European Facility for Airborne Research

EUFAR
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For Airborne
Research

Coordinating airborne environmental science research in Europe

Instrumented aircraft are an important scientific tool, allowing researchers to observe the atmosphere and land and ocean surfaces in support of a wide range of applications in the environmental sciences. EUFAR – the European Facility for Airborne Research – links the operators and scientific users of research aircraft, seeking to broaden access and improve efficiency in the use of these resources.

1. Introduction

EUFAR is an Integrating Activity currently supported by the 7th Framework Programme (FP7) of the European Commission, following three previous contracts. It brings together 24 European institutions and organisations involved in airborne research, operating 19 instrumented aircraft and 5 separate remote-sensing instruments. The available aircraft range from an Enduro microlight operated by a single pilot-scientist to a 4-engined BAe146 capable of carrying around 4 tons of instrumentation and up to 19 scientists on board.

There is a long history of airborne observational research contributing incremental developments in the scientific understanding of earth-system processes. These developments have proceeded in parallel with similar developments in the capabilities to observe these processes on a global scale from space and to model them in operational Numerical Weather Prediction (NWP), climate and Earth-System models. The fields of science that are impacted by an airborne research observing capability are very broad, and span the atmosphere, ocean, land surface and biological systems. The ability to maintain access to the required broad range of airborne observing facilities is critically important to our future ability to study processes in the environment and to develop and use the models that will, for example, be used to study mitigation strategies in a changing climate.

EUFAR's overall goal is to provide researchers with easy and open access to the airborne research facilities that are most suited to their needs and that are not available/financially accessible in their home countries. To this end, EUFAR aims to:

- Develop transnational access to national infrastructures;
- Optimise the use and development of research aircraft and instruments;
- Improve the quality of the services provided by aircraft and instrument operators by strengthening expertise through knowledge exchange;
- Develop and maintain a central database of airborne data and to develop standards and protocols for this database to be fully interoperable with other environmental science and Earth observation databases;
- Support joint instrumental research activities dedicated to (i) the development of methodologies and tools for the integrated use of airborne hyperspectral imaging data and airborne laser scanning data and (ii) the development of robust calibration systems for the core gas-phase chemical measurements currently made on-board research aircraft;
- Promote the use of research aircraft and instruments, especially for young scientists from countries where such facilities are lacking, by providing education and training courses on airborne research topics;

• Support innovation in airborne research, and develop a culture of cooperation between the airborne research community and industry in order to transform airborne research instruments, methodologies and software into new products and services.

2. EUFAR Activities

i. Transnational Access

The principal objective of the Transnational and Open Access Coordination activity is to continue to support scientific flight activities through the Transnational Access (TA) process. Transnational Access provides fully-funded flight time to Principal Investigators and User Groups who do not have access to the required airborne observing facilities via national funding within their country of employment. Applications are encouraged from new users who have not participated previously in airborne research. A small amount of travel/subsistence funding is available to assist the PI and other users to participate in the field campaign and/or any necessary pre- or post-project meetings.

The amount of flight time available to each project is approximately 10 hours. In order to maximize the scientific impact of the TA-supported flying, applications are encouraged that can be clustered with larger nationally- or internationally-supported flight observing campaigns. This allows the TA project to spend longer in the field with a greater chance of obtaining optimum observing conditions and interacting with a larger group of experienced scientists. At the present time, 32 projects have been approved for funding, evenly split between the use of in-situ atmospheric measurements and the use of imaging systems for Earth Observation. As a result of clustering, TA flight

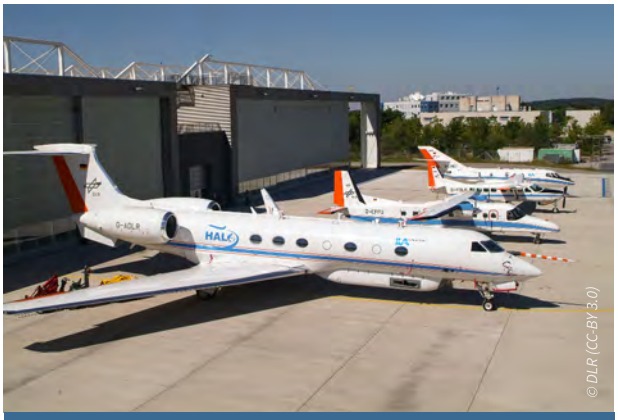

Figure 1. The four aircraft operated by DLR, the German Aerospace Research Centre at Oberpfaffenhofen. From front to back: HALO Gulfstream 550, Dornier 228, Cessna Caravan and Falcon-20. The latter three aircraft have all participated in Transnational Access projects.

Figure 2. The pilot's seat and some of the instrumentation of the Enduro microlight operated by Karlsruhe Institute of Technology. Although small and light in weight, the aircraft is comprehensively-equipped to measure a wide range of parameters in and above the atmospheric boundary layer.

activities have been possible in West Africa as part of the multi-national DACCIWA campaign, in the Cape Verde Islands and also Namibia.

ii. Networking Activities

EUFAR presently supports a number of Networking Activities amongst its consortium members. These are intended to support the EUFAR objectives of improving efficiency and spreading best practice in airborne research observations.

Within this area, EUFAR supports an Education and Training activity which is designed (i) to attract early-stage researchers to airborne research; (ii) to educate and train early-stage researchers and trainers (e.g. university lecturers) in airborne atmospheric research observations and airborne remote sensing of the Earth surface; (iii) to define an optimised (fixed) EUFAR training course concept; (iv) to develop/consolidate EUFAR training course educational material. By the end of its present contract, EUFAR will have supported a further four summer schools on airborne research topics hosting approximately 80 students.

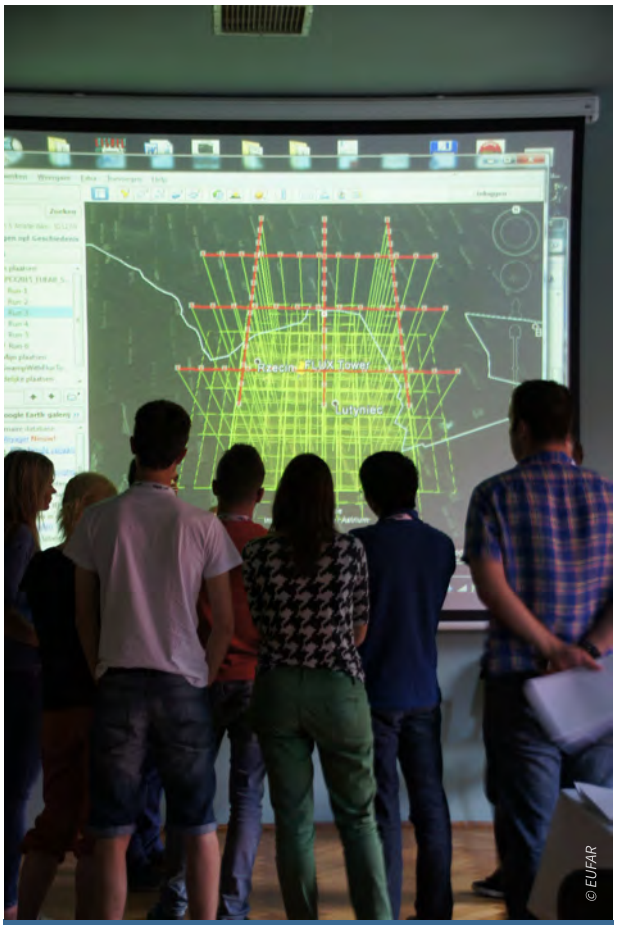

Figure 3. Students at a lecture during the SWAMP training course on the use of airborne imaging for studies of photosynthesis in a wetland region that was held in Poland in 2015.

The Standards and Protocols activity aims to harmonise different processes and documentation concerning the processing and management of data within the EUFAR community. The full range of EUFAR's airborne activities is addressed, ranging from atmospheric research to Earth observation and including both in-situ and remotely-sensed airborne data. A number of best practice guidelines, and software toolboxes were developed during the previous funding period (2008-2013) and these are being further developed and extended. A focus has been on the update and extension of the common protocols and assuring their compatibility with international standards. Within this activity, EUFAR is actively engaging with the ENVRIplus community of environmental research infrastructures via the implementation of its Reference Model for data. This seeks to promote interoperability and to put access to airborne data on the same footing as data from other infrastructures.

The Database activity ensures that the valuable data and supporting metadata collected during EUFAR transnational access projects are widely available through a central portal to facilitate data exchange, collaboration and re-use. Providing a well-formed, well-documented, long-lasting archive and linking to existing repositories

Figure 4. One of the more obvious external modifications that converts a BAe146 into the UK's FAAM atmospheric research aircraft. Underwing pylons carry a range of probes that are used for counting and sizing individual cloud droplets and aerosol particles.

facilitates discovery and re-use of the data, and therefore, maximises its potential. The dedicated EUFAR archive set at the Centre for Environmental Data Analysis (CEDA) in the UK, has been reviewed and made ready to receive further data – this includes updates of the archive structure, metadata catalogue records, and existing supporting software. The archive is accessible via the EUFAR website.

iii. Joint Research Activities (JRA)

Two JRAs are currently being undertaken within the present EUFAR consortium. Both are aimed at improving the quality of data and developing new data products and services supplied to scientific users by EUFAR aircraft and instrument operators.

HYLIGHT results from discussions and priorities identified during the EUFAR joint Expert Working Group meeting in April 2011, the previous Joint Research Activity HYQUAPRO (11 EUFAR beneficiaries), the user requirement survey conducted by FP6 HYRESSA and the fact that more full-waveform Airborne Laser Scanning (ALS) systems become available at various EUFAR operators. The objectives of HYLIGHT are to develop, test and validate improved Hyperspectral Image (HSI) processing using ALS data and improved ALS data processing using HSI and to make developed HYLIGHT tools freely available worldwide.

HYLIGHT software tools will contribute to a better management of forests, where the combined measurements can yield much more detailed information on the nature of the forest canopy. Forest ecosystems play a crucial role in our society, both for their recreational and also economical purposes. The majority of HYLIGHT tools together with installation guides and user manuals including contact details can be downloaded by registered members from the EUFAR website.

Figure 5. Scientists and crew of the Polar 6 research aircraft in Antarctica for the Oldest Ice Reconnaissance (OIR) project in January 2017. The aircraft, operated by the Alfred Wegener Institute in Germany, was using radar and magnetic measurements to determine the optimum location for drilling to find the oldest ice and hence the longest potential climate record.

Delegates to the ICARE-2017 conference together with students attending the EUFAR RS4ForestEBV (Remote Sensing for Essential Biodiversity Variables in Forest ecosystems) summer school. The three aircraft are, from left to right, the Grob Egrett currently operated by its manufacturer but previously flown by Airborne Research Australia, the Falcon-20 of DLR and the BAe146 of the Facility for Airborne Atmospheric Measurements (FAAM) in the U.K.

The concept of the second JRA, TGOE has long been a key discussion item in the EUFAR 2008-2013 gas-phase EWG. The objective of TGOE is to develop robust calibration systems for the core gas-phase chemical measurements currently made on-board research aircraft. It will reduce the uncertainty in these key parameters and will facilitate improved cross platform research by ensuring that the measurement technologies are all tied to a common baseline.

Airborne observations of trace gas species contribute substantially to the development of numerical models that are used for both air-quality forecasting and longer-term climate studies. They contribute important information on the vertical distribution of species that is difficult to obtain by other means. They are also an important source of local and regional validation for satellite observations that are used for global-scale measurements. It is common that studies of trace gas emissions and evolution involve one or more aircraft together with fixed, ground-based measurements. By developing the best calibration techniques for these measurements, TGOE seeks to reduce their uncertainties and so enable them to be used to provide more detailed analyses of the processes involved in the transport and chemical evolution of atmospheric trace gases.

TGOE has performed intercalibrations of measurements and standards within EUFAR and with the IAGOS and ACTRIS communities. This work seeks to establish and document best practice for the larger community. Beyond the laboratory work there have been some comparisons in the field during aircraft deployments involving EUFAR aircraft. A final such opportunity will take place in July 2017.

iv. International Conference on Airborne Research for the Environment (ICARE-2017)

EUFAR maintains close connections with the airborne research community in the USA, working through organisations including NASA and the National Center for Atmospheric Research (NCAR). Together, they recently organised the 2nd International Conference on Airborne Research for the Environment (ICARE-2017) which was hosted at DLR, the German Aerospace Centre at

Oberpfaffenhofen near Munich. The objective of this conference was to bring together all parts of the airborne research community including scientists, instrument developers, research aircraft operators and representatives of the funding agencies.

The conference program included presentations on a variety of science topics that will drive the demand for airborne research facilities in coming years, reviews of innovative new instrumentation and a workshop on the logistical and diplomatic issues facing the organisers of future airborne observing campaigns. With 175 registered delegates from across Europe, the USA and elsewhere attending over the four days of the conference, the meeting was considered a great success.

3. The Future of EUFAR

Members of the present consortium are seeking to establish EUFAR as a legal entity, in the preferred form of an AISBL (international non-profit association). Such an association, supported by its members through both cash and in-kind contributions will ensure that key EUFAR activities can continue beyond the duration of its present funding by the European Commission. These activities will include the maintenance of its website and broadening access both to the aircraft themselves and to data obtained from flight campaigns. EUFAR is also currently seeking Expressions of Interest in future Joint Research Activities that may be undertaken within the framework of the AISBL.

Significant progress has been made in gaining the commitment of a core group of partners to form such an association and on drafting its statutes, internal rules and financial plans. Whilst this has taken longer than planned, nevertheless significant agreements have been obtained concerning the governance of the AISBL. These will enable as wide a range of organisations as possible to participate in its work, either as members or partners, hence broadening its impact in countries not presently operating their own research aircraft. It is expected that the AISBL will finally be formally established at the start of 2018.

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This project has received funding from the European Union's 7th Framework Programme for research, technological development and demonstration under grant agreement no. 312609.