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Airborne and ground measurements for vertical profiling of secondary ice production during ice pellet

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Predicting the accurate type of precipitation during winter storms is crucial for the implementation of mitigation measures such as aircraft deicing in commercial aviation or the spreading of salt and abrasives on roads. For this reason, a better understanding of the microphysical processes leading to winter precipitation types is essential. During freezing rain events, secondary ice produced by the freezing of supercooled raindrops via the fragmentation of freezing drops (FFD) process can initiate a chain reaction, potentially transitioning freezing rain into ice pellets. However, including this process in numerical weather prediction models is challenging due to the uncertainty in the efficiency of this mechanism. To bridge this gap, this study aims to evaluate the efficiency of the FFD process during ice pellet precipitation using measurements collected onboard the NRC Convair-580 research aircraft during the WINTRE-MIX field campaign, in February 2022. Specifically, measurements from two missed-approaches conducted in the Saint Lawrence Valley, Quebec, Canada during an ice pellet storm are analyzed. These missed-approaches provide unique datasets collected above, within, and below the ice pellet freezing altitude using in-situ and remote sensing instruments. In the region characterized by completely frozen ice pellets, a bi-modal particle size distribution, indicative of secondary ice production, was measured. Observations from imaging and optical-array probes suggest that particles smaller than 200 µm in diameter were, likely, non-spherical ice crystals, whereas the particle size mode with the larger diameters was associated with ice pellets. The observations of fractured ice pellets and ice pellets with bulges and spicules on most large particles suggested the occurrence of the FFD process. Subsequently, the measured number concentration of small ice particles, which was of the order of 500 L^{-1}, was compared with the number concentration of ice particles simulated through existing parametrizations of secondary ice production. This analysis will be valuable for selecting the most accurate FFD process parametrization to use for freezing rain and ice pellets simulation.