Abstract

The Indian subcontinent is one of the most highly irrigated regions of the world where agricultural water use has intensified since the second half of the twentieth century. This agricultural intensification has resulted in changes in the water and energy balance between land surface and atmosphere is affected by these changes, which further influences climatic parameters that directly affect us. Even today Indian agriculture remains predominantly rainfed (60% of sown area producing 40% of the production). Therefore, any changes in climate resulting from irrigation can have significant impacts on food production and are important to quantify. In addition to the impacts of irrigation, a changing climate driven by anthropogenic greenhouse gas and aerosol emissions can also produce changes to the climate which can alter the irrigation water requirement. Over India, the practice of irrigation has changed in recent years resulting in an increased agricultural productivity as well as a depletion of groundwater.

In this thesis, the Community Earth System Model (CESM1.2) comprising of the Community Land Model (CLM4.5) with an active crop model coupled to the Community Atmospheric Model (CAM5) and a slab ocean (SOM) is used to examine the sensitivity of India's climate to the amount of irrigation. The amount of irrigation water is varied by changing a single parameter - the irrigation factor - in the CLM4.5 to produce a range of conditions from saturated soil to a bare minimum of no water stress in the crop. In the first set of simulations, all other forcings are set at year 2000 levels, and changes in temperature and precipitation for various regions of India as well as the link between the changes in Indian summer monsoon rainfall and

irrigation are examined. It is found that irrigation decreases the mean as well as maximum and minimum temperatures by nearly 3-4°C (with a larger impact on the minimum temperature) over the heavily irrigated parts of the Indian subcontinent as a result of increased latent heat partitioning of energy. The resultant cooling impacts the monsoon circulation and reduces the moisture transport resulting in a statistically significant decrease in monsoon season rainfall over the eastern part of the Indo-Gangetic plains while increasing it slightly over the Punjab region of Pakistan and India. There is a delay of about two days in the onset of the monsoon over India due to irrigation and much of the reduction in precipitation is due to reduced large-scale (stable) precipitation.

A second set of experiments under warmer conditions were carried out. In these experiments, forcings for the year 2080 under RCP8.5 scenario were used. The warmer temperatures due to higher forcings are reduced to a similar extent as the year 2000 simulations by irrigation water use. The higher precipitation due to the larger forcings is also reduced by irrigation - but to a larger extent in the future. The reductions are primarily in the convective rainfall in the future as against the large-scale precipitation in the previous set of simulations.

While the large effect on temperature and precipitation may be a result of the CESM simulations having an irrigation seasonality that peaks in April just before the monsoon onset, there is significant disagreement across different model based irrigation estimates on the timing of the peak irrigation. This uncertainty in irrigation water added needs to be resolved to better understand the effects on India's climate.