Soil CO_2 efflux rates after wildfires in ecosystems of Central Siberia

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Fire is a main disturbance factor in boreal forest ecosystems, which is very important to the ecology of these sensitive forests and plays a central role in carbon cycling. The rapid influence of fire on carbon cycle occurs through the emission of carbon into the atmosphere during biomass burning. Besides this direct influence fire initiates succession and thus regulates patterns of C accumulation through net primary production and also influences the soil thermal and moisture regime, which, in turn, affect patterns of soil respiration.
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 high-frequency trace gas measurements at the tall tower are used in atmospheric inversion studies to infer the distribution of C sinks and sources over central part of Northern Eurasia. We present our estimates of carbon release through soil respiration in boreal forest ecosystems of Central Siberia after large-scale fires that occured in 2012 in the tall tower footprint area.
Burned landscapes in the tall tower footprint area were estimated based on Landsat ETM 5,8 satellite images. For selected burned areas a magnitude of ecological change caused by fires (“burn severity”) was measured and mapped with a Normalized Burn Ratio index (*dNBR*) and further calibrated by a complementary field based Composite Burn Index (*CBI*). Additionally, values of combustion efficiency (*CE*) for studied areas were calculated based on the time series of CO/CO_2 mixing ratios measured at 300 m a.g.l. in fire plumes while 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. Active fire spots were detected from Terra/Aqua MODIS satellite data. 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 mapping were made with a laser-based field instrumentation system. Soil respiration rates were measured within the plots using a dynamic closed chamber method by a portable LI-6400 system.
Within all studied ecosystems soil efflux rates 3 yrs after fire demonstrated 15 - 25% lower values compared to pre-fire conditions. The highest values within ecosystems after fire have been found out in wet and less disturbed dark and mixed forests (up to 3,8). In these ecosystems fires occured mostly in a smoldering phase (*CE* = 0,92 - 0,93) and a field calibrated *dNBR* didn’t exceed 25 –30%. Such fires could cause only a surface mineralization that resulted in soil fertilization after fire and a spread vegetation cover was found within the plots. A linear regression analysis has shown a good correlation (r^2=0.91 –0.98) of soil efflux rates and soil temperature (10 cm depth), which confirms the essential input of autotrophic respiration into a total C flux. In turn the lowest values (≈ 2,5) were typical within the dry pine stands with the highest *dNBR* (≈ 45%), where *CE* could reach up to 0,99 demonstrating a prevailing flame phase of fire. Within these plots we found out >80% of dead trees and highly damaged vegetation cover with patches of exposed mineral soil. Decomposition processes in C cycling of such ecosystems are believed to be prevailing. Linear regressions analysis of efflux rates and soil temperature didn’t demonstrate any correlation (r^2 =0.02), which also suggests a primarily heterotrophic origin of C flux.
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