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An investigation into shallow system dynamics during strombolian activity at Mt Etna using UV cameras, seismic data and modelling of gas flow

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During rapid strombolian activity observed at the Bocca Nuova (BN) crater of Mt Etna on the 27th July 2012, ultra-violet cameras were used to measure SO_2 emissions from the active vent over $\approx$ 30 minutes of activity. This resulted in the first determination of SO_2 masses for strombolian activity at Etna, with individual bursts of $\approx$ 0.1 – 14 kg. By combining this with Multi-GAS measurements of gas ratios in the BN plume, we estimate a total gas mass for individual bursts of $\approx$ 0.2 – 165 kg. By calculating the degassing paths of typical H_2O and CO_2 contents for Etnean magmas and matching this with the measured CO_2/SO_2 ratio of $\approx$3 we estimate that the depth that gas decouples from the melt at 0.5 – 6.2 km. Statistical analysis of the repose time between bursts showed an average interval of $\approx$3 – 5 s with a maximum of $\approx$ 45 s. Plotting the repose time following bursts against their gas masses indicates that larger events were not followed rapidly by a subsequent event. The subsequent event also always had a significant emission speed, i.e. following larger events there was a minimum wait period and minimum emission speed for the subsequent burst. This could be the result of a number of different processes or effects: 1) bubble coalescence and the consequent faster rise of larger gas masses,, 2) the coalescence of ascending Taylor bubbles (slugs), 3) an atmospheric transport effect related to changes in magma level, and 4) the partial collapse of a foam or a form of trap-and-release mechanism. Subsequent analysis of the fluid dynamics was performed using several numerical models, including: Del Bello et al. (2012) to estimate magma and conduit parameters, Seyfried and Freundt (2000) with Llewellin et al. (2012) to estimate where transition to full slug flow occurs, and Noguiera et al. (2006) for the wake length of slugs. The use of these models in combination with the James et al. (2008) dynamic slug model suggests that coalescence between gas masses, reasonably assumed to be slugs, occurs more frequently in the upper $\approx$ 100 m of the conduit, where gas expansion becomes significant. The depth at which transition to slug flow occurs is similarly shallow. Comparison of individual burst events and a range of lags with filtered seismic displacement data from the EBCN seismic station of the INGV network, demonstrated no correlation between maximum peak-to-peak amplitude in the vertical component. Although, a tentative (due to the discrete 10 minute period used with omission of anomalous data) correlation of r2 = 0.88 exists for the sum of burst mass in a minute against equivalent RMS when offset by a lag of 2 minutes. Considering the approximate rise speed of gas masses, the location of gas at the time of correlation is estimated to be a depth of $< \approx$ 250 m.