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A multi-sensor approach for deriving volcanic ash heating rates: application to the 2015 Calbuco eruption

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Previous studies concerned with the radiative forcing of volcanic eruptions have focused mainly on the impact of volcanic sulphates. However, as the radiative influence of sulphates on climate has been extensively studied there is a need for further investigation into the radiative influence of volcanic ash clouds on shorter timescales, especially during developing stages of an eruption. Multi-sensor satellite observations provide insight into the radiative properties of nascent ash clouds. In particular, measurements provided by the Afternoon-train (A-train) constellation of satellites can be used to characterise the evolving optical and geometric properties of ash plumes. We present A-train observations of the recent stratospheric ash clouds produced by the eruption of Calbuco (Chile) in April 2015. We use collocated space-borne lidar (CALIOP) and passive infrared sounder (AIRS) measurements to retrieve volcanic ash optical depth profiles at visible and infrared wavelengths, respectively. The retrieved optical depth profiles are then input into a one-dimensional (1D) radiative transfer model to calculate volcanic ash heating rate profiles. Finally, we compare the modelled shortwave (SW) and longwave (LW) radiative fluxes at the top of the atmosphere (TOA) to CERES radiative flux observations, which are treated as truth in order to test the validity of our model assumptions. The implications of our results are discussed and we speculate on the possible radiative effects of water vapour in the Calbuco plume.