Performance evaluation of real-time DustTrak monitors for outdoor particulate mass measurements in a desert environment

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Abstract

This study aimed to evaluate the performance of the TSI DustTrak DRX® aerosol monitor against the filter-based gravimetric method and establish suitable correction factors in the real-world operating conditions for bias correction of this real-time monitor. Overall, the DustTrak DRX monitor demonstrated high precision but significant deviation from the reference method in measuring $PM_{2.5}$ and PM_{10} concentrations. DustTrak DRX overestimated $PM_{2.5}$ mass concentration by a factor of 2 and underestimated PM_{10} concentrations by about 20% compared to the gravimetric method. The acceptable correction accuracy of DustTrak measurements was obtained by a constant-proportion correction; however, the humidity-adjusted correction resulted in better measurement correction. The identified correction factors can be used for bias correction of the DustTrak monitors in a similar environment with similar aerosol properties to obtain more accurate aerosol measurements. The proposed correction models in this study could also guide other studies using various types of real-time optical monitors for their accurate field calibration and measurement data correction.

Keywords: Correction factor; Accuracy; Precision; Relative humidity; Particle composition

INTRODUCTION

Airborne particulate matter (PM), as a major air pollutant, has well-reported adverse health effects, including respiratory, cardiovascular, and neurological problems and premature mortality

(Anderson *et al.*, 2012). Therefore the PM mass concentrations, particularly $PM_{2.5}$ and PM_{10} particles (aerodynamic diameter ≤2.5 and ≤10 μm, respectively), are routinely monitored and regulated by establishing air quality monitoring networks to enforce PM concentration standards by governments and regulatory agencies. Over the past two decades, portable real-time optical aerosol monitors and sensors have found increasing use in air quality monitoring (Liu *et al.*, 2017; Zhang *et al.*, 2018). These monitors offer numerous advantages over the reference filter-based samplers. Traditional gravimetric samplers are accurate, reliable, and robust devices for determining the PM mass concentration and its detailed characteristics. However, this reference sampling technique is expensive, labor-intensive, and time-consuming. It requires long sampling and analysis time and hence does not provide real-time information (Chung *et al.*, 2001).

The optical aerosol monitors for measuring airborne PM concentrations (e.g., the TSI DustTrak® aerosol monitor) are based on light scattering to detect light scattered by particles onto a photodetector (Wang *et al.*, 2009; Wang *et al.*, 2016; TSI, 2019). These light-scattering aerosol monitors can provide high spatiotemporal resolution as they are very portable and capable of reporting PM concentration near real-time. These direct-reading monitors can report high PM concentration spikes and short-term peak events, which could be essential for emergency responses, public health advisories, and regulatory purposes. Due to the high portability, these real-time monitors can be used to locate pollution hotspots and generate three-dimensional (horizontal and vertical) aerosol profiles, and also to measure aerosol PM exposure characteristics in different indoor micro-environments where people spend most of their time, such as in buildings and transit (McNamara *et al.*, 2011; Wheeler *et al.*, 2014; Wang *et al.*, 2016; Li *et al.*, 2017). However, before using these aerosol monitors in routine monitoring networks, it is crucial to develop confidence that these instruments are capable of accurately measuring PM concentrations under the prevailing ambient conditions both indoors and outdoors.

Compared to the gravimetric techniques, the performances of light-scattering aerosol monitors, including the DustTrak monitors, are strongly affected by the weather conditions and properties of particles used for calibration and in the ambient environment (Wang *et al.*, 2016; Liu *et al.*, 2017; Li *et al.*, 2019). For example, ambient relative humidity (RH) has been recognized as a key meteorological factor affecting the performance of the DustTrak aerosol monitor (Jayaratne *et al.*, 2018; Li *et al.*, 2019). Moreover, properties of particles (e.g., density, refractive index, size, shape, and chemical composition) also affect the performance of the light-scattering aerosol monitors (Wang *et al.*, 2016; Liu *et al.*, 2017; Zhang *et al.*, 2018). The optical response of the light-scattering instruments for various aerosol components (e.g., sulfate, organic, and elemental carbon) is related to their refractive index, and particles with a larger refractive index result in a higher optical measurement (Zhang *et al.*, 2018). The light-scattering monitors are typically calibrated with particular test dusts by the manufacturer, which may or may not represent real-world operating conditions and aerosol characteristics at a given location. The calibration of these aerosol monitors by considering aerosol composition and size is essential to get true measures of airborne PM for a specific application.

Previous studies have provided examples of the measurement correction of light-scattering DustTrak aerosol monitors. Most of these studies employed the correction method with laboratory-generated particles of different sizes and compositions (Liu *et al.*, 2017; Zhang *et al.*, 2018). The results of laboratory studies may not be representative of the performance of aerosol monitors in real-world conditions. A few other studies have reported the performance of DustTrak monitors (model 8533 and earlier) as compared to reference methods in the indoor environments (Kam *et al.*, 2011; McNamara *et al.*, 2011; Wang *et al.*, 2016) as well as in outdoor field measurements (Apte *et al.*, 2011; Both *et al.*, 2013; Zhang *et al.*, 2018; Li *et al.*, 2019). It has been consistently reported that the DustTrak monitors overestimate $PM_{2.5}$ compared to the reference method (McNamara *et al.*, 2011; Wallace *et al.*, 2011; Both *et al.*, 2013; Wang *et al.*, 2016; Zhang *et al.*, 2018; Li *et al.*, 2019), but the correction factors vary widely in these studies. As the correction factor is dependent on local aerosol properties and meteorological conditions, it is important to determine it in the region where the instrument is used. Until now, there have been no reports on the correction factor for the DustTrak DRX in ambient conditions in the Middle East.

This study aimed to evaluate the performance of the TSI DustTrak DRX aerosol monitor in terms of accuracy and precision against a filter-based gravimetric method and establish suitable correction factors for the DustTrak DRX monitor in this arid desert environment. The effect of key meteorological factors, in particular RH and particle composition, were evaluated in real-world operating conditions.

METHODOLOGY

In this study, side-by-side ambient PM monitoring and filter sampling were carried out from 18 May to 14 December 2015 at the Outdoor Test Facility (25°19'32" N and 51°25'59" E), a research field station located at the Qatar Foundation's Education City premises in Doha, Qatar. The details of the sampling area and site can be found in our previous study (Javed and Guo, 2020). A broad range of meteorological conditions and PM concentrations were recorded during the study period (as shown in Fig. S1), allowing the evaluation of DustTrak performance under a wide range of atmospheric conditions. The ambient temperature, RH, and wind speed varied from 15-40°C, 18-70%, and 0.64-5.15 m s^{-1}, respectively. The prevailing wind direction was from the northwest (38%).

Gravimetric measurements

The gravimetric mass measurement of filter samples is used as a reference method for PM mass concentrations. Three types of 24-h $PM_{2.5}$ and PM_{10} (particles less than 2.5 and 10 μm in diameter, respectively) filter samples were collected simultaneously on every second day (9 am to 9 am local time) during the study period (n=93). Samples were weighed and chemically analyzed for PM mass concentrations, OC/EC contents, and water-soluble anions. The weighing was carried out after the filter equilibration (24-h for pre-sampling and 48-h for post-sampling weighing), kept at 18-24 °C temperature and 40 ±5% RH conditions in the weighing room. The detailed sampling protocol, quality control/assurance, and sample analysis procedures are reported in our recent study (Javed and Guo, 2020).

$PM_{2.5}$ and PM_{10} samples were collected by using low-volume Harvard Impactor samplers equipped with polyurethane foam (PUF) impaction substrates to remove particles bigger than the specified cut-off diameter. The $PM_{2.5}$ sampler, run at a flow rate of 16.7 L min^{-1}, uses two identical impactor stages in series with PUF impaction substrates, and the PM_{10} sampler (run at 10 L min^{-1} flow rate) has only one impactor stage with PUF substrate. PM_{10} and $PM_{2.5}$ samples were collected on Teflon, quartz, and nylon filters for PM gravimetric mass, EC/OC, and nitrate/sulfate anions analysis, respectively. Six sets of filter and field-blank samples and 12 duplicate PM samples (6 for $PM_{2.5}$ and 6 for PM_{10}) for each PM mass, EC/OC, and anions analysis were collected using the pairs of collocated samplers. The reported concentration values of each species are also field- and filter-blank corrected.

DustTrak measurements and corrections

The real-time concentrations of both size PM fractions were also measured simultaneously with a co-located DustTrak DRX® aerosol monitor (model 8533EP, TSI, Inc., Shoreview, MN). The DustTrak DRX monitor is a combined photometer and optical counter instrument that uses a 90° light-scattering technique. It measures real-time PM mass concentrations corresponding to PM_1, $PM_{2.5}$, PM_4, and PM_{10} size fractions having a detection range from 0.001 to 150 mg m^{-3} with a mass resolution of ±0.1% of reading or 0.001 mg m^{-3} (TSI, 2019). The instrument manual does not provide any detail on the accuracy and precision of this direct-reading monitor.

The monitor was deployed next to the filter sampling station at the same height of about 2 m to ensure that both instruments sampled the same air masses. DustTrak measurements were logged at 2 min intervals and averaged for 24h from 9 am - 9 am to match data from the gravimetric method. The factory set flow rate of 3.0 L min^{-1} was used. The monitor was set to auto-zero calibration at 15 min intervals by using an Auto Zero module (TSI, P/N 801690). The default calibration factor "Factory Cal" of 1.00 was used. As per the manufacturer, the DustTrak monitors are calibrated to Arizona Road Dust/ISO 12103-1, A1 test dust, which has a particle density of 2.65 g cm^{-3}, a refractive index of 1.54, and particle size distribution between 0.1 to 10 μm (TSI, 2013). This calibration factor can be changed, or instead, a correction can be made to the raw data based upon comparison with the reference method.

In this study for model calibration and validation, the whole dataset (n=93) was split into two halves by putting the consecutive samples into each half (i.e., one data point into the first half and the next one into the second half, and so forth). The one-half dataset (n=47) was used to develop the correction model, and the second-half to validate the model. Herein, two approaches were applied to correct DustTrak PM measurements to match the gravimetric measurements. The first approach involves a constant correction factor:

$$PM_{LR\_corrected} = a_1\, PM_{DT}\ ,\ a_1 = \frac{PM_{grav}}{PM_{DT}} \tag{1}$$

where PM_{DT} and PM_{grav} are PM measurement from DustTrak and gravimetric method, respectively; a_1 is the correction factor (i.e., the slope of regression) that was determined through the least-square regression method comparing PM_{grav} against PM_{DT} measurements. In the second approach, the correction factor (a_1) is a function of ambient RH:

$$PM_{RH\_corrected} = (a_2 + b\, RH)\, PM_{DT} \tag{2}$$

where a_2 and b are the intercept and slope parameters (as shown in Fig. S3) that were determined through least-squares regression using the correction factor (a_1) values against the measured RH (expressed as a fraction of 100%, e.g., RH 50% = 0.5). The regression parameters a_1, a_2 and b were determined using XLSTAT™ add-in for Microsoft Excel (Addinsoft Inc., NY, USA) with the DustTrak, gravimetric PM data, and the RH data. The accuracy (A) and precision of the measured and corrected DustTrak measurements were evaluated against the reference measurements (Li *et al.*, 2019):

$$A = \frac{1}{n}\sum_{i=1}^{n}\frac{PM_{DT,i} - PM_{grav,i}}{PM_{grav,i}} \tag{3}$$

where *n* is the number of data pairs, PM_i is the measured or corrected DustTrak measurement for the *i*th day and $PM_{grav,i}$ is the gravimetric measurement for the *i*th day. The precision was assessed in terms of coefficients of determination (R^2) and root means squares error (RMSE) of the linear regression between readings of two measurement methods.

RESULTS AND DISCUSSION

The TSI DustTrak DRX aerosol monitor measured $PM_{2.5}$ and PM_{10} concentrations (24-h average ±SD) of 81.2 ±48.5 and 121.7 ±75.5 μg m^{-3}, respectively, having a significant variability during the study period (as shown in Fig. S1). In contrast, the filter-based gravimetric method reported $PM_{2.5}$ and PM_{10} concentrations of 40.2 ±15.0 and 145.7 ±64.0 μg m^{-3}, respectively. The raw DustTrak $PM_{2.5}$ measurements had an accuracy value of 105% and an R^2 value of 0.90 (Fig. 1) compared to the gravimetric method. The intercept of the regression line was not significantly different from zero (α = -0.95, p =0.96), but the slope was significantly higher than 1 (β = 2.02, $p < 0.001$), suggesting significant and consistent proportional bias between these two methods. This is is in line with previous studies that reported DustTrak $PM_{2.5}$ concentrations 2 to 4 times higher than the readings of reference methods (Wang *et al.*, 2009; McNamara *et al.*, 2011; Both *et al.*, 2013; Wang *et al.*, 2016; Zhang *et al.*, 2018; Li *et al.*, 2019). The high precision suggests that the DustTrak monitor can be reliably used for characterizing $PM_{2.5}$ mass concentrations when an appropriate correction factor is applied.

On the other hand, DustTrak underestimated PM_{10} mass concentrations (24-h average) by about 20% comparing to the reference gravimetric method (Fig. 1). DustTrak PM_{10} measurements have relatively better accuracy (19.83%) but lower precision (R^2 value of 0.73) than $PM_{2.5}$ measurements. Particularly, the precision of DustTrak PM_{10} readings is relatively low at higher PM_{10} levels (>200 μg m^{-3}) as measured by the gravimetric method; those were mostly under dust storm conditions in this desert environment (as shown in Fig. S1). The deviation of the highest PM_{10} concentrations from the regression line may be partially due to the coincidence error of single-particle sizing and counting by the DustTrak for larger particles (Wang *et al.*, 2020). Airborne coarser particles ($PM_{2.5-10}$) can have significantly different compositions than fine particles (Javed and Guo, 2020). This discrepancy in measuring large-sized particles might also be related to the sampling efficiency and the lower mass scattering efficiency or specific photometric responses to coarser particles by the light-scattering DustTrak monitor (Wang *et al.*, 2009; Liu *et al.*, 2017). These are apparently the reasons that DustTrak compared differently to the gravimetric method in terms of $PM_{2.5}$ and PM_{10}.

The DustTrak PM_{10} measurements may have been affected by particle size, shape, and number concentration in this desert environment (Wang *et al.*, 2016). It has also been reported that light-scattering-based monitors tend to measure slightly lower concentrations of large-sized particles than $PM_{2.5}$ particles (Wang *et al.*, 2009; Wang *et al.*, 2016; Liu *et al.*, 2017). Also, Zhang *et al.* (2018) reported that the relationship between PM mass concentration and light scattering is strongly dependent on particle size and, to a lesser extent, on PM composition. The measurement results reveal that the response of the DustTrak DRX monitor decreases as the particle size of the measuring aerosols increases and vice versa, so the correction of $PM_{2.5}$ and PM_{10} measurements can be done by applying the appropriate correction factor separately for each size fraction. The correction parameters obtained in this study through a regression on the half model dataset (see Fig. 2) and the full dataset (see Figs. S2 and S3) are given in Table 1.

The coefficient of 0.48 for the constant-proportion approach (for $PM_{2.5}$) is in general agreement with previous studies (Wang *et al.*, 2016; Zhang *et al.*, 2018; Li *et al.*, 2019), but higher than the manufacturer recommended photometric correction factor of 0.38 for ambient $PM_{2.5}$ aerosol (Wallace *et al.*, 2011; TSI, 2013). If this recommended correction factor was applied, the DustTrak $PM_{2.5}$ concentrations were 23% lower than the gravimetric method. By following the TSI recommended advanced calibration method (TSI, 2012), the size calibration factor (SCF) of 1.375 is calculated using both $PM_{2.5}$ and PM_{10} Dusttrak and gravimetric measurements. This custom SCF can be programmed in the DustTrak™ DRX monitors by replacing the factory default value (1) of SCF in the user calibration settings for accurately measuring size segregated mass concentrations of various size fractions. With the constant-proportion correction, the DustTrak $PM_{2.5}$ reached an accuracy of 11% with RMSE of less than 5 μg m^{-3} (see Fig 2(a)); with the RH-adjusted correction, DustTrak $PM_{2.5}$ reached better accuracy with greater R^2 (0.94) and lower RMSE (Fig. 2(b)). Similarly, with the constant-proportion correction, DustTrak PM_{10} also had improved the accuracy (Fig. 2(c)), but the RH-adjusted correction had no statistically significant further improvement, as shown in Fig. (d). The relatively less effect of RH-adjusted correction on the accuracy of PM_{10} measurement might be related to the low influence of RH on coarse particles due to the variation of particle composition and size (Zhang *et al.*, 2018).

A few previous studies reported correction factors for the DustTrak DRX in ambient conditions. For example, Wang *et al.* (2016) found a correction factor of 0.42 for DustTrak DRX $PM_{2.5}$ measurements in an indoor environment with RH conditions in the range of 13% - 68% and observed a relatively low (~5%) impact of RH variation on DustTrak readings. Zhang *et al.* (2018) reported a correction factor of 0.51 for DustTrak DRX 1-h ambient $PM_{2.5}$ under RH <40% by using a dryer. On the other hand, Li *et al.* (2019) reported correction factors (0.31-0.43) for DustTrak 30-min $PM_{2.5}$ at higher RH conditions (50%-90%) and higher values of the correction factor (0.44-0.50) at RH <60%. Consistent with this range of correction factors and RH conditions of the above studies, we have found the correction factor for the DustTrak $PM_{2.5}$ measurements lying towards the upper end of this range under the prevailing dry to moderate RH (18%-70%) conditions.

This study found that the DustTrak readings were significantly affected by the ambient RH, and therefore, RH-adjustment was considered for correcting the DustTrak measurements. The relationships between the correction factors of DustTrak 24-h $PM_{2.5}$ and PM_{10} measurements and the ambient RH are shown in Fig. S3, and the obtained regression coefficients for RH-adjustment are given in Table 1. Previous studies have also reported that PM mass concentrations measured by light-scattering instruments such as DustTrak increase with increasing RH due to the condensational growth of the hygroscopic particles (Liu *et al.*, 2017; Jayaratne *et al.*, 2018; Li *et al.*, 2019).

It can also be seen in Fig. 3 that more significant concentration differences of $PM_{2.5}$ mass measured by the DustTrak and gravimetric method are typically associated with the high RH levels as well as higher particulate contents, which are hygroscopic constituents of fine particles and subject to the condensational growth at high RH (Wang *et al.*, 2016; Liu *et al.*, 2017; Zhang *et al.*, 2018; Li *et al.*, 2019). A significant positive correlation was found between the $PM_{2.5}$ measurement difference and the ambient RH as well as $PM_{2.5}$ constituents, including SO_4^{2-}, NO_3^-, OC, and EC (see Table S1). Since the DustTrak monitor is factory calibrated using an Arizona test dust that is mostly composed of mineral dust particles, it is not surprising that the DustTrak over-estimation is correlated with particulate hygroscopic constituents. These aerosol components varying in refractive indices can affect the light-scattering response of the optical instruments. For example, Zhang *et al.* (2018) have found a higher response of DustTrak DRX monitor for sulfate and organic particles with a higher refractive index for the optical measurements.

These results suggest that both correction approaches are capable of achieving accurate measurement corrections of DustTrak monitors deployed in dry environments. The constant-proportion approach for DustTrak bias correction can be used in places where RH variation is relatively low, as reported in most previous studies (Chung *et al.*, 2001; Kingham *et al.*, 2006; Both *et al.*, 2013; Wang *et al.*, 2016). However, in areas where humidity varies greatly throughout the day, the DustTrak measurements without RH adjustment may lead to significant errors in reporting the actual concentration of atmospheric PM. It would be a feasible practice to record RH values along with the DustTrak measurements and then take RH into account to correct the measurement data, as proposed in this study. However, using a daily average RH correction against 24-h gravimetric measurements might not accurately represent the RH effect as the ambient RH has a diurnal cycle and water uptake/evaporation by particles are different during the process of drying or humidifying. Therefore, a better correction could be achieved in further studies using RH and reference PM data with higher time resolution. Furthermore, for reducing the RH effect, another way is to control ambient RH at monitors' sampling inlets to below a certain threshold using a dryer or heater such as used in BAM, TEOM instruments, and other photometers. For field calibration of aerosol monitors, it is essential to consider RH and aerosol properties for deriving the site-specific correction models for the DustTrak and other light-scattering monitors to reliably use these in air quality monitoring and regulatory applications.

CONCLUSIONS

This study evaluated the performance of the DustTrak aerosol monitor against the reference gravimetric method and proposed suitable correction factors for DustTrak bias correction in real-world operating conditions. In general, the DustTrak DRX monitor demonstrated high precision but low accuracy against the reference method in measuring $PM_{2.5}$ and PM_{10} concentrations. DustTrak overestimated $PM_{2.5}$ mass concentration by approximately a factor of 2, in general agreement with previously published work. At the same time, it underestimated PM_{10} concentrations by about 20% compared to the gravimetric method.

The results suggest that the DustTrak's measurement accuracy compared to the reference method can be improved by applying an appropriate correction factor for each size fraction. An acceptable correction accuracy of DustTrak measurements was obtained by a constant-proportion method; however, the RH-adjusted correction approach led to better measurement correction. The proposed correction factors could be used for bias correction of the DustTrak monitors in a similar environment with similar aerosol properties to obtain more accurate aerosol pollution measurements. However, RH conditions and aerosol properties may change from location to location, so it is recommended to conduct calibration experiments at other locations to develop site-specific correction factors for each real-time optical monitor under a combination of the influencing factors.

DustTrak monitors are relatively low cost, highly portable, and real-time instruments associated with low operating cost. However, for accurate PM mass measurements, these monitors must be calibrated for a particular location and application. The general high precision of DustTrak against the reference methods, in combination with accurate correction factors for each aerosol type, may allow the DustTrak monitor to be used reliably in cost-effective and low-maintenance aerosols monitoring networks.

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Table 1. Correction parameters obtained through regression.

Correction Approach	Dataset used	Parameters	
		$PM_{2.5}$	PM_{10}
Constant Proportion	Half (n=47) [*]	$a_1 = 0.483$	$a_1 = 1.226$
	Full (n=93) [**]	$a_1 = 0.489$	$a_1 = 1.192$
RH-Adjusted Proportion	Half (n=47)	$a_2 = 0.58$; $b = -0.17$	$a_2 = 1.30$; $b = -0.19$
	Full (n=93)	$a_2 = 0.57$; $b = -0.14$	$a_2 = 1.33$; $b = -0.28$

[*] One-half dataset was used to calibrate the models and the second-half to validate the models.

[**] In this case, the whole dataset was used to derive the model parameters for comparison purposes with that of half dataset.

Figure Captions

Fig. 1. Comparison of $PM_{2.5}$ and PM_{10} 24-h average concentrations determined by DustTrak DRX and the reference gravimetric measurements (sampling period from 18 May to 14 December 2015, n=93). Solid lines show linear fit, and the dashed line is the 1:1 ratio.

Fig. 2. The established correction models for DustTrak versus reference gravimetric measurements using a half dataset (n=47) of $PM_{2.5}$ (a,b) and PM_{10} (c,d) and the models' validation on a second-half dataset. The DustTrak data correction in (a) and (c) is based on the LR constant proportion method (Equ. 1), and in (b) and (d) is based on the RH-adjusted proportion approach (Equ. 2). Solid lines show linear fit, and the dashed line is the 1:1 ratio.

Fig. 3. Correlations of $PM_{2.5}$ concentration difference between DustTrak and gravimetric measurements with concentrations of particulate SO_4^{2-}, NO_3^- and EC contents as a function of ambient RH.

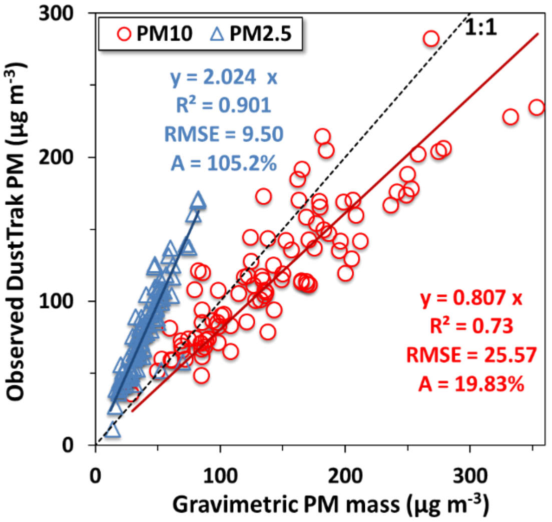
○ PM10 △ PM2.5
y = 2.024 x
R² = 0.901
RMSE = 9.50
A = 105.2%
1:1
y = 0.807 x
R² = 0.73
RMSE = 25.57
A = 19.83%
Observed DustTrak PM (μg m-3)
Gravimetric PM mass (μg m-3)
0
100
200
300
0
100
200
300

Fig. 1.

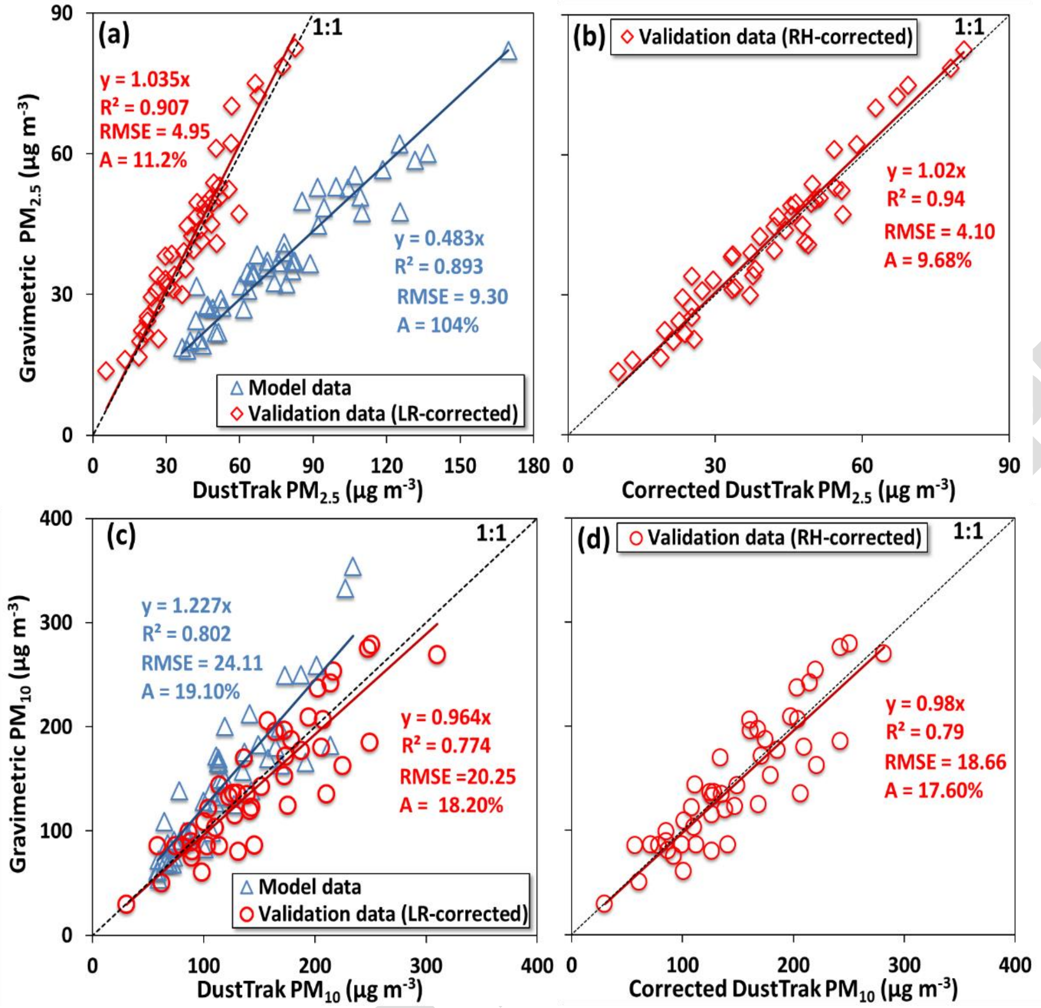
(a)
1:1
y = 1.035x
R² = 0.907
RMSE = 4.95
A = 11.2%
y = 0.483x
R² = 0.893
RMSE = 9.30
A = 104%
△ Model data
◇ Validation data (LR-corrected)
Gravimetric PM2.5 (µg m-3)
DustTrak PM2.5 (µg m-3)
0
30
60
90
120
150
180
(b)
◇ Validation data (RH-corrected)
y = 1.02x
R² = 0.94
RMSE = 4.10
A = 9.68%
Corrected DustTrak PM2.5 (µg m-3)
(c)
y = 1.227x
R² = 0.802
RMSE = 24.11
A = 19.10%
y = 0.964x
R² = 0.774
RMSE =20.25
A = 18.20%
○ Validation data (LR-corrected)
Gravimetric PM10 (µg m-3)
DustTrak PM10 (µg m-3)
100
200
300
400
(d)
○ Validation data (RH-corrected)
y = 0.98x
R² = 0.79
RMSE = 18.66
A = 17.60%
Corrected DustTrak PM10 (µg m-3)

Fig. 2.

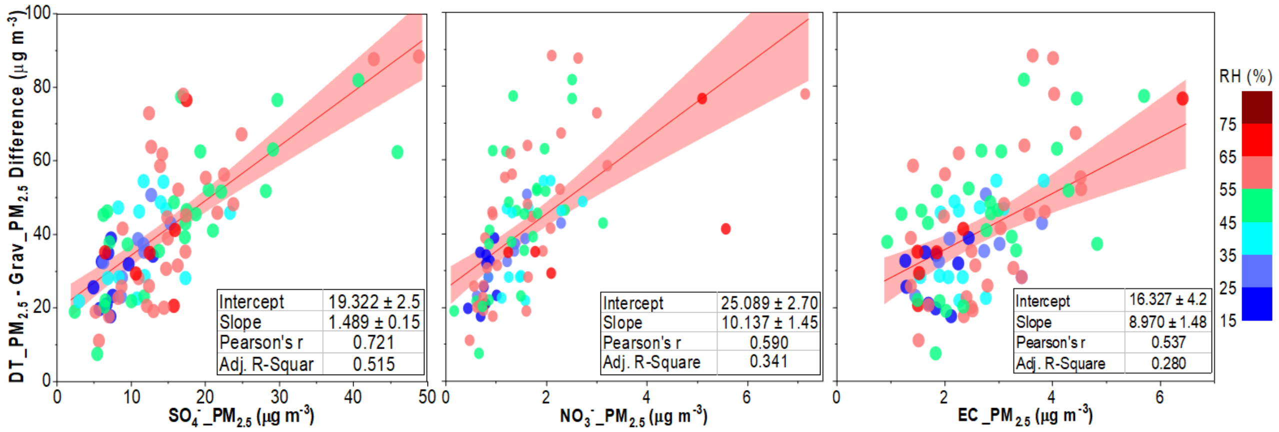
DT_PM2.5 - Grav_PM2.5 Difference (µg m-3)
0
20
40
60
80
100
Intercept 19.322 ± 2.5
Slope 1.489 ± 0.15
Pearson's r 0.721
Adj. R-Squar 0.515
SO4- _PM2.5 (µg m-3)
0
10
20
30
40
50
Intercept 25.089 ± 2.70
Slope 10.137 ± 1.45
Pearson's r 0.590
Adj. R-Square 0.341
NO3- _PM2.5 (µg m-3)
2
4
6
Intercept 16.327 ± 4.2
Slope 8.970 ± 1.48
Pearson's r 0.537
Adj. R-Square 0.280
EC _PM2.5 (µg m-3)
RH (%)
75
65
55
45
35
25
15

Fig. 3.