Sediment cores indicate more heavy rain events in warm periods and less climate variability in cold periods

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The maars of the volcanic Eifel provide a glimpse into the past of the Central European climate. Using sediment cores, scientists have been able to reconstruct the climate of the last 60,000 years. Credit: Frank Sirocko, JGU

Fewer than one hundred kilometers lie between the flood-ravaged district of Ahrweiler and the volcanic lakes in the Eifel. These maars have now provided evidence that weather extremes could increase. Researchers at Johannes Gutenberg University Mainz (JGU) and the Max Planck Institute for Chemistry have used sediment cores from maar lakes and dry maars in the volcanic Eifel to precisely construe how the climate in Central Europe changed over the last 60,000 years. In cold periods, the climate fluctuated less, and weather extremes were less pronounced. In warm periods, on the other hand, there were more extreme precipitation events, and abundant decadal fluctuations. This result suggests that Central Europe will have to adapt to more extreme weather events as a result of human-induced climate change.

Many scientists believe that the stable climate of the past 10,000 years was a prerequisite for human development. Before that, the earth's climate was characterized by strong fluctuations. These became noticeable in the alternation of glacial and interglacial periods. In the glacial periods, particularly cold and somewhat warmer phases followed one another. The present, unusually stable period of the Holocene also falls into such a warmer period of a glacial period. But humankind is disrupting this steady phase – mainly by emitting greenhouse gasses. The consequences of this can also be seen from climate history. A team led by Frank Sirocko, professor at Johannes Gutenberg University in Mainz, and Gerald Haug, Director at the Max Planck Institute for Chemistry, is now using analyses of sediment cores from the Eifel maars to show how climate change has affected Central Europe in the pasta and might do so in the future.

Extreme events occur every 20 to 150 years

In particular, the sediments of the dry maar of Auel allowed the researchers to understand that changes in the North Atlantic current system, which includes the Gulf Stream, have directly influenced the

climate in Central Europe. "Here, the sediment core data from the Eifel maars show that during warmer periods, there were stronger climate fluctuations with more variability in temperature and precipitation as well as more extreme events," says Sirocko, who played a key role in the study.

From the sediments, the researchers construed short periods of a few decades of additional warming during the interglacial periods and even years with extreme climate and weather events (e.g. heavy rain), which occurred every 20 to 150 years. During the glacial periods, on the other hand, the climate was much more stable.

"The sediment cores are so well stratified that we can decipher the climate of almost every year of the past 60.000 years. This is because in Auel, for example, about two millimeters of sediment were deposited every year," explains Sirocko. His team determined the organic carbon content layer by layer while researchers at the Max Planck Institute for Chemistry analyzed the concentrations of silicon and aluminum. From these, they can infer the amount of diatoms in the water.

Particularly thick sediment layers during floods

The special feature of the Eifel maars is that sediments were deposited undisturbed in the oxygen-free depth of the lake basins. These unique conditions preserved the annual layers. The climate, environment, fauna, flora, and volcanic activity of the Eifel can thus be reconstructed quite accurately from these. In interglacial periods, even the course of the seasons can be seen in the layers – similar to the annual rings of a tree. During flood events during these phases, particularly thick sediment layers also formed; these can range from several millimeters to a few centimeters. In glacial periods, on the other hand, the layers are very thin and hardly visible. Not even the seasonal variations are visible in them.

"Our climate is essentially determined by the interaction of the warm gulf stream and cold air from Arctic sea ice in the North Atlantic. This determines the intensity and frequency of low-pressure areas and the position of the Northern Hemisphere jet stream," says Sirocko. The climate development in the Atlantic and in Central Europe is absolutely synchronous. "This synchronicity clearly shows that temperatures in the Gulf Stream region, in particular, have controlled the European climate," says Alfredo Martinez-Garcia, one of the Max Planck researchers involved. "Upcoming changes in the Atlantic current system and sea ice cover, in particular, will also have a direct and immediate effect on the European climate."

Careful planning of settlements and infrastructure

"What we have reconstructed for the climate of the Eifel confirms a frequent observation in the climate history of other regions of the Earth, especially the tropics and subtropics, of the last millennia. The frequency and intensity of climate and weather extremes increased during warmer periods. Extremes no longer occurred only every hundred years but rather at much shorter intervals. The differences observed in climate conditions during glacial periods and interglacial periods also provide further evidence that human-induced warming will lead to increasingly more intense climate and weather extremes," says Haug, co-author of the study. "Therefore, in the most vulnerable regions such as the Eifel, careful consideration should be given to how settlements and infrastructure such as roads or pipeline networks are planned."

Haug's colleague Sirocko and his team have meanwhile archived 52 long cores from the Eifel at the Institute of Geosciences in Mainz, thereby opening up one of the most important geoarchives in Central Europe. For the publication in *Nature Geoscience*, he combined drill cores from the Schalkenmehren, Holzmaar, and the dry maar lake of Auel to create a complete sequence of the last 60,000 years.

The maar sediments have been studied since the 1980s. In 1998, Sirocko started the Eifel Laminated Sediment Archive (ELSA) project with the aim of fully developing the sedimentary deposits in the maar lakes and the old, now silted-up maars of the Eifel with drill cores as a geoarchive.

More information: Frank Sirocko et al, Muted multidecadal climate variability in central Europe during cold stadial periods, *Nature Geoscience* (2021). DOI: 10.1038/s41561-021-00786-1

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