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The combined use of CALIOP, MODIS and OMI level 2 aerosol products for calculating direct aerosol radiative effects

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We describe a technique for combining CALIOP aerosol backscatter, MODIS spectral AOD (aerosol optical depth), and OMI AAOD (absorption aerosol optical depth) measurements for the purpose of calculating direct aerosol radiative effects. In the first step of our strategy for combining these data sets we seek to find combinations of bi-modal microphysical aerosol particle models that are reconcilable with the MODIS, OMI and CALIOP observations within the uncertainties of their respective retrievals. In a second step, we use these models to forward calculate the aerosol radiative properties required for a full assessment of the direct aerosol radiative forcing, i.e. spectral extinction/AOD, single scattering albedo and asymmetry parameter. In the final step, we use a radiative transfer model to determine how the range of microphysical retrievals translates into a range of radiative forcing estimates. We show sensitivity studies and first results from actual collocated CALIOP V3, MODIS and OMI data collected in 2007.

As a prerequisite for the application of our methodology to the actual satellite observations, we assessed the consistency between comparable measurement quantities from the different A-Train sensors. In particular, for eight months (Jan., Apr., July, Oct. 2007 and 2009), comparisons of the standard MODIS-Aqua (Collection 5) AOD data to the AOD calculated from the latest release (Version 3) of the CALIOP level-2 aerosol extinction profile data set show an order of magnitude increase for the CALIOP V3 data density by comparison to V2. Differences in global, monthly mean, over-ocean AOD (532nm) between CALIOP and MODIS range between 0.02 and 0.06 for CALIOP V2, and between 0.025 and 0.04 for CALIOP V3, with CALIOP generally biased low. Mean differences in instantaneously collocated AOD retrievals by the two instruments are reduced from values of greater than 0.1 using CALIOP V2 to values near 0.07 for CALIOP V3. A restriction to scenes with cloud fractions below 1% (as defined in the MODIS aerosol retrievals) generally results in improved correlation (r^2>0.5). For AOD at 1064nm, there is equal improvement between CALIOP V2 and V3, with the mean in instantaneously collocated AOD differing by generally 0.06 or less between the two instruments.

As a test of our methodology, we applied our multi-sensor retrievals of aerosol radiative properties to airborne HSRL (High Spectral Resolution Lidar) aerosol backscatter data, sunphotometer derived AOD, and in situ aerosol absorption measurements in a fire plume study during the ARCTAS (Arctic Research of the Composition of the Troposphere from Aircraft and Satellites) field campaign in 2008. Radiative fluxes modeled based on the multi-sensor aerosol retrievals compare well with radiative fluxes measured by an airborne spectral flux radiometer (SSFR) aboard the same aircraft. We found good agreement for the entire SSFR wavelength range of 350-2150 nm, indicating the validity of our approach for determining spectral radiative properties from spectrally limited retrieval input.