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# Effect of ash on the initial development of a volcanic plume and its radiative forcing

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Strong explosive volcanic eruptions inject in the lower stratosphere a mixture of $SO_2$, volcanic ash, water vapor, halogens, and other tracers. The large ash particles sediment relatively quickly and therefore it is believed are not important for a long-term plume development and radiative effect. However, ash solar and IR heating and chemical/microphysical interactions could affect the initial plume formation and shape its long-term development.

Here we simulate the aerosol plume from the 1991 Pinatubo eruption using ECHAM5/MESSy atmospheric chemistry general circulation model (EMAC) employing Chemistry-Climate Model Initiative (CCMI) chemistry mechanism, details aerosol microphysics (GMXe) and a comprehensive anthropogenic, biomass and biogenic emissions inventory. We initially inject 75Mt of fine ash distributed with normal distribution in horizontal and vertical direction with a peak concentration at 25km. in addition, 17Mt of $SO_2$ is initialized and is estimated from SAGEII observations. Volcanic ash is introduced as an independent tracer in two modes, accumulation and coarse. Therefore, we do not account for very big particles that sediment within a few hours.

Fine ash particles are being coated and chemically interact with water and sulfate developing in the lower stratosphere due to $SO_2$ oxidation. The coating and aging of ash particles increase their size, alter their optical properties, and increase their deposition velocities. The enhanced ash settling removes a portion of sulfate. Ash solar and IR absorption causes lower stratospheric heating, affects stratospheric temperature and dynamics preconditioning the long-term plume development.

The preliminary results show that most of the coarse mode volcanic ash is removed from the atmosphere within 10 days after the eruption while the fine ash in accumulation mode lasts for a few months and is transported and deposited at higher latitudes. The stratospheric heating associated with volcanic ash at the beginning exceeds 10 K $day^{-1}$ but quickly declines. The global average surface radiative cooling caused by ash is significant during the first week after the eruption until sulfate aerosols develop. However, uptake of sulfuric acid by fine ash particles affects the plume formation for about three months. As a result of chemical aging of volcanic ash, 50Mt of volcanic ash is removed by scavenging within the troposphere compared to 10Mt for non-aged ash, and 21Mt is removed by sedimentation compared to 59Mt for the non-aged case. The results show the significant impact of chemical aging on volcanic ash removal and radiative effect.