Convolutional neural networks for aerosol scattering: the analogy to image recognition problems

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Remote sensing of aerosol properties by inversion commonly requires directionally averaged aerosol light-scattering shape models such as spheres or spheroids. However, using shape-averaged models often yields discrepancies in retrievals at different wavelengths, leading to inaccurate or at-best ambiguous aerosol classification. Furthermore, shape-averaging does not allow discrimination of trace, non-averaged, scattering patterns. In our work, we have applied machine-learning algorithms to the calculated light-scattering patterns from particles of seven different, common, and naturally occurring shapes to test whether their shapes can be classified. Our dataset consists of either the scattering intensity distribution or the degree of linear polarization. Furthermore, our dataset was either one-dimensional, depending on the polar angle, or two-dimensional, depending on both the polar and azimuthal angles. The implementation of a one- or two-dimensional scattering dataset input can be analogous to an image recognition problem, requiring either a fully connected or a convolutional neural network. Prediction capabilities were much greater when the two-dimensional scattering data was used than when only one-dimensional data were considered. When the two-dimensional intensity patterns are considered, the prediction capabilities were approximately 70% for the regularly shaped particles and above 90% for the highly irregularly shaped particles. These capabilities increased slightly when linear polarization was used as input. These results suggest that trace-aerosol shape classification can be achieved using two-dimensional light-scattering patterns and convolutional neural networks.

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