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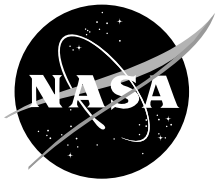

EOS Aqua AMSR-E Arctic Sea Ice Validation Program: Arctic2003 Aircraft Campaign Flight Report

D. J. Cavalieri and T. Markus

September 2003

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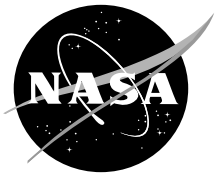

EOS Aqua AMSR-E Arctic Sea Ice Validation Program: Arctic2003 Aircraft Campaign Flight Report

D. J. Cavalieri and T. Markus

National Aeronautics and
Space Administration

Goddard Space Flight Center
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September 2003

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Abstract

In March 2003 a coordinated Arctic sea ice validation field campaign using the NASA Wallops P-3B aircraft was successfully completed. This campaign was part of the program for validating the Earth Observing System (EOS) Aqua Advanced Microwave Scanning Radiometer (AMSR-E) sea ice products. The AMSR-E, designed and built by the Japanese National Space Development Agency for NASA, was launched May 4, 2002 on the EOS Aqua spacecraft. The AMSR-E sea ice products to be validated include sea ice concentration, sea ice temperature, and snow depth on sea ice. This flight report describes the suite of instruments flown on the P-3, the objectives of each of the seven flights, the Arctic regions overflown, and the coordination among satellite, aircraft, and surface-based measurements. Two of the seven aircraft flights were coordinated with scientists making surface measurements of snow and ice properties including sea ice temperature and snow depth on sea ice at a study area near Barrow, AK and at a Navy ice camp located in the Beaufort Sea. Two additional flights were dedicated to making heat and moisture flux measurements over the St. Lawrence Island polynya to support ongoing air-sea-ice processes studies of Arctic coastal polynyas. The remaining flights covered portions of the Bering Sea ice edge, the Chukchi Sea, and Norton Sound.

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I Introduction

On May 4, 2002 the Advanced Microwave Scanning Radiometer (AMSR-E) developed by the National Space Development Agency (NASDA) of Japan was successfully launched on NASA's EOS Aqua spacecraft. This new state-of-the-art satellite radiometer provides a wider range of frequencies and twice the spatial resolution than is currently available with the Defense Meteorological Satellite Program Special Sensor Microwave/Imager. The standard AMSR-E sea ice products include sea ice concentrations at spatial resolutions of 12.5 km and 25.0 km (Comiso et al., 2003; Markus and Cavalieri, 2000), snow depth on sea ice at a spatial resolution of 12.5 km (Markus and Cavalieri, 1998), and sea ice temperature at a spatial resolution of 25 km (Comiso et al., 2003). The scientific usefulness of these products depends on their level of accuracy which will be determined through the implementation of a sea ice product validation program. The overall sea ice validation program consists of three elements: satellite data comparisons, coordinated satellite/aircraft/surface comparisons, and a modeling and sensitivity analysis component (Cavalieri et al., 2003). Arctic2003, the first of two coordinated Arctic satellite/aircraft/surface campaigns, was completed in March 2003. Seven flights were made with the NASA Wallops P-3B aircraft covering portions of the Bering, Beaufort, and Chukchi Seas. This flight report describes the aircraft instrumentation, summarizes the validation objectives of each flight, and provides illustrated examples of the coordination among satellite, aircraft, and surface-based measurements made in the vicinity of Barrow, Alaska and at a Navy ice camp located in the Beaufort Sea.

The main objective of the sea ice validation program is to establish statistical relationships between the sea ice parameters derived from the new AMSR-E sea ice algorithms and those same parameters derived from other data sets obtained from satellite, aircraft, and surface-based measurements covering as many different sea ice conditions as possible for the purpose of providing a comprehensive measure of accuracy for each product. Other objectives are to understand the limitations of each of the AMSR-E sea ice algorithms including the reasons for their particular level of performance under different conditions and to suggest improvements to each of the algorithms based on the results of the validation studies.

The Arctic2003 aircraft flights also supported ongoing air-sea-ice processes studies of Arctic coastal polynyas. The prime objective of the polynya flights is to assess the accuracy to which the AMSR-E sea ice concentration algorithms can map the size of coastal polynyas and to measure the degree of low ice concentration bias, if any, resulting from the presence of thin ice. A second objective is to measure directly surface heat and moisture fluxes over coastal polynyas to evaluate the parameterizations currently used in bulk formulation models and to measure the falloff of these fluxes downwind as the sea ice concentration and ice thickness increase.

Participants in the Arctic2003 EOS Aqua AMSR-E sea ice validation field campaign are listed in Appendix A including those associated with the aircraft flights as well as those making surface measurements at the Barrow, Alaska study area and at the Navy ice camp in the Beaufort Sea. National Ice Center (NIC) sea ice analysis charts and hand drawn charts made by the NIC ice observer on the aircraft are given in Appendix B. The aircraft flight logs for each of the seven flights are provided in Appendix C.

II NASA Wallops P-3B Aircraft Instrumentation

A key component of the validation effort is the acquisition of high resolution passive microwave radiometer data at the same frequencies and polarizations as those measured by AMSR-E. The platform for acquiring these data was the NASA Wallops Flight Facility (WFF) P-3B aircraft. The P-3 aircraft is a 4-engine turboprop capable of long duration flights (8-12 hours), large payloads up to 15,000 pounds, altitudes up to 30,000 feet, and true airspeeds up to 330 knots. More detailed information may be obtained from the Web site www.wff.nasa.gov. A summary of the performance of this aircraft is reproduced from the Web site and is given in Table 1.

Table 1. NASA WFF P-3B altitude, range and airspeed matrix.

	High Altitude 5-30K Feet	Medium Altitude 10-25K Feet	Low Altitude 500-10K Feet
Endurance (Hours)	12	10	8
Range (Nautical Miles)	3,800	3,000	2,400
Speed (Knots)	330	300	270

The P-3 aircraft was equipped with the NOAA Environmental Technology Laboratory (NOAA/ETL) polarimetric scanning radiometers (PSR-A and PSR-CX) covering the AMSR-E range of frequencies (6.9 GHz to 89.0 GHz) and polarizations (H&V). Boresighted with each PSR scanhead was an infrared scanning radiometer operating at 9.6-11 μm. The aircraft also carried the NASA Langley Research Center Turbulent Air Motion Measurement System (TAMMS) for measuring surface heat and moisture fluxes over coastal polynyas. The NASA Wallops Airborne Topographic Mapper (ATM) was flown to obtain high resolution ice surface topography. IR radiometers provided surface temperature, while aerial (digital and video) cameras documented sea ice conditions. Sensor placement on the aircraft is illustrated in Figure 1 and a summary of their characteristics and purpose is summarized in Table 2.

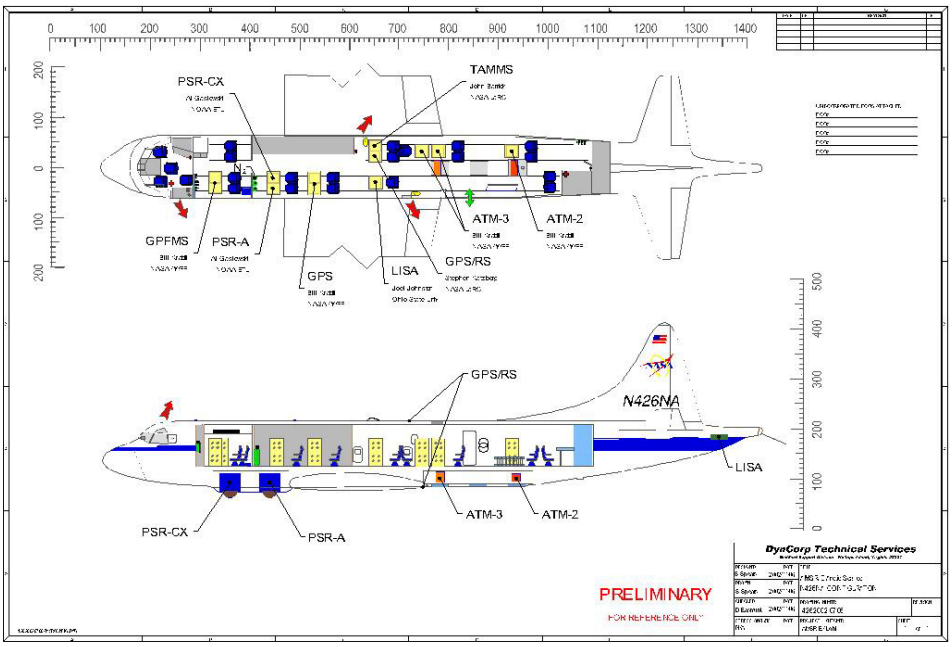

Figure 1. Configuration of the NASA WFF P-3B aircraft for the Arctic2003 aircraft campaign.

Table 2. NASA Wallops P-3B Sensors for Arctic2003.

Sensor	Characteristics	Purpose	Sensor Scientist
Polarimetric Scanning Radiometer (PSR-A)	Operating Frequencies (H&V-pol):10, 18, 22,37, 89 GHz	Simulate AMSR-E Measurements.	A. Gasiewski/NOAA/ETL
Polarimetric Scanning Radiometer (PSR-CX)	Operating Frequencies (H&V-pol): 6 ,10 GHz	Simulate AMSR-E Measurements.	A. Gasiewski/NOAA/ETL
Turbulent Air Motion Measurement System (TAMMS) IR radiometer	Pressure ports coupled with pressure transducers, temperature sensors, and water vapor instruments. 9.6-11 μm radiometer	Measure turbulent heat and moisture fluxes over coastal polynyas Surface temperature	K. Lee Thornhill/ NASA Langley John Barrick/NASA Langley
Airborne Topographic Mapper (ATM-II)	Scanning Lidar altimeter combined with a differ-ential GPS system	Maps ice surface topography at high resolution	William Krabill/NASA Wallops John Sonntag/ NASA Wallops
Video and digital Cameras	Tv video camera; 3 megapixel digital camera (KODAK)	Visible record of ice surface	William Krabill/NASA Wallops John Sonntag/ NASA Wallops

III NASA Wallops P-3B Flight Summary

The P-3 made a total of 7 flights from Fairbanks International Airport (FAI), Alaska. The regions overflown included the Bering, Beaufort, and Chukchi Seas as well as two special study sites over Elson Lagoon near Barrow, Alaska and at a Navy Ice Camp in the Beaufort Sea (Figure 2). Each of the 7 flights are summarized below including a brief description of the flight objective, sea ice characteristics, and coordination with satellite and/or surface-based measurements with illustrations.

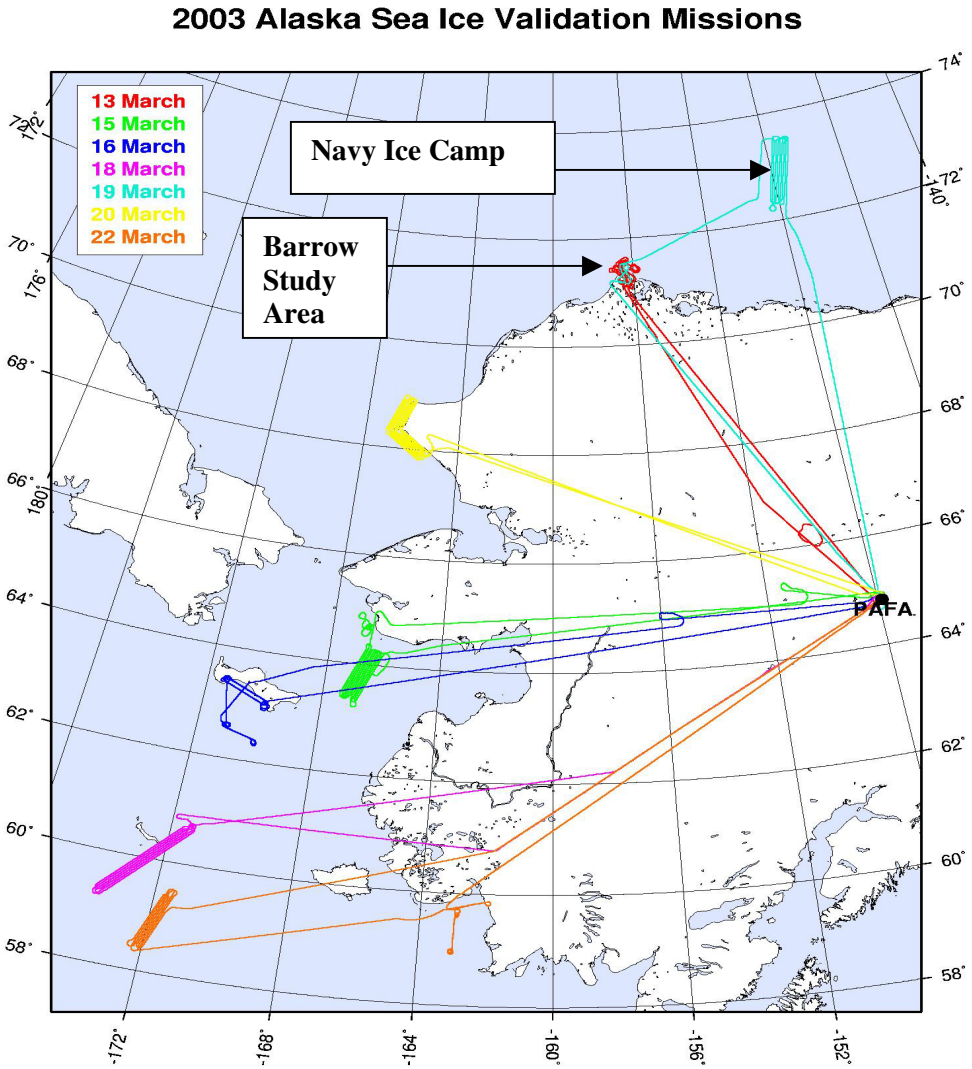

Figure 2. Location of the seven NASA P-3 flights during the EOS Aqua AMSR-E Arctic sea ice campaign. (Courtesy J. Sonntag)

Flight #1 (7.1 hrs): March 13, 2003 Barrow (Elson Lagoon): This flight was dedicated to obtaining aircraft measurements coincident with surface measurements of sea ice temperature and snow depth on sea ice. Surface measurements were made along two transects each approximately 7 km long (Figure 3). Aerial photographic reconnaissance was undertaken with a small aircraft at an altitude of 4,000 feet to provide a large-scale view of the study area before the NASA WFF P-3B arrived in Alaska (Figure 4, bottom). The P-3 made nine runs at an altitude of 500 ft along each of the two transects to ensure complete coverage of the ground measurements and to investigate local variability. The PSR operated in stare mode at this altitude. In addition, the P-3 also made a survey flight at an altitude of 4300 ft to provide microwave and ATM coverage of the entire study region. A Radarsat image of the study area is shown in Figure 5 along with the P-3 flight tracks. Preliminary results show a wide range of snow depths (Figure 4, top) promising an excellent validation data set.

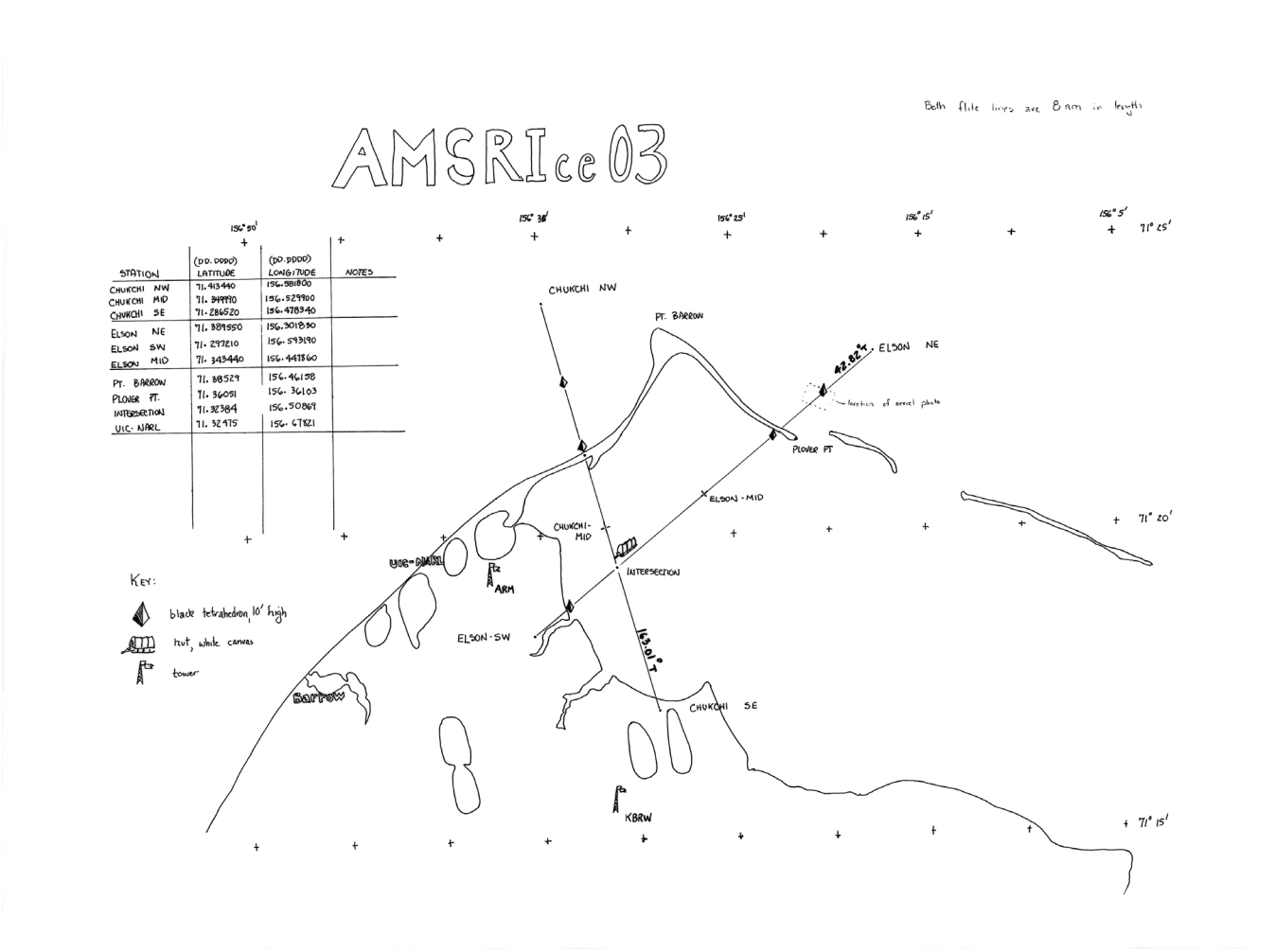

Figure 3. Hand-drawn map showing the surface transects along which sea ice and snow measurements were made at the Barrow study site. The "Chukchi" transect runs in a NW to SE direction whereas the "Beaufort" transect runs in a NE to SW direction. Both transects cut across Elson Lagoon. (Courtesy of M. Sturm & J. Maslanik)

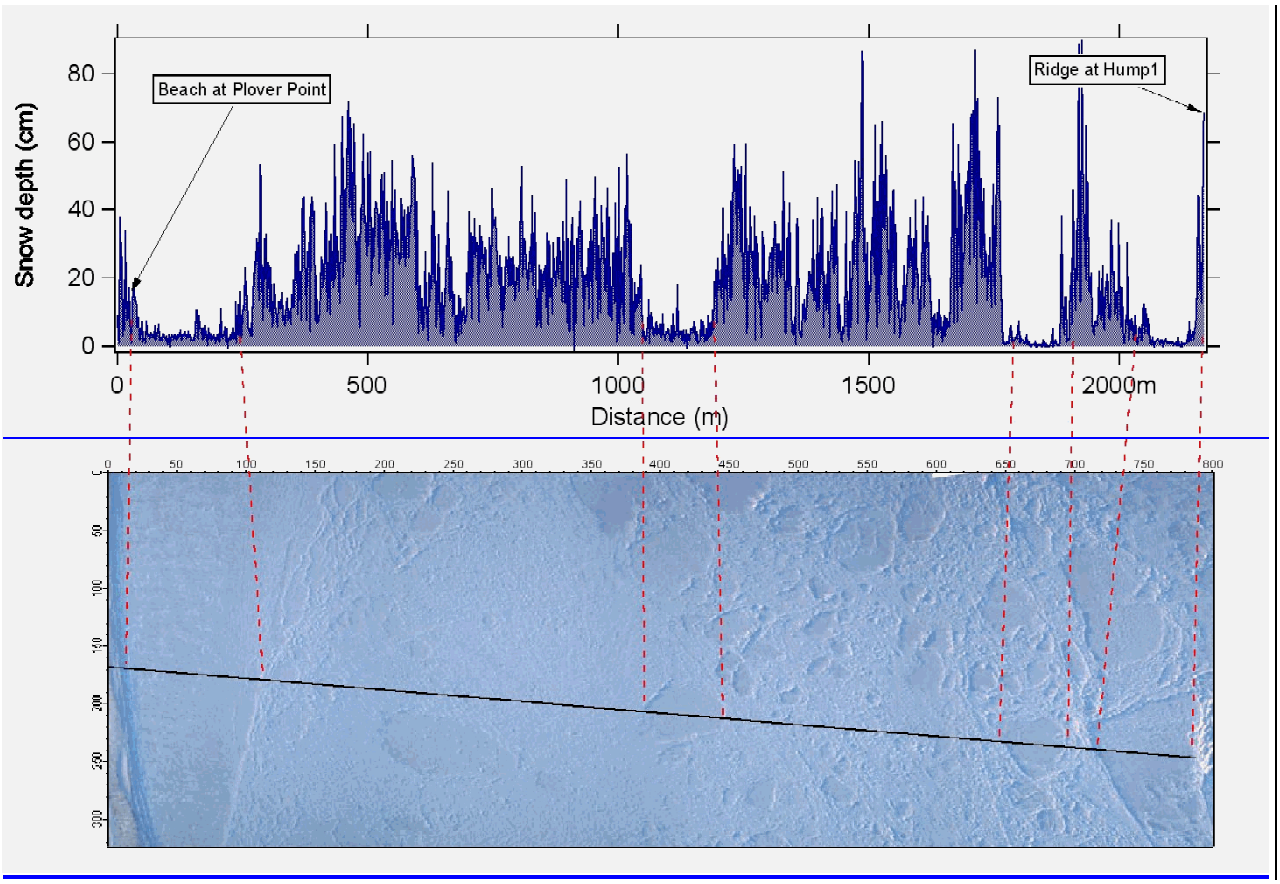

Figure 4. In-situ snow depth measurements (top) and aerial reconnaissance photographic image (bottom) of a portion of the "Beaufort" transect (Figure 3). (Courtesy of M. Sturm, T. George)

Flight #2 (7.3 hrs): March 15, 2003 Norton Sound/Bering Sea: The objective of this flight was to obtain PSR maps of an divergent ice cover coincident with Landsat 7 ETM+ imagery. A total of 10 parallel flight lines were completed at an altitude of 4,300 ft. Landsat imagery shows a coastal polynya off the Nome coast. The polynya contained new, nilas, and gray ice, but very little open water. Farther south, the sea ice concentration varied between 90-100% consisting of primarily first-year thin ice with grease ice and nilas between the diverging ice floes. A Landsat 7 ETM+ image with the P-3 flight lines superimposed is shown in Figure 6.

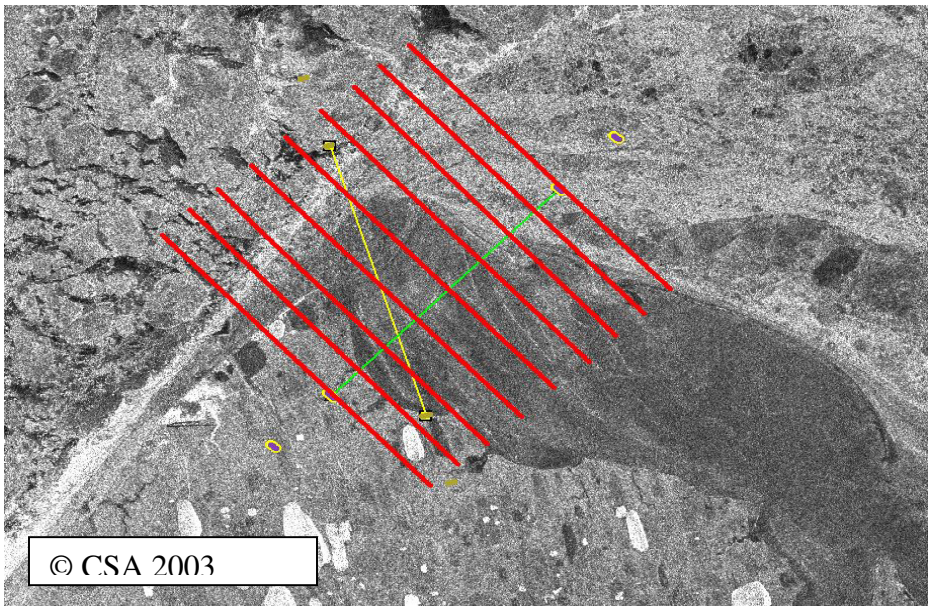

Figure 5. Radarsat image of Elson Lagoon near Barrow. The P-3 500 ft runs are shown in green and yellow for the "Beaufort" and "Chukchi" surface transects, respectively. The red lines indicate the P-3 flight lines at 4,300 ft. (Radarsat image courtesy of the Canadian Space Agency and J. Maslanik)

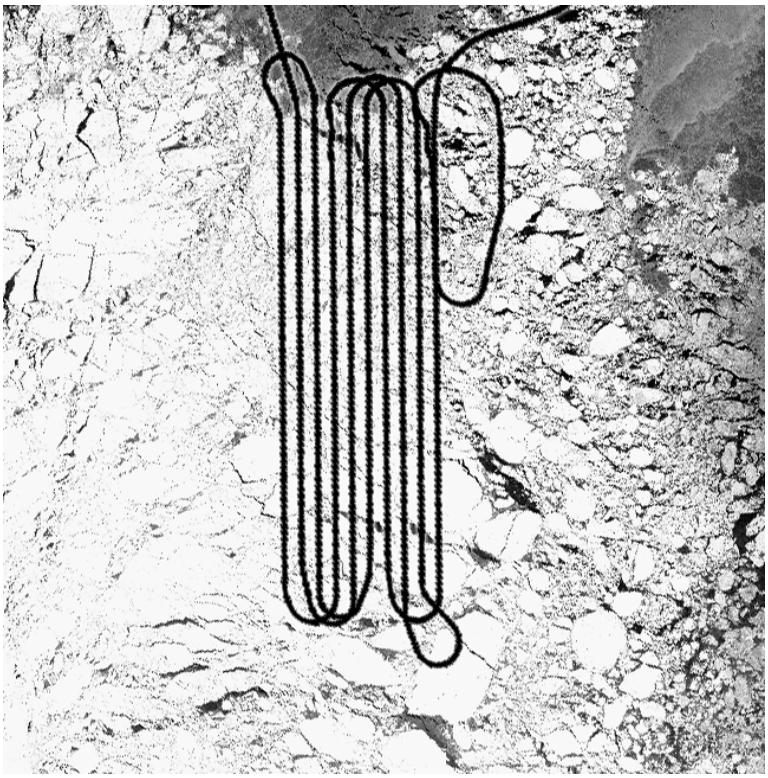

Figure 6. Landsat 7 ETM+ image of the Norton Sound/Bering Sea for March 15, 2003 with the NASA P-3 flight lines overlain. (Courtesy A. Ivanoff)

Flight #3 (8.3 hrs): March 16, 2003 St. Lawrence Island polynya: The objectives of this flight were (1) to measure heat and moisture fluxes over the polynya at three different altitudes (500, 750, and 1000 ft) and at two different distances downwind from the polynya; (2) to map the polynya with the PSR in scan mode and with the ATM from an altitude of 4,300 ft covering the central portions of both stacks. The PSR operated in stare mode for each of the stacks. Similar to the polynya off the coast of Nome, the St. Lawrence Island polynya contained mostly light gray, and dark nilas with little open water. Areas of open water and grease ice were found close to the southern coast of the island and between areas of nilas (Figure 7).

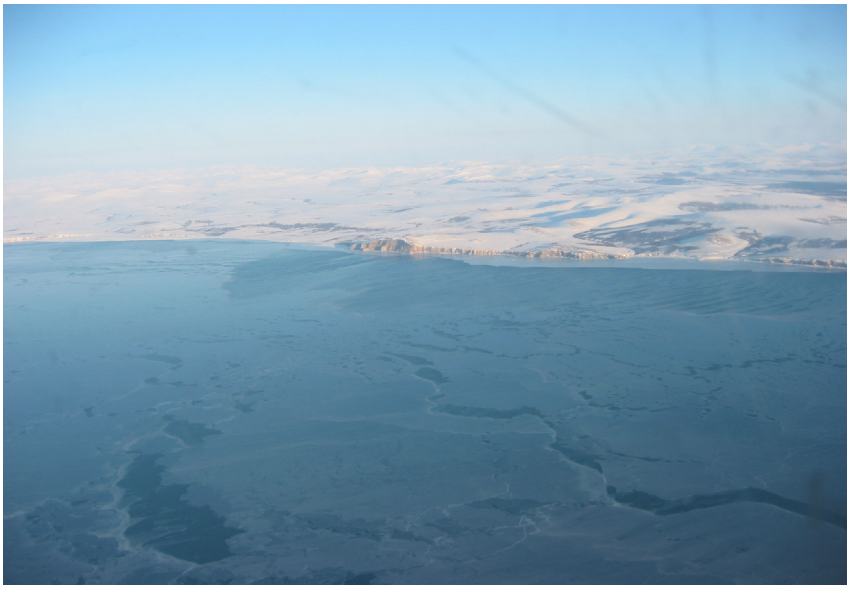

Figure 7. A digital photo of the St. Lawrence Island polynya taken on March 16, 2003. The image shows mostly nilas and gray ice covering the polynya area with open water and grease ice close to the coast and between areas of thicker ice.

Flight #4 (8.0 hrs): March 18, 2003 Bering Sea ice edge near St. Matthew Island: The objective of this flight was to map the ice edge just east of St. Matthew Island. Six lines were flown at an altitude of 4300 ft with the PSR operating in scan mode. An example of the PSR-A scan data is shown in Figure 8 and a coincident RADARSAT image of the area is shown in Figure 9 (left). The RADARSAT image shows many ice bands and streamers at the ice edge and the very diffuse nature of the marginal ice zone. Some large-scale features seen in the RADARSAT image are also visible in the PSR mosaic (Figure 9 (right)).

Flight #5 (7.8 hrs): March 19, 2003 Navy ice camp, Beaufort Sea, Elson Lagoon, Barrow: The objectives of this flight were (1) to map an area of the Navy ice camp with the PSR coincident with surface measurements of sea ice temperature and snow depth on sea ice, and (2) to repeat the coverage of the surface transects flown 6 days earlier on 13 March 2003 over Elson Lagoon near Barrow. Mapping of the ice camp area consisted of flying 9 parallel lines at an altitude of 4300 ft. The 10^{th} line was offset for the purpose of underflying an ICESat overpass. The sea ice conditions consisted of consolidated first-year and multiyear ice.

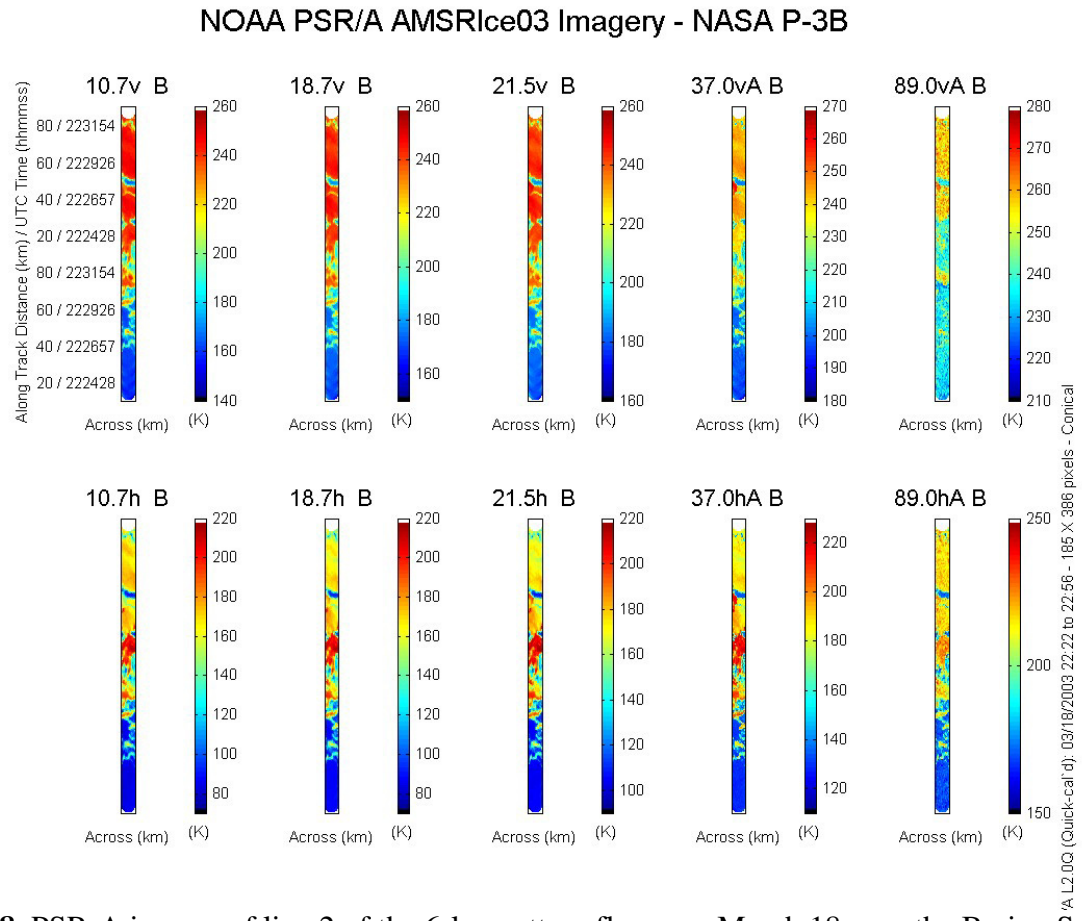

Figure 8. PSR-A images of line 2 of the 6-leg pattern flown on March 18 over the Bering Sea ice edge. The images clearly show the transition from ice-free water (dark blue) to consolidated sea ice (red or yellow) at each frequency and polarization. (Courtesy A. Gasiewski)

Flight #6 (6.2 hrs): March 20, 2003 Point Hope/Kotzebue Sd.: The objective of this flight was to map various first-year sea ice types for direct comparison with AMSR-E. The mapping was done at an altitude of 4300 ft and consisted of two eight-track mosaics adjacent to the coastline north and south of Point Hope. On this day we had both RADARSAT and Landsat 7 ETM+ coverage. The ice types, which included nilas, gray, gray-white, and first-year thin, and their spatial distribution are provided by the National Ice Center ice charts in Appendix B.

Flight #7 (9.0 hrs): March 22, 2003 Ice edge and Kuskokwim Bay: The two objectives for this flight were (1) to map the marginal sea ice zone coincident Landsat 7 ETM+ coverage and (2) to measure heat and moisture fluxes over the coastal polynya in Kuskokwim Bay. The ice edge just east of St. Matthew Island in the Bering Sea was imaged at an altitude of 4300 ft and consisted of seven parallel lines 60 nmi in length. 30 nmi stacks were done at altitudes of 500, 750, and 1000 feet over a mixture of open water and nilas in Kuskokwim Bay. A Landsat 7 ETM+ ice edge scene for this day is shown in Figure 10 with the NASA P-3 flight lines. Jeff Andrews of the National Ice Center provided an ice analysis based on his observations during the flight (Appendix B).

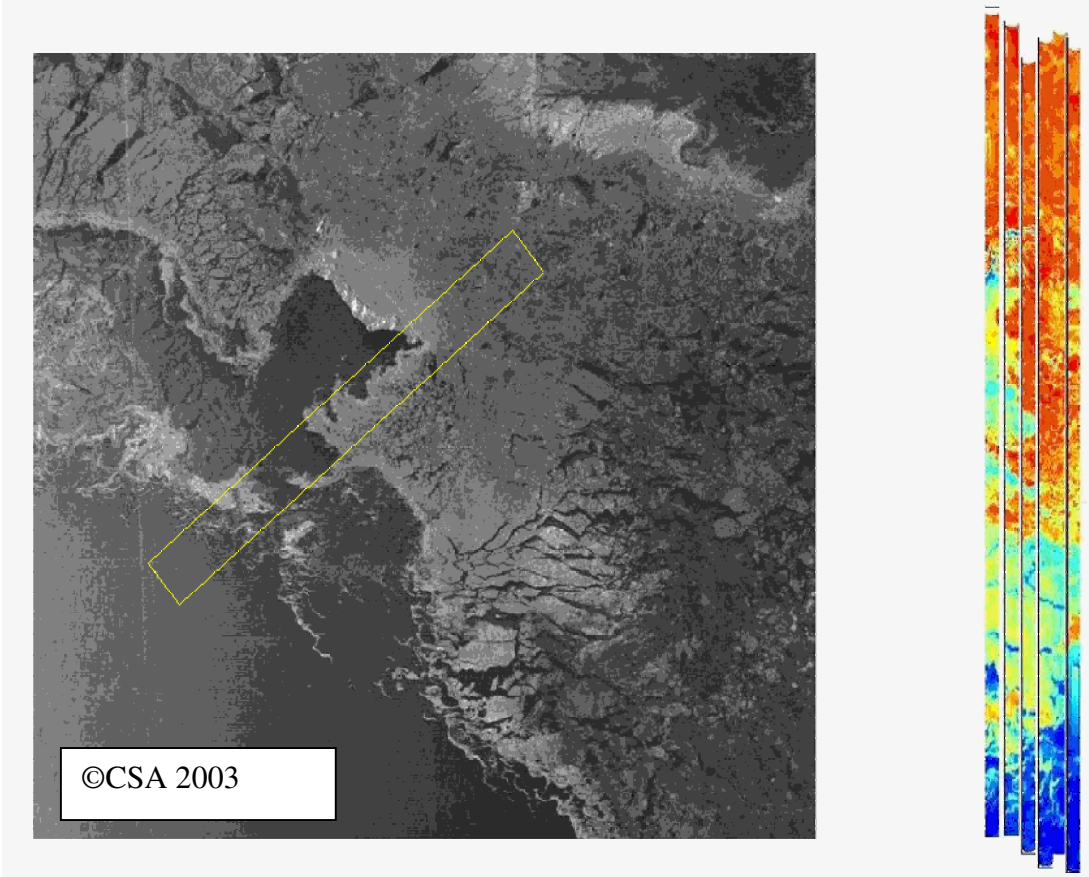

Figure 9. Radarsat image of the Bering Sea ice edge on 18 March 2003 and coincident PSR data. The yellow box in the Radarsat image outlines the PSR area. (Radarsat image courtesy of the Canadian Space Agency and A. Liu and Y. Zhao)

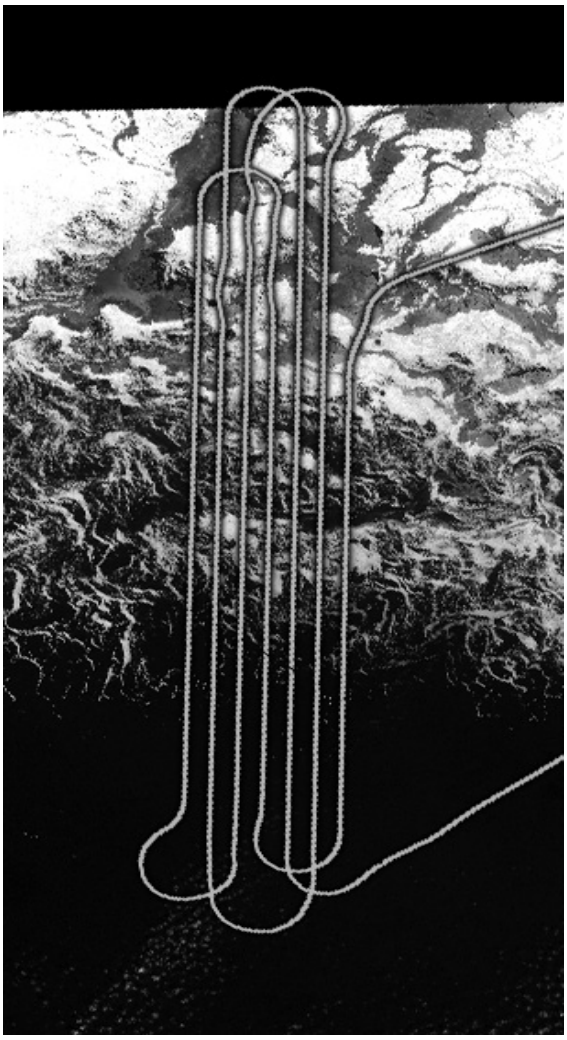

Figure 10. Landsat 7 ETM+ image of the Bering Sea ice edge on March 22, 2003 with the NASA P-3 flight lines overlain. (Courtesy A. Ivanoff)

V Concluding Remarks

The successful completion of the Arctic2003 aircraft campaign promises to provide the data sets needed to validate the AMSR-E sea ice products. The Landsat 7 ETM+ imagery acquired over the Bering and Chukchi seas during the flights will be particularly useful for validating the sea ice concentration products, whereas the coordinated satellite/aircraft/surface data sets acquired in the Barrow and Navy ice camp study sites are expected to serve as the basis for the validation of the sea ice temperature and snow depth products. A new airborne snow radar (Gogineni et al., 2003) will be tested in the Antarctic this autumn and will provide the spatial coverage needed for truly validating snow depth over much larger areas of the Arctic. It is anticipated that this radar together with an airborne AMSR-E simulator will be flown in the 2005 Arctic campaign.

VI Acknowledgements

We thank Michael King, EOS Senior Project Scientist, and David Starr, EOS Validation Scientist, for their full support leading to the successful completion of this mission.

Elena Lobl, EOS Aqua AMSR-E Science Team Validation Scientist, provided the coordination needed for implementing the various AMSR-E aircraft validation campaigns.

Albin J. Gasiewski, Chief of the Microwave Systems Development Division at NOAA/ETL, served as senior sensor scientist for Arctic2003. Marian Klein and Vladimir Irisov operated the PSR-A and PSR-CX microwave radiometers.

Dave Easmunt, NASA Wallops Aircraft Office, as mission manager for Arctic2003 provided invaluable assistance in preparing for and implementing this campaign.

Mike Singer, Rich Rogers, and George Postell, the P-3 pilots, and crew of the NASA P-3 were responsible for maintaining a rigorous flight schedule and meeting all flight objectives.

Jeff Andrews, National/Navy Ice Center ice observer, provided visual observations during each of the flights, interpretation of satellite imagery, and guidance with regard to weather and ice conditions during our flight planning sessions.

John Sonntag, NASA GSFC Wallops, operated the NASA Airborne Topographic Mapper (ATM) and provided the requisite GPS navigation for insuring flight line precision during the coordinated flights over the surface measurement transects at Barrow and at the Navy Ice Camp.

John Barrick operated the NASA Langley Turbulent Air Mass Measurement System (TAMMS) for obtaining heat and moisture fluxes over the coastal polynyas.

Bernard Walter of NorthWest Research Associates provided guidance in the planning of the polynya flights and helped with weather forecasts and flight planning.

John Heinrichs provided near-realtime Radarsat data.

Tom George provided the aerial reconnaissance imagery over the Barrow study area.

Melinda Marquis and Jeff Smith of the National Snow and Ice Data Center helped with flight planning by providing subsetted near-realtime AMSR-E and SSM/I data that.

Michelle Harbin of the UAF Alaska SAR Facility provided office space and internet connection.

John Dragomir and his team of forecasters at the National Weather Service in Fairbanks permitted access to their daily weather briefings and were extremely helpful in providing specific information for our flight planning sessions.

VII References

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VIII Appendix A: List of Participants

Arctic2003 Sea Ice Validation Campaign Participants

P-3B Aircraft Participants	**Affiliation**
Donald J. Cavalieri	NASA Goddard Space Flight Center
Thorsten Markus	NASA Goddard Space Flight Center
John Barrick	NASA Langley Research Center
Lee Thornhill	NASA Langley Research Center
Dave Easmunt	NASA Wallops Flight Facility
Mike Singer	NASA Wallops Flight Facility
Rich Rogers	NASA Wallops Flight Facility
George Postell	NASA Wallops Flight Facility
John Sonntag	NASA Wallops Flight Facility
Rob Russel	NASA Wallops Flight Facility
Richard Mitchel	NASA Wallops Flight Facility
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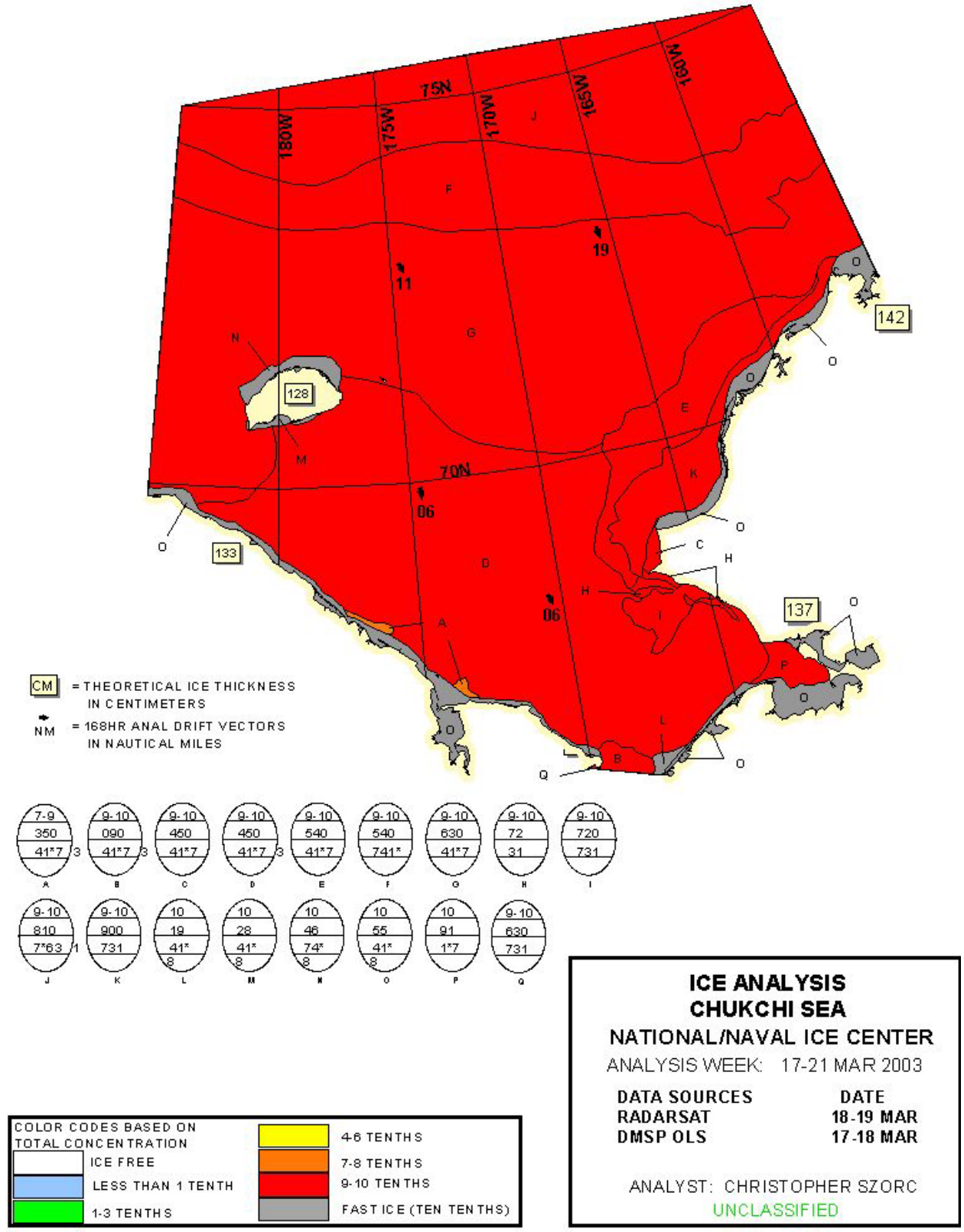
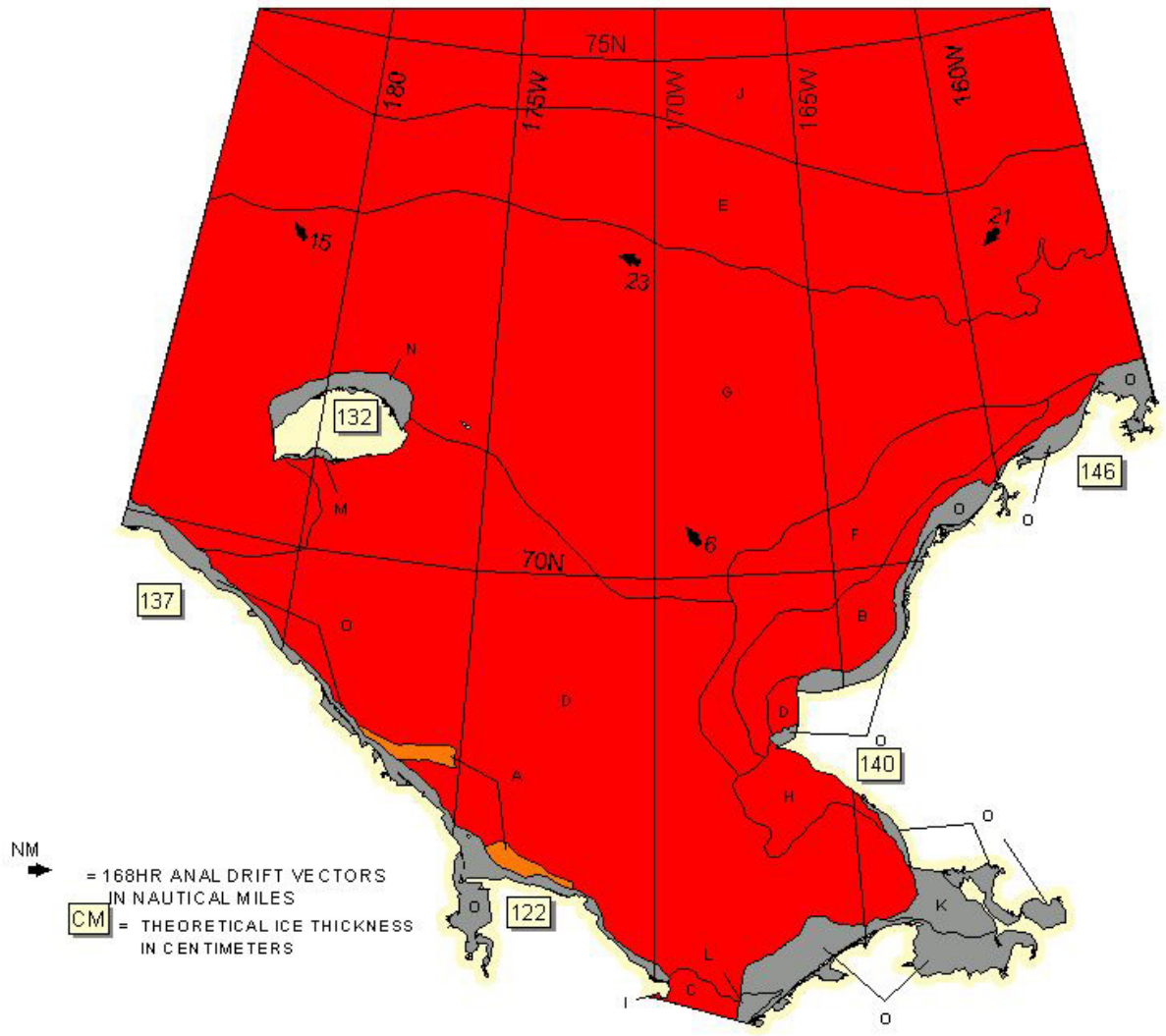
William P. McAnallen	National/Navy Ice Center
Albin J. Gasiewski	NOAA/Environmental Technology Laboratory
Vladimir Irisov	NOAA/Environmental Technology Laboratory
Marian Klein	NOAA/Environmental Technology Laboratory
Bernard Walter	NorthWest Research Associates
Sinead L. Farrell	University College, London UK
Surface-Based Participants	**Affiliation**
James Maslanik	University of Colorado, Boulder
Julienne Stroeve	University of Colorado, Boulder
Matthew Sturm	CRREL, AK
Jon Holmgren	CRREL, AK
John Govonni	CRREL, AK
Jackie Richter-Menge	CRREL, NH
John Heinrichs	Fort Hayes State Univ., KS
Cessna 185 Aerial Reconnaissance	**Affiliation**
Tom George	Terraterpret, Inc.

IX Appendix B: National /Naval Ice Center Analyses





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COLOR CODES BASED ON TOTAL CONCENTRATION

- ICE FREE
- LESS THAN 1 TENTH
- 1-3 TENTHS
- 4-6 TENTHS
- 7-8 TENTHS
- 9-10 TENTHS
- FAST ICE (TEN TENTHS)

ICE ANALYSIS
CHUKCHI SEA

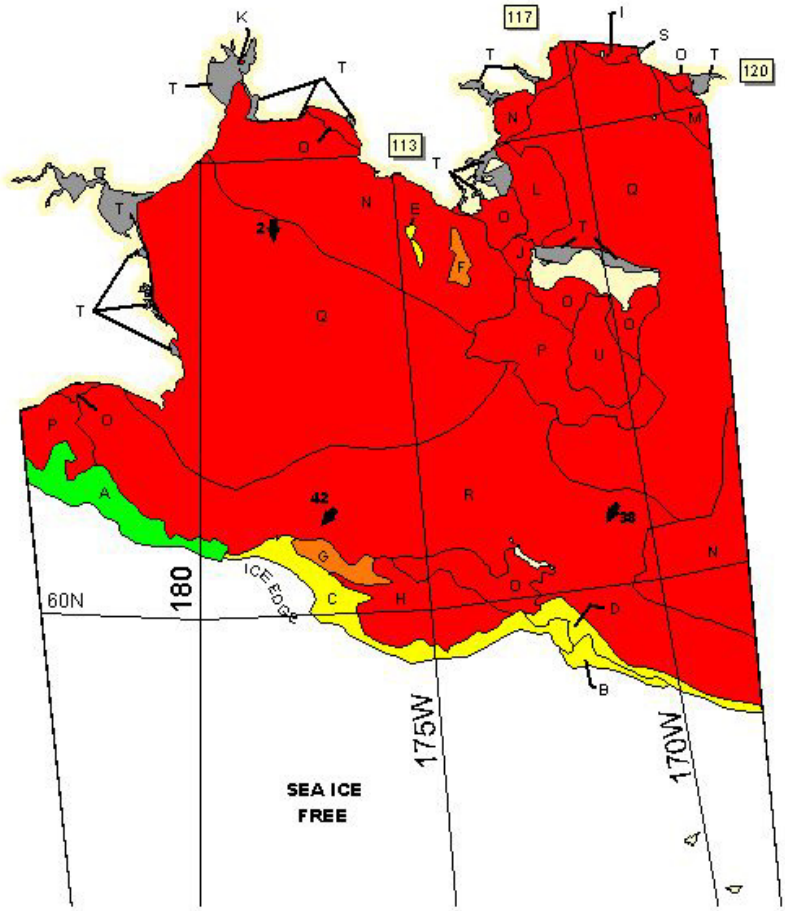
NATIONAL/NAVAL ICE CENTER

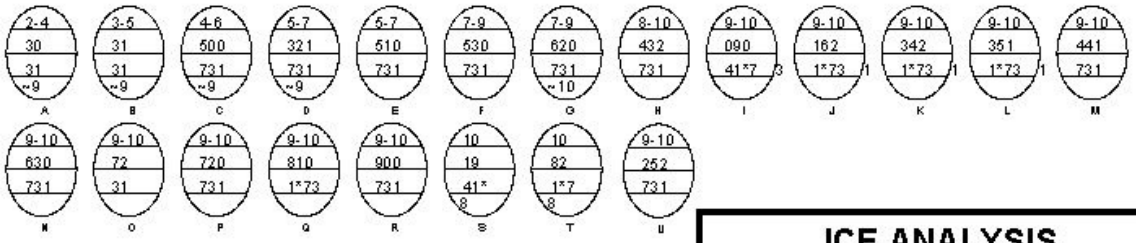
ANALYSIS WEEK: 24-28 MAR 2003

DATA SOURCES	DATE
RADARSAT	23-24 MAR
DMSP OLS	24 MAR
AVHRR	24-25 MAR
ESTIMATED	24-25 MAR

ANALYST: AG1 (SW) LOTITO
AG1 (AW) POORMAN U/I

UNCLASSIFIED





NM =168 HR ANAL DRIFT VECTORS
➨ IN NAUTICAL MILES.

CM =THEORETICAL ICE THICKNESS IN CENTIMETERS

COLOR CODES BASED ON TOTAL CONCENTRATION

- ICE FREE
- LESS THAN 1 TENTH
- 1-3 TENTHS
- 4-6 TENTHS
- 7-8 TENTHS
- 9-10 TENTHS
- FAST ICE (TEN TENTHS)

ICE ANALYSIS
WEST BERING

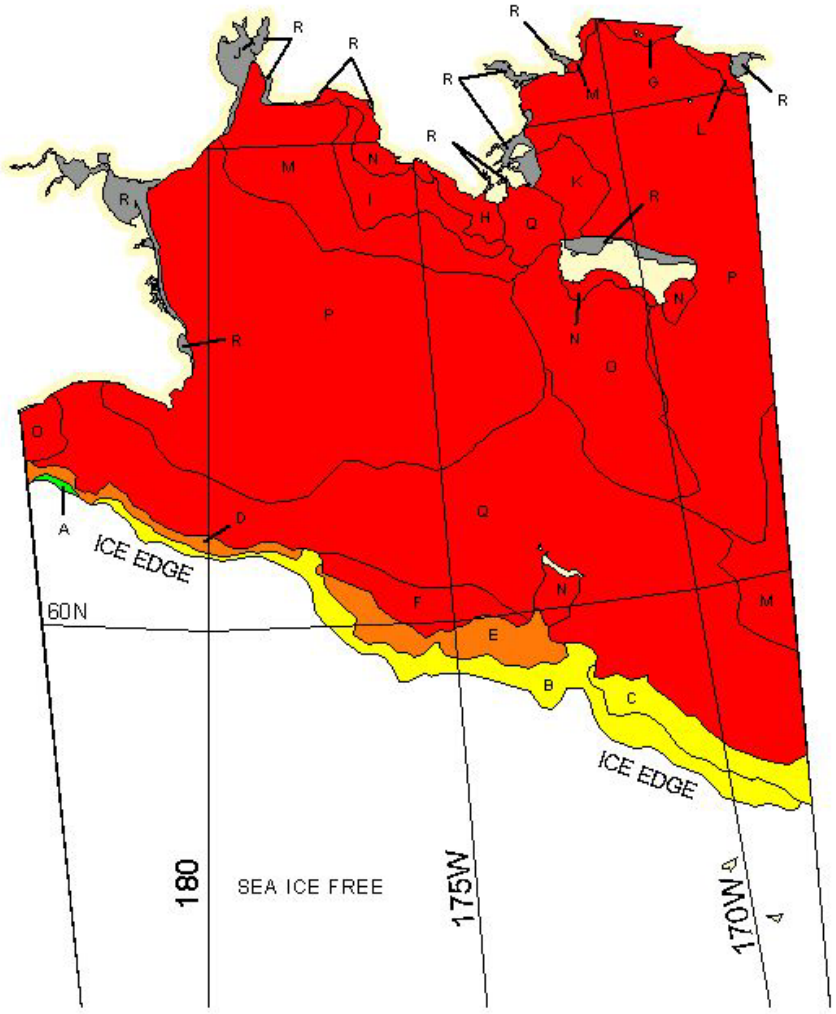
NATIONAL/NAVAL ICE CENTER

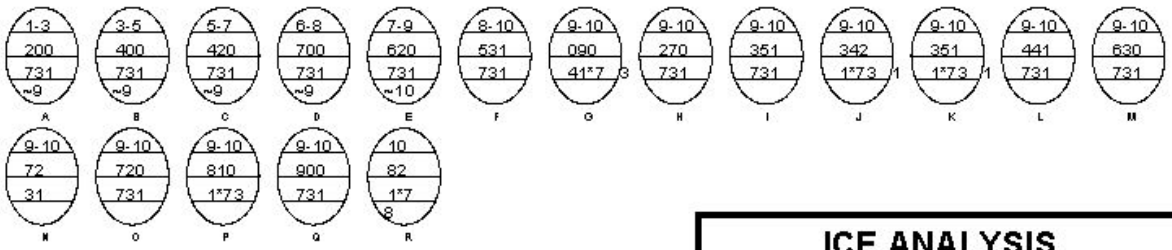
ANALYSIS WEEK: 17-21 MAR 2003

DATA SOURCES	DATE
RADARSAT	16-17 MAR
DMSP OLS	16 MAR

ANALYST: CHRISTOPHER SZORC

UNCLASSIFIED





ICE ANALYSIS
WEST BERING
NATIONAL/NAVAL ICE CENTER
ANALYSIS WEEK: 21 MAR 2003

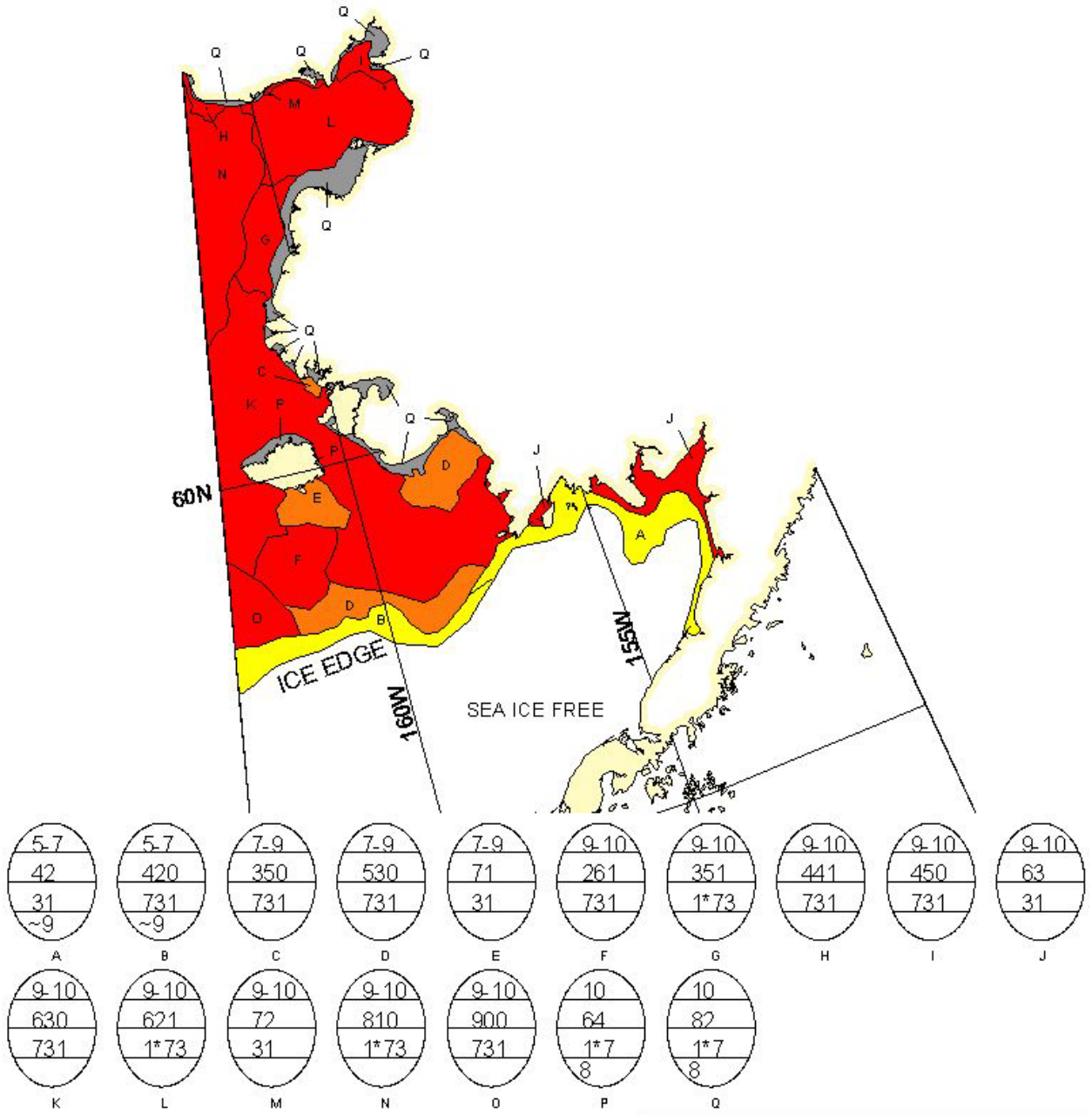
DATA SOURCES	DATE
RADARSAT	19-20 MAR
DMSP OLE	19 MAR

ANALYST: CHRISTOPHER SZORC

UNCLASSIFIED

COLOR CODES BASED ON TOTAL CONCENTRATION

- ICE FREE
- LESS THAN 1 TENTH
- 1-3 TENTHS
- 4-6 TENTHS
- 7-8 TENTHS
- 9-10 TENTHS
- FAST ICE (TEN TENTHS)



COLOR CODES BASED ON TOTAL CONCENTRATION

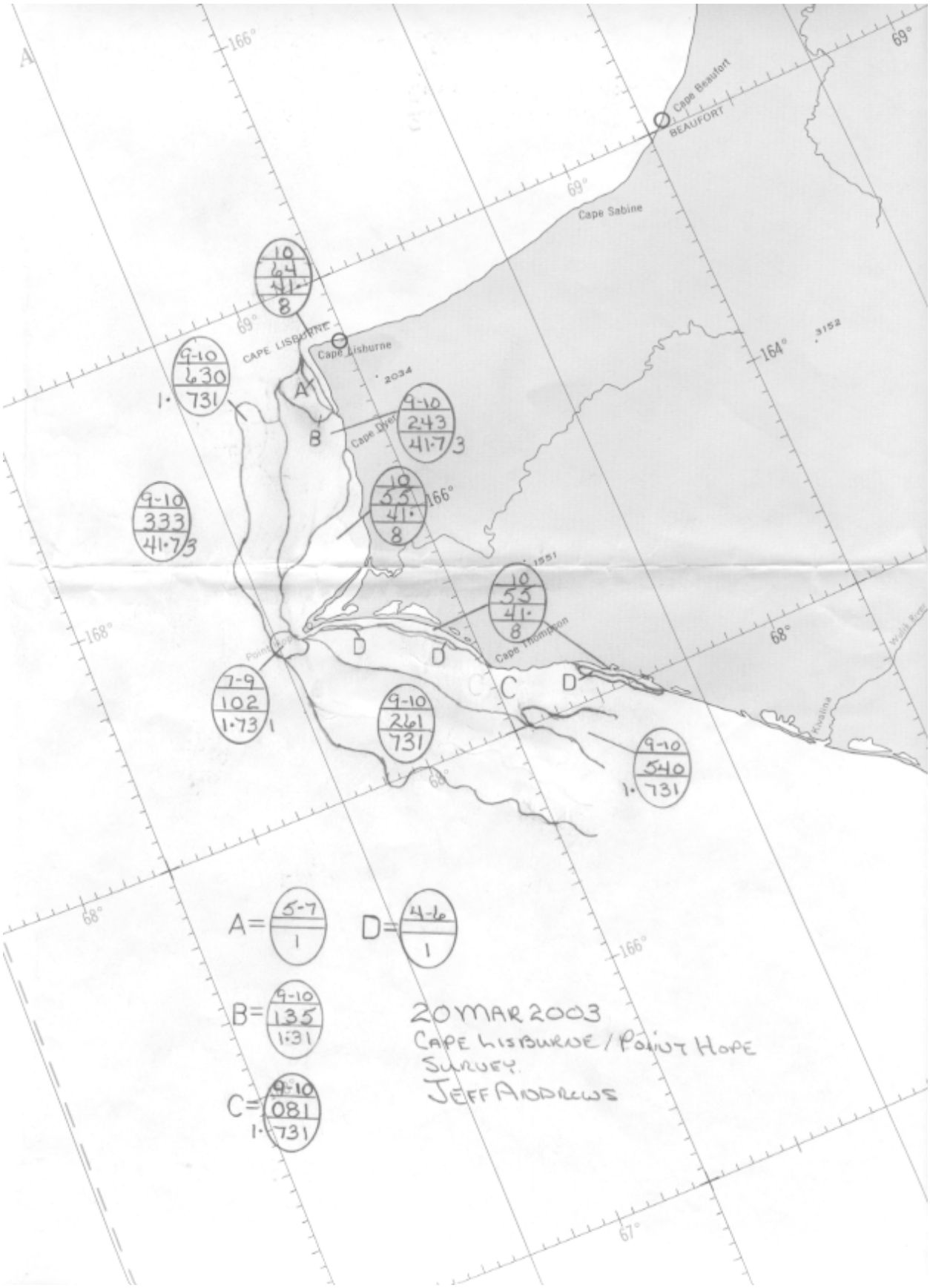
- ICE FREE
- LESS THAN 1 TENTH
- 1-3 TENTHS
- 4-6 TENTHS
- 7-8 TENTHS
- 9-10 TENTHS
- FAST ICE (TEN TENTHS)

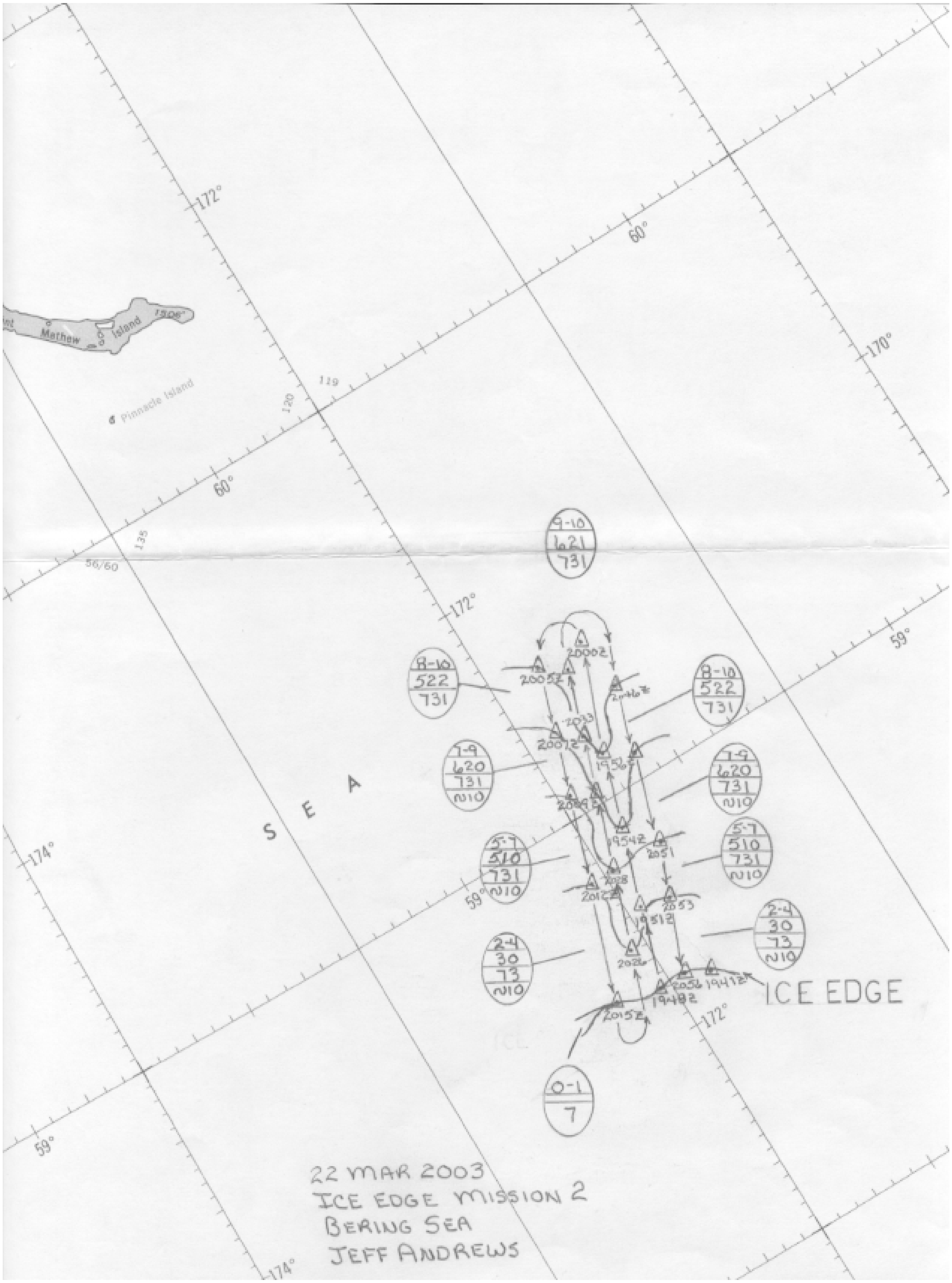
ICE ANALYSIS
EAST BERING
NATIONAL/NAVAL ICE CENTER
ANALYSIS WEEK: 21 MAR 2003

DATA SOURCES	DATE
DMSP OLS	20 MAR
ESTIMATED	21 MAR

ANALYST: CHRISTOPHER SZORC

UNCLASSIFIED


Cape Beaufort
BEAUFORT
Cape Sabine
CAPE LISBURNE
Cape Lisburne
Cape Thompson
Point Hope
Kivalina
Wulik River
166°
164°
168°
69°
68°
67°
A
B
C
D
10 / 64 / 41· / 8
9-10 / 430 / 1· / 731
9-10 / 243 / 41·7 / 3
9-10 / 333 / 41·7 / 3
10 / 55 / 41· / 8
10 / 55 / 41· / 8
7-9 / 102 / 1·73 / 1
9-10 / 261 / 731
9-10 / 540 / 1· / 731
A = 5-7 / 1
D = 4-6 / 1
B = 9-10 / 135 / 1·31
C = 9-10 / 081 / 1· / 731
20 MAR 2003
CAPE LISBURNE / POINT HOPE
SURVEY.
JEFF ANDREWS


172°
60°
Mathew
Island
1506
Pinnacle Island
119
120
135
56/60
60°
170°
172°
59°
S E A
174°
9-10
621
731
8-10
522
731
8-10
522
731
7-9
620
731
N10
7-9
620
731
N10
5-7
510
731
N10
5-7
510
731
N10
2-4
30
73
N10
2-4
30
73
N10
0-1
7
2000Z
2005Z
2046Z
2033
2007Z
1956Z
2003
1954Z
2051
2012Z
2028
2053
1951Z
2026
2056
1941Z
1948Z
2015Z
ICE EDGE
172°
59°
59°
174°
22 MAR 2003
ICE EDGE MISSION 2
BERING SEA
JEFF ANDREWS

X Appendix C: Flight Logs

AMSRICE03 Experiment Log - PSR on NASA Wallops P-3 N426NA

Date(s):	March 13, 2003
PSR Flight Code:	DF004
NAVFLIR Number:	
T/O Location:	Fairbanks, Alaska
T/O Time (UTC):	180153
Recovery Location:	Fairbanks, Alaska
Landing Time (UTC):	010308
Mission Scientist:	Al Gasiewski
PSR Operator(s):	Marian Klein, Vladimir Irisov
Scanhead(s):	PSR/A, PSR/CX
Purpose of Sortie:	Ice mapping over Barrow coastline and Elson lagoon.
Synoptic Conditions:	
Local Site Conditions:	Overcast above all aircraft mapping altitudes at Barrow, else clear to surface. Clear, -28°C, sunny at Fairbanks, light winds.
Instrument Status:	PSR/A and PSR/CX both operating normally, some non-critical software bugs. Stalls of PSR/CX at transit airspeeds required somewhat slower than expected operation of both scanners and impacted ability to perform PSR/CX sky calibrations. Buffer errors leading to redundant PSR/CX radiometric data occurred on three files, each of which was manually corrected during archival. PSR/A Tempscan power supply failed after flight on ground, replaced next day. PSR/CX scanhead computer failed to boot after flight on ground, booted properly after several hours in warm hangar. Both of the above two problems are attributed to excessive cold soak on ground after flight.
Operating Instruments on P3:	PSR/A, PSR/CX, TAMMS (Turbulent Air Mass Measuring System), ATM (A Topographic Mapper)
Notes/Flight Synopsis:	Overall, very stable radiometer operation during excellent observation conditions over Barrow.

Time (UTC)	Event N2 Status: 700 psi
180153	Takeoff
180700	Begin acquisition (start_all_nodes)
	Scanning in conical –n 55 100 4 0 causes stall. We tried different periods for scanning and 10 s works. The cause for stall is probably increased air pressure on the belly of the aircraft during climeout.
1832	Motion switched to conical –n 55 100 8 0
193730	Line 1 starts Chuckchi
193957	Line 1 ends
195110	Line 2 starts Chuckchi
195317	Line 2 ends
195708	Line 1 starts Elson
195913	Line 1 ends
200733	Line 2 starts Elson
200959	Line 2 ends
201524	Line 3 starts Chuckchi
201751	Line 3 ends
202559	Line 4 starts Chuckchi
202807	Line 4 ends
203323	Line 3 starts Elson
203534	Line 3 ends
204356	Line 4 starts Elson
204601	Line 4 ends
	Line 5 starts Chuckchi – missed beginning of line, will repeat
205347	Line 5 ends
210214	Line 6 starts Chuckchi
210341	Line 6 ends
210906	Line 5 starts Elson
211105	Line 5 ends
211951	Line 6 starts Elson
212237	Line 6 ends
2128	Line 7 starts Chuckchi missed beginning of line, will repeat
212954	Line 7 ends
213636	Line 8 starts Chuckchi
213835	Line 8 ends
214242	Line 7 starts Elson
214439	Line 7 ends
215307	Line 8 starts Elson
215510	Line 8 ends
220007	Line 9 starts Chuckchi

220220	Line 9 ends
220737	Line 9 starts Elson
220944	Line 9 ends
	High altitude (4300ft) mapping lines: PSR/CX and PSR/A in conical scan mode, 55 degrees incidence. Scan periods that worked without stall were found to be 5 and 3 seconds for PSR/CX and PSR/A (respectively) at 205 kts TAS.
221630	Line 1 starts:
	Two stalls of PSR/A during first mapping line, will repeat later.
221951	Line 1 ends
222430	Line 2 starts
222758	Line 2 ends
223330	Line 3 starts, ground speed 204 knots.
223700	Line 3 ends
224110	Line 4 starts
224420	Line 4 ends
225000	Line 5 starts
225345	Line 5 ends
225845	Line 1 starts again
230107	Line 1 ends
	Re-flight of the missed low altitude lines.
231006	Low altitude line 7 Chuckchi start
231221	Line 7 ends
231910	Low altitude line 5 Chuckchi start
232115	Line 5 ends
2321	Return to Fairbanks starts
	Conical scanning mode: PSR/CX 5 second period and PSR/A 3 second period
	After stall PSR/CX restarted with 7 seconds and PSR/A with 3.5 seconds scanning period.
	PSR roll maneuvers:
002740	Roll 1 (Both PSR/A and PSR/CX properly positioned at 65 degrees above nadir to starboard)
002833	Roll 2 (Only PSR/A properly positioned)
002925	Roll 3 (Only PSR/A properly positioned)
003135	Roll 4 (Only PSR/A properly positioned)
	During rolls thePSR/CX stalled in xtrack mode moving from the hot to cold calibration target. Recovery was lengthy and before the third roll it stalled again. As a results of these stall, the velocity of the motion in xtrack mode was lowered. The velocity of the motion between the calibration targets was set by V. Irisov to a value corresponding to an 8 second scanning period (velocity=1/8=0.125).
~0040	Acquisition stopped.
010308	Landing

	N2 status: 650psi (Note: Using an internally regulated tank, therefore no significant drop in pressure is expected.)

AMSRIce03 Experiment Log- PSR on NASA Wallops P-3 N426NA -

Date(s):	March 15, 2003
PSR Flight Code:	DF005
NAVFLIR Number:	
T/O Location:	Fairbanks, AK
T/O Time (UTC):	170656
Recovery Location:	Fairbanks, AK
Landing Time (UTC):	002243
Mission Scientist:	Don Cavalieri, Al Gasiewski,
PSR Operator(s):	Marian Klein, Vladimir Irisov
Scanhead(s):	PSR/A, PSR/CX
Purpose of Sortie:	Sea ice mapping in Norton Sound, including mapping and low-altitude flux lines. First Norton Sound mission.
Synoptic Conditions:	Low pressure system over Pacific to south of Alaska, producing NE flow. Clear, calm over Fairbanks.
Local Site Conditions:	Very clear above and below aircraft all times during flight. Variety of first-year ice types, from open water/small floes to pack ice.
Instrument Status:	Both scanheads and positioners in normal operation. Some time stamp problems to be reconciled manually.
Operating Instruments on P3:	PSR/A, PSR/CX, (ATM) Airborne Topographic Mapper, TAMMS (Turbulent Air Mass Measuring System)
Notes/Flight Synopsis:	10 mapping lines performed successfully.

Time (UTC)	**Event** N2 Status: 750 psi
170656	Takeoff
1824	Begin acquisition (start_all_nodes)
1835	Test of scanning velocity. PSR/A works with 2.9 s period and PSR/CX works with 4.0 s scanning period.
	Lines at Norton Sound:
184735	Line 10 starts, stall of PSR/A after ~4 minutes into the line
185147	Line 10 ends

190347	Line 10 restarted, PSR/A 3.1 period, PSR/CX 4.0 scanning period. Line is slightly off we are flying between line 1 and 2
191654	Line 10 ends. Date and time are not properly set on nodes 3 and 5. Nodes are showing July 13, 1999, IRIGB time is correct to the secod but off by four years. To be changed at next possible opportunity.
192026	Line 7 starts
193402	Line 7 ends
193746	Line 4 starts
195123	Line 4 ends
195507	Line 1 starts
200837	Line 1 ends
201358	Line 3 starts
202729	Line 3 ends
203056	Line 6 starts
204430	Line 6 ends
204809	Line 9 starts
210150	Line 9 ends
210830	Line 8 starts
212215	Line 8 ends
2116	IRIGB time on node 5 is not correct, observed in data by AJG. Node #5 is showing no-sync. Node #5 IRIGB time is within the second when compared with other nodes.
212611	Line 5 starts
2128	IRIGB time on node #5 is synchronized again.
213941	Line 5 ends
214323	Line 2 starts
215707	Line 2 ends
	Eastern lines:
222836	Line 1 starts ~500 feet altitude, mixed gray nilus, leads, and thin layered first year ice.
222903	Line 1 ends
223500	Line 1 start – we found a better location
223645	Line 1 ends, no open water, begin return transit
2237-2241	2x hwtrigger tests
224145	Resume conical, PSR/A 3.1 second period, PSR/CX 4.5 second period, climbout to return transit altitude.
2249	Flyying continuously over mountainous snow fields…
2250	PSR/A stopped, homed for aziumuthal motor current tests. Increasing azimuthal drive current from 6.02 ot 7.12 A using DIP switches on motor amplifier. Restart in 2.5 second scan period.
	PSR calibration rolls:
235048	Roll 1

235159	Roll 2
235448	Roll 3
000654	Acquisition stopped (stop_all_nodes)
002243	Landing
	N2 Status: 550 psi

AMSRIce03 Experiment Log - PSR on NASA Wallops P-3 N426NA -

Date(s):	March 16, 2003
PSR Flight Code:	DF006
NAVFLIR Number:	
T/O Location:	Fairbanks, Alaska
T/O Time (UTC):	180907
Recovery Location:	Fairbanks, Alaska
Landing Time (UTC):	022827
Mission Scientist:	Don Cavalieri, Al Gasiewski
PSR Operator(s):	Marian Klein
Scanhead(s):	PSR/A, PSR/CX
Purpose of Sortie:	Sea ice mapping in Bearing Sea, south (leeward) of St. Lawrence Island, including low-altitude flux measurement lines. First Bearing Sea mission.
Synoptic Conditions:	Low centered over Pacific S-SE of Alaska bringing cold, clear conditions over much of Alaska.
Local Site Conditions:	Thin scattered cirrus overhead, - 11°C OAT.
Instrument Status:	Both PSR/CX and PSR/A scanheads operating within established parameters.
Operating Instruments on P3:	PSR/A, PSR/CX, ATM (Airborne Topographic Mapper), TAMMS (Turbulent Air Mass Measuring System)
Notes/Flight Synopsis:	

Time (UTC)	**Event** N2 Status: 550 psi
180907	Takeoff
1821	Begin acquisition (start_all_nodes)
	PSR/A: conical1 –n 55 100 3.5 0
	PSR/CX conical2 –n 55 100 7 0
2010	Spiral down – both scanheads in xtrack mode
	Low altitude lines: PSR in 55 degree forward stare mode.
202420	Flux line 1a altitude 500 feet starts
203015	Flux line 1a ends

203607	Flux line 2a altitude 500 feet starts – GPS altitude is ~176 – 179 m.
204616	Flux line 2a ends
	Repeat of lines 1 and 2 at 500 ft altitude:
205240	Flux line 1b altitude 500 feet starts
205854	Flux line 1b ends
210443	Flux line 2b altitude 500 feet starts
211334	Flux line 2 ends
211959	Flux line 1a altitude 750 feet starts. GPS altitude is ~240 m.
212604	Flux line 1a ends
213145	Flux line 2a altitude 750 feet starts
214023	Flux line 2a ends
	Repeat of line 1 and 2 at 750 feet altitude:
214637	Flux line 1b altitude 750 feet starts
215258	Flux line 1b ends
215924	Flux line 2b altitude 750 feet starts
220809	Flux line 2b ends
221429	Flux line 1a altitude 1000 feet starts. GPS altitude ~ 314 m.
222050	Flux line 1a ends
222558	Flux line 2a altitude 1000 feet starts
223448	Flux line 2a ends
	Repeat of lines 1 and 2 at 1000 feet altitude:
224034	Flux line 1b altitude 1000 feet starts. PSR in conical scan mode for this line only.
2244	PSR/A stalls, period 3.1 sec
224658	Flux line 1b ends
	(Flux line 2b cancelled)
	Mapping lines: PSR in conical scan mode.
225124	IceSat mapping line from the west end of St. Lawrence Island extending ~south ~15 nmi along IceSat satellite subtrack starts.
2300	IceSat mapping line ends
230656	Flux line 3a starts low altitude ~ 500 feet.
231224	Flux line 3a ends.
231835	Flux line 3b starts opposite direction (East-West now) low altitude ~ 500 feet. GPS
232352	Flux line 3b ends.
233026	Flux line 3a starts West – East ~ 750 feet.
233556	Flux line 3a ends.
234227	Flux line 3b starts East - West ~ 750 feet.
234759	Flux line 3b ends.
235434	Flux line 3a starts West – East ~ 1000 feet.
000000	Flux line 3a ends.

000554	Flux line 3b starts East - West ~ 1000 feet.
001125	Flux line 3b ends.
001733	Originally planned PSR ice mapping Line 5 starts, heading ~N-NE
002744	Line 5 ends
	PSR 60 degree left calibration rolls:
014426	Roll 1
014529	Roll 2
014630	Roll 3
014911	Acquisition stopped
022827	Landing

AMSRIce03 Experiment Log - PSR on NASA Wallops P-3 N426NA -

Date(s):	March 18, 2003
PSR Flight Code:	DF007
NAVFLIR Number:	
T/O Location:	Fairbanks, AK
T/O Time (UTC):	171332
Recovery Location:	Fairbanks, Alaska
Landing Time (UTC):	010853
Mission Scientist:	Al Gasiewski, Thorsten Markus
PSR Operator(s):	Marian Klein, Al Gasiewski
Scanhead(s):	PSR/A, PSR/CX
Purpose of Sortie:	Sea ice mapping across southern ice edge in Bering Sea E-SE of St. Mathews Island.
Synoptic Conditions:	
Local Site Conditions:	Clear skies above and below flight level during all mapping, excellent visibility.
Instrument Status:	Normal preflight operation. PSR/A, PSR/CX operated during flight within established parameters: 1) One stall occurred for PSR/A at the start of line 1. 2) PSR/A and PSR/CX exhibited hesitancy to start acquisition processes, required reboot and specific node startup. Problem may have been the result of exceptionally cold & fast transit leg out to ice edge. 3) One unusually large redundant file written for PSR/CX, to be corrected during post processing.
Operating Instruments on P3:	PSR/A, PSR/CX, ATM (Airborne Topographic Mapper), TAMMS (Turbulent Air Mass Measuring System)
Notes/Flight Synopsis:	Sea ice mapped from heavy pack (~0.9-1.0 concentration) to open water beyond ice edge.

Time (UTC)	Event N2 Status: 400 psi
171332	Takeoff
1721	Begin acquisition (start_all_nodes)
	PSR/A conical –n 55 100 3.5 0
	PSR/CX conical –n 55 100 7 0
1749	PSR/CX radiometric files are empty and PSR/A files have file length that is similar to the PSR/CX size under normal operation. Acquisition process was stopped on both nodes and then started again without success.
1757	Full cold reboot of all nodes.
1804	After cold reboot Nav2 (node#6) computer has trouble during start-up. After connecting a monitor a message on the node #6 was read as: “Operating system not found”. After warm reboot node #6 successfully started. Suspect cold temperatures at fault.
1806	Start_all_nodes – all processes started successfully.
1937	N2 bottle change – new N2 status 2000psi.
	Mapping lines E-SE of St. Mathews Island:
194339	Line 1 starts
1947	PSR/A stalled, both scanheads restarted PSR/A 3.1 s and PSR/CX 5 s scanning period
201028	Line 1 ends
201319	Line 4 starts
204018	Line 4 ends
204613	Line 6 starts
211323	Line 6 ends
211653	Line 3 starts
214448	Line 3 ends
215112	Line 5 starts
221809	Line 5 ends
222322	Line 2 starts
225024	Line 2 ends
	PSR calibration rolls:
225600	Roll 1
225658	Roll 2
225814	Roll 3
2301	PSR/A and PSR/CX returned to conical scanning mode with 3.5 and 7 seconds scanning periods, respectively.
2350	Acquisition processes stopped
010853	Landing
	N2 status:1200 psi

AMSRIce03 Experiment Log - PSR on NASA Wallops P-3 N426NA -

Date(s):	March 19, 2003
PSR Flight Code:	DF008
NAVFLIR Number:	
T/O Location:	Fairbanks, AK
T/O Time (UTC):	175715
Recovery Location:	Fairbanks, AK
Landing Time (UTC):	013938
Mission Scientist:	Al Gasiewski, Don Cavalieri, Elena Lobl
PSR Operator(s):	Marian Klein, Al Gasiewski
Scanhead(s):	PSR/A, PSR/CX
Purpose of Sortie:	First- and multi-year ice pack mapping over ice camp ~100 nmi N of Alaska coast in Beaufort Sea (nine lines). Icesat underpass mapping in Beufort Sea (one line). Ice mapping over Barrow, AK (three lines).
Synoptic Conditions:	
Local Site Conditions:	Clear below aircraft for all lines, mostly clear overhead for all lines (some thin cirrus occasionally overhead). Visibility ~30 nmi.
Instrument Status:	PSR/A and PSR/CX both operated within established parameters during preflight testing and flight. Hydraulic fluid from the PSR/A (P-1) elevation motor was cleaned from the PSR/A scanhead lenses with alcohol prior to flight.
Operating Instruments on P3:	PSR/A, PSR/CX, ATM (Airborne Topographic Mapper), TAMMS (Turbulent Air Mass Measuring System)
Notes/Flight Synopsis:	A total of five PSR/A stalls occurred at 220 kias, 3.1-3.2 second scan period. A significant flow of hydraulic fluid was seen via the PSR/A scanhead camera to be dripping from the PSR/A (P-1) elevation motor during return transit.

Time (UTC)	**Event** N2 Status: 1100 psi
175715	Takeoff
1827	Acquisition processes started
	Ice camp lines over Beaufort Sea:
193519	Line 9 starts. We start with the South end of the most Eastern line.
195211	Line 9 ends

195643	Line 6 starts
201342	Line 6 ends
201829	Line 3 starts
2022	PSR/A stalled, restarted with the same scanning period 3.1 s.
2024	PSR/A stalled, restarted with the same scanning period 3.1 s.
203557	Line 3 ends
204103	Line 1 starts
2052	PSR/A stalled, restarted with the scanning period 3.2 s.
205611	Line 1 ends
210007	Line 4 starts
211803	Line 4 ends
212201	Line 7 starts
213722	Line 7 ends
214245	Line 8 starts
2158	PSR/A stalled, restarted with the same scanning period 3.2 s.
220037	Line 8 ends
220452	Line 5 starts
222037	Line 5 ends
223120	Line 2 starts, fast decent, landing gear is out, it could be seen in PSR/CX camera
2238	PSR/A stalled, restarted with the same scanning period 3.2 s.
224940	Line 2 ends
225415	Icesat line starts
230858	Icesat line ends
2328	Pitch variations maneuvers
234933	Chukchi Line 1 at Barrow starts
235136	Chukshi Line 1 ends
235654	Elson Line 2 at Barrow starts
235913	Elson Line 2 ends
000403	Line 3 at Barrow starts
000654	Line 3 at Barrow ends
	PSR calibration rolls
000931	Roll 1
001041	Roll 2
001213	Roll 3
0013	Return to Fairbanks
0106	Acquisition stopped
013938	Landing
	N2 status: 50 psi

AMSRIce03 Experiment Log - PSR on NASA Wallops P-3 N426NA -

Date(s):	March 20, 2003
PSR Flight Code:	DF009
NAVFLIR Number:	
T/O Location:	Fairbanks, AK
T/O Time (UTC):	175208
Recovery Location:	Fairbanks, AK
Landing Time (UTC):	000527
Mission Scientist:	Al Gasiewski, Thorsten Markus
PSR Operator(s):	Marian Klein, Al Gasiewski
Scanhead(s):	PSR/A, PSR/CX
Purpose of Sortie:	Sea ice mapping W and W-SW of Point Hope, AK
Synoptic Conditions:	
Local Site Conditions:	Clear sky, visibility ~50-70 nmi, surface temperature -15°C.
Instrument Status:	Normal preflight operation. PSR/A, PSR/CX operated during flight within established parameters.
Operating Instruments on P3:	PSR/A, PSR/CX, ATM (Airborne Topographic Mapper), TAMMS (Turbulent Air Mass Measuring System)
Notes/Flight Synopsis:	Total of three PSR/A stalls occurred during mapping. Lines 5 & 6 south showed a strong directional anisotropy in the Quicklook spectral gradient between 10 & 6 GHz.

Time (UTC)	**Event** N2 Status: 2100 psi
175208	Takeoff
1806	Acquisition processes started
192554	South Line 1 starts
1938	PSR/A stalled restarted immediately with the same scanning period 3.2s
194314	North line 1 ends
194655	North line 4 starts
195443	North line 4 ends
195552	South line 4 starts
1959	PSR/A stalled restarted immediately with the same scanning period 3.2s

200354	South line 4 ends
200853	South line 7 starts
201745	South line 7 ends
202056	North line 7 starts
203020	North line 7 ends
203456	North line 8 starts
204243	North line 8 ends
204612	South line 8 starts
205415	South line 8 ends
205817	South line 5 starts
210716	South line 5 ends
210904	North line 5 starts
211814	North line 5 ends
212212	North line 2 starts
212941	North line 2 ends
213120	South line 2 starts
213813	South line 2 ends
214215	South line 6 starts
215115	South line 6 ends
215341	North line 6 starts
220253	North line 6 ends
220547	North line 3 starts
221344	North line 3 ends
221551	South line 3 starts
222302	South line 3 ends
	PSR calibration rolls
222838	Roll 1
222955	Roll 2
223120	Roll 3
232525	Acquisition processes stopped.
000527	Landing
	N2 status: 700 psi

AMSRIce03 Experiment Log - PSR on NASA Wallops P-3 N426NA -

Date(s):	March 22, 2003
PSR Flight Code:	DF010
NAVFLIR Number:	
T/O Location:	Fairbanks, AK
T/O Time (UTC):	171022
Recovery Location:	Fairbanks, AK
Landing Time (UTC):	020403

Mission Scientist:	Al Gasiewski, Don Cavalieri
PSR Operator(s):	Marian Klein, Al Gasiewski
Scanhead(s):	PSR/A, PSR/CX
Purpose of Sortie:	Ice mapping over the Bering Sea ice edge S. of St. Mathews Island. Flux measurements in Koskokwim Bay.
Synoptic Conditions:	
Local Site Conditions:	Clear over Bering Sea mapping area, visibility > 30 nmi. A few scattered low clouds over flux site, good visibility.
Instrument Status:	Normal preflight and in flight operation.
Operating Instruments on P3:	PSR/A, PSR/CX, ATM (Airborne Topographic Mapper), TAMMS (Turbulent Air Mass Measuring System)
Notes/Flight Synopsis:	1) One redundant file written by PSR/CX. 2) Leakage of hydraulic fluid from PSR/A elevation motor seen again from scanhead video camera during return transit.

Time (UTC)	**Event** N2 Status: 2000 psi
171022	Takeoff
1743	Acquisition processes started, both scanheads in conical mode:
	PSR/A conical –n 55 200 3.5 0, PSR/CX conical –n 55 100 7 0
1820	PSR/A stalled – restarted in conical again with the same scanning period 3.5 s.
1843	PSR/A stalled – restarted in conical again with the same scanning period 3.5 s.
1851	PSR/A stalled – restarted in conical again with the same scanning period 3.6 s.
1917	PSR/A stalled – restarted in conical again with the same scanning period 3.6 s.
193325	Line 1 starts, PSR/A, PSR/CX scanning periods 3.1 s and 5 s respectively.
194331	Line 1 ends
194650	Line 4 starts
200019	Line 4 ends
200405	Line 7 starts
201700	Line 7 ends
202130	Line 5 starts
203858	Line 5 ends
204303	Line 2 starts
205757	Line 2 ends

210219	Line 6 starts
212009	Line 6 ends
212300	Line 3 starts
213917	Line 3 ends
	Three flux measurement lines, twice at each altitude:
223314	Heat flux line starts, altitude 500 feet.
224520	Heat flux line stops, altitude 500 feet.
	New location for flux lines was found:
230008	Heat flux line starts, altitude 500 feet.
230800	Heat flux line stops, altitude 500 feet.
231407	Heat flux line starts, altitude 500 feet.
232306	Heat flux line stops, altitude 500 feet.
232824	Heat flux line starts, altitude 750 feet.
233626	Heat flux line stops, altitude 750 feet.
234140	Heat flux line starts, altitude 750 feet.
235042	Heat flux line stops, altitude 750 feet.
235453	Heat flux line starts, altitude 1000 feet.
000243	Heat flux line stops, altitude 1000 feet.
000804	Heat flux line starts, altitude 1000 feet. – Last line PSR/A/CX in conical mode 3.1 and 5 seconds scanning period.
001702	Heat flux line stops, altitude 1000 feet.
	PSR calibration rolls:
002048	Roll 1
002154	Roll 2
002255	Roll 3
0024	Return to base
0120	Acquisition stopped
020403	Landing
	N2 status: 300 psi

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13. ABSTRACT *(Maximum 200 words)*

In March 2003 a coordinated Arctic sea ice validation field campaign using the NASA Wallops P-3B aircraft was successfully completed. This campaign was part of the program for validating the Earth Observing System (EOS) Aqua Advanced Microwave Scanning Radiometer (AMSR-E) sea ice products. The AMSR-E, designed and built by the Japanese National Space Development Agency for NASA, was launched May 4, 2002 on the EOS Aqua spacecraft. The AMSR-E sea ice products to be validated include sea ice concentration, sea ice temperature, and snow depth on sea ice. This flight report describes the suite of instruments flown on the P-3, the objectives of each of the seven flights, the Arctic regions overflown, and the coordination among satellite, aircraft, and surface-based measurements. Two of the seven aircraft flights were coordinated with scientists making surface measurements of snow and ice properties including sea ice temperature and snow depth on sea ice at a study area near Barrow, AK and at a Navy ice camp located in the Beaufort Sea. Two additional flights were dedicated to making heat and moisture flux measurements over the St. Lawrence Island polynya to support ongoing air-sea-ice processes studies of Arctic coastal polynyas. The remaining flights covered portions of the Bering Sea ice edge, the Chukchi Sea, and Norton Sound.

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