A 1.55 \( \mu \)m Rotating Shadow-band Radiometer

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To better define the retrieval of bimodal particle size distributions, Alexandrov (private communication) has demonstrated the usefulness of a longer wavelength measurement of aerosol optical depth than 870 nm now available with the MFRSR. At PNNL a demonstration unit with a single channel was assembled in the open channel position of an MFRSR; the large size of the detector only allowed this single channel within the MFRSR detector cube. The sensor is an InGaAs detector with an Intor filter centered near 1550 nm. Measurements during this winter at SGP were used to derive a Langley calibration for the unit. The retrieved optical depth has contributions from water vapor, carbon dioxide, some Rayleigh and, of course, aerosol.

This plot shows the CO\(_2\) and H\(_2\)O transmission (for nominal summer conditions) and the filter profile (solid blue). To avoid absorption features, a better choice is 1625 nm. Note that the dashed blue profile is near AERONET’s nominal wavelength.

This plot shows two determinations of cosine response of the single-channel 1550-nm MFRSR for the South to the North measurement as a solid and as a dashed line. This information is used to correct the direct normal irradiance.

This plot shows two determinations of cosine response for the West to East measurement as a solid and as a dashed line. Two measurements were made to determine the repeatability of the data.

Langley plot for a clear stable day with solid cosine correction applied. Should be straight, but note the curvature, which is not due to atmospheric instability.

Langley plot for same clear stable day with dashed cosine correction applied. The Langley plot is not significantly changed.

This is a Langley plot when data were taken with sun-pointed instrument on another day. Still some curvature, perhaps, because of water and carbon dioxide within the filter.

NIMFR 5 wavelengths and 1.55 \( \mu \)m MFRSR channel AOD time series. Not sure what to expect for the behavior of the longwave channel, but the differences are not totally correlated.

In this plot the sun-pointing 1550-nm channel instrument is used to get AOD time series for a different day. The question remains whether this is physically reasonable behavior, or it may be an artifact caused by a poor determination of \( V_o \), since only four Langleys were used for the calibration.

The error from this is expected to vary as \( 1/(\text{air mass}) \), which is consistent with the behavior above.

A Langley plot in the form of \( \ln(V) + \tau_{\text{water}} \cdot m_{\text{water}} = \ln(V_o) - \tau_{\text{aer}} + \tau_{\text{ray}} \cdot m \) was attempted to remove the non-linear curve of growth issues possibly related to water vapor contamination with no change in the retrieved \( V_o \).

Using the Langleys to determine a calibration (\( V_o \)), we plot the MFRSR 1550-nm channel aerosol optical depth (AOD) time series along with the five nominal normal incidence multi-filter radiometer (NIMFR) channels; the next plot uses the 1550-nm channel in normal incidence mode to get AOD time series for another day.

Summary: The good news is that the signal to noise for the 1550-nm channel is sufficient in the MFRSR mode of operation. There is still a question as to whether it can be used in the normal MFRSR configuration, that is, can we get a smaller detector in the cube, say in the open channel position, along with the normal filter set.

Attempts to remove water vapor from influencing the Langley plot did not seem to work; either the expression we used for the water vapor optical depth underestimated the optical depth or carbon dioxide needs to be removed, as well, to remove the curve of growth effects in the Langley plot. Of course, a better filter position should reduce these effects significantly.