# Topic 6 – Robust findings, key uncertainties
# (31 August 2007)

As in the TAR, a robust finding for climate change is defined as one that holds under a variety of approaches, methods, models and assumptions, and is expected to be relatively unaffected by uncertainties. Key uncertainties are those that, if reduced, could lead to new robust findings. {TAR SYR Q.9}

Robust findings do not encompass all key findings of the AR4. Some key findings may be policy-relevant even though, or in some cases because, they are associated with large uncertainties or depend on assumptions and possible futures. {WGII 20.9}

The robust findings and key uncertainties listed below do not represent an exhaustive list.

## 6.1 Observed changes in climate and their effects, and their causes

### Robust findings

Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level. {WGI 3.9, SPM}

Many natural systems, on all continents and in some oceans, are being affected by regional climate changes. Observed changes in many physical and biological systems are consistent with warming. {WGII 1.3}

Global total annual anthropogenic GHG emissions, weighted by their 100-year GWPs, have grown by 70% between 1970 and 2004. As a result of anthropogenic emissions, atmospheric concentrations of $CH_4$ and $N_2O$ now far exceed pre-industrial values spanning many thousands of years, and $CO_2$ now far exceeds the natural range over the last 650,000 years. {WGI SPM; WGIII 1.3}

Most of the global average warming over the past 50 years is *very likely* due to anthropogenic GHG increases and it is *likely* that there is a discernible human induced warming averaged over every continent except Antarctica[26]. {WGI 9.4, SPM}

At the global scale, anthropogenic warming over the last three decades has *likely* had a discernible influence on observed changes in many physical and biological systems. {WGII 1.4, SPM}

### Key uncertainties

Climate data coverage remains limited in some regions and there is a notable lack of geographic balance in data and literature on observed changes in natural and managed systems, with marked scarcity in developing countries. {WGI SPM; WGII 1.3, SPM}

[26] Antarctica had insufficient observational coverage to make a continental-scale assessment.

Analysing and monitoring extremes including drought, tropical cyclones, extreme temperatures, and the frequency and intensity of precipitation is more difficult than for climatic averages as it requires longer data time-series of higher spatial and temporal resolution. {WGI 3.8, SPM}

Effects of climate changes on human and some natural systems are difficult to detect due to adaptation and non-climatic drivers. {WGII 1.3}

Difficulties remain in reliably simulating and attributing observed temperature changes to natural or human causes at smaller than continental scales. At these smaller scales, factors such as land-use change and pollution also complicate the detection of anthropogenic warming influence on physical and biological systems. {WGI 8.3, 9.4, SPM; WGII 1.4, SPM}

The magnitude of $CO_2$ emissions from land-use change and from individual methane sources remain as key uncertainties. {WGI 2.3, 7.3, 7.4; WGIII 1.3, TS.14}

## 6.2 Drivers and projections of future climate changes and their impacts

### Robust findings

With current climate change mitigation policies and related sustainable development practices, global GHG emissions will continue to grow over the next few decades. {WGIII 3.2, SPM}

For the next two decades a warming of about 0.2°C per decade is projected for a range of SRES emission scenarios. {WGI 10.3, 10.7, SPM}

Continued GHG emissions at or above current rates would cause further warming and induce many changes in the global climate system during the 21st century that would *very likely* be larger than those observed during the 20th century. {WGI 10.3, 11.1, SPM}

The pattern of future warming where land warms more than the adjacent oceans and more in northern high latitudes is seen in all future scenarios. {WGI 10.3, 11.1, SPM}

Warming tends to reduce terrestrial ecosystem and ocean uptake of atmospheric $CO_2$, increasing the fraction of anthropogenic emissions that remains in the atmosphere. {WGI 7.3, 10.4, 10.5, SPM}

Anthropogenic warming and sea level rise would continue for centuries even if GHG emissions were to be reduced sufficiently for GHG concentrations to stabilise, due to the timescales associated with climate processes and feedbacks. {WGI 10.7, SPM}

Equilibrium climate sensitivity is *very unlikely* less than 1.5°C. {WGI 8.6, 9.6, Box 10.2, SPM}

Some systems, sectors and regions are more vulnerable to climate change than others. Vulnerable sectors are some ecosystems, low-lying coasts, water resources in dry tropics and subtropics, agriculture in low-latitude regions, and human health in areas with low adaptive capacity. Vulnerable regions are the Arctic, sub-Saharan Africa, small islands and Asian megadeltas. Within other regions, even those with high incomes, some people, areas and activities can be particularly at risk. {WGII TS.4.5}

Impacts are *very likely* to increase due to increased frequencies and intensities of some extreme weather events. Recent events have demonstrated the vulnerability of some sectors and regions, including developed countries, to heat waves and tropical cyclones, providing stronger reasons for concern as compared to the findings of the TAR. {WGII Table SPM.2, 19.3}

**Key uncertainties**

Uncertainty in equilibrium climate sensitivity creates uncertainty in the expected warming for a given $CO_2$-eq stabilisation scenario. Uncertainty in the carbon cycle feedback creates uncertainty in the emission trajectory required to achieve a particular stabilisation level. {WGI 7.3, 10.4, 10.5, SPM}

Models differ considerably in their estimates of the strength of different feedbacks in the climate system, particularly cloud feedbacks, oceanic heat uptake, and carbon cycle feedbacks, although progress has been made in these areas. Also, the confidence in projections is higher for some variables (e.g. temperature) than for others (e.g. precipitation), and is higher for larger spatial scales and longer time averaging periods. {WGI 7.3, 8.1-8.7, 9.6, 10.2, 10.7, SPM; WGII 4.4}

Aerosol impacts on the magnitude of the temperature response, clouds and precipitation remain uncertain. {WGI 2.9, 7.5, 9.2, 9.4, 9.5}

Future changes in the Greenland and Antarctic ice sheet mass, particularly due to changes in ice flow, are a major source of uncertainty that could increase sea level rise projections. The uncertainty in the penetration of the heat into the oceans also contributes to the future sea level rise uncertainty. {WGI 4.6, 6.4, 10.3, 10.7, SPM}

Large scale ocean circulation changes beyond the 21$^{st}$ century cannot be reliably assessed because of uncertainties in the meltwater supply from Greenland ice sheet and model response to the warming. {WGI 6.4, 10.3, 10.7, SPM}

Projections of climate change and its impacts beyond about 2050 are strongly scenario- and model-dependent, and improved projections would require improved understanding of sources of uncertainty and enhancements in systematic observation networks. {WGII TS.6}

Impacts research is hampered by uncertainties surrounding regional projections of climate change, particularly precipitation. {WGII TS.6}

Understanding of low-probability/high-impact events, which is required for risk-based approaches to decision-making, is generally limited. {WGII 19.4, 20.2, 20.4, 20.9, TS.6}

## 6.3 Responses to climate change

### Robust findings

Some adaptation is occurring now, and more extensive adaptation is required to reduce vulnerability to higher levels and rates of warming. {WGII 17.ES, 20.5, Table 20.6, SPM}

Unmitigated climate change would, in the long term, be *likely* to exceed the capacity of natural managed and human systems to adapt. {WGII 20.7, SPM}

A wide range of mitigation options are currently available or projected to be available by 2030 in all sectors, with the economic potential at costs from net negative up to 100 US$/t$CO_2$-equivalent, sufficient to offset the projected growth of global emissions or to reduce emissions to below current levels over the coming decades. {WGIII 11.3, SPM}

The range of stabilisation levels assessed can be achieved by deployment of a portfolio of technologies that are currently available and those that are expected to be commercialised in coming decades, provided that appropriate and effective incentives are in place. In addition, further RD&D would be required to improve the technical performance, reduce the costs, and achieve social acceptability of new technologies. The lower the stabilisation levels, the greater the need for investment in new technologies during the next few decades. {WGIII 3.3, 3.4}

The lowest stabilisation scenarios (445-490 ppm, with best estimate equilibrium temperature increase of 2-2.4°C above pre-industrial) could significantly reduce the risks of many major impacts on vulnerable systems over the longer term. In these scenarios, global emissions would need to peak over the next decade and to fall below 50% of current levels by 2050. {WGII Table 20.6; WGIII 3.3}

Making development more sustainable by changing development paths can make a major contribution to climate change mitigation and adaptation and to reducing vulnerability. {WGII 18.7, 20.3, SPM; WGIII 13.2, SPM}

Decisions about macro-economic and other policies that seem unrelated to climate change can significantly affect emissions. {WGIII 12.2}

### Key uncertainties

Understanding of how development planners incorporate information about climate variability and change into their decisions is limited. This is a key uncertainty in the integrated assessment of vulnerability. {WGII 18.8, 20.9}

The evolution and utilisation of adaptive and mitigative capacity depend on underlying long-term socio-economic development pathways. {WGII 17.3, 17.4, 18.6, 19.4, 20.9}

Barriers, limits and costs of adaptation are not fully understood, partly because effective adaptation measures are highly dependent on specific geographical and climate risk factors as well as institutional, political and financial constraints. {WGII SPM}

Estimates of mitigation costs and potentials depend on assumptions about future socio-economic growth, technological change and consumption patterns. Uncertainty arises in particular from assumptions regarding the drivers of technology diffusion and the potential of long-term technology performance and cost improvements. {WGIII 3.3, 3.4}

The effects of non-climate policies on emissions are poorly quantified. {WGIII 12.2}