

From the Throat of a Volcano to the Throat of an Athenean: Do Actively Degassing Volcanoes Affect Air Quality in the Greece and Elsewhere in the Mediterranean?

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This work investigated the role of constant degassing from Stromboli (926m; Aeolian Is) and Etna (3350m; Sicily) in air pollution around the Mediterranean. Although the total air pollution output from these two volcanoes amounts to only a negligible component of total European industrial and natural emissions, they are among the largest continuous point sources of sulphur dioxide, hydrogen chloride and hydrogen fluoride in the world. Under normal steady-state degassing, Stromboli's sulphur dioxide emission rate is greater than all sources in Greater London combined; Etna's emissions exceed this by more than a factor of 3. The suggestion that point-source emissions on this scale are responsible for regional air pollution events is reasonable; not only are the emissions highly concentrated at the source, but additionally they may be transported great distances downwind before being effectively dispersed or removed. If passive volcanic gas and aerosol plumes are concentrated by topographical barriers after long-range transport, then locally acute air pollution events (dry fogs) may be generated. In this work, two methods were employed to test this hypothesis: (a) trajectory modelling of plumes from Stromboli and Etna; and (b) a novel analysis of archived air quality data from European cities.

First, we modelled horizontal and vertical transport of the Stromboli and Etna plumes for 12 months using Hysplit_4 and NOAA FNL data. Three daily trajectories were run simultaneously from different altitudes to measure plume dispersion by bifurcation and wind shear. We found that the Stromboli plume can descend to below the 975 hPa pressure surface and travel in excess of 1000 kms before being effectively dispersed. Twenty-five possible dry fog events were generated by the model over the 12 month period. Transport of this type was most common over the ocean, demonstrating a widespread air quality hazard in coastal zones of the Mediterranean, particularly in southern Italy, Greece, western Turkey and northern Africa. Etna is less likely to cause such problems (despite its greater emissions) because of the relatively high emission height.

The second component of the work analysed archived air quality data from Mediterranean cities for evidence of dry fog events - have any dry fogs occurred in recent years, as suggested by the modelling results? Here we present data from Athens, Greece. Analysis was based upon co-variation of air pollutants during smog events. Relative concentrations of gases and particulates usually follow a pattern set by the local emissions (which remain relatively consistent on a day-to-day basis); disproportionate concentrations of any air pollutants indicates that particular pollution episode to be untypical. Possible reasons for abnormalities include the contribution of pollutants from external point sources, including volcanoes and forest fires. Statistical analysis identified 14 untypical air pollution episodes recorded between 1985 and 1993 at the Patission monitoring station in downtown Athens. These were all characterised by an excess of particulate matter or sulphur dioxide relative to carbon monoxide. To rule out meteorological or local causes for the abnormalities we made detailed analyses of ECMWF data and pollution data from 3 other stations in the city. After this 'filtering', six pollution episodes remained to be fully explained. In one case, an excess of particulate matter appeared to be sourced from an off-shore location to the west; this occurred two days following a powerful phase of fissure activity in the Valle del Bove on Etna. The ECMWF meteorological data show clear transport of an air mass from Sicily to Greece during the event. Claiming an association between the eruption and the pollution episode is speculative at this stage, but the work highlights the need for further research which will better define the role of very large, persistent volcanic gas sources in regional air pollution budgets.