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Field Evaluation of the Differential TEOM Monitor for Continuous $PM_{2.5}$ Mass Concentrations

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The performance of a prototype differential TEOM monitor (Rupprecht and Patashnick Co., NY) and its ability to measure the "actual" ambient near-continuous PM-2.5 mass in an area often high in semivolatile particulate matter has been evaluated. Measurements were made within a mobile particle instrumentation trailer (PIU) located in Claremont, CA—a "receptor" site in the Los Angeles Basin. The Differential TEOM monitor has been developed to directly measure ambient PM mass concentrations while accounting for collection artifacts, including loss of semivolatile aerosols and temperature changes. The Differential TEOM monitors used in this study were self-referencing, providing mass concentration measurements at 5 min intervals. To reference the semi-continuous mass measured by the Differential TEOM monitor, its 24 h time-integrated mass concentrations were compared to those determined by collocated filter-based samplers, i.e., MOUDI (Model 110) and Partisol (Model 2025). A HEADS was used to evaluate ammonium nitrate losses from the time-integrated samplers. The results show that PM-2.5 mass measurements using the Differential TEOM monitor are consistent with those of the MOUDI and Partisol, while differences can be generally explained by loss of ammonium nitrate from the reference samplers. The field results also demonstrate the ability of the Differential TEOM monitor to track adsorption and desorption processes from its sample filter. Although adsorption and evaporation can be dynamic processes, and difficult to estimate, the results of this study also suggest that the Differential TEOM monitor provides a very good estimate of the "actual" ambient particulate mass present on a near-continuous basis.

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INTRODUCTION

Ambient particulate matter (PM) is composed of many chemical species of varying vapor pressures. Ammonium nitrate and organic carbon are labile species that are relatively abundant constituents of particles in the Los Angeles Basin (Christoforou et al. 2000). Time-integrated sampling of these semivolatile species often leads to positive or negative artifacts, resulting in an underestimation or overestimation of the particulate mass.

A direct measurement of PM mass on filters is the basis of regulatory PM reference methods. The loss of semivolatile PM mass collected on filters and filter sampling artifacts can produce nonquantifiable biases in reference method measurements depending on the thermodynamic history of the filter; therefore, a reference method cannot be considered a scientific reference standard. The Differential TEOM monitor, described by Patashnick et al. (2000), has been developed to overcome these problems inherent in filter-based reference methods.

Two prototype Differential TEOM monitors have been tested in a major field study sponsored by the US Environmental Protection Agency (EPA). For nearly one year, the Differential TEOM monitors have been collocated with integrated and semi-continuous mass monitors in a mobile particle instrumentation unit (PIU) operated by staff of the Southern California Supersite, a monitoring program sponsored by the US EPA. The sampling location was in Claremont, CA, a downwind receptor site in the Los Angeles Basin, located approximately 45 miles east of downtown Los Angeles. Claremont is a receptor site of the eastern inland valleys of the Los Angeles basin, in which aerosol plume generated by millions of vehicles, mostly west of the site, is advected by the predominant westerly winds after aging for

several hours to a day (Pandis et al. 1992; Kleeman and Cass 1998). A high fraction of PM-2.5 mass in that location consists of labile species such as ammonium nitrate and semivolatile organic compounds (Turpin and Huntzicker 1995). Thus, this location and research facility was well suited for this field evaluation and for testing the ability of the Differential TEOM monitor to perform in a challenging environment. The field evaluation was conducted, as a collaboration between the Southern California Particle Center and Supersite (SCPCS) and the manufacturer, Rupprecht & Patashnick Co., Inc., to support a major emphasis of the Southern California Supersite: to develop and characterize novel state-of-the-art particulate monitors.

TEST EQUIPMENT

Differential TEOM

Theory of Operation. The Differential TEOM monitor concept is based on the direct mass reading and real-time capability of the well-established TEOM mass monitor (Patashnick and Rupprecht 1991). The Differential TEOM monitors used during this study were a variation of the concept described in the original paper (Patashnick et al. 2000). Instead of a matched pair of TEOM sensors, the system used during this study operated as a self-referencing mass monitor, which was proposed as a possible configuration by Patashnick et al. (2000). The system used in this study is depicted in Figure 1 and consists of a size-selective inlet, in this case a PM-10 inlet, followed by a PM-2.5 sharp-cut cyclone and then a Nafion dryer. Downstream from the Nafion dryer and ahead of the TEOM mass sensor is an electrostatic precipitator (ESP). The ESP is alternately switched on and off, in this case for equal time periods, Δt, and removes aerosol from the sample stream during the periods that it is energized. Oscillation frequency data were collected from the TEOM sensors on a continuous basis. As previously described in detail (Patashnick and Rupprecht 1991), the measured frequency can be converted to mass through a simple spring mass approach:

$$\Delta m = K0\left(1/f_1^2 - 1/f_0^2\right), \qquad [1]$$

where Δm is the change in mass with change in frequency, K0 is the calibration constant, f_1 is the second frequency reading, and f_0 is the initial frequency reading.

It is possible to write a somewhat simplified expression for the "effective" amount of mass, M_{eff}, measured by the mass sensor during the two time periods, Δt_n, when the ESP is turned off and alternately when the ESP is energized (Patashnick et al. 2000). The effective mass for each period is the mass that is calculated from the frequency of the TEOM sensor, including all sources that affect the frequency during the given time period. For the periods when the ESP is turned off the subscript A is used, and for the periods when the ESP was energized, the subscript B is used.

In the case for the periods when the ESP was turned off,

$$M_{Aeff} = M_{pnv} + M_{pv} - \alpha M_{pv} \pm M_{filt\,art.} \pm M_{eff\Delta T,etc.}, \qquad [2]$$

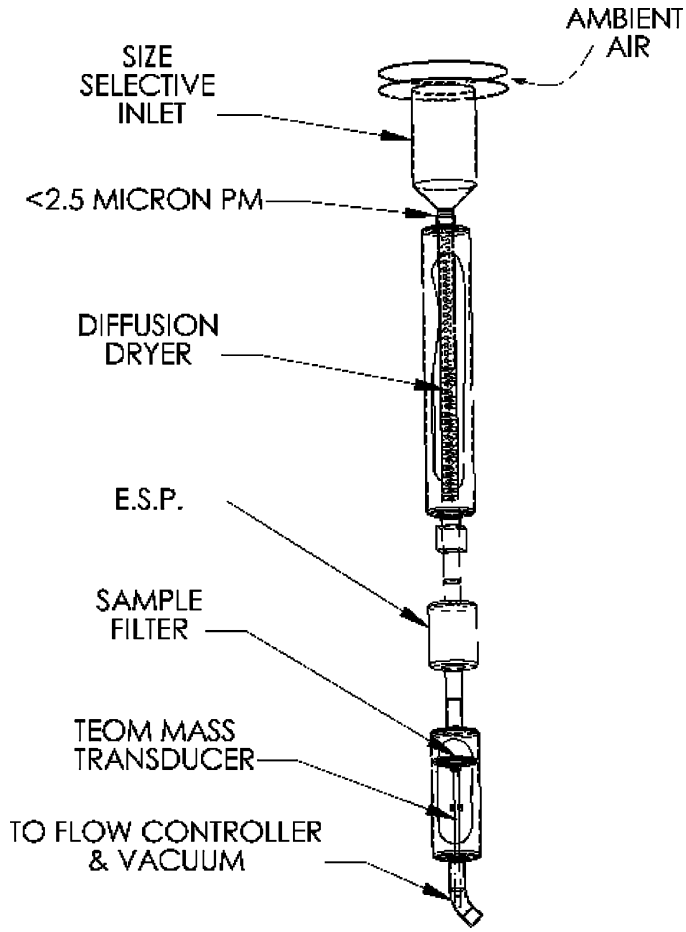

Figure 1. Schematic of the prototype Differential ESP TEOM, noting a linear sample train, modified from the earlier version with parallel ESPs used to minimize large particle losses.

where M_{Aeff} is the Effective mass reported during time Δt_n, M_{pnv} is the nonvolatile component of particle mass collected during Δt_n, M_{pv} is the volatile component of particle mass collected during Δt_n, αM_{pv} is the fraction of volatile mass vaporized during Δt_n, $M_{filt\,art}$ is the mass gain or loss due to filter artifacts during Δt_n, and $M_{eff\Delta T,etc.}$ is the effective mass equivalent of frequency change due to temperature and other sensor sensitivities during Δt_n.

For the periods when the ESP is energized, particles (M_{pnv} and M_{pv}) are not collected on the TEOM sample filter but are removed from the sample stream inside of the ESP. Volatilization of previously collected particles and any adsorption of gaseous species in the sample stream continues:

$$M_{Beff} = -\alpha M_{pv} \pm M_{filt\,art} \pm M_{eff\Delta T,etc.}. \qquad [3]$$

Comparing two adjacent time periods yields the effective mass concentration of the system over two switching periods of

the ESP:

$$M_{eff} = M_{Aeff} - M_{Beff} = M_{pnv} + M_{pv}. \quad [4]$$

The technique works due to the referencing aspect of the TEOM sensors. The switching time of the ESP must be chosen to be less than the time for changes to occur in the ambient particle concentration. In addition, the chosen time interval must be less than the time it takes for a volatile species of interest on the particles to vaporize. Clearly, the system approaches the most accurate representation of particle mass as it exists in its undisturbed state in the atmosphere as Δt approaches zero. There are practical limits to the minimum time for switching the ESP on and off.

It is important to point out that the Differential TEOM system minimizes the problems associated with other particle measurement techniques (including manual filter systems), especially in its handling of volatile material, because of its ability to measure particle mass on a semicontinuous basis.

The mass concentrations during each switch segment are calculated by obtaining the least-squares fit of the frequency data to time elapsed data for each ESP switch interval and converting the computed slope, df/dt, to mass change, dm/dt, through the calibrated TEOM mass sensor. Dividing by the flow rate yields the effective mass concentration for each interval.

Interpretation of Data. Unlike a standard TEOM monitor, which collects samples and reports mass concentration continuously, the differential TEOM monitor only collects mass on the TEOM sample filter during half of the measurement time of the monitor, the period where the ESP is turned off. During the other half of the operation, the ESP is energized and only the affects of the sampled gases and any evaporation of previously collected sample are measured by the TEOM sample filter. As described above in the theory of operation, this allows the system to self-correct and determine the amount of material collected by the monitor at the time of collection. Samples collected using the federal reference method (FRM), on the other hand, are influenced by the sample composition and its interaction with the sampled air stream during the history of the sample and the resulting sampling artifacts. Figure 2 elucidates this critical aspect. There are three lines on the figure—the final reported ambient mass concentration, the mass concentration determined when the ESP was energized, and the mass concentration when the ESP was turned off. Reportable ambient mass concentration is calculated by subtracting the mass concentration during periods when the ESP was energized from the mass concentration when

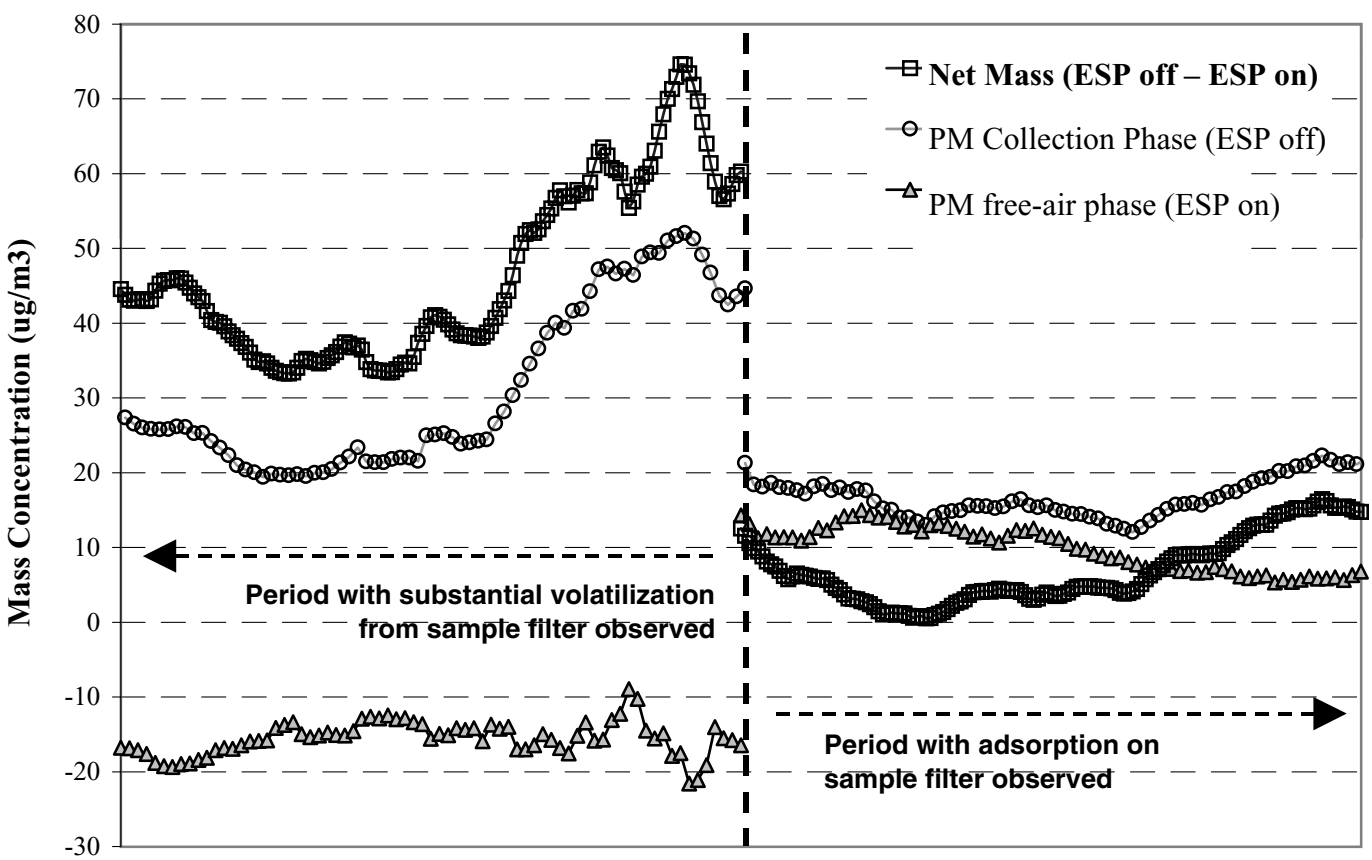

Figure 2. Time series composite of typical hourly data used for the interpretation of gas phase and particle-laden air. Each segment of the figure represents approximately 12 h of data collection.

the ESP was turned off. The figure is also divided into two sections. The left side of the figure depicts a period where there was primarily evaporation of previously collected material from the TEOM sample filter during the periods when the ESP was energized, and the right side of the figure depicts similar data when there was adsorption onto the TEOM sample filter during similar sample periods. The figure represents a composite of data collected at different times and locations, but was joined onto a common graph only to illustrate how the data collected from the Differential TEOM is interpreted for analysis. The graph is not meant to represent any specific event or sample location.

ESP energized sampling periods. During periods when the ESP is energized, no collection of "particles" is occurring. That is, all of the nonvolatile and semivolatile particle matter is being captured in the ESP and does not reach the sample filter. Other factors, such as the evaporation of previously collected material, adsorption of gas phase species onto the collected sample or sample filter, or mass changes caused by chemical reactions on the filter surface, may still occur during the periods when the ESP is energized.

The left side of Figure 2 shows periods of evaporation from previously collected material. The mass concentrations for the sampling segments when the ESP is energized are negative, representing a net loss from the sample filter. There may still be adsorption or other nonparticle increases in the sample mass, but the overall effect of sample and filter artifacts is to create a net negative mass concentration. On the right side of the figure, the reported mass concentration for the ESP energized segments is positive. This generally results from gas adsorption onto the sample filter and previously collected material.

Reported net mass concentrations of zero, when the ESP is energized, do not necessarily imply that there are no volatile components either being evaporated or adsorbed, just that the relative activity of evaporation or adsorption is balanced, resulting in a net change of zero.

ESP De-Energized Sampling Periods. During the periods when the ESP is turned off or de-energized, the differential TEOM samples as a standard TEOM monitor does. During this period, nonvolatile and semivolatile particles are collected on the sample filter, increasing the reported mass on the sample filter.

Simultaneously, sample artifacts measured during periods when the ESP was energized are also occurring. That is, previously collected semivolatile material may evaporate, reducing the mass on the filter, or gas-phase species may adsorb, increasing the mass of the sample on the filter. The mass sensor in the differential TEOM monitor does distinguish between the two operational segments of the monitor but provides a near real-time mass measurement of the material on the sample filter.

Referring back to Figure 2, the PM collection phase represents the periods when the ESP is turned off. On the left side of the figure, even though there was appreciable evaporation of previously collected material, the amount of nonvolatile and semivolatile material collected by the monitor is substantial. During periods where there is adsorption of material onto the sample filter, as illustrated on the right side of the figure, there are periods where the levels of nonvolatile and semivolatile material are similar in magnitude.

Reported Mass Concentrations. The third line presented in Figure 2 is the reported net mass concentration. This is the effective mass concentration measured by the instrument and is the result of subtracting the concentration for the periods when the ESP is energized from when it is turned off. When there is evaporation from the TEOM sample, as illustrated in the left side of the figure, the resultant ambient mass concentration is greater than the concentration obtained during normal sampling (i.e., when the ESP is off). When there is adsorption onto the TEOM sample filter, the resultant mass concentration is lower than the normal sampling concentration. Since the sampling artifacts, for example, evaporation or adsorption, are always occurring, the net result is that the reported mass concentration will never be less than zero. As the artifacts increase and the amount of collected material decreases, the final result may approach zero. This is illustrated in the results presented on the right side of the figure. There is a short segment where the data for the ESP on and off phases is almost identical, indicating that little PM mass was present in the atmosphere at the time the sample was collected.

Installation and Operation. Two prototype differential TEOM monitors were installed in the SCPCS PIU located in Claremont, CA. The two monitors shared a common inlet, consisting of a standard 16.67 lpm PM-10 inlet and a 16.67 lpm PM-2.5 sharp-cut cyclone. This approach was used for one primary reason. If two separate inlets were used, the locations of the inlets would have been less than one meter apart, possibly causing interference of one inlet by the other. By using a single inlet, these potential errors are eliminated from the measurements and any variability in the results would be attributable solely to the variation in the performance of the monitors and not variations in the sampling locations of different inlets. Downstream of the inlet and after the sample entered the trailer, the sample was symmetrically split into two equal flows, with half being directed to each prototype monitor.

The ESP switching rates and ESP current levels were controlled via a PC interface and software developed for this project. The interface and software were also used to collect the data during operation for postprocessing. Because of the uncertainty in some of the development issues early in the program, this approach was used because it allowed the flexibility to modify the algorithms during the evaluation process. In practice, the same data reduction approach was used throughout the test program. For this program, the ESPs were cycled between the energized state and the de-energized state every 5 min. The TEOM monitors were maintained at 30°C.

To determine the mass concentration for each ESP switching segment, the TEOM frequency output was recorded, with a short delay to account for the residence time of the sample gases in the system. Using this frequency, the instantaneous mass was

calculated for each frequency point collected, and the mass collection rate over the entire ESP switching period was determined. Correcting this value by the flow rate through the monitor yields the effective mass concentration for each ESP switch segment of the monitor. To calculate the actual mass concentration, a least-squares approach was used to determine the slope of the dm/dt data determined in a previous calculation step. This yielded one value for the mass concentration for each 5 min ESP switching period.

PIU Integrated and Semicontinuous Monitors for Comparison

To reference the differential TEOM measurements, 24 h time-integrated filter-based PM-2.5 monitors were collocated at the PIU in Claremont: (1) a Micro-orifice uniform deposit impactor (MOUDI; Model 110; MSP Corp., MN, USA), and (2) a dichotomous Partisol (Model 2025; Rupprecht and Patashnick Co., NY, USA). Forty-seven-millimeter Teflon filters (PTFE, Gelman, 2 μm pore, Ann Arbor, MI, USA) were used as MOUDI impaction substrates, whereas particles smaller than 0.1 μm were collected on a 37 mm Teflon afterfilter. Forty-seven-millimeter Teflon filters were also used in the Partisol sampler to collect PM-2.5. The Teflon filters and impaction substrates for the MOUDI and Partisol were pre- and postweighed using a Mettler Microbalance (MTX, Mettler-Toledo, Inc, Hightstown, NJ, USA) after 24 h equilibration under controlled humidity (35–40%) and temperature (22–24°C) conditions to determine particle mass concentrations.

To evaluate semivolatile losses of filter-based ammonium nitrate, a Harvard-EPA annular denuder sampler (HEADS; Koutrakis et al. 1992) was used. The HEADS uses a $NaHCO_3$-coated annular denuder, which efficiently scrubs gas-phase HNO_3 from the sampled aerosol, while a Nylasorb particle collection filter prevents HNO_3 loss from NH_4NO_3 volatilization. Thus, in theory and practice (Fine et al. 2002), the HEADS can be used as a reference sampler for ambient NH_4NO_3. Time-series plots of 24 h integrated measurements and scatter plot regressions are compared with the differential TEOM monitor results. Loss of nitrate by the MOUDI is referenced to HEADS results, while loss of mass from the MOUDI is referenced to the differential TEOM monitor results.

RESULTS AND DISCUSSION

Instrument Precision

In Figure 3, the results from the two differential TEOM monitors are compared using 24 h time-integrated data collected at the Claremont, CA sample location over a seven-month period. Overall, the precision of the two instruments is very good, as indicated by the high correlation ($R^2 = 0.97$). The slope of 0.98 also strongly supports that there is no significant bias between these two instruments ($p < 0.05$) in this application.

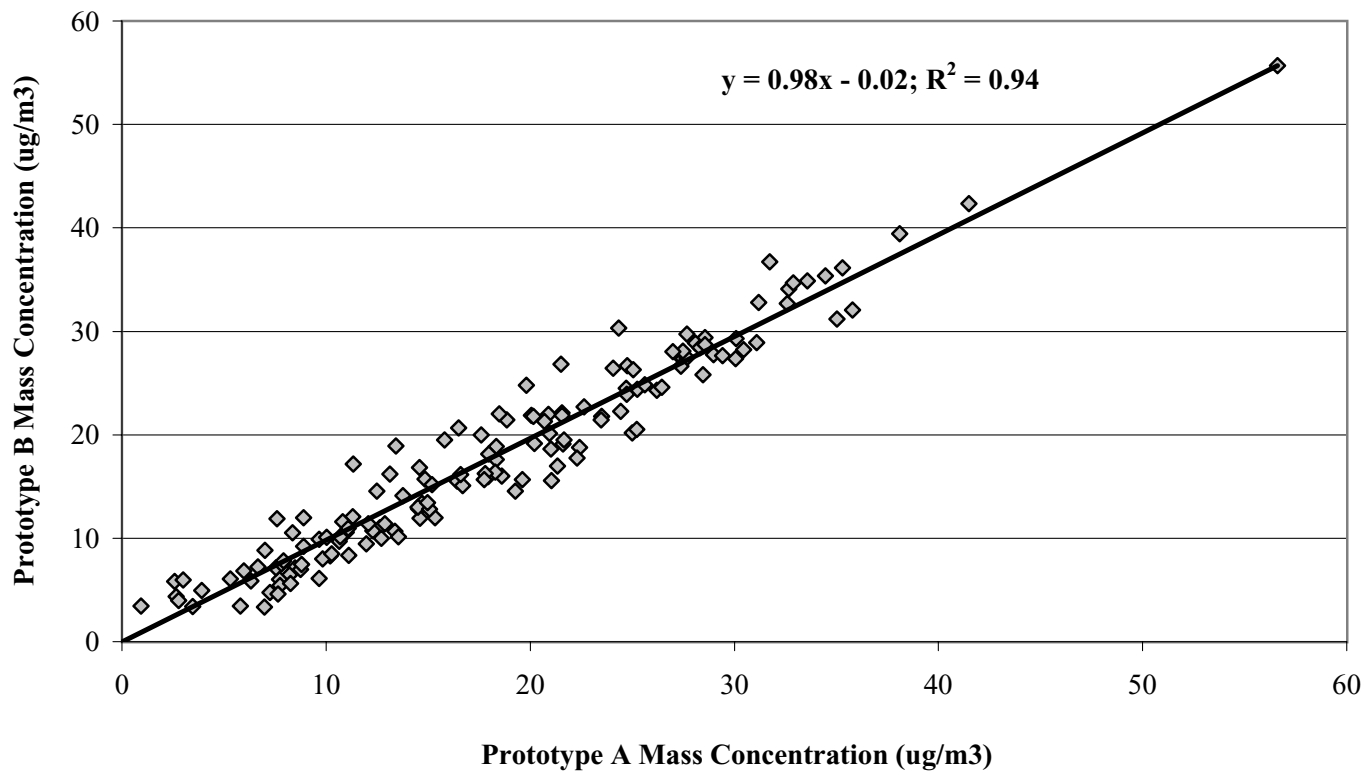

Figure 3. Scatter plot of 2 identical Differential TEOMs, presenting collocated 24 h measurements in PIU at Claremont, CA between February and August 2002.

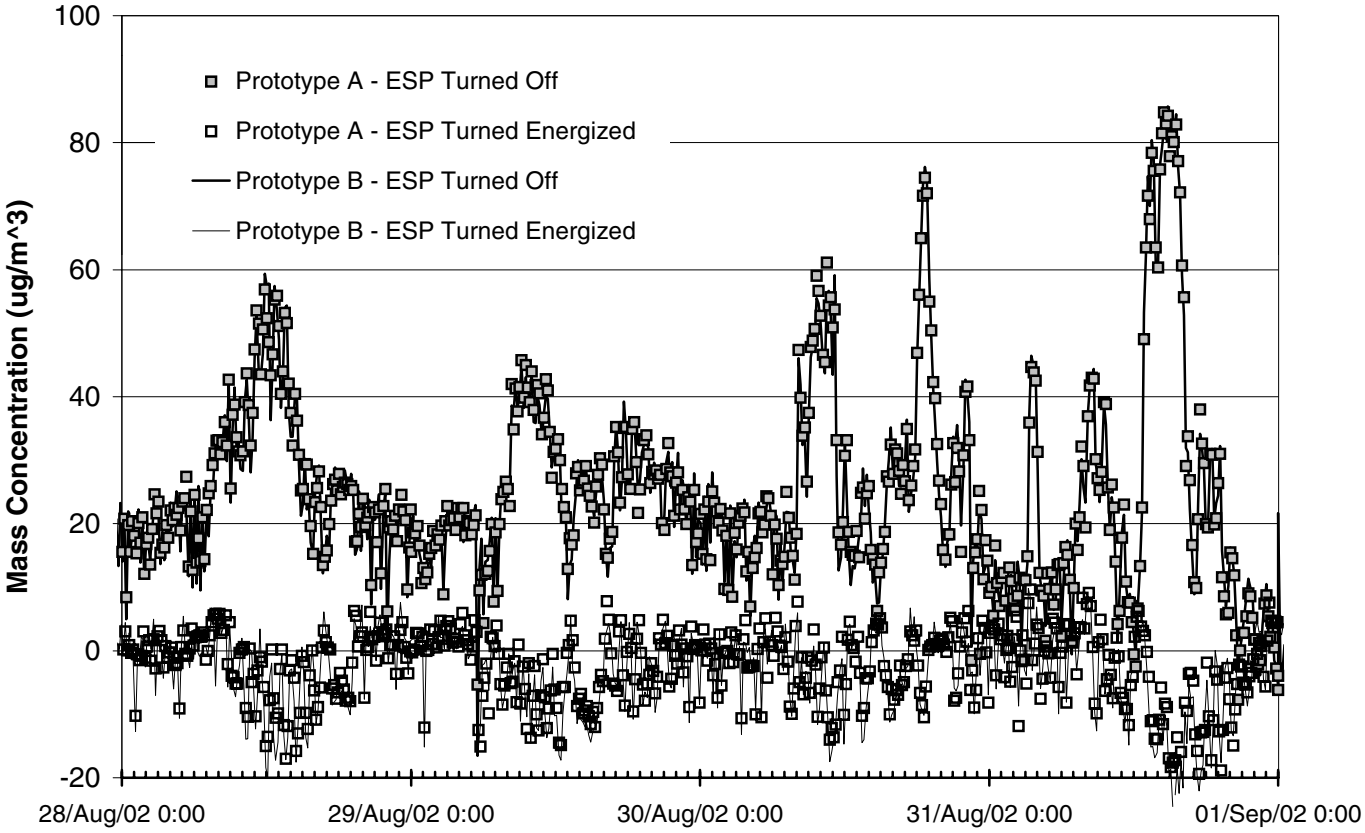

Figure 4. Paired prototype ("A" and "B") Differential TEOM monitor mass measurements for 5 min measurement intervals over four days in August 2002. Presented with raw ESP on and off data.

In addition to the 24 h average comparisons, it is also important that the two instruments compare favorably when examining the short term (i.e., semicontinuous) data. Figure 4 illustrates an intercomparison of raw 5 min data covering 28 August 2002 through 31 August 2002. The data in Figure 4 presents the raw 5 min mass concentrations collected by the two instruments when the ESP was turned off and when the ESP was energized. The data for prototype A is represented by the symbols in the figure, and the data for prototype B is represented by the solid lines. The data for the two instruments when the ESP was turned off is generally the upper data in the figure, and the data for when the ESP was energized is the lower data. It is evident from the results that the two instruments track well over the entire four days presented, but also that the differential TEOM is able to properly detect and interpret very short-term changes in ambient PM levels. It is also clear that significant changes to ambient PM levels occur on a time scale as short as 15 min.

Continuous Hourly Results

As a representation of the results obtained at Claremont, two sets of continuous hourly data are presented. The first set is representative of periods during which desorption of labile species from time-integrated samplers are more pronounced (Figure 5), whereas the second set represents a period of high adsorption of organic vapors onto the sample filters of the differential TEOM monitors (shown in Figure 6).

In the mid-morning of 7 February 2002 (Figure 5a) there was a sharp rise in mass concentration from 20 μg/m^3 to 60–80 μg/m^3. This was likely influenced by a directional wind change that occurred nearly concurrently (see Figure 5b). Thus, these trends may not be associated with local increases in ambient PM levels. To identify the cause of this rise in concentration, additional information is required. By examining the raw mass concentrations obtained during the periods when the ESP was energized and turned off, much of this information is revealed. It is clear from this data that an increase in the levels of semivolatile PM in the atmosphere accompanied the increase in overall mass concentrations. Mass concentrations for periods when the ESP was energized (i.e., where all of PM is removed from the sample by the ESP) show a large negative trend. This negative result represents significant evaporation from the TEOM sample filter, which, based on PM-2.5 chemical composition in Claremont was likely caused by the evaporation of collected ammonium nitrate, as is discussed in more detail below.

Results from this period on 7 February suggest that there were significant levels of ammonium nitrate in the atmosphere beginning mid-morning on that day, as evidenced by the negative mass concentration for the periods when the ESP was energized.

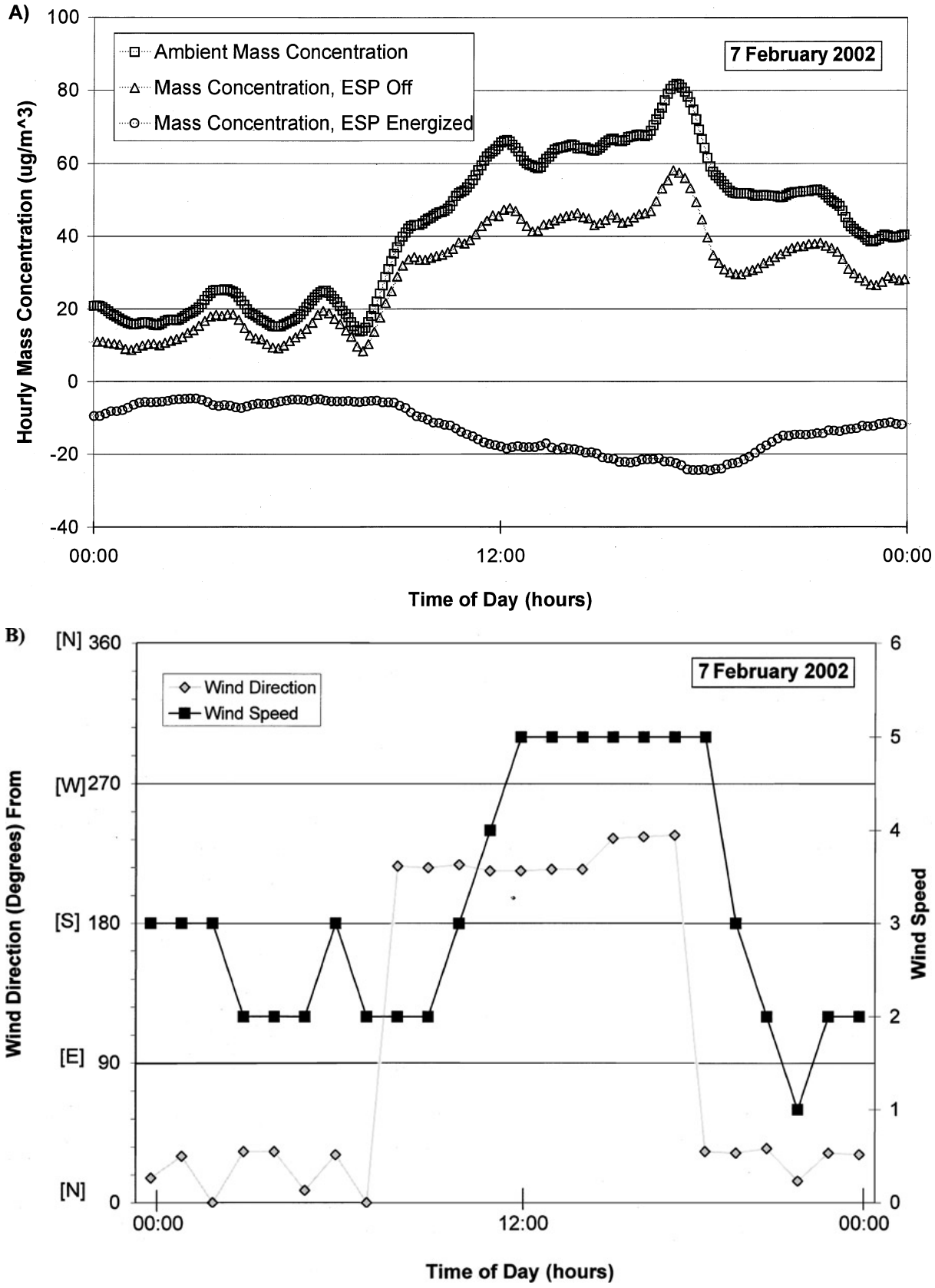

Figure 5. (A) Differential TEOM monitor results with ESP on/off data, and computed difference, computed as moving hourly averages for 7 February 2002 at Claremont, CA. (B) Wind direction and speed for 7 February 2002 at Claremont, CA.

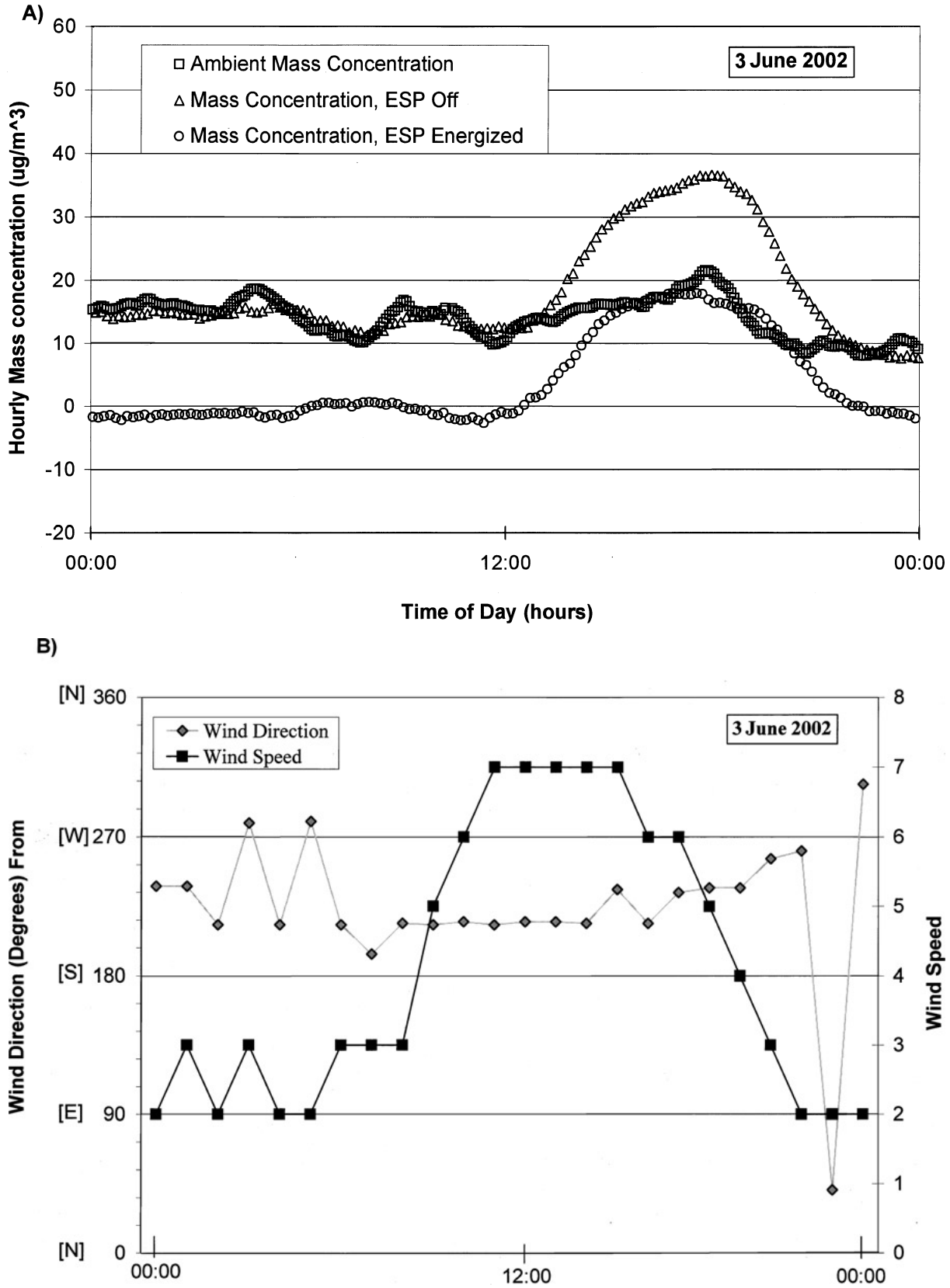

Figure 6. (A) Differential TEOM monitor results with ESP on/off, and computed difference, computed as moving hourly averages for 3 June 2002 at Claremont, CA. (B) Wind direction and speed for 3 June 2002 at Claremont, CA.

Comparing the 24 h average results for this day confirms this hypothesis. The 24 h average mass concentration level measured by the differential TEOM monitor was 41 $\mu g/m^3$, while the nitrate concentration measured by the HEADS was 22 $\mu g/m^3$.

The second set of data, collected in early June 2002, is a marked contrast to the sample collected in February (see Figure 6A). For the entire morning of 3 June 2002, there is little evaporation or adsorption on the TEOM sample filter, and the reported mass concentration from the instrument averages around 15 $\mu g/m^3$. At about noon on, there is a sharp rise in the amount of material adsorbing onto the TEOM sample filter as shown in the data collected when the ESP was energized. It is also clear that this same behavior occurs during the normal sample collection, as evidenced by the similar rise in mass concentration during the same sample period when the ESP was turned off. Since this adsorption onto the TEOM sample filter occurs during both sample phases of the system, this is not ambient PM and is not reported as such by the instrument. Incidentally, the amount of adsorbed material is approximately equal to the level of ambient PM collected. A similar event occurs in the early morning of the following day, but unfortunately data was only available until noon as the system was shut down for prescheduled maintenance. As during the February "ammonium nitrate" event, the episode of likely gas-phase organic carbon is concurrent with a shift in wind (see Figure 6B). An increase in the mid-morning wind speed on 3 June, without a major change in direction, suggests enhanced transport of regional carbon emissions from upwind freeway sources located to the southwest of the sampling site. 24 h filter mass and chemical speciation data were collected for 4 June, but because of the maintenance on the differential TEOM monitors a direct comparison of the 24 h data between the different measurements is not possible for that day.

Instrument Intercomparisons

Differential TEOM Comparisons with FRM and MOUDI. Figure 7 presents a pair of scatter plots referencing the differential TEOM monitor and Partisol to 24 h integrated measurements by the MOUDI for PM-2.5. For discussion and comparison purposes, the MOUDI is used as the reference herein, as it has been found to be more comparable to a continuous monitor that measures the volatile component of nitrate predominantly found in this region of Los Angeles (Fine et al. 2002). These collocated results are highly correlated (R^2 = 0.86 and 0.83, respectively). However, the Partisol underestimates the MOUDI measured mass by about 17%, while the differential TEOM is higher than the MOUDI by about 18%, as indicated by the regression slopes. The differences between the differential TEOM monitor results and the MOUDI-Partisol samplers can be attributed

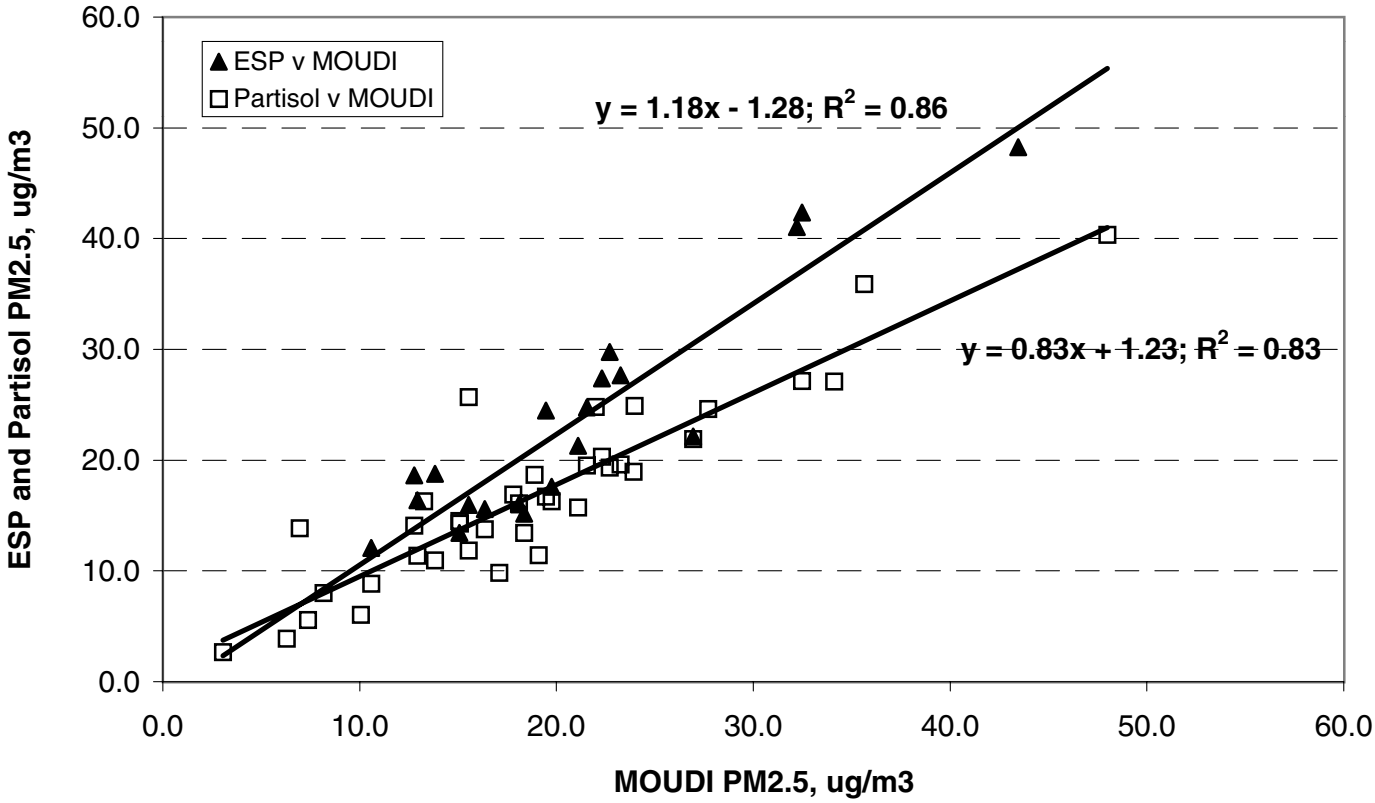

Figure 7. Scatter plot of Differential TEOM (ESP) and Partisol versus MOUDI for full period at Claremont (September 2001 to August 2002).

to losses of evaporative species from the collected PM in the integrated samplers. The higher MOUDI than Partisol concentrations indicate that these losses are probably smaller in the MOUDI. Nitrate losses have also been shown to depend on the type of samplers used for particle collection. Both theoretical (Zhang and McMurry 1987) and experimental (Wang and John 1988; Zhang and McMurry 1992; Sioutas et al. 1997; and Cheng and Tsai 1988) studies have demonstrated that nitrate losses in impactors are generally lower than those in filter samplers. Wang and John (1988) found ammonium nitrate evaporative loss is as high as 85–95% at low mass loading (93–208 μg) and is less than 10% when the loaded mass is heavy (more than 2500 μg) in Teflon filters (2 μm pore, Zefluor). Also, evaporation losses from filters are more serious than those from impactor samplers, primarily due to higher deposited particle surface area per mass exposed to airflow in filter samplers than in impactors. Our field data seem to corroborate these previous findings.

Differential TEOM Monitor Mass Comparisons with Nitrate by the HEADS. Twenty-four-hour time-integrated PM-2.5 mass using the differential TEOM monitor and the MOUDI are paired with HEADS and MOUDI NH_4NO_3 for this one-year study. The differential TEOM monitor closely tracks the MOUDI and on 14 of 20 occasions is generally greater than the MOUDI by as much as 10 $\mu g/m^3$ (15 August 2002), a result that further supports the argument that losses from the MOUDI and impactors occur, in general, although lower than those from filter samplers. Additionally, NH_4NO_3 measurements by the HEADS and MOUDI typically both track the differential TEOM monitor, as does mass measured by the MOUDI. As expected, the HEADS is always greater than the MOUDI for NH_4NO_3. Also, for high PM-2.5 mass concentration days, NH_4NO_3 tends to be the dominant compound, contributing to the overall particle mass.

The mass differences between the paired differential TEOM monitor and MOUDI are regressed against the paired ammonium nitrate differences between the HEADS and MOUDI (see Figure 8). Here we assume that all nitrate measured by MOUDI and HEADS is associated with ammonium nitrate, hence the nitrate concentrations measured by both samplers were multiplied by 1.29 (i.e., the ratio of the molecular weights of ammonium nitrate and nitrate, respectively). For the 14 paired differences, the "mass loss" has a relatively high correlation with that of

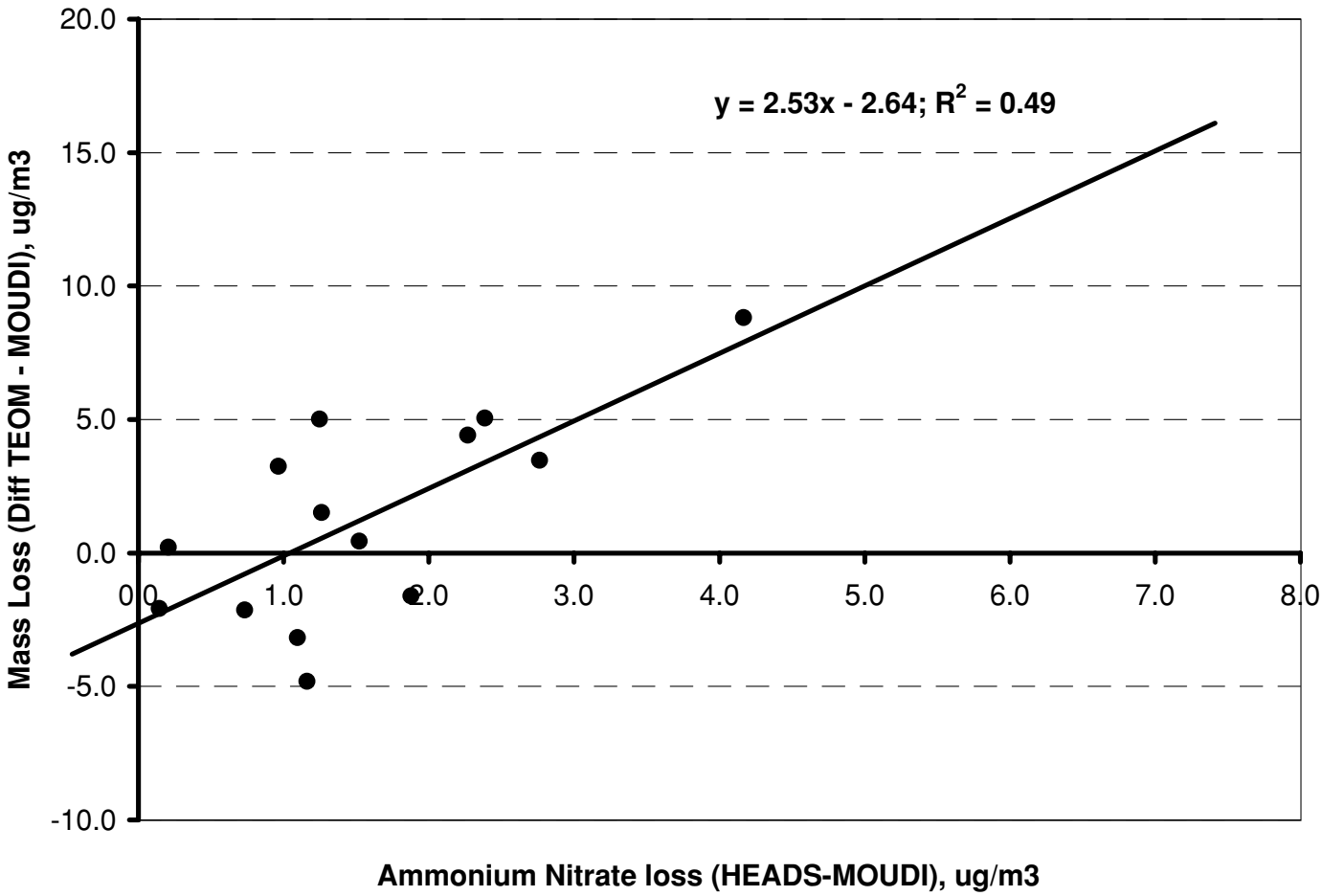

Figure 8. Scatter plot presenting the relationship of mass and Nitrate loses by MOUDI with ESP and HEADS as reference.

"nitrate loss" ($R^2 = 0.51$). Also, 9 of the 14 pairs are greater in "mass loss" (between 0.2 and 8.8 $\mu g/m^3$), than for "nitrate loss" (between 0.1 and 4.2 $\mu g/m^3$). The relatively high degree of correlation between the TEOM–MOUDI mass differences and HEADS–MOUDI ammonium nitrate differences suggests that there may be a relationship between the mass loss and nitrate loss from the MOUDI substrate. Also, the slope of 2.53 suggests that a substantial portion of mass loss (about 40% on the average) may be from the volatilization of other compounds, such as semivolatile organics, which are also abundant in the Los Angeles Basin (Pandis et al. 1992).

It should be noted that these paired measurements cannot quantitatively determine the amount of evaporation or adsorption, in part because of the dynamics between these coexisting processes, especially when integrated over 24 h. The relative amount of adsorption and evaporation may be approximated by observing differences between the on and off periods of the ESP operation on the Differential TEOM monitor (see Figure 2, and the "Results and Discussion" section). Although these relative processes may not be quantified, the results herein suggest that the net differences measured by the Differential TEOM monitor generate a reasonable estimate of the "true" mass of ambient PM.

SUMMARY AND CONCLUSIONS

Two PM-2.5 differential TEOM monitors were field tested and characterized at the Claremont Los Angeles Supersite location for nearly one year. Twenty-four-hour integrated mass measurements of these semicontinuous monitors have been compared to the PM mass and nitrate mass of other filter-based systems that ran concurrently. Although there is no true reference for particulate mass, in general the differential TEOM monitor compares well with these other methods. Comparisons of two collocated differential TEOM monitors demonstrate high precision, suggesting a reliable method. Future comparisons with other semicontinuous mass, nitrate, and organic carbon measurements can be conducted to more closely evaluate the dynamic chemical processes that occur on the sample filters over time. It is also important to note that the differential TEOM not only compares well with itself and other integrated mass measurements, but it is a useful tool to identify and evaluate dynamic gas and particle phase interactions that are associated with atmospheric conditions and trends.

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