Development of an Algorithm for Volcanic Ash Detection using MSG-SEVIRI and Neural Networks

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Artificial neural networks (ANNs) have been proven to be a powerful tool for classification and parameter estimation and have been successfully applied to various remote sensing problems (e.g. Piscini et al. 2014, Strandgren et al. 2017). Here we use them to detect and analyze volcanic ash clouds pixelwise in MSG-SEVIRI images. The quality of the training dataset is of crucial importance for the accuracy of such an algorithm. Our approach relies on detailed radiative transfer calculations based on realistic ash properties to train the ANN. Therefore we present thoroughly investigations of the different aspects that must be considered to perform these radiative transfer calculations.

First, we address the question of the refractive index (RI) of volcanic ash. In the past, this was a major uncertainty as it can vary strongly between different eruptions (Reed et al. 2017), but for a long time there existed only a few RI measurements reported by Pollack, Toon and Khare (1973) and Volz (1973). Here we show that it is possible to mimic the RI and the dense rock equivalent density of different ash samples using typical volcanic ash compositions and measurements of individual minerals and volcanic glasses. Based on this we compile a collection of different ash compositions and calculate their RIs.

Second, we tackle the big uncertainty represented by the shape and size of the ash particles. For instance many retrievals assumed spherical particles in the past (e.g. Prata and Grant 2001, Gangale et al. 2009, Lee et al. 2014), although ash particles are usually highly aspherical and irregular (Cashman and Rust in "Volcanic Ash: Hazard Observation", 2016). The effective radius varies between different measurements and eruptions by more than one order of magnitude, e.g. between 0.5μm and 9μm (Grainger et al. 2013).

Third, we estimate the influence of the vertical profile and multiple ash layers on the measured brightness temperature as well as typical column concentrations and cloud top heights that are retrievable.

Finally, we present the training dataset based on the previous findings and calculated using the radiative transfer model libRadtran (Emde et al. 2016), as well as a first prototype algorithm for the retrieval.