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Assessing the Combined Risk of Fire and Flood on A National Scale for Sweden

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Abstract. Floods and wildfires are two critical hazards that impose substantial direct and indirect costs to society, including the resource needs of rescue services. Their occurrence is strongly linked to meteorological conditions, playing a fundamental role in hazard development and assessment. These hazards are notably distinguishable due to opposing weather requirements, wet conditions for floods and dry conditions for wildfires. However, certain regions are exposed to the convergence of these hazards simultaneously or in temporal proximity, demanding different levels of resources and mitigation strategies. Consequently, there is a vital need for a comprehensive combined risk assessment to enhance the effectiveness of rescue services to face such risks. This study presents an analysis for the combined risk of wildfires and floods on a national scale in Sweden over an 11-year period based on daily values on the Fire Weather Index (FWI) and river flow data, taken as proxies for the occurrence of fire and flood, respectively. The present study employed different methods to assess the joint occurrence of fire and floods including simultaneous plots of FWI and flow time series, scatter plots with risk categorization, and index plots combining standardized FWI and flow, offering both qualitative and quantitative insights into combined risk assessment.

Keywords: Combined risk, Fire weather Index, Flood risk, Flow, Rescue service, Wildfire risk

1 Background

Methods for risk assessment involving several hazards that may occur simultaneously have been developed during the latest decades [1-3]. Such methods may range from purely qualitative approaches, where applications will involve elements of subjective judgement, to quantitative approaches resulting in index values that yield firm estimates related to the impact of interest [2]. The quantitative approaches require more elaborate methods to normalize and combine the descriptors representing the different hazards, as well as data to validate the approach [4].

In this study, the joint occurrences of the two hazards wildfire and flood were investigated for the entire country of Sweden. As a descriptor for wildfire, the Fire Weather Index (FWI) was employed, whereas the flow was taken to represent flooding. Although using quantities that have a clear correlation with fire and flood, this was a rather schematic approach that did not attempt to resolve the details of the specific hazard and its impacts. An underlying aim of the present study is to estimate the resource needs for rescue services to deal with multiple hazards in a planning perspective, not to address specific events in space at short time scales. Thus, the overall objective of the present paper is to assess the combined risk for wildfire and flood on a country-wide scale, which will provide useful information for rescue services in dealing with these hazards.

2 Results and Discussion

Although the analysis encompassed eight locations, the study only presents the results for a few locations that illustrate the main characteristics relevant to the key discussion. Analysis of the time series was conducted to explore the temporal fluctuations in FWI and flow over an 11-year period. The analysis indicated distinct regional differences in the behavior of FWI and flow values across the country. FWI values typically peak during the summer regardless of location, indicating a higher

likelihood of wildfires by encompassing warmer and drier conditions. Conversely, flow variations exhibit significant temporal shifts from north to south. In the north, peak river flows occur during late spring due to snow melt, thus creating a scenario where both hazards could occur in temporal proximity. In the south, peak flows emerge during winter when wildfires are less likely, yet warm summer temperatures can lead to intense rainfalls [5,6], presenting the potential for concurrent hazards. Figure 1 shows annual average of daily FWI and flow for Vidsel and Ljungby, located in the north and south of Sweden, respectively.

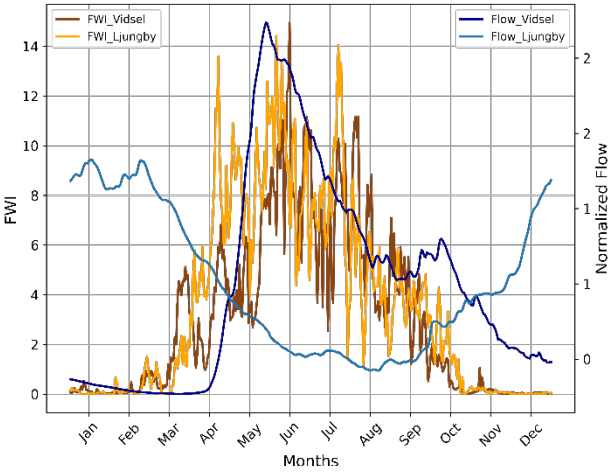

Figure 1. Annual average of daily FWI and flow for the locations Vidsel and Ljungby; flow values are normalized by the mean flow.

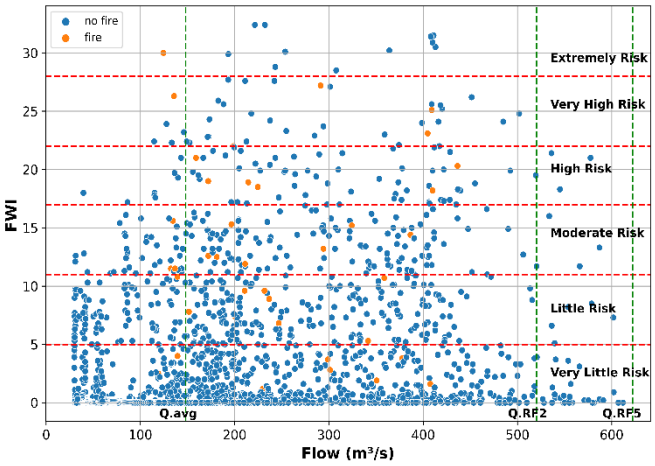

Figure 2. The characteristics of FWI and flow at location Vidsel for the same day.

The scatter plots with risk categorization were developed for the study locations to visualize concurrent characteristics of FWI and flow for period of interest. The risk categorization were marked on the plots based on wildfire risk classes defined by MSB [7] and on flows with specific return periods. Furthermore, days of actual wildfire occurrences are marked with orange color points. As an example, the scatter plot classification for Vidsel is shown in figure 2, indicating that there were few, but significant, instances in the past where both FWI and flow were high during the same day. An approach was also explored to develop an index called Extreme Index (EI) by integrating wildfire and flood risks that could aid rescue services in collectively assessing threats and resource needs in a particular environment.

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