



C41D-0724



- NASA satellites are measuring surface and atmospheric conditions, including sea-ice, clouds, and radiation to help answer these questions. *The Clouds and the Earth's Radiant Energy System (CERES) program combines these information to quantify cloud radiative effects globally and to monitor climate change*
- **ARISE data provide** a critical evaluation of satellite data products and provide other information that are difficult to measure or are currently unavailable from satellites.

Wing tip probe with atmospheric temperature, humidity and wind sensors

Broadband SW and IR, spectral SW, IR window radiometers measuring downwelling radiation, cloud and aerosol properties aloft

In-situ probes to measure cloud properties

Digital Camera System

Laser Altimeter to characterize sea/and ice properties and cloud top height

Broadband SW and IR, spectral SW, IR window radiometers measuring upwelling radiation and cloud properties below

NASA

Parameters	Instrument	Manufacturer/Model	Range
Breadth/absorption coefficient, scattering and downwelling	Cahill Pyrrometer (BIR SR SITE)	Key & Zimm, Modified Cahill (ZM)	0.2 to 0.3 (µm)
Breadth/absorption coefficient, scattering and downwelling	Pyrrometer (PBR SR SITE)	Key & Zimm, Modified Cahill (ZM)	0.5 to 0.7 (µm)
Total, diffuse, diffuse radiance, scattering and downwelling	Sunshine Pyrrometer	Delta-T Systems SPN-1 3002	0.2 to 2.7 (µm)
Spectral radiance, downwelling	Spectral scanning pyrrometer (SPSR)	NA&A Pyras	380-700 nm (6 nm resolution)
Spectral radiance transmittance, upwelling and downwelling	SPSR Spectral Solar Flux Radiometer (SPSR)	U of Colorado	550-1250 nm (6 nm resolution)
Cloud & Solar Temperature, up- and down- welling	Pyrrometer	Hemicon TR 08.1 Series II (N&A)	9.6 to 15.1 (µm)
Surface topography, vertical structure and structure and sea level water content	Land, Vegetation & Ice Scanner (LIVS) Multi-medium scattering system (WCM- 2000)	SNASA GISC SEA, Inc. (NASA LARC)	1064 nm (12 horizontal planes) Water contents 0 to 100 %
Cloud droplet size distribution	Cloud droplet measuring device (CDM)	DMT, Inc. (NASA LARC)	25 to 500 µm
Liquid water phase, precipitable water content	Cloud (IK2) phase water vapor radiometer (CVR)	Pro Sensing, Inc.	1.875-3000 (µm) (200 nm)
Temperature and pressure	3-stage pyrometer	Aerotech ARD2000 (NASA)	
Relative Humidity	3-stage pyrometer	Edgerton Vickers (NASA)	
Wind and Imagery, Near surface	Digital camera	Edgerton and NASA	

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1. From the NASA-130, measure spectral and broadband radiative flux profiles, quantify surface characteristics, cloud properties, and other atmospheric state parameters under a variety of Arctic atmospheric and surface conditions (including open water, sea ice, and land ice), and **coinciding with satellite overpasses as much as possible**.
2. Acquire detailed measurements of land and sea ice characteristics to help fulfill the NASA Operation IceBridge (OIB) mission objectives. OIB is an ongoing airborne science program to bridge gap in NASA IceSat satellite missions to characterizing annual changes in sea-ice, glaciers and ice sheets.

- 1. **Monitoring Sheet Changes**
 - Significant flight lines over sea ice and glaciers for Icebridge (laser altimeter - LVIS surveys) including repeat lines from previous campaigns
- 2. **Sea-ice characterization to support radiation experiments**
- 3. **Satellite Validation**
 - CERES grdnbox experiments: Map radiative fluxes from C-130 to test CERES grdnbox and 5FC products over wide range of arctic surface conditions
 - Atmosphere Characterization: Acquire other data (clouds, aerosols, ice sheets, T, q) to test CERES ancillary data inputs including MODIS and VIIRS imager cloud products
 - Surface Albedo Experiments to test TOA calculations & satellite obs
 - CRYOSAT underflight
- 4. **Measure Cloud Radiative Effects**
 - Low cloud vertical profiles focused on radiation & cloud properties: Test radiative closure, cloud retrievals (from satellite and aircraft radiometers)

Data, Flight Science Reports, Data Management Plan & more can be found at the current ARISE mission website:
<https://www-air.larc.nasa.gov>

Radiometer and in-situ cloud data and products:
<https://eosweb.larc.nasa.gov>

LVIS data, snow and ice products:
<http://nsidc.org>

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Broken ice pack (80N 140W)

Broken ice pack (77N 128W)

Broken sea-ice and clouds (74N 152W)

Melt ponds (77N 143W)

Refreezing black ice (76N 141W)

Refreezing (73 N 129W)

- 17 Science flights conducted (150 hours)
- 6 grid box experiments for CERES (all GOLDEN days)
- Numerous sea-ice lines and Alaskan glaciers characterized for ice/die
- Observed the sea-ice transition (melting early, then refreezing), and documented a wide range of sea-ice conditions and associated cloud properties and radiative effects
- Low clouds were geometrically and optically thin, often multi-layered with fog at the surface at times
- Conducted several focused low cloud radiative closure experiments (one GOLDEN day – Sept 19, 2014)
- Conducted first ever melt season under-flight of Cryosat-2 with LVIS
- Conducted calibration flight for radiometers including Langley for 4STAR, maneuvers to characterize airframe effects and to calibrate the MET data system.

Figure 1 is a map of the Lake Superior watershed. It features a color-coded overlay representing surface elevation data from the NASA GSFC Land, Vegetation & Ice Sensor (LVIS) on September 5, 2014, at 80°N. The color scale ranges from blue (low elevation) to red (high elevation). A scale bar at the bottom indicates distances from 0 to 100 km.

Figure 10.10.10

Measuring Cloud Radiative Effects

Scattered clouds: Expanding tops

Warmer large particles: more longwave loss

Fewer large particles: less longwave loss

Net cloud radiative effect

Shortwave cloud radiative effect

Longwave cloud radiative effect

Net shortwave cloud radiative effect

Net longwave cloud radiative effect

Illustration by Sam LeBlanc, NASA ARC

- Tests CERES most popular climate data product
- Mapping pattern (2-3 hr) focused on TOA or SFC plus cloud and atmosphere characterization
- Anchored to NASA A-train
- Coincident with up to 6 CERES overpasses and numerous other meteorological satellites
- Targets pre-selected to coordinate rotating azimuthal scans from CERES FM-1 on TERRA

AQUA Satellite

CERES Gridbox Experiment
Sept 7, 2014 (Arctic Ocean)

Typical wide range of cloud conditions
Found over complex surface conditions

C-130@224h

CALIPSO Satellite

Over a dozen meteorological satellites passed thru the area
providing coincident data

Figure 1 is a dot plot with error bars showing the difference in W/m² between CERES and C-130 for various experiments. The y-axis lists the experiments: SW T5.1, SW T12, SW T1.1, SW T2.2, SW T7.1, LW T5.1, LW T12, LW T1.1, LW T2.2, and LW T7.1. The x-axis represents the difference in W/m², ranging from -40 to 20. A vertical dashed line at 0 indicates zero difference. For each experiment, a black dot represents CERES and a grey dot represents C-130, with horizontal error bars indicating 2-sigma uncertainty. The differences are generally negative for SW experiments and positive for LW experiments.

Experiment	CERES (W/m²)	C-130 (W/m²)
SW T5.1	-12	-15
SW T12	-10	-12
SW T1.1	-10	-12
SW T2.2	-15	-18
SW T7.1	-10	-12
LW T5.1	5	8
LW T12	5	8
LW T1.1	5	8
LW T2.2	5	8
LW T7.1	5	8

Three other flights were flown at low altitude (500-1000 ft) over the same three regions shown above in order to test CERES SFC fluxes. These comparisons have just started.