SAND2015-6960C

Past & Current Missions at ARM Alaska Sites

31 Aug 2015
Alaska UAS Interest Group

Dari Dexheimer
Joe Hardesty
Sandia National Labs

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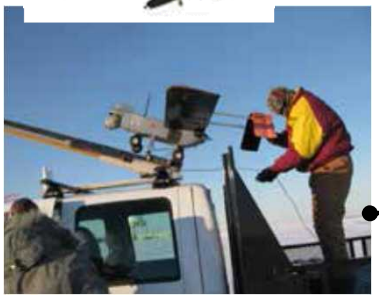
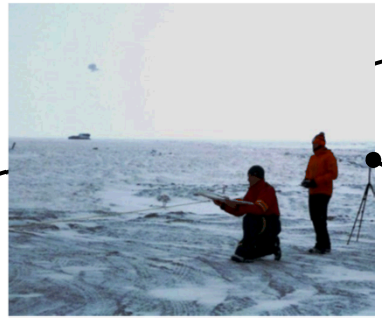
ARM-NSA and UASs: Last 15 Years





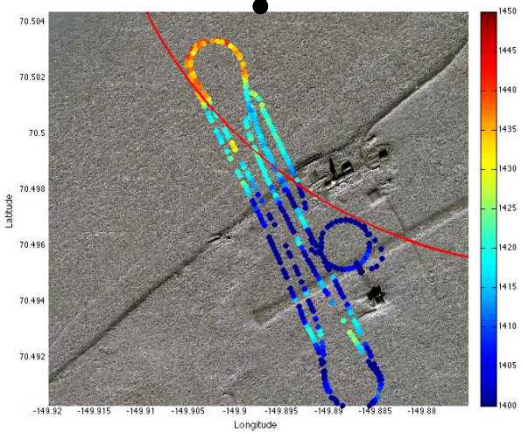






- **Past Campaigns:**
  - Aerosonde Project (2001, Barrow) with NSF and Aerosonde; using Aerosonde platform
  - IPASRC II (2001, Barrow) with UAF; included radiosondes using Vaisala RS-80 sonde
  - Simultaneous Aerosonde-Radiosonde IOPs (2002, Barrow) with ANL and NSF; using Vaisala sondes and Aerosonde platforms
  - ARM Radiosondes for NPOESS/NPP Validation (2012-15)
  - AIRS Validation radiosondes (2002-07, Barrow) with NASA, PNL and ANL; using Vaisala sondes
  - Mixed-Phase Arctic Cloud Experiment (M-PACE, 2004, Barrow, Atqasuk, Oliktok, Toolik Lake) with UAF, PSU, UIUC, UND, UWisc, PNNL and NOAA; using Vaisala sondes and ARM-Proteus platforms
  - Arctic Lower Troposphere Observed Structure (ALTOS, 2010) with SPEC, PSU, Scripps and UAF; using SPEC 78m^3 He-filled moored balloon
  - UAS Engineering Evaluations (2012, Oliktok) with NMSU; using BAT-3 and Aeryon Scout
  - Marginal Ice Zone Observation & Process Experiment (MIZOPEX, 2013-16, Oliktok) with NASA, UAF and CU; using NASA Sierra, Datahawk and ScanEagle platforms
  - Coordinated observations of the Arctic lower atmosphere (COALA, Oct 2014, Oliktok) with CIRES/UC-Boulder; using DataHawk platform.

ARM-NSA and UASs



- Recent/Current Campaigns:
  - Arctic Shield (July 2015) with USCG, Conoco-Phillips, Insitu/Boeing, NOAA, FAA, NSB and Era Helicopter; using ScanEagle platform
  - Evaluation of Routine Atmospheric Sounding Measurements using Unmanned Systems (ERASMUS-I, Aug 2015) with CIRES/UC-Boulder; using DataHawk platform
- Future Campaigns:
  - Evaluation of Routine Atmospheric Sounding Measurements using Unmanned Systems (ERASMUS-II, April 2016) with CIRES/UC-Boulder; using Pilatus platform
  - TBS (Tethered Balloon System) (Sep 2015, Oliktok) with PNNL; using SkyDoc aerostats
  - Multi-phase UAS research (tentative 2016, Oliktok) with Insitu; using Flexrotor, ScanEagle and sonde platforms
  - Arctic Shield 2016 (preliminary planning)

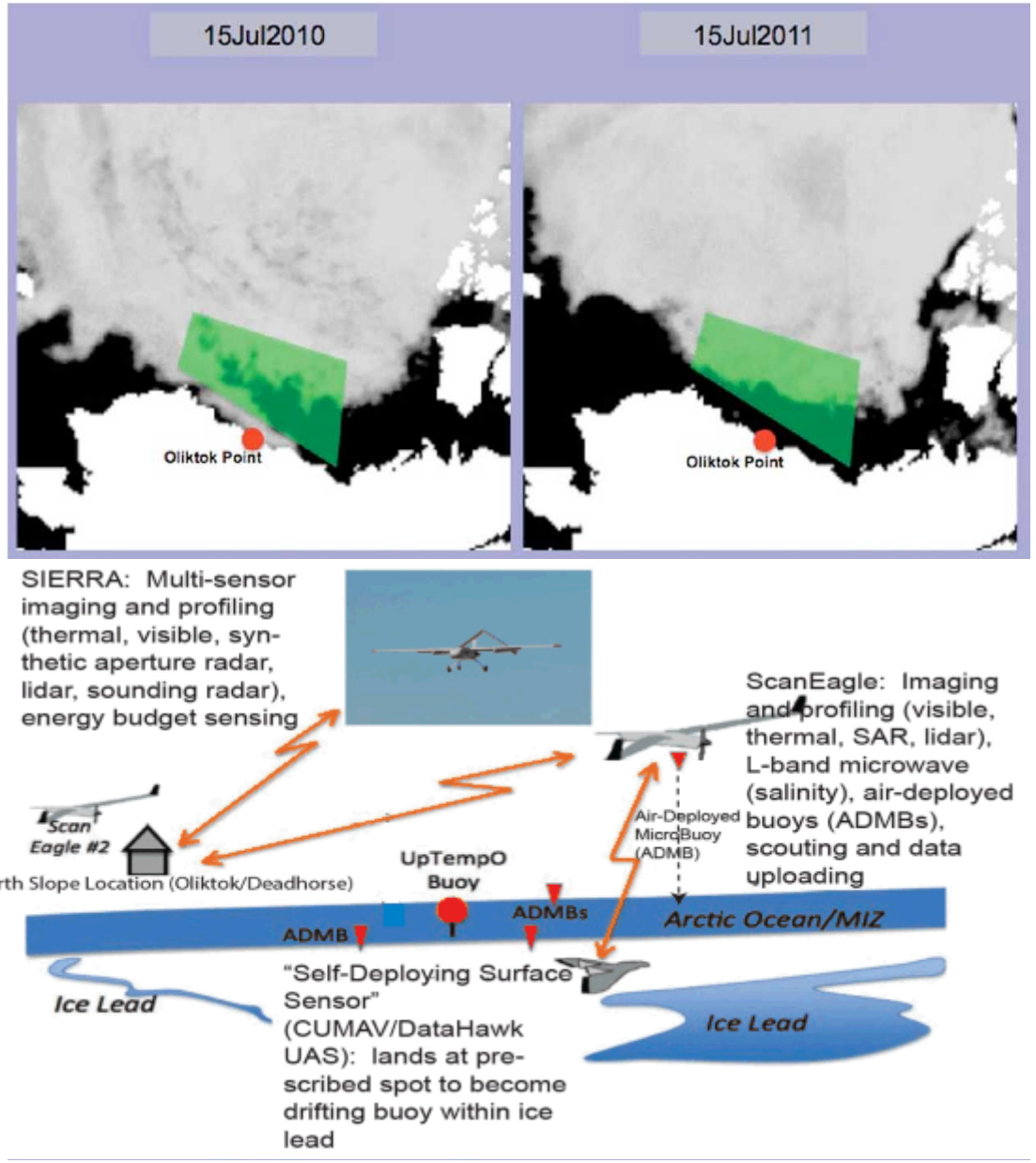
Summary of UAS and manned missions:

- MIZOPEX, July - August 2013
  - NASA Ames Research Center, University of Alaska Fairbanks, University of Colorado Boulder
- Arctic Shield, July 12-17 2015
  - USCG, ConocoPhillips, InSitu, Era Helicopter
- ACME-V, Jun 1-Sep 15, 2015
  - Manned G-1 portion of program with PNNL and SNL
- ERASMUS, Aug 2- 16, 2015
  - University of Colorado Boulder, NASA, University Corporation for Atmospheric Research
- TBS, September 2015-2016
  - SNL and PNNL

MIZOPEX Science Goals

Marginal Ice Zones Observations and Processes Experiment: July - August 2013

- Clarify relationships between ocean skin temperatures and subsurface temperatures
- Understand how these temperatures evolve over a summer season
- Measure variability in sea ice thickness, age, and albedo in the Marginal Ice Zone
- Study interaction of SST, salinity, and ice conditions during the melt cycle
- Perform validations of satellite-derived SST and sea ice concentration fields



MIZOPEX

Wing Span: 20 ft.
Length: 11.8 ft.
Height: 4.6 ft
Wing Area: 42.4 sq. ft.
Empty Weight: 215 lbs.
Gross Weight: 370 lbs.
Max Speed: 80 kts.
Cruise Speed: 55 kts.
Stall Speed (clean): 30 kts.
Rate of Climb: 550 ft./min.

Wingspan: 10.2 ft, Length: 4.5 ft
Weight: 29 lbs (empty), 44 lbs (max takeoff wt.)
Gas engine (1.9 hp), rear propeller, onboard generator for electric power
48 knot airspeed (cruise)
Catapult launch, wing tip capture via cable
Autonomous flight control with GCS control while in line of sight radio range (approx 40 km)
Iridium satcom for over the horizon operations
Endurance: 20+ hours
Ceiling: 19,500 ft.
Payload: up to ~6 lbs.

Wingspan: 1m
Weight: ~700 gm
Electric propulsion
Rear folding propeller
14 m/s airspeed
Power: 40-min lifetime battery
Cost: ~ $600
Airframe: EPP foam
Autonomous flight control, with user supervision while in comm. range
Comm. range: about 5km
Flight range: ~30 km
Has received multiple Certificates of Authorization from FAA

MIZOPEX Payloads

Sierra Systems

System Name	System Type	Geophysical Measurement	Affiliation
DMS	Visible Still Camera	Ice Concentration, Topography, Melt	NASA WFF
MIS	Pyrometers	Skin SST, Ice Surface Temperature	
	Spectrometers	Spectral Radiance, Albedo	
	Pyranometers	Solar Irradiance, Albedo	
Applanix	GPS, IMU	Aircraft Position, Attitude	
Bobcat	Visible Still Camera	Ice Concentration, Topography, Melt	LDEO
Jade	Thermal IR Still Camera	Skin SST, Ice Surface Temperature	
Shallow Ice Radar	L-Band Radar	Snow & Ice Thickness	
Snow Radar	Ultra-Wideband Radar	Snow Thickness	CReSIS
BESST	Thermal IR Still Camera	Skin SST, Ice Surface Temperature	Ball
SlimSAR	Imaging SAR	Ice Concentration, Roughness	Artemis
CULPIS	Profiling Laser Altimeter	Ice Thickness, Topography	CU
AIS	VHF Communications	Ship Identification and Tracking	NOAA

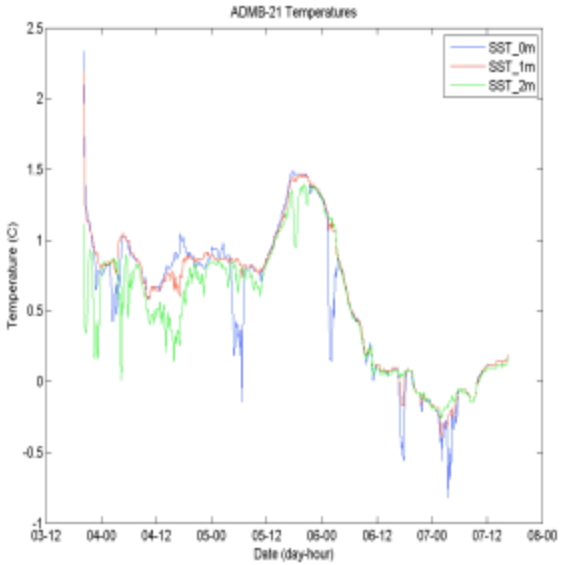
MIZOPEX Payloads

ScanEagle & Buoy Systems

System Name	System Type	Geophysical Measurement	Affiliation
NanoSAR	Imaging SAR	Ice Concentration, Roughness	UAF
Gimbal	Visible Video Camera	Ice Concentration, Melt	
Bobcat	Visible Still Camera	Ice Concentration, Topography, Melt	LDEO
Atom	Thermal IR Still Camera	Skin SST, Ice Surface Temperature	
ADMB	Surface Buoy	Bulk SST	CU
CULPIS	Profiling Laser Altimeter	Ice Thickness, Topography	
Ariel	Microwave Radiometer	SSS	UPC
BESST	Thermal IR Still Camera	Skin SST, Ice Surface Temperature	Ball

System Name	System Type	Geophysical Measurement	Affiliation
SDSS	SRE UAS & Surface Buoy	Bulk SST	CU
UpTempO	Surface Buoy	Bulk SST	APL-UW

ADMB: Air Deployed Micro Buoys



Arctic Shield

July 12-17 2015

USCG exercise to explore how UAS can be used to enhance capabilities for its Search and Rescue (SAR) mission and gain a better understanding of how it could work jointly with private industry for response operations in remote regions.

Simulated PIW (human heat signature)

Operational scenario:

Small plane has gone down off Oliktok Point

- CGC Healy begins searching
  - Conoco Phillips asks Insitu to launch ScanEagle from Oliktok Point in DOE's Restricted Airspace and transit out to CGC Healy
    - ScanEagle pilot-operated Ground Control Station (GCS) onboard CGC Healy takes control of ScanEagle and flies search pattern to locate persons in the water (PIWs)

Arctic Shield

July 12-17 2015

One USCG and one Era helicopter locate PIW and send in divers

Launch and recovery of ScanEagle at ARM's AMF3 facility at Oliktok Point during Arctic Shield 2015. Video shot on 7/13/15 by Brian O'Kronley of Fairweather LLC.

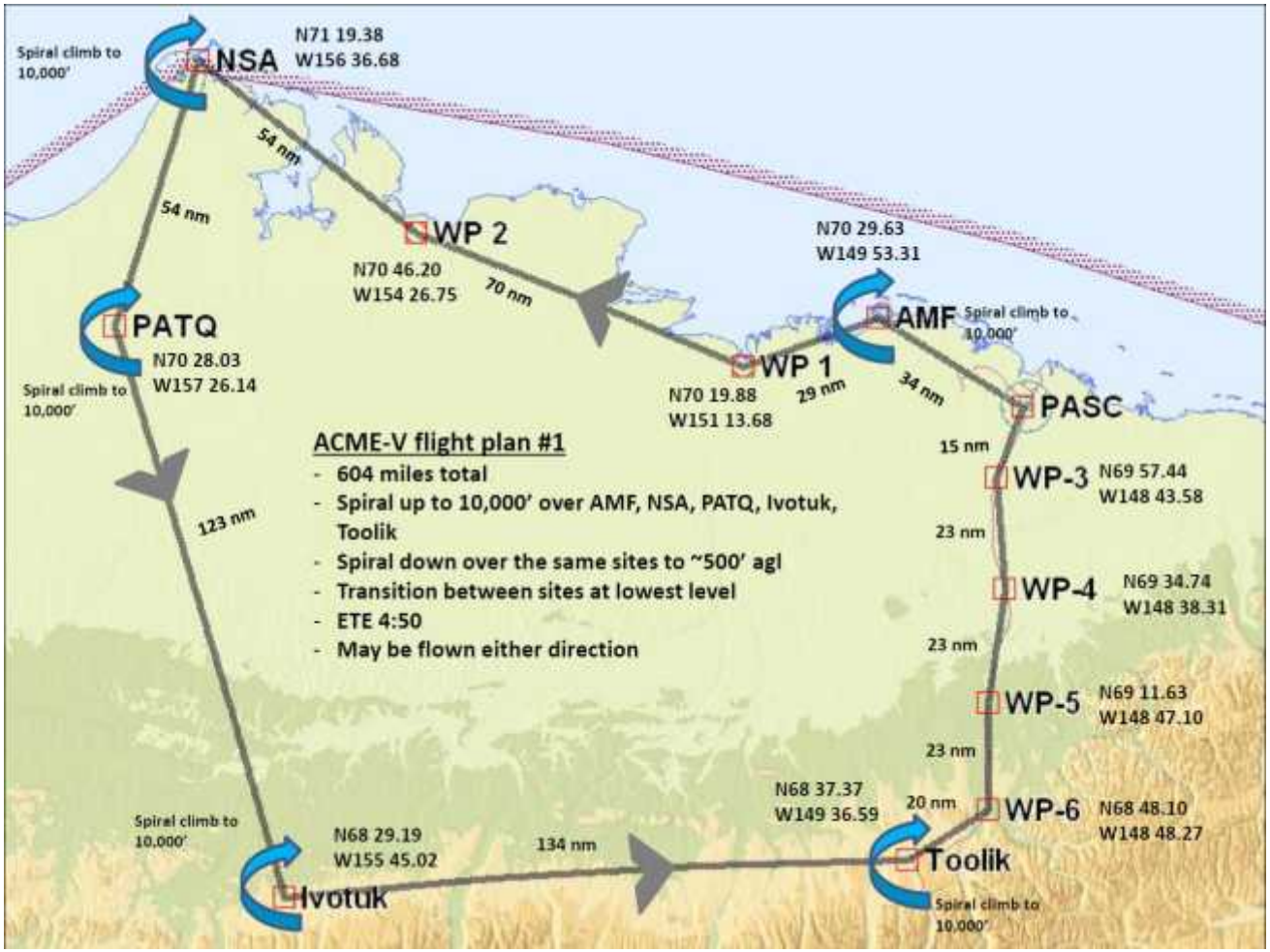
ACME-V G-1 Flights

Airborne Carbon Measurements: June 1 – Sep 15 2015

G-1 Instrumentation:
6 meteorological sensors
7 radiometers
8 aerosol sensors
3 trace gas analyzers
5 cloud properties sensors
2 video cameras

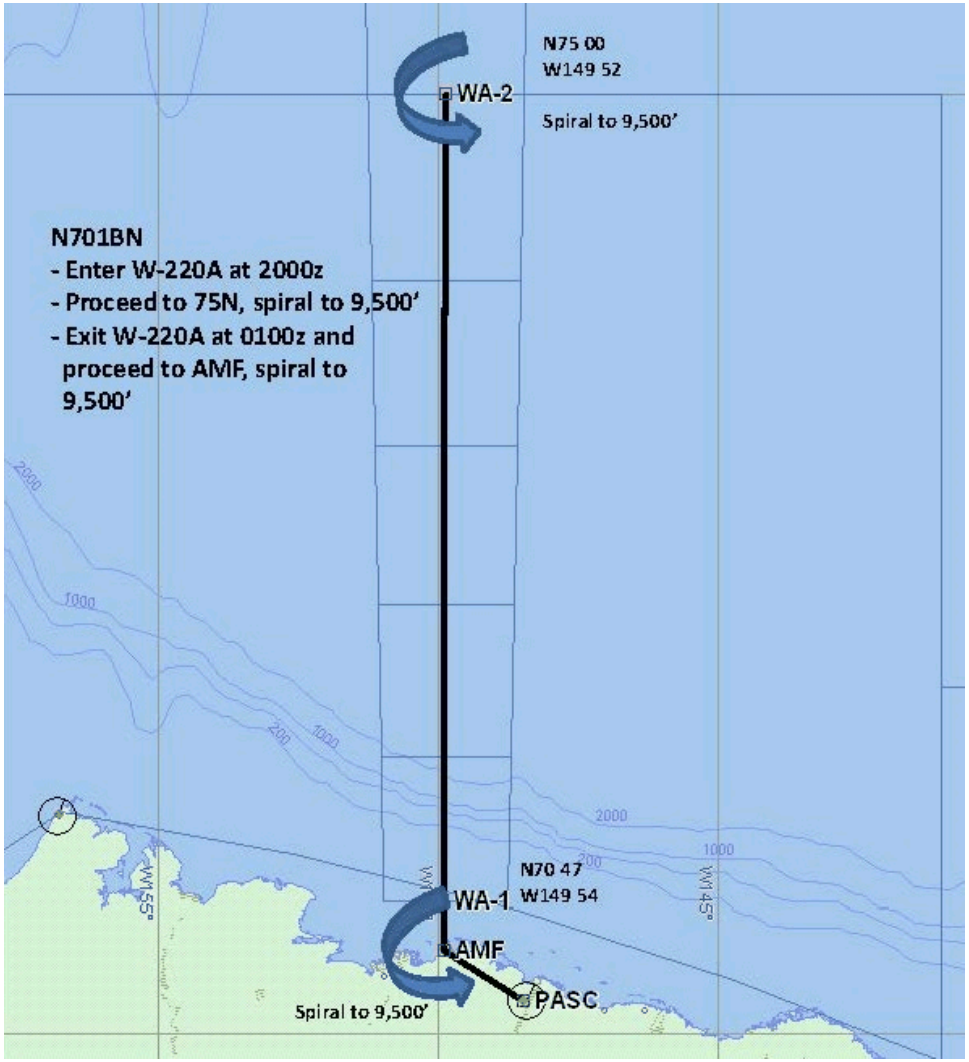
Airborne observations of atmospheric trace gases, aerosols, and cloud properties at the North Slope of Alaska are improving our understanding of global climate.
Goal: reduce uncertainty in global and regional climate simulations and projections

ACME-V G-1 Flights



June 1-Sep 15, 2015: ARM Aerial Facility will deploy the G-1 research aircraft to fly over the North Slope of Alaska.
Vertical profiling to measure trace-gas concentrations between Prudhoe Bay, Oliktok Point, Barrow, Atqasuk, Ivotuk, and Toolik Lake.

ACME-V G-1 Flights



- **W-220 first used successfully by G-1 on 8/16/15.**
- W-220 A-E low and high segments were activated from 12:00 – 17:00 ADT.
- No current plans to activate W-220 for remainder of 2015. SNL will send a courtesy notice to North Slope aviators once a final determination is made that the warning area will remain deactivated until spring.

Erasmus

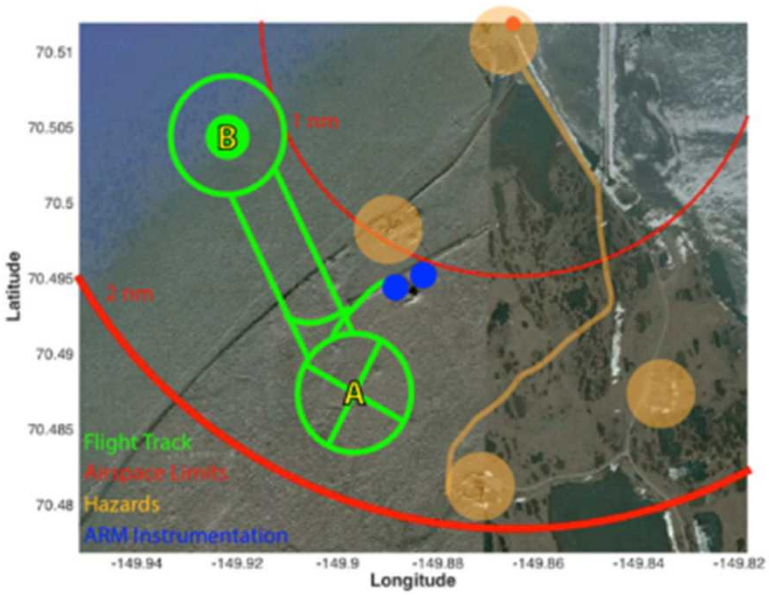
Evaluation of Routine Atmospheric Sounding Measurements using Unmanned Systems: Aug 2- 16, 2015

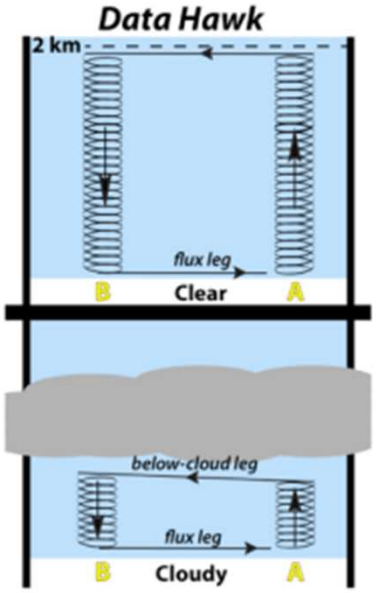
- Campaign supports the collection of a detailed set of atmospheric measurements designed to complement those concurrently obtained by the ARM Facility AMF3.
- These measurements will provide researchers with a focused case-study period for future observational and modeling studies pertaining to Arctic atmospheric processes.
- Measurements geared toward improved understanding of Arctic moisture, aerosol and radiation budgets.

DataHawk ops: 8/2/15 - 8/16/15
Planned Pilatus ops: 4/14/16 - 4/30/16

Preparation and DataHawk launch at AMF3

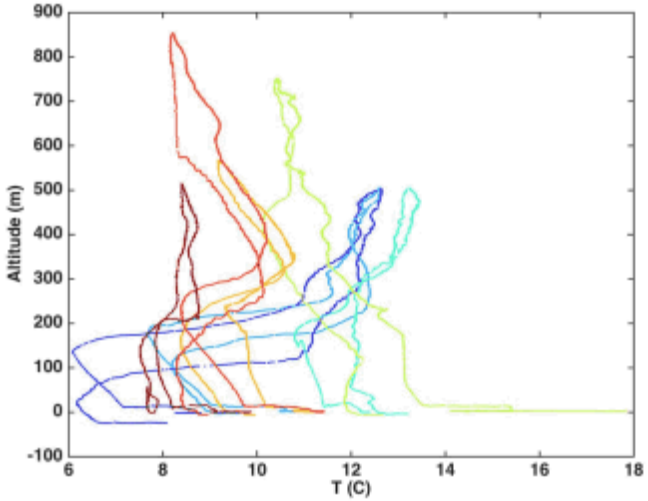
Erasmus





Flight pattern:

- low-altitude flight to a fixed off-shore location
- a spiral ascent to 2km or cloud base (whichever is lowest)
- a high-altitude traverse back to the coastline
- a spiral descent back to ~ 10 m above ground level.



Temperature profiles from 7 DataHawk flights on 8/8/15. Earliest profiles in blue, latest profiles in red. Shows near-surface air heating quickly in the morning and the subsequent decrease in temperature towards the later afternoon.

Photos and graphics from CU Boulder's Erasmus blog: http://ciresblogs.colorado.edu/erasmus/

TBS

Tethered Balloon System: Sep 2015 - 2016

ARM is developing a tethered balloon system capable of routine daily operations at AMF3. Operations will be conducted up to 7,000' AGL within DOE's R-2204 restricted area. The balloon will remain aloft for up to 18 hours/day. The TBS will operate within clouds and collect high vertical resolution atmospheric data. Increased vertical resolution of meteorological properties and cloud measurements will improve process understanding and complement the data concurrently obtained by existing AMF3 instrumentation.

Current ARM TBS equipment:

- *2* 35 m^3 helikites (31 lbs minimum lift @ sea level (MLSL))
- 1 SkyDoc™ Aerostat Model #26 (116 lbs MLSL)
- 1 SkyDoc™ Aerostat Model #28 (121 lbs MLSL)
- 2 10,000' tether capacity winches
- 2 1,000' tether capacity winches

TBS

Current ARM TBS Instrumentation:

- 14 tethersondes (measure pressure, temperature, wind speed, wind direction, altitude, latitude, longitude)
- 2 upward-facing cameras used to monitor the TBS in-flight
- Clinometer used to determine tether angle and perform redundant calculation of sensor altitude
- Wireless temperature and wetness/icing sensor
- 2 supercooled liquid water content (SLWC) sondes

Current interest in a distributed temperature sensing (DTS) fiber system. Fiber would run along balloon tether and sample temperature every 8 m at a 30 s sampling rate with an accuracy of .06°C.

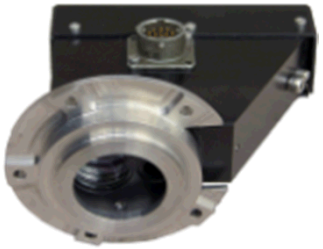
SLWC

Upward-facing camera image

Tethersondes

TBS

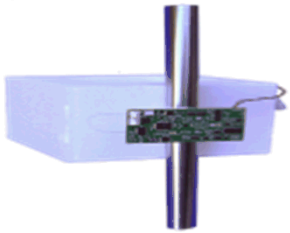
Instrumentation under consideration for future purchase:



Back-scatter cloud probe: Particle diameter (7-75 microns), particle number concentration, liquid water content (LWC), effective diameter (ED), median volume diameter (MVD)

Cloud droplet probe: Same as BCP but 2-50 microns

Back-scatter cloud probe with polarization: Can determine if particles are liquid or ice for 2-40 microns



Cryogenic frost point hygrometer: Measures water vapor in ice clouds at the parts per million level

Ozonesonde: Atmospheric ozone concentrations to +/- 5% accuracy

More Information

www.arm.gov

ddexhei@sandia.gov

joharde@sandia.gov

Public Wiki website for information about ARM UAS operations on the NSA:

https://wiki.arm.gov/bin/view/AAF/NSAAerialObservations