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# Combining temporally-integrated heat stress duration and frequency with multi-dimensional vulnerability characteristics to derive local-level risk patterns

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The observed changing in the nature of climate related events and the increase in the number and severity of extreme weather events has been changing risk patterns and puts more people at risk. In recent years extreme heat events caused excess mortality and public concerns in many regions of the world (e.g., 2003 and 2006 Western European heat waves, 2007 and 2010 Asian heat waves, 2006 and most recent 2010-2012 North American heat waves). In the United States extreme heat events have been consistently reported as the leading cause of weather-related mortality and have attracted the attention of the international scientific community regarding the critical importance of risk assessment and decoding its components for risk reduction. In order to understand impact potentials and analyze risk in its individual components both the spatially and temporally varying patterns of heat stress and the multidimensional characteristics of vulnerability have to be considered.

In this study we present a composite risk index aggregating these factors and implement that for the U.S. National Capital Region on a high level of spatial detail. The applied measure of assessing heat stress hazard is a novel approach of integrating magnitude, duration, and frequency over time in the assessment and is opposed to the study of single extreme events and the analysis of mere absolute numbers of heat waves that are independent of the length of the respective events. On the basis of heat related vulnerability conceptualization, we select various population and land cover characteristics in our study area and define a composite vulnerability index based on aggregation of three groups of indicators related to demographic, socio-economic, and environmental factors.

The study reveals how risk patterns seem to be driven by the vulnerability distribution, generally showing a clear difference between high-risk urban areas and wide areas of low risk in the sub-urban and rural environments. This is particularly obvious for the core center of the study area around the District of Columbia which is largely characterized by high index values despite not having experienced the peak of the heat stress as compared to other regions in the metropolitan area. Illustrating data on impact characteristics that are only available on county level (e.g., mortality figures) and setting it into comparison to our modeled high-resolution vulnerability and risk patterns, we highlight the additional value gained by sub-county analysis. While in our highly granular model the overall picture is often characterized almost entirely by very low risk values and therefore seems to contradict related county-level high impact values, a closer look reveals what is happening inside and shows the urban centers to be most relevant in that context.

The study aims to set a framework for local-level heat stress risk assessment that can provide valuable input in a risk management context with the aim of supporting risk reduction and optimization of resource distribution as well as long-term climate adaptation planning.