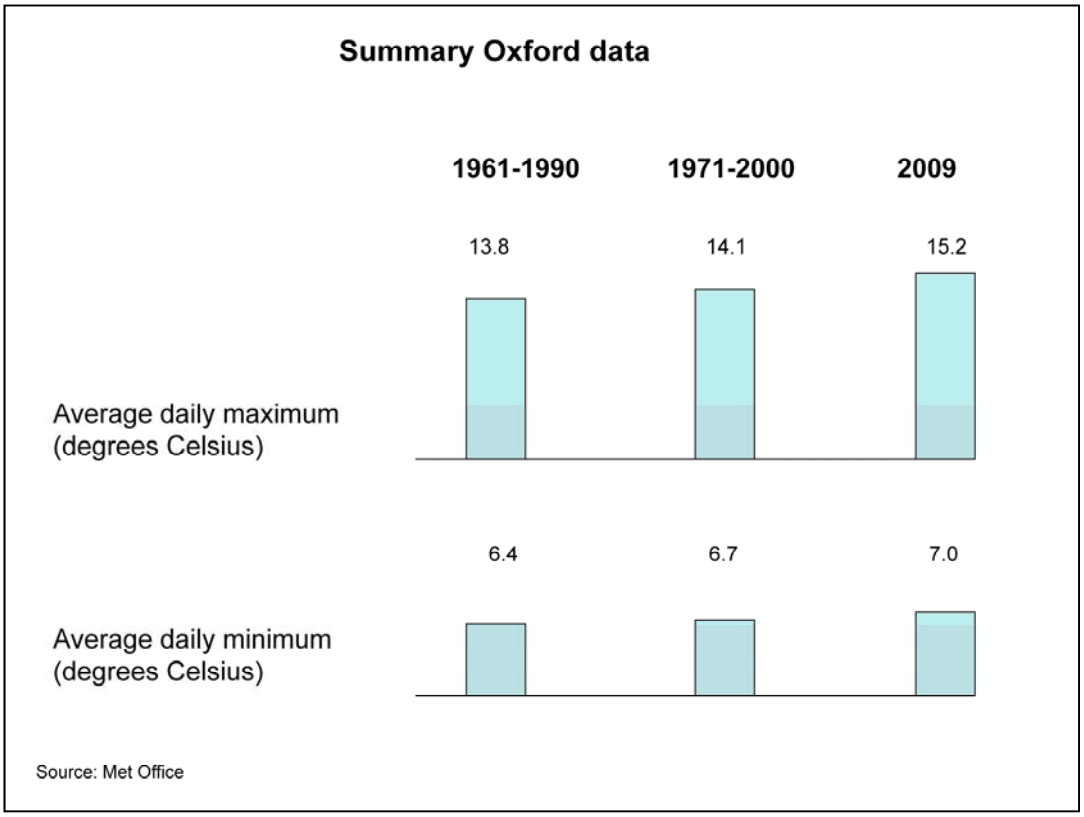
You can see that the maximum temperature has risen in later periods. Of course one year's records don't mean anything much, but 2009 was generally higher than the later thirty year period. 1971-2000 was hotter than 1961-1990. This probably surprises you – 2009 wasn't thought to be a warm year and the summer rainfall was quite high in Oxford. More than anything else this tends to show that we don't have a good sense of whether today's temperatures are higher or lower than average. We – quite literally – acclimatise.

**Oxford average daily minimum temperatures for three periods**



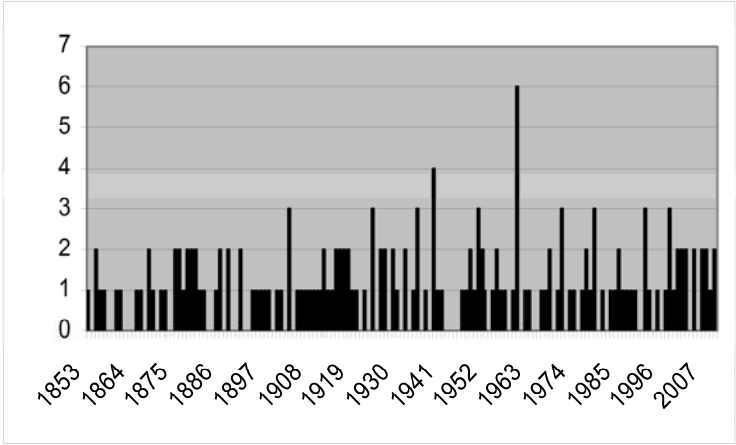

Source: Met Office

Approximately the same pattern is seen for January minima. But in 2009, the winter was much colder than in the two thirty year periods.




In Slide 5 I present this data in a more sensible form – as yearly averages. This shows that the 1961-1990 averages are about 0.3 degrees below the 1971-2000 figures.

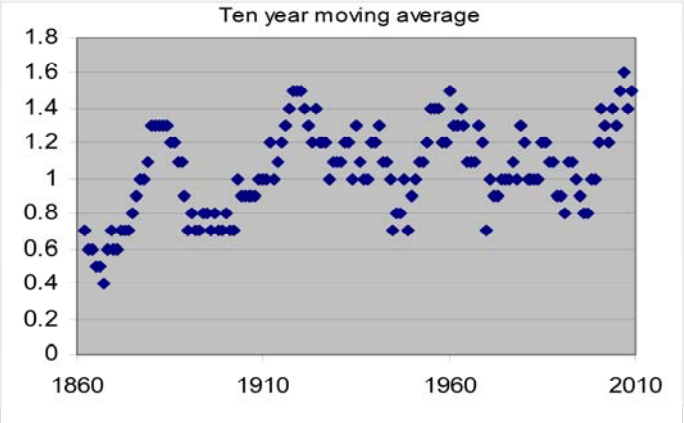
**Number of months in year with over 100mm rainfall**




Source: Met Office

I'm now going to look at the longer term record to see what we can say about changes in Oxford's climate. Slide 6 examines the record for the number of months with over 100mm rainfall. You can see that in most years there are a small number of months with rainfall over this level.

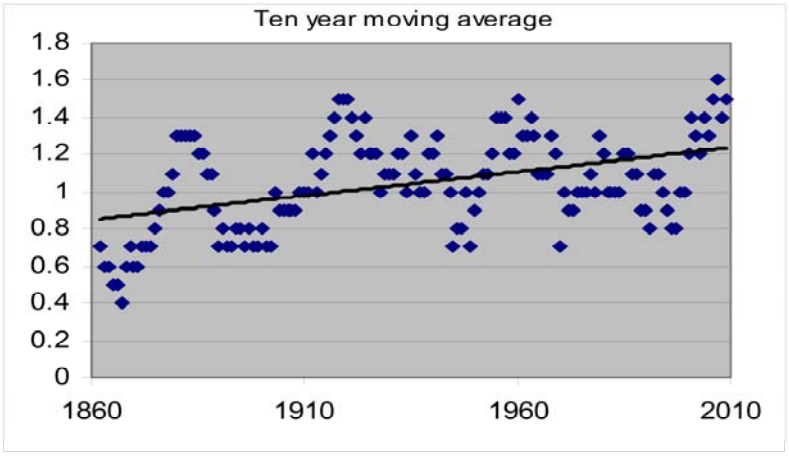
**Number of months in year with over 100mm rainfall**




Source: Met Office

When we get data like this it isn't visually obvious whether the trend is increasing or decreasing, or indeed whether there is any trend at all. We have two techniques we can use: averaging the data over a period of years and plotting a trend line on the chart. Slide 8 looks first at a ten year moving average. The number we plot is the simple mean of a year and the nine previous years. So the 1910 10 year moving average is the mean of the ten years 1901 to 1910. This slide gives us much more information – we can see that the occurrence of high monthly rainfall appears to go in cycles and the trend is generally upwards.

**Number of months in year with over 100mm rainfall**

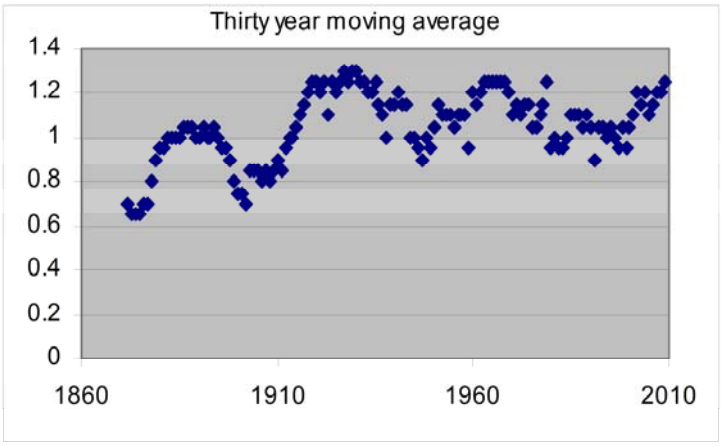



Source: Met Office

When we plot a trend line (simple linear regression for fans of these things), it becomes clear that the statistical trend is indeed rising. In the middle of the 19th century, we would have expected about 0.8 months of high rainfall compared to about 1.2 now. But it is very important to note that the cycles around the trend line mean that at three periods in the past the ten year average was well above the what we might predict today for the very long term average. Around 1920, the figure was about 1.5 months a year, for example. What's clear about this chart and many of those that follow is that there is a lot of 'noise' in climate data compared to the relatively slow pace of change in the underlying 'signal'.

By the way, climate scientists generally expect the intensity of rainfall events to rise as a result of the greater energy levels in the atmosphere. So the trend may continue and – as a result – Oxford's river flooding problems are possibly going to get more severe

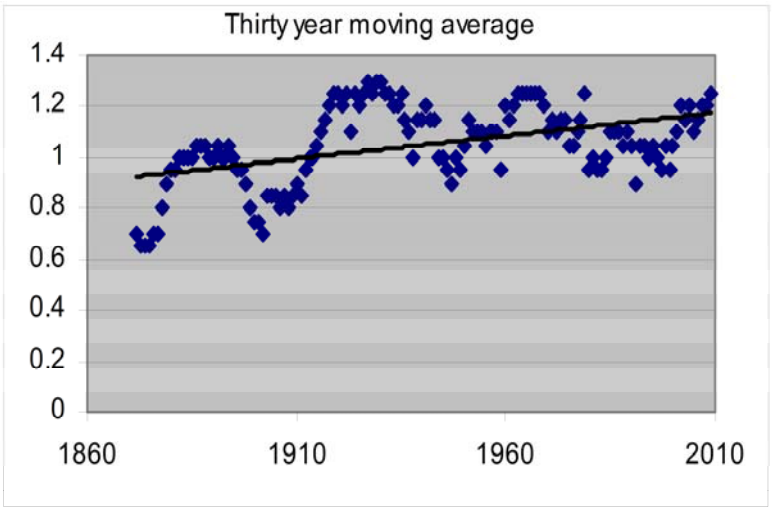
**Number of months in year with over 100mm rainfall**




Source: Met Office

If we plot a moving average over a longer period – the thirty year cycle I mentioned earlier - the pattern looks very different. A quick scan suggests that the frequency of high rainfall months hasn't increased much at all. The lesson is clear: how we present the data really does affect the impression we give our readers.

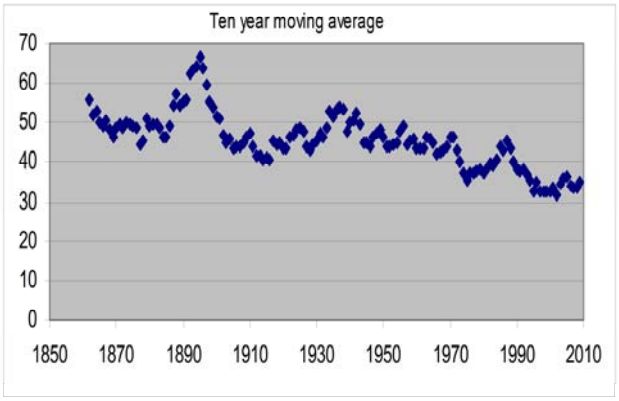
**Number of months in year with over 100mm rainfall**




Source: Met Office

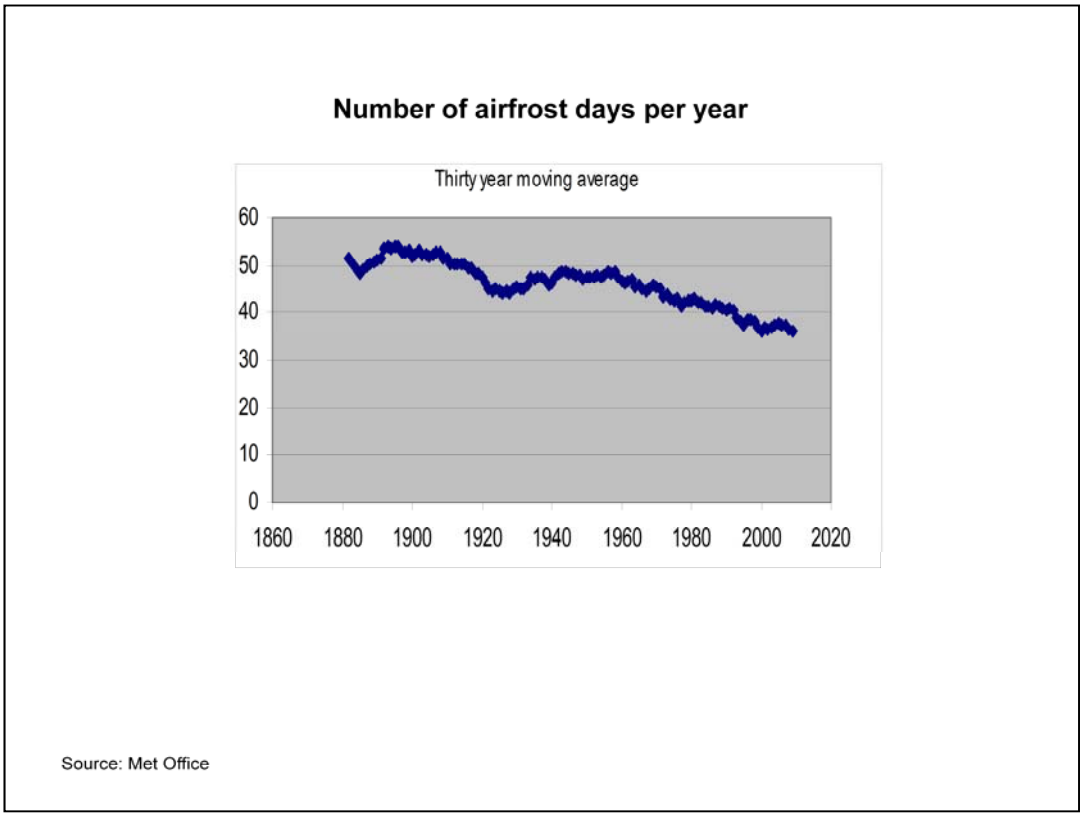
In slide 10, I put the trend line back. Unsurprisingly to those of you with a little mathematics, the trend is almost the same as with the 10 year moving average.

**Number of airfrost days per year**



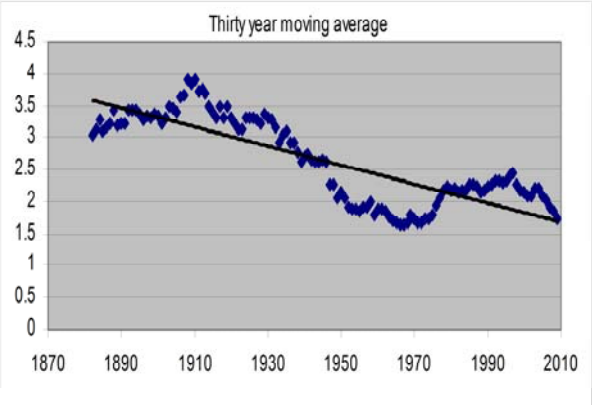

Source: Met Office

In Slide 11, I move to look at the number of airfrost days. (An airfrost day in one on which the temperature ever drops below zero at, I think, one metre above ground level.) The ten year moving average shows a fairly steady fall, consistent with the theory that the climate is getting warmer.




In this case, if we plot a 30 year moving average, the chart becomes much clearer to the casual viewer. The decline looks impressively regular and predictable.

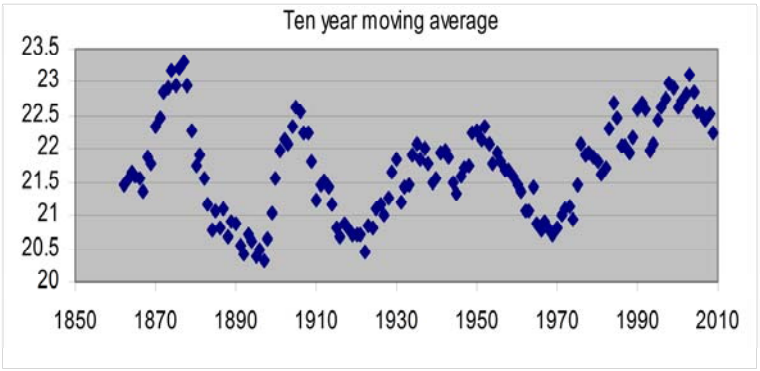
## April airfrost days




Source: Met Office

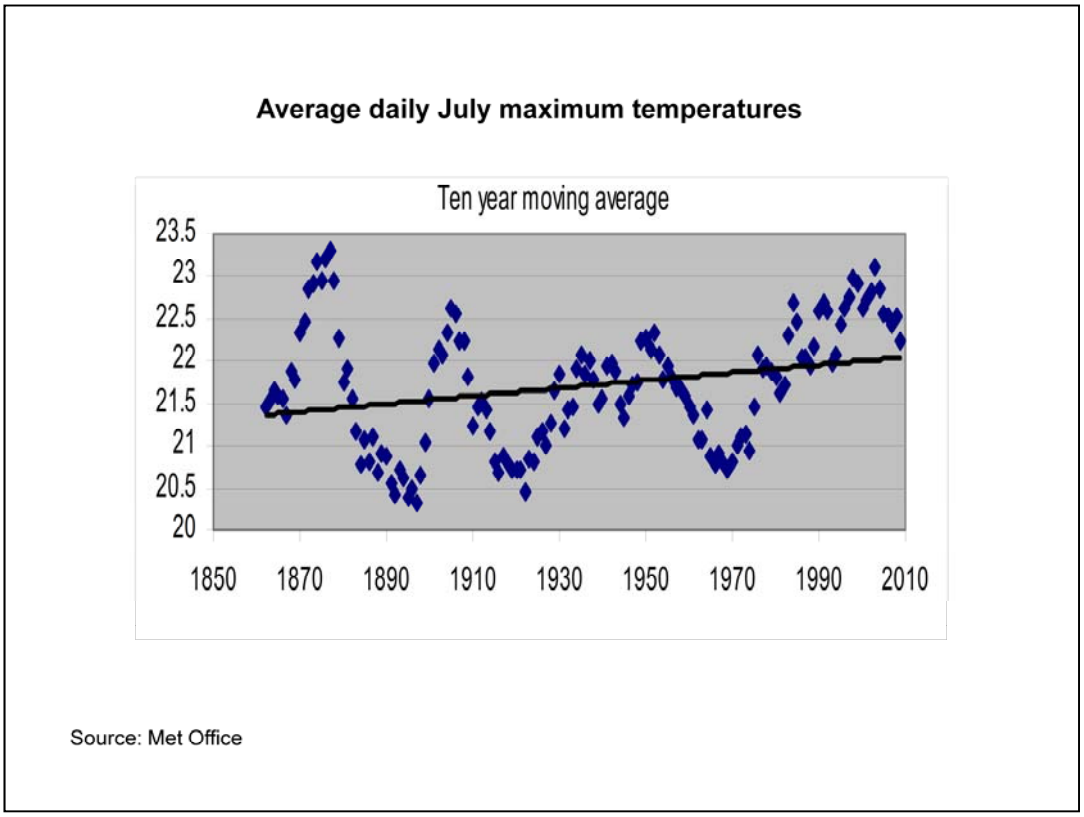
In the next slide, we can see a much less regular picture. If you just plot the number of airfrost days in April – the end of the frost season in our part of the world – you see a line that drops sharply until 1970 and then rises quite quickly. If you wanted to question whether climate change was actually happening in Oxford you might say that the evidence suggests that the frost season is no shorter now than it was in 1970. This wouldn't really be a fair statement – after all the trend line is strongly downward – but you would be literally correct in what you said.

**Average daily July maximum temperatures**



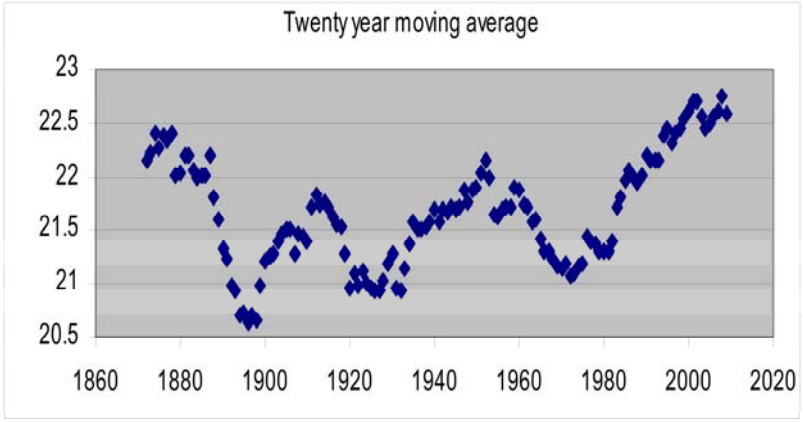

Source: Met Office

Let's move on to temperatures. Here's the ten year moving average for daily maximum July temperatures. Once again, a quick look says that the warmth of the 1870's matches today's figures and, moreover, in recent years July maxima have actually fallen from the peak of the early 2000s.




Putting a trend line on the graph shows a more balanced picture. Over the last 150 years, the statistical tendency has been upward, although the change isn't great.

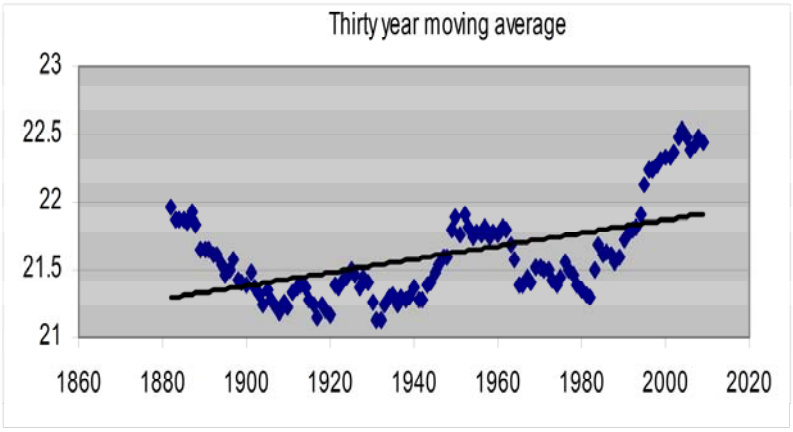
**Average daily July maximum temperatures**




Source: Met Office

**The next chart shows the twenty year average and the pattern appears clearer and the 1870s peak isn't higher than recent figures.**

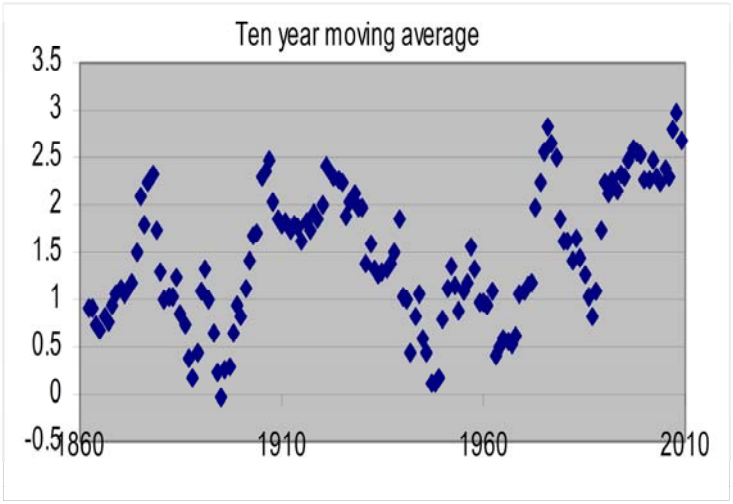
**Average daily July maximum temperatures**




Source: Met Office

The thirty average produces a strikingly more convincing chart

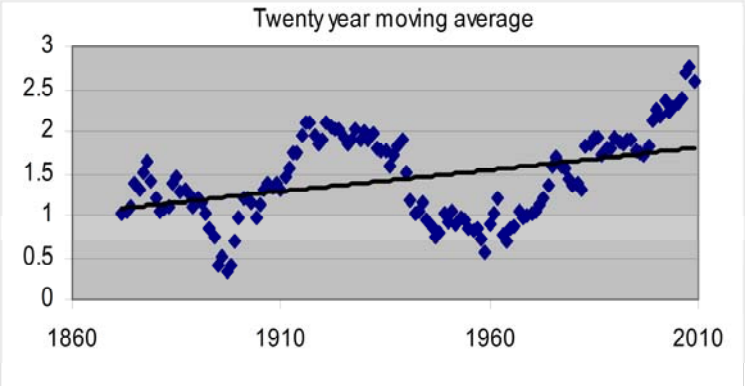
**Average daily January minimum temperature**




Source: Met Office

January minima have tended to rise. But plotted as a ten year average, the pattern isn't at all clear.

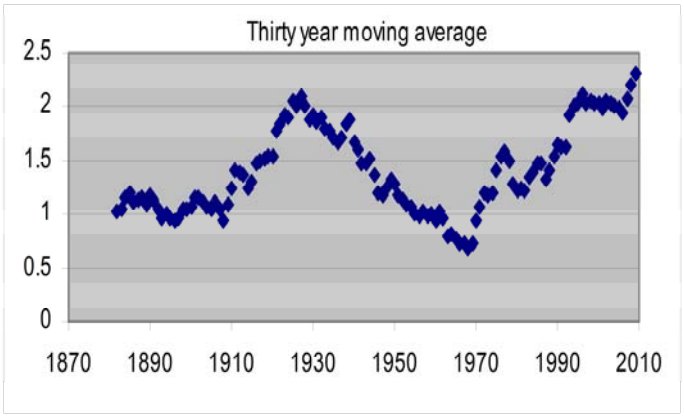
**Average daily January minimum temperature**




Source: Met Office

It becomes easier to see with a twenty year average and with a trend line added for visual clarity.

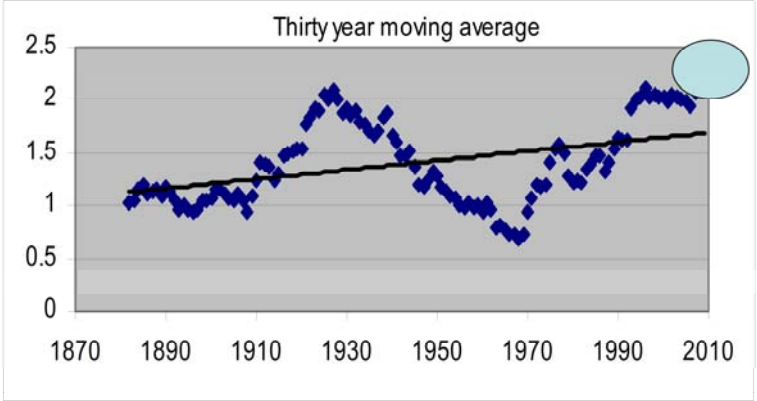
**Average daily January minimum temperature**




Source: Met Office

But the thirty year pictured without a plotted trend gives a strong visual sense that the trailing average in 1930 was about the same as the 1990s.

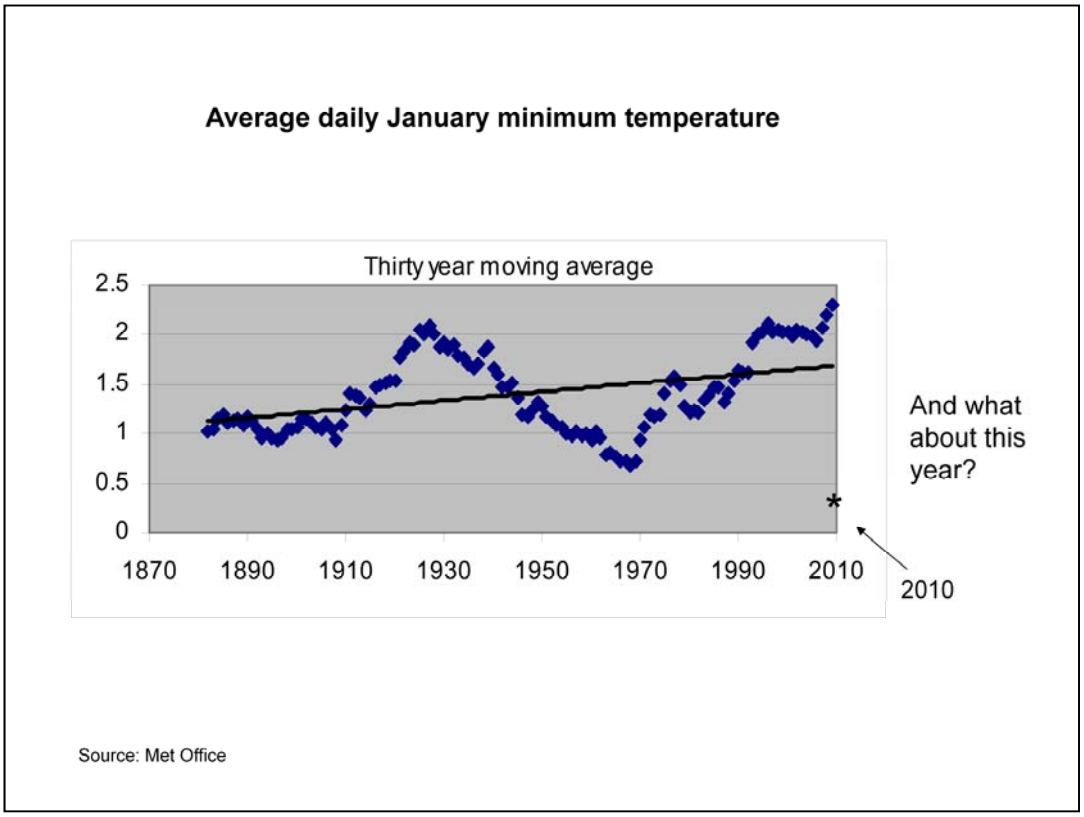
**Average daily January minimum temperature**



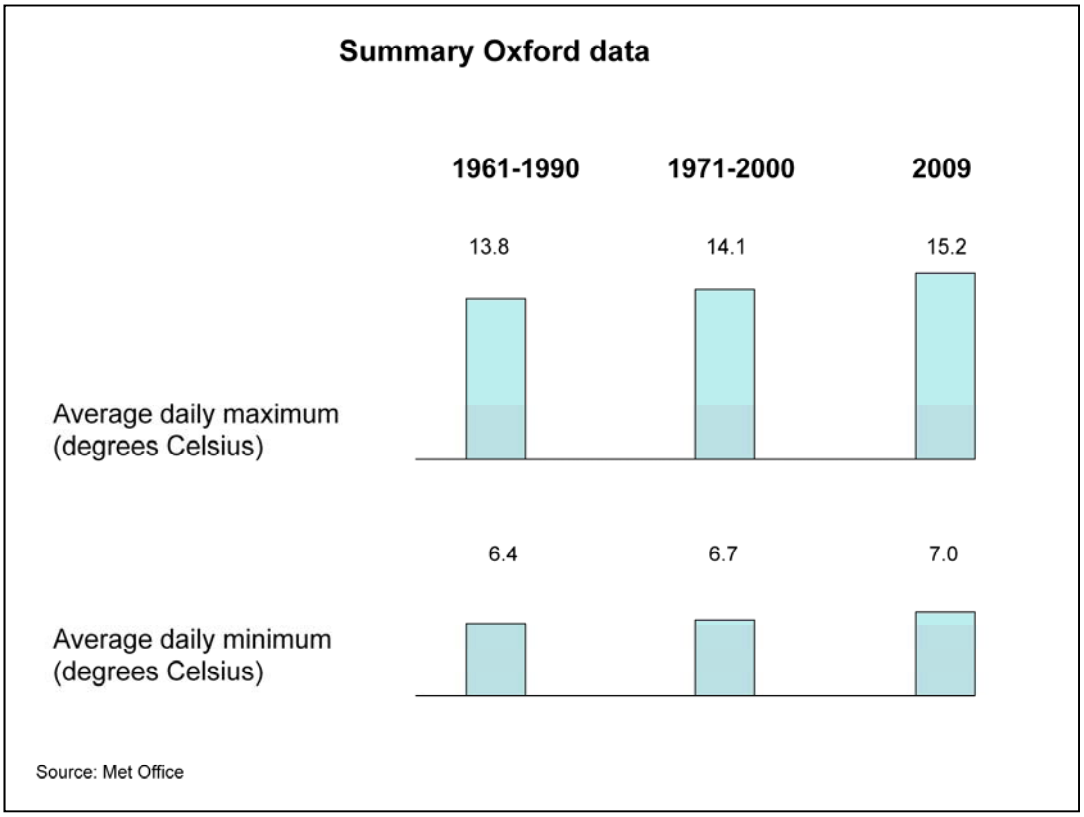

What did this chart look like five years ago?

Source: Met Office

And if you present the data without the last five or so years the effect is to suggest a cycle that isnt showing much rise, even when you plot the trend as well.




And if you include the 2010 figure, the effect is quite striking to the eye.




What I've tried to show that climate data is so variable and 'noisy' that trends are difficult to determine, even at one single recording station. This means two things. Anybody wanting to put their own spin on the data is quite able to do so. And, second, that any reasonably sceptical person can legitimately note the predictably unpredictable outcomes and say that the underlying trends are really quite unclear.

But the fact is that Oxford is, on long-term averages, getting a little bit warmer and more rainstormy each year. I think the rational person looks at the record and says that weather variability is very high but the trends are fairly obvious. The climate scientists tell us that the world climate has a great deal of momentum. With the heat trapping gases already in the atmosphere, we are likely to see continued warming even if we stop burning fossil fuels tomorrow.

In Oxford, the main implication is that the Thames is probably going to flood more often. If you are affected by this, it is utterly devastating. But we can cope with temperatures quite a lot hotter than today with few ill effects. In other parts of the world, already on the margins of human survival, continued human habitation is at threat as rivers dry up and summer temperatures reduce agricultural production.