Presenter: Dr Ailie Gallant - *2016*

Title: Ice, trees, supercomputers and Australian droughts - (13:18)

Time	*Dialogue*
00:010 00:40	"I love a sunburnt country, A land of sweeping plains, Of ragged mountain ranges , Of droughts and flooding rains". Now I'm sure that many of you have heard these lines before from Dorothea Mackellar's famous poem, My Country. So when drought struck South Eastern Australia in the late 1990's we thought nothing of it. Things would be bad for a year or so, maybe a few years but then they would largely return to normal as they always did. After all drought is a normal part of the Australian landscape. By the mid 2000's the drought had not disappeared. Agricultural productivity was down. The dams were drying out and we'd had large fires track across the Victorian and southern New South Wales landscape. We were beginning to get into uncharted territory. At this time I was about midway through my PhD project – examining droughts in the historical records. So looking at rain gauge data.
01:08 01:40	And droughts are not unusual in Australia. At the turn of the 20th century we had the "Federation Drought" which lasted for about 5 years. We had an eight year drought from 1937 to 1945 which unfortunately coincided with World War 2. But ultimately what was now daubed the "Millennium Drought" was completely unprecedented. It lasted for 13 years and didn't end until 2010 when summer brought drought breaking rains. So by this time scientists were trying to understand the drought in detail. It was unprecedented. What caused it and was it unusual? And those were big questions. The causes of the drought were very very difficult to untangle but that question of was it unusual or perhaps that's what we could answer.
02:01 02:30	But of course we only had 100 years of rain gauge data and looking at a 13 year long drought with 100 years of data isn't the greatest thing. We don't have a lot there to look at. But was there a way that we could go back further? Well I discovered there was over lunch with a colleague at a new job that I had just started. And we decided that we could combine our expertise using an area of study called paleoclimatology. So paleoclimatology exploits measurable chemical and biological responses of the natural world that are sensitive to changes in climate. In other words they're nature's rain gauges. So for examples we have trees. Some species, every year that they grow, add an extra ring to the outside of the tree. And depending on whether that year is warm or cold or wet or dry, effects how the tree grows and therefore effects the width of that ring as it grows on the tree.
03:02 03:30	And so that can tell us something about the climate. Corals are similar. Corals also put down these growth rings although corals are sensitive to ocean temperatures and things like salinity. So the saltiness of the ocean. And of course there are ice cores which are nature's snow gauges and in areas like Antarctica where we don't actually get melting of ice or snow in the summer. Every time snow falls it compacts and we end up getting nice annual layers in an ice core. So perhaps we could use these paleoclimate data that were sensitive to changes in the climate to tell us a bit about South Eastern Australia's rainfall and this drought that we were in the midst of. So we began gathering data. Scientists had looked at this data before individually for one tree or one piece of coral or one ice core but what they hadn't looked at was the data collectively and we thought that was the key to unlocking the secrets of South Eastern Australia's drought.

Time	Dialogue
04:06 04:30	But of course science never did run smooth. We were trying to understand rain fall here, in that grey box of South Eastern Australia but we soon discovered that the types of records that we really needed to look at were practically non-existent in this region and instead they were here where these dots are. We had a few trees from South Western Tasmania but unfortunately western Tasmania has a very different climate to the rest of that grey box, so it wasn't necessarily overly useful. So were didn't have the data where we wanted it … but was this a problem? Well as it turns out, it wasn't because using the power of collaboration between scientists of different disciplines we were able to work out that climate processes that effect not just South Eastern Australia but other areas around the globe also effect South Eastern Australia. And so we could use that to our advantage.
05:09 05:34	So how can we use data from outside South Eastern Australia to tell us about what's going on there. What we use is called Atmospheric Teleconnections. So what is an atmospheric teleconnection? Basically you can think about a change in one part of the climate affecting something else downstream. Think about as throwing a rock into a pond. When you throw a rock into a pond you get a ripple and that's exactly what's happening in the climate. Now one of the most famous of these atmospheric teleconnections is called the El Niño Southern Oscillation. The extreme phases of which are El Niño and La Niña which you may have heard of before. So typically the atmosphere works to create an area that is usually more conducive to rainfall to the north and the east of Australia. There are very warm ocean temperatures there so that tends to bring rainfall to the region.
06:07 06:40	But during El Niño which is one of these extreme phases of the El Niño Southern Oscillation, we get a very distinct pattern of sea surface temperatures, ocean temperatures in the east and central tropical pacific and what this does is that it has knock on effects to the atmosphere and changes the winds, changes the circulation to move that area of rainfall further east to the central and eastern Pacific. And so that makes that region and also Australia, particularly Eastern Australia less conducive to rainfall and makes it less likely to rain during El Niño and hence El Niño's are usually associated with drought in the South Eastern and Eastern Australia. But of course the El Niño is not the only teleconnection pattern. There are many others. These are just three of the major ones.
06:57 07:23	We have the Southern Annular Mode which tells us how the storms that populate the southern ocean move north and south. So those cold fronts and storms that bring rain, sometimes they go further north and sometimes they go further south. And then we have the Indian Ocean Dipole off to the north west which also gives us a response kind of like the El Niño southern oscillation and makes it more or less likely to rain depending on what state it is in and interestingly enough all that paleoclimate data that we had, a lot of it is sensitive to these teleconnection patterns. So changes in the paleoclimate data according to these teleconnection patterns might be able to tell us something about the South Eastern Australian rainfall and it turns out that's exactly what we found … and that's shown here.
07:53 08:21	So if we look at the plot on the right you see areas of blue around South Eastern Australia and around South Eastern Queensland. Now those areas of blue show us where we have a strong relationship between the common signals in that paleoclimate data. So we use sophisticated statistical techniques to pull out a common signal and the blue areas here show us where the strongest relationship is. The darker the blue the stronger the relationship. The map on the left, shows red and dark pink areas, shows where the millennium drought was at its worst – South east Australia and South East Queensland. Exactly where we are seeing that strongest response from the paleoclimate data. And so we were able to use that to our advantage and to reconstruct rainfall back in time to see just how unusual the millennium drought was. And that is what we did and that's what is shown here.

Time	*Dialogue*
08:52 09:18	So the black line is the best estimate that we could get of South Eastern Australian rainfall. And we could reconstruct that and we almost doubled the length of out records back to 1783 providing an extra 120 odd years of data. So that's what the black line is. The grey shading shows some uncertainty around that because obviously these are estimates from natural things like trees and ice and they are not going to be perfect. There's some uncertainty around this. But what the green and red line shows are two different networks of rainfall stations. So actual gauge data that was read and you can see how closely the red and the green follow the black line even as far back in time as we can get. And so we were fairly confident that our black line is a pretty decent estimate of what actually happened to rainfall way back from 1783.
09:48 10:18	What we could also do is collaborate with non-scientists. We actually talked to historian as well. Environmental historians who had been studying early settlers around South Eastern Australia, and one of the records we looked at was from a place called Lake George. Not too far from Canberra. Now this lake is very sensitive to rainfall and basically acts as a big rain gauge. So it builds up when it rain a lot and it dries out when we've got drought. If you look at that record what you find is things like this. In 1824 the record describes Lake George as completely full and a wall of water while in 1838 by that stage the lake had dried out completely. And in fact they describe that you could "drive a team" straight through it. In other words a team of horses. So the lake is completely dry.
10:43 10:13	So that also gives us some additional evidence that what we are seeing here likely did happen. So what does that mean for the Millennium Drought? So the Millennium Drought you can see at the very end of that red time period. Up towards the far right. That lowest point is the Millennium Drought and compared with the longer historical records you can see that it is certainly unusual but not necessarily completely outside what we had seen in the past. The results are a bit ambiguous. They were not exactly what we were hoping to find. Of course nothing in science ever is. Right? So it certainly tells us that the Millennium Drought is at the edge of our past experience but not necessarily completely unprecedented. And this tells us a couple of things.
11:35 12:05	This can tell us that perhaps we should expect droughts like the Millennium Drought to occur in the future. OK? But it also shows us that they don't happen all the time which is also a good thing. So if we look at the Millennium Drought is it unusual? The answer is actually … Maybe? We are not sure yet and it is still an area of very active research and a work in progress. People are looking at the causes of drought and people are trying to see in longer term records, using techniques similar to this whether it really is unusual. But of course we can look at the more recent records as well. As I said the Millennium Drought ended in 2010 and we can look at ongoing data and that is what's shown here.
12:23 12:39 13:07	This is from the Australian Bureau of Meteorology and here the red bars show rainfall below average and the blue bars show rainfall above average. Now this is for what we call the Southern Wet Season. So pretty much Autumn, Winter and early Spring rainfall. And this is for South Eastern Australia in the same area where we had the Millennium Drought. You can see the millennium Drought throughout the early 2000's and you can see 2010 is the one lone blue bar above the line. But what you can also see is that since 2010 we have reverted back to a very dry period and that's something that as a drought scientist I'm certainly keeping an eye on. Thank-you.