SAIL-Net: Investigating spatial variability of aerosol and cloud nuclei in mountainous terrain

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SAIL-Net Introduction

SAIL-Net was a DOE funded project in the East River Watershed (ERW) near Crested Butte, Colorado with the goal of advancing our understanding of aerosol-cloud interactions in complex, mountainous regions. Through the deployment of a network of six low-cost microphysics nodes in Fall 2021 in the same domain at the SAIL campaign, SAIL-Net supported the SAIL campaign by observing additional aerosol variability that could be missed by SAIL alone. Each SAIL-Net site provided data on aerosol size distribution using the Portable Optical Particle Spectrometer (POPS), cloud condensation nuclei (CCN) using the CloudPuck, and ice nucleation particles (INP) using the TRAPS. All three instruments are manufactured by Handix Scientific.

The SAIL-Net network enables the investigation of small-scale variations in complex terrain. The six SAIL-Net sites were selected to span the SAIL domain and cover a large portion of the elevations present in the ERW. Table 1 provides a list of the six sites with their locations, elevations, and descriptions of the sites. Figure 1 shows a map of the six sites.

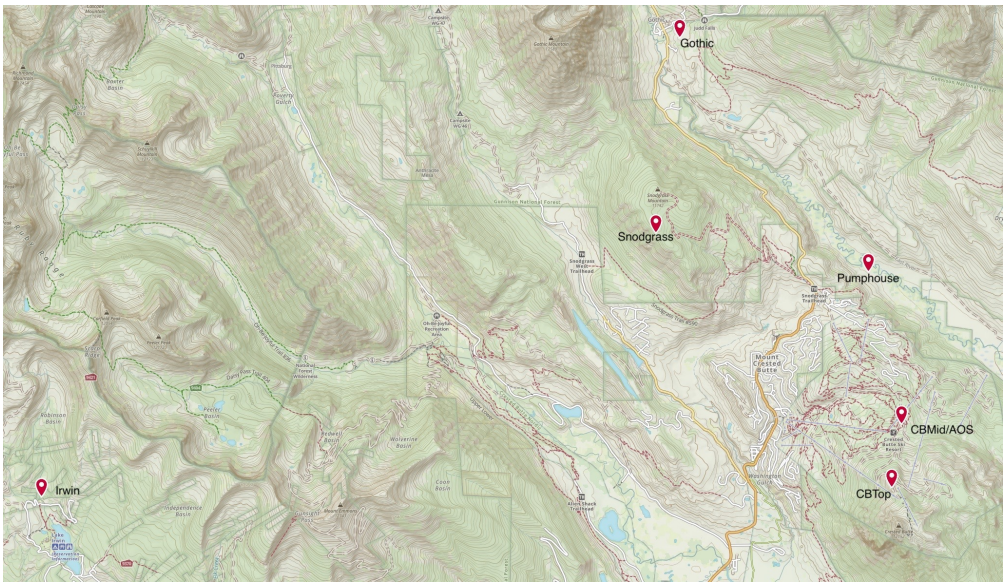

Figure 1: A map of the network of six sites in the East River Watershed near Crested Butte, Colorado. The network spans approximately 5 miles vertically (North-South) and 9 miles horizontally (East-West).

Site Name	Location	Elevation	Vegetation	Description
Pumphouse	38.921°N, 106.949°W	2768 m	Meadow	Instrumentation on scaffolding; running on solar power; located near the East River
Gothic	38.956°N, 106.986°W	2916 m	Meadow	Colocated with AMF2; instrumentation on scaffoling; running on ground power; located near busy dirt road in summers
CBMid	38.898°N, 106.943°W	3137 m	Meadow/Forest	Colocated with AOS; instrumentation mounted of AOS trailer; running on ground power; near groomed ski run in winter
Irwin	38.887°N, 107.109°W	3177 m	Evergreen Forest	Instrumentation on scaffolding; running on solar power; located near snowcat road in winter
Snodgrass	38.927°N, 106.991°W	3330 m	Meadow/Evergreen and Aspen Forest	Instrumentation on scaffolding; running on solar power, remote location but directly north of Crested Butte town
CBTop	38.889°N, 106.945°W	3468 m	Evergreeen Forest	Instrumentation on shared tower; running on solar power

Table 1: Descriptions and location of the six sites in SAIL-Net's network.

About the CloudPuck

The Handix Scientific CloudPuck uses a static gradient diffusion chamber (SGDC) design, in which a supersaturation profile is generated between a pair of horizontal, wetted, and temperature-controlled plates. The supersaturation profile is established by cooling the bottom plate, causing linear gradients of temperature and water vapor partial pressure between it and the top plate. Saturation vapor pressure has a non-linear dependence on temperature, giving rise to a parabolic supersaturation profile with a maximum supersaturation close to the center of the chamber. A pump draws sample air into the measurement chamber and then turns off. When the pump is off, a supersaturation gradient quickly forms in the chamber and particles capable of acting as CCN at those conditions take up water and form droplets. CCN are detected by counting the number of cloud droplets activated using measurements of light scattering. The sample is the volume illuminated by a laser beam and imaged by the camera (roughly 0.073 cm^3).

The CloudPuck has a time resolution of about 30 seconds, depending on operating conditions, and can measure at supersaturations between 0.1 to 3.0% by adjusting the temperature gradient between the plates.

The CloudPuck requires a liquid water reservoir, which was enlarged for this study to allow for less frequent site visits. However, harsh winter conditions caused these reservoirs to freeze, so we only have ClouckPuck data for summer/fall 2022.

CloudPuck Data Processing

For SAIL-Net, instruments were pre-programmed to cycle through three different supersaturation settings every hour, measuring at each setpoint for 15 minutes and allowing 5 minutes for the instrument to stabilize between setpoints. The temperature gradient between the two plates was set to either 2, 4, or 6 °C, which converts to roughly 0.1%, 0.5%, and 1% supersaturation with respect to water, calibrated using size selected ammonium sulfate aerosol.

The raw CloudPuck data reports the status of the pump (on or off), the temperature gradient, and the number of CCN counted at a one second interval. To process this into meaningful results, we do the following for each temperature gradient batch:

- Determine the maximum number of CCN counted while the pump is off and use this as the total number of activated particles for that batch.
- Average the CCN counts over the multiple batches in the 15 minute period.
- Convert the counts to concentration.

Within an hour, we gain approximately three data points for three different supersaturations. These resulting concentrations results are reported in the data here. Incorrect data have been removed, so the reported data are what we believe to be as accurate as possible.

Please direct additional questions to Leah Gibson, lgibson@handixscientific.com.