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Effect of Climate Change over Kashmir Valley

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ABSTRACT

In the present study fourty five years instrumental record (1970-2015) of four meteorological stations (Srinagar, Pahalgam, Qazigund and Gulmarg) located in different physiographic divisions in the valley of Kashmir was analysed.GCM data was also employed to project future temperature and rainfall of the Kashmir valley upto 21st century. It was observed that temperature shows an increasing trend at all the four stations while as precipitation shows a decreasing trend over the coming century.

1. Introduction

Climate in a narrow sense is defined as "average weather", or more rigorously, as the statistical description in terms of mean and variability of relevant quantities of weather parameters over a period of time ranging from months to thousands or millions of years. The classical period is 30 years, as defined by WMO. These parameters are most often surface variables such as temperature, precipitation and wind. Climate change is not only a major global environmental problem, but also an issue of great concern to a developing country like India. Scenarios of future climate change are usually developed using the GCMs with different scenarios of GHG emissions. GCMs are complex 3-dimensional models of the land, atmosphere and oceans. GCMs are invaluable tools for identifying climatic sensitivities and changes in global climate characteristics, the major problem of the current generation of GCMs is the limitation of their spatial resolution. A single grid of GCM may encompass hundreds of square kilometers and include mountainous and desert terrain, oceans and land areas. Usually, the output of GCMs is given for a scale much larger than that of even a large watershed. There are more than 200 GCMs available which have been developed by different agencies. Input data requirement for the these GCMs are generally same but the output results vary and sometimes with slight variation in input parameters (which may be due to different data collection agencies) the results are contradictory giving confusing future climate scenarios. Despite recent improvements in modeling of the climate dynamics with complex and large-scale models, use of GCMs is still limited in evaluating regional details of climatic changes. For generating future climate scenarios on regional basis there are downscaling models called RCMs which use output of GCMs. However, RCMs do not give basin level scenarios.

The valley of Kashmir has a modified sub-tropical climate and it is also called as sub-Mediterranean type on account of its rainfall distribution pattern (Mehor Homji, 1971).

Owing to sharp annual variations in temperature and precipitation many scholars have identified it as "Irregular type" of climate as it does not show any coherence with standard climatic division of the world. Although, the valley of Kashmir experiences mild summers and severe winters despite being located in subtropics but its most interesting feature is its highly fluctuating temperature and precipitation regimes, which manifest in the form of extreme weather events.These extreme weather events in temperature and precipitation in a delicate and fragile environmental framework are having manifold implications and consequently are of vital interest for climatologist and environmentalist as they provide vital clues about the sensitive climate of Kashmir and western Himalayas.

The weather and climate of Kashmir valley are intrinsically linked with the weather mechanism in the sub-continent in general. The Kashmir valley located at an altitude of about 1600 metres in the north-western corner of the Himalayas, encircled by mountains on all sides gives it a unique geographical character with distinctive climatic characteristics. Within the valley interesting variations in weather are witnessed largely owing to variations in altitude and aspect. The characteristic features of the climate of the valley are: mild summers, vigorous and severe winters with rain and snow, a muggy and oppressive weather in July and August and the most exquisite pleasant spring.

January is the coldest month in the study area. Kashmir valley receives most of its precipitation in the form of snow in the winter season. At Srinagar city, in the month of November the mean maximum and the mean minimum temperatures read about 14ºC and 1.5ºC respectively. From November to January the temperature starts declining. Many years of extreme cold in the valley had been recorded in which the temperatures were as low as -15ºC at Srinagar city. June to September is the summer season in the valley of Kashmir.

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The mean monthly temperature in May at Srinagar city is usually about 22ºC, the mean maximum and mean minimum being about 29.4ºC and 15ºC respectively. July is the hottest month in which the maximum temperature on a particular day may shoot upto 35ºC in Srinagar city. The mean maximum and mean minimum temperature in this month fluctuate between 30ºC and 18ºC respectively. This is the time when the Kashmir valley has almost all of its floods as it receives the maximum proportion of its rainfall during this period.

According to the report of the Intergovernmental Panel on Climate Change (IPCC), the mean annual global surface temperature has increased by about 0.3–0.6°C since the late 19th century and it is anticipated to further increase by 1.0–3.5°C over the next 100 years (Houghton et al., 1996).valid conclusions regarding the climatic variability in a particular region can be drawn to some extent after long term study of influential climatic variables. Therefore the present study is based on fourty five years instrumental record (1970-2015) of four meteorological stations (Srinagar, Pahalgam, Qazigund and Gulmarg) located in different physiographic divisions representing several micro climates in the valley of Kashmir.

The basic aim of the present paper is to study the effect of climate change over Kashmir valley. For that purpose four IMD stations for which almost continuous data of 45 years was available were selected. The historic trend in temperature and rainfall for the period 1970-2015 was studied. Future temperature and rainfall at all the 4 IMD (Indian Meteorological Department) stations upto 2100 was projected using linear regression technique in MS-excel.

2. Database and Methodology

The data for the present study has been obtained from the Central Research Institute Metrology, Pune and Regional Meteorological Station, Srinagar which is centrally located. The study is based on 45 years (1970-2015). This data, which was available for a period of 45 years (1970-2015) for Kashmir valley, included: Monthly temperature and precipitation data at four climate stations, viz Srinagar, Qazigund, Pahalgam, and Gulmarg of Kashmir valley. To project the future climate of the valley GCM predictor data was required which was made available from Canadian Climate Data and Scenarios (CCDS) website http://ccds-dscc.ec.gc.ca/ and www.cccsn.ec.gc.ca/.

In the present study the multiple linear regression technique was employed to relate the GCM predictors with the predictands such as the locally observed precipitation and temperature at four meteorological observatories namely Srinagar, Pahalgam, Qazigund, and Gulmarg of Kashmir valley India. Minitab 15.0 statistical software was also used for regression analysis. The large scale GCM predictors were related to locally observed precipitation and temperature.

A statistical relationship has been derived between observed small scale (station level) variables and large (GCM predictors) scale variables, using a transfer function. The GCM predictors selected were Tempas (mean temperature at 2m), Mslpas (mean sea level pressure), Humas (specific humidity at 2m), Relative humidity(rhum),Zonal velocity component(u), Meridional velocity component(v) and 500hpa geopotential height(p500-as) after predictative-test analysis. As the GCM predictor variables are available upto 21st century so we can predict the future climate of valley by using them in the regression equation which we obtain from the historic available or past data.

Table 1. The latitude and longitude of the meteorological stations in the Jhelum river basin

S. no	Station name	Index no. of the station	Latitude (°N)	Longitude(°E)	Elevation (m.a.s.l)
1	Srinagar	42027	34.09	74.79	1560
2	Qazigund	42044	33.63	75.15	1670
3	Pahalgam	9215	34.01	75.19	2740
4	Gulmarg	42026	34.15	74.25	2690

3. Results and discussions

Despite the fact that the study is based on four meteorological stations, Srinagar is the only station with continuous available instrumental record from (1970-2013). Therefore the information regarding the climate scenario of the valley from1970-2013 is heavily dependent on Srinagar which is located in central Kashmir and may be aptly considered the ideal representative of valley floor. The valley floor appears to be a uniform entity but there are great spatial variations on account of altitude and orographic effect in various parts of the valley. Besides the climatic complexity is largely influenced by a multitude of factors, some of them are originating from far off regions.

The analysis reveals that variability is an important feature of Kashmir climate. Temperature and precipitation regimes have been dominated by two contrasting trends in the period 1970-2015. There prevailed a warming trend in the valley from 1970-1995which was vigorous and is still in operation. On account of the warming trend there was an abrupt increase in mean minimum and mean maximum temperatures in every part of the valley. The warming trend in temperature was accompanied by a modest downward trend in precipitation during which the annual rainfall was 1-2cm below normal in Srinagar.

The warming trend was replaced by a cooling trend in mid eighties. The average annual temperature during this period was 0.2°C below the normal. The resurgence of warming trend was facilitated by a corresponding increasing trend in precipitation during which Kashmir witnessed a net increase of 1-2 cm in low altitudes and 5-8 cm in high altitude regions. The cause of inverse relationship between precipitation and Temperature trends in existence of significant negative correlation between these two variables. Fig.1 and 2 provide a graphical representation of the precipitation and temperature regimes in the valley in the second half of twentieth century.

The valley of Kashmir is dominated by two different precipitation regimes .i.e. western disturbances in winter, spring and autumn while as south-west monsoon also causes certain amount of precipitation in summer season, when it is strong enough to cross over the Pir Panjal ranges which are having comparatively lower average altitude of 2770 meters. During the last two decades there has been considerable decline in the efficiency of both these regimes which facilitated the general increase in temperature. The valley receives major share of its precipitation in winter and spring through western disturbances and the impact of these disturbances is more pronounced in north-western part than south-eastern Kashmir due to typical shape and structure of the valley. As this region used to remain under ice cover for months together due to heavy snowfall in the past decades but owing to decline in the efficiency of western disturbances and

recurrent droughts in winter, mean min temp increased faster than mean max temp which is manifested.

Among all the four stations Srinagar station shows relatively more temperature followed by Qazigund, Pahalgam and Gulmarg. Similarly Gulmarg station records more rainfall and Srinagar least from 1970-2015 Fig.1 and 2. Also temperature record at these stations is clear and distinct but precipitation record of all these stations is not clearly distinct because rainfall is more erratic and random phenomenon than temperature.

The average annual temperature shows an increasing trend for coming century for all the four stations. However Srinagar station shows more increase in temperature at the end of 21st century followed by Qazigund, Pahalgam and Gulmarg. Similarly precipitation shows a decreasing trend at all the four stations for coming century with maximum increase in rainfall at Gulmarg station Fig.3 and 4 and Table 2.

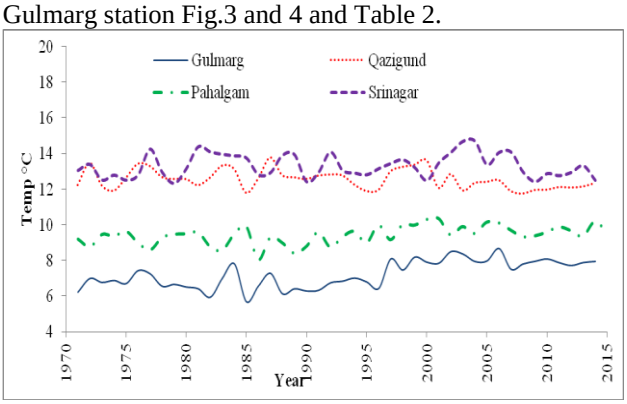

Figure 1. Average annual temperatures of all the four IMD (Indian Meteorological Department) Stations of the Kashmir valley.

Source: Compiled from meteorological data

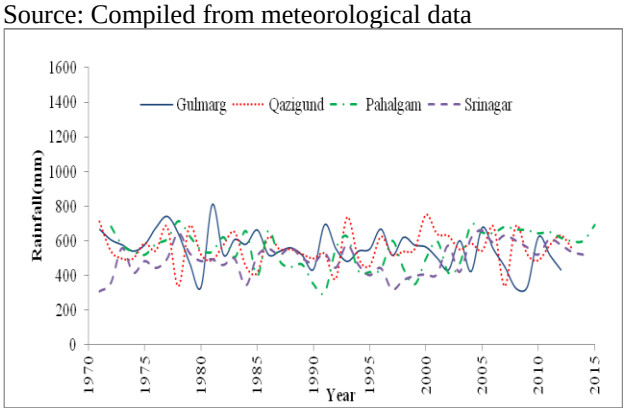

Figure 2. Total annual rainfall at four IMD Stations of the Kashmir valley

Source: Compiled from meteorological data

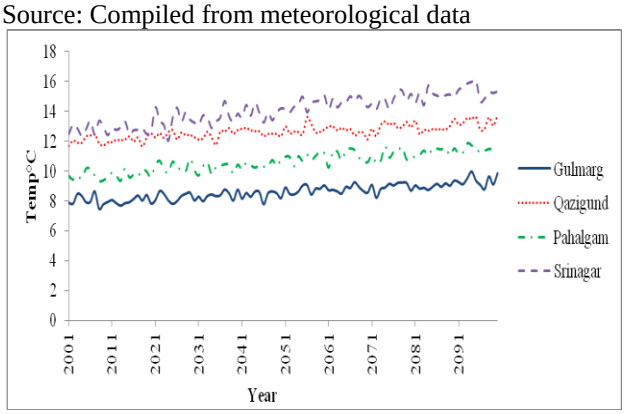

Figure 3. Variation of average annual temperature at four IMD Stations of the Kashmir valley during 2001-2100.

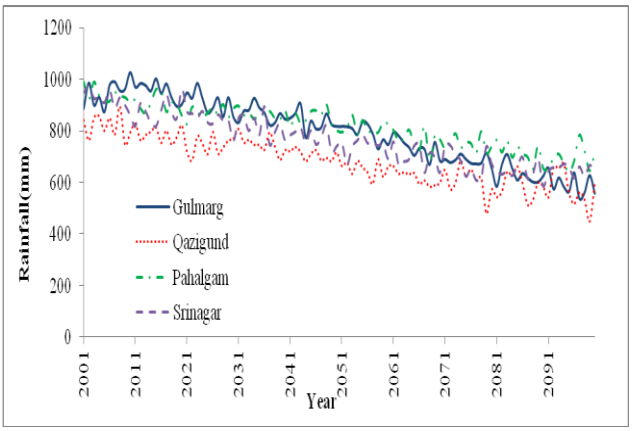

Figure 4. Variation of total annual temperature at four IMD Stations of the Kashmir valley during 2001-2100.

Table 2. Change in the mean temperature of the Jhelum basin at the end of 21st century from 2001.

S.No.	Station	Increase in average temperature over 21st century(°C)	Decrease in total rainfall over 21st century (%)
1.	Gulmarg	1.95	37.39
2.	Qazigund	2.06	28.72
3.	Srinagar	2.84	41.42
4.	Pahalgam	1.91	27.56

4. Conclusions

1) Srinagar station shows more increase in average annual temperature than other three stations.

2) Precipitation is increasing at much faster rate at Gulmarg station than the rest of the chosen stations.

3) Temperature shows general increasing trend and precipitation shows decreasing trend for coming century for all the 4 stations and hence for Kashmir valley.

4) Temperature shows more increase in rate during second half of 21st century.

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