# A Comparison of Minimum Temperature Trends with Model Projections

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***Abstract***

*Evaluation in the performance of a downscaling model is very important to gain the full advantages of future predictions of a model. Pakistan is an agrarian country with different climate region and majority of the people linked with agriculture. This study aimed at investigation of the recent trend of global warming for this region and to test the reliability of future data generation by a statistical downscaling model "SDSM" The present study has been performed on the evaluation of projected minimum temperature of SDSM ( Statistical Downscaling Model). The evaluation has been performed for the period 1991-2010. Meteorological data and model projected data has been used for the 44 stations. The annual as well as monthly analysis has been done for the validation of model. There was a significant increase in temperature on the annual basis but the monthly change is not significant according to the Mann-Kendall test. The result showed a good accordance of the projected temperature with real time data. The Pearson correlation and value of $R^2$ was above 90 for most regions which was highly optimistic. However model over estimates for the entire region, the value of overestimation was also calculated. Different statistical techniques were applied to investigate the trend and significant change in minimum temperature. The change was more for the northern regions as compared to the southern parts of the country. . The strong correlation suggested that SDSM can be used with reasonable level of confidence to obtain future projections of night time temperature for the country.*

**Keywords:** SDSM, Correlation coefficient, Mann-Kendall, Projected data, Pearson correlation, Overestimate.

## Introduction:

In a country like Pakistan ( 23 1/2°N and 40°N, 60°E and 80°E ) where about 70% of the population linked with agriculture and find employment from this profession. Less than one fifth of land area has the potential for intensive agricultural use. Almost all of the arable land is dynamically cultivated, but the outputs of agriculture sectors are below than the world standard. Cultivation is meager in the Northern Regions, the Southern deserts and the western plateaus. Pakistan is an agriculture country with total geographical area 79.6 Mha and out of which cultivable area is 31.28 Mha (39.3% of total land area) (GOP, 2004). Agriculture contributed 25% of G.N.P in 2000-2001 and 60% of foreign exchange earning that has been reduced to 19.4% in 2006-2007 due to climate change impacts.

The Punjab and Sindh has fertile soil that enables Pakistan to feed its Population under usual climatic conditions. The contribution of Punjab in agriculture sector is 56.1% to 65.1%. Total crop area of Punjab is 14.60 Mha, out of which agriculture area is 10.33 Mha and area that is not available for agriculture is 2.91 Mha (www: Statpakgov.pk).

Punjab has always contributed the most to the national economy of Pakistan. Punjab's economy has quadrupled since 1972. Its share of Pakistan's G.D.P has historically ranged from 51.8% to 54.7%. It is especially dominant in the Service and Agriculture sectors of the Pakistan Economy. With its contribution ranging 56.1% to 61.5% in the Agriculture Sector (www: siteresources.Worldbank.org/Pakistan). The major food crops are wheat, rice, bajra, and jawar and maize. Whereas cash crops are rice, cotton, wheat sugarcane etc.

The importance of predicted temperature towards planning and ensuring food security for the country is vital. Like precipitation temperature also very important for the proper growth of a plant. Every crop required a threshold heat unit at different stages. Night temperature has a pronounced effect upon plant growth. For the level of most favorable temperature there is a steady fall in growth rate with decrease in night temperature, where as mean temperature are less significant (Roberts,1999;Want,1953).

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Minimum temperature is one of the most important environmental factors influencing leaf growth (Lyons, 1973). At night plant utilized accumulated dry matter and release energy during respiration process. For better development of plants the temperature of plants leaves and environment should be equal. If the minimum temperature falls leaves release their dry matter rapidly, as a result they may be injured. During a cold and clear night a leaf may be $2^{0}$C cooler than the surrounding air. During cloudy nights the difference in air and leaf temperature is small (Harpal et al., 2004).

Many a studies with different approaches have discussed the climatic variation as well as the temperature trend for future (e.g., Chaudhry and Sheikh, 2002; Chaudhry and Rasul, 2007; Afzal et al., 2009). The developing society of Pakistan needs better understanding of climate and its impacts on agriculture and the fast growing population (Hussain and Mudassar, 2004).

Pakistan is an agrarian country basically; the economy of the country depends upon agriculture, the projections of temperatures, their evaluation and effects of temperature on agriculture are very important. For developing projections of climate change in the future, climate models are main tools (Hough et al., 1995). In the present study we tested the projected temperature of a Statistical Downscale Model (SDSM) over the period of 1991-2010, as national as well as regional level.

The paper is organized as follow; the Section 1 briefly describe impacts of minimum temperature on plant growth; Section 2 describe the software used, data and methodology; Section 3 is the main part of the paper which elucidates results and discussion including temperature trends and co-relation for both data set at regional level. Conclusions and recommendations are given in Section 4.

## Data and Methodology

In this study daily temperature data from 44 meteorological stations in Pakistan (Fig.1b) for the mentioned period (1961-1990) is used, which is provided by Pakistan Meteorological Department. The Daily observed data of Tmin was obtained from CDPC (Climate Data Processing Center) and the A2 scenario generated data of model SDSM for the same parameter also used for the period 1991-2010. The A2 scenario is globally inhomogeneous economic development, with a continuous increase in the world's population and a medium-high rise in green house gases. In order to have the original detail and or the study of spatial distribution of temperature Pakistan has been strewn in five region i-e cold, cool, mild, warm and hot as shown in fig 2.

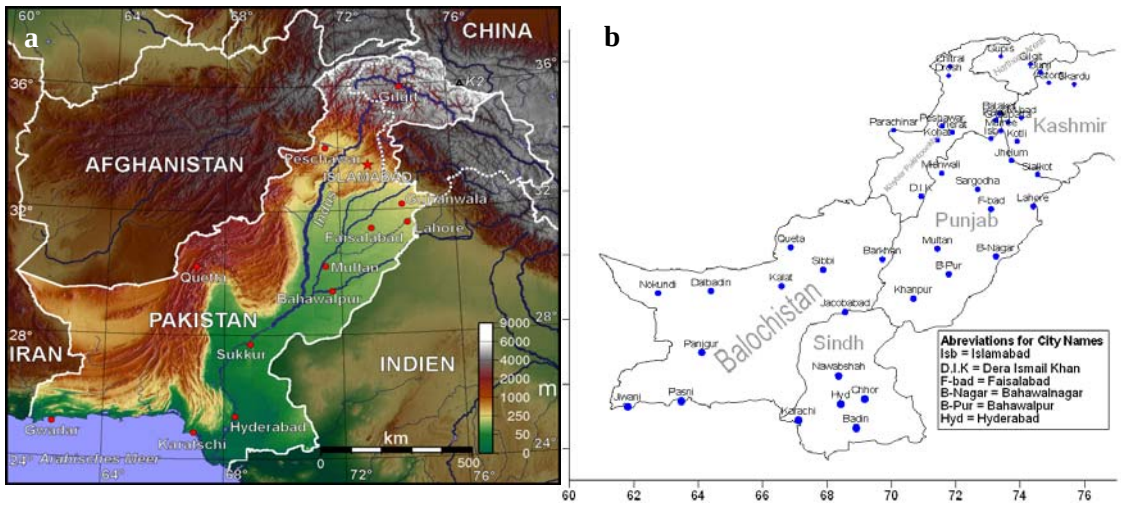


**Figure 1: (a)** Topographic map Pakistan **(b)** The stations incorporated in this study.

In this study the daily minimum temperature data were obtained from Climate Processing Unit Department (CDPC) Karachi and scenario generated minimum temperature data of the SDSM model. The

model SDSM (4.2) was generated data for the 44 stations of the country. A comparison was made between the observed data (1991-2010) and projected data of SDSM for the same period .The stations which are incorporated in this study are shown in fig 1-b. The Computation and analysis is done with the help of MS-Excel, Arc GIS, Surfer8, XL Statistic and SPSS soft ware. The coefficient of correlation between two data sets was calculated by the scatter plot in MS-Excell-2007, regression line also plotted to examine the trend in minimum temperature. The Pearson co-relation co-efficient or simply the co-efficient of co-relation was deliberated. Pearson co-relation is a measure of association between two dataset having value '+1' or '-1'. To observe the significant change statistical tests were applied like Student T-test, Z-test and Mann Kendall test.

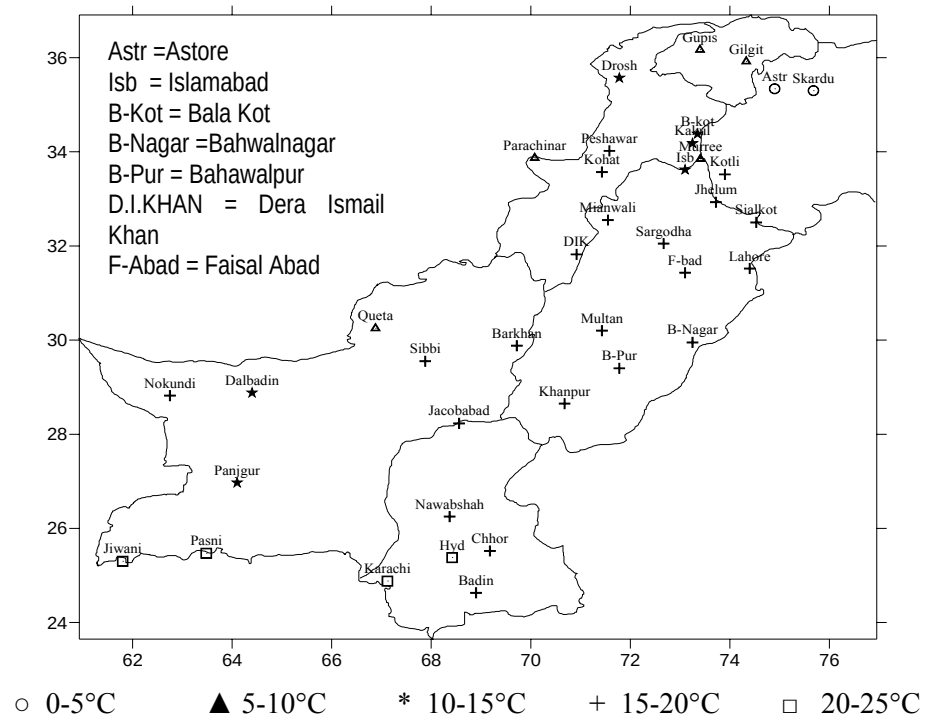


**Figure 2:** Distribution of stations network according to normal temperature (1961-1990), 1: cold region, 2: cool region, 3:mild region, 4:warm region, 5:hot region.

## Methodology

The daily real time data of mean minimum temperature for the specified stations was scrutinized and compiled on monthly as well as annual basis. The same approach was applied for the generated data as well. Both the data sets were analyzed on monthly and annual basis in order to investigate the general trend on individual as well as comparative basis. For individual analysis the ordinary linear trend was incorporated while to compare the two data sets statistical based application "scatter plot" incorporated. "A statistically test gives a clue for making quantative decisions about a process or processes" (Storch and Zwiers, 1999). To observed the significant change in temperature for both data set different test was applied like, Z-test and student T-test. The above data sets are analyzed by applying different statistics techniques like linear regression, co-efficient of co-relation, Pearson –co-relation. Pearson co-relation is a measure of association between two datasets having value of "+1" or "-1". In this study an attempt has been made to discuss the temperature trend for both data sets on regional level (provisional level).The following software are used Arc GIS, Golden software Surfer 8, Microsoft Excel, SPSS and Exl Stat.

## Results and Discussion:

To understand climate change and evaluating model output (projected data) in atmospheric temperature, documentation trends are considered a key for this change (Houghton et al., 2001). The Third Assessment Report (TAR) of the Intergovernmental Panel on climate change (IPCC) in 2001 reported that the global mean surface temperature has risen by 0.2° to 0.6°C over the 20th century. According to IPCC, 2001 report, 1990s was the warmest decade, and 1998 recorded as warmest years. Since the 1950s the occurrence of lowest maximum temperature events has increased and occurrence of lowest minimum temperature events has decreased (IPCC, 2001). The impacts of minimum and maximum temperature on environment and agriculture are much more important than that of mean surface temperature (Yong et al., 2007).

According to WMO report 2010, 2010 was recorded second hottest year behind 1998. The temperature was almost a degree above than normal in summer for South-East Asia, China, Japan and the Russian Federation all had their hottest summer in 2010 (WMO,2010). Keeping this in view the analysis of previous minimum temperature for the last two decades is carried out first which confirmed the idea. Temperature variation for both the data sets analyzed on provisional basis and justify by statistical tests.

### Punjab:

Punjab lies in the semi arid lowlands zone. Most of the people are associated with agriculture; Irrigation of the upper Indus basin has the capacity to improve the condition of crop. But change in temperature has adverse effect on crops. At central Punjab like Lahore the mean daily minimum temperature in the coldest month of January is 5°C. Whereas for upper Punjab like Murree the mean daily minimum temperature is -0.6°C and extreme minimum recorded -11°C (Shamshad, 1985).

The Fig (3a) 3b depict an increasing trend for both the data sets. Although SDSM projected temperature is over estimated with an average value of 1.01°C for the province.

The $R^2$ value is 0.936 which show a strong co-relation between observed and model generated temperature data. The Pearson co-relation and $R^2$ value for all stations of Punjab has been represented in Table 1.

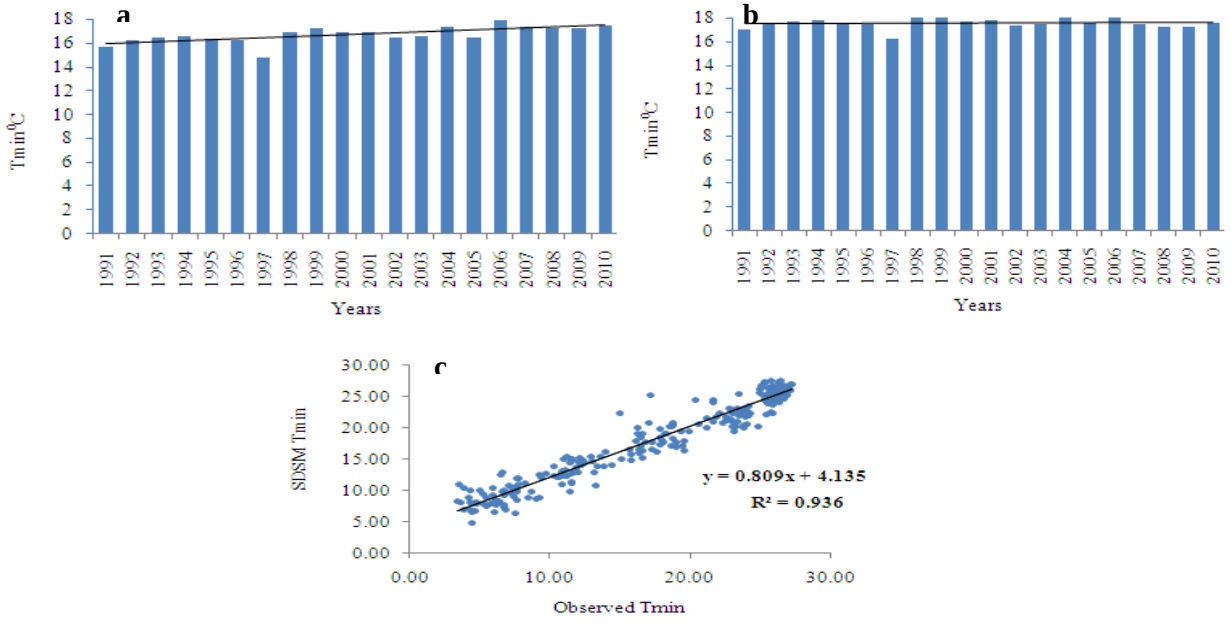


**Figure 3:** Annual average minimum temperature trend of Punjab (1991-2010) **(a)** Realtime data trend **(b)** SDSM projected trends **(c)** Scatter plot between real time and model Tmin for the period (1991-2010).

Standard Deviation values are above mean and towards the positive skewness. Trends are linear for minimum temperature and statistical analysis reveals the significance change at 95% confidence. Value of Z and student T-test are given in table 7. Both values are above 1 that mean there is an increasing trend of temperature at a significant level of 95% as given by alpha value and P-value is less than 0.05. Statistical test interprets that H0, hypothesis show that the difference between the mean is equal to zero and Ha hypothesis define as the difference between the mean is different from 0. As the computed p-value is lower than the significance level alpha=0.05, the null hypothesis H0 should be rejected and accept the alternative hypothesis Ha. The Punjab is the major source for wheat production, the increasing temperature affect the crop yield. High temperature will have direct effect on growth rate, reduce soil moisture and increase disease risk. When both temperatures are increased by 6°C yield would be decreased 37% about 5000kg/h (KOCYIGIT et al., 2010).

**Table 1:** Punjab Stations used in this study with elevations, locations and co-efficient of correlation between SDSM and Observed minimum temperature.

| Stations | LAT | LONG | Elevation (meters) | Pearson coefficient | $R^2$value (SDSM vs. Obs) |
|---|---|---|---|---|---|
| Faisalabad | 31.43 | 73.1 | 183 | 0.971 | 0.942 |
| Islamabad | 33.62 | 73.1 | 507 | 0.948 | 0.898 |
| Jhelum | 32.93 | 73.72 | 232 | 0.921 | 0.848 |
| Khanpur | 28.65 | 70.68 | 87 | 0.962 | 0.925 |
| Lahore | 31.52 | 74.4 | 213 | 0.906 | 0.821 |
| Sargodha | 32.05 | 72.67 | 187 | 0.964 | 0.928 |
| Bahwalnagar | 29.95 | 73.25 | 161 | 0.956 | 0.914 |
| Bahawalpur | 29.4 | 71.78 | 116 | 0.951 | 0.904 |
| Murree | 33.85 | 73.41 | 2167 | 0.909 | 0.825 |
| Sialkot | 32.5 | 74.53 | 251 | 0.846 | 0.716 |
| Mianwali | 32.55 | 71.55 | 210 | 0.966 | 0.933 |
| Multan | 30.2 | 71.43 | 122 | 0.973 | 0.945 |

## Balochistan

Balochistan is located at the Western edge of the Indian plateau and in the border region between Southwest, central and south Asia. Geographically it is the largest of the four provinces and covers 48% of the total land area of Pakistan. The maximum increase in mean temperature was examined in Quetta which is 0.057°C per year (Sadiq et al., 2010). For province of Balochistan 9 stations with minimum temperature data (1991-2010) were incorporated in this study.

Observed and projected Tmin exhibits the same pattern for temperature variation except in few years that are 2006, 1994 and 1999. Hence projected SDSM temperature is over estimated with an average value of 0.896. The slope of the line for figure 4(c) is a positive value which means there is an increasing trend of temperature. Regression result is 95% for Balochistan. The comparative study of correlation between real time and generated Tmin is $R^2 = 0.913$ which is statistically significant on monthly basis.

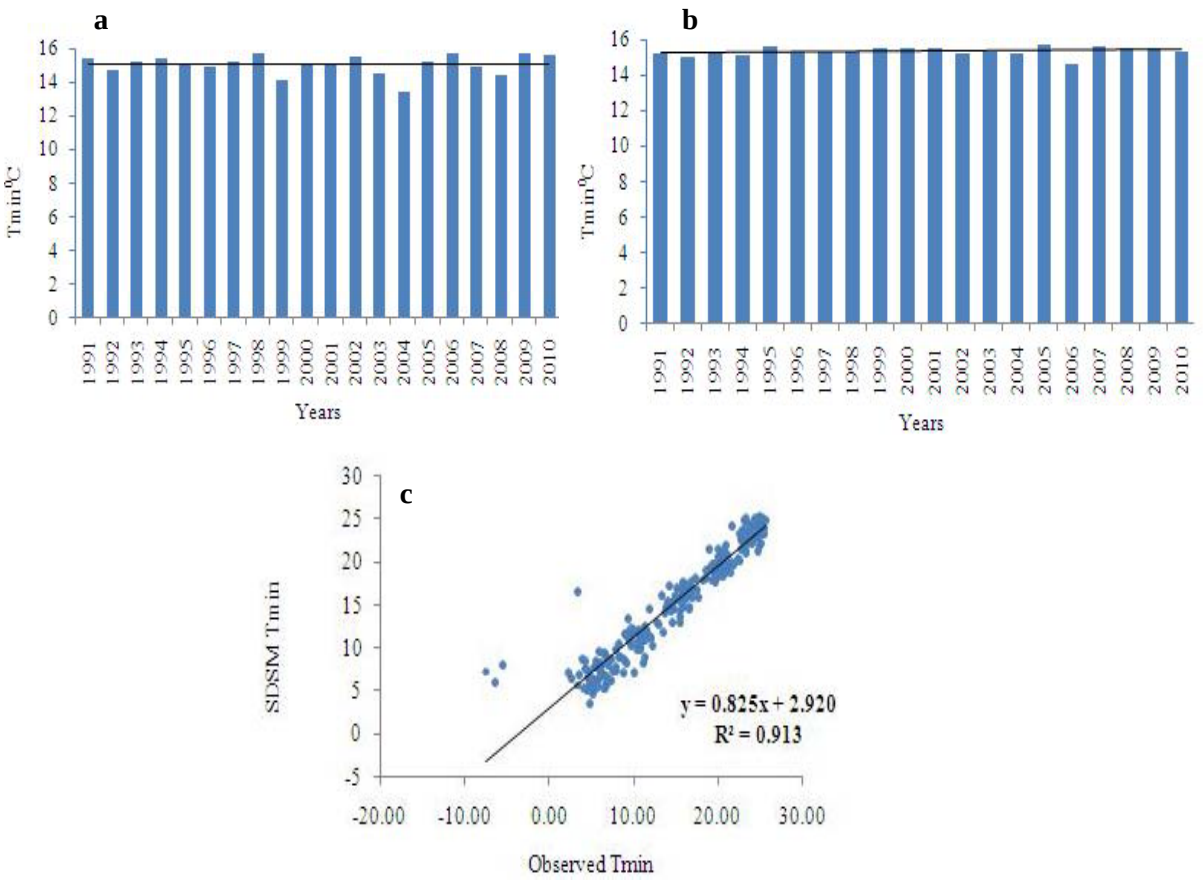


**Figure 4:** Annual average minimum temperature trend of Balochistan (1991-2010) **(a)** Realtime data trend **(b)** SDSM projected trends **(c)** Scatter plot between real time and model Tmin for the period (1991-2010).

**Table 2:** Balochistan Stations used in this study with elevations, locations and co-efficient of correlation between SDSM and Observed minimum temperature.

| Stations | LAT | LONG | Elevation(meters) | Pearson coefficient | $R^2$value (SDSM vs. Obs) |
|---|---|---|---|---|---|
| Dalbandin | 28.88 | 64.4 | 848 | 0.973 | 0.946 |
| Jiwani | 25.37 | 61.8 | 56 | 0.939 | 0.881 |
| Kalat | 29.03 | 66.58 | 2015 | 0.927 | 0.858 |
| Pasni | 25.47 | 63.48 | 4 | 0.88 | 0.774 |
| Quetta | 30.25 | 66.88 | 1600 | 0.921 | 0.847 |
| Sibbi | 29.55 | 67.88 | 133 | 0.897 | 0.804 |
| Barkhan | 29.88 | 69.72 | 1097 | 0.925 | 0.855 |
| Nokkundi | 28.82 | 62.75 | 682 | 0.969 | 0.939 |
| Punjgur | 26.97 | 64.1 | 980 | 0.971 | 0.943 |

## Sindh:

Pakistan is an agricultural country with different types of climates. The climate of Pakistan has been discussed by different authors and they have used different techniques to describe the climate of

Pakistan. Rasul and Chaudhry (2004) classified the climate of Pakistan on the basis of moisture index. They reported that two third of the country has arid to semi arid climate type. According to them most of the Southern half lies under arid climate. The Sindh is situated in subtropical region. It is hot in summer and average temperature frequently rise above 48°C in Summer in May and August, but the minimum temperature of 2 °C average occur in December and January. For Karachi, the temperature is uniform than in Punjab like Murree, Jhelum, Sialkot etc. Mean minimum temperature is 13 °C during winter and mean maximum temperature is 34 °C. The bar graph for both datasets on annual basis is analyzed separately. Both the graphs are homogenous and showed same variation. Out of 20 years there are only three years when temperature is lower than 18 °C for both data sets. Figure 5 (a&b) reveals the maximum temperature was recorded in 1998, 2009, 2010 and minimum temperature was recorded in 2005.This variation may be due to El-Nino and La-Niña episode.

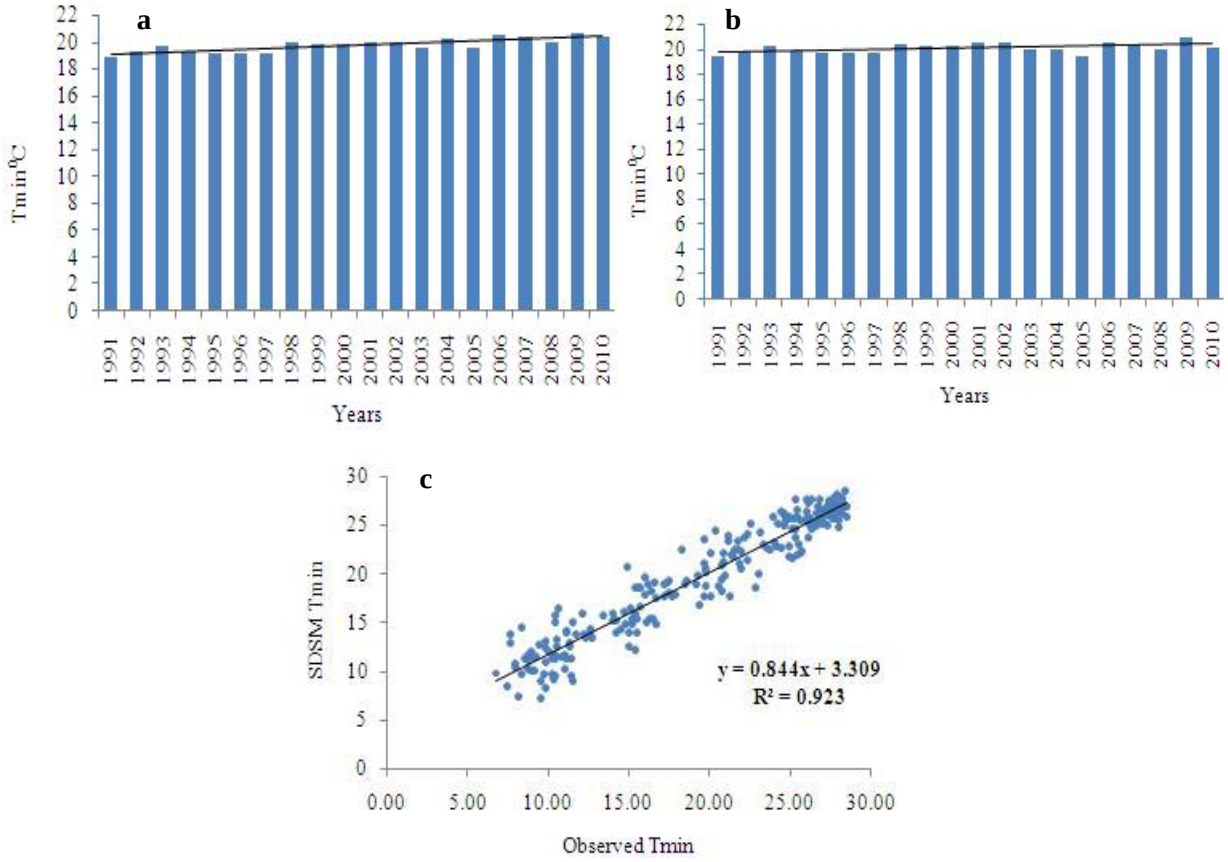


**Figure 5:** Annual average minimum temperature trend of Sindh (1991-2010) **(a)** Realtime data trend **(b)** SDSM projected trends **(c)** Scatter plot between real time and model Tmin for the period (1991-2010).

To examine the significant change , if any the z and student T-Test has been applied at 95% significant level ,the result for Z,T and P value with a standard deviation are shown in table 7. To understand the further co-relation $R^2$ and Pearson value calculated. The result for 6 stations has been shown in table 3. The value of correlation coefficient between the two data sets for the period was <90, which shows a strong agreement between both the datasets.

**Table 3:** Sindh Stations incorporated in this study with elevations, locations and co-efficient of correlation between SDSM and Observed minimum temperature.

| Stations | LAT | LONG | Elevation (meters) | Pearson coefficient | $R^2$value (SDSM vs. Obs) |
|---|---|---|---|---|---|
| Badin | 24.63 | 68.9 | 10 | 0.937 | 0.877 |
| Chor | 25.52 | 69.18 | 5 | 0.943 | 0.889 |
| Hyderabad | 25.38 | 68.42 | 40 | 0.937 | 0.877 |
| Jacobabad | 28.23 | 68.56 | 55 | 0.971 | 0.943 |
| Karachi | 24.7 | 67.13 | 21 | 0.91 | 0.828 |
| Nawabshah | 26.25 | 68.37 | 37 | 0.955 | 0.912 |

## Northern areas

The night temperatures are increasing in the Northern parts of the country. The correlation was up to optimum level for upper areas of Pakistan lies above 32°latitude (Cheema et al., 2010). Rasul et al (2008) states that; "In the northern parts of the country Himalaya-Karakorum-Hindu Kush together makes the largest mountain chain that covers the earth". They are custodian of the third largest ice reserves after the Polar Regions. They possess a treasure of solid water which melts with high temperature in summer and makes this precious resource available in rivers during dry spells. The environment has given the operational control of this water tank in terms of temperature after the strong buildup of greenhouse gases (Rasul et al., 2006).

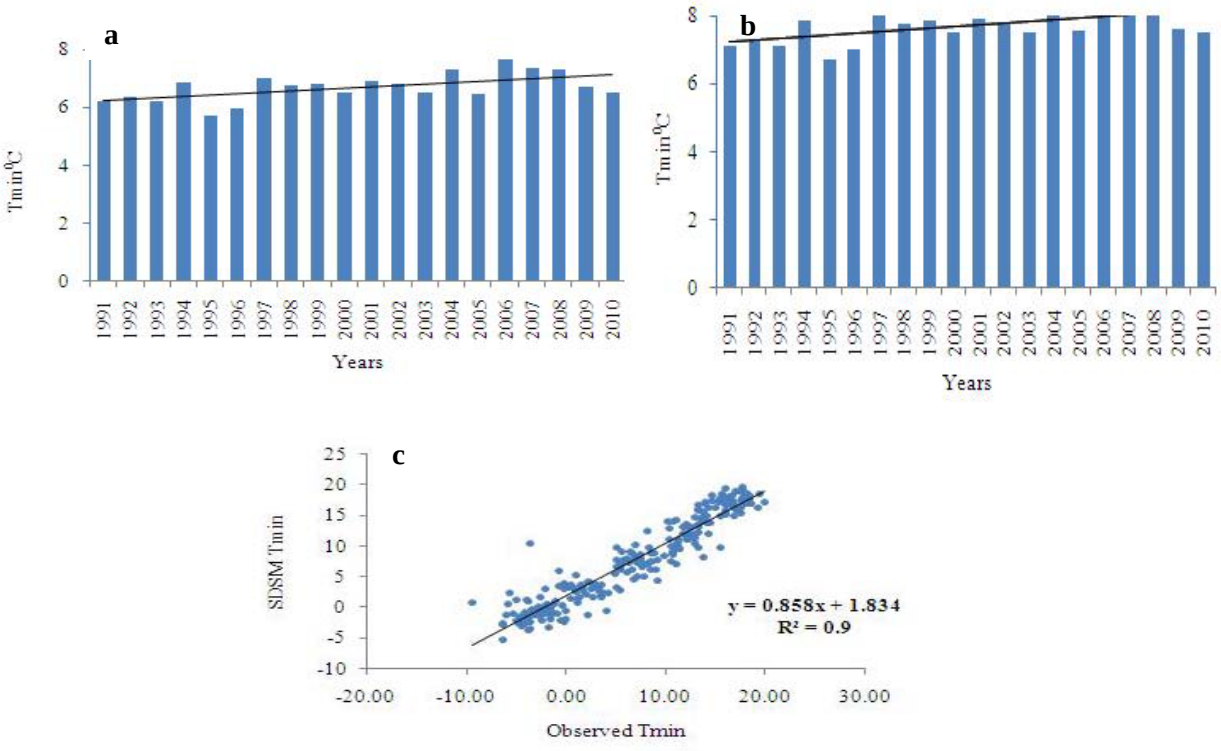


**Figure 6:** Annual average minimum temperature trend of Northern areas (1991-2010) (a) Realtime data trend (b) SDSM projected trends (c) Scatter plot between real time and model Tmin for the period (1991-2010).

For Northern areas the correlation between the observed and the generated data was very good. Both the correlations were above to 0.90 which can be considered a good result. However in the case of Gupis the correlation is not so strong but significant. These results show that the relevant scenarios are reliable.

Some very large and significant glaciers like Baltoro, Siachen, Batura and Biafo are located in this region. As Figure 6(a&b) show an increasing trend which causes the melting of glacier more than required. If increasing temperature is causing ice glaciers to melt faster, the reduced ice cover over earth in turn is causing temperatures to rise further. Ice glaciers deflect almost 80% of the heat from the sun and absorb about 20% of the heat. When an ice glacier vanishes and exposes the earth below, 80% of the heat from the sun is absorbed by the earth, and only about 20% of this heat is deflected back. As a result there may be more flash flooded, melting glacier finally empty in sea, causing a further increase in sea level.

**Table 4:** Northern areas Stations incorporated in this study with elevations, locations and co-efficient of correlation between SDSM and Observed minimum temperature.

| Stations | LAT | LONG | Elevation (meters) | Pearson coefficient | $R^2$value (SDSM vs. Obs) |
|---|---|---|---|---|---|
| Astore | 35.34 | 74.9 | 2167 | 0.949 | 0.9 |
| Bunji | 35.67 | 74.63 | 1372 | 0.944 | 0.83 |
| Gilgit | 35.92 | 74.33 | 1459 | 0.915 | 0.837 |
| Gupis | 36.17 | 73.4 | 2155 | 0.811 | 0.656 |
| Skardu | 35.3 | 75.68 | 2317 | 0.934 | 0.871 |

## KPK (Khyber Pakhtoonkhwa ):

Chaudhry et al. (2009) indicate a non-significant increasing trend for annual mean temperature over the mountainous areas of the Upper Indus Basin in Pakistan. Analysis of temperature data showed a significant increasing trend in annual temperature over North Western Himalayan region, on the basis of long –term data sets since the late 19th century (Bhutiyani et al., 2009).

Figure 7(a&b) shows the annual minimum temperature plotted between the observed and SDSM. The biasing also calculated and average value of biasing is 0.965. For this region the temperature variation for both data set have shown almost same increasing or decreasing trends in the annual minimum temperature. Student's T-Test at 95% significance level has been used to compare the mean of both the data sets. The test yielded the significance of 2.01 and H=0 which means that null hypothesis can be rejected. Z-Test has also been used to compare the two datasets .The Z calculated is greater than critical value 1 .Which mean that both data sets are identical at 95% confidence level on annual basis comparison. The correlation coefficient for the observed and modeled projected minimum temperature is resulted as 0.99 which is the highest value of $R^2$ as compared to the all other study areas. Increasing temperature may have positive impacts on agriculture for mountainous regions through shortening of growing period especially for the winter crops (Hussanin and Mudassar, 2007).

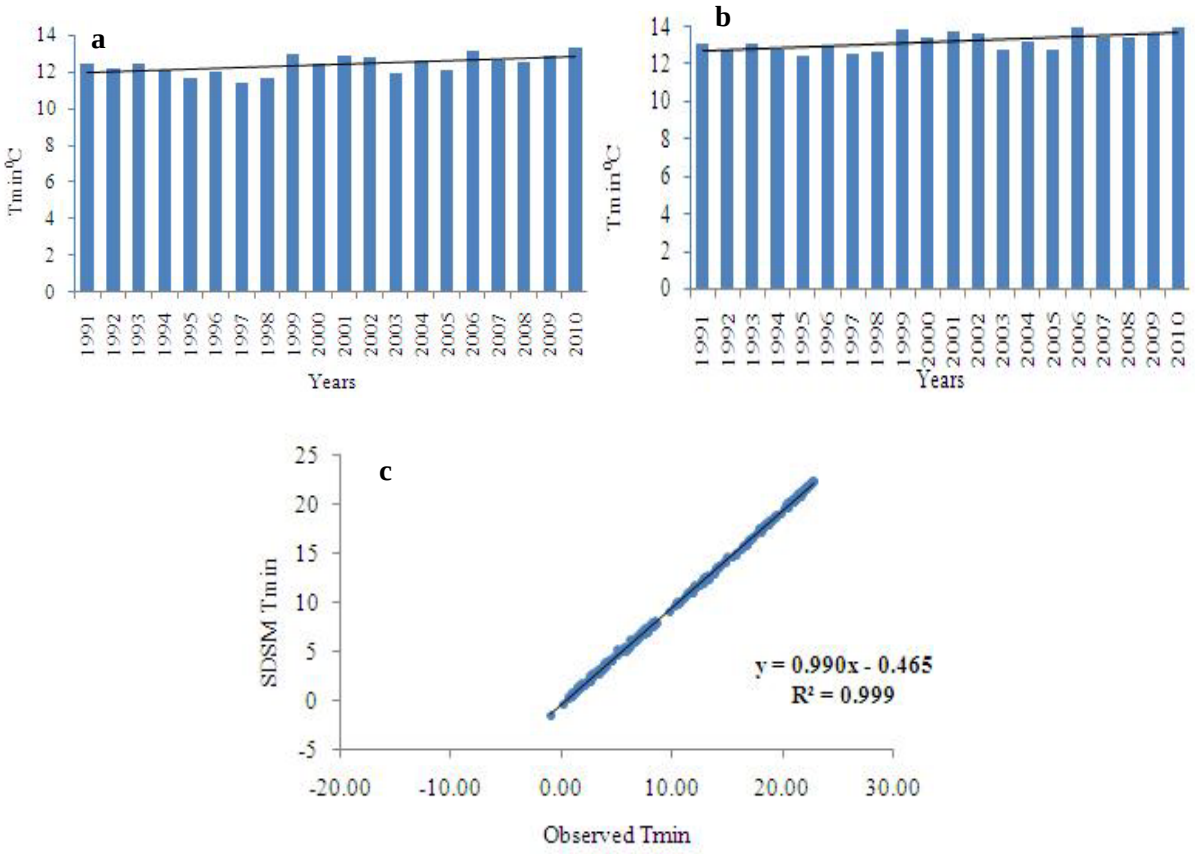


**Figure 7:** Annual average minimum temperature trend of KPK (1991-2010) **(a)** Realtime data trend **(b)** SDSM projected trends **(c)** Scatter plot between real time and model Tmin for the period (1991-2010).

**Table 5:** KPK Stations incorporated in this study with elevations, locations and co-efficient of correlation between SDSM and Observed minimum temperature.

| Stations | LAT | LONG | Elevation (meters) | Pearson Coefficient | $R^2$value (SDSM vs. Obs) |
|---|---|---|---|---|---|
| Cherat | 33.82 | 71.88 | 1301 | 0.884 | 0.782 |
| Chitral | 35.85 | 71.83 | 1499 | 0.893 | 0.797 |
| D-I-Khan | 31.82 | 70.92 | 173 | 0.961 | 0.912 |
| Drosh | 35.57 | 71.78 | 1464 | 0.917 | 0.84 |
| Kakul | 34.18 | 73.25 | 1308 | 0.948 | 0.898 |
| Kohat | 33.57 | 71.43 | 510 | 0.961 | 0.924 |
| Parachanar | 33.87 | 70.08 | 1725 | 0.914 | 0.834 |
| Peshawar | 34.02 | 71.58 | 359 | 0.931 | 0.891 |

## AJK (Azad Jammu Kashmir)

Jammu and Kashmir lies to the North-East of Pakistan, North to the India and western boundary adjacent with China. Geographically it can be divided into two zones.

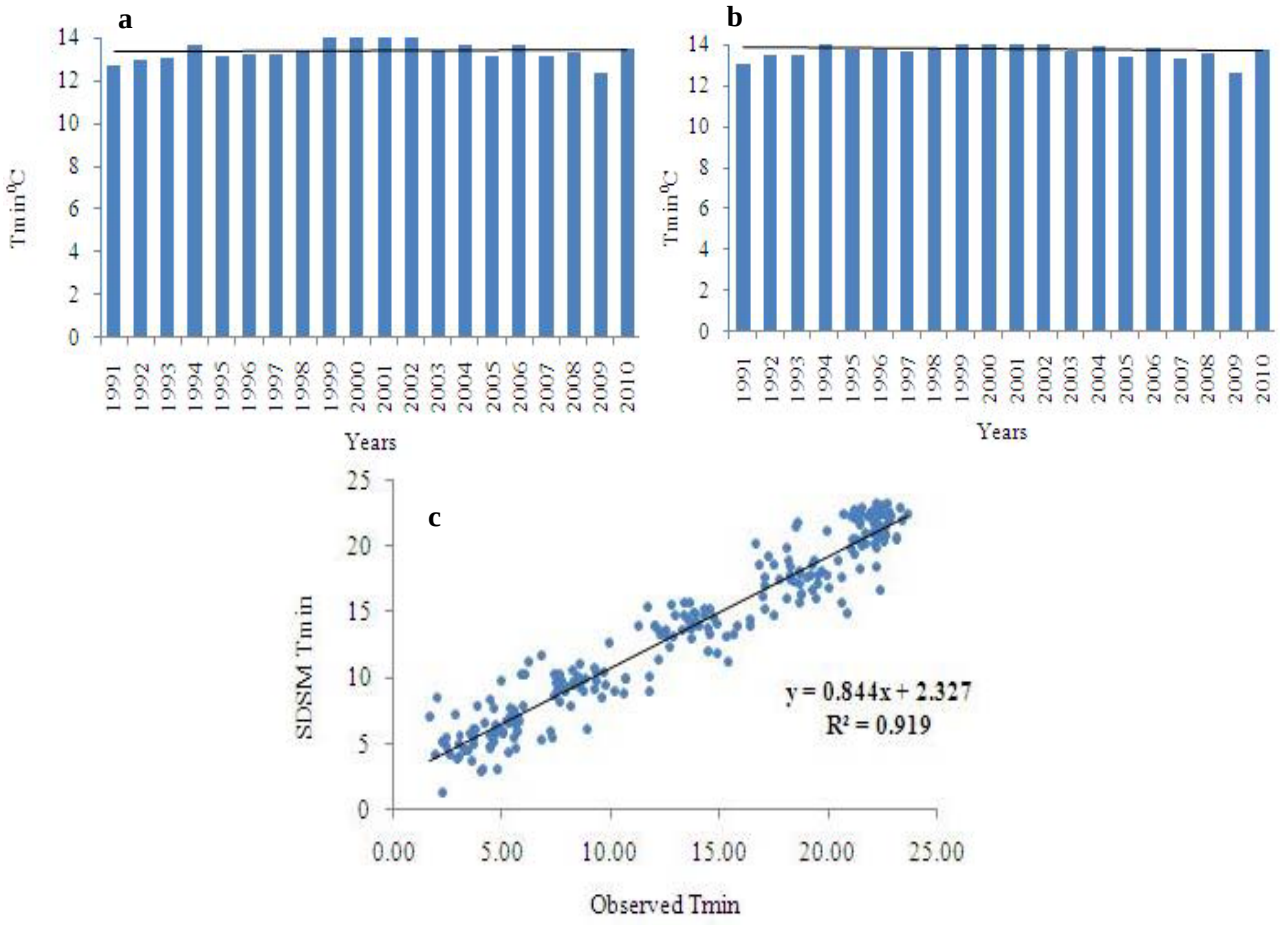


**Figure 8:** Annual average minimum temperature trend of KPK (1991-2010) **(a)** Realtime data trend **(b)** SDSM projected trends **(c)** Scatter plot between real time and model Tmin for the period (1991-2010).

The Northern and Eastern areas are hilly and mountainous, while areas consist to the South and west consists mainly of valleys and plains. The area lies between 30° and 35°N has a subtropical highland climate.

The analysis for AJK indicates that there was low temperature for first three years then an increasing trend after 1997 up to 2003 for both datasets as shown in figure 8(a&b). SDSM projected temperature is 0.243 $^{0}$C more than the real time values. The value of co-relation co-efficient $R^2$ and Pearson co-relation is shown in table 6 for four stations of Azad Jammu Kashmir. The result suggests that the annual variability in this region is well projected by the SDSM. Muhammad, 2000: stated that for any scientific based comparison value for the correlation coefficient greater than 0.49 is reliable.

**Table 6:** KPK Stations incorporated in this study with elevations, locations and co-efficient of correlation between SDSM and Observed minimum temperature.

| Stations | LAT | LONG | Elevation (meters) | Pearson coefficient | $R^2$value (SDSM vs. Obs) |
|---|---|---|---|---|---|
| Balakot | 34.38 | 73.35 | 980 | 0.944 | 0.891 |
| Garhi Dupatta | 34.12 | 73.62 | 812 | 0.893 | 0.797 |
| Kotli | 33.52 | 73.9 | 613 | 0.942 | 0.886 |
| Muzaffarabad | 34.25 | 74.04 | 701 | 0.948 | 0.897 |

## Conclusions:

Under the SRESA2, a consistent increasing trend of annual minimum temperature over Pakistan during 1991-2010 is projected and this projected temperature exhibits a good relationship with observed minimum temperature. Although the SDSM generated temperature was overestimated up to 0.86°C. The projected and real time data indicates increasing trend at 95% confidence level on annual basis. For monthly analysis the Mann-Kendall give positive Z-values although that are non significant. Statistical analysis of the two datasets give sufficient evidence that the annual and monthly minimum temperature over Pakistan generated by SDSM model is reasonably well accordance with the real time data provided by PMD. It is also revealed that the northern parts of the country may experience such intensive increase in temperature in future, but the southern parts of the country may not experience such intensive change. Ferro et al; (2005) reported that "night temperatures seem to be increasing at much high rates than the day temperatures". The minimum temperature are expected to increase more than 5°C over most parts of India, the highest maximum temperatures shown an increase of 2°C. Even during the recent study period it was also observed that the night temperatures are increasing more rapidly than the maximum temperatures not only over India, but also across several regions in the world. The result of this study agrees with the finding of above authors.

## Recommendations

Some other parameters like precipitation, pressure, solar radiations and relative humidity etc should be taken under observation for the validation of SDSM. This will provide skills and a detail analysis of performance of the model. The calculated biasing in this study may be beneficial in the analysis of future scenarios produced by the model. The analysis should be performed for maximum temperature also.

**Table 7:** Statistics of Observed and SDSM data sets (1991-2010).

| NORTHERN ARES | Minimum | Maximum | Mean | Std. deviation | \|z\| value | \|t\| value | p-value | alpha |
|---|---|---|---|---|---|---|---|---|
| Observed | 5.720 | 7.678 | 6.726 | 0.491 | 1.960 | 2.101 | < 0.0001 | 0.05 |
| SDSM | 6.707 | 8.555 | 7.622 | 0.489 | 1.960 | 2.101 | < 0.0001 | 0.05 |
| AJK | Minimum | Maximum | Mean | Std. deviation | \|z\| value | \|t\| l value | p-value | alpha |
| Observed | 12.364 | 14.266 | 13.448 | 0.493 | 1.932 | 2.10 | < 0.0001 | 0.05 |
| SDSM | 12.772 | 14.380 | 13.673 | 0.379 | 1.87 | 2.06 | < 0.0001 | 0.05 |
| KPK | Minimum | Maximum | Mean | Std. deviation | \|z\| value | \|t\| value | p-value | alpha |
| Observed | 11.433 | 13.353 | 12.413 | 0.535 | 2.01 | 2.106 | < 0.0001 | 0.05 |
| SDSM | 12.747 | 13.910 | 13.395 | 0.353 | 2.01 | 2.106 | < 0.0001 | 0.05 |

| Balochistan | Minimum | Maximum | Mean | Std. deviation | \|z\| value | \|t\| value | p-value | alpha |
|---|---|---|---|---|---|---|---|---|
| Observed | 13.459 | 15.754 | 15.034 | 0.596 | 1.64 | 1.76 | < 0.0001 | 0.05 |
| SDSM | 14.608 | 15.724 | 15.354 | 0.260 | 1.52 | 1.82 | < 0.0001 | 0.05 |
| SINDH | Minimum | Maximum | Mean | Std. deviation | \|z\| value | \|t\| value | p-value | alpha |
| Observed | 19.096 | 20.699 | 19.806 | 0.492 | 1.22 | 1.970 | < 0.0001 | 0.05 |
| SDSM | 19.380 | 20.791 | 19.992 | 0.380 | 1.13 | 1.920 | < 0.0001 | 0.05 |
| PUNJAB | Minimum | Maximum | Mean | Std. deviation | \|z\| value | \|t\| value | p-value | alpha |
| Observed | 14.785 | 17.934 | 16.777 | 0.686 | 1.76 | 1.98 | < 0.0001 | 0.05 |
| SDSM | 16.986 | 18.028 | 17.725 | 0.243 | 1.72 | 2.09 | < 0.0001 | 0.05 |

**Note:** alpha=0.05 means level of significance is at 95% confidence level.

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