Characteristics of dust event in East Asia: Focus on the Gobi Desert, and Mongolia regions

Yasunori KUROSAKI
Center for Environmental Remote Sensing (CEReS), Chiba University
E-mail: ykurosak@faculty.chiba-u.jp, ykurosaki2004@yahoo.co.jp

Abstract

This study investigated the effect of snow and vegetation covers on dust emission by the correlation analysis of strong wind frequency and dust emission frequency, where the strong wind is defined with a constant threshold 6.5 m/sec. This correlation should be high (low) where the variance of land surface environment is low (large). In addition to this idea, referring to the parameterizations of threshold wind speed by NDVI and snow cover fraction, we built four hypotheses as shown in section 3.1. However, our obtained results disagreed with these in many points, and this indicates problems in the current parameterizations. We will discuss the reasons of these disagreements and some methods will be proposed to clarify these problems.

1. Introduction

Dust gives impacts on our lives from many aspects, which are climate change via radiation process, changes in ice cap albedo, respiratory disease, cropland losses, damages on transportation, ocean fertilization, neutralization of acid rain, disease transmission, etc. Many researchers have developed numerical models of dust cycle (i.e., emission, born, and deposition processes), which have played an important role in assessing such impacts of dust. However the current models have insufficient accuracy especially in the treatment of emission process. One of the reasons of such problem is the immature skill of the treatment of geographic information system (GIS) data concerning land surface environment (e.g., soil particle distribution, soil wetness, vegetation cover, snow cover, land cover type) in dust emission model. In some models, the threshold wind speed of dust emission is parameterized by leaf area index (LAI) derived from Normalized Difference Vegetation Index (NDVI) and snow cover fraction from satellite data (Kurosaki and Mikami, 2004). When we use these parameterizations, the threshold wind speed is high in summer and winter because NDVI and snow cover fraction are large, respectively. Moreover, the interannual variance of threshold wind speed is large as well because of the large variance of NDVI and snow cover fraction.

Kurosaki and Mikami (2005) discussed the variation of land surface environment with the correlation of strong wind frequency and dust emission frequency where the strong wind is defined by a constant threshold wind speed 6.5 m/sec. This correlation should be high (low) where the variance of land surface environment is low (large). Although their analysis period is limited to spring (March, April and May), they obtained following results: (1) the correlation is high in March and April but low in May in the Gobi Desert; (2) they are high in March but low in April and May in the Northern and the Western Mongolia, whose major land cover type is grassland. These results suggest that the vegetation cover begins to suppress dust emission from April in Mongolia and from May in the Gobi Desert.

This study discusses the effect of snow and vegetation covers on dust emission with the correlation of strong wind frequency and dust emission frequency. Although the analysis period is limited to spring in Kurosaki and Mikami (2005), we calculated the correlation coefficient of each month from January to December. From this analysis, we discuss the interannual variance of land surface environment in each month in each region.

2. Data and method

In the discussion of dust emission and surface wind, we used the present weather and the wind speed at a 10 m height included in SYNOP, which is a routine report of 3-hourly surface meteorological data. The period is March 1988 to June 2005. The regions are the Gobi Desert, the Northern Mongolia, and the Western Mongolia, which are given in Kurosaki and Mikami (2005). According to the data from U.S. Geological Survey, the major land cover types are semi desert shrubs in the Gobi Desert, grassland in the Northern Mongolia, and the semi desert shrubs and grassland in the Western Mongolia.

The frequency of dust emission is defined as the percentage of the number of dust emissions to the total number of observations in the given period and the given region. Similarly, the frequency of strong wind is defined, where a strong wind is defined with a constant threshold 6.5 m/sec, which is the threshold wind speed for a dust emission in some numerical models.

Our used snow cover and vegetation cover data are derived from satellite images. The snow cover data is derived from the Special Sensor Microwave/Imager (SSM/I). This product, whose title is Near Real-Time SSM/I EASE-Grid Daily Global Ice Concentration and Snow Extent, is distributed by the National Snow and Ice Data Center (NSIDC). We define the snow cover fraction as the ratio of the number of snow cover days to the total days during the given period. In the discussion of vegetation cover, we used the NDVI of the NOAA/NASA Pathfinder AVHRR Land (PAL) program.

3. Results and discussion

3.1 Seasonal variation

In spring, dust emissions are frequent in the Gobi Desert, and they are frequent as well in the Northern and Western Mongolia, though the dust emission frequencies are lower than those of the Gobi Desert. From summer to winter, dust emissions are observed in the Gobi Desert, though the frequency is low. On the other hand, they are seldom or never observed in the Northern and Western Mongolia. The NDVI are almost the same and very low in these three regions during spring, while they are much larger in the Northern and Western Mongolia than that in the Gobi Desert during summer. In winter, snow cover entirely extends over the Northern and the Western Mongolia. In March, the major dust source regions are not covered by snow. These results suggest that snow and vegetation covers suppress the dust emission in Mongolia during winter and summer. In comparison with these grassland regions (i.e., Mongolia), as the NDVI is not so large and snow cover is seldom observed throughout the year in the Gobi Desert, we can guess that the frequency of strong wind might control the dust emission frequency.

From these results, we can built four hypotheses; (1) the correlations are low in the Northern and the Western Mongolia during winter because of high snow cover fraction; (2) the correlations are low in the same regions during summer because of vegetation cover; (3) the correlations are high in the same regions during spring and autumn because of less snow and vegetation covers; (4) the correlation is high throughout the year in the Gobi Desert because of less snow and vegetation covers throughout the year.

3.2 Correlation of strong wind frequency and dust emission frequency

In the Northern and the Western Mongolia, the correlation of strong wind frequency and dust emission frequency is high in spring and low in summer. This result agrees with the hypotheses given in the previous section. However, the following all results disagree with the hypotheses. The correlation coefficient reaches the highest in winter, although the snow cover fraction is high. Moreover, the correlation is not so high in autumn, although NDVI and the snow cover fraction are not so high. In the Gobi Desert, the correlation coefficient clearly varies with the seasonal march as well as in Mongolia.

These results suggest that the current parameterization of threshold wind speed should not be applied in the dust emission model. Some potential reasons of the above disagreements occur to us. For example, the land surface environment frequently differs in the place and in the season, even if NDVI is the same. Although NDVI is low in Mongolia in both spring and autumn, we can guess possible land surface environment, which are rare vegetation cover in spring and broadly distributing dry grass in autumn. Similarly, although the snow cover fraction is high in winter, if the quality of snow is dry and powdery, the threshold wind speed is not so high. On the contrary, although the snow cover fraction is not so high just like in spring, the threshold wind speed might be very high, if snow is wet. By parameterizing the threshold wind speed by such factors, we can newly define the strong wind by a variable threshold in accordance with snow quality and LAI including dry grass. The correlation coefficient using such variable threshold wind speed can be a good index to validate this parameterization. To achieve this goal, we need GIS data concerning land surface environment obtained from field surveys and satellite observations.

4. Summary

This study investigated the effect of land surface environment on dust emission by the correlation analysis of strong wind frequency and dust emission frequency, where we define the strong wind with a constant threshold. This correlation should be high (low) where the variance of land surface environment is low (large). In addition to this idea, referring to the parameterizations of threshold wind speed by NDVI and snow cover fraction data, we built four hypotheses indicated in section 3.1. However, our obtained results disagreed with these hypotheses, and this pointed out the problems in the current parameterizations. This study presented some potential reasons of these disagreements, which are snow quality and dry grass. One of the methods to validate the effect of these factors on dust emission is to build a new parameterization using such factors. The correlation coefficient using such new parameterization can be a good index to validate this parameterization. To make a parameterization, we need GIS data concerning land surface environment obtained from field surveys and satellite observations.

References

Kurosaki, Y. and M. Mikami (2004), Effect of snow cover on threshold wind velocity of dust outbreak, *Geophys. Res. Lett.*, **31**, L03106, doi:10.1029/2003GL018632.

Kurosaki, Y. and M. Mikami (2005), Regional difference in the characteristics of dust event in East Asia: relationship among dust outbreak, surface wind, and land surface condition, *J. Meteor. Soc. Japan*, **83A**, 1–18.