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Report

Joint AWI-NIPR airborne operations in the past and the future

Andreas Herber[1*], Hartwig Gernandt[1], Wilfried Jokat[1], Uwe Nixdorf[1], Daniel Steinhage[1],
Heinz Miller[1], Renate Treffeisen[1], Takashi Yamanouchi[2], Kazuyuki Shiraishi[2],
Yoshifumi Nogi[2], Kazuo Shibuya[2] and Makoto Wada[2]

[1]*Alfred Wegener Institute for Polar and Marine Research,*
PO 120161, 27515 Bremerhaven, Germany
[2]*National Institute of Polar Research, Kaga 1-chome, Itabashi-ku, Tokyo 173-8515*
[*]*Corresponding author. E-mail: Andreas.Herber@awi.de*

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Abstract: The Alfred Wegener Institute for Polar and Marine Research (AWI) has in the past operated two ski equipped aircraft (Dornier Do228-101) for scientific and logistic purposes in polar regions—called POLAR 2 and POLAR 4. Both aircraft are easily able to be adapted to different science programs. Aero-geophysical instrumentation and various atmospheric systems are available. In recent years, a long and fruitful cooperation with the National Institute of Polar Research (NIPR), Tokyo, has been established, whereby so far three joint airborne campaigns have been already performed in the Arctic, namely ASTAR 2000 (Arctic Study of Tropospheric Aerosol and Radiation), AAMP 2002 (Arctic Airborne Measurement Program), and ASTAR 2004. The ANTSYO (Antarctic flight missions at Syowa region: Airborne Geophysical, Glaciological, and Atmospheric Research in East Antarctica) operations of the AWI research aircraft, POLAR 2, started in the season 2005/06, from S17, near Syowa Station in December 2005. Running such surveys presents a logistical challenge that can only be met with the combined support of Alfred Wegener Institute, Bremerhaven, and the NIPR, Tokyo. Therefore, both national Antarctic programs put their logistical capabilities together in order to perform the first extensive airborne missions in this area over a period of three Antarctic summer seasons (2005/06 till 2007/08).

key words: Antarctica, airborne operation, geophysics, aerosols

1. Introduction

Generally it is assumed that the climate changes in the polar regions can influence the climate on a global scale. The Arctic and Antarctica represent only a small proportion of the Earth's surface. However, the polar regions have sensitive ecosystems, which, due to their extremely long recovery cycles are highly susceptible to climate. Moreover, they serve as an early indicator of changes on a global scale and therefore also constitute an ideal laboratory for geophysical and atmospheric studies. Each, however, poses its own very special challenge, emanating from its unique environment and role within the Earth system, which needs to be met individually. The aim of airborne research is to contribute to the understanding of relevant processes and interdependencies in the highly dynamic Earth system, especially in the polar regions and finally to improve our understanding of interactions between the lithosphere, ice, ocean, and atmosphere.

The direct and indirect radiative effects of aerosol particles and clouds have been identified as key uncertainties for the prediction of the future global climate (Houghton *et al.*, 2001). At the polar, special conditions of unusually high surface albedo and low solar elevations cause enhanced aerosol/cloud effects due to multiple scattering, which therefore have a climate impact. There is convincing observational evidence that the Arctic environment is changing (Stone *et al.*, 2002). In order to improve knowledge of the origin, transport pathways, and vertical structure of aerosol and cloud physical and chemical properties, as well as their impact on climate in the polar regions, a combined effort of surface-based, airborne and space-borne measurements is crucial. Therefore, the atmospheric project is focussed on aircraft-based measurement campaigns in the period from 2000 to 2007. Climate reconstruction using ice core records from Greenland and Antarctica will benefit from this dataset.

Antarctica is characterized by very low temperatures, marked seasonality, a huge continental ice shield and large oceanic areas permanently or seasonally covered by sea ice. During the past 10 years, airborne geophysical surveys in the Atlantic sector of Antarctica have been focused on mapping regional lithospheric structure. An example of this is the EMAGE (East Antarctic Margin Aeromagnetic and Gravity Experiment) survey (Jokat *et al.*, 2003; König and Jokat, submitted). The main objective was to identify magnetic sea floor spreading anomalies to constrain the break-up scenario of Gondwana. Furthermore, the mapping of the deeper structure of the transition from the continent to the ocean basins was a prime target. The results of the EMAGE surveys provided surprising results, and led to a revised age and geometrical models. Another advantageous technique with an aircraft is the airborne radio echo sounding system, which allows, to investigate the internal structure of the Antarctic and Greenland ice sheets, especially between deep ice core drill sites. In the future, it is planned to extend the operation area in the direction of the Enderby Land and Lützow-Holm Bay (East Antarctica), see Fig. 1.

The current ANTSYO (Antarctic flight missions at Syowa region: Airborne Geophysical, Glaciological, and Atmospheric Research in East Antarctica) project with POLAR 2 took place during austral summer 2005/06 in the areas near Syowa Station (69°S, 40°E). The two national Antarctic programs have combined their logistical capabilities to perform the first extensive airborne missions in this area.

Two further airborne surveys are scheduled for the next two austral summer seasons until 2007/08. The anticipated airborne operation in Antarctica is a unique opportunity to improve the insight into the interdependencies between the atmospheric sciences and glaciology and between glaciology and geodynamics.

2. Aircraft Platform

The Alfred Wegener Institute (AWI) has owned two research aircraft—called POLAR 2 and POLAR 4—since 1983. Both aircraft are operated by DLR flight facilities (German Aerospace Centre). Unfortunately during the ferry flight of polar aircraft from the German Neumayer Station (71°S, 8°W) to Punta Arenas POLAR 4 was seriously damaged during a

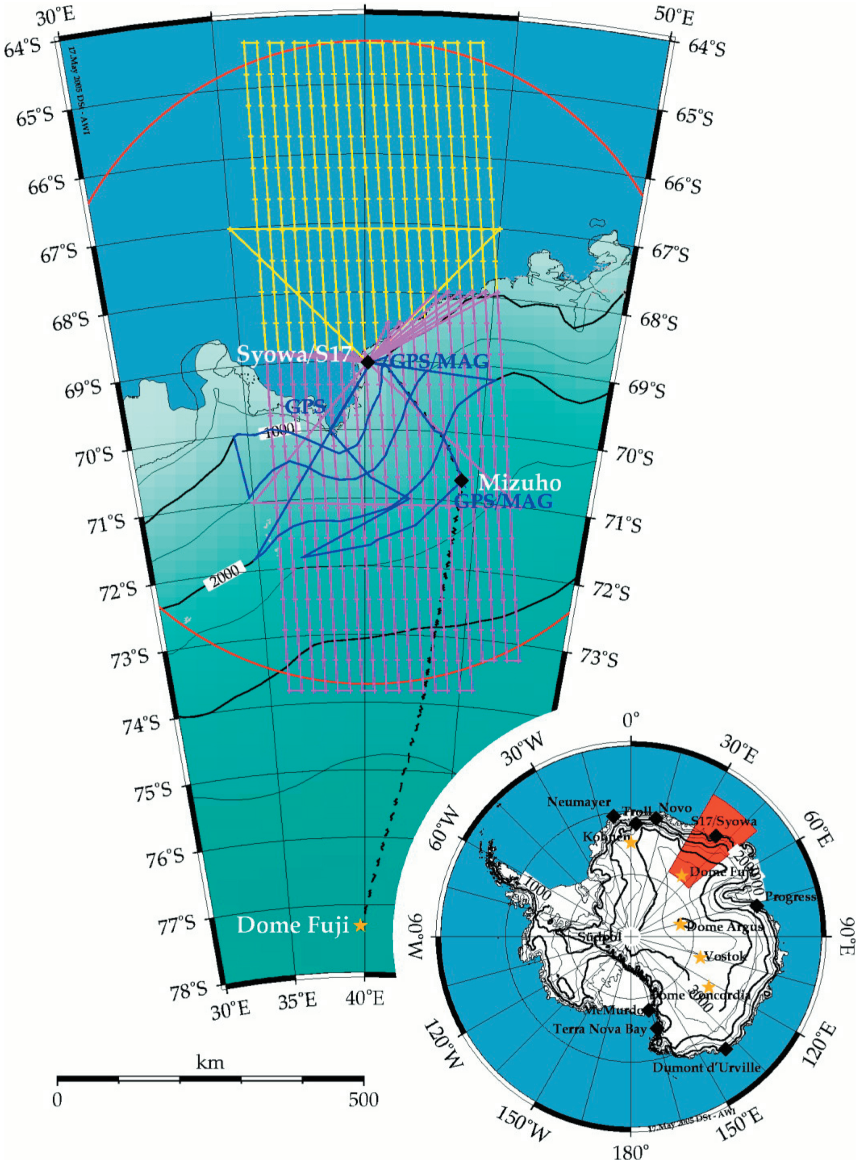

Fig. 1. Operation area for the ANTSYO project.

hard landing at the British station Rothera in January 2005. As a result of this accident, AWI presently operates only one aircraft, POLAR 2. The twin-engine polar research aircraft are a special version of the Dornier 228-101 multipurpose aircraft. Main purpose is their use as an airborne research platform. But the aircraft are also used for transportation of passenger (up to 15 passengers) and cargo. During its operation in Antarctica they are on standby also for SAR (Search and Rescue) missions. The scientific instrumentation of the aircraft is maintained by OPTIMARE Sensorsystem AG, Bremerhaven. Optimare has also developed the on-board data acquisition systems.

Fig. 2. POLAR 2 in operation during the 2004/05 Antarctic campaign.

The aircraft can be equipped with a ski undercarriage, enabling them to take off and land on concrete or snow runways. The aircraft is specially equipped for operations in remote areas (Arctic and Antarctic), with enhanced specifications, powerful generators, de-icing equipment on the propellers and wings, provisions to heat the batteries and the engines. Both aircraft are equipped with modern navigation systems (2 × GPS, INS, TCAS) for stand-alone navigation without ground facilities, and common aviation radios (VHF, HF) as well as modern satellite communication systems as Iridium and InMarSat systems (telex, email, voice). The most important technical capability of the aircraft is to take off and land on short and unprepared runways and yet to travel at high cruising speeds (370 km/h). The flight crew consists of two pilots and one flight engineer to ensure operation without ground infrastructure. Figure 2 shows POLAR 2 during geophysical operation in Antarctica, near Neumayer Station. The technical specifications are:

- Max take off mass: 6400 kg (with skis: 6800 kg),
- Cruising speed: 370 km/h (with skis: 280 km/h),
- Max range (empty): 2900 km (with skis: 1700 km),
- Service ceiling: 7620 m,
- Engine power: 2 × 715 HP,
- Length: 15 m, and wing span: 17 m.

3. Past joint AWI-NIPR airborne campaigns in the Arctic

3.1. ASTAR 2000

The ASTAR 2000 (Arctic Study of Tropospheric Aerosols and Radiation) campaign took place from 12th March until 25th April 2000 with extensive flight operations in the vicinity of Svalbard (Norway) from Longyearbyen airport (78°N, 16°E), see Yamanouchi *et al.* (2005) for details. ASTAR 2000 was a joint Japanese (National Institute of Polar Research-NIPR, Tokyo)–German (AWI Bremerhaven/Potsdam) airborne campaign using the AWI aircraft POLAR 4. Simultaneous ground-based measurements were conducted at the international research site Ny-Ålesund (79°N, 12°E, at sea level) in Svalbard, at the joint German-French AWIPEV Station, at the Japanese Rabben Station and at the Scandinavian Station at Zeppelin Mountain (79°N, 12°E, 475 m a.s.l.). During the campaign 19 profiles (totalling 67 flight hours) of various aerosol properties were measured.

In general, the Arctic spring aerosol in the vicinity of Svalbard has significant temporal and vertical variability (Treffeisen *et al.*, 2004). A strong haze event occurred between 21st and 25th March, in which the optical depth from ground-based observation was 0.18, significantly greater than the background value of 0.06 in the visible spectral range (Herber *et al.*, 2002). Airborne measurements on 23rd March, during this haze event, showed a high aerosol layer with an extinction coefficient of 0.03 km^{-1} or more up to 3 km and a scattering coefficient from 0.02 in the same altitude range. From the chemical analysis of airborne measurements (Hara *et al.*, 2002, 2003) sulphate, soot, and sea salt particles were dominant, and there was a high mixing ratio of external soot particles in some layers during the haze event. The high aerosol loading is very likely due to direct transport from anthropogenic source regions. In addition, the airborne aerosol measurements were successfully used to validate SAGE-II satellite (Stratospheric Aerosol and Gas Experiment) observations (Thomason *et al.*, 2003). Another aim of the project was the incorporation of the observational results into an Arctic regional climate model in order to quantify the radiative forcing of aerosols over a wide area, which could be realised for two days of the campaign (Treffeisen *et al.*, 2005). Using these airborne results, Rinke *et al.* (2004) studied the direct climate effect of aerosols within a regional atmospheric model for the Arctic. They demonstrated that, through the aerosol-radiation-circulation feedback, the scattering and absorption of radiation by aerosols cause pressure changes which have the potential to modify Arctic tele connection patterns like the Barents Sea Oscillation. These investigations showed that to assess future Arctic climate changes, it is necessary to improve our knowledge of the spatial and temporal aerosol variation and the aerosol and cloud properties in the Arctic.

3.2. *AAMP 2002*

The AAMP 2002 (Arctic Airborne Measurement Program), a campaign was performed as a trans Arctic flight from 4th to 15th March 2002 (totalling 49 flight hours) by NIPR Tokyo with the cooperation of AWI Bremerhaven and several other institutions, as one of the sub programmes of "Variations of atmospheric constituents and their climatic impact in the Arctic" (Special Japanese Scientific Research Program, No. 11208201). One of the research objectives was to elucidate the spatial distribution, long-range transport and transformation of greenhouse gases and aerosols, related to stratosphere–troposphere exchange and polar vortex, including radiative forcing on the Earth-atmosphere system. A further aim of the campaign was also to investigate the structure of atmospheric disturbance especially of polar low. An instrumented jet plane, a Gulfstream II (G-II), was used and flown from Nagoya (35°N, 136°E), Japan via Barrow (71°N, 157°W), Alaska, to Longyearbyen, Svalbard, crossing the Arctic Ocean at 12–13 km height, and three local flights over the Greenland Sea around Svalbard, see Yamanouchi *et al.* (2003). During the campaign, intensive surface operations were conducted at Ny-Ålesund, Svalbard. Airborne measurement data were also compared with surface observations at Barrow by NOAA/CMDL, and SAGE-III satellite measurements by NASA. Vertical profiles of ozone and CO_2 showed different tendencies from the troposphere to the stratosphere; for ozone profiles a distinct change at the tropopause could be demonstrated (Morimoto *et al.*, 2003), whereas the CO_2 profile showed a gradual change from upper troposphere to the stratosphere and no distinct change at the tropopause. The increase of CO_2 concentration in the lower stratosphere (around 12 km) between March 1998 and 2002 was about 6–8 ppmv. Aerosol sampling was performed with a filter sampler and impactor. Ionic components were analyzed with ion chromatography, and elemental components with an electron microscope. From sun photometer measurements, optical depth of the stratospheric aerosols shows a good agreement in wide area of flight, around 0.004 to 0.005 at λ=500 nm from the height range 11–12 km. In addition a good agreement was found between the derived extinction profile of the sun photometer measurements and SAGE-III satellite measurement (near Pt. Barrow) in the altitude range from 3 to 15 km, at 72°N (Treffeisen *et al.*, 2006).

3.3. ASTAR 2004

ASTAR 2004 (Arctic Study of Tropospheric Aerosols, Clouds and Radiation) campaign was performed in order to investigate the transition from Arctic spring to Arctic summer aerosol conditions. The main focus of the project was to provide an observational over-determined aerosol data set, which is necessary to improve the assessment of the direct and indirect effects of aerosols on the Arctic radiative balance. This had been achieved by utilizing unique aircraft instrumental payloads, addressing both aerosol and cloud measurements, combined with ground-based and satellite observations, and by using appropriate modelling tools. During ASTAR 2004, intensive flight operations were performed in the vicinity of Svalbard (Norway) from Longyearbyen airport by using both AWI aircraft POLAR 2 and POLAR 4. The ASTAR 2004 campaign took place from 10th May until 11th June 2004, with total of 133 flight hours, during 46 flights, on 19 days. Supporting ground-based measurements were carried out simultaneously at the international research site Ny-Ålesund, at the joint German-French AWIPEV Station, the Japanese Rabben Station and the Scandinavian Station at Zeppelin Mountain and at the Polish Research Station Hornsund (77°N, 16°E). ASTAR 2004 was a collaborative effort between the AWI Bremerhaven/Potsdam, Germany, the NIPR Tokyo, Japan, the Air Pollution Laboratory of Stockholm University, Sweden, the Institute of Atmospheric Physics DLR Oberpfaffenhofen, Germany, and the Laboratory of Physical Meteorology, Clermont—Ferrand, France. The analyses and interpretation of the collected data is still on going. Another Arctic airborne campaign is scheduled for spring 2007 with the focus on validation of CALIPSO (Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation) data and as part of the IPY Project POLARCAT (Polar study using Aircraft, Remote sensing, surface measurements and modelling of Climate, chemistry, Aerosols and Transport).

4. ANTSYO

As mentioned earlier, is ANTSYO a joined Japanese-German effort to study the atmosphere, lithosphere, and ice sheet in east Dronning Maud Land–Enderby Land using airborne measurements. Unfortunately it is impossible to operate the AWI polar aircraft from the Japanese wintering base Syowa. Therefore a new summer station had to be established at S17, some 20 km east of Syowa by the Japanese Antarctic Research Expedition (JARE) to enable the proposed geophysical and atmospheric research flights.

4.1. Logistic setting: summer station S17

The field camp S17 located at 40°07′E, 69°01′S, 608 m a.s.l., which is located 20 km east of Syowa will be used for flight operations in the coming seasons in the East Antarctica. The joint efforts of NIPR Tokyo and AWI Brermerhaven allowed airborne operation from this specially designed field camp for a maximum of 20 scientists, pilots, and engineers (see Fig. 3). The facilities at S17 consist of a building on a raisable platform, several Weatherhaven tents, and snow vehicles. The hut on the platform houses a combined kitchen and mess room and the generator and sanitary facilities in another room. In season 2005/06 3 Weatherhaven and 2 snow vehicles will be used to provide accommodation for up to 18 persons in the camp. Several computer workplaces for data back-ups, archiving and a first data evaluation are also established in the tents. Communication is organized via INMARSAT-C, Iridium and various radios, which are placed in the mess room. The station will be closed at the end of the austral summer and all tents will be removed and stored away.

The landing strip will be prepared with a length of 1000 m and a groomed width of 20 m with flags every 100 m on the northern side. The orientation of the skiway is east-west, parallel to the prevailing wind direction. The main fuel depot is placed in a safe distance to the camp and fuel for 2–3 flights will be kept a sledge at the parking position of the survey aircraft. Electrical power at the parking position for refueling and heating the scientific equipment is provided by an extra generator.

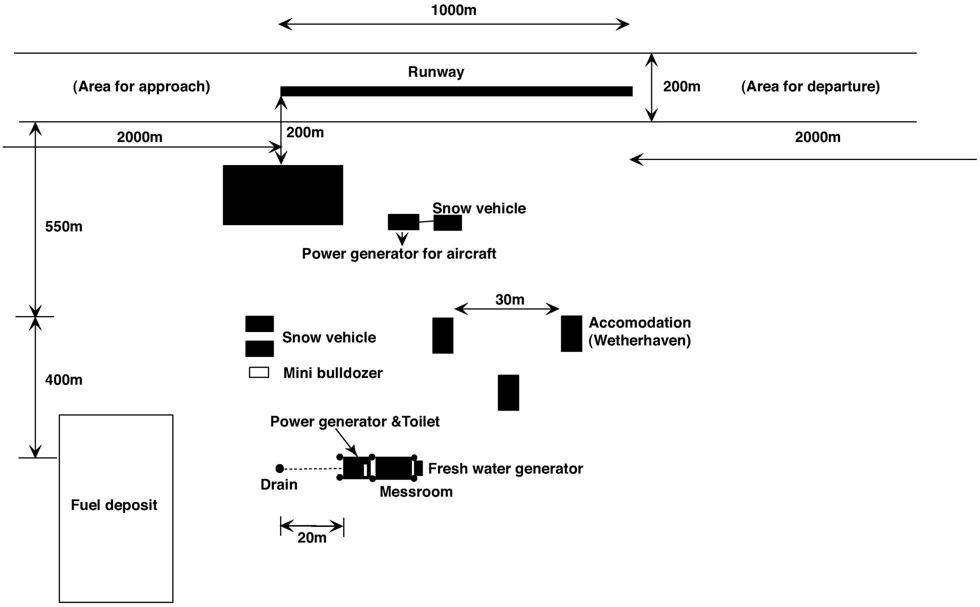

Fig. 3. Layout of the base camp S17, near Syowa Station.

The expected temperatures and wind during the planned activity in December/January are in the range from –15°C up to +5°C and the wind speed is in the range between 5 m/s to 15 m/s, mainly east.

4.2. Geophysical activity

The geophysical part of ANTSYO started in December 2005 (austral summer 2005/06) with the aircraft POLAR 2. After integration and successful test flights at Neumayer Station, operation will be started at S17, near Syowa Station (East Antarctica). It is planned that the geophysical program will be continued in austral summer 2007/08. A special focus of the geophysics and glaciology groups is to investigate the internal structure of the Antarctic ice sheet, especially between deep ice core drill sites as well as the distribution of ice accumulation in Antarctica revealed by radar. Furthermore, questions about the crustal structure of the Antarctic craton and adjacent plates, and the geometry and dynamics of Gondwana break-up are of special interest. This geophysical program, therefore, is divided into two research activities:

- The geophysical activity named WEGAS (West-East Gondwana Amalgamation and its Separation).
- The glacialogical activity named DISTINCT (Dronning Maud Land Ice Sheet Incorporative Task).

4.2.1. WEGAS

The focus of Antarctic geophysical research in the past two decades was to investigate the geometry and dynamics of the Gondwana break-up. The East Antarctic craton formed over a long geological timescale in the centre of the super-continent Gondwana. Onshore geological investigations have unravelled the older history of Gondwana from its formation to its break-up. The geometrical fit of South America, Africa, Madagascar and India with East Antarctica allowed some speculations on the continuity of geological features from the surrounding continents into Antarctica. Here, most of the information on the geology was derived from a few rock outcrops at the tips of the mountain ranges buried by up to 3 km of ice. In the 80’s a Russian regional aeromagnetic survey yield invaluable data to constrain and extrapolate the results of the geological investigations. But it also is clear from those investigations that, for most problems, the line spacing (mostly 20 km), see Golynski *et al.* (2000), is too large and that, thus the data coverage needs to be extended. Recent aeromagnetic data acquired in tandem with ice thickness surveys by Germany within the EPICA program, indicate some magnetic anomalies in the far south. However, these anomalies cannot be correlated as the line spacing is too wide, but the data show the potential that significant geological structure are present south of Heimefrontfjella and that new results concerning the pre-break-up geological history can be expected.

Concerning the post-break-up history of Gondwana an extension of the existing flight lines towards the east are necessary within the next steps of the project. In the seasons 2002/3 to 2004/5 the backwards western segments of the WEGAS project were partly filled (WEGAS-I–III/VISA1-3). The gap in data acquisition between Novolazarevskaja and Syowa Stations can, at the moment, not be filled due to the limit of existing logistics. Thus WEGAS-IV and V will be concentrated, during two austral summer seasons (2005/06 and 2007/08), around Syowa Station at the eastern, most area of interest. The line spacing will be mostly 10 km to get a more detailed view on the subsurface structures. On the other hand, the SEAL II (Structure and Evolution of East Antarctic Lithosphere II) project has conducted within the JARE (Japanese Antarctic Research Expedition) to reveal the formation of the East Antarctic craton and a enhanced break-up scenario for the Eastern Dronning Maud Land and Enderby Land by geological and geophysical onshore projects. The focus of this part of the WEGAS and SEAL II projects will be to constrain the early movements of Madagascar and India during Gondwana break-up. Here, a combination of aeromagnetic/gravity and marine magnetic/gravity is necessary:

- Definition of the continent-ocean boundary in the Riiser Larsen and Cosmonaut seas.
- Mapping of the seafloor spreading anomalies in the eastern Riiser-Larsen and Cosmonaut seas.

4.2.2. DISTINCT

While the magnetic data will provide information on the geological structures buried beneath the thick ice shield, gravity/radio echo sounding data will allow a first estimate of crustal thicknesses/ice thickness in the area investigated. Furthermore the gravity data are essential to define the continent/ocean boundary along the coast of East Antarctica. Beside being of glaciological interest the ice thickness data will provide important constraints for magnetic and gravity modelling in the ice covered areas. Furthermore, the new data will refine the existing bedrock topography maps and improve the reliability of ice sheet models. In relation to the past, present, and future development of the ice sheet, DISTINCT focuses on the structure of the ice sheet. The major aims are to improve the knowledge of the spatial variations of geophysical properties and to provide new insights into the structure and properties of the ice sheet. The radio-echo sounding system installed on the AWI aircraft is operated concurrently with other geophysical measurements like gravimetry, magnetic, radar- and laser-altimetry.

The Antarctic ice sheet is a unique archive for the reconstruction of paleo-climatic conditions and plays at the same time an active role in the global climate system. The atmospheric composition of past times can be directly probed in ice cores, and the significance of climatically relevant processes for future predictions can be analysed. Changes in the equilibrium state of the Antarctic ice sheet decisively influence the global sea level. To estimate the future development of the Antarctic ice sheet and evaluate related changes, a detailed knowledge of the present state of the ice sheet and the underlying processes is essential. Presently, the total mass balance of the big ice sheets can only be indirectly estimated. Absolute values are currently only slightly larger than the measurement uncertainties, and determined changes in the total mass balance are within the error range (Wingham *et al*., 1998; Wahr *et al*., 2000). One major difficulty within this subject is the transient state of the ice dynamics, as the Antarctic ice sheet is still adjusting to the climatic changes since the last glacial maximum at roughly 20000 years before present. Despite this problem, it is possible to rather accurately determine the mass balance of individual drainage basins by comparing the outflow through outlet glaciers into ice shelves with the present surface mass balance in the drainage area. Profiles of physical and chemical parameters measured along ice cores form time series which only represent a singular point of the ice sheet. To derive past climatic conditions from this singular information, like temperature and precipitation, dynamic effects related to ice sheet motion and determining the ice-sheet geometry have to be taken into account. The present state-of-the-art approach to investigate the ice sheet's evolution involves numerical modelling experiments that use *in-situ* measurements of geophysical properties as initial and boundary conditions.

As in the case of mass balance estimates, extrapolation of the properties' distribution, like accumulation, age-depth profiles, or ice thickness, from a singular point to an aerial coverage requires a dense network of geophysical surveys. Radio-echo sounding has become one of the most important tools for the investigation of glaciers and ice sheets (Bogorodsky *et al.*, 1985). The well-established and by-now routine application to determine ice thickness (Lythe *et al.*, 2001; Steinhage *et al.*, 1999) has, in the last decade, been complemented by studies covering a variety of topics, such as the spatial and temporal distribution of surface accumulation on the Antarctic polar plateau and at coastal sites (Richardson *et al.*, 1997; Frezzotti *et al.*, 2002; Rotschky *et al.*, 2004) and the correlation between ice cores with internal electromagnetic reflectors, or the matching of ice core records (Hempel *et al.*, 2000; Eisen *et al.*, 2004).

The characterization of the present state of the ice sheet is the most necessary component for studies interpreting paleo archives and predicting future changes of related systems. Within the project a variety of scientific goals are put forward to achieve a comprehensive state description. For instance, continuous information on ice thickness and bedrock topography in the catchment's area of the Shirase Glacier is so far only available from a limited number of ground-based radio echo sounding traverses (Fujita *et al.*, 1999; Matsuoka *et al.*, 2003). The objectives are directly related to the acquisition of fundamental geophysical properties:

- Provide continuous data sets on ice thickness and bedrock topography in the catchment area of the Shirase Glacier.
- Determine the outflow of ice from the inland plateau in the eastern part of DML through the Shirase and other outlet glaciers.
- Determine the spatial distribution of accumulation in the Shirase catchment area. A number of ground-based measurements provide *in-situ* information on accumulation.
- Map the distribution of continuous internal reflection horizons. As these are, in a number of cases, caused by volcanic events, they can be considered isochrones.

Concerning the geophysical and glaciological scientific problems it is of outmost importance to cover the area between the Astrid Ridge and the Enderby Land with a dense flight track network (line spacing at least 10 km) to unravel the geodynamic history, the geological relationship of Antarctica to the surrounding continents, reliable information on the ice thickness and information on the internal structure of the ice shield. Furthermore, in the future serious attempts should be made to extend our geophysical knowledge also into the interior of the continent. Keeping in mind the Antarctic continent has a size of approximately 14.6×10^6 km^2, little is known about the geological and glacial history of the interior. Detailed and systematic geophysical surveys are likely to produce relevant new and surprising results.

4.3. Atmospheric activity

To assess present, past, and future impacts of aerosols in a changing atmosphere we need to understand the processes that determine the physical and chemical characteristics of the aerosol particles at a particular place and time especially in remote areas like the Antarctic. In the past a small number of airplane missions up to 6 km altitude were performed from Syowa Station to the Antarctic plateau till 2004, using single engine air plane of JARE, Pillatus PC-6, Cessna A 185F (Yamanouchi *et al.*, 1999; Wada *et al.*, 2001; Osada *et al.*, 2006). A laminar structure of the aerosol number densities between 100 and 2000 cm^{-3} was reported, somewhat similar to previous observations in the Arctic. The AGAMES (Antarctic trace gas and aerosol airborne measurement study) project will provide detailed insight into many aspects of the Antarctic tropospheric aerosol properties and their vertical and spatial distribution. This ambitious goal will be achieved with coordinated international effort covering extensive airborne *in-situ* measurements, satellite and LIDAR remote sensing observations and ground-based long-term measurements at several Antarctic monitoring sites. The aerosol vertical distribution in the Antarctic troposphere, and therefore aerosol transport patterns and life cycle in general, cannot be sufficiently described based on ground-based observations only. This gap in knowledge considerably limits the ability to decipher Antarctic ice core records of past climate and paleo-environment. The campaign is scheduled for the austral summer season 2006/07 by using the aircraft POLAR 2. The project was initiated by the Alfred Wegener Institute Bremerhaven (Germany), the NIPR Tokyo (Japan), together with the Institute of Applied Environmental Research/ Department of Meteorology Stockholm University (Sweden), the Institute for Physics of Atmosphere of DLR Oberpfaffenhofen (Germany) and the Institute of Atmospheric Sciences and Climate (CNR-ISAC) Bologna (Italy). Aircraft based measurements will be performed as a joint international collaboration in East Antarctica (Camp S17, near Syowa Station) and in the Atlantic sector of Antarctica (Neumayer and Kohnen Stations). During the intensive airborne campaigns coordinated ground-based activities are planned additionally at several Antarctic coastal and inland stations, including Aboa (73°S, 13°W), Dome Concordia (75°S, 123°E, 3233 m a.s.l.), Halley (75°S, 26°W), Mario Zucchelli (75°S, 164°E), South Pole (90°S, 102°W, 2841 m a.s.l.), and Troll (72°S, 2°E; 1298 m a.s.l.). To extend the vertical profile observation for the greenhouse gases over Syowa Station, as well as to obtain information about air-sea exchange of CO_2 and also as a useful tracers for investigations of aerosol transport and exchange processes, we will carry out additional *in-situ* airborne measurements of several trace gases during the AGAMES project. The components to be analyzed are concentrations of CO_2, CH_4, SF_6, O_2 and N_2O and isotope, $\delta^{13}CO_2$ and $\delta^{13}CH_4$. The primary objectives and main tasks are:

- Characterisation of the vertical structure of Antarctic aerosol based on the first ever comprehensive aerosol *in-situ* measurements made by aircraft in Antarctica.
- Study of transport pathways and transformation processes as well as the importance of local aerosol sources versus long-range transported aerosols.
- Investigation of new particle formation based on Dimethylsulfide (DMS) emission from sea surface in the marginal ice zone.
- Study of clear sky precipitation and heavy precipitation events and the role of aerosols deposited on the Antarctic plateau.
- Trace gas measurements to investigate the troposphere-stratosphere exchange over the Antarctic and to study their variability.

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