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Refined CO_2 fluxes from Campi Flegrei using an enhanced dispersion modelling approach

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In cities located near active volcanoes, natural sources can increase urban CO_2 levels; and, this is the case in Naples, where much of the city lies downwind of the Campi Flegrei volcanic area (Southern Italy). Carbon dioxide has a molecular weight greater than air and therefore tends to accumulate in low-lying areas, forming invisible but potentially lethal traps. However, at Solfatara the discharged gas is warmer than surrounding air, so the greater molecular weight of CO_2 is compensated by the density decrease due to its higher temperature. Under such conditions, the CO_2 plume is dispersed depending on meteorological conditions and atmospheric turbulence, typically moving towards the downwind densely populated western quarters of Naples or its suburbs (Granieri et al., 2013).

This study investigates fumarolic CO_2 emissions at Campi Flegrei and their dispersion in the lowest atmospheric boundary layer. We innovatively utilize a Lagrangian Stochastic dispersion model (WindTrax) combined with an Eulerian model (DISGAS) to diagnose the dispersion of diluted gas plumes over large and complex topographic domains. New measurements of CO_2 concentrations acquired in the area of Pisciarelli and Solfatara, the two major fumarolic fields of Campi Flegrei caldera, and simultaneous measurements of meteorological parameters are used to: 1) test the ability of WindTrax to calculate the fumarolic CO_2 flux from the investigated sources, and 2) perform predictive numerical simulations to resolve the mutual interference between the CO_2 emissions of the two adjacent areas. This novel approach allows us to a) better quantify the CO_2 emission of the fumarolic source, b) discriminate "true" CO_2 contributions for each source, and c) understand the potential impact of the composite CO_2 plume (Pisciarelli "plus" Solfatara) on the highly populated areas inside the Campi Flegrei caldera.

The soundness of our combined approach is testified by the successful comparison of Lagrangian-Stochastic-derived fluxes (this study) with previous estimates based on the integration of CO_2 concentration contour maps (Pedone et al., 2014) and by the possibility offered by the method of evaluating the "additive" CO_2 term arising from each source. This latter feature provides detailed information about variations in volcanic/hydrothermal degassing by establishing an accurate time-series of CO_2 fluxes for each site of emission and increasing the possibility of reliable predictions for possible paroxysmal output stages. This allows the potential impacts on human health from exposure to volcanic plume gases to be more easily evaluated should there be an increase of volcanic activity.

In light of above advantages, our combined procedure shows great potential for inverse modelling aimed at the identification of multiple sources of emission into the atmosphere from given local CO_2 concentration datasets.

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Pedone, M., Aiuppa, A., Giudice, G., Grassa, F., Cardellini, C., Chiodini, G., Valenza, M., 2014. Volcanic CO_2 flux measurement at Campi Flegrei by Tunable Diode Laser absorption Spectroscopy. Bulletin of Volcanology, doi: 10.1007/s00445-014-0812-z.