REQUEST FOR A SPECIAL PROJECT 2010–2012

MEMBER STATE: GERMANY

Principal Investigator[1]**:** Dr. Andreas Dörnbrack

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Project Title: Support Tool for HALO Missions

If this is a continuation of an existing project, please state the computer project account assigned previously.	**SP** DEHALO	
Starting year: (Each project will have a well defined duration, up to a maximum of 3 years, agreed at the beginning of the project. For projects started before 2009, please state 2009 as the start year.)	2009	
Would you accept support for 1 year only, if necessary?	YES ☐	NO ☒

Computer resources required for 2010-2012: (The maximum project duration is 3 years, therefore a continuation project cannot request resources for 2012.)	**2010**	**2011**	**2012**
High Performance Computing Facility (units)	50000	50000	50000
Data storage capacity (total archive volume) (gigabytes)	80	80	80

An electronic copy of this form ***must be sent*** *via e-mail to:* *special_projects@ecmwf.int*

Electronic copy of the form sent on (please specify date): 23 April 2009

Continue overleaf

[1] The Principal Investigator will act as contact person for this Special Project and, in particular, will be asked to register the project, provide an annual progress report of the project's activities, etc.

Principal Investigator: Dr. Andreas Dörnbrack

Project Title: Mission Support Tool for HALO operations

Extended abstract

It is expected that Special Projects requesting large amounts of computing resources (500,000 SBU or more) should provide a more detailed abstract/project description (3-5 pages) including a scientific plan, a justification of the computer resources requested and the technical characteristics of the code to be used. The Scientific Advisory Committee and the Technical Advisory Committee review the scientific and technical aspects of each Special Project application. The review process takes into account the resources available, the quality of the scientific and technical proposals, the use of ECMWF software and data infrastructure, and their relevance to the Centre's objectives. - Descriptions of all accepted projects will be published on the ECMWF website.

High-quality meteorological forecast and analysis products are essential for the successful planning and evaluation of airborne measurements. The novel and outstanding research possibilities offered by the German High Altitude and Long Range Research Aircraft (HALO) dedicated for atmospheric and geophysical research prompt the development of an innovative instrument in support of HALO missions. This special project is dedicated to access ECMWF's meteorological forecast and analysis products for developing and deploying such a mission support tool.

HALO can reach altitudes of 15 km, has a horizontal range of more than 10000 km, and the maximum payload of 3 tons will allow the simultaneous operation of a multitude of meteorological instruments. This offers exciting new possibilities for atmospheric research but also requires new strategies for flight planning and operation as the individual strengths and requirements of many instruments need to be coordinated. Currently, the following specific characteristics of HALO missions are envisaged for atmospheric research:

(i) HALO missions investigating very **different areas of the global atmosphere** (troposphere, UT/LS, stratosphere – tropical vs. extratropical) and focusing on a **broad variety of scientific objectives** (atmospheric chemistry, cloud physics, radiation, weather prediction, etc.).

(ii) Flight missions investigating **areas with distinct meteorological properties**. Examples are tropospheric/stratospheric mountain wave clouds, the upper-tropospheric outflow of deep convection; plumes of e. g. high CO, and regions susceptible to contrail formation.

(iii) **Quasi-Lagrangian flights** for remote sensing of clouds, e. g. LIDAR observations of polar stratospheric clouds along the stratospheric wind direction where the clouds have been forecasted or detected (Carslaw et al, 1998 a and b).

(iv) **Lagrangian "match flights"** where an air mass is probed several times separated by a few hours or days. This novel approach is particularly useful to analyze the life cycle of chemical plumes, aerosol layers and clouds whilst these features evolve within the ambient flow and for experimental analysis of long-range transport of air pollution (see Methven et al. (2006) for a first application of this flight strategy).

(v) **Optimized flight routing for targeted observations** in sensitive regions based on particular forecast fields (e.g. singular vectors) from the ECMWF or other forecasting centers. This technique has been applied for instance during the A-TreC experiment (Leutbecher et al., 2004, Weissmann et al., 2005)) and constitutes one of the key strategies for the ongoing WMO programme to improve weather forecasts (THORPEX, see http://www.wmo.int/thorpex/ and Shapiro and Thorpe 2004).

In order to successfully perform these HALO missions, the availability of specific high-quality forecast products during the flight planning process will be essential as in one single mission different - sometimes diverging - interests of the experimental groups have to be coordinated in an objective way. As stated in the application for the HALO priority programme of the German Science Foundation, research is needed to optimize the costly deployment of HALO[2].

In our institute, such a tool will be developed and tested during the upcoming HALO demonstration missions. This instrument will serve for planning, conducting and evaluating of aircraft campaigns. HALO-MST will be designed, built and improved in a continuous dialog with experimental HALO scientists, pilots and technical aircraft experts, with researchers from other universities and research centres, and, finally, with the German Weather Service, DWD. The design of the modular tool with a web-based user interface will be guided by the needs of experimental HALO scientists and by previous flight planning experience. Essentially, it will contain standard and campaign-specific products and allows the flexible incorporation of additional modules. During the upcoming years the following modules will be developed:

- standardized general meteorological charts for flight planning (e.g. forecast charts on flight levels, vertical cross sections from meteorological and chemical forecasts) that will be available for all HALO missions,
- tailored products that are specified before the campaign (e. g. ice cloud forecasts for cirrus campaigns or others),
- prediction of lidar backscatter to optimize flight routing for targeted observations,
- flexible Lagrangian tools for predicting "matches" as well as an interactive flight planning tool, where flight routes can be chosen such that a later "match" will not be hampered by flight restrictions, and
- a variety of user-defined products that can be produced via an interactive web interface.

The final goal of the project will be an interactive flight planner. Here, the user can enter a suggested flight route and different modules will provide information about the technical feasibility of the route (fuel consumption, ascents and descents, range, altitude), flight regulation issues (restricted access to certain areas), flight safety issues (expected maximum winds, turbulence, convection), predicted meteorological and chemical parameters along the flight and the Lagrangian history of the encountered air masses.

For achieving the goals of this enterprise, we require the access to the meteorological archive of the ECMWF and to the sensible forecast data before and during the respective HALO missions.

References

Carslaw, K. S., et al., 1998a: Increased stratospheric ozone depletion due to mountain-induced atmospheric waves, *Nature*, **391**, 675– 678.

Carslaw, K. S., M. Wirth, A. Tsias, B. P. Luo, A. Dörnbrack, M. Leutbecher, H. Volkert, W. Renger, J. T. Bacmeister, and T. Peter, 1998b: Particle microphysics and chemistry in remotely observed mountain polar stratospheric clouds, *J. Geophys. Res.*, **103**, 5785–5796.

Eckermann, S. D., A. Dörnbrack, S. B. Vosper, H. Flentje, M. J. Mahoney, T. P. Bui and K. S. Carslaw, 2006: Mountain wave-induced polar stratospheric cloud forecasts for aircraft science flights during SOLVE/THESEO 2000, *Weather and Forecasting*, **21,** 42-68.

Grunwald, J., Kalthoff, N., Fiedler, F. and Corsmeier, U., 1998. Application of Different Flight Strategies to Determine Areally Averaged Turbulent Fluxes. Contributions to Atmospheric Physics, 71: 283-302.

[2] "Advice from numerical weather prediction and chemistry models has been used in previous field experiments. However, so far a standardized systematic and flexible community tool for selecting an optimized flight pattern on the basis of a broad variety of different model prediction results is not yet available. Different viewpoints for the selection between various flight strategies in the atmospheric boundary layer have been presented by Grunwald et al. (1998) and Santoso and Stull (1999), and the topic is also discussed in Mahrt (1998). A recent study of Vihma and Kottmeier (2000) presents a method based on the systematic utilization of mesoscale model fields to select the optimal flight patterns for various conditions. Guidance for stratospheric missions came from weather prediction models operating at different spatial scales (Dörnbrack et al., 1998) as well as contour-advection methods (Konopka et al., 2003). Consequently, research is needed to optimize the deployment of HALO and the scientific value of its costly missions."