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Study on the Variability of Solar Parameters and Earth's Climate over the Vindhya Region

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Abstract: The internal dynamics between monthly average rainfall, monthly mean temperature and the solar parameters over the 30-year period from 1971 to 2000 for Vindhya Region is observed and analyzed. The selected data set affecting climates were tested by using statistical and data mining methods. We have observed the impact of solar wind velocity (v), geomagnetic indices (ap), sun spot number (ssn) and temperature on rainfall. A negative correlation with rainfall for most of the period is found. The temperature and rainfall show positive correlation for the period 1971-2000, except for the years 1982-1984 and 1987-1989. The temperature has a very low positive skewness (0.056) and rainfall has a negative and high skewness (0.581). We have applied various clustering methods (EM, simple k-means and Density based Cluster) in the classes. We found that all the clustering models give quite similar results for the selected data sets. We have observed that maximum data (65-68%) are classified to the cluster#0 which means false values. These values indicate that the selected parameters do not have any significant association between them. Only 32-35% values are classified to cluster#1, which reflects the poor internal dependencies between the selected parameters.

Keywords: Earth's Climate, Solar Parameters, Cluster, EM, Rainfall

I. Introduction

The solar activity, such as flares, solar radiation bursts, solar wind and plasma movement cause radiation enhancement on the earth's surface. The variability of total solar radiance (TSI) affects earth's climate. Temperature and rainfall are important climatic inputs for fluctuation of climate. Cooper et al [1] found that not only the seasonal rainfall totals and their season-to-season variability were important, but also the "within season" variability had a major effect on climate. Alder et al [2], reported that there exists significant correlation between rainfall and temperature over tropical oceans and land. Aldrian and Susanto [3] examined the relationship between rainfall and sea surface temperature and found that rainfall variability revealed some sensitivity to sea-surface temperature variability in adjacent parts of the Indian and Pacific Oceans. Black [4] also studied the relationship between Indian Ocean sea surface temperature and East Indian rainfall and concluded that strong East Indian rainfall was associated with warming in the Pacific and Western Indian Oceans and cooling in the Eastern Indian Ocean. Rajeevan et al [5] examined the temporal relationship between land surface temperature and rainfall. Kniveton et al [6], investigated the relationship between cosmic ray flux in solar minimum and maximum years and the precipitation during the period of 1979-1999 and found a strong statistical correlation between the two datasets over mid to high latitudes. This study suggests that small changes in solar output can cause significant changes in Earth's climate. The effects of solar variability on the earth's climate have been the subject of considerable investigation over many years. Joanna et al [7] have long term observation on solar variability, TSI and radiation forcing of climate change. They suggest that the warming during the latter part of the 20th century cannot be ascribed entirely to solar effects. However, chemical and dynamical processes in the middle atmosphere may act to amplify the solar impact.

Data mining techniques introduce the effective and efficient way to analyze large amount of data in climatology. Clustering technique helps to transfer the retrieved information into usable knowledge for classification and prediction of interplanetary conditions [8]. Clustering is a powerful tool which has been used in several forecasting works, such as time series forecasting, real time storm detection, flood forecasting and so on. For weather forecasting incremental K-means clustering algorithm is widely used [9]. The k-means algorithm takes the input parameter and converts into k-clusters. It is found that intra cluster similarity is high and inter cluster similarity is low. These similarities are measured in regard to the mean value of object in a cluster, which can be viewed as cluster centroid [10-11].

In the present study we used various statistical methods and data mining algorithms to model the interdependence between the temperature and rainfall over the selected data sets for vindhya region.

II. Materials and Methods

Vindhya region of central India is selected as a study area. As this region is surrounded by forest, rivers and mountain on three sides, it has a rainy climatic area. The winters are mild but the summers are hot similar to the summers in the central region. Monthly temperature and rainfall data for Vindhya region from 1971 to 2000 was obtained from the National Climatic Data Centre (NCDC) and National Metrological Data Report, IMD Pune. This study presents the impact of solar activity parameters V, SSN, Ap on the earth climate. We have applied statistical correlation, regression and data mining clustering method to observe internal dynamics among these parameters. The original sets are normalized; normalized values are plotted in table 1. Normalized value = $\text{Number}/\text{Max}(\text{xi}-\text{xn}) * 100$.

	V	Ap	SSN	Temp	Rainfall
V	1				
ap	0.7150736	1			
SSN	0.0249038	0.483506	1		
Temp	-0.3577994	-0.45001	-0.37939	1	
Rainfall	-0.0114742	0.067689	0.057156	0.138367	1

Table 1 : The correlation coefficient between solar activity and climatic parameters

Best First algorithm (Attribute Selection)

=== Attribute Selection on all input data ===

Search Method:

Best first.

Start set: no attributes

Search direction: forward

Stale search after 5 node expansions

Total number of subsets evaluated: 49

Merit of best subset found: 0.267

Attribute Subset Evaluator (supervised, Class (nominal): 11 class):

CFS Subset Evaluator

Including locally predictive attributes

Selected attributes: 3,4,6,7,9 : 5 (a2, a3, a5, a6, a8)

Clustering Model and evaluation on data set :

S.No.	Name of method	Cluster instances		Number of Iterations
		Cluster#0	Cluster#1	
1.	Expectation Maximation (EM)	68 (68%)	32 (32%)	40
2.	Simple k-means	65 (65%)	35 (35%)	04
3.	Make Density Based	68 (68%)	32 (32%)	04

Table 2 : Run information from data mining tool

III. Results and Discussion

Solar activity parameters mainly affect the earth's environment. This study shows the variability of climate with rainfall and temperature. The selected data set affecting climate were tested by using statistical and data mining methods. We have observed the impact of solar wind velocity (v), geomagnetic indices (ap), sun spot number (ssn) and temperature on rainfall. A negative correlation with rainfall for most of the period is found. The temperature and rainfall show positive correlation for the period 1971-2000, except for the years 1982-1984 and 1987-1989 as shown fig.-2. The temperature has a very low positive skewness (0.056) and rainfall has a negative and high skewness (0.581). The statistical analysis is also carried out shown in fig.1.

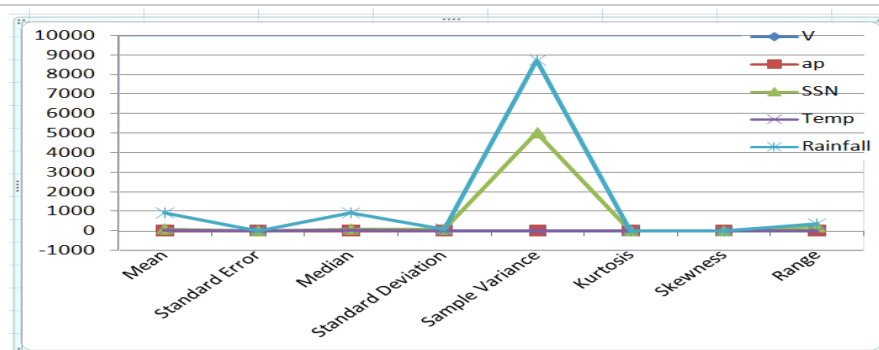


Fig. 1 : Relationship among of v, ap, ssn, temperature and rainfall during 1971 to 2000

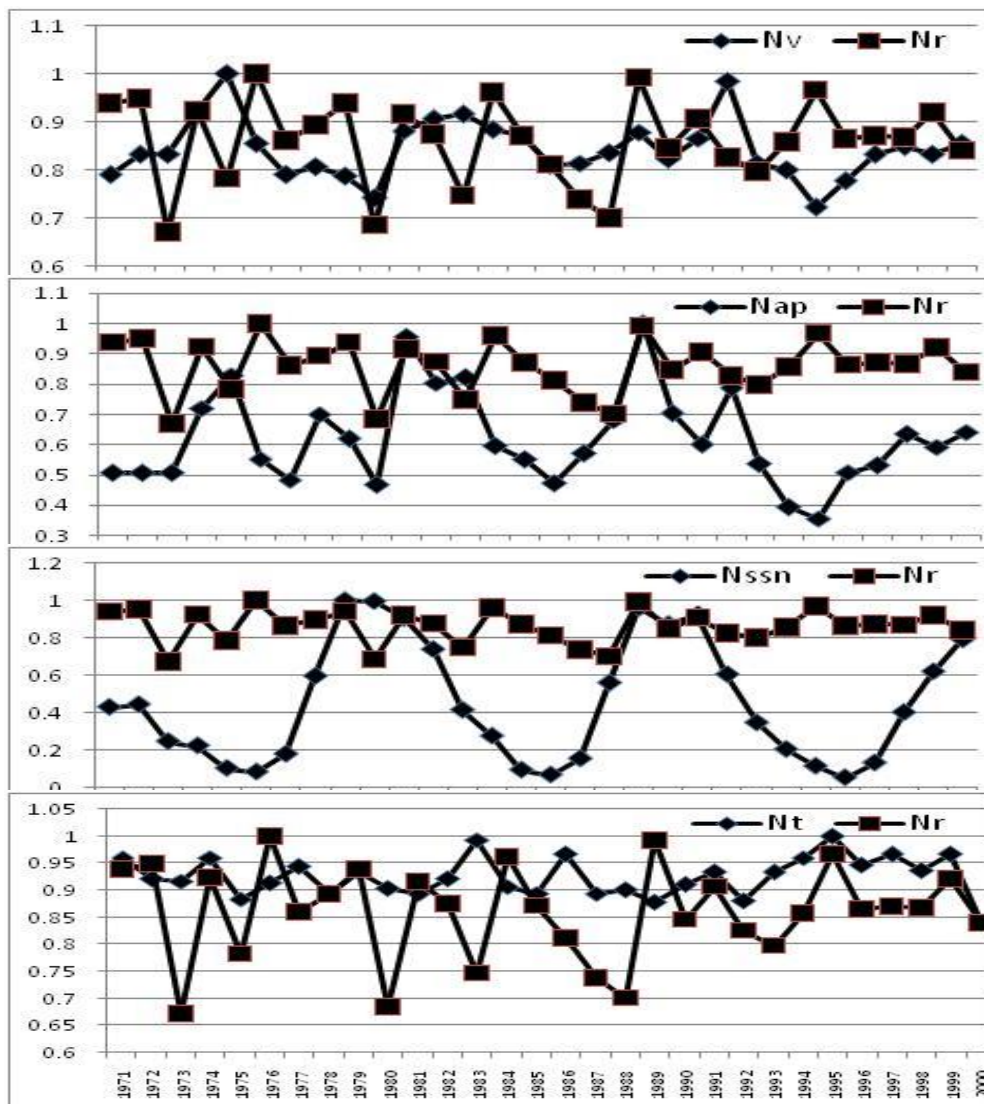


Fig. 2: Impact normalized values of v, an, ssn and temperature on rainfall during 1971 to 2000

We have applied best first algorithm for attribute selection on all the given input data. Attribute subset evaluator supervised 11 classes from a_0 a_{10} and this algorithm predict a_2 , a_3 , a_5 , a_6 and a_8 class for training data. After the selection of attribute various clustering methods (EM, simple k-means and Density based Cluster) are applied in the suggested classes. The Expectation Maximization (EM) based clustering model form two clusters i.e. cluster#0 and cluster#1. Here cluster#0 shows classification of non significant values where as cluster shows classification of most significant values. Data generator classifiers, classify maximum data values (68%) to c_0 where as c_1 classified with 32% values of data set. The Make Density Based clustering model also give the same result as above 68% data values for c_0 and 32% values for c_1 . Another simple k-means clustering based model is used to classify the selected data set, which gives similar result i.e. 65% distribution of data for c_0 and 35% data values for c_1 .

The above analysis shows that all the clustering models give quite similar results for the selected data sets. Here we have observed that maximum data are classified to the cluster#0 which means false values. These values indicate that the selected parameters do not have any significant association between them. Only 32-35% values are classified to cluster#1 for all the methods. Our findings reflect that very less internal dependencies were observed between the selected parameters.

Variability of average rainfall and temperature based methodology for modeling are of great importance for climate prediction. The data mining clustering method and statistical analysis shows similar results for climate prediction.

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