Postprint: Spatiotemporal Variation Characteristics of EVI in the Gurbantunggut Desert, 2000-2018

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Abstract

Based on MODIS-EVI data and employing simple linear regression, Empirical Orthogonal Function (EOF), and coefficient of variation, this study analyzes the spatiotemporal variation characteristics of Enhanced Vegetation Index (EVI) in the Gurbantunggut Desert from both temporal and spatial dimensions. The results indicate that from 2000 to 2018, the interannual variation of overall EVI in the Gurbantunggut Desert exhibited a significant increasing trend, with a growth rate of 0.0160 · (10a)-1 ($P<0.01$), and the interannual variations of EVI in fixed dunes, semi-fixed dunes, and mobile dunes also demonstrated significant increasing trends. During the growing season, the variation trends of EVI for the desert as a whole and for different dune types were broadly consistent, gradually increasing from March and reaching the annual maximum in June-July. EVI in most regions of the Gurbantunggut Desert showed an upward trend, with notably increasing areas concentrated primarily in the southern margin of the desert and the reclamation areas on the western margin, while the upward trend was relatively modest in the desert hinterland, and regions with decreasing EVI were mainly distributed in the northern part of the desert. Areas with greater EVI fluctuations in the Gurbantunggut Desert were located on the western and southern margins, with the most substantial fluctuations occurring in the reclamation areas on the western margin, while EVI fluctuations were relatively small in the desert hinterland. EVI can effectively reflect vegetation cover changes in desert regions dominated by fixed and semi-fixed dunes, and the vegetation conditions it portrays hold important reference value for the spatial classification of regional desert geomorphic types.

Full Text

Spatiotemporal Change of EVI in the Gurbantunggut Desert from 2000 to 2018

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Abstract

Based on MODIS EVI data, the spatiotemporal change of EVI in the Gurbantunggut Desert was studied using one-dimensional linear regression analysis, empirical orthogonal function (EOF), and variable coefficient analysis. The results showed that the interannual variation of EVI in the Gurbantunggut Desert from 2000 to 2018 was in a significant increase trend with an increase rate of $0.0160 \cdot (10a)^{-1}$ ($P<0.01$), and this trend was also significant on fixed dunes, semi-fixed dunes, and mobile dunes. The variation trend of EVI in the whole desert and different desert types was similar in the growth season. From March, EVI increased gradually and reached the highest value during the period from June to July. The EVI was in an increase in most areas of the Gurbantunggut Desert, especially in the southern and western marginal zones; the increase trend was low in the hinterland of the desert, and the areas with a decrease of EVI were mainly distributed in the northern part of the desert. The areas with high EVI fluctuation were mainly distributed in the southern and western marginal zones of the Gurbantunggut Desert; the fluctuation of EVI was the most significant in the western marginal zone, and it was low in the hinterland. EVI can be used to reflect the change of vegetation coverage in the desert with fixed and semi-fixed dunes, and these results have important reference significance for spatial division of regional desert types.

Keywords: EVI; spatiotemporal change; empirical orthogonal function (EOF); Gurbantunggut Desert

1. Introduction

The Gurbantunggut Desert is the second largest desert in China, and monitoring its vegetation dynamics is crucial for understanding ecosystem responses to climate change. Previous studies have utilized the Normalized Difference Vegetation Index (NDVI) for vegetation monitoring [**?**, **?**]. However, the Enhanced

Vegetation Index (EVI) offers improved sensitivity in high-biomass regions and better atmospheric correction capabilities. This study employs MODIS EVI data to analyze vegetation change patterns across different dune types in the Gurbantunggut Desert from 2000 to 2018.

2. Data and Methods

2.1 Study Area and Data Sources The study area encompasses the entire Gurbantunggut Desert region in Xinjiang, China. The desert classification map was derived from the 1:100,000 geomorphological atlas of China [Figure 1: see original paper]. MODIS EVI data (MOD13Q1 product) at 250m spatial resolution were obtained for the period 2000-2018.

2.2 Data Processing The Savitzky-Golay filter was applied to smooth the EVI time series data and reduce noise [**?**, **?**]. This filtering method uses a moving window polynomial regression to preserve the shape and features of the time series while suppressing high-frequency noise. The filter operates according to the principle of local least-squares polynomial approximation, where the coefficients are determined by the window size and polynomial order [**?**].

2.3 Empirical Orthogonal Function (EOF) Analysis EOF analysis was performed to extract the dominant spatial patterns of EVI variability. The first two EOF modes explained 96.86% and 99.16% of the total variance, respectively . This indicates that the first two modes capture the primary characteristics of EVI spatiotemporal variation in the Gurbantunggut Desert.

2.4 Trend Analysis Linear regression analysis was conducted to detect temporal trends in EVI at both pixel and regional scales. The significance of trends was tested at $P<0.05$ and $P<0.1$ levels. The variable coefficient (Cv) was calculated to assess the magnitude of interannual fluctuation.

3. Results

3.1 Interannual Variation of EVI The overall EVI in the Gurbantunggut Desert showed a significant increasing trend from 2000 to 2018, with a rate of 0.0160 per decade ($P<0.01$). This increasing trend was consistent across all dune types, including fixed dunes, semi-fixed dunes, and mobile dunes.

3.2 Seasonal Variation of EVI During the growth season (March-October), EVI exhibited similar variation patterns across different desert types [Figure 4: see original paper]. EVI began to increase gradually from March, reaching its peak value during June-July. The maximum EVI values ranged from 0.0429 to 0.1066, with the highest values occurring in July (0.0922) and remaining relatively stable through September (0.1066). The minimum EVI values ranged from 0.0551 to 0.0966.

3.3 Spatial Distribution of EVI Trends Most areas of the Gurbantunggut Desert exhibited increasing EVI trends, particularly in the southern and western marginal zones [Figure 7: see original paper]. The increasing trend was relatively weak in the desert hinterland, while decreasing trends were primarily observed in the northern part of the desert. Areas with significant EVI fluctuations (high variable coefficient) were concentrated in the southern and western marginal zones, with the most pronounced fluctuations in the western marginal zone and minimal fluctuations in the hinterland.

3.4 Statistical Significance of EVI Trends Statistical analysis revealed that 96.46% of the study area showed increasing EVI trends, with 28.91% being statistically significant at $P<0.05$ and 43.00% significant at $P<0.1$. Only 0.06% of the area exhibited decreasing trends significant at $P<0.1$.

4. Discussion

The significant increase in EVI across the Gurbantunggut Desert suggests overall vegetation improvement during 2000-2018, consistent with regional climate change patterns and ecological restoration efforts. The spatial heterogeneity in EVI trends, with stronger increases in marginal zones, reflects the influence of precipitation gradients and human activities. The EOF results demonstrate that the first two modes effectively capture the dominant patterns of vegetation variability, with the first mode representing the overall trend and the second mode likely capturing seasonal variations.

The application of the Savitzky-Golay filter effectively reduced noise in the EVI time series while preserving important phenological information. This is particularly important in arid regions where atmospheric effects and soil background can introduce substantial noise in satellite-derived vegetation indices.

5. Conclusion

This study reveals a significant increasing trend in EVI across the Gurbantunggut Desert from 2000 to 2018, with notable spatial variations. The results demonstrate that EVI is an effective indicator for monitoring vegetation dynamics in desert ecosystems, particularly for distinguishing between different dune types. The findings provide important reference values for regional desert classification and ecological assessment.

References

[7] Citation about NDVI application in desert vegetation monitoring (1981-2003 period)

[8] Citation about EVI advantages over NDVI

[18] Reference for desert classification mapping

[19] Reference for Savitzky-Golay filter application in remote sensing

[20-21] Methodological references for polynomial fitting and filter coefficients

[Figure 1: see original paper] The types and location of the Gurbantunggut Desert in Xinjiang

The variance contribution rates of the first two modes of EVI in the Gurbantunggut Desert from empirical orthogonal function

[Figure 4: see original paper] The change of EVI in different desert types of the Gurbantunggut Desert in growth season from 2000 to 2018

Statistic results of EVI trend in the Gurbantunggut Desert

[Figure 7: see original paper] The distribution of variable coefficient of EVI in the Gurbantunggut Desert from 2000 to 2018

Note: Figure translations are in progress. See original paper for figures.