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STUDY OF THE CHARACTERISTICS AND CONNECTIVITY OF DIFFERENT CLIMATIC PARAMETERS: TEMPERATURE, HUMIDITY, BMD & TRMM RAINFALL OF SUMMER MONSOON IN BANGLADESH

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Abstract

This paper attempts to look into the characteristics aspect of different climatic parameters and the inter-relationships among the different parameters in summer monsoon over the region of Bangladesh throughout the last decade using surface data and TRMM satellite data. This study reveals a positive linear relationship between the relative humidity and rainfall and both of them decrease with the increase in temperature and vice-versa over the study region. The yearly mean temperature has increased 0.32°C and the relative humidity has decreased 0.5% over the last decade. The duration as well as the beginning and endings of summer monsoon both have changed during the study time. Almost identical characteristics features found for TRMM satellite precipitation data and BMD observational rainfall data over the study area.

Key words

Precipitation, TRMM, BMD, Humidity, Temperature, Climatology, Correlation

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INTRODUCTION

The climate of Bangladesh has changed much over the last thirty years. Moreover, it behaves so bizarrely over the last decade (2001-2011). Bangladesh is one of the regions of the heaviest rainfall in the world. The maximum climatic rainfall over this country is approximately 6000 mm during the summer monsoon (Matsumoto et al., 1996) and 60% of its annual rainfall happens during summer monsoon season. Climatology deals with the spatial distribution of average values of climatic elements, e.g. temperature, rainfall, pressure and winds, humidity, evaporation, orography, etc. and their relation to man's activities. The short-term variations of atmospheric conditions are comprised in climatology. Temperature is an independent variable among the climatic parameters whose variation causes corresponding changes in the pressure distribution and consequently in the direction of the wind as well as its velocity that controls atmospheric humidity, condensation, the formation of cloud and their drafting in the sky, precipitation, and storms. Knowledge of the variation of temperature, relative humidity, rainfall is very important for a complete understanding of the variability of the global energy and water balance. It is worth to study their characteristics all over the year and more importantly how they are interrelated. Some works have been done about the characteristics behavior of temperature, humidity and rainfall separately over the different parts of Bangladesh using observational data (Mondal, 2013) and (Keka, 2013). In addition, A study on the diurnal variations of precipitation over Bangladesh using TRMM remote sensing data reveals that the monsoon season over these regions shows a gradual shift (late start and endings), and it's also evident that Bangladesh received less rainfall over the last decade (2001-2010), especially over the last three years, (Bhuiyan, 2014). Further study, regarding correlation among the climatic parameters, is necessary for better understanding of the trend of climatology. The main objective of this paper is to study the characteristics of three fundamental

factors of climatology (i.e., Temperature, Relative humidity and Rainfall) over the last decade with BMD observational data as well as study the correlations between different climatic parameters and also check the new findings with the results of previous research on TRMM (Tropical Rainfall Measuring Mission) satellite data whether they show any similarities or dissimilarities.

MATERIALS AND METHODS

The temperature, Relative humidity, and Rainfall data used in this study were collected from "Bangladesh Meteorological Department (BMD), Climate Division, Agargaon, Dhaka" and these data are recorded from 30 selected meteorological stations of the country for last ten years (2001-2011). The three hourly TRMM 3B42 precipitation data of 0.25° x 0.25° spatial resolution is taken from the NASA's Tropical Rainfall Measuring Mission and is extracted from **Netcdf** file format using **GrADS** software for our study area between 17°-27° latitude and 85 °-95 ° longitudes for last decade from 2001 to 2010. We have used Microsoft Office Excel to perform our analysis.

ANALYTICAL DISCUSSION

In this section, we will analyze characteristics of temperature, relative humidity, rainfall (both TRMM precipitation data and BMD rainfall data) in summer monsoon during the 2001 to 2011 over the region of Bangladesh. We will also study the relationship among the different climatic parameters from the different point of views (i.e., monthly, yearly variations).

Month to Month variation in different climatic parameters

We analyzed the monthly data of temperature, relative humidity, and rainfall for every year separately throughout the last ten years. This paper also studied the correlation between different climatic parameters during the last decade over the region of Bangladesh. The characteristics of monthly temperature, relative humidity, rainfall and their correlations are discussed below:

A. Temperature Vs Relative humidity:

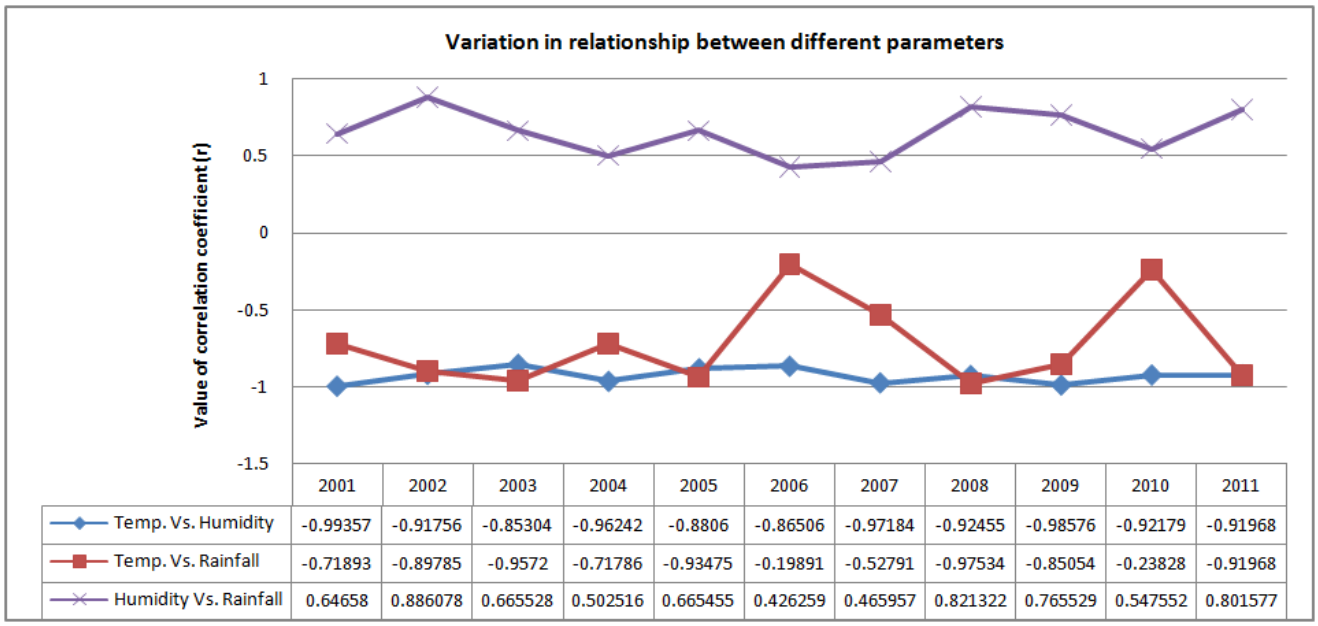
Analysis of monthly temperature and humidity data in summer monsoon (June to September) over the complete study period, illustrated in figure-1, gives a statistically significant negative linear relationship between relative humidity and temperature. The average value of correlation coefficient between temperature and humidity is r = -0.93, whereas, the maximum value is r = -0.994 in summer 2001 and the minimum value is r = -0.865 in summer 2006. It is also found that these interconnections irregularly altered between stronger and weaker value for every one year (roughly) interval throughout the last ten years.

B. Temperature Vs Rainfall:

From the figure-1, a statistically significant uneven weak and strong negative linear relationship is observed between the monthly temperature and rainfall throughout the study period in summer monsoon season all over the Bangladesh except the years 2006 and 2010, and in these two years a less significant relation between temperature and rainfall with the correlation coefficient value r = -0.199 and -0.238 is found respectively. The highest strength of negative linear relationship (with r = -0.975) between temperature and rainfall is noticed in summer 2008, and the average value of r is -0.714. Moreover, almost similar characteristics also found between temperature and precipitation over the study area.

C. Rainfall Vs Relative humidity:

Figure-1 also illustrates that unlike the negative linear relationship between the monthly temperature and rainfall or monthly temperature and relative humidity, an irregular weak and strong positive linear relationship between humidity and rainfall is observed over the whole summer monsoon season throughout the complete study period in Bangladesh. The strongest positive linear relationship between humidity and rainfall is found in 2002, and the average value of correlation coefficient (r = 0.4211) between relative humidity and rainfall is noticed over the summer monsoons from 2001 to 2011, whereas, the maximum value is r = 0.886 in summer 2002 and the minimum value is r = 0.426 in summer 2006. These characteristics features are almost true in the case of precipitation and humidity.



	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Temp. Vs. Humidity	-0.99357	-0.91756	-0.85304	-0.96242	-0.8806	-0.86506	-0.97184	-0.92455	-0.98576	-0.92179	-0.91968
Temp. Vs. Rainfall	-0.71893	-0.89785	-0.9572	-0.71786	-0.93475	-0.19891	-0.52791	-0.97534	-0.85054	-0.23828	-0.91968
Humidity Vs. Rainfall	0.64658	0.886078	0.665528	0.502516	0.665455	0.426259	0.465957	0.821322	0.765529	0.547552	0.801577

Figure-1: Comparison of monthly variation in relationships among the climatic elements from 2001 to 2011.

Yearly variation in different climatic parameters:

We analyzed the yearly mean of temperature, relative humidity, rainfall (both BMD observational data and TRMM satellite data), for every year separately from 2001 to 2011. The characteristics of yearly mean temperature, relative humidity, rainfall and their changing trends are discussed below:

A. Characteristics of Temperature in summer monsoon:

The annual temperature in Bangladesh is rising at a rate of about 1.2°C per century. More importantly, this trend has become stronger in recent years, M. S. Mondal (2).

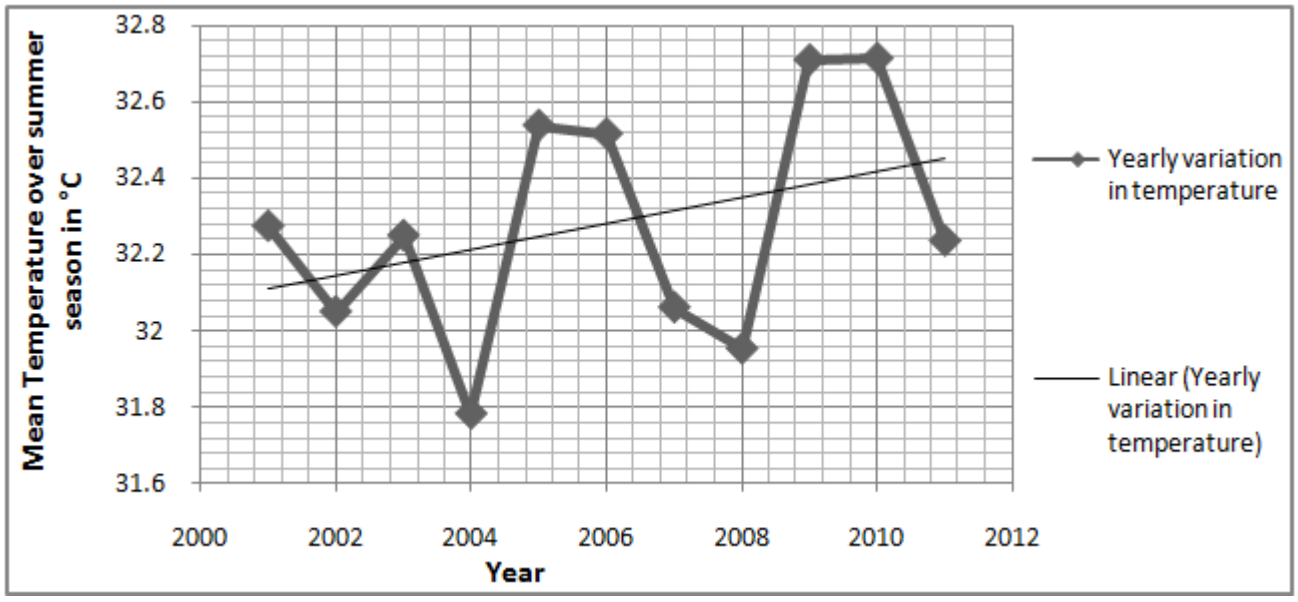


Figure-2: Variation of mean value of yearly temperature in summer monsoon

The trend in recent annual mean temperatures (1980-2010) is almost the double (2.4°C per century) of the longer-term trend. This rising trend is also indicated in our study of yearly mean of summer monsoon temperature throughout the complete study period from 2001 to 2011. From figure-2, it is seen that the mean yearly temperature in summer monsoon has increased from 32.1°C to 32.42°C during the last decade.

B. Characteristics of relative humidity in summer monsoon:

The aspects of annual mean of relative humidity are illustrated by figure-3. It is seen that the humidity in the summer seasons has decreased from 86.22% to 85.7% throughout the last decade (2001-2011). The maximum relative humidity 84.44% was found in 2008 and the lowest value 85.21% in 2009.

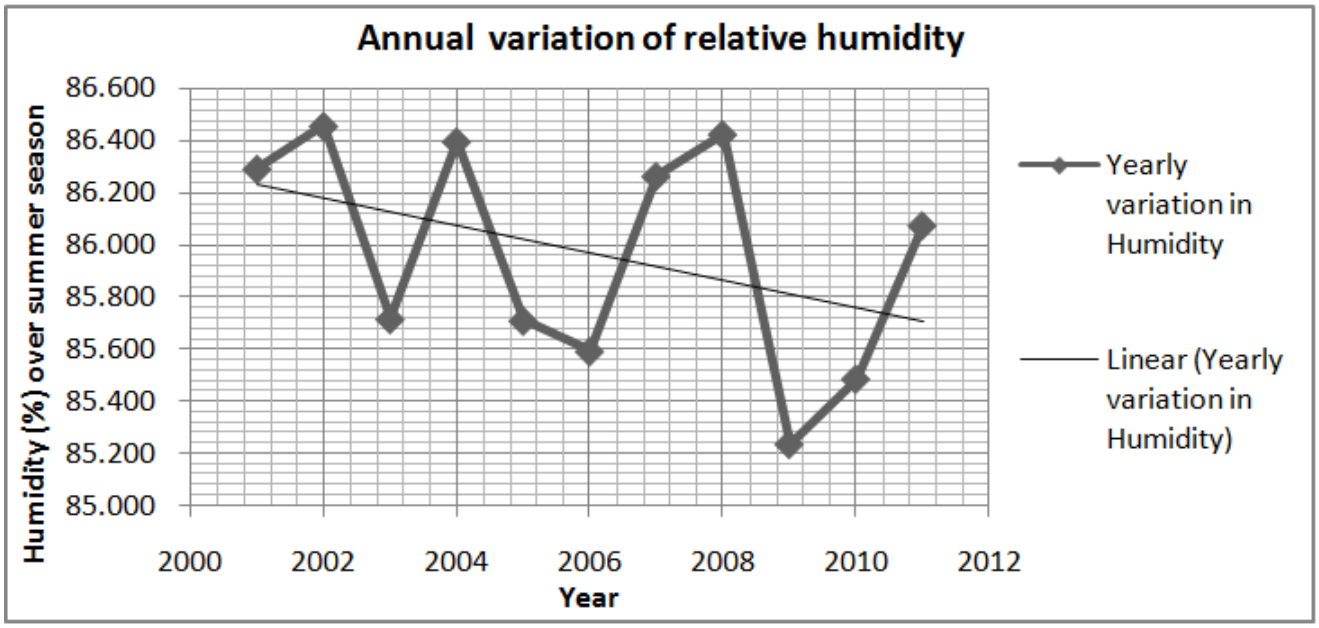


Figure-3: Variation of mean value of yearly relative humidity in summer monsoon.

C. Characteristics of Rainfall in summer monsoon:

The time series of mean of annual rainfall in summer monsoon over the entire region of Bangladesh throughout the last decade is shown in Figure-4. The analysis of measured rainfalls and TRMM satellite rainfalls data reveals some significant results over the complete study period.

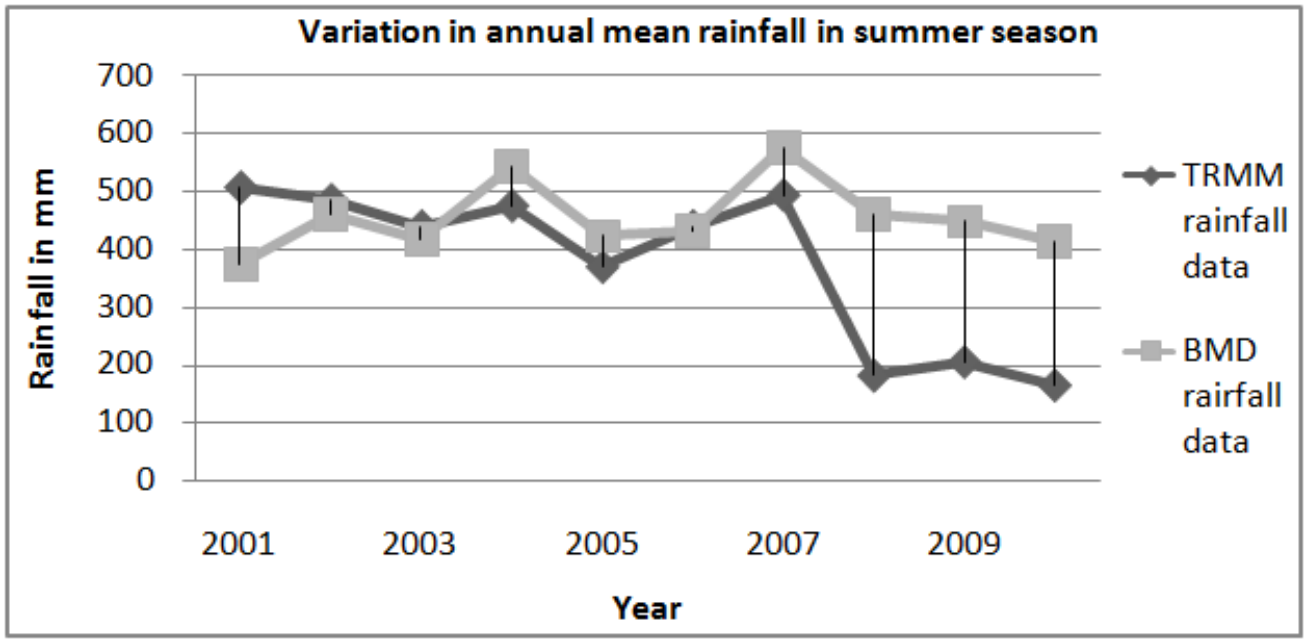


Figure-4: Variation of mean value of yearly rainfall in summer monsoon

From the figure-4, it is seen that unlike the features of observational data, the satellite rainfall data indicate the overall decrease in yearly mean rainfall in summer monsoon over the decade, whereas, the observational BMD rainfall data shows slightly increase in mean rainfall during the study period. Moreover, TRMM data indicates very significant decrease in annual summer monsoon rainfall in last three years (i,e., 2008, 2009, and 2010) from 500mm to

less than 200mm and it does not agree with the BMD observational data. Also, an almost similar rainfall trend is found for the rest of the years for both observational and satellite data. It also illustrates that the mean of annual observational BMD rainfalls have not changed much in Bangladesh throughout the study period.

D. Annual variation in rainfall in pre-summer, mid-summer, and post-summer:

Prior research with TRMM satellite data showed the pre-summer, mid-summer, and post-summer rainfall increased significantly during September, the last month of monsoon, for the last few years and monsoon season has shifted slightly, Bhuiyan (1). Figure-5 shows the rainfall trend of pre-monsoon, mid-monsoon and post-monsoon seasons. It is seen from the figure-5(a) and 5(c) that average rainfall in the pre-monsoon and post monsoon season has decreased significantly from 400mm to 325mm in pre-monsoon season and 290mm to 220mm in post-monsoon over the last decade. That means the rainfall trend in pre- monsoon agrees with Bhuiyan (1) and M. S. Mondal (2) and the rainfall trend in post-monsoon disagree with their results. In contrast, the average rainfall trend increased from 400mm to 450mm in mid-monsoon season over the last decade shown in figure-5(b) agrees with the results of Bhuiyan (1) and M. S. Mondal (2).

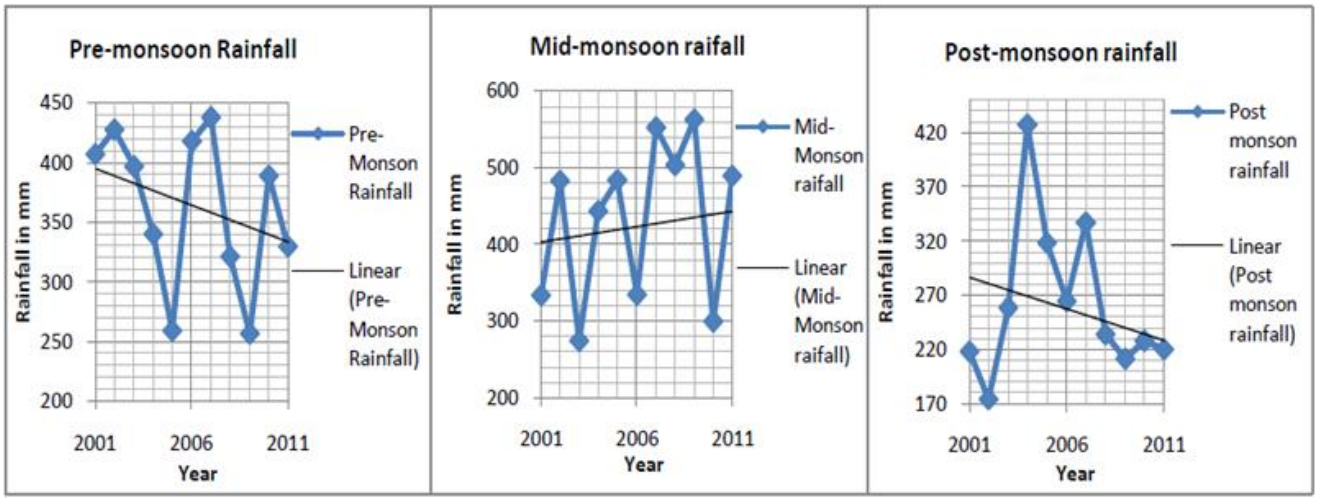


Figure-5: Yearly variation of rainfall in (a) pre-summer, (b) mid-summer, and (c) post-summer.

SUMMERY AND CONCLUSION

Analysis of monthly temperature and humidity data in summer monsoon over the full study period gives a strong negative linear relationship between relative humidity and temperature, and therefore suggests that over the study area relative humidity change inversely with temperature during the summer monsoon. Similarly, a statistically significant negative linear relationship is also found between rainfall and temperature, and it also indicates that the increase in temperature reduction in rainfall and vice-versa over the study region. An opposite characteristic is found from the analysis of monthly rainfall and relative humidity data in summer monsoon over the complete study period and gives a strong negative linear relationship between relative humidity and temperature, and it imply that the relative humidity changes inversely to the temperature over the study area. More importantly, an almost similar characteristics feature also found in the case of TRMM satellite precipitation data instead of BMD observational rainfall data over the study area.

Analysis of yearly mean of temperature, relative humidity, rainfall (both BMD observational data and TRMM satellite data) indicate that the mean of yearly temperature in summer monsoon has increased from 32.1°C to 32.42°C during the last decade. The relative humidity in summer seasons has decreased by 0.5% over the last decade, and it could be due to the rise in temperature and availability of water for evaporation. It is also hinted that the TRMM satellite precipitation data indicate overall decrease in mean of yearly rainfall in summer monsoon over the decade. In contrast, the observational BMD rainfall data shows slightly increase in mean rainfall during the study period. The annual mean observational BMD rainfalls have not changed much in Bangladesh throughout the study period.

The analysis of observational and satellite rainfall data also reveals that the duration as well as the beginning and endings of summer monsoon both have changed significantly during the study time. The summer monsoon starts lately (i.e., deferred slightly) and lasted for the short period and it could be due the rise in average temperature over the last few decades. The pre-monsoon season has shows a statistically significant rainfall increasing trend. Whereas, mid-monsoon and post-monsoon shows just opposite trend in rainfall of the pre-monsoon period. In rare cases, BMD observational rainfall data shows slightly deviation from the TRMM satellite data and it could be due to the study area considered in TRMM data cover entire Bangladesh and its adjacent areas including some part of the Bay-of-Bangle.

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