Presenter: Dr Jennifer Catto, Monash University - *2015*

Title: On the front line: finding out how much rain comes from a front. (13:36)

Time	*Dialogue*
00:08 00:38	Whenever I tell people that I work on researching fronts, I'm pretty sure they think I do something like this. My name is Jennifer Catto and today I 'm going to tell you about how I got into researching fronts, what it involves and why it is important. So first of all let me tell you a little about what fronts are. The term front actually comes from the military term for the line where the two sides would meet in battle and this is something like what happens in a front with the battling of warm and cold air. So you can see in this top figure here if you look at the winter average temperature. So this is the climate. You might have heard the phrase, Climate is what you expect and weather is what you get. So the top here is the climate. You can see that between the warm tropical air and the cold polar air there's quite a straight line.
01:04 01:37	On a day to day basis, so the figure at the bottom, you can see that this straight line becomes very wiggly. So this gives us the weather. So in some of these wiggles the warm and the cold air get pushed much closer together … and that's what gives us this battling. So what happens at a front? Well when you have got this battling of the warm and cold air coming together, the warm air rises up over the cold air. So this can happen slightly differently at warm fronts and cold fronts. So at a warm front the warm air rises over the cold air quite slowly, so it rises up like this and it gives you large clouds and rainfall. At a cold front like the picture shown here you get descending cold air cutting in under the warmer air and this causes the warm air to rise up really quickly.
01:58	So when warm air rises up it cools down and the moisture that is held in that air condenses and forms clouds and gives us rainfall. So in Melbourne we get a lot of cold fronts passing. We don't get that many warm fronts around here but we get a lot of cold fronts passing and they bring a lot of rain and this is why we see fronts shown on weather maps because it tells us when the rain is coming. So knowing about fronts is clearly very important, fronts bring rain and without rain we can't survive. Water coming from rain is vital for agriculture, for ecosystems and for human health. If we don't get enough rain then we get droughts and subsequent consequences for crops. Too much rain in one go and we get flash flooding which also has dangerous consequences.
02:48 03:18	Another reason we are interested in fronts is because of climate change. So we know that the climate is changing due to increased emission of greenhouse gases and human activity but as well as increasing the average global temperature, climate change is changing rainfall patterns over the globe. So one of the tools, the major tool that scientists use to look at how the climate might change in the future are climate models. So these are massive computer models, mathematical models that contain all of the equations that govern the motion of the winds and the oceans and they are run on huge super computers like the one shown here that would probably just fit into the Monash University gymnasium. They're huge. So these climate models use all of these equation and they tell us about what might happen in the future.
03:41	But before we can use these to look at the future we need to make sure that these models are representing the present climate correctly. So we would compare what comes out of the model with observations. But before we can compare the models with observations we really need to understand what is going on in the real world. So I got into researching fronts not because of the fashions but because of a fundamental gap in the knowledge – How much rain comes from fronts? So I remember sitting in my supervisor's office just chatting about where to take my research next and we were discussing the declining rainfall in Perth, Western Australia.

Time	*Dialogue*
04:22 04:52	So this is a region that has already undergone a large decline in rainfall and it's already had a very large effect on how much rainfall is going into the rivers in Western Australia and it has had an impact of shortening the cropping season in W.A. So there is a general consensus that he declining rainfall in Perth was due to a decline in the number of fronts passing over that region. But a colleague of mine had already shown that the number of fronts in that region hadn't declined over the past 30 years. So the rainfall had declined but the number of fronts hadn't. It must be something to do with the rainfall coming from the fronts? But then we realised that we didn't really know how much rainfall comes from fronts in a global sense. So when we realised that we were onto something that no one had really looked at before, we got quite excited about getting started on this.
05:13 05:44	So hang on a minute … why is it we didn't know how much rain comes from fronts? We know that rain comes from fronts. This is why they show it on the forecast maps. Well a lot of people have looked at individual events, or weather events to see what the structure of rainfall is around a front and these systems. And some people have looked at long term patterns over a few years in smaller regions, so for example in South Eastern Australia or in the United States of America but often when they do these studies they identify the fronts by eye. So they look at charts of temperature and they identify fronts by eye. So you can see this is a map of a smallish region over the world. This is for Europe and the North Atlantic. The number of fronts at one particular time is huge. So imaging if you had to do this, looking globally for the past 30 years and you can see that that would take for ever.
06:15 07:05	Another problem with doing this by eye is that a different set of eyes might see different things. So if two people looked at the same maps to identify fronts they might actually count a different number of fronts. So this is why it is very difficult to do a manual analysis by eye on a global scale. So luckily a colleague around this time developed some new software to identify fronts automatically. So the first step of my work was to apply my colleague's snazzy new software to some gridded data. This is gridded data that is our best observational estimate of the state of the atmosphere and these data sets are produced by taking all the observations you get from taking lands based observing stations plus satellite information and they ingest it into a big computer program and it spits out the state of the atmosphere every six hours for the past 30 years or so on a global scale.
07:23 07:47	So you can tell that that is a lot of information that we are dealing with. So I set this new software running on this new data set. There is no cool user interface do this. It is just a matter of typing the command into the computer and letting it go. So that's identifying the fronts. So the next thing we needed was rainfall data. When you want to look globally at rainfall you are a little bit limited in the data sets that you can use. There are some data sets globally that give you information about rainfall on a monthly basis but when we are considering fronts that pass over in a day or two then we really need higher temporal resolution information. So the data set we used was actually based on mostly satellite information but mixed with rain gauge data.
08:14 08:36	One of the draw backs of this data set which was actually daily information, one of the draw backs was it was only twelve years long. So this isn't very long when you are doing climate studies and it isn't long enough to look at long term changes in rain fall because there is quite a lot of year to year variability in rainfall. So with the fronts identified in the gridded data and now the rainfall the next step in the analysis was to find a way of linking these two data sets. So here you have got rainfall in the colours and the fronts drawn by the black lines. So we (came up with, we) tested a few different ways of linking rainfall and fronts. There wasn't any real right way of doing this so we tested a few different search areas. So if you look at this by eye you might associate the rainfall with the fronts in a certain way.

Time	*Dialogue*
09:07 09:34	But the idea was we wanted this to be automatic and reproducible so that somebody coming along with a different rainfall data set would be able to apply it in exactly the same way. We tested some different areas. We tried a very small box but we realised that we would be missing some of the fronts that passed over quite quickly or fronts that were slightly further away from the rainfall, but too big a box and all of the rainfall over the globe would be associated with fronts. So we compromised and went with a fixed area box that we thought was the best search box. And like I said the idea was that this could be reproduced by anybody with any different data set. So gathering the data, (doing) writing the code and doing the analysis probably took a couple of months work and then we had some results. The main result or one of the main results that we found was that in the mid-latitudes of the globe, 68% of rainfall comes from fronts.
10:09 10:37	Ok so that sound like a fairly simple number for so much work but really nobody had found this number before. Nobody had looked globally at how much rain comes from fronts. So we were the first people to come up with a number like this. So obviously we had some more detail in the results, so you can say that I different regions, over South East Australia, 70% of rainfall comes from fronts. Over Scotland, where I come from about 80% of rainfall comes from fronts and there is a bit of a different split between cold fronts and warm fronts for rainfall. So for example in Melbourne we don't get many warm fronts so more of the rainfall comes from cold fronts, whereas in the UK it's a bit different. There are maybe more warm fronts than cold fronts. And another thing we found was that rainfall coming from fronts is actually twice as heavy as rainfall coming when there are not fronts.
11:05 11:28	So this wasn't really a surprise because we know that fronts bring a lot of rainfall but again nobody had quantified this number. So we … we wrote up these results and we sent them to a really good journal and when you send papers to a journal they get sent to at least two reviewers who can comment and criticise and give their suggestions on your work. So we got the reviews back and one of the reviewers loved it and thought it was great. Loved what we had done, thought it was really important and that it should be published. The other reviewer had a few criticisms. So one of the criticisms was that if we had used a slightly different technique, we would have got different answers, which is true because this is why we tested the different search areas.
11:49 12:18	This is one of the interesting things about science that there's (not really or) very rarely a right way of doing something, it's more that this is the best way we can come up with right now and we can justify it with these arguments. So we justified our choice of search area based on the speed that fronts move and the previous studies that show what the structure of cloud and rainfall coming from fronts and individual events looks like. So having to argue these things with the reviewer can be a little bit frustrating but in the end it means you probably didn't justify your choices well enough in the paper to start with, so it can be quite a useful exercise. So much to my relief and delight a little while later my paper was published and it is a large part of what we do writing papers but I always think it is cause for celebration when a paper is published, so I probably celebrated with a few 'Tim Tams' (chocolate biscuits) at morning tea.
12:44 13:09 13:28	So this paper has really been a jumping off point for my more recent research. So now that we have a better understanding of the real world and how much rain comes from fronts we can then use this to evaluate our climate models to ensure that they are representing this correctly and then we can then further look at what might happen in the future. How will the rainfall patterns changes and how will this relate to fronts? So we will always need our forecasters to tell us when the fronts are coming but maybe in the future the fashion and the hairstyles will be a bit different. Thank-you … (applause).