**Part III Project Proposal**

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**Title: Investigating the Climatic Impact of the 1257 Samalas Eruption**

**Supervisors:**

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**Background:**

The 1257 Samalas eruption on the Indonesian island of Lombok was one of the largest eruptions of the Holocene epoch. With a VEI = 7, the eruption column is estimated to have reached altitudes of 43km and spread tephra up to 660km away in Java (Vidal et al., 2015). The eruption ejected an estimated 126Tg of SO2 into the stratosphere, ten times that of the 1991 Mt Pinatubo eruption, which is detectable as a large sulphate spike in ice cores from the Arctic to Antarctica (Vidal et al., 2016).

Proxy data, such as from tree rings and lake sediments, suggests the global cooling due to sulphur aerosol emission from the Samalas eruption was of the order of -0.7 to -1.2°C and persisted for up to three years following the eruption. However, previous attempts to simulate the global climatic impact of the eruption using climate models have tended to overestimate the eruption’s radiative forcing and thus estimated global surface cooling of up to -4°C (Liu et al., 2020). Recent work by Wade et al. (2020) was able to reconcile model predictions with proxy data for the first time by accounting for aerosol microphysical processes such as coagulation of particles in their Earth System Model simulations.

The eruption is considered to have had wide-ranging and regionally heterogeneous impacts on climate. Western Europe and Siberia experienced the greatest summer cooling in 1258-59 along with reduced precipitation due to changes to water vapor transport by the NAO (Liu et al., 2020). In North America, the cooling effect of the eruption is considered to have been mitigated by the warming of the El Nino Southern Oscillation (Guillet et al., 2017). It has also been suggested that the 1257 eruption, along with later activity in 1269, 1278, and 1286, was responsible for the growth of ice caps which through positive feedback loops led to the onset of the Little Ice Age (Zhong et al., 2010).

The eruption ejected an additional 227Tg of chlorine and 1.3Tg of bromine, although Wade et al. (2020) suggest that only minor amounts of this could have been injected into the stratosphere as there is little evidence for catalytic ozone layer destruction.

As utilised by Guillet et al. (2017) the impacts of the eruption were also recorded in several historical texts. Locally, the Babad Lombok, a palm leaf document, records eyewitness accounts of the eruption whilst chronicles as distant as Germany and France report cold summers, poor harvests, and subsequent famine in the years 1258-61.

**Scientific Objectives:**

[1] To investigate the climatic response of the 1257 Samalas Eruption using a combination of model simulations and proxy data.

[2] To investigate how prior atmospheric conditions, such as ENSO and QBO state, as well as the timing of the eruption affect the climatic impact.

[3] To determine if an ENSO response is present following the eruption and if so, to understand the mechanisms behind this response and whether the response is sensitive to pre-eruption initial conditions.

**Methods:**

As part of the Schmidt Group, through the work of Dr Lauren Marshall, an ensemble of UK Earth System climate model simulations has been conducted for a set of large explosive eruptions including 1257 Samalas. These model simulations include state-of-the-art aerosol microphysics, a requirement needed to be able to reconcile model simulations and proxy records of climate change following large eruptions. Nine ensemble members were conducted for 1257 Samalas to investigate the impact of eruption timing and pre-existing atmospheric conditions, such as ENSO and QBO state, on climatic response.

Using the outputs of this ensemble, I will investigate the climatic response of the Samalas eruption through key metrics including surface temperature changes, precipitation, ENSO state, wind dynamics, ice volume, and ozone thickness. The dependence of the radiative forcing and climatic response on pre-existing conditions such as ENSO and QBO state will also be assessed. I will also be investigating the presence and potential driving forces behind an ENSO response to the eruption. For example, the influence of the amount of aerosol pre-cursor gases emitted or prevailing atmospheric conditions.

Where appropriate proxy data, such as from tree rings, and historical texts will also be included.

Note: The exact research aims and questions will be developed through further reading and initial investigations of model outputs. Thus, some of the objectives and methods outlined in this proposal may be subject to alteration over the course of the project, although the broader aims will remain the same.

**Logistical Feasibility/Resources/Finances:**

No fieldwork will be required as part of this project, as such there are no associated costs.

Computing resources will be provided as part of the Schmidt group, such as undertaking additional scientific computing training in Python.

**References:**

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