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Episode 46: The Human Hand in Climate Change

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VOICEOVER
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SHANE HUNTINGTON
Hello and welcome to Up Close, coming to you from Melbourne University, Australia. I?m Dr Shane Huntington, and today?s topic is climate change. As we move further into the 21st century, the threat of climate change becomes even more difficult to ignore. We are constantly bombarded with information and political rhetoric, much of which is difficult to digest and even harder to act on. The science case for the threat of climate change gets stronger every year, and the consequences of inaction are of global concern.
After many decades of work scientists successfully brought this global threat into discussions at every level of our society. Today on Up Close, we are joined by a recognised world leader in meteorology and climate change science, Professor David Karoly, Nobel Laureate and Federation Fellow in the School of Earth Sciences, the University of Melbourne, Australia. Welcome to Up Close David.

DAVID Karoly
Thank you very much. It?s a pleasure to be here Shane.

SHANE HUNTINGTON
Let?s start with just broadly what the term climate change means, what we?re referring to.

DAVID KAROLY
Climate change is a change in weather conditions over an extended period of time, and climate change can occur by natural causes, natural variations and in fact the climate of the earth has changed a large amount in the past. What we?re really talking about and what the concern is about is not these natural climate variations,

but climate change as it?s occurred over the last 100 years of the 20th Century, and as it might occur due to human influences over the next 100 years.

SHANE HUNTINGTON
What are the primary effects, and not just recently in terms of what we think of as climate change, but more historically of these changes in climate?

DAVID KAROLY
Climate has changed a lot in the past. We hear a lot about ice ages and the last ice age finished about 20,000 years ago, but there have been regular ice ages about every 100,000 years for at least the last million years. And during an ice age the climate is much colder, there are large increases in the coverage of ice, particularly in the northern hemisphere, much colder average temperatures and these lead to major shifts in ecosystems, they lead to changes in the weather systems on the earth. But the biggest impacts are really these changes in where different plants and different animals can survive on the earth.
And the way that we can recognise that information is in fact from changes in the geological evidence for climate, as well as the information that we see from pollens and from other sorts of records buried in the earth?s if you like history. Now we can see also lots of evidence of climate variations over say the last two or three hundred years, when we actually have information from where people take documentary evidence. And so we can see that climate varies from year to year, from decade to decade.
There was a period about 200 years ago to 400 years ago called the Little Ice Age, where in Europe there was a significantly cooler period, and then there was a period about 1,000 years ago in the Medieval period, called the Medieval Warm Period, and that was somewhat warmer. And we can use evidence from historical records. In the Medieval Warm Period there were Vikings living in Greenland having farms, and so that was relatively warmer because Greenland for much of the 20th Century didn?t have much agricultural activity.

SHANE HUNTINGTON
David, there are a number of things that affect our environment, and the environmental changes we?re talking about other than climate. Can you mention a few of those?

DAVID KAROLY
Sure. There are many factors in addition to climate, other human influences like deforestation, like air pollution, like water pollution, like introduction of invasive species, which will have major impacts on a range of different if you like natural ecosystems. And if you want to try to understand where the changes in, for instance, a species of bird and its egg laying or its migration. Or a plant species, whether it is changing because of climate change or whether it?s changing due to other factors, you have to really look at the effect of human activity. Not just in terms of climate change but also in terms of invasive species, in terms of land use change, deforestation, pollution, lots of different factors like that.

SHANE HUNTINGTON
And when we look around the globe at the moment with all of these factors in mind, what sort of percentage are being caused by climate change as opposed to these other influences?

DAVID KAROLY
This relates to a research study that I was involved in over the last five years, and what this research study looked at was trying to analyse all research papers that have been published in the last 10 years, that looked at significant observed changes in natural systems. Natural systems like ecosystems, like plants, birds, animals, insects, as well as natural systems like glaciers or lake ice or snow cover or river temperatures, all those sorts of things.

Any study that reported a significant change in one of those systems that might be associated with climate change, but might not be, we analysed. And this looked at more than 150 published studies that looked at more than 500 different locations in all continents, including Antarctica, we analysed them all. And we compared studies that showed or reported observed significant changes in one direction or in the other direction, but we specifically then said well what direction of change might you expect consistent with a warming climate?

What we did when we combined all this analysis, was we found that 90 per cent of the systems that were showing significant changes, were showing changes consistent with a warming climate system. So all around the globe in each of the continents and whether we were looking at biological systems or looking at physical systems, we found that in each of those we found 90 per cent of the systems that were changing showing significant change, were showing changes that were consistent with a warming climate.

Now of course not all the systems are independent and we actually looked at that in our analysis as well, because then we tried to say, ?Well, okay. We found these vast majority of systems showing changes were consistent with warming. But maybe they could have been due to land use change or air pollution or invasive species.? And what we found was when we synthesised across all the different systems, it was very, very unlikely that anything apart from local warming could have explained these changes.

The next part of the analysis was ?Well, okay. We?ve seen that the best explanation of these observed changes around the globe is warming at each of the locations. But was that warming due to increasing greenhouse gases, climate change due to human causes, or was it more likely to be due to natural variability or other local climate change??

To do that we had to look at what might be the causes of the climate change locally and globally.

And what we found was when we did this analysis essentially to look at the different causes, we could not explain the warming at these locations. When we combined the analysis over the whole globe or the continents in the northern hemisphere, we found that we couldn't explain the warming either due to natural climate variability from decade to decade, or climate variations due to say changes in the amount of sunlight coming from the sun.

The only explanation that could explain these observed warming patterns across the globe or even across the continents in the northern hemisphere, was warming due to increasing greenhouse gases due to burning fossil fuels and deforestation, increasing greenhouse gases in the atmosphere.

SHANE HUNTINGTON
We?re pretty much addicted at the moment to energy use and it?s getting worse, and as a result our carbon emissions are high and becoming higher. How have those emissions changed over the last century?

DAVID KAROLY
You?re absolutely right. The energy sources that have been used to drive the industrial revolution and to drive economic development over the last century, are almost exclusively due to burning of fossil fuels and associated industrial developments, so there are other energy sources. But as a total contribution, fossil fuel use is the major energy source and that has led to these increases in greenhouse gases in the atmosphere, and we know with very, very, very high confidence that the increases in greenhouse gases are due to human activity. They?re not due to emissions from volcanoes. They?re not due to say carbon dioxide coming out of the oceans, which has in fact happened in the past. But we know for sure that the large increases now are due to human activity, burning fossil fuels and land clearing.
SHANE HUNTINGTON
I can imagine that there would be scenarios where some of the changes we see are non-intuitive or sort of head in the wrong direction. So are there scenarios where the weather globally is getting warmer but locally is doing quite the opposite?

DAVID KAROLY
Absolutely. The climate system is extremely complex and while the most direct effects from a warming climate are just warming temperatures, when it comes to say patterns of circulation change or patterns of rainfall change, they may not be obvious. So let me talk about first of all rainfall changes.
Overall we would expect with a warmer climate increases in the total rainfall over the planet and increases in heavy precipitation. As the air gets warmer the air can hold more water vapour. When it rains, the rain is actually heavier, a bit more like an environment like the tropics, where it?s more humid and when it rains the rain?s heavier.
That also means if you like the hydrological cycle in the whole planet speeds up a little bit. That means that unfortunately when the air is descending in regions that are called the sub-tropics, the current dry regions essentially between about 20 and 35 degrees of latitude, where we currently have deserts, they actually get drier. And so this is if you like counterintuitive. You can have global increases in rainfall average but some regions get drier.
You can also have changes in the wind systems, which mean that whilst many regions get warmer you can have some locations that are getting colder. And an example of that, associated both with increasing greenhouse gases and also ozone depletion in the stratosphere is that the Antarctic region, the middle of Antarctica has been getting colder for the last 20 or 30 years, which is counterintuitive again. The

reason is that the increases in greenhouse gases are warming the oceans and the land masses in the tropics, but Antarctica is so big and so cold it?s remaining cold. That increases the temperature gradient and increases the westerly winds. That isolates Antarctica and it?s been getting colder, even though the rest of the globe?s been getting warmer, but it is well explained by anthropogenic climate change.

SHANE HUNTINGTON
You?re listing to Melbourne University Up Close. I?m Dr Shane Huntington, and we?re speaking with Professor David Karoly about climate change. Now David, we hear a lot about carbon dioxide, but it is certainly not the only gas of concern. There are other greenhouse gases. Tell us what are they and how do they impact the problem we?re facing?
DAVID KAROLY
Sure. Carbon dioxide is the most important greenhouse gas in terms of its human sources, but in fact we probably should take a step back and the most important greenhouse gas in the atmosphere is not carbon dioxide, but in fact water vapour. And water vapour is more important in terms of its contributions to the radiative forcing, the effects of greenhouse gases on the climate system.
However, the amount of water vapour in the atmosphere is determined not by human emissions of water vapour, not even by the amount of water vapour that?s available in terms of liquid water at the surface, but by the temperature of the atmosphere. Water vapour acts to enhance the changes due to other factors. So when carbon dioxide increases and then warms the climate system due to absorbing infrared radiation or heat radiation coming up from the surface, then water vapour can increase in concentration as the atmosphere warms and amplify that response.
So let me now talk about some of the other greenhouse gases that are due to human activity. And these include methane, which is produced primarily by agriculture but is also a waste product from decomposition of biological material, vegetation, particularly when it?s removed from exposure to oxygen. So methane is produced from what?s called anaerobic decomposition of biological material. It means decomposition when there?s no oxygen around, and you can get it therefore from swamps, from rubbish dumps. You can also get methane just leaking out of coal mines or from natural gas seams and things like that. But the big sources at present are from agricultural activity. There is some sources from industrial activity.
There are other greenhouse gases. Nitrous oxide is also an important greenhouse gas produced from human activity, mainly from industrial activity and agriculture. And the other group is very important that you don?t hear very much about at present, are a group of gases called halo carbons, things like chlorofluorocarbons, which were ozone depleting substances, and other, if you like, artificial gases that were produced for refrigerants to replace chlorofluorocarbons. These new gases, the halo carbons, don?t have much ozone depleting effect but unfortunately they have a very big effect in terms of their contribution molecule per molecule in terms of warming up the atmosphere.
If we look at the total contribution, the most important greenhouse gas is carbon dioxide. The next most important is methane in terms of its warming contribution compared to pre-industrial terms, and the third most is in fact the total contribution from these halo carbons, the CFC?s and their replacement.

But if you think gas by gas or molecule by molecule, the most important ones are in fact individual halo carbons like CFC?s. They have about 1,000 times the warming influence as carbon dioxide that?s emitted, and methane itself has about 25 times the warming potential for a tonne of methane emitted compared to a tonne of carbon dioxide.

SHANE HUNTINGTON
Now David, when we talk about the energy coming from the sun, we hear everything about the weather on earth but the sun has a variability in what it sends us. How predictable is that?

DAVID KAROLY
The variations in the amount of if you like radiation or energy coming from the sun turn out to be not very predictable on day to day or week to week time scales. Because there are solar storms and sunspots that occur on the sun, different from but somewhat analogous to the weather systems and storms on the earth. There are some longer term cycles, something called the 11 year sunspot cycle and the 22 year sunspot cycle, which turn out to be relatively predictable on the sort of 11 and 22 year time scales. And they do affect the amount of energy that the sun emits, that?s received by the earth, but the variations are small. They?re about a tenth of a percent in terms of the amount of solar radiation, and they lead to quite small temperature variations.
Globally average temperature variations, the best estimate is less than about one tenth of a degree over the 11 year sunspot cycle, possibly less than that. However, they also have a big influence in the impacts on ozone. Remember that the ozone is generated by the absorption of short wavelength radiation from the sun. That?s much more greatly affected in the sunspot cycle, and we see a big 11 year cycle in the amount of ozone in the atmosphere in the upper regions, at heights of between 30 and 50 kilometres. And we can use observations of those ozone variations to estimate how much really is the input from the sun happening, and how is it varying. Is it trending over time?
We can actually see that there is in fact no big increase in solar radiance, either from the measurements of the surface or directly from measurements in ozone. So we cannot explain the warming over the last 30 years or over the last 50 years, in terms of changes in intensity of the energy or the sunlight coming from the sun.

SHANE HUNTINGTON
You?re listening to Melbourne University Up Close. I?m Dr Shane Huntington, and we?re speaking with Professor David Karoly about climate change. As part of the inter-governmental panel on climate change, Professor Karoly was jointly awarded the 2007 Nobel Peace Prize for his scientific contributions. David, congratulations on this incredible award and a great level of recognition of the work you?ve been doing.

DAVID KAROLY
Well thank you very much for that Shane, and in practice I should add that this was something that was shared with a very large number of colleagues involved in the preparation of these reports. Depending on how you count, it was either at least

2,000 or 5,000 people. The inter-governmental panel on climate change decided that it would be stupid to try to split up the funds that were received as part of the prize amongst the different authors. And in fact has made a commitment to use the funds that it received as part of the award, to improve communication of climate science and its impact in developing countries. So that is a very admirable way to use the funds received from the award of the Nobel Peace Prize, to the inter-governmental panel on climate change and to Al Gore.

SHANE HUNTINGTON
David, we?re talking about world changing weather patterns. You have a lot of expertise in the atmosphere itself. What large scale changes should we expect to see in terms of atmospheric patterns that affect our weather?

DAVID KAROLY
There are a number of changes that we?re expecting. As I said before, the most common ones and the easiest ones to explain are the temperature increases that affect more heat waves, more hot extremes, less cold extremes. But the rainfall is often brought by changes in the wind patterns, and what we expect to see is an increase in heavy precipitation, particularly in the tropics. But let?s think about middle latitudes now, and often the weather systems move from west to east.
What we would expect to see on average is in fact a slight poleward shift in those westerly winds and in the weather patterns, and if you like an expansion of these drier regions a little further away from the equator. And that means that for some regions like the Mediterranean coastline, like the Sahel and even like regions in southern Australia, that poleward shift is moving rainfall bearing systems away from populated areas. And so we?re expecting decreases in rainfall in the Mediterranean, decreases in some parts of China and decreases in many parts of southern Australia.

SHANE HUNTINGTON
David, let?s move on now to some of the suggested solutions. I?d like to know what your primary recommendations are for addressing the climate issue into the future?

DAVID KAROLY
Well, the biggest problem is both the increase in greenhouse gas concentrations in the atmosphere, and the warming of the climate system. The most obvious way to address that is to reduce human caused greenhouse gas emissions into the atmosphere, and we have been involved through the inter-governmental panel in climate change in various assessments of how much those greenhouse gas emissions need to be reduced, to minimise dangerous changes to the climate system.
And those reductions need to be very large and they need to be very rapid. The climate system has taken a long time to respond to the greenhouse gases that we?ve been putting in over the last 150 years due to industrial activity, so what we need to do is rapidly reduce our emissions of greenhouse gas emissions essentially to below present day levels within the next five years globally. And then reduce them globally by more than 50 per cent by 2050, and then we also need to ? because developed countries have much higher emissions per person, the developing

countries, developed countries need to take the lead in reducing their emissions. So for a country like Australia or the United States, there needs to be 90 per cent or greater emission reductions by 2050, and 20 per cent or 30 per cent emission reductions by 2020. Essentially over the next 10 years there have to be dramatic cuts in greenhouse gas emissions right away.

SHANE HUNTINGTON
Professor David Karoly from the School of Earth Sciences, the University of Melbourne, Australia, thank you very much for being our guest on Up Close today.

DAVID KAROLY
It?s been my pleasure.

SHANE HUNTINGTON
Relative links, a full transcript and more info on this episode can be found on our website at upclose.unimelb.edu.au. We also invite you to leave your comments or feedback on this or any episode of Up Close. Simply click on the add new comments link at the bottom of the episode page. Melbourne University Up Close is brought to you by the Marketing and Communications Division in association with Asia Institute of the University of Melbourne, Australia.
Our producers for this episode were Kelvin Param and Eric Van Bemmel. Audio recording by Craig McArthur. Theme music performed by Sergio Ercole. Melbourne University Up Close is created by Eric Van Bemmel and Kelvin Param. I?m Dr Shane Huntington. Until next time, thank you for joining us. Goodbye.

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