

Environment Committee – 3 June 2014

Transcript of Item 10: Severe Weather

Stephen Knight AM (Chair): That brings us to our discussion this morning, and I think we are going to start off, if we may, be asking Dr Huddleston to give us a short introduction to the topic of severe weather risk in London and how that has changed in recent years.

Dr Matt Huddleston (Met Office Climate Scientist and representative on the London Climate Change Partnership): Thank you very much for the invitation to speak to you this morning. London has a mild maritime and very unpredictable climate. It is moderated by the Atlantic Ocean and it is at a latitude that experiences a great dynamic variability in the types of weather and extremes that it experiences.

It is not in isolation to what is going on in the rest of the world. It is linked through the global weather systems, to great phenomena like the El Niño phenomena in the Pacific and what is happening in the stratosphere and many other things, so we do not sit as an island in the global climate, as it were.

Depending where you look in terms of the parks which have the observing sites in London, you will find London has about 30 days of frost a year, about 100 days of rain and about 0.5 to 0.6 of a metre of rainfall in an average year, nearly four hours of sunshine. However, these kinds of average statistics do hide a great deal of variability in day-to-day, week-to-week, year-to-year and decade-to-decade weather.

To get some feel for the moderating impacts of the Atlantic on us, we are about the same latitude as Calgary and the average winter temperatures in Calgary are about minus 15 centigrade, so you can see we are very lucky in terms of having the warm Atlantic Ocean to our west. However, that does mean that we get a lot more rainfall as the air is heated and picks up moisture, and prevailing wind direction brings us weather fronts and storms.

The weather is very much dominated by something that has kind of reached the popular ear now called the jet stream, which is a ribbon of very fast moving air high in the atmosphere that separates the polar air masses from the equatorial ones; and its position decides whether we are getting the storms and the weather fronts barrelling towards London and the south of England, or normally going up towards Scotland and out into the Faroe Islands which is the normal position for those in wintertime.

We can see in the last winter this very much determined our weather and what sort of events we received in terms of 12 storms, 13 if you include the Saint Jude Day storm, hitting us in December and then again in February.

England and Wales have just experienced the wettest January and winter season on record since records began in 1766 and southern England was particularly wet with some areas receiving two or three times their normal rainfall. As I say, it is largely due to the position of the jet stream.

The jet stream is not something that is very predictable on longer range, so it is a challenge for climate science to understand going forward where it will be and where those storms will go. I would like to put it into a little bit of context though, that it is normal for London to have extreme weather. Being such an ancient city we have great records and we can find the largest storm that has ever hit London was probably the great storm of 1703 where 2,000 chimneys fell, the lead was ripped off Westminster Cathedral and Queen Anne had to hide in the cellar of St James's Palace to avoid the roofs collapsing. Seven hundred ships were piled together in the port of London in that event.

Extreme events do happen under normal climate to London and the question, of course which is for us: what are the variations in climate that are natural, that drive those, so that we can better understand and predict them, and what are the variations that are man-made and are changing the frequency of those events?

Stephen Knight AM (Chair): Thank you very much indeed. I think we have a number of questions to probe a little bit deeper on some of these issues.

Murad Qureshi AM (Deputy Chair): Thank you for that introduction, Doctor, and the history lesson as well as the science lesson. Essentially, what we want to do in the immediate future is look at the likelihood of extreme weather events in London in the next few years. Are there any particular things we should be looking out for?

Dr Matt Huddleston (Met Office Climate Scientist and representative on the London Climate Change Partnership): We have had, in the last decade a sequence of extreme seasons and events that have hit the southern UK. These are driven by the chaotic nature of the atmosphere and some natural variability patterns you may have heard of, for instance the North Atlantic oscillation and other scientific patterns that are well understood. At this time it is not possible to say exactly what is going to happen this next winter or the following few years, in terms of extreme events, but we can look at the propensity of those events in the historical record to see how likely they are. At this time that is a very good guide for what we need to adapt to in terms of the current climate.

Murad Qureshi AM (Deputy Chair): I will give you an example: at the beginning of this particular term we had two dry winters and Thames Water suggesting a drought situation before the Olympics. Is that something we can expect to be occurring more often?

Dr Matt Huddleston (Met Office Climate Scientist and representative on the London Climate Change Partnership): I had a look at the drought question and the drivers of drought, in terms of consecutive years, is a subject for scientific study, as it is not well understood what drives consecutive years of drought. If we look at it over the last 140 years there have been nine winters, if we just look at the months December, January, February, with two consecutive years of low average rainfall; and there have been six with three consecutive

winters with low average rainfall, acknowledging that the recharge period is a bit longer than that from October to March. It gives you a feeling that three dry winters might occur once every 20–25 years, something like that and two dry winters might occur once every 15 years or something like that. In terms of preparedness you can see that they are not rare in terms of never happening, but they are not happening on a frequency like every other year.

The return periods are a bit of a confusing thing also for scientists, I have to say, because it does not mean that they are going to come on a regular basis. You can get events that bunch together, so you can see over the last 100 years there have been periods, say, the 1920s and the 1990s which were extremely stormy; and then you had periods like the 1960s which were very placid and there were very few storms. There is some kind of decadal patterns in these things.

Murad Qureshi AM (Deputy Chair): Dr Black, we have heard the likelihood of extreme weather events in London in the next few years. Do you have your own analysis?

Dr Emily Black (Senior Research Scientist, National Centre for Atmospheric Science, University of Reading): Yes. A particular hazard for London and for the whole of the UK, for example, is heatwaves, such as the very intense heatwave which happened in 2003. This is an area of active research, just how likely these sorts of heatwaves are in the current climate. There are some indications that not just the average temperature is changing but also the variability of temperature is changing; which means that you are more likely to get very intense heatwaves more often than you might expect by looking purely at the historical records.

Having said that, there is a lot of long-term variation, so you get some warmer decades and some cooler decades. You have probably all heard about discussion of this global warming hiatus, for example, which is a period not of getting colder, but just of slower warming. That sort of variation also affects the frequency of heatwaves. While events like 2003 are exceptional, even taking into account what we know about climate change in the current climate, it is still important to be aware that events like 2003, 2006 there are more heatwaves in the current climate than you might expect by, say, just looking through the records of London temperature in the past.

Murad Qureshi AM (Deputy Chair): That deals with heatwaves. We have also had a cold snap during 2010, so conversely we are getting into the extremes, heatwaves and then major cold snaps. Is that something we are going to see more of?

Dr Emily Black (Senior Research Scientist, National Centre for Atmospheric Science, University of Reading): Actually the frequency of cold snaps is generally found to be reducing. The fact that we had a very cold snap in 2010 illustrates the importance of variability in the climate and the importance of remaining prepared, not just depending on trends. The cold snap of 2010, although it was a very cold December, as a season overall it was significantly less cold than say the 1962–1963 winter, for example. It is very important to remain prepared, even within a changing climate.

Stephen Knight AM (Chair): Can I just ask, would you say we have had almost more than our fair share of extreme weather incidents in the last decade or so? It seems that we have had an awful lot of events in the last decade or so, given the overall frequencies which you spoke about earlier, Dr Huddleston. It has been a very eventful decade.

Dr Matt Huddleston (Met Office Climate Scientist and representative on the London Climate Change Partnership): It certainly feels like that, because of the impacts that extreme weather has on our built environment and our ability to operate, but we can see if we look back, other periods where there have been equally dramatic periods. There are times when the climate is more quiescent than now, so it is not necessarily indicative of something more sinister. I would say, as Emily mentioned, there are some features of the climate that we can be rather more sure about increasing and certainly heatwaves is one of those.

As you may have seen in the papers at the weekend, some new science has been released by the Met Office Hadley Centre, showing that if we start to resolve thunderstorms in our climate simulations, we can see the most intense rainfall becoming more frequent. With our general understanding that the warmer air holds more moisture, we can expect in the future more intense rainfall events; these kind of extreme rainfall events where you get maybe six inches of rain falling within a couple of hours, as happened in Hampstead in 1975, leading to quite significant impacts, for instance on our Underground systems.

James Cleverly AM: Dr Huddleston, and I suppose Dr Black as well, we are looking at this in the context of public policy and making decisions about litigation and adaptation and that kind of stuff. Obviously one of the dangers is, I suppose, the natural human instinct to recognise patterns where no formal pattern exists. You stare at clouds, you see animal faces and you see buses, because that is what you project on to that. In terms of the coverage that you get around this, is that a phenomenon that you are all seeing happening?

Dr Matt Huddleston (Met Office Climate Scientist and representative on the London Climate Change Partnership): I think it is fair to say. I also sit on the London Climate Change Partnership and we meet often in this room here, and you can see that people's memories are quite short in terms of the things that they remember, often not recognising that we have had some hot summers in the last ten years, for instance. What we do, and take great pains to do, is to analyse the data very objectively and peer review it, get it out to the scientific domain, so we can see if there really are other trends and things that we need to be aware of happening. Then we work very closely with the London Climate Change Partnership or other stakeholders to help them to be best informed about how to act. We try to use the latest science, the best understanding at any one moment in time, for people to take the best steps forward.

Dr Emily Black (Senior Research Scientist, National Centre for Atmospheric Science, University of Reading): Can I just add to that, as Matt pointed out earlier, understanding the processes, the basic physics of what is going on and putting what we are seeing in the context of that, also really helps us interpret patterns and work out where something might be quite random and where something might be a systematic change; which also helps us evaluate our models. The example that Matt gave before was of the increase in very intense rainfall events,

which is based on some well-understood physical phenomenon of warm air being able to hold more water.

Jenny Jones AM: I wonder if I could bring Professor Parry in and ask more or less the same question, which is: are these extreme weather events becoming the new norm, or is that overstating things?

Professor Martin Parry (Adaptation Sub-Committee and Centre for Environmental Policy, Imperial College London): The Intergovernmental Panel on Climate Change (IPCC), in its report last year, concluded that across the board, on all continents and most oceans, there is an observed increase in certain types of extreme events; and also there is a decrease in others and it is quite complex of course. The point is that there now is a new science developing, which is about recording already simulated and projected what would have been future changes, recording them now, as we walk into the future, if you see what I mean.

We have projected patterns of change, which my colleagues have talked about, we have past observed patterns and we are now walking into a future where we are beginning to see the changes that we had forecast, and are consistent with current projections. Some of these do include an increase in the number of warm days and warm nights. London's high temperatures are 2 degrees warmer than they used to be 30 or 40 years ago. On top of that we have an urban heat island that is much bigger than [Professor] Tony Chandler [climate change scientist] when he invented the phrase, in the University of London, 40 years ago, about twice the level, so that is us adding to climate change.

There are whole patterns of events, including possibly, but less certainly, patterns of rainfall, which are much more complicated, as one can imagine, which at the moment we would probably say are consistent in their change with what we would expect. The fall-back position you often hear from. In other words, we cannot say with confidence that the sorts of events we are seeing are part of a human-induced, greenhouse gas-induced change, but they are consistent with it. As time goes on that phraseology will probably change, as it has done for temperature events, into something where we would say there is a likely connection between the two.

Jenny Jones AM: The heat island effect obviously will keep ratcheting up, presumably.

Dr Matt Huddleston (Met Office Climate Scientist and representative on the London Climate Change Partnership): I can speak to that. We are talking about a warming, especially on summer nights, from 11.00pm to 3.00am of between three to six degrees. I think in 2003 the urban island of London was up to nine degrees warmer than the surrounding countryside.

It is dependent on the physical urban environment. It does have a component to do with pollution, in terms of aerosols trapping heat as well, but is not amplified further by climate change. It is certainly something that makes London quite uncomfortable in a heatwave in the night time.

Jenny Jones AM: Can I ask you about the impact that this is all going to have on London itself and on Londoners in terms of health and wellbeing?

Dr Matt Huddleston (Met Office Climate Scientist and representative on the London Climate Change Partnership): The London Climate Change Partnership did a report on heat thresholds, which makes interesting reading in terms of different impacts. I think one thing that stood out for me there is that the health impacts start to happen at 24.7 degrees. You get a couple of days of warmth at that level --

Jenny Jones AM: That is during the day?

Dr Matt Huddleston (Met Office Climate Scientist and representative on the London Climate Change Partnership): Average over the two days. If you think that is actually much lower than a heatwave temperature, so you start to see increased mortality, morbidity and increased hospital admissions. There are impacts across a range of temperatures but maybe I should pass on to Martin Parry in terms of impacts.

Professor Martin Parry (Adaptation Sub-Committee and Centre for Environmental Policy, Imperial College London): Just to pick up about the number of these events and how we see it. Hot days, let us call them, or overheating days, as defined by whatever temperature it is, whether it is 24 or 28 degrees. It varies from room to room, bedrooms, living rooms, the Chartered Institute of Building Services Engineers (CIBSE) defines different temperatures to a maximum comfort level and they are different for living rooms and bedrooms. The number of those overheating days has increased, we can see that. It is something like four days. My preparation for this meeting was very interesting. I had not realised a detectable increase of about that magnitude. There is now about an average of 18 days a year, overheating days, where you would discern the effects on individuals, for example cardiovascular illness as well as possibly fatalities in particular extremes. But we can get into that later.

Say it is something like 18 days on average per year, now under current climate. That would vary a lot, that is an average, we might expect to see that double by the 2020s under the projected changes in climate for this part of the UK, to about 33 days. There is a range from about 21 to 55 days, if I am right. That expresses our uncertainty and it is useful always to remember that. The central tendency of that, 33 days to be precise, but if you cannot be that precise it is about double. We need to think in terms of these impacting events on people, particularly the elderly and the young, as changing quite importantly. The tails of a distribution do change much more than the mean in a sense. If we have only a few events like this, 18 days, and they are important, they can double over this time, whereas average temperature might only increase by 0.25 degrees. Do you see what I mean?

We could talk about rainfall events as well, they are less well pinned down. This becomes, I think, quite important in designing London and its buildings and its architecture generally for the future. One thing it seems to me that London has done - again from my reading over the last two days - is that it did encourage CIBSE, looking at your literature from two years ago, to go away and design a 'summer year' as it was called, in which events like this would become difficult, the sort of thing one would want to protect against. The 'design summer year' they

called it. I thought to myself, "Well, have they gone and done this?" and they have and last year they published it, so there is now a metric for a threshold to which one would want to protect oneself.

I think the next stage for any local government, any city, any responsible authority, is to try to invest that threshold and the new levels of frequency in the codified regulations or building codes. I think I am right in saying that while on an impacts review group, which I chaired for the Government 20 years ago, we asked for this. We repeatedly asked for it. It has not been done yet. In other words, we do not have a national set of building codes that have been updated for the observed warming climate, or can capture the future warming that we feel increasingly confident about. We actually have building regulations that create buildings that are designed to avoid a return period, or accommodate a return period based on data probably from 1930s and 1940s, the period 1921 to 1951.

Jenny Jones AM: This could be a recommendation in our report, could it not, both to the Mayor and to Government?

Stephen Knight AM (Chair): I think that would be a very important point.

Jenny Jones AM: Could I go back to the impact on Londoners themselves, because you talked about illnesses and early deaths. There could be of course new diseases as well, could there not? I presume that malaria is something that could happen any year now and that would increase pressure on all sorts of sections of the population, children and elderly.

Professor Martin Parry (Adaptation Sub-Committee and Centre for Environmental Policy, Imperial College London): The IPCC in its health chapter in its Working Group 2, published in March, called fatalities under heatwaves the tip of the iceberg. I wrote that down, because I thought that is quite useful to realise that we tend to -- Paris gets known for the 2,000 that die, 600 I think is the number for London in 2003. Actually what is going on underneath is probably much more debilitating for the community as a whole, and much, much larger numbers of individuals' health was affected and basically had a very miserable time. They may not have died. I do not know if we have numbers on those. In the London Risk Register it talks about the number of people, casualties as opposed to fatalities, being something like ten times the casualty level. I am not sure if that is an adequate rule of thumb. That is one thing. I think most of that effect is cardiovascular. I am not an expert on this area. There are other immediate heat stressing conditions. There is a work capacity issue, which I am not sure has been well researched, but my guess is the potentials of that for London are huge, if you were able to measure it. Simply the lost output added over however many working Londoners you have, added over lots of days, is big.

Then you mentioned the indirect ones of disease, which I think primary practitioners would say they could handle, given the money. They could control Legionnaires disease, which tends to be given a spurt under situations like this. They can control waterborne diseases, which are more likely to break out, because they are well rehearsed at it. Malaria is something they would say that was in Britain in the 1300s, we called it the ague then, when the death rates were much higher in swamps and we eradicated it. I think apart from individual outbreaks brought by

migrating individuals the medics would probably say that they could handle the indirect effects of such as disease, but I am not an expert on that.

Dr Matt Huddleston (Met Office Climate Scientist and representative on the London Climate Change Partnership): Maybe I will just mention that a lot of these diseases are brought by insects that are blown on to our land, so we have been doing quite a lot of modelling of how these insects are spread to the UK, for instance the Schmallenberg disease for sheep, so some of these things are managed on shorter timescales. We call it dispersion modelling, modelling how the wind blows things. It has been used for foot and mouth disease and other things, so it is not just humans that will be impacted by a changing climate but also animals and livestock. Of course they supply London, so that is also very important.

Jenny Jones AM: That is exactly the next question I have actually. What might we see in terms of disruption of wildlife and ecosystems generally and also tree loss, for example? Trees are incredibly important to mitigate our heat island effect. What sort of impact on wildlife and diversity could there be?

Professor Martin Parry (Adaptation Sub-Committee and Centre for Environmental Policy, Imperial College London): We have a whole splurge of diseases affecting indigenous trees, oaks and ashes and London plane trees and it probably is due to a syndrome of stresses and pressures. Much of it might be warming, and this has, I think, surprised us. It looks like we cannot contain it. It has lagged by some years, because maybe that is the nature of plants, behind other globalised impacts and there probably is a whole nexus of these that we are going to confront on plants. It is probably useful to think of it as being impacted by a ton of different things. It might be air pollution as well that is aggravating it, as well as the urban heat island, as well as a set of warmer summers and milder winters not killing off disease. Londoners used to say in the Middle Ages that a mild winter leaves a full graveyard. It was useful to have cold winters of the kinds we saw in the 1600s and 1700s because it killed off the viruses and bacteria, one or the other, which tended otherwise to linger on.

To summarise on that, again I am not a specialist, but one suspects that there is a whole set of these things that are in motion at the moment. We detected some of them, more particularly on animals, because the vectors travel more easily, and on our big trees more recently. One just has a suspicion that there are more of these that are going to come to the surface.

Jenny Jones AM: I have one last question which I think is outside the scope of our investigation, but obviously these global weather events are making huge changes in other countries, other populations. Has any work been done on the sort of impact that we might get from people coming to this country from other countries because of environmental degradation?

Professor Martin Parry (Adaptation Sub-Committee and Centre for Environmental Policy, Imperial College London): The Prime Minister's Office conducted a Foresight study on international events and in the next risk assessment, which the Adaptation Sub-committee is leading and will be ready for Parliament two years from now, there will be a specific section on the international dimensions of climate change. Not just people arriving on our shores, driven

elsewhere by, let us say, the reduction of water resources, but in the supply chain for the water that is embodied in a lot of food, as well as the disease context.

Jenny Jones AM: I do not think we can wait two years to put that in our report. Thank you.

James Cleverly AM: One of the things that really struck me is the timescale of these things, and you are saying that there are things that we are now living through, in terms of building regulations, for example, which were set by habits driven from the 1920s and 1930s, in response to the world as it was in the 1920s, 30s, 40s, etc.

I am very much thinking about the balance of public demand for a response at governmental level to things in the type of timescales we are talking about. After we had that cold winter there was massive demand for us to be better prepared for winters, to have more rock salt, have more snow ploughs and there was a great demand for public expenditure; and then we did not get any more cold winters for a number of years. I just want to explore the segregation of-- we are talking about extreme weather events, the unusual extremes as we discussed, just the funnies that we get, and the things which will increasingly be not thought of as extreme weather events but are just how the weather is progressing. For example, very, very cold snowy winters may still happen, almost certainly will still happen, but if that is going to be an outlier, whereas warmer, wetter winters are likely to be the more consistent norm. How do we communicate that to policymakers and the wider public so that we do not start chasing a whole load of policy white rabbits?

Professor Martin Parry (Adaptation Sub-Committee and Centre for Environmental Policy, Imperial College London): Let me have a stab at that. I think the smartest way to do this is to, and you imply in your question that one cannot adapt to everything, if you try to adapt to everything perfectly it would be impossibly expensive, so government all over and particularly in London, you hedge your bets. The design code is designed traditionally for a one in 30 years event for rainfall. The guttering on our downpipes is designed to take a one in 30 event of something like 45mm over a day. I will go back in a minute and say that that has changed importantly.

The smart thing to do is at least to make sure that one is in train with the observed record that we are experiencing and make sure we are not planning for the past, especially where the observed is, and I use this word, 'consistent' with what we expect more in the future. I was really surprised to read in your Adaptation Strategy that the number of rainfall events in London of this 45mm per day, the one in 30 event, is now a one in six event. The one in 30 event would, coincidentally have been the design horizon. Do you see what I mean? You design for that, but now actually it is a one in six event. What is the new one in 30? I do not know, but I think the point to illustrate here is I would think it is smart to make sure that the planning, designing, and building of things in London keeps pace with those trends. That is actually what we are experiencing and particularly it is not mainly a decadal aberration, it is probably a part of an ongoing trend and that is wise, it seemed to me.

I think one could do the same for heatwave planning as well. We have experienced an increase in frequencies of certain heat events that you want to avoid. We ought to be redesigning for that in our building codes.

Then the next question, which is about hedging one's bets is how much do you do of the future stuff, which is not coming through yet. Then it depends upon how far is your planning. If it is a big project, which has a 50-year lifetime, you want to look further ahead. If you are shorter term, if it houses, or footpaths or swimming pools or something, you would do less. I am trying to say no one has done this yet and one is inevitably in the forefront of it and we have to find a smart way of firstly keeping up to date, point one; and point two, trying to pick the big hits and maybe avoiding those and protecting against them in the future.

Stephen Knight AM (Chair): I was going to ask, clearly the issue of building regulations and how we design our buildings and homes is going to have to form part of our recommendations I suspect, in this report. Clearly some of the things that we do are going to be fairly neutral in terms of the mitigation effect of carbon, or better, insulation and so on. If we do have all these much hotter days in the summers and hotter nights and we resort to lots more air conditioning, then of course you could have an effect of more carbon and of course making the climate change issue worse. I just wondered whether we would also see a bigger heat island effect, because presumably there are cities where they rely much more on air conditioning than London does at the moment. You could say is this heat island effect much bigger in cities in warmer climates now and can we see how that is likely to change if London resorts to a lot more air conditioning in the future?

Professor Martin Parry (Adaptation Sub-Committee and Centre for Environmental Policy, Imperial College London): I read somewhere yesterday, and maybe Alex [Nickson] will correct me on this, that if one were to allow for uncontrolled air conditioning development into the future, in the 2030s, something like that, one would be adding something like an additional third to the amount of ambient warming on a city like this. There is the warming that is expected from climate change, and you might get an additional warming from any uncontrolled further development. That is based on an assumption of whatever it is, income levels in London projected and a simple equation extrapolating across. I am not sure if that one gives the right impression but I think you are right that firstly uncontrolled air conditioning would burn more carbon and contribute to emissions, part of the whole global swipe of things; and then specifically within the urban heat island, as I understand it, there would be an effect of the sort of magnitude that I have mentioned.

Stephen Knight AM (Chair): Thank you very much for that.

Simon Hughes (Deputy Director London, Environment Agency): I just wanted to reflect on the approach that Professor Parry described about planning for a different future, observing where you are and the line towards that future. I know that you have already had a brief conversation about flood risk and protecting London from flood risk at this Committee, so I will not dwell on it too much, but to reassure you that London is planning for managing tidal flood risk, and its tidal defences, using exactly that pathways approach, which is one of predicting from the latest models what alternative futures may exist and may happen. Then making

conscious decisions about which of those futures we plan for, and by 'we' I mean London and the UK as a whole.

Then monitoring relatively frequently to make sure that you are on track to your assumption of which future you are planning for. These are very important decision points in this monitoring, because at some point you may trigger investment in a multi-million pound infrastructure, like a new barrier for example, and those decisions need to be taken very wisely and based on really good knowledge of where you are going, because you do not want to be building a barrier unless you really are going to need one.

Professor Parry and a colleague of mine sitting in the audience have both been really influential in taking London down that route. That pathway approach can be applied to anything. I think what Professor Parry has just described is a very good way of helping London prepare for alternative futures and make conscious decisions about which bits of the future you might prepare for and which you might not, so I really commend that approach to the Committee.

Murad Qureshi AM (Deputy Chair): On the back of Jenny's question. I just wanted to ask Alex, our representative from the Greater London Authority (GLA). Professor Parry talked about some of the probabilities changing, a one in 30 event is now a one in six event. How well prepared are we to deal with those changes in probabilities of events in the plans for London?

Alex Nickson (Policy and Programmes Manager, GLA): Thank you, Murad, for your question. That is a piece of work we have underway. I think at the last flood discussion we talked about the London Sustainable Drainage Action Plan, where we are working with the Environment Agency and Thames Water to look at what the capacity is of London's drainage systems today; and as you apply more population, more development and climate change on top of it, where does that capacity become insufficient and lead to unacceptable impacts like flooding and toilets not being able to flush, etc. We are doing that modelling work with Thames Water and the Environment Agency at the moment to identify where we have got critical sub-catchment areas where we have real problems. We are already having them, for example the Counters Creek area in Hammersmith and Fulham; and Westminster where we have got a lost river that has basically been turned into a sewer and now when it has rainfall, it backs up into about 700 homes on average, when we have an extreme rainfall event. That is the kind of thing we could see more of in the future if we do not start to plan for it, so that is the purpose of this work, to understand exactly where and when through the century we hit these pinch points and to understand how we avoid them. The key thrust of the work being to try to keep rainfall out of our drains so we do not contaminate clean and potentially very useful rainwater by putting it into a sewer system that then has to run and be pumped for many miles and then be cleaned before it gets put back into the river.

Murad Qureshi AM (Deputy Chair): Just to follow up. Alex, as you know, we did extensively deal with floods at the beginning of the year when we had a flooding situation in certain parts of London. What about in the case of heatwaves?

Alex Nickson (Policy and Programmes Manager, GLA): Yes, we have been working with the London Climate Change Partnership on exactly that. They did a study into heat thresholds,

which was referred to previously in the report and it is exactly that approach that we are recommending, that the Thames Estuary 2100 adaptive pathways approach is applied both to heat and to water resources.

We have been encouraging the water companies to take the same approach, “Look at your future”. The key thing in flooding is quite easy to translate your threshold. Your threshold is “when does water spill over the top of a flood defence and cause flooding?” With heat and drought you do not have those nice simple thresholds. It is much more difficult to define. Are you talking about buckling of railways? Are you talking about melting of roads? Are you talking about exceeding temperatures that lead to people getting sick, etc. There are many, many complex thresholds which, as Professor Parry referred to, have a syndromic approach behind them. To try to identify what is the killer threshold we want to stay above or below is the key challenge and that is the complexity of the work.

Murad Qureshi AM (Deputy Chair): You are saying it is easier with flooding, because we know what the tipping point is.

Alex Nickson (Policy and Programmes Manager, GLA): Yes, exactly.

Murad Qureshi AM (Deputy Chair): With other weather extremes it is less obvious and they still have to be learned.

Alex Nickson (Policy and Programmes Manager, GLA): Yes. With a flood defence you know the height of the flood defence, you know how much water it can protect against, you have very good records in terms of how much rainfall in a catchment, or a tidal surge coming down the North Sea will lead to challenging that flood defence. With heat, every building is a slightly separate threshold height of a flood defence, for example, or every person has a slightly difference response to heat, depending on their age, where they work, etc, so it is a far more complex picture.

One piece of work we have had underway for quite a while now, working with the London School of Hygiene and Tropical Medicine, is to try to develop what we call a ‘triple jeopardy map’ of London. Where have we got areas of the urban heat island that are much higher than the background area? Where within those areas do we have buildings that are likely to overheat, so intensifying a more strategic problem; and where in those buildings do we have groups of people who are vulnerable to overheating themselves? In effect, it tells you where your hot spots quite literally are. Therefore, that will give us an ability to breakdown a very large city-wide almost intractable problem into some areas where we can start to have real effect.

Stephen Knight AM (Chair): I think we are going to move on from looking at where we are now to the coming decades.

Nicky Gavron AM: The Mayor is doing a 40-year, to 2050, infrastructure plan at the moment. We are definitely going to have an infrastructure plan, we are looking at the future, so everything you have been saying is very relevant. I think we have to be a bit more focussed

about which of these extreme weather events we think are going to be the most likely ones over the next, let us say to 2030. It is not very far away actually when you are building out something, it is 15 years. 2030 to 2040. What would you say? I do not mind who answers, we need all of you to answer.

Dr Matt Huddleston (Met Office Climate Scientist and representative on the London Climate Change Partnership): Shall I start on the weather end?

Nicky Gavron AM: Yes. Also, it is two parts really, which are the most likely and then, if you were sitting in front of the Mayor, what are we supposed to do? What should we be doing? Not different pathways, but what should we be doing?

Dr Matt Huddleston (Met Office Climate Scientist and representative on the London Climate Change Partnership): I will leave the second part to the other end of the table, but the first part, there are some of these hazards we are more confident about and the likelihood of a summer heatwave like we had in 2003 or 2006 has already doubled under climate change; and we are expecting them to be normal, as in to occur every other year by 2040. We could be rather confident that we must prepare for heatwaves.

In terms of understanding rainfall, as Martin said, there is less certainty but there is a picture emerging from the underlying data and from the models saying, "We can expect much more intense heavy downpours during the summer". Where we have less certainty, for instance around how the frequency of storms will change, it does not mean there will be no storms, so we still need to maintain preparedness for a stormy environment and extreme winds, even though our understanding of what the impact of climate change is on those storms is not yet clear.

We need to be a bit careful to not neglect areas where we do not have clear understanding from preparedness. It does seem that the likelihood of drought years, and there is not a clear driver for those that we understand at the moment, will continue as it has been in the past.

Those are the four main things. I think planet science has also widened, let us say, its explanation of natural variability. So if we get easterlies and Siberian winds we are going to have a cold winter, so those are not going to go away, even with one or two degrees of warming we are still going to have those experiences. There is a wider range of potential climates.

Dr Emily Black (Senior Research Scientist, National Centre for Atmospheric Science, University of Reading): I think something else which is not my particular area of expertise, but the Committee should also think about, is the impact of some of these changes in temperature and in climate in general, on air quality and air quality events. There is the impact on climate on that and also the constant variability which we have as well in terms of dust influx and things like that. These things are going to keep on happening, so that is also an area which the Committee could think of investigating.

Also just again to emphasise that within these changing climates we do expect to see variability. There will be decades which are cooler, decades which are warmer. We cannot say, for example,

that in 2040 to 2050 it will definitely be two degrees warmer than now because we might be in a cold decade; but the underlying trend is there and, in my opinion, that is what you should be preparing for.

Nicky Gavron AM: The underlying trend.

Dr Emily Black (Senior Research Scientist, National Centre for Atmospheric Science, University of Reading): The underlying trend, yes.

Professor Martin Parry (Adaptation Sub-Committee and Centre for Environmental Policy, Imperial College London): I was thinking about this as I was on my way walking through Liverpool Street, where would one put one's money if one had to choose between the rainfall, as the impacting future, as opposed to heat in London. I guess I concluded, as I wandered over Tower Bridge that it would be preparation for heatwaves, given the experience of the last few years and the role of urban heat islands and the debilitating effect of uncomfortable levels of heat already in certain parts of London transport and so on. That is not my day job, I do not have to do that. Fortunately it is you and not me.

I would also say, on top, at number is one of planning for heatwaves. I would put number two planning for high intensity rainfall events, summer or winter. Generally they do not kill people as much and generally they do not debilitate people as much as heat, but certainly they would cost London big time if there were large areas flooded.

That is really thinking of the event as an impacting issue, the size of the impact, rather than the probabilities of it. I am coming at it rather differently, if you see what I mean. I think there are three layers of this. One is the probability of these events and how they change in the future. Dr Huddleston and others can answer that better. Then there is the scale of the event in terms of its impact, which is a function of the raindrops and temperature but also the vulnerability. Thirdly, I think, in your equation would come in answer to your question: just how big is my design issue? If I was thinking of large-scale infrastructural planning and --

Nicky Gavron AM: We are.

Professor Martin Parry (Adaptation Sub-Committee and Centre for Environmental Policy, Imperial College London): -- building and spending on, then I would look to those, they might be the ones that which one would ask, "Well, what are these most sensitive to?" Because I am making assumptions about heatwaves. I am thinking about elderly enclaves as the Joseph Rowntree Foundation report interestingly called them, elderly enclaves, and I was very interested that Alex's group is looking at that. I think that is very important indeed that you are, but more about that later.

If one wanted to think in terms of the infrastructural issues that you want to meet and the challenges and then ask: what are they sensitive to, what are the events that impact on those? They might not be sensitive to heat, or they might be, so I think you can come at it in a number of ways.

It is difficult issue and there are no perfect solutions to this. It probably is the case that London is in the vanguard of cities thinking about this. When I see the stuff that you have published on this, and it took me more than a day to skim read it, it is encouraging just to see how high is the awareness amongst people like yourselves and how much is going on, not to say one cannot learn from other cities like Rotterdam or Paris or whatever. There is a whole package of these issues, apart from the top two that I listed, heatwaves and intense rainfall, those are the ones. Drought is more incremental, is it not? This builds over periods whether it is one or two or three years, and one has time. Heatwaves and intense rainfall events you have to be ready beforehand. Once it happens that is it, you do not really have time to put things in place .

Thirdly, and I guess you have talked about this, is a storm surge up the River Thames and that is another whole issue that a lot of money has been put into it and a lot of your time as well. That is still there in the background. The IPCC concluded that without any big changes in the West Antarctic ice sheet, without as yet uncertain changes in the North Atlantic oscillation, which are out there, we have suspicions about, but the IPCC concluded that these are not likely to be big new drivers in a rising sea level beyond, whatever it is, the 46cm that I think is already within the planning context.

Nicky Gavron AM: Would you add anything to that, Alex?

Alex Nickson (Policy and Programmes Manager, GLA): No, I think that sums it up very well. I think surface water flooding is our big one. We are about to do some work looking at groundwater flooding. We have always said that groundwater flooding is the big unknown. It is very, very complex to understand how rainfall, over most of the south east, on the North Downs, for example, makes its way towards London, how it moves from our fractured geology and where it pops up. There are very poor records on that and we are going to commission a scoping study into that to understand it. That is the only one I would add to the list. I think winter storms are never off the radar and I think it is probably something we need to look at more. In terms of building regulations they are pretty good, it is about how you manage the existing stuff, the loose window tiles, the trees that have not been blown down in previous years, that sort of stuff.

Nicky Gavron AM: Does anyone else want to come in?

Simon Hughes (Deputy Director London, Environment Agency): If I may. I think just reflecting on London's position in adapting to climate change you are showing really excellent leadership. What I see, as a relative newcomer to the way the city is preparing is really good practice. My advice to the Mayor and to you is adopt the long-term approach to planning as Professor Parry has described. Look at what your different futures could be and then make conscious decisions about where you want to invest and which futures you wish to respond to; and monitor and review that regularly and frequently so that you can adapt your plan as new evidence comes along. Because as sure as eggs are eggs we will know more about how the climate will be in the future in ten years' time than we do now, and we will be able to adapt our approach.

Nicky Gavron AM: We already seem to know quite a lot and we have just had the issue of the urban heat island effect on air conditioning; and we are building at the moment as though there is no tomorrow. I do not know how many of these buildings have the sort of air conditioning that you might recommend. What would you say about what we are doing at the moment, as opposed to what we might be planning to do and all the good documents we have, which nevertheless may not translate actually into practice?

Simon Hughes (Deputy Director London, Environment Agency): I was just reflecting on something James [Cleverly] said about how short memories can be and how difficult it can be to remind people that only recently we were preparing for drought. I think that is where all of us have a role in leading the society through these difficult changes. Yes, we are implementing building regulations that were designed for situations tens of years ago, that is because we have not made a convincing case to Government for them to change those building regulations. That is incumbent on all of us, I think, to be able to deploy the information and the evidence we all represent on this side of the table, to people who make those decisions.

What I found in my experience of working with the pathways approach on Thames Estuary 2100 is that it presents a compelling, irrefutable case, which drove a degree of investment which was obvious that it was required. That is why I really commend that approach to you, because it makes a very objective straightforward case, based on the evidence we have at the moment.

Nicky Gavron AM: Alex, you just said that the building regulations were all right, I think.

Alex Nickson (Policy and Programmes Manager, GLA): No, I said they were all right for winter storms, with regard to heat it is a different matter. In the London Plan and the Adaptation Strategy we have a cooling hierarchy suggesting that people design to avoid overheating, rather than try to cool a building, and we suggest that they need to consider particularly single aspect buildings where there is no possibility for cross-current ventilation. If your only opening is your inside door then you are going to be in trouble there. We were the ones that commissioned the CIBSE Technical Manual 49 (TM49) study into saying developing future design in some years based upon where you are located in London, what kind of building you are; obviously a big yellow storage box needs a different thermal profile and risk approach to a hospital, and that will be coming out very soon. We are trying to push that. I am working with the Department of Communities and Local Government (DCLG) on the review of the National Housing Standards, trying to make sure that in our efforts to ensure that we make development as easy as possible, we do not create buildings that are going to give us a future retrofit handover. We are just trying to keep as much environmental quality as we can, within the view of trying to get quantity as well.

Professor Martin Parry (Adaptation Sub-Committee and Centre for Environmental Policy, Imperial College London): Can I answer that just a little bit? It is the case, and Alex sort of followed up on something I said a few minute ago, that I think a feather in the GLA's cap is that you asked CIBSE to identify thresholds at which temperatures combined with humidity become uncomfortable and you call that TM49. From that they developed a metric, a way of measuring that called Technical TM52 and I am looking at the August 2013, so just last year, *CIBSE Journal* which describes the equation. I cannot understand it, it is quite mathematical,

but it is, as I understand it, quite a ready, easy way for engineers to take the outside temperature and calculate what the inside temperatures would be as a result of that, over certain days. That is the mean, and it is over certain days and then calculate from that what living room and bedroom temperatures would be. That is great that one has established a marker or a measure for this. It seems to me what is missing is the embedding of that in regulation and code that builders have to follow.

I do not know how this happens but I am pretty certain that the national codes do not embody this at all. The Adaptation Sub-Committee (ASC) next month will publish our third or fourth annual report and it has a chapter on infrastructure and has some things to say about infrastructure specifically. I cannot really comment on that ahead of it, as it is still in its not yet final draft. It would seem to me important for London to ensure that these now agreed thresholds of tolerability, in terms of heat and humidity, are coded up and are embedded in regulation. I am not sure if that is something one can do at the London level, or whether it has to be at the national level. I can say that the ASC found when looking at infrastructure, that in the absence of national codes particular industries such as energy, building power stations and electricity substations and nuclear power stations and other sections of infrastructure building, I think the water sector, had gone ahead and modified their own design codes. So you have big industry in certain areas of infrastructure development moving ahead, revising their codings to meet higher standards - and it is higher standards accommodating climate change, I should have said - but it is not being done across the board. I am fairly certain it is not embedded in regulations that the average house builder needs to follow, the living rooms and the bedrooms. There, for example, as Alex is saying, it would be sensible to design such that we have, it is called passive cooling isn't it, Alex? Lower levels of temperature and humidity in the living room before one needs to switch on the air-conditioning. That is due to lots of windows which open in louvers that are more common in the Mediterranean, that have sunshades over them, that have blinds that one can ratchet down, Mediterranean-style, to keep the sun off. These are quite effective ways and there is quite a lot of literature on how effective these are in terms of the passive cooling.

Again, just to finish this little intervention, embedding those, codifying - whatever is the right word - in regulations so that they are followed in what we are building now, I would think that is the important next step and I do not think it is being done nationally. I suspect that London is going to need to push ahead and be the vanguard on this again.

Nicky Gavron AM: Can I just ask, I do not know who would answer this, but we have environmental impact assessments on buildings. We are building a lot of mid-rise and very high-rise and very, very high-rise super-density at the moment and I do not know how far these environmental impact assessments can be manipulated. I have talked to now about six different engineers and they all give you a slightly different story. I do not know what you feel, whether we really have the regulation we need as we build. We are building so much now, you could almost say the stable door has been left open for rather a long time.

Professor Martin Parry (Adaptation Sub-Committee and Centre for Environmental Policy, Imperial College London): I cannot comment on the specific question of different levels of height of buildings, but just to sum up, it is my impression - and I have got a

reputation among the Adaptation Sub-Committee for hammering on this question of codifying - the best knowledge that we have, even with the current climate that we are now, getting up to speed, as opposed to the regulations that are probably based upon, as I say, the 30-year period of 1921 to 1951. Because generally one takes 30 years of data, you look at the return periods of big storms, high winds, heavy downfalls, high temperature and that is how we constructed our building codes in the 1950s, that is what we used. In many cases, we can now look back at those data and say if we take the current 30-year trend, which would be - do my math - 1981 to 2011, would it? Yes, we have that data now, the 30-year period. I am darn sure those return periods would be different and sufficiently different that one would wish to shift the design. You could still say, "I want to plan for one 30 year event" but the one 30 year event structurally is different because the weather has changed. That was recommended in the 1990 Climate Change Impact Review Group for Government, which I chaired, and it was repeated in the second review group in 1996, and I would be happy, Chair, to provide references to that. It is not the first time that this has been asked for.

Stephen Knight AM (Chair): That would be very helpful if you could send them through to us for our report.

Dr Matt Huddleston (Met Office Climate Scientist and representative on the London Climate Change Partnership): Just to mention something there, the UK's temperature is rising faster than the global average and I think we are looking at 0.28 or 0.23 degrees per decade for summer and winters. It is something that is very real and has already been measured, so it makes good sense to adapt to your current climate, if not future climates, in terms of the things where we have the confidence, like in temperatures.

Nicky Gavron AM: Alex, could you just follow up on the environmental impact assessment of buildings?

Alex Nickson (Policy and Programmes Manager, GLA): I am not sure I can really add much more to that, I am afraid, Nicky. We look at the planning applications and so on and we make sure that they are finding opportunities to find things like decentralised cooling connections and so on. I do not really get to review many of the environmental impact assessments to know how well they are being used - or to use your term, manipulated - to support the development.

Nicky Gavron AM: OK. I do not know if anyone has got a comment on it, but I think it is an area that we should be looking at.

Stephen Knight AM (Chair): I think that is certainly something we might look at in our next session, because our next session is very much going to look at the policy response to some of these issues, but Simon, you wanted to come in.

Simon Hughes (Deputy Director, London Environment Agency): Yes, just a small additional point. Building regulations are a great tool if you are renewing your housing stock or you are renovating and you have got a massive retrofit of existing stock challenge as well. I think one really good example of good progress there is Thames Water's plans for metering penetration into existing housing stock, which can help them both plan much more effectively

the way they distribute water and help residents understand their water use and change it, because London does have a very high per capita water consumption.

Stephen Knight AM (Chair): That is very helpful.

Jenny Jones AM: I am hearing sort of a central assumption that we are talking about one or two degrees increase in the average global surface temperature for the next century. Is that where you are working, because the latest IPCC assessment report actually had a variety of scenarios, didn't it, which went from below two degrees to above six degrees? Do you have a central assumption that it is only one or two degrees? That is sort of what I was hearing. I was not hearing any higher figures, but --

Dr Matt Huddleston (Met Office Climate Scientist and representative on the London Climate Change Partnership): It rather depends. The different scenarios do depend on global greenhouse emissions, certainly when you look towards the end of the century, but if we look at the 2020s and 2030s, those different scenarios are very similar, so we are committed to a certain amount of warming. I think for London, the figures are, for instance, 1.6 degrees of warming for the 2020s and 2.7 degrees in the 2050s, with very hot days, getting 6.5 degrees warmer as some sort of central estimate, but it is dependent on global greenhouse emissions when you go beyond that. Certainly I think in terms of adaptation and planning you need the detail of where the systems are going to be and not just the global temperatures. I think globally we have been fixated on two degrees of warming, but what is going to happen here in London is a much more pertinent question now, and I think there is where climate science is really starting to focus. We will get more interesting and useful science coming out over the next few years.

Dr Emily Black (Senior Research Scientist, National Centre for Atmospheric Science, University of Reading): The other thing to comment on is that, as has already come up a few times, an increase in the mean, which might sound quite small, can have very dramatic effects on the return periods of extreme events. It is not necessarily straightforward exactly how these probabilities, this distribution of probabilities, is going to change and that is also an area of active research to know exactly what does a two-degree warming for London even mean in terms of the experience of extreme events? That is also an active area of research and one where there is, I would say, still significant uncertainty.

Alex Nickson (Policy and Programmes Manager, GLA): We have been using the UK Climate Projections (UKCP09), which is an ensemble model, so it is built up of many models run many thousands of times. Those models are weighted according to the ones that best represent what we have been seeing in the past, so that distribution range that Matt talked about includes the variability of different greenhouse gas emission scenarios as well, so perhaps --

Jenny Jones AM: Globally you mean or London?

Alex Nickson (Policy and Programmes Manager, GLA): Well they take the global scenarios and downscale them to 25 kms and then downscale them again to five. The Met Office released a one and a half kilometre grid model for extreme rainfall at the beginning of the week. We are

using that and we do get a sense of that variability, so you can choose different probabilities and different greenhouse gas scenarios to plan for. At the moment, we have mainly fixed on a medium greenhouse gas emission scenario, so we have not taken the highest, because that best represents the pathway we are on at the moment, but we are looking at how big is the envelope. That comes back to the point we made earlier about needing to take a pathways approach, look at where your system starts to break and try to understand the probability of that happening and then start to ask the real questions about, “Are we comfortable with that? Are we investing enough to make sure we bring down the likelihood of that sufficiently and do we have a good emergency plan if our worst fears are realised?” That is the approach I think we are all aiming for.

Dr Emily Black (Senior Research Scientist, National Centre for Atmospheric Science, University of Reading): One thing I would say is that even with the quite comprehensive assessment in the UKCP09, there is still the potential for surprises within the simulations and there is still a lot of ongoing development, particularly with extra processes being taken into account in the models. This will certainly affect our estimation of return periods of extreme events and especially of events not only relating to temperature, but also relating to the hydrological cycle and rainfall, so I think that is something to keep watching.

Professor Martin Parry (Adaptation Sub-Committee and Centre for Environmental Policy, Imperial College London): The other aspect of uncertainty is what globally may be emissions policy and agreed international action, so of the two to six degree range, let us say, to simplify, one element of it - a big element of it - is our uncertainty of the sensitivity of the climate; how it will react to what we are doing to it in terms of putting out greenhouse gases. The other element is what will be the international actions between now and 2050 to reduce emissions? We do not know is the answer to that, but to follow Alex’s point, a growing rule of thumb in the field of adaptation is, I guess you would say, “Hope for the best and plan for the worst” and the least is two degrees. Even if we were to implement all the agreed actions in all the countries in Paris and follow them through 100%, we would probably still reach two degrees above pre-industrial warming. That is about one and a third degrees above now.

Nicky Gavron AM: By when?

Professor Martin Parry (Adaptation Sub-Committee and Centre for Environmental Policy, Imperial College London): The 2050s, mid-century, so we would at least be sensible to plan for that. We have experienced something like a 0.7 degree warming, so another 1.3 degrees, absolutely minimum, I would say. If there is no action, then the model suggests the numbers we have been talking about, globally six or seven degrees. The southern UK, actually rather conveniently for us, broadly follows the global mean, we are sort of mid-latitude and temperate, so we are talking about three degrees global which probably means something like three degrees again over the long-term average for the southern UK. In between, the very least we can expect at the most is your bet, but I think it would take a real optimist to assume that in Paris next year, when the United Nations Framework Convention on Climate Change (UNFCCC) meets and has set its goal on international agreement on emissions, that everyone will sign up to that.

Jenny Jones AM: Alex talked about emergency measures if the worst should happen. A six-degree rise, for the average person it does not sound an awful lot. We all go away to countries where it is probably ten degrees hotter for a holiday, but six degrees is an emergency scenario, isn't it?

Dr Matt Huddleston (Met Office Climate Scientist and representative on the London Climate Change Partnership): Yes, but just to mention that six degrees I mentioned was the very hottest days, it is these hottest days getting hotter. That was not the global average or the UK's temperature I was mentioning, but if we look at the hottest day that we have experienced here in London, it was 10 August 2003 and I think it was 38.1 degrees in Kew Gardens, 38.5 in Faversham in Kent, so over 38 degrees. Those are measures in rather green and leafy areas, and we saw temperatures of over 40 degrees at the entrance to King's Cross tube, so the amplification effect of the urban heat island can mean very uncomfortable temperatures and certainly temperatures that have significant heat impacts. It is an issue that two degrees sounds rather benign in terms of global temperatures, but what it can do to extremes and things is much more damaging.

Our infrastructure in our cities are fixed, they cannot simply be moved. This is the big change now from historical climate change, that we are very vulnerable because of our exposure and our investment in our cities. One thing we have not mentioned so much perhaps is the Environment Agency's work in the Thames Estuary 2100, the sea level is inexorably rising at a slow rate. Professor Chris Rapley, who chairs the London Climate Change Partnership, recommended that we should mention this, that there is evidence there is some very serious warming happening in the Antarctic that will lead the sea level rise that London cannot cope with under business as usual for the Thames Barrier, beyond the year 2100.

It is not going to happen immediately, but there are some very long-term things that are inexorable and have very serious consequences, so those are things certainly within this pathways process that are very much a part of the plan. For coastal cities around the world, there are some inexorable issues that will mean some very serious choices have to be made, bearing in mind what happened with Hurricane Sandy in New York. The one component of that event we could really point at to say there was an increase because of climate change was the storm surge because of the sea level rise; so even with a normal storm, the extra sea level will give you a bigger push of water coming through.

Professor Martin Parry (Adaptation Sub-Committee and Centre for Environmental Policy, Imperial College London): This relationship between the impacting extremes are things that one is really interested in because they affect people, whether they get their feet wet or they overheat, and the normal, on the average, is something I think really needs to be looked at more. If you, in a sort of bottom-up approach, can get your people like Alex to consider what are - well, actually, from Nicky Gavron --

Jenny Jones AM: I will tell him immediately.

Professor Martin Parry (Adaptation Sub-Committee and Centre for Environmental Policy, Imperial College London): -- the important issues that we really want to protect

London against, then Alex's team investigates the weather events that cause that impact, and as often as not our assumption on this side has been the extremes, such as overheating days and the number of them, and then you can look at the relationship. It can be just taking a statistical viewpoint to start with, assume the same distribution of hot and cold days, let us say, ramp up by one degree and what do you get in the hot tail here? It is, as Emily has said, quite surprising, and that figure of the number of overheating days now, on average 18 days, doubling to something like 33 days, but being somewhere in between 21 and 55 days. Back to your question about the uncertainty range, it is a doubling and it must be for something less than one degree of warming by the 2020s you see these are. That encapsulates it, at less than one degree of warming, it does big things to the tail and the more extreme the tail, the greater is that relationship. It is often sort of geometric or exponentially related and I think that is the way to get it through to the public, if that was your concern. You said, "It seems small. Why can it have such a big impact?" and I would say that it is less easy to do it for rainfall, isn't it - I am looking at the experts here - because one year is so different from another, but it is the same mathematical relationship between the overall distribution and the tails.

Stephen Knight AM (Chair): I suppose that begs the obvious question, if one degree of extra average heat produces a doubling of the hot days, what does, I do not know, three or four degrees of average heat, which perhaps is not that unlikely, produce in terms of the number of exceptionally hot days?

Professor Martin Parry (Adaptation Sub-Committee and Centre for Environmental Policy, Imperial College London): As an example, the 2003 heatwave in Paris in a subsequent paper - I cannot remember where it was - but what traditionally would have been thought of as something like a one in 50, one in a 100 year event, it actually had not occurred before, so you could call it a one in X event, really; but it would become an every other year event under something like a four-degree warming. It would make it the norm, if you see what I mean. That is an example of how big average changes can have an impact on the tails of the distribution, and I think communicating that to the public is obviously important and was behind your question; but communicating it to the designers and builders, is also very important indeed.

Jenny Jones AM: It is a bit depressing, isn't it?

Stephen Knight AM (Chair): It is depressing. Is there a review on to what extent --

James Cleverly AM: We adapt. That is what we do.

Stephen Knight AM (Chair): Is there an extent to what extent Londoners would adapt to that kind of new norm of heat and hot summers, because we are talking about a few decades away, really?

Dr Matt Huddleston (Met Office Climate Scientist and representative on the London Climate Change Partnership): In terms of adaptation, one of the tools we have of course is forewarning, so weather forecasts, the skill has improved such that the skill of a one-day forecast 30 years ago is the skill of a four-day forecast now; so five days out you have got good

advice about what is going to happen. Now following the review and the flooding in 2007, the Met Office and the Environment Agency work very closely together and we have a joint flood forecasting centre. Therefore all of those weather forecasts are fed through the flood and the river models and give very good advice, and every day all the key managers through Government and through the Environment Agency get a sheet on their desks saying exactly what is going to happen in coming days and weeks.

Tony Arbour AM: How often is it right?

Dr Matt Huddleston (Met Office Climate Scientist and representative on the London Climate Change Partnership): Actually, the weather forecasts now, six days out of seven, so the detail and the skill of forecasting has improved markedly, and that is an adaptation mechanism. We have the skills, if it is flooding, to get people to get their property onto a high level, to get vulnerable people out of the situation, but there is also another development. Now it is much more about impact forecasting, so for the national severe weather warning service that we provide, we issue a likelihood of an event and an impact forecast, so you get a traffic light kind of event. We saw just one day for last winter when you had a red warning, and everybody knows that is the danger of loss of life. People get familiar with those warnings and know what to do, so there is a communication exercise through the populous and everybody knows what to do with the extreme warnings coming from the Environment Agency on flooding, from the extreme wind and heavy rainfall and the snow, fog and everything else that we do. That has also been expanded out into the natural hazard partnerships where we are not just looking at communicating flood and wind, but earthquakes, landslips and natural health all in one coherent thing; so there has been a big development in the UK's ability to manage extreme events where they are predictable, get the advice to the right people, work with the local Resilience Forums through the public weather service advisers and such.

Stephen Knight AM (Chair): Even a weeks' warning may be enough to pop out and buy a paddling pool or fill your freezer with ice-cream, but it is not actually going to give you the time to adapt your home in terms of insulation or fit air-conditioning or whatever else is needed to cope with major events; so I guess we are really talking about preparing based on risk assumptions, aren't we, in terms of buildings and all the other things?

Dr Matt Huddleston (Met Office Climate Scientist and representative on the London Climate Change Partnership): That is right. Adaptation has these different components, you prepare for what you know about. You have to take short-term measures for things you are not cognisant about. There is insurance, and London as a capital leading on insurance in terms of risk management and being able to prepare and restore after the event, so adaptation has many different strands, but a lot has developed in the last five years in terms of extreme risk management and impact forecasting.

Professor Martin Parry (Adaptation Sub-Committee and Centre for Environmental Policy, Imperial College London): Perhaps it is worth adding that although the numbers look big and can be depressing, as James Cleverly said, we can adapt. There is no question that we can adapt to this because people live under these conditions quite happily in other parts of Europe and the numbers that we have been talking about are not very dissimilar to, say,

Bordeaux, or at the most, Toulouse, south-west France. They have hot days there, but the cities do not stop, and we should ask ourselves how they have done that. I think there is some work to be done on that, looking at the design, whether it has been successful. I would not say they are perfectly adapted to their current climate, those places, but they may yield examples of how buildings, for example, and transport infrastructure work under those conditions and does not grind to a halt when they have many more hot days than we do. They have the number of hot days that I am talking about 20 years down the line, so all these things, I would have thought, in a wealthy city, are adaptable to. The question is really, I suppose, prioritising the investment for public expenditure into it and inducing, nudging the private sector into doing the things such that they are in place when they are needed and do not lag behind so that the adaptation is not there.

I would have thought it is - I repeat myself a little bit, but to try to make the point - not a question of can we adapt. No, it is a question of what do we do first and leave until later, it is about the pathway thing, really. What do we do now until later? When we do it now, what do we do rather than leave other things undone? That is then a question about trading off uncertainties in the science against the likelihood of things that will happen against the cost of retrofitting or redesigning. Getting the combinations right and looking at how people live in other cities that have a climate analogous to something that we could expect in London in the 1930s and 1940s is not a bad way of going about it.

Jenny Jones AM: I am interested in what you were saying about the timeline, because of course given our housing stock, our building stock, it is going to be incredibly difficult to adapt fast enough, I would imagine, for the majority of those buildings. You talked about the pathway and the questions you ask, but isn't one of the questions - and a really important question - does what I do today actually make things worse in ten years' time or 20 years' time? Should we not always be aware that we should not make things worse downstream?

Professor Martin Parry (Adaptation Sub-Committee and Centre for Environmental Policy, Imperial College London): Yes, that is certainly at the very least what we should be doing, making sure that any new build now or new design is not aggravating the situation and there are a number of those; I think people in the field are starting to call this 'man adaptation', if you know what I mean, instead of locking ourselves into corners. A lot of air-conditioning may be one of those and passive cooling may be a way of designing a smart way around --

Jenny Jones AM: Windows and air-conditioning units?

Professor Martin Parry (Adaptation Sub-Committee and Centre for Environmental Policy, Imperial College London): Yes, and designing for open space, designing for greenery and shading to make people feel comfortable, encouraging builders to design for green roofs on top, designing for an open, more café-style culture. It sounds trivial, but actually as a part of a package of things, it can make people more comfortable in a city that otherwise would seem to be hot and sweaty.

Murad Qureshi AM (Deputy Chair): Could I just raise one point on the back of a recent study which suggests future heatwaves pose a risk for the population of Greater London? It

comes from the Oxford University. They have concluded that the risk of heat-related deaths could be significant, to the extent of an additional 800 heat-related deaths per year by 2050. They also suggest actually we can adapt our buildings for it, but do you think that is going to be sufficient? There is adaptation and there is also I think what Jenny was touching on, mitigation, and I just wondered where the balance is between those two. Professor?

Professor Martin Parry (Adaptation Sub-Committee and Centre for Environmental Policy, Imperial College London): By mitigation, coming from the scientific side, we would generally think of that being reducing emissions that are part of the global contribution, so it is very much the UK has adopted a lead within the European Union (EU) and the EU has adopted a lead globally on mitigation to basically try to say, "Look, it is possible to do it and still it not be a cost on people and indeed, we believe, for it to give us a technological edge". That is one issue. Any mitigation that Londoners do is exogenous as a public good, whereas any adaptation that Londoners do, every pound that they spend they can measure the benefit or otherwise of that, so the trade-offs are sort of different in that respect.

On the specific issue in the Oxford study, which I do not know about, but you said, "What can we do about it in terms of building and safeguarding and adapting?" I was very encouraged to hear that Alex mentioned the study of vulnerable people as part of the survey, because I am reading here from this Joseph Rowntree Foundation study in the UK, with a localised example in Manchester, but here is a quote:

"London's neighbourhoods have the highest socio-spatial heat vulnerability in the UK."

I have not come across that before; Alex I am sure would have,

"London's neighbourhoods have the highest socio-spatial heat vulnerability. 25% of London's neighbourhoods are highly socially vulnerable."

What they mean by that is, when I looked at it - and some of you may know it more than me - is they looked at metrics of the vulnerable, the poor, the elderly, those with a history of illness and so on, and ward by ward - and they are quite good at this - compiled this data, because that is what the Joseph Rowntree Foundation does. Making these assumptions about exposure and vulnerability led them to this conclusion. In Manchester, they did much more work on this, and one of their main conclusions to local and central government in the UK is, we really need to have a much better picture of who are the vulnerable people and where are they, particularly the elderly enclaves, as they call them.

I think for you and your research team to conduct studies to create information on where the most vulnerable people are is a very important part of the adaptation. We have talked a lot about design and fabric and infrastructure, but it is the people when it comes to heatwaves and their exposure to this that are the other element; and to have good information on where they are and then action plans on what they can do when you know there is a heatwave coming up. I learned that in Paris in the Plan Canicule, which is their heatwave plan, they have texting on people's mobiles as an alert system. That may work for some, but probably not for a lot of elderly Parisians or Londoners, who probably do not use mobiles like that. It probably is

important, having conducted a thorough study of where the most vulnerable people are in London at the neighbourhood level, to then think of creative ways in which one can make contact with them or have in place the methods by which they can be easily contacted when a heatwave is onset through one or three or four days.

Nicky Gavron AM: We already have that, don't we, Alex?

Alex Nickson (Policy and Programmes Manager, GLA): Yes. Well, we tried. Basically, the risk map looked a bit like a blizzard because there are vulnerable people everywhere and of course what makes you vulnerable today may change tomorrow: is your carer in, are you feeling well today, what activity you have got to perform in that day. We went down that approach quite a long way and we found it very difficult, which is why we started to, as you say, focus where we perhaps have a higher density of known vulnerable people; but some of the classic indicators like poverty do not necessarily ring true in terms of heat vulnerability. There has been a number of studies: a very good book looking at the heatwaves in America called *The Anatomy of a Heat Wave* basically showed that poverty was a very poor descriptor of vulnerability, because poor communities sometimes tend to pull together better. Certainly social fragmentation in London is a challenge.

James Cleverly AM: I am very cognisant that I am drifting in towards my own function in the Resilience Forum, but you talk about the difficulty of creating this vulnerability heat map because of the level of granularity and you have got lots and lots, a very, very high number of very small points of presence and then you went on to talk about communities pulling together. I am wondering if any of you have anything - and again, I suppose I am going to lean towards you, Professor Parry - about community resilience and about that more organic, human adaptation rather than relating to hard physical design, if there has been work done around that?

Professor Martin Parry (Adaptation Sub-Committee and Centre for Environmental Policy, Imperial College London): I am not an expert on this, but my guess is that using civic society and its various elements, from Women's Institutes to toddlers' groups and whatever entities exist, support systems, would be logically a way of insinuating support on this into the community. That is a role that probably Government can do, not heavy top-down by trying to do something new, but using these informal mechanisms somehow. That is my best stab at it, but as I say, it is not anything I have researched on.

James Cleverly AM: I appreciate that, thank you.

Simon Hughes (Deputy Director, London Environment Agency): I am no expert in this at all, but just a reflection on 20-odd years of working with communities affected by flooding. It is very clear to me that those communities, where they come together and work together and help each other out, have a much better experience of flooding, if you can have a better experience of flooding, and bounce back much more effectively. I use Boscastle as a really good example of a community where the vulnerable people were identified very quickly, and they were actually the tourists. They were helped by local people who had a rough idea of what was going to happen, because it was in their folk memory that these things had happened before. They got

them out of their cars and got them up the hill, and they worked together to look after each other and help each other through the recovery phase as well. I have no doubt that there is lots of work out there, particularly around earthquake and volcano risk as well, of responses to that around building strong, resilient communities who look out for each other, because they know much better than any list does who is in, who has broken their leg and cannot move, who might always normally be fit and healthy. It is that sort of community-level knowledge that will get you through very, very difficult times.

James Cleverly AM: I suppose the other advantage of that is it is not risk dependent, that community resilience is going to be as useful in an extreme snow event as it is in a flood event as it is in an extreme heat event perhaps.

Jenny Jones AM: It does not let the Government off the hook though, does it? It does not mean the Government can just sit back and let communities do their own thing or does it?

Simon Hughes (Deputy Director, London Environment Agency): The challenge is, I think, that it is very, very difficult to have -- maybe I will rephrase this. Decision makers like to have lists and like to have maps of where people are so that there is a feeling of some kind of control. If you are opening up a - and I would hate to be preaching to you about that - responsibility or an accountability on a community to take control, that can feel, I am sure, very uncomfortable. But I think the challenge is, as decision makers and policy makers, what are the policy measures you could implement that would make that easier for communities to do whilst giving yourselves obviously the comfort or Government giving themselves the comfort that they have done everything they could have done.

Professor Martin Parry (Adaptation Sub-Committee and Centre for Environmental Policy, Imperial College London): It would seem to be, again as an outsider, a much less expensive thing to have to do. I am not saying one or the other, but when one talks about retrofitting housing, however many hundreds of thousands there are in London, or designing to new specifications which is probably less expensive, as against establishing the most vulnerable and making contact with them and somehow lubricating the whole system or increasing the resilience of it, would seem to me - again, not an expert - to be much the cheaper of the three. I am not saying they are alternatives. It is something we could do now, and as James Cleverly said, it is potentially sort of win-win. It potentially not only increases the resilience of those groups to other impacting events, but probably has other social trade-offs of a kind. I do not know, but that is my guess.

Stephen Knight AM (Chair): I think Alex is indicating.

Alex Nickson (Policy and Programmes Manager, GLA): Yes, I was just going to say London authorities now have a public health duty and we have this new tier of local health resilience partnerships; so I think that sort of nexus is probably the best area. Local authorities understand their communities best, the decision between the London strategic level resilience partnership and the local health partnership is a good way to do that. We funded a couple of community flood plans, the most successful being in Purley, where we have local flood wardens and they know who the vulnerable people are and they liaise with the borough about

disseminating emergency information and response and so on; and I think that is what we need to see more of, I would agree.

Stephen Knight AM (Chair): Shall I move on to the final area, which was around the degree to which policy makers are engaging with scientists to really understand these issues and the degree to which policy is adapted? We have covered a lot of this area, I think, and we have certainly talked about one area being building regulations that have not kept pace with the science. As a general rule however, do the scientists feel that you are being listened to by the policy makers and are the policy makers feeling they are getting the best advice from scientists? Perhaps you could start off, Matt.

Dr Matt Huddleston (Met Office Climate Scientist and representative on the London Climate Change Partnership): Sure. The lion's share of the climate research done at the Met Office is through the Met Office Hadley Centre Climate Prediction Programme, which is funded by the Department for Environment, Food and Rural Affairs (Defra) and the Department of Energy & Climate Change (DECC); so we work very closely on their policy questions and then they let us get on with the work and peer review and publish. We published 324 papers last year, and there is a specific knowledge integration team now that tries to understand the policy questions, so we can better present the scientific results in a way they can actually use them. There are also wider consortia, like the AVOID [Avoiding Dangerous Climate Change] programme, that works with all of the UK main research institutions to present the planet science in a way that can be readily used, so I think that has been a very exciting and useful development in recent years, and it has enabled the science to be much more focused.

Clearly, now getting the detail down so that adaptation and risk-based decisions not just on climate change but natural variability, what has been driving the extreme events, are the kind of questions that people want to know more of. If other departments, indeed the devolved administrations, need advice, they tend to take the science that has been produced and use their own teams, like Alex here, to ask those questions. We are very interested in getting closer to your policy questions, and the other devolved administrations, to understand how they differ from the central Defra and DECC questions that are being asked so that science can be made as useful as possible; but just to reiterate the scientists do get on and do their own peer review kind of objective assessment and then present that back to the policy makers.

Dr Emily Black (Senior Research Scientist, National Centre for Atmospheric Science, University of Reading): A lot of our engagement with policy-makers is via our strong partnership with the Met Office. For example, there is the joint Weather and Climate Research Programme now, which is a joint initiative between the Met Office and Natural Environment Council-funded institutes, such as the one I work for, which is very helpful. In addition to working with the Met Office and others to identify the sort of metrics which people like the Greater London Assembly are interested in, there is also the other angle where scientists work with policy makers on defining mitigation policy and understanding and attributing climate change. That is something where the UK has had really a leading role in the IPCC assessments and hopefully in Paris and in the Conference of the Parties (COP) meetings over the next few years.

Stephen Knight AM (Chair): Thank you very much. Professor Parry?

Professor Martin Parry (Adaptation Sub-Committee and Centre for Environmental Policy, Imperial College London): Adaptation is now clearly on the table. It was not for several years and I think the issue of climate change always seemed to be couched in terms of just mitigation, and adaptation was almost a dirty word, because it admitted that we could not solve the problem. Now it is potentially the biggest one, because there has been this dawning realisation by the global politicians that they cannot spirit climate change away by mitigation wholly, certainly not wholly, and maybe not at all, if we are unlucky. We will see what happens, as I say, in Paris, so it is on the table and there are now entities that create this engagement between the researchers on adaptation.

People like Alex Nickson and his equivalents in Government departments centrally are the key links, in my view, between the research community and through the practitioners to committees like you that steer the ship, as it were. Defra have very sound scientific civil servants of this kind that are that sort of pipeline. In the UK we have various programmes like the United Kingdom Climate Impacts Programme (UKCIP) you are probably familiar with. It was independent, it is now embedded in the Environment Agency, isn't it; and internationally, the International Council for Local Environmental Initiatives (ICLEI). Are you familiar with this? It is an international group of cities that meet annually to discuss issues, and there is the group of C40, of which London is a member; that is a sort of flagship, pushing this ahead. That is internationally, and then above that, we have now set in place a United Nations Programme of Research on Climate Change Vulnerability, Impacts and Adaptation (PROVIA) just now at the highest possible level to try to get international co-operation on this.

Incidentally, I mention that in Rotterdam two years from now there will be an international meeting focusing on specifically cities and climate change, which will be the theme, with the Mayor of Rotterdam. In planning this, which I am partly engaged in, there was a thought of trying to get the London Mayor, together with the Mayor of Rotterdam, for example, to have an entire day on this issue of adapting mega-cities to climate change. I think the parts of the puzzle are in place now.

There has been ten years of catching up to do, in a way, but I do just reiterate - and I am not just saying it because he is here - there are these key individuals who sit between the practice and the theory; and people like Alex are very important in that they are the sort of conduit of knowledge up. I think if we can get that knowledge up one way, paralleled by knowledge down, which is the sort of questions that I was trying to articulate earlier, if you can formulate the questions that you have in your mind, we can sort of convert those into questions and metrics that then we can research on. Too often I think research has not been practically directed towards solving a particular problem, it has been blue sky in this area for the first 20 years. It is only in the last five it has become quite targeted. We may need to focus our work more specifically on those policy questions.

Nicky Gavron AM: I want to just ask what they know about the Rockefeller emphasis on resilient cities, achieving 100 resilient cities, and it seems to me very relevant on how any members are engaging with that.

Alex Nickson (Policy and Programmes Manager, GLA): I will wrap that into my answer.

Stephen Knight AM (Chair): That would be helpful.

Alex Nickson (Policy and Programmes Manager, GLA): I would say academics and policy makers are working better together than ever before. I have sat, on my time at the GLA, on probably in excess of £30 million worth of research projects funded by European money, Natural Environment Research Council (NERC), Engineering and Physical Sciences Research Council (EPSRC) and so on, so it is good and getting better. Quite a few of those early-day academic programmes were really about publishing papers. Academics now have to show impact. If they want money, future years' money, they have to show how they are translating their current findings into having real impact at the policy level, so this is good. A lot of the research that supported the Mayor's Adaptation Strategy was only possible because we were able to plug in early years into those sorts of research projects at a budget we would never have been able to afford at the GLA, so that is good.

On the London Climate Change Partnership, we have obviously got a wide range of members and an ever-growing academic representation on there. Like I say, we have got the Met Office and we have the major London universities, they are all represented on it, so they have got to hardwire into understanding what are the thorny policy and delivery questions we are asking. Then moving on to cities, I think we are almost learning more from other cities than we are learning from academics, because you do not just get the research that they have undertaken, you understand how they have translated that research into practical application, which is something very few academics are able to tell or prove in a model.

Then to finish with Nicky's answer, Rockefeller we are watching with interest. Rockefeller have said that they will fund 100 resilient cities, provided each city nominates a chief resilience officer. We work with London Resilience to actually understand what does that mean and we actively decided we would sit back and watch the first round of cities to see how they are working. Ironically enough, I have a telephone conference this afternoon with Glasgow who are one of those cities, just to see is it working for them or are they finding that they are having a top-down process applied on them that does not necessarily work for their aspect of the way they run the city. We are also working with New York and Rotterdam, who are also pilots of this, to say, "Do we want to jump on to that one the second time round?" because that time is coming up soon.

Stephen Knight AM (Chair): Thank you very much. Finally, Simon, from the Environment Agency's perspective, are the scientists giving you the information and tools you need for making decisions?

Simon Hughes (Deputy Director, London Environment Agency): There is very little I can add to what has been said already, to be honest. Just to give a couple of examples, Dr Huddleston talked about the Forecasting Centre, which is a centre of excellence which brings together weather forecasting and written modelling science to give me, as a decision maker, and colleagues like James Cleverly in the London Resilience Forum the information they need on a

daily basis to make decisions about deploying resources during emergencies; and fortnightly river and groundwater level reporting during floods to allow water companies to make decisions about how they deploy themselves during a drought. I really commend the London Climate Change Partnership approach. I think looking across the country, it has got to be one of the most effective forums for bringing together policy makers, scientists and practitioners and some of the product coming from that in London, if adopted and delivered, is very, very effective, good quality, best in breed if you like.

Looking at the National Climate Change Adaptation Sub-Committee, it is just commissioning some work to look at how we might plan for changes in water availability in future, and that is bringing together the sorts of climate science that people much more qualified than me have talked about with the practical water resource modellers whom I work with to give water companies advice on how they might best plan for not just 25 years ahead, but 100 years ahead. I would not discount the challenge that a third dry winter or fourth dry winter drought might prove to London. There are things we can do, but after a third dry winter, moving into a fourth, you are into some very, very challenging circumstances and they were discussing that at the LRF yesterday.

My experience is there are some really excellent collaborations. Some of the challenges are around then getting that delivered, as others have described, in shaping the way decisions are made about what is built and how things are retrofitted, but I think that for me, the scientists and the practitioners and the policy-makers work well together.

Stephen Knight AM (Chair): Thank you very much. I think we have got a few final questions from our side.

Murad Qureshi AM (Deputy Chair): Can I go back to Alex? Can you just give us an indication of how regularly the Mayor's Office actually reviews climate science research? I have given the example of one that was released from Oxford University in April 2014 and the implications of it across the mayoral strategies. I just want some idea, have we got processes for taking on board all the latest scientific research?

Alex Nickson (Policy and Programmes Manager, GLA): Certainly any information I come across I think is relevant, I share it with my Mayoral Advisor and with other teams, we share, so I think there are networks there. We certainly made sure that particularly the Infrastructure Investment Plan, we are bringing a climate perspective to that to make sure that this new infrastructure we are predicting we need is designed and located in a way that is climate resilient, so I think there is a baseline there for information sharing. Is it as good as it needs to be? I am unable to answer. I think we work hard at it.

Murad Qureshi AM (Deputy Chair): OK, you have given one on the infrastructure. I mean, the emphasis by and large in another context is transport infrastructure. To what extent has it gone into --

Alex Nickson (Policy and Programmes Manager, GLA): Transport for London (TfL) are members of the London Climate Change Partnership. I meet regularly with Helen Woolston,

who is TfL's appointed representative on climate change adaptation. She links into the Health and Safety Executive network across all the modes, so we are sharing the latest climate science with them and we are working with them on London Underground's flood study, for example, so I think it is there. I think there are the networks, there is the information being shared. TfL are regularly contacted by a group that Matt sits on, which is a national infrastructure resilience working group, so I think it is there.

Murad Qureshi AM (Deputy Chair): OK, I will take your word as gospel on how the GLA group does that. I just want to come back to a scientist. This question is done on a policy level, interaction of policy makers with scientists. What about scientists with politicians? Do you find yourself, for example, when you deal with national or local politicians, differences in the comprehensiveness of what needs to be dealt with? I do not know, Dr Huddleston, whether you have got more experience on that.

Jenny Jones AM: Can I come in? Just to take it a bit further, it is true that the GLA is showing leadership on climate change and Alex's team is doing some excellent work, but at the same time we have a Mayor who does not talk about climate change very much and when he does, he suggests that it is solar activity rather than human activity. Therefore I am curious about which advisers you think he ought to use, rather than Piers Corbyn.

Dr Matt Huddleston (Met Office Climate Scientist and representative on the London Climate Change Partnership): I am not sure I want to address that question, but I will.

Jenny Jones AM: No, go on, please. Who would be a good adviser?

Dr Matt Huddleston (Met Office Climate Scientist and representative on the London Climate Change Partnership): Our aim is to get objective information out there and support debates, to be honest. Scientists are naturally sceptical and I can tell you from working for a number of years in the Met Office Hadley Centre they are a pretty dry and sour and objective bunch. Where we do see debate, we just try to make sure the facts are on the table and then let people make up their own minds. We do see alarmism as well as scepticism, let us say, so it is a funny place to be, but often we are as much reining in things that are overstated as understated. Beyond that, we do not have a national remit for communicating climate change, but we do many, many documentaries, radio interviews - our Met Office Chief Scientist, Professor Dame Julia Slingo, is often on the Today Show - and we engage as much as we can within our remit. It is not for us of course to recommend individual advisers for politicians, but we do try to make sure that everybody has got the information that they need to make a good decision.

Murad Qureshi AM (Deputy Chair): Are there any other views and opinions? Here is an example. It just strikes me amongst the political parties we have got probably more lawyers than anything else, and the way they look at things is quite different from the way the scientific community look at things.

Professor Martin Parry (Adaptation Sub-Committee and Centre for Environmental Policy, Imperial College London): We have a Government at present in which departments

have quite strongly different views of climate change and its relevance for policy. DECC is strongly admitting it is a working assumption in everything they do, but in Defra one would say things are different.

Jenny Jones AM: That is interesting.

Professor Martin Parry (Adaptation Sub-Committee and Centre for Environmental Policy, Imperial College London): Oh, very different, yes, and rather than expand on that now in public, as it were, that is an issue that researchers have to contend with, nothing like an issue that local governments need to contend with. That is a far bigger issue for them, feeling their way through these differences, but specifically in response to Jenny Jones' question, there are very good people in central Government such as the Head of Science on Climate Change in DECC, who has been there for many years and was in Defra beforehand and has a long experience in this area. I would think he is probably one of the best people for the Mayor's Office and the GLA people to be in touch with. I am sure that Alex Nickson will know him and works with him already.

Stephen Knight AM (Chair): There we go, we have got a recommendation.

Jenny Jones AM: I just think it is a lack of leadership from the Mayor that is giving us problems in London.

James Cleverly AM: It is not lack of leadership, it is what happens when someone does not agree with you.

Stephen Knight AM (Chair): Finally, can I ask, is there anything any of our panellists feel they would like to say or wish they had said but they have not had a chance to say?

Professor Martin Parry (Adaptation Sub-Committee and Centre for Environmental Policy, Imperial College London): I was interested to read the National Adaptation Plan, which is something the Adaptation Sub-Committee (ASC) is going to have to do in detail next year, because our job is to advise Government on how far the country is adapting and to go through the adaptation plan. As you know, it is quite a general document couched in quite general terms, things like, "Appropriate actions will be taken to meet timely objectives" and so on, but there is an element here called 'innovative solutions' and it caught my eye. It said:

"Core cities, London Councils and the GLA commit to deliver innovative solutions to climate change based on the following principles."

It says that you have committed to do and then it gives these three:

"Embed climate risk management in the built environment, strengthen climate resilience of infrastructure, address and build resilience to health and wellbeing impact of climate change, address impacts on business and services and work jointly to develop a business case."

Nicky Gavron AM: What are you reading from, please?

Professor Martin Parry (Adaptation Sub-Committee and Centre for Environmental Policy, Imperial College London): I am reading from page 103 of the National Adaptation Plan. Here is a central Government document that is, as it were, stating in fairly bold terms that local government in London has undertaken certain commitments to do things, which is encouraging and I am sure you have, and it sounds to me like you are doing them already, but there is a page and a half of stuff here that is worth looking at, which although it is couched in general terms, is quite interesting. For example:

“With the assistance from currently available tools and guidance documents to take action with them to develop council corporate plans and community resilience plans.”

I am sure you are on top of all this, but I had not realised actually that the National Adaptation Plan says that you have agreed certain things and it might be worth going back and having a look at that to see whether they tell you or not; not that I think Defra are going to tick every box and say, “We are doing this, we are doing that”.

Nicky Gavron AM: With your indulgence, can I just come in? One of the things that has worried me is, it is fine to have all these plans, the monitoring of whether anything is implemented, and I think have some of the key performance indicators for local government and the GLA on adaptation and climate change been removed?

Jenny Jones AM: Yes.

Professor Martin Parry (Adaptation Sub-Committee and Centre for Environmental Policy, Imperial College London): At 196 or something.

Alex Nickson (Policy and Programmes Manager, GLA): 188. The whole local authority indicator suite was removed by this Government, so yes. There is no formal report, no statutory formal reporting.

Nicky Gavron AM: On adaptation and --

Alex Nickson (Policy and Programmes Manager, GLA): On many things. As this was 188, there was a fairly extensive list of indicators that local government had to report on, some of which were compulsory, some of which were encouraged, some of which were entirely voluntary.

Professor Martin Parry (Adaptation Sub-Committee and Centre for Environmental Policy, Imperial College London): Which could be used, amongst other things, to measure local government’s actions on adaptation, absolutely.

Alex Nickson (Policy and Programmes Manager, GLA): It is part of localism.

Nicky Gavron AM: Not just for the local government, it is true for -- well, we are a form of local government. It is true for the GLA to, they have been removed?

Professor Martin Parry (Adaptation Sub-Committee and Centre for Environmental Policy, Imperial College London): Yes. What the ASC is doing in its next report - we have been working on it for several years, actually - is to try to set up a set of indicators with metrics attached. In other words, units of measurement attached that can be used to look at each of the National Adaptation Plan's objectives and be those sort of indicators, the matter of the 188, so that one could say, "What is the progress we are making in increasing our resilience to flooding in Britain?" Big question. Well, one might take certain measures such as is the rate of build in the flood plain at risk going up or down, and if it was going up higher than the rest of the country, we are building more on a flood plain than elsewhere, for obvious reasons, it is flat and easy, but it is can we bring that line down? Now, we can count the number of houses, so that is a metric and it is quite a useful yardstick of an indicator of vulnerabilities, so that is one example of a whole set.

Another example might be what is the rate of houses being metered for water as opposed to being unmetered? About 40% of the houses UK-wide are metered and the rest are not, and unmetered houses use about a fifth more water. In our last report, we reckoned that we could almost make good any shortfall of water due to climate change - a pretty broad statement, this - from plugging our leaks, 22% of water we lose that way, and metering and 100% metering. Those two things --

Nicky Gavron AM: Tell Thames Water that.

Professor Martin Parry (Adaptation Sub-Committee and Centre for Environmental Policy, Imperial College London): Those two things would sort of make good on the demand side from the reduction in the supply side. Anyway, just to close on this, that we do think we can come up with a set of indicators and metrics to accompany and things that can examine these statements in the adaptation plan and try to start to answer the question, "Are we making progress towards achieving them?"

Nicky Gavron AM: Will the reporting be mandatory though?

Professor Martin Parry (Adaptation Sub-Committee and Centre for Environmental Policy, Imperial College London): The set of indicators we have set up for ourselves in the Adaptation Sub-Committee and we are using them ourselves. Whether they are adopted nationally by Defra, that is our hope, that they will become a set of standards --

Nicky Gavron AM: You are trying to get them in again?

Professor Martin Parry (Adaptation Sub-Committee and Centre for Environmental Policy, Imperial College London): -- that can be then used in the future to monitor.

Nicky Gavron AM: Very good.

Stephen Knight AM (Chair): OK, thank you very much indeed. The focus of our next session is really going to be looking at the degree to which we are actually putting in place measures to ensure we have properly adapted for these kind of events that we have been talking about. This session I think has really very helpfully set the scene for our next session, so I really want to thank all of our guests for giving up their time to come and talk to us and answer our questions. They have been very informative and very, very helpful. Thank you all very, very much.