COMMONWEALTH OF AUSTRALIA

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HOUSE OF REPRESENTATIVES

STANDING COMMITTEE ON INDUSTRY, SCIENCE AND INNOVATION

Reference: Long-term meteorological forecasting

MONDAY, 18 MAY 2009

MELBOURNE

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HOUSE OF REPRESENTATIVES

STANDING COMMITTEE ON INDUSTRY, SCIENCE AND INNOVATION

Monday, 18 May 2009

Members: Ms Vamvakinou *(Chair)*, Fran Bailey *(Deputy Chair)*, Mr Bidgood, Mr Champion, Mr Cheeseman, Dr Jensen, Mr Johnson, Mr Ramsey, Ms Rishworth and Mr Symon

Members in attendance: Fran Bailey, Dr Jensen, Mr Ramsey, Mr Symon and Ms Vamvakinou

Terms of reference for the inquiry:

To inquire into and report on:

Long-term meteorological forecasting with particular reference to:

- The efficacy of current climate modelling methods and techniques and long-term meteorological prediction systems;
- Innovation in long-term meteorological forecasting methods and technology;
- The impact of accurate measurement of inter-seasonal climate variability on decision-making processes for agricultural production and other sectors such as tourism;
- Potential benefits and applications for emergency response to natural disasters, such as bushfire, flood, cyclone, hail, and tsunami, in Australia and in neighbouring countries; and
- Strategies, systems and research overseas that could contribute to Australia's innovation in this area.

WITNESSES

Committee met at 9.11 am

CHAIR (Ms Vamvakinou)—Good morning, ladies and gentlemen. I declare open this public hearing of the inquiry into long-term meteorological forecasting in Australia being conducted by the House of Representatives Standing Committee on Industry, Science and Innovation. The inquiry arises from a request to this committee by Senator the Hon. Kim Carr, the federal Minister for Innovation, Industry, Science and Research. Written submissions were called for and 29 have been received to date. The committee is now conducting a program of public hearings and inspections. This hearing is the first for the inquiry.

[9.11 am]

COUGHLAN, Dr Michael James, Acting Chief Climatologist, Bureau of Meteorology

JONES, Dr David Arfon, Supervisor, Climate Analysis, National Climate Centre, Bureau of Meteorology

WALLAND, Dr David James, Acting Superintendent, National Climate Centre, Bureau of Meteorology

KEENAN, Dr Thomas, Deputy Director, Centre for Australian Weather and Climate Research

ALVES, Dr Jose Oscar dos Santos, Leader, Seasonal Prediction and Climate Variability Group, Centre for Australian Weather and Climate Research, Commonwealth Scientific and Industrial Research Organisation

CHAIR—Welcome. Although the committee does not require you to give evidence under oath, I should advise you that these hearings are formal proceedings of the parliament. Consequently, they warrant the same respect as proceedings of the House itself. It is customary to remind witnesses that giving false or misleading evidence is a serious matter and may be regarded as a contempt of parliament. We thank you for your submission and now welcome you to make a brief opening statement before we proceed to questions.

Dr Coughlan—On behalf of the Acting Director of the Bureau of Meteorology, Dr Neville Smith, may I welcome you and the committee to the headquarters of the Bureau of Meteorology. Under the Meteorology Act 1955, the Bureau of Meteorology has responsibility for the collection of meteorological and related data and the forecasting of weather and the state of the atmosphere, including the issuing of warnings for severe weather associated events likely to endanger life and property. While there is no explicit time frame to which the bureau should limit its forecasts, it is constrained in this regard by the high level of complexity of the earth's system and the current state of scientific knowledge. Nevertheless, progress in scientific knowledge has been such that for the past two decades the bureau has been issuing forecasts on expected anomalies in rainfall and temperature across Australia for the coming three months—that is, seasonal forecasts. Indeed, this function was explicitly recognised through the government's endorsement of the recommendations of the 1996 Slatyer review of the operations of the Bureau of Meteorology.

The bureau continues to strive to improve its seasonal forecasting capabilities and supports ongoing research principally through its partnership with the CSIRO in the operation of the Centre for Australian Weather and Climate Research, from which you will hear more later in this hearing. Of equal importance with getting the forecast right is knowing the state of the climate system at the beginning of the forecast. In particular, the Bureau of Meteorology on a routine basis monitors conditions throughout the country that are conducive to or are maintaining ongoing drought.

Seasonal forecasting, like all attempts to look into the future, carries a level of uncertainty that leaves outlooks being expressed in terms of probabilities of specific outcomes. The Bureau of Meteorology recognises the importance of communicating the levels of uncertainty—what a forecast is saying and what it is not saying—to its users. To help ensure that its forecasts are interpreted correctly, the bureau has developed close working relationships with the agricultural community as represented in government, the rural press and farming organisations.

I am now at your disposal, Madam Chair, but before we proceed to questions the committee might be interested in going through a typical seasonal forecast briefing that we would regularly give, for example, to the Primary Industries Ministerial Council or the Murray-Darling Basin Authority. I have provided you with a handout. The typical outline is that we give a summary of recent climate conditions. This is establishing where we are now—what the state of the climate system is. As I indicated, that is almost as important, if not equally as important, as knowing where you are going in the future. Are we in current drought? Is the soil moisture profile at good levels for agriculture? We like to set the base. Then we start to look at the outlook in terms of rainfall, temperatures, what is happening to the major driver of climate variability on seasonal time scales. Typically, the main driver is the El Nino/Southern Oscillation. We also look at the Indian Ocean. Then we sum up with the prospects for the coming season.

The current state of conditions across south-eastern Australia for the beginning of this year have been particularly dry. In fact, in some areas, particularly the south-west of Western Australia and parts of southern Victoria, it has been the driest start to the year on record. If we also look at the last three to seven years, we can see that rainfall across much of southern Australia for these longer periods is also at the lowest values on record. This is evident, of course, in the big draw down of our major water storages across the Murray-Darling Basin, in parts of Victoria and South Australia, and in WA. So not only is there a short term deficiency in rainfall, we also have this long-term hydrological drought which is affecting major parts of our irrigation systems across the Murray-Darling and southern parts of Australia. Temperatures over the last three months have been average—if anything, above average—across much of the southern half of Australia, which would go along with the fact that temperatures over Australia have tended to be warmer than normal over the last 20 to 30 years.

If we look at the major drivers, El Nino—what is going on in the Pacific—is of critical importance to seasonal conditions across Australia. When the Southern Oscillation, which is an indicator of the major pressure patterns across Australia in comparison to the Pacific, goes negative we start to worry, because it generally means a higher potential of drier conditions over southern Australia or over eastern Australia. Essentially that means we have higher pressure over Australia and lower pressure over the central Pacific. The Southern Oscillation in the last week or so has dropped below zero, and we anticipate that it will continue to fall over the coming months.

In terms of an outlook, this suggests that conditions could begin to dry out over south-eastern Australia. We have seen significant rainfall during the past season over parts of eastern Australia—and you would have heard reports that Lake Eyre is, if not full, filling, and that is a result of the La Nina conditions that we have had over the last year or so—but we now see the pendulum starting to swing the other way. That is quite a worry for southern Australia because southern Australia did not get the benefit out of the La Nina that we saw over parts of Queensland and the more northern parts of New South Wales.

That is the sort of briefing information that we give. Those values are expressed typically in terms of probability above or below the median. The forecast you have in front of you suggests that there is a slightly below 50 per cent chance of getting rainfall higher than the median—or, if you like, a higher chance of getting rainfall below the median—across southern Australia over the next three months. That is typical of the sort of briefing we will give. The forecasts are statistically based. We are looking to move towards a more dynamic system. We look at those experimental forecasts but the actual official forecast that we do provide is statistically based.

I am now ready to respond to any questions on my opening remarks, the forecast material you have or the formal submission that we sent to the committee.

CHAIR—Thank you. I will ask the most obvious question for me as a lay person trying to understand a lot of what is very highly technical and scientific documentation. Reference has been made to the models that have been used to date and that they seem to have run their course. There is a lot of talk about new forms of interpreting the data. Can you address that? Can you tell us a little bit about the statistically based method of predictions and this new dynamic modelling system that you wish to move to?

Dr Coughlan—For any statistics you need a record of climatic data. Australia now has about 100 years of good quality records. The bureau has been going for 100 years—last year was our centenary. We have 100 years of good data on which we can characterise the climate of the past. By characterising the climate of the past and understanding again where you are now, you can go back into that record and extract similar occurrences of conditions like we have now. If one can find those similar conditions in the past, one can use that history of how the climate evolved from those conditions to forecast conditions.

The problem we are experiencing now is we are seeing a very unstable climatic regime or, to use the statistical term, non-stationary climate. Anybody who has done statistics knows that, if you have non-stationarity in your statistics, it introduces problems when using those statistics as a forecasting tool. That is the problem we are starting to face now. There are rather large trends in temperature and rather large trends in rainfall—in other words, we are experiencing climatic conditions that are not well represented in the past. That then compromises our statistically based forecast.

You will hear a lot more about those dynamical models in the presentations from CSIRO and CAWCR, because that is where the research is being done. So I would like, if possible, to defer any detailed discussion of those models to that presentation. Essentially, what the models attempt to do is to take the conditions as they are now and model them, using the equations of motion and all the physics and so on, and the understanding of the climate system, and use conditions as they are now as a basis to move into the future. In other words, it is not dependent upon having history tell you what is going into the future. It attempts to model the system forward on our understanding of how the climate system functions in a model and how it can use the current system, the situation now, to move forward.

We moved from a heuristic approach to weather forecasting—where you had an experienced weather forecaster on the bench who, through his knowledge of weather, was able to make forecasts into the future—to a model based system, which became much more reliable and more able to proceed much further into the future, so we see that as being the path for seasonal

forecasting. The models are more complex. They are not just models of the atmosphere, as they were when we starting doing weather forecasting. We have to use what is called a coupled system, which includes not only the atmosphere but also the ocean and also the land surface. You need those components to be able to proceed.

CHAIR—On that—I am thinking very much in terms of a layperson—is this awareness about modelling based more on the fact that we have a lot of new technology that can help us understand the complexities of the weather? When you talked about 'non-stationary', does that mean that the weather prior to that was far more predictable and stationary than it is today? How do you respond to this conversation that goes on about weather being 'always like this'—we have droughts, floods and all sorts of other things. I am asking you this because I have conversations with people every day about this. In fact, someone in Sunbury yesterday suggested that I ask the question, and I am doing it just to be funny—that forecasting is really telling us what we want to hear. It is not true, but I am just trying to convey certain lay thinking. Where are we with weather? Was it more predictable? Is it now less predictable and therefore requires new approaches, or is technology allowing us to read the complexity of weather forecasting in a way that it did not in the past.

Dr Keenan—I think that saying that weather is more or less predictable is a very difficult thing to quantify, and I think there are elements of the weather or climate system that are predictable. But what we are doing now is applying what I characterise as physically based models, and using these techniques has enabled us to gain more predictive skill. The reflection of people saying that weather is more predictable now or less predictable may be a realisation that the amount of information that we are providing through weather forecasts is far more comprehensive than it was in the past. So people tend to look at the information content in weather forecasts and think that we are concentrating more on extreme events, or maybe we did not have as many of these extreme events. But I think there is a recognition of the impact on society of weather—much more than in the past—and the scope of weather forecasting that is now underway is much more comprehensive than it was in the past. So people tend to think of these extreme events that maybe did not occur in the past and they make these judgments.

The important thing is that we are moving to these physically based models. They are extremely dependent upon the specification of the initial state for the outcome, but once the initial state is specified, with all sorts of uncertainty, you can actually develop a forecast.

This provides a much more comprehensive information set than is available through statistical relationships. Statistical relationships tend to be one-on-one connections, but with a physically based model you can actually have the full three-dimensional—and four-dimensional as well, with time—state of the relationships between the wind, the rain, the temperatures and so forth. You can customise much more readily from that the sort of information that is required for specific users. In a statistical relationship you may focus just on temperature or rainfall, but in these physically based models you can actually look at the soil moisture, the temperature, the winds, the rain, and have a much more comprehensive description. That enables a much larger product set or information source to be available, apart from improving the overall predictive skill that is obtained through these types of techniques. I hope that goes somewhere—

CHAIR—It does actually. I was thinking of the old-timers that read the sky and read things that maybe statistics do not pick up, and it begins to make sense—to me anyway.

FRAN BAILEY—Dr Coughlan, I appreciate the statistical method of forecasting and the more innovative, dynamic form of forecasting. It is my understanding that the UK and the USA are the leaders in the dynamic form of forecasting and that part of the reason why we are behind in that method of forecasting is that we lack the computers and the technology that deal with the speed that is required. Am I correct in that?

Dr Coughlan—Broadly that is the case. Remember, no matter where you are, whether you are in the US, Australia, Japan, Europe or the UK, it is still in the research domain. I am not aware of any forecast service which has at the present made that leap from a statistically based forecast to a dynamical model base. If you go into the websites of the UK Met Office or the European Centre for Medium-Range Weather Forecasts or NOAA, if you do see a model based forecast it will generally have a caveat on it saying: 'This is an experimental product. Be careful if you are using it in an operational situation.' If we are behind, we are not a great deal behind. Yes, doing seasonal forecasting with a dynamical model is a heavily computer based system, so if you have the biggest and the fastest computer in the world—which we tend to see in the US and in Europe—then your capacity to actually drive the models and do the experimentation is clearly going to be at a higher level than anything we have in Australia. But we are doing our best to catch up.

FRAN BAILEY—That is good. Is this new method, this newer, dynamic form of forecasting—which, if I understood Dr Keenan, is able to measure other aspects, like humidity and other aspects like that—a more reliable form of forecasting for severe events like bushfire?

Dr Keenan—I think the strategy is: if you want to make a robust statistical relationship with one element—and you can make quite good statistical forecasts for things like fire, but the important thing is, with the underlying changes that are occurring in the current state, the atmosphere, as Dr Coughlan stated, we have more uncertainty about the future application of those. So what we are trying to do here is have a physically based model which for fire weather can actually take into account or work towards taking into account not only the role of the oceans and the large-scale atmosphere but also the land surface processes and so forth, and incorporate those all into one framework, so that when it comes to forecasting the likelihood of conditions conducive to fire it is not only atmospheric conditions; it is the state of the vegetation, the fuel and all these sorts of things.

FRAN BAILEY—Yes.

Dr Keenan—And, through these physically based models, this is the avenue we see as being able to incorporate those sorts of processes into one framework which will enable us to undertake quite comprehensive forecasts, which would suit.

As for the specific question about extremes, at the moment we cannot quantify whether tropical cyclones are going to occur in a particular location at a particular time, but we can give the estimates of the general conditions which are conducive to tropical cyclones or extreme events through these types of models. So that is our strategy for enabling more information on extremes to be manifested—from the utilisation of these particular models.

FRAN BAILEY—If I could just have one more question—

CHAIR—Yes, one more question.

FRAN BAILEY—Sorry; I do not want to take up too much time. I am particularly interested in forecasting for bushfires. With those different parameters that you have mentioned, such as dryness, soil, fuel loads, are you working in conjunction with CSIRO? Is there partnership development where dynamic forecasting, along with CSIRO work, can give a more complete picture that is going to enable you to be more accurate, for example, in briefings to emergency services?

Dr Keenan—The briefings to emergency services and so forth are an aspect of the operational side of the bureau.

FRAN BAILEY—Yes, I understand that, but there is a need for a collaborative approach with CSIRO, because I am aware of some of the work that CSIRO are doing.

Dr Keenan—I am the deputy director of the Centre for Australian Weather and Climate Research, which is actually a collaborative venture between the Bureau of Meteorology and CSIRO. Among other things we are doing, we are undertaking the development of an earth system modelling approach. The very reason for doing that is to actually enhance the collaborations that you talk about, to take advantage of those. CSIRO will talk later about the land surface modelling and the expertise they have in fire activities to bring that collaboration within the centre so that we can actually build this earth system model much more effectively, building on their expertise. One particular item is the land surface model, which is one component of the earth system model—that is of particular relevance to you—and that is a component that CSIRO are working heavily on at the moment in building our future models. The important thing, for the seasonal forecasting and so forth, is that these components are part of that strategy that we have for the development of our seasonal modelling capability, and they will all feed into the system that we are undertaking development of at present.

FRAN BAILEY—Okay. Thank you.

Dr JENSEN—I have a couple of questions. Dr Coughlan, we were talking about the statistical and dynamic models and the fact that the dynamic models are not there yet in terms of superior climate predictions, if you will, in the medium term. But there is also some discussion in your submission about the loss of expertise, or the reduced expertise, in the statistical area. Is that because there has been a transfer of effort into the dynamic area or is it related to some of the instabilities in the climate system at the moment?

Dr Coughlan—David, would you like to have a go at that?

Dr Jones—I can. The major issue we have with the statistical forecasting systems is that they really look at the past to find analogues. An example that is probably fairly close to home with Fran Bailey and certainly with me, we being in Victoria, is if you look at droughts. The longest previous drought we have had was five years long in Victoria, and we are now on 13 years, so you can see that if you are running a statistical forecasting system to try to explain to the public when this drought might end then you are in uncharted waters. That is the kind of problem we are finding with the climate system generally: we are having increasing difficulty in finding analogues to situations that are now mapping out quite routinely.

With that in mind, there has been a push towards the dynamical side, physically modelling the world rather than looking at the past, because the world is changing. We knew in the past that most El Ninos were dry and most La Ninas were wet in Victoria. That has broken down over the last 10 to 15 years—most El Ninos are still dry but most La Ninas seem to be pretty close to normal if we are lucky—so you can see that this is the story with the statistical forecasting system. The world is changing and it is very difficult to find pasts that look like the present.

Dr JENSEN—That also brings in the issue of data records in initial states. Kevin Trenberth, one of the coordinating lead authors with the IPCC, has made the point that with their modelling none of the models have an initial state that is anywhere close to what is observed. You have pointed out that with dynamical modelling it is critical that you have a good initial state. There have been problems in the US with some of the data from some of their weather stations and the WMO sites which are located near air-conditioning outlets or in car parks and so on. What sort of confidence do we have in the Australian system? Michael, I know that I spoke to you about this earlier, but I think it is important to get this on record.

Dr Coughlan—We have many, many stations, as the bureau has been going for 100 years or so. We have relied on a broad range of different types of stations to collect our data. We have our own stations—about 35 major stations around the country. Clearly that is not enough to get a good characterisation of the climate across the country, but they provide a very strong benchmark for our data. In the past we have relied on cooperative observers—postmasters, police stations, teachers or farmers—to collect the data for us. Some of those records stop and start as we go backward and forward through time. Nevertheless, we have probably trawled through 10,000 or 11,000 different rainfall stations, and we have now come up with a set of rainfall statistics. We have been very carefully looking at them, looking at the history of the site, whether it has shifted and whether or not it has been contaminated by, as you said, a car park, a building or a tree; even a growing tree can contaminate a climatic record. We have been very carefully through a subset of our records to develop a set of, I believe, about 100 of what we would call major climatic stations which we believe fairly represent the broad-scale climate. They do not represent the building of cities, changing farming practices or what we would call non-climatic effects; they truly represent the climate. So we are now quite confident that the stations that we have to document what we call the climate record of Australia are well established, and of course we do everything in our power to maintain that climate record. We believe that is the sine qua non of any meteorological service. If you do not have a sound climatic record then it compromises a lot of what you do.

Dr JENSEN—How about the ocean record? Obviously temperatures, both atmospheric and of the ocean itself, are critical. This is something where obviously in the past it was somewhat problematic due to the fact that you would have a ship at a certain location where it would be taking data and the accuracy of the data might be questionable et cetera. Now, for instance, you have Argo buoys and satellites. To what extent has that improved both the accuracy of the data that you have in those oceanographic areas and, in effect, the resolution that you have in terms of the data blocks that you use?

Dr Coughlan—Certainly if the situation deteriorates over the land as you go back in time then over the oceans it does even more so. You mentioned the Argo buoys. Roughly over the last five to 10 years we have been seeding the oceans. Again there is standardisation. The instruments out there are very similar and you get a consistent record. Of course, that is what we

are doing in Australia with our automatic weather stations. We are now switching from having human observers to having automatic weather stations, which are all the same and all record to a set standard. That standardises and improves the record.

Going back to the oceans, you are right; ships had various ways of measuring the temperature. The traditional one was to throw a bucket over and take the temperature in the canvas bucket. Then there was a move towards measuring the water as it came into the ship. There are people who spend almost their whole lives working on those records trying to remove the anomalies from the system.

There is the increasing use of satellites. The satellite sensors over the oceans are quite good now. You have a roughly uniform surface. We believe that our ability to measure from satellites the patterns of temperature variation over the oceans is very good. We use the various ships, buoys and so on to lock that pattern of temperatures in. We believe our measurement at least of the surface temperature of the oceans now is better than it ever has been. We can push that record back now to the beginning of the satellite era—20 or 30 years.

Dr JENSEN—Would it be fair to say that, even if we had had the computer grunt and the background theory to drive the models, we would not have had the data in the past to have an effective dynamic modelling system anyway?

Dr Coughlan—As Tom indicated, if you do not have a good base data set to drive the models then the models do not know where to take the climate system. You can seed it if you like with the climactic state but then you are moving into a totally different problem. You are moving into the issues of running the climate out and trying to develop the climate over much longer timescales. You are really moving into projections of climate rather than into predictions, and I think we are about predictions here and not projections.

Mr SYMON—You mentioned that the bureau has 35 stations for data collection and that that is not enough and you rely on various community organisations to collect the rest. Is the data collected by the non-bureau stations of the same quality?

Dr Coughlan—The people in our own stations are fully trained observers. In the past we have had to rely on cooperative observing sites—and there have been several hundred going back over a good part of the record—for measuring accurately. Of course, they get some training in how to do that and how to maintain a stevenson screen and the instruments in it. We have had to rely on what one would call non-professional people. Nevertheless, the sort of data we are collecting from them has not been complicated. It is a matter of measuring the temperature, the humidity and the wind and reading a barometer. It is fairly basic instrumentation. You would get a measurement once a day in some cases and up to half a dozen or eight times a day for full observations every three hours.

The move now is away from the human observer and, as I mentioned earlier, towards the automatic weather station. In other words, all we need now is a place to put the instrumentation. It is telemetered automatically into the bureau. We are then able, of course, to get measurements not every three hours but measurements as frequently as we like. We can even go down to one minute; we can be recording the wind, the temperature and the pressure every minute or every

six minutes or whatever period we want. The move towards automation is really the way to go. We get much better, consistent and reliable data.

Mr SYMON—Is that automation replacing your cooperative centres or does it actually replace some of your manned centres as well?

Dr Coughlan—Mostly replacing the cooperative observers. We are fairly static in terms of our major observing stations. We have been at this number—you have the wrong people at the table to give you the exact numbers on that but we can certainly take it on notice if you want any particular statistics.

Mr SYMON—No, that is fine; I am just going by your numbers.

Dr Coughlan—For our major observing sites that we operate ourselves with radars and balloons that we use to sound the atmosphere, the numbers are very close to static. Most of the automation is now going into replacing the cooperative observers.

Mr SYMON—On a slightly different topic: there was an announcement in the budget from Minister Garrett for some funding. I do not fully understand how it flows through; I have only read briefly what it is. There was something regarding GFE. Is that something that is of use to the bureau? Is that something you have been pushing for?

Dr Coughlan—You are moving into the shorter time, into the weather forecasting area. You do not have the right people at the table here but if you want to take the discussion outside the brief we can get people into the room who can address it. GFE stands for graphical forecast editor, but I think we are now starting to use the term 'new generation weather forecasting system'. That is essentially what was referred to in the budget. We have had a trial running in Victoria for the last year or so and we are now ready and confident to roll that trial out to the rest of the country.

Mr SYMON—One last question: do you think that will have a knock-on improvement in your seasonal forecasting—if you have a better short-term system?

Dr Coughlan—There is not a direct connection at the moment. Essentially the graphical forecast editor is a way of producing short-term weather forecasts. I would be only speculating at the moment that as we start to produce seasonal forecasts, which are also model based—weather forecasts are model based—then we will be able to draw on some of the experience and capabilities that we are using to improve our weather forecasting and apply those to improving the way in which we distribute our seasonal forecasting. So instead of providing a seasonal forecast for a general area of south-eastern Victoria we would be able to use some similar system to provide a seasonal forecast for Warrnambool, Whyalla or wherever.

CHAIR—Mike has raised a couple of issues that we can pick up again later in our conversation. I would like to raise those with you also.

Mr RAMSEY—Thank you very much for your presentation, Michael and Tom. I would just like to focus a bit on the SOI and the mechanisms for its predictions of where we go. We have just gone through a period of a high SOI, which is an El Nino condition, and you said it really

has not delivered rainfall for south-eastern Australia, and that is quite right. Do we know why? We know the links are not constant, but what is the complicating factor that means we probably do not have the ability to say, 'Yes, we're going to have El Nino; it will deliver rainfall or it won't deliver rainfall'? Do we know that?

Dr Jones—El Nino is essentially an oscillation or a variability in our climate system, and, of course, there are a lot of other things going on. One of the clearest things that we have got in southern Australia at the moment is a tendency towards increasing pressures, so it is putting in place essentially a background drying trend on which the El Nino-La Nina operates. If you look at the last 10 to 15 years, the El Ninos have been, almost without fail, drought years, while La Ninas have tended to be average or maybe a little bit above or below average. So there is still this pattern of wetter and drier conditions during the El Ninos and La Ninas but an apparent background drying which is now coming into play. We do not know whether that background drying is climate change or a very slow climate variability. The fact is it is probably both. The old rules are still working, but the averages against which they operate are changing as the climate changes.

Mr RAMSEY—In a physical sense, what actually increases that pressure? Is it more sunshine somewhere? Do we know that or not?

Dr Jones—It is part of a fairly close to global pattern, so what we are seeing across the whole of the subtropics, both in the Northern Hemisphere and the Southern Hemisphere, is increasing pressures—and decreasing pressures in polar latitudes. Essentially what it is setting in place is a contraction of the westerly rainfall belt towards the poles. That is evident in both hemispheres. We get a pattern like that operating on both variability timescales and climate change timescales. What is actually the root cause of this pattern of change is still very much a research issue, but it would appear to be a mix of climate variability and climate change coming into play here.

Mr RAMSEY—If this committee were given the wonderful power of being able to double your budget overnight—and maybe some other things as well—would that really hasten the unlocking of your understanding of those issues or are we bounded by the maximum road of human discovery anyhow in any given region? Are we reaching some kind of blocking here that is saying we cannot advance this science more quickly, or are we going about as quickly as we can?

Dr Coughlan—Tom or Oscar, would you like to answer? Limits of predictability—are we there yet?

Dr Alves—To be fair, I think we do not know what the limits of predictability are at present. We do know that our models that we use have a lot of deficiencies—not just the models we use here in Australia but the models we use internationally. For example, they all have El Ninos but they all have different types of El Ninos. Each model generates an El Nino in a slightly different way. Some recent research has suggested that maybe the flavour of El Nino, the type of El Nino, is important for Australian climate. The models that we use as an example are the same models that we use for weather forecasting and for climate change projections. They have received a lot of attention, particularly for mid-latitude weather, for weather forecasting, because that is really what, in Europe and in Australia, a lot of the development has focused on. Where perhaps they have their weaknesses is in the simulation of the tropical processes, like what is happening in the

Pacific, the El Nino in the Indian Ocean, the Indian Ocean Dipole. In summary, I think it is fair to say that we do know there are a lot of problems with the models. We know there are some things we can do to tackle them. There are some issues we know are very difficult to solve but I think we certainly can make progress. I often say that dynamical seasonal forecasting is a little bit like weather forecasting in the seventies. We are at that stage where we are just beginning to start off and there is potential to make a lot more progress.

Dr Keenan—If I could just add something there. It is a multifaceted problem, as I see it. It is understanding predictive skill—that is one component of it. It is developing models, and that means infrastructure in terms of computers, and also utilisation of observations—how to bring those into the model and utilise them effectively to improve predictive skill, as well as to improve the model representation of the physical processes. So there are a whole range of issues that come into trying to realise the sort of information that you are after. Oscar is right; it is like weather forecasting. And how did weather forecasting improve? It improved by investments in the infrastructure of the science, all combined, observing techniques and so forth. So all those components make up the road map to providing increased predictive skill, I think, of the sort that you are after. It is not just one thing.

CHAIR—Is that it, Rowan?

Mr RAMSEY—I could ask a heap more, but—

CHAIR—We will get another opportunity a bit later. I think Fran really wants to ask a quick question.

FRAN BAILEY—Yes, just a quick question about technology and innovation. We have heard about the computers and, given that your work largely depends on the gathering of data and its processing and interpretation, I am just wondering if there is anything new in the satellite technology and where Australia is placed in that regard.

Dr Alves—In terms of seasonal prediction, the main importance is observation of the oceans, particularly the tropical oceans. Probably the biggest revolution recently has been Argo, as Dr Jensen mentioned. That has been quite big revolution. That has enabled us, for the first time, to measure ocean salinity. We have not been able to do that before. Satellites provide information, and there are different types of satellites. Sea surface temperature has been provided for quite a few decades now and, since the early nineties, satellite altimeters have measured the elevation of the sea surface. Some centres use that in their forecast systems; we do not. It is something that we hope to do in the future. More recently, there is some new technology that enables satellites to measure the ocean surface salinity. The accuracy at this point in time is probably not good enough for us to use that, but we are hoping that in the next decade or so the accuracy will be good enough that it becomes a routine operational product that we can use to initialise our models. So those are some of the new developments in satellite observing systems for the ocean.

Dr Coughlan—If I could just add to that. One of the important consequences of international meteorology has been the fact that all the data, virtually no matter who collects it, is freely available. So, while Australia does not have satellites up there, all the satellite data is—

CHAIR—We borrow from others, yes.

Dr Coughlan—We can access the same data that is pretty well available to any meteorological service around the world. So, from that point of view, we are not hampered in our access to data, even if we are not responsible for generating it in the first case.

Dr JENSEN—Just one very quick question on the international data—how do you go about checking its accuracy?

Dr Coughlan—It depends on the question that you are asking. For example, just as we in Australia, in the Bureau of Meteorology, have been looking very carefully at climate variability over time, as I said, and extracting a subset of data from what we believe are the best available sets of data to monitor climate, so too are our counterparts in the National Oceanic and Atmospheric Administration in the US and the UK meteorological service. All these similar people are extracting a subset of data about which, in all honesty, they can put their hand on their heart and say, 'This is the best set of data that we think characterises the climate,' over Australia or the UK or Europe—

Dr JENSEN—I am just thinking of some place like Africa or South America—

Dr Coughlan—Africa is difficult, but there are programs in place. We can perhaps mention the South Pacific. Small meteorological services in the South Pacific have got climatic records, but a lot of those climatic records are on paper, not in computer compatible form. But through our interactions with AusAID and now the Department of Climate Change we have programs in place to extract all that data, or to help the countries extract the data, go through it and do the same sorts of quality control checks on them that we have done on our own data. So, over the next five to 10 years, we hope we will be able to put in place as good a record for the islands of the South Pacific as is entirely possible with the data that is available.

CHAIR—Because we are actually assisting in the process, so that is the safety net. We are involved in that. Thank you very much.

[10.25 am]

ALVES, Dr Jose Oscar dos Santos, Leader of Seasonal Prediction and Climate Variability Group, Centre for Australian Weather and Climate Research, Commonwealth Scientific and Industrial Research Organisation

CLEUGH, Dr Helen, Theme Leader, Climate and Atmosphere, Commonwealth Scientific and Industrial Research Organisation

HOWDEN, Dr Mark, Theme Leader, Adaptive Primary Industries and Enterprises, Climate Adaptation Flagship, Commonwealth Scientific and Industrial Research Organisation

McINTOSH, Dr Peter Christopher, Principal Research Scientist, Commonwealth Scientific and Industrial Research Organisation

WHETTON, Dr Penelope Helen, Leader, Climate Change Research Group, Commonwealth Scientific and Industrial Research Organisation

CHAIR—Welcome. Is there anything you would like to add to the capacity in which you appear today?

Dr McIntosh—Yes, I am also the principal research scientist with CAWCR.

Dr Alves—While I am the leader of the seasonal prediction group within the Centre for Australian Weather and Climate Research, I am actually a bureau employee.

CHAIR—Although the committee does not require you to give evidence under oath, I should advise you that these hearings are formal proceedings of the parliament. Consequently, they warrant the same respect as proceedings of the House itself. It is customary to remind witnesses that giving false or misleading evidence is a serious matter that may be regarded as a contempt of parliament. We thank you for your submission, and we now welcome you to make a brief opening statement before we proceed to questions.

Dr Cleugh—We have decided that the opening remarks made by Dr Coughlan from the Bureau of Meteorology will suffice. We are quite keen to get into the questions, so we will pass on the opportunity for an introductory statement, unless you really require it from us, and move straight into the questions.

CHAIR—Thank you. That being the case, we will take off from where we left off a few minutes ago.

FRAN BAILEY—I would invite any or all of you to comment. The whole concept of research is fantastic, but I am particularly interested in the practical applications of that research and how industry in particular could make use of the innovative research. I am also interested in how that research could be used to better inform and equip a lot of our emergency response

organisations in Australia. I am giving you a very wide question, and I invite any or all of you to respond.

Dr Cleugh—I will respond to begin with, and then I will direct that question to some of my colleagues, who will have some responses as well. From my perspective, there two key ways that I want to highlight for CSIRO. The first goes to your second point about supporting emergency management. The relationship, the partnership between CSIRO and the Bureau of Meteorology through CAWCR—the Centre for Australian Weather and Climate Research—is one of the drivers. We are a research agency. By working closely with an operational agency—that is, the bureau through CAWCR—that is one of the ways that we can ensure that our research is delivered to our clients and stakeholders and the community that needs it.

FRAN BAILEY—Could you give me some examples of the sort of research that would be applicable to emergency service organisations?

Dr Cleugh—One of the key people who could answer that is sitting behind me. I will see if Oscar from the bureau, whom you have already heard from, has a particular example that he could give to you.

Dr Alves—Could you repeat the question?

FRAN BAILEY—The type of collaborative research that you are engaged in, what are the practical applications of that for emergency service organisations?

Dr Alves—The bulk of our research on seasonal prediction in CAWCR is focused on a forecast system for bureau operations. Even though it is a merger between the bureau and the CSIRO, the research focus mostly is to try to develop better forecast systems to eventually provide the bureau with increased operational capacity to be able to deliver real-time forecasts for different applications.

Dr Cleugh—For example, the seasonal prediction capability that Dr Alves leads is the sort of underpinning research that the climate group that Dr Coughlan—that you heard about in the earlier session—would use to deliver, for example, briefings to the emergency management authorities around what the seasonal outlook might look like for, say, bushfires.

FRAN BAILEY—Could I drill down a little bit further here. Would your research include, for example, rates of humidity and their effect over a period of time? I am obviously thinking in terms of bushfire and rates of humidity, rates of wind, change of direction of wind, and elements like that. I am aware that a number of agricultural organisations will use your research, but I am interested if the sort of work you are doing is being picked up by emergency service organisations—and actually if the work that you are doing has a practical application for emergency service organisations.

Dr Cleugh—Some of those aspects that you are referring to—humidity, wind changes—are aspects of much more short-term weather forecasting than was in the scope of this inquiry, for which the focus was long-term meteorological prediction. That said, I would like to ask Dr McIntosh or Dr Howden—who is on the telephone—whether there are some examples from the

work that they are doing with the Climate Adaptation Flagship that may help answer that question.

Dr McIntosh—In terms of the bushfire question, some work that I did a few years ago was looking at forecasting plant growth. That points towards the sort of fuel load that you might expect. Seasonal forecasts of rainfall also help towards how wet or dry that fuel load might be. So I can see some applications there. I am not sure the extent to which that information is currently used, but certainly in the future I think forecasts of plant growth and rainfall will be most useful.

FRAN BAILEY—In your collection of data that you use in long-term forecasting, would the rate of humidity, for example, be one of the variables that you would include in your data?

Dr McIntosh—The models carry humidity as one of the variables that they predict, both on short timescales and long timescales. We have not really looked at using long-term predictions of humidity. I think that could probably be done. We have looked at using long-term predictions of temperature. For example, in the lettuce industry they need to know about temperature in the future to decide what varieties they might plant. I can imagine that humidity could be used in a similar way but perhaps the fuel load for fires.

Dr Cleugh—Building on a comment that came in the earlier session, you will have heard that CSIRO and the bureau together are working towards building a new earth system model capability, which is a climate and a system. That includes the land surface and the atmosphere. Our vision would be that when that is fully functioning we would have much better predictive capability of the state of the land surface out into the future to support that sort of predictive capability. That is a modelling capability that we are developing as a research enterprise—

FRAN BAILEY—How far away are you from achieving that?

Dr Cleugh—The vision for access is what we call ‘seamless prediction’—everything from weather prediction ultimately through the seasonal timescales and then out to the climate projection timescales. How far are we towards achieving that? We already have a research version of access delivering weather forecasts. The experts in that field are not here right at the moment, our focus being on seasonal. If you wish, Oscar could talk about the timeframe for the dynamic seasonal predictive capability within that access framework, but we are making very good progress. The information is in our submission.

Dr Alves—I think there is some uncertainty about the time line for the full access system for seasonal prediction. At the moment, the time line will be roughly five to 10 years. That is our present plan with the current resources that we have. There is some uncertainty in how fast we can progress that into the future. Partly that is because a lot of the work that we do depends both on internal funding and on external partnerships with different organisations, and it is very difficult to know how many external partnerships we are going to be able to develop in the next few years. That is why I have given quite a wide—five to 10 year—time scale for a full access system.

FRAN BAILEY—I will let some of my other colleagues ask some questions. If we have time, I will come back and ask a few more.

CHAIR—I have here a document before the committee, 'A Critical Review of Some Recent Australian Regional Climate Reports', by John McLean. It suggests that any real discussion of climate factors other than temperature and rainfall was omitted. Can you comment on the influence of onshore winds, continental winds and clouds on climate, please.

Dr Cleugh—I would like to know a little bit more about what you would like me to comment on. Certainly onshore winds do affect the climate. Cloudiness affects the climate. But I am just not quite sure I—

CHAIR—Are you familiar with the paper?

Dr Cleugh—No, I am not.

CHAIR—Is anyone else familiar with the paper?

Dr McIntosh—I can say perhaps a little bit. The models that we use carry winds as one of the variables as well as temperature, humidity and rainfall—as a diagnostic variable that you get out at the end—so the models do predict the winds into the future. Onshore winds can bring rainfall if you get uplift over topography, so that is quite important for the east coast, for example. The models do take those into account. The models also have clouds, so the models take those into account as well.

Dr Cleugh—I will follow that up to say that, if your question is around our ability to predict those sorts of interactions, we certainly do have in CSIRO a range of model systems that can simulate those sorts of processes—onshore winds at a very fine scale, their impact on local temperatures and humidity, and so on. We do have those modelling tools.

CHAIR—Okay.

Mr RAMSEY—This comes back to some of the questions I was asking the Bureau of Meteorology before about our predictive capability for ocean currents and ocean temperatures. Are we limited at all in our ability to predict those currents by a lack of investment by neighbouring countries around the Indian Ocean rim or the Pacific Rim, understanding that a lot of your information now comes from satellites and whatever? Is that a limiting factor at all, or can we just circumnavigate that?

Dr Cleugh—Peter, would you like to answer that?

Dr McIntosh—The satellite observations are pretty good. The coverage is pretty good. The sea surface temperature satellite observations are available from about 1980 onwards, so that gives us a good 30-year period to test our models. The altimeter observations, which give you an idea of the heat content below the surface—so not just surface temperature—are available from about 1991. The Argo floats, which are robotic floats that sink down to 1½ to two kilometres and measure temperature and salinity—there are about 3,000 of those throughout the world's oceans; that is an amazing network—have been available for the last five or six years. Australia contributes to some of those, but we also rely heavily on other countries to seed them into the waters, even waters that you might consider are our responsibility, if you like. The TOGA-TAO network, which is a set of buoys moored along the equator in the Pacific, has been around since

about 1990, I think. That sends data back in real time about El Nino, so it is a way of us knowing exactly what is going on. We would love to have a similar array in the Indian Ocean, and I think a couple of the moorings are out there. That would be a wonderful opportunity to contribute to something that would be very important for us, because we are starting to understand that the Indian Ocean could be just as important, particularly for south-east Australia, as the Pacific Ocean is.

Mr RAMSEY—My next question is on our comparative understanding of the southern oscillation index and the Indian Ocean dipole. We are behind, obviously. How far behind are we in understanding those two oceans?

Dr McIntosh—It is certainly true that a lot more effort has been put into understanding the Pacific Ocean, because it has the biggest impact on global climate, but in the last 10 years, maybe, people have been beginning to understand that the Indian Ocean is important in its own right but it also acts together with the Pacific Ocean. When the two act together, you can get a very strong effect in Australia. When the two oppose each other, you can get parts of Australia wet and parts of Australia dry, which is a possibility for this year. This year we could have the Indian Ocean making us wet and the Pacific Ocean making us dry. Trying to understand where those two effects matter regionally in Australia is quite important. We do not understand the Indian Ocean as well yet. We do not understand some of the dynamical mechanisms of how the Indian Ocean affects us, but there is a lot of research happening right at the moment that is starting to unravel that.

Mr RAMSEY—Just on the Indian Ocean again, you say there is a possibility that this year there may be warming on the North West Shelf—or is it cooling?

Dr McIntosh—Warming—that is correct.

Mr RAMSEY—How long is it since we have had a condition of warming there—conditions in the Indian Ocean that would, at least in theory, drive a wetter period in Australia?

Dr McIntosh—A long time—not this century. I think 1998 or 1999 would have been about the last time. Some research that I have been involved in recently established a linkage between the fact that these negative Indian Ocean Dipole events have just not been there for the last decade and long-term drought over south-east Australia.

Mr RAMSEY—That is what I was reading recently, yes. Do we have enough history on the Indian Ocean to know whether that has occurred before for that length of the period, or is it just an unknown science because we have not had the reporting procedure in the past?

Dr McIntosh—We can go back to about 1900 and say that the Federation drought and the World War II drought and the current big dry all seem to be related to the fact that the negative phase of the Indian Ocean Dipole did not occur for a long period of time or occurred very infrequently. The ocean temperatures going back to the 1900s are not as certain as more recently, as was discussed earlier. The measurements were probably based on buckets of water drawn on board ships. But nonetheless there is some information there, enough that we think we understand that the Indian Ocean Dipole is really quite important for us.

Mr SYMON—I was quite interested in the ACCESS system that was mentioned before and how it is actually going to impact on seasonal forecasting, how it is going to, hopefully, make it even higher in the range of skill. As it is adapted from the UK model, are there any differences that need to be taken into account for Australia's specific circumstances compared to the work has already been done from the UK end?

Dr Cleugh—I should point out that the ACCESS model has a dynamical core that is the part that we have taken from the UK Met Office. There are other components. The land surface model, for example, is an Australian developed component, so it is not all borrowed from international sources. I would like to ask Dr Alves to address the comment about whether ACCESS is adequately representing the important drivers for Australia's climate, which I think is the essence of your question.

Dr Alves—ACCESS is an earth system model that will span the range from weather forecasting to seasonal prediction. The atmospheric component is taken from the UK. The ocean component is actually taken from the USA, from Geophysical Fluid Dynamics Laboratory in the USA. The ice component is taken from the Los Alamos laboratory in the USA. There are some Australian components. Land surface is being developed in Australia and is quite specific to Australian land surface properties. Also, the technique for using the ocean observations to initialise seasonal forecasts is being developed in Australia. So it is a bit of a combination of different components. Within ACCESS we have decided to keep the bits where we think we are leading and take from other countries the bits where we feel that they are ahead.

In terms of the atmospheric model which we have taken from the UK, part of the collaboration with the UK was under the assumption that we in Australia would contribute to that collaboration through working on the bits that are important for Australian climate but also other countries depend upon. Particularly, the UK felt that our speciality was in processes like El Nino and the Indian Ocean Dipole, and there are other processes on shorter time scales—there is something called the Madden Julian Oscillation, which you may have heard of—and it was felt that that is where we could contribute from a seasonal forecasting perspective. On other aspects of climate, the Southern Ocean is also an area where it was felt that we had a speciality. So part of that partnership, which is not so much just taking their model but entering into a partnership with the UK Met Office, is that we will use their infrastructure but at the same time contribute to parts of that system which are important for us and which they will also benefit from and, in turn, we will benefit from their contribution. In summary, things like El Nino, the Indian Ocean Dipole and the Southern Ocean are where we feel in Australia we would be contributing to the development of that part of the model which we took from the UK. It is part of that partnership.

Mr SYMON—Going on from there, an interesting point with ACCESS, I read in your submission, is the environmental prediction for air quality and renewable energy resources. I take it you are referring, in terms of renewable energy resources, to areas most likely to be or possibly able to be used for tidal power. I am also interested in air quality predictions as well. In Melbourne, where we are today, we have certain weather patterns that cause a bit of havoc with air quality.

Dr Cleugh—To answer the question of renewable energy, we are already using weather and climate models—we may as well refer to them as weather models—to enable us to forecast, for example, the wind, which is one of the furthest developed of our renewable energy resources in

Australia. So we are already developing that capability for forecasting wind for renewable energy applications. Solar is another one, as well as tidal. The forecasting of wind is probably the most mature in terms of the renewable energy technologies and our ability to forecast that. That is an active area of research going on in CSIRO with our partners now. Solar is the same. And we are scoping the areas in terms of oceans—tidal and wave.

To go back to the ACCESS question, we envisage ACCESS ultimately as a model system or a platform to enable us to do the simulations for a variety of applications. Predicting the weather is the first one. Seasonal climate forecasting is another one. Long-term climate projections is another. And environmental predictions such as air quality and renewable energy are other examples that we would want ACCESS to be the platform for delivering. On your question on air quality forecasting, between CSIRO and the Bureau of Meteorology we already have an air quality forecasting system delivering those sorts of forecasts. Part of our scoping for what ACCESS will deliver into the future is potentially including that capability within the ACCESS system. So we already have it and we would hope that through ACCESS we could continue to deliver that sort of environmental forecasting into the future.

Mr SYMON—Thank you.

Dr JENSEN—I have a question on dynamical models. Obviously you would have done a sensitivity analysis. What inputs create the greatest variability in terms of model results and therefore are most problematic as far as your seasonal predictions are concerned?

Dr Alves—In a dynamical seasonal prediction system there are two components. One is the model which projects information to the future and the other one is the system which takes observations and converts those into the initial set for the model. From our past experience, probably the No. 1 area where we feel there are deficiencies is in the simulation of tropical processes in the atmosphere. Probably No. 2 is in the techniques that we use to ingest observations and convert those into an estimate of the state of the ocean atmosphere. That is because the ocean, particularly if we go back in time, was quite sparse, pre Argo, and therefore the techniques we need to use have to be quite sophisticated to get as much information from as little data as possible.

Our past experiences investing are (1) improving the atmospheric model for tropical processes and (2) improving the way we initialise those models. Probably (3) and (4) would be improving the simulation of the ocean and the land surface processes. At the moment, we are perhaps dominated by problems in the atmospherics of simulation that get some of the tropical phenomena not quite right. Once we have solved that, we will go to the next stage, which would be things like the land surface and what is happening more locally. We are still not really able to simulate El Nino properly. This is a common deficiency in most models. They do have an El Nino, but its properties are not quite right. The warming in the ocean is not in the right place. That is still the No. 1 problem. Because El Nino and the Indian Ocean are the main drivers of climate, if you do not get that right the rest is difficult to get right. Those are still the main issues. We have to get the tropical variability right. Once you have got that right, you can start looking more at how those impact on your regional climate. You can start looking regionally at how the different synoptic systems are impacted by El Nino. At the present point in time, it is about getting those large scale—

Dr JENSEN—In terms of those long-scale processes, what about the effects of Pacific decadal and Atlantic multidecadal oscillations? Do they have much effect on Australian climate or medium-range forecasts?

Dr Alves—At present it is not clear whether those, particularly the Pacific decadal oscillation, are true oscillations or just reflections of what is happening in the ocean. Sometimes you get several El Nino events in a short period of time; sometimes you do not have them. It is not clear whether it is a natural modal variability or whether it is just looking at the past and seeing an oscillation that is there by random chance. On the nominal systems, in a sense it does not really matter. When you produce a nominal forecast they initialise with the latest state of the full ocean and atmosphere, so everything is built into that initial condition.

Dr JENSEN—On the specific observations you make—on things like wind, humidity, temperature—in terms of the sensitivity of analysis you may have done with each of those inputs where, let's say, you hold everything constant and you just change one of the variables, which one seems to be most problematic? In other words, which one of those factors is most important to making sure that our observational data is spot on?

Dr Alves—There has been limited research to look at the impact of different observing systems. There has been some research looking at different impacts of the ocean observing system on seasonal forecasting, particularly on the forecasting of El Nino—not directly on local climate. It has shown that the most critical observing system has been the TOGA-TAO array in the tropical Pacific. There have been some recent studies looking at Argo that have shown that that has had quite a significant impact as well. Probably next in line would be altimeter data.

Dr JENSEN—With altimeter are you talking about the altitude as such or are you talking about the temperature to altitude relationship?

Dr Alves—The altimeter measures just the surface elevation of the ocean.

Dr JENSEN—Okay. You are talking about things like Topex and Poseidon and so on.

Dr Alves—That is what measures. The temperature is ostensibly derived from that. There are different ways of doing that.

CHAIR—Do you want to add to that?

Dr McIntosh—Just to clarify: Dr Alves essentially said most of the things I wanted to say, but the important thing is the subsurface ocean temperature. We have measured the surface ocean temperature with satellite since 1980. It is much harder to measure below the surface. The ways we do that are altimeter, which gives us a vertically summed up version—because the warmer the water is the higher the sea level is. Salinity has an effect there too, but it is mostly temperature. Altimeter gives us some information about that. The Argo floats are fantastic, because they profile up and down.

Dr JENSEN—Yes, 2,000 metres.

Dr McIntosh—The ocean controls the longer time scale of the whole climate system. If we had a dry planet then the weather would vary on time scales of one to two weeks and there would essentially be no predictability beyond that. Because it has such a high heat capacity compared to the atmosphere, the ocean controls the long time scale. So, if we can understand the heat content of the ocean patches that are warm and those that are cold below the surface, it helps because they eventually come to the surface and have an effect on the atmosphere. That is the whole basis of seasonal forecasting: knowing that the ocean controls the long time scale and knowing something about the subsurface temperatures of the ocean. The Pacific in particular, with the TOGA-TAO Array, has been well observed for a while now, and that really helps us to know something about whether we are about to have an El Nino or a La Nina. With the Indian Ocean we have just started to get some subsurface data in the last few years, and that is really helping as well. Subsurface data is crucial.

Dr JENSEN—Yes. Argo is seeded planet wide, so I guess you are now getting some good readings from the Indian Ocean from that network.

Dr McIntosh—That is right. The floats are quite well spaced, though—I think five degrees, or 500 kilometres.

Dr JENSEN—There are only about 3,300 out there.

Dr McIntosh—That is right.

Dr JENSEN—This is my last question in this section. We have been talking about the changeover from statistical to dynamical modelling of weather and seasonal forecasting. I know that this gets somewhat into what you were talking about, Dr Alves. What factors are the major limitation in dynamical models at the moment? It seems we are at a strange place where the predictions with statistical models are falling off because of factors that we discussed earlier on, yet we are still not at the place where the dynamical models can actually take over and have been validated to be better than the statistical models.

Dr Alves—That is true. I discussed earlier some of the deficiencies in the numerical models. At the present point in time, one of the issues with numerical models is that they are complex. They forecast the whole state of the ocean and atmosphere everywhere. We also use ensembles, so we do not just do one forecast; we might do 30 forecasts to get a measure of uncertainty. At this point in time, some characteristics of those models are actually better than the statistical system. For example, suppose we are forecasting south-eastern Australia's spring rainfall and we are trying to forecast the probability of above median rainfall. Forecasts will be more accurate more of the time than with a statistical system. They might be accurate approximately 70 per cent of the time, whereas with a statistical system it might only be 60 per cent of the time. But, because it is a much more sophisticated product with these ensembles, some of the characteristics of that are holding us back from making that an operational product.

One of those characteristics is what we call the reliability, which means that the present forecasts are too emphatic. What that means is that the ensembles all tend to go one way or the other. Even though they are more often right than wrong, there are times when they all go one way and are wrong. It is that characteristic of the forecasts which is stopping the National Climate Centre from replacing its statistical system. As an example, if you look at the forecasts

of the probability of above median rainfall then you see that the dynamical model might show a 90 per cent probability of above average or below average rainfall, but you do not really feel confident with that. You know that maybe 70 per cent of the time it is going to be right, but 30 per cent of the time it is going to be wrong. If it says it is 90 per cent certain, you can go back in your past records from your model and say that it is really too sure of itself. That is probably the No. 1 thing which is stopping the National Climate Centre from adopting dynamical models even though, in terms of other scale measures, they are better.

Part of that is because the statistical system in a way is much simpler. It has been designed to forecast one specific thing, and you can get it right for that one specific thing. The dynamical model is much more complex, and you have all the information. You have to then work on that product. Because of its complexity, it is easy to get characteristics in there which you do not feel happy with. Part of our solution is to try and understand why all those ensembles go one way or the other. Maybe in the short term we will have some more pragmatic solution to that; in the longer term we are trying to understand the real physical problems that cause the models to behave in that way. We are hoping that in the short term we can address some of that—for example, by combining the statistical model with the dynamical model as a short-term measure.

CHAIR—I was going to ask you about that. Just listening to you speak, it seems to me that you are obviously on the cusp of moving from one way of doing things to another which you are not quite certain about yet, so you are kind of in this zone. Is there any prospect for combining the two? What happens to the statistical approach once the dynamic approach is deemed to be not only comfortable but fairly good at doing what it needs to do? What do you do with whatever experience and the processes of what is called the statistical part?

Dr Alves—That has been an active area of research as part of the south-east Australia climate initiative. We have been looking at whether we can add value to the dynamical model by adding statistics or some kind of statistical relationship on top of the dynamical model. We have had some mixed results. You would think that by adding extra statistical information you would produce a better forecast, naturally. But the problem is that, because the observing system degrades as you go back in time, we can only go back about 25 or maybe 30 years and produce hindcasts. That only gives you a short period over which you can deduce that extra statistical relationship, whereas, with a purely statistical model, you can go back maybe 100 years. The end product of that is that there was no conclusion as to the added value of trying to add sophisticated statistics on top of the dynamical model. You might as well, particularly for the current model, take the rainfall directly from the model. That was looking at skill. There may be some benefit from this reliability problem in trying to combine it in a simple way with the current statistical system, and that is something we would like to investigate in the future as a short-term solution to this reliability problem.

Dr JENSEN—I am not sure if this was in your submission or the Bureau of Meteorology's, but possibly you can deal with it as well, and that was basically an improvement to productivity of farmers through having these medium-range seasonal forecasts. How do we arrive at that? If I am a farmer and you are predicting that I am not going to have a good year as far as rainfall is concerned, do I as a farmer take the risk of not actually sowing my crop based on your prediction? And if you are wrong, it means that I have wasted what could be a very good year in terms of crop yields. So at what stage do you have a situation where farmers are going to say, 'Okay, I have a lot of confidence in this and I will decide not to sow my crop'? Statistically, if

you took it over the whole, obviously you would improve productivity if you had the situation where all of the farmers were responding on your model as a whole. The problem is that for an individual farmer it is a huge risk to take. How do we capitalise on the fact that you can provide information that is valuable, but on an individual basis it is too big a risk for a farmer to take?

Dr McIntosh—The work that we have done with farmers is in telling them that the information we are giving them is of this quality—maybe it is 60 to 40, maybe it is 70 to 30—but that the information has to be part of an overall risk management system. They cannot take just that information and just decide to either plant or not plant on the basis of that forecast. They might plant less area or they might delay planting or, if it was a dry year, they might plant a different variety that matures earlier—those sorts of decisions. They might decide to put less fertiliser on at the start, if the forecast was bad, and delay it to top dressing and wait to see if they got rainfall. There is a number of ways you can use the forecast information that is not black and white. The pay-off is in the long run. In any one year a forecast could be wrong and a farmer could come unstuck. That is why I think they should not follow the forecast only; they have to take a whole bunch of other things into consideration and just make slight changes based on the forecast. As the forecast gets more reliable, I think that firstly more farmers will follow the forecast and they might make bigger decisions based on those forecasts. So I think they have to tailor their management response to the quality of the forecast, and that is where we have to give them adequate guidance.

Dr JENSEN—Is there evidence that the farmers are actually doing this at the moment—taking these seasonal forecasts into consideration with their strategies in terms of planting crops and so on?

Dr McIntosh—Certainly the farmers I work with up in the Mallee-Wimmera region look at all the information they can get hold of on the web. They look at POAMA, our seasonal forecast model; the Japanese one, SINTEX; and the ECMWF, which is probably the most skilful model. They look at all the information they can get and they make a risk management decision based on all that information. The other thing that is important is that researchers go and talk to the farmers, interact with them. There are two benefits to that. Firstly, they start to understand how good, or otherwise, the models are. There was a good example this year. The Japanese SINTEX model has predicted a positive IOD for the last three years. It got it right three years in a row, and that is a really unusual phenomenon. The Japanese model is predicting a negative IOD for this year, which I really hope happens. If we examine the skill of the SINTEX model at predicting the IOD over as long a time as we can, which is 30 years, we find that it is no better than some of the other models. It is no better than our own model, POAMA. So it is important to tell the farmers: 'Don't follow this model slavishly just because it's got three in a row right. It's no better than some of the other models.' That kind of information is invaluable to farmers, and that is where I think we researchers need to interact with them.

The other side of that coin is that the farmers tell us that their important decisions are at such and such a time of year and that they need to know such and such, and they ask us if we can we build something into the models in some way or whether the information we provide them can be tailored to their management decisions. This two-way feedback is really important. It is very time intensive because there are not many researchers doing this and we cannot go out and talk to all farmer groups. We try and talk to farm advisers, who then go and talk to the farmers, but

then we are one step removed. The farmers absorb the information; they love it—they love to talk about the weather and the seasons, and the more they can find out—

CHAIR—And they obviously understand it as well, and it is useful to them in that sense. Just listening to you, I did not realise there was such a relationship and such interaction.

Dr McIntosh—There is, but not with all farmers, just with the key farmer groups that are inviting us out, who just absorb this information. There are not many of us to go and do this sort of thing.

CHAIR—Is there scope to broaden it and make it more of a practice to have that interaction with all farmers?

Dr Cleugh—Doctor Howden may or may not be on the end of the line. This is in his area. I just want to make sure that he has an opportunity to speak to this as well.

CHAIR—Absolutely.

Dr Cleugh—Mark, are you there?

Dr Howden—Yes, I am. Thanks, Helen. I think the points that Peter makes are right, that it is very time-intensive to go through what we call a participatory research process with those farmers. This has not been worked through accidentally; it is the end result of about 20 years of engagement and trying out different ways of dealing with farmers and advisers. We have gone down quite a few different routes, like having a computerised decision support system and accreditation and training, and this is the one we find has the most impact. So what Peter is talking about has actually been worked out over a long time, through integrating the understanding of how the climate affects farming systems and the understanding of how people use that information. So it is not a new idea; it is just that we have to go incrementally through these and test what works and what does not.

The other point that is important here is that it is not just about climate. Farmers will make decisions based on how much soil moisture they have, what the forecast prices are for their product, what the forecast costs are for their inputs and a whole range of other things. It is about trying to get the climate in there in an appropriate way and with an understanding of the uncertainties around that information so that farmers are able to make better decisions. That, at least, is the theory. But we have found that there are a whole stack of barriers to people using that information effectively and that there is not necessarily a linear link between improved forecast accuracy and improved benefit to users. So it is not just about developing better climate models; it is also about developing a better understanding of how to use that information with users, particularly when we start to go into dynamic forecasting and ensemble models. It is not clear how to best use that information.

CHAIR—You would agree, then, that this is an area that we need to look at. This is especially so when we look at the whole issue of food quality and food security in the future and Australia's role in being a potential player in this area. I think making the link between the kind of data that is given to farmers by the bureau and CSIRO becomes an important part of this. I know what you do is not accidental but it is not easily available to every farmer in Australia. It strikes me

that maybe this is an area that needs to be looked at. It is par for the course: if you are in agriculture, you ought to be in partnership with the weather forecasters in a more meaningful way.

FRAN BAILEY—Just to follow up on that issue: I am particularly interested in the very practical applications. As well as the predictive side of your research, is there any collaboration going that step further? For example, is there research of soil types so that not only do farmers have the climatic information on which to base their decisions but they also have information on the type of crop that is going to be most successfully grown? Is there a linking of climatic conditions with soil type and water availability? Do you go that step further? Are there collaborative research projects that go those further steps?

Dr Howden—Again, that is a very good question. The approach we take is what we call 'a systems approach', which is where we look at all the factors that are significant in influencing the decision and the end result, say, in terms of improved yields or improved productivity of livestock. We do that over both the short and the long term. So the short term deals with finances and the long term deals with soil degradation and the risks of that. In all cases, we have to take into account the things that you are talking about—for example, what are the differences in soil types? A given rainfall event on a sandy soil will have a very different impact on plant growth from the same rainfall event on clay soil. Also, it will have a different impact if you have good fertilisation versus bad fertilisation practices. You have to include that other information to get a sensible integrated result out of what your climate forecast might mean in terms your management.

Australia is in a really good position in relation to this. We have been working on this for about 40 years and we have probably got some of the world's best descriptions of farming systems. That takes into account the soils, the climate, the vegetation, the crops, the management practices, and the financial aspects in terms of forward selling, and then that is put into a package so that people can make better decisions. One of those is Yield Profit—a product of the Birchip Cropping Group, which was developed with CSIRO. It is a web based system which pulls together all of that sort of information—soil type, management activity, seasonal forecasts. It gives people direct information in a probabilistic sense of telling them to lean, not jump. That was the point that Peter McIntosh was making before. It was about getting people to see this not as black and white but as shades of grey. Farmers make much better decisions as a result of that because they understand the risk and also the benefits there.

FRAN BAILEY—I like that phrase 'lean, not jump'. Thank you.

CHAIR—Are there any other questions before we go to the next—

Mr RAMSEY—I have one, and it is out of left field. I am sorry I do not have the name of the proponents, but are you aware of those that think that the aerosol component coming out of South-East Asia has a major effect on the recent dryness of Australia, particularly the burning of the forests in Kalimantan and all that kind of stuff—that it is actually providing a shading effect over the northern oceans of Australia? If that is something that you have considered or are even aware of? I am sorry I do not have with me the names of those who actually promote that theory.

Dr Cleugh—I will give an answer, and my colleagues here might like to make a comment as well. CSIRO do run climate models that include the effects of aerosols on the climate, and there have been some simulations done. There was a research exercise in the last few years to try and capture the effect that aerosols have on the climate system, including the sorts of things you are talking about. Those results are suggesting that there could be feedbacks between the aerosols coming from South-East Asia and the rainfall in Australia, but my feeling—and I will check with my learned colleagues here—is that these are quite preliminary research results, needing more research and understanding. But we are actively researching in that space. Peter?

Dr McIntosh—These are colleagues of mine in CSIRO that have conducted this research, so I know a little about it but not a great deal. I understand that the so-called Asian brown cloud, the aerosols that come down, particularly over the north-west of Australia, have increased the rainfall, and the mechanism for that is that they act as cloud condensation nuclei—to form raindrops, you need a tiny little seed for the moisture to form around. So I understand that the modelling has indicated that this is the effect of the Asian brown cloud, and in fact the observations show that in the last, I guess, 30 years roughly the rainfall in the north-west of Australia has actually increased.

Dr JENSEN—This theory that Rowan is getting at—and I did hear about it in South Australia—is that with the global dimming you get reduced solar insulation and, as a result, not quite as warm temperatures there. So you get a splitting of the intertropical convergence zone and you get a movement further south of some of the trade winds and so on which actually bring rainfall to southern Australia.

Dr McIntosh—I am afraid I do not know much about that.

Dr Cleugh—The interactions between aerosols—and there are many different kinds of aerosols too, not just the ones we are talking about—and the climate system are complex, and there is currently a lot of research. I am not sure that it is hugely appropriate for us to make too much of what is probably not in the scope of the inquiry.

Dr JENSEN—Sure. I am just reporting on what I understood when I went to South Australia a couple of years ago and heard this. I have not seen anything subsequently.

Dr Cleugh—As I said, it is an active area of research. So some of the things that you are talking about are some of the effects of aerosols, but there are other, secondary effects as well on cloud development and cloud condensation processes, as Dr McIntosh said.

Mr RAMSEY—If I can find the original source, I might send it to you. I am just interested. Thank you.

CHAIR—One last question, from Ms Bailey.

FRAN BAILEY—Funding is always an issue. Are there any other factors that inhibit your research here in Australia? Now is your chance!

Dr McIntosh—You have excluded funding, though, which is the main thing!

FRAN BAILEY—I am acknowledging that that is always an issue!

CHAIR—That is always a factor, but there may be some other issues too.

Dr Cleugh—From my perspective, I think there are three factors, and funding is tied up in them, but let us tease them out. In terms of what the inquiry is about, long-term meteorological prediction, our infrastructure in terms of supercomputing is something that has been a challenge, and we are still working with that and building that supercomputing capability. Observational infrastructure capability is also a factor. We have spent quite a lot of today talking about the absolute importance of ocean observations in particular for seasonal timescales, and my colleagues have already mentioned the enhancement that enhanced observations have had. So we need to continue to ensure that we are able to receive and utilise satellite observations. I am not saying it is a hindrance, but we will need to continue to do that to achieve the improvements that we want. As I said, it is about accessing those observations from satellites and utilising them in our models.

That requires staff with the right skills, so again it is from a capability perspective but now from a human perspective. Finding scientists and technical people with those sorts of skills is always challenging in the Australian context as well, so that is where we need to keep building and maintaining our people skills in that space.

Thirdly—or am I up to four?—there need to be observations not just from satellites, as important as they are, but in situ as well. There was the announcement last week that the Marine National Facility was going to keep going. That sort of observational infrastructure is also key to our science, so that is an important aspect. There are also our relationships—our international collaborations. It was mentioned earlier that one of the reasons that we are able to keep acquiring our observational data sets is that we have these international agreements; we give back and we receive. Maintaining those international collaborations is critical for us to continue in our science. Those are my three or four comments. I will open it up to my colleagues to see if there is anything they have to say.

Dr McIntosh—I would definitely say that it is having the right people and enough people to do the research. There are a lot of research issues. We have a long list of things that we would like to address. We have been trying to put together projects to address all of those. Then you have to have the right people with the right research skills. Sometimes attracting the right people from overseas can be quite difficult, because I am not sure that we—

CHAIR—What about home-grown? Let us get on to that, because we had a previous inquiry about this. I was going to ask you about the changing nature of the courses as you move into dynamical forecasting. Where are we with that in terms of our own capability?

Dr Cleugh—I think it is really important to ensure that we do both. Yes, we should attract expertise from overseas, because sometimes we might not have it home-grown. But, having said that, I say we need partnerships with our universities in Australia and we need to build access, which we have talked about. There is actually a partnership not just between CSIRO and the bureau but also with the universities. I think ensuring that we are training our own people too has to be very much part of the picture here, but we may not always be able to bring in sufficient capacity or capability domestically.

CHAIR—I understand that. I just wonder whether the slack in maths and science that we are all very familiar with is having an impact in your disciplines as well.

Dr Cleugh—I would like to see if Dr Whetton has any comments on this, especially as she has just been involved with a fairly major recruitment exercise. Do you have any comments about the home-grown capacity issues in Australia?

Dr Whetton—It has been a concern for some time to attract a sufficient number of well qualified people for the positions that we seek to fill to be able to do our research. We have recently been recruiting some new scientists for another program. The quality of the applicants from Australian sources was actually reasonably good for this most recent round of positions that we are seeking to fill. It is a concern, but I am a little bit encouraged by the most recent response we have had around the positions.

FRAN BAILEY—I have one very final question. What is it that we are doing in this area in Australia that the international community is most interested in? You spoke about the importance of the international collaboration, and that has to be a two-way process. What is it about which the international community says, 'Hey, those Australians are really leading the way in this area'?

Dr Cleugh—I can think of two or three key ones. One of the areas on the satellite side that our international collaborators are very enthusiastic about is the ability to validate and calibrate their observations using Australian land surfaces, because we have some fairly unique characteristics. That is, if you like, a useful data set. It is actually more than useful; it is quite essential. So we have collaborative arrangements around what we call calibration and validation activities. That is just a little example, but it is quite important for much of what we do. The same is true of some other observational work we are doing here in the Southern Ocean as well as terrestrially. We are representing a part of the earth's system that the rest of the earth science community might not have invested as much time in exploring, and they get that insight from the research that we are doing. I think there is also our research into some of the core climate drivers that Dr Alves talked about, such as the role of the Indian Ocean, the role of the Southern Ocean and ENSO. They are things that are so important to Australia that we have spent effort researching them; they are of value. They are the things that I am very aware of; I again go to my colleagues.

Dr Howden—One of the key things, over and above what Helen has talked about, is that Australia has a huge lead here because we have expertise in making this climate information useful. It might sound like a really simple thing, but right across the globe there are very few people, or very few institutions, which actually have a focus on taking that climate information and converting it into decisions that improve wellbeing for people or for governments. That is a fundamental thing which we do well and that other people are waiting to catch up on, and they really look to us for a lead here. In some ways we have actually dropped the ball on this because we have had quite a fragmented institutional funding arrangement and we have not been investing in the people, which was mentioned before. It might be hard getting people trained in the climate systems research, but it is even harder in terms of agricultural natural resource management systems approaches to those. And we do have really great difficulty in attracting good quality applicants either in Australia or overseas. For example, Australia's agricultural

sciences is now down to, I think, two mainstream courses in universities in Australia, so it is becoming increasingly hard to get those sorts of graduates without that sort of experience.

FRAN BAILEY—Thank you.

CHAIR—Thank you very much for your evidence here today.

Dr Howden—Thank you very much for the opportunity to participate.

[11.35 am]

ALVES, Dr Jose Oscar dos Santos, Leader, Seasonal Prediction and Climate Variability Group, Centre for Australian Weather and Climate Research, Commonwealth Scientific and Industrial Research Organisation

CLEUGH, Dr Helen, Theme Leader, Climate and Atmosphere, Commonwealth Scientific and Industrial Research Organisation

KEENAN, Dr Thomas, Deputy Director, Centre for Australian Weather and Climate Research, Commonwealth Scientific and Industrial Research Organisation

McINTOSH, Dr Peter Christopher, Principal Research Scientist, Commonwealth Scientific and Industrial Research Organisation

MAPSTONE, Dr Bruce, Director, Centre for Australian Weather and Climate Research, Commonwealth Scientific and Industrial Research Organisation

Evidence from Dr Mapstone was taken via teleconference—

CHAIR—Welcome. We do not have any specific questions to ask at this point; this is a final opportunity for us to hear from you and for you to raise things that have not been raised in the dialogue we have had with you as separate entities. You could tell us a bit more about the sort of collaboration you are involved in and anything else you feel may be necessary that we should be aware of. I am sure that will precipitate questions from us.

Dr Cleugh—Firstly, Dr Mapstone will give a brief introduction. Secondly, I am going to hand over the emcee duties to Dr Tom Keenan, who is a Deputy Director of CAWCR. He will manage the proceedings.

CHAIR—Dr Mapstone, would you like to start?

Dr Mapstone—I am sorry I could not join you earlier. We wondered whether it would be useful to the committee if I gave a very brief summary of what CAWCR is, where it comes from and what our main objectives are.

CHAIR—Yes; please go ahead.

Dr Mapstone—CAWCR comes under a joint research agreement between CSIRO and the Bureau of Meteorology. It is not a new institution. It is an unincorporated joint venture or partnership between CSIRO and the bureau. It is put together to essentially bring together research and development expertise from those organisations focussed on weather and climate research in the broadest of senses. It grew out of a recognition that Australia is a relatively small country which could not really afford to maintain separate R&D activities in different organisations, and it made sound sense for the bureau and CSIRO to get together and collaborate with the university sector to develop, in particular, Australia's future weather and climate

forecasting capability. That is a key focus of the centre. The centre does not provide services directly to the community. Our research outputs are provided into the bureau for finessing into services as appropriate or as research outputs through CSIRO flagships and research themes. We do research across a very broad range of areas ranging from aviation, weather forecasting, research to support aviation forecasting, right through to climate and climate change simulation. We also are working closely with WIRADA, which works specifically on water issues for Australia, to bring weather and climate R&D capability to bear on the specific questions that relate to Australia's water cycle and water management in Australia. I do not think I need to go on further. I will leave it for you folk to ask questions as need be or for my colleagues to add details that have not been covered in the earlier hearings.

CHAIR—Thank you. Does anyone want to add to that?

Dr Keenan—If I may add, as the then of CAWCR—and this has come out a little bit in the past discussion—the strong link that CAWCR provides between the research and the services side of the Bureau of Meteorology is extremely important in the context of the discussion about the uptake of research outcomes for the community. The bureau itself does provide a lot of services through its regional offices and so forth. It has a strong connection with both state and local authorities in a range of activities. This does provide a link for us to enhance the value of the research that is done through CSIRO. It has other mechanisms, but, importantly, from a bureau perspective, providing that link to the services side of the Bureau of Meteorology is an extremely important outcome. Our links with Mike Coughlan and the climate side of the bureau is extremely important in enhancing the value of that research. One of the motivations on the bureau side is to actually increase the scope of capability available to the Bureau of Meteorology to deliver its service outcomes. It is one of the reasons why the bureau has become involved in CAWCR, apart from the other activities related to earth system modelling development, understanding the water cycle, and the utilisation of observations within our research framework.

CHAIR—Is your involvement part of an awareness that the information that one has is becoming more relevant and pertinent to be shared with the bureau in terms of the way you do weather forecasting? I just get the sense that you are separate entities. Is that right? You have a partnership going that aims towards better outcomes for both.

Dr Keenan—That is exactly right. At the moment, in terms of things related to access development, we have both bureau and CSIRO staff working as a team on this activity. So they be employed by different organisations but they can be supervise by staff in either organisation, delivering capability for these sorts of project outcomes. The access model will be delivered using capability sourced both from the Bureau of Meteorology and from CSIRO, working towards a common and. That is the real advantage of undertaking this initiative. It gives a real national approach to a national scale problem—having the capability available to implement an earth system modelling capability within Australia. There is recognition there that it was almost too big for either organisation—

CHAIR—To do separately?

Dr Keenan—to do this separately. There is much more benefit if we engage nationally in a partnership—and, importantly, with access to engage with a university colleagues. They are important players in this. They participate in our team meetings and are contributing to the

development of access. We just had a meeting on Friday with the involvement of the universities within Australia.

CHAIR—Which universities feature, because I think there was reference before by you, Penny, about only two universities offering courses. I am not sure if I have got that right.

Dr Cleugh—The two courses that you heard about was from Dr Howden and was with regard to agricultural science. In the climate space, there are quite a lot of universities.

Dr Keenan—There are a number of universities: Monash University are involved; the University of New South Wales; Macquarie University and so forth.

Dr McIntosh—University of Tasmania with the oceanography as well as climate.

Dr JENSEN—It strikes me that this is somewhat similar to the way ARC centres of excellence are set up. Would that be a fair comment?

Dr Keenan—I think the ARC centres of excellence are certainly related. We are working to manifest working relationships with the ARC centres of excellence. I would characterise it at this stage as a more informal rather than formal linkage.

Dr JENSEN—But it sounds like the linkages are very similar. Admittedly, the funding model is very different.

Dr Keenan—The funding has to come through whatever mechanism—either the bureau, CSIRO or the universities can facilitate those processes. But the important point is that this as a shared vision, if you like, between these various groups, and it is in the national interest to work together as a group.

Dr JENSEN—In your view is this something that should be funded separately from the CSIRO or the bureau—or, indeed the universities?

Dr Keenan—This has been looked at from a number of points of view, and each organisation has its own way, but I think things like the national climate framework are extremely important in influencing the ARC and other different avenues that are available so that there is coordination between the funding frameworks. Rather than necessarily trying to reinvent a new system, I think it is important to make sure that the frameworks that do exist are working cooperatively, and that can spread across a huge range of activities.

Dr Mapstone—Could I just add something? I think there is a significant advantage in the CAWCR model and, indeed, the same model being used in WIRADA, being formed as a partnership of two major institutions in the Australian R&D landscape. Those partnerships leveraged the depths of both the bureau and CSIRO across a whole range of areas that you would not capture if you had a separate organisation funded under some separate stream. I think Tom flagged one of the major benefits of having the partnership essentially embedded, in part, within the bureau, which is that there is a direct line of sight from the R&D into national benefit through service delivery. I think there would be a risk of losing that direct line of sight if a separate organisation were set up. Similarly, in CSIRO there is a wealth of research being done

across other domains that can draw directly on the R&D being done in CAWCR, which might be more difficult to access if CAWCR were set up as a separate entity.

Dr McIntosh—I might add something here as an example of the way in which these different organisations work together. CAWCR has brought together Dr Alves and me, in particular, on a project working in south-west Western Australia on seasonal climate forecasting. The bureau is developing the model, which is POAMA. We are looking at the outputs and validating those outputs—looking at the rainfall—and then passing on the information on probability to a colleague of mine in south-west Western Australia, who is also in CSIRO. He works with farmers there but he is also involved with the state department of agriculture, because they have a better connection with the farmers. So there is a long chain from the bureau right through to the state department of agriculture which is helping farmers in south-west Western Australia. This is a project that is funded by Land and Water Australia, and I think it is working really well in connecting all these groups together.

Mr RAMSEY—What will happen to that program now that Land and Water is being wound up?

Dr McIntosh—We do not know for sure. I understand that existing projects will continue.

Mr RAMSEY—That is right, I think.

Dr McIntosh—But we were in the process of signing off four or five projects with MCV, which is the Managing Climate Variability Program part of Land and Water Australia, which I believe will just not happen now. I do not know that for sure. We are in a state of limbo at the moment on that one.

Mr RAMSEY—I am from South Australia. On a positive note, Dr Peter Hayman, whom I am sure you are aware of, who works with SARDI is doing a great job of transferring the information that you people generate into stuff that the farmers can understand and access at the coalface. He does a fine job.

Dr McIntosh—In fact, the phrase 'knowing which way to lean, not which way to jump' is one of Peter's.

CHAIR—Did you want to comment, Dr Alves?

Dr Alves—I will describe the current state of the negotiations with Land and Water prior to the changes. Over the last few years we have been through a series of workshops developing some projects that they were prepared to fund. Over the last year we came down to a list of 10 projects totalling just under $6 million and in the last few months four of those projects were approved by the MCV board. We were in the drafting stages of those agreements. We are in contact with LWA but we do not know whether or not those projects will go ahead. I guess it came at an unfortunate time when we were negotiating with LWA. The four that the board has approved and that were in the contracting stage totalled $3.1 million from the Managing Climate Variability Program. There will be a bit of uncertainty in the next few years because we are not sure whether or not we are going to get that.

Dr Coughlan—I thought one point which perhaps had not come out as strongly as it might was mentioned earlier there at WIRADA, which is the water research activity. It is a sort of a parallel to CAWCR in the climate area. WIRADA is a parallel between the bureau and CSIRO in the water area. Clearly, those two efforts are working very closely together. On the operational side, of course, the bureau now has the national responsibility for the generation of national water accounts and also national water assessment which, of course, involves attempting to then apply seasonal forecasts to the whole water assessment and water forecasting area. So we see this new capacity within the bureau to inform the nation on its water resources clearly benefiting from any improvements in operational climate forecasting. We see those as being very important also for doing assessments on our water resources into the future. That responsibility for developing a national approach to water is now within the bureau. So we have got that marrying, if you like, between weather, climate and water on the operational side being handled within the bureau, and, as to weather, climate and water, we are also now working very closely with WIRADA and CAWCR on the research side. So we feel that package together is probably close to unmatched anywhere else in the world.

CHAIR—It also makes a lot of sense, doesn't it, that it should be. In fact, one of the benefits of having one of these things is that you can tap into it. Are you aware—I am going to raise this because it came up when we talked about agriculture—that there is a global biosecurity conference in Brisbane next year? I am assuming you will have an interest in what is discussed there. I do not know what the agenda is but it is about safeguarding agriculture and the environment. So there seems to be perhaps even some international thinking about the relationships.

Dr Coughlan—That is certainly the case. One of the other big conferences coming up—which is not going to be held in Australia, unfortunately—is the world climate conference; the third in the series of world climate conferences. The previous ones led to the establishment of the World Climate Program. In fact, the Intergovernmental Panel on Climate Change, and even the UN Framework Convention on Climate Change, came out of those earlier world climate conferences. The focus of this one is to try to improve the delivery of climate services to the community, to assist the community to handle not only climate change but also the fact that the climate varies on long timescales. So there is a big emphasis now on improving this delivery of services and the uptake of those services by the community. That is getting a boost not only locally but also internationally.

CHAIR—And we seem to be doing well in the marrying of those services for the purposes of making the community more aware and making it more accessible to the community. I am assuming that Australia is out there doing that already?

Dr Coughlan—I think that is because we are a developed country and we have such a variable climate that it is such an important issue for our whole productivity, particularly on the land. So we have become extremely sensitive to it and have become very adept at using that information, but these are still challenging times for us with the climate moving the way it is.

FRAN BAILEY—Could I bring you back to the local area and leave the international area for a moment, to talk about marrying different areas of research. I want to talk about fire weather forecasting. Is there any provision for not only the prediction of extreme temperatures, winds,

humidity, et cetera, but also the marrying of areas of research that I understand that CSIRO is involved in with fuel loads on the ground in particular areas? Is this happening?

Dr Cleugh—Some of the research that you are talking you about is scoped for the CRC for bushfire research, RABit, and there is the opportunity in there to connect what is on the ground, fuel content, with something about the weather. It is unclear at the moment where the RABit is at. I think there is good potential for marrying those areas of research and even more good potential through CAWCR—which as we have just been talking about—to bring the CSIRO's research and activity that might sit outside the part of CSIRO that is in CAWCR but still sits in CSIRO through to the operational side, which is what the Bureau of Meteorology do, as Dr Keenan explained. So I think there is very good potential for marrying those areas of research, in the sense of CAWCR being the central core here.

FRAN BAILEY—What has to happen for those areas to be married?

Dr Cleugh—What has to happen?

FRAN BAILEY—Yes.

Dr Cleugh—The reason I am hesitating is that I am just not sure where things are at at the moment because I have not been involved with the outcomes with regard to the bushfire CRC. I think that is one mechanism that can help make that happen.

FRAN BAILEY—Is that an area that you could follow up on and get back to us?

Dr Cleugh—I would be happy to take it on notice. I am also just wondering whether either Dr Keenan or Dr McIntosh have any comments to make on this in their different roles that I am not aware of.

Dr Keenan—There are discussions occurring. I was at a meeting the week before last, I think, specifically talking about bushfire and where we could contribute. The very CSIRO colleagues that you mentioned were at that meeting. We were looking at ways in which we could discuss the very issue that you mentioned about what capability we could bring to start addressing some of these significant issues, which I would characterise as understanding the danger that fire represents both on various time scales through to seasonal time scales, what capability we could bring together to look at understanding fire behaviour and so forth—a range of different problems. So the capability does exist within CAWCR. With the new bushfire CRC coming up, we were essentially looking at how we could formulate the right sorts of strategic approaches to meet not only the bushfire CRC but maybe national interests in that.

FRAN BAILEY—There would also be an international application. You only have to look at what has been happening recently in California.

Dr Keenan—We have very strong links with colleagues both in the bureau and in CSIRO and also with colleagues in the US and Europe and so forth undertaking that sort of research.

FRAN BAILEY—It seems such as an obvious connection that one wonders why it has not happened in the past.

Dr McIntosh—Perhaps I can say something about that, just from my own experience. A number of years ago, I had interactions with a post doctoral fellow with the CSIRO division of forestry down in Hobart. He was modelling fuel load and having a look at how moisture went into it, how it dried out and that sort of thing. I was doing statistical seasonal forecasting. We ended up not collaborating. The reason was that he did not know enough about how the moisture got into the fuel load, and so there was some very basic research that he needed to do, and my statistical forecast in Tasmania was not yet accurate enough to be of use to him. So there were two separate areas of research that both of us had to progress before we could put them together.

FRAN BAILEY—Isn't the quantity of the fuel load one of the variables of the research, as well as the moisture?

Dr McIntosh—That is right. So that would have been another part that he would have needed to look into. He was developing the model for that kind of area. I think more generally that, as the skill in the seasonal forecasting improves and as our models get better, they will become more useful to people and then we will find more collaborations. The more skilful our forecasts are, the more people will want them.

Dr Keenan—In the discussions last week and this week, there was a little bit of the sort of discussion that we have been having about fitting into a common framework approach in order to undertake these activities. That is important not just within the climate community but also in the other communities. When you have a common framework in which to work, you can take advantage—

FRAN BAILEY—Again, it is a practical application of the research.

Dr Keenan—That is right. When other agencies are cooperating on a common framework, we can use their expertise more effectively through these common approaches. So that is an approach we have taken with access, in collaboration with CAWCR. But I can see that approach has important implications as well. So I think getting these common frameworks in place and a common way of doing things nationally is important.

CHAIR—As there are no further questions, I would like to thank you for appearing before us today. I would also like to put on record our thanks and gratitude to Beth Riordan, Meredith Shier and Atliana Safich for their assistance with today's hearings.

Resolved (on motion by **Dr Jensen**, seconded by **Mr Ramsey**):

That this committee authorises publication of the transcript of the evidence given before it at public hearing this day.

Committee adjourned at 12.00 pm