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Technical Note

Latitudinal precipitation characteristics and trends in Pakistan

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SUMMARY

Precipitation variability has direct and serious impacts on society. In this study, the latitudinal precipitation characteristics and trends in Pakistan have been examined to identify vulnerable areas. Nonparametric statistical method was used to detect trends in observational data collected over a 60-year period from 48 rain gauges. The results reveal increasing precipitation trends over high latitudes, and no significant trends over lower latitudes. The spatial display of the observed trends is also shown to understand the significant variation and shift of monsoon rainfall in the specific areas. This study not only provides important information on precipitation variability in Pakistan, but is also helpful for policy makers seeking to adopt measures to mitigate the effects of rapidly changing climate in the vulnerable areas.

1. Introduction

Pakistan is a land of great topographic contrasts and the climate of the country therefore has large spatial and temporal variations. The northern and western mountain ranges in the country add to the wide variation in the climate of places located in the same latitudinal belts. Most of the areas of Pakistan are very sensitive to the changes in precipitation. Some of the regions of the country over higher latitudes are vulnerable to flood disaster, whilst most of the southern regions are extremely vulnerable to droughts. The intensity and frequency of extreme precipitation events, mostly associated with monsoon season have also increased as experienced during recent decades. Peoples' perception is also in the favour of changes in the frequency of occurrence of these extreme weather events. The occurrence of these extreme events indicates that Pakistan may be seeing a shift in the climate that may attribute to climate change.

Monsoon is the major rainy season of Pakistan, which yields nearly 60% of total rainfall during the season (June–September), and therefore stands critical for agriculture, industry, drinking water and human health. Hence, the monsoon rainfall characteristics have also been considered in this study. In the future, the pressures of an increasing population will bring additional stresses on society and the environment, with serious implications for water resources, health and food security. So, the possibility that the precipitation distribution, especially monsoon rainfall may become less stable as a result of climate change has serious consequences for Pakistan.

The global mean surface air temperature is the most commonly used indicator of climate change of the planet, and all reports published by Intergovernmental Panel on Climate Change (IPCC) have already indicated the increasing trend of global temperature. Many studies during last three decades have detected the human influence on increasing temperature trends. The precipitation may also be equally important component of global climate change, but the reasons for precipitation change are more complicated than those for temperature by human activity. Many attempts have been made to examine the precipitation changes and trends for different regions of the world. Very few studies are available for global precipitation changes because it is a most challenging task to measure the global precipitation. Zhang et al. (2007) has detected the anthropogenic impact on global precipitation and a latitudinal redistribution of mean precipitation, which is the best work so far. The work based on 14 powerful models showed an increasing precipitation at high latitudes and decreasing precipitation at subtropical latitudes. This study provided the motivation to examine the latitudinal rainfall distribution in Pakistan, extended north to south covering mid latitudes and subtropics (24–37°N). The study area has a complex climate due to topographic contrast and

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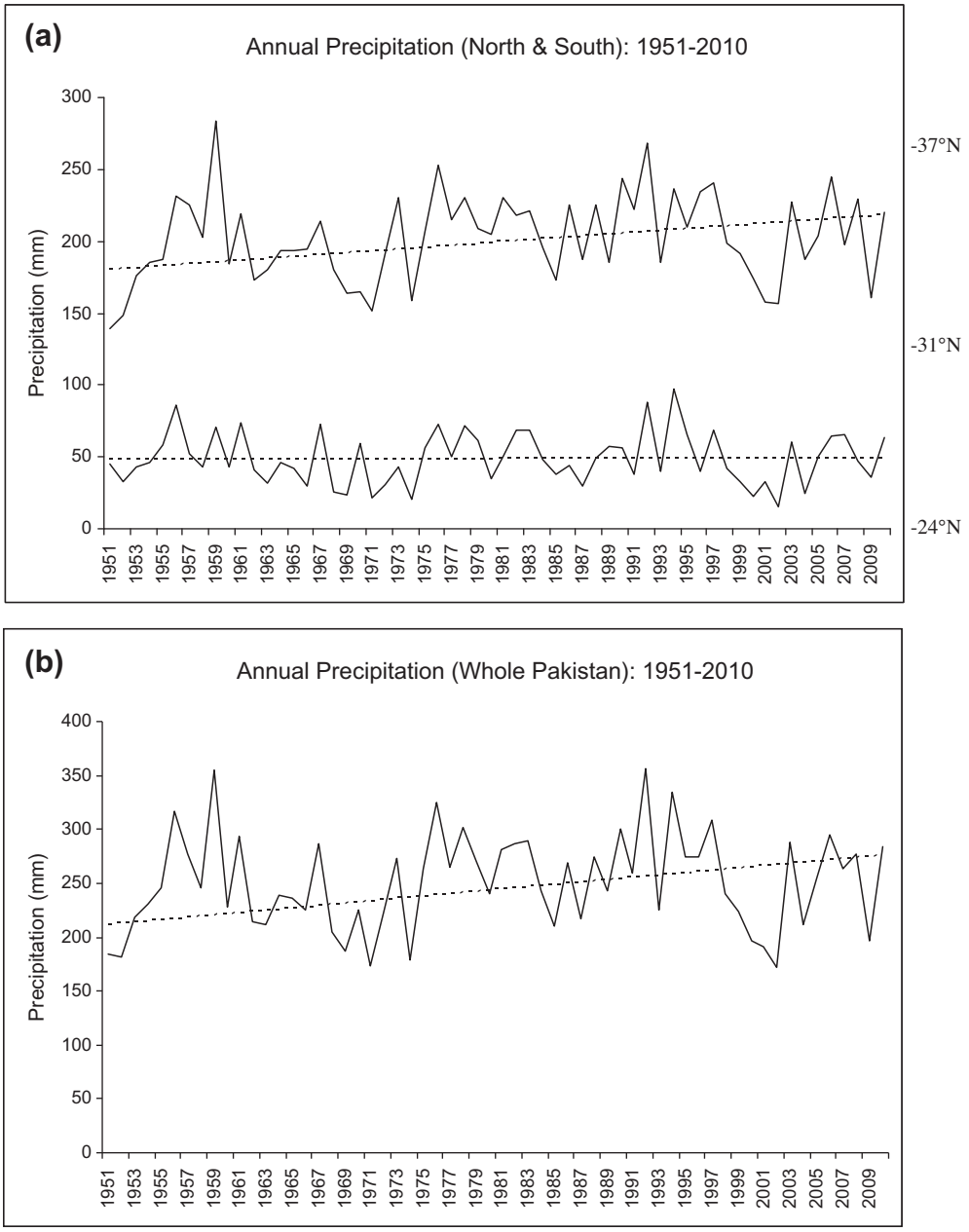

Fig. 1. Time series of annual precipitation (1951–2010); (a) Northern and southern Pakistan. (b) Whole Pakistan.

geographical location. The northern half of Pakistan experiences both weather systems (i.e. mid-latitude and monsoonal weather systems). While the eastern areas of southern half receives only summer rains (monsoon) and the western areas of southern half receives only winter rains. Hence this southern half of study area stands critical to drought during any seasonal rainfall failure. The rainfall variability is highly associated with the upper air atmospheric circulation particularly with sub-tropical high pressure area of the sub-continent as mentioned in several studies. Due to large topographic and temperature contrast, the precipitation pattern is multifarious in Pakistan during both summer and winter season.

Climate changes can be indicated by the observed differences in the mean values of climate statistics in successive time periods, and several studies have indicated the changing trends in regional temperatures and precipitation. An increasing trend in the monsoon seasonal rainfall was found in north-west India after the analysis of long term rainfall data by Kumar et al. (1992). Kothyari and Singh (1996) used long-term data for India as a whole, and detected an increasing trend in the temperature and a decreasing trend in seasonal (monsoon) rainfall. A follow up work by the same authors (Kothyari et al., 1997) found the same trend in the long-term data of monsoon rainfall and the annual maximum temperatures for northern India. By using statistical tests, Treydte et al. (2006) indicated increasing precipitation during 20th century, caused by global climate, over northern Pakistan. Dash et al. (2007) detected the temperatures and precipitation trends during twentieth-century as an evidence of changing climate in India. The work showed that the temperature and the precipitation changes and trends are not same for the whole area and for all seasons. The climate of India has large spatial and temporal variations due to vast size of the country, and such results are therefore acceptable. Kripalani et al. (2007) examined the South Asian summer monsoon precipitation and its variability from the outputs of