Interactive comment on "Spatio-temporal dynamics of snow cover based on multi-source remote sensing data in China" by Xiaodong Huang et al. Anonymous Referee #2

Received and published: 8 August 2016

In this manuscript, a synthesized snow cover product was produced first, which combined optical and passive remote sensing snow cover products. Cloud removal method and downscaling method were developed to retain the advantage of both optical and passive remote sending product, i.e., fine spatial resolution and cloudless, respectively. Then, based on the product, spatiotemporal dynamics of snow cover in China over the past 14 years were carefully analyzed. As a good data is the foundation of a reliable analysis. This synthesized snow cover product is considered of high quality, due to reasonable cloud removal and downscaling method. Also the analyses are well-organized, the results are quite specific. So, this manuscript is considered quite suitable to this journal. But still, some minor revisions are needed.

1. The descriptions of sentences need to be more carefully considered, especially some improper prepositions. In addition, some confused words or sentences are listed below: a) Line 31: "Middle-latitude". Usually we say middle latitude, or mid-latitude, but merely middle-latitude. b) Line 155: "SDi is the 25-km spatial resolution snow depth value in year i". This definition is not clear to me, as I cannot tell if SDi should be a daily result or annual mean result. c) Line 194: "Because some remote sensing data were lost". This sentence is quite confusing, especially with the word "lost". d) Line 268: "(December-February next year". There should be a ")" after "(" .

Response: We are sorry the inconvenience caused to you about our English writing. Some confusing sentences you mentioned were revised. In additional, editorial changes for language usage throughout were also made by a native English scientific editor.

Author's changes in manuscript:

a) High and mid-latitude regions contain abundant snow cover and glacial resources, and they are the source regions for many rivers.

b) where SD_{sp} is the sub-pixel daily SD with a 500 m spatial resolution, *SD* is the daily SD with a 25 km spatial resolution, SDY_i is the average number of SCDs for each MODIS pixel in year *i*, and SDT_i is the sum of the total SCDs for each SD pixel in year i.

c) Because some remote sensing data were missing (Wang et al., 2014).

d) We used the M-K method to analyze the variation in the number of snow-covered days in the different seasons of winter (December–February next year), spring (March–May), summer (June–August), and fall (September–November) in the grid cells.

2. Some detailed problems in figures. a) Resolution of figures (dpi) should be enhanced, especially the maps. b) In figure titles, when it refers to "average annual", it is suggested to add time duration. Take Figure 3 for example, it is advised to be: ". . . annual average snow depth in China from 2001to 2014".

Response: The resolution of each figure was enhanced by 400 dpi, hope can meet the Journal's requirement. And the time duration of each figure title was also added based on your comments. Thank you so much.

Author's changes in manuscript:

a) Resolution of figures was enhanced with 400 dpi.

b) The time duration added for each figures.

3. There are some strange "missing" words or blanks throughout the manuscript. a) Line 173, Line 177: "at a given significance level " b) Line 233: "(<0) "

Response: The missing words or blanks throughout the manuscript were modified.

Author's changes in manuscript:

a) At a given significance level α, if $|S| \geq S_{\alpha/2}$, the trend of the series is significant; otherwise, it is insignificant.

b) At a given significance level α, we looked up the critical $Z_{\alpha/2}$ in the normal distribution table.

4. There are some leap years during the study period, but it seems that you assumed every year to be 365 days. Explanations are needed.

Response: Among them, the 2004, 2008 and 2012 are leap years. The average snow-covered area refers the mean of 366 days.

Author's changes in manuscript: Fig. 2 summarizes the average annual SCA between 2001 and 2014. Leap years occurred in 2004, 2008 and 2012, so the average SCA refers to the mean of 366 days for these years.

5. As you speak highly of the M-K method in analyzing the variation and trend of snow cover data, why you used Sen's median method "to test the accuracy of this result" (Line 230)? Do you have any explanations?

Response: The M-K method can test the variation and trend of the snow cover, but can't examine the slope of the variation of the snow cover. We are sorry about the wrong statement of "to test the accuracy of this result" in the manuscript. The purpose of the Sen's median method used in the paper was to calculate the slope of the variation in the SCD.

Author's changes in manuscript: The results of the M-K variation analysis showed that the annual number of SCDs in South China increased significantly. To further analyze the trend of the SCDs in China over the past 14 years, we calculated the slope of the variation in the annual SCDs using Sen's median method (Fig. 7).

6. The long time series of snow depth in China you used in WESTDC have been updated based on the following publications: a) Che, T., Dai, L.Y., Zheng, X.M., Li, X.F., Zhao, K., 2016. Estimation of snow depth from MWRI and AMSR-E data in forest regions of Northeast China. Remote Sensing of Environment 183, 334-349. b) Dai, L., Che, T., Ding, Y., 2015. Inter-Calibrating SMMR, SSM/I and SSMI/S Data to Improve the Consistency of Snow-Depth Products in China. Remote Sensing 7, 7212. c) Dai, L.Y., Che, T., Wang, J., Zhang, P., 2012. Snow depth and snow water equivalent estimation from AMSR-E data based on a priori snow characteristics in Xinjiang, China. Remote Sensing of Environment 127, 14-29.

Response: Updated as your suggestion, thanks a lot.

Author's changes in manuscript:

New references updated are as follows:

Che, T., Dai, L.Y., Zheng, X.M., Li, X.F., Zhao, K.: Estimation of snow depth from MWRI and AMSR-E data in forest regions of Northeast China. Remote Sens. Environ, 183, 334-349, 2016.

Dai, L., Che, T., Ding, Y.: Inter-Calibrating SMMR, SSM/I and SSMI/S Data to Improve the Consistency of Snow-Depth Products in China. Remote Sens, 7, 7212-7230, 2015.

Dai, L.Y., Che, T., Wang, J., Zhang, P.: Snow depth and snow water equivalent estimation from AMSR-E data based on a priori snow characteristics in Xinjiang, China. Remote Sens.

Environ, 127, 14-29, 2012.

Hall, D. K., Riggs, G. A., Salomonson, V. V., Digirolamo, N. E., & Bayr, K. J.: MODIS snow-cover products. Remote Sens. Environ, 83(1): 181-194, 2002.

Qian, Y. F., Zheng, Y. Q., Zhang, Y., Miao, M. Q.: Responses of China's summer monsoon climate to snow anomaly over the Tibetan Plateau. Int. J. of Climatol., 23, 593-613, 2003.

Zhao, P., Zhou, Z. J., Liu, J. P.: Variability of the Tibetan spring snow and its associations with the hemispheric extropical circulation and East Asian summer monsoon rainfall: An observational investigation. J. Climate, 20, 3942-3955, 2007.

Ke, C. Q., Li, X. C., Xie, H. J., Ma, D. H., Liu, X., Kou, C.: Variability in snow cover phenology in China from 1952 to 2010. Hydrol. Earth Syst. Sci., 20, 755-770, 2016.

Figure List：

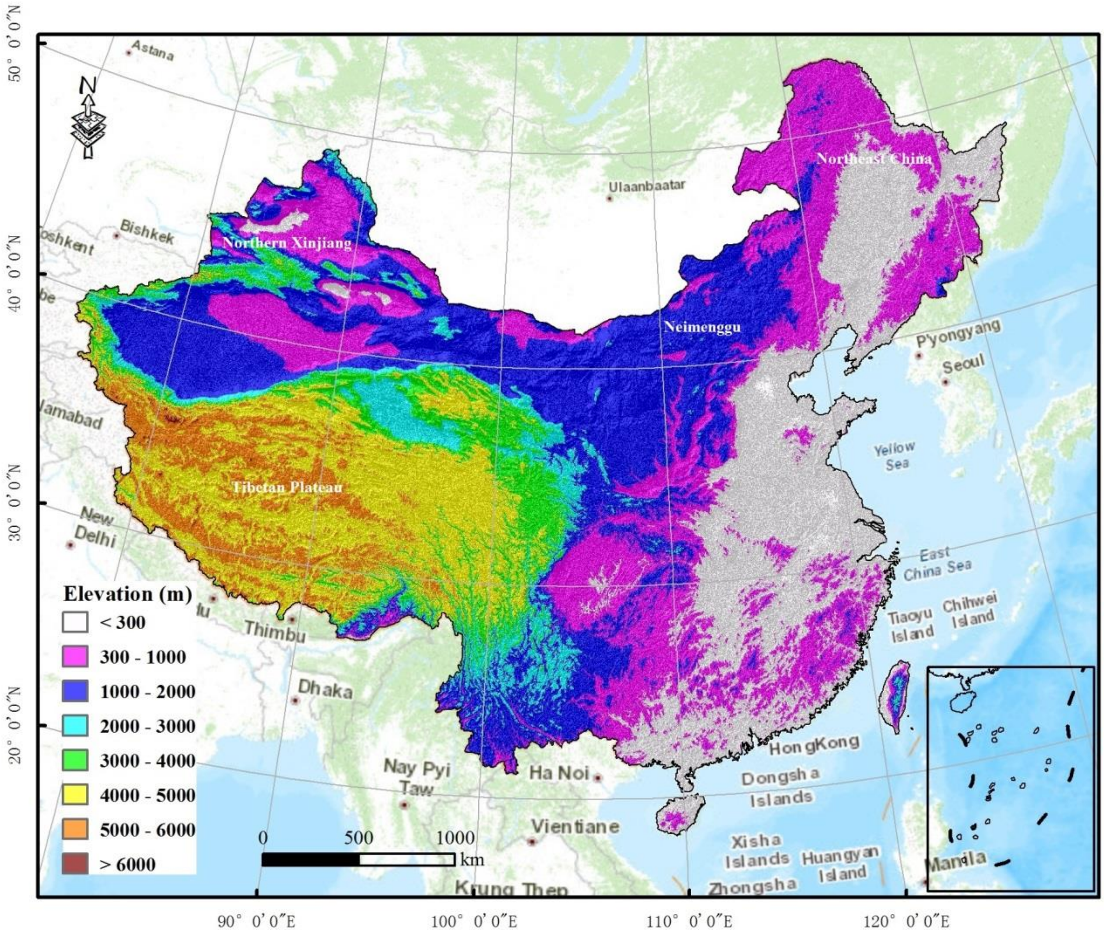


Figure 1: Schematic diagram of the study region.

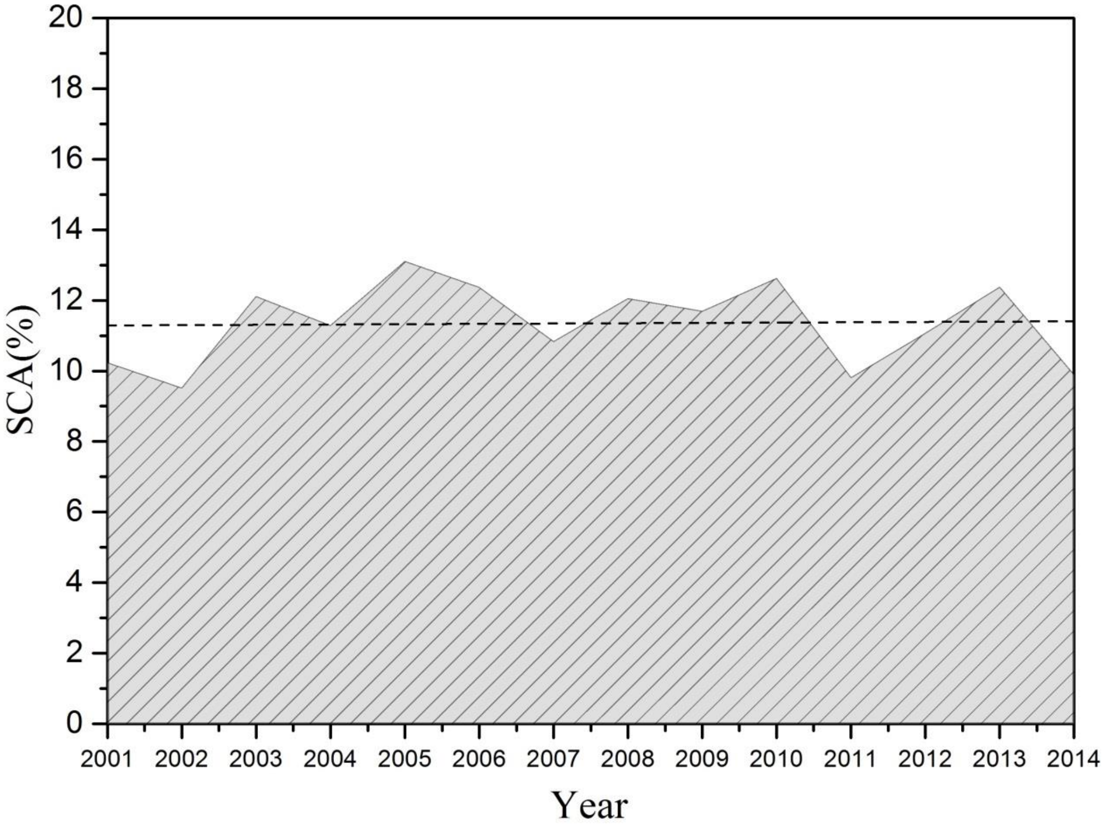
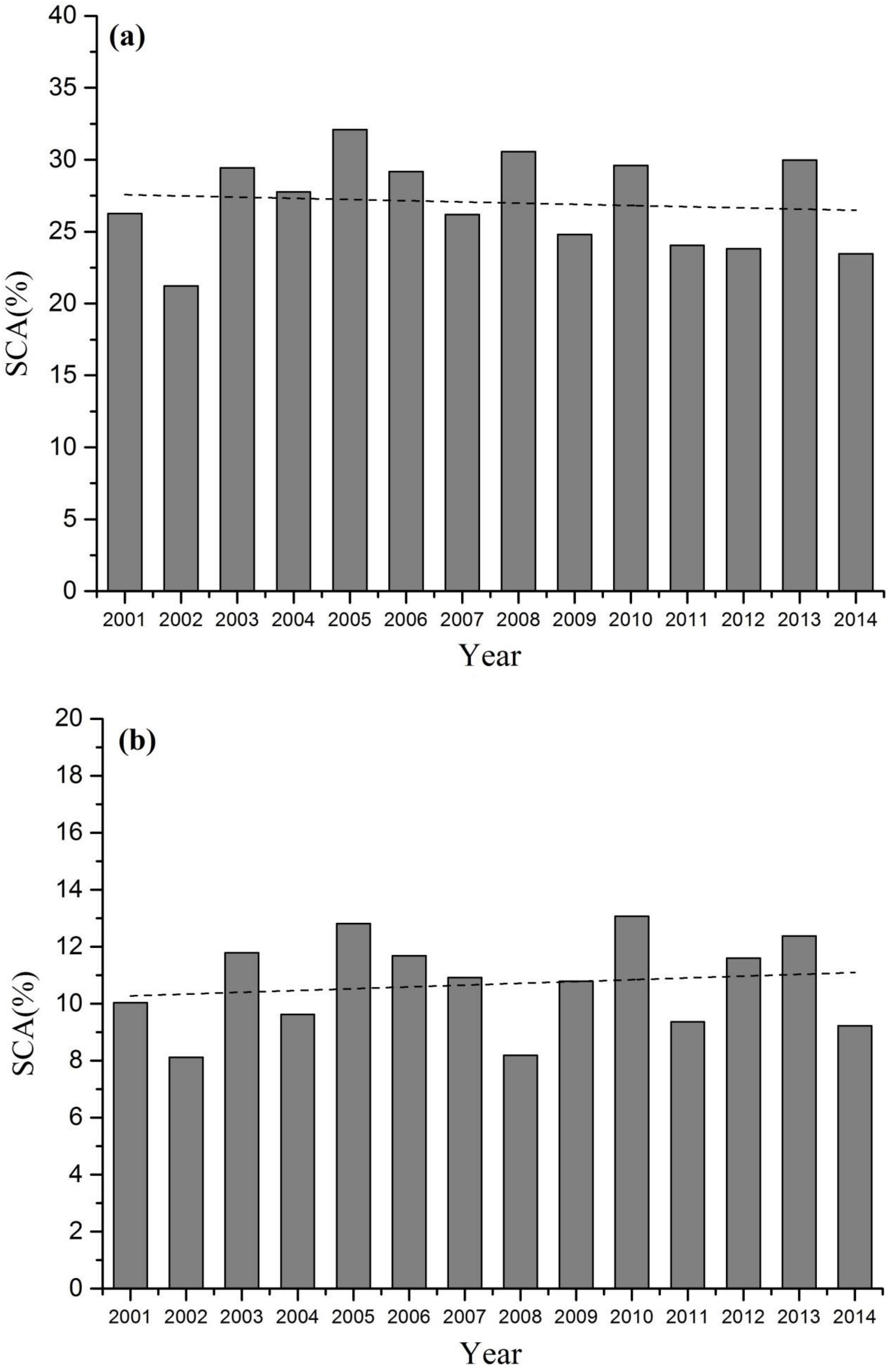


Figure 2: Average annual SCA in China between 2001 and 2014.



(a)
SCA(%)
40
35
30
25
20
15
10
5
0
2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014
Year
(b)
SCA(%)
20
18
16
14
12
10
8
6
4
2
0
2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014
Year

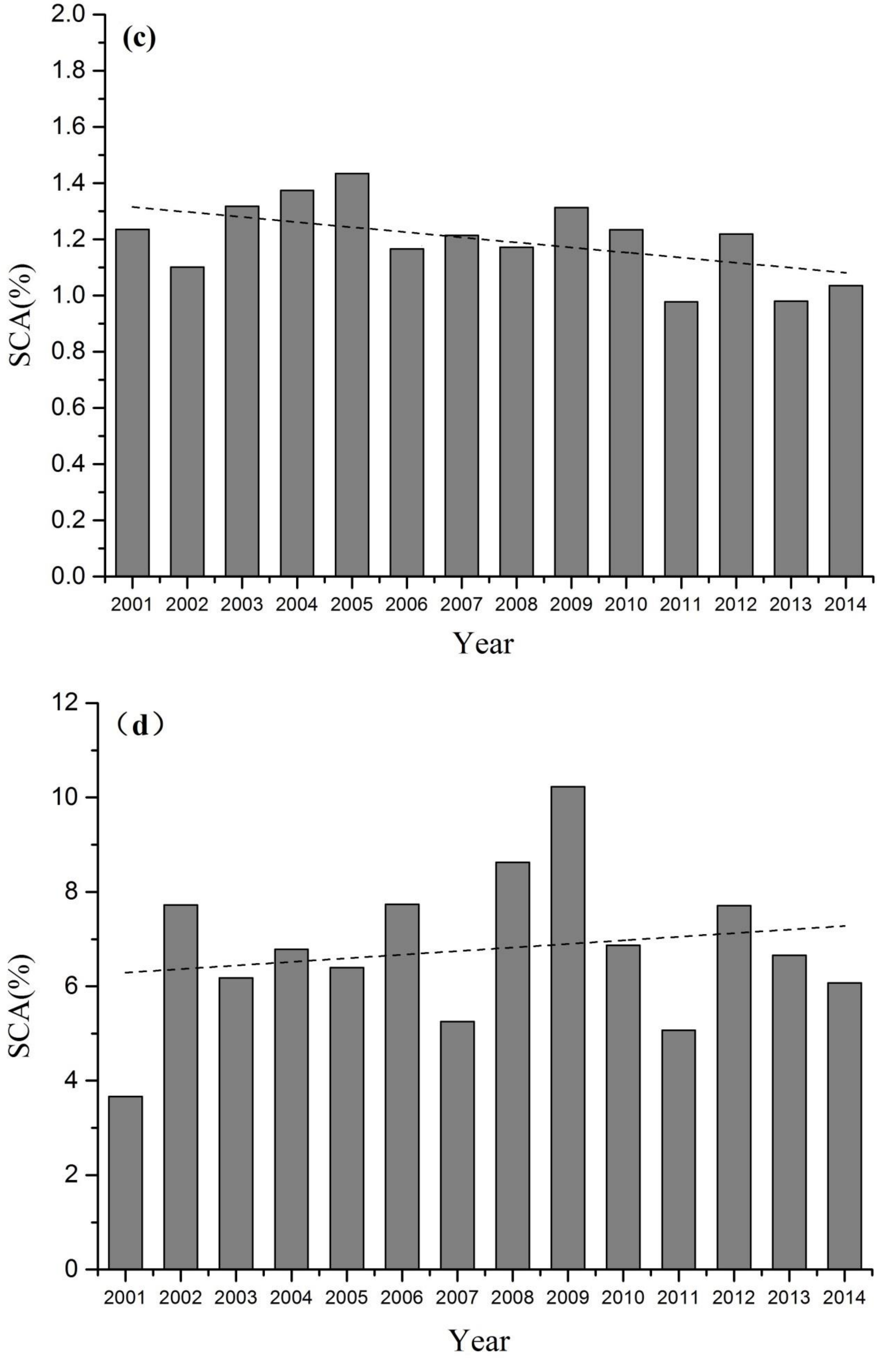


Figure 3: Histograms of the average SCA in each season in China from December 2000 to November 2014. (a), (b), (c), and (d) are the average SCA in winter, spring, summer, and fall, respectively.

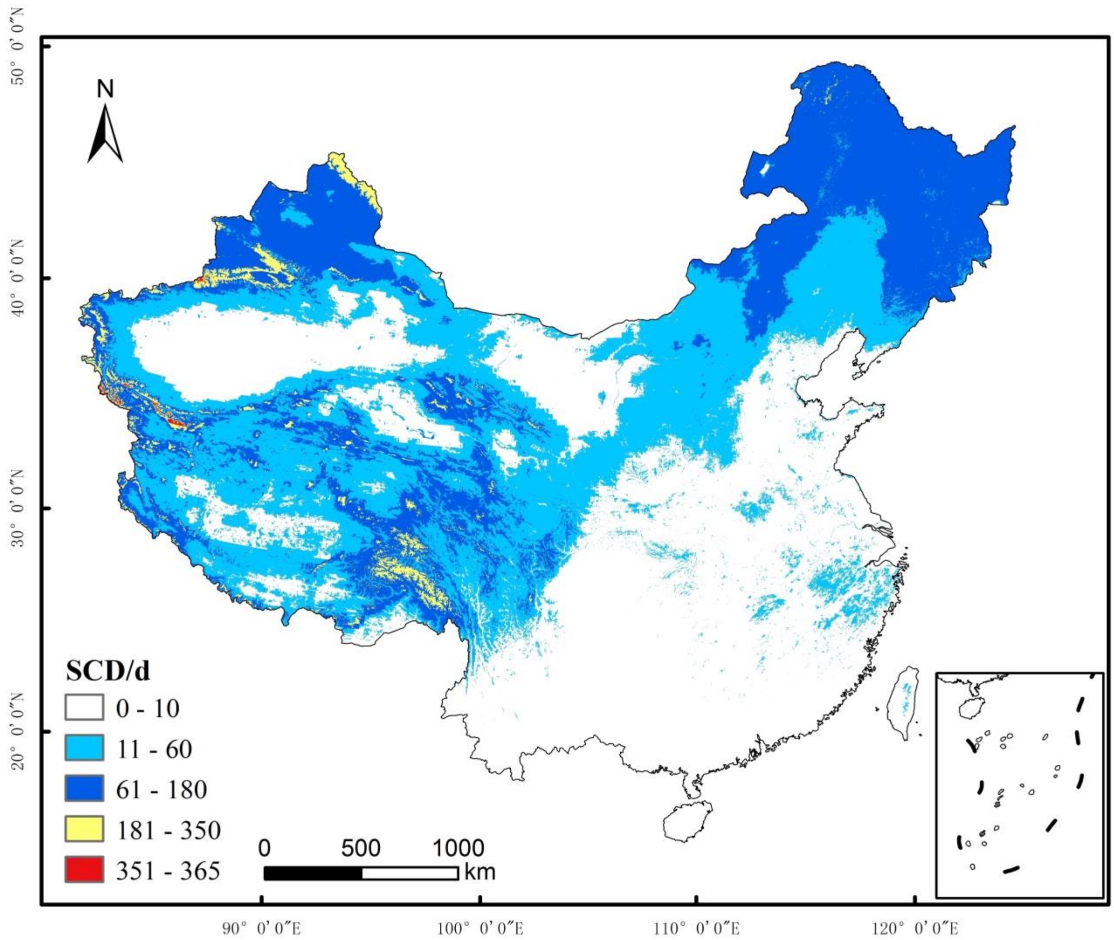
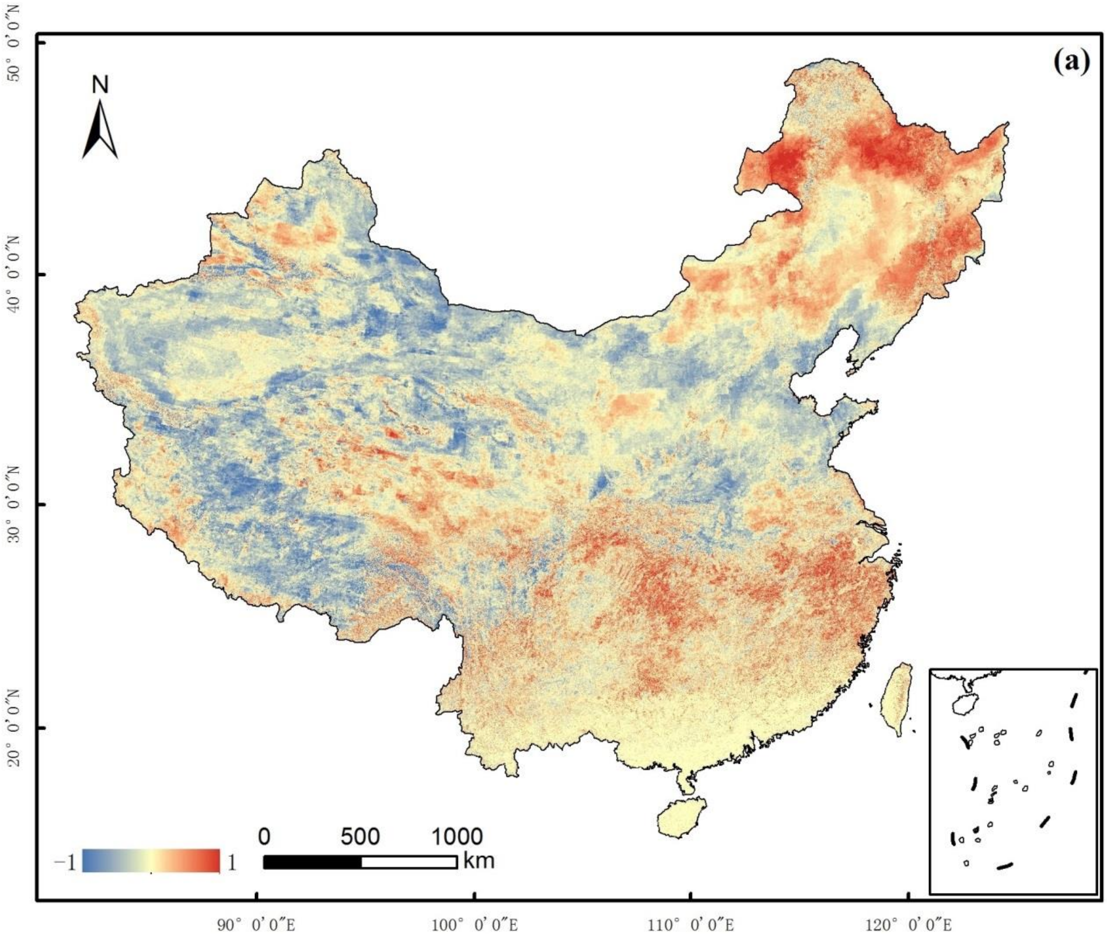


Figure 4: Spatial distribution of the average annual number of snow-covered days during 2001-2014 in China.


(a)
N
50° 0′0″N
40° 0′0″N
30° 0′0″N
20° 0′0″N
−1
1
0
500
1000
km
90° 0′0″E
100° 0′0″E
110° 0′0″E
120° 0′0″E

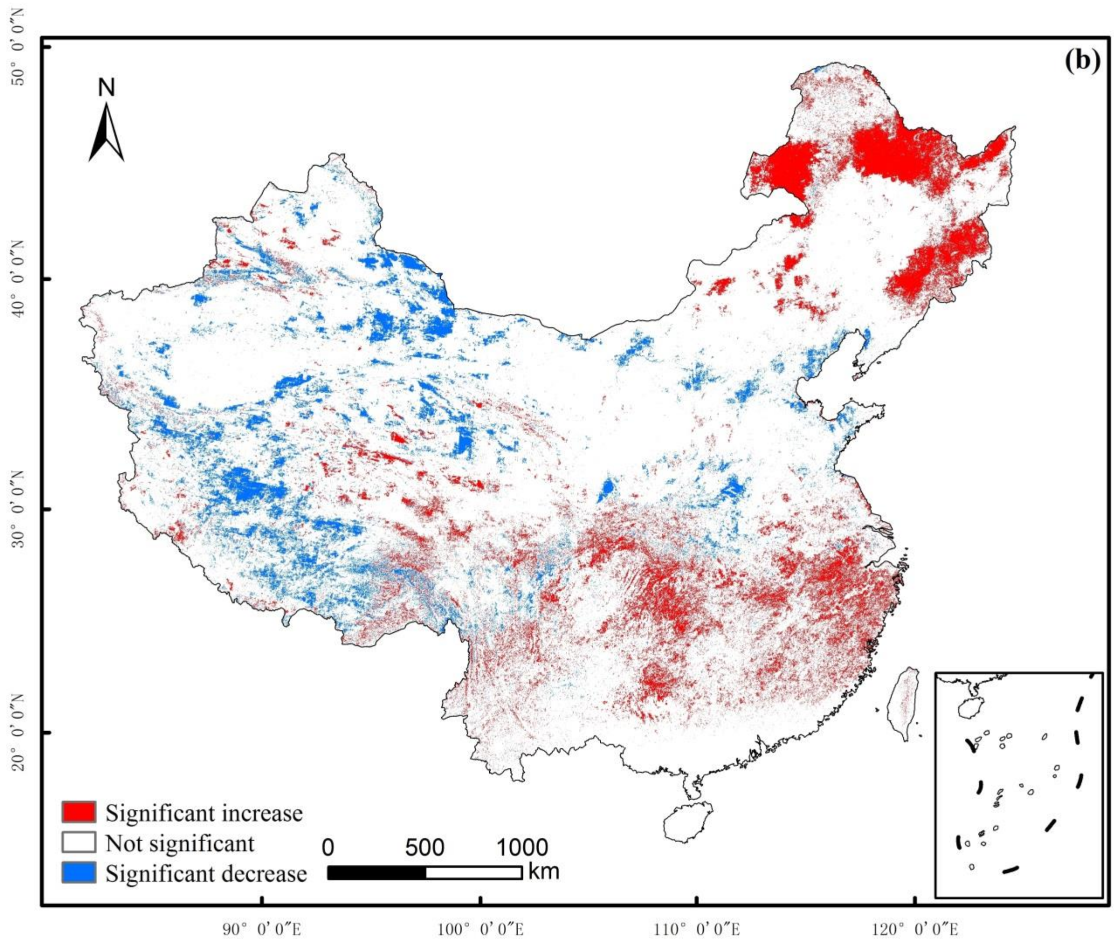
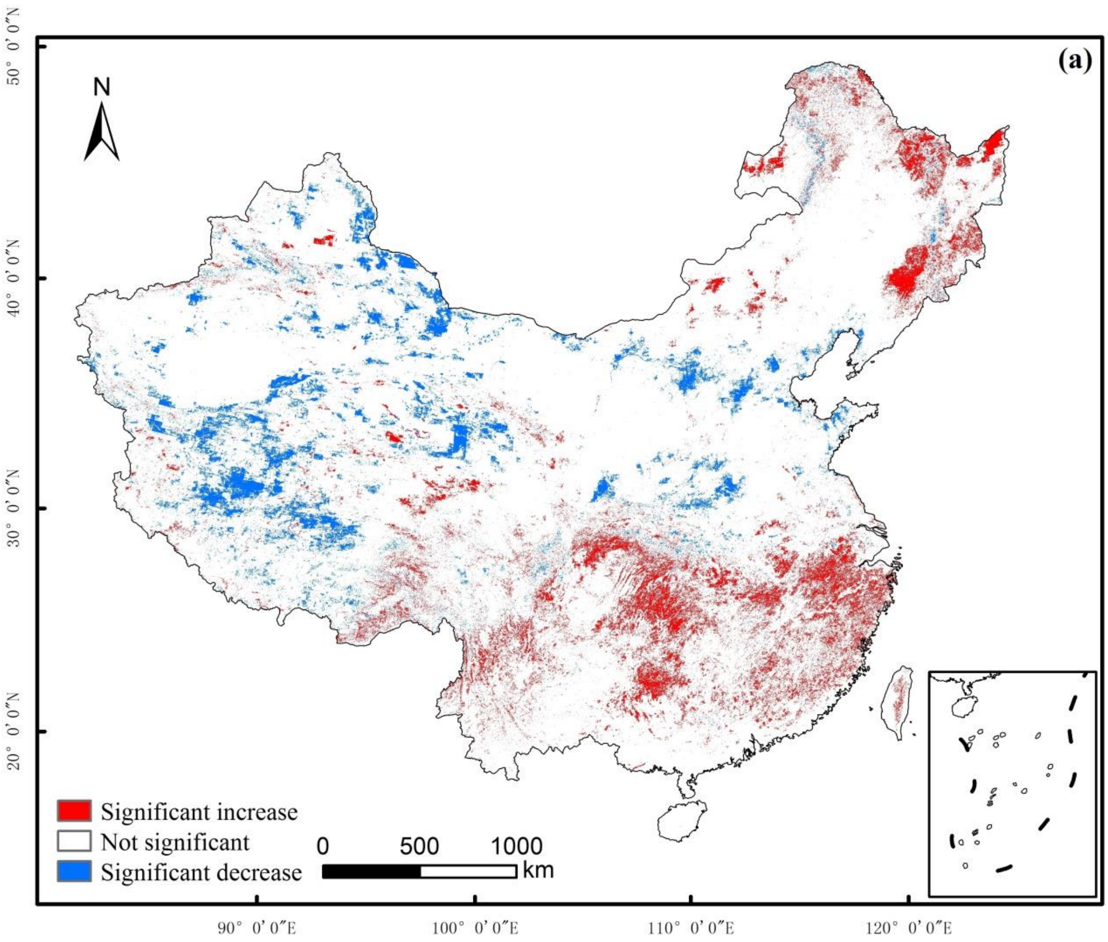
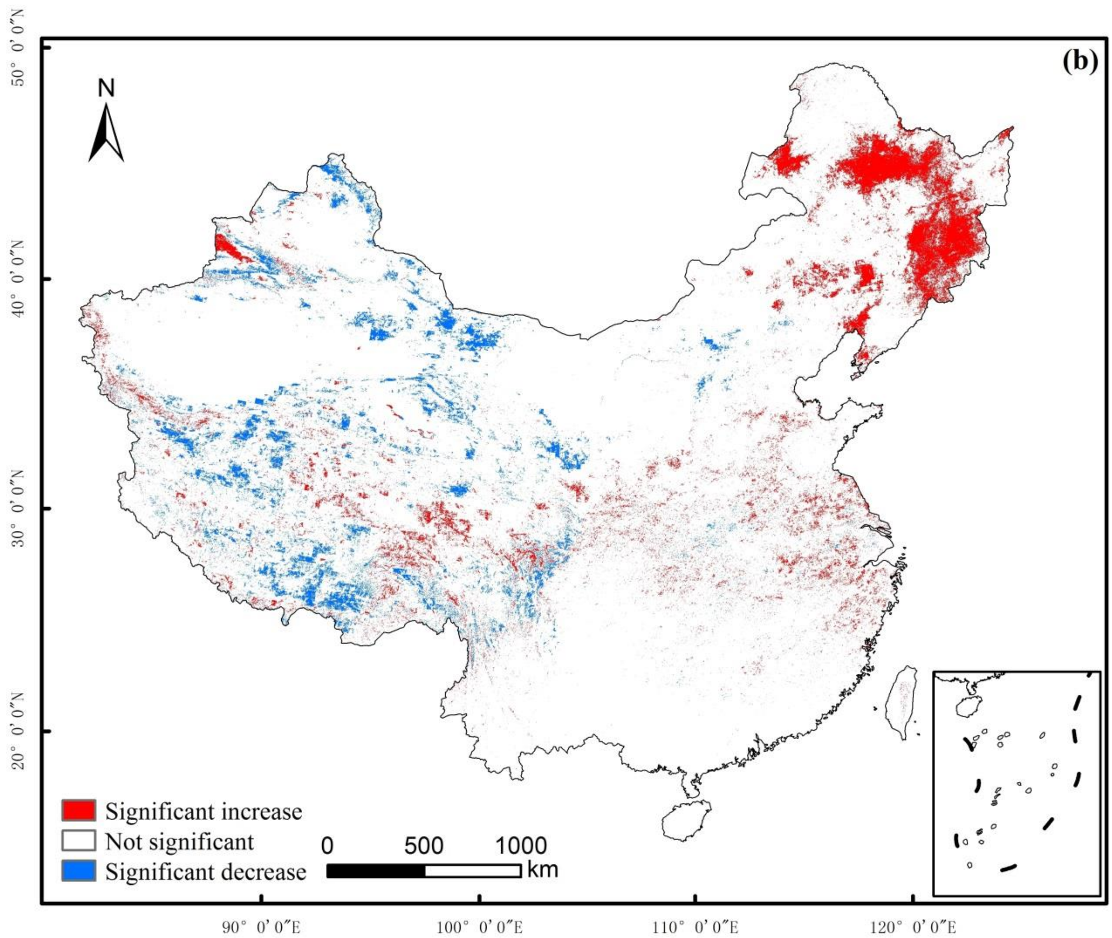
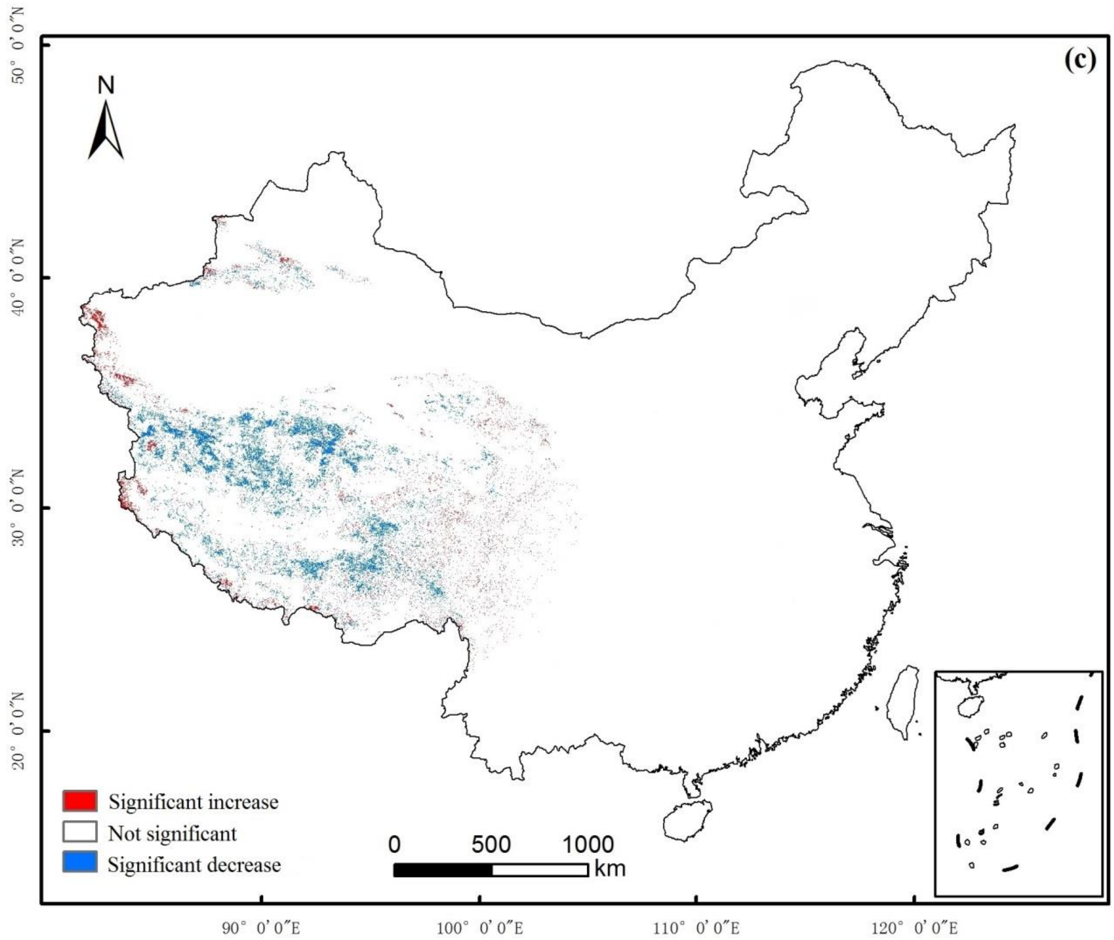


Figure 5: Variation in the average annual SCDs in China based on the Mann-Kendall method from 2001-2014. (a) Variation in the annual SCDs; (b) significance of the variation in the annual SCDs.



50° 0′0″N
40° 0′0″N
30° 0′0″N
20° 0′0″N
90° 0′0″E
100° 0′0″E
110° 0′0″E
120° 0′0″E
(a)
N
Significant increase
Not significant
Significant decrease
0 500 1000
km


50° 0′ 0″N
40° 0′ 0″N
30° 0′ 0″N
20° 0′ 0″N
(b)
N
Significant increase
Not significant
Significant decrease
0 500 1000
km
90° 0′ 0″E
100° 0′ 0″E
110° 0′ 0″E
120° 0′ 0″E


(c)
N
Significant increase
Not significant
Significant decrease
0 500 1000
km
50° 0′ 0″N
40° 0′ 0″N
30° 0′ 0″N
20° 0′ 0″N
90° 0′ 0″E
100° 0′ 0″E
110° 0′ 0″E
120° 0′ 0″E

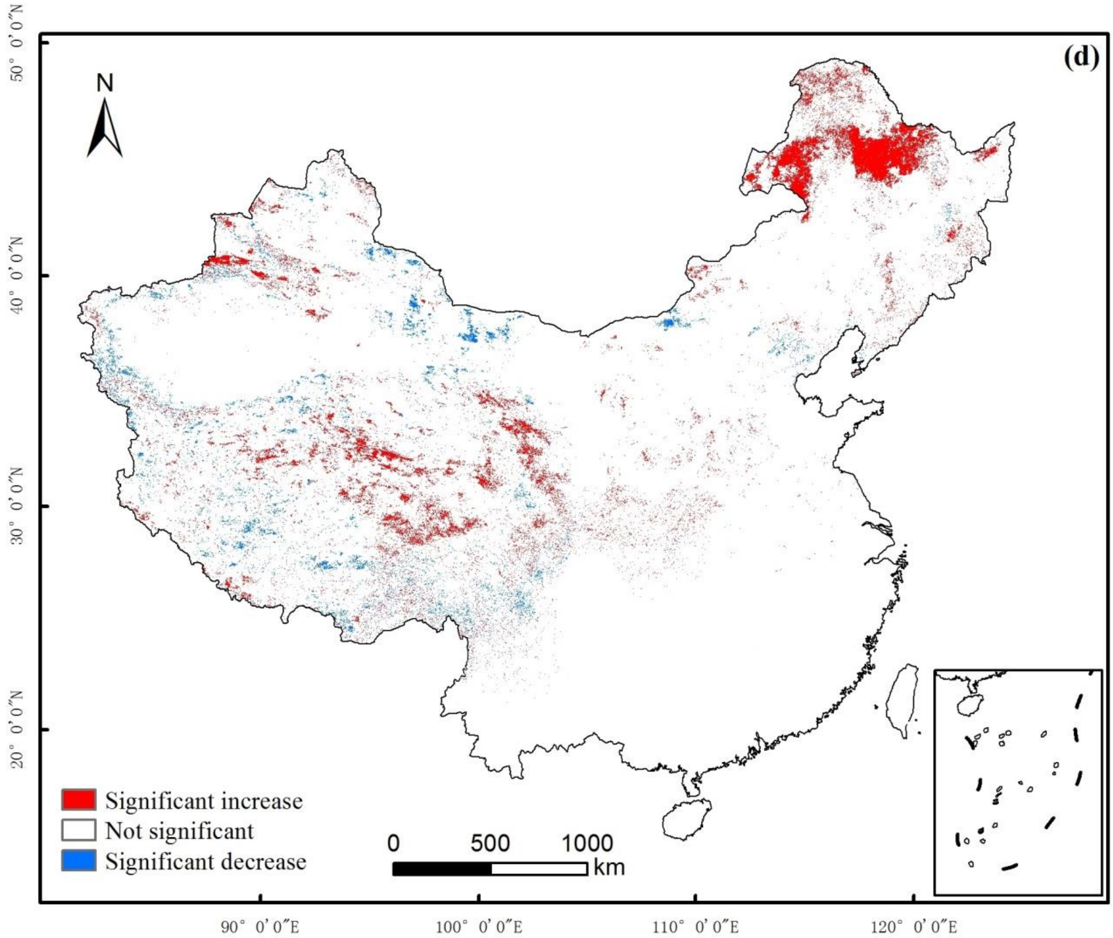


Figure 6: Variation in the number of SCDs during each season in China based on the Mann-Kendall method from 2001to 2014. (a), (b), (c) and (d) show the significance of the variation in the number of SCDs during the winter, spring, summer, and fall, respectively.

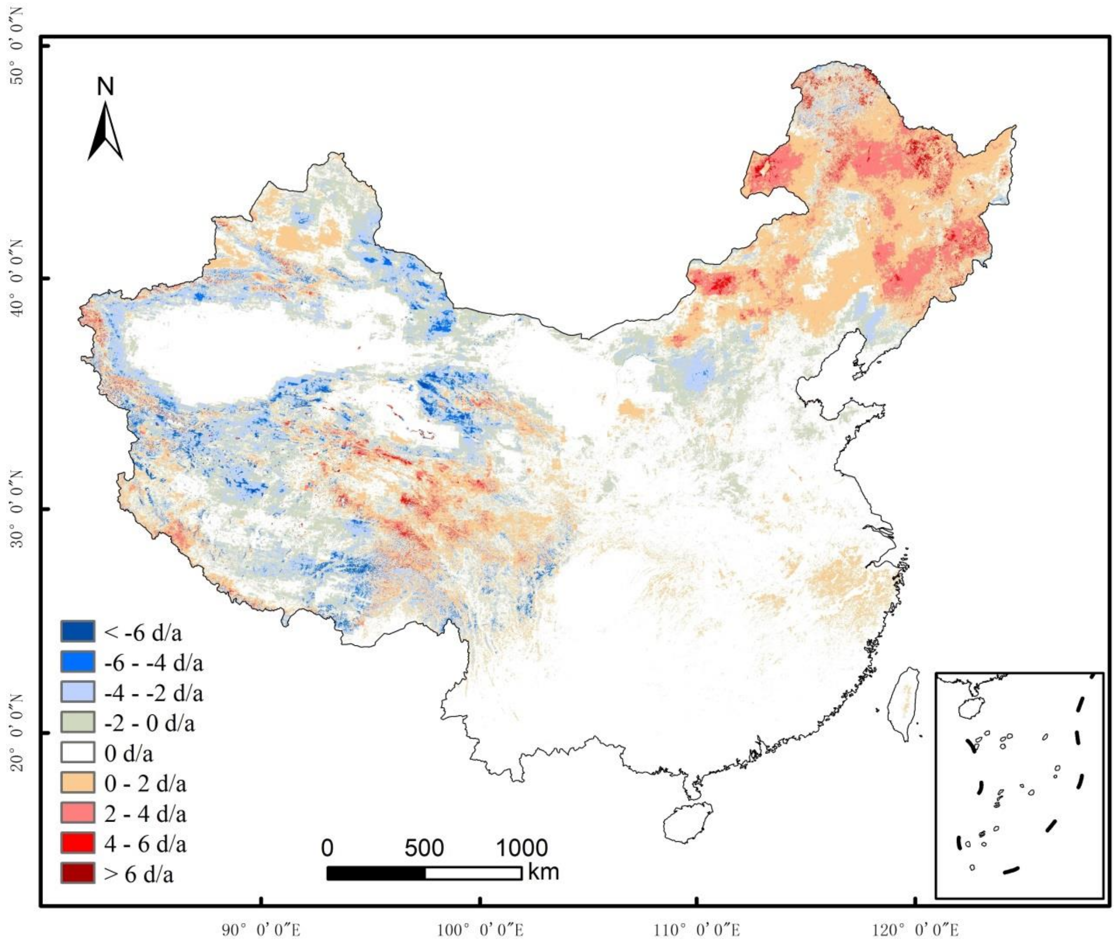


Figure 7: Variation slope of the average annual number of SCD in China based on Sen's median method during the period of 2001-2014.

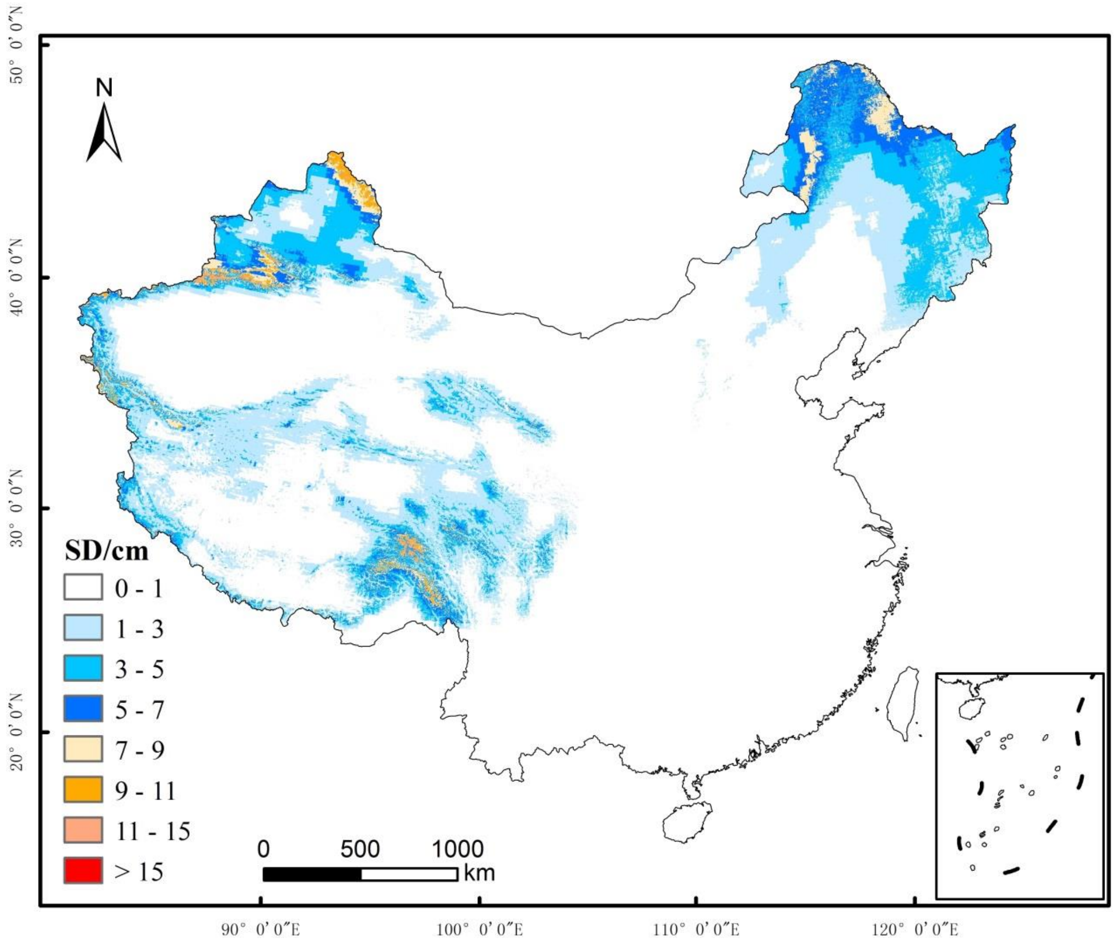
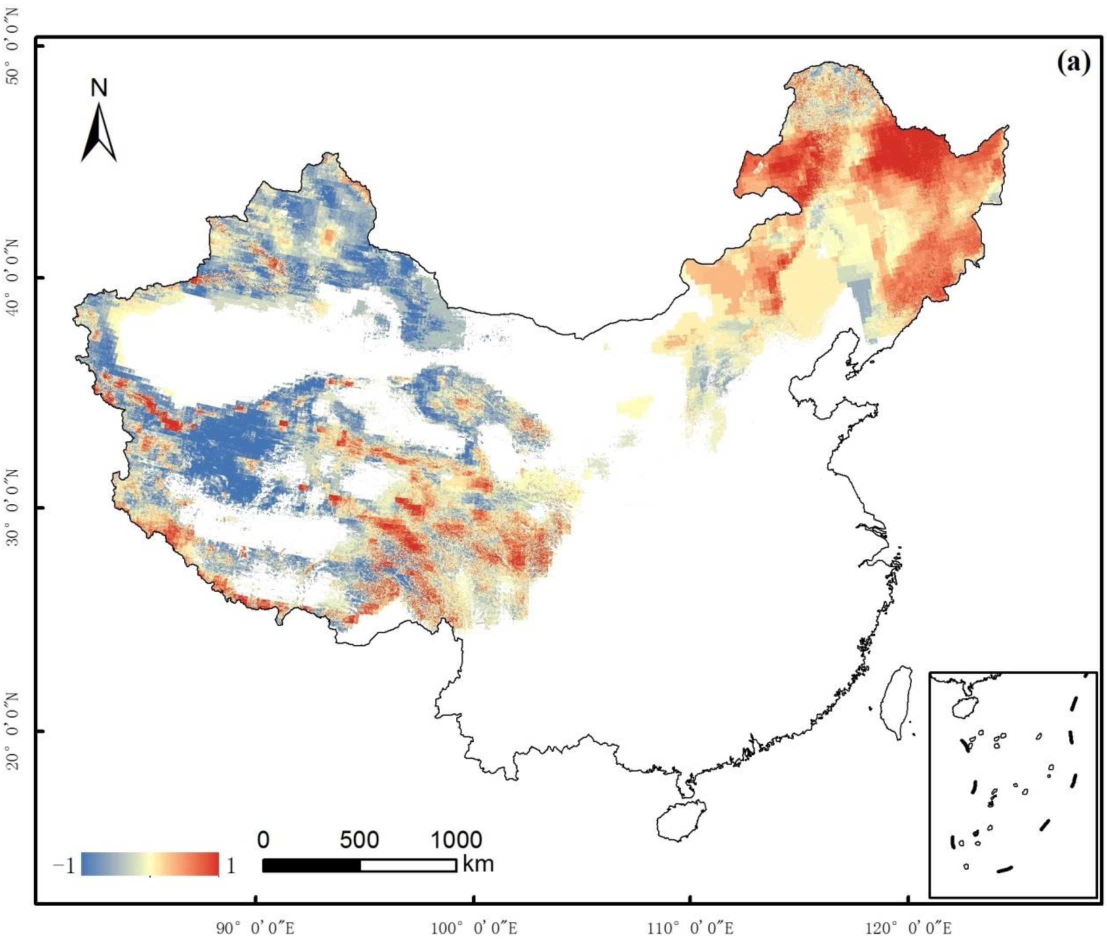


Figure 8: Spatial distribution of the average annual snow depth in China from December 2000 to November 2014.



(a)
N
50° 0′0″N
40° 0′0″N
30° 0′0″N
20° 0′0″N
90° 0′0″E
100° 0′0″E
110° 0′0″E
120° 0′0″E
−1
1
0
500
1000
km

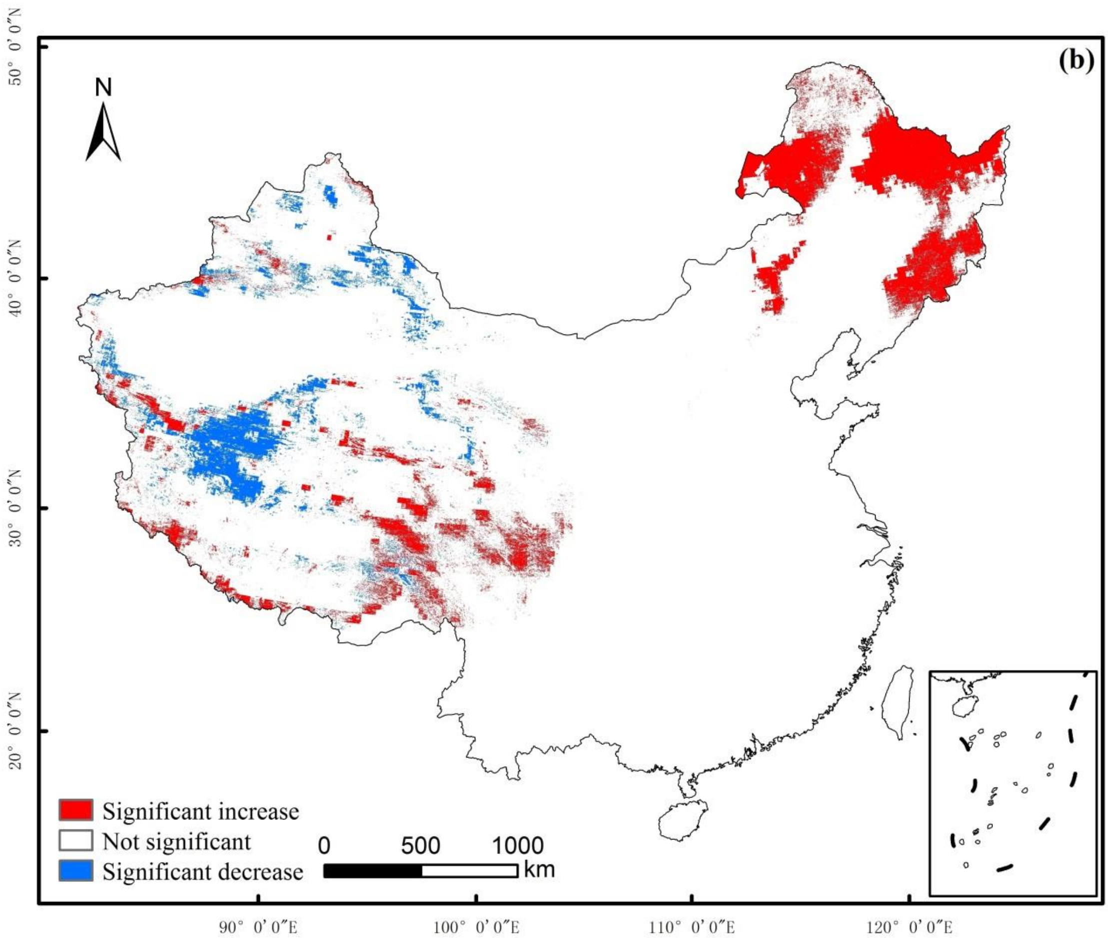
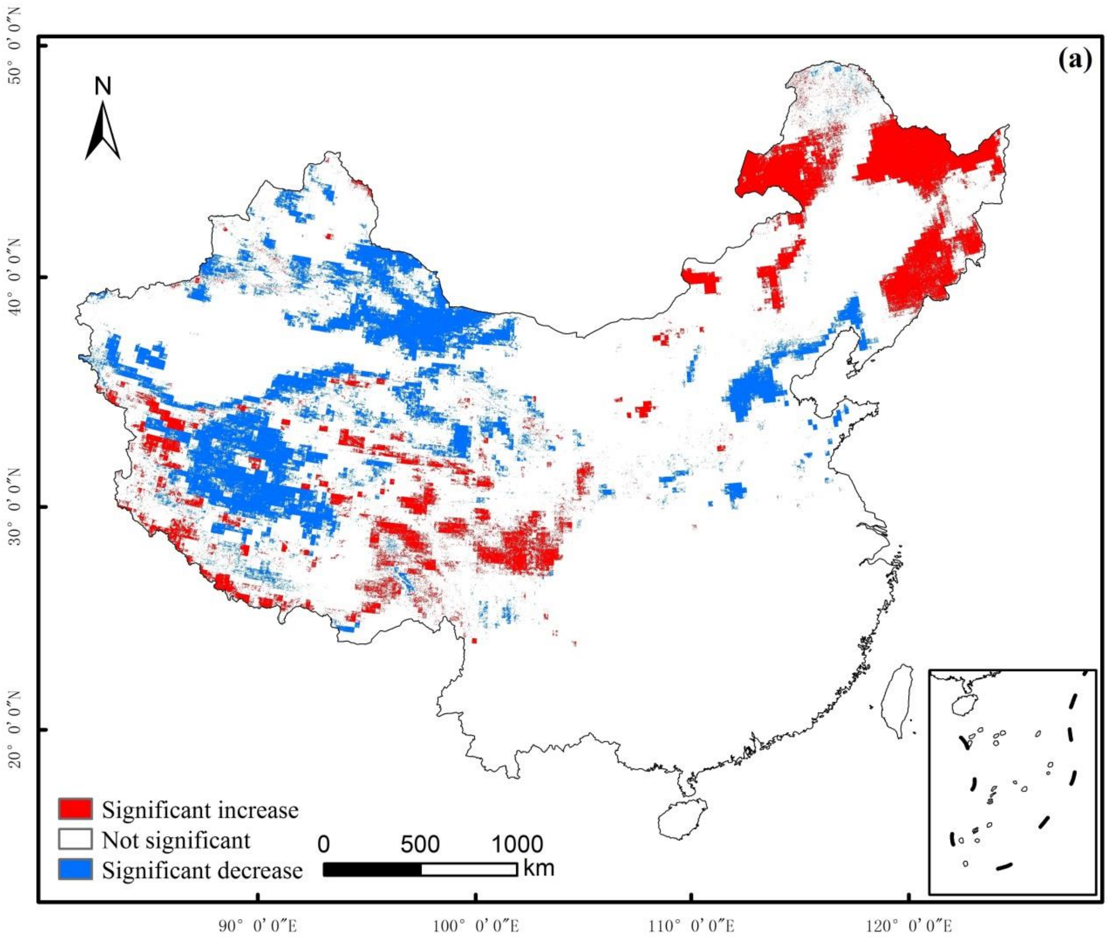
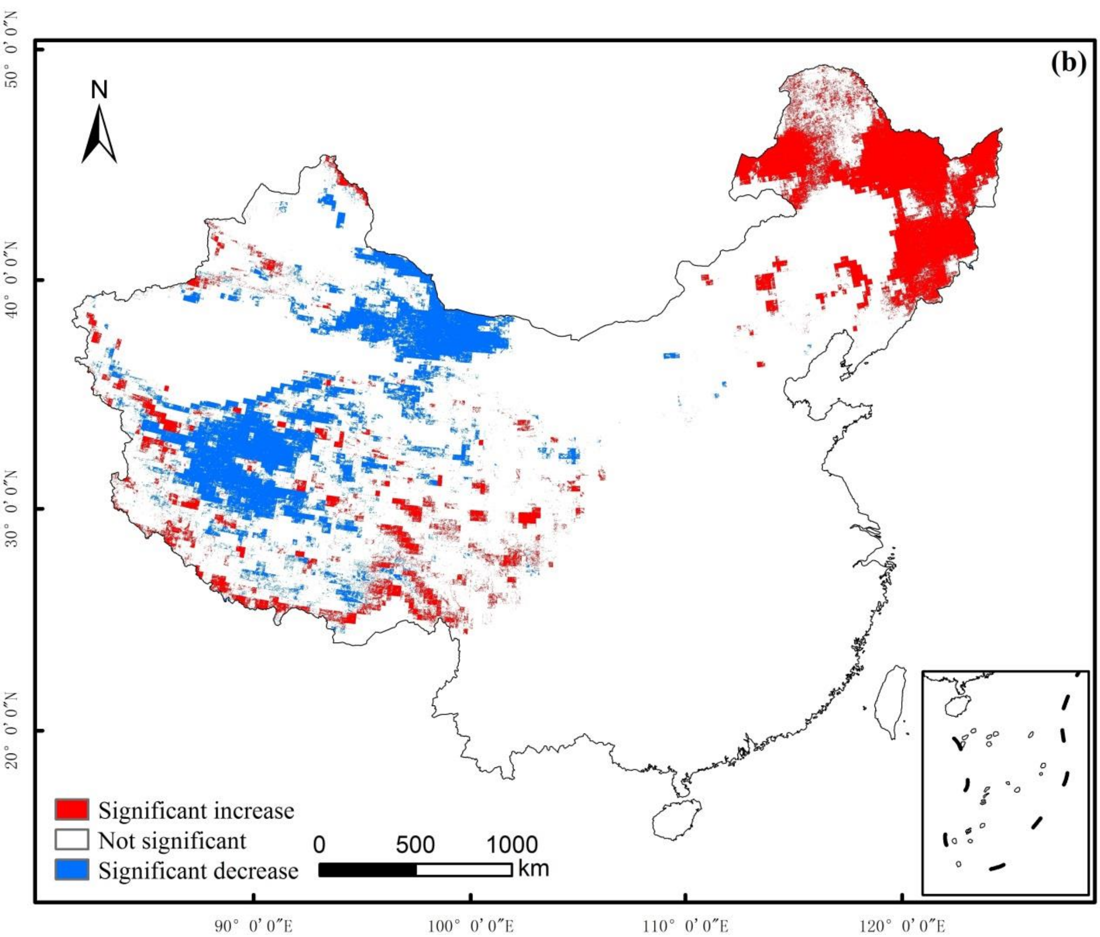
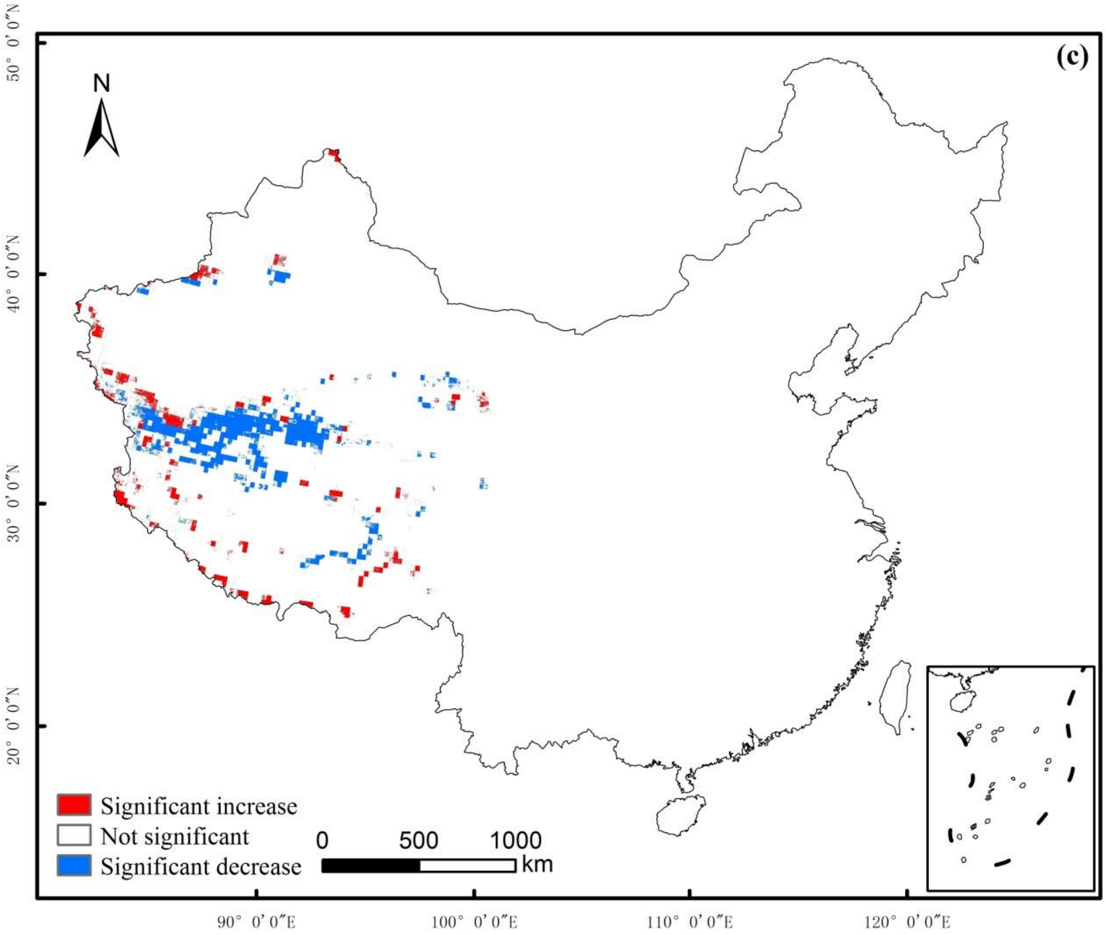


Figure 9: Variation in the average annual SD in China based on the Mann-Kendall method between 2001 and 2014. (a) Variation in the average annual SD; (b) significance of the variation in the average annual SD.


(a)
N
50° 0′0″N
40° 0′0″N
30° 0′0″N
20° 0′0″N
90° 0′0″E
100° 0′0″E
110° 0′0″E
120° 0′0″E
Significant increase
Not significant
Significant decrease
0
500
1000
km


(b)
N
50° 0′0″N
40° 0′0″N
30° 0′0″N
20° 0′0″N
90° 0′0″E
100° 0′0″E
110° 0′0″E
120° 0′0″E
Significant increase
Not significant
Significant decrease
0 500 1000
km


(c)
N
50° 0′0″N
40° 0′0″N
30° 0′0″N
20° 0′0″N
90° 0′0″E
100° 0′0″E
110° 0′0″E
120° 0′0″E
Significant increase
Not significant
Significant decrease
0
500
1000
km

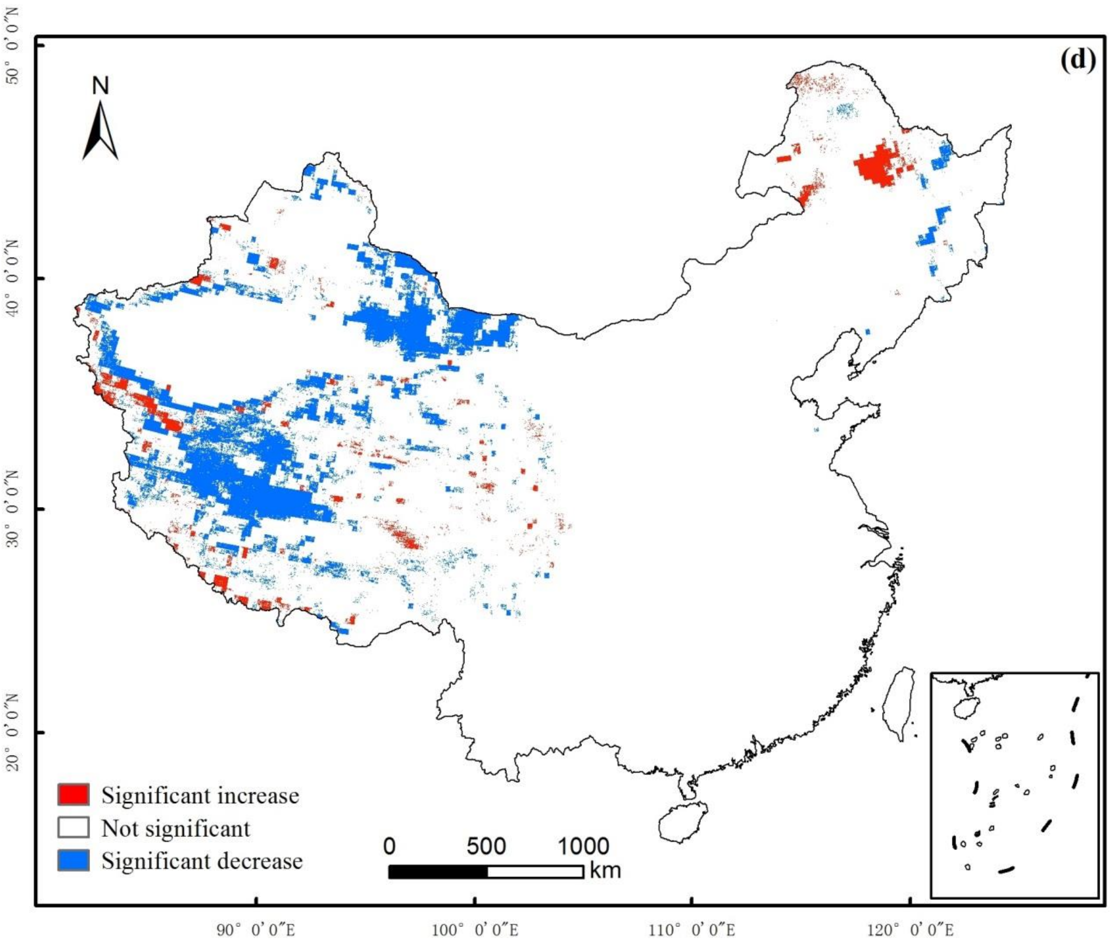


Figure 10: Variation in the average SD during each season in China based on the M-K method from 2001to 2014. (a), (b), (c), and (d) show the significance of the variations during the winter, spring, summer, and fall, respectively.