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Editorial

Working Group 1 report of the IPCC Fourth Assessment—An editorial

The world is increasingly thirsty for information on climate change. The IPCC has again met this challenge in its Fourth Assessment, providing a wealth of carefully documented information on the nature of contemporary and past climate change, with some model-based looks at the future. The report is not without controversy, however, and the debate on sea-level rise typifies the difficulty in dealing with important but highly uncertain aspects of climate change.

The Working Group 1 report of the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report (AR4) continues in the tradition of earlier IPCC WG1 reports with regard to its authoritative character, its careful construction and its comprehensiveness. Like its predecessors, the WG1 report is very solid scientifically and is full of useful information, in general clearly presented with the degree of certainty or uncertainty in statements or projections explicity provided. Given the obvious policy relevance of the report, it has justifiably made a huge impact on the policy community and indeed on the public, presenting a thorough yet comprehensible synthesis of our current knowledge base on a very complex topic.

There are several features of the report that are significant improvements over earlier WG1 reports. For example;

- The chapter on palaeoclimate (chapter 6) is a gem, and highly recommended reading for anyone interested in how the present anthropogenically forced changes to climate compare with natural variability. The treatment of glacial–interglacial cycling is very informative, particularly with regard to the interplay of the carbon cycle and the physical climate. The issue of the 1000–2000 year northern hemisphere surface temperature record—the so-called ‘‘hockey stick’’, is dealt with in a refreshingly open and honest way. I was also pleased to see reference to the paucity of palaeoclimatic data for the southern hemisphere; hopefully that will be rectified in coming years. A related strength of the WG1 report more generally is the integration of palaeoclimate information throughout the rest of the report, beyond a stand-alone treatment in chapter 6.
- One of the most important aspects of climate change in terms of impacts and adaptation is the change to the hydrological cycle. Here the AR4 has made a big step forward (see Section 3.3). The increased precipitation over the northern high latitudes and the increased water vapour content in the troposphere is now better documented. However, it is not yet clear whether the hydrological cycle is intensifying, as predicted. On the other hand, significant regions in the tropics and subtropics have become drier, with droughts becoming more common. Increased evapotranspiration associated with higher temperatures is an important factor contributing to the severity of the droughts. Given the high population density in many regions in the tropics and subtropics, these observed drying trends are especially important in terms of the consequences of climate change.
- A potential problem with many analyses of anthropogenic climate change is that the model projections and associated discussion end at the year 2100 (or in the AR4 often at the decade 2090–2099). This can subconsciously give the reader the impression that the ultimate target is dealing with the projected change at 2100. Section 10.7, on ‘‘long term climate change and commitment’’ dispels any illusions that all will be well after 2100. An innovative feature of this section is the discussion of long-term simulations that include the so-called ‘‘overshoot’’ phenomenon, in which atmospheric CO_2 concentrations rise above their ultimate stabilisation level for some time efore being reduced. Such scenarios are being more frequently discussed as the difficulty of reaching desired stabilisation targets becomes increasingly appreciated.
- A feature of the report that I particularly appreciated is the set of boxes on frequently asked questions. These tackle some of the more difficult questions surrounding climate change, and present very informative responses, without glossing over the details. Examples range from ‘‘How are temperatures on Earth changing?’’ (FAQ 3.1) to ‘‘What caused the Ice Ages and other important climate changes before the industrial era’’ (FAQ 6.1) and to ‘‘If emissions of greenhouse gases are reduced, how quickly do their concentrations in the atmosphere decrease?’’ (FAQ 10.3). This last box is essential reading, in particular, for economists working on various emission reduction schemes.

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As suggested above, a general feature of the report is its relevance for climate impact and adaptation studies. Examples include the discussion on changes to the hydrological cycle, with the associated implications for droughts, flooding and water resources more generally, and its information on possible changes to the frequency and intensity of extreme events such as tropical cyclones.

One of the more interesting examples of the report's usefulness for impact and adaptation studies is based on the wealth of information on sea-level rise. The topic is not without contention, however, and the WG1 report's treatment of sea-level rise has triggered a considerable amount of discussion in the research community. On a quick read, the projections of sea-level rise for the remainder of this century (Section 10.6.5, Table 10.7 and Fig. 10.33) are somewhat puzzling, as they indicate a smaller range of projected change than the IPCC Third Assessment Report (TAR) despite the observed acceleration in the rate of sea-level rise in the 1993–2003 period (Section 5.5.2 and frequently asked question 5.1) and recent observations of instabilities in ice sheet dynamics, especially in Greenland. The range for AR4 is 0.18–0.59 m (column labelled ''Sea level rise'' in Table 10.7 and Summary for Policymakers, page 11), compared to the TAR projection of 0.11–0.88 m.

A more careful reading provides some important insights into this apparent paradox. First, the estimates for sea-level rise due to thermal expansion of the ocean have improved, leading to a tighter range of projections in the AR4. This is important, as thermal expansion currently contributes about two-thirds to the total sea-level rise projection. Second, the TAR projections included some guesses about the overall contribution of the polar ice sheets (Greenland and Antarctica). The AR4 has dealt with these in more detail but in a more complicated way. The contributions of changes in surface mass balance (the difference between overall accumulation and ablation) of the polar ice sheets have been included in the overall estimates of sea-level rise, but the contributions due to changes in the dynamics of ice-sheet discharge (the flux of ice crossing the ''grounding line'', usually manifested as the disintegration and calving of ice streams as they approach the ocean) have not. The effects of such processes are estimated separately in the final row of Table 10.7, labelled ''Scaled-up ice sheet discharge'', and add 0.00–0.17 to the estimates of sea-level rise. Thus, including estimates of all processes by which the polar ice sheets can affect sea level gives an upper limit of 0.76 m to the AR4 projections, not dissimilar to the upper bound of 0.88 m in the TAR and certainly within the uncertainty bounds of both reports. In addition, the two reports have used different treatments for some small terms that affect sea level, such as melting of permafrost.

So the apparent paradox has been explained. Not quite. An obvious but important feature of the AR4 is that more time has passed since the publication of the earlier projections of sea-level rise and thus longer observational records are available to test model-based projections. About the time of publication of the AR4, a comparison of observed temperature and sea-level rise and the model projections from 1990 to the present was also published (Rahmstorf et al., 2007). Both observed temperature and sea-level rise are tracking at or near the top of the envelope of model projections. With regard to sea level, the current trajectory, should it be maintained, would lead to a sea-level rise of nearly 1 m by 2100, well above the median of the AR4 projections and slightly above its upper projection, even including estimates of the dynamics of ice sheet discharge.

The AR4 deals with the comparison of observations and its model projections in a complicated (but defensible) way. The report notes the increased rate of sea-level rise in the 1993–2003 period, but adds that it is not possible to ascertain whether this represents a long-term acceleration of the rate of sea-level rise or reflects decadal variability. The report describes the large number of papers since 2001 that report rapid changes in the flow velocities of the outlet glaciers of large ice sheets (Section 4.6.3.3) but questions whether this increased discharge of ice from the polar ice sheets is a response to recent climate change and thus will continue into the future or whether it represents a rapid, short-term adjustment that will diminish in coming decades (Section 10.6.5). In a longer time frame, on the other hand, it is suggested that catastrophic changes, such as the collapse of the West Antarctic Ice Sheet or the rapid loss of the Greenland Ice Sheet, although not likely in this century, will become more likely as the perturbation of the climate system continues (frequently asked question 10.2). And the chapter on palaeoclimate reports that during the last interglacial period about 130 k years ago, sea level was 4–6 m higher than at present (Section 6.4.3.3).

So what are we to make of this complex array of information, especially with regard to adapting to the potential impacts of a rising sea level? Should we now be less concerned that we might have been 6 years ago with the publication of the TAR? There is one suggestion (by James Hansen, 2007) that a special panel be convened to re-assess the sea-level rise issue, taking account of the ''scientific reticence'' he suggests is hindering communication to the public about the risks of climate change.

The apparent contradictions, contrasting observations and model projections, and considerable uncertainties about key processes that have led to the vigorous discussion in the scientific community on sea-level rise are precisely the qualities of the WG1 report (with or without possible supplementary assessments) that make it a useful tool to inform adaptation.

There are two broadly contrasting approaches to climate adaptation studies, often referred to as ''top down'' and ''bottom up''. The former starts with a climate change scenario or scenarios and uses these to drive simulations of potential impacts on the system or sector of interest. The latter focuses first on the system or sector of interest, analyses how climate affects its functioning along with other factors, and then often uses a risk management approach to deal with potential changes in climate. Concepts like enhancing resilience or building adaptive capacity are important in implementing a risk management approach. In my view, the risk management approach is the more effective for climate adaptation, and is especially useful when dealing with aspects of climate change that have high uncertainties, such as sea-level rise.

The types of climate information used in the two approaches are also somewhat different. In the scenario-focused approach, the climate change scenario is the starting point, and then is often used to drive a second model that estimates the projected impact (e.g., gain or loss in crop yield, level of inundation in a coastal city). This approach can be strengthened by using multiple scenarios or by applying probabilistic analyses to the climate projections.

For the risk management approach, a broader range of information—increasingly based on observations of change over the past few decades as well as improved process-level understanding—usually proves to be useful. The fact that there are large uncertainties, varying interpretations of observations and an apparently bewildering mix of model outputs, assumptions and caveats is less of a problem for the bottom-up approach. This information—including worst-case scenarios—is all assimilated by those who know their systems well to inform a risk analysis, much as they do in dealing with other critical uncertainties such as the future behaviour of the stock market or the effect of future changes to the World Trade Organisation on the prices of agricultural products. The lack of certainty or complexity of information should thus not be a barrier to effective action. The re-insurance industry has already shown (Munich Re Group, 2005) how the current state of knowledge about sea-level rise, tropical cyclones and storm frequencies and intensities can be used in their decision making.

So in terms of providing useful information for adaptation, the WG1 report deserves high marks. In many other ways, the report is an outstanding example of assessing and presenting scientific information in a highly credible way. One can safely assume that statements in the IPCC that are labelled ‘‘virtually certain’’ or ‘‘highly likely’’ are based on a consensus that has been built with exceptional care—there is very little or no doubt in the community of their veracity. This is important to note for the media, the political sector and the public. On some of the most fundamental and important aspects of climate change, such as whether the world is warming and what is the primary cause, the debate is over in the scientific community. However, for many other important aspects of climate change, such as sensitivity of climate to greenhouse gas forcing, the role of aerosols in the radiative balance and in the hydrological cycle, and carbon cycle feedbacks, there remain significant and somewhat stubborn uncertainties.

I am very much looking forward to the AR5, where no doubt some of the currently uncertain issues such as sea-level rise can be addressed with a higher level of confidence. With another 5–7 years of observations, our understanding of the nature and rate of climate change will be enhanced, as well as our ability to test the models by which we project the course of climate change over the rest of this century and beyond.

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