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JOINT STANDING COMMITTEE ON TREATIES

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JOINT STANDING

COMMITTEE ON TREATIES

Monday, 1 December 2008

Members: Mr Kelvin Thomson *(Chair)*, Senator McGauran *(Deputy Chair)*, Senators Birmingham, Cash, Farrell, Ludlam, Pratt and Wortley and Mr Andrews, Mr Briggs, Mr Forrest, Ms Hall, Ms Neal, Ms Parke, Mr Simpkins, Mr Trevor and Ms Vamvakinou

Members in attendance: Senators Birmingham, Cash, Farrell, McGauran and Pratt and Mr Forrest, Ms Hall, Ms Parke, Mr Simpkins and Mr Kelvin Thomson

Terms of reference for the inquiry:

To inquire into and report on:

Kyoto Protocol to the United Nations Framework Convention on Climate Change

WITNESSES

ASH, Dr Andrew, Director, Climate Adaptation Flagship, Commonwealth Scientific and Industrial Research Organisation..... 1

AYERS, Dr Gregory, Chief Marine and Atmospheric Research Division, Commonwealth Scientific and Industrial Research Organisation 1

HARLE, Dr Katherine, Senior Adviser, Commonwealth Scientific and Industrial Research Organisation 1

WRIGHT, Dr John, Director, Energy Transformed Flagship, Commonwealth Scientific and Industrial Research Organisation..... 1

Committee met at 10.09 am

ASH, Dr Andrew, Director, Climate Adaptation Flagship, Commonwealth Scientific and Industrial Research Organisation

AYERS, Dr Gregory, Chief Marine and Atmospheric Research Division, Commonwealth Scientific and Industrial Research Organisation

HARLE, Dr Katherine, Senior Adviser, Commonwealth Scientific and Industrial Research Organisation

WRIGHT, Dr John, Director, Energy Transformed Flagship, Commonwealth Scientific and Industrial Research Organisation

Evidence from Dr Ash, Dr Ayers and Dr Wright was taken via teleconference—

CHAIR—Welcome. Proceedings are being televised and broadcast by the Department of Parliamentary Services. Although the committee does not require you to give evidence under oath, I should advise you that this hearing is a legal proceeding of the parliament and warrants the same respect as proceedings of the House and the Senate. The giving of false or misleading evidence is a serious matter and may be regarded as a contempt of parliament. If you nominate to take any questions on notice, could you please ensure that your written response reaches the committee secretariat within seven working days of your receipt of the transcript of today's proceedings.

I invite you to make a statement before we move to questions. I understand that Dr Harle is more associated with organising presentations rather than making statements or answering questions.

Dr Harle—Yes, that is correct. Andrew, I do not know whether you want the presentation to be a statement. Just let me know. I am ready to go on your call.

Dr Ash—I think the best way to proceed is to run through the first part of this presentation and then deal with questions.

CHAIR—That is fine. Please proceed.

Dr Harle—Andrew, I have the first page up.

Dr Ash—Kate, if you move on from the title slide to the next slide, we will see the CSIRO's response to national climate change. This frames how we have organised our research response to climate change and the science of climate change in terms of both mitigation and adaptation. We are explicitly addressing all three of those areas. I will not dwell on the yellow boxes at the bottom of the slide, but structurally we have a range of flagships and joint research operations with the Bureau of Meteorology that deal specifically with climate science. Mitigation space deals with energy and transport through the Energy Transformed Flagship, and issues of agricultural emissions and biosequestration are dealt with through an agricultural sustainability initiative. On the right hand side you can see adaptation being dealt through the climate

adaptation flagship that I represent and also through our water flagship. That gives you a sense that we are trying to address reasonably comprehensively all the issues associated with climate change.

The next slide shows the specific areas that we were asked about: the evidence of climate change, its impacts and how we are responding to that. In terms of the evidence of climate change, this slide gives a record that goes back 400,000 years or so into the past. It is just to highlight that the climate has always been variable. The red line on the slide shows the temperature change over the last 400,000 years or so going up and down, pretty much in alignment with glacial and interglacial periods. The carbon dioxide concentration, which is the green line on the right, is pretty much cycling in parallel with the temperature changes. The carbon dioxide ranges from about 180 parts per million up to around 280 parts per million. Right at the very end of the line, you can see the blue and the red where we have moved out of that cyclical range of 180 up to 280 up to the current CO2 concentrations in the atmosphere of around 380 parts per million.

The next slide shows what is happening with temperature. The graph represents global temperatures over the last 150 years or so. The long-term trend is an increase in temperature, particularly over the last century. It is not an even increase. You can see a period in the 1940s and 1950s where the temperature actually drops down a bit, and then in the last 10 years or so it has plateaued a bit—but it has plateaued at a level much higher than the previous 150 years. Over the last 100 years or so, global temperature increases have been an increase of about 1.75 degrees Celsius and for Australia it has been an increase of about 0.9 degrees Celsius.

The next slide shows that the temperature increase is not just in our measuring stations at the surface of the planet. The graph represents ocean heat content. The oceans contain a lot more of the stored energy than does the atmosphere. All I want to highlight here is that from 1950 ocean heat content is increasing. We are storing more and more energy in the ocean.

We move on to the next slide, which shows the human contribution. This slide is from the Inter-governmental Panel on Climate Change's fourth assessment report. I do not want to go into the details on the numbers here, it is just trying to position the relative contributions to the warming that we have seen since 1950. The red bars on the right indicate the positive warming effects and the blue bars are where we have had a cooling effect. The warming effect is largely brought about by carbon dioxide, methane and, to a lesser extent, ozone. We have had counteracting cooling influences, particularly as shown on the left-hand side where it says 'total aerosols'. This is particulate matter put into the atmosphere—a large chunk of that is pollution from industrialisation—and that has a cooling effect.

The bottom of the slide shows that solar radiation—so this is a natural form of warming—has had a very small impact on temperature compared with the human influences. The net effect at the bottom of the slide is that warming effect and it is expressed in this radiative forcing terminology. The point we are trying to make is that there are warming influences and cooling influences. The warming influences greatly outweigh the cooling and they are almost entirely attributable to human influence.

Senator BIRMINGHAM—What is the cooling influence related to land use and surface albedo there? Can you explain that?

Dr Ash—Where you get changes in land use you get a different reflection from the land surface. Where we have made surfaces more even in, say, cropping land and what-not, you get more reflection than absorption.

Dr Ayers—The natural vegetation that is often cleared for agricultural purposes is darker than the crops, so it absorbs more radiation than crops over the same area.

Dr Ash—We will move on to the next slide, which tries to put that evidence together in what we use to try to predict the climate of the future and also to explain what has happened in the past. The black line on the graph represents the observed temperature increase in the last 100 years. The blue swathe that runs through the bottom are the very complex climate models that we use where no human CO2 and other gas increases are put into those models. It is just as if the climate system was running almost pre-industrialisation. It does not show the observed temperature increase that we have seen in the last 100 years. The pink swathe that pretty much mirrors and matches the observed temperature is when we include the anthropogenic influences, the human influences, of greenhouse gases in those models. That gives us a lot of confidence that the models are representing the climate system in these longer term runs fairly well.

The next slide moves from temperature to rainfall, and it shows the observed changes in rainfall in Australia for the last 57 years. We can observe a strong drying trend in south-west Western Australia and also quite a strong drying trend through eastern Australia. The causes of these drying trends are much more complex than the temperature increases. The drying trend in south-west Western Australia and, to a smaller extent, in south-eastern Australia we believe is attributable to climate change and the way that the frontal systems that go across southern Australia in winter, which bring a fair bit of the rain, have moved southwards as a result of a change in pressure systems from Antarctica up to the middle latitudes.

We are confident that some of the rainfall decreases that we are observing in southern Australia are at least in part attributable to greenhouse gas emissions. Through eastern Queensland and up north it is still very unclear what has been causing that rainfall decrease, particularly over the last 30 years or so.

The next slide highlights some of the challenges we face, moving ahead, in trying to reduce greenhouse gas emissions. The coloured lines going out into the future, to 2010 and much further than that, are the Intergovernmental Panel on Climate Change emission scenarios that they use in all the climate models. These were developed back in the mid-to-late 1990s and it shows the range of pathways.

That top red line is a fossil fuel intensive pathway that continues into the future and is a pathway which estimates fairly high development in terms of the economic growth of developing countries and is the highest emissions scenario. The dashed blue line at the bottom is where we reduce emissions fairly rapidly through technology, and that covers a range of possibilities that the IPCC uses. The black line and the dots going out to 2005-06 and 2006-07 represent the actual emissions that we have seen in the last 10 years or so. The emissions are tracking at the highest emissions scenario that the IPCC is using. The growth rate of emissions at about three per cent a year is continuing to take us further outside that top emissions scenario line. It is a worrying trend when we have actual emissions outside the range that the IPCC is using.

The next graph shows how well temperature is tracking and so those high levels of emissions are now reflected in a very similar graph to the previous one. That grey swathe with the coloured lines that goes out to the right using that IPCC emissions scenario range now relates to the temperature range that we might see. The red line is the observed temperature. As the emissions are at the high end of the scenario range, so are the temperatures. We are tracking right at the top end. If we move on to the next graph, this is for sea level, very similar, and we are tracking right at the upper limit of all the projections in terms of sea level increase, in the order of about three millimetres per year at the moment.

We move on to the next slide. What we are showing here is taking those climate models now and projecting into the future for Australia. For 2030, using one of those midrange IPCC emissions scenarios somewhere in the middle of the band that I showed you before, we get a further warming of around one degree Celsius by 2030. It is important to note they are with an uncertainty range, so it could be as little less as 0.6 degrees Celsius or as much as 1.5 degrees Celsius. That is using a midrange emissions scenario. It is worth noting that on our current track of emissions we are heading for a higher emissions scenario result for 2030 than that number reflects.

If we now look at 2070, because of the uncertainty of our emissions in the future, we just choose a low and high emissions scenario. If we can get our act together and reduce emissions significantly, on that B1 scenario we will have a warming of around 1.8 degrees Celsius with an uncertainty range from one to 2.5 degrees Celsius, and with a high emissions scenario a further warming of around 3.4 degrees Celsius. So the outcome we will get in the future will be fairly strongly dependent on our emissions scenarios over the next 30 to 40 years.

Moving on to the next slide, as I mentioned before, rainfall is a much more difficult thing to project into the future. Looking at southern parts of Australia, which are dominated by a Mediterranean climate with winter rainfall, there is a fairly consistent pattern of drying in winter and spring. There is a large range, going from 2030 with no change in rainfall down to a 10 per cent decline and, as we go into the future, the range of the projected decreases generally go in one direction—down.

The picture for northern Australia is much less clear. The effect of greenhouse gases and the climate system on the monsoonal influences—the summer dominant rain of northern Australia—is much less clear, so we have a lot of uncertainty in the models. They go from an increase in rainfall down to a decrease. There is still a fair bit more work to be done to try to understand how greenhouse gas emissions will affect rainfall patterns in northern Australia. The issue with rainfall is that small changes can be amplified through our system. For example, a one per cent decrease in rainfall leads to something like a three or four per cent decrease in runoff. So a five per cent decrease in rainfall can lead to quite significant declines in runoff into our storage areas and dams.

I will very quickly deal with the impacts of climate change shown on the next slide. They will be on all sectors of the economy and the environment, and there will be differential effects on sectors and regions. Climate change will play out in different ways in different sectors and in different regions—the impacts are very localised and regionalised. There are mostly losers but, potentially, there are some winners from climate change in the way that certain sectors might be able to take advantage of some warming, particularly in southern Australia.

Particular hot spots for vulnerability include the urbanised coastal areas because of their exposure to sea level rise and extreme events. One of the big issues with climate change is not some of the slow-moving trends that you see in temperature or rainfall, it is the combination of that trend with extreme events. If there is a combination of some sea level rise and then an extreme weather event, the storm surge that is a result of that has a very large impact, particularly in our coastal areas. That is why our urbanised coastal areas—especially South-East Queensland, where there is a lot of low-lying developed land from the Sunshine Coast down to the Gold Coast—are particularly vulnerable. Kakadu, for example, is particularly vulnerable because of salt water coming into the Kakadu wetlands.

For agriculture, especially in the Murray-Darling—and we have seen a significant drought in the last 10 years or so in the Murray-Darling—climate change will add to the impacts of drought that we have witnessed in the last 10 years. Our world heritage areas—for example, the wet tropics and our Great Barrier Reef—will be impacted, and there are issues which go beyond climate for the Great Barrier Reef. Even without any climate change, the additional CO2 in the atmosphere is also being absorbed by the oceans and that is causing acidification. Even without any change in the climate—

Mr SIMPKINS—What is the main cause of drought?

Dr Ash—In Australia, there is the strong influence of El Nino and La Nina. That gives us a lot of our cyclical pattern in rainfall from the Pacific side of things. Over the last 10 years or so we have had more El Ninos than we have had La Ninas. We had a La Nina in 2007. Particularly for southern Australia—and the Murray-Darling, where we have had significant droughts—rainfall is also influenced by the Indian Ocean quite significantly. In the last few years, particularly in the winter periods, there have been equivalents of El Nino and La Nina occurring in the Indian Ocean—where we have a relative cooling off north-west Australia and a warming further over towards Africa. That leads to a decrease in the rainfall band that comes from the north-west down. So the combination of the equivalent to El Nino events in the Indian Ocean has led to the significant drought that we have had in the last 10 years or so. They are natural cyclical events, and the role of climate change on those rainfall patterns is still unclear. But what is clear, in terms of droughts—particularly the one we have witnessed in the last 10 years or so—is that the increase in temperatures that we have observed in Australia, about 0.9 degrees Celsius, exacerbates droughts because, as it gets hotter, plants use more water. So, even with the same amount of water in the system, you are getting an impact of the drought through increased temperatures.

Mr SIMPKINS—So those classic photographs of very dry country with cracked earth and cattle standing around with nothing to drink are not really showing climate change, but more El Nino?

Dr Ash—Dorothea Mackellar was right when she said, ‘of droughts and flooding rains’. Australia has a highly variable climate, particularly in the context of rainfall. That makes it more difficult to tease out the climate change signal in rainfall. When you have a lot of noise in the system—which we do in a highly variable climate—trying to get the signal of climate change out of it is more difficult. Yes, a lot of the droughts that we are observing now are still largely within the bounds of historical natural cycling in terms of rainfall. But, as I said, what have

exacerbated them significantly are the higher temperatures over the last hundred years. That extra one degree may not seem like a lot, but it does add a lot to the drought.

Senator FARRELL—I was under the impression—based on evidence that we received from the Coorong inquiry—that, in fact, the rainfall levels, particularly for the Murray, were at historically low levels.

Dr Ash—Yes. In terms of run-off into the streams. As the drought continues, we are now moving out of the historical—two years ago you could have said that the drought in the Murray was on par with the Federation drought. The extremely dry winters and springs that we have had in the last two years are now probably even taking it outside the Federation drought. I talked about amplifying effects—increased water use by plants means that there is less water available to run-off, so, when you do get a rainfall event, the ground is very dry and a lot of it is taken up by the ground. We are not getting the run-off events. You are getting a combination of very low rainfalls and higher temperatures drying out the whole system, so, when you do get a rainfall event, you are not getting the run-off, and that is why the dam levels and water levels are at historic lows.

Senator McGAURAN—I have a question about the same issue about the Murray and rainfalls. The Murray-Darling Commission said that what is occurring at the moment is the second-driest decade. The driest decade the Murray experienced included the years 1939-45, which, I guess, was drier than even the notorious Federation drought. I am desperately looking for the evidence to this statement; please take it on trust. I am sorry; I do not have the evidence here, but I suspect it was in their annual report or one of their publications. You would be across that anyway. Is that a true statement, and how do you align that with the slide up there?

Dr Ash—If you are talking about rainfall, that could well be the case. In terms of flows into the Murray system, I might have to take that one on notice. In terms of interventions to the flows in that period 1939-45 and now in the way we—

Senator McGAURAN—True, but would you not agree that the flows are related perhaps to the man-made demand on the water, irrigation primarily, and South Australia has grown, et cetera. So the flow in is perhaps less water taken by a man, which is not something I would imagine you necessarily scientifically would look at. You have got to present to us the rainfall patterns to try and sell it as, 'But the flow-in is different.' I am not sure that is in your sphere of research. We want to know whether it is wetter or not and we are finding out it is the second driest period.

Dr Ash—In terms of rainfall, I will do the checking on that. It depends on whether you are using parts of the Murray-Darling Basin or the whole Murray-Darling catchment the way the rainfall pattern has occurred. For example, for the whole of the Murray-Darling catchment, if you look at the long rainfall trend, so over the last 50 or 100 years or so, and in fact that map I showed before, you will find that there is not much of a drying factor. It is pretty stable and if anything you might have seen a slight increase in rainfall in that 100-year record over the whole of the Murray-Darling catchment. So in terms of rainfall patterns it is probably not much different. I will get back to you on the exact rainfall records for the whole of the Murray-Darling catchment across those two periods. CSIRO has just completed the Murray-Darling yield assessment. We can also check with them. But I think even allowing for the interceptions of

flows, we can look out what the flows into the system would have been, and I think you will find that in the most recent drought the actual flows would be lower than even 1939-45 because of the extra temperature we are now seeing and the drying effect that has had.

Senator McGAURAN—I would say it is less related to climate change and more related to man's demand on it. Just on that point, all I am trying to do here is bring balance back. You are the CSIRO, the flagship, and you are presenting a tremendous slideshow here. I think the question asked by my colleague Luke Simpkins was whether the drought along the Murray Darling is climate change related as in man-made related or El Nino related. CSIRO tell us, as others have, that it is El Nino related. That is pretty significant. It had to be asked of you and it is not in your slides there. In your hot spots the Murray-Darling is going to be severely affected by climate change when the real effect is El Nino. I think you want to put a proviso in there about the Murray-Darling. That is the high profile area, that is what everyone's eyes are on, and it ought to be brought into the discussion.

Dr Ash—Our response to that is that in terms of the historical rainfall patterns, as I said, over the Murray-Darling they are still within the natural bounds of variability from El Nino and Indian Ocean influences, so I think we can say that is certainly the case. As I have said before and reiterate again, the temperature increase we have seen even in the last hundred years does exacerbate slightly that natural drought that we see. The slide there that talks about hot spots includes the Murray-Darling. This is looking forward into the future because of the projected decrease in rainfall that we are likely to see across southern Australia due to climate change. So that might start to take things outside that natural cycling of El Ninos and La Ninas and the influence of the Indian Ocean.

Senator McGAURAN—You don't know that.

Ms HALL—What Senator McGauran verballed you on—saying that it had nothing to do with climate change and was just El Nino—is not your position? You are saying that climate change has exacerbated the situation and is impacting quite significantly. That is what your scientific research says—

Senator McGAURAN—Talk about verballed!

Ms HALL—That is what your scientific research shows. Is that true or is it not?

Dr Ash—We are saying that the rainfall patterns that we have received are still within the bounds of natural variability, albeit we are in a very significant drought at the moment. But the impacts of drought have been exacerbated by the observed increase in temperature, which has caused a further drying of the system and the way plants use water.

Ms HALL—So it is a combination of factors?

Dr Ash—Yes.

Ms HALL—Thank you very much.

Mr FORREST—With regard to that line of questions, it might be useful if you could explain to the committee what El Nino and La Nina are and what the southern oscillation index is. We get back to the situation where we are still talking about temperature and changes. My question is about the interconnection of global warming and El Nino with the temperature of the oceans, particularly the Pacific. Could you answer that to help the committee?

Dr Ash—El Nino is when we have a significant warming of the ocean in the equatorial region over in the central-eastern part of the Pacific and a corresponding cooling of the ocean in the western Pacific closer to Australia. With the high heat content in the ocean in the eastern Pacific, you tend to get more rainfall over the western part of South America and we end up with a drying in Australia. That is the El Nino event. La Nina is the reverse of that, where we see a cooling in the ocean in the eastern Pacific, usually matched by a warming of the ocean closer to Australia, in the equatorial regions in particular but also further south down into the Coral Sea areas. That drives some of the variability in rainfall that we see in Australia. I also mentioned that the Indian Ocean also plays a significant role. Those are the two natural influences that drive a lot of our variability in climate.

The role of global warming on El Nino and La Nina as phenomena is still very unclear and uncertain. Some studies indicate that there will be an influence of global warming on the El Nino phenomenon in having more persistent El Nino conditions, but the science on that is certainly not settled. Perhaps it might be useful for Greg Ayers to comment on that side of things.

Dr Ayers—I think that is a fair summary. I think the point you have made, though, is quite important here. Although the science is not settled on the effect on El Nino overall, the projections forward suggest a more El Nino-like state as we go into the future. That is coupled with, as Andrew has said, increasing temperatures that have a compounding effect upon the droughts.

Senator McGAURAN—What is the CSIRO's position on the El Nino effect and climate change? Have you done any work on that?

Dr Ayers—It is an area in which we are actively working with colleagues around the world. The current view, as I have said, is that when the climate models project out into the future, a more El Nino like state becomes more common. But I do not think the science is settled at this stage. I think the key point that is being made here is that the El Nino/Indian Ocean dipole influences on Australian climate are quite clear, and they interact with whatever trends will be there in the climate as well. I think the increasing temperature and a tendency towards dryness in the southern latitudes that are inherent in the models will overlay the El Nino and Indian Ocean effects.

Mr SIMPKINS—I want to clarify something that Dr Ash said about current rainfalls in Australia remaining within natural variations. Is that an accurate statement?

Dr Ash—It is accurate for what we have seen over the Murray-Darling Basin. There is now clear evidence that the drying that we have seen over south-west WA, for example, has a human induced influence. Research has shown that there is a strengthening of the pressure systems between Antarctica and the mid latitudes, and that is dragging further south the frontal systems that just hit the bottom of Australia in winter and spring. There is also fairly clear evidence now

that that movement in the frontal systems is a result of both ozone increase—that the ozone hole, in fact, is still around—and some of the greenhouse gas warming, and that is expected to continue. So it is not true to say that across the whole of Australia there is not some observable influence of climate change on rainfall patterns. In northern and north-western Australia, for example, we have seen quite a reasonable increase in rainfall in the last 30 to 40 years, and there is some suggestion that is related to aerosols over Asia. As Asia has started to industrialise, increased aerosol use has influenced rainfall in that monsoonal part of the north-west of Western Australia. Across Australia there are signals of climate change influencing the rainfall patterns. It is still not clear, though, over the Murray-Darling. In that area there has not been, in the long term, a significant shift.

CHAIR—Dr Ash, I invite you to resume the presentation.

Dr Ash—In talking about the Great Barrier Reef there, and indicating that there are not just direct climate influences, the same applies in our natural ecosystems. The carbon dioxide increase that we have seen in the atmosphere, even without any other climate changes, will significantly alter the competitive interactions between plants. So we will start to see a shift in natural vegetation patterns simply as a result of CO2 increase and, similarly, we will see, simply as a result of CO2 increase, an increase in ocean acidification which will not only affect iconic areas like the Great Barrier Reef but also life in the ocean more generally. Part of the shell that supports single cell organism types of algae is based on calcium carbonate, so they will also be affected. Alpine areas will also be influenced in that as they get warmer, plants and animals cannot go any higher. I mentioned also that south-west Western Australia, because of the drying trend and because it is one of Australia's biodiversity hotspots, is projected to be particularly vulnerable.

If we move on to the next slide, this is now getting into how we are responding to climate change. We are here using a little sea film model to show that if we have low mitigation and we do not reduce greenhouse gases significantly, we are likely to see higher impacts and a need to adapt to climate change more significantly in the future. In comparison, if we do start to reduce greenhouse gases now, the impacts of climate change are likely to be lessened and our adaptation response will not need to be as great. It is worth noting, though, that we have already got enough greenhouse gases in the atmosphere, and it will take a number of decades to play out. Even if we capped our emissions now, we would still see a significant impact 20, 30 or 40 years down the track to which we would need to respond.

So that was really just giving you a picture of the interaction between adaptation and mitigation. There is now a set of slides which are very specifically about how we are responding, in some of our technology research, in reducing emissions. Dr John Wright is the best person to be speaking to those.

Dr Wright—We have put in a selection of slides illustrating some of the CSIRO's work in looking at low emission technologies in the Energy Transformed Flagship program. The first slide is the carbon capture impact. This is a program where we are developing a series of processes for extracting carbon dioxide from the flue gases of existing power plants. We use a combination of different chemicals to do this and we are running these as pilot plant operations. These are very small demonstrations of the technology—just so that we can get used to what is going on in these plants under a variety of different conditions. We take pilot plants, connect

them to operating power stations, take a sidestream from their flue gases and measure the efficiency with which we can extract the CO2. At the moment we have four of these, three of them in operation: one in Loy Yang in Victoria, a brown coal power station; and one at Delta Energy in New South Wales, a black coal power station. We also have one in Queensland, at Tarong power station, approved now. It is being built as I speak. We also have one operating at a Chinese power station close to Beijing; it got up in time for the Olympics.

All these plants work slightly differently with different gas compositions. So we are building up, I think, quite a magnificent database of information as to how this particular technology, which we call post combustion capture, is working. That is the sort of technology that will be needed if and when we need to reduce the CO2 emissions from operating our plants. These are all coal based in this case, but it can also be retrofitted to gas-fired power stations if we get to that stage.

The next slide is a cutaway that comes from the CO2CRC, and that is a pilot operation run by that CRC in the Otway Basin in Victoria. The graphic shows that in that area CO2 occurs naturally. It is a source of CO2 that we take from the deep strata and it is 'relatively' cheap. It is processed into liquid CO2 and then injected back into the formation about two kilometres distant. We have a whole series of monitoring exercises to look at the way that CO2 is behaving. The gold stars you see on that diagram are where the CSIRO is active with the CO2CRC. We are basically demonstrating how that CO2 that we extract from power stations can be effectively handled and sequestered—stored—in the deep earth. So that project is proceeding. They are looking at storing something like 10,000 tonnes of CO2 and they are about halfway through. Obviously the whole process has been extensively modelled from our reservoir engineering experience and, of course, we are keen to see whether the reservoir and the storage process actually does what our models are saying. At this stage it is a case of so far, so good.

The next slide illustrates something a little bit different. It is a technology that we have developed called the UltraBattery, which is a very advanced lead acid battery that contains some really advanced technological attributes that make it ideal for hybrid car use. We have developed this in conjunction with a Japanese company. We put it into a Honda Insight in the UK and drove that car for 100,000 miles—160,000 kilometres, as we would put it—over the test track, and it went perfectly.

The advantage of the UltraBattery is that it is only slightly heavier than the nickel metal hydride batteries it replaces and we could make these for one-third of the cost. It is being looked at very seriously around the world at the moment. We have licensed the technology in the USA, we have a company in Japan and we are negotiating with European interests to have the UltraBattery accepted as a hybrid car battery around the world. If we can do that then it will make the hybrid car technology cheaper and, hopefully, encourage more people to use it and reduce overall CO2 emission intensities from the transport industry.

The next slide is not a mobile application, but an energy storage application. The UltraBattery is an extraordinarily robust battery. It has a lifetime of something between three to five times that of a conventional lead acid battery and we are working with a wind manufacturer who installs the UltraBattery in a smoothing device, as an energy storage device with wind. We have spun out a company called Ecoult. It used to be called Smart Energy Storage Pty Ltd and it is a

combination of ecology and UltraBattery—chosen by them, I might say. This company is now marketing this technology worldwide.

The next slide is a pretty picture, labelled solar gas, of our whole-of-field that we have built at the Newcastle Energy Centre. It is a 500-kilowatt solar field which contains about 200 mirrors reflecting the sun's energy up to a central tower. There is a reactor mounted on that tower, and that reactor is basically a solar furnace. It can get up to temperatures of 1,200 degrees if needed, but we are running it at about 800 degrees at the moment. It is re-forming natural gas through to what we call 'synthesis gas' with the addition of steam. Synthesis gas contains about 30 per cent more energy than the original gases that go in. In other words, we are storing solar energy in the form of a changed gas composition. We are storing it in chemical bonds, in effect, and we can take that synthesis gas and burn it in a turbine for the generation of electricity. We could take it and turn it into liquid fuel if that was what we wanted to do.

We are at the tail end of negotiations with the State of Queensland and a couple of gas companies through the Asia-Pacific partnership to set up a five-megawatt demonstration system in Queensland. That is proceeding quite well at the moment. Again, this is renewable energy technology. It really takes advantage of Australia's solar energy resources. This system is probably the closest packed field based on a multi-tower system in the world at the moment. If you wanted to scale this up, you would just continue to build towers and fields. It is readily scalable and really quite compact compared to some of the other solar energy systems being developed around the world. They are just a few examples of some of the low emission technologies that the CSIRO is working on.

CHAIR—Is there anything else by way of presentation before we move to questions?

Dr Ash—It might be worth going to the very last two slides. The other side of mitigation that we are looking at in the CSIRO is biosequestration—how we extract CO2 from the atmosphere through plants and soils. There is a fair amount of work going on about what is achievable through forestry, agricultural land management and sorb carbon. We are improving our measurement methods and also examining the trade-offs between different land uses and what impacts there are by going down a strong biosequestration route—what that means in terms of food, water and other issues. There is a fair bit of work going on there.

The last area I wanted to touch on was adaptation, recognising that we need to adapt to both climate variability and climate change. To use a coastal example, there are a number of ways we can adapt to climate variability and climate change in particular. There is event protection, where you can move things, such as sand, around. You can start thinking about putting in hard sea walls—barrages. For example, the Dutch have decided they are going to deal with the issue by building their wharves and their docks higher and higher. You can also have natural barriers that reduce the event such as foreshores which are well protected. Then you move on to issues like damage protection, harm minimisation. For example, cyclone building codes currently stop around Bundaberg in Queensland. Is there a need to shift those further south? They are relatively low cost to include in a new house but offer a fair amount of protection from wind events—and not just cyclone wind events. I live in Brisbane. If you had cyclone building codes, there would have been much less damage to all those houses after the storm event that we had a couple of weeks ago. As I said, it is relatively low cost at the time of construction.

There are those sorts of events The last slide is about getting into planned avoidance and planning and building codes, getting consistency around our planning and building codes so that we build in places that are not vulnerable. Other ways of adapting are through loss distribution—things like insurance and government support through disasters. Finally, there is acceptance, where we decide an area is no longer liveable and have a planned retreat. That is an example of how you might go about adapting to climate change in our coastal environment. They are the sorts of scenarios that we will need to start looking at fairly soon. I will wrap up the presentation there.

CHAIR—I have four matters I want to ask about. When you talked about radiative forcing, is that the expression that you are using to cover the net effect of the warming and cooling influences that you described?

Dr Ash—Yes. That is the warming in watts per square metre. The warming influence goes back to basic physics on how they respond in the atmosphere.

CHAIR—That chart you had about observed changes in rainfall for Australia had a striking correlation with where our population is in terms of the areas that are being hit with reduced rainfall projections. Are there any other factors that could contribute to this? I have thought about the loss of vegetation cover that you might get with population settlements—though I am from Melbourne and, while I think there has been a lot of clearing, there has also been a lot of tree planting. I do not want to jump to conclusions, but it is striking that the areas that are projected for the reduced rainfall are the areas where the people are.

Dr Ash—A point of clarification: that is not the projection. It is the rainfall we have observed in the last—

CHAIR—Sorry—1950 to 2007.

Dr Ash—You are correct that it is where a lot of the people are living. There was a paper published by the University of Queensland last year which looked directly at the influence of land clearing that we have had in the last 200 years and whether that has played a role in terms of regional rainfall. They detected a signal from land clearing in the way they looked at it by putting land clearing into climate models and leaving it out. But there is still more work to be done in that space. I do not think it could explain all the rainfall decrease that we have seen to date, particularly in eastern Queensland.

CHAIR—We were having an extensive discussion about the Murray-Darling Basin earlier. Senator McGauran talked about the issue of reduced flows into the Murray-Darling, but I thought he might have been confused about the difference between run-off and extraction for irrigation, stock and domestic et cetera. When you say to us that there are reduced inflows into the Murray-Darling system and that you attribute that to the temperature increase, you are measuring inflows as opposed to extraction and water being taken out.

Dr Ash—Yes. I will take part of that question on notice. I will get some more detailed information from our group in Water for a Healthy Country who deal with that so that I can give you more precise answers on inflows. With the way they do the calculations, they can calculate

what the inflows into the system would have been before anyone has extracted any water—effectively the run-off into the system.

CHAIR—You talked about forestry agriculture soil carbon. I think we have been told in terms of policy making in the past that this is an important area but it is very difficult to measure. Work is being done on this question of measurement. Do you think we are getting to the point where these things can be measured sufficiently well to include them in the policy making?

Dr Ash—Yes. There has just been initiated a whole future farm industries funding package to try to get a better handle on the measurement of the sequestration in soils and in vegetation and to get it to a point where it can be included in a policy setting. It is probably fair to say that for trees, where 80 per cent of the carbon is above ground, there are some pretty robust relationships for estimating the carbon stored in those situations. So I think that is certainly feasible. Soil carbon is a much more difficult one; it is more difficult to measure. It is highly spatially variable, and also it is more susceptible to change over time. For example, a drought will reduce the soil carbon, and you get more turnover. You end up with a highly variable pool. Where you measure it in a point of time can influence what might appear to be what you have stored there. So it is a very challenging one both in terms of measurement and how you use its uptake when it is not stable through time.

Ms PARKE—In following up on the chair's question in relation to agriculture, I am particularly interested in methane gasses since they are 21 times more powerful than carbon dioxide. What kind of research has been done to look at ways of reducing methane emissions, given that a rapid reduction in those gasses would have a significant effect on the overall greenhouse gasses in the atmosphere because they are so much more powerful than carbon dioxide?

My second question relates to the submission that we had earlier from the Forest Industries Association. They talked about carbon being stored in wood products and how that is not being sufficiently taken into account in policy making. I would like to hear your views on that as well.

Dr Ash—In relation to the first question on methane, work has been going on there in two areas. One area is feed quality. The amount of methane produced depends on the feed quality. If you have very low feed quality then you tend to get relatively more methane produced. The idea is to improve the feed sources so that the amount of methane produced per kilogram of product, whether it be beef, lamb or whatever, is a much lower contribution of methane.

The second area is much more challenging. I think a fair bit can be done in the first area but the second area is about trying to alter in some way the functioning of the rumen microflora, the gut microflora, that produce methane: CSIRO has a reasonable history in this area. At one stage it tried to develop a vaccine that might have knocked out some of the methanogenic bacteria in the gut, but that was not all that successful.

Worldwide there is a fair research effort going on for ways by which the methanogenic bacteria might be reduced. People are looking at genetic manipulation technologies and other ways of altering the competitive balance. It is a pretty challenging area because the whole gut of a ruminant animal that produces methane is incredibly complex and robust to assaults on it in terms of trying to alter the mix in there. I think it will be some time off before any breakthroughs

are made in that particular area to reduce methane. But certainly, in terms of improving feed quality and getting much faster rates of growth of animals, you can, per unit of product, reduce the methane footprint quite a bit.

Ms PARKE—I was in a delegation to Argentina in August and the Argentinians expressed a keen interest in working with the Australian research bodies on reducing emissions in agriculture because I think over 50 per cent of their greenhouse gas emissions come from agriculture. So they have a primary interest in that. I do not know if you have had any contacts with Argentinian departments or research agencies.

Dr Ash—Yes, we do have a bit of contact with those departments. As part of the Future Farm Industries R&D call-up there will be some nationally coordinated projects on methane reduction.

Ms PARKE—Right.

Dr Ash—I think there is a reasonable effort being made to get a coordinated effort across Australia to tackle that issue. In relation to the second question around wood quality, I do not have a lot of understanding or knowledge of that area, and we would have to take that on notice, particularly as it related to the way wood is, or the way it is stored—I am making that one up! The carbon that is stored in wood products, and the way that is currently treated, is not all that conducive to putting timber away, so to speak. We will have to speak with our colleagues in our Forestry and Forest Products area to give you an answer on that one.

Ms PARKE—Thank you, that would be good. Wood products include things like paper made from wood chips, according to the industry, so we would be particularly interested in hearing the CSIRO's views on that.

Dr Ash—Okay.

Mr FORREST—I have six questions, and Dr Ayers will not be surprised by some of them. I want to stretch the chair's question about noticing observed changes in rainfall for the Australian continent and the coexistence of the brown areas with the high population of the east coast. Are there local initiatives or impacts in addition to what is happening globally that are effective? I am particularly interested in the brown area east of Melbourne and the brown areas around Sydney and Brisbane, particularly where there is an enormous amount of industrial activity, power stations sites and whatever. Has the CSIRO done any work to satisfy the question of local impacts?

Dr Ayers—The CSIRO has looked at both the potential physical effects of aerosol pollution from cities on rainfall and in the regions concerned. I note that whilst it is true there are areas near capital cities, equally there are areas in-between of decreased rainfall in whole regions where there are no populations that are upwind of or between cities. We need to be careful to look at the areas where there are people and the areas where there are few people.

Having said that, the international scientific community has just completed a review of the effects of aerosol particles on clouds and on climate and the role that they play. The conclusion reached there is that, both in Australia and internationally, the evidence that fine particles have suppressed rainfall—I think this goes to the heart of Mr Forrest's question—is not convincing.

There are both rainfall reduction and rainfall enhancement effects caused by urban environments that have been demonstrated at the physical level but not have been demonstrated adequately at the area level. Whilst it is possible that small particles have a physical effect upon clouds that would lead to rainfall reduction, there are other effects of larger particles that would counterbalance that and lead to enhancement of rainfall. I will not go into the details of the physics; I will just say that this can be looked into later if required.

The other influence of cities and urban areas is to increase heat input to the atmosphere through the urban heat island effect, which stimulates convection and local convergence, which in a number of studies suggests that rainfall would be increased by cities. I am afraid that, like many other aspects of climate and weather science, there are many competing processes at hand and there is not a straightforward and simple answer. But the summary that was published recently suggests that at this stage there is no compelling, strong evidence that the sorts of declines that are evident here, which are quite profound, could be attributed in the main to effects such as those which I have been discussing and in which, I know, you have an interest.

Mr FORREST—To summarise: you are relying on international work rather than local work? I was not quite clear.

Dr Ayers—There is international work. There is also local work. I have a paper that at the moment is going through review in the Swedish journal *Tellus*. It looks at evidence that has been presented in the past that suggests that rainfall in south-east Australia has been suppressed by air pollution from Adelaide and other industrial plant in the area. My conclusion, from analysing the data, is that that particular proposition is not valid; it is unproven.

Mr FORREST—I look forward to your paper. I go to the first couple of slides you showed us, which boldly allow us to project back 400,000 years. How, unless you are Methuselah, do you do that projection? That is temperature and CO2 levels.

Dr Ayers—Those are not modelled. They are deduced from observations made in Antarctic ice cores. There is three-to-four-kilometre-deep ice at the centre of the Antarctic continent, and the ice at the bottom is up to a million years old. By drilling a core, you can get ice that has been laid down between the present and backwards perhaps as far as a million years. There is a project going on at the moment to drill a million-year ice core—an international activity in which Australia has some interest and some contribution to make. Having that record of ice that goes back a very long time, there are methods for dating the ice and working out the time. Then you can analyse the ice itself. By looking at the ratios of oxygen-16 to oxygen-18 or deuterium to hydrogen in the ice—these are the two atoms in the water molecules—changes in those ratios reflect the temperature at which the ice was formed. In effect, you have a proxy thermometer and can determine the temperature at which the ice was formed. It is not a global average temperature; it is the temperature locally in the Antarctic. That gives the temperature record.

The same small samples of ice at different times along that record have dissolved carbon dioxide in it. Carbon dioxide is known to be stable and has been demonstrated to be stable in ice, so the trace quantities of carbon dioxide can be extracted and analysed. What you have here is an archive of temperature through the isotope ratios in the ice and the content of CO2 and methane—that can be done as well—greenhouse gas levels going back a long way. These are records that are deduced from measurements made on ice cores.

Mr FORREST—I note, whilst I can see the unprecedented results of the last century, that there is a cyclic pattern in all this. How can you be convinced that that cyclic pattern will not be different in the future? I concede that the concentrations and temperature are much higher of late, but the temperature is very cyclic. I am wondering how you can be convinced that this is not part of a thousand-year cycle.

Dr Ayers—I think you are right that we would expect in the future the causes of the climate variability shown in these paleo-records to continue, so the climate forcing, if you like—and you can reduce it to watts per square metre if you really want to—will continue into the future. The difference here is that human activities have intervened by adding greenhouse gases at the very end, near the present time, around zero. That is the point of this slide.

The reason that there have been previous ice ages and warm interglacial periods is understood. It is driven by what are called Milankovic cycles. They are to do with slight wobbles in the earth's orbit as it revolves around the sun. These have periodicities of 100, 000, roughly 40,000 and 20,000 years for three different sorts of wobbles. Each of those wobbles affects the distance between the earth and the sun and the angle, such that there are slight variations in solar input to the earth. It is those slight variations in solar input to the earth on these long timescales that drive the climate change.

The point of adding the carbon dioxide here is that this demonstrates that carbon dioxide is an important greenhouse gas, because as the earth is warmed coming out of a glacial period by slight changes in its orbit, the change in energy that comes from the sun is not sufficient to cause a temperature increase of five degrees or so. What happens is that, as the earth warms, more CO2 is put into the atmosphere by biological processes, and that CO2, through the feedback that we are talking about in terms of human addition of CO2, enhances the warming. This is an ice demonstration of a coupling between temperature and greenhouse gases.

Mr FORREST—I am interested in precipitation and wondering about mitigation. I can understand why the emphasis is on the reduction of carbon emissions and on research going into abatement and everything else, but what is the CSIRO doing about strategies for enhancing precipitation, particularly for the Murray-Darling Basin?

Dr Ayers—At this stage, CSIRO is not engaged in precipitation enhancement activities. Our view is that, with regard to precipitation enhancement, there is a physical basis behind the proposition that cloud seeding, for example, may be effective and, as you know, we have had a long history of engagement in that activity. However, we believe at this stage that enhancing precipitation via, for example, cloud seeding is unlikely to be effective in a situation where we have decreased rainfall and drought conditions. At best, that sort of rainfall enhancement will be useful for water management in periods when there is a lot of rain and so an enhancement might induce additional rain, but when in fact you have a drought and the conditions for cloud formation and rain formation in clouds is below normal then this seems, in our judgement, not to be an effective means of managing the water resources. Our view is that the contribution that we can make from the science is better made through understanding the changes that are going on and assisting in water management, rather than attempting to modify the weather—at our current level of understanding.

In Israel there has been a recent review, which you may not be aware of, of the efficacy of cloud-seeding activities carried out in Israel. The review is in parallel with those carried out in Tasmania by CSIRO some time ago. To my knowledge, they are the only two situations in which there have been full scientific evaluations. The recent analysis carried out in Israel by a group independent of the scientists who carried out the work suggests that the efficacy of rainfall enhancement in Israel has been much less than the scientists involved in the project had believed.

Mr FORREST—A supplementary question: in your answer, in reference to the Murray-Darling Basin, you were still talking about drought. Are you also not convinced that the current situation and the issue of global warming and climate change are related, or did I mishear what you said? At the moment, none of us is sure whether the massive reduction in precipitation for the Murray-Darling Basin is a direct result of the issue of climate change or whether it is just part of the normal droughts which the continent has endured for centuries. You made reference to the current drought, so I am assuming from that that you are also not convinced that what we have seen for the last seven or eight years will not naturally heal itself.

Dr Ayers—When I used the term 'drought', I meant a dry period. I was not attributing cause; that was just a generic use of the word. We know from recent work in the Murray-Darling Basin that there has been a strengthening of the subtropical ridge. In the south-west part of eastern Australia, the southern annular mode referred to by Dr Ash before has been strengthening, and we can see a relationship between that and a decline in rainfall in the period May through October. That is in the southern part of the Murray-Darling region. That relationship—the strengthening of the subtropical ridge—has been trending upwards since the 1970s, and it follows the curve of the global temperature increase in the planet fairly well. On the southern part of the region, there seems to be a rainfall decline in the autumn-winter period that is related to this strengthening of the subtropical ridge. In the northern part of the Murray-Darling Basin, the rainfall relates not to the strength of the subtropical ridge and the southern annular mode but to the north-south gradient in mean sea level pressure along the east coast.

Overall, in the southern part, this strengthening of the subtropical ridge is evident in terms of an increased surface level pressure. So there is some signal there that suggests a relationship to some degree, but it is complicated, and the fact that there are different drivers on either side of the subtropical ridge, which roughly cuts across the middle of the Murray-Darling Basin region, means that we are in an active area of research at the moment. I would say that we have a little more understanding, having identified this strengthening of the ridge, and it does seem quite plausible that it is related to some of the other pressure changes associated with the southern annular mode as referred to by Dr Ash. Those sorts of changes are the changes we expect based on the global climate models associated with increased carbon dioxide and greenhouse gas emissions and with increased radiative forcing.

Mr SIMPKINS—I have three or four questions. I will try to be concise and try to frame them so that you can be precise as well. I appreciate all of you being available today. Clearly the CSIRO stands unequivocally with the concept of anthropogenic global warming. Would you say that all scientists within the CSIRO stand by it?

Dr Ash—That is a difficult question to answer. I am sure that in a community of 6,000 scientists there will be a variety of views. I do not directly know of any within CSIRO, but I am

sure there would be a number of scientists within CSIRO who have some doubts about the link between human-induced greenhouse gases and climate change. But I think the vast majority of them would support the concept of anthropogenic global warming.

Mr SIMPKINS—When considering the parts per million of CO2, there would have to be a direct correlation, would there not, between parts per million and increases in global temperatures?

Dr Ayers—Perhaps I will answer that question, if I may. The correlation overall, over long time periods, is one that you would expect but perhaps not year to year. I will give you an example: you would expect that it would be warmer in November than in August because we get more sunshine and things have warmed up, but we cannot guarantee that every day in November will be warmer than every day in August because there is natural variability in the climate systems and weather systems. So, whilst overall that conclusion is absolutely right—and you see it in the long time series shown in the ice core records; the relationships are quite clear—you cannot guarantee on an individual day, year or location. Another example is that the global temperature maximum was in 1998 but Australia's temperature maximum, the hottest year in Australia, was in 2005. These are typical of the variability that we experience in our weather on a daily basis but it also scales right up to the climate scale as well.

Mr SIMPKINS—I want to go back to one of the charts in your presentation, 'Causes of climate change since 1900'. The graph itself is predominantly blue. That finishes in the year 2000 and the IPCC's copy mark line there is 2007. Is there more to that graph somewhere else, and does it show the same things?

Dr Ash—This graph is from the IPCC fourth assessment report. The model runs would now extend beyond the 2000 period. I think that is the period the IPCC chose because even in the 2007 report a lot of the models and outputs had to be completed by about 2003 or 2004, so it reflects a bit of a lag period and that they wanted to have a set period when all of these cut off. Those model runs could now extend out to 2006 or 2007. Greg might want to comment on that.

Dr Ayers—The model runs done by the IPCC extend out to 2100 and beyond, depending on which series of simulations were performed. That demonstration was just to show models over the period for which there are observed data, so that you can compare the model with the observed data. But the models themselves go out much further than that.

Mr SIMPKINS—Global temperatures are determined and assessed via satellite and weather balloon—is that correct?

Dr Ash—Yes.

Mr SIMPKINS—They are pretty clear and objective sources, as opposed to having stations on the ground. Have there been any average decreases in global temperatures since 1998? Have they plateaued, decreased or just continued to rise?

Dr Ash—I think that Greg, in part, answered this question before. The temperature over the last 10 years or so has plateaued at a higher level. In some ways it reflects taking just a 10-year slice rather than a longer slice, because 1998 was a significant El Nino year and produced, on a

global basis, the highest temperature on record, and in the last couple of years we have had some La Nina events. So you are going from looking at an El Nino to, in more recent years, looking at a La Nina event. That natural variability may well mask what is an ongoing increasing trend in temperature.

Mr SIMPKINS—There was a significant El Nino event in 1998. It was also the time when a lot of people started to be greatly concerned about anthropogenic global warming. As you have just indicated, you attribute that increase in temperature in the world to El Nino, yet such a view did not seem to gain a whole lot of airplay with the IPCC. What would you say to that?

Dr Ash—Sorry, I did not get the gist of that particular question. Are you suggesting that the IPCC did not make prominent the fact that 1998 was the warmest year on record?

Mr SIMPKINS—Yes: that, along with the influence, as you have just stated, of the El Nino effect.

Dr Ash—I think that within the IPCC report, particularly in the Working Group 1's full report, the issue of natural variability in the climate system is fairly well covered. Greg, do you have any particular comments on this?

Dr Ayers—No. My experience with the IPCC is that they recognise the influence of El Nino. Like you, Andrew, I do not quite understand the gist of the question. I believe the IPCC does pay attention to those activities as well.

Mr SIMPKINS—What I am getting at is that 1998 was held up as a year of great significance in advancing the theory of anthropogenic global warming. All the impact of a hot year in 1998 seems to have been attributed towards—and this is not really science, I guess—AGW. In the wide variety of non-scientific commentary it was all about AGW and there was no mention of El Nino.

Dr Ash—I see where you are coming from there. I think it is an issue of needing to do a better job on the communications side of things in trying to highlight a long-term trend occurring in the context of a highly variable climate system at scales that go from days to weeks to months to decades. The issue is in communicating that long-term climate trend, because the years in the early 2000s, while they were not as warm as 1998, were still years where, even though they were cooler than in 1998, we had the second, third, fourth and fifth warmest years.

Senator CASH—Dr Ash and Dr Ayers, a number of people have made representations to me regarding what they believe have been the effects of the Kyoto protocol on the world's rainforests. What is the CSIRO's position in relation to the question of perverse effects of the Kyoto protocol on the world's rainforests? Has the Kyoto protocol led to the destruction of the world's rainforests and, if so, could you quantify the amount of rainforest that has been destroyed because of it?

Dr Ash—I am not in a position to be able to answer that one now.

Senator CASH—Are you able to provide some information on the position of the CSIRO in relation to the Kyoto protocol and the world's rainforests?

Dr Ash—Yes, if we can. I am not sure we can actually derive the numbers or establish that link. I think this is just speculation here. The link would be fairly tenuous. But we can certainly see if there has been any work published on that. I do not believe the CSIRO, to the best of my knowledge, has done any specific work on the link between the Kyoto protocol and land-use activities that have occurred in other parts of the world.

Senator CASH—The second area where people have made representations to me is that of carbon leakage. Dr Ash, I believe you were the one who was talking about the slide on responding to climate change. You said we need to cut down on our emissions to reduce the impact of climate change. When you say 'we' are you talking about Australia or about a global approach? One of the issues that has been raised with me on a number of occasions is that if Australia goes it alone in reducing its carbon emissions, whilst on a domestic level that may have an impact, globally we might be increasing the carbon footprint because of potential carbon leakage. Does CSIRO have a position on that?

Dr Ash—Sorry for being unclear before. The 'we' I was referring to there was more on a global basis than an Australian basis. To have an impact on the climate system we need to reduce emissions globally, not just within Australia. As you said, we are a modest contributor on a global basis to world emissions—somewhere in the order of one per cent—but making an effort to reduce emissions in Australia, we saw through Dr Wright's presentation, involves the development of new technologies. Those technologies can be deployed elsewhere in the world, so Australia can start to have an influence well beyond its shores in reducing greenhouse gas emissions through new technology development.

Senator CASH—What happens if, by reducing our emissions in Australia, the overall impact is carbon leakage in the types of actions that we take to reduce our emissions? Will that have any advantageous impact overall if what we are contributing to is carbon leakage?

Dr Ash—I am not entirely sure of your question there, but I presume you are saying that if by reducing emissions through whatever mechanisms that industry might disappear offshore and be—

Senator CASH—Absolutely. Correct.

Dr Ash—less carbon efficient in wherever it goes, and that you could have trade-offs in that sense. I might get John Wright to comment on that one. I am not aware of any research in that particular context that is going on in CSIRO.

Dr Wright—We are not actually researching carbon leakage. I think years back ABARE did quite a lot of work on carbon leakage, but perhaps that now has become somewhat superseded. I assume you are referring to a carbon-intensive industry in Australia that perhaps would be disadvantaged by having a price on carbon.

Senator CASH—Correct. For example, the cement industry is one of those industries.

Dr Wright—It puts their whole cost structure up. They become trade exposed and they find that, with that added impost, it is perhaps more sensible economically and commercially to either get out of the industry or transfer the production of that product, whatever it might be, to an

overseas country which, the assumption has to then be made, is going to be higher greenhouse gas intensive per unit of product. That is really the scenario for carbon leakage as I see it.

A number of things are happening here. Let's pick a developing country, a big one, and let's say that the product is going to be reduced in Australia and picked up by that big developing country. In all the developing countries now there is a much greater degree of acknowledgement and sense that the increasing CO2 levels in the atmosphere are a worldwide problem and that no country is going to be immune from them or the possible effects that will arise. For example, the power plant that we have set up in China is a good illustration of that. China is really putting its maximum effort into growth and lifting its standard of living and, as a result of the growth, their CO2 emissions are going up and will overtake the United States very soon.

But they are also very well aware that they are part of the global community and they also have a need to look at their own carbon intensity, which is precisely why they are working with the CSIRO to start to look at ways and means of reducing it. Also, if there are new plants going in to produce that product, they will be the latest, leading-edge technology. For example, all of the new coal-fired power plants going into China at a rate of about one a week—I find it hard to get my mind around that statistic, but it is apparently true—are using leading-edge technologies. Conventional technologies, yes, CO2 emitters, yes, but they are the best technologies that can be delivered. So I suspect the carbon leakage is a possibility, but I think it is somewhat modified in recent times as the issue of carbon emissions becomes much more accepted as a global problem.

Senator CASH—Thank you, Dr Wright. I have one more question to follow-up: are you aware of any carbon leakage from European countries and, if so, what is that?

Dr Wright—I have to say I am not. That does not mean that it does not occur, but I do not have that information.

Senator McGAURAN—I heard it said before that the increased aerosol use from our Asian region has created the extra rainfall in Northern Australia. Is that what I heard? What is the science behind that?

Dr Ayers—This is a hypothesis that has been articulated by CSIRO scientists. Climate model runs were done with and without air pollution, if you like, in the so-called Asian brown cloud region—India and China, that region—where there is a great deal of emissions of fine particles to the atmosphere. So the science behind it effectively is that when you add those pollutant aerosols to the atmosphere, just as you saw on the IPCC's climate forcing diagram, there is a slight cooling effect caused by these particles in the atmosphere. They obscure the surface and reflect sunlight back, so there is local cooling in effect in regions where there is very dense air pollution. The effect of that over a large region, and in the tropics, is to shift the convection driven by surface heating—it happens in the Southern Hemisphere—further to the south and enhancing the convection over the tropical part of Australia in contrast with where it would occur in the Northern Hemisphere if there were not this local cooling effect. Essentially, that is the physics behind it.

Senator McGAURAN—So the bottom line is the India-China pollution is increasing rainfall in Northern Australia?

Dr Ayers—That is a hypothesis that has been investigated with the climate model, and there is an indication that that may be one of the potential—

Senator McGAURAN—Is it a hypothesis indication or is it so? When you first stated it, it was so.

Dr Ayers—I believe that was part of Dr Ash's statement before, and I am sure that whatever he stated was not meant to be stated with 100 per cent certainty. That is an area that we are working on and the indication is that that is a plausible fiscal hypothesis. That has been tested and there has been a peer review publication on that matter released recently. It is a very plausible—

Senator McGAURAN—Why hasn't it reached Perth then, in southern Australia, this increased rain from our nearest neighbours?

Dr Ayers—Because the distance between the tropics in the north-west—so this is about the monsoonal precipitation being strengthened because of differential heating in the tropical regions where the moisture derives from the ocean. Perth is too far south; it is not subject to the same summer rainfall maximum as happens in the tropics driven by the monsoonal circulation. In fact, Perth's rainfall is a maximum in the winter and derives from the mid-latitude winter storms. It is a different meteorological regime.

Senator McGAURAN—It was an aerosol effect that I heard initially. Is that true?

Dr Ayers—Aerosol is the word that scientists give to fine particles in the atmosphere.

Senator McGAURAN—Whatever happened to the aerosol effect upon the ozone hole? By the way, whatever happened to the ozone hole?

Dr Ayers—The ozone hole is still in existence. If you wish to follow it up, the World Meteorological Organisation website has a bulletin and at this point in the year the ozone is recovering. In fact, I was looking at a graph of it just this morning for another purpose. So that still exists. I would like to make a clarification: the aerosol effect on the ozone hole is not due to fine particles, but the word 'aerosol' means tiny particles suspended in the atmosphere, and so spray cans generate aerosols when they spray. It was not the aerosols themselves—the tiny particles—that affected the Antarctic ozone hole; it was the ozone-depleting propellants used in the cans. So perhaps there is a little bit of confusion there. But there are two different effects. One is the depletion of Antarctic ozone because chemicals of an ozone-depleting kind—those that contain chlorine and bromine in particular have made their way to the stratosphere. That is a different effect from the aerosols that are fine particles in South-East Asia affecting convection over Australia.

CHAIR—Thank you very much for presenting your evidence today. You have been very generous with your time and forthcoming with your answers and the committee appreciates that. The committee has accepted your slide presentation as an exhibit.

Resolved (on motion by **Mr Simpkins**, seconded by **Mr McGauran**):

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

Committee adjourned at 11.51 am