Small Uncrewed Aircraft for Weather and Climate Research: Insights from Decades of Research at the University of Colorado

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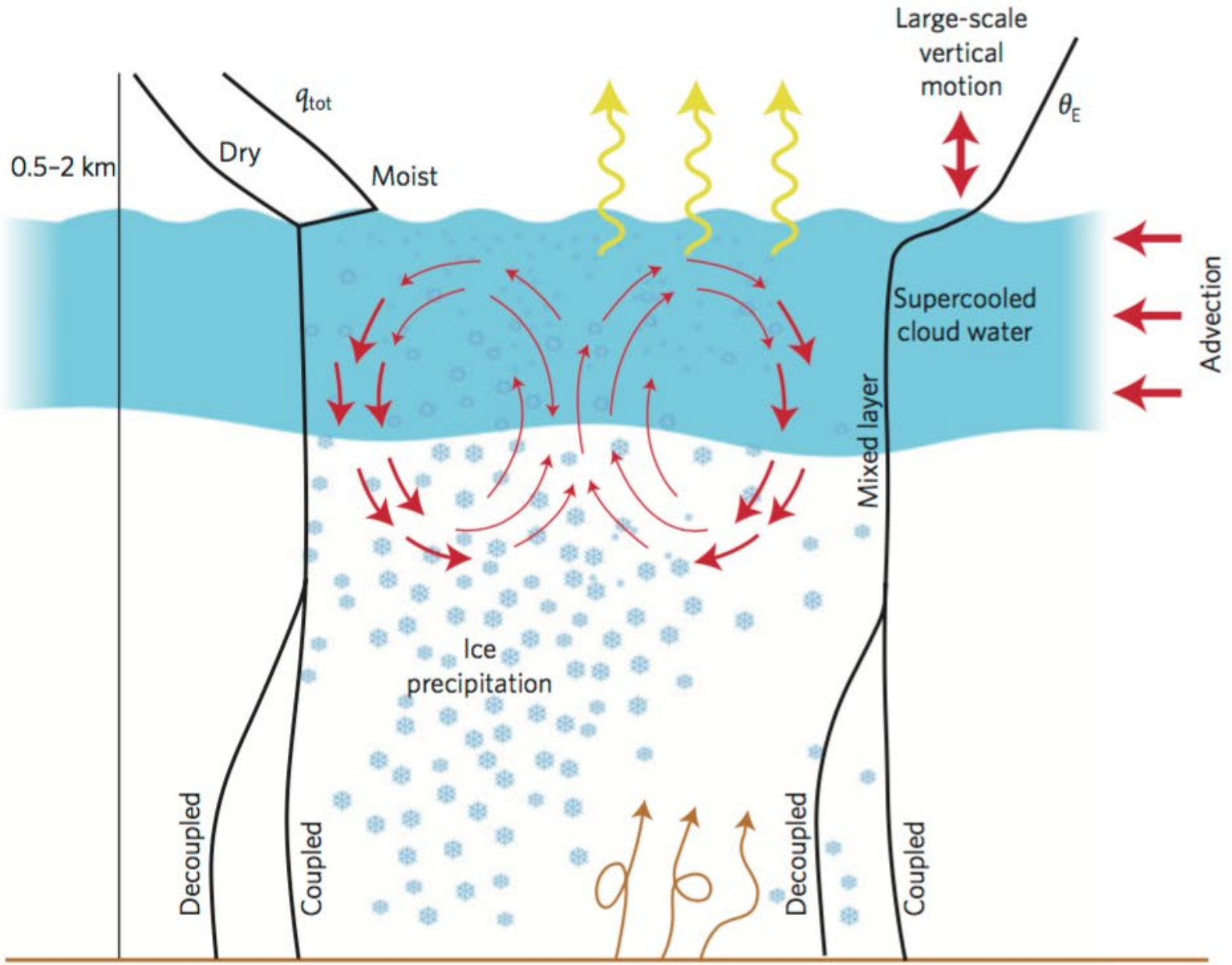
IRISS INTEGRATED REMOTE & IN SITU SENSING

NOAA

NCAR FARE Users' Workshop, 21 September, 2023, Boulder, CO

How it started…



Morrison et al., 2012

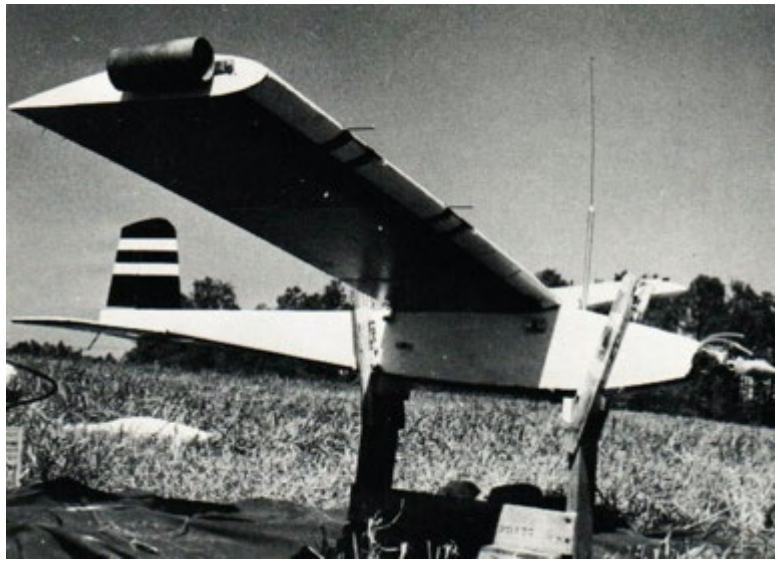
Radiative Cooling
- Drives buoyant production of turbulence
- Forces direct condensation within inversion layer
- Requires minimum amount of cloud liquid water

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

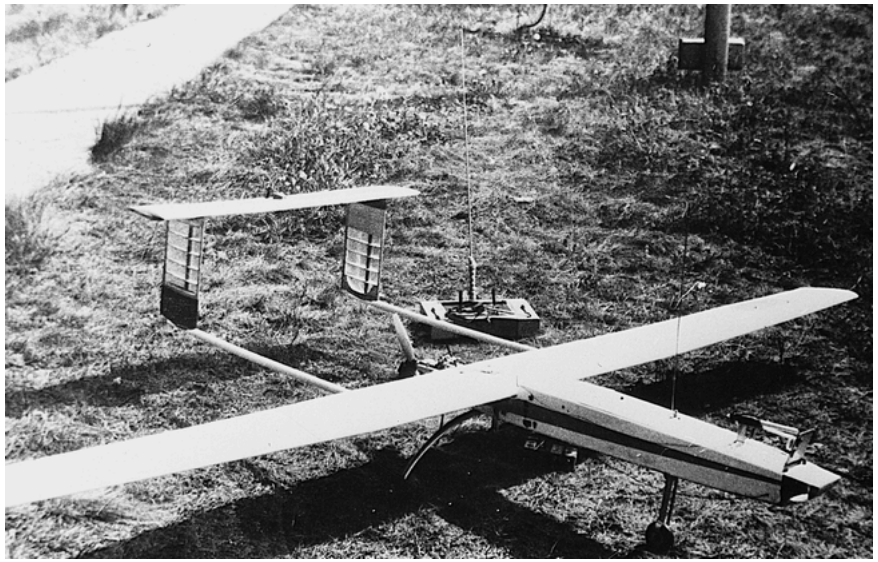
Dynamics
- Cloud-forced turbulent mixed layer with strong narrow downdrafts, weak broad updrafts, and q_{tot} and θ_E nearly constant with height
- Small-scale, weak turbulence in cloudy inversion layer
- Large-scale advection of water vapour important

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

A solution?

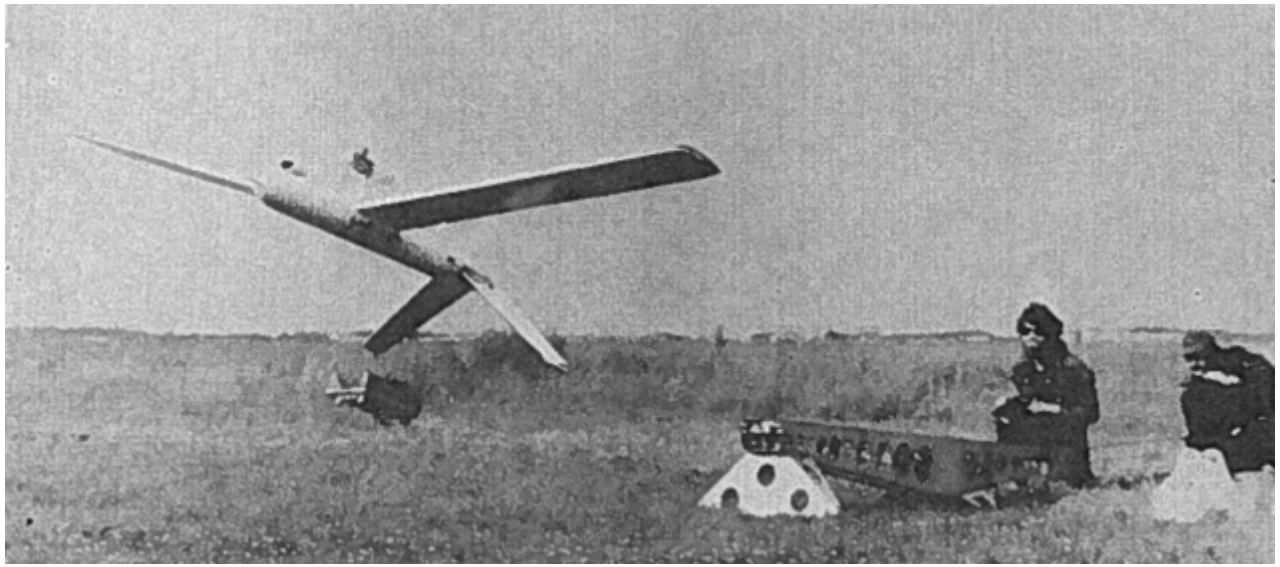


Konrad et al., 1970



Kukharets and Tsvang, 1998

Holland et al., 1992



Martin et al., 1980

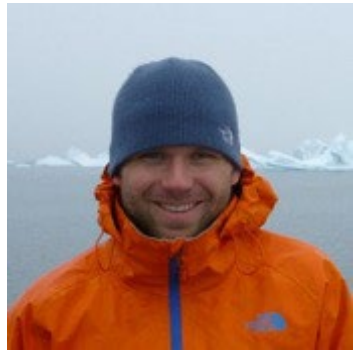
A lucky landing…


B. Argow


D. Lawrence


S. Borenstein


J. Intrieri


J. Elston


M. Rhodes, C. Choate


J. Cassano


R. Calmer


G. Jozef


J. Hamilton


M. Stachura


A. Jensen


J. Pinto


A. Doddi


J. Osborn

University of Colorado Boulder

BlackSwift TECHNOLOGIES

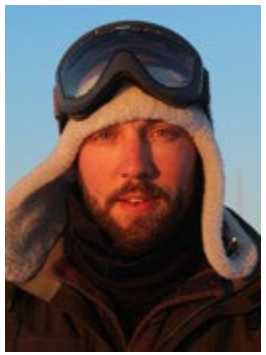
NOAA

NCAR


D. Quint


S. Palo


T. Hock


B. Butterworth


T. Thornberry


E. Asher

Why UAS: Small Operational Footprint

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Video: Robin Webb/Barb DeLuisi

Why UAS: Small Operational Footprint

Video removed for size!

Why UAS: “Low and Slow” Flight

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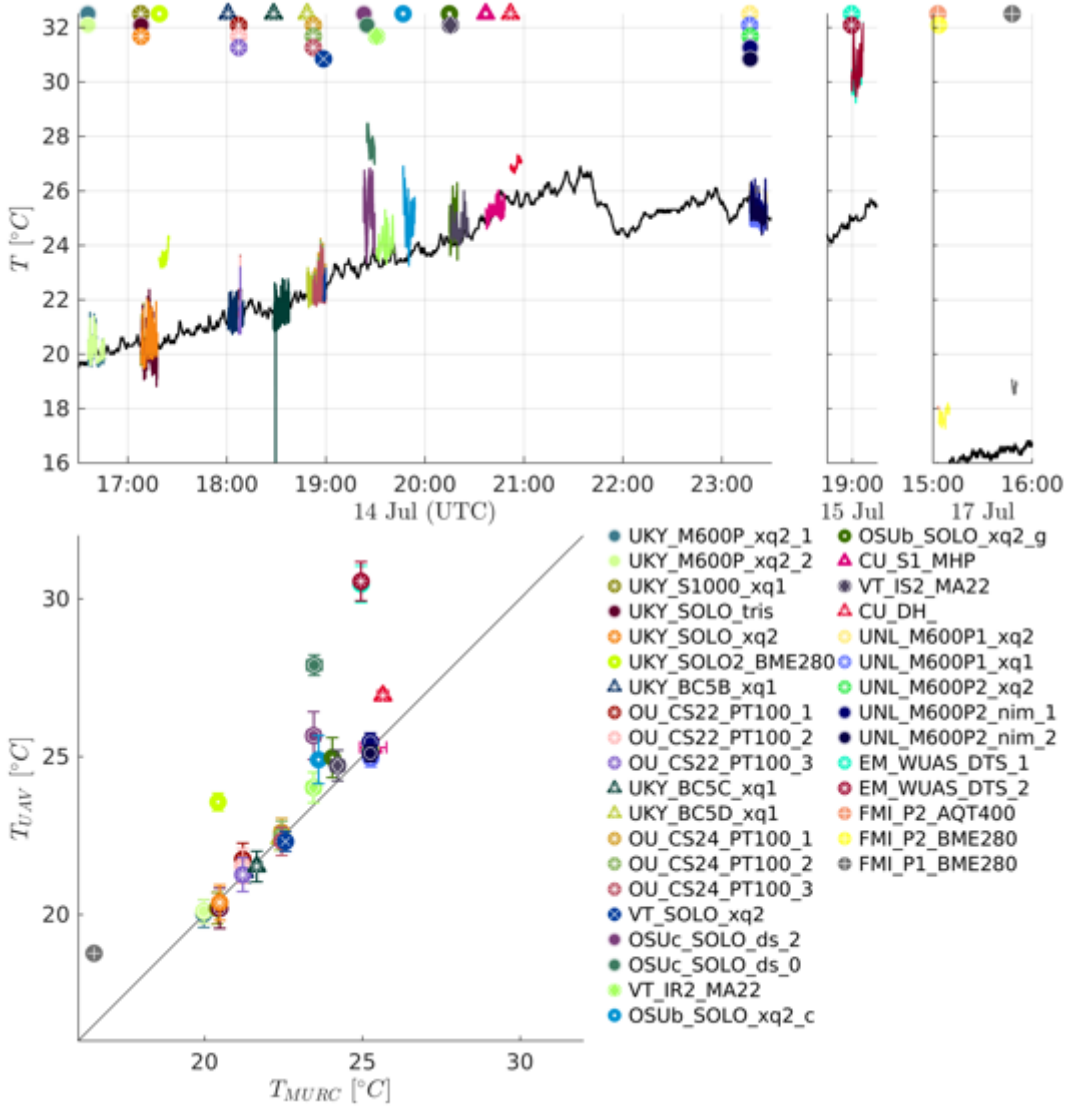
Why UAS: Access to dangerous conditions

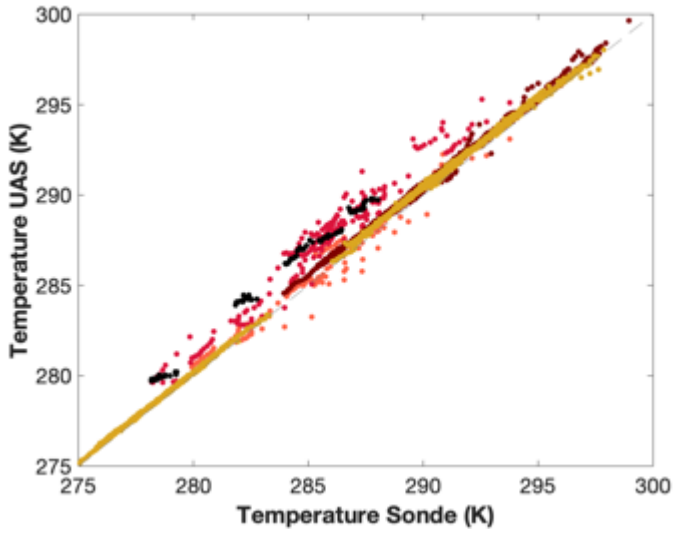
Video removed for size!

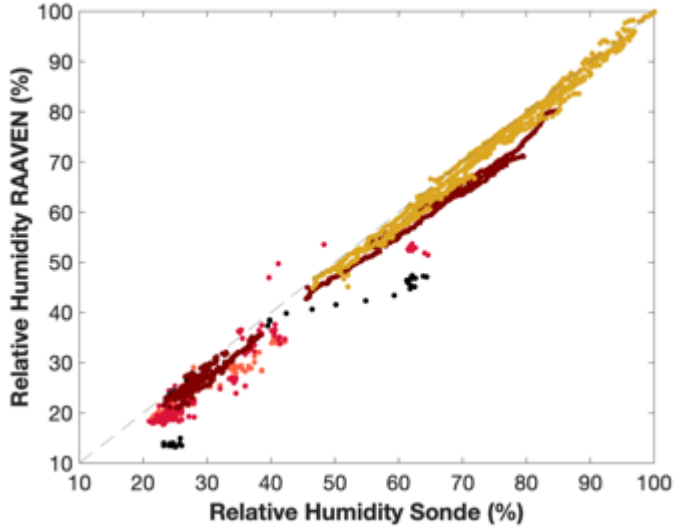
Why Facility: Data Quality and Repeatability

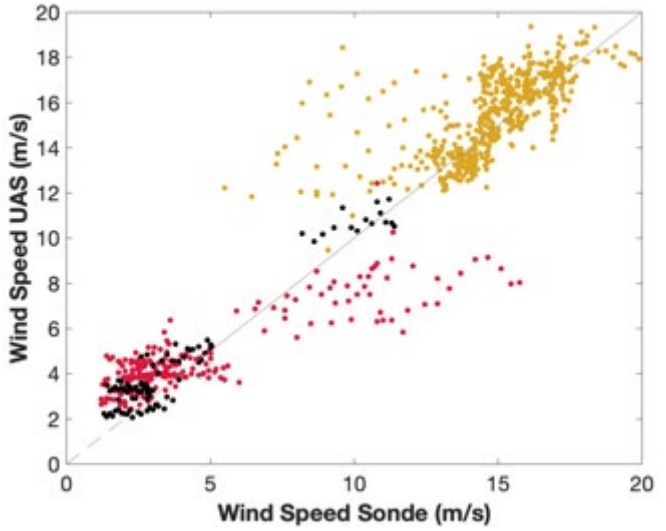
RAAVEN S2 CopterSonde Meteodrone M600

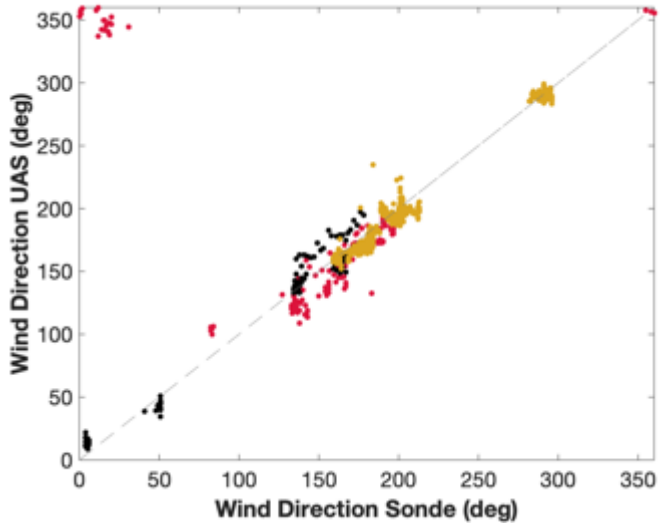


Barbieri et al., 2019





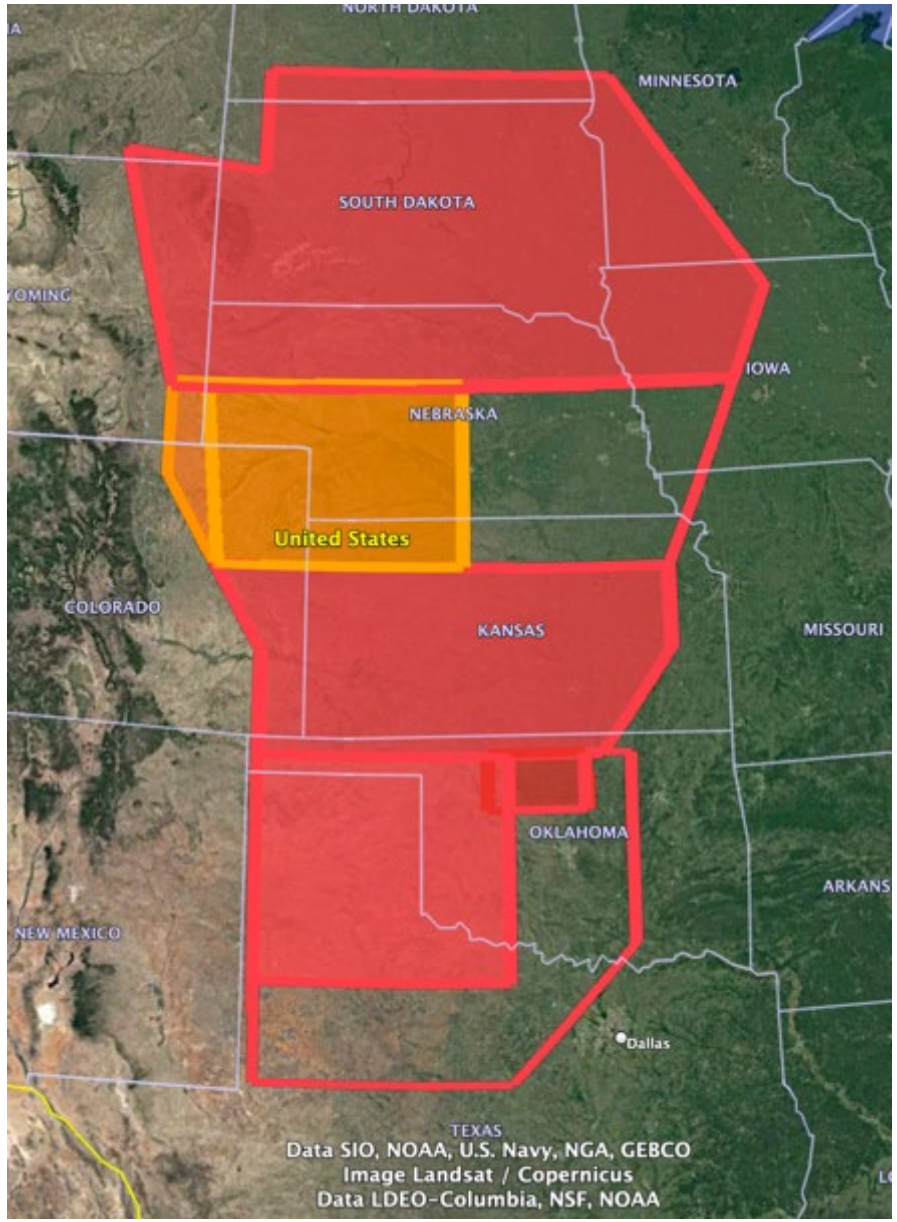




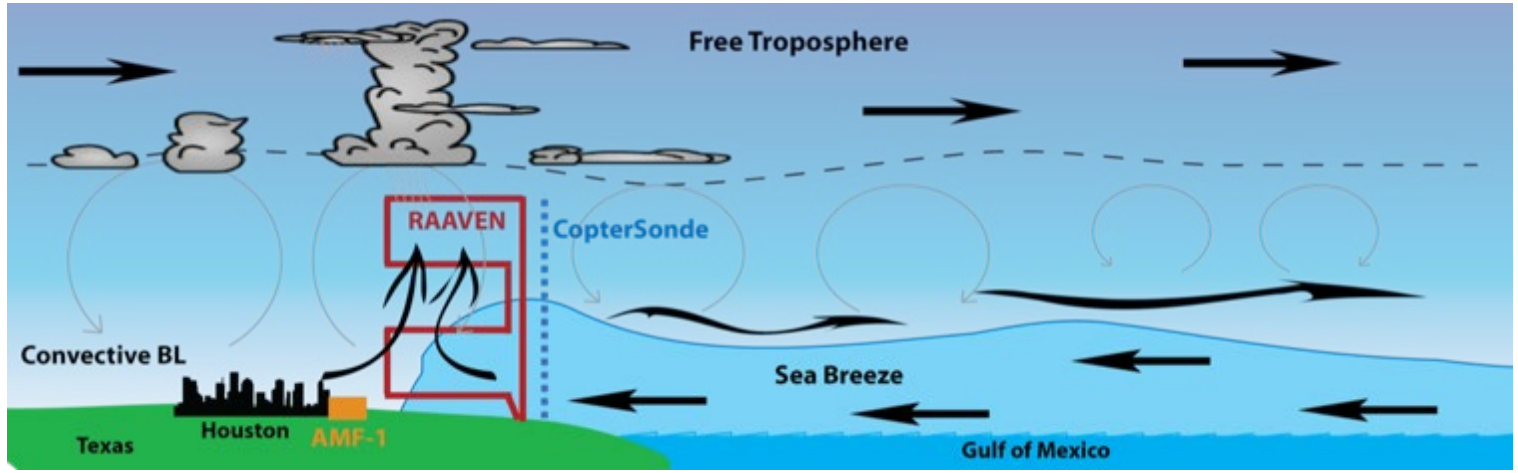
de Boer et al., 2023

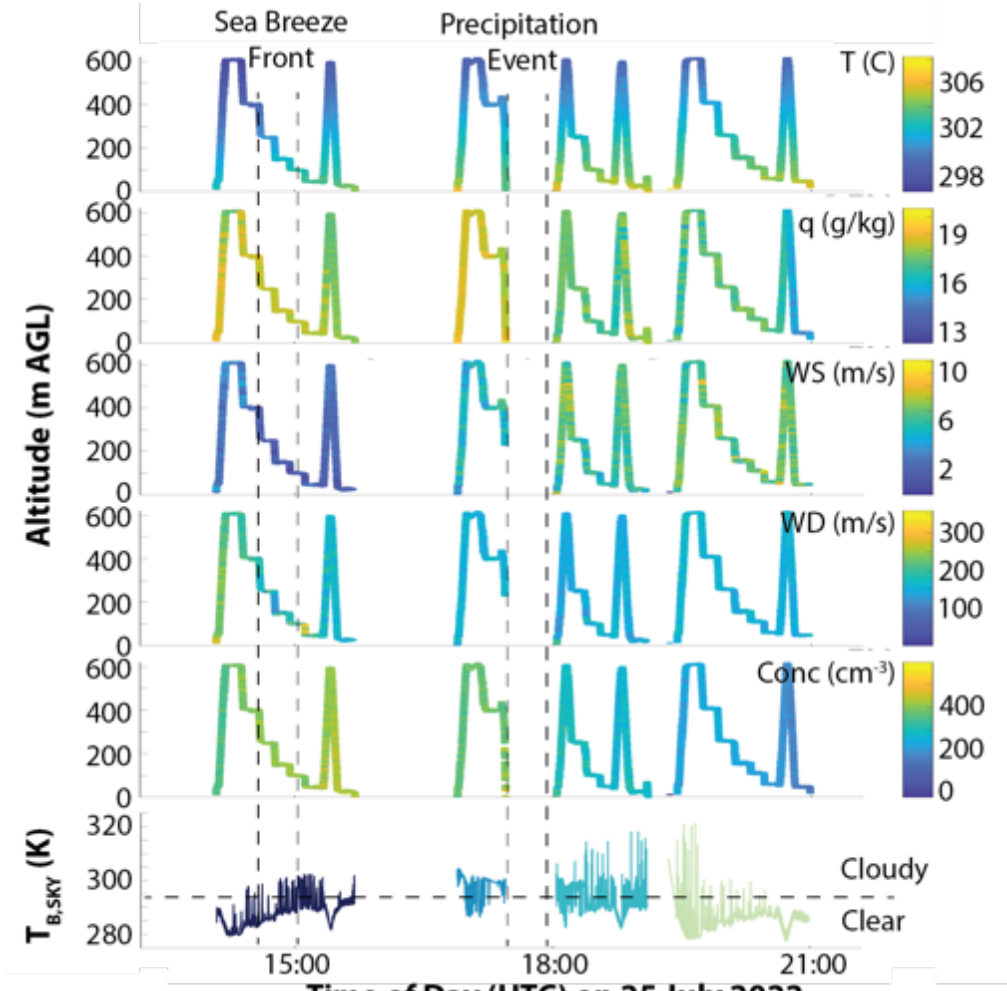
Why Facility: Infrastructure Requirements

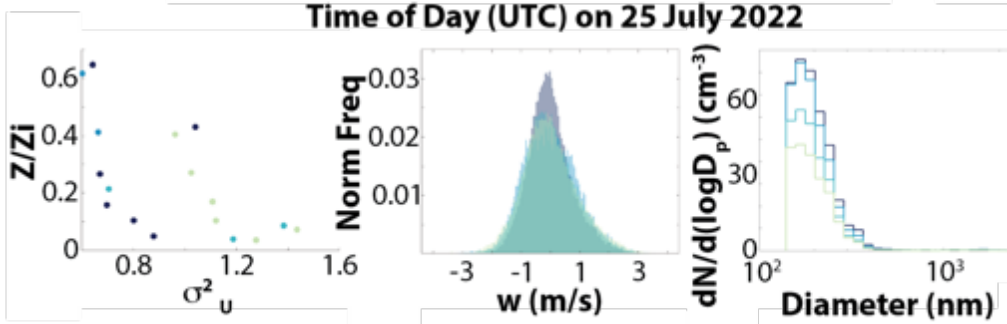
Why Facility: Operational and Airspace Experience



Use Case Example: TRACER

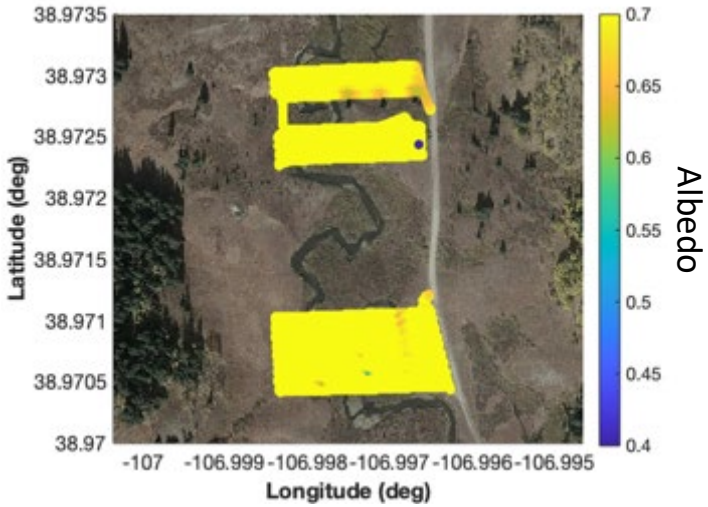






Use Case Example: SPLASH

03/12-03/16



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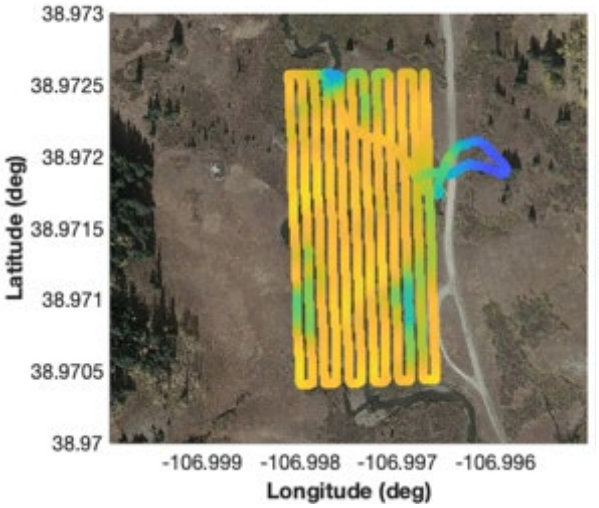

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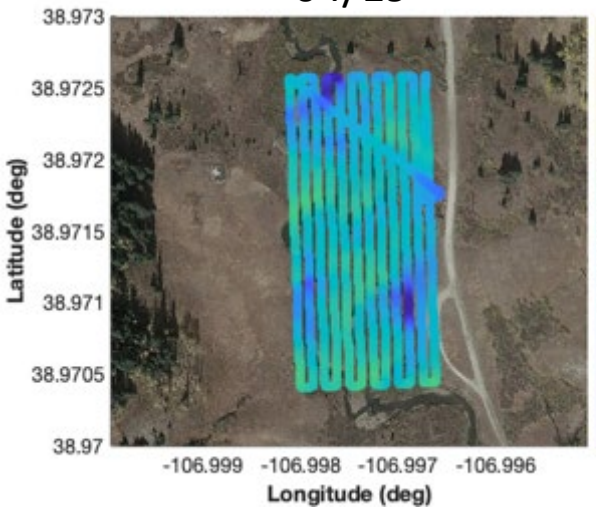

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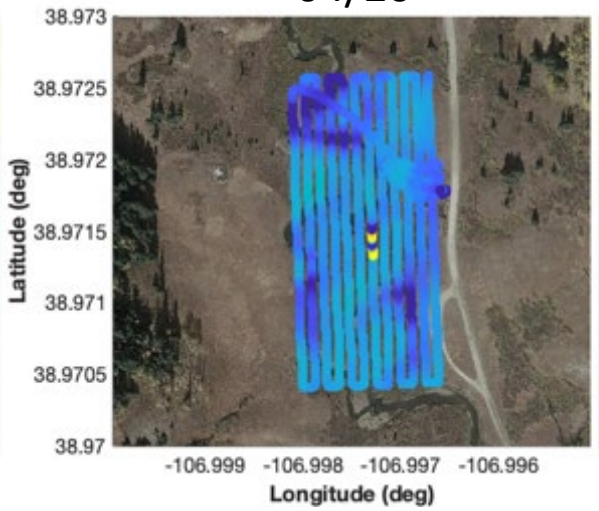

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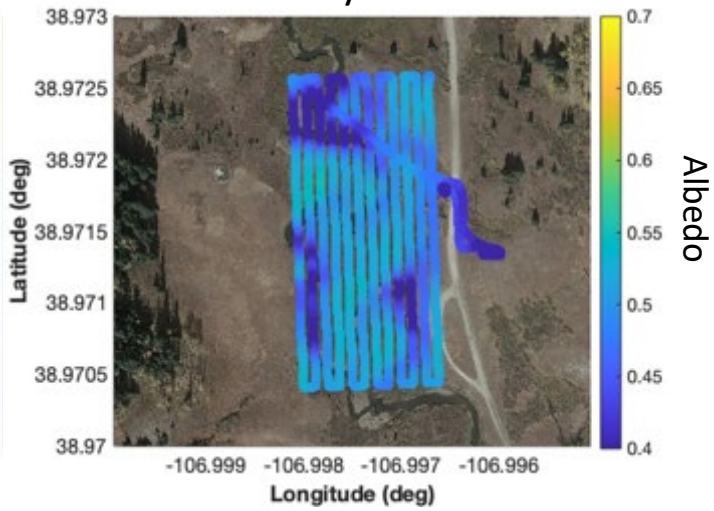
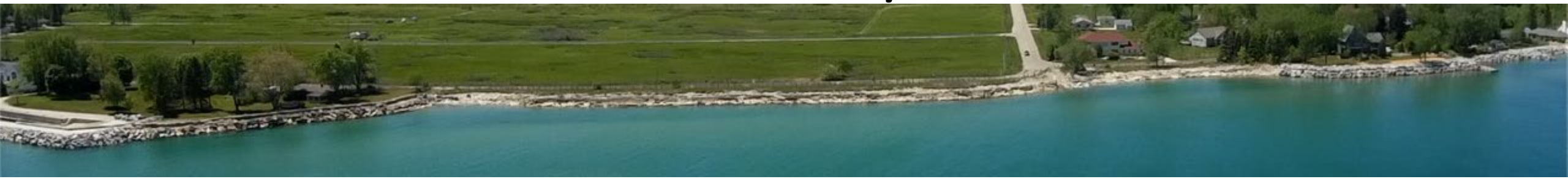


Summary



- Small UAS are a useful tool to provide new perspectives on the lower atmosphere and its interactions with the surface
- From the poles to the tropics, these systems have been deployed to document the kinematic and thermodynamic structure of the atmosphere, and support understanding of lower atmospheric physics
- These systems offer the following benefits:
  - High-resolution, in-situ sampling
  - Relatively small operational footprint
  - “Low and slow” flight abilities to capture details at very high spatial resolution near the surface
  - Can be flown into hazardous conditions
- These capabilities require investment at a facility level due to:
  - Infrastructure requirements and significant training and practice related to aircraft operations
  - Improved data quality related to extensive experience with platforms and sensors
  - Challenges associated with working with the FAA to obtain flight permissions for complex operations
- Research opportunities are out there! CU CIRES and IRISS are actively seeking collaborators who see potential benefits to integrating UAS into their ongoing Earth System research. ***Reach out if interested in exploring potential collaborations!***