Aerosol/Radiation, VNIR/NIR/TIR Imaging, Net Solar and Longwave Radiation, Meteorological Fluxes, Atmospheric Dropsonde, and Ocean T/S Microbuoy Payloads for Earth Observations using a Manta Unmanned Aerial System (UAS)

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**SPRING**

**BC Snow/Ice Albedo**

Less reflection from snow/ice surfaces

Earlier melting

$\Delta T_s > 0$

**SUMMER**

Direct Effect

Indirect Effect

BC enhances absorption in the atmosphere

$\Delta T_A > 0$

Added heating increases downward longwave radiation

$\Delta T_s > 0$

$\Delta T_s \approx 0$?
Coordinated Investigation of Climate-Cryosphere Interactions (CICCI) Objectives

• (1) Measure the vertical distribution of BC, chemical tracer species and aerosol properties in the Svalbard region;
• (2) use chemical tracer species and FLEXPART modeling to identify the sources and transport pathways of BC to the Arctic
• (3) Determine the concentration of BC in snow, assess deposition processes, and the processing of BC in the snow layer;
• (4) determine snow properties and measured surface albedo to investigate the effect of BC deposition on the albedo of surface snow and ice.
Manta Science Payload

Measurements

- Total particle number
- Aerosol light absorption (black carbon)
- Filter samples for post-flight chemical analysis
- Temperature/RH
- Aerosol size distribution (calculated scattering and single scattering albedo)
Ground based comparisons of UAS sensors with commercial instruments

Average particle number = 400/cc
Ground based comparisons of UAS sensors with commercial instruments
Ground based comparisons of UAS sensors with commercial instruments

Average absorption = 0.56 Mm$^{-1}$
Ground based comparisons of UAS sensors with commercial instruments

Aerosol Light Absorption (Mm$^{-1}$)

- NOAA/PMEL (Gruvebadet)
- NOAA UAS (Gruvebadet)
- SU (Zeppelin)
- ISAC/CNR (Gruvebadet)
Take off from launcher and autonomous landing on runway
Manta Flight Paths

Kongsfjorden (yellow)

Holtedahlfonna glacier (magenta)

Konsvegen glacier (green)

18 Flights
38 Flight hours

Typical flight plan: ascend to 2700m, descend to altitude of maximum aerosol concentration, sample at that altitude for remainder of flight.
Generally there was an inversion between 1000 and 1500 meters capping the boundary layer. Zeppelin Station is below this inversion.
The boundary layer aerosol number concentration and aerosol absorption coefficient are similar to the average values measured at Gruvebadet.
The aerosol number concentration was generally higher aloft. This layer occasionally contained absorbing aerosol (black carbon).
Conclusions from Svalbard

• UAS can provide high quality vertical distributions of aerosol properties.
• Aerosol transport to Ny-Ålesund occurs above the boundary layer and is not necessarily sampled by ground or mountain stations.
• Regular UAS measurements could provide the vertical aerosol data needed to test climate models and satellite retrievals.

Current Research Efforts
OAR seed grant and the Gordon and Betty Moore Foundation

New Payloads:
• Improved Aerosol/Radiation payload with OPC and upward looking radiometer
• Improved visible and infrared imaging payload
• Hyperspectral aberration-corrected imaging spectrometer
• Up and downward-looking hemispheric pyrgeometers and pryanometers
• Turbulent momentum, sensible and latent heat fluxes
• Dropsonde-microbuoys

Return to Svalbard in April 2015
Measurements

- Total particle number
- Aerosol light absorption (black carbon)
- Aerosol size distribution (calculated scattering and single scattering albedo)
- Filter samples for post-flight chemical analysis
- Temperature/RH
- Radiant flux densities

NOAA/PMEL & NOAA/ESRL/CSD
Improved Visible and Infrared Imaging Payload
Lamont-Doherty Earth Observatory (LDEO)

precise measurements of ice/snow/ocean surface temperatures accurate to 0.1°C.
Hyperspectral Aberration-Corrected Imaging Spectrometer Payload
Lamont-Doherty Earth Observatory (LDEO)

VNIR (400-1000 nm) and NIR (900-1700 nm) spectral radiance of the upper-ocean and sea ice to determine ocean color, ice-age distributions and ice-surface type
Up- and Downward-looking Hemispheric Pyrgeometer and Pyranometer Payload
Lamont-Doherty Earth Observatory (LDEO)

Net longwave and shortwave radiation for ice-ocean albedo studies with an onboard visible camera to determine the sea ice fraction and whitecapping.
The four DMB measure temperature, pressure, and relative humidity as they descend through the atmosphere. Once they land on the ocean’s surface, they deploy a string of sensors that measures temperature and salinity of the upper three meters of the ocean. The ocean sensors telemeter data back to the UAS on subsequent flights. The DMB can also be dropped on an ice flow to measure the rate of the ice movement.
Meteorological Payload
Lamont-Doherty Earth Observatory (LDEO)

Meteorological measurements of turbulent momentum, sensible, and latent heat fluxes.
Future plans

• Test flights in Yakima in January 2015.
• Svalbard flights in April 2015 to demonstrate performance of new payloads.
• Looking for funding to repeat the black carbon transport/deposition study in the Arctic.
• Continue efforts for shipboard launch and recovery. Possibly convert Mantas to VTOL.