Detection And Attribution Of Climate Change Over India

Abstract

Human activities have significantly affected the natural environment. Anthropogenic greenhouse gas and aerosols emissions have been shown to have changed the climate of earth on global and continental scales. The surface air temperature and precipitation patterns over India have also been observed to have changed significantly over the last 100 years but there is no clear understanding of the extent to which these changes have been driven by natural or anthropogenic factors. Rising temperatures and altered rainfall patterns pose an immense threat to water availability, agricultural production and human health and can result in adverse consequences for the Indian economy. Therefore, quantifying the contribution of anthropogenic forcings on temperature and precipitation over India is of prime importance for developing mitigation and adaptation strategies.

In this thesis, a detailed Detection and Attribution (D&A) analysis of annual and seasonal mean temperature and precipitation over India for the 1906-2005 period is presented. Together with results from a multimodal archive of forced and unforced climate model simulations, multiple D&A approaches and available observational datasets are used to examine robustness of results. The causes of surface air temperature (TAS) changes over sub-regions (based on demarcation of homogeneous temperature zones) of India are examined using two observational datasets. The D&A analysis examines the sensitivity of the results to a variety of regression based optimal fingerprinting methods and temporal-averaging choices. This study could robustly attribute TAS changes over India between 1956–2005 to anthropogenic forcing mostly by greenhouse gases and partially offset by other anthropogenic forcings including aerosols and land use land cover change.

A pattern based fingerprint D&A method was used to look for time-increasing correspondence between observed changes between 1906-2005 and model-based fingerprints (spatial patterns) of historical temperature and precipitation responses over the Indian region to the individual (greenhouse gas, anthropogenic aerosol) or combined (natural, anthropogenic) external climate forcings. In this approach, the first EOF pattern of individual forcing runs were considered as the raw fingerprint. To enhance the detectability of fingerprint in observations, the raw fingerprint is optimized by rotating it in the direction of maximum signal-to-noise (S/N) ratio. The sensitivity of results to optimization is explored in the analysis. The detection times of each of the forced signals in the observations were estimated at 1% and 5% significance levels.

The findings indicate that the increase in temperature cannot be explained by internal climate variability alone and is primarily due to increases in greenhouse gases and partially offset by the anthropogenic aerosol forcings. While the natural forcings are not detected, they might have contributed to a delay in the emergence of the anthropogenic influence in observations. The same pattern-based detection approach was employed for attributing precipitation
changes using two observed datasets. The analysis shows the dominant role of GHG and anthropogenic aerosols forcings on the observed rainfall changes, where GHG forcings contribute to an increasing trend in precipitation, but the anthropogenic aerosols forcings contribute to a negative trend in rainfall resulting in an overall decreasing effect from anthropogenic forcings. But the results for precipitation are sensitive to the choice of observed dataset. In the case of temperatures, the fingerprint optimisation does not enhance detection of the forced signals but optimization does aid in the case of signal detection for precipitation. Overall, all the findings discussed in the thesis point out that the influence of human activities plays a significant role in the observed climate changes over India and are in line with global scale attribution studies that point to human influence on temperature and precipitation.