Potential climate conditions of forest fire in northern Mongolia

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Abstract

Forest in Mongolia protects the permafrost and watershed from drying. Although the forest affects the environment significantly, huge areas of forest have disappeared by wildfires. In this study, climate conditions of forest fire occurrence in northern Mongolia, Khovsgol province, were analyzed. In the last decade, forest fires of Khovsgol mainly occurred in spring (April-May; 49%) and autumn (September; 25%). The timing of forest fires were very different from those in the central Taiga forests where fire usually occurs in summer. Since air temperature in spring and autumn in Hovsgol province was below 30 °C, we consider that forest fires in this region were related to human activities. According to in situ meteorological observations at Tsagaannuur, the climate in spring shows high solar radiation (mean ~ 20MJ/m^2/dy), low humidity (min. R.H. < 20%) and high wind speed (max. gust speed ~ 20m/s). Therefore we conclude that dryness and wind speed are the potential climate index of forest fire in northern Mongolia.

Keywords: Forest fire, Khovsgol, Climate, Meteorological observation

1. Introduction

Boreal forests in Mongolia are located in permafrost regions and protect the permafrost and watershed from drying. The boreal forest has also acted as an important large carbon sink. Since global warming has been thawing the permafrost gradually, the boreal forest is declining. Wildfires damaged the forest to the point where regeneration is not possible anymore.

Forest fires in Mongolia have been increasing since 1996 (IFFN, 2007), and most of them were occurred in spring and autumn (IFFN, 2002). Ivanova (1996) suggested that the forest fires occurrence in the central taiga forests of Russia was in summer and depended on flammable biomass density in the forests, and climate conditions; dryness: long rainless period (precipitation < 2.5mm), dry days (relative humidity < 30%), and hotness: maximum air temperature > 30°C. Thus, the peak seasons of forest fires appear to be different between Mongolia and Russia. In this study, we analyze climate characteristics and climate conditions of forest fire occurrence in northern Mongolia, Khovsgol province.

2. Data and Methods

2.1 Meteorological data

GHCN (Global Historical Climatology Network) monthly data and GSOD (Global Surface Summary of Day) data by the National Climatic Data Center, NOAA (Lawrimore *et al.*, 2011), were used to analyze monthly normal climate conditions and potential climate conditions of forest fire in Khovsgol province. In order to understand the meteorological conditions, we conducted meteorological observations, using an Automated Weather Station (HOBO U30-NRC-SYS-B, Onset), in Tsgaannuur meteorological station. Incoming solar radiation (insolation), air temperature, relative humidity, wind speed and direction, gust and precipitation (only above 0°C) were collected every 10 minutes.

2.2 Forest fire

Data of forest fire occurrence, annual forested area damaged by fire in whole Mongolia (IFFN, 2007) and monthly forest fire occurrence in Khovsgol, were used for comparison with meteorological data.

3. Results and discussions

Figure 1 shows normal seasonal variations of air temperature and precipitation at meteorological stations in northern Khovsgol. Annual mean air temperatures at Tsagaannuur, Renchinlhumbe and Murun were -6.1, -7.1 and -0.4°C, respectively. Since Tsagaannuur and Renchinlhumbe are located in Darkhad valley (see Figure 3), these stations were colder than Murun especially in winter. Annual precipitations at Tsagaannuur, Renchinlhumbe and Murun were 203.8, 273.9 and 226.1mm, respectively. Renchinlhumbe is the nearest to Khovsgol Lake among these stations and slightly wet. The highest air temperatures and precipitations of this region were found in summer (over 100mm from July to August). Although most forest fires occurred in summer in central Taiga forests of Russia (Ivanova, 1996), forest fires rarely occurred in summer in northern Khovsgol under these conditions.

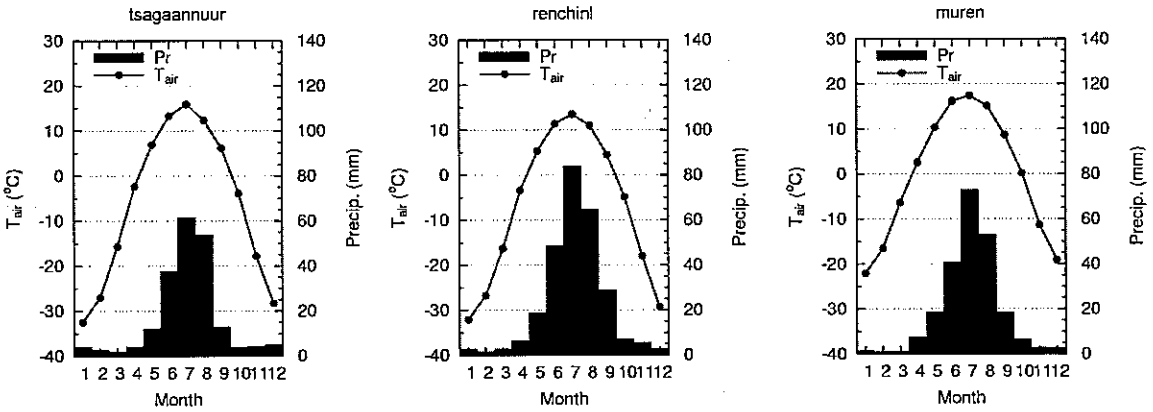

Figure 1 Monthly air temperature and precipitation (averaged for 1974-2006)
Left: Tsagaannuur, center: Renchinlhumbe, right: Murun.

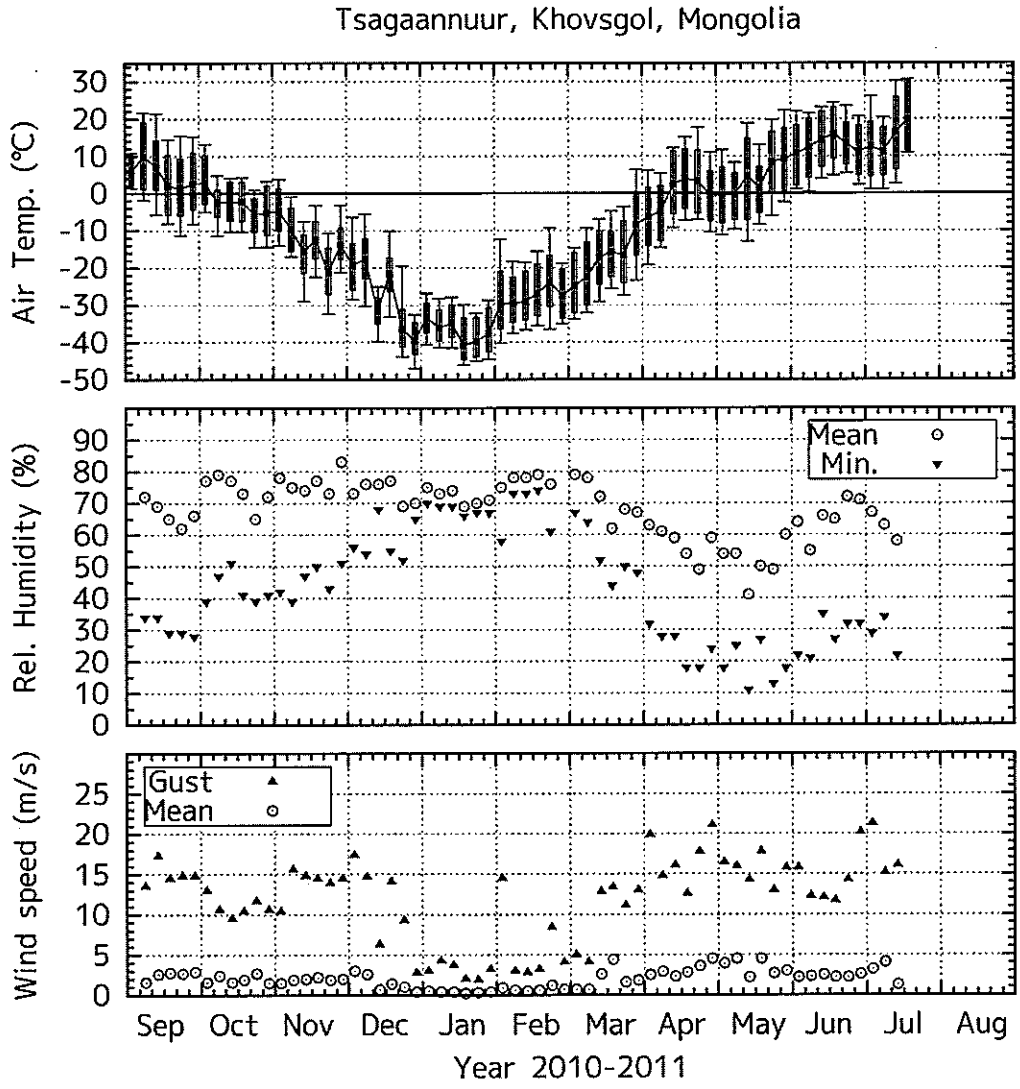

Figure 2 Meteorological observation data at Tsagaannuur.
Top: air temperature (bar: max. and. min., box: 5-days averaged max. and min., point: averaged value), middle: relative humidity (RH), bottom: wind speed.

Figure 2 shows meteorological data related to fire at Tsagaannuur. Annual air temperature range was over 70°C. In spring, mean air temperature rose above 0°C, in contrast, minimum relative humidity dropped under 30%. Additionally, strong gusts, over 20m/s, blew in spring. Autumn was under similar conditions, but was not as dry as spring. Such flammable climate conditions in spring and autumn might have induced forest fires in northern Mongolia.

Table 1 shows monthly frequencies of forest fires in Khovsgol from 1999 to 2008. Most fires were occurred in spring (April-May; 49%) and autumn (September; 25%). While fires in spring occurred every year, those in autumn were concentrated in particular years (e.g. 2002). Therefore, the most dangerous season of forest fire can be spring.

In spring, maximum air temperature sometimes reached 20°C. But it was not hot enough to induce fire naturally, so we suspect fires were induced by human activities.

Table 1 Monthly forest fire occurrence in Khovsgol province.

Year	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Total
1999	0	5	2	0	0	0	0	0	**7**
2000	2	14	5	0	0	0	0	0	**21**
2001	1	4	2	0	0	0	2	3	**12**
2002	1	4	3	0	5	18	38	1	**70**
2003	0	1	3	1	0	0	0	0	**5**
2004	0	1	2	0	0	0	0	0	**3**
2005	1	4	2	0	0	0	0	0	**7**
2006	1	5	2	0	0	0	3	0	**11**
2007	1	5	5	0	5	1	3	0	**20**
2008	0	11	11	8	0	0	0	0	**30**
Total	7	54	37	9	10	19	46	4	186
Ratio	**4%**	**29%**	**20%**	**5%**	**5%**	**10%**	**25%**	**2%**	**100%**

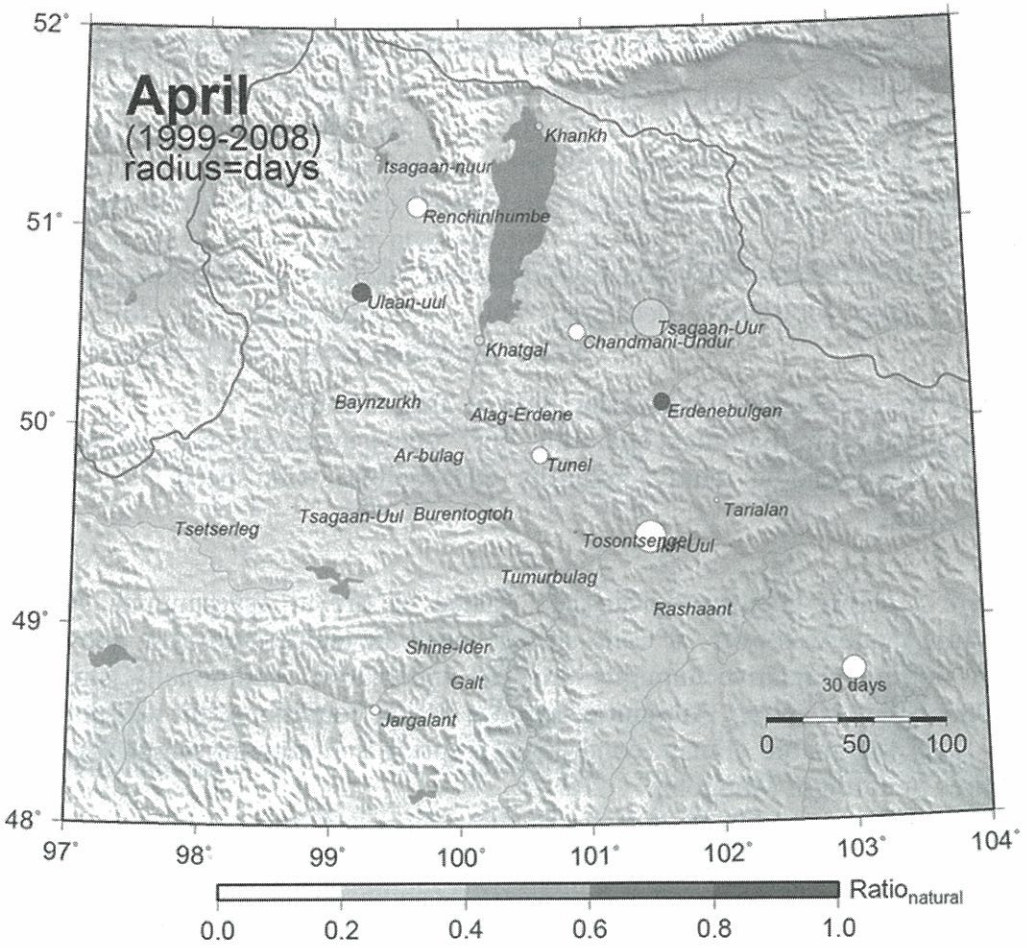

Figure 3 Distribution map of forest fire occurrence days in Khovsgol (April, 1999-2008). Circle size and color indicate fire occurrence days and factor ratio (gray: natural, white: human induced), respectively.

It is clearly seen that fires occurred heterogeneously, and many of them were human-induced (gray: natural, white: human-induced; Figure 3). High air temperature is not the main condition for the spread of human-induced fires. Thus, we should focus on dry conditions for spring forest fires, not on warm conditions. Moreover, strong winds should be taken into account for enlarging and prolonging fires. Strong winds may be caused by Foehn, orographic strong and dry down-slope winds.

The combination of dryness and wind condition time series was used to indicate fire occurrence days and factor ratio (Figure 4). Therefore, large gray circle represents that dry days continued and minimum relative humidity was low. It is usually dry and windy in spring for all 3 stations. Since Murun is warmer than 2 other stations, these characteristics were clearly seen in Murun where is far from the Khovsgol Lake. Many fires occurred in 1977-78, 1986-87 (IFFN, 2002), and corresponded to very dry spring seasons. According to IFFN (2007), forest fires have increased drastically since 1996, and the spring seasons of recent years have been unusually dry. In Khovsgol, several spring fires occurred in 2000 and 2008, and these spring seasons were also very dry (Table 1). There were many forest fires in dry autumn of 2002. From these cases, we conclude that the dryness is the most important necessary conditions for forest fires.

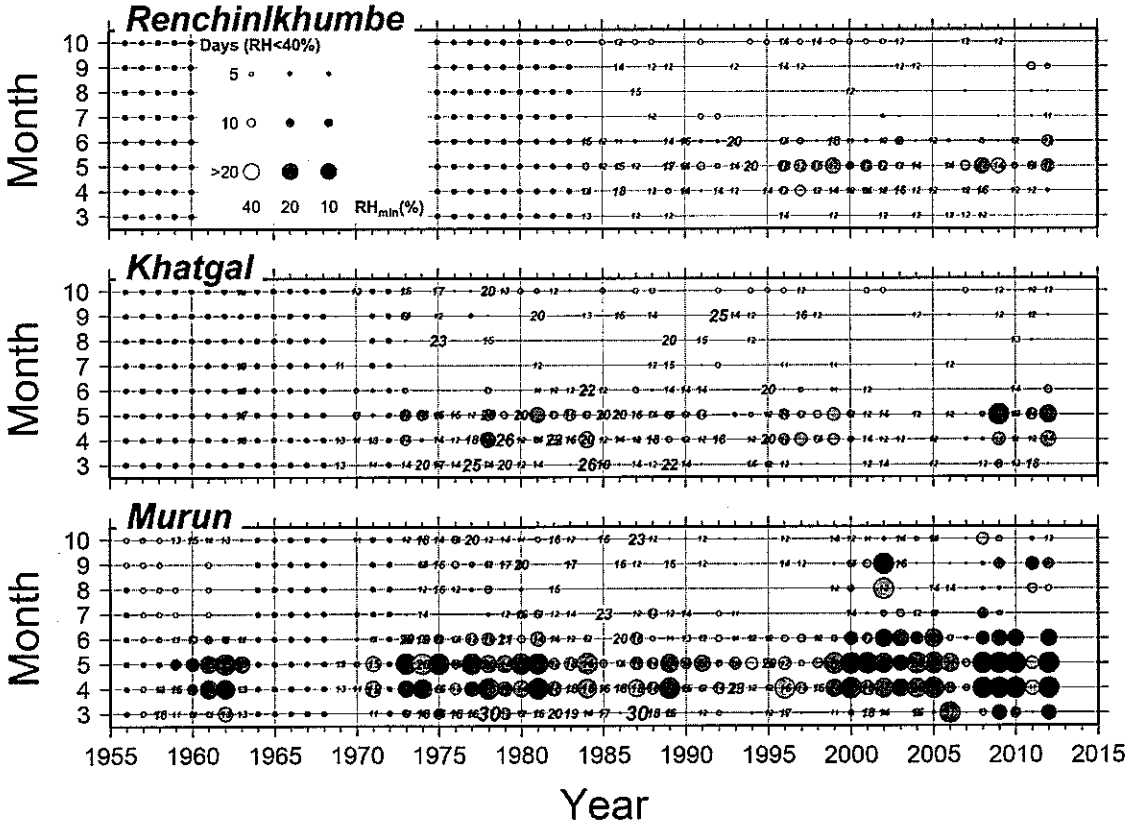

Figure 4 Monthly relative humidity and wind speed.
The size and the color of circles indicate number of dry days (RH<40%) and minimum RH (see legend), respectively. Numerical values indicate maximum gust wind speed (m/s). Black dots indicate missing data.

4. Conclusion

Khovsgol province is characterized by a wide annual temperature range and small precipitation with peaks in summer. In spring, forest fires occurred annually because the climate is usually very dry and windy. Since forest fires in spring are mainly induced by human activities, we conclude that potential climate conditions of forest fires in northern Mongolia are dryness and strong wind, not high temperatures. More detailed analysis (i.e. satellite image analysis, case studies and so on) is still needed to understand locality of forest fires.

Acknowledgements

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