ID: 234

Session 1: Ecosystem responses to climate variability and weather extremes
Type of Contribution: Oral Presentation / Talk

The transition of an upland spruce forest ecosystem through a catastrophic wind-fall event: measurements and simulation of the carbon balance

Matthias Lindauer, Rüdiger Grote, Matthias Mauder, Benjamin Wolpert, Rainer Steinbrecher, Hans Peter Schmid
Karlsruhe Institute of Technology, Germany

Intact forests, especially in mid-latitudes, are generally large carbon sinks. However, stand-replacing (catastrophic) disturbance events like fires, insect-infestations, or severe wind-storms can shift an ecosystem from a net carbon sink to a source almost instantly, and keep it as such for an extended transition period. The duration of this transition is determined by the time scales involved in the development of competing vegetation types (e.g., trees vs. grass) as well as in the evolution of dead biomass carbon pools, and their contributions to net ecosystem exchange (NEE). However, with few exceptions, these transition processes are still largely unknown. The urgency to study carbon cycling through disturbance-transition periods is underlined by the recognition that extreme events leading to ecosystem disturbance are likely to increase in a warming world. A unique opportunity to study a major wind-fall event was caused by the winter-cyclone Kyrill in January 2007. Extreme winds in Kyrill caused a large wind-throw area (ca. 600 m diameter) in a mature upland spruce forest in the Bavarian Forest National Park (Lackenberg, 1308 m a.s.l., Bavaria, Germany). This wind-throw area is particularly notable, because dead-wood was not salvaged and remains on the ground.

Fluxes of CO2, water vapor and energy have been measured by Eddy Covariance (EC) since 2009 in the center of the wind-throw area. In addition, we used an ecosystem model (MoBiLE, with dynamic vegetation) to simulate the behavior of the ecosystem through the wind-fall transition and to estimate the time evolution of relative contributions to gross ecosystem productivity (GEP) from trees and grass, as well as the partitioning between autotrophic and heterotrophic respiration. Observations from 2009-2011 were used to test and calibrate the model, and reconstruction of ecosystem and environmental drivers were used to extend simulations to before the wind-fall event.

For 2009 - 2011 EC-based estimates of annual NEE showed that the wind-throw remained a marked carbon source. However, during daytime on sunny and warm summer days, the wind-throw is already seen to act as a net carbon sink only two years after the wind-throw event, indicating the resilience of the ecosystem achieved by the few remaining trees and newly emerging vegetation (grass, sparse young spruce, etc.). Model simulations conformed well with measurements (2009-20011) and showed that the formerly mature forest shifted from carbon sink (NEE ≈ -100gCm-2yr-1) one year before the storm event to a marked carbon source (NEE ≈ +500gCm-2yr-1) afterwards. Model simulations indicate a rapid release of carbon from the soil in the first year after Kyrill. This emission was markedly reduced in the second year, but further decrease was slowed in subsequent years. The contribution of spruce to gross ecosystem productivity as well as respiration tends to increase, while the contribution of grass remains rather constant. We will use the model in short-term projections to estimate the time scale needed for the resilience of the forest ecosystem as a carbon sink.