Satellite-derived spatiotemporal patterns of environmental changes caused by 2018-2019 wildfires in Arctic-Boreal Russia

Cherepanova Elena*, Bondur Valery, Feoktistova Natalya, Zamshin Victor

State scientific Institution "Institute for Scientific Research of Aerospace Monitoring "AEROCOSMOS", 105064, Moscow, Gorokhovsky lane 4.
(**Author for correspondence lel.cherepanova@gmail.com*)

INTRODUCTION

Forest fires affect environmental changes both directly, changing the type of land cover, causing local and regional air pollution through emissions of greenhouse gases and aerosols, and indirectly through a secondary effect on atmospheric, soil and hydrological processes. In high latitude areas wildfires lead to the permafrost degradation, a change in the balance of greenhouse gases in the atmosphere, and it results in the negative impact on the Earth's climatic system.

STUDY AREA AND DATA

This study examined the Arctic-Boreal territories of the Yakutia, Russian Federation, where the large wildfires in larch forests were observed in 2018-2019. In most of these areas, the wildfires are not actively controlled, with only passive satellite monitoring.

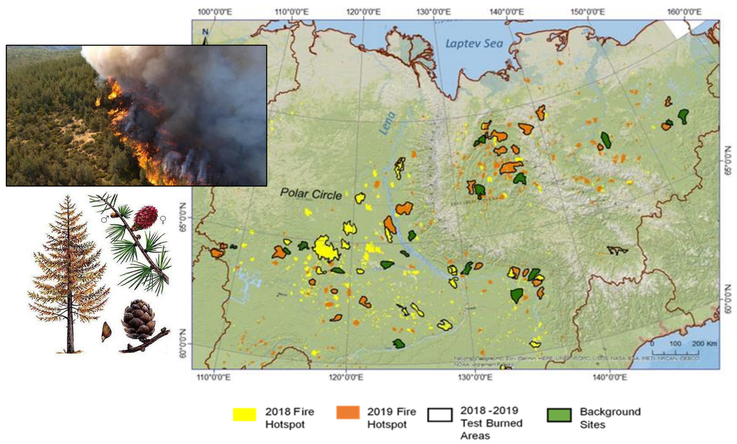


Fig.1 Wildfire Sites (MOD/MYD 14 Hotspot/Fire) and large burns >400 sq. km (MCD 64 Burned Area), detected in Yakutia by TERRA/AQUA satellites during the fire hazard period 2018-2019.

In total, 47 test sites of burns with areas from 400 to 7,500 sq. km (18 sites in 2018, 29 sites in 2019) and 17 background sites of larch forests were analysed (Fig.1).

Various indices have been calculated from Landsat and MODIS data for the pre-fire and post-fire periods to identify the spatiotemporal patterns of environmental change caused by large wildfires. Also the Sentinel 5 TROPOMI time series have been analysed for the short-term and season atmospheric anomalies over burned areas.

SEASON METHANE ANOMALIES OVER BURNED AREAS

The most intriguing result of the TROPOMI atmosphere monitoring over the test areas were obtained for methane (CH4). The reason is that CH4 is a long-lived gas unlike other trace gases and therefore it is more applicable for low resolution satellite monitoring in highly clouded circumpolar territories.

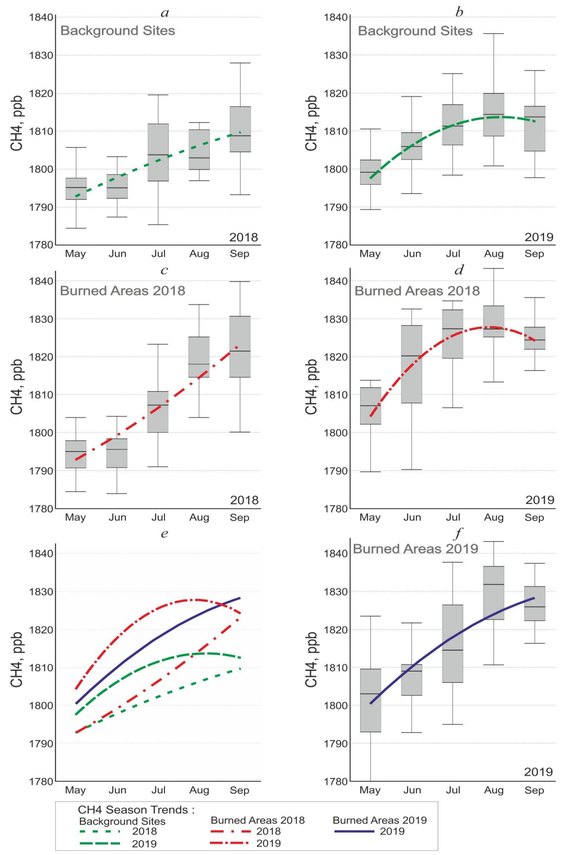


Fig.2 Monthly TROPOMI CH4 averaged over the tested areas in Yakutia in 2018-2019

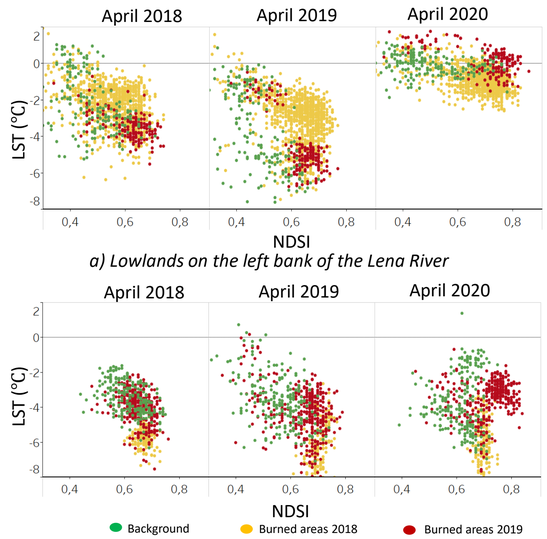
Another factor could be that, the territory is located within the permafrost zone, where in addition to CH4 emissions directly from fires (Fig. 2 *c,f*), it can be assumed that there are sources of CH4 emissions from wetlands and as a result of permafrost thawing (Fig. 2 *a,b,d*).

LST AND SNOW INDEX DYNAMICS

Indirect patterns of environmental changes (e.g. permafrost thawing) due to wildfires can be detected based on an analysis of the spatiotemporal dynamics of Land Surface Index (LST) and Normalized Difference Snow Index (NDSI).

Preliminary studies of MODIS data indicated that LST and NDSI greatly depend on the latitude and relief of the study area and most revealing in April and October. Based on this, two regions with similar conditions and a radius of 200 km each were selected.

As shown in Fig.3a, b LST values on lowlands are higher and more variable than on highlands. Burned areas of both regions is characterized by higher NDSI than in forests in April.



a) Lowlands on the left bank of the Lena River

b) Highlands on the right bank of the Lena River

Fig.3 Spatial-temporal relationship of LST(MOD11) and NDSI (MOD10) for tested areas in April 2018-2020

CONCLUSIONS

1. Anomaly methane concentrations detected by satellite correlate well in time and space with large burned areas. There is a tendency to exceed monthly background CH4 values on 5-15 ppb July-Sept over new burns, and on 10-15 ppb May-Sept over the last year burns.
2. False constant anomalies were found over non fire circumpolar areas which requires additional work on validation of CH4 TROPOMI data.
3. The post-fire LST is colder for highlands and hotter for lowlands if compared to pre-fire LST values for study area. The need to extend the time series of observations to increase the reliability of the results.

ACKNOWLEGMENTS

The reported study was funded by RFBR, MOST (China) and DST (India) according to the research project № 19-55-80021.

Bondur V.G., Tsidilina M.N., Cherepanova E.V. Satellite monitoring of wildfire impacts on the conditions of various types of vegetation cover in the federal districts of the Russian Federation // Izvestiya, Atmospheric and Oceanic Physics. 2019. Vol. 55. No. 9. P. 1238-1253. DOI: 10.1134/S000143381909010X.

Bondur V.G., Ginzburg A.S. Emission of Carbon-Bearing Gases and Aerosols from Natural Fires on the Territory of Russia Based on Space Monitoring // Doklady Earth Sciences. 2016. Vol. 466. No. 2. P. 148-152. DOI 10.1134/S1028334X16020045.

Robinne F-N, Burns J, Kant P, Flannigan M, Kleine M, de Groot B, & Wotton DM (2018). Global Fire Challenges in a Warming World. IUFRO, Vienna, Austria.