New Climate – Future or Reality?

A presentation for the British Council by Paul Mobbs, 10th November 2006

This week and next, the “Convention of the Parties” (COP) of the United Nations Framework Convention on Climate Change (UNFCC) are meeting in Nairobi. This assembly of the world's government, scientific academies and other interested groups will be debating how global agreements will restrict the emissions of greenhouse gases when the Kyoto Protocol expires in 2012. Next year, the Intergovernmental Panel on Climate Change (IPCC) will release their Fourth Assessment Report, and it is likely that, from the information released to date, it will outline a more serious picture of our impact upon the Earth's climate, and the time that we have remaining to avoid damaging climate change. In this presentation I'll briefly outline some of the scientific principle behind how the Earth's climate operates, how we are affecting it, and what the future for our climate may be.

The Stable Climate (Slide 1)

The world's climate has been changing since our atmosphere developed three to four billion years ago. Over that time the world's average temperature has varied greatly, as have sea levels, and the types of vegetation that cover the globe. Around 220 million years ago a large part of the Earth's surface turned into desert during the *Permian Extinction* – an effect now attributed to very large volcanic eruptions in Siberian – but within 30 to 40 million years the Earth natural systems recovered and we enter the *Jurassic Age* which saw the development of the dinosaurs.

There is a clear link between the condition of the atmosphere, average global temperature, and the evolution of life on Earth – a relationship summed up in the *Gaia Hypothesis*. The through a complex interaction of natural biochemical system the Earth's climate always seeks to operate at an ideal temperature. As this temperature is determined by biological systems any non-biological interference can significantly disrupt this balance. Over history this has been caused by asteroid impacts, volcanic activity and the changes in the distribution of land and oceans caused by movement of the Earth's crust. Today there is a new phenomena that is changing the natural balance of the climate – *human society*.

Although, compared to humans, the Earth is huge, the atmosphere of the Earth is not. If you imaging the Earth to be a tomato, the Earth's atmosphere is roughly the thickness of the tomato's skin. In terms of volume, the atmosphere makes up less than 5% of the Earth's volume. Therefore although the planet is large, the volume of the atmosphere is relatively small, and so it is possible for the human species to affect its composition. Another example would be the ozone layer, which in volume terms is a far smaller part of the atmosphere – the ozone layer was seriously damaged by only fifty to sixty years of human activity (the large-scale production of chlorofluorocarbon compounds).

Temperature Balance (Slide 2)

The Earth's atmosphere is in balance with the space around it. The Sun heats the atmosphere with short-wave infra red radiation (only light can travel through the vacuum of space, not heat). As the atmosphere and the surface of the Earth warms it re-radiates heat energy as long wave infra-red radiation. Eventually the Earth heats up to a point where the energy re-radiated is equal to the energy absorbed, and the temperature remains stable – a point called *thermal equilibrium*. So long as the energy coming from the Sun remains constant, so the temperature on the Earth remains constant.

Given it's distance from the Sun, the Earth should be around 30ºC cooler than the present global temperature. What causes the increase are *greenhouse gases* within the Earth's atmosphere – primarily water vapour, carbon dioxide and methane, but other gases such as nitrous oxide (N_2O, or *laughing gas*). These trap the heat from the Sun and raise the level of the thermal equilibrium.

By introducing additional greenhouse gases into the atmosphere the human species has begun to modify the natural thermal balance of the atmosphere. Around 60% of the heating effect has been caused by carbon dioxide, mostly from the burning of fossil fuels. Methane releases, mostly from agriculture and land use change, account for another 20%. Nitrous oxide emissions, from burning fuels at high temperature (in car or jet engines) accounts for around 5% of the change. As the air warms, it can hold more water vapour, which causes further heating. We have also released small quantities of man-made gases, such as fluorinated hydrocarbons, that have a high impact on climate than carbon dioxide or methane.

To complicate matters, we have also released compounds that cause cooling of the atmosphere. Dust particles and sulphur dioxide cause more clouds to form, which reflect more of the Sun's energy back into space and cool the climate. The increase in aircraft travel has also generated a large quantity of high cloud in the form on vapour trails which also reflect the Sun's energy. This is why climate science is so complex – human activity can both assist and antagonise the stability of the climate, although the current balance is towards greater heating.

Historic Changes (Slide 3)

If the level of the Sun's energy input changes, so the temperature on the Earth will change. There are two factors which naturally effect this: the wobble of the Earth on its axis changes the position of the equator, the tropics and the arctic circles over a period of 25,600 years; the eccentricity of the Earth's orbit moves it closer to and further away from the Sun over a period of 100,000 years. These two cycles work together to change the level of energy falling on the Earth, which affects the temperature, and as a result of the Earth's natural systems trying to stabilise the climate the level of greenhouse gases.

In environmental science there are some correlation which are beautiful – for this this is one of them. There is a correlation of temperature and carbon dioxide (the principal greenhouse gas) for the last half a million years. The Earth's wobble and orbital eccentricity produce regularly changing cycles, one within another. As the temperature falls over the 100,000 year cycle we see progressively greater ice ages develop every 25,000 years. The last ice age ended around 10,000 years ago and we should be entering a cooling period – but instead the planet is warming.

The stability of the climate over the last million years or so has allowed the Earth's biodiversity to develop, including the human species. By disrupting this stability we are changing the future course of life on Earth. This is nothing new. The Earth has been through a number of warming phases, biological extinctions, and it has recovered each time. The greater issue here is not the survival of the planet, or life in general, but the human species.

Recent Changes (Slides 4 and 5)

If we take the average temperature from 1961 to 1990 and look back, we can see the effects that the human species has had upon the climate. Humans have been using fossil fuels for at least 5,000 years, but we only started to burn large quantities of fossil fuels around 250 years ago at the start of the Industrial Revolution. In fact, from the point of view of energy analysis, the changes that have taken place since the beginning of the Industrial Revolution could not have happened without the energy input provided by fossil fuels. Before this point human society relied on biomass – food and wood – for survival, and consequently the growth of human society was always limited from the energy available in the biomass that they could cultivate and use. Fossil fuels removed this restriction.

The last 100 years has seen a significant warming – nearly 1ºC since 1900, and almost 0.5ºC over the last three decades. The plot of temperature changes over the last 1,000 years has come to be known as the “hockey stick” due to its shape – a long period of stability followed by s sharp rise in the last 100 years. Until recently there was much debate as to whether the recent warming was due to human intervention. The improvement in data collection and analytical methods since climate change became a critical global issue in the late 1980s now means that, beyond statistical doubt, it is possible to say that the recent increase in temperatures cannot be explained by natural change, but only by the activity of humans and the effect this has had on the atmosphere.

Temperature Projections (Slide 6)

Climate science is led by the development of computer models of the Earth's climate, similar to those used by weather forecasters. Although it is very difficult to tell the precise composition of the weather for more than a week ahead, by averaging data for very long periods it is possible to predict the possible changes in the climate for decades to come, but not for any particular year. Using tens of thousands of temperature measurements climate scientists first use models to predict the weather in the past. When their model produces a good fit with the data collected about the climate in the past, by varying the level of greenhouse gases, or atmospheric pollutants, in the model they can make projections about the future climate.

As part of the assessment carried out by scientists various models have been developed that show the outcome of different “scenarios” or “storylines” (within the IPCC's projections there are around 35 in total). Each scenario represents a particular change in greenhouse gas emissions, economic activity and other changes in human development over the next one or two centuries. These models are grouped around general headings: the “A” models represent changes in human activity led by technology and economic development; the “B” models represent a far more “ecological” level of change, at the local and regional level, related to the wholesale reform of the economy and our systems of energy use. For this reason the emission of greenhouse gases under the “A” models tend to be higher than the comparable “B” models.

If we look at these projections context of the current negotiations in Nairobi, most developed states are seeking change that falls within the scope of the “A” model, whereas many of the non-governmental groups are advocating more radical change that falls within the scope of the “B” models. Ultimately, it is a matter of how much it will cost the world economy to change (more on this at the very end).

All models carry with them a certain amount of uncertainty. What this means is that the central projection of temperature changes has the least uncertainty, by if we look at what is statistically possible we would say that each model predicts a change within a certain range of temperature. The six main scenarios predict a warming of the Earth's climate (relative to the 1961-1990 average) over the next 100 years of between 1.5ºC and over 6ºC.

At an international conference of climate scientists in the UK in 2005 it was decided that to avoid “dangerous” climate change the heating of the Earth's atmosphere must be kept below 2ºC. A 1ºC would destroy the world's coral reefs. 2.7ºC would melt the Greenland ice cap causing widespread coastal flooding. A 3ºC warming would destabilise the Western Antarctic Ice Sheet causing catastrophic sea level rise. Taking the equivalent level of different greenhouse gases together as a single value based on carbon dioxide, restricting the level of warming to 2ºC requires that equivalent carbon dioxide concentrations do not rise above 450 to 500 parts per million (ppm). In 2005, the levels were already above 420ppm.

Carbon Emissions (Slide 7)

The critical issue for the future is the rate of change that we can achieve. This issue will become clearer with the IPCC's *Fourth Assessment Report*, due out in late 2007. The current time frame for action (based on the conference in the UK last year) is 30 to 50 years – otherwise we cannot avoid a dangerous level of climate change.

If we look at historic carbon emissions they have risen from just a few million tonnes per year in 1750 to over seven billion tonnes (or “giga-tonnes”, GteC) in 2003. The problem is that it takes around 30 years for carbon emissions to have an effect of climate. This means that the heating that is being caused today is due to the carbon emissions of the 1970s. In the 223 years between 1750 and 1973 it is estimated that 129 giga-tonnes of carbon were emitted, but in the 30 years between 1974 and 2003 a further 176 giga-tonnes were emitted, and these emissions have yet to take full effect on our climate. Therefore, irrespective of what we do in the future, there will be climate change – it is unavoidable. We cannot stop climate change. Instead we must begin to adapt to it by changing our lifestyles, and especially changing our systems of agriculture and economic activity.

How we change over the next 30 to 50 years will determine whether or not climate change will be “manageable” (less than 2ºC) or “dangerous” (more than 2ºC). If we cut emissions of carbon by 50% over the next 40 to 50 years, we will emit another 247 giga-tonnes of carbon – that's as much carbon as we have emitted over the last sixty years. If we can cut emissions by 75% over the next 40 to 50 years we will emit 197 giga-tonnes – that's equal to the carbon emissions of the last 35 years. This is why the speed of change is critical. We are already emitting such a large quantity of carbon compared to our historic level of emissions that delaying cuts by five or ten years can have significant impacts on the final outcome.

How Long Will Climate Change Last? (Slide 8)

How long the effects of climate change will last is not precisely known, but it is certainly long enough that we can talk in terms of *many generations* of humans rather than our children or our grandchildren.

As noted above, it takes at least 30 years for carbon emissions to have an effect, but removing that carbon from the atmosphere can take a few centuries. Even if carbon emissions peak and fall significantly in the next 50 years, the level of carbon in the atmosphere will take 100 to 300 years to stabilise. The time for the rise in global temperature to stabilise will therefore be around 1,000 year or more – although the majority of the heating will take place over the next 100 to 150 years.

Sea level rise is more complex. It is cause by both an increase in the water volume of the sea as polar ice melts, and an increase in volume of the sea in total due to the heating of the water. Realistically sea level rise is likely to continue for the next 2,000 to 3,000 years, although the majority of that change will take place over the next 1,000 years.

We should not think of climate change as a temporary problem, as with other national emergencies. It is a problem that will change the environment for the next fifty to one hundred generations. For this reason our adaptation to climate change should not be based upon half-hearted changes to human society, but upon change that looks to the long-term, taking into account the needs of future generations (which, essentially, is the whole rationale behind the philosophy of *sustainable development*).

Climate Change in Russia (Slides 9 to 12)

The effect of climate change in Russia is complex. In July 2005, the chairman of the Economic Affairs committee of the House of Lords (the UK's Upper House of Parliament) said that, with climate change, Siberia would become a nice place to live. This is an over-simplification of the effects of climate change. Whilst climate change makes the world warmer, it does not change the location of the Arctic circle. Although Siberia might have warmer summers, it would still have shorter or completely dark days in winter leading to cold periods and seasonal vegetation. North of the Arctic circle it will still be dark all day a few months of the year. Consequently a warmer climate, with potentially less or unseasonal rainfall, adds to the problem of living and growing food in Russia rather than making it easier.

Earlier I outlined the IPCC's various “A” and “B” scenarios. If we look at the change in temperature and rainfall (“precipitation”) across Russia the effects are not the same (note that Irkutsk is marked with a small blue circle). The IPCC's projections give an average change in temperature for the whole year. Consequently, although the average temperature change is greater for northern Russia, the annual variation in temperature might result in slightly warmer winters with a very much hotter summer.

Under the “A” scenario, where emissions do not reduce as quickly, most of Russia experiences a significant rise in temperature. Under the “B” scenario, where the world curbs emissions more quickly, the greatest effect is in the north. Under either scenario there will be a great impact upon the permafrost in Siberia, and this will lead to an increased risk of flooding (ironically, the Permafrost Institute in Yakutsk was flooded recently). The melting of the permafrost will also cause subsidence of the land, which will cause damage to the roads, rail tracks and built on permafrost. It is also likely that west of the Urals in the Western Siberian Plain there will be a much higher risk of forest fires – the effects upon the forests in the Central Siberian Plateau and in eastern Siberia will not be as great, but the risk of forest fires will increase.

Under the “A” scenario rainfall to the west of the Urals will decrease. However, under both scenarios, rainfall will increase across northern Siberia. The greatest changes will be to the south of Russia. Here the arid regions around the Caspian and Aral Seas will extend further north and east through Kazakstan. Much of central China and the Indian subcontinent, which are dependent upon rivers that are sourced from glaciers in the Himalayas, may be starved of water as the flow of these rivers decrease when the glaciers melt.

Dangerous Climate Change (Slide 13)

If the world does not act quickly enough, or the level of greenhouse gas emissions is not cut sufficiently, the the level of warming will exceed 2ºC. This will lead to “dangerous” climate change.

Globally, sea levels may rise up to 80cm by 2100. However, if temperatures rise by more than 2ºC the rise might be a few metres as first the Greenland Ice Sheet and then the Western Antarctic Ice Sheet melt. This would lead to a rise in sea level that would affect between 10% and 20% of the world's current population within 500 years (most humans live close to the sea and in major river valleys).

The greatest effect on the Northern Hemisphere would be if the North Atlantic Thermohaline Circulation, or NATC, were to stop. The *ocean conveyor*, a series of ocean currents that work as a result of the warmth and salinity of sea water, move heat around the globe. In the Northern Atlantic Ocean heat from the Caribbean is transported to the north of Iceland where is warms the climate. As the Greenland Ice Sheet melts, and as the permafrost in Siberia melts, more freshwater enters the North Atlantic and dilutes the salty water in the NATC. If enough fresh water enters the system it will shut down. The level of heating which will certainly stop the NATC is 3ºC, although is possible that a lesser amount might interrupt the current or reduce its effect. Recent data suggests that the current stopped for 10 days in 2004, although we do not have enough data to demonstrate whether this was a freak occurrence, or whether it is indicative of a weakening of the current.

The NATC is significant not just because of the heat it brings to Europe, but also to the amount of humid air that it generates. Without this warmth the air above western Europe would dry, and the level of rainfall to the west of the Urals would reduce and become more seasonal, leading to drier winters.

Energy Supply and Climate Change (Slide 14)

If we look at this issue holistically, considering all the relevant impacts, there is no “problem” of climate change. The problem is our energy supply – climate change is a “symptom” of the form of our current energy supply. Globally, over 85% of the greenhouse gases generated each year are the direct result of energy consumption, either in industry, power stations or transport. If we are to solve climate change, then the greater issue that we must tackle is our use of energy.

In 2005, 88% of all the energy traded commercially around the globe was made up of fossil fuels – 36% was oil, 28% coal and 24% natural gas. Nuclear power only supplied 6% of the worlds energy, and renewable energy (much of which is made up of large hydro-power systems) another 6%. The last set of data supplied to the UNFCCC by the Russian Federation shows that in 1999, energy use accounted for 89.5% of Russia's greenhouse gas emissions. The rest were made up of industrial emissions (4.3%), agriculture (4.2%) and waste disposal (2%). If we are to significantly reduce carbon emissions then we must reduce the amount of fossil fuels that we consume.

For Russia fossil fuels are both a blessing and a curse. Russia currently has just over one quarter of the world's proven natural gas reserves. It also has nearly one-fifth of the world's proven economic coal reserves. Therefore, as the world begins to run short of oil and natural gas, Russia will be under pressure to produce it's coal and gas reserves (coal and gas can both be turned into oil) whilst at the same time the need to reduce greenhouse gas emissions might penalise Russia because of its large mineral energy reserves. To resolve this, Russia needs to evolve a means of development that reduces the consumption of energy and resources in the longer-term, but which does not necessarily rely on the earnings created by the sale of its energy resources on the world market.

In Conclusion

Climate change is not the end of the world – it's just the end of the world as we know it. What it is is a signal that we must change the way that human society works today. If we look at the natural world change is normal – and inevitable. The fact that the current systems of world trade and globalised markets exist today does not mean that these systems must always exist in the future in their current form. The problem in the short term is that tour systems of development and growth are inextricably linked to the use of fossil fuels, and so reducing the use of fossil fuels we consume requires systemic change.

The type of energy that humans rely upon, and that is critical to our existence, is not oil or gas – it is food. The challenge that we face in the future is producing food in a way that requires little fossil fuels (currently we use oil for farm machines and agricultural pesticides, and natural gas to manufacture nitrate fertilisers) and that is able work around the problems of heat, drought, or unseasonable heavy rain, that climate change might create. Producing sufficient food in a warming climate is the important issue of the future – other forms of energy consumption beyond that are negotiable.

The next human need after food is warmth. In Northern Europe, heating and hot water use 80% to 90% of the energy consumed in homes. Therefore we have to tackle the issue of how we heat our buildings. The solution here is not to look forward, but to look back. Traditional methods of construction from one or two centuries ago were able to provide a liveably warm building with a minimal level of energy invested in the building materials they were made from. Today those who specialise in eco-design do not look at developing new space-age insulation materials to save energy. Instead they are looking at the traditional buildings from previous centuries in order to understand how people then were able conserve energy using natural building materials that were produced locally.

Finally, we have to concentrate on our consumption of resources. This is where the various views of managing climate change collide. Those proposing radical solutions to climate change advocate that the Western industrialised states (Russia would only be on the margin of this definition) must significantly cut personal consumption in order that those in developing states might increase their consumption to improve their lifestyles. Those who advocate market-based reforms believe that new technologies and increased level of efficiency can deliver material wealth without carbon emissions, so allowing developing nations to increase their consumption further.

At the moment this argument over resource use has yet to be resolved, primarily because there is a lack of reliable data to prove the issue either way. Many forms of highly efficient production are still theoretical, and have not been proven in practice, and in any case such technological developments in the past have increased rather than decreased personal consumption. Likewise various means of clean energy production, such as carbon capture and storage or nuclear fusion, have not been successfully proven in practice. Even without the problem of carbon emissions, there is a growing body of evidence that our use of resources in general, particular oil and natural and some metals such as copper and silver, are beginning to reach their natural limits.

The pressing problem is time. Given that carbon capture and storage might take 10 or 15 years to develop, and nuclear fusion may be 50 years away, it leaves little time for change as we must significantly cut emissions by 2030, or 2050 at the latest. At the end of October the UK government released its independent study into climate change by Sir Nicholas Stern, head of the UK Government's Economic Service and former World Bank Chief Economist. The study estimated that each tonne of carbon dioxide released would cost the future economy of the world $85. The costs of adapting to climate change and reducing carbon emissions was estimated at 5% of the world's annual wealth, but the cost of doing nothing would ultimate be 20% of the world's annual wealth. In other words, undertaking change now, although difficult, would ultimately produce a positive benefit in the future. Sir Nicholas summed up the outlook for the world when he said, “The conclusion of the Review is essentially optimistic. There is still time to avoid the worst impacts of climate change, if we act now and act internationally. Governments, businesses and individuals all need to work together to respond to the challenge. Strong, deliberate policy choices by governments are essential to motivate change. But the task is urgent. Delaying action, even by a decade or two, will take us into dangerous territory. We must not let this window of opportunity close”.

Ultimately then, this is a matter of choice. We have a clear window of time within which we must change, and a set of options for how that change might be carried out in the future. What we appear to lack, as individuals, as citizens of our nations, or as a global community, is the will to implement change.

Further information

Climate change information kit (UNFCCC/UNEP)
in English – http://unfccc.int/resource/docs/publications/infokit_2002_en.pdf
in Russian – http://unfccc.int/resource/docs/publications/infokit_2003_ru.pdf

About the IPCC
in English – http://www.ipcc.ch/about/faq/IPCC%20Introduction.pdf
in Russian – http://www.ipcc.ch/about/faq/IPCC%20Introduction%20R.pdf

IPCC Third Assessment Report on Climate Change, 2001

- *Synthesis Report*
  in English – http://www.ipcc.ch/pub/un/syreng/spm.pdf
  in Russian – http://www.ipcc.ch/pub/un/syrrussian/spm.pdf
- *The Scientific Basis*
  in English – http://www.ipcc.ch/pub/wg1TARtechsum.pdf
  in Russian – http://www.ipcc.ch/pub/un/ipccwg1r.pdf
- *Impacts, Adaptation & Vulnerability*
  in English – http://www.ipcc.ch/pub/wg2TARtechsum.pdf
  in Russian – http://www.ipcc.ch/pub/un/ipccwg2r.pdf
- *Mitigation*
  in English – http://www.ipcc.ch/pub/wg3spm.pdf
  in Russian – http://www.ipcc.ch/pub/un/ipccwg3r.pdf

IPCC Emissions Scenarios, 2000
in English – http://www.ipcc.ch/pub/sres-e.pdf
in Russian – http://www.ipcc.ch/pub/srlulucf-r.pdf

Interagency Commission of the Russian Federation on Climate Change Problems
in Russian – http://unfccc.int/resource/docs/natc/rusnc4r.pdf