T R A N S C R I P T

LEGISLATIVE COUNCIL ENVIRONMENT AND PLANNING COMMITTEE

Inquiry into the 2022 Flood Event in Victoria

Melbourne – Wednesday 6 December 2023

MEMBERS

Ryan Batchelor – Chair
David Ettershank – Deputy Chair
Melina Bath
Gaelle Broad
Jacinta Ermacora
Wendy Lovell
Samantha Ratnam
Rikkie-Lee Tyrrell
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John Berger
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WITNESSES

Professor Julie Arblaster, Deputy Director, and

Dr Kimberley Reid, Research Associate, ARC Centre of Excellence for Climate Extremes.

The CHAIR: Welcome back to the committee's public hearing for the Inquiry into the 2022 Flood Event in Victoria. Welcome to our witnesses from the ARC Centre of Excellence for Climate Extremes.

All evidence that we take is protected by parliamentary privilege as provided by the *Constitution Act 1975* and the provisions of the Legislative Council standing orders. Therefore the information you provide during the hearing is protected by law. You are protected against any action for what you say during the hearing, but if you go elsewhere and repeat the same things, those comments may not be protected by this privilege. Any deliberately false evidence or misleading of the committee may be considered a contempt of Parliament.

All evidence is being recorded. You will be provided with a proof version of the transcript following the hearing, and transcripts will ultimately be made public and posted on the committee's website.

I might ask members of the committee to introduce themselves, starting with our screen friends.

Jacinta ERMACORA: Hello. Jacinta Ermacora, Western Victoria Region.

The CHAIR: Sorry, I think that is all we have got online, so we might go down to –

Rikkie-Lee TYRRELL: Rikkie-Lee Tyrrell, Member for Northern Victoria Region.

Wendy LOVELL: Wendy Lovell, Northern Victoria Region.

David ETTERSHANK: David Ettershank, Western Metro Region.

The CHAIR: Ryan Batchelor, Southern Metropolitan Region and Chair of today's proceedings.

I will invite you to make an opening statement, as I think you have been advised, of around 10 minutes in total. We will then ask you some questions. So I will hand over to you, and before you start, for the Hansard record, if you could state your name and the organisation you are appearing on behalf of. Thank you.

Julie ARBLASTER: Thank you. Good afternoon. My name is Professor Julia Arblaster, and I am here in my role as Deputy Director of the ARC Centre of Excellence for Climate Extremes. I have over 20 years of experience as a climate scientist in understanding climate extremes in Australia and globally. I am a highly cited researcher, and I have been a lead author on many climate assessment reports, including the Intergovernmental Panel on Climate Change.

The Centre of Excellence for Climate Extremes leads national research into the fundamental science of climate extremes, what causes them, how they are changing and how they will change further in the future. We are a team of over 100 scientists with Australia's next generation of outstanding climate researchers in science, maths, engineering and computer science.

The events of October 2022 were record-breaking. October 2022 was Victoria's wettest October. It was the wettest month on record, and those records began in 1900. Some regions in Victoria experienced 2½°to four times their normal rainfall. We do understand the key meteorological and climate drivers of some aspects of the extreme rainfall, and my colleague Dr Reid will speak to some of the specifics of that. Understanding changes in extreme rainfall is an active area of research in our centre.

In my opening statement I would like emphasise two key points this afternoon. The first is that the science is clear that the climate is changing due to human emissions of greenhouse gases, predominantly from the burning of fossil fuels such as coal, oil and gas. This warming of the climate is already increasing the risk of some extreme events. We know from temperature observations in Australia that there is a clear trend in more frequent, more intense and longer lasting heat waves, with temperatures exceeding 50 degrees Celsius in some regions.

Climate change is also disrupting the water cycle, with an increase in short-duration, high-intensity rainfall events projected with additional warming of the climate. However, future changes in rainfall patterns for regions such as Victoria are very complex and dependent on very regional and local-scale conditions. So while in general we can expect rainfall variability to increase with climate change, and more frequent swings from extreme droughts to flooding rainfall, it is however our view that any more detailed projections for extreme rainfall change at this very local scale – for example, for a city or a catchment – are beyond the current state of climate science. So I want to caution the committee to be extremely wary of products that are being offered to local, state and federal governments that claim to have some accurate and specific data on how extreme rainfall will change in the future, because they are not supported by our scientific understanding. These have the potential to provide false confidence around climate projections and risk really economically costly investments and maladaptation.

In the face of this uncertainty, we need to plan for both increases and decreases of extreme rainfall and its impacts. Every additional fraction of warming of the climate system is likely to lead to further increases in the risk of climate extremes, which brings me to my second point: in the face of this uncertainty and future changes in extreme rainfall the most important action we can take today is to reduce greenhouse gas emissions. The Victorian government has been a leader in setting strong emissions targets, and I guess I urge you as members of all parties to keep aiming for and implementing policies that will achieve rapid and substantial reductions in emissions. Every fraction of additional warming, as I said, increases the risk of extreme events, and reducing emissions is the key action that can be taken to make us more resilient to climate change.

In our submission we also argue that we can improve our assessment of risk and increase our resilience to extreme events by building narratives around plausible future climate scenarios. It is important that these are undertaken with local communities and incorporate knowledge from other disciplines such as social sciences, engineering and economics as well as climate science to provide case-by-case information in collaboration with these local communities. Greater collaboration of this sort as well as continued investment into the fundamental climate science is vital for increasing our climate resilience. Additionally, present research environments and research funding opportunities currently hinder this type of interdisciplinary collaboration.

In summary, our Centre of Excellence for Climate Extremes is very willing to work with you to help provide advice on climate extremes and climate change, and with that I will pass over to my colleague Dr Kim Reid for her opening statement.

Kimberley REID: Thank you, Julie. Thank you for the opportunity to speak today. I am a climate scientist with the ARC Centre of Excellence for Climate Extremes at Monash University, and I am currently leading a research study on why 2022 was so wet in eastern Australia. On 13 September 2022 the Bureau of Meteorology declared La Niña was underway, as well as a negative Indian Ocean Dipole and Positive Southern Annular Mode. These are the three wet phases of the main climate influences on south-east Australian weather in spring. The last time all three were in their wet phase was in spring 2010, which you may recall was also followed by devastating flooding in Victoria. The time before that was 1975. October 1975 was the previous wettest month on record for Victoria prior to 2022. In other words, the atmosphere was primed to be a wet spring well before October. October was characterised by the repeated slow-moving weather systems that were able to tap into tropical moisture to bring heavy and persistent rainfall to Victoria. We know that slow or stalled weather systems with an ample supply of moisture are key ingredients to heavy rainfall in Victoria. Recent research by myself and colleagues found that spring 2022 had the highest number of slow-moving weather systems since reliable observations began in 1980. In addition, the amount of moisture that travelled over Melbourne during the heavy rainfall on 25 October was in the top 0.2 per cent. That is the same likelihood as an ATAR of 99.8.

We know that atmospheric moisture will likely increase with a warmer atmosphere and therefore bring more intense rain when these weather systems occur; however, the timing of when and where these weather systems will occur in the future is more uncertain and an active area of research. But this does not mean that we cannot act to reduce climate hazards now. The effects of climate change are felt through extreme weather events. While rainfall and floods are strongly related, understanding how rainfall may respond to climate change is very different from understanding how floods may change, and this is because flood risk is strongly related to non-weather factors such as where we build, the materials we use to build and how we manage water. Despite the uncertainties in how extreme rainfall and floods may behave in the future, there are still ample opportunities to mitigate to reduce flood risks within the present climate. We know the climate is changing. We may not know the exact details of the impacts that will bring for Victoria, but do not let uncertainty in future climate

projections be the barrier to action. And with that, I am happy to answer questions on the causes of heavy rainfall and Australian rainfall patterns generally.

The CHAIR: Thank you very much for the opening statement. I might start. It is fair to say that October and the months leading up to it were the worst in terms of rainfall that we have seen in a long time. Is that true?

Kimberley REID: Since 2010, yes.

The CHAIR: Since 2010. And it is these particular sets of climactic circumstances that particularly precipitated that set of conditions – that is right? So whilst we cannot predict in the future, we can be, sort of, on the lookout for these things occurring.

Kimberley REID: Yes.

The CHAIR: Would that be fair? I am trying to interpret your complexity to distil it down to utterly no complexity.

Kimberley REID: Yes. There are indicators we can look for that point to whether it will be wet.

The CHAIR: Point us in the right direction or alert us to circumstances that we should be more attuned to risk around.

Kimberley REID: Yes.

Julie ARBLASTER: And some of them are more predictable than others, I guess, in certain lead times. So we know La Niña is more predictable.

The CHAIR: So La Niña events, the negative Indian Ocean Dipole – would they be the two? Are there others that you think we need to be sort of aware of coming in the future to be alert to?

Kimberley REID: Yes. So in the Southern Ocean we have what is called the Southern Annular Mode, and when that is in the positive phase, there is an increased likelihood of tropical moisture being able to penetrate down to Victoria, and that helps get these really heavy rainfalls.

The CHAIR: We have heard evidence about the intensity of events and the frequency of events. I assume they are not the same. Can you unpack it a little bit for us? When people talk about intensity of events and frequency of extreme weather events, what do each of those things mean in their own way?

Kimberley REID: Okay. So when we talk about frequency, we talk about just the number of events, so how many fronts or how many days of above X per cent rainfall we will see. When we talk about intensity, we talk about how heavy the rain is. Are we getting 25 mm in a day? Are we getting 100 mm in a day? So both of those factors can combine to produce a heavy rainfall event. And what was interesting about October was that the intensity on any given one day was not necessarily record-breaking, but we just had a lot of very heavy rainfall days all within that month.

The CHAIR: It was not one exceptionally intense day.

Kimberley REID: Correct.

The CHAIR: It was a lot of reasonably intense days over an extended period of time.

Kimberley REID: Yes.

The CHAIR: And do you know how long the build up was? In terms of – we have heard a lot of evidence about saturated ground and the like. How far back from the flood event that we are looking into, those October dates –

Kimberley REID: From August we saw that soil moistures over large areas of Victoria were close to saturation. From September we knew that water storages were at 95–100 per cent. La Niña was declared in September but there were La Niña watches, so indications that it might form from I think July. I spoke to the

media in July about the bureau's forecast for a wet spring. So we did have a few months of indication that it would be wet. Of course knowing exactly which week is going to be wet is something that we cannot tell.

The CHAIR: So all the preconditions were pointing us in the one direction –

Kimberley REID: Yes.

The CHAIR: although we never know exactly when is going to happen.

Kimberley REID: Or where the weather systems will actually fall.

The CHAIR: That is right, because it may well be that it does not all quite work.

Kimberley REID: Yes.

The CHAIR: In terms of Victoria's rainfall patterns, are there circumstances where we see those sorts of build-ups and then rainfall in different places that has different outcomes? Is there a consistency to the way rain falls across Victoria in these sets of circumstances?

Julie ARBLASTER: La Niña does push us towards wetter springs in general in Victoria, and our skill in understanding that relationship is greatest in winter and spring for rainfall. We do not have much skill in how El Niño or La Niña will affect rainfall in summer. But again, it is often the small-scale weather systems that actually deliver the rainfall, and that is not predictable more than a week to 10 days in advance. So where they exactly fall can determine where the floods will occur.

The CHAIR: Yes, sure. I think I want to just come back to something you mentioned. It seemed like a warning to us about people – and these are my terms, not yours – going round hocking models to governments, telling them they can predict the future. How widespread is that? What do people need to be alert for in terms of claims that – I assume it is – 'X weather system can tell you what's going to happen in terms of frequency of future rain events'?

Julie ARBLASTER: Yes, it is becoming something that we are more aware of, that these datasets are being produced from climate model data without expert knowledge, and they are getting down to fine scale of hundreds of metres of resolution, whereas our climate models are run currently at 100-kilometre grid cells. Having finer scale information is really not possible at this time; it is not supported by the science. But there are a lot of entities out there that are –

The CHAIR: Sorry, these would be commercial entities – so people with datasets?

Julie ARBLASTER: Yes, you can download them from the web.

The CHAIR: Right, so it could be people selling them or just individuals with a bit of processing power? I am just trying to figure out who we need to be sceptical of in terms of providing –

Kimberley REID: I bought a house last year – there are organisations that will give you a report on your individual property, which climate models are not capable of doing, and they will charge.

The CHAIR: Yes, okay. What are those reports purporting to tell you?

Wendy LOVELL: You can get them from the CMA free.

Kimberley REID: Yes, the risk of an extreme rainfall – how that might change in the future for your property or your mortgage or whatever it is.

The CHAIR: Right, based on future risk of extreme rainfall events.

Kimberley REID: Yes.

The CHAIR: Okay. So we just need to be a bit cautious about those, in your opinion.

Kimberley REID: I think so, yes.

Julie ARBLASTER: And I guess our statement is really that there are improvements that can potentially be made in our climate modelling and in fundamental climate science, but right now it is not possible to get down to that local scale for projections. There is just no certainty in that.

The CHAIR: I might leave my questions there. Mr Ettershank.

David ETTERSHANK: Thank you. Thanks for your presentation – it was great. I want to move on to the implications of what you are saying for planning, as in property planning and stuff like that. Our planning laws currently are premised upon this concept of 'We build above one in 100 years.' On the basis of what we have been hearing, if the government or the authorities get that correct, then probably those areas subject to one-in-100-year floods are going to get bigger. I guess I am interested to know: do you have a sense of whether or not the current assumptions around that are correct and what that will actually mean in practical terms?

Julie ARBLASTER: Assumptions around where the one-in-100 flood lines are?

David ETTERSHANK: What it might look like, and what it will impact.

Julie ARBLASTER: That is beyond our expertise, but I will say that I think the data for estimating those flood lines is – we need more data to actually be able to do that. We just do not have enough information in Australia to actually give really accurate information to have those, but some number needs to be set. I think it is really difficult to actually make those estimates precisely and accurately.

David ETTERSHANK: All right. I mean, we have still got people building on flood plains. I am going to pitch lower this time. We still have it everywhere – we have got people building on flood plains. Have you got some words of advice on that question?

Kimberley REID: I think if you are building on a flood plain, expect it to flood. I do not know when, but –

David ETTERSHANK: I mean, obviously people like to be by the river and to have the water views and suchlike, but clearly we have seen in the 2022 event what that means. Are there some – I am trying to think of the right wording here – constructs or some concepts you could share with us as to the implications of future climate change on what people currently consider to be relatively safe?

Julie ARBLASTER: I think, again, that local-scale information is really hard to give accurate projections for. We know in Victoria we have actually had a decline in rainfall, so we need to prepare for droughts as well as extreme rainfall events. So actually being able to say in my home town of Swan Hill what the likelihood of future extreme rainfall events in the future is is really, really difficult and beyond the state of the science.

Kimberley REID: I also think that we are building in flood plains currently and it is flooding currently, so before we even worry about the future change there is more we can do to address the present risk.

David ETTERSHANK: Okay. Yes, we have already got a problem, and all the science would tell us that that problem is going to get worse, albeit that maybe the nature of downfalls and the rain precipitation patterns will change. Overall, we are going to have more floods, whether of a sustained nature or of a flash flood variety. Is that a safe assumption?

Julie ARBLASTER: We can say that overall –

David ETTERSHANK: And I am not talking about in any one particular location; I am talking on average.

Julie ARBLASTER: Yes, overall we can say that extreme rainfall is increasing and we do expect it to increase further if the climate system continues to warm. There are some extremes that we have much more confidence in. We do know that temperature extremes are increasing, and we have a lot of confidence in future projections of those, so we can say more about those. But extreme rainfall particularly is one that our climate models and our observations are just not good enough at the moment to be able to make really concrete, robust projections.

David ETTERSHANK: Okay. I was reading about the fact that there have been some pretty amazing increases in the incidence of flash flooding, as opposed to sort of 'normal flooding' – I am not sure what the term is. Sorry, as you can see, Ryan and I are both struggling as we are getting towards the end of the day.

Could you provide us with some commentary on whether that is correct and what that means in terms of the infrastructure that we have to have in place to deal with it?

Kimberley REID: Yes. The key difference is – there are two main ingredients you need for rainfall. One is what we call thermodynamics, which is basically moisture, and the other is what we call dynamics, so we need a weather system to lift the water up and the rain to fall out. Climate change is having a very clear impact on the thermodynamics, so it is affecting the temperature and the moisture, and that is the key driver of flash floods, which are basically your short-duration floods, a half an hour or hourly downpour that will stop all the trams in the city. Your longer duration events like we saw that caused this larger scale flooding rely on both the thermodynamics, so there being enough moisture, and the dynamics, so there being a weather system to sit there and dump all the rain. It is the dynamics which is where the uncertainty in our projections of floods lie. The climate models do a pretty good job of showing us that there is going to be more moisture in the atmosphere, but it is the positioning, the frequency and the intensity of these dynamic systems. I hope I have explained that clearly, but that is why we have a lot more confidence that short duration flash-flooding rainfall is likely to increase with climate change based on fundamental physics, but the larger scale, longer duration floods rely on the dynamics which the climate models still are not quite capable of reproducing yet.

David ETTERSHANK: Okay. So when our engineers and suchlike have been developing that infrastructure for dealing with your more traditional, longer duration, does this change have – this might be a really dumb question, actually – this increase in the propensity for flash flooding, does that have implications for the adequacy of the current water management infrastructure to be able to deal with getting the water away and getting people back onto the road and suchlike?

Kimberley REID: I guess it is a big question about how we define events. So if you talk about a one-in-100-year event, is that over a few days? Whereas flash flooding, we are talking about timescales of hours, so we need drains that are able to move that huge amount. The actual amount of water could be similar, but whether it falls over an hour or whether it falls over a few days will affect the drain size and infrastructure that you need. So I think being very clear about how we define these events and engineers talking to scientists more is important.

David ETTERSHANK: Is that dialogue happening? I mean, in terms of your expertise, is that discussion happening between government and engineering and meteorology, if I can lump it in that way?

Julie ARBLASTER: We can speak to the research community, and we are starting to form more interdisciplinary collaborations with engineers and social scientists, as I said. But it is still something that I think really needs to be informed more on a case-by-case basis for different conditions in different communities.

David ETTERSHANK: We have got an inquiry coming up on adaptation.

The CHAIR: We do.

David ETTERSHANK: So we are going to want to be talking about this a lot. Okay. Chair, I think that will do me. Thank you so much.

The CHAIR: Yes, that is fine. You are almost out of time, anyway. Ms Lovell.

Wendy LOVELL: Thanks very much for your presentation. I am just going to say that I do believe the climate is changing and there is a lot we need to be doing about it. I just struggle, from the presentations that you have given, to understand or to have any belief that the floods of 2022 were caused by climate change. If we look at the history of floods – I live in Shepparton, the Goulburn River is my back fence. I live in the home that was my family home. I have lived through every flood since 1974. For 1974, we had a May flood that was relatively exactly the same – not quite exactly the same, a few centimetres difference – to the flood of 2022. The homes in our street that were inundated were the same houses that were inundated in 74. The houses that were not inundated in 74, were not inundated.

You talked about October 75 and the rain events of that, and we had minor floods; again, we were cut off from town, but homes were not inundated. In 2022 again, October, the rains – I remember those rains very clearly – and again, we were cut off from town but no-one in the street was inundated. The 2022 floods, comparable

levels to 74, exactly the same homes inundated; 48 years difference between the two floods, both floods were considered a one-in-50-year level. No house in Shepparton that has been built since 1974 was inundated; after major floods, of course building levels are adjusted. They were adjusted in 74 and obviously those levels have been successful because no house built post-1974 was inundated. So how do we come to the conclusion that the floods of 2022 had anything to do with climate change and that they were not just a one-in-50-year flood, 48 years after the last one-in-50-year flood?

Julie ARBLASTER: Yes, I can speak to that first, and I am sure Kim can add. In our submission we did make the statement that linking the floods to climate change is beyond the capacity of the existing science right now, and so we are not saying that there is this direct link with climate change. It does not mean that there is not. It is just that, you know, the scientific evidence to really robustly link climate change to the floods or even to the extreme rainfall is not there at this stage. Maybe Kim can add.

Kimberley REID: Yes, I agree. This is the first question we get asked – is it climate change? And unfortunately with rainfall and flooding events it is very hard to disentangle the climate change from the natural year-to-year variations. I agree. I think with these floods – well, we know that they happened and that they have happened in the past. They have been just as big in the past. So I do not think we can blame this flood event on climate change. I think it would have been possible in the absence of climate change as well. But that does not mean that future floods might not be affected by climate change.

Wendy LOVELL: Or that we might not have more frequent floods.

Kimberley REID: Yes, exactly. With heatwaves of course we can very confidently say that it is climate change, but I agree that for rainfall and flooding, just because they are so complex, it is very difficult to scientifically tease out the contribution from La Niña versus climate change versus other human factors like where we build and how we build.

Wendy LOVELL: Or how much water is already in water storages.

Kimberley REID: Exactly.

Julie ARBLASTER: But I guess, again, the risk of extreme rainfall occurring, especially these short duration, hourly kind of flash flooding events, is projected to increase. Exactly where – it is difficult to have a pinpoint for a certain time line. But we do expect it to increase, and Australia is no different from the rest of the world in that those extreme heavy rainfall events are projected to increase.

Wendy LOVELL: And I think those flash flooding events are going to be really interesting at our next inquiry into the preparedness for climate change, around infrastructure and drainage and all those sorts of things. So yes, thank you. That is really all I had, so thank you very much for your presentation and for the work that you are doing.

The CHAIR: I might see if Ms Ermacora is available.

Jacinta ERMACORA: Hello, and thank you very much for attending today. I will plead ignorance on climate change and all the science to do with it. I have had a fair bit to do with climate modelling as a part of strategic planning in the water sector, but I am interested in your presentation and have a couple of questions if that is all right. I was curious listening to you earlier – are there standards for developing climate modelling? Are there international accepted standards where certain characteristics or certain levels of scientific credibility are present to then deem a model acceptable?

Julie ARBLASTER: I can speak to that. I am on the Coupled Model Intercomparison Project panel, which is the international body that does design experiments for climate projections, and it is very much a research-based activity. There are certain protocols that need to be followed to have a climate model participate there, and these are the experiments that then get used by the IPCC and other climate assessments and governments around the world. The director of our climate extremes centre as well as Professor Christian Jakob, who is at Monash University and is leading a new centre of excellence that we are involved with as well, on 21st century weather, have a recent article that says the climate modelling needs to become more operationalised. Similar to weather forecasting, which has very strict protocols, climate information is now being used for billion-dollar decisions, and so as a research scientific community it needs to become more operationalised. There is some

movement towards that with the establishment in Australia of the Australian Climate Service, which is an agency in the Bureau of Meteorology, with others – Geoscience Australia and the Bureau of Statistics – involved, where they are tasked with delivering a climate service that will provide that information similar to how weather information is now provided to the community and to stakeholders. Does that answer your question?

Jacinta ERMACORA: It is a very interesting space, and I kind of have sympathy for Ms Lovell's question: are we just seeing seasonal variation, or is this climate change? There are so many different ways you can ask that question: is this the biggest flood I have ever seen, or is this climate change? The notion of living memory versus actual data – and I think flood and rainfall modelling is very difficult to do. But we have got those aggregate temperature increases, so how do you communicate those kinds of dilemmas? I guess it is a form of scientific communication, because on the other hand we do not want a sense of Henny Penny either, do we – that the sky is falling in, and it is not.

Julie ARBLASTER: They are good points. I think future climate change is difficult because we are trying to provide information for something that we cannot test the skill of, whereas with weather forecasting we can test the skill every day and see whether our modelling was correct and whether forecast models were correct. Climate models are the best tool we have for assessing future risk. They are not perfect, but they have come a long way. We have an Australian national climate model that is state of the art. Again though, more can be done to improve those climate models and to then also communicate the broad range of projections that do come out of that modelling. We cannot just use one model, because we cannot test the skill. There is no best model, so we need to get this aggregate of risk across different models for different scenarios.

Kimberley REID: I was going to say we published a paper on this earlier in the year, this issue of communicating climate science in the context of the February–March floods in Queensland and New South Wales. One of the challenges we pointed out is that there are a lot of non-scientists that have very large voices in the media, for example, who are very quick to blame climate change, and for the journalists in the room I encourage you to just pause and maybe direct your questions more to the climate scientists. I think one of the issues with blaming climate science is that we forget that we are sort of blaming this other entity rather than realising we have a lot of agency ourselves and there is a lot that can be done to mitigate climate change, and we do urge scientists in particular to think about how we communicate to the public that these events can happen. It is not always climate change, and just being more cautious about communicating the risk is an important thing that scientists are starting to think about as well.

Jacinta ERMACORA: That is very interesting. The other thing was: what is the risk of us being very Euro settlement centric around our data collection? One example that I would refer to, for instance, is the 1946–47 floods, and at that time governments provided incentives for land clearing post World War II. There is a subsequent, decades later understanding that those floods were exacerbated by the recent land clearing that had happened immediately after World War II when soldiers were allocated land. So that is just one example, but I know that you use non-human-connected data. But then there is a lot of post-settlement human data that seems to have a disproportionate weighting on stories that are told, as if that 1956 line on the pub in Port Fairy is a very significant story. What it says about the future might actually not be anything significant, or it might be. Do you look into that very much? Not that specific issue, sorry, I just mean broadly that kind of pre settlement, post settlement, and then perhaps the obfuscation of data and perception.

Kimberley REID: I have a colleague at the University of Melbourne, Dr Linden Ashcroft, whose area of expertise is on digging out this historical human data. For example, ship records are a great source of pressure measurements. The one problem with this sort of human data is the reliability and robustness. With the more traditional European, or what the bureau would use, for example, they are automated weather stations. We know how they work, and we therefore can make more robust conclusions about future trends. For example, one of the issues with human data that often comes up is the Sunday–Monday problem. Because a lot of the rainfall records were collected at post offices, there was always not enough rainfall on a Sunday and a high amount of rainfall on a Monday. So there was this idea that, well, more rain falls on a Monday, but that is just because no-one worked on a Sunday. So with this sort of data there are these extra challenges that we need to take into account.

Wendy LOVELL: It just does not rain on a Sunday.

Kimberley REID: While they are an excellent resource, especially before we had automated weather stations, and there are people trying to dig into this, there are these – what is the word I am trying to use?

The CHAIR: Anomalies?

Kimberley REID: Yes, anomalies. They are not following the standards that we want, so we have to just be cautious as well. But yes, there are people trying to find these different types of datasets that can provide a longer record of the weather.

The CHAIR: That is your time, Ms Ermacora. Mrs Tyrrell.

Rikkie-Lee TYRRELL: Thank you, ladies, for coming in today. A quick one to start off with is: how often is your science challenged by opposing scientists with a different point of view saying that climate change is not a thing from humans, it is a generational weather pattern around the earth?

Julie ARBLASTER: I would say not from climate scientists.

Rikkie-Lee TYRRELL: Yes, so with an opposing point of view?

Julie ARBLASTER: I think 99 per cent of climate scientists agree that the climate is changing due to human activities and the burning of fossil fuels.

Rikkie-Lee TYRRELL: Okay, thank you. When you are taking into account predicting rainfall, do you look at, say, solar flares? I know irrigators in northern Victoria some of them, pay a lot of attention to solar flares and the sun because it seems that they can get an idea that we are going to get a wetter season depending on solar flares.

Kimberley REID: In my reading of the literature it is not a major contribution to rainfall that I have heard of.

Julie ARBLASTER: That has been suggested as something, but the scientific literature has not established that that is a root cause of rainfall variability. There are other suggestions out there, but it has not been in the peer-reviewed scientific literature.

Rikkie-Lee TYRRELL: All right. I did say I was going to be quick. Everybody has asked questions that I had. Being last is always a challenging spot.

The CHAIR: Thank you, Mrs Tyrrell. I just want to come back to the measurement question, not to drill into the post offices and the Sundays. How good do you think our current set of data measurements for meteorological and climate-related data are? Are there any improvements you think could be made that would assist us in better understanding weather patterns and weather events in the country but in the state in particular?

Julie ARBLASTER: The Bureau of Meteorology does maintain a fantastic network of rain gauges and weather stations. I would say Australia is above and beyond in terms of some other countries in the world that have this information, especially for us as researchers to analyse it. Radar information is becoming something that we can now look into – the records of radar. Particularly there is a study from our centre in Sydney. There are now 20 years of radar data, so that gives us more detailed information about some of these really small hourly rainfall events. Our colleague Hooman Ayat has published a study suggesting that that is increasing. So I think we can get better at using the data that we have. We are very reliant on satellite data. Kim here is working on a study over the Southern Ocean. Our information on the Southern Ocean weather is really critical for predicting rainfall in Victoria. Our information is very sparse there.

The CHAIR: So we do not have a lot of satellite data on the Southern Ocean? Do we have enough?

Kimberley REID: We have satellites, but they have various issues.

The CHAIR: In an ideal world, would we have more?

Kimberley REID: In an ideal world we would have a bunch of stations somehow on the ocean to measure it, but we cannot really do that. One of the challenges with rainfall is that you have got a station, which is a point somewhere on a map. Rain could fall over the station and you record it; rain could fall 10 kilometres to the west and you would miss it in the data. So having more stations is always great. There are a lot in eastern Victoria, so I think spreading them around the country, especially over the centre of Australia, would be ideal. The other point is that it is a big challenge for the bureau to maintain such a vast network, so any extra help that they could get, I am sure, would be appreciated.

Wendy LOVELL: Ryan, can I just do –

The CHAIR: Yes, of course.

Wendy LOVELL: Given Ryan has asked about how is this accurate data now, how accurate do you think the historical data is? Given that we would not have had satellite data, are there adjustments made for comparing that data when we are talking about measuring climate change?

Julie ARBLASTER: Certainly the Bureau of Meteorology has a high-quality network of stations that they have maintained that give us really long, consistent records of rainfall and temperature.

Wendy LOVELL: But historically we would not have had satellite data – you know, 100 years ago, for instance.

Julie ARBLASTER: That is correct, yes. The satellite data is only really available from the late 1970s, and that gives us lots of information about the weather patterns and sort of the larger scale environments.

Wendy LOVELL: But what period of time are you measuring climate change over? Are you only measuring it since the 1970s for comparable data, or are you measuring it from the 1800s? And is there an adjustment made then for what we would not have captured?

Julie ARBLASTER: In terms of temperatures, you do not actually need many stations across the country to capture the signal of warming, so temperatures kind of warm very evenly. Rainfall definitely – that is where you need more stations to sort of tease that out to get that real local scale. But in terms of temperatures, we have high-quality dataset for Australia from 1910, so we can really get a good sense of how Australia has warmed, and it has warmed by 1.4 degrees over that 1910 to present time period. So it is undisputable that Australia's temperatures have warmed, and the Bureau of Meteorology has best practice in terms of how you do adjust some of those movements of stations and things like that.

Wendy LOVELL: Okay. Thank you.

The CHAIR: Thanks very much, and thank you both for coming in and giving us the benefit of your significant wisdom today. You will get a copy of the transcript to review in about a week or so, before it is published on our website. With that the committee will take a short break.

Witnesses withdrew.