

The applicability of regional climate models at the scale of small island states

Statement by IPCC Working Group I: June 2000

Introduction

In the Report of the 11th Session Subsidiary Body for Scientific and Technical Advice (FCCC/SBSTA/1999/14), Paragraph 83e (i), the SBSTA requested the secretariat to:

Consult with the IPCC about the feasibility of the IPCC providing information to the SBSTA at its twelfth session on the applicability of regional climate models at the scale of small island states. Issues to be considered could include: projected sea-level rise; storm surges; projected atmospheric temperature changes; sea surface temperatures; climate variability; rainfall; changes in global circulation patterns; human health and settlement; and any other finding that could assist in the evaluation of coastal adaptation technologies.

This paper has been prepared in response to that request.

General Circulation Models

The IPCC Second Assessment Report (SAR) published in 1996 describes in detail the use of Climate Models as the main tool available for developing projections of Climate Change into the future. These models are computer simulations of the climate that incorporate the basic physics and dynamics of the climate system and that take into account the interactions between the different components of the climate system (the atmosphere, oceans, land, ice and biosphere). The most advanced of these models simulate the climate over the whole globe and are known as Atmosphere-Ocean General Circulation Models (AOGCMs) because they couple together in a detailed way the circulations of the atmosphere and the oceans. The horizontal resolution of a typical AOGCM is mainly limited by computer power and is typically in the range 100 to 500 km. Processes that occur on smaller scales are taken into account through algorithmic techniques known as parametrizations.

AOGCMs provide good descriptions of climate on scales larger than the horizontal resolution. They cannot provide detailed description of current climate or detailed projections of likely climate change on space scales smaller than the horizontal resolution. For the most part therefore projections of climate change with AOGCMs have focussed on the global and sub-continental scales. However, since the most advanced models are now being run for limited experiments with resolutions around 100km, they are beginning to become available for the provision of information on the regional scale. Since the SAR substantial development in AOGCMs has occurred and confidence in their use on the global and sub-continental scales has increased.

Regional Climate Simulation

Two techniques have been employed to simulate climate and provide climate change projections on the regional scale. The first is the use of regional models covering a limited area of the globe at higher resolution (typically around 50 km) for which conditions at its boundary are specified from an AOGCM; it is said to be 'nested' in the AOGCM.

The second is to use empirical/statistical methods to relate local climate to parameters on the larger scale. This technique has been widely employed for local weather forecasting with considerable success. The main problem with its application for climate projection is that the parameters describing the projected climate are often outside the range for which the statistics are known to apply.

Since the IPCC SAR, substantial research has been carried out on the development of these techniques and progress has been made. However, results from different models still differ widely and model development is not yet at a stage when they can be employed with much confidence for regional or local scale projections. A chapter in the IPCC Third Assessment Report (TAR) will be devoted to an assessment of regional modelling techniques.

Local Impact Studies

Climate Change impacts human communities on the local scale so that impact studies require the development of what are known as climate scenarios. These are plausible representations of future climate in terms of parameters that can be employed for studies of the possible or likely impact of anthropogenic climate change –for instance parameters such as temperature, precipitation, soil moisture, carbon dioxide concentration etc that apply to the growth of particular crops. Over the last few years, methodologies for the development of appropriate climate scenarios have been developed, mostly using the results of AOGCMs to provide the basic large scale information. Again, a chapter in the IPCC TAR will be devoted to an assessment of these methodologies.

The IPCC Working Groups I and II have set up a Task Force on Climate Impact Assessment (TG CIA) to facilitate co-operation between the modelling and impacts communities particularly addressing issues relating to availability and accessibility of model data. One of the ways this has been achieved is through the establishment of a Data Distribution Centre which makes available standard sets of climate projections for use in impact assessment. At present these are all based on GCM data so to carry out impact assessments at the regional scale one of a number of downscaling techniques, described above, needs to be used. However, in the longer term it is hoped that it will be possible to make available standard sets of regional scale climate data for impact assessment and the group is in discussion with various regional modelling initiatives with this in mind.

Particular Issues

The following paragraphs address the particular issues raised by the small island states.

Sea Level Rise

In the IPCC SAR projections of sea level rise for the 21st century and beyond were provided for the global scale. The central estimate gave a sea level rise of about 50cm by 2100. It was pointed out that, because the expansion coefficient of water varies with temperature and because the ocean does not warm uniformly, there are substantial regional variations in the magnitude of sea level rise over a range of around +/- 50% of the average. These variations in the regional distribution of sea level rise have been explored by AOGCMs although as yet there is poor consistency in detail between different models. Again the IPCC TAR will assess the results so far.

Storm Surges

The impact of storm surges depends on the sea level and on the intensity of the wind creating the waves. Tropical cyclones are particularly damaging. Many studies have been made of the frequency, distribution and intensity of tropical cyclones in the past showing no clear trends during the 20th century. Model studies have also been carried out although individual storms cannot be resolved in most models. Such studies so far do not show any clear result and the IPCC SAR concludes that it is not possible as yet to say if any change is likely to occur in the frequency, intensity or distribution of tropical cyclones.

Projected Changes in Atmospheric Temperature and Precipitation

The areas of some small islands are very close to sea level; the climate of such islands is close to that of the surrounding ocean and projected temperature or precipitation changes will follow those of the large scale average in that region.. Many other islands possess varying topography creating a local climate that can vary substantially around the island. The distribution of atmospheric temperature and precipitation will depend substantially on this local climate. Local area regional models are the appropriate tools for elaborating this local climate.

Sea Surface Temperatures (SSTs)

The sea surface temperature in the vicinity of small islands will be mainly dependent on the large scale atmospheric and ocean circulations, information on which is provided by AOGCMs. The IPCC SAR suggested sea surface temperature increases of 1-2deg C for most tropical and sub-tropical ocean areas by around 2050.

Of particular importance to many small islands is the influence of the El Nino, which causes substantial changes in

sea surface temperature, cloudiness, atmospheric temperature and precipitation. This is mentioned again below under 'Climate Variability'.

Climate Variability and Changes in Global Circulation Patterns

As the Earth's surface on average warms because of the increase in the concentrations of greenhouse gases, it will not warm uniformly. The pattern of climate response in any given area due to the increased radiative forcing will depend substantially on how the main atmospheric circulation patterns as a whole respond to the forcing. During the last few years, scientists have shown a lot of interest in the way in which AOGCMs simulate these large scale circulation patterns and in the possibility that the character or frequency of these patterns might change in response to anthropogenic forcing.

The most important of these patterns is the El Nino. The IPCC SAR assessed the results of research at that time. In general it was inconclusive, although the SAR mentioned that there could be enhanced precipitation variability associated with ENSO events in the increased CO₂ climate, especially over tropical continents, associated with the mean increase of tropical SSTs. It also mentioned the possibility of enhanced interannual variability of area-averaged summer south Asian monsoon rainfall as indicated by several models.

The character of ENSO during the 1990s has been significantly different from that in previous decades (with a persistent warm (El Nino) phase) raising the question as to whether there is influence on ENSO due to the forcing arising from the increase in greenhouse gases. Since the SAR research in this area has continued to be very active with a wide variety of model results. The IPCC TAR will provide a further assessment.

Climate change impacts

The SAR and the Special Report on 'Regional Impacts of Climate Change' consider impacts based largely on climate scenarios developed from AOGCM results. Gradually we can expect greater use of regional model results by the impacts community – this is still in very early stage, we probably will not see such results reported in the TAR, but should start to see results coming through in subsequent IPCC assessments.

Issues that might be of particular relevance to small island states:

- If extreme weather events (e.g., droughts, floods, storms etc.) were to occur more often, increases in rates of death, injury, infectious diseases and psychological disorders would result.
- Projected climate change would increase the potential transmission of many vector-borne diseases (e.g., malaria), although some of the more remote small island states might be less vulnerable to this.
- Non-vector-borne diseases could also increase through climatic impacts on water distribution, temperature and microorganism proliferation.
- There would be many health impacts of the physical, social and demographic disruptions caused by rising sea levels and climate related shortages in natural resources (especially fresh water).
- A potentially important category of health impact would result from the deterioration in social and economic circumstances that might arise from adverse impacts of climate change on patterns of employment, wealth distribution, and population mobility and settlement. Conflicts might arise over dwindling environmental resources. Such issues could be particularly severe for small island states where possibilities for adaptation may be more limited.
- Some ecosystems critical to small island states, such as coral reefs, are highly sensitive to changes in temperature and hence climate change.
- Tourism is the dominant economic sector in many small island states and could be affected both directly and indirectly by climate change. The loss of beaches to erosion and inundation, increasing stress on coastal ecosystems, damage to infrastructure, and an overall loss of amenities would jeopardise the tourist industry in many small islands.

Coastal adaptation technologies.

The IPCC have recently assessed this area in a Special Report on Technology Transfer. Three basic strategies exist for adaptation to climate change in coastal areas and a range of technologies exist which have proved effective in

dealing with climate variability:

Protect – decrease the probability of occurrence e.g., by building dikes, floodwalls etc.

Retreat – limit potential effects e.g., by establishing set-back zones or relocating threatened buildings.

Accommodate – increase society's ability to cope with the effects of an event e.g., by emergency planning or modification of land-use and agricultural practices.

However, the small size and limited human and financial resources of many small island states may make some of these possible adaptation technologies inappropriate and costs may be prohibitive. Effective adaptation to climate change also needs to consider numerous non-climatic stresses.