

EGU24-11131, updated on 20 May 2024

<https://doi.org/10.5194/egusphere-egu24-11131>

EGU General Assembly 2024

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Stalagmite-based cave flood records as a proxy for reconstruction of extreme rainfall frequency over the Holocene from two different cave sites in South-eastern Brazil

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Extreme rainfall events are expected to become more frequent and intense worldwide due to climate change, as indicated by the Sixth Assessment Report from the Intergovernmental Panel on Climate Change. This includes the most populated region in South America, southern and southeastern Brazil, where several studies document a consistent pattern of intense rainfall increases. The increasing intensity and frequency of these events have a direct impact on society, triggering natural disasters such as flash floods and landslides, accounting for 74% of natural disaster-related deaths and an impact of 6.2 billion dollars between 2010 and 2019.

The scarcity of available data and limitations to the instrumental period hamper assessments regarding the frequency and intensity of extreme rainfall events beyond this period. This limitation precludes the assessment of how larger-scale forcings, atmospheric circulation, and environmental changes can affect the frequency and magnitude of those events. Previous studies show that extreme rainfall events in the study area are caused by Extratropical Cyclones and Frontal Systems, as well as the South Atlantic Convergence Zone. Our 5-year cave flood monitoring indicates that extreme rainfall events are responsible for triggering the cave floods, therefore stalagmites subjected to those cave floodings can be used as a proxy for extreme rainfall events. In this context, we use a large set of Holocene stalagmites collected from two different caves (Lage Branca and Malfazido cave). Reconstructions are based on detrital layers within stalagmites identified using thin-section petrography.

Records from Malfazido cave exhibit a higher sensitivity to high-frequency cave flood events (subdecadal to decadal frequency), as demonstrated by reconstructions. In contrast, Lage Branca records are sensitive to high-magnitude events (multidecadal, centennial, or multi-centennial frequency) due to their high topographic position (20-50 m above the underground river) and slow growth rate. We present new cave flood records for Malfazido and Lage Branca caves, covering the last 7000 years and 10000 years, respectively. Periods of increased occurrence of flood layers in

the stalagmites are observed for both caves around 4.1 kyr during the transition from the Middle to Late Holocene. For higher-frequency events, a remarkable increase in cave flood frequency is observed during the Little Ice Age. To assess the mean climate state in which the changes in frequency are observed, a high-resolution multiproxy record based on stalagmites ($\delta^{13}\text{C}$, $\delta^{18}\text{O}$, trace elements) is used to reconstruct paleohydrology and environmental conditions.

New paleoflood cave records from both caves are used to assess how the frequency of extreme rainfall events can vary over time, providing insights into how different forcings and climate changes, such as atmospheric circulation changes and variations in SSTs, can affect the frequency of those events.