Evaluation of wildfire occurrence considering Foehn wind as meteorological drought drivers in Japan

Tohoku University Graduate Student ○ Yiwei WANG
Kyoto University Member Yoshiya TOUGE
AIST Nonmember Yuya TAKANE
Tohoku University Member Ke SHI

1. INTRODUCTION

Affected by climate change in the future, there is a trend of global warming. Continued drought and high temperatures create more favorable conditions for wildfires. According to Japan's Ministry of Agriculture, Forestry and Fisheries, there were an average of 1,300 wildfires a year from 2016 to 2020, burnt area of about 600 hectares and causing economic losses of 350 million yen. In dry and hot conditions, if foehn winds occur, they make it easier for wildfires to start and spread. Foehn wind is a kind of dry and hot air formed by the increase of temperature and the decrease of humidity when the air is in adiabatic sinking motion (Elvidge et al, 2016). Foehn wind is a localized air movement caused by mountains, which is usually found on the leeward slope of mountains (Takane et al, 2017). Foehn was regarded as a meteorological drought driver (Khan et al, 2018). In this study, foehn event's contribution to wildfire events will be evaluated. Using the difference between the potential temperature and specific humidity of the air flow before and after descending from the mountain top as the conditions for detecting foehn events with appropriate thresholds. Then evaluate the correlation between foehn events and wildfire events, and how foehn contribute to wildfire combined with wildfire statistics of Japan.

2. STUDY AREA

Study area of this study are totally ten areas selected from the region where foehn winds frequently occur in Japan. These include four source areas (S1-S4) and six affected areas (A1-A6). The source area was defined as above 800 meters above sea level and the affected area was defined as below 300 meters above sea level. **Fig.1.** shows the predefined study areas in Japan.

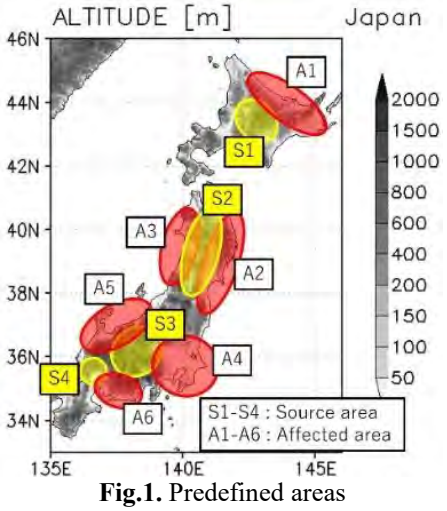

Fig.1. Predefined areas

S areas:
S1: Central Hokkaido
S2: Ou mountains
S3: Japanese Alps
S4: Ibuki mountain
A areas:
A1: 1 Hokkaido's Doutou area
A2: 5 Akida, 6 Yamagata
A3: 3 Iwate, 4 Miyagi, 7 Fukushima
A4: 8 Ibaraki, 9 Tochigi,
10 Gunnma, 11 Saitama, 12 Chiba,
13 Tokyo, 14 Kanagawa
A5: 16 Toyama, 17 Ishikawa
A6: 22 Shizuoka, 23 Aichi

3. METHODOLOGY

3.1. Method of detection

In ideal situation, if the height of the mountain is greater than 800 m, then when the airflow is blow from top to leeward, the value of potential temperature and specific humidity is almost the same (Vergeiner, 2004). After averaging the meteorological data for the source areas and affected areas, using the appropriate thresholds (Plavcan et al, 2014) of these two values, then typical foehn events are selected by expert judge in AIST (The National Institute of Advanced Industrial Science and Technology).

3.2. Analysis

Selected foehn events were analyzed together with wildfire statistics. First, find the foehn season March and April and May. Then select all wildfire events during foehn season in different situations, finally, find correlation and evaluate the contribution to wildfire.

3.3. Dataset

1. JRA-55 Area Downscaling (DSJRA-55)

The Japan Meteorological Agency conducts a 55-year long-term reanalysis (JRA-55, Kobayashi et al. 2015) of the Japan Meteorological Agency for the purpose of understanding climate characteristics such as long-term changes in remarkable phenomena in Japan and analyzing case studies of remarkable cases. Conditional region downscaling (DSJRA-55, Kayaba et al. 2016) was carried out for the period from 1958 to 2012, and a horizontal resolution 5km grid that can appropriately reproduce the phenomenon reflecting the fine topography of the region in Japan.

2. Wildfire statistics

Discover time, watering time, burnt area, trigger factor, economic loss, weather conditions and so on. All the details of wildfire events from 1995 to 2020 in Japan are recorded.

Keywords: Foehn, Foehn detection, Wildfire, Dryness, Japan
Tohoku University, 6-6-20 Aoba Aramaki, Aoba-Ku, Sendai 980-8579, Japan. Tel & Fax: +81-22-795-7460

4. RESULTS AND DISCUSSION

Get all the numbers of single wildfire cases and multi-site wildfire cases in the condition when wind direction is from source area to affected area and wind in all direction.

Calculating the difference of potential temperature (PT) and specific humidity (SP), then using them to draw scatter plots of all the events including wildfire events in the wind direction from source area to affected area. For the detail, we can see **Fig.2.-Fig.7.**

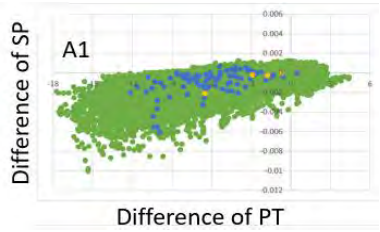

Fig.2. Cases in A1 area

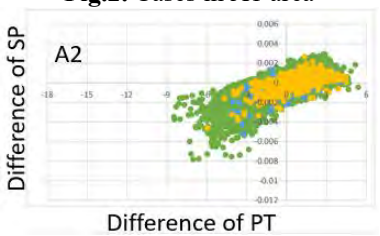

Fig.3. Cases in A2 area

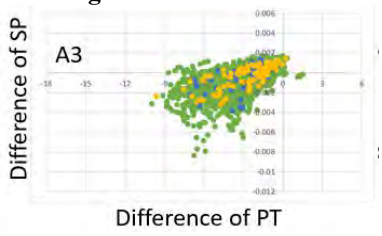

Fig.4. Cases in A3 area

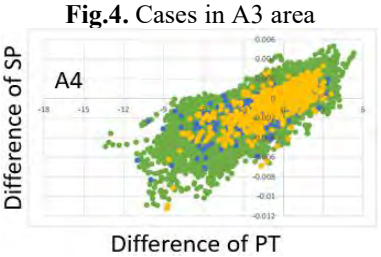

Fig.5. Cases in A4 area

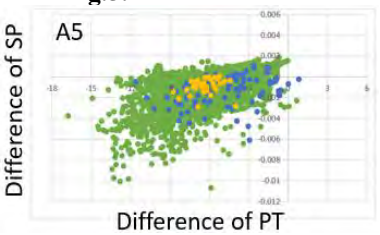

Fig.6. Cases in A5 area

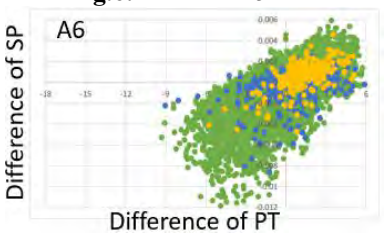

Fig.7. Cases in A6 area

The green dot means all time cases (Wind direction from source area to affected area).

The blue dot means single wildfire event (Wind direction from source area to affected area).

The yellow dot means the multi-site wildfire events at one time (Wind direction from source area to affected area).

5. CONCLUSIONS

From the above explanation, we can conclude as follows:

1. In the six target areas, A2/A4/A6 areas are more likely to have multi-site wildfires when the wind is blowing from source to affected areas.
2. Comparing with no-fire cases, wildfire events occurring in condition when the difference between the two values is smaller.

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REFERENCES

Fire and Disaster Management Agency, Annual Report on Fires in Japan, Ministry of Internal Affairs and Communications, 1995-2020.

Elvidge A D, Renfrew I A. The causes of foehn warming in the lee of mountains[J]. Bulletin of the American Meteorological Society, 2016, 97(3): 455-466.

Takane Y, Kondo H, Kusaka H, et al. Foehnlike wind with a traditional foehn effect plus dry-diabatic heating from the ground surface contributing to high temperatures at the end of a leeward area[J]. Journal of applied meteorology and climatology, 2017, 56(7): 2067-2079.

Khan A L, McMeeking G R, Schwarz J P, et al. Near‐surface refractory black carbon observations in the atmosphere and snow in the McMurdo dry valleys, Antarctica, and potential impacts of Foehn winds[J]. Journal of Geophysical Research: Atmospheres, 2018, 123(5): 2877-2887.

Vergeiner J. South foehn studies and a new foehn classification scheme in the Wipp and Inn valley[M]. na, 2004.

Plavcan D, Mayr G J, Zeileis A. Automatic and probabilistic foehn diagnosis with a statistical mixture model[J]. Journal of Applied Meteorology and Climatology, 2014, 53(3): 652-659.

Kobayashi S, Ota Y, Harada Y, et al. The JRA-55 reanalysis: General specifications and basic characteristics[J]. Journal of the Meteorological Society of Japan. Ser. II, 2015, 93(1): 5-48.

Kayaba N, Yamada T, Hayashi S, et al. Dynamical regional downscaling using the JRA-55 reanalysis (DSJRA-55)[J]. Sola, 2016, 12: 1-5.

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