Arctic UAS Operations in Support of Earth Science

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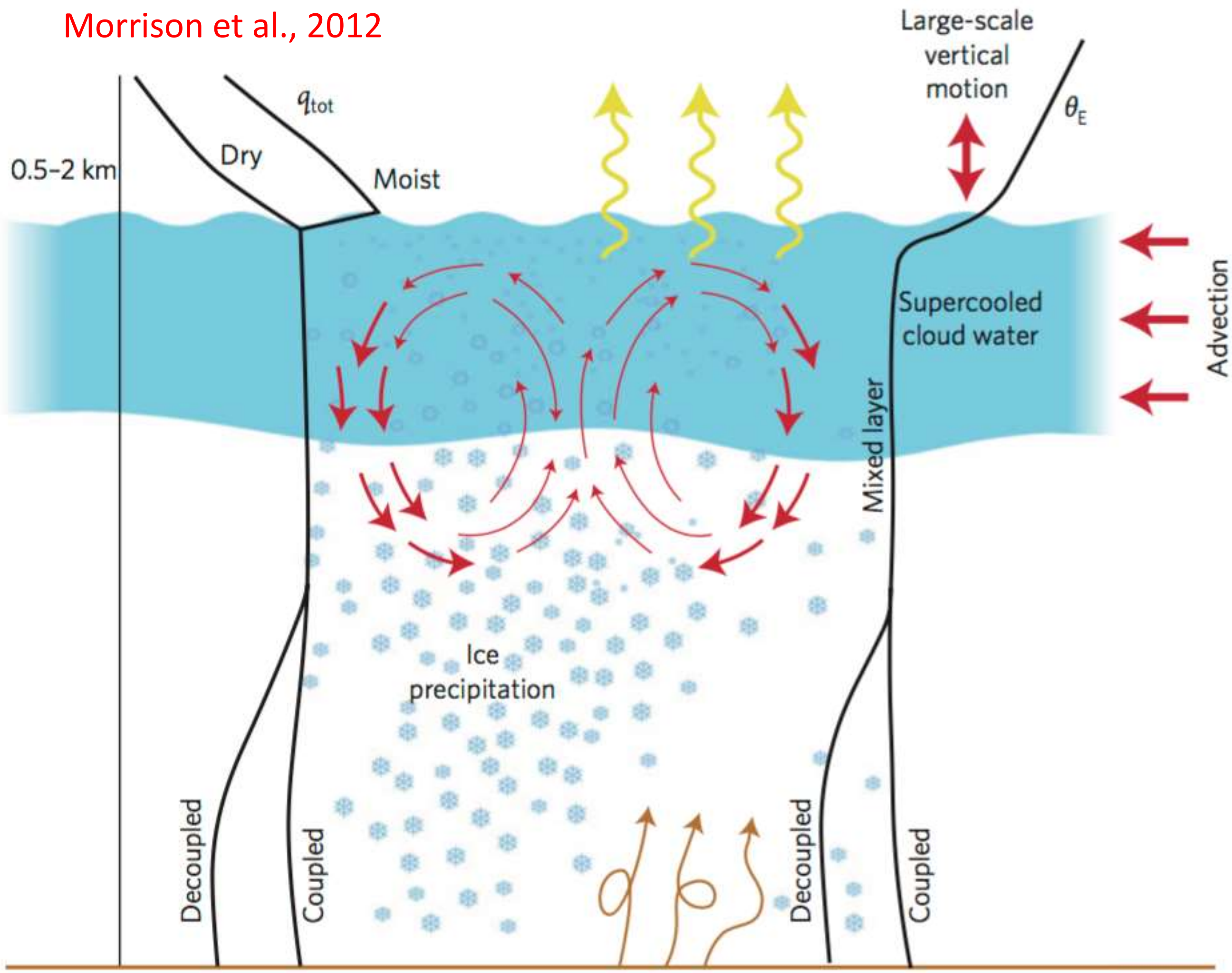
(2)

U.S. Arctic Icebreaker Coordinating Committee Briefing, 14 June 2021

My Journey With UAS

Morrison et al., 2012



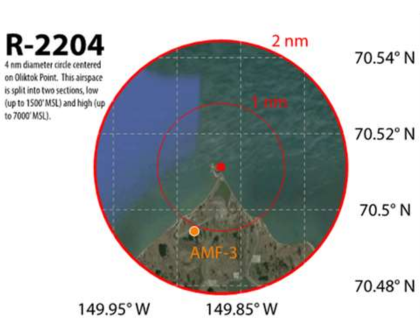
Radiative Cooling
- Drives buoyant production of turbulence
- Forces direct condensation within inversion layer
- Requires minimum amount of cloud liquid water

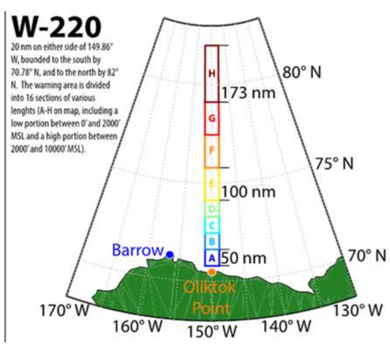
Microphysics
- Liquid forms in updrafts and sometimes within the inversion layer
- Ice nucleates in cloud
- Rapid ice growth promotes sedimentation from cloud

Dynamics
- Cloud-forced turbulent mixed layer with strong narrow downdrafts, weak broad updrafts, and q_{tot} and θ_E nearly constant with height
- Small-scale, weak turbulence in cloudy inversion layer
- Large-scale advection of water vapour important

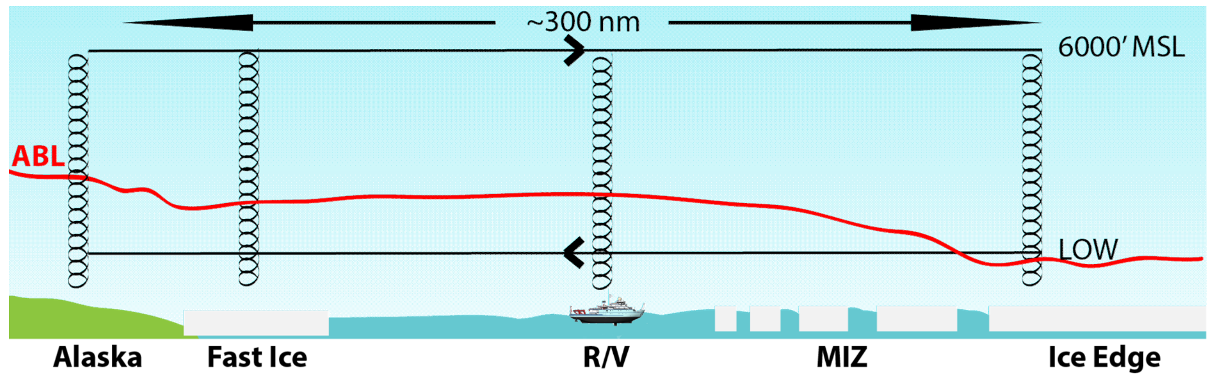
Surface Layer
- Turbulence and q contributions can be weak or strong
- Sink of atmospheric moisture due to ice precipitation
- Surface type (ocean, ice, land) influences interaction with cloud

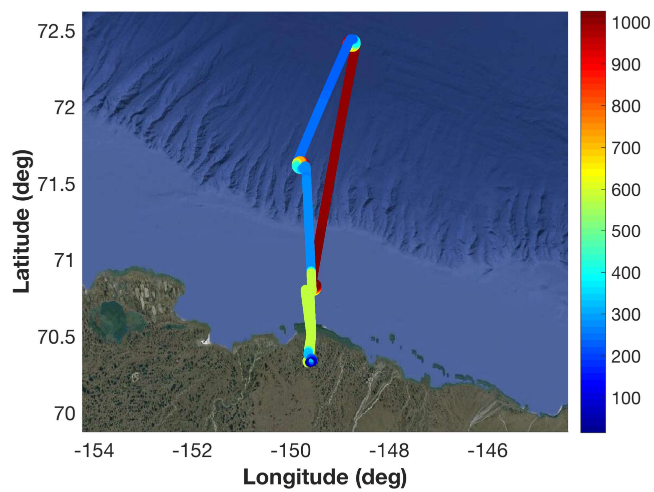
Early Arctic Campaigns: COALA through SODA



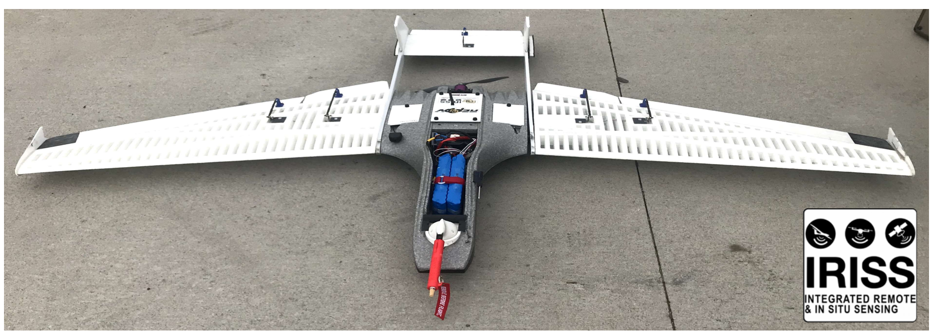


de Boer et al., 2016a

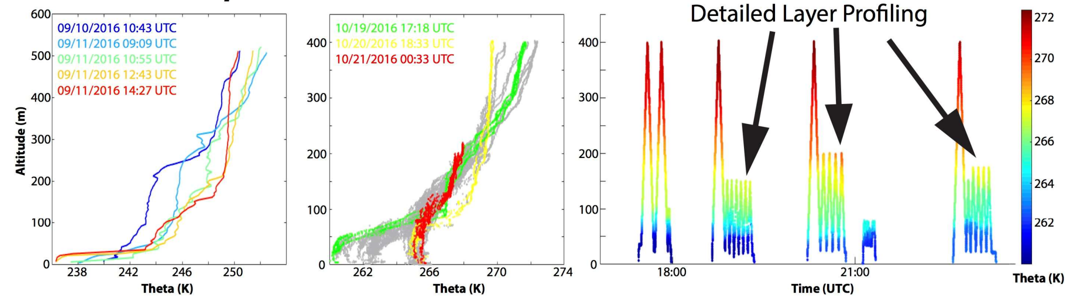




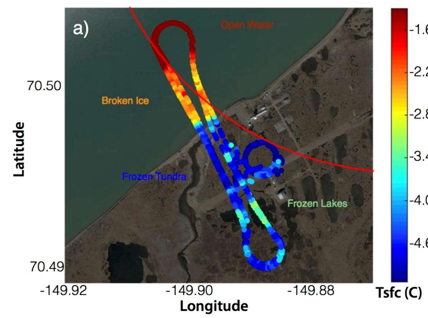
MOSAiC

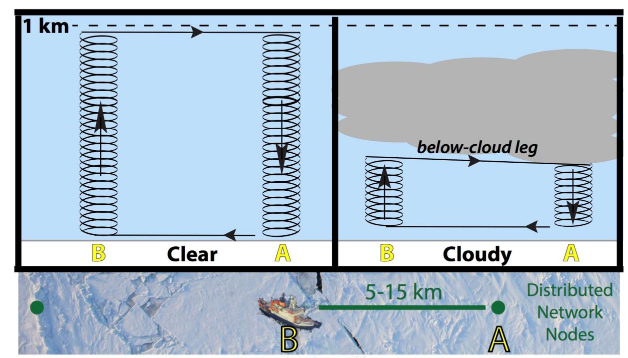


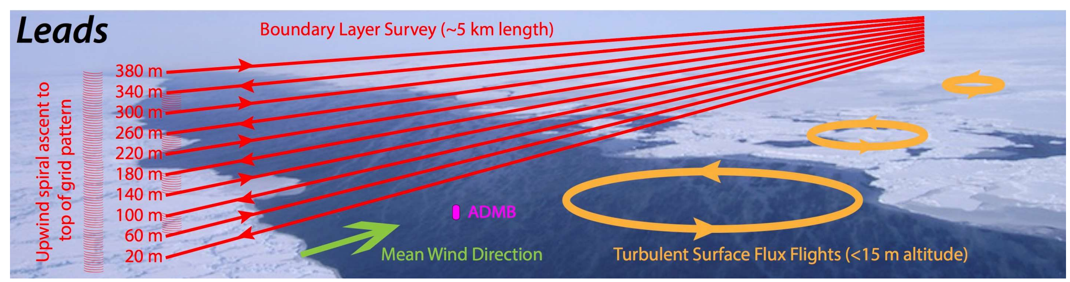
Lower Atmospheric Structure



Spatial Variability







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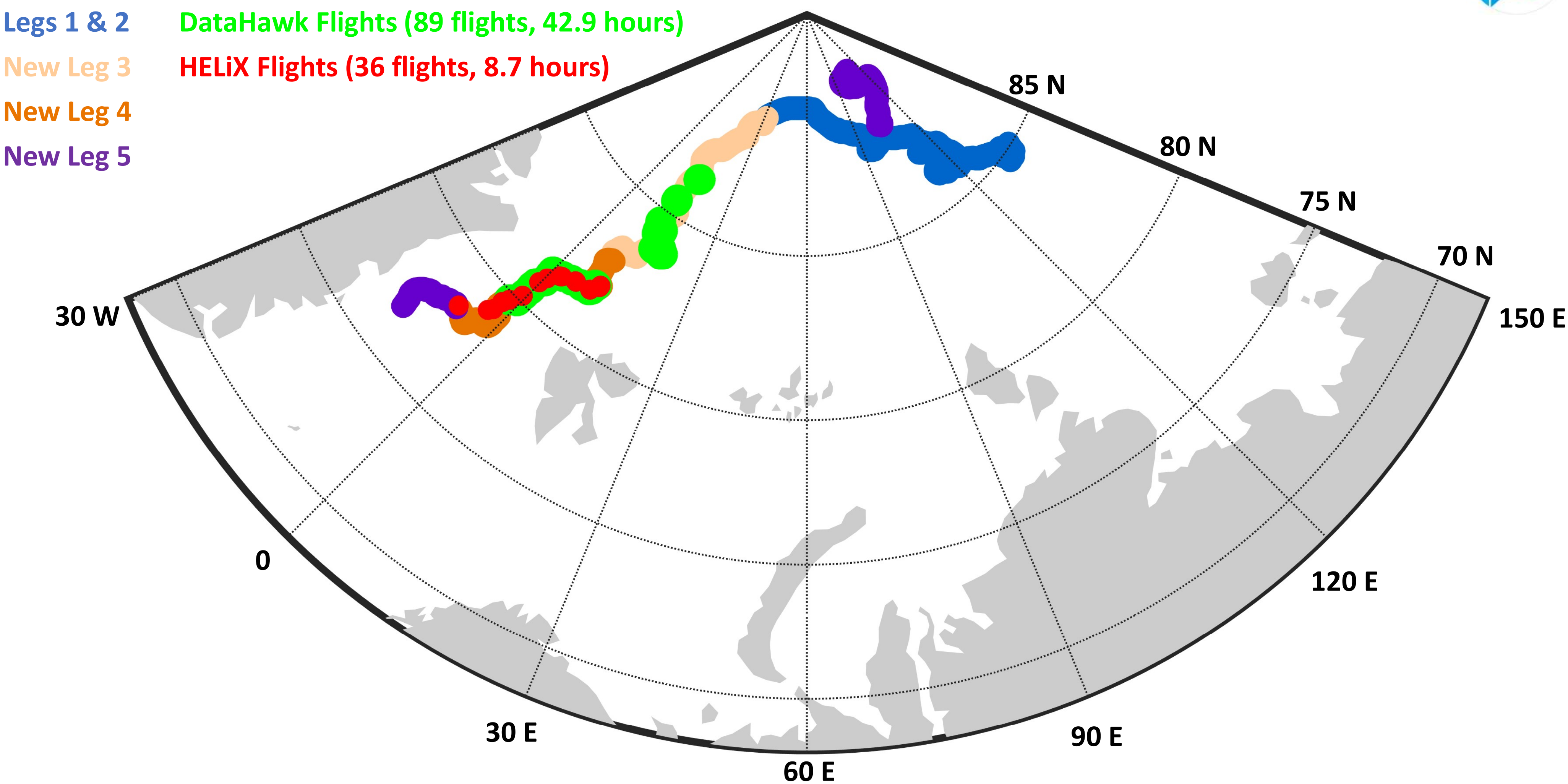
MOSAiC Drift and Flights



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DataHawk2

Aircraft Specs

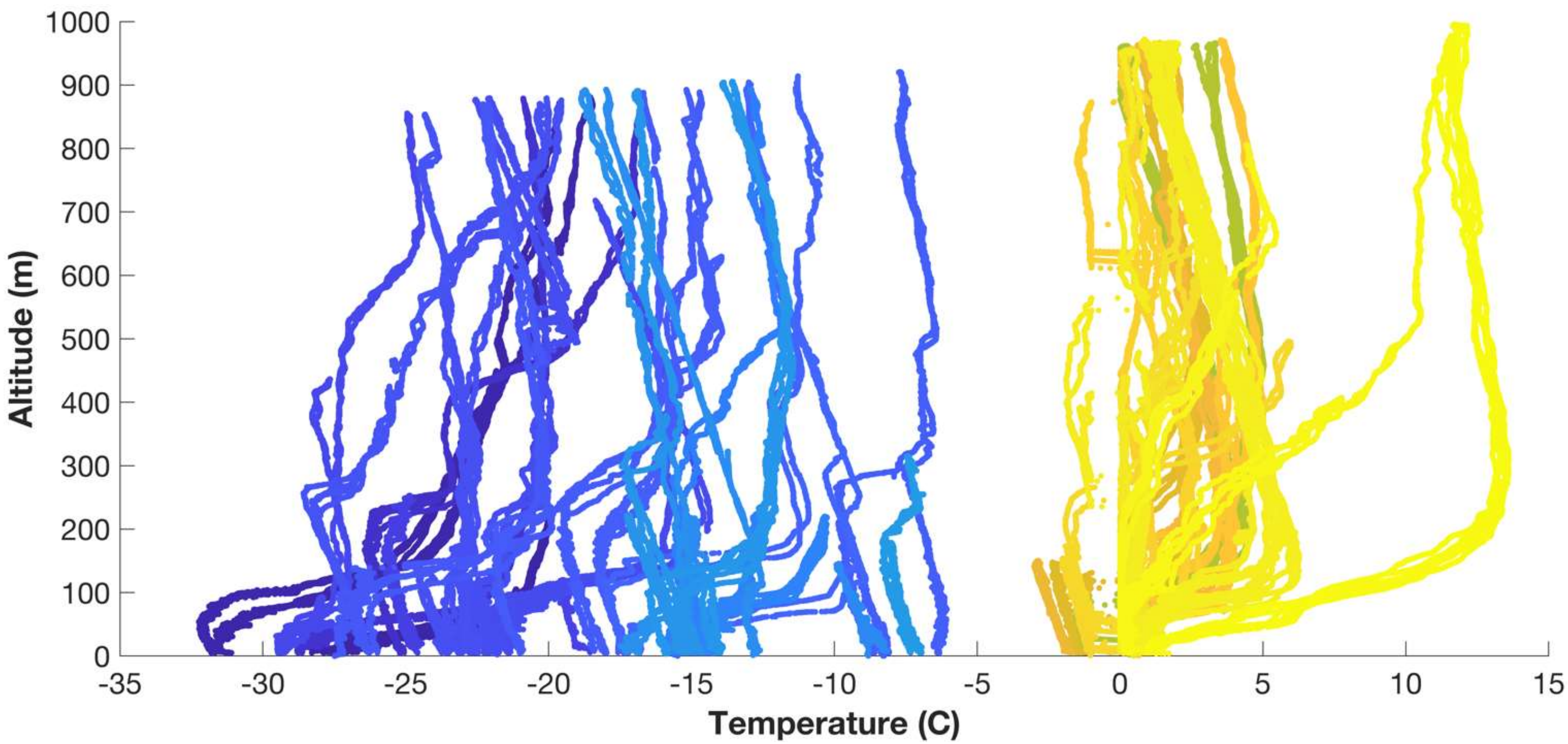
- 1.1m wingspan
- 1.8kg weight
- 40-min endurance time

Primary objectives:

- Atmospheric boundary layer profiling
- Support model evaluation and improvement
- Characterize surface impacts on overlying atmosphere

Delphin Ruche

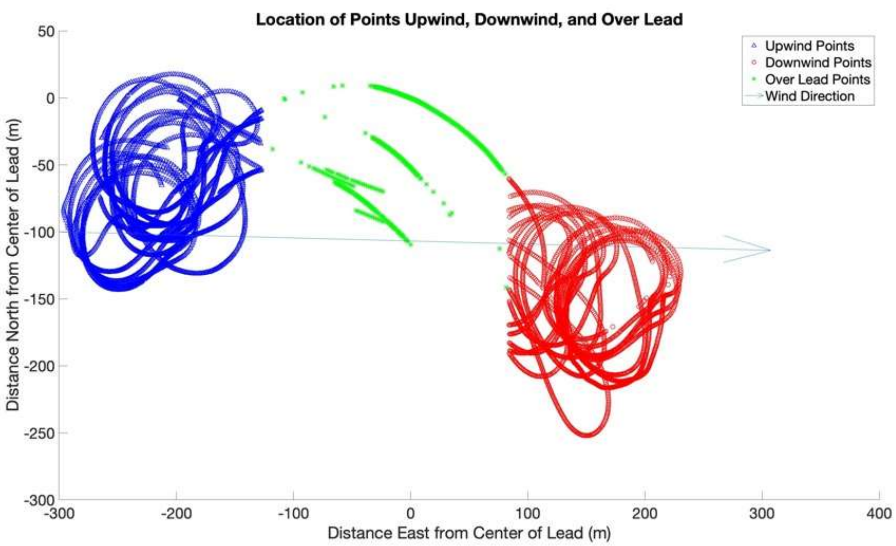
MOSAiC DataHawk2 Profiling

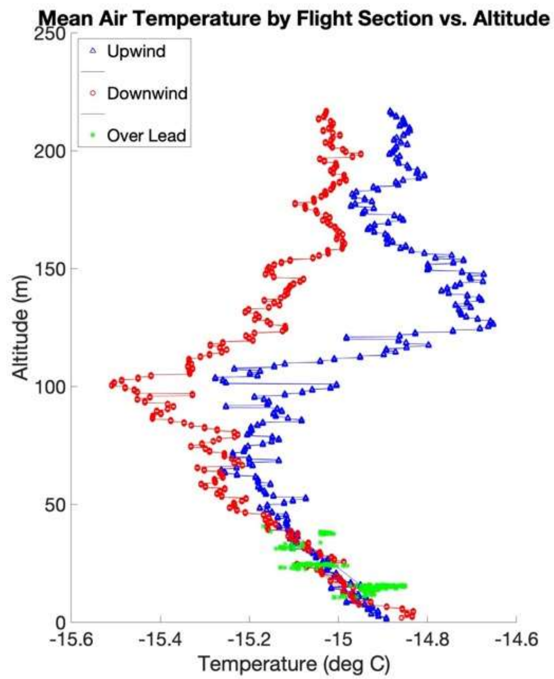


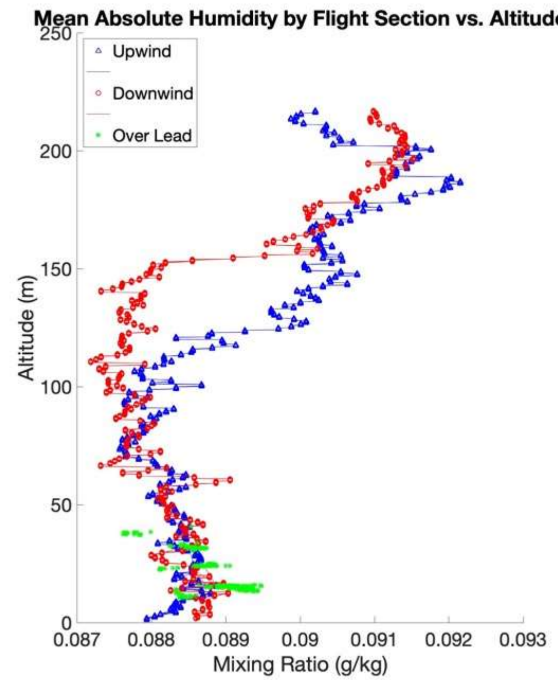
Leg 3 : March to May 2020

Leg 4 : June to July 2020

MOSAiC DataHawk2 Lead Sampling







MOSAiC

HELiX

Aircraft Specs

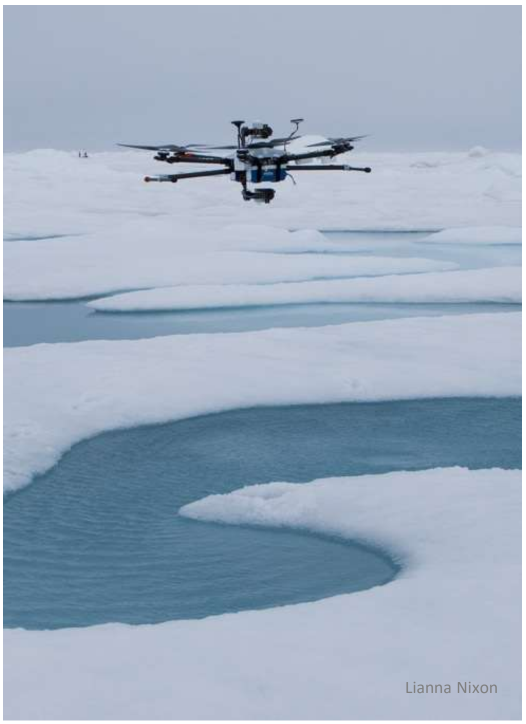
- 12 kg weight
- 20-min endurance time

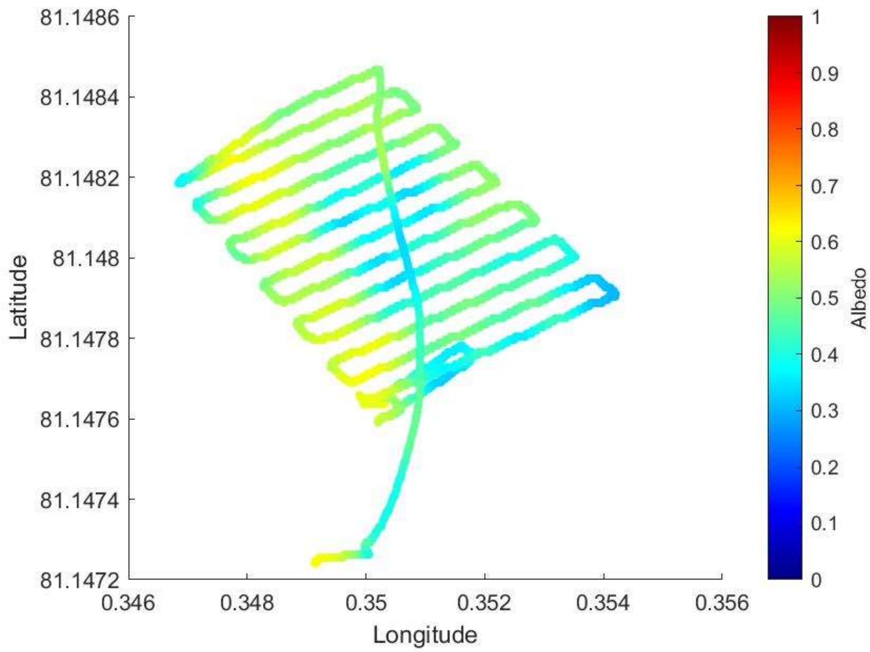
Primary objectives:

- Surface albedo variability
- Surface mapping
- Near surface thermodynamic state

Lianna Nixon

MOSAiC HELiX Albedo Mapping





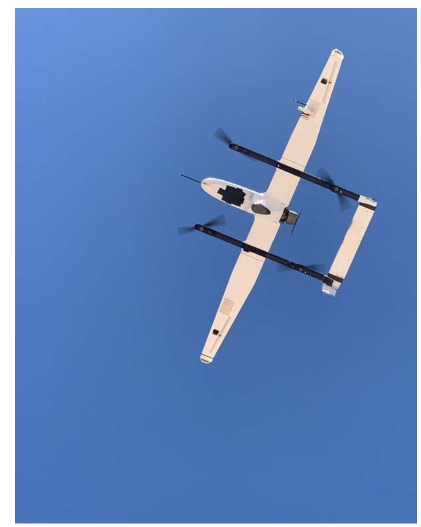
Albedo

Multi-spectral camera
Assembled images

Looking Ahead: Hybrid VTOL Systems

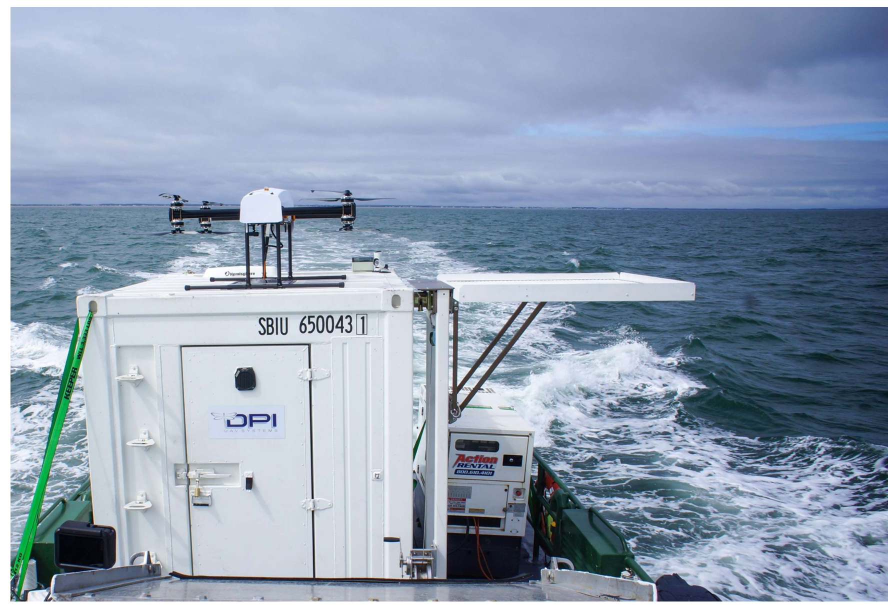
Overview:

- Easier take off and landing – no runway or cable catch required
- Extended horizontal range and endurance (2-8 hours, ~150-600 km)
- Can carry significant payloads
- Can cover larger altitude range

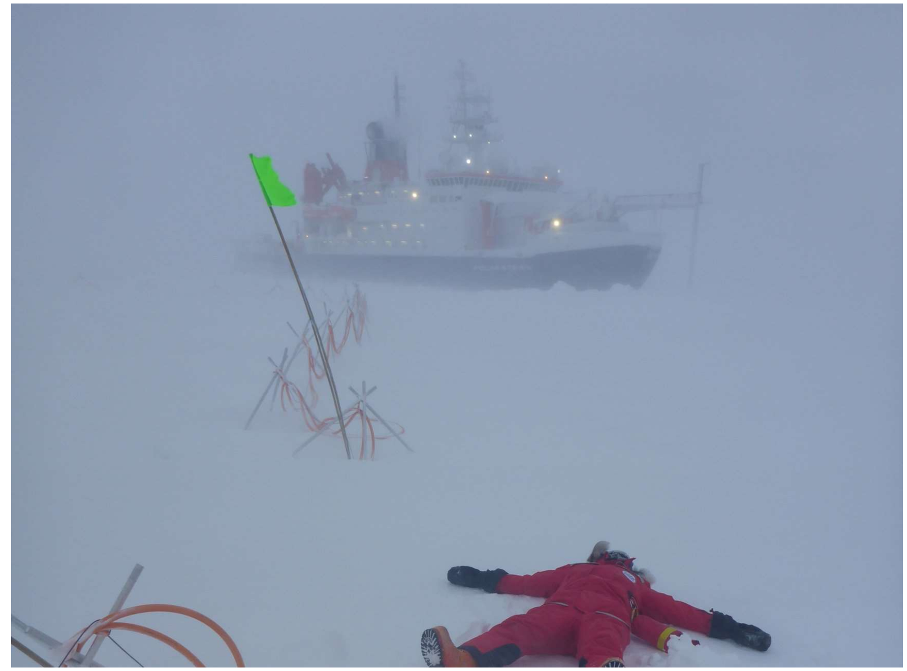


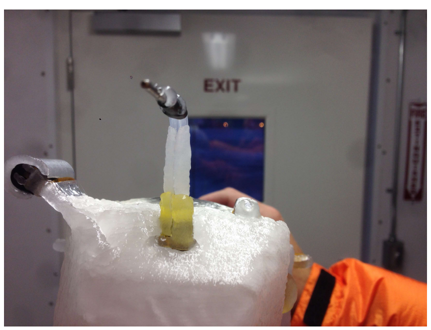
Looking Ahead: Tethered Systems

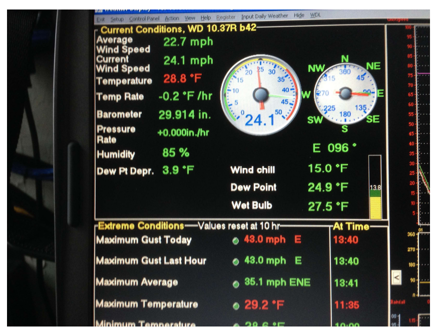
Tethered systems:
- Limited altitude (~500 ft)
- Long Endurance (400+ hours)
- Communications and Reconnaissance
- Relatively small operational footprint



General Challenges: Weather

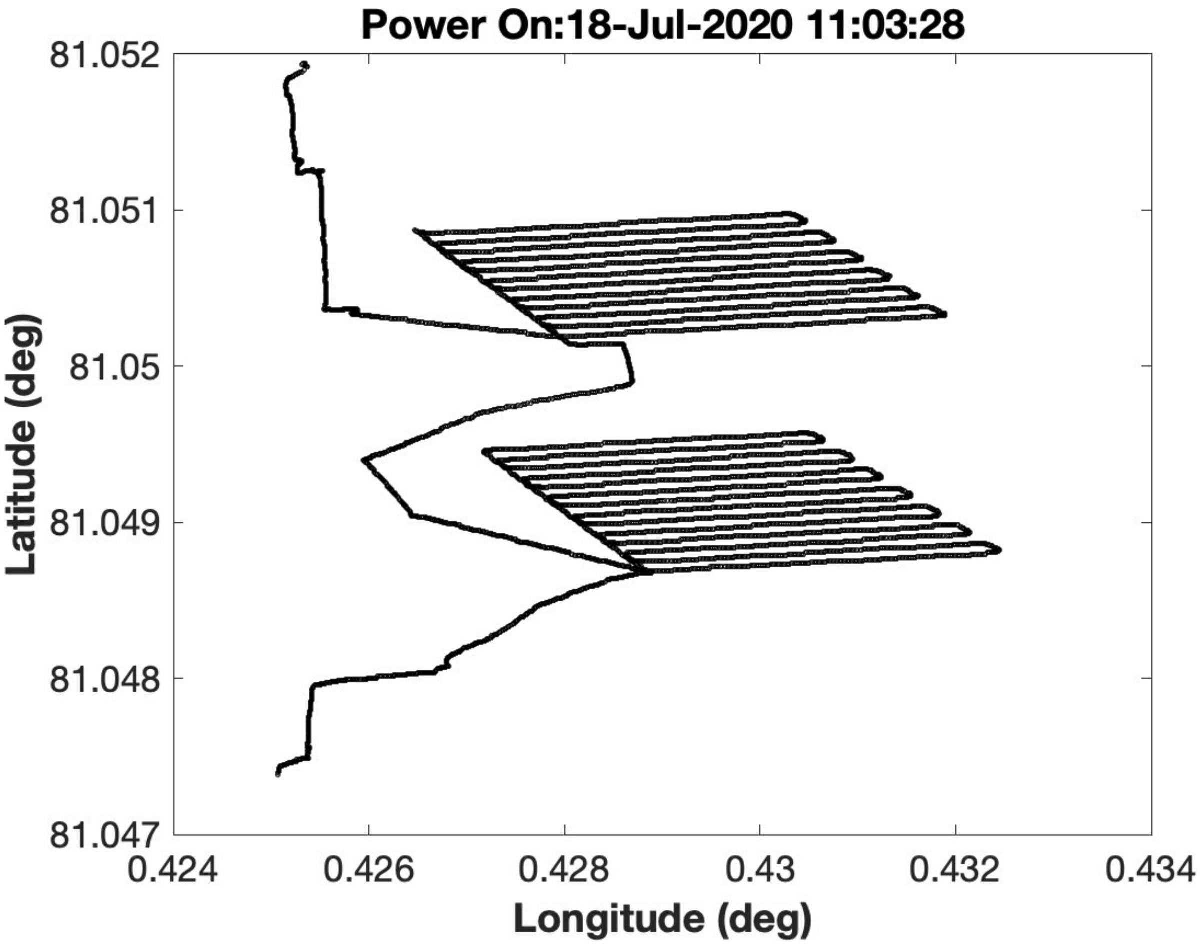


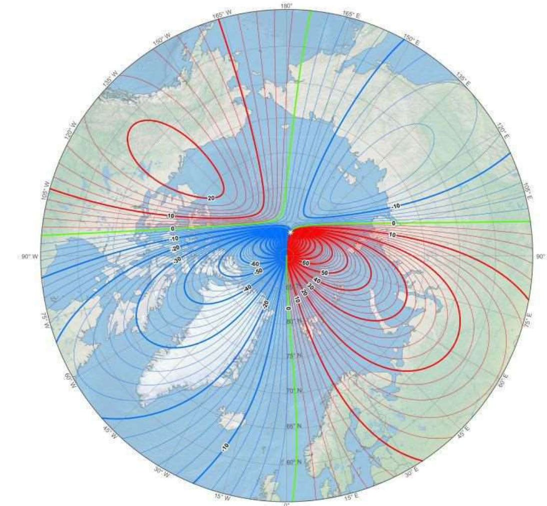


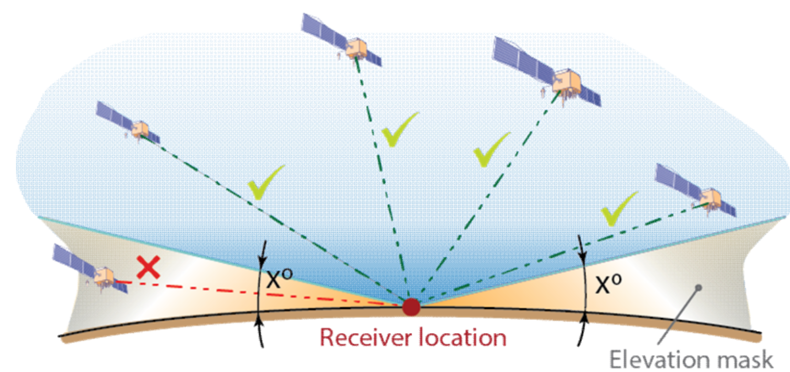


General Challenges: Airspace

General Challenges: Navigation Challenges







Summary

- UAS have the potential to offer unique perspectives on the Arctic environment, particularly when partnered with icebreakers that provide access to the "central" Arctic.
- Such platforms can also support ship operations by extending communications networks, providing surveillance on ice conditions, and providing frequent profiling of atmospheric conditions.
- Challenges associated with weather, navigation, and airspace access must be considered to fully leverage these capabilities.
- Use of robust and tested systems is highly recommended to avoid potential UAS loss and/or damage. At the same time, newly developed systems stand to simplify the operational footprint of these systems and support for high-latitude and ship-based testing is required.

EXTRA SLIDES

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MOSAiC Platforms: HELiX

Aircraft Specs
- 12kg weight
- 20-min endurance

Measurements
- Upwelling and downwelling shortwave radiation – albedo
- Multispectral camera for surface imaging
- Pressure, temperature, relative humidity

Photo: Radiance Calmer

MOSAiC Platforms: DataHawk2

Aircraft Specs

- 1.1m wingspan
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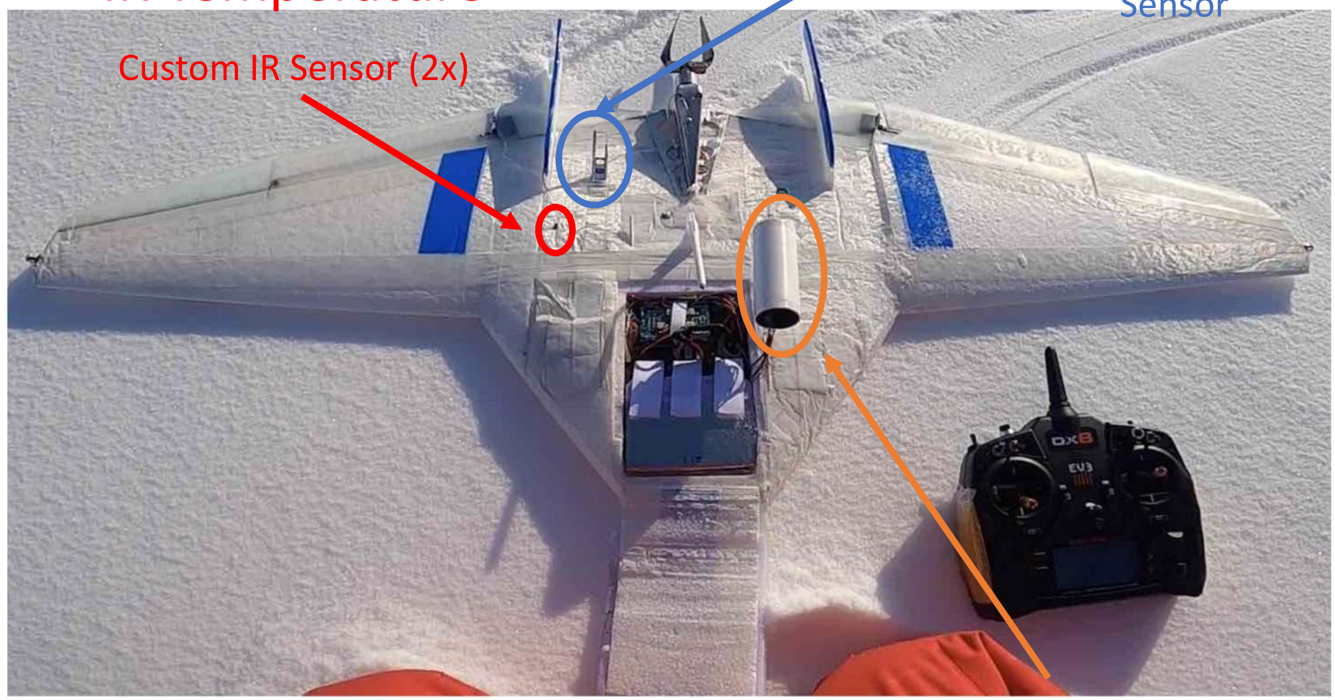
Measured Variables

- Temperature, pressure, humidity, wind speed
- IR temperature
- Turbulence

Pressure, Temperature, Relative Humidity

Vaisala RSS-421 PTH Sensor

IR Temperature



Turbulence

Custom fine wire array with Sensirion SHT85

Examples of Science from Tropics