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Measured In Situ Atmospheric Ambient Aerosol Size-Distributions, Particle Concentrations, and Turbulence Data for RSA TA-6 Test Range, Redstone Arsenal, AL, April–May 2015

by Kristan Gurton, Stephanie Cunningham, and Edward E Montgomery

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Measured In Situ Atmospheric Ambient Aerosol Size-Distributions, Particle Concentrations, and Turbulence Data for RSA TA-6 Test Range, Redstone Arsenal, AL, April–May 2015

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14. ABSTRACT
This report documents a series of in situ measurements designed to characterize atmospheric effects that influences electromagnetic (EM) propagation (i.e., ambient aerosol loading and optical turbulence), during the 5-day periods of April 20–24 and May 4–8, 2015, at the RSA TA-6 Test Range, located at Redstone Arsenal, Alabama. Specific aerosol parameters presented in this report include, ambient aerosol size distributions (0.54 µm < diameter <20 µm), aerosol particle concentrations (#/cm^3), and submicron number density (diameter <0.54 µm). In addition, we present a measure of the magnitude of the optical turbulence, i.e., the refractive index structure parameter, C_n^2, which was measured along a horizontal path approximately 2 m above the surface of the site. Also presented are the corresponding meteorological conditions that influence the formation of ambient aerosols and that influence the relative strength of the optical turbulence at the site, e.g., temperature, relative humidity, and visibility.

15. SUBJECT TERMS
Electromagnetic (EM) propagation, aerosols, optical turbulence, particles

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Acknowledgments

We would like to thank the staff of RSA TA-6 Test Range, Redstone Arsenal, for their exceptional support during the test period in which this study was conducted. We would also like to thank Mr TG Henderson and Dr Justin Munsell for providing the metrological and turbulence data presented in this report.

1. Site Measurement

During the 5-day periods of April 20–24 and May 4–8, 2015, a series of measurements designed to characterize various aerosol and atmospheric parameters were made in support the All Weather Tracker (AWT) Experiment that was conducted at the RSA TA-6 Test Range, located at Redstone Arsenal, Alabama. Since the primary objective of the experiment was to investigate both active and passive polarimetric imaging methods in the short-wave infrared (SWIR), efforts were taken to characterize the 2 atmospheric effects that most influence efficient electrometric (EM) propagation, i.e., ambient aerosols and optical turbulence.

Aerosol measurements were conducted using a TSI aerodynamic particle sizing (APS) spectrometer, Model 3321 that provides high-resolution, real-time aerodynamic measurements of aerosol particle diameters within the range 0.5 to 20 microns. The aerosol probe was located in the field approximately 500 m from the source trailers that were used for the optical experiments. The aerosol spectrometer was operated 24/7 during each test period in order to characterize diurnal variations in the formation of ambient aerosols. The ambient aerosol parameters were continuously monitored using a 10-min sample window, in which particles were sized and counted for the specified period. The photograph shown in Fig. 1 show the RSA TA-6 test range and the approximate location of the TSI particle sizing spectrometer.

Fig. 1 Photograph of RSA TA-6 field site and location of the APS spectrometer

2. Data

The aerosol measurements showing the overall particle concentrations (#/cm^3), daily averaged size distributions, submicron (fine) particle counts (within a 10-min sample), and the diurnal variation of the ambient size distributions, are shown in Figs. 2–15.

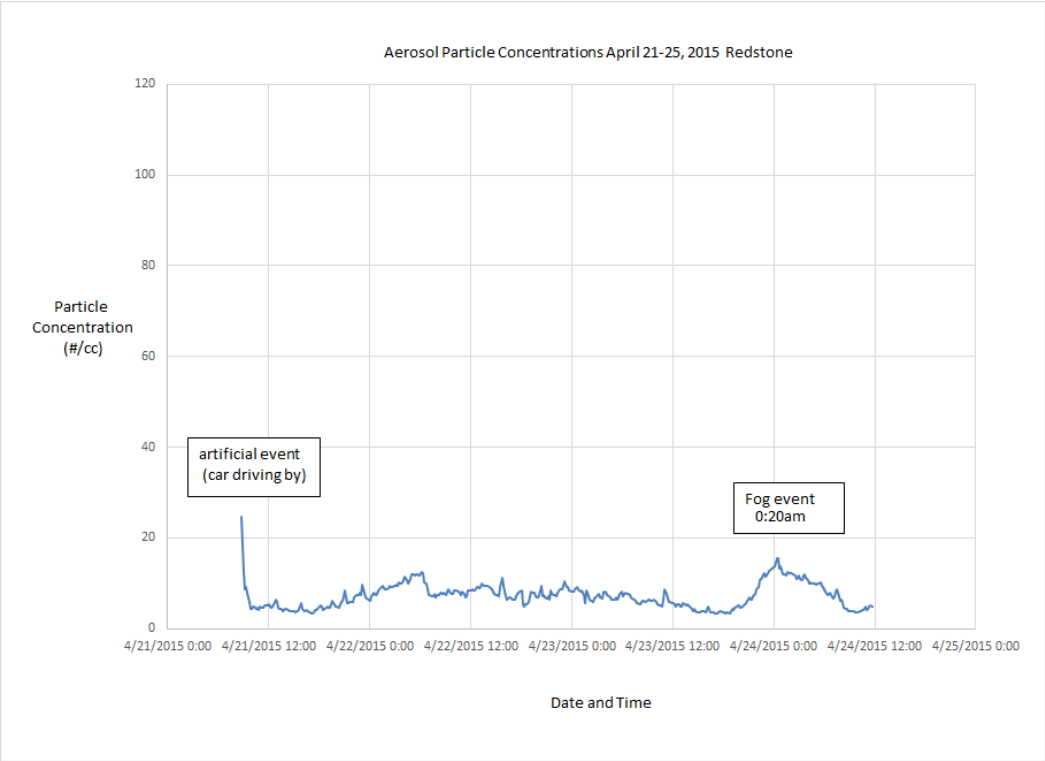

Fig. 2 Ambient particle concentrations (#/cm^3) recorded at RSA TA-6 Test Range during the week of April 20–24, 2015. Note the identified fog event at 12:20 am on April 24, 2015.

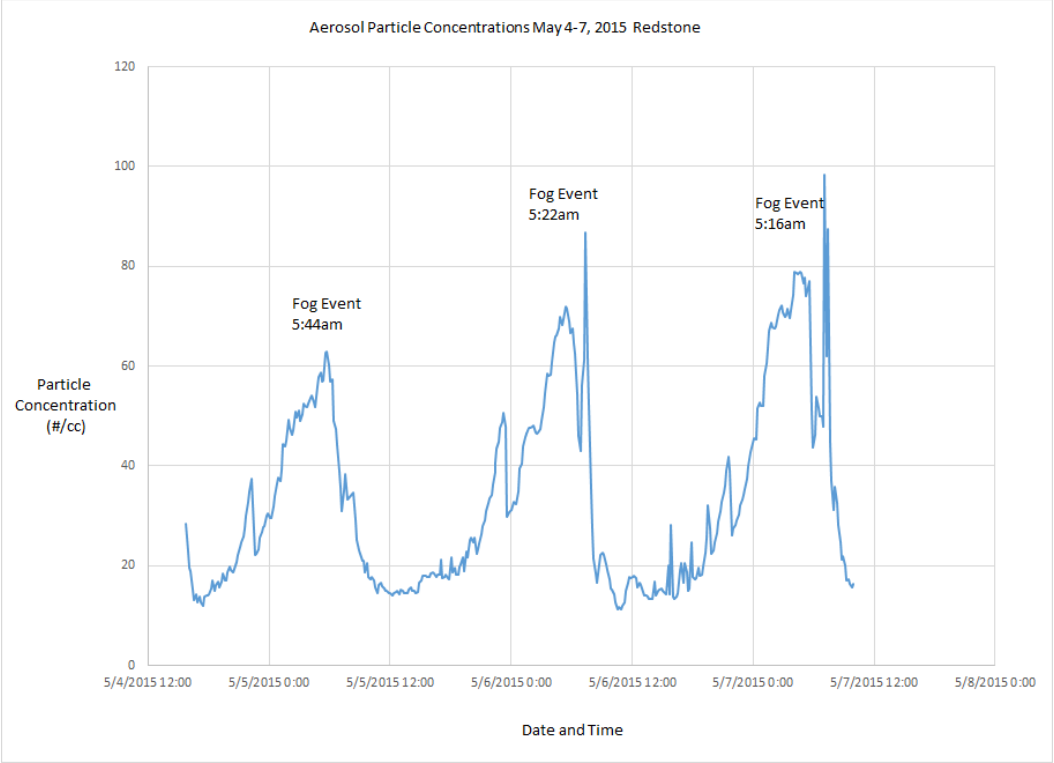

Fig. 3 Ambient particle concentrations (#/cm^3) recorded at RSA TA-6 Test Range during the week of May 4–7, 2015. Note the identified fog events in the early hours of May 5–7, 2015.

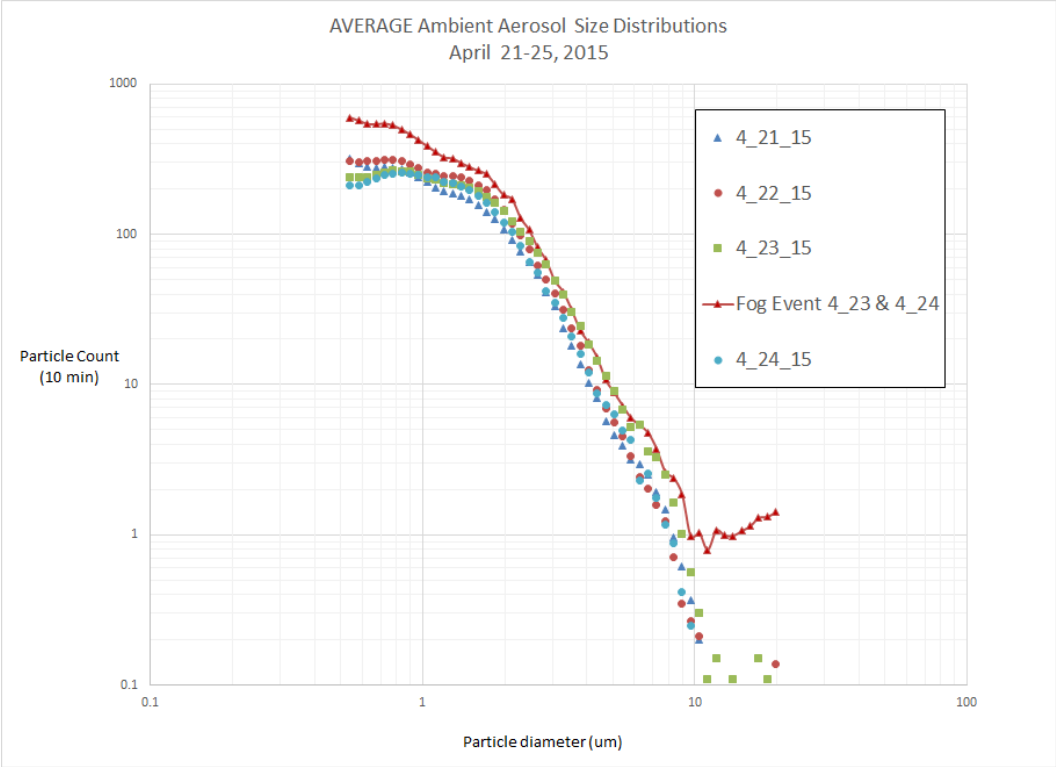

Fig. 4 Daily average size distributions for the week of April 21–25, 2015. Please note fog event recorded during the early morning of April 24, 2105.

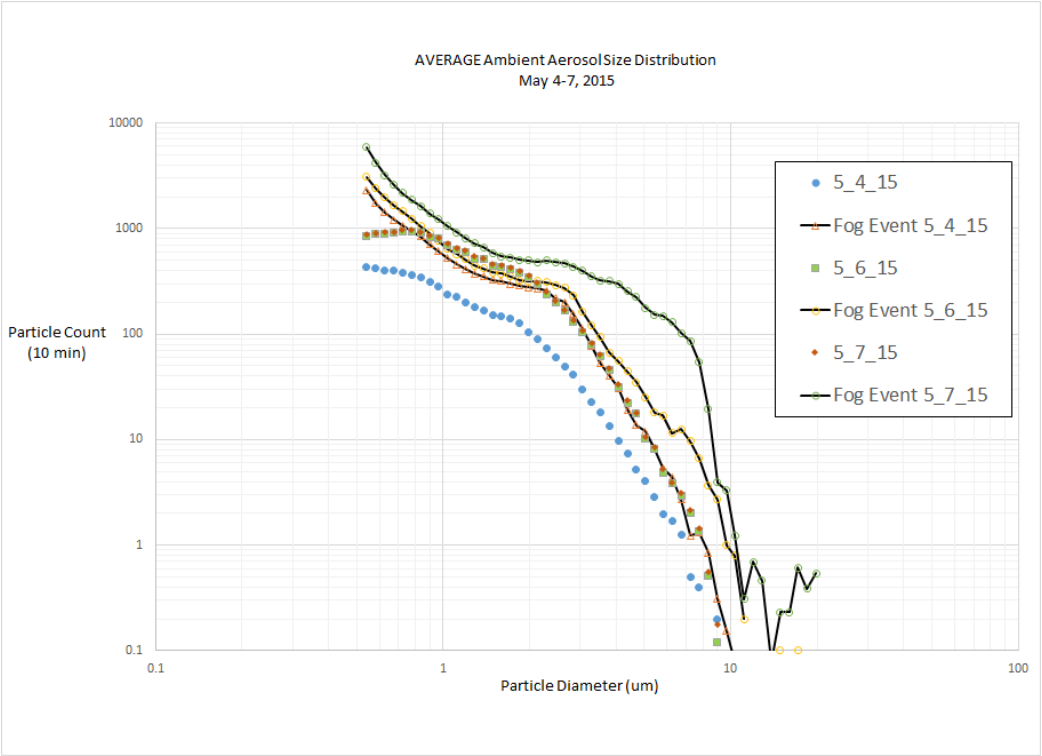

Fig. 5 Daily average size distributions for the week of May 4–7, 2015. Please note fog events recorded during the early morning hours of May 4, 6, and 7, 2105.

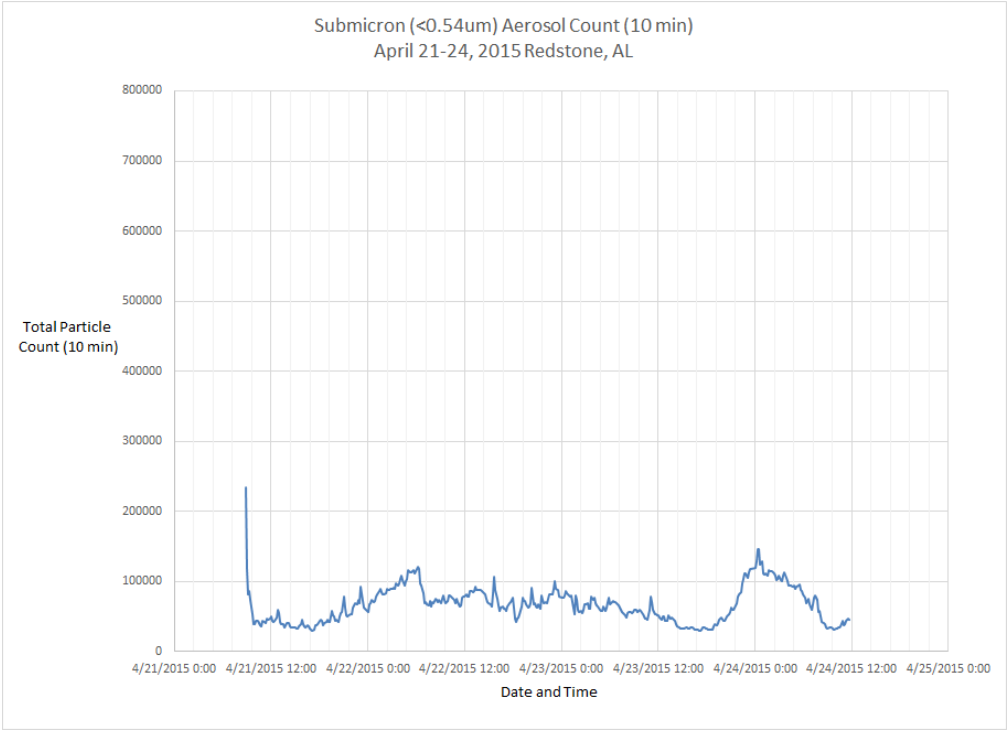

Fig. 6 Small particle count (d < 0.54 µm) recorded at RSA TA-6 Test Range during the week of April 20–24, 2015

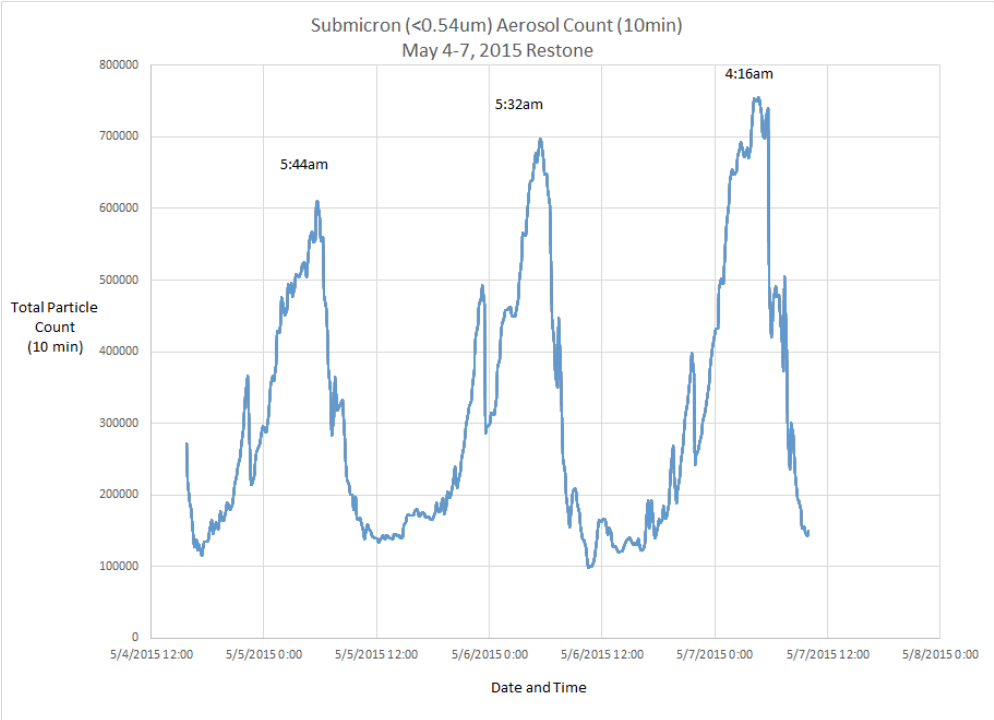

Fig. 7 Small particle count (d < 0.54 µm) recorded at RSA TA-6 Test Range during the week of May 4–7, 2015

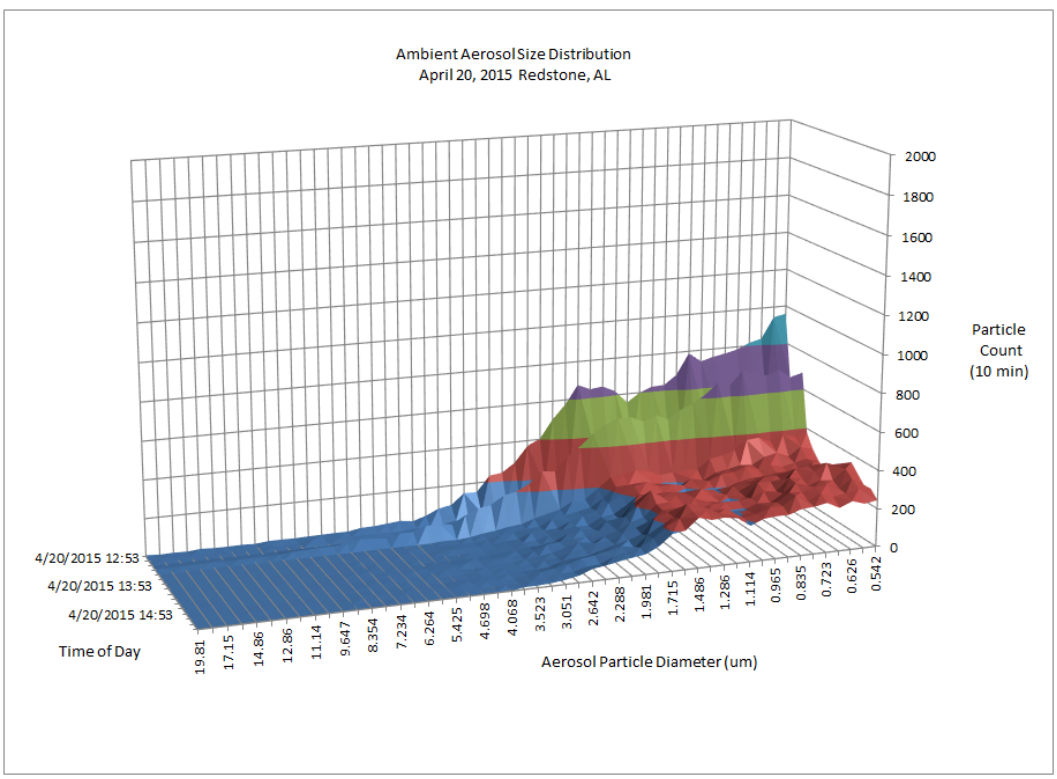

Fig. 8 Ambient aerosol size distribution measured at RSA TA-6 Test Range, on April 20, 2015

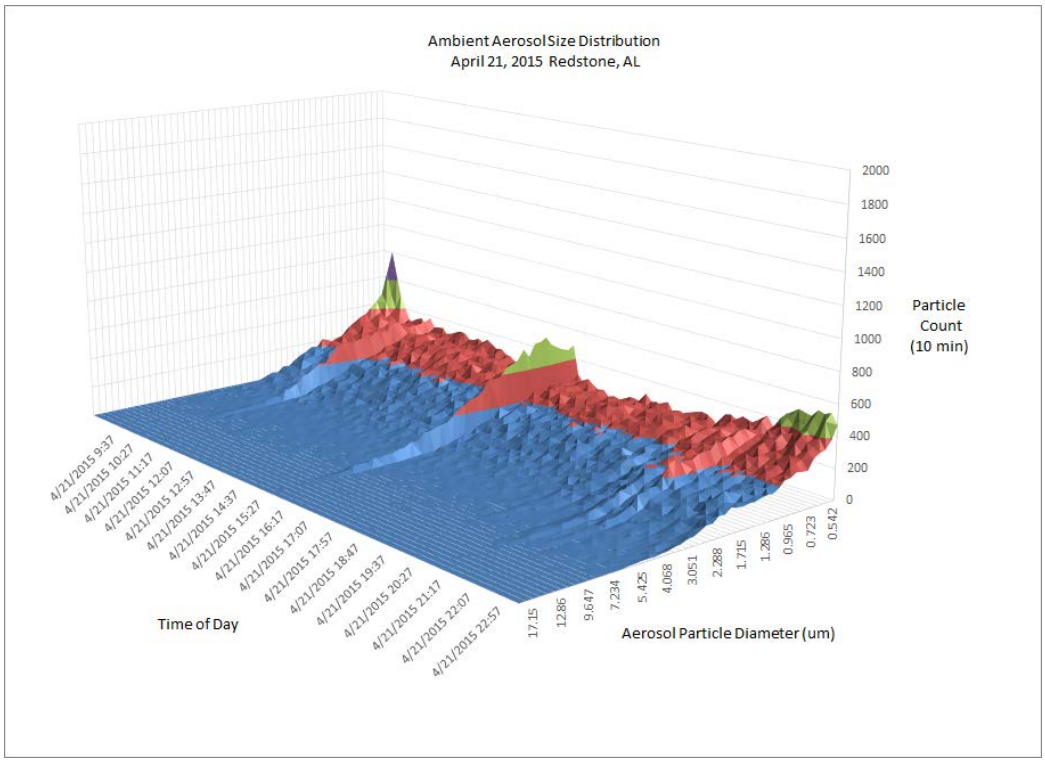

Fig. 9 Ambient aerosol size distribution measured at RSA TA-6 Test Range, on April 21, 2015

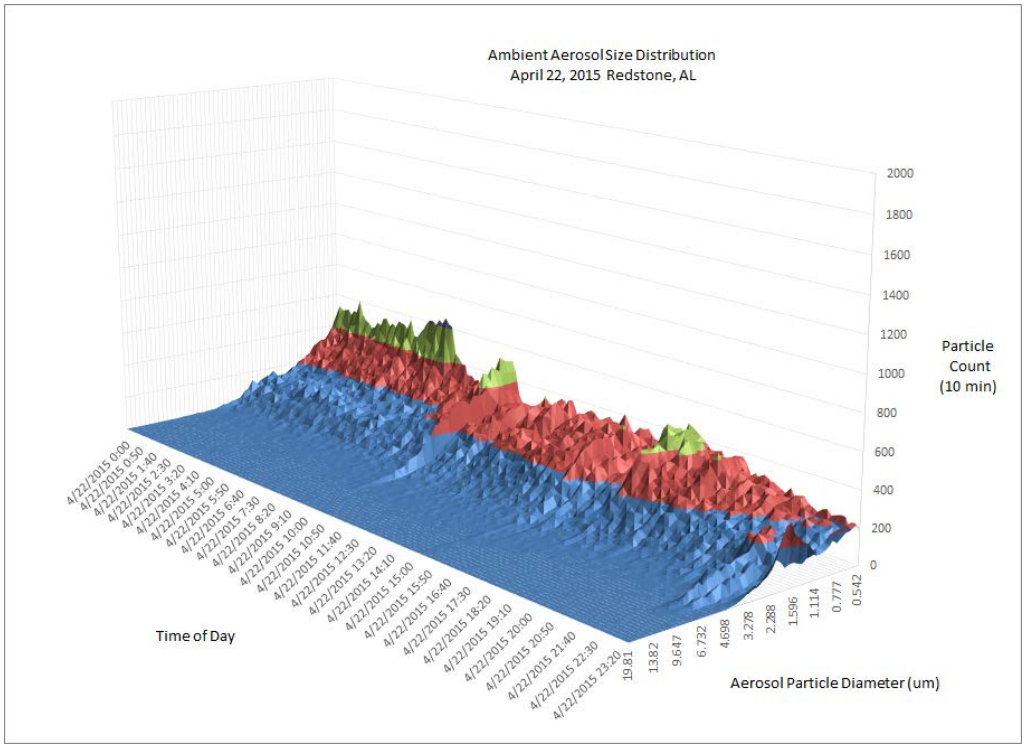

Fig. 10 Ambient aerosol size distribution measured at RSA TA-6 Test Range, on April 22, 2015

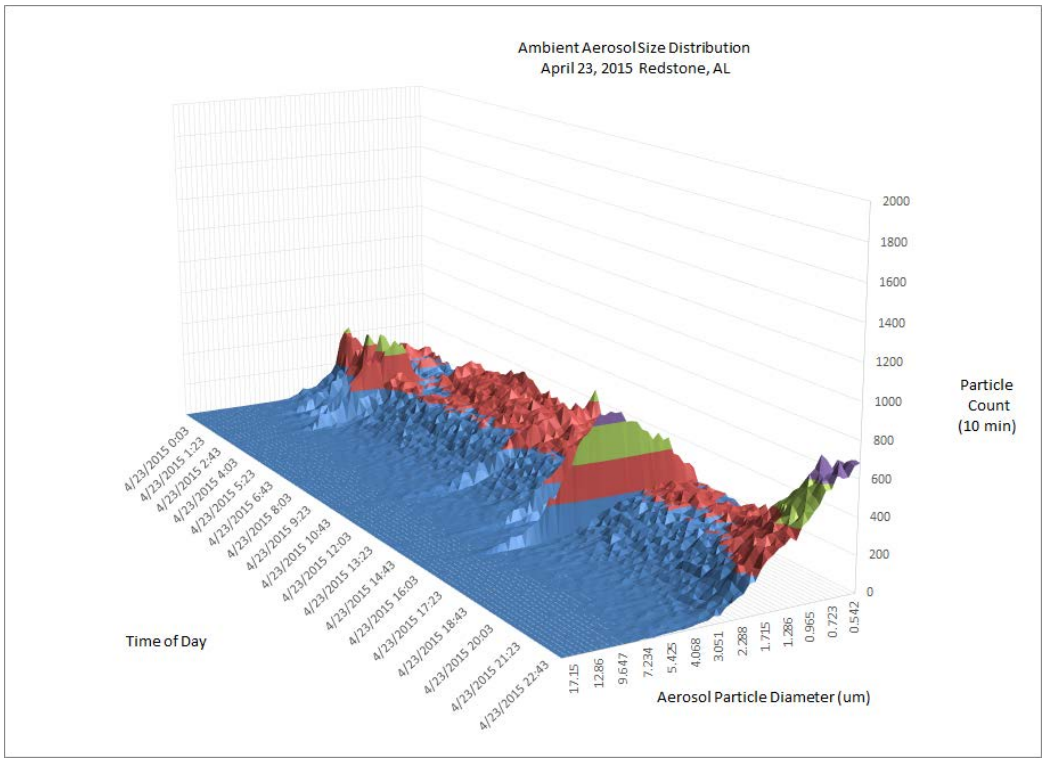

Fig. 11 Ambient aerosol size distribution measured at RSA TA-6 Test Range, on April 23, 2015

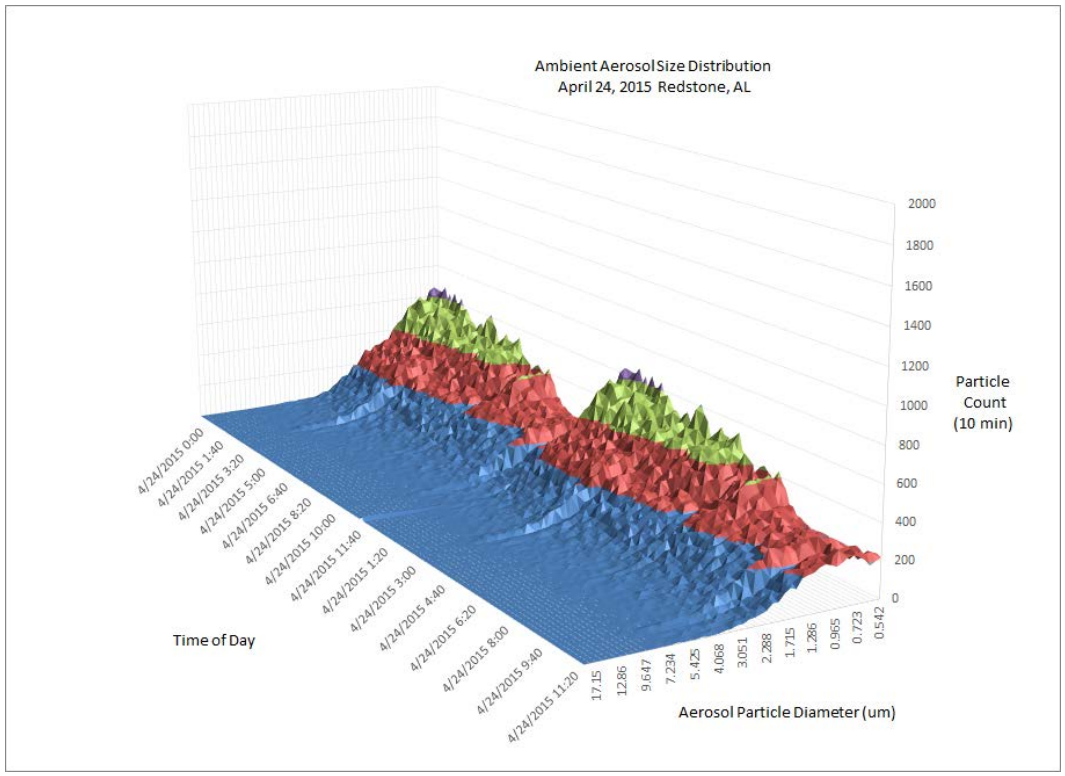

Fig. 12 Ambient aerosol size distribution measured at RSA TA-6 Test Range, on April 24, 2015

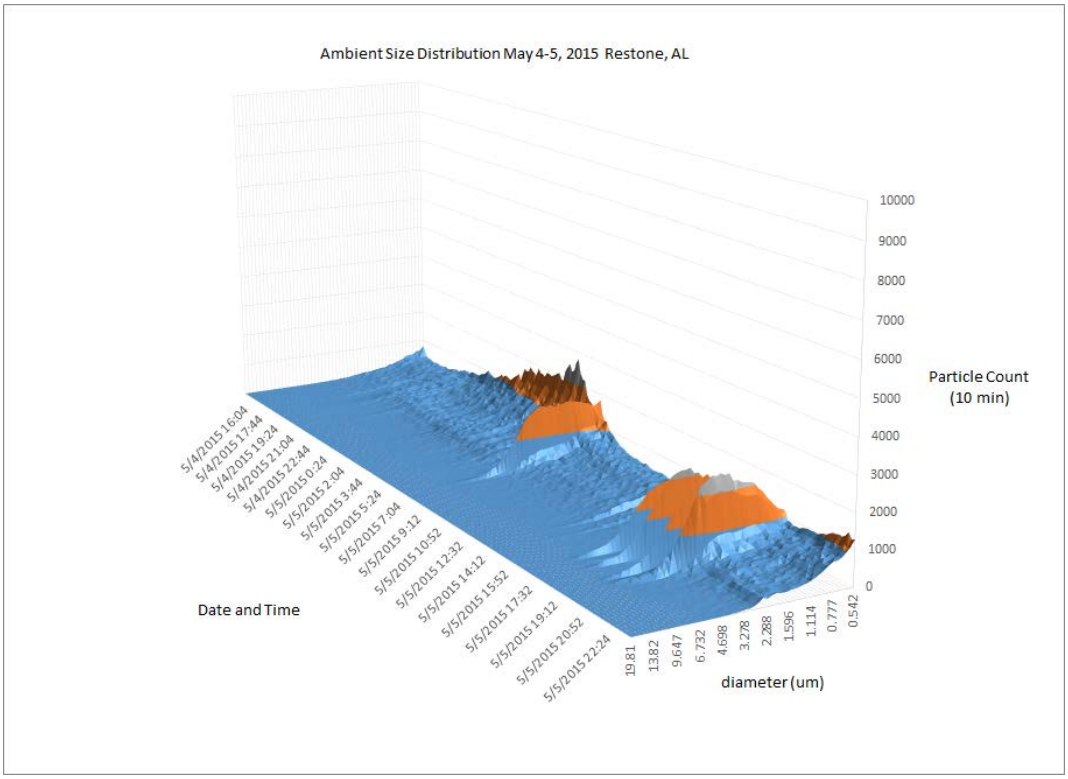

Fig. 13 Ambient aerosol size distribution measured at RSA TA-6 Test Range, on May 4–5, 2015. Note artificial aerosol events in the morning (approx. 7:00 am) and late afternoon due to movement of vehicles as the field test gets set up.

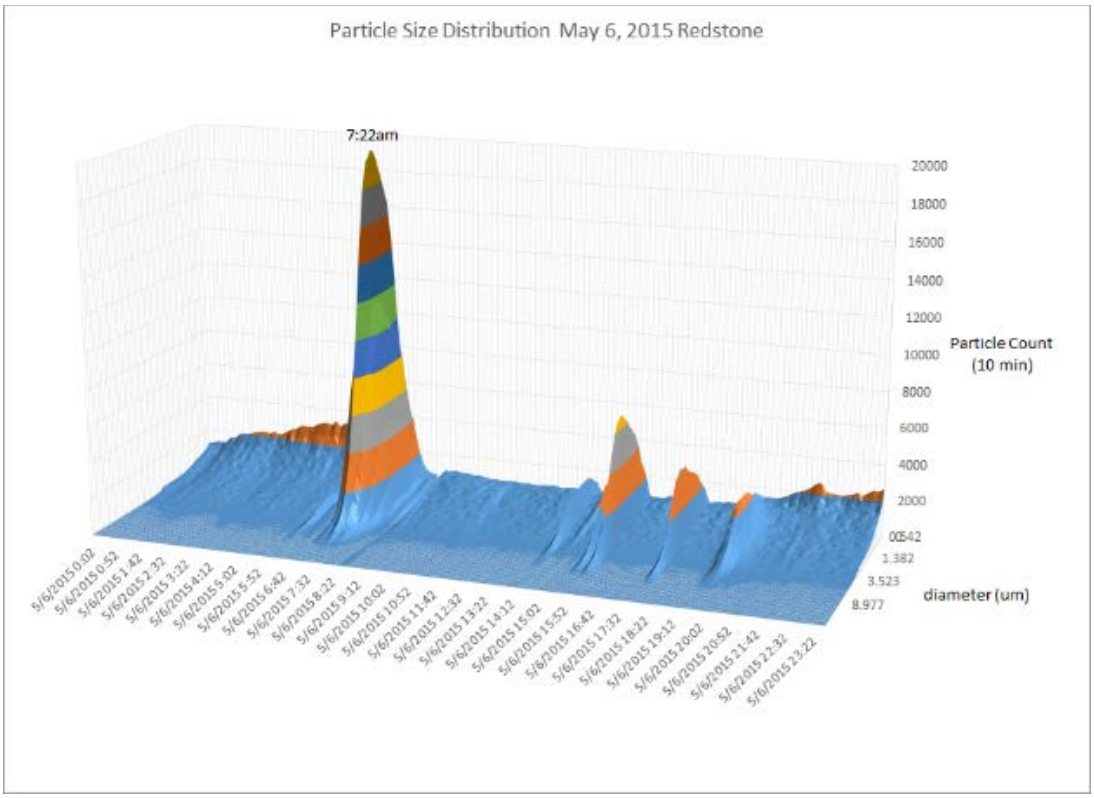

Fig. 14 Ambient aerosol size distribution measured at RSA TA-6 Test Range, on May 6, 2015. Please note: The obvious aerosol events at 7:22 am and later in the afternoon were a result of vehicular travel along the road that boarders the TSI aerosol probe.

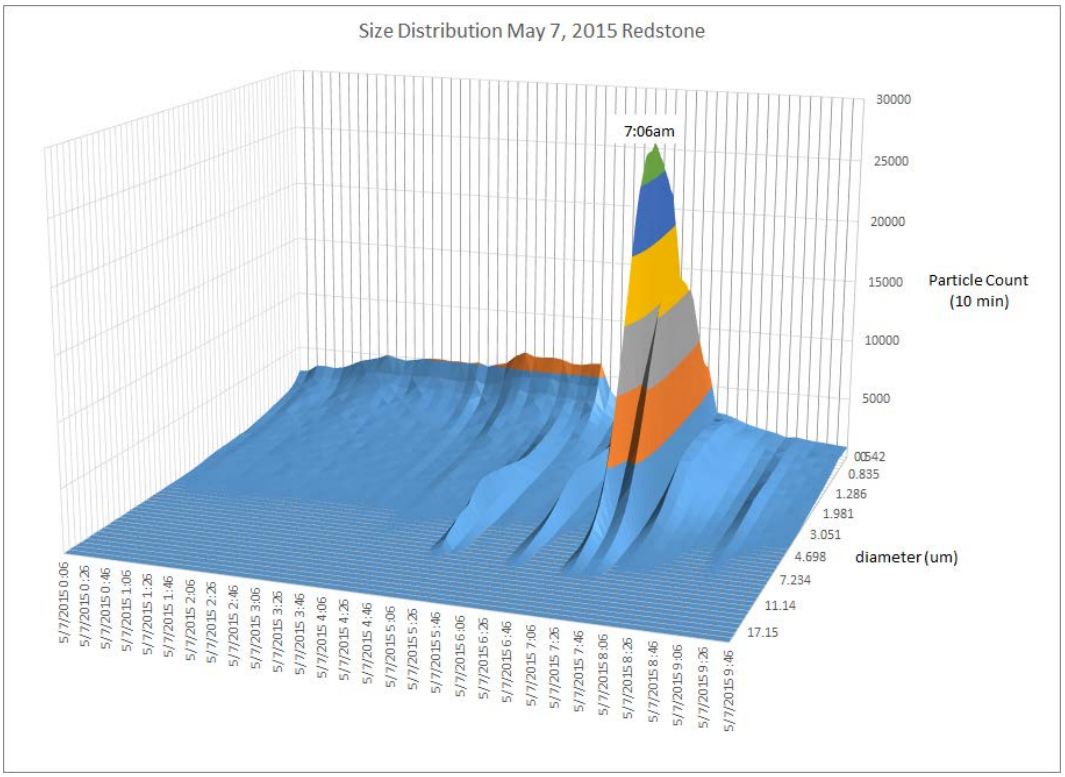

Fig. 15 Ambient aerosol size distribution measured at RSA TA-6 Test Range, on May 7, 2015. Please note: The obvious aerosol events at 7:06 am was a result of vehicular travel along the road that boarders the TSI aerosol probe.

Figures 16–19 shows the turbulence and metrological data.

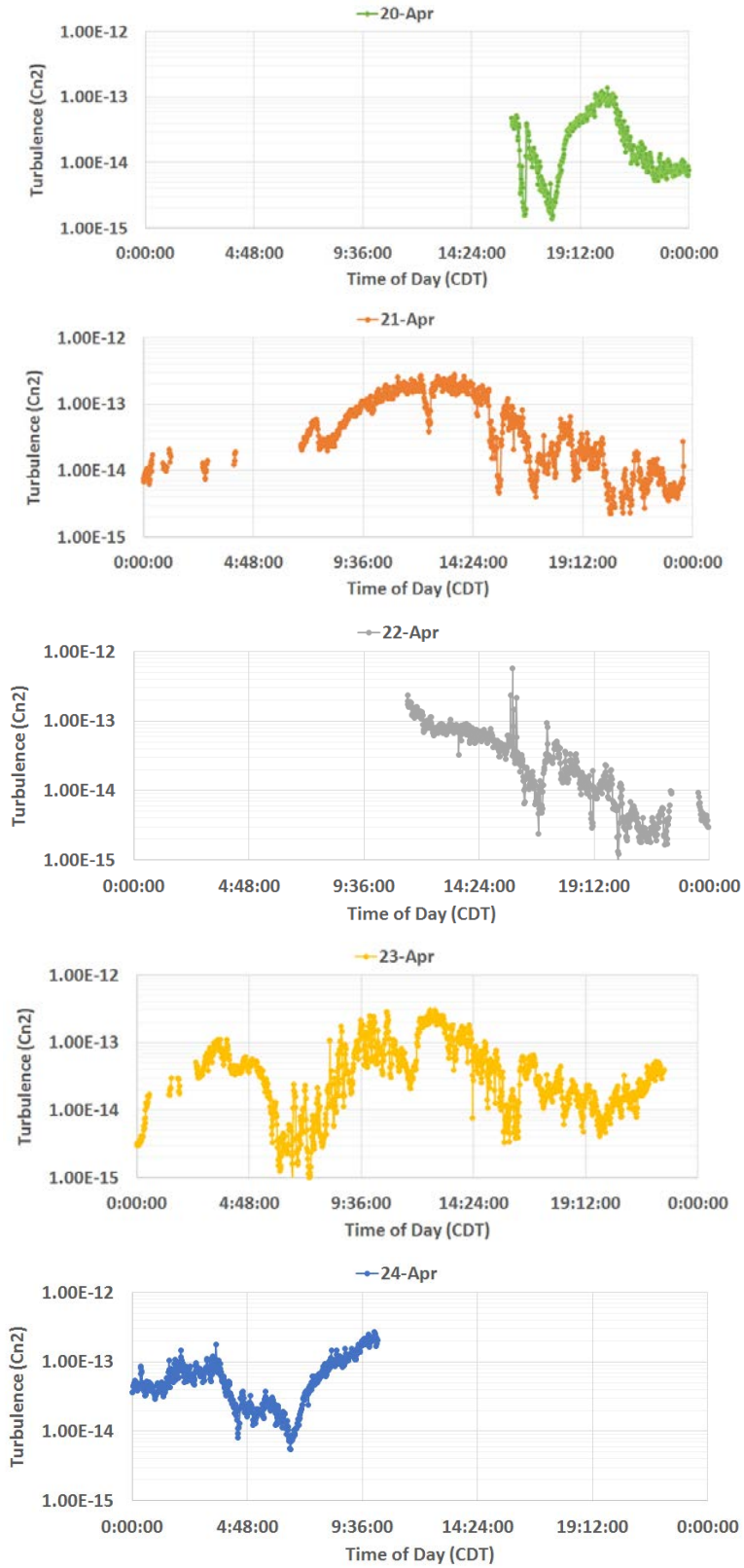

Fig. 16 Measured refractive index structure parameter, C_n^2, for the week of April 20–24, 2105

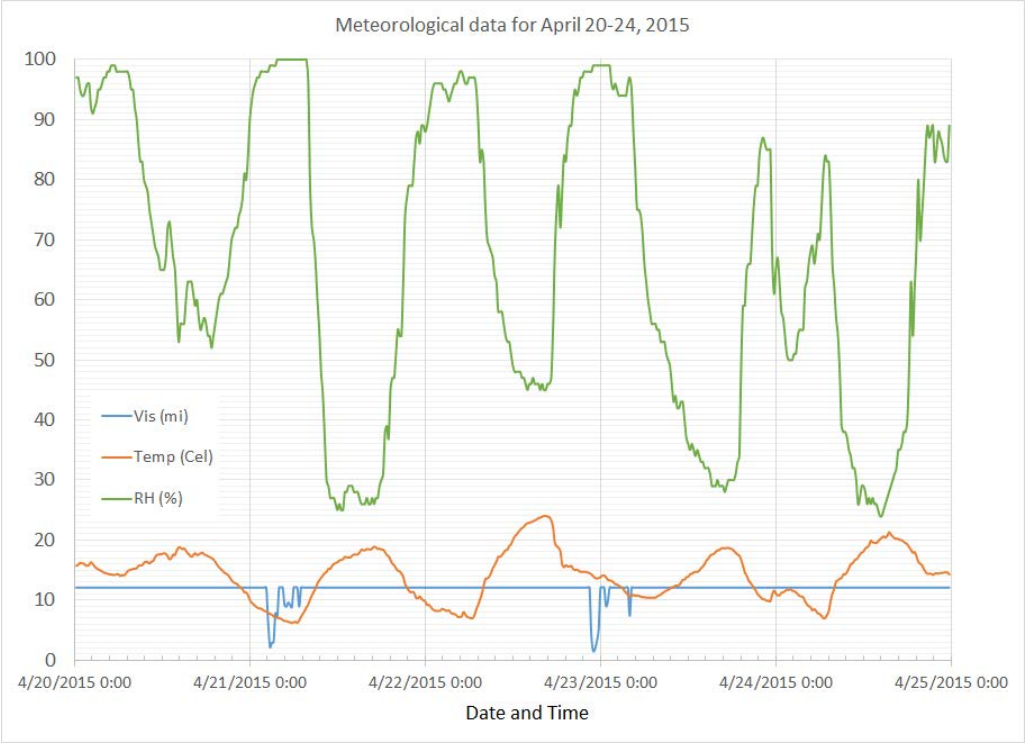

Fig. 17 Measured visibility (miles), air temperature (°C), and relative humidity (%), for the week of April 20–24, 2105

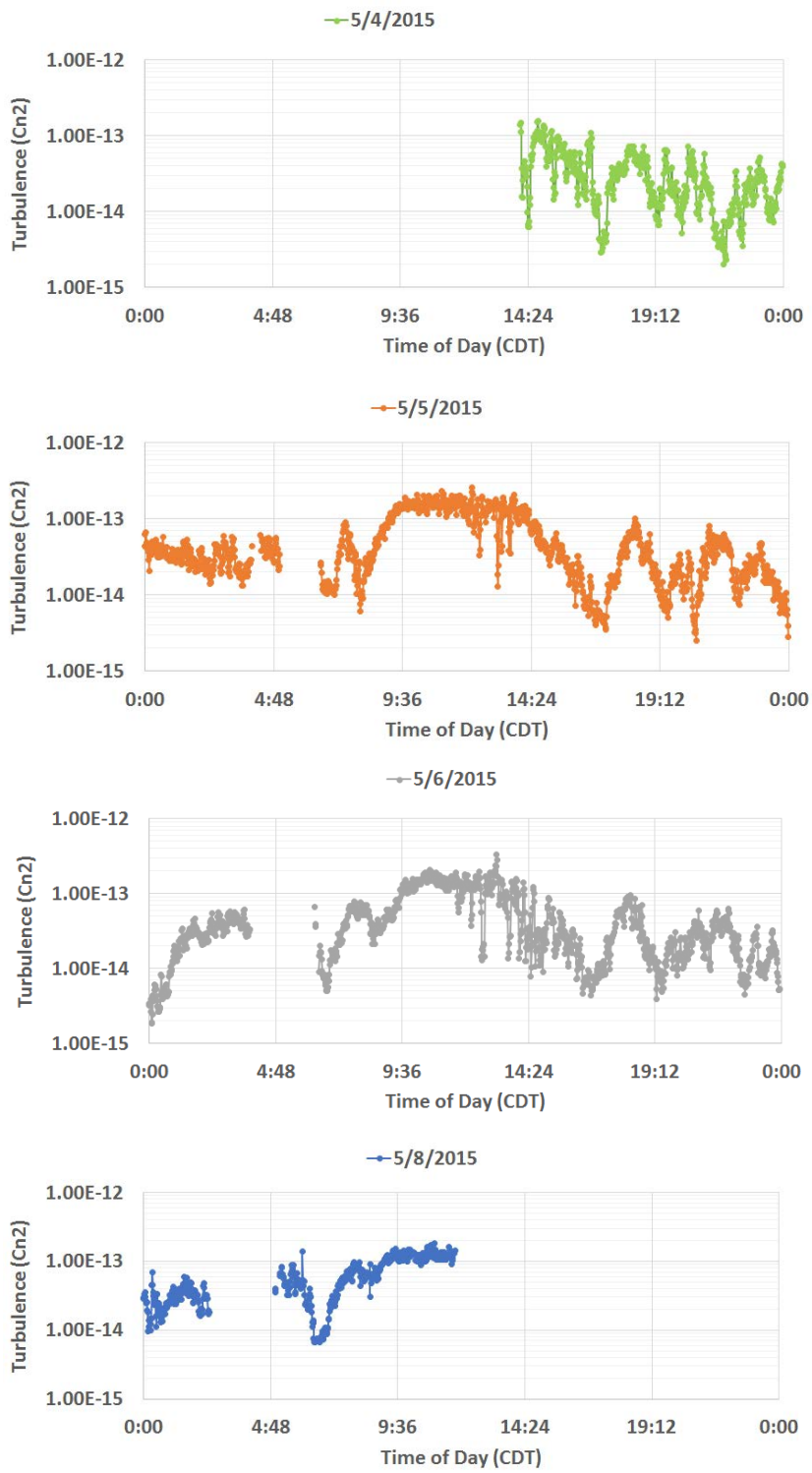

Fig. 18 Measured refractive index structure parameter, C_n^2, for the week of May 4–8, 2105. Please note the refractive structure parameter data for May 7 was omitted due to technical problems.

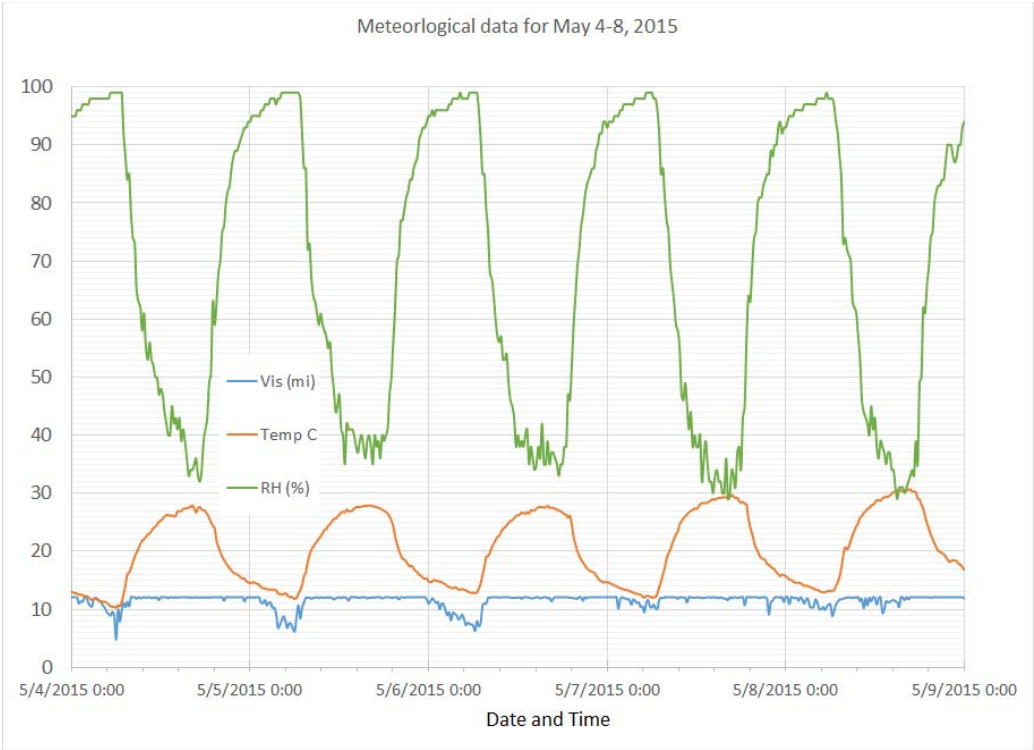

Fig. 19 Measured visibility (miles), air temperature (°C), and relative humidity (%), for the week of May, 4–8, 2105

3. Summary and Conclusion

A simple comparison conducted between the weeks of April 20–24 and May 4–7, 2015, show an obvious increase in aerosol mass that is best seen by comparing the aerosol concentrations shown in Figs. 2 and 3. One can only speculate on the exact cause, but it is well known that there is a seasonal transition from early to mid-spring in which ambient aerosol characteristics in rural environments are quite dynamic. Also lending to the uncertainty was the noted mowing of grass at the field site during the week of May 4–7, 2015, which undoubtable affected the overall particle concentration and number densities measured during that week. Similarly, the aerosol probe (particle sizer) was affected by transient events due to vehicle movement around the RSA TA-6 Test Range, see Figs. 14 and 15, for example.

Observation of the daily average size distributions (where the transient events have been omitted), which are shown in Figs. 3 and 4, show a degree of consistency from day to day, and even week to week. The exceptions, of course, take place during the evening/early morning hours of April, 24, and May, 5, 6, and 7, in which fog event(s) were observed at which time air temperatures fell to a minimum and relative humidity climb to 100%. Under these condition warm water vapor (relative

to the particle) condense on the nuclei particles, which causes the aerosol particle to grow in diameter, see Fig. 5.

Figure 4 clearly shows the formation of fog generated particles (small nuclei particle encapsulated by water) resulting in a significant increase in the number of submicron particles, mid-size particle (4–9 µm range) and large particle >20 µm. Finally, we should note the consistent form of the daily variation in the measured refractive index structure parameter, C_n^2, shown in Figs. 16 and 18. As one can see in the figures, optical turbulence is generally less in the evening hours as compared to the daytime, decreases to a minimum during dusk and dawn, and reaches maximum intensity during the afternoon hours. Finally, all data presented in this report will be made available in ASCII form to any interested parties upon request to the authors.

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