

Relationship between surface dry conditions, snow cover, and carbon dioxide emission from forest fire in Far East Russia

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Background

- Positive feedbacks of the disturbances of forests to the global warming are reported many previous studies recently (Bradshaw et al., 2009).
- The effects of global warming to high latitudinal region are more severe than the other ecosystems which is formed under the low temperature. It assumed as twice of tropical (Pimm et al., 2009)
- Wildfire events are common and regularly detected in forests in Far East Russia (Mollicone et al., 2006, Loboda and Csizsar, 2007).



After the winter snow melts in Amur province, people often burn grass and croplands. (by Adam Voland, NASA, April 4, 2018)

Background

- For mitigation of wildfire in this region, the reason and influence of the fire should be clarified.
- Fire is related with dry condition of surface (Keetch-Byram, 1968, Gray, 2015)
- Satellite-based KBDI was developed and analyzed with FO in this region (Park and Takeuchi, 2019, Spring conference of RSS).
- In high latitudinal area, low temperature environment makes KBDI insensible by snow coverage.

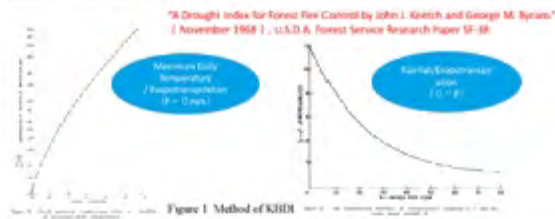


Figure 1 Method of KBDI

Objective of this study

- Goal "A system for mitigating fires in Far East Russia region using satellite-based data"
- To analyze impact of surface dry condition (KBDI) and fire emissions (FE)
- To compare in-situ meteorological data and KBDI with several latitudes condition
- To reveal the relationship between FE and KBDI under the snow or non-snow coverages

Study Area

- Far East Russia (40-55N, 120-145E)

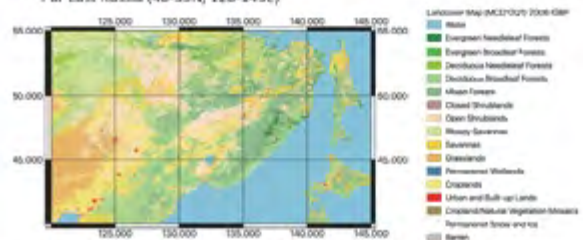


Figure 2 Study Area with MCD12Q1 in background

Data

Fire Emissions (FE) (Takeuchi et al., 2013)

MODIS Fire Product (MOD14)

- Burnt Date
- Fire Radiative Power (used it as combustion completeness)

MODIS Burned Area (MCD45A1)

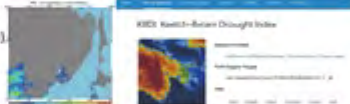
Biomass - from VISIT model (Ito and Oikawa, 2002) - NDVI



Keetch-Byram Drought Index (KBDI) (Keetch and Byram, 1968)

Land Surface Temperature (LST) of Himawari (MTSAT from 2006-)

Precipitation (GSMaP)



Advanced Microwave Scanning Radiometer 2 (AMSR-2)

Snow Coverage Product

Snow covers are detected using the difference between TbV18 and TbV36 when > 0.

Methodology

- Fire Occurrences (FO) were counted in each land cover type
- Time-series of Snow coverage, FE, and KBDI were shown.

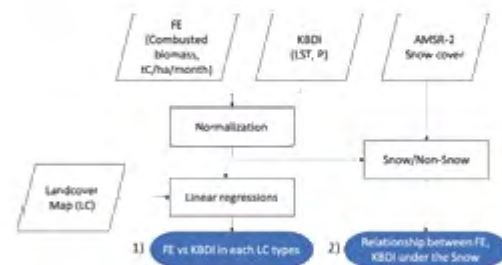
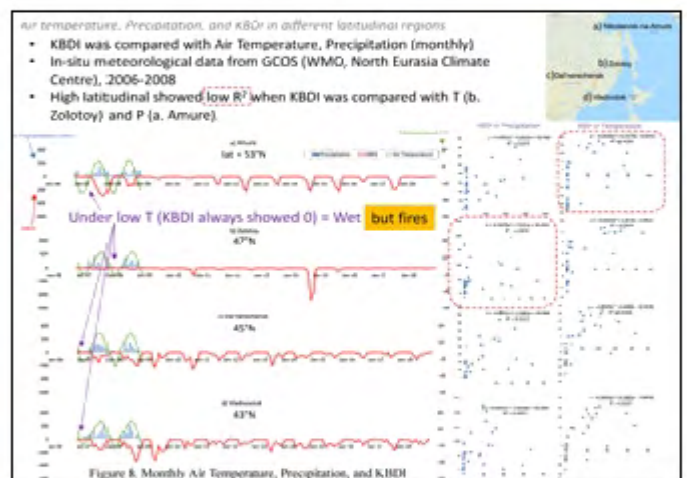
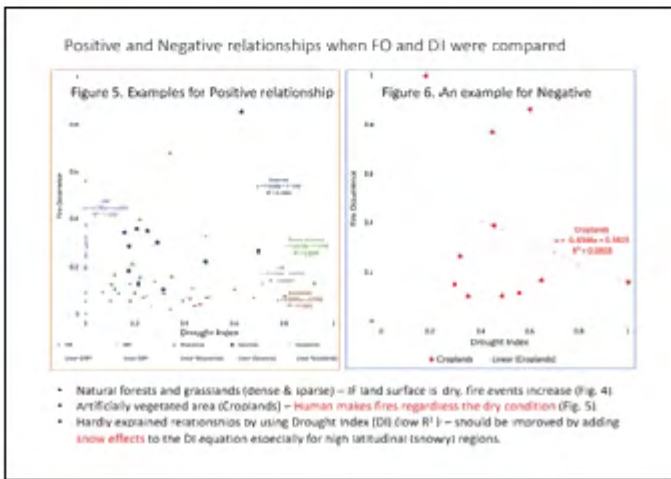
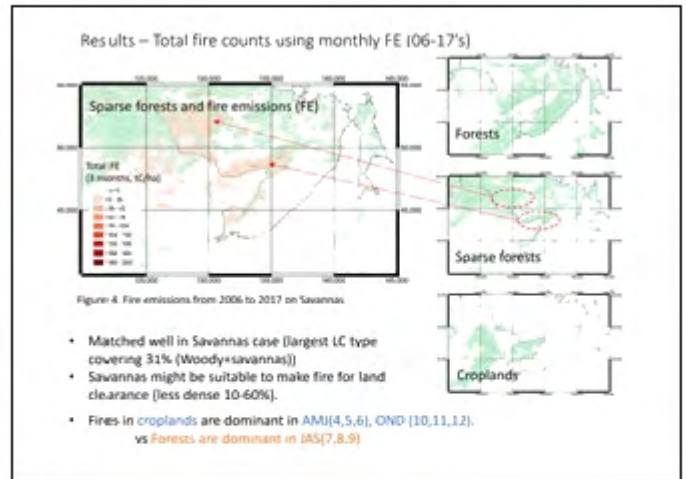
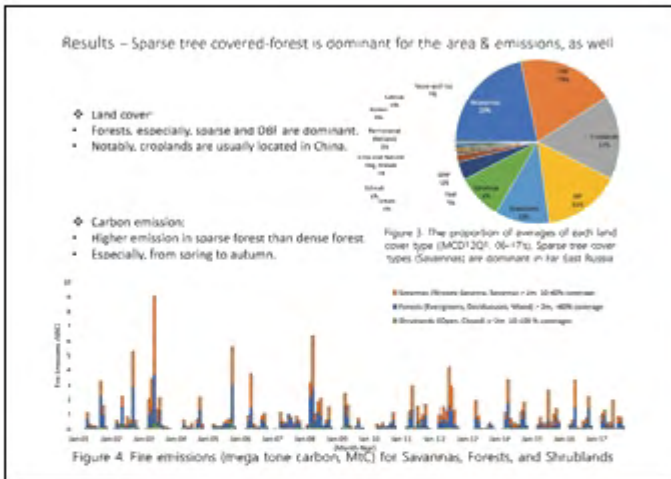


Figure 3 Study flow



Results

Regional case in Ussuriysk in Far East Russia

- As the result, snow coverage has increased during winter and the KBDI has oppositely decreased.
- In spring (snow melting), fires were increased.
- Agricultural fires are usually known as land clearance. If it is happened by human activities, fires are dominant in spring when before the seeding.
- But, KBDI can provide how the fire will be expanded.

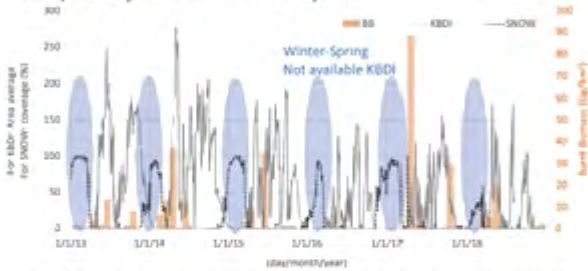
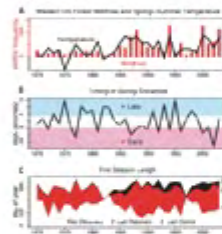


Figure 9. Regional comparison among KBDI (Daily), Snow coverage (Daily), Burnt Biomass (BI) or FF, Monthly in Ussuriysk in Far East Russia.

Discussions

- Kimball et al. (2006): Freeze-thaw in cryosphere is analyzed with productivity of trees. Thaw anomaly durations are related with GPP anomaly. *E1 related issue*
- Zhang et al. (2011): Low temperature suppresses ET because of low demands of evaporation of air capacity & transpiration of plants in Tundra.
- Romanovsky et al. (2010) used snow depth and air temperature for describing degradation of permafrost of Russia.
- Westering et al. (2006) found that early snow melting causes fire vulnerability in western US.



← (Westering et al., 2006)

Figure 10. (A) Annual frequency of large (9400 ha) western U.S. forest wildfires (bars) and mean March through August temperature for the western United States (line) (28, 30). Spearman's rank correlation between the two series is 0.76 ($P < 0.0001$). Wilcoxon test for change in mean large-forest fire frequency after 1987 was significant (W 042; $P < 0.0001$). (B) First principle components of winter timing of streamflow in snowmelt dominated streams (line). Low (pink shading), middle (no shading), and high (light blue shading) circle values indicate early, mid-, and late timing of spring snowmelt, respectively. (C) Annual time between first and last large-fire ignition, and last large-fire control.

Conclusions

- Satellite-based KBDI is an index for fire vulnerability representing dynamics of surface dryness.
- KBDI is more suitable to explain fire expansion pattern. (Natural case)
- In spring, KBDI (dry) and FO (fire) are increasing.
- Delineation of the dryness of surface in this timing is important.
- Under the snow coverage, KBDI showed almost 0.
- Uncertainties in KBDI for low temperature were implied.
- Evapotranspiration in permafrost uses air temperature and snow melting parameter for delineating freeze-thaw cycle.
 - This concept will be added into KBDI in near future.
- As conclusions, estimation of snow melting area and the timing of melting would be helpful to make a robust drought index for high latitudinal area.

