STANDARD OPERATING PROCEDURES

Generating Time-Resolved $PM_{2.5}$

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TABLE OF CONTENTS

1.0 SCOPE AND APPLICATION

This SOP describes the method of combining quality assured nephelometer data (SPARTAN SOP Nephelometer Revision 2.0) with filter average $PM_{2.5}$ mass concentrations (SPARTAN SOP Gravimetric Analysis Revision 3.0) and chemical composition information (SPARTAN SOP RCFM Revision 3.0) to produce hourly and daily estimates of $PM_{2.5}$ concentrations. The assessment of $PM_{2.5}$ hygroscopicity as described in SPARTAN SOP RCFM Revision 3.0 is site specific and time varying based on the measured chemical composition. The temporally resolved, site-specific κ-Kohler parameters for volume (κ_v) are calculated and used to refine the relationship between total nephelometer scatter and $PM_{2.5}$. Hygroscopic growth factors are used to estimate dry (RH = 35 %) hourly $PM_{2.5}$ from hourly nephelometer measurements of total scatter at 550 nm at ambient relative humidity. A cut-off of 80 % RH is applied to calculation of temporally-resolved $PM_{2.5}$, above which hygroscopic uncertainties and total water mass dominate scatter measurements.

REVISION HISTORY			
Revision No.	Change Description	Date	Authorization
2.0	General reorganization and clarification; update to classification of satellite overpass times	August 29, 2018	Crystal Weagle

2.0 CALCULATION OF TIME-RESOLVED $PM_{2.5}$

2.1 Volume growth factors

The κ-Kohler parameter for the total $PM_{2.5}$ mass ($\kappa_{v,tot}$) of each filter is determined by linear combination of mass measurements (m_i,), assumed densities (ρ_i), and κ-Kohler constants for each measured chemical component ($\kappa_{v,i}$):

$$\kappa_{v,tot} = \frac{1}{V}\sum_i \frac{m_i}{\rho_i}\kappa_{v,i} \qquad (1)$$

where V is the total volume sampled over the filter. It is assumed that the relative contribution of the chemical components remains constant of the sampling period, thus the κ parameter also remains constant. The resultant volume growth factor (f_v) is a simple function of filter-specific κ-Kohler parameter and the measured ambient relative humidity (RH):

$$f_v(\mathrm{RH}) = 1 + \kappa_{\mathrm{v,tot}} \frac{\mathrm{RH}}{100 - \mathrm{RH}} \tag{2}$$

2.2 Determining dry total scatter and $PM_{2.5}$

Nephelometer scatter measurements at three wavelengths (457 nm, 520 nm, and 634 nm) are averaged into hourly intervals and converted to 550 nm via a fitted angstrom exponent. The volume growth factor is then used to estimate dry total scatter:

$$b_{sp,\mathrm{dry\text{-}1h}} = \frac{b_{sp,\mathrm{1h}}(RH)}{f_v(\mathrm{RH})} \tag{3}$$

Changes in dry scatter are proportional to changes in $PM_{2.5}$ mass as,

$$b_{sp,\mathrm{dry}} = \alpha\, PM_{2.5,dry} \tag{4}$$

where α ($m^2\ g^{-1}$) is the mass scattering efficiency and is a function of aerosol size distribution, effective radius, and dry chemical composition. For the determination of time-resolved $PM_{2.5}$ concentrations from integrated filter samples, composition, density, and size distribution are treated as constant over the sampling period such that α is approximately equal to the average over sampling period ($< \alpha >$). Under this assumption, the predicted mass changes in low humidity (35 % RH) are proportional to water-free (0 % RH) scatter:

$$\mathrm{PM}_{2.5,\mathrm{dry\text{-}1h}} = < \mathrm{PM}_{2.5,\mathrm{dry}} > \frac{b_{sp,\mathrm{dry\text{-}1h}}}{< b_{sp,\mathrm{dry}} >} \tag{5}$$

where the < > indicates the average $PM_{2.5}$ concentration measured on the PTFE filters over the sampling period, which is typically 9 days. The explicit compensation for aerosol water is then:

$$PM_{2.5,dry-1h} = \frac{< PM_{2.5,dry} >}{< \frac{b_{sp}(RH)}{f_v(RH)} >} \cdot \frac{b_{sp-1h}(RH)}{f_v(\mathrm{RH})} \tag{6}$$

4.0 DATA VALIDATION

- The mass fraction of chemical components can lead to $\kappa_{v,tot}$ values > 0.6. When this occurs, the value is flagged as suspicious and investigated for potential erroneous measurements such as very low $PM_{2.5}$ mass or high value obtained from IC or ICP-MS analysis.
- When the hourly-averaged ambient relative humidity, as recorded by the nephelometer, exceeds 80 % the $PM_{2.5}$ is not estimated as hygroscopic uncertainties increase, and water mass dominates the scatter measurement.
- When a long-term η value is less than 20 µg m^{-3} or exceeds 250 µg m^{-3}, the data is investigated for potential erroneous measurements such as very high scatter, or very low $PM_{2.5}$that could be effecting the average.