

EXPLORING THE RELATIONSHIP BETWEEN MONITORED GROUND-BASED AND SATELLITE AEROSOL MEASUREMENTS OVER THE CITY OF JOHANNESBURG

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1. INTRODUCTION

Aerosol particles can have large impacts on human health and the radiative balance of the atmosphere, and thus it is critical that they are properly characterized. In South Africa, aerosol particles are a main component of air pollution, especially in urban areas. There are few long-term continuous measurements outside of urban areas, though studies do suggest that high levels of aerosol particles do exist outside of urban areas (Terblanche et al., 1993). In order to properly characterize aerosol particles across South Africa, it is critical to have information on the aerosol particles for the entire country. Satellites provide information on aerosol particles with large spatial coverage, and thus may be helpful in characterizing aerosol particles across the country.

Some research has been performed on using satellite information for air quality monitoring and modelling, however the applicability to health research, particularly in South Africa, is not well understood (e.g., Gupta et al., 2006; Li et al., 2011; Tsai et al., 2011; Kloog et al., 2011). An important consideration in using satellite information for air quality and health research is that satellites provide information for the whole column of air, or at a specific altitude, while the ground-level concentrations of pollutants are what are needed for air quality and health research. Previous research has explored a linear relationship between satellite information on aerosols and ground-based data; however these relationships are very dependent on characteristics such as location of the site, aerosol composition and meteorology (e.g., Tsai et al., 2011; Gupta et al., 2006; Li et al., 2011). Thus, these parameterisations cannot be applied directly to South Africa, but rather new parameterisations need to be derived and tested.

This project studied the relationship between aerosol optical depth (AOD) from the Multi-angle Imaging SpectroRadiometer (MISR) instrument on the Terra satellite, and ground-based monitored particulate matter (PM) mass concentrations measured at the City of Johannesburg monitoring sites. AOD is the vertical integral of the extinction coefficient (σ_{ext}) at a specific wavelength in a column of air from the surface to the top of the atmosphere. In general, higher AOD values

indicate a larger aerosol load in the column of air. However as σ_{ext} is dependent upon the optical properties of the aerosols, which in turn can be impacted by factors such as refractive index, size and shape, the AOD of a column of aerosol particles is dependent upon more than just the aerosol load. These parameters can be impacted by meteorological factors as well. Thus, the PM-AOD relationship may be complex.

2. DATA AND METHODS

Ground-based PM mass concentrations from the eight City of Johannesburg monitoring sites were provided by the City through the South African Weather Service Air Quality Information System (SAAQIS) (<http://www.saaqis.org.za/>). All PM data underwent quality control, with negative values and all repeating values (i.e., more than 3 consecutive equal values) being removed. In addition, when averaging, the 'data completeness' was considered. If more than 30% of the data were missing for an averaging period, then the data in that averaging period was considered to not have enough data to be representative of the whole period, and no average was calculated. PM data from all eight stations were used to determine trends of ground-based measurements. However, only PM data from the Buccleuch monitoring station (26.0453°S, 28.0991°E) were compared to the MISR data.

The MISR satellite retrievals of AOD ($\lambda = 555$ nm) used in this study are similar to those from Tesfaye et al. (2011). In that study, the aerosol climatology over South Africa was probed using these MISR data; however, the findings were not compared to ground-based measurements of aerosol particles.

3. RESULTS

Monthly trends of PM₁₀ mass concentration at all eight monitoring sites within the City of Johannesburg and the AOD from MISR were analyzed for 2004-2009 (Figures 1a and b). For PM₁₀, both the mean and the median values peak in May – September. And while for the eight sites the maxima and minima values of PM₁₀ mass concentration varies (not shown), the overall trends on a monthly scale are similar. This suggests that on a monthly scale, the PM₁₀ pollution trends at the ground are driven by regional pollution and not by local emissions near one monitoring station alone. Such

considerations may be helpful in managing air quality in the City of Johannesburg.

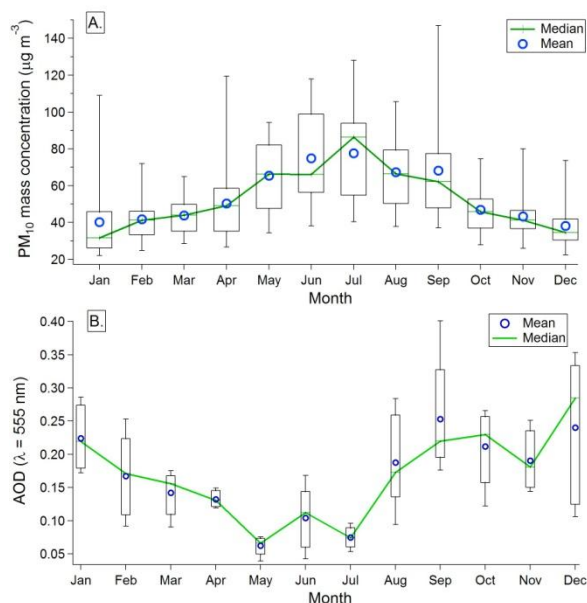


FIG 1 Monthly trends of (a) PM₁₀ mass concentrations and (b) AOD. The limits of the boxes are the 25th percentile and 75th percentile, the vertical lines extend to 5th and 95th percentiles, the green line is the median and the blue circles represent the mean values.

For AOD (Fig 1b), the peak is in September-December. Previous studies in South Africa have found similar timing for peak in AOD (Queface et al., 2011; Tesfaye et al., 2011). A key consideration in the differences in AOD and PM₁₀ mass concentration peaks may be the fact that the column of aerosols has different trends and properties than those on the ground. This highlights the caution that must be used when using column techniques of measuring aerosols to describe trends in aerosol particles in the region. Further research is needed to understand what characteristics of the aerosol particles are driving these differences in these trends between the column and ground-based measurements.

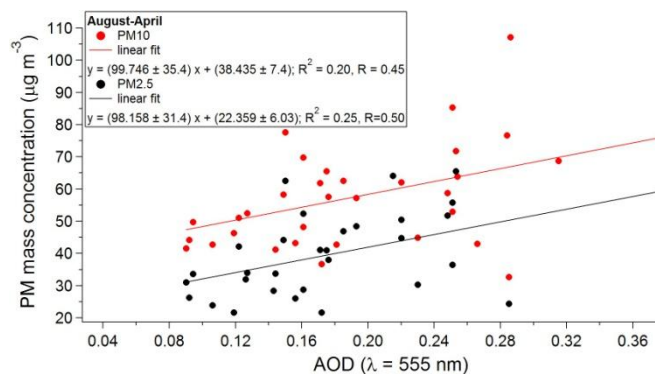


FIG 2. PM mass concentration for Buccleuch versus AOD from MISR. PM₁₀ data and linear fit are in red and the PM_{2.5} data and linear fit are in black.

Figure 2 displays the AOD from MISR vs. the PM₁₀ and PM_{2.5} mass concentrations from the Buccleuch monitoring station for August-April. These months are highlighted as it was found that there is a different PM-AOD relationship in May-July and August-April (not shown), with the more robust relationship being found in August-April. The R values for the relationship shown in Fig 2, while they do indicate a weak linear correlation, are similar to previous studies of PM-AOD relationships, though studies have also found larger R values (Li et al., 2011; Gupta et al., 2006). While the R value from this current study is promising, it does not indicate a relationship that could be used yet to accurately predict surface PM mass concentration from AOD. As found in previous studies, this relationship may be more robust if other factors (e.g., meteorological factors, characteristics of aerosol particles) are included in the analysis, and as such is an needed area of further research (Tsai et al., 2011; Gupta et al., 2006; Li et al., 2011).

4. ACKNOWLEDGEMENTS

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