Scenarios for climate impact and adaptation assessment

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Amongst the most important gaps in our current knowledge of the potential effects of greenhouse-induced climate change are: (a) an insufficient picture of potential impacts in different parts of the world (there are large areas, especially in developing countries, where few impacts studies have been completed), (b) an almost complete lack of information on impacts under different development pathways and under different amounts of mitigation and (c) little analysis of the capacity and costs of adaptation that might avoid such effects. This was concluded by the Intergovernmental Panel on Climate Change (IPCC) in its Third Assessment (IPCC, 2001a-d).

Where studies have been conducted they often assume different scenarios of climate change, different economic and social projections, and different current baselines. This has often led to inconsistency in the use of climate and emissions scenarios, which has in turn resulted in difficulties in comparing and integrating the results to build a regional or global picture of impacts and adaptation options. These were the reasons that led to the IPCC establishing a Task Group on Scenarios for Climate Impact Assessment (TGCIA) in 1998. Its purpose is to facilitate the provision of scenarios (both climate and socio-economic) for impacts and adaptation research, and to provide guidance on the use of these. The purpose of this note is to inform impacts and adaptation researchers about what data on scenarios are now available and to encourage use of them.

1. Data and guidance now available

The TGCIA has developed a Data Distribution Centre (DDC) which is run by the Climatic Research unit, University of East Anglia (CRU) in the UK and Deutsches Klimarechenzentrum (DKRZ/MPI) in Hamburg, Germany, and has a mirror site in Australia. Other mirror sites are being developed (e.g., Brazil) to aid access to the datasets and visualisation software on the DDC. The DDC contains sets of climate projections from model experiments that meet a number of criteria agreed by the IPCC and observational baseline data. The data sets can be accessed from the DDC website: http://ipcc-ddc.cru.uea.ac.uk and include the following:

The climate models: The DDC currently contains data from nine global climate models (GCMs) produced by seven climate modelling centres. These are listed in Table 1. The Task Group has recommended that a range of these data be used in impact assessment, in order to capture some of the range of uncertainty. The models perform differently in different regions and graphed regional patterns of their outputs will be added to the DDC shortly to help analysts in their choice of climate scenarios. An example is given in Fig. 1. All the models and experiments need to have met the following criteria:

- be full 3D coupled ocean-atmospheric GCMs,
- be documented in the peer reviewed literature,
- have performed a multi-century control run (for stability reasons)
- have participated in CMIP2 (Second Coupled Model Intercomparison Project).

In addition, the models preferably should:

- have performed a 2 x CO2 mixed layer run,
- have participated in AMIP (Atmospheric Model Intercomparison Project),
- have a resolution of at least T40, R30 or 3 x 3°,
- Consider explicit greenhouse gases (e.g. CO2, CH4, etc.)

The GCM experiments: All the model results assume approximately a 1 per cent p.a. increase in greenhouse gas forcing, an assumption which approximates to the
Table 1
GCMs with experimental results currently held on IPCC’s Data Distribution Centre

<table>
<thead>
<tr>
<th>Modelling centre</th>
<th>Country</th>
<th>Model name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commonwealth Scientific and Industrial Research Organisation (CSIRO)</td>
<td>Australia</td>
<td>CSIRO-Mk2</td>
</tr>
<tr>
<td>Deutsches Klimarechenzentrum (DKRZ)</td>
<td>Germany</td>
<td>ECHAM4/OPYC</td>
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<tr>
<td>ECHAM3/LSG</td>
<td></td>
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<tr>
<td>Hadley Centre for Climate Prediction and Research</td>
<td>United Kingdom</td>
<td>HadCM2</td>
</tr>
<tr>
<td>Canadian Centre for Climate Modelling and Analysis (CCCMA)</td>
<td>Canada</td>
<td>CGCM1</td>
</tr>
<tr>
<td>Geophysical Fluid Dynamics Laboratory (GFDL)</td>
<td>USA</td>
<td>GFDL-R15</td>
</tr>
<tr>
<td>National Centre for Atmospheric Research (NCAR)</td>
<td>USA</td>
<td>NCAR DOE-PCM</td>
</tr>
<tr>
<td>Center for Climate Research Studies (CCSR), and National Institute for Environmental Studies (NIES)</td>
<td>Japan</td>
<td>CCSR-NIES</td>
</tr>
</tbody>
</table>

Fig. 1. Scaled outputs of mean December–February (left) and June–August (right) temperature and precipitation change by the 2050s relative to 1961–1990 over land grid boxes representing Northern Asia (top) and Southern Africa (bottom) from eight simulations with five AOGCMs (including a four-member ensemble). Simulations assume forcing by greenhouse gases but not aerosols, and are standardised according to the climate sensitivity of each AOGCM. Lines connect four points for each simulation, all in the same order from the origin: B1-low, B2-mid, A1-mid, A2-high. Each point represents the standardised regional changes in climate from the AOGCM, linearly scaled according to the global warming estimated with a simple climate model for one of four preliminary SRES marker emissions scenarios (B1, B2, A1 and A2) and a value of the climate sensitivity (low = 1.5°C, mid = 2.5°C and high = 4.5°C). Also plotted are ±1 and ±2 standard deviation ellipses from the 1400-year HadCM2 and 1000-year GFDL unforced simulations, which are used to indicate natural multi-decadal variability and are orientated according to the correlation between modelled 30-year mean temperature and precipitation. Source: Carter et al. (2000).
IS92a emissions scenario in the IPCC’s Second Assessment (IPCC, 1996).

**Time slices 2020s, 2050s and 2080s**

The DDC contains 30-year averaged data for three time periods in the future centred on the decades 2020s, 2050s and 2080s (2010–2039, 2040–2069 and 2070–2099). Monthly time-series data for the whole period (1960–2100) are also available.

**The model variables currently available**

For each GCM the following core variables will be found on the DDC, provided on a global grid that varies from model to model: cloud, diurnal temperature range, precipitation, radiation, mean temperature, minimum temperature, vapour pressure, wind.

**The observed climate data currently available**

The DDC contains a 0.5° × 0.5° longitude and latitude gridded observed climate dataset for the land surface of the globe. The observational data available as monthly means for the 1961–1990 baseline period and as decadal means from 1901–1990 include: cloud cover, diurnal temperature range, ground-frost frequency, precipitation, radiation, wet day frequency, mean temperature, maximum temperature, minimum temperature, vapour pressure, wind.

**Other atmospheric and environmental data**

A range of other non-climatic data is also available:

- Atmospheric CO2 concentrations and other greenhouse gases (methane, nitrous oxide, etc.).

**Guidance on the use of the scenarios**

The DDC website contains extensive written guidance on how the climate scenarios and baseline data can be used in impact and adaptation assessment; and in order to facilitate comparable results, it also advises on reporting standards.

### 2. New information on climate change under different development pathways

In its Third Assessment the IPCC developed a characterisation of six development pathways in its *Special Report on Emissions Scenarios* (IPCC, 2000). These SRES scenarios characterise a range of different future greenhouse gas emissions that would result from different socio-economic futures. The six scenarios can be summarised as follows:

- **A1FI**—A future world of very rapid economic growth, and intensive use of fossil fuels.
- **A1T**—A future world of very rapid economic growth, and rapid introduction of new and more efficient technology.
- **A1B**—A future world of very rapid economic growth, and a mix of technological developments and fossil fuel use.
- **A2**—A future world of moderate economic growth, more heterogeneously distributed and with a higher population growth rate than in A1.
- **B1**—A convergent world with rapid change in economic structures, “dematerialization”, introduction of clean technologies, and the lowest rate of population growth.
- **B2**—A world in which the emphasis is on local solutions to economic, social, and environmental sustainability, intermediate levels of economic development and a lower population growth rate than A2.

**SRES climate data on the DDC**

To encourage speedy access of impacts researchers to the SRES scenarios, the TGClA has asked modelling centres to run GCMs with SRES scenarios, at least for the A2 and B2 scenarios, and (following these two) with preference then being given to A1FI, B1 and A1B. At the time of writing (July 2002), six models have been run for the A2 and B2 scenarios, and one for all six SRES scenarios (see Tables 1 and 2). Three GCMs are expected to have run the six scenarios by the end of 2002.

**SRES population and income data on the DDC**

The Center for International Earth Science Information Network (CIESIN) at Columbia University has prepared national-level and gridded data on population and per capita income (GDP) to be added to the IPCC Data Distribution Centre. These data are for 4 SRES futures (A1, A2, B1 and B2) for 5-year time intervals up to 2100. With these data, impacts analysts will be able to explore the different vulnerabilities or sensitivities of society at different times and for various types of development pathway.

### 3. Impacts under different amounts of emissions reduction

In the IPCC’s Third Assessment there was extensive analysis of the costs of emission reduction. An example of this is shown in the following Viewpoint in this volume (Swart et al., 2002). But not a single analysis of impacts under such mitigation scenarios was reported because none had been completed. It is likely that the IPCC, in its next assessment, will seek to remedy this omission but it can only do so if the underlying research has been conducted. The Task Group has therefore written to climate modelling centres to encourage them to complete stabilisation experiments for a range of CO2 concentrations (e.g., 450, 550, 650 and 750 ppm), so that these climate projections can be available for use by impact analysts. The following Viewpoint in this volume explains this in more detail (Swart et al., 2002).

As a result, a few stabilisation experiments are now available on the DDC, and more are expected in the near future. These offer an opportunity for impact
analysts to compare effects under unmitigated climate change and under different amounts of mitigation, and thus to make some assessment of effects avoided by different amounts of emissions reduction.

One problem is the large number of possible futures that need exploring, given that there are six development (SRES) pathways each with several possible stabilisation levels. However, the analysis by Swart et al. in the following paper shows that relatively few experiments are required to cover the range. In summary: the forcing in B1 (unmitigated) is approximately similar to forcing in the 550ppm stabilisation pathway, the forcing in B2 (unmitigated) is approximately similar to that in the 650ppm stabilisation pathway, and that in A1B (unmitigated) is similar to the 750ppm stabilisation pathway.

Consequently, if we apply the B1 climate to the B2 population/income case we can estimate effects of a 550ppm pathway on a B2 socio-economic world; and, likewise, if we apply both the B1 and B2 climates on each of the A1F and A2 population/income cases we can estimate effects of the 550 and 650 pathways on the A1F and A2 socio-economic worlds. Of course, these estimated effects will be preliminary because the assumed mitigation actions may themselves affect vulnerability in a given socio-economic world. But it is a start, and we need to make a start now. The Swart paper describes how refinements can subsequently be introduced to the analyses.

4. Achieving more detail using regional climate models

Impact and adaptation assessments are increasingly using climate projections from regional climate models to achieve greater spatial detail in climate scenarios. Guidance on the use of regional models for impact assessment is now available on the IPCC’s Data Distribution Centre. There is also an inventory of climate change projections made with regional climate models (at the time of writing, July 2002, the total is 30).

5. Next steps: scenarios that serve early detection and evaluation of adaptive capacity

The IPCC’s Third Assessment Report contained a brief summary of currently detectable early effects of recent warming, particularly at high latitudes. An important conclusion from this was that we can discern some effects now. It will be important to extend this analysis across a wider range of regions and exposure fields, and the Task Group is now evaluating data sets (such a gridded daily temperatures for the past 50 years), that could assist this research.

In addition, the TGCIA is considering how far guidance and data can be provided that could enable more comparable research on different levels of adaptive capacity for different development pathways. For example, impacts analysts are currently making their own inferences about future technology levels and investment levels from levels of GDP in the SRES scenarios. Are there ways in which inferring this ‘fine-grain’ characterisation of the future from population and income can be done in a more co-ordinated manner?

6. Conclusions

It is important that some key gaps in current knowledge be filled. Amongst these are estimates of impacts in developing countries, estimates of impacts for different development (SRES) pathways, estimates under differing amounts of emissions reduction and the need to ensure consistency in the use of climate and emissions scenarios. We need research in these areas to move ahead rapidly so that the next assessment by the IPCC, which will start in 2004 and be completed in 2007, will be able to draw some key new conclusions.
References


IPCC (Intergovernmental Panel on Climate Change), 2001c. In: Metz, B., Davidson, O., Swart, R., Pan, J. (Eds.), Climate Change 2001: Mitigation. Cambridge University Press, Cambridge, United Kingdom.
