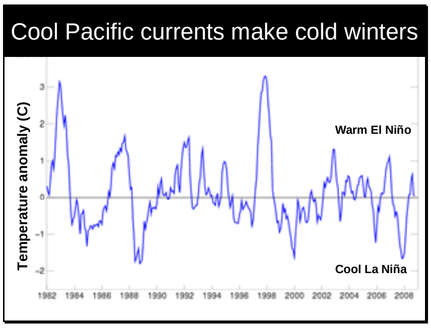
Slide 1

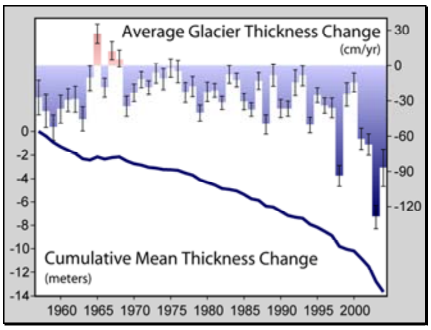
{Note: this lecture is based on many sources, some of which are quoted directly alongside the slides. Ask for specific sources if you need them: dyec@who.int.} This has been the coldest winter in Europe for a decade. I took the picture on the left on the track above my house in France, looking away from Geneva and into the Jura mountains. These are no more than hills in comparison with the alps (over my shoulder), reaching a maximum height of 1700m (5600 ft). The mast at the top marks the top of the ski run, but this has become marginal territory for skiing, even in the decade that I've lived in this area. This winter, skiing is big business, and the snow has stayed on the lower slopes for the whole season. This reflects short-term changes in the weather, not the longer-term changes in climate. Climate change is better reflected in the right-hand picture, taken just above Chamonix looking towards Mt Blanc. The patches of snow in the foreground were the weather of the moment; the Mt Blanc glaciers in the background tell the real story of climate change. They have been retreating for 3 decades.

Slide 2



We can put the previous two pictures into numbers. First the temporary and recent cold winters. The El Niño Southern Oscillation (ENSO) phenomenon is a large-scale, natural fluctuation of the ocean-atmosphere system centred across the tropical to sub-tropical Indo-Pacific region. Through connections to higher latitudes in both hemispheres, ENSO impacts can extend globally during strong phases of its El Niño or La Niña extremes. Warm El Niño events in the eastern equatorial Pacific Ocean in 1982-83, 1987, and 1997-98 coincided with global warmth, but El Niño events are often followed by cooler La Niña events as in 1985, 1988, 1998-99, and again in 2008.

Slide 3



Second, the longer term temperature trend as reflected by melting glaciers. The World Glacier Monitoring Service reports on changes in the terminus, or lower-elevation end, of glaciers from around the world every five years (WGMS). The accelerating downward trend in the late 1980s is symptomatic of the increased rate and number of retreating glaciers (Wikipedia). Over the 5-year period from 1995 to 2000, 103 of 110 glaciers examined in Switzerland, 95 of 99 glaciers in Austria, all 69 glaciers in Italy, and all 6 glaciers in France were in retreat. Virtually all the glaciers in the mid-latitudes are in a state of negative mass balance and are retreating.

Slide 4

10 warmest years have happened since 1997

Global Top 10 Warm Years (Jan-Dec)	Anomaly °C	Anomaly °F
2005	0.61	1.10
1998	0.58	1.04
2002	0.56	1.01
2003	0.56	1.01
2006	0.55	0.99
2007	0.55	0.99
2004	0.53	0.95
2001	0.49	0.88
2008	0.49	0.88
1997	0.46	0.83

The retreat of glaciers is caused by long-term global warming. The 12 years since 1997 include the warmest 10 since records began in 1850 (www.ncdc.noaa.gov).

Slide 5

Health warnings for a hot planet

1. Global climate change
2. How climate affects health
   - Hunger & malnutrition
   - Extreme weather
   - Air pollution
   - Infectious diseases
3. What to do

With that background, part 1 will be a fuller view of global climate change. In part 2 I'll show you the main effects of climate on health. Finally in part 3, I'll say what we can do about it.

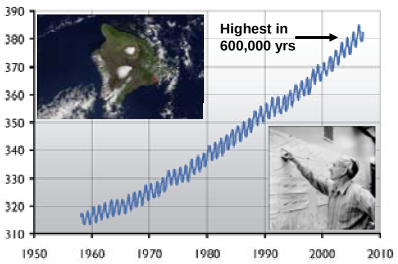
Slide 6

Patterns in climate change

We begin with two key observations that shook climate science: measured trends in (1) CO2 and (2) temperature.

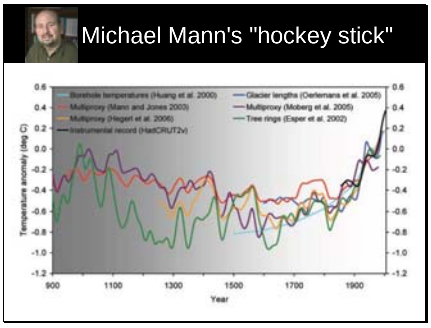
Slide 7

CO_2 Mauna Loa, Hawaii, 1958-2006



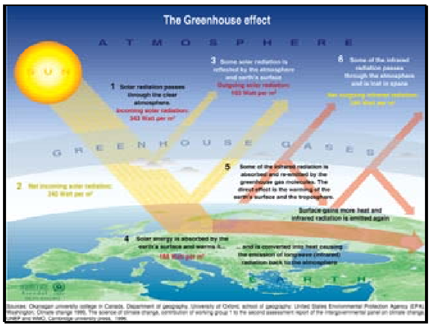
Charles Keeling measured the carbon dioxide abundance in the atmosphere for 47 years, from 1958 until his death in 2005. He designed and built the instruments that made accurate measurements possible. He began making his measurements near the summit of the dormant volcano Mauna Loa on the island of Hawaii. At every latitude there is the same steady growth of carbon dioxide levels, but the size of the annual wiggle varies strongly with latitude. The wiggle is largest at Point Barrow where the difference between maximum and minimum is about fifteen parts per million. At the South Pole the difference between maximum and minimum is about 2 parts per million. The only plausible explanation of the annual wiggle and its variation with latitude is that it is due to the seasonal growth and decay of annual vegetation, especially deciduous forests, in temperate latitudes north and south. The asymmetry of the wiggle between north and south is caused by the fact that the Northern Hemisphere has most of the land area and most of the deciduous forests. The wiggle is giving us a direct measurement of the quantity of carbon that is absorbed from the atmosphere each summer north and south by growing vegetation, and returned each winter to the atmosphere by dying and decaying vegetation. When we put together the evidence from the wiggles and the distribution of vegetation over the earth, about 8% of the carbon dioxide in the atmosphere is absorbed by vegetation and returned to the atmosphere every year. This means that the average lifetime of a molecule of carbon dioxide in the atmosphere, before it is captured by vegetation and afterward released, is about 12 years. If we could control what the plants do with the carbon, the fate of the carbon in the atmosphere is in our hands. (Dyson NYRB 2008, graph: www.cmdl.noaa.gov/ccgg/trends/co2_data_mlo.php).

Slide 8



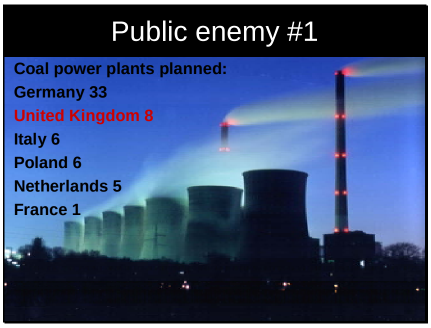
This is a reconstruction of Michael Mann's "hockey stick", first published in 1998. It shows the temperature changes over the past 1100 years, and the marked recent rises. Smoothed reconstructions of large-scale (Northern Hemisphere mean or global mean) surface temperature variations from six different research teams are shown along with the instrumental record of global mean surface temperature. Each curve portrays a somewhat different history of temperature variations, and is subject to a different set of uncertainties that generally increase going backwards in time. The evidence allows us to say now, with a high level of confidence, that global mean surface temperature was higher during the last few decades of the 20th century than during any comparable period during the preceding 4 centuries.

Slide 9



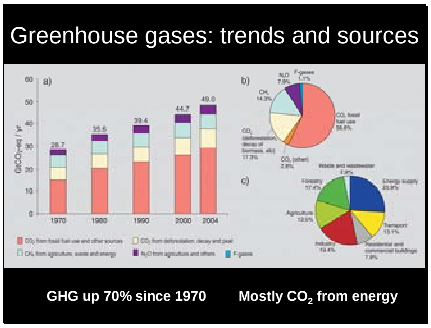
How does the greenhouse effect work to increase temperature? Greenhouse gases (GHG), which include water vapour, carbon dioxide (CO2) and methane (CH4), warm the atmosphere by efficiently absorbing thermal infrared radiation emitted by the Earth’s surface, by the atmosphere itself, and by clouds. As a result of its warmth, the atmosphere also radiates thermal infrared in all directions, including downward to the Earth’s surface. So greenhouse gases trap heat within the surface-troposphere system. This mechanism is fundamentally different from that of glasshouses, which isolate air inside the structure so that the heat is not lost by convection and conduction. The greenhouse effect was discovered by Joseph Fourier in 1824.

Slide 10



Some European countries will continue rely heavily on power generation from the source that generates most C02 – coal-fired power stations. The UK, this week branded a "climate criminal" by activists, is among them.

Slide 11



Global atmospheric CO2, CH4 and N2O have increased markedly as a result of human activities since 1750 and now far exceed pre-industrial values determined from ice cores spanning thousands of years. GHGs increased 70% between 1970 and 2004 (A). The largest growth in GHG emissions between 1970 and 2004 has come from energy supply, transport and industry, while residential and commercial buildings, forestry (including deforestation) and agriculture sectors have been growing more slowly. The atmospheric concentrations of CO2 and CH4 in 2005 exceed by far the natural range over the last 650,000 years. (B) Global increases in CO2 concentrations are due primarily to fossil fuel use, with land-use change providing another significant but smaller contribution. According to the IPCC, It is very likely that the observed increase in CH4 concentration is predominantly due to agriculture and fossil fuel use. The increase in N2O concentration is mainly due to agriculture.

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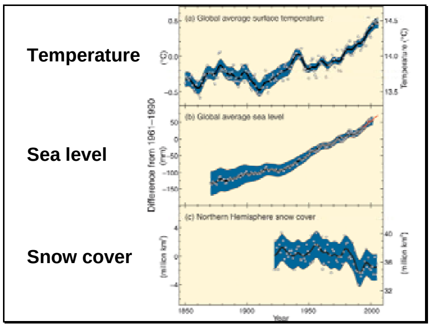

The warming of the climate system is unequivocal: not just of surface temperature (top), but also in its effects on sea level (middle) and on the widespread melting of snow and ice (bottom). The consequence of the increase in GHGs is a rise in temperature. The graph shows how independently measured sea-surface temperature, air temperature from fixed long-term stations over land and air temperature over the oceans have followed similar trends through time. The data have been filtered to show the longer-term fluctuations. The increase compared to the 1961-90 average is now about 0.5C on average (www.metoffice.gov.uk/climatechange).

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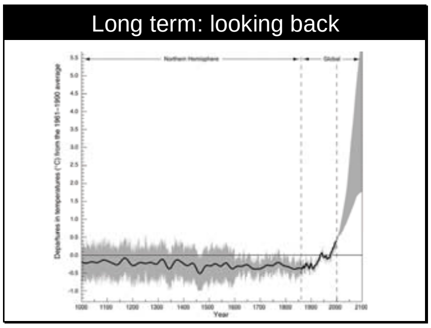
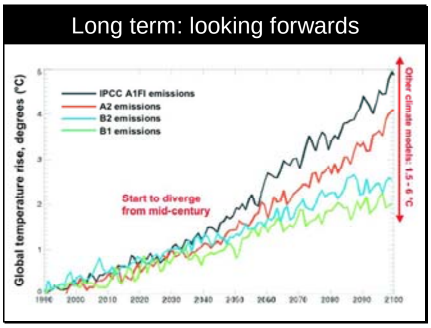


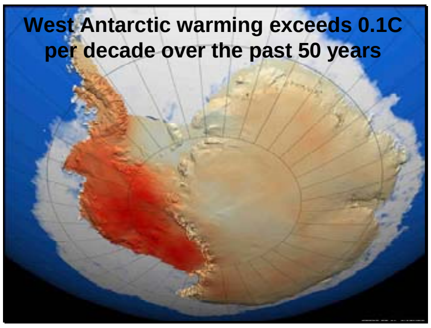
Variations of Earth's surface temperature since 1000CE, showing the outstanding changes in the past 100 years (www.jri.org.uk/brief/climate/climate_2.gif).

Slide 14



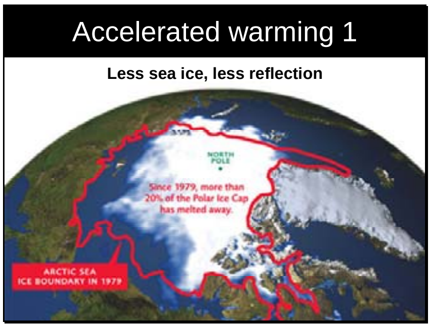
The global average temperature will increase by 2-3C this century according to IPCC's mid-range estimates. This is a bigger rise in temperature than any in the last 10,000 years.

Slide 15



Every new piece of data enriches the picture. The latest data from the Antarctic shows that warming in the west has exceeded 0.1C per decade over the past half century. This is linked to regional changes in sea surface temperature and sea ice (Steig Nature 2009).

Slide 16

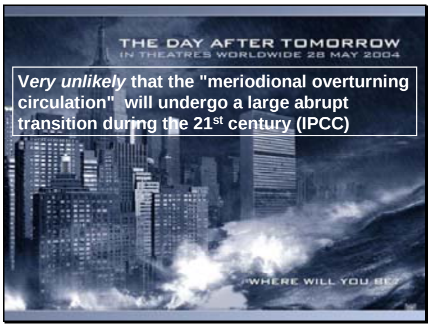


There are at least two processes that accelerate warming, which are not yet factored into IPCC models. So the projections of these models are in this sense conservative. As the cover of sea ice decreases, here in the Arctic, less heat is reflected back into space, a process that accelerates warming.

Slide 17

The thawing of permafrost in the northern tundra is a second process that is expected to accelerate warming. The warming tundra releases methane, a more potent greenhouse gas than CO2. The melting of western Siberia alone has the potential to release up to 70 billion tons of methane - about 2,000 times more methane than the total annual anthropogenic forcing introduced currently by human processes. For comparison, the United States releases about 6 million tons of methane into the atmosphere from livestock operations (mainly cattle) each year, while globally total human related methane release totals 30 million tons. The warming effects of additional methane could mean that there will be no sea ice in the arctic by 2100.

Slide 18



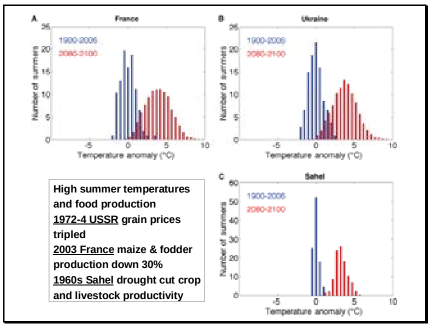
Lastly, I have to mention "the day after tomorrow". Wherever you will be (see poster), you need not plan for this. The film was based on the idea that the Atlantic warm-water conveyor, the meridional overturning circulation (MOC), will stop and reverse, with disastrous consequences. It is likely that the MOC will slow down during the 21st century. But it is very unlikely that the MOC will undergo a large abrupt transition during the 21st century. Large-scale and persistent changes in the MOC are likely to affect marine ecosystem productivity, fisheries, ocean CO2 uptake, oceanic oxygen concentrations and terrestrial vegetation. These may in turn feed back, positively or negatively, on the climate system.

Slide 19

Hunger & malnutrition

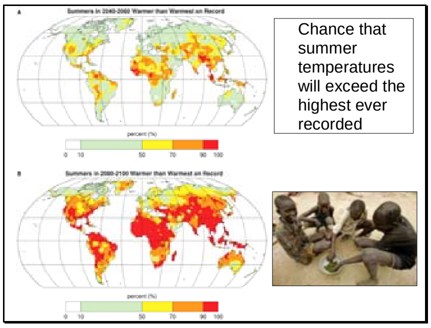
Most effects of climate change will ultimately have a bearing on health. More directly, the health of millions of people will probably be affected through increases in malnutrition; deaths, diseases and injury due to extreme weather events; diarrhoeal diseases; cardio-respiratory diseases due to higher concentrations of ground-level ozone in urban areas; and the expanded distribution of some infectious diseases. Climate change will bring some benefits in temperate areas, such as fewer deaths from cold exposure, and some mixed effects such as changes in range and transmission potential of malaria in Africa. Overall it is expected that benefits will be outweighed by the negative health effects of rising temperatures, especially in developing countries.

Slide 20



High summer temperatures in the USSR in 1972 contributed to disruptions in world cereal markets and food security. The price spike 1972-74 was an anomaly within a long-term trend decline in grain prices during a 50-year period after World War II. Prices for wheat rose from $60 to $208 per metric ton in international markets between the first quarters of 1972 and 1974, and real prices more than tripled. Although extreme summer averaged temperature in the USSR was among several factors contributing to the international price spike, this climate event was largely responsible for setting the dynamics in motion. Severe heat in the summer of 2003 affected food production as well as human lives in Europe. Record high daytime and night time temperatures over most of the summer growing season reduced leaf and grain-filling development of key crops such as maize, fruit trees, and vineyards; accelerated crop ripening and maturity by 10 to 20 days; caused livestock to be stressed; and resulted in reduced soil moisture and increased water consumption in agriculture. Italy experienced a record drop in maize yields of 36% from a year earlier, whereas in France maize and fodder production fell by 30%, fruit harvests declined by 25%, and wheat harvests declined by 21%. Another region at risk from higher temperatures is the Sahel, where crop and livestock production play an essential role in the region's economy, employing roughly 60% of the active population and contributing 40% to gross national product. The Sahel suffered a prolonged drought from the late 1960s to the early 1990s that caused crop and livestock productivity to plummet, and which contributed to countless hunger-related deaths and unprecedented rates of migration from north to south, from rural to urban areas, and from landlocked to coastal countries (Battisti Science 2009). These droughts will become more frequent and, without remedial action, we can expect their effects to be the same.

Slide 21



Increasing temperatures and more variable precipitation are expected to reduce crop yields in many tropical developing regions. In some African countries, yields from rain-fed agriculture could be reduced by up to 50% by 2020. This is likely to aggravate the burden of under-nutrition in developing countries, which currently causes 3.5 million deaths each year, both directly through nutritional deficiencies and indirectly by intensifying vulnerability to diseases such as malaria and diarrhoeal and respiratory infections (WHO 2008). The maps show the likelihood (%) that future summer average temperatures will exceed the highest summer temperature observed on record (A) for 2050 and (B) for 2090. For example, for places shown in red there is greater than a 90% chance that the summer-averaged temperature will exceed the highest temperature on record (1900–2006). Notice that tropical and sub-tropical areas – those areas that are already hot -- are among the worst affected.

Slide 22

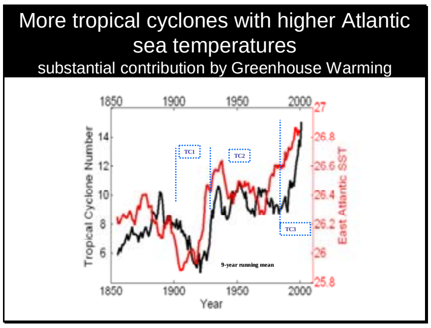
Extreme weather

Extreme weather means storms & floods, heatwaves & cold snaps, and droughts.

Slide 23

The images generated by hurricane Katrina are still fresh in the mind. But are hurricanes linked to climate change?

Slide 24

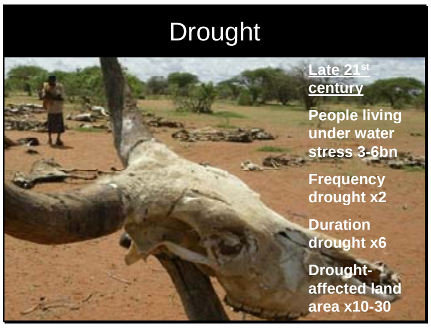


The emerging evidence says yes. A marked increasing trend in tropical cyclone frequency closely associated with increasing eastern North Atlantic SSTs, which indicates a substantial contribution by Greenhouse Warming (Holland Phil Trans R Soc 2007).

Slide 25

It's clear who will suffer most. Almost 90% of the burden of diarrhoeal disease is attributable to lack of access to safe water, sanitation, and reductions in the availability and reliability of freshwater supplies are expected to amplify this hazard (WHO 2008). By how much, we cannot be sure.

Slide 26



This 2006 photo shows a resident of a drought ravaged Wajir in Kenya's north-eastern province walking among livestock carcasses following a prolonged drought that has devastated the region's herds (AFP/Getty Images). Shifting rainfall patterns, increased rates of evaporation and melting of glaciers, combined with population and economic growth, are expected to increase the number of people living in water-stressed water basins. Rough calculations suggest increases from about 1.5 billion in 1990 to 3–6 billion by 2050. By the 2090s, climate change may bring a doubling in the frequency of extreme drought events, a 6-fold increase in mean duration, and a 10–30-fold increase in the land area in extreme drought (WHO 2008).

Slide 27

Hundreds of people have died during one of the worst heat waves in 100 years to hit the south-east of Australia. Most of them were elderly people who had been struggling in the heat. The heat wave caused power outages in Melbourne, and bush fires burnt homes to the ground. This particular event could have was been driven in part by the equivalent of La Nina in the Indian Ocean – the Indian Ocean Dipole. But the consequences of overheating in future are likely to be the same, whatever the underlying cause. In the extremely hot European summer of 2003, there were more than 70,000 excess deaths (WHO 2008).

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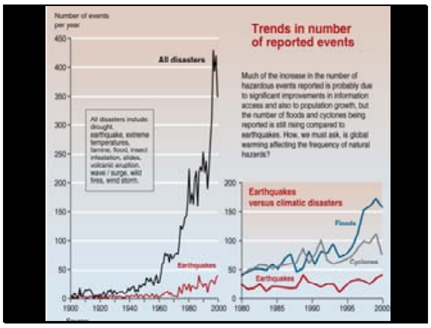
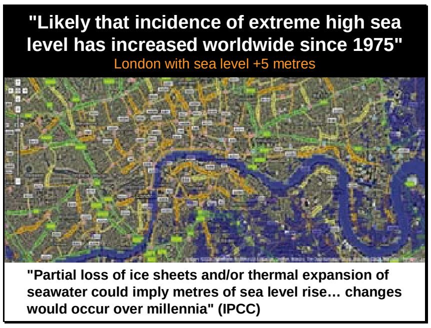


With growing population and infrastructures the world's exposure to natural hazards is increasing. This is particularly true as the strongest population growth is in coastal areas, with greater exposure to floods, cyclones and tidal waves. Any land remaining available for urban growth is generally risk-prone, for instance flood plains or steep slopes subject to landslides. The statistics in this graphic reveal an exponential increase in disasters. Is the increase due to a significant improvement in access to information? What part does population growth and infrastructure development play? Is climate change behind the increasing frequency of natural hazards? (CRED 2005). Assuming that it is, WHO projects that climate change will multiply the number of people exposed to coastal flooding more than 10-fold, to >100 million people/year. These trends will also increase the hazards of weather-related natural disasters, which killed approximately 600 000 people during the 1990s. Repeated floods and droughts may force population displacement – which, in turn, is associated with heightened risks of a range of health effects, from mental disorders such as depression to communicable diseases and, potentially, civil conflict (WHO 2008). However, despite the reported increases in floods and storms, the number of reported victims has remained relatively stable, so the number of victims per disaster has fallen.

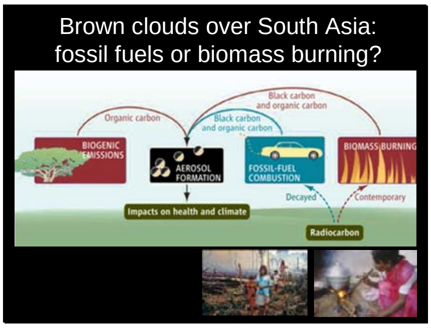
Slide 29



Maps online quickly show the impact of rising sea levels along coasts and in estuaries. With a 5 metre rise in seal level, this is where the water would come to in London, submerging the Elephant and Castle. More important would be the storm surges and flooding that come from extreme weather coupled with much smaller rises in sea level (map: flood.firetree.net).

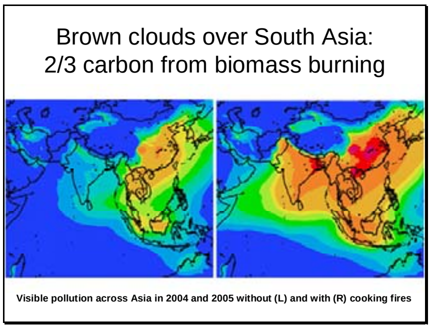
Slide 30

Slide 31



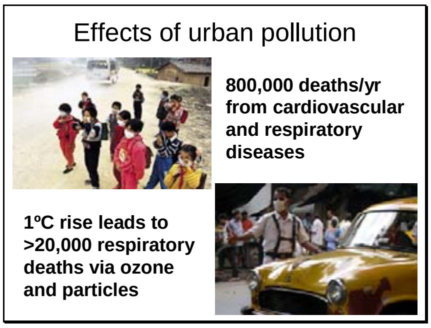
Although the burning of fossil fuels, especially coal-driven power stations, is the major source of CO2 worldwide, the balance differs among regions of the world. SE Asia has become notorious for haze linked to biomass burning, especially the burning of forests and smoke from many millions of domestic cooking stoves. Around half of the world's population cooks on stoves that burn biomass such as wood, crop residues or dung, development specialists say. According to WHO estimates, smoke emitted by traditional cookers kills 1.6m people each year, most of them women and children (WHO 2007). If these trends continue, in Africa alone indoor air pollution will kill 10m people by 2030. Of these deaths, up to 3.7m could be saved by switching to petroleum-based fossil fuels such as kerosene (Bailis Science 2005). Lung cancer, pneumonia and acute lower respiratory infections are prevalent as a result of constant exposure to carbon monoxide, particulates, hydrocarbons and carcinogens such as formaldehyde and benzene that are contained in cooking smoke. Recent research has measured the contribution of biomass burning as compared with fossil fuel combustion. Radiocarbon analysis distinguishes between fossil and non-fossil sources of black carbon and organic carbon.

Slide 32



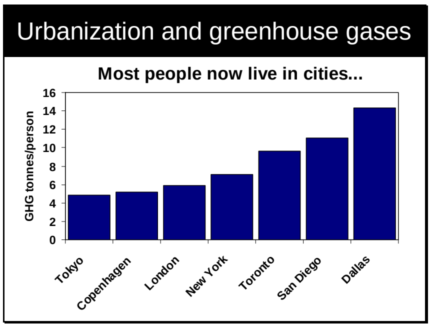
This is the intersection of a process that contributes to climate change with the age old problem of air pollution (London smogs). The two maps illustrate the potent pollution impact from cooking on dung and firewood. At left is an estimate of visible pollution across Asia in 2004 and 2005 from sources other than cooking. At right is the estimate with emissions from cooking fires added (Scripps Institution of Oceanography/UCSD). The general finding is that black carbon could have as much as 60% of the current global warming effect of carbon dioxide, more than that of any greenhouse gas besides CO2, and more than recently estimates by the IPCC (Ramanathan Nature Geoscience 2008).

Slide 33



Urban air pollution currently causes about 800 000 deaths each year, mainly by increasing mortality from cardiovascular and respiratory diseases. The effects of just a 1C rise in temperature on ozone and particulate levels may increase global deaths from air pollution by over 20 000 per year. Ozone irritates airways, reduces lung function, aggravates asthma. Mitigation is possible now with existing technology (including bicycles) and would have immediate health benefits as well as reduce global warming pressure.

Slide 34



Cities – where the majority of people now live -- have a special role in contributing to, or mitigating, air pollution. Whether it is improving the heating and cooling efficiency of the buildings and power plants, improving the fuel efficiency of the cars, or reducing the amount of electricity consumed, most greenhouse gas–reduction strategies will pay off in terms of reduced local air pollution as well as improved public health. More walkable, transit-oriented cities that are less dependent on cars, like Copenhagen and Tokyo, have lower per capita carbon emissions than sprawling, car-oriented cities like San Diego and Dallas. Less driving, more walking, and more transit ridership means less carbon introduced into the atmosphere, and less local air Pollution (Bloomberg Am J Prev Med 2008).

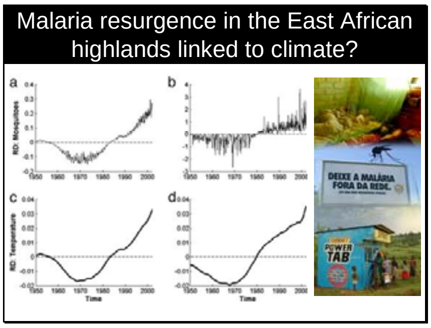
Slide 35

Infectious diseases

Slide 36

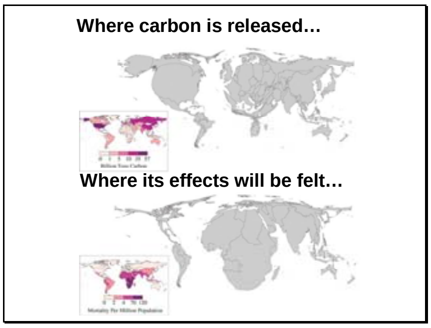
There has been much debate about the effects of climate change in parts of the world that we already think of as warm – the topics. The cooler parts of the tropics are the highland areas, like the summit of Mt Kilimanjaro, which is losing its snow cover. As the slopes of the mountain get warmer, are vector borne disease becoming more common?

Slide 37



The incidence of malaria in the East African highlands has increased since the end of the 1970s. The role of climate change in the exacerbation of the disease has been controversial, and the specific influence of rising temperature (warming) has been hotly debated. Some have preferred to explain highland malaria in terms of resistance of the malaria parasite to drugs and the decrease in vector control activities (Hay Trends Parasitol 2002). A 2006 study examined 4 high-altitude sites in East Africa where malaria has become a serious public health problem, finding a significant warming trend at all sites. The impact on malaria of observed temperature changes would be significantly amplified by the mosquito population dynamics (Pascual PNAS 2006). Generally, rising temperatures, shifting rainfall patterns and increasing humidity affect the transmission of diseases by vectors and through water and food. Vector-borne diseases currently kill over 1.1 million people a year, and diarrhoeal diseases 1.8 million. Studies suggest that climate change may swell the population at risk of malaria in Africa by 90 million by 2030,18 and the global population at risk of dengue by 2 billion by the 2080s.

Slide 38



The two world maps represent the contribution of different nations to global warming, as measured in atmospheric carbon output (top) and the health effects of global warming as measured in mortality for diseases and other effects of a warming world climate (bottom, maps: J Patz). But these estimates of mortality, while possible, are highly uncertain. The uncertainty in these and many other figures I've quoted is very significant is deciding what to do. It is much hard to call for action when we cannot confidently set costs against benefits.

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What to do

Slide 40

Stern carbon budget

- GHG not to exceed 500 ppm $=CO_2$
- Temperature rise <4ºC
- Emissions to peak within 15 years
- Falling to half 1990 level by 2050
- Human C added 10 gt/yr max (now 45 gt/yr)
- Cost 2% global GDP annually
- Financial crisis >> low-cost investment

So what must we do? We need clear, simple guidance and a consensus to act. Nicholas Stern's summary is an attempt to achieve this (New Scientist 2009). To get carbon down to 10gt/yr from the present levels of more than 40 gt/yr will require heroic efforts. It's not the purpose of this lecture to say how we stop GHG emissions, but there is agreement that we have the technology to do it, albeit with some debate. Some of the most vocal point out, for example, that carbon trading is "greenwash" (J Hansen) and "a gigantic scam" (J Lovelock). Hansen argues for severe carbon taxation and zero coal use asap. Stern argues that, during this financial crisis, green measures should account for 20% of economic recovery plans. Barack Obama's $100bn in green measures (Feb 2009) represents about 13% of the total package, less than the 20% benchmark. It also fails to meet the UN target of 1% of GDP. South Korea devoted two-thirds of its $36bn recovery package, or about 3% of its GDP, to green investment. China allocated about a third of its $580bn recovery plan to green measures, concentrating on energy efficiency. That is much higher than most European countries. The green portion of the EU recovery plan comes in higher than the US plan at 14% (Guardian Feb 2009).

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The tough arguments for action

1. Uncertainty
   - Scientific consensus
   - Known unknowns
   - Efficient spending
   - Who should act
2. Distant future
3. Self interest

There are 3 groups of problems in taking action: (1) there is much uncertainty, to be set against cost: scientific consensus, known unknowns, can money be well spent, who should act; (2) many of the effects will happen in the distant future; (3) countries are inclined to look after their own interests.

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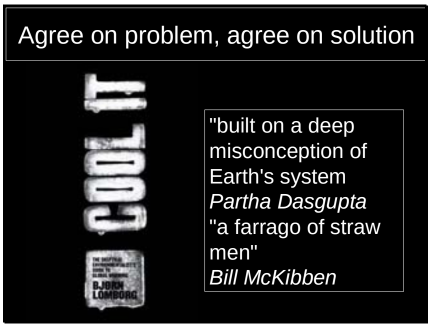

First we must agree on the problem, and agree on the solution. This presents scientists with a dilemma, because science progresses by challenging established views. The public perception is that scientists do not agree, so how do we know who to believe? In the context of climate change, the work of the IPCC is hugely valuable in building consensus. Of course, some of the challenges to consensus are opportunistic, self-serving and wrong. Lomborg's central idea that we can't do much about global warming, and that anything we do attempt will be hugely expensive. Yet the IPCC has said at length that it is technically feasible to reduce emissions to the point where temperature rise could be held below 2C — the point where many climate scientists now believe global warming may turn from a miserable problem into a catastrophe. The question about mitigation is whether we are prepared to invest to avoid the risk of longer-term, catastrophic climate change.

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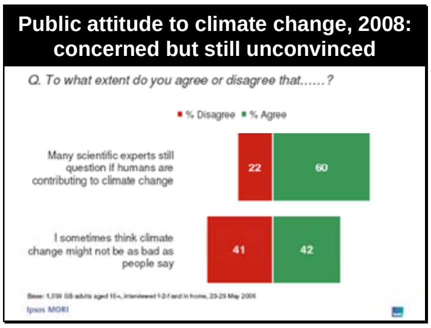

Here is one view of the current public perception of climate change, as revealed in a Mori poll. There remain uncertainties about the science and the impact of climate change. In this poll, 60% agreed that many scientific experts still question whether humans are contributing to climate change; 42% said they sometimes think climate change may not be as bad as people say.

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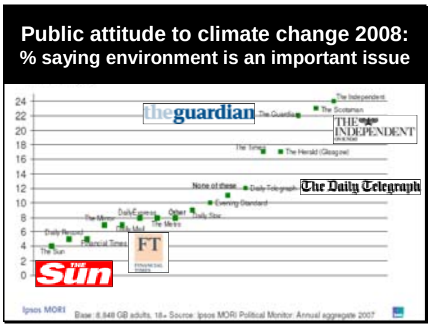

There is a remarkable association (even stronger than expected) between Newspaper readership and beliefs about climate. "Broadsheet" readers are much more likely to agree that the environment is an important issue than those who buy the tabloids. The FT has taken an unusual position.

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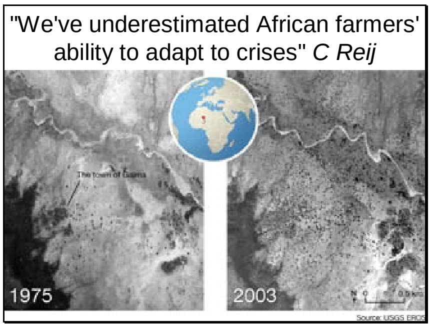

Reforestation, town of Galma and surroundings, Niger 1975 and 2003. In 1970s and 1980s - years of environmental crisis, there were few trees remaining in Niger. Wind-blown sands razed farmers' young crops and they often had to plant crops three times to succeed. Since the middle of the 1980s in the most densely populated parts of Niger farmers have begun to protect and manage young trees and bushes regenerating on their cultivated fields. This is natural farmer-managed forest regeneration. Some trees fix nitrogen from the air on their root system, which helps to maintain and improve soil fertility. Improved soil fertility leads to higher crop yields. The trees and bushes protect crops against wind and sand and farmers now often need to sow only once, which increases the length of the growing season. Women are perhaps the biggest winners. They spend much less time now on the collection of firewood than they did 20 years ago - about 0.5 hours/day now instead of 2.5 hours/day in 1984. They also now own 80% of the goats and sheep, which provides them with income. Fodder is much less of a problem now than 20 years ago as the trees produce seedpods and leaves, which are a major source of fodder in the dry season. The most important incentive for tree regeneration by farmers was a change in perception of ownership of the trees. In 1985 the perception was that trees were owned by the State, but farmers now perceive an exclusive right to their on-farm trees. Farmer-led tree regeneration has happened on at least 5 million hectares - once barren, sandy soils almost devoid of vegetation now has 20, 40 or more trees/ha (UNEP Reij 2006).

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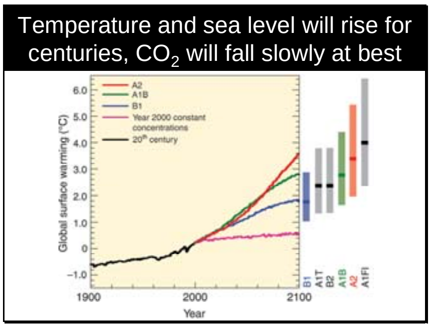

Another concern in putting the argument is this: man-made warming and sea level rise would continue for centuries due to the time scales associated with climate processes and feedbacks, even if GHG concentrations were stabilised. If radiative forcing were stabilised, keeping all the radiative forcing agents constant at B1 or A1B levels in 2100, model experiments show that a further increase in global average temperature of about 0.5°C would still be expected by 2200. In addition, thermal expansion alone would lead to 0.3 to 0.8m of sea level rise by 2300 (relative to 1980-1999). Thermal expansion would continue for many centuries, due to the time required to transport heat into the deep ocean.

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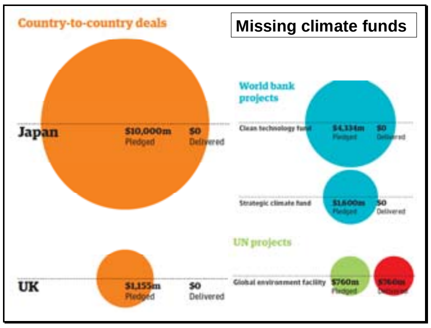

The world's richest countries have pledged nearly $18bn to help poorer countries adapt to climate change, but less than $1bn has been disbursed. The facts are: Britain has pledged nearly $1.5bn but has so far deposited under $0.3bn; Africa, the poorest continent, has received less than 12% of all the climate fund money spent in the last 4 years; it can take poor countries more than 3 years to access money; most of the money promised for climate change comes out of official aid budgets, leaving less for health, education and poverty action. According to the UN, $50-70bn a year needs to be invested immediately to help the poor countries adapt to extreme floods, droughts and heat waves, with much more needed later (Guardian 21 Feb 2009).

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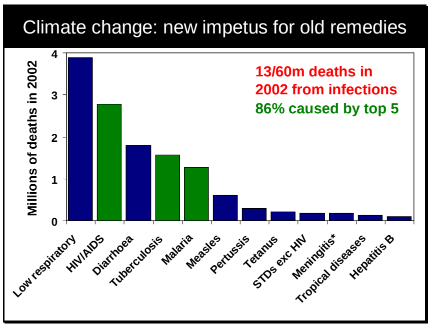

So far as health is concerned, we can partly resolve the dilemma. Most of the impacts on health are major problems now, and can be fixed. Most deaths in the developing world are due to a few major conditions, and the remedies have been known for a long time.

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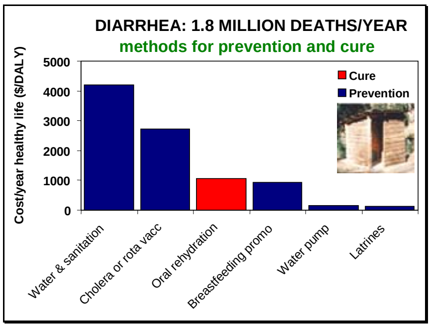

The methods of prevention are obvious, and they are cheap. So why have they not been used? (1) Increases in malnutrition – food distribution; (2) Increased deaths, diseases and injury due to extreme weather events – these have fallen in areas where preventive measures have been taken; (3) Increased burden of diarrhoeal diseases – an age old problem with simple remedies; (4) Increased frequency of cardio-respiratory diseases due to higher concentrations of ground-level ozone in urban areas – but this is the same problem of urban pollution; (5) The altered spatial distribution of some infectious diseases – they have spread before, for reasons other than climate.

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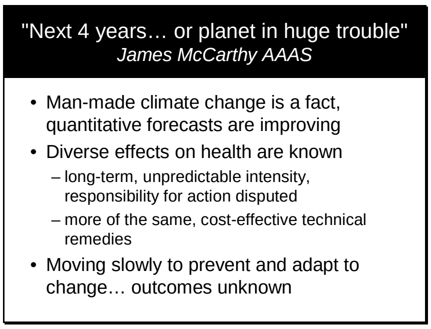

If "environmentalism has replaced socialism as the leading secular religion", as some think, we might hope for action based on belief. We are likely to move slowly in the right direction, and we do not know what the consequences will be.