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Present and future fire risk changes in Central Europe

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Abstract

Fire risk is projected to increase under future climate change. Most projections focus on fire-prone regions, such as the Mediterranean-type ecosystems, whereas little attention has been paid to regions of low fire risk such as Central Europe. Here, future projections of fire risk which are tailor-made for its specific conditions are scarce. With our study we aim to fill this gap. We use meteorological station data and interpolated climate datasets to compute future fire risk for Central Europe (covering Germany, Poland and the Czech Republic) using the Fire Weather Index. In a next step, we analyse the spatial distribution of reported fire ignitions to identify additional drivers that can explain the spatial pattern of fire ignition and risk, or accelerate fire risk under climate extremes (drought or extreme heat). We analyse how transport infrastructure and proximity to settlements have influenced fire ignition in Central Europe and compare it against relationships known from fire-prone regions. We aim to build on recent adjustments of the FWI to account for respective increased fire risk and apply it to our study area.

In a next step, downscaled future climate scenarios (CMIP6) are applied to compute changes in future fire risk for the entire study area as well as selected sites in Central Europe. Uncertainty ranges of future fire risk projections will be covered by using several climate scenarios for the entire study region.

1. Introduction

Central Europe is until now characterized by relatively low fire risk. Fire occurrence is rare and most fires remain small. For example, the mean annual total burned area in Germany was around 800 ha in 1991-2019 (European Forest Fire Information System). Fires occur mainly in dry lowland pine forests in eastern Germany and in Poland, especially in young to medium forest stands (< 40 years) (Müller 2019). The low level of fire occurrence is caused by the temperate climate conditions and by the development of various forest fire protection measures over the past century. Fire monitoring and forest fire protection has a long tradition in those regions (König 2007). For example, the first fire lookout tower was invented and patented in eastern Germany in 1902. Several forest management practices, forest fire protection measures and public education initiatives were introduced during the 1970s and 1980s that resulted in a general public awareness about forest fire risks and ultimately in a decline in fire occurrence (König 2007). Many past forest fires were caused by military activities and the occurrence of such fires dropped after 1990 (Müller 2019). As most of the pine forests are now in older age classes and thus have less ladder fuels, the occurrence of large devasting crown fires was declining further. Given those developments in forest management and fire protection, societies and foresters are rarely confronted with forest fires in Central Europe.

Despite those past developments, unexpected large fires occurred in Germany during the drought of 2018, which had similar burned area like fires back in the 1970s. Although the dry and hot conditions promoted those recent fires, the large burned area is explained with the impossibility to fight those fires because they occurred at areas contaminated with old ammunition (Müller 2019). However, those recent fires demonstrate that extreme dry and hot weather conditions can suddenly increase fire risks also in forests of Central Europe and that fire occurrence at former military sites or close to public infrastructures are indeed a risk to society and a challenge for fire fighters. We assume that fire risks will increase in future in central Europe because regional climate warming and a possible increased occurrence of droughts will increase fire danger conditions. Currently, there

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is no recent assessment of fire risks in Central Europe that accounts for the specific regional patterns and developments of forest fire protection and for future climate change conditions. Here we aim to develop a comprehensive assessment of present and future fire risks in Central Europe (Germany, Poland, Czechia).

2. Analysis of fire risk under current climate

The fire season in Central Europe is characterized by short dry and hot spells in the order of a few days during the summer months. Plant productivity (via phenology) is limited by temperature and light, making the growing season to last from spring (April) through early autumn (September). Therefore, enough fuel is available throughout the fire season, while the fire risk is limited by climatic conditions. Due to its continental climate, sandy soils and fire-prone pine forests, fire risk is slightly elevated in eastern Germany and in Poland or in some lowland sites in Czechia, while the mountain sites in those countries generally experience less fires because of the colder and moister site conditions that are largely dominated by spruce forests. Interannual climate variability is relatively low compared to Mediterranean or semi-arid regions and lightning is in most cases associated with storms and rain. Hence almost all fires in Central Europe are human-caused and occur in a managed agricultural and forestry landscapes. An analysis of the drivers determining these ignitions is important to manage future fire risks.

2.1. Analysis of settlements and transport infrastructure on current fire risk

We use data on reported fire events to analyse the spatial structure of observed ignitions in the study area and relate them to fire risk under current climate conditions. To achieve this objective, we compute the Fire Weather Index using data from meteorological stations as well as interpolated climate data sets, e.g. climate re-analysis data from GLDAS. We analyse differences obtained from both data sets to verify possible error propagation. We then compare the spatial pattern of observed ignitions against climate and land-cover data to determine their importance in explaining observed pattern using spatial statistical methods. Recently, the FWI was extended to account for risk stemming from urban areas. Since the extension was developed for fire-prone Sardinia, we analyse how the modelled influence of proximity to urban areas can be applied to the central European fire regimes under temperate climate conditions. Fire fighters in Central Europe recently reported that forest fires were caused by forest machinery, an effect which was also investigated for Sweden (Sjöström et al. 2019). In a next step we analyse the implication for fire risk.

3. Towards improved estimates of future fire risks

Changes in future fire risk are usually quantified based on fire weather indcies such as FWI using seasonal forecast and future climate scenario data. In EFFIS, the respective risk is computed for the EU member states and is reported regularly. However, such approaches do not account for changes in vegetation types, fuel loads or socieconomic effects. At continental to global scales, fire-enabled Dynamic Global Vegetation Models (DGVMs) can be used to assess the effects of climate change and vegetation dynamics on climatic fire risk, ignitions, spread and effects of fire. DGVMs simulate the composition, amount and characteristics of live and dead fuel and form the input to the fire module. Similarly, fire effects, including combusted dead and alive biomass and post-fire mortality, affect the regeneration of the simulated vegetation. Composition and dynamics of the vegetation, including fuel composition and fuel load, depend on the fire sensitivity of the affected vegetation and resulting vegetation productivity. Therefore, bi-directional feedbacks establish between fire and vegetation in the model.

However, because of the low fire risk in Central Europe, model quality of fire-enabled DGVMs to match observed spatio-temporal pattern of fire occurrence has been rarely assessed. Building on the data analysis and application of the FWI for present fire risks, we will evaluate model simulations and analyse uncertain model functions to suggest ways of improving respective model components. Specifically, we will apply the LPJmL-SPITFIRE model (Thonicke et al. 2010, Drüke et al. 2019) with downscaled climate input data (9 km resolution). We will compare the simulated climatic fire danger and fire ignitions against the FWI computations in the study area. Spatial and temporal patterns will be analysed using respective statistical methods to quantify model error and benchmarking techniques.

We will analyse how the adjusted ignition component in the FWI calculation is changing under projected changes in land cover in the study area. We conduct a factorial analysis to identify the influence of land-cover change against climate change on fire ignition. We will attribute the influence of a changing fire season, which is expected to increase in length and/or intensity under high fire risk, against the influence of land-cover change on potential human-caused ignitions. We will compare changes in spatiotemporal pattern against contemporary pattern and identify areas of increased high fire risk and actual ignitions.

In a second step, projected changes in climatic fire danger and fire ignitions applying the improved LPJmL-SPITFIRE model will be analysed. We will compare the influence of changes in vegetation dynamics on future fire risk and fire ignitions using LPJmL-SPITFIRE against FWI computations. Finally, the maps of future fire risks will be used as updated input to the mapping of fire risk areas at the wildland-urban interface.

4. References

Drüke, M., Forkel, M., von Bloh, W., Sakschewski, B., Cardoso, M., Bustamante, M., and Thonicke, K.: Improving the LPJmL4-SPITFIRE vegetation-fire model for South America using satellite data, 2019.

König, H. C.: Waldbrandschutz: Kompendium für Forst und Feuerwehr, 1., Edition., Fachverlag Grimm, Berlin, 200 pp., 2007.

Müller, M.: Waldbrände in Deutschland, Teil 1, 18/2019, 27–31, 2019.

Müller, M.: Waldbrände in Deutschland, Teil 1, AFZ- Der Wald 18/2019, 27–31, 2019.

Sjöström, J., Plathner, F. V., and Granström, A.: Wildfire ignition from forestry machines in boreal Sweden, Int. J. Wildland Fire, 28, 666, https://doi.org/10.1071/WF18229, 2019.

Thonicke, K., Spessa, A., Prentice, I. C., Harrison, S. P., Dong, L., and Carmona-Moreno, C.: The influence of vegetation, fire spread and fire behaviour on biomass burning and trace gas emissions: results from a process-based model, Biogeosciences, 7, 1991-2011, 10.5194/bg-7-1991-2010, 2010.