

Analysis and Evaluation of principal climatic factors of NDVI in the Yarlung Zangbo River Basin

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Abstract. The normalized difference vegetation index (NDVI) of vegetation covers is influenced by many climatic factors such as precipitation and average temperature. In this paper, NDVI is calculated on the basis of waveband characteristic of NOAA/AVHRR data for the YarlungZangbo River Basin. Then, the spatial-temporal change of NDVI is analyzed. The basin's NDVI is in consistency with season from 2011 to 2013. Large value zone of NDVI is mainly distributed in the lower reaches and part of the middle reaches. Meanwhile, point-data of principal climatic factors are interpolated to spatial grid data with Kriging method consistent with NDVI based on DEM of the YarlungZangbo River Basin. Then, the relation of precipitation and normalized difference vegetation indexes or average air temperature is analyzed with F checking and two-sample variance test in the basin. The result is $P=0$, which shows that correlation analysis has larger confidence. The linear and logarithmic correlation of precipitation and normalized difference vegetation indexes or average air temperature is analyzed at confidence level of 0.05. The conclusion is that precipitation and normalized difference vegetation indexes and average air temperature in the basin vary with seasons and are closely correlated. The linear correlation coefficient of precipitation and normalized difference vegetation indexes is 0.8, and that of NDVI and average air temperature is about 0.77. And the logarithmic correlation coefficient of precipitation and normalized difference vegetation indexes is 0.71, and that of NDVI and average air temperature is 0.7.

Keywords: average air temperature, vegetation cover, Yarlung Zangbo River basin, normalized difference vegetation index, precipitation,

1. Introduction

Vegetation dynamics, especially over large scales, can be monitored using remote sensing. Of the spectral indices derived from remote sensing which identify vegetated areas and their condition, the Normalised Difference Vegetation Index (NDVI) is still the most well-known and frequently used [12-

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13]. NDVI is based on the differential reflectance that plants exhibit for different parts of the solar radiation spectrum. Healthy green leaves strongly absorb photosynthetically active radiation for energy in photosynthesis, whereas internal mesophyll structures in the leaf scatter radiation in the near-infrared region to prevent overheating of the plant [12,14]. Calculated by obtaining the difference between the remotely sensed visible (red) and near-infrared bands and normalising it over the sum of the two, NDVI is a good index of the capacity of vegetation to absorb photosynthetically vigorous energy and therefore of land-cover which comprises unstressed vegetation [14,15].

In studying NDVI of basins, NOAA/AVHRR (National Oceanic Atmospheric Administration/Advanced Very High Resolution Radiometer) has been on the spot for its unique characteristic. For its available information in studying vegetation cover, and its long series observations with low price, the NOAA/AVHRR data has been proved to be valuable for studying vegetation at regional, continental and global scale. At the same time the NOAA/AVHRR data has outstanding advantage in studying large or middle-scale vegetation distribution and dynamic variation [1-4].

Recently, the relationships between the normalized difference vegetation index and some primary climatic factors (such as average air temperature and precipitation) are important for researches of global changes. Weiss et al. researched relationships between climatic factors and regular and inter-annual vegetation in central New Mexico in USA [5]. The linear relationship between vegetation NDVI and antecedent rainfall in arid to semi-arid regions has been well documented [16-18]. In China, some scholars also have reported the relationships between main climatic factors and NDVI in different regions. The study of the spatial features of spring vegetation NDVI coupling with temperature over Northern Hemisphere presented the high relationship between the Normalised Difference Vegetation Index and air temperature [6]. Climatic factors that drove NDVI variation in China from 1983 to 1992 was reported [7]. The research of the relationship between NDVI of several typical vegetation types and seasonal and inter-annual precipitation change in northern China from 1983 to 1992, and impact of spatial distribution of precipitation on vegetation were reported [8]. The relationship of NDVI of Northeast China sampled area and climatic factors such as air temperature was reported [9]. Also some researches is in advance in relationship of the Normalised Difference Vegetation Index and precipitation in the Yellow River Basin, of which the relationship of vegetation cover and precipitation etc. is reported [10]. Sun Rui et al researched the relationship between the incomplete vegetation coverage changes and rainfall with 8km resolution multi-temporal NOAA AVHRR-NDVI databases in the Yellow River Basin from 1982 to 1999 [11]. NDVI data derived from satellite imagery to measure the different types of land use. As a particularly high and cold region. However, there was little study on the relationship of normalized difference vegetation indexes and some primary climatic factors as a particularly high and cold region in the Yarlung Zangbo River Basin. In this paper, it included the NDVI changed with temporal and spatial variation and the relationships was indicated in the Yarlung Zangbo River Basin, where the NDVI was changing corresponding with primary climatic factors.

2. The geographical position

The Yarlung Zangbo River Basin is at 27°9'~31°9' north latitude, 81°9'~97°1' east longitude. The basin's area is more than $2.4048 \times 10^5 \text{ km}^2$. The altitude of most of the basin is above 3000m. From the lower reaches to the riverhead, named JieMaYangZong glacier, the basin is composed of humid, semi-dry and semi-humid regions and arid areas.

The hydrological and meteorological stations, which lie in humid and semi-dry and semi-humid regions, are located at middle and lower reaches of the Basin (see figure 1, red points are stations). The precipitation of the Basin is specially uniform in space, and the maximum precipitation of humid regions is more than 4000mm, while, only 10mm in dry region. Similarly, the air temperature is special uniform in spatial distribution, which changes with terrain regularly. The temperature of the basin changes in the region about -20°C at headstream and approximate 40°C at the mouth of the Yarlung Zangbo River during the whole year. The great difference of main climatic factors (precipitation and average air temperature) results in different ecological and environmental conditions. In the Basin, as an index of vegetation cover, NDVI can reflect ecological and environmental

conditions and be influenced by main climatic factors. So far, there is no paper for the relationship between NDVI and main climatic factors in the Yarlung Zangbo River Basin, so it is in great significance to research the relationship between NDVI and main climatic factors in the basin.

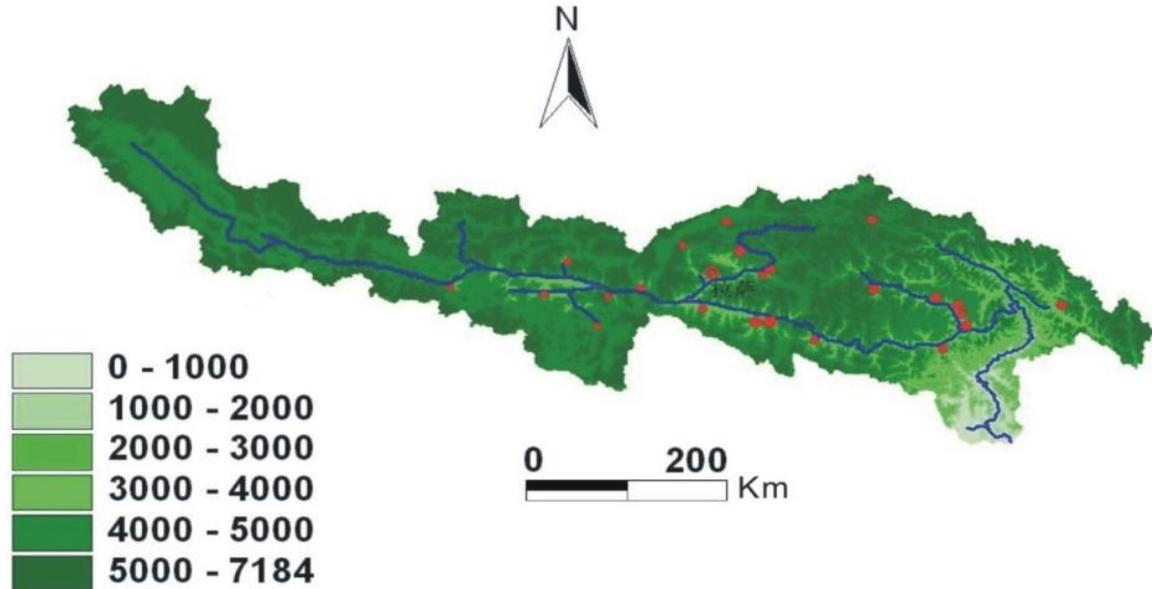


Figure 1 Geographic position of Yarlung Tsangpo River Basin and its hydrographic and meteorological stations

3. The source of data and its disposal method

3.1 The source of data

The NOAA/AVHRR data are from Earth Resources Observation System of USA, which are mainly data of daytime from Jan. 1 2001 to Dec. 31 2003. the spatial resolution of the data is 1.1km×1.1km. table 1 is the band characteristics of NOAA. The DEM(Digital Elevation Model) of the Basin is from 1:250000 digital data of National Fundamental of GIS, and the projection is longitude and latitude one, and is transferred to ALBERS projection with Arc/info. The data DEM is provided by the Institute of Chinese Academy of Sciences (CAS), the monthly data of precipitation and average air temperature and Geographical Sciences and Natural Resources Research (IGSNRR) in the Basin is provided by Hydrological information center, Hydrology and Water Resources Survey Bureau of Tibet Autonomous Region.

3.2 The disposal method of data

The NOAA data is disposed of with radiometric calibration、 geometric rectification、 mosaic data and ALBERS projection. The definition of NDVI is got by reflectivity of the first channel of AVHRR (visible light) and second channel (near- Infrared light):

$$NDVI=(CH2-CH1)/(CH2+CH1) \quad (1)$$

Where, CH1and CH2 is reflectivity of visible light(0.58~0.68um) and near- Infrared light(0.73~1.10um), respectively.

Based on the monthly average air temperature of 2011~2013, which is got from hydrological station and meteorological station, Grid spatial data of the monthly average air temperature is obtained with method of Kriging interpolation. The average air temperature is revised with elevation when interpolating, that is, the average air temperature of meteorological stations is revised to sea-level height with elevation, then interpolated, the result is revised to actual height with DEM of 1.1 km×1.1km. When revising, the rate of air temperature decreases with elevation is 0.0065°C/m. Using ENVI, monthly average air temperatures on basin surface is obtained, then, its relationship with NDVI of the basin is analyzed.

Table.1 Band characteristics of AVHRR

Band	Spectrum scope	Resolution /km	Representative application
1	0.58~0.68	1.1	Cloud layer, Snow, ice and vegetation at daytime
2	0.73~1.10	1.1	Cloud layer, vegetation, water and Water vapor at daytime
3	3.55~3.93	1.1	Cloud layer, Snow, ice, vegetation, wate, fire examination at daytime
4	10.30 ~ 11.30	1.1	Cloud layer, vegetation and water at daytime
5	11.50 ~ 12.50	1.1	Cloud layer, Snow, ice, vegetation, Sea-level temperature at daytime

4. Temporal and spatial changes of NDVI in the basin

4.1 spatial changes of NDVI in the basin

One monthly composite NDVI figure of 2011—2013 is analyzed. As NDVI value is the largest in July and August, and its contrast in space is more obvious than that of other month in the basin, NDVI figure of August in 2013 is chosen to show vegetation cover distribution of the basin(see Figure 2). The larger value of NDVI is largely scattered in the inferior reaches and part of the middle reaches, while, the value of NDVI in the Middle-Upper reaches and headwater of the basin is smaller from Figure 2. Seeing the spatial distribution of NDVI, there is a relationship between the large value of NDVI and main branches, that is, the value of NDVI in main branches area is comparative large, correspondingly, the value of NDVI is smaller in the area far from mainstream and main branches.

4.2 Temporal dynamic changes of NDVI in the basin

In order to show temporal dynamic changes of NDVI in the basin, monthly composite NDVI figure is got from daily NDVI data of 2011—2013, and The average value of NDVI WAS calculated for the whole basin. as a result, the figure of monthly NDVI changes with time from 2001 to 2003 is obtained (seeing Figure.3). From the figure.3, it can be aberseved that NDVI of the basin changes greatly with season. The NDVI value changes smoothly before May; Between MAY and June,NDVI of the basin had a rapid creaseing ,and then,the NDVI was in higher value and kepted stably beteen June and August;From August, NDVI was decreaseing slowly, and the minimum of NDVI was abserved beteen February and March in second year. The monthly NDVI changes tendency equation of 2011-2013 is got with the method of trend analysis (seeing equation.2). Another result was obtained that NDVI value increaseed slowly from 2001 to 2003,and the general tendency of NDVI between August and December was becoming reducing from 2001 to 2003.(According to Figure 2, from 2011 to 2013, the value of NDVI was decreasing gradually. Furthermore, in every year, from August to December, the tendency of reduction was increased for the value of NDVI.)

$$NDVI_{TREN D}=0.0016T+0.1636 \quad (2)$$

Where, $NDVI_{TREN D}$ is corresponding NDVI value with trend line, and T is month(0~36). NDVI of the basin was changed greatly with season,where the mainly reason was the climatic factors.(In Yarlung Tsangpo River, climatic factors such as raining, atmospheric temperature and sunlight resulted in the value of NDVI followed commutative seasons.)

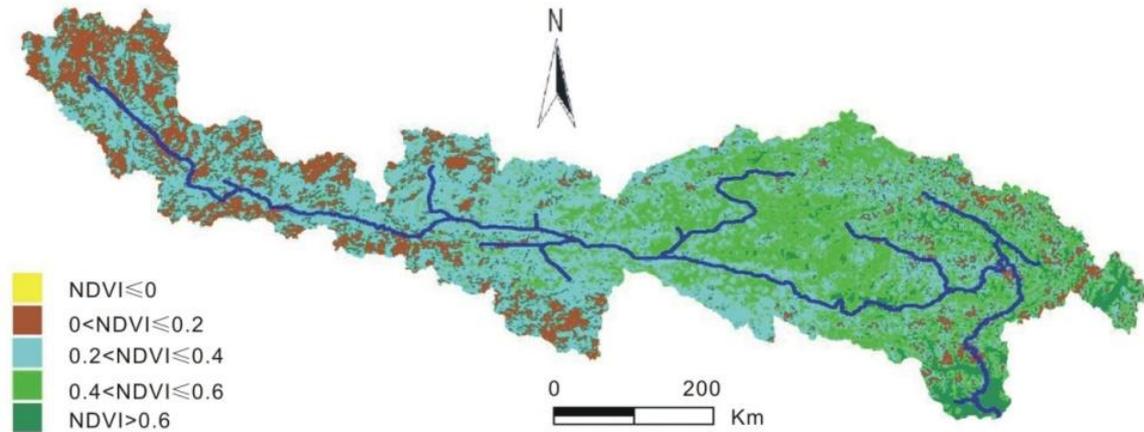


Figure 2 Spatial distribution of normalized difference vegetation index in Yarlung Tsangpo River Basin

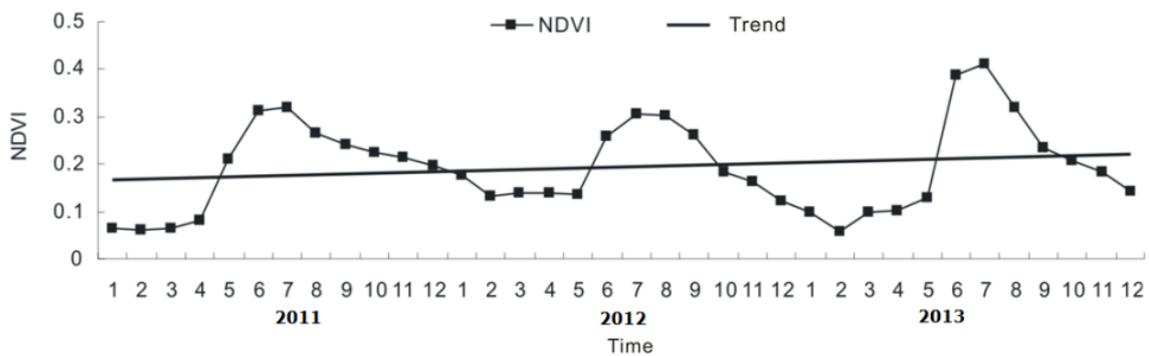


Figure 3 change of monthly normalized difference vegetation index in the Yarlung Tsangpo River Basin

5. The relationship between normalized difference vegetation index and main climatic factors

5.1 The relationship between normalized difference vegetation index and precipitation

To report the relationship between precipitation and normalized difference vegetation indexes of the basin, monthly precipitation data got from hydrological and meteorological stations is transformed to monthly precipitation spatial Grid data with the method of Kriging interpolation in the basin. Then, in the every month, the average precipitation of the basin is received with calculation. And then, the monthly average precipitation and normalized difference vegetation indexes is analyzed. It is obvious that both of the average precipitation and NDVI change with time in the every month (see Fig.4)

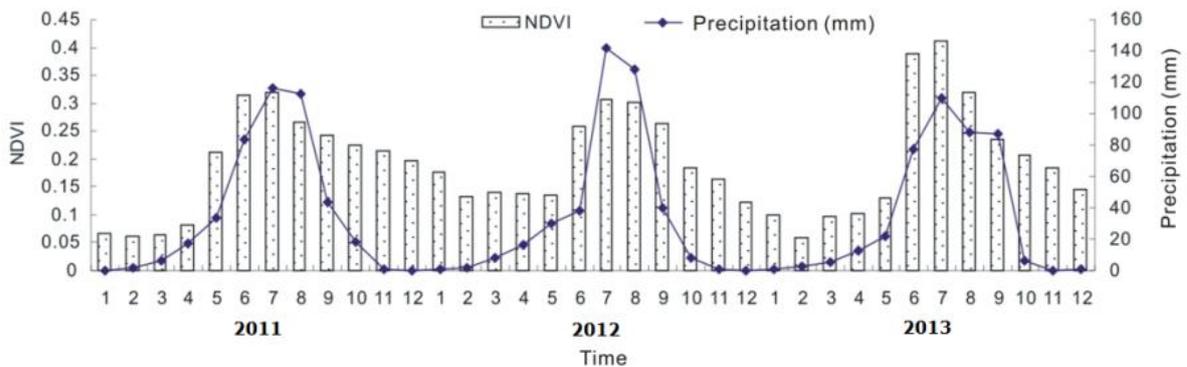


Figure 4 relation of precipitation and normalized difference vegetation indexes in the Yarlung Tsangpo River Basin

F checking and two-sample variance test were applied to s analyze the relation of precipitation and normalized difference vegetation indexes. At confidence level of 0.05, P=0, the linear and logarithmic correlation equations is got with correlation analysis:

$$NDVI=0.0017P+0.1334 \tag{3}$$

$$NDVI=0.0289\ln (P) +0.1299 \tag{4}$$

Where, P is precipitation.

From 2011 to 2013, linear correlation coefficients of precipitation and normalized difference vegetation indexes is about 0.8, and the logarithmic correlation coefficient is 0.71, which indicates that precipitation is one of the most important factors that influences NDVI in the basin.

5.2 The relationship between NDVI and average air temperature

To report the relationship between NDVI of the basin and average air temperature, the monthly average air temperature data got from hydrological and meteorological stations is transformed to monthly average air temperature spatial grid data accompanied with DEM by using the method of Kriging interpolation, wich is analyzed with NDVI. It is can be seen clearly that both NDVI and the monthly average air temperature change greatly with time (see Fig.5).

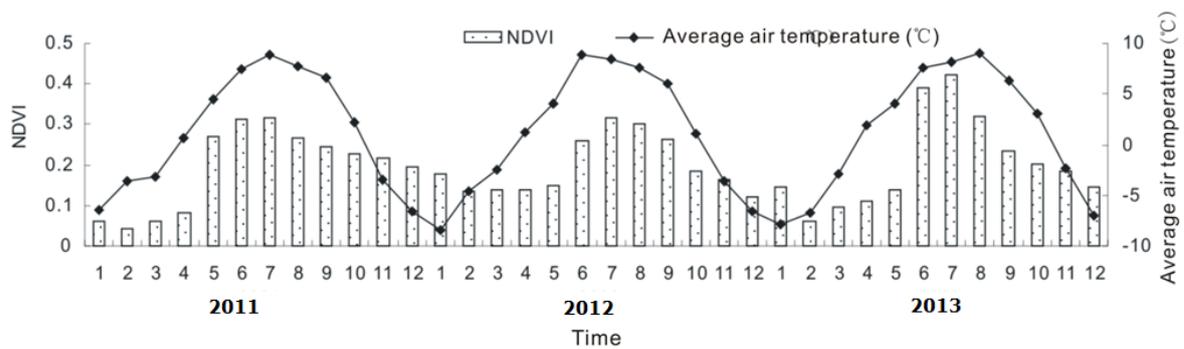


Figure 5.the relation of average air temperatures and NDVI in the Yarlung Tsangpo River Basin

From Figure 5, the average air-temperature increases three months ahead of NDVI, F checking and two-sample variance test were used to analyze the relation of NDVI and the monthly average air temperature, at confidence level of 0.05, P=0, The linear and logarithmic correlation equations of the average air temperature and normalized difference vegetation indexes is obtained with correlation analysis:

$$NDVI=0.0123Ta +0.1334 \tag{5}$$

$$Ta =7.2301\ln (NDVI) +13.842 \tag{6}$$

Where, Ta is average air temperature of the basin.

From 2011 to 2013, the logarithmic correlation coefficient is 0.7 and the linear correlation coefficient of NDVI and average air temperature in the every month is about 0.76, which indicates that precipitation is one of the main factors that influence the NDVI in the basin.

6. Conclusion

As an index of denoting vegetation cover, the change of NDVI reflects the condition of the vegetation cover in the basin. The air temperature and precipitation are the main factors which influenced vegetation cover of the basin. The paper analyzes temporal and spatial distribution of the normalized difference vegetation indexes in the basin, and then, analyzes the relationship between the normalized difference vegetation indexes and average air temperature or the relationship between the normalized difference vegetation indexes and precipitation. The following conclusions are obtained:

- (1).Larger value of the relationship between the normalized difference vegetation indexes is distributed in the inferior reaches and part of the central-point reaches, while the value of NDVI in the Upper reaches and headwater of the basin is smaller. Generally speaking, the NDVI value increases

gradually from upstream to the downstream of the basin,. The value of NDVI is comparatively large in mainstream or main branches and nearby area.

(2) NDVI value changes small from February to April, and NDVI value increases rapidly after May, and NDVI value is largest and keeps stable from June to August, and then, the NDVI value reduces slowly until February of the next year. The NDVI values from 2011 to 2013 is analyzed that annual mean NDVI value increases slowly.

(3). Average air temperature and precipitation in the basin are main climatic factors that influenced the change of NDVI. The change of NDVI is generally consistent with the changes of average air temperature and precipitation in time, which changes greatly with season. The change of precipitation is consistent with the change of NDVI in the basin in time. While average air temperature increases ahead of NDVI three months. The relation of precipitation and normalized difference vegetation indexes or average air temperature and normalized difference vegetation indexes is analyzed with F checking at confidence level of 0.05, which indicate both of correlation analysis has larger confidence. The linear correlation coefficient of precipitation and normalized difference vegetation indexes is 0.8, and the logarithmic correlation coefficient of precipitation and normalized difference vegetation indexes is 0.71. And the linear correlation coefficient of average air temperature and normalized difference vegetation indexes is about 0.77, and the logarithmic correlation coefficient of average air temperature and normalized difference vegetation indexes is 0.7.

(4). The NOAA/AVHRR data is obtained only from 2011 to 2013, which needs to be got more in the following research. Moreover, vegetation cover interpreted from NOAA data should be proved with underlying surface vegetation type in the basin.

In the future work, it will be integratedly analyzed that the vegetation coverage in river basins and underlying surface vegetation type in the basin with NOAA data.

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