Inaugural Campaigns for ARM Research using Unmanned Systems (ICARUS)

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with contributions from:

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The ARM TBS Team: Dari Dexheimer, Joe Hardesty, Al Bendure, Fred Helsel

ARM CLIMATE RESEARCH FACILITY

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NOAA

Sandia National Laboratories

Pacific Northwest NATIONAL LABORATORY

Introduction

Initial Meeting

Where/When:
26-27 January, 2016, Boulder, CO

Attendees:
Gijs de Boer, Matthew Shupe, Allison McComiskey, Amy Solomon, Sergey Matrosov, Christopher Williams, Jessie Creamean, John Hubbe, Fan Mei, Dari Dexheimer, Joe Hardesty, Al Bendure, Fred Helsel, Dale Lawrence, Jim Mather

Topics Discussed:
- Science Needs
- Observational Capabilities, current and soon to come
- Preliminary schedule for summer evaluation activities
- Planning of sampling patterns for identified science topics

Science Targets Identified

1A, 1B) Turbulence and Thermodynamic structure

- Improved characterization and observation of cloud-driven mixed-layer
- Evaluation of surface (e.g. KAZR) based turbulence estimates
- Understanding differences between clouds coupled to the surface and decoupled layers

2) Aerosols

- Seasonal differences in aerosol size distribution at Oliktok Point and comparison with Barrow
- Vertical distribution of aerosol properties — bridging gap between surface and cloud processes
- Provide insight into the radiative impact of aerosol layers

3) Ice crystal habit

- Verification of radar-derived estimates of ice crystal habits
- Develop library of habit types observed under different thermodynamic regimes
- Understand vertical evolution of ice crystals from top of the cloud to surface (bridge radar and MASC)

4) Cloud top environment

- Obtain detailed, continuous measurements of the inversion (both T and q) layer
- Measurements of aerosol properties across the inversion layer
- Obtain estimates of turbulence in and above the cloud-top environment

Science Targets Identified

5) Surface fluxes

- Seasonal evolution of surface fluxes over land and ocean surfaces
- Spatial variability in surface fluxes over land (i.e. tundra vs. ponds)
- Impact of runway and other factors on OLI ECOR measurements
- Gradient in turbulent fluxes from the shoreline to more inland locations
- Note: There are stronger connections with NGEE work in this area.

6) Horizontal winds

- Improved measurement wind vertical profile to understand diurnal cycle, mesoscale circulations, etc.
- Validation/Verification of ground-based retrievals

7) Radiation

- Interest in heating rate profile and impact of aerosols and clouds
- Sensors generally too heavy for ICARUS platforms

8) Cloud structure

- Interest in microphysics (beyond ice habit) and co-variability of water and thermodynamics and turbulence
- Beyond ICARUS sensing capabilities

Technology to be Deployed

DataHawk2

Description:

1 m wingspan
800 g total weight
~$850 vehicle parts cost
15-20 m s^{-1} typical airspeed
75 min flight duration (level)
~70 km range (level)
~4 km max altitude (powered)
50 m turn radius
5 m s^{-1} maximum climb rate

Measurement Capabilities

- Temperature
- Relative Humidity
- Pressure
- 3D wind vector estimate
- IR Surface Temperature
- Location

Technology to be Deployed

DataHawk2

Description:

1 m wingspan
800 g total weight
~$850 vehicle parts cost
15-20 m s^{-1} typical airspeed
75 min flight duration (level)
~70 km range (level)
~4 km max altitude (powered)
50 m turn radius
5 m s^{-1} maximum climb rate

Measurement Capabilities

- Temperature
- Relative Humidity
- Pressure
- 3D wind vector estimate
- IR Surface Temperature
- Location

Technology to be Deployed

35 m³ helikite
2200’ tether
Tether weight is 4 lbs/1,000’ dry, can double with ice riming

83 m³ and 103 m³ aerostats
7000’ tether
116/121 lbs. minimum lift

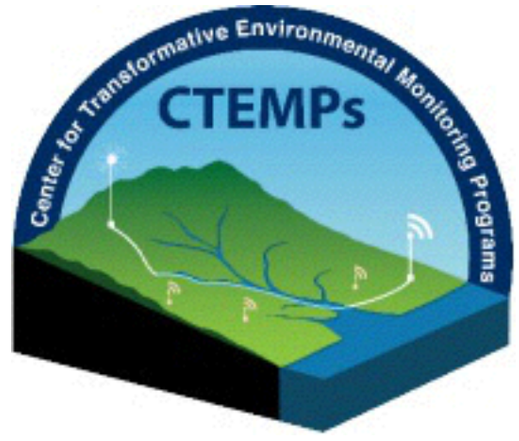
ARM TBS Instrumentation for ICARUS

Tethersondes

- ~24 hour battery life
- Provides estimates of T, RH, p, wind

Distributed Temperature Sensing

- Fiber-optic based temperature sensing at 1-2 m resolution
- Can be strung along tether of sonde
- Position determined through co-location with position sensors on tether



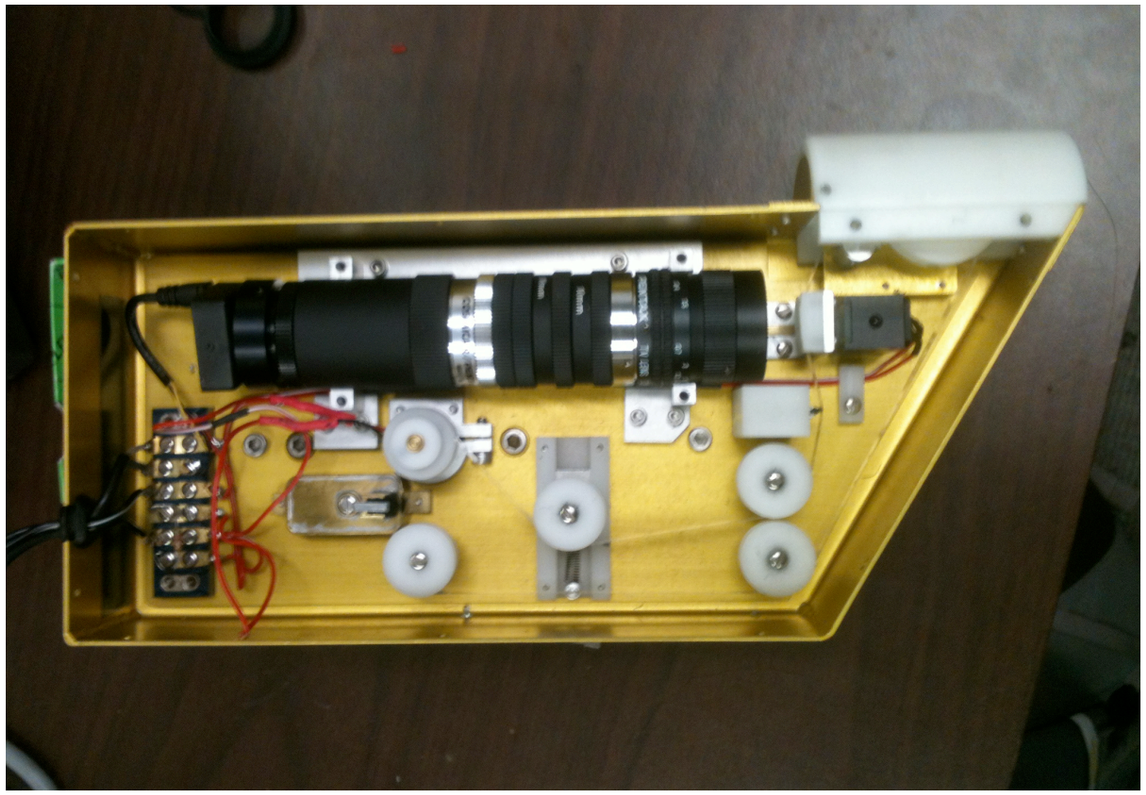
POPS

- Printed Optical Particle Spectrometer
- Aerosol size distribution (dry) for particles with sizes between 150-2500 nm diameter
- Aerosol concentration

Supercooled liquid water sensor

- Estimates liquid water content in supercooled clouds
- Detects change in frequency on vibrating wire
- Developed under DOE and NASA SBIR programs

Guest TBS Instrumentation for ICARUS

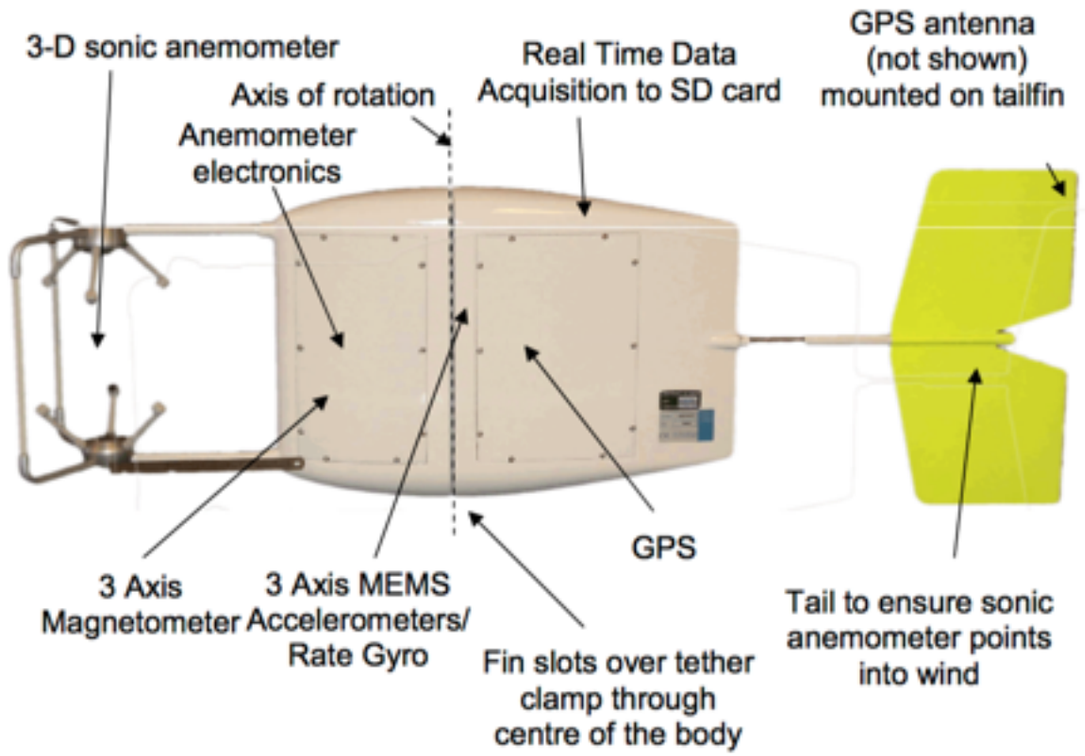


NCAR video ice particle sampler (VIPS)

- C. Schmitt PI
- provides high resolution imagery of ice crystals
- crystal sizes: 10-1000 microns
- continuous sampling
- dimensions: 10”x5”x2”

U. Leeds Turbulence Package

- I. Brooks PI
- 3D sonic anemometer coupled to IMU
- vaned to stay pointed into the wind
- previously Arctic-deployed during ASCOS



Summer 2016 Schedule of Flight Activities

April 17-30: TBS (Tethersondes, SLWC, DTS)
- Main Objectives:
  - Familiarization with DTS system, organization of equipment

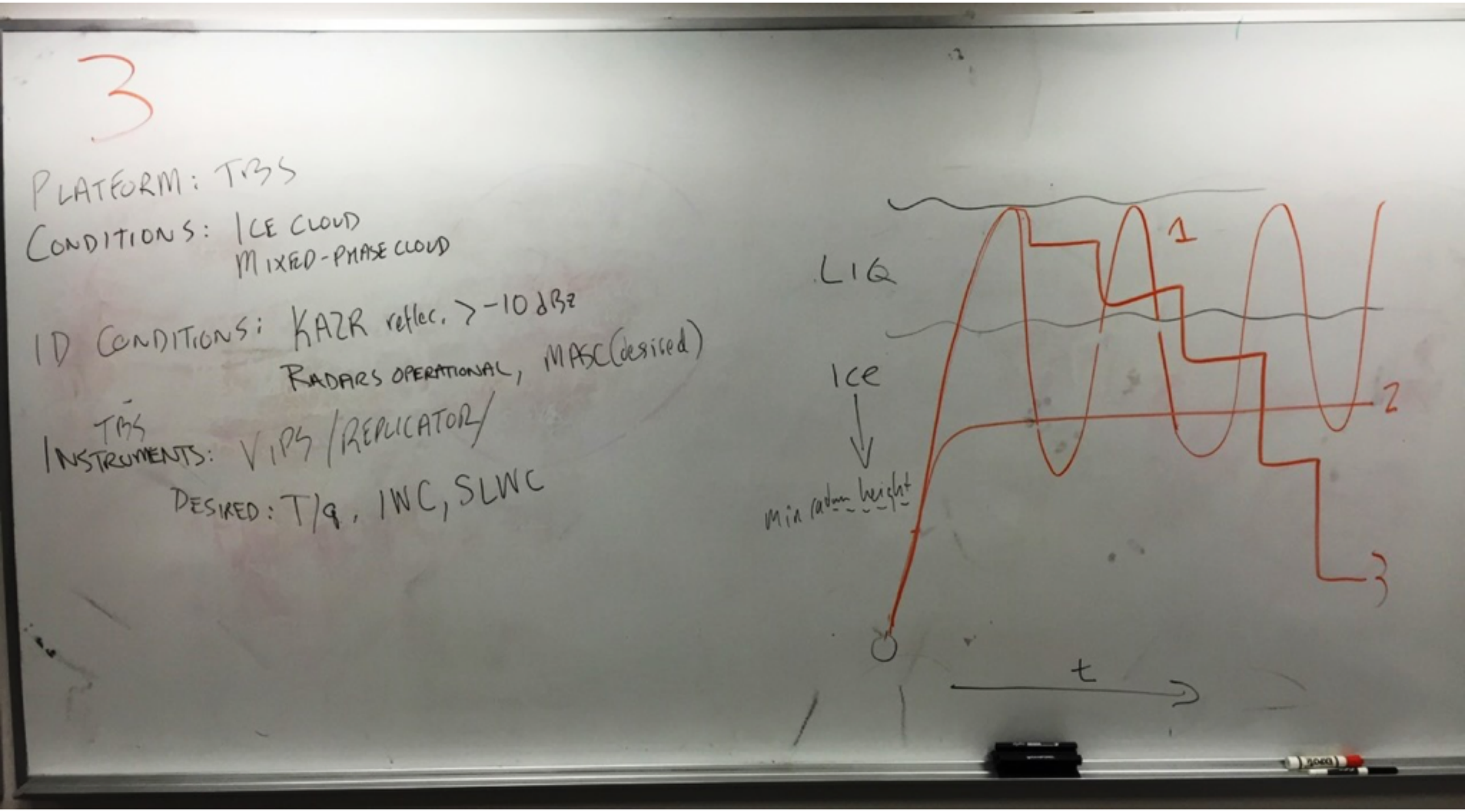
June 5-11: DataHawk 2 and TBS (POPS, Tethersondes, DTS)
- Main Objectives:
  - AAF familiarization with OLI environment
  - Evaluation of sensible and latent heat flux measurements relative to ECOR
  - Sensor comparison between DTS, DH2, AMF3
  - Aerosol size distribution profiling

26 June - 23 July: DataHawk 2
- Main Objectives
  - Survey of thermodynamic environment during sea ice thaw period
  - Sampling of mesoscale circulations resulting from land/sea temperature gradient
  - Thermodynamic sampling of near-cloud environment

August 7-20: DataHawk 2 and TBS (POPS, Tethersondes, DTS)
- Main Objectives:
  - Thermodynamics and aerosol observations of cloud-top environment
  - Profiling of cloud-driven mixed-layer thermodynamics and interface with surface layer
  - Surface turbulent fluxes over water and land surfaces

October 9-22: TBS (POPS, Tethersondes, DTS, VIPS, Turbulence, IWC/SLWC/LWC
- Main Objectives:
  - Measurements of ice crystal habits from mixed-phase clouds using NCAR VIPS
  - Information on turbulence and cloud-driven mixed-layer from Leeds turbulence package
  - Aerosol profiles between surface and mixed-phase clouds (and above, if conditions permit)
  - Thermodynamic structure of atmosphere between surface and cloud base
  - Observations of cloud-top environment (if conditions permit)

Flight Pattern Examples



Flight Pattern Examples

(1b) Thermodynamic Structure:

> Platform: TBS + Datahawk2

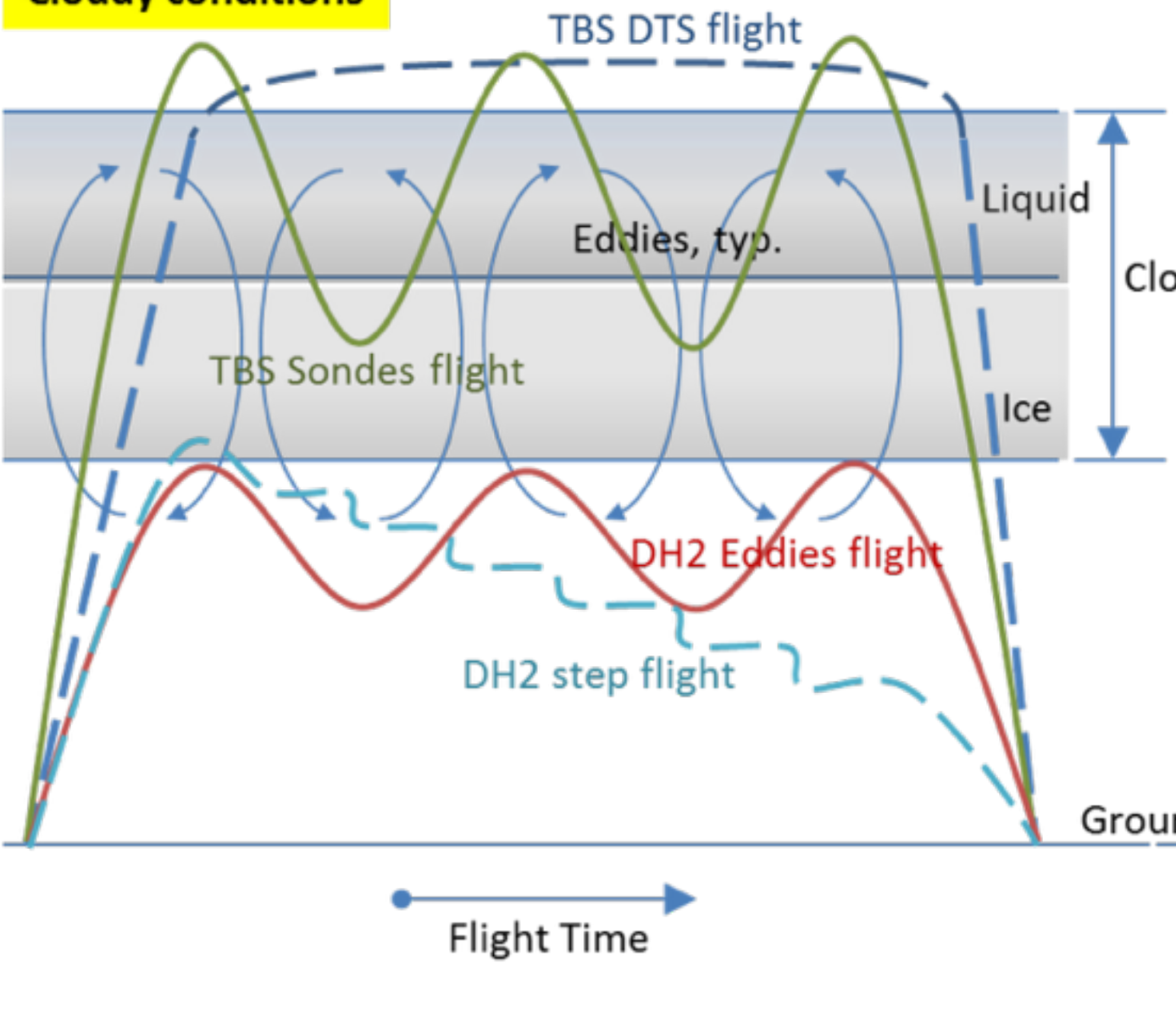
> Target conditions:"Winds <15m/s (~30mph) for both TBS and DH2; no fog, visibility for flight(DH2)/launch (TBS)

> Ground instruments (desired): AERI, MWR, RL, CEIL, radiosondes.

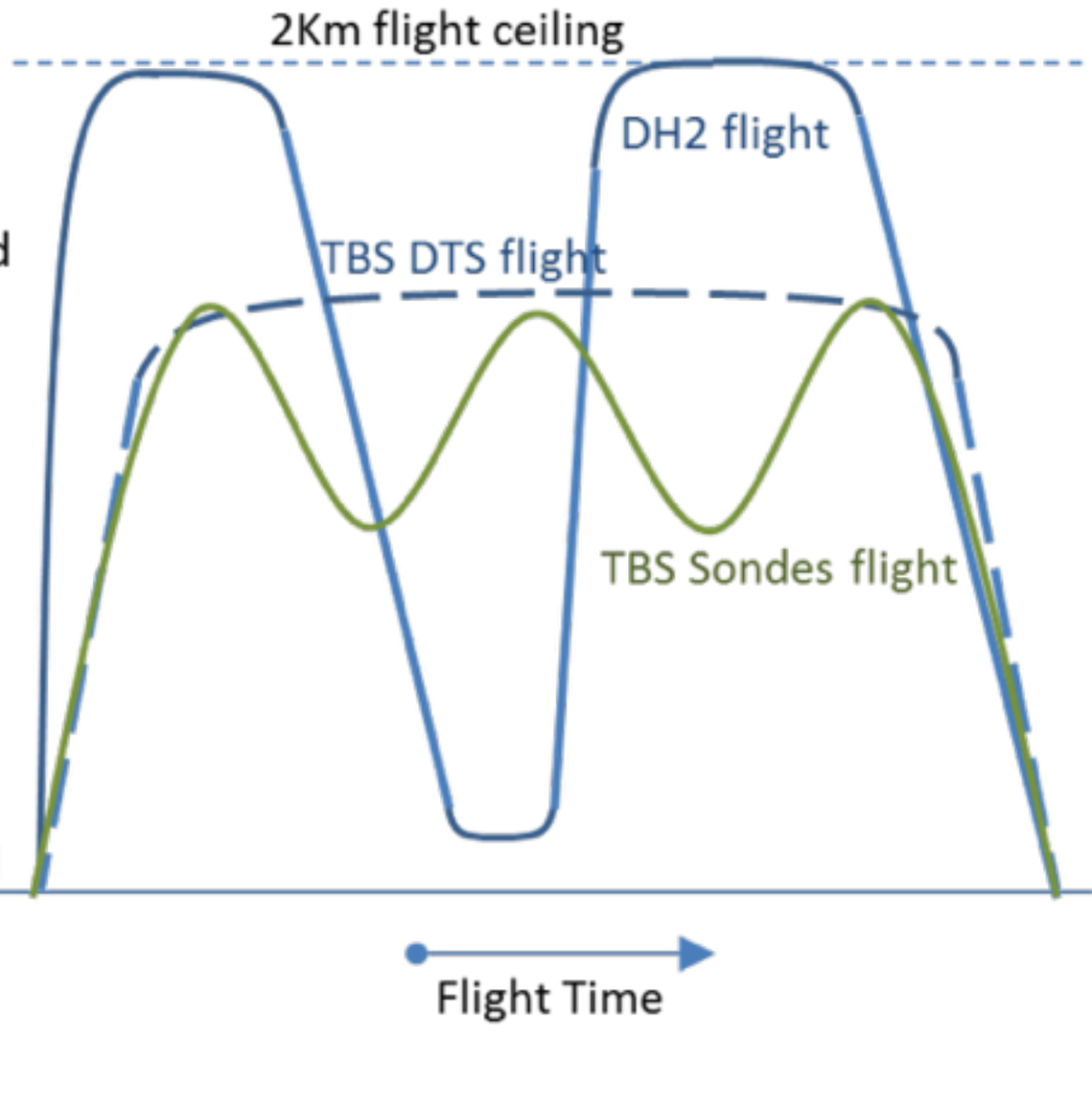
> TBS instruments: Tethersondes (at 10 m spacing desired), DTS
DH2 instruments: Coldwire, T/RH

Flight Plan options:

Cloudy conditions



Clear Conditions



Summary

- UAS and TBS flights are planned at Oliktok Point as an engineering activity during the 2016 “warm” season. These flights will happen across a variety of deployment times between April and October.
- Initial discussions with the OLI site science team have identified several potential scientific targets, including ones related to thermodynamic structure and turbulence, aerosols, winds, ice crystal habits, turbulent surface fluxes, and the cloud-top environment.
- Guest instruments are planned for deployment on the ARM TBS in October 2016 — these include the Leeds turbulence package and the NCAR VIPS.