How fast does a cold front move?

An investigation using data from the Met Office WOW network

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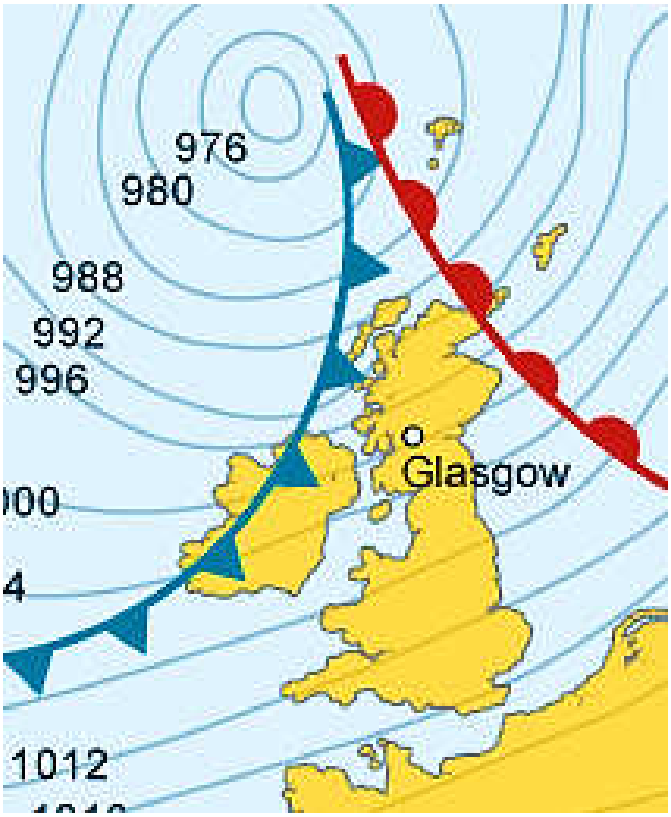
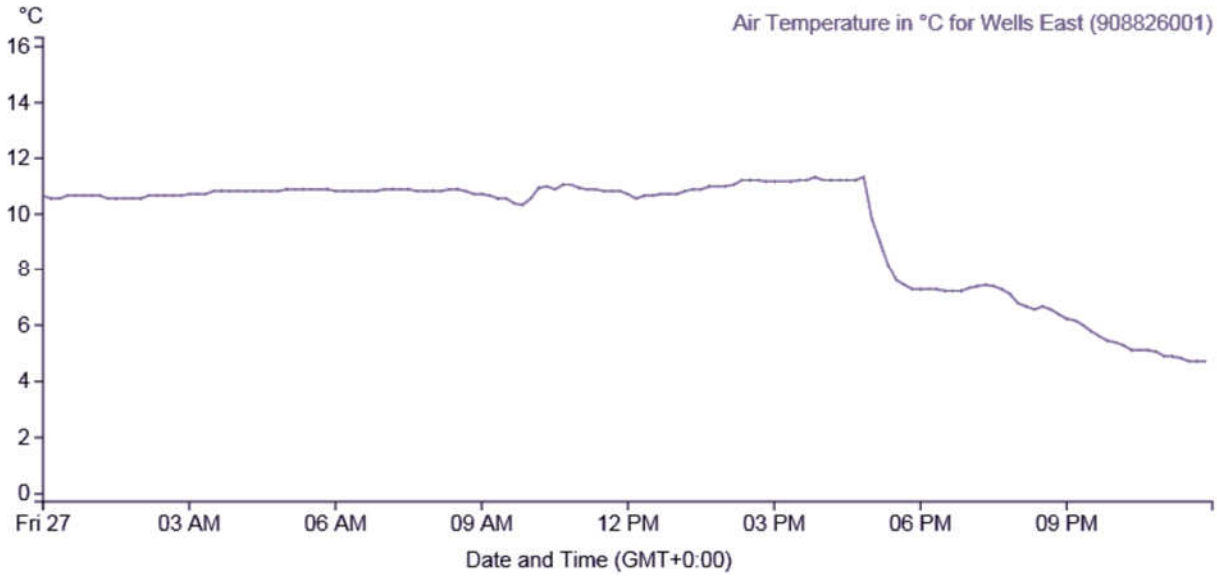
Aim

A cold front is one of the features of mid-latitude weather systems that we often see in the UK. As the name suggests, it brings in colder, drier, air to replace warmer, moister, air. Ahead of it is usually a band of rain, which stops, and the skies clear, as the surface cold front goes past us – known as a "cold front clearance". There are typically 100 or so cold fronts passing over the UK every year – more in winter than in summer. They are not evenly spaced – there may be a week or two where fronts pass nearly every day, followed by a week or two of high pressure when there are no fronts at all. For every cold front there is usually a warm front preceding it, but these are not as easy to identify or track.



A typical mid-latitude weather system, with a depression to the north-west of Scotland. The cold front is thick blue line with triangles showing the direction of travel; warm front is red line with semicircles. Pale blue lines are isobars with pressure in hPa (or millibars) written on them.

Because it usually has a clear signal – a sharp drop in temperature - we can spot a cold front easily on the temperature graph on WOW from your weather station – see the example below (although they are not always as sharp or as big a drop as this one). If we can also pick up the same frontal passage at other weather stations at different times, we can use this to calculate the speed of the front. This is what we aim to do in this investigation.

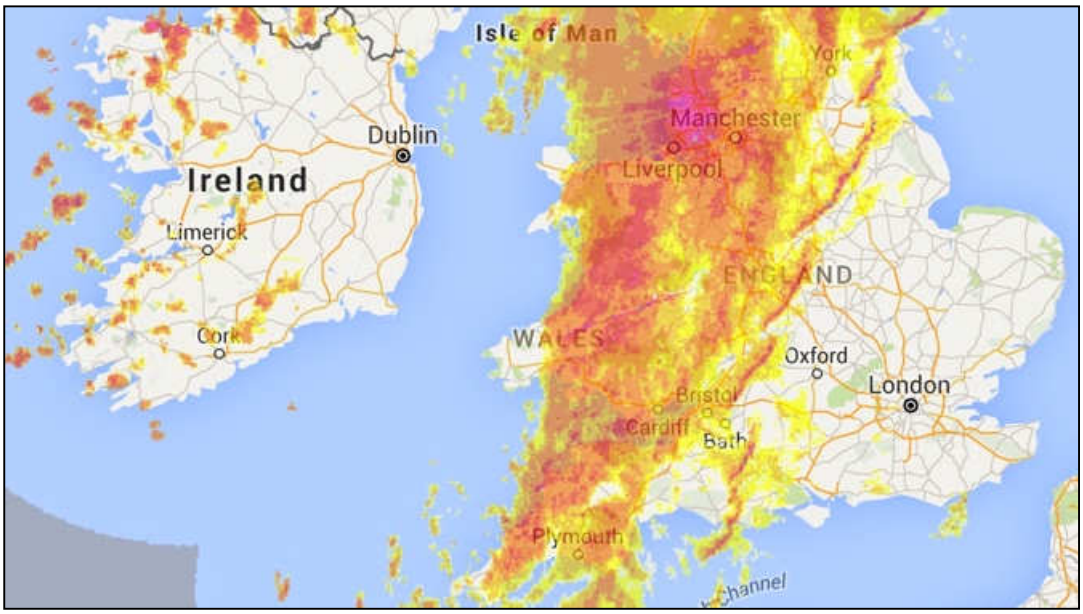


WOW graph of a cold front passing Wells, Somerset, at about 17:00h on 27 November 2015

Investigation

1. Notice when a cold front has passed you – this is often marked by a period of heavy rain suddenly stopping, skies clearing and a drop in temperature by a few degrees, called a "cold- front clearance". Check the WOW http://wow.metoffice.gov.uk graph for your station and you may well see a sudden temperature drop as in the graph above. Finally, check the weather map at http://www.metoffice.gov.uk/public/weather/surface-pressure/ which should show a cold front as a blue line with blue triangles showing the direction of travel (or the archive at http://www.wetterzentrale.de/topkarten/tkfaxbraar.htm in black-and-white)

2. Look at the radar rainfall map for the day, to see if it is a well-defined front and clearance, similar to the one shown below. Rainfall maps over the past few hours can be seen at www.raintoday.co.uk or the archive over last 3 days is at http://www.weathercast.co.uk/radar/archive-for-united-kingdom.html Both originate from the chain of radar stations set up by the Met Office in the UK and Met Eireann in Ireland.

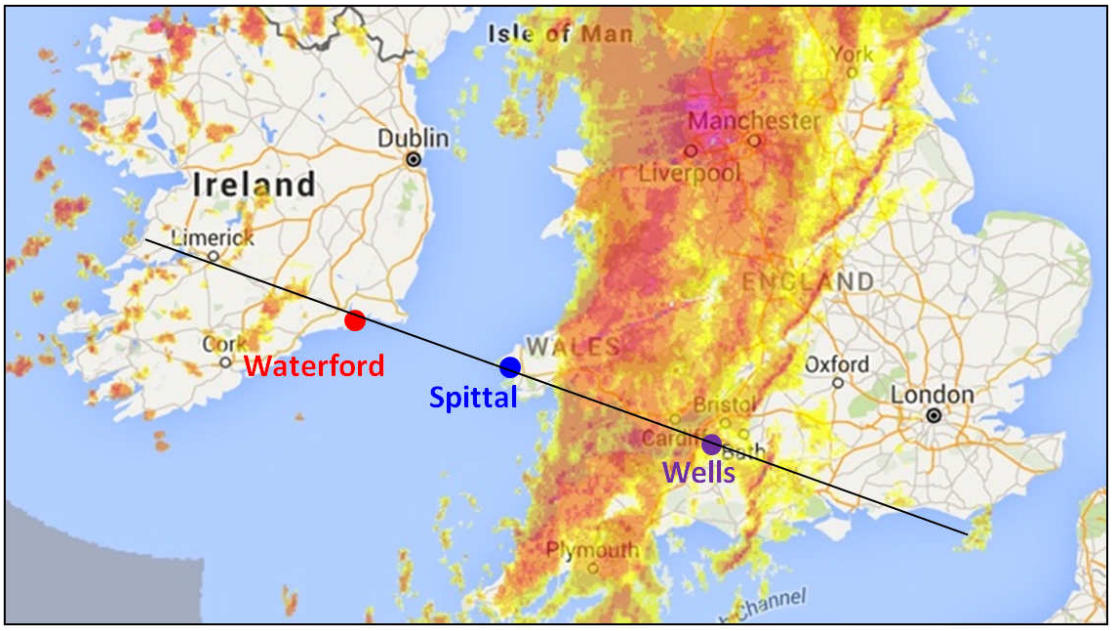


A radar rainfall map showing a rain band on a cold front across the country on 27 November 2015. The clearance at the surface is the western edge of the band.

3. If the temperature drop at your station is sharp and more than about 2-3 degrees, then it is likely that graphs from other WOW stations will probably show the same sort of feature. Copy the WOW temperature graph for your station (left click, copy) and paste it onto a new PowerPoint slide. This will give you a graph similar to the one above.

4. Make an assumption that the front has moved roughly at right angles to its length (usually, but not always, true), so imagine a line through your station at right angles to the front

5. Look for another WOW station 100 - 200km away (towards the west rather than east, as fronts normally come from the northwest, west or southwest) along this line, and click on it to look at its data for the same period. In this example, we have chosen the WOW station of Spittal in Pembrokeshire.

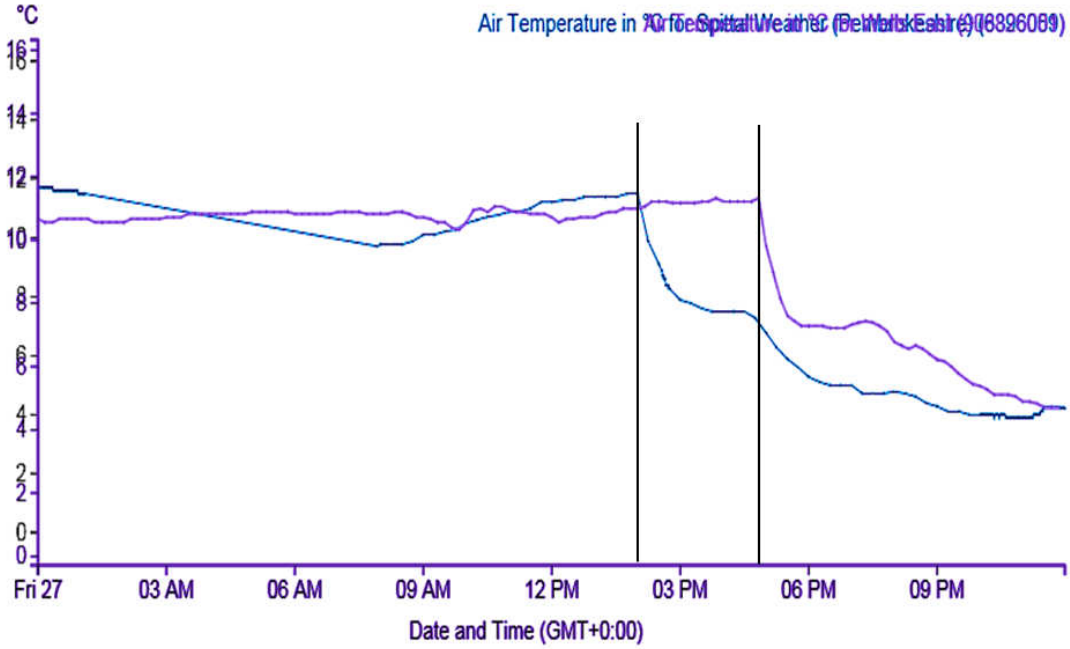


The radar rainfall map with the initial station (Wells), the line drawn through it roughly at right angles to the front, and the two other stations near the line at which good cold front temperature drops can be seen on their WOW graphs.

6. If you find it also shows a clear temperature drop, copy the graph and paste it into the same PowerPoint slide as the one you already pasted your WOW observation onto. To compare them, you need to make their backgrounds transparent so you can see one behind the other.

7. Give the two graphs a transparent background by clicking on one of them, going to Format – Color then clicking on the "Set transparent color" pencil tool, dragging the pencil to the graph and clicking it. Do the same with the other graph.

8. Bring one graph over the other so that the time and temperature scales overlap. This should show the temperature lines from the two stations superimposed, as below. It doesn't matter if the two temperature scales on the left don't agree; we are interested in the time of the temperature drop and not its magnitude.

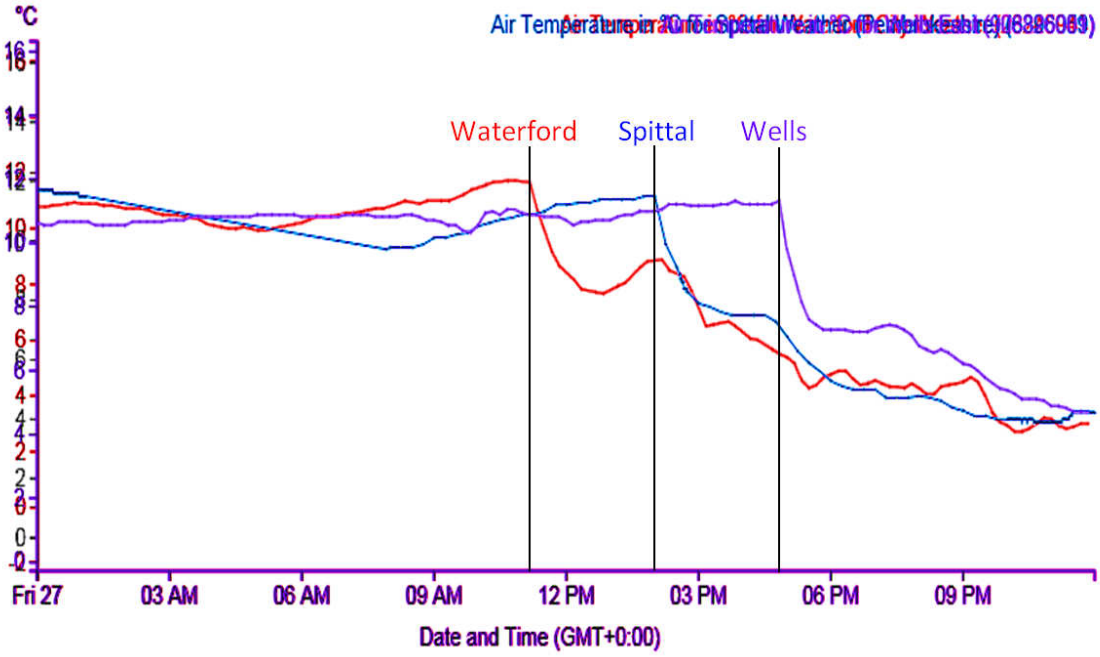


The same cold front passing Spittal (blue) and Wells (purple)

9. Estimate the time that the cold front passed at each of the stations. To do this, make two vertical lines in PowerPoint and move them to coincide with the start of the cold front passages (sharp temperature drops). This shows the times of the passages on the x-axis.
   Measure the time scale of the graph by measuring the distance in mm between two markers (say) 12 hours (e.g. measure the distance between 03AM and 3PM) and then dividing by 12 to get the time scale in mm/hour.
   Use the time scale (mm/hour) to calculate the time of passage of the front at the two stations, in GMT.
   In the graph above the clearance occurred at 16.89h in Wells, but at 14.08h in Spittal. It is easier to use hours and decimal hours rather than hours and minutes.

   Alternative to para 9, if just using two stations
   - Estimate the time that the cold front has taken to travel from one station to the other. To do this, make two vertical lines in PowerPoint and move them to coincide with the start of the cold front passages (sharp temperature drops). Measure the distance between them in mm.
   - Convert this to hours by measuring how much time one hour corresponds to in mm on the graph. Measure the distance in mm between two markers (say) 12 hours apart (eg measure the distance between 03AM and 3PM) and then divide 12 by the distance between markers to get the time scale in hour/mm.
   - Multiply the time scale (hour/mm) by the distance (mm) between the two vertical lines, and this will tell you how long (in hours, eg 2.81h) the front took to pass from one station to the other.
   - Measure the distance between the two stations, roughly parallel to the cold front, in km (eg 181km).
   - Divide this distance by the travel time of the front, to get the speed, eg 181km/2.81h = 64.4 km/h.
   - End of investigation

10. If you can, choose another station even further away and repeat the exercise, so you now have 3 temperature graphs superimposed. Below, we have included Waterford, in southwest Ireland, when the front cleared at 11:19h

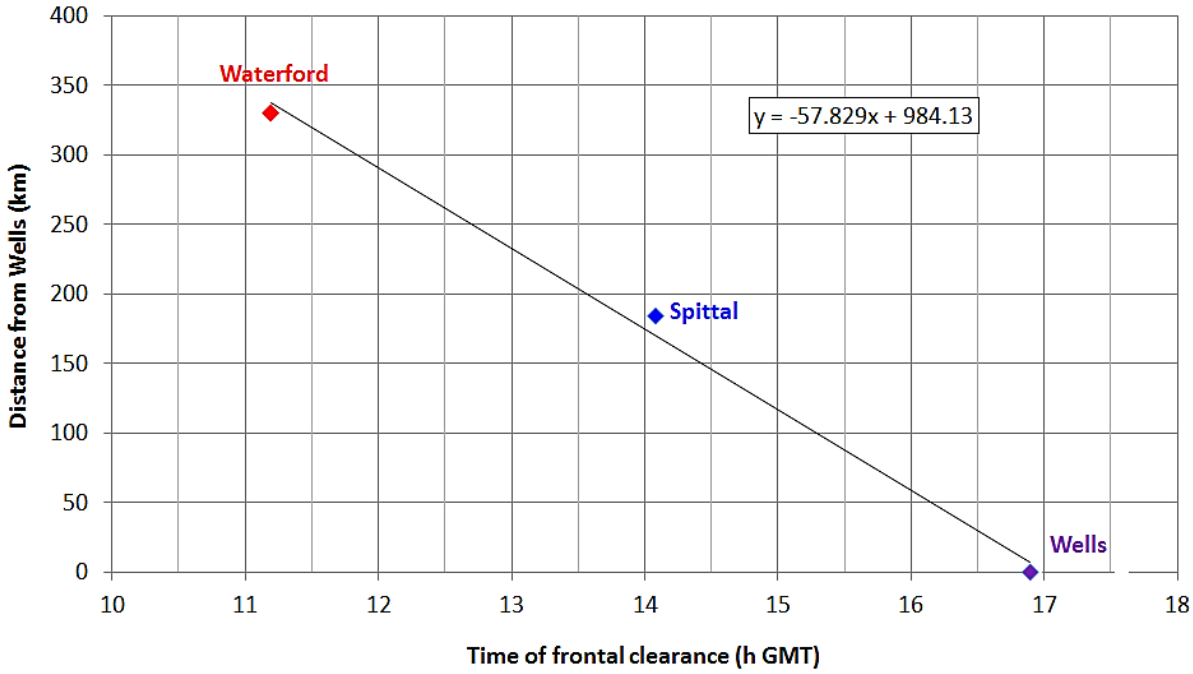


The same cold front clearance passing Waterford (red), Spittal (blue) and Wells (purple)

11. Using the combined graph, find the time when the initial drop in temperature passed over each station

12. On a map, find the location of your weather station and the other one or two you have chosen. Measure the distance in km from your station (in the example, Wells) to the other one or two.

13. Plot a graph (using Excel, or just graph paper) with the time of the start of the temperature drop as the x-axis and the distance from your station as the y-axis. If you are using Excel, click on the Chart Layout that puts a line of best fit through the points, click on the line and tick the box saying Display Equation on Chart – the speed of the front is the gradient in the equation, so in the example below it is almost 58kph. If using graph paper, draw a line of best fit just by eye, and measure its gradient with a ruler.



An Excel graph showing the three station times and distances from Wells, together with the line of best fit and its equation in the box.