

# Appendices

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## **Systematic Analysis of the Flash Drought Research: Contribution, Collaboration and Challenges**

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### **Abstract**

Compound extreme events, such as flash drought, have received wide attention in recent decades due to their far-reaching effects on the ecosystem. Thus, a new concept of flash drought has begun to spread globally in the scientific community and it is continuously being developed. This study offers for the first time an overview of the global trends in flash drought research from 2000-2021. The analysis was based on the Scopus database in order to investigate the publication trends, contributions, collaborations and challenges on a global scale. Furthermore, collaboration analysis was performed to detect collaboration networks within the flash drought research field. A total of 76 studies were published in the studied period. The research output grew exponentially with an average growth rate of 30% per year. The challenging issues in the field of flash drought research are the search for appropriate definition of flash drought, development of effective early warning systems and scarcity of high-resolution data. By presenting the details of the evolution of this new conceptualization in drought research, our study highlights the main pathways of scientific progress and stimulates future research.

# The Space and Time Characteristics of Flash Droughts in Central Europe

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## Abstract

Flash drought is a unique natural hazard due to its rapid rate of intensification. In previous studies, little work was done to investigate the space and time behaviour of flash drought across Central Europe. In this study, we examine the space and time characteristics (frequency, rate of intensification, severity, and extent) of flash drought events in Central Europe between 1970 and 2020. The anomalies in weekly averaged topsoil moisture (SM) data from the Global Land Data Assimilation System (GLDAS) was used for identifying flash drought events. Here, we adopted a new definition of flash drought that does not only consider intensity, and duration but also incorporates the persistence of flash drought. The results of this study revealed that the occurrence of flash droughts over Central Europe increased rapidly over the last decades. The intensification rate and severity of flash drought were positively correlated with each other. Moreover, the areal extent of flash drought events has increased since 1970, and their centroid shifted from the north to the southern part of Central Europe. Overall, the finding of this study contributes towards a better understanding of flash drought characteristics and their dynamics over Central Europe.

# Rapid Onset Droughts: Unraveling Ecosystem Response to Flash Droughts

Under writing

## Abstract

Flash drought is a rapid complex extreme climate disaster, causing adverse damages to the structure and functions of terrestrial ecosystem. The recent developments in the field of flash drought highlights the importance of understanding its characteristics and impacts on the terrestrial ecosystems. Here, in this study we identify the soil moisture flash drought by considering the intensification rate and persistency and investigate the resistance of ecosystem in the terms of response time to flash drought during onset stage. We use the Global Land Data Assimilation System (GLDAS) 8-daily averaged soil moisture data of three different layers (0-10cm, 10-40cm, 0-100cm) and investigate the characteristics of flash drought across each layer of soil moisture. The 8-daily Gross primary productivity (GPP) is used as indicator to investigate the response of crop, grass, and forest lands ecosystem to flash drought. The results of the study revealed that the ecosystem responded 95% to flash droughts events identified across mid (10-40cm) and root zone (0-100cm) layer of soil moisture. The average response time of ecosystem to flash drought events varies from 20 to 30 days depending upon the depth of soil moisture layer. The ecosystem of lower altitude ( $< 1000$  msl) shows high resistance to flash drought events having high onset intensification rate. Moreover, the ecosystem of the high altitude ( $> 1000$  msl) shows low resistance to the flash events having high onset intensification rate. Overall, the forest land is shows high resistance to the flash drought as compare to grass and crop land ecosystem of central Europe. These finding provide inside characteristics flash drought and the response of ecosystem to flash drought which could be helpful for timely mitigate the impacts of flash droughts on the terrestrial ecosystems.