Recent Severe Forest Fire in Alaska and Weather Conditions

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Recent concurrent widespread fires in Alaska are evaluated to assess their associated synoptic-scale weather conditions. Several severe fire-periods from 2002 to 2015 were extracted using Moderate Resolution Imaging Spectroradiometer (MODIS) hotspot data by considering the number of daily hotspots and their continuity. Fire weather conditions during the top six severe fire-periods in the fire years of 2004, 2005, 2009, and 2015 were analyzed using upper level (500hPa) and near surface level (1000hPa) pressure atmospheric reanalysis data. The top four fire-periods occurred under similar unique high-pressure fire weather conditions related to Rossby wave breaking (RWB). Following the ignition of wildfires, fire weather conditions related to RWB events typically result in two daily hotspot peaks occurring before and after high-pressure systems move from south to north across Alaska. A ridge in the Gulf of Alaska resulted in the first hotspot peak under south-westerly wind. After the high-pressure system moved north under RWB conditions, the Beaufort Sea High developed and resulted in a second (largest) hotspot peak during each fire period under relatively strong easterly wind in Interior Alaska. Low-pressure-related fire weather conditions occurred under cyclogenesis in the Arctic and resulted in a single large hotspot peak under south-westerly wind.

1. Fire History in Alaska - Burnt area from 1956

Fire data provided by the Alaska Interagency Coordination Center (AICC) for 1956-2015 was analyzed to identify annual total burnt area and number of fires, and burnt area of each fire. The annual burnt area due to forest fires for 1956-2015 are ranked in descending order and are displayed in Fig.1. From Fig.1, the top 12 years (burnt area >6,000 km^2) stand out among the remaining years (burnt area <6,000 km^2). We will call them "fire years". The total burnt area of the top 12 fire years is about 169,300 km^2 and 2.3 times lager than that of the other 48 years combined (about 72,400 km^2, years of 13th to 60th).

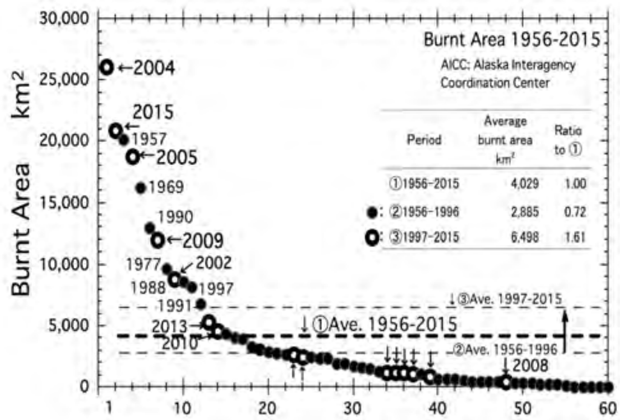

Fig.1. Alaska annual burnt area trend of 60 years from 1956.

The table inset in Fig.1 shows three different average burnt values: (1) the last 60 years average (①Ave. 1956-2015 in Fig.2) is 4,029km^2, (2) the 41 year average from 1956 to 1996 (②Ave. 1956-1996 in Fig.2) is 2,885km2 and (3) the most recent 19 year average from 1997 to 2015 (③Ave. 1997-2015 in Fig.2) is 6,498km^2 (year of 1997 is chosen just because for comparison with the summer Beaufort Sea High (BSH) activities from late 1990s (Moore 2012)). The ratios of ②Ave./①Ave. and ③Ave./① Ave. are 0.71 and 1.61 respectively. The ratio of ③Ave./②Ave. is 2.25. These large ratios suggest that there is a trend to larger fire years in the most recent 19 years that started around 1997.

2. Recent fire trend by MODIS hotspot data from 2002

The MODIS hotspot data during 2002-2015 were obtained from NASA FIRMS (Fire Information for Resource Management System). MODIS hotspot data contains various information such as latitude, longitude, brightness, acquisition date and time, satellite name, confidence, etc. We used only the spatial and temporal hotspot data in this study. The number of daily hotspots was used to identify fire periods, i.e. periods of days when numerous fires occurred, and to identify the important dates of major hotspot peaks during the fire periods. The MODIS hotspot data over the entire Alaska domain except Juneau region were used. Hotspots near, but beyond, the border (i.e. 141°W) with Canada to 140°W were also included to identify large fire areas that extended into Canada. Each detection day and time of hotspot data were converted to Alaska local time using UTC (-8 hours) for a consistency.

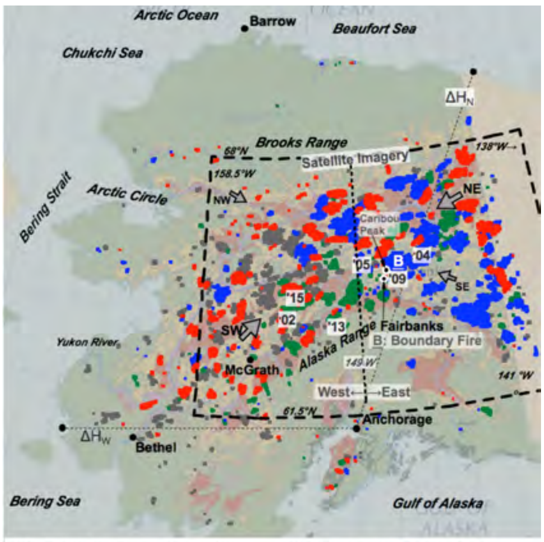

Fig.2 Study area and fire (hotspot) distribution in 2004, 2005, 2009, and 2015.

In Fig.2, the hotspot data for the top four fire years of 2004, 2005, 2009 and 2015 (see Fig.1) are represented by four different color dots (blue for 2004, red for 2005, green for 2009, and gray for 2015) to show the large-scale widespread fires. The center point of fire activity for each year was defined by averaging the longitude and latitude of each hotspot data area.

3. Severe fire periods and their hotspot peaks

The number of daily hotspots was used to find active fire-periods during fire season of each year. The active fire-period was extracted by considering the succession of active fire days. The fire-period was defined as the consecutive fire days when the number of daily hotspots was greater than 300. This definition allowed us to extract several severe fire periods over the MODIS hotspot record.

The number of daily hotspots during the four "fire years" of 2004, 2005, 2009, and 2015 are plotted in Figs.3. Mark of H and a circle are putted when high-pressure system movement from south to north occurs (H stands for high-pressure and a circle in Figs.3 shows exact date of occurrence). Four high-pressure system movements were checked by weather maps at 1000hPa. This movement is discussed in the latter part of paper (weather maps for 2005 in Fig.7). Totally seven severe fire periods are found during four fire years and ranked by total number of hotspots of each fire period.

For major hotspot peaks in four fire years in Figs.3, average wind directions in western and eastern side of Alaska found in the satellite imagery was putted like "S,E". "S" and "E" stand for southerly wind and easterly wind. In addition to wind directions, mark of ① and ② are putted for specified hotspot peaks of seven severe fire periods in Figs.3. ① and ② stand for first and second largest hotspot peaks of each fire periods (except "2. Late Aug."). Only top four severe fire period has both mark of ① and ②. For other three fire periods, ① or ② is putted for first or second largest hotspot peak. These wind directions and marks are used to classify each severe fire period.

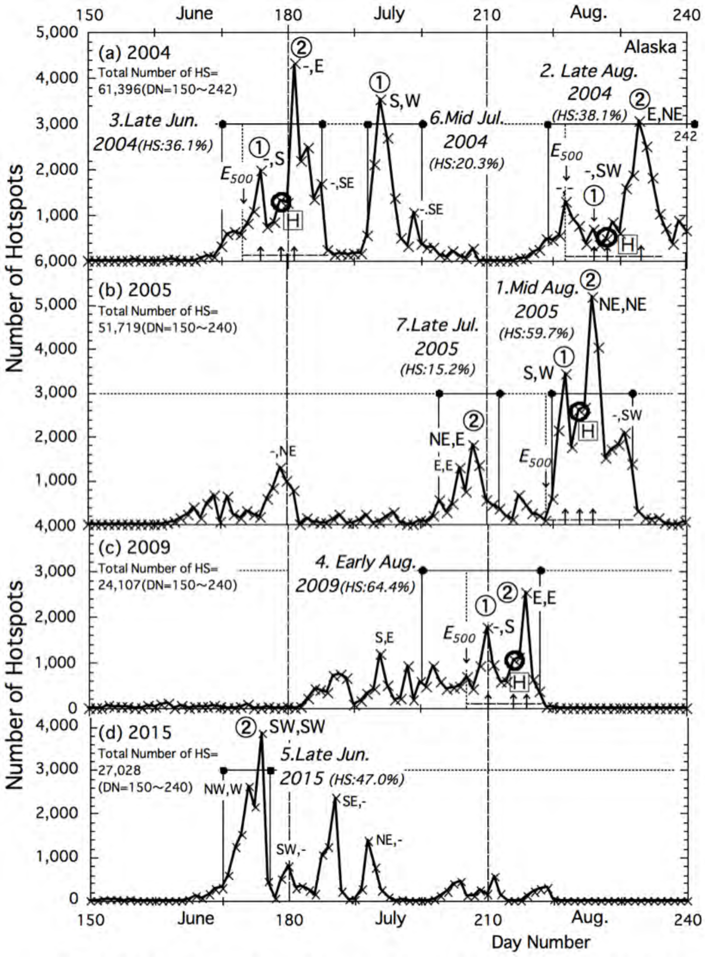

Fig.3. The number of daily hotspots during the 2005 (a), 2004 (b), 2009 (c), and 2015 (d) fire seasons.

4. Conclusions

This study focused on the synoptic-scale fire weather conditions that occurred during several widespread fire-periods in 2004, 2005, 2009, to 2015. Analysis results showed that there are two types of fire weather conditions or high- and low-pressure weather types. High-pressure fire weather conditions occurred under unique weather phenomena related to RWB. After the onset of a large meandering of Jet stream near Alaska, a blocking high was formed over Alaska at upper air levels (500hPa) and the high-pressure system then moved from south to north across Alaska at the lower level (1000hPa). Along with the high-pressure system movement, the wind direction changed from southerly and westerly (SW) to easterly (E) within a several days in Interior Alaska. The switch from SW and E winds occurred with two distinctive hotspot peaks. The largest hotspot peak during each fire-period occurred only in E wind conditions under the Beaufort Sea High. Because E wind from BSH was stronger than the SW wind and blew continuously day and night (from our preliminary analysis results of Caribou Peak weather station data). Under low-pressure weather type, SW wind made one large hotspot peak. This wind condition was made by large pressure difference between low-pressure system in the Arctic Ocean and high-pressure system in the Bering Sea. The onset of two types of severe fire weather conditions for Alaska may be predictable. This study suggest two weather phenomena: (1) onset of large meandering of Jet stream in the west of Alaska for the high-pressure weather type, (2) onset of low-pressure system development (cyclogenesis) in the Arctic Sea and high-pressure system in the Bering Sea for the low-pressure weather type. This study also suggest there is a wind passage (corridor) in the central Alaska made by terrain of Alaska (between the two mountain ranges). The above-mentioned E and SW wind actually blew through this wind passage.