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Next-Generation Video Ice Particle Sampler Field Campaign Report

C Schmitt

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C Schmitt, University of Alaska, Fairbanks

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Executive Summary

The next-generation video ice particle sampler (ngVIPS) was operated on the U.S. Department of Energy (DOE) Atmospheric Radiation Measurement (ARM) user facility's tethered balloon system (TBS) during the IFFExO (Ice Fog Field Experiment at Oliktok Point) project in November, 2020. The purpose of the project was to study ice fog microphysics and the environmental conditions during ice fog to enable better predictions during low-visibility conditions. This project was conducted at the site of the third ARM Mobile Facility (AMF3) at Oliktok Point, Alaska. Among a suite of other instruments, the ngVIPS was operated to observe atmospheric ice particles.

This was the first deployment of the ngVIPS and, as with all new instrumentation, there were challenges, but good data were collected for some flights. As presented at the International Conference on Clouds and Precipitation (ICCP) in the poster led by Gultepe et al. (titled: IFFExO Arctic Ice Fog Microphysics Study: Impact on Local weather and Climate), all of the measurements were conducted when the surface temperature was warmer than -20C and, not surprisingly, the bulk of the particles observed were water droplets.

The ngVIPS was operated at one of its lower magnifications, leading to particles all appearing to be near the pixel size limit. However, the field of view was much larger and therefore the sample volume was quite high. Due to the limitations of sizing particles smaller than 50 microns, analysis has solely been conducted to estimate relative particle concentrations rather than to determine exact particle size distributions.

Data analysis: Data quality ranged from great to OK to challenging. For the "great" periods, the ngVIPS operated nearly perfectly. For the OK periods, some image manipulation was required to get good data, but the analysis is the same quality as for the "great" periods. For the "challenging" periods, data will not be archived by the time of submission of this report. Significant investigation will be required to determine if it is possible to retrieve useful results. For the analyzed periods, relative concentrations will be uploaded to the ARM Data Center around the time of submission of this report.

Acronyms and Abbreviations

AMF	ARM Mobile Facility
ARM	Atmospheric Radiation Measurement
DOE	U.S. Department of Energy
ICCP	International Conference on Clouds and Precipitation
IFFExO	Ice Fog Field Experiment at Oliktok Point
LED	light-emitting diode
NCAR VIPS	National Center for Atmospheric Research Video Ice Particle Sampler (the predecessor of the ngVIPS)
ngVIPS	next-generation video ice particle sampler
RH	relative humidity
TBS	tethered balloon system

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1.0 Background

The Ice Fog Field Experiment at Oliktok Point (IFFExO) project was designed to study ice fog microphysics and its environmental conditions to better monitor and predict low-visibility (high-extinction) conditions and their impact on local weather and climate. The project was conducted at the U.S. Department of Energy (DOE) Oliktok Point, Alaska ARM Mobile Facility (AMF3) site, during November 10-20, 2020. The main goal was to characterize ice fog conditions based on microphysical and aerosol properties such as ice nucleating particles, flow dynamics (e.g., velocity and turbulence), radiation, and environmental thermodynamics (e.g., relative humidity [RH], air temperature).

The ngVIPS was included in the TBS payload to image ice particles and differentiate between ice and liquid water drops. For the periods of operation, observed atmospheric particles were on the order of 90% liquid water with the occasional ice particle. The predecessor of the ngVIPS (the National Center for Atmospheric Research Video Ice Particle Sampler [NCAR VIPS]) has been used for surface ice fog observations (Schmitt et al. 2013).

2.0 Notable Events or Highlights

As a new instrument in its first deployment, a brief overview of the data collected by the ngVIPS is presented here. An interesting variety of data were observed with the ngVIPS during the project. The image below (Figure 1) is an example of an ngVIPS image including a high concentration of atmospheric particles.

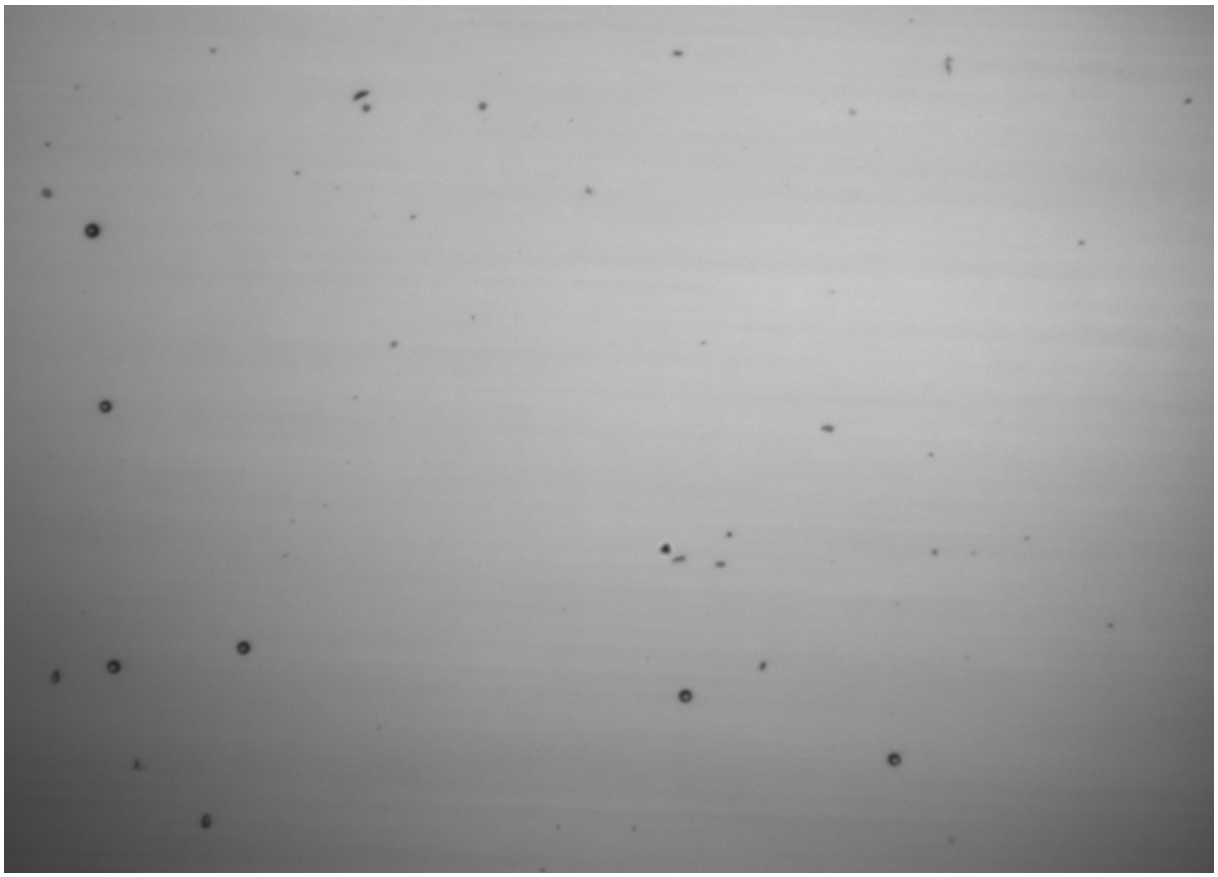


Figure 1. An ngVIPS image from a heavy fog period. The field of view is approximately 3mm across with the larger drops in the lower portion of image being approximately 30 microns in diameter. Some slightly irregular particles are visible in the frame that are likely ice particles. More typically, the particles were similar to the smaller specks in this image, indicating that they were on the order of 5-10 microns.

The previous version of the Video Ice Particle Sampler used a plastic strip for imaging that often became scratched, thus showing substantial artifacts even after a short period of operation (Matrosov et al. 2017). The ngVIPS uses a glass ring for particle capture that is much more durable. Streaks in the collection oil were also a problem with the previous version of the VIPS but were not an issue during IFFExO, likely due to the warmer temperatures during observation. Figure 2 shows an ngVIPS image from later in the campaign that displays no artifacts.

Figure 2. ngVIPS image from one of the later functional periods showing no artifacts and very little oil streaking. Note that the one particle in the center is likely a bit of dirt on the optics and was present in every image.

While not frequently observed, ice particles were occasionally observed during the functional periods. Figure 3 shows a few of the more notable ice particles observed.

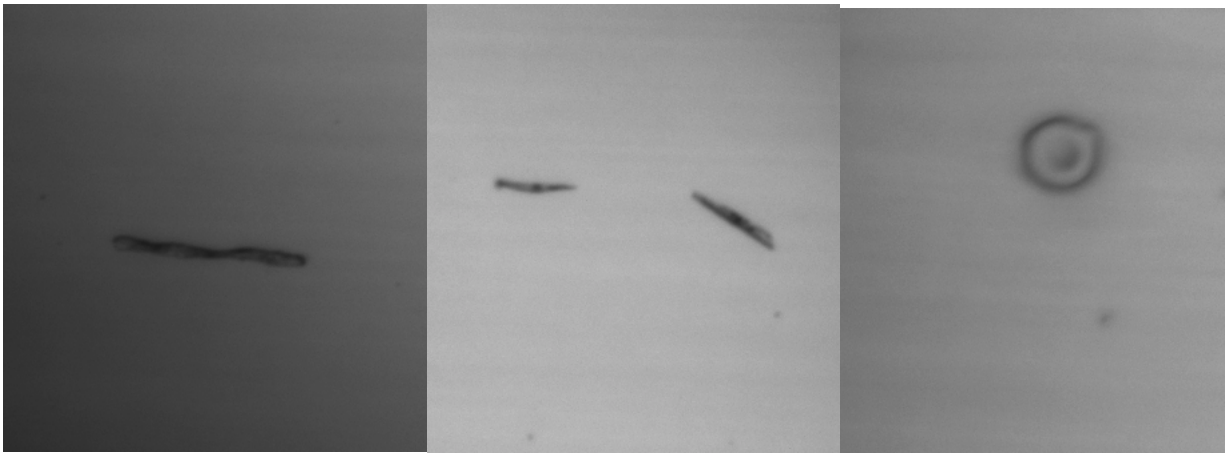
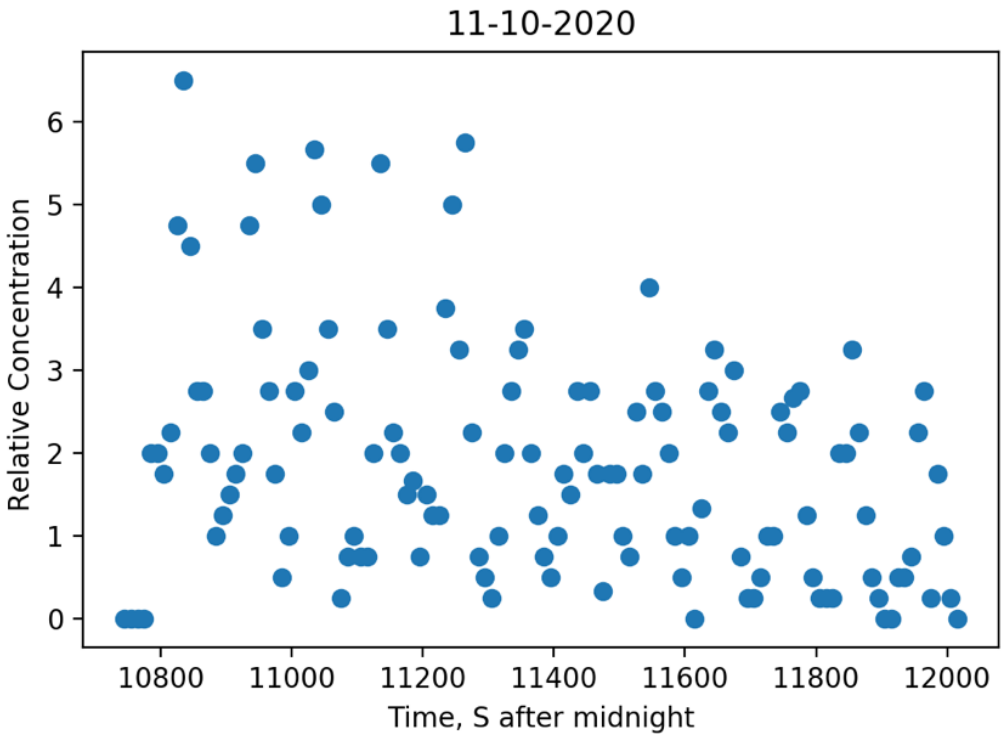


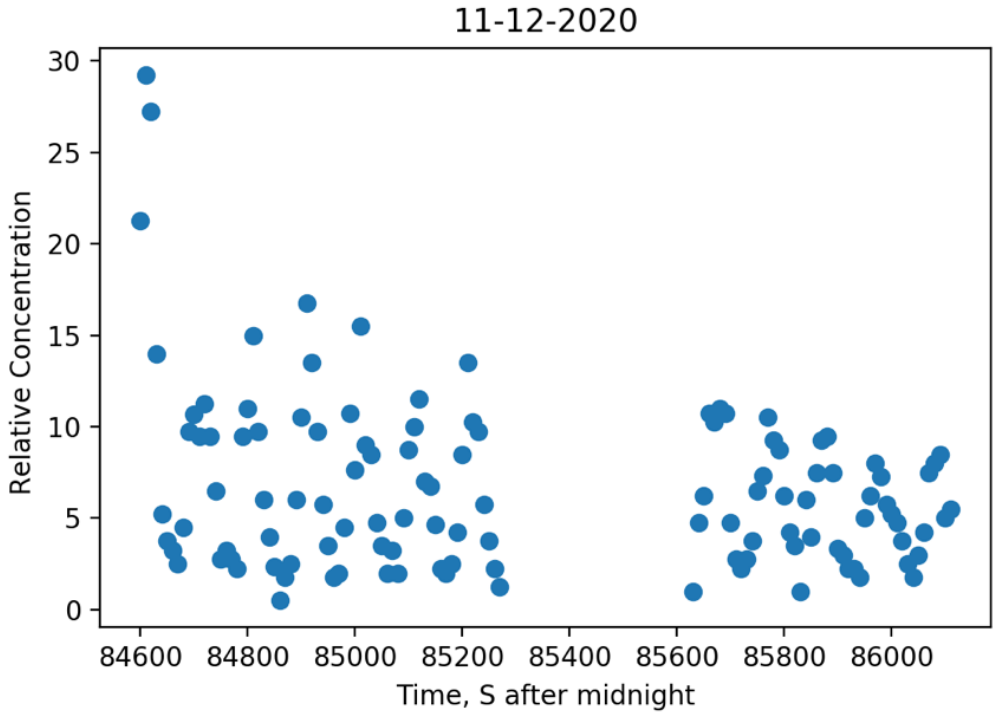
Figure 3. While rare, ice particles (mostly needles) were observed.

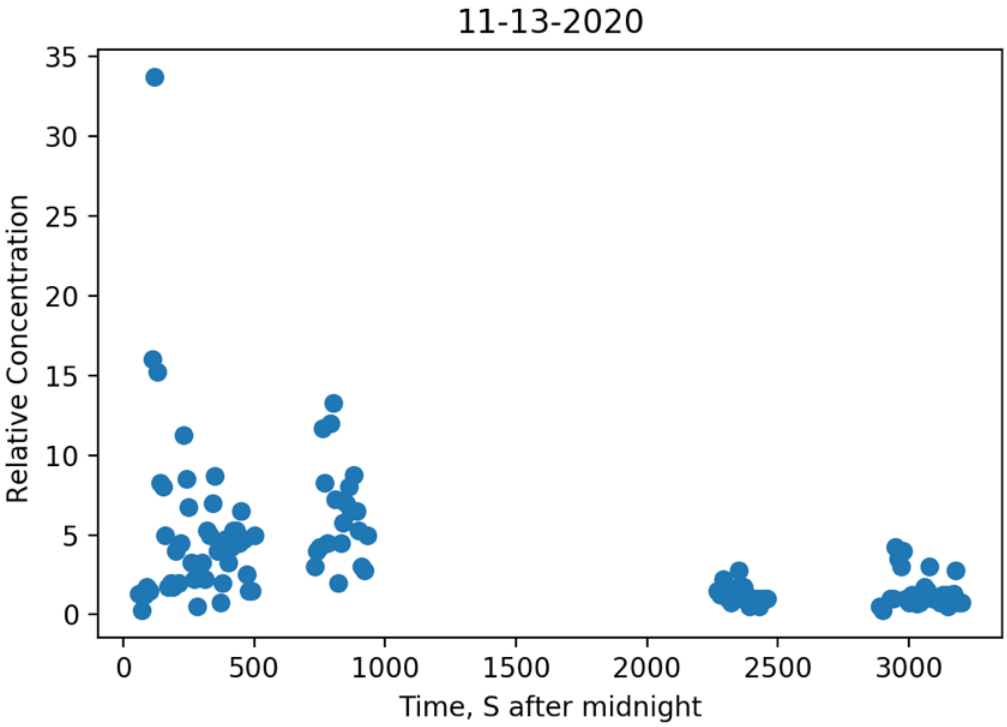
3.0 Results

As is typical with VIPS field projects, approximately 15% of the collected data has been analyzed in detail. (Guidance as to high-priority times for analysis was not provided until late August, so initial analysis focused on earlier time periods.) Additional analysis will be conducted depending on data quality.

Relative concentration time series are presented below for the three days of good data quality. For each day, approximately 500 images were analyzed representing approximately 15% of the full data set. To calculate particle concentration, the user will need to scale the results shown here by the airspeed. (Data for the archive will be prepared in this way).




11-12-2020
Relative Concentration
0
5
10
15
20
25
30
84600
84800
85000
85200
85400
85600
85800
86000
Time, S after midnight


11-13-2020
Relative Concentration
0
5
10
15
20
25
30
35
0
500
1000
1500
2000
2500
3000
Time, S after midnight

4.0 Publications

None as yet.

4.1 Meeting Abstracts/Presentations/Posters

Gultepe, I, H Fernando, M Shaw, D Dexheimer, G de Boer, Krishnamurtha, S China, R Newsom, S Waugh, A Vakhtin, and C Schmitt. 2021. "IFFExO Arctic Ice Fog Microphysics Study: Impact on Local weather and Climate." International Conference on Clouds and Precipitation.

5.0 References

Matrosov, SY, CG Schmitt, M Maahn, and G de Boer. 2017. "Atmospheric ice particle shape estimates from polarimetric radar measurements and in situ observations." *Journal of Atmospheric and Oceanic Technology* 34(12): 2569−2587, https://doi.org/10.1175/JTECH-D-17-0111.1

Schmitt, CG, M Stuefer, AJ Heymsfield, and CK Kim. 2013. "The microphysical properties of ice fog measured in urban environments in interior Alaska." *Journal of Geophysical Research − Atmospheres* 118(19): 11136−11147, https://doi.org/10.1002/jgrd.50822

6.0 Lessons Learned

The ngVIPS preformed reasonably well for its first deployment. Image quality is good and improvements to the collection surface make it vastly easier to identify real particles as there are nearly no artifacts. The main weakness during the project is suspected to be due to the deterioration of the lighting system. The imaging surface is backlit by a LED and it appears that the LED slipped out of its holder through the campaign, thus giving less light. Data quality is reduced later during the project (the 14th and later). While the deterioration of the data quality could have been reduced, further analysis will be conducted to determine if useful data can be retrieved from the later days in the project.

Due to COVID, it was not possible for the ngVIPS principal investigator to travel to Oliktok Point for the project. As I gain experience with the ngVIPS, I will develop a better operators checklist to enable testing in advance of flights to assure a higher probability of high-quality data collection.

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