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Regional Differences in Suitable Drought Descriptions for Wildfires in Japan

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1. Introduction

Fuel resources are abundant and continuous in humid temperate regions, but low combustibility limits wildfires. This study defines atmospheric and soil drought based on their impact on fuel moisture content (FMC). High temperatures and low humidity reduce fuel moisture through enhanced vapor exchange, a phenomenon referred to as atmospheric drought. Conversely, soil drought is defined as a reduction in fuel moisture caused by low soil moisture, which inhibits capillary action and evaporation, resulting in the drying of fuels. Most of Japan experiences a temperate climate. However, significant latitudinal differences result in substantial climatic variation between the northern and southern regions. Current drought and wildfire alerts are based solely on effective humidity and wind speed in Japan, but the mechanisms driving drought wildfire in various climatic regions of Japan and the appropriate assessment of drought remain unclear. As presented in Sun et al. (2024), this study aimed to elucidate the seasonal and spatial characteristics of the interrelationships between soil drought and atmospheric drought with wildfire in Japan, as well as to assess the primary drought type driving wildfire in different regions of Japan during the wildfire season.

2. Method

2.1 Effective humidity (EH)

The effective humidity is an index showing the degree of dryness of wood. It is given by the following equation:

$$H_e = (1-r)(H_0 + rH_1 + r^2H_2) \quad (1)$$

Where H_e is the effective humidity and H_0, H_1, and H_2 are the relative humidities within 3 days. r is generally set to 0.7.

2.2 Soil moisture from land surface model (SM)

The soil moisture from the simple biosphere including urban canopy (SiBUC) model was used in this study. In this study, the soil moisture content of the first layer was focused on, as it directly influences the moisture content and combustion of dead fuel.

2.3 Wildfire statistics

The fire reports, managed by the Fire and Disaster Management Agency (FDMA) since 1995, were used in this study[1]. This study utilized 45,070 wildfire cases in Japan during 1995–2012, with a total burned area of 241.06 km².

3. Results

To assess the spatial characteristics of seasonal variations in Japan, EH and SM thresholds were calculated for 80% of the wildfire incidence in each prefecture for each season, along with the proportion of days below these thresholds. T_{EH}^{80}/T_{SM}^{80} represents the EH/SM threshold where 80% of seasonal fires occur in a prefecture, while D_{EH}^{80}/D_{SM}^{80} denotes the proportion of days in a season with EH/SM below this threshold.

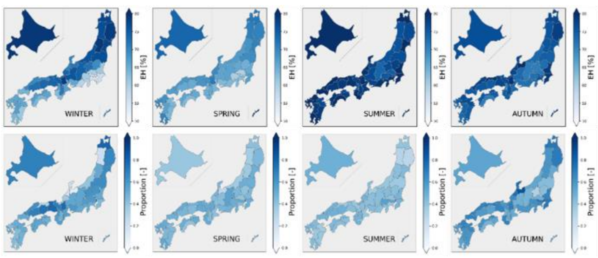

Figure 1 Seasonal spatial patterns of effective humidity thresholds ($\boldsymbol{T_{EH}^{80}}$) and the proportion of days below these thresholds ($\boldsymbol{D_{EH}^{80}}$)(Modified from

Sun et al. (2024))

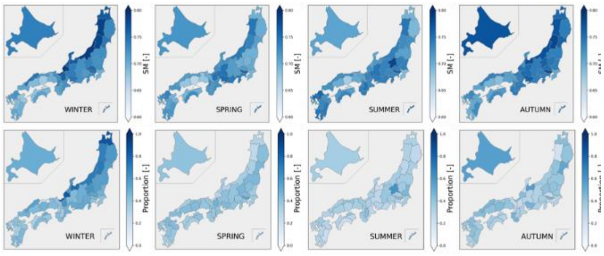

Figure 2 Seasonal spatial patterns of soil moisture thresholds ($\boldsymbol{T_{SM}^{80}}$) and the proportion of days below these thresholds ($\boldsymbol{D_{SM}^{80}}$) (Modified from Sun et al. (2024))

Each prefecture in Japan adopts different EH thresholds for wildfire warnings, all set below 65%. However, this study indicates that these thresholds are only valid during specific seasons in certain prefectures. The results showed that EH had a relatively strong ability to assess drought in Japan during spring, particularly in the Tohoku and Chugoku regions along the Sea of Japan, where T_{EH}^{80} was low and D_{EH}^{80} was approximately 0.4. In winter, higher T_{SM}^{80} values in northern Japan indicated that most wildfires occurred under high SM conditions, particularly along the Sea of Japan coast. In the Tohoku and Chubu regions, where D_{SM}^{80} exceeded 0.7, SM showed minimal influence on wildfire occurrence.

To evaluate the suitability of drought descriptions, Pearson correlation was utilized to examine the relationships between wildfire and drought indices. **Figure 3** shows the Pearson correlation coefficient between the monthly total number of wildfires (NO)/the logarithm of the monthly total burned area (BA) and drought indices for each prefecture in Japan during wildfire season. The number of wildfires showed a strong correlation with EH in northern Japan, particularly along the Sea of Japan coast, with coefficients ranging from 0.5 to 0.75 in Hokkaido and Tohoku region. Conversely, a strong correlation with SM was observed along the Pacific coast, exceeding 0.65 in fire-prone prefectures like Chiba, Hyogo. For burned areas, EH showed correlations in 32 prefectures (0.28–0.68), with stronger values in Hokkaido and Tohoku. SM correlated with burned areas in 39 prefectures (0.28–0.67), predominantly along the Pacific coast, where larger burned areas were observed.

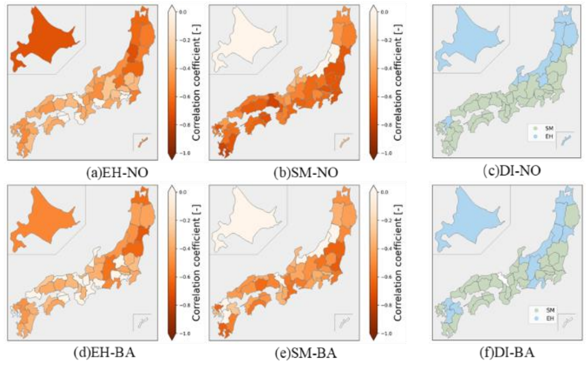

Figure 3 Spatial pattern of Pearson's correlation between the drought index and NO/BA during the wildfire season from 1995 to 2012 (Modified from Sun et al. (2024))

4. Conclusion

The results demonstrate that EH is significantly influenced by seasonal and regional factors, leading to variations in its ability to assess drought for wildfires. In comparison, SM shows a more consistent ability to assess drought across seasons and regions.

5. Acknowledge

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6. Reference

1) Fire and Disaster Management Agency, fire reports. 1995-2012.
2) Sun C, Touge Y, Shi K, et al. Assessment of the suitability of drought descriptions for wildfires under various humid temperate climates in Japan[J]. Scientific Reports, 2024, 14(1): 23759.