Estimation of Net Primary Production (NPP) of Inner Mongol in China by MODIS Data

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Abstract: Remotely sensed data can be used to estimate biomass production using methodologies relating vegetation indices to light absorption or to leaf photosynthetic capacity. The considerations of both light absorption and photosynthetic capacity in remote sensing-based modeling to estimate biomass production or NPP was introduced based upon Monteith model NPP is one of a evaluation of land degradation. NPP was estimated from annual maximum NDVI by MODIS data. It was known that NPP of the grassland that except the forest and the farming ground was distributed between 50-200g /m2.
Keywords: MODIS, Biomass, Vegetation Index

1. Introduction

In the latter part of 1970's, it was emphasized that fixed-quantity of global land vegetation must be calculated more precisely, because of necessity of estimating carbon income and expenditure with a global level. According to the record of Mauna Loa, it is clear that CO2 density of atmosphere is increasing. This is caused mainly by human activities and breathing of the animals and plants. CO2 income and expenditure amount does not agree with value of artificial source and natural one which is sinking into ocean and land. It became clear that correct measured value of the primary production of land in a global scale is lacking. The calculation methods of primary production are as follows,

1. approach of ecology
2. approach of climatology
3. approach of satellite vegetation.

In the case of ecological approach, result is correct, for sampling is done directly on the ground, but it will take long time to get samples globally. A representative method of climatological approach is global circulation model (GCM) using temperature or precipitation. There is doubt in the reliability of prediction result that global temperature increases 4 degrees Celsius by model output. It is necessary to estimate not only global vegetation classification but also energy/ material flow and NPP quantitatively, for solution of problems in earth ecology. Therefore approach of satellite vegetation such as model of Monteith was suggested. By using satellite data, application with a global level is immediately possible, and it has higher estimate precision in what it binds a model of ecosystem together. Shimada et al. analyzed relationship between vegetation index and biomass using pattern decomposition method as a study around Mongolia. Honda et al. developed vegetation model which is application into satellite data in even wide grassy plain and Yokoyama et al. estimated primary production using NOAA/AVHRR data for dry grassy plain such as inner Mongolia. However, application study in different area is difficult because of biomass changes from different plants having different characteristics. In this study, we analyzed and compared Hohhot with a Naiman area of Inner Mongolia using in situ observation data (biomass of each vegetation and reflection measurement) since 1999 to 2002. In addition, we estimated vegetation biomass in wide area by vegetation index which was pursued from Terra/MODIS data

2. Characteristic of a study area

Inner Mongolia ward is temperate zone of the north inland of China, east contacts with north part Da Hinggan Ling, west part contacts with Helan Shan. Inner Mongolia has a characteristic of the topography, which was the immensity / evenness, and the others were between 1,000-1,500 meters above the sea level. So Pacific monsoon is shut out in Da Hinggan Ling, this area is clearly dry natural environment. The biggest dry area of north China is an advantageous condition for growth of perennation, dry and low temperature

plants. This area has very long history in stock farming, the number of animals increased 5 times after grazing, this is one of the reason of desertification advanced by over-grazing. Wide area taboo grazing by animal, was a countermeasure of desertification since 2002. Natural plants of Inner Mongolia ward are a step basically. The perennation, dry and low temperature plants can grow easily in stock constitution as a characteristic. Most of the grass is a kind of gramineous while the others are mixed with many kinds of mongrels or shrub. Within 4 months from June to September, it rained 80-90 % of year-precipitation at 200-400 mm. Precipitation decreases gradually from the east to the west. Temperature falls steadily from south to north, but most of the grass dies suddenly in the middle of September as it becomes cold. As humidity decreases from east to west, it changes from Gramineae to Compositae and Leguminosae. Most of Gramineae and a Leguminosae plants are eaten by domestic animal. Different kinds of plants have leaves arranged in different direction, and have different size of a stems too.

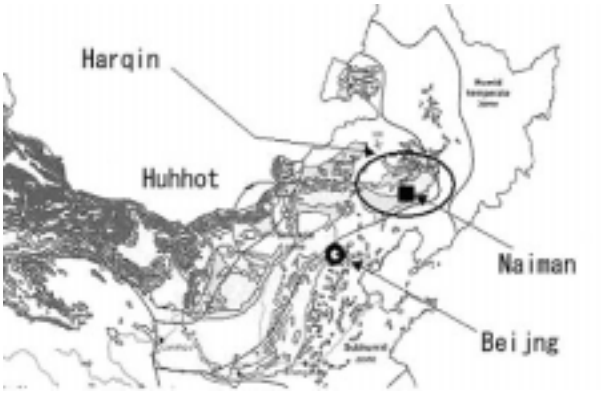

Fig. 1. Study area

3.Relationship between vegetation index and biomass by in situ observation

3.1) Yearly variation of vegetation index of biomass

The ground observation was done from May to September at 1999, 2001 and also was done in August, 2002 around Harqin and Hohhot by measuring dry weight (biomass) of cut down grasses. As ground investigation method, we set unit area of 1m*1m every observation positions and investigated about species composition, concentration rate and covering rate of grasses. In addition, we measured spectral radiation every unit area and calculated biomass of grasses. Dry weight was measured by a method of drying at 65 degrees Celsius in oven for 24 hours. We had dried grasses at 80 degrees Celsius for 48 hours in Japan but upper method was general measurement in dry area such as China. Figure 2 shows relationship between biomass and vegetation index from May to August around Harqin grassland (an experiment area : grazing was restricted zone). X axis express an vegetation index (NDVI), Y axis is expressed as log scale (biomass : g/m2). In May, we can know that vegetation index and biomass are increasing with passing time, as shown in figure 2. However, we can be realized that regressive equation is different in vegetation index with biomass. Here, X axis express an vegetation index (NDVI), Y axis is expressed as log scale.

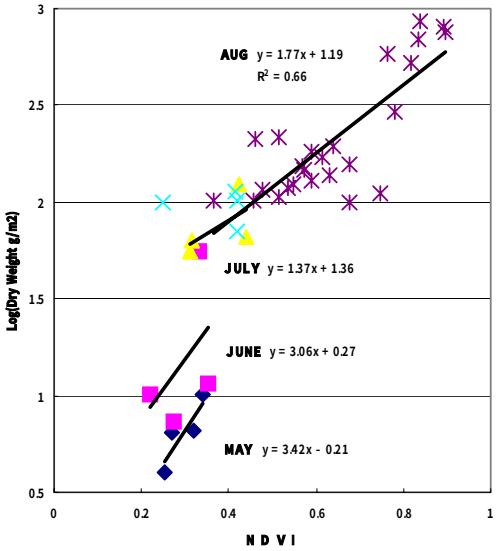

Fig.2. Yearly variation of NDVI and Biomass

3.2) Relationship between Biomass and vegetation index

In general, gramineous grass is distributed over Inner Mongolia broadly. But the ground changes from Gramineae to Compositae and Leguminosae if the precipitation and humidity decreasing. As a gramineous characteristic, sliced shape of a stem is circle, and leaves are long and thin, and distribution structure is broad. Therefore we can understand why does biomass little even though vegetation index is high. A characteristic of Leguminosae, which matures into one place greatly, is different from Gramineae such as broad distribution structure. In addition, biomass is big even if vegetation index is low for high ratio of stem/leaf. Figure 3 is in situ observation data around Hohhot in the middle of August, 2002. We know that biomass and vegetation index distribution of Gramineae and Compositae resemble, but they are different from Leguminosae. Most of researcher has suggested vegetation index using characteristics of spectral reflection of vegetations. Vegetation absorbs the spectrum in visible band, but reflects it in near-infrared band. Here, RED express reflection in visible level (red), NIR is relfection in near-infrared level and BLUE express reflection in visible level (blue). Ratio Vegetation Index(RV) has the minimum as 0, and the maximum is unsettled. As covering rate of

ground is bigger and overlap of leaf is more, Normalized Difference Vegetation Index(NDVI) is bigger. Non-vegetation (mainly, soil) was not considered, as a weak point. A range is normalized within -1 - 1. As Soil Adjusted Vegetation Index(SAVI), which is expanded conception of NDVI, is normalized by a soil adjustment factor of L, Background Effect can be controlled by a minimum. It is known that a value of L varies with vegetation amount, generally we can get good results if L is set 0.5. Modified Soil Adjusted Vegetation Index (MSAVI) is one of the convenient vegetation index which is independent parameter on a biomass amount. This index can control background effect of a minimum without other index. It is effective in high value of biomass using Enhanced Vegetation Index (EVI), which minimizes aerosol and Background Effect of the atmosphere. It is one of a normal product (MOD13) of Terra/MODIS data to use a blue band of a visible level. Because NOAA/AVHRR data do not use a blue band, EVI cannot be calculated. There are many kinds of vegetation index, such as DVI, PVI, OPVI, APVI, WDVI, GVI, GEMI. We showed the results of regressive analysis of vegetation index (NDVI, EVI) with biomass in Figure 4. For a result, it was known that decision coefficient of NDVI is higher than EVI and SAVI in figure 3.
Here, X axis expresses NDVI, Y axis expresses biomass (g/m2). In this study, we estimated a ground biomass using regressive analysis by NDVI.

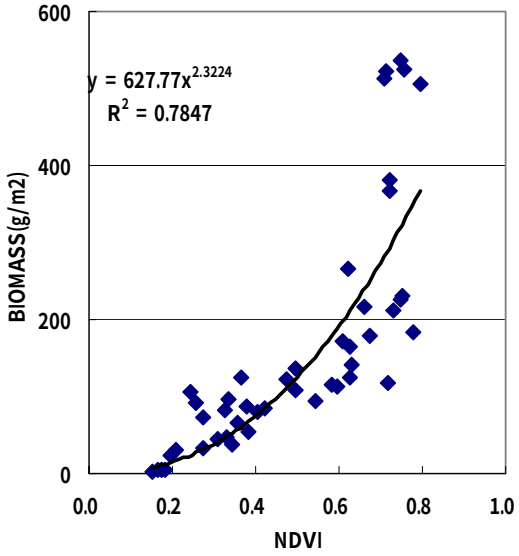

Fig. 3. Regression analysis of NDVI and Biomass

NDVI : $Y = 627.77\ X^{2.3224}$ $R^2 = 0.7847$
EVI : $Y = 3028.9\ X^{2.7815}$ $R^2 = 0.7005$
SAVI : $Y = 3991.1\ X^{3.0497}$ $R^2 = 0.7222$
RV : $Y = 57.686\ X - 55.73$ $R^2 = 0.667$

4. Application to satellite data

4.1) Masking of forest area

The vegetation of Inner Mongolia is an actual state, and Gramineae is a dominant species.
Biomass of farmland by human activities and the forest is greatly different from other vegetation. The farm products which are used for ground observation are buckwheat noodles, foxtail millet, corn, Sorghum nervosum, kidney beans, which are mainly cultivated in Inner Mongolia. among the products, corn has greatest biomass with 2715g/m2(figure 6). In addition, it is necessary to mask forest from grassland and farmland because forest has very big biomass. In the research made from April to October a profile of NDVI was revised by the TWO method to remove the cloud effect. It did forest mask making on the basis of Chinese vegetation map (1/1,000,000). The corn which was C4 vegetation had to be removed, but this time only mask making forest was made because farmland information was not enough.

4.2) Biomass estimation by satellite data

It estimated biomass of Inner Mongolia with regression equation of NDVI and biomass from ground observation.
As a result, biomass was estimated 30-150 g/m2 near Hohhot and 50-200 g/m2 near Naiman. In addition, there are farmlands near the river so it is estimated to have 200-500g/m2 biomass.

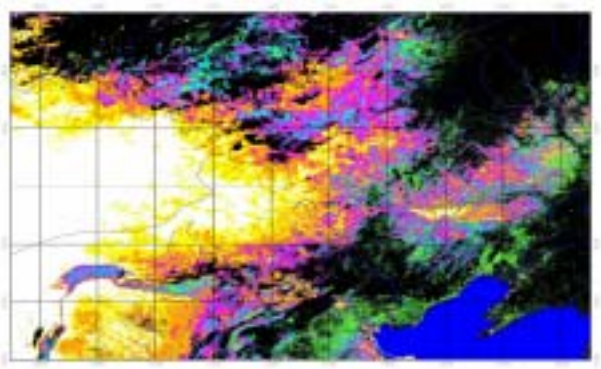

Fig. 4. Biomass map

5. Summary and a future study

We estimated a biomass of Inner Mongolia from maximum yearly-vegetation index, which is provided by satellite observation.
As a result, we knew that the grassland was distributed between 50-200 g/m2 mainly.
In the future, it must be studied about a mixture model and also investigated about linear correlation between vegetation index and biomass.

Acknowledgement

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