TREND ANALYSIS FOR DETECTING LAND DEGRADATION OF MONGOLIA USING MODIS NDVI TIME SERIES DATA

Munkhdulam Otgonbayar

Institute of Geography and Geoecology, Mongolian Academy of Sciences, Ulaanbaatar, Mongolia

munkhdulamo@mas.ac.mn

Co-author: Renchinmyadag Tovuudorj, Bayanjargal Bumtsend

Abstract: Accurate assessment of land degradation is a global need, especially in arid and semi-arid regions. In practice, synergistic uses that integrate field and long term observational studies are more significant. Observation data with long term as vegetation can acquire from remotely sensed data that can be used for assessing land degradation. Because satellite sensors including light detection and ranging (LiDAR), radio detection and ranging (RADAR), and multi-spectral images provide highly informative remote measurements at different spectral, spatial, and temporal resolutions which can be used to detect mapping and monitor of land degradation for decision-makers dealing with environmental management. The aim of this study is to assess land degradation using trend and sen's slope. Time series analysis used MODIS normalized difference vegetation index (NDVI) data with a resolution of 250 m, 16-day composites for the period 2002-2019. For detection of land degradation used trend analysis methods including linear regression model, and Sen's Slope. Regression slope values were derived, and trend maps covering Mongolia at a 250 m were generated that takes account of each time series vector significance.

Keywords: Time series analysis, residual trend analysis, Sen-slope value, land degradation

Introduction

Land degradation is a global issue recognized by the United Nations conventions on climate change, biodiversity, and combat desertification (UNEP, 1992, 2007; UNCCD, 1994; UNCED, 1992). There are numerous different definitions, giving the idea of the complexity of the phenomenon (Middleton and Thomas, 1997; Cherlet et al., 2018). In the United Nations Convention to Combat Desertification (UNCCD), and United Nations Environmental Programme used more inclusive definitions:

Land degradation is a long term through which reduction of biological, economic productivity, and loss of heterogeneity in the landscape (UNCCD, 2004). Land degradation is a long term loss of ecosystem function and services, caused by disturbances from which the system cannot recover (UNEP, 2007), and it effects on food security, livelihoods, and production. Land degradation is associated with carrying capacity, resilience, and sensitivity of land, also to the susceptibility of people living on and from this land (Zorn and Komac, 2013).

Moreover, the UNCCD adopted land degradation neutrality (LDN) in 2015. LDN is defined as a "state whereby the amount and quality of land resources necessary to support ecosystem functions and services and enhance food security remain stable or increase within specified temporal and spatial scales and ecosystems" (Kust et al., 2017). LDN in which no land is lost to degradation at the bottom line and was adopted as a common target under the Sustainable Development Goals (SDG).

Over the past two decades, two kinds of methods have been widely used to assess land degradation or changes land productivity (Rishmawi and Prince, 2016; Higginbottom and Symeonakis, 2014). The first approach for degradation analysis is to assess change in vegetation phenology derived from remotely sensed time-series imagery (Xu et al., 2020; Atzberger et al., 2014; Eerens et al., 2014; Atzberger and Eilers, 2011; Beck et al., 2006). The second approach for degradation analysis is to detect changes in the relationship between climate variables and a VI which is an estimate of vegetation greenness and a proxy assessment of land degradation (Yengoh et al., 2015; Bai et al., 2008). In the second part, the most widely used method is the Residual trend (RESTREND) analysis (Evans and Geerken, 2004).

Data and Method

In this study used MODIS time series normalized difference vegetation index (NDVI) data with a resolution of 250 m, 16-day composites, combined TERRA and AQUA sensors (MCD13Q1) for the period 2002-2019 from the Land Processes Distributed Active Archive Center (LP DAAC). Times series of NDVI are vital important data sources for environmental monitoring (Atzberger et al., 2014). To assess land degradation used trend analysis methods including the linear regression model, and Sen's Slope.

Firstly, we used ordinary least square (OLS) regression model. The OLS minimizes the sum of the squared residuals and it is widely used in environmental studies. This method measures the linear relationship between dependent and independent variables. In this study, time was defined as the independent variable and the NDVI value as the dependent variable. The accurate trend measures are highly influenced by the variability and autocorrelation of the noise process (Weatherhead et al., 1998). Therefore, the number of years needed to give the trend significance. There are widely used two methods to detect trend significance includes Sen's Slope and Mann-Kendall test. Mann Kendall is a non-parametric statistical test. This test measures consistency of a trend (Kendall, 1938). The test is a cumulative value of the instances of increases or decreases from a pairwise comparison, with values of +1 indicating a continually increasing and −1 a continually decreasing trend (Higginbottom and Symeonakis, 2014).

Sen's Slope is a non-parametric method requiring the test data independent and insensitive to missing and abnormal data. In our research used basic Sen's Slope equation (1) (Sen et al., 1968) to detect trend significance.

$$\boldsymbol{Slope} = \boldsymbol{Median}\left[\frac{x_j - x_i}{j - i}\right] \qquad (1)$$

Where and are the values at times and, respectively ($1 \leq \boldsymbol{i} < \boldsymbol{j} \leq \boldsymbol{n}$). n is time-series data length. The slope sign reflects data trends, highlighting the rate of variation of the time series data. Slope >0 means the upward trend and the slope <0 means the downward trend. For data analysis used the R statistical program (R Development Core Team, 2008).

Result

This study applied the MODIS 16-day composite NDVI time series for 2005-2019, to detect land degradation of Mongolia. Time series vectors were analyzed for trends using regression analysis. Regression slope values were derived, and trend maps covering Mongolia at 250 m were generated that takes account of each time series vector significance (Figure 1, 2).

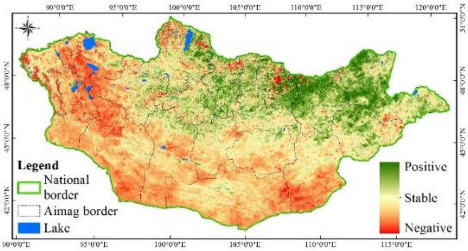

Figure 1. Linear regression trend analysis derived from 16-day composite MODIS NDVI data from 2005 to 2019

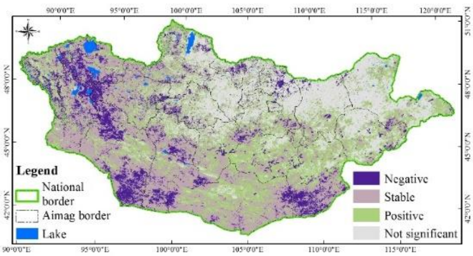

Figure 2. Significance slope value for trend derived from 16-day composite MODIS NDVI data from 2005 to 2019

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