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Meteorological controls on local and regional ash dispersal revealed using high-resolution dispersion modelling: The eruptions of Soufrière St. Vincent

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Volcanic ash has the capacity to impact human health, livestock, crops and infrastructure, in addition to disrupting international air traffic. A significant improvement in understanding and simulating volcanic ash dispersal is necessary for enhanced prediction and mitigation of these impacts. For recent major eruptions, information on the plume and ash distribution has typically been combined with relatively coarse-resolution meteorological model output to provide simulations of regional ash dispersal, with reasonable success on the scale of hundreds of kilometres. Here, we present results from the dynamic meteorology-ash-dispersion model WRF-CHEM configured with sufficient resolution to represent local topographically-forced flows and initialised with realistic atmospheric and ash-distribution structures. We focus on an archetypal volcanic setting, Soufriere, St. Vincent, and draw on the exceptional historical record of the 1902 and 1979 eruptions to compare with our simulations. We find that the evolution and characteristics of ash deposition on St Vincent and nearby islands can be accurately simulated when the wind shear associated with the Trade Wind inversion and topographically-forced flows are represented. Sensitivity tests demonstrate that the wind shear has a primary role in local ash dispersal, with topographic flows having an important secondary role on the island of St Vincent itself. We discuss the spatial characteristics of proximal deposition and distal secondary maxima in the context of the result of interactions between mesoscale meteorology and the ash plume.