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Polar aircraft Polar5 and Polar6 operated by the Alfred Wegener Institute

Alfred-Wegener-Institut Helmholtz-Zentrum für Polar- und Meeresforschung, Bremerhaven, Germany *

Instrument Scientists:
- Daniel Steinhage, Alfred-Wegener-Institut Helmholtz-Zentrum für Polar- und Meeresforschung, phone: +49(0) 471 4831 1198, email: daniel.steinhage@awi.de

Logistics:
- Uwe Nixdorf, Alfred-Wegener-Institut Helmholtz-Zentrum für Polar- und Meeresforschung, phone: +49(0) 471 4831 1160, email: uwe.nixdorf@awi.de
- Christine Wesche, Alfred-Wegener-Institut Helmholtz-Zentrum für Polar- und Meeresforschung, phone: +49(0) 471 4831 1967, email: christine.wesche@awi.de

Abstract: Due to the remoteness and difficulty to access the snow covered polar regions, ski-equipped aircraft are an indispensable tool for polar research. The Alfred Wegener Institute has a long tradition in airborne polar science – starting with the aircraft Polar1 and Polar2 in 1983. In 2007 the first Basler BT-67 (Polar5) and in 2011 the second Basler BT-67 (Polar6) were brought into service and replaced Polar2 and Polar4. They carry a variety of scientific equipment for investigation of the lithosphere, atmosphere and cryosphere and all their interactions. Beside being deployed for science missions, the aircraft are also part of the Dronning Maud Land Air Network (DROMLAN), a logistical partnership to transport equipment and personnel to various stations in Dronning Maud Land, Antarctica.

1 Polar aircraft Polar5 and Polar6

Since 1983, the Alfred-Wegener-Institut Helmholtz-Zentrum für Polar- und Meeresforschung (AWI) has been operating aircraft for the German scientific community. While the first four aircraft (Polar1 to Polar4) were Dornier Do128, respectively Do 228, the newest generation of AWI's polar aircraft, the Polar5 and Polar6 (Figure 1), are Basler BT-67. The Basler BT-67 is a modern version of the Douglas DC-3, which is equipped with modern avionics, turbo-prop engines and a combined ski-wheel gear.

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Table 1: Facts about the research aircraft Polar5 and Polar6.

		Polar5 / Polar6
Registry		C-GAWI / C-GHGF
Model		Basler BT-67
Year of commissioning		2007 / 2011
Technical parameter		
Length / height over-all	m	20.00 / 5.20
Wingspan	m	29.00
Length / width of cabin	m	12.85 / 2.34
Height of cabin	m	2.00
Empty weight (wheel)	kg	8387
Maximum take off weight	kg	13068
Engine		Pratt & Whitney (PT6A-67R)
Engine power (per engine)	Ps	1281
Fuel consumption	l/h	570
Service ceiling	m	7600
Mission Parameter		
Max. payload (3 flight h)	kg	2500
Endurance without payload	km	3000
Maximum cruising speed	km/h	380
Number of passenger	pax	18
Maximum take off height	m	3800
28V DC science power	A	550

This allows landing and take-off from paved, gravel or snow covered surfaces. The fuselage provides space for a variety of scientific installations, which can be adapted to the different scientific programs. The main facts about both aircraft are given in Table 1. The scientific community can apply for using AWI polar aircraft (http://www.awi.de).

Figure 1: Polar6, Photo: Alfred-Wegener-Institut/R. Ricker.

2 Science

Scientific equipment is mounted either inside the aircraft or on the wings to investigate the lithosphere, the atmosphere and the cryosphere in the Arctic and Antarctica.
In the following sub-sections, only examples of scientific projects using AWI's polar aircraft are presented.

2.1 Pre-site survey for a deep-ice core drilling site

Within the framework of the European Project for Ice Coring in Antarctica (EPICA), a deep ice core should be drilled in Dronning Maud Land (DML). Main goal was to drill an ice core that shows a climate record at a high temporal resolution which requires relatively high accumulation and slow horizontal ice movement, e.g. ice divides or summits (Steinhage, 2001; Steinhage et al., 2001). A pre-site survey was conducted between seasons 1995/96 and 1998/99 using airborne Radio Echo Sounding (RES). Overall more than 90,000 km long ice thickness profiles covering over 1 million km^2 of DML were measured (Steinhage et al., 2001). The RES system (Nixdorf et al., 1999) was fixed under the wings of the Polar2 aircraft. The RES instrument and other scientific instruments used on bord of Polar2 and 4 were transferred to the successor aircraft Polar5 and 6. Figure 2 shows Polar6 equipped with ice thickness accumulation radar. For the pre-site survey the RES system was configured in toggle mode, transmitting 60 and 600 ns long bursts with a centre frequency of 150 MHz.
The 600 ns pulses were used for ice thickness determinations, and the 60 ns pulses for tracing internal horizons. The AWI ice thickness measurements were complemented by six additional flights conducted by the British Antarctic Survey (Steinhage et al., 2001). A map of the subglacial topography of DML was derived by the subtraction of the ice thickness measurements from a digital elevation model. With the aid of the local subglacial topography and ice thickness measurements, the optimal location for the EPICA DML deep ice core was defined in the region around 75°S and 0°. Based on this investigation, Kohnen Station was inaugurated in 2001 at 75°S and 00°04'E as a logistics base for deep ice core drilling. The ice thickness was determined to be 2750 m in this region (Steinhage, 2001), which is very close to the length of the ice core (2774.15 m – Wilhelms et al. (2014)).

Figure 2: Polar6 with ice thickness radar antennas (large boards) and high frequency accumulation radar antennas (small housings near wing tips) underneath the wings, Photo: Alfred-Wegener-Institut/D. Steinhage.

2.2 Atmospheric boundary layer observations

In March 2013, the aircraft campaign Spring-Time Atmospheric Boundary-Layer Experiment (STABLE) took place over ice-covered regions of the Fram Strait to study the influence of leads on the atmospheric layer at the air-ice transition. The meteorological instruments measuring the temperature, pressure, wind vector and humidity were mounted on a 3 m long noseboom Figure 3. Additionally, a radiation thermometer and an infra-red scanner were used to measure surface temperatures. Several low-level flights perpendicular and parallel to the course of the leads were conducted (Tetzlaff et al., 2015). The results show that the turbulent fluxes, mean variable winds, temperatures and humidity over leads are strongly variable. For further reading on this topic please refer to Tetzlaff et al. (2015).

Figure 3: Polar5 with 5-hole probe at the noye boom, Photo: Alfred-Wegener-Institut/C. Lüpkes.

2.3 CryoVEx

Within the framework of the CryoSat Validation Experiment (CryoVEx) European Space Agency's (ESA) Airborne SAR / Interferometric Radar Altimeter System (ASIRAS) was mounted on AWI's polar aircraft. This system has a similar functionality to the radar altimeter onboard the CryoSat-2 (SIRAL – Synthetic Interferometric Radar Altimeter). ASIRAS measures in Ku-band (13.65 GHz) and was used for the first time in 2004 (Helm et al., 2007). The CryoVEx was a ESA funded joint project of AWI, Technical University of Dresden, and Technical University of Denmark in Copenhagen. The main goal was to understand the scattering of the ASIRAS signal and, consequentially the development of a signal re-tracker for SIRAL onboard CryoSat-2. Helm et al. (2007) presented first results over the percolation zone in Greenland and compared ASIRAS measurements with data derived from laser scanning and single beam laser for validation. Within the following years, several flight campaigns were conducted over Antarctica and Greenland to gain more experience with the signal processing and hence the development of a re-tracker of the CryoSat-2 data. In April 2009, the CryoSat-2 satellite was launched and the re-tracker could be applied and refined. Helm et al. (2014) published digital elevation models of Antarctica and Greenland derived from CryoSat-2 data, using the AWI re-tracker. Consequently, the work which was done within the CryoVEx projects was essential for the understanding of the CryoSat-2 signal processing.

2.4 AIRMETH

During the joint AIRMETH (AIRborne measurements of METHane emission) campaign of AWI, the Institute for Environmental Physics of the University of Bremen and the Helmholtz Center Potsdam German Geoscience Center (GFZ) in 2011, differential optical absorption spectroscopy (DOAS) was mounted on the Polar5 aircraft. As Nitrogen dioxide (NO_2) is a toxic trace gas in the Earth's atmosphere and it is produced by the reaction of nitrogen monoxide (NO) with ozone (O_3). NO is produced by the photolysis of NO_2. Source of NO_x can either be natural processes as lightning, natural biomass burning events, soil emissions or anthropogenic activities as fossil fuel combustion by power plants, industry and traffic (Schönhardt et al., 2015).

Additionally to the DOAS onboard Polar5, the Aircraft-Integrated Meteorological Measurement System (AIMMS-20) was used during the flight on 4 June 2011 in the region of Ibbenbüren, Germany. Goal of the project was to observe the pollution plumes from a coal mine with a coal-fired power plant in the near vicinity. The measurements of the AIRMETH-2011 demonstrated that the onboard system using the DOAS method is applicable for emission plume detection at a good spatial and temporal resolution. NO_2 was successfully observed on small spatial scales. For details on the method and further reading it is referred to Schönhardt et al. (2015).
Measurements of methane (CH_4) emission over permafrost regions were conducted within the framework of AWI and GFZ joint AIRMETH campaigns in 2012 and 2013.

3 DROMLAN

The Dronning Maud Land Air Network (DROMLAN) is a non-profit project of international partners to provide a more economic, flexible and timely entry into Antarctica for them. Member states are Belgium, Finland, Germany, India, Japan, The Netherlands, Norway, Russia, South Africa, Sweden and United Kingdom. A map of the network in presented in Figure 4.

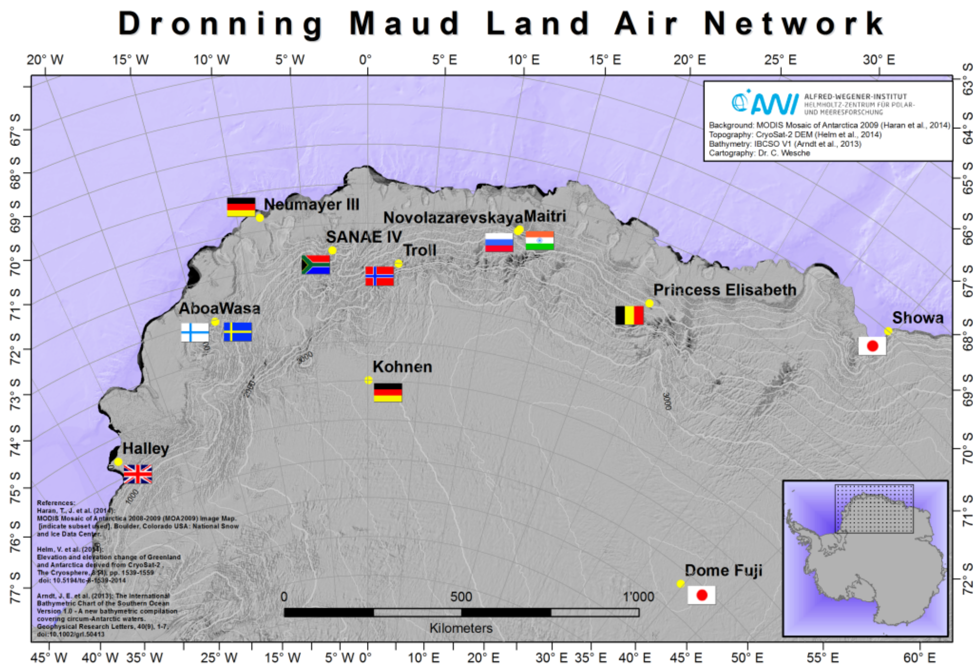

Figure 4: DROMLAN map with stations of the members.

As AWI is an active member of DROMLAN, Polar5 and Polar6 are used to transport cargo and staff between the DROMLAN stations. They also serve a role in potential SAR operations in the area.

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