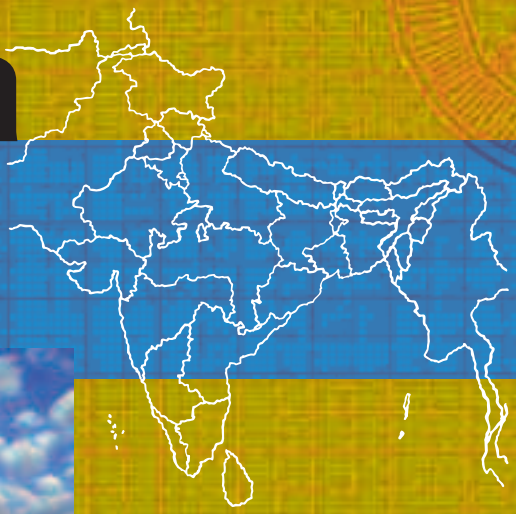
Keysheet 2

Climate Change Scenarios for India



Climate change is predicted to impact India's natural resource base, including water resources, forestry and agriculture, through changes in precipitation, temperatures, monsoon timings, and extreme events. Climate change scenarios were developed for India, in conjunction with the socio-economic scenarios (see Keysheet 3), for input to the modelling of climate impacts on different sectors (see Keysheets 4 to 9).

Understanding the importance of climate change scenarios for India

Climate change in India may pose additional stresses on ecological and socioeconomic systems that already face tremendous pressures from rapid urbanisation, industrialisation and economic development. By examining these potential stresses and impacts, climate science seeks to predict future trends to help inform policymaking.

Climate science uses scenario development and forecasting to understand the degree of change in climate that could occur, and the different factors that could effect the degree of climate change. For example, economic and population growth can increase greenhouse gas emissions, contributing to climate change, while technological advances may reduce these factors. Given the projected high growth levels in India's economy and population, combined with the potential consequences of climate change, information about how these factors inter-relate may be useful to guide policy making at the community, regional and national levels.

The Indian Institute of Tropical Meteorology (IITM) in collaboration with the Hadley Centre for Climate Prediction and Research, UK carried out an analysis of climate change scenarios for India. IITM used the Hadley Centre Regional Climate Models (RCMs) for the Indian subcontinent (See Box 2.1) to model the potential impacts of climate change. These models incorporate the socio-economic scenarios for India (see Keysheet 3) and form the basis for the topical studies conducted as a part of this research programme (see Keysheets 4 to 9).

The Indian Institute of Tropical Meteorology

The Indian Institute of Tropical Meteorology (IITM) is an autonomous research organisation under the Department of Science and Technology, Government of India. It functions as a national centre for basic and applied research. It is a unique research organisation in South-Asia covering almost all aspects of atmospheric sciences and meteorological research. IITM is active in studying long-term climate change from observed and proxy data as well as model diagnostics and assessment of climatic impacts, with a particular focus on the Indian summer monsoon. http://www.tropmet.res.in

Description of methodology

The RCM was set up for the South Asian domain and run to simulate the climate for the present (1961-1990) and a future period (2071-2100). The high-resolution regional simulations generated using the RCM were compared with observed regional climatological data to verify the model's ability to realistically represent the regional climatological features in India, especially for the summer monsoon season.

Climate change is affected by population and economic growth, and therefore the socio-economic forecasts (see Keysheet 3) are important to understand how different growth scenarios might impact on the degree of climate change. Two different socio-economic scenarios were incorporated into the model, both characterised by regionally focused development but with priority to economic issues in one (referred to as A2) and to environmental issues in the other (referred to as B2).

Box 2.1

The Hadley Centre Regional Climate Models (HadRM2/HadRM3H/PRECIS)

The Hadley Centre for Climate Prediction and Research, which is part of the Met Office in the UK, provides a focus in the UK for the scientific issues associated with climate change.
The computer climate models used for the majority of the work at the Hadley Centre are detailed three-dimensional representations of major components of the climate system, one of which is the Regional Climate Model (RCM). The RCM, the latest version of which is known as HadRM3H can be characterised as follows:

- High-resolution limited area model driven at its lateral and sea-surface boundaries by output from HadAM and HadCM
- Formulation identical to HadAM
- Grid : 0.44º x 0.44º
- One-way nesting

The RCM simulations and scenario development were performed by installing the models HadRM3H and PRECIS (Providing REgional Climates for Impacts Studies) at IITM and running them with lateral boundary conditions supplied by the Hadley centre from the global models HadCM3/HadAM3H for two time slices 1960-90 and 2070-2090.

In the initial phase of the project, simulations performed by the Hadley Centre using an earlier version of the RCM, HadRM2, for the present-day concentrations of greenhouse gases (GHG) and a future scenario (IS92a) of transient increase of GHG up to 2050s were analysed to assess the model skills and provide quantitative estimates of future changes at a resolution of ~50 x 50 km. Some additional scenarios were also developed using a pattern scaling approach, for the time slices 2020s and 2080s.

Regional projections of climate change over India

The RCMs have shown significant improvements over the global models in depicting the surface climate over the Indian region, enabling the development of climate change scenarios with substantially more regional detail. This project has generated high-resolution climate change scenarios not only for different states of India, but also for other South Asian nations. Some of the major results of this project are:

- Model simulations under scenarios of increasing greenhouse gas concentrations and sulphate aerosols indicate marked increase in both rainfall and temperature over India into the 21st century.
- The change in rainfall under the B2 scenario is relatively less than that under the A2 scenario.
- There are substantial spatial differences in the projected rain fall changes. The maximum expected increases in rainfall (10 to 30%) occur over central India.
- There is no clear evidence of any substantial change in the year-to-year variability of rainfall over the next century.
- Surface air temperature shows comparable increasing trends in A2 as well as B2 scenarios. The temperatures are projected to increase by as much as 3 to 4°C towards the end of the 21st century.
- The warming is widespread over the country, and relatively more pronounced over northern parts of India.

Figure 2.1
Spatial patterns of the changes in (a) summer monsoon rainfall (%) and (b) annual mean surface air temperature (°C) for the period 2071-2100 with reference to the baseline of 1961-1990, under the A2 scenario.

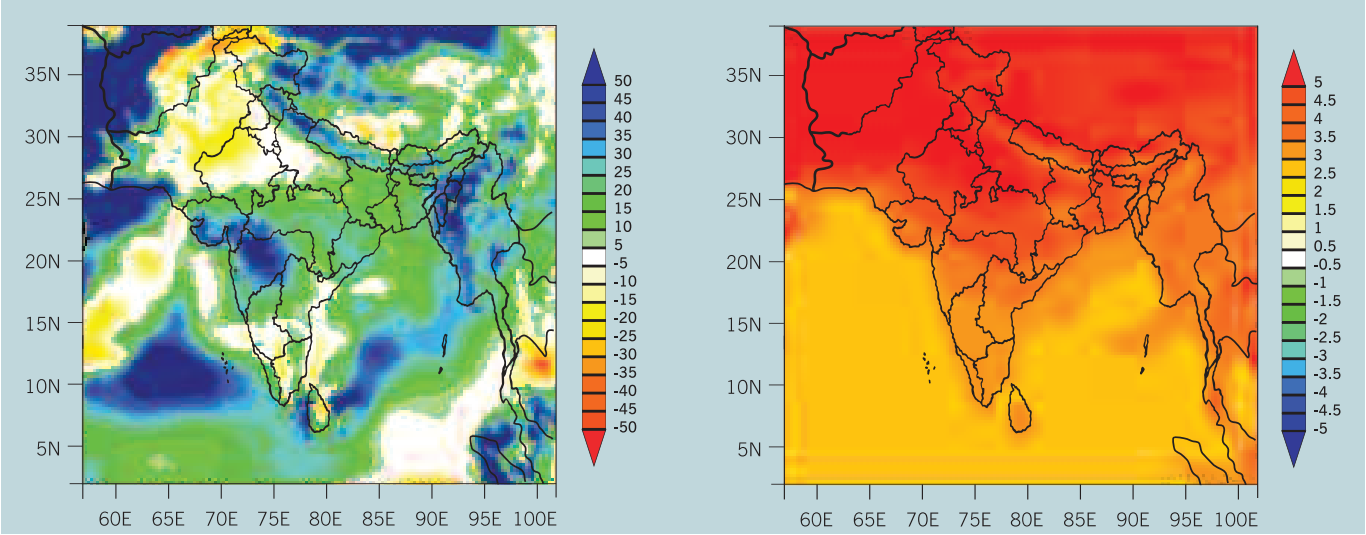
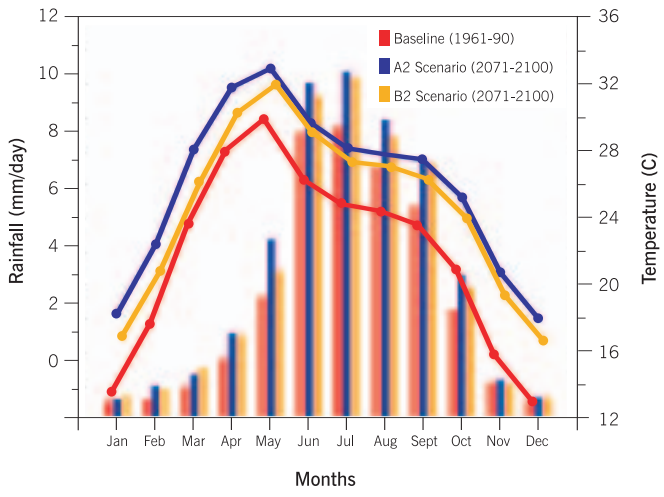


Figure 2.2
Mean Annual Cycles of All-India Rainfall and Temperature, Baseline and Simulated



Needs for further research

This study on climate change patterns for India represents a first step towards understanding the science behind the range of impacts that are discussed in Keysheets 4 to 9. While the scenarios developed in this project are indicative of the expected range of rainfall and temperature changes, the quantitative estimates still have large uncertainties associated with them. Further research is needed to strengthen assessments and reduce uncertainty in predictive models. Specifically, additional research is required to:

- Improve the models by minimising the known biases in simulating observed regional climatic patterns, especially the Indian summer monsoon;
- Develop an ensemble of plausible scenarios in the regional context;
- Improve spatial resolution for regional/local manifestations of climate change impacts;
- Develop sensitivity studies for regional/local manifestations of climate change impacts; and
- Develop predictive models that focus on short term variations as well as longer-term change, to help guide policy making over time.

Keysheet
2

Climate Change Scenarios for India

FOR FURTHER INFORMATION PLEASE CONTACT:

IITM Dr K. Rupa Kumar, Indian Institute of Tropical Meteorology, Pune
Email: kolli@tropmet.res.in

IITM Dr G B Pant, Indian Institute of Tropical Meteorology, Pune
Email: gbpant@tropmet.res.in

MoEF Dr Subodh K Sharma, Ministry of Environment and Forests, Government of India
Email: subodh.kumar@nic.in

Defra Email: indiaimpacts@defra.gsi.gov.uk

Designed by Jo Menhinick www.jmd.eu.com