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Dynamics of eruptive pulses – A case study of the second explosive phase of the 2010 Eyjafjallajökull eruption (Iceland)

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Current ash plume models of long-lived eruptions usually consider sustained ash plumes to be a continuous steady emission of tephra at the volcanic vent. The 2010 eruption of Eyjafjallajökull volcano, however, often displayed pulsating activity, where emissions from the vent occurred by frequent but discrete bursts (with pulses in the order of seconds) that merged at higher altitude in a sustained eruption column. High resolution near-field video recordings of the vents, taken from a distance of $\sim$850 m during the second explosive phase from 8 – 10 May and supplemented by aerial observations, were used as a case study to describe the mechanism of such pulsating eruptions. The dynamics of discrete pressurized jets were characterized and their pressure history quantified between discharge from vent until they reached the height of transition at $\sim$100 m, where the expanding regime turned into a convective buoyant one. It is suggested that during the analyzed initial expansion phase of eruption, a rapid decompression of the pulses caused a significant decrease in particle volumetric concentration within the jets, allowing and enhancing further-up air entrainment and buoyancy and leading to the establishment of dilute ash plumes that eventually merged and form the quasi-continuous eruption column. Based on the results and conclusions of our case study we examine how to link the eruption source parameters of multiple discrete expansive jets to the over-all mass eruption rate derived by "classical" continuous ash plume models (being in the order of $\sim 10^4$ kg/s). Furthermore, the implications for real-time assessment by using near-field monitoring systems under pulsatory eruption conditions are discussed. Finally, the expansion dynamics of the analyzed pulses are compared to those of pulses generated in large-scale experiments designed for reproducing explosive magmatic eruptions, allowing us to evaluate the strengths and restrictions of using such experimental simulations for calibrating near-field sensors to pre-set eruption source parameters.