Warehousing and Disseminating Single-Scattering Properties for Particulate Matter Remote Sensing

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Space-based quantitative snowfall remote sensing has advanced in the last decade to using single-scattering properties derived from realistically shaped hydrometeors, whose value is amply demonstrated with the drastic improvement in the consistency between active and passive retrievals and has benefited the active-passive combined algorithm of NASA's Global Precipitation Measurement mission. However, the two principal processes required to obtain these scattering properties, i.e. the numerical generation of synthetic hydrometeors with realistic morphology and the subsequent solution of the electromagnetic scattering problem, are orders of magnitude more demanding in computation and storage resources than those required for hydrometeors with shapes based on simplifying assumptions. Recent evidence from microwave radiometer polarization signals suggests that uniform random orientation of the hydrometeors in solid precipitation is rarely a valid assumption. Axially symmetric scattering properties derived from orientation averages, in turn, rarely apply. The consistent quantitative physical retrieval of snowfall now calls for polarimetric and orientation-dependent scattering properties. Due to the general lack of symmetry for the solid hydrometeors, each orientation has a unique scattering solution. Since hundreds of orientations may be needed for each particle the storage demand grows proportionally. This challenge is not unique to snowfall remote sensing. Space-based quantitative remote sensing of cloud ice and aerosol face similar problems, for the particles of concern in these applications are mostly non-spherical and complexly shaped as well. Furthermore, heterogeneous composition of the pertinent particles, such as melting hydrometeors, hydrometeors with pollutant enclosures, and mixed composition aerosol or dust particles, further exacerbates the problem. For example, as we attempt to deal with the nearly ubiquitous melting layers in precipitation systems, we have discovered that, since the solid hydrometeors in the melting layer may likely be at different stages of melting, we must consider a range of liquid mass fraction for each solid hydrometeor. We thus need tens of melting instances at different liquid mass fractions with their associated scattering properties, ballooning the resource requirement further by ~10 fold! We, as a community in particulate matter remote sensing, can ill afford to repeat such computationally intensive electromagnetic scattering calculations or duplicate the needed storage for storing their results. We must find a strategy to sustainably enhance the long-term availability, accessibility, and usability of these valuable data. For such a purpose, we need first a more suitable and better designed means than "data files" to warehouse the realistic hydrometeor structures along with associated single-scattering properties and second a flexible and extensible means to disseminate the warehoused data. Both of these must also be scalable and performant. In terms of technological choices, we recommend employing a parallel (distributed) database management system for warehousing with web services enabled for access and dissemination. We believe the data centers and services of NASA through its Earth Science Data Systems program provide the best long-term solution to this challenge.