POLAR 5 – a new research aircraft for improved access to the Arctic

A. Herber[1], K. Dethloff[1], Ch. Haas[2], D. Steinhage[1], J. Walter Strapp[3], Jan Bottenheim[3], Tom McElroy[3], T. Yamanouchi[4]
1: Alfred Wegener Institute (AWI) Bremerhaven/Potsdam, Germany
2: University of Alberta, Canada
3: Environment Canada Toronto, Canada
4: National Institute for Polar Research (NIPR) Tokyo, Japan

1. INTRODUCTION

The Alfred Wegener Institute for Polar and Marine Research (AWI) has operated two ski-equipped research aircraft (Dornier 228-101) for the German and international science community since 1983. Several surveys have been carried out each year in both the Arctic and Antarctic polar regions, for studies of the interaction between the lithosphere, ocean, cryosphere, and atmosphere. At the end of 2006, a new Basler BT-67 aircraft called POLAR 5 was purchased. The pilot research study PANARCMIP (Pan-Arctic Measurements and Arctic Regional climate model simulations) will make use of the new POLAR 5 capability to provide a unique snapshot of aerosol and cloud distributions, meteorological and atmospheric conditions, and sea ice thickness in a latitude band between about 60 and 80 degrees North. In situ discrete and/or continuous trace gases measurements will also be made over a wide region in the Arctic, providing a reference to which future monitoring can be compared. The intent is to obtain a latitudinal snapshot of critical parameters over a short time period in order to close key gaps in our understanding of Arctic processes, and ultimately reduce uncertainties in model simulations important for weather and climate prediction. The suite of measurements will allow characterization of the atmospheric thermodynamics and winds (using drop sondes), aerosol, cloud and important gas properties, their longitudinal variation and vertical distribution, and finally sea ice thickness distribution in the central Arctic. The mission will be closely coordinated with ground (CryoVEx) and satellite observations (e.g. Calipso), particularly the network of observatories established by international institutions. The project is being organized under the leadership of AWI in cooperation with several institutions in Europe and Canada, USA and Russia.

2. THE POLAR 5 PLATFORM

The new Basler BT-67 research aircraft, POLAR 5, was put into service by AWI in 2007. The aircraft is based on the venerable DC-3 airframe, and is rebuilt and modernized by Basler Co. with state-of-the-art advanced avionics and navigation systems, and turbo prop engines for scientific and logistic purposes in polar regions. The POLAR 5 can be easily adapted to different science programs. The fuselage provides sufficient space for abundant scientific installations. Loading capacity and cabin volume allows for efficient logistic activities. The passenger transport capacity of POLAR 5 is 18 passengers up to maximum of 2000 kg. Modifications to the “standard" Basler BT-67 for AWI include large belly retractable doors, several large openings in the cabin, wing stations for antennas and probes, and more powerful generators for 15.4 KVA of electrical power. This will allow more extensive and flexible scientific systems relative to earlier polar research aircraft. The aircraft has an operational range of more than 2500 km. Take-off ability using skis at elevations exceeding 3800 meters on the Antarctic plateau has been demonstrated. Based on the capability to take-off from elevations up to 4100 m, the aircraft can return from all locations on the Antarctic ice plateau and from every point in the Arctic. Outside landing on unprepared surfaces is also possible. The aircraft requires less maintenance than previous AWI polar aircraft, and can be operated 800 hours per year. The home base is the regional airport in Bremerhaven, Germany. The technical and mission parameters for POLAR 5 are summarized in Table 1 and Fig. 1. During Antarctic deployments the aircraft operates mainly from the German Neumayer station. Arctic operation will be performed mainly from Svalbard, Greenland and the Canadian Arctic. Equipped with combined ski and wheel gearing, open field and sea ice landings are also possible. During the 2008 season, a deployment from the Arctic floating station NP 35 in the Arctic (April 2008), and the meteorological campaign MELTEX (May/June 2008), operated from Inuvik, Canada, have been successfully accomplished.

Technical parameter		Mission Parameter	
Length over all	20.66 m	Endurance for Ferry	2,600 km
Height over all	5.20 m	Endurance with 1500 kg cargo	1,700 km *
Wing span	29 m	Number of passengers	18 PAX
Length of Fuselage	12.85 m	Lowest cruising Speed	185 km/h
Width of fuselage	2.34 m	Maximum cruising Speed	400 km/h
Height of fuselage	2.00 m	Take off/ landing speed	118 km/h
Maximum take off weight	13,039 kg	Maximum take-off Elevation	4,100 m
Maximum payload	3,900 kg	Lowest flight Altitude	32 m
Fuel consumption	500 kg/h	Pitch angel during Flight	0 °
Maximum service Ceiling	7,600 m	Power supply for Science	550 A/28VDC

Tab. 1. Technical and Mission parameter of POLAR 5

Fig. 1. The view of Polar 5

3. THE PANARCMIP ARCTIC MISSION

Atmospheric studies: The main aim here is to improve the understanding of physical processes in the Arctic atmosphere and to use these measurements to improve the performance and parameterizations of regional and global climate models in the Arctic. A key to better understanding the development of the Arctic atmosphere is in the improvement of regional climate models. This in turn depends on the availability of high quality atmospheric measurements, which lead to improvement of the model parameterizations, particularly for cloud-radiation interaction processes or the development and pathways of cyclones. High resolution observations over long distances are required for this purpose, which can be obtained by regular airborne measurements. Data from such airborne measurements provide a link between data from the few, scattered surface meteorological observatories in the Arctic with high temporal resolution, and the temporally less resolved data from space. Such data is especially needed for high resolution regional modeling, e.g. to help in model validation and inter-comparison with respect to Arctic atmosphere-ocean-sea ice interactions as described by Dorn et al. (2008). Measurements of aerosol – cloud interactions shall be a particular area of interest. Aerosol optical properties feed into radiation transfer calculations (Rinke et al., 2004) and the aerosol – cloud interactions are important for the parameterization of cloud formation processes.

Sea ice studies: The summer of 2007 saw another record low sea-ice coverage in the Arctic Ocean, with a minimum monthly ice extent of 4.28 x 10^6 km^2, 23% less than during the previous minimum in 2005 (Stroeve et al., 2008). Although the ice coverage is likely to retreat similarly dramatically in 2008, questions arise as to whether this drastic reduction of ice extent is just the result of natural variability superimposed on a generally declining trend, or if the Arctic sea ice cover has transitioned into a different climatic state where completely ice-free summers would soon become normal (Holland et al., 2006). The rate of the Arctic summer sea ice decline is much faster than predicted by any of the Intergovernmental Panel of Climate Change model scenarios (Stroeve et al., 2007). By means of airborne electromagnetic (EM) sea ice thickness surveys Haas et al. (2008) have shown that modal and mean ice thicknesses in the region of the North Pole have decreased by up to 53 and 44%, respectively, between 2001 and 2007, and that they were only 0.9 and 1.27 m in the summer of 2007. However, much of this thinning was due to a regime shift from older ice to predominantly first-year ice in the region. This ice drift and wind related regime shift suggests that other regions of the Arctic have to be surveyed as well to obtain a full and conclusive estimate of the Arctic Ocean sea ice mass balance. The PANARCMIP aircraft study will provide the unique opportunity to obtain a snapshot of ice thickness in a vast region of the Arctic, and to generate an inventory of Arctic sea ice volume. The planned flight tracks north of the coasts of Svalbard, Greenland, Canada, and Alaska will survey the regions with the thickest and oldest ice of the Arctic Ocean, and quantify the gradients towards the thinner first year ice zones between the North Pole and Siberia.

Trace gases and aerosol measurements: Dramatic depletion of ozone and mercury in the Arctic surface boundary layer is annually observed in the spring after polar sunrise. Observations of this effect are largely limited to coastal observatories, but it is now assumed that most of the active processing takes place over the frozen Arctic Ocean where measurements are very sparse and difficult to undertake. This hypothesis is based on chemical transport modeling and satellite information on the occurrence of bromine oxide, a definitive marker for the depletion chemistry but confirming in-situ measurements are not available. For this purpose POLAR-5 will be outfitted during PANARCMIP with equipment to measure ozone, mercury and bromine oxide in the marine boundary layer, with the expectation of shedding more light on the conditions that lead to the depletion processes. This will be a contribution of the IPY project OASIS-CANADA, (http://www.ec.gc.ca/api-ipy). The Composition and Photodissociative Flux Measurement (CPFM) experiment during PANARCMIP is based on a small, light-weight photodiode array diffrac- tion-grating spectrophotometer called the SPS (SunPhoto Spectrometer), which makes measurements of the solar flux on a quasi-horizontal surface, the limb brightness and the apparent surface brightness below flight level from the POLAR-5 research aircraft. Trace gas concentrations below the aircraft retrieved from measurements of the flux of light upward from the nadir (McElroy et al., 1999). Concentrations of gases near flight level can be retrieved from limb observations. Aerosol properties are retrievable from the polarization characteristics of the limb and nadir scattered light. Soot is a critical component in atmospheric aerosols in assessing the climate impact of aerosols and atmospheric transformation. It accounts for much of the optical absorption of aerosols in the atmosphere and thus can affect the aerosol single albedo. Over the Arctic, little information is available for the geographic distribution of atmospheric soot carbon measurements, and the radiative impact of soot carbon is not well known. In PANARCMIP, measurements of soot carbon and its particle size distribution will be made to obtain this critical information to help understand the radiative impact of aerosols in the Arctic. A Single Particle Soot Photometer (SP2) will be deployed together with a high time resolution particle sizing instrument (UHSAS) to determine the particle size distribution on a 1 s basis on board POLAR-5. With the aircraft covering the western part of the Arctic from Europe to the Canadian archipelago, a spatial distribution of the particle sizing and concentration of soot carbon will be obtained.

4 PANARCMIP FLIGHT PLAN

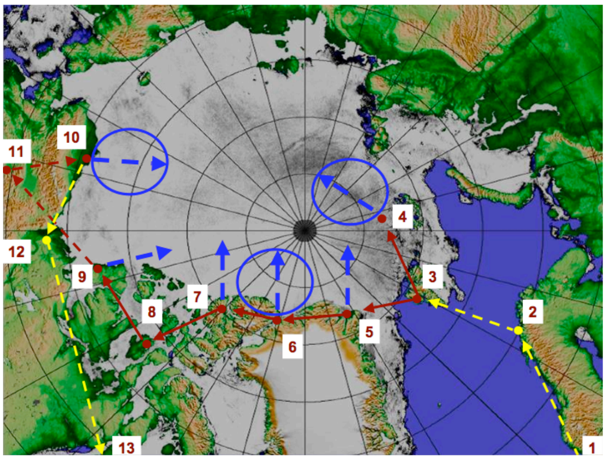

Fig. 2. The tentative route for the PANARCMIP flight program in April 2009

NO.	AIRPORT	DISTANCE TO NEXT	LATITUDE	LONGITUDE
1	BREMERHAVEN (EDWB)	1011 nm	53°30'31" N	8°34'49" E
2	TROMSOE (ENTC)	517 nm	69°40'53"N	18°55'04"E
3	LONGYEARBYEN (ENSB)	*	78°14'46"N	15°27'56"E
4	NP 36	*	83°00'00"N *	55°00'00"E *
3	LONGYEARBYEN (ENSB)	385 nm	78°14'46"N	15°27'56"E
5	STATION NORD (BGNO)	372 nm	81°36'30"N	16°40'42"W
6	ALERT (CYLT)	260 nm	82°31'04"N	62°16'50"W
7	EUREKA (CYEU)	338 nm	79°59'41"N	85°48'51"W
8	RESOLUTE BAY (CYRB)	538 nm	74°43'01"N	94°58'10"W
9	SACHS HARBOUR (CYSY)	652 nm	71°59'38" N	125°14'33"
10	FAIRBANKS (PAFA)	436 nm	64°29'20"N	147°30'50"W
11	POINT BARROW (PABR)	511 nm	71°17'08"N	156°45'58"W
12	INUVIT (CYEV)	2219 nm	68°18'15" N	133°29'00" W
13	OSHAWA (CYOO)		43°45'22"N	78°53,42"W

Tab. 2. List of airports/stations during transit, * means here: the position is yet not clear

Fig. 2 and Table 2 show the tentative flight track for PANARCMIP. The intention is to fly POLAR-5 during April 2009 on a semi circum-navigation of the Arctic from western Europe to Alaska, including a landing at the floating station NP 36. The program will require about four weeks, including ferrying the aircraft from Germany to the starting point at Longyearbyen, Svalbard. From there, the aircraft will fly west to the final destination Pt. Barrow, making strategic stops to refuel and perform research flights. The longest leg will be approximately 650 nm. The total flight time will be approximately 75 hours, including transit flights (40 h).

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