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Small-scale volcanic aerosols variability, processes and direct radiative impact at Mount Etna during the EPL-RADIO/REFLECT campaigns

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The aerosol properties of Mount Etna's passive degassing plume and its short-term processes and radiative impact were studied in detail during the EPL-RADIO/REFLECT campaigns (summer 2016, 17 and 19), using a synergistic combination of remote-sensing and in situ observations, and radiative transfer modelling. Summit observations show extremely high particulate matter concentrations, with no evidence of secondary sulphate aerosols (SA) formation. Marked indications of secondary SA formation, i.e. by the conversion of volcanic SO2 emissions, are found at larger spatial scales (<20 km downwind craters). Using portable photometers, the first mapping of small-scale spatial variability of the average size and burden of volcanic aerosols is obtained, as well as different longitudinal, perpendicular and vertical sections. A substantial variability of the plume properties is found at these spatial scales, revealing that processes (e.g. new particle formation and coarse aerosols sedimentation) are at play, which are not represented with current regional scale modelling and satellite observations. Vertical structures of typical passive degassing plumes are also obtained using observations from a fixed LiDAR station constrained with quasi-simultaneous photometric observations. These observations are used as input to radiative

transfer calculations, to obtain the shortwave top of the atmosphere (TOA) and surface radiative effects of the plume. Moreover, the radiative impact of Mount Etna's emissions is studied using a medium-term time series (a few months during summer 2019) of coupled aerosol optical properties and surface radiative flux at a fixed station on Etna's eastern flank. These are the first available estimations in the literature of the radiative impact of a passive degassing volcanic plume and are here critically discussed. Cases of co-existent volcanic aerosol layers and aerosols from other sources (Saharan dust transport events, wildfire from South Italy and marine aerosols) are also presented and discussed.