CONSTRUCTING DAILY 8KM NDVI DATASET FROM 1982 TO 2000 OVER EURASIA

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ABSTRACT:

The impact of the interannual climatic variability on the vegetation sensitively appears in the timing of phenological events such as green-up, mature, and senescence. Therefore, an accurate and temporally high-resolution NDVI dataset will be required for analysis on the interannual variability of the climate-vegetation relationship. We constructed a daily 8km NDVI dataset over Eurasia based on the 8km tiled data of Pathfinder AVHRR Land (PAL) Global daily product. Cloud contamination was successfully reduced by Temporal Window Operation (TWO), which is a method to find optimized upper envelop line of the NDVI seasonal change. Based on the daily NDVI time series from 1982 to 2000, an accurate (daily) interannual change of the phenological events will be analyzed.

KEY WORDS: PAL NDVI, Daily Data, Phenology, Temporal Window Operation

1. INTRODUCTION

To predict the global environmental change, better understandings in terms of the climate-vegetation relationship are necessary. The Normalized Difference Vegetation Index (NDVI) data, which are derived from measurements of a satellite remote sensing, have a great potential to analyze the vegetation over wide areas. Suzuki *et al.* (2003) found a phenological green wave propagating from west to east over northern Asia by using weekly NDVI data, and its close relation to climatic factors.

The impact of the interannual climatic variability on the vegetation sensitively appears in the timing of phenological events such as green-up, mature, and senescence. Therefore, an accurate and temporally high-resolution NDVI dataset will be required for analysis on the interannual variability of the climate-vegetation relationship.

For the construction of NDVI data, a process to reduce the cloud contamination is necessary. Most of major NDVI datasets employed Maximum Value Composite (MVC) (Holben, 1986), a method to adopt the maximum NDVI value in a sampling time interval, to reduce that. The sampling time interval was usually set at 10- or 15-daily, and that implies the temporal resolution of the NDVI becomes 10- or 15-daily. These temporal resolutions are not enough when a detail timing shift of the phenological events caused by the climate variability is examined.

We constructed a new NDVI dataset which has daily temporal and 8 km horizontal resolutions over Eurasia by employing the Temporal Window Operation (TWO) method for reducing the cloud contamination.

2. DATA AND METHOD

2.1 Original NDVI Data

The original NDVI data were obtained from the 8km tiled data of Pathfinder AVHRR Land (PAL) Global daily product. The temporal coverage is from July 31, 1981 to December 31, 2000 with the daily temporal resolution. The data cover the global terrestrial area by 1000 x 1000 km tiles which have 8 x 8 km (125 x 125 line-pixel for a tile) horizontal resolution. This analysis used NDVIs in 101 tiles that covered Eurasia continent.

2.2 Smoothing for Horizontal Domain

Original PAL NDVI data involve noises which are apparent on a NDVI distribution map (Fig. 1). To reduce those noises, Neighbor 8-pixel Comparison Method (NECM) was applied. If the difference between a NDVI in a pixel (pixel A) and the mean NDVI of the 8 pixels (pixels E) around the pixel A exceeds a threshold, the NDVI at the pixel A is substituted by the mean NDVI of the pixels E. Threshold was set at 0.3.

Fig. 1 demonstrates an example of the noise reduction process by this method over central-south part of Russia

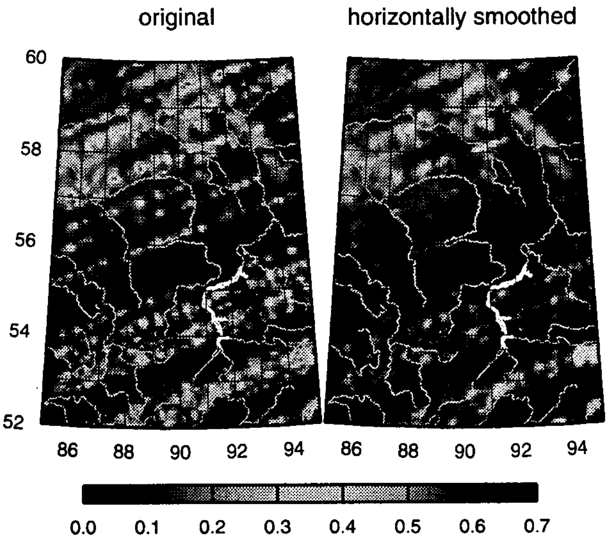

Figure 1. Example of noise reduction process for horizontal domain by Neighbor 8-pixel Comparison Method (NECM). Threshold was set at 0.3. This example is one of extreme cases contaminated by noise on April 23, 1986.

on April 23, 1986. Although NECM did not completely eliminate noises, considerable reduction of the noise was executed for NDVI distribution. The example in Fig. 1 is an extreme case that has much noise contamination, but generally this scheme can sufficiently eliminate the noise from most cases.

2.3 Temporal Window Operation (TWO)

To reduce the cloud contamination from the daily NDVI value, we employed the TWO method developed by Park *et al.* (1999) which is a method to find optimized upper envelop line of the NDVI seasonal change. The temporal resolution of the original time series is conserved after the process.

The algorithm of TWO starts at the beginning of the NDVI (start point) time series, and checks whether the NDVI for the current NDVI is equal to or greater than the previous NDVI value within the window, which includes some NDVI values (the number of values is constant, that is, the window size is fixed) of the time series. If it is higher or equal, current value is assigned as the start point of next window (new window shifted forward). If there is no higher value within the window, select the second biggest value as a next start point of next window and replacing these by linearly interpolated value from current start point to next start point.

Fig. 2 demonstrates an example of the effect of reducing the cloud contamination from NDVI data by TWO. In the original NDVI distribution (left panel in Fig. 2), it is obvious that the cloud cover conceals the land surface, and subsequently, there are large areas that shows unrealistic small NDVI. After the process of TWO (right panel of Fig. 2), such small NDVI areas disappear and high NDVIs, which extensively cover the forest zone, can be seen.

Fig. 3 compares the time series of the original daily NDVI, the daily NDVI processed by TWO with 15 days window, and the 10-daily NDVI derived by MVC. The original NDVI time series has so many depressions of NDVI due to cloud contamination. By contrast, the daily NDVI time series processed by TWO is successfully corrected for such depressions and shows a smooth seasonal change on the daily basis. The 10-daily MVC also reduces the cloud contamination from the NDVI time series, but the temporal resolution declines down to 10-daily from daily, which is insufficient temporal resolution for accurate phenological analyses.

We tried TWO with 10 days, 15 days, and 30 days temporal windows, and compared the results over northern Asia. When the window size was set at 10 days, short term fluctuations of NDVI due to cloud contamination were apparently remained. When the size was set at 30 days, such short term fluctuations were

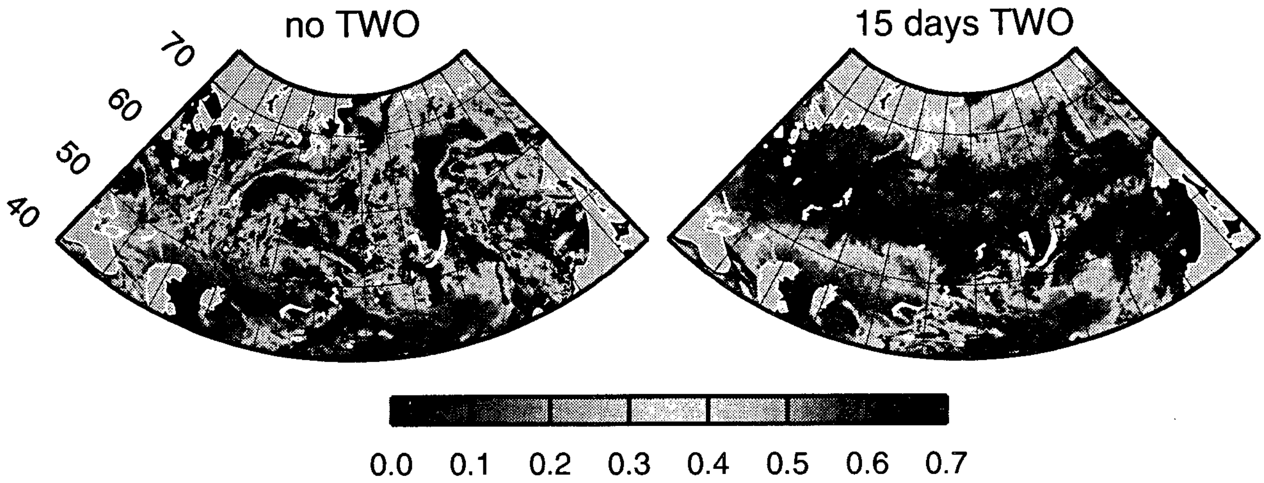

Figure 2. An example of the geographical distribution of the original daily NDVI (left) and the daily NDVI processed by Temporal Window Operation (TWO) with 15 days window (right) on July 1, 1990.

almost completely removed, while the resultant NDVI time series was too insensitive to NDVI seasonal change. Consequently, 15 days were selected for the TWO window size for the phenological analysis.

3. PRELIMINARY ANALSYS ON PHENOLOGY

Based on the daily 8 km NDVI data set that was processed by TWO with 15 days window, the 19-year mean daily NDVI was calculated for each day. Fig. 4 demonstrates the distribution of the three phenological events derived from this 19-year mean daily NDVI over northern Asia: green-up date (D-a) defined by the date when the NDVI exceeds 0.2 first time in the year, maximum date (D-b) defined by the date when the NDVI reaches to the annual maximum, and the senescence date (D-c) defined by the date when the NDVI drops below 0.2 fist time after the maximum occurrence. The threshold NDVI value, 0.2, was adopted according to Suzuki *et al.* (2003).

The geographical distribution of the phenological timing revealed by the NDVI with daily temporal resolution illustrates the characteristics of vegetation phenology in detail. Over the southern Siberia and coastal area of far east Siberia, there are regions having an extremely early D-a, before 70 day-of-year (DOY). These areas appear to be corresponded to the evergreen forest area.

D-a around the Black and Caspian Seas also shows relatively early date, around 90 DOY. The D-a north of 60°N gradually becomes later farther northward, and the D-a in tundra areas shows 170 – 190 DOY. The D-a south of 50°N is also late, especially in the arid area of Mongolia (later than 190 DOY).

D-b contains more essential information on the vegetation phenology in Siberia than D-a or D-c, because D-a and D-c will change with the definition of the threshold value (i.e., 0.2 in the current analysis) in the seasonal NDVI cycle, while the maximum NDVI is not altered by the definition.

The overall distribution of D-b was similar to D-a. D-b occurs earliest in the region north to the Caspian and Aral Seas which includes the Kazakh steppe, around 130 DOY. By contrast, D-b near the Mongolian steppe was the latest, after 240 DOY. There is a marked west-early/east-late contrast in the D-b in Kazakh and Mongolia (about 120 days) which was mentioned by Suzuki *et al.* (2003).

In the 50 – 60°N-zone, the west-early east-late gradient, that was found by Suzuki *et al.* (2003), is not obvious in D-b likely due to the difference in the source data set (Suzuki *et al.* (2003) used weekly Global Vegetation Index dataset) or the difference in years analyzed. To the north of 60°N, D-b gradually becomes later, and the latest date in the tundra area is 220 DOY, which is about 100 days later than in the earliest area.

In the map of D-c, areas with extremely early values (before 200 DOY) are seen in the Kazakh steppe area, similar to the map of D-b. D-c in tundra area also indicates early value, while D-c near Black Sea and over the coastal area of far east Siberia shows extremely late date after 340 DOY.

4. CONCLUSION

8 km resolution daily NDVI data set from 1982 to 2000 over Eurasia continent was constructed base on daily PAL data for the analysis of vegetation phenology. The cloud contamination was effectively reduced by the TWO method.

In this report, the geographical distribution of phenological timings (green-up, maximum, senescence) over northern Eurasia was demonstrated. This report has

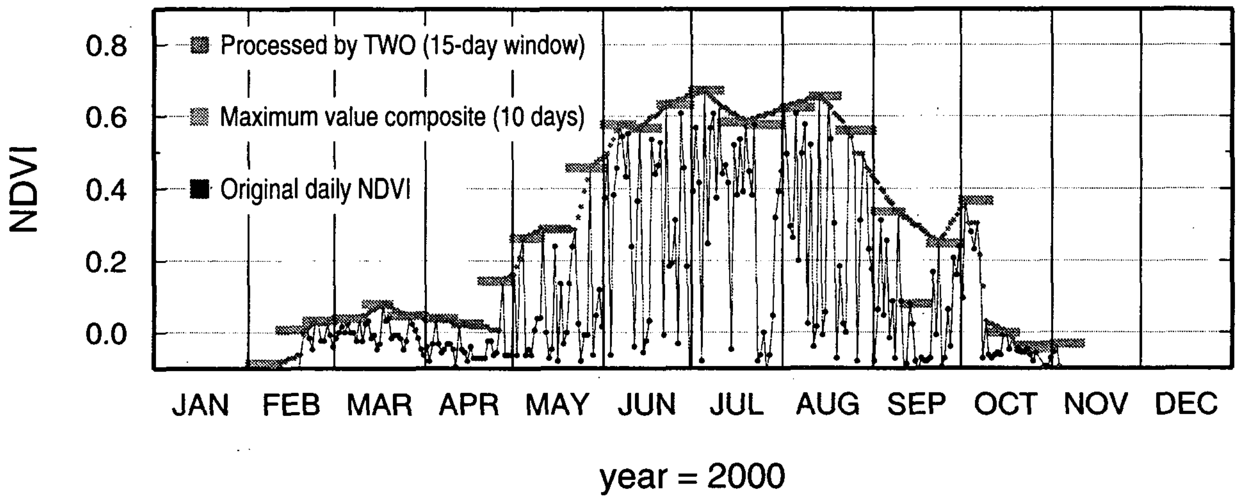

Figure 3. An example of daily NDVI time series that the cloud contamination was reduced by TWO (green) and MVC (orange) at a 8 x 8 km pixel near Yakutsk in eastern Siberia. The window of TWO was set at 15 days. The sampling time interval for MVC was set at 10 days.

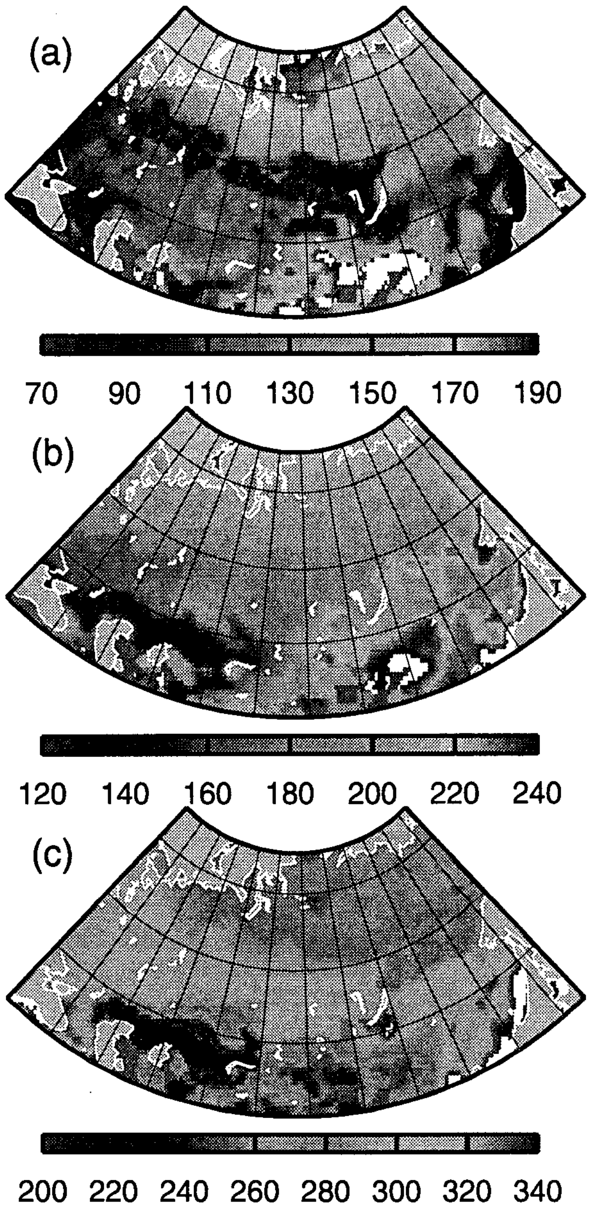

Figure 4. The distribution of the phenological timing (day-of-year) derived from 19-year mean daily NDVI which was processed by TWO. Green-up date (a), maximum date (b), and the senescence date (c).

introduced a result based on the 19-year mean value, but this daily NDVI dataset which covers from 1982 to 2000 has a great potential to examine the interannual change of the phenological timings, because of its daily resolution. Next step is to reveal the spatio-temporal characteristic of the interannual variation of the phenological event timing, and investigate the relationship to the climatic interannual variation. Finally, we plan to open and distribute this daily 8km NDVI data set to scientists.

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