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Vulnerability and resilience of European ecosystems towards extreme climatic events: The ecosystem perspective

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Extremes of meteorological events may but do not have to cause damages in ecosystems. Climate change is expected to have a strong impact on the resilience and stability of ecosystems worldwide. So far, the impacts of trends and extremes of physical drivers on ecosystems have generally been studied regardless of the extremeness of the ecosystem response.
We base our analysis on a Probabilistic Risk Assessment concept of Van Oijen et al. (2013) quantifying the vulnerability of vegetation dynamics in relation to the extremeness of meteorological drivers such as temperature, precipitation or drought indices. Here, the definition of extreme, hazardous weather conditions is based on the ecosystem response. Instead of searching for extreme meteorological events, we define extreme ecosystem responses in terms of threshold levels of carbon uptake, and search for the meteorological conditions which are responsible. Having defined hazardous events in this way, we quantify the vulnerability or resilience of ecosystems to such hazards.
We apply this approach on results of different vegetation models (such as LPJmL, Orchidee, JSBACH or CLM4) and the forest model BASFOR using climatic input for Europe from the WATCH-ERAI-REMO climate dataset with the SRES A1B emission scenario. Our results show that under current climatic conditions, the southern part of Europe already suffers severe heat and drought stress which is reflected in our approach by vulnerability values being high for precipitation, relatively high for the SPEI index, moderately high for temperature and quite high for the consecutive dry days. Thus, hazard occurrence is frequent enough to determine ecosystem vulnerability but this depends on the definition of the threshold of hazardous ecosystem responses. Vulnerability values in the Mediterranean increase towards the end of the 21st century for all models indicating that a tipping point towards drought damages has been reached for the chosen climate scenario.