van Donkelaar et al. (2010) conceptualized that PM$_{2.5}$ = η × AODs, where η is influenced by relative humidity (≥ 35 and ≥ 50% for North America and Europe, respectively) and computed using AODs, the AOD from three-dimensional chemical transport models (3-D CTM). This has several problems: Failing to account for other factors, including boundary layer height, atmospheric pressure, and surface characteristics, can bias PM$_{2.5}$ prediction. van Donkelaar et al. computed η at 2° × 2.5° and then interpolated η at 0.1° × 0.1°, which must have resulted in the same value of η for all 10 km AODs within each 2° × 2.5° area (at the equator), and hence strong spatial autocorrelation in the predicted PM$_{2.5}$. Because the average lifetime of aerosols is one week and aerosols move across geographic space and time, AODs (i.e., the extinction of beam power due to the presence of aerosols) records a very strong spatiotemporal structure. Failing to account for spatiotemporal structure in AODs is likely to produce biased estimates of PM$_{2.5}$ (Kumar 2010).

The CTM is a data-driven methodology and the robustness of its output is largely dictated by input emission and meteorological data. Because such data are rarely complete and 100% accurate, it is difficult to accurately predict PM$_{2.5}$ and AOD, using CTM. Researchers are moving toward data assimilation techniques, in which predicted values are calibrated with respect to in situ measurements, van Donkelaar et al. failed to take advantage of data assimilation techniques to calibrate AODs.

Because of problems with version 5.0 or earlier of AODs (Levy et al. 2007), NASA is developing a Deep Blue version to estimate AODs over bright surfaces (Hsu 2010). Given the methodological constraints described above, I question van Donkelaar et al.’s (2010) conclusions. In their figures, the predicted PM$_{2.5}$ in sub-Saharan Africa was unexpectedly high. It is unclear how coarse dust in that part of the world could result in high PM$_{2.5}$ concentrations. This must be a result of the overestimated AODs due to surface brightness.

The integration of AODs and CTM, coupled with spatiotemporal dynamic modeling, holds great potential to develop time-space resolved estimates of PM. Future research should be geared toward assimilation of the strengths of these methodologies. CTM has a great temporal resolution and is not constrained by cloud cover or biased by surface brightness, but the reliability of CTM output is dictated by the quality of input data. AODs have great spatial resolution (10 km) and can be estimated at finer spatial resolutions (5 km and 2 km), which is likely to be more robust than the coarse resolution AOD (Kumar et al. 2007); however, under cloud-free conditions it captures only two snapshots (at ~ 1030 hours and ~ 1330 hours local overpass time of the Terra and Aqua satellites) per day. Calibrating AODs for the problems mentioned above, daily (morning and afternoon) AODs can be produced globally. The best approach to integrating the strengths of these two methodologies would be to (a) develop an empirical relationship between the calibrated AODs and AOD (estimated using a nested grid at a fine spatial resolution); (b) utilize this relationship to predict a calibrated AOD (AOD$_{c}$) for all data points with available AODs; (c) utilize AOD$_{c}$ to predict PM$_{2.5c}$; (d) develop an empirical relationship between predicted PM$_{2.5c}$ and in situ measurements of PM$_{2.5}$ with the adequate control for spatiotemporal structures and other subsidiary variables; and (e) utilize this empirical relationship to develop the calibrated PM$_{2.5c}$ (PM$_{2.5c}$ predicted using the the empirical model) for all data points for which PM$_{2.5c}$ is available. PM$_{2.5c}$ in turn, can be aggregated and/or interpolated to any spatiotemporal scales using time–space Kriging, an interpolation method that minimizes error in the predicted values across geographic space and time. The author declares he has no actual or potential competing financial interests.

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A Hybrid Approach for Predicting PM$_{2.5}$ Exposure: van Donkelaar et al. Respond
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We thank Kumar for his comments on our article (van Donkelaar et al. 2010). We agree that integration of satellite-based aerosol optical depth (AOD) with a chemical transport model (CTM) is valuable to develop estimates of air quality. We also agree that despite the major recent advancements in remote sensing and CTMs, further development of these methods would continue to improve the estimates of fine particulate matter (< 2.5 µm in aerodynamic diameter (PM$_{2.5}$)). We are grateful for the opportunity to expand on those issues here.

As pointed out by Kumar, the relationship between ground-level PM$_{2.5}$ and AOD is complex, with dependence on the scattering properties of the local aerosol (a function of aerosol type and atmospheric conditions) and their vertical distribution (a function of boundary layer height, transport, production, and loss). These factors include effects of atmospheric pressure and surface concentration. The method we used in our study (van Donkelaar et al. 2010) was designed specifically to account for all of these factors (not only relative humidity, as implied by Kumar). η is defined as the ratio of surface PM$_{2.5}$ to total column AOD, where the definition of PM$_{2.5}$ is at either 35% or 50% relative humidity, in accordance with regional ground measurement standards, and total column AOD includes the effects of local relative humidity on aerosol extinction.

We agree that higher resolution calculations of η would continue to improve the PM$_{2.5}$ estimates and are actively developing this capability. However, it is worth clarifying that the long (~ 1 week) aerosol lifetime does not detract from, but rather it contributes to the accuracy of a simulation at 2° × 2.5°. Short-lived species (< 1 day) have more subgrid spatial variation due to the effects of more rapid atmospheric losses. The smoothing associated with longer-lived aerosols enables a global model to sufficiently capture major processes affecting η.

A number of promising developments are also occurring in satellite remote sensing. The Deep Blue algorithm (Hsu et al. 2006) noted by Kumar is one that attempts to retrieve AOD from MODIS (Moderate Resolution Imaging Spectroradiometer) observations over bright surfaces. We took a different approach by using AOD retrievals from the MISR (Multispectral Imaging Spectroradiometer) instrument, which are robust to surface brightness, and by removing biased AOD retrievals from both MODIS and MISR. We found little bias (< 20%) between AERONET (AErosol RObotic NETwork) and our combined satellite AOD in sub-Saharan Africa. Although our PM$_{2.5}$ estimates over sub-Saharan Africa (van Donkelaar et al. 2010) are subject to uncertainty, recent PM$_{2.5}$ measurements in Ghana (Dionisio et al. 2010) indicate that Saharan dust is a significant regional source of PM$_{2.5}$ and that our estimates may in fact be too low, both in contrast with Kumar’s expectations. We welcome additional in situ measurements for future comparisons.

The combination of satellite observations and CTMs offers great potential. The approach we presented in our article (van Donkelaar et al. 2010) took advantage of the fine resolution and observational nature of satellite AOD retrievals and estimates ground-level PM$_{2.5}$ using the physically based framework of a CTM. Empirical methods, such as proposed by Kumar, can be effective over regions where sufficient surface measurements are available to train empirical (or semiempirical) models. However, sufficient in situ measurements do not exist for most of the world, thus limiting the geographic scope of any method that is too dependent upon them.

Expansion of the current global ground-based aerosol measurement network would provide a valuable data set to evaluate and improve the ability of CTMs to capture the AOD-PM$_{2.5}$ relationship as well as the quality of the resultant satellite-based PM$_{2.5}$ estimate. The authors declare they have no actual or potential competing financial interests.

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Errata
In the article by Ferreira et al. [Environ Health Perspect 118:249–252 (2010)], the units for fiber length were incorrect in the first column of page 252; “millimeters” should have been “micrometers.” The corrected sentence is as follows:

Human macrophages can phagocytose fibers ≤ 20 µm (Zeidler-Erdely et al. 2006).

The authors apologize for the error.

Scinicariello et al. have reported two text errors in their article “Modification by ALAD of the Association between Blood Lead and Blood Pressure in the U.S. Population: Results from the Third National Health and Nutrition Examination Survey” [Environ Health Perspect 118:259–264 (2010)].

First, in the third paragraph of their article (p. 259), the sentence summarizing results of a study of Korean lead smelter workers should have been as follows:

A study conducted among Korean lead smelter workers (n = 798; mean BLL = 32.0 µg/dL) found that the ALAD polymorphism did not change the association between blood lead and hypertension at occupational exposure levels compared with ALAD1 homozygous carriers (Lee et al. 2001).

Second, the sentence in the third paragraph of the “Discussion” (p. 262) was incorrect. The corrected sentence is as follows:

Two previous studies on ALAD, BLL, and BP—one conducted among occupationally exposed workers (Lee et al. 2001) and the other conducted at lower lead exposure level (Smith et al. 1995)—found no association of ALAD polymorphism and BP outcomes.

The authors apologize for the errors.
