An Investigation of Global Warming Effects on Siberian High Pressure

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1. Introduction

The Siberian high (SH) is a quasi-stationary and semi-permanent surface high pressure system residing over the Eurasian continent during winter with its climatological–mean central pressure exceeding 1030 hPa. This most important atmospheric center of action controls the climate of a wide area of this continent. The SH forms generally in October mainly in response to strong radiative cooling over the snow covered Eurasian continent in the lower troposphere and persists until around the end of April in 90-110 °E and 40-55° N Gong & Ho, 2002., Shahgedanova, 2002., Shahgedanova, 2002., Takaya & Nakamura,2005). The Asian climate is mainly affected by the SHI activity at winter. Despite the prominence and large spatial extent of SH in the northern hemisphere, its spatial and temporal variations are not comprehensively known (Panagiotopoulos et al., 2005, p. 1411). Global warming has been intensified in middle of the 1970s and significant changes of mean sea level pressure (MSLP) in the northern hemisphere and changes of atmospheric circulation on many regions (Nakamura et al, 1997., Trenberth & Hurrell, 1994., Wang et al, 2007) have been reported. A variation in temperature results in sea level pressure decrease according to barometric relation. In other words, the SH is expected to be weakened by global warming as has occurred after the 1976/1977 (Panagiotopoulos et al., 2005). The obtained findings by Hori and Ueda (2006) and Romanić *et al* (2014), verify the same relation between global warming and SH weakening. Panagiotopoulos *et al*. (2005) have shown that the SH has experienced a negative trend of -2.5 hPa in each decade during 1978-2001 while a slighter rate has been reported during the later decades (Jeong et al., 2011). A plenty of studies have considered the temporal variability of SHI while the spatial variability and also the simultaneous spatial and temporal variability of SHI during global warming period have been often neglected. Thus, the present research aims to study the spatial and temporal variation of SHI during the global warming period.

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2. Material and Methods

2.1. Data

The present research has used the sea level pressure (SLP) data (Kalnay et al., 1996) obtained from the NCEP/NCAR Reanalysis 1 (NOAA National Center for Environmental Prediction). These data are gridded at 2.5º latitude by 2.5º longitude meshes, and cover 65 years (1948-2013). The SHI index is defined as the maximum pressure in SH spatial domain and the spatial and temporal variations have been considered during the global warming through the analysis of this index. The annual global land temperature anomalies data was also extracted from the national climatic data center to consider the intensified global warming. Having collected the needed data and using regression method, the studied period (1948-2013) was divided into two parts presenting two discrete periods having different global warming intensities. Two mentioned periods were named intensified and slight global warming. The significance of the spatial and temporal variability of SHI during two mentioned global warming periods were discussed through the compare means tests.

2.2. Siberian High Intensity

In this research, the SHI is defined as maximum of December to February mean SLP over northern Mongolia between 40 and 65°N and 80–120°E. The same or similar definitions of the SHI have been utilized in many previous studies.

2.3. Slight and Intensified Global Warming

The time series of data during 1880-2013 were used to consider the annual global land temperature anomalies of data using regression method. The obtained results indicated that the pattern of mentioned data during 133 years can be divided into three smaller periods. Three periods of 1880-1933, 1934-1973, and 1974-2013 have the negative, near zero, and greater upper zero anomalies, respectively. The recent period (1974-2013), having higher slope and increasing rate, was considered as intensified global warming while the 1934-1973 was considered as the slight global warming period having the slope near zero.

3. Results and Discussion

3.1. Temporal Variability

The SHI were obtained during DJF through gridded. The weakening of SHI and its intensification recovery are evident during 1970-1980 and recent decades, respectively. The SHI decreased during intensified global warming (1974-2013) compared to slight global warming (1948-1973). The remarkable point is the noticeable reduction of variance during intensified global warming indicating a great change in annual SHI during intensified global warming. Regarding the maximum and minimum of SHI during two studied periods, it can be concluded that the variance decrease is due to decreasing maximum, meaning that the SHI variation range is decreased because of a decrease in SHI maximum

3.2. Spatial Variability

The SHI centers' location during intensified global warming shows that the centers have been focused toward zone 1 and 94.17% of them are in zone 1 while only 5 and less than 1% of them are located in zone 2 and other zones respectively. The longitude and altitude time series of SHI also show a decrease in SHI centers distribution More SHI centers have been formed in 50°N and 90°E since 1974.

After the specification of SHI centers' displacement, it is expected that their range be changed. Thus, two 1020/5 (reported as SH boundary in many references, for example IPCC; 2013, 224) and 1034 (more than 95% of SHI centers have a pressure higher than 1034 hPa and contour has been noticed as an area in which most SHI centers are formed) contours were plotted during the two studied periods. Having extracted the mentioned contours during DJF at 1948-2013, the average of each contour was calculated and plotted during the two global warming periods.

4. Conclusion

Starting the average sea level pressure changes in the northern hemisphere from 1970, we observed a noticeable change in spatial and temporal of SHI, resulting in a dramatic change in the average of the Earth's temperature. The SHI has been weakened as the intensified global warming started (1974-2013) and the annual variation range has shown a considerable decrease compared to the period before (1948-1973). This annual variation decrease is due to a decrease in maximum and an increase in a minimum of SHI. It's noteworthy that the decrease in maximum SHI has had a more dominant effect. The spatial SHI variations during intensified global warming (which is significant in error level lower than 0.01) has been resulted in a reduction in spatial distribution of SHI centers in such a way that the SHI centers have been shifted toward 50°N and 90°E as the average global temperature increases. Additionally, the isobar 1020.5 hPa (as maximum SH distribution) and 1034 hPa (as an area in which most SHI centers are formed) have been shifted toward west. A remarkable area decrease has been observed in 1034 hPa isobar during intensified global warming which is justified regarding the reduction of maximum SHI. Regarding the point that a significant change of atmospheric circulation has occurred at mid-1970 in many areas of the world, it seems that the spatial variability of SHI have been due to noticeable changes in atmospheric circulation in such a way that the Aleutian low shifting toward west during 1977-1988 winters and variabilities of ocean temperatures during last 1970s have resulted in a long-term NAM/NAO and have led to SHI shifting consequently. Meanwhile, the important issue is that all of the mentioned changes have been coincident with a noticeable change in land temperature. Thus, it can be concluded that the global temperature increase has resulted in changes in atmospheric circulation and reorganizing the climate system. A scrutinized understanding of details, physical mechanisms, and real dynamics resulting in such changes necessitates a more comprehensive study and more data.

Key words: Siberian high intensity; Global warming; Temporal variability; Spatial Variability; Compare means test.

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