Relationship Among Sunspot Numbers, Solar Radio Flux (F-10.7 INDEX) And Solar Wind Parameters For Solar Cycle – 24

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Abstract: -This paper gives an investigation about the interrelationship among a variety of solar activity (SA) parameters. A relationship has been performed using the correlative study. In correlation, we have used the yearly data of various solar activity parameters, such as sunspot number, solar radio flux (F-10.7 index) and solar wind parameters etc. for the time period 2007 to 2017, which is known as solar cycle – 24. We show the correlation between sunspot numbers with solar radio flux, solar wind parameters (speed, temperature and density) and solar radio flux with solar wind parameters (speed, temperature and density) and solar wind plasma speed with solar wind plasma temperature. Then we observed, good correlation between various parameters. The coefficient of correlation for sunspot numbers (R_z) Vs solar radio flux (r = 0.989) and for sunspot numbers (R_z) Vs solar wind plasma speed (v) (r = - 0.235) and for sunspot numbers (R_z) Vs solar wind plasma temperature (r = - 0.058) and for sunspot numbers (R_z) Vs solar wind proton density (r = 0.608) and for solar radio flux Vs solar wind plasma speed (r = - 0.252) and for solar radio flux Vs solar wind plasma temperature (r = - 0.071) and for solar radio flux Vs solar wind proton density (r = 0.649) and for solar wind plasma speed Vs solar wind plasma temperature (r = 0.965). The result show significantly positive and negative correlation between various solar activity parameters. But we found very high correlation between sunspot numbers Vs solar radio flux and solar wind plasma speed Vs solar wind plasma temperature.

Key Words: -solar activity (SA), sunspot numbers (R_z), solar wind plasma speed (v), solar radio flux (F-10.7 index).

I. INTRODUCTION

Any natural phenomena occurring on or in the sun, is called solar activity such as: sunspots, solar flares, solar wind, coronal mass ejection etc. solar activities evaluate for the present study are sunspots, solar wind parameters, and solar radio flux. And in this paper, we are studying the interdependence between various solar activity parameters during the solar cycle – 24.

As we know that sunspots are areas on the photosphere. The number of sunspots rises and falls and rises again in about 11 years. Which is known as sunspot cycle. The sunspot cycle is an important form of solar variability that illustrate the extent of closed magnetic field structure on the sun. Hale observed that sunspots usually occur in pairs of opposite polarity. These are called bipolar pairs as opposed to the less common unipolar sunspots [1]. Sunspots are one of the attractive aspects of solar cycle and activity phenomena. The improvement of the solar cycle is always mostly similar, but there are also important differences between cycles. During periods of solar maximum, the dominant component of the solar wind plasma appears to be slow solar wind [2]. The high variability of the solar wind in space and time reflects the underlying coronal structures [3].

As we know that the solar wind is a stream of charged particles discharged from the upper atmosphere of the sun. This plasma consists of particularly electron, protons and alpha particles. Plasma have speed about 400 km/sec and temperature 1 million degrees (Celsius), [4]. Approximately 100 tons of solar wind are discharged per day from the sun. solar wind consists of a large amount of kinetic and electrical energy. The relation between the solar wind parameters and sunspots has been examined by many authors such as [5][6][7].

The F-10.7 MHz solar radio flux is a measure of the radio flux per unit frequency on the wavelength 10.7 cm. near the peak of the observed solar radio emission. It represents a measure of diffuse, non – radiative heating of the coronal plasma draped by magnetic field over active regions and it is an excellent indicator of overall solar activity levels. The solar F – 10.7 cm record extends back to 1947, and is the longest direct record of the solar activity available, other than sunspot related quantities.

In this study, we have analyzed the interdependence of sunspots, solar radio flux and solar wind parameters, namely solar wind plasma speed, temperature and density. As the solar wind moves outwards, velocity (speed) and temperature remain coherent, whereas density does not [8]. This study covers the time period 2007 to 2017. Which is known as solar cycle – 24.

II. DATA ANALYSIS

In this investigation daily average value have been collect and then converted it into yearly average data, over the time period of 2007 to 2017 to determine sunspot numbers, solar radio flux and solar wind parameters (speed, temperature and density). This data has been taken from omni web data explorer (https://omniweb.gsfc.nasa.gov./form/dx1.html). For analyzing the data and correlation, we used statistical methods.

III. RESULT AND DISCUSSION

In present study, we have analyzed the interdependence of sunspots, solar radio flux (F – 10.7 index) and solar wind parameters namely solar wind plasma speed, temperature and proton density during the time period 2007 to 2017, which is known as solar cycle – 24. We describe the relation

between various solar activity parameters by using line diagram and correlation curve as shows in following figures:-

Figure (1a) & (1b) shows the linear plot and correlation curve for sunspot numbers (R_z) and solar radio flux (F – 10.7 index). The correlation coefficient was found to be (r = 0.989). As sunspot numbers increases solar radio flux also increases.

Figure (2a) & (2b) shows the linear plot and correlation curve for sunspot numbers (R_z) and solar wind plasma speed (v). The correlation coefficient was found to be (r = - 0.235). As sunspot numbers increases solar wind plasma speed decreases.

Figure (3a) & (3b) shows the linear plot and correlation curve for sunspot numbers (R_z) and solar wind plasma temperature. The correlation coefficient was found to be (r = - 0.058). As sunspot numbers increases solar wind plasma temperature decreases.

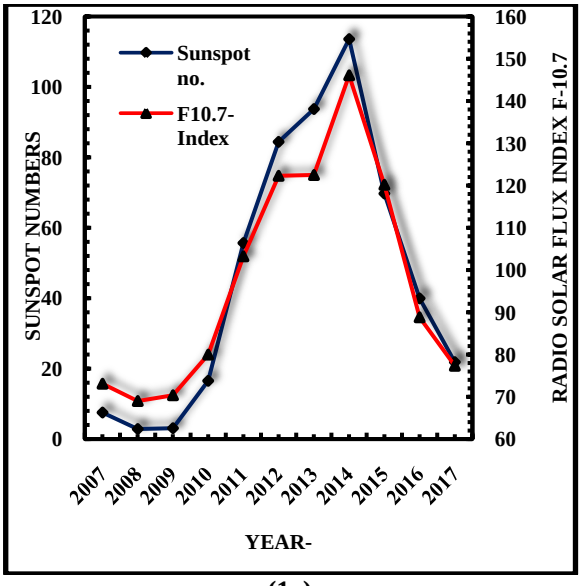
Figure (4a) & (4b) shows the linear plot and correlation curve for sunspot numbers (R_z) and solar wind proton density. The correlation coefficient was found to be (r = 0.608). As sunspot numbers increases solar wind proton density also increases.

Figure (5a) & (5b) shows the linear plot and correlation curve for solar radio flux (F – 10.7 index) and solar wind plasma speed (v). The correlation coefficient was found to be (r = - 0.252). As solar radio flux increases solar wind plasma speed decreases.

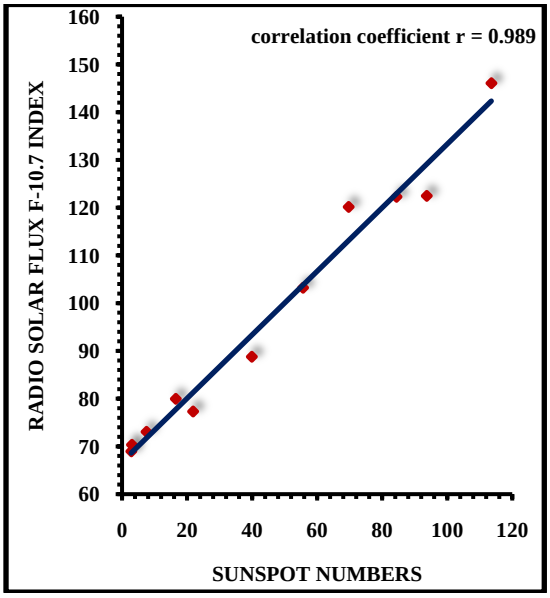
Figure (6a) & (6b) shows the linear plot and correlation curve for solar radio flux (F – 10.7 index) and solar wind plasma temperature. The correlation coefficient was found to be (r = - 0.071). As solar radio flux increases solar wind plasma temperature decreases.

Figure (7a) & (7b) shows the linear plot and correlation curve for solar radio flux (F – 10.7 index) and solar wind proton density. The correlation coefficient was found to be (r = 0.649). As solar radio flux increases solar wind proton density also increase.

Figure (8a) & (8b) shows the linear plot and correlation curve for solar wind plasma speed and solar wind plasma temperature. The correlation coefficient was found to be (r = 0.965). As solar wind plasma speed increases solar wind plasma temperature also increases.

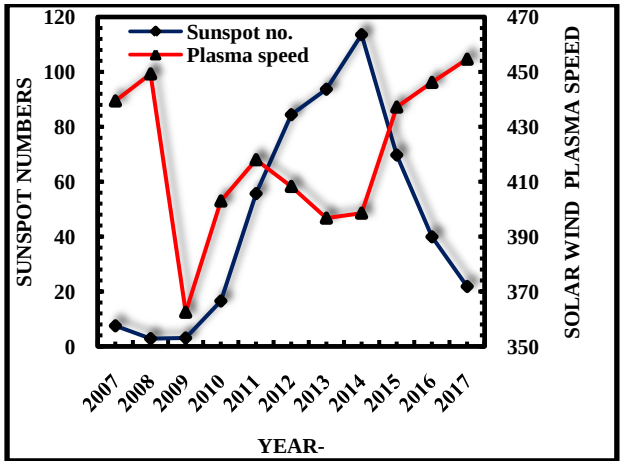


(1a)

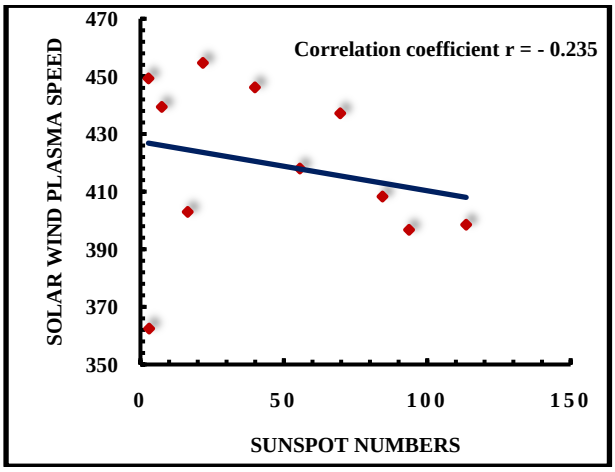


(1b)

Figure (1a) & (1b) shows the linear plot and correlation curve for sunspot numbers (R_z) and solar radio flux (F – 10.7 index) for 2007-2017.

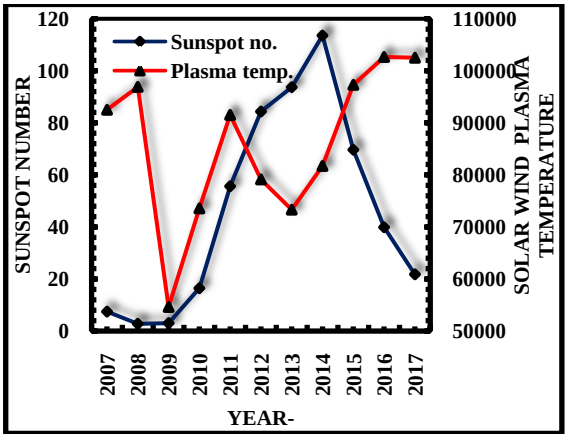


(2a)

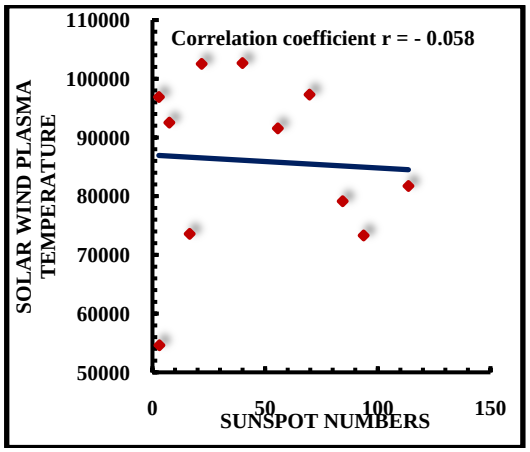


(2b)

Figure (2a) & (2b) shows the linear plot and correlation curve for sunspot numbers (R_z) and solar wind plasma speed (v) for 2007-2017.

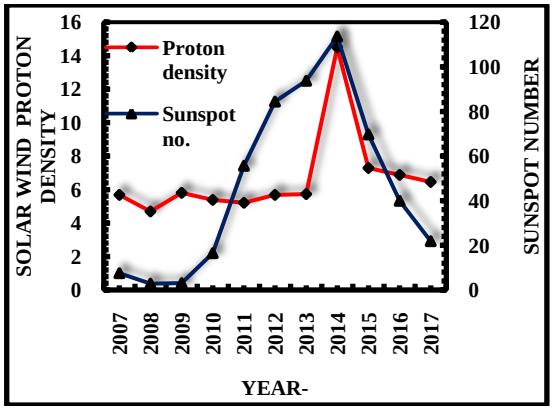


(3a)

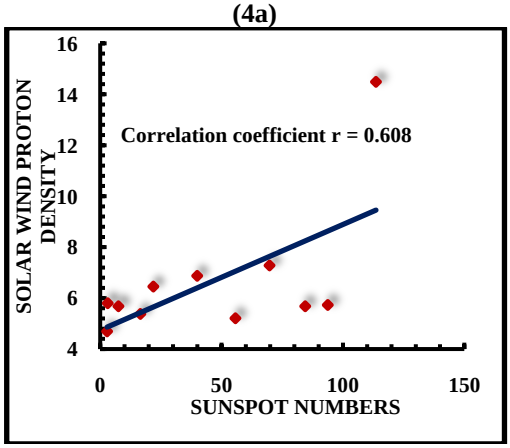


(3b)

Figure (3a) & (3b) shows the linear plot and correlation curve for sunspot numbers (R_z) and solar wind plasma temperature for 2007-2017.

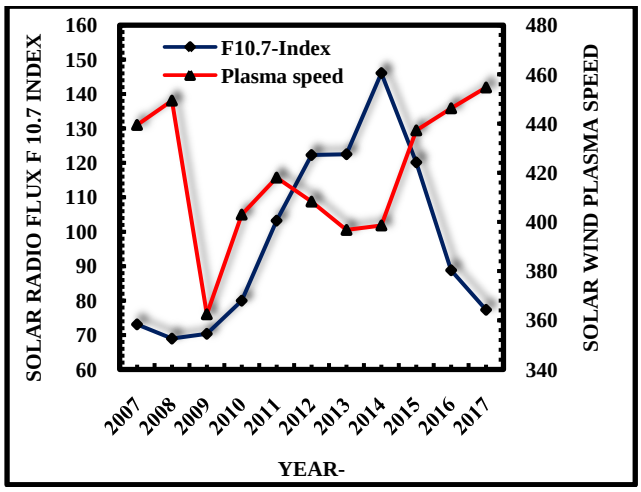


(4a)

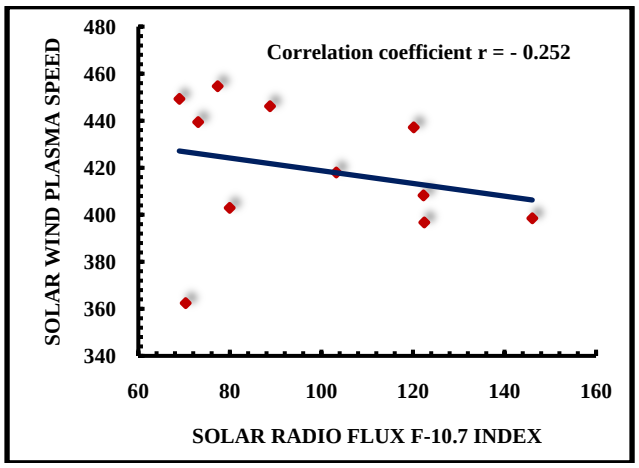


(4b)

Figure (4a) & (4b) shows the linear plot and correlation curve for sunspot numbers (R_z) and solar wind proton density for 2007-2017.

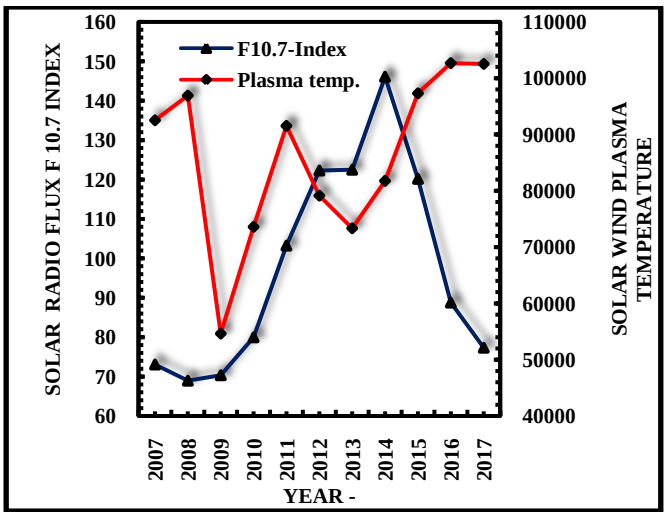


(5a)



(5b)

Figure (5a) & (5b) shows the linear plot and correlation curve for solar radio flux (F – 10.7 index) and solar wind plasma speed (v) for 2007-2017.



(6a)

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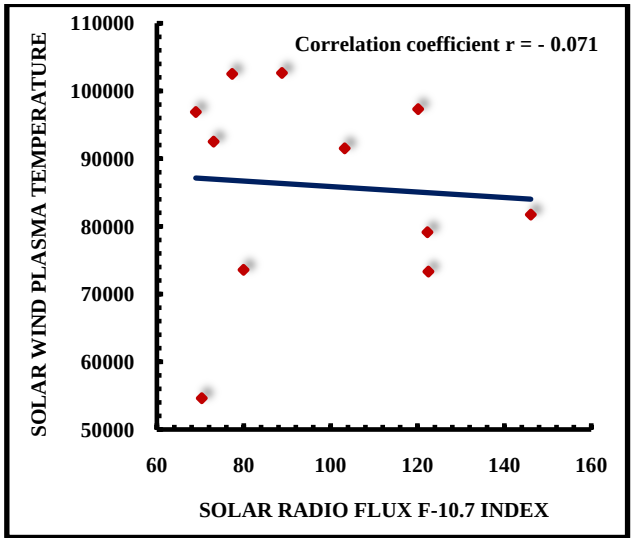
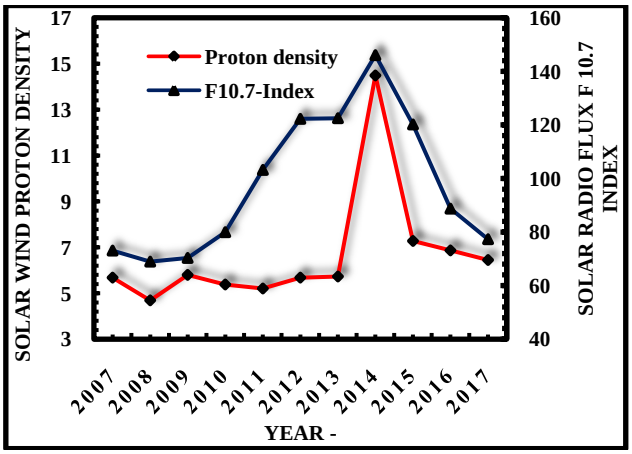
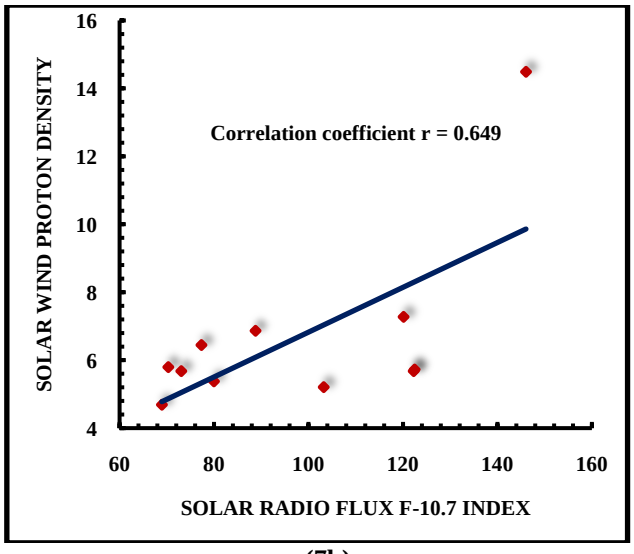


(6b)

Figure (6a) & (6b) shows the linear plot and correlation curve for solar radio flux (F – 10.7 index) and solar wind plasma temperature for 2007-2017.

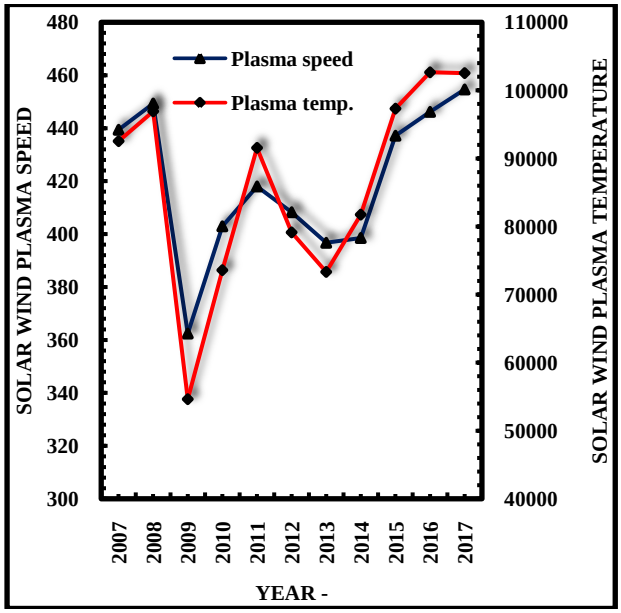


(7a)

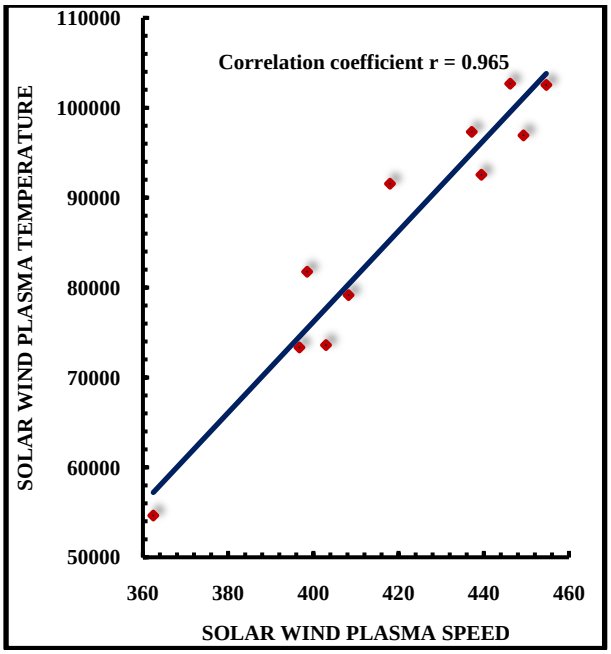


(7b)

Figure (7a) & (7b) shows the linear plot and correlation curve for solar radio flux (F – 10.7 index) and solar wind proton density for 2007-2017.



(8a)



(8b)

Figure (8a) & (8b) shows the linear plot and correlation curve for solar wind plasma speed and solar wind plasma temperature for 2007-2017.

IV. CONCLUSION

We summarize the main findings of this study as follows: -

1) Solar cycle – 24 has initially displayed much less activity. The number of sunspots isobserved very less in initial period.
2) Sunspot numbers (R_z) and solar radio flux (F – 10.7 index) show very high and positive correlation. Which indicates that sunspot numbers are strongly related with solar radio flux.
3) Sunspot numbers (R_z) and solar wind plasma speed (v) show very poor and anti – correlation (negative correlation). Which indicates that no definite relationship between sunspot numbers and solar wind plasma speed.

4) Sunspot numbers (R_z) and solar wind plasma temperature show very poor and anti – correlation (negative correlation). Which indicates that no definite relationship between sunspot numbers and solar wind plasma temperature.
5) Sunspot numbers (R_z) and solar wind proton density show high and positive correlation. Which indicates that sunspot numbers are strongly related with solar wind proton density.
6) Solar radio flux (F – 10.7 index) and solar wind plasma speed (v) show very poor and anti – correlation (negative correlation). Which indicates that no definite relationship between solar radio flux and solar wind plasma speed.
7) Solar radio flux (F – 10.7 index) and solar wind plasma temperature show very poor and anti – correlation (negative correlation). Which indicates that no definite relationship between solar radio flux and solar wind plasma temperature.
8) Solar radio flux (F – 10.7 index) and solar wind proton density show high and positive correlation. Which indicates that solar radio flux is strongly related with solar wind proton density.
9) Solar wind plasma speed and solar wind plasma temperature show very high and positive correlation. Which indicates that solar wind plasma speed is strongly related with solar wind plasma temperature.

V. ACKNOWLEDGEMENT

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