Aerosol size distributions / CCN and their temporal variability in the Southern Great Plains

Peter J. Marinescu, Ezra J. T. Levin, Don Collins,

Sonia M. Kreidenweis, and Susan C. van den Heever

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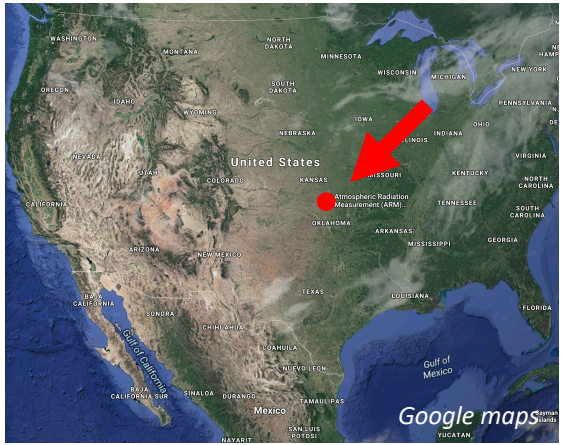
Marinescu et al. Quantifying aerosol size distributions and their temporal variability in the Southern Great Plains, USA, Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2019-131, in review, 2019.

Southern Great Plains (SGP) Site

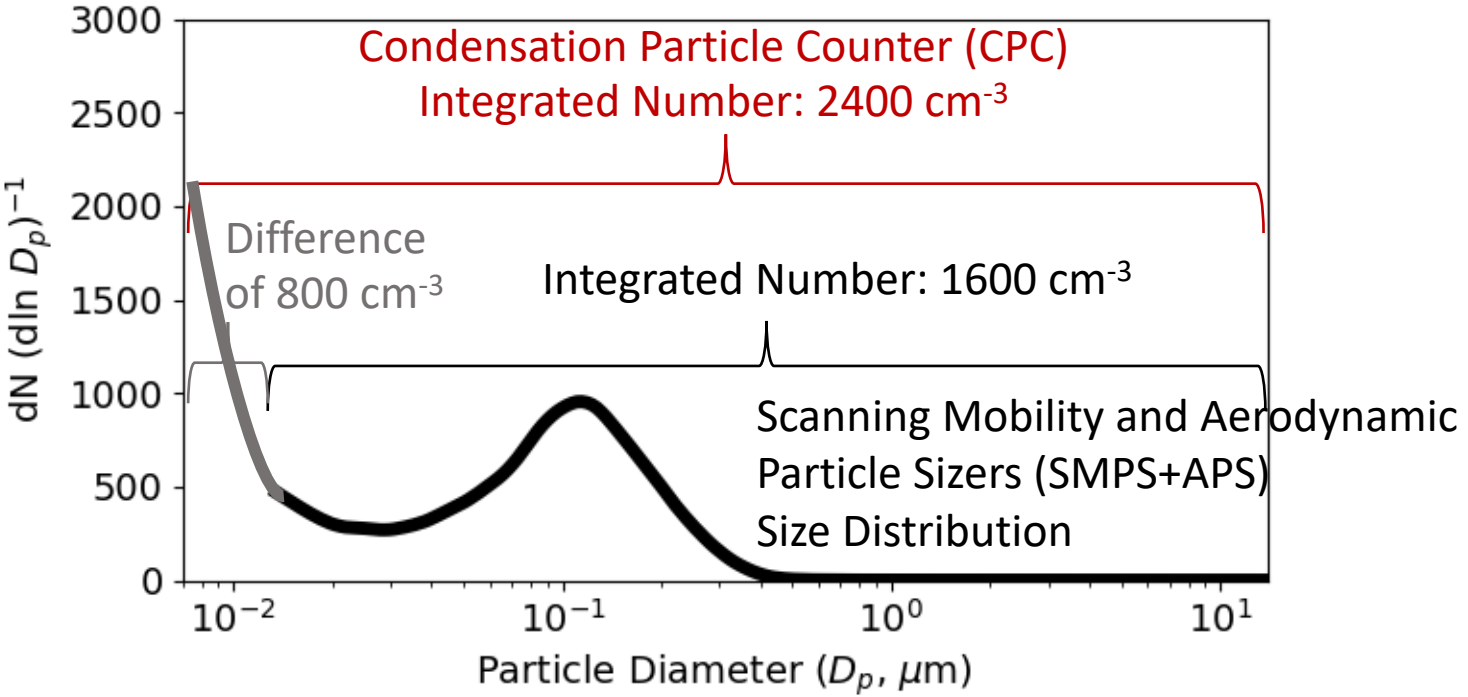


- Located in north central Oklahoma
  - Representative of a typical continental, North American site
  - Wide range of seasonally dependent aerosol conditions (e.g., Sheridan et al. 2001; Andrews et al. 2011)

- Long-term aerosol observations that allow for robust statistics
  - Scanning Mobility Particle Sizer (SMPS) (ARM Climate Research Facility 2010, 2015)
    - Part of HTDMA system (Collins 2010)
  - Aerodynamic Particle Sizer (APS) (ARM Climate Research Facility 2010, 2015)
  - Condensation Particle Counter (CPC) (ARM Climate Research Facility 2011)
  - CCN Counter (CCNC) (ARM Climate Research Facility 2011)

Combining several SGP aerosol observations (2009-2013) to better assess aerosol size distribution properties and variability

Aerosol Size Distribution Adjustments



Science Goals

1. Characterize the typical seasonal aerosol size distribution at the SGP site and the differences between seasons

2. Quantify key cycles in aerosol concentrations, ***especially for aerosol particles of different sizes***

3. Use these size distributions with hygroscopicity data to develop full CCN spectra

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Poster #8

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Today's Presentation

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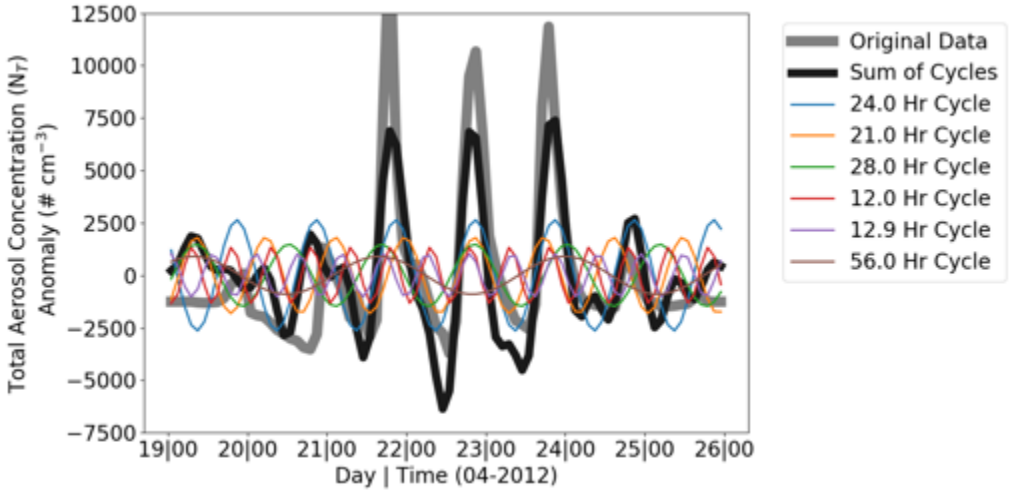
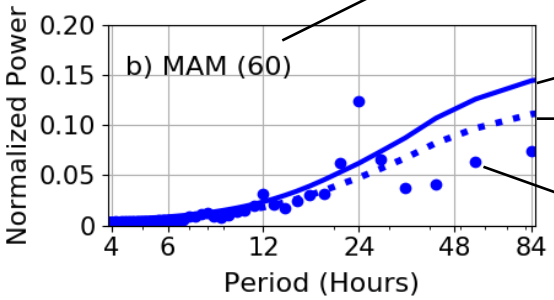
Today's Presentation

Temporal Variability and Cycles

- Power spectral analysis
  - Long-term, continuous, evenly-spaced datasets
  - Decomposing a time series into harmonic functions with different frequencies / periods
  - Power – how much each individual frequency/period contributes to the original data





Season (Sample Size)

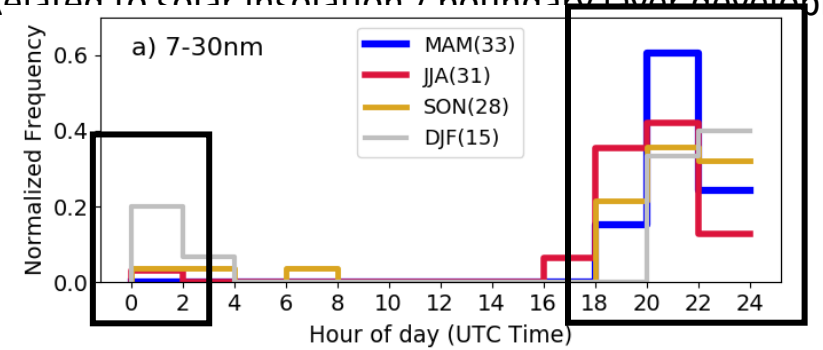
Solid Line: 99% Significance (F-Test)

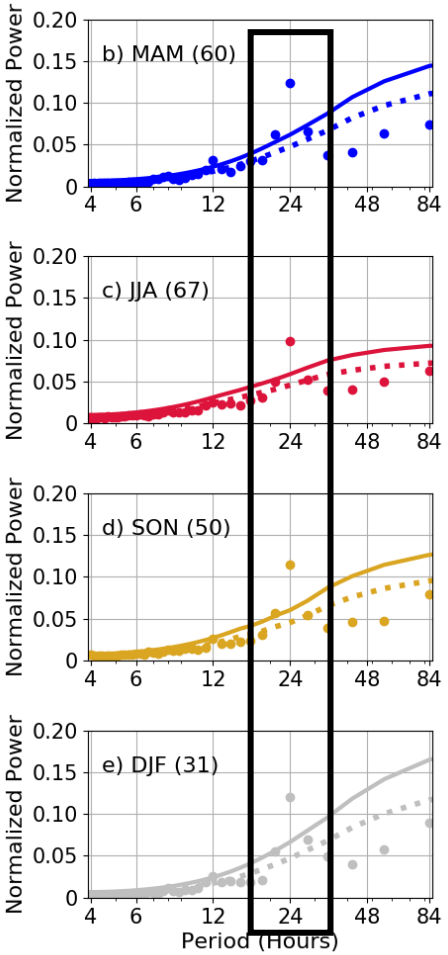
Dashed Line: Estimate of power spectrum with no cycles (red noise)

Dots: Power spectrum of SGP data

Hourly-to-Daily Cycles in the **Smallest Particles** (7nm < D_p < 30nm)

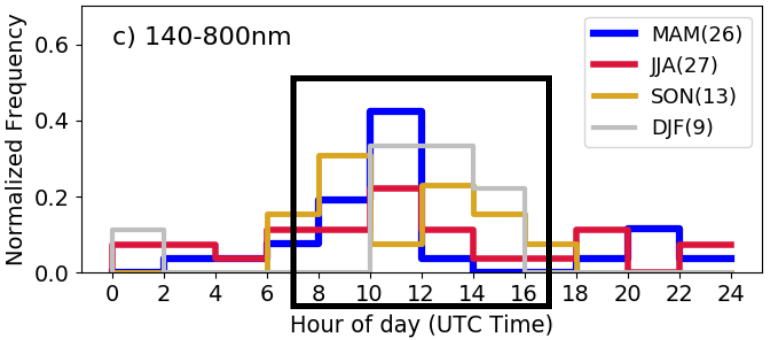
- Importance: health effects, new particle formation and growth, contribution to total number concentrations
- Significant diurnal cycles in ALL seasons
  - More than just a spring / summer phenomenon
- Timing: Diurnal cycle peak concentrations at 18-02 UTC (13-21 local time)
  - Related to solar insolation / boundary layer development

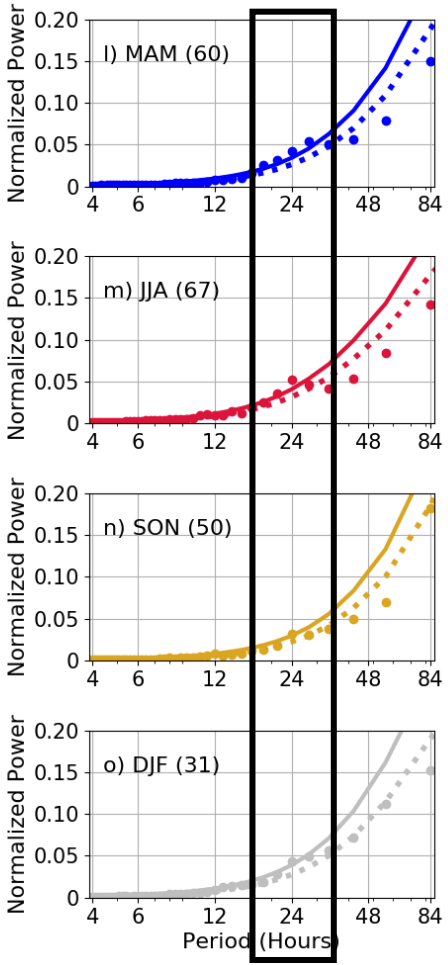




Hourly-to-Daily Cycles in the **Accumulation Mode** (140nm < D_p < 800nm)

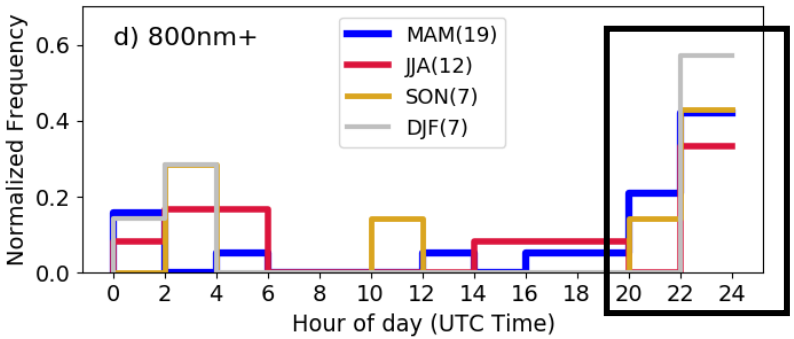
- Importance: radiative effects, cloud impacts
- Significant diurnal cycles in all seasons
  - Weaker diurnal signal as compared to the smallest particles
- Timing: Diurnal cycle peak concentrations at ~08–16 UTC (~03-11 local time)
  - Associated with nitrate and organic aerosol mass cycles

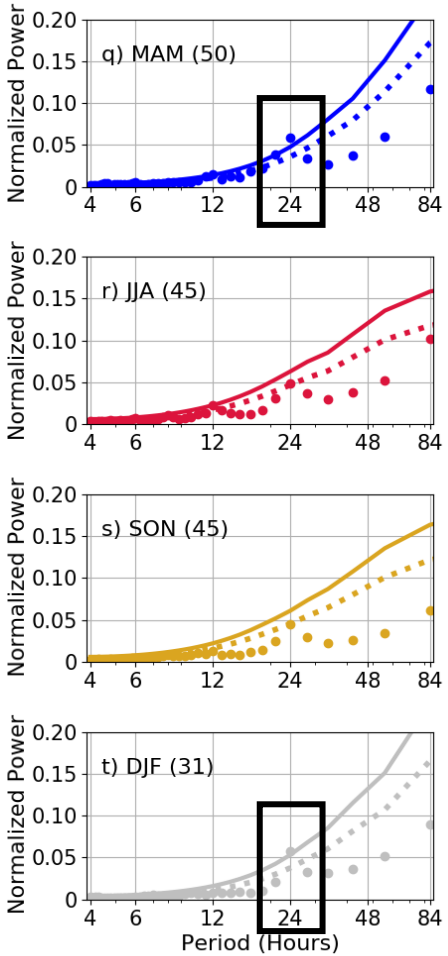




Hourly-to-Daily Cycles in the **Coarse Mode** (D_p > 800nm)

- Importance: health and radiative effects, ice nucleation
- Diurnal cycles in each season again, although most significant in MAM and DJF
- Timing: Diurnal cycle peak concentrations at ~20-24 UTC (~15-19 local time)
  - Occurs simultaneously with peak wind gusts at SGP
  - Localized lofting of large particles (e.g., dust)





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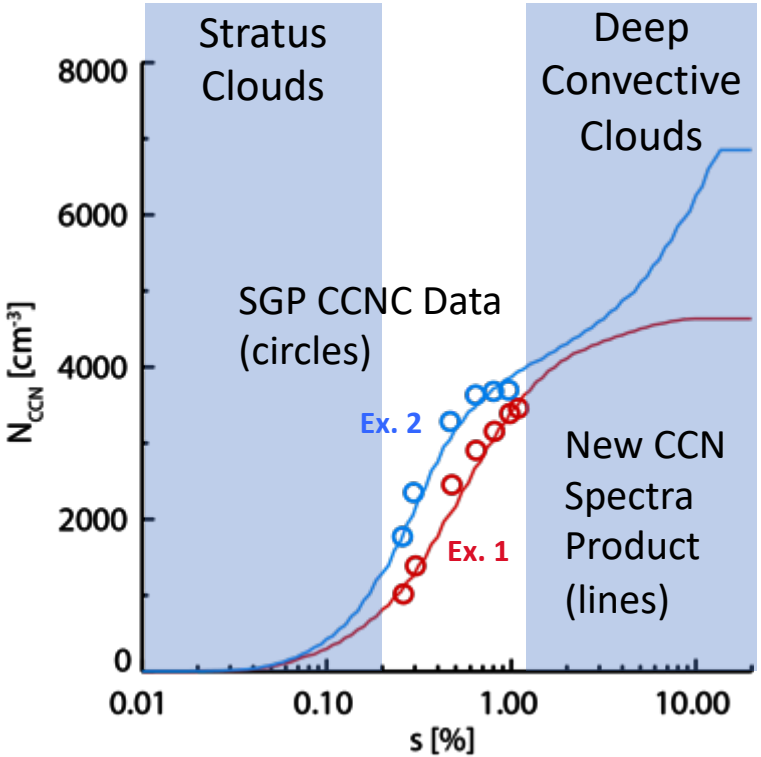
Today's Presentation

New SGP CCN Spectra Product

- Aerosol particles can impact clouds through their roles as cloud condensation nuclei (CCN)
  - CCN data have both observational and modeling applications
- SGP CCN counter (CCNC)
  - Specified saturation levels (stability range of instrument)
  - Implications for status and deep convective clouds
- Full CCN spectra (solid lines) are calculated using kappa-Kohler theory
  - Using both the aerosol size distribution data and size-resolved aerosol hygroscopicity data (HTDMA system, Collins 2010)
  - Available as a data product on the ARM archive

Two examples of CCN Spectra



Conclusions

- Utilized 5 years (2009-2013) of SGP aerosol size distribution data to:
  - Provide the typical seasonal aerosol size distributions for SGP and characterize differences between seasons (see Poster #8)
  - Calculate the key cycles in aerosol size distribution data, specifically for the 4 different lognormal modes
    - Diurnal cycles were present for almost all particle size ranges and in all seasons
    - Impacts of new particle formation and growth seen consistently throughout the year
    - Timing of cycles provide insights into key processes driving aerosol concentrations at SGP
  - Develop full CCN spectra for this time period from a range of 0.01% through 20.0% supersaturation that will be available in the upcoming months
- Questions

Contact: peter.marinescu@colostate.edu

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Multi-Day Cycles in the Total Aerosol Number Concentrations

- Longer time series needed to explore longer cycles
  - 10 years of data (2007 – 2016) of CPC concentrations
- Although no clear peaks in power spectra, several notable cyclic signals
  - 7-day cycles: MAM and SON
  - 3.5-4-day cycles: SON and DJF
  - No clear signal in JJA
  - Related to time scales of synoptic scale variability in the continental U.S.