Met Office

Ask the expert — Prof Julia Slingo

Part 1

As Chief Scientist of the Met Office, I'm delighted to have the opportunity to respond to your questions that you, the public, have sent in around the science of climate change. It is very confusing and there are a lot of mixed messages out there about what climate change really means, how robust the science is and, of course, the science is also very complex, but I think there are some clear messages, and these messages are really important, particularly as we go into the really unprecedented negotiations that must go on in Copenhagen in the next two weeks, to address the challenge that we the world face from growing emissions of carbon dioxide in particular. So, in the next ten minutes or so, in this podcast, we're going to talk round some of the questions that you've raised and I hope that you will go away understanding a little bit more about what we at the Met Office and indeed what the international scientific community understand about climate change, and the enormous challenge that the world faces from global warming.

There's been a lot of questions about carbon dioxide and whether it's generally responsible for climate change, and so the first question would really be, how do we know that carbon dioxide is responsible for the climate change that we have seen and can we prove it?
Well we know that carbon dioxide is a very potent greenhouse gas, and although it's not the dominant greenhouse gas in our atmosphere, by increasing its concentrations we know that it will have a very significant impact on the radiative balance of the planet and lead to changes in temperature. But it's important to put this in context because in fact water vapour is the most abundant greenhouse gas in the atmosphere and it's the reason why this planet is inhabitable. Without it, we would be a much colder place and life would not thrive if we didn't have water vapour.

What carbon dioxide is doing now is enhancing that greenhouse gas effect. So we understand the basic physics of that. It's enhancing that greenhouse effect and leading to an increase in temperature, so we're trapping more energy into the planet because of increasing levels of carbon dioxide.

How do we know that it matters? Well you don't have to really think to hard that if you've gone from before we started our industrial activities in the 19th century, carbon dioxide levels were at 280 parts per million by volume. We are now rapidly approaching 390 parts per million which means it's been a 40% increase. Most of that increase has happened in the last 50 years. And if we know that carbon dioxide is a greenhouse gas, it's hard to believe that if you increase it by 40% you're not going to do something to the temperature of the planet.

One of the other questions related to carbon dioxide was whether we genuinely know that the carbon dioxide that's causing climate change is man made, or could it be from natural causes?
That's right, of course carbon dioxide does exist naturally in the atmosphere and is part of the carbon cycle of the planet which we increasingly understand in considerable detail now, of how the biosphere and of course indeed animals, such as cows, contribute not just to carbon dioxide but methane is another carbon based gas in the atmosphere which is also a potent greenhouse gas.

So in fact it's methane we're often talking about when we think about how animals contribute to the carbon loading in the atmosphere. What of course is happening now is that we can track our emissions, we can actually monitor how much we're emitting through energy production and transport and so forth, and we can relate that quite closely to the trend that we've seen in carbon dioxide levels, which we also monitor very carefully in various places across the world, we've seen that rise over the last few decades and we can relate that to emissions levels from human activities.

It's also been raised that in the studies of the paleoclimate, in the climate going back hundred of thousands of years, that there is evidence that temperature rises came first and then there were rises in carbon dioxide. How do we know that's not happening now?

So this is looking back at the glacial and interglacial cycles, which is looking at records of past climate based on ice cores and we can work out what the carbon dioxide concentration was and we can use other proxies to tell us how we think the temperature changes. The important difference here is, as you rightly say, temperature changes have led the changes in carbon dioxide levels by as much as hundreds of years.

What the ice core records tell us and the reason that happened is that the forcing agent in that case was changes in the earth's orbit about the sun, so quite big changes in the amount of energy that the planet receives from the sun. So that was the forcing agent, that caused the temperatures to change, as the temperature changed then the biosphere responded and carbon dioxide levels changed and served to amplify the temperature change forced by changes in the input of solar radiation into the planet from the sun.

What is happening now is a completely different situation where we know that the input of energy from the sun to the planet is almost constant and the variations are so small that they are a tenth of what would be needed to explain the temperature changes that we are seeing. So what we know now is that actually it's carbon dioxide that's changing first through our activities and temperature is responding, and what we now fear is that as our planet warms, then the effect we saw through these glacial and interglacial cycles, where carbon dioxide followed the temperature change, will also come into play — probably in the latter half of this century and beyond — and amplify even further the warming that we're seeing as a result of our emissions into the atmosphere.

Many people have asked whether the currant global warming we're seeing could be because of natural causes as it has been in the past. What would your answer be to that?

This is a really difficult question and this is the one that I think challenges us most of all and I think if we go back to what I previously said about how carbon dioxide acts on the energy of the planet and how our activities have contributed to that, we can test that in our climate models and we can see that actually the sorts of patterns of change that we've observed over the last 50 years we cannot explain unless we bring in this enhanced level of carbon dioxide as the cause.

So yes it's right that the climate does have natural variations on all sorts of time scales, from year to year associated with things like El Niño, which we hear a lot about, to longer timescales and even things like the variations that we see in the record around the middle ice age, medieval warm period, they are all parts of natural variability of the climate system. But what we're finding now is that the fingerprint as we might call it of global warming, looks very different if we look at it not just in terms of surface temperature but if we look at it in terms of the temperature changes throughout the atmosphere, through changes in rainfall patterns, through changes in how much water the atmosphere is holding, all those things are the fingerprints which tell us this is not the same as the natural variations that we've seen in the past.

Even if we go back to the big gyrations that the climate of the planet has gone through in the ice ages as I've already discussed, those are not the same as the ones we are seeing now and in particular the rate of warming is far more rapid then we have ever seen in any of those records of glacial and interglacial cycles, so our planet is changing at an unprecedented rate and that, again, is not consistent with natural cycles within the climate system.

Part 2

You mentioned models in your last answer, and people have asked whether we can really rely on models to tell us about the future of our climate?
It's a very good question, but of course we have to remember they are the only thing we have to tell us about the future. We are trying to look into the future to predict what's going to happen based on the best science and our best understanding of how the climate system works. The only way to do that is through using these models.

I think what people find difficult to understand is what is this thing that we call a model? Well, it's a huge computer code and it's about solving the very fundamental equations of physics which describe the motion of the atmosphere, the motion of the oceans, how clouds form, how the land interacts with the sun's rays, how it interacts with rainfall and so on and so on.

So what these models are is hundreds and thousands of lines of code which capture and represent our best understanding of how the climate system works. So they are not in a sense tuned to give the right answer, what they are representing is how weather, winds blow, rain forms and so forth, absolutely freely based on the fundamental laws of physics.

How do we know that they're good? Well we continually test them against observations of the current climate in lots and lots of ways. At the Met Office we use the same model to make weather forecasts as we do to make our climate predictions, so every day we are testing the model and saying, 'how well did we do with the weather forecast?' We know that on many occasions our weather forecasts are incredibly skilful and that's increasingly giving us confidence that the science in our models is fit to do this 'crystal ball gazing' into the future to say what will happen to our climate as we go really into uncharted territory. Because we are taking this planet to somewhere where it has never been before, or at least for millions of years.

With CO2 levels at the level they are at now and the level they will be in the coming decades, whatever we do, we are going into temperature regimes that civilisation has not seen. So we have to trust these models and understand the scientific basis behind them, and accept that they are our best way forward for looking at what the future could look like for this planet in terms of our climate.

People have drawn attention to the fact that there's been talk of global cooling over the last decade, or a stabilisation in temperatures, and also a recovery of Arctic sea-ice in the last couple of years. Is this proof that global warming has stopped?
It's back to this question of what is natural variability and what's anthropogenic human induced climate change? We know the climate varies naturally, as I've already said. We have El Niño, we have other changes that we understand very well. Mostly these things are driven by circulations in the oceans which operate on much longer time scales than the weather in the atmosphere.

So, if we look at the global mean temperature record over the last decade or so, in 1998 we had the warmest year on record. The reason for that was because it was an El Niño year. We know that El Niño, which is a periodic warming of the tropical Pacific Ocean and has global impacts, leads to an elevation of the global mean temperature. We understand that very well.

Since the turn of the millennium we have had a number of years with fairly stable global temperatures and that's partly because we've been also into a colder phase in the Pacific. We will be publishing very shortly now our latest results for 2009. They will show that if we take the whole decade from the 2000 to 2009 this will be the warmest decade on record. So what we need to be careful is not to just take the temperatures from a few years and say 'global warming has gone away'. It doesn't work like that, because they are on a year by year basis affected by natural variability. We need to take these longer term averages and then you'll see that the warming trend is irrefutable.

The last three decades have progressively been warmer than the previous one, and this last decade, that we have now just got the results for, show it is way outside the warmth of any previous decade that we've had since instrumental records began.

And is this the same for Arctic sea-ice?

So the Arctic sea-ice again, a very interesting question. In 2007 we had suddenly this dramatic decline in summer sea-ice covering the Arctic. We were looking at this very closely. It was very interesting because everybody said 'this is a sign of global warming'. What was actually going on was that we had a change in winds over the Arctic which altered the movement of the summer sea-ice. In fact, it pushed it pushed a lot of it to one side of the basin and exposed a lot of open water.

What's been happening over the last couple of years since 2007 is that those circulation, those wind changes, have not been so acute and the summer sea-ice has started to recover a little bit. But if you look at this more carefully, that variation that we saw in 2007 and the recovery since then is on top of a gradual decline in Arctic sea-ice cover as the planet warms up. So we expect to see these year to year variations but they don't mean global warming has gone away or doesn't exist. They're just part of that natural variability of the climate system which will be printed on top of the global warming trend.

Another question is that is global warming necessarily all bad? Aren't there some advantages?
If you're just thinking about yourself personally and, say you were living in the north of England or somewhere and might suddenly be able to grow grapes and olives, you might think, 'well this is not so bad'. But I think for the planet as a whole we have to be clear that this is very bad news.

As I said, what's happening is happening very rapidly. What we will find is that all sorts of aspects of not just our lives, but all life on the planet, will be affected in ways that will be very difficult to adjust to. So we see real dangers for loss of major ecosystems, loss of biodiversity, for some communities a complete loss of livelihoods, or even — if we think about some of the island states that are facing sea-level rise — complete loss of where they live.

We have to look at this in the global context. We all live together on this planet and, for all of us, we will be affected in one way or another by the adverse effects of global warming on food security, water security, migration of populations who can no longer live where they currently live, coastal cities in danger from rising sea-levels, from extreme weather. Wherever we look the impacts are profound and damaging.

There has been a lot of talk about climate change potentially impacting the Gulf Stream, which is obviously the current which brings warm water across the Atlantic. Potentially melting of the ice-cap and changes in temperature could affect that, slow it down or even stop it. Is that the case, and if so, what would the impact be?
That's quite right. We do think this thing called the Gulf Stream, which is driven by changes in heat and saltiness of the water that's formed in these northern oceans, could be changed by climate change. In fact, we've undertaken a lot of research over the last few years, working also with our colleagues in academia, and we've also, with the Americans, put in a monitoring array so we can actually observe what's happening to the Gulf Stream.

The result of all that research and those observations is that we don't think that the Gulf Stream will change that much, at least in the coming century, as we go into global warming. Most of the evidence suggests there might be a slight slow-down of the Gulf Stream, but no evidence at all now that it would collapse. Even if it did collapse, and we can do these 'what if?' experiments in our climate models, yes, there would be a real cooling influence on the UK and western Europe because we do enjoy the effects of the Gulf Stream through the fact we have much milder winters and so forth. We don't think even that would be enough to counteract the effects of global warming.

Part 3

People have asked whether we can really stop climate change by cutting our carbon emissions. What would you say to that?
Yes, of course we can. Going back right to the beginning of my podcast, when I talked about why rising levels of CO2 lead to global warming, what we really have to do now is to reduce as much as possible how much carbon we accumulate in the atmosphere, whether it's carbon dioxide or methane or whatever. Because carbon dioxide actually has a very long lifetime in the atmosphere, its residence time is 100 years.

So, two points come from that. First of all, from what we've already emitted into the atmosphere, that 40% increase that I've already talked about in CO2 levels in the atmosphere, has committed us to a level of warming for the next 30 years that we cannot change. This is because of thermal inertia in the system but also because of how long carbon dioxide stays in the atmosphere. The second thing that we've learnt and we understand more clearly in the last few years is this whole business of long-term commitment to climate change and how, again going back to how long CO2 stays in the atmosphere, how long we are committed to warming even if we stopped our emissions today.

Both of those things tell us that reducing our emissions as much as possible and as quickly as possible will limit that accumulation of CO2 in the atmosphere and will help to limit the effects of global warming. We cannot stop it, because we are on a trajectory now which has been determined by what we have already emitted. What we can change is where we go beyond the next two or three decades, how much we take this planet into what we consider to be really dangerous climate change.

Another question is that if the world can't unite to cut global carbon emissions whether there are any other alternatives we have to try and stop climate change?
So this is the geoengineering debate. This is about looking for solutions such as carbon capture and storage, which means taking carbon directly out of the atmosphere, capturing, storing it down in the deep Earth. Then there are other solutions which are to do with changing the energy balance of the planet by putting mirrors in space, so you reflect a bit of the sunshine back out, so less energy coming in. That will counteract the fact we're trapping more energy by our increased greenhouse gas levels. Or we might change the clouds by seeding them — this is

blowing particles up into the air to create clouds, putting tiny particles in the high atmosphere, again, to change the radiation balance of the planet.

These are all really difficult areas. Apart from carbon capture and storage, which — to a large extent — is non-invasive on the climate system, all these other proposals interfere with the climate system in some way or other, in much the same way, I would say, that we're currently doing with increasing carbon dioxide. So we are already doing geoengineering in a relatively simple way, by putting a chemically inactive, well-mixed gas into the atmosphere — carbon dioxide. Yet we are struggling to understand all the ramifications of that, in terms of what it will mean regionally, for rainfall for temperature and weather patterns.

So any proposal that we might do more things like that needs to be looked at really carefully. This is where, again, the only way you can do that is to use the sorts of climate models we use to make climate predictions. And we are beginning to test those ideas at the Met Office, to run those experiments with our models, to do the 'what if'? Saying 'if we modified the clouds, what would happen?'

The answers are quite disturbing. Yes you can change global mean temperatures through these means, but you have to keep on doing it because, as I said before, carbon dioxide stays in the atmosphere a long time. So as soon as you stop modifying the clouds, global warming takes off again, within a decade or so, very very rapidly. So these are really difficult problems and I think we need to see this literally as the last result.

What can individuals and the government do to prepare for the climate change that's to come?

I think there's a lot we can do as individuals and I think we have to follow the guidance that comes from the Government. A lot of actions now, look at the ACT ON CO2 — lots of things that as an individual people can find out, go to websites, find out what they can do within their homes and so forth to contribute to reducing emissions.

From the point of view of what the Met Office can do it's really clear to us that as we go forward into a warmer world that how we adapt to that and how we make decisions on how to mitigate global warming is going to really need the best science. It's the science that is showing that climate change is happening and that we need to address it. It's because of the science that we will be in Copenhagen discussing these things — many leaders, including our own Prime Minister, will be in Copenhagen to discuss these things.

The science will continue to play a really crucial role as we go forward with this and what we are now working towards in the Met Office is to provide the Government with the best possible advice, scientific advice, on what we think future climate will look like so the Government can then put in place the right policies to protect our citizens, to work with the rest of the world on how we mitigate climate change and so forth. So that's how we are working with the Government to hopefully make a big difference.

Many of the questions referred to what has been termed by the media as 'climategate' which, as you know, is the hacking into of data from the Climate Research Unit at the University of East Anglia. Does this undermine climate science in any way?
Not at all. I think the dataset that we are talking about, which is one of three records of global temperature going back over the last century or more, the message is still clear. Our planet is warming. We can defend those data. We can defend how that record was constructed. The three independent records are entirely consistent that our temperatures, as I said earlier in the podcast, have been rising rapidly and we will show that the current decade is the warmest we have had since the instrumental records began.

This in no way undermines the science case for climate change. In fact, global mean temperatures are only one measure of global warming and we have many other variables that we can draw on and show. Sea-level rise is one, retreating glaciers is another, shifts in rainfall patterns that we are beginning to see — all consistent, and support the science of climate change. So I think we must not be diverted by this. It's unfortunate and the way we are approaching it from the Met Office to say we have nothing to hide, everything will be open, we will release the data, we will release the codes as soon as we possibly can and it will be shown that this record is robust and the global warming signal is irrefutable.

So I hope you found those answers to your questions helpful. I think you'll have got the sense that, yes, this is complex science, but the fundamental messages are quite clear. If you've still got more questions please do go to our website, www.metoffice.gov.uk, and go to our climate change pages and hopefully you'll find more answers to your questions. Over the coming months we'll be working very hard to put more material available for the public to really get the science of climate change out there so that you, and we need you support in this, can understand what we're really talking about. So I hope this has been helpful, and thank you for watching.