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Impacts of the agricultural Green Revolution–induced land use changes on air temperatures in India

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[1] India has one of the most intensive and spatially extensive irrigation systems in the world developed during the1960s under the agricultural Green Revolution (GR). Irrigated landscapes can alter the regional surface energy balance and its associated temperature, humidity, and climate features. The main objective of this study is to determine the impacts of increased irrigation on long-term temperature trends. An analysis of the monthly climatological surface data sets at the regional level over India showed that agriculture and irrigation can substantially reduce the air temperature over different regions during the growing season. The processes associated with agriculture and irrigation-induced feedback are further diagnosed using a column radiation-boundary layer model coupled to a detailed land surface/hydrology scheme, and 3-D simulations using a Regional Atmospheric Modeling System. Both the modeling and observational analysis provide evidence that during the growing season, irrigation and agricultural activity are significantly modulating the surface temperatures over the Indian subcontinent. Therefore irrigation and agricultural impacts, along with land use change, and aerosol feedbacks need to be considered in regional and global modeling studies for climate change assessments.

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1. Introduction

[2] The complex interrelationships between land cover and land use change in the context of variable climatic conditions have been widely investigated [e.g., *Chase et al.*, 2000; *Bounoua et al.*, 2002; *Baidya Roy et al.*, 2003; *McPherson et al.*, 2004; *Feddema et al.*, 2005a]. According to *Houghton* [1990], changes in land uses have contributed to about 25% enhanced levels of greenhouse gases in terms of anthropogenic activities. *Pielke et al.* [2002] concluded that land use change is an important climate policy consideration beyond the radiative effects of greenhouse gases. The majority of studies in the last century have focused on the effects of deforestation and denudation of natural landscapes and associated impacts on the surrounding environment [*Brown et al.*, 1991; *Flint and Richards*, 1991]. Some of the findings from these studies are related to greater temperature variations, decreased proportions of soil retention of carbon, and increased levels of pollution and changes in precipitation pattern [*Houghton*, 1994; *Kauppi et al.*, 1992; *Pielke et al.*, 2002, 2007a].

[3] However, in recent years awareness about the impact of changes in agricultural land use in terms of cropping practices and irrigation on the resulting local weather conditions has substantially increased [*Stohlgren et al.*, 1998; *Foley et al.*, 2005; *Douglas et al.*, 2006, 2007; *Pielke et al.*, 2007b]. One such study by *Ramankutty and Foley* [1999] systematically focused on changes in land use patterns over the last three centuries from 1700 to 1992. They used a combination of historical land use data and satellite imagery to monitor the changes in cropland acreage over different time periods. This study found, globally, significant conversion of forest lands to croplands since the year 1700. A primary example of this trend is the northwestern (NW) Indo-Gangetic Plain of the Indian subcontinent which extends eastward along the foothills of the Himalaya in north-central (NC) India; here the gradual intensification of cropland has been replacing forests/woodlands since 1940. This regional expansion of agricultural cropland has been even greater since 1947 because of independent India’s rising population and its subsequent increased demand for agricultural products.

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