Volcano eruptions at different latitudes impact sea surface temperature differently

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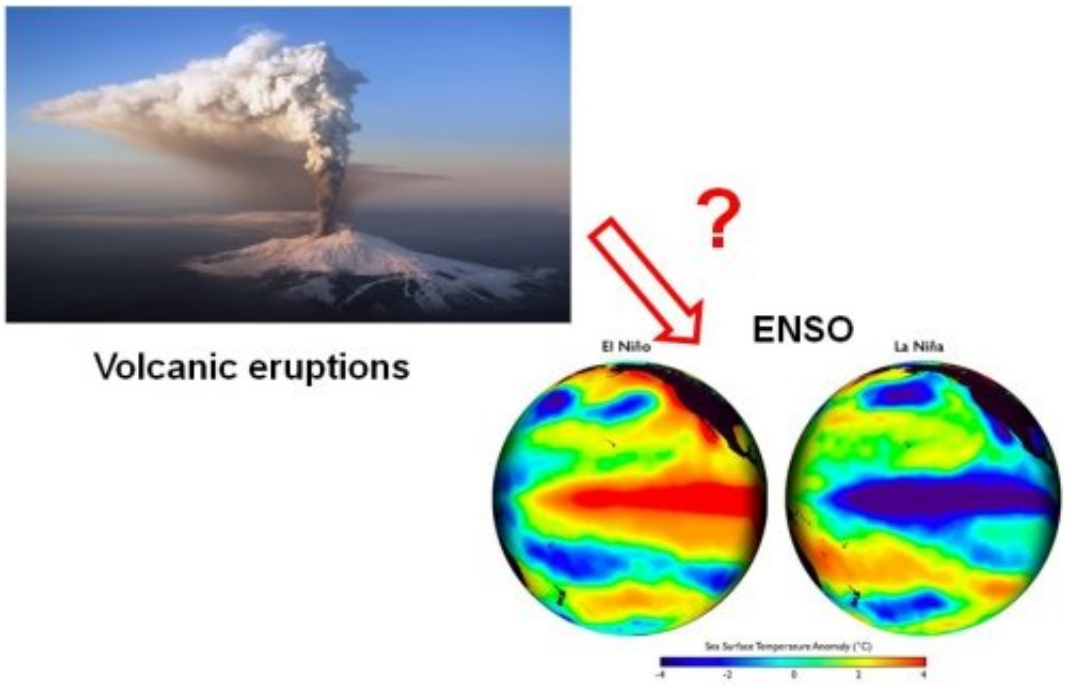

Relationship between volcanic eruptions and El Nino-Southern Oscillation (ENSO) phase. El Nino (La Nina) is the warm (cold) phase of ENSO, with a warm (cold) SST anomaly over the eastern equatorial Pacific. Credit: Chinese Academy of Sciences

Volcanic eruptions are among the most important natural causes of climate change, playing a leading role over the past millennium. Injections of sulfate aerosols into the lower stratosphere reduce the incoming solar radiation, in turn cooling the surface. As a natural

external forcing to the Earth's climate system, the impact of volcanic aerosols on the climate has been of great concern to the scientific society and the public.

In recent years, scientists have found that there is a relationship between volcanic eruptions and the El Niño-Southern Oscillation (ENSO) based on reconstructions and model simulations, which is manifested in increased/decreased sea surface temperature (SST) gradient over the equatorial Pacific. Since ENSO influences the global climate through atmospheric teleconnections, it is of great importance to understand the influence of volcanic eruptions on ENSO phase changes. Many studies have shown the phenomenon, but the reasons remain ambiguous.

Recently, Zuo Meng, a doctoral student from the Institute of Atmospheric Physics, Chinese Academy of Sciences, along with her mentors Prof. Zhou Tianjun and associate Prof. Man Wenmin, used the CESM Last Millennium Ensemble (LME) simulations, which has the largest ensemble of LM simulations, to investigate the impacts of northern, tropical and southern volcanic eruptions on the tropical Pacific SST. Analysis of the simulations indicates that the Pacific features a significant El Niño-like warm SST anomaly five to 10 months after northern and tropical eruptions, with the Niño3 index peaks at the winter of next year. Compared with northern eruptions, the warm SST anomaly is mainly confined to the eastern Pacific with a stronger intensity following tropical eruptions.

Following southern eruptions, the Pacific shows a weaker warming anomaly over the eastern Pacific, and the time at which the Niño3 index reaches its peak is about four months earlier than that after northern and tropical eruptions. They further advance the underlying mechanism: The shift of the intertropical convergence zone (ITCZ) can explain the El Niño-like response to northern eruptions, which is not applicable for tropical or southern eruptions. Instead, the westerly anomaly in the

western Pacific triggered by the ocean dynamical thermostat mechanism can explain the divergent SST responses following three types of eruptions.

"In contrast to previous works on the impacts of volcanic eruptions on SST, our results are based on the CESM-LME simulation. From a modeling perspective, ensemble simulations are the most helpful method to study volcano-forced responses. Most importantly, the different mechanisms of SST response to three types of eruptions can help us better understand the divergent formation processes of SST anomalies," said first author Ms. Zuo Meng. "We hope the results are useful for the mitigation and adaptation of climate change after volcanic eruptions and the associated socioeconomic impacts, and can also provide insight for understanding future SST changes induced by large volcanic eruptions."

Corresponding author Prof. Man Wenmi said, "Differences are also seen among different models. The difference may result from the uncertainties in the reconstruction of external forcing volcanic aerosol data, model bias, and also the initial condition of volcanic eruptions. We hope to deepen our understanding of the tropical Pacific responses to different volcanic forcing and the physical processes by using the VolMIP experiments which has defined a coordinated set of idealized volcanic perturbation experiments to be carried out in alignment with the CMIP6 protocol in the near future."

More information: Meng Zuo et al, Different Impacts of Northern, Tropical, and Southern Volcanic Eruptions on the Tropical Pacific SST in the Last Millennium, *Journal of Climate* (2018). DOI: 10.1175/JCLI-D-17-0571.1

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