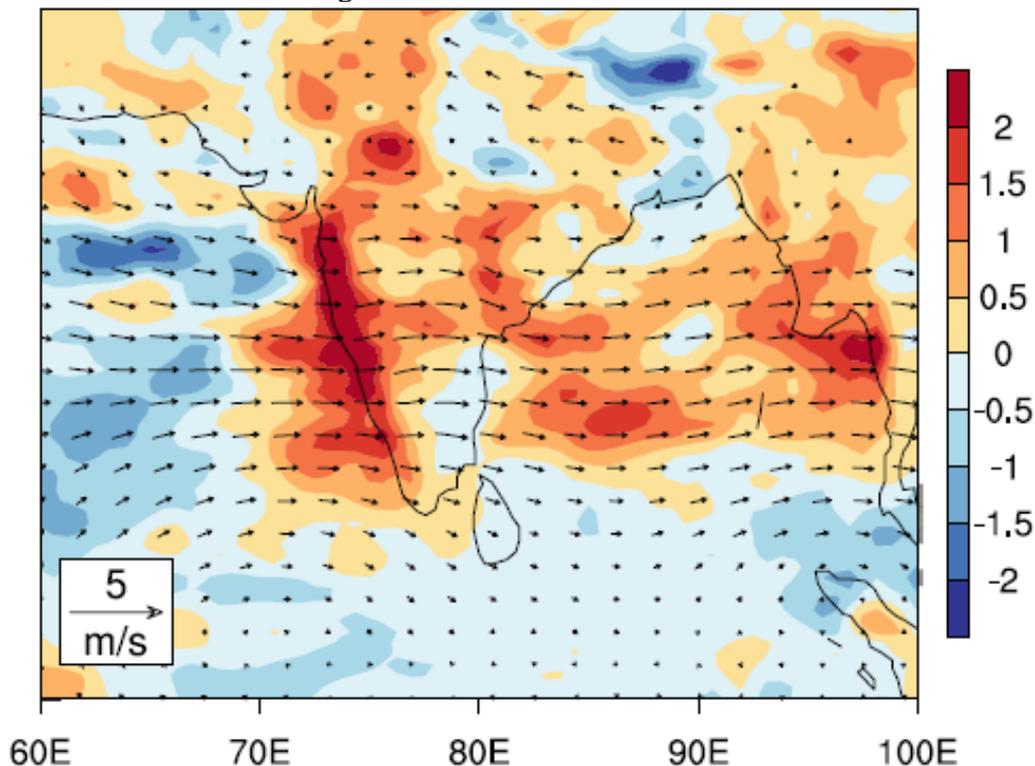


The impact of irrigation on the Indian monsoon

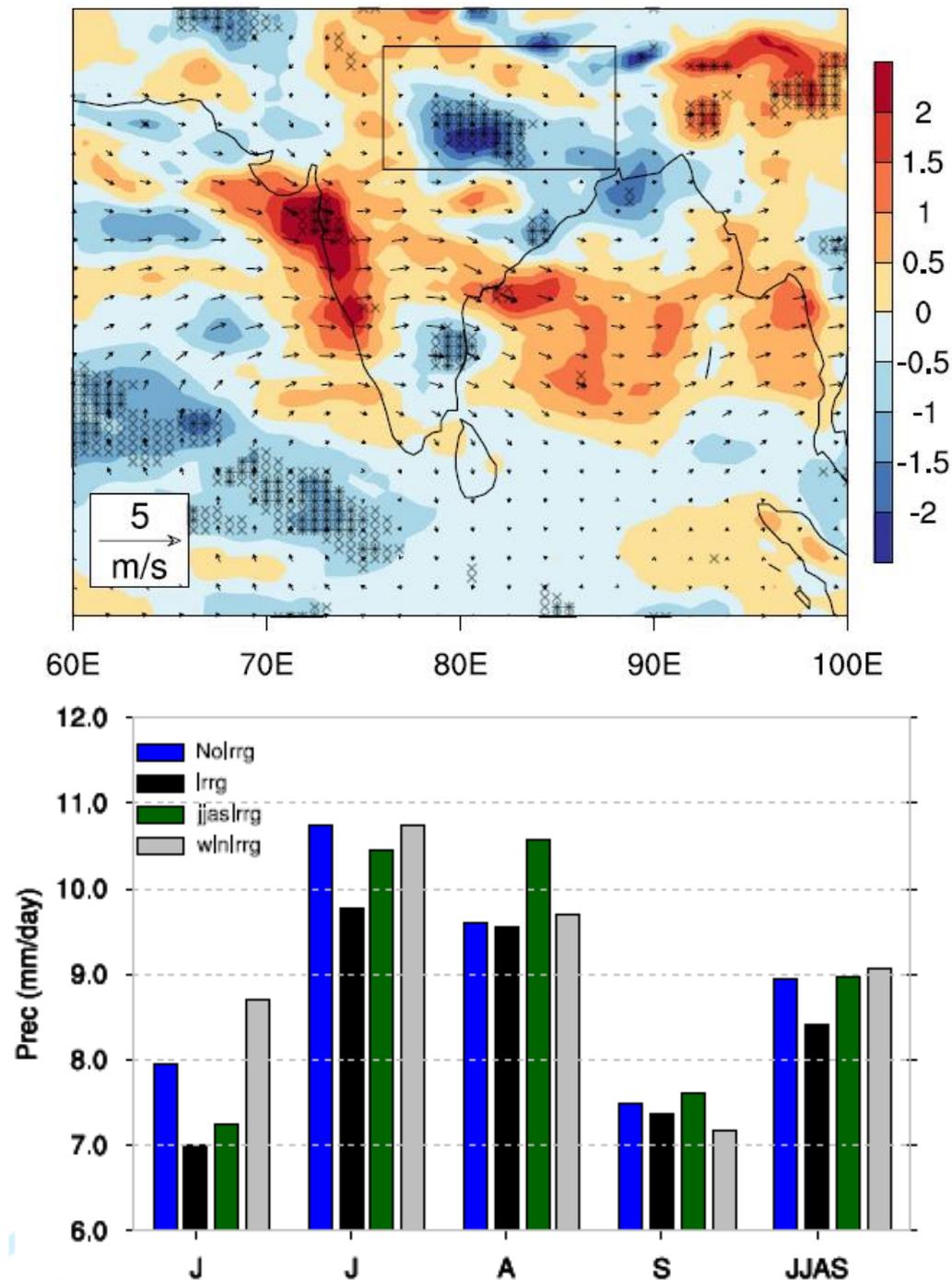
The impact of human activities on the Indian monsoon has been examined by many scientists. The effect of global warming, aerosols and deforestation has been studied extensively. The advent of agriculture has changed the land use pattern in India. In the past 100 years there has been a large increase in land that is irrigated by surface or ground water. What impact will irrigation have on the Indian summer monsoon?

About 70% of the global freshwater withdrawal is used for irrigation. In the last 100 years the amount of water used globally for irrigation has increased from about 500 cubic kilometres to 2500 cubic kilometre. Most of this increase has occurred in Asia. Irrigation will increase surface evaporation and reduce the soil and air temperature near the ground. The amount of water vapor in the atmosphere will increase, when compared to no irrigation and hence increase cloudiness and the greenhouse effect due to water vapor.

This issue has been examined in a recent paper by Shubhi Agrawal et al. published in the journal *Climate dynamics* in February 2019. They have used a coupled atmosphere-land climate model developed by the National Centre for Atmospheric Research in Boulder, Colorado, USA. They used the soil moisture data from JULES (Joint UK Land and Environment Simulator). Among the many cases discussed in this paper, the most interesting is the impact of winter irrigation in the Indo-Gangetic plains on the summer monsoon rainfall. The figure below shows the difference in summer monsoon rainfall (in mm/day) with and without winter irrigation. We find that in many parts of central India rainfall increases by 1 to 2 mm/day and winds have also increased in strength. The largest increase in rainfall is seen in the month of May and June. How does the winter irrigation influence the summer monsoon rainfall? The major parameter is the total amount of water vapor in the vertical column of the atmosphere. The irrigation in winter increases the amount of water vapor in the atmosphere during May and June. Water vapor is lighter than air and hence a higher amount of water vapor promotes vertical motion and this leads to higher rainfall.



When irrigation is undertaken throughout the year, Agrawal et al., (2019) find that Indian monsoon rainfall decreases in the Indo-Gangetic plains. This unusual pattern of rainfall changes can be attributed to local changes in circulation on account lower surface temperature in the Indo-Gangetic plains when irrigation is undertaken throughout the year. The changes in seasonal cycle of rainfall in the Indo-Gangetic plains shows a more complex pattern. There is an increase in rainfall in June with winter irrigation but not in summer or annual irrigation.



Shubhi Agrawal, Arindam Chakraborty, Nirupam Karmakar, Simon Moulds, Ana Mijic, and Wouter Buytaert, Effect of winter and summer-time irrigation over Gangetic plain on mean and intra-seasonal variability of Indian summer monsoon, **Climate Dynamics**, 2019, <https://doi.org/10.1007/s00382-019-04691-7>