A13F-2514: Characteristics of In Situ Fine Fraction Aerosol Spectra from 300-700 nm Observed Around the Korean Peninsula During KORUS-OC

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In situ aerosol extinction and absorption spectra covering the 300-700 nm range at ≤ 1 nm spectral resolution were measured aboard the R/V Onnuri during the Korea U.S. – Ocean Color (KORUS-OC) cruise around the Korean Peninsula from May 21 through June 3, 2016. Total absorption spectra were obtained from aerosols collected on glass fiber filters and subsequently placed in the center of an integrating sphere (Labsphere DRA-CA-30) attached to a dual beam spectrophotometer (Cary 100 Bio UV-Visible Spectrophotometer, 0.2 nm spectral resolution). Absorption spectra from methanol and deionized water extracts of aerosols collected on Teflon filters were measured in a liquid waveguide capillary cell (World Precision Instruments LWCC-3100, ~0.4 nm spectral resolution). Extinction spectra were measured with a custom built instrument (SpEx, ~0.8 nm spectral resolution). The measurements were obtained at a height of ~10 m above the sea surface with an inlet that limited the measured aerosols to diameters ≤ 1.3 µm. All four sets of spectra exhibit curvature in log-log space with 2nd order polynomials providing a better fit to the measured spectra than power law fits. The deionized water extracts were also analyzed with an ion chromatograph (Dionex ICS-3000 Ion Chromatography System) and with an aerosol mass spectrometer (Aerodyne Research, Inc. HR-ToF High Resolution Aerosol Mass Spectrometer) to examine chemical composition. These data indicate the optical spectra are sensitive to differing chemical properties of the measured ambient aerosols and suggest differing sources and/or atmospheric processes influence the observed optical signatures.

The measured suite of spectra are combined to examine the spectral characteristics of single scattering albedo, as well as to examine the contribution of soluble absorbing chromophores to the total absorption spectra. Additional measurements made during the affiliated Korea U.S. - Air Quality (KORUS-AQ) campaign will be used to provide further insight on the observed spectral characteristics.
Introduction: KORUS-OC & In Situ Aerosol Measurements

• Affiliated with airborne KORUS-AQ & KOCOA cruise
  – joint missions to study the Korean air quality (AQ) & OC
• Under way of S. Korean Genetalization Ocean Color Imager (GOCI)
• Cruises conducted from May 20 to June 4, 2016
• OC objectives for atmospheric measurements to
  – address atmospheric correction requirements
  – explore interdisciplinary science questions

• 1 minute Data Set: 3 visible wavelengths
  – Scattering (AirPhoton Nephelometer model (N101-450, 532, and 632 nm)
  – Absorption (Brechtel Tricolor Absorption Photometer, TAP, model 2901: 467, 528, and 652 nm)

• Key Points
  1 min scattering and absorption coefficients (UC and AC, respectively) used to flag ship cruise
  – Simple scattering albedo (SSA) decreases occur when scattering decreases (middle panel)
  – Absorption Ångström Exponents model scattering variability with time of wavelength pair used in calculation (Left: bottom panel)
  – Scattering Ångström Exponents show some variability with wavelength pair, along with an increase in values late in cruise (Left: bottom panel)
  – The cruise track (Below: right panel, excluding periods within the S. Korean Terrestrial Zone) was moved to the east of the peninsula for the 2nd half of the cruise, then returned to the western coast prior to the 3rd leg of the cruise.

• Spectra Data Set: 300-700 nm wavelengths
  – Extinction (Spectral Aerosol Extinction (SpEx) instrument, 4 nm resolution)
  – Total Absorption (Glass fiber filter measured in liquid waveguide capillary cell (World Precision Instruments LWCC-3100))
  – DIW- and MeOH-soluble Absorption (extracts from Teflon filters measured in liquid waveguide capillary cell (World Precision Instruments LWCC-3100)
  – Filters sampled – 3 hr daytime, 12 hr nighttime

• Characterizing Spectral Shapes
  – Aerosol interaction with light is wavelength dependent often characterized by a power law: $p(\lambda) \propto \lambda^n$
  – Where, $n$ is known as the Ångström exponent and $p$ may be scattering, absorption, extinction, etc.

• Ambigous results of a 2nd order polynomial fit (filters 15-22)
  – Only values 3 sigma above the mean blank are included
  – The strong wavelength-dependence of known carbon results in many partial spectra over the 300-700 nm range for the soluble absorbing features
  – Extreme values for $a_2$ and $a_1$ for both DIW- and MeOH-Abs arise from partial spectra
  – All Ext and Total Abs spectra were complete spectra resulting in a more limited range of values for $a_2$ and $a_1$

• Exploring Information Content of 2nd order Spectral Fit Parameters: $a_2$ and $a_1$
  – Extinction (or AOD) Ångström exponents are typically used to distinguish particle sizes, i.e., $a_1$ indicates coarse dust or sea salt aerosols with diameters $> 1 \mu m$ while $a_2$ indicates small aerosols with diameters $< 1 \mu m$

• Previous studies using ambient total column measurements and/or models have investigated sensitivities of the 2nd order polynomial coefficients
  – and considered additional information content they may offer (e.g., Eck et al., 2001; Schuster et al., 2006)

• Here, we can map various in situ observations into $a_2$ vs. $a_1$ coefficient space following Schuster et al. (2006) to examine the relationship between these observations and the spectral shape of extinction, total absorption, and soluble absorption; a few examples are shown below

• Magnitudes
  – Extinction shows clear separation in $a_2$ vs. $a_1$ space as a function of the magnitude of extinction; This holds for all wavelengths (365 nm shown)
  – This is not the case for any of the absorption spectra

• DIW-soluble Absorption Wavelength-Dependent
  – SSA, absorption and extinction results:
    – Only values 3 sigma above the mean blank are included
    – The strong wavelength-dependence of known carbon results in many partial spectra over the 300-700 nm range for the soluble absorbing features

• Implications of Results & Future Work
  – In situ aerosol spectral measurements have been combined with other in situ aerosol measurements showing that both targeting specific wavelengths, as well as evaluating the spectral shape, can provide insight into the linkages between chemical and optical aerosol properties
  – Work is ongoing to fully assess these data and investigate the results obtained within the broader KORUS-AQ data set; Efforts are also underway to refine and expand the spectral measurement capabilities as deployed during KORUS-OC
  – Future studies combining these spectral measurement techniques with more extensive microphysical and chemical information will no doubt provide a wealth of new information regarding key aerosol characteristics responsible for particular optical signatures