

# Development of the routine small unmanned aerial system (sUAS) and tethered balloon system (TBS) observation

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## Introduction & Motivation

- Unmanned aerial systems (UAS) are significantly expanding observational perspectives in atmospheric science.
- Large number of recent community workshops held by various agencies supporting atmospheric science (NOAA, NASA, DOE, NSF/NCAR)
- The Inaugural Campaigns for ARM Research using Unmanned Systems, or ICARUS (2016-2017) is an internal effort of ARM's first foray into routine UAS and TBS (tethered balloon systems) operations with ARM instruments and measurement platforms to study the Arctic's atmosphere.
- The main objectives of ICARUS are:
  - Demonstrate how low-cost small UAV (sUAV) can be used to continuously study the atmosphere in the Arctic.
  - Collect spatial information about the rapidly changing Arctic environment in conjunction with ground-based instruments, which are part of the ARM Mobile Facility (AMF3).
  - Study the feasibility of routine TBS operation with aerosol payload, which include Printed Optical Particle Spectrometer (POPS, Handix Inc.) and Condensation Particle Counter (CPC, TSI 3007).
  - Characterization of North Slope aerosol properties and seasonal variability using TBS aerosol payload.
  - Understand the different processes that affect the cloud life cycle.

## sUAV Flight Patterns and Periods



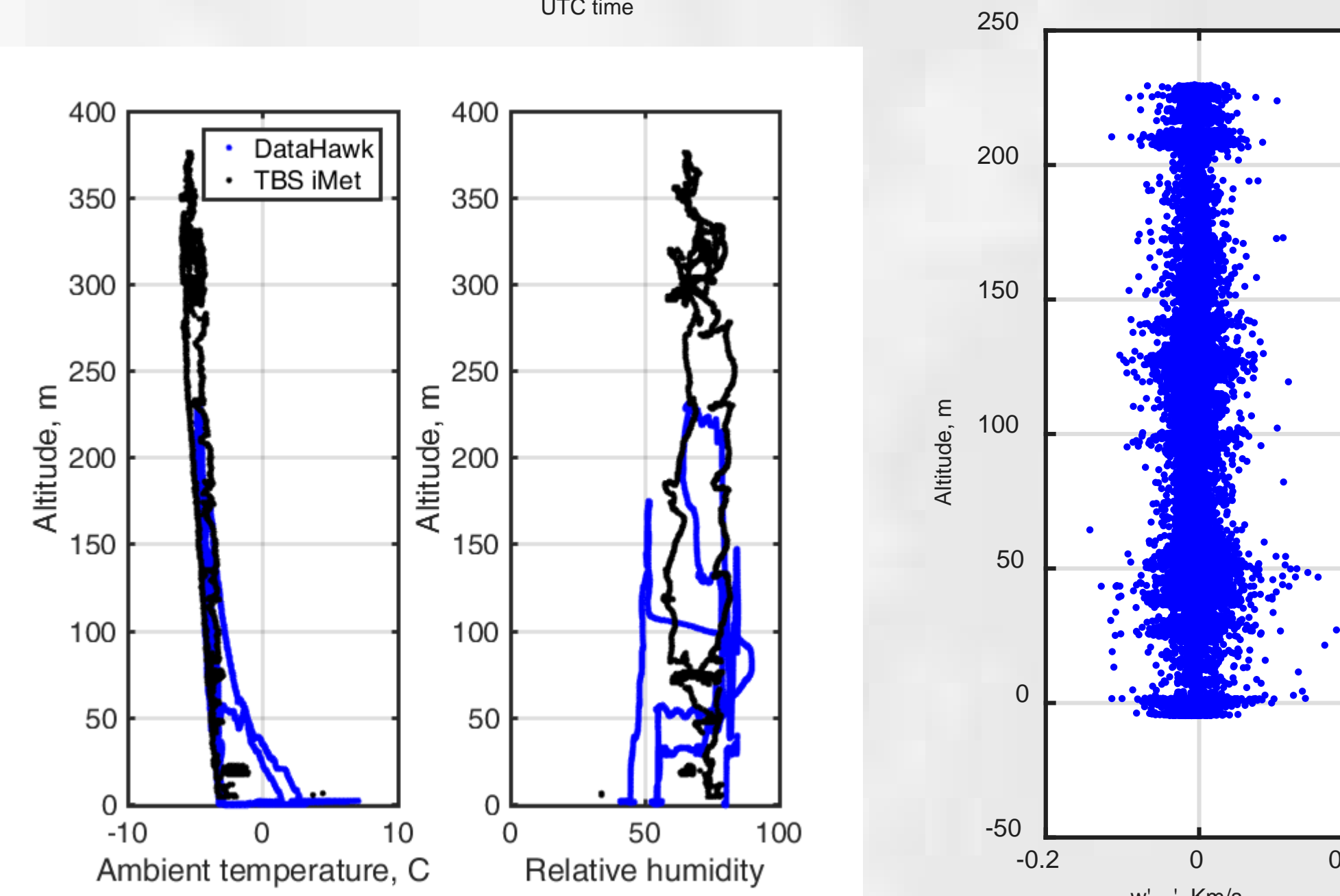
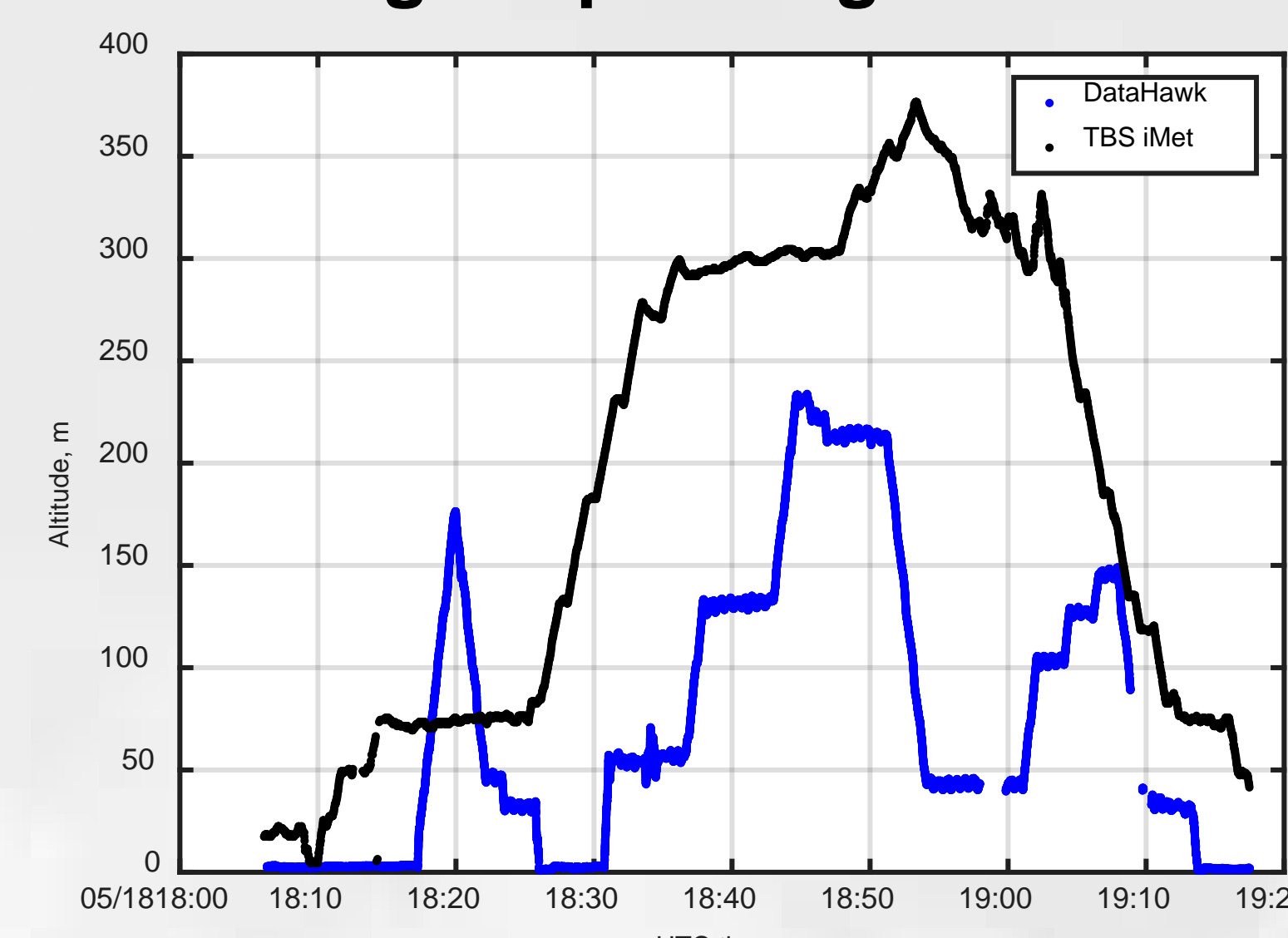
Typical sUAV and TBS flight pattern: Profiling near AMF3 or ECOR point below cloud base.

Several sampling Periods Between 06/01/2016 to 10/31/2017

<https://www.arm.gov/news/features/post/37859>

## Atmospheric profiling at Oliktok Point, AK

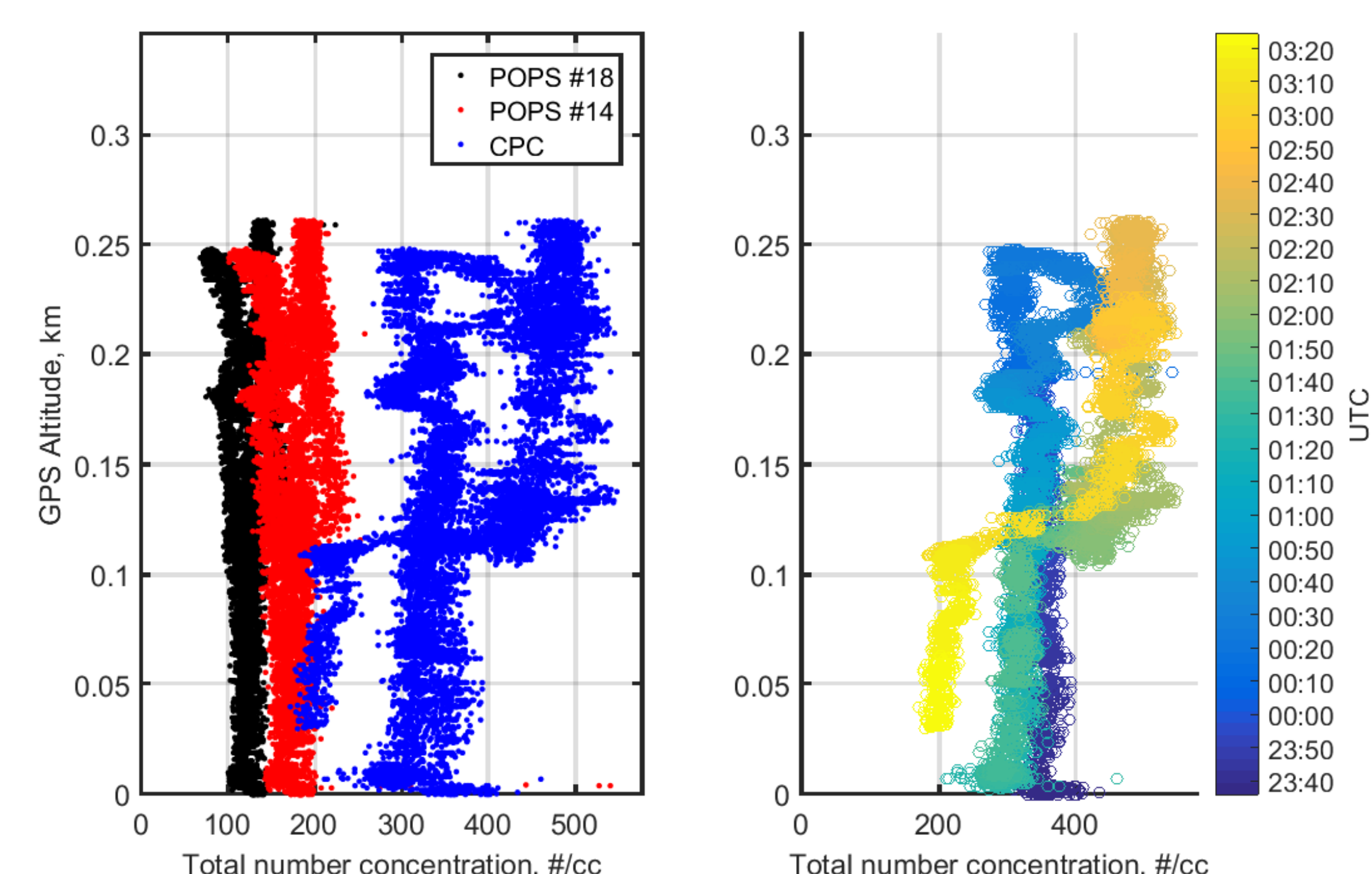
### Meteorological profiling from sUAV flights



- Reasonable good agreement in the T and RH measurements.
- The product of the vertical velocity anomaly and potential temperature anomaly

### Aerosol profiling on April 3<sup>rd</sup> 2017 from TBS flight

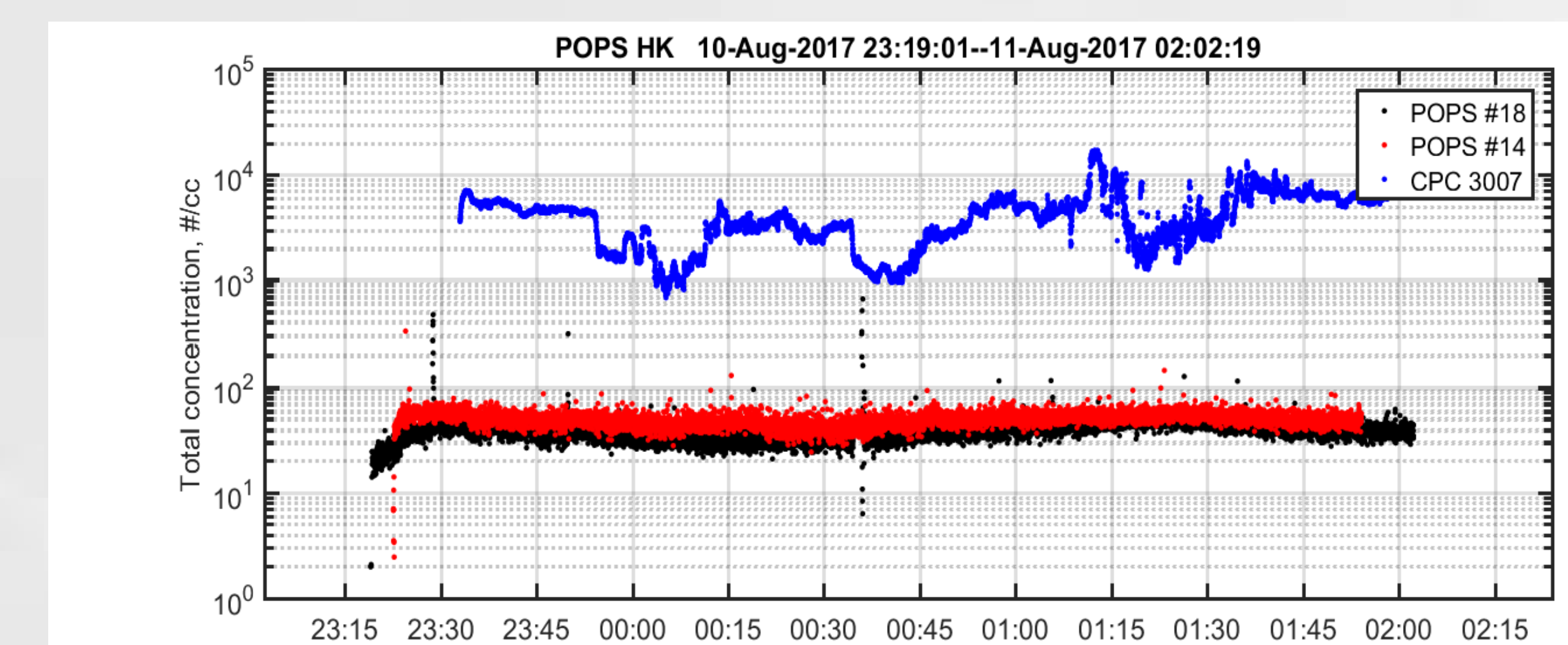
- The concentration difference between POPS #14 and #18 mainly due to the different inlet condition. POPS #14 operated at ambient temperature (-18 C) and POPS #18 inlet was heated to 24 C.
- Comparing CPC and POPS concentration, number concentration of small particles (<150 nm, Aiken mode) increased in the later afternoon.



## Preliminary results from TBS aerosol payload

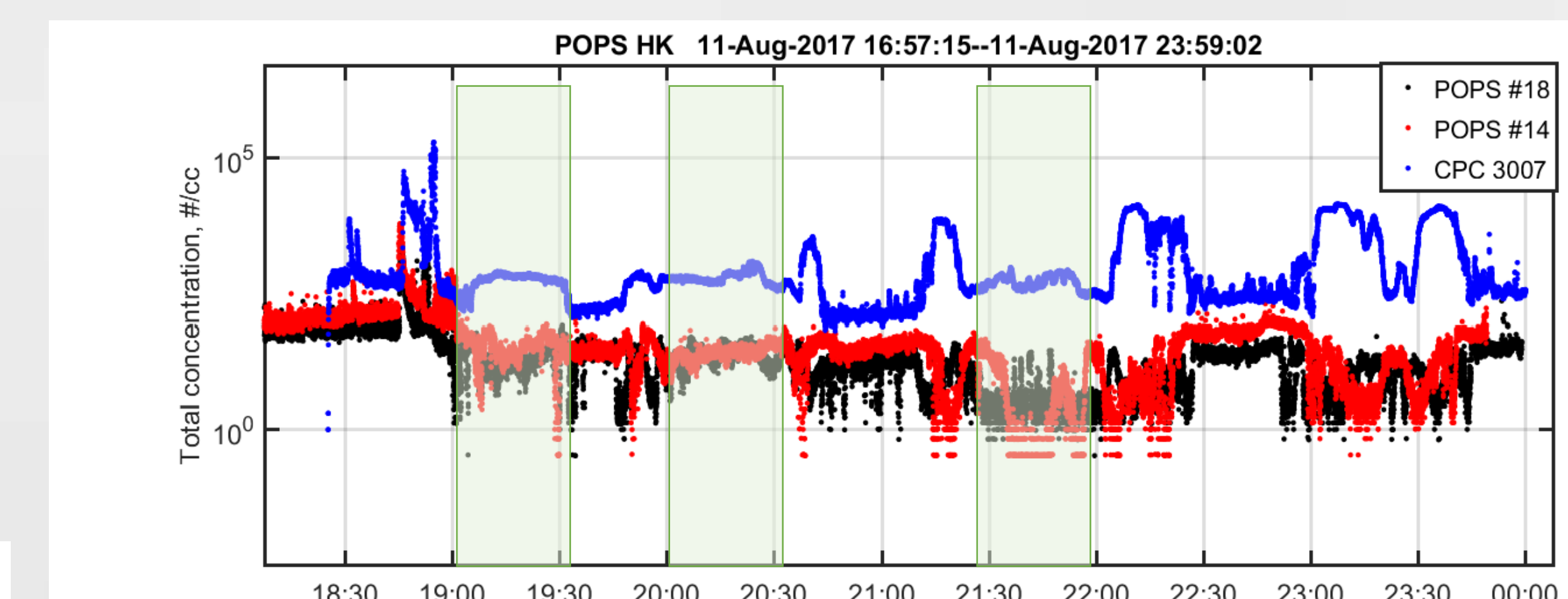
### Dominant Aiken mode particles during non-cloud day.

- 200 m AGL aerosol profiling – no cloud
- No significant change in accumulation mode
- Small particles ( $D_p < 150$  nm) dominated the area



### Significant daily variation was observed at Oliktok Point.

- Cloud base ~240 m, in-cloud sampling at 400m, 600 m and 800 m.
- No significant change in total aerosol concentration from CPC concentration.
- Significant accumulation mode aerosol concentration decreases at 800 m



400 m 600 m 800 m

## Summary

- ARM small UAS – DataHawk made good quality measurements during ICARUS.
- A turbulence parameter can be developed as a value-added product from DataHawk observation.
- Routine TBS operation with aerosol payload provides useful vertical information about Arctic environment.

