

# New Particle Formation Events and the Impacts on Cloud Condensation Nuclei at Storm Peak Laboratory

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## Introduction and Objectives

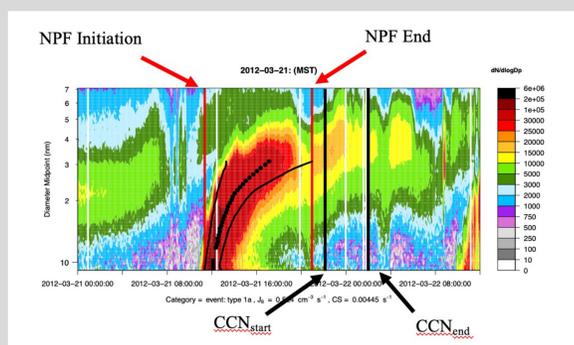
- Atmospheric aerosols are solid or liquid particles suspended in air and emitted primarily or through secondary gas to particle conversions [1].
- Nanoparticles are formed from the gas phase by nucleation and then grow through new particle formation (NPF) [2][3][4].
- Particles from NPF can affect climate by activating as cloud condensation nuclei (CCN) after reaching proper sizes and under specific meteorological and chemical conditions [5][6][7].
- In the preindustrial atmosphere, NPF contributed to 67% of CCN compared to 54% in today's atmosphere [5].
- Observations of NPF and CCN can provide regional understanding.
- We present 15 years of aerosol and CCN data from Storm Peak Laboratory (SPL) to evaluate the relationship between NPF and CCN.**



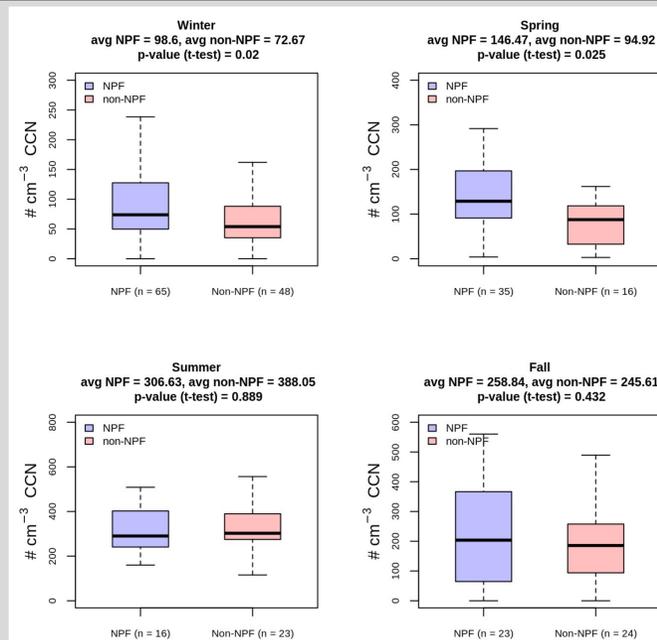
## Methods

- SPL is a mountaintop observatory in Colorado that experiences frequent NPF events especially in the spring [8].
- SMPS 3936 observes aerosols from 8 nm to 340 nm.
- DMT CCN counter directly measures CCN concentrations.
- NPF events are classified by statistical methods to analyze particle growth by fitting a linear regression to Gaussian maximums at each size bin.
- The time at which CCN consideration begins ( $CCN_{start}$ ) is the first time after NPF initiation where 25% of particles in a scan are  $> 40$  nm.
- The end time of CCN consideration ( $CCN_{end}$ ) is the last inflection point (positive to negative) of particle growth.

**Figure 1:** An example of an NPF event occurring on March 21, 2012. The points (black circles) on the plot represent the fitted Gaussians for each size bin. NPF initiation and end times are represented by the vertical lines in red.  $CCN_{start}$  and  $CCN_{end}$  are represented by vertical black lines.



## 15 years of NPF and CCN



**Figure 2:** Box and whisker plots comparing seasonal CCN concentrations ( $\# \text{ cm}^{-3}$ ) between NPF events (blue) and non-events (red). Statistical significance is determined by analyzing p-values from a t-test.

- NPF occurs on 50% of days at SPL.
- NPF significantly increases CCN concentrations in winter (factor of 1.36) and spring (factor of 1.54).
- Springtime NPF is characterized by  $\text{SO}_2$  transport from powerplants upwind and regional, persistent NPF [9].
- CCN concentrations are highest in summer and fall.
- Suggests important factors for CCN enhancement by NPF are  $\text{H}_2\text{SO}_4$  precursors, lower temperatures, pre-existing particles, and environmental conditions.

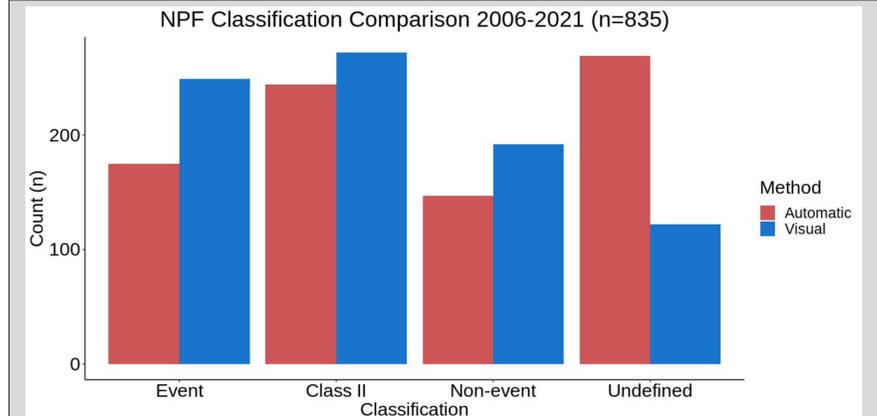
## References

- [1] Lee et al. *Journal of Geophysical Research: Atmospheres* 124, no. 13 (2019): 7098-7146. [2] Kulmala et al. *Science* 339, no. 6122 (2013): 943-946. [3] Kulmala et al. *Journal of Aerosol Science* 35, no. 2 (2004): 143-176. [4] Bzdek, Bryan R., and Murray V. Johnston. (2010): 7871-7878. [5] Gordon et al. *Journal of Geophysical Research: Atmospheres* 122, no. 16 (2017): 8739-8760. [6] Kerminen et al. *Environmental Research Letters* 13, no. 10 (2018): 103003. [7] Stocker, Thomas, ed. *Climate change 2013: the physical science basis: Working Group I contribution to the Fifth assessment report of the Intergovernmental Panel on Climate Change*. Cambridge university press, 2014. [8] Hallar et al. *Atmospheric Environment* 45, no. 24 (2011): 4111-4115. [9] Yu, Fangqun, and A. Gannet Hallar. *Journal of Geophysical Research: Atmospheres* 119.21 (2014): 12-246.

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## Automatic vs. Visual Classification



**Figure 3:** A comparison of automatic classification techniques (red) to visual classification (blue). The "event" category includes type 1a events and type 1b events.

- Raw agreement is 51%.
- Agreement is 79% after coupling classification categories into events (event and class II) and non-events (non-event or undefined).
- Removing undefined days due to lack of Gaussians increases the agreement to 85%.
- Future work aims to further refine methodology to improve both automatic and visual classification.

## Conclusions and Future Work

- Automatic methods provide an efficient way to classify NPF events and determine times when NPF is enhancing CCN.
- NPF events occur on 50% of days at SPL.
- CCN is significantly enhanced by NPF during the winter and spring.
- Automatic methodology compares well to visual classification.
- Future work aims to widely implement automatic methods and further analyze long-term CCN trends.
- Upwind powerplants will be decommissioned in the next decade.



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