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NPFTURBULENCE-Turbulent Layers Promoting New Particle Formation Field Campaign Report

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Acronyms and Abbreviations

ABL	Atmospheric boundary layer
AGL	above ground level
CDT	Central Daylight Time
CPC	condensation particle counter
BKN	Blackwell-Tonkawa Airport
mSEMS	miniaturized scanning electrical mobility sizer
PI	principal investigator
SGP	Southern Great Plains
SMPS	scanning mobility particle sizer
TKE	total kinetic energy

Contents

Figures

1.0 Summary

This field campaign took place at the U.S. Department of Energy Atmospheric Radiation Measurement (ARM) use facility's Southern Great Plains (SGP) atmospheric observatory, located near Lamont, Oklahoma. The ArcticShark uncrewed aerial system conducted 10 research flights, accumulating 40.7 flight hours over the SGP site. Each flight originated from the Blackwell-Tonkawa Airport (BKN) and followed a "racetrack" pattern around the SGP field site. During these flights, mission scientists initiated vertical profiling based on the real-time performance of the aerosol instruments aboard the ArcticShark. Figure 1 below illustrates the flight paths of all missions.

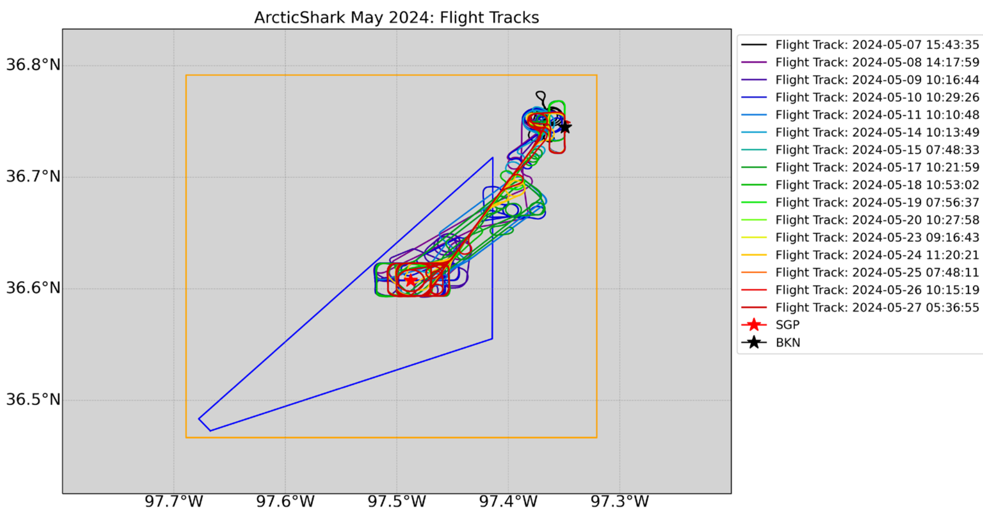

Figure 1. ArcticShark mission flight paths at the SGP observatory.

2.0 Results

Across 10 research flights, observations indicate convective boundary-layer development, where newly formed particles from surface-level new particle formation are transported into the boundary layer through intense mixing and turbulence.

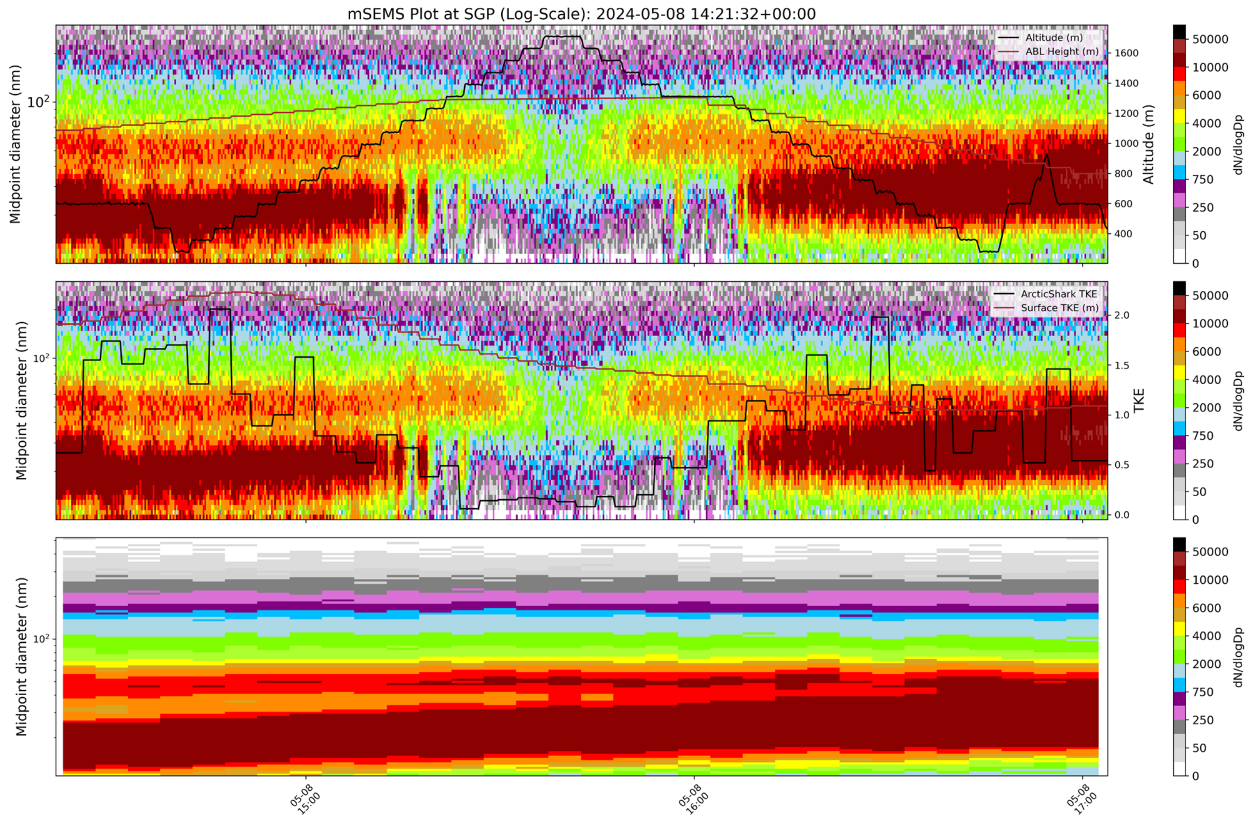

Figure 2. 2a presents the altitude of the ArcticShark (black line) and the estimated atmospheric boundary-layer (ABL) height (brown line) over the SGP field site overlaid onto an aerosol size distribution from the miniaturized scanning electrical mobility sizer (mSEMS) aboard the ArcticShark. 2b displays the same aerosol size distribution plot in Figure 1a, but overlaid by a time series of total kinetic energy (TKE) aboard the ArcticShark (black line) and at the surface of the SGP field site (brown line). 2c is an aerosol size distribution from the scanning mobility particle sizer (SMPS) at the surface of the SGP field site.

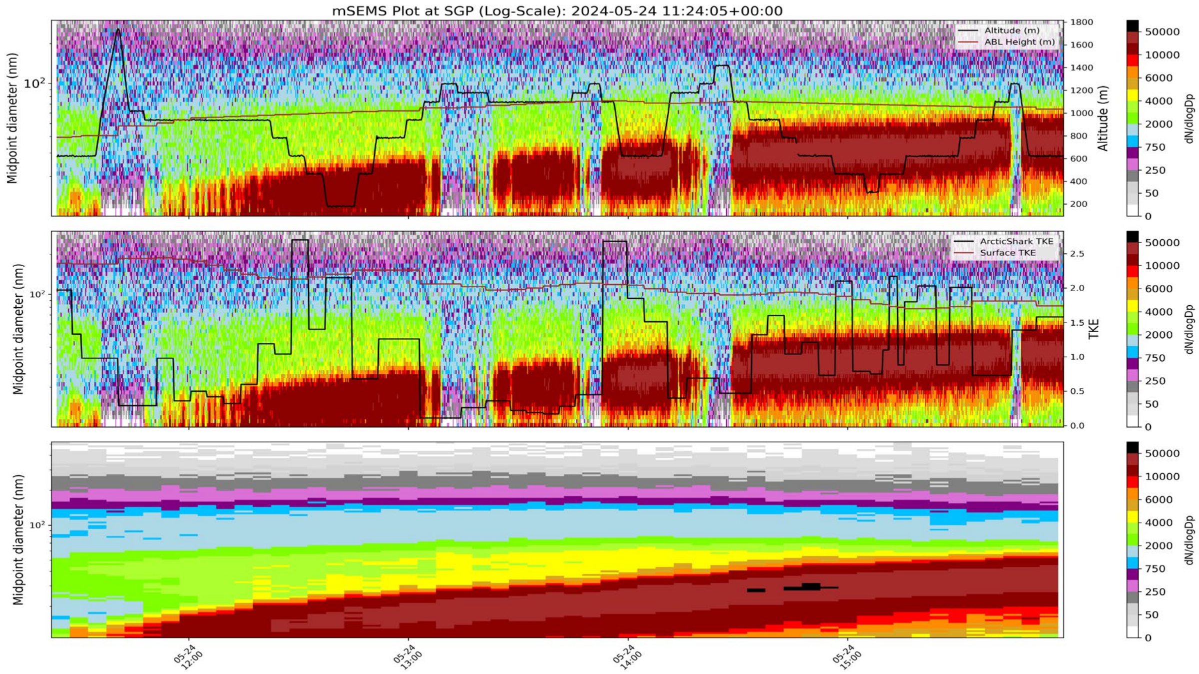

Figure 3. 3a presents the altitude of the ArcticShark (black-line) and the estimated ABL height (brown line) over the SGP field site overlayed onto an aerosol size distribution from the mSEMS aboard the ArcticShark. 3b displays the same aerosol size distribution plot in Figure 2a, but overlayed by a time series of TKE aboard the ArcticShark (black line) and at the surface of the SGP field site (brown line). 3c is an aerosol size distribution from the SMPS at the surface of the SGP field site.

Additionally, there is evidence of new particle formation occurring aloft over the SGP site, with these particles subsequently being advected downward before being detected by aerosol instruments on the ground. The May 10 research flights exemplify the latter. Figure 4 below depicts a direct comparison between aerosol size distribution instrumentation aboard the ArcticShark and at the surface at the SGP site (Figure 4a and 4b, respectively), and aerosol total concentration (Figure 4c). In Figure 4a, the ArcticShark detects an increase in aerosol concentration around 14:15 CDT at an altitude of 600 m AGL, whereas this increase is not yet observed at the surface (Figure 4b). To quantitatively assess this, we calculate the difference in total aerosol concentration measured by the condensation particle counter (CPC) aboard the ArcticShark and at the SGP site, providing an estimate of the number of particles in the 5-10 nm size range. The aerosol concentration aboard the ArcticShark (blue line) shows a sharp increase at 14:15 CDT, while the surface measurement (green line) rises shortly after, around 14:30 CDT. This time lag results in a positive difference between the two instruments, indicating an excess of aerosol nanoparticles (5-10 nm) aloft. This suggests that new particle formation occurs above the SGP site and is detected at the surface approximately 15 minutes later.

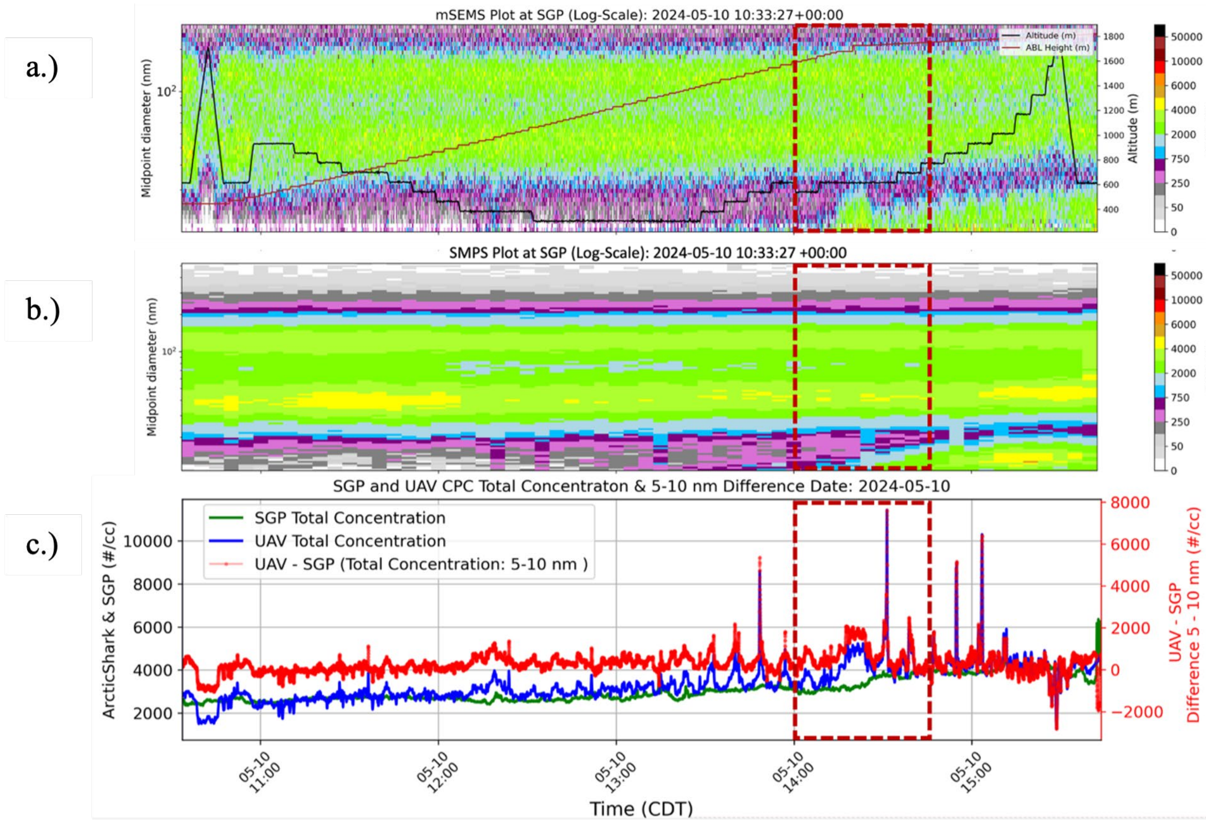

Figure 4. Comparison of aerosol measurements between the ArcticShark and surface instrumentation at the SGP field site. 4a shows the aerosol size distribution measured by the mSEMS aboard the ArcticShark, while 4b presents the aerosol size distribution from the SMPS at the SGP site. 4c displays a time series of aerosol concentration, comparing measurements from the ArcticShark (blue), the surface (green), and the difference between the two (red).

3.0 Publications and References

Carrillo-Cardenas, G. (2025, January 8). Exploring Boundary-Layer Dynamics and New Particle Formation using In Situ Land-Based and Airborne Measurements [Seminar talk]. Department of Atmospheric Science, University of Utah, Salt Lake City, Utah.

Hallar, AG, G Carrillo-Cardenas, F Mei, B Schmid, M Pekour, J Mao, and F Yu, F. 2024. Study of vertical distribution and influence of boundary-layer dynamics on new particle formation [Poster presentation]. American Geophysical Union (AGU) Conference, Washington, District of Columbia

Hallar, AG, G Carrillo-Cardenas, F Mei, B Schmid, M Pekour, J Mao, and F Yu. 2025. Study of Vertical Distribution and Influence of Boundary Layer Dynamics on New Particle Formation [Poster presentation]. 2025 Joint Atmospheric Radiation Measurement (ARM) User Facility/Atmospheric System Research (ASR) Principal Investigators Meeting, Rockville, Maryland.

Wasem, M. 2024. "ASR researchers look to the origins of new particle formation." Atmospheric System Research. https://asr.science.energy.gov/news/program-news/post/18365

4.0 Lessons Learned

Although we included needs for SGP in the ArcticShark science proposal (including additional radiosonde launches), these were not communicated to SGP staff. Principal investigator (PI) Hallar takes responsibility for this, as she did not realize that she also needed to request this in additional forms to SGP. It may be ideal to have a meeting between ArcticShark staff, on-site staff, and the PI before future campaigns to ensure all needs are communicated across the teams.