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Sunspots Influence on Climatic Variability of Karachi and Rohri

Kanwal Aftab and Saifuddin Ahmed Jilani*
Institute of Space and Planetary Astrophysics, University of Karachi, Karachi-75270, Pakistan
Department of Physics, University of Karachi, Karachi-75270, Pakistan

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Abstract. The Sun is undoubtedly the most important thrust of the climate system. However, only little is known how variable this force is acting on different time scales ranging from minutes to millennia and how the climate system reacts to changes in this forcing. In the present study possible effect of solar activity on maximum temperature T (max) and minimum temperature T (min), humidity and precipitation have been investigated. The analysis comprises over a period of 2000-2015 that consists of the decreasing phase of solar cycle-23 and the increasing phase of solar cycle-24. To optimize the number of signicant trends, different phases of solar activity have been implemented there to observe the variation in climate of Karachi and Rohri in response of it. These detection and adjustment are carried out using the computer software Statistica and Minitab. Correlation analysis for different seasons of these two regions is performed in this study.

Keywords: sunspots, precipitation, humidity, temperature, solar cycle

Introduction

Change in climate is most evident from increase in temperature on the surface of the earth. For the period since 1976, the rate of change is roughly 3 times that for the past 100 years as a whole. There has been a small positive trend in global precipitation of about 1% during the 20th century over land (Houghton *et al*., 2001). Global warming is often confused with climate change by laymen electronic media print media and to the general public, news media and policy makers. Climate change is often synonymous with global warming, but this generally used term is quite wide in its real sense. It is not only characterised by changes in temperature and also by changes in other variables of the climate system for instance precipitation.

Climate of earth is most certainly affected by several natural phenomenons such as atmospheric composition, solar energy flux, albedo and anthropogenic (e.g. atmospheric pollution) factors. However, there are also slight natural phenomena which can have a significant impact on the climate. One of such phenomena is solar activity. In the current epoch, solar variation impacts on regional climate appear to be quite significant. For example, Europe in winter but on a global scale are likely to be much smaller than those due to increasing greenhouse gases (Elizbarashvili *et al*., 2013; Le Mouël *et al*., 2009).

*Author for correspondence;
E-mail: sajilani@uok.edu.pk

Environmentalists has been concerned about alteration in physical parameters like temperature and precipitation and a number of studies on these changes have already been made for different regions of the country in past (Keggenghoff *et al*., 2015; Six months into floods, 2011; TFCC, 2010). The Sindh province of Pakistan is lack in such research studies. One of the reason may be less access to the climate related data and some time because of the unpublished research studies. Sindh region has limited resources for different low-lying islands and is exposed to tropical cyclones, thus it is more susceptible to climatic changes. If reported climate change occurs and have adverse affect on eco-system and on human beings. The maximum temperature, heat waves and heavy rain expected to be increased (Easterling *et al*., 2000). These occasions, along side rising ocean levels, will compound surges and disintegration, debilitating essential foundation and water quality (Sheikh *et al*., 2014; Rasul *et al*., 2012; Wang and Zhao, 2012). The current data contrasted with the past changes in the mean atmosphere and so far is less thought about late changes in atmosphere extremes. There is a pressing need to nearly screen recent climatic variety in the locale and some arrangement making to secure assets for long haul use.

Study area. The region under investigation is situated in Sindh and the second biggest territory of the nation with an aggregate land region of 14.09 million hectares constituting 17.7 % of the Nation's Topographical Zone with a width of 4 to 6 km and length is too long around

855 kilometers. It begins shape Guddu barrage to Arabian sea (Abbasi, 2011).

Karachi. Karachi with its longitude and latitude 24.8607° N, 67.0011° E, has seared atmosphere, in spite of the fact that a direct form of this atmosphere. Karachi is situated on the drift and subsequently has a moderately tranquil atmosphere. Karachi has two principle seasons i.e. summer and winter, while spring and pre-winter are short. Summer season holds on for longest period amid the year. The level of precipitation is low for a large portion of the year. Less precipitation amid summer is because of reversal layer. The rain storm in the Karachi likewise downpours from July to September. The city appreciates a tropical atmosphere enveloping mellow winters and warm summers. The moistness levels generally stay high from March to November, while low in winter as the breeze bearing in winter is north Easterly. Since summer temperatures (from the end of April till the end of August) are around 30 °C or 86 °F to 36 °C or 97 °F, the winter months (from November till the end of March) are the best time to visit Karachi. Most guests, travelers come to Karachi amid the long stretch of December (WMO Climate Normals for Karachi 1961-1990).

Rohri. Rohri has 27.6752° N, 68.9003° E and also has sweltering desert atmosphere with a great degree sweltering summers and gentle winters. It is extremely dry with the little rain and gets generally falling in the rain storm season from July to September (Nadiem, 2004).

Materials and Methods

Data analysis. The specified data was used to analyze local climate:

- Means of monthly T (max) and T (min), humidity and precipitation have been obtain by the meteorological department of Sindh (observation period from 2000-2015).
- The variations of the Sun Spot Numbers (SSN) are analyzed by using monthly average Sun Spot Numbers from 2000-2015, taken by https://blog.quandl.com/category/free-data-on-quandl.
- Smooth Sun Spot Number from 2000-2015 taken from www.sws.bom.gov.au/solar/1/6

The climatic variables of T (max), T (min), humidity and precipitation for different months were analyzed separately during the solar period 2000-2015 and then for solar minima (2008), solar maxima (2001) the equinoxes (March and September) and solstices (June and December) of each year and the Sun's decreasing phase (2000-2008) and increasing phase (2009-2015). Both smooth and non-smooth series of SSN were use to examine solar climatic relation.

The significant correlation coefficients have been estimated in response of their P-values. The P-value less than 0.05 with respect to 95% confidence interval indicate the significant correlation.

The correlation coefficients between the climatic variables and SSN with their P-values are indicated in Table 1-4.

Result and Discussions

The correlation analysis for the monthly data gives us some significant relation between solar and the atmospheric variables. The significant results of correlation are obtained for humidity and precipitation during winter season at Rohri region with non-smooth series of SSN where, both these two climatic variable found negatively correlated. Again with non-smooth series of SSN significant correlation exist for T (max) and humidity in summer season at Karachi region, where T (max) is negatively correlated and humidity is positively correlated. This observation is not unexpected. It is in accordance with the already reported results by (Le Mouël *et al*., 2009). From Tables 1-4 have been observed that high correlation exist between climatic variables and smooth series of SSN rather than non-smooth series. The correlation between humidity and SSN (both for smooth and non-smooth series) are found significant at Rohri region during decreasing phase, winter season and for the period 2000-2015 whereas, precipitation have significant correlation with smooth series of SSN for Karachi region during the period 2000-2015. However, humidity found more strongly correlated with smooth series of SSN during winter for Karachi and while, for Rohri region the humidity and rain both are strongly correlated during winter and decreasing phase of both for smooth and non-smooth series of SSN.

Maximum temperature T (max) during summer for Karachi region found correlated with SSN while, using non smooth series this correlation disappears by using smooth series. It indicates that the solar activity is not only a possible parameter for the climatic variations but it can be a participant or the internal atmospheric processes effect or facade the solar effect. By utilizing

Table 1. Correlaton coefficients and P-level values between non-smooth SSN and climatic parameters for Karachi

For Karachi					
Non-smooth SSN Vs Climatic parameters					
		T (max)	T (min)	Humidity	Rain
Maxima	r	0.325	0.2	0.101	-0.351
	p	0.303	0.534	0.755	0.234
Minima	r	0.234	-0.151	-0.434	-0.581
	p	0.464	0.64	0.159	0.078
Solstices	r	0.072	0.047	0.028	-0.333
	p	0.697	0.799	0.879	0.103
Equinox	r	-0.204	-0.078	-0.09	0.024
	p	0.263	0.67	0.626	0.913
Decreasing	r	0.039	0.041	-0.003	-0.138
phase	p	0.69	0.674	0.975	0.187
Increasing	r	-0.043	-0.016	-0.048	-0.101
phase	p	0.698	0.882	0.665	0.4
Winter	r	0.144	-0.066	-0.285	-0.305
	p	0.334	0.657	0.052	0.05
Spring	r	-0.045	-0.307	-0.078	-0.068
	p	0.762	0.8	0.597	0.662
Summer	r	-0.247	-0.191	0.486	0.259
	p	0.049	0.131	0	0.067
Autumn	r	0.024	0.024	-0.035	-0.001
	p	0.897	0.897	0.851	0.996
2000-2015	r	0.008	0.020	-0.019	0.125
	p	0.909	0.782	0.795	0.109

Table 2. Correlaton coefficients and P-level values between non-smooth SSN and climatic parameters for Rohri

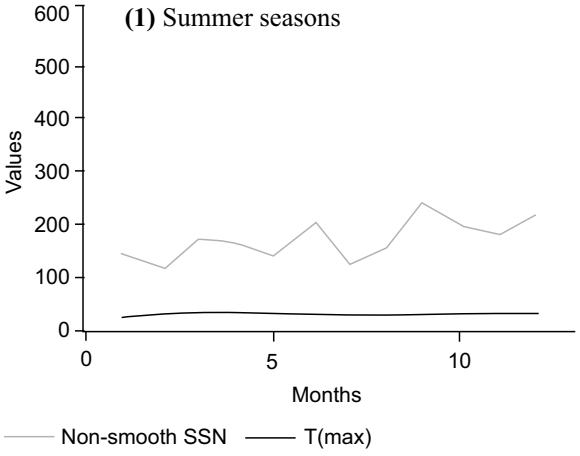
For Rohri					
Non-smooth SSN Vs Climatic parameters					
		T (max)	T (min)	Humidity	Rain
Maxima	r	0.112	0.126	0.174	-0.25
	p	0.728	0.695	0.589	0.516
Minima	r	0.044	-0.153	-0.541	-0.405
	p	0.891	0.634	0.069	0.245
Solstices	r	0.055	-0.004	-0.241	-0.373
	p	0.77	0.982	0.191	0.05
Equinox	r	0.034	-0.078	-0.337	0.001
	p	0.856	0.676	0.064	0.995
Decreasing	r	0.099	0.034	-0.249	-0.183
phase	p	0.309	0.725	0.009	0.071
Increasing	r	-0.041	-0.02	0.073	0.032
phase	p	0.721	0.857	0.512	0.777
Winter	r	0.119	-0.081	-0.381	-0.347
	p	0.426	0.588	0.008	0.023
Spring	r	0.089	0.026	-0.204	-0.078
	p	0.547	0.859	0.164	0.605
Summer	r	0.046	-0.235	-0.155	-0.057
	p	0.723	0.063	0.22	0.666
Autumn	r	-0.04	0.008	-0.021	0.001
	p	0.832	0.965	0.91	0.998
2000-2015	r	0.061	0.009	-0.178	-0.084
	p	0.403	0.906	0.014	0.262

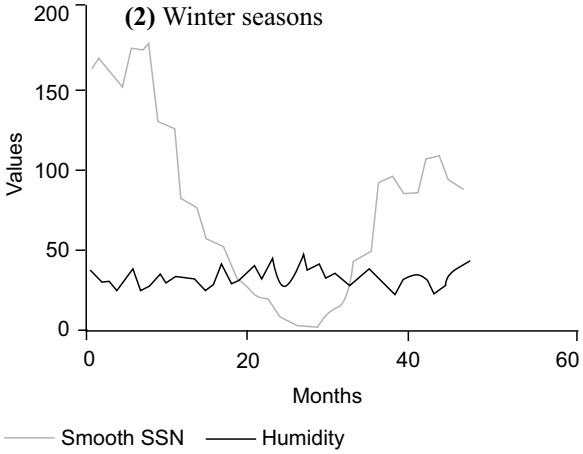
Table 3. Correlaton coefficients and P-level values between smooth-SSN and climatic parameters for Karachi

For Karachi					
Smooth SSN Vs Climatic parameters					
		T (max)	T (min)	Humidity	Rain
Maxima	r	0.301	0.308	0.341	0.211
	p	0.341	0.33	0.278	0.534
Minima	r	-0.3	-0.21	-0.181	-0.165
	p	0.343	0.512	0.573	0.648
Solstices	r	0.092	0.06	0.021	-0.37
	p	0.615	0.745	0.907	0.068
Equinox	r	-0.259	-0.135	-0.156	-0.094
	p	0.152	0.461	0.394	0.669
Decreasing	r	-0.007	-0.021	-0.068	-0.164
phase	p	0.944	0.827	0.483	0.117
Increasing	r	-0.063	-0.014	-0.047	-0.164
phase	p	0.566	0.903	0.67	0.168
Winter	r	0.144	-0.018	-0.3	-0.252
	p	0.334	0.906	0.04	0.107
Spring	r	-0.067	-0.053	-0.091	-0.091
	p	0.65	0.719	0.539	0.556
Summer	r	-0.241	-0.188	0.45	0.214
	p	0.055	0.138	0.00	0.132
Autumn	r	0.05	0.04	-0.078	-0.061
	p	0.788	0.829	0.67	0.751
2000-2015	r	-0.027	-0.019	-0.062	-0.160
	p	0.707	0.793	0.390	0.040

Table 4. Correlaton coefficients and P-level values between smoothed SSN and climatic parameters for Rohri

For Rohri					
Smooth SSN Vs Climatic parameters					
		T (max)	T (min)	Humidity	Rain
Maxima	R	0.192	0.299	0.68	-0.176
	P	0.55	0.346	0.015	0.65
Minima	R	-0.058	-0.149	-0.494	-0.375
	P	0.858	0.645	0.102	0.285
Solstices	R	0.075	0.014	0.271	-0.371
	P	0.014	0.941	0.14	0.052
Equinox	R	0.022	-0.11	-0.395	-0.03
	P	0.907	0.556	0.028	0.875
Decreasing	R	0.039	-0.03	-0.263	-0.204
phase	P	0.686	0.756	0.006	0.043
Increasing	R	-0.005	0.009	0.024	0.042
phase	P	0.965	0.939	0.832	0.712
Winter	R	0.184	-0.043	-0.452	-0.334
	P	0.215	0.774	0.001	0.029
Spring	R	0.085	0.021	-0.212	-0.069
	P	0.567	0.886	0.148	0.647
Summer	R	0.057	-0.219	-0.171	-0.069
	P	0.658	0.085	0.176	0.605
Autumn	R	0.001	0.009	-0.132	-0.049
	P	0.995	0.961	0.486	0.804
2000-2015	R	0.024	-0.032	-0.190	-0.094
	P	0.746	0.658	0.008	0.209





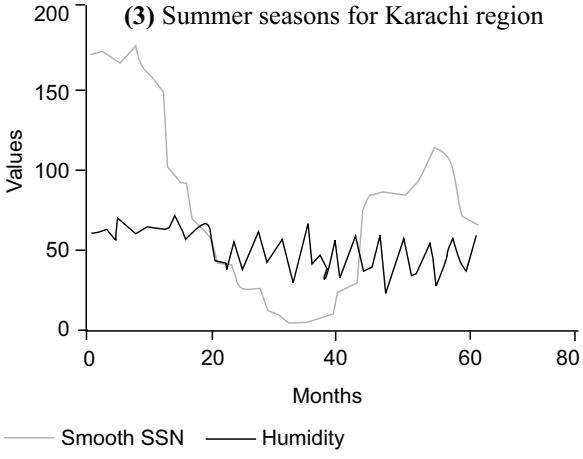


Fig. 1-3. Shows the correlation between the solar variable SSN both for smooth and non-smooth series and four climatic variables for different phases of Sun at Karachi region.

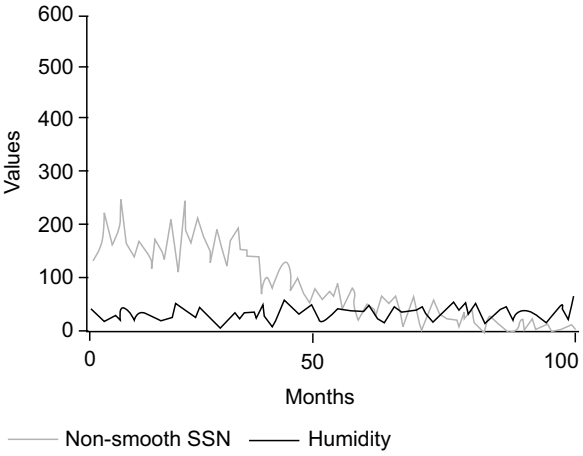


Fig. 4. Decreasing phase of Sun in Rohri region.

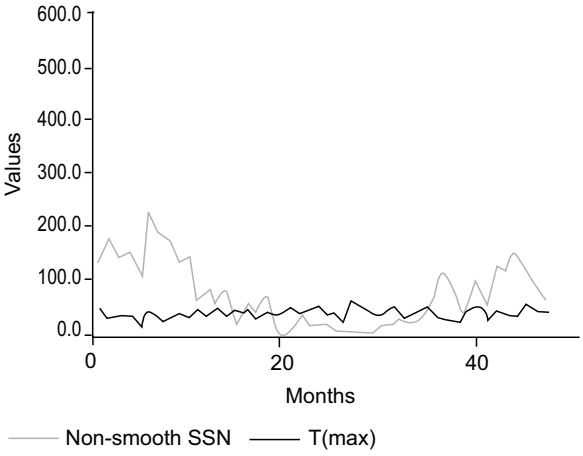


Fig. 5. Winter seasons in Rohri region.

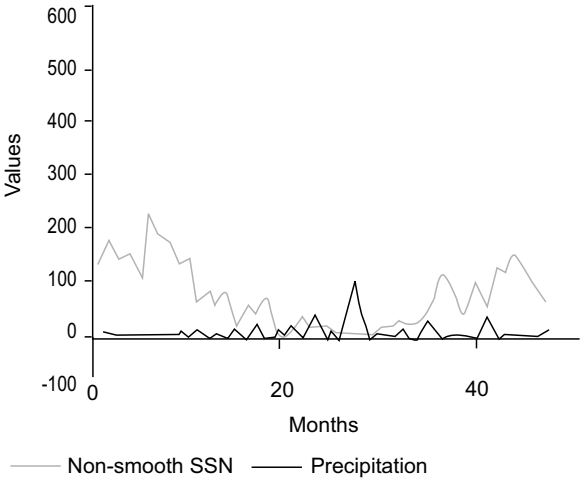


Fig. 6. Winter seasons in Rohri region.

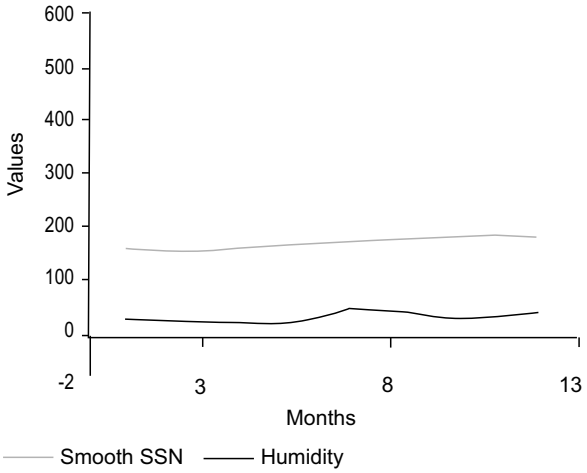


Fig. 7. Sunspot maxima in Rohri region.

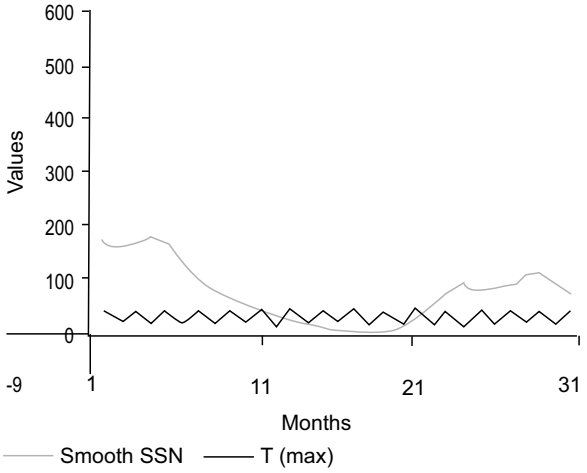


Fig. 8. Sun at solstices in Rohri region.

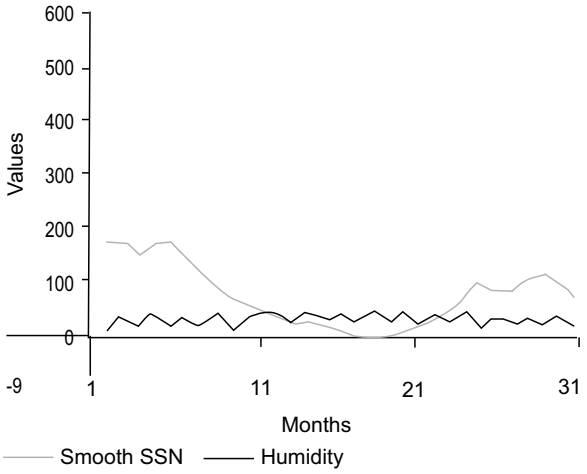


Fig. 9. Sun at equinox in Rohri region.

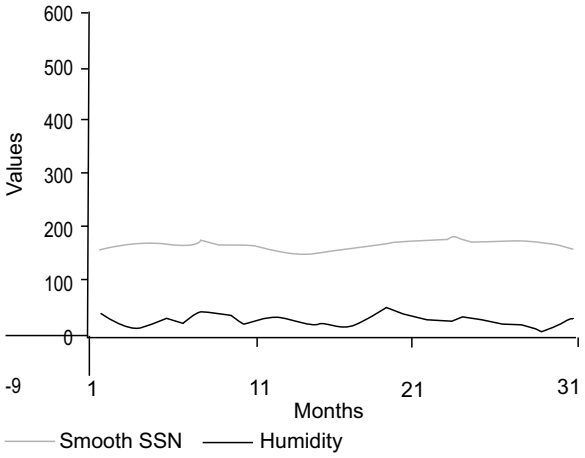


Fig. 10. Decreasing phase of Sun in smooth series in Rohri region.

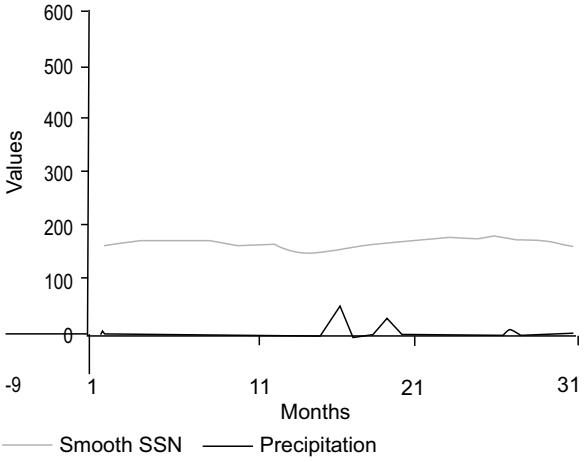


Fig. 11. Decreasing phase of Sun in smooth series in Rohri region.

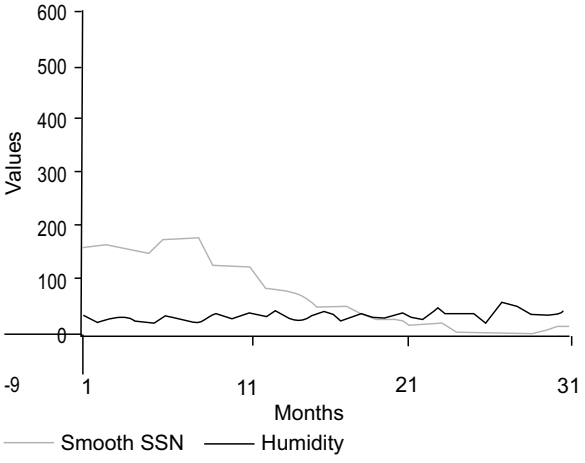


Fig. 12. Winter seasons in smooth SSN humidity in Rohri region.

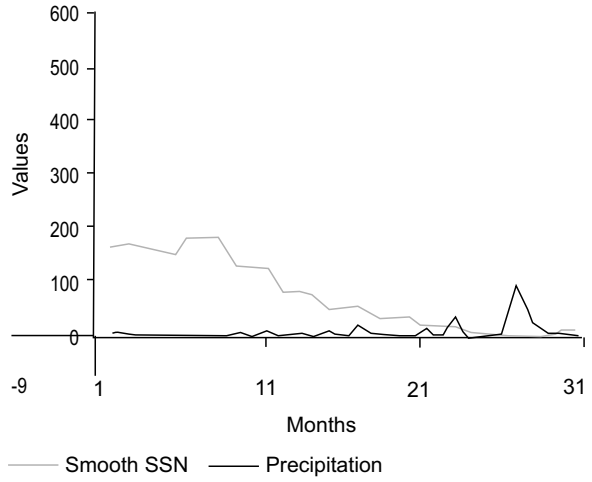


Fig. 13. Winter seasons in smooth SSN precipitations.

Figs. 4-13. Shows the correlation between the solar variable SSN both for smooth and non-smooth series and four climatic variables for different phases of Sun at Rohri region.

smooth series of SSN, the correlation turn out to be more associated with the climatic variables. The smooth SSN causes an expansion of the connection of the information. Therefore, if the smooth data series are subjected to authentic inspection, the signification of the measurable parameters must be computed by utilizing example sizes rather than the real sizes.

Conclusion

The correlation between the climatic variables with smooth & non-smooth series of SSN has been established in this study. This analysis defines that there is no significant correlation of T (min) with both smooth and non-smooth series of SSN in all phases of Sun for both Karachi and Rohri regions. Therefore, provides evidence for comparison of reliability between T (min) and T (max) in response of solar activity variable SSN.

In this study we measure the humidity variables and found mainly dependent on SSN. It is negatively correlated with SSN except at Rohri region during maxima for smooth series and at Karachi region during summer season for non-smooth series and it is found positively correlated. Albeit, SSN was not only the reason for climate change but it may be one of the factor for future climatic variability. In Rohri region there is more influence of SSN on humidity in comparison of Karachi region. In winter season Rohri region also found negatively correlated with Rain for both smooth and non-smooth series of SSN. Therefore, it conclude that climate of Karachi is not mainly depend on SSN activities, it may be because of the coastal area.

It has further been concluded that:

- Significant correlation is found between SSN and humidity, which further improved in case of smooth series of SSN.
- For T (max), T (min) and precipitation the correlation with SSN are relatively less significant.

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