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Dynamics of combined forest damage risks for 21st century (SRES A1B, B1)

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The ongoing climate change can result in increasing frequency of weather extremes (Leckebusch et al., 2008) which in turn can produce wide area forest damage (windthrows, droughts, insect attacks) within forest ecosystems in Europe. The probability and extent of damage, depend not only on a strength of a driving force itself but especially on combinations of effecting agents and their interactions with forest ecosystem structure and soil properties. The combined effect of several factors which are not the extremes themselves can lead to the biotic and/or abiotic damage so that the combination becomes an extreme event. As soon as a damage event occurs, the forest structure is changed. The changes in forest structure in their turn strengthen or inhibits the influence of different climatic factors thus increase or decrease the probability of the next damage event creating positive or negative feedbacks. To assess the roles of separate meteorological factors and their combinations in forest damage under present and future climatic conditions the coupled model was created in University of Goettingen, as a part of a Decision Support System (Jansen et al, 2008, Panferov et al., 2009). The model combines the 3D ABL Model SCADIS (Panferov and Sogachev, 2008) with modified soil hydrology model BROOK 90 (Federer, 2003, Ahrends et al. 2009) and the model of climate dependent biotic damage. The projected future developments of forest damage events in 21st Century were carried out under conditions of SRES scenarios A1B and B1; the present conditions were evaluated using the measured data of German Weather Service. Climate scenario data of coupled ECHAM5-MPIOM were downscaled by the regional climate model Climate Local Model (CLM) to the spatial resolution of 0.2° x 0.2° and temporal resolution of 24 hours. Using these data as input the small-scale coupled process based modeling was then carried out for example region of Solling, Germany calculating the water and energy balance of forest ecosystems, wind loading on trees and biotic damage for several tree species and typical soil types. The damage risks a certain forest stand at a given soil results from daily combinations of air and soil temperatures, soil water characteristics, static and gust wind loads on trees with dynamic LAI and of soil texture. Some damaged stands show higher vulnerability and thus - positive feedbacks to climate forcing (Vygodskaya et al., 2007). Therefore, changes of microclimate in remaining stands after changes in forest structure are taken into account. Model output is aggregated to 30-years periods and compared to “present conditions” of 1981-2010. The results show considerable increment of both biotic and abiotic risks towards 2100 relatively to “present” caused by weak changes in precipitation and wind patterns and strong increase of mean air temperature and soil temperatures. It is shown, e.g. that the wind- damage-induced changes of structure and microclimate provide a positive feedback i.e. - increase the probability of the next damage event.
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