THE USE OF SOIL MOISTURE ACTIVE PASSIVE (SMAP) DATA FOR LARGE-SCALE FIRE MANAGEMENT OVER GANG-WON PROVINCE

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ABSTRACT: Due to weather, climate change, and partially anthropogenic reasons, the outbreak of wildfires are increasing. Especially, wildfires in Gang-Won province are unusually large-scale, and thus extremely severe, unlike other regions in South Korea. However, the large-scale wildfires are neglected from the current fire management to decrease environmental damages and casualties. Thus, this study reports one approach to apply 1km high resolution SMAP satellite-retrieved land surface data, which are neglected from current fire prediction models, for fire events (1260 ha) in Kang-Reung this year. From the results, it is found that fuel moistures expressed as soil and vegetation are very low prior to severe fire occurrence, exhibiting low surface soil moisture, high brightness temperature and low vegetation water contents. Thus, it is suggested that this land surface satellite data may be used as a 7 day-predictor for fire occurrence and severity that may occur a week later. This is a much earlier prediction than current Near-Real-Time monitoring scheme.

1. Introduction

One of the most interesting characteristics of wildfires in Kang-Won province is that they are large-scale megafires. 'Large-scale' implies the fire events with more than a thousand hectares. Megafires are referred to as the fire events out of control regardless of firefighting facilities (Tedim et al. 2015). Because of severe damage, and low frequency, wildfires in Kang-Won province may be categorized as extreme events. In addition to Kang-Won province, the mega-fires were also found in Europe, and the United States over the last two decades. The reasons may include weather, and climate change such as drought, or heatwave as well as human activity (Peterson et al. 2014).

There are various approaches for firefighting strategy. Current forest fire prediction model on the Korean Peninsula is based upon the Daily Weather Index (DWI) described as functions of air temperature, humidity, wind and other meteorological variables (원명수 et al. 2012). According to Korea Forest Research Institute, model prediction accuracy is approximately 70 % in spring, while it is less than 50 % in Fall. However, at the moment, large-scale fire occurrence or severity is not monitored or managed yet. In addition, such a DWI does not describe the combustibility of vegetation or plant litters fallen on the land surface as a fuel biomass. Satellite data are not used for the purpose of fire prediction instead of monitoring weather conditions.

The objectives of study are 1) to suggest a 7 day fire risk predictor over large-scale wildfires; 2) to characterize land surface variables relevant to fire predictions. In method sections, study area and SMAP data sets are introduced. In results, three land surface variables effective for the prediction of large-scale fire occurrence and severity are discussed.

2. METHODS

2.1 STUDY AREA

This study area is located at longitude 129° to 129°5´ and latitude 37°34´ to 37°37´ around Kang-Reung city of Gang-won province in Republic of Korea. Soil texture is sandy loam (https://soil.rda.go.kr/soil/soilmap/crop.jsp). Land use is diverse, ranging from farmland, fruit trees, grassland, to forests. Large-scale wildfires occurred on April 4th 2019. Burnt area at 1260 ha is shown in Figure 1. According to the central disaster safety headquarters of the Korean government, wildfires are supposedly ignited by a short circuit. 3.5 million $ was spent for fire suppression and damage restoration. Economic loss is estimated up to 75 million $. Four hundreds of houses, more than nine hundreds of livestock production facilities, and a hundred of buildings were destructed. Main difficulty in disaster control was known to be large-scale fire that occurred in night-time.

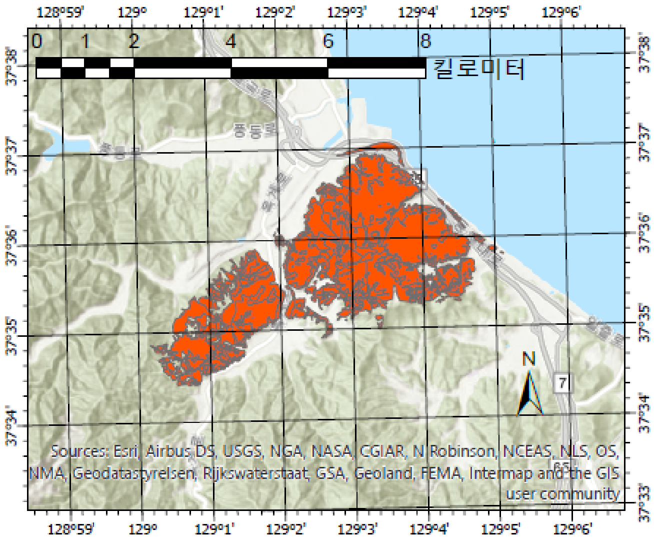

Figure 1. Bunt area in Kang-Reung, Gang-Won province.

2.2 SATELLITE DATA

NASA Soil Moisture Active Passive (SMAP) carries L-band radiometer and radar instruments. Brightness temperature measurement with 9 km resolution is used to retrieve surface soil moisture from the top 5 cm of the soil (Cui et al. 2018). For this study, 1km disaggregated SMAP brightness temperature and 1km surface soil moisture, as well as 3km vegetation water contents (VWC) are acquired from SMAP/Sentinel-1 L2 Radiometer/Radar 30-Second Scene 3 km EASE-Grid Soil Moisture (version 2) (for EOSDIS Earth data, https://earthdata.nasa.gov/) (Das 2018).

3. RESULTS AND DISCUSSIONS

By examining various resolutions (i.e. 1, 3, and 9 km) over the same variable, it is found that a high resolution of at least 1 km is required for effective monitoring of large-scale fire events. In detail, three land surface variables of surface soil moisture, brightness temperature, and vegetation water content are found to be relevant to a large-scale fire events.

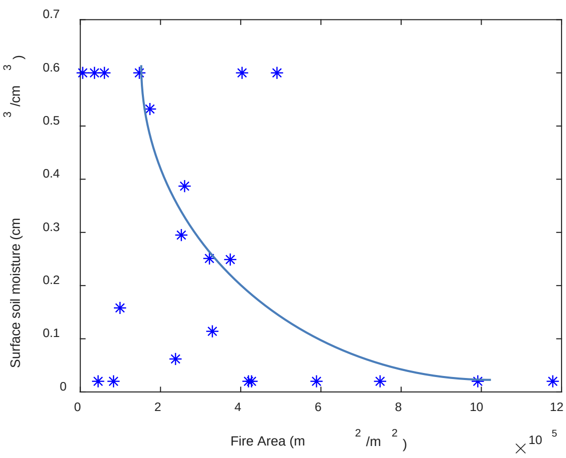

Figure 2. 1km SMAP surface soil moisture over fire area (March 28th in Kang-Reung)

To be in agreement with (Jensen et al. 2018; Krueger et al. 2015), it is found that surface soil moisture is closely related to fire severity expressed as fire area. In Figure 2, surface soil moisture gets drier as the fire area becomes larger. It implies that fuel moisture as the most important factor for fire combustion is sufficiently low at a large scale to cause fire events for any reasons. It is suggested that surface soil moisture is a good indicator for monitoring fuel moisture.

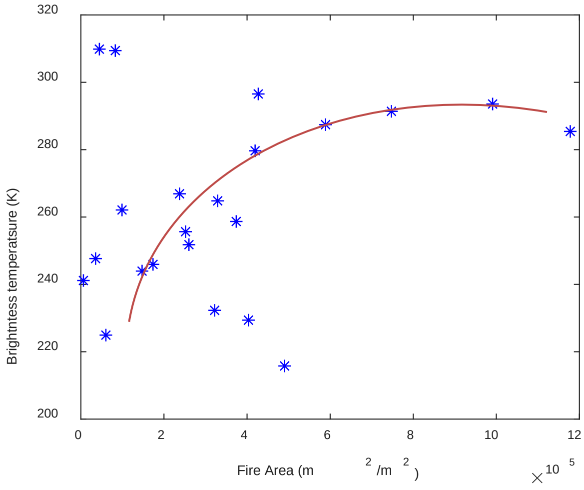

Figure 3. 1km, disaggregated SMAP brightness temperature over fire area (March 28th in Kang-Reung).

Secondly, SMAP brightness temperature is also found to be closely related to fire severity. In Figure 3, brightness temperature increases as the fire area gets larger. In particular, at larger fire event (~6×10^5 m^2/m^2), brightness temperature consistently shows elevated levels, implying extremely dry conditions. This well follows the principle of soil moisture retrieval, in which soil moisture is inversely related to brightness temperature. This is discussed that the brightness temperature of satellite measurement itself - before retrieving it to soil moisture of a physical variable - can be a good indicator for fire risk.

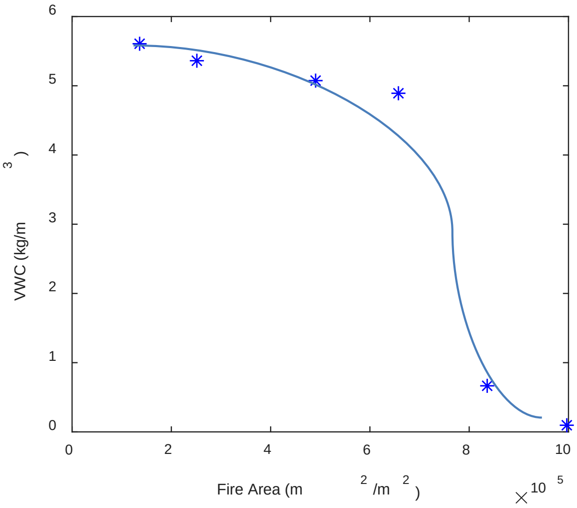

Figure 4. 3km VWC over fire area (March 28th in Kang-Reung)

Finally, the vegetation water content acquired from SMAP data is also related to the monitoring of large-scale fire risk. In Figure 4, WVC informs that the vegetation of large fire event (~6×10^5 m^2/m^2) is in a very dry condition. It can be inferred that WVC is also a land surface indicator of informing canopy moisture. However, there may be a potential limitation in this indicator. The temporal resolution may not be prompt enough, as SMAP VWC is estimated as a function of NDVI available weekly or monthly.

In summary, this study suggests three land surface variables retrieved from SMAP data as a large-scale fire risk predictor. Prediction range is 7 days. This large-scale predictor may also be useful for fire suppression, as it informs us of the directions of wet soils to drive burning fire into. Future works may embed these variables into current fire prediction models, and see if this will improve its prediction accuracy.

5. Acknowledgement

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