Biomass Burning Emissions Estimates in the Boreal Forests of Siberia

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Introduction

Wildfire is an important disturbance in boreal forest burning up to 10-30 million hectares annually, thus modifying the global carbon budget through direct fire emissions and postfire biogenic emissions. Fires in the Russian boreal forest range from low-severity surface fires to high-severity crown fires. Biomass burning emissions vary depending on vegetation type and loading, age of forest, fire weather, and the time of day and year when the fire burns. Estimates of carbon emissions from fires in Russian boreal forests vary substantially due to differences in ecosystems types, burned area calculations, and the amount of fuel consumed (Fig.1).

The concentration of this study is on the Siberian region, which lies east of the Ural Mountains and east to Far East (Fig.2). This region occupies about 2/3 of the Russian territory and accounts for the largest area burned (Sukhinin *et al.* 2004; Vivchar 2011).

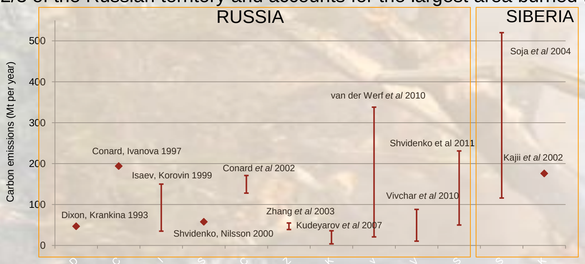

Fig.1. Carbon emission estimates in Russia by different data source

Fig.2. Map of Russia showing the Siberian region under study

Materials and Methods

To estimate uncertainties in biomass burning emissions, data on burned area, ecosystem type burned, and carbon consumption completeness in Siberia obtained from different sources were analyzed.

Area burned. Satellite area burned products used to assess differences and the potential for error over the Siberian region for the 12-year period (2000-2011) include Advanced Very High Resolution Radiometer (AVHRR) and MODerate resolution Imaging Spectroradiometer (MODIS) burned area data obtained by VN Sukachev Institute of Forest (Sukhinin *et al.* 2004), MODIS thermal anomaly data (Giglio *et al.* 2003), and MODIS MCD45 burned area data (Roy *et al.* 2008).

Vegetation type burned. To examine ecosystem type burned, burned area data of the Institute of Forest was overlaid on three vegetation maps: GLC-2000 (Bartalev *et al.* 2003), Globcover-2009 (Bontemps *et al*. 2011), and the Digitized Ecosystem map of the Former Soviet Union (Soja *et al.* 2004). To minimize classification ambiguities we combined land cover classes to 5 generalized classes depending on the dominant vegetation type (forest, shrubland, grassland and cropland, forest-grassland, wetland).

Results

Fires in Siberia vary from year to year both by area burned and number of fires (Fig.3). Area burned differs significantly by data source, with satellite data being by an order of magnitude greater than official Avialesookhrana data. Among satellite data MODIS burned area product shows the lowest values while Institute of Forest data always exceeds all other data (up to 380%). However, at the same time, there is a correlation between different sources of area burned (Fig.4).

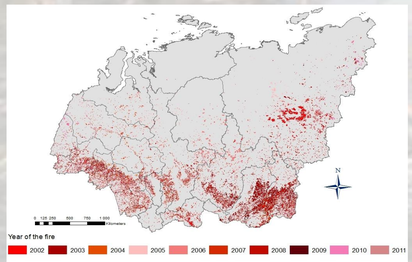

Fig.3. Fires in Siberia from 2002 to 2011

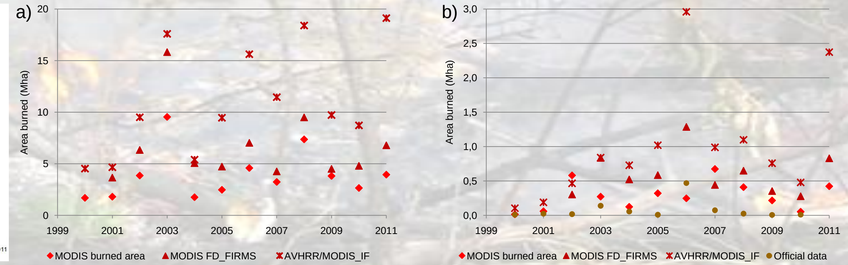

Fig.4. Comparison of satellite and official burned area data for Siberia (a) and Krasnoyarsk region (b)

Our examination of Institute of Forest burned area data overlaid on different land cover maps showed that ecosystem type burned in Siberia varies substantially for the same year from map to map. Originally different maps had different definitions and number of ecosystem categories could associated with different fuel loadings. While there is an overall tendency in area burned in different categories the disagreement in ecosystems burned between maps reaches more than 40% (Fig.5).

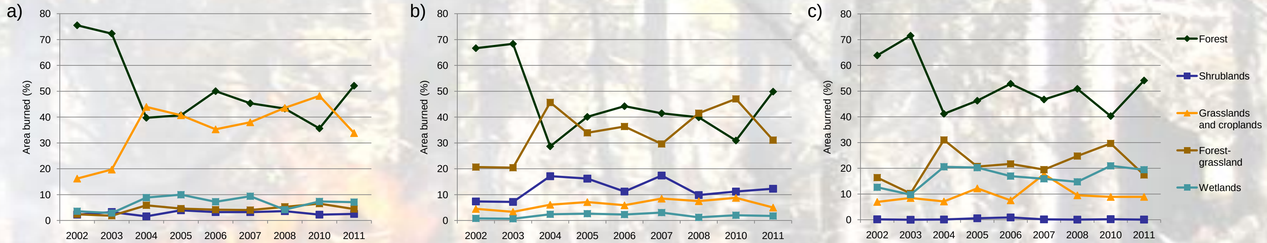

Fig.5. Ecosystem type burned in Siberia from 2002 to 2011 according to GLC-2000 (a), GlobCover-2009 (b) and the Digitized Ecosystem map of the Former Soviet Union (c)

Different ecosystem maps could give as much as 70% difference in carbon emission estimates. The other source of potential error in biomass burning emissions estimate is fuel consumption that could vary drastically in the same ecosystem type depending of weather conditions that determine fuel moisture (Fig.6,7).

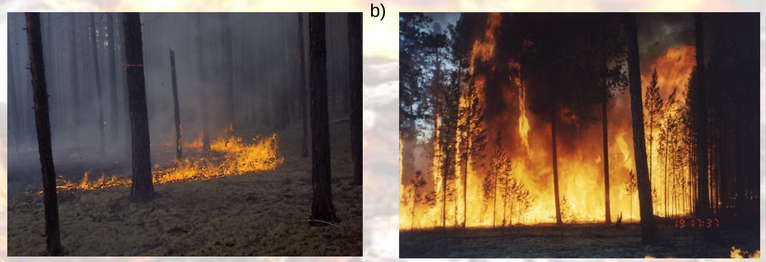

Fig.6. Fire of low (a) and high (b) severity in *Pinus sylvestris* stand of central taiga

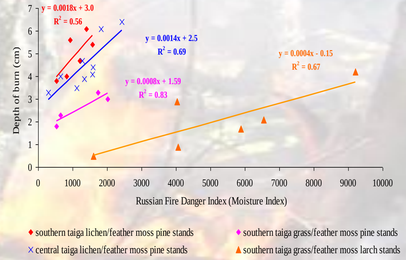

Fig.7. Depth of burn vs weather conditions in different forest types of Siberia (experimental FIRE BEAR (Fire Effects in the Boreal Eurasia Region) Project data)

Conclusions

Being a huge reserve of carbon and a large potential to sequester through its forests or release carbon through the vast area burned each year, Siberia could substantially impact the global carbon balance. Adequate biomass burning emissions estimates remain an open issue for the Siberian region. Climate change and increasing drought length would increase the probability of high-severity fire occurrences. Estimating fire contribution to carbon balance should consider fire type and severity, as well as vegetation type. The developing of methods for improved estimates of large-scale carbon emissions due to fires by using field data, carbon loading maps and satellite data on fires are desperately needed in boreal forests of Siberia due to their considerable contribution to the regional and global atmosphere quality.

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