Land surface temperature (LST) estimation using satellite data NOAA-AVHRR over Mongolia.

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Abstract

Mongolia is an agricultural country.The limiting factor in agriculture in Mongolia is availability water (moisture) during the crop growing period (April-October). Therefore the assessment of land surface temperature is highly useful in estimation of the soil moisture and in agriculture of Mongolia.

The goal of this research is to study the land surface temperature (LST) using channels 4 and 5 from NOAA-AVHRR data and to compare it with normalized difference vegetation index (NDVI) during the crop growth period in Mongolia. NOAA-AVHRR derived NDVI will be used for assessing the vegetation cover and in conjunction with the land surface temperature also to assess the soil moisture tendency. Global data sets of GAC data base used to compare the land surface temperature (LST) in good and deficit rain years to develop an understanding of the response. The information will be useful in estimation of the surface soil moisture tendency of arable land and pastures in Mongolia.

Introduction:

Land surface temperature is the most important parameter in the vegetation and soil moisture assessment. One of the main determining the daily variation of the active surface temperature is the state of the vegetation cover. LST has a strong dependence on weather condition and vegetation cover. The slore of the morning tempearture increase as a function of Normalized Difference Vegetation Index (NDVI). LST and surface soil moisture are related. Therefore, in the future study we will try to use LST information for the estimation of surface soil moisture tendency. The moisture provision during the growing period depends on soil moisture and precipitation.

Increase in LST causes decrease in the soil moisture.

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For LST estimation we have used thermal data of channel 4 and 5 from NOAA-AVHRR satellite, which has 5 channels in visible and infrared regions. The channel 4 gives information from the band 10.3-11.3 μm and the channel 5 collects from the band 11.5-12.5 μm.

The estimation of the line defining the relationship between NDVI and LST can be very difficult and often ambiguous task (Nemani and Ruunning 1989; Goward and Hope 1990). Mixtures of varying surfaces such as clouds and water with vegetation and bare soil can cause a wide range in temperature for any given NDVI, leading to a LST/NDVI relationship for which an accurate definition of slope becomes untenable.

Land vegetation plays an important role in the transfer of matter and energy from the surface of the earth to the atmosphere. The main processes involved are evapotranspiration and net photosynthesis.

Methodology:

The land Surface Temperature (LST) for each pixel will be calculated using brightness temperature derived from thermal channels 4 and 5 from NOAA-AVHRR by assuming the surface emmisivity. This approach is designed to reduce atmospheric water vapor attenuation in the thermal infrared radiance (TIR) region (Price 1984). The following formula:

$$LST = T_{ch4} + 3.3\,(T_{ch4} - T_{ch5})$$

Was used a simple model for calculation of LST.

Used data:

- Channel 4 and 5, NDVI decadly (10 days) NOAA AVHRR data from the Local Area Coverage (LAC) between 1984 - 1991.
- Biweekly NDVI data from CD ROM between 1985 - 1991.
- Spring wheat crops in Mongolia between 1961 - 1996.
- Latitude and longitude parameters at four stations of Mongolia.
- Geographic, Administrative, Natural zoning, Soil, Cultivated area maps of Mongolia.

Results and discussion:

Calculation of Land Surface Temperature (LST).

From channel 4 (Fig 1) and 5 (Fig 2) images we have calculated the land surface temperature (LST) using the Price's formula for four periods of good year (1985) and dry year (1990) using a simple model (Fig 3) for Mongolia.

Fig 1. Channel 4 image for the second decade of July 1985 (Mongolia)

Fig 2. Channel 5 image for the second decade of July 1985 (Mongolia).

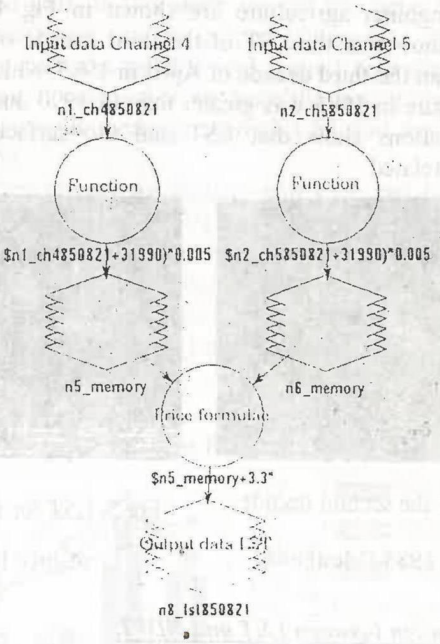


Fig 3. The simple model for calculation LST.

Earlier we have analyzed spring wheat crops (1961 to 1996) in the central agricultural region of Mongolia. The division of years into good and bad years [6] is based on previous investigation.

Based the crop growth cycle, the four periods are categorized as:

- The third decade of April, has been selected as the first period, which shows the beginning condition of the cultivation in Mongolia.
- The second period is the second decade of May, which shows the sowing condition of the growing period in Mongolia.
- The third period selected the second decade of July, which is the peak growing period in Mongolia.
- The fourth period is selected the third decade of August, which is the maturity condition of the growing period in Mongolia.

LST were calculated for the 4 selected periods of 1985 and 1990. Calculated LST for the second decade of July for good and bad years in Mongolian agriculture are shown in Fig 4 and 5. These calculations show that the LST of the third decade of April in 1990 was higher than the third decade of April in 1985, which indicates that the soil moisture in 1985 was greater than in 1990 during this period. These calculations show that LST and the surface soil moisture tendency are related.

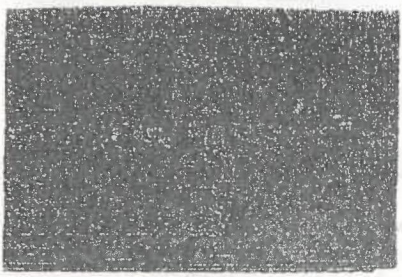


Fig 4. LST for the second decade of July 1985 (Mongolia).

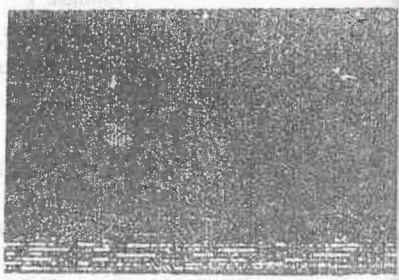


Fig 5. LST for the second decade of July 1990 (Mongolia).

Relation between LST and NDVI.

In this study we have compared LST and NDVI from NOAA-AVHRR for the peak growing period of plants in Mongolia (Fig 4, 5, 6, 7). The vegetation cover changes according the meteorological

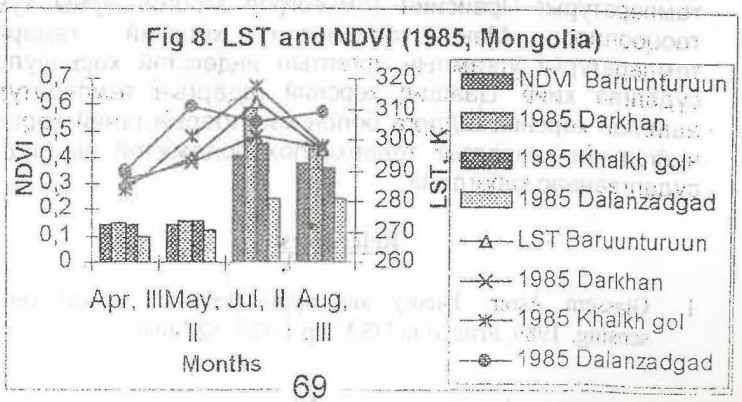
conditions. LST for the second decade of July in 1985 was cooler than LST for the same period of 1990.

Fig 6. The vegetation in the second decade of July 1985 (Mongolia).

Fig 7. The vegetation in the second decade of July 1990 (Mongolia).

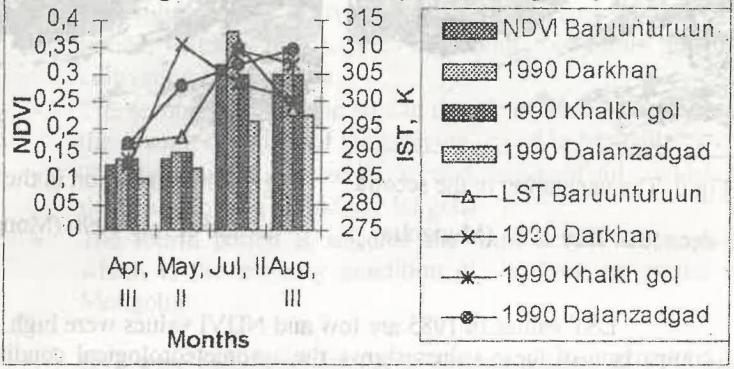
LST values in 1985 are low and NDVI values were high. The comparison of these values shows the agrometeorological conditions of 1985 were good year for agricultural crops in Mongolia and the 1990 was bad year. In this study we got the same result, which we have got earlier using only the ground station data. Therefore, we can conclude that both the satellite and ground data showed same good and bad years. It means that we have the possibility to estimate the surface soil moisture tendency through LST and the vegetation cover through NDVI.

Except images we tried to plot LST and NDVI graphically using values of LST and NDVI for 4 stations, from different natural zones of Mongolia. The Baruunturuun station is in the western part of the country in an hilly agricultural area. The Darkhan station situates in the central agricultural region. The Khalkh gol station is in the steppe agricultural area. The Dalanzadgad station is located in Gobi region.



Figures 8 and 9 show the linear relation between LST and NDVI for 1985 and 1990. If LST increases, NDVI decreases. So, the vegetation cover depends on soil moisture, which depends on LST.

Fig 9. LST and NDVI (1990, Mongolia)



Conclusions:

- The surface soil moisture tendency can be estimated by using LST.
- The vegetation cover depends on LST.
- LST and NDVI have a strong relationship.
- In the future, the surface soil moisture tendency need to be studied by using satellite data.

Товчлол:

Энэхүү ажилд АНУ-ын НОАА хиймэл дагуулын 4, 5 дугаар сувгийн мэдээг ашиглан хөрсний гадаргын температурыг Праисийн томьёогоор Монгол орны хувьд тооцооллоо. Мөн тооцоолсон хөрсний гадаргын температурыг ургамлын ургалтын индекстэй харьцуулсан судалгаа хийв. Цаашид хөрсний гадаргын температурыг ашиглан хөрсний гадарга болон хагалбарын гүний хөрсний чийгшлийн хандлагыг тодорхойлох боломжтой нь бидний судалгаанаас харагдлаа.

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