Geophysical Research Abstracts
Vol. 15, EGU2013-9726, 2013
EGU General Assembly 2013

Models of ash-laden intrusions in a stratified atmosphere

Andrew Hogg, Chris Johnson, Steve Sparks, Herbert Huppert, Mark Woodhouse, and Jeremy Phillips
University of Bristol, United Kingdom (a.j.hogg@bris.ac.uk)

Recent volcanic eruptions and the associated dispersion of ash through the atmosphere have led to widespread closures of airspace, for example the 2010 eruption of Eyjafjallajokull and 2011 eruption of Puyehue-Cordón Caulle. These episodes bring into sharp focus the need to predict quantitatively the transport and deposition of fine ash and in particular, its interaction with atmospheric wind. Many models of this process are based upon capturing the physics of advection with the wind, turbulence-induced diffusion and gravitational settling. Buoyancy-induced processes, associated with the density of the ash cloud and the background stratification of the atmosphere, are neglected and it is this issue that we address in this contribution. In particular, we suggest that the buoyancy-induced motion may account for the relatively thin distal ash layers that have been observed in the atmosphere and their relatively weak cross-wind spreading.

We formulate a new model for buoyancy-driven spreading in the atmosphere in which we treat the evolving ash layer as relatively shallow so that its motion is predominantly horizontal and the pressure locally hydrostatic. The motion is driven by horizontal pressure gradients along with interfacial drag between the flowing ash layer and the surrounding atmosphere. Ash-laden fluid is delivered to this intrusion from a plume source and has risen through the atmosphere to its height of neutral buoyancy. The ash particles are then transported horizontally by the intrusion and progressively settle out of it to sediment through the atmosphere and form the deposit on the ground. This model is integrated numerically and analysed asymptotically in various regimes, including scenarios in which the atmosphere is quiescent and in which there is a sustained wind. The results yield predictions for the variation of the thickness of the intrusion with distance from the source and for how the concentration of ash is reduced due to settling. They illustrate the potential for the intrusion to remain as a relatively thin layer and explicitly reveal the significant dynamical role played by the atmospheric wind as the flow is accelerated or decelerated by the action of atmospheric drag.