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Millimeter wave radars: the way forward for remote sensing of ash plumes?

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Ground-based observation of volcanic ash clouds after an eruption is currently done using weather radars which were originally designed for monitoring meteorological clouds. As ash particles and aggregates have different sizes and refractive indices compared to raindrops and ice crystals, certain parts of the volcanic ash cloud can go undetected by these low frequency weather radars. This can lead to incorrect predictions from the volcanic ash transport prediction models to the aviation industry; the field could benefit from higher frequency radars designed exclusively for ash cloud monitoring. However, the increased sensitivity to fine ash from high frequency signals comes at a cost of significant path attenuation as the wavelengths (in the order of millimeters) are comparable to the ash sizes, and any selection of frequencies should take into account the increased attenuation. In this talk we present a radar forward operator 'SynRad' that numerically simulates the radar measurement process and generates synthetic return signals. SynRad is used to evaluate the performance of three radar frequency bands (C-,Ka- and W-bands) to detect a volcanic ash cloud. The numerically simulated volcanic ash cloud of the Redoubt 2009 eruption serves as the case study. Results suggest that a dual-frequency radar with a C- and Ka-band is the best option to detect the predominantly larger ash particles and aggregates at the early stages of the eruption and the fine ash in the distal ash cloud during the later stages of the eruption respectively. The W-band radar undergoes heavy attenuation at all locations except for downwind of the ash cloud.