

# Comparing Optical and Microwave Remote Sensing-based Vegetation Density over Mongolia for 1988-2006

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**Abstract – Vegetation density plays an important role in water and energy balance. Satellite-based optical and microwave sensors are expected to provide complementary vegetation information. Here we compared NDVI from AVHRR and vegetation optical depth (VOD) from SSM/I over Mongolia from 1988 through 2006. Both products show similar spatial distribution in annual average and are able to capture similar inter-annual variations. However, the long term changes reflected by them are divergent. Microwave based VOD shows considerable decreasing trends over grassland, whereas NDVI shows slight declines and even increasing trends. Further investigations are required to identify the causes for their divergence.**

**Keywords: Remote sensing, Optical, NDVI, Microwave, Vegetation Optical Depth (VOD)**

## 1. INTRODUCTION

The Normalized Difference Vegetation Index (NDVI), derived from the Advanced Very High Resolution Radiometer (AVHRR) series of satellites (first launched in 1981), is one commonly used satellite-based long term vegetation greenness product (Tucker et al., 2005). It can provide a relatively high spatial resolution product (up to 1km), but is affected by the state of the atmosphere and clouds and is limited to monitoring the canopy level. Satellite-based passive microwave instruments have shown the capacity to monitor the total above ground vegetation biomass at global scales, albeit at relatively coarse spatial resolution (>10km) (Shi et al., 2008). The advantages of microwave based approaches are the near all-weather retrieval capacity and deeper penetration capacity into the canopy. Therefore NDVI and passive microwave vegetation products are expected to be complementary and provide more reliable vegetation information when combined.

To better understand the similarities and differences between these two independent vegetation products, we compare NDVI from AVHRR and vegetation optical depth (VOD) - a measurement of vegetation density - retrieved from the Special Sensor Microwave/Imager (SSM/I) over Mongolia for the period from 1988 through 2006. During this time Mongolia experienced considerably increasing temperature and decreasing precipitation (Badarch et al., 2009). In addition, the population of goats increased dramatically due to the world demand for cashmere products (Chimedtseren, 2006). Therefore the vegetation in Mongolia is expected to have changed due to both climatic and human-induced factors.

Section 2 describes the NDVI and VOD data used in this study in more details. Section 3 presents the comparison of results in terms of annual average, inter-annual variations and long-term changes. The last section puts forward suggestions for future studies.

## 2. DATA

The NDVI product, derived from AVHRR instruments on-board the National Oceanic and Atmospheric Administration (NOAA) platforms, is provided in the Global Inventory Monitoring and Modeling Studies (GIMMS) (see <http://glcf.umiacs.umd.edu/data/gimms/>) dataset (Tucker et al., 2005). VOD products used in this analysis are VU University Amsterdam – NASA (VUA-NASA) passive microwave products derived from SSM/I (Owe et al., 2008).

Prior to this study, both NDVI and VOD products were re-sampled into 0.25° and aggregated to monthly averages from 1988 through 2006. A temperature mask was developed based on ERA-Interim reanalysis data (publicly available on the ECMWF Data Server at 1.5° resolution

[http://data-portal.ecmwf.int/data/d/interim\\_daily/](http://data-portal.ecmwf.int/data/d/interim_daily/)). The NDVI from AVHRR and VOD from SSM/I were masked when the reanalysis indicated surface temperature below 0°C or non-zero snow depth.

### 3. METHODS AND RESULTS

#### 3.1 Annual Averages

The spatial distribution of annual average NDVI and VOD from 1988 through 2006 are displayed in Figure 1. These two independent products show similar spatial patterns. Low values are observed over the southern Gobi regions, high for forests in northern Mongolia, and moderate over pastureland and cropland regions situated in between these areas.

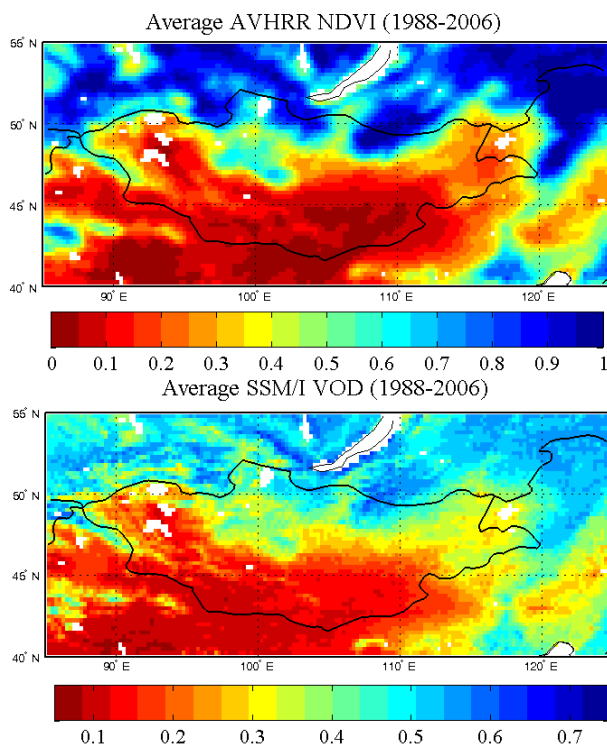


Figure 1. Annual average NDVI and VOD during 1988-2006. For better visualization purpose, the NDVI scale is set up to 0.05-0.75.

#### 3.2 Inter-annual Variations

The monthly average NDVI and VOD for August 2003 (a wet year) and 2004 (a dry year) are displayed in Figure 2. The inter-annual variations between 2003 and 2004 can be clearly observed in NDVI and VOD. For example, over central Mongolia (45°N–50°N, 100°E–110°E) and northeast Mongolia (45°N–50°N, 110°E–120°E), NDVI and VOD values for August 2004 are clearly lower than those in August 2003.

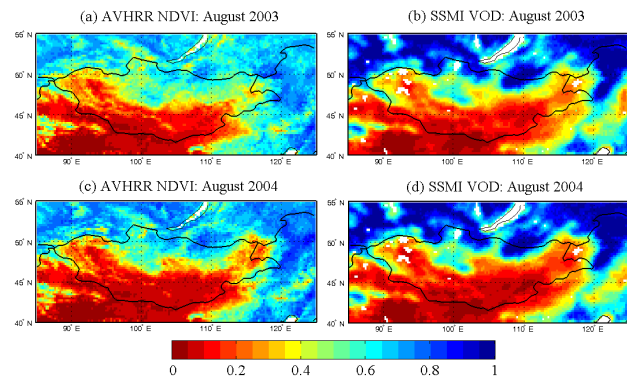


Figure 2. Monthly NDVI and VOD for August 2003 and 2004.

#### 3.3 Long-term Changes

Trends in annual mean NDVI and VOD from 1988 to 2006 based on Mann-Kendall analysis are displayed in Figure 3. It can be seen that nearly all regions covered by herbaceous vegetation experienced considerable declines in VOD. Decreasing trends in NDVI can also be observed, but not as considerable as VOD in terms of magnitude and spatial extent. Over central-west Mongolia, slight increasing trends in NDVI are observed. Trend analysis was also conducted on the annual maximum monthly NDVI and VOD (see Figure 4). The results seem similar as Figure 3.

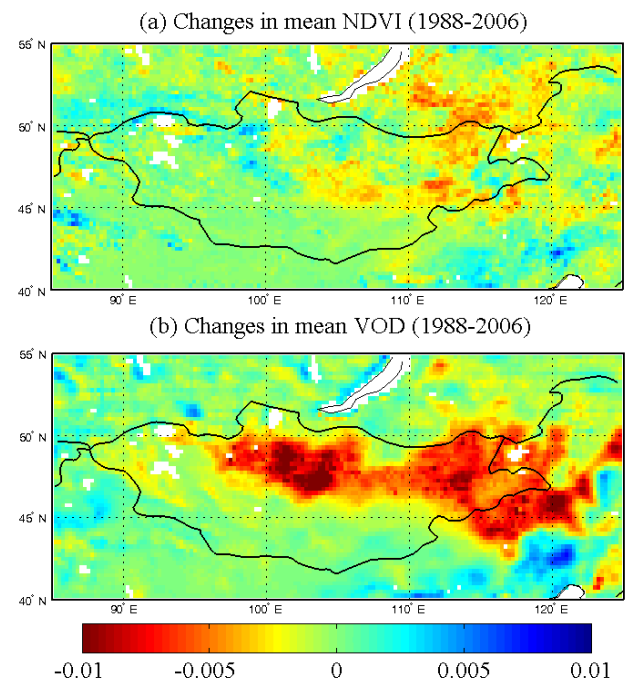


Figure 3. Trend in annual mean NDVI and VOD during 1988 – 2006 using Mann-Kendall analysis.

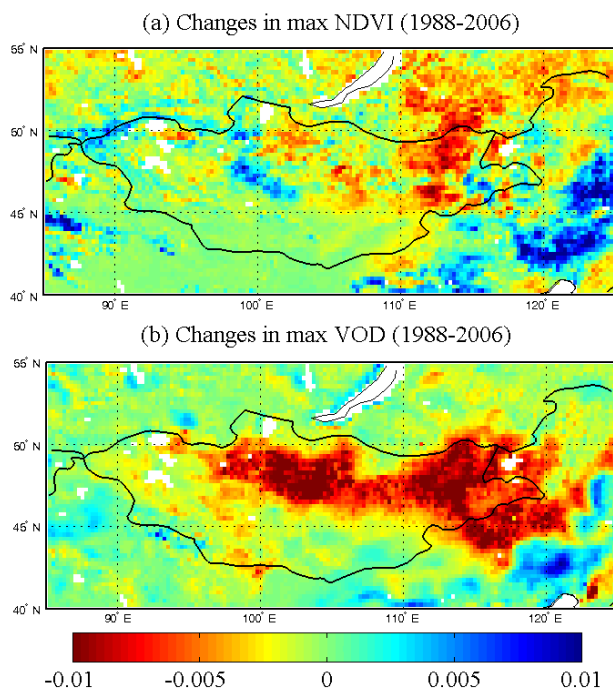


Figure 4. Trend in peak monthly NDVI and VOD of each year during 1988 – 2006 using Mann-Kendall analysis.

#### 4. Conclusions

In this study, we compared AVHRR NDVI and SSM/I VOD over Mongolia for the period from 1988 through 2006. They show similar spatial distribution in annual average. Low values are observed over the southern Gobi regions, high for forests in northern Mongolia, and moderate over pastureland and cropland regions situated in between these areas. In addition, both products capture similar inter-annual variations between wet 2003 and dry 2004.

However, their long term changes during 1988-2006 are divergent. Nearly all regions covered by herbaceous vegetation experienced considerable declines in VOD, particularly over central and eastern Mongolia. Only slight declines in NDVI are observed. To understand the causes for their divergence, further investigation are required in future analysis.

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