REMOTELY DETECTED FIRE EVENTS: POTENTIAL AND CHALLENGES OF VALIDATING AGAINST NATIONAL GROUND DATA

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ABSTRACT

The Earth Observation data are recognized as valuable source of information about fire events. In this paper we present the potential of using the satellite-based 'hotspots' in management of fires as well as challenges of validating the remotely detected fire events in Poland. We compare the spatio-temporal distribution of fires derived from satellites against ground-based fires reported in the National Forest Fire Information System. The preliminary results showed that about 35% of the remotely detected fires were recorded in the ground-based fire database over the period 2002-2013. The satellites has missed the vast majority of vegetation fires. The limitation of both databases was also discussed. The analysis of fire intensity, for the fires detected both remotely and on the ground, demonstrated that forest fires were the greatest and the most intensive fires. However, the analysis of the mean Fire Radiative Power values calculated for all recorded MODIS hotspots confirmed that wetland fires are the most intensive considering that the number of burning events was relatively low.

Index Terms – fires, hotspots, carbon losses, intensity, MODIS FRP

1. INTRODUCTION

Number of extreme fire events reported in Europe has recently increased predominantly due to climatic change and human activities. According to the statistics provided by the European Join Research Centre (JRC) in Ispra/Italy Poland is a third European country after Portugal and Spain in number of fires reported annually [1]. The National Forest Fire Information System functioning currently in Poland is based explicitly on the ground data collection. The Earth Observation data, which is recognized as valuable source of information about fire event is not included into the existing system. It is known that ground data collection is usually time consuming and cost ineffective especially at large scale as national and sub-national levels. Therefore, the main aim of this study was to examine and assess the suitability of remotely detected fires for providing additional information on the fire regime in Poland. The objectives were: 1) to compare spatio-temporal distribution of fires derived from satellites against ground-based fires reported in the National Forest Fire Information System, 2) to identify the limitations of both datasets, 3) to compare fire intensity derived from analysis of MODIS Fire Radiative Power (MODIS FRP) against the

ground-based data on fire extent and type of burned land cover, and 4) to calculate the amount of biomass consumed by wildland fire of wetlands using 'top-down' and 'bottom-up' approach.

2. DATA AND METHODS

The national satellite-based Active Fire Database contains 'hotspots' (thermal anomaly) derived from MODIS sensor on board Terra and Aqua satellites (viewing the Earth's surface twice a day in complimentary orbit), from ATSR sensor on board of ENVISAT satellite (viewing the Earth's surface at night) and from AVHRR on board of NOAA polar orbiting satellites. The national satellite-based Active Fire Database contains only 'vegetation fires' which occurred in Poland over the period 2001-2013. The 'non-vegetation hotspots' (located on artificial surfaces, e.g. cities, industrial sites) were masked out using CORINE land cover classification (CLC2006). The National Forest Fires Information System (KSIPL) is designed and managed by the Forest Research Institute in Poland. This database comprises several parameters characterizing single fire (i.e. date of first alert, time of intervention, position (Lat/Lon), province code, burned area, presumed caused, type of land cover affected by fire (forest, other wooded land, other non-wooded natural land and agricultural land). Firstly, the detailed analysis of the KSIPL database was performed to identify limitations and errors that may influence the method of comparing both databases. The satellite-based 'hotspot' database covering the period 2001-2013 was compared against the fire data reported in KSIPL for the equivalent period. Due to the limitation of detection of small fires from space only fires with burned area equal or greater than 1 ha were considered. The drawback of the ground-based database was the incorrectly recorded position of fires. This make the direct comparison of fires impossible. Thus, the comparison was performed on the bases of administrative divisions NUTS3 taking into account the information on the time of fire alarm, time of intervention and the duration of a fire. The positive and false detections were identified. The positive detections (fires detected both remotely and on the ground) were then subject to further analysis of the relationship between fire intensity and the size of a fire and the type of affected land cover (derived from the KSIPL database). Fire intensity was obtained from the analysis of MODIS Fire Radiative Power product (MODIS FRP). The FRP of a fire represents the amount of radiant heat energy liberated from the burning 'pixel' [2, 3], which is directly proportional to the combustion rate [4]. The satellite-based FRP data has provided a quantitative assessment of fire intensity across the globe. Fire intensity is not measured on the ground and thus not incorporated into the fire monitoring system in Poland. The satellite measurements of the FRP was integrated over time to yield the Fire Radiative Energy (FRE) released from ignition. Knowing that FRE is linearly related to the total biomass burned, the amount of biomass consumed by fire was calculated using the equation by [4]:

Fuel biomass combustion (kg) = 0,368 (±0,015) FRE(MJ)

The results of the amount of biomass consumed using the 'top-down' FRP approach were compared with the results of the 'bottom-up' approach based on ground measurements. The ground-based

method requires various ground-based data such as burned area, the type of biomass/fuel affected, fraction of available fuel burned (combustion factor). These parameters are not easy to determine, thus they are often based on theoretical assumptions or limited spatially scattered ground measurements. The FRP is less dependent on external parameters, because it relies on energy released from combustion.

The estimation of biomass losses following the 'top-down' and 'bottom-up' approaches was performed over the wetland area burnt in autumn 2002.

3. RESULTS AND DISCUSSION

The satellite-based Active Fire Database yielded almost 6500 active fires over the period 2001-2013. By contrast, about 115 000 fires equal and greater than 1 ha was recorded in KSIPL for the equivalent period. The preliminary results showed that about 35% of the remotely detected fires were recorded in KSIPL. The highest agreement was obtained for the year 2012 (48%), 2008 (43%), 2009 (39%), and 2003 (39%). In 2001 and 2002, the agreement reached the lowest values (13 and 19%, respectively), which was due to the incompleteness of the MODIS database. About 94% of KSIPL fires were missed by satellites over the investigation period. This result indicates that satellites has missed the vast majority of vegetation fires in Poland. The high omission error is mainly due to the limitation of remote detection of fires caused by cloud, smoke, and small fire size (less than 1 hectare) dominate in Poland. Additional investigation of the relationship of cloudiness and rate of fire detection is required. The high commission error is more likely to be related to the accuracy and completeness of the KSIPL database. Lack of the precise information on position of fires on the ground influence reliability of the comparison. Furthermore, the national KSIPL database requires standardization of the procedure of fires reporting to avoid further error propagation.

The analysis of fire intensity, for the fires detected both remotely and on the ground, demonstrated that forest fires were the greatest and the most intensive fires compare to the agricultural burning or to fires on the other non-wooded natural land. Forest fires, for example, showed the highest mean FRP value and at the same time the highest variation (mean FRP=15MW, stD=83). For comparison, agricultural fires had lower mean FRP value and much smaller variation (mean FRP=35MW and stD=35). The lowest mean and stD FRP values were observed on the other non-wooded natural land.

The estimation of biomass losses calculated using the satellite-bases 'top-down' method showed that on average almost 45 000 ton of biomass was consumed during the fire in wetland area in the year 2002. By comparison, following the 'bottom-up' approach, the amount of burned biomass reached the value of around 49 000 tons, however this value does not include the below-ground biomass (peat soil) that burned away. The follow up step is to conduct the quantitative estimation of emissions from burning biomass (considering both above- and below-ground biomass). The emission can be calculated using the emission factors reported in various publications [5, 6]. Investigation of fire intensity and quantification of

biomass/carbon losses and emissions from burning is essential to mitigate climate changes.

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5. REFERENCES

[1] R. Szczygiel, B. Ubysz, and T. Zawila-Niedzwiecki, "Chapter 10: Spatial and Temporal Trends in Distribution of Forest Fires in Central and Eastern Europe", in *Developments in Environmental Science*, 8, Elsevier B.V., Eds.: A. Bytnerowicz, M. Arbaugh, A. Riebau, C. Andersen, 2009.

[2] J.Y. Kaufman, C. Justice, L. Flynn, J. Kendall, E. Prins, D.E. Ward, P. Menzel, and A. Setzer, "Monitoring Global Fires from EOS-MODIS", *Remote Sensing of Fires from EOS-MODIS*, 1998.

[3] M. J. Wooster, B. Zhukov, and D. Oertel, "Fire radiative energy for quantitative study of biomass burning: Derivation from the BIRD experimental satellite and comparison to MODIS fire products", *Remote Sensing of Environment*, 86, pp. 83-107, 2003.

[4] M.J. Wooster, G. Roberts, G.L.W Perry, and Y.J Kaufman, "Retrieval of biomass combustion rates and totals from fire radiative power observations: FRP derivation and calibration relationships between biomass consumption and fire radiative energy release", *Journal of Geophysical Research-Atmospheres*, 110, 2005.

[5] S.K. Akagi, R.J. Yokelson, C. Wiedinmyer, M.J. Alvarado, J.S. Reid, T. Karl., J.D. Crounse, and P.O Wennberg, "Emission factors for open and domestic biomass burning for use in atmospheric models", *Atmospheric Chemistry and Physics*, 11, 4039-4072, doi:10.5194/acp-11-4039-2011, 2011.

[6] M.O. Andreae, and P. Merlet, "Emission of trace gases and aerosols from biomass burning", *Global Biogeochem. Cy*., 15 (4), 955-966, doi:10.1029/2000GB001382, 2001.