Quantifying wildfires in Central Siberia: linking “top-down” and “bottom-up” observation strategies

*Alexey Panov[1], Anatoly Prokushkin[1], Alexander Bryukhanov[1], Mikhail Korets[1], Evgenii Ponomarev[1], Allison Myers-Pigg[2], Patrick Louchouarn[2,3], Marina Bryukhanova[1], Nikita Sidenko[1], Rainer Amon[2,3], Meinrat Andreae[4], Martin Heimann[5]

1.V.N. Sukachev Institute of Forest SB RAS, Krasnoyarsk, Russia, 2.Department of Oceanography, Texas A&M University, College Station, Texas, USA, 3.Department of Marine Sciences, Texas A&M University, Galveston,Texas, USA, 4.Max Planck Institute for Chemistry, Mainz, Germany, 5.Max Planck Institute for Biogeochemistry, Jena, Germany

Boreal wildfires are large sources of reactive trace gases and aerosols, and their emissions, accounting for up to 20% of global C emissions from biomass burning, are believed to significantly influence the chemical composition of the atmosphere and the global earth’s climate system. Although the problem of quantifying direct emissions from wildfires has received attention, their calculations still remain uncertain due to problems with emission factors (i), available carbon for combustion (ii), and imprecise estimates of burned areas (iii). Linking simultaneous instrumental observations of atmospheric composition in fire plumes, GIS-based estimates of active fire spots, burned areas and related parameters (fire disturbances of vegetation, fire intensity etc), and *in-situ* calculations of changes in ecosystem C pools prior and after fire is a powerful tool to fill this gap in our knowledge.
Since 2006 the Zotino Tall Tower Observatory (ZOTTO; www.zottoproject.org) a research platform for large-scale climatic observations is operational in Central Siberia (60°48’N, 89°21’E). The data of the high-frequency trace gas measurements at the tower are used in atmospheric inversion studies to infer the distribution of C sinks and sources over central part of Northern Eurasia. We present the results of our multidisciplinary research to reducing uncertainties in quantifiyng fire influence on atmospheric composition deduced from the large-scale fires that occured in 2012 in the tall tower footprint area.
Analysis of air composition in fire plumes was based on time series of $CO/CO_2/CH_4$ mixing ratios measured at 300 m a.g.l. at ZOTTO. Air transport from specific wildfires upwind of the measurement site was traced based on ensembles of 24-hrs backward trajectories from ARL NOAA HYSPLIT model, while active fires were detected from Terra/Aqua MODIS satellite data. Burned areas were estimated based on Landsat ETM 5,8 satellite images. Additionally, a Normalized Burn Ratio index (*dNBR*), further ranged by a complementary field based Composite Burn Index (*CBI*), and a fire radiative power (*FRP*) provided estimates of fire disturbances of vegetation, fire intensity and the amount of biomass combustion. Field investigations were performed on study plots established after fire in the dominant ecosystems of Central Siberia (lichen pine, moss pine, mixed forest, dark forest and peat bog) where estimations of woody C pools and their geographical distribution were determined using a laser-based field instrumentation system. Aforesaid investigations allowed us calculations of total carbon emissions from the specific wildfires. Furthermore, chemical analysis of samples of atmospheric particulate matter (PM) was performed in fire plumes during the same time for identifying biomarkers, or compounds indicative of a unique biological source, and thus served as a powerful tool to trace the origin and transformations of organic matter (OM). Inter alia levoglucosan (1,6-anhydro-b-D-glucopyranose) and its isomers (mannosan and galactosan) as dehydro-monosaccharide derivatives formed exclusively during incomplete combustion of fuels containing cellulose/hemicellulose and lignin phenols (vanillyl, syringyl and cinnamyl phenols) and their compositional changes were used to differentiate signals among tissue types (woody/nonwoody)

and vascular plant groups (angiosperm/gymnosperm). The Lignin Phenol Vegetation Index (LPVI) as a quantitative parameter representing the entire characteristics of the vegetation was used to be an additional tool to partition OM among end-member sources.
This research was supported financially by the Max Planck Society (Germany), project of RSF # 14-24-00113 and RFBR grant # 15-45-04423.

Keywords: Climate, Wildfires, Siberia, Boreal forests, Carbon cycle, Tall tower