Corrigendum

Corrigendum to “Mann-Kendall Monotonic Trend Test and Correlation Analysis using Spatio-temporal Dataset: the case of Asia using vegetation greenness and climate factors” [MethodsX 5 (2018) 803–807]

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A B S T R A C T

The Earth Trends Modeler (ETM) is an earth observation software tool that allows for modeling environmental changes and trend analyses of earth observation data. We used Global Inventory Modeling and Mapping Studies (GIMMS)-Normalized Difference Vegetation Index-3rd generation (NDVI3g) and Climatic Research Unit Time Series (CRU-TS) for climate data. We applied Mann-Kendall Monotonic Trend (MKMT) test using the ETM for changing trend analyses, correlation and multiple regression for analyzing relationship between vegetation greenness and climate factors. These methods are effective approaches for conducting long-term monitoring and correlation analyses in broad area using satellite data. These methods were used to analyze the long term data, but mostly focused on national scale study. Our study expanded the methodological applicability over the whole Asia during the last 33 years. In addition, we used spatio-temporal data such as vegetation greenness, rainfall, temperature, and potential evapotranspiration in order to estimate changing trends and relationship analysis of vegetation greenness and climate factors.

* The authors deeply regret that the original version of our article published in MethodsX 5 (2018: 803–807) (10.1016/j.mex.2018.07.006) has duplicated the title, “Long-term trend and correlation between vegetation greenness and climate variables in Asia based on satellite data” and large portion of the contents from our original paper at STOTEN (Science of the Total Environment) 618 (2018: 1089–1095) (10.1016/j.scitotenv.2017.09.145) [1]. We would like to express our deepest apologies for any inconvenience caused by the duplication. We, all co-authors, did not use our paper at MethodsX 5 before this corrigendum as our publication. Along this line, we would like to ask readers to cite our original paper at STOTEN [1], not our duplicated paper at MethodsX. Our corrigendum version of the paper at MethodsX is presented below.

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MKMT test was an applicable method for broad area and analyzed the increasing or decreasing trends using time series dataset with a predetermined level of significance.

The correlation and regression analysis were suitable and useful methods to estimate spatial relationships between vegetation greenness and climate factors in the long term period.

Method details

We identified the changing trends of the vegetation greenness, temperature, rainfall, potential evapotranspiration using Mann-Kendall Monotonic Trend (MKMT) over the last 33 years in Asian region [1]. Moreover, the relationship between vegetation greenness (a dependent variable) and the three climatic factors (independent variables) were analyzed using the multiple regression and the correlation.

For analyzing the changing trends, we used the MKMT of the Earth Trend Modeler (ETM). The ETM is a one of applications of TerrSet, providing effective tools for the analysis of trends and the dynamic characteristics of environmental phenomena [2]. The TerrSet software was developed from IDRISI GIS and Image Processing tools [2]. The TerrSet is the user-friendly software containing various geospatial tools without requiring additional extensions [3]. The following the figure illustrates overall structure of methodology (Fig. 1).

Changing trend analysis

We used MKMT test for the changing trends of vegetation greenness and climate factors (rainfall, temperature, and potential evapotranspiration). The MKMT test illustrates a non-linear trend test, which calculates monotonic upward and downward trends over certain time period. It also evaluates the degree of similarities between two sets of ranks given by the same datasets [4]. This test uses the number of inversions with the pair of datasets. The datasets are required to transform one rank order into another one to demonstrate the steadily increasing and decreasing trends. It varies from −1 to +1. The +1 value is the continuously increasing trend and shows a trend that never decreases. The value −1 and 0 show the decreasing and no consistent trend [4]. For instance, the MKMT test is the non-parametric method applied to identify trends on the Advanced Very-High-Resolution Radiometer (AVHRR) data in regional level [5]. The previous researches used to analyze the vegetation greenness based on temperature, rainfall, and Normalized Difference Vegetation Index (NDVI) in the local and regional level such as rainfall [6], drought [7,8], and temperature [9] in global level [10].

In our proposed method, we applied the trend analyses over Asian region using the satellite-based vegetation data and the gridded climate data over a period of 33 years [1]. We used monthly climate data for the same period as the NDVI time series (1982–2014), including monthly average temperature, rainfall, and evapotranspiration for all the seasons from January to December, totaling 1,536 data points from 384 months. We changed the cell size to 0.083-deg (degree grid cell) resolution, which is the same as NDVI data (8 km), with 1,319 columns and 598 rows covering all the climate data using ArcGIS 10.2 version. We computed trend analysis each factor and each in the all months and summer, winter season for eight times.
Fig. 1. Structure of methodology.
Relationship analysis

We used correlation and multiple regressions between vegetation greenness and the climate factors such as rainfall, temperature, and potential evapotranspiration. The correlation coefficient (R) is a strong measure for analyses of a linear relationship among variables. The coefficient of determination (R²) is the ratio of the variation of a response variable with the explanation by a fitted statistical model. We are able to evaluate single correlation coefficient (R) and coefficient of determination (R²) analyses among the variables from the linear correlation between NDVI and temperature, rainfall, and potential evapotranspiration by assessing the per-pixel from 33-year processed monthly datasets (January 1982 to December 2014). Annual time steps (starting from January 1982) were to examine how it influences the climate drivers and vegetation growth [11]. Nicholson and Farrar [12] mentioned that local differences in the relationship between NDVI and precipitation came from soil, vegetation types, and their individual rain use efficiencies considering respective intercropping of rainfall and slopes for each pixel.

The proposed method used correlation and regression to find the relationship between the vegetation greenness and climate variables [1]. Per-pixel slope, intercept terms, and a spatially explicit coefficient of determination were used as the auxiliary input data to run the ETM of the TerrSet software package. The models were calculated using the 33-year series, containing data for 396 months on each factor and 33 independent annual series. We estimated relationships between vegetation greenness and each climate factor in the all months and summer, winter season for six times.

Data

We used Global Inventory Modeling and Mapping Studies (GIMMS)-Normalized Difference Vegetation Index-3rd generation (NDVI3g) [13] for vegetation greenness and Climatic Research Unit Time Series (CRU-TS) data [14] for three climatic variables.

Remotely sensed vegetation data (GIMMS-NDVI3g)

The GIMMS-NDVI3g dataset is the latest version of NDVI [11]. This product was created by the AVHRR satellite of the National Oceanic and Atmospheric Administration (NOAA) of the United States. The NDVI3g data was recorded from July 1981 to December 2015 with 8 km of spatial resolution and calculated, based on monthly NDVI from January to December.

Gridded climate data (CRU-TS)

Daily maximum temperature (°C), rainfall (mm per month), and potential evapotranspiration (mm per day) from CRU-TS were modified as monthly data [15]. The CRU-TS 3.2 version data were established in 2012, based on the 4,000 meteorological data stations with 0.5-deg resolution (approximately 55 × 55 km). In this study, we used monthly average temperature, precipitation, and evapotranspiration from January to December for the same period as the GIMMS-NDVI3g time series (1982–2014). Total 1,152 data from three climate factors were prepared and transformed cell size to 0.083-deg, similar to that of NDVI3g data (8 km), with 1,311 columns and 598 rows into all the climate data.

Data processing

Our data acquisition consisted on pre-processing and post-processing. In the pre-processing, we used ArcGIS 10.2 version, and the post-processing was done by TerrSet. As CRU-TS and GIMMS-NDVI3g data were provided as NetCDF format from the original source, we converted NetCDF data to single raster format (RST). After that, we converted them into the same resolution and imported into TerrSet software, which it was converted to RGF (Raster Group File), TSF (Time Series File), and prepared for the post-processing.
1 Downloaded all data between 1982–2014 GIMMS-NDVI3g, daily maximum temperature (°C), rainfall (mm per month), and potential evapotranspiration (mm per day).
2 Convert all data from NetCDF to monthly data in raster format (RST).
3 Extraction process of all data.
4 Convert all data for the same resolution, row & column, and data type.
5 Convert all data by each factor to RGF (Raster Group File).
6 Convert all data by each factor to TSF (Time Series File).
7 Simulate the ETM. If applying one data with different formats or resolutions, the data leads to malfunction. Thus, the most critical procedure is the data preparation.

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