Relationship between Surface Temperature in JRA-25 and Vegetation

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1. Introduction

Relationship between surface 2m temperature in the JRA-25 and annual cycle of vegetation activity derived from satellite observation is investigated in high latitude regions. Especially, relationship between increase in surface 2m temperature and growth of vegetation activity in boreal spring and early summer is investigated in view a point of snow cover retreat.

2. Data

(1) Reanalysis data

As a meteorological dataset, we use the Japanese 25-year reanalysis (JRA-25). In the JRA-25, atmospheric and land analysis are performed, and over hundred variables are produced as analyzed fields from observation data and model background field. Out of these variables, we use surface 2m air temperature (T2m) and snow depth analysis fields. In the JRA-25, T2m is analyzed with many surface observations as possible (Onogi et al., 2007). Figures 1 and 2 show distribution of averaged T2m climatology and snow depth climatology for April-June. From both figures, we find that zero Celsius in T2m is not corresponding to snow retreat lines and there is some time delay between them in Eurasia and North America. Figure 1 shows that the zero Celsius zones are laid on around 70N in northern hemisphere in this season. On the other hand, figure 2 shows that the snow cover retreat zones are laid on around 50N. Roughly speaking, it seems that latitudinal zones with around T2m=10 Celsius correspond to snow cover retreat lines in the Eurasia and North America.

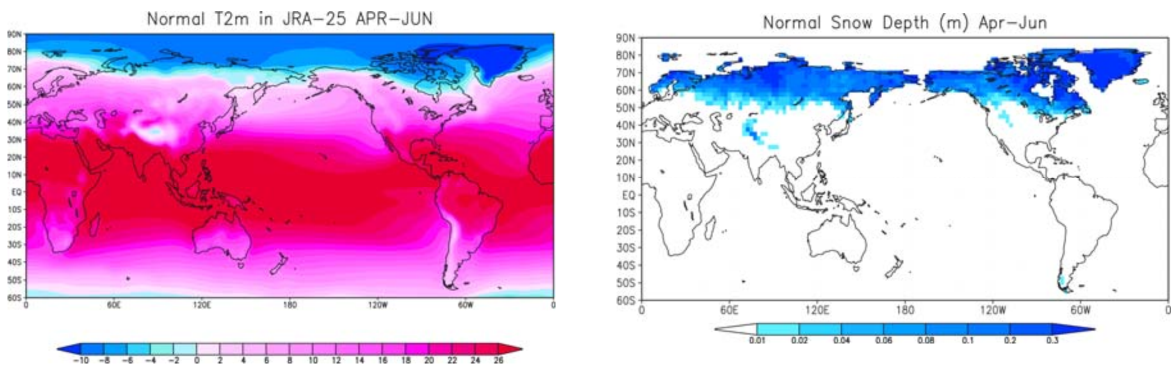


Figure.1. Distribution of averaged surface 2m air temperature climatology in Celsius (T2m; left), and snow depth climatology in *m* (right) for April-June in the JRA-25.

(2) Vegetation data

The vegetation data we used, is the normalized difference of vegetation index (NDVI) defined by

$$NDVI = (Ch2 - Ch1) / (Ch2 + Ch1),$$

derived from the NOAA satellites visible and near infrared observations. Where Ch1 is the reflectance in the visible wavelengths (0.58-0.68 um) and Ch2 is the reflectance in the infrared wavelengths (0.725-1.1 um). This is non-dimensional variable, and roughly indicates large vegetation activity for NDVI=1, and no activity for NDVI=0, because chlorophyll in plants well absorbs visible radiation, but well reflects infrared radiation. Figure 2 shows distribution of the seasonal NDVI climatology for April-June, and its seasonal variation. There are large extents of active vegetation in tropical forest regions, like Amazon, central Africa, Maritime continent, and Indochina Peninsula. As other active regions, we can find high latitude belts in the Eurasia and northern America. In contrast that the vegetation is active through whole seasons in the tropics, activity is concentrated

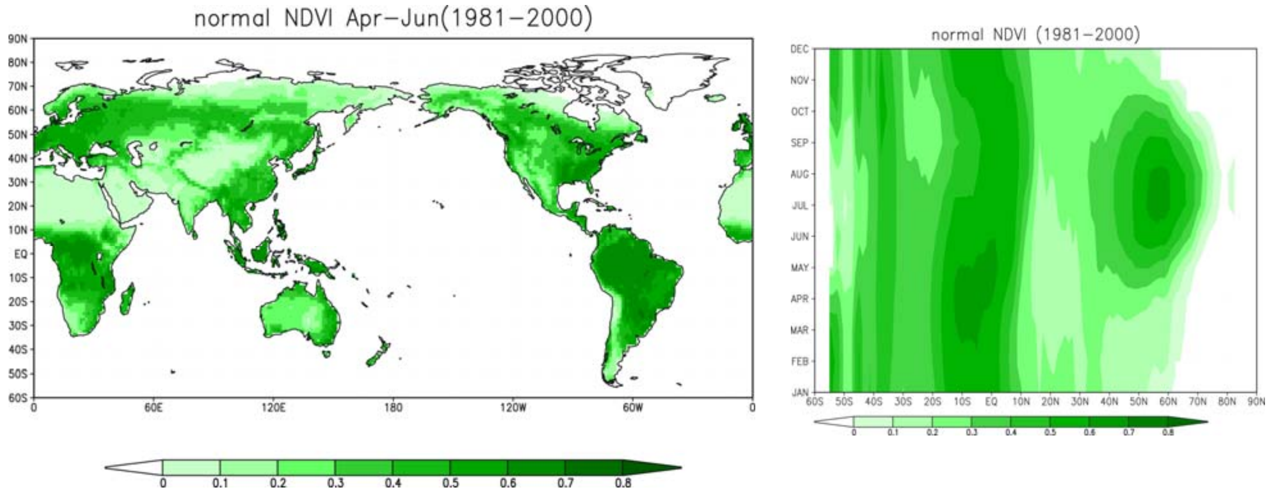


Figure.2. Geophysical distribution of the seasonal NDVI climatology for Apr-Jun (left), and seasonal variation of the NDVI climatology (right).

only in summer season in high latitude northern hemisphere. We study relationship between vegetation activity, T2m and snow depth variation in the high latitude region in northern hemisphere.

3. Correlation between T2m and NDVI

Figure 3 shows averaged correlation coefficients between monthly NDVI and T2m in boreal spring and early summer (April-June). There are large positive correlation areas over northern Eurasia and North America. Especially, high correlation areas are in north than around 50N in northern Eurasia and north than 40N in North America. Most other regions indicate negative correlation, however their amounts are not significant. Why high positive correlation concentrates in high latitude areas in the northern hemisphere?

Figure 4 shows zonal mean correlation between the monthly NDVI and T2m in the western Eurasia (40E-80E), in eastern Eurasia (80E-120E), and in North America (140W-80W). Figure 5 shows zonal mean monthly T2m and snow depth climatology in the three areas. As common features in all regions,

(1) There are northward shifting positive correlations with the seasons in the boreal spring and early summer, and southward shifting positive correlations in the boreal autumn.

(2) The snow cover retreat lines are roughly corresponding to the maximum NDVI-T2m correlation.

Therefore, we can expect that the NDVI-T2m correlation reflects dependency of growth of vegetation activities on year by year snow retreat or extension variability. In the boreal spring and early summer, snow retreat lines correspond to around 10 Celsius in T2m. On the other hand, snow extension lines correspond to around 2 Celsius in the boreal autumn.

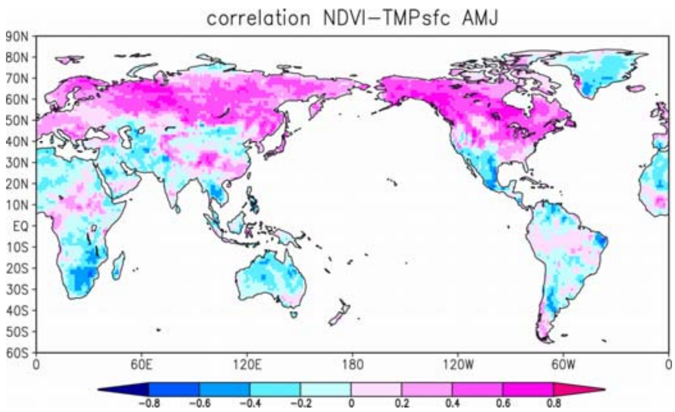
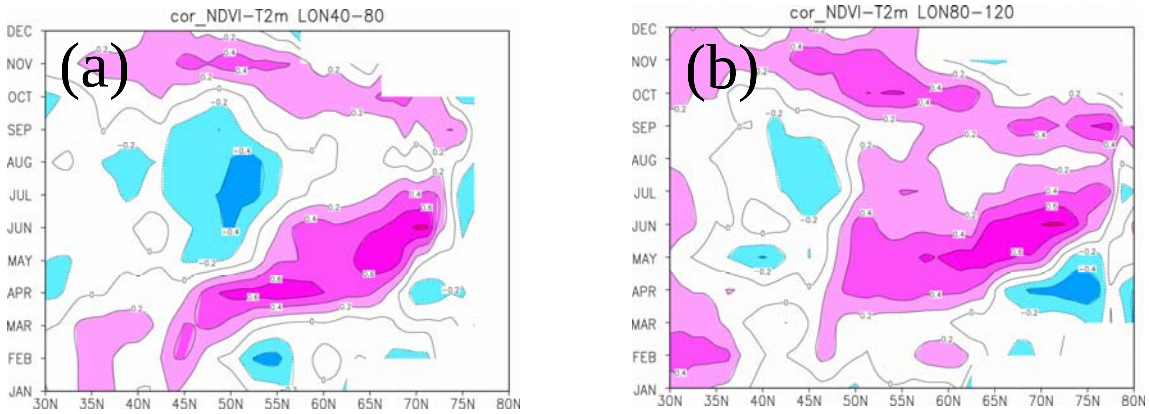


Figure 3. Distribution of seasonal averaged correlation between monthly T2m and NDVI for April-June.



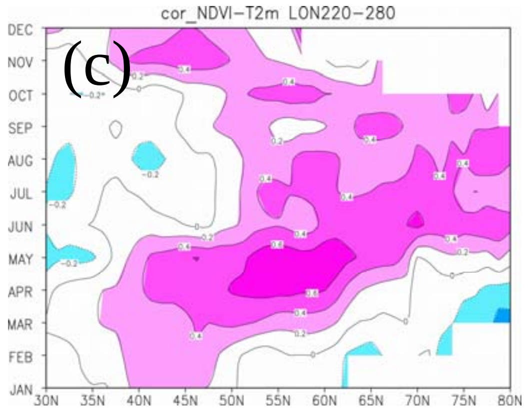
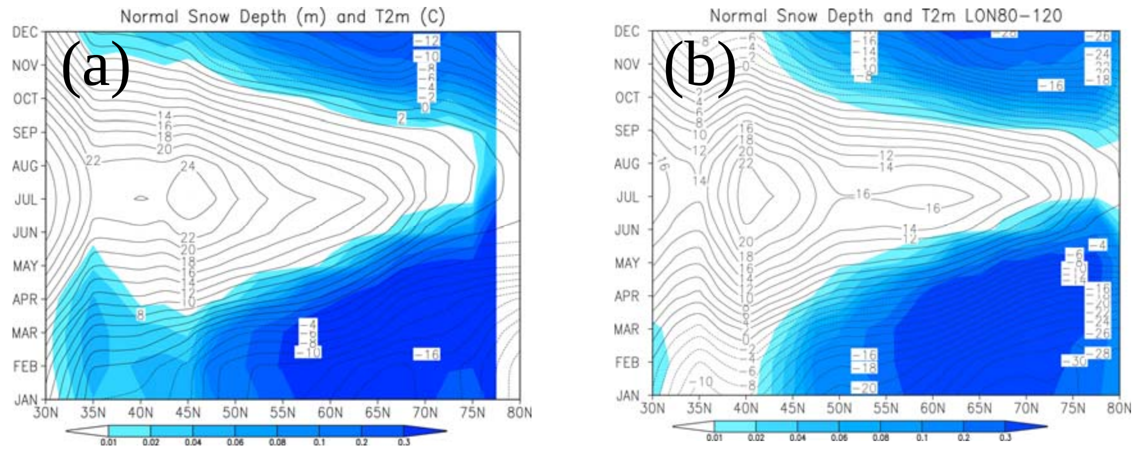


Figure 4. Zonal mean correlation between the monthly NDVI and T2m for western Eurasia (40E-80E, upper left), eastern Eurasia (80E-120E, upper right), and North America (140W-80W, lower). Vertical coordinate is season and horizontal coordinate latitude. Warm colors indicate positive correlation, and cold color negative correlation.



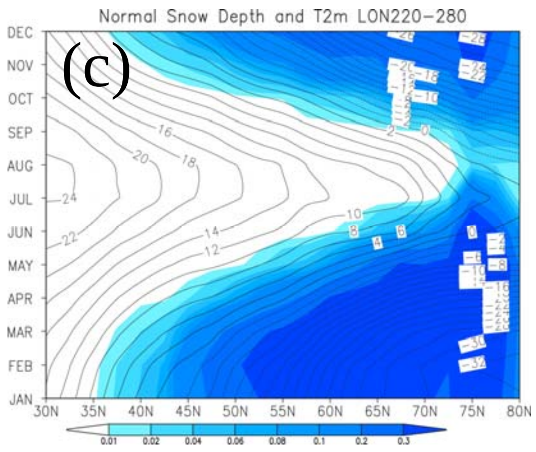


Figure 5. Zonal mean of the monthly snow depth in *m* (shade) and T2m in Celsius (contour) for western Eurasia (40E-80E, upper left), eastern Eurasia (80E-120E, upper right), and North America (140W-80W, lower). Vertical coordinate is season and horizontal coordinate latitude.

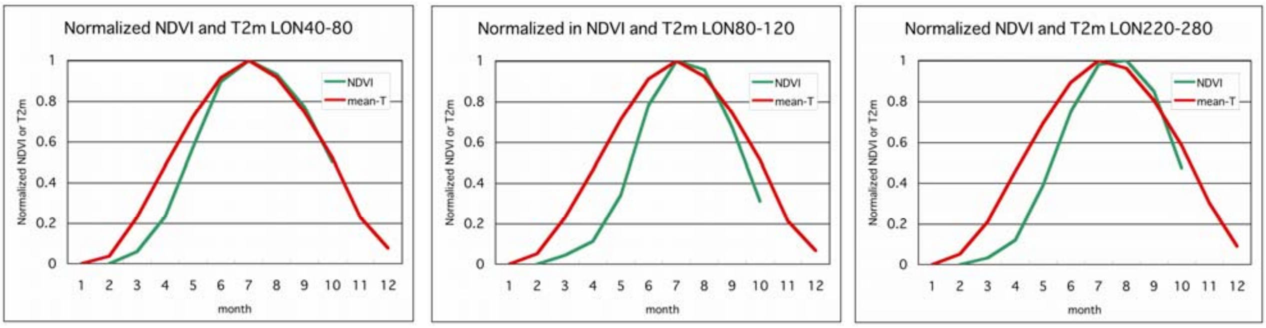


Figure 6. Annual cycle of normalized NDVI (green) and T2m (red) climatology over the western Eurasia (left), eastern Eurasia (center) and North America (right). Normalization is made with their maximum and minimum month.

4. Seasonal phase in the NDVI and T2m

We compare annual cycle of T2m and NDVI to evaluate differences in their seasonal phase in the three high latitude regions. Figure 6 shows annual cycle of normalized NDVI and T2m climatology over the three regions. We find following features.

(1) Western Eurasia (40E-80E, 50N-70N)

Spring NDVI growth is delayed by 1 month compared with T2m increase. Fall NDVI decay is in same phase with T2m decrease.

(2) Eastern Eurasia (80E-120E, 50N-70N)

Spring NDVI growth is delayed by 2 month compared with T2m increase. Fall NDVI decay is earlier than T2m decrease.

(3) North America (140W-80W, 50N-70N)

Similar NDVI-T2m relation in seasonal phase as the eastern Eurasia.

Why different phase relation between NDVI-T2m? We can consider some possibility.

(1) Due to different temperature.

Table 1 shows T2m climatology in three regions. Western Eurasia is warmer than other regions. So, we can expect earlier vegetation activity in the western Eurasia.

(2) Due to different vegetation type.

The western Eurasia is dominated with evergreen trees, on the other and, the eastern Eurasia with deciduous trees. Therefore, we can expect some vegetation activity in the western Eurasia in whole year.

Table 1 T2m climatology in boreal spring and early summer in Celsius.

	W-Eurasia	E-Eurasia	N-America
Mar	-7.8	-11.0	-12.5
Apr	0.5	-2.3	-4.6
May	8.3	7.0	3.1
Jun	14.7	14.5	9.5

5. Conclusion

We find well-defined correlation between T2m and NDVI in spring and early summer in high latitude northern hemisphere. It is considered that this relation reflects dependency of vegetation activity on snow retreat or extension variability.

There is different phase relation in T2m-NDV in three regions. To verify detailed relation and their mechanisms, further study is necessary.

Acknowledgment

The NDVI data is provided from Center for Environmental Remote Sensing, Chiba University (ftp://dbx.cr.chiba-u.jp/data/TWO).

References

Onogi, K., J. Tsutsui, H. Koide, M. Sakamoto, S. Kobayashi, H. Hatsushika, T. Matsumoto, N. Yamazaki, H. Kamahori, K. Takahashi, S. Kadokura, K. Wada, K. Kato, R. Oyama, T. Ose, N. Mannoji and R. Taira, 2007: The JRA-25 Reanalysis. J. Meteo. Soc. Japan, 85, 369-432.