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The Science of Climate Change: Implications for Risk Management

Maureen Agnew and Ana Catalano

Summary

- The warming of the climate is unequivocal, and is mainly due to emissions of greenhouse gas from human activities. Further increases in temperature are inevitable, and rises in sea level will continue for centuries. In the UK, negative impacts like more hot days, more winter floods and stronger winter storms are expected.
- The risk of summer drought is likely to increase in Europe. Heat waves will become more frequent across most land areas. In London, the number of hot days (i.e. at least 25°C) could double by the 2020s, and could be three to five times greater by the 2050s.
- At the same time, heavy precipitation events are very likely to increase in frequency and will augment flood risk. In the UK, the greatest increase in rainfall is projected for southern England, where there could be 4.5 more days of heavy precipitation in the winter season. Such an increase in heavy rainfall events will have serious consequences for the environment and human activities.
- It is important that underwriters recognise that climate risk has already increased, and incorporate climate into estimates of future risk as a dynamic component. Risk management should consider a wide range of climate projections from multiple climate models, rather than relying on a single model output. The insurance industry must also engage the wider economy in creating future scenarios.

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CII Introduction: This thinkpiece is the first in a series of several articles on the subject of climate change to be published in 2009. This preludes a detailed report to be published on 23 February by the CII edited by shared Nobel Prize winner Andrew Dlugolecki, entitled <u>Coping with Climate Change: Risks and Opportunities for Insurers</u>. In this article, CII policy & research manager Ana Catalano summarises a chapter of the report by Maureen Agnew that presents an overview of the science of climate change. It argues that climate change is happening, that this is happening due to human activity, and it already has become serious for society as a whole and for the insurance industry in particular.

Floods, droughts, heat waves, extreme cold, storm surges: major changes in climate extremes have occurred in the past 40 years, and major changes are expected in the future. "Climate change" refers to any change in the climate over time, whether due to natural variability or as a result of human activity. Society is particularly vulnerable to a shift in the intensity and frequency of extreme events, especially severe storms and tropical cyclones, flood, drought and heat waves. Even a small change (<10%) in the severity of an event can result in a huge increase in property damage and associated financial losses. This article focuses on observed and predicted changes in climate extremes, highlighting some of the most serious challenges that lie ahead and emphasising the clear and pressing need for insurers to assess and effectively manage these risks.[1]

Emissions and Global Warming

Increases in atmospheric concentrations of greenhouse gases (GHGs) since pre-industrial levels (1750) are largely due to human activities. The increase in the long-lived GHGs (carbon dioxide, methane and nitrous oxides) in the last four decades far exceeds that of any other time found in ice-core records which date back 650,000 years. Collectively, these gases produce a warming effect. Atmospheric carbon dioxide (CO_2) is the principal agent in global warming, and accounts for 63% of the effect of the long-lived GHGs. Since 1750, emissions of CO_2 have increased (due to increasing use of fossil fuel and land use changes such as deforestation) from 280 parts per million (ppm) to 384 ppm in 2007. Annual changes in global mean CO_2 emissions since 1990 are shown in **Figure 1**.

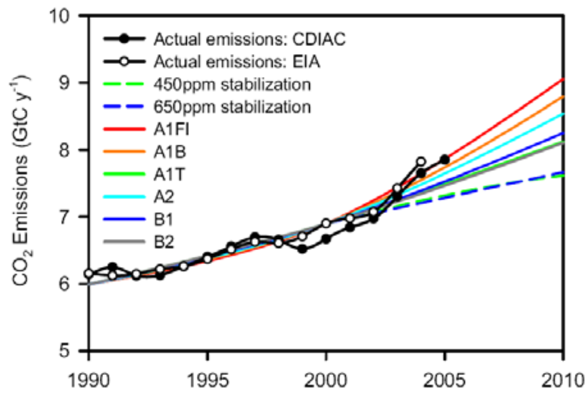

Figure 1. Observed CO_2 emissions (1990-2005), compared with six IPCC emissions scenarios and two stabilization trajectories Source: Raupach *et al*. 2007, p10289.[2]

"Even a small change (<10%) in the severity of an event can result in a huge increase in property damage and associated financial losses."

Scientists confirm that 'warming of the climate system is unequivocal'. Twelve of the previous thirteen years (1995-2007) rank among the warmest in the global surface air temperature record since 1850. Formal attribution assessments undertaken by the Intergovernmental Panel on Climate Change (IPCC) in its Fourth Assessment Report suggest that it is very likely (>90% probability) that human activity since the mid-20th century has caused much of the observed increase in global mean temperatures and contributed to sea level rise, that it is likely (>66% probability) that human influence has contributed to ocean warming, and to reductions in the extent of Arctic sea ice and widespread glacial retreat.[3]

Even if GHG and emissions were held constant, warming would still continue for several decades due to the thermal inertia of the oceans and cryosphere. By the end of the 21st century European temperatures are simulated to be between 2.2°C and 5.4°C warmer than the end of the 20th century. This warming is likely to be greater in northern Europe in the winter and greater in the Mediterranean area in the summer.

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[1]Most of the scientific evidence in this article comes from: IPCC (2007) *Climate Change 2007: The Physical Science Basis. The Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. Research since the Fourth Assessment has also been reviewed. For complete citation, please contact us at thinkpiece@cii.co.uk.

[2] Raupach M, *et al.* (2007) "Global and regional drivers of accelerating CO2 emissions", *PNAS* 104(24): 10288-93; http://www.pnas.org/cgi/content/abstract/104/24/10288.

[3] Standard terms used to define the likelihood of an event in the IPCC AR4 from Solomon *et al.*, 2007; IPPC Technical Summary p23.

Circulation Patterns

Trends in large-scale atmospheric circulation patterns have also been observed during recent decades, such as a poleward shift and strengthening of the westerly winds in the mid-latitudes of both hemispheres. In the Northern Hemisphere these changes are evident in the increase in the winter North Atlantic Oscillation (NAO) index from the mid-1960s to the mid-1990s, which is a measure of these winds and their associated storm track in the Atlantic part of the hemisphere. Changes in large-scale patterns of circulation could explain some of the observed changes in climate extremes. For example, the observed tendency towards positive values of the NAO index in the 1980s/1990s is associated with an increasing trend in heavy winter precipitation in northern Europe and a decreasing trend in heavy winter precipitation in southern Europe over the period 1958-2000.

Regional perspective

The human influence on warming is discernible at a continental scale, but there are difficulties in simulating and attributing temperature changes at smaller geographical scales. Analysing a network of long-term records across Europe, a 2006 study demonstrated a clear warming trend which is stronger in winter (1.0°C per century) than summer (0.8°C per century).[4] In addition, they found the warming to be greater for extreme warm periods than extreme cold periods.

The European Environment Agency (2004) assembled 22 indicators of climate change in Europe, including temperature and precipitation extremes, sea level rise, flooding and human health. For many of these indicators a clear trend exists, and negative impacts are already being observed. Perhaps one of the most striking examples of this to date has been the increase of heavy rainfall events in the UK, which has led to increased risk of flooding (see corresponding section and **Figure 2**).

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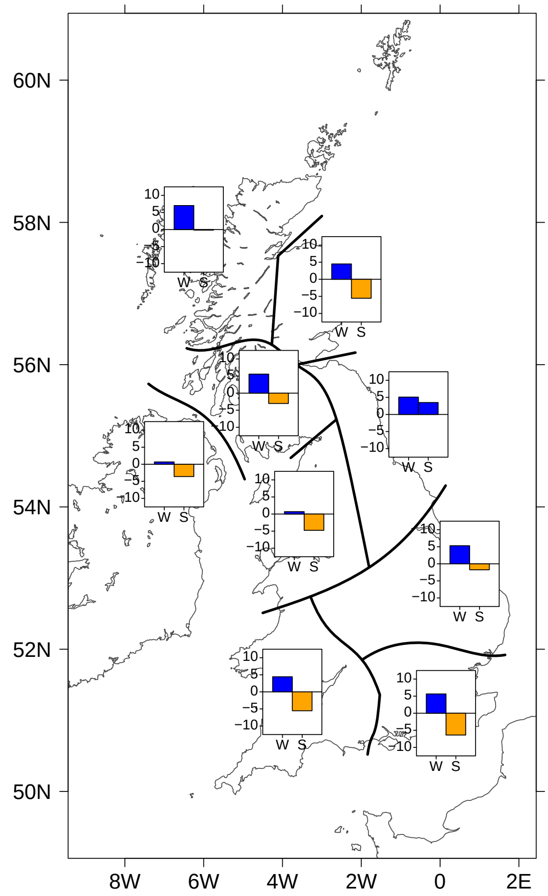

Figure 2. Regional trends over the period 1961-2006 in the contribution (%) made by heavy precipitation events to total winter (left-hand bars labelled "W") and summer (right-hand bars labelled "S") rainfall. Source: Maraun *et al.*, 2008.[5]

Present and Future Climate Change

Heavy Rainfall and Flooding

In the UK, nearly 2 million properties are at risk from flooding along the coast, rivers, and estuaries, and 80 000 properties are at risk of flooding in urban areas due to storm drainage systems being overwhelmed.

Since 1950, there have been substantial increases in the number of heavy precipitation events over many land areas around the globe and in Europe in winter.[6] In the UK, daily rainfall has followed the European winter pattern, by becoming more intense. Over the period 1961–2006, most regions (**Figure 2**) show a trend towards increased importance of heavy rainfall events during winter (except for north-west England and Northern Ireland) and a trend towards decreased importance of heavy rainfall events during summer (except for north Scotland and north-east England). Although the summer

[4] Moberg A, *et al*. (39 co-authors) (2006) Indices for daily temperature and precipitation extremes in Europe analyzed for the period 1901-2000*. Journal of Geophysical Research* 111, D22106, doi:10.1029.2006JD007103

[5] Maraun D, Osborn TJ and Gillett NP (2008) United Kingdom daily precipitation intensity: improved early data, error estimates and an update from 2000 to 2006. *International Journal of Climatology* 28: 833-842.

[6] Moberg A, *et al*. Op.cit. Note 3

floods of 2007 in the UK are out of step with the observational trends, they serve to demonstrate the dangers posed by flash flooding particularly in urban areas.

Extremes of daily rainfall are very likely to increase in northern Europe, south Asia, East Asia, Australia and New Zealand (in part these areas reflect the geographical coverage of research). In the UK, for the northwest and southeast of England, winter rainfall is likely to increase by a factor of 1 to 1.25 by the end of the 21st century. A study in 2001 found more days of high precipitation (upper 10% of baseline precipitation) are projected for all seasons for the period 2080-2100.[7] The greatest increase is projected for southern Britain where there could be up to 4.5 more days of heavy precipitation in the winter season. There could be up to 3 more days of heavy rainfall in western Britain for the other seasons. Although the rate of increase in flood risk in the UK is sensitive to the chosen emissions scenario, there is more consistency in the spatial pattern which shows a concentration of maximum risk in the Lancashire/Humber corridor, the coastline of southeast England, and the major estuaries.

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An increase in heavy rainfall events such as described above will have serious consequences for the environment and human activities, and may stress urban infrastructure beyond the limits of its initial design. Intense short duration rainfall events have implications for the design of urban storm drainage and sewer systems, while the longer duration extremes have implications for flood defence schemes. Even a small increase in storm rainfall would require considerable adaptation of storm drainage systems to maintain service levels.

Sea Level Rise and Storm Surges

Thermal expansion of the oceans and the melting of glaciers and ice caps have contributed substantially to sea level rise over the last 40 years. Between the years 1961 and 2003, the global mean sea level rise is estimated (using tide gauge records) to be 1.8 mm per year.

Storm surges tend to accompany tropical or extra-tropical cyclone activity and generally culminate in serious coastal flooding particularly when combined with a high tide. Of the relatively few stations with long-records of sea level heights, the majority of sites show an increasing trend in extreme sea level height. In the EU, one third of the population lives within 50 km of the coast. In the UK, it is estimated that one million properties are at risk from sea and tidal flooding.[8]

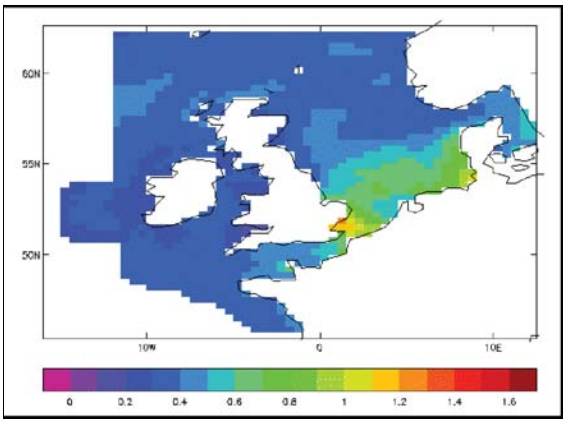

Figure 3. The change with respect to 1961-1990 in the 50-year return period storm-surge height (m) in the North Sea for the period 2071-2100 under the A2 scenario. Source: Lowe and Gregory, 2005.

Rising sea levels and greater storm activity suggest that storm surge risk is likely to increase along many coasts, especially since the rate of increase in extreme sea level could be greater than the increase in mean values locally. Lowe and Gregory (2005) project increases in extreme sea level (storm surges with a 50-year return period) along the entire coastline of the UK (**Figure 3**).[9] The largest increases in storm surge are along the coast of southeast England and amount to 1.2 m by the end of the 21st century.

The ABI estimates that the financial costs of a flooding event equivalent to that of 1953 (which affected 1600 km of the East Anglian coastline and resulted in 300 fatalities) of around £2 billion for the existing sea level could rise to around £7 billion for a sea level rise of 0.4 m (excluding the costs of disruption, or the economic impact on essential public services). Assuming improvements to coastal defences, the estimated financial costs are reduced to around £1 billion and £3.7 billion respectively.

[7] Jones PD and Reid (2001) Assessing future changes in extreme precipitation over Britain using regional climate model integrations *International Journal of Climatology* 21 (11): 1337-1356.

[8] DEFRA (2004) *Making space for water: developing a new government strategy for flood and coastal erosion risk in England. A consultation exercise*. Department of the Environment, Food and Rural Affairs, London.

[9] Lowe JA, Gregory JM (2005) The effects of climate change on storm surges around the United Kingdom. *Philosophical Transactions of The Royal Society A-Mathematical Physical and Engineering Science*s 363 (1831): 1313-1328

Drought

Since the 1970s, droughts have become longer and more intense, particularly in the tropics and sub-tropics and are strongly influenced by the cycle of El Niño events. Recent extreme droughts have occurred in Central and Southwest Asia (1998-2003); Australia (2002-2003), and Western North America (1999-2004). In the UK, there has been a succession of dry summers in the last two decades: 1990, 1995, 2003, 2006.

The risk of summer drought is expected to increase in Europe, particularly in Southern Europe. By the latter half of the 21st century, droughts in the Mediterranean could start earlier in the season and have a longer duration. The regions most likely to be impacted are the southern Iberian Peninsula, the Alps, the eastern Adriatic seaboard, and southern Greece. An ever increasing demand for water is likely to exacerbate problems of water shortage due to climate change.

In the UK, two major aspects of drought are of relevance to the financial sector: First, clay shrinkage due to soil moisture deficits following protracted droughts can induce building subsidence; Second, the negative effect of water scarcity in manufacturing processes and in energy production (for cooling and for hydroelectricity).

Heat Waves

Since the latter half of the 20th century, the duration of summer heat waves has increased globally. The summer of 2003 in western and central Europe was the warmest since instrumental records commenced. For central Europe, the summer temperature was 3.8°C higher than the long-term average (**Figure 4**). Estimates vary, but the final death toll resulting from the summer European heat wave of 2003 could be in excess of 70,000.

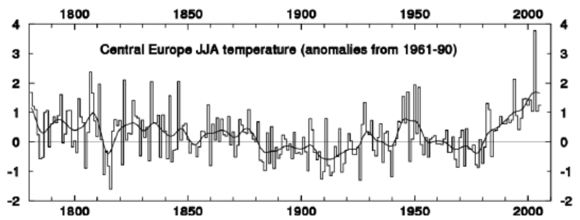

Figure 4. Central Europe summer temperature (anomalies from 1961-90) Source: IPCC, 2007: Box 3.8.5.

The results from multi-model simulations suggest that it is very likely that heat waves will become more frequent over most land areas. Heat waves will intensify, be more frequent and of longer duration. By the end of the 21st century in Europe, it has been projected that every summer in many regions of Europe will be hotter than the 10% hottest summers during the period 1961 to 1990. Every second summer could be as hot, or hotter, than the summer of 2003, for high emissions scenarios by 2080.

The effects of heat waves are accentuated in urban areas. In London, the number of hot days (i.e. at least 25°C) could double by the 2020s, and could be 3 to 5 times greater by the 2050s. Very hot days, with temperatures greater than 30°C will also become more common, as will extreme temperatures such as those experienced during the heat wave of August 2003. In London, there could be a 40% increase in the number of nights with intense urban heat island incidents.

"By the end of the 21st century in Europe, it has been projected that every summer in many regions of Europe will be hotter than the 10% hottest summers during the period 1961 to 1990"

The young, the elderly and the sick, are at risk particularly to the lack of nocturnal relief in temperatures. In addition, a greater incidence of warm daytime temperature extremes could lead to a higher incidence of heat stress in the work place. If temperatures far exceed the comfort zone, business activities may be interrupted. Business can also be interrupted or delayed through the damaging effects of extreme heat on transport infrastructure.

Cold Extremes

A decreasing trend in the number of frost days has been identified for the period 1951-2003 for over 70% of the global land area, and most parts of Europe. The shift towards a positive phase of the NAO from the 1960s to the 1990s, and the associated strengthening of the westerly circulation, probably contributed to the observed trend towards milder European winters and a decrease in the number of cold and frost days.

In Europe, cold winters (occurring every 10 years during the period 1961-90) are projected to disappear almost completely by 2080. The greatest decrease in frost days is projected for Scandinavia and the smallest decrease for the Atlantic and Mediterranean coasts of Europe.

Recommendations to Insurers and the Wider Economy

This article has summarised the scientific evidence: climate change is already happening, and major changes are anticipated in the future. Indeed, there may be future changes and impacts that are beyond the range suggested by the IPCC. Uncertainties remain about the exact path of future climate, because of uncertainties in climate models, the natural variability of the climate system, and because we can alter that path by changing our emissions. How should the insurance industry and other stakeholders respond to these very serious and urgent challenges, particularly given the current financial stress brought about by the credit crunch?

Perhaps most importantly, underwriters need to incorporate climate into estimates of future risk – as a dynamic rather than a stationary component. Insurance market bodies should expand the time horizon for assessing impacts of climate change to clearly identify and understand the long-term risks and opportunities. Risk management should consider a wide range of climate projections from multiple climate models, and should not rely on a single model output. Appropriate consideration is needed of the new generation of probabilistic projections of climate change in order to optimize adaptation decisions.

"Insurance market bodies should expand the time horizon for assessing impacts of climate change to clearly identify and understand the long-term risks and opportunities"

The CII report *Coping with Climate Change: Risks and Opportunities for Insurers* identifies and explores the implications of climate change across the insurance industry. However as potential victims of the negative effects of climate change and therefore customers of insurance, the wider economy too has a role to play in assessing the risks and implications and taking the appropriate actions, both in terms of preparing and mitigating the worst effects. *ClimateWise*'s independent review published in November 2008 recommended that insurers must not only consider systemic risks to the economy posed by climate change, but also engage the wider economy in creating future scenarios.[10]

While the insurance market comprised of customers, insurers, brokers and underwriters provides one vehicle for risk-assessing, preparing and responding to climate change effects; government can also play a critical role in facilitating actions by the wider economy. The Stern Review (2006) identified key areas of change, most notably its plans to achieve an 80% reduction in Kyoto greenhouse gas emissions by 2050, which link closely with the work of the insurance industry. The areas of agreement between the Stern Review, the work of *ClimateWise*, and the forthcoming CII report could provide a starting point for developing a joined-up plan of action.

More dialogue and collaboration is required with respect to understanding and communication of climate change uncertainties, and with other economic sectors, NGOs, and community groups to find sustainable solutions and provide risk management expertise. Professional bodies like the CII have a role to play in furthering this debate, keeping their own members up to date, and speaking out on issues like insurability and mitigation priorities. Future thinkpieces in this series will explore further the various ways that climate change impacts on the insurance, how the risks can be effectively managed, and how coherent mitigation and adaptation strategies can be developed.

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[9] *One Year Review: A Report on Behalf of ClimateWise for Forum for the Future*, ClimateWise, November 2008. http://www.climatewise.org.uk/review-2008/

This article summarises Chapter 3 of the report entitled Coping with Climate Change: Risks and Opportunities for Insurers to be launched on 23 February 2009 at the Insurance Hall in London. For more information, see: www.cii.co.uk/cii/news_events.aspx

If you have any questions or comments about this publication, please contact us on:

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