CLOUD AND AEROSOL RESEARCH GROUP

SUMMARY OF FLIGHTS AND TYPES OF DATA COLLECTED ON THE UNIVERSITY OF WASHINGTON'S (UW) CONVAIR-580 AIRCRAFT IN THE FIRE-ACE/SHEBA PROJECT IN THE ARCTIC FROM 19 MAY THROUGH 24 JUNE 1998

UNIVERSITY OF WASHINGTON
DEPARTMENT OF ATMOSPHERIC SCIENCES
SEATTLE, WASHINGTON
98195-1640

SUMMARY OF FLIGHTS AND TYPES OF DATA COLLECTED ON THE UNIVERSITY OF WASHINGTON'S (UW) CONVAIR-580 AIRCRAFT IN THE FIRE-ACE/SHEBA PROJECT* IN THE ARCTIC FROM 19 MAY THROUGH 24 JUNE 1998

by

Peter V. Hobbs

December 1998

* Research supported by NASA, NSF (grant OPP-9808163) and DOE.

Frontispiece: The University of Washington's Convair-580 research aircraft in Barrow in June 1998 for the FIRE-ACE/SHEBA field project. (Photo: A. Rangno)

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1. OBJECTIVES OF THE UW CONVAIR-580 FLIGHTS IN FIRE-ACE/SHEBA

The first field project for the University of Washington's (UW) Convair-580 research aircraft was in the Arctic. The aircraft was based at Barrow, Alaska, in support of the FIRE **A**rctic **C**loud **E**xperiment (FIRE-ACE) and SHEBA (**S**urface **HE**at **B**udget of the **A**rctic Ocean). Twenty-three research flights were carried out between 15 May through 26 June 1998.

The main research goals and tasks of the UW Cloud and Aerosol Research Group (CARG) in FIRE-ACE/SHEBA were:

- To carry out coordinated flights beneath the NASA ER-2 aircraft for the purpose of providing in situ measurements of cloud microphysical structures and thicknesses simultaneously with remote sensing measurements from the ER-2. Of particular interest were multi-cloud layer situations over highly reflecting ice surfaces (a scenario that provides a severe test for remote sensing of clouds).

- To obtain measurements of the absorption of solar radiation by layer clouds, using the NASA-Ames SSFR radiometers and the NASA-Goddard CAR (for clouds thick enough to be in the "diffusion domain").

- To obtain measurements of surface spectral albedo and the **b**idirectional **r**eflectance **d**istribution **f**unction (BRDF) using the SSFR radiometers and the CAR.

- To explore radiative interactions between layer clouds (or highly reflecting surfaces) and overlying absorbing aerosol layers.

- To obtain statistical measurements of the microstructures of arctic stratus clouds over long path lengths (to test a number of hypotheses based on previous measurements in the Arctic by the CARG).

- To see whether anthropogenic pollutants (from Barrow or from long-range transport) affect the microstructures and radiative properties of arctic clouds.

- To obtain in situ measurements (particularly of cloud heights and cloud structural and radiative properties) over the SHEBA research ship (frozen into the Arctic Ocean), and the ARM site at Barrow, for comparisons with surface-based remote sensing measurements at those two sites. Also, surface albedo and BRDF measurements around the SHEBA ship and ARM site.

- To evaluate the utility of the new Gerber Scientific Inc.'s g-meter (for measuring optical scattering and extinction, the asymmetry parameter, and the back-to-forward scattering ratio for cloud and precipitation particles in clouds—including mixed phase clouds).

- To obtain measurements of aerosols in non-cloudy and cloudy conditions, including vertical profiles over the ARM site at Barrow for "closure" studies with a ground-based sunphotometer at that site.

- To exploit the several new scanning modes of the CAR on the Convair-580.

A number of idealized flight scenarios to achieve the objectives outlined above were devised prior to the field project. These flight scenarios are described in the CAR report entitled *"University of Washington Flight Scenarios for the Convair-580 in the Arctic (15 May-26 June 1998)"* by Peter V. Hobbs, which is available on the CARG Homepage (http://cargsun2.atmos.washington.edu/sys/research/fire-ace/) or on request to the CARG.

Most of the data collected aboard the UW Convair-580 has been formally archived in the NASA Langley DAAC.

This was the first field deployment of the UW 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 fly from Barrow to the SHEBA ship, with adequate time on station to obtain important measurements, even when the ship was well over 400 nm from Barrow.

2. INSTRUMENTATION ABOARD THE UW CONVAIR-580 IN FIRE-ACE/SHEBA

The instrumentation that was aboard the Convair-580 for these studies is listed in Table 1.

3. TYPES OF DATA COLLECTED ABOARD THE UW CONVAIR-580 IN FIRE-ACE/SHEBA

Twenty-three research flights, totaling over 97 research hours, were flown by the UW Convair-580 for FIRE-ACE/SHEBA during the period May 19 through June 24, 1998.

Table 2 gives an overview of the main accomplishments of these flights. Table 3 contains a complete listing of the flights. Tables 4 and 5 provide information on the Convair-580 flights over the SHEBA ship and the ARM site at Barrow, respectively. Table 6 lists the photographs that were taken aboard the Convair-580 during the FIRE-ACE/SHEBA flights.

(Text continued on page 39.)

Table 1. Instrumentation Aboard the University of Washington's Convair-580 Aircraft for FIRE-ACE/SHEBA

(a) Navigational and Flight Characteristics

Parameter	Instrument Type	Manufacturer	Range (and error)
Latitude and longitude, ground speed	Global positioning system	Bendix/King KLN900	Global
True airspeed	Variable capacitance	Rosemount Model 831 BA	0 to 250 m s^{-1} (<0.2%)
Heading	Gyrocompass	King KCS-55A	0 to 360˚ (± 1˚)
Pressure altitude	Variable capacitance	Rosemount Model 830 BA	150 to 1100 mb (<0.2%)
Pitch, roll, and azimuth	Differential GPS	Trimble TANS/Vector	0 to 360˚ (±0.15˚)
Pitch and roll	CAR Gyro	--	±20˚

(b) General Meteorological

Parameter	Instrument Type	Manufacturer	Range (and error)
Total air temperature	Platinum wire resistance	Rosemount Model 102CY2CG and 414 L Bridge	-60 to 40˚C (<0.1˚C)
Static air temperature	Reverse-flow thermometer	In-house	-60 to 40˚C (<0.5˚C)
Dew point	Cooled-mirror dew point	Cambridge System Model TH73-244	-40 to 40˚C (<1˚C)
Absolute humidity	IR optical hygrometer	Ophir Corp. Model IR-2000	0 to 10 g m^{-3} (~5%)
Air turbulence	RMS pressure variation	Meteorology Research Inc. Model 1120	0 to 10 $cm^{2/3}$ s^{-1} (<10%)
Horizontal winds	GPS	Bendix/King KLN900	Global
UV hemispheric irradiance (upward and downward)	Diffuser, filter photo-cell (0.295 to 0.390 µm)	Eppley Lab. Inc. Model 14042	0 to 70 W m^{-2} (±3 W m^{-2})
VIS-NIR hemispheric irradiance (upward and downward)	Eppley thermopile (0.3 to 3 µm)	Eppley Lab. Inc. Model PSP	0 to 1400 W m^{-2} (±10 W m^{-2})
Surface radiative temperature*	IR radiometer 1.5˚ FOV (8 to 14 µm)	Omega Engineering 053701	-50˚ to 1000˚C ±0.8% or reading
Video image	Forward-looking camera and time code	Sony Hi8 camera	SVHS tape

(c) Aerosol

Parameter	Instrument Type	Manufacturer	Range (and error)
Number concentration of particles	Condensation particle counter	TSI Model 3760	10^{-2} to 10^{4} cm^{-3} (>0.02 µm to ~0.3 µm)
Size spectrum of particles	Forward light-scattering	Particle Measuring Systems Model FSSP-300	0.3 to 20 µm (31 channels)

(Cont.)

* Malfunctioned during most of study

TABLE 1 (continued)

(c) Aerosol (continued)

Parameter	Instrument Type	Manufacturer	Range (and error)
Size spectrum of particles	35 to 120˚ light-scattering	Particle Measuring Systems Model PCASP-100X	0.10 to 3.0 µm (15 channels)
Size spectrum of particles	90˚ light-scattering	Particle Measuring Systems Model LAS-200	0.5 to 11 µm (15 channels)
Size spectrum of particles	Forward light-scattering	Particle Measuring Systems Model FSSP-100	2 to 47 µm (15 channels)
Size spectrum of particles	Differential Mobility Particle Sizing Spectrometer (DMPS)	TSI, modified in-house	0.01 to 0.6 µm (21 channels)
Light-scattering coefficient	Integrating 3-wavelength nephelometer with backscatter shutter	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
Light-scattering coefficient (for bag-house)	Integrating nephelometer	Radiance Research	1.0×10^{-6} m^{-1} to 2.0×10^{-4} m^{-1} or 1.0×10^{-6} m^{-1} to 1.0×10^{-3} m^{-1}
Light absorption and graphitic carbon	Particle soot/absorption photometer	Radiance Research	Absorption coefficient: 10^{-7} to 10^{-2} m^{-1}; Carbon: 0.1 µm m^{-3} to 10 mg m^{-3} (±5%)
Graphitic and/or Organic Carbon	Quartz filters thermal optical technique*	Lawrence Berkeley Lab. (T. Novakov)	4 to 160 µm m^{-3} (±1.6 µg m^{-3}) for 1 m^3 sample
Humidification factor for aerosol light-scattering	Scanning humidigraph	In house (designed and built for UW by Mark Rood)	b_{sp} (RH) for 30% ≤ RH ≤ 85%

(d) Cloud Physics

Parameter	Instrument Type	Manufacturer	Range (and error)
Cloud and precipitation particle images	Digital holographic camera	SPEC, Inc. Model CPI-230	5 µm to 3 mm
Size spectrum cloud particles	Forward light-scattering	Particle Measuring Systems FSSP-100	2 to 47 µm (15 channels)
Size spectrum of cloud and precipitation particles	Diode occultation	Particle Measuring Systems OAP-200X (1D-C)	20 to 310 µm (15 channels)
Images of precipitation particles	Diode imaging	Particle Measuring Systems OAP-2D-C	Resolution 25 µm
Liquid water content	Hot wire resistance	Johnson-Williams	0 to 2 or 0 to 6 g m^{-3}
Liquid water content	Hot wire resistance	King/PMS†	0 to 5 g m^{-3}
Liquid water content; particle surface area; effective droplet radius	Optical sensor	Gerber Scientific Inc. PVM-100X	0.001-10 g m^{-3}; 5-10,000 cm^2 m^{-3}; 2-70 µm

(Cont.)

* Guest filters (measurements invalid)
† Malfunctioned during most of study

TABLE 1 (continued)

(d) Cloud Physics (continued)

Parameter	Instrument Type	Manufacturer	Range (and error)
Optical scattering/extinction coefficients at 630 nm, asymmetry parameter, and back-to-forward scattering ratio for cloud and precipitation drops and ice particles	g-meter	Gerber Scientific, Inc.	Particles to 10-2000 µm. Rate 5-100 Hz. Asymmetry parameter (g) to 1-2% accuracy. Optical extinction coefficient to 5-10%.

(e) Chemistry†

Parameter	Instrument Type	Manufacturer	Range (and error)
Particulate species $SO_4^{=}$, NO_3^{-}, Cl^{-}, Na^{+}, K^{+}, NH_4^{+}, Ca^{++}, Mg^{++}	Teflon filters and ion exchange chromatography	Gelman Dionix	0.1 to 50 µg m^{-3} (for 500 liter air sample)
SO_2	Pulsed fluorescence	Teco 43S (modified in-house)	0.1 to 200 ppb
O_3	Chemi-luminescence (C_2H_4)	Monitor Labs Model 8410 A	0 to 5 ppmv (<7 ppb)
CO	Infrared correlation spectrometer	Teco Model 141	0 to 50 ppmv (~0.1 ppmv)
CO_2	Infrared correlation spectrometer	LI-COR Li-6262	0 to 300 ppmv (0.2 ppmv at 350 ppmv)
NO/NO_x	Chemi-luminescence (O_3)	Modified Monitor Labs Model 8840	0 to 5 ppmv (~1 ppb)

(f) Remote Sensing

Parameter	Instrument Type	Manufacturer	Range (and error)
Absorption and scattering of solar radiation by clouds; BRDF and albedo of surfaces	Thirteen wavelength scanning radiometer	NASA-Goddard/ University of Washington	13 discrete wavelengths between 470 and 2300 nm
Solar Spectral irradiance or radiance; Spectral transmission and reflectance*	Up and down looking hemispherical signal collectors	NASA Ames Solar Spectral Flux Radiometer (SSFR) (P. Pilewskie)	300-2500 nm (5-10 nm resolution). FOV 1 mrad. 1 Hz spectral sampling rate.
Weather radar	Pilot's radar (λ=3 cm)	Bendix/King (now Allied Signal)	160 nm

(Cont.)

* Guest instrument

† Due to problems with a newly constructed inlet tube, the gas measurements (SO_2, O_3, CO, CO_2 and NO/NO_x) were not reliable.

TABLE 1 (continued)

(g) Data Processing and Display

Parameter	Instrument Type	Manufacturer	Range (and error)
In-flight data processing and recording	Microcomputer	In-house, based on Motorola MVME-133A technology	
Recording (analog voice transcription)	Cassette recorder	---	
In-flight data processing and display	Laptop PC	NEC Versa 5060X	
Digital printout	Impact printer	Epson MX-80	

TABLE 2. OVERVIEW OF MAIN ACCOMPLISHMENTS OF CONVAIR-580 FLIGHTS IN FIRE-ACE/SHEBA.

- Six carefully coordinated flights beneath the NASA ER-2. Five of these flights (UW Flights 1750, 1751, 1754, 1759, and 1762) were in the vicinity of the ARM site at Barrow, and one (UW Flight 1760) was over the SHEBA ship.
- Eight dedicated flights over the SHEBA ship (UW Flights 1756, 1757, 1760, 1763, 1766, 1768, 1770, and 1771). These flights generally included a vertical profile over the ship for cloud and aerosol measurements, and BRDF and albedo measurements in the vicinity of the ship.
- Eleven flights over the ARM site in Barrow (UW Flights 1750, 1751, 1754, 1755, 1758, 1759, 1762, 1763, 1765, 1769, and 1770). These flights generally included a vertical profile of the site for cloud and aerosol measurements, and BRDF and albedo measurements in the vicinity of the site.
- Measurements of cloud optical and radiative properties, and cloud microstructures, in stratus, altocumulus, and cirrus clouds. Total flight paths in stratus/stratocumulus, altocumulus, and cirrus/altostratus were about 1750, 900, and 5300 km, respectively.
- Aerosol measurements in arctic haze layers (from long-range transport) and under very clean conditions.
- Measurements of the effects of pollution from Barrow on the structure of stratus clouds (UW Flight 1767).
- Several new or modified instruments were operated on the Convair-580 including the Gerber Scientific Inc. g-meter, the NASA/Ames solar spectral flux radiometer, the NASA/Goddard spectral *full-scanning* radiometer, and the SPEC Inc. cloud particle imager.

TABLE 3. COMPLETE LISTING OF THE CONVAIR-580 FLIGHTS IN FIRE-ACE/SHEBA.

Date (1998)	UW Flight Number	Time of Takeoff (UTC)	Time of Landing (UTC)	Main Accomplishments of Flight*	Weather
May 19	1750	2106	2453	1) Measurements over ARM site and Chukchi sea. 2) BRDF measurements of the surface with overlying stratus. 3) Long track measurements in stratus (CAR diffusion-domain measurements?). 4) Aerosol measurements above cloud top.	A large surface high pressure system occupied all of the Beaufort Sea. It was centered northeast of the SHEBA ship. A low pressure system was centered in the Bering Sea, off the southwest coast of Alaska. Barrow was about half way between these two systems. An extensive, though thin, deck of stratus/stratocumulus clouds, overlain by scattered to broken thin cirriform clouds, characterized the cloud cover during the flight. The winds were east to northeast in the boundary layer.
May 20	1751	1947	2351	1) Measurements over ARM site as ER-2 flew overhead (PSU Raman lidar operating at ARM site). 2) BRDF measurements of Chukchi Sea-ice with clear skies and ER-2 overhead.	A large surface high pressure system occupied all of the Beaufort Sea. It was centered northeast of the SHEBA ship. A weak low pressure system was centered in the Bering Sea, and lower pressures extended across southern Alaska; Barrow was about half way between these two systems. Blustery northeasterly winds swept the North Slope of Alaska. The clouds in the vicinity of Barrow consisted of scattered stratus fractus that filled in to become overcast stratus/stratocumulus clouds toward the west of Barrow.

(continued)

* More details on the measurements obtained on each flight can be found on the CARG homepage (http://cargsun2.atmos.washington.edu).

TABLE 3 (continued)

Date (1998)	UW Flight Number	Time of Takeoff (UTC)	Time of Landing (UTC)	Main Accomplishments of Flight	Weather
May 21	1752	2005	2255	1) Profiles over Chukchi Sea through three thin stratus layers with cloud structural measurements, radiative and aerosol measurements. 2) BRDF measurements over sea ice and open water with stratus clouds above. 3) Aerosol measurements around clouds.	A large surface high pressure system occupied the Beaufort Sea; its center was east of the SHEBA ship. A major low pressure system was in southern Alaska. Barrow and the Arctic Coast were under northeasterly winds between these two systems. Barrow experienced sunny conditions with scudding stratus fractus clouds at takeoff. These scud clouds increased to the southwest over the large open lead southwest of Barrow. Also, an additional, slightly higher stratiform layer than the boundary layer scud clouds filled in from translucent scattered clouds to a solid gray overcast while on a southwesterly heading from Barrow.
May 23	1753	1904	2053	Radiation measurements 10 miles west of ARM site in horizontal runs in clear air above the tops of Ac, between two Ac layers, and between the base of the lower Ac and the top of the stratus. (NOAA-12 satellite overpass at 1951 UTC.)	The large high pressure system continued to occupy the Beaufort Sea. It was centered northeast of the SHEBA ship. A low pressure system was centered in southwestern Alaska. Barrow and the Arctic coast were under northeasterly winds between the two weather systems. The flow was from the northeast in the boundary layer. Overcast stratus/stratocumulus clouds, topped by broken to scattered altocumulus clouds are present during the flight.

(continued)

TABLE 3 (continued)

Date (1998)	UW Flight Number	Time of Takeoff (UTC)	Time of Landing (UTC)	Main Accomplishments of Flight	Weather
May 27	1754	2238	2707	1) Radiation and cloud microstructure measurements in Ac over Chukchi Sea and ARM site. 2) BRDF measurements over highest layer. 3) Radiative measurements above, between, and below Ac cloud layers. 4) Microphysical measurements in the cloud layers. 5) Measurements in upper cloud layer beneath ER-2 and over ARM site. 6) Climbed to 25,000 ft through Ac layers and Cs (did not quite clear tops) near ARM site. Spiral down from 25,000 ft to close to surface over ARM site. 7) BRDF measurements centered on ARM site; no cloud below but broken Ac above. 8) Level runs at 2,000 ft through ARM site over snow-covered tundra, open ocean, and ice-covered ocean (CAR measurements).	The high pressure system in the Beaufort Sea moved east into the Canadian Islands. A large low pressure center occupied eastern Siberia. Winds were easterly on the surface at Barrow, veering to southerly by 700 hPa. The cloud coverage consisted of multiple layers of altocumulus that merged with a deep altostratus ice cloud later in the flight.

(continued)

TABLE 3 (continued)

Date (1998)	UW Flight Number	Time of Takeoff (UTC)	Time of Landing (UTC)	Main Accomplishments of Flight	Weather
May 28	1755	2000	2316	1) Measurements in low stratus over Chukchi Sea. 2) Climbed to 15,000 ft and descended in deep cloud layer over ARM site. Descended to 500 ft over ARM as cloud was thinning. (PSU Raman lidar operating at ARM site.) 3) Straight and horizontal run through ARM site at 500 ft in clear air for radiation measurements.	A large low pressure system was located near the Siberian Coast. The high pressure system that formerly occupied the Beaufort Sea, was in the northern Canadian Islands. Barrow was still between these systems and under a southerly flow at all levels. Barrow and vicinity was covered by fairly dense, but broken, cirrus, altocumulus and altostratus clouds. Widespread regions of very shallow stratus clouds lay under these higher clouds offshore of Barrow.
May 29	1756	1919	2524	Vertical profiles over SHEBA ship from 21,500 to 500 ft through cloud layers. BRDF measurements looking down on the highest altocumulus layer.	A small low pressure system was located just north of the SHEBA ship. Because of this low over the SHEBA ship, there were considerable broken clouds up to about 6 km. A small high pressure system occupied the Alaskan coast centered east of Barrow. The boundary layer flow at Barrow was from the southwest. The sky condition was overcast altocumulus clouds with breaks at Barrow as the flight began. Altocumulus and cirriform clouds were sampled enroute to the SHEBA ship. At the SHEBA ship, a complicated, multi-layered cloud situation was encountered with several droplet cloud layers in the mid-levels, and extensive low clouds near the surface. Considerable precipitation fell from the mid-level clouds. Extensive low clouds were present at Barrow when the CV-580 returned.

(continued)

TABLE 3 (continued)

Date (1998)	UW Flight Number	Time of Takeoff (UTC)	Time of Landing (UTC)	Main Accomplishments of Flight	Weather
May 30	1757	1906	2426	Measurements over the SHEBA ship above, in, and below Ac. BRDF measurements above Ac layer over the ship. Two straight and level runs above both legs of ground, L-shaped, albedo array (satellite overpass).	A low pressure system was positioned northwest of the SHEBA ship, and a weak high occupied the Beaufort Sea to the southeast. The main center of the high pressure was in the Canadian Islands. The boundary layer flow was from the northeast. The cloud situation at Barrow at takeoff consisted of two layers, a broken layer of stratocumulus topped by an overcast layer of altocumulus clouds, intermittent sampling of a few thin cirriform clouds enroute to the SHEBA ship, an overcast altocumulus layer over the ship, and patchy surface fog around the ship. Some thin cirriform clouds were again sampled during the return flight to Barrow.
June 1	1758	2000	2505	1) Surface albedo and BRDF measurements over ARM site; spiral to 14,000 ft over ARM. BRDF measurements centered on ARM site. 2) BRDF and structural measurements of cirrus.	A very large high pressure system in the northernmost Canadian Islands extended southwestward into the Beaufort Sea. Generally clear conditions prevailed over Barrow during the first half of the flight. The flow from near the surface to aloft was from the south. Banks of altocumulus and cirriform clouds overspread the region south of Barrow during the second half of the flight. The cirriform clouds thickened to become altostratus clouds and multiple altocumulus cloud layers appeared during the second half of the flight. Considerable precipitation was encountered at mid-levels, though it did not reach the ground.

(continued)

TABLE 3 (continued)

Date (1998)	UW Flight Number	Time of Takeoff (UTC)	Time of Landing (UTC)	Main Accomplishments of Flight	Weather
June 2	1759	1959	2317	Coordinated flight with the ER-2 over the ARM site. Level runs above and below Sc layer for radiation measurements. BRDF measurements above Sc. Study of unusual precipitation event.	A weakening region of high pressure continued over the Canadian northern islands with a weak surface low pressure center in the Bering Sea. The surface flow at Barrow was light and from the northeast at the beginning of the flight, but was light and northwesterly at the end of the flight. However, the flow aloft continued from the south and southeast to 9 km ASL. Scattered to overcast regions of stratocumulus clouds were present in the vicinity of Barrow. Though the tops of the clouds were marginally supercooled at -5.5° C, some regions of them produced copious concentrations of ice crystals.
June 3	1760	1906	2439	1) Radiation and cloud measurements over SHEBA ship with ER-2 overhead. BRDF measurements above Ac and of surface around ship. Measurements over ground, L-shaped albedo array. Measurements in Ac. 2) Measurements in Ac on return to Barrow.	A small low pressure system in the Chukchi Sea was dissipating while another larger low pressure center was moving toward the SHEBA ship from the west. A high pressure system occupied the coast east of Barrow. Extensive cloud layers from boundary layer clouds to cirriform clouds were present at Barrow and these produced light rain at takeoff. The highest portions of these clouds gradually thinned enroute to the ship so that at the ship only a thin layer of altocumulus shedding a few ice crystals and two layers of stratus/stratocumulus clouds near the surface were present. Multi-layered clouds and precipitation were again intercepted enroute to and at Barrow.

(continued)

TABLE 3 (continued)

Date (1998)	UW Flight Number	Time of Takeoff (UTC)	Time of Landing (UTC)	Main Accomplishments of Flight	Weather
June 5	1761	2146	2528	1) "Aerosol-Cloud Shading" study over the Chukchi Sea. 2) BRDF measurements made above cloud top.	Pressure gradients very slight, with little wind at Barrow. The cloud field at Barrow consisted of two layers: a boundary layer stratus/stratocumulus cloud, and an altocumulus cloud layer. The flight took place in a mesoscale-sized clearing of the altocumulus cloud located to the west of Barrow in which the solid overcast lower boundary layer cloud was sampled.
June 6	1762	1932	2319	1) Flight beneath the ER-2 in the vicinity of the ARM site. 2) "Aerosol-Cloud Shading" study. 3) BRDF measurements of the Sc just prior to the arrival of ER-2.	Barrow and vicinity had extensive low stratus/stratocumulus cloud cover with flow from the west to northwest from the surface to 9 km. No higher clouds were in the immediate vicinity of Barrow. The very light surface flow from the northwest was associated with a receding and very weak trough of low pressure that extended from the Pole southeastward to the coast of the Northwest Territory of Canada to the east of Barrow.

(continued)

TABLE 3 (continued)

Date (1998)	UW Flight Number	Time of Takeoff (UTC)	Time of Landing (UTC)	Main Accomplishments of Flight	Weather
June 7	1763	1904	2535	1) Measurements over SHEBA ship. A front passed over the ship during the period of measurements. BRDF measurements under overcast sky. Several level runs over ground, L-shaped albedo array. Measurements in cirrus. 2) Aerosol measurements in vertical profile under cloudless conditions in the vicinity of the ARM site.	A sharp cold front, connected to a large low pressure center near the Pole, crossed the SHEBA ship in the morning (before the CV-580 aircraft arrived). The flight to the ship passed through this front and its banded cloud system near 5.5 km ASL. The up-stream side of this band exhibited highly convective castellanus-type cumuliform tops. At the ship, the vaulted frontal band of (liquid-topped, ice under-neath) altostratus clouds wedged downward toward the receding front to the southeast. Below the receding altostratus clouds and over the ship, there was a solid overcast of stratus/stratocumulus clouds emitting spotty but surprisingly dense precipitation shafts which obscured the horizon behind them. The surface flow was from the northwest. The altostratus clouds thinned to cirriform patches as a clearing of the higher clouds advanced from the northwest during the flight. Clear conditions were observed at Barrow at takeoff and landing.
June 9	1764	1859	2250	1) Cloud-aerosol radiation study over the Chukchi Sea. 2) "Aerosol-Cloud Shading" measurements. 3) BRDF measurements of stratus tops.	A surface ridge of high pressure extruded eastward from northeastern Siberia across the Chukchi and Beaufort Seas and produced northwesterly flow at Barrow. Conditions at takeoff from Barrow were broken stratus fractus with thin broken cirriform clouds above. Mesoscale-sized regions of solid stratocumulus clouds were soon encountered west and northwest of Barrow. Some of these clouds produced very thick shafts of precipitation in the vicinity of Barrow late in the flight.

(continued)

TABLE 3 (continued)

Date (1998)	UW Flight Number	Time of Takeoff (UTC)	Time of Landing (UTC)	Main Accomplishments of Flight	Weather
June 11	1765	1801	2102	1) Cloud microstructure measurements over the Chukchi Sea. 2) Cloud, aerosol and radiation measurements over ARM site.	A large surface high pressure system occupied the Beaufort Sea to the east of Barrow and extended into the Northwest Territory of Canada. This situation produced light northeasterly winds at Barrow. Solid stratocumulus clouds were overlain by broken to overcast, and multi-layered altocumulus clouds in the vicinity of Barrow. A deeper, but transparent ice cloud enveloped the altocumulus clouds in some regions, but did not dissipate them. By flights end the stratocumulus clouds had become broken and a shallow stratus fractus scud cloud near the surface began moving off the ice toward Barrow by flight's end.
June 13	1766	1746	2259	Cloud and radiation measurements around SHEBA ship. BRDF measurements over single stratus layer. BRDF measurements of surface, centered on the ship, in diffuse light. Spiral over ship through stratus plus two altocumulus layers.	A large high pressure system that covered the entire Beaufort Sea was centered east of SHEBA ship. The resulting winds at the SHEBA ship were southeasterly. The weather at Barrow was overcast in stratus/stratocumulus clouds with clear skies above at takeoff and at landing with northeasterly winds. Enroute to the ship, thin cirriform clouds were occasionally flown under, and a few ice crystals sampled, while below there were extensive layers of altocumulus and/or stratocumulus clouds. At the ship, the west edge of an extensive altocumulus deck lay in a north-south line exactly over the ship when the plane arrived. To the east of the ship, there were a few scattered altocumulus clouds that tended to fill in toward the knife-edged layer to the west as the flight over the ship progressed. Spotty, very light drizzle fell from the stratus/stratocumulus deck over the ship. Cloud conditions on the return flight to Barrow were pretty much the same as on the leg to the ship. (continued)

TABLE 3 (continued)

Date (1998)	UW Flight Number	Time of Takeoff (UTC)	Time of Landing (UTC)	Main Accomplishments of Flight	Weather
June 14	1767	1912	2218	Stratus cloud microstructure measurements over the Chukchi Sea (including effects of Barrow plu on stratus).	The large high pressure system centered east of the SHEBA ship continues to cover the entire Beaufort Sea. At Barrow, the clouds are overcast to broken in varying thicknesses of stratocumulus clouds. Above these clouds were well-developed altocumulus castellanus clouds, cirriform clouds, and cumulonimbus clouds capable of producing lightning with extremely dense rainshafts immediately to the south of Barrow. Some large raindrops from the edges of these rainshafts were encountered during takeoff and during the return leg of the flight. Extensive regions of drizzle were encountered in some portions of the slightly supercooled stratocumulus clouds to the west of Barrow.
June 18	1768	1856	2414	1) Measurements over SHEBA ship. BRDF measurements above the highest cloud layer. Passes over surface, L-shaped albedo array. BRDF measurements over altocumulus layer. 2) Sampled extensive ice clouds (various forms of cirrus and ice-shedding altocumulus) on the return trip to Barrow.	A large high pressure system covering the Beaufort Sea (and much of the Arctic) was positioned north-east of the SHEBA ship with a low pressure center to the west of the ship. Winds at the ship were south-easterly at 10-20 knots. The winds at Barrow were from the east. The clouds at Barrow consisted of overcast stratus/stratocumulus with cirrus above. A multilayered cloud system consisting of cirriform clouds, altocumulus, and stratus/stratocumulus clouds was present from Barrow to the ship with numerous cirriform clouds sampled. The middle and higher clouds over the ship consisted of cirriform clouds and several layers of altocumulus clouds with the lowest layer producing large altocumulus castel-lanus turrets, some of which produced rainshafts to the ground in the vicinity. Below these clouds was a solid overcast of stratus clouds with bases near the surface. The clouds encountered on the return trip to Barrow consisted of the same types as had been encountered on the way to the ship. All of the low clouds sampled on this day produced drizzle.

(continued)

TABLE 3 (continued)

Date (1998)	UW Flight Number	Time of Takeoff (UTC)	Time of Landing (UTC)	Main Accomplishments of Flight	Weather
June 19	1769	2051	2450	1) BRDF orbits over cirrus clouds with no cloud below. 2) Downward spiral over ARM site.	A weakening area of high pressure covered the eastern Beaufort Sea and very weak low pressure center advanced toward the North Slope from the west. High broken to overcast cirriform clouds, borne on southwesterly winds aloft, overspread Barrow during the late morning hours and dominated the sky for the remainder of the day. At least three layers of cirriform clouds were present. Very shallow low stratus fractus and fog moved in from the northeast of Barrow as the flight ended.
June 22	1770	1800	2327	1) Flight over SHEBA ship. BRDF over ship. Straight runs above surface, L-shaped albedo array. Sampled clouds over ship. 2) Climbed to near cirrus tops (26,000 ft) over the ARM site, followed by descent through the patchy cirriform cloud over ARM site.	The expansive high pressure system dominating the circulation in the Beaufort Sea drifted to a position north of the SHEBA ship, while a large low pressure center lay over the Bering Sea. Due to the location of these large systems, the surface winds from Barrow all the way to the SHEBA ship were easterly. Low, thin stratus clouds were widespread from Barrow to the SHEBA ship. Above the stratus clouds was an extensive band of middle and cirriform clouds which was oriented from the southeast toward the northwest and extended from Barrow to the SHEBA ship. Thus, the flight track to and from the SHEBA ship was parallel to and in the cirriform clouds, but generally above mid-level clouds. At the SHEBA ship, the cloud cover mainly consisted of patchy cirriform clouds, generally broken in coverage and showing no shading.

(continued)

TABLE 3 (continued)

Date (1998)	UW Flight Number	Time of Takeoff (UTC)	Time of Landing (UTC)	Main Accomplishments of Flight	Weather
June 23	1771	2120	2609	Flight over SHEBA ship. BRDF and surface albedo measurements under clear sky.	An exceptionally clear day over the SHEBA ship. The satelite images, radar, and lidar were all void of clouds in the afternoon. Low level fog and/or haze also was absent. The large high pressure system, formerly in the Beaufort Sea, had move directly north of the SHEBA ship near the pole. A large clear area protruded south from the high over the SHEBA ship. At Barrow, and to within about 70 NM of the SHEBA ship, solid low overcast stratus clouds were present. The low clouds terminated in a spectacular and nearly straight line extending from northwest to southeast.
June 24	1772	2014	2310	1) BRDF of cirriform clouds SW of Barrow. 2) Descent from cloud top to cloud "base" for cloud microstructure measurements. 3) Haze layer intercepted (possibly Barrow plume, or cloud top CN nucleation) on landing approach to Barrow.	A large high pressure center near the pole had moved to a position northwest of the SHEBA ship, while a trough of low pressure continued in the Alaska interior. This situation provided a light northeasterly flow at Barrow with very low stratus and fog present at takeoff. A northwest to southeast oriented band of multi-layered cirriform clouds 30-40 nm southwest of Barrow were the focus of flight. Underneath the cirriform clouds was a sprinkling of altocumulus and cumulus humilis clouds. The fog and stratus at the coast had dissipated in the vicinity of Barrow by the end of the flight.

TABLE 4. UW CONVAIR-580 FLIGHTS OVER THE SHEBA SHIP.

Date (1998)	UW Flight Number	Period Over Ship (UTC)	Clouds in Vicinity of Ship	Main Measurements from Convair-580
May 29	1756	2127-2254	Multiple cloud layers (cirrus and altocumulus). Low visibility and fog at surface.	1) In cloud layers. 2) BRDF above Ac (ER-2 above).
May 30	1757	2050-2230	Single layer of broken altocumulus	1) BRDF above Ac. 2) In altocumulus. 3) Radiation measurements above ground, L-shaped albedo array. 4) BRDF of surface centered on ship.
June 3	1760	2050-2240	Altcumulus	1) Radiation measurements above cloud top. 2) BRDF above cloud top. 3) BRDF of surface over ship. 4) Radiation measurements above ground, L-shaped albedo array. 5) In-cloud measurements.
June 7	1763	2048-2238	Multiple cloud layers (stratus and cirrus).	1) In-cloud measurements. 2) BRDF of surface. 3) Radiation measurements above ground, L-shaped, albedo array.
June 13	1766	1933-2103	Multiple cloud layers (stratus and altocumulus)	1) BRDF of St layer. 2) Measurements in stratus. 3) Radiation measurements above ground, L-shaped albedo array. 4) BRDF of surface around ship. 5) Measurements in two altocumulus layers.
June 18	1768	2055-2220	Multiple cloud layers (altocumulus and cirrus).	1) BRDF over altocumulus. 2) In-cloud measurements. 3) Radiation measurements above ground, L-shaped albedo array.

(continued)

TABLE 4 (continued)

Date (1998)	UW Flight Number	Period Over Ship (UTC)	Clouds in Vicinity of Ship	Main Measurements from Convair-580
June 22	1770	1955-??	Multiple cloud layers (cirrus and altocumulus).	1) In-cloud. 2) BRDF of surface. 3) Radiation measurements above ground, L-shaped, albedo array.
June 23	1771	2332-2420	Clear	1) BRDF of surface with cloudless sky. 2) Radiation measurements above ground, L-shaped, albedo array.

TABLE 5. UW CONVAIR-580 FLIGHTS OVER THE ARM SITE AT BARROW.

Date (1998)	UW Flight Number	Period in Vicinity of ARM Site (UTC)	Main Measurements Over ARM Site	Clouds in Vicinity of ARM Site
May 19	1750	2130-2200	Measurements above, within and below stratus layer.	Stratus
May 20	1751	2000-2200	As on May 19, but with ER-2 overhead.	Broken stratus over ARM site. Continuous and thick stratus south of ARM site. Clear sky over Chukchi Sea.
May 27	1754	2420-2645	1) Measurements in upper cloud layer beneath ER-2. 2) Vertical profiles. 3) BRDF centered on ARM site with no cloud below and broken altocumulus above. 4) Level runs at 2,000 ft over ARM site.	Multiple cloud layers (altocumulus, cirrostratus).
May 28	1755	2230-2300	1) Vertical profile through deep cloud (PSU Raman lidar operating at ARM site). 2) Level runs at 500 ft in clear air. 3) Level runs at 1,500 ft, with CAR scanning downward.	Thick cloud layer to 15,000 ft.
June 1	1758	2013-2430	Level runs at 2,000 ft under clear sky.	Clear (10% cloud cover).
June 2	1759	2030-2219	1) Level runs above and below stratocumulus (ER-2 overhead). 2) BRDF above stratocumulus.	Multiple cloud layers (broken stratocumulus, stratus).
June 6	1762	1934-2315	1) BRDF over stratocumulus. 2) Flow cross-pattern above, in and below Sc centered on ARM site (ER-2 overhead).	Stratocumulus, stratus
June 7	1763	2420-2500	Aerosol measurements in haze layers.	Cloudless

(continued)

TABLE 5. (continued)

Date (1998)	UW Flight Number	Period in Vicinity of ARM Site (UTC)	Main Measurements Over ARM Site	Clouds in Vicinity of ARM Site
June 11	1765	1946-2034	1) Descent from 21,000 ft to 700 ft through five cloud layers. Intensive measurements in aerosol layer at ~11,000 ft. 2) Albedo measurements over ARM site in diffuse lighting.	Multiple cloud layers.
June 19	1769	2310-2440	1) Level runs above, in and below cirroform clouds. 2) Vertical profile over ARM site.	Cirroform, scruff of stratus.
June 22	1770	2240-2310	1) Climb to near cirroform tops (26,000 ft), followed by descent through patch cirroform clouds. 2) Measurements in deep haze layer from 15,000 to 2,100 ft. 3) Measurements in stratus.	Cirroform and stratus.

TABLE 6. PHOTOGRAPHS TAKEN FROM THE UW CONVAIR-580

(a) Peter V. Hobbs' Roll Number 1

University of Washington Flight Number	Date (1998)	Photograph Number	Time of Photograph (UTC)	Subject of Photograph
1750	May 19	4	2150	Cloud top
1750	May 19	5	2227	Cloud top
1750	May 19	6	2236	Broken ice surface
1750	May 19	7	2300	Sea ice and leads
1750	May 19	8	2303	Ice surface and leads for BRDF measurements
1751	May 20	9	2122	Cloud tops near ARM site
1751	May 20	10	2132	Cloud tops heading south
1751	May 20	11	2209	Sea ice for BRDF measurements
1751	May 20	12	2210	Sea ice for BRDF measurements
1751	May 20	13	2212	Sea ice for BRDF measurements
1751	May 20	14	2214	Broken ice for BRDF measurements
1751	May 20	15	2218	Sea ice for BRDF measurements
1751	May 20	16	2235	Broken cloud over ARM
1751	May 20	17	2333	Cloud top over ARM site
1751	May 20	18	2344	Barrow from air
1751	May 20	19	2344	Barrow and sea ice offshore
1752	May 21	20	2103	Ice for BRDF measurements
1752	May 21	21	2118	Ice surface for BRDF measurements
1753	May 23	22	1941	Altocumulus tops
1753	May 23	23	2005	Between cloud layers
1753	May 23	24	2021	Between cloud layers

(b) Peter V. Hobbs' Roll Number 2

University of Washington Flight Number	Date (1998)	Photograph Number	Time of Photograph (UTC)	Subject of Photograph
	May 25	1-7		Barrow from ground
1754	May 27	8	2358	Between altocumulus BRDF on lower layer
1754	May 28	9	0149	Altocumulus layer above

(continued)

(b) Peter V. Hobbs' Roll Number 2 (continued)

University of Washington Flight Number	Date (1998)	Photograph Number	Time of Photograph (UTC)	Subject of Photograph
1754	May 28	10	0158	(?)
1754	May 28	11	0200	(?)
1754	May 28	12	0202	Barrow
1754	May 28	13	0207	ARM site
1754	May 28	14	0235	Sea ice off Barrow
1754	May 28	15	0236	Broken sea ice
1754	May 28	16	0247	Snow to south of ARM
1756	May 30	17	0019	Cloud for BRDF measurements
1756	May 30	18	0026	Stratus circling above
1756	May 30	19	0034	Glory
1757	May 30	20	2058	Altocumulus for BRDF
1757	May 30	21	2059	Altocumulus for BRDF
1757	May 30	22	2137	Cloud below (glory?)
1757	May 30	23	2150	SHEBA ship
1757	May 30	24	2155	SHEBA ship

(c) Peter V. Hobbs' Roll Number 3

University of Washington Flight Number	Date (1998)	Photograph Number	Time of Photograph (UTC)	Subject of Photograph
1757	May 30	1	2200	Ice below aircraft
1757	May 30	2	2200	Ice below aircraft
1757	May 30	3	2201	Ice below aircraft
1757	May 30	4	2201	Ice below aircraft
1757	May 30	5	2201	Ice below aircraft
1757	May 30	6	2201	Ice below aircraft
1757	May 30	7	2201	Ice below aircraft
1757	May 30	8	2201	Ice below aircraft
1757	May 30	9	2201	Ice below aircraft
1757	May 30	10	2210	SHEBA ship and surroundings
1757	May 30	11	2211	Good shot of ship and surroundings

(continued)

(c) Peter V. Hobbs' Roll Number 3 (continued)

University of Washington Flight Number	Date (1998)	Photograph Number	Time of Photograph (UTC)	Subject of Photograph
1757	May 30	12	2212	L-shaped region for albedo measurements
1757	May 30	13	2214	SHEBA ship and camp
1757	May 30	14	2214	Leads near ship
1758	June 1	15	2020	Looking down on ARM
1758	June 1	16	2020	Looking down at ARM site
1758	June 1	17	2022	Right over ARM site
1758	June 1	18	2027	Looking down near ARM
1758	June 1	19	2027	Looking down near ARM
1758	June 1	20	2032	Looking down at ARM—last track through
1758	June 1	21	2040	View of ARM—tower at center
1758	June 1	22	2041	ARM site with tower
1758	June 1	23	2113	Good shot of ARM from side
1758	June 1	24	2252	Top of cirrus for straight runs

(d) Peter V. Hobbs' Roll Number 4

University of Washington Flight Number	Date (1998)	Photograph Number	Time of Photograph (UTC)	Subject of Photograph
1758	June 2	1	0112	Nice photo of cirrus sampled on Flt. 1758 on June 1
1759	June 2	2	2048	Altocumulus flying above
1759	June 2	3	2054	Nice shot of broken cloud flying over
1759	June 2	4	2102	Edge of altocumulus
1759	June 2	5	2107	Tundra and snow patches
1759	June 2	6	2114	Base of altocumulus
1759	June 2	7	2127	Sea ice below aircraft
1759	June 2	8	2159	Tops of altocumulus for BRDF measurements
1759	June 2	9	2244	Tops of stratocumulus for ice precipitation studies
1760	June 3	10	1948	Altocumulus for CAR
1760	June 3	11	1950	Subject (?)
1760	June 3	12	2101	Altocumulus for radiation measurements

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(d) Peter V. Hobbs' Roll Number 4 (continued)

University of Washington Flight Number	Date (1998)	Photograph Number	Time of Photograph (UTC)	Subject of Photograph
1760	June 3	13	2114	Altocumulus for CAR
1760	June 3	14	2127	Between altocumulus and stratocumulus layers
1760	June 3	15	2132	Cloud layers descending through
1760	June 3	16	2141	Multicloud layers
1760	June 3	17	2142	Surface (Poor photo)
1760	June 3	18	2143	Surface
1760	June 3	19	2143	Surface
1760	June 3	20	2149	Leads
1760	June 3	21	2153	Broken ice and water
1760	June 3	22	2214	General cloud scene
1760	June 3	23	Time ?	Above clouds

(e) Peter V. Hobbs' Roll Number 5

University of Washington Flight Number	Date (1998)	Photograph Number	Time of Photograph (UTC)	Subject of Photograph
1761	June 5	1	2303	Stratus for radiation
1761	June 5	2	2332	Stratus
1761	June 6	3	0026	"Amorphous" cloud, featureless
1761	June 6	4	0036	Clouds for BRDF measurements
1761	June 6	5	0054	Ice surface below
1762	June 6	6	1953	Clouds for BRDF measurements
1762	June 6	7	2009	Uniform stratocumulus
1762	June 6	8	2101	Sea ice
1762	June 6	9	2103	Sea ice and patchy stratus (?)
1762	June 6	10	2137	Edge of cloud/sea ice
1762	June 6	11	2138	Cloud edge/sea ice
1762	June 6	12	2139	Hole and cloud in background
1762	June 6	13	2140	Land/shoreline/ice
1762	June 6	14	2141	Other edge of hole and cloud
1762	June 6	15	2154	Ground beneath hole in cloud

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(e) Peter V. Hobbs' Roll Number 5

University of Washington Flight Number	Date (1998)	Photograph Number	Time of Photograph (UTC)	Subject of Photograph
1762	June 6	16	2219	Sea ice--green patches
1763	June 7	17	2049	Tops of altocumulus approaching SHEBA. Representative of clouds over SHEBA
1763	June 7	18	2053	Variable cloud tops
1763	June 7	19	2101	Between cloud layers
1763	June 7	20	2103	Uniform cloud and gap
1763	June 7	21	2114	SHEBA ship
1763	June 7	22	2122	Ship. Beginning of BRDF measurements
1763	June 7	23	2124	Area of BRDF measurements
1763	June 7	24	2126	Ship and tower at L apex

(f) Peter V. Hobbs' Roll Number 6

University of Washington Flight Number	Date (1998)	Photograph Number	Time of Photograph (UTC)	Subject of Photograph
1763	June 7	1	2129	SHEBA ship and albedo tower
1763	June 7	2	2130	SHEBA ship and tower
1763	June 7	3	2130	Main open water for BRDF measurements
1763	June 7	4	2135	SHEBA ship
1763	June 7	5	2136	Frozen surfaces for BRDF measurements
1763	June 7	6	2226	Top of cloud and cloud above
1763	June 7	7	2232	Cirrus cloud sampled
1763	June 7	8	2244	Inside cabin--photo too dark
1763	June 7	9	2248	Inside cabin--photo too dark
1763	June 7	10	2248	Inside cabin--photo too dark
1763	June 7	11	2249	Inside cabin--photo too dark
1763	June 7	12	2249	Inside cabin
1763	June 7	13	2249	Inside cabin--photo too dark
1763	June 7	14	2249	Inside cabin--photo too dark
1763	June 7	15	2253	Inside cabin--photo too dark
1763	June 8	16	0015	Near ARM site. Frozen areas are lakes. Tundra largely exposed

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(f) Peter V. Hobbs' Roll Number 6 (continued)

University of Washington Flight Number	Date (1998)	Photograph Number	Time of Photograph (UTC)	Subject of Photograph
1763	June 8	17	0016	Frozen lagoon near ARM site
	June 8	18	0336	Photo of Barrow coastline from ground
	June 8	19	0336	Photo from ground. Chukchi Sea and ice along shoreline
	June 8	20	0337	Photo from ground. Nice shot of ice along shoreline, Barrow
	June 8	21	0337	Photo from ground. Broken ice along Barrow shoreline
	June 8	22	0340	Photo from ground. Whale jaw bone at Barrow Community College
	June 8	23	0350	Downtown Barrow
1765	June 11	24	1934	Altocumulus over ARM site

(g) Peter V. Hobbs' Roll Number 7

University of Washington Flight Number	Date (1998)	Photograph Number	Time of Photograph (UTC)	Subject of Photograph
1765	June 11	1	2021	Barrow Community College and general area of ARM site
1765	June 11	2	2028	Ice surface with albedo 0.62
1765	June 11	3	2032	ARM site
1766	June 13	4	1814	Looking to rear
1766	June 13	5	1816	Interior of aircraft (dark photo)
1766	June 13	6	18??	Interior of aircraft
1766	June 13	7	18??	Interior of aircraft
1766	June 13	8	1855	View backwards from dome
1766	June 13	9	1855	View forward from dome
1766	June 13	10	1855	Looking back from dome
1766	June 13	11	1855	CAR personnel (photo dark)
1766	June 13	12	1932	Subject--?
1766	June 13	13	1933	Shadow of upper cloud on lower cloud
1766	June 13	14	1937	Cloud for BRDF measurements
1766	June 13	15	1952	Cloud for BRDF measurements

(continued)

(g) Peter V. Hobbs' Roll Number 7 (continued)

University of Washington Flight Number	Date (1998)	Photograph Number	Time of Photograph (UTC)	Subject of Photograph
1766	June 13	16	2013	Surface and clouds for absorption measurements
1766	June 13	17	2043	
1766	June 13	18	2045	
1766	June 13	19	2046	Photos black
1766	June 13	20	2046	
1766	June 13	21	2047	
	June 13	22	2303	On ground--Bob Eatwell
	June 13	23	—	On ground--Tim Garrett
	June 13	24	—	On ground--Jack Russell

(h) Peter V. Hobbs' Roll Number 8

University of Washington Flight Number	Date (1998)	Photograph Number	Time of Photograph (UTC)	Subject of Photograph
1767	June 14	1	2020	Clouds
1767	June 14	2	2043	Clouds
1767	June 14	3	2054	Cloud base at bag sample point B
1767	June 14	4	2054	Cloud base at bag sample point B
1767	June 14	5	2054	Cloud base at bag sample point B
1767	June 14	6	2117	Cloud top where bag sample taken
1767	June 14	7	2117	Cloud top below bag sample site
1767	June 14	8	2142	Stratus with overlying cirrus
1767	June 14	9	2142	Stratus and overlying cirrus
1768	June 18	10	2040	Cloud below
1768	June 18	11	2056	Clouds
1768	June 18	12	2105	Clouds
1768	June 18	13	2131	Cloudscape at 19,500 ft
1768	June 18	14	2131	Cloudscape at 19,500 ft
1768	June 18	15	2146	Clouds
1768	June 18	16	2307	Fallstreaks
1768	June 18	17	2308	Fallstreaks

(continued)

(h) Peter V. Hobbs' Roll Number 8

University of Washington Flight Number	Date (1998)	Photograph Number	Time of Photograph (UTC)	Subject of Photograph
1769	June 19	18	2117	Cirrus above
1769	June 19	19	2124	Halo around sun
1769	June 19	20	2140	Thin cirrus in or below aircraft
1769	June 19	21	2218	Center of BRDF circles
1769	June 19	22	2231	BRDF circles off right wing
1769	June 19	23	2250	Cloud edge
1769	June 19	24	2306	Ground below

(i) Peter V. Hobbs' Roll Number 9

University of Washington Flight Number	Date (1998)	Photograph Number	Time of Photograph (UTC)	Subject of Photograph
1770	June 22	1	1930	Nice photo of K-H waves
1770	June 22	2	1931	Nice photo of K-H waves
1770	June 22	3	1957	View off right wing and beginning of descent
1770	June 22	4	2005	View of surface near SHEBA for BRDF measurements
1770	June 22	5	2006	View of surface near SHEBA for BRDF measurements
1770	June 22	6	2007	Good for BRDF and clouds above
1770	June 22	7	2009	Good shot of SHEBA ship and ice for BRDF
1770	June 22	8	2012	Good shot of SHEBA ship and ground for BRDF
1770	June 22	9	2016	Cirrus clouds
1770	June 22	10	2045	Very nice shot of SHEBA ship and ice
1771	June 23	11	2151	Cloud streets in stratus below
1771	June 23	12	2151	Streets in stratus below
1771	June 23	13	2212	Haze layer
1771	June 23	14	2337	Ice below, clear sky
1771	June 23	15	2338	Ice below
1771	June 24	16	0140	Brown sea ice closest to Barrow
1771	June 24	17	0140	Brown sea ice??
1772	June 24	18	2106	Clouds off left wing

(continued)

(i) Peter V. Hobbs' Roll Number 9 (continued)

University of Washington Flight Number	Date (1998)	Photograph Number	Time of Photograph (UTC)	Subject of Photograph
1772	June 24	19	2112	Looking down on cirrostratus
1772	June 24	20	2137	Cloud below
1772	June 24	21	2255	Brown ice off left wing
1772	June 24	22	2257	Brown sea ice
1772	June 24	23	Time ?	Brown sea ice
1772	June 25	24	1849	Cabin--dark

(j) Art Rangno's Roll Number 1

University of Washington Flight Number	Date (1998)	Photograph Number	Time of Photograph (UTC)	Subject of Photograph
1751	May 20	3	~2252-2255	Stratus fractus near lead offshore of Barrow
1751	May 20	4	~2252-2255	Stratus fractus near lead offshore of Barrow
1751	May 20	5	2325-2327	Stratus fractus over lead offshore of Barrow
1751	May 20	6	2325-2327	Stratus fractus over lead offshore of Barrow
1751	May 20	7	2325-2327	Stratus overcast over lead offshore of Barrow

(k) Art Rangno's Roll Number 2

University of Washington Flight Number	Date (1998)	Photograph Number	Time of Photograph (UTC)	Subject of Photograph
1757	May 30	1	2140-2150	Heavily precipitating stratus clouds, higher altocumulus deck at SHEBA site
1757	May 30	2	2140-2150	Heavily precipitating stratus clouds, higher altocumulus deck at SHEBA site
1757	May 30	3	2220	Heavily precipitating stratus clouds in distance, few higher altocumulus clouds at SHEBA site

(continued)

(l) Art Rangno's Roll Number 3

University of Washington Flight Number	Date (1998)	Photograph Number	Time of Photograph (UTC)	Subject of Photograph
1760	June 3	7	2045	Narrow NW-SE rift in altocumulus deck
1760	June 3	8	2045	Narrow NW-SE rift in altocumulus deck

(m) Art Rangno's Roll Number 4

University of Washington Flight Number	Date (1998)	Photograph Number	Time of Photograph (UTC)	Subject of Photograph
1760	June 3	6	2045	Narrow NW-SE rift in altocumulus deck
1760	June 3	7	2045	Narrow NW-SE rift in altocumulus deck
1760	June 3	8	2045	Narrow NW-SE rift in altocumulus deck

(n) Art Rangno's Roll Number 5

University of Washington Flight Number	Date (1998)	Photograph Number	Time of Photograph (UTC)	Subject of Photograph
1762	June 6	11	2112	Near tops of stratus/stratocumulus deck; cirriform clouds in distance
1763	June 7	12	1913	View of ARM site and Barrow looking toward the west from offshore

(o) Art Rangno's Roll Number 6

University of Washington Flight Number	Date (1998)	Photograph Number	Time of Photograph (UTC)	Subject of Photograph
1763	June 8	1	0022	View of ARM site and Barrow
1764	June 9	4	2033	Stratus/stratocumulus boundary at mesoscale-sized clearing
1764	June 9	5	2033	Stratus/stratocumulus boundary at mesoscale-sized clearing
1764	June 9	6	2232	Heavily precipitating weak cumuliform cloud in distance looking west near Barrow
1764	June 9	7	2232	Heavily precipitating weak cumuliform cloud in distance looking west near Barrow

(continued)

(o) Art Rangno's Roll Number 6 (continued)

University of Washington Flight Number	Date (1998)	Photograph Number	Time of Photograph (UTC)	Subject of Photograph
1764	June 9	8	2232	Heavily precipitating weak cumuliform cloud in distance looking west near Barrow
1764	June 9	9	2238	East-west row of cumulus humilis just onshore near Barrow
1764	June 9	10	2239-2240	Three-part panorama of heavily precipitating stratocumulus clouds just offshore Barrow
1764	June 9	11	2239-2240	Three-part panorama of heavily precipitating stratocumulus clouds just offshore Barrow
1764	June 9	12	2239-2240	Three-part panorama of heavily precipitating stratocumulus clouds just offshore Barrow

(p) Art Rangno's Roll Number 7

University of Washington Flight Number	Date (1998)	Photograph Number	Time of Photograph (UTC)	Subject of Photograph
1766	June 13	8	1931-1932	East edge of altocumulus deck that was over the SHEBA ship casting shadow on lower stratus
1766	June 13	10	1933-1940	East edge of altocumulus deck in distance that was over the SHEBA ship casting shadow on lower stratus
1766	June 13	11	1933-1940	East edge of altocumulus deck in distance that was over the SHEBA ship casting shadow on lower stratus

(q) Art Rangno's Roll Number 8

University of Washington Flight Number	Date (1998)	Photograph Number	Time of Photograph (UTC)	Subject of Photograph
1768	June 18	1	2300-2330	Cirriform clouds en route to Barrow from SHEBA ship
1768	June 18	2	2300-2330	Cirriform clouds en route to Barrow from SHEBA ship
1768	June 18	3	2300-2330	Cirriform clouds en route to Barrow from SHEBA ship

(continued)

(q) Art Rangno's Roll Number 8 (continued)

University of Washington Flight Number	Date (1998)	Photograph Number	Time of Photograph (UTC)	Subject of Photograph
1768	June 18	4	2300-2330	Cirriform clouds en route to Barrow from SHEBA ship
1768	June 18	5	2300-2330	Cirriform clouds en route to Barrow from SHEBA ship
1768	June 18	6	2300-2330	Cirriform clouds en route to Barrow from SHEBA ship
1768	June 18	7	2300-2330	Cirriform clouds en route to Barrow from SHEBA ship
1768	June 18	8	2300-2330	Cirriform clouds en route to Barrow from SHEBA ship
1768	June 18	9	2300-2330	Cirriform clouds en route to Barrow from SHEBA ship

(r) Art Rangno's Roll Number 9

University of Washington Flight Number	Date (1998)	Photograph Number	Time of Photograph (UTC)	Subject of Photograph
1768	June 18	5	1915-1918	Semi-transparent stratus deck near surface
1768	June 18	6	2054-2055	Multilayered altocumulus and cirriform clouds near SHEBA
1768	June 18	7	2302-2309	Cirriform streak cloud above amorphous cirriform cloud
1768	June 18	8	2302-2309	Cirrus uncinus streaks in distance apparently descending into amorphous cirriform cloud below

(s) Art Rangno's Roll Number 10

University of Washington Flight Number	Date (1998)	Photograph Number	Time of Photograph (UTC)	Subject of Photograph
1768	June 18	1	2302-2309	Cirrus uncinus streaks at the top of amorphous cirriform cloud
1768	June 18	2	2302-2309	Cirrus uncinus streaks at the top of amorphous cirriform cloud

(continued)

(s) Art Rangno's Roll Number 10 (continued)

University of Washington Flight Number	Date (1998)	Photograph Number	Time of Photograph (UTC)	Subject of Photograph
1768	June 18	3	2302-2309	Cirrus uncinus streaks at the top of amorphous cirriform cloud
1768	June 18	4	2302-2309	Cirrus uncinus streaks at the top of amorphous cirriform cloud
1771	June 23	10	2147	Stratus undulatus offshore Barrow en route to SHEBA ship
1771	June 23	11	2256	Knife-edge north boundary of stratus en route to SHEBA ship
1771	June 23	12	2258	Knife-edge north boundary of stratus en route to SHEBA ship

(t) Art Rangno's Roll Number 11

University of Washington Flight Number	Date (1998)	Photograph Number	Time of Photograph (UTC)	Subject of Photograph
1771	June 23	1	2335-2340	Clear sky view of ice pack near SHEBA
1771	June 23	2	2335-2340	Clear sky view of ice pack near SHEBA
1771	June 23	3	2338-2345	Clear sky view of ice pack near SHEBA
1771	June 23	4	2410	Clear sky view of ice pack near SHEBA
1771	June 23	5	2410	Clear sky view of ice pack near SHEBA
1771	June 23	6	0120-0130	Stratus undulatus offshore of Barrow en route to Barrow from SHEBA ship
1771	June 23	7	0120-0130	Stratus undulatus offshore of Barrow en route to Barrow from SHEBA ship
1773	June 25	8	1844	Departing view of Barrow/north slope with cirriform and stratus/stratocumulus clouds in distance
1773	June 25	9	2036	Amorphous ice cloud from convection immersing altocumulus clouds
1773	June 25	10	2036	Amorphous ice cloud from convection immersing altocumulus clouds
1773	June 25	11	2110	Artificial cirriform cloud in rope-like semi-circle on approach to Anchorage

(continued)

(t) Art Rangno's Roll Number 11 (continued)

University of Washington Flight Number	Date (1998)	Photograph Number	Time of Photograph (UTC)	Subject of Photograph
1773	June 25	12	2110	Artificial cirriform cloud in rope-like semi-circle on approach to Anchorage

(u) Art Rangno's Roll Number 12

University of Washington Flight Number	Date (1998)	Photograph Number	Time of Photograph (UTC)	Subject of Photograph
1773	June 25	6	2000	Complex cirriform layering/interaction en route to Anchorage
1773	June 25	7	2005-2015	Various cirriform clouds en route to Anchorage
1773	June 25	8	2005-2015	Various cirriform clouds en route to Anchorage
1773	June 25	9	2005-2015	Various cirriform clouds en route to Anchorage
1773	June 25	10	2005-2015	Various cirriform clouds en route to Anchorage
1773	June 25	11	2005-2015	Various cirriform clouds en route to Anchorage
1773	June 25	12	2005-2015	Various cirriform clouds en route to Anchorage

(v) NASA Photographs

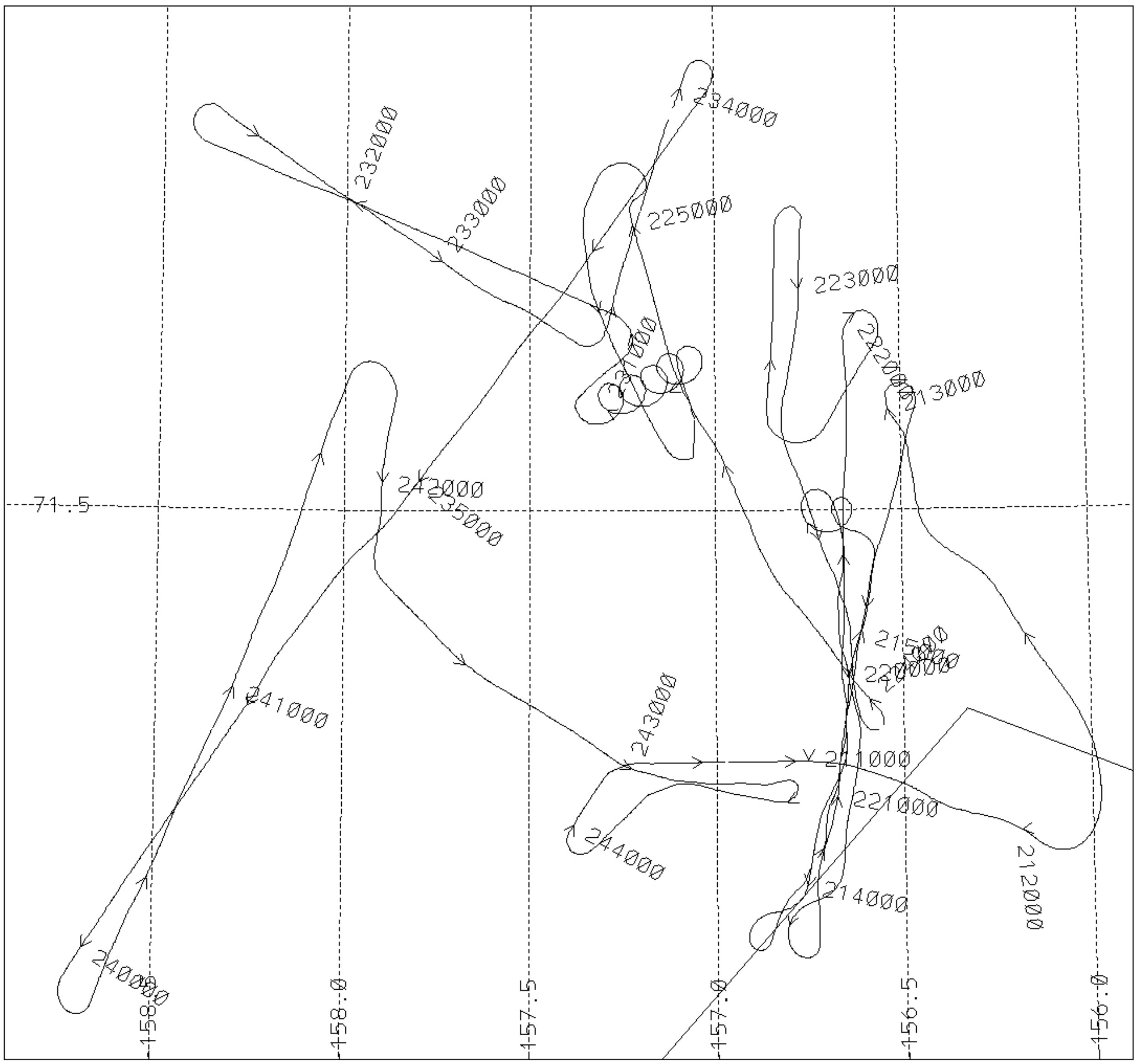
For photographs taken by NASA scientists aboard the UW Convair-580 (which related particularly to CAR measurements) download their report (PDF format) entitled "FIRE III Arctic Cloud Experiment: Field Mission Report" from their FTP site (server: macx.gsfc.nasa.gov; login: ftp; password: <your e-mail address>; directory: ftp/Public; file name: FIREIII.pdf).

4. CONVAIR-580 FLIGHTS AND FLIGHT TRACKS IN FIRE-ACE/SHEBA

Figures 1-23 show the aircraft flight paths for each of the Convair-580 flights. The times given in Figures 1-23 are Universal Time Coordinated (UTC*), the solid lines are the flight tracks, and the dotted lines show latitudes and longitudes. Note that in these figures the location of the Alaskan coastline is not exactly correct.

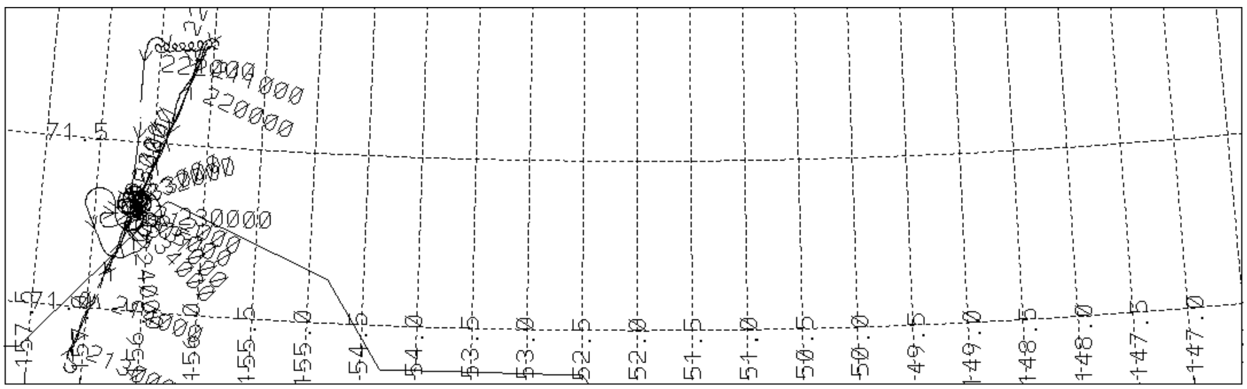
(Text continued on page 63.)

* UTC = Local Daylight Time + 8 hours



GPS track of flight 175Ø, 1998-Ø5-19 21:Ø9:26 - 24:48:23

Figure 1. Flight track for Convair-580 for FIRE-ACE/SHEBA on May 19, 1998.



GPS track of flight 1751, 1998-05-20 20:02:10 - 23:45:24

Figure 2. Flight track for Convair-580 for FIRE-ACE/SHEBA on May 20, 1998.

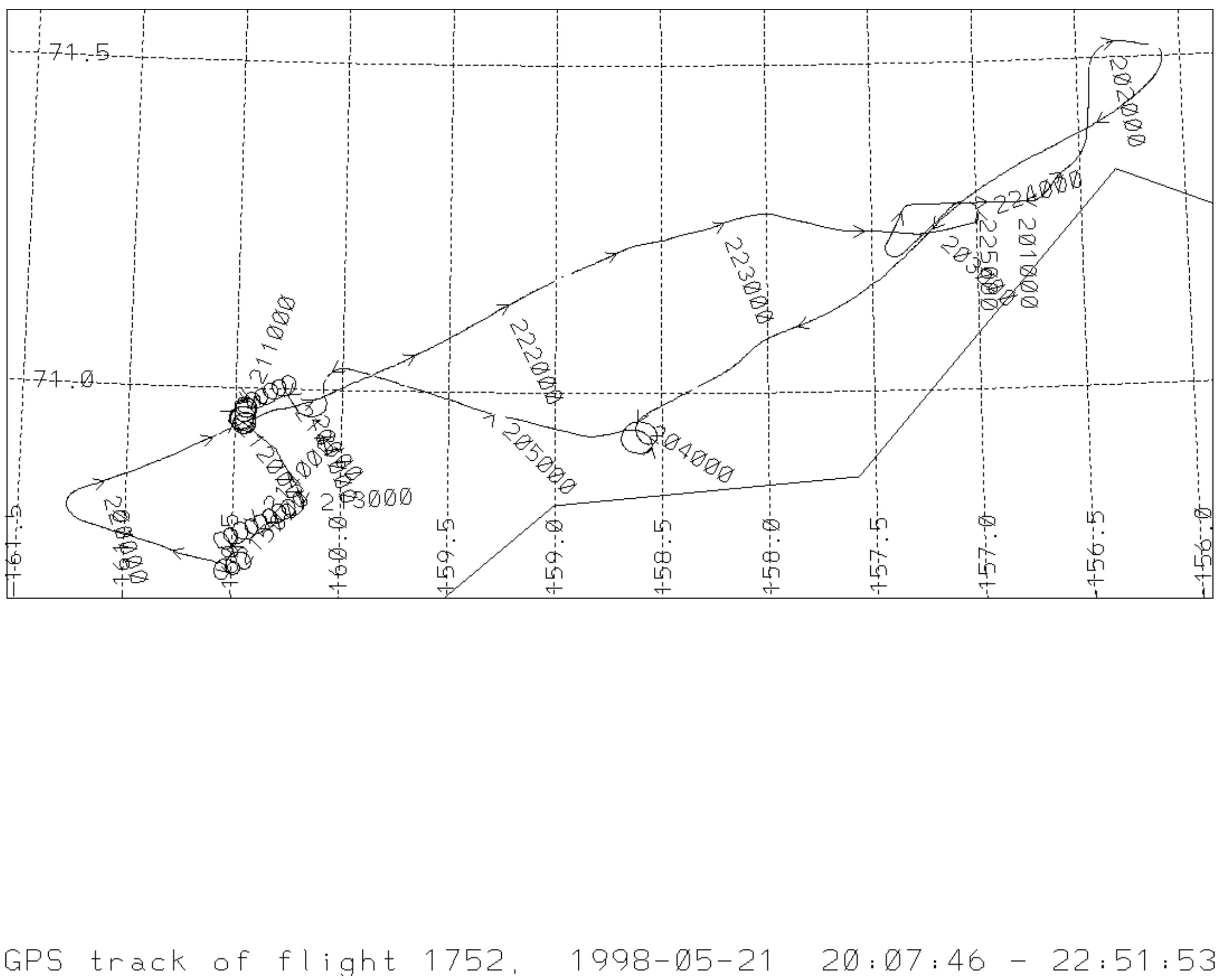
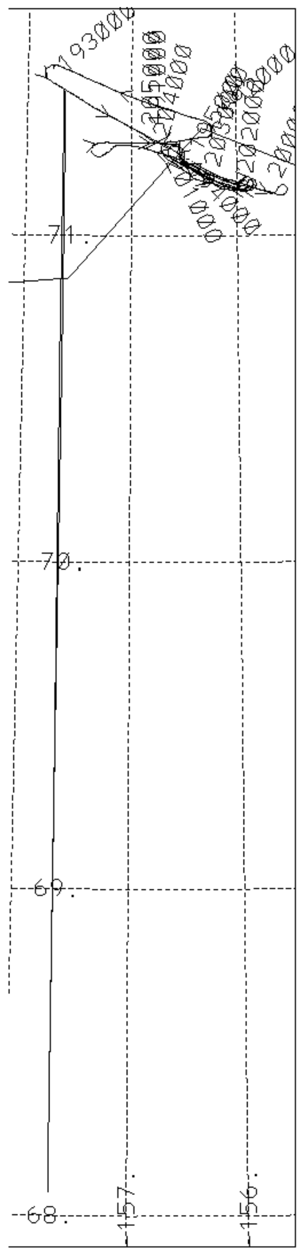


Figure 3. Flight track for Convair-580 for FIRE-ACE/SHEBA on May 21, 1998.



GPS track of flight 1753, 1998-05-23 19:07:44 - 20:50:20

Figure 4. Flight track for Convair-580 for FIRE-ACE/SHEBA on May 23, 1998.

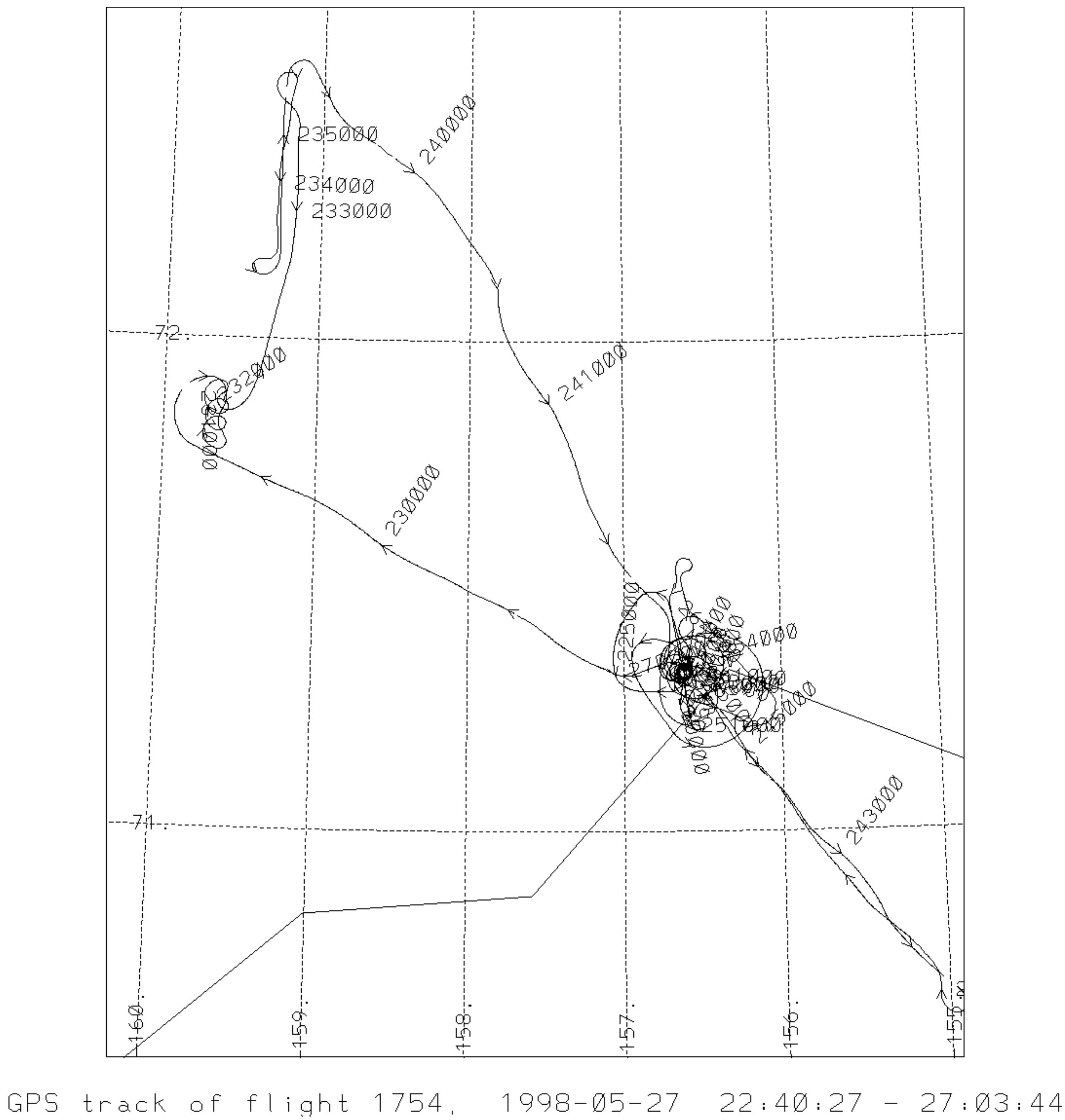


Figure 5. Flight track for Convair-580 for FIRE-ACE/SHEBA on May 27, 1998.

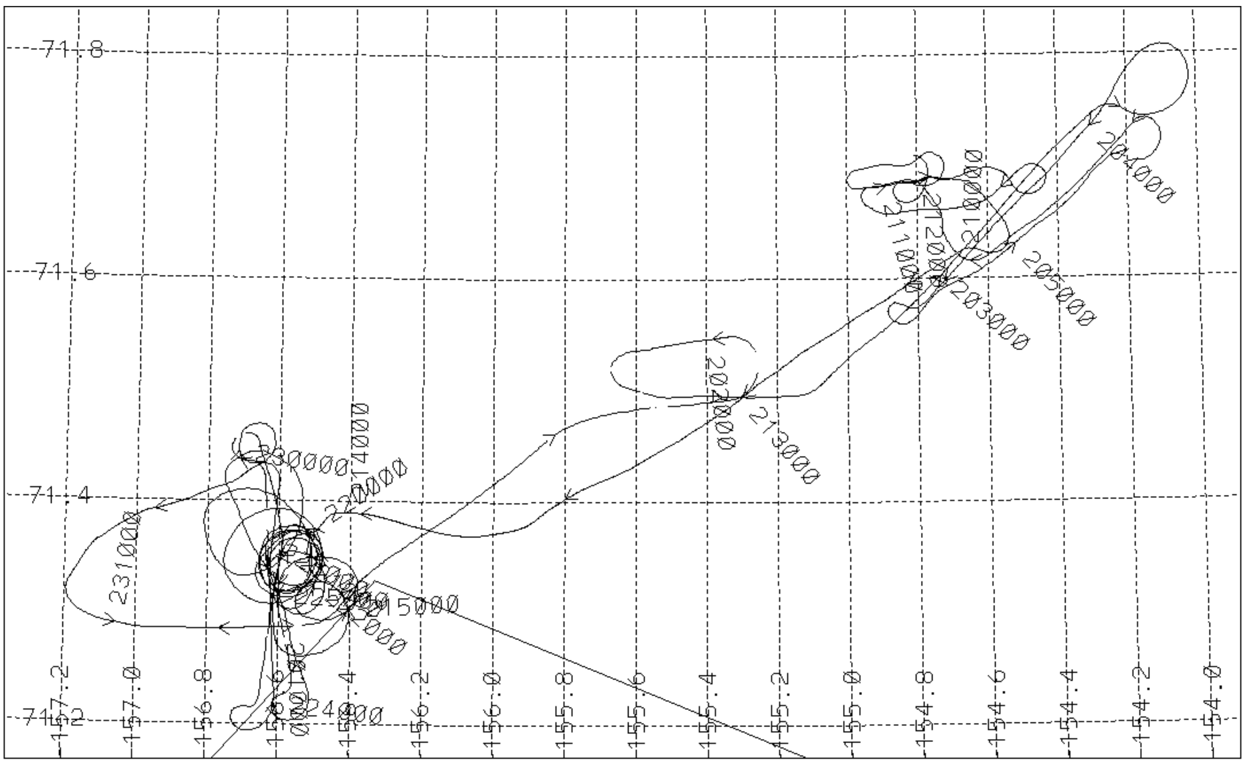
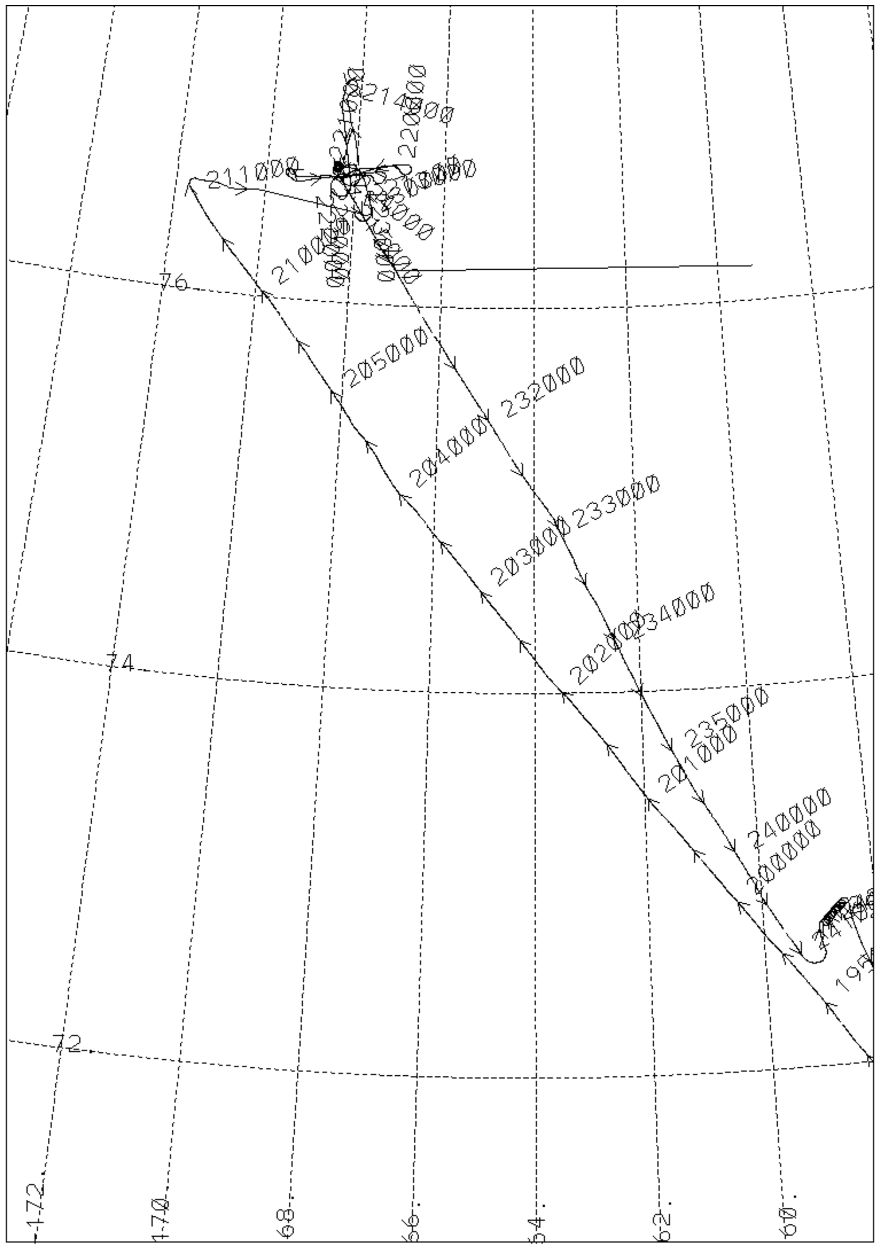


Figure 6. Flight track for Convair-580 for FIRE-ACE/SHEBA on May 28, 1998.



GPS track of flight 1756, 1998-05-29 19:22:24 - 25:18:26

Figure 7. Flight track for Convair-580 for FIRE-ACE/SHEBA on May 29, 1998.

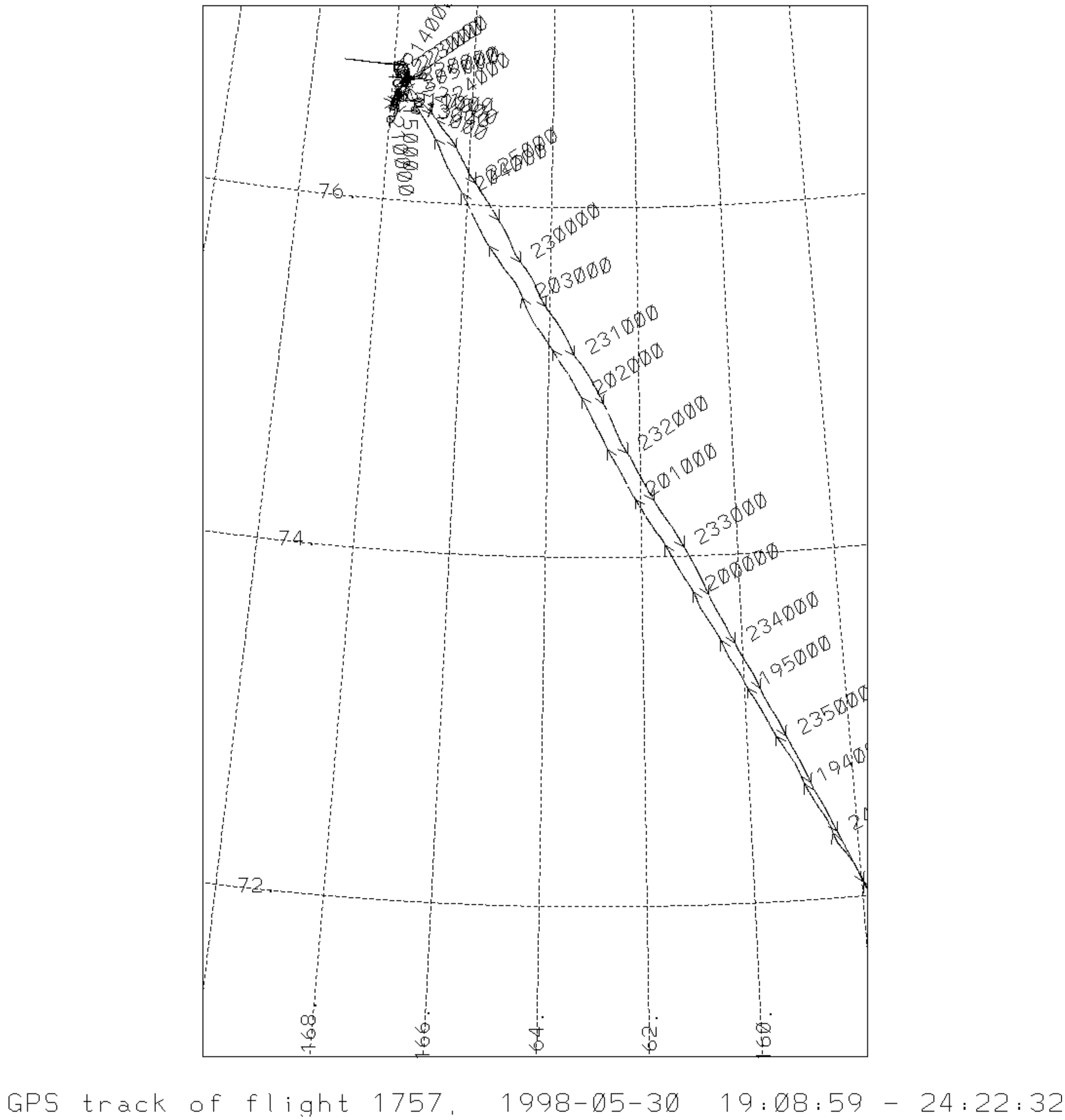


Figure 8. Flight track for Convair-580 for FIRE-ACE/SHEBA on May 30, 1998.

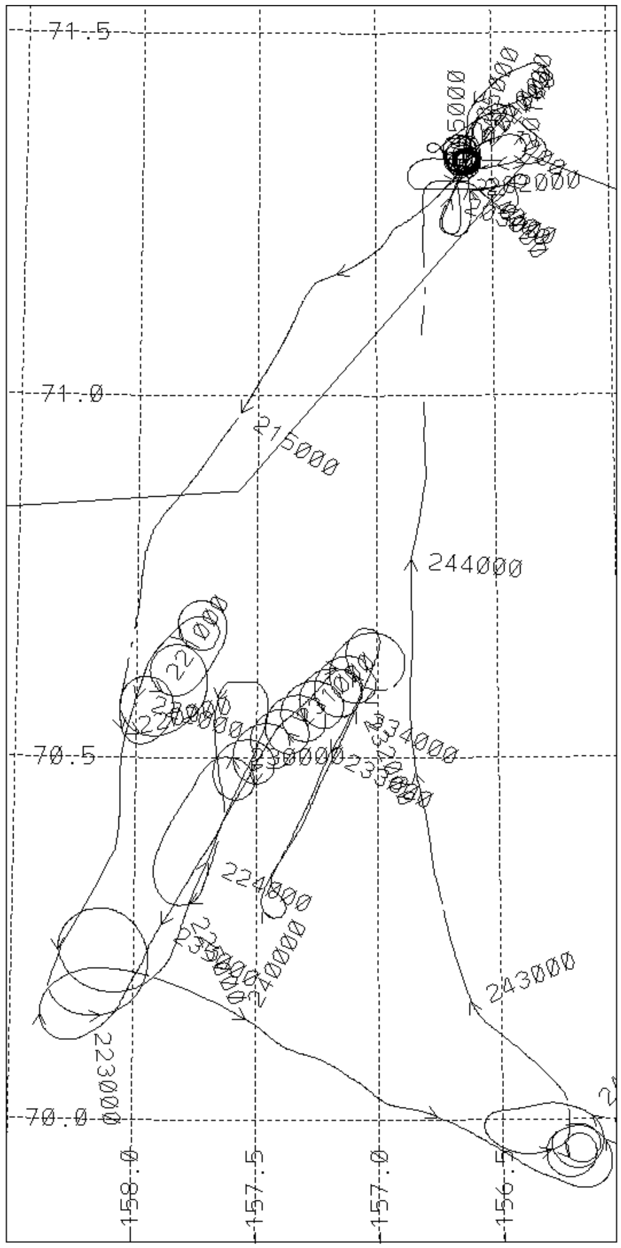


Figure 9. Flight track for Convair-580 for FIRE-ACE/SHEBA on June 1, 1998.

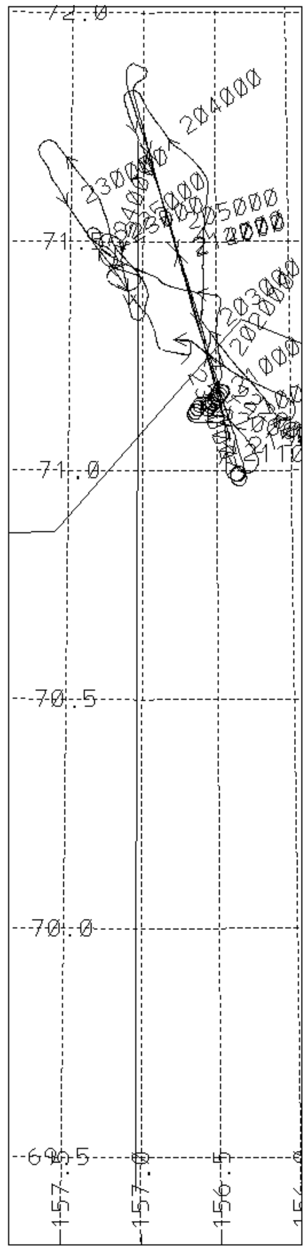
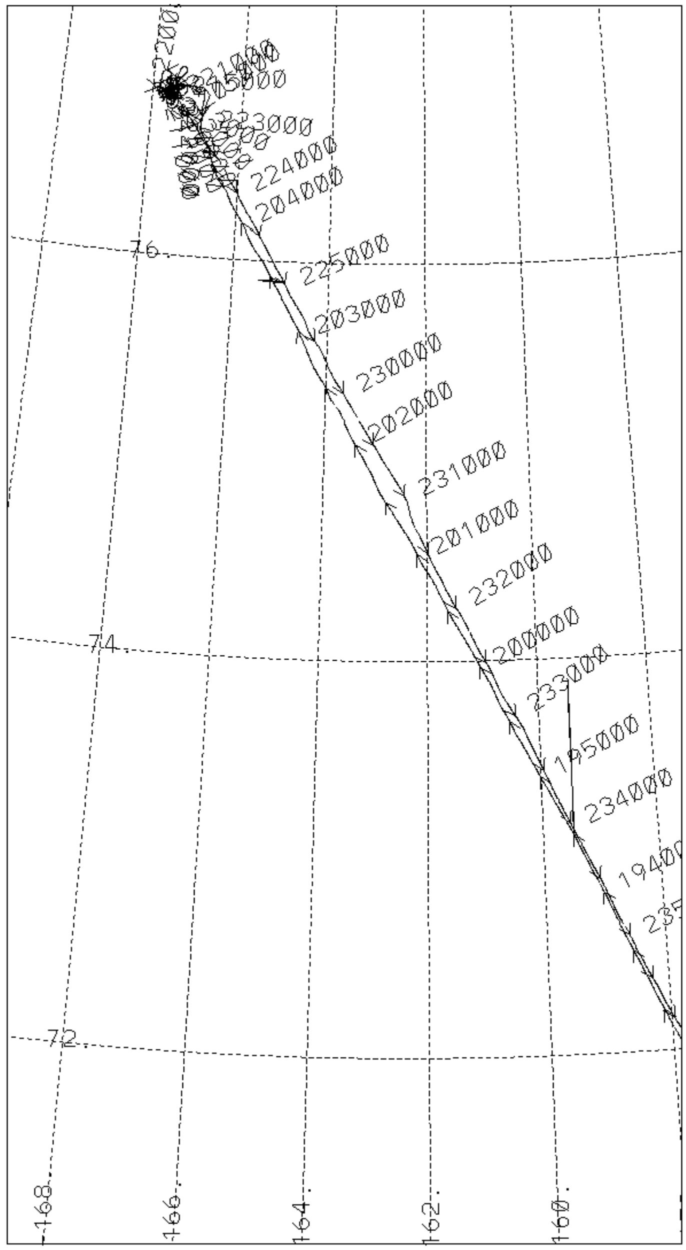
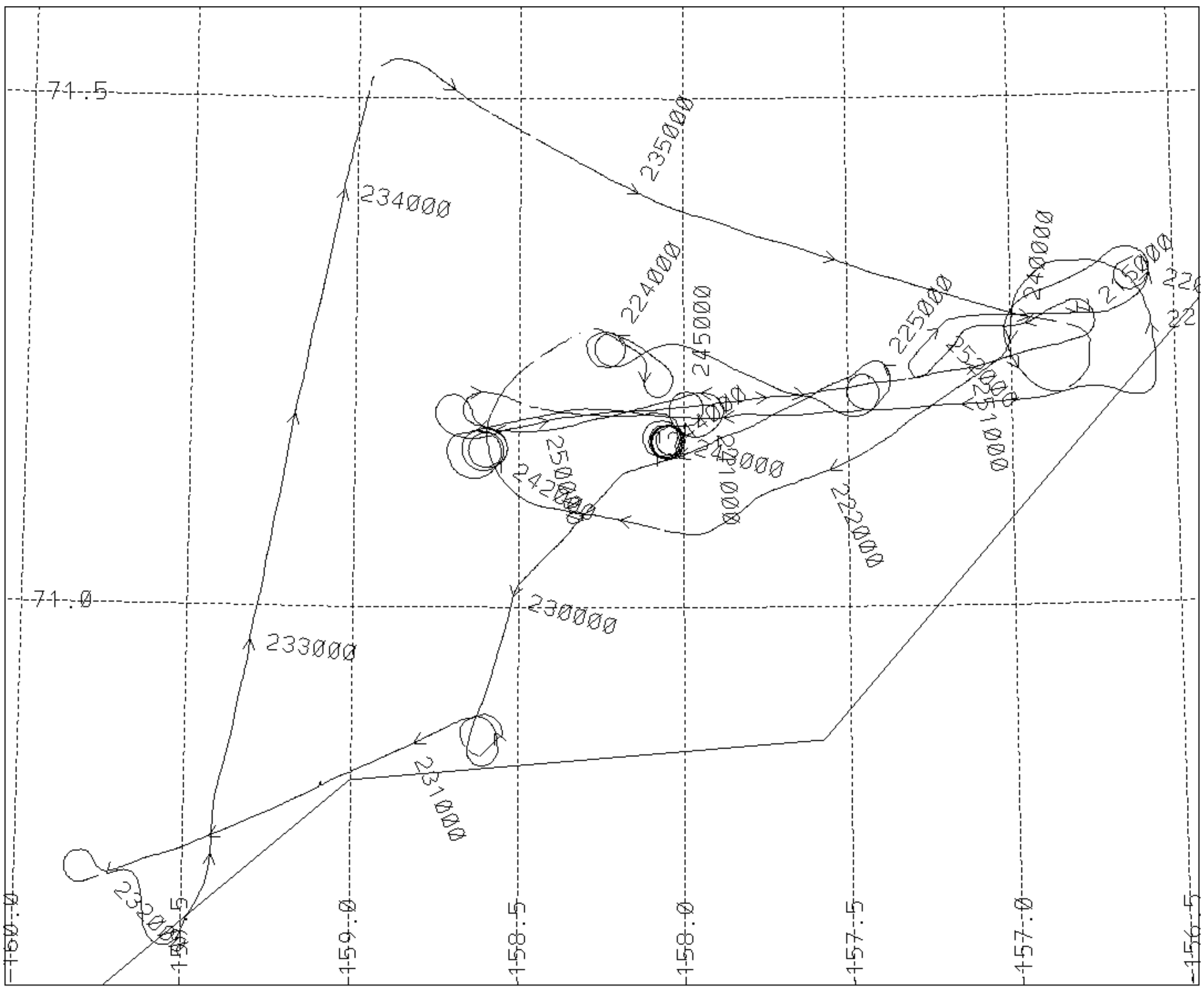


Figure 10. Flight track for Convair-580 for FIRE-ACE/SHEBA on June 2, 1998.



GPS track of flight 1760, 1998-06-03 19:08:23 - 24:35:52

Figure 11. Flight track for Convair-580 for FIRE-ACE/SHEBA on June 3, 1998.



GPS track of flight 1761, 1998-06-05 21:49:48 - 25:23:48

Figure 12. Flight track for Convair-580 for FIRE-ACE/SHEBA on June 5, 1998.

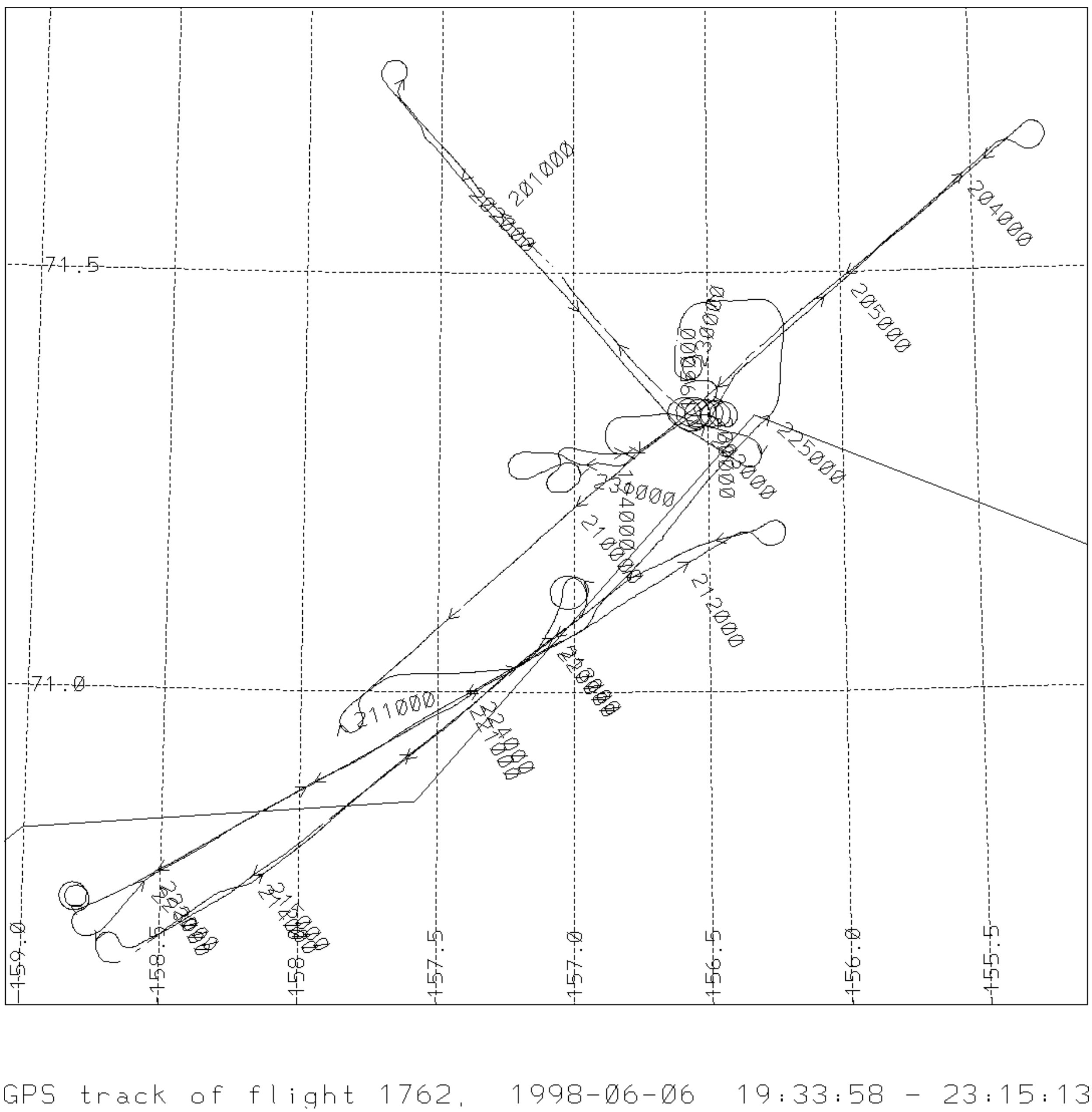


Figure 13. Flight track for Convair-580 for FIRE-ACE/SHEBA on June 6, 1998.

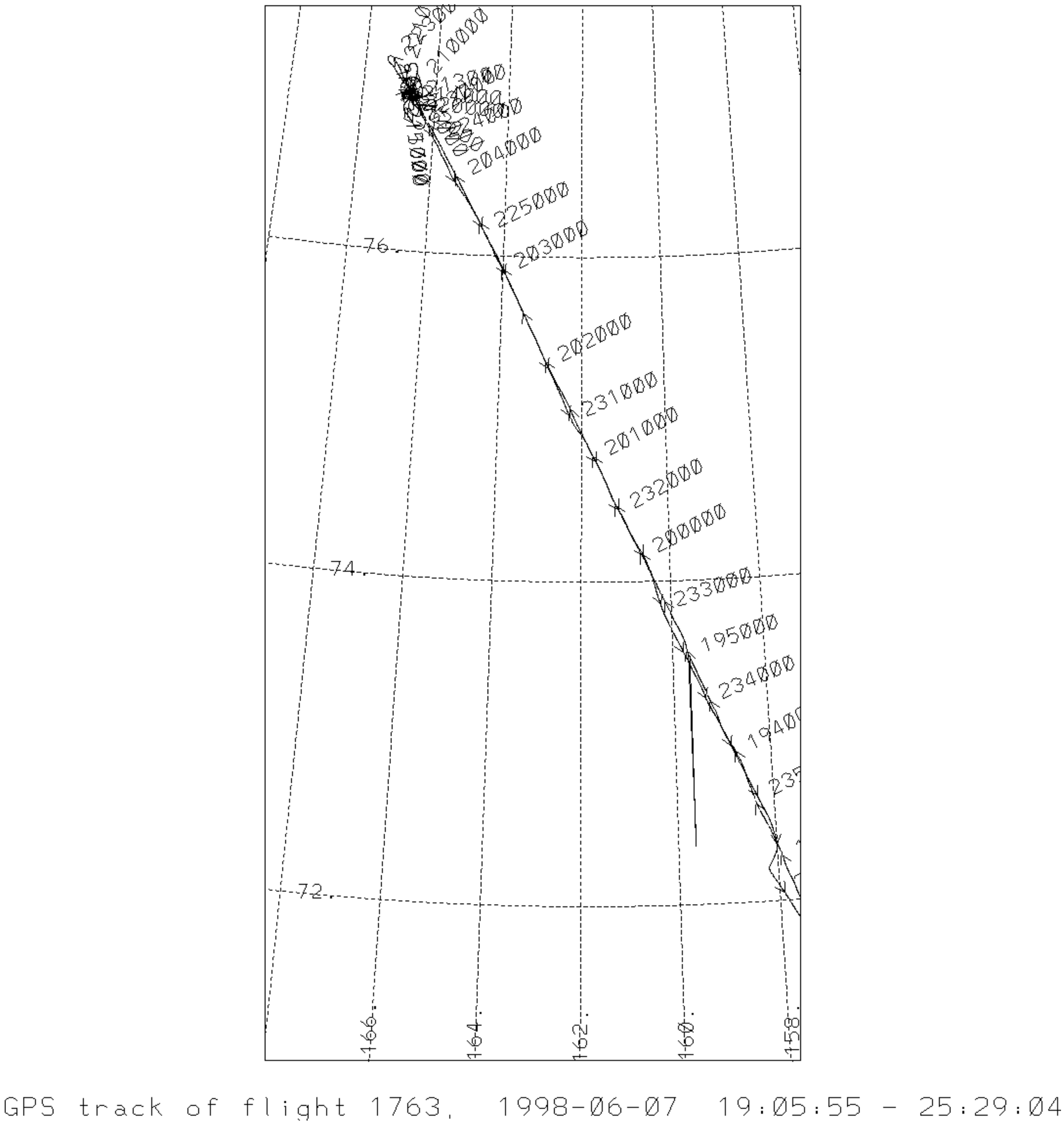
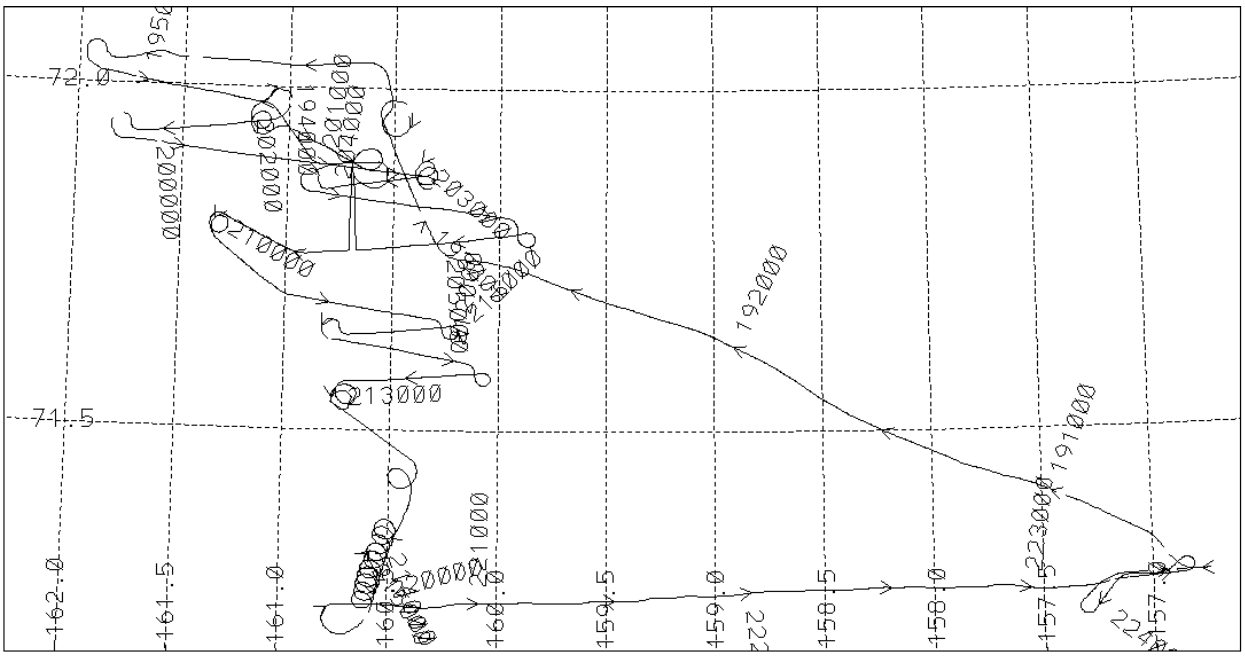
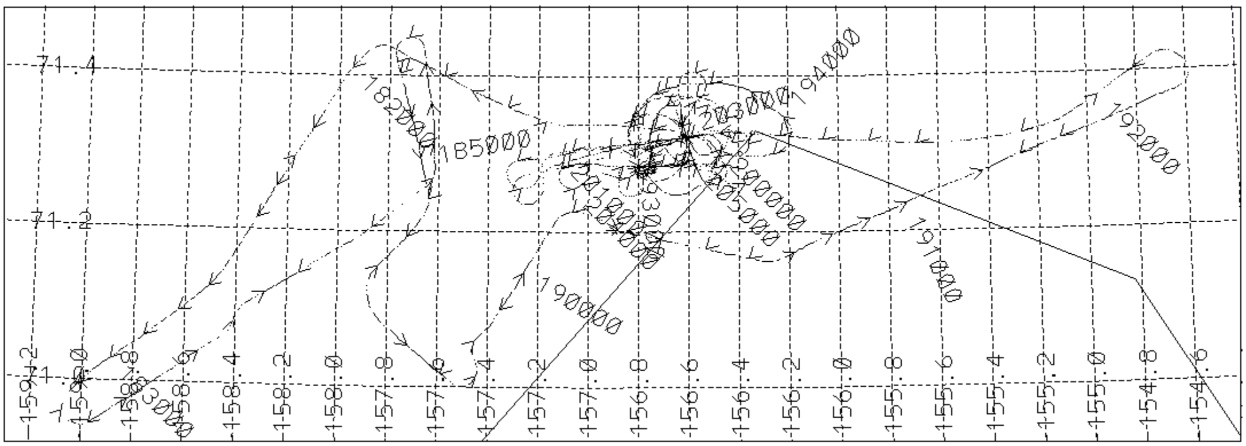


Figure 14. Flight track for Convair-580 for FIRE-ACE/SHEBA on June 7, 1998.



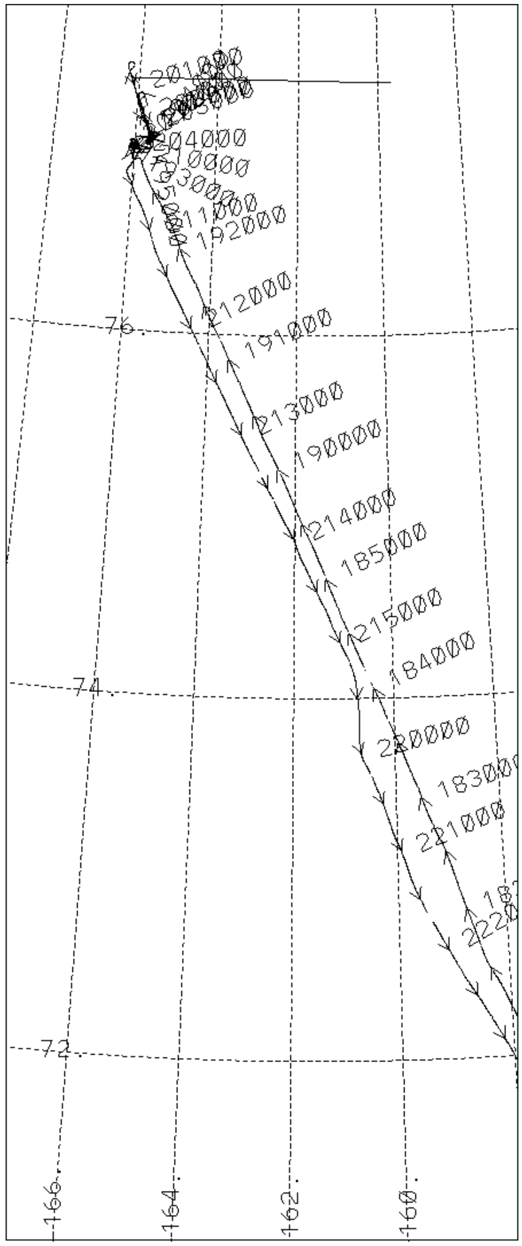
GPS track of flight 1764, 1998-06-09 19:00:46 - 22:46:19

Figure 15. Flight track for Convair-580 for FIRE-ACE/SHEBA on June 9, 1998.



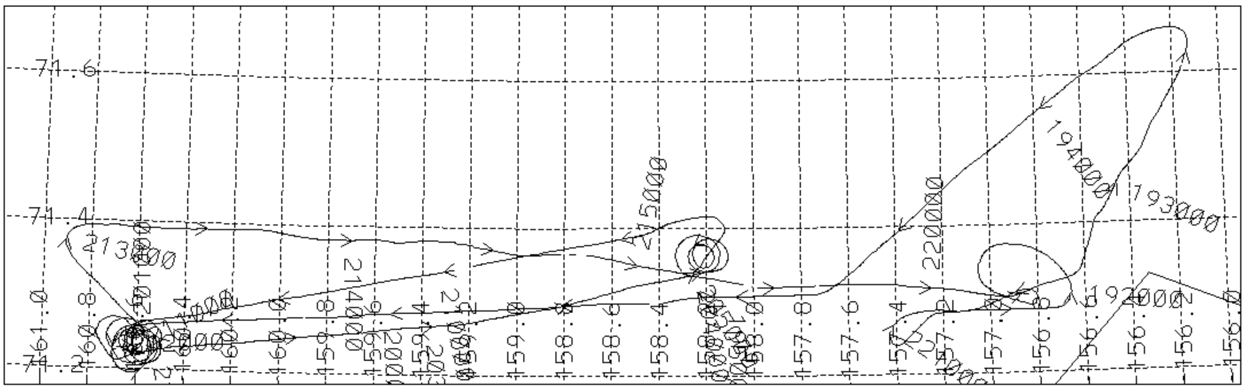
GPS track of flight 1765, 1998-06-11 18:02:17 - 20:58:55

Figure 16. Flight track for Convair-580 for FIRE-ACE/SHEBA on June 11, 1998.



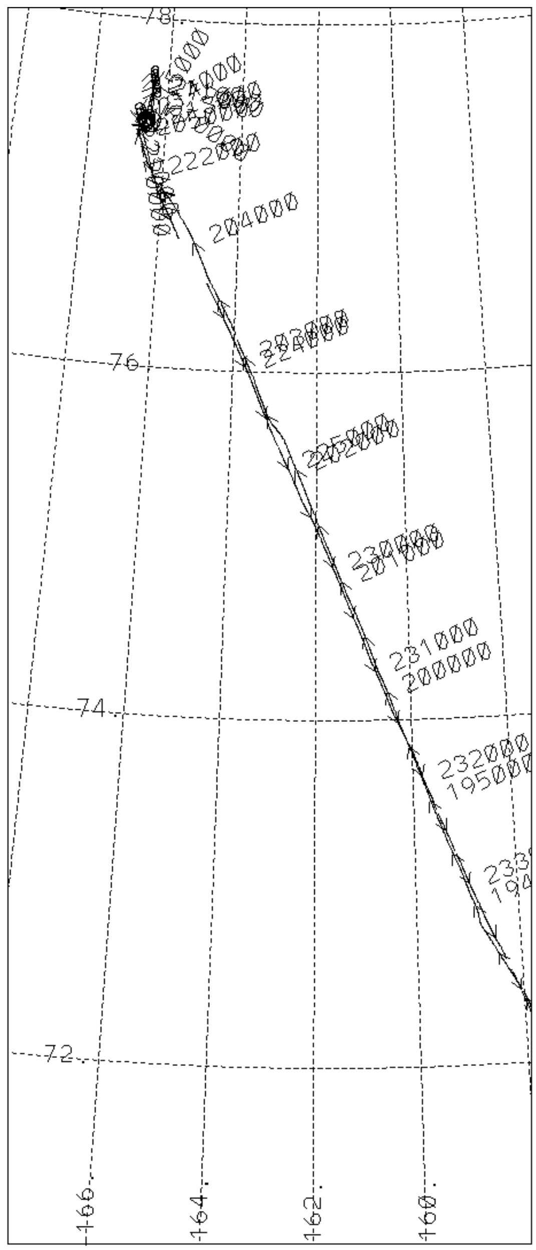
GPS track of flight 1766, 1998-06-13 17:48:10 - 22:55:44

Figure 17. Flight track for Convair-580 for FIRE-ACE/SHEBA on June 13, 1998.



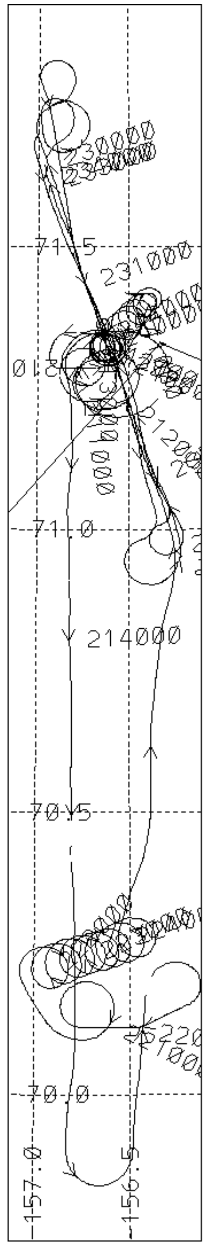
GPS track of flight 1767, 1998-06-14 19:15:38 - 22:16:30

Figure 18. Flight track for Convair-580 for FIRE-ACE/SHEBA on June 14, 1998.



GPS track of flight 1768, 1998-06-18 19:02:46 - 24:10:14

Figure 19. Flight track for Convair-580 for FIRE-ACE/SHEBA on June 18, 1998.



GPS track of flight 1769, 1998-06-19 20:54:01 - 24:48:16

Figure 20. Flight track for Convair-580 for FIRE-ACE/SHEBA on June 19, 1998.

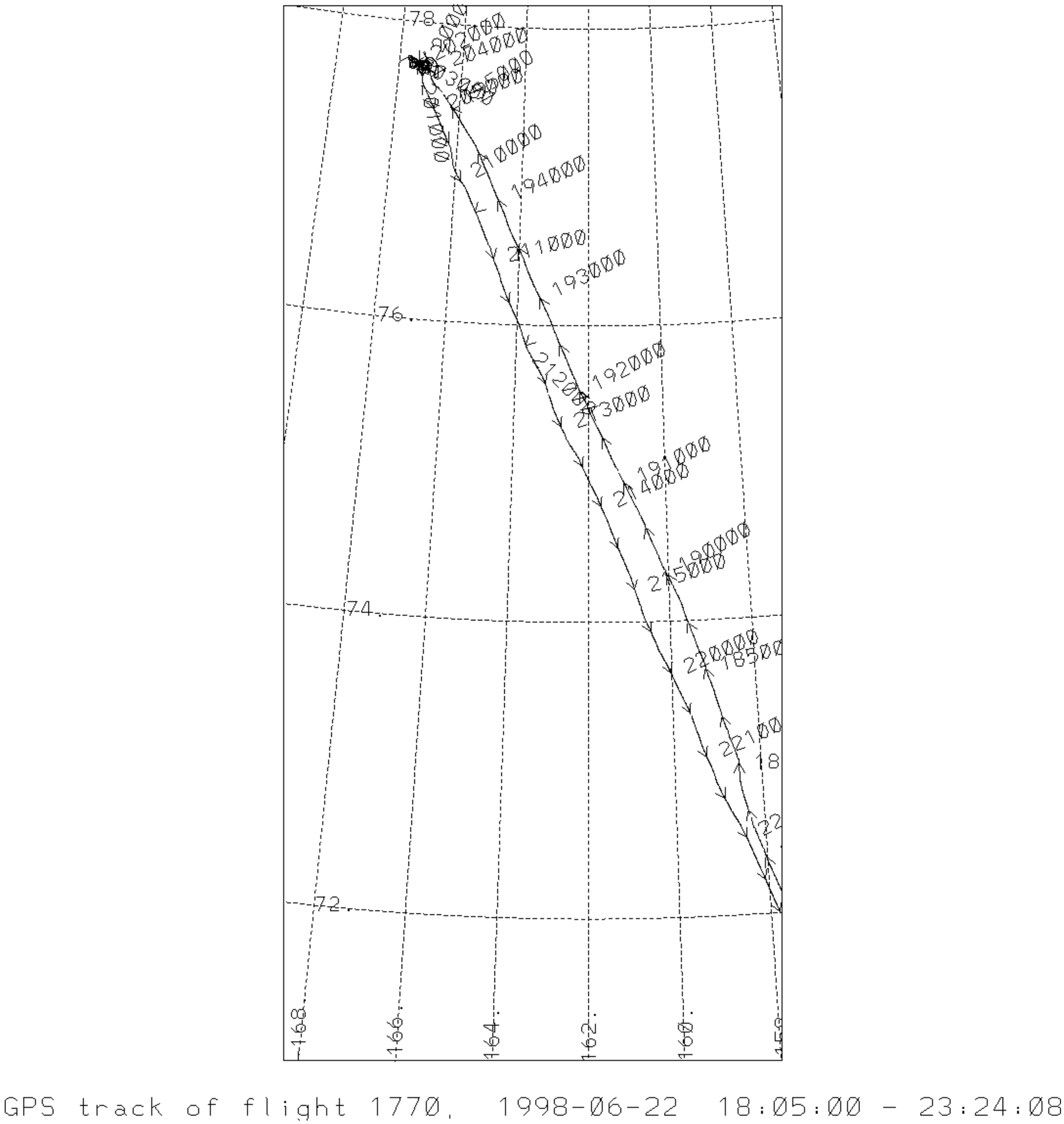
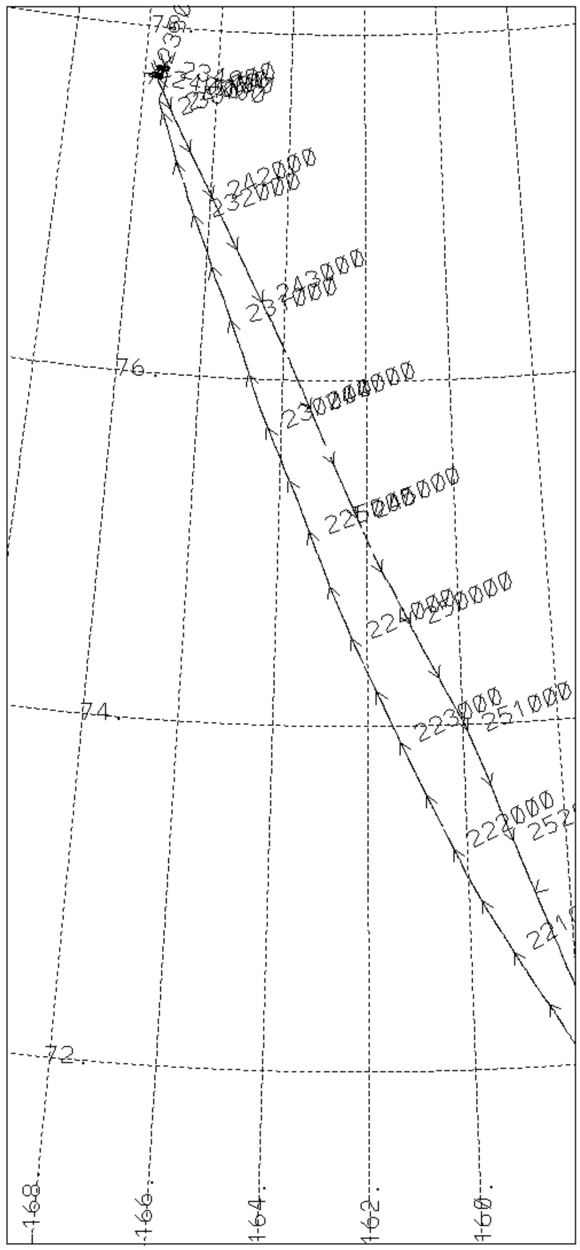


Figure 21. Flight track for Convair-580 for FIRE-ACE/SHEBA on June 22, 1998.



GPS track of flight 1771, 1998-06-23 21:23:39 - 26:04:47

Figure 22. Flight track for Convair-580 for FIRE-ACE/SHEBA on June 23, 1998.

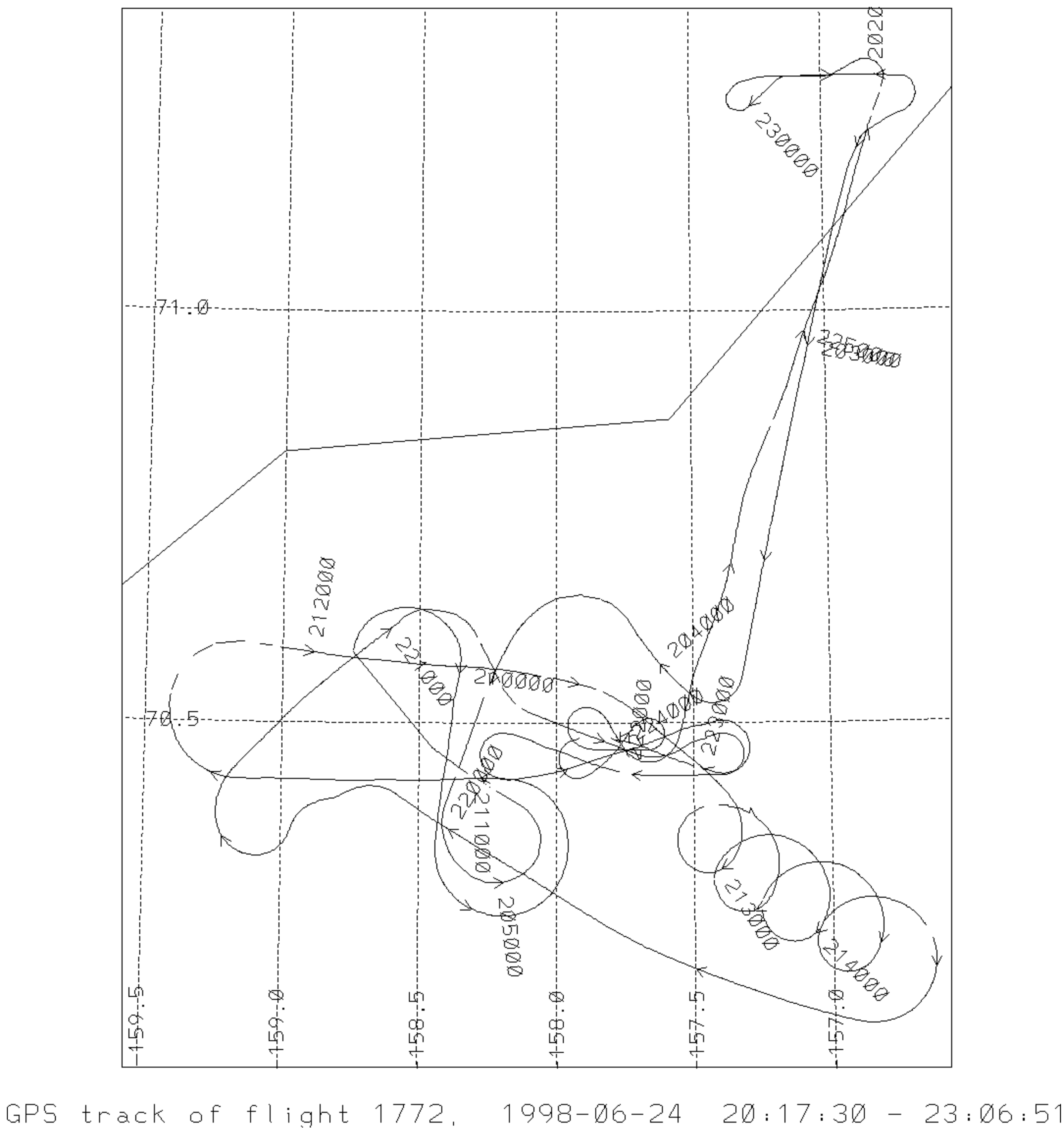


Figure 23. Flight track for Convair-580 for FIRE-ACE/SHEBA on June 24, 1998.

5. IN-FLIGHT SUMMARIES FOR EACH UW CONVAIR-580 FLIGHT IN FIRE-ACE/SHEBA

Complete typed transcriptions are available for all of the in-flight voice recordings (made by crew members on the UW Convair-580) in FIRE-ACE/SHEBA. These "blow-by-blow" recordings provide detailed information on what transpired on each flight. However, because of their volume, these transcriptions are not reproduced here. Instead, given below are typed transcriptions of the *summaries* that crew members recorded aboard the aircraft toward the end of each flight. Although subsequent data analyses might reveal important aspects of a flight, and of the data collected, that are not mentioned in these summaries, they do summarize most of the main features of a flight and they have the advantage of spontaneity.

(a) Summary of UW Flight 1750 (May 19, 1998)*

12:00 AM†

PH: Okay, are you up, Peter?

PP: Yes, I am.

PH: Why don't you give a summary on the tape of what you got on this flight?

PP: We turned on the SSFR during our initial ascent and we have kept it on during the entire flight so we could measure upwelling and downwelling, solar spectral flux from about 0.3 to 2.5 microns during the entire flight. We've had legs above cloud and below cloud, over both land and over the ice. We saw the effect of the open water and the leads on that albedo measurement if we take the ratio of those two measurements (upwelling and downwelling). We had some in-cloud flights as well. During those legs we've seen some ice buildup on the leading edge of the dome, but it seems to have very quickly blown off when we've gotten back above cloud, so I'm no too worried about that. It seems like we can clear that dome off

* AR = Art Rangno (UW, meterologist), BC = Bob Curran (NASA, guest), BE = Bob Eatwell (aeromechanic), DS = Don Spurgeon (UW, engineer), JL = Jason Li (NASA, CAR), JR = Jack Russell (UW, engineer), KL = Kim Larsen (NASA, guest), KM = Ken McMillen (pilot), LP = Larry Pezzolo (NASA, SSFR), LR = Larry Radke (NCAR, guest), LS = Larry Sutherland (pilot), MG = Mark Gray (NASA, CAR), MK = Michael King (NASA, CAR), PH = Peter Hobbs (UW, flight scientist), PP = Peter Pilewskie (NASA, SSFR), PS = Peter Soulen (NASA, CAR), RS = Rod Sorensen (pilot), RW = Ray Weiss (Radiance Research, aerosol), SY = Suzanne Young (NASA, CAR), TB = Tami Beitzel (NASA, CAR), TG = Tim Garrett (UW, chemist).

† All times are UTC (= Local Daylight Time + 8 hours).

pretty quick. In fact on the ground we left with a tiny bit of ice on the dome and it seemed to blow off very rapidly so that's a good sign. For the most part then I'm extremely pleased with what we've gotten here today. We did quite a lot of different scenarios and things have operated well during the entire flight.

PH: Great. Can you put Don on the headset?

PP: Will do.

12:02 AM

AR: Peter, for a minute or two at a time we're in the diffusion domain here. I can't see the disk of the sun or the ground.

PH: Good. We've still got the CAR going so maybe we can get some cloud absorption measurements.

DS: What do you want, Peter?

PH: Just summarize what went on with the CAR today, what problems you had and how you overcame them. By the way, before you do that, we are still doing the CAR scans to the right, aren't we?

DS: As far as I know, yes.

PH: Okay, go ahead.

DS: We had a little bit of trouble getting the display for the CAR to look correctly, but the scope looks okay. The scanning on the screen looks a little odd. We think we have one byte too many or one byte too few. Beyond that, it has worked. I've been able to rotate the CAR, and I've been able to tell from the oscilloscope that the data looks fine; I can read it and tell what I'm looking at.

PH: Jack, let us know what is working and what wasn't working from your viewpoint.

JR: Okay. Well, we're getting the lat/long and altitude just fine from the Tansvector, but the pitch and roll and heading are not right. I'm not satisfied with the King liquid water either.

PH: Tim are you up?

TG: Yes.

PH: Summarize what you did on this flight.

TG: Took some DMPS samples, but I think they are probably all bad. It seems there is a problem with the DMPS. I haven't quite figures out what it is. All the samples read exactly the same. I didn't take any filters. There are a couple of other things. Ethylene needs filling. As you know, the computers crashed quite frequently. Too frequently to make it any use during the flight.

PH: Yes, that's just the display; we're still recording all the data. It's a nuisance, and must be fixed. Is anyone else on the headset at the moment, Art or Ray?

AR: Yes, I'm here.

PH: Go ahead.

AR: The weather situation today was a large cyclone in the Aleutian Islands. The circulation covers most of Alaska, and we have strong east-northeast flow aloft, and southeast flow from 850 mb to almost 500 mb. The result was that it appeared that the flow was first taking the low-level stratus and stratocumulus offshore from near continental areas in Canada toward Barrow. This produced what appeared to be, from the droplet concentrations, polluted stratus. Tops running around 1,100 ft and some of our first couple of penetrations to as high as 1,750 ft ASL above sea level. Some of our later penetrations encountered droplet concentrations well over 100 cm^{-3} and droplet sizes truncated around the mid-20 microns or so. As a result of these possibly anthropogenically-affected clouds, we had some periods of diffusion domain I think, possibly attributable to the high droplet concentrations.

In the last hour of the flight there were several periods where neither the disk of the sun nor the ground was visible for one to several minutes at a time. Cloud tops were generally around -6.5˚ C in the shallow regions to -8˚ C in the deeper regions, and almost no ice. We don't normally see much ice when the tail in the FSSP is topping out at around 25 microns, and that was pretty much the case all day. All most no ice and no drizzle.

Extensive haze layers aloft. We sampled a haze layer just above stratocumulus. There were multiple haze layers, as much as we ever saw in the 1995 or this field project. I think this is about as much haze aloft as we will ever see in the Arctic.

PH: Thanks, Art. Ray, do you have anything?

RW: The nephelometer seemed to work well. I tried different filter holders on the absorption instrument, different styles, to see which one is best. There is a small leak in the optical unit. Also, the vacuum line that is supplying all of these instruments appears collapsed from pressure, so that probably needs to be changed. That's about it.

PH: This flight was intended as a cloud flight for radiation purposes over the ARM site. After takeoff we went above cloud top, we did a run above the stratus layer over the ARM site. We then dropped down into the cloud, did a run over the ARM site in-cloud, where we obtained cloud microphysical measurements. Because the cloud base was about 700 ft, we couldn't do a good run below cloud base over the ARM site so we headed out offshore, dropped below cloud base there, and then headed back to the ARM site and briefly got some measurements over the ARM site just below cloud base.

Since the situation was quite interesting offshore, we went back offshore and repeated measurements above and below the stratus deck for cloud radiation and in-cloud measurements. That was followed by some BRDF measurements over the broken ice surface offshore, some open water leads but mainly sea ice. Then we climbed and attempted to find some aerosol layers, but we only climbed about 5,000 ft. There were a few haze layers but generally it was very clean.

We then tried our scenario for an aerosol layer overlying a cloud layer. We attempted to get measurements below the cloud, above the cloud top, above the haze layer, and then to sample the haze layer. However, the haze layer was very weak and probably not absorbing. If we had climbed up to 10,000 ft we might have found some more haze layers, but we didn't do that.

The last part of the flight, which we are currently just completing, was long tracks in clouds to get some statistical measurements on cloud microphysical properties.

12:17 AM

AR: I wanted to add that the stratocumulus clouds here are extremely solid, unusually solid in our previous experience. Normally we would see little areas of clearings or even little holes between the clouds, but this was absolutely solid for almost this entire flight. No breaks whatsoever.

(b) Summary of UW Flight 1751 (May 20, 1998)

9:53 PM

PH: While we're doing this, I might as well summarize as best as I can remember what happened on yesterday's flight which was May 20 because we didn't do a summary of that flight on the tape yesterday. It was a very good coordinated flight with the ER-2.

9:54 PM

PH: I was just summarizing what we did on yesterday's flight, which was on May 20. We did a coordinated flight with the ER-2, which was a very good flight. We ran parallel with the ER-2 over the ARM site running from a southerly point through ARM to the northerly point over the Chukchi Sea. In the south there was a nice uniform fairly thick stratus layer. Over the ARM site there was a broken layer, and over the open ocean it was a clear sky. Our tracks were below cloud, in cloud, and above cloud as the ER-2 was flying the same parallel track. After the ER-2 left, which was about 2:00 PM LT, we did BRDF measurements over our northerly point over the Chukchi Sea. We then went back to the ARM site and flew from about 500 ft above the ARM site to 20,000 ft for aerosol and cloud measurements.

(c) Summary of UW Flight 1752 (May 21, 1998)

9:53 PM

PH: While we're doing this, I might as well summarize as best as I can remember what happened on yesterday's flight which was May 20 because we didn't do a summary of that flight on the tape yesterday. It was a very good coordinated flight with the ER-2.

9:54 PM

PH: I was just summarizing what we did on yesterday's flight, which was on May 20. We did a coordinated flight with the ER-2, which was a very good flight. We ran parallel with the ER-2 over the ARM site running from a southerly point through

ARM to the northerly point over the Chukchi Sea. In the south there was a nice uniform fairly thick stratus layer. Over the ARM site there was a broken layer, and over the open ocean it was a clear sky. Our tracks were below cloud, in cloud, and above cloud as the ER-2 was flying the same parallel track. After the ER-2 left, which was about 2:00 PM LT, we did BRDF measurements over our northerly point over the Chukchi Sea. We then went back to the ARM site and flew from about 500 ft above the ARM site to 20,000 ft for aerosol and cloud measurements.

9:57 PM

PH: We're going to be heading back now so we'll start our summary of today's flight. On this flight there was several layers of stratus and stratus fractus. Then above that there was another layer of stratus at about 2,000 ft and some altocumulus when we started out, or maybe another stratus layer. We then dropped down over the Chukchi Sea.

10:01 PM

PH: Continuing with the summary: We did our BRDF measurements beneath the stratus, with diffuse lighting beneath the stratus deck. First of all we did 10 turns over the ice and then we went out over the open ocean (just a few bits of ice in it). Did several turns there over the ocean maybe another ten. Then we did a couple of turns banked to the left just to get the diffuse lighting. Now we have climbed up above the stratus deck, and we're heading back.

10:04 PM

PH: Jason?

JL: Jason here.

PH: Would you summarize what you've got on this flight?

JL: Okay. First of all, are we headed back now?

PH: Yes, we're heading back now.

JL: We're going to power down instruments. We did two categories of BRDF measurements. The first set was over the open leads of water and ice surface. We did a total of 10 circles. The first 5 circles on the 1.6 micron channel. The second 5 circles we locked onto 2.2 micron. These two channels are good for differentiating ice and snow. The second set of BRDF measurements we did over the open ocean. All of the BRDF measurements were under diffuse lighting conditions, with the low cloud layer at 2,400 ft. The top and cloud bottom at 900 mb base and 100 ft base. So I think we got pretty good data sets today.

PH: Okay, good.

JL: By the way, as part of our engineering test on the CAR, I'm conducting the gain-setting experiment at the moment.

PH: Fine. Anyone else up on the headset? Tim or Ray?

RW: This is Ray.

PH: Anything to say, Ray?

RW: Not much. The nephelometer worked well. There is not much of a range of values all day about 3 to 6×10^{-6} m^{-1}. During some parts of the flight the absorption instrument worked fairly well. It seems to work better if it's an unpressurized sampling environment.

PH: Yes, I think for our low altitude we're just going to have to keep unpressurized. It's much simpler. Someone tell Art or Tim to get on the headset.

10:07 PM

TG: Tim here.

PH: Summarize what you did?

TG: I took about five DMPS samples. All of them seemed to be good. Some over the ice, some over the ocean. I wanted to get some over the cloud layer, but the bag house blew. Some of the gas probes seem to be working now, but I'm still having problems with the CO_2 and possibly the CO as well.

PH: You know we do now have that wired in. It's in Larry's room, as well as your tweezers by the way, for making the connection for the humidification measurements to the bag house.

TG: Sounds good.

PH: Jack, what happened at your end, apart from having cold feet.

JR: I keep getting cold feet. I think everything went well for me. But of course, I can't believe the IR temp and, of course, everybody's laptops doesn't seem to be up to snuff. Other than that, everything seems to be fine.

LR: The IR thermometer looks pretty decent right now about -2˚C over the solid ice, which seems reasonable.

PH: That's over cloud top. That's still reasonable. Art? Summarize.

AR: Today's flight was in a situation where you have low pressure over southern Alaska, high pressure over the Beaufort Sea, and driving the strongest gradients located over the North Slope region. Driving northeasterly flow toward the coast with a rather sparse stratus. Satellite imagery indicated all the stratus to the west of Barrow in a narrow zone from Pt. Barrow down to Wainwright and then expanding and enlarging from there. We went out there and found stratus, a multilayer stratus, stratocumulus situation with the scruffy boundary layer stratus fractus becoming eventually overcast over the ice region near Wainwright. Above that we had layers and the base of that layer was around 900 ft, tops around 1,600 ft at its thickest point. Then we had layers based at 2,200 ft, top 4,100 ft, about 1,900 ft layer. Then on top of that a third layer based at 4,600, top 4,700 ft, and all the cloud top temperatures were almost the same so that for the IR satellite it was impossible to differentiate the various layers here, nor were they differentiable on the visible.

On the way back, following those circles out over the sea, we climbed up through this situation again, but the thicker layers above the boundary layer stratus had thinned appreciably. In fact, there was only one layer on top of the surface based, stratus based at 900 ft. The tops now were at 2,600 ft, about 1,000 ft higher than the surface stratus we had initially encountered. The remaining high cloud layer was based at about 3,300 ft, top 3,500 ft. So it had thinned considerably. We continue to have rather hazy conditions aloft on top of these clouds.

I guess that's about it, Peter. Oh, easterly flow continues to be the case above the stratus. Northeasterly flow in the stratus. East flow up to 50 knots all the way up through 500 mb above Barrow.

PH: Thanks. Don, are you there? Or Tami?

AR: I forgot to mention we did have an isolated crystal and drizzle drop from the stratus situations that we sampled.

PH: Tami or Don? Larry, do you have anything to summarize?

LR: Well, I really enjoyed watching the CPI at work here. One of the things you can do with that is you can certainly tell the difference between a 40 micron droplet and a 40 micron something else. A nice diffraction phenomena, lovely instrument, very impressed. Drizzle plus ice crystals were present on a number of occasions.

PH: Is Don there or Tami?

DS: Don's here.

PH: Anything to add, Don?

DS: No. I mostly just ran around and helped people run their equipment today.

10:14 PM

PH: Is Tami there?

TB: I'm here.

PH: Anything to report on the SSFR?

TB: Well, the SSFR didn't really have too much to look at, but I guess it was interesting to see the difference between having it over the ice and having it over the ocean. Over the ocean there was basically no reflectivity and the albedo was little to nil. Other than that there wasn't much going on with the SSFR. It seemed to have the same shape as usual with the different elements absorbing the same sorts of materials.

PH: Right, the ocean is very dark.

(d) Summary of UW Flight 1753 (May 23, 1998)

8:40 PM

PH: On this flight we had one stratus layer and a couple of altocumulus layers. We ran backwards and forwards first above the altocumulus layer, then in the altocumulus, below the altocumulus between the two cloud layers, and then in the stratus layer. We would have run under the stratus layers as well except, because of some concern about one of the engines, we decided to come in and land. Anything not working, Jack?

JR: No. I think everything is working okay except again the IR thermometer is high and Tim's laptop doesn't seem to come up right.

PH: Yes, my position plot has disappeared again. Okay, Art, would you summarize today.

AR: We took off in low level stratus, bases 1,100 ft, tops 2,100 ft, and continued to climb to two levels of altocumulus. The first based around 8,500 to 8,800 ft, tops 9,095 ft; upper layer based around 10,000 ft, tops 10,500-11,000 ft. No precipitation to speak of, a couple of ice crystals in a billion liters, but otherwise a very chaotic situation because the two layers of altocumulus, the lower layers spawned altocumulus castellanus and was very patchy. The upper layer more contiguous but also generally broken and chaotic. So it made the going a little tough. The flow out of the east again. Lots of haze above the highest altocumulus layer. Droplet concentrations today a little bit lower than we've seen before running at about 90 to 130 cm^{-3}. The lower layer also no drizzle to speak of, a couple of drops here and there. Had an inversion at the top "humidity inversion" (as it has been called) and we got a couple of samples of that. I think that about wraps it up.

(e) Summary of UW Flight 1754 (May 27, 1998)

2:08 AM

PH: We might as well start summarizing here. Is Art on the headset?

AR: Yes, I am.

PH: Why don't you summarize, Art?

AR: This morning's takeoff was characterized by scattered to broken altocumulus clouds. We found the base somewhere around 14,500-15,500 ft. There were three layers, I think Peter has already noted this, topping out somewhere around 19,000-19,500 ft. Temperature at the tops were around -21˚C. These clouds were of a consistency that the ground was visible most of the time through the clouds. The unusual characteristic was the low droplet concentrations in at least one of the layers, which was only around 10-20/cc. Extraordinarily low droplet concentration indicative of the clean conditions up here today. As we left that region, we did create a few APIPS. An APIPS trail that looked like it was adjacent to our track in cloud after we had flown on top of the cloud. We then came back to the ARM site where we encountered the overspreading cirrostratus layer, which thickened into altostratus and tops were above 25,000 ft. I didn't catch the bottom, but I think it was around 10,000 or 11,000 ft. Then around that time we also had a scattered layer of altocumulus. Since then we added another droplet cloud above that 11,000 ft layer of altocumulus, and above that we have what would be termed from the ground altostratus translucidus. It thickens toward the horizons. That's about it. It was a classic example of sampling altostratus today from the top, where just below top you had cirrostratus halo and vivid optics, which have been described by others. Then as you got a little further down the ice crystals increased and the optical depth of the cloud increased. You would classify it as an altostratus translucidus. That is the sun is visible through it, no optics.

PH: Good. Thanks, Art. I'll do my summary. I summarized the first part of the flight already, but I'll just do it again quickly. We headed out north climbing. Got above about three layers of altocumulus. Then sampled down through those clouds. Before descending through the three altocumulus layers, we also tried a BRDF measurement on top of the altostratus. But, because it was so inhomogeneous and changing rapidly, we only did three turns. We then descended through the clouds, sampled them backwards and forwards in-cloud, between clouds, and below cloud bases. Then we picked up the ER-2 as it was heading back from SHEBA, back toward the ARM site, and we followed it into the ARM site. I think we were just behind it because it was ahead of schedule by 5 min. We were in cloud as we passed over the ARM site. The ER-2 was then heading south of us back to Fairbanks. We followed about 50 miles south in cloud and we came back to the ARM site I think below cloud base, I'm not quite sure of that. Then we did an altitude climb. Over the ARM site we spiraled up to about 25,000 ft. Didn't get completely above the cirrostratus, but anyway went to 25,000 ft and then circled down from there over the ARM site all the way down to about 400 ft or so. Now we're doing the BRDF circles around the ARM site with the altocumulus above. It has changed somewhat since we sampled it, but a fairly continuous altocumulus layer above us.

PH: Larry, do you want to make any summary remarks about the flight.

LR: The flight was rather remarkable for the depth of cirrus precipitation that we saw. The structure was pretty much the same from beginning of the flight to the end. Large sector plates as precipitation and short columns with frozen droplets mixed in. The frozen droplet mixture was most noticeable near the cloud base, but there were also pockets of droplets frozen or unfrozen, probably all frozen.

PH: Okay. Thanks. Jack, comments?

JR: Nothing unusual occurred on this flight. The laptops seemed to work the whole flight.

PH: Except for the profile, right?

JR: Well, yes, the profile program didn't work, but at least the laptops stayed up most of the time. The IR thermometer doesn't seem to have cured itself. The King LWC may be working better.

PH: Okay. Tim?

TG: In the aerosol station there are still some problems with some of the gas instruments, particularly the CO_2. We'll need to replace the desiccate of the CO, which is still broken. I'm not sure what the reason is. Otherwise the profiles in clouds today will probably be an excellent test of the g-meter, the CPI and the Pilewskie radiometer.

PH: Okay, good. Ray?

RW: Well, I think we have some problems with airflow through the nephelometer. I can't tell which direction it is, especially in high altitude. So we're going to solve that because it relies on air going the right way to set the zero. If it doesn't, the filters don't work so you get a bad zero. Anyway we'll have to figure that out.

PH: Have you noticed that on previous flights or did it just occur on this flight?

RW: Well I mainly noticed it on this flight because we flew so high. It was such a high pressure differential. But I don't think the pump overcomes the outside vacuum pull.

PH: Okay, Ray, see if you can work on that and see if you can fix it. Tami? Not there? Jason, do you want to summarize or do it after we finish these turns? Anyone there?

JL: Yes, I'm here. Do you want to put Tami on?

PH: Yes, put Tami on and let her summarize.

JL: Okay.

PH: Are you there, Tami?

TB: Yes.

PH: Do you have any comments to make?

TB: Not really. The SSFR seems to be running just fine. We did a calibration beforehand and we're going to do a calibration after we land to see how the instrument is functioning. Make sure it's not getting messed up during flight or whatever. Otherwise it's running fine and the reflections seem normal for the cloud layers that we were in.

PH: Good. Jason?

JL: It's Jason here at the CAR station. First of all the CAR works beautifully today. Never stuck in any position. Pretty smooth, that's very good. There are three things we did today as far as from CAR's point of view. No. 1 is the BRDF above stratus clouds, three circles. Peter has already summarized that. The second thing is the imaging of the sky radiance. There were a lot of optical phenomenon, which were very interesting to us. I think we got good data for those haloes and all that stuff. The third thing we did is the BRDF over the ARM site. The fourth thing, hopefully we are going to do after this one, is imaging the surface over the melting seasons. Some of the radiation people are very interested just to see. So there are four things. A very fruitful day for us.

PH: Thanks, Jason.

(f) Summary of UW Flight 1755 (May 28, 1998)

10:55 PM

PH: Let's start summarizing. We'll start with Art if he's on the headset.

AR: I'm on the headset. Do you copy?

PH: Yes. Go ahead.

AR: We had strong southerly flow aloft and very shallow easterly flow. We went offshore from Barrow to the northeast. We encountered some stratus beginning just off the coastline. The tops were around 300 ft sometimes thinning to maybe as low as 200 ft. Then, as we continued northeast bound, the tops rose from about 400 ft all the way up to about 800 ft in about a 20-nautical mile distance. During that time the droplet concentrations were quite low, I believe they were well under 100 perhaps around 50 cm^{-3}. The liquid water contents less than 0.1 g m^{-3}. After that we went back to the ARM site and then climbed up through a band of altostratus with layers of embedded altocumulus. At the time we started our climb we were about in the thickest part of that band, which produced rain to the surface, sprinkles really is about all, although heavier rain was off in some areas. We climbed through that band. As we began our climb, we were still in the thickest part; but by the time we reached the top, we had actually come into a saddle area and looking downwind to what we had climbed in before was deep icy-looking cirroform cloud probably at least 2 or 3 kilometers above where we popped out. The tops where we popped out were generally a liquid composition, low in ice at the very, very top. Very low liquid water content of 0.1 or 0.2 g m^{-3} maybe maximum. Present in the area were protruding castellanus-like tops, and in some places they were well glaciated. They were probably only say 2,000 ft or 3,000 ft higher than our cloud top level of about 17,000 ft and our cloud top temperature of -15˚C, I think it was. On the way down we went through mixed phase clouds. Packed together layers that were practically inseparable and when we popped out the bottom. The visual bottom was probably 7,500 ft to 8,000 ft. The droplet cloud bottom was more like 9,000 ft. Virga extended below those levels, but precipitation did not reach the ground because we were in the thinning portion of this large band of clouds. It continued to thin as we descended down to the ARM site. Eventually when we were finishing our research, the very southwest and south back edge was at the south part of our turn the sun was almost full out with exception of a few very, very thin altocumulus clouds at that south end. So during the ARM traverses, we were going through thinner clouds at south end and thicker clouds at the north end as we had done, I think, before on another occasion. (I think it was yesterday.) I guess that's about it, except that when we did our circle above the stratus, we were above the inversion tops and the winds were 170˚ at 15 knots and that's a continental-origin wind. We had a lot of CN, but when we went down in the stratus we did have a chance where there was some wind blowing and saw that the wind was out of the east at about 10 knots and that suggests at least a more ambiguous continental origin and the droplet concentrations were very low and the CN concentrations were rather low. I think that's it.

PH: Thanks, Art. Jason, do you want to summarize?

JL: Yes. From the CAR operator's point of view, for the most part I locked the CAR on the imaging mode. We imaged the CAR sites as we just did, two straight legs. One for Peter Pilewskie's machine and the other one is for the CAR pretty much at 1,500 ft. The other interesting thing is we mapped leads. I missed the first run, but I did catch the second run. At altitudes of 100 ft, there are some interesting features of the leads and the ice looking out from the imaging mode. The CAR filter wheels do not work perfectly and it generates a noise when we are on the automatic mode.

PH: Is that it?

PH: Ray?

RW: The nephelometer works a whole lot better since Don and I fixed the leaks last night. So the response is a lot more reasonable. I moved the absorption inlet to the nephelometer so now in the inlet it probably ought to go in the outlet since we're still getting some strange behavior inside the clouds. But there were some periods when it looked like we were got some reasonable single-scattering albedos at least with some confidence. It looks like it's sort of 0.9 to 0.95. Anyway we'll carry on. There are a few other changes we want to try.

PH: Okay. Good, Ray. Keep working at it. Tim?

TG: Still having problems with the carbon dioxide and the CO. They aren't fixed yet. I'm a bit speculative about the DMPS. I think maybe the data is dumped for this flight as well. Otherwise we saw some interesting CN readings at low altitudes at the beginning of the flight with a very strong vertical gradient. Right now it seems to be much cleaner at low altitudes. Other than that, it wasn't very interesting.

PH: Jack?

JR: Well, the IR thermometer, despite the fact that I put some foam rubber around the hole to try to seal it up, still seems to be dubious, although there were some periods where it was looking really good. King LWC probe was mostly unusable today.

PH: What we did today was first of all we climbed out to the north over the Chukchi Sea, got above some low stratus cloud that was extending down near to the ocean surface. We did some horizontal runs just above the top of that cloud for radiometer measurements. There was an altocumulus deck above us. We then did some runs in cloud, but we couldn't get below cloud base because it was too close to the surface. It was below 100 ft and we couldn't get down that low.

Second part of the mission was concerned with low-level flying over the sea ice in and around leads looking for any smoke, but there wasn't much if any, probably because the air temperatures were too high plus there was the bits of low stratus which confused the situation anyway. We also tried running along the length of leads and across leads to see if we could see any CN emissions, but I don't think that will produce much of interest because there was a very strong vertical gradient of CN and nothing was apparently due to the leads (at least looking at the real-time data).

We then headed back to the ARM site at low level and in clear air, ran into some drizzle as we came over the land. Over the ARM site we climbed to 15,000 ft, cleared the cloud top. We then descended to 500 ft spiraling over the ARM site.

Following that we did a straight run at 500 ft in clear air through the ARM site. We then climbed to 1,500 ft and, still in clear air, did some straight horizontal runs over the ARM site for downward-pointing CAR measurements. We did three legs at about 5 miles to the north through the ARM site and 5 miles to the south.

So that was about it. We are now heading in to land. Larry, do you have anything to add?

LR: We are definitely in a different airmass here with lots of Aitken nuclei. The CPI was showing us new things. We saw needles and sheaths, bundles of needles today, and this phenomena of the twin droplet or the triple drop, frozen droplet, seems a lot more common than what one might have guessed. I think on the PMS probe, when looking at these, you think you are looking at short columns, but in fact they are two droplets frozen together (as described in a paper by Hobbs in the 1960s!).

PH: Yes, that's what I called "dumb bells."

LR: Remarkably interesting. We also saw some droplets frozen on the end of some branched sectored plates. That was interesting too. I don't think I've ever seen that, except very rarely on the old replicator, but you certainly won't see it on the 2-D cloud probe. That was interesting as well.

PH: If Don's around, and if he's got anything to say, he can go on the headset.

LR: Another thing we saw that you don't see very often is warm moist air coming across cold water forming a little fog.

PH: As we head towards landing, we're getting a big clearing coming in from the west. So there's a rapid thinning of the cloud between our climb over the ARM site and our descent, which only took about 45 min, but a big change in cloud depth between those times. Is Don there?

11:09 PM

LR: In about two more days the shore-fast ice will be gone.

(g) Summary of UW Flight 1756 (May 29, 1998)

11:25 PM

PH: I'll start the summary here of the flight so far. We took off at 19:28 UTC and headed out to SHEBA. Arrived over the SHEBA site at about 21:10 UTC at altitude. Climbed above the thin cirrus. Then, between about 21:27 and 22:33, we flew beneath the ER-2 at various altitudes gradually lowering down through the cloud until we were, I think, about 500 ft above the ground. We should have passed exactly beneath ER-2 several times during that cross pattern. Then we spiraled up over the SHEBA site through all the cloud layers, except for perhaps the highest very thin cirrus layer. Then we did half a dozen CAR BRDF turns above the highest altocumulus layer, which was a fairly uniform cloud layer; couldn't see the ground below it.

We left the SHEBA ship for our return trip to Barrow at 22:54 UTC. So it worked out pretty well. We couldn't get below the cloud deck over SHEBA because of the poor visibility (a 1/2 mile, drizzle, etc.), but we did pretty much everything else that we planned to do.

Anyone else on the headset want to do their summary? Jack, any instrument problems?

JR: Well, I guess the Gerber probe seems to have a big offset in it. I don't know why. I suspect it's probably frozen with something.

PH: We're talking about the Gerber PVM?

JR: Yes, that's right.

PH: Yes, the g-meter is okay, I think.

JR: Yes, I was looking at the g-meter. That looks all right. But the PVM liquid water seems to have a large offset, so I suspect there is something stuck in there or frozen in it.

PH: That only happened late in the flight after we had lowered down and maybe even went up again through the cloud layers.

JR: Droplet condensation maybe or something.

PH: Is the King LW probe still out?

JR: Yes.

PH: Why did the position plotter drop out several times, do you know?

JR: On your display?

PH: Yes, on mine a couple of times and I think on Tim's as well. You fixed it about 15 min ago and it's working now.

JR: Has it caught up with the right time?

PH: Yes.

JR: I don't know. Mine never went away. However, the critical display is gone.

PH: What's the critical display?

JR: The display that allows me to start the computer.

PH: Oh, you lost that?

JR: Yes, I have to fix that tonight.

PH: Okay. Anyone else for a summary? Michael, are you on the headset, or Ray or Tim?

JR: Ray is on the headset now.

PH: Okay, Ray. Give a summary.

RW: Well, the nephelometer and the absorption instruments both seemed to work pretty well for periods. However, there seem to be two different regimes for the single-scattering albedo, sort of 0.9 to 0.95 and then around 0.8. That's sort of what it is right now. That's about it.

PH: We should check in post analysis whether that change in the single-scattering albedo correlates with where we were detecting haze layers.

Okay, we've been flying in clear air and we've got altocumulus below us. Sort of fairly continuous but typical altocumulus tops and no cirrus immediately above us but some cirrus bands off to the south.

11:32 PM

PH: Michael?

MK: I'm here.

PH: Would you summarize what you saw from your seat today?

MK: For everybody to hear?

PH: If you wish, yes. Of course, not the pilots. Just put it on "Science."

MK: Don's talking to me in the other ear, just a second.

11:34 PM

MK: Okay.

PH: Go ahead.

MK: We climbed out of Barrow today heading northwest. The sky was mostly blue above. It was very uniform, thick stratus. Most of the flight out the CAR was in the nadir-viewing mode. There was occasionally very thin cirrus above, but it was mostly clear. The BRDF scan, which is basically a cross strike image here, was very similar to what the ER-2 would be able to obtain or a satellite. Very smooth, very uniform radiation field. We later rotated the nose to the BRDF mode around some uniform stratus preparing to do a BRDF mode flight. Then it was discovered we were too far out into the Russian FIR and moved east. So I went back to another coordination with the ER-2. At that point the clouds were a little more broken, clear sky above. This is going to be easier to do in my notes afterwards, Peter, than with all my scribblings here.

PH: It's good to get it on the tape. It doesn't have to be in great detail or exact times, just general impressions.

MK: Anyway most of the flight we kept the filter wheel in the locked position, 2.2 microns. Occasionally I switched it to 1.6 microns. We kept it in manual mode in one of those two for most of the science coordination with the ER-2. Later (and in fact right now) on the return leg back to Barrow, I'm back in the nadir-scanning mode position and I am in the automatic filter wheel position so we can get a run of data to see whether we've got noise or not. The displays are perfectly fine on the screen. How it's coming on the data stream we will find out later.

PH: Now you said earlier on in the flight something about when we were out in the Russian airspace you were doing BRDF, but that was not in banked turns. You were just trying scanning on the right-hand side of the plane, right?

MK: Correct. We had configured the scanner to that BRDF mode anticipating the BRDFs and then we realized we were too far and so I switched it back when we got back with the ER-2. So when it was in that mode, we actually never made any circles then. The circles were made in a much later point and time.

PH: Right, they were made after we climbed above SHEBA, and then we did the circles above the highest altocumulus layer. Okay, good.

11:34 PM

PH: Art, why don't you summarize?

AR: Well, I'm in the data free and display free zone. I'll try to recollect everything that happened. We took off from Barrow heading northwest bound. We intercepted an altocumulus layer based 8,100 ft, tops about 8,500 ft. Then from there on out we continued to climb to about 19,000 ft whereupon we came across some patchy cirrus that became a little more widespread as we continued toward SHEBA. Climbed on top of that at about 23,000 ft. Most of the time we were on top, a few ice crystals going by in a virtually clear sky, however. Then when we came to SHEBA we actually flew to the west a little bit and got out of the cirrus, but then when we had to backtrack a bit to get back to SHEBA we again came into cirroform clouds, it would be cirrostratus nebulosus. There wasn't much structure to it at all. We flew at the top of that occasionally getting a few ice crystals and then we tried to drop back down to do a reciprocal in the cirrostratus. I think probably we ended up being a little bit too much toward the top of that as went back toward the upper portion of that vellum of cirrostratus cloud.

Next we dropped down to about 14,500 ft. At that point we hit the real precipitating clouds, which were very chaotic. Some cumuliform tufts and sticking up indicative of altocumulus castellanus and altocumulus floccus regions and in some cases they had profuse fallstreaks coming from them. Also there was an area that was just over the SHEBA ship that the altocumulus layer jutted up to become a completely glaciated almost like a very weak convective element. We keep passing back and forth through that.

Then we dropped down to about 9,000 ft. At that point we had multiple cloud layers. The main rain layer, precipitation producing layer, based at near that level. I didn't quite catch the lowest bottom of that, but it was a mid-level situation precipitating into the lower stratus and eventually we got down to about penetrating some of the stratocumulus at about 5,000 to 6,000 ft. A humped up region, but we had to continue descending. Once we got down to this boundary layer situation down to about below 1,000 ft to hit the top of the true stratus and at that point we kept passing through the rain from the mid-level range generating clouds and in and out of the stratus. An exceedingly unusual situation to have rain reaching the ground at 76˚N in May. Probably almost unprecedented. Anyway there was obviously a situation where we had possible accretion of the rain falling into the thick fog stratus that was just about on the deck. In-cloud visibility was very low, it appeared to me, I didn't see the droplet concentration, but it appeared to me that it might have been a little higher than maybe 100 or 200 cm^{-3} even. So if anybody caught that, they can amend that. The tops of the stratus were above freezing and the precipitation had completely melted before entering the stratus.

Now we're heading back. We're flying on top of surface stratus. I don't see any altocumulus right now except off the left wing there we have a little piece. A little too far away to tell what we're going to have at Barrow.

AR: I think straight below us we've got stratus. Up about 2 or 3 miles we are going to have a higher layer of altocumulus on top of that. I wanted to add one more thing to my summary, Peter. The precipitating tops that they saw at SHEBA were probably just about right because that's where the stuff was really coming down from was that layer around 14,000 to 16,000 ft. It topped out at 14,000 to 16,000 ft, I think.

PH: Larry. Do you want to say anything on the summary?

LR: Well, this has been one of the most extensive arctic haze days that I've seen. There are lots of layers, but it's not as strongly layered as I've seen it before. Also, PCASP has been suspect today, but is very well correlated with CN.

12:44 AM

PH: To finish off my summary of the flight. On the way back, just off the coast of Barrow, we did 10 circles for BRDF measurements. These were over a fairly uniform altocumulus layer; had a "glory." Unfortunately, we couldn't drop down into the altocumulus layer to get some drop size measurements because the pilots wanted to head straight back at this altitude to conserve fuel.

12:49 AM

PH: Michael, you could summarize what you got on that last little experiment. Is he on the headset?

MK: Okay. Over some altocumulus translucidus, our meteorologist tells us, we flew ten circular right-hand BRDF overflights. Very, very nice clouds which were very uniform to the eye, had a very crisp and clear multi-ring "glory." We flew ten circular orbits, five of which were locked filter wheel 1.6 microns, five of which were 2.2 microns. Aircraft was drifting consistently about 45˚ to the northeast with the winds we obtained a very valuable set of BRDF measurements over these clouds, but were too high above and too low in fuel to go in and penetrate for in situ microphysics following the measurements.

(h) Summary of UW Flight 1757 (May 30, 1998)

12:03 AM

AR: Summarizing today's flight we took off below a stratiform layer. Bases turned out to be 5,800 ft for the first base and about 6,500 ft for the second base. Tops were about 8,800 ft. Flew on top of that until we reached the north edge some 10 to 15 min into the flight. Thereafter, clear sailing until encountering a more or less east-west band of cirrus, which was above the aircraft, but put out ice crystals down to the level of the aircraft. However, CPI did not capture these. It was not functioning at that time due to a sensitivity setting. Thereafter we passed through that cirrus and found the patch of what turned out to be altocumulus. It wasn't clear from the flight level that it was altocumulus, but anyway we went down to 1,000 ft above cloud top and did our radiation circles and then passed through the cloud. A couple of ice crystals were noted. Cloud top -12˚C. Plates were observed, just a couple.

MK: The CAR flight for today, flight 1757. After taking off from Barrow, we penetrated some altostratus and I switched CAR to NADIR imaging mode over these clouds. There was very little cirrus above. Nice cloud layer that we flew over for quite a while. It was much brighter, 0.47 of a micron, than other bands. Leads became apparent a little bit through the ice.

AR: And spun down to the altocumulus, which was topped out at 8,100 ft, bases about 7,500 ft.

MK: Eventually we popped though a thin altostratus, went on top and put the CAR in a NADIR-viewing mode and then scanned continuously for a long time over altostratus. The pyranometers were indicating the albedo of the sea ice was about 0.68. When we went over the clouds it was much higher maybe 0.79. When we approached SHEBA, we started doing a number of circular flight tracks above the thicker clouds downwind a little bit from SHEBA. Initially were going to go upwind and drift over SHEBA, but the clouds were thinning there. So we did ten different circular orbits with the CAR in five orbits at 1.6 microns and five orbits at 2.2 microns. Then we returned along the track that we had drifted with the wind, wings level, for SSFR measurements as well as CAR measurements above the cloud for a nice straight run.

We then descended through cloud down to the SHEBA ice station. We could see the ice camp, the ship and all the instruments on the ice. Did horizontal runs below cloud. Also did BRDF measurements near the SHEBA ice station. I think we did six orbits as I recall, three at 1.6 microns, three at 2.2 microns. We did a series of horizontal legs that were perpendicular to one another. We went straight with the CAR in the upward-looking mode under the cloud and then the reversed leg with the CAR in the downward-looking mode. SSFR was operating the whole time. Then we did a perpendicular flight leg. Did the same thing with the CAR upward mode and CAR downward mode. Then we climbed out through the cloud, did some brief microphysics in the cloud. Effective radius 6 microns with LWC of one-tenth of a gram, droplet concentration of 150/cc. When we penetrated the cloud, the CAR was in the starboard historic mode. Cloud top we returned then to Barrow. Filter wheel I put into the automatic scanning mode. There is no noise at all on the instrument.

Finally, as we got close to Barrow, we put it in the NADIR mode to image above the arctic stratus clouds which are very, very low now over the ice.

AR: When we got down to the surface, there was a stratus layer producing remarkable amounts of precipitation. The precipitation shafts were so thick you couldn't see behind them. The stratus layer itself was probably a good 200 ft thick. We then spiraled back up into the altocumulus perlucidus tending toward opacus. The sun's disc was not visible. The cloud that we spiraled back through was virtually identical. It appeared to the cloud that we sampled as it turned out because that was the leading edge of the mesoscale patch of altocumulus that had drifted toward the SHEBA ship during the research time. We finished up by going on top of that altocumulus and then descending once again to look for, on the way back to Barrow, any interesting stratus clouds and find out what in the world was going on in terms of how those thin clouds could produce so much precipitation. But as it turned out, we encountered thinner clouds and more cumuliform clouds than we had seen previously.

PH: Okay, Art. Can you give a summary? Keep it brief.

AR: Peter, I was just finishing one up. I thought maybe something had happened, maybe I was off the headset when you asked for it, so I put one on the tape. It's fairly long; but, you know, just the clouds.

PH: Okay. Jack, any instruments out?

JR: Well, the King, of course, is still out and the IR thermometer is still flaky.

12:10 AM

PH: Today's mission was to SHEBA. We were by ourselves as far as aircraft go. We left at about 19:10 UCT and arrived on station at SHEBA at about 20:50 UCT. There was an altocumulus deck.

We first of all did BRDF circles over SHEBA drifting with the wind, ten circles. We then came back on a straight-line path through the center of the circles for the SSFR measurements. We then dropped down through cloud rather quickly to get below cloud base. Then we did a run below cloud base parallel to the straight one we did above cloud base for the other set of radiometer measurements.

We then spotted the SHEBA ship a few miles away and zeroed in on that, located the L-shaped site where they are doing their albedo measurements on the surface. We did straight line passes two of them back and forth along each of the arms of the "L," which had their vertex at a tower with the ship about 0.2 miles away from the tower. So I think we located that all right. We should also have SSFR, radiometer measurements above that site. We had at that time broken altocumulus overhead.

We then did a set of six BRDF circles drifting over the ship beneath the cloud, with the broken altocumulus above. Starting at about 22:21 UTC we did an ascent over SHEBA, first of all in clear air up through cloud base, up through the cloud on top of the cloud. After doing that we dropped down into the altocumulus cloud and did a straight-line pass over the SHEBA ship. So we did our ascent up above cloud top and then we dropped down into the altocumulus and did a straight-line pass over SHEBA. So the ascent defined cloud base and cloud top, a rather thin cloud layer, quite precisely and can be compared with the radar measurements and other measurements on board the SHEBA ship for a nice case of a simple cloud layer.

Then we got the in-cloud measurements. We then spent 10 or 15 min looking for the precipitation from the stratus cloud, but by that time it had disappeared. We departed the SHEBA site at about 22:30 UTC and headed straight back to Barrow. Anyone not done a summary?

RW: Yes, Ray.

PH: Okay, Ray, go ahead.

RW: Actually it was a pretty good flight. Got high correlation between absorption and scattering of both the ferry in and the ferry out. During the turns at SHEBA where we hit our own exhaust, was a high correlation between absorption and CN as you would expect, but no scattering increase. It's very clean over the SHEBA site. Scattering was in the order of just a few times 10^{-7} m^{-1}. Anyway that's about it.

PH: What's not working at your station now, anything?

RW: The humidigraph doesn't look like it's going to work at all, ever.

PH: Tim, have you given your summary?

TG: No. There probably isn't much to summarize because we haven't had much luck with our gas probes yet. I saw some haze layers.

PH: Did you operate the bag house at all today and if so at what altitude?

TG: Yes. I operated it twice. I took some DMPS samples at 1,000 ft and at around 100 ft.

PH: With no problems?

TG: No problems that I was aware of.

PH: And DMPS is now working?

TG: I'm pretty sure it is. The air was very clean so that DMPS didn't give a good curve for the aerosol sample, but that's what I would expect anyway because the DMPS doesn't have very high sensitivity.

(i) Summary of UW Flight 1758 (June 1, 1998)

11:35 PM

PH: I'm going to start the summaries now, although we've got some work ahead of us. We started out with clear air measurements, straight and level passes at 2,000 ft over the ARM site for radiation measurements. That was between about 20:13 and 20:30 UTC. The Pilewskie radiometers were then clean and clear with their new O-rings in. That was followed by CAR circles, ten of them centered on the ARM site, in clear air, drifting with the wind, roll angle changing quite a bit. Those were completed at 21:00.

We then went in over the ARM site at 200 ft, passed over it at 21:12 UTC in clear air. We then spiraled up over the ARM site and completed our spiral up to about 14,000 ft at 20:35 UTC. We then descended back down to where there was an aerosol layer at about 9,000 ft and we ran horizontal at roughly that altitude in the aerosol layer. A weak layer showed up on the CN but not on the nephelometer.

We then had some problems with our cabin pressure and oxygen so that took a while to sort those out. When they were sorted out, we climbed to the top of some cirrus layers with some broken altocumulus below them and that climb was completed at 22:40 UTC.

11:35 PM

PH: And then from 22:40 to 22:50 UTC we did some straight and level runs above the cirrus and we cleared the tops of the cirrus in 14-mile long runs. Two of them A to B, B back to A.

From 22:52 to 23:51 UTC we did some CAR circles above the cirrus keeping in the same location. As we completed, I think, No. 8 of those circles at about 23:50 UTC we lost some instrument power on the CPI and the 2-D probe, probably due to trying to heat the CPI outside against very low temperatures, which were below -40˚C. That occurred during our descent through the cirrus at some point that failure occurred, so we didn't get a complete profile of the crystals on the descent.

When we got below cirrus base we ran two horizontal level runs, A to B, B to A, from 23:25 and 23:35 UTC. Took full radiation measurements beneath the cirrus. But not in the same region that we did the measurements above, or where we did the CAR circles above.

We are now heading back to some cirrus and we'll see if we can climb up through it to complete our sampling of the particles in the cirrus.

Is anyone on the headset that wants to summarize because we'll be heading back after about half an hour.

MG: I can do my summary if you want, Peter?

PH: Okay, good. This is Mark who is working for NASA summarizing the CAR measurements.

MG: Flight 1758 on 1 June, conditions on takeoff were clear. We booted up the CAR and the accompanying computers without any problem. We initially flew with our downward-looking scanning at the beginning of the ten other flights for BRDF measurements over the ARM site. We set it to BRDF scanning position 3. We did five loops with filter 5 first off, followed with five loops with filter 2. On completing the ten BRDF loops over the ARM site, the CAR appears to have been stuck in position 3, where it remained for the rest of the flight. The next item of interest.

PH: Just interrupt you for a moment. We're climbing now up through the cirrus and the CPI and the 2-D probe are now working. Go ahead.

MG: Since the CAR is stuck in BRDF mode, we continued to collect data, but it's of questionable value. We had a second set of BRDF measurements over initially thick cirrus at about 27,000 ft. Started off with the first of all scans at filter 2. This is at about 22:15. First of all scans at filter 2, the second 4 scans at filter 5. At the end of the eighth loop, at about 23:22, we lost power to the CAR. This made it able to eject the tape and we got a new tape started at about 23:34. The CAR is still stuck in the position 3. That's the end of our log.

PH: Okay, good.

11:47 PM

PH: Jack, why don't you do your summary.

JR: Before the flight I rerouted the ethernet cable so that Peter's computer was closer to the server. It appears that there are more problems now than there were before, so I put it back the way it was.

PH: Also, I might add, Jack, that I did minimum manipulations on this flight. I didn't even try to run a profile.

JR: Right. But I'm pretty convinced that it has to do with the network rather than software. The IR temperature seems to be working real well when we were at the beginning of the flight under warm air conditions, but now it's reading +25˚C when it should read about -25˚C. And, of course, the CPI with all the heat, why it seems to pop the breaker, but we can probably eliminate that by the next flight.

PH: Okay, and the King is still out, of course. The gas instruments appear not to be working. That's about it, isn't it?

JR: Yes, I guess Tim should comment about the gas instruments. I don't know.

PH: At 23:49 UTC the CPI is back up as we continue our climb. Anyone else on the headset there for a summary?

TG: I can do a summary.

PH: Go ahead, Tim.

TG: Prior to the flight we had replaced the scrubber on the CO_2. We'd found a leak for the trace gas system and fixed both of those. So things should have been working, but apparently they aren't. Both the CO_2 and the rest of the trace gas instruments aren't giving reasonable results as far as I can tell. So there is still probably a problem. On the DMPS the butanol was empty and seems to be empty again, actually, even though Don filled it mid-flight, so we're losing butanol quickly on the DMPS and we didn't get good results with the samples I took. Otherwise, there was a haze layer we picked up at 9,500 ft, which had elevated CN concentrations of about 1,000/cc compared to about 200/cc below that. That's about it for this flight.

PH: Ray?

RW: From an aerosol point of view it was pretty uneventful. Real low concentrations for most of the flight. Jack and I moved the RH sensor on the humidigraph from the outlet of the nephelometer to the inlet of the nephelometer yesterday. And I ran a humidigram today and it made it all the way to about 85% without melting the system down or saturating the inlet lines so we might be able to get something.

PH: Isn't it only supposed to run to 85% RH?

RW: It's supposed to run to 90%.

PH: Well, if we can only run to 85%, then we should do that. Don't push it beyond that.

RW: It's probably lower than that.

PH: You might have a word with Dean about that on the telephone, Ray. See if he has any ideas. Okay, Larry, summarize.

LR: We had a number of classic arctic haze encounters today, where the nephelometer would go up and the CN would go down very abruptly and vice versa on the other side of the layers. So surface area and homogeneous nucleation are certainly related. Very nice samples. And also at 27,000 ft minus 46˚C, we encountered a number of periods of low concentrations of entirely spherical particles on the CPI. So those particles were frozen not too long ago. There isn't a crystal habit that causes spheres to grow.

PH: We also saw lots of nice columns and bullet rosettes when we were up in the cirrus clouds.

LR: And it's nice to demonstrate that we're flying the cirrus cruiser here. That was very nice. We clean this aircraft up and lighten it a bit and we'll have the capability for winter time cirrus work anytime.

PH: Maybe if someone puts Larry Radke on the headset, he can say something about what he's seen on the Pilewskie or if anyone else has comments about what they've seen on the Pilewskie. Does anyone have any comments on what they've seen with the Pilewskie on the upper fuselage?

11:47 PM

PH: Does anyone have any comments on what they've seen with the Pilewskie on the upper fuselage?

LR: Early in the flight when I was looking at it trying to take a picture with my digital camera, there was hint of sort of a condensation line near the top of the dome. I wasn't positive about it. I failed to take a picture of it.

PH: I know that Art noted at some point that he was seeing some condensation and maybe some frost when we were climbing.

AR: Roger that. I was just going to chime in there that Larry and I both ascertained that there were frost crystals on the inside of the dome and they were there, I think they were there after we got below -30˚C. I'm almost positive they weren't there prior to -30˚C.

PH: We have a cabin pressure of 10,000 ft now and still climbing. Does anyone else want to make any comments on the tape? Does Don want to make any comments.

LR: I'm very concerned about the gas rack sampler. I don't know what's happening there, but something is preventing a proper sample from being drawn whether it's pressurized or unpressurized.

AR: And we did discover that the deicer heater on the CPI was blowing the circuit and causing the 2-D and the CPI to quit.

PH: Is there any reason to run that except for when we're in icing conditions in super cooled clouds? I see no reason.

AR: No, you're exactly right, Peter. It's just one of those things that everything is the default and you just go with it, but you're absolutely right.

PH: Someone put Don on the headset. Maybe he's got some comments.

DS: The only comments that I have is that I haven't looked at the radiometer recently so I'm not quite sure how it's doing right now. The earliest one, the frost was later on in the flight was very light. How does it look now, Art, the dome up there?

AR: I think I can see a couple of ice crystals still in there, but they've definitely diminished I would say over what they were.

PH: We have an outside temperature of -41˚C.

DS: So at least we've improved it. It doesn't look like it's getting any more in it, so it's probably as good as we're going to get it.

PH: Larry, on the gas instruments, you said you put some smoke into the inlet just where it breaks into the fuselage, right?

LR: That was successful.

PH: So the blockage must be from there out through the fuselage?

LR: I'm coming to suspect that the Venturi on the in and out lines is too efficient and actually there is no positive pressure, there's a negative pressure in the sample line. So the thing sucks all the time when it's properly connected outside. So there's a lowered pressure there and so whether we're pressurized or not we have a potential for a leak.

12:37 AM

AR: We took off and climbed through some cirrus. I'm going to leave off the first portion of the flight, by the way, as I start my summary, because it was too boring to even mention since it was not in clouds.

(j) Summary of UW Flight 1759 (June 2, 1998)

10:25 PM

PH: I'm going to start the summaries. This was a coordinated flight with the ER-2 over the ARM site. We had a layer of stratocumulus. The ER-2 and the Convair-580 flew along parallel tracks from the southeast to the northwest centered on the ARM site. The ER-2 tracks were 140 nautical miles long. The CV-580 tracks were 16 nautical miles long, roughly, except towards the southeast we ran out of stratocumulus clouds so the track was shortened in that direction.

From about 20:30 to 21:00 UTC, we did our horizontal runs above the stratocumulus layer with the CAR scanning down and the Pilewskie radiometers working (no condensation on the upper one). Over the ARM site there wasn't any upper cloud above us, but towards the northwest there was some thin cirrus.

From 21:00 to 21:10 UTC we descended at our southeast point in clear air. Then from 21:10 to 21:29 we ran back to the ARM site and out to our northwest point below-cloud base for the below-cloud radiometer measurements. At 21:16 UTC the ER-2 and the Convair-580 were over the ARM site at exactly the same time. We also crossed over the ER-2 at various other points as we were going backwards and forwards. We had positive contact with the ER-2 so we know that they were on station and doing their planned flight.

From 21:29 to 21:31 UTC we climbed through the stratocumulus at the northwest point. Then we headed back in the stratocumulus to the ARM site and finished that run in the cloud at 21:51 UTC.

It should be noted that the stratocumulus was very variable and breaking up and changing its areal coverage during the flight, but probably not changing its basic microstructure.

We climbed in clear air at our southeast point. Then from 21:56 to 22:19 we did BRDF measurements (ten turns above the stratocumulus deck). In this last part of the flight, we are doing a little precipitation study, since this thin stratocumulus is producing precipitation.

10:30 PM

PH: The precipitation study will take us through the precipitation below cloud base and then we'll gradually climb into the cloud base and out through the cloud top. That will complete the precipitation study.

If anyone else is on the headset, they can do their summary now.

TG: I can do a summary. We tried to follow Dean's suggestion for the gas rack and shut off the NO_X vacuum for this flight to see if it would make any difference in the measurements, but were still unable to sense our own plume so clearly there's another problem. I'll have to find out what it was later. The DMPS had a problem at the beginning of the flight. I found a hole in the bag which was then repaired and that seemed to make things better, but still the type of CN concentrations we're seeing here in the Arctic seem to be too low to lead to meaningful spectrum from the DMPS. We're seeing about 200/cc. Perhaps we need more to get a good DMPS spectrum. In the stratocumulus cloud we flew through the concentrations varied.

In some decks they were about 15 to 20/cc, which was remarkably clean, and in others they were more substantial with LWC up to 3 g m^3 in concentrations of 50/cc, but still very clean.

PH: Ray?

RW: From the point of view of the aerosol station, the most interesting measurements were those of our own exhaust. I moved the inlet to the absorption instrument up to the exhaust of the nephelometer to try to keep the sample dry. And there's a high correlation between the CN count and the PCASP, which indicates that we are sampling outside air. I am reasonably confident now that all the instruments over here are working well.

PH: Jack?

JR: Well, the usual two items didn't work. Well, no, actually the IR thermometer seemed to be working a lot better today, but it's in and out so it's probably rather useless. And of course the King liquid water is not working. The laptops seem to be working perfectly today.

PH: Yes, they did. What was the problem in the beginning with the computer? Was it just dust in there?

JR: Yes, that deserves a mention. No, it was not dust. It was just the disc drive was too cold and had to warm up a little bit.

PH: Anyone at the CAR station want to summarize?

DS: All right. Not a whole lot on the CAR. It was pretty uneventful today. The CAR worked pretty well. We put the CAR into the automatic dwell for filter switching for awhile. It seemed to work fine for 30 to 45 min. Then I started getting noise so I shut that off and went back to manual and locked it back in position 5. We started the BRDF measurements in position 5. Did 5 circles in that, switched to position 2, did the final 5 circles in that. As the ER-2 was passing over, we had it in the downward position for the first couple of passes. Then we switched it to the upward position, while we were in the cloud for the final pass with the ER-2. Right now we're in position 1 and before we go into land I'll put it back up in position 4.

PH: Good.

PH: Have you done your summary, Art?

AR: No, I haven't.

PH: Why don't you do that now? We are just about to descend through cloud base, and then we'll be heading back.

AR: Understand. Today's flight, June 2, we took off just after a weak rainband had passed over the Barrow area and was still lurking offshore when we took off. The clouds overhead had feathered more or less to a layer of stratocumulus. Actually, it looked very much like altocumulus from the ground. The granulation of the cells were so small that it looked much higher than it was. The bases turned out to be about 4,100 ft, tops about 4,500 ft, and running around -3.5 to -4˚C. We flew on top of that trying to coordinate with the ER-2. Eventually we made a few passes. The first pass was north to south as I recall. There was a hole just passing over the ARM site as we passed over on that first pass in a mesoscale region of solid overcast just upstream of that. We came back over that. By that time, on our second pass to the north, the hole had filled in or moved away and we had solid clouds over the ARM site. That may have been below cloud base actually. I'm going to get this a little confused I think today, but I believe maybe on that northbound pass we were actually below the base of the main layer of stratocumulus that passed over the ARM site.

As we passed offshore at that level, another layer of stratocumulus appeared below the aircraft, just as we hit the coastline, and we passed between layers for a couple of minutes and then we reentered the little rainband that had passed over Barrow that morning and went into some ice crystals on top of some stratocumulus clouds below. We turned around and went back. At that time the next pass, which was meant to be in cloud, the clouds had broken up considerably and we found generally scattered to broken over the ARM site. At that time we went on top to look for a solid area and we found a mounding region of stratocumulus clouds and we started out over that and the mounding regions seemed to propagate off to the west while our circle with the wind seemed to drift over clouds that were dissipating.

By the end there were some significant holes. By the tenth circle, there were significant holes down there. So that turned out to be not maybe as good as it was. Spotting some unusual precipitation of very shallow clouds, we finished up by sampling those clouds, which were off to the west in a more or less north-south line. We started at cloud base and went through some shafts and then gradually climbed to cloud top (at about 300 ft/min) which was around -5˚C. Then sampled some tops and then descended back down through the precipitation. Ice crystal concentrations appeared to be in the 100s per liter at cloud top temperatures of around -5˚C. We didn't get very high above the clouds, but there was an extensive haze layer above the aircraft. In one of the passes over ARM, when we were southbound, the haze layer actually descended to the flight level of the aircraft at our southernmost point. I guess that's about it.

PH: Thanks, Art.

(k) Summary of UW Flight 1760 (June 3, 1998)

10:56 PM

PH: I'm going to start our summaries. This flight so far has been concerned with measurements over the SHEBA ship with the ER-2 overhead. We arrived at the SHEBA site at 20:50 UTC, and for the next several minutes we did level runs above an altocumulus cloud top from what we called A to B centered on SHEBA. First of all in the principal plane and then perpendicular to the principal plane.

AR: Peter, there seems to be some haze aloft. I don't know whether it makes any difference or not. Did you want to porpoise through any haze layers.

PH: No. Okay, so that first leg from A to B above cloud top was from 20:50 to 20:53 UTC. Then from 20:58 to 21:00 we did the perpendicular to AB (which we called

CD) also above cloud top. At 21:03 the ER-2 should have arrived over the SHEBA ship. At 21:04 we started our CAR turns drifting over the SHEBA ship, although we didn't drift very far. Those were completed at 21:19 for the purpose of BRDF measurements above the altocumulus.

We then descended below cloud base. Tops were at 10,300 ft. We descended through two altocumulus layers and some stratus and we got down below (or nearly below anyway) the cloud at 21:31. From 21:34 to 21:41 UTC we ran again along the AB and CD orientations centered on the ship, but now below cloud base at 200 ft above the ship above the surface. We then did six CAR turns at about that same altitude drifting over the ship, which was from 21:44 to 21:57 UTC, for BRDF measurements of the surface.

AR: We appear to be reentering the cirrus seeded portion of the altocumulus. Lots of falls and openings.

PH: For the next several minutes (5 min or so), we did 1 mile runs running along the two arms of the "L"-shaped surface albedo site, which has its apex at the tower on the ground. That was for albedo measurements with the Pilewskie radiometers, plus the CAR was running scanning downwards on one of those legs and scanning upwards on the other.

At about 22:05 UTC we started to climb back up to the base of the upper-level altocumulus. It was actually a fairly thin layer and we punched our way through it before we knew it, so we were then on top with a clear sky and a nice altocumulus deck below us. We then did another straight run to get solar flux measurements coming in along a line that we called AB (although it wasn't the same AB as at the beginning of the mission). That was from 22:14 to 22:17 UTC. Then we went back from B to A below that thin altocumulus layer from 22:19 to 22:21. So that gave us a very quick, within a few minutes, measurements above and below the altocumulus for solar absorption calculations. Then from 22:24 to 22:25 UTC we did in cloud measurements also running along the new AB. So those in-cloud measurements should correspond to the same cloud structure that the above and below radiation measurements were done on.

From about 22:27 to 22:40 UTC we did in-cloud measurements in the general area of the SHEBA ship in the upper altocumulus layer, which was located at about 9,800 ft. We left the SHEBA site at 22:40 UTC and we are now heading back to Barrow with a broken altocumulus layer below us at the moment and clear sky above.

We were on station at the SHEBA site for about 1 h 45 m, and we managed to do quite a wide variety of things. This shows its feasible to accomplish our main mission over SHEBA, but if there were an upper cirrus layer then it would be more difficult to do everything and we would have to make a choice between working the upper cloud layers and working the lower layers. As it was, on this mission, there wasn't any upper-level cirrus so we didn't have to make that choice.

If anyone's on the headset, they can do their summaries.

TG: We rigged up some new tubing today to the gas rack with separate inlets to each of the gas instruments and single outlet for the exhaust. The hope was that it would provide good measurements when we passed through our plume, but still there is the same problem as we observed before that when we pass our own plume the gas instruments do not sense anything. So there are still some remaining problems. Otherwise in the aerosol measurements we saw a nice haze layer at about 11,500 ft on the way out to SHEBA above an altocumulus layer with CN concentrations up to 2,000/cc and corresponding increases in large particles measured by the PCASP and total scattering. That's about it for the aerosol and gas.

PH: Anyone else there.

MG: Yes, I can start, Peter.

PH: Go ahead.

MG: We flew out to the SHEBA site scanning down. We reached the SHEBA site at about 20:25.

PH: Speak up a bit, Mark, I can't hear you.

MG: Okay.

PH: Put the mike right on your lips.

MG: I've got it. The CAR instruments are two sets of BRDF measurements and several sets of straight line measurements above and below cloud. The first BRDF measurement were straight runs at AB/CD. Plot was at 11,500 ft. Scanning down for the first AB leg and scanning up for the second CD leg on filter 5. We then did BRDF measurements at 12,500 ft above altocumulus cloud. Six runs, the first three on filter 5 and the second three on filter 2. We then dropped to about 200 ft and did another AB/CD set of runs. The first was looking up at the cloud and the second leg looking down at the ice and some low fog.

This was followed by another set of BRDF measurements this time over open water, some large sections of open water and large sections of ice, in the vicinity of the SHEBA site. The first 3 are on filter 5 and the second 3 are on filter 2. This was followed by the L-legs. The first leg, which was with the CAR facing down, and the second leg had the CAR facing up.

We then climbed again and did some more AB/BA runs. The first time over the altocumulus looking down at the altocumulus, and the second time underneath the altocumulus looking up with the CAR instrument. We then flew through the altocumulus. We left the CAR in the down-scanning mode for the remainder of the trip, and we're still recording data.

PH: Good. Next person.

AR: I guess I'm giving a cloud report here.

I missed the takeoff because the problems with the setting of the CPI the vertical profile through the precipitating clouds. We had some interesting observations on the way out, first flying out over what appeared to be a very homogeneous cloud top of altocumulus. When breaks were visible it was a multilayered situation and then, not in the same region we're in now, we actually saw a nice cirrus seeding of altocumulus producing a huge rift. However, as we went northbound, and got over the homogeneous altocumulus there appeared to be a natural rift, almost a very artificial looking narrow canal, of about the same magnitude with no cirrus above it with the exception of some fine streaks with no fallstreaks underneath.

As we approached the SHEBA ship, probably 20 to 30 miles south of SHEBA, the altocumulus took on a totally different texture and ice tops were visible in a very widespread pattern maybe extending 10 miles around the aircraft. It was very inhomogeneous and eventually one of those holes where the ice was forming approached SHEBA during our period there, and that was the one that we finally ended up in when we exited the region and started heading for that other bank of altocumulus. That was the hole that was originally formed in one of those ice-forming regions. But anyway, that inhomogeneous region of altocumulus for whatever reason, quit and we found a region of extremely homogenous topped altocumulus. The ground was never visible from my vantage point, even though it was a multilayered situation. We overflew that and then descended there with tops at 10,300 ft and bases, according to I believe Larry, at 9,100 ft. So it was about 300 meters thick. Then we descended through into a clearly multilayered situation.

PH: 22:39 UTC. About 2,400 ft.

AR: Peter, do you want me to finish here or should I hold off? Was somebody trying talk here?

PH: No, go ahead.

AR: When we came down through the first altocumulus layer over SHEBA, we encountered a multilayered situation at one point to the south of SHEBA. I counted five layers, including the stratus fog on the surface. However, when we were doing our measurements around SHEBA we were exclusively in three layers, with the stratus flog enveloping the ship from time to time, a layer of stratus/stratocumulus at about 2,000 ft, and then the altocumulus perlucidus layer.

Because of the time involved in sampling, the altocumulus aloft was feathering out toward the hole that was creeping up over the SHEBA site. So it was a little bit thinner aloft than what we had penetrated coming down. There was no indication of a ship plume visually, and there was no indication of any heat perturbing the fog that was topping out at just above the ship, so if there's a heated plume it's not much.

We circled back up sometimes losing the middle layer. The thin layer of clouds probably 300 ft thick or occasionally a bit more than that. Occasionally lost that as we did our circles and then eventually spiraled up. I don't believe we intercepted any of that middle cloud on the way up, and by the time we got up the altocumulus had thinned quite a bit, probably to half or even less of its original thickness that we found when we penetrated it. We sampled that both on top, and will talk about the radiation part. Tops both times are right around -13˚C, I believe, maybe -14˚C at the lowest.

Then, after we decided to find a little bit thicker altocumulus, something that looked a little more representative, we headed southwestward toward a bank of thicker altocumulus. First sampling a thin altocumulus all the way until it widened up as it turned out. When we were doing the porpoising, we again passed through the mottled area of altocumulus clouds that have the patchy high ice-forming areas. For some unknown reason, it had remained very conservative and was creeping upward toward the SHEBA ship and it was also very localized. Probably within 5 to 10 min of encountering it and porpoising through it, we again flew over the homogeneous altocumulus apparently at the same level, but with absolutely no ripples or mottling indicating ice formation. After we passed that region of homogeneous altocumulus, we came back into the region where cirrus seeding was producing many of the big rifts (such as we have out the right wing). I think I'm going to be quitting right there.

PH: Good. I might add that for most of the flight anyway, and I think during our critical measurements, the radiometers (including the Pilewskie radiometers) were probably pretty clear, not much by way of condensation.

AR: That's affirmative, Peter. I saw just a couple little glints when we were up on top there of some crystals that formed underneath, but then they were gone when we descended through that altocumulus layer the first time. By the time we got the temperature up, they went away.

PH: Jack, instruments. Jack, any equipment failures?

JR: No, just the usual King and laptops.

PH: The gas instruments have been no go right from the beginning, still are probably. My computer seems particularly vulnerable to going down, and Jack is trying to find out the reason for that and the King probe as usual. Anything else down?

JR: Not that's been reported to me. I don't know of anything else.

PH: The cabin air pumped onto my viewing port here helps a great deal. So we'll be asking for that to be put in permanently. How about Ray for a summary?

RW: The most interesting scattering was on the ferry out and the ferry back. The scattering coefficients were relatively constant at about 5×10^{-6} m^{-1} and absorption at about 20% of that. As we approach SHEBA the absorption went up where single-scattering albedo dropped to about 0.75 and was very constant. It seemed to be anticorrelated with CN. Did run a humidigraph down near the surface (where we could use the bag house), but there was no aerosol down there. But Don reprogrammed the RH controller, so it's getting up above 80% so it looks like it would probably work. That's about it.

PH: Does Don have anything to say or Larry?

LR: I just talked to my brother Larry and said at about 30 min out to get a good weather report from Barrow that we could descend to cloud or whatever to get some science done in the last 30 min if we want.

PH: Do you want to do a summary, Larry, of the flight?

LR: You bet. Despite great optimism that we had cleaned up the problems of the gas rack, we still have some flow peculiarities there, which seem to prevent the samples from going in the right places. So we'll work on that after landing and hopefully that will work better. We have a number of nice samples today showing the aircraft going through its plume with a strong soot signal and a small CN signal, no nephelometer signal.

PH: Larry, when you say the soot signal, that's on the nephelometer, right?

LR: That's affirmative and we've got no trace gas signals on that even though we've got good trace gas signals from a cigarette lighter here in the airplane. So I've got another idea, which I'm going to talk over with Tim and Ray of how we might make the flows positive in the right direction. So maybe we can get a little something done on the last little bit of the flight at lower altitudes.

PH: Did Don have anything to add to the tape?

AR: He answers in the negative.

PH: So that's the end of the summaries.

(l) Summary of UW Flight 1761 (June 5, 1998)

12:58 AM

PH: Jack, do you want to say what worked and what didn't work today? We're starting our summaries now.

JR: Everything seemed to work, except the usual King LWC and IR thermometer and, of course, just as you mentioned the laptops working we did in fact jinx it. Mine still seems to be working. Well, Ray's went down.

TG: Mine went down once too, but it's up again.

PH: Ray, would you like to summarize?

RW: Well, for the first time we ran two humidigrams and they both worked pretty well. Got growth factors of about factor 2 for RH between dry and about 80%. So that's pretty good. And in some of these parallel traverses absorption scattering ratios varied quite a bit. I don't know how much of it's real, but it varied from about 80% up to 95%. Single-scattering albedo was at 0.8 to 0.95.

PH: Art, the CPI is flashing again. Okay, Tim, go ahead.

TG: First, in the cloud microphysics area, calibrations were done on the FSSP and especially the PVM yesterday, but they served to increase the discrepancy between these two instruments, but more of that will come in post analysis. Otherwise, the CO probe is giving physically meaningful results today because Don fixed a leak in the exhaust, which is great, but still the gas rack is not sensing our plume. We figure it might have something to do with the sensors not being far enough from the inlet.

TG: We ran filters and I hoped they were a success. Everything went very smoothly and I also got the best DMPS spectra that I've seen so far on this flight all in the same location. In the haze layer we measured above the stratocumulus layer we've been sampling today. So it's been a success.

PH: Well done, Tim. We're making progress at that station. Mark or Susan?

MG: Yes, ready now. Okay, everything went well with the CAR today. The original set of measurements were in the aerosol layer. We kept the CAR pointed at the aerosol layer so that when we were above it we were pointing down and when we were beneath it we were pointing up. Following that we did some straight runs through aerosol layers. We kept the CAR pointed down for those measurements. Then we did some straight runs from X to Y, above and below aerosol layers, and kept the CAR pointed at the aerosol layer where possible. This is for the six loop BRDF measurement, which seemed to be pretty successful. The roll angle was fairly steady between about 18˚ and 20˚. Then we returned beneath the clouds to do Y and X runs again. Kept the CAR pointed up at the clouds for those remaining measurements.

PH: Good. Susan or Don?

1:03 AM

SY: Well, I just wanted to say we spotted some condensation on the inside of the SSFR at 22:28. That condensation remained there for most of the flight. At 23:17 there was 50% of the condensation covering the dome.

PH: Okay. Is that it?

SY: Yes, that's about it.

PH: Okay. Don, anything?

DS: I haven't got really anything to add to what anybody said.

PH: I won't try to describe everything we did on this flight because it was quite complicated in terms of flight pattern, but basically what we were doing on the whole flight was concerned with "Scenario No. 4," which I called in short "the aerosol cloud shading effect," which is described on pages 12 and 13 of our Flight Scenario booklet. We were doing patterns that corresponded to Figure 7 in that booklet. Basically we did two such patterns. We started out flying below the cloud at point A and we climbed up through the cloud, which was a low stratus deck, very close to the surface, not very thick. Up through a thin aerosol layer, which had some absorption characteristics to it. Tried to get on top of the aerosol layer. Ran above it and then below it. Then we ran into the aerosol layer and got three bag samples, which were passed through a pair of ionic and carbon filters, and humidification factor measurements from a fourth bag.

Then we basically repeated the above scenario, since I thought that conditions had actually improved somewhat. We had clear sky above. We flew above the aerosol layer and then below the aerosol layer. Dropped down below the cloud layer, but prior to that we did BRDF measurements on top of the stratus cloud layer. Then we dropped below the stratus cloud layer and got a level run as close as we could to the surface, which was actually still in the stratus cloud. The base of the cloud probably reached to the surface. All of this second part was in the form of level runs between what we called XY points. Finally, we climbed a few hundred feet up and into the cloud and ran back toward Barrow in the cloud layer. It should be a pretty good set of measurements for exploring the aerosol cloud shading effect, even though the aerosol layer wasn't particularly dramatic it did have some strong absorption in it. Ray at one point mentioned the absorption was about 50% of the scattering.

That's the end of the summaries. We're now heading back toward Barrow.

1:08 AM

AR: I can't really provide too much more information than what we just heard, but cloud tops ranged from 800 to about 1,600 ft in this really nice amorphous steady state stratus out here with very few holes in it with lots of haze on top. Haze extended to levels above 10,000 ft by quite a bit. Droplet concentrations were maritime, that is somewhere below 100 cm^{-3} in this stratus, and water contents are around 0.2 g m^{-3} at the most. Tim pointed out we had a discrepancy in the PVM and the FSSP effective radius. Although we didn't penetrate the clouds, takeoff was under conditions of a mid-level cloud producing precipitation into a lower layer of elevated stratocumulus and then down into the stratus. The kind of light sprinkly rain we saw before takeoff.

I guess that's about it, except there was, I don't know if it will be visible in anything, a kind of an anomalous zone that reminded me of a shiptrack. And about that time we seemed to hit almost like a plume as you looked under the sun toward the cloud top, the haze layering disappeared and it seemed as though you were in like a smoke plume of some kind that was well mixed rather than layered as we normally see when looking off toward the sun. The cleanest portion of the flight seemed to be within about 10 ft of cloud top with layers above that.

(m) Summary of UW Flight 1762 (June 6, 1998)

10:31 PM

PH: I'm going to start the flight summaries.

This flight can be divided into two parts. The first part was concerned with flying beneath the ER-2. The second part with our Scenario 4, which is the "aerosol-cloud shading" scenario (as depicted in Figure 7 on page 13 of our Flight Scenario booklet for this project).

The first part of the flight was a run over the ARM site, along a track that took us to the north and back again through the ARM site, and then a perpendicular track east and west. The ER-2 was above us, and we confirmed that. We did tracks above, below and in the cloud during that period. So that was a stratocumulus layer from about 1,500 ft to 2,500 ft, no cloud above us. That lasted from about 19:50 UTC and we finished about 21:22.

The second part of the mission was the "aerosol-cloud shading" scenario. We found a region of a nice fairly continuous stratus cloud to the west of Barrow, with an aerosol layer above it and a bit of a gap between the aerosol layer and the cloud layer (as depicted in Figure 7). So we ran first of all above the aerosol layer, then below the aerosol layer but above the cloud layer, and we found a hole in the cloud (as depicted in Figure 7). So we ran those two tracks to B. First of all above the continuous cloud, then over the hole, and then above some broken cloud on the other side of the hole. We then ran a track beneath the cloud base again running from the continuous cloud above us, to the hole above us, and then to the broken cloud above us. Then we climbed back on top of the cloud, tried to find the peak in the aerosol layer, and we're now running at that altitude as we head back toward Barrow for filters samples. We also got a couple of DMPS measurements in the aerosol layer. So that may work out as a pretty good depiction of my Figure 7.

10:42 PM

PH: Let's continue with the summaries. Art, would you summarize?

AR: Yes. I can't add a lot to what you said about the clouds, Peter, except that coordination with the ER-2 was again in one of those situations where the clouds were deeper in the south and east portions of our track compared to the northeast and northwest portions of our track. In other words, the northwest semicircle tended to have thinner clouds at the turnaround points than they did at the two other turnaround points opposite of that. Other than that there is not a lot to say except that the track toward the hole, we did find some merge layers of stratus from the surface all the way up to about 2,100 to 2,200 ft and along the way.

PH: Art, I think it's going to be confusing unless you talk first of all about the first part of the mission and then the second part separately.

AR: Okay, Peter. That's what I've tried to do, but I guess I didn't do it. On the first part of the mission, I'll repeat this, with the ER-2, we again had a wedge-shaped cloud that at the northeast and northwest turnaround points was thinner than the turnaround points at the southern southeast semicircle of the experiment the two legs to the southeast and southwest.

On the second part of the flight, when we went westbound and we were looking for the stratus and the hole, the stratus tops actually had descended from the first part of the experiment, that's the part with the ER-2 they were at 2,500 ft, and had descended out to the west to around 2,100 ft. Along a line paralleling the coast, we intercepted probably the thickest stratus of all, which was a stratus ground fog that merged with the higher layer of stratus and at that time was one of the few times that we saw the sun's disc obscured.

I think I'll just quit there, Peter, because I think you've got pretty much all of it.

PH: Thanks, Art. Mark?

MG: We started the flight with a BRDF measurement, which was fairly successful over a continuous stratus deck. Roll angle was fairly constant, 19˚ to 20˚, which was quite pleasing.

Following that we under flew the ER-2 at which point we went above the cloud. We had the CAR pointed down. Then we went beneath the cloud and we had the CAR pointed up.

This was followed with some runs about a haze layer above some stratus cloud and again when above the haze layer we kept CAR down. When beneath the haze, we kept the CAR pointed up. When we went beneath the cloud layer, we were looking at the cloud above us. Since then we had the CAR in position 1 looking down at the cloud beneath us.

That's the summary of the CAR.

PH: Good. You mentioned the BRDF measurements at the beginning, which I've forgot about, and those may be rather important with the ER-2 above us a few minutes after we completed those turns. Okay, Jack?

JR: Nothing new to report that hasn't been reported on previous flights, except maybe that we tried grounding the network cable the computers might work better.

PH: Things that were out as usual were the King, the IR thermometer and the gas instrument. Anything else?

JR: Oh, yes. That's right the ozone initially had some large offset. I don't know what it was, but it came back 30 min into the flight.

DS: I can answer that, Jack. I went up there and looked at the NO_x box. The NO_x box has an ozone generator that was turned on, but the pump was not turned on so you had a buildup of ozone in the line that the ozone machine was sensing until I turned it off and we turned the pump on a little bit later and cleared it out.

JR: That might explain it.

PH: In any case, I consider none of the gas measurements of any use in this mission. Okay, Ray?

RW: I don't really have very much to say other than scattering was higher than it has ever been before. It got up to about 2×10^{-5} m^{-1} in one of the early layers and the typical high layer that we had was about half of that, about 10^{-5} m^{-1}. Absorption was reasonably low. Anyway, that's about it.

PH: What was the peak absorption you've seen today?

RW: I'd say about 10% of scattering.

PH: Susan?

SY: At 20:01 UTC there was condensation on the inside of the Pilewskie radiometer dome. During our coordinated measurements with the ER-2, there was rime icing on the forward portion of the Pilewskie dome at 20:11. It was when we were descending through and doing a run through the clouds. At 20:17:45 UTC there was a big chunk of ice on the forward part of the dome and it remained there while we did our runs 100 ft above cloud top and when we did our runs below cloud top. At 21:36 UTC, during the aerosol runs, the Pilewskie on-top radiometer looked clear, with only a hint of fine fog or condensation on about 10 to 20% of it. That's about all.

PH: Thanks, Susan. It's your last flight today so thanks for joining us. Is Tim ready to do a summary?

TG: I've got nothing new to add to what's already been said. One quick question though.

PH: You should summarize what you've done on bag samples and DMPS.

TG: We did a number of DMPS samples both in clear air and in various haze layers. Also we did some filter samples in the haze layer immediately above the cloud layer. The best one was in the first bag sample that we took and the worst was the last one, but hopefully combined they should add to a good filter sample. Otherwise, as Jack mentioned, the ozone analyzer has a problem with it that hasn't shown up before with the large offset and otherwise the gas rack is not working just as it has always been not working. That's it for the summary.

(n) Summary of UW Flight 1763 (June 7, 1998)

10:59 PM

PH: I'm going to start the flight summary.

So far this flight has been devoted entirely to SHEBA. After arriving at the SHEBA site, we had a report from the SHEBA ship that there were multi-cloud layers over the ship with ceilings varying from about 800 to 1,600 ft, then variable clouds from 1,600 to 8,200 ft, and more solid cloud from 8,200 to 19,000 ft.

After arriving on station at 19,000 ft we spiraled down over SHEBA through those various cloud layers and the remote sensing from the ship seemed to have got it pretty much right, but we'll have to look at the details in post analysis. When we got down below cloud base, I could see the ship quite clearly. That descent by the way, from above cloud top to below cloud base, was from 20:48 to 21:08 UTC. Then from 21:08 to 21:57 UTC we did runs over the surface albedo site, both legs of the L-shaped site in both directions. At one point our computer dropped out, but we got it back up and repeated the leg.

We also did ten CAR turns with the SHEBA ship at the center. The roll angle was changing because of the wind, but we centered them on the SHEBA ship with a diffuse lighting due to the continuous cloud overhead. From 21:57 to 22:38 UTC we climbed back over the SHEBA ship with the intent of doing a staircase pattern with level runs at different levels in the cloud, but by that time the cloud above the SHEBA ship had changed quite a bit. We had anticipated this because we could see the back edge of the cloud as we came in on site and the back edge was approaching the SHEBA ship and going out toward the east and in fact pretty much passed over us by the time we started our climb. So we found much less cloud on the climb and we sampled the two main cloud layers.

The first level straight leg was at 1,400 ft passing 6 miles on either side of the SHEBA ship. Then we climbed through altocumulus water clouds and we did another level leg in the highest cloud near 19,300 ft, which was cirrus. Then we headed back from our most northerly point back through the SHEBA ship in cloud and out beyond some ways toward the southeast in cloud. Finally, climbing out above the cloud top and heading back towards Barrow. So this should be a pretty interesting data set for comparing with the radar and the lidar and the various other remote sensing instruments on the ship as far as clouds are concerned.

The BRDF measurements made at the surface with the SHEBA ship at the center should be fairly good for diffuse lighting, although one part of that circle we encountered some thin ice showers, which might interfere with the measurements, but generally it should be a good data set.

The main concern with the instrumentation today was that, as far as the laptops are concerned, we seemed to have lost the first channel of the g-meter. Although Tim thinks that this channel may still be recorded on Gerber's computer; that remains to be seen. But the other three channels, Jack thinks, are being recorded okay on our system. The laptops behaved quite well today. Jack found on the last flight that grounding them seemed to help. So maybe that's paying off now. The CPI behaved pretty well today, although we believe that when the temperatures outside falls below -30˚C, and the heaters are full on, it takes too much power and that trips the circuit and drops out the heater. But that's just a hypothesis.

Okay, anyone else on the headset to do a summary?

MG: I can go, Peter.

PH: Go. This is Mark on the CAR.

MG: We started the flight after Barrow with the CAR looking down and flew through a nice frontal passage also with the CAR down at I guess it was about 19,000 ft we flew through the front. After that the main highlight for the CAR was the BRDF measurement centered over the SHEBA site. Ten loops, one in filter 5, one in filter 2. The ice underneath the BRDF measurements was consistent mostly with one or two large leads. Cloud above was diffuse. There was definitely no sign of the sun. The only problem with the BRDF measurement was an occasional run through a snow shower as previously mentioned. That showed up especially in the second set of five loops. After that some straight runs in the vicinity of the SHEBA site. Had the CAR looking down at all times.

One interesting note is that the condensation earlier on in the flight led us to turn the heater on the CAR. Then when we tried the autofilter we noticed that the noise that had been showing up previously on the autochanging filter wasn't showing up any more and further experimentation revealed that the heater somehow suppresses the noise that has been showing up previously. So from now on we'll be flying with the autofilter on other than BRDF measurements with the low heater setting. When we take the instrument back to Goddard, we can find out why this is happening. For now, we're just glad that it does. And that's my summary.

PH: Good. So we learned something else today. Next person.

AR: I can say something about the clouds, Peter. I though you did a pretty good job there. It was a nice transect (as Mark pointed out) of a frontal system. We reached SHEBA just at about the peak time of precipitation. I'm guessing that probably they were getting precipitation from that deeper cloud about the time we arrived on site, because by the time we got well down you could see that precipitation just to the southeast of SHEBA reaching the ground, falling into that stratus layer that we sampled.

The stratus layer we sampled also had tremendous fallstreaks as I'm sure you saw. What we would call code 2, 3 and 4 precipitation, where code 4 is the horizon is not visible behind the precipitation shaft. Once again the tops are in the -5 to -7˚C or so range, and thus very warm for producing so much ice. In this case you would really have to wonder about since the stratus are moving at a different speed than those higher level clouds and certainly the possibility that the ice was a result of ice falling through it from aloft and triggering the loss of reaction that you would guess as to why there was so much ice. So it would be a nice study if we come out there again with no high cloud to investigate that type of precipitating stratus. Tops are about 2,100 to 2,200 ft in the stratus by SHEBA, bases 1,400 to 1,500 ft. I guess that's about all I'll say.

PH: Would you say something about the history of the Pilewskie radiometer dome on this trip. Particularly as we did our measurements over the SHEBA site.

AR: All in all, I thought it was pretty free of ice and condensation. There is a cap on there now covering the top maybe 40% of the whole dome. It looks like it is on the outside and it may be supplemented by something on the inside. The droplets or dirt are so small that you can't see the individual features like we have in the past when we're up around -40˚C and so forth you can see the crystals themselves almost dendritically spreading around in there and doing something anyway. It's very obvious. This time the icing was not a problem. Whenever we had a little patch of ice on there, it was quickly gone after we changed altitude, that was more on the front of the dome. So, in general, I thought it was pretty clean. But it has always been contaminated by something in there. It's never been completely clear.

PH: I've asked Don to clean the radiometer domes on top of the fuselage tomorrow, if we have a day off. Anyone else?

JR: I'll go. Today was a little more interesting than usual for me because the Gerber probe quit and the computer went down once. But I think the computer problem was more associated with laptops again than anything else. The Gerber probe is a little more complex.

PH: Anyone else there?

RW: Yes, I am. The flight out was pretty interesting from about 20:00 to 20:45 UTC as we flew about 18,000 ft in and out of ice in a droplet cloud and alternately clean air. Scattering was high the whole time and absorption was also really high. It sort of varied between about 10 and 30% of scattering and correlated very, very highly with the scattering coefficient. So it's pretty interesting.

PH: That was Ray Weiss just for the record. I should also note that we think there was a correlation between the high light scattering when ice crystals were brought into the nephelometer. We're hypothesizing that maybe they are evaporating and releasing particles that trigger the high light scattering coefficients. I think a post analysis of that portion of the data where we were going in and out of ice crystal fall out and the light scattering was oscillating will reveal if that's correct or not.

11:14 PM

PH: Tim, give a summary.

TG: Nothing much to report from the aerosol stations for today other than that the ozone meter seems to be working better than yesterday. The gas probes are still the same problem as before. Hopefully, that will get fixed soon. The big thing is that it looks as if the g-meter has officially died. The computer has crashed and the hard disk has crashed on Hermann's computer. I'm going to let it cool and check it out again, but it seems like there is some major problems and they will have to be addressed.

1:24 AM

PH: To finish off the summary, over the Barrow area we sampled two aerosol layers, one at 9,300 ft and one at 8,400 ft. The higher level, 9,300 ft, we did three bags for filters, several DMPS, and humidification factor measurements. At 8,400 ft we just did the humidification factor measurements. There is some question about whether the humidification instrument is working correctly. We do get a ramping up with RH, but at some point it starts to produce smoke so that may be affecting the measurements at the higher RHs.

(o) Summary of UW Flight 1764 (June 9, 1998)

9:34 PM

PH: I'm going to start summarizing the flight at this time. We headed out over the Chukchi Sea just off of Barrow. We found a nice stratus layer with clear sky, clear view of the sun, no cloud between us and the sun, no cloud below the stratus. We started off by doing level runs above the cloud. This is a cloud absorption experiment on a single stratus layer. We started off running above the cloud level for radiation measurements coming into the cloud top. Then below the cloud for the radiation getting through the cloud and then in-cloud measurements. We started it at 19:40 and finished it at 20:07 UTC.

Since the situation was also good for the "aerosol-cloud shadowing" experiment (because we had an aerosol layer above cloud top and we had a break in the stratus cloud), we then went into the aerosol-cloud shadowing scenario. We started that at about 20:19 UTC and finished it at about 21:19 UTC. That consisted of a lot of legs. I won't describe them all, but they were above the aerosol layer, between the aerosol layer and the cloud top, in the aerosol layer, including bag samples and filter samples. All this was with cloud beneath us and extending out to where there was a hole in the cloud beneath us. Then runs beneath the cloud. Those runs beneath the cloud also extended out to where the hole was and we got another set of filter samples because there was an aerosol layer between the ground and the cloud base.

We have just climbed up above cloud top to do BRDF circles, but we're waiting for the computer to come back up before we do those. If all goes well, we'll do those turns. We'll do some more measurements in cloud and then we'll head back.

PH: Tim, are you on the headset?

TG: As far as instruments are concerned, the gas rack still isn't working and the g-meter is not working either, at least the forward scattering channel of the g-meter. I got some good filter samples in the haze layer that was above the cloud deck at about 4,300 ft and a second set of filters at about 1,100 ft below cloud. Both were very substantial haze layers, which should provide good filter loading. At the same time, I took DMPS measurements. The DMPS measurements did not read very much; but possible reason for this is that the particles were generally large, in which case the DMPS would not have picked them up because it tends to sense smaller particles. I'm currently taking a filter blank. That's it for today.

PH: Did you notice what the absorption measurements were or did Don?

TG: I didn't. I'll ask Don.

PH: Jack, summarize.

JR: Well, everything seemed to work okay until just one laptop went down or one of the computer's hung or something a couple of minutes ago. Other than that, everything is all right.

PH: The King LWC probe is out still. The gas probes are out. We're not going to put the humidigraph on again because of the smell we get from that, which we are concerned about. The IR is still out, right? Anything else?

JR: Well, right now I believe the IR thermometer.

PH: It comes and goes. One channel of the g-meter is out. But there is no reason to think the other three channels are not working, is there?

JR: No, they seem to be coming up with something. I don't know how useful the information will be.

TG: Yes, I think the channel we lost is probably the most critical one.

PH: Okay.

AR: Tim, did you say the PVM lost the effective radius channel?

TG: Well, I'm not entirely sure about that. It may have been a problem with my laptop. I'll have to look at that after the flight. Let me see, the surface area channel, that was in question.

JR: It seemed to be okay when I looked at it, Art.

PH: Art. Why don't you summarize now?

AR: Our flight began by taking off under thick high clouds, altostratus cirrus, various kinds of cirrus and some altocumulus. We exited those about 30 miles offshore and found a cold air invection case of stratus. A little bit different than we've seen in the last couple of weeks and resembled those cases that we saw early in our flight mission. That is, the surfaces tending to be a bit warmer than the encroaching airmass and the stratus took on a texture of more like stratocumulus or in some cases very cumuliform-like at times, but generally the tops overall are fluffier having more of a turreted appearance than we have seen on many of our flights. Tops of the base of the clouds running 1,100 to 1,400 ft. In various places tops running 2,500 to 2,800 ft. Tops being around -7 to -8˚C. A little bit colder than some of the stratus cases we have seen. However, in spite of that being a little colder, precipitation was muted. There were a few isolated precipitation shafts here and there, but we did not happen to go through any of the thicker ones that I saw.

At the present time, we have a situation of large mesoscale clearings. Probably, would be easily visible on satellite imagery and solid thick stratus, stratocumulus, with the sun being obscured much of the flight legs that we took. We didn't see any drizzle drops or anything like that. I think that's about it, Peter. I've dribbled on here long enough.

PH: Okay.

9:45 PM

DS: Peter, did you want me to say something. I was busy doing things when you were calling.

PH: Yes, you can do a summary now. Did you notice what the absorption coefficient was when we were sampling the aerosol layers?

DS: No, I didn't look at that. I was watching other things. Although, I can say as far as the IR thermometer it looks like it has worked the entire flight. I've been watching that in particular.

PH: Did you have a summary?

DS: Everything here seemed to work fine. Beyond that I haven't got much to say because there are no problems really.

PH: Good. Then the CAR is working fine?

DS: The CAR has been doing great back there. Mark has it all figured out on how to turn it. He's had no problems.

MG: Peter. I'd like to start my summary.

PH: Go ahead on your summary, Mark.

MG: A couple of highlights from today's flight. The first one is that after the good luck on the last flight in discovering that the heater seemed to suppress the noise we noticed with the autofilter, today we've been running continuously with the autofilter on except during the BRDF measurements with the heater on low and we've noticed no noise on any of the channels. So it's great. We're going to continue that for the rest of the experiment.

We started the flight with some runs over and some under a uniform stratus cloud. We aimed the CAR at the cloud so that when we're above the cloud we were pointed at the cloud and when we were below the cloud the cloud we were still pointed at the cloud. When we were in the cloud, I had the CAR pointed up, because I thought the backgrounds of the broken CO smoke made things just a little bit too confusing. During the in-cloud run, we noticed some diffusion domain, but the CAR was stuck so we couldn't get it around to the diffusion angle quickly enough. A subsequent run for some further diffusion domain experiments yielded a fairly short run of what we could confidently call diffusion domain. The ground kept peaking through and the sun kept peaking through at various points, which made only about 100 scans (as far as I could tell) of continuous diffusion domain data.

After that, there was a variety of aerosol runs beneath, above and through an aerosol layer that we discovered. For that I had the CAR pointed at the aerosol layer for the duration of those, there were many runs, I won't describe them all.

Then we finished off today with a fairly successful, I think, BRDF experiment. The roll was pretty steady at 18˚ to 20˚. The stratus deck that we were flying above was thick. We couldn't see anything around. There was no cirrus or anything above us. The sky was completely clear.

That concludes the CAR summary. The last thing we will be doing on the way back is that I will be doing a gang experiment that Tom Arnold asked me to do.

PH: Thanks. Just another note about the diffusion domain that was when we were doing our straight, level passes through the cloud for microstructure measurements. It appeared that in some brief portions of the cloud we couldn't see the sun, we couldn't see the ground, maybe we were in the diffusion domain. So there may be a few minutes of data there on that very nice stratus cloud that we spent the whole flight studying.

We're just coming down now into cloud tops at 2,390 ft on the GPS and we'll do our run back into Barrow in cloud.

(p) Summary of UW Flight 1765 (June 11, 1998)

8:34 PM

PH: We've finished the research now. Larry Sutherland is going to do a couple of approaches to the airfield since we have a bit of fuel to burn off before we can land. We can start the summaries.

This was a flight over the Barrow area and over the Chukchi Sea. Initially, we had hoped to do some radiation measurements on stratocumulus and cirrus clouds, but when we got up we found it was a very confused cloud situation, not really suitable for good radiation measurements. So we ended up during the first part of the flight doing microstructure measurements in stratocumulus/altocumulus, maybe some altostratus and cirrus over the Chukchi Sea.

The second part of the flight was concerned with a vertical spiral downwards from 21,000 ft to 700 ft over the ARM site from 19:46 to 20:34 UTC. Quite a few cloud layers over the site. We paused at about 11,000 ft, did intensive aerosol measurements with three bag samples, some filters and DMPS. Continued our descent and at 700 ft, which was the lowest altitude, we did a few passes straight over the ARM site to get albedo measurements. The surface around the ARM site is mainly bare tundra now, water saturated, with some standing water. The ARM site itself still has snow around it's immediate vicinity.

That was about it for this flight. Next person for a summary.

DS: Art, before you do anything you probably ought to go sit down and buckle up because they're going to be shooting some approaches. In case they have problems.

AR: Okay, thanks, Don.

PH: Yes, everyone should buckle up.

MG: Can I start my summary now, Peter?

PH: Go ahead.

MG: As Peter mentioned, the radiation seemed pretty confused today. We didn't do any BRDF measurements and no really consistent straight line runs that were particularly notable. In fact, the most notable thing that happened today with the CAR was that we think we diagnosed at least the symptoms of the noise problem we've been having with the autofilter. We found that the noise spikes we see definitely correlate to filter changes, while at least one of the channels is maxing up. We'll be discussing that with technical staff on the ground in the near future, but at least this gives us a handle on the problem. Throughout the flight we had the CAR in the downward position until about scan 58,000 we touched the upward position for the end of flight tests for the pilots. That's about it.

PH: Jack?

JR: Nobody has reported any serious problems. Of course, the g-meter in channel one is still out and the IR thermometer is still in its intermittent mode and, of course, the King probe is dead.

PH: Tim. I guess Tim is still busy with his filters. Don?

DS: Well, I have very little to report right now. I changed the filter on the soot absorption. Apparently, yesterday when we were flying in circles and were picking up our own contrail it really sooted one of them up. So I did that at the very beginning of the flight, reset that and got that running and after I got the aerosol station going I came back and tried to diagnose the noise problem on the CAR. That's about it.

AR: Today's weather was marked by easterly flow in the stratus fractus level. The tops out here about 700 ft. The voluptuous stratocumulus layer we penetrated on takeoff was based at 2,500 ft to 6,200 ft. That's probably the deepest contiguous cloud that we've seen here in the Arctic yet for a low cloud. And that cloud layer was moving from the south-southwest. Then aloft at altocumulus level the winds were out of the northwest suggesting a post trough passage situation. That may have contributed to the complexity that we saw here.

We started out by going toward a large clearing. It was almost identical in shape to the one we saw in the previous flight, but, however, the stratocumulus became rather anorexic out there and there were large holes and we had to abandon our plan to do the radiation measurements in that area because it was just too thin. We decided to climb into the altocumulus levels and it turned out the altocumulus was complicated by at least three layers at one time. So we had a total of five layers. We had some cirrus at points, three layers of altocumulus clouds and some stratocumulus below, which was also fragmenting into multiple layers with stratus fractus near the boundary layer. The altocumulus clouds topped out variously at 16,200 ft at the highest point and 15,200 ft in our descent over the ARM site and before that one the altocumulus clouds were topped out at 16,200 ft we headed eastbound and came into some amorphous ice crystal cloud. Hardly could be called a cirrus. It had no structure whatever. It was just a haze of ice crystals. We flew in that. Tried to top that out. Got to 21,500 ft or so and it looked like it continued on for another 2,000 or 3,000 ft.

Then another even higher cirrus layer began to encroach on the site so we again headed westbound. Out of the ice crystals, which were falling into the lower altocumulus clouds, seeding them as it were, in the eastern part of our flight track, we headed for the west and descended through the altocumulus clouds, which were now located at 15,200 ft, bottoms 14,200 ft, another layer 13,200 ft, bottom 12,800 ft, and finally toward the end of that run and even lower altocumulus layer popped out at 12,200 ft and bottoms about 11,800. So there were three layers of altocumulus at that point as we did our descent. So it was an extremely complicated situation.

As Tim pointed out droplet concentrations were rather high in the altocumulus layer, something we had seen before perhaps as high as 250 cm^{-3}, I think he indicated. Along with that, visually, they actually had a brown tinge, which sometimes we have seen in those polluted versions of altocumulus clouds. I guess that's about it. Can you think of anything I might have left out, Peter?

PH: No. But, "voluptuous" and "anorexic." Pretty good! It's getting interesting; I can't wait for the next episode.

TG: I can give a summary now. It's very brief. I took a set of filters and DMPS samples at 11,500 ft in a solid haze layer that had high scattering and also high particle volumes. So that should make for a good filter sample. We observed some good haze layers lower down in altitude earlier on in the flight between 3,000 and 6,000 ft, but those did not appear later on in the flight. So we didn't take a filter sample there. I think that's it. The gas rack still isn't working, but that's the same as it has always been.

PH: So that does it for the summaries. We're still doing our approaches.

(q) Summary of UW Flight 1766 (June 13, 1998)

9:15 PM

AR: I'm going to give a cloud summary now, while it is still fresh in my mind.

Took off from Barrow with cloud bases at the surface were 300 to 400 ft depending on where you were. When the plane left it happened to be a little bit on the high side. There was fog touching the ground in the area. After that we ascended through several haze layers. The highest being topped out at just about our flight level and seemed to slope downward toward the SHEBA site. As we got within 50 miles or so, we actually went above the haze layer. Perhaps it was 100 nautical miles of the SHEBA site. In topping out the haze layer, there was some altocumulus perlucidus translucidus. Very small regions covering less than 30% of the sky. At the same time, we began to pick up mesoscale region of altocumulus clouds largely to the west of the track of the aircraft and clear skies to the east for many kilometers. Then eventually picked up all of that stuff and as it turned out the eastern edge of those mid-level clouds (based at about 8,000 ft, tops 8,500-8,600 ft) were almost exactly over the SHEBA ship. In fact, the shadow and the upper level layer was over the SHEBA ship at the time we began our experiments, but as we went on the eastern edge of that layer moved toward the west or northwest slightly and the SHEBA ship was clear of it for a time, but at the same time some altocumulus clouds formed on the backside of the upper level, the mid-level layer and filled in what was a nice dry slot behind it. Before we (standby one).

9:20 PM

AR: To continue the cloud summary, as we climbed up over the SHEBA ship, we found a much more complicated scenario than we had seen before. The cloud base had risen to about 4,500 ft and then it was only about 100 ft thick. We popped out in a dry slot for maybe not even 100 ft and then so the higher layer of the lower layer began at about 4,700 ft. Then we popped out on top at about 5,000 ft. So a much thinner cloud over the SHEBA ship than we saw at the north end of our climb there where bases were 3,900 ft, tops 5,100 ft and a very uniform layer. So again, we're encountering a wedge-like cloud or undulating bases cloud, thicker at the north end this time, thinner at the south end.

Above the lower layer as we climbed up, we found that the dry slot behind the sharp edge had filled in with some of the clouds that had been off to the east. Instead of the dry slot being there we now had thin altocumulus perlucidus and that was only about 100 to 200 ft thick, base at 8,000 ft, tops 8,200 ft, whereas the thicker portion the bases 8,000 ft, tops 8,400-8,600 ft. That would have been in the inside wall part of the cloud formation. The thinner part in the perlucidus formation over the ship. Over that a small patch of another altocumulus/cirrocumulus we did not get into it. Estimated height above aircraft about 1,000-2,000 ft. Didn't get a good eyeball on that. Again it was a perlucidus formation completely transparent and no shading to the sun. So from the ground, it probably would have been called cirrocumulus. To the south of that, a little wispy patch of cirrus with not much in the way of striations in it at all and that was not over the ship as of yet. A very complicated cloud scenario.

As we head southbound from SHEBA, we are approaching some of the clearing area that we had encountered on most of the trip out here before over flying the altocumulus and then later the two layers of altocumulus and the stratocumulus/stratus. From the bottom, I'm calling the lowest layer stratus because it had no visible undulations in it. So while the details are fresh, I'm going to terminate this summary here.

9:24 PM

PH: I'm going to start my summary of this flight, which was out over the SHEBA ship. We had hoped to find clear sky conditions, but that was not to be. When we arrived, there was a lower stratus layer over the ship and there was an encroaching higher altocumulus layer, the edge of which was very close to the ship. So we decided to first of all to concentrate on the lowest stratus layer just northwest of the ship where the altocumulus layer was not overrunning. So we had one single and fairly uniform stratus cloud layer. We started off by doing BRDF measurements, ten turns, above that stratus layer. We then did a 20-mile level run just above the top of the stratus layer drifting with the wind, with the cloud. So that was for absorption measurements of incoming solar radiation. We then dropped below the stratus layer and did another 20-mile level run still drifting with the wind, which should have been roughly below the run we did above the cloud. Measured the radiation getting through the clouds. So the difference between those two intensities of radiation should get the cloud absorption.

We then went up into the cloud and did another run within the cloud still drifting with the wind and, therefore, still aligned with our AB line.

After that we dropped below the cloud base and did level runs just 300 ft above the surface, above the two arms of the L-shaped surface albedo array just close to the ship. The apex of that being the tower. So that was for albedo measurements (downward-radiation from the upper radiometers, and reflected radiation from the surface from the lower radiometers on the plane).

We then did BRDF measurements, four turns, under diffuse lighting and those were centered on the ship. Between 20:54 and 20:58 UTC we spiraled up over the ship. By this time, the cloud situation had changed quite a bit from what it was an hour and a half previously when we spiraled down. When we spiraled up over the ship, there were now four cloud layers: the lowest stratus layer, an altocumulus layer that was divided into two thin portions, and then above that another broken altocumulus layer. We climbed up through the stratus layer and through the two lower altocumulus layers, that is through three layers, but we didn't climb above the broken altocumulus above. As we started to head back south to Barrow, we ran for a few miles within the altocumulus layer that was just below us. Counting from the bottom, there was the stratus layer, the first altocumulus layer, the second altocumulus layer. We ran in the second altocumulus layer to get some more microstructure measurements. But it was mainly droplets, didn't see hardly any crystals. And that was it.

We are now heading back to Barrow and this will be my last flight on this project. The next two weeks will be concerned primarily with three more flights to SHEBA under various conditions, and another 6 1/2 h of miscellaneous research flying. Is anyone else on the headset? Is that Jack for instrumentation?

JR: Okay, I'll go first. At the beginning of the flight, I tried an experimental version of a computer program running. It refused to accept a lat/long. In a few minutes I had the old version going again.

PH: Jack, the laptops have stopped.

JR: Only yours. It was intentional. Other than that, everything seemed to work okay.

PH: What was not working, the usual suspects: the King probe, the one channel of the g-meter? How was the IR doing on this flight?

JR: The IR and the King were both in their usual state of not working.

PH: So just three things, the King, g-meter (one channel), and the IR.

JR: Yes, that's right.

PH: Anyone else up?

MG: Yes, Peter. I think I can do my summary now.

PH: Go ahead. It's the CAR operator.

MG: Yes, it's Mark Gray here, CAR operator. We started the flight over stratus and flew to Barrow with the CAR facing down. Did some noise checks on the way out, which showed that our earlier thoughts about the culpability of the noise in the CAR were incorrect. The noise doesn't seem to be related to the maxing out of any channels. It seems to come whenever the filter is on auto no matter what. Arriving at SHEBA, we did ten loops over some continuous stratus cloud, not quite over the SHEBA site due to the presence of some high level cloud causing a shadow in the presence of the ship. It worked fairly well. The roll varied between about 17 and 20˚.

Then after that we were getting ready for a 20-mile straight track when we found out that the CAR was stuck in position 3. That's the BRDF mode. Persistent attempts throughout the remainder of the flight have failed to release it from this position. So it's still there. This has meant that we've been stuck in that position for the whole time. We are now at the end of that run over the SHEBA site. We did five loops, the first three on filter 5 and the second two with filter 2 over the loops around the ship over the ice in diffused lighting conditions. Roll varied from 15 to 23˚. In essence we were keeping in constant location. After that, we have continued to try to free the CAR from position 3, but failed to do so. We are returning back to Barrow.

TG: I'd like to do a brief summary of the aerosol and gas station. On the flight out to SHEBA, we encountered a haze layer at 18,000 ft. At first we were below it, but it sloped down as we progressed and eventually we were running through it and it had high scattering and very high particle volume and large particle number concentrations.

We spiraled down to below the cloud deck over SHEBA and then below the cloud deck I took a number of DMPS samples that appeared to be the best DMPS samples I've taken yet, and I attribute that to a couple of holes being found in the bag yesterday and then being fixed. Otherwise, a problem was found with the inlet to the nitrogen oxide analyzer and the ozone analyzer. They are both on the same inlet, which shouldn't be a problem, but because the nitrogen oxide analyzer generates ozone it could have gotten mixed back into the ozone analyzer and caused high readings. So that was changed. They are now on separate inlets. Otherwise though, the gas rack still does not work. It does not even sense our own plumes. That's it.

PH: Art has already given his summary. Don, do you have anything?

9:48 PM

DS: Yes. The aerosol station worked fine. I changed the filters on the nephelometer early on in the flight. It didn't change the readings. The readings were very low. When we encountered our own plume during the loops, the nephelometer worked fine. Beyond that, that's all I have to say.

AR: Peter, the only thing I would have to add to my summary that I gave before was that we're in a situation of long-range transport from the southeast and then the stuff curving up more from the south over the ship. But this would definitely be long-range transport from North America or possibly Asia. It certainly goes over North America before reaching here.

9:49 PM

PH: That's the end of the summaries.

(r) Summary of UW Flight 1767 (June 14, 1998)

9:42 PM

AR: We'll be landing in about 10 to 15 min. I guess closer to 15 min and so you'll want to compose a few thoughts for a summary here of what we did.

9:43 PM

AR: Here's a brief summary of today's flight. We prepared for our flight today for a SHEBA mission, but it was scraped at the last minute because of encroaching clouds at SHEBA. According to M. J. Post some cirrus and low clouds are encroaching. So, with 5 min to door close time, we altered our mission to sample local clouds, beginning with stratus and potentially cirrus later on in the flight if it should present itself.

When we took off the stratus was in the process of thinning from the 3,000 ft depth or more at 12:00 UTC, the time we took off it was bases 700 ft, tops 1,100 ft. We initially headed out to the northeast where the stratus further thinned. More of a surprise was a very chaotic situation aloft with significant convection and cumulonimbus clouds, rain showers down to the ground. We passed through one of the light showers on the way out to the north and northeast and there was a heavy rain shaft and probable cumulonimbus cloud with even perhaps lightning off to the south to emphasis just how chaotic it was. As the stratus thinned in the northeast, we decided to go westbound and try to chase down the thicker stratus, which had been over Barrow earlier in the day.

So, as we traveled out to the west, about 30 to 40 miles west of Barrow, we found a point where the ground was obscured. We decided to begin our point there marking it Alpha and proceed on a true heading to the west and these were approximately 15- to 20-min legs at the top of the cloud and the middle of the cloud and below the cloud to gather some statistics on the stratus. At each end, we did profiles of the clouds spinning down to the surface and back up on top, at Tim's suggestion, which turned out to be fruitful because we found a very heavy haze layer at one end anyway. I believe it was point Bravo. We took some bag samples, which Tim will elucidate a little bit more. As usual the cloud tops changed in height and the bases changed in height from tops around 1,100 ft at the eastern point of our west-east line rising to 1,600 ft at point Bravo. Bases similarly dropped at point Bravo down to about 300 ft at point Bravo and that was down from about 800 ft to 400 ft range at point Alpha. Cloud was stably stratified it appeared. It looked like there was a droplet concentration discontinuity toward the top of it, at least on one of the profiles (this was brought out by Tim).

Now we're heading back, and as we do so we're coming into this complex of convection and cumulonimbus clouds aloft. Bases are probably 8,000 ft or higher AGL and we're entering rain shaft now, and the rain is again so dense as to obscure the horizon behind (or code 4 precipitation) off to the southeast and south of our track as we approach Barrow. The rain appears to have demolished the stratus below us at this point. Perhaps the downdrafts would be rain shafts. That's about all I have to say here. Anybody else want to comment on any part of it? Tim?

TG: Yes, we flew a bunch of legs from Alpha to Bravo. We went from Alpha to Bravo and then Bravo to Alpha and then back from Alpha to Bravo. On each of these legs, I noticed what appeared to be a sort of transition zone with more polluted cloud with higher droplet concentrations on the order of 70 to 80/cc close to Alpha and lower droplet concentrations of between 10 to 30/cc close to Bravo. Going along with that was, I believe, an increase in effective cloud drop radius closer to Bravo than Alpha, about 6 microns close to Alpha and 8 microns close to Bravo. Because of this, I decided we should fly from Bravo to Alpha above cloud. I expected to see a higher albedo closer to Alpha than above Bravo. But as it's turned out, the opposite has been the case, which suggests maybe a thinning of the cloud layer closer to Alpha. Otherwise, I got DMPS samples in the haze layers above the cloud top. I don't know if they are actual haze layers themselves, but at least there was a lot of nucleation, a lot of particles on the order of 2,000/cc. Also a few DMPS samples below cloud base and that's it.

AR: Thanks, Tim. Do you want to say anything, Peter Soulen?

PS: On the cloud absorption radiometer, we rotated the nose cone so that we were in the downward imaging mode throughout most of the flight. We set the filter wheel alternating between 1.6 microns and 2.2 micron channels. For this mission, I'd say that we measured upwelling radiance from the sea ice below through differing amounts of cloud to the plane. Perhaps this will be of some use as we try to figure out how to distinguish between clouds and surface ice for future MODIS retrievals.

AR: Thanks, Peter.

9:51 PM

AR: I also want to mention that the CPI could not be operated for almost the entire flight. Also, the 2-D monitor seems to be shot. It's not picking up any images now. The screen is scrambled.

(s) Summary of UW Flight 1768 (June 18, 1998)

11:31 PM

AR: We were just informed by the pilots that we won't have enough fuel for any extracurricular maneuvers after coming into the Barrow approach zone, where we normally begin our descent. The question was whether we could go on top of some cirrus as priority one or do a Barrow plume study west of Barrow. Well, it looks like the cirrus is going to be too thin, and we can't do anything on the Barrow plume because now we're short on fuel and the primary reason for this is the low marginal conditions at Barrow and Prudoe Bay and the great distance to the SHEBA ship, which is now 405 nautical miles from Barrow instead of the anticipated 250 nautical miles (in our Flight Scenario booklet). So, as it has turned out we're a little bit short on this one. With better weather at Barrow and Prudoe Bay, we probably could have tacked on a cirrus study had we had the good cirrus, but not this time.

11:39 PM

AR: We'll be landing in about 20 to 25 min if anybody wants to pipe up and give the good, bad and ugly of this flight, they are welcome to do so.

11:40 PM

AR: I'll try to do a recapitulation. On the ground at Barrow, it was pretty evident from the texture of the clouds that we had a very clean situation. The sun was quite visible and we had periods of mist coming out of what appeared to be relatively shallow clouds, but that usually ends up being misleading because of the low droplet concentrations. They actually topped out at around, I think it was 1,600 ft, but maybe it was 2,100 ft. Standby one. It was 1,600 ft. Bases around 200 to 400 ft depending on where you were. Droplet concentrations were in the 10 to 20 cm^{-3} range, which is astonishingly low. I think it's the lowest we've seen. We didn't have much drizzle though. A couple of drops appeared on the 2-D.

Our transect to SHEBA was through a nice frontal band, series of bands actually. A bit chaotic because it's the Arctic and there is not much lifting going on. So, the clouds were at multilevels; we first encountered a layer of altocumulus below flight level and then some altocumulus near flight level, which was about 19,000-18,000 ft. We then encountered some cirrus passing overhead, but all of these layers were well separated. Except very briefly, we really didn't get into any of the ice crystals of the cirrus clouds that were encroaching. As it turned out, the highest cirrus clouds were well above 25,000 ft, and had not yet gotten to the SHEBA site. So in anticipation they were there, or were going to be there shortly, we began to climb and it turned out to be unnecessary. Clouds weren't over SHEBA and so we didn't really need to do that. If fact, the cloud tops of the altocumulus layer were down around 14,000-15,000 ft. Also in that area we had a lot of castellanus multilayered altocumulus situation. Tops of the main layer about 14,200 ft with some mounding tops poking out of that. On descent we had layers around 12,000 and 12,200 ft. Very thin cloud that we happened to pass through, I believe that was the height. Then the main altocumulus castellanus' spawning layer was around 10,000 ft. Once we got below that higher layer, and were in the area between layers of the 10,000 ft based layer and the layer based at about 14,200 ft, it was just like a forest of turrets. It was an amazing sight. Strong convective look, really not much layering indicated except for a little piece of in-between altocumulus amongst these trees of altocumulus castellanus turrets. Once we popped out the base of that around 10,000 ft, you could see fallstreaks here and there falling to the ground. Some of them quite spectacular, very heavy looking. Then we continued down to the stratus, which was only around 1,100 ft. Bases 100 to maybe 400 or 500 ft in places. Almost down to the surface.

We did a leg over the SHEBA ship in cloud, just to make sure we had nailed that stratus with the top of 1,100 ft down pretty well. Droplet concentrations were also extremely low again. Very clean stuff down around 10 to 20 cm^{-3}; this was apparent, I should say, from the overflight of the clouds the whole trip. The stratus, when you could see it, were little cloudlets like perlucidus, which were virtually transparent. You could look down through them, very little in the way of shadow on the ground, which would be a sure sign that sunlight was getting through and the clouds were not causing much in the way of shadows.

We then did a quickie pass over the L-shaped array. Our time was running out and one run each time. Unfortunately, the conditions weren't quite right. We didn't have the diffuse domain down there. Diffuse skylight, it turned out to be sun breaks here and there along the array and went back on top.

I should add an addendum here that on top we did do seven BRDF circles over a patch of the densest altocumulus that we could find in the area that looked like it was going to be under open sky. Then it turned out, at least from the backscattering direction, there was a little almost invisible piece of cirrus that turned out to transect the circles. Then, to make matters even worse, the little cirrocumulus depth was probably 10 ft. Little tiny cloudlets began to literally to just form under the blue in that same area. So the sun's disc would go through both the little cirrocumulus and the little wisp of cirrus up there. So, anyway, it didn't turn out to be real successful on that score. After that circle, I'll just repeat, we did a level run at about 14 over the ship in cloud. We did not go down below the cloud exactly at the circles. It looked all the same in every direction and with the time constraint we just didn't do it.

Anyway now we're on the way back. We sampled some altocumulus from time to time, but we didn't have much in the way of flexibility here because of the great distance to the ship and the maneuvers we did do. Anyway, I should mention we climbed back over the ship and tried to get up to the top of the stuff, which was around 20,000 ft. Had a little cirrocumulus up there again and didn't quite make that. We were probably within 500 ft or less or the very highest top over the ship. We did get into just a couple of ice crystals that were falling out of these cirrocumulus/altocumulus perlucidus clouds.

Then on the way back we had long, long periods of being in ice crystal cloud. In the beginning it was underneath altocumulus perlucidus very much like we have off the right wing now. A little segment out there showing fallstreaks all by its lonesome. Anyway, it was a type of cloud like that where the ice was forming in a very thin water droplet cloud, falling out the bottom. We couldn't get to the top of the cloud, we didn't have enough climb ability at that point. Then a little bit down the road the altocumulus perlucidus, very thin droplet cloud, metamorphosed and the situation changed into all cirrus. There was no more droplet cloud and long cirrus uncinus fallstreaks for another good half hour or so. Just absolutely spectacular fallstreaks. The cirrus not that high above the aircraft. It was actually much lower cirrus than we've seen before. Our flight level about 20,000 ft and the cirrus I'm estimating between 23,000-25,000 ft tops.

Anyway once we exited the ice crystal clouds and got into clear air, we learned that we didn't have any time left to do the maneuvers. Our last maneuver will be sampling some stratus on our approach, as much as we can anyway, and call it a day. We also have the usual multiple haze layers. Some of them or most of that seeming to be before we started getting into the storm system itself seemed to be thinning out. It was very smoggy looking on the climb out and we went through multiple layers on the way up. Anybody else want to present any words of wisdom on today, the good, the bad and the ugly. Over.

TG: A few things I would like to comment on. I didn't know if you already mentioned them, Art. We saw two exceptionally clean cloud layers both on take off and over the SHEBA ship. These were stratus cloud layers. The stratus cloud layer close to Barrow had droplet concentrations between 10 and 20/cc and stratus cloud over SHEBA with bases around 400 ft perhaps had concentrations on the average of 5/cc. A veritable soufflé of a cloud. I took DMPS measurements below that cloud layer over SHEBA at 400 ft and a second DMPS at 4,500 ft. Otherwise I think everything has been covered.

AR: Peter Soulen, do you want to add any comments on whether your equipment worked and that kind of thing?

PS: Not much to add to what you've said already. Actually, the BRDF rotation mechanism worked very well except for very near the end when it got jammed. Other than that, I hope that in the next flight we can actually get above a nice clean cloud layer and get some really good BRDFs.

11:50 PM

TG: As far as other instruments being down, maybe these have been noted. The gas rack is still down, of course, and the g-meter is down or at least the forward scattering channel. The new instrument that is down is the CPI.

AR: Thanks for mentioning that Tim. I didn't mention any of that stuff.

DS: Yes, I was getting ready to mention CPI myself. And the other one is the usual one the King LWC probe is not working.

11:51 PM

AR: Everything else, pretty much okay, Don?

DS: Yes, everything else worked just fine.

(t) Summary of UW Flight 1769 (June 19, 1998)

12:11 AM

AR: And we're coming down to the major haze layer here at 13:11:5 UTC. Takeoff in clear skies with cirrus over head. Spiraled up to the bottom of the cirrus over the airport roughly about 17:7:18 on tops in multiple cirrus layers extended to above 30,000 ft in cirrostratus fibratus, which we tried to get out from under in various location as well as get on top of the amorphous cirrus, which comprise the lowest layer of cirrus. Able to do so, so we picked a thin spot where the tops of the amorphous cirrus dropped down and tried to stay out from under the highest layer of cirrus. Unfortunately, we had a tough time doing that because in the saddle regions that we looked at there were scattered altocumulus. Little patches covering 10% of the area perhaps, but nevertheless seeming to bisect the good hole in the upper cirrostratus fibratus that we are trying to get rid of, fly away from. Created huge contrails, which during the period of the BRDF circles that we did anyway in spite of nearly invisible cirrus below us and, unfortunately, as we've seen in the past experiment at -40˚C or so and drifting with the wind.

AR: And then we exited the circle region after doing eight circles, I believe it was. It might have been seven.

AR: As we headed out from the site where we did the circles, we once again encountered some of the higher patchy cirrostratus fibratus on top of the amorphous cirrus, which had mounding tops to about flight level which at that time was 31,000 ft. Then there were saddle areas. We passed through some humps on the way to ARM and then began pretty much north-south legs over ARM at 31,000 ft descending to cloud top, which was lower over ARM. I believe it was about 29,000 ft and then preceded from about a couple minutes south of ARM to 5 min north of ARM and then repeated that leg and tried to stay in cloud as much as possible. But, as usual, clouds are inhomogeneous and there were humped tops at the north end of the run. A saddle almost clear area just north of ARM and then ARM was on the edge of the cirrus when we went through going southbound. It seemed to be more impacted on the first northbound run. Anyway it was just on the edge going southbound at 29,000 ft.

Then we did a leg trying to stay in the middle, which required some contouring because of all the saddle, the topography and the cirrus tops. As it happened when we passed over ARM, we had a fallstreak of the cirrus uncinus variety just about exactly over the ARM site. We nailed that right in the middle as we were descending rapidly from the higher middle of cloud estimated south of ARM to the lower middle of cloud over and north of ARM. At the north end of ARM, the clouds, the cirrus, broke up into two layers so it's a little fuzzy whether we're in the middle there. It looked like we had broken out between clouds.

Then we made another southbound pass at cloud base trying to keep as much as we could in the bottom part of the ice crystals and that required some contouring. As it turned out, the bottom of the lowest cirrus base seemed to be right over ARM as we passed it. After that we did some aerosol stuff, which I'll let the other guys describe. Okay. I just finished a huge cloud summary report. I didn't talk about aerosols, but I tried to discuss the flight and I didn't want to impact too much and I was afraid the tape was going to run out, so I thought I'd better get my piece in first.

RS: Over back into the orbits over the ARM site now.

AR: Thanks, Rod. I tried to squeeze in a summary there without impacting a lot of people, so if you have some words of wisdom you want to slip in while we descend to the ground, you're welcome.

DS: Get in quickly.

TG: There's an aerosol layer on the bottom 15,000 ft.

PS: We got a BRDF. The highest we've ever gone above 30,000 ft. Too bad there were contrails of contamination; but, so what, couldn't help it.

AR: Good summary, Tim. I liked it. I'm going to follow your model from now on.

12:19 AM

AR: And the one thing we did learn on this flight is that we can get to 31,000 ft. It wasn't high enough to do the job on cirrus up there. There was still a layer probably 1,500 ft above. That's the cirrostratus fibratus. It had a little structure in it. That's why fibratus. But we did learn that and I thought that was a valuable lesson.

(u) Summary of UW Flight 1770 (June 22, 1998)

11:13 PM

AR: Summary of SHEBA flight. Transit to SHEBA. No clouds over Barrow. Sampled altocumulus layer on the way out. However, that is no low clouds over Barrow and bases 10,600 ft, tops 10,800 ft. Then continued to climb out and thereafter in and out of amorphous cirrus pretty much the whole way out there.

When we got to the SHEBA ship, cloud tops and bases were indicated to be 23,000 and 17,500 ft (we did not climb to the 23,000 ft). We began our descent from 20,000 ft over the ship and down to the surface. There was no stratus in the vicinity. We did our circles. They were a bit off center because the wind was underestimated at the beginning point and so we drifted off center, but we did get the ten circles in under a partially cloudy sky. Two layers, altocumulus at about 18,000 ft to 20,000 ft and cirrus 20,000 to 23,000 ft. That would be cirrus uncinus mainly and altocumulus perlucidus, very thin, no shading. Nevertheless, the experiment was not quite right. Then we did the array, 10-nautical mile legs over the array, clear conditions. Again, except as noted, that is, there was no low clouds. We then had to depart without climbing into cloud because there wasn't enough fuel. The ship had drifted further away in the previous 24 h and thus cutting our time further than it has been.

On the way back, we sampled cirrus extensively flying in a lower layer of amorphous cirrus much like we had seen on Flight 1769. On the way back, we climbed to 26,000 ft to get on top of the cirrus. We were not on top of the higher tops, but we were on top of cirrostratus nebulosus, barely visible type of cirrus below us, and as we spiraled down a patch of heavier cirrus, that is spiraling over the ARM site, heavier patch of cirrus moved over and we took bigger and bigger bites of it until it too, by the end of our circle, had passed, was small enough that by the time we had reached 18,000 ft we had gone below the base of that and then accelerated our descent to 1,500 ft/min until we found a fairly well indicated haze layer as indicated by Tim and he took a sample. Then we continued down and passed as low as 400 ft over the ARM site, which had an extremely thin stratus cloud probably 30 ft thick that we happened to sample as we passed over the ARM site at 400 ft.

We sampled, more or less inadvertently, stratus during our landing pattern, tops 2,100 ft, bases about 1,600 ft. I think that's about it. Well, I forgot to mention summaries. If you can nucleate or condensate your summary into a few words, why you might slip them in now.

TG: I saw a thick haze layer on the way out. That was about 15,000 ft deep. Almost identical to the one we saw 3 days ago in the flight around ARM. I did not see a similar haze layer out at SHEBA the air was much cleaner. I took a DMPS sample in the boundary layer near SHEBA. On the way back, the haze layer I observed near Barrow had diminished in height. It's top was at 10,000 ft rather than 15,000 ft as observed on the way out. A spiral was made over ARM in which we did the aerosol sampling with the continuous instruments and a DMPS record was made at, I think, 7,200 ft.

PS: Another BRDF with somewhat diffused conditions but still good quality data.

DS: And everything worked pretty well this flight except for the usual, the King and the CPI. That's about it.

AR: Thanks, Don. I gave a summary and I didn't subject everybody to it.

11:20 PM

DS: I'm going to go ahead and take this all the way to the ground again so we can get a profile all the way to zero.

TG: Thanks, Don.

(v) Summary of UW Flight 1771 (June 23, 1998)

1:39 AM

AR: As you can tell, we're beginning our descent from Barrow. That means that we must summarize the flight. I guess I can start off by saying that, as a cloud person, I was deeply offended by this flight because we only had 10 s of cloud right at liftoff, bases on the surface to 200 ft, tops 1,000 ft and clear air all the way except for the haze and I'll let Tim describe that.

We descended prior to getting to SHEBA to save time to start our first BRDF orbits upwind of the ship. We tried to counter for the asymmetry of yesterday's circles by being upwind a little bit more and using the surface wind report at SHEBA. However, the surface wind was deviant from the wind at 2,000 ft apparently and we were off the mark a bit and so after four and a fraction circles, we took a short leg to better drift over the ship at 2,000 ft and then completed six circles, so we actually completed ten and a fraction or somewhere around eleven circles possibly.

After that we had just enough time for 1-nautical mile legs of the L-shaped surface array and that pretty much finished up our measurements at SHEBA. We had no cirrus. Cirrus threatened from a distance; but it stayed off and at no time was there any cirrus over the disc of the sun or anywhere near the disc of the sun and that was confirmed by the SHEBA lidar, which had no return of any kind possibly of the type that could have been produced by "invisible" cirrus.

On the way back to Barrow we'll be sampling some of the stratus that was over the Barrow Airport when we took off. Very clean stratus at least the little segment we were in. We will probably pick up another few minutes of that on our landing. So if anybody else wants to chime in, especially about the haze, I haven't said a darn thing about that. So Tim, I'll leave that to you.

TG: I can chime in. Incidentally, Hobbs' photographs #16 and #17 are of that interesting brown sea ice that we have observing here, patchy, closest to Barrow.

As far as haze is concerned, we observed thick haze layers today as we have in days earlier this week. However, the haze layers have been notably different in that they do not extend to the surface. The haze layer on the way out was between 11,500 ft and seemed to have tops at around 18,000 ft. Another thing that was interesting about this haze layer, as compared to previous days this week was that absorption was a higher proportion of the total extinction than it was earlier. It was typically about 20%, but it was at times as high as 50%. Closer to the ship, the haze layer did extend a bit quite far down to the surface, but it was not particularly strong. Here on the way out we were seeing haze as high as 20,000 ft, which maybe one of the higher altitudes at which we've observed haze. This is quite a substantial haze layer we're observing here at this altitude. That's it.

LR: One of the things that was interesting to observe in the haze is that there have been waves in the haze. You could see the peak and the troughs in the waves looking edge on and we certainly seen it in horizontal flight here. As our flight horizontal legs have hundreds of nautical miles, you can see waves as we're near the top probably of the haze layer. So very pronounced waves and lots of layers as well just to keep it interesting. So it certainly was an interesting haze flight and a very successful surface reflectance mission. I think we've actually done some very interesting surface mapping here. Things are very different than they were two weeks ago out.... (END OF TAPE AND SUMMARY)

(w) Summary of UW Flight 1772 (June 24, 1998)

10:41 PM

LR: Well, from my perspective, this was a nice tidy little experiment with cirrus that's at least understandable if not as uniform as one might ideally like if the 2-D data is good enough to characterize the ice crystals. Lots of fun aerosol as well. A nice tidy little experiment.

DS: Flight engineer's log. This time everything went pretty well. We had to restart the computer once because the CAR went down and that required restarting the main processor. I found a broken wire, which I have clipped, which may have been what caused the problem. That's fixed for now. I'll do a more permanent fix when I get a chance. The other thing that I wanted to note was the PCASP laser. Up at 31,000 ft we ran about -52˚C. The PCASP laser started flashing on and off. When we got down and it warmed up to somewhere between -35˚ and -40˚C, the PCASP laser came back on steady.

AR: Here's a cloud summary. We headed out for ostensibly cirrus expecting to be topped out at 23,000 and 25,000 ft and ended up topping out at 31,000 ft. The types of clouds were mainly the cirrus uncinus and cirrus spissatus (an amorphous cirrus), and cirrus intortus. After some searching around we were able to find a region in which the tops were somewhat lower than the mounding tops of the cirrus spissatus and cirrus uncinus. We performed some semi-orbits drifting against the wind a bit. This proved to be a successful maneuver that Larry Radke came up with and gave us some good BRDF data. At times we were in the banked angle over tops that were a good 1,000 to 2,000 ft below. The clouds themselves were a tangle of fallstreaks, but nevertheless that's real clouds and not model clouds; that's what we had and that's what we were on top of. We did not have the contrail situation over those clouds because of the drying that was occurring at that level and so we only had an intermittent contrail that persisted. The other parts of the flight the contrail left only carbon it appeared.

After a momentary problem with the CAR, we got it in the proper position to do all this, so it was a great effort by Don and Peter to get things going after it looked like we might have a problem. After we did the orbits to get some CAR data, we then decided to run down this more or less east-west line of broken cirrus and try to stay as much in it as possible while conducting a slow descent for maximum acquisition of data to produce a profile in and cloud bases at the tops of cirrus indicated before about 31,000 ft at maximum and the bottoms ended up being were the last dying embers of crystals was at about 21,000 ft. So it was about 3 kilometers thick of clouds and, looking back at them now, they are very plainly evident this little west-east line and even at those depths they are not capable of producing but the faintest of shadows in their thickest portions.

I think that's about it for the cloud summary. We also had an unusual situation I'll mention as far as wind goes at those levels. The Barrow sounding was indicating very, very light winds of 5 to 15 knots from 20,000 to 30,000 ft. And that's it.

LR: The fact that the winds were so light aloft meant that these looping turns that I had us do was to keep us out of our own pollution. We had exact hits when we crossed our geographic position we got a little blip in FSSP and CN. That was kind of fun, because one could almost predict these hits. We had just completed a passage through another haze layer which had been visible out the front. I think we got about one more to go.

AR: Roger, Larry, and I forgot a cloud if you can imagine that. On takeoff we sampled a clean stratus coming out of the east. Bases 200 to 400 ft, lower toward the east and tops were 800 ft. Very thin, very transparent layers we've seen the last couple of days indicating some clean air down toward the very bottom of this high pressure aloft situation that we have today.

PS: CAR report. On the latter part of this flight we actually got some good downward imaging of reflectances of ponds, tundra and this brown ice we've been seeing at 1.6 and 2.2 microns. However, one thing we have to work on is that whenever the CAR automatically goes to the filter wheel channels the data system seems to freeze. So that's something we'll have to work on.

TG: Hobbs' photograph #21 is the brown ice off the left wing. I got a photograph of that on Hobbs' photograph #21, brown sea ice.

DS: Just a short correction on it. It doesn't always freeze when it's in the scan mode, but that's when I've seen it freeze back there and I have not seen it freeze when it's on manual.
