Progress in the Validation of Dual-wavelength Aerosol Retrieval Models Via Airborne High Spectral Resolution Lidar Data

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It is well known that aerosol retrievals from elastic-scatter lidars such as the Cloud Aerosol LIdar with Orthogonal Polarization (CALIOP) lidar onboard the CALIPSO satellite require at least one of several possible boundary constraints/assumptions in conjunction with the Fernald retrieval relation (F.G. Fernald, *Appl. Opt.*, 1984), which retrieves aerosol backscatter versus range for a specified value of the lidar ratio assumed to be reasonably constant with range. In the case of an elevated aerosol layer, direct transmittance may be used as a constraint in the retrieval, thereby determining the lidar ratio, S_a. Otherwise, a table lookup approach is commonly utilized, estimating S_a based on geographic or climatological cues.

Where dual-wavelength information is available (at 532 and 1064 nm) from CALIOP or the Geoscience Laser Altimeter System (GLAS) lidar onboard ICESat, the Constrained Ratio Aerosol Model-fit (CRAM) technique (Reagan, et al., 12th AMS Atmos. Rad. Conf., 2006, Reagan, et al., IGARSS'07, 2007) has been used with some success for aerosol retrievals, as verified by accompanying measurements (McPherson, et al., *J. Geophys. Res.*, 2010, in press). The CRAM technique makes use of parameterizations of a number of characteristic models of aerosol (e.g., dust, biomass burning, urban/industrial, etc.) in terms of spectral ratios (532 to 1064 nm) of aerosol extinction, backscatter and S_a, then evaluates retrievals made from the S_a pairs from the various models based on the relative degree of fitness of the retrieved spectral parameters with those of the corresponding model. The current model parameterizations are based on a study of global AERONET data, and are thought to characterize the spectral behavior of the various optical properties of a number of aerosol types observed around the world (Cattrall, et al., *J. Geophys. Res.*, 2005). Thus, the available dual-wavelength information is brought to bear on the aerosol retrieval problem so as to improve upon retrievals which do not take advantage of this added information.

High Spectral Resolution Lidar (HSRL), as it is implemented on the NASA Langley Airborne HSRL (Hair, et al., *Appl. Opt.*, 2008) at 532 nm, employs an atomic absorption filter to differentiate between molecular and aerosol scattering, resulting in unambiguous, direct measurements of aerosol backscatter and extinction profiles, and consequently the extinction-to-backscatter (or lidar) ratio, S_a. This capability at 532 nm, together with an elastic backscatter channel at 1064 nm opens the door to a number of very interesting applications for the NASA Langley Airborne HSRL with respect to aerosol studies. Notably, an extension of the CRAM technique has been developed (Reagan, et al., *IGARSS'08*, 2008) to take advantage of the HSRL capability at 532 nm to additionally constrain aerosol retrievals at 1064 nm, as well as validate the assumption of spatial homogeneity of S_a that is the practical basis for aerosol retrievals via the Fernald relation.

One application of this extended CRAM ("E-CRAM") technique using HSRL data at 532 nm is to make retrievals from the 1064 nm elastic backscatter channel using the additional constraint of fully known aerosol scattering parameters at 532 nm. This is done in the context of spatial regions where the Fernald retrieval assumption of limited spatial S_a variability at 532 nm can be directly confirmed so that the 1064 nm retrieval is made based on a least-squares minimization of the spatial variability of S_a at 1064 nm. This method has been shown to yield very reliable aerosol retrievals at 1064 nm across the range of S_a values observed at that wavelength. Enough HSRL data are now available (currently more than 500 flight hours in a variety of locations) that meaningful conclusions can begin to be drawn about the accuracy of the AERONET-derived models that are the basis for dual-wavelength elastic-scatter aerosol retrievals from CALIPSO via CRAM. This paper discusses the progress of this research and elaborates on the broader implications for considerably more accurate aerosol retrievals from CALIPSO.

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