Integrated Analysis of Airborne In-situ Cloud and Aerosol Microphysics Data during the 2022 The Chemistry in the Arctic: Clouds, Halogens, and Aerosols (CHACHA) Field Campaign

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CHACHA Field Project, February-April 2022

Chemistry in the Arctic: Clouds, Halogens, and Aerosols (CHACHA) is a collaborative project aiming to improve understanding of atmospheric chemistry in the Arctic using data collected during a field campaign February-April, 2022 out of Utqiaġvik, Alaska. With warmer temperatures, the Arctic has begun to experience changes in melt season, sea spray production, convection, and clouds. CHACHA was designed to explore the importance of heterogenous chemical processes (which can involve sea ice, precipitation, aerosols, cloud droplets and gaseous compounds) to atmospheric chemistry in the New Arctic, by flying within the Arctic boundary layer and sampling clouds, aerosols and gases under different conditions. Two planes were flown during CHACHA: The University of Wyoming (UWyo) King Air (KA) and Purdue ALAR. This poster highlights the cloud-focused flights, and sampling conducted via the King Air.

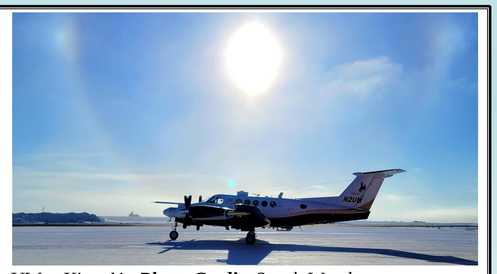
Particle-into-Liquid Samples (PILS) obtained at 3-minute time resolution during CHACHA are low in sample volume (~1.5mL), requiring samples to be combined for some of the offline chemical analyses planned. In this study, cloud and aerosol microphysical datasets were evaluated, and protocols were developed to determine which samples might safely be combined.



Photo of "Sea Smoke" emanating from the open ocean surface off the coast of Utqiaġvik AK during a UWyo KA flight on March 22, 2022. ***Photo Credit:*** *Sarah Woods*

UWyo King Air Flights

During CHACHA, the Uwyo King Air flew 16 Cloud-focused flights, including 15 Lead Cloud-focused flights. Lead clouds form over breaks in sea ice where the ocean and atmosphere can interact.



UWyo King Air. ***Photo Credit****: Sarah Woods*

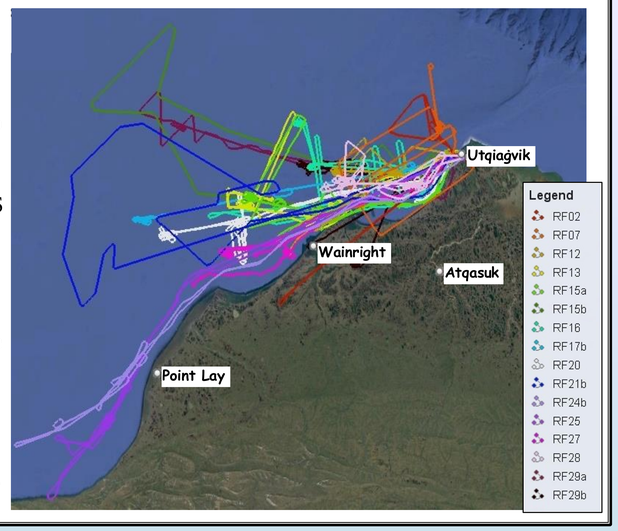
Measurements:

Instrument	Acronym	Species or property measured
Particle-into-Liquid Sampler*	PILS	Aerosol samples collected in water, allowing for subsequent offline analyses of particle composition
Counter-flow Virtual Impactor Inlet*	CVI	Inlet used to sample cloud droplet residuals (the particles remaining after cloud droplets evaporate)
Roger's Inlet*	N/A	Inlet used to sample aerosols (when sampling in clear-air) or interstitial aerosols (when sampling in-cloud)
Chemical ionization Mass Spectrometer	CIMS	Gas phase chemical speciation, including halogen compounds
Ozone	O3	ozone
Davis Rotating-drum Universal-size-cut Monitoring sampler*	DRUM	3-stage aerosol impactor, 0.1-0.34um, 0.34-1.15um, >1.15um
Portable Optical Particle Spectrometer*	POPS	Particle size distribution, 0.13-3um
Condensation Particle Counter*	CPC	Particle number concentrations, > 10nm
Cloud Droplet Probe*	CDP	Cloud droplet size distributions, 1-50um
Two-Dimensional Stereo Probe*	2D-S	Ice particle size distributions and habits, 10-2000um
Passive Cavity Aerosol Spectrometer Probe*	PCASP	Ambient particle size distribution, 0.1-3um (as sampled outside the fuselage of the King Air)
Dropsonde(s)*	N/A	Vertical profiles of wind, humidity & temperature to the surface
Radiometer*	N/A	Upwelling and downwelling radiation

**Instruments operating during cloud-focused flights onboard the UWyo King Air*

Cloud-Focused Flights

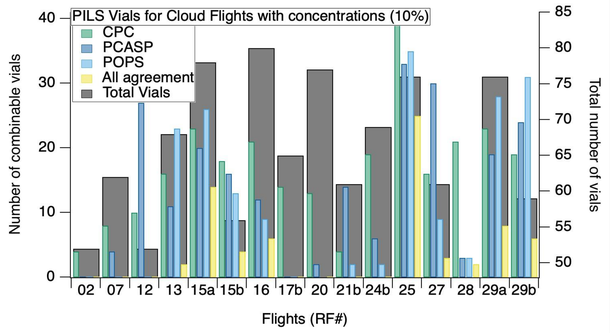
Flight tracks for all 16 Cloud-focused flights are shown at right. CVI, CDP, CPC, POPS, and PCASP data have been analyzed so far for these flights to assess the appropriateness of combining specific PILS samples. Research Flight RF20 was missing POPS data. Altitude, latitude, and longitude data have also been evaluated for the time periods of each PILS sample. Dropsonde data is being evaluated to assess the vertical profile of meteorological parameters.

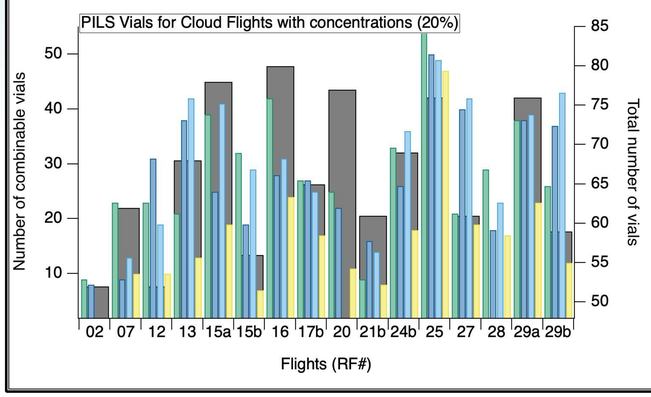


CPC, POPS, PCASP data

PILS allows aerosol samples to be collected and analyzed later in a lab setting using Ion Chromatography and Water-Soluble Organic Carbon analyzers.[1]

Averages and standard deviations of particle concentrations measured by the CPC, POPS, and PCASP were calculated. If the percent changes and coefficients of variance were ≤10%, samples were considered chemically similar and combinable. Requiring ≤10% variability for all 3 aerosol measurements (CPC, POPS and PCASP) resulted in no combinable vials for several flights. Using a threshold of 20% variability instead of 10% resulted in more potentially combinable vials, as shown below.

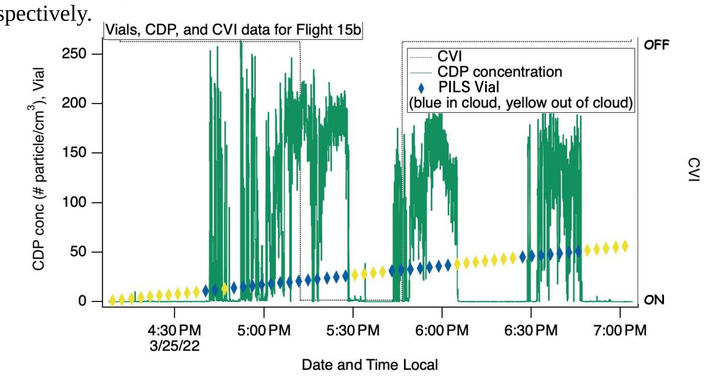




Which measurement(s) we ultimately decide to rely on for determining whether to combine vials will be based on what particle sizes we are most concerned about for specific time periods and specific flights. For example, for sea spray aerosols, we may opt to only rely on POPS data due to the larger sizes of dried sea spray particles.

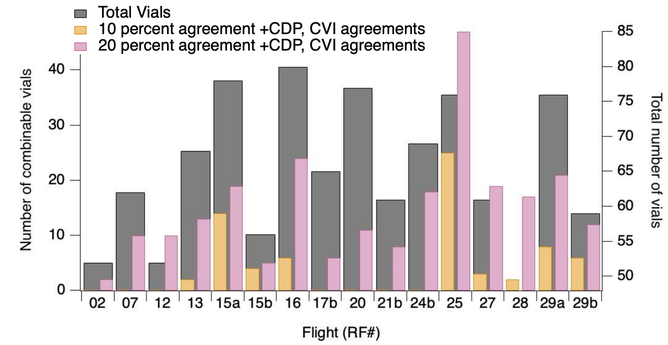
Incorporating CDP and CVI data

CDP concentrations were used to calculate how many seconds of each PILS sample was obtained while sampling in-cloud. Vials corresponding to CDP concentrations ≤10 cm^{-3} were considered potentially combinable as clear-air aerosol samples.[2] During in-cloud periods, the PILS, POPS and CPC sampled either cloud droplet residuals or interstitial aerosol when the CVI was on or off, respectively.



Combining the Data

The CVI, CDP, CPC, POPS, and PCASP data were assessed altogether below.



As shown in the graph, if all measurements are limited to 10% or 20% variation, fewer PILS vials are combinable. For future work, each flight will be assessed on what instruments are most important to consider for combination. DRUM data will also be analyzed to see if PILS samples are influenced by the same sources based on the particle size distribution.[3] Then, PILS samples will be combined and analyzed in the laboratory, which will be an important exercise to undertake with caution given their limited sample volumes, precluding repeat analyses.

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