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Understanding floods and fires risks in tropical peatlands as part of humid tropical river basins using remote sensing

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1. Introduction

More frequent and deeper floods are expected to affect the land use in the downstream part of major river in humid tropical river basins. The area includes the tropical peatlands which are also vulnerable to fires. Currently, big farmlands and timber companies which are located on the peatlands are regulating groundwater level so that it is low enough to grow crops but high enough to prevent fires. However, planting crops in a frequently flooded area is not economically viable therefore these areas are usually abandoned as open land or covered by shrub/grass. The water level in this area may not be maintained anymore. Remote sensing results show that these abandoned areas experienced fires and floods alternately. Further, Simulation using land use model showed that most of the farmlands which occupied most of the area will turn into shrubs/open land (Yamamoto et al., in prep.). As the abandoned area will increase in the future, so does the area prone to fire.

To date, research on tropical peatland focus only on either flood or fire. However, since they occur alternately, it is important to address them simultaneously. The overall objective of this study is to understand floods and fires in tropical peatland as an integrated part of humid tropical river basin. The research will be carried out in three stages including hydrological simulation using GCM variables. This abstract discusses preliminary results obtained in the first stage of the research framework which is to understanding the temporal and spatial pattern of fire and soil moisture using in-situ and remotely sensed hydrological data.

2. Study Area

The study area consists of Sumatra and Kalimantan Islands, Indonesia, which encompasses the largest area of tropical peatlands in the lowland. The area has experienced significant land use conversion over 30 years, leading to fire risks. In extremely dry period, the severe fire occurred in the peatland, causing haze issues in neighboring countries.

3. Methodology

Data

After comparing some satellite products, we decided to use Soil Moisture Active Passive (SMAP) which was corrected with Multi-Temporal Dual Channel Algorithm (MT-DCA) (Konings et al., 2017) for soil moisture (cm3/cm3), ERA5 Daily Aggregates (Copernicus Climate Change Service (C3S), 2017) for mean air temperature (deg. C), and GSMaP Operational (mm) for rainfall.

We used data from 12 station from Peatland Restoration Agency (BRG) to bias correct the satellite products.

Fire Index

In this study we compare some variables and indexes and assess their effectiveness in estimating fire risk: In this study we compare several variables and indexes to assess fire risk:

1. Soil moisture threshold using SMAP MT-DCA;
2. Bias-corrected soil moisture threshold using SMAP MT-DCA;

3. Keetch-Byram Drought Index (KBDI) (Keetch and Byram, 1968)
4. Modified Keetch-Byram Drought Index (mKBDI) (Taufik et al, 2015) using SMAP MT-DCA;
5. Modified Keetch-Byram Drought Index (mKBDI) using bias-corrected SMAP MT-DCA.

The bias correction method used in this study is the Empirical Quantile Mapping (eQM). We finally evaluate the effectiveness of these variables/indexes in estimating fire risks by decide on a threshold value so that only 5% of fire events are missed and develop a contingency matrix. Fire events are estimated from burned area based on MODIS MCD64A1 C6.

4. Results and Discussions

This study is still in progress, thus in this report we present some preliminary results. Figure 1 shows the fire frequency map in 20 years based on MODIS MCD64A1 C6. The map shows that most of the fires in Sumatra and Kalimantan islands occurred at the coastal areas where the tropical peatlands are located.

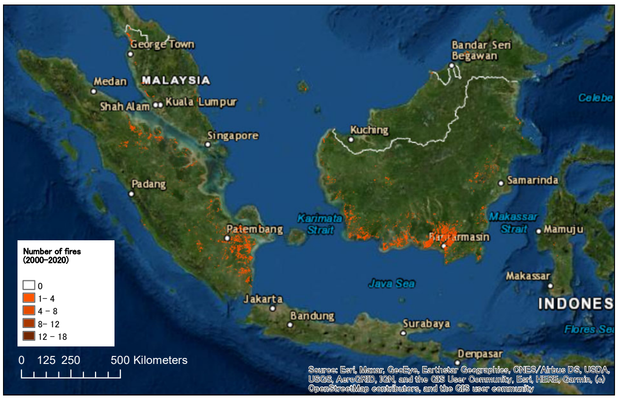

Fig.1 Number of fires from November 2000 to December 2020

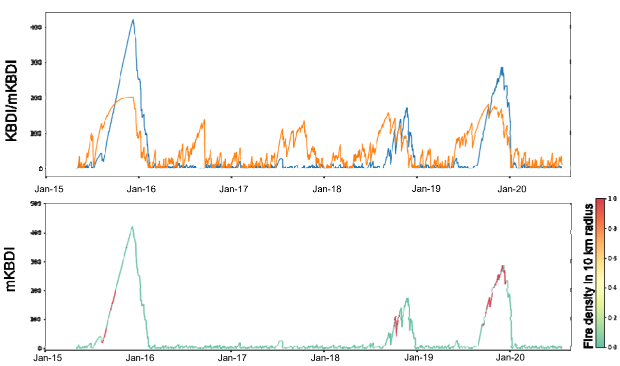

Fig.2 KBDI and mKBDI at Station Oki-2

To date, we have not concluded all results. As preliminary results, we compare the KBDI and mKBDI using bias-corrected soil moisture in some of the stations. One example is shown in Figure 2.

We also compare results of 2D index map of mKBDI (non-bias corrected) and KBDI and one example is shown in Figure 3.

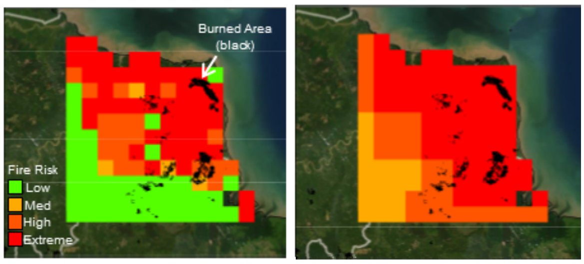

Fig.3 2D map of KBDI and mKBDI at peatland downstream of Jambi Province

5. Summary

Due to climate change the humid tropical river basin will have more floods in the future, particularly in the downstream part where tropical peatlands are located. In the recent years, the tropical peatlands were opened and drained for agricultural crop or production forest which increase the risk of fire in the area. In this fiscal year, we carried out preliminary study in order to understand how to effectively estimate fire risk in tropical peatlands using hydrological variables and fire indexes. We also analyze and compare the use of satellite products to observed data in this area since data is scarce. As preliminary results, we clarify that the use of soil moisture in addition to precipitation and air temperature is important in estimating fire risks in tropical peatland area.

6. References

(1) Yamamoto et al, Prediction of future land use change based on SSP and flood damage assessment of a tropical agriculture (in prep.)
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(3) Keetch and Byram, Res. Paper SE-38, 1968
(4) Taufik et al, Agr. and Forest Meteorology, 2015