PAMARCMiP 2011

[Polar Airborne Measurements and Arctic Regional Climate Model Simulation Project]

GENERAL OVERVIEW / INTRODUCTION

The Arctic environment is changing more rapidly than most other regions of the world. The dramatic decrease in Arctic sea ice cover is well documented [Serreze et al., 2007; Overland et al., 2009, Haas et al., 2010]. Many other processes and variables, such as the surface-atmosphere radiation balance, cloud cover, aerosol properties, and trace gas concentrations [Bottenheim et al., 2009, Stone et al., 2010, Lampert et al., 2011] are also changing but are not easily monitored from space. Surface observations are sparse, particularly over the central Arctic, where changes may be pronounced. The Planetary Boundary Layer (PBL) plays a crucial role for exchange processes of momentum, heat, water vapour, trace gases and aerosol particles involving the cryosphere, land and sea surface and the atmosphere. Accurate representations of the vertical structure of the stable Arctic ABL still pose a serious challenge for climate models [Tjernström et al., 2004, Dorn et al., 2009]. Our ability to understand present changes and to predict future developments are further complicated by two-way feedbacks and interactions between the sea ice cover and the atmosphere, affecting the radiation balance as well as the fluxes of momentum, heat, moisture, gases, and aerosols. Satellites do not yet provide synchronous, coincident observations of various relevant sea ice and atmospheric parameters, nor possess sufficient spatial, temporal, and vertical resolution for the improvement of models. Satellite retrievals also require careful validation in the Arctic [Liu et al., 2010]. Airborne surveys can address many of these issues and therefore provide an important component of the Arctic observing system.

The campaign PAMARCMiP 2011 (Polar Airborne Measurements and Arctic Regional Climate Model Simulation Project) was organized around the capacity of the AWI research aircraft POLAR 5 to provide unique data of aerosol, trace gases distributions, meteorological and atmospheric conditions, as well as sea ice thickness in a latitude band between about 65 and 85 degrees North. The strategy was hereby to obtain snapshots of critical parameters over a short time period in order to close key gaps in understanding of Arctic conditions and processes. The actual campaign was based on the experiences of a successful pilot study, which was performed in April 2009, starting in Longyearbyen (Svalbard), and continuing to Barrow (Alaska.) The 2011 campaign was embedded in ESA's CryoSat-2 Calibration/Validation Experiment (CryoVEx) from Alert, Nunavut, where different coordinated flight activities took place. Long-range sea ice flights from different stations except Alert have also been performed related to another satellite project, called CALIPSO – global aerosol and cloud mapping.

The existing network of Arctic climate observatories served the logistical needs of the mission very well. Under severe conditions of cold it would not have been possible to conduct research flights without well-spaced stations to refuel and take rest. Ground support provided by international teams expedited operations allowing the mission to be completed in just over six weeks, enabling the acquisition of a "snapshot" of conditions during a period of quasi-stable atmospheric conditions. Access to hangars, power supplies and heating was essential to the success of the mission. While there was significant ground support provided by a number of groups, the core personnel on board the aircraft consisted of three flights crew and five engineers/scientists.

PREPARATION AND LOGISTICS ASPECTS

The PAMARCMiP 2011 campaign started from Barrow, Alaska, eastbound to Longyearbyen, Svalbard. For operations at the different bases it was not only necessary to have the flight permission, but also science permits, see below. Different institutions and companies gave the support, which was requested by AWI and Environment Canada.

SCIENCE PERMISSION:

- Barrow, Alaska: not needed – only flight permission
- Inuvik, NWT: License number 14895
- Eureka, Nunavut: License number: 02 110 11N-A
- Alert, Nunavut: License number: 02 110 11N-A
- Station, Greenland: License number: C 11-16
- Longyearbyen, Svalbard: not needed – only flight permission

- **FAIRBANKS**

  Arctic Kingdom Toronto provided the logistic support during the stop over in Fairbanks and the local contact person was Krystin Thoburn. The overnight stay was in Sophie Station Suites (1717 University Avenue, Fairbanks, Alaska 99709 – phone: ++1-907-479-3650). During the stay in Fairbanks the hangar from Alaska Aerofuel (phone: ++1-907-474-0061) was used. Offices were not necessary during the stay in Fairbanks. It was necessary to rent some cars, we used finally Budget. The most important action item in Fairbanks was the custom clearance for entry in the USA, which was organized by Arctic Kingdom. Alaska Aeroful provided aircraft ground facilities.

- **BARROW**

  University of Fairbanks, Alaska provided the logistic support during the stop over in Barrow and the local contact person was Andy Mahony. The stay in Barrow was mostly funded by the NSF Project SIZONET (Seasonal Ice Zone Network) under leadership of the University of Alaska, Fairbanks. The overnight stay was in the facilities of Polar Field Services, Inc. (360 NARL Street, Barrow, AK 99723, phone: ++1 9078520904). During the stay in Barrow no hangar space was available. For future activity use of the Shell hangar could be possible, contact via Tom Elkins (Era Aviation, phone: ++1-907-852-8333). Offices, cars and aircraft ground facility were rented from Polar Field services, Inc..

- **INUVIK**

  Arctic Kingdom Toronto provided the logistic support during the stop over in Fairbanks and the local contact person was Krystin Thoburn. The overnight stay was in Nova Inn (Box 3169 - 300 Mackenzie Road, Inuvik, NT XOE OTO – phone: ++1- 867-777-6682). During the stay in Inuvik the own hangar and offices from KBAL were used. It was necessary to rent some cars, the number of car rental companies was limited and finally we used Alamo/National. The custom clearance for reentry into Canada was organized by Arctic Kingdom. Aircraft ground facilities were provided by KBAL.

Formatiert: Englisch (USA)

Formatiert: Englisch (USA)

Formatiert: Englisch (USA)

Formatiert: Englisch (USA)

- **RESOLUTE BAY**

  KWA Support Service provided the logistic support during the stop over in Resolute Bay and the local contact person was Ken Asmus. The overnight stay in Resolute Bay was in the facility of Polar Continental Shelf Program – PCSP (Polar Continental Shelf Program, Natural Resources Canada, Earth Science Sector, 615 Booth Street, Ottawa, ON K1A 0E9). During the stay in Resolute Bay the hangar from KBAL was used. The PCSP Base Resolute Bay provided the offices and one truck. Ground facilities were provided by KBAL.

- **ALERT**

  Environment Canada provided the logistic support during the stop over in Alert and the local contact person was Kevin Anderson, supported by Jim Milne, Defense Research and Development Canada DRDC. The overnight stay in Alert was in the DND base facilities (George A. Stewart, CAS D Air Prog. - 8Wg Alert Management Office (Ottawa), National Defense, Ottawa, Canada, K1A OK2). During the stay in Alert no hangar space was available. Offices, transport vehicles and ground facilities were from EC, DRDC, and DND.

- **EUREKA**

  KWA Support Service provided the logistic support during the stop over in Eureka and the local contact person was Ken Asmus. The overnight stay in Eureka was at the Environment Canada weather station facility (John MacIver, Station Program Manager - Eureka, Aerological and Surface Operational Programs Atmospheric Monitoring Section, Meteorological Service of Canada , Environment Canada , 123 Main Street,- Suite 150 , Winnipeg, Manitoba R3C 4W2) . During the stay in Eureka no hangar space was available. Offices and vehicles were provided by Environment Canada. Ground facilities were provided by Environment Canada.

- **STATION NORD**

  Consulting Aviation Services - FinkCAS provided the logistic support during the stop over in Station Nord and the local contact person was Heinz Finkenzeller. The overnight stay in Station Nord was in the military camp of the Danish air force, contact over Gronlandskommando - Gronnedal, DK-3930 Kangilinnguit - phone: ++45 00299691911. During the stay in Station Nord no hangar space was available. Offices were used in the overnight facility. Cars were not necessary. For uploading and loading the aircraft as well aircraft ground activity we were supported by the base commander.

- **LONGYEARBYEN**

  Consulting Aviation Services - FinkCAS provided the logistic support during the stop over in Longyearbyen and the local contact person was Heinz Finkenzeller. The overnight stay was in Spitsbergen Guesthouse – Nybyen (P.O. Box, N-9171 Longyearbyen, Svalbard– phone: ++47 79026300). During the stay in Longyearbyen the hangar from Airport Svalbard could partly be used and they also provided us with offices in the hangar building. Cars were rented from Arctic Autorent AS (P.O. Box 184, 9174 Longyearbyen - phone: ++47 91702258). Aircraft ground facilities were provided from the airport Svalbard.

NAME OF PARTICIPANTS

The project was organized under the leadership of the Alfred Wegener Institute Bremerhaven in cooperation with several partners in Germany (Jade HS Elsfleth, FIELAX) Canada (EC Toronto, University of Alberta, York University, KBAL Calgary, LCA Muskoka, Arctic Kingdom) USA (NSF, NOAA Boulder, NASA LaRC Hampton, University of Fairbanks), Europe (AARI St-Petersburg, ESA Nordwijk, NILU Kjeller). The name of participants can be seen in Tab 1.

Full legal name	Institution	Participation in:	email adress
Andreas Herber	AWI Bremerhaven	Barrow - Resolute Bay, Longyearbyen	andreas.herber@awi.de
Manuel Sellmann	AWI Bremerhaven	Barrow - Longyearbyen	manuel.sellmann@awi.de
Stefan Hendricks	AWI Bremerhaven	Barrow, Resolute Bay - Longyerarbyen	stefan.hendricks@awi.de
Dirk Kalmbach	AWI Bremerhaven	Barrow	dirk.kalmbach@awi.de
Gerit Birnbaum	AWI Bremerhaven	Longyearbyen	gerit.birnbaum@awi.de
Roland Neuber	AWI Potsdam	Barrow, Resolute Bay - Longyerarbyen	roland.neuber@awi.de
Keith Kruger	KBAL	Barrow - Resolute Bay	herc700@hotmail.com
Mike Armstrong	KBAL	Barrow - Resolute Bay	mike@armstrongemail.name
Doug Mackenzie	KBAL	Barrow - Longyearbyen	dmackenzeus@yahoo.com
Dean Emberley	KBAL	Resolute Bay - Longyearbyen	dndemberley@msn.com
John Sipko	KBAL	Resolute Bay - Longyearbyen	jon.sipko@gmail.com
Johannes Käßbohrer	FIELAX	Barrow - Longyearbyen	kaessbohrer@fielax.de
Ralf Brauner	FH Elsfleeht	Barrow, Longyerabyen	brineera@t-online.de
Peter Liu	EC Toronto	Barrow - Resolute Bay	peter.liu@ec.gc.ca
Walter J. Strapp	EC Toronto	Resolute Bay	walter.strapp@ec.gc.ca
Mike Harwood	EC Toronto	Resolute Bay, Eureka	mike.harwood@ec.gc.ca
Peter Toose	EC Toronto	Resolute Bay, Eureka	Peter.Toose@ec.gc.ca
Chris Derksen	EC Toronto	Resolute Bay, Eureka	Chris.Derksen@ec.gc.ca
Ralf Staebler	EC Toronto	Alert, Station Nord, Longyearbyen	ralf.staebler@ec.gc.ca
Kevin Anderson	EC Toronto	Alert	kevin.anderson@ec.gc.ca
Christian Haas	University of Alberta	Barrow - Resolute Bay, Alert	christian.haas@ualberta.ca
Jeff Seebrook	York University	Barrow - Resolute Bay	jseab@yorku.ca
Lawrence Gray	York University	Barrow	lhgray@yorku.ca
Robert S. Stone	NOAA Boulder	Barrow	robert.stone@noaa.gov
David M. Winker	NASA LaRC	Barrow	david.m.winker@nasa.gov
Andy Mahoney	University of Alaska	Barrow	mahoney@gi.alaska.edu
Kristyn Thoburn	Arctic Kingdom	Inuvik	krystin@arctickingdom.com
Ken Asmus	KWA Support Service	Resolute Bay, Eureka	ken.asmus@gmail.com
Heinz Finkenzeller	FinkCAS	Longyearbyen	heinz.finkenzeller@awi.de

Table 1: List of participants, including email addresses

FLIGHT OPERATION

The campaign 2011 took place from March 25, 2011 to May 6, 2011 in the Arctic. The research flights commenced out of Barrow, Alaska and continued eastbound via Inuvik, Resolute Bay (NWT), Eureka, Alert (Nunavut), Station Nord (Greenland) to Longyearbyen (Svalbard). Trace gases and aerosol in-situ as well as Lidar measurements were performed also during the ferry flights. The total number of flight hours was 136.7. The flight activity is sketched in Figure 1 and is summarized in Table 2.

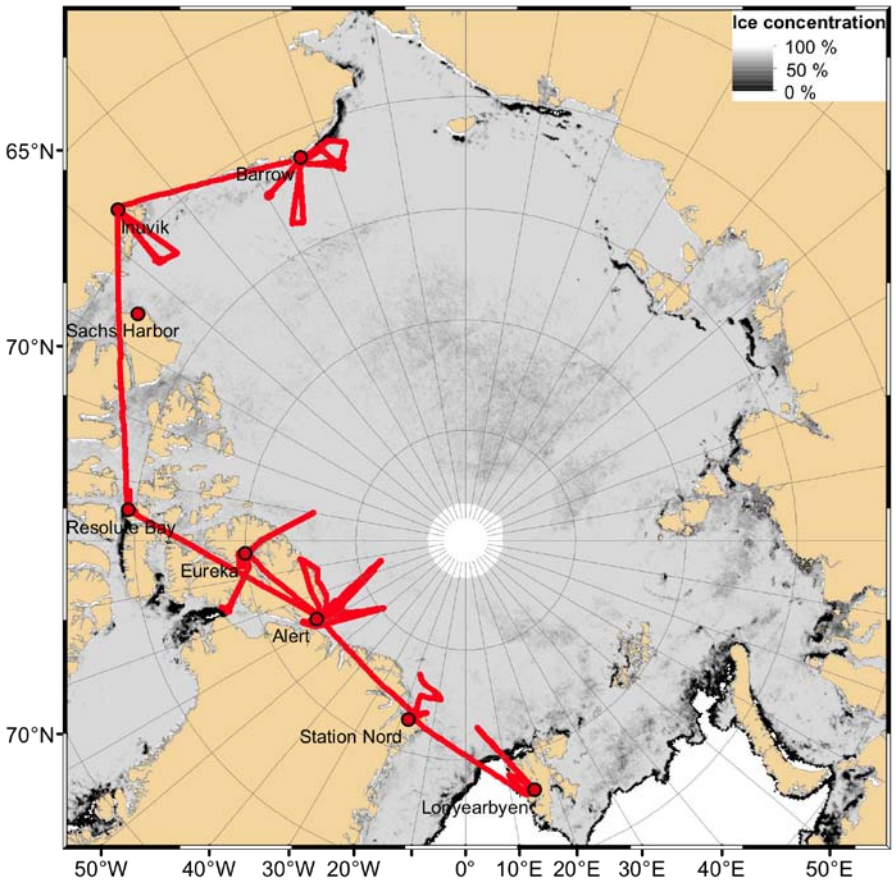

Figure 1: **Flight route of the POLAR-5 during PAMARCMiP 2011 (red). Background map shows sea-ice concentration from mid April from the AMSR-E satellite (courtesy of Georg Heygster, University of Bremen, Germany). Along the route from Alaska to Svalbard, different stations were used as bases for re-fuelling.**

Date of flight Date	Flight Area	Air time	Subject
Nr. 1-3 / March 2011	Muskoka	3.7	Test flights
Nr. 4 / 25.03.2011	Muskoka – Edmonton	8.8	Ferry
Nr. 5 / 27.03.2011	Edmonton – Fairbanks	8.5	Ferry
Nr. 6 / 29.03.2011	Fairbanks – Barrow	2.7	Ferry
Nr. 7 / 30.03.2011	Barrow	3.5	Sea Ice Survey
Nr. 8 / 31.03.2011	Barrow	3.2	Aerosol & Trace Gases
Nr. 9 / 01.04.2011	Barrow	2.9	Aerosol & Trace Gases
Nr. 10 / 02.04.2011	Barrow	4.2	Sea Ice Survey
Nr. 11 / 03.04.2011	Barrow – Inuvik	2.9	Ferry
Nr. 12 / 04.04.2011	Inuvik	3.9	Sea Ice Survey
Nr. 13 / 05.04.2011	Inuvik	3.9	Sea Ice Survey
Nr. 14 / 06.04.2011	Inuvik – Resolute Bay	4.2	Ferry
Nr. 15 / 09.04.2011	Resolute Bay	1.4	Test flight
Nr. 16 / 10.04.2011	Resolute Bay - Alert	3.6	Ferry
Nr. 17 / 11.04.2011	Alert	2.0	Aerosol & Trace Gases
Nr. 18 / 14.04.2011	Alert	3.8	Sea Ice Survey
Nr. 19 / 14.04.2011	Alert	2.0	Aerosol & Trace Gases
Nr. 20 / 15.04.2011	Alert	3.4	Sea Ice Survey
Nr. 21 / 16.04.2011	Alert	2.9	Sea Ice Survey
Nr. 22 / 17.04.2011	Alert	3.8	Sea Ice Survey
Nr. 23 / 18.04.2011	Alert	3.0	Sea Ice Survey
Nr. 24 / 18.04.2011	Alert	2.2	Aerosol & Trace Gases
Nr. 25 / 19.04.2011	Alert – Eureka	1.6	Ferry
Nr. 26 / 20.04.2011	Eureka	3.9	Snow Radiometer
Nr. 27 / 21.04.2011	Eureka	4.1	Snow Radiometer
Nr. 28 / 22.04.2011	Eureka	3.9	Sea Ice Survey
Nr. 29 / 22.04.2011	Eureka	2.0	Aerosol & Trace Gases
Nr. 30 / 23.04.2011	Eureka –	3,5	Aerosol & Trace Gases
Nr. 31 / 23.04.2011	Eureka	1.5	Test flight
Nr. 32 / 27.04.2011	Eureka – Alert	1,7	Ferry
Nr. 33 / 27.04.2011	Alert – Station Nord	2.5	Ferry
Nr. 34 / 28.04.2011	Station Nord	4.0	Sea Ice Survey
Nr. 35 / 28.04.2011	Station Nord	2.0	Aerosol & Trace Gases
Nr. 36 / 29.04.2011	Station Nord – Longyearbyen	2.3	Ferry
Nr. 37 / 30.04.2011	Longyearbyen	3.2	Aerosol & Trace Gases
Nr. 38 / 04.05.2011	Longyearbyen	3.3	Sea Ice Survey
Nr. 39 / 04.05.2011	Longyearbyen	3.5	Aerosol & Trace Gases
Nr. 40 / 05.05.2011	Longyearbyen – Tromsoe	2.8	Ferry
Nr. 41 / 05.05.2011	Tromsoe - Trondheim	2.5	Ferry
Nr. 42 / 06.05.2011	Trondheim - Bremerhaven	3.1	Ferry
TOTAL		**136.7**	

Table 2: **All flights during the PAMARCMiP campaign, including 24 research (82.9 hours), 5 test flights (6.6 hours) and the ferry flights with 47.2 hours in total**

FLIGHT AND SCIENTIFIC ACTIVITY

During the campaign, 136.7 flight hours (82.9 hours for research and 47.2 hours for ferry, and 6.6 hours for test flights) were spent as listed in Table 2. Average air speed was 205 km/h during most of the flights. Flight operations were conducted from as low as 200 feet altitude, when measuring sea ice thickness, up to 20,000 feet when profiling aerosols and trace gases. Altitude during ferry legs and at the time when drop sondes were launched and/or the LIDAR was operated was between 8.000 and 10.000 feet. The longest research flight was approximately 4.2 hours in duration. Fortunately, delays due to adverse weather were limited. Air temperatures generally hovered around -30°C, presenting particular challenges because equipment needed to be kept warm even when not flying.

The PAMARCMiP campaign carried out sea ice measurements with the EM-Bird, as well as aerosol, trace gases and atmospheric measurements by using different remote sensing and in-situ systems, including a drop sounding system. During the first part from Barrow to Resolute we operated the ozone LIDAR (DIAL) and from Alert and Eureka additional snow thickness measurements with a specially designed snow microwave radiometer were carried out with the aim to compare these measurements with the EM-Bird measurements. Unfortunately the planned research flight to the Russian drifting station NP 38 had to be canceled due to the short runway there and also due to bad weather on the way to the drifting station (see Figure 2).

Based on three successful test flights in Muskoka, Ontario in March 2011, the ferry flight to Barrow, Alaska was started on March 25, 2011. Due to bad weather on the way to Fairbanks the arrival time was later than expected, with arrival on March 29, 2011. Additional problems originated from missing paper work for the entry to US airspace. The operator – Kenn Borek Air Service Ltd, solved these problems within two days. On the way from Edmonton to Fairbanks some problems with flying under moderate icing occurred. The recommendation is therefore to carry the EM-Bird on-board the aircraft during future ferry flights. During the ferry from Muskoka to Barrow no systems were in operation.

- **BARROW**
  The first research flight was performed immediately on the next day, as POLAR 5 arrived in Barrow fully equipped under operational conditions. During the stay in Barrow four research flights were performed, two related to the sea ice study and two related to the aerosol and trace gases study. The planned flight over the ICEX camp could not be performed due to technical problems with the EM-bird. The flight was scheduled on the April 1, 2011 as a combined flight with a Twin Otter from the ICEX group. Based on the weather forecast for the April 4, 2011 (bad weather on the way from Barrow to Inuvik) we decided to fly to Inuvik one day earlier than the originally planned. On the way to Inuvik we have performed ozone LIDAR measurements and the aerosol and trace gases package from EC was in operation.

Date of flight	Flight Area	Sea ice	In-Situ	Snow radar	Lidar	Photo-meter	Drop sonde	DIAL
30.03.2011	Barrow	YES	YES	---	---	YES	---	YES
31.03.2011	Barrow	---	YES	---	YES	YES	---	YES
01.04.2011	Barrow	---	YES	---	YES	YES	---	YES
02.04.2011	Barrow	YES	YES	---	YES	YES	---	

During the stay in Barrow it was planned to fly to the Russian drifting station NP 38. The flight had to cancelled due to bad weather (see Figure 2 and 3). The Russian colleagues tried to built three times for us a runway, but due to very bad weather conditions (strong wind) the runway braked every time. The used runway beginning of April was to short for landing. So also from this point the flight was impossible.

- **Inuvik**
  From Inuvik we have performed two research flights, of which the first one was only partly successful due to technical problems with the EM-bird. However, during the first flight out of Inuvik we made the first successful drop soundings on the way back from the northern point of the flight. The second research flight from Inuvik was a combined sea ice and CALIPSO flight with profiling at the northern point of the flight. Due to bad weather in Sachs Harbour we could not use the refueling possibility, which would have extended our endurance. On the April 6, 2011 we left Inuvik on time and arrived safely at the next station, Resolute Bay. In Resolute Bay the instrument configuration was changed. The Ozone LIDAR went out and the snow radiometer and the microphysical probes under the wing were installed.

Date of flight	Flight Area	Sea ice	In-Situ	Snow radar	Lidar	Photo-meter	Drop sonde	DIAL
04.04.2011	Inuvik	YES	YES	---	YES	YES	YES	
05.04.2011	Inuvik	YES	YES	---	---	YES	---	

- **ALERT**
  After a successful test flight in Resolute Bay on April 9, POLAR 5 was flying to Alert on the April 10, 2011 on time. At Alert, we flew a total of eight missions. Four of them were emphasizing EM bird measurements over the Arctic Ocean. Luckily, the weather at Alert cooperated and we were grounded for only 2 out of 8 days. Three flights were along a CryoSat2 ground track and two featured coincident measurements with a Danish Twin Otter within the CryoVEx project of the ESA (European Space Agency), see http://www.esa.int/esaCP/SEM2N1ASJMG_index_0.html. Four flights were primarily dedicated to studying the spatial characteristics of air masses depleted of ozone and mercury. Also lucky was the fact that the largest ozone depletion of this year thus far occurred right in the middle of our time in Alert, from April 12 – 16, and we had a chance to investigate it in detail. We also continued making extensive measurements of physical characteristics of aerosols and their black carbon content, and had a few chances to fly through mid-tropospheric Arctic Haze layers.

Date of flight	Flight Area	Sea ice	In-Situ	Snow radar	Lidar	Photo-meter	Drop sonde	DIAL
11.04.2011	Alert	---	YES	---	---	---	---	
14.04.2011	Alert	YES	YES	---	YES	---	YES	
14.04.2011	Alert	---	YES	---	YES	---	---	
15.04.2011	Alert	YES	YES	---	YES	---	YES	
16.04.2011	Alert	YES	YES	---		---		
17.04.2011	Alert	YES	YES	---	YES	---	YES	
18.04.2011	Alert	YES	YES	---	YES	---		
18.04.2011	Alert	---	YES	---	---	---	---	

- **EUREKA**
  The science activity from Eureka was also very productive with finally six research flights. The radiometer flights over the terrestrial snow lines near Eureka were successfully performed two times. The measurements look very promising and the pilots were very precise in covering our snow survey lines. Additional we performed three EM-bird flights, but the data output was limited due to technical troubles with the EM-bird. Finally one flight during a CALIPSO overpass has been performed. Afterwards we de-install the EC radiometers and left Eureka for Station Nord.

Date of flight	Flight Area	Sea ice	In-Situ	Snow radar	Lidar	Photo-meter	Drop sonde	DIAL
20.04.2011	Eureka	---	YES	YES	---	---	---	
21.04.2011	Eureka	---	YES	YES	---	---	---	
22.04.2011	Eureka	YES	YES	---	YES	---	YES	
22.04.2011	Eureka	---	YES	---	YES	---	---	
23.04.2011	Eureka –	---	YES	---	YES	---	---	

- **STATION NORD**
  The ferry flight from Eureka to Station Nord was originally planned for the 25th of April. Due to bad weather in Station Nord the departure was delayed by two days compared to the original plan and we arrived Station Nord on April 27, 2011. In Station Nord we have performed two research flights on one day, one of them with the focus on sea ice measurements and the other one as an aerosol and trace gases study (vertical profile close to Station Nord). During the ferry to Longyearbyen the Lidar and also EC trace gases measurements were done.

Date of flight	Flight Area	Sea ice	In-Situ	Snow radar	Lidar	Photo-meter	Drop sonde	DIAL
28.04.2011	Station Nord	YES	---	---	YES	---	---	
28.04.2011	Station Nord	---	YES	---	---	---	---	

- **LONGYEARBYEN**
  After arrival in Longyearbyen with one-day delay we started the program with a sea ice flight to the North. Due to technical problems with the EM-bird the data output was limited and we decided to concentrate for the next flights a comparison with atmospheric measurements at the AWIPEV base and the coordinate flights with the CICCI (Coordinated Investigation of Climate-Cryosphere Interactions) program as well as the CALIPSO over flights. Due to bad weather we had a three days break in flight operation. The planned aerosol measurements were then done on the May 4, 2011. Fortunately the weather was excellent so that we could fly two times. On the May 5, the ferry was started to Germany via Tromsoe and Trondheim.

Date of flight	Flight Area	Sea ice	In-Situ	Snow radar	Lidar	Photo-meter	Drop sonde	DIAL
30.04.2011	Longyearbyen	---	YES	---	YES	---	YES	
04.05.2011	Longyearbyen	YES	YES	---	YES	---	YES	
04.05.2011	Longyearbyen	---	YES	---	YES	---	---	

SCIENTIFIC EQUIPMENT

During the entire campaign the aerosol and trace gas package from Environment Canada worked very well. On the first flight from Inuvik the Ozone DIAL failed due to power supply issues and we had to stopped the DIAL measurements. Two radiation sensors broke during the first research flights and were exchanged in Resolute Bay. During the first flights a failure in the cabling of the AMALi and also a leakage in the cooling systems were detected. Both problems could be solved and afterwards the AMALi worked properly. The AIMMS 20 meteorological sensor data storage was only partly successful. During the first part of the campaign until Resolute Bay we often had encountered problems with a frozen dome due to its weak ventilation. On the first research flight in Alert the sun photometer failed due to broken cables inside the body. The failure could not be repaired so that no more AOD data could be obtained. The EC radiometers have been installed in Resolute Bay. Due to some unrealistic temperature readings a second calibration in Eureka was needed. After calibration the radiometers worked properly. During the entire campaign we had experienced communication errors between the EM-bird and the data computer. This problem could not completely be solved during the campaign. Fortunately during the coordinated flights within CryoVEx from Alert the EM-bird systems worked properly.

Scientific System	Derived parameter	Responsibility
Basic Meteorology	Temperature, relative Humidity	AWI
Integral Radiation Sensors, VIS & IR	Up-and downward radiance	AWI
Radiation Sensor KT 15	Surface Temperature	AWI
Scanner VQ580	Actual height over ground	AWI
Digital Photo Camera	Surface Sea ice information	
AMALI LIDAR	Scattering coefficient	AWI
Drop-sounding launcher & AVAPS	PTU, wind	AWI
AIMMS - 20	3-dim wind field	AWI
Bird Provision and EM Bird	Sea ice thickness	AWI / Alberta
Slewable Video Camera	Control of Bird operation only	AWI
Sun photometer	Aerosol optical depth	AWI / NOAA
CLAP	Aerosol Absorption	EC/NOAA
Ozone LIDAR*	Ozone profile	York University
- Ozone & mercury monitor - UHSAS aerosol spectrometer - Single Particle soot photometer SP2 - CN counter CN7610 - TSI nephelometer (new) - PMS probes, FSSP-100 and 2DC	- In-Situ O_3 and Hg - Aerosol spectra: 0.06 – 1 um - Black carbon - Condensation nucleus conc. - Aerosol scattering - Cloud microphysics	EC
SMPS TSI 3936L72	Aerosol spectra: 0.01 – 0.5 um	EC
microwave radiometer [6.9, 19.35, 37 und 89 GHz]**	Snow surface characterisation	EC
CPFM grating spectrometer	Column Bro & others	EC
Hygrometer CR2 (Module 722)	Relative Humidity	EC

Table 3: List of scientific systems with information on the derived data

[* Only from Barrow to Resolute Bay / ** only in Alert and in Eureka]

In general we have to say, that the endurance of POLAR 5 for ferry and research flights was really limited during the 2011 campaign and less effective in compare to the 2009 campaign, see table 4. The actual payload of science equipment made is possible to carry out research flight only up to 4.3 hours with an endurance less than 300 nm. The longest flight 2009 was approximately 6 hours due to less scientific systems on board. The recommendation for future campaign is to optimize the science equipment and spare parts and should consider reducing the number of operators during the ferry, if possible. We would like to limit the scientific equipment of 1000 kg. The plan is to get an ferry endurance of 3 hours without reserve and an endurance for research flights up to 400 nm (5 hours flight time), The calculation based on the assumption of 850 pounds fuel consumption per hour.

	lbs	kg
installed science eqt.	3252	1475
AWI spares&tools	386	175
EC spares&tools	121	55
KBAL spares&tools	300	136
Operation tools like blower, generator (provide by KBAL)	143	65
4 survival boxes	229	104
8 survival bags	176	80
8 survival suits	176	80
3 Mission seats	238	108
2 Payloader seats	49	22
3 crew @230lbs incl. luggage	690	313
polar clothing for 8 Pax	265	120
life raft + tents	99	45
5 pax @230lbs incl. luggage	1150	522
total payload	**7274**	**3300**
empty weight	18538	8409
max takeoff weight	28750	13041
total fuel weight	2937	1332
[Ozone DIAL: 460 pounds / RADIOMETER + BOX: 510 pounds]		
max flight hours (no reserve) @1000 lbs/h ca.	3	
max flight hours (1h reserve) @1000 lbs/h ca.	**2**	
max range [NM] @ 205kts (1h reserve)	397	

Table 4: Overview on the cargo estimation and resulted endurance for ferry and research flights during PAMARCMiP 2011, based on 850 pounds fuel consumption per hour.

WEATHER SITUATION DURING THE CAMPAIGN

Ralf Brauner did the weather forecast during the entire campaign from the Jade HS Elsfleth as part of a scientific cooperation between AWI and Jade HS. The used data and weather charts based on the ECMWF data output, which was provided by the German Weather Service.

Barrow/Alaska

POLAR 5 arrived in Barrow later than expected due to bad weather conditions on the flight from Fairbanks to Barrow. The reason was a low-pressure system over the southern part of Alaska, which dominated the weather until the 28th of April with severe icing conditions in many parts of Alaska. On the April 29 – 30, 2011 cold air masses streamed in after a cold front. The cold front belonged to a surface and upper air low northwest of Barrow. The weather conditions were good, only marginal over the sea ice with sea smoke due to leads. Also radiation fog occurred sometimes in the morning and around midday. The low pressure system moved slowly eastward and produced strong winds from west to southwest while sitting north of Barrow the next days until the April 2, 2011.

March 31, 2011: Barrow – NP 38 – Barrow (planned flight activity)

The weather conditions for the flight from Barrow to NP38 (Figure 2) and landing were marginal to bad due to upper air winds. Landing at NP38 was not restricted by weather, also not at Barrow. But the upper low north of Barrow (Figure 3, upper part) set the limiting factor for this flight, resulted by the fact that the distance was the limit of the Polar 5 endurance. Strong upper air winds (Figure 3, lower part) with headwinds of 30 to 35 knots were predicted.

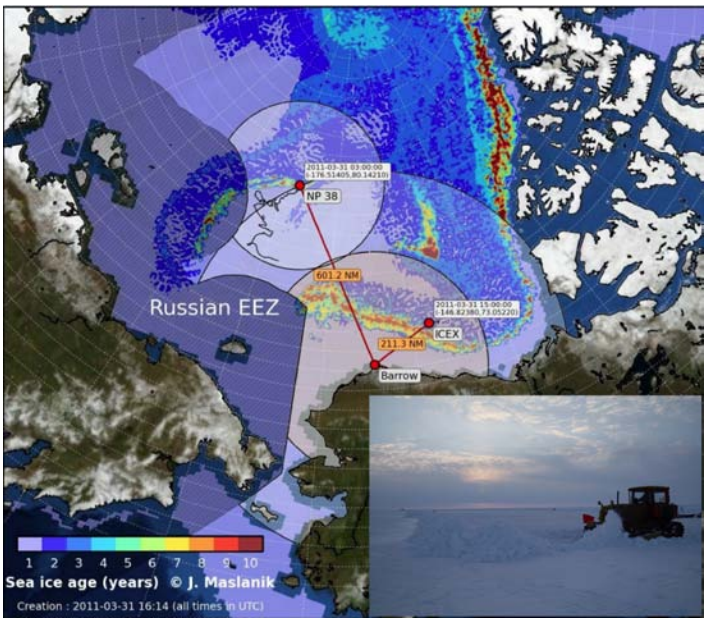

Figure 2: planned NP 38 flight – cancelled due to bad weather and too short runway, photo from the runway (lower right side) – courtesy NP 38 team

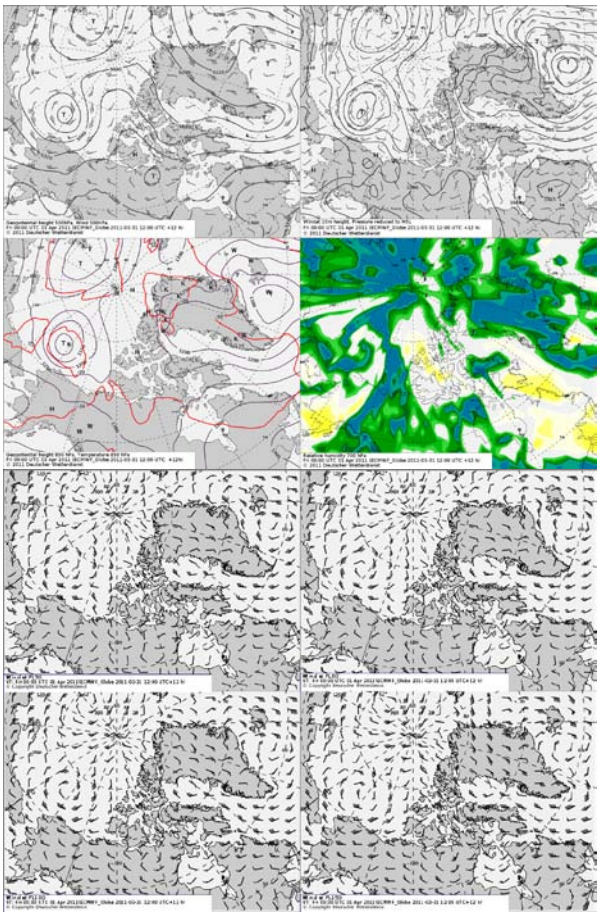

Figure 3: Weather charts from end of March/beginning of April (western Arctic)

Ellsmere Island:

Until the April 8, 2011 mainly high pressure influenced the weather in the region. After the April 8, an intensive low established south of the landing sites. Dry and cold air masses streamed in and only sea smoke restricted the flight conditions temporarily. The low moved slowly northeastward before getting stationary close west of Greenland for some days. The wind direction shifted to northwest. The prevailing flight conditions were good, only snow showers and stronger surface winds were affecting the low level flights.

Station Nord, Longyearbyen:

The general weather situation for Station Nord and Lonyearbyen was divided. A High-pressure influence dominated during the flights from Station Nord. After the ferry flight to Longyearbyen a widespread low moved from Iceland to Svalbard. Warm air masses with heavy snowfall, low visibility and a low cloud ceiling reduced the flight activities for three days. On the May 4, 2011 the low moved to a position east of Svalbard. Therefore colder and air masses reached the region and the visibilities and cloud ceiling improved rapidly.

OUTLOOK

It is a great challenge to obtain simultaneous measurements of different atmospheric and sea ice parameters that are needed to understand the complex processes that underlie climate change in the Arctic. During PAMARCMiP, many vertical profiles and extended horizontal, low-level and cruising altitude transects were undertaken. Ongoing, in depth analyses are being conducted to gain an understanding of the data obtained, while refinements to the measurement strategy are considered to improve future observations of this kind. Our initial measurements worked out very well: during the sea-ice thickness surveys we were able to map extensive areas of boundary layer ozone and mercury depletion as well as determine properties of aerosols that may have an influence on the chemistry taking place within the Planetary Boundary Layer. This demonstrates the great value in cross-disciplinary collaboration, wherein multiple objectives can be achieved simultaneously and results are complementary to one another. Based on the positive experience of the inaugural campaign we intend to undertake yearly PAMARCMiP missions during the spring, including measurements from northern Greenland, see Figure 4 – planned flight route for 2012. This is the time of maximum sea ice extent and thickness, and coincidentally the period when aerosols and trace gases show important, but not well-understood variations that can influence the surface-atmosphere radiation balance. In conjunction with observations made at an expanding network of Arctic climate observatories, [see SEARCH, http://www.arcus.org/search/]. comprehensive aircraft measurements will improve verification of regional and global climate models and contribute to the validation of satellite retrievals of surface and atmospheric properties. Over all, operations during PAMARCMiP and support by US, Canadian, and European partners were exceptional, resulting in a very successful campaign. Collectively, we demonstrated the importance of close international collaboration that will be the cornerstone of planned, future Arctic surveys.

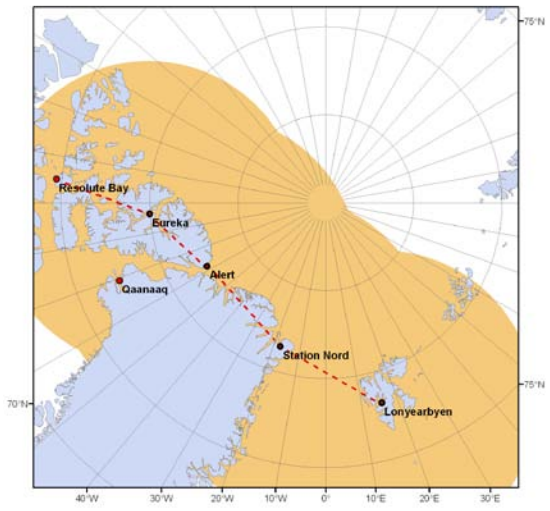

Figure 4: **Flight Route of the POLAR-5 for PAMARCMiP 2012 – the time window is from March 20, 2011 (Longyearbyen) to April 10, 2011 (Eureka)**

ACKNOWLEDGEMENT

PAMARCMiP was a success thanks to behind-the-scenes efforts by many individuals from the participating institutes and affiliates. Personnel at different ground stations across the Arctic provided for our needs. We gratefully acknowledge support from our Canadian (Environment Canada, Toronto; University of Alberta, Edmonton; York University Toronto, Lake Central Air Muskoka), Russian (AARI St. Petersburg), US (NSF, NOAA Boulder, CO; NASA LaRC Hampton, VI; University of Fairbanks, AK), and German (Jade HS, FIELAX Bremerhaven) collaborators. The highly demanding flying would not have been possible without the professionalism and commitment of the crew of Kenn Borek Air Ltd. (Calgary, Canada), namely the captains Keith Kruger, Dean Emberly, co-pilots Mike Armstrong and Jon Sipko and mechanic Doug Mackenzie. The operation of the scientific equipment would not have been possible without the professionalism and commitment of our engineers Manuel Sellmann (AWI) and Johannes Käsbohrer (FIELAX Bremerhaven).

REFERENCES

Bottenheim, J.W., S. Netcheva, S. Morin, and S.V. Nghiem; Ozone in the boundary layer air over the Arctic Ocean: measurements during the TARA transpolar drift 2006–2008, Atmos. Chem. Phys., 9, 4545–4557, 2009.

Dorn, W., K. Dethloff, and A. Rinke; Improved simulation of feedbacks between atmo-sphere and sea ice over the Arctic Ocean in a coupled regional climate model, Ocean Modelling, 29(2), 103-114., doi:10.1016/j.ocemod.2009.03.010, 2009.

Haas, C., S. Hendricks, H. Eicken, and A. Herber; Synoptic airborne thickness surveys reveal state of the Arctic sea ice cover, Geophysical Research Letters, VOL. 37, L09501, doi:10.1029/2010GL042652, 2010.

Lampert, A., M. Maturilli, M. Stock, C. Ritter, A. Hoffmann, A. Herber, R. Neuber, K. Dethloff, R.S. Stone, R. Brauner, and C. Haas; LIDAR and drop sondes characterization of the boundary layer over sea ice covered Arctic Ocean, submitted in Atmospheric Environment, 2011.

Liu, Y., S.A. Ackerman, B.C. Maddux, J.R. Key, and R.A. Frey, Errors in Cloud Detection over the Arctic Using a Satellite Imager and Implications for Observing Feedback Mechanisms. J. Climate, 23, 1894, 2010

Overland, J., H. Eicken, W. Meier, and H. Wiggins; International Arctic sea ice monitoring program continues into second summer, Eos, Transact., 90(37), 321-322, 2009.

Serreze, M. C. Holland, and M. M. Stroeve, J. Perspectives on the Arctic's shrinking sea-ice cover Science 315 (5818), pp. 1533 - 1536, 2007.

Schroeder, W. H., K.G. Anlauf, L.A. Barrie, J.Y. Lu, A. Steffen, D.R. Schneeberger, and T. Berg, Arctic springtime depletion of mercury, Nature, 394, 331–332, 1998.

Stone, R.S., A. Herber, V. Vitale, M. Mazzola, A. Lupi, R. Schnell, E.G. Dutton, P. Liu, S.M. Li, K. Dethloff, A. Lampert, C. Ritter, M. Stock, R. Neuber, and M. Maturilli, A three dimensional characterization of Arctic aerosols from airborne sun photometer observations: PAM-ARCMIP – April 2009, Journal Geophysical Research, VOL. 115, D13203, doi:10.1029/2009JD013605, 2010.

Tjernström, M., C. Leck, P.O.G. Persson, M.L. Jensen, S.P. Oncley, S.P., and A. Targino; The Summertime Arctic Atmosphere: Meteorological measurements during the Arctic Ocean Experiment 2001 (AOE-2001), Bulletin American Meteorological Society, 85, 1305–1321, 2004.