Explaining the Seasonal Variation of MultiFilter Rotating Shadowband Radiometer (MFRSR) *in situ* Calibrations and Effects on Aerosol Optical Depth (AOD)

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Long-term visible MFRSR *in situ* top-of-atmosphere (TOA) spectral channel calibration (V_o) time series show a repeatable seasonal periodicity that, if not treated properly, could adversely impact AOD climatologies. Relatively high calibrations in summer, low values in winter, and an orderly transition through the equinoxes are observed. The average amplitude is ±4%, which translates to an AOD error of 0.04, if interpolation of the calibrations to individual days for AOD analysis is not treated properly. This seasonal behavior is reproducible for all MFRSRs and is superimposed on sensor drift. The nature of the observed periodicity suggests a temperature dependence. Although the MFRSR head is designed to be stabilized at 40°C operational data show that the temperature of the head electronics varies in the same direction as the outside temperature but to a lesser degree, while the temperature of the filters and detectors, which are better exposed to the heater, remains stable. Possible sources of the periodicity were narrowed to changes in the transmission of the diffuser with temperature and the thermal response of the head electronics. A laboratory experiment was designed to test these effects. Several MFRSR heads were placed in an environmental chamber and exposed to ambient air temperatures that were systematically stepped from -5°C to 45°C, and back (light blue ramps in Figure 1). The head electronics temperature responded by varying from 34°C and 45°C. Because the MFRSR has no cooling capacity, when the air temperature surpassed 40°C the electronics' temperature matched the outside temperature. A sample response of the MFRSRs spectral channel output for a constant light source is shown in Figure 1 as a function of the chamber air temperature (light blue ramps). Channel response to the constant light source departed from the initial value (measured at -5°C) by a maximum of 9% to 58% as the chamber temperature approached 40°C. When measurements without a light source (dark signal) were removed, those amplitudes reduced to 2% - 7%, strongly indicating that the response of the head electronics to changes in temperature is a likely source of the observed seasonal variation of *in situ* calibrations. The experiment also revealed that the MFRSR diffuser transmission changes by 1% as its temperature passes through 19°C. That effect is caused by molecular structural changes to Spectralon (a form of Teflon that the diffuser is made of) that occur around 19°C. The maximum effect of this change in diffuser transmission on V_o was found to be 0.22%, which is negligible compared to the ±4% seasonal variation of V_o, most of which is attributable to the thermal response of the head electronics. This experiment proved that the seasonal variation of MFRSR *in situ* TOA calibrations is real and must be accounted for when interpolating those calibrations to individual days for AOD analysis.

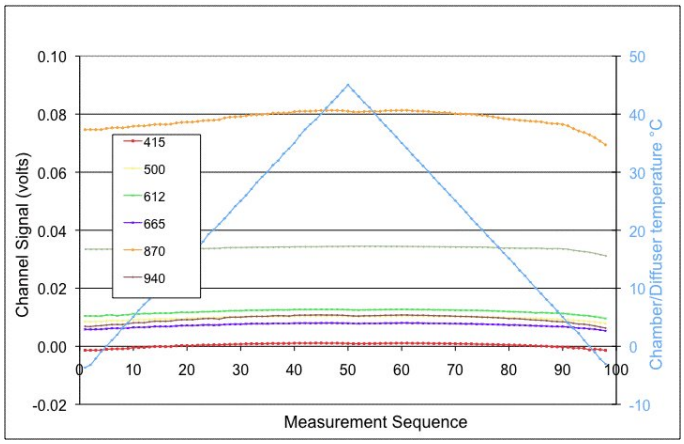

Figure 1. MFRSR channel voltage (left y-axis) output time series for a constant light source as the air temperature changes from -5°C to 45°C and back (light blue ramps, right y-axis).