Title of dissertation			
Study of the regional climatic impacts of tropical explosive volcanism in the Middle East and North Africa region			
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Explosive volcanism is considered as a strong climate forcing with profound global and regional scale direct and indirect radiative impacts. The direct radiative effects of volcanic eruptions resulting in solar dimming, surface cooling, and reduction in rainfall have been well documented. The global and regional climate is also affected by the internal variability. For example, changes in the updraft branch of Hadley circulation could largely affect surface temperature, evaporation, and precipitation patterns especially in monsoon fed regions such as the Middle Eastern, African, and South Asian tropical rain belt regions. Likewise, teleconnection modes such as El Nino Southern Oscillation (ENSO) and North Atlantic Oscillation (NAO) strongly affect global and regional climate. However, the contribution of circulation anomalies in post-eruption years associated with natural internal variability is not well understood. Hence, quantification of magnitude and spatial patterns of direct volcanic impact and the circulation anomalies during the post-eruption years is important for a better understanding of climate variability and changes, especially in the tropical rain belt regions.

In earlier literature it is noticed that the studies dealing with volcanism have matured in terms of their global climatic impacts; however, uncertainties remain in their regional impacts. Therefore, the main aim of this research is to improve our understanding of the regional climatic impacts driven by volcanism, especially in the Middle East and North Africa (MENA) region. This study focused on the MENA region, as this region appears to be very sensitive to the effects caused by explosive volcanism. Several earlier studies have documented this cooling anomaly over the Middle East after large eruptions with snowy conditions over the Gulf of Aqaba and pointed out that this cooling response is produced as a result of the direct radiative impact of volcanism. However, there is rarely any studies available that looked at the contributions of circulation anomalies in the post-eruption years, such as ENSO, NAO, and Indian monsoon anomalies. Therefore, this dissertation investigated the impacts of volcanic direct radiative forcing and circulation anomalies over the MENA region. A better understanding of volcanic eruption’s impact on the global and regional climate allows scientists to better account for the relative contributions of natural and human-induced factors on the long-term warming trends. This suggests that for a better assessment of the climate variations, one needs to consider the contribution caused by major explosive eruptions in our climate system.

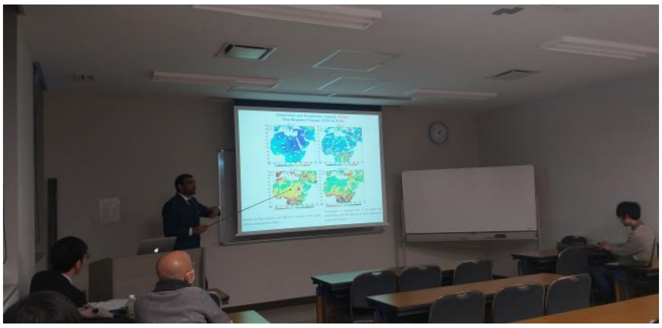
For this purpose, I choose the two strongest low-latitude tropical eruptions of the late 20th century, El Chichón of 1982 and Pinatubo of 1991 occurred in the satellite era, which have better observational records. The climate responses to the El Chichón and Pinatubo volcanic eruptions are analyzed using observations, reanalysis data, and output from the

Geophysical Fluid Dynamics Laboratory's High-Resolution Atmospheric Model (HiRAM). A multiple regression analysis both for the observations and the model output is performed on summer and winter composites to separate out the contributions from climate trends, ENSO, NAO, Indian summer monsoon, and volcanic aerosols.

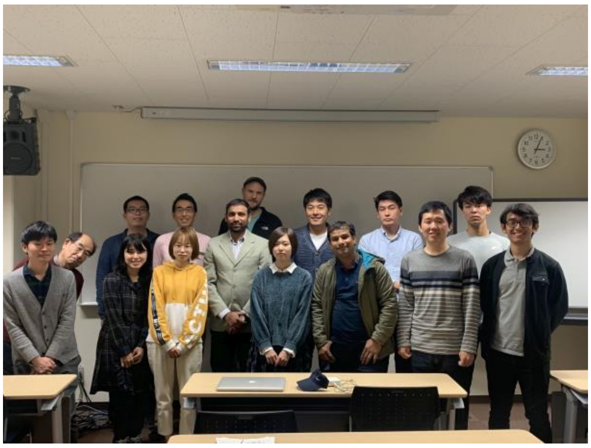
Strong regional temperature and precipitation responses over the MENA region are found in both winter and summer. This study shows that the Northern hemisphere tropical volcanism produces a significant reduction in rainfall and concomitant drought conditions over the Sahel region by weakening the land-sea thermal gradient in boreal summer. Furthermore, ENSO and Indian monsoon amplifies the rainfall deficit by shifting the ITCZ southward in the boreal summer. The model and the observations both show that the positive phase of NAO amplifies post-eruption cooling over MENA in winter. The HiRAM results are consistent with observations in general, however, it underestimates NAO and ENSO magnitude in the post-eruption years and associated climatic impacts over MENA in winter. This study confirms that the MENA and South Asian climate regime responds vigorously to direct impacts of explosive volcanism and circulation anomalies. The conducted analysis sheds light on the mechanisms of MENA climate variability.

This dissertation develops a sound understanding of the direct and indirect radiative impacts of tropical volcanic eruptions over the MENA region in the winter and summer seasons. This improved understanding is expected to advance climate model simulations to account for circulation impacts caused by strong tropical volcanic eruptions. It will help the climate community to better simulate the regional impacts of volcanism. Moreover, it could be very useful for studies dealing with solar radiation management and geoengineering applications.

Photos



Presentation at the final defense



Group photo with laboratory members