Quotations Andreas Herber (AWI)

What is special about the field campaign HALO-(AC)³?

The HALO-(AC)³ aircraft campaign combines the capabilities of two completely different airborne measurement platforms. On the one hand, there is the aircraft HALO (High Altitude and Long Range Research Aircraft), which can make remote-sensing measurements of the entire troposphere at high altitudes (15 km) over extremely long distances (up to 10,000 km), including the ability to measure clouds at all levels. The AWI research aircraft complement the operation of HALO, operating in the altitude range up to a maximum of 8 km, having a maximum flight time of 5-6 h and thereby covering up to 1500 – 2000 km. Their flights are closely coordinated with those of HALO, so that simultaneous measurements are made at two different additional altitudes on a section of the HALO flight track. Although their range is shorter, the advantage of the polar aircraft is that they can fly slowly and low, giving a snapshot of very specific processes in, below, and above clouds or in the planetary boundary layer. The instrumentation of the polar aircraft, Polar 5 equipped with remote-sensing systems and Polar 6 with in-situ instruments, is an ideal complement to HALO's remote sensing systems. This type of coordinated deployment of three different research aircraft, especially simultaneous measurements at different altitudes, using pre-calculated paths of air masses is being carried out for the first time. Thereby, we expect to gain knowledge for the understanding of the processes that determine the weather and the climate of the Arctic.

Why did you pick the European Arctic as the targeted region for the campaign HALO-(AC)³?

The Arctic is one of the most sensitive regions on Earth. Environmental and climate changes have an even greater impact there than in the mid-latitudes. For example, a global temperature increase of 1.5 °C, means a much higher temperature increase for the Arctic, which is proven by the measurements of the last years. Weather patterns in Europe and North America are decisively determined by atmospheric processes occurring in the Arctic. Although our knowledge has improved in recent decades, many questions remain unanswered. This is partly due to logistical difficulties for any measurements in the Arctic, but also to the limitations under which aircraft measurements can be made. The Arctic Ocean is surrounded by continents where the number of airports near the coast is limited. In addition, the regions bordering the ocean are divided into territories of different countries. Although there is coordination through the „Arctic Council", measurement missions over the entire Arctic are difficult to carry out. We are concentrating our measurements on the European Arctic with Longyearbyen (Spitsbergen) as the base of operations for the polar aircraft and Kiruna (Sweden) for HALO.

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Which research aircraft are used for the campaign? What is their task?

In addition to HALO (High Altitude and Long Range Research Aircraft), the AWI research aircraft Polar 5 and Polar 6 are used in the HALO-(AC)³ campaign. The tasks of HALO have already been explained and described. For the campaign, Polar 5 and Polar 6 will also be deployed with complementary instrumentation at different altitudes in coordinated measurement flights. Polar 5 is equipped with a cloud radar, an aerosol lidar and a solar spectrometer for the measurement of aerosol and cloud properties. By means of different spectral radiation sensors and camera systems, the radiation fluxes can be characterized. Furthermore, with the help of a turbulence measurement system, the energy and momentum fluxes in the Arctic boundary layer (atmospheric layer below about 1 km) and of clouds can be recorded. Dropsondes will also be launched from Polar 5, providing information of meteorological structures in the altitude range up to 4 km. In addition to the coordinated flights with HALO, we are interested in the energy and momentum fluxes (transport of kinetic energy of the wind) and the exchange processes in the boundary layer taking into account the surface, such as sea ice, ditches, sea ice edge zone and open ocean. The Polar 6 is equipped with different in-situ measurement systems for the acquisition of aerosol and cloud properties. This includes measurements in Arctic clouds as well as above and below clouds. By measuring directly in the clouds and characterizing special cloud parameters such as particle sizes and shapes as well as detecting different aerosol types and soot, also above and below clouds, the quality of the remotely sensed measurements (by our own aircraft or by satellites) can be assessed. Based on this, the remote-sensing measurements can be calibrated if necessary. The combination of remote-sensing and in-situ measurement systems allows an optimal characterization of aerosol and cloud parameters and represents a crucial added value especially for the further use of data for models and model parameterization. In addition to the coordinated flights of Polar 6 to measure along an air mass and to detect warm air intrusions (WAI) and marine cold air outbreaks (CAO), measurements of the horizontal and vertical distribution of aerosols and black carbon as well as measurements in the Ny-Ålesund area will be performed to better characterize the long-term measurements at a fixed location.

Why is the multitude of three research aircraft necessary to achieve the aims of the campaign?

The coordinated deployment of three aircraft with simultaneous measurements at three different heights in the atmosphere will attempt to track air masses into and out of the Arctic. This will be done primarily with the HALO aircraft, but the simultaneous deployment of the polar aircraft at two other levels of the atmosphere will provide a much better description of the transport processes. A similarly elaborate approach has never been carried out in the Arctic. It may be possible

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better reproduce the transformation processes that air masses undergo on their journey south or north by coordinating the deployment of the three aircraft. With specific information from three different altitudes, meridional transport can be characterized in a way that more realistically represents the relationships between the Arctic and midlatitudes. In summary, the HALO-(AC)³ mission has two main objectives. First, through the coordinated deployment of the three research aircraft, to make quasi-Lagrangian observations of air mass transformation processes during meridional transport within warm air intrusions (WAIs), marine cold air outbreaks (CAOs), and atmospheric rivers (ARs), which has not been attempted before in the Arctic. Second, to test the ability of numerical atmospheric models to reproduce measurements made from aircraft.