# Integral models of volcanic plumes in a cross wind.

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Explosive volcanic eruptions can inject large quantities of ash into the atmosphere which can be transported over large areas. The recent eruptions of Eyjafjallajökull 2010, Grimsvötn 2011 and Cordón-Caulle 2011 demonstrate the fragility of international transport infrastructure to relatively small volcanic eruptions. Managing airspace during volcanic crises by forecasting atmospheric ash dispersion requires, as an input, estimates of the source conditions at the volcanic vent. The source conditions are currently difficult to measure directly during an eruption.

Integral models of volcanic plumes can be used to estimate the source conditions during eruptions by comparing model predictions with observations. The simple mathematical structure of integral models allows solutions to be readily obtained, allowing an assessment of source and atmospheric controls to be made. We formulate an integral model of volcanic eruption columns that utilizes meteorological observations to determine the trajectory of the plume motion. We demonstrate, for weakly-explosive eruptions, atmospheric conditions have a strong effect on the rise of the plume. In particular, atmospheric winds strongly influence the rise of volcanic plumes, with the wind restricting the rise height such that obtaining equivalent rise heights for a plume in a windy environment would require an order of magnitude increase in the source mass flux over a plume in a quiescent environment.

The mixing of atmospheric air with the magmatic gases and pyroclasts plays a crucial role in the dynamics of the ascent of the plume. The entrainment process is typically parameterized in integral models using simple, phenomenological closures based on the classical entrainment assumption of Morton, Taylor & Turner (1957). Here we discuss the parameterization of entrainment, investigate the effect of wind enhanced entrainment on plume dynamics, and assess the sensitivity of integral model results to the entrainment coefficients employed.