
FACTS ON CLIMATE CHANGE

HIGHLIGHTS FROM THE 1995 SECOND ASSESSMENT REPORT OF THE INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE*

Introduction

What follows are direct quotations from the published version (Cambridge University Press, 1996) of the Second Assessment Report of the Intergovernmental Panel on Climate Change (IPCC). The Second Assessment Report (SAR) includes the product of three working groups, each having gone through its own clearance and approval process following many months of research and deliberations. The quotations have been collected under subject headings to make it easier for the reader to track specific topics. It should be noted that many of these citations have been altered substantially from the original version as approved by the IPCC Rome Plenary meeting in December, 1995. The cumulative impact of the alterations diminish the high level of uncertainty expressed in the original text.

HUMAN IMPACTS ON CLIMATE

" 'Detection of change' is the process of demonstrating that an observed change in climate is highly unusual in a statistical sense. This requires distinguishing any human effects on climate from the background 'noise' of climate fluctuations that are entirely natural in origin. Such natural fluctuations can be either purely internal or externally driven, for example by changes in solar variability or the volcanic dust loading of the atmosphere." (WGI FSM, Summary, Chapter 8, p. 411)

"Although these global mean results suggest that there is some anthropogenic component in the observed temperature record, **they cannot be considered as compelling evidence of a clear cause-and-effect link between anthropogenic forcing and changes in the Earth's surface temperature.** It is difficult to achieve attribution of all or part of a climate change to a specific cause or causes using global mean changes only." (WGI FSM, Summary, Chapter 8, p. 411)

"In summary, '**detection of change**' is the process of demonstrating that an observed change in climate is highly unusual in a statistical sense, but **does not provide a reason for the change.** '**Attribution**' is the process of establishing cause and effect, i.e., that changes in anthropogenic emissions are required in order to explain satisfactorily the observed change in climate." (WGI FSM, section 8.1.1, p. 413)

"Statements regarding the detection and attribution of an anthropogenic effect on climate are inherently probabilistic in nature. They do not have simply 'yes-or-no' answers." (WGI FSM, section 8.1.1, p. 413)

"Most of the recent work in the detection field has been this type of 'Stage 1' study. A number of these investigations (both pre- and post-IPCC (1990)) have claimed the detection of a highly significant change in observed global mean temperature over the last 100 years. **However, none of these studies has convincingly demonstrated that this change can be uniquely attributed to anthropogenic influences.**" (WGI FSM, section 8.1.2.1, p. 414)

"Defining an anthropogenic climate change signal is only one part of the detection problem. **The climate state of the Earth is always changing in both space and time for reasons that have nothing to do with anthropogenic forcing.** The space-time structure of this natural variability must be estimated in order to decide whether the changes that have been observed in the past or that will be observed over the next 10-20 years are due primarily to human activities or natural causes. **This spectrum of natural variability is a critical element** in the significance-testing portion of any practical detection or attribution scheme." (WGI FSM, section 8.3, p. 418)

"Claims of non-significance of the global warming trend have also been made by Ghil and Vautard (1991) using Singular Spectrum Analysis (SSA)." (WGI FSM, section 8.4.1.1, p. 422)

"Any such attribution-related conclusions, however, rest heavily on the reliability of our estimates of both century time-scale natural variability and the magnitude of the observed global mean warming trend. At best, therefore, trend significance **can only provide circumstantial support** for the existence of an anthropogenic component to climate change." (WGI FSM, section 8.4.1.1, p. 423)

"In summary, such studies offer support for a ΔT_{2x} value similar to that obtained by GCMs, *and suggest that human activities have had a measurable impact on global climate, but **they cannot establish a unique link between anthropogenic forcing changes and climate change.***" (WGI FSM, section 8.4.1.3, p. 424)

"This result does not mean that the regional-scale features of a model-predicted greenhouse warming pattern have been detected and convincingly attributed to increases in atmospheric CO₂." (WGI FSM, section 8.4.2.1, p. 426)

"In essence, this result says that the most recent (20-30 year) trends in global mean temperature are significantly different from the estimated level of background noise. As noted for Stage 1 studies, this does not resolve the attribution issue." (WGI FSM, section 8.4.2.1, p. 426)

"In summary, attempts to detect a CO₂-only signal in the climate system have given ambiguous results." (WGI FSM, section 8.4.2.1, p. 430).

"To date, pattern-based studies **have not been able to quantify the magnitude** of a greenhouse gas or aerosol effect on climate. (WGI FSM, section 8.4.2.3, p. 434)

"The best available evidence suggests that observed near-surface air temperature has increased by 0.3 C to 0.6 C in the last 100 years (Chapter 3). This result is in accord with both simple and more complex model predictions....This **agreement does not, however, constitute identification of an anthropogenic effect on climate and may be serendipitous**. The degree of consistency between modeled and observed global mean, annually averaged temperature changes depends on a variety of factors. These include the model's climate sensitivity, the magnitude and sign of simulated multi-decadal variability (and or climate drift), oceanic thermal inertia, and the relative strength of the positive forcing due to greenhouse gases and the negative forcing due to aerosols. **It is certainly feasible that qualitative agreement could be due to compensating errors**, such as a climate sensitivity that is too high being partially offset by cooling due to a residual drift, or by an overestimated aerosol effect. " (WGI FSM, section 8.5.2, p. 437)

"Because humans have influenced mountain ecosystems in many different ways throughout history, anthropogenic impacts generally cannot be dissociated from climate change impacts. **Climatic influences are often obscured by the impact of change in land use.**" (WGII FSM, section 5.2.4, p. 202)

"Some of the **impacts** of global climate change are **beneficial**, some are **neutral**, and some are **adverse.**" (WGII FSM, section 8.5.3, p. 284)

"Regarding specific industry emissions, **energy-intensive industries** such as chemicals, cement, and steel **have shown substantial improvements in energy efficiency** during the past 20 years...." (WGII FSM, Executive Summary, Chapter 20.0, p. 651)

"...**the general trend for GHG emissions from fuel combustion** in the manufacturing sector of industrial nations in the past 2 decades has been downward (Torvanger, 1991; Figure 20-1). The overall decrease from 1973 to 1991 was about 15%." (WGII FSM, section 20.2.3.1, p. 656)

SCIENTIFIC UNCERTAINTY

"GCM estimates seldom extend beyond about 100 years, due to the uncertainties attached to such long-term projections....**In many economic assessments, on the other hand, projections may not be reliable for more than a few years ahead.**" (WGII FSM, section 26.6.2.1, p. 828).

"**The development of a baseline describing conditions without climate change is crucial**, for it is this baseline against which all projected impacts are measured." (WGII FSM, section 26.6.3, p. 829).

"**No method yet exists of providing confident predictions of future climate.** Instead, it is customary to specify a number of plausible future climates." (WGII FSM, section 26.6.5, p. 829)

"However, it is clear **that the period of instrumental record began during one of the cooler periods of the past millennium**". (WGI FSM, section 3.6.4, p. 179).

"All the forms of data used to examine climate change and variability suffer from problems of quality and consistency, so conclusions reached on the basis of just one form of data must always be somewhat suspect." (WGI FSM, section 3.7, p. 179)

"**...current data and systems are inadequate for the complete description of climate change.** Virtually every monitoring system and data set requires better data quality and continuity. New monitoring systems, as well as improvements on current systems and studies to reduce quality problems from historical data, are required." (WGI FSM, section 3.7, p. 180)

"**Historical temperature data are plagued by inhomogeneities** from changes in instrumentation, exposure, site-changes, and time-of-observation bias." (WGI FSM, section 3.7, p. 181)

"Conclusive detection and attribution of global climate change will require an ongoing homogenous, globally representative climate record. This needs to be given high priority in the design and maintenance of meteorological and oceanographic monitoring systems." (WGI FSM, section 3.7, p. 181).

"Future population and economic growth are uncertain; future greenhouse gas emissions, given population and economic activity, are uncertain; future greenhouse gas concentrations, given emissions, are uncertain; future climate, given atmospheric concentrations of greenhouse gases, is uncertain; future physical impacts of climate change are uncertain; and the future valuation of the physical impacts attributable to climate change is uncertain." (WGIII, FSM, Section 10.3, p. 379)

"It is recognised that many remaining uncertainties need to be reduced in each of the above-named disciplines which is why IPCC projections and scenarios are often expressed with upper and lower limits. These ranges are based on the collective judgment of the IPCC authors and the reviewers of each chapter, but it may be appropriate in the future to draw on formal methods from the discipline of decision analysis to achieve more consistency..." (WGI FSM, section 11.1, p. 523)

"The simulation of clouds and their seasonal variation remains a major source of uncertainty in atmospheric models." (WGI FSM, section 5.3.1.1.7, p. 253)

"Although the concentration of methane in the atmosphere is well documented, the magnitudes of its sources and sinks and the processes involved are **poorly understood.**" (WGI FSM, section 10.3.5.1, p. 506)

"The single largest uncertainty in determining the climate sensitivity to either natural or anthropogenic changes are clouds and their effects on radiation and their role in the hydrological cycle. Although there are many important unresolved issues relating to the basic physics of cloud-radiation interactions and their parameterization in climate models, **even perfect parametrizations of radiation and cloud optical properties cannot produce realistic radiative fluxes and heating rates unless they are provided with a realistic distribution of cloudiness.** At the present time, weaknesses in the parametrization of cloud formation and dissipation are probably the main impediment to improvements in the simulation of cloud effects on climate." (WGI FSM, section 6.7.1.1, p. 345)

EXTREME WEATHER EVENTS & CLIMATE VARIABILITY

"Overall, there is no evidence that extreme weather events, or climate variability, has increased, in a global sense, through the 20th century, although data and analyses are poor and not comprehensive. On regional scales there is clear evidence of changes in some extremes and climate variability indicators. Some of these changes have been toward greater variability; some have been toward lower variability." (WGI FSM, section 3.5.4, p. 173)

"In the few analyses available, there is little agreement between models on changes in storminess that might occur in a warmer world. Conclusions regarding extreme storm events are obviously even more uncertain." (WGI FSM, Summary, Chapter 6, p. 290)

"There is little or no evidence of consistent increases in such events. For instance, Ostby (1993) found no evidence of increased occurrence of strong or violent tornadoes in the USA, although the numbers of reports of less severe tornadoes appears to have increased, perhaps due to increased population, eagerness in reporting, or improved reporting procedures. Grazulis (1993) reported a drop in damaging tornadoes in the 1980s over the USA." (WGI FSM, section 3.5.3.5, p. 172)

"In summary, temperature shows no consistent, global pattern of change in variability. Regional changes have occurred, but even these differ with the time-scale considered." (WGI FSM, section 3.5.2, p. 168)

"A study of floods in Sweden (Lindstrom, 1993) found **no convincing evidence** of trends through the 20th century, although the 1980s had larger floods than usual and the 1970s had few high floods." (WGI FSM, section 3.5.2.2, p. 169)

"Atlantic hurricane (tropical cyclone) activity over the period 1970 to 1987 was **less than half** that in the period 1947 to 1969 (Gray, 1990)." (WGI FSM, section 3.5.3.1, p. 169)

"Figure 3.19 shows the mean maximum sustained wind speed attained each year in Atlantic hurricanes (Landsea et al., 1996). **Mean maximum wind speed appears to have decreased.**" (WGI FSM, section 3.5.3.1, p. 170).

"In summary, the evidence on changes in extra-tropical synoptic systems is **inconclusive**. There is no clear evidence of any uniform increase." (WGI FSM, section 3.5.3.2, p. 171).

"There are grounds for believing that **intense tropical cyclone activity has decreased** in the North Atlantic,...." (WGI FSM, section 3.5.4, p. 173).

"Widespread significant changes in extreme high temperature events have not been observed, even in areas where the mean temperatures have increased." (WGI FSM, section 3.5.4, p. 173).

"It is **presently uncertain** whether the frequency and severity of tropical cyclones will increase due to climate change." (WGII FSM, Executive Summary, Chapter 8, p. 269)

"**It is not possible to say** if the intensity, frequency, or locations of cyclone occurrence would change in a warmer world (High Confidence)." (WGII FSM, Executive Summary, Chapter 9, p. 291)

"At present, there is **no evidence of any systematic shift in storm tracks.**" (WGII FSM, section 9.3.2, p. 298)

"In short, it is not yet possible to say whether the intensity or frequency of tropical cyclones (or ENSO) would increase or the areas of occurrence would shift in a warmer world." (WGII FSM, section 9.3.2, p. 298).

"Despite the often repeated assertion that climate variability could increase in a warmer world, there is little evidence from climate models to support this notion (Gates et al., 1992)." (WGII FSM, section 9.3.2, p. 298)

"Although there is uncertainty, the extent of damage caused by great windstorm catastrophes has expanded in recent years. The concentrations of people living in high-risk coastal regions must be considered the main reason for this alarming trend....It is therefore quite possible to get a scientific assessment of low injury to an ecosystem combined with high economic loss value, especially given that the value of waterfront real estate is normally high (see also chapter 17)." (WGII FSM, section 8.3.1.6, p. 278)

POTENTIAL HEALTH IMPACTS

"Of course, it is not possible to attribute particular, isolated events to a change in climate or weather pattern; other plausible explanations exist for each of them, and a number of different factors may combine to produce each event." (WGII FSM, section 18.7, p. 580)

"Improved primary health care for vulnerable populations could play a significant role in reducing a range of health impacts, including some vector-borne and other communicable diseases, and the effects of extreme events." (WGII FSM, section 18.5, p. 579)

"A range of adaptive mechanisms for offsetting the potential human-health effects of global warming lie in improving certain aspects of health services and other public services that settlements provide in any case. (World Bank, 1993). Improved sanitation and water treatment both reduce the spread of waterborne diseases and may provide a measure of safeguard against importing exotic enteric waterborne diseases such as cholera...Finally, disease surveillance could be strengthened and integrated with other environmental monitoring to design early warning systems; develop early, environmentally sound public health interventions; and develop anticipatory societal policies to reduce the risk of outbreaks and subsequent spread of epidemics." (WGII FSM, section 12.5.6, p. 420)

"Adaptive options to minimize health impacts include improved and extended medical care services; environmental management; disaster preparedness; protective technology (housing, air conditioning, water purification, vaccination, etc.); public education directed at personal behaviors; and appropriate professional and research training." (WGII FSM, Executive Summary, Chapter 18, p. 565)

"In the already endemic areas, especially in the subtropics, malaria may increase (although in some hot climates, **further temperature increases may shorten the life span of mosquitoes, and local malaria transmission would then decrease**)." (WGII FSM, section 18.3.1.1, p. 573)

POLICY IMPLICATIONS

"**Local environmental and socioeconomic situations are changing rapidly for reasons other than climate change. Worldwide, population growth, industrialization, urbanization, poverty, technological changes, and government policy could overwhelm any effects of climate change.**" (WGII FSM, section 12.0, p. 401)

"In applying CBA [cost benefit analysis] to the global climate change problem, and in particular to the evaluation of alternative policies to optimize net benefits, **several major sources of uncertainty** need to be considered:

1. Uncertainty about the **actual rates of emission....**
2. Uncertainty about the **costs of emissions reduction....**
3. Uncertainty about scientific linkages.... As already noted in Section 5.3, there exists a **chain of scientific uncertainty** (see Figure 5.3). The extent to which these uncertainties can be resolved by future research is itself subject to uncertainty....
4. Uncertainty in **valuing the costs and benefits of the physical impacts....**
5. Uncertainty about the **assumptions underlying policy options....**
6. Uncertainty about the **effectiveness of policies....**
7. Uncertainty about **joint benefits and costs....**" (WGIII, FSM, section 5.5.1, p. 161)

"**A well-chosen portfolio of climate change investments will yield greater benefit for a given cost than any one option undertaken by itself.** For an individual country, the issue is how to choose the portfolio of policy measures best suited to its circumstances and to adjust the portfolio over time in response to new developments. Governments will be making climate change decisions for several decades at least. This means that they will have many opportunities to adjust the size (total resources) and mix (choice of measures) of their portfolios of responses. Portfolios may differ from country to country." (WGIII, FSM, section 1.3.1.1, p. 24).

"As a policy question, global climate is sometimes posed as a choice between a) doing nothing at all or b) committing to an all-out effort. Given the large current uncertainties about the costs and benefits of greenhouse mitigation, this is the wrong way to frame the issue.... **A more useful formulation is: 'Given current knowledge and concerns, what actions should we take over the next one or two decades to position ourselves to act on new information that will become available?'**" (WGIII, FSM, section 1.3.2, p. 26)

"Enforcing compliance with international legal agreements presents **a number of legal and political problems**. Many states resist compulsory use of the judicial process; **this provides an incentive for free riding.**" (WGIII, FSM, section 1.3.4.3, p. 30).

"**Because of the large uncertainties and differences between parties, there may be no 'globally' optimal climate change strategy.....**Climate actions under the FCCC should be sequential; countries should implement a portfolio of mitigation, adaptation, and research measures; and they should adjust this portfolio continuously in response to new knowledge. The value of better information is potentially very large." (WGIII, FSM, Chapter 2, Summary Section, p. 57)

"Because of **decision uncertainties** and the **differing interests and values** of international parties, there is **no unique globally optimum response** to climate change." (WGIII, FSM, section 2.4, p. 69).

"The analysis suggests that the emissions time path may be as important as the concentration level itself in determining the costs of emission abatement. **Time is needed both for an economical turnover of the existing capital stock and to develop and deploy low-cost carbon-free alternatives. The most cost-effective emission time-paths are those which** provide the greatest flexibility in managing the transition away from fossil fuels. Shifting emission reductions into the outer years can reduce costs substantially while preserving both the concentration target and the date at which the target is achieved." (WGIII, FSM section 9.2.5.1.6, p. 343)

"A major difficulty in determining the impact of climate change on human habitat is the fact that **many other factors, largely independent of climate change, are also important. In many cases, these others factors are far more important than climate change in terms of the risk they pose for human settlements.** These non-climate factors will also increase the vulnerability of some regions to climate change. The most important of these factors include population growth, urbanization and industrialization, technology choices, and government policies. Other social factors, such as cultural clashes and warfare, also play a role." (WGII FSM, section 12.2, p. 403)

"Because of the high cost of being wrong in either direction, the **value of information** about climate change is likely to be great." (WGIII, FSM, section 1.3.2, p. 26)

ECONOMIC ASSESSMENTS

"Apart from the scientific uncertainty of climate change, there are additional uncertainties associated with

- (a) **Limited knowledge of regional and local impacts**
- (b) **Difficulties in measuring the economic value of impacts**, even where the impacts are known. This is particularly the case for nonmarket impacts and the impacts in developing countries
- (c) **Difficulties in predicting future technological and socioeconomic developments**
- (d) The possibility of catastrophic events and surprises

This uncertainty must be emphasized when interpreting the social cost figures in this chapter." (WGIII, FSM, section 6.8, p. 218)

"No scientific consensus exists on the framework for deciding the burden of financing mitigation and adaptation." (WGIII, FSM, section 1.3.4.2, p. 29)

"Our knowledge about how anthropogenic emissions of greenhouse gases affect global temperature, what kind of effects a change in global temperature may have, and how efforts to mitigate climate change may work is clearly restricted. How different greenhouse gases react in the atmosphere is not fully understood, and even if exact predictions of the average increase in global temperature could be made, the different regional effects of these increases will be exceedingly difficult to foresee. There is also considerable uncertainty about the economic and social effects of abatement measures, which are decisive for determining their associated costs and benefits." (WGIII, FSM, section 5.5.1, p. 159)

"To change the target for climate policy from emissions to atmospheric concentrations indicates a radically different cost effectiveness strategy. A stabilization of CO₂ emissions at present levels is not sufficient to stabilize the atmospheric concentrations. Richels and Edmonds (1995) have compared the costs of reaching a particular concentration by 2100 for a variety of strategies. They show that a given concentration in 2100 could be achieved at a considerably lower cost if emissions were not stabilized immediately. The reason is that **a more gradual reduction of emissions would avoid the economic shock that would follow a sudden stabilization**, enable future advanced technologies to be utilized to a larger extent, and facilitate the postponement of sizable abatement costs." (WGIII, FSM, section 5.2, p. 150)

"The level of sophistication of climate change damage analysis is comparatively low. Damage estimates are generally tentative and based on several simplifying and often controversial assumptions. The degree of uncertainty is correspondingly high, with respect to both physical impacts and their consequences for social welfare." (WGIII, FSM, section 6.1, p. 184)

"Attempts to quantify long-term damage are rare and highly speculative." (WGIII, FSM, section 6.3, p. 207)

"The study finds that the removal of energy subsidies has a major impact in reducing energy consumption and carbon emissions." (WGIII, FSM, section 9.2.4.1.2, p. 326)

"An immediate response to the greenhouse problem is to invest in research and development to reduce greenhouse uncertainties and subsequently to provide new information to decision makers." (WGIII, FSM, section 11.1.2, p. 402)

"Many researchers argue that unilateral action by the U.S. or by OECD countries are likely to be less effective than global action, and that unilateral actions are likely to exaggerate the impact on GDP." (WGIII, FSM, section 5.4.3, p. 156)

"Despite the current limitations of these various techniques, modern CBA (broadly defined) remains the best framework for identifying the essential questions that policy makers must face when dealing with climate change." (WGIII, FSM, section 5.6, p. 170)

"Climate change presents the analyst with a set of formidable complications: large uncertainties, the potential for irreversible damages or costs, a very long planning horizon, long time lags between emissions and effects, a global scope, wide regional variations, and multiple greenhouse gases of concern." (WGIII, FSM, section 1.2, p. 22)

GENERAL CIRCULATION MODELS

"Current models are simplistic and provide poor representations of dynamic processes. The effect of climate change adaptation in particular is poorly understood." (WGIII, FSM, Chapter 6, Summary section, p. 183)

"As a result, GCMs are currently unable to reproduce accurately even the seasonal pattern of present-day climate observed at a regional scale. Thus GCM outputs represent, at best, broad-scale sets of possible future climatic conditions and should not be regarded as predictions." (WGII FSM section 26.6.5.3, p. 830)

“Model validation is one of the most important components in our efforts to predict future global climate change. Although model performance has generally improved over the last decade, both coupled and uncoupled models still show systematic errors in their representation of the mean state and variability statistics of current climate (see Chapter 5, and also Gates et al., 1990, 1992). Such errors reduce our confidence in the capability of AOGCMs to predict anthropogenic change.” (WGI FSM, section 8.2.1, p. 416).

“Realistic simulation of the present climate is probably a necessary, but not sufficient condition to ensure successful simulation of future climate. To be confident that a model has predictive skill on time-scales of decades or longer, we would also have to be sure that it incorporates correctly all of the physics and feedback mechanisms that are likely to be important as greenhouse gas concentrations or aerosol producing emissions increase. As discussed in Chapter 4, it is unlikely that all important feedbacks have been included correctly in current AOGCMs. Feedbacks involving clouds and the surface radiation budget are poorly understood, and different schemes for parametrizing cloud processes can lead to substantially different results in greenhouse warming experiments (Cess et al., 1989; Mitchell et al., 1989). Other feedbacks that are either currently neglected or highly uncertain include interactions between the land biosphere and the carbon cycle, and between climate and atmospheric chemistry (See chapters 2 and 4).). Deficiencies in the treatment and incorporation of feedbacks are a source of signal uncertainty” (WGI FSM, section 8.2.2, p. 416).

"Analysis of surface air temperature and precipitation results from regional climate change experiments carried out with AOGCMs indicates that the biases in present day simulations of regional climate and the inter-model variability in the simulated regional changes are **still too large to yield a high level of confidence in simulated change scenarios**.... This adds a further degree of uncertainty in the use of GCM-produced scenarios for impact assessments." (WGI FSM, section 6.6.3, p. 344)

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“The so-called ‘cold-start’ problem results from the neglect of anthropogenic forcings (and hence some portion of the climate response) that happened before the start of the simulation....Such simulations are inevitably subject to a ‘cold-start’ error....Errors which the cold start effect may introduce into the time evolution of an anthropogenic signal constitute a further source of uncertainty in detection studies.” (WGI FSM, section 8.2.6, p. 418)

DEVELOPING COUNTRIES

"First, for the purposes of analysis, *it is useful to separate efficiency from equity*....Second, **it is inappropriate to redress all equity issues through climate change initiatives**.... A third approach is based on contribution to the problem. Because the industrialized countries have contributed more than two-thirds of the stock of anthropogenic greenhouse gases in the atmosphere today, this approach seems to suggest that they have a larger responsibility for bearing the costs. On the other hand, by the time greenhouse gas concentrations double from preindustrial levels, **the developing countries are projected to be contributing more than half of annual emissions, and roughly half of the total stock in the atmosphere** (IPCC, 1990a; Cline, 1992). Thus, under this criterion, **the developing countries might eventually pay far more of the mitigation costs** than under the other principles described earlier. (WGIII, FSM, section 1.3.4.2, p. 29).

"The controversial issues of population growth and consumption patterns, although central to economic development, bear on climate change largely through their effects on emissions. **Population growth in developing countries may also exacerbate the ecological and socioeconomic impacts of climate change.** (WGIII, FSM, section 1.3.4.2, p. 29)

"The potential for the **greatest growth in CO2 emissions**--in both percentage and absolute terms--is in the **developing world**...." (WGII FSM, Executive Summary, Chapter 22, p. 715)

"The **largest single additive impact** in all respects will come from **industrial growth in developing countries**." (WGII FSM, section 20.2.3.3, p. 657)

"...growth in both the number of households and in equipment stocks per household is **increasing much faster in the developing countries than in the industrial countries**, and the average efficiency of new equipment is lower because of the need to keep initial costs low...Thus, there is much potential to affect future CO2 emissions by **improving the efficiency** of residential buildings and appliances in these countries." (WGII FSM, section 22.4.1, p. 720)

"Implementation problems for energy-efficiency improvements in developing and transitional economies are more severe than those in industrial countries....Moreover, developing and transitional economies, in general, are characterized by lower overall productivity, including energy productivity. **One should not attempt to solve energy-efficiency problems in isolation from other efficiency problems.** Problems related to vintage equipment, scarcity of management skills, small-scale production, or poor technological infrastructure will not be solved by addressing climate-change or energy goals alone." (WGII FSM, section 20.5.3.2, p. 672)

"Alternatively, if the developed countries choose to embark on an aggressive control regime now, and if this cuts into their growth rates, the result will shrink export markets for developing countries and thus reduce growth there. In addition, if developed countries view their greenhouse efforts as, in effect, aid to developing economies, they may cut back on other programmes (sanitation, water, education for women, etc.) that have a more immediate impact on life expectancy, health, and well-being." (WGIII, FSM, section 1.4.2, p. 33)

SEA LEVEL RISE & THE HYDROLOGICAL CYCLE

"There is as yet no evidence for any acceleration of sea level rise this century...The evidence, or lack of it, for sea level accelerations over the past century depends critically on a small number of long tide gauge records which is unlikely to be supplemented significantly in the future." (WGI FSM, section 7.2.2, p. 366)

"In general, the **ocean is so poorly observed** and the instrumental record so incomplete that **there are regions of the ocean for which no observations exist...**Since there are now no continuous long-term measurement sites in the deep ocean, the establishment of such a system is important for the evaluation of climate models and for the measurement of the natural variability that is necessary for the unambiguous detection of a climate response to anthropogenic forcing (see Chapter 8)." (WGI FSM, section 5.3.3.4.3, p. 267)

"Changes in climate near ecosystem borders could mask impacts from harvesting excesses and other anthropogenic changes, generating **misguided international disputes...****Globally, overfishing and diverse human stresses on the environment will probably continue to outweigh climate-change impacts** for several decades." (WGII FSM, section 16.2.2.3, p. 524)

"Regionally, and locally, **vertical land movement can be quite large**, even on the decadal time scale. For example, parts of Scandinavia experience uplift (and thus a relative sea-level decline) of about 1 meter per century...In contrast, **the Mississippi delta is experiencing subsidence** (a relative sea-level rise) **of about 1 m per century...**" (WGII FSM, section 9.3.1.2, p. 296)

"As **most of our observations extend over a few decades only, this immediately poses a problem:** how can we decide from observations whether a small change in ice sheet configuration is a response to a short-term climatic fluctuation or an ongoing process of slow adjustment to changes that happened a long time ago?" (WGI FSM, section 7.3.3.2, p. 374)

"Given our present knowledge, it is clear that while the ice sheet has had a very dynamic history, estimating the likelihood of a collapse during the next century is not possible. **If collapse occurs, it will probably be due more to climate changes of the last 10,000 years rather than to greenhouse-induced warming.**" (WGI FSM, section 7.5.5, p. 389)

"In Antarctica, recent break-ups of the Larsen and Wordie Ice Shelves in the Antarctic Peninsula and discharges of enormous icebergs from the Filchner and Ross Ice Shelves, and the discovery of major recent changes in certain Antarctic ice streams, have focused public attention on the possibility of 'collapse' of this ice reservoir within the next century, with potential impacts on sea level. **Changes in floating ice shelves, of course, cannot affect sea level directly.**" (WGI FSM, section 7.3.3.1, p. 374)

"...the short response of ice streams removes the flux imbalance at the grounding line so that the **purported instability may not exist.**" (WGI FSM, section 7.5.5, p. 389)

"No systematic changes of minima or maxima and **no general warming has been observed in the Arctic** over the last 50 years or so...." (WGI FSM, section 3.2.2.4, p. 146)

"Although some of the principal linkages between climate and hydrological system are well understood, **predicting the effects of global warming is very uncertain.** Current general circulation models (GCMs) work at a spatial resolution that is too coarse for hydrological purposes, producing weather averaged over too large a geographic area and producing average conditions rather than changes in ranges, frequencies, seasonal distributions, and so forth. **They do not yet include all of the relevant feedbacks between the land surface and the atmosphere.**" (WGII FSM, section 10.1, p. 329)

"**No clear evidence** of wide-spread change in the annual streamflow and peak discharges of rivers in the world was found." (WGI FSM, section 3.3.5.1, p. 158)

"Unfortunately, our ability to determine the current state of the global hydrological cycle, let alone changes in it, is hampered by **inadequate spatial coverage, inhomogeneities in climate records, poor data quality, and short record lengths.**" (WGI FSM, section 3.3.1, p. 152)

"Water vapour is the most abundant greenhouse gas and makes the largest contribution to the natural greenhouse effect....**Monitoring atmospheric moisture presents many difficulties...**Measurement problems also make detecting trends of water vapour difficult....These factors make it difficult to separate climate changes from changes in measurement programs (Elliott and Gaffen, 1991)." (WGI FSM, section 3.3.7, p. 161)

"**Future erosion risk is more likely to be influenced by increases in population density, intensive cultivation of marginal lands, and the use of resource-based and subsistence farming techniques than**

by changes in climate. One can anticipate that erosion, mass movement, and landslides are most likely to increase in and near regions of high population density." (WGII FSM, section 4.2.5, p. 176)

"**The existing climate models are not able to generate reliable estimates on regional temperature, precipitation, and hydrology....** In addition, in order to assess the quantitative implications of ecophysiological processes under chronic climatic change, climate models must describe the regional and seasonal changes of temperature and precipitation." (WGII FSM, section 15.7.2, p. 507)

"**Forests themselves may to some extent acclimate or adapt to new climatic conditions,** as evidenced by the ability of some species to thrive outside their natural ranges. Also, **elevated CO2 levels may enable plants to use water and nutrients more efficiently** (e.g., Luo et al., 1994)." (WGII FSM , section 1.3.7, p. 113)

THE ROLE OF TECHNOLOGY

"**In the energy supply sector, we conclude with a high degree of confidence that GHG emissions reductions can be achieved through technology options....**" (WGII FSM, Executive Summary, Chapter 19, p. 589)

"....within a period of 50-100 years, the entire energy supply system will be replaced at least twice. New investments to replace an old plant or to expand capacity are **opportunities to adopt technologies that are more environmentally desirable at low incremental cost.**" (WGII FSM, section 19.1, p. 591)

"Timing of reductions in greenhouse gas emissions should reflect differences in costs, discounting (to evaluate those costs), and risk. **If technological change will make future emission reductions much less costly, some reductions should be postponed.**" (WGIII, FSM, section 1.3.3.2, p. 27)

"**Industrial GHG reductions can be achieved by good housekeeping** (operational performance), additional investments in energy-efficient technologies (both conversion and end-use equipment), or redesigning the manufacturing process itself (process innovation and integration)." (WGII FSM, section 20.5, p. 670)

"Greater use of available, **cost-effective technologies** to increase energy efficiency in buildings **could lead to sharp reductions in emissions of CO2** and other gases contributing to climate change." (WGII FSM, section 22.5.1, p. 731)

"Because future global industrial growth will take place largely in the developing and transitional economies, the **early transfer of advanced energy-conservation technology may be crucial to curb worldwide GHG emissions.**" (WGII FSM, section 20.5.2, p. 671)

AGRICULTURE

"If climate change is gradual, it may be a small factor that goes unnoticed by most farmers as they adjust to other more profound changes in agriculture stemming from new technology, increasing demand for food, and other environmental concerns such as pesticide use, water quality, and land preservation." (WGII FSM, section 13.9, p. 452)

"Given the wide range of microclimates already existing in mountain areas that have been exploited through cultivation of diverse crops, **direct negative effects of climate change on crop yields may not be too great.**" (WGII FSM, section 5.2.4.1, p. 204)

"While uncertainties continue to exist about the direction of change in global agricultural production resulting from climate change, changes in the aggregate level of production have been found to be small to moderate... **More recent work considering global agriculture under climate change found far greater potential for global agriculture to adapt to changing climate than earlier studies.**" (WGII FSM, section 13.8.2, p. 451)

THE ROLE OF TAXATION

"Internalizing environmental costs in energy prices and tariffs through ecotaxes is particularly problematic for the industrial sector because of the consequences for national competitiveness on international markets. **Taxes that are not levied on a global scale may provoke industry relocation**, which may adversely affect emissions efficiency as well as international competitiveness. Most countries are hesitant to embark on policy ventures that might endanger their international market position and their attractiveness as industrial locations...**It is difficult for a single nation to impose full environmental cost accounting and remain competitive unless other nations do the same.**" (WGII FSM, section 20.5.3.3, p. 673)

"One implication of general equilibrium theory has already been noted: **Taxes imposed on one part of the global economy may have little if any effect on global emissions**; they may simply result in a relocation of economic activity.... If, for example, the OECD countries impose carbon taxes on energy-intensive industries, those industries may relocate outside the OECD. Further, if greenhouse mitigation puts an economic drag on the developed countries, developing countries would be affected through trade. If different countries have different obligations to reduce greenhouse emissions, different implicit tax rates will result. **This will interfere with world economic efficiency--**

decreasing world real output--possibly with little effect on total greenhouse gas emissions."
(WGIII, FSM, section 1.3.6, p. 31)

"Estimates range from \$20 to \$150 per tonne for the carbon taxes required to hold emissions at 1990 levels in 2010. Estimates of the carbon taxes required to reduce emissions by 20% below 1990 levels in 2010 range from \$50 to \$330 per tonne." (WGIII, FSM, section 9.2.1.1.3, p. 307)

"Based on the above findings, the study concludes that in the absence of effective controls on deforestation, **carbon taxes would create incentives to deplete forests for energy use.**" (WGIII, FSM, section 9.2.4.1.3, p. 327)

INSURANCE INDUSTRY

"Since the relationship between weather-related events and climate change is not known, insurance to cover the risks of climate change, *per se*, is probably not feasible or necessary." (WGIII, FSM, section 2.4.4, p. 71).

"There are several reasons for the escalation in the cost of severe weather. Developed countries have become wealthier. Many more people now live in coastal areas with costly infrastructures. Personal goods and business processes are generally more vulnerable to water damage. The built environment also contributes through inappropriate or incorrect design and construction. The insurance industry has compounded matters by extending the basis of coverage. It is a common perception in the insurance industry that there is a trend toward an increased frequency and severity of extreme climate events. **The meteorological literature fails to substantiate this in the context of long-term change, though there may have been a shift within the limits of natural variability.**" (WGII FSM, Executive Summary, Chapter 17, p. 541)

"World population is increasingly concentrated in urban areas, coastal regions, and river valleys (Marco and Cayuela, 1992). The concentration of property in such areas exposes insurers to potentially large losses from extreme events. Already, two-thirds of the world population live within 60 km of the coast; this is expected to rise to 75% by 2010 (IPCC, 1994).**Prosperity has resulted in an increasing stock of personal property, often vulnerable to water, salt, and smoke damage.** Parallel changes have occurred in commercial/industrial properties." (WGII FSM, section 17.3.3, p. 545)

"The recognized source of information on future climate change is the general circulation model, or GCM...but at present **GCMs are of limited use to the financial sector**, for the following reasons:

- The length of model run is generally too short for statistical analysis of extreme events....
- For analysis of extreme events, model output may be required at the daily timescale....

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- Current models cannot generate sufficient spatial detail....
- There may be a lack of consistency in model results....”

(WGII FSM, section 17.4.2, p. 546)

***Bold Highlights added.**

WGI, WGII, WGIII = IPCC Working Groups One, Two and Three

FSM = Full Supporting Material, the peer reviewed portion of IPCC's work.

The full set of documentation is available from Cambridge University Press. Copies of portions of the FSM can be obtained from the Global Climate Coalition by calling Krista Johnson at (202) 628-3622.

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