FIRE III ARCTIC CLOUD EXPERIMENT
Field Mission Report

Sponsored by: NASA, NSF, DOE, NOAA, ONR

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First ISCCP Regional Experiment/Arctic Cloud Experiment

FIRE/ACE

Mission summary and objectives:

FIRE, the First ISCCP (International Satellite Cloud Climatology Project) Regional Experiment, went to the Arctic to study a variety of Arctic cloud systems under spring and summer conditions during May and June of 1998. The scientific objectives of FIRE / ACE were to study the impact of Arctic clouds on radiation exchange between surface, atmosphere, and space, and how the surface characteristics of sea ice, leads, and ice melt ponds influence these clouds.

Aircraft observations were made over surface measurements provided by FIRE, SHEBA (Surface Heat Budget of the Arctic Ocean), and ARM (Atmospheric Radiation Measurements). SHEBA, which is sponsored by the National Science Foundation (NSF) and the Office of Naval Research (ONR), is a research program designed to document and understand the physical processes that couple the atmosphere, ice, and ocean in the Arctic. It is currently conducting a yearlong extensive set of measurements directly on, under, and above the sea ice in the Beaufort sea, using the Canadian Coast Guard icebreaker Des Groseilliers as a permanent ice station. The ARM program is sponsored by the Department of Energy (DOE) to resolve scientific uncertainties about global climate change with a specific focus on improving the performance of general circulation models used for climate research and prediction. ARM is providing a number of key surface-based remote sensing instruments specifically designed for the measurements of clouds and radiation at the SHEBA ice station. ARM is also operating a duplicate set of instruments at Barrow, Alaska, as part of a decade-long program to measure the clouds and radiation in the Arctic Basin. During the FIRE / ACE experiment, research aircraft coordinated with both the SHEBA ice station and the ARM site at Barrow to observe the Arctic clouds and their affect on the Arctic climate.

FIRE / ACE will attempt to document, understand, and predict the Arctic cloud-radiation feedback, including changes in cloud fraction and vertical distribution, water vapor cloud content, cloud particle concentration and size, and cloud phase, as atmospheric temperature and chemical composition change. FIRE / ACE will use the data to focus on improving current climate model simulations of the Arctic climate, especially with respect to clouds and their effects on the surface energy budget. In addition, FIRE / ACE will address a number of scientific questions dealing with radiation, cloud microphysics, and atmospheric chemistry.

Arctic Cloud Experiment Objectives:

The overall objective of the FIRE Arctic Cloud Experiment is to produce an integrated data set that:

supports the analysis and interpretation of physical processes that couple clouds, radiation, chemistry and the atmospheric boundary layer; provides in situ data for testing satellite, aircraft and surface-based remote sensing analyses; and provides initial data, boundary conditions, forcing functions, and test data to support Arctic FIRE cloud modeling efforts.

The scientific payoff from FIRE does not come merely from collecting a set of measurements, even if the set is comprehensive and some of it has been analyzed to retrieve key quantities. Rather the real payoff comes from using the retrieved results to answer questions about what is going on in the Arctic. The key overarching question for FIRE is:

- *How do the radiative feedback processes occurring between the clouds and the sea ice surface influence the Arctic energy balance?*

The subsidiary questions are:

- What are the properties of Arctic clouds, including their synoptic and annual variations?
- How do Arctic clouds alter radiative exchanges between the surface, atmosphere and space?
- Why are these particular clouds produced in the Arctic?

To answer these questions from observations requires reducing the measurements of the most important quantities that are associated with the controlling cloud and radiative processes, and characterizing the variations of these quantities over the relevant space and time scales. To cover these scales requires employing many remote-sensing observations which need to be validated for the difficult Arctic conditions.

Dates:

May 15 - June 24, 1998

Location:

Base: Fairbanks, Alaska and Barrow, Alaska
Flights: Over ARM site near Barrow and SHEBA station in Arctic Ocean

Surface Measurements:

SHEBA ice station, Des Groseilliers, Beaufort Sea
ARM, Barrow

Satellites:

NOAA Polar Orbiter 12 & 14
DMSP F12 & F13
LANDSAT 6
RESURS
RADARSAT
Earth Probe

Aircraft:

NASA ER-2
NCAR C-130
UW CV-580

NASA ER-2

Based out of Fort Wainwright in Fairbanks, Alaska, the ER-2 flew 11 missions from May 18 - June 6, 1998 for the FIRE / ACE experiment.

Science Objectives:

- Comparison of spectral properties of sea ice and cloud layers
- Validation of satellite and airborne retrieval algorithm
- Test AMSR algorithm for distinguishing first year, multi-year and fast ice using microwave
- Validate MODIS cloud mask algorithm for distinguishing clouds from snow and sea ice surfaces in polar regions
- Test MODIS cloud retrieval algorithms over sea ice surfaces during summer daytime conditions
- Determine radiative energy budget of clouds and sea ice in polar regions
- Comparison of satellite and ground based observations of clouds and clear sky in polar regions
- SHEBA and ARM long term ground based remote sensing sites

Instrumentation:

• Airborne Multi-angle Imaging Spectroradiometer (AirMISR)
PI - R. Marchand and J. Conel
Along-track scanning push broom radiometer that produces multi-angle imagery at 9 look angles and 4 visible wavelengths (433, 555, 670, and 865 nm)

• Advanced Microwave Precipitation Radiometer (AMPR)
PI – R. Hood
Cross track passive microwave imager at four frequencies (10.7, 19.35, 37.1, and 85.5 GHz)

• Cloud LIDAR System (CLS)
PI – J. Spinhirne
Vertical cloud structure in nadir direction

• High-resolution Interferometer Sounder (HIS)
PI – S. Ackerman, H. Revercomb
Nadir-viewing Michelson interferometer with continuous spectral coverage from 3 - 17 μm (0.5 spectral resolution)

• MODIS Airborne Simulator (MAS)
PI – M. D. King
Spectral radiance imagery in cross track direction (50 bands between 0.47 and 14.3μm)

• Millimeter-wave Imaging Radiometer (MIR)
PI – J. Wang
Cross-track scanning microwave imager at seven frequencies (89, 150, 183.3±1, 183.3±3, 183±7, 220, and 340 GHz)

• Solar Spectral Flux Radiometer (SSFR)
PI – P. Pilewskie
Solar irradiance spectrum at moderate resolution from 0.30 - 2.2 μm in both zenith and nadir directions

NCAR C-130

Also based out of Fort Wainwright, the C-130 flew 8 missions from May 4 - 27, 1998 mainly over the SHEBA ice ship.

Science Objectives:

- To take in situ measurements of cloud particles above, below, and inside the clouds in correlation with the satellites, SHEBA, ARM, and the ER-2
- To measure the microphysics of clouds while flying at a low altitude
- To correlate video data with radiation measurements over Arctic clouds and surfaces

Instruments:

- PMS
  Aerosol and cloud droplet spectrum and mean particle diameter and water/ice content
  Total Number of Cloud Particles
- OAP-260X
  Cloud Droplet spectrum, mean particle diameter, water/ice content & computed reflectivity
- Hygrometer
  Ambient dew pt. temp. & water vapor pressure; Derived absolute humidity
- Multi-angle Spectrometer Probe(MASP)
  Aerosol Size and Number
- Gerber PVM 100A
  Cloud Liquid Water and Effective Radius
- Rosemount 871F ice-accretion probe
  Derived supercooled liquid water content
- TSI CN counter
  CN concentration
- Heimann KT19.85 IR Radiometer
  Surface Temperature
- NCAR-modified Eppley PIR Pyrgeometer
  Hemispheric IR Radiation
- NCAR-modified Eppley PSP Pyranometer
  Up/down hemispheric SW Radiation
- Eppley UV radiometer/photometer
  UV irradiance
- Multi-channel Cloud Radiometer (MCR)
  Cloud Fraction, Optical Depth, Surface Temperature, Melt Pond Coverage/depth
- Airborne Imaging Microwave Radiometer (AIMR)
  Lead fraction, New Ice Fraction
- Honeywell Laser Inertial Reference System
  3D Position, Attitude and Ground Speed
- Cloudscope
- Video Tapes of Collected Particles Particle Area/Time Plots Particle Habit and Size
  Particle Volume Concentration Particle Mass and Density
- External Video; Down & Left & Fwd
  Video Tapes of Clouds
- Continuous Flow Diffusion (CFD) Chamber
  IFN Number Concentration
- Condensation Nuclei (CN) Particle Counter
  CN Number Concentration (total larger than 0.012 μm)

- Cloud Particle Imager (CPI)
  Particle Images and Physical Char.
- CCN Spectrometers & CN counter
  CCN Activation Spectrum CN Concentration
- Radiometers (RAMS)
  Up and Downwelling Solar Flux

University of Washington CV-580

Based in Barrow, Alaska, from May 15 to June 24, 1998, the University of Washington carried out 23 research flights, amounting to 97.26 hours.

Science Objectives:

The main goals of the CV-580 were to measure the radiative properties and microphysical structures of various cloud types in the Arctic, to measure the BRDF and albedos of various surfaces (ice, snow and tundra) and various cloud types, and to obtain these measurements whenever possible either beneath the NASA ER-2 aircraft, over the SHEBA ship, or over the ARM site in Barrow for the purpose of comparing remote sensing and in situ measurements. Considerable data were collected relevant to all of these goals.

The data include: 10 sets of measurements over the ARM site (many with vertical profiles from close to the surface to above the main cloud and/or aerosol layers, and BRDF and albedo measurements), 8 flights over the SHEBA ship (including vertical profiles of cloud and aerosol properties, and BRDF and albedo measurements), and 4 flights beneath the ER-2 (three over ARM and one over the SHEBA ship). Other studies were carried out over the Chukchi Sea.

Measurements of cloud optical and radiative properties, and cloud microstructures, were obtained in stratus, altocumulus, and cirrus clouds. Total flight paths in stratus/stratocumulus, altocumulus, and cirrus/altostratus were approximately 1750, 900, and 5300 km, respectively.

Aerosol measurements were obtained in arctic haze layers, some no doubt from long-range transport, and also under very clean conditions.

Several new (or modified) instruments were operated on the CV-580 including the Gerber Scientific g-meter, the Pilewskie Solar Spectral Flux Radiometer (SSFR), the NASA-Goddard / UW Spectral Scanning Radiometer, and the SPEC Inc. Cloud Particle Imager.

This was the first field deployment of the University of Washington's Convair-580 research aircraft. The aircraft performed very well, exceeding expectations in several respects. For example, the aircraft reached an altitude of 31,000 ft, and was able to deploy to the SHEBA ship, with adequate time on station to obtain measurements, even when the ship was well over 400 nautical miles from Barrow.

Instruments:

Aerosol:

- Condensation particle counter
  Number concentration of particles; TSI Model 3760, 10^{-2} to 10^{4} cm^{-3} (> 0.02 μm)
- Forward light-scattering
  Size spectrum of particles; Particle Measuring Systems Model FSSP-300, 0.3 to 20 μm (30 channels)

35° to 120° light-scattering

Size spectrum of particles; Particle Measuring Systems Model PCASP-100X, 0.12 to 3.0 μm (15 channels)

90° light-scattering

Size spectrum of particles; Particle Measuring Systems Model LAS-200, 0.5 to 11 μm (15 channels)

Forward light-scattering

Size spectrum of particles; Particle Measuring Systems Model FSSP-100, 2 to 47 μm (15 channels)

- Differential Mobility Particle Sizing Spectrometer (DMPS)

  Size spectrum of particles; TSI, modified in-house, 0.01 to 0.6 μm (21 channels)
- Integrating 3-wavelength nephelometer with back scatter shutter

  Light-scattering coefficient; MS Electron 1.0×10^{-7} m^{-1} to 1.0×10^{-3} m^{-1} for 550 and 700 nm channels, 2.0×10^{-7} m^{-1} to 1.0×10^{-3} m^{-1} for 450 nm channel

  Integrating nephelometer

  Light-scattering coefficient; Meteorology Research, Inc. Model 1567 (modified for increased stability and faster response time), 1.0×10^{-5} m^{-1} to 2.5×10^{-3} m^{-1}
- Particle soot/absorption photometer

  Light absorption and graphite; Radiance Research Absorption coefficient: 10^{-7} to 10^{-2} m^{-1}; Carbon: 0.1 μg m^{-3} to 10 mg m^{-3} (+/- 5%)
- Quartz filters Thermal optical technique

  Graphite and/or Organic Carbon; Lawrence Berkeley Lab. (T. Novakov), 4 to 160 μg m^{-3} (+/- 1.6 μg m^{-3}) for 1 m^3 sample
- Scanning humidigraph

  Humidification factor for aerosol light-scattering; In house (designed and built for UW by Mark Rood) b_{sp} (RH) for 30% RH 85%

Cloud Physics:

- Digital holographic camera

  Cloud and precipitation particle images; SPEC, Inc. Model CPI-230, 5 μm to 3 mm
- Diode occultation

  Size spectrum of cloud and precipitation particles; Particle Measuring Systems OAP-200X (1D-C), 20 to 310 μm (15 channels)
- Diode imaging

  Images of precipitation particles; Particle Measuring Systems OAP-2D-C, Resolution 25 μm
- Hot wire resistance

  Liquid water content; Johnson-Williams, 0 to 2 or 0 to 6 g m^{-3} & King/PMS, 0 to 5 g m^{-3}
- Optical sensor

  Liquid water content, particle surface area, effective droplet radius; Gerber Scientific Inc. PVM-100A, 0.001 - 10 g m^{-3}; 5 - 10,000 cm^2 m^{-3}; 2-70 μm
- g-meter

  Optical scattering/extinction coefficients at 635 nm, asymmetry parameter, and back-to-forward scattering ratio for cloud and precipitation drops and ice particles Gerber Scientific, Inc.*, Particles 10 - 2000 μm. Rate 5 - 100 Hz. Asymmetry parameter (g) to 1-2 % accuracy. Optical extinction coefficient to 5-10%.

Chemistry:

- Teflon filters and ion exchange chromatography

  Particulate species $SO^{=}_4$, NO^{-}_3, Cl^-, Na^+, K^+, NH^+_4, Ca^{++}, Mg^{++} ; Gelman Dionix, 0.1 to 50 μg m^{-3} (for 500 liter air sample)
- Pulsed fluorescence

  SO_2; Teco, 43S (modified in-house), 0.1 to 200 ppb
- Chemi-luminescence (C2H4)

Ozone; Monitor Labs Model 8410 A, 0 to 5 ppmv (< 7 ppb)

- Infrared correlation spectrometer
  CO; Teco Model 141, 0 to 50 ppmv (~0.1 ppmv)
- Infrared correlation spectrometer
  CO_2; LI-COR Li-6262, 0 to 300 ppmv (0.2 ppmv at 350 ppmv)
- Chemi-luminescence (O_3)
  NO/No_x; Modified Monitor Labs Model 8840, 0 to 5 ppmv (~1 ppb)

Remote Sensing:

- Pulsed 35 GHz radar (λ = 0.86cm)
  (same as ground units at Barrow and Ship but without Doppler)
  Radar reflectivity; In-house, Upward or downward pointing (600 m to 20 km)
- Cloud Absorption Radiometer (CAR)
  Absorption and scattering of solar radiation by clouds and aerosols, reflectivity of surfaces; NASA-Goddard/University of Washington, 13 discrete wavelengths between 300 and 2300 nm
- Pilot's radar (=3 cm)
  Weather radar Bendix/King (now Allied Signal), 160 nm
- NASA Ames Solar Spectral Flux Radiometer (SSFR)
  Solar Spectral irradiance or radiance, spectral transmission and reflectance; Up and down looking hemispherical signal collectors, 300-2500 nm (5-10 nm resolution. FOV 1 mrad. 1 Hz spectral sampling rate.

** This summary is organized chronologically in order to view correlating data from each day of the experiment. Each day is then subdivided into aircraft and surface data from that particular day.*

Acknowledgements

Michael D. King, Flight Scientist for ER-2, NASA Goddard Space Flight Center
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Steven Platnick, Flight Scientist for ER-2, University of Maryland – Baltimore County
Jason Y. Li, Research Scientist for CAR instrument, Space Applications Corp.
Dennis Hlavka, Research Scientist for CLS instrument, SSAI

Bibliography

ER-2

MAS http://ltpsun.gsfc.nasa.gov/MAS/fireacehome.html
CLS http://virl.gsfc.nasa.gov/firensa.html
HIS http://cimss.ssec.wisc.edu/fireiii/results
AMPR http://eosweb.larc.nasa.gov/ACEDOCS/data/ace_ampr_imagelist.html

CV-580

Flight Information http://cargsun2.atmos.washington.edu
CAR http://climate.gsfc.nasa.gov/~jyli/Car/data/fire3

C-130

Flight Information http://polarbear.colorado.edu/cu-sheba.html
Radiometers http://cloud.ucsd.edu/missions/fire.ace.html
MCR http://raf.atd.ucar.edu/~krista/shebamcr.html

SHEBA

LIDAR
http://www.joss.ucar.edu/cgi-bin/joss-catalog/ship_instrument_browse?Cloud_Lidar
Sounding
http://www.joss.ucar.edu/cgi-bin/joss-catalog/ship_instrument_browse?GLAS_skewt

Satellite SSM/I

http://eosweb.larc.nasa.gov/ACEDOCS/data/ace_ampr_imagelist.html

** All information was taken from the worldwide web on June 23, 1998.*

May 1998

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	FIRE/ACE begins C-130 flight 15	16
17	ER-2 and C-130 flights 18	CV-580 flight 19	ER-2, CV-580 and C-130 flights 20	CV-580 flight, BRDF measurements in totally diffuse conditions 21	ER-2 flight, over the surface site at Barrow 22	CV-580 flight, in-cloud radiation measurements 23
ER-2 and C-130 flights 24	Down Day 25	ER-2 flight, repeated ground tracks near the SHEBA ice station 26	ER-2, CV-580 and C-130 flights 27	mid-experiment review meeting for ER2 and C-130 28	ER-2 flight CV-580 flight Last C-130 flight 29	CV-580 flight 30
31						

June 1998

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
	CV-580 flight, BRDF measurements near ARM site 1	ER-2 overflew the ARM site in coordinatiion with the CV-580 2	ER-2, and CV-580 flights out to SHEBA 3	ER-2 flight 4	CV-580 flight, BRDF and aerosol measurements 5	ER-2 last flight CV-580 flight over the ARM site 6
7	CV-580 flight over the SHEBA site 8	CV-580 flight 9	10	CV-580 flight 11	12	CV-580 flight BRDF measurements over stratus and sea ice + 13
CV-580 flight 14	15	16	17	CV-580 flight 18	CV-580 flight 19	20
21	CV-580 flight 22	CV-580 flight 23	CV-580 flight 24	25	26	27
28	29	30				

May 15, 1998

C-130

Flight summary

Flight track

MCR images

Radiometer data

SHEBA

LIDAR image

Sounding

Satellite SSM/I

Ice concentration

Brightness temperature 19 volts

Brightness temperature 37 volts

C-130 Flight Summary
May 15, 1998

Daily Mission Scientist: James Pinto
Deputy Daily Mission Scientist: Qing Wang
Report prepared by: Qing Wang, James Pinto, Julie Haggerty

Objectives: Cloud radar validation, radiation, cloud microphysics and aerosol emission from leads, video-mapping of the surface, higher-resolution AIMR mapping of region in vicinity of ship. Coordination with the NASA ER-2 for BDRF studies.

Meteorological conditions at the SHEBA camp (morning report):

Ship position	Wind at 20 m	Ta (2 m)	Radar, LIDAR cloud
76.28N 165.19W	17 kts 100°	- 9° C	cloud = 1.75-2.0 km AGL, ice precip to 750 m, mixed-phase

Flight Plan: High altitude mapping (AIMR) with 50 km raster grid, video-mapping of the surface if cloud base is high enough, east-west transects at several heights through the cloudy boundary layer, and box pattern at 2 km to characterize the surface at higher resolution with AIMR, lead sampling.

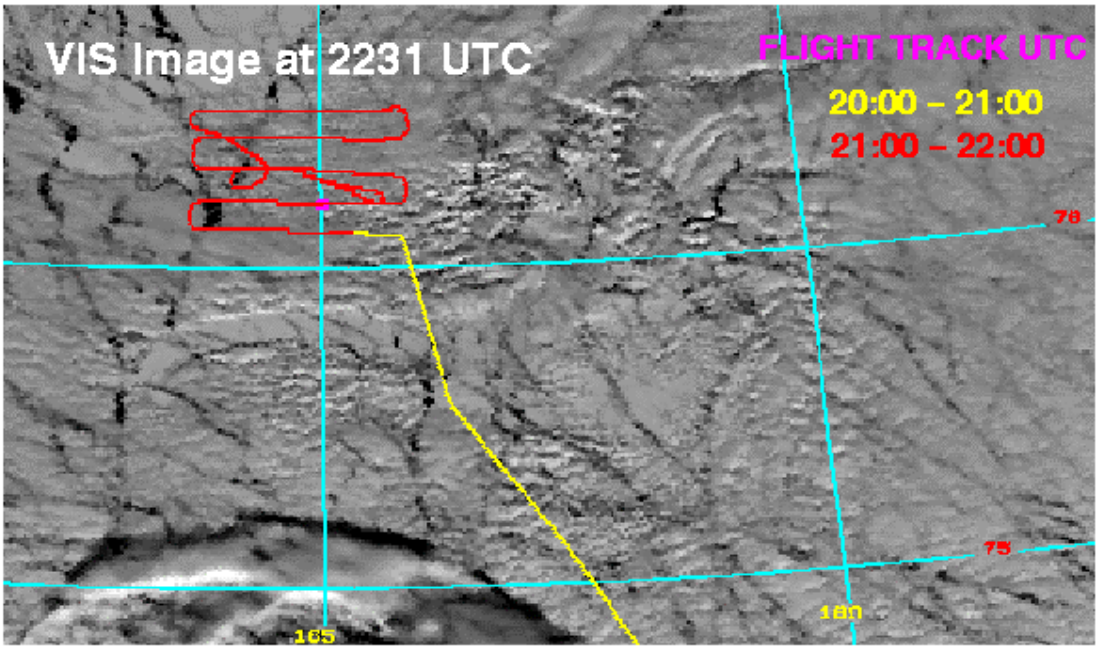
Principal accomplishments: Surface mapping at two heights (1.4, 3.9 km) giving different scales and resolutions over SHEBA. Detailed sampling of a two-layer, predominantly liquid, Arctic stratus cloud, and sampling over leads for aerosol emission. Another good case for inter-comparison with remote cloud sensors at surface and coincident satellite overpasses (NOAA-14 and DMSP).

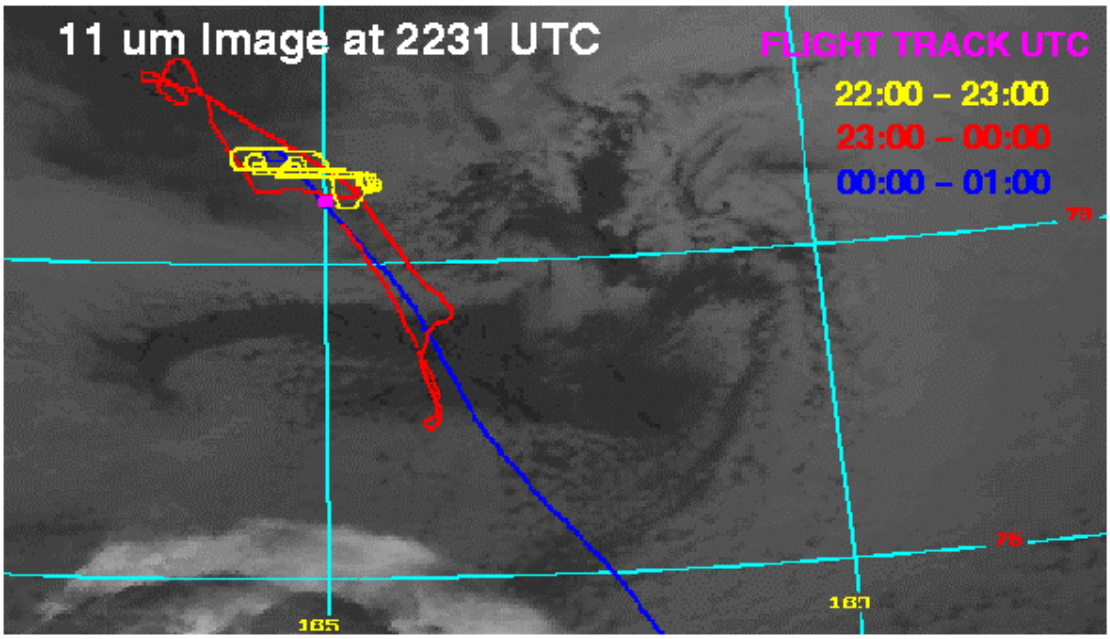
Comments: Coordination with ER-2 scrubbed as strong cross winds prevented the ER-2 from departing. Cloud conditions changed considerably during transit to SHEBA camp. Cloud base lowered to less than 200 m causing us to scrap the video-mapping pattern. Reduced number of channels operating on MCR limits the utility of the mapping patterns. The cloudy BL sampled over the ship appears to be indicative of things to come. Two cloud layers were observed separated by a clear layer of about 100 m. The upper cloud layer was very thin (about 50 m) and difficult to sample with the aircraft. The lower cloud layer between 150-500 m contained a significant amount of super-cooled water (up to 0.3 g/kg). The cloudy boundary layer was well mixed and persisted over the ship for the duration of C-130 operation. Very low concentration of CCN and CN within BL indicate that the surface is not a good source of CCN. Rodger's measurements indicate that open water regions may be an important contributor to the IFN concentrations in the BL.

Instrument problems:
AIMR: Scan rate still limits full scan coverage to above 1.6 km. Data dropouts at 1925, 2046 and 2114 GMT.
MCR: 3 channels working (CH 1, 4, 6)
Icing detector: functional

Radiometers: NCAR's downward-looking UV sensor (UVB) not available, NCAR upward-looking pyranometer (SWT) malfunctioning for entire flight.

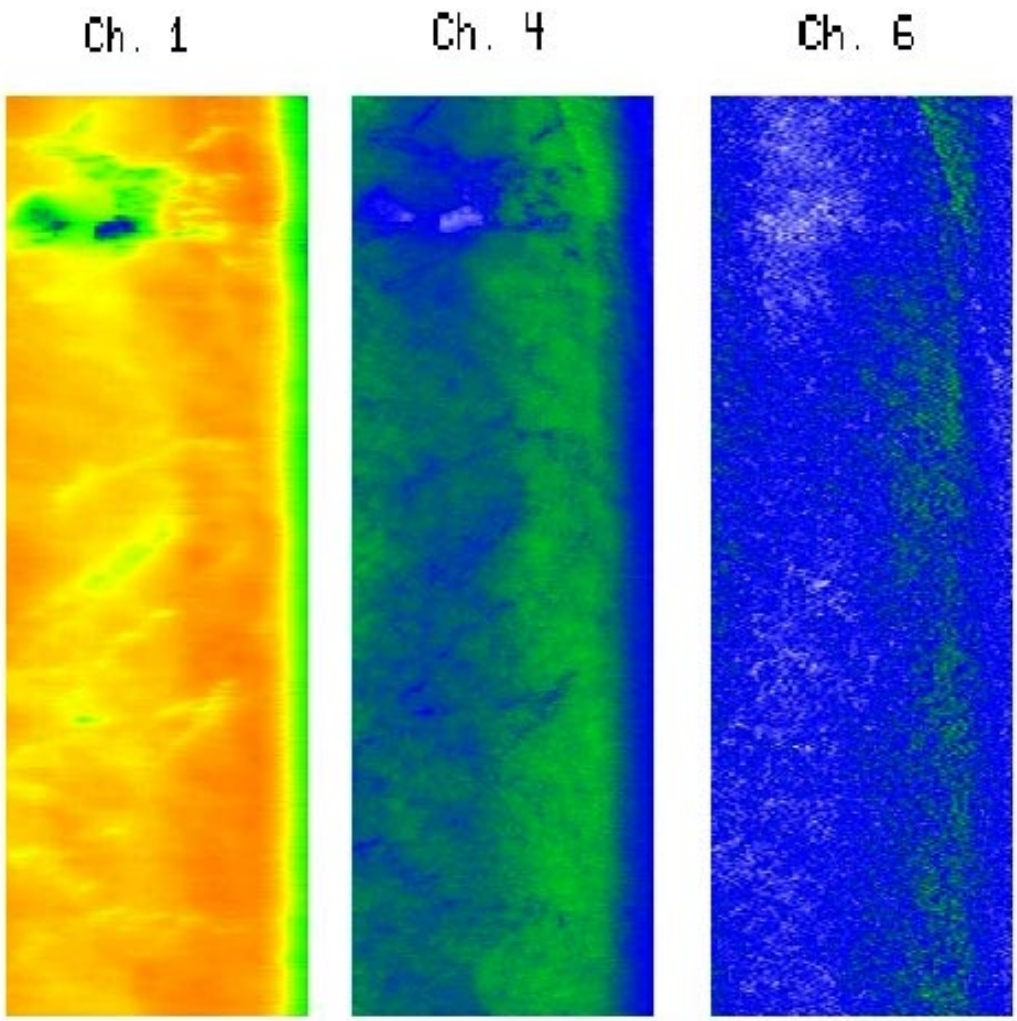
C–130 FLIGHT TRACK AND NOAA–14 AVHRR IMAGES ON MAY 15, 1998 OVER THE ICE STATION





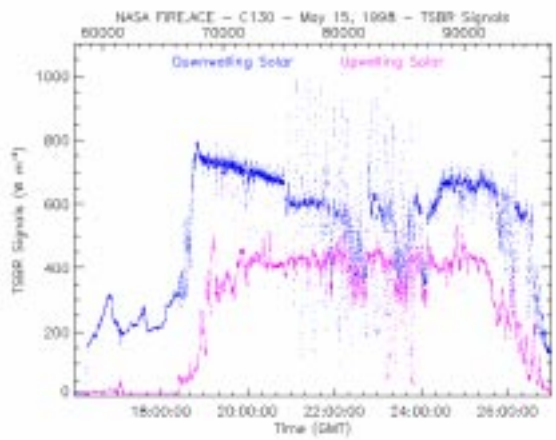
C-130 MCR Images

These three MCR images were taken on May 15 between 19:55 – 20:00, when the C-130 was flying at an altitude of approximately 6200 meters over Barrow above a cloud layer. Channel 1 is centered on .64 µm, channel 4 at 1.06 µm, and channel 6 at 2.16 µm. The flight direction is from the bottom of the page to the top, and the MCR is scanning from left to right.

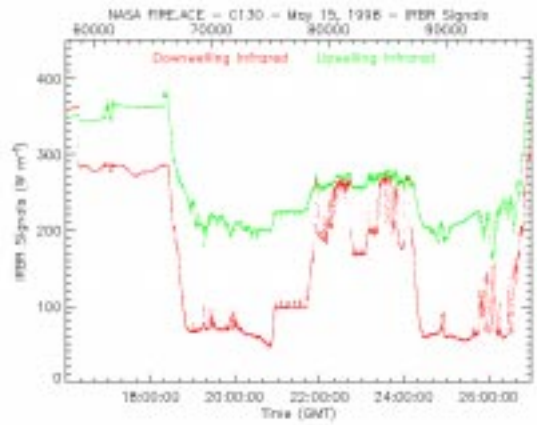


C-130 Radiometer Measurements
May 15, 1998

TSBR - Total Solar Broadband Radiometer

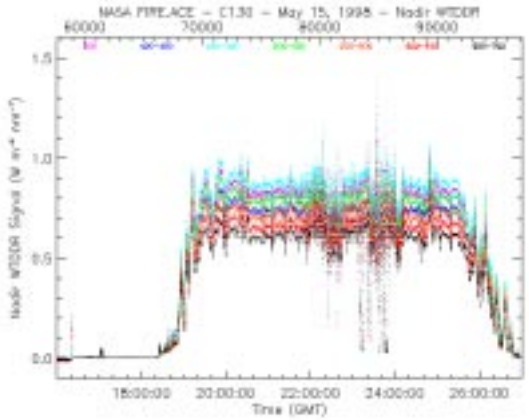


IRBR - IR Broadband Radiometer

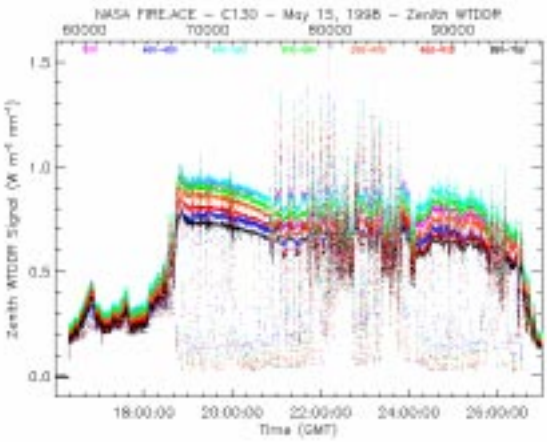


WTDDR - Wide Bandpass Total-Direct-Diffuse-Radiometer
(1 shadow ring on Zenith WTDDR)

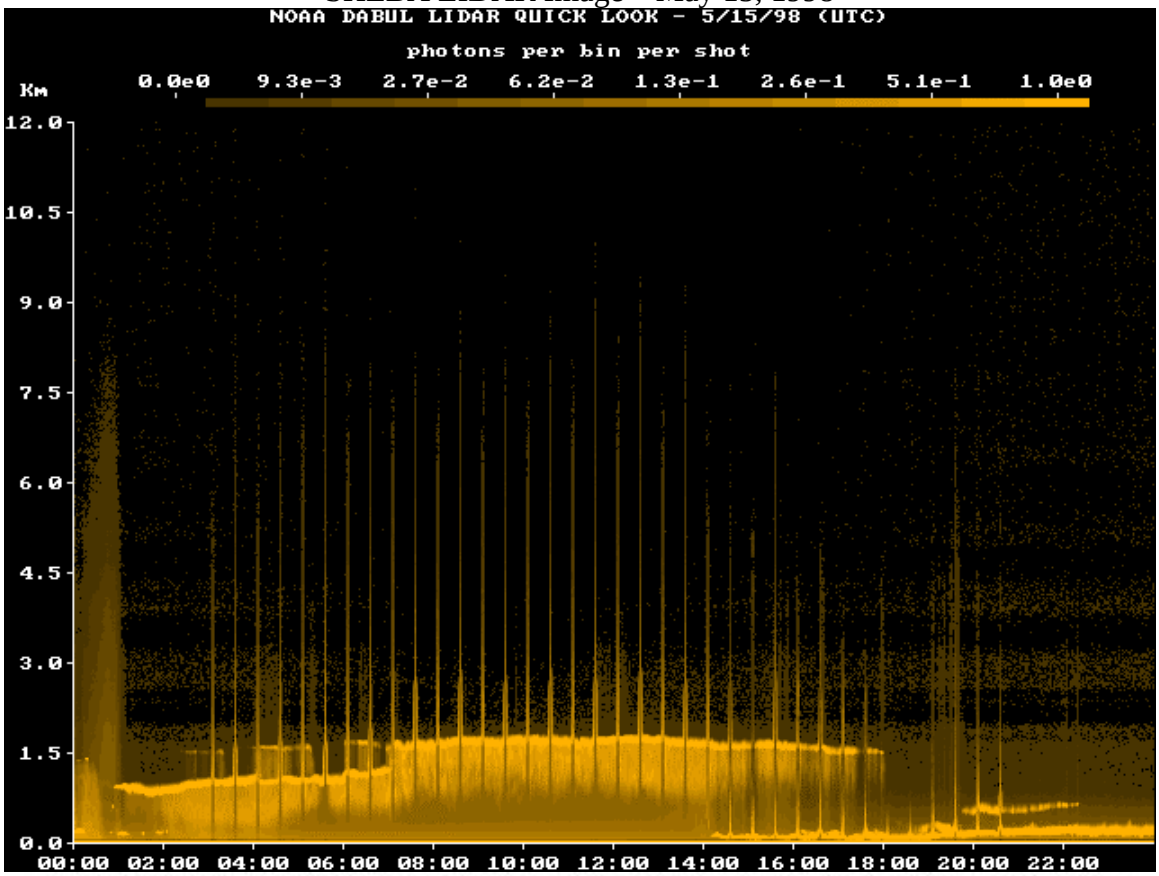
Nadir



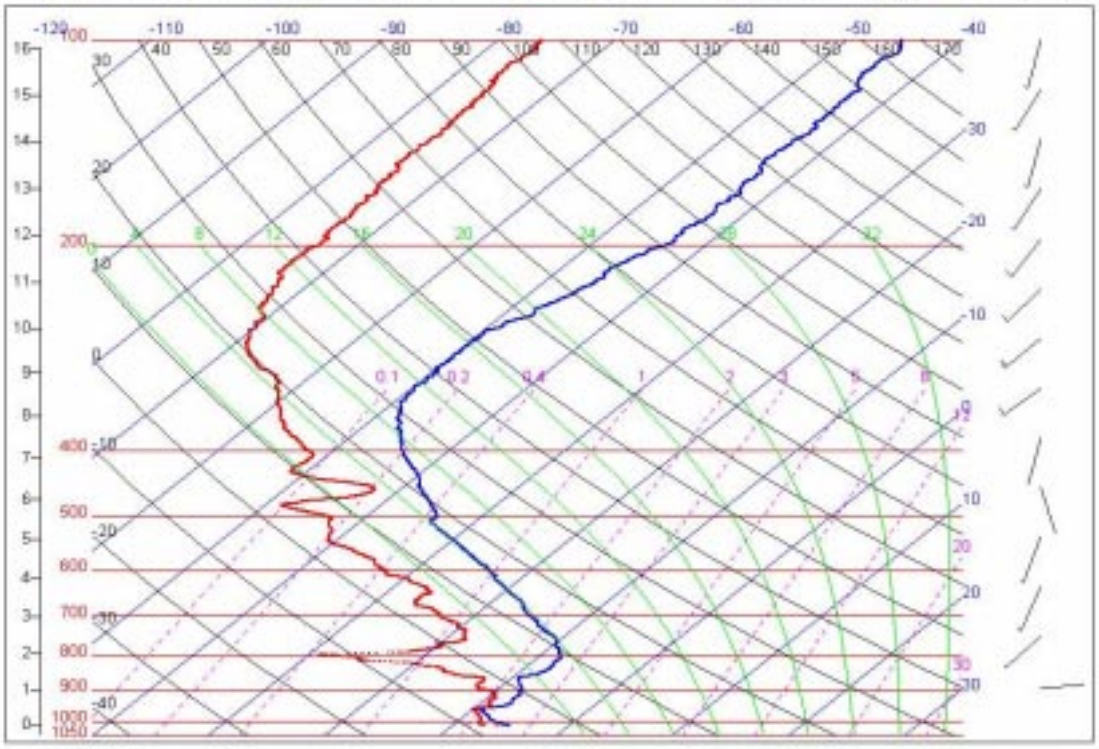
Zenith



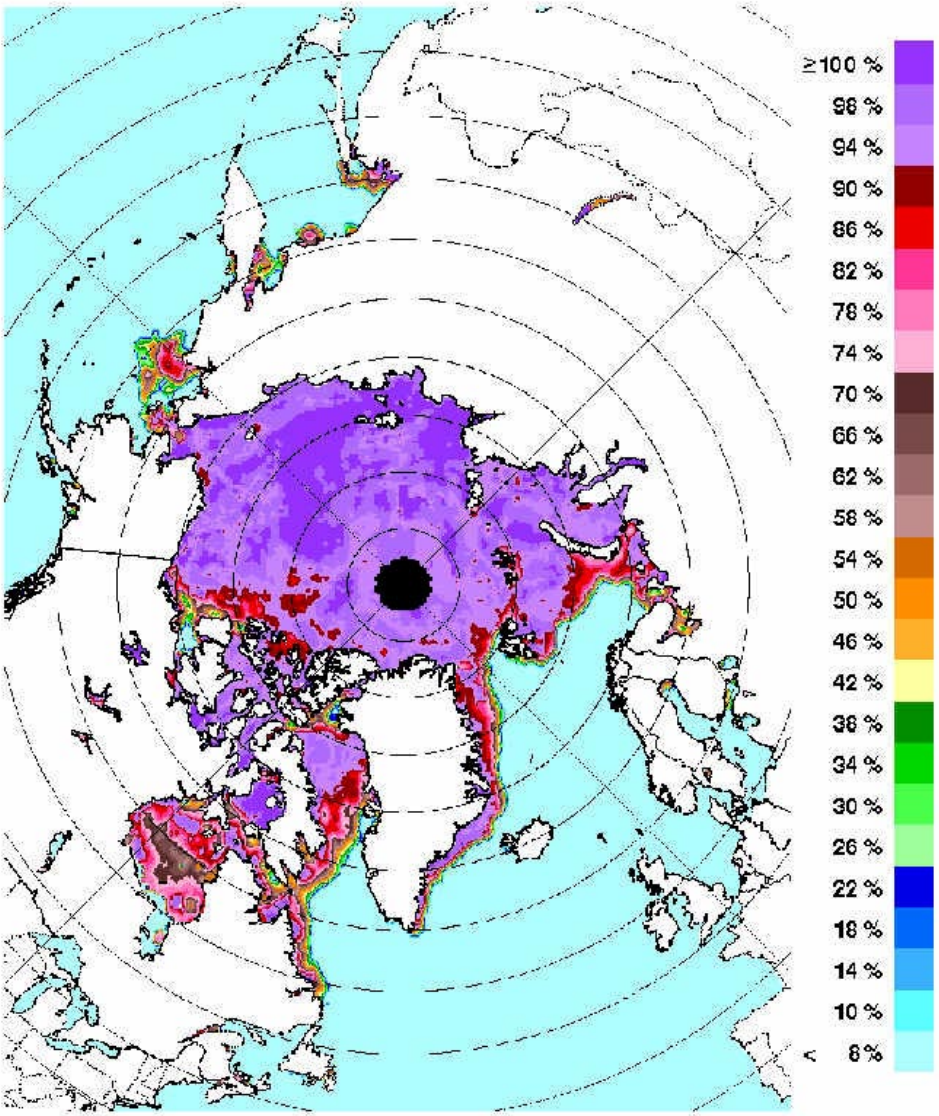
SHEBA LIDAR Image – May 15, 1998



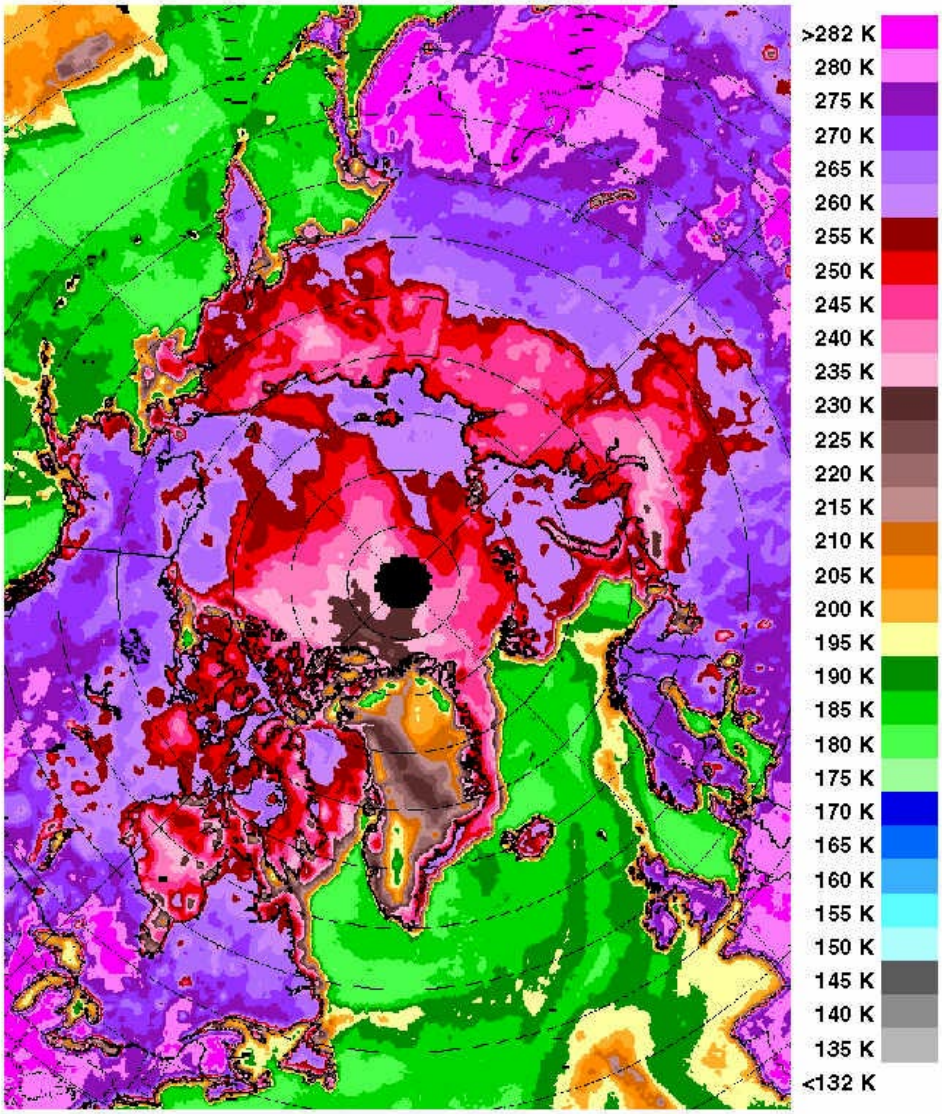
Version: SHEBA--GPS Soundings, GLASS 1.10 Fixed, SHE, 1998,05,15, 23:40:31



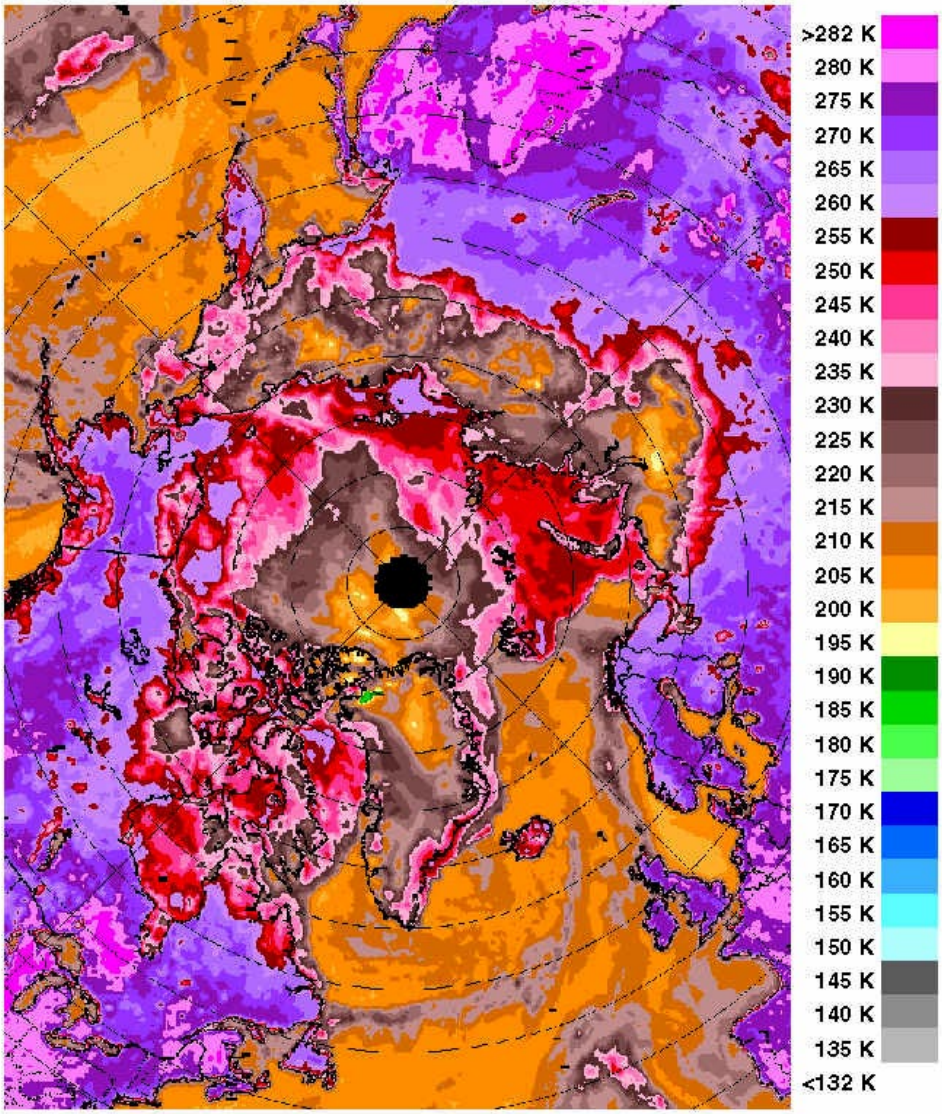
Ice Concentration: May 15, 1998



19V Brightness Temperature: May 15, 1998



37V Brightness Temperature: May 15, 1998



May 18, 1998

ER-2

Flight summary

Ground track

MAS images

HIS measurements

AMPR images

C-130

Flight summary

Flight track

MCR images

Radiometer data

SHEBA

LIDAR image

Sounding

Satellite SSM/I

Ice concentration

Brightness temperature 19 volts

Brightness temperature 37 volts

ER-2 Mission 1

Monday, May 18, 1998

Michael King: Flight Scientist

Objectives: To fly the ER-2 over surface sites at Barrow (71°19.37'N, 156°34.9'W) and the SHEBA ice station (76°18.7'N, 166°7.1'W), then to fly a repeated E-W and N-S cross pattern over SHEBA. The mission was coordinated with the C-130Q at 2300 (local noon), with the ER-2 flying north over the SHEBA ice station while the C-130Q was within the mid-tropospheric cloud layer for 50 km on a southbound leg. Other coordination included:

- F-14 satellite (2145 and 2326 UTC)
- NOAA-14 satellite (2207 UTC)
- Solar noon (2300 UTC)

ER-2 Mission:

Pilot:	Jim Barrilleaux
Takeoff	1940 UTC
Landing	0140 UTC (May 19)
Duration	6:00

The ER-2 flew over the SHEBA ice station (point 1) during an E-W grid from point 2 (76°18.7'N, 167°45'W) to/from point 3 (76°10'N, 157°W) that consisted of 2 flight legs 284 km in length, followed by a N-S grid from point 4 (74°18.7'N, 166°7.1'W) to/from point 5 (77°12.7'N, 166°7.1'W) that consisted of 2.4 flight legs 285 km in length. These flight tracks passed over the SHEBA ice station at:

- 2137, 2222, 2234.5, 2259, and 2322 UTC

The AirMISR was turned on for two acquisitions over the Barrow ARM site (en route and return) and 3 acquisitions over the SHEBA ice station, and operated at the following times:

- 2042.5-2057 UTC (ARM)
- 2216.5-2230 UTC (SHEBA)
- 2253.5-2306.5 UTC (SHEBA)
- 2316.25-2331.25 UTC (SHEBA)
- 0009.75-0026 UTC (ARM)

The ER-2 pilot reported 98% low cloud cover (undercast) starting about ~200 nm north of Fairbanks. Very few breaks in the clouds were observed.

Instrument Status

- AirMISR – no aft camera viewing (C&D camera positions) and log files not written
- AMPR – worked well
- CLS – LIDAR worked properly, but navigation data not recorded
- HIS – worked from take-off to near SHEBA the first overpass (~1.5 hr) and then failed; cause not determined
- MAS – port 4 bands (8.3-14.0 μm) noisy and unsatisfactory; will be taken off MAS for next 5 days to purge with nitrogen to evaporate ice

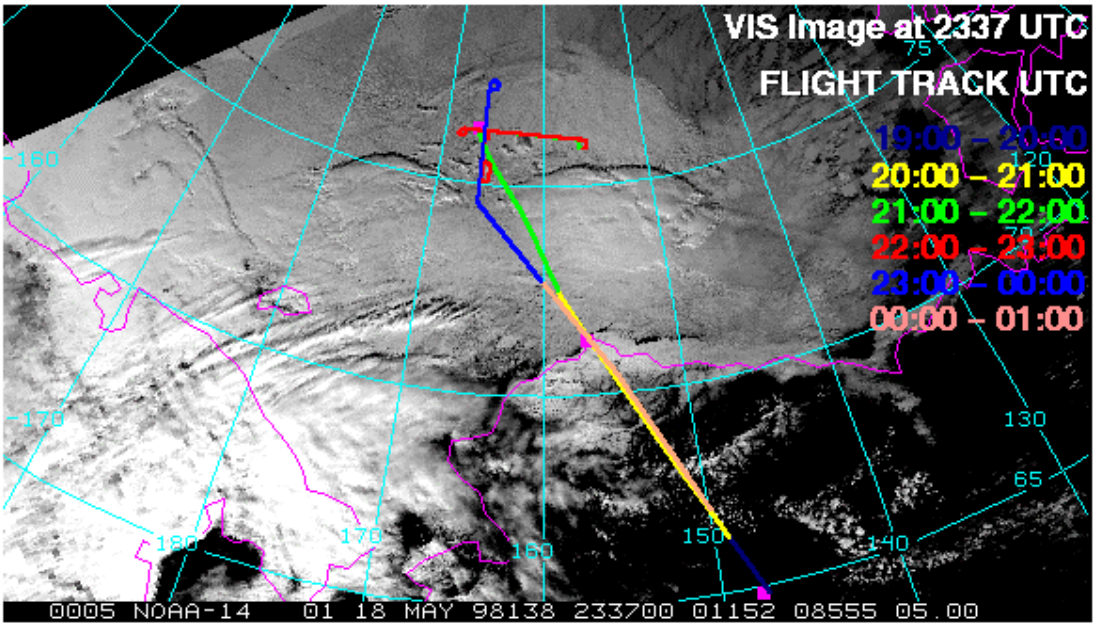
- MIR – worked well
- SSFR – worked well

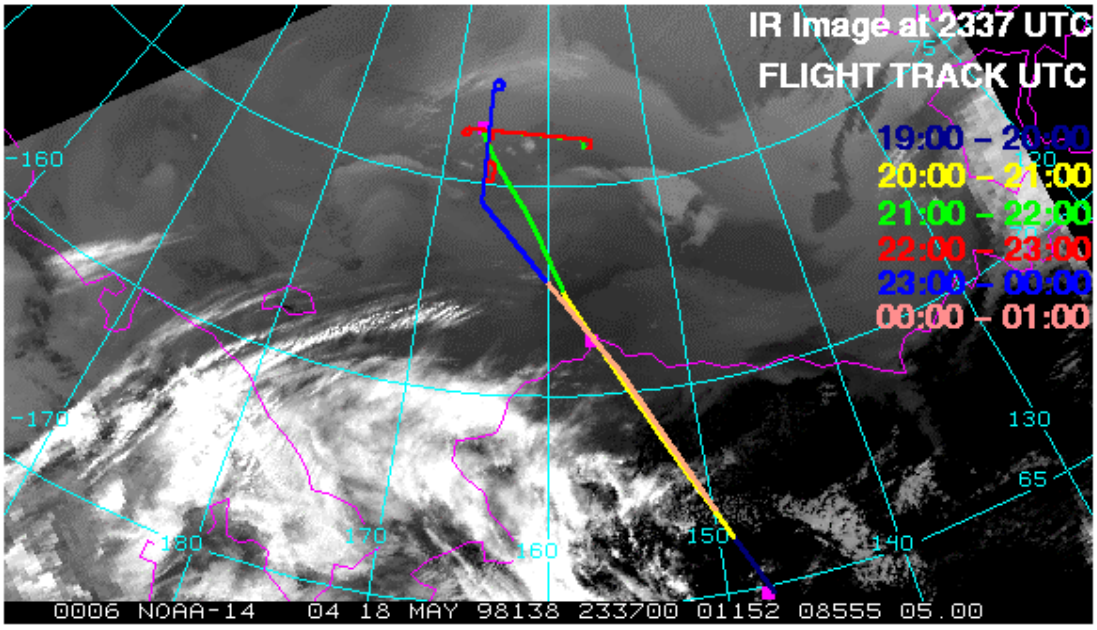
Meteorology: A multi-layer cloud system consisting of low stratus, mid-level altocumulus (3-4.5 km) and upper level cirrus (7.25-8 km) reported at the SHEBA ice station. A dry layer was seen in the sounding from the ice station between 900 and 650 mb. The satellite imagery showed a low-level cloud to the south of SHEBA and a multi-layer cloud at SHEBA at 1415 UTC, with temperature inversions at 0.5, 3.2, and 4.2 km. Winds were from the 65° at a speed of 21 kts.

Instruments:

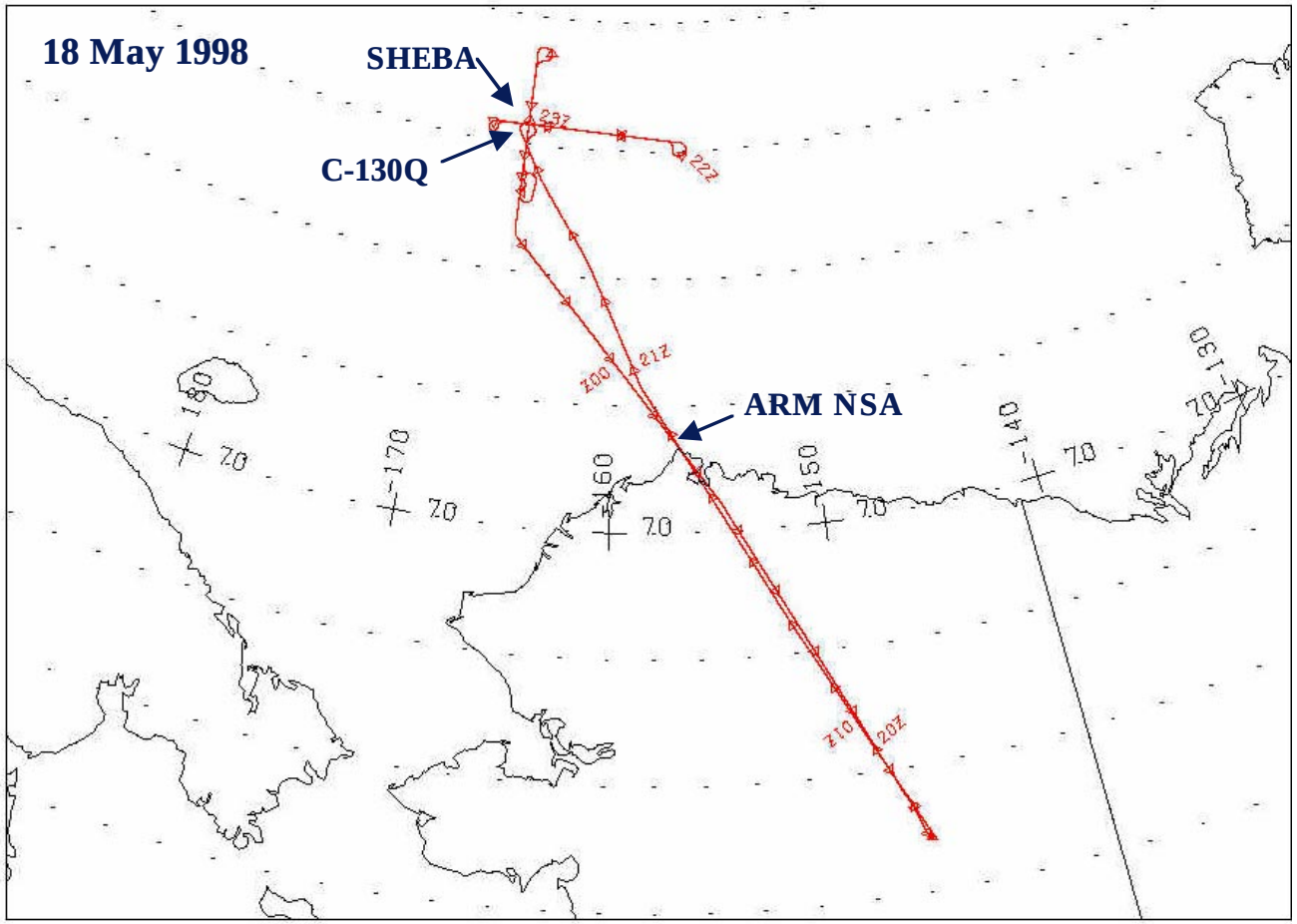
AirMISR – Airborne Multi-angle Imaging Spectroradiometer
AMPR – Advanced Microwave Precipitation Radiometer
CLS – Cloud LIDAR System
HIS – High-resolution Interferometer Sounder
MAS – MODIS Airborne Simulator
MIR – Millimeter-wave Imaging Radiometer
SSFR – Solar Spectral Flux Radiometer

ER2 FLIGHT TRACK AND NOAA–14 AVHRR IMAGES ON MAY 18, 1998





ER-2 Ground Track



Multilayer Clouds near SHEBA

Red = 2.13 μm

Green = 1.62 μm

Blue = 0.55 μm

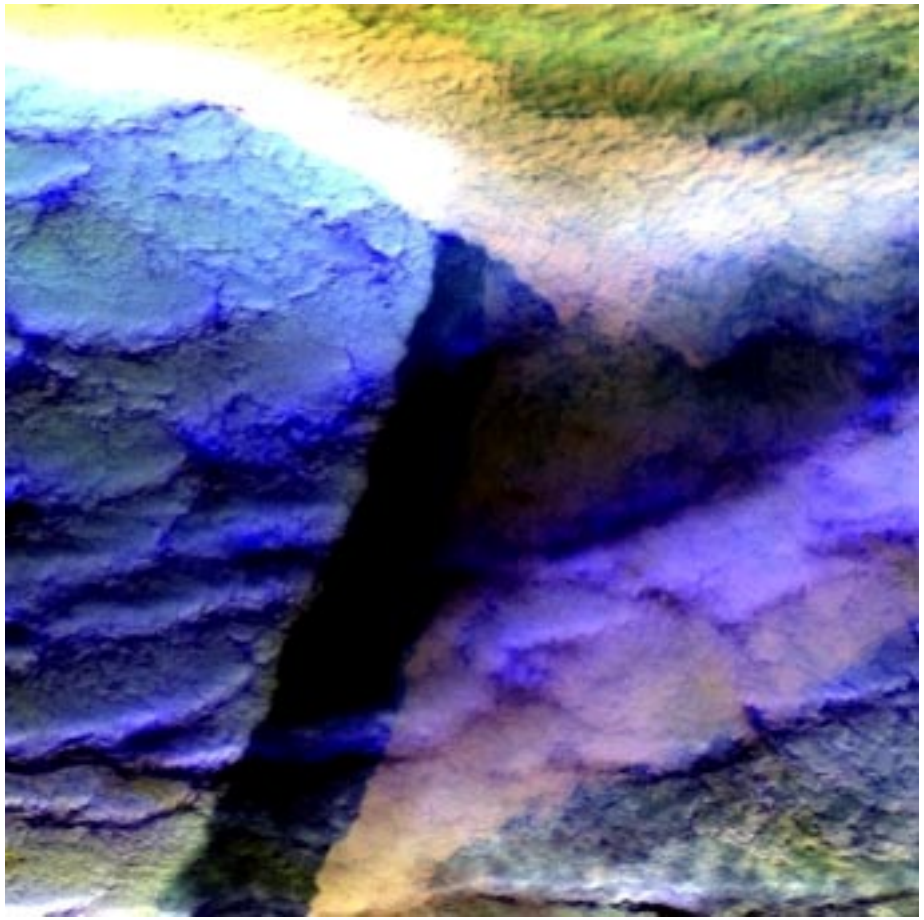
18 May 1998

76°19'N 165°52'W

2221 UTC

Flight Direction

279.8°



37.2 km

23.6 km

θ_0 **= 56.9°**

ϕ_0 **= 169.1°**

$\phi - \phi_0$ **= 20.7°**

Stratocumulus near SHEBA

Red = 2.13 μm

Green = 1.62 μm

Blue = 0.55 μm

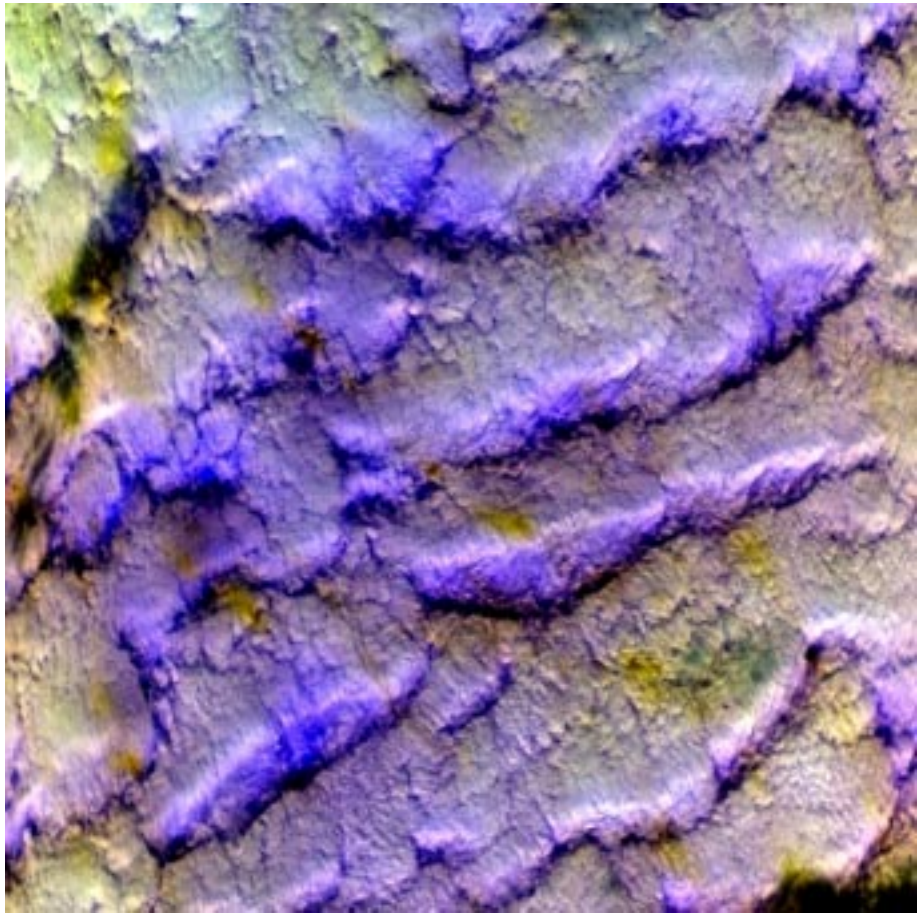
18 May 1998

76°13'N 166°07'W

2323 UTC

Flight Direction

182.4°



23.6 km

37.2 km

θ_0 **= 56.7°**

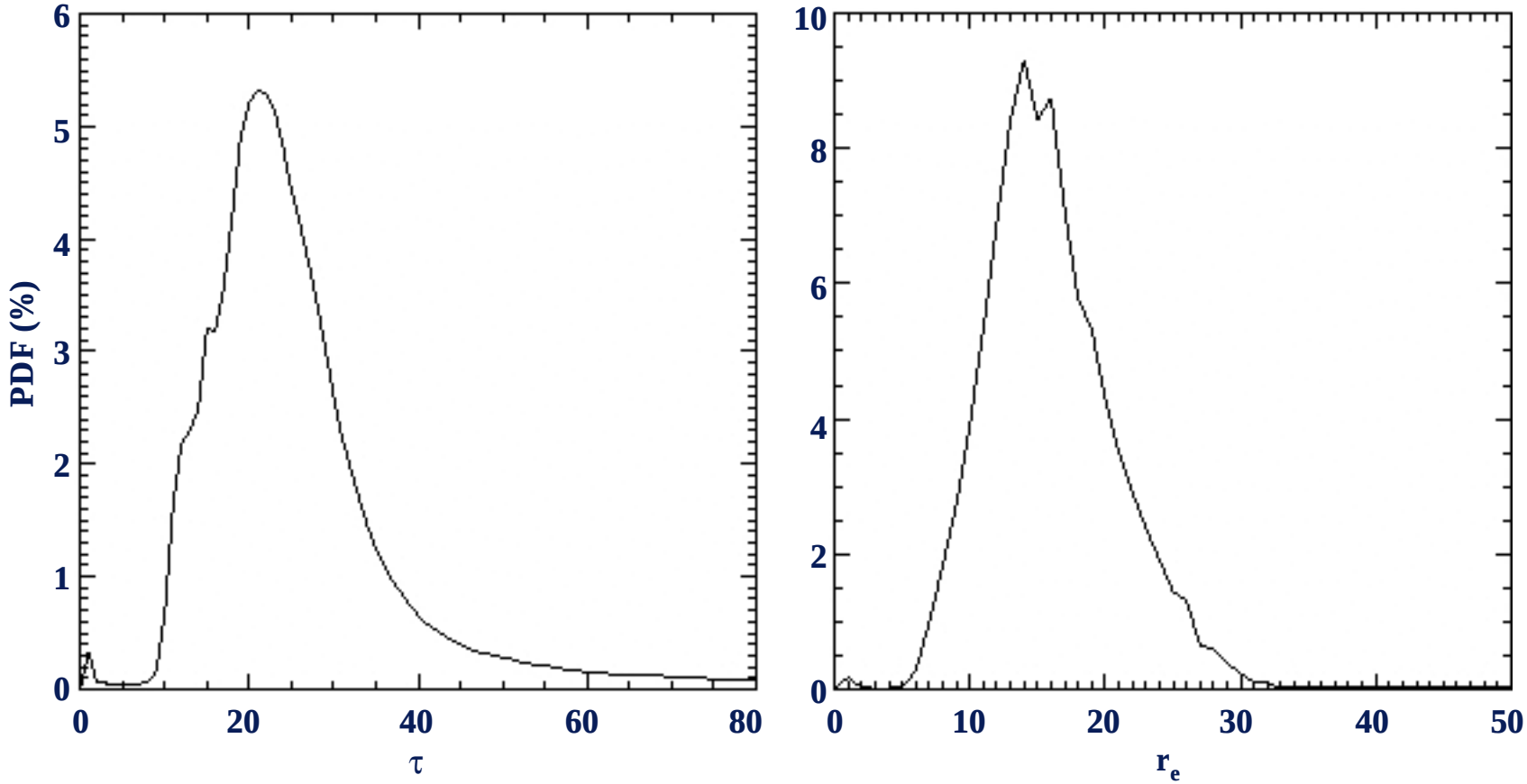
ϕ_0 **= 186.3°**

$\phi - \phi_0$ **= 93.9°**

Cloud Retrieval Results

18 May 1998 **2136-2156 UTC**

76°19'N 165°52'W

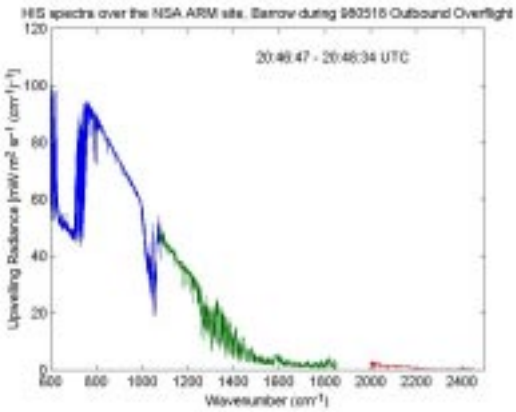


ER-2 HIS Measurements

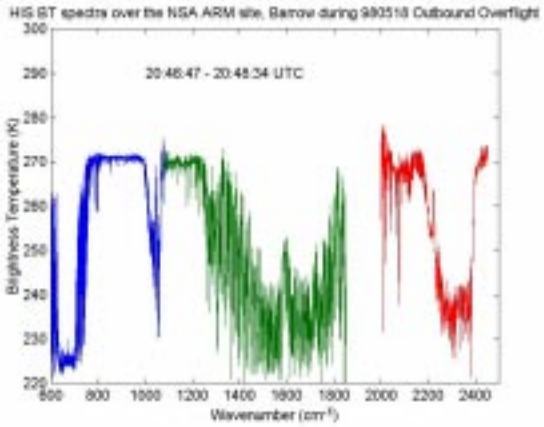
Overpass over the NSA ARM site, Pt. Barrow, Alaska
May 18, 1998

During this flight, the HIS obtained radiances from approximately 2000 UTC to 2130 UTC. The ER-2 passed over the North Slope of Alaska (NSA) Atmospheric Radiation Measurement (ARM) site at approximately 2047 UTC. Here is the average upwelling radiance spectrum for the overpass of the NSA ARM site and the corresponding brightness temperature spectrum for all 3 HIS bands. The HIS brightness temperature in the atmospheric window region shows temperatures around 272 K. The corresponding downwelling radiance spectrum at the surface from the same time was measured by the Atmospheric Emitted Radiance Interferometer (AERI) at the NSA ARM site. The fact that the downwelling radiance at the surface is similar to a Planck function indicates that there is low, thick cloud cover at this time.

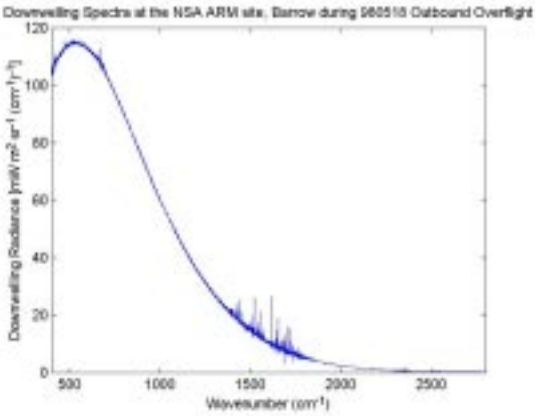
HIS Average Upwelling Radiance



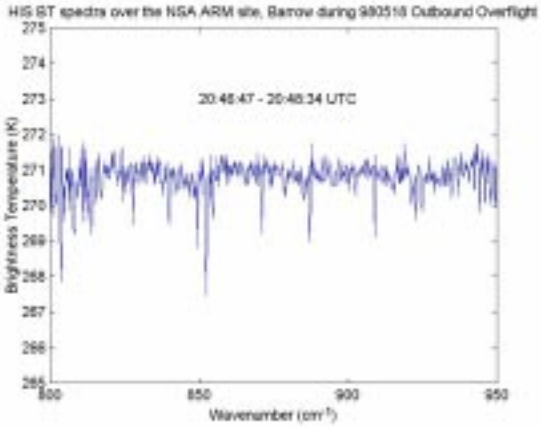
HIS Average Brightness Temperature

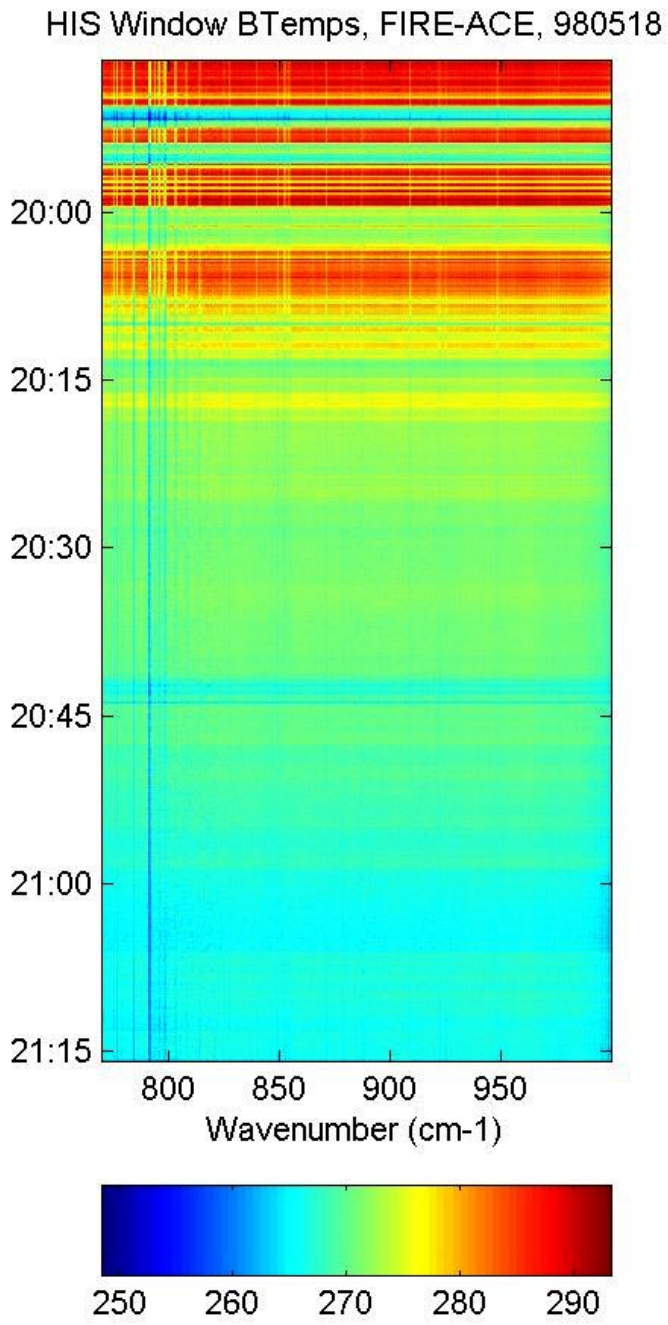


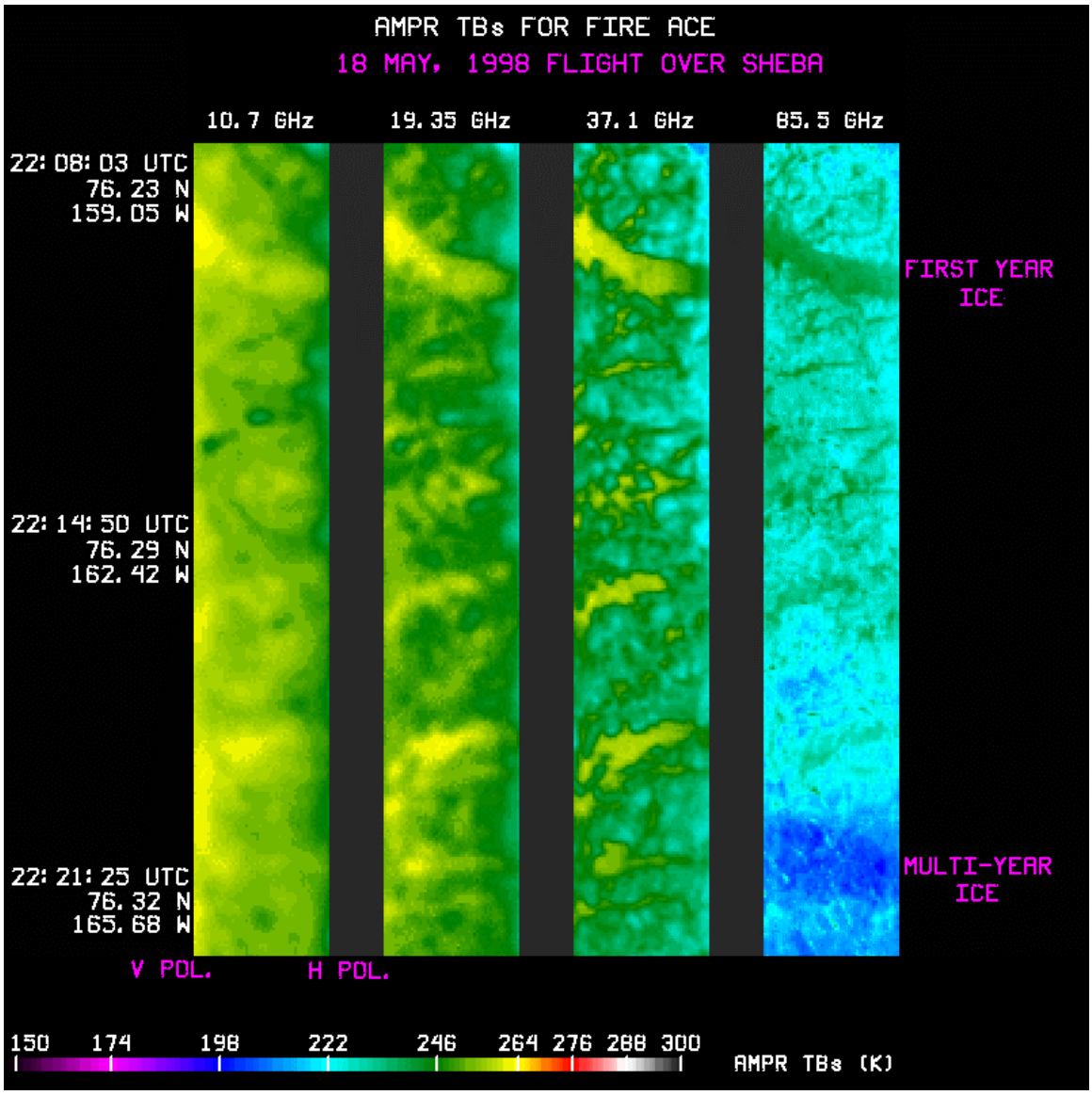
AERI Radiance Spectrum



HIS Brightness Temperature
in Atmospheric Window




HIS Window BTemps, FIRE-ACE, 980518
20:00
20:15
20:30
20:45
21:00
21:15
800
850
900
950
Wavenumber (cm-1)
250
260
270
280
290


AMPR TBs FOR FIRE ACE
18 MAY, 1998 FLIGHT OVER SHEBA
10.7 GHz
19.35 GHz
37.1 GHz
85.5 GHz
22:08:03 UTC
76.23 N
159.05 W
22:14:50 UTC
76.29 N
162.42 W
22:21:25 UTC
76.32 N
165.68 W
FIRST YEAR ICE
MULTI-YEAR ICE
V POL.
H POL.
150 174 198 222 246 264 276 288 300
AMPR TBs (K)

C-130 Flight Summary
May 18, 1998

Daily Mission Scientist: James Pinto
Assistant Daily Mission Scientist: Judy Curry
Report prepared by: Judy Curry, James Pinto, etc

Objectives: Underflight with ER-2, sampling of altostratus, sampling of cloudy boundary layer, mapping patterns, leads as source for aerosols.

Meteorological conditions reported at the SHEBA camp:
SHEBA Surface observations at 7:30 ADT reported cloud radar returns up to a height of
8 km, with layers 0-2 km, 3-4.5 km, and 7.25-8 km. Ceilometer showed cloud base at 0.2 km. Considerable liquid in the layer 0.2-0.4 km, attenuating the LIDAR above this level. Low level cloud is unbroken and homogeneous. The boundary layer is well mixed, with an inversion at 500 m. The surface is relatively unchanged for the past few days.

Ship position	Surface wind	Surface temperature
76.3117 N	21 knots	-7° C
166.118 W	65°	

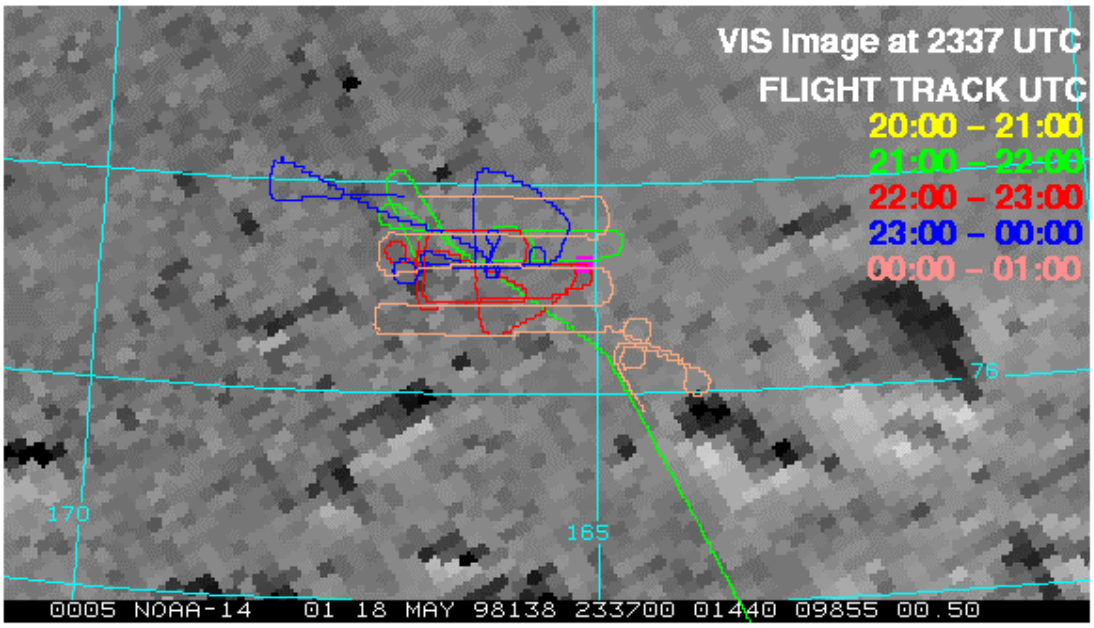
Flight Plan: Mapping pattern at 5 km (approx. 4 km above low cloud), descent to surface, look for open leads, sample cloudy boundary layer. At local solar noon (2300 GMT), fly N-S transect centered over SHEBA ship in the As cloud layer. Sample the As cloud layer. Do a mapping pattern at 2.5 km.

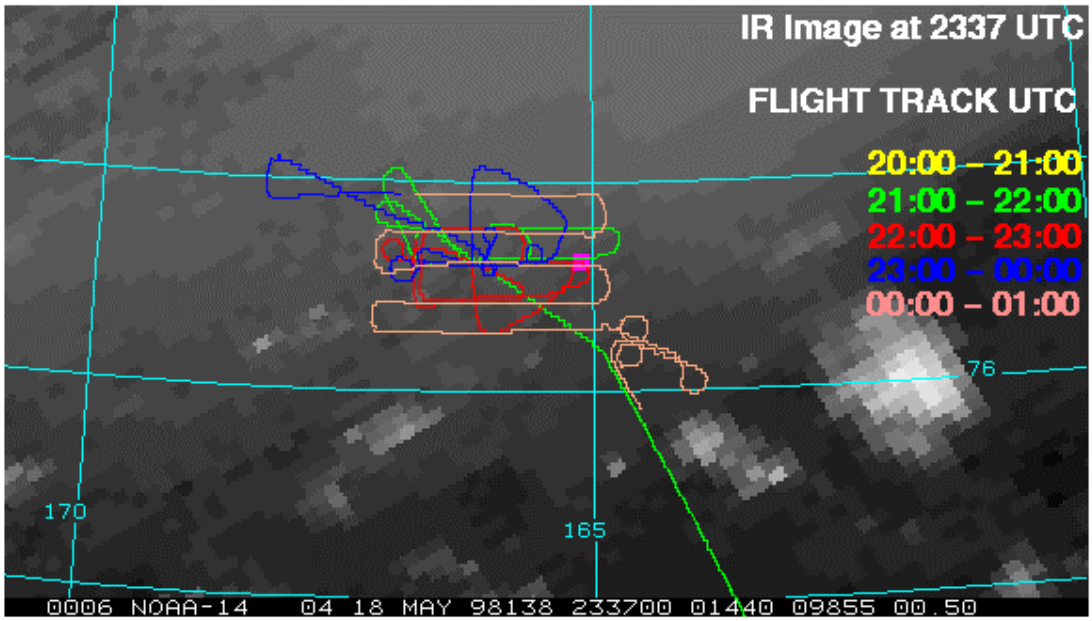
Principal accomplishments: High altitude mapping pattern, sampling of liquid cloudy boundary layer. Sampling of ship modification of cloud. "Clean" sample of aerosol particles over open lead. ER-2 underflight.

Comments: By the time we flew over SHEBA camp, the upper level cirrus cloud had dissipated, and the altostratus was in the process of dissipating. Hence we focused on the boundary layer cloud. This was an extremely interesting cloud, super-cooled liquid water at -11C with very few crystals apparent. The exhaust from the ship was modifying the CN and possibly the cloud characteristics. This will be an interesting case to look at aerosol-microphysics interactions, and to look at SW absorption in cloud.

Instruments problems:
Best flight yet for instrumentation
AIMR: scanning at twice the rate that it has been for previous flights
MCR: Best flight for MCR. No useable data from Ch. 2 & 3, noise in channels 5, 7 but otherwise worked very well for the entire flight

C130 FLIGHT TRACK AND NOAA-14 AVHRR IMAGES ON MAY 18, 1998 OVER THE ICE STATION



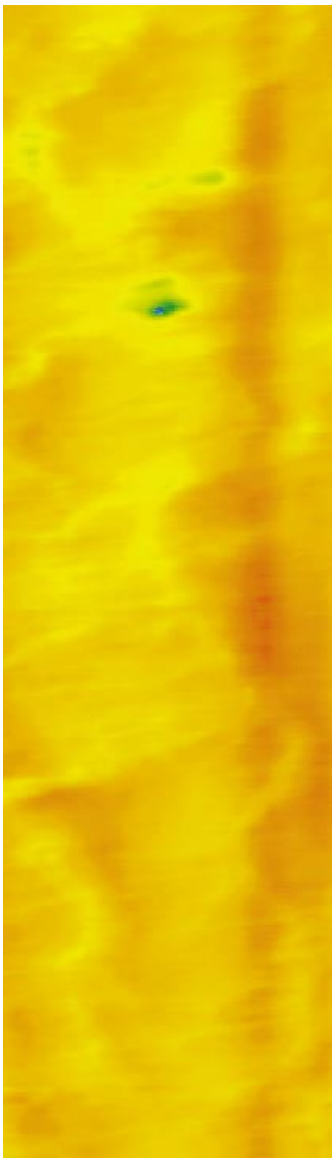


C-130 MCR Images

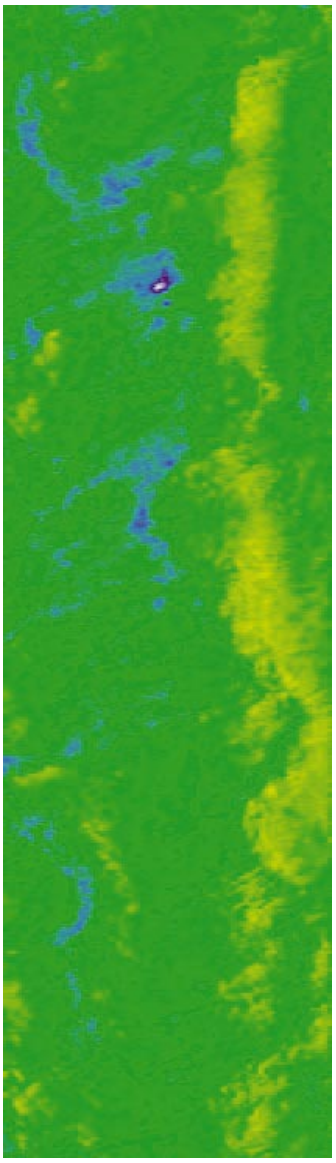
These images were taken by the MCR on May 18. The flight direction is from the bottom of the page to the top, with the MCR scanning from left to right. The channels are centered on .64, 1.06, and 2.16 μm respectively.

00:10 - 00:15 UTC

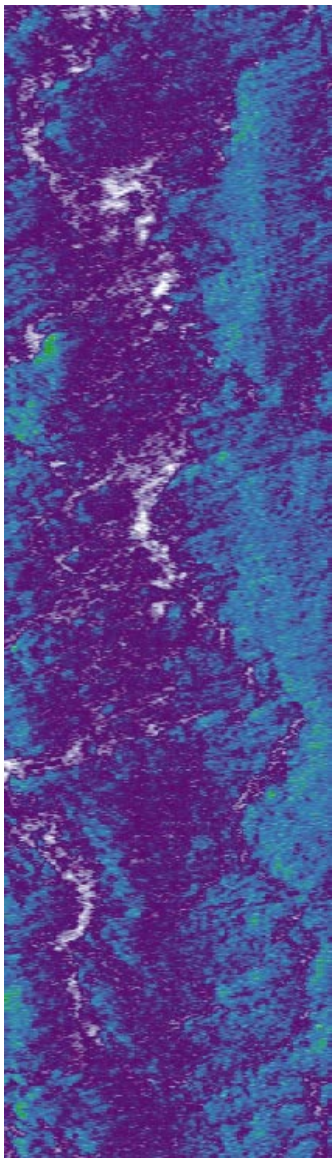
Ch.1



Ch.4

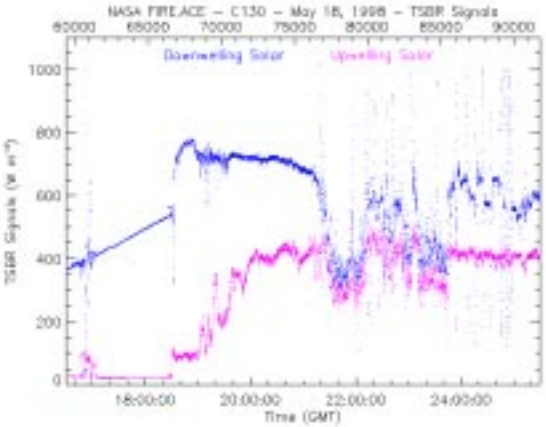


Ch.6

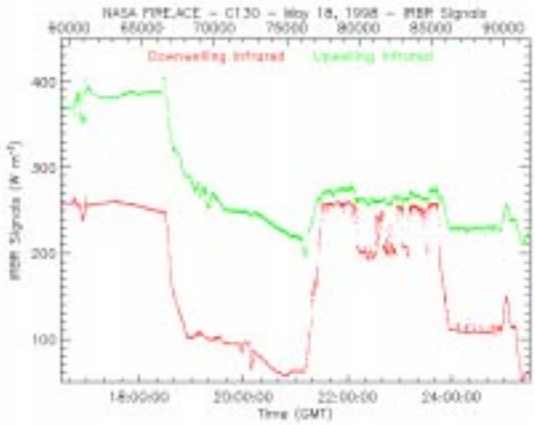


C-130 Radiometer Measurements
May 18, 1998

TSBR – Total Solar Broadband Radiometer

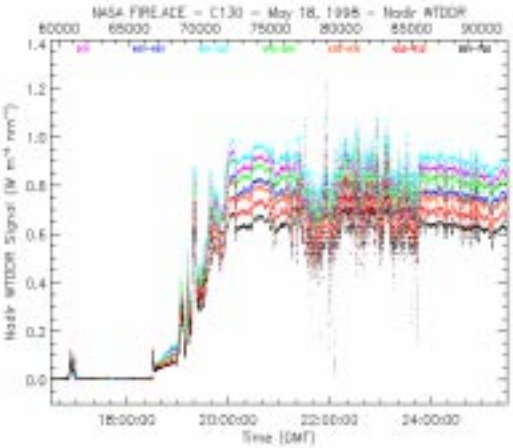


IRBR – IR Broadband Radiometer

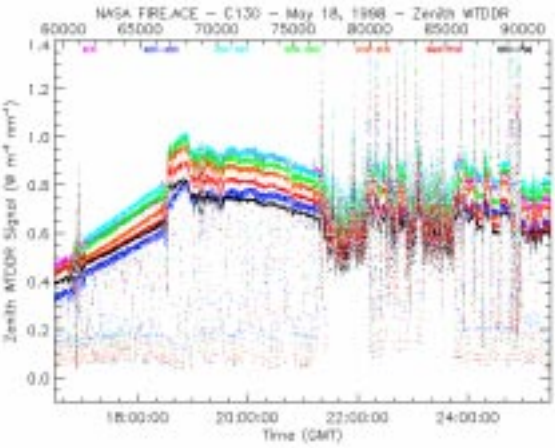


WTDDR – Wide Bandpass Total-Direct-Diffuse-Radiometer
(1 shadow ring on Zenith WTDDR)

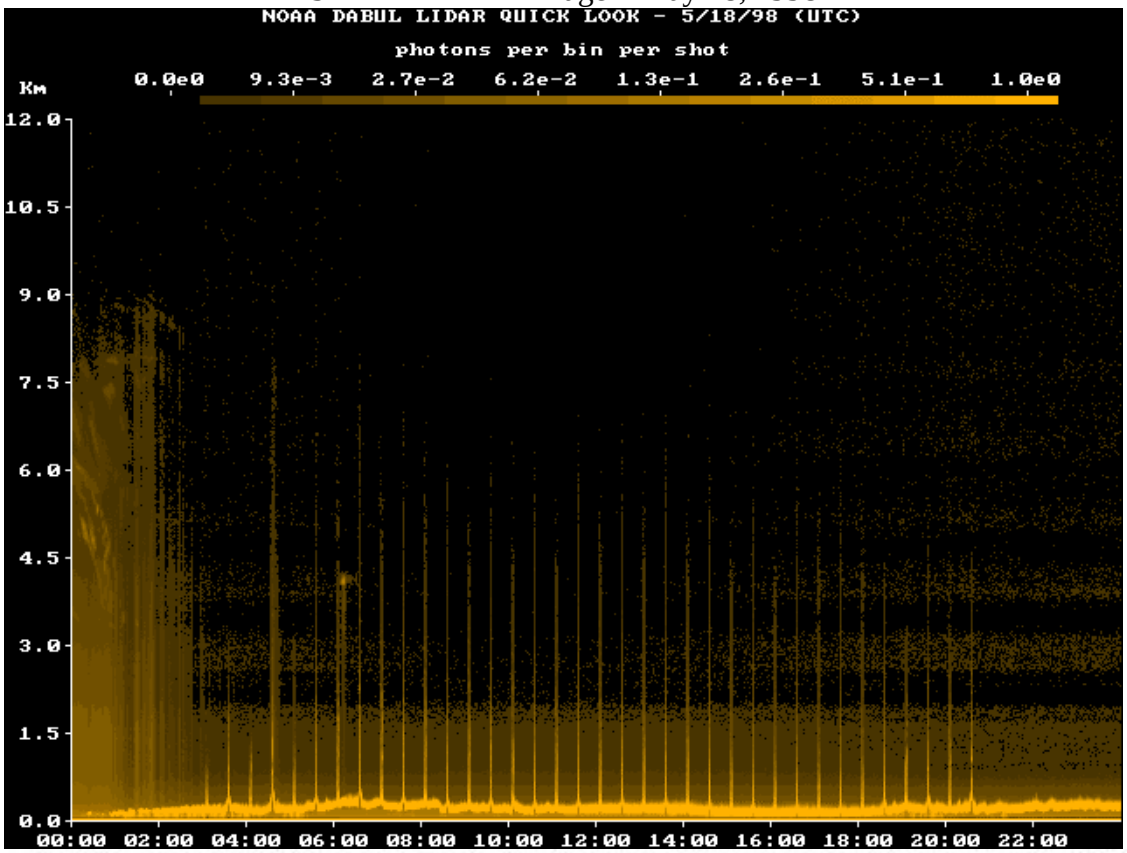
Nadir



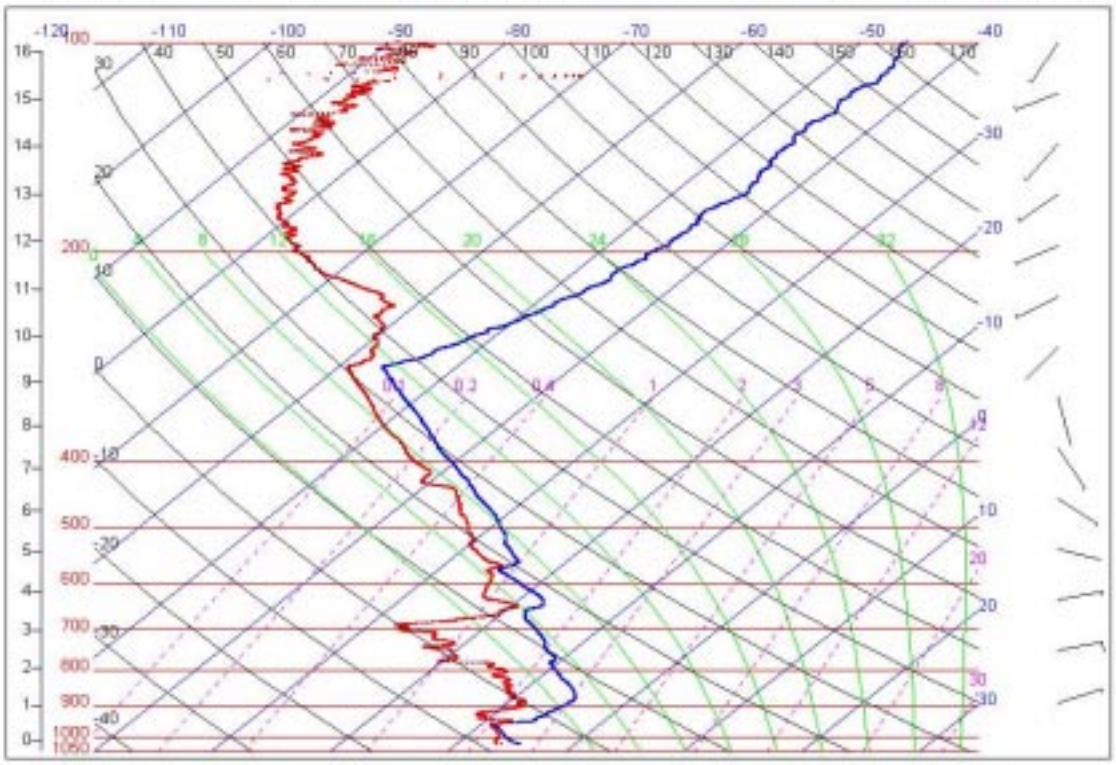
Zenith



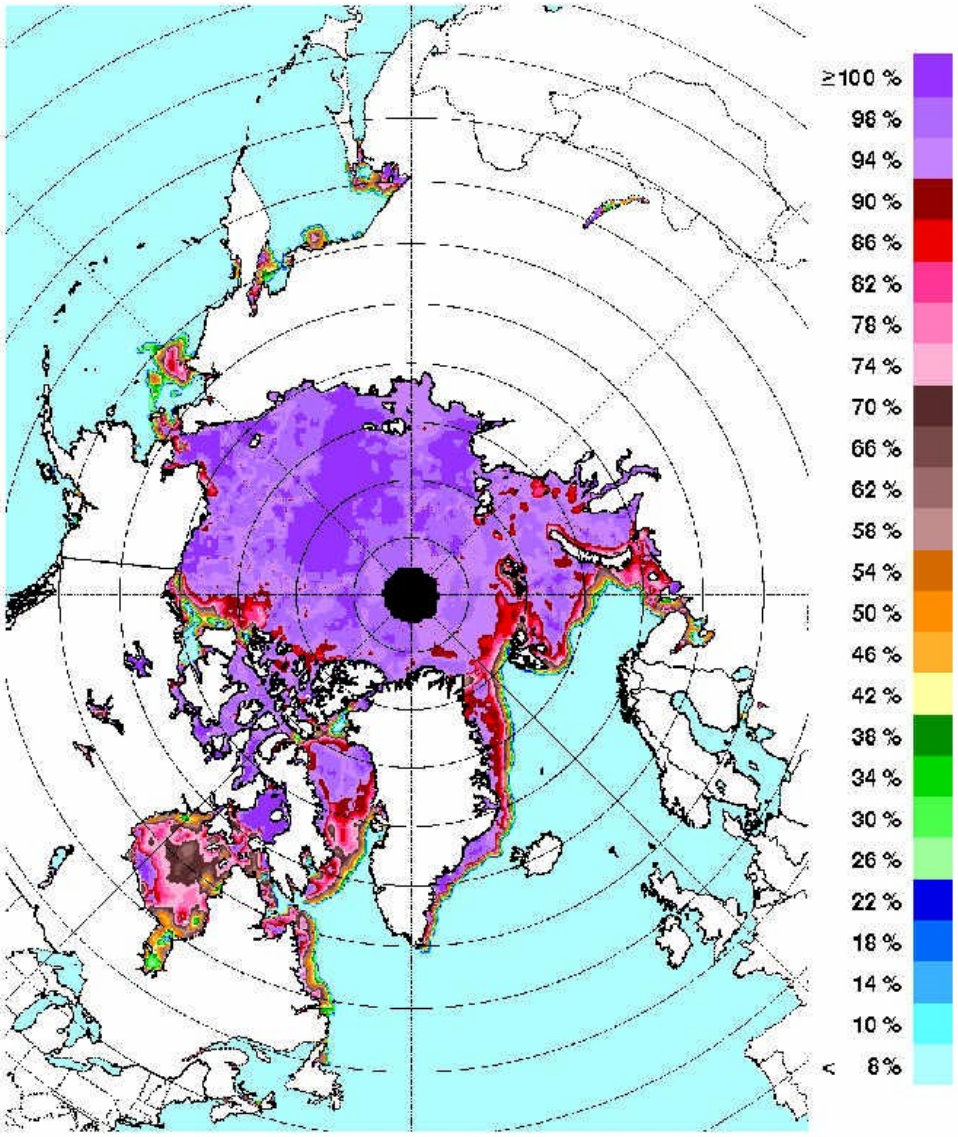
SHEBA LIDAR Image – May 18, 1998



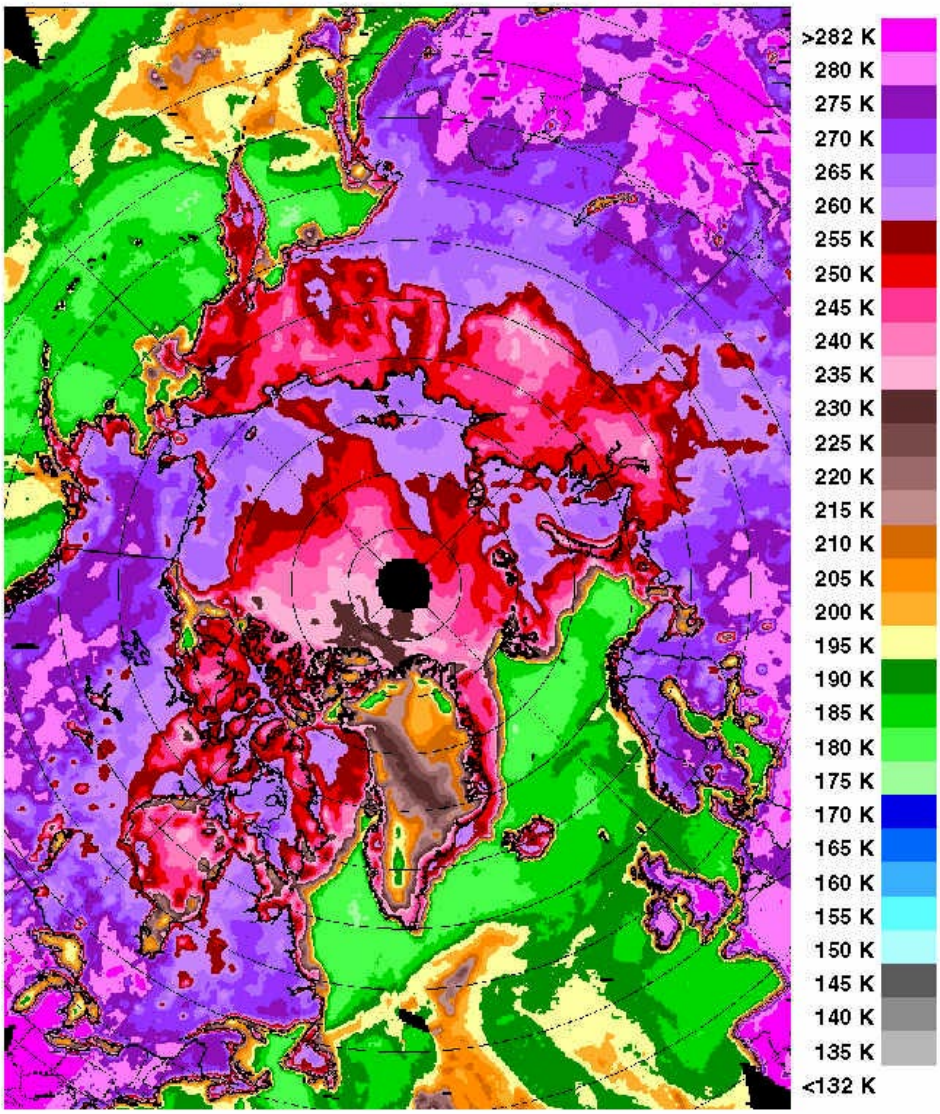
Version: SHEBA--GPS Soundings, GLASS 1.10 Fixed, SHE, 1998,05,18, 11:15:19



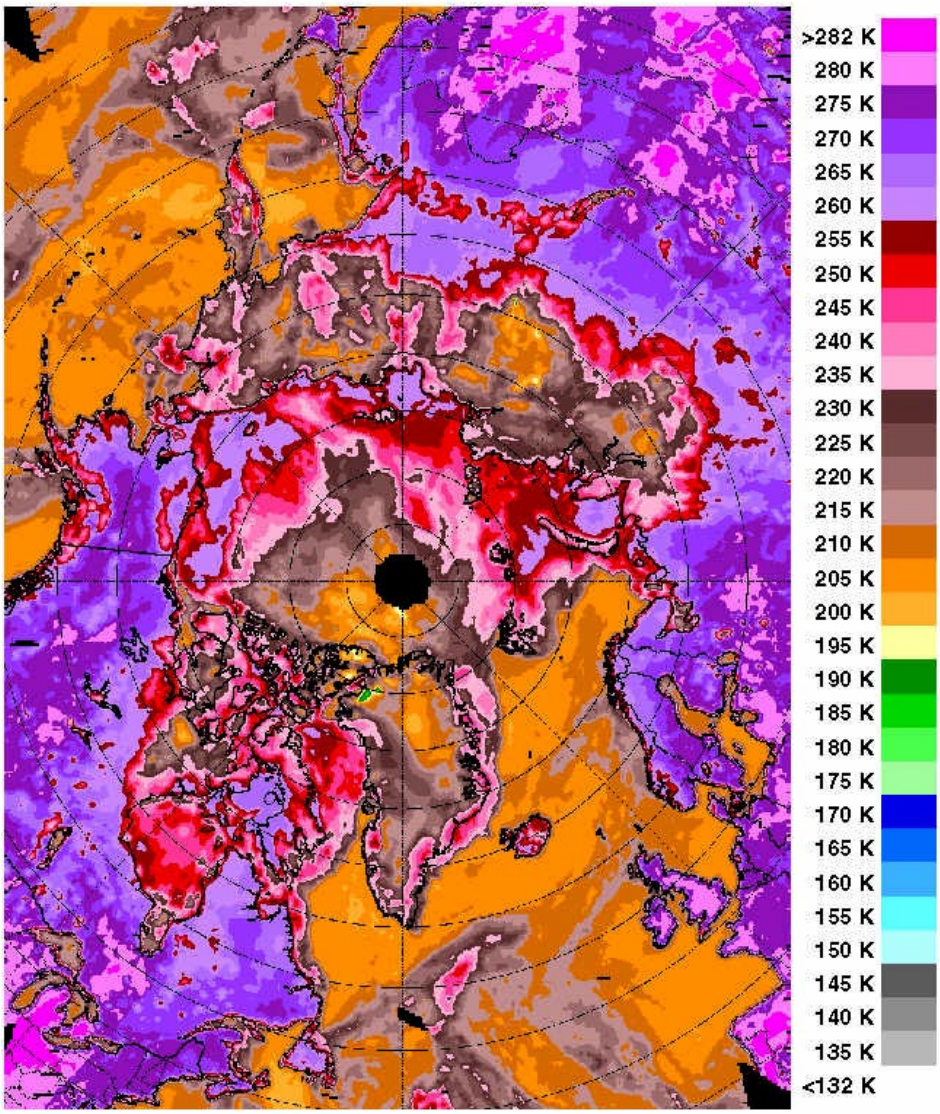
Ice Concentration: May 18, 1998



19V Brightness Temperature: May 18, 1998



37V Brightness Temperature: May 18, 1998



May 19, 1998

CV-580

Flight summary

SHEBA

LIDAR image

Sounding

UW CV-580 FLIGHT LOG
May 19, 1998

Author (Mission Scientist): Hobbs , Peter

Flight Number: 1750
Engines On: 2106
Engines Off: 2453
Departure Airport: Barrow
Arrival Airport: Barrow

Clouds sampled: St Ci

Experimental Observations: Stratus layer from ~700 to 1100 ft over Barrow and vicinity.

Main Objective: radiation measurements and cloud microstructure measurements over ARM-Barrow site.

Flight Summary: After several days of being grounded by bad weather etc. in Barrow, we had our first research flight today (Tuesday, 19 May) from 2106-0053 UTC. The main accomplishments of the flight are summarized below:

1) Traverses above, within, and below a stratus deck over the Barrow-ARM site for comparisons with ground-based remote sensing measurements and for cloud absorption and cloud structure measurements. (Due to low cloud base, measurements below cloud were restricted.)

2) Repeated the above series of measurements off-shore over sea-ice in the Chukchi Sea with greater success because of ability to fly with more freedom below cloud base. Also measured BRDF of ice surface with overlying stratus deck.

3) Did some long-track measurements in the stratus cloud over the Chukchi, including possible diffusion-domain measurements with the CAR.

4) Some sampling of aerosol layers above cloud top.

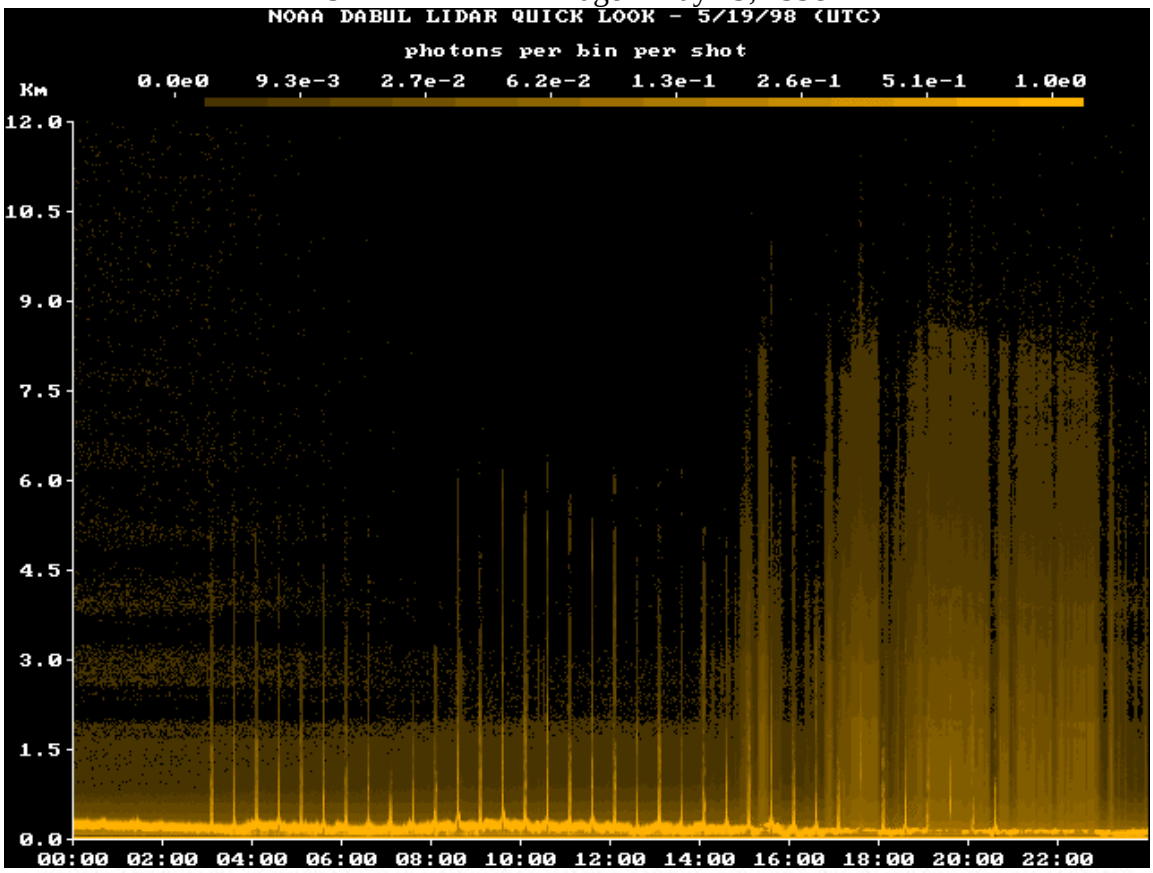
Main Segments of flight in sequence:
1) ~2130-2200: 20 n mile legs with ARM site at center above cloud and in-cloud. Short pass under cloud.
2) Off-shore over broken sea-ice: A more complete set of radiative measurements above, in and below stratus deck.
3) BRDF measurements with CAR on sea-ice (stratus overcast).
4) Long-track in-cloud microphysical measurements (ran CAR for diffusion-domain measurements.
5) Aerosol sampling (no filters)

Research crew:
Hobbs, Rangno, Garrett, Russell, Spurgeon, Weiss, McMillan, Sorenson
Pilewskie, Beitzel

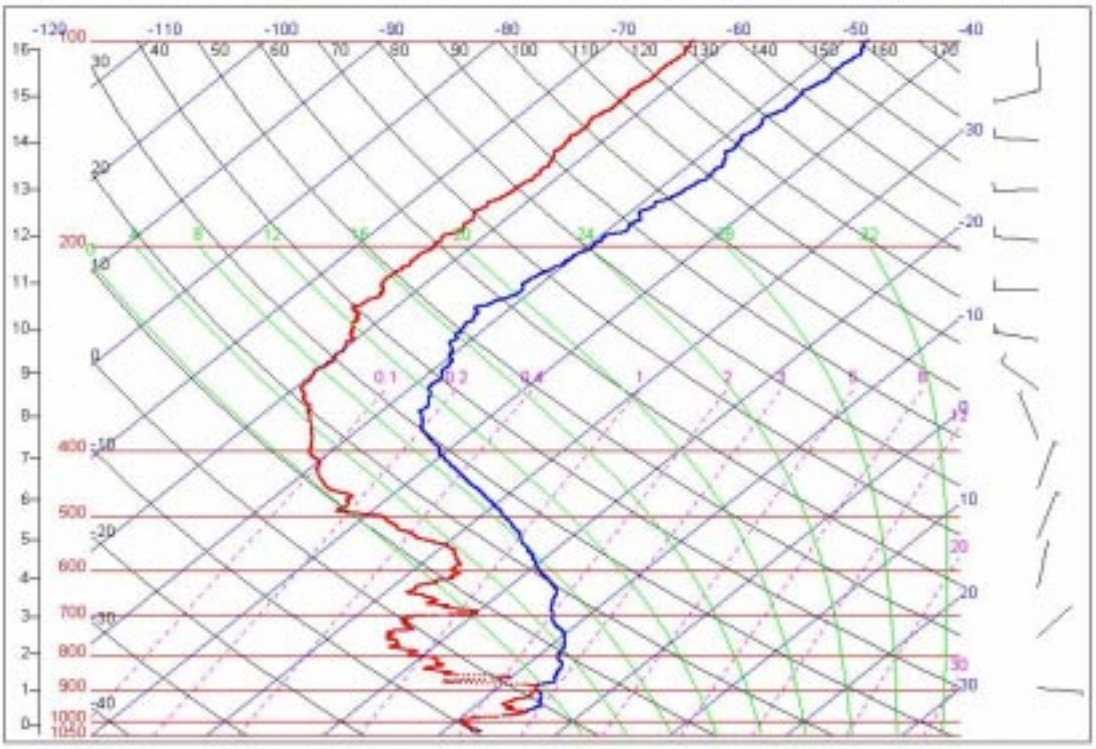
Equipment Failure:
1) O3 (no ethylene)
2) TANS/Vector (a/c attitude)
3) Aethelometer
4) DMPS (?)

FIRE-III Objectives Addressed:
1) Cloud radiation
2) Cloud structure
3) BRDF of sea-ice with St overcast
4) Cloud absorption measurements
5) Aerosols

SHEBA LIDAR Image - May 19, 1998



Version: SHEBA--GPS Soundings, GLASS 1.10 Fixed, SHE, 1998,05,19, 11:32:29



May 20, 1998

ER-2

- Flight summary
- Ground track
- MAS images
- Cloud LIDAR System image
- HIS measurements
- AMPR images

CV-580

- Flight summary
- Flight track
- CAR notes

C-130

- Flight summary
- Flight track
- MCR images
- Radiometer data

SHEBA

- LIDAR image
- Sounding

Satellite SSM/I

- Ice concentration
- Brightness temperature 19 volts
- Brightness temperature 37 volts

ER-2 Mission 2

Wednesday, May 20, 1998

Michael King: Flight Scientist

Objectives: To fly the ER-2 repeatedly over the surface site at Barrow (71°19.37'N, 156°34.9'W), coordinated with the University of Washington CV-580, followed by a flight to the SHEBA ice station (76°20.31'N, 166°37.45'W) and finally to a flight track parallel to the NOAA-14 ground track. The mission was coordinated with the CV-580 between 2009 and 2202 UTC, with the ER-2 flying flight legs between single level Arctic stratus clouds over the tundra south of Barrow, to broken clouds over the ARM site, to clear sky over the ice. The entire flight track over the Chukchi and Beaufort Seas was cloud free. Other coordination included:

- F-14 satellite (2121 and 2301 UTC)
- NOAA-14 satellite (2326 UTC)
- Solar noon (2301 UTC)

ER-2 Mission:	Pilot:	Ken Broda
	Takeoff	1905 UTC
	Landing	0135 UTC (May 21)
	Duration	6:30

The ER-2 flew a NNE flight line from point 1 (70°17'N, 158°W) to point 2 (72°40'N, 155°W), flying over the ARM site each time, that consisted of 5 flight legs 285 km in length. Following this coordinated pattern with the CV-580, the ER-2 flew a NW flight track to point 4 (74°N, 166°37.45'W), where it turned and headed north to point 6 (77°N, 166°37.45'W), consisting of a single flight leg 333 km in length. This flight track passed over the SHEBA ice station at:

- 2303 UTC

Finally, the ER-2 headed SSE on a heading of 143.76°, aligned with the NOAA-14 overpass at 2326 UTC. The AirMISR was turned on for four acquisitions over the Barrow ARM site, one over the SHEBA ice station, and one at the time of the NOAA-14 overpass. The AirMISR operated at the following times:

- 2011-2025 UTC (ARM)
- 2043.75-2058 UTC (ARM)
- 2112.75-2125 UTC (ARM)
- 2145.75-2200 UTC (ARM)
- 2256-2308 UTC (SHEBA)
- 2320-2328 UTC (NOAA-14)

The ER-2 pilot reported undercast conditions over all of Alaska en route to and from Barrow, with thick Arctic stratus clouds on the south side of Barrow, with clear sky over the ice.

Instrument Status

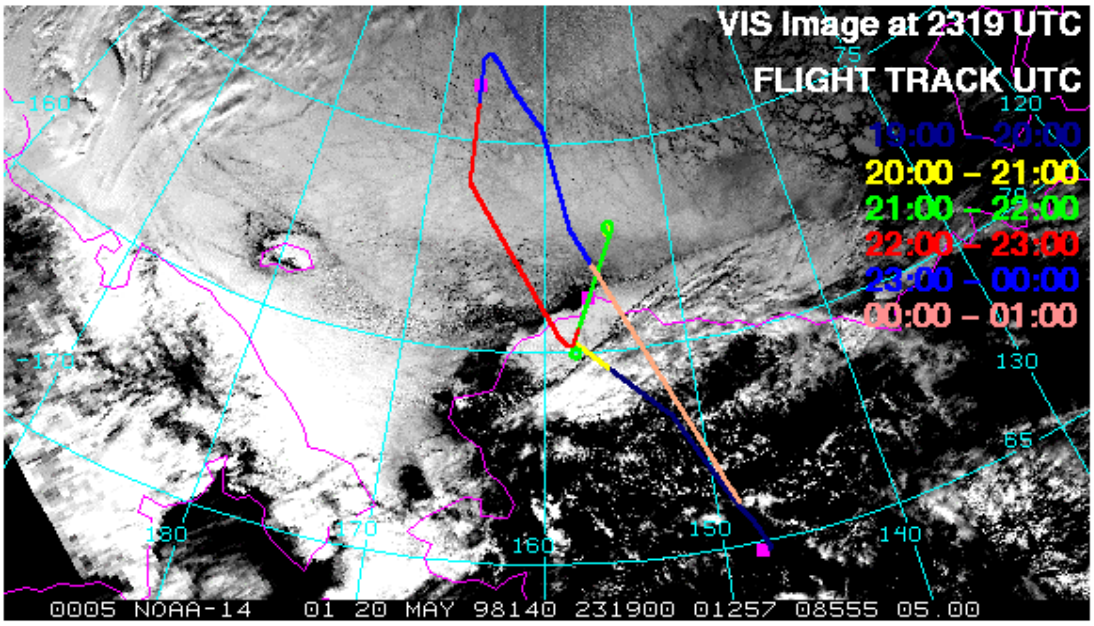
- AirMISR – the first two scenes collected 5 of 9 look angles (nadir and the last 3 aft view angles not recorded); subsequent acquisitions obtained all 9 look angles until the SHEBA acquisition when the data collection was truncated; final data collection sequence during the NOAA-14 overpass was not acquired
- AMPR – worked well
- CLS – worked well
- HIS – worked well
- MAS – port 4 (8.3-14.0 μm) disconnected for nitrogen purge
- MIR – worked well
- SSFR – worked well

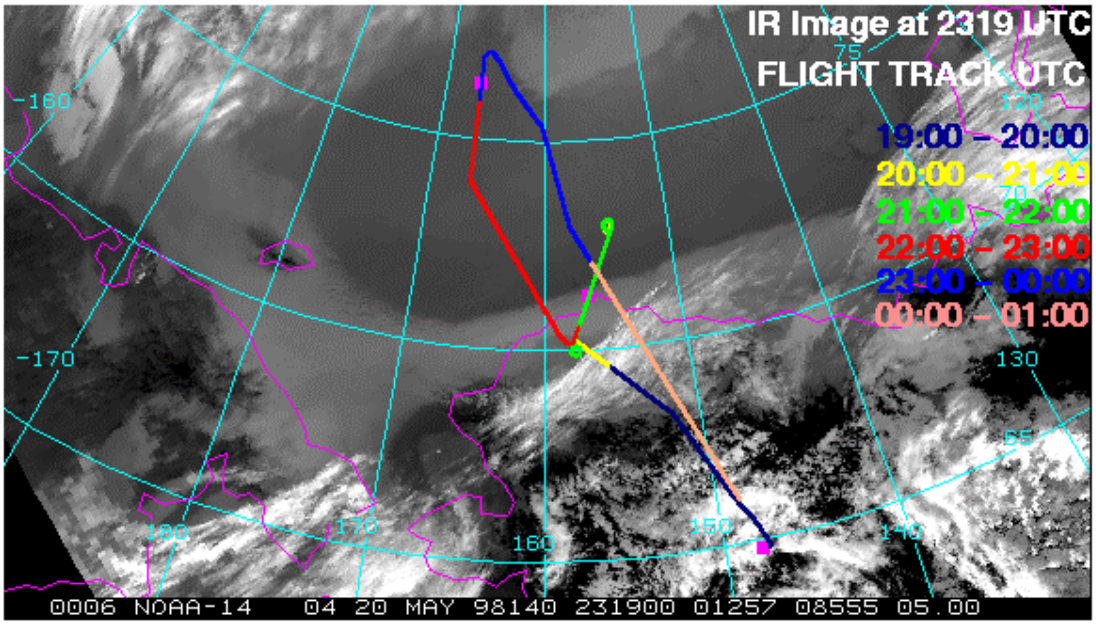
Meteorology: A single layer cloud system occurred near and to the south of Barrow, with severe clear over the Beaufort Sea. A high-pressure system was located just NE of the SHEBA ice station, with low stratus to the NE. This cloud was moving toward the west, but did not move over the SHEBA ice camp at any time during the mission.

Instruments:

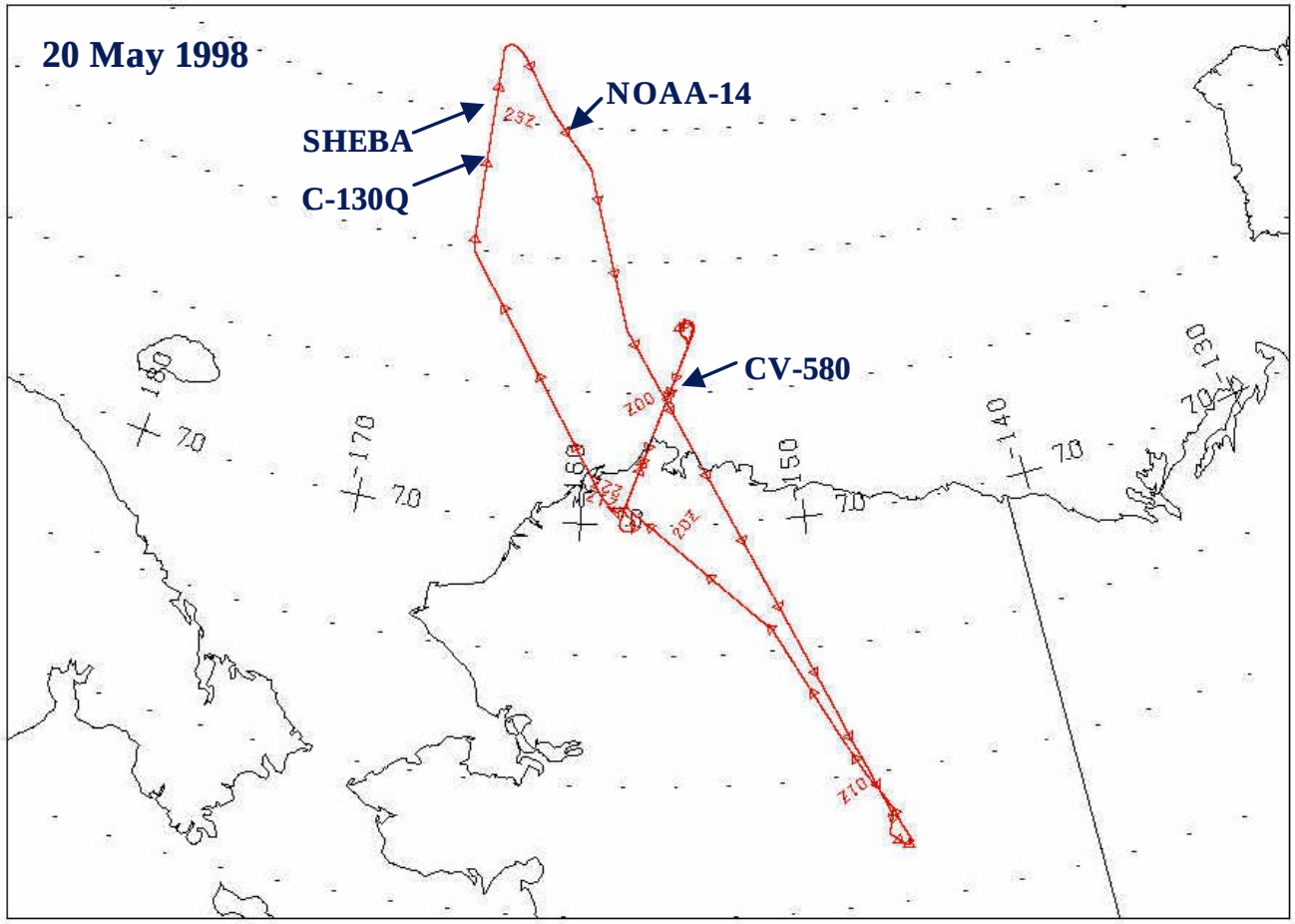
AirMISR – Airborne Multi-angle Imaging Spectroradiometer
AMPR – Advanced Microwave Precipitation Radiometer
CLS – Cloud LIDAR System
HIS – High-resolution Interferometer Sounder
MAS – MODIS Airborne Simulator
MIR – Millimeter-wave Imaging Radiometer
SSFR – Solar Spectral Flux Radiometer

ER2 FLIGHT TRACK AND NOAA–14 AVHRR IMAGES ON MAY 20, 1998





ER-2 Ground Track



Arctic Stratus over Tundra – Barrow

Red = 2.13 μm

Green = 1.62 μm

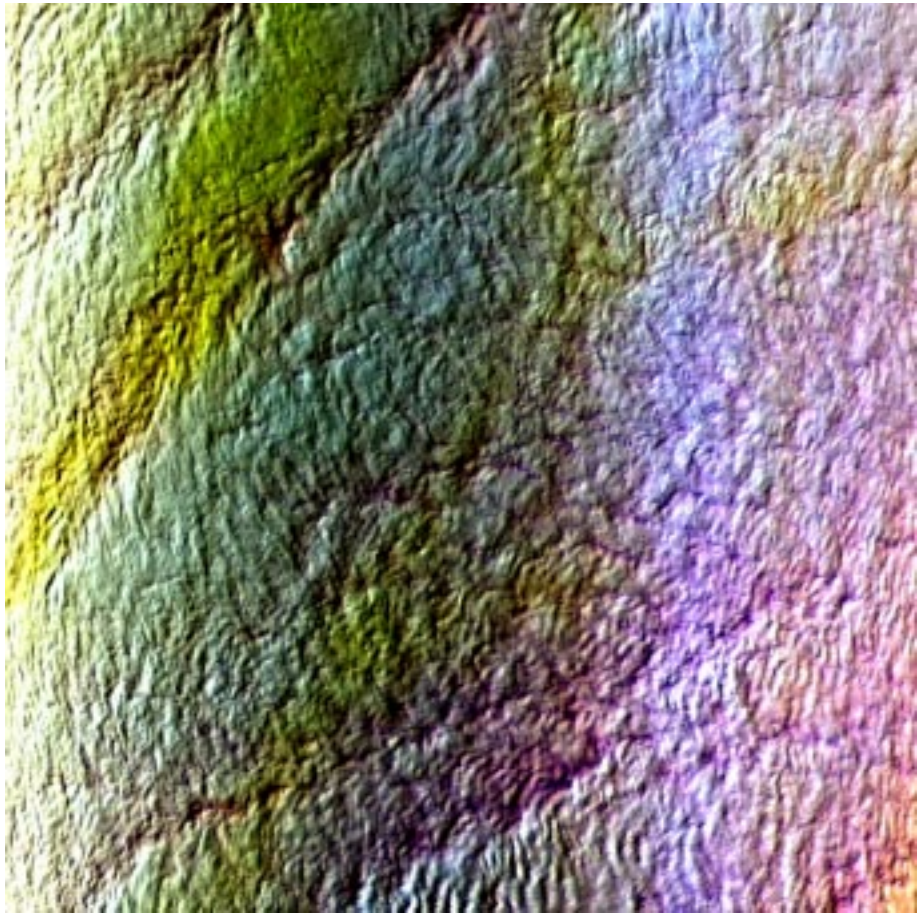
Blue = 0.55 μm

20 May 1998

70°25'N 157°31'W

2011 UTC

23.6 km



37.2 km

Flight Direction

23.5°

θ_0 **= 54.3°**

ϕ_0 **= 139.9°**

$\phi - \phi_0$ **= 26.4°**

Cloud Streets, Open Water, and Fast Ice – Barrow

Red = 2.13 μm

Green = 1.62 μm

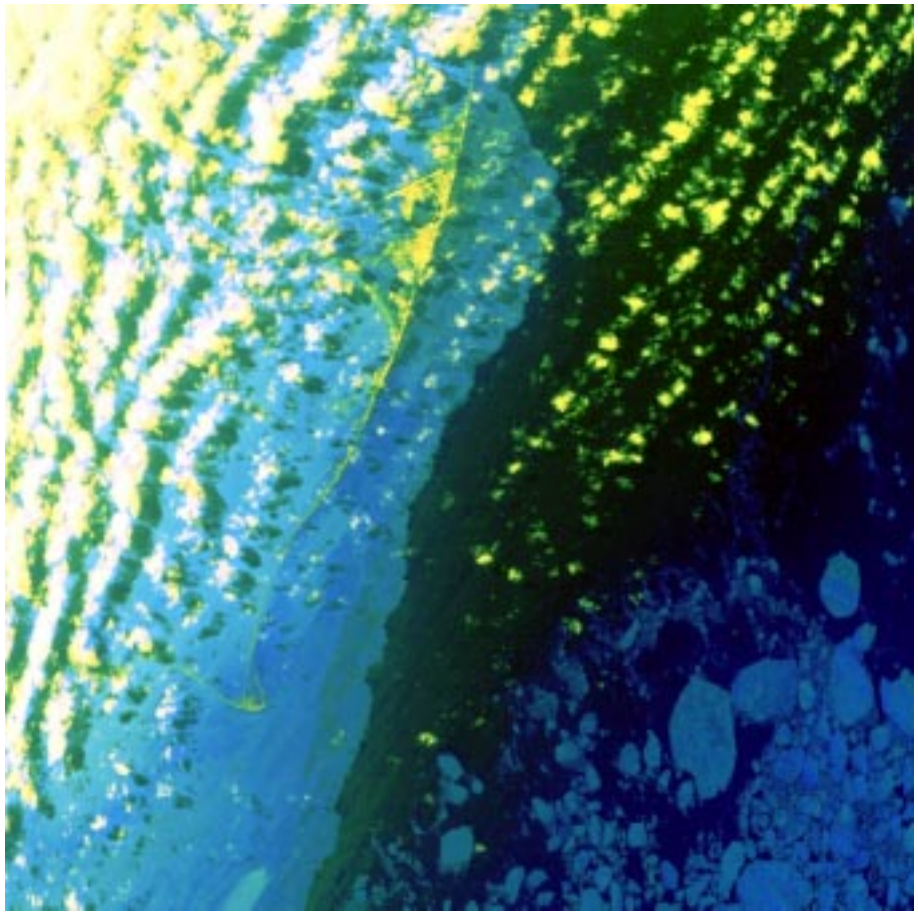
Blue = 0.55 μm

20 May 1998

70°10'N 156°29'W

2017 UTC

23.6 km



Flight Direction

23.7°

θ_0 **= 54.3°**

ϕ_0 **= 143.0°**

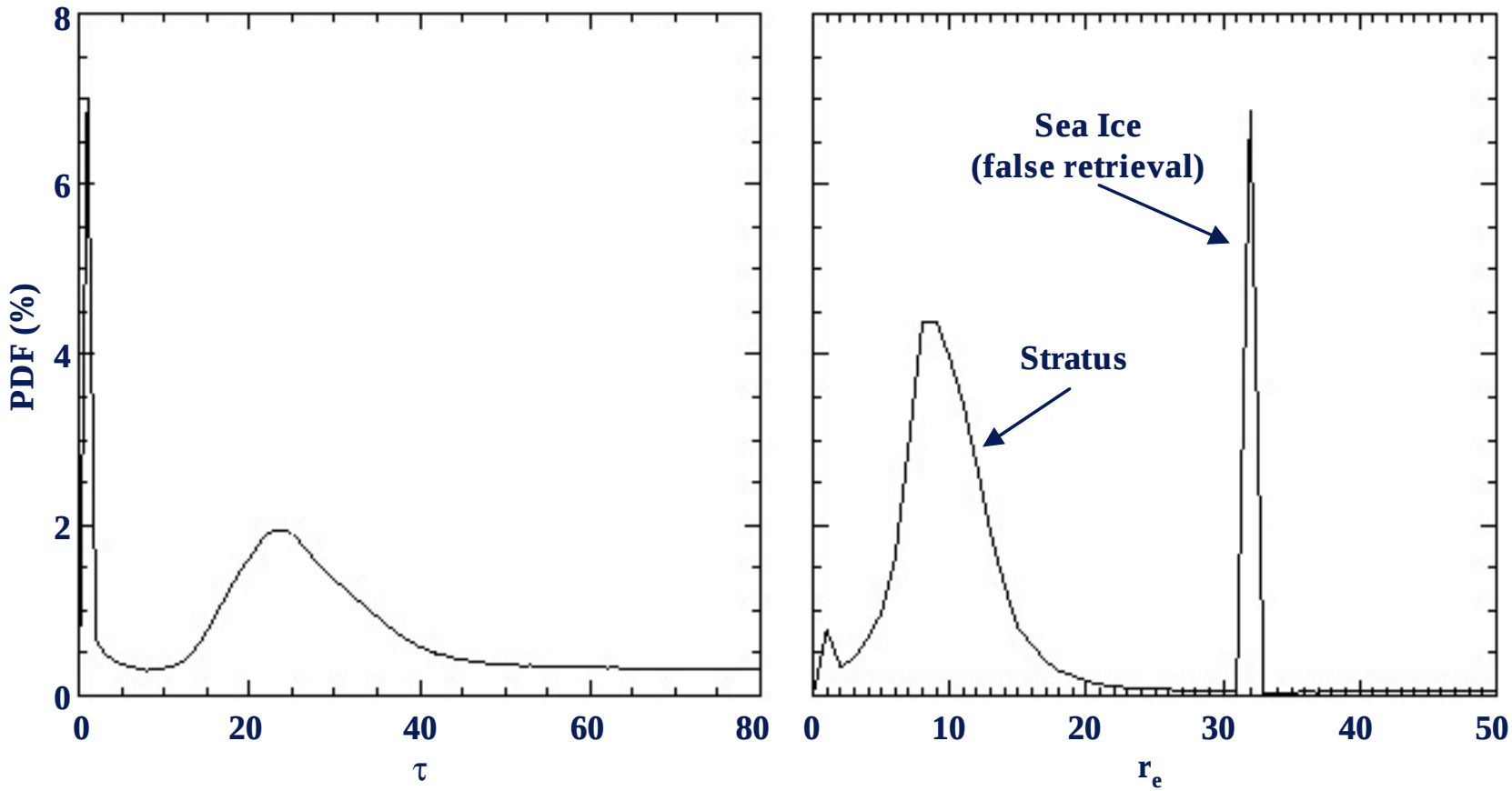
$\phi - \phi_0$ **= 29.3°**

37.2 km

Cloud Retrieval Results

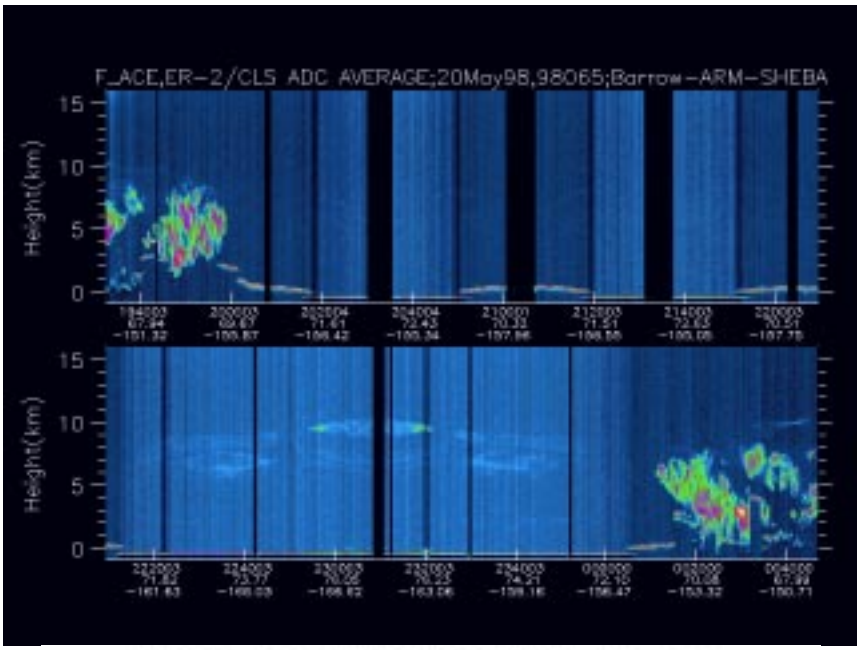
20 May 1998 **2009-2029 UTC**

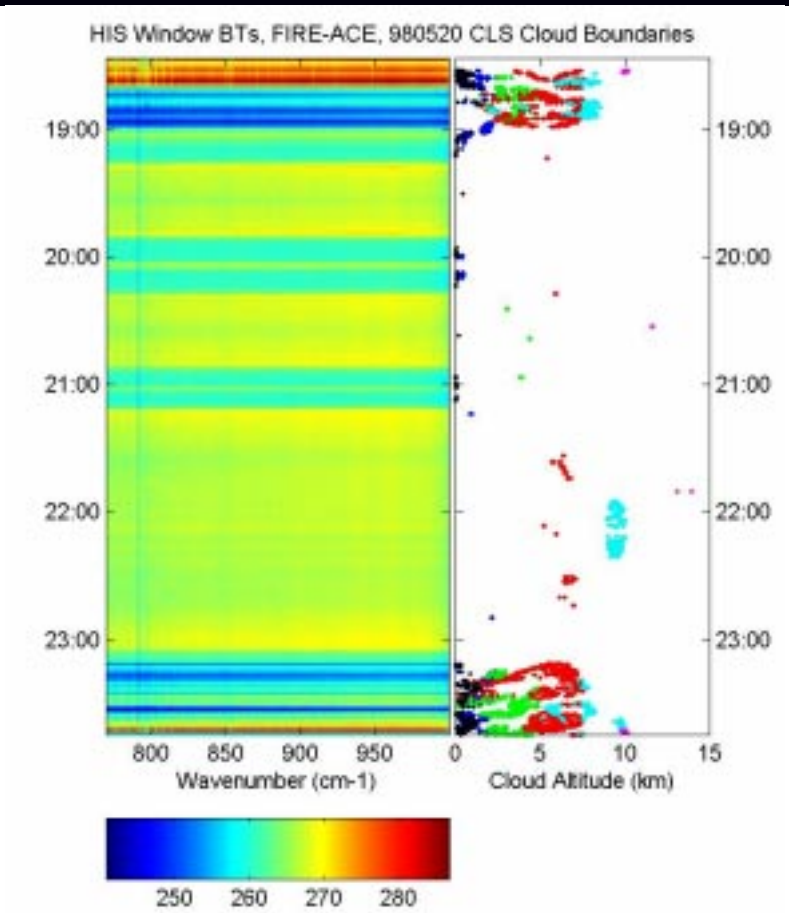
70°10'N 156°29'W



Cloud LIDAR System Image

May 20, 1998 - Instrument worked nominally. The image reveals cirrus over the Brooks Range of Alaska, stratus over the tundra near Barrow, and both clear and cirrus areas over the Arctic Ocean.



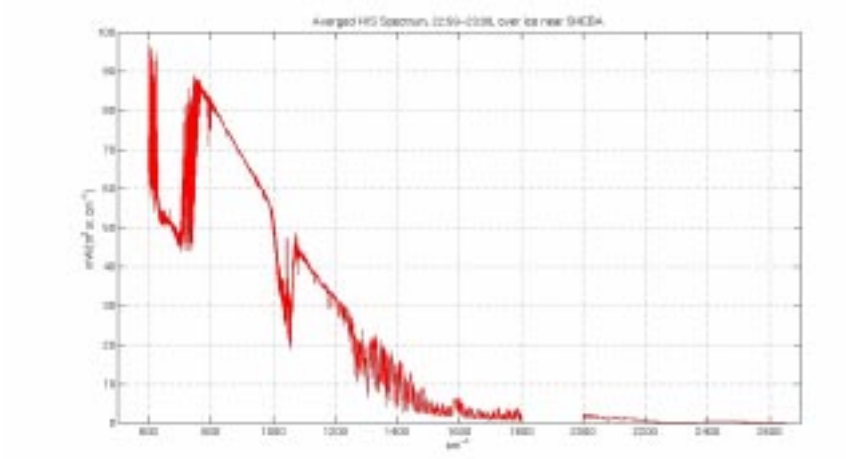


ER-2 HIS Measurements

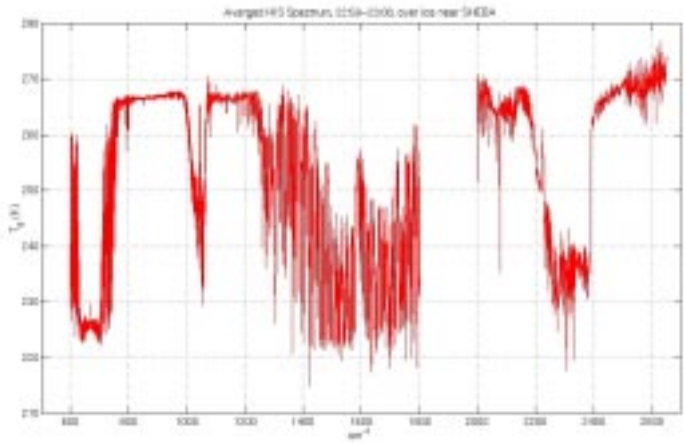
May 20, 1998

22:59 – 23:08 UTC Over Ice Near SHEBA

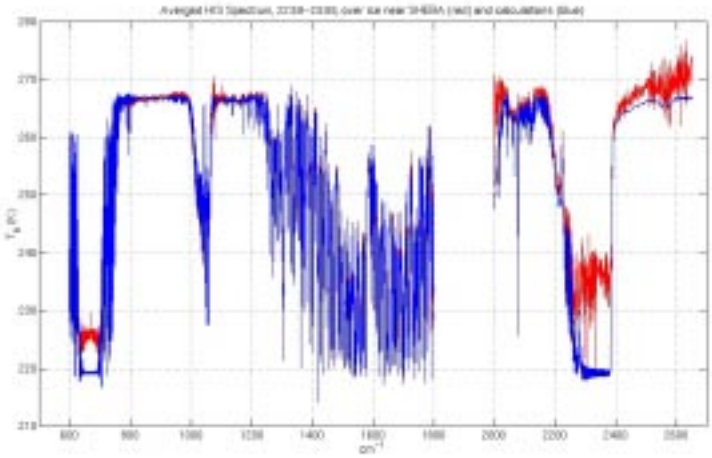
Averaged HIS Radiance Spectrum (All Bands)

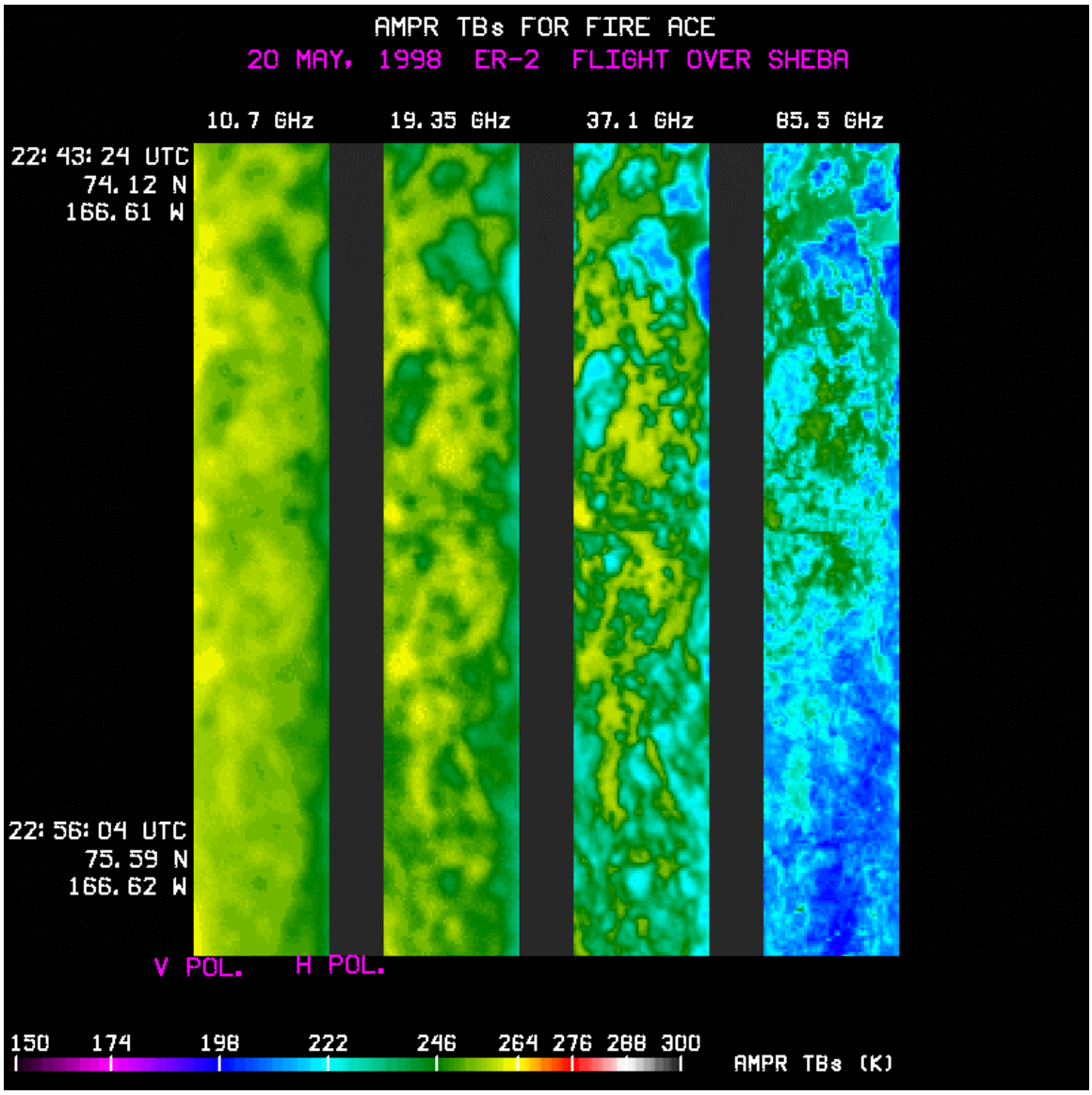


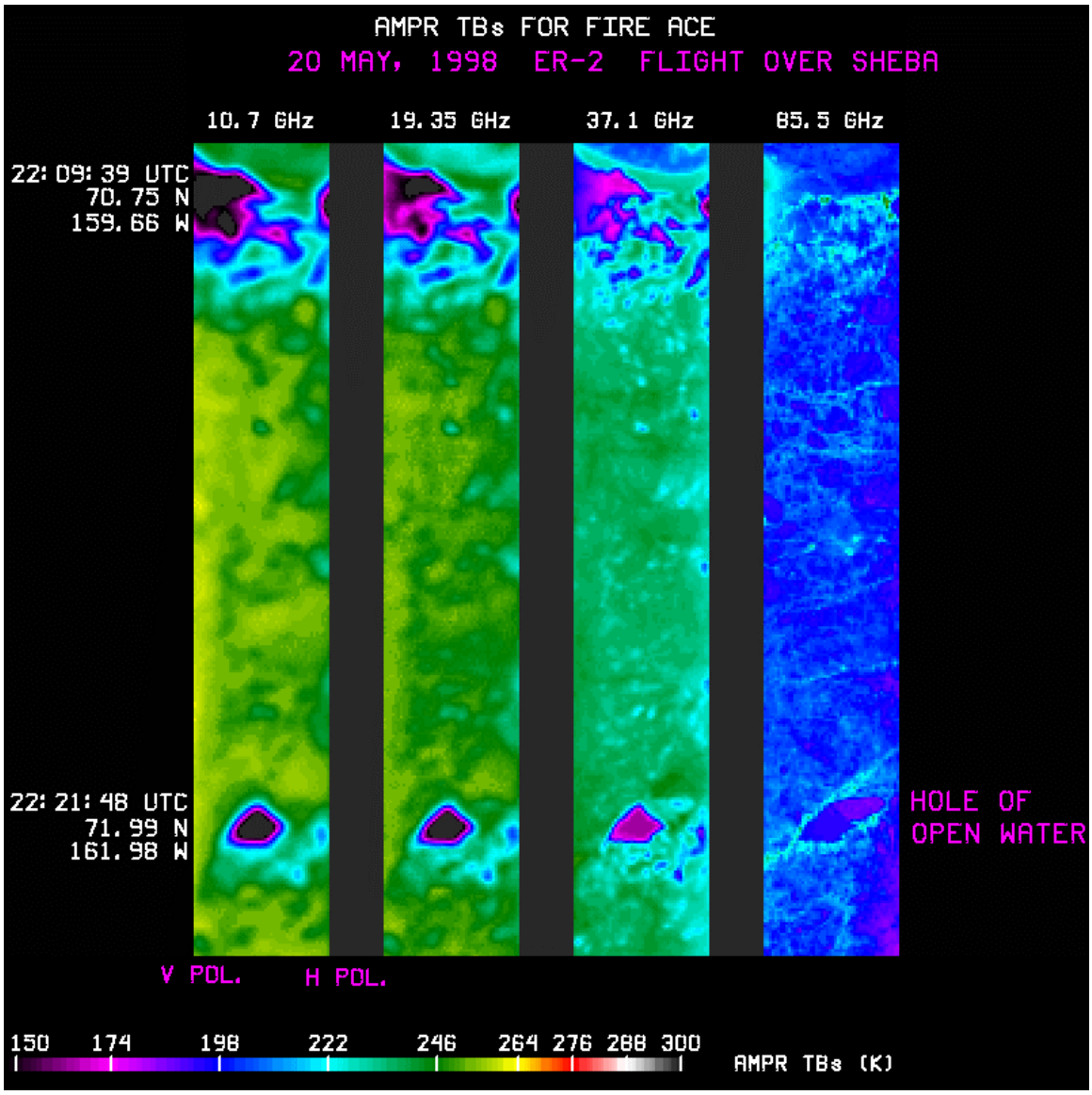
Averaged HIS Temp Brightness (All Bands)



Observed (red) and Calculated (blue) Spectrum (All Bands)




AMPR TBs FOR FIRE ACE
20 MAY, 1998 ER-2 FLIGHT OVER SHEBA
10.7 GHz
19.35 GHz
37.1 GHz
85.5 GHz
22:43:24 UTC
74.12 N
166.61 W
22:56:04 UTC
75.59 N
166.62 W
V POL.
H POL.
150
174
198
222
246
264
276
288
300
AMPR TBs (K)


AMPR TBs FOR FIRE ACE
20 MAY, 1998 ER-2 FLIGHT OVER SHEBA
10.7 GHz
19.35 GHz
37.1 GHz
85.5 GHz
22:09:39 UTC
70.75 N
159.66 W
22:21:48 UTC
71.99 N
161.98 W
HOLE OF
OPEN WATER
V POL.
H POL.
150 174 198 222 246 264 276 288 300
AMPR TBs (K)

UW CV-580 FLIGHT LOG
May 20, 1998

Author (Mission Scientist): Hobbs, Peter

Flight Number: 1751
Engines On: 1947
Engines Off: 2351
Departure Airport: Barrow
Arrival Airport: Barrow

Surface Met & Visual Obs on Take-off:
Broken cloud
Strong easterly winds all levels

Clouds sampled: Stratus

Summary:
On May 20 the CV-580 carried out a coordinated research flight with the ER-2 over the Barrow ARM site. Stratus clouds were broken over ARM, continuous and relatively thick south of ARM, and the sky was clear north of ARM over the Chukchi Sea. CV-580 measurements were obtained below cloud, in cloud, and above cloud top, with the ER-2 flying overhead, from 2000-2200 UTC.
Following the above, the CV-580 made BRDF measurements of sea-ice under clear skies at the most northerly point of the CV-580 track when it was flying beneath the ER-2.
The CV-580 then returned to the ARM site and did a vertical profile from 300-20,000 ft. (Note: PSU Raman LIDAR is operating at the ARM site.)

Experimental Observations:
1) ~2000 UTC to 2700 UTC flew back and forth through ARM site below cloud, in-cloud, and above cloud with ER-2 overhead. Cloudy in southern portion of track, partly cloudy over ARM, clear in northern portion of track (see Fig. 2, pg. 5 of UW flight scenarios for configuration)
2) CV-580 did BRDF over its most northerly point (u)- sea ice.
3) Vertical profile from ~300 ft to 20,000 ft over ARM

Research crew: Hobbs, Rangno, Weiss, Garrett, Russell, Spurgeon, Beitzel, Larsen, Sutherland, Sorensen

Equipment Failure:
1) Laptops
2) King LW probe
3) IR thermo.
4) Bag House

FIRE-III Objectives Addressed:
1) Comparison of in situ (CV-580) and remote sensing (ER-2 and ARM) measurements

Flight 1751 - May 20, 1998

main

1 Summary

2 Photos

3 Quicklooks

1 CAR Flight Summary

Observed both the top and bottom of a stratus layer, using the CAR instrument to either scan upward through the zenith, or downward through the nadir while viewing the cloud. Also scanned the inside of the stratus layer within the diffusion domain with the CAR in the starboard viewing mode. Conducted BRDF measurements over pack ice with a few dispersed leads. (A lead is a small section of open ocean that occurs as the pack ice melts and breaks in the summer time.). Total of 22864 scan data was collected between 19:55:55 - 23:45:04 UTC.

19:56: the filterwheel channel for the CAR for the entire flight was locked on 1.725 µm. Leaving Barrow, the CV-580 flew just under a stratus layer over a surface that was mostly pack ice [1].
20:00 the CAR was locked on nadir viewing mode to scan the icy surface.
20:37 the CV-580 entered the lower third of the stratus layer.
20:42 the CV-580 passed over the ARM site, where the CAR was able to scan lower broken stratus over broken pack ice and leads [2].
20:42 the CV-580 entered the middle of the stratus layer and the CAR was put in the starboard scanning mode to observe the sinusoidal pattern of the radiation in the diffusion domain. As the CV-580 climbed to the upper third of the stratus layer, the CAR was returned to nadir scanning.
20:50 the CV-580 exited the stratus layer at the top.
20:54 the CAR was put into zenith viewing mode while flying above the stratus cloud [3].
21:19 the CAR was put in nadir viewing mode to view the uniform cloud deck below [4].
21:30 while still over the stratus cloud tops, the CAR was put in zenith viewing position. Once again the CV-580 turned around and dropped back into the diffusion domain, where the CAR was put back into starboard scanning mode.
22:00 BRDF measurements over mostly pack ice and some leads, with clear skies above. We did about 5 circles with a bank of 20 degrees to the right.
22:20 we returned to level flight and the CAR was put back in nadir scanning mode, where it remained for the rest of the flight.
22:27 we flew out below the cloud deck over mainly open ocean with occasional ice.
22:29 we returned to the the ARM site and began climbing through the cloud layer again. We continued circling and climbing above the cloud deck to check cabin pressure.
22:54 we reached 20,000 MSL and began descent.
23:32 we re-entered the cloud layer above the ARM site
23:35 we exited the base of the cloud deck, and began our return to Barrow.

During this flight, we encountered a nice thick stratus layer. The base of the cloud layer was located at 900 ft MSL and its top at 2402 ft MSL.

Fire Ace

May - June, 98
Barrow, Alaska

Photo Records:

1. stratus cloud over ice

2. broken pack ice

3. two layer clouds

4. stratus over leads/ice.

Flight Track and Quicklook Images:

- CV-580 flight tracks
- GPS altitude, roll and pitch angle plot

Back to Top

C-130 Flight Summary
May 20, 1998

Daily Mission Scientist: James Pinto
Assistant Daily Mission Scientist: Judy Curry
Report prepared by: Judy Curry, James Pinto, Tara Jensen, Dave Rodgers

Objectives: Clear day! Implement several mapping patterns at various levels for AIMR, MCR and video. Characterize the surface albedo as a function of height above the surface. AVHRR and ER-2 overpasses while making high resolution surface observations. Potential for turbulence measurements in stable BL if winds are strong enough.

Meteorological conditions reported at the SHEBA camp: SHEBA surface observations at 6:30 ADT reported no echo on cloud radar. Lidar sees thin layer of haze in lowest 100 m. The 12 Z sounding shows strongly stable layer from surface to 500 m and extremely dry conditions above 1km. The surface is relatively unchanged for the past few days.

Ship position	Surface wind	Radar	Lidar	Surface Temp
76.3383 N	12 knots	Clear	Haze at 100 m	-12°C
166. 625 W	75°			

Flight Plan: Raster mapping pattern with 50 km legs at 4 km, descent to 1.5 km downwind of ship. Implement several surface mapping patterns each having 20 km legs:

1. raster grid-like pattern at 1.5 km ;
2. 5-leg box at 30 m;
3. 5-leg box at 150 m;
4. surface albedo mapping pattern at 100 m.

Time and conditions permitting may sample open water regions just north of Barrow.

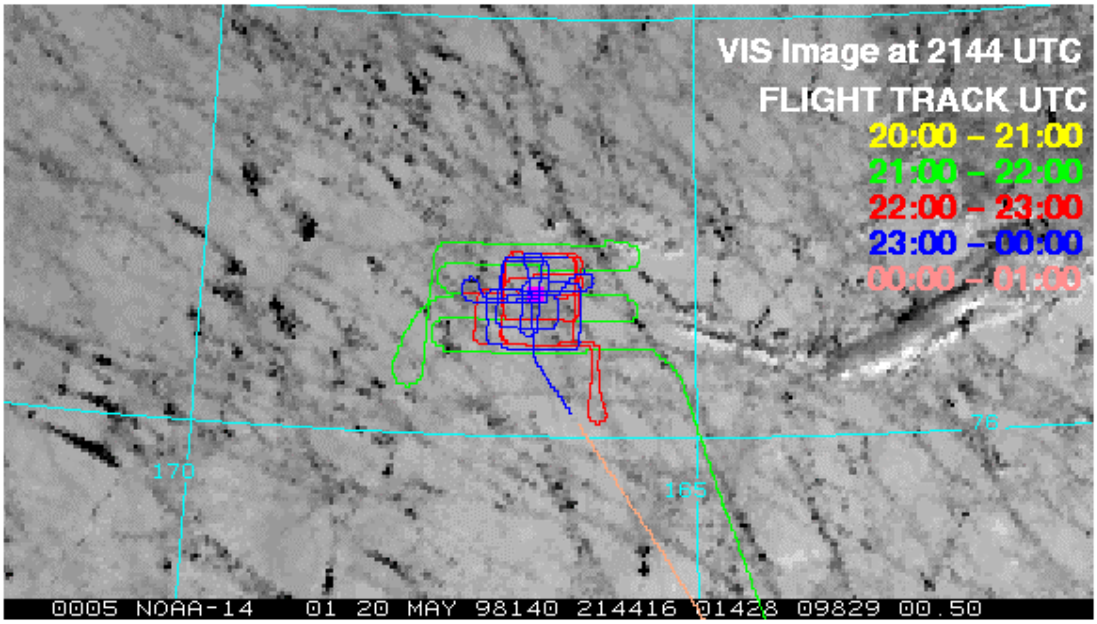
Principal accomplishments: A very good day for surface-mapping at several heights under almost entirely clear conditions with coincident overpasses of ER-2 and AVHRR.

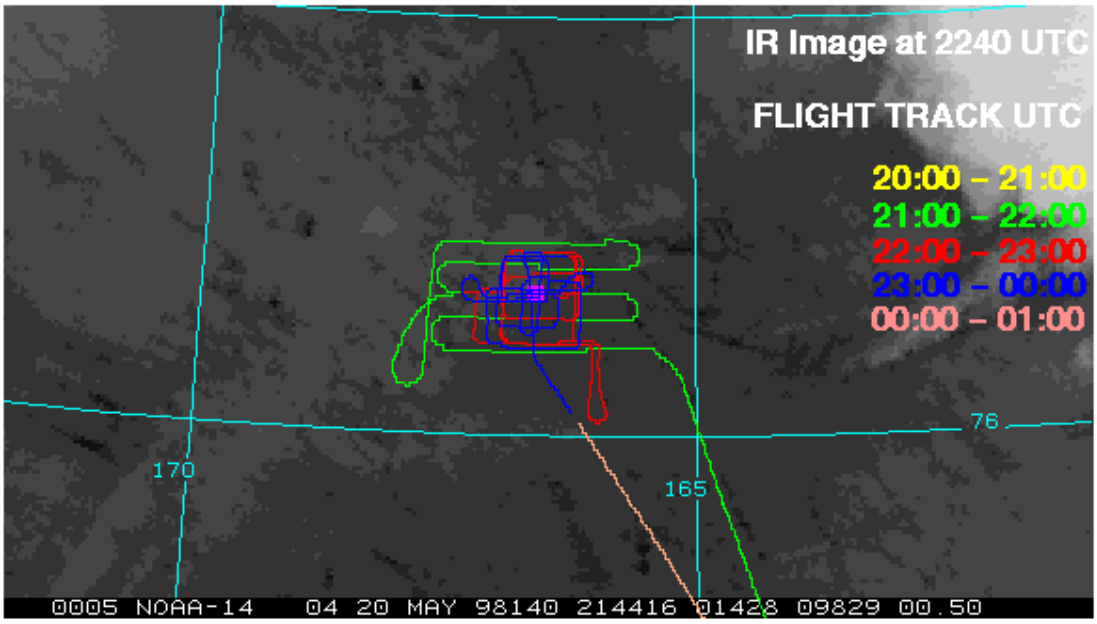
Longwave radiometric measurements under extreme dry conditions. Aerosol measurements at low-levels over Barrow and open water region north of Barrow.

Comments: Pilots did an excellent job executing complex surface mapping patterns. A patch of thin low clouds was present but should not have much of an impact on the surface mapping. Extreme dry conditions above 1 km should provide a good test for longwave
radiative transfer models in the dirty-window region. Times when thin cloud was present are noted in log.

Instruments problems:
MCR Channels 2,3,5,7 contain noise limiting their utility.
Cryogenic dew point hygrometer malfunctioned from 2159 - 0005, 1004 -0300
Large offset between KT-19 Radiometers (RSTB & RSTB1), radiometers track each other well.
CFD system: CN counter still showing evidence of a leak (problem at higher altitudes but okay below about 1km)

C130 FLIGHT TRACK AND NOAA-14 AVHRR IMAGES ON MAY 20, 1998 OVER THE ICE STATION



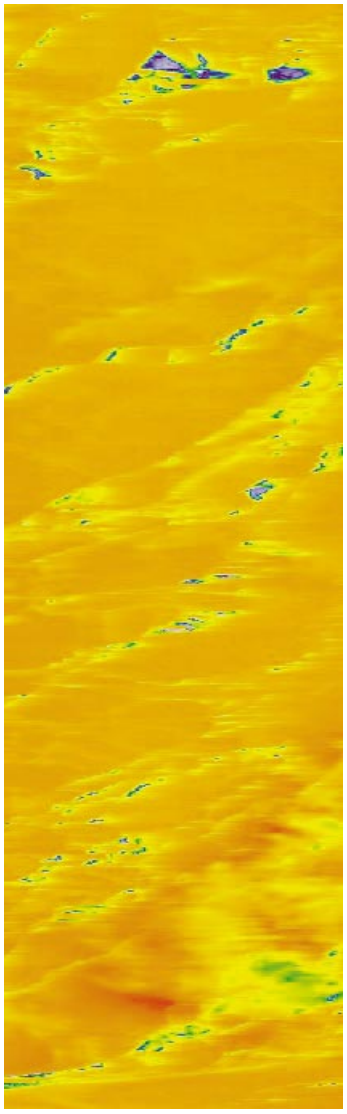


C-130 MCR Images

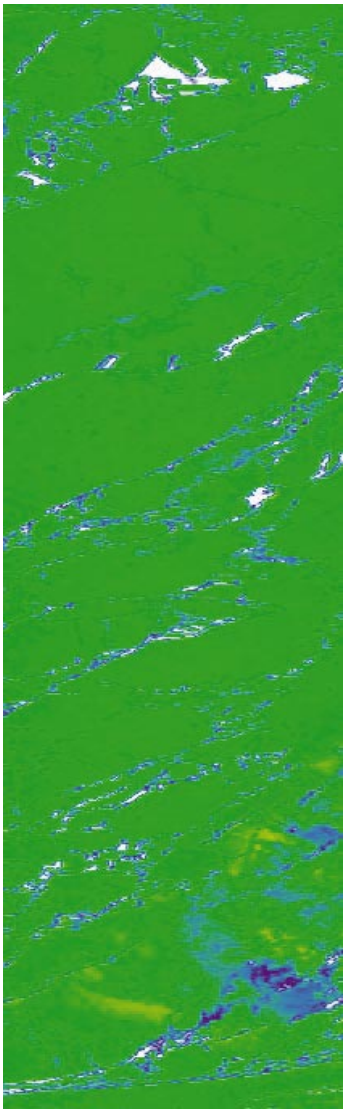
These images were taken by the MCR on May 20. The flight direction is from the bottom of the pageto the top, with the MCR scanning from left to right.The channels are centered on .64, 1.06, and 2.16 µm respectively.

21:27 - 21:32 UTC

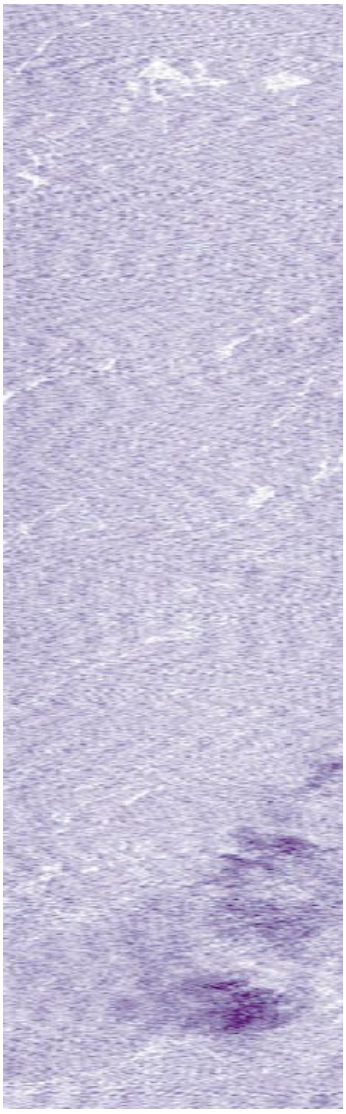
Ch.1



Ch.4

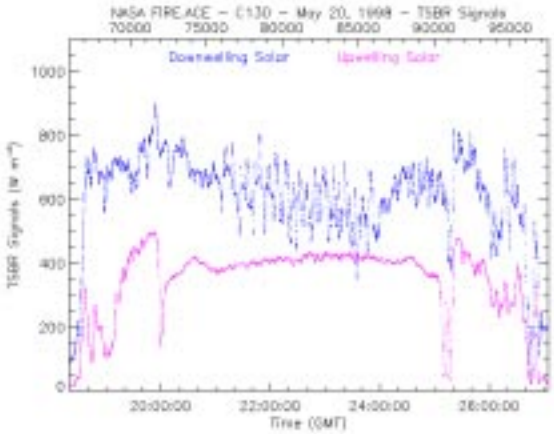


Ch.6

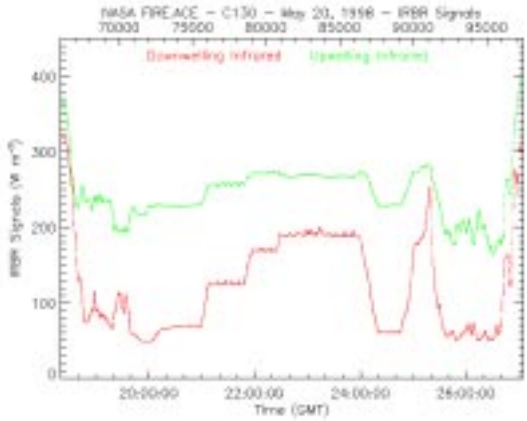


C-130 Radiometer Measurements
May 20, 1998

TSBR – Total Solar Broadband Radiometer

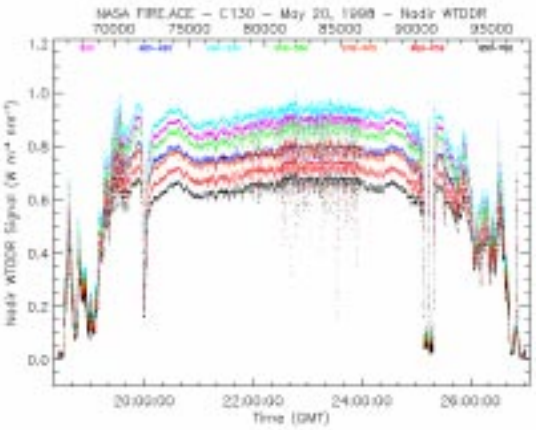


IRBR – IR Broadband Radiometer

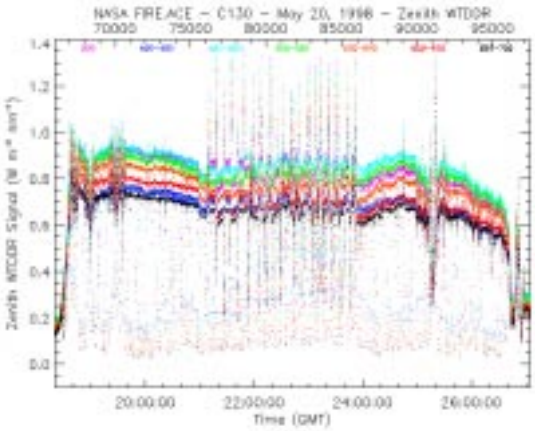


WTDDR – Wide Bandpass Total-Direct-Diffuse-Radiometer
(1 shadow ring on Zenith WTDDR)

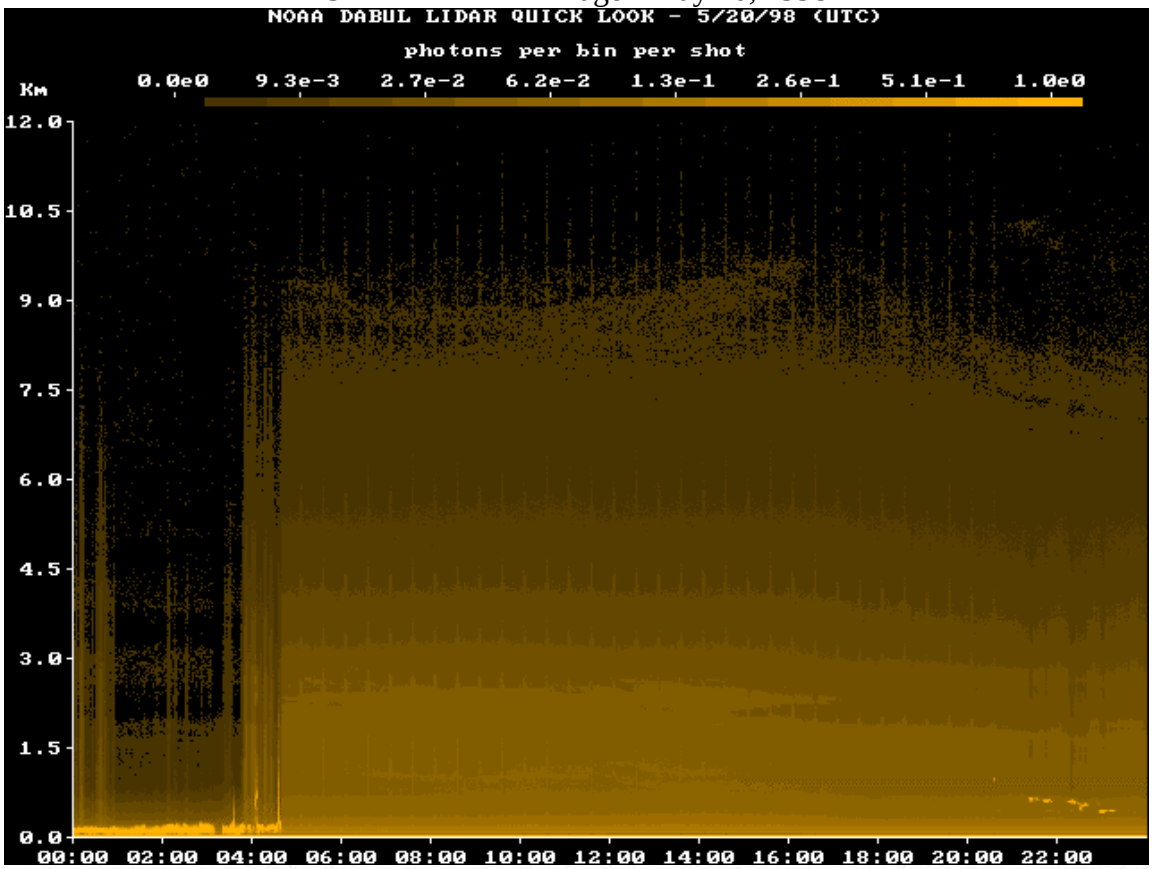
Nadir



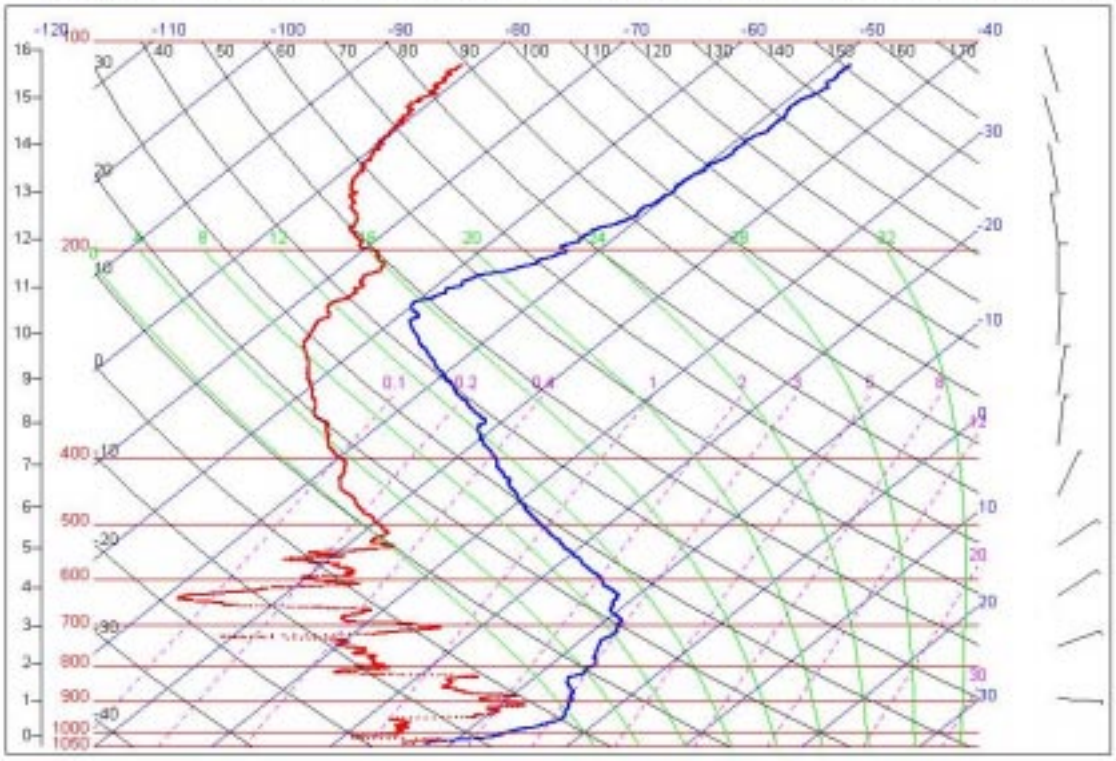
Zenith



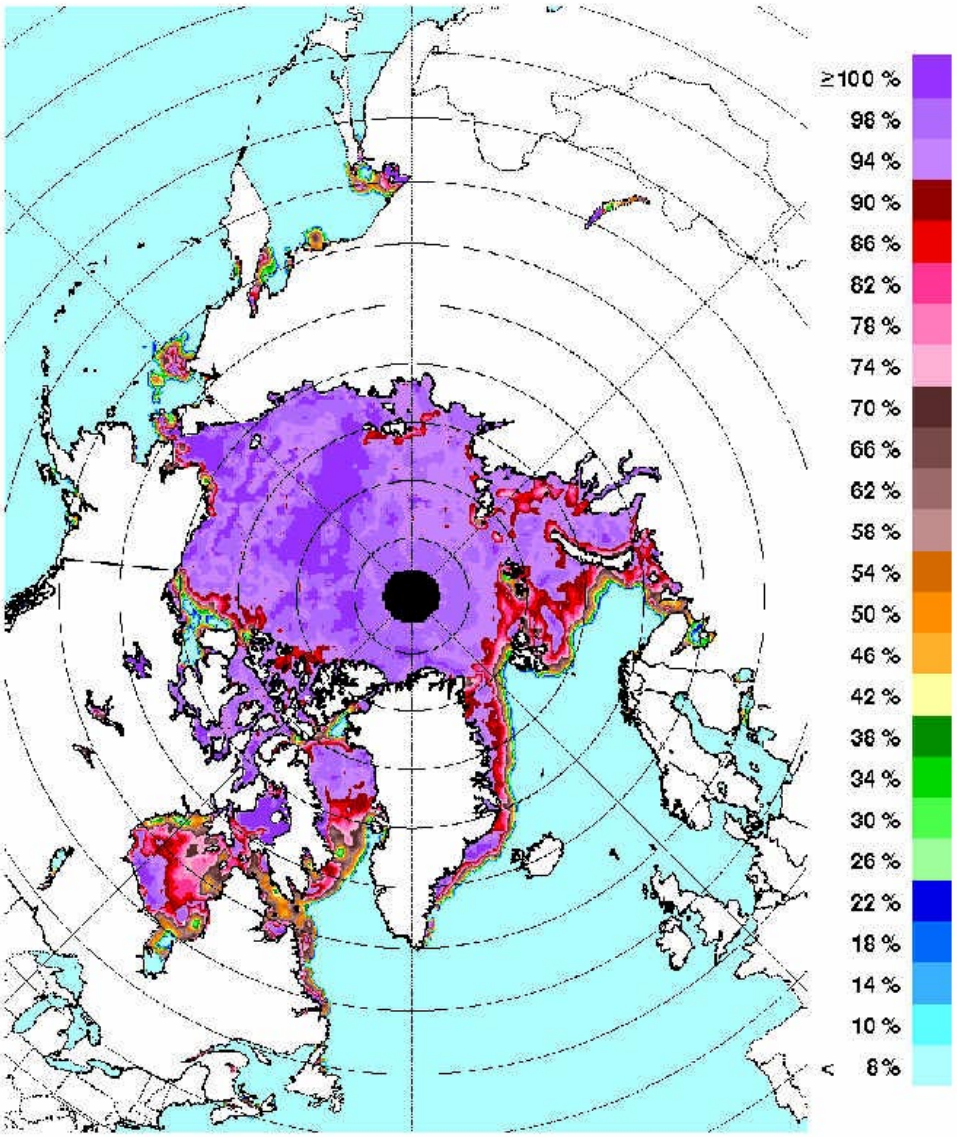
SHEBA LIDAR Image - May 20, 1998



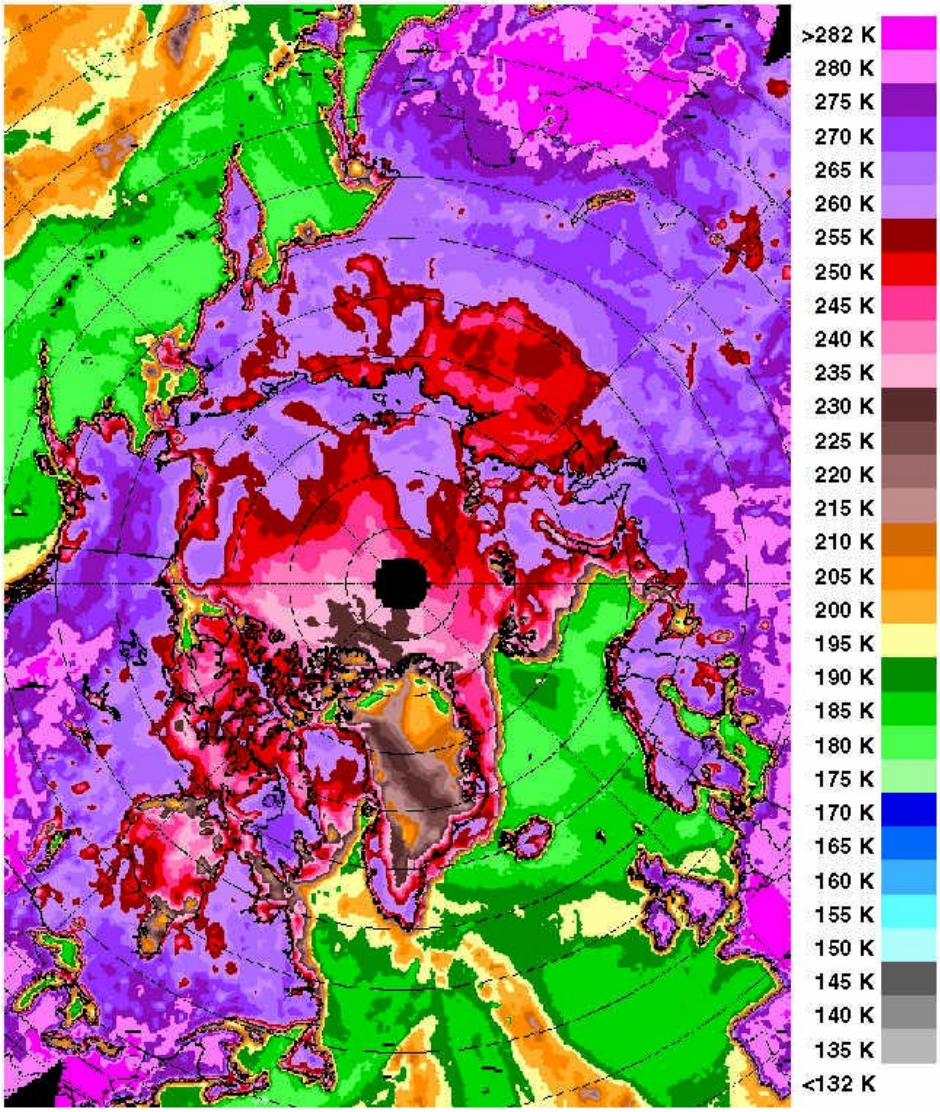
Version: SHEBA--GPS Soundings, GLASS 1.10 Fixed, SHE, 1998,05,20, 11:51:47



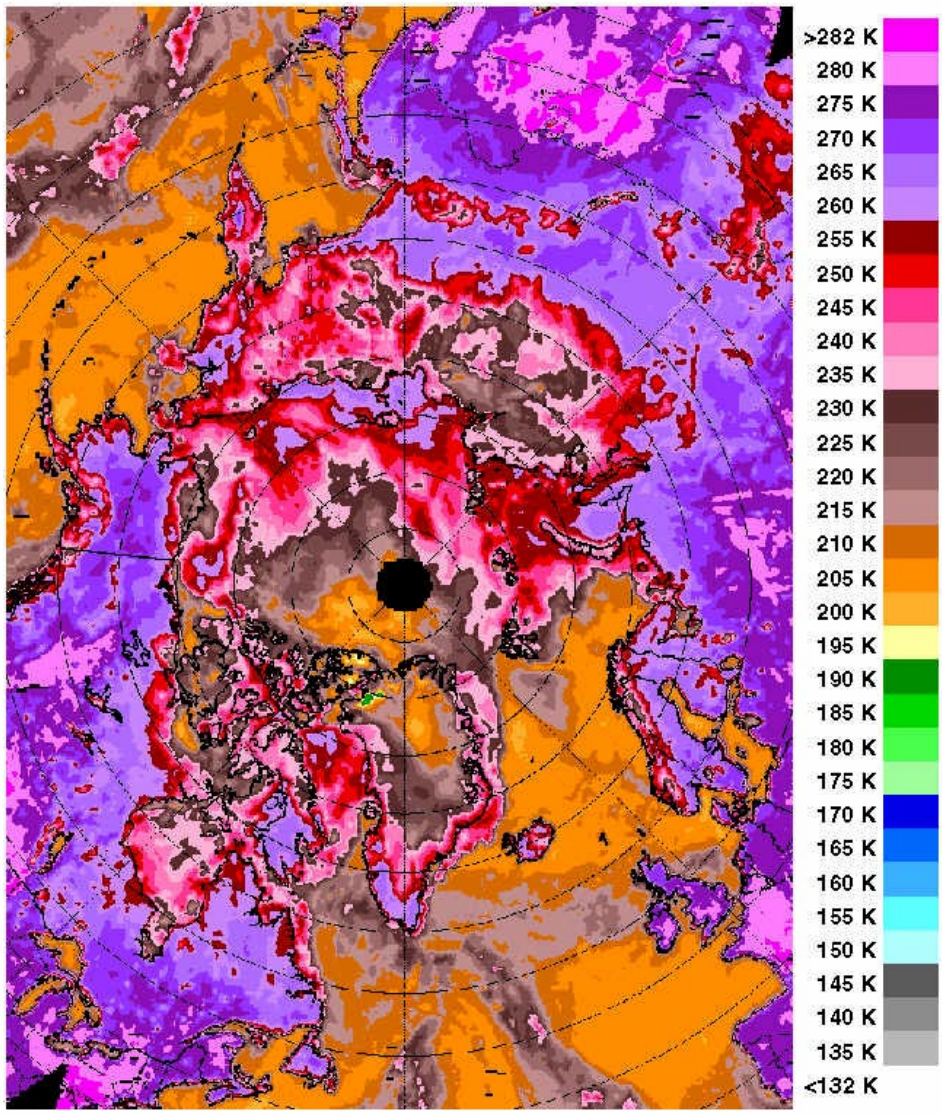
Ice Concentration: May 20, 1998



19V Brightness Temperature: May 20, 1998



37V Brightness Temperature: May 20, 1998



May 21, 1998

CV-580

Flight summary

Flight track

CAR notes

GPS plots

SHEBA

LIDAR image

Sounding

UW CV-580 FLIGHT LOG
May 21, 1998

Author (Mission Scientist): Hobbs , Peter

Flight Number: 1752
Engines On: 2005
Engines Off: 2255
Departure Airport: Barrow
Arrival Airport: Barrow

Clouds sampled: Ac St

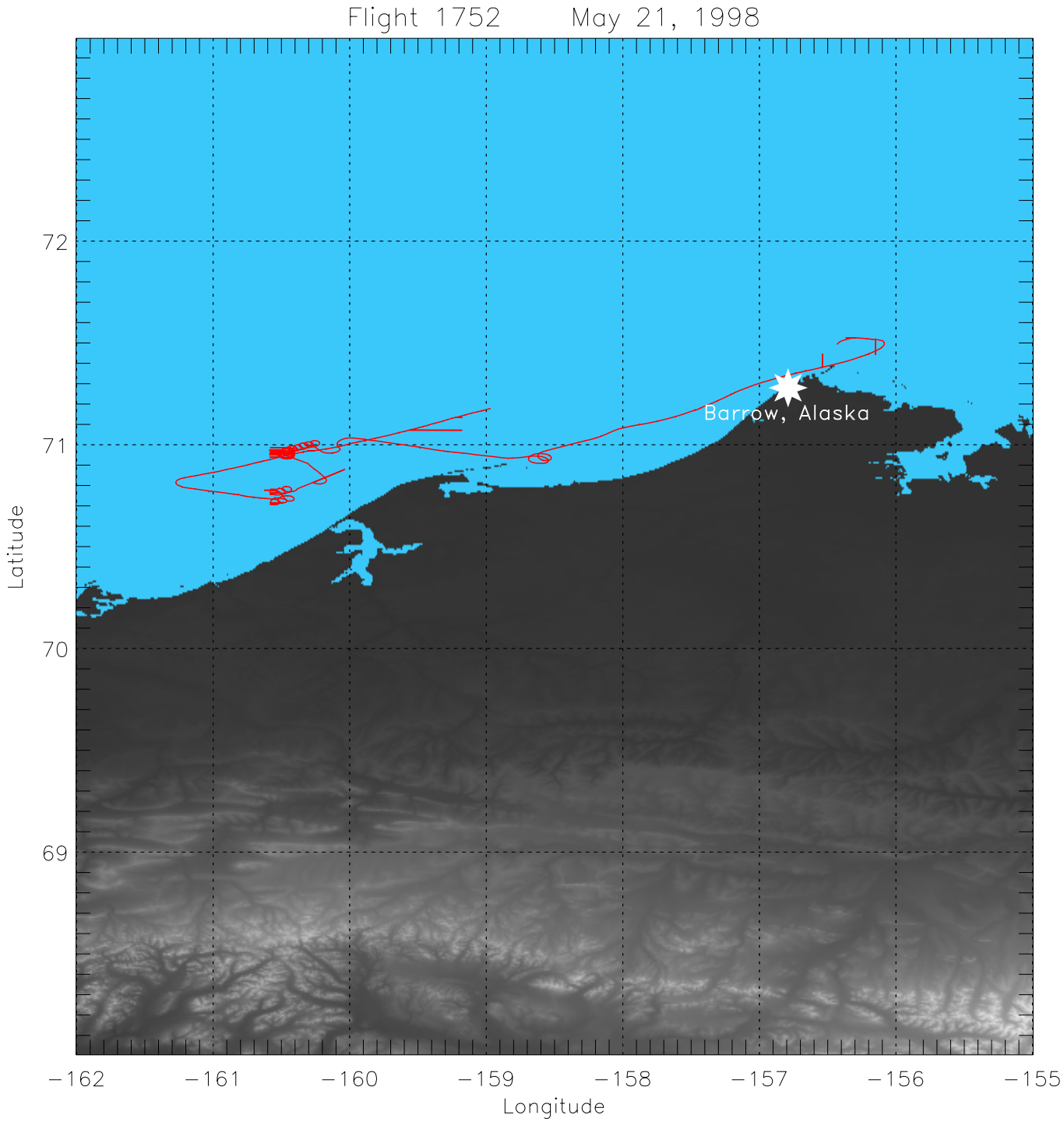
Summary:
This flight took place just offshore over the Chukchi Sea from about Pt. Barrow to Wainwright from about 2020-2250 UTC.

Experimental Observations:
1) Profiles thru three thin stratus layers at different heights with cloud structure measurements, radiative measurements, aerosols etc.
2) BRDF measurements over sea ice and open water under diffuse light with stratus clouds above.
3) Aerosol measurements around clouds.

Research crew:
Hobbs, Rangno, Radke, Garrett, Russell, Spurgeon, Li, Beitzel, Weiss, McMillan, Sutherland

Equipment Failure:
1) Laptops (on and off)
2) Humidograph

FIRE-III Objectives Addressed:
1) Surface reflectivity
2) In-cloud measurements (brief)


Flight 1752 May 21, 1998
Barrow, Alaska
72
71
70
69
Latitude
−162
−161
−160
−159
−158
−157
−156
−155
Longitude

Flight 1752 - May 21, 1998

main

1 Summary

2 Photos

3 Quicklooks

1 CAR Flight Summary

```
Conducted BRDF measurements over a surface of both leads and sea ice,
and over open ocean water - all under totally diffuse conditions. Manual
gain setting test was also performed towards the end of the flight.
Total of 12392 scan data were collected between 20:18:59 - 22:22:50 UTC.
```

On the way out of Barrow, the filterwheel channel for the CAR was locked on 1.6 µm. At 20:27, 156.78 W and 71.35 N, the CV-580 flew over many open leads [1]. At 20:32, the CAR was locked on zenith viewing mode to scan the bottom of a higher stratus cloud layer. At 20:40, the CAR was changed to nadir viewing mode to scan lower stratocumulus.

BRDF measurements [2][3][4][5][6][7][8] over leads/sea ice began at 20:59 (count 4194), filterwheel channel was on 1.64 µm. At 21:10 (count 5290), switched to 2.2 µm and BRDF measurements continued. At 21:25 (count 6813), BRDF measurements over leads/sea ice completed.

We then headed out to sea for more BRDF measurements. This set of BRDF measurements were taken over open ocean water [9][10]. At 21:30 (count 7286), we began BRDF measurements over the open water and the filterwheel channel was on 2.2 µm. At 21:40 (count 8306), filterwheel was changed to 1.6 µm. Then the CV-580 was banked to the left to make a couple sky radiance measurements.

Generally speaking, we encountered two layers of clouds. The base of the lower cloud layer [11] was located at 900 ft and its top at 2400 ft. The upper layer cloud was at about 3500 ft.

At 22:01 (count 10444), conducted manual gain setting testing with CAR door closed. The gain setting was cycled from 1 at scan count 10627 all the way to gain setting 8 at scan count 11520.

Note: CAR gyro readings are incorrect because of a broken wire. GPS navigational information is sometimes corrupted while on its way to the CAR data stream (residual byte stayed behind in the FIFO buffer).

Fire Ace

May - June, 98
Barrow, Alaska

Photo Records:

1. open leads

2. BRDF over leads/ice

3. BRDF over leads/ice

4. BRDF over leads/ice

5. BRDF over leads/ice

6. BRDF over leads/ice

7. BRDF over leads/ice

8. BRDF over leads/ice

9. BRDF over open ocean

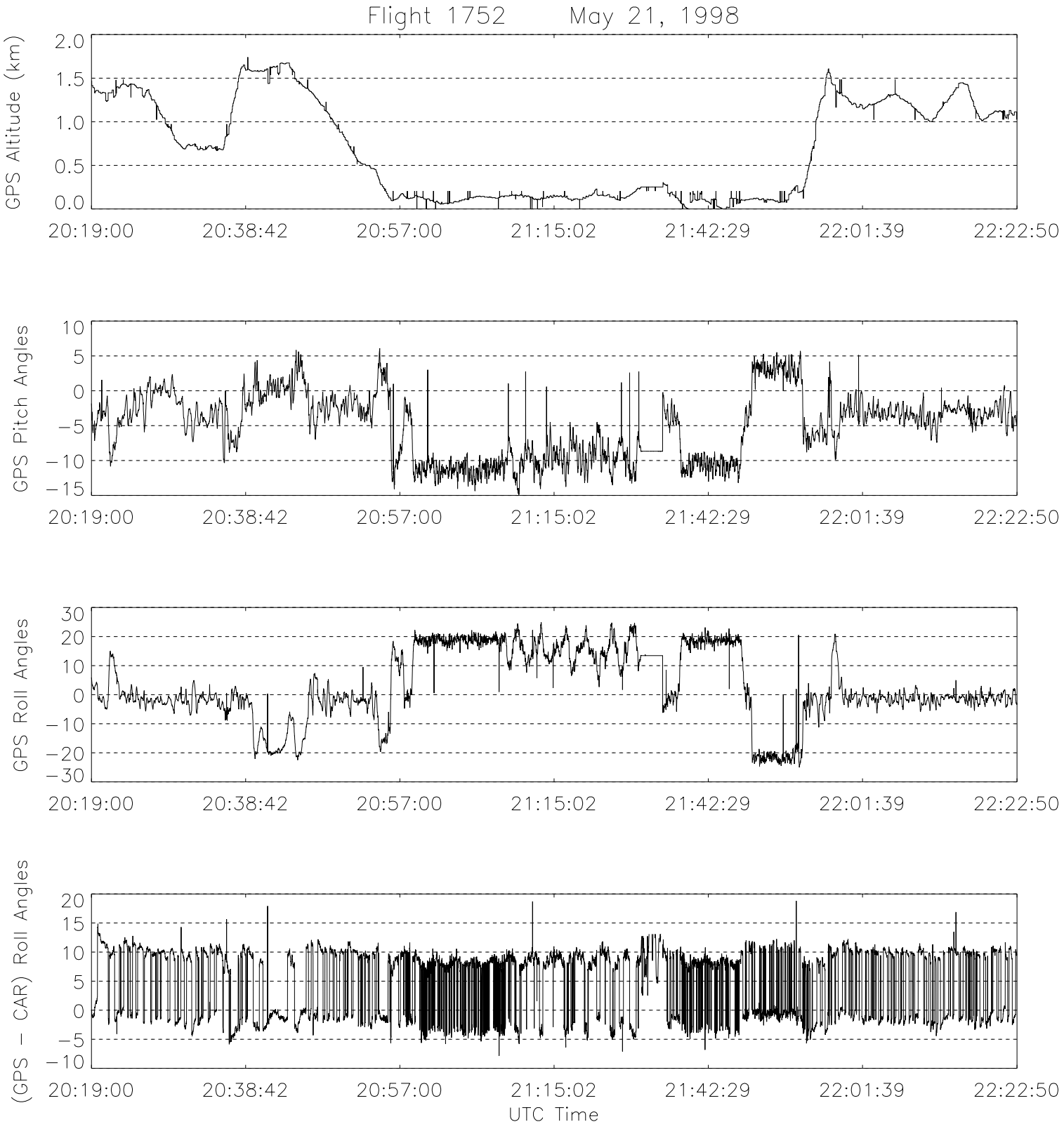
10. BRDF over open ocean

11. stratus cloud layer

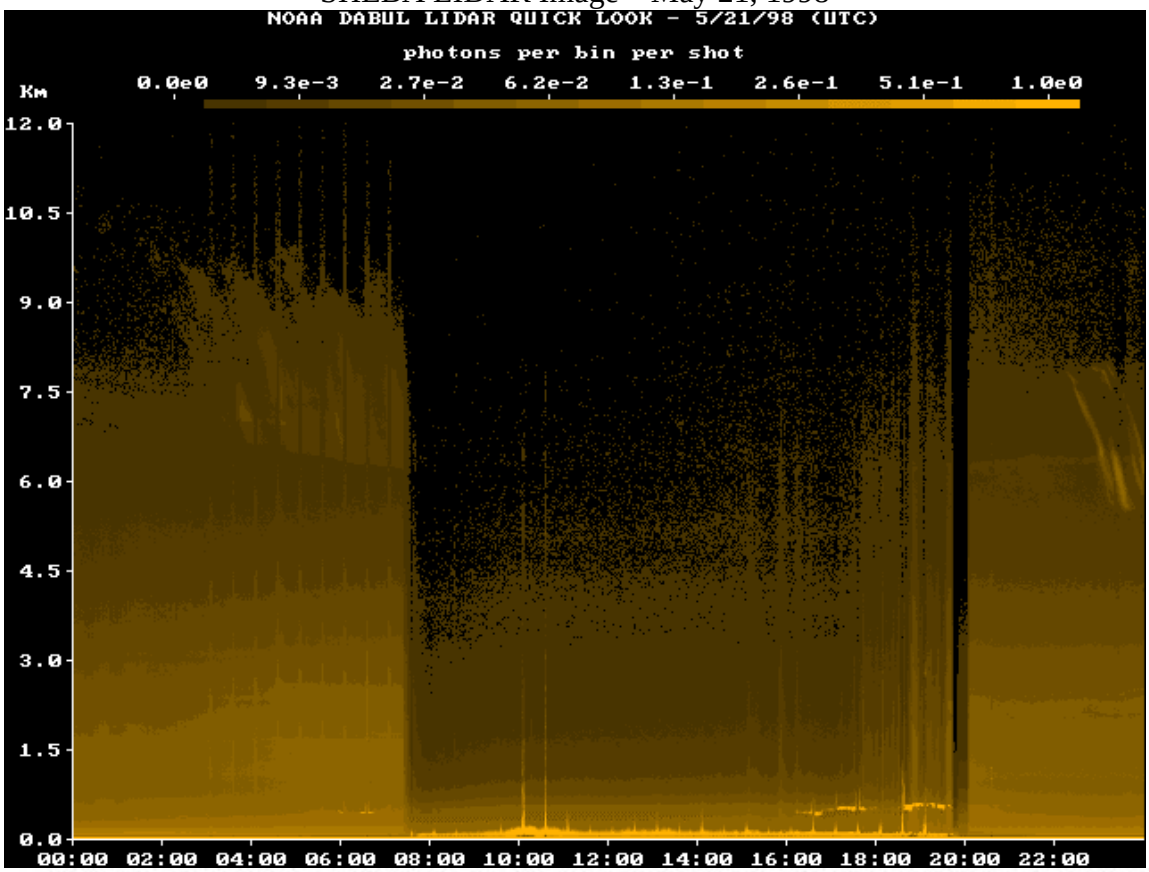
Flight Track and Quicklook Images:

- CV-580 flight tracks
- GPS altitude, roll and pitch angle plot

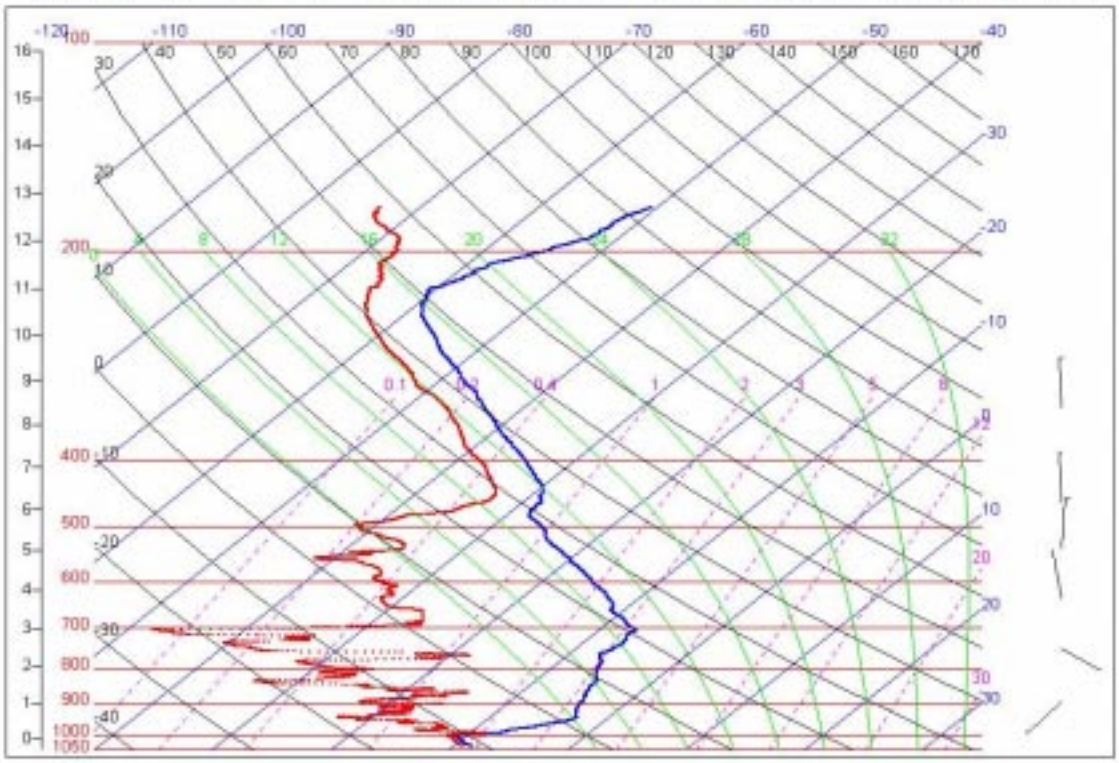
Back to Top


Flight 1752 May 21, 1998
GPS Altitude (km)
2.0
1.5
1.0
0.5
0.0
20:19:00
20:38:42
20:57:00
21:15:02
21:42:29
22:01:39
22:22:50
GPS Pitch Angles
10
5
0
−5
−10
−15
GPS Roll Angles
30
20
10
0
−10
−20
−30
(GPS − CAR) Roll Angles
20
15
10
5
0
−5
−10
UTC Time

SHEBA LIDAR Image – May 21, 1998



Version: SHEBA--GPS Soundings, GLASS 1.10 Fixed, SHE, 1998,05,21, 11:44:33



May 22, 1998

ER-2

Flight summary

Ground track

MAS images

Cloud LIDAR System image

HIS measurements

AMPR images

SHEBA

LIDAR image

Sounding

ER-2 Mission 3

Friday, May 22, 1998

Michael King: Flight Scientist

Objectives: To fly repeatedly over the surface site at Barrow (71°19.37'N, 156°34.9'W) and nearby open water and fast ice of the Chukchi and Beaufort Seas. The ER-2 flew three parallel and repeating ground tracks of 261 km in length that were parallel to the NOAA-14 ground track at 2304 UTC (heading of 347.13° at SHEBA). Due to malfunction of the backup navigation equipment onboard the aircraft, the mission design, which included parallel ground tracks over SHEBA, was modified to fly a similar pattern over ARM.
The entire flight track over the Chukchi and Beaufort Seas was cloud free, with Arctic stratus present over land and nearby coastal fast ice. Other coordination included:

- F-14 satellite (2237 UTC)
- NOAA-14 satellite (2304 UTC)
- Principal plane of the sun (2218 UTC)

All times, orbital inclinations, and timings were based on flights over SHEBA (76° 20.76' N), rather than Barrow, so some of the angles are off of the intended times and orbits planned for this mission.

ER-2 Mission:	Pilot:	Jim Barrilleaux
	Takeoff	2010 UTC
	Landing	0100 UTC (May 23)
	Duration	4:50

The ER-2 flew a NNW flight line from point 1 (70°09'N, 155°31'W) to point 2 (72°26'N, 157°14'W), then reversed course, flying over the ARM site each time (two passes). The aircraft then flew a parallel track displaced 40 km to the west with two round trip flight legs, followed by another pair of flight legs displaced 40 km to the east. Each flight leg was 261 km in length. The flight tracks were all parallel and on a heading of 347.1°/167.1°, corresponding to the orbital inclination of NOAA-14 as it flew over the SHEBA ice station at 2304 UTC.
The AirMISR was turned on for six acquisitions over the Barrow ARM site and nearby tundra, including acquisitions when the sun was in the orbital inclination of NOAA-14 (at least at SHEBA), and when the NOAA-14 and F-14 satellites passed over the area. The AirMISR operated at the following times:

- 2112.5-2128.5 UTC (ARM)
- 2139.5-2154.5 UTC (ARM; sun in principal plane at ARM)
- 2208.5-2225.5 UTC (west; sun in principal plane at SHEBA)
- 2234.25-2250 UTC (west; F-14)
- 2302.5-2317.5 UTC (east; NOAA-14)
- 2330.75-2345.75 UTC (east)

The ER-2 pilot reported Arctic stratus conditions over the tundra until 55 km north of Barrow, with clear sky and possible haze or thin cirrus over the ice.

Instrument Status

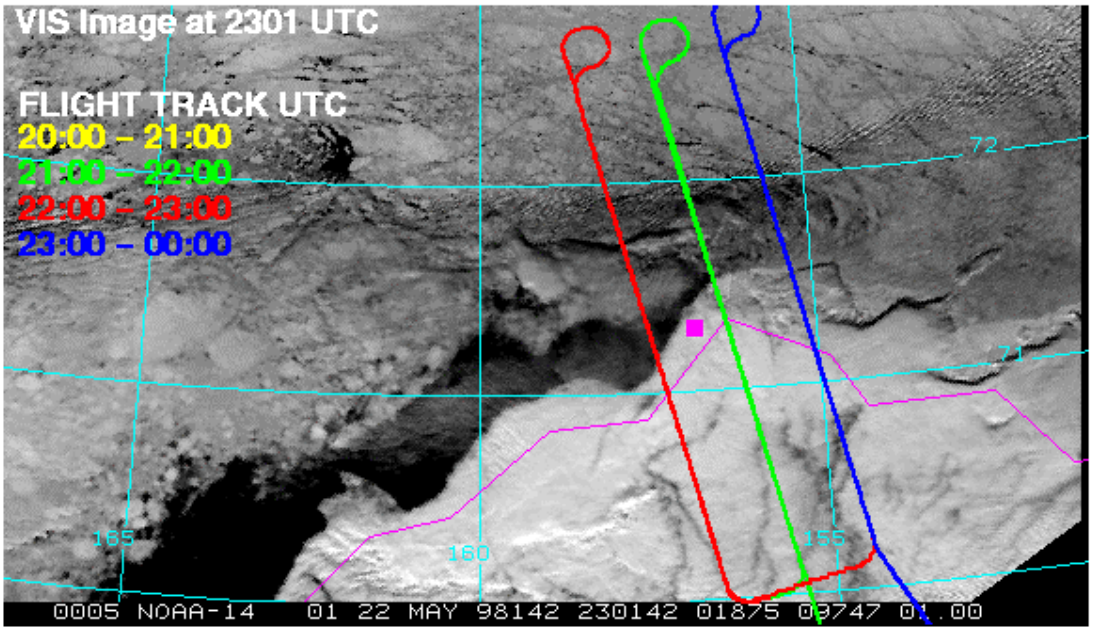
- AirMISR – the 2nd, 3rd, and 4th runs collected all 9 look angles, while the remaining 3 scenes collected a minimum of nadir and the first 4 view angles
- AMPR – worked well
- CLS – worked well
- HIS – worked well
- MAS – port 4 (8.3-14.0 μm) disconnected for nitrogen purge
- MIR – worked well
- SSFR – worked well

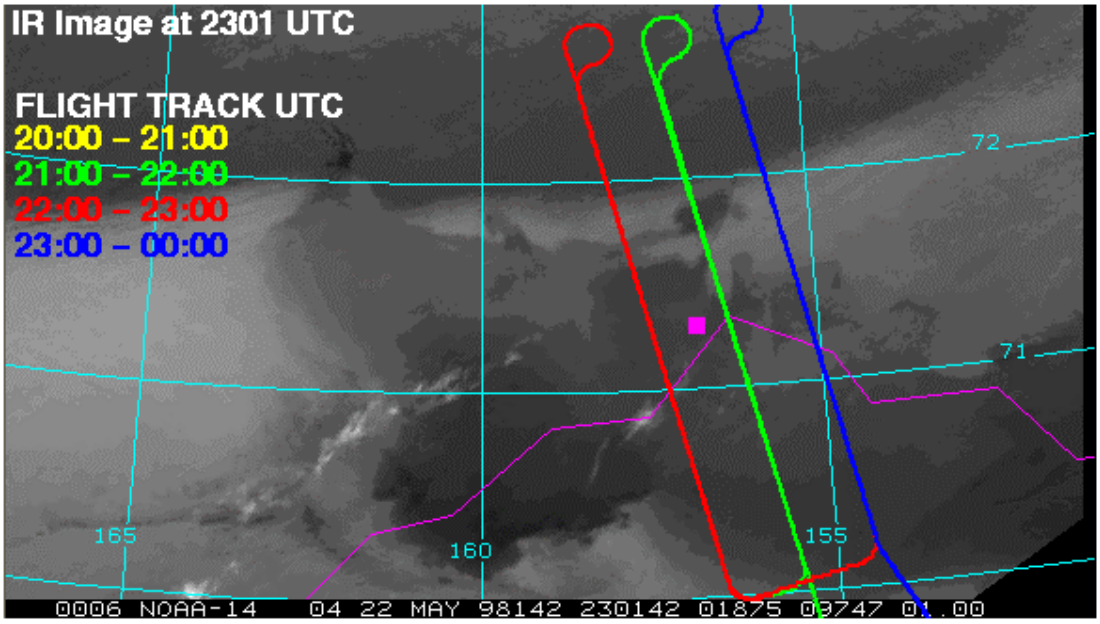
Meteorology: A single layer cloud system occurred near and to the south of Barrow, with clear sky over the Beaufort Sea.

Instruments:

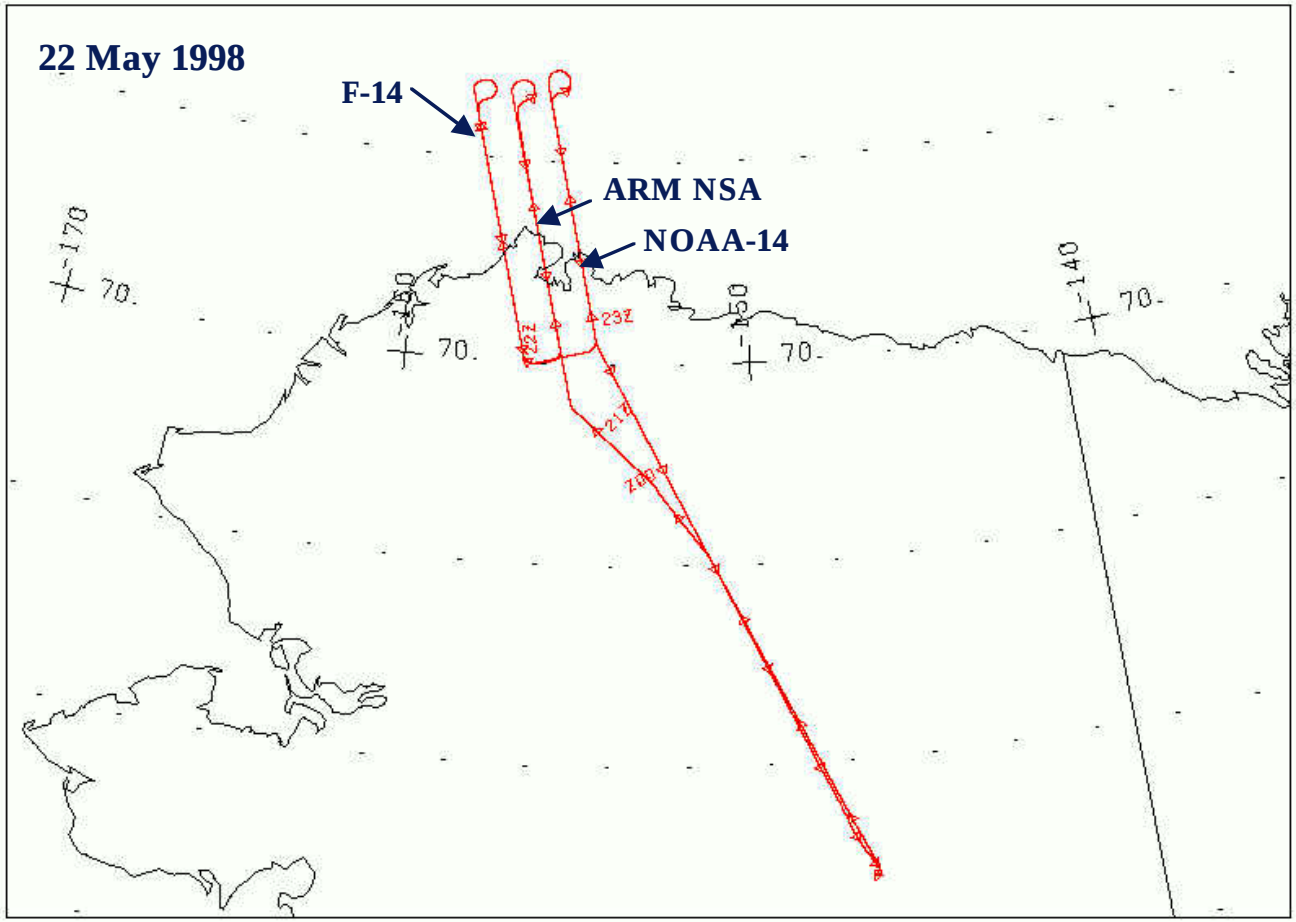
AirMISR – Airborne Multi-angle Imaging Spectroradiometer
AMPR – Advanced Microwave Precipitation Radiometer
CLS – Cloud LIDAR System
HIS – High-resolution Interferometer Sounder
MAS – MODIS Airborne Simulator
MIR – Millimeter-wave Imaging Radiometer
SSFR – Solar Spectral Flux Radiometer

ER2 FLIGHT TRACK AND NOAA–14 AVHRR IMAGES ON MAY 22, 1998 OVER BARROW





ER-2 Ground Track



First Year Ice – Chukchi Sea

Red = 2.13 μm

Green = 1.62 μm

Blue = 0.55 μm

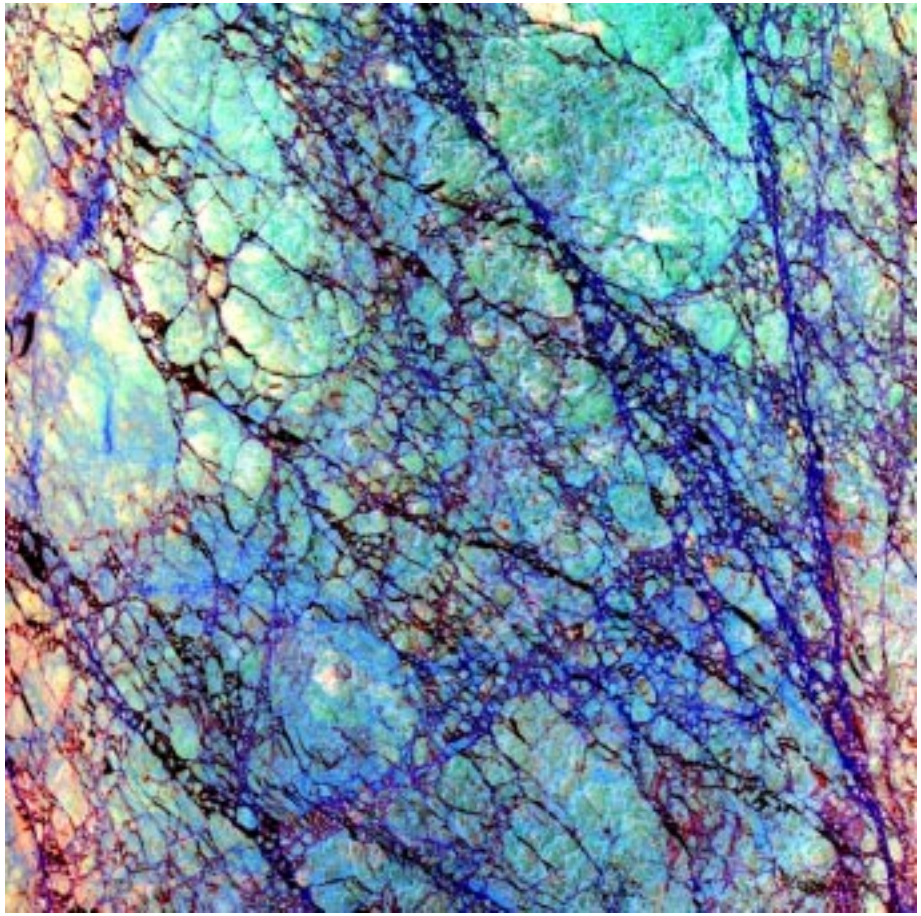
22 May 1998

72°14'N 157°07'W

2136 UTC

Flight Direction

166°



37.2 km

37.2 km

θ_0 **= 52.3°**

ϕ_0 **= 165.5°**

$\phi - \phi_0$ **= 89.5°**

Stratus over Open Water

Red = 2.13 μm

Green = 1.62 μm

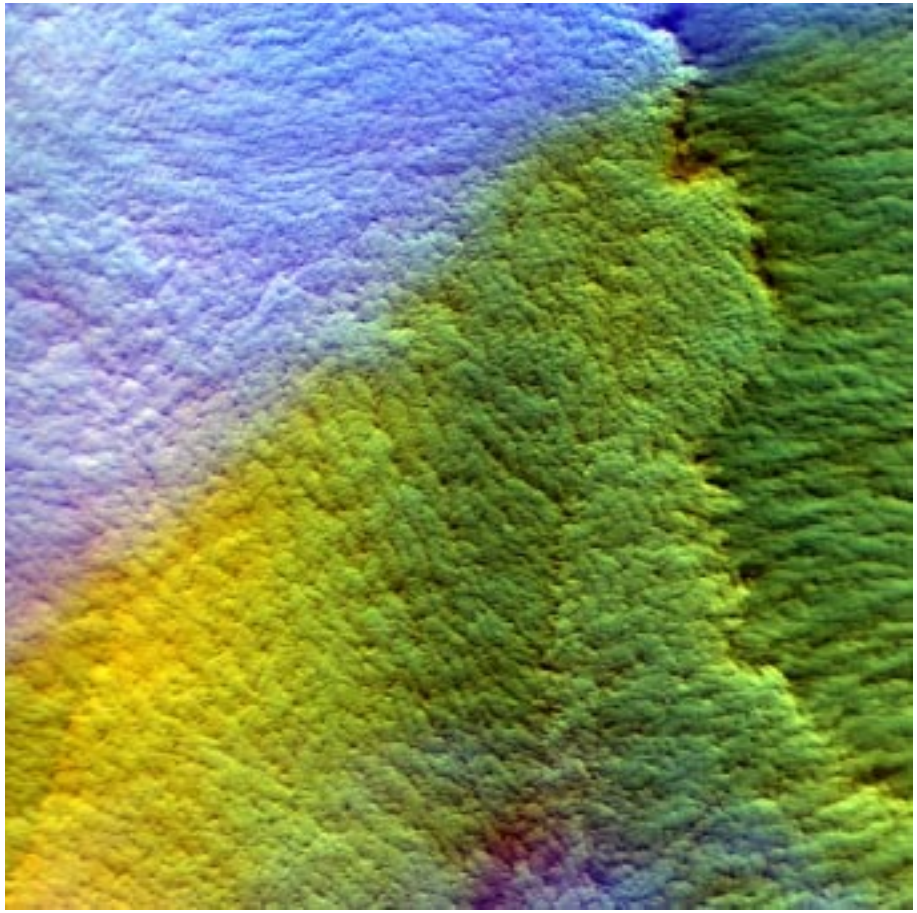
Blue = 0.66 μm

22 May 1998

71°14'N 157°27'W

2211 UTC

37.2 km



37.2 km

Flight Direction

348.2°

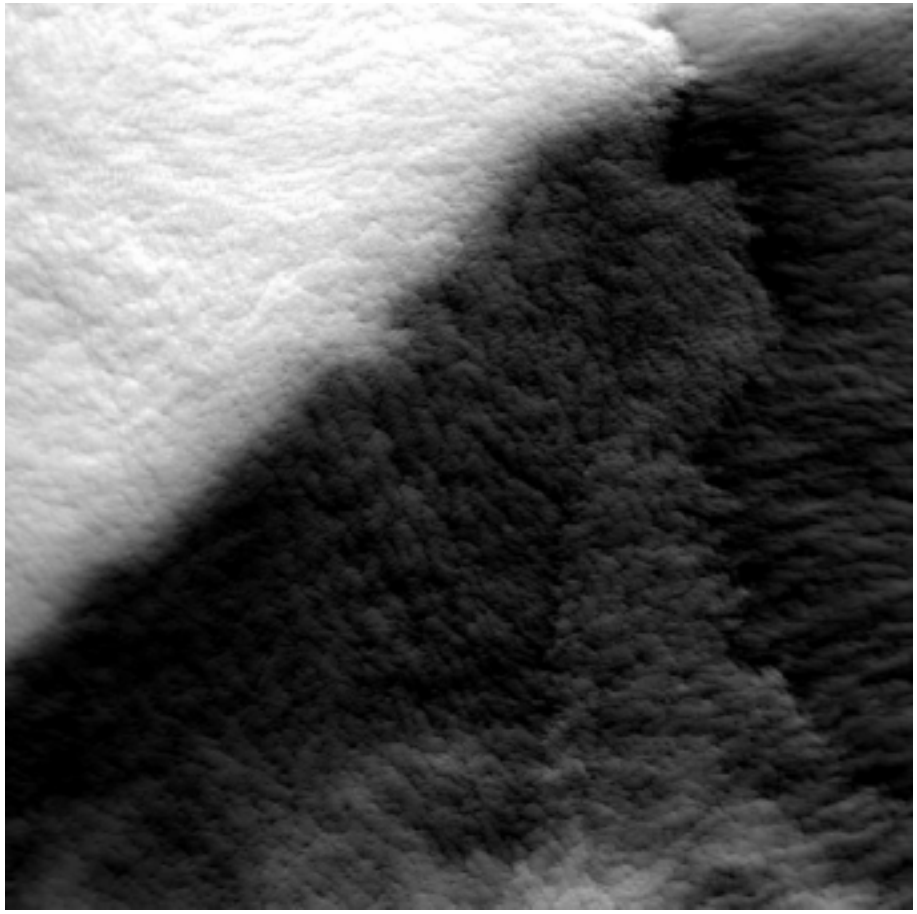
θ_0 **= 50.9°**

ϕ_0 **= 175.4°**

$\phi - \phi_0$ **= 82.8°**

Stratus over Open Water

λ = 0.66 μm



37.2 km

37.2 km

22 May 1998

71°14'N 157°27'W

2211 UTC

Flight Direction

348.2°

θ_0 = 50.9°

ϕ_0 = 175.4°

$\phi - \phi_0$ = 82.8°

Stratus over Open Water

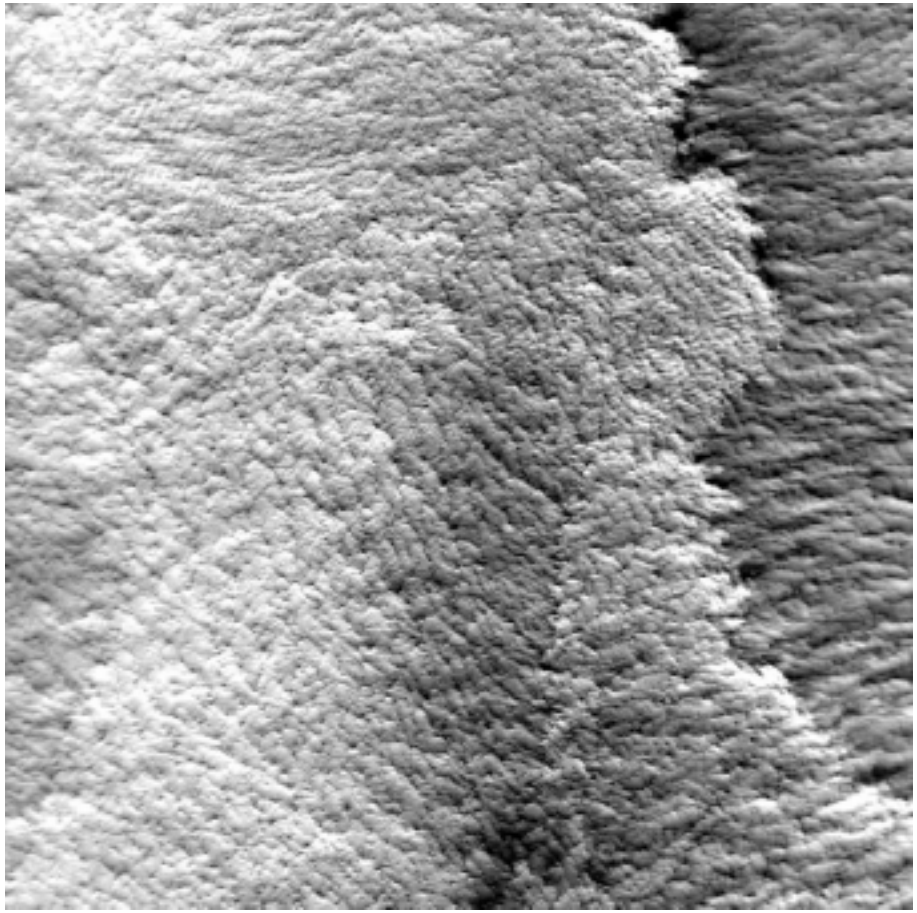
λ = 1.62 μm

θ_0 = 50.9°

ϕ_0 = 175.4°

$\phi - \phi_0$ = 82.8°

37.2 km



37.2 km

22 May 1998

71°14'N 157°27'W

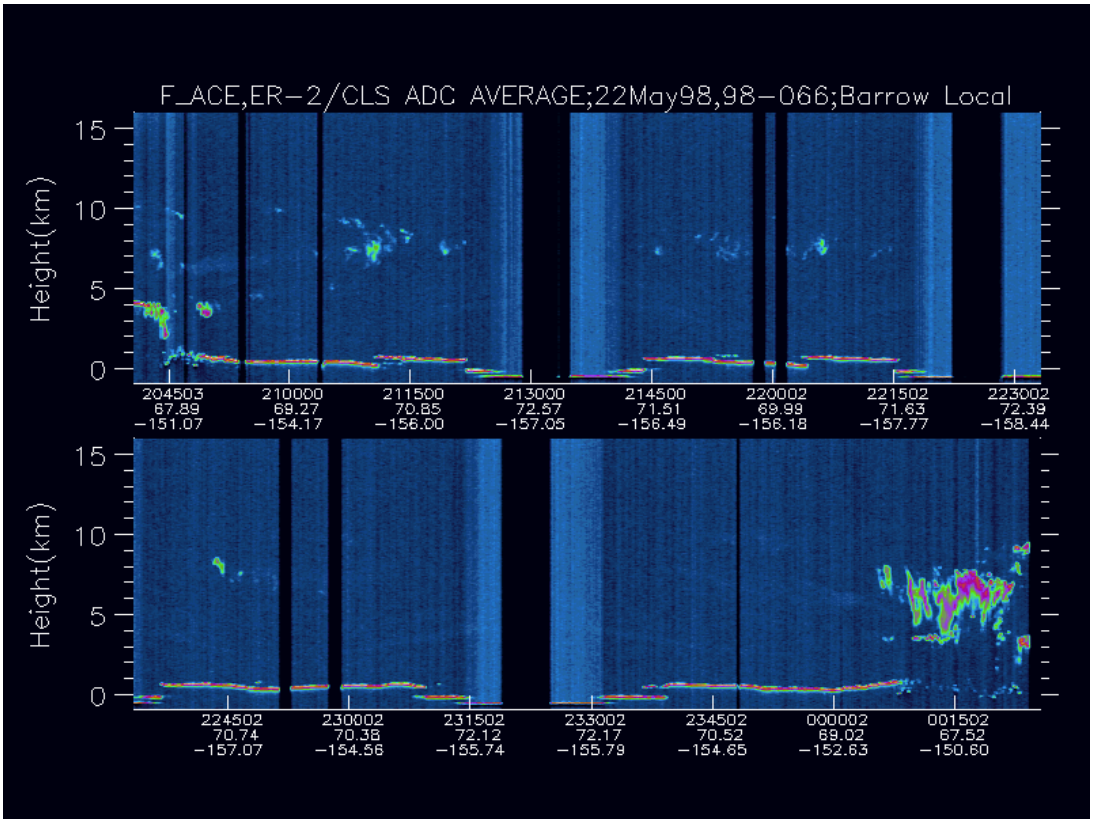
2211 UTC

Flight Direction

348.2°

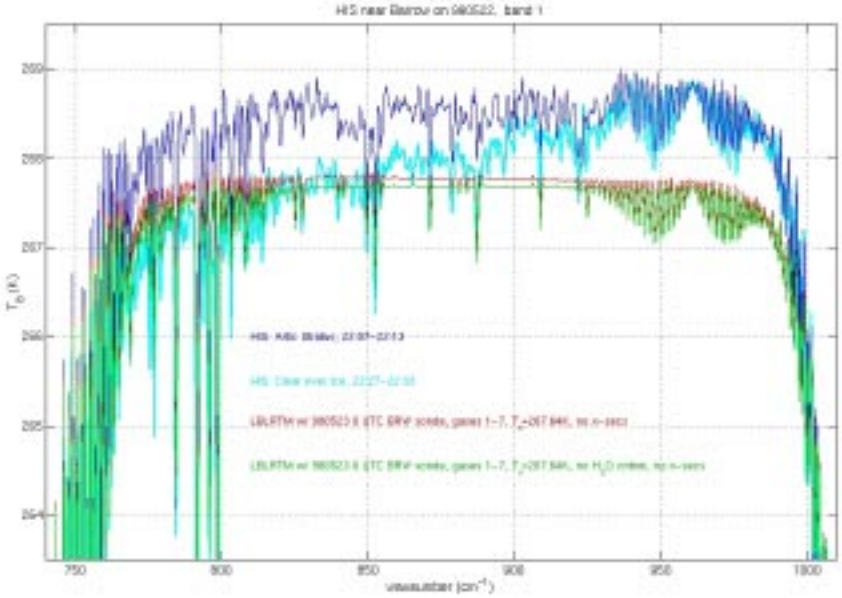
Cloud LIDAR System Image

May 22, 1998 - Instrument worked nominally. Image of cirrus over Brooks Range and both clear and stratus over the Arctic Ocean.

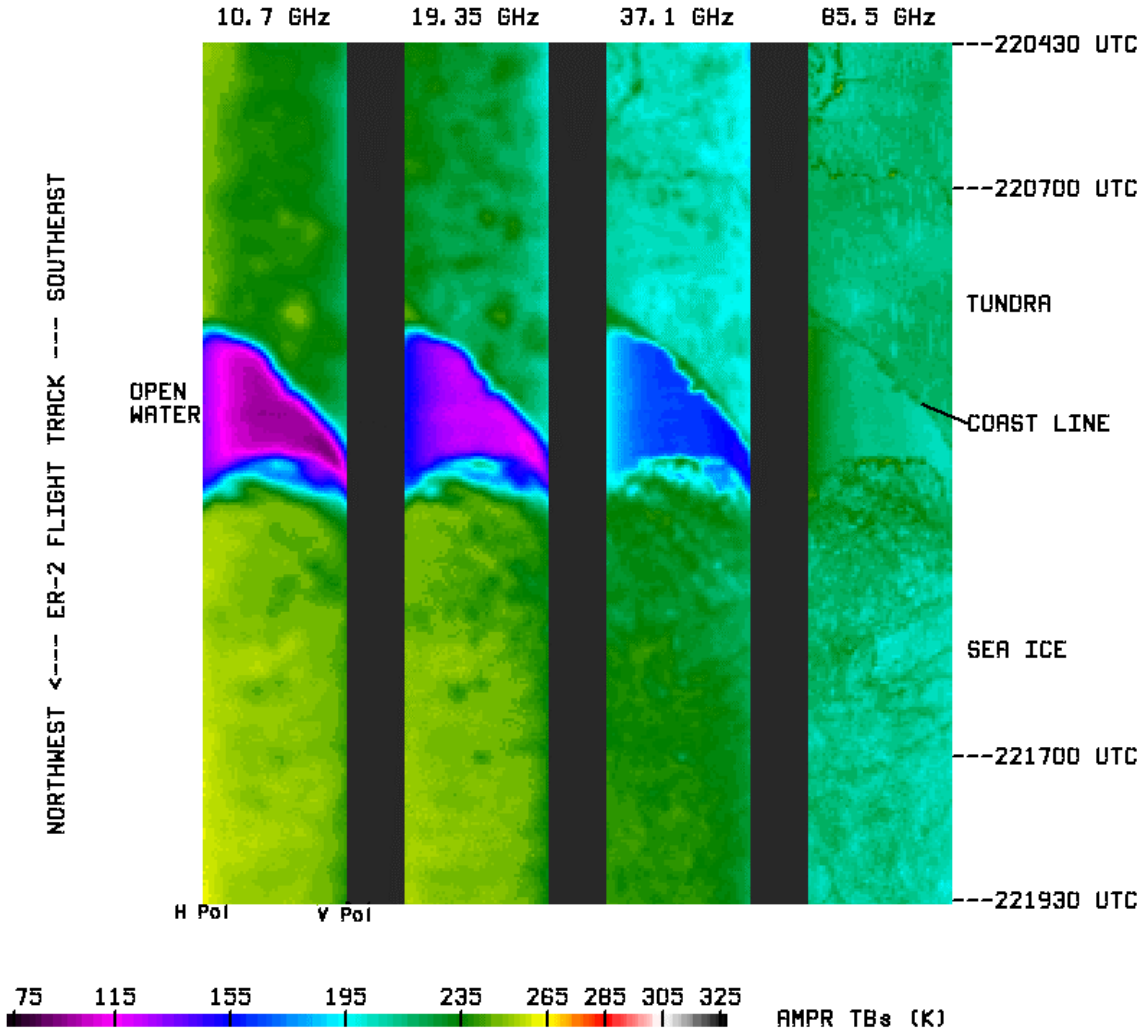


HIS IR Spectrum

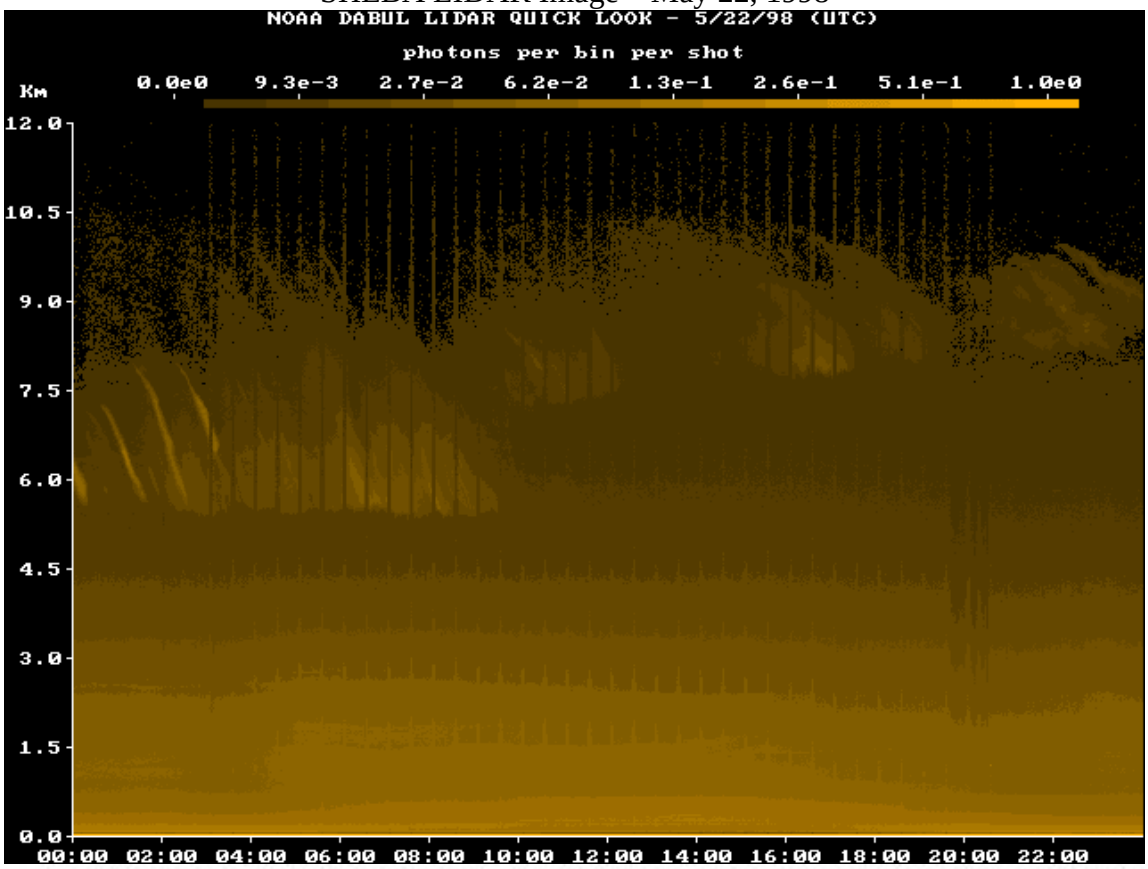
Long-wave Window with Calculations



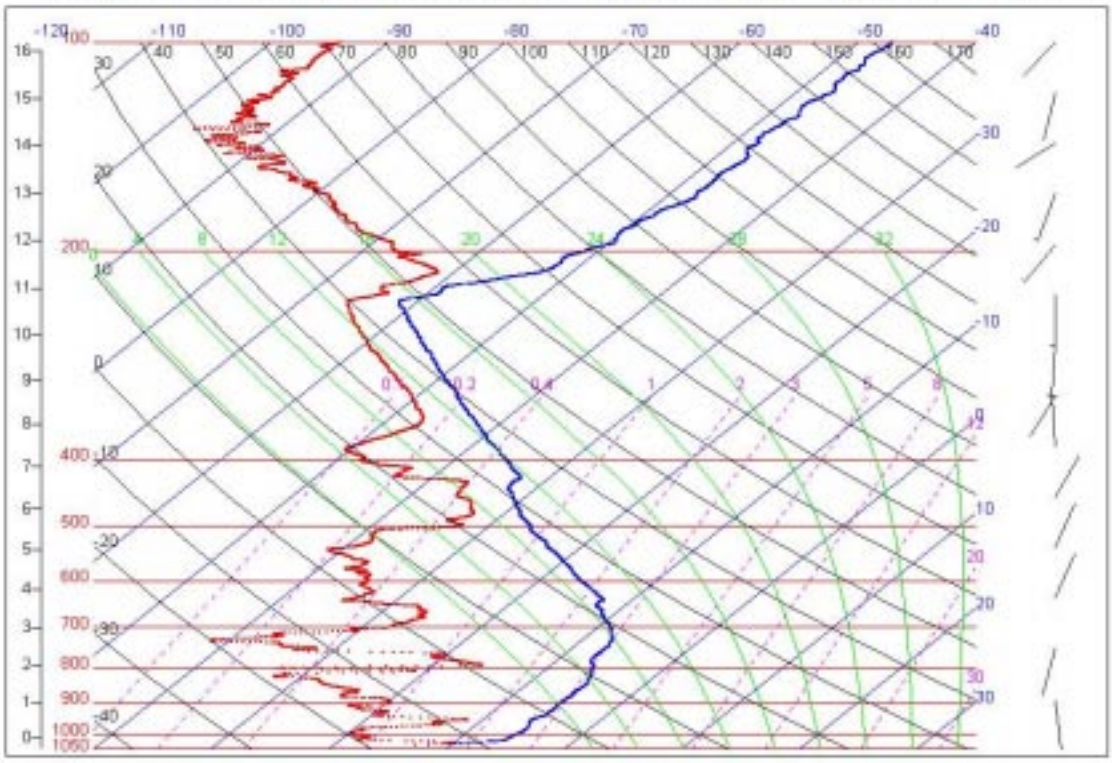
AMPR TBs FOR FIRE ACE
22 MAY 1998



SHEBA LIDAR Image – May 22, 1998



Version: SHEBA--GPS Soundings, GLASS 1.10 Fixed, SHE, 1998,05,22, 11:12:42



May 23, 1998

CV-580

Flight summary

Flight track

CAR notes

GPS plots

SHEBA

LIDAR image

Sounding

UW CV-580 FLIGHT LOG
May 23, 1998

Author (Mission Scientist): Hobbs , Peter

Flight Number: 1753
Engines On: 1904
Engines Off: 2053
Departure Airport: Barrow
Arrival Airport: Barrow

Clouds sampled: Ac St

Summary:

This flight took place about 10 miles west of the ARM site from about 1900-2100 UTC. The NOAA-12 satellite overpass was at 1951 UTC. The cloud situation was complex, but common for the Artic, namely, mutilayed clouds: two altocumulus layers centered at about 10,500 and 9,000 ft, and a stratus layer between 1100-1550 ft.

We obtained radiation measurements in horizontal runs in clear air above the tops of the Ac, between the two Ac layers, and between the base of the lower Ac and the top of the stratus. During the descent, measurements were obtained in horizontal legs of cloud microstructures in all three cloud layers. The upper Ac layer was at -8C, the lower Ac layer at -4C and the stratus layer -6C.

The flight was terminated prematurely due to a (probably erroneous) indication of the right engine overheating.

Experimental Observations:

Measurements of cloud structures and radiation in a complex (but no doubt) common situation in the Arctic, namely, multi-cloud layers.

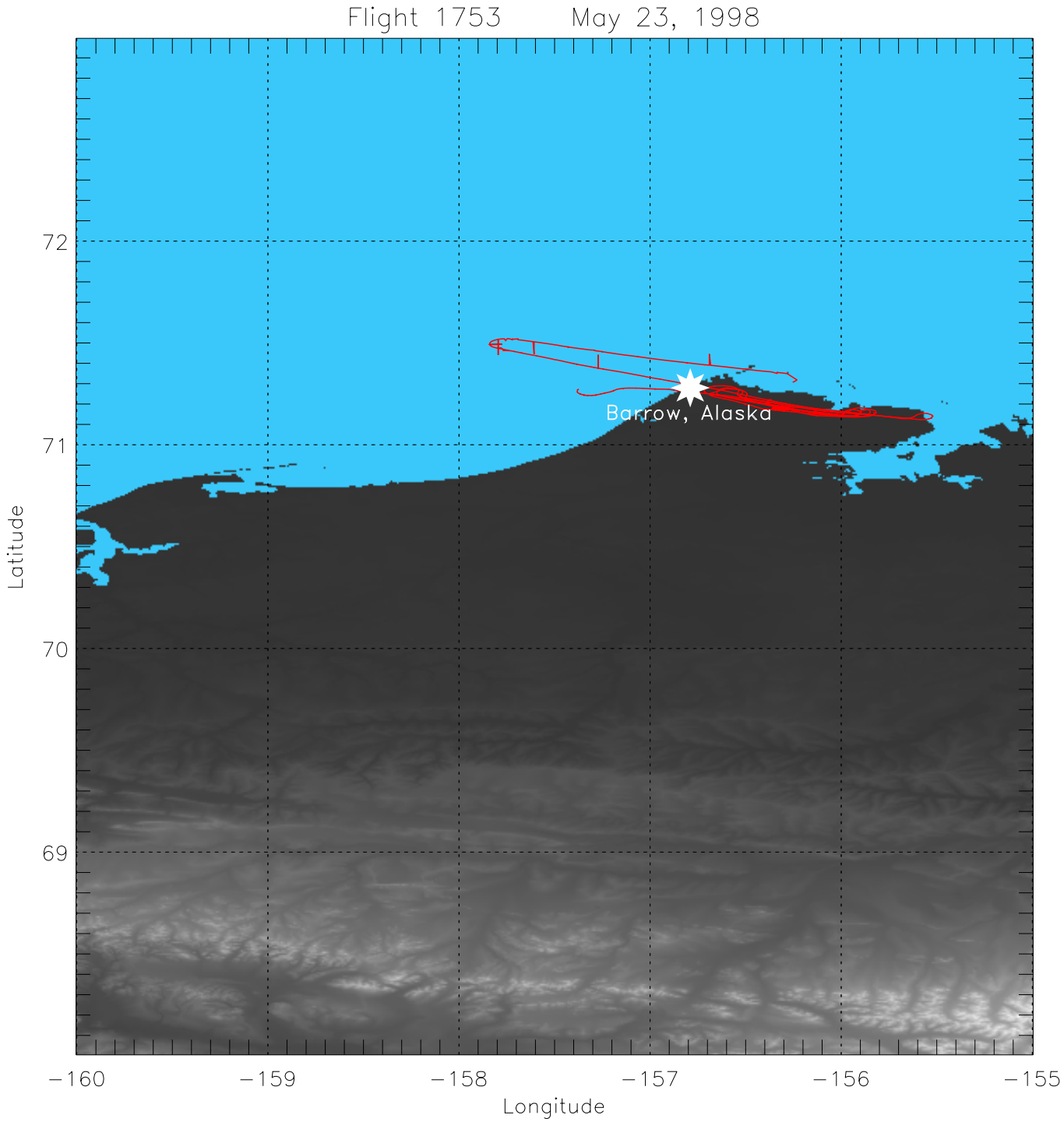
```
                ___  ___  ___  ___
10K  ft   (___) (___) (___) (___)  <- Ac layer 1

                __   __   __
 9K  ft    (__)  (__)  (__)    <- Ac layer 2
1550 ft  _______________________
         (_______________________) <- St layer 3
1100 ft
         ________________________
         /  /  /  /  /  /  /  /
```

Obtained radiation measurements above layer 1, between layers 1 and 2, above layer 3. Also, in-cloud measurements in Ac layers and in stratus layer.

Research crew: Hobbs, Rangno, Weiss, Radke, Garrett, Russell, Spurgeon, Li, Beitzel, McMillan, Sorensen

Equipment Failure:
1) IR therm (?)
2) Radar altimeter
3) CAR "froze up" above Ac
4) Flt chem computer

FIRE-III Objectives Addressed:
Cloud structure and cloud radiative properties


Flight 1753 May 23, 1998
Barrow, Alaska
72
71
70
69
Latitude
−160
−159
−158
−157
−156
−155
Longitude

Flight 1753 - May 23, 1998

main

1 Summary

2 Photos

3 Quicklooks

1 CAR Flight Summary

We did mostly in-cloud radiation measurements above and in between altocumulus and stratus cloud layers. The data from this flight was less than ideal for the CAR instrument because the cloud layers were not distinct, the CAR got stuck in BRDF mode, and the flight was cut short due to a faulty engine alarm. The CAR was able to observe some stratus and cumulus layers. Total of 8522 scan data were collected between 19:19:17 - 20:44:40 UTC.

The filterwheel channel for the CAR for the entire flight was locked on 1.6 µm. At 19:20, the CV-580 flew between cloud layers to the West at around 4185 ft MSL, with the CAR in nadir scanning mode. At 19:22 the CV-580 climbed to 500 ft above the tops of broken stratus over a surface of broken ice. Above were 2 slivers of altocumulus clouds.

At 19:28, we ran out of stratus below us and the altocumulus began to thin, so we decided to turn back East and fly just below the base of the higher altocumulus layer. At 19:32, the CV-580 flew just at the tops of the altocumulus clouds at around 10,300 ft MSL.

In order to observe the fairly uniform altostratus deck below us, the CV-580 began running a racetrack pattern about 12 miles in length just above the altostratus at about 19:37. During this pattern the CAR was put in BRDF mode, and was then stuck in this mode for the remainder of the flight.

At 19:53, the CV-580 descended below the stratus cloud tops into a very thin altostratus layer. At 20:00, we turned around and descended below the stratus layer. That layer did not remain constant, however, and the CV-580 was forced to climb and descend in order to stay below some broken stratus. At 20:09, another lower stratus layer appeared below us and the CV-580 descended down into that cloud layer. Again, the stratus was very thin and so the CAR was not always inside the cloud layer.

While we continued to try to move the CAR out of the BRDF position, we were unsuccessful. Only when the CV-580 experienced an alarm from one of the engines and we were on approach to Barrow, could we successfully move the CAR into another position. At that point, the chance to take measurements was past.

Photo Records:

1. pre-flight calibration for SSFR

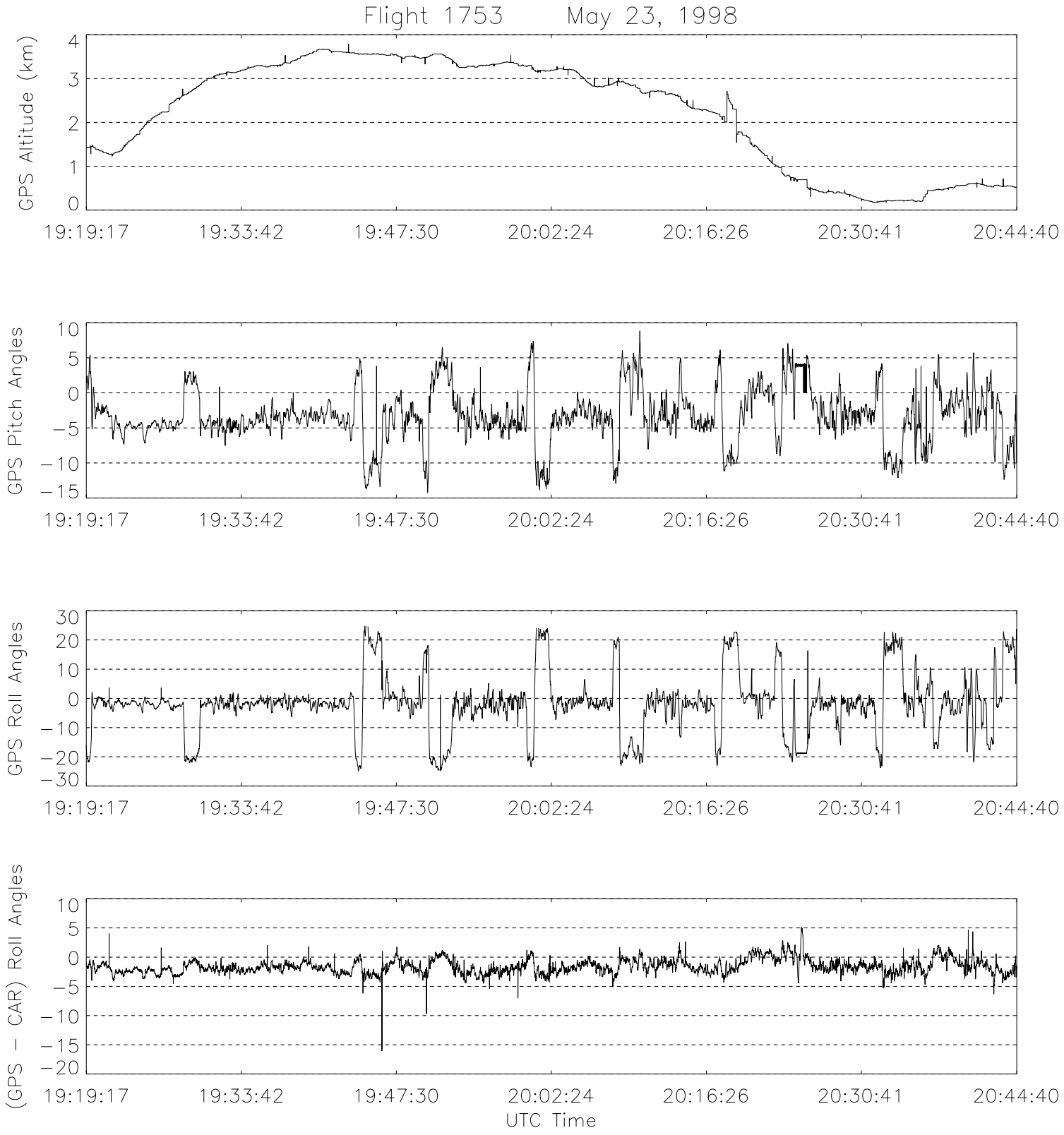
2. two layer stratus clouds

3. between altocumulus and stratus

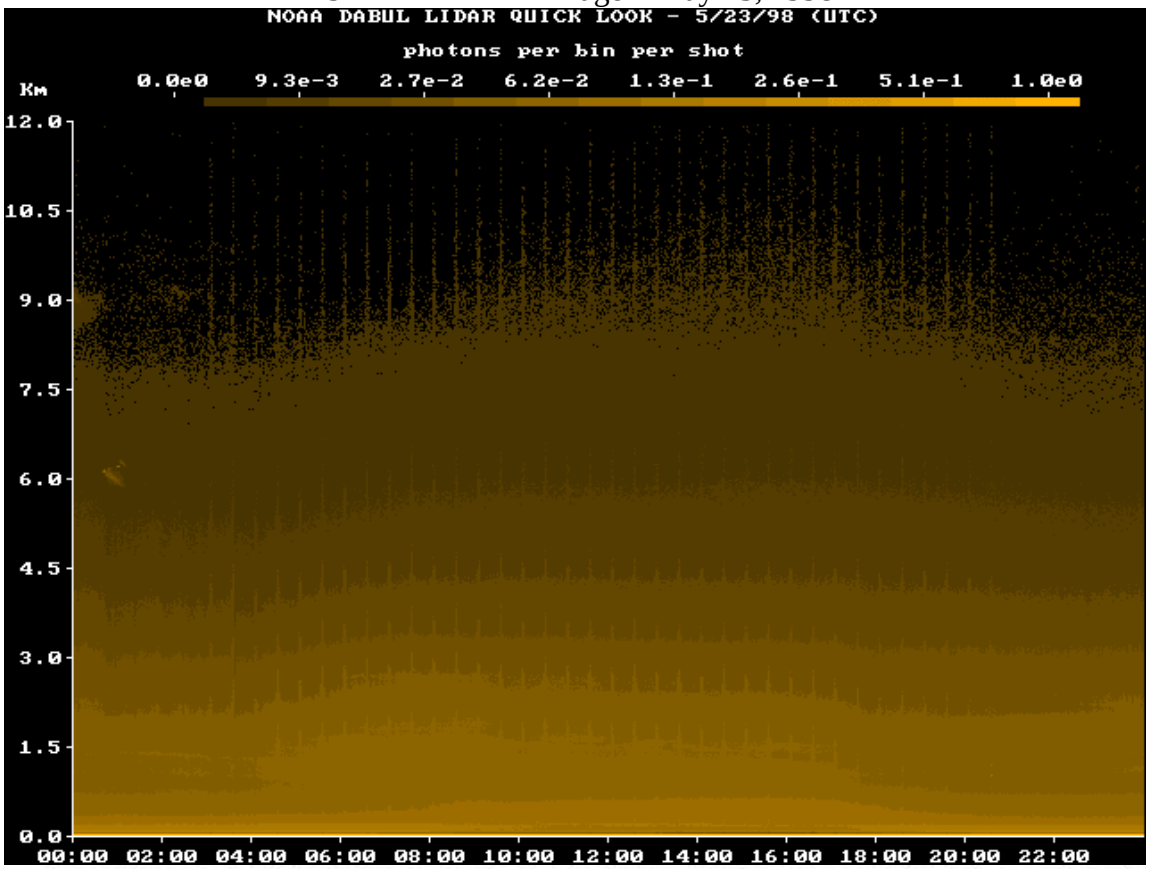
Flight Track and Quicklook Images:

- CV-580 flight tracks
- GPS altitude, roll and pitch angle plot

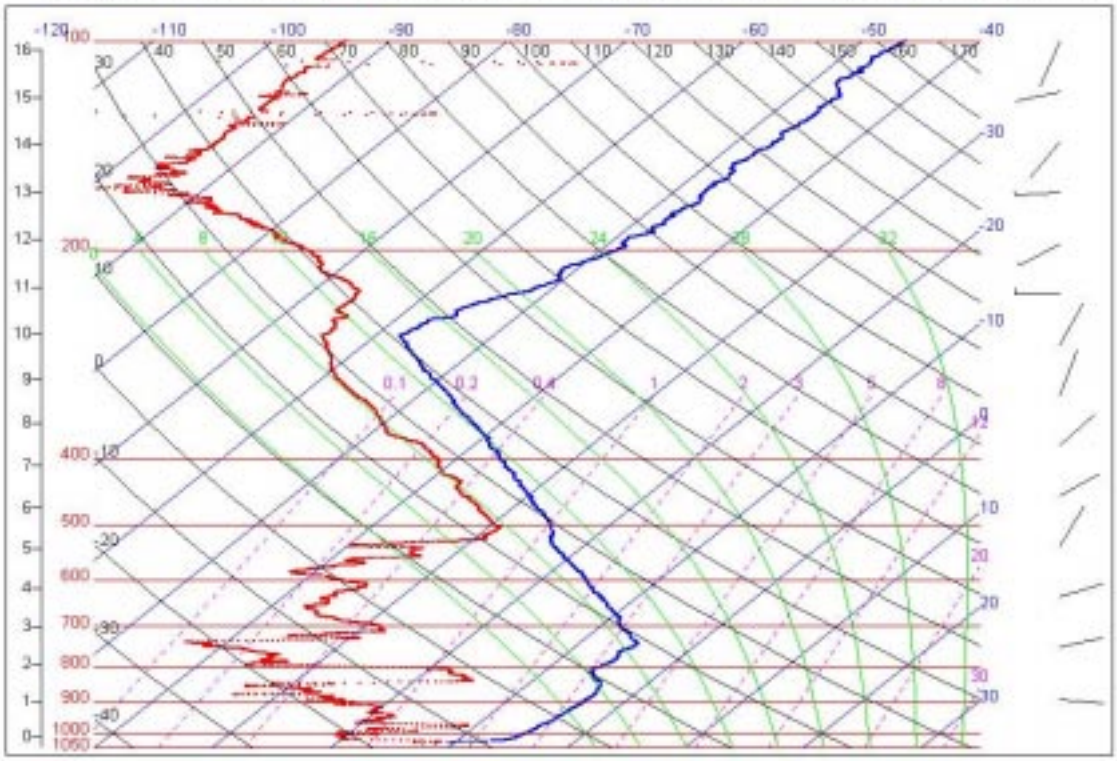
Back to Top


Flight 1753 May 23, 1998
GPS Altitude (km)
4
3
2
1
0
19:19:17
19:33:42
19:47:30
20:02:24
20:16:26
20:30:41
20:44:40
GPS Pitch Angles
10
5
0
−5
−10
−15
GPS Roll Angles
30
20
10
0
−10
−20
−30
(GPS − CAR) Roll Angles
−20
UTC Time

SHEBA LIDAR Image – May 23, 1998



Version: SHEBA--GPS Soundings, GLASS 1.10 Fixed, SHE, 1998,05,23, 11:11:34



May 24, 1998

ER-2

Flight summary

Ground track

MAS images

Cloud LIDAR System image

C-130

Flight summary

Flight track

MCR images

Radiometer data

SHEBA

LIDAR image

Sounding

ER-2 Mission 4

Sunday, May 24, 1998

Michael King: Flight Scientist

Objectives: To fly repeatedly over the surface site at Barrow (71°19.37'N, 156°34.9'W) and nearby open water and fast ice of the Chukchi Sea. The ER-2 flew three parallel and repeating ground tracks of 294 km in length that were parallel to the NOAA-14 ground track at 2240 UTC (heading of 320.31° at Barrow). The take-off was delayed one hour to allow the University of Washington to test their engine-overheating indicator. Due to continued malfunction, the University of Washington never ended up coordinating any of the flight legs over Barrow on this flight.

The bulk of the flight tracks over the Chukchi Sea were cloudy, with uniform Arctic stratus present over land and nearby coastal fast ice, with scattered-broken overlying altostratus and cirrus, with single layer cirrus on some occasions. Other coordination included:

- F-14 satellite (2032 UTC)
- NOAA-14 satellite (2240 UTC)

ER-2 Mission:	Pilot:	Ken Broda
	Takeoff	2000 UTC
	Landing	0105 UTC (May 25)
	Duration	5:05

The ER-2 flew a NW flight line from point 1 (70°22.5'N, 154°44'W) to point 2 (72°25'N, 160°W), then reversed course, flying over the ARM site each time (two passes). The aircraft then flew a parallel track displaced 40 km to the west with two round trip flight legs, followed by another pair of flight legs displaced another 40 km to the west. Each flight leg was 294 km in length. The flight tracks were all parallel and on a heading of 320.31° / 140.31°, corresponding to the orbital inclination of NOAA-14 as it flew over the ARM NSA site at 2240 UTC.

The AirMISR was turned on for six acquisitions over the Barrow ARM site and neighboring flight legs west of Barrow, including acquisitions when the sun was in the orbital inclination of NOAA-14, and when the NOAA-14 and F-14 satellites passed over the area. The AirMISR operated at the following times:

- 2025-2039 (Brooks Range en route—scattered-clear sky)
- 2100-2113 UTC (ARM—uniform stratus with scattered-broken AS)
- 2126-2139 UTC (eastern line; ARM)
- 2149-2202 UTC (central line)
- 2219-2238 UTC (central line; stratus below at time of NOAA-14 overpass)
- 2251-2307 UTC (western line)
- 2329-2343 UTC (western line)
- 0008-0022 (Brooks Range on return—thick cirrus)

The ER-2 pilot reported multi-layer stratus clouds over the ice near Barrow, with clear sky over the tundra. The Brooks Range had thin cirrus over it on the way out and thicker stratus with some underlying altostratus on the return to Fairbanks.

Instrument Status

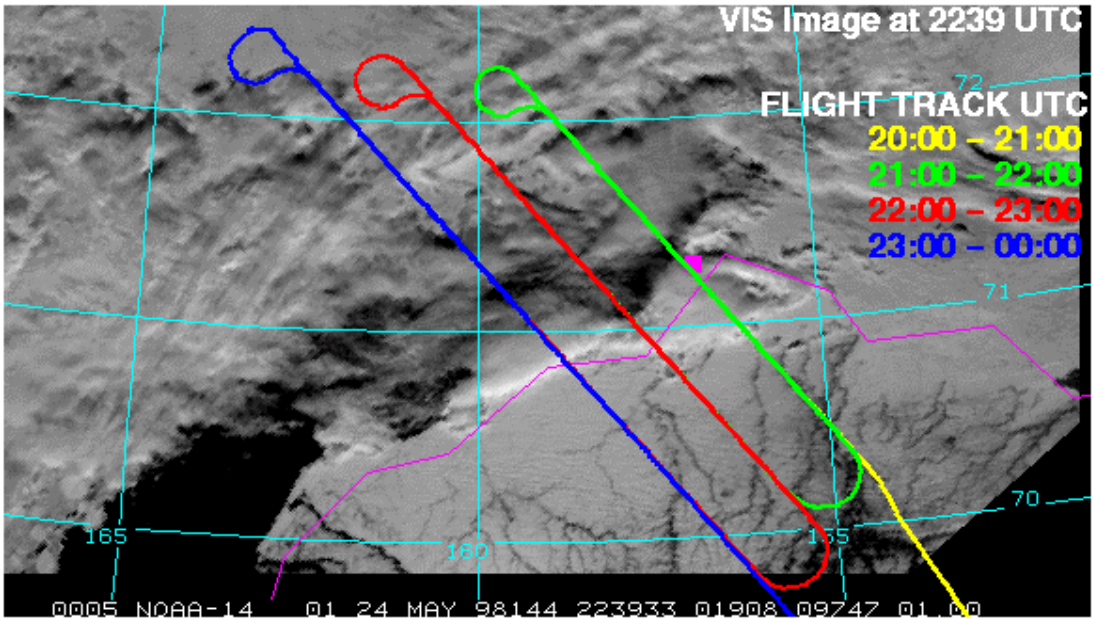
- AirMISR – the 4th, 5th, 6th runs collected all 9 look angles, while the other 4 early runs collected between 3 and 8 view angles; the last run over the Brooks Range failed to collect any data
- AMPR – worked well
- CLS – worked well
- HIS – worked for take-off through first 2 flight legs over ARM site (flight lines 1 & 2) and then failed (1:42 hr of mission)
- MAS – port 4 (8.3-14.0 μm) disconnected for nitrogen purge
- MIR – worked well
- SSFR – worked well

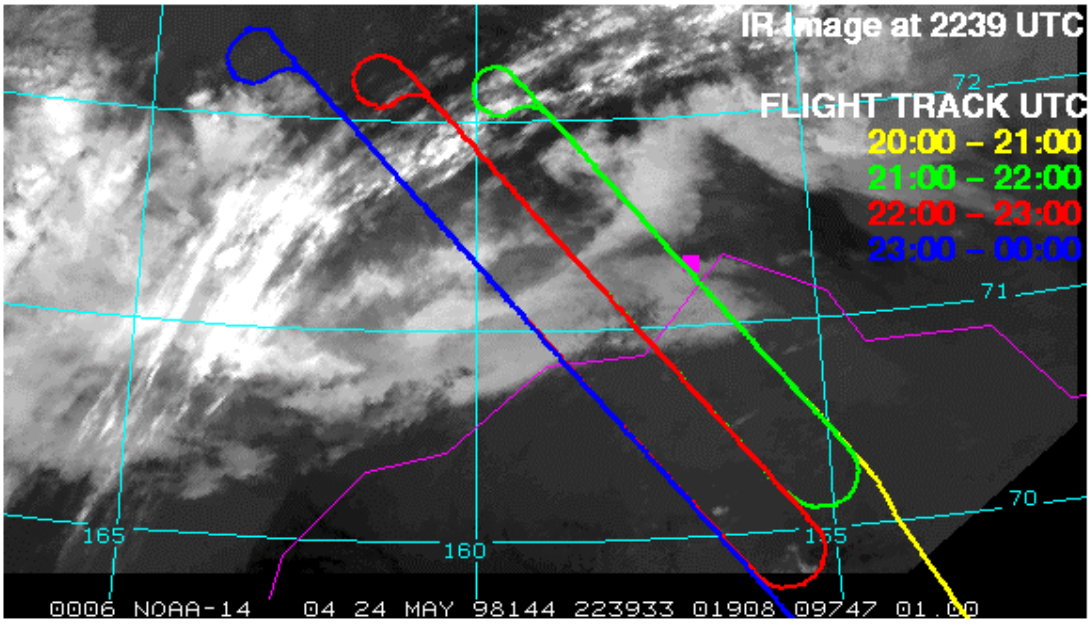
Meteorology: Winds have decreased to 16 kts easterly, with some snow and drizzle. The coastal stratus broke up in the early afternoon, leaving broken clouds at two levels (500 and 1500 m). Some cirrus clouds were present over Barrow in the morning.

Instruments:

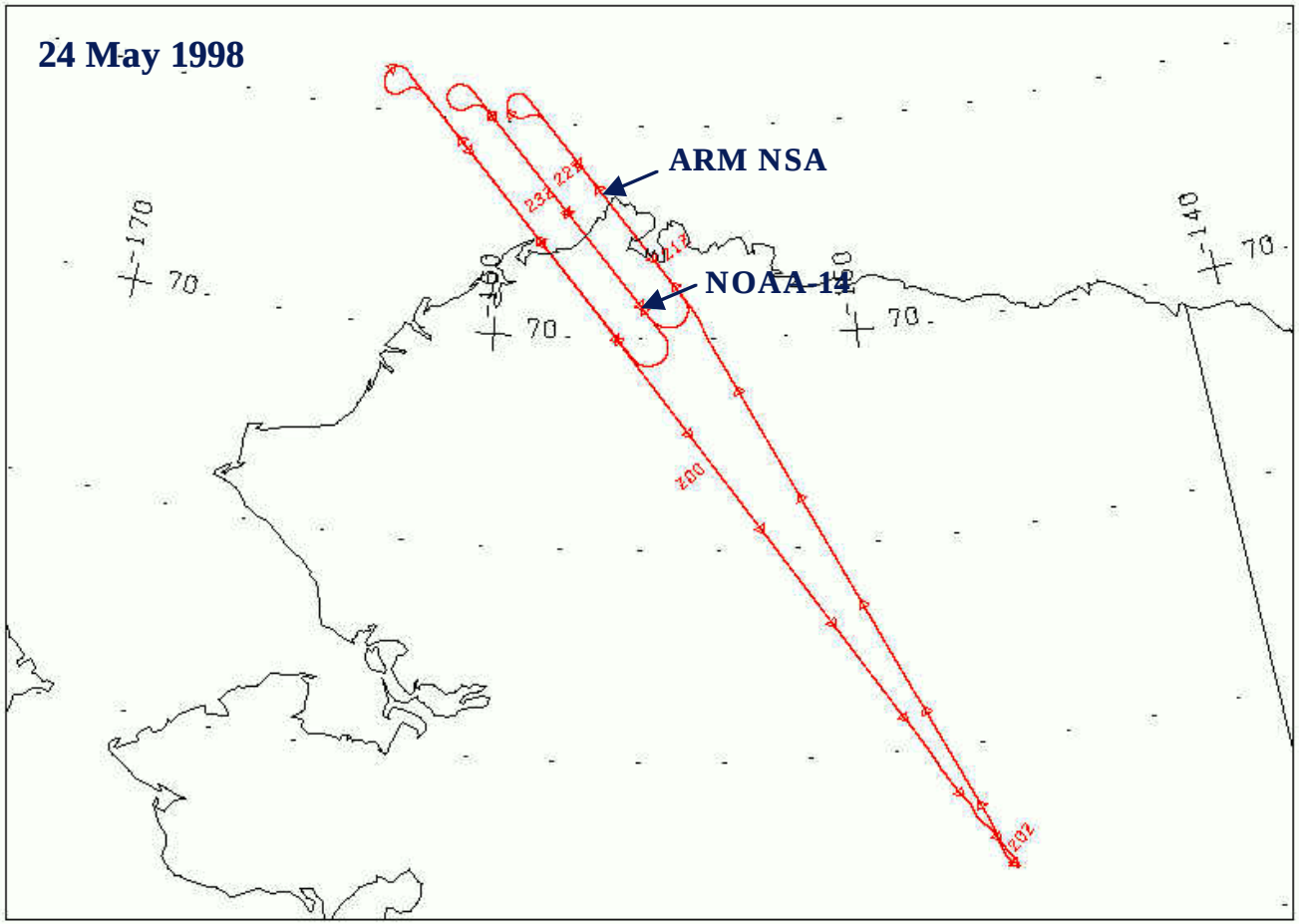
AirMISR – Airborne Multi-angle Imaging Spectroradiometer
AMPR – Advanced Microwave Precipitation Radiometer
CLS – Cloud LIDAR System
HIS – High-resolution Interferometer Sounder
MAS – MODIS Airborne Simulator
MIR – Millimeter-wave Imaging Radiometer
SSFR – Solar Spectral Flux Radiometer

ER2 FLIGHT TRACK AND NOAA–14 AVHRR IMAGES ON MAY 24, 1998 OVER BARROW





ER-2 Ground Track



Gates of the Arctic National Park – Brooks Range

Red = 1.62 μm

Green = 0.75 μm

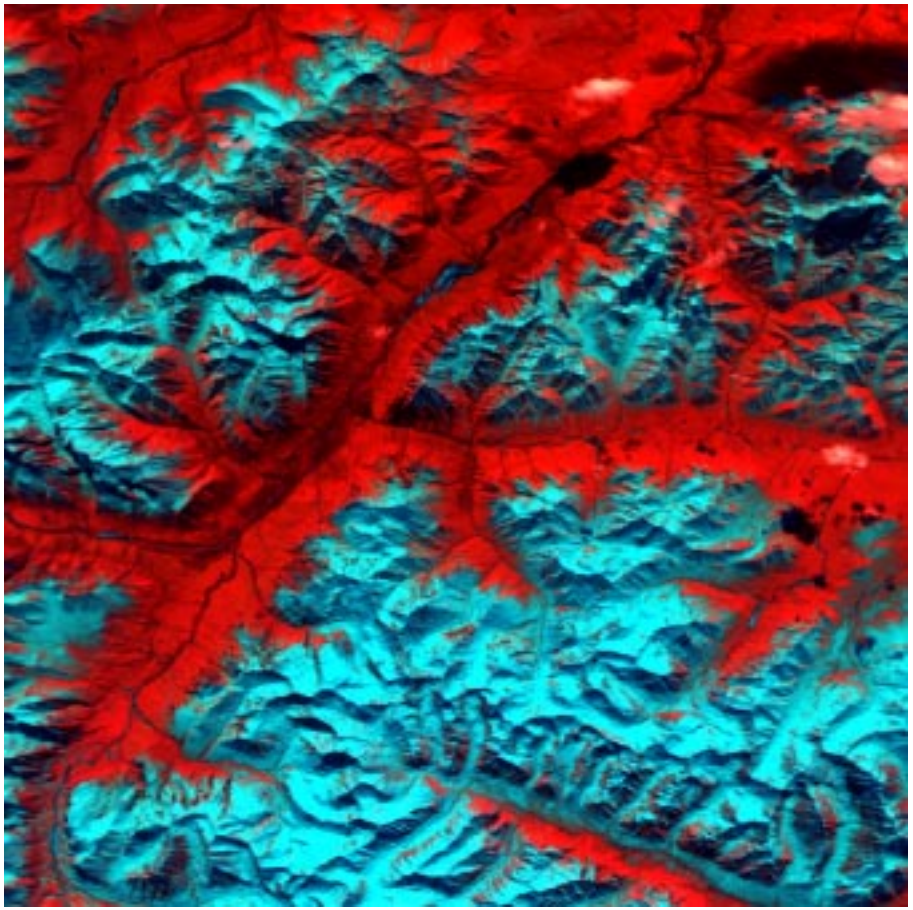
Blue = 0.47 μm

24 May 1998

67°31'N 151°0'W

2032 UTC

37.2 km



37.2 km

Flight Direction

335.4°

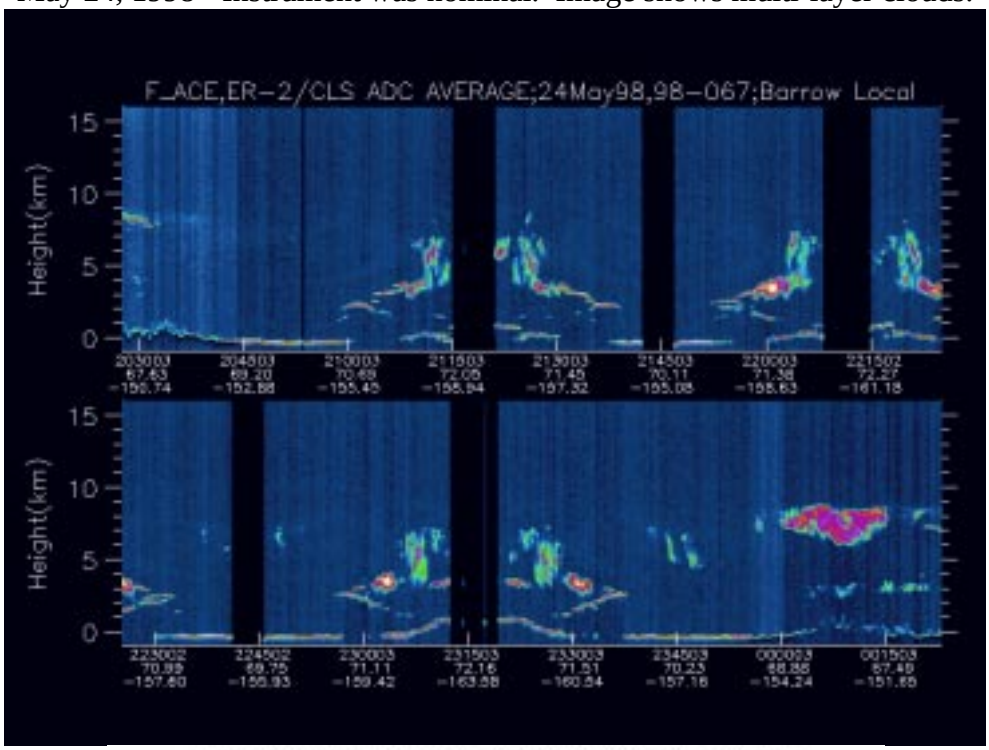
θ_0 **= 54.2°**

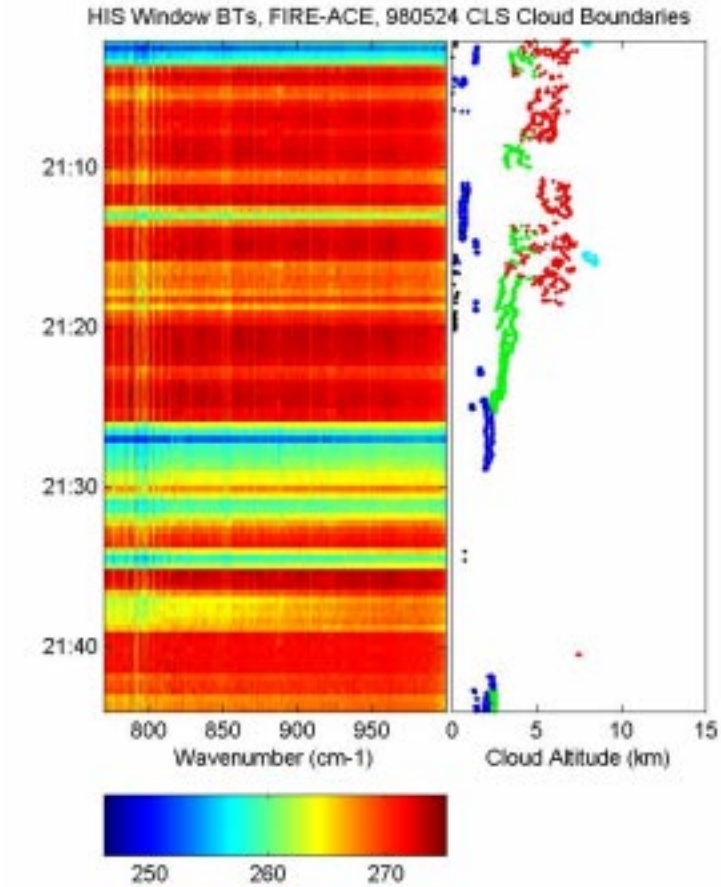
ϕ_0 **= 227.6°**

$\phi - \phi_0$ **= 165.8°**

Cloud LIDAR System

May 24, 1998 - Instrument was nominal. Image shows multi-layer clouds.





C-130 Flight summary
May 24, 1998

Daily Mission Scientist: James Pinto
Assistant Daily Mission Scientist: Judy Curry
Report prepared by: Judy Curry, James Pinto

Objectives: Surface mapping and radiation, sampling of cloud edge off coast of Barrow to see if clouds over sea ice are more or less reflective than sea ice itself.

Meteorological conditions reported at the SHEBA camp: SHEBA Surface observations at 6:30 ADT reported clear skies, with a very dry lower atmosphere. Unchanged for the past few days.

Ship position	Surface wind	Surface Temperature
76 21.69' N	15 knots	-12 C
166 52.66' W	90°	

Flight Plan: Mapping pattern at 4, 1.5, and 0.7 km. Sample cloud north of Barrow by flying above, below, and in the cloud. May
implement stable BL pattern if conditions allow.

Principal accomplishments: Surface mapping and radiation, sampling of cloud edge off coast of Barrow.

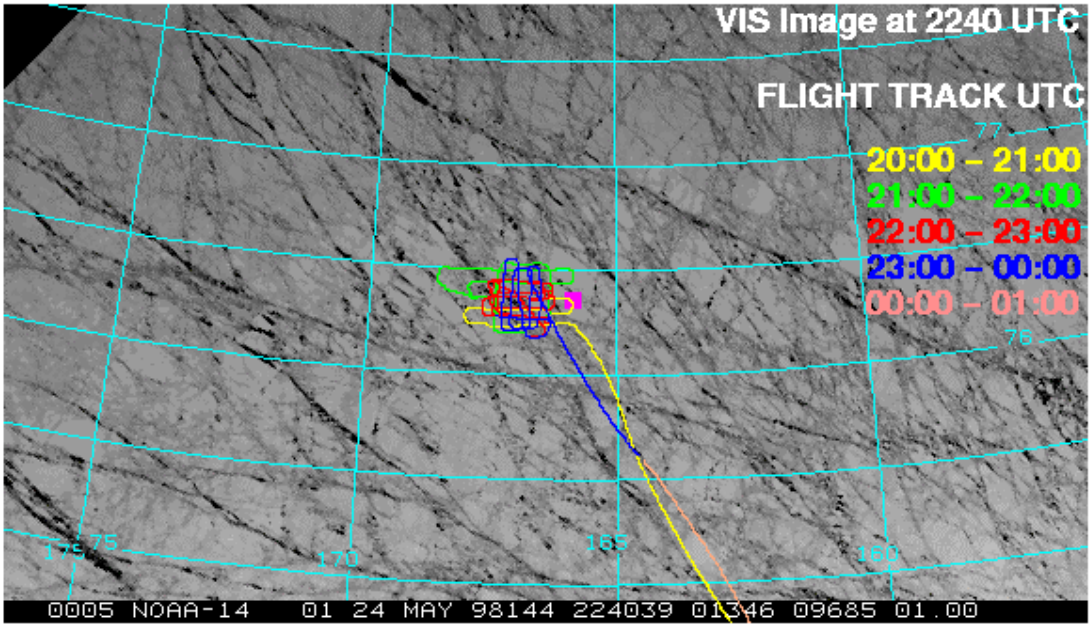
Comments: This was an excellent day for surface mapping.

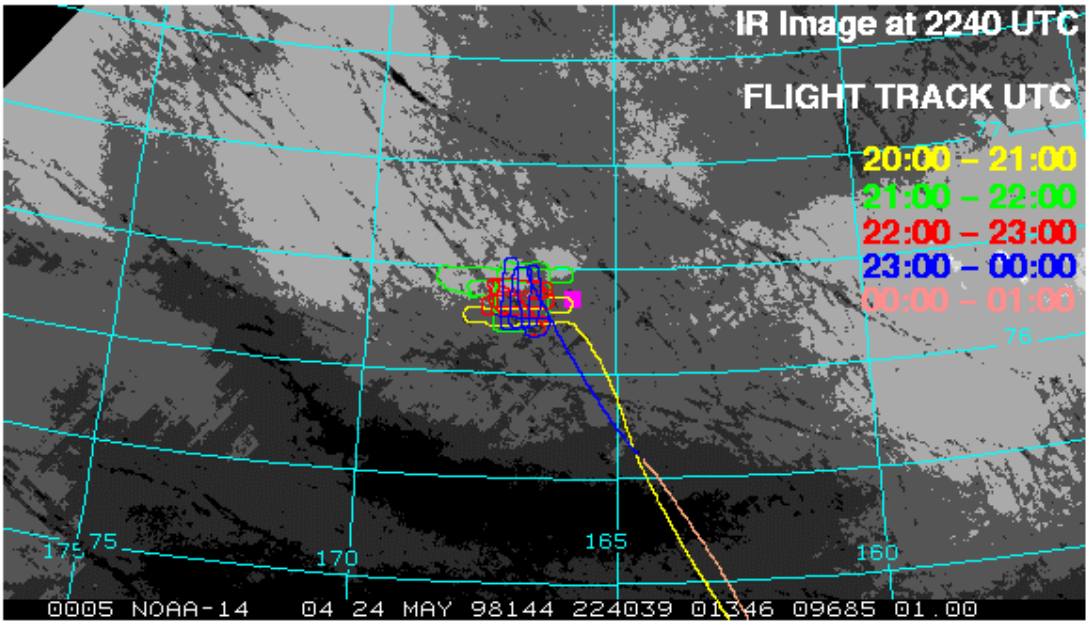
Instruments problems:

MCR: Still problems with channels 2, 3, 5, and 7.

Valero's upward-looking shadow-band radiometer jammed during the upper portion of cloud boundary pattern.

C130 FLIGHT TRACK AND NOAA-14 AVHRR IMAGES ON MAY 24, 1998 OVER THE ICE STATION

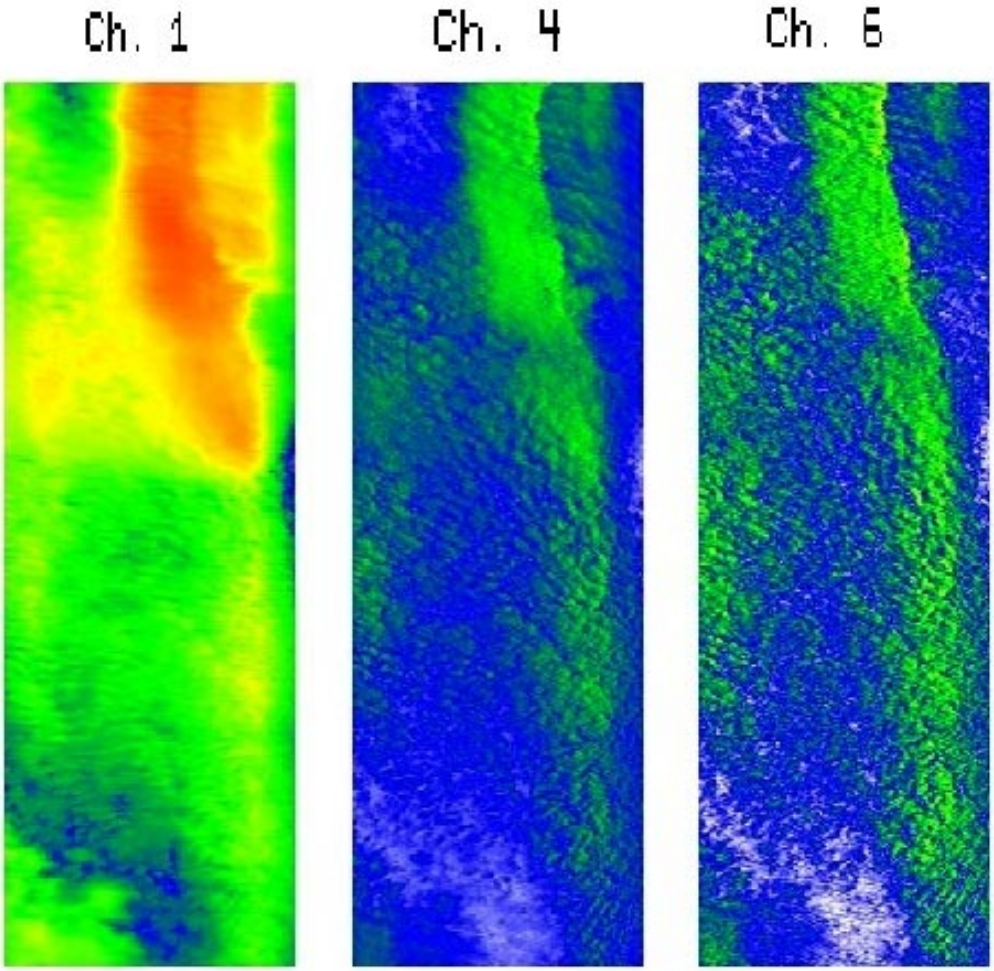




C-130 MCR Images

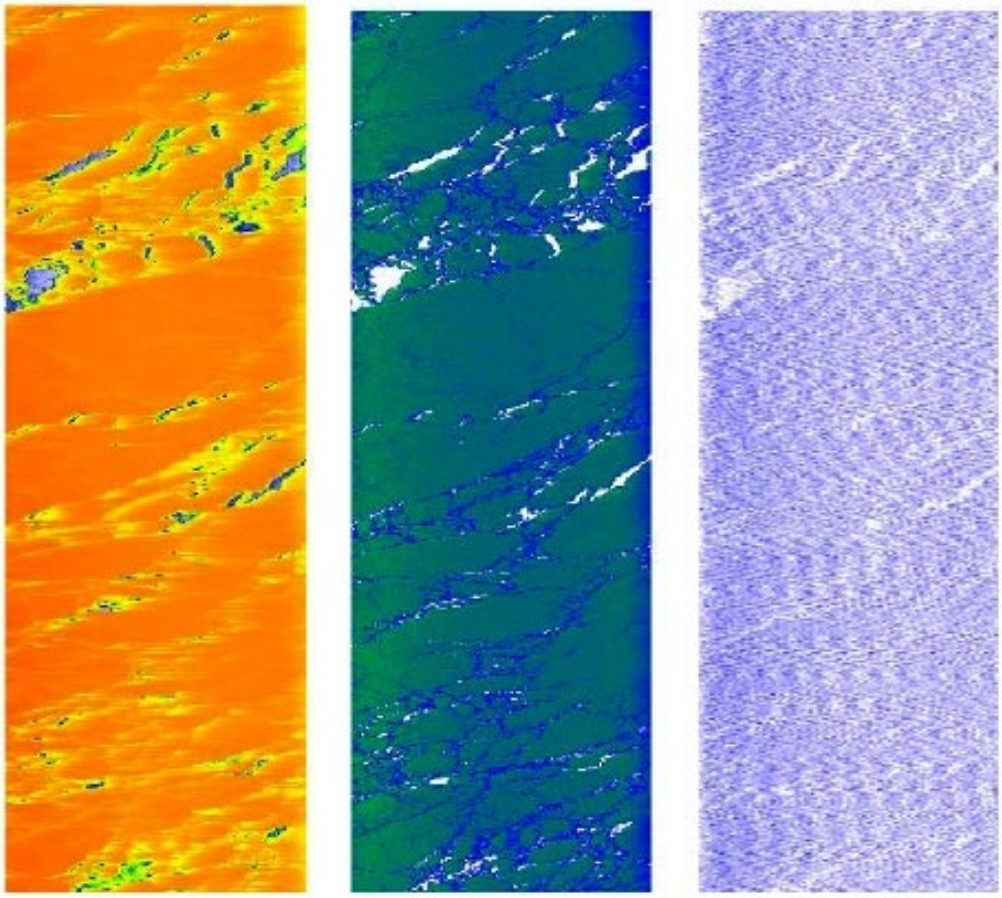
For each of the following images, the direction of flight is from the bottom of the image to the top. Thus, the start time of each image is at the bottom, and the end time is at the top. Also, it should be noted that the MCR scan direction is from left to right for each image. Pitch and roll corrections have not been applied to any of the images yet. Also note that channel 1 is centered on wavelength .64 µm, channel 4 is at 1.06 µm, and channel 6 is 2.16 µm.

01:41-01:46 GMT



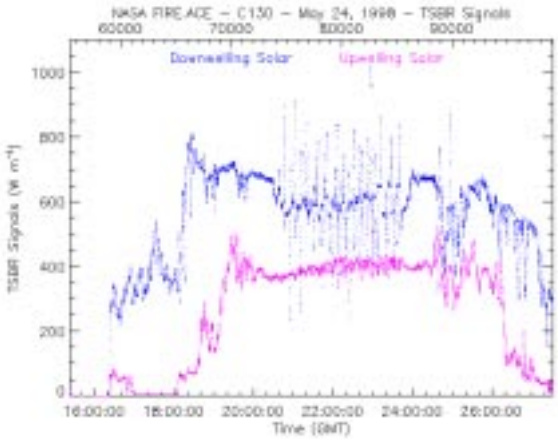
20:57:55 - 21:02:55 GMT

Ch. 1 Ch. 4 Ch. 6

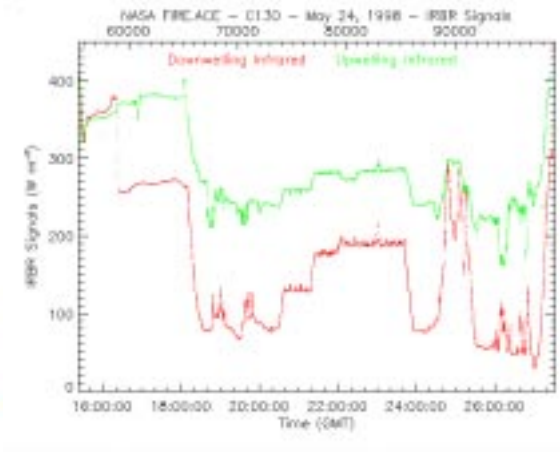


C-130 Radiometer Measurements
May 24, 1998

TSBR – Total Solar Broadband Radiometer

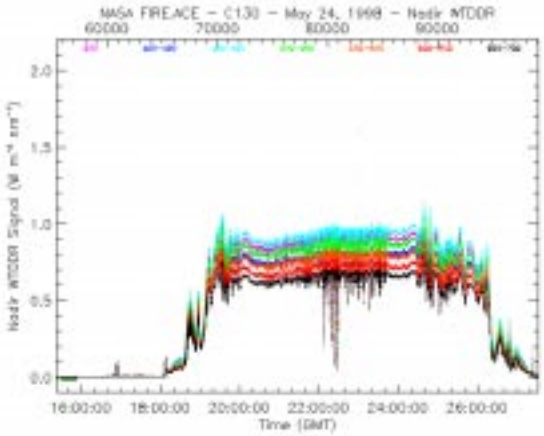


IRBR – IR Broadband Radiometer

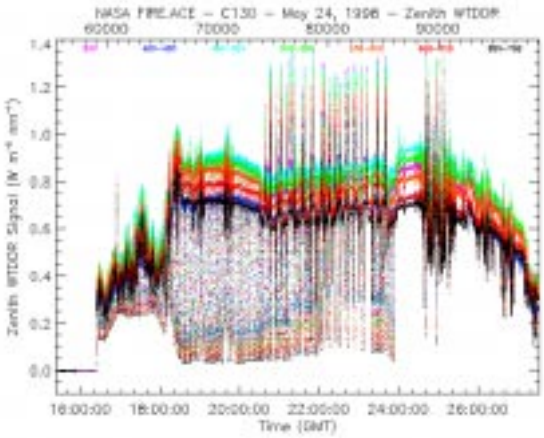


WTDDR – Wide Bandpass Total-Direct-Diffuse Radiometer

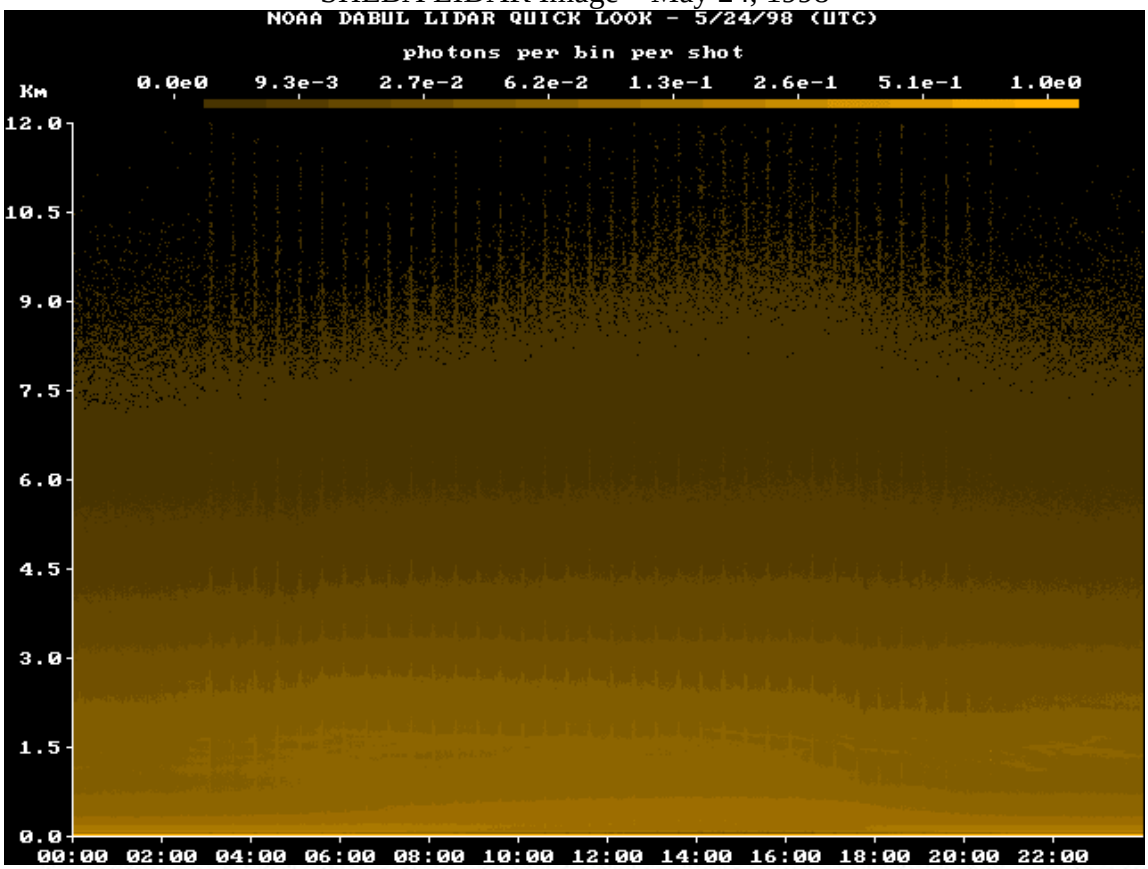
Nadir



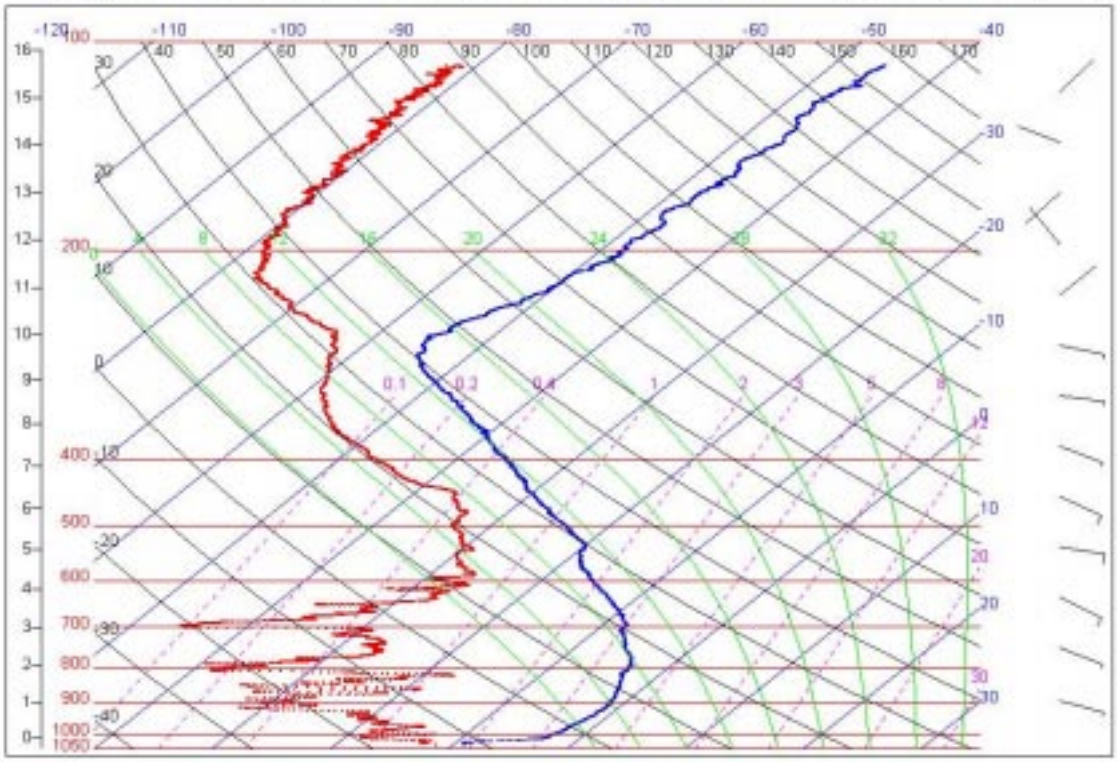
Zenith



SHEBA LIDAR Image – May 24, 1998



Version: SHEBA--GPS Soundings, GLASS 1.10 Fixed, SHE, 1998,05,24, 11:21:35



May 26, 1998

ER-2

Flight summary

Ground track

MAS images

HIS measurements

Cloud LIDAR System image

SHEBA

LIDAR image

Sounding

ER-2 Mission 5

Tuesday, May 26, 1998

Michael King: Flight Scientist

Objectives: To fly repeated ground tracks over and near the SHEBA ice station (76°27.96'N, 167°30.1'W) and nearby sea ice of the Chukchi Sea. The ER-2 flew three parallel and repeating ground tracks of 261 km in length that were parallel and at a heading of 330°.
The bulk of the flight tracks over the Chukchi Sea were cloudy, with thick cirrus between 4 and 10 km with underlying Arctic stratus on some occasions. Other coordination included:

- F-14 satellite (2146 UTC)
- NOAA-14 satellite (2219 UTC)

ER-2 Mission:	Pilot:	Jim Barrilleaux
	Takeoff	1900 UTC
	Landing	0125 UTC (May 27)
	Duration	6:25

After flying over the ARM site at point 1 (71°19.37'N, 156°34.9'W), the ER-2 flew a NW flight line from point 2 (75°37'N, 164°00'W) to point 3 (77°20'N, 168°00'W), then reversed course. The aircraft then flew a parallel track displaced 40 km to the west with two round trip flight legs, between point 4 (75°27'N, 165°15'W) and point 6 (77°30'N, 170°10'W), flying over the SHEBA ice station (point 5). Each flight leg was 261 km in length. The flight tracks were all parallel and on a heading of 330°/150°. Finally, the ER-2 flew a third flight line displaced 40 km further west between point 7 (75°16'N, 166°30'W) and point 8 (77°20'N, 171°35'W). The return leg flew over the ARM site en route back to Ft. Wainwright.

The AirMISR was turned on for 8 acquisitions over the Barrow ARM site and flight legs in the vicinity of SHEBA, including acquisitions when the sun was in the plane of the ground track, and when the NOAA-14 and F-14 satellites passed over the area. The AirMISR operated at the following times:

- 2003.25-2019.25 (ARM—broken cirrus)
- 2052-2053.5 UTC (eastern line)
- 2116-2131 UTC (eastern line)
- 2138.75-2154 UTC (SHEBA, F-14, central line; broken cloud)
- 2207-2222 UTC (SHEBA, NOAA-14, central line)
- 2232-2247 UTC (western line)
- 2259.75-2315 UTC (western line)
- 2352.75-0008 (ARM)

The ER-2 pilot reported thick cirrus clouds over the ice up to the northern extent of the flight lines at 77°N, where the clouds started to break up. The Brooks

Range had thin to moderately thick cirrus over it on the way out and thin cirrus with some underlying altostratus on the return leg to Fairbanks.

Instrument Status

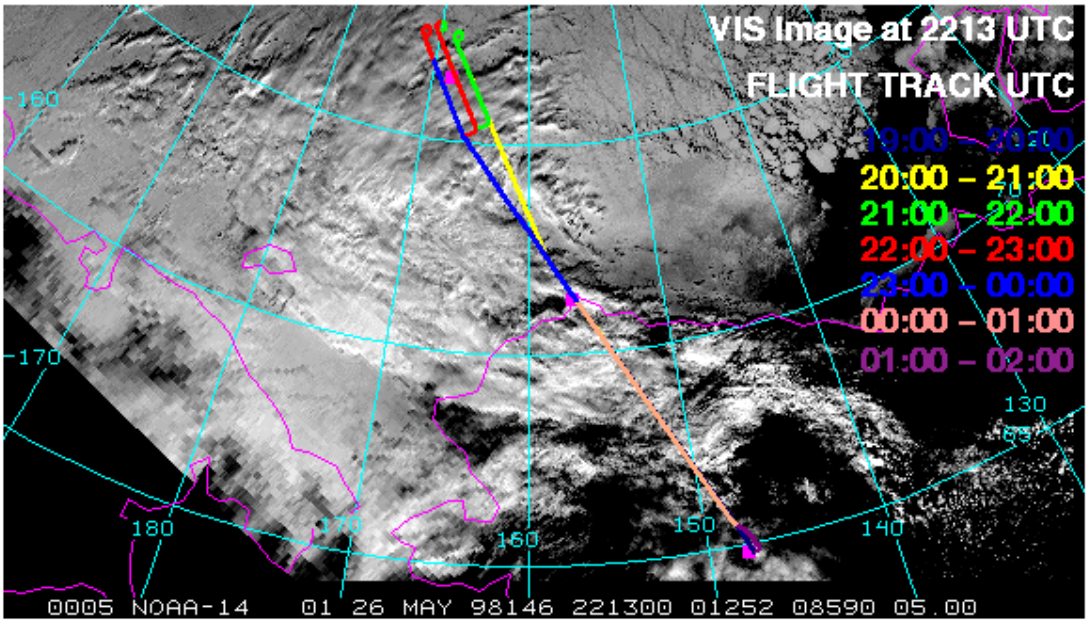
- AirMISR – the 1st and 2nd scenes failed, but all remaining scenes collected all 9 look angles
- AMPR – worked well
- CLS – worked well
- HIS – worked well
- MAS – worked well
- MIR – worked well
- SSFR – worked well

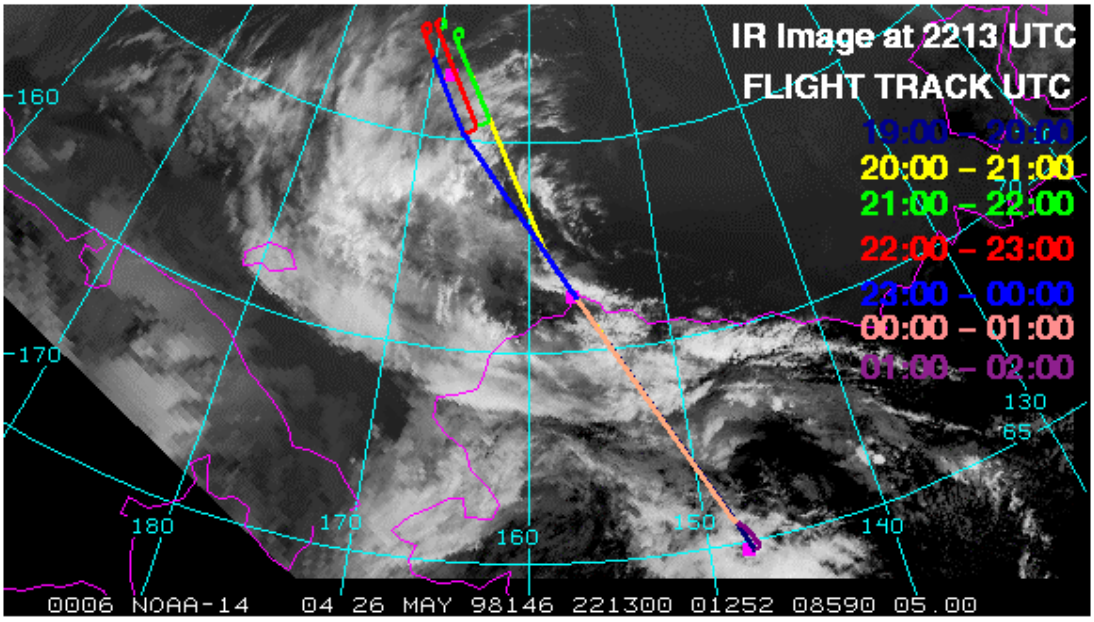
Meteorology: Cirrus moved over the ice camp during the morning. Lower stratus occurred over the camp during the previous evening. Both cirrus and stratus were highly broken and covered the camp throughout the mission. Winds at the surface were 13 kts from the southeast and temperatures dropped from Monday's high of -2° to -4°C during the night.
The surface high-pressure system east of the camp was moving slowly to the east. The upper air ridge that kept the cloud cover away from the camp on Sunday was moving slightly to the east. Upper level winds and clouds were from the south.

Instruments:

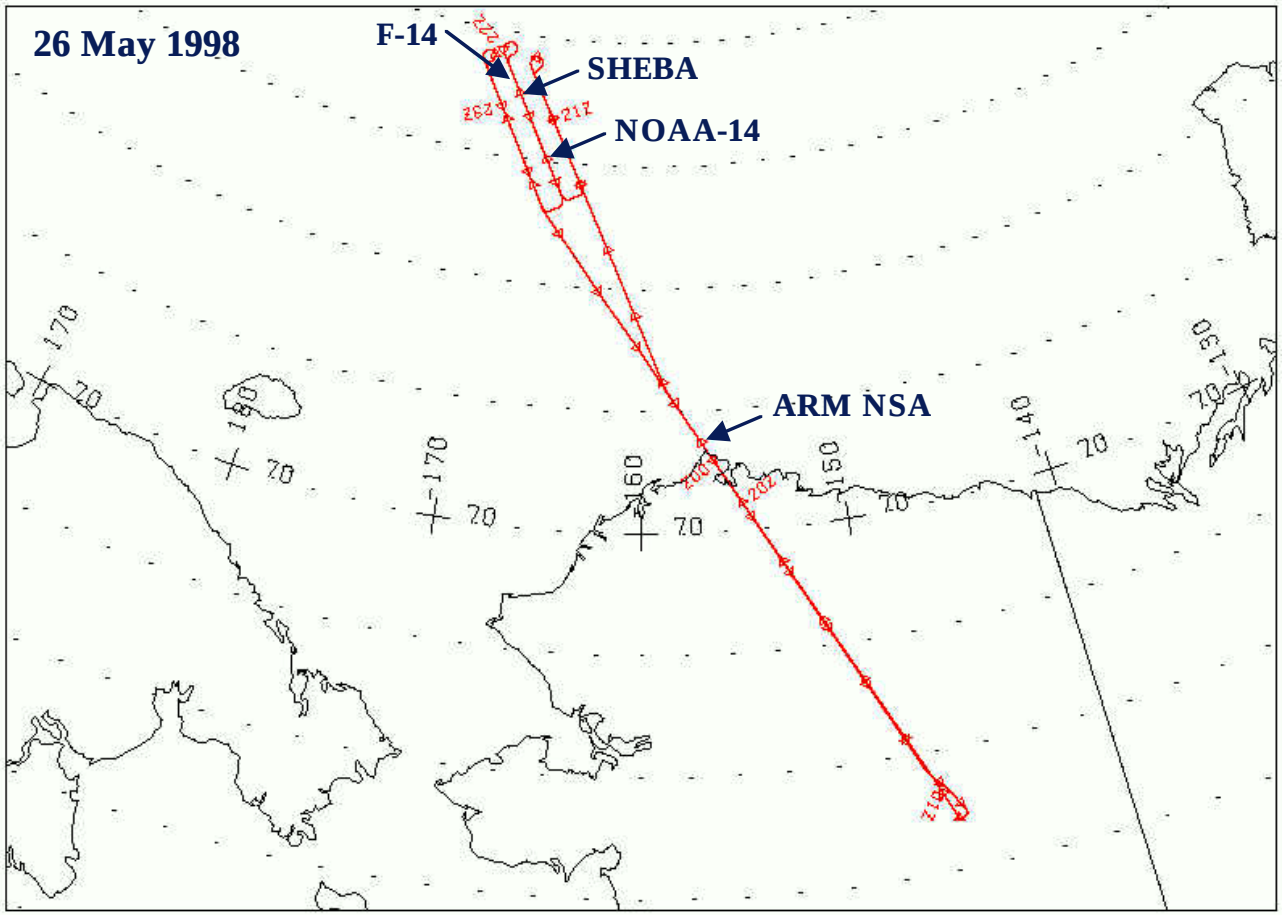
AirMISR – Airborne Multi-angle Imaging Spectroradiometer
AMPR – Advanced Microwave Precipitation Radiometer
CLS – Cloud LIDAR System
HIS – High-resolution Interferometer Sounder
MAS – MODIS Airborne Simulator
MIR – Millimeter-wave Imaging Radiometer
SSFR – Solar Spectral Flux Radiometer

ER2 FLIGHT TRACK AND NOAA–14 AVHRR IMAGES ON MAY 26, 1998





ER-2 Ground Track



SHEBA Ice Station

Red = 2.13 μm

Green = 1.62 μm

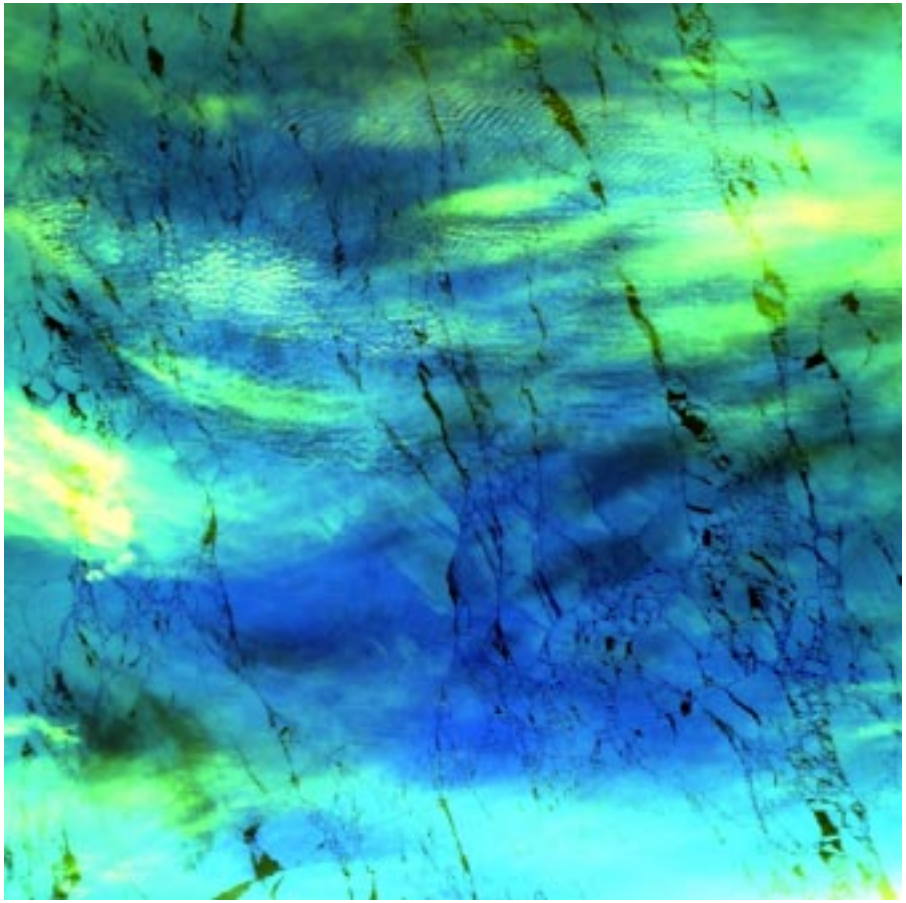
Blue = 0.66 μm

26 May 1998

76°28'N 167°30'W

2145 UTC

37.2 km



Flight Direction

330.9°

θ_0 **= 56.2°**

ϕ_0 **= 157.1°**

$\phi - \phi_0$ **= 83.8°**

37.2 km

Sea Ice - NW of SHEBA Ice Station

Red = 2.13 μm

Green = 1.62 μm

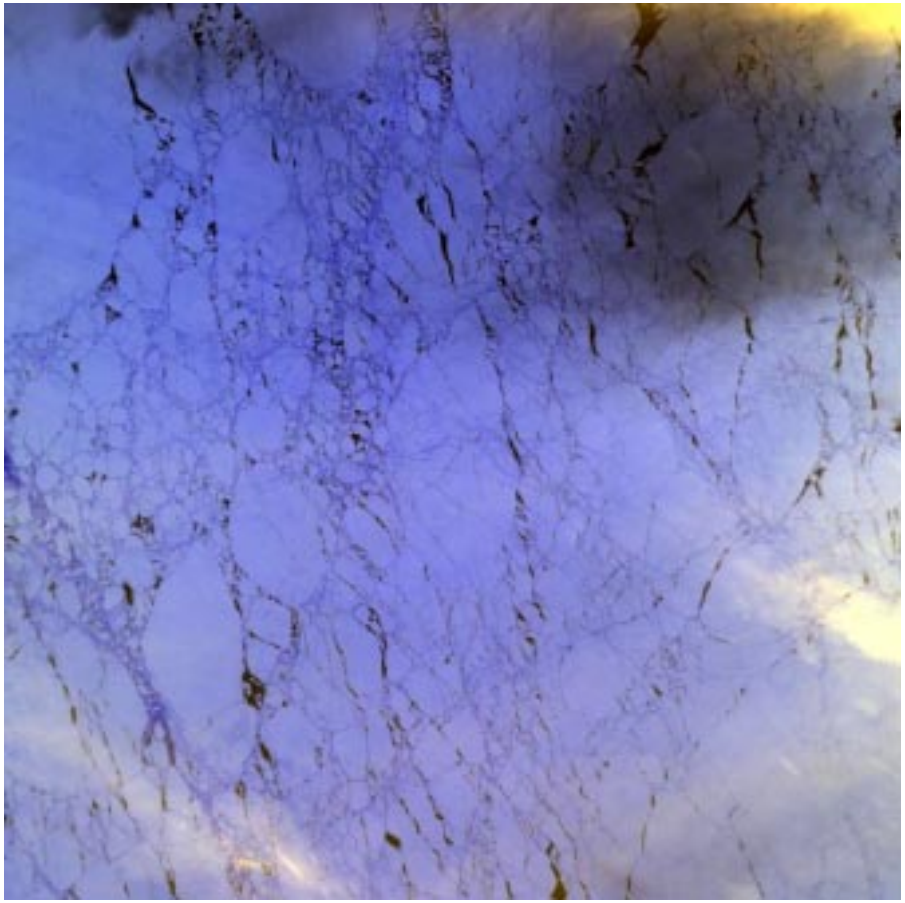
Blue = 0.66 μm

26 May 1998

77°06'N 169°04'W

2151 UTC

37.2 km



37.2 km

Flight Direction

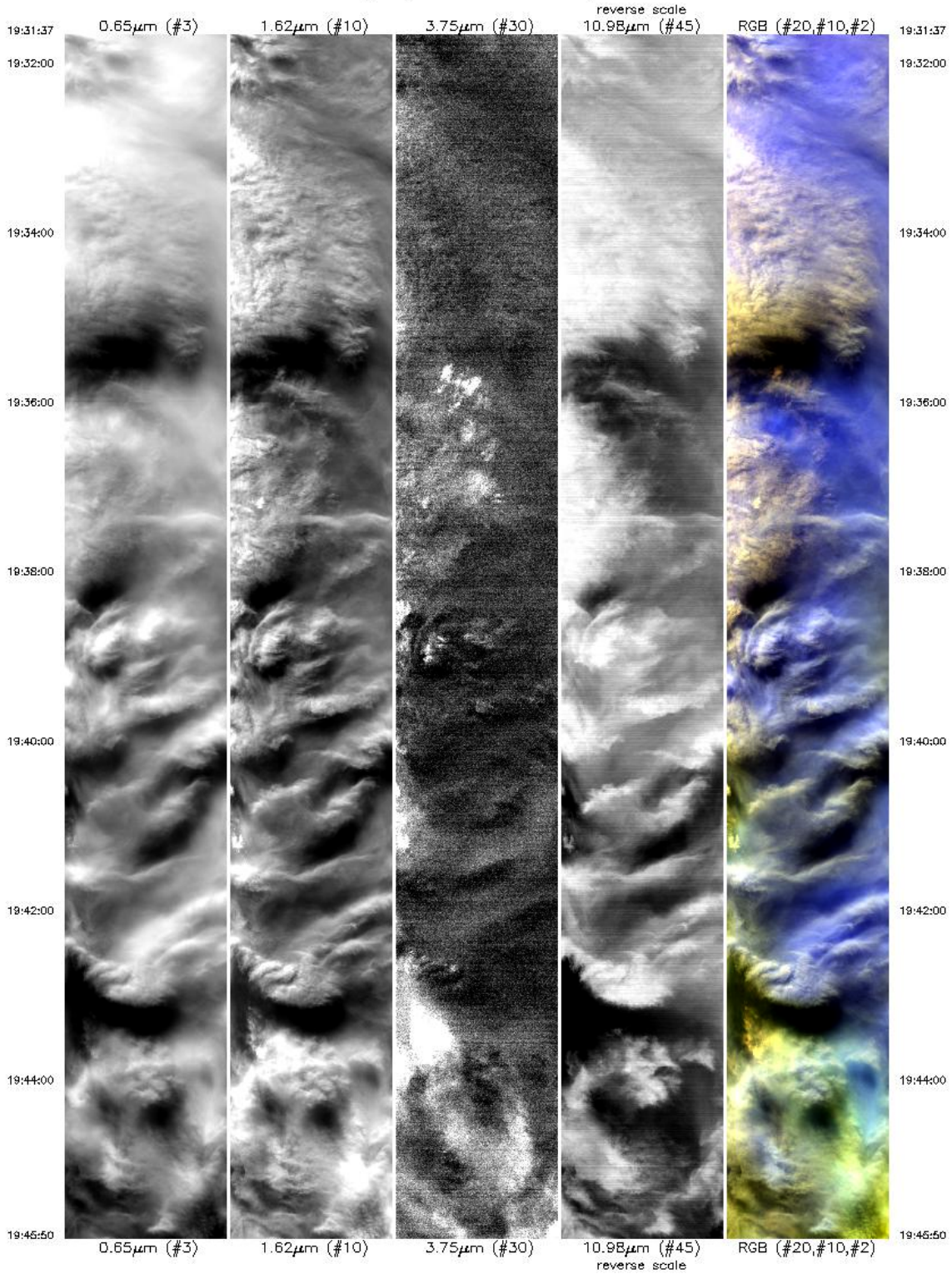
330°

θ_0 **= 56.8°**

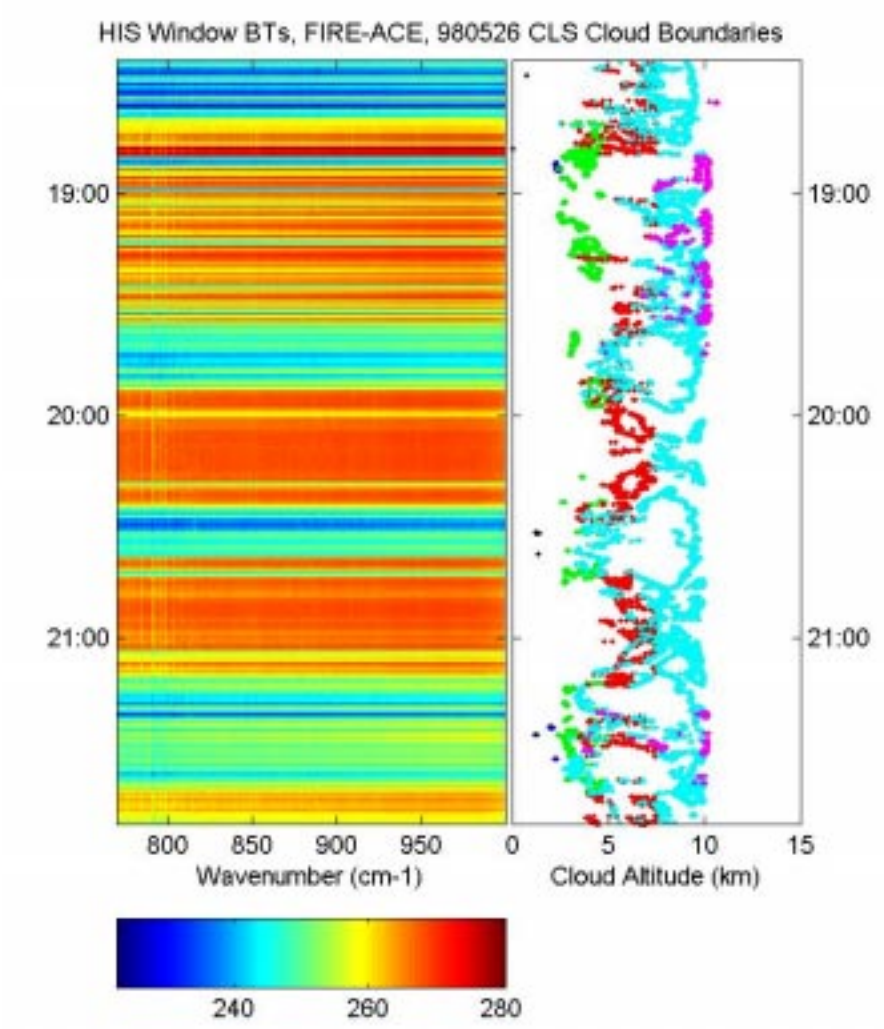
ϕ_0 **= 157.0°**

$\phi - \phi_0$ **= 83.0°**

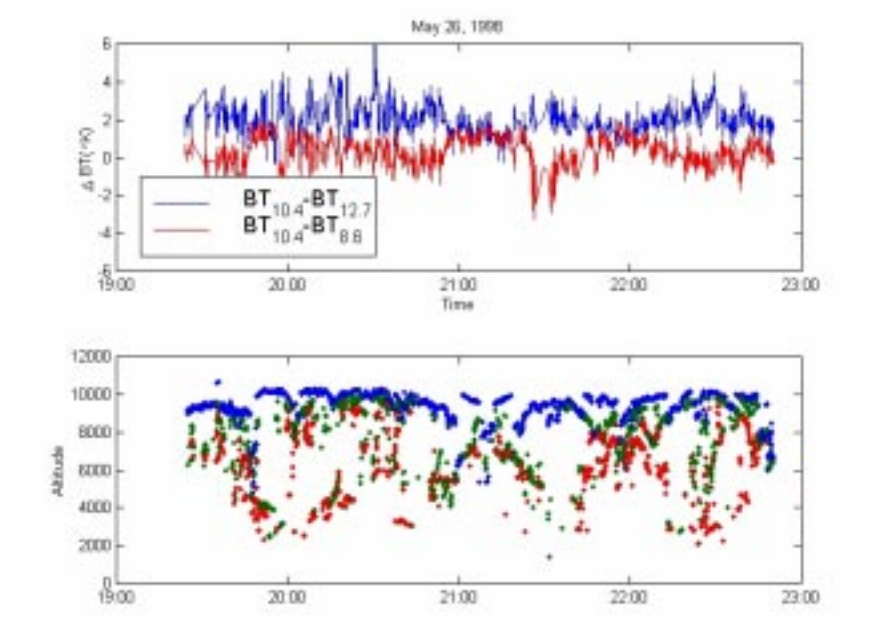
MODIS Airborne Simulator Browse Imagery
FIRE–ACE Campaign – 26–27 May 1998
Flight #98–068 Track #2



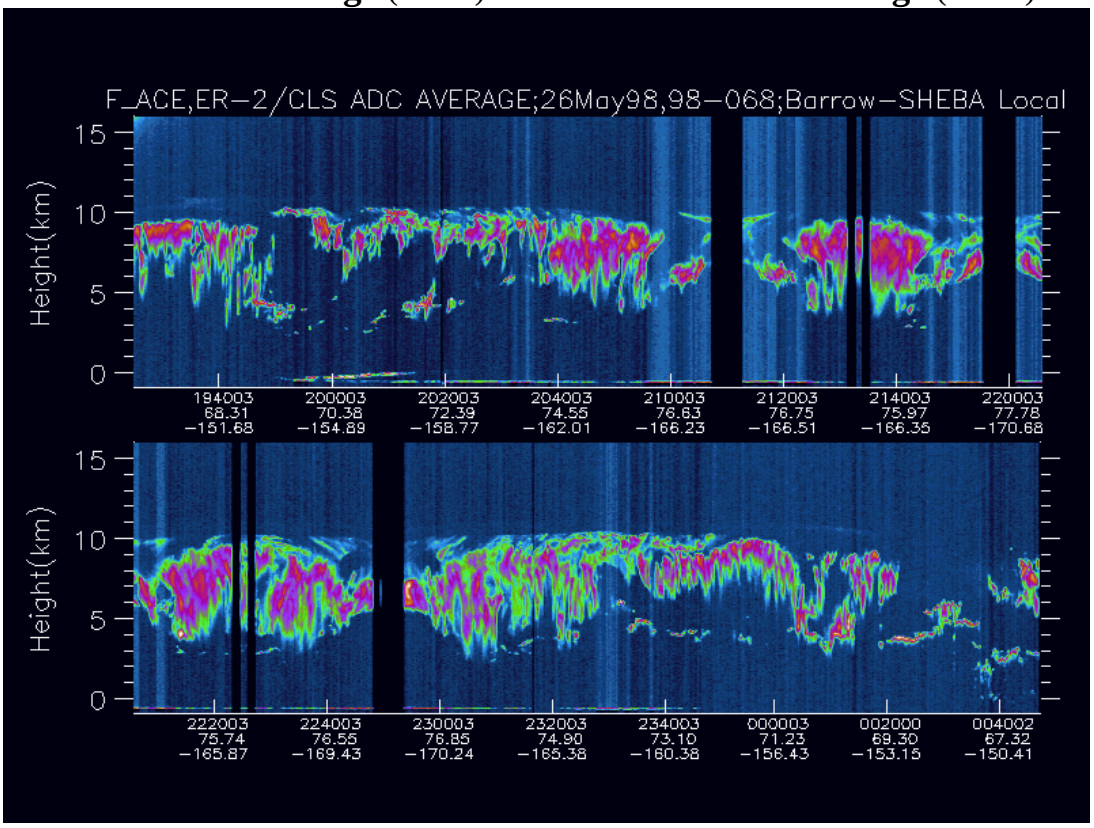
ER–2 Heading = 335.4°
Solar Zenith = 51.6°
Solar Azimuth = 135.1°

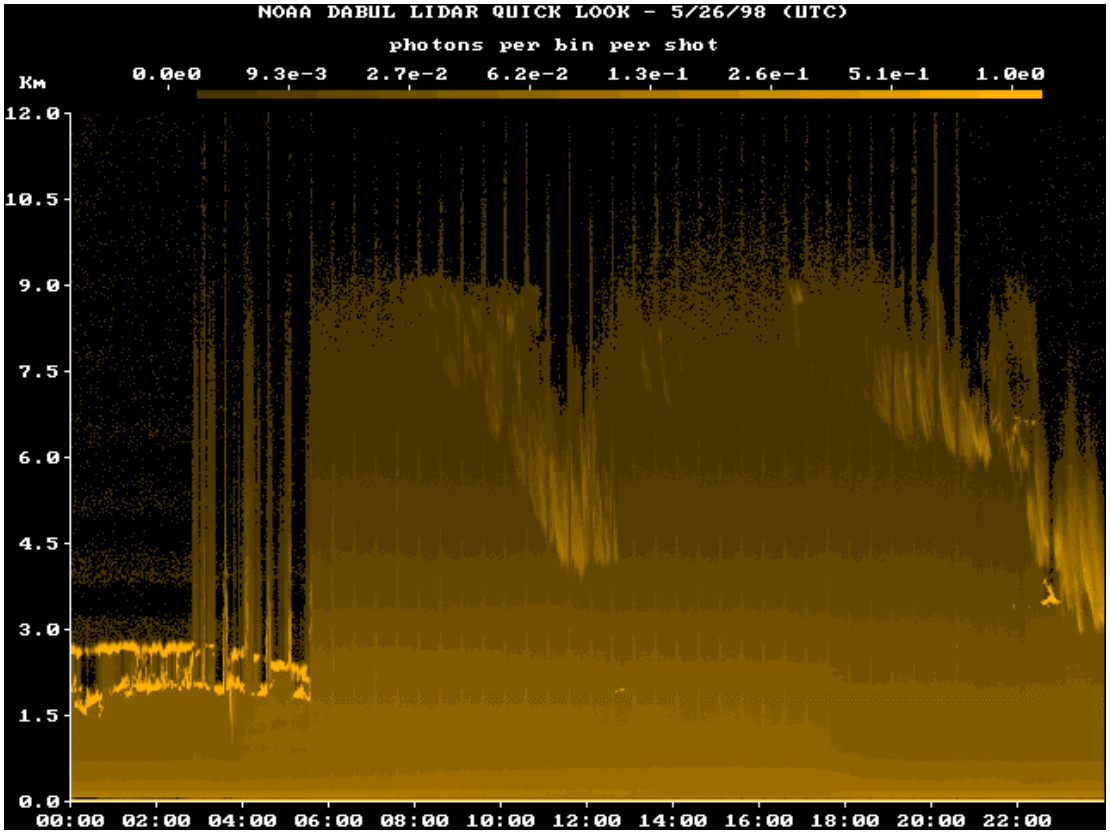


Delta Brightness Temp (on top) and CLS Time Series (below)



ER-2 LIDAR Image (above) **and SHEBA LIDAR Image** (below)

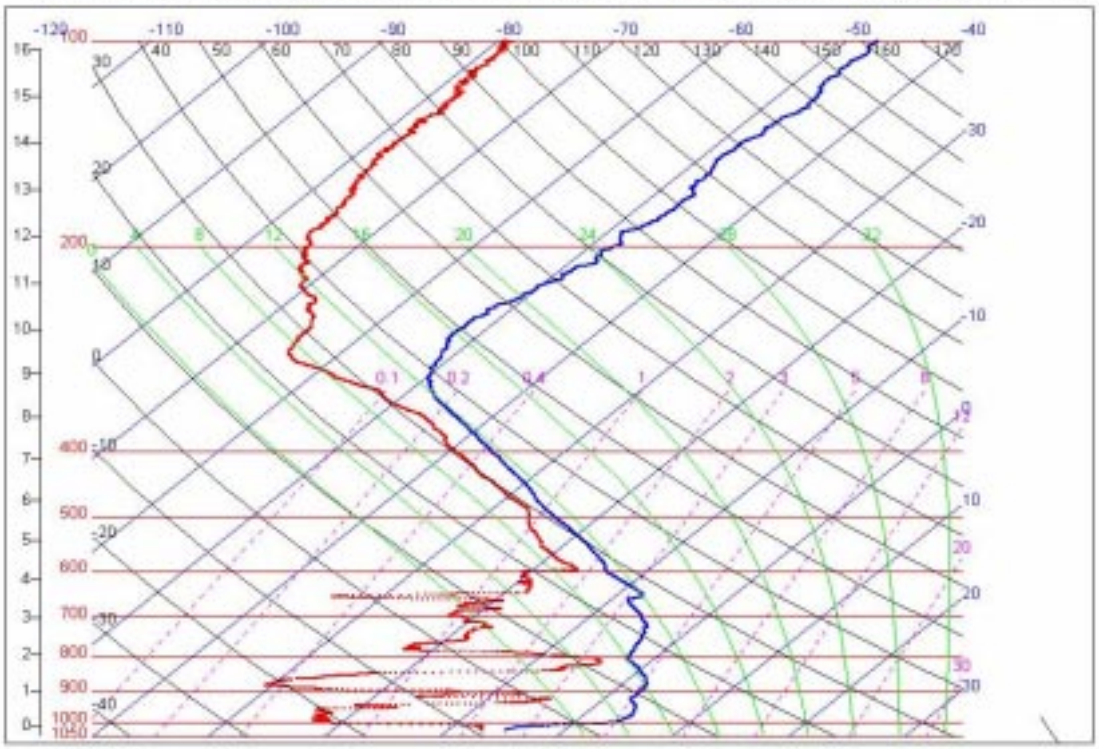




SHEBA Sounding

May 26, 1998

Version: SHEBA--GPS Soundings, GLASS 1.10 Fixed, SHE, 1998,05,26, 11:15:04



May 27, 1998

ER-2

Flight summary

Ground track

MAS images

Cloud LIDAR System image

HIS measurements

CV-580

Flight summary

Flight track

CAR notes

GPS plots

C-130

Flight summary

Flight track

Radiometer data

SHEBA

LIDAR image

Sounding

ER-2 Mission 6

Wednesday, May 27, 1998

Michael King: Flight Scientist

Objectives: Fly over ARM site and open water area west of Barrow, flying roughly parallel to the coast, then continue on to SHEBA (76°31.5'N, 167°56.03'W) and fly two ground tracks of 260 km in length with north-south heading. Return flight flown parallel to NOAA-14 ground track (heading 327.54°). Take off was delayed by 70 minutes in order to match the NOAA-14 overpass time on the return leg.
Coordination included:

- F-14 satellite (2315 UTC)
- NOAA-14 satellite (2349 UTC)

ER-2 Mission:	Pilot:	Jan Nystrom
	Takeoff	2010 UTC
	Landing	0140 UTC (May 28)
	Duration	5:30

After flying over the ARM site at point 1 (71°19.37'N, 156°34.9'W), the ER-2 flew a SW flight line off shore and paralleling the coast to a location of about 70°N, 163°W. The aircraft then flew northward to point 2 (75°00'N, 167°56.03'W) to begin two north-south overpasses over the SHEBA ice station (point 2 to point 3 and back to point 2). Each flight leg was 260 km in length. After returning to point 2, the aircraft flew a 380 km leg at a heading of 327.54° to parallel the NOAA-14 flight track. The return leg flew over the ARM site en route back to Ft. Wainwright.

The AirMISR was turned on for 6 acquisitions: over the ARM site, on the coastal flight leg, twice over SHEBA, and on the NOAA-flight leg, and once again over the ARM site on the return. The AirMISR operated at the following times with pilot notes regarding observed clouds:

- 2112-2135 (ARM site – low thin scattered clouds)
- 2137-2146 UTC (Coastal leg – scattered broken)
- 2250-2259 UTC (SHEBA – overcast multiple layers)
- 2311-2320 UTC (SHEBA – overcast)
- 2345-2354 UTC (NOAA-14 – broken clouds)
- 0010-0019 UTC (ARM – overcast)

The ER-2 pilot reported broken clouds over the coastal leg with some clear sky to the western end of the leg, and possibly to the beginning of the leg. Multi-layer clouds were reported during the SHEBA overpass.

Instrument Status

- AirMISR – runs 1-4 collected all 9 look angles, run 5 data gathered at all angles but only three (+70.5, + 60, +45.6) with correct angles, run 6 failed

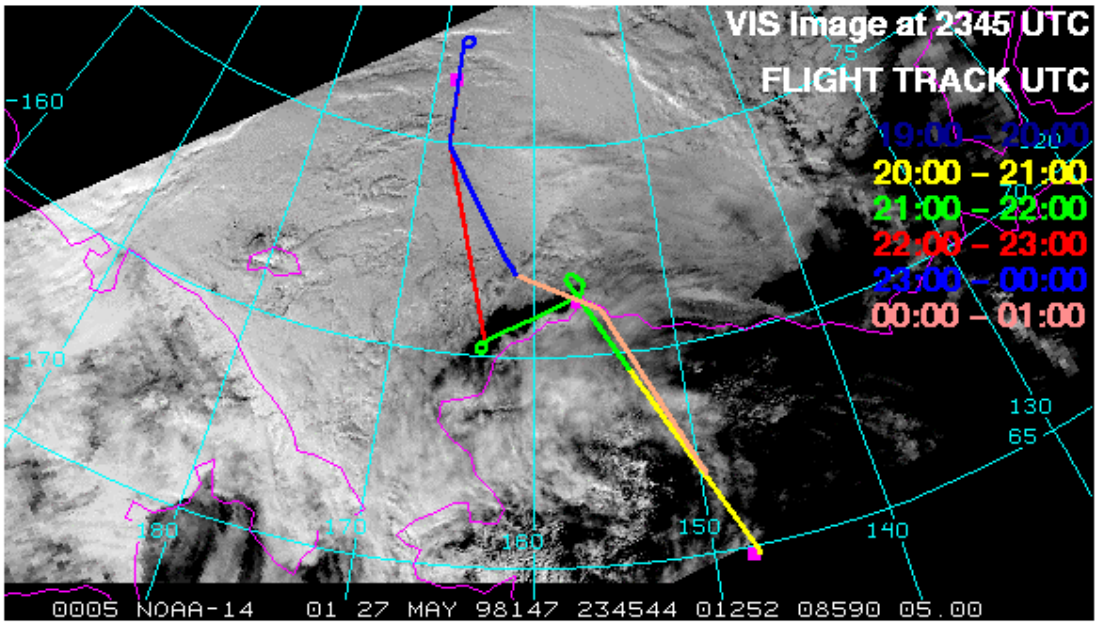
- AMPR – worked well
- CLS – worked well
- HIS – worked well
- MAS – worked well
- MIR – worked well
- SSFR – worked well

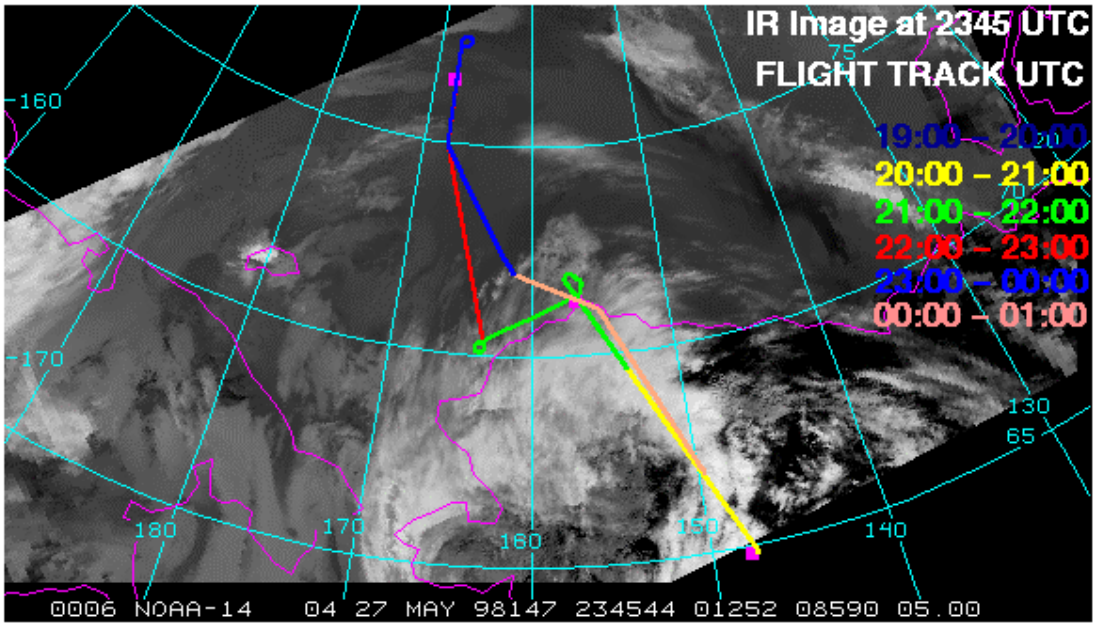
Meteorology: The ship reported freezing rain, cloud layers at 2-3.5 and 4.5-5.5 km, with some cirrus at 9 km. Winds at the surface were 20 kts from the east with a surface temperature of -5 C.
The surface high pressure system moved east near the Canadian Islands. The upper air ridge over the Beaufort Sea weakened slightly, but is still minimizing cloud cover in the Beaufort Sea. Surface and upper level winds were forecast to be southerly at both Barrow and SHEBA.

Instruments:

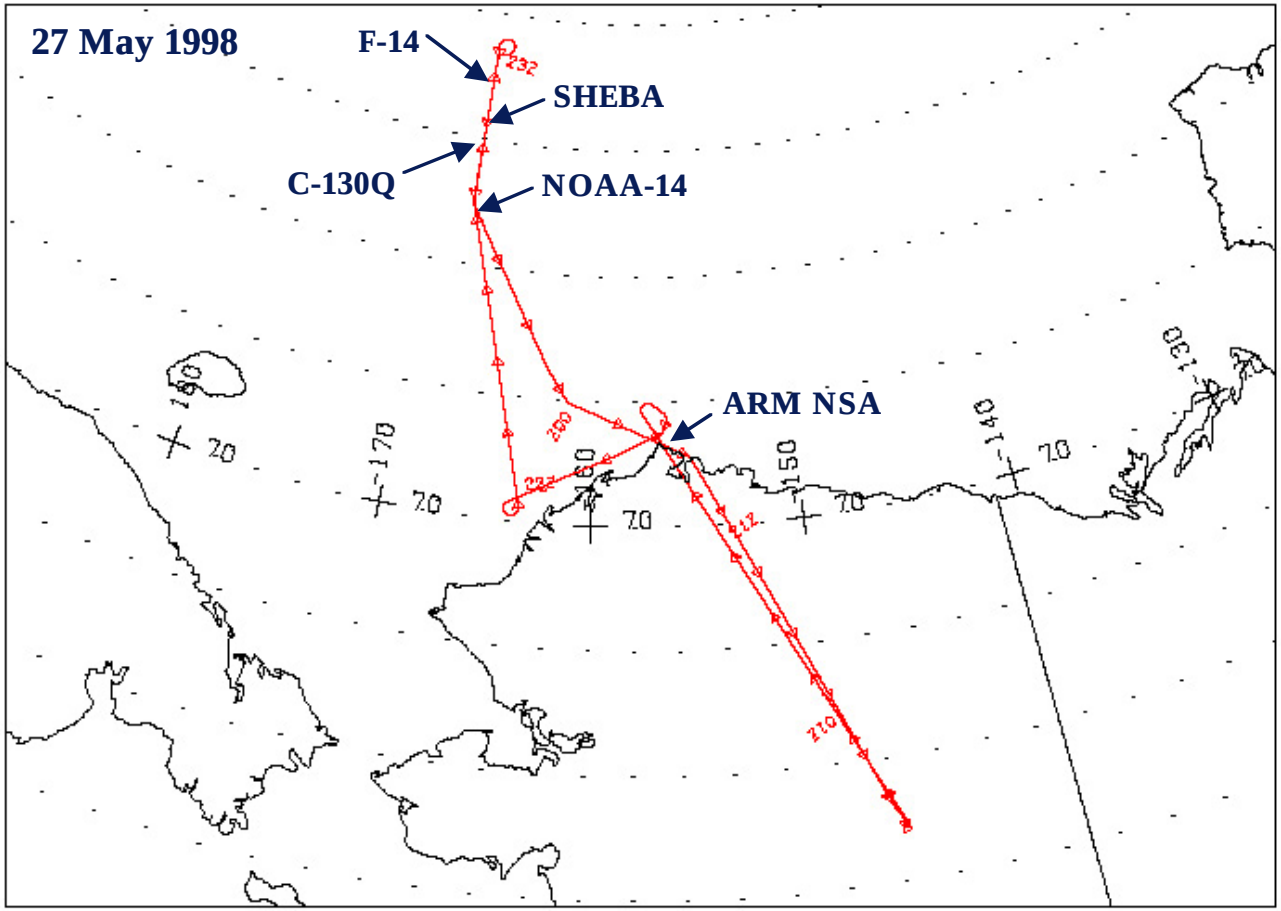
AirMISR – Airborne Multi-angle Imaging Spectroradiometer
AMPR – Advanced Microwave Precipitation Radiometer
CLS – Cloud LIDAR System
HIS – High-resolution Interferometer Sounder
MAS – MODIS Airborne Simulator
MIR – Millimeter-wave Imaging Radiometer
SSFR – Solar Spectral Flux Radiometer

ER2 FLIGHT TRACK AND NOAA–14 AVHRR IMAGES ON MAY 27, 1998

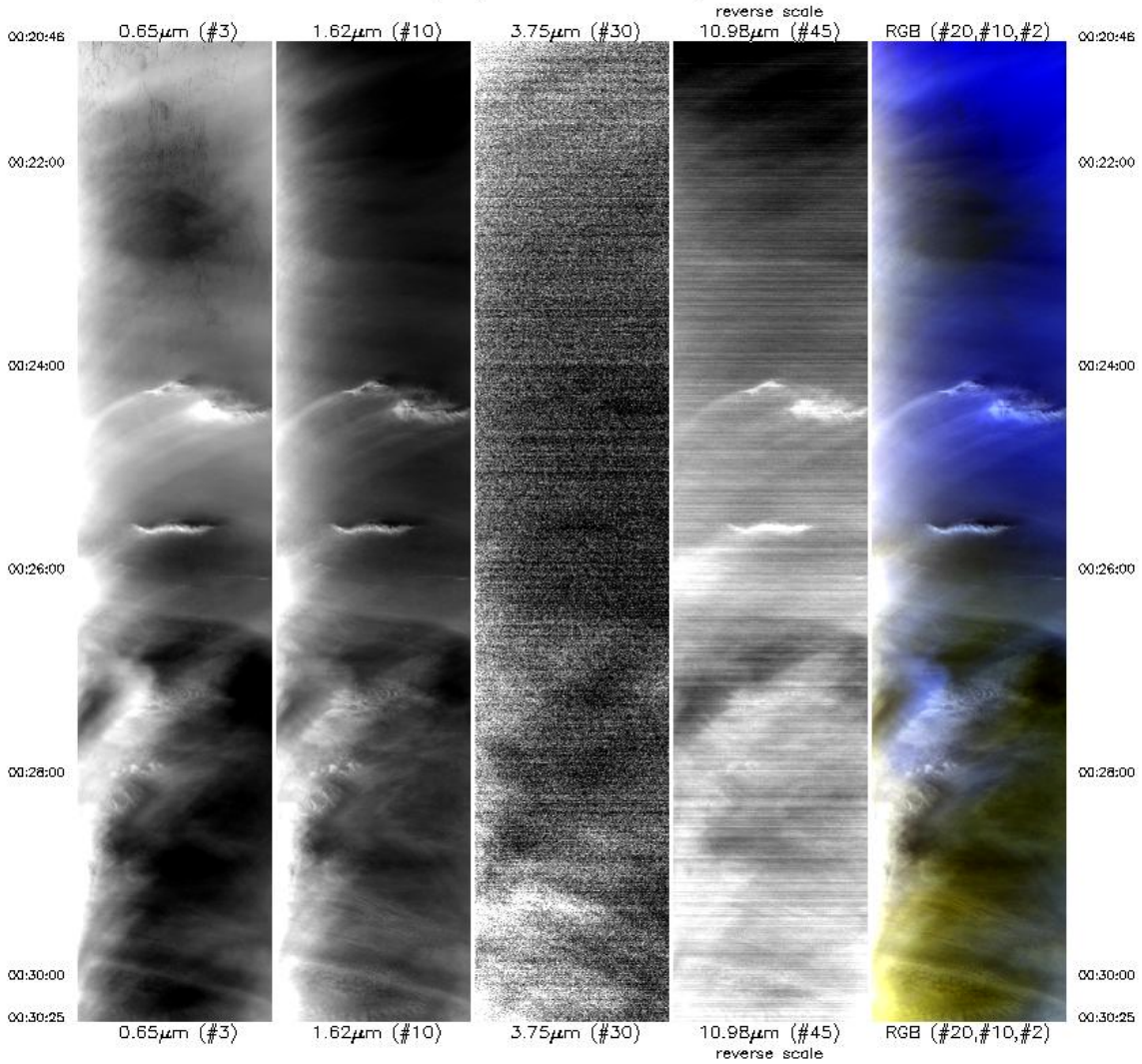




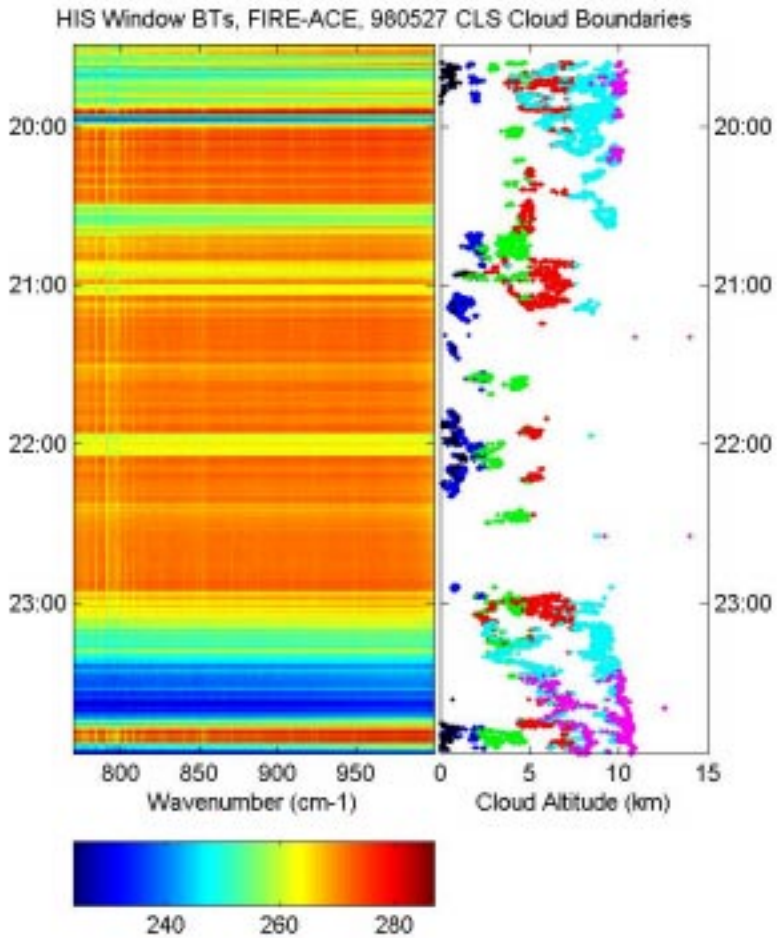
ER-2 Ground Track



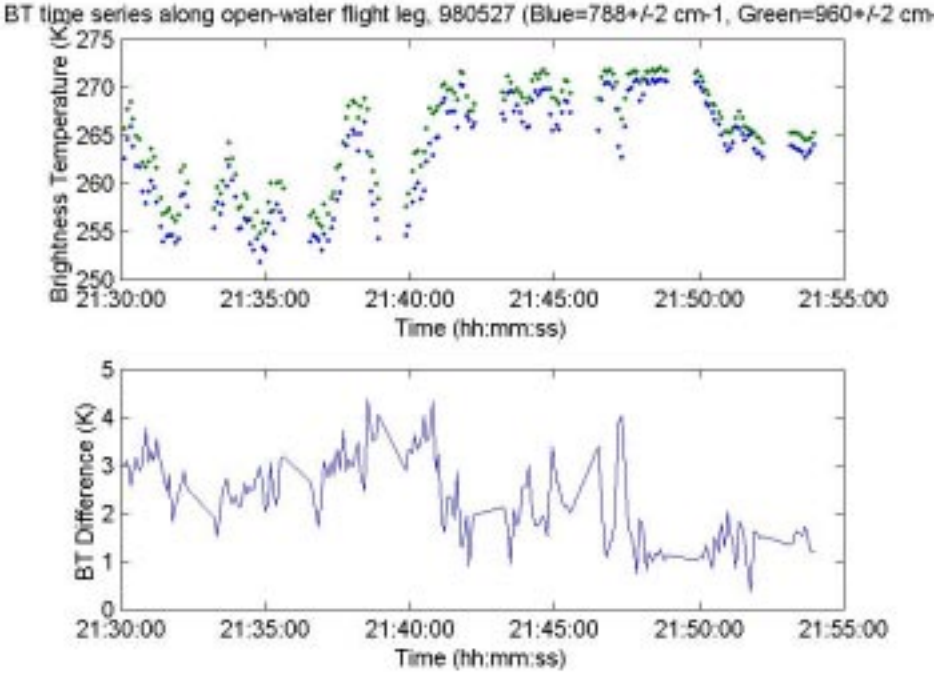
MODIS Airborne Simulator Browse Imagery
FIRE–ACE Campaign – 27–28 May 1998
Flight #98–069 Track #16



ER–2 Heading = 152.1°
Solar Zenith = 52.8°
Solar Azimuth = 216.7°

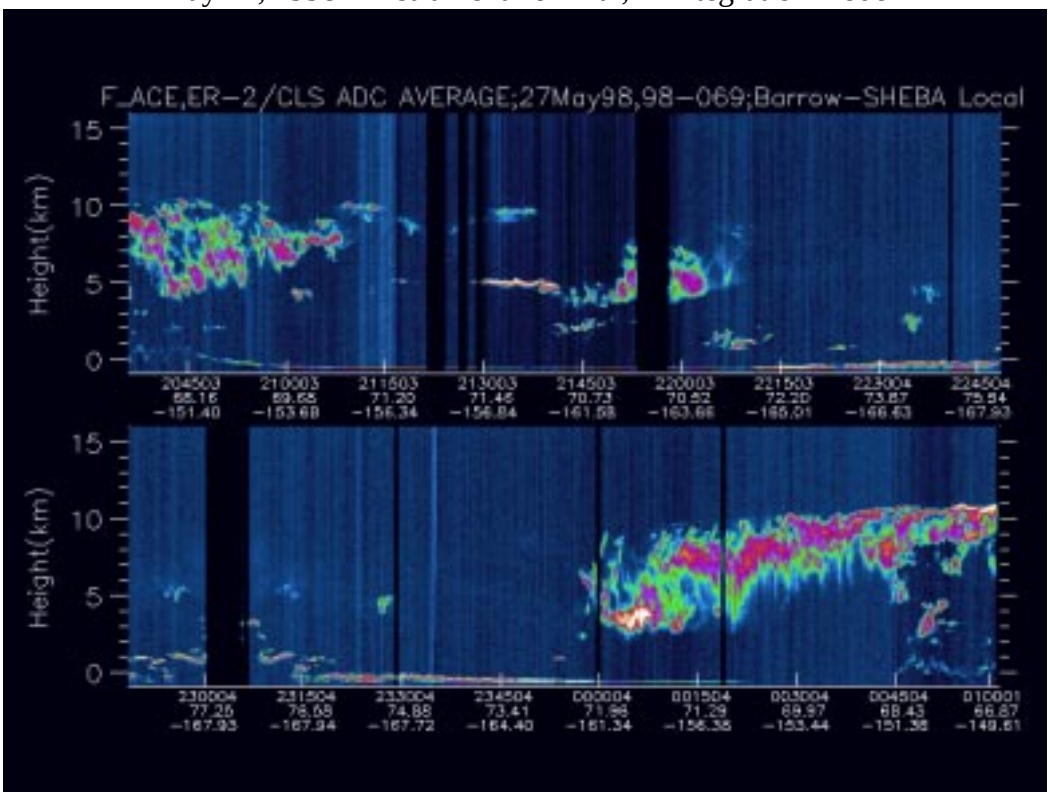


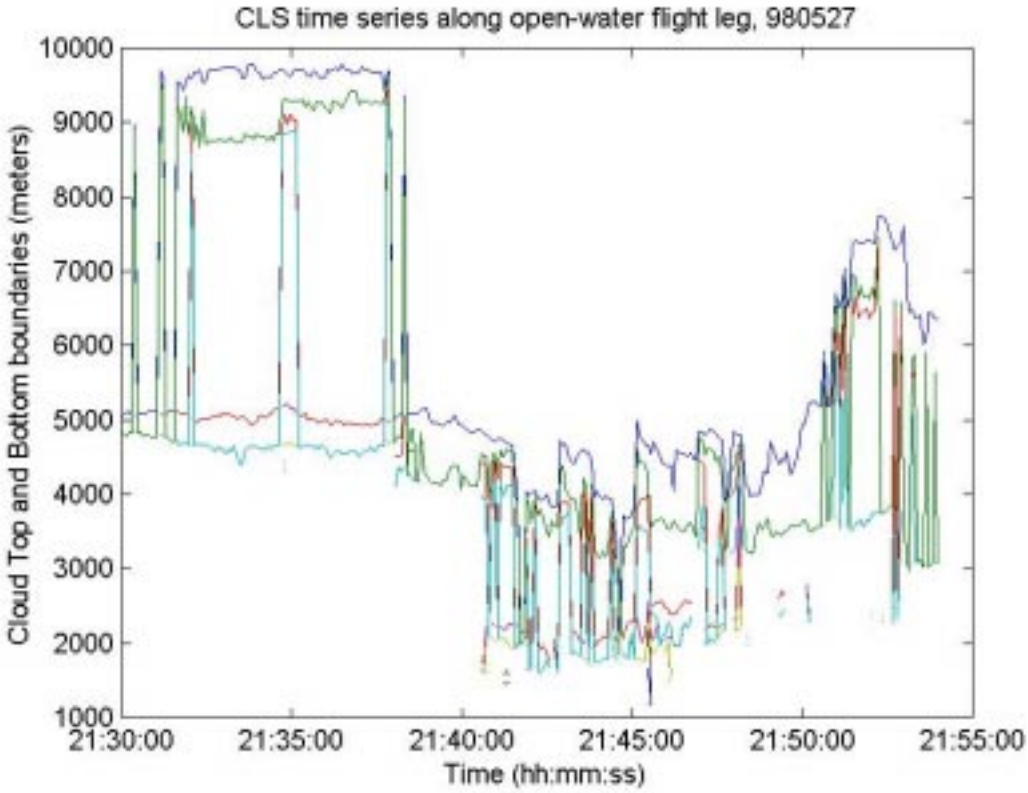
HIS Brightness Temperature Measurements



Cloud LIDAR Image

May 27, 1998 – Instrument nominal, in integration mode





UW CV-580 FLIGHT LOG
May 27, 1998

Author (Mission Scientist): Hobbs, Peter

Flight Number: 1754
Engines On: 2238
Engines Off: 2707
Departure Airport: Barrow
Arrival Airport: Barrow

Clouds sampled: Ac

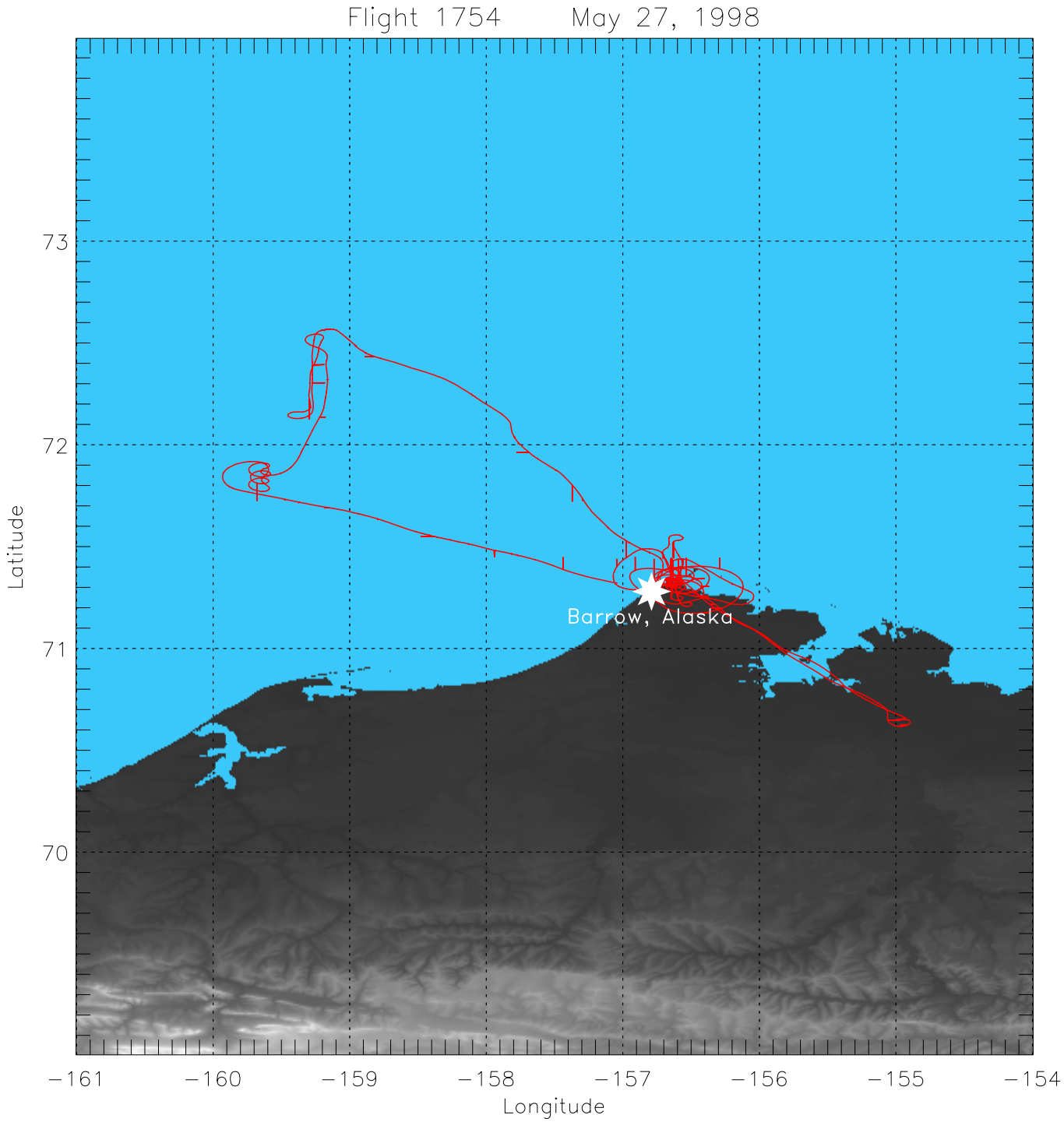
Summary:
1) Climbed north out of Barrow over Chukchi Sea through three Ac layers.
2) BRDF measurements over highest Ac layer.
3) Radiative measurements above, between, and below Ac cloud layers.
4) Microphysical measurements in the cloud layers.
5) Flew (in upper cloud layer) beneath ER-2 to ARM site, and 50 miles south.
6) Climbed to 25,000 ft thru Ac layers and Cs (did not clear tops) near ARM.
7) Spiraled down from 25,000 ft to near surface over ARM site.
8) BRDF centered on ARM with no cloud below but broken Ac above.
9) Level runs at 2,000 ft through ARM site over snow-covered tundra, open ocean, and ice-covered ocean, with CAR scanning down on two runs and upward on one run.

Experimental Observations:
1. Climbed to north over Chukchi through three Ac layers. BRDF (3 turns) above top Ac layer (not uniform). Then measurements above, in between and below cloud layers.
2. Tracker behind ER-2 from Chukchi, over ARM site, to 50 miles south of ARM.
3. Climbed through Ac, Cs to 25,000 ft near ARM.
4. Spiraled down to 25,000 ft to ~400 feet over ARM.
5. BRDF over ARM, with Ac above.
6. Horizon runs at 2,000 ft through ARM site over snow cover tundra, open water ice-cover water, CAR scans up and down.

Research Crew: Hobbs, Rangno, Radke, Garrett, Russell, Spurgeon, Beitzel
Pilots: Sutherland, Sorensen

Equipment Failure:
IR temp King, Ac Profile Software / FFFR - condensation in bulb (at altitude?)

FIRE-III Objectives Addressed:
1. Cloud Structure over Chukchi and ARM with ER-2 overpass
2. Cloud radiative properties over Chukchi and ARM with ER-2 overpass.
3. Surface reflectivity and BRDF over ARM site.


Flight 1754 May 27, 1998
Barrow, Alaska
73
72
71
70
Latitude
−161
−160
−159
−158
−157
−156
−155
−154
Longitude

Flight 1754 - May 27, 1998

main

1 Summary

2 Photos

3 Quicklooks

1 CAR Flight Summary

The highlights of this flight can be grouped into four categories: made 3 circles of BRDF measurements above altocumulus, locked into zenith imaging mode to observe the sun halo and many other interesting optical phenomena (upper helic arc, lower tangential arc, circum helic arc, subsub and sun dogs), made 10 circles for BRDF measurements over ARM site under cloud cover and used nadir imaging mode to map the ARM site.

22:45 heading North out of Barrow in scattered altoclumulus [1]. CAR was in zenith imaging mode.
22:48 climbed into the lowest altocumulus layer whose base was at 15643 ft, and about 90% of ice.
22:58 in the process of going through all three layers of altocumulus [2].
23:05 went through 3rd layer of altocumulus and are now above all 3 layers, at 18000 ft.
23:06 change to BRDF viewing mode at scan count 1912 and ready to do BRDF over altocumulus cloud layer [3]. This cloud layer is not uniform, some parts are very thick [4] and others are thin enough that ground is clearly visible [5].
23:22 completed 3 BRDF circles at scan count 3468, but altocumulus layer is too thin, so we concluded BRDF measurements.
23:26 changed CAR to nadir imaging mode at scan count 3895 and started level flight over altocumulus layer.
23:32 dropped into a very non uniform cloud layer and did race track runs at cloud top.
23:43 turning and going below cloud base at 17200 ft.
23:45 just about below cloud deck, some snowflakes and ice crystals. Usual surface features below cloud [6].
23:51 climbing back into the altocumulus layer, upper cirrostratus layer is visible.
00:08 changed to zenith imaging mode in order to observe the halo that appeared around the sun [7][8][9].
00:14 cloud size ice crystals becoming thicker.
00:17 locked filterwheel to 2.2 µm and observed the halo [10].
00:20 passed over ARM site, still in ice cloud at 18,317 ft (ER-2 overhead)
00:43 climbed up higher, still in cloud at 20,722 ft and observed interesting cloud optical phenomena [11] that can also be seen on the CAR monitor [12].
01:06 can't get above cloud, so begin spiral descent through cloud over ARM site. Observed subsub at lower left of the CV-580 [13].
01:35 exited base of cloud.
01:47 changed CAR to the BRDF mode.
02:03 began total of 10 BRDF circles over the ARM site at 507 ft above the ground, with altocumulus above and snow below [14][15]
02:28 done with the BRDF, began to level off for the race track runs over the ARM site.
02:47 changed the CAR to nadir imaging mode and began to collect imaging data at 1500 ft above the ground. There are variety of surface types in the tracks as shown in [16][17][18][19][20].

Photo Records:

1. scattered altocumulus

2. between alto cu layers

3. BRDF over altocumulus

4. thick part of altocumulus

5. thinner part of alto cu

6. surface below altocumulus

7. halo around the sun

8. halo around the sun

9. halo around the sun

10. optical phenomena

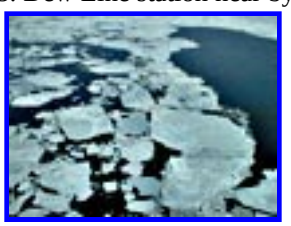
11. optical phenomena

12. CAR display of the halo

13. subsub

14. BRDF near ARM site

15. Dew Line station near by



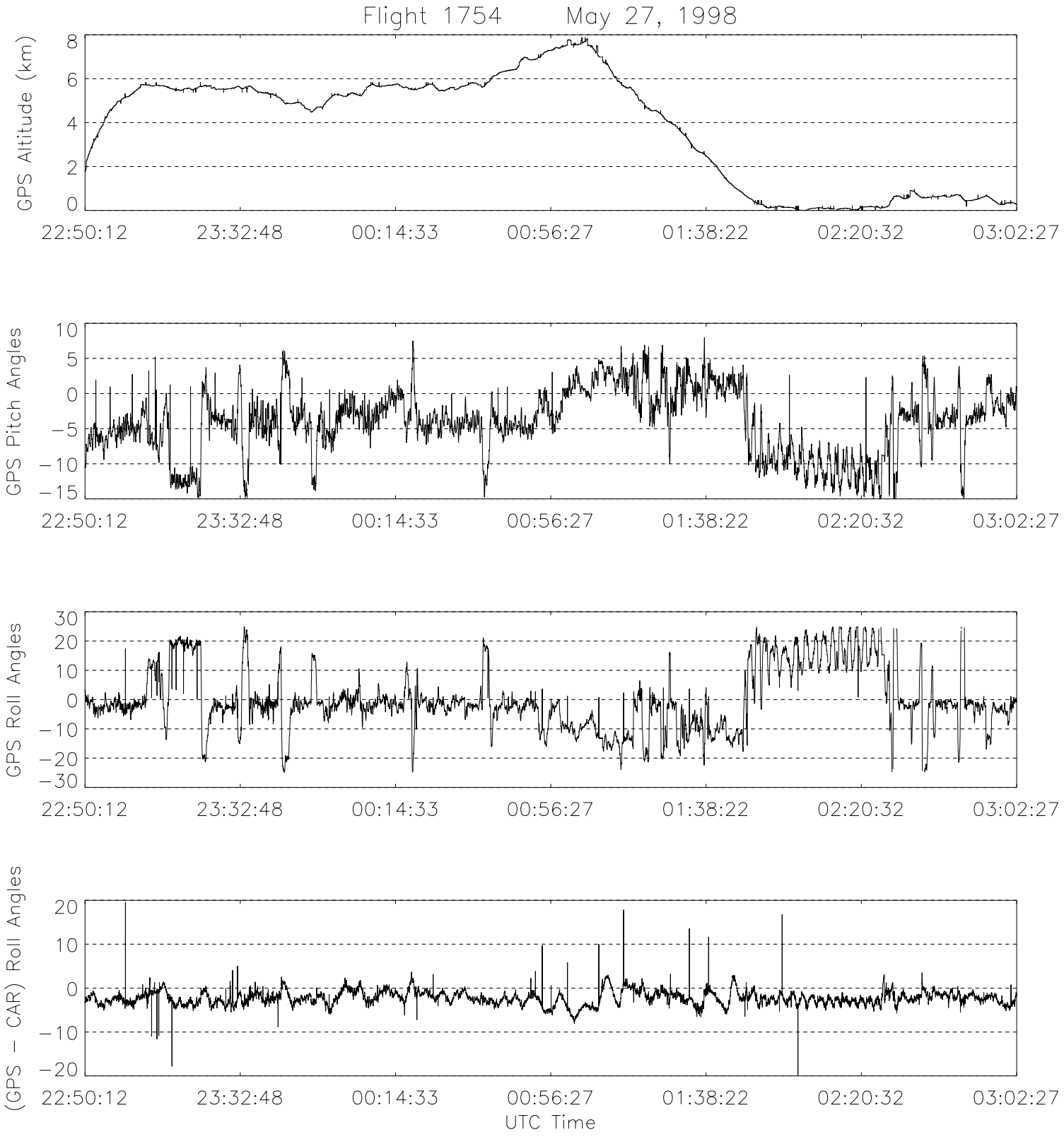
16. race track run over ARM

17. race track run near ARM

18. race track run near ARM

19. race track run near ARM

20. race track run near ARM


Flight 1754 May 27, 1998
GPS Altitude (km)
8
6
4
2
0
22:50:12
23:32:48
00:14:33
00:56:27
01:38:22
02:20:32
03:02:27
GPS Pitch Angles
10
5
0
−5
−10
−15
GPS Roll Angles
30
20
10
0
−10
−20
−30
(GPS − CAR) Roll Angles
20
10
0
−10
−20
UTC Time

C-130 Flight Summary
May 27, 1998

Daily Mission Scientist: James Pinto
Deputy Daily Mission Scientist: Judy Curry
Report prepared by: Judy Curry, James Pinto

Objectives: Cloud radar validation, measurement of precipitation, microwave remote sensing of precipitation, radiation, cloud microphysics and aerosol emission from leads..

Meteorological conditions reported at the SHEBA camp: SHEBA ship reported two layers of altostratus, with intermittent freezing rain over the site.

Ship position	Surface wind	Surface temperature
76 31.53 N	20 knots	-5° C
167 56.03	90°	

Flight Plan: High altitude mapping (AIMR and MCR), east-west transects through the cloudy boundary layer, and box pattern at intermediate levels.

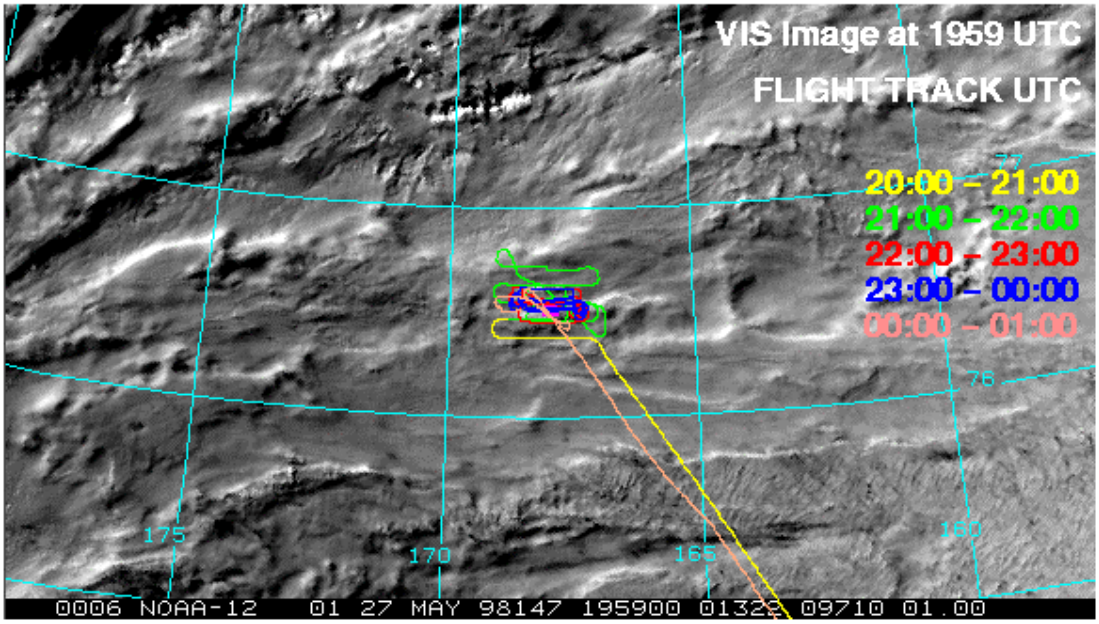
Principal accomplishments: Mapping at 6300 m, transecting at various levels through the condensation, sampling over leads for aerosol emission, albedo transect over dirty snow and ice in MIZ, open water and land near ARM site at Barrow, sampling altostratus over ice north of Barrow and a deep layer of cirrus over and just south of Barrow.

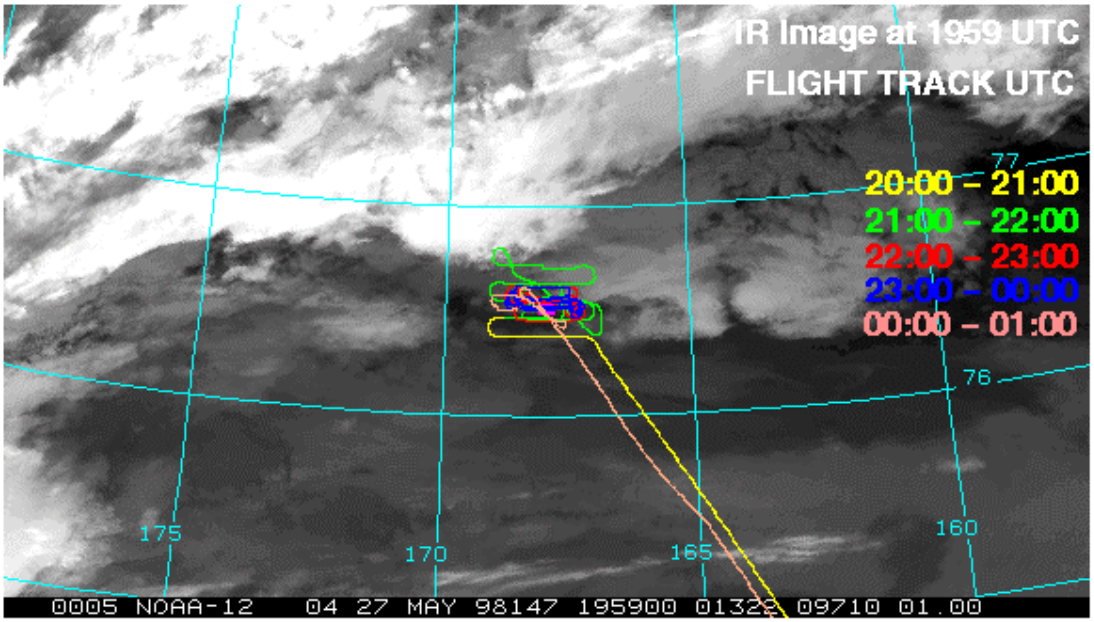
Comments. The cloud situation over the ship was changing rapidly. Upper level clouds were gone. There was a persistent low-level stratus or stratocumulus cloud deck between 50-500 m. Intermittent cloud decks between 500 and 2000 m passed over the ship during the duration of the flight. Interesting CN signal observed downwind of mostly ice-covered (some open water) lead south of the ship.

Instrument problems:

AIMR: Scan rate still limits full scan coverage to above 1.6 km.
MCR: continuing problems with channels 2,3,5,7.
Radiometers: a lot of noise on RAMS uplooking short-wave.

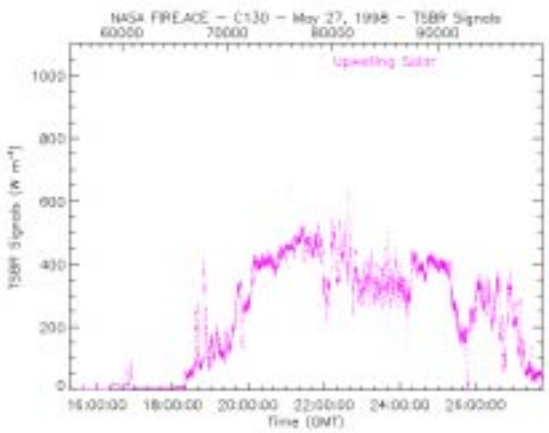
C130 FLIGHT TRACK AND NOAA–12 AVHRR IMAGES ON MAY 27, 1998



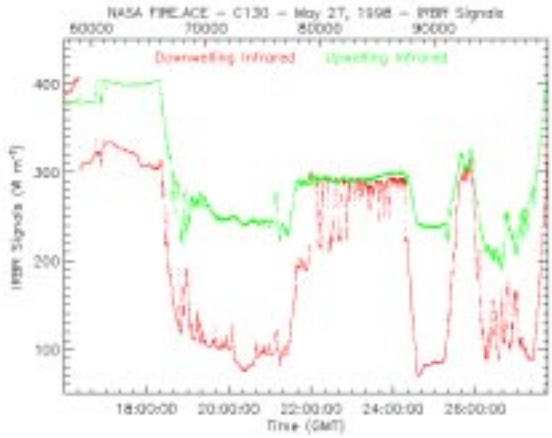


C-130 Radiometer Measurements
May 27, 1998

TSBR – Total Spectral Broadband Radiometer

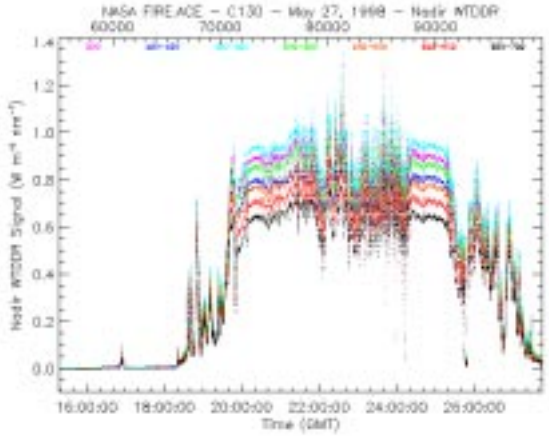


IRBR – IR Broadband Radiometer

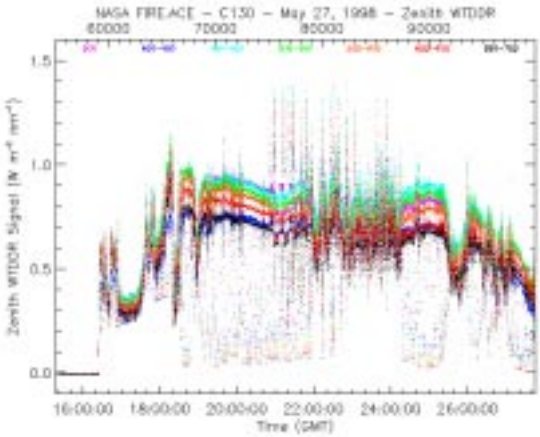


WTDDR – Wide Bandpass Total-Direct-Diffuse Radiometer
(1shadow ring on Zenith WTDDR)

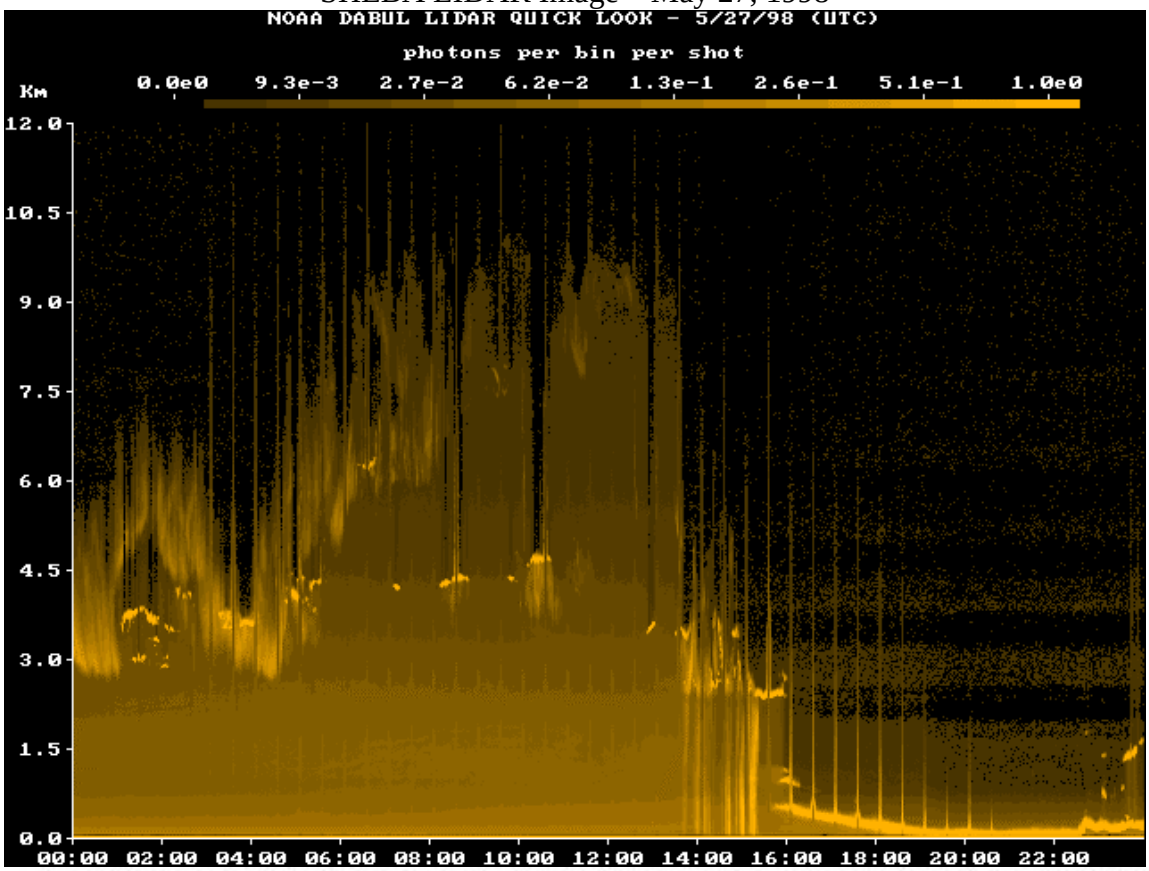
Nadir



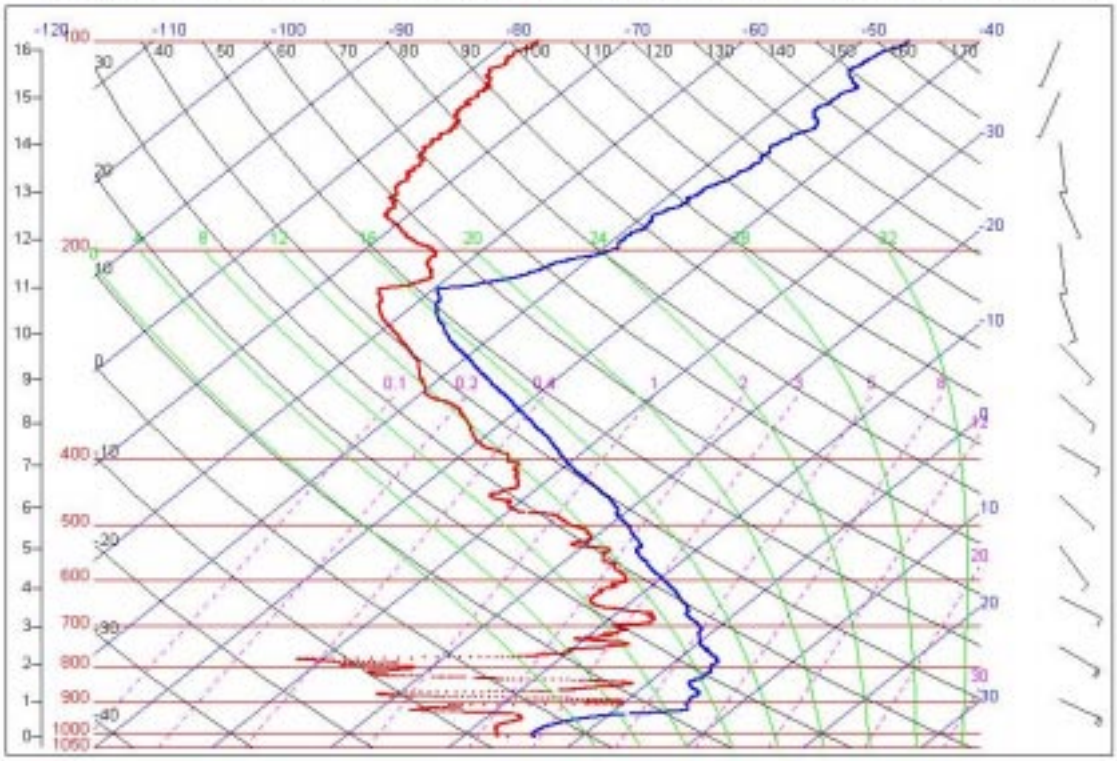
Zenith



SHEBA LIDAR Image – May 27, 1998



Version: SHEBA--GPS Soundings, GLASS 1.10 Fixed, SHE, 1998,05,27, 11:35:15



May 28, 1998

CV-580

Flight summary

Flight track

CAR notes

GPS plots

SHEBA

LIDAR image

Sounding

UW CV-580 FLIGHT LOG

May 28, 1998

Author (Mission Scientist): Hobbs , Peter

Flight Number: 1755
Engines On: 2000 Z
Engines Off: 2316 Z
Departure Airport: Barrow
Arrival Airport: Barrow

Clouds sampled: Ac As

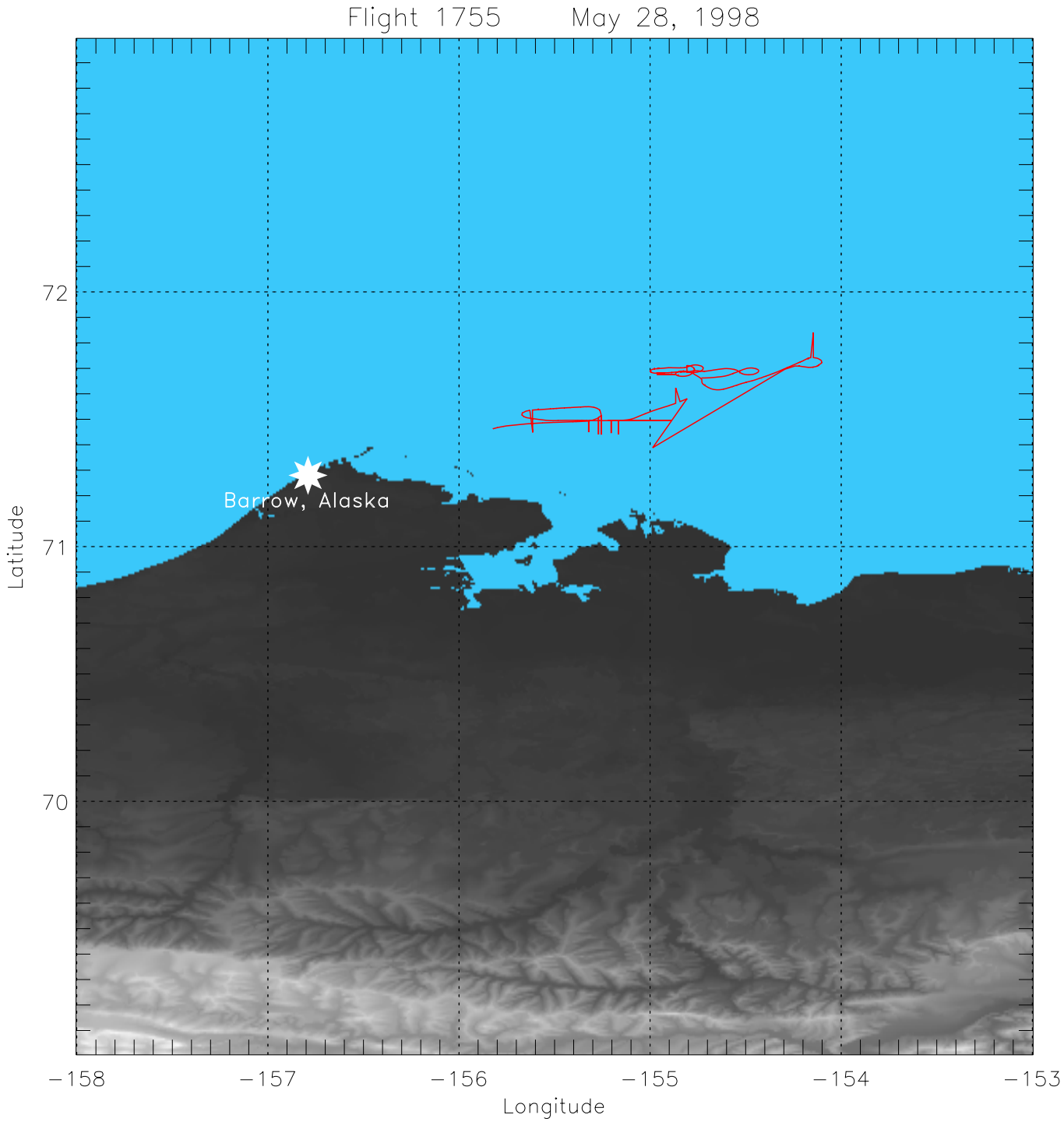
Flight Summary:
1) Flew above and in low stratus over Chukchi Sea for radiative and microphysical measurements. Could not fly below cloud base because stratus extended almost to the surface. Ac and Cs layers above.
2) Low-level measurements over leads for emission measurements. (Nothing apparent in real-time displays, but complex situation.)
3) Climbed to 15,000 ft in deep cloud layer over the ARM site, cleared cloud top. (PSU Raman LIDAR, as well as ARM instruments, operating).
4) Descended to 500 ft over ARM as cloud was thinning.
5) Straight and horizontal run through ARM site at 500 ft in clear air for radiation measurements.
6) Ditto at 1500 ft for downward-scanning CAR measurements.

Experimental Observations:
1. 1200-1250 local time: Measurement over Chukchi Sea above and in stratus layer (Ac, Cs above). Could not get below St - too low.
2. 1250-1320: Low-level measurements over sea-ice and leads.
3. 1320-1340: Return to ARM site at low level.
4. 1340-1430: Climb to 15,000 ft (above cloud), and descended 500 ft over ARM.
5. 1430-1440: Straight, horizontal run through ARM in clear air at 500 ft.
6. 1440-1450(?): Climb to 1500 ft.
7. 1450-1500: Straight run at 1500 ft over ARM in clear air for downward CAR.

Research Crew: Hobbs, Rangno, Garrett, Weiss, Russell, Spurgeon, Radke, Li, McMillan, Sutherland

Equipment Failure:
1. IR thermo.
2. King LWC
3. DMPS
4. Condensation inside SFFR top and bottom (on take off)

FIRE-III Objectives Addressed:
1. Radiation
2. Cloud microphysics


Flight 1755 May 28, 1998
Barrow, Alaska
72
71
70
Latitude
−158
−157
−156
−155
−154
−153
Longitude

Flight 1755 - May 28, 1998

main

1 Summary

2 Photos

3 Quicklooks

1 CAR Flight Summary

This flight was more or less a scout mission. The most useful data collected on this flight was the nadir imaging data over the ARM site towards the end of the flight.

Note the latitude and longitude for Barrow airport: 71.28° N, 156.76° W.
Note the latitude and longitude for ARM site: 71.1929° N, 156.3712° W.

20:15 (scan count=500) lock the CAR to nadir viewing mode, over sea ice, thin stratus below and cirrostratus high above [1].
20:18 (scan count=790) try automatic gain settings, set dwell to 5 scans. We are on a 20 mile long track run, in a thin stratus cloud layer.
20:38 right hand viewing (starboard mode), sandwiched between two cloud layers [2].

Not getting data, so we rebooted the computer. Signals come through and seem to have been written on the tape, but nothing shows on the CRT display. May not be receiving the live header feed from Jack's master computer.

20:55 CAR is working again and recording data on a second tape. We are in two layer clouds and the lower layer is not particularly thick [3][4].
21:03 use zenith viewing mode to scan the bottom of a cirrostratus cloud layer.
21:15 mapping large open leads from 100 ft altitude, switched the CAR to nadir viewing mode [5][6].
21:27 cycling manually through the filterwheel channels. Heading back to Barrow ARM site. Good imaging data of sea ice.
21:43 arrived at Barrow ARM site, spiral up through the cloud layer whose base is at 7500 ft and top is at 14780 ft..
21:58 set CAR to right hand viewing mode (starboard), ice crystals are visible. Thin stuff off in the distance [7]. Clouds are not thick enough to do any diffusion domain measurements.
22:22 set CAR to nadir viewing mode near the ARM site.
22:34 dedicated to SSFR measurements, straight run 500 ft above ground over ARM site.
22:41 1 mile south of ARM site at 1500 ft, 1 straight run over ARM site again for CAR to collect imaging data. Record surface conditions around ARM site with digital camera [8][9][10][11][12].
23:02 (scan count=13221) cycling through all gain settings (possibly with the door closed).
23:07 (scan count=13691) auto cycle manual gain and set dwell on 2.
23:10 (scan count=14000) all done, CAR is shut down.

Photo Records:


1. multi-layer clouds near Barrow


2. multi-layer clouds near Barrow


3. sandwiched in between cloud layers


4. lower level cloud not very thick


5. mapping large open leads


6. mapping large open leads

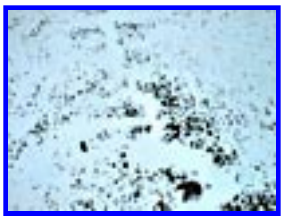

7. thin Cirrus off in the distance


8. surface scene near the ARM site


9. surface scene near the ARM site


10. surface scene near the ARM site

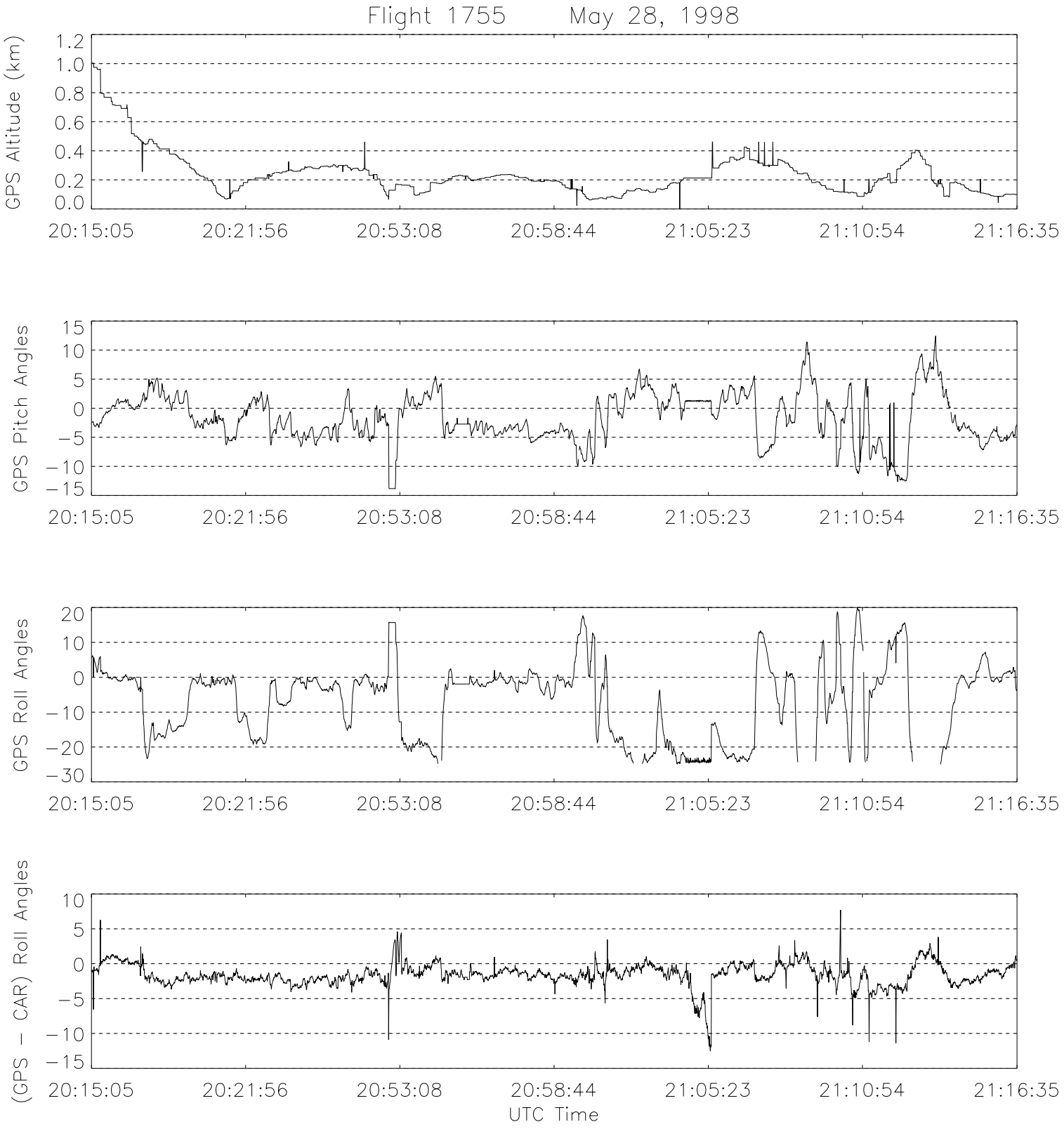

11. surface scene near the ARM site


12. surface scene near the ARM site

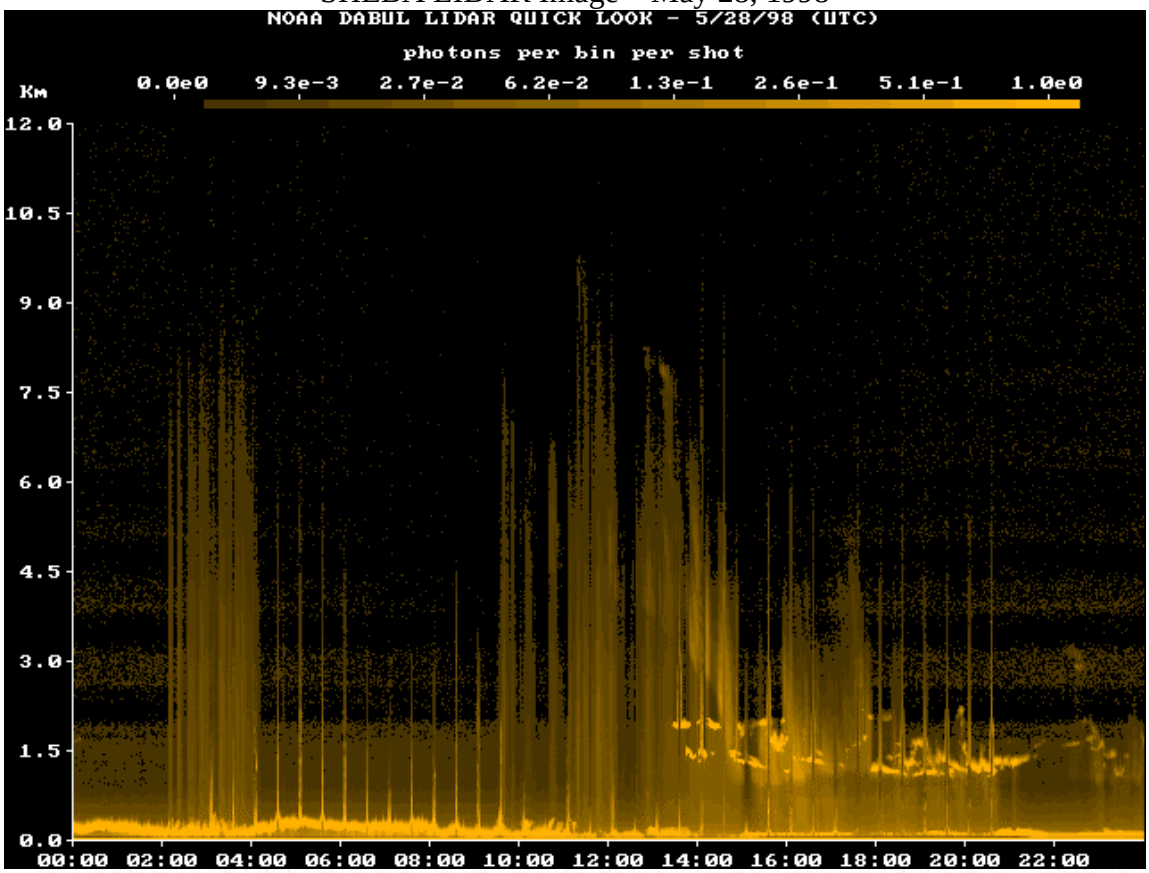
Flight Track and Quicklook Images:

- CV-580 flight track plot
- GPS altitude, pitch and roll angle plot

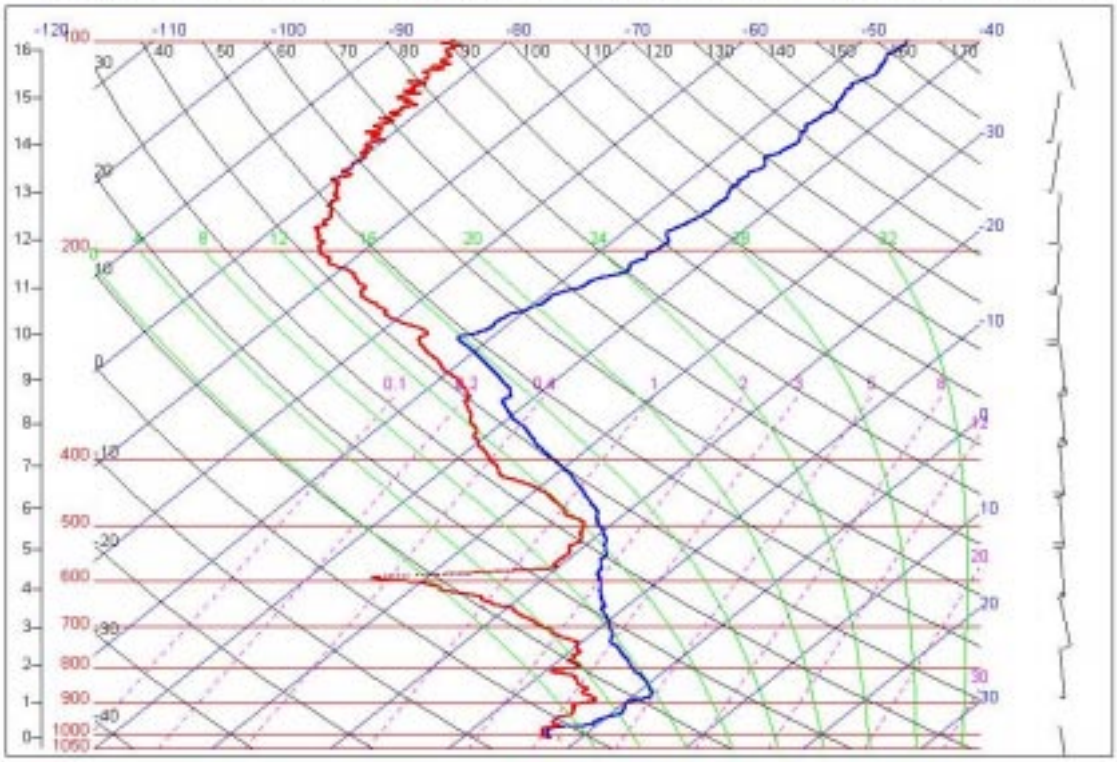
Back to Top


Flight 1755 May 28, 1998
GPS Altitude (km)
1.2
1.0
0.8
0.6
0.4
0.2
0.0
GPS Pitch Angles
15
10
5
0
−5
−10
−15
GPS Roll Angles
20
10
0
−10
−20
−30
(GPS − CAR) Roll Angles
10
5
0
−5
−10
−15
20:15:05
20:21:56
20:53:08
20:58:44
21:05:23
21:10:54
21:16:35
UTC Time

SHEBA LIDAR Image – May 28, 1998



Version: SHEBA--GPS Soundings, GLASS 1.10 Fixed, SHE, 1998,05,28, 11:15:03



May 29, 1998

ER-2

Flight summary

Ground track

MAS images

Cloud LIDAR System image

AMPR images

CV-580

Flight summary

Flight track

CAR notes

GPS plots

SHEBA

LIDAR image

Sounding

Mission 7
ER-2 Sortie 98-070
Friday, May 29, 1998

Flight Scientist: S. Platnick

Objectives: Fly over SHEBA ice camp (76°40'N, 168°09'W) in coordination with University of Washington CV-580 for remote sensing validation and cloud masking. Thick low clouds with scattered higher level clouds were expected over the SHEBA site during the mission. The ER-2 flew a repeated cross pattern, with flight legs of about 260 km in length, oriented perpendicular and parallel to the solar azimuth, while CV-580 attempted above and below-cloud bi-directional reflectance measurements and in situ profiles through the cloud. Take off was delayed by 30 minutes in order to match the NOAA-14 SHEBA overpass at the end of the flight pattern. Outgoing and return flights were made over the ARM site.
Coordination included:

- F-14 satellite (2250 UTC)
- NOAA-14 satellite (2327 UTC)

ER-2 Mission:	Pilot:	Bill Collette
	Takeoff	1930 UTC
	Landing	0140 UTC (May 30)
	Duration	6:10

After flying over the ARM site, the ER-2 flew a NW flight line toward the SHEBA ice station to begin the cross pattern with legs of about 260 km in length. One-and-a-half flight legs were flown in a NW-SE orientation, followed by one-and-a-half flight legs in a perpendicular direction chosen such that the imaging instruments would be scanning into the solar plane. The ER-2 pilot had wings level during the F-14 overpass. The last leg over the ice station was at the time and heading of the NOAA-14 overpass. The return leg flew over the ARM site en route back to Ft. Wainwright.

The AirMISR was turned on for 6 acquisitions: twice over the ARM site, three times over SHEBA, and once along the NOAA-14 flight leg. The AirMISR operated at the following times:

- 2029-2041 (ARM site)
- 2122-2134 UTC (SHEBA)
- 2215-2227 UTC (SHEBA)
- 2244-2256 UTC (SHEBA)
- 2321-2334 UTC (NOAA-14 overpass)
- 0007-0024 UTC (ARM)

The ER-2 pilot reported undercast conditions everywhere between Barrow and the ice station, and also throughout the ice station legs. Clear over Barrow on return leg.

Instrument Status

- AirMISR – first five runs worked well, last run failed
- AMPR – worked well
- CLS – worked well
- HIS – possible problem during return leg
- MAS – worked well
- MIR – worked well
- SSFR – worked well

Meteorology:

SHEBA: The ice camp reported rain, temperatures around freezing, and winds southeasterly at 8-12 kts. A variety of clouds were reported from the surface up to 3.5 km on the radar. Sounding and satellite images indicated moisture and cloud layers up to 7 km. All cloud layers were broken including the boundary layer stratus with bases of 100, 250, and 500 meters on the ceilometer.

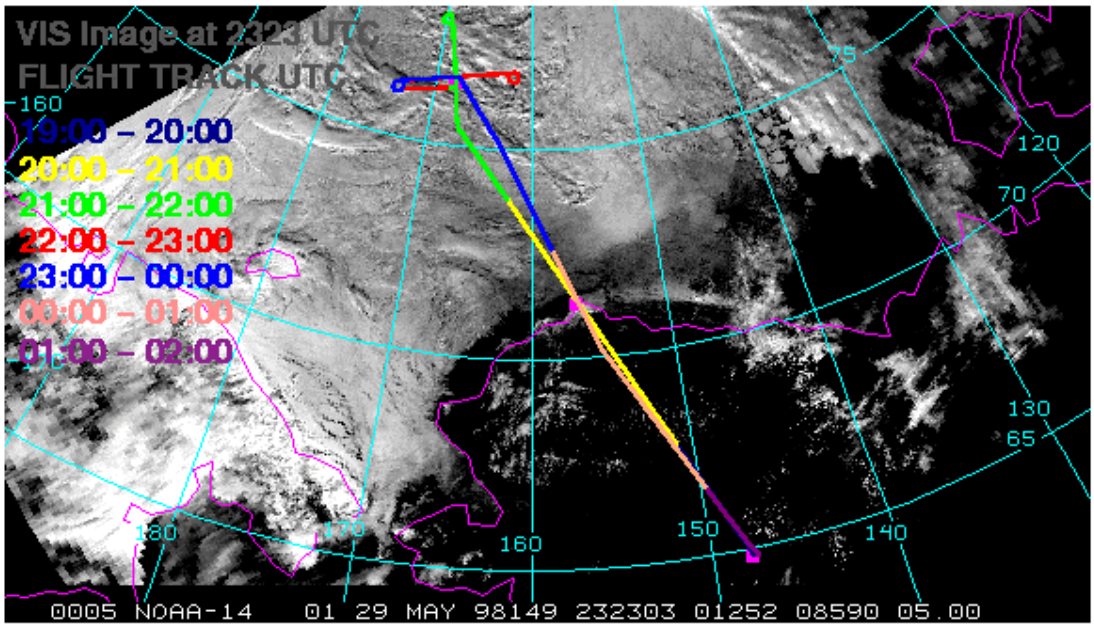
Forecast: It was expected that upper level clouds might begin to dissipate by mission time with lower level clouds remaining. Some clearing possible during the day.

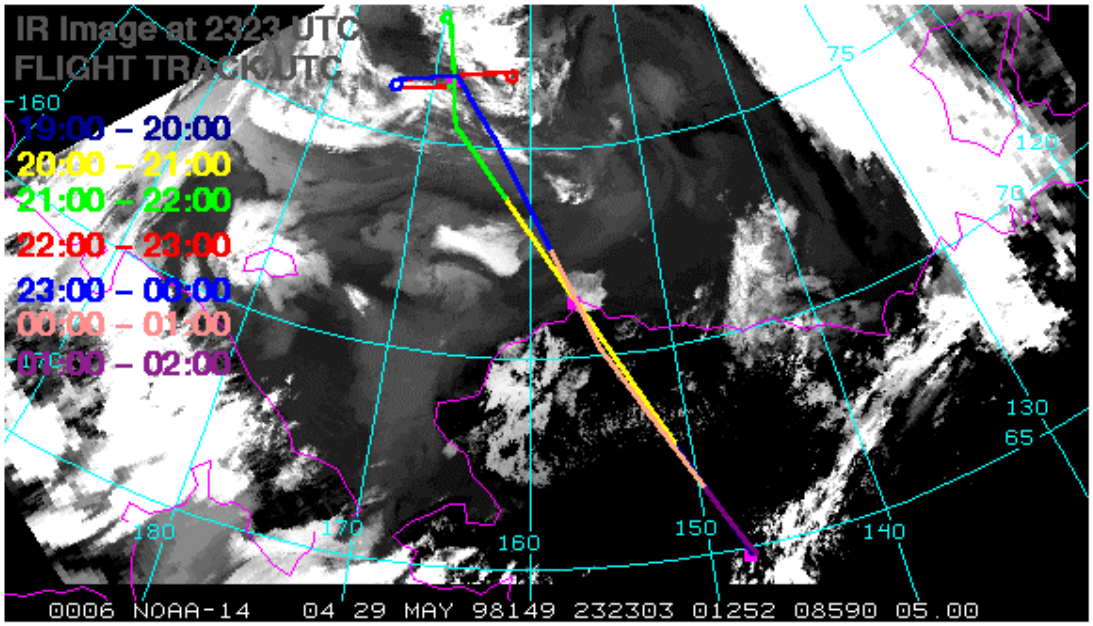
The CV-580 reported extensive low stratus between Barrow and the SHEBA ice camp on both outgoing and returning transits, with clear skies above. Higher level stratus observed at SHEBA.

Instruments:

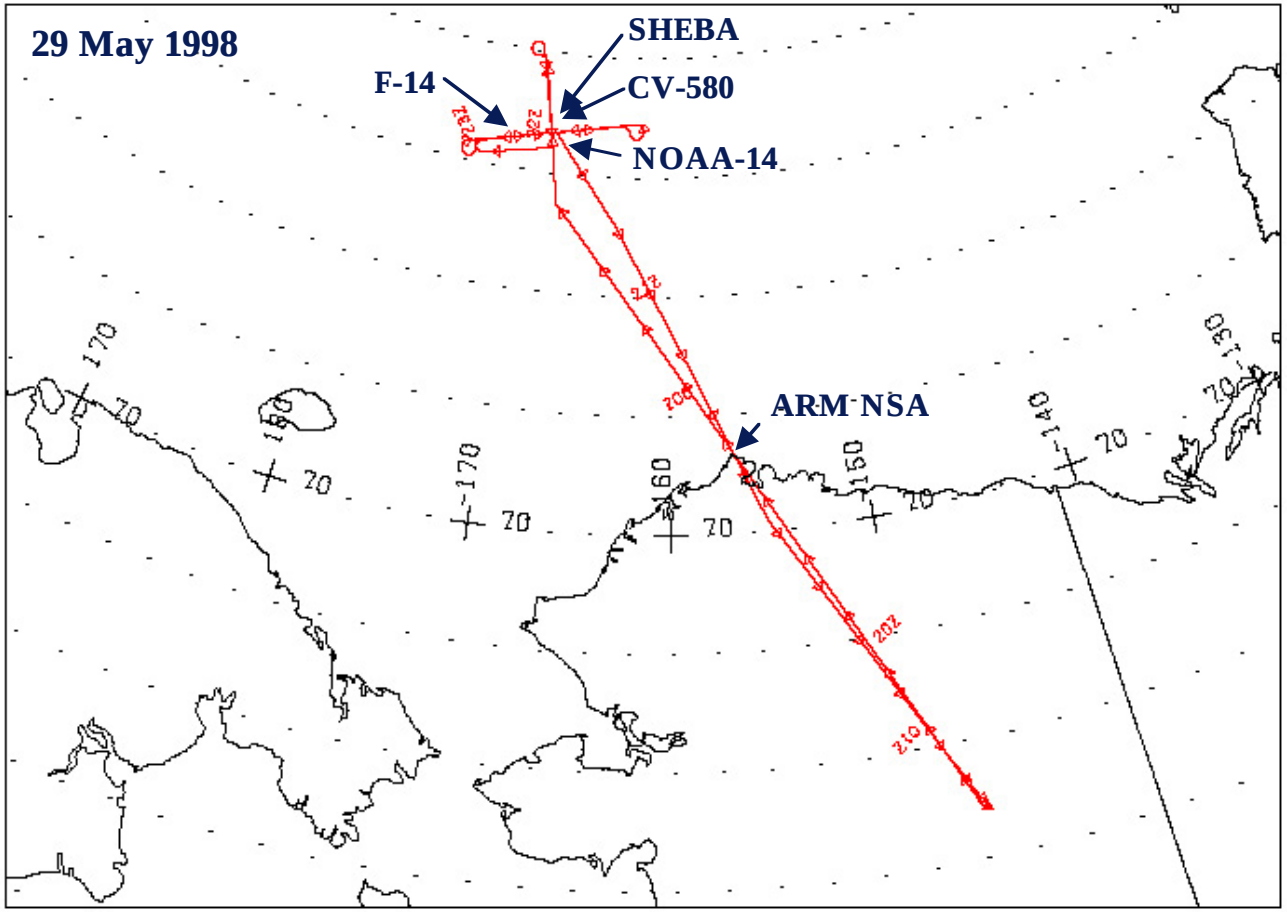
AirMISR – Airborne Multi-angle Imaging Spectroradiometer
AMPR – Advanced Microwave Precipitation Radiometer
CLS – Cloud LIDAR System
HIS – High-resolution Interferometer Sounder
MAS – MODIS Airborne Simulator
MIR – Millimeter-wave Imaging Radiometer
SSFR – Solar Spectral Flux Radiometer

ER2 FLIGHT TRACK AND NOAA–14 AVHRR IMAGES ON MAY 29, 1998

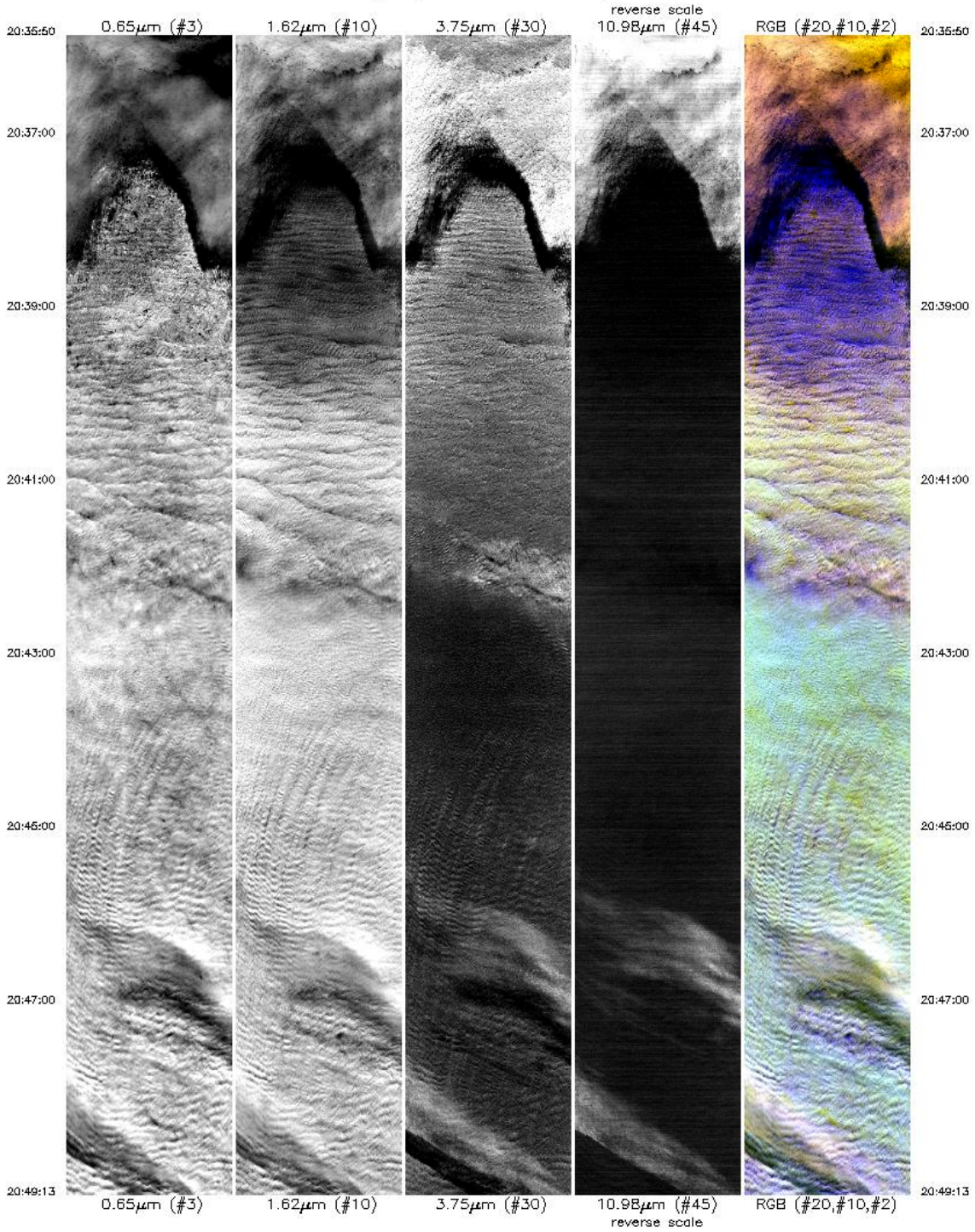




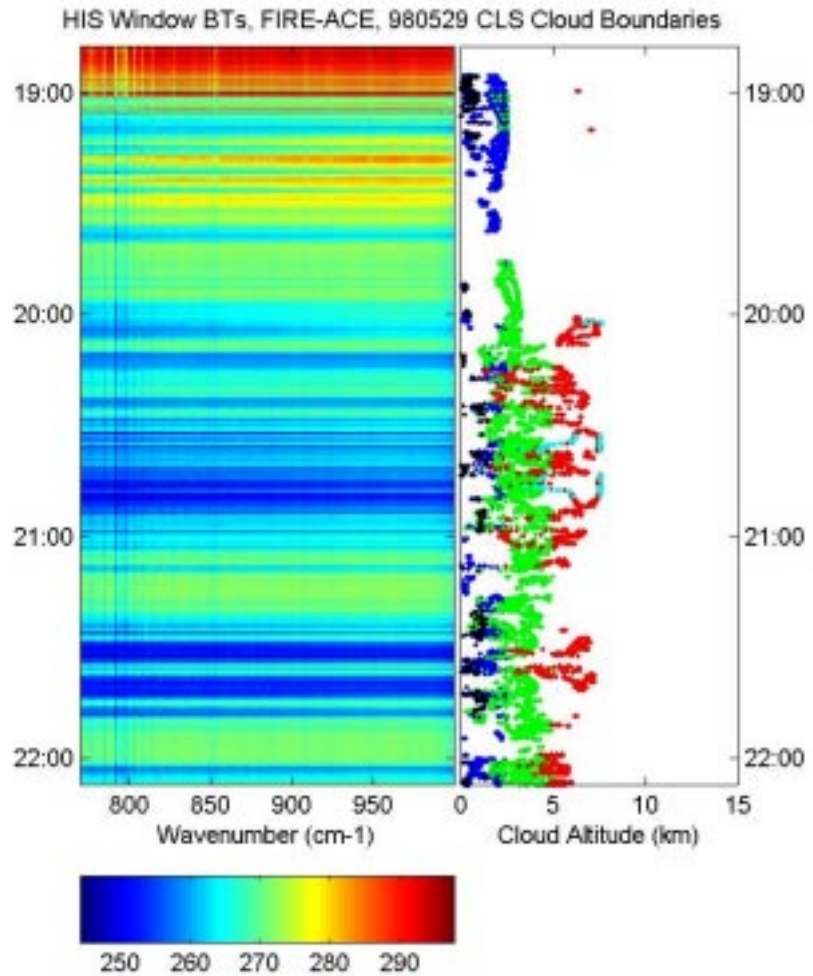
ER-2 Ground Track



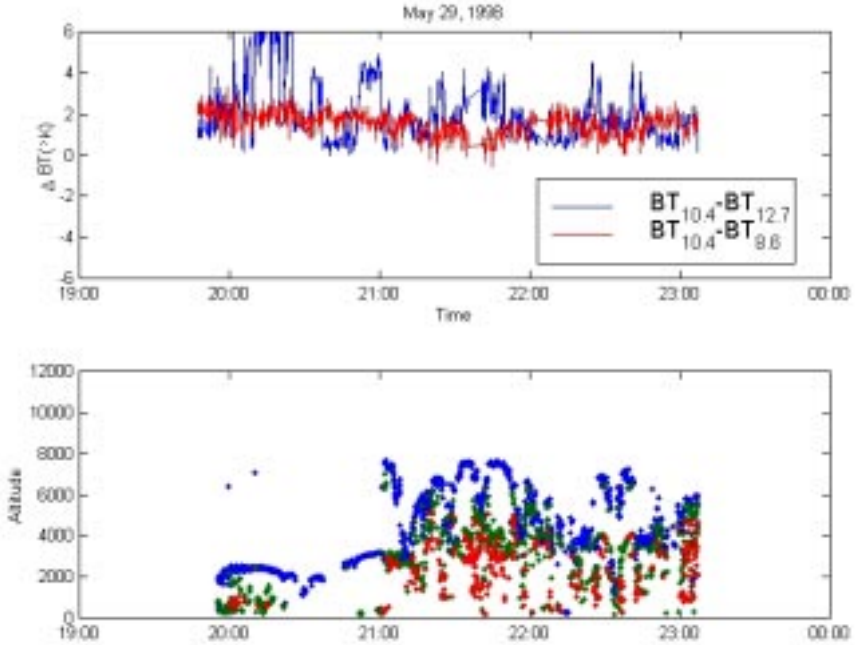
MODIS Airborne Simulator Browse Imagery
FIRE–ACE Campaign – 29–30 May 1998
Flight #98–070 Track #4



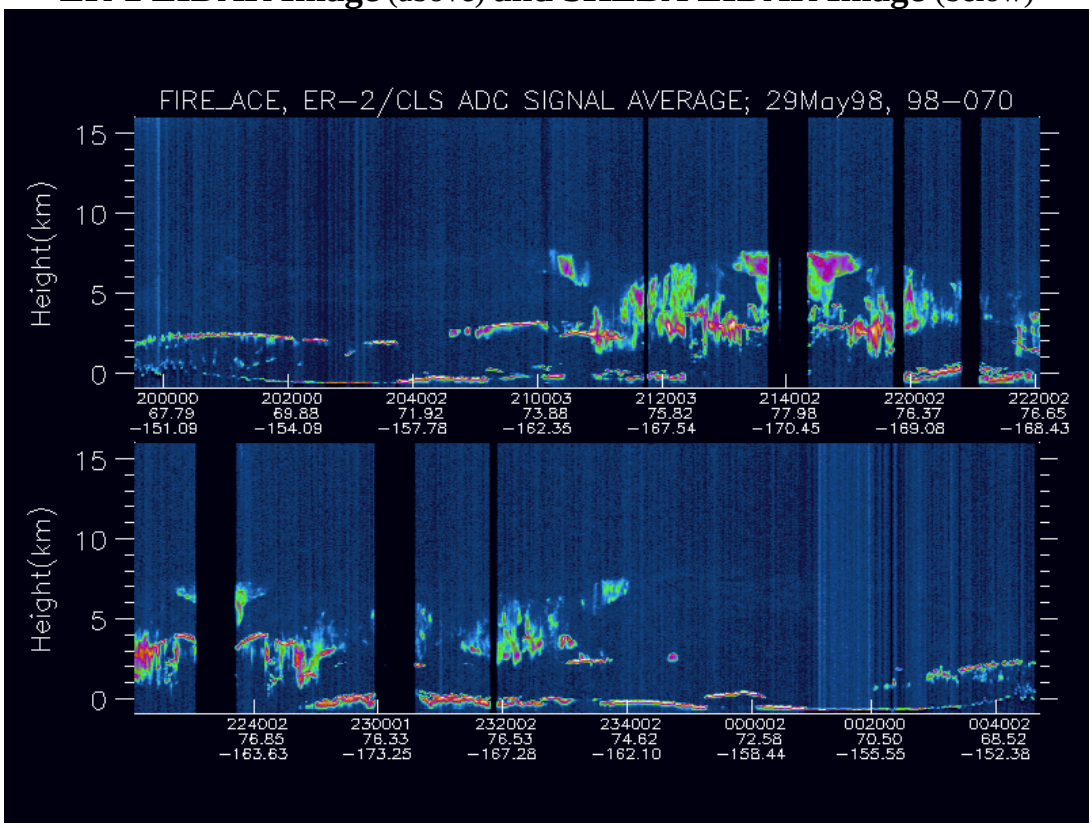
ER–2 Heading = 329.5°
Solar Zenith = 52.3°
Solar Azimuth = 148.0°

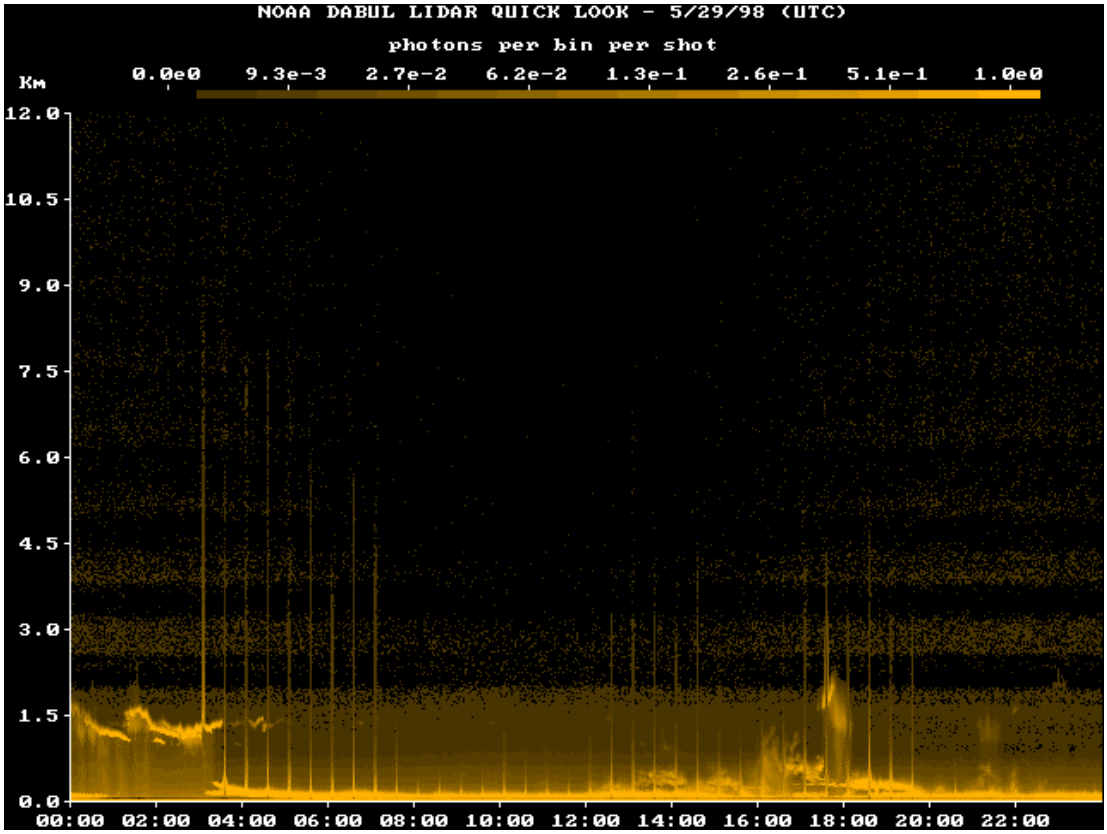


Delta Brightness Temp (on top) and CLS Time Series (below)

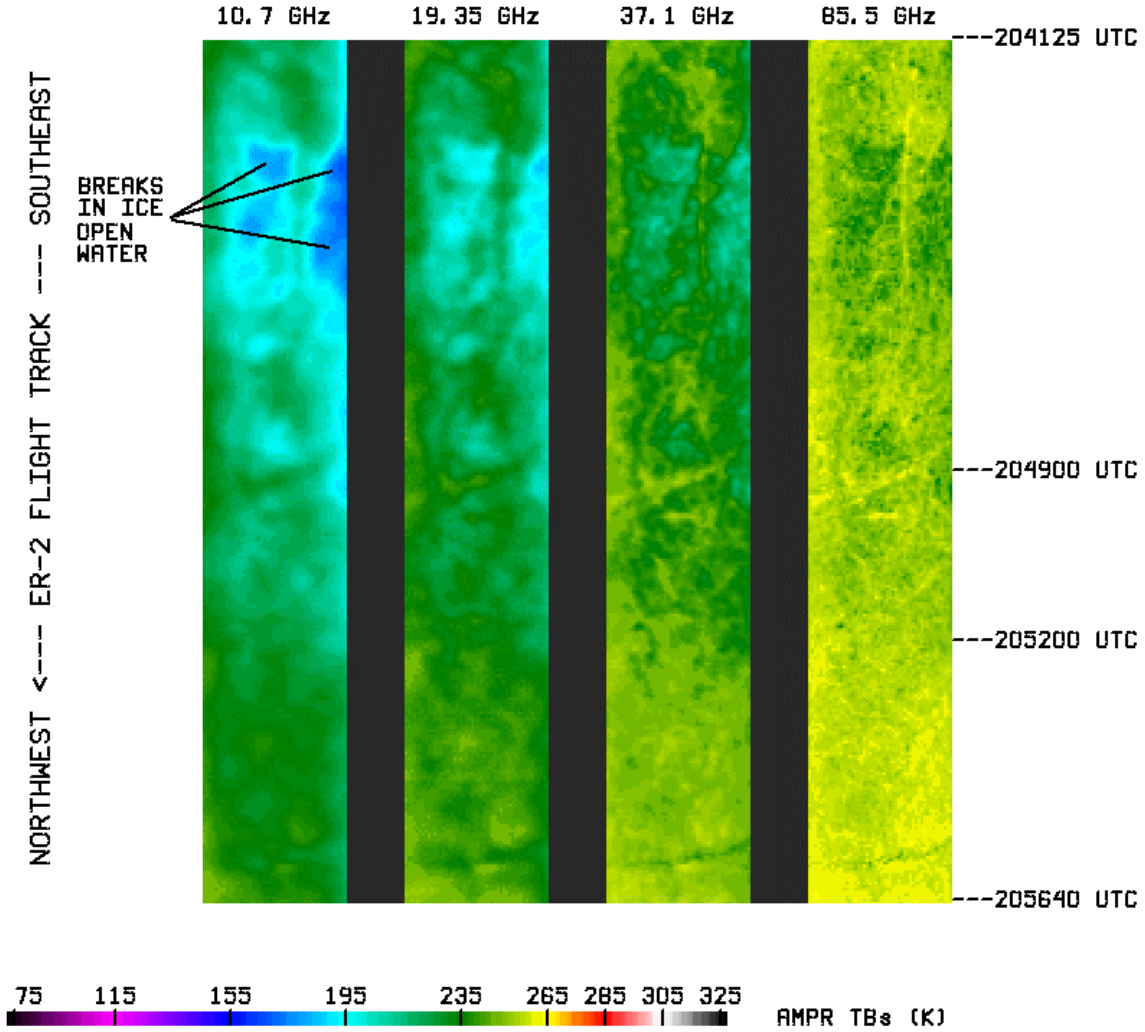


ER-2 LIDAR Image (above) **and SHEBA LIDAR Image** (below)





AMPR TBs FOR FIRE ACE
29 MAY 1998



UW CV-580 FLIGHT LOG
May 29, 1998

Author (Mission Scientist): Hobbs, Peter

Flight Number: 1756
Engines On: 1919
Engines Off: 2524
Departure Airport: Barrow
Arrival Airport: Barrow

Clouds sampled: Ac

Summary:
This was our first flight to the SHEBA ship, which was located about 375 nautical miles north of Barrow.

1) 1928-2110 UTC: Transit to SHEBA site mainly in clear air. Haze layers apparent.

2) 2127-2231 UTC: Descended from 21.5,000 ft (above Ci) to 500 ft through cloud layers in a step-wise fashion, with horizontal legs centered on SHEBA ship. ER-2 flew parallel legs above. Low visibility and drizzle at the surface (at 76° 40 min north in May!!), prevented us from flying below 500 ft over SHEBA.

3) 2233-2245 UTC: Spiral up over SHEBA through clouds to above Ac layers.

4) 2245-2254 UTC: BRDF measurements above highest Ac layer with uniform cloud top.

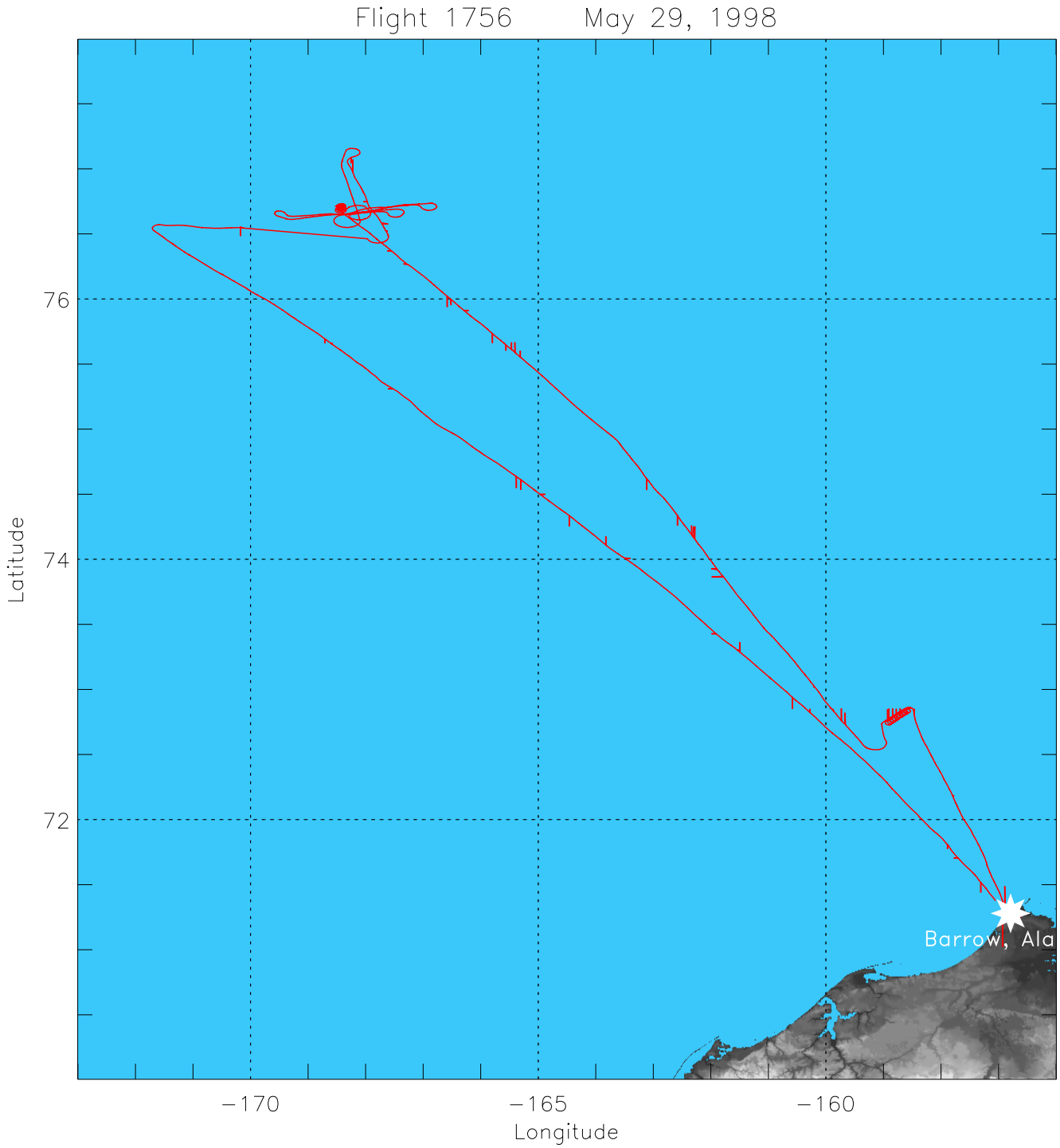
5) Left SHEBA site at 2254 UTC.

6) 0018-0040 UTC: On way back to Barrow did BRDF measurements (10 turns) above highest Ac layer; clear sky above, glory in Ac.

NOTE: ALL TIMES APPROXIMATE. EXACT TIMES AVAILABLE WITH POST ANALYSIS.

Equipment Failure:
1) King
2) PVM
3) IR
4) Ophir(?)

FIRE-III Objectives Addressed:
Cloud studies and cloud BDRF over SHEBA


Flight 1756 May 29, 1998
76
74
72
Latitude
−170
−165
−160
Longitude
Barrow, Ala

Flight 1756 - May 29, 1998

main

1 Summary

2 Photos

3 Quicklooks

1 CAR Flight Summary

Flight from Barrow to SHEBA ice station, where the CV-580 was coordinated with the NASA ER-2 for a two hour period where both aircrafts flew a coordinated crossing pattern. The arctic stratus en route was uniform for most of the flight out to SHEBA, with blue sky above. During most of this transit the CAR was scanning in the nadir viewing mode with the filterwheel locked at 2.2 µm. The Eppley pyranometers indicated a cloud albedo of 0.63. Later, the stratus layer appeared to thin somewhat with cloud streets perpendicular to the flight track, with a moderate haze layer aloft and uniform stratocumulus below. Cirrus subsequently appeared with corresponding halos. The CAR scanned the overlying cirrus in the zenith scanning mode.

For the ER-2 coordination over the SHEBA ice station, the CAR operated above cloud in the nadir scanning mode, which provides an excellent intercomparison opportunity for the CAR and ER-2/MAS. The Eppley pyranometers indicated the cloud albedo was 0.73 at the time. The clouds near SHEBA were more structured and layered than those observed earlier in the flight, but were relatively uniform on top during the ER-2 overflight. SHEBA reported 1.5 mile visibility and precipitation. The CV-580 then descended and reversed course, this time flying a parallel ground track in the cirrus at the time and heading of the ER-2. This flight line was in the principal plane of the sun (heading of 169°/349°). Following this flight line, the CV-580 flew an east-west flight line coordinated with the ER-2 (heading of 79°/259°). The top of the clouds was at 14000 ft, and a subsun was observed on the starboard (towards the sun). The CAR operated in a starboard scanning mode. Short columns were observed on the CPI.

Fire Ace

May - June, 98
Barrow, Alaska

log by CAR scan count

Flight from Barrow to SHEBA; climbed out through stratus cloud layer. Switched CAR to nadir imaging mode over stratus [1].
824: breaking stratus, 0.3 µm smooth, other channels see structure of cloud, pretty isotropic. Uniform altocumulus below on transit to SHEBA, no upper layer cloud. Eppley reading 0.63.
2211: haze above us, altocumulus thinning, flying to bands.
4600: little haze above, uniform stratocumulus below.
4900: cirrus above and halo is visible, few more holes in cloud layer on left.
6800: ice crystals shown from above.
7100: approaching ship, cirrus above.
7300: thick cirrus [2] above switch to zenith mode. Multi-layer cloud at SHEBA. 1.5 mile visibility at cirrus.
8100: mostly blue sky, switching back to nadir imaging mode, very thin cirrus [3] above at 22,000 ft. Optically thin uniform stratus below (probably multiple cloud layers), column precipitation from above (CPI).
8700: clear now.
9300: cleared all cirrus, rotate nose to BRDF mode, uniform stratus, in Russian FIR (about 172 degree West and 76.56 latitude).
10500: back to nadir scan prepare for ER-2 coordination, more broken cloud near SHEBA.
11615: clear sky above uniform cloud, ER-2 ground tracks over SHEBA. One flight leg above cloud aligned with ER-2 overpass, uniform clouds below. Nadir viewing mode. MAS/CAR calibration at 21911 ft [4] (NorthWest to SouthEast track). Ac = 0.73.
12075: over SHEBA.
12270: switch to 1.6 µm, cirrostratus nebulosis. Banded cirrus.
12800: more structured cloud near SHEBA ship [5][6][7][8][9][10][11].
12980: descend, reverse course under ER-2, uniform radiation [12]. In cirrus for second ER-2 leg.
13610: over SHEBA. Flights into and away from principal plane.
14300: east leg in crossing patterns, top of clouds 14,000 ft, subsun off right wing, righthand (starboard mode), scan near the principal plane (Sun), short columns.
16860: 90° scanning between cloud layers, scan in principal plane, diffuse anomaly from other clouds (cirrus and stratus).
19300: 6 circles (4 at 1.6 µm, 2 at 2.1 µm). BRDF scan (5 circles) and standard scan (1.5 circles). Isotropic field [13][14][15].
27000: transit back, nadir scanning mode, on atomatic filterwheel mode. In haze layer.

Return cruise at 130 m/s, BRDF 95 m/s. BRDF mode, homogeneous cloud. BRDF orbit is 2000 ft above cloud .
28400: locked on 2.2 µm, altitude 12,000 ft, featureless altocumulus or stratocumulus translucidus, no cloud layer above [16][17][18][19]. Glory observed in cloud (visual and CAR measurements), very isotropic. After standard mode, descend through cloud on return to Barrow. Frost on SSFR whole flight (inside dome) [20].

Photo Records:


1. stratus cloud layer near Barrow


2. imaging the bottom of cirrus


3. column precipitation from cirrus


4. MAS/CAR calibration scene


5. cloud scene over the SHEBA site


6. cloud scene over the SHEBA site


7. cloud scene over the SHEBA site


8. cloud scene over the SHEBA site


9. cloud scene over the SHEBA site


10. cloud scene over the SHEBA site


11. surface scene very near SHEBA site


12. multi-layer cloud scene near SHEBA site


13. BRDF measuremtns (case 1)


14. cirrus contamination at BRDF site (case 1)


15. BRDF measurements (case1)

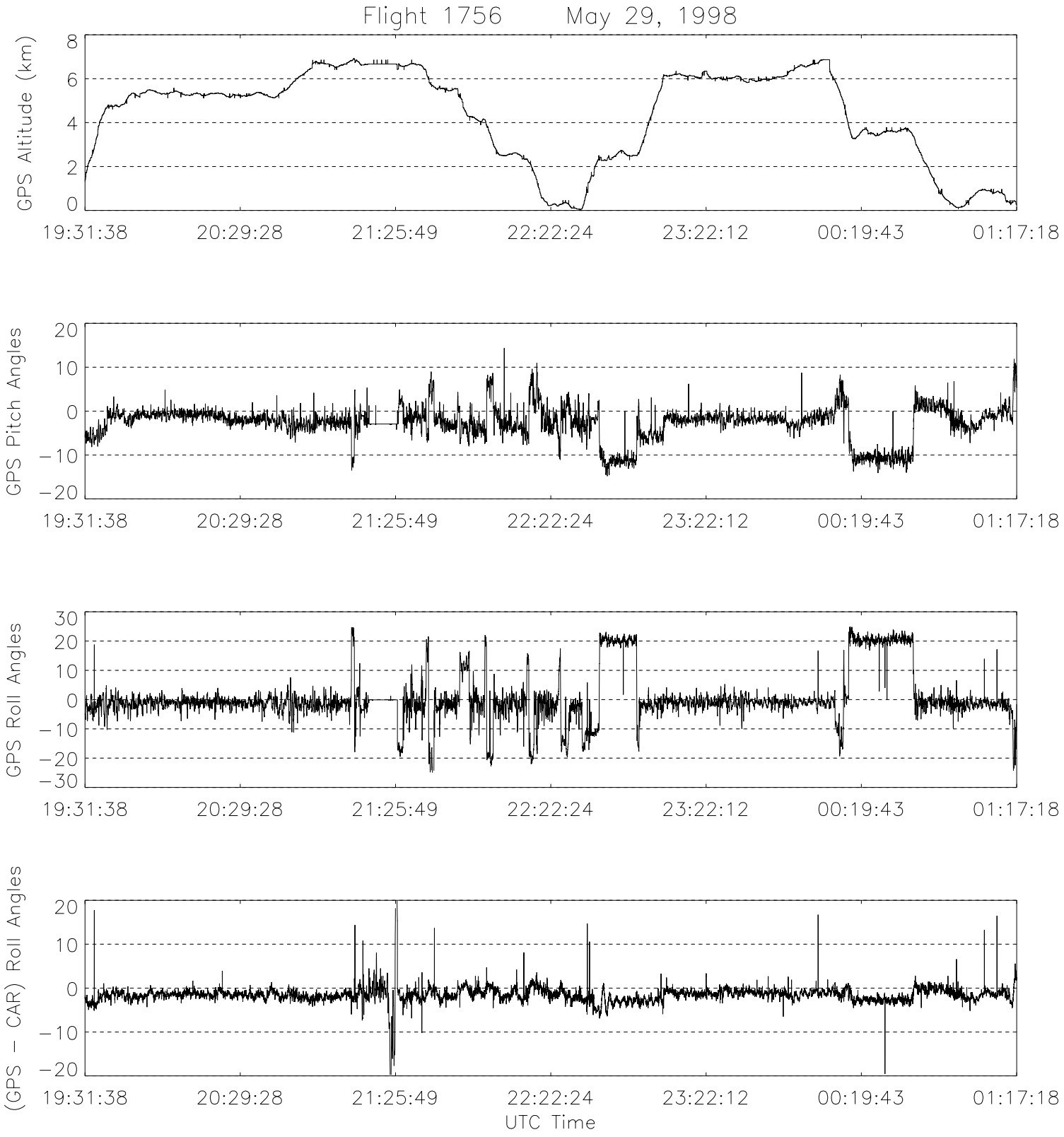

16. BRDF cloud scene (case 1)


17. BRDF cloud scene (case 2)


18. BRDF cloud scene (case 2),glory visible


19. BRDF cicles drifted with wind to NE

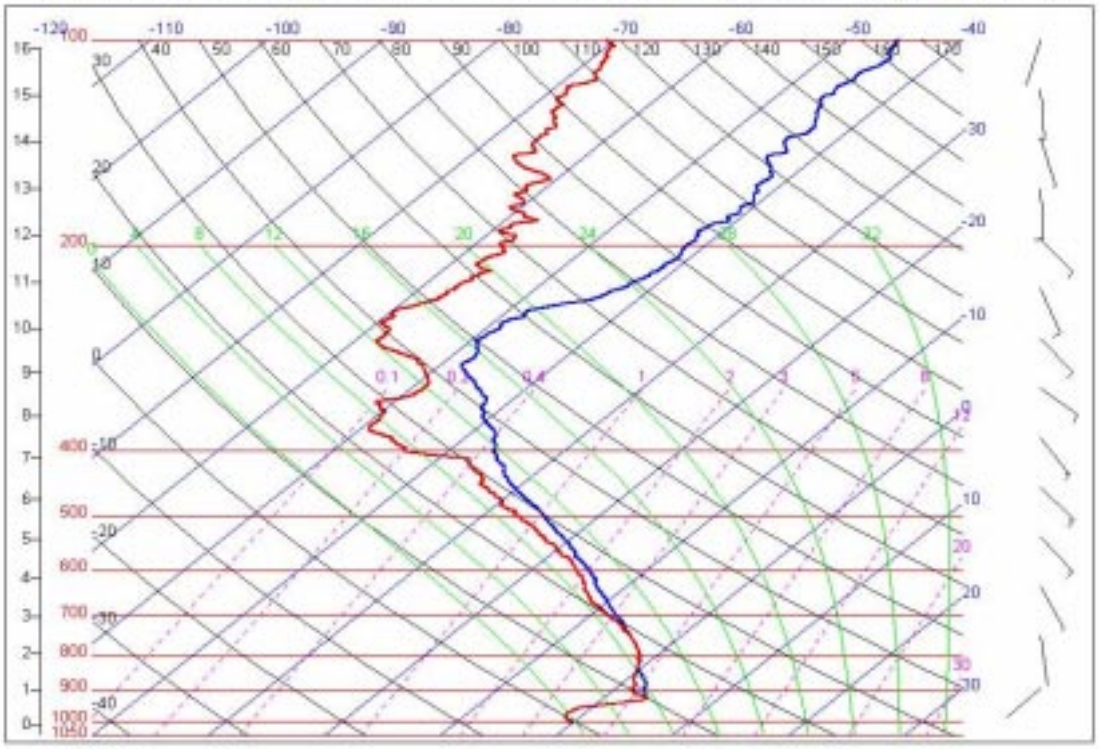

20. icing/riming check on SSFR dome


Flight 1756 May 29, 1998
GPS Altitude (km)
8
6
4
2
0
19:31:38
20:29:28
21:25:49
22:22:24
23:22:12
00:19:43
01:17:18
GPS Pitch Angles
20
10
0
−10
−20
GPS Roll Angles
30
20
10
0
−10
−20
−30
(GPS − CAR) Roll Angles
UTC Time

SHEBA Sounding

May 29, 1998

Version: SHEBA--GPS Soundings, GLASS 1.10 Fixed, SHE, 1998,05,29, 11:21:05



May 30, 1998

CV-580

Flight summary

Flight track

CAR notes

GPS plots

SHEBA

LIDAR image

Sounding

UW CV-580 FLIGHT LOG
May 30, 1998

Author (Mission Scientist): Hobbs , Peter

Flight Number: 1757
Engines On: 1906
Engines Off:2426
Departure Airport: Barrow
Arrival Airport: Barrow

Clouds sampled: Ac

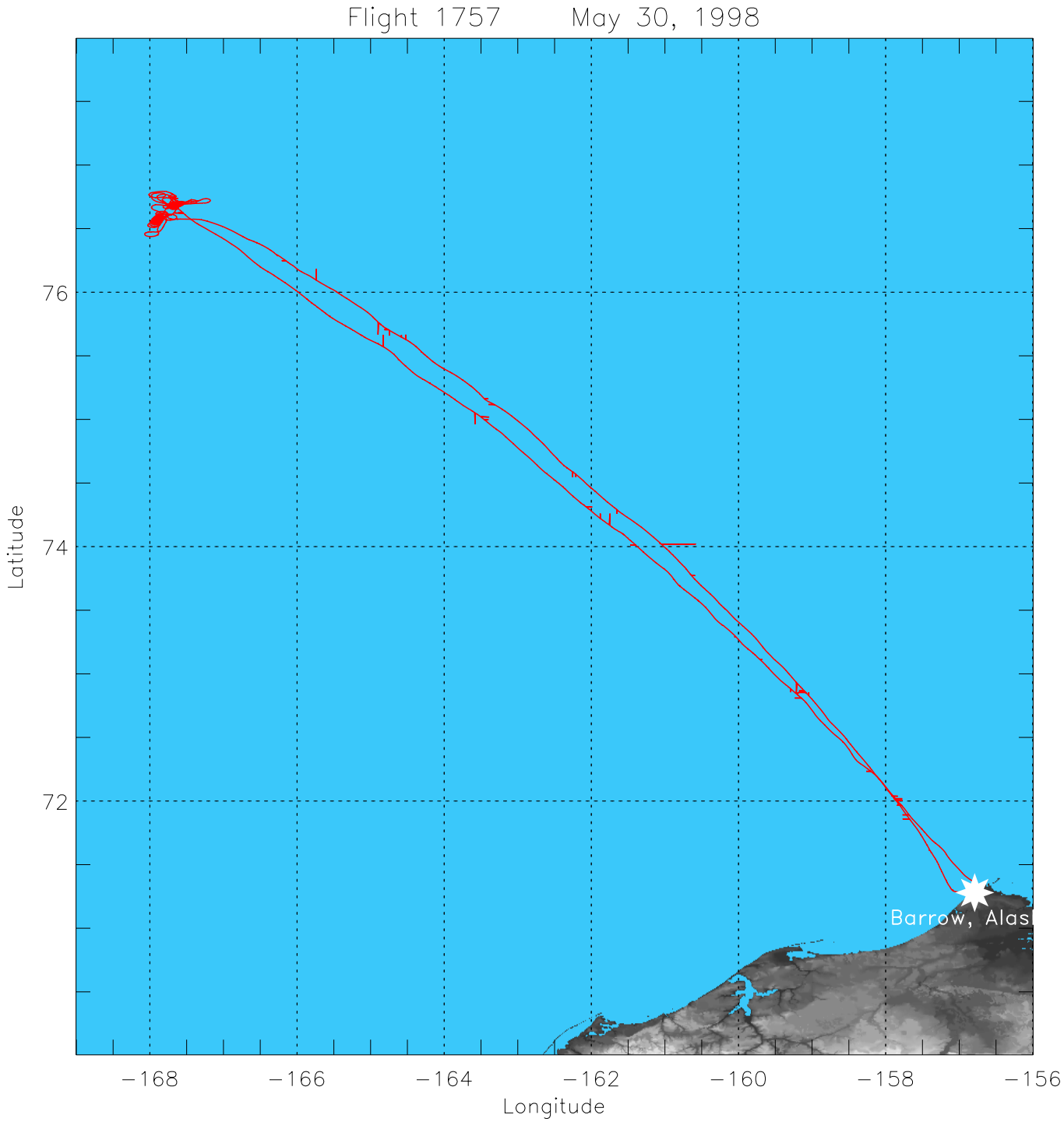
Summary:
We concentrated on measurements over the SHEBA ship on this flight. There was a single layer of shallow, broken Ac over the ship, and visibility at the surface was good. Therefore, airborne measurements were possible above, in, and below the cloud. Unfortunately, the ER-2 was grounded. However, there was a satellite overpass during the two hours we were on station.
1) 1910-2050 UTC: Transit to ship. (variable cloud above and below)
2) 2056-2120 UTC: BRDF measurements above patchy Ac layer over the ship.
3) 2120-2125 UTC: Level pass above Ac layer through center of the BRDF turns (for SFFR measurements).
4) Descended through Ac layer.
5)~ 2135-2140 UTC: BRDF measurements again, but below Ac layer this time.
6)~2140-2200 UTC: Two straight and level runs above both legs of ground-based, L shaped, albedo site for radiation measurements.
7) BRDF circles in clear air, with broken Ac above, centered on the SHEBA ship.
8) 2221 UTC: Ascended over ship through Ac layer. (good measurements of cloud base and top heights.
9) Flight over ship in Ac layer.
10) 2230 UTC: Left SHEBA site for return to Barrow.

NOTE: Pilewskie SSFR radiometer on top had ice inside, at back outside of dome on ground after flight no ice on lower radiometer dome.

Research Crew: Hobbs, Rangno, Russell, Spurgeon, King, Weiss, Garrett, Young, Radke, Sutherland, Sorensen

Equipment Failure:
1. King
2. IRTHAR
3. Humidograph (overheating?)
4. Gas instrument not receiving flow (leak?)

FIRE-III Objectives Addressed:
Cloud and radiative measurements over SHEBA ship.


Flight 1757 May 30, 1998
76
74
72
Latitude
−168
−166
−164
−162
−160
−158
−156
Longitude
Barrow, Alas

Flight 1757 - May 30, 1998

main

1 Summary

2 Photos

3 Quicklooks

1 CAR Flight Summary

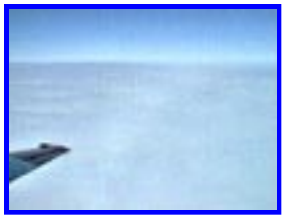
For this flight, we mainly concentrated on measurements over the SHEBA ship. Take off was at 19:10. There was stratus cloud cover below on the way out to the ship with clear skies above. The cloud layer became thin and patchy at times. We did BRDF measurements above the altocumulus cloud layer over the ship. The cloud layer was patchy and some sea ice visible. At other points during the BRDF measurements, the cloud layer was uniform and no ground was visible. We then did a pass through the center of the BRDF measurements above the altocumulus cloud layer over the ship. There was another set of BRDF measurements taken over the ship below cloud layer. During these circles, the car was in position 3, BRDF mode with sea ice below with large leads and broken clouds above. For the last part of the flight, we flew in the cloud layer over the ship before returning to Barrow.

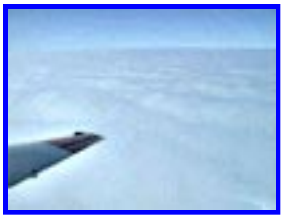
Climbed out through altocumulus cloud layer over Barrow, switched CAR to nadir imaging mode, filterwheel was locked on 2.2 µm band, imaged clouds then clear ice, pure first year ice, brighter in the 0.47 µm band then in the other bands, leads apparent in the ice.

1700: perfectly clear ice, switched filterwheel to 1.6 µm band.
3600: full halo.
5688: switched filterwheel to 2.2 µm band, imaging stratocumulus clouds.
6030: stratus cloud layer below breaking, open ice appearing, cruising at 17,454 ft.
6384: albedo ~ 0.68.
6878-7229: some ice is visible through patchy altocumulus clouds, albedo ~ 0.63.
7366: sea ice is very visible, very thin cloud layer below.
8444: very solid cloud layer below, albedo ~ .79.
9260: switched to position 3 to BRDF mode, 4 miles to SHEBA ship.
9479: uniform altocumulus below, GPS altitude 9,263 and leveling off.
9748: cloud layer breaking up below, ice is visible.
10032: starting BRDF circles [1][2].
10291: glory visible, attempted to take a picture of glory but failed.
10376-10533: ground is visible through patchy altocumulus, GPS altitude 8,900 ft [3].
10855: altocumulus cloud layer over the SHEBA ship breaking up at points during the BRDF measurements [4][5], sea ice visible through breaking cloud layer.
11175: switched filterwheel to 1.64 µm band at GPS altitude 9,000 ft.
11787: clouds thicker here, no ground is visible.
12166: completing 9th turn, thin cloud layer with some ice visible.
12430-12520: switched CAR to nadir imaging mode, specular reflection of the sun off of the clouds.
13144: CAR was switched to position 2, penetrate cloud layer at 8500 ft.
13253-13339: below cloud layer at GPS altitude 6500 ft.
13476: broken stratus below, sea ice visible, reff = 8 µm.
13728: descending at 6,200 ft.

13942: glory visible.
14105-15805: clear view of ice below, no lower cloud layer, CAR in nadir imaging mode with the SHEBA ship on the right side of plane [6][7][8][9][10].
14798: CAR switched to zenith scanning mode, patchy altocumulus clouds above.
15290: CAR switched to nadir imaging mode.
15917: altocumulus clouds on top, stratus below.
16187: CAR is in zenith imaging mode, broken clouds.
16505: CAR was switched to BRDF mode, ice with large leads.
16770: start BRDF measurements, broken altocumulus above, start 1.64 µm filterwheel.
16975: big lead in scan.
17127: over the SHEBA ship.
17555: switched CAR to 2.2 µm filterwheel.
18099: CAR is now in zenith imaging mode.
18788: band of blue on the horizon.
19033: switched to BRDF mode, ice with large leads.
19134: cloud base at 7400 ft, super cooled water droplets.
19405: CAR is in nadir position, GPS altitude 8100 ft, well outside of cloud thickness, 7777 ft cloud top reff = 6µm, very few columns.
19820: switch to starboard position, precip out of this stratus.
24500: switched to zenith mode, overlying cirrostratus.
28455: turned CAR to nadir mode, scan near principle plane, auto filterwheel.
29244: clouds left, only ice, nadir scan, leads in ice visible.

Photo Records:


1. BRDF over alto cu


2. BRDF over alto cu

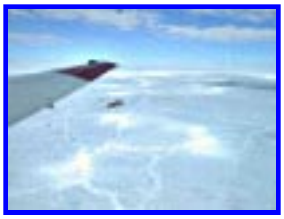

3. BRDF scene


4. BRDF scene


5. BRDF scene

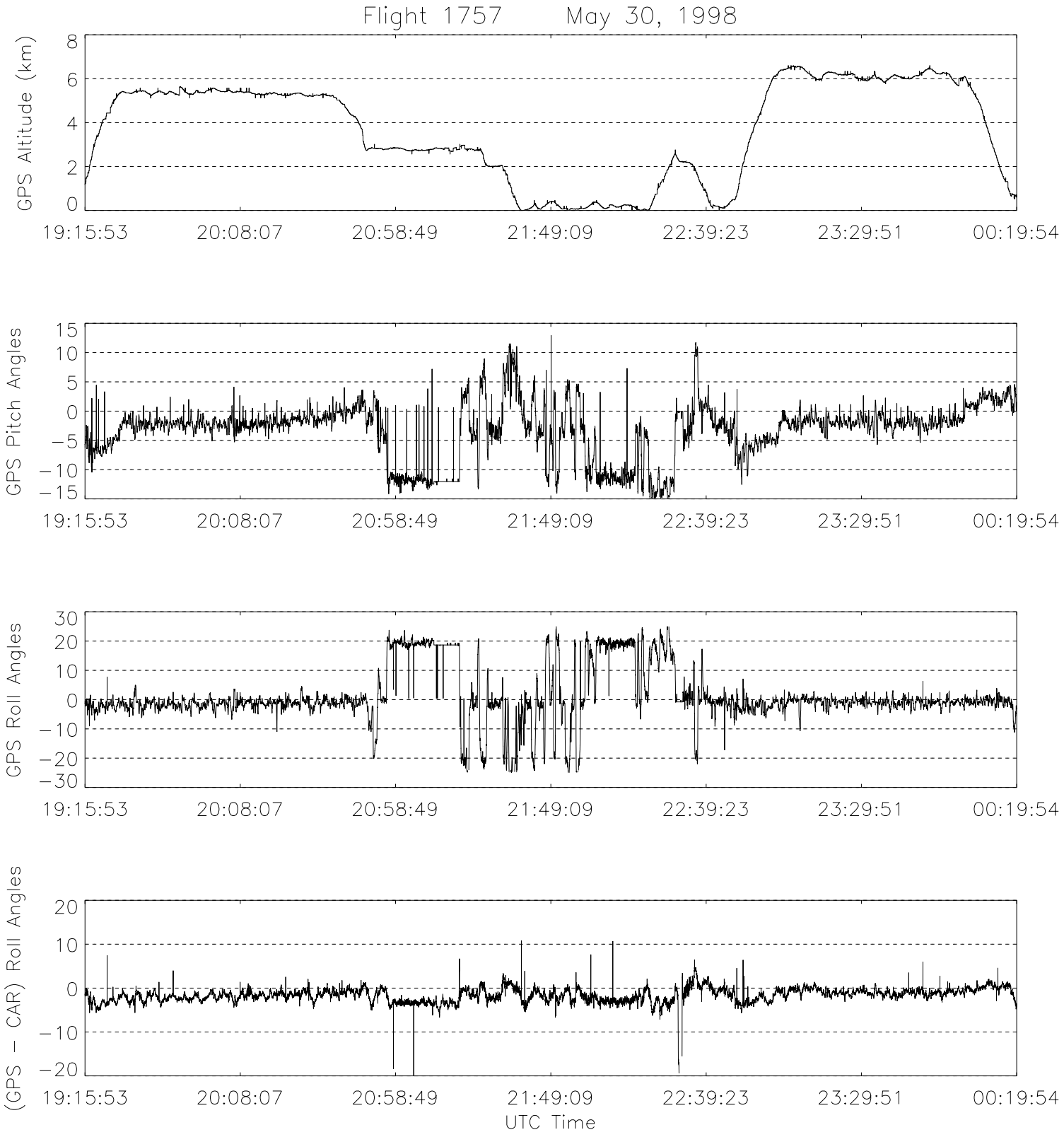

6. SHEBA ice station


7. SHEBA ice station

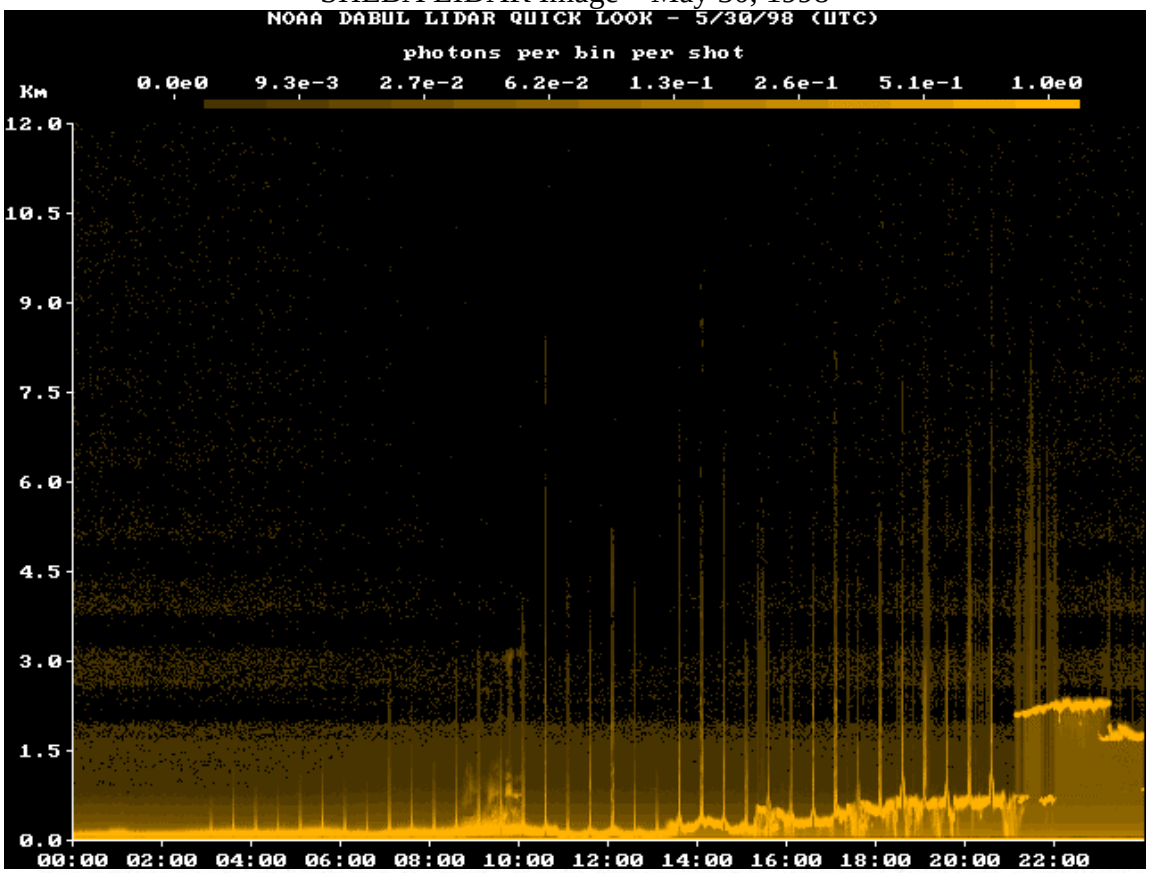

8. SHEBA ice station


9. SHEBA ice station

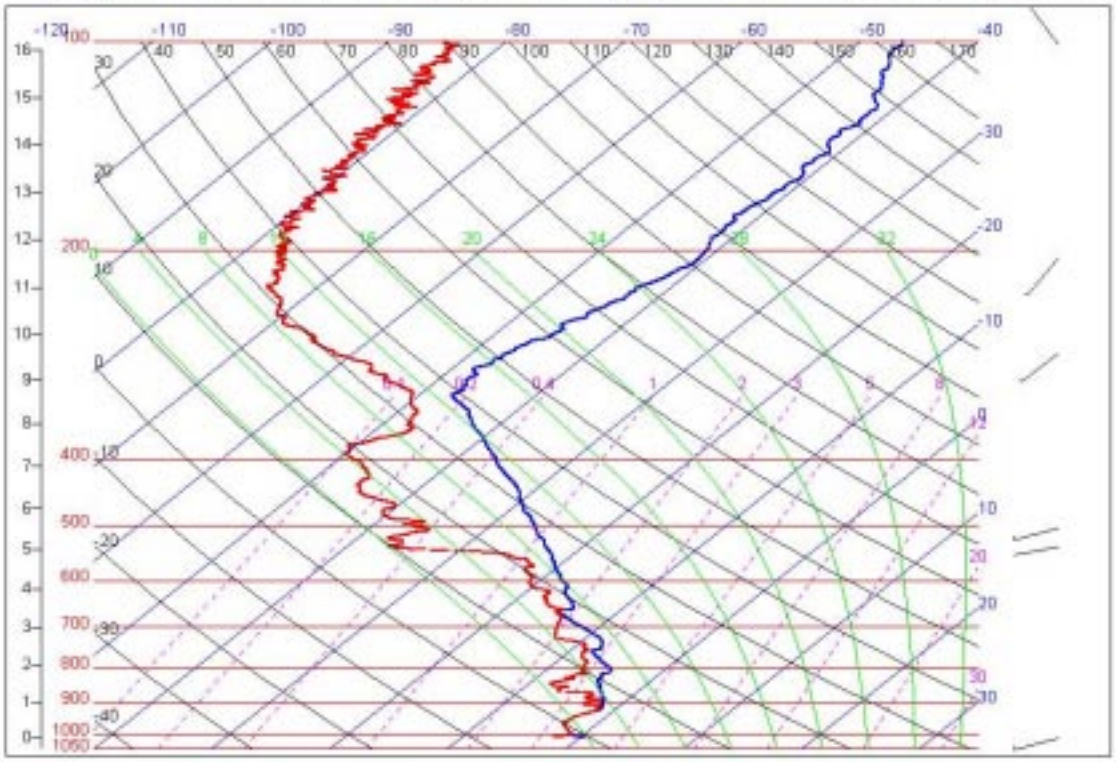

10. SHEBA ice station


Flight 1757 May 30, 1998
GPS Altitude (km)
8
6
4
2
0
19:15:53
20:08:07
20:58:49
21:49:09
22:39:23
23:29:51
00:19:54
GPS Pitch Angles
15
10
5
0
−5
−10
−15
GPS Roll Angles
30
20
10
0
−10
−20
−30
(GPS − CAR) Roll Angles
20
10
0
−10
−20
UTC Time

SHEBA LIDAR Image – May 30, 1998



Version: SHEBA--GPS Soundings, GLASS 1.10 Fixed, SHE, 1998,05,30, 11:15:03



June 1, 1998

CV-580

Flight summary

Flight track

CAR notes

GPS plots

SHEBA

LIDAR image

Sounding

UW CV-580 FLIGHT LOG
June 1, 1998

Author (Mission Scientist): Hobbs, Peter

Flight Number: 1758
Engines On: 2000
Engines Off: 2505
Departure Airport: Barrow
Arrival Airport: Barrow

Surface Met & Visual Obs on Take-off: Ci

Clouds sampled: Ac

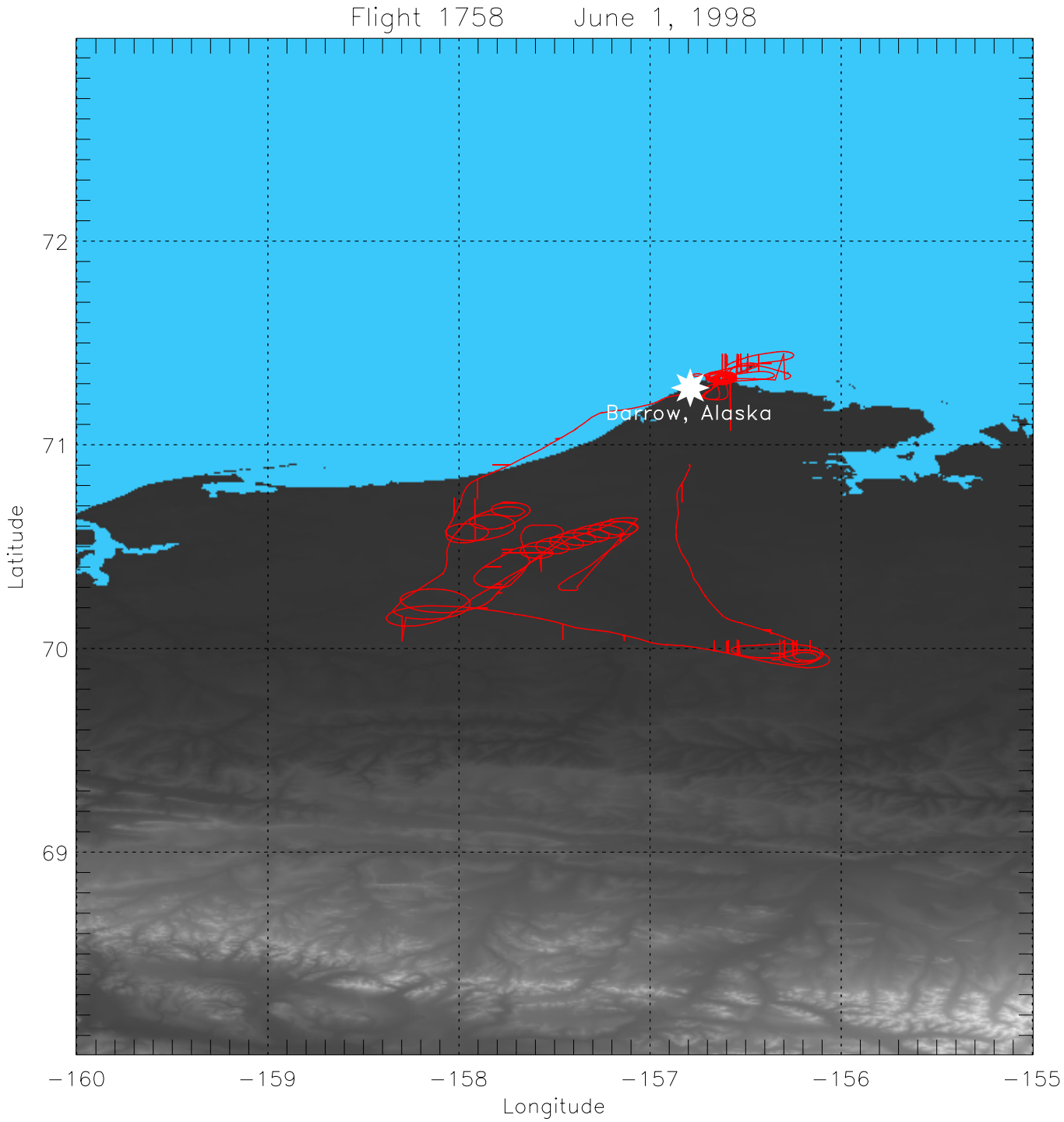
Summary:
Surface albedo and BDRF measurements over ARM site with cloudless sky, followed by spiral to 14kft over ARM. BRDF and structural measurements of Ci. Structural measurements in Ci.

Time Sequence:
1) 2013-2030 UTC: Level flights at 2,000 ft over ARM under clear sky.
2) 2037-2100 UTC: BRDF measurements centered on ARM (ten turns)
3) 2112 UTC: Over ARM at 2,000 ft.
4) 2112-2035 UTC: Spiral to 14,000 ft above ARM in clear air. Weak aerosol layer at 9,500 ft.
5) 2135-2142 UTC: Level run at 9,500 ft in aerosol layer.
6) 2218-2240 UTC: Climb to above cirrus tops.
7) 2240-2250 UTC: Level runs above cirrus.
8) 2252-2351 UTC: BRDF of cirrus.
9) 2325-2335 UTC: Level runs beneath Cirrus.
10) 2400-2410 UTC: Level runs in cirrus at 25,000 ft.
11) 2410-2430 UTC: Descent through cloud to altocumulus layer followed by a level run through the cloud.

Research Crew: Hobbs, Radke, Rangno, Weiss, Garrett, Russell, Spurgeon, Gray, Pezzolo, McMillan, Sutherland

Equipment Failure:
1. King Probe
2. Gases
3. IR unreliable

FIRE-III Objectives Addressed:
1. ARM surface albedo and BRDF
2. Ci BRDF
3. Ci structure and Ac structures


Flight 1758 June 1, 1998
Barrow, Alaska
72
71
70
69
Latitude
−160
−159
−158
−157
−156
−155
Longitude

Flight 1758 - June 1, 1998

main

1 Summary

2 Photos

3 Quicklooks

1 CAR Flight Summary

Made 2 BRDF measurements (over tundra and cirrus cloud) near the ARM site.

The flight started at 20:07 (UTC) with clear skies (10% cloud cover). Initially the CAR was set scanning downwards (position1) and a test of the auto rotating filter wheel revealed continuing noise problems.

Soon after the start of the flight a BRDF measurement was attempted over the ARM site. Ground cover was open tundra, partially snow covered (~50%). The decision was made to fly around a constant location. Moderate wind in the area meant that maintaining a constant roll angle was not trivial for the pilots. For the 10 loops the roll angle varied (often) between -1° and 28°. Most often the roll angle was between 9° and 25° (scans 2807-5177) [1][2][3][4][5][6][7] (hi-resolution version: [4][5][6][7]).

On completing the first BRDF, there was a problem with the CAR positioning system. The CAR was stuck in the BRDF mode (position 3) and frequent attempts to re-position the CAR failed. As a result all measurements were taken in the BRDF position. There is a question over the value of the data collected.

A second BDRF measurement was made over cirrus cloud while the aircraft flew at 27500 ft. 10 loops were made over the cloud, which thinned during the measurement. At the completion of the loops the ground was clearly visible through the cloud

Photo Records:


1. BRDF over ARM


2. BRDF over ARM


3. BRDF over ARM


4. BRDF over ARM


5. BRDF over ARM

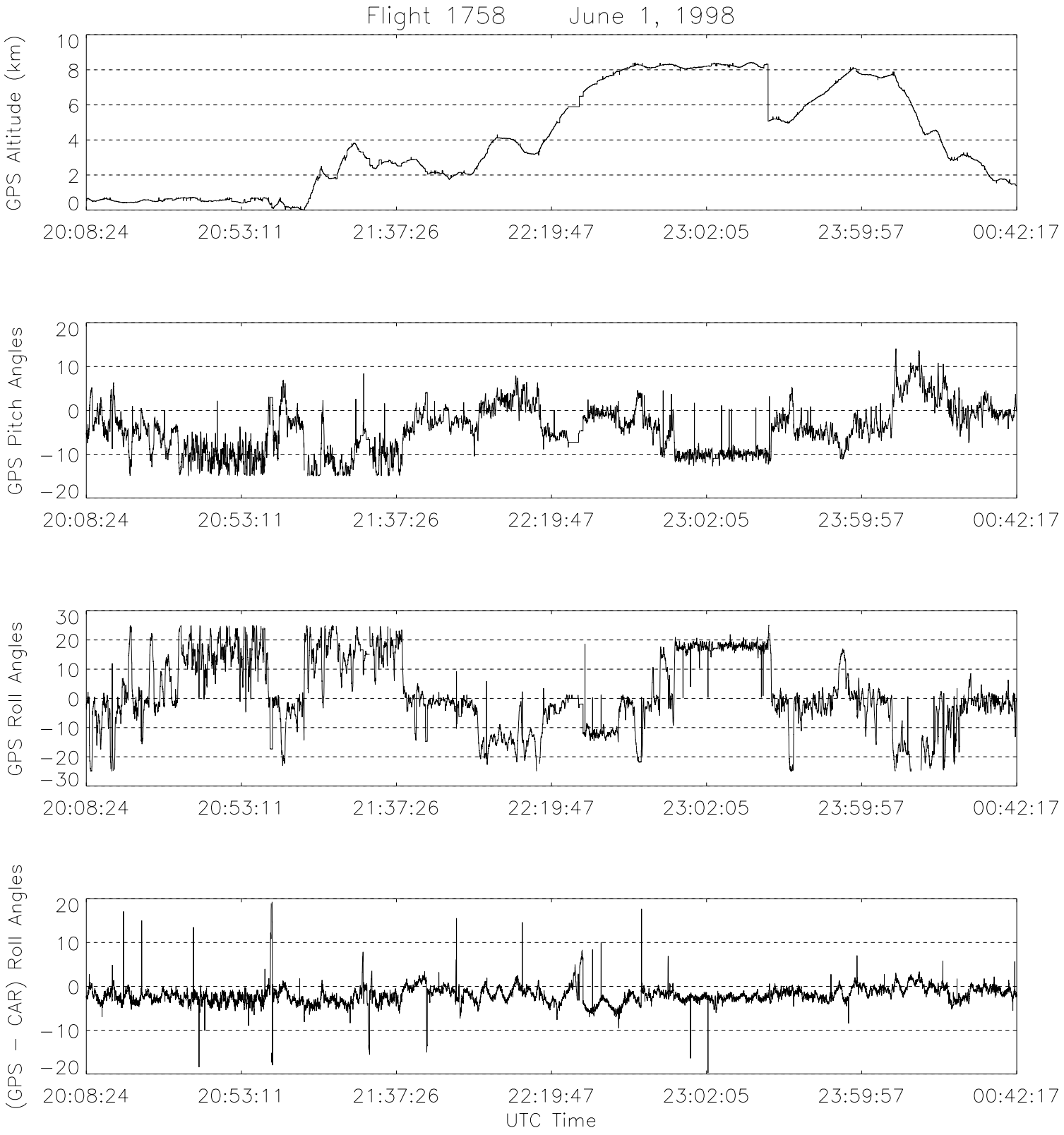

6. BRDF over ARM


7. Barrow and vicinity

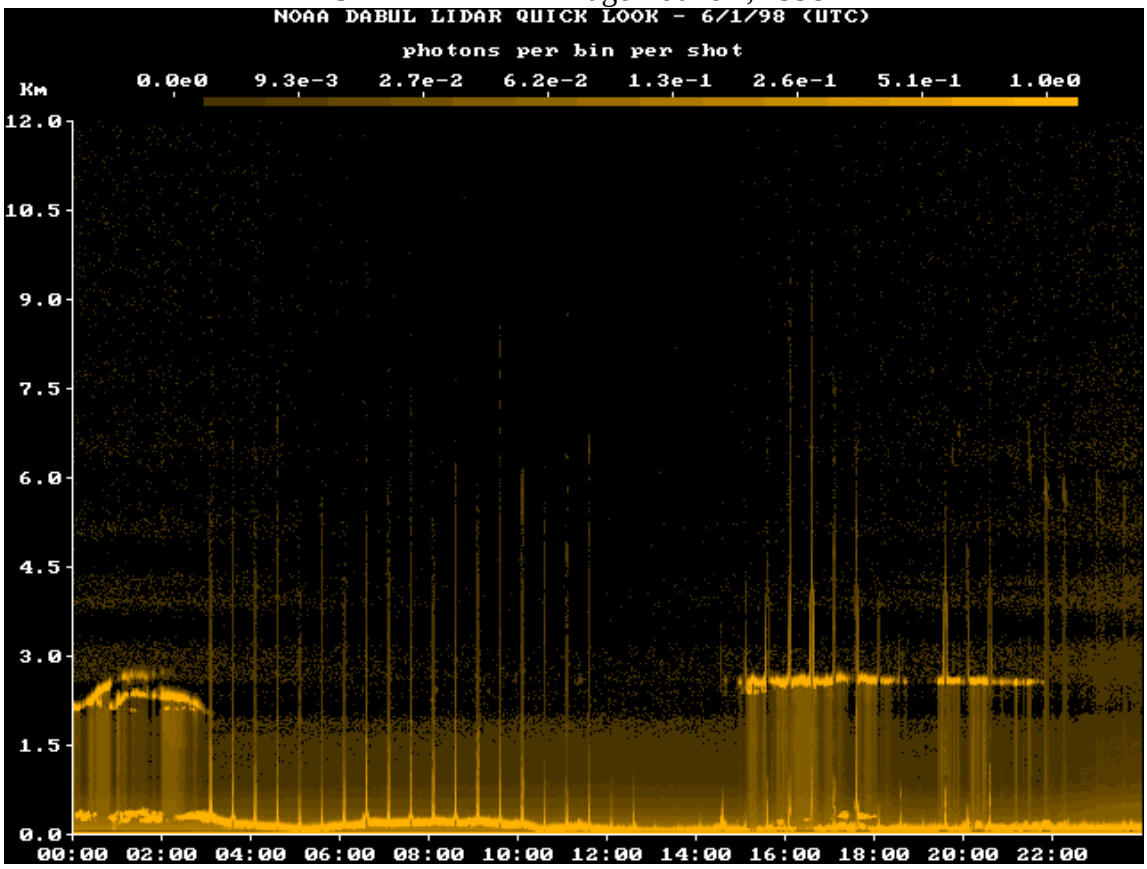
Flight Track and Quicklook Images:

- CV-580 flight tracks
- GPS roll and pitch angle

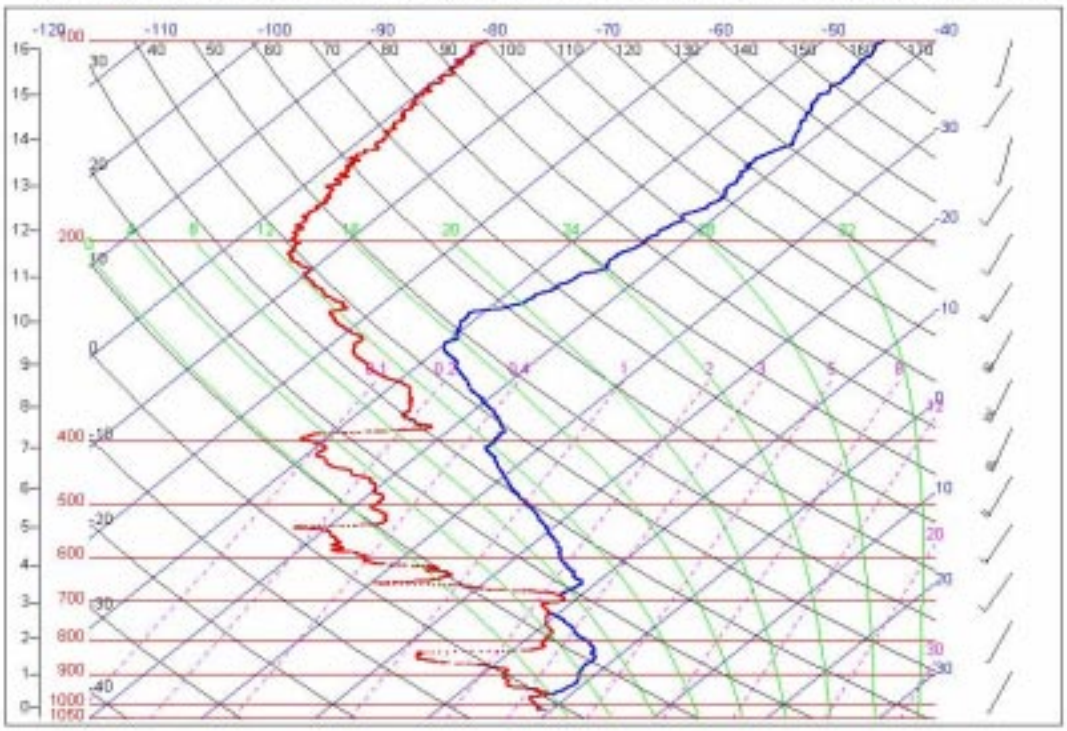
Back to Top


Flight 1758 June 1, 1998
GPS Altitude (km)
10
8
6
4
2
0
20:08:24
20:53:11
21:37:26
22:19:47
23:02:05
23:59:57
00:42:17
GPS Pitch Angles
20
10
0
−10
−20
GPS Roll Angles
30
20
10
0
−10
−20
−30
(GPS − CAR) Roll Angles
UTC Time

SHEBA LIDAR Image – June 1, 1998



Version: SHEBA--GPS Soundings, GLASS 1.10 Fixed, SHE, 1998,06,01, 11:15:04



June 2, 1998

ER-2

Flight summary

Flight track

Ground track

MAS images

HIS images

Cloud LIDAR System image

AMPR images

CV-580

Flight track

CAR notes

GPS plots

SHEBA

LIDAR image

Sounding

ER-2 Mission 8

Tuesday, June 2, 1998

Flight Scientist: Steve Platnick

Objectives: Fly over the ARM site in coordination with University of Washington CV-580 aircraft for remote sensing validation and cloud masking. Continue northward without the CV-580 to fly several legs over the SHEBA ice camp (76°48'N, 167°31'W). The leg from the ARM site to the ice camp was flown in coordination with a NOAA-14 overpass. Return flight leg was over the ARM site.
Coordination included:

- F-14 satellite (2341 UTC)
- NOAA-14 satellite (2242 UTC)

ER-2 Mission:	Pilot:	Bill Collette
	Takeoff:	1940 UTC
	Landing:	0230 UTC (June 3)
	Duration:	6:50

The ER-2 flew three flight legs of about 260 km in length, oriented with the solar azimuth (about 164° at mean time of overpasses), while the CV-580 attempted above and below-cloud bi-directional reflectance measurements and in situ profiles through the cloud.
After flying over the ARM site, the ER-2 flew a NW flight line coordinated with NOAA-14 (318° heading). Because of a slightly earlier then scheduled takeoff, the pilot had to make to two circular turns en route to the start of the SHEBA legs to match the timing of the satellite overpass.
At the SHEBA ice station, the ER-2 made two-and-one-half north-south legs of about 260 km in length. Because of a late turn-on for AirMISR during the southbound leg over the ice station (point 6 to point 4), the pilot turned back to repeat the start of the leg (at point 6).
The ER-2 flew over the ARM site on the return to Ft. Wainwright.

The AirMISR was turned on for 6 acquisitions: three times over the ARM site, twice over SHEBA ice station, and once on the return over the ARM site. The AirMISR operated at the following times with notes of observed clouds as seen by the instrument:

- 2043-2055 UTC (ARM - first 5 of 9 angles gathered; broken clouds)
- 2111-2123 UTC (ARM - complete run of 9 angles; broken clouds)
- 2139-2151 UTC (ARM - complete run; broken clouds)
- 2249-2301 UTC (SHEBA - complete run; overcast with thin cloud)
- 2332-2344 UTC (SHEBA - complete run; overcast with thin cloud)
- 0101-0113 UTC (ARM - complete run; clear)

Pilot report: The ER-2 pilot reported cloud cover just north of Barrow during the flight legs over the ARM site, with clear sky to the south. Some cirrus was seen en route to SHEBA. The ice station was at the northern end of an extensive solid cloud sheet with clear sky just to the north. Barrow was clear on the return leg.

Instrument Status

- AirMISR – partial first run, last five runs worked well
- AMPR – worked well
- CLS – worked well
- HIS – worked well (had correctable time clock offset)
- MAS – worked well
- MIR – worked well
- SSFR – worked well

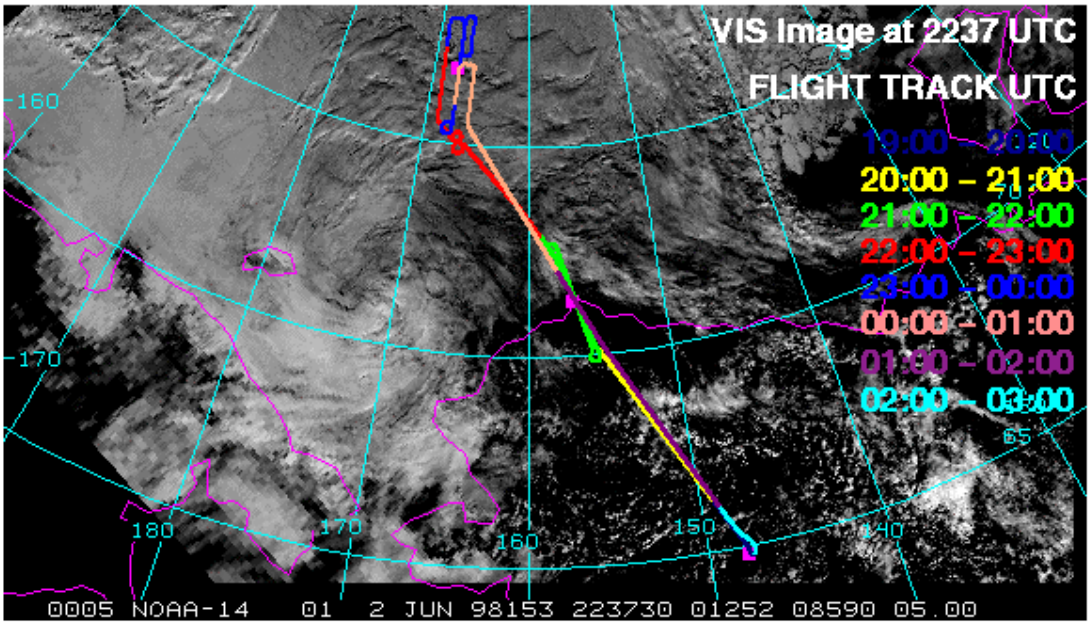
Meteorology:

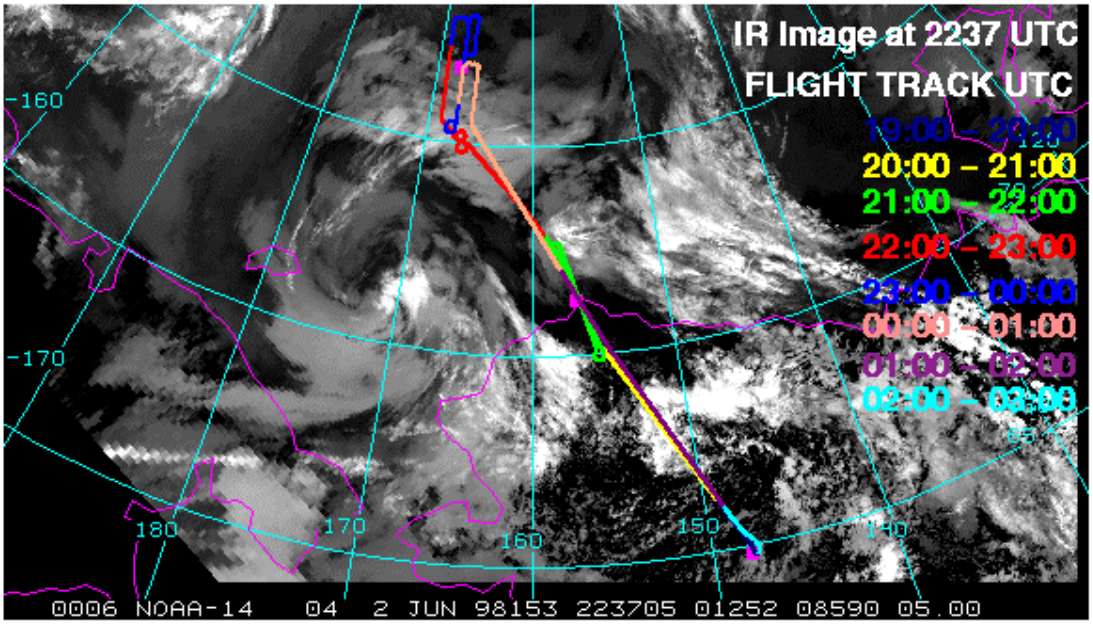
Multilevel clouds, including cirrus, were expected throughout the region.
SHEBA: Morning report of fog and clouds at all levels, including cirrus. Morning radar reported clouds from 3.1-3.8 km; surface winds southeasterly at 5 kts. Near the time of the ER-2 overpass (2100 UTC) the ice station radar reported multiple cloud layers between 0.3-1.5 km and 1.5-3.7 km. LIDAR reported liquid stratocumulus at 3.5 km. Surface observations were clear to the NE, solid cover to the south, clearer to the west, with surface winds from the northeast at 5 kts.
Barrow: Cloud conditions were expected to be similar to those at the ice station. The CV-580 flew coordinated patterns over the ARM site and reported a broken stratocumulus layer.

Instruments:

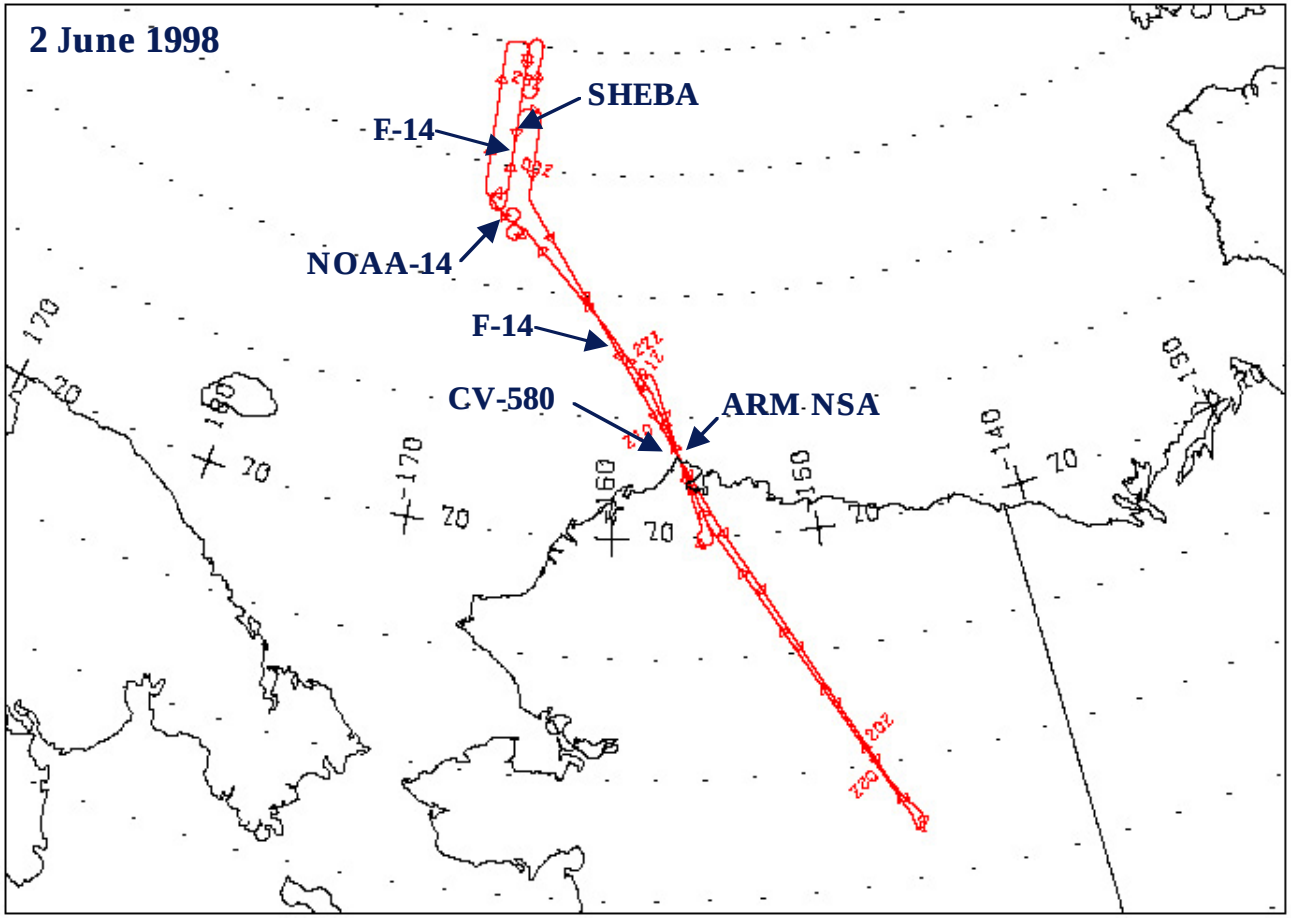
AirMISR – Airborne Multi-angle Imaging Spectroradiometer
AMPR – Advanced Microwave Precipitation Radiometer
CLS – Cloud LIDAR System
HIS – High-resolution Interferometer Sounder
MAS – MODIS Airborne Simulator
MIR – Millimeter-wave Imaging Radiometer
SSFR – Solar Spectral Flux Radiometer

ER2 FLIGHT TRACK AND NOAA–14 AVHRR IMAGES ON JUNE 2, 1998





ER-2 Ground Track



Point Barrow

Red = 1.62 μm

Green = 0.75 μm

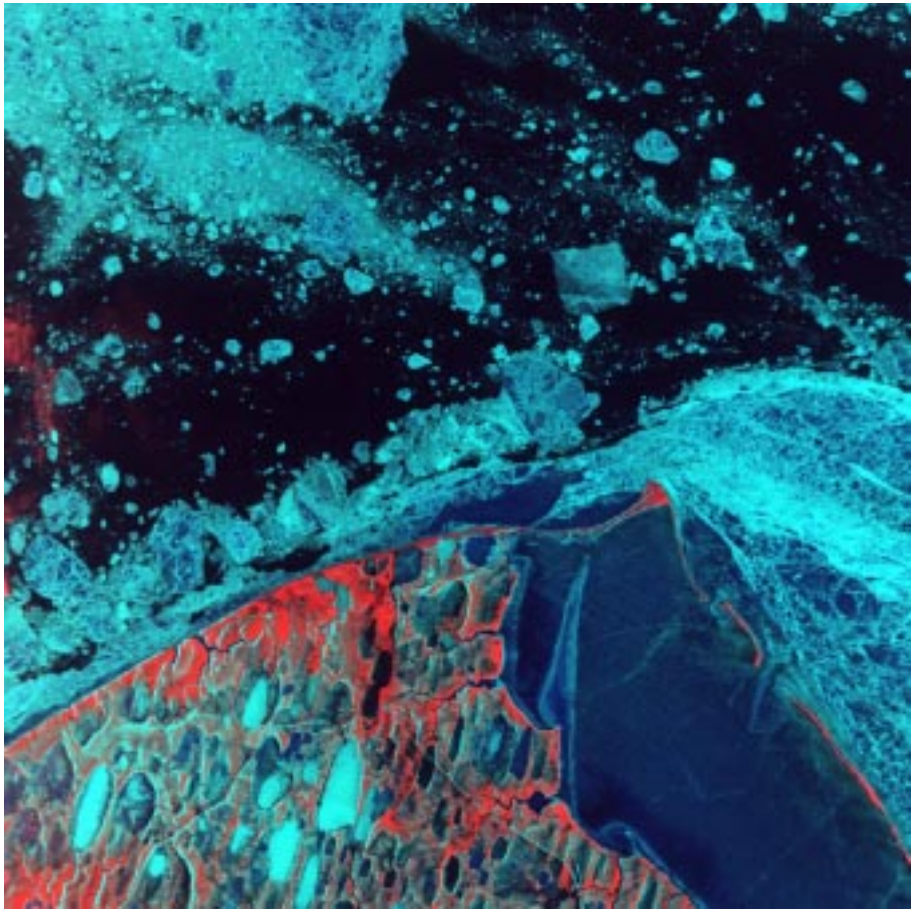
Blue = 0.47 μm

3 June 1998

71°22'N 156°41'W

0106 UTC

37.2 km



Flight Direction

151.8°

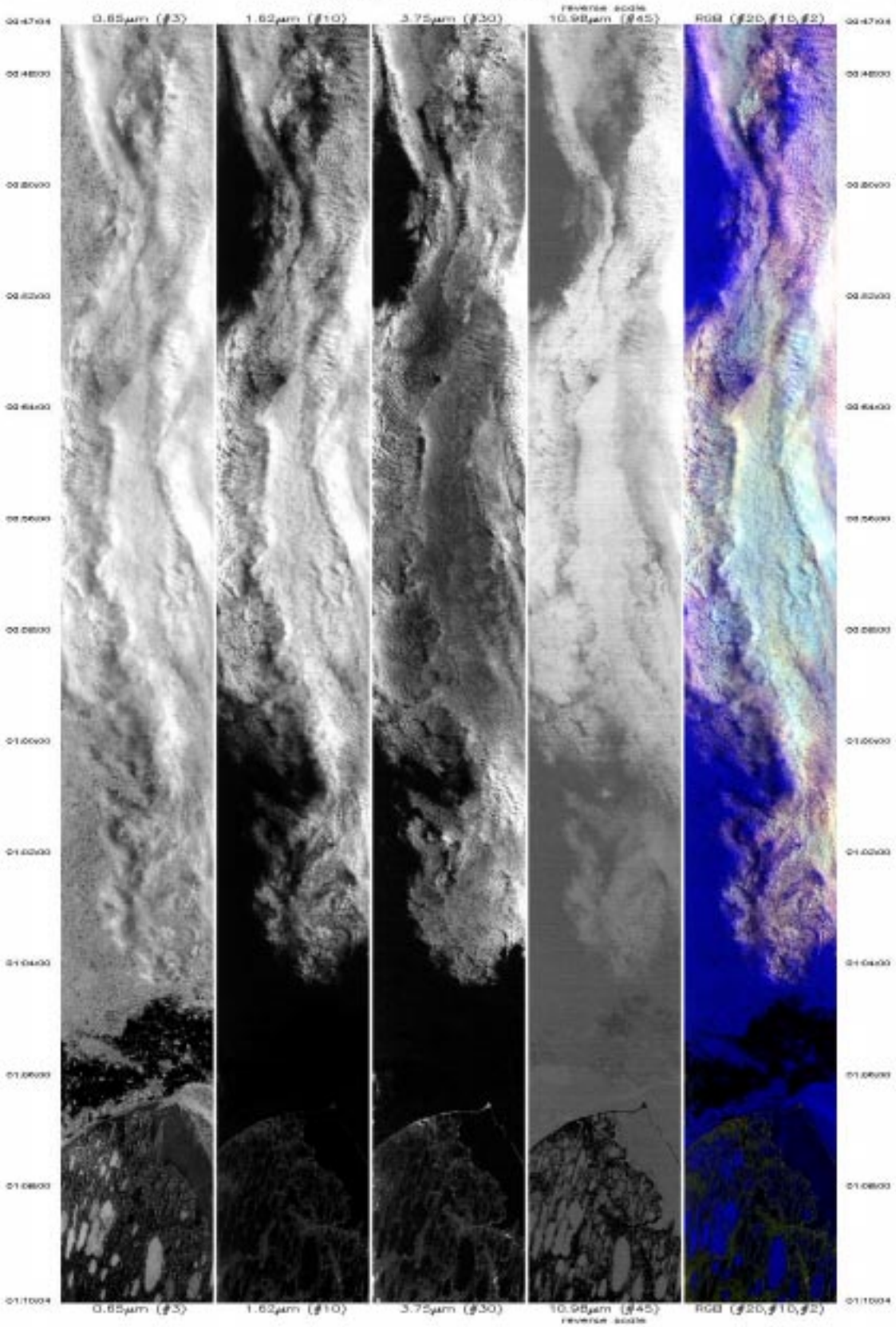
θ_0 **= 54.2°**

ϕ_0 **= 227.6°**

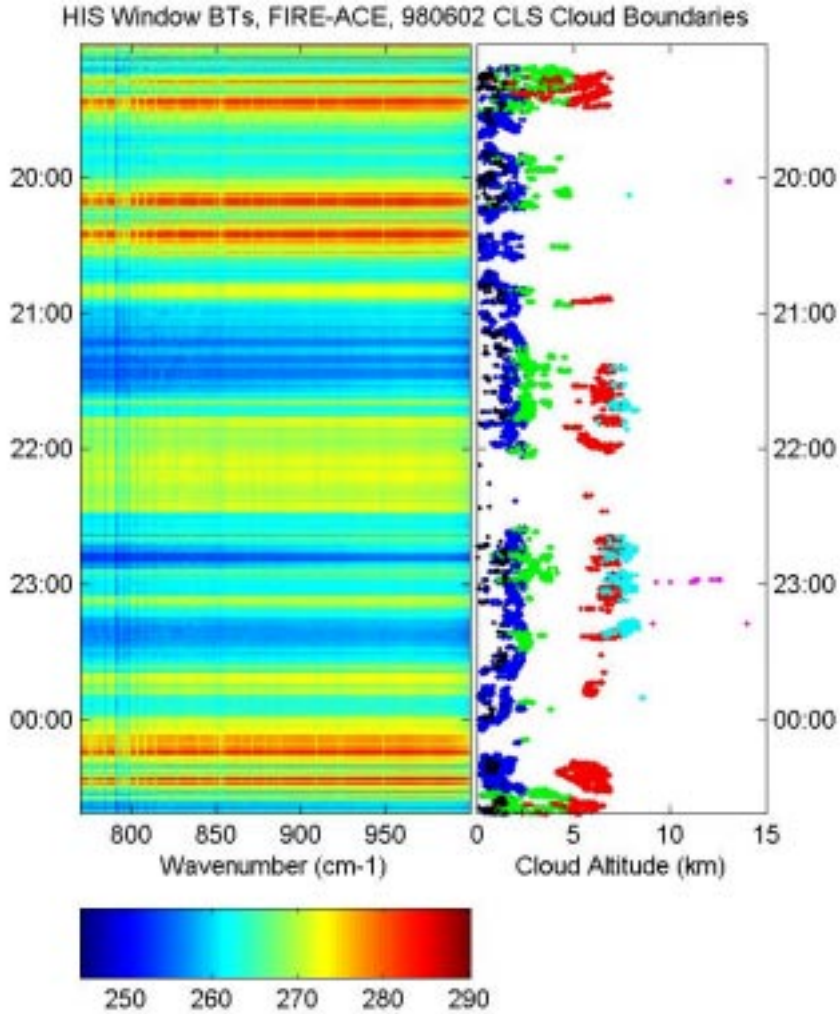
$\phi - \phi_0$ **= 165.8°**

37.2 km

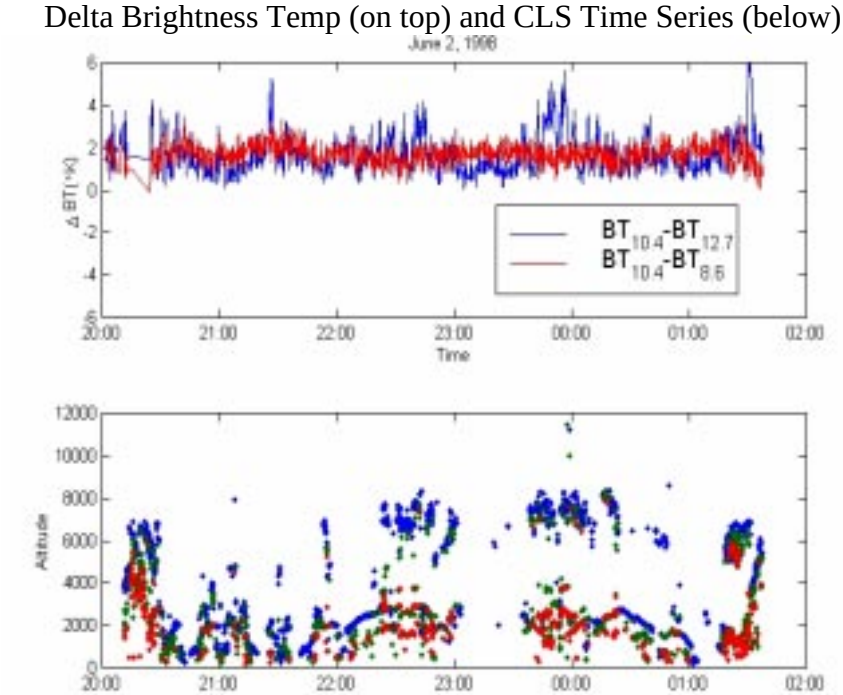
MODIS Airborne Simulator Browse Imagery
FIRE–ACE Campaign – 02–03 June 1998
Flight #98–073 Track #17



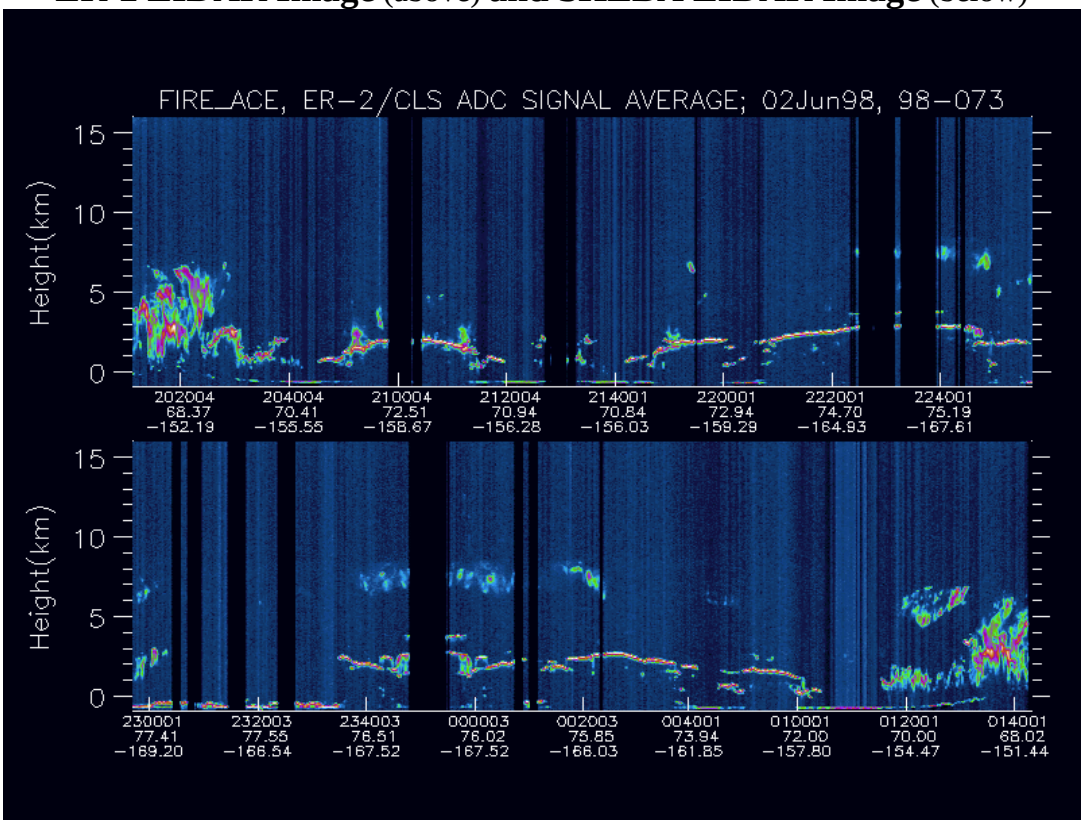
ER–2 Heading = 149.1°
Solar Zenith = 54.0°
Solar Azimuth = 216.9°

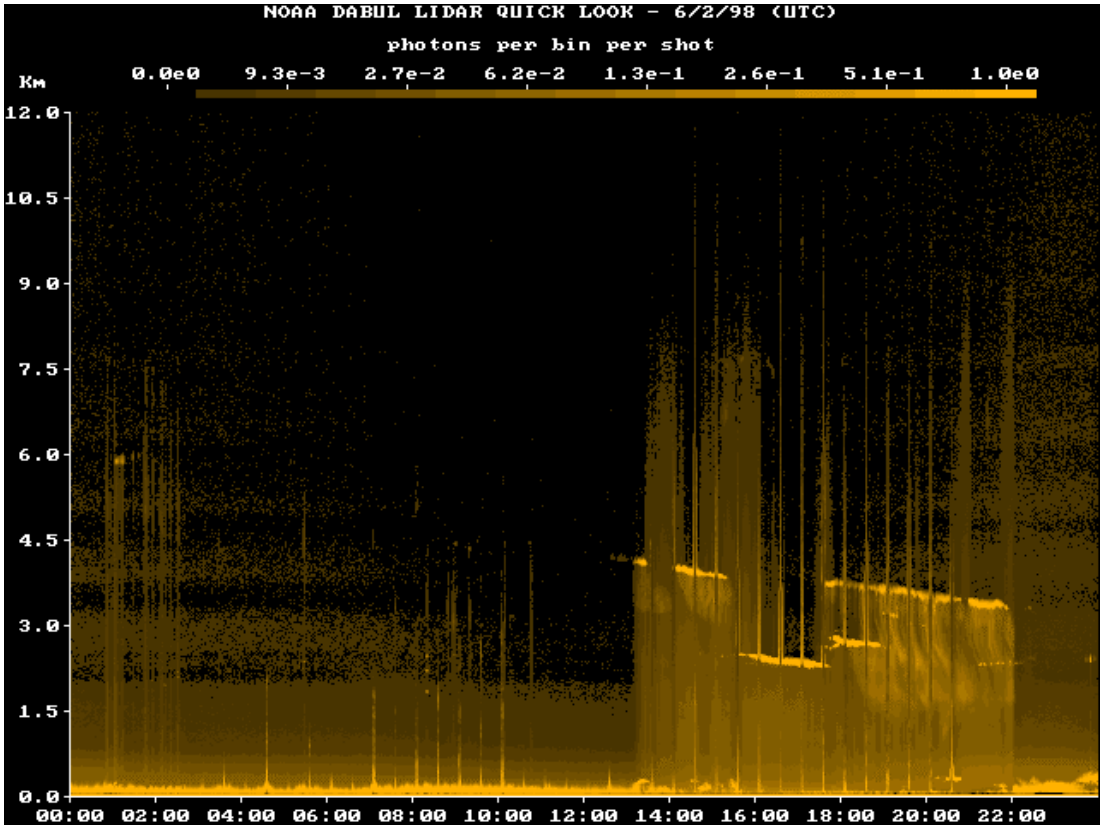


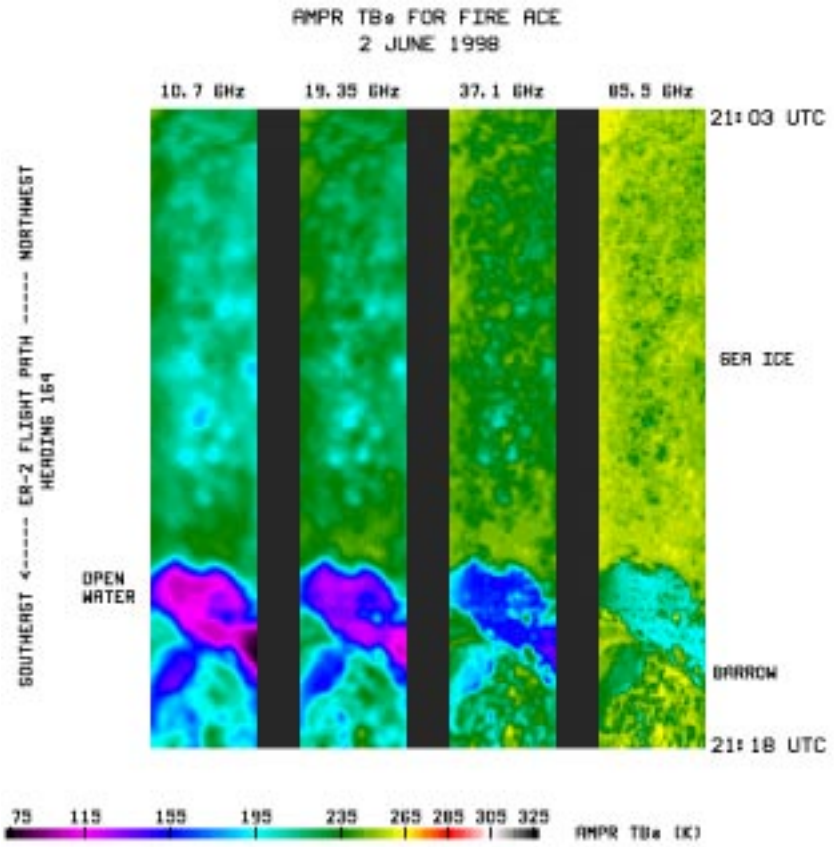
Delta Brightness Temp (on top) and CLS Time Series (below)

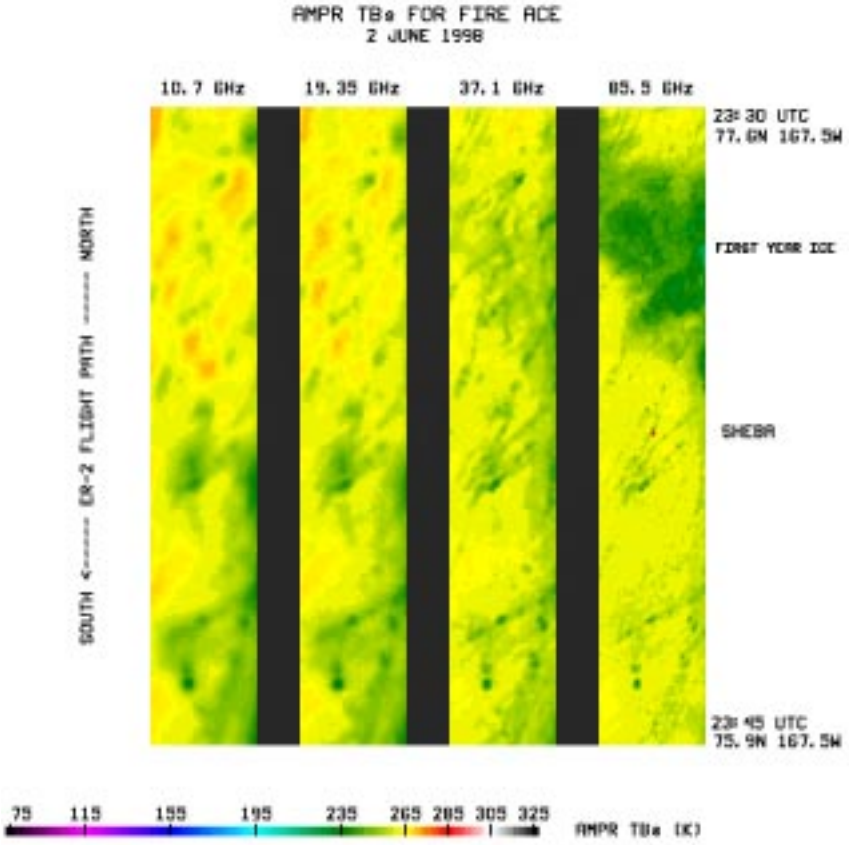


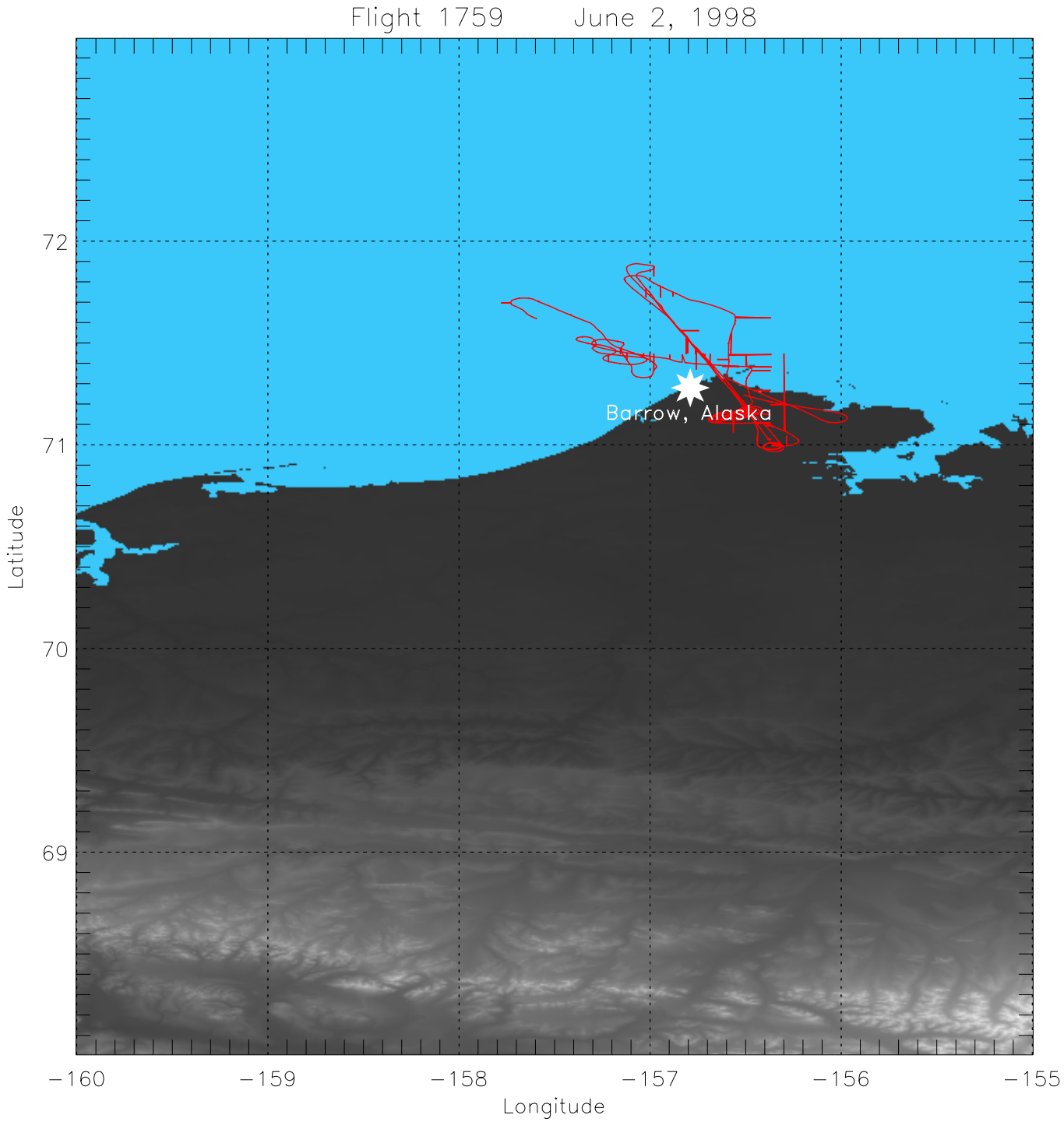
ER-2 LIDAR Image (above) **and SHEBA LIDAR Image** (below)






AMPR TBs FOR FIRE ACE
2 JUNE 1998
10.7 GHz
19.35 GHz
37.1 GHz
85.5 GHz
21:03 UTC
SEA ICE
OPEN WATER
BARROW
21:18 UTC
SOUTHEAST <----- ER-2 FLIGHT PATH ----- NORTHWEST
HEADING 164
75 115 155 195 235 265 285 305 325
AMPR TBs (K)


AMPR TBs FOR FIRE ACE
2 JUNE 1998
10.7 GHz
19.35 GHz
37.1 GHz
85.5 GHz
23:30 UTC
77.6N 167.5W
FIRST YEAR ICE
SHEBA
23:45 UTC
75.9N 167.5W
SOUTH <----- ER-2 FLIGHT PATH ----- NORTH
75 115 155 195 235 265 285 305 325
AMPR TBs (K)


Flight 1759 June 2, 1998
Barrow, Alaska
72
71
70
69
Latitude
−160
−159
−158
−157
−156
−155
Longitude

Flight 1759 - June 2, 1998

main

1 Summary

2 Photos

3 Quicklooks

1 CAR Flight Summary

The measurements for this flight were taken over the ARM site. There were several straight runs over the ARM site and 10 circles of BRDF measurements. The CAR started out scanning downward through the nadir with cumulus clouds patchy at times. The CAR was switched to zenith scanning mode flying through a stratocumulus cloud layer and then scanning clear sky. The last part of the flight consisted of 10 circles above the stratocumulus cloud layer for BRDF measurements.

20:19 (scan 12) the CAR was in nadir scanning mode (position 1) and 2.2 µm (filter wheel 5) scanning the broken cumulus below.
20:28 there is a patchy stratocumulus cloud layer below, the surface showing through is 50 percent exposed tundra and 50 percent ice
20:30 over the ARM site and heading NW at 6100 ft GPS altitude.
20:33 testing automatic filterwheel.
20:36 layer of altocumulus clouds above, over ice covered surface.
20:40 cleared main altocumulus layer, thin layer of cirrus above, leveling off at 7160 ft [1][2].
20:52 CAR scanning down at the patchy stratocumulus clouds over the sea ice [3][4].
20:55 Over the ARM site [5].
21:03 clearing the edge of the altostratus we had been flying over, cloud base 4156 ft
21:05 GPS altitude 4700 ft, large leads partially melted.
21:11 CAR in nadir scanning mode (position 1) and scanning down at partially exposed tundra below [6].
21:16 passed over the ARM site and crossed the ER2, [7] first year sea ice.
21:22 two layers of broken strato cumulus above.
21:27 30 miles outside of ARM site, begin climb through stratocumulus layer.
21:34 between two cloud layers, albedo = .61.
21:35 switched to zenith scanning mode (position 1), in and out of stratocumulus cloud layer, with cloud layer above.
21:40 CAR in zenith position and scanning clear sky.
21:42 flying through the stratocumulus layer.
21:43 over Arm site heading SE at GPS altitude 5000 ft.
21:49 continuing to go in and out of the cloud layer.
21:53 BRDF mode.
21:56 start BRDF mode at 7100 ft , will do 10 BRDF circles.
22:00 [8] the cloud layer that the BRDF measurements were being taken in.
22:08 switched to 1.6 µm (filterwheel 2) for remaining 5 circles at approx.7200 ft.
22:20 CAR switched to nadir scanning mode (position 1) and looking down at exposed tundra.

Photo Records:


1. altocumulus cloud layer below


2. altocumulus cloud layer below


3. stratocumulus clouds near ARM site


4. stratocumulus clouds over sea ice


5. over ARM site


6. partially exposed tundra

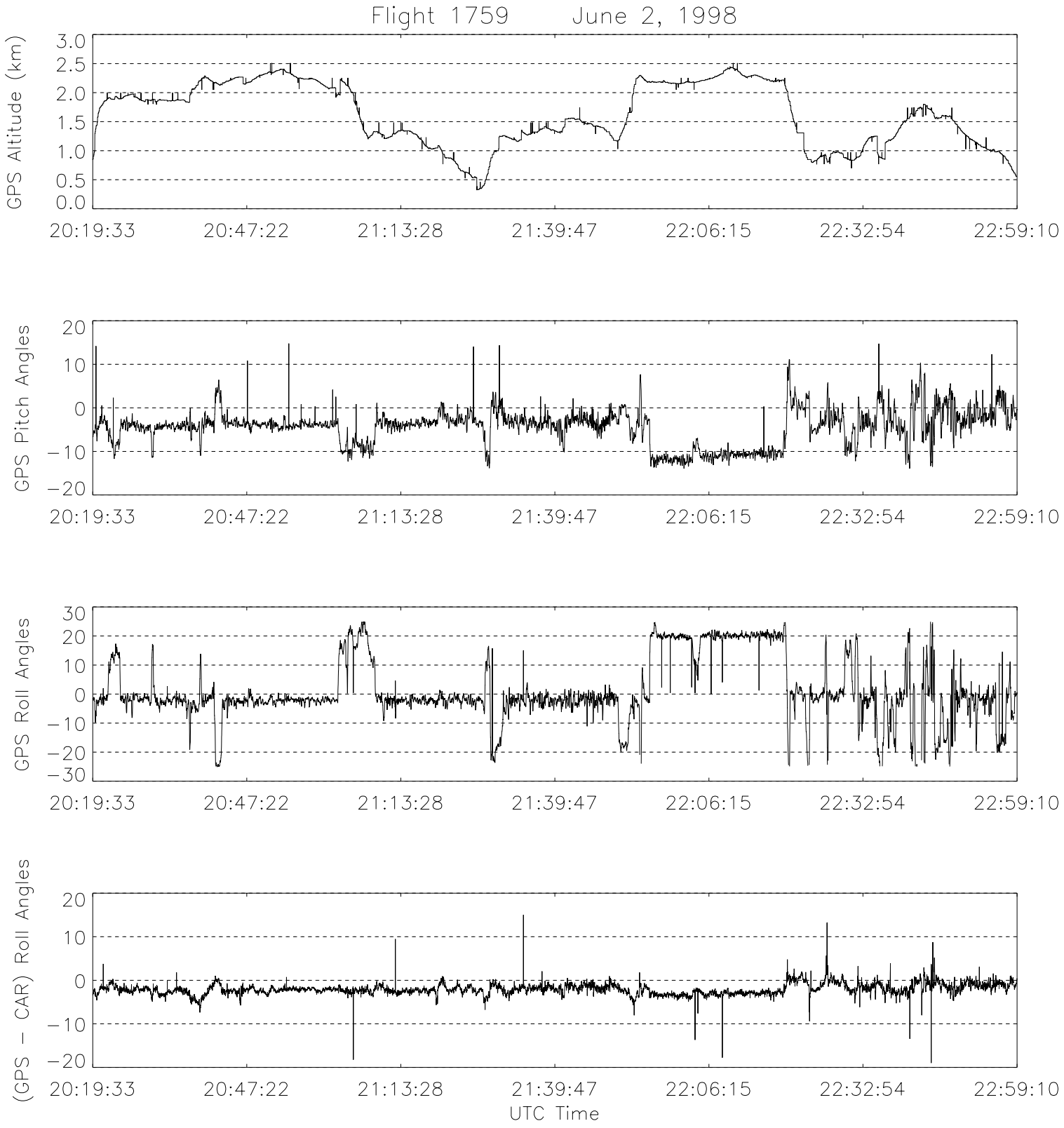

7. first year sea ice


8. BRDF measurements

Flight Track and Quicklook Images:

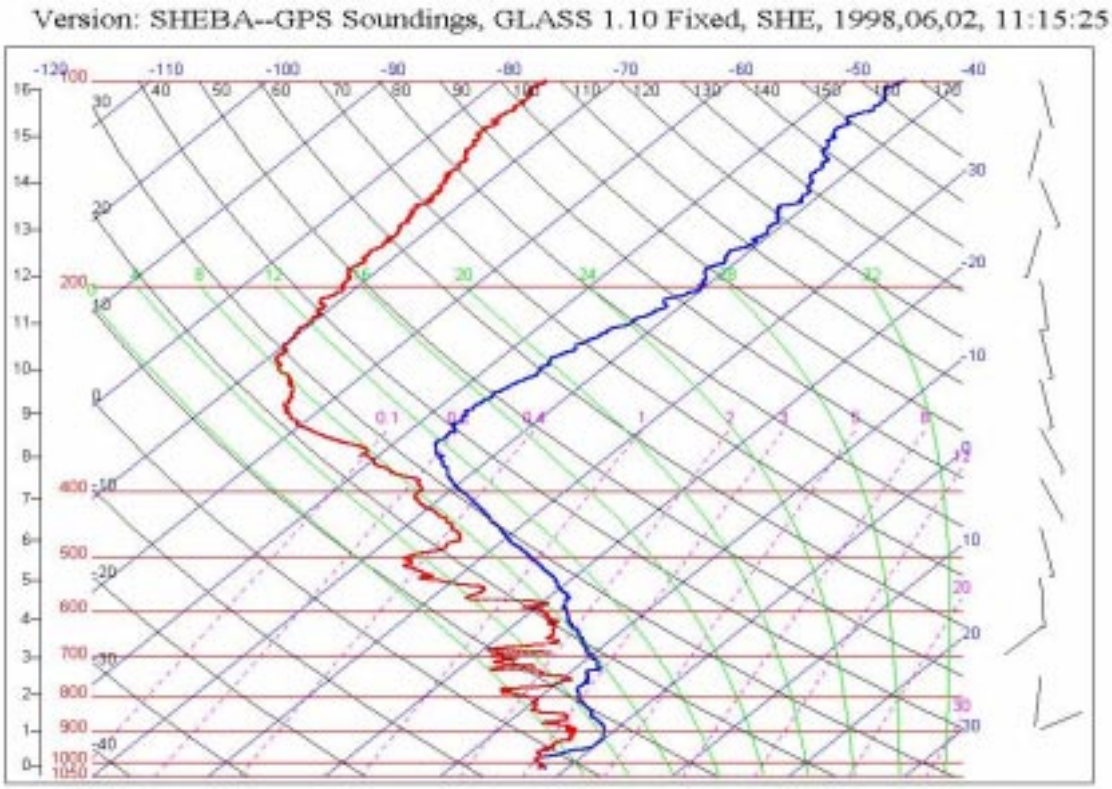
- CV-580 flight tracks
- GPS roll and pitch angle

Back to Top


Flight 1759 June 2, 1998
GPS Altitude (km)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
20:19:33
20:47:22
21:13:28
21:39:47
22:06:15
22:32:54
22:59:10
GPS Pitch Angles
20
10
0
−10
−20
GPS Roll Angles
30
20
10
0
−10
−20
−30
(GPS − CAR) Roll Angles
UTC Time

SHEBA Sounding

June 2, 1998



June 3, 1998

ER-2

Flight summary

Ground track

Flight track

MAS images

HIS measurements

Cloud LIDAR System image

AMPR images

CV-580

Flight summary

Flight track

CAR notes

GPS plots

SHEBA

LIDAR image

Sounding

ER-2 Mission 9

Wednesday, June 3, 1998

Flight Scientist: S. Platnick

Objectives: Fly over the SHEBA ice camp (76°49'N, 167°34'W) in a star-shaped or "shamrock" pattern in coordination with University of Washington CV-580 aircraft for cloud remote sensing and cloud masking validation, cloud bi-directional reflectance measurements, and sea ice retrievals in the presence of changing cloud cover for AMPR. Fly over the ARM site on outgoing and incoming flight legs.
Coordination included:

- F-14 satellite (2148 and 2329 UTC)

ER-2 Mission:	Pilot:	Jan Nystrom
	Takeoff	1900 UTC
	Landing	0155 UTC (June 4)
	Duration	6:00

The ER-2 flew over the ARM site on a NW flight line en route toward the SHEBA ice station. The ER-2 made four legs of about 260 km in length centered over the SHEBA ice station, with legs offset by 45°. A south-to-north leg was run first, repeating a pass from the previous day's flight of 2 June 1998 (requested for assessing changes in AMPR sea ice retrievals with different cloud types and amounts). The CV-580 flew to SHEBA and attempted above and below-cloud bi-directional reflectance measurements and in situ profiles through the cloud. The ER-2 flew over the ARM site on the return to Ft. Wainwright.

The AirMISR was turned on for 6 acquisitions: once over the ARM site on the outgoing leg, four times over the SHEBA ice station, and once more over the ARM site on the return leg. The AirMISR operated at the following times with notes of observed clouds as seen by the instrument:

- 2001-2015 UTC (ARM - complete run of 9 angles; stratocumulus visible with thin high cloud)
- 2057-2110 UTC (SHEBA - complete run; stratus clouds)
- 2126-2138 UTC (SHEBA - complete run; stratus clouds)
- 2154-2208 UTC (SHEBA - complete run; stratus clouds)
- 2222-2235 UTC (SHEBA - complete run; stratus clouds)
- 2330-2346 UTC (ARM - complete run; stratocumulus visible through moderately thick high clouds)

Pilot report: The ER-2 pilot reported solid midlevel cloud cover over the ice station on the initial flight tracks, with gradual clearing during the mission (some ice seen with the clearer regions to the northwest). On the outbound leg over the ARM site – undercast to the west, thin cirrus over broken stratus. On return over ARM site – clouds at all levels, some cirrus, some clearing.

Instrument Status

- AirMISR – worked well
- AMPR – worked well
- CLS – worked well
- HIS – worked well
- MAS – worked well
- MIR – intermittent noise in higher frequency channels
- SSFR – no data taken during flight, under investigation

Meteorology:

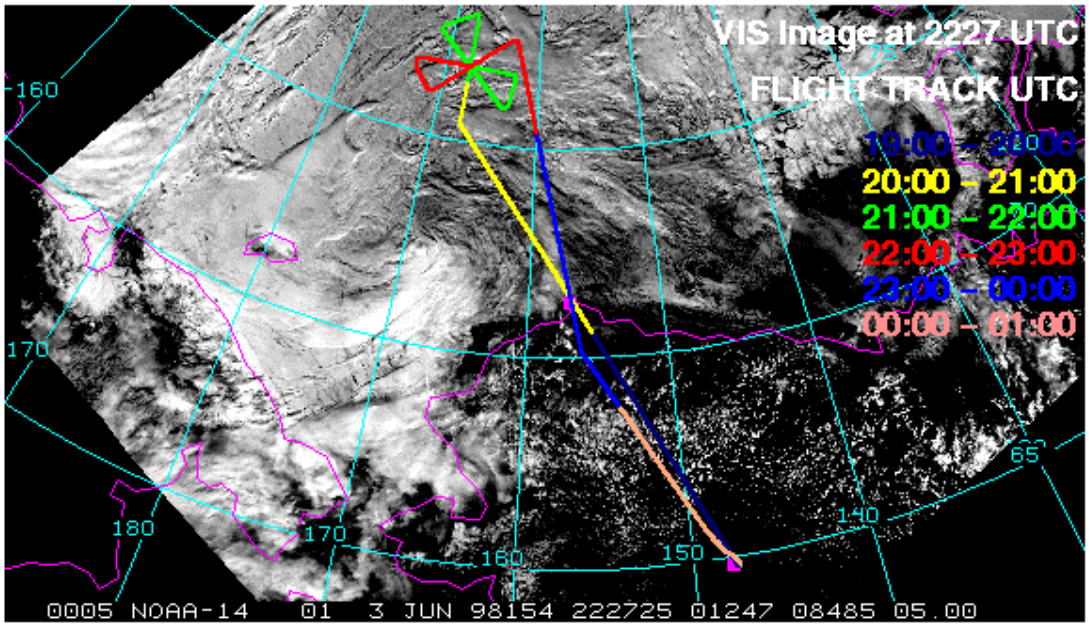
Extensive stratus clouds with heights at about 3.5 km were expected over the SHEBA ice station. Morning report of fog with solid overcast clouds with flat and uniform tops at about 3.5 km associated with a strong inversion. Light cirrus between Barrow and the ice station. Surface winds out of the southwest at 5 kts. Morning satellite imagery showed a uniform stratus deck above the ice station. Later imagery from about the time of the ER-2 takeoff indicated that the upper stratus deck might be breaking up, some light cirrus seen in some locations.

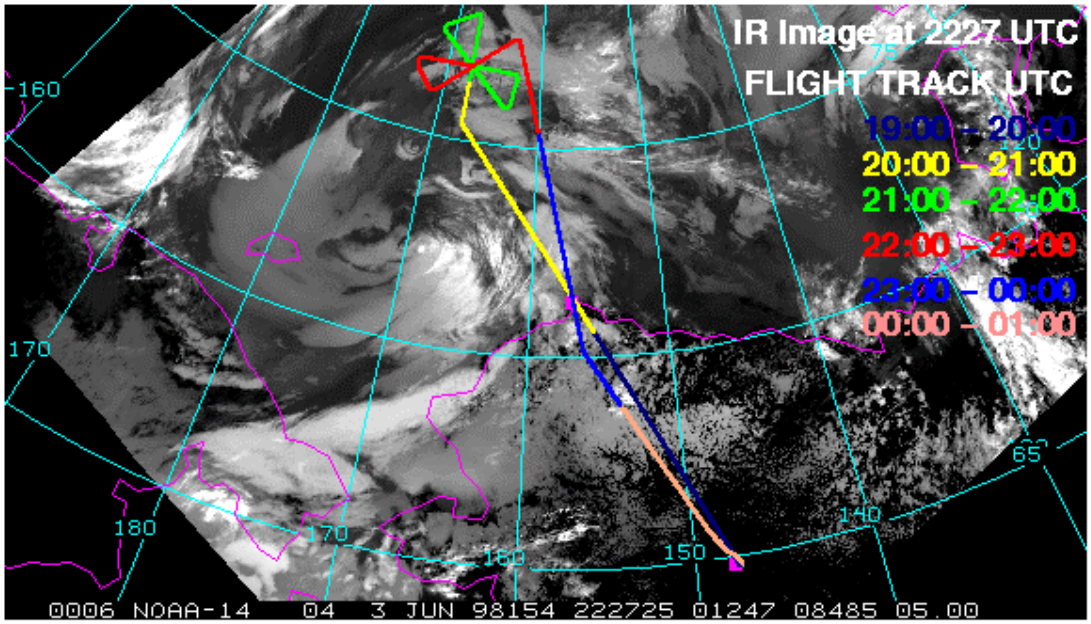
At 2000 UTC, the ice station reported surface winds at 6 kts, 125° and a ceilometer cloud base of about 1 km. Radar showing two cloud layers: lower one at 1-1.2 km and a higher layer at 1.6-3 km. Near the time of the ER-2 arrival (2100 UTC), the lower cloud dissipated with the higher cloud layer thinning to 2-3 km, possibly liquid at the top. Low fog present at 2230 UTC.

Instruments:

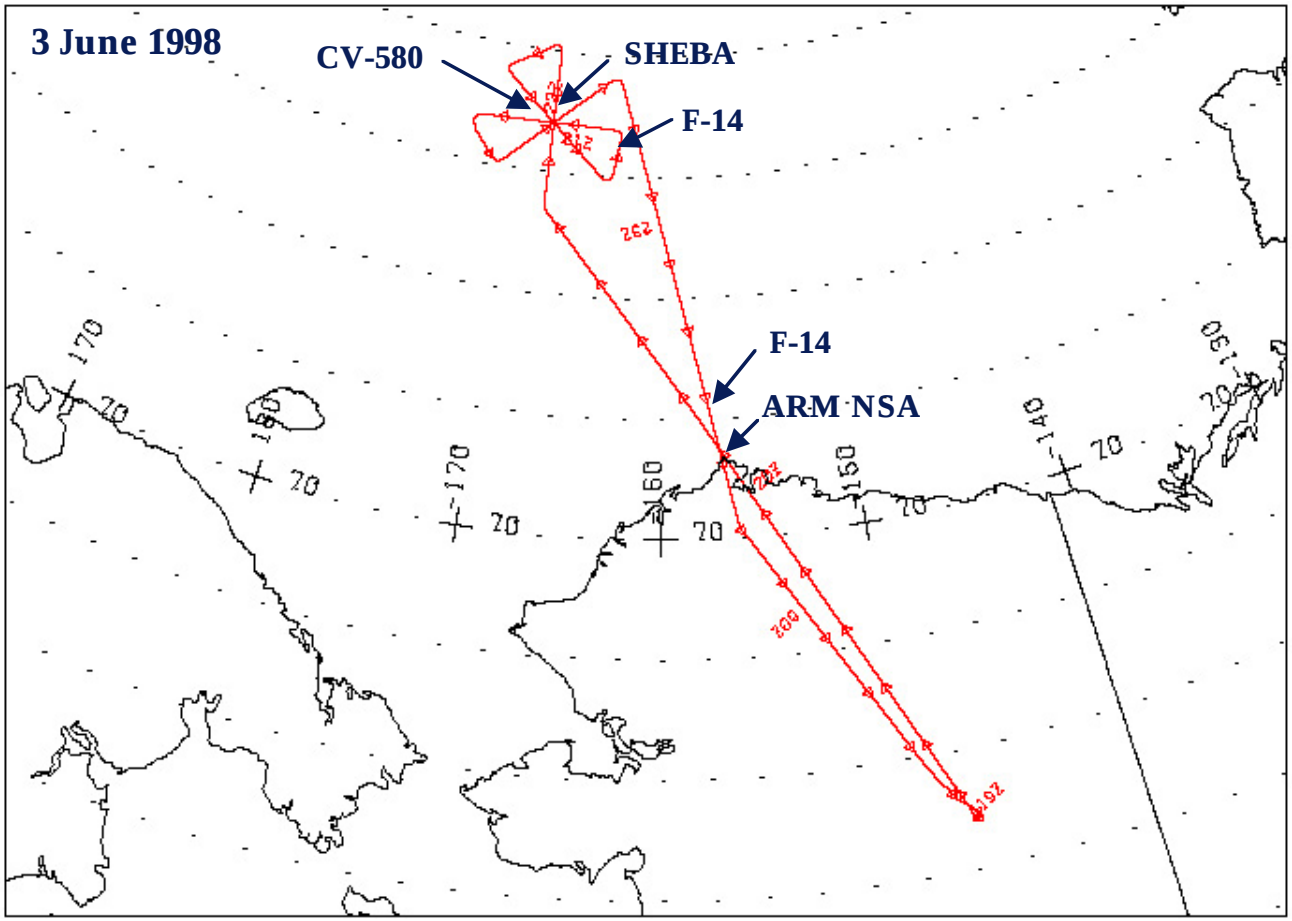
AirMISR – Airborne Multi-angle Imaging Spectroradiometer
AMPR – Advanced Microwave Precipitation Radiometer
CLS – Cloud LIDAR System
HIS – High-resolution Interferometer Sounder
MAS – MODIS Airborne Simulator
MIR – Millimeter-wave Imaging Radiometer
SSFR – Solar Spectral Flux Radiometer

ER2 FLIGHT TRACK AND NOAA–14 AVHRR IMAGES ON JUNE 3, 1998





ER-2 Ground Track



Altocumulus Opacus

Red = 2.13 μm

Green = 1.62 μm

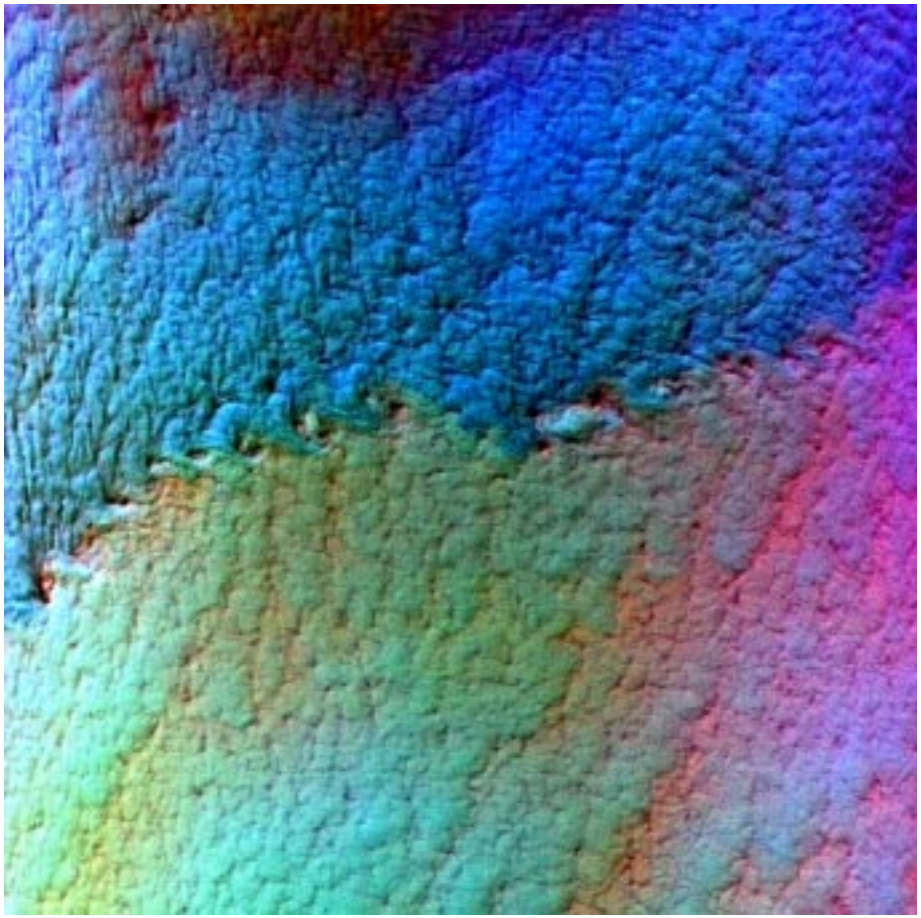
Blue = 0.66 μm

3 June 1998

76°48'N 167°34'W

2102 UTC

23.6 km



37.2 km

Flight Direction

151.8°

θ_0 **= 56.6°**

ϕ_0 **= 144.7°**

$\phi - \phi_0$ **= 52.0°**

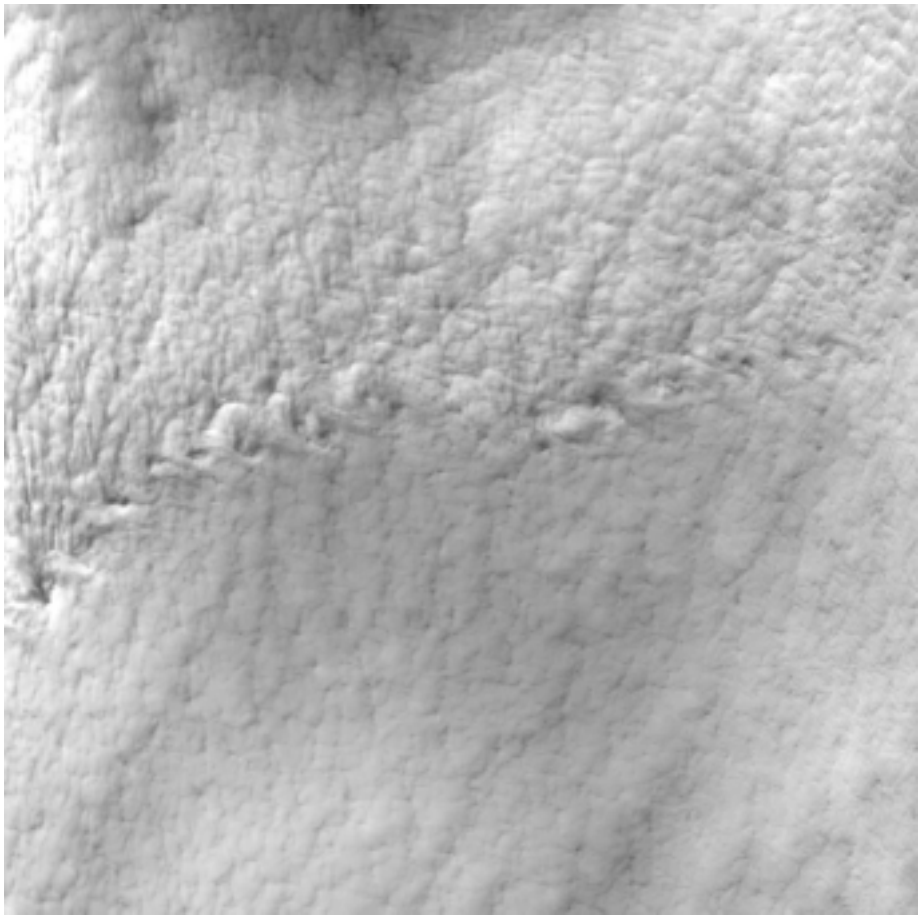
Altocumulus Opacus

λ = 0.66 μm

θ_0 = 56.6°

ϕ_0 = 144.7°

$\phi - \phi_0$ = 52.0°



23.6 km

37.2 km

3 June 1998

76°48'N 167°34'W

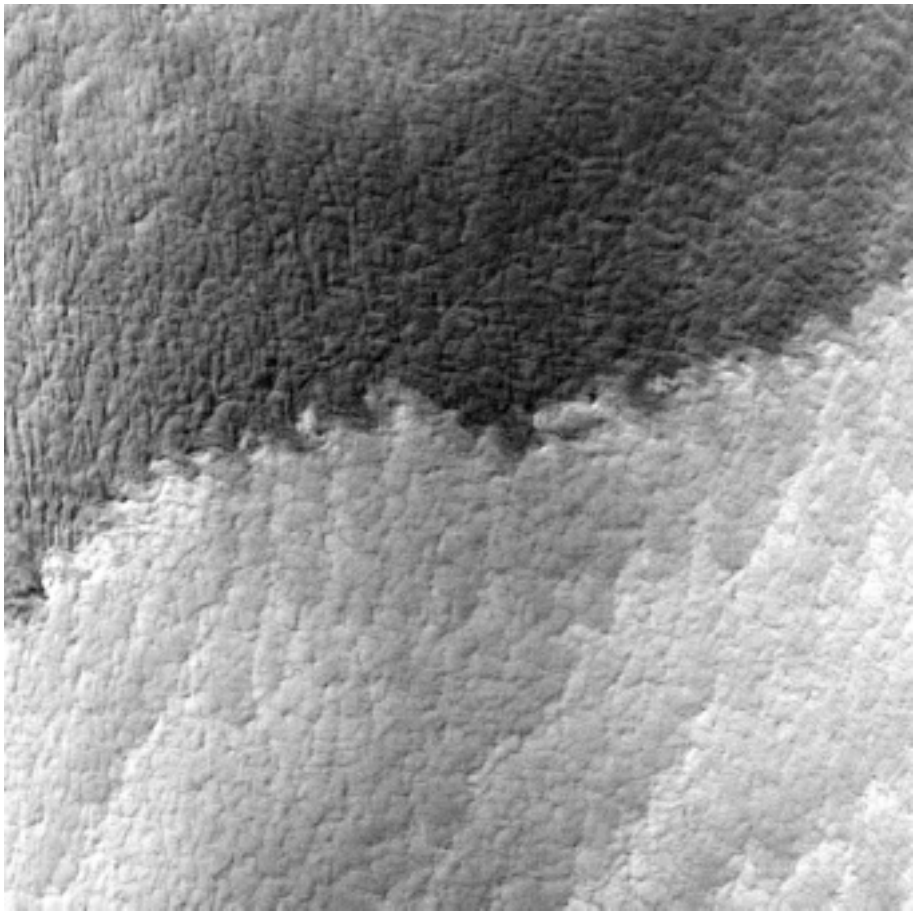
2102 UTC

Flight Direction

2.7°

Altocumulus Opacus

λ = 3.76 μm



23.6 km

37.2 km

3 June 1998

76°48'N 167°34'W

2102 UTC

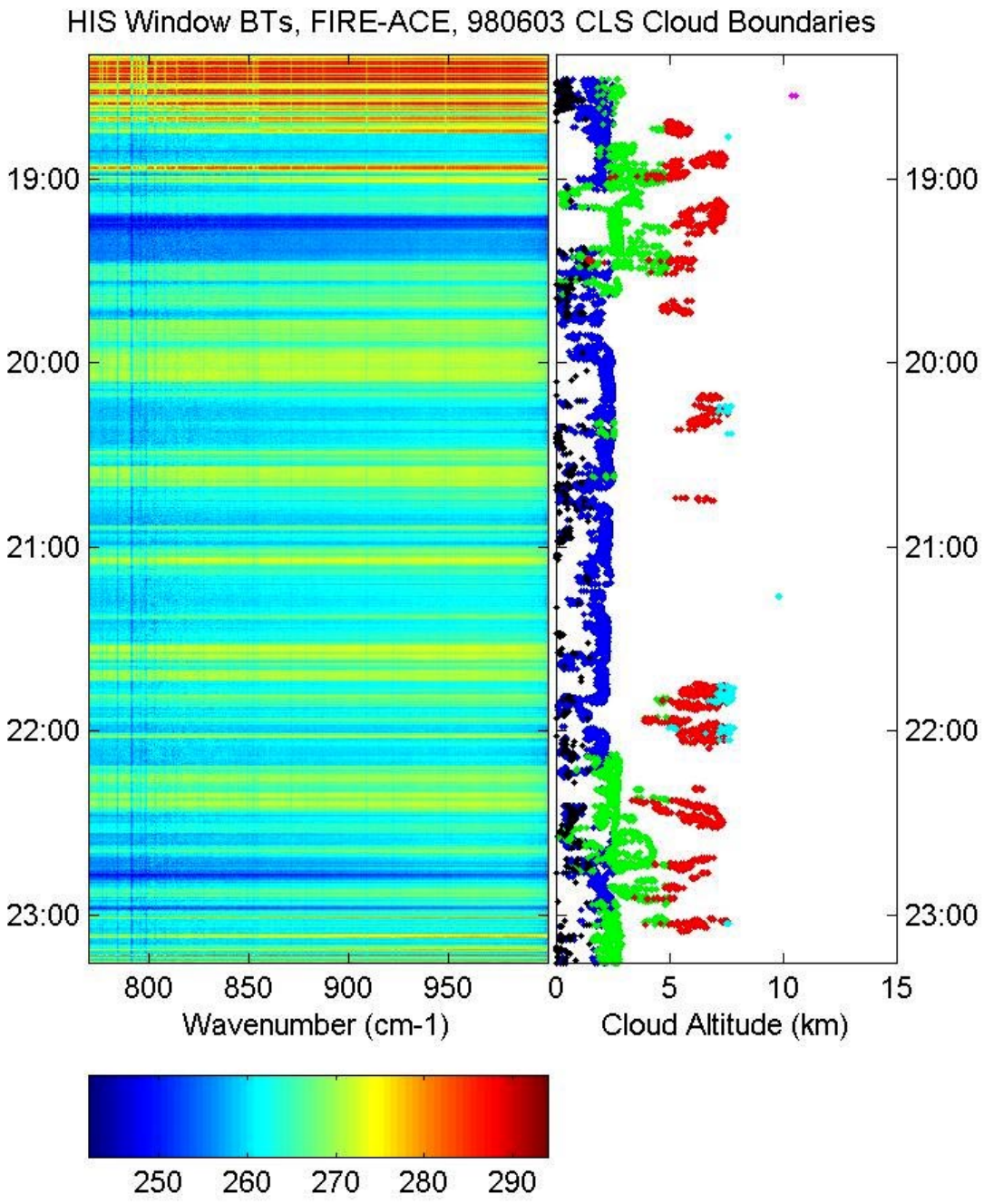
Flight Direction

2.7°

θ_0 = 56.6°

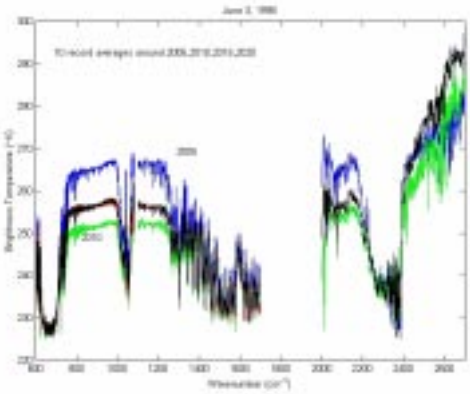
ϕ_0 = 144.7°

$\phi - \phi_0$ = 52.0°

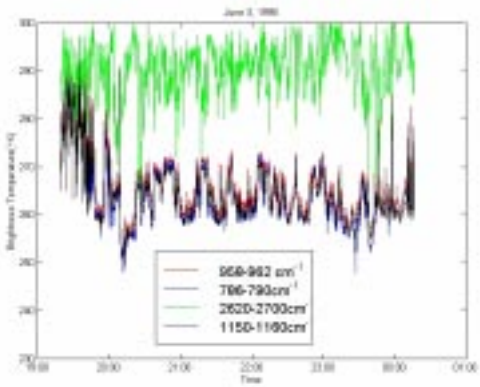

HIS Window BTs, FIRE-ACE, 980603 CLS Cloud Boundaries
19:00
20:00
21:00
22:00
23:00
800
850
900
950
Wavenumber (cm-1)
0
5
10
15
Cloud Altitude (km)
250
260
270
280
290

ER-2 HIS Measurements

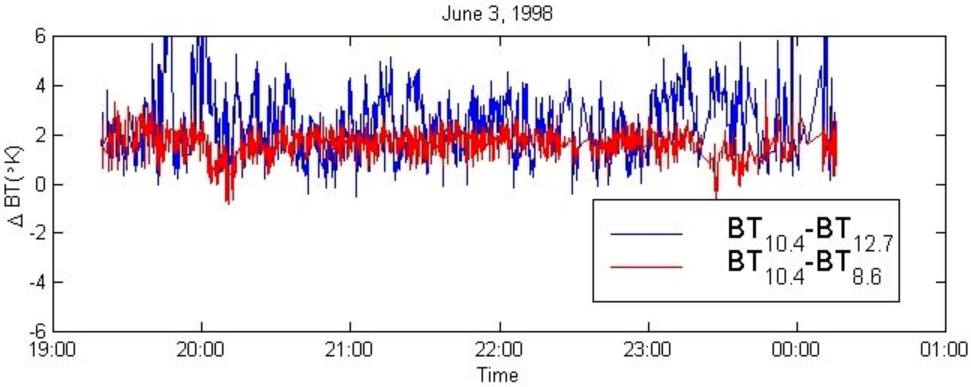
Average Brightness Temperature

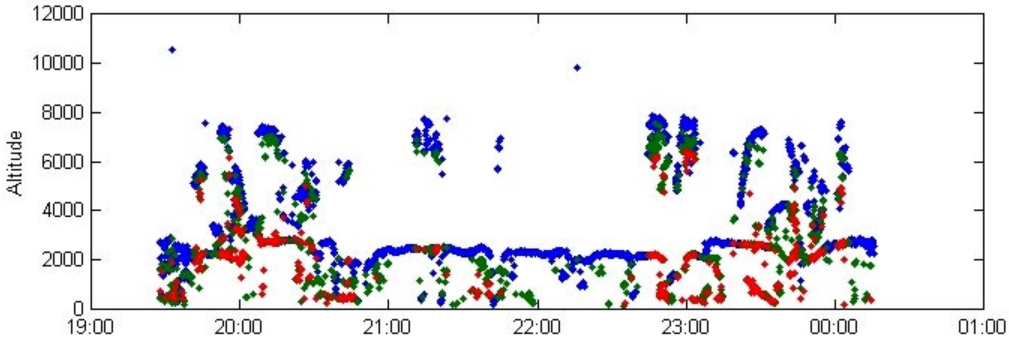


Brightness Temp Time Series



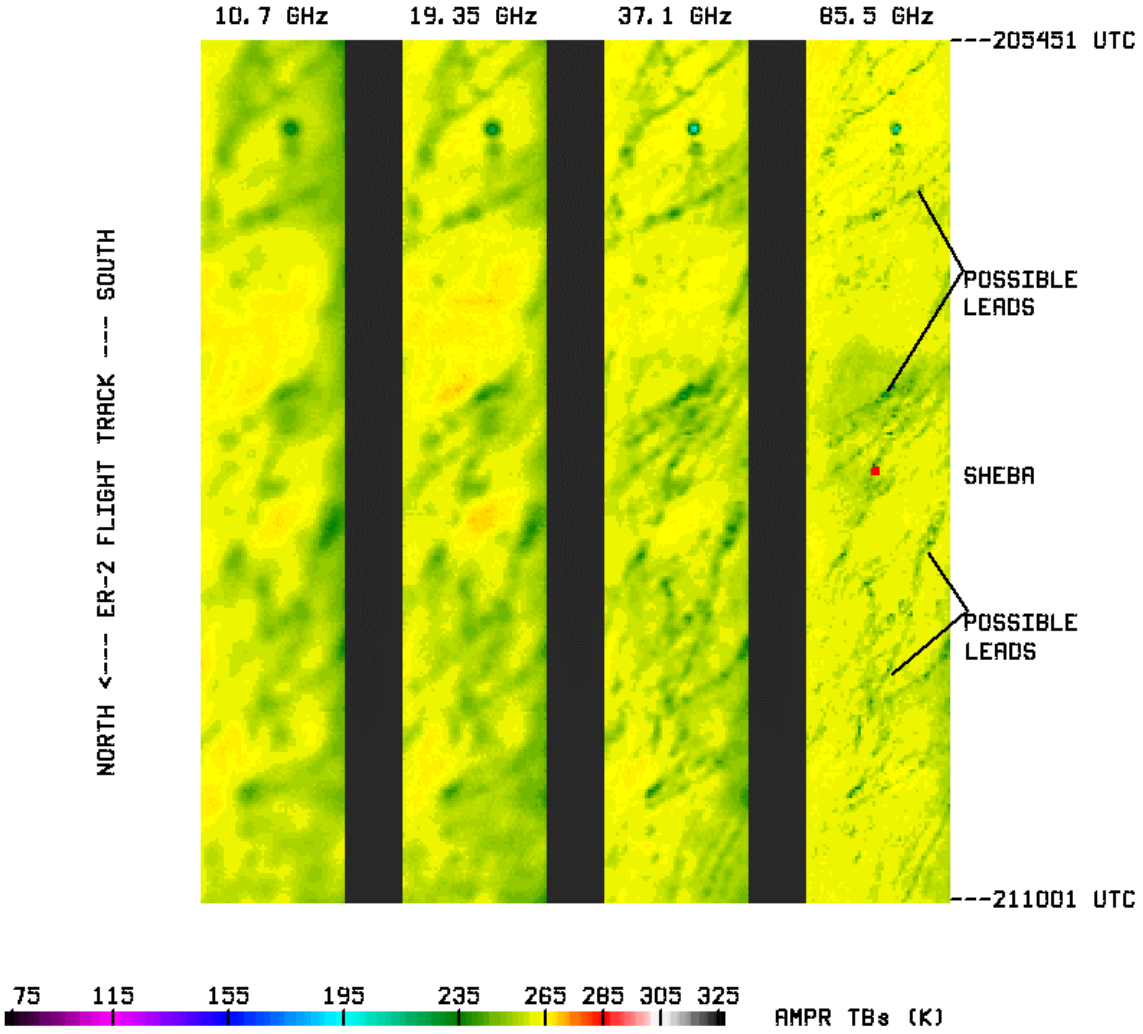
Delta Brightness Temp (above) and Cloud LIDAR System Time Series (below)



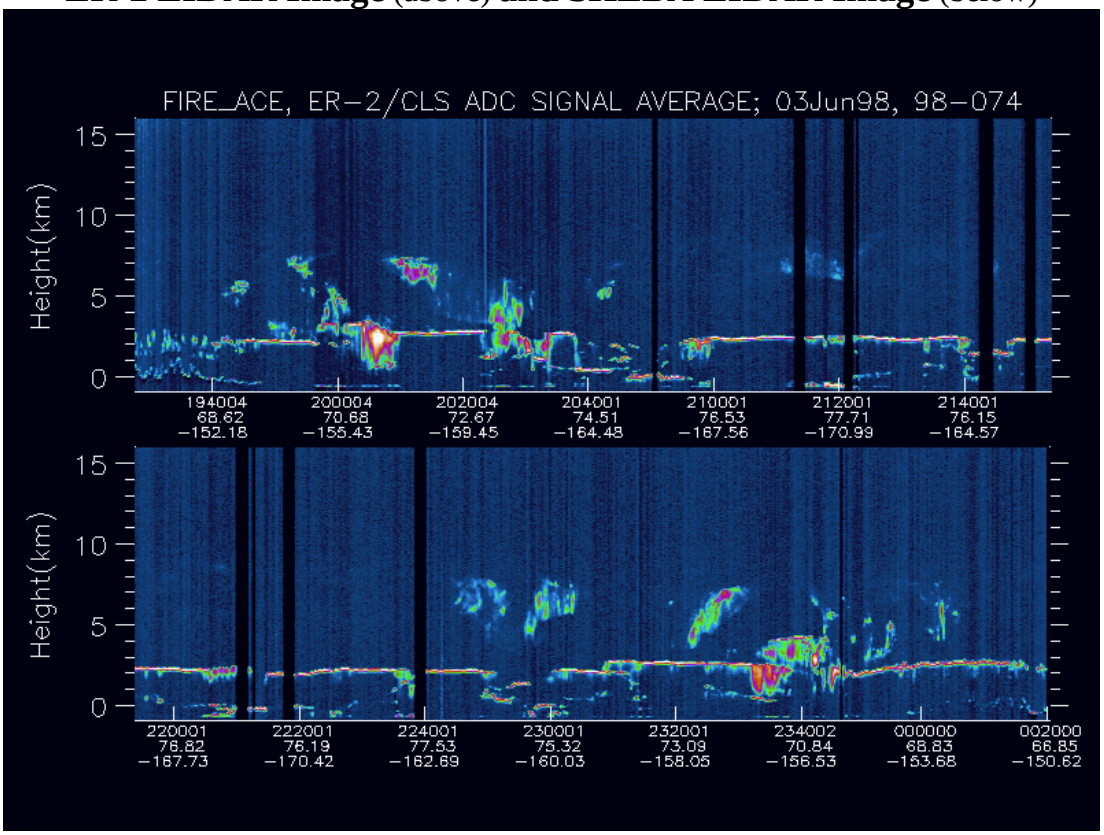


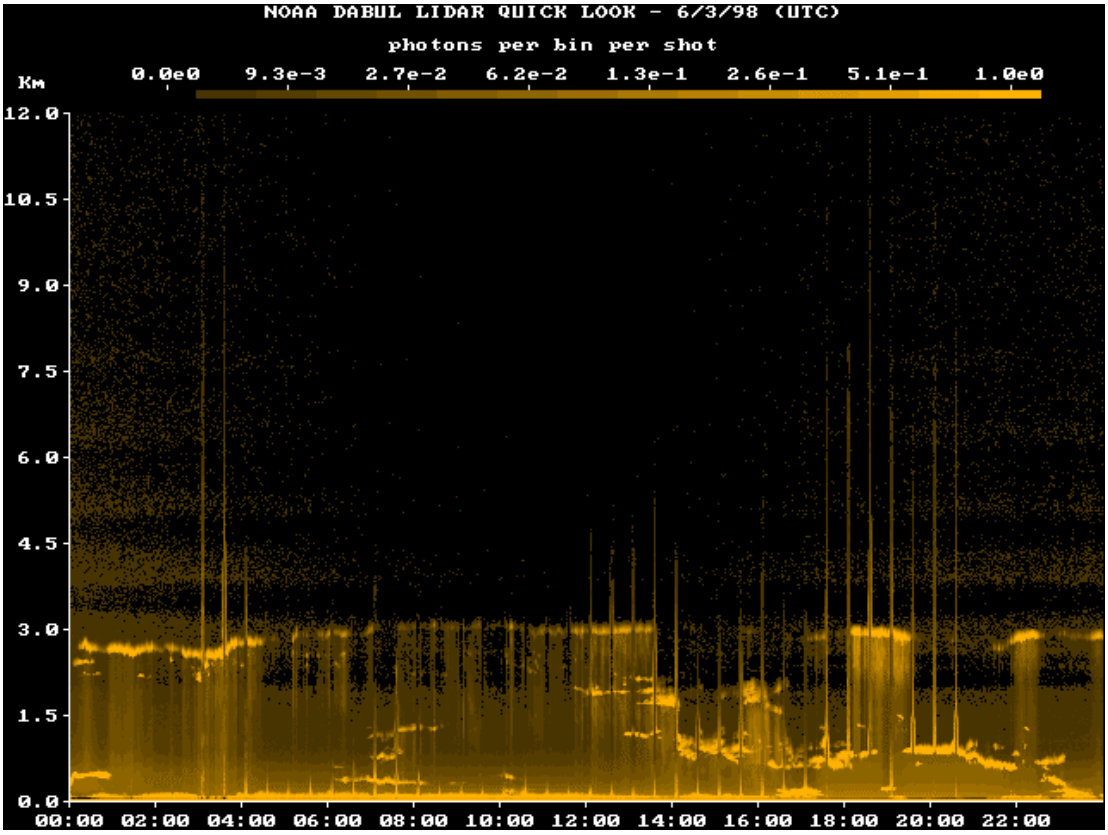
AMPR TBs FOR FIRE ACE

3 JUNE 1998



ER-2 LIDAR Image (above) **and SHEBA LIDAR Image** (below)





UW CV-580 FLIGHT LOG
June 03, 1998

Author (Mission Scientist): Hobbs, Peter

Flight Number: 1760
Engines On: 1906
Engines Off: 2439
Departure Airport: Barrow
Arrival Airport: Barrow

Experimental Observations:

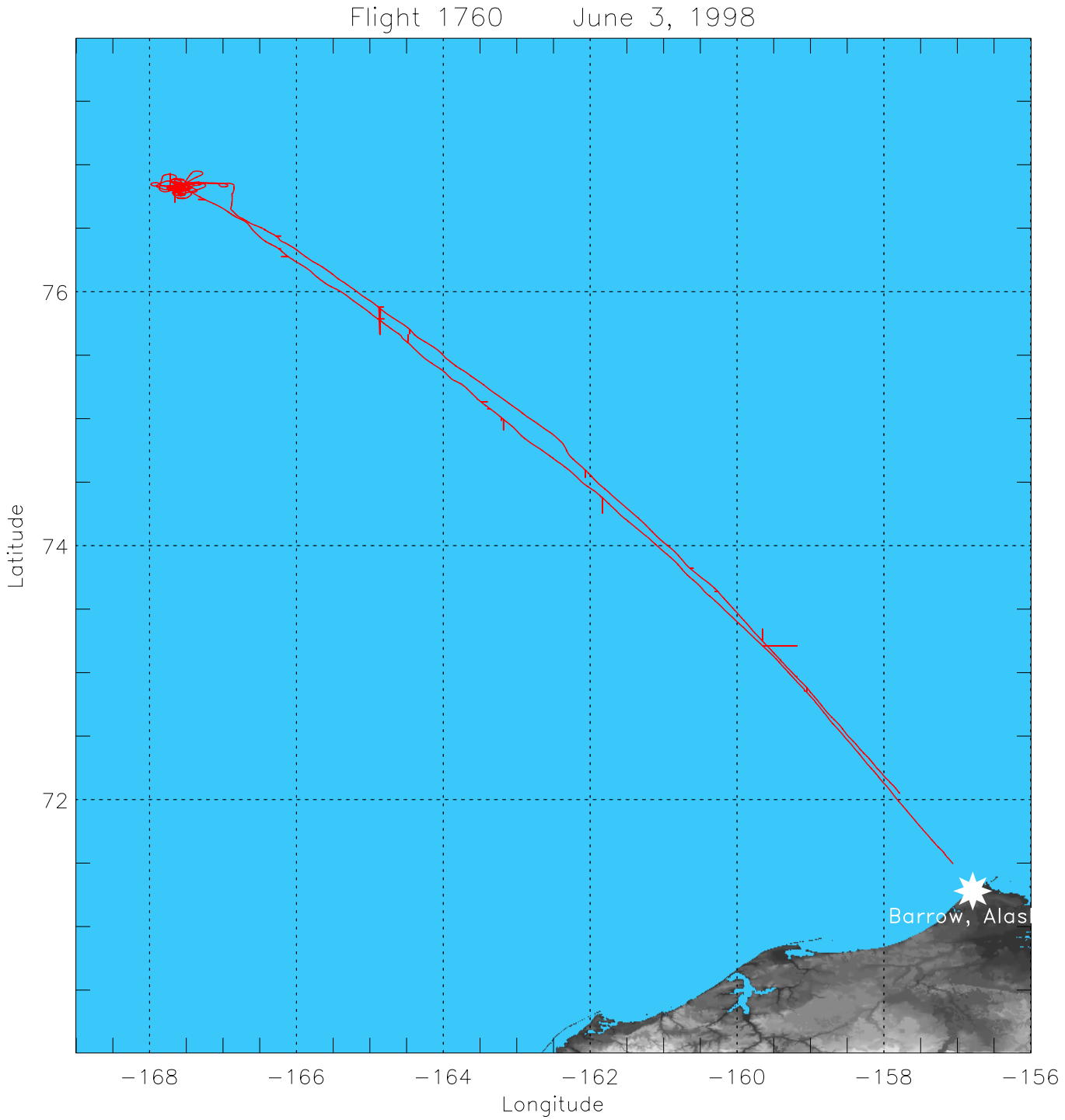
Coordinated flight with ER-2 over SHEBA ship.

1. ~1912-2050 UTC: Transit from Barrow to SHEBA.
2. ~2050-2053 UTC: Level run above cloud top in principal plane (2,000 ft above tops) centered on ship. (ER-2 arrived over SHEBA at 2103 UTC)
3. 2058-2100 UTC: Level run as in (2) above but perpendicular to principal plane.
4. 2104-2119 UTC: Six CAR turns above Ac cloud top (and over ship) for BRDF.
5. 2119-2131 UTC: Descent to below cloud bases (some St send below)
6. 2134-2141 UTC: Level runs at 200 ft above surface along same two perpendicular lines as in (2) and (3) above, and centered on ship.
7. 2144-2157 UTC: Six CAR turns (for BRDF) drifting over ship.
8. 2200-2210 UTC: Level runs above the two arms of the L-shaped surface above site.
9. 2210-2217 UTC: climb to top of upper Ac layer.
10. 2217-2221 UTC: Level run above Ac. (A' -> B')
11. 2224-2225 UTC: Level run below Ac (B' -> A')
12. 2227-2239 UTC: Measurements in upper Ac.

Research Crew: Hobbs, Rangno, Garrett, Weiss, Radke, Russell, Spurgeon, Sorensen, Young, Gray

Equipment Failure:

1. King
2. Gas rack
3. F5 computer intermittent


Flight 1760 June 3, 1998
Latitude
76
74
72
Longitude
−168
−166
−164
−162
−160
−158
−156
Barrow, Alas

Flight 1760 - June 3, 1998

main

1 Summary

2 Photos

3 Quicklooks

1 CAR Flight Summary

Straight runs above and below cloud layers over the SHEBA site; BRDF measurements over altocumulus cloud and the ground (below cloud) over the SHEBA site.

The CAR started recording at 19:17 UTC, scan 100. On the flight out to the SHEBA site the aircraft ascended above uniform altocumulus clouds. At scan 3000 the auto-changing filter was tested and revealed the noise earlier noted in this mode. For the remainder of the flight the CAR was set to filterwheel 5 (2.2 µm) [1][2].

On arrival at the SHEBA site 2 straight runs were made over the SHEBA site, scanning first down (position 1) with filterwheel 5 (2.2 µm), then up (position 4). The aircraft was flying at 11,500 ft over uniform altocumulus. This was followed by a 6 loop BRDF measurement over the cloud at 12,500 ft. Roll varied between 16-20 °.

Loop	1	2	3	4	5	6
Filter	5	5	5	2	2	2
Scan Count	10767	11020	11282	11530	11735	11979

The ER-2 was reported on-station at the beginning of the BRDF measurement (21:04 UTC) [3].

At 21:21 UTC the aircraft descended to 200 ft (GPS altitude, inaccurate at the altitude) over the SHEBA site. There was some surface fog and broken ice, with stratus cloud above. Here the straight line runs and BRDF measurements made earlier were repeated, with the CAR first up (position 4), then down (position 1) on the straight line runs. Roll during the BRDF varied between 18-20°.

Loop	1	2	3	4	5	6
Filter	5	5	5	2	2	2
Scan Count	14789	15022	15277	15450	15800	15973

The flight was completed with several straight line runs over the SHEBA site, above, below and through the altocumulus cloud. During these runs the CAR was positioned to scan the cloud. During the flight through the cloud the CAR was in position 4 (scanning up).

Photo Records:


1. altocumulus cloud layer

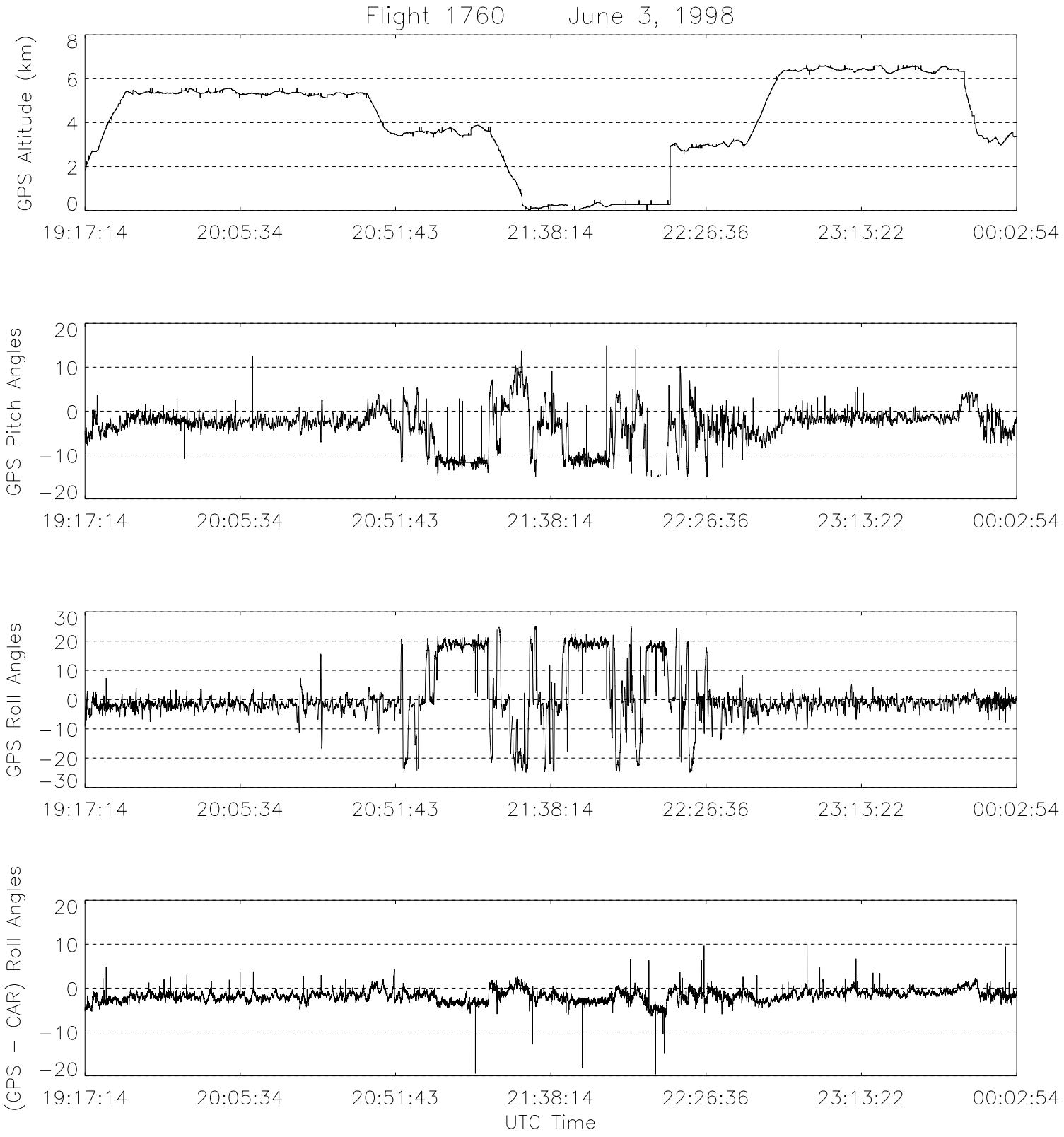

2. altocumulus cloud layer


3. BRDF measurements

Flight Track and Quicklook Images:

- CV-580 flight tracks
- GPS roll and pitch angle

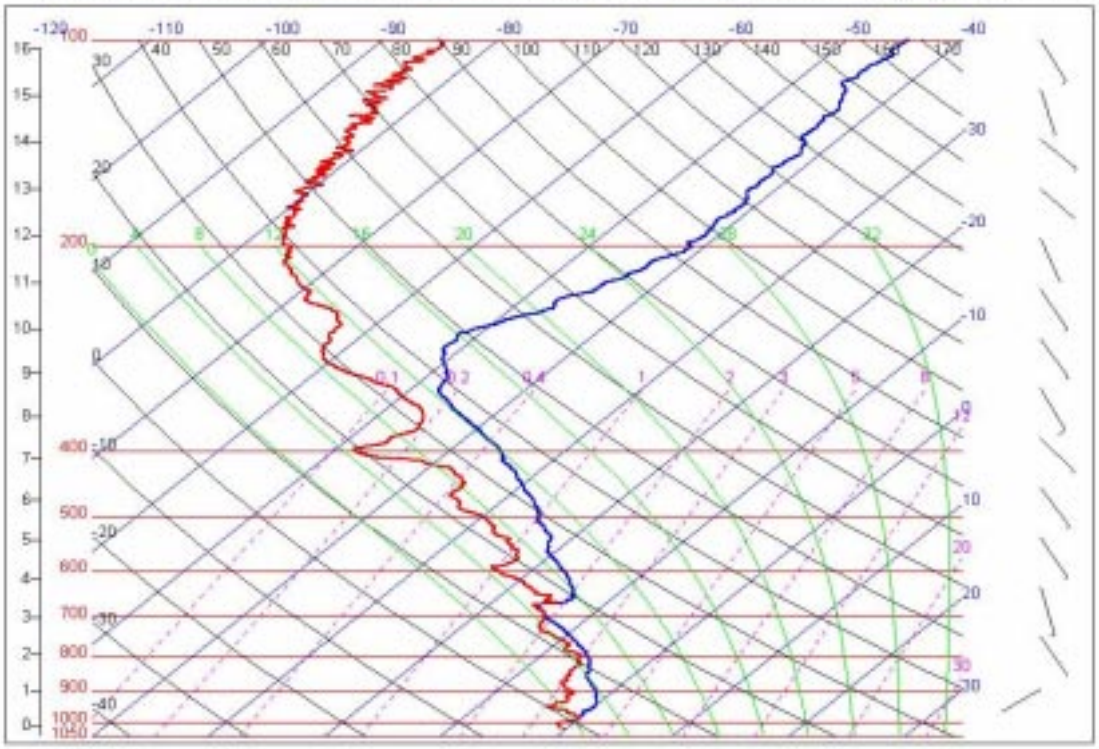
Back to Top


Flight 1760 June 3, 1998
GPS Altitude (km)
8
6
4
2
0
19:17:14
20:05:34
20:51:43
21:38:14
22:26:36
23:13:22
00:02:54
GPS Pitch Angles
20
10
0
−10
−20
GPS Roll Angles
30
20
10
0
−10
−20
−30
(GPS − CAR) Roll Angles
UTC Time

SHEBA Sounding

June 3, 1998

Version: SHEBA--GPS Soundings, GLASS 1.10 Fixed, SHE, 1998,06,03, 11:15:02



June 4, 1998

ER-2

- Flight summary
- Ground track
- MAS images
- HIS measurements

SHEBA

- LIDAR image
- Sounding

ER-2 Mission 10

Thursday, June 4, 1998

Flight Scientist: S. Platnick

Objectives: Fly over region between the SHEBA ice camp (76°51'N, 167°30'W) and an area about 80 km to the east to fly over cirrus being advected over the region from the northwest. Flight useful for cloud remote sensing and cloud masking validation, and sea ice retrievals in the presence of changing cloud cover. Fly over the ARM site on outgoing and incoming flight legs. Coordination included:

- F-14 satellite (2317 UTC)

ER-2 Mission:

Pilot:	Bill Collette
Takeoff	1900 UTC
Landing	0030 UTC (June 5)
Duration	5:30

The ER-2 flew over the ARM site and then headed northwest towards the SHEBA ice station. Then flew four parallel north-south flight legs of about 280 km in length, offset by 40 km, starting from the east of the ice station and ending over the station. The ER-2 flew over the ARM site on the return to Ft. Wainwright.

The AirMISR was scheduled for six runs, twice over the ice station and four times during the parallel flight legs. All six runs failed for an unknown reason. Pilot report: The ER-2 pilot reported solid undercast cloud cover over the entire mission.

Instrument Status

- AirMISR – failed
- AMPR – worked well
- CLS – partial failure (only linear channel worked)
- HIS – worked well
- MAS – worked well
- MIR – intermittent noise in some channels
- SSFR – worked well

Meteorology:

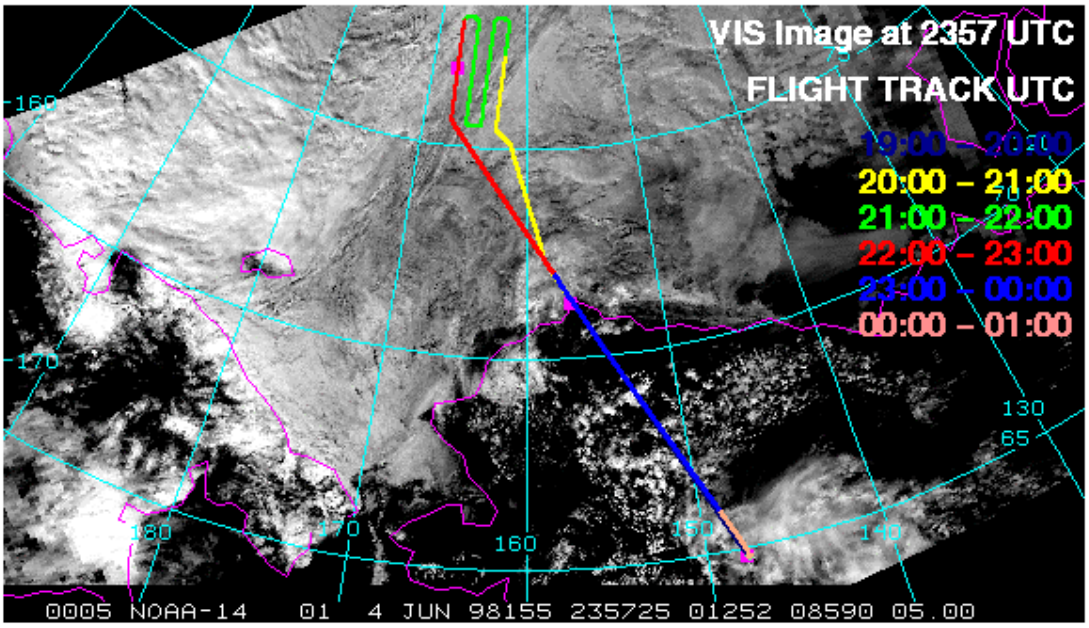
Extensive clouds cover over the ice station in the morning report. At 1600 UTC, the radar showed cloud layers at the surface, 0.8-1.0 km, and 6.5-8.5 km. Satellite imagery showed cloud tops around 3-3.5 km. Light surface winds out of the southwest at 5 kts. A band of cirrus running southwest to northeast was expected to move over the ER-2 operations area during the morning, with thinner cirrus likely in the eastern flight legs. The cirrus was associated with a low to the northwest of the ice station.

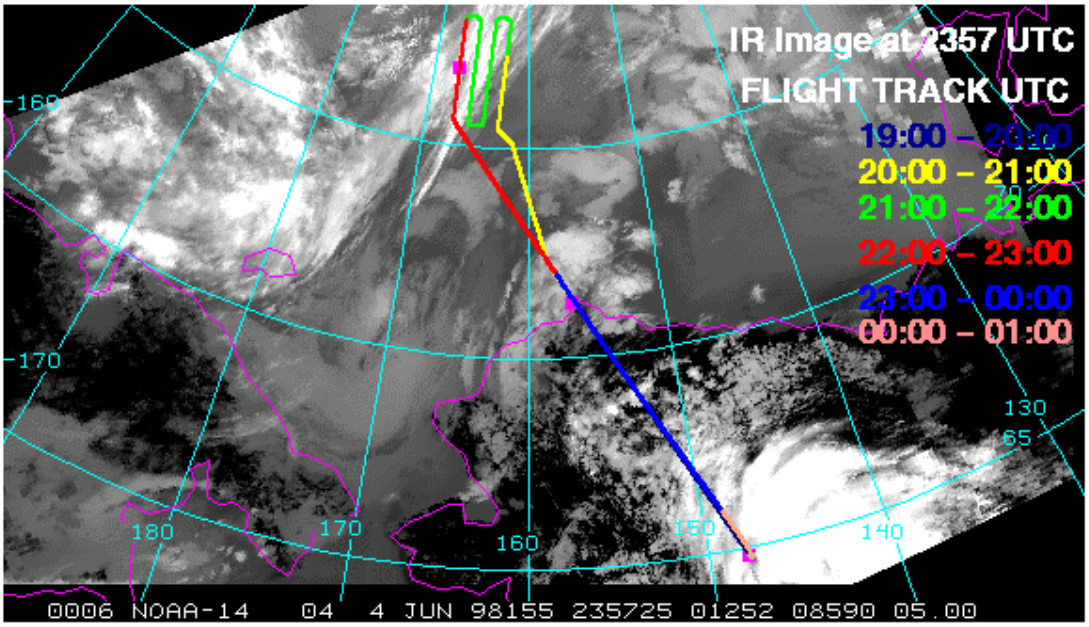
At 2000 UTC (about 45 minutes before the ER-2 began its eastern most leg), the ice station reported surface winds at 22 kts, 190° and a ceilometer cloud base of about 0.2 km. Radar showed two cloud layers: a lower one just over the surface up to 0.5 km and a higher layer between 4.5 - 7 km, and intermittently up to 9 km.

Instruments:

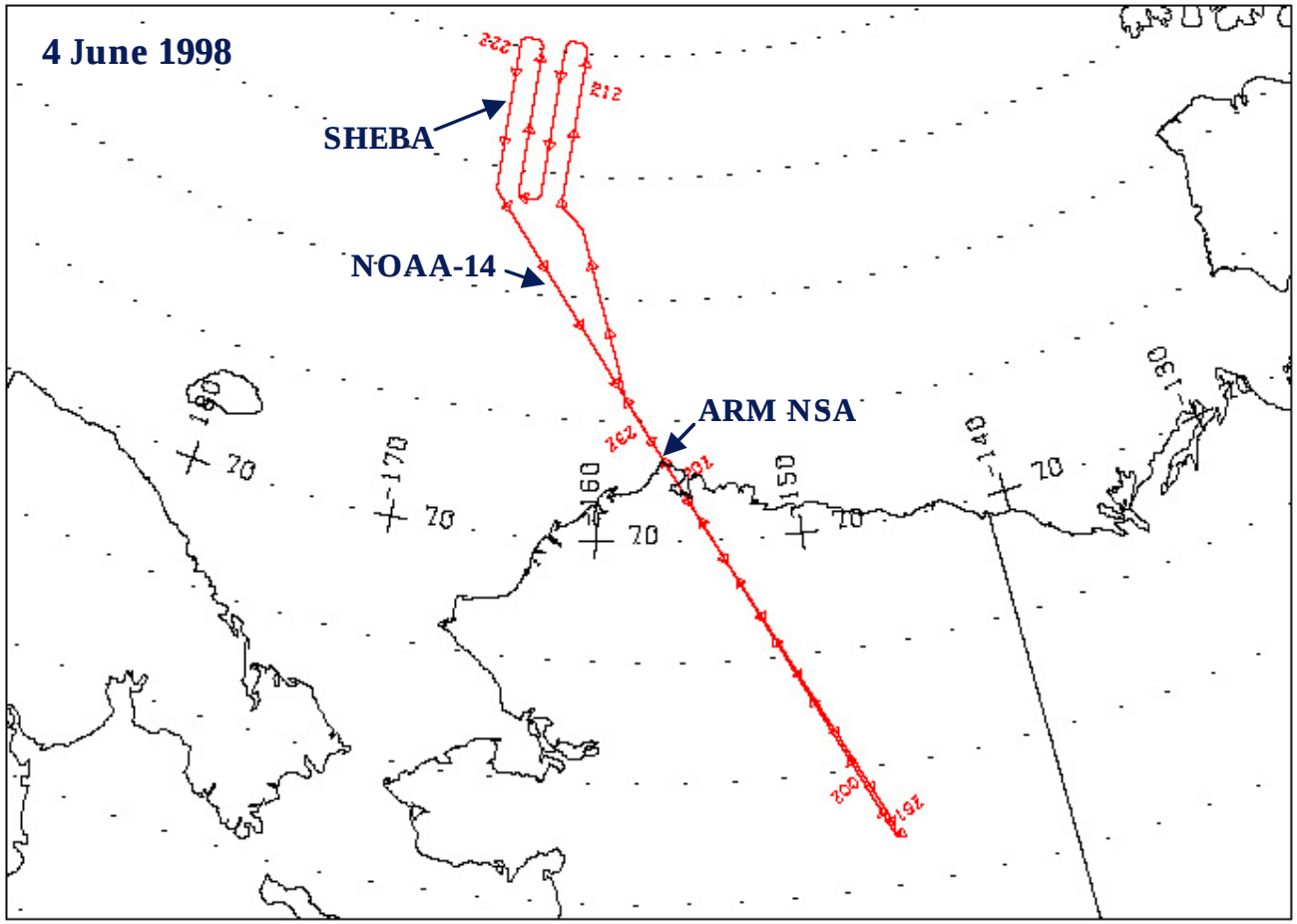
AirMISR – Airborne Multi-angle Imaging Spectroradiometer
AMPR – Advanced Microwave Precipitation Radiometer
CLS – Cloud LIDAR System
HIS – High-resolution Interferometer Sounder
MAS – MODIS Airborne Simulator
MIR – Millimeter-wave Imaging Radiometer
SSFR – Solar Spectral Flux Radiometer

ER2 FLIGHT TRACK AND NOAA–14 AVHRR IMAGES ON JUNE 4, 1998

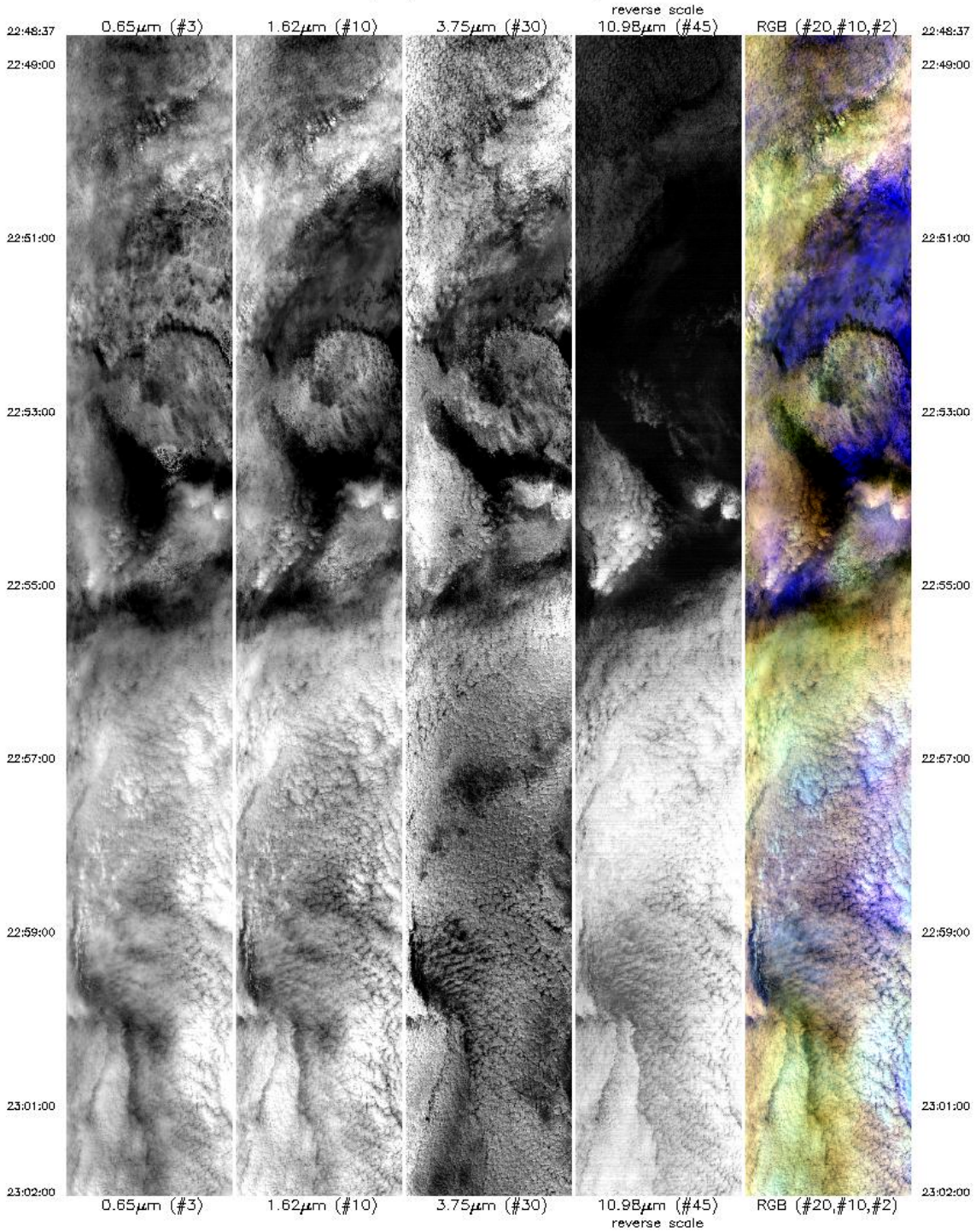




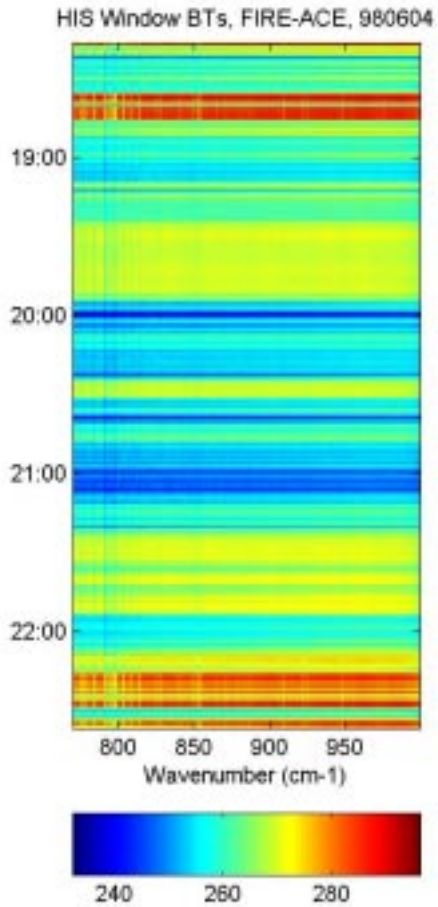
ER-2 Ground Track



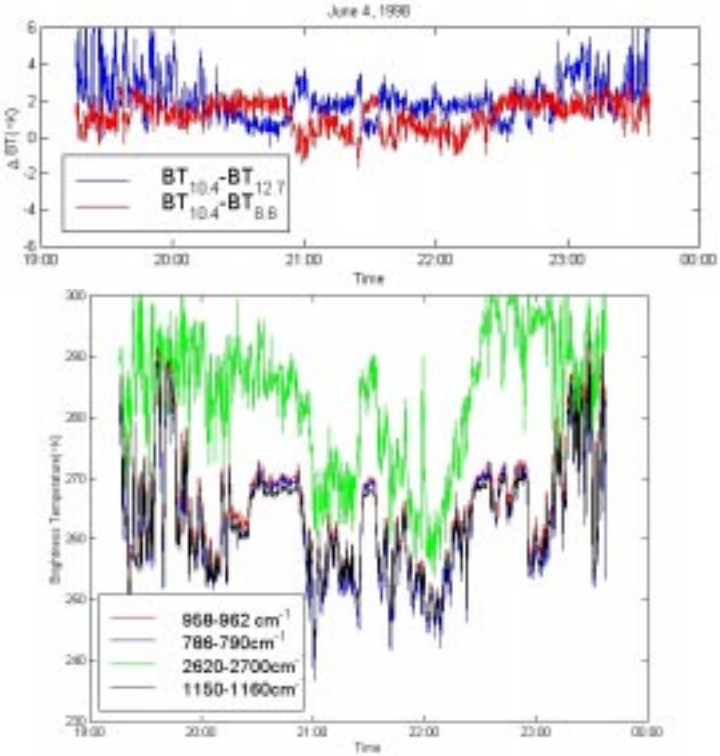
MODIS Airborne Simulator Browse Imagery
FIRE–ACE Campaign – 04–05 June 1998
Flight #98–075 Track #15



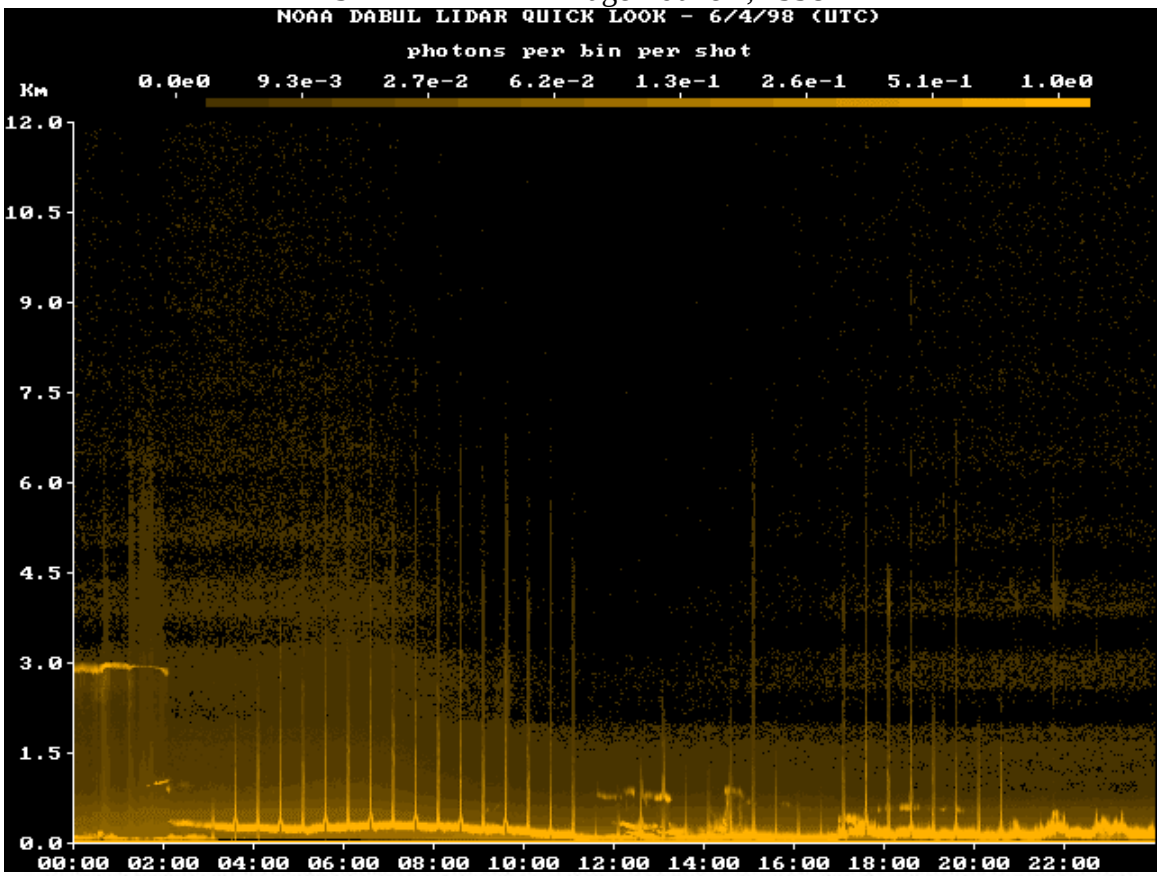
ER–2 Heading = 147.1°
Solar Zenith = 50.5°
Solar Azimuth = 182.3°



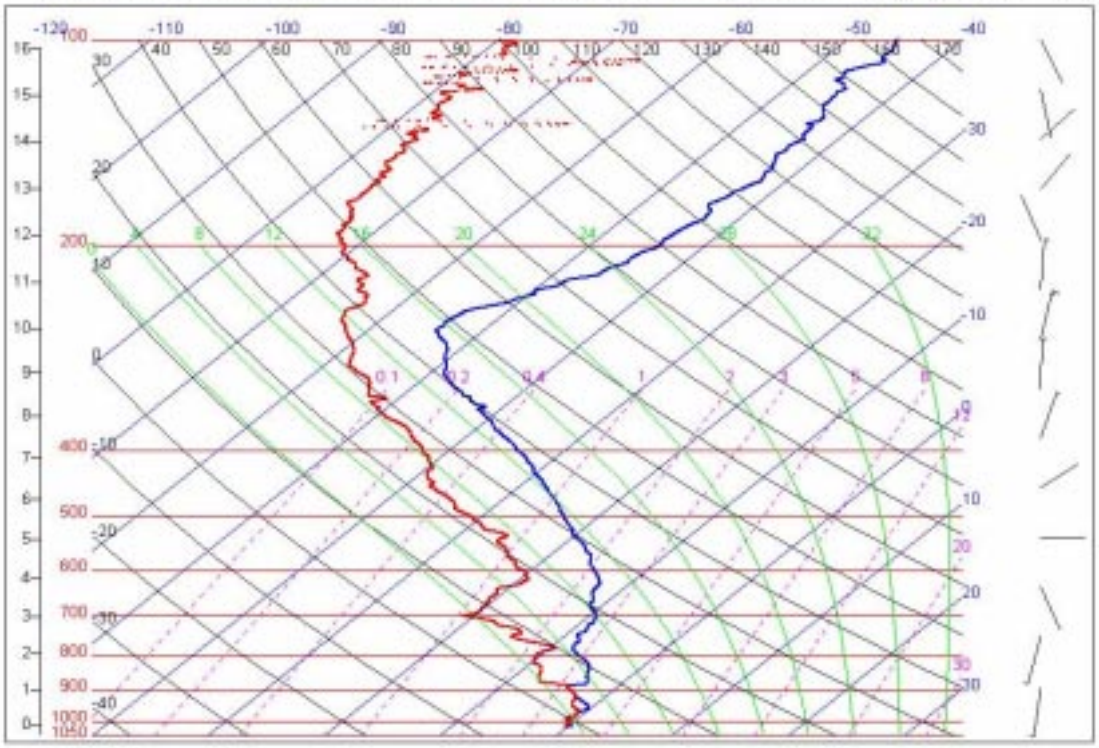
Delta Brightness Temp (on top) and Average Brightness Temp (below)



SHEBA LIDAR Image – June 4, 1998



Version: SHEBA--GPS Soundings, GLASS 1.10 Fixed, SHE, 1998,06,04, 11:15:12



June 5, 1998

CV-580

Flight summary

Flight track

CAR notes

GPS plots

SHEBA

LIDAR image

Sounding

UW CV-580 FLIGHT LOG
June 05, 1998

Author (Mission Scientist): Hobbs , Peter

Flight Number: 1761
Engines On: 2146
Engines Off: 2528
Departure Airport: Barrow
Arrival Airport: Barrow

Clouds sampled: Ac St

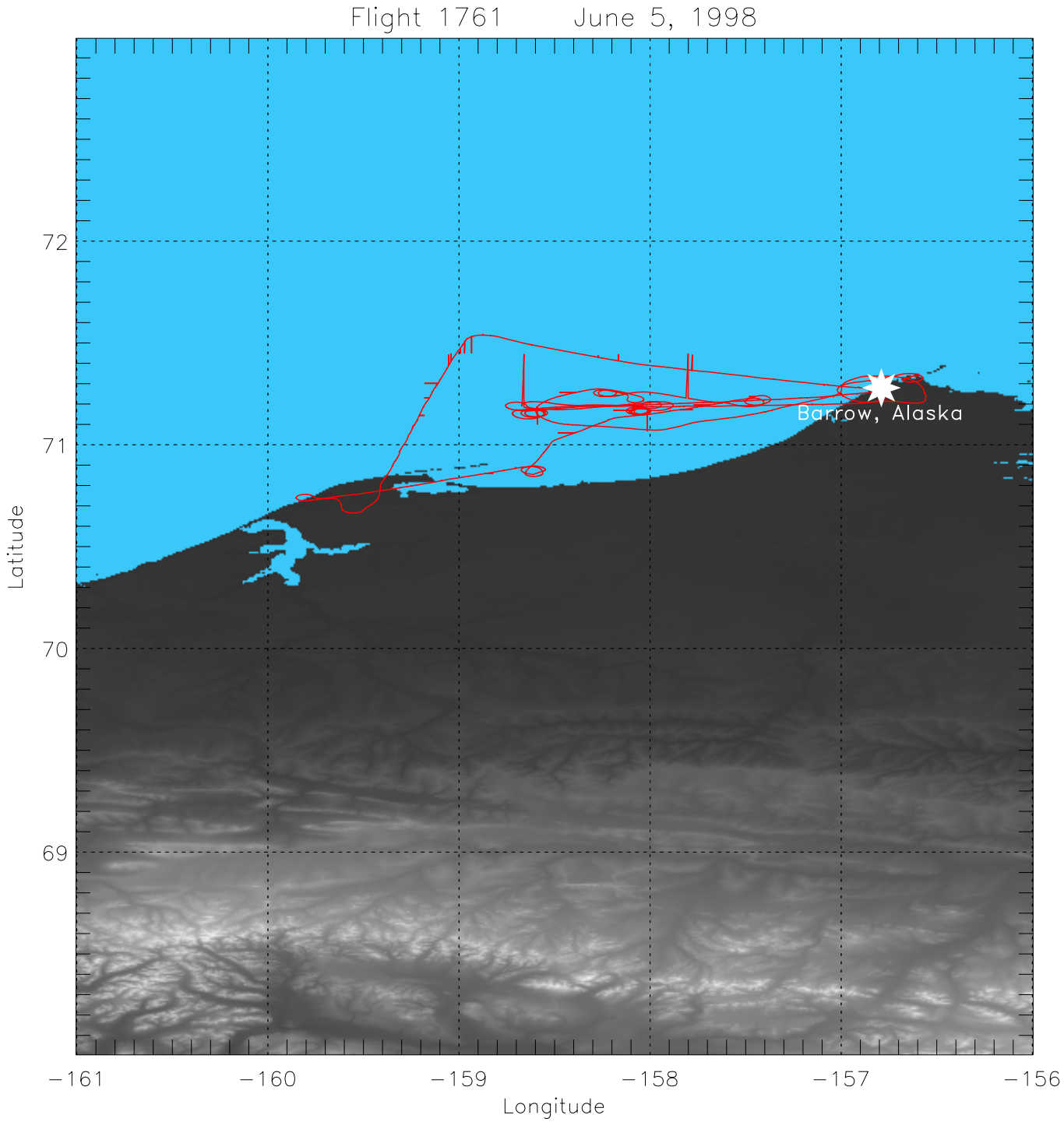
Experimental Observations:

Flight devoted to "Aerosol - Cloud Shading" Effect (UW flight scenario #4). Cloud was a low-level stratus. Aerosol layer from near cloud top to ~3600 ft. Aerosol layer at CN ~ 1500 cm^-3 and light scattering of ~ 3 x 10^-6 m^-1 absorption revealed ~50% of scattering. Obtained concentration and carbonaceous filter (sp) in aerosol layer and humidification factor measurements. BRDF above stratus tops.
(sp) measurements over ice-covered Chuckchi Sea to NW of Barrow. At beginning of flight did circle in clear air around Barrow in effort to detect Barrow plume. Did not detect any plume.

Research crew: Hobbs, Rangno, Weiss, Russell, Spurgeon, Young, Gray, McMillan, Sutherland, Garrett

Equipment Failure:
1. King
2. IR thermo
3. Gases

FIRE-III Objectives Addressed:
1. Clouds and radiation
2. Aerosol - Cloud interactions.


Flight 1761 June 5, 1998
Barrow, Alaska
72
71
70
69
Latitude
−161
−160
−159
−158
−157
−156
Longitude

Flight 1761 - June 5, 1998

1 CAR Flight Summary

```
Took measurements in and around an aerosol layer above stratus cloud;
BRDF measurement above uniform stratus cloud.
```

Data recording for the CAR started at scan 200. Skies were mostly overcast with a stratocumulus layer, and an altocumulus layer above that [1]. Weather at the surface was occasionally rainy at Barrow.

The first set of measurements were made around an aerosol layer above the stratus layer over sea ice, some distance from Barrow. The flight plan started under a hole in the stratus layer and continued above and below the aerosol layer to form a large vertically aligned loop through and around the aerosol. When above the aerosol layer the CAR was set to look down at the layer, and when below the aerosol or the cloud layer the CAR was set to position 4 (zenith) to examine the layers [2][3][4].

The aircraft then returned to Barrow, flying through the aerosol layer, during which the CAR scanned downwards. On return a number of straight line runs were made above the cloud layers over Barrow. This was followed by another loop through an aerosol layer, and a BRDF measurement over the uniform stratus cloud. During this measurement the surface could not be seen through the cloud and the roll angle varied from 17-20 °.

Loop	1	2	3	4	5	6
Filter	5	5	5	2	2	2
Scan Count	15190	15454	15685	15915	16150	16355

Following this the aircraft flew a straight line leg under the stratus cloud and landed.

Photo Records:


1. 2-layer clouds


2. tundra, some ice


3. aerosol layer

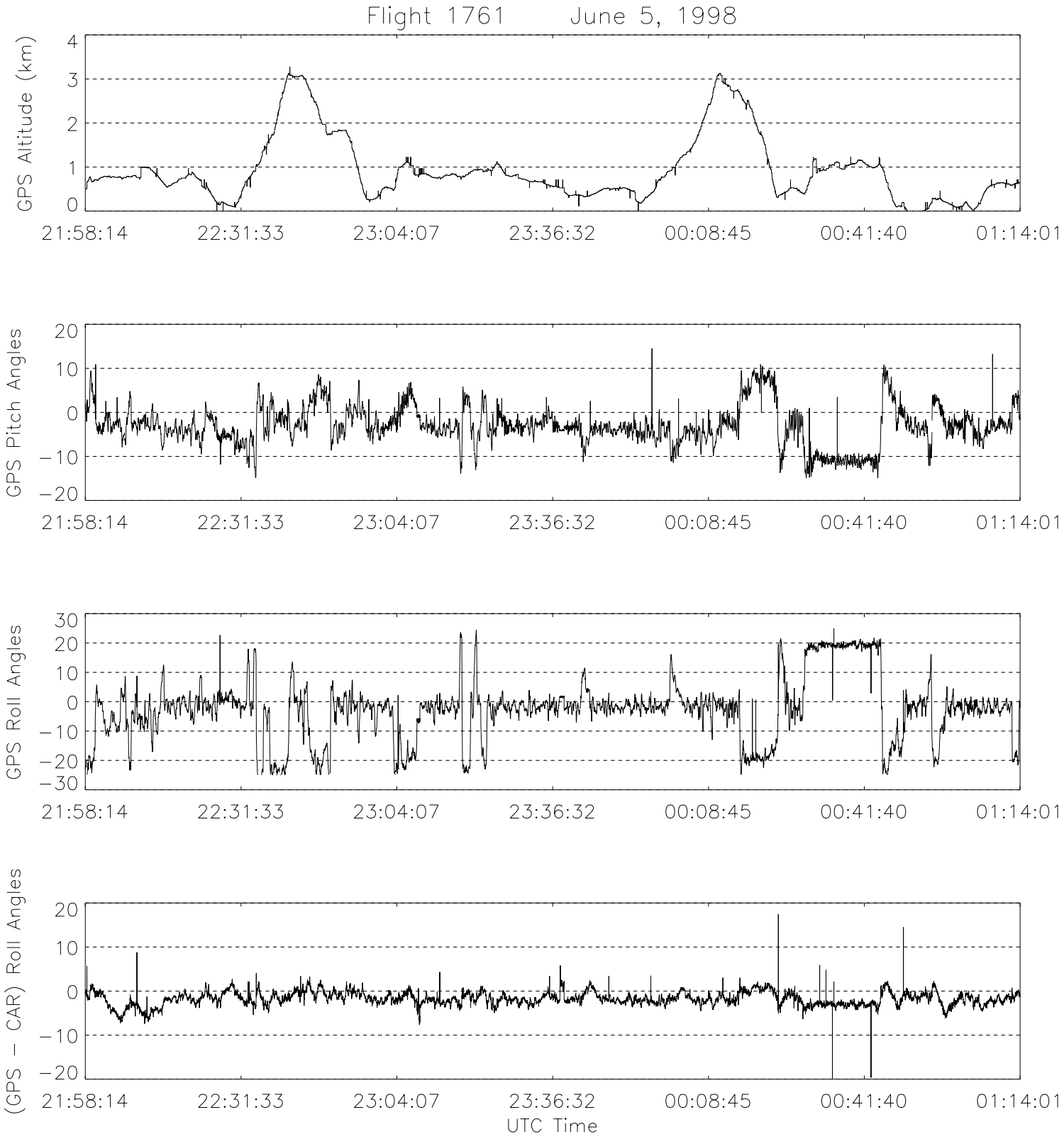

4. glory


The CAR drivers:
Han Solo, Princess Leia and Mr. Chewbacca

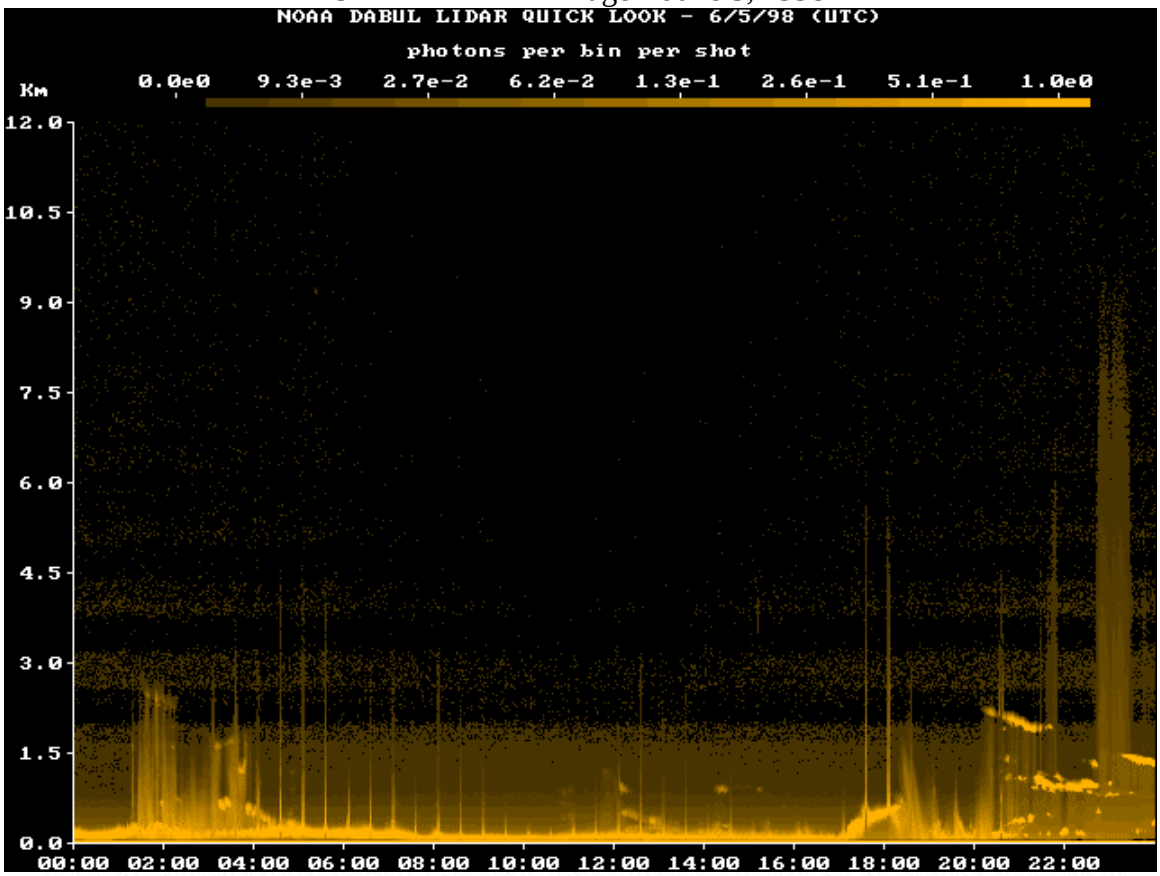
Flight Track and Quicklook Images:

- CV-580 flight tracks
- GPS roll and pitch angle

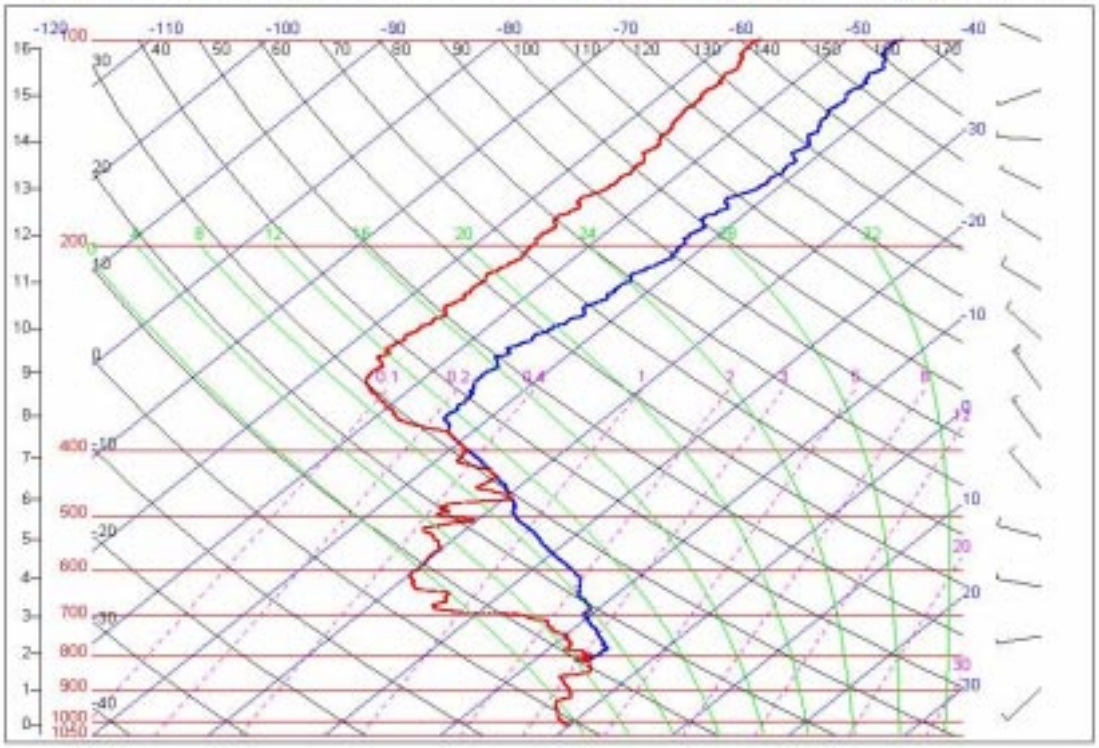
Back to Top


Flight 1761 June 5, 1998
GPS Altitude (km)
4
3
2
1
0
21:58:14
22:31:33
23:04:07
23:36:32
00:08:45
00:41:40
01:14:01
GPS Pitch Angles
20
10
0
−10
−20
GPS Roll Angles
30
20
10
0
−10
−20
−30
(GPS − CAR) Roll Angles
UTC Time

SHEBA LIDAR Image – June 5, 1998



Version: SHEBA--GPS Soundings, GLASS 1.10 Fixed, SHE, 1998,06,05, 11:17:04



June 6, 1998

ER-2

Flight summary

Ground track

MAS images

CV-580

Flight summary

Flight track

CAR notes

SHEBA

LIDAR image

Sounding

June 6, 1998

ER-2

Flight summary

Ground track

MAS images

HIS images

CV-580

Flight summary

Flight track

CAR notes

GPS plots

SHEBA

LIDAR image

Sounding

ER-2 Mission 11

Saturday, June 6, 1998

Flight Scientists: S. Platnick

Objectives: Fly over several flight legs over the NSA ARM site where relatively uniform stratus clouds are expected. Flight pattern coordinated with the University of Washington CV-580 aircraft for cloud remote sensing and cloud masking validation, cloud bi-directional reflectance measurements, and sea ice retrievals.
NOTE: The cloud LIDAR is down for the remainder of the mission making flights over multilevel clouds and cirrus more difficult for other ER-2 instruments to analyze. Therefore, the present flight, as well as tomorrow's remaining potential flight (Sunday 7 June 1998), will be planned for areas with well-defined cloud layers or clear sky.
Coordination included:

- F-14 satellite (2112 UTC)

ER-2 Mission:	Pilot:	Bill Collette
	Takeoff	1855 UTC
	Landing	2300 UTC
	Duration	4:05

The ER-2 flew a NW flight line toward the ARM site to begin a cross pattern with legs of about 280 km in length. One-and-a-half flight legs were flown in a NW-SE orientation such that the imaging instruments scanned perpendicular to the solar azimuth, followed by a total of two flight legs in a direction chosen such that imaging instruments scanned into the solar plane.
The CV-580 flew above the ARM site in coordination with the ER-2, making above and below-cloud bi-directional reflectance measurements and in situ profiles through the cloud. The CV-580 reported a stratocumulus deck with a top at about 2500 ft. and about 1000 ft. thick, with a little stratus below. They reported clear skies above the stratocumulus deck during ER-2 overpasses.

The AirMISR was turned on for 5 acquisitions: twice over the Brooks Range en route to and from Barrow, and three times over the ARM site. The AirMISR operated at the following times with notes of observed clouds as seen by the instrument:

- 1921-1933 UTC (outgoing leg over Brooks Range - gathered 8 of 9 angles; broken clouds)
- 1957-2009 UTC (ARM - complete run; stratocumulus)
- 2056-2108 UTC (ARM - complete run; stratocumulus)
- 2127-2139 UTC (ARM - complete run; stratocumulus)
- 2141-2154 UTC (return leg to Ft. Wainwright - complete run; broken clouds over land)

Pilot report: The ER-2 pilot reported solid low-level stratus deck over the entire flight operations area.

Instrument Status

- AirMISR – worked well
- AMPR – worked well
- CLS – not working
- HIS – worked well
- MAS – worked well
- MIR – worked well
- SSFR – worked well

Meteorology:

At 1500 UTC, the ice station reported stratus overcast clouds with surface winds at 4 kts, 310° and a ceilometer cloud base of about 0.5 km. Radar showing two cloud layers: lower one at 0.2-0.8 km and a higher layer at 3.9-4.5 km. The 1113 UTC sounding showed moisture increasing in a broad layer centered about 9 km. Satellite imagery showed broken high-to-midlevel clouds moving in from the northwest. Cloud cover at all levels expected to be over the ship by the time of an ER-2 flight.

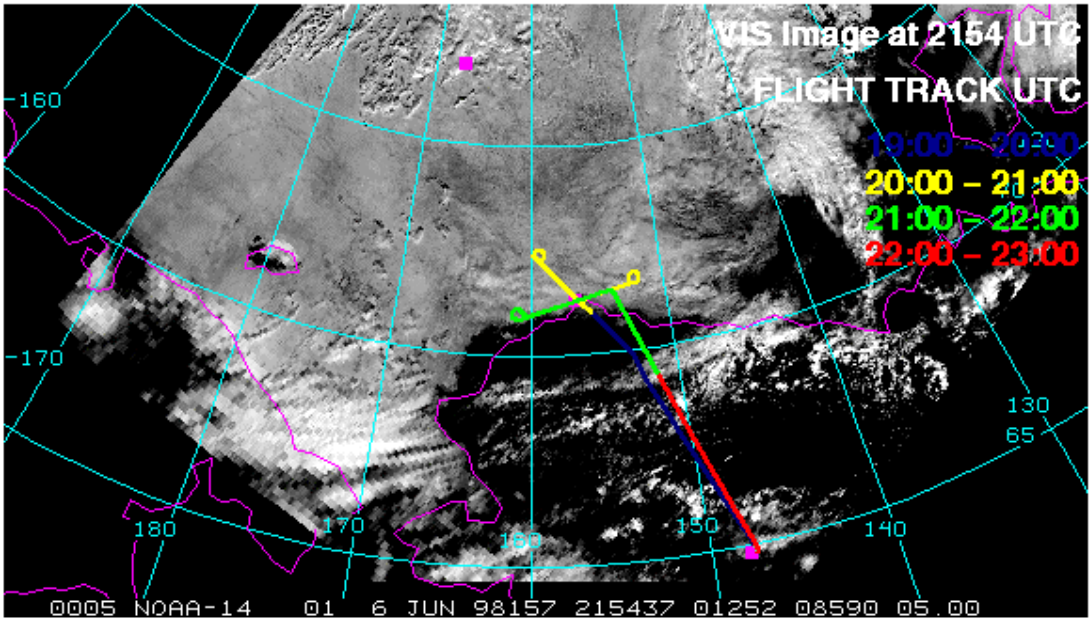
The Barrow sounding showed two cloud layers, the upper one with cloud tops at about 3-3.5 km. Imagery was showing a rather uniform stratus deck across the Barrow region with a possible breaking up of the upper level cloud layer.

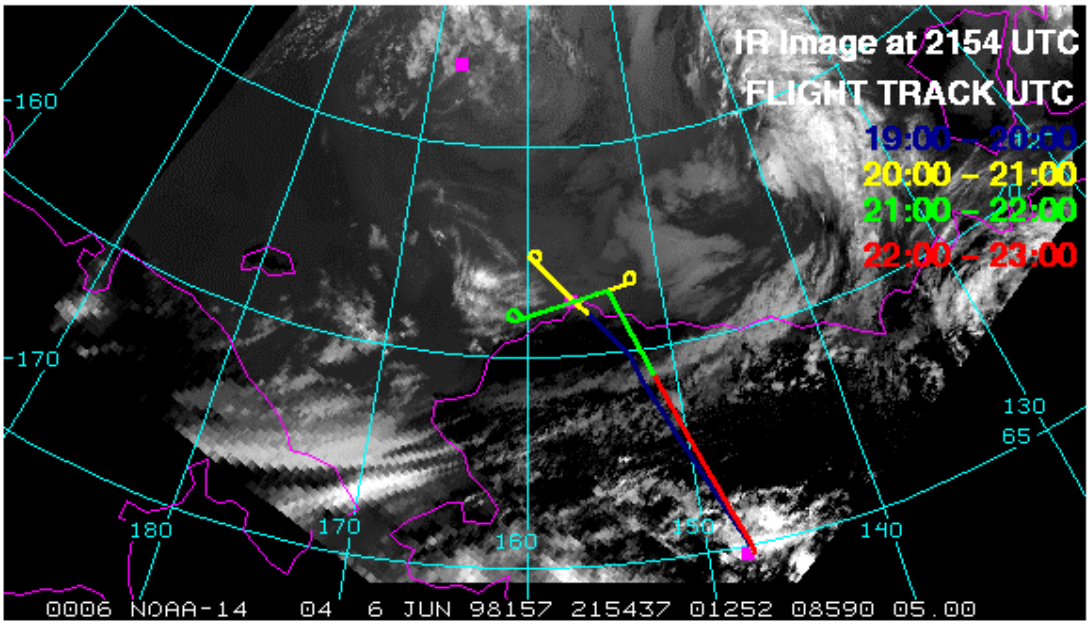
Due to lack of a working LIDAR on the ER-2, it was decided to focus a mission on Barrow where cloud layers were likely to be the most spatially uniform.

Instruments:

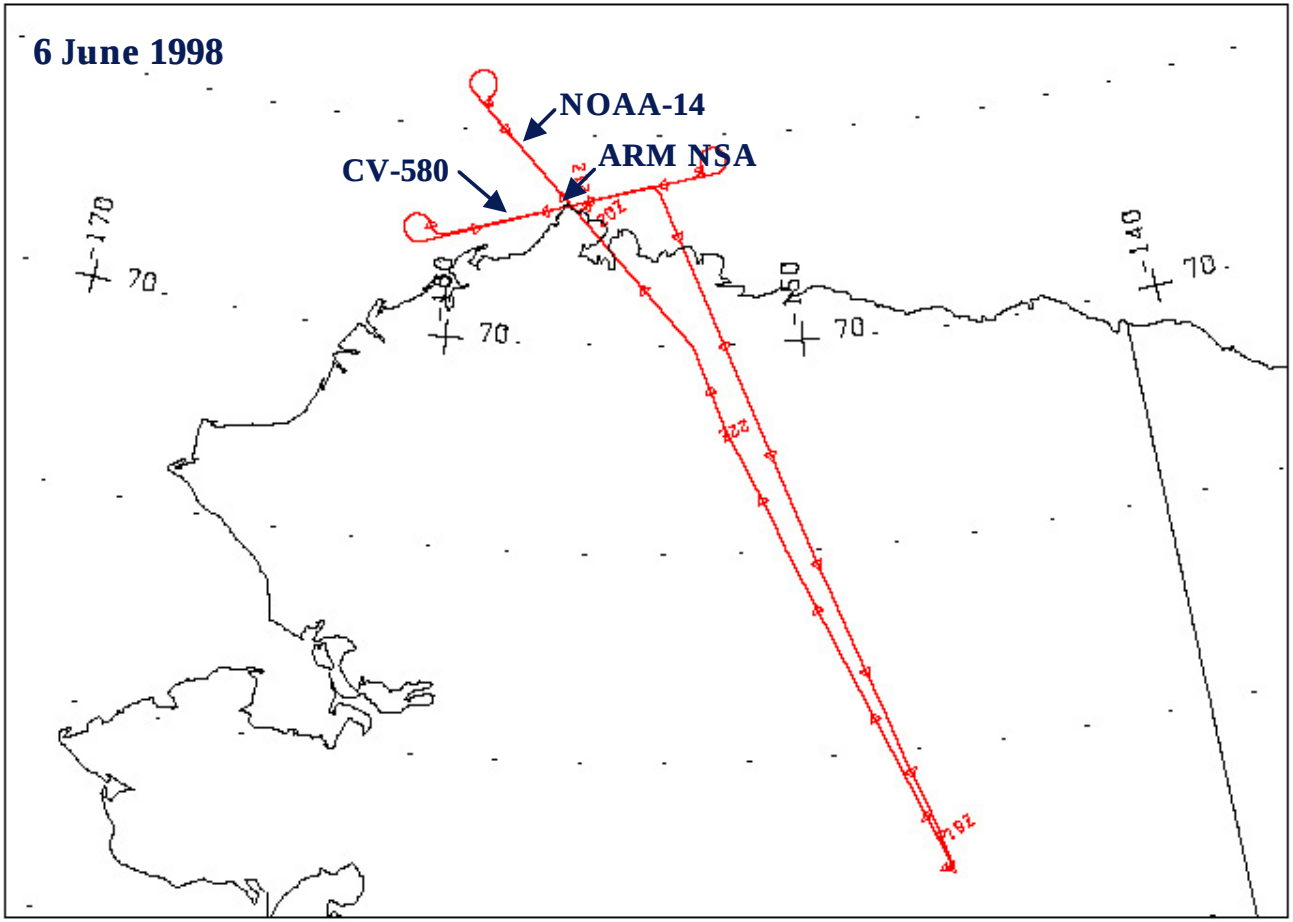
AirMISR – Airborne Multi-angle Imaging Spectroradiometer
AMPR – Advanced Microwave Precipitation Radiometer
CLS – Cloud LIDAR System
HIS – High-resolution Interferometer Sounder
MAS – MODIS Airborne Simulator
MIR – Millimeter-wave Imaging Radiometer
SSFR – Solar Spectral Flux Radiometer

ER2 FLIGHT TRACK AND NOAA–14 AVHRR IMAGES ON JUNE 6, 1998

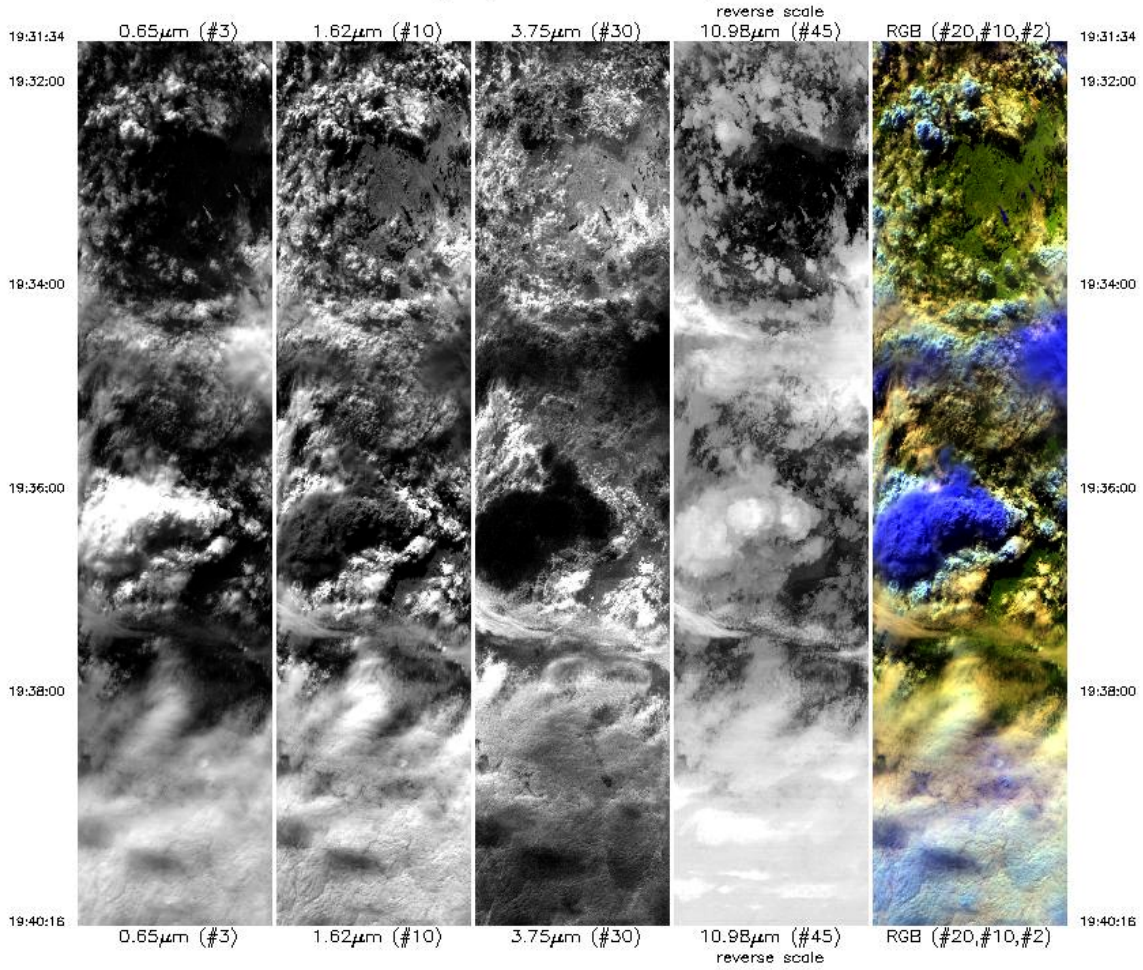




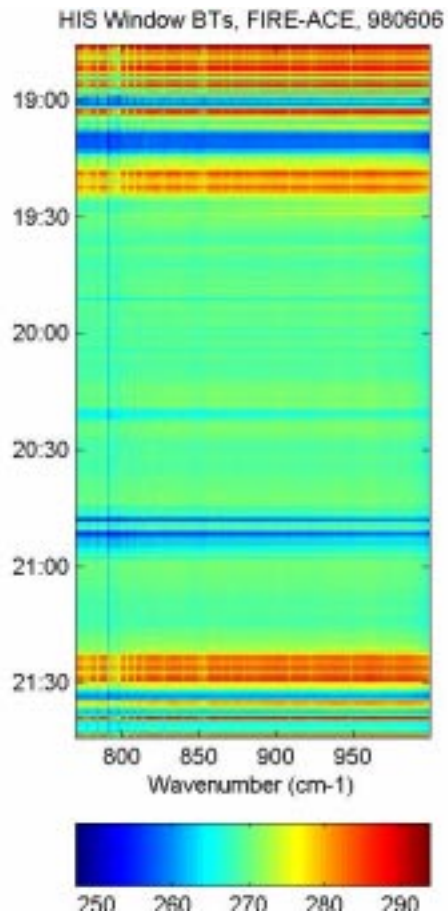
ER-2 Ground Track



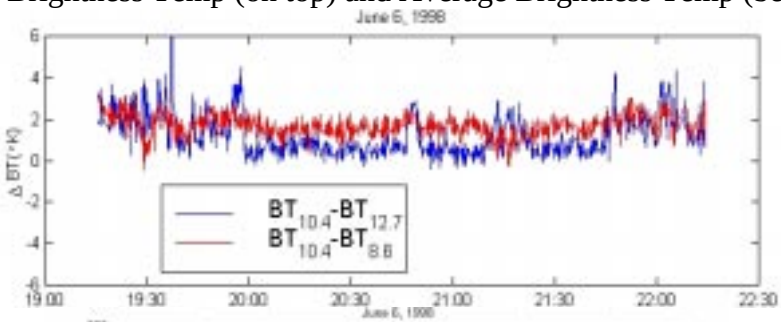
MODIS Airborne Simulator Browse Imagery
FIRE–ACE Campaign – 06 June 1998
Flight #98–076 Track #3

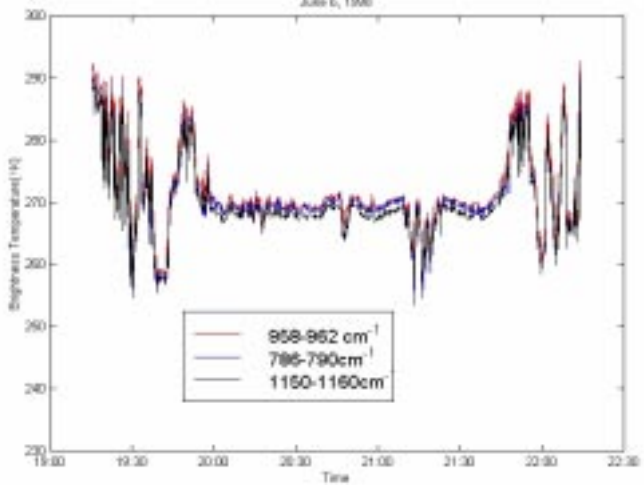


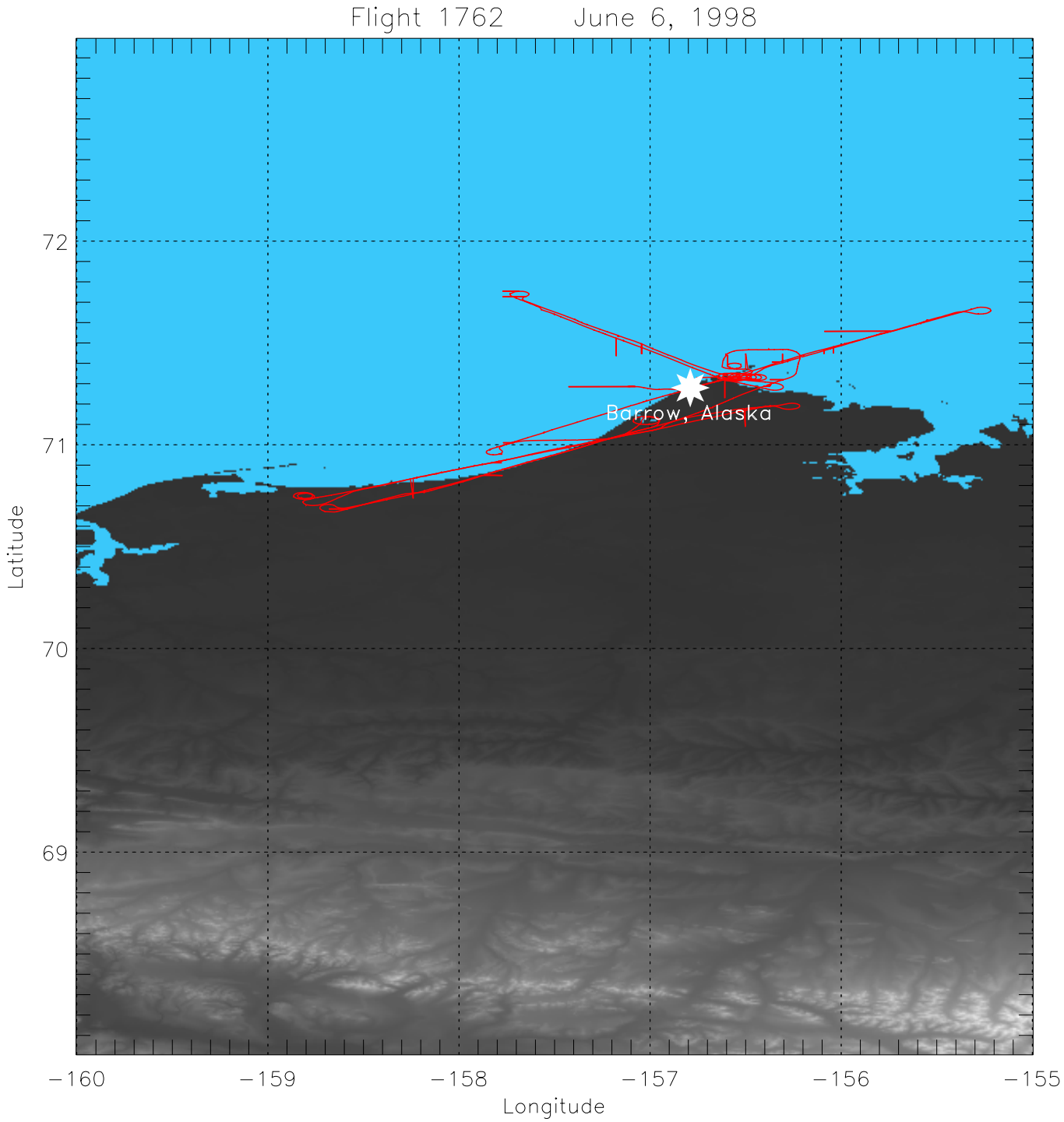
ER–2 Heading = 337.3°
Solar Zenith = 51.0°
Solar Azimuth = 134.0°



Delta Brightness Temp (on top) and Average Brightness Temp (below)






Flight 1762 June 6, 1998
Barrow, Alaska
72
71
70
69
Latitude
−160
−159
−158
−157
−156
−155
Longitude

Flight 1762 - June 6, 1998

main

Summary

Photos

Quicklooks

CAR Flight Summary

```
Flight to coordinate with ER-2 over the ARM site at Barrow; BRDF
measurement over stratus cloud.
```

This flight, over the ARM site at Barrow, was coordinated with an ER-2 overpass of the area. Weather in the area at take-off was cool and overcast, with a continuous stratus deck providing cloud cover. Measurements started with a BRDF measurement over the stratus cloud in the vicinity of the ARM site. Skies were clear above the stratus deck [1][2][3].

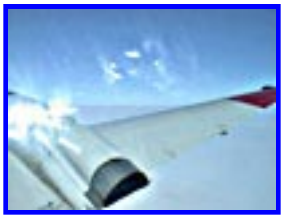
Loop	1	2	3	4	5	6
Filter	5	5	5	2	2	2
Scan Count	610	825	1040	1255	1474	1714

Following the BRDF measurement the aircraft flew straight-line paths (under the ER-2 flightpath) over the ARM site, above, beneath and occasionally through the cloud [4]. The cloud was insufficiently thick to allow diffusion domain measurements.

Photo Records:

1. BRDF over stratus cloud

2. BRDF over stratus cloud

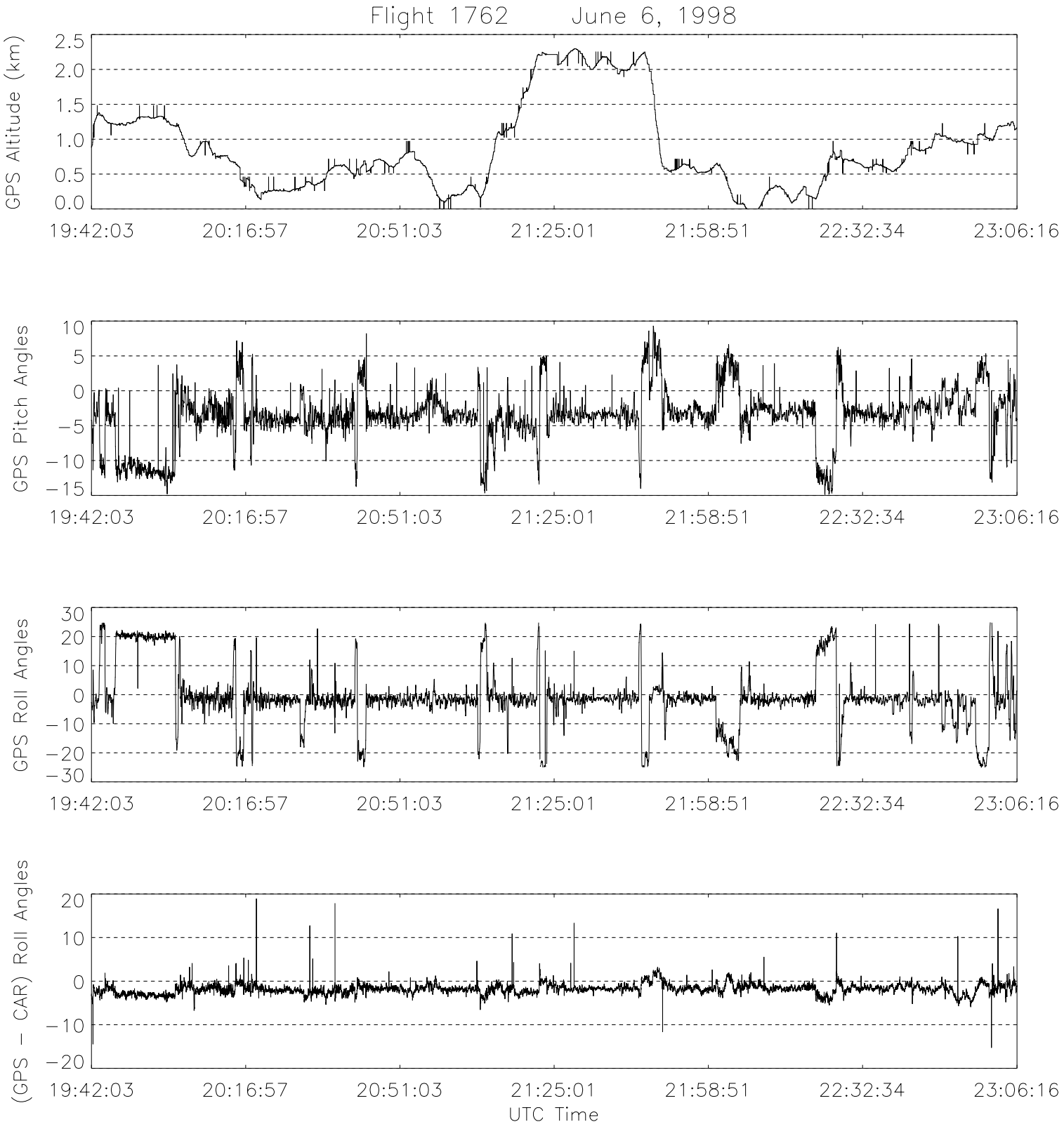


3. stratus cloud

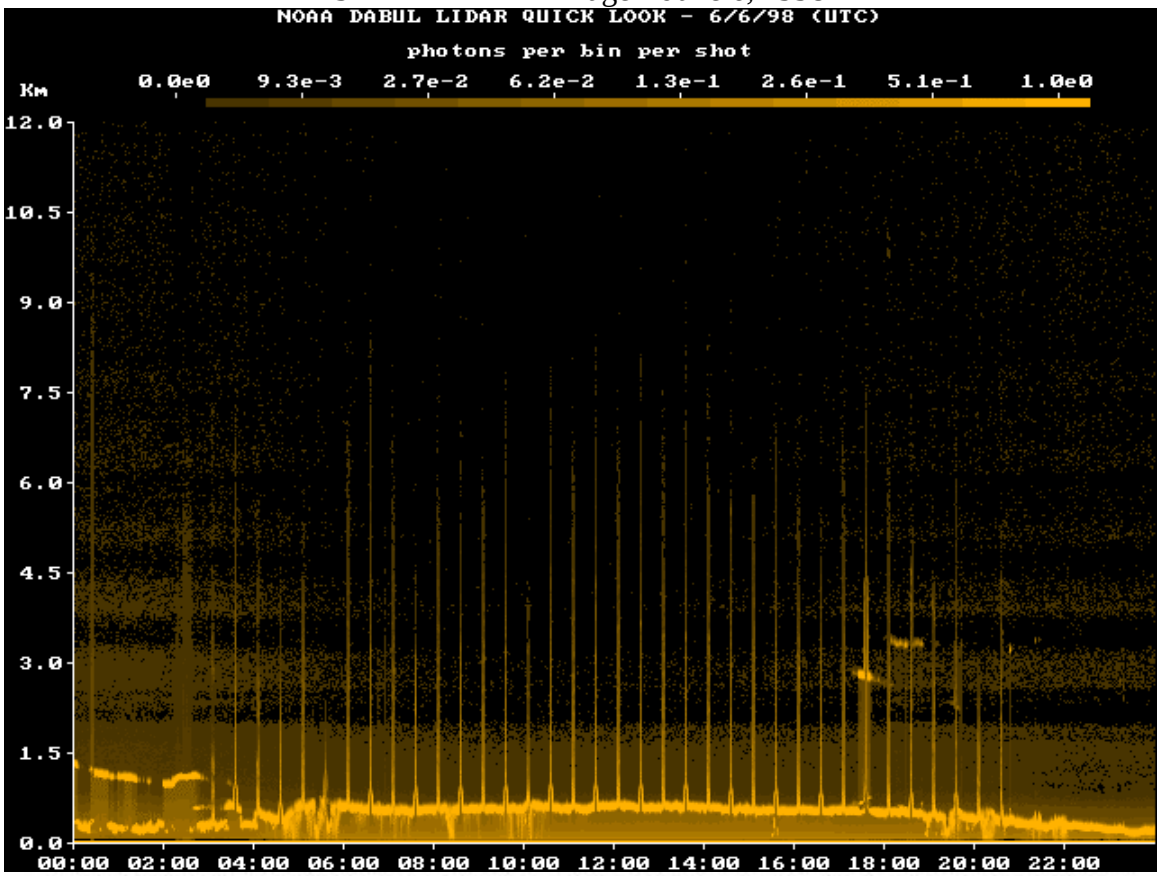
4. below cloud near ARM site

Fire Ace

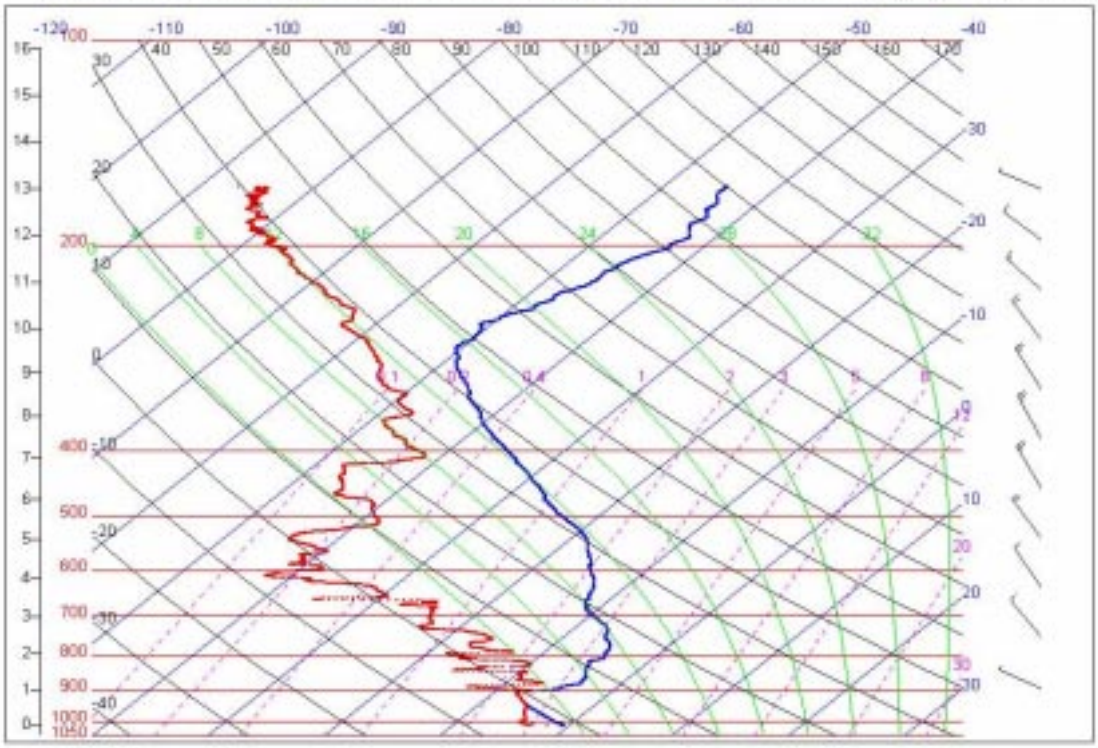
May - June, 98
Barrow, Alaska


Flight 1762 June 6, 1998
GPS Altitude (km)
2.5
2.0
1.5
1.0
0.5
0.0
19:42:03
20:16:57
20:51:03
21:25:01
21:58:51
22:32:34
23:06:16
GPS Pitch Angles
10
5
0
−5
−10
−15
GPS Roll Angles
30
20
10
0
−10
−20
−30
(GPS − CAR) Roll Angles
20
10
0
−10
−20
UTC Time

SHEBA LIDAR Image – June 6, 1998



Version: SHEBA--GPS Soundings, GLASS 1.10 Fixed, SHE, 1998,06,06, 11:12:47



June 7, 1998

CV-580

Flight summary

Flight track

CAR notes

GPS plots

SHEBA

LIDAR image

Sounding

UW CV-580 FLIGHT LOG
June 07, 1998

Author (Mission Scientist): Hobbs, Peter

Flight Number: 1763
Departure Airport: Barrow
Arrival Airport: Barrow

Experimental Observations:

This flight was concerned primarily with measurements over the SHEBA ship, now located at 77°00 min N / 166°40.6 min W. A front passed over the ship during the period of our measurements. After returning to the Barrow area, aerosol measurements were made in a vertical profile under cloudless conditions in the vicinity of the ARM site.

Measurements Over the SHEBA Ship:

1) 2048-2109 UTC: Spiral descent over SHEBA ship from 19,000 ft to below cloud base (~1500 ft) through several cloud layers.

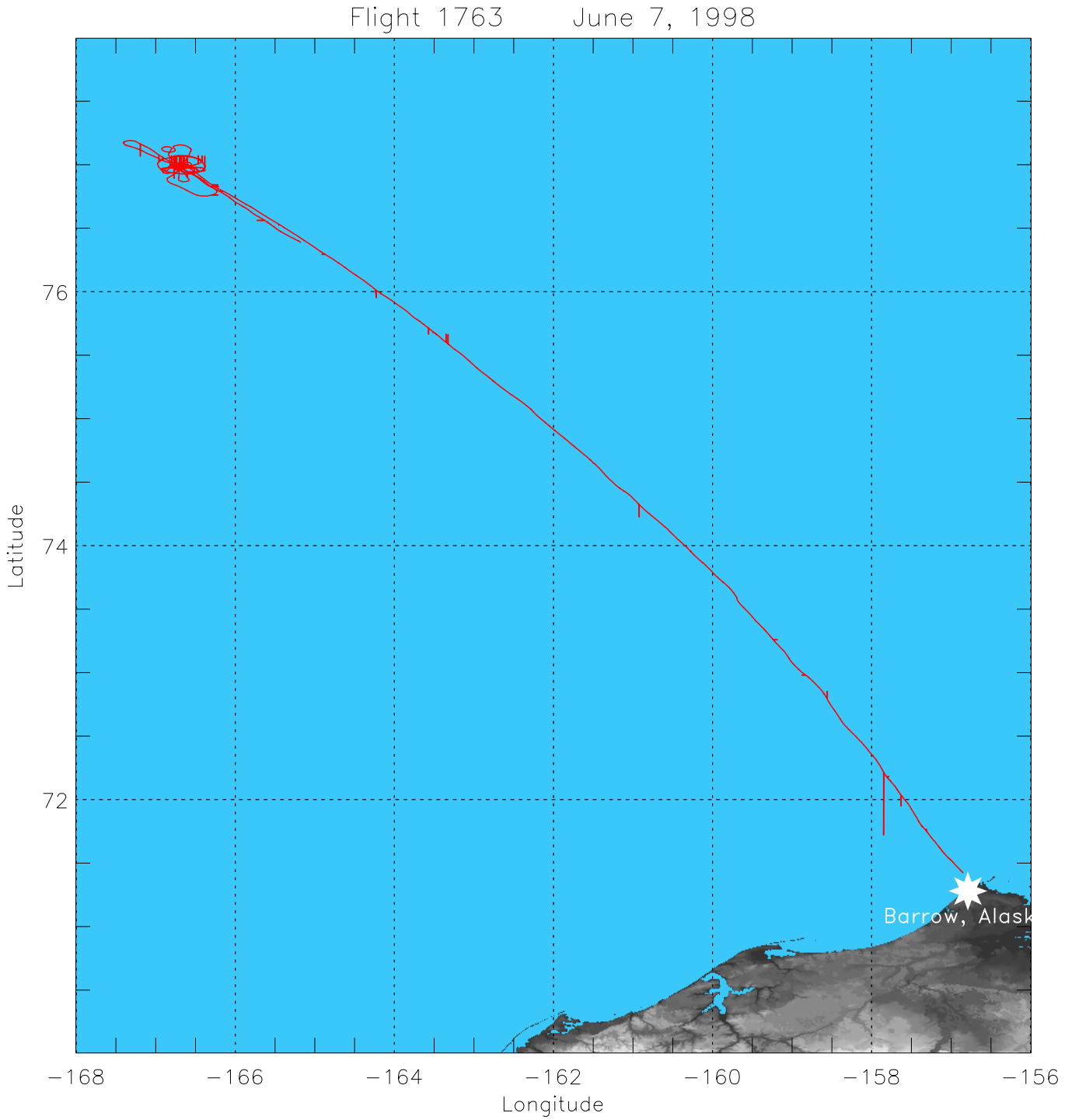
2) 2108-2157 UTC: Ten CAR circles, centered on ship, for BRDF measurements under diffuse lighting (i.e. overcast sky). Also, several level runs over ground L-shaped surface albedo array for albedo measurements.

3) 2157-2238 UTC: Spiral ascent over ship. Level run, centered on ship and extending 6 nm on either side of ship, at 1400 ft in stratus layer. Level run at 19,300 ft in cirrus, also centered on ship and 6 nm on either side of ship.

4) 2238-2412 UTC: Return to Barrow

Measurements in Barrow Area:

Vertical profile from 22,000 ft to surface in cloudless sky. Intensive aerosol measurements in haze layers at 9,300 and 8,400 ft, including filter samples.


Flight 1763 June 7, 1998
Latitude
76
74
72
Barrow, Alask
−168
−166
−164
−162
−160
−158
−156
Longitude

Flight 1763 - June 7, 1998

1 CAR Flight Summary

Flight over the SHEBA site, for straight line paths and BRDF measurements; temporary fix for the noise problem may have been indentified.

Weather at Barrow on take-off was clear and cool. On the flight out to the SHEBA site cloud increased and haze layers were evident. The highlight of this section of the flight was the frontal passage at 20:06 UTC (scan 5494) [1][2].

At 20:48 UTC we arrived at the SHEBA site. There were multiple cloud layers over the ship; altocumulus 18200-19000 ft, variable cloud layers to 1600-8200 ft [3]. At scan 11795 we started straight line flight paths over the ship at about 800 ft [4][5]. After this we performed a BRDF measurement in the vicinity of the ship. Skies were uniformly overcast and the surface was ice covered with some large leads. The roll angle was observed to vary between about 12 and 25 °.

Loop	1	2	3	4	5
Filter	5	5	5	5	5
Scan Count	12610	12852	13077	~ 13300	13677

Loop	6	7	8	9	10
Filter	2	2	2	2	2
Scan Count	13900	14137	14351	14608	14813

Testing during the flight appeared to show that the noise previously noted using the automatic filterwheel was suppressed when the heater was used. This was noted during the initial descent over the SHEBA site, when condensation was indicated on the mirror. The heater was activated, and left on for some time. During a test of the filter wheel no noise appeared. Upon switching the heater off the noise reappeared. This worked successfully several times.

At 22:46 UTC a power outage required a change of tape. On return to the Barrow area a new tape was loaded (flt-1763B) and some tracks were taken over the ARM site. There were, however, few level tracks over the ARM site. After a few tracks over the ARM site the flight ended.

Photo Records:


1. clouds behind front


2. frontal passage


3. variable clouds at SHEBA


4. passes over SHEBA ship

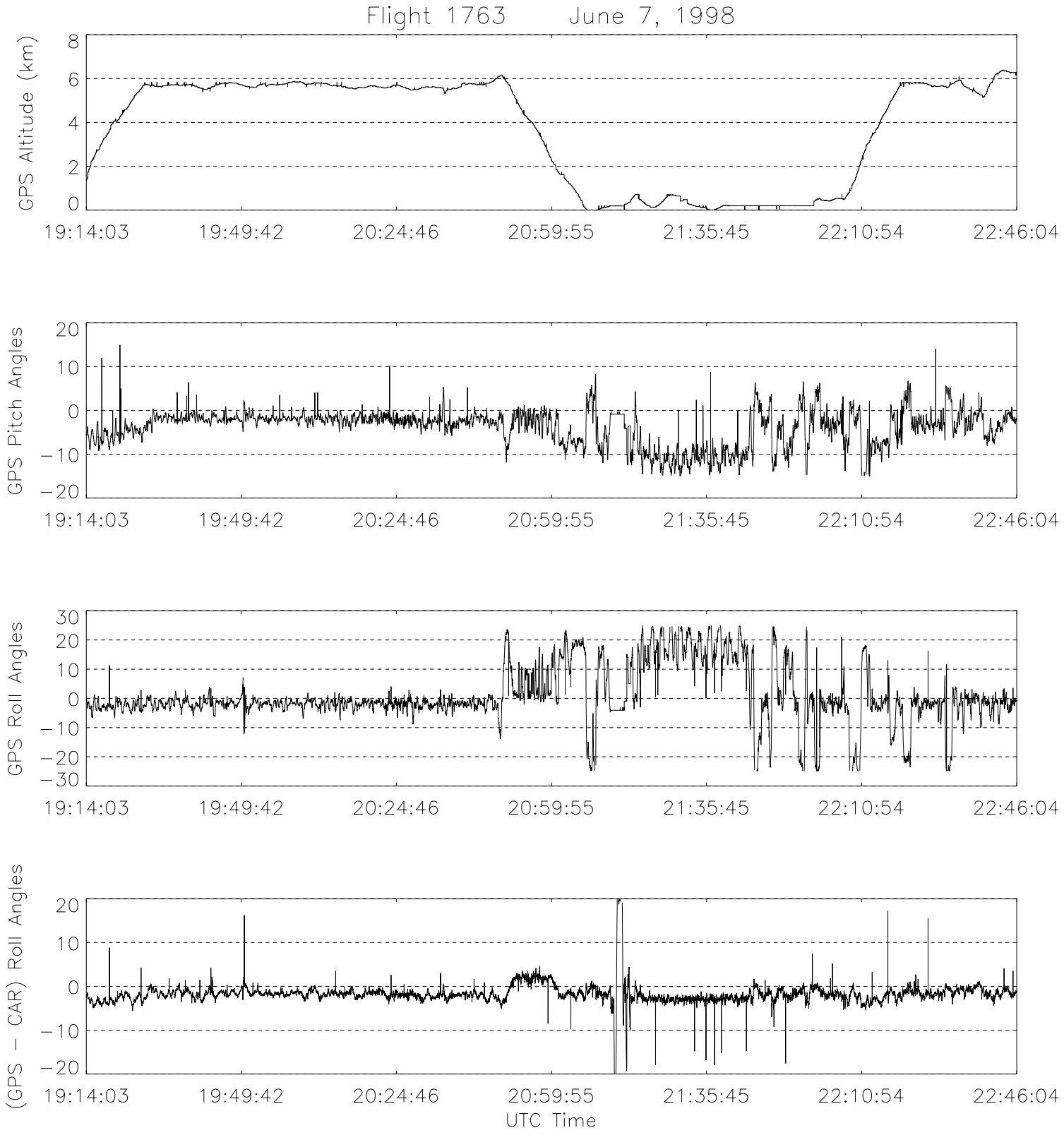

5. passes over SHEBA ship


6. aerial shot of Barrow

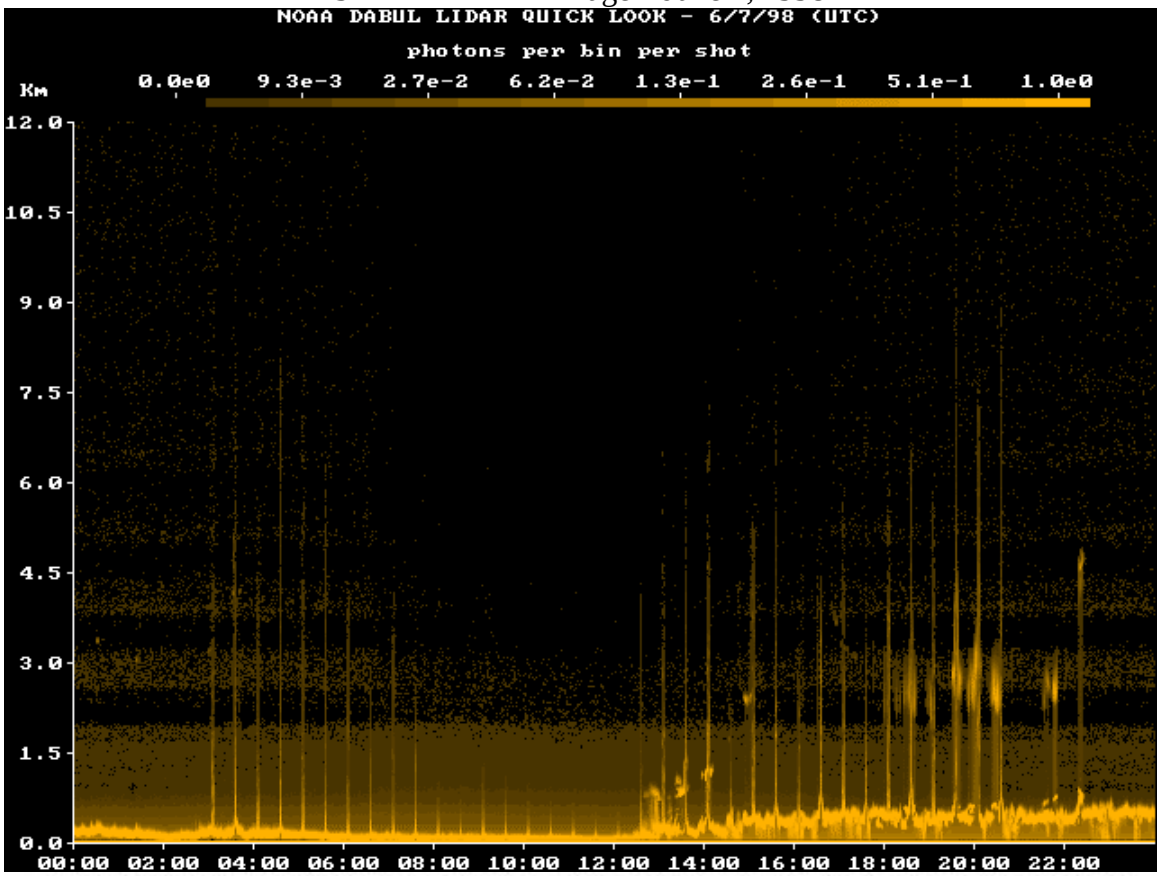
Flight Track and Quicklook Images:

- CV-580 flight tracks
- GPS roll and pitch angle

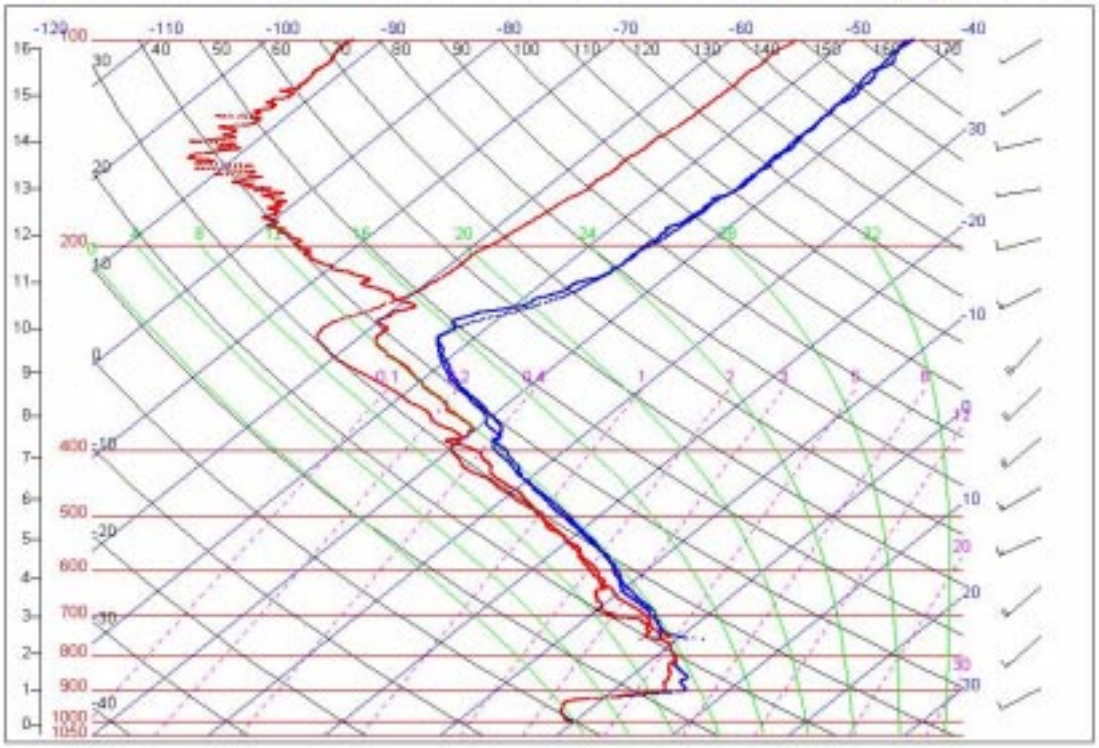
Back to Top


Flight 1763 June 7, 1998
GPS Altitude (km)
8
6
4
2
0
19:14:03
19:49:42
20:24:46
20:59:55
21:35:45
22:10:54
22:46:04
GPS Pitch Angles
20
10
0
−10
−20
GPS Roll Angles
30
20
10
0
−10
−20
−30
(GPS − CAR) Roll Angles
UTC Time

SHEBA LIDAR Image – June 7, 1998



Version: SHEBA--GPS Soundings, GLASS 1.10 Fixed, SHE, 1998,06,07, 11:16:12



June 9, 1998

CV-580

Flight summary

Flight track

CAR notes

GPS plots

SHEBA

LIDAR image

Sounding

UW CV-580 FLIGHT LOG
June 09, 1998

Author (Mission Scientist): Hobbs, Peter

Flight Number: 1764
Departure Airport: Barrow
Arrival Airport: Barrow

Summary:
This flight was concerned with a cloud-aerosol-radiation study over the Chukchi Sea.

Experimental Observations:
1) ABSORPTION OF SOLAR RADIATION BY A STRATUS LAYER.

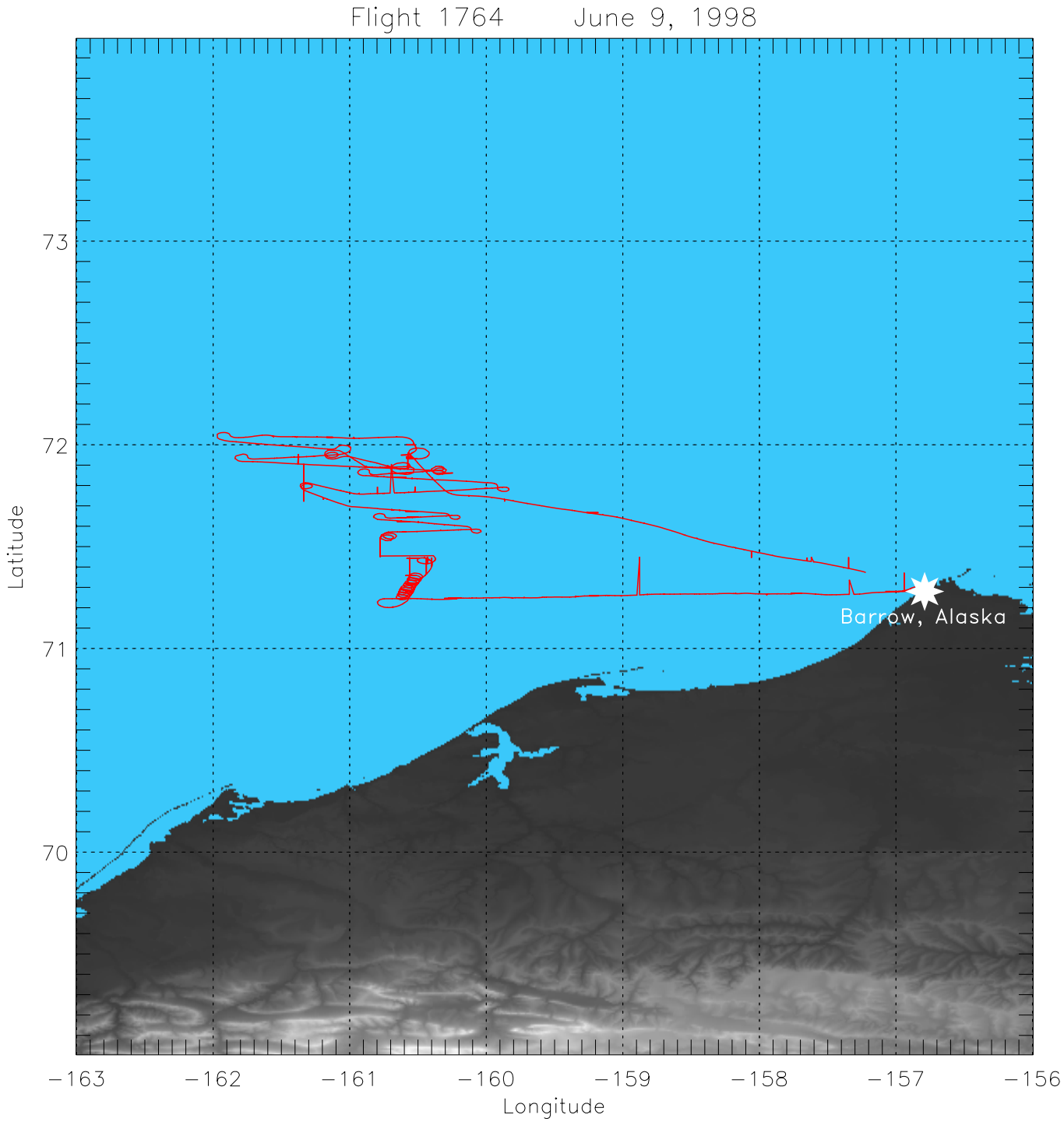
With clear sky above, and sea ice below, radiation measurements were made above and beneath a fairly uniform stratus layer consisting mainly of water drops. Measurements were then made within the cloud.

1) "AEROSOL-CLOUD SHADING" EFFECT

Since the cloud referred to above had a significant aerosol layer above it, and the cloud also had a hole in it (to the west), it corresponded closely to Fig. 7 in "Hobbs Flight Scenarios for FIRE-ACE". Therefore, immediately following 1) above, we moved into a study of the "Aerosol-Cloud Shading" Effect. Detailed radiation and aerosol measurements were obtained above and in the aerosol layer, between the aerosol layer and cloud top, below cloud base, and within the cloud. These various runs extended above and below both the cloud and the 'hole" in the cloud.

3) BRDF MEASUREMENTS were then made of the stratus tops.

4) FURTHER IN-CLOUD measurements were obtained on the return to Barrow.


Flight 1764 June 9, 1998
73
72
71
70
Latitude
Barrow, Alaska
−163
−162
−161
−160
−159
−158
−157
−156
Longitude

Flight 1764 - June 9, 1998

main

1 Summary

2 Photos

3 Quicklooks

1 CAR Flight Summary

Flew straight line paths in and around stratus cloud over sea ice. There was a partially successful attempt at diffusion domain measurements. Also conducted BRDF measurement over uniform stratus cloud.

At the beginning of the flight we flew out to a region of uniform stratus cloud over the sea ice for a 20 mile straight line run (starting scan 3200). During the flight out a clear glory was noted on the cloud beneath the cloud [1][2][3][4][5][6][7][8][9][10][11]. During the run the cloud noticeably thinned to the extent that that surface was occasionally visible (hi-resolution version: [1][3][4][7][8][9]).

In preparing for the initial run, the cloud was definitely thick enough for diffusion domain measurements (neither the ground nor the sun were visible from deep within some sections of the cloud). Following the large run we returned for an attempt at diffusion domain measurements, however the diffusion domain proved to be more elusive than expected. The following scan regions seemed to be the most likely candidates for diffusion domain; 5559-5616, 5725-5770, 5790-5900.

Following this we performed measurements around an aerosol layer with runs above and beneath the aerosol layer [12][13][14][15][16]. And following this we performed a BRDF measurement over uniform stratiform cloud in the oceanic area where previous measurements were performed. Roll angle during the measurement varied between 18° and 20° [17][18][19][20][21][22] (hi-resolution version: [18][19][24]).

Loop	1	2	3	4	5
Filter	5	5	5	5	5
Scan Count	15165	15398	15618	15843	16068

Loop	6	7	8	9	10
Filter	2	2	2	2	2
Scan Count	16290	16534	16752	16980	17290

Following these measurements the cloud situation was no longer optimal for measurements, and the aircraft returned to Barrow.

Photo Records:


1. broken clouds over ice


2. Stratus and cirrus


3. cumulus area


4. glory


5. twenty mile run


6. twenty mile run


7. glory


8. uniform stratus


9. stratus edge


10. sea ice


11. forward from dome


12. upper SSFR dome


13. cloud edge and ice


14. ice and broken cloud


15. clouds in aerosol run


16. aerosol run


17. haze layer


18. gap in clouds

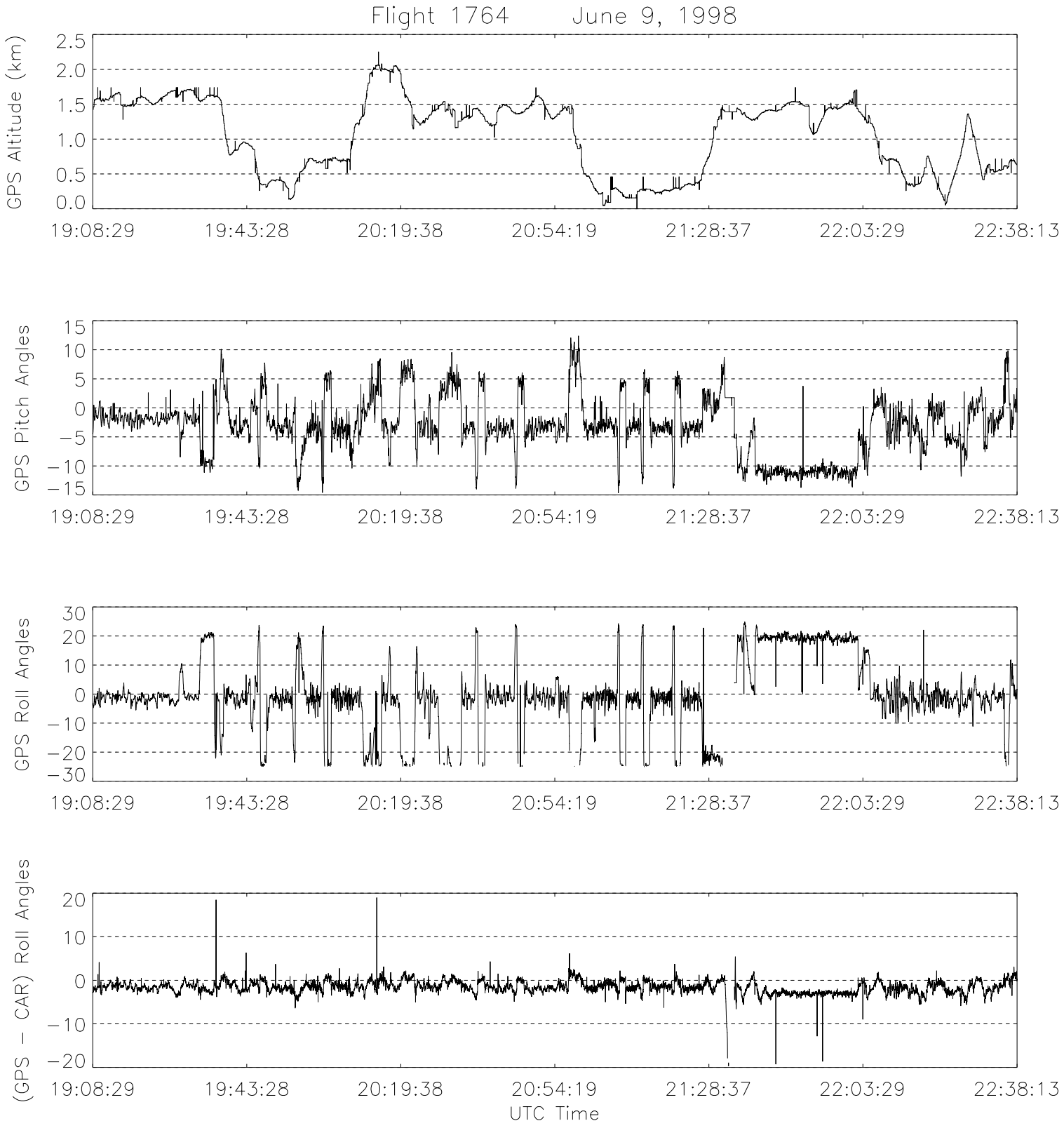

19. BRDF area


20. BRDF area

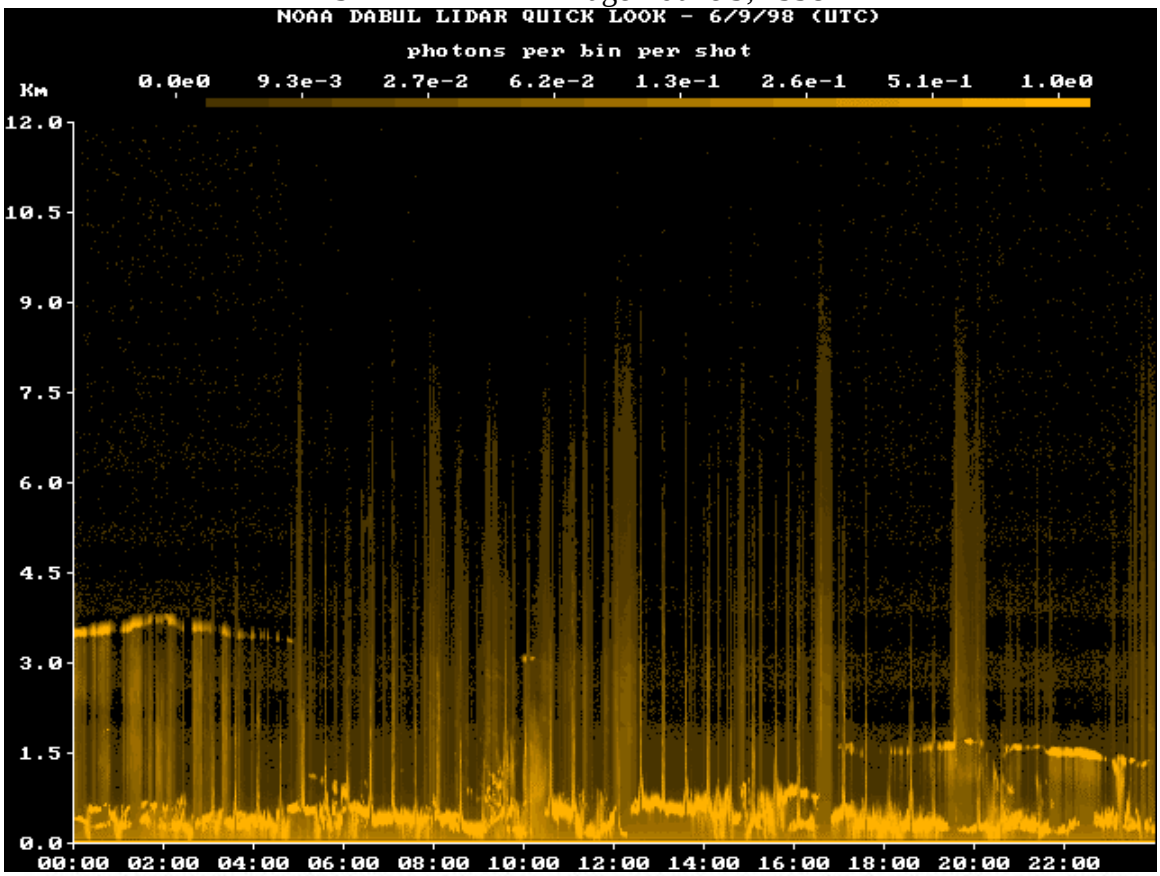

21. BRDF area


22. visible haze layer

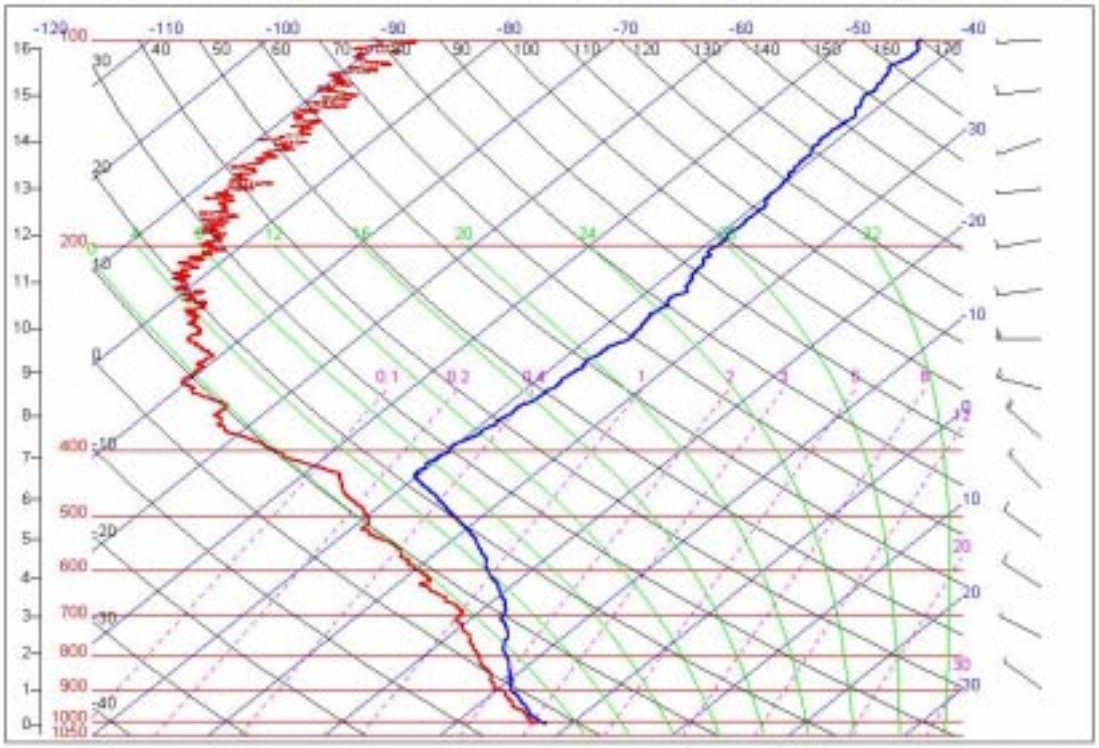

23. ice buildup on SSFR dome


Flight 1764 June 9, 1998
GPS Altitude (km)
2.5
2.0
1.5
1.0
0.5
0.0
19:08:29
19:43:28
20:19:38
20:54:19
21:28:37
22:03:29
22:38:13
GPS Pitch Angles
15
10
5
0
−5
−10
−15
GPS Roll Angles
30
20
10
0
−10
−20
−30
(GPS − CAR) Roll Angles
20
10
0
−10
−20
UTC Time

SHEBA LIDAR Image – June 9, 1998



Version: SHEBA--GPS Soundings, GLASS 1.10 Fixed, SHE, 1998,06,09, 11:18:56



June 11, 1998

CV-580

Flight summary

Flight track

CAR notes

GPS plots

SHEBA

LIDAR image

Sounding

UW CV-580 FLIGHT LOG
June 11, 1998

Author (Mission Scientist): Hobbs, Peter

Flight Number: 1765
Departure Airport: Barrow
Arrival Airport: Barrow

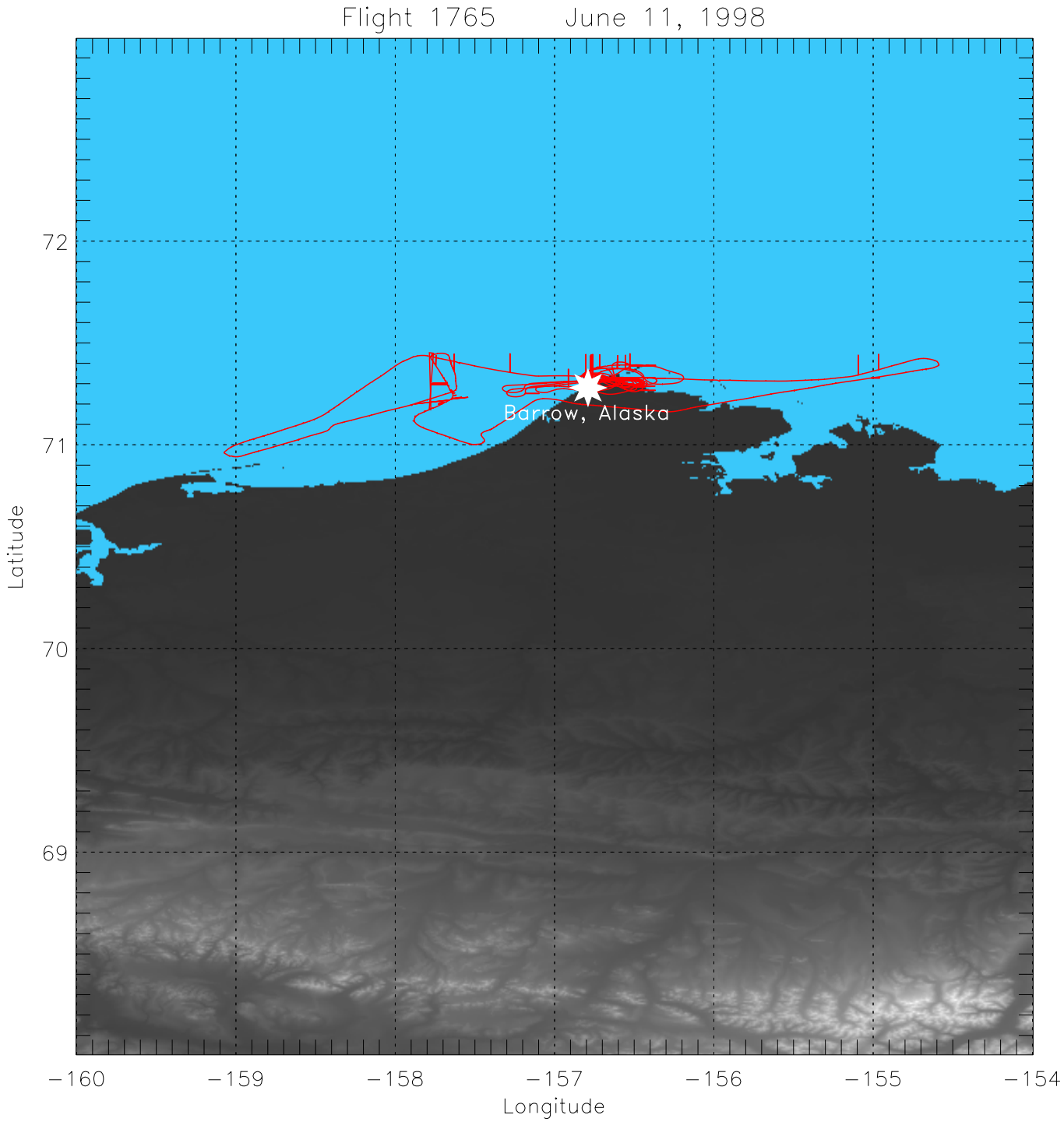
Experimental Observations:

1) CLOUD MICROPHYSICS MEASUREMENTS (~1830-1925 UTC)

Measurements of structures in Sc, Ac, As, Ci over Chukchi Sea. The complex multi-layered clouds confounded any simple radiative investigations.

2) MEASUREMENTS OVER ARM SITE (1946-2034 UTC)

Spiral descent from 21,000 ft to 700 ft over ARM site through five cloud layers. Intensive measurements in an aerosol layer at ~11,000 ft.


Flight 1765 June 11, 1998
Barrow, Alaska
72
71
70
69
Latitude
−160
−159
−158
−157
−156
−155
−154
Longitude

Flight 1765- June 11, 1998

main

1 Summary

2 Photos

3 Quicklooks

1 Flight Summary

This flight plan was to fly over the ARM site. The cloud situation was very complex (contrary to expectations), with at least 3 cloud layers. The noise problems seem to have been repeatable, after experimentation during the flight.

Observed weather at the surface was cool and overcast with stratocumulus cloud. Ascending through the cloud base at 2000 ft revealed a fairly thick cloud layer which seemed a to be a good candidate for diffusion domain measurements [1]. Flight through the cloud revealed that it thinned rapidly. Ascending further several distinct altocumulus layers were identified, further complicating the situation. Further flight over the sea revealed a no less complicated situation [2][3] (hi-resolution version: [2][3]). The decision was made to abort the flight and return to base.

On return to Barrow a low pass over the ARM site and surrounding tundra was made [4][5][6][7][8] (hi- resolution version: [5][6][7][8]).

During this flight we noted that noise reappeared while using the auto-changing filter, despite the fact that the heater was on low. This showed that the heater does not suppress noise, as we had believed. Examining the incidence of noise revealed the conditions under which the noise appears. After several tests of the auto filter channel it appears that the noise spikes appear when one of the channels is indicated as saturated on the screen display, and the filter is changing. The noise spike appears to show up on all channels. This could indicate a problem with the amplifier chip (suggested by Don Spurgeon).

Photo Records:


1. stratus, alto cu over Barrow


2. multi-layer cloud


3. multi-layer cloud


4. tundra near ARM


5. tumdra near ARM


6. dewline station


7. ARM site


8. tundra (at 300 ft)

Flight Track and Quicklook Images:

- CV-580 flight tracks
- GPS roll and pitch angle

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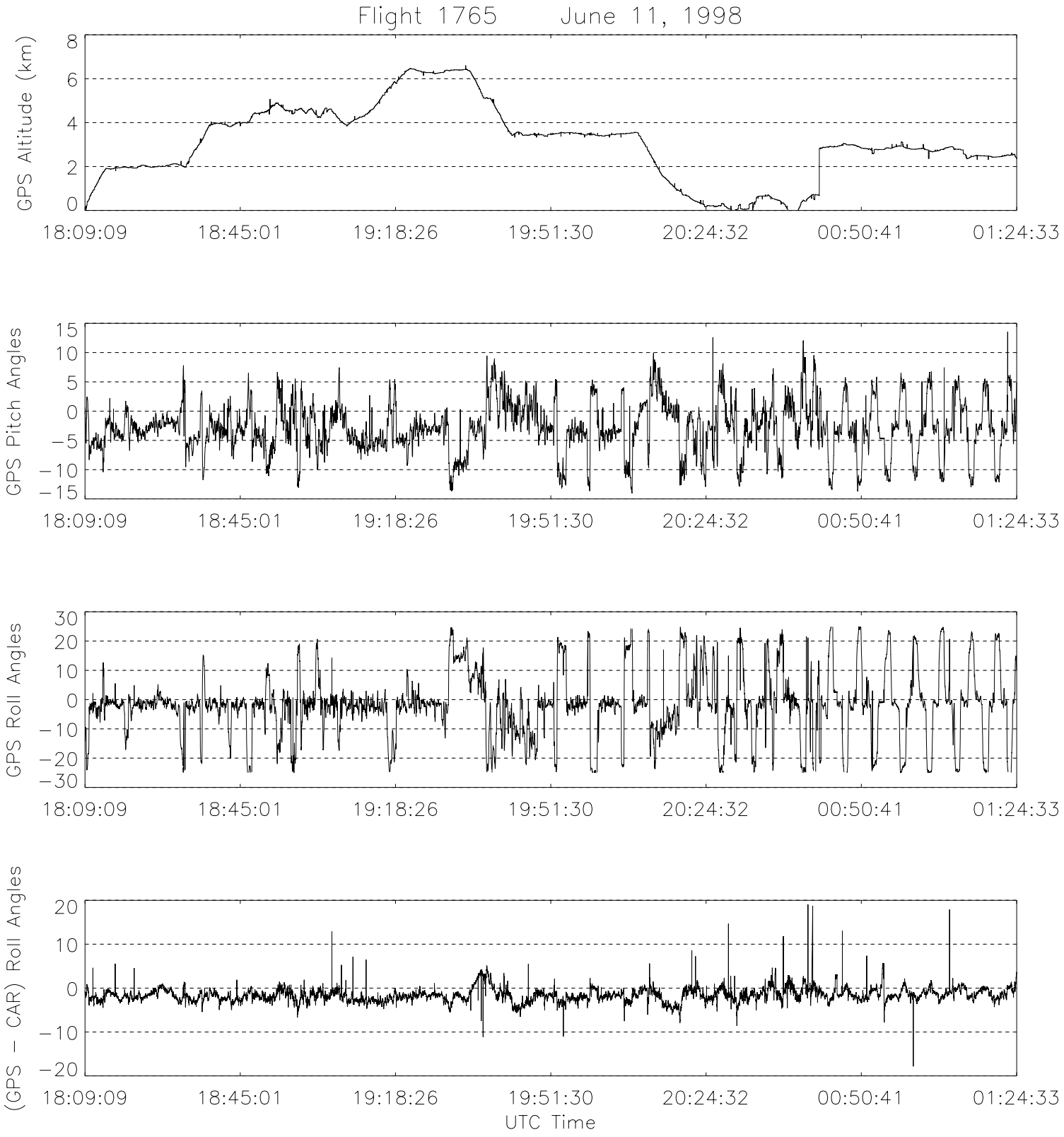
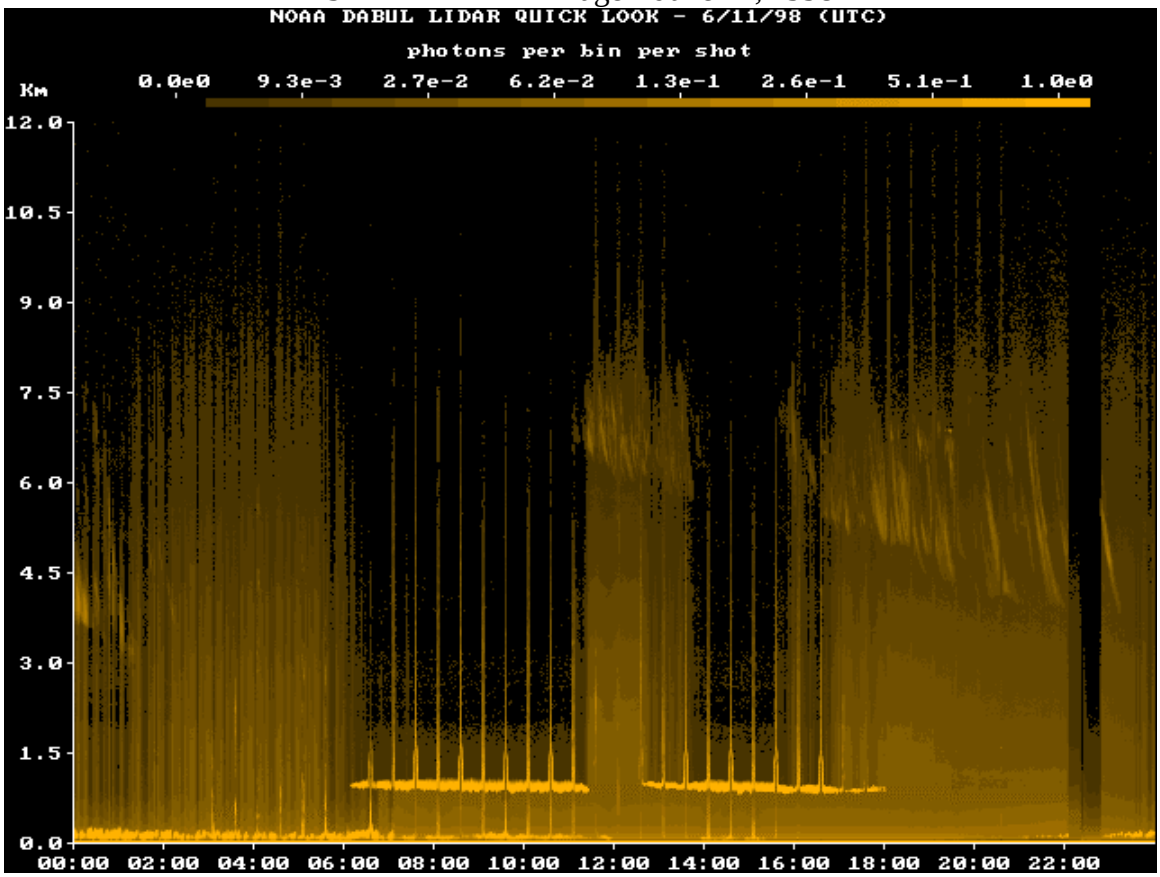

Flight 1765 June 11, 1998
GPS Altitude (km)
8
6
4
2
0
18:09:09
18:45:01
19:18:26
19:51:30
20:24:32
00:50:41
01:24:33
GPS Pitch Angles
15
10
5
0
−5
−10
−15
GPS Roll Angles
30
20
10
0
−10
−20
−30
(GPS − CAR) Roll Angles
20
10
0
−10
−20
UTC Time

SHEBA LIDAR Image – June 11, 1998



June 13, 1998

CV-580

- Flight summary
- Flight track
- CAR notes
- GPS plots

SHEBA

- LIDAR image
- Sounding

UW CV-580 FLIGHT LOG
June 13, 1998

Author (Mission Scientist): Hobbs, Peter

Flight Number: 1766
Departure Airport: Barrow
Arrival Airport: Barrow

Summary:
Cloud and radiation measurements around SHEBA ship.

Details:
1) 1933-1956 UTC: BRDF measurements over single stratus layer just to NW of ship. (Immediately above the ship there was an encroaching Ac layer above the stratus. We, therefore, decided to do cloud absorption measurements on the stratus layer in a region unaffected by the Ac).

2) 1958 - 2005 UTC: 20 nm level run above top of the stratus (very uniform cloud layer), Ac drifted with wind (A -> B).

3) 2008 - 2016 UTC: 20 nm level run below cloud base (B-> A).

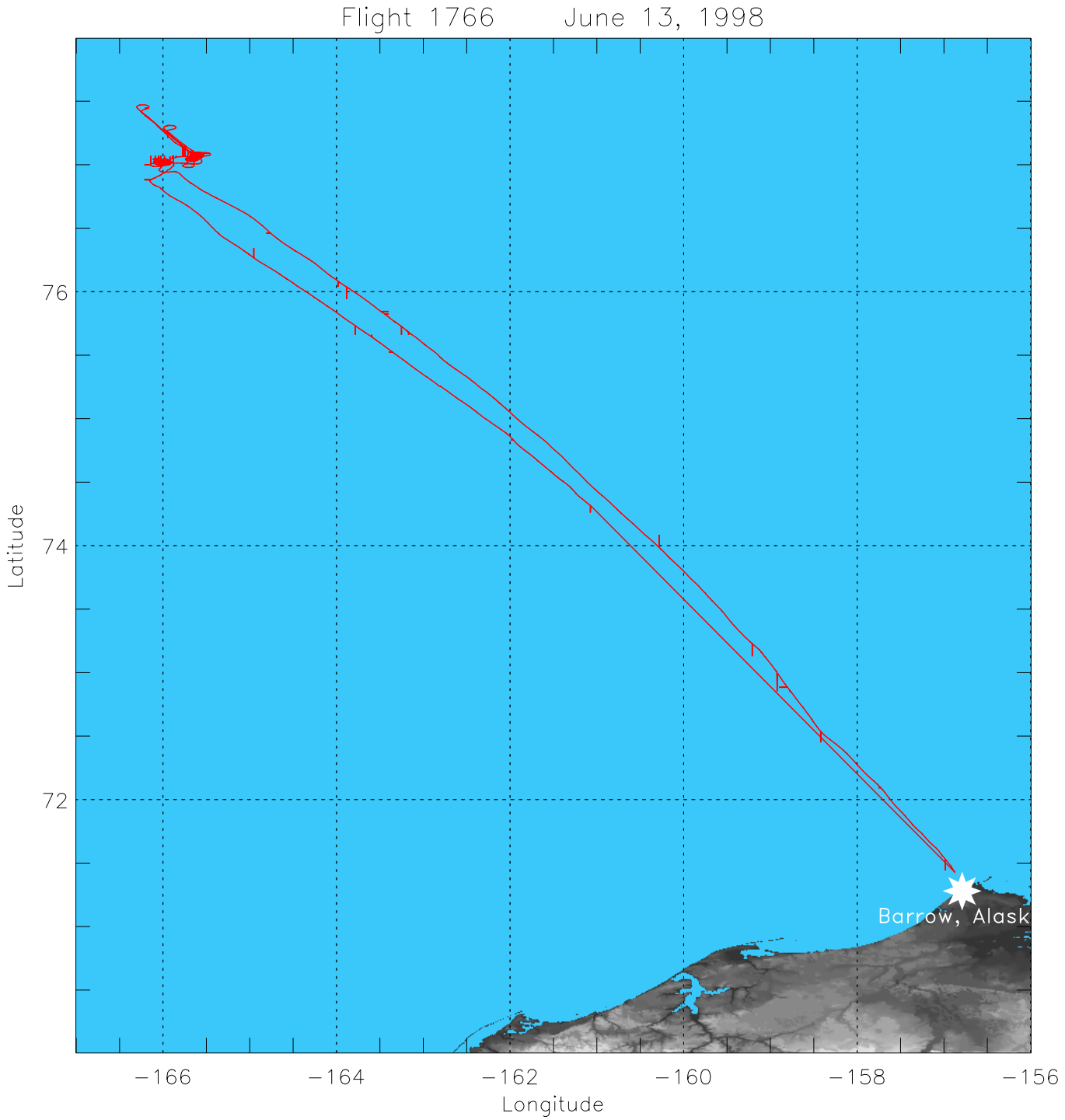
4) 2020 - 2031 UTC: level run within St cloud.

5) 2037 - 2042 UTC: Level runs in clear air at 300 ft AGL over both arms of surface L-shaped albedo site.

6) 2045 - 2053 UTC: BRDF measurements of surface, centered on the ship, in diffuse light, centered on ship.

7) 2054 - 2058 UTC: Spiral over ship through St plus two Ac layers (another broken Ac layer above which we did not climb).

8) 2100 - 2103 UTC: Measurements in main Ac layer (one from top.)


Flight 1766 June 13, 1998
76
74
72
Latitude
−166
−164
−162
−160
−158
−156
Longitude
Barrow, Alask

Flight 1766 - June 13, 1998

main

1 Summary

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1 CAR Flight Summary

Conducted BRDF measurements over stratus cloud and sea ice in the vicinity of the SHEBA site. The CAR was stuck in position 3 (BRDF mode) for most of the flight.

Weather over Barrow at the beginning of the flight was 90% cloud cover (stratocumulus) and some cirrus. Started the CAR at scan 60 (17:05 UTC) and set the CAR to nadir scanning (position 1). Leaving the CAR in this mode some test were performed to assess the previous flights conclusions on the filter-wheel associated noise problem.

Although on the previous flight we had hesitantly concluded that the noise was repeatable, in that noise spikes would appear in all channels during a filter change when any channel was saturated. In this flight further tests (approx. scan 6022, 18:55 UTC) revealed that this may not be the case. Setting the gain to its minimum value and repeating the noise tests yielded further noise when the filter wheel was used. This implies that the noise may have another source. (after this the filter wheel was not used for this flight)

On arrival at the SHEBA site several cloud layers were evident. The edge of a shadow from an upper level cloud deck fell directly over the SHEBA site, so a planned BRDF measurement was made near, but not over, the SHEBA site. The BRDF measurement was performed over uniform stratus cloud and was always well clear of the shadow boundary over the ship.

Loop	1	2	3	4	5
Filter	5	5	5	5	5
Scan Count	9830	10057	10279	~10550	10737

Loop	1	2	3	4	5
Filter	2	2	2	2	2
Scan Count	11015	11200	11425	11658	11915

On completion of this measurement the CAR was stuck in BRDF mode (3). Despite frequent attempts to change position it remained in this position throughout the flight. At the end of flights over SHEBA another BRDF measurement was performed (time constraints allowed only five loops over Barrow). This measurement was made at low altitude over the SHEBA site. The sun was visible (barely) through the cloud at this point.

Loop	1	2	3	4	5
Filter	5	5	5	2	2
Scan Count	16840	~17050	17250	17500	17740

Photo Records:


1. cloud streets near Barrow


2. cloud streets near Barrow


3. under cloud shadow


4. under cloud shadow


5. under cloud shadow


6. edge of upper layer cloud


7. edge of upper layer cloud


8. edge of upper layer cloud

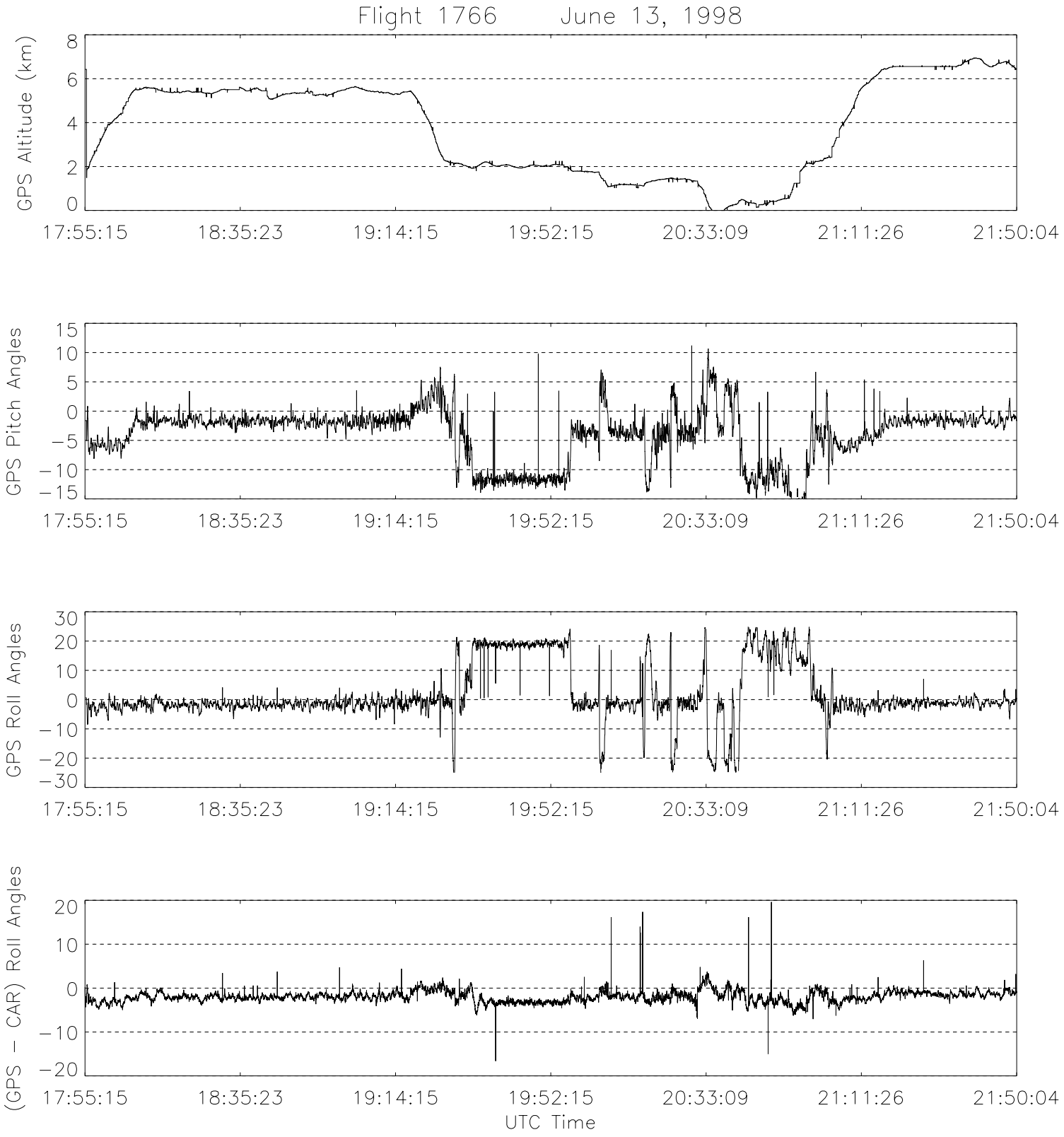

9. BRDF #1


10. BRDF #1

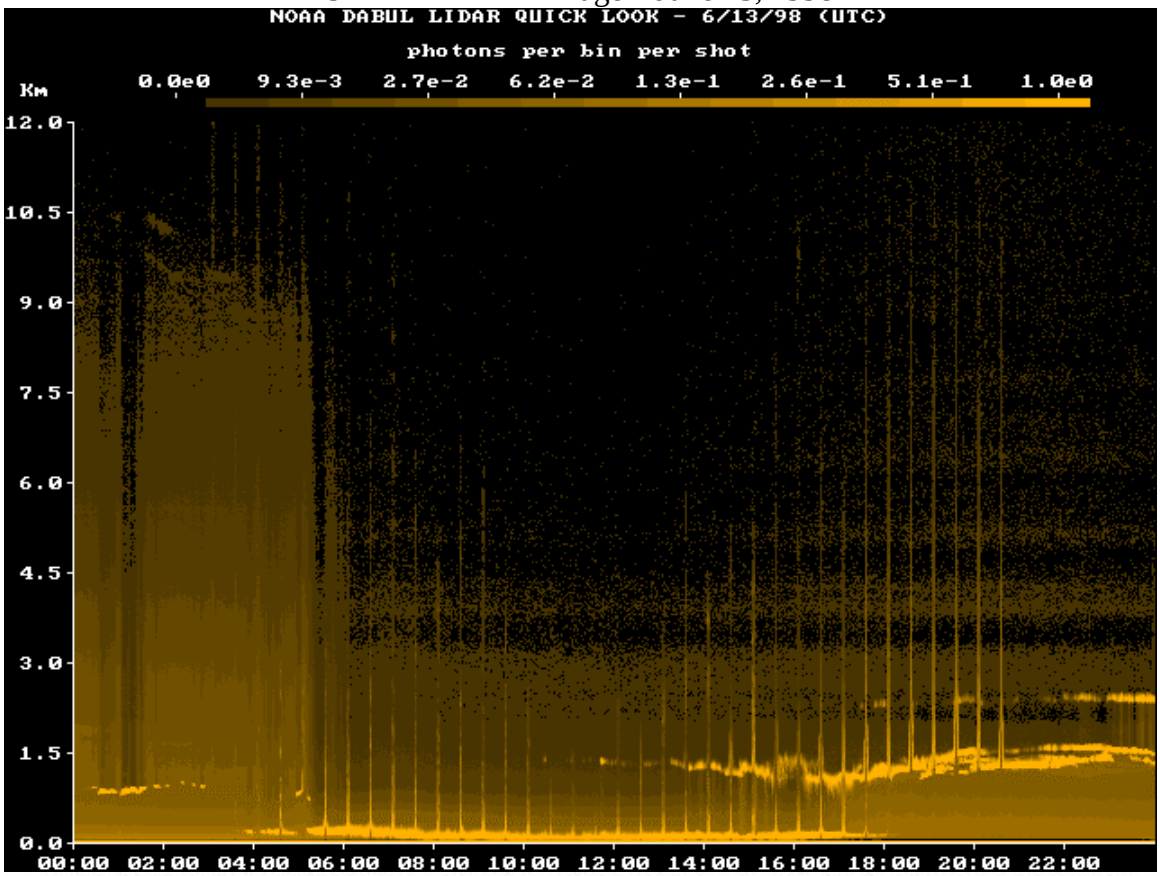

11. BRDF #2


12. SHEBA

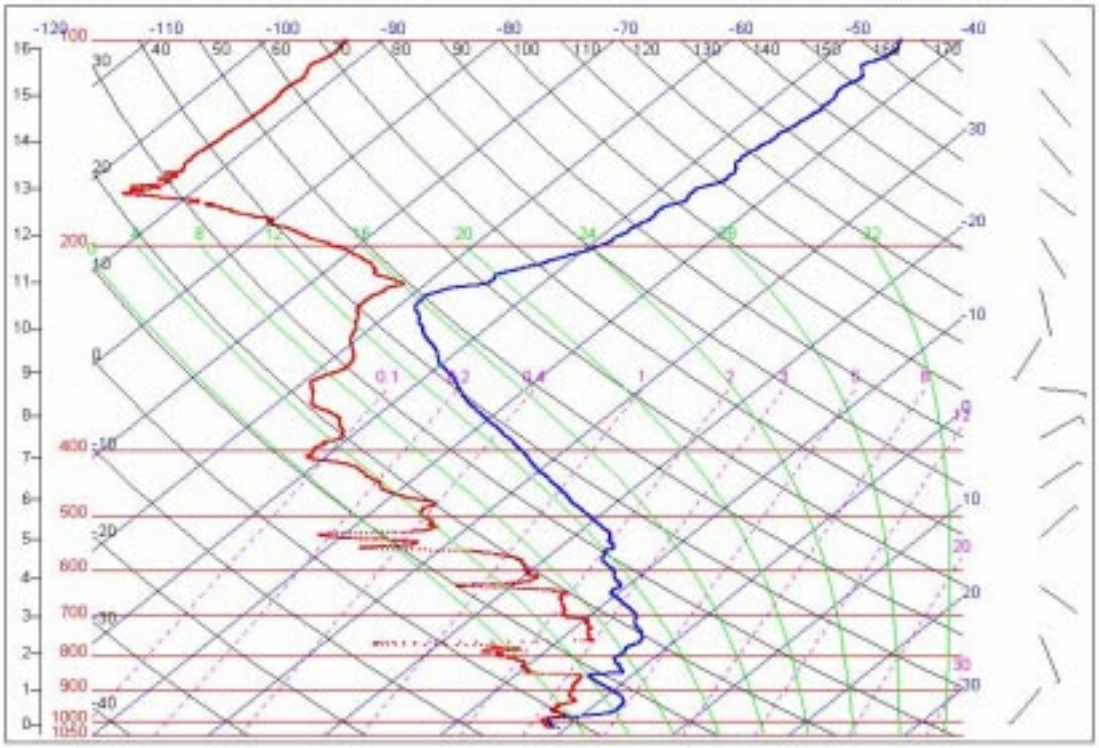

13. SHEBA


Flight 1766 June 13, 1998
GPS Altitude (km)
8
6
4
2
0
17:55:15
18:35:23
19:14:15
19:52:15
20:33:09
21:11:26
21:50:04
GPS Pitch Angles
15
10
5
0
−5
−10
−15
GPS Roll Angles
30
20
10
0
−10
−20
−30
(GPS − CAR) Roll Angles
20
10
0
−10
−20
UTC Time

SHEBA LIDAR Image – June 13, 1998



Version: SHEBA--GPS Soundings, GLASS 1.10 Fixed, SHE, 1998,06,13, 11:15:05



June 14, 1998

CV-580

Flight summary

Flight track

CAR notes

GPS plots

SHEBA

LIDAR image

Sounding

UW CV-580 FLIGHT LOG
June 14, 1998

Author (Mission Scientist): Hobbs , Peter

Flight Number: 1767
Departure Airport: Barrow
Arrival Airport: Barrow

Clouds sampled: St

Summary:
This flight took place over the Chukchi Sea for stratus cloud microstructure measurements. Long in-cloud legs were flown near cloud top, in mid-cloud, and just above cloud base. The cloud was observed to vary in thickness over 60 nautical mile legs from about 400 feet to about 1400 feet. The cloud had a stable lapse rate (isothermal near cloud top). The cloud exhibited modest inhomogeneities in structure along these legs.

Experimental Observations:
1) 1950-2010 UTC: First leg near cloud top (-2° C). Liquid water contents reached 0.3 g m^{-3}.

2) 2010-2015 UTC: Vertical profile from 1000 feet above cloud top to 100 feet above surface.

3) 2019-2040 UTC: Mid-cloud leg.

4) 2041-2050 UTC: Vertical profile as in 2)

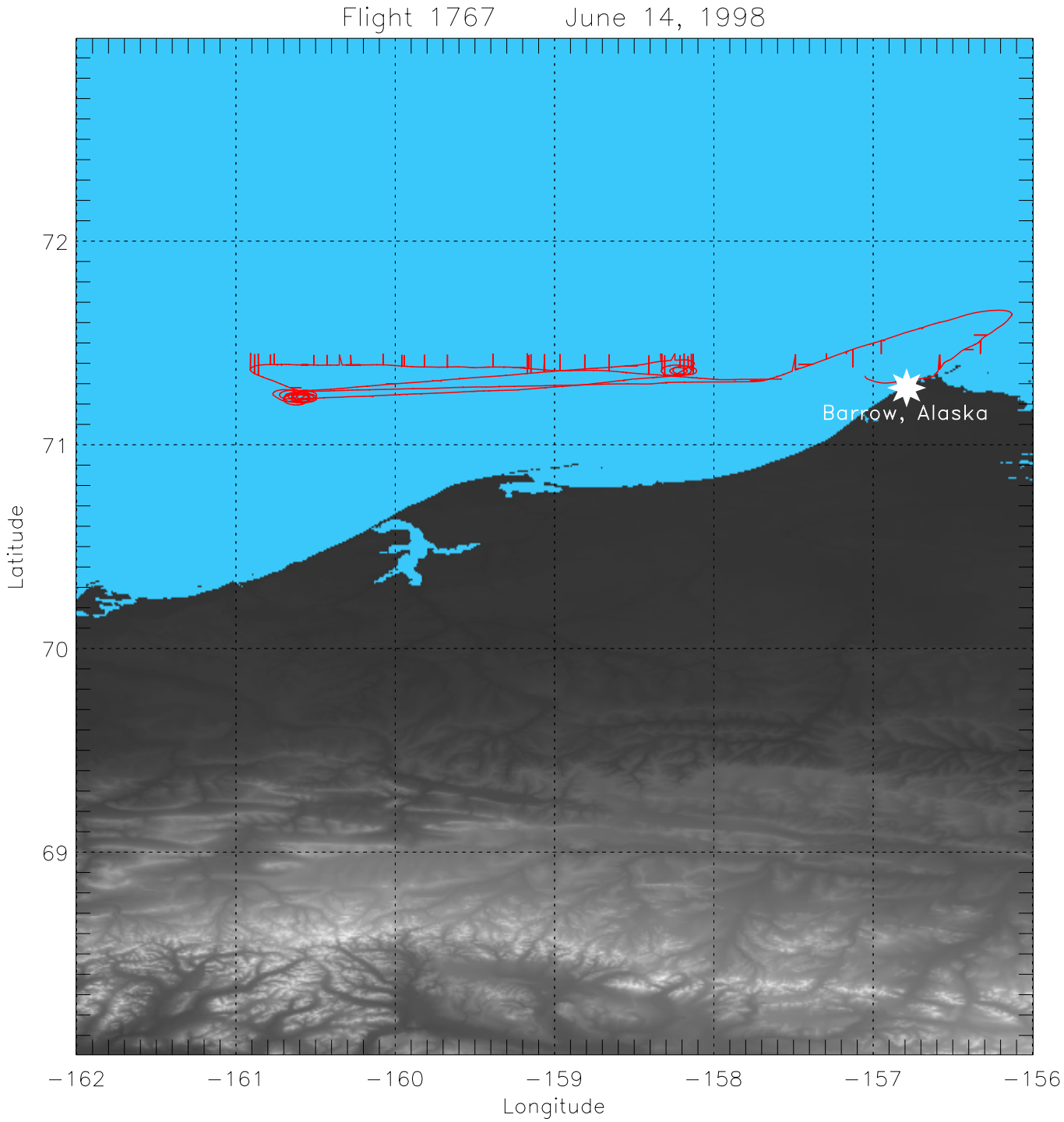
5) 2053-2109 UTC: Leg just above cloud base. Cloud bases varied from around 800 feet to 200 feet AGL.

6) 2109-2121 UTC: Vertical profile.

7) 2122-2130 UTC: Search for new substantial stratus region for sampling.

8) 2121-2134 UTC: "Porpoise" maneuver in stratus layer.

9) Return to Barrow at 500 feet above stratus layer for aerosol and CAR measurements.


Flight 1767 June 14, 1998
Barrow, Alaska
72
71
70
69
Latitude
−162
−161
−160
−159
−158
−157
−156
Longitude

Flight 1767 - June 14, 1998

main

1 Summary

2 Photos

3 Quicklooks

1 Flight Summary

The main purpose of this mission was in situ cloud profiling. The CV-580 spiral descended through a cloud around an alpha point, ascended to a beta point within another cloud, spirally descended around the beta point, ascended to the alpha point, etc. CAR did downward imaging during cloud profiling, with the filterwheel channel alternating between the 1.6 and 2.2 µm channels.

19:12 UTC engine start
19:18 take-off; filterwheel set to 1.6 µm
19:25 cumulonimbus off of starboard
19:30 shift from upward imaging position to downward imaging position, over open water [1], albedo is 0.09
19:31 switch filterwheel to 2.2 µm channel, slight fog over water and ice [2]; only very thin stratus below
Scan count 1792 (19:39 UTC) fog over broken ice, under cumulonimbus [3]
1889 switch filterwheel to 1.6 µm channel, albedo is 0.59
2218 thundercloud (occur only 2% per year in the Arctic) off of port side, albedo is 0.63
2520 switch filterwheel to 2.2 µmchannel, albedo is 0.68; cannot see surface
3860 switch filterwheel to 1.6 µm channel, albedo is 0.60; still cannot see surface
4498 rising in altitude to 2000 ft. above cloud deck.
4647 sun is visible, altitude is 2200 ft., above all clouds, except a few cirrus [4]
4900 highest altitude of 2300 ft., starting spiral descent through the cloud [5][6].
5582 sea ice, altitude is 100 ft., albedo is 0.62.
5680 switch to 2.2 µm channel for second ascent through the clouds
6378 cannot see surface well; albedo is 0.60
8094 slight haze layer. albedo is 0.58; altitude is 2158 ft.
8275 begin slow spiral descent again
8344 switch filterwheel to 1.6 µm channel
8466 enter cloud at 1100 ft.
8730 surface ice at 300 ft. [8], cloud base at about 700 ft.
9300 into our ascent through the cloud
10000 200 ft. above sea ice [9], albedo is 0.45
10240 We are doing circles at cloudbase here, 250 ft. above sea ice; albedo is 0.52
10680 altitude is 1000 ft., albedo is 0.68; Ground is barely visible here. Begin spiral ascent to 1000 ft. above cloud, then descend.
10980 altitude is 2700 ft.
11030 switch filterwheel to 2.2 µm channel
11111 [10] albedo is 0.58, altitude is 2450 ft.
11450 begin spiral to ground, unexceptional haze layer near cloud top [11]:
11838 begin climb from the ground
12540 Decision is made to not do BRDF measurements of ice clouds today. Cloud Particle Imager (which would have given three-dimensional images of crystals) is not functional.
13558 Begin flying to about 500 ft. above cloud top
15584 Last scan

Photo Records:


1. open water


2. fog over water and ice


3. fog over broken ice


4. few cirrus above


5. starting spiral descent


6. sea ice and clouds


7. sea ice off port side


8. slight haze layer


9. two hundred ft above sea ice


10. sea ice viewed from 2450 feet


11. haze layer near cloud top

Flight Track and Quicklook Images:

- CV-580 flight tracks
- GPS roll and pitch angle

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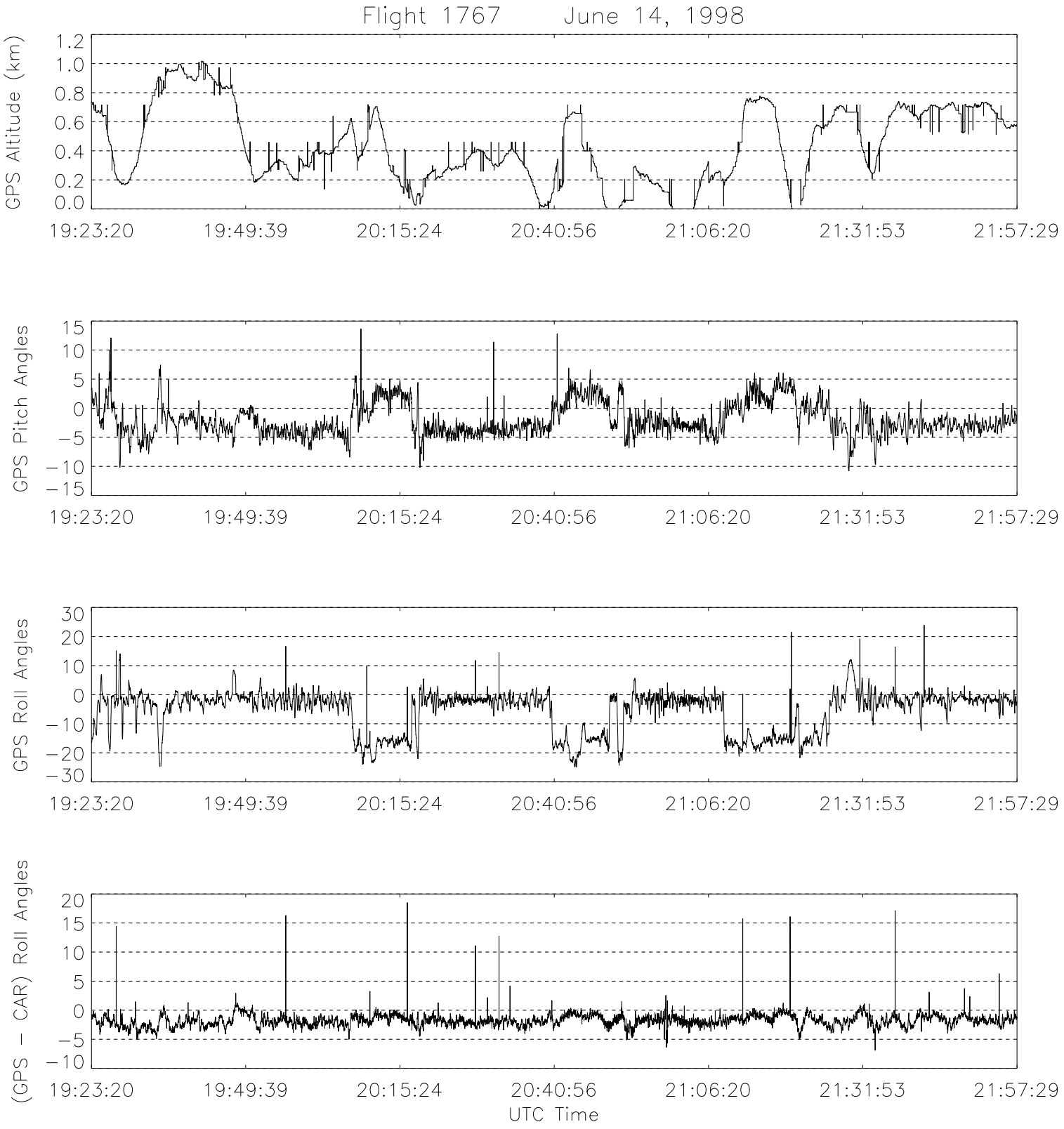
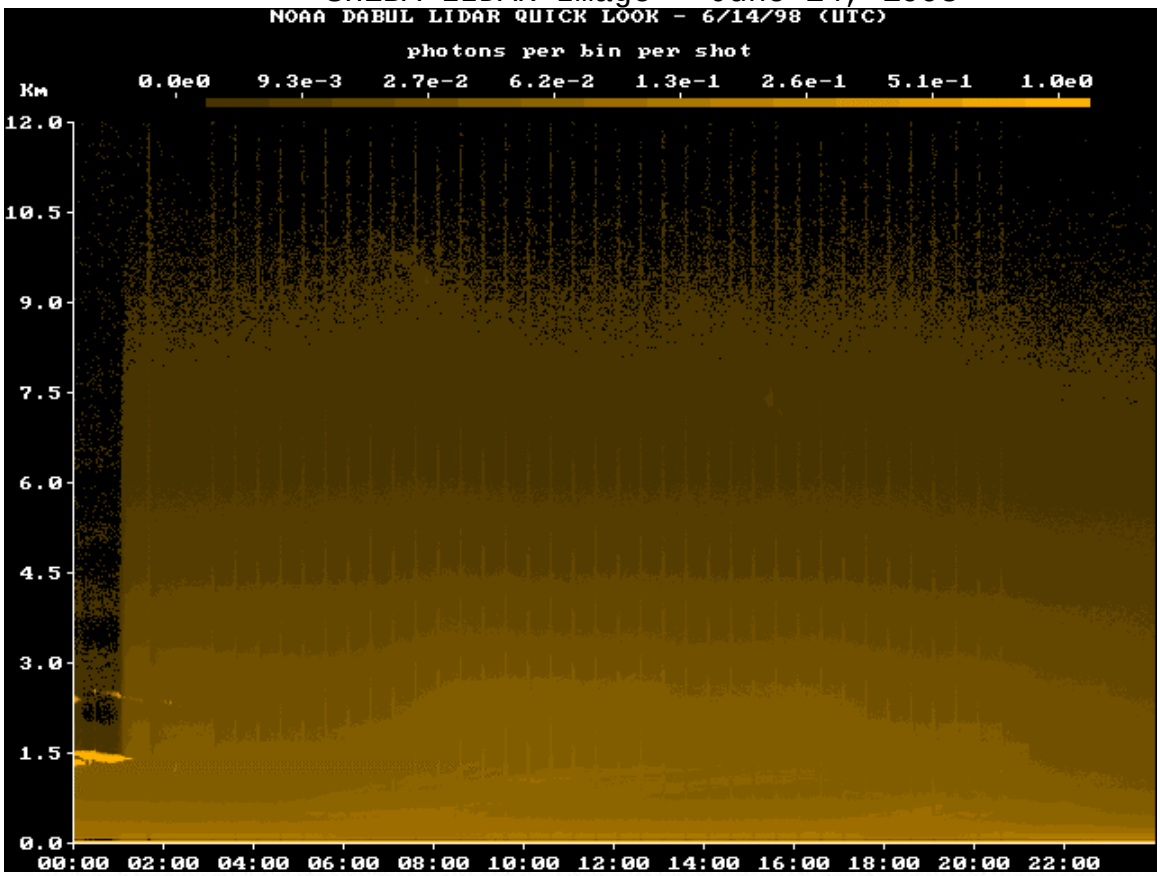

Flight 1767 June 14, 1998
GPS Altitude (km)
1.2
1.0
0.8
0.6
0.4
0.2
0.0
19:23:20
19:49:39
20:15:24
20:40:56
21:06:20
21:31:53
21:57:29
GPS Pitch Angles
15
10
5
0
−5
−10
−15
GPS Roll Angles
30
20
10
0
−10
−20
−30
(GPS − CAR) Roll Angles
20
15
10
5
0
−5
−10
UTC Time

SHEBA LIDAR Image – June 14, 1998



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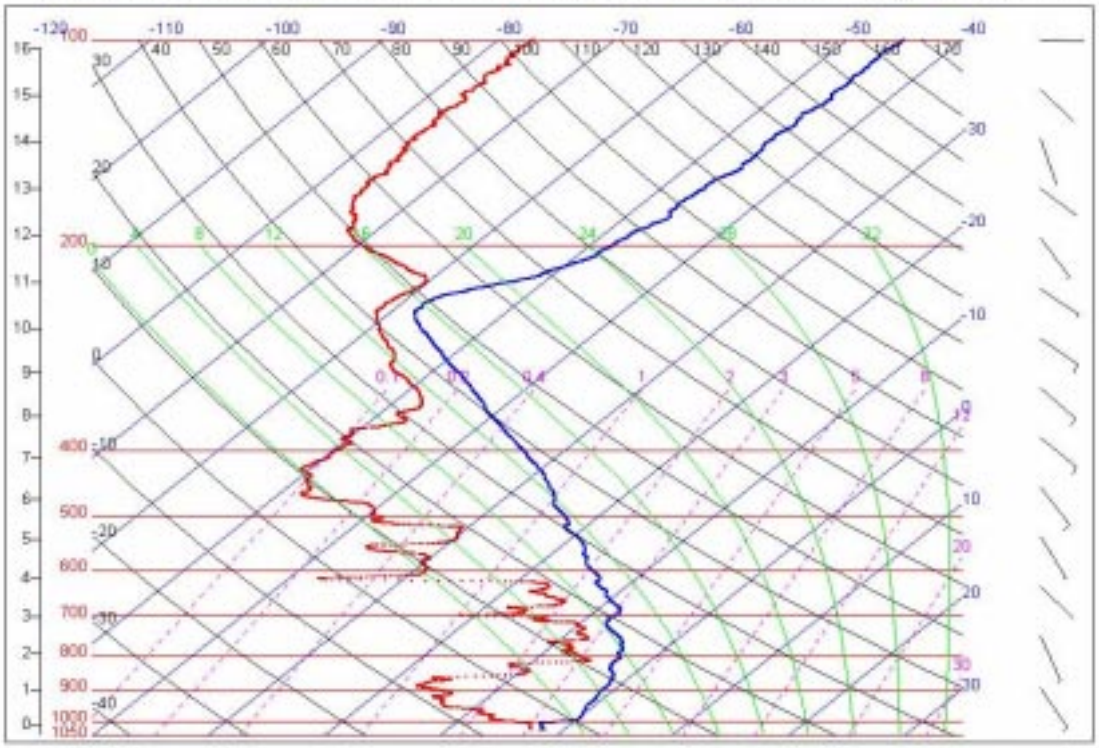


June 18, 1998

CV-580

Flight summary

Flight track

CAR notes

GPS plots

SHEBA

LIDAR image

UW CV-580 FLIGHT LOG
June 18, 1998

Author (Mission Scientist): Hobbs, Peter

Flight Number: 1768
Engines On: 1856
Engines Off: 0014
Departure Airport: Barrow
Arrival Airport: Barrow

Surface Met & Visual Obs on Take-off: transparent stratus, drizzle

Clouds sampled: St, Ci, Ac

Summary:
This was our 6th flight over the SHEBA ship (now located 405 nautical miles from Barrow). The flight took place as a trough with multi-layered clouds overspread the SHEBA site, a preferred scenario for the purpose of comparing aircraft data with that obtained from the vertically-pointed radar/LIDAR on the SHEBA ship. Two vertical profiles were made over the ship. BRDF measurements were made above the highest cloud layer, and single passes for surface albedo measurements were made over the L-shaped surface array.

Experimental Observations:
1) 1908-1911 UTC: The climb at takeoff was through unusually transparent stratus clouds that were producing drizzle episodes at Barrow. The lowest droplet concentrations yet encountered in Arctic stratus during this campaign (10-30 cm^{-3}) were measured.

2) 1911-2055 UTC: The transit leg of the flight was largely cloud free, with only a few ice crystal clouds encountered in the otherwise cloudy, multi-layered scene. (The multi-layered clouds were either too high or too far below the aircraft for efficient sampling while en route).

3) ~2055 UTC: Arrived at SHEBA ship. Altocumulus cloud layers were present over SHEBA, with the highest tops intercepted at about 14,000 ft with isolated mounding cloud tops of altocumulus castellanus clouds 100 feet or so above this level. Cirrus clouds and cirrocumulus clouds were scattered above the altocumulus clouds.

4) 2059-2116 UTC: A BRDF maneuver consisting of seven circles was carried out over the altocumulus layer a few miles northeast of the SHEBA ship (to avoid higher clouds). However, a patch of nearly transparent cirrocumulus cloud extruded itself into the clear region around the second or third orbit. A nearly invisible cirriform wisp was also present overhead.

5) 2120-2143 UTC : A level pass was made over the ship in the higher altocumulus. A spiral descent was then made through the various cloud layers to

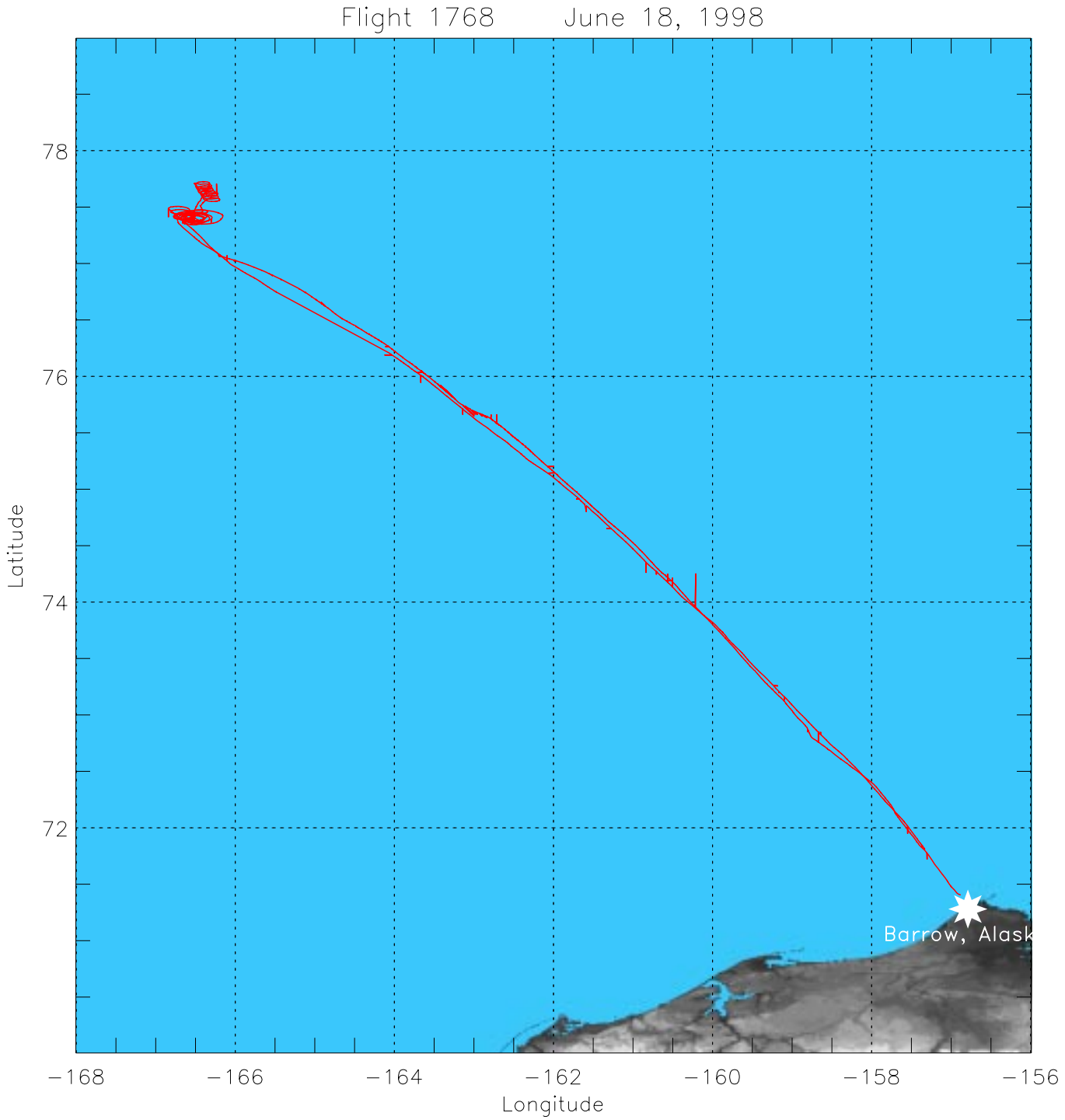
about 300 feet above the surface. The clouds over the ship consisted of four layers: three patchy layers of altocumulus clouds with bases at 14,000, 12,000, and 10,000 ft. (the lowest were the bases of the Ac cas), and a stratus layer (with breaks) with tops at 1100 feet and bases between about 200 and 500 feet. An unusual aspect of the stratus clouds was the extremely low droplet concentrations (~10 cm^{-3}).

6) 2143-2148 UTC: Level passes were made over the L-shaped surface albedo array.

7) 2148-2220 UTC: A spiral ascent was then made over the ship to within a 100 feet of the highest cloud top (a very thin, ice shedding patch of cirrocumulus droplet clouds at about 20,000 ft) before departure from the site was required.

8) 2220-2330 UTC: Extensive ice clouds (various forms of cirrus (uncinus, fibratus), and ice shedding altocumulus clouds) were sampled on the return trip to Barrow.

9) 2358-2410 UTC: The landing at Barrow found much different clouds than at takeoff: elevated stratocumulus/stratus with tops at 2500 feet and bases at 1500 feet. Droplet concentrations were ~100 cm^{-3}


Flight 1768 June 18, 1998
78
76
74
72
Latitude
−168
−166
−164
−162
−160
−158
−156
Longitude
Barrow, Alask

Flight 1768 - June 18, 1998

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1 Summary

2 Photos

3 Quicklooks

1 Flight Summary

The CV-580 flew to SHEBA on this flight. During this flight, the CAR performed downward imaging of sea ice and a BRDF of sea ice arond SHEBA under diffuse lighting conditions. The CAR filterwheel channel was alternated between the 1.6 and 2.2 µm channels. At the end of the flight, the CAR door was closed, and dark scans were done with all filter wheel channels at all gain settings. A second data tape was started in the latter half of this mission.

Fire Ace

May - June, 98
Barrow, Alaska

19:08 UTC take-off; filter wheel set to 1.6 µm channel
200 approximate first recorded scan
522 shift from upward imaging position to BRDF mode
599 initial IR channel noise has settled down
741 shift from BRDF mode to downward imaging mode
870 [1] carpet of white clouds, albedo is 0.61, altitude is 14,208 ft.
1298 switch filter wheel to 2.2 µm channel
1850 [2] sea ice with some cirrus above the aircraft, albedo is 0.5, altitude is 18,500 ft.
2479 We are flying through sparse pockets of ice crystals.
2614 [3] scattered clouds with shadows over sea ice, some cirrus above us. Albedo is 0.59 and GPS altitude is 19,000 ft.
2729 switch filterwheel to 1.6 µm channel, clouds filling in below us more
4910 sea ice with a few scattered clouds below. Albedo is 0.52 and GPS altitude is 19,100 ft.
5900 thick altocumulus on port side [5], scattered, very thin clouds (can see ground very clearly) [6]. We are flying along a line of discontinuity in cloud cover. Albedo is 0.54 and GPS altitude is 18,900 ft.
9000 Attempted to rotate CAR to BRDF mode but was unsuccessful. Plane is moving too fast (118 m/s). The locked-in indicator light still lights up from both directions, so it's likely this is not a mechanical jamming problem, but an air loading problem overwhelming the motor (If the light fails to light up in either direction, there is likely a mehcanical jamming problem that will have to be fixed on the ground).
10300 During a bank turn of the plane, the CAR was successfully rotated to BRDF mode. Begin BRDF measurements, trying to avoid shadows from cirrus above, as well as brown haze layer. Altitude is 16,500 ft.
10994 Beginning of turn 1. Filterwheel set to 1.6 µm channel. Unstable altocumulus.
11240 Beginning of turn 2. Cirrocumulus just under us.
11435 BRDF scene, haze layer is above us [7]. Albedos varying from 0.8 to 1.50. Albedo measurements are not to be trusted, they must be corrected for angle.
11506 Beginning of turn 3.
11768 Beginning of turn 4.
12014 Beginning of turn 5.
12260 Beginning of turn 6, switch filterwheel to 2.2 µm channel.
12495 Beginning of turn 7.

12798 End of turn 7 (too much cloud-shadow contamination now-BRDF measurements halted. Now descending towards SHEBA).
13943 sea ice around SHEBA [8], sea ice at 500 ft., more sea ice [9][10][11][12][13].
15947 Switch CAR to downward imaging mode
16390 Switch CAR to BRDF mode
20311 Main computer crash. RESTARTED NEW TAPE. (Note from flight engineer Don Spurgeon: This was not necessary, but no real harm done.)
10 (new scan number) at 22:36 UTC, starting of the second tape.
6500 (new scan number) CAR door closed. Went to filter wheel channel 1, and increased and decreased gain settings with door shut at all filterwheel channels.

Photo Records:


1. carpet of white clouds


2. cloud layer


3. scattered clouds with shadows


4. sea ice


5. thick alto cu on port side


6. scattered very thin clouds


7. BRDF scene over sea ice


8. view sea ice at aproximately 400 ft.

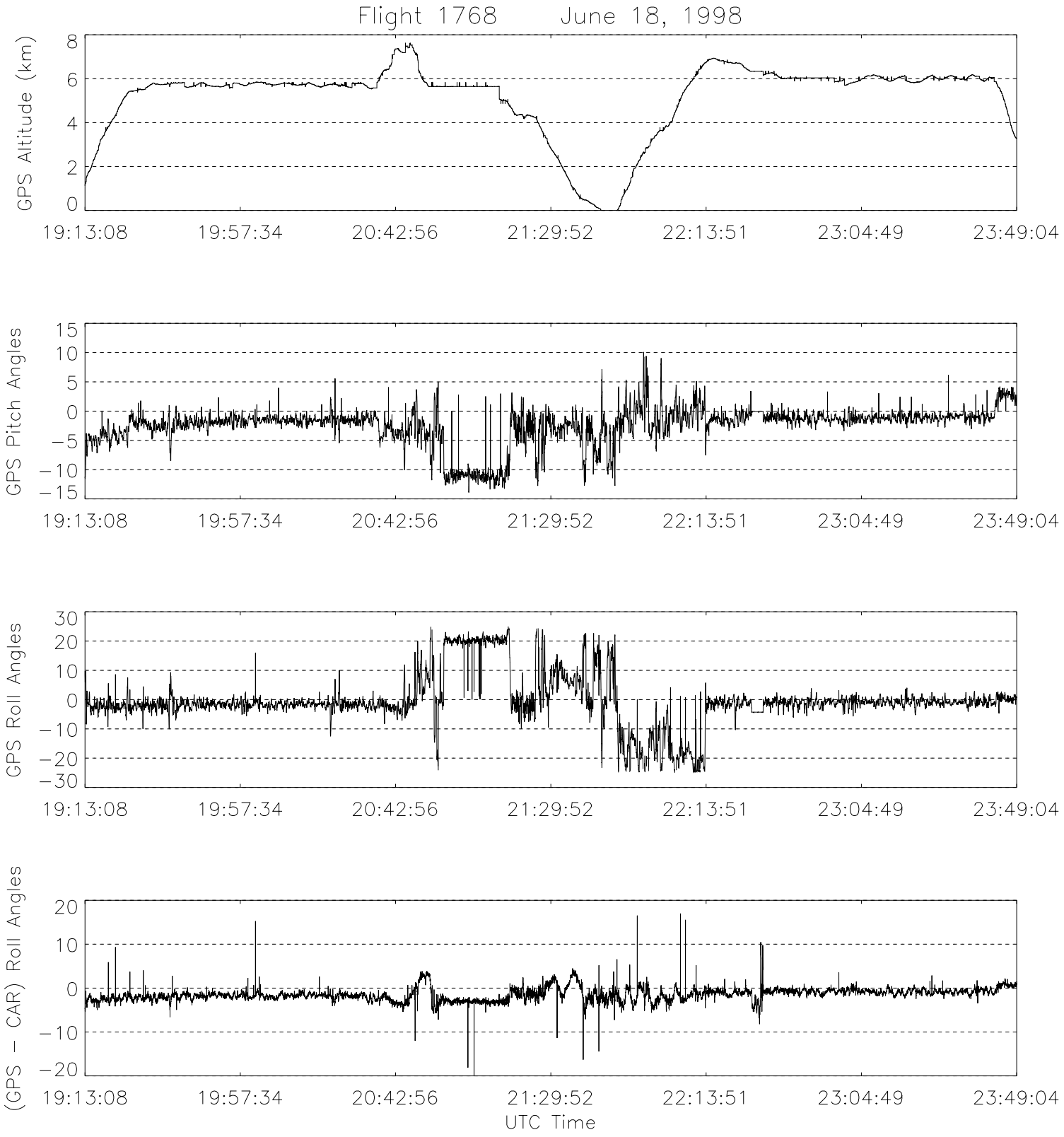

9. sea ice


10. sea ice

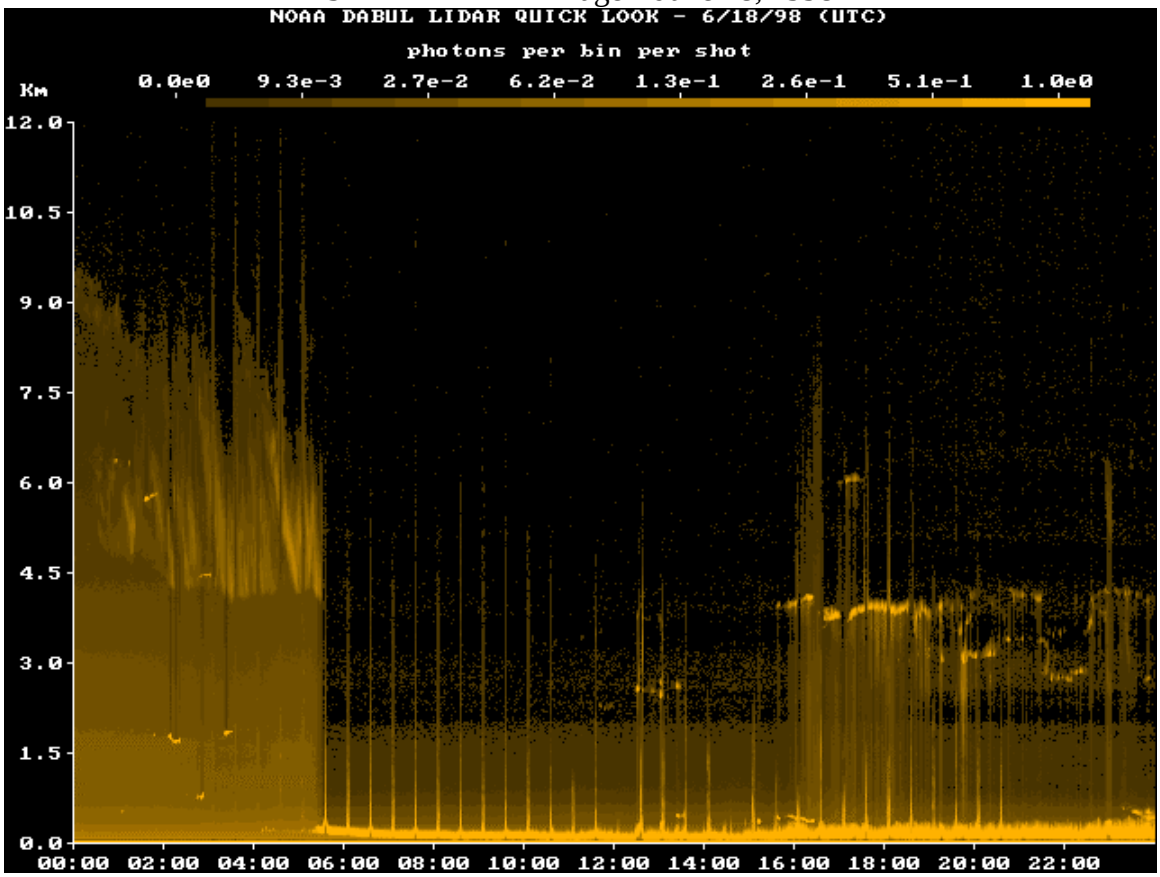

11. sea ice


12. sea ice


13. sea ice


Flight 1768 June 18, 1998
GPS Altitude (km)
8
6
4
2
0
19:13:08
19:57:34
20:42:56
21:29:52
22:13:51
23:04:49
23:49:04
GPS Pitch Angles
15
10
5
0
−5
−10
−15
GPS Roll Angles
30
20
10
0
−10
−20
−30
(GPS − CAR) Roll Angles
20
10
0
−10
−20
UTC Time

SHEBA LIDAR Image – June 18, 1998



June 19, 1998

CV-580

Flight summary

Flight track

CAR notes

GPS plots

SHEBA

LIDAR image

Sounding

UW CV-580 FLIGHT LOG
June 19, 1998

Author (Mission Scientist): Hobbs, Peter

Flight Number: 1769
Engines On: 2051
Engines Off: 0050
Departure Airport: Barrow
Arrival Airport: Barrow

Clouds sampled: Ci, Cs

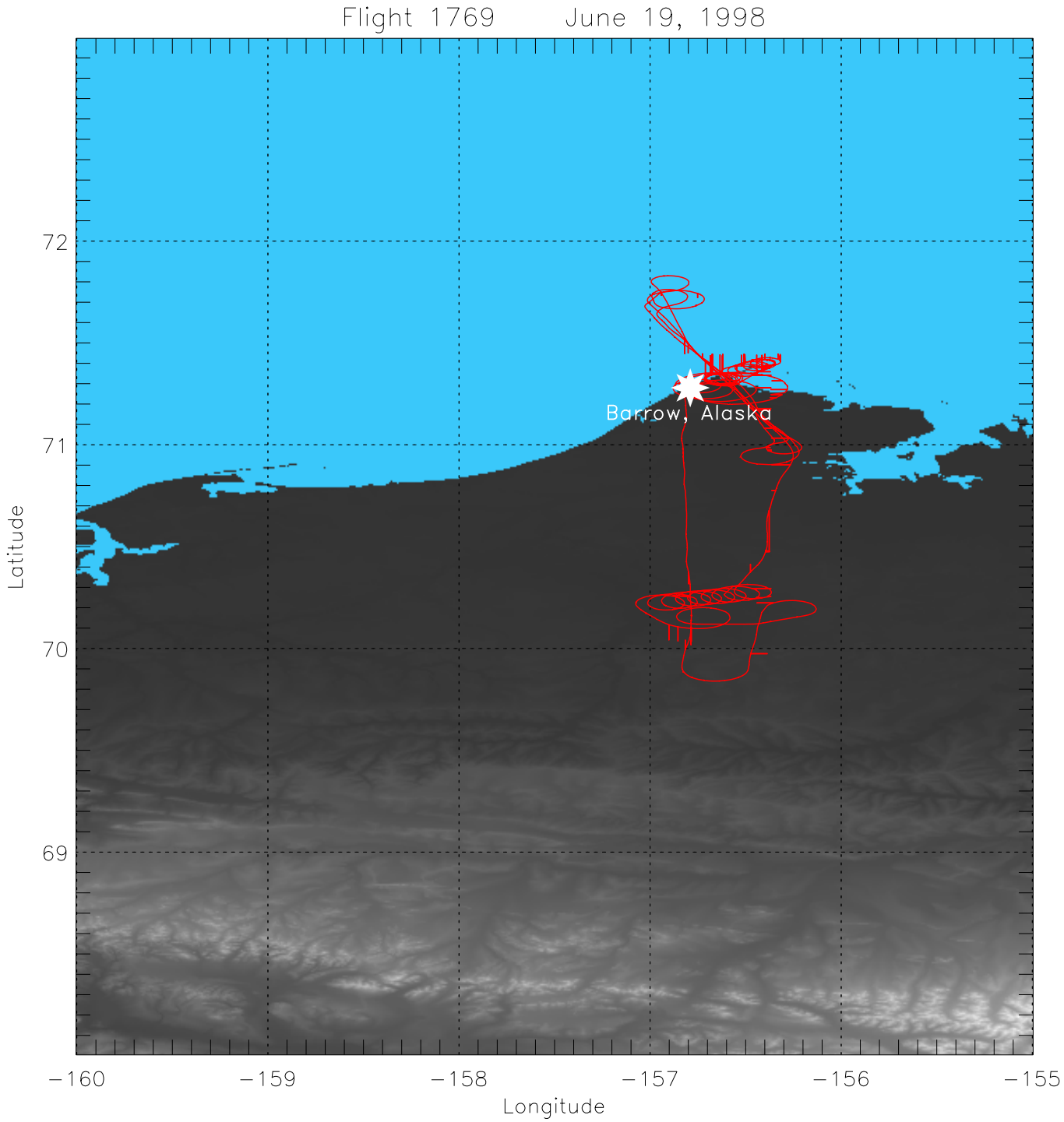
Summary:
The goal of this flight was to perform BRDF orbits over cirrus clouds with no cloud below, a rare situation that presented itself at Barrow on 19 June during the mid-day hours. A downward spiral over the ARM site was also made.

Experimental Observations:
1) 2104-2155 UTC: Took-off and climbed to 31,000 ft MSL. From below the cirrus appeared amorphous, producing a strong halo with no visible structure (cirrostratus nebulosus). However, as the spiral ascent continued, more structure in the forms of striations and chaotic patchiness began to appear. By the time the flight level reached 31,000 ft, three layers had been detected, with the highest, very thinnest layer (cirrus fibratus / cirrostratus fibratus) 1000-2000 ft higher than the aircraft could reasonably reach. Cloud top heights of the lower, mainly amorphous, cirrus mounded to 31,000 ft, or slightly higher, with saddle regions where tops dipped to below 29,000 ft. Cloud opacity ranged from "ground barely visible" through the mounding cirrus portions to "cloud barely detectable" in the saddle regions.

2) 2200-22300 UTC: After a brief search for the best region to perform the BRDF orbits, seven BRDF orbits were carried out over a region of barely visible cirrostratus nebulosus. Heavy CV-580 contrails were intercepted on numerous occasions. Also, a region that was large enough for the orbits, but was also free of both isolated altocumulus clouds and the more widespread higher layer of Cs fibratus above the aircraft, could not be found even though they covered less than 10% of the region where the orbits were performed.

3) 2300-2310 UTC: Transit to ARM site in cirroform clouds.

4) 2310-2440 UTC: Straight 10 min legs at the top (29,500 ft), middle (variable height), and bottom (variable height) through cirroform clouds over the ARM site followed by spiral descent to the surface over the ARM site. A haze layer extended from near the lowest cirrus cloud base (18,000 ft nearly over ARM) to below 4,000 feet. Extremely clean conditions were noted at the lowest pass (200 ft) over the ARM site; a scruff of stratus clouds, just upwind of ARM, had droplet concentrations of about 10 cm^{-3}


Flight 1769 June 19, 1998
Barrow, Alaska
72
71
70
69
Latitude
−160
−159
−158
−157
−156
−155
Longitude

Flight 1769 - June 19, 1998

main

1 Summary

2 Photos

3 Quicklooks

1 Flight Summary

The CV-580 attempted to profile cirrus clouds on this flight. During this flight, the CAR performed a BRDF of a cirrus cloud, and also flew above the ARM site at Barrow. The CAR filterwheel channel was alternated between the 1.6 and 2.2 µm channels. The quality of the BRDF is probably not optimal, as contrail contaminated about half the measurements.

21:03 UTC take-off; filterwheel set to 1.6 µm channel, scan line 72 is approximate first recorded scan.
21:14-21:15 sea ice [1], halo [2][3].
1355 tundra with frozen ponds [4].
2482 moved over sea ice, starting to move towards land
3507 temperature is 42°C, lots of ice on top of SSFR dome. Albedos are suspect now-radiometers have never been calibrated at temperatures this low. We are 1500 ft. above cloud level. BRDF of cirrus:
5390 CV-580 moving to avoid scruffy altocumulus clouds.
6725 Beginning of turn 1. Filter wheel set to 1.6 µm channel.
7057 We just passed through our contrail.
7082 Beginning of turn 2.
7118 Contrail puff visible.
7244 We just passed through a big contrail puff.
7283 Cirrus in center of circle of right wing.
7397 Big contrail.
7428 Beginning of turn 3.
7445 Extended contrail puff. Northwest corner of circle is invisible cirrus above us, with small halo.
7605 CLEAR (no cirrus above, no contrail contamination either)
7740 We are 1500 ft. above cloud, spending about half our time in contrail.
7748 Beginning of turn 4.
7801 Invisible cirrus above us again (small halo).
7862 Clear of higher cloud.
7974 Altitude is 30,400 ft.
8068 Beginning of turn 5.
8088 We're making lots of circles of contrail.
8207 Heavy, natural cirrus above right wing now.
8397 Beginning of turn 6. Filter wheel set to 2.2 µm channel.
8714 Beginning of turn 7.
9040 End of turn 7; remaining turns cancelled (too much contamination)
9088 We're flying below contrail now (50 ft. below previous altitude).
9574 [5] surface below us at end of BRDF measurements out the portside window (starboard bubble frosted over).
12540 Just passed over the ARM site 1 minute ago.

13032 Begin descent into clouds, altitude 28,400 ft.
15076 [6] altitude is 21,400 ft. Now spiraling down over ARM site, trying bank at +20° whenever possible so we can capture as much as possible with the CAR in BRDF mode.
15928 [7] by ARM site, altitude is 18,240 ft., albedo is 0.24 (not corrected for angle).
17307 Pass over ARM site now, start spiral (albedo is 0.31).
18062 Change filterwheel to 1.6 µm channel.
19687 [8][9]: Buildings around Barrow, ARM site?

Photo Records:


1. sea ice


2. halo


3. halo


4. tundra with frozen ponds

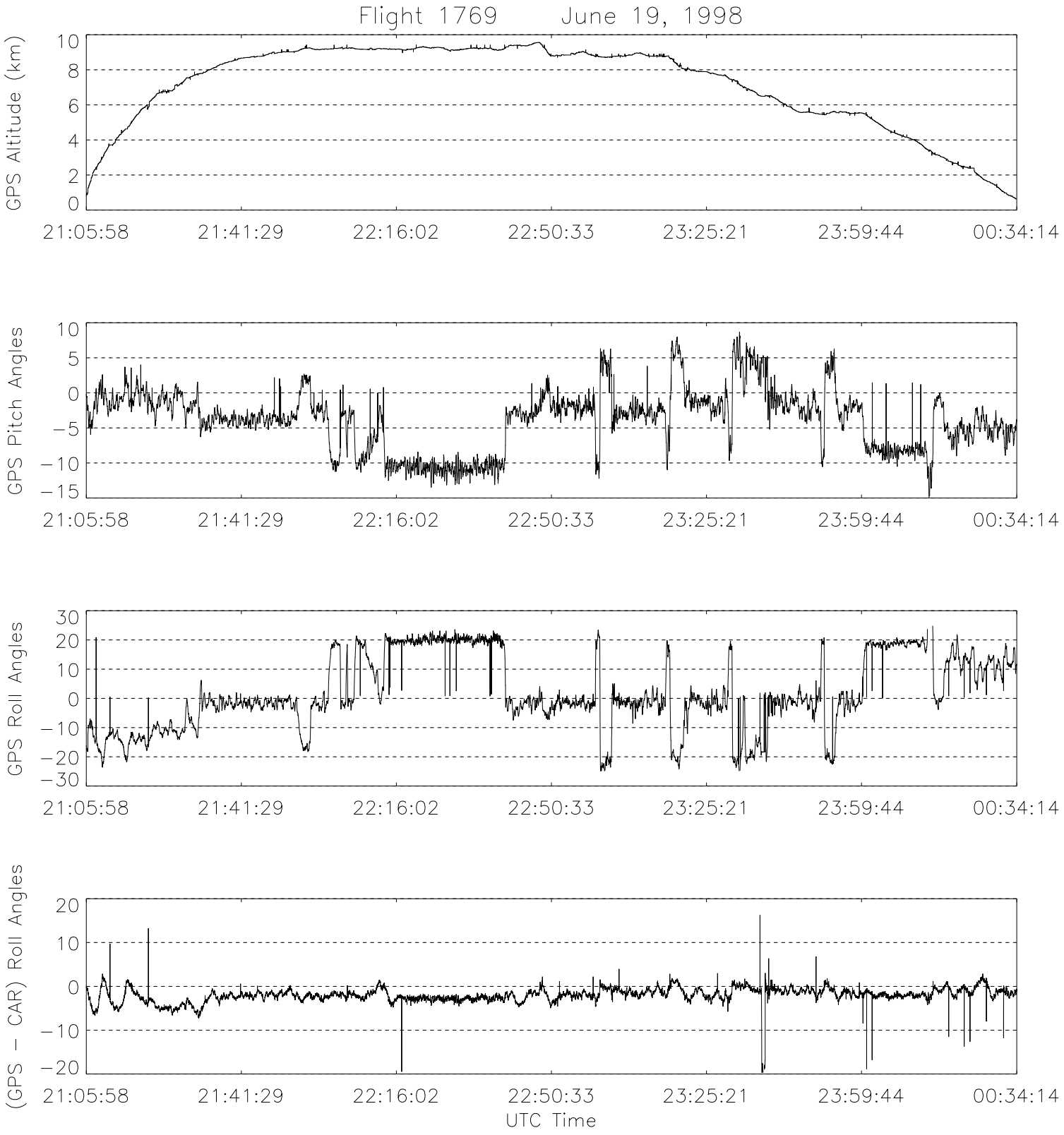

5. end of BRDF


6. over ARM site

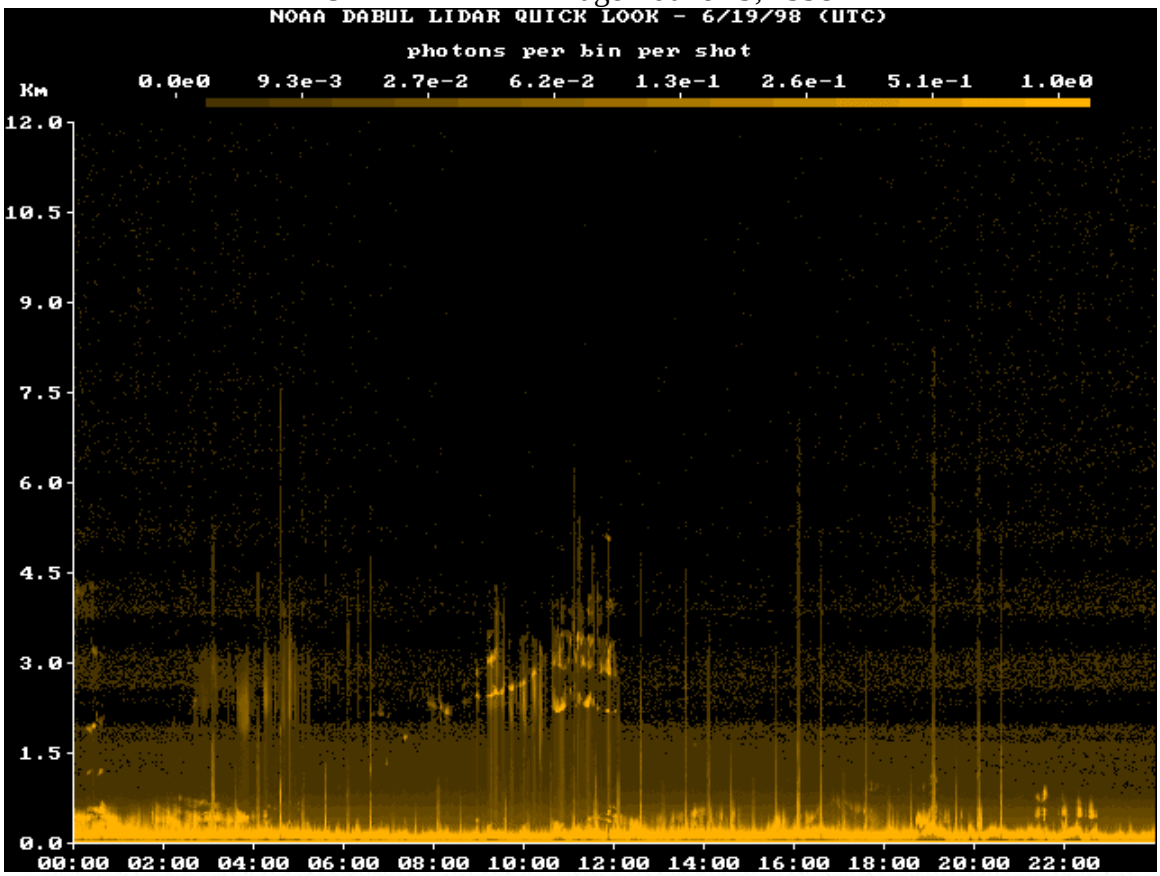

7. by ARM site


8. buildings around Barrow

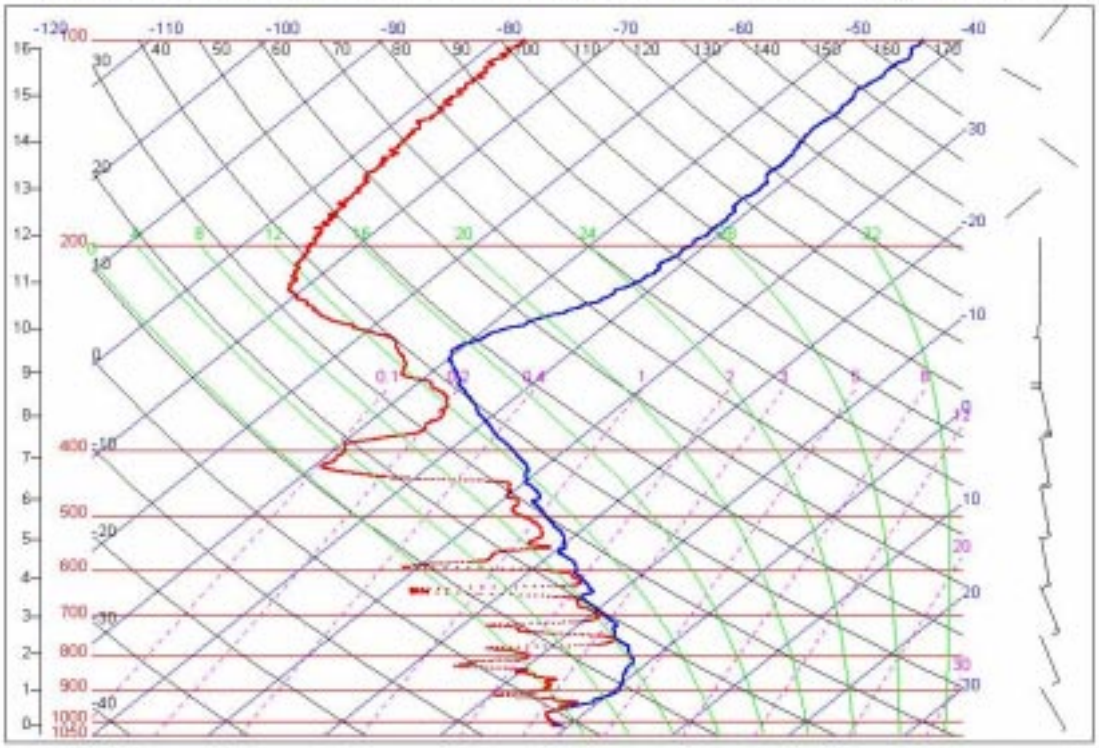

9. buildings around Barrow


Flight 1769 June 19, 1998
GPS Altitude (km)
10
8
6
4
2
0
21:05:58
21:41:29
22:16:02
22:50:33
23:25:21
23:59:44
00:34:14
GPS Pitch Angles
10
5
0
−5
−10
−15
GPS Roll Angles
30
20
10
0
−10
−20
−30
(GPS − CAR) Roll Angles
20
10
0
−10
−20
UTC Time

SHEBA LIDAR Image – June 19, 1998



Version: SHEBA--GPS Soundings, GLASS 1.10 Fixed, SHE, 1998,06,19, 11:13:42



June 22, 1998

CV-580

Flight summary

Flight track

CAR notes

GPS plots

SHEBA

LIDAR image

Sounding

UW CV-580 FLIGHT LOG
June 22, 1998

Author (Mission Scientist): Hobbs, Peter

Flight Number: 1770
Engines On: 1800
Engines Off: 2327
Departure Airport: Barrow
Arrival Airport: Barrow

Surface Met & Visual Obs on Take-off:

Clouds sampled: Ac, Ci, St

Summary:
This was a flight to the SHEBA ship, now located 420 nautical miles northwest of Barrow. The flight took place in a band of scattered to broken layers of cirriform and mid-level altocumulus clouds, which stretched from Barrow to the SHEBA ship. The main objectives were to obtain BDRF over the ship, measure surface albedo over the L-shaped surface albedo array, and to sample clouds over the ship.

Experimental Observations:
1) 1807-1955 UTC: Takeoff and transit to the ship. Altocumulus layer sampled over Barrow during climb out. For the remainder of the flight the aircraft was in and out of the bases and mid-points of cirrus clouds at 19,000 ft. No stratus clouds were seen below the aircraft during the entire transit leg.

2) 1955-2009 UTC: Descent from 20,000 ft to 2,000 ft over ship. Portions of tenuous cirrus clouds were sampled at the top of the descent spiral. Measurements in the tops of the cirrus (SHEBA-indicated 23,000 ft AGL) were not obtained due to time constraints.

3) 2010-2031 UTC: Ten BDRF orbits were carried out upwind, over, and downwind of the ship. Scattered thin cirriform and altocumulus clouds were present, which occasionally crossed the sun's disk during the orbits.

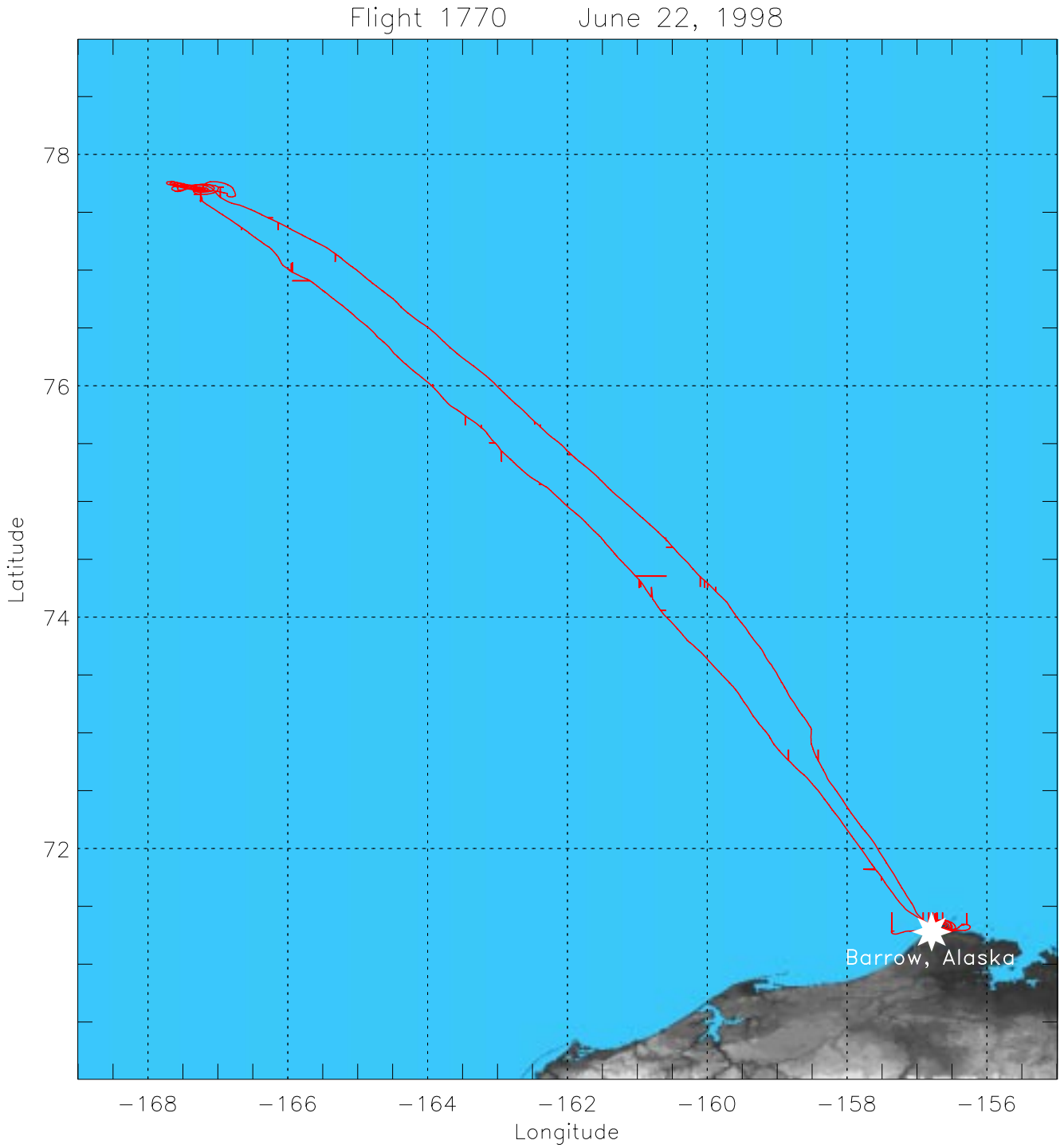
4) 2032-2046 UTC: Two 10-nautical-mile legs (one in each direction) over the L-shaped surface albedo array.

5) 2047-2240 UTC: Climb out and transit to Barrow at 20,000 ft. Considerable cirriform clouds sampled at mid-levels.

6) 2240-2310 UTC: Due to better than expected weather at Barrow, a climb to near cirriform tops (26,000 ft) over the ARM site was made, followed by a slow descent (500 foot per minute) through the patchy cirriform cloud overhead of ARM. When exiting cloud "base", the descent was accelerated to 1500 feet per minute until the lowest pass at 400 feet was made. A DMPS sample was taken at

7,200 ft in a deep haze layer that extended from the 15,000 ft to just above stratus cloud tops (2,100 ft).

7) 2311-2323 UTC: Stratus clouds were sampled during the set up for the approach and landing. Droplet concentrations were about 130 cm^{-3}. Tops were 2,100 ft and bases 1,500 ft. The cloud was orographic in nature, forming at the coastline in 20-30 kts easterly winds. A clearing to the east of the airport persisted for several hours. Hence, the cloud sampled near the airport was "young".


Flight 1770 June 22, 1998
78
76
74
72
Latitude
−168
−166
−164
−162
−160
−158
−156
Longitude
Barrow, Alaska

Flight 1770 - June 22, 1998

main

1 Summary

2 Photos

3 Quicklooks

1 Flight Summary

The CV-580 went to SHEBA on this flight. During this flight, the CAR performed a BRDF of sea ice with light diffused by cirrus clouds, and also did downward imaging of sea ice during the latter part of the flight. The CAR filter wheel channel was alternated between the 1.6 and 2.2 µm channels. The quality of the BRDF is probably good.

18:00 UTC engine-start, scan line 95 was the approximate first recorded scan, filterwheel set to 1.6 µm channel
500 rotate CAR to BRDF position
800 [1] sea ice

The plan is to go to SHEBA (420 nautical miles out), descend in circles over the ship, do BRDF circles, and return to Barrow.
1192 more sea ice [2] (it seems darker than before)
2200 We've been flying in wispy ice clouds for about 10 minutes; some shadows on the ice below.
2480 [3]: halo
2630 As in previous flights, our flight path has been going straight down the middle of a break in clouds; port-side clear, starboard-side somewhat cloudy and foggy.
2805 clouds moving into our flight path now
3642 [4]: sea ice
7540 [5]: Kelvin-Helmholtz waves
7690 cirrus above us (altitude approx. 25,000 ft.) seem to have dissipated; altitude of aircraft is 18,000 ft.
9340 [6]: cirrus clouds off starboard
9900 report from SHEBA: clouds are between 17,000 and 23,500 ft., altitude of aircraft is 19,500
10130 beginning downward spiral
10400 sea ice [7], We occasionally pass through cirrus. Altitude is 14,000 ft.; albedo is 0.55.
10680 SHEBA (slightly right of center) and surrounding ice [8].
10900 SHEBA [9][10]; GPS altitude is 7300 ft., albedo is 0.40.
11255 Switch filterwheel to 2.2 µm channel.

BRDF measurements; cirrus is dispersing about 95% of direct beam:
11600 Beginning of turn 1
11820 Beginning of turn 2
12040 Beginning of turn 3; sea ice at 12,300 ft [11].
12252 Beginning of turn 4
12449 Beginning of turn 5; sky more clear here, beginning of turn 6 not announced.
12860 Beginning of turn 7
13094 Beginning of turn 8; switch filter wheel to 1.6 µm channel.
13313 Beginning of turn 9; we'll have drifted about 9 miles during BRDF loops.
13512 Beginning of turn 10; top SSFR dome still has condensation inside.
13730 End of turn 10

Start descent to criss-cross over SHEBA; altitude is 2045 ft.
14800 Switch to downward imaging mode
16200 Switch filterwheel from 2.2 µm channel to 1.6 µm channel. From this point on, the filterwheel channel is switched between 1.6 µm and 2.2 µm channels approximately every 1000 scan counts.
27350 [12] sea ice around Barrow
27775 [13] Barrow under cirrus
28647 varied scene below with water, ice, and tundra, with clouds covering about 1/3 of the scene. Really dark areas seem to correspond to water.
29040 [14] Barrow, with some wisps of cloud.
30363 Last scan, Landing at 23:20 UTC

Photo Records:


1. sea ice


2. sea ice


3. halo

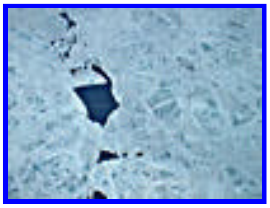

4. sea ice


5. Kelvin-Helmholtz waves


6. cirrus clouds off starboard


7. sea ice


8. SHEBA and surrounding ice


9. SHEBA

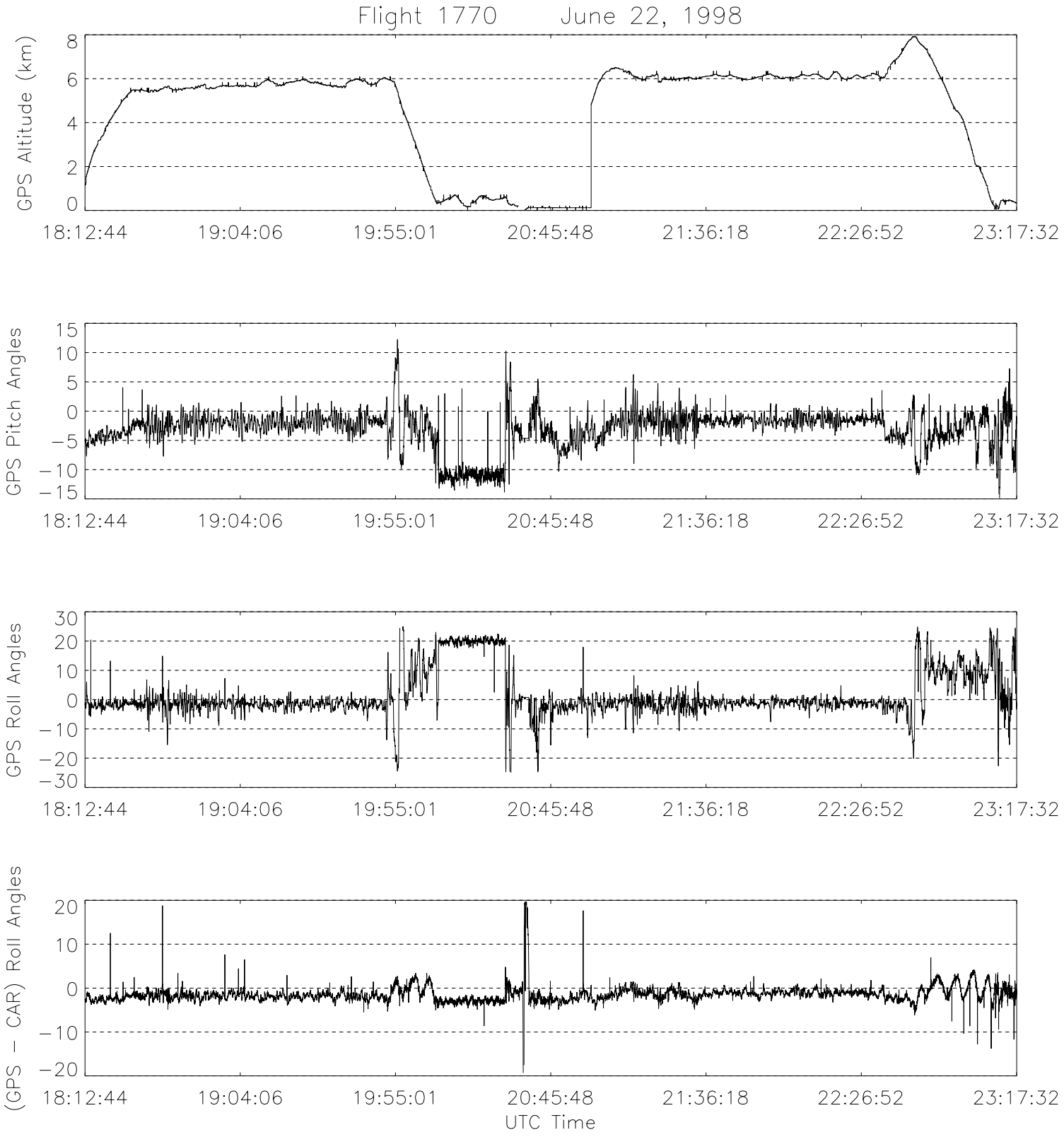

10. SHEBA


11. sea ice

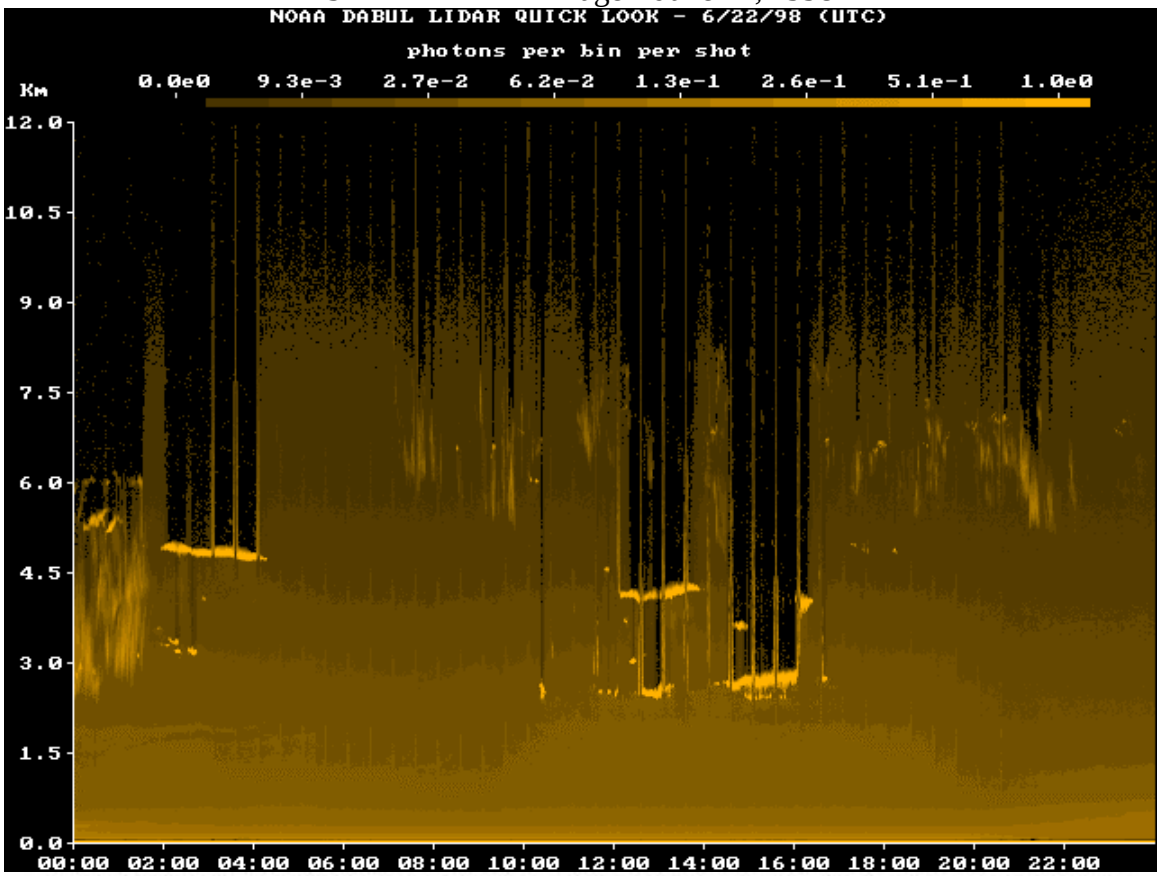

12. sea ice around Barrrow


13. Barrow under Cirrus

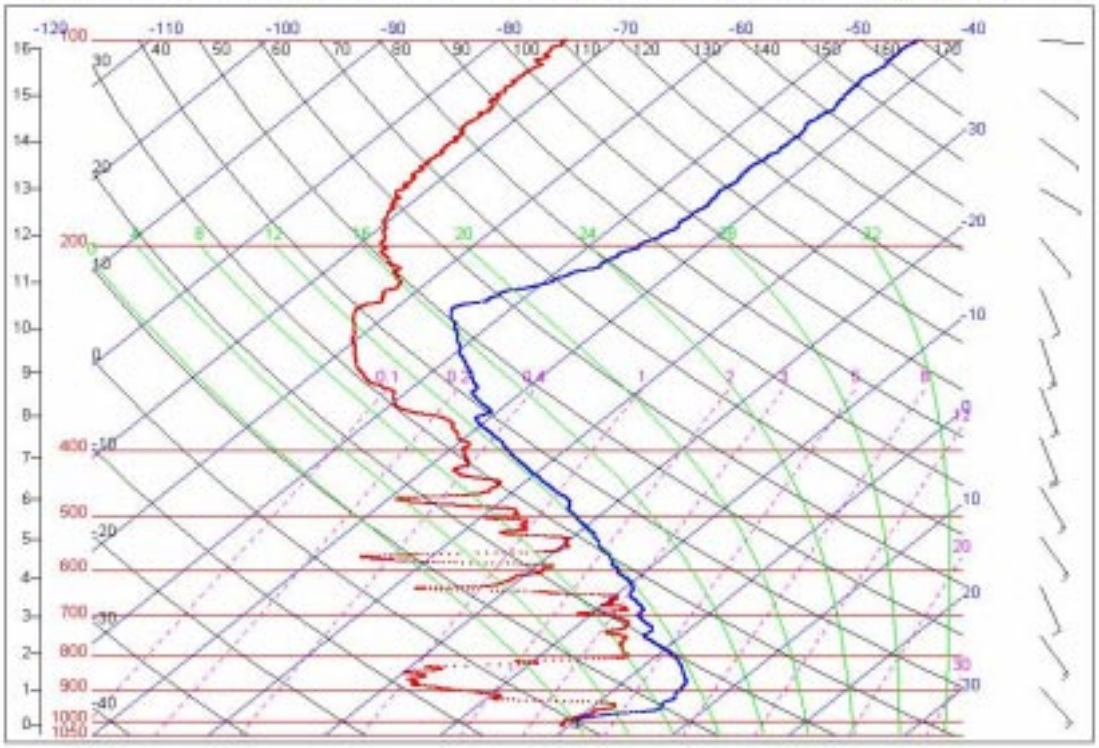

14. Barrow with some whisps of coulds


Flight 1770 June 22, 1998
GPS Altitude (km)
8
6
4
2
0
18:12:44
19:04:06
19:55:01
20:45:48
21:36:18
22:26:52
23:17:32
GPS Pitch Angles
15
10
5
0
−5
−10
−15
GPS Roll Angles
30
20
10
0
−10
−20
−30
(GPS − CAR) Roll Angles
20
10
0
−10
−20
UTC Time

SHEBA LIDAR Image – June 22, 1998



Version: SHEBA--GPS Soundings, GLASS 1.10 Fixed, SHE, 1998,06,22, 11:15:01



June 23, 1998

CV-580

Flight summary

Flight track

CAR notes

GPS plots

SHEBA

LIDAR image

Sounding

UW CV-580 FLIGHT LOG
June 23, 1998

Author (Mission Scientist): Hobbs, Peter

Flight Number: 1771
Engines On: 2120
Engines Off: 0209
Departure Airport: Barrow
Arrival Airport: Barrow

Clouds sampled: St

Summary:
In this, our final flight over the SHEBA ship, we were successful in obtaining our first BRDF and surface albedo measurements under a clear-sky.

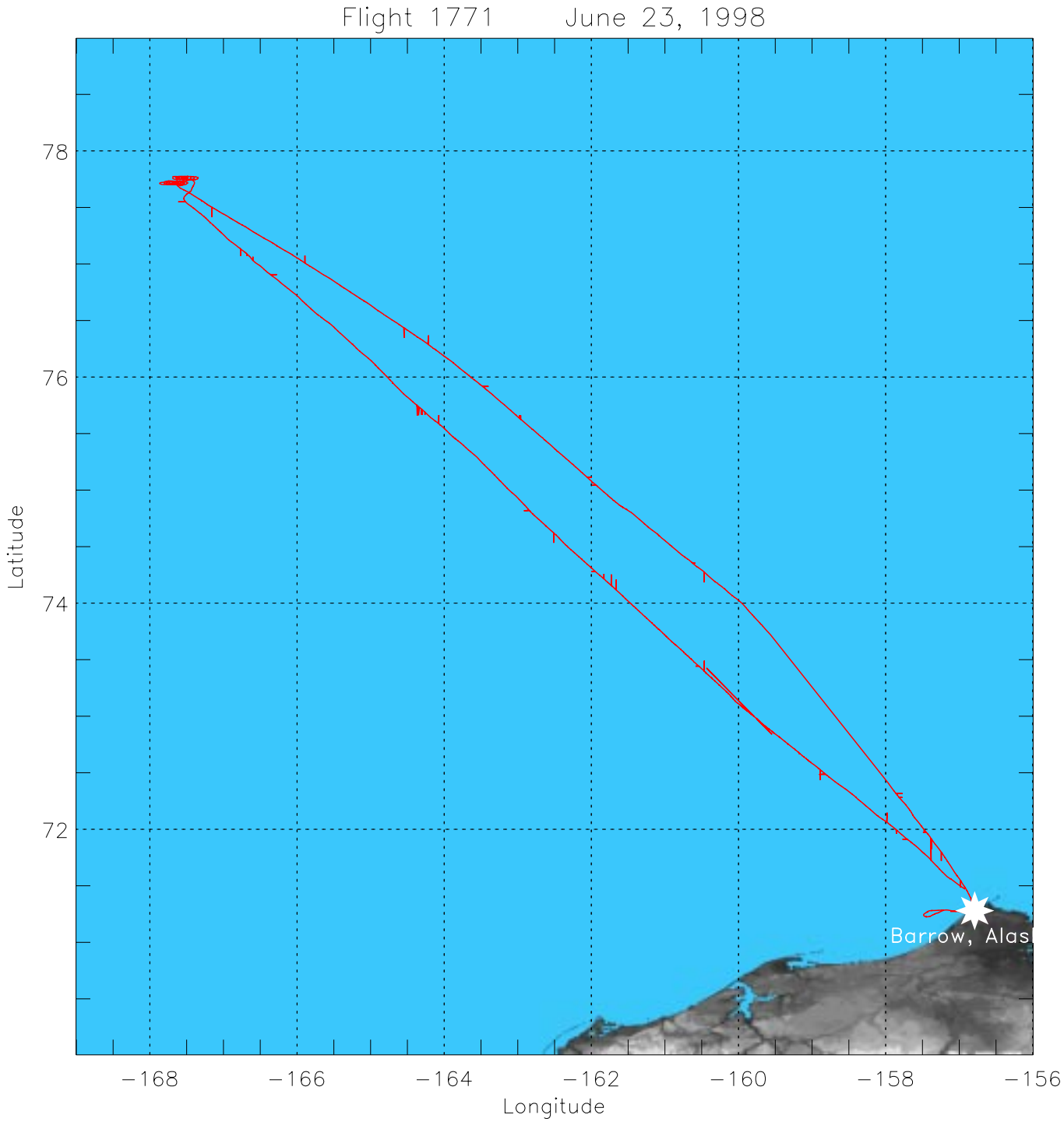
Experimental Observations:
1) 2140-2142 UTC: Takeoff through very clean broken stratus clouds with bases near and on the surface at the east end of the runway and about 300 feet at the west end of the runway. Stratus tops were at 1000 feet. Droplet concentrations were about 10-20 cm^{-3}, and some drizzle drops were present. (Takeoff was considerably delayed due to incoming air traffic.)

2) 2142-2332 UTC: Transit to SHEBA in clear air. Haze was unusually thick, with tops in excess of the cruising altitude of 18,000 ft. Occasionally, undulations (rolls) in the heights of the haze layers were observed when the haze tops were near the flight level. The main body of the haze was confined above 10,000 ft. (Back trajectories suggest a European origin for the haze). The stratus cloud at Barrow extended as an overcast to 75°N 163°W, where an abrupt clearing occurred and no further stratus was seen. During this entire time, the stratus was unusually transparent, being barely visible when looking straight down at the surface. Leads and other surface features were easily seen through the stratus out to about 10 nautical miles from the aircraft. Also drawing attention on the transit flight was a large region (a few to tens of km^2) of discolored ice and water having a brownish or muddy hue located about 10 nautical miles north of Barrow (at 71.28°N and 156.79°W). Many photos were taken of this feature.

3) 2332-2412 UTC: BRDF orbits were carried out very near the SHEBA ship. The first set of orbits, however, was interrupted for a location adjustment when the surface wind at the ship proved to be quite different from that at the flight level of 2,000 ft, and it became clear that, as the aircraft drifted with the wind during the course of its orbits, it would miss the ship by perhaps a mile or more. Following a 1 min leg to locate more accurately upwind of the ship, the BRDF orbits were resumed and six were carried from the new location. The ship's LIDAR confirmed that there was no cloud above the ship (isolated cirrus clouds were present in the northeast quadrant from the ship but were never closer than about 20 nautical miles.)

4) 2414-2420 UTC: Straight passes (at 300 ft) over the L-shaped surface albedo array for airborne albedo measurements.

5) 2420-2609 UTC: Transit leg to Barrow in clear air at 20,000 ft. The top of the polluted layer was near or slightly above this level during the entire transit. Upon descent into Barrow, the main body of the haze was once again found above 10,000 ft. The broken to overcast stratus layer at Barrow had changed little during the time of the flight, with tops again at 1000 feet and droplet concentrations of 20-30 cm^{-3}. A few drizzle drops were also observed. The stratus bases were near the ground just upwind of the airport, but elevated at the downwind end of the field. A large cloud bow was observed upon landing.


Flight 1771 June 23, 1998
78
76
74
72
Latitude
−168
−166
−164
−162
−160
−158
−156
Longitude
Barrow, Alas

Flight 1771 - June 23, 1998

main

1 Summary

2 Photos

3 Quicklooks

1 Flight Summary

The CV-580 went to SHEBA on this flight, during the best (only?) extremely clear day during the entire experiment. During this flight, the CAR performed a BRDF of sea ice with direct sunlight , and also did downward imaging of sea ice during the latter part of the flight. The CARÕs filter wheel channel was alternated between the 1.6 and 2.2 micron channels. The quality of the BRDF is probably very good. However, the data recording system froze when the CARÕs filter wheel was set to automatically advance. There are two data tapes for this flight.

21:20 UTC engine-start; Scan count 75: approximate first recorded scan, CAR in upward imaging mode

Data collection stopped: Recording halted (Important to remember buffer period at beginning)

Restart data collection at scan count 195
1068 rotate car to BRDF position
1355 [1] sea ice, with banded clouds below. Some ice appears dirty brown.
5609 [2] haze layer transported by gravity waves from Europe
7011 [3] sea ice
7778 [4] sea ice (blue melt ponds, some open water, patchwork pattern)

Larry Radke question: Do freshwater and brine ponds have different emissivities?
10029 haze top showing
10080 lots of aerosol here
10321 no cirrus, so far an unusually clear day

BRDF measurements of sea ice with a clear sky:
10456 Beginning of turn 1; filterwheel set to 2.2 µm channel
10699 Beginning of turn 2
10799 [5] sea ice below
10900 Beginning of turn 3
11058 SHEBA LIDAR reports absolutely clear sky above
11103 Beginning of turn 4
11284 [6] sea ice below; with some haze 2000 ft., the few wisps of contrail should not be a factor
11323 Beginning of turn 5
11524 Switch filterwheel to 1.6 µm channel
~11600 Interrupt BRDF circles to center more over the ship
11840 Beginning of turn 6
11963 Beginning of turn 7
11997 [7] sea ice
12171 Beginning of turn 8
12367 Beginning of turn 9
12441 [8] sea ice
12582 Beginning of turn 10
12792 Beginning of turn 11

Fire Ace

May - June, 98
Barrow, Alaska

13000 End of turn 11; switch filterwheel to 2.2 µm channel
13059 Rotate CAR to downward imaging position
13317 Switch filterwheel to 1.6 µm channel
14450 Attempt automatic filterwheel scanning mode
17542 No pparent noise problem-getting smooth signal
17600 [9] and [10] starboard and portside views (hazy, white)
18709 [11] banded cloud structure above ice
19050a [12] portside view of banded structure, ending in distance.
19050b [13] small stratus deck shading clouds below
20124 filterwheel channel 6 (channel 13) has been really noisy
20352 Recording stopped (frozen) at 1:13:52.9 UTC

New scan count 28, ~1:33 UTC. Taping RESTARTED. Brown ice in 3:00 direction from plane.
325 brown ice below us under left wing, with streaks of stratus below us
480 [14]: some brown ice in center of picture
2645 Final scan, 2:00:53.7

Photo Records:


1. banded clouds


2. haze layer


3. sea ice


4. sea ice


5. sea ice


6. sea ice with some haze


7. sea ice


8. sea ice


9. starboard view of the airplane


10. port side view of airplane

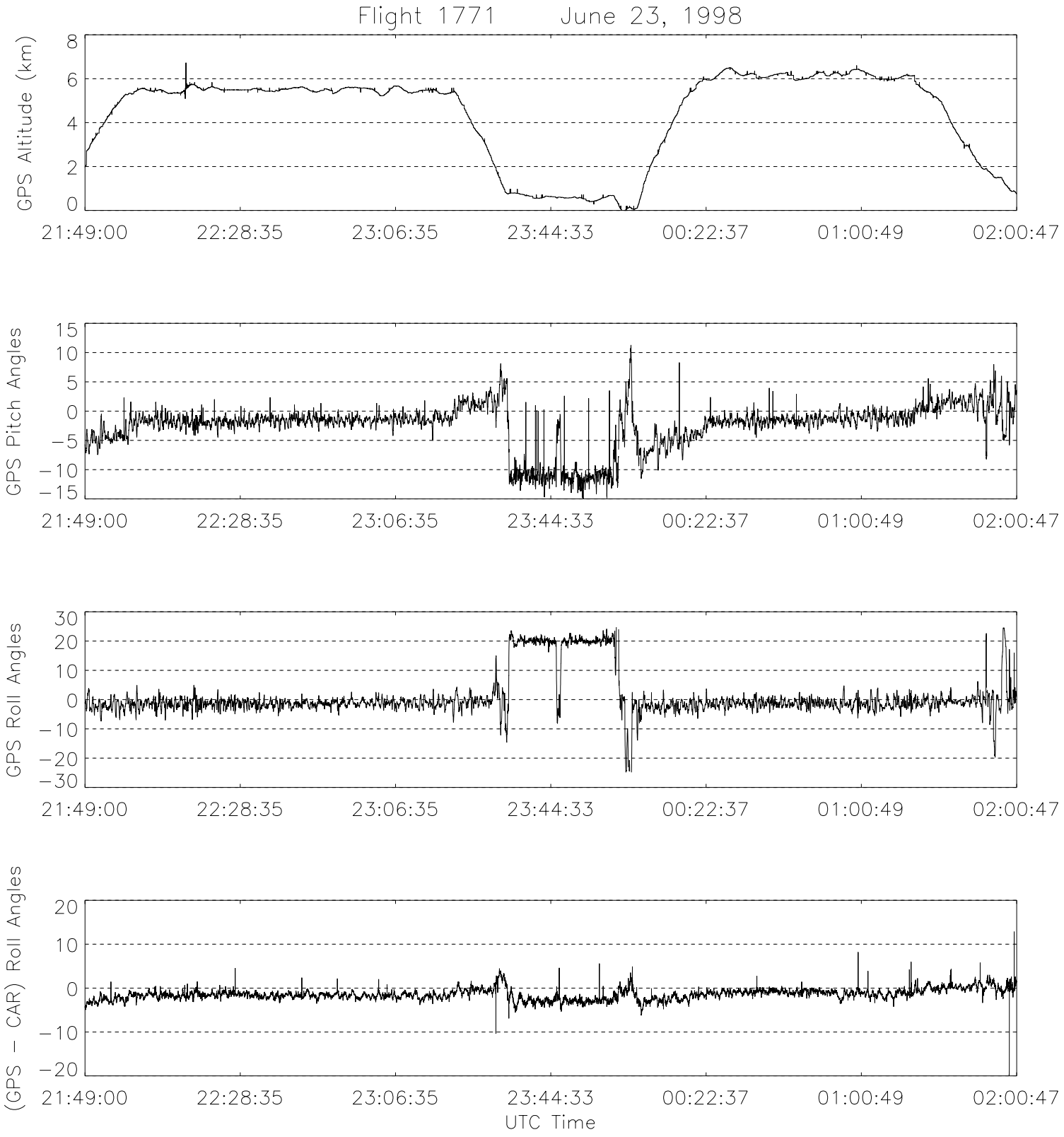

11. banded cloud structure above ice


12. port side view of banded structure

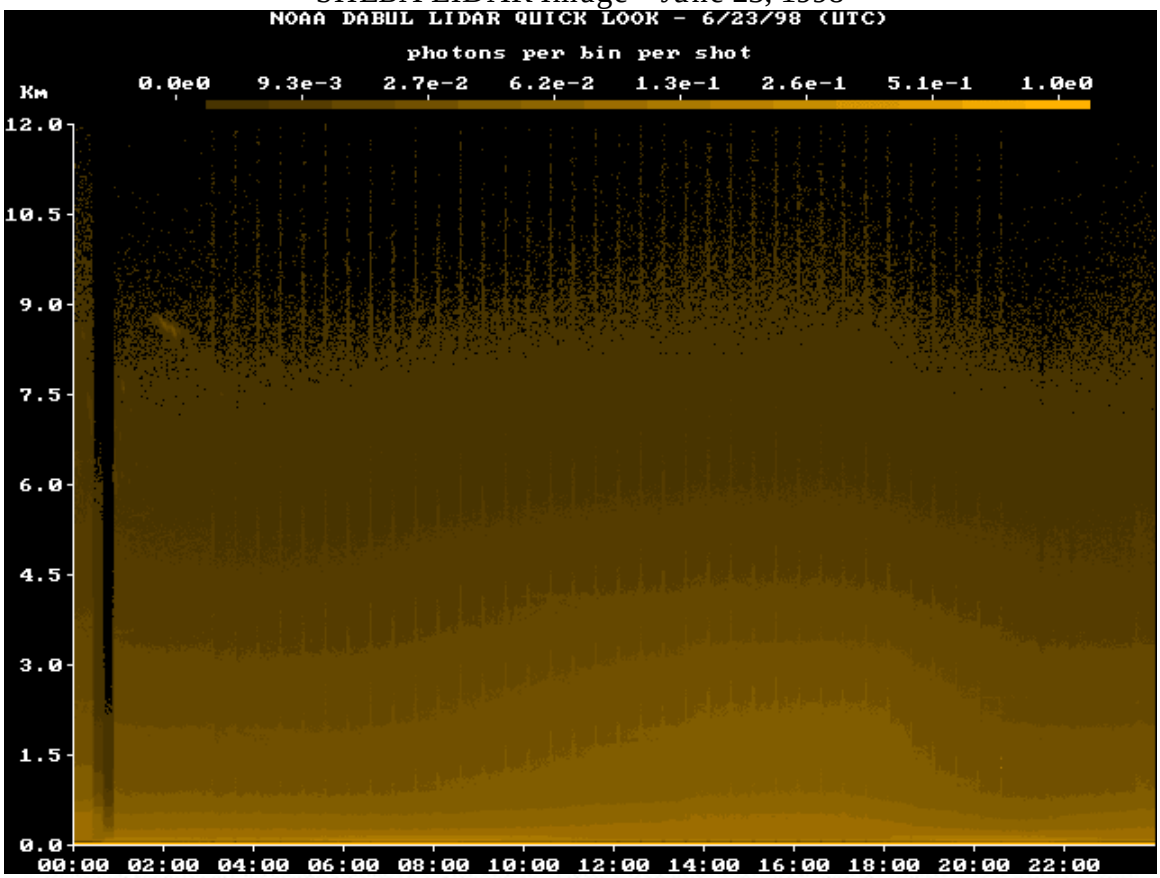

13. stratus deck


14. brown ice

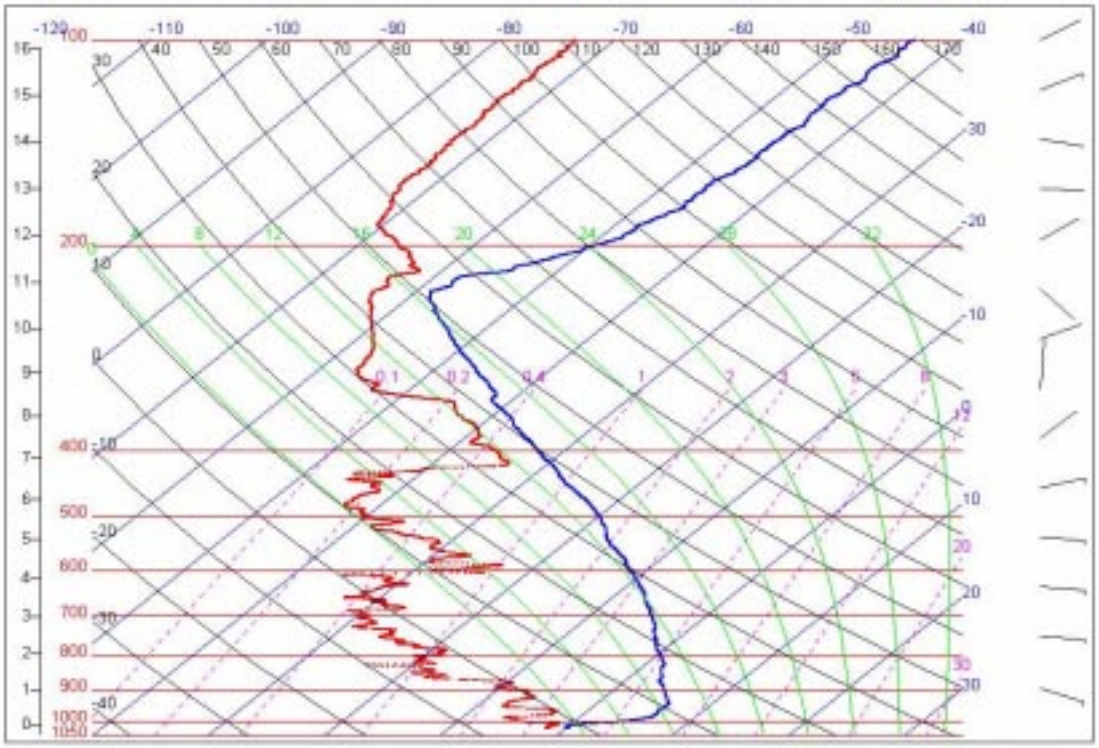
.


Flight 1771 June 23, 1998
GPS Altitude (km)
8
6
4
2
0
21:49:00
22:28:35
23:06:35
23:44:33
00:22:37
01:00:49
02:00:47
GPS Pitch Angles
15
10
5
0
−5
−10
−15
GPS Roll Angles
30
20
10
0
−10
−20
−30
(GPS − CAR) Roll Angles
20
10
0
−10
−20
UTC Time

SHEBA LIDAR Image – June 23, 1998



Version: SHEBA--GPS Soundings, GLASS 1.10 Fixed, SHE, 1998,06,23, 11:31:45



June 24, 1998

CV-580

Flight summary

Flight track

CAR notes

GPS plots

SHEBA

LIDAR image

Sounding

UW CV-580 FLIGHT LOG
June 24, 1998

Author (Mission Scientist): Hobbs, Peter

Flight Number: 1772
Engines On: 2014
Engines Off: 2310
Departure Airport: Barrow
Arrival Airport: Barrow

Clouds sampled: Ci, St

Summary:
BRDF of cirriform clouds in Barrow region, followed by a slow descent from cloud top to cloud "base" to obtain cloud microstructure measurements.

Experimental Observations:

1) 2014-2044 UTC: Took off and climbed to the middle (24,000 ft) of a WNW-ESE oriented line of broken cirriform clouds southwest of Barrow. A broken, and very clean, layer of stratus clouds (bases 300 feet, tops 800 feet) was sampled on climb out. Droplet concentrations in the stratus were about 10 cm^{-3}. Aerosol loading comparable to the previous day was observed at the base of the cirrus clouds (determined from a distance to be 20,000 ft).

2) 2044-2135 UTC: Continued climb to cloud top at 31,000 ft (-52° C) and survey of clouds for most suitable region (devoid of upper or lower clouds) for BRDF measurements of the cirrus. The highest tops of the cirrus uncinus and cirrus spissatus reached this level, with saddle top regions several thousand feet lower. A brief apparent nucleation/release of CN was noted at cirrus top.

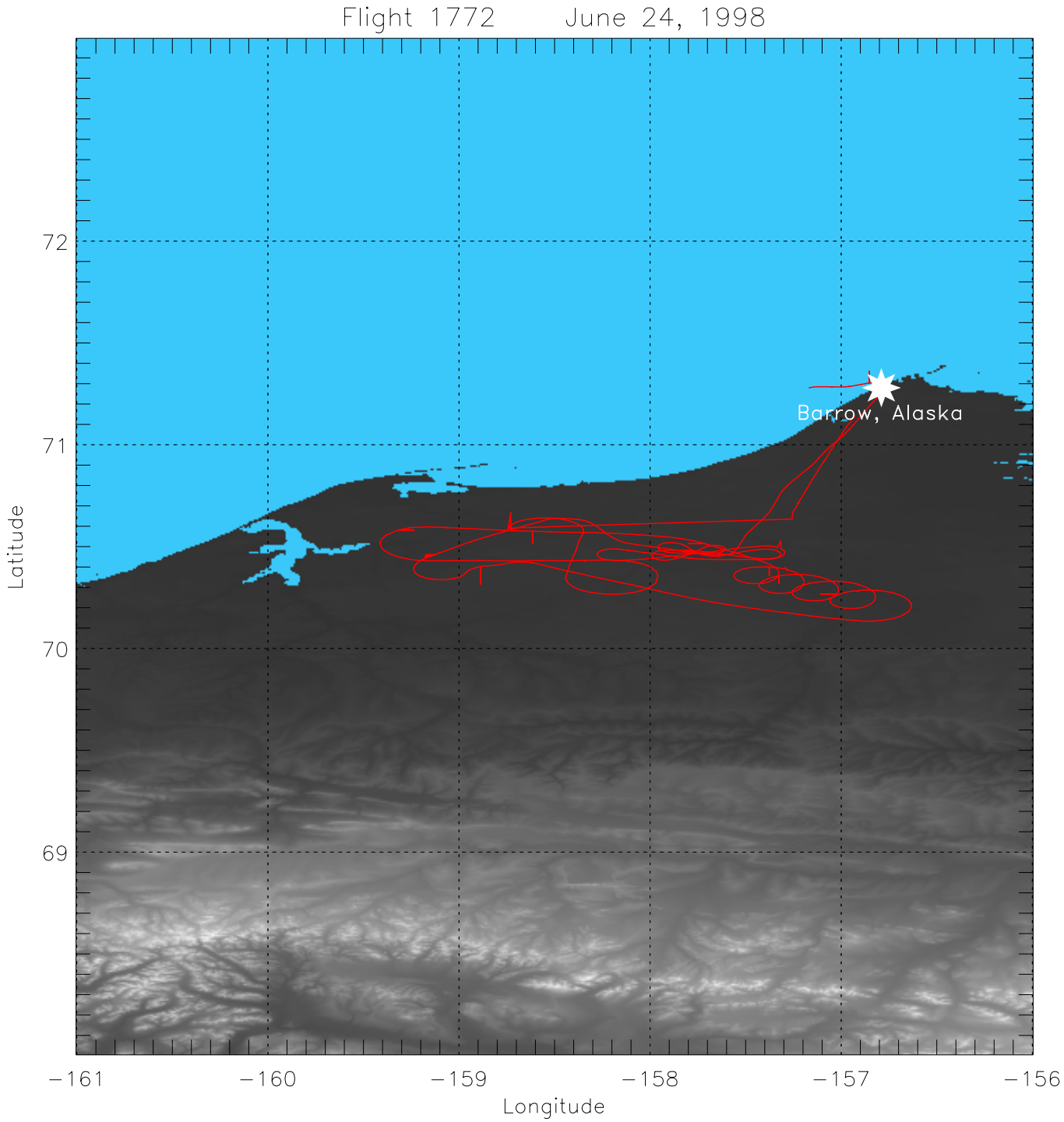
3) 2135-2145 UTC: Searched for best cloud situation for BRDF measurements. A region of subsided cirrus uncinus and cirrus intortus ("tangle of strands") was chosen.

4) 2145-2210 UTC: A modified BRDF maneuver, for the purpose of avoiding contrails, was carried out over a saddle region of the cirrus tops. While an isolated cirrus uncinus/cirrus intortus top did extend to the flight level, 90% of the ice crystals in the region where the BRDF measurements were made were 1000-2000 feet or more below the flight level. Contrail production was heavy in the region where an ice crystal top was intercepted, but virtually non-existent in the regions where the clouds tops were lower and the air drier. To avoid contrails, the roll angle was changed during the BRDF orbits. No visible contrails were intercepted by the aircraft.

5) 2215-2240 UTC: Slow (500 feet per minute) descent through the clusters of cirrus uncinus, cirrus spissatus, and cirrus intortus clouds from cloud tops at 31,000 ft to bases at 21,000 ft. The ice crystals were mainly bullet rosettes.

6) 2240-2307 UTC: Descent and transit to Barrow. Haze layer intercepted. Possible Barrow plume, or cloud top CN nucleation, noted on final approach to Barrow (downwind of Barrow and in evaporating clouds). CNC-3 concentrations were more than 2000 cm^{-3} at this point near cloud top height.

This was our last research flight for FIRE / ACE.


Flight 1772 June 24, 1998
Barrow, Alaska
72
71
70
69
Latitude
−161
−160
−159
−158
−157
−156
Longitude

Flight 1772 - June 24, 1998

main

1 Summary

2 Photos

3 Quicklooks

1 Flight Summary

The CV-580 hunted cirrus on this flight. During this flight, the CAR performed a BRDF of a cirrus cloud, probably the cleanest (least contaminated by contrails and shadows) during the entire experiment. The CAR also did downward imaging of tundra and ice/melting ponds during the latter part of the flight. The CAR filter wheel channel was alternated between the 1.6 and 2.2 µm channels. The quality of the BRDF is probably very good. However, the data recording system froze when the CAR filter wheel was set to automatically advance near the beginning of the flight. There are two data tapes for this flight.

21:21 UTC engine-start, CAR rotated to downward imaging mode
474 [1] tundra, sea, sea ice, and melt ponds
909 (20:35 UTC) drive status light still blinking normally, but scan number and scans on screen have frozen.
20:40 UTC arctic haze popping above cirrus deck to starboard
20:44 UTC [2] brown ice on lake below
353 (20:57 UTC) screen back up and running after rebooting of primary processors. This strange freezing has happened only when the filterwheel has been set to automatic advancing mode (flight engineer Don Spurgeon's observation). From now on, we will stick to manual setting of filterwheel channels. Filterwheel set to 1.6 µm channel.
Prepare CAR for BRDF measurements:
2060 Don got CAR rotated to BRDF position, but not locked into position. Rotation might be half a degree off.
3166 altitude is 30,790 ft.-the highest the plane can go and still turn at all.
We will stagger the BRDF loops to avoid our contrails.
3500 Beginning of turn 1; filterwheel set to 1.6 µm channel; ground below is 40% lake coverage, no ice, and brown tundra. Cloud top is ~2000 ft. below us.
4002 Beginning of turn 2
4465 We just crossed our track-no plume or particles in our former path.
4521 Beginning of turn 3; [3] ground as seen through frosted bubble at CAR station : brown tundra, 30% unfrozen ponds and lakes below.
4989 just crossed our path again-very clean
5045 Beginning of turn 4
5118 switch filterwheel to 2.2 µm channel
5500 just crossed our flight track again, very clean-most of our contrails have dissipated
5888 rolling out, headed west to find another cloud
5910 soot registered, but not necessarily from contrail
8760 at top of cloud
8785 switch filterwheel to 1.6 µm channel
9683 successfully switched to downward imaging position-locked in place (lights go on in both directions. If a light does not go on in one direction, it usually means that the rotating mechanism for the CAR is jammed badly enough so that it must be fixed on the ground.)
10565 sunglint off of ice pond to right causing saturation of signal
11435 [4] brown ice and whiter ice off starboard
11700 [5] brown ice
11909 water pond right below (to starboard)
12541 Rotated CAR to upward imaging mode for landing.

First ISCCP Regional Experiment
May - June, 98
Barrow, Alaska

Photo Records:

1. tundra, sea, sea ice, and melt ponds

2. brown ice on lake below

3. exposed tundra

4. brown ice

5. brown ice

Flightrack and Quicklook Images:

- CV-580 flight tracks
- GPS roll and pitch angle

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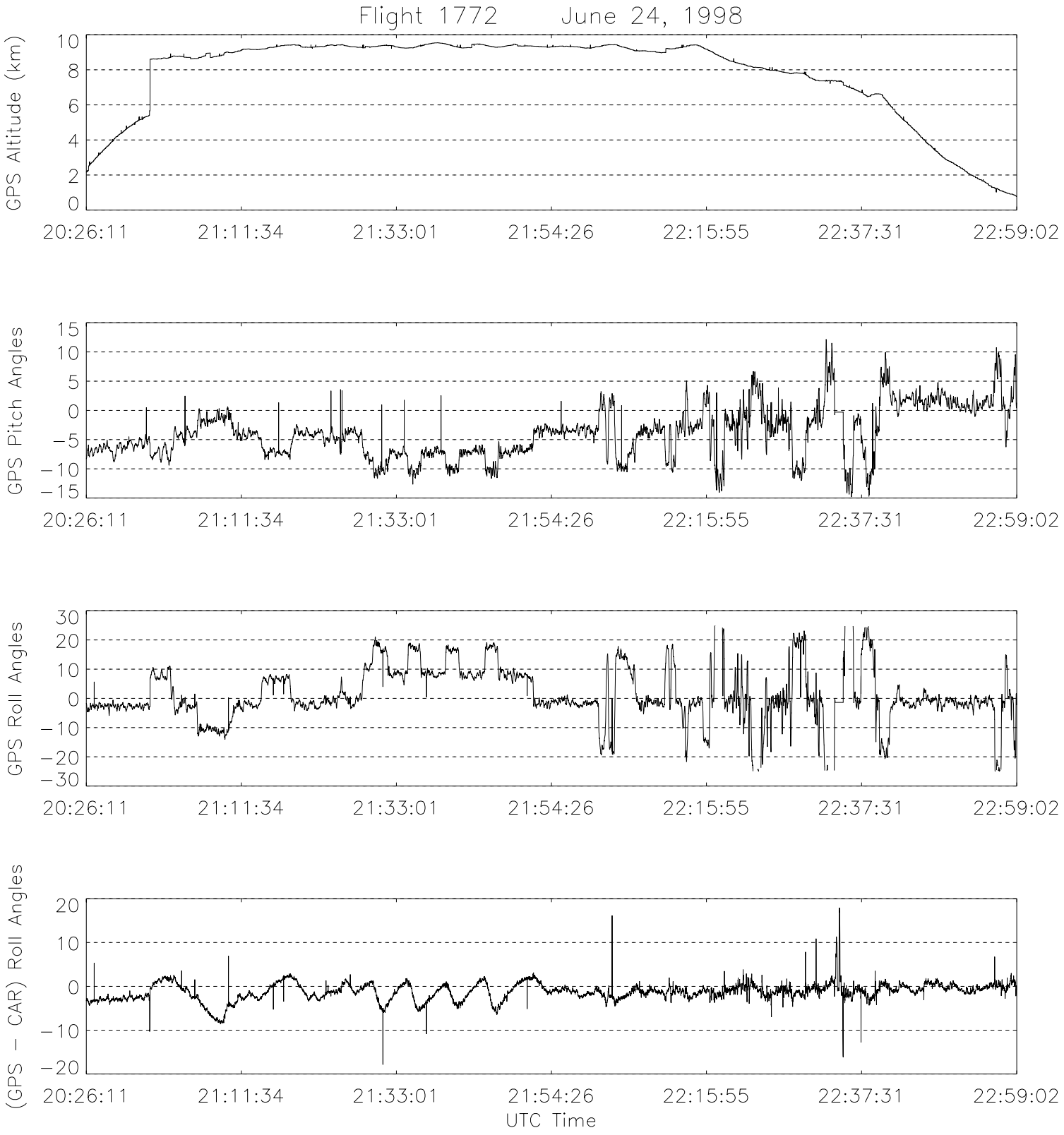
Flight 1772 June 24, 1998
GPS Altitude (km)
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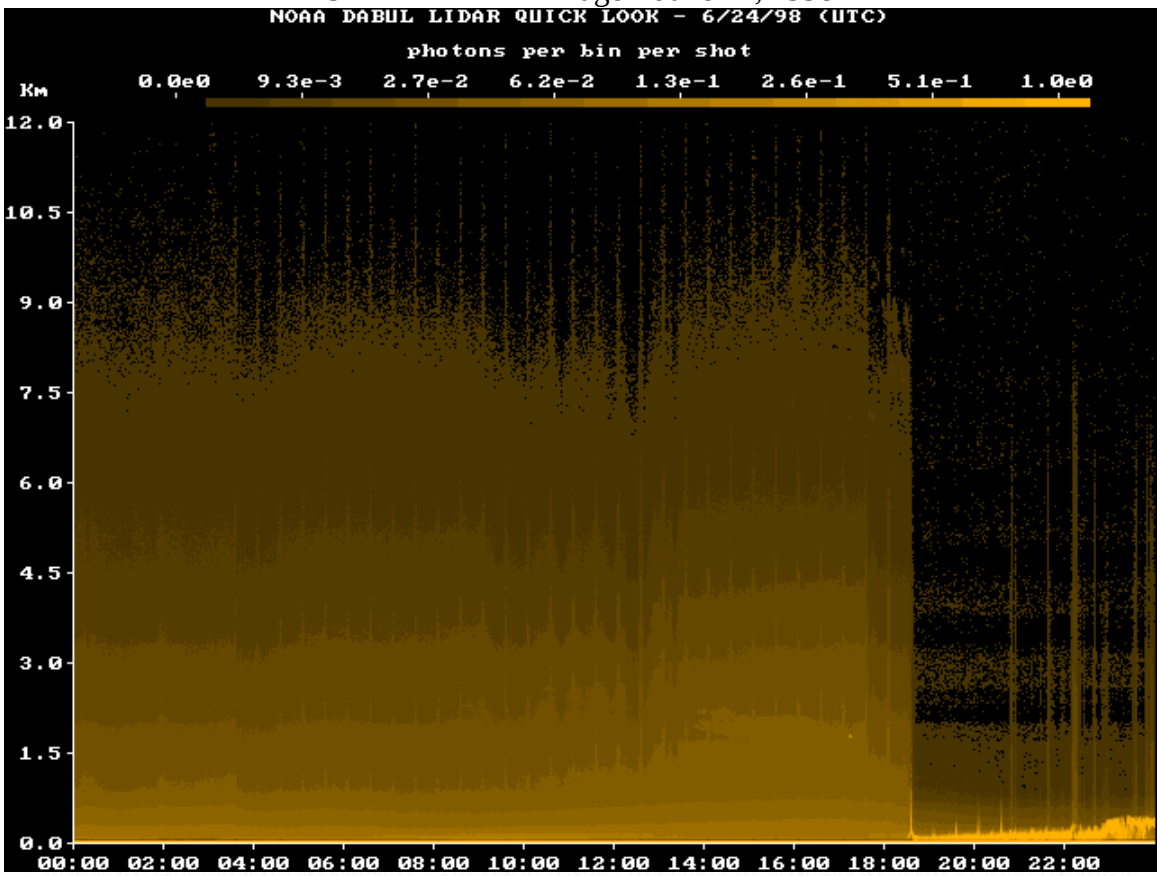
8
6
4
2
0
20:26:11
21:11:34
21:33:01
21:54:26
22:15:55
22:37:31
22:59:02
GPS Pitch Angles
15
10
5
0
−5
−10
−15
GPS Roll Angles
30
20
10
0
−10
−20
−30
(GPS − CAR) Roll Angles
20
10
0
−10
−20
UTC Time

SHEBA LIDAR Image – June 24, 1998



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