Abstract

Stratospheric aerosol plumes exert significant control on Earth's radiation budget and regional climate. They could originate from both volcanic eruptions and intense wildfires. Volcanic eruptions produce radiative forcings ranging from -0.1 $\mathrm{W\,m^{-2}}$ (weak eruptions) to -0.3 $\mathrm{W\,m^{-2}}$ (medium-strength events), while recent wildfire-driven stratospheric smoke plumes, such as the Australian Black Summer fires of 2019–2020, have generated radiative forcings as high as +0.5 $\mathrm{W\,m^{-2}}$, persisting in the stratosphere for up to two years. Despite their demonstrated climate relevance, the underlying processes controlling stratospheric aerosol transport, their interaction with atmospheric conditions, and their regional radiative and dynamical impacts remain inadequately represented in current modeling frameworks.

This project comprises two complementary phases using ICON-HAM and ICON-ART simulations. We would first validate model performance by simulating the well-documented Mount Pinatubo eruption of 1991, assessing model fidelity in reproducing observed aerosol optical depth, transport pathways, and stratospheric residence times. Following successful validation, we would perform regional sensitivity simulations to examine climate sensitivity to stratospheric aerosol perturbations, with particular focus on quantifying radiative forcing mechanisms and resulting temperature impacts over the mid-latitudes when aerosol loading is introduced at different latitudes.

By combining historical validation with process-oriented sensitivity analysis, this work advances the understanding of regional climate sensitivity to stratospheric aerosol loading. The resulting insights will enable improved predictions of regional climate impacts as wildfire-driven stratospheric aerosol plumes become increasingly frequent.