

SPECIAL PROJECT PROGRESS REPORT

Progress Reports should be 2 to 10 pages in length, depending on importance of the project. All the following mandatory information needs to be provided.

Reporting year 2009

Project Title: Support Tool for HALO Missions

Computer Project Account: SPDEHALO

Principal Investigator(s): Dr. Andreas Dörnbrack
Marc Rautenhaus
Lisa Klanner

Affiliation: DLR Oberpfaffenhofen,
Institut für Physik der Atmosphäre

Name of ECMWF scientist(s) collaborating to the project
(if applicable)

Start date of the project: 2008

Expected end date: 2011

Computer resources allocated/used for the current year and the previous one
(if applicable)

Please answer for all project resources

		Previous year		Current year	
		Allocated	Used	Allocated	Used
High Performance Computing Facility	(units)			50000	50000
Data storage capacity	(Gbytes)			80	0

Summary of project objectives

(10 lines max)

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.

Summary of problems encountered (if any)

(20 lines max)

No problems encountered.

Summary of results of the current year (from July of previous year to June of current year)

This section should comprise 1 to 8 pages and can be replaced by a short summary plus an existing scientific report on the project

The project activities of the previous 12 months can be grouped into three categories:

- a) the development of tools to support mission planning during the field campaigns POLARCAT-GRACE, T-PARC and CONCERT,
- b) active mission support during these campaigns with meteorological forecasts using ECMWF data, and
- c) an extensive investigation of technologies suitable for the development of an integrated mission support system.

(a) Tool development

In order to provide meteorological support for three field campaigns with DLR involvement, existing tools were extended and new ones developed. First, a web page for the display of ECMWF forecast data visualised by the Metview system was improved with better navigation and extended functionality including an option to view two meteorological loops side by side. For this web page, the Metview system was run in batch mode on the ECMWF computers to create large numbers of figures visualising the current forecast data. Furthermore, an interactive user interface to control the

Lagrangian trajectory model LAGRANTO and to analyse its output was developed in order to provide quick trajectory analysis during the campaigns. LAGRANTO uses ECMWF forecast data for the trajectory computations. Finally, a simulator for Lidar measurements was developed in a Diploma thesis by Lisa Klanner.

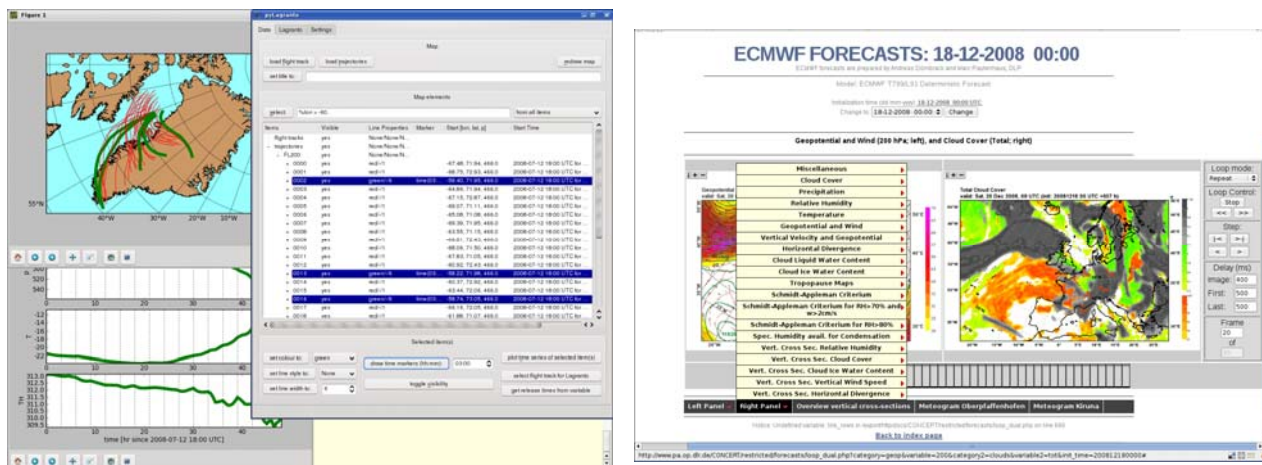


Fig. 1: Interactive user interface of the trajectory code LAGRANTO (left) and public webpage displaying ECMWF operational forecasts for airborne field campaign developed at DLR (right panel).

Doppler lidar simulator for observational coverage

In her diploma thesis, Lisa Klanner developed a simulator to estimate the observational coverage of the Falcon's 2 μm coherent Doppler lidar and to optimize the Falcon flight tracks for good observational lidar coverage. The coverage of the Doppler lidar depends on relative humidity, aerosol concentration and size distribution and clouds in the observed volume. The lidar signal can penetrate clouds as long as the optical thickness is small, i.e. the ice water and liquid water content are low. Otherwise the lidar signal is attenuated or blocked completely. Based on ECMWF and GEMS model forecasts, the Doppler lidar simulator can be used to forecast the observational coverage.

Two products of the observational coverage can be calculated with the simulator:

- horizontal maps of the observational coverage for a possible flight level (e.g. at 8, 9, 10, 11, or 12 km altitude),
- vertical cross sections along a predefined flight track, where a profile of the observational coverage is calculated approximately every 5 km. These are considered as a useful product for a fine-tuning of the flight track, e.g. adjustment of the flight level.

The simulator uses ECMWF (T_L799/L91) and GEMS¹ (T_L159/L91) forecasts as input. The used ECMWF parameters are pressure (P), temperature (T), specific humidity (Q), surface height (ZB), cloud cover (CC), cloud ice water content (CIWC) and cloud liquid water content (CLWC). The used GEMS data consist of the mass mixing ratio of eleven aerosol classes which include three size ranges of sea salt (SS), three size ranges of dust (DU), organic matter (OM) in hydrophilic and hydrophobic stage, black carbon (BC) in hydrophilic and hydrophobic stage and sulphates (SU).

¹ GEMS: Global Earth-system Modelling using Space and in-situ data
www.ecmwf.int/research/EU_projects/GEMS/index.html

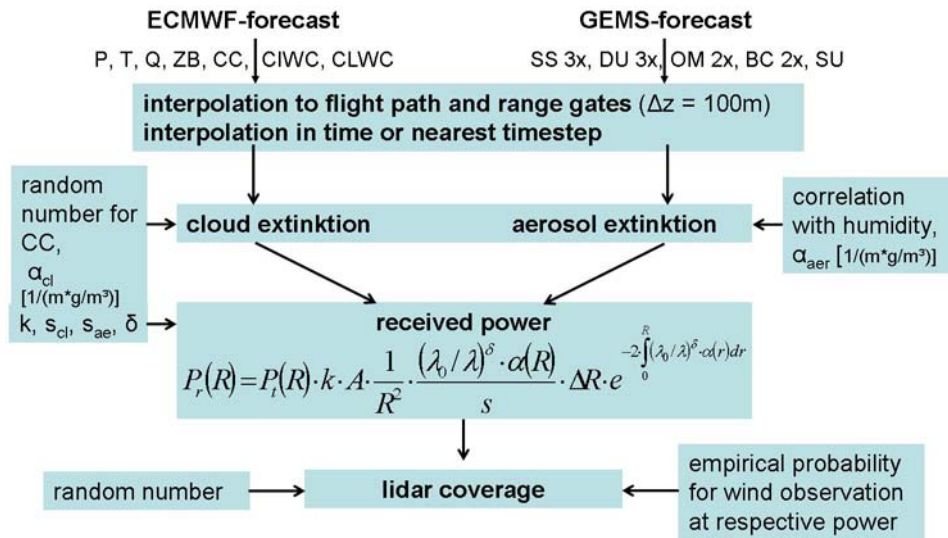


Fig.2: Design of the Doppler lidar simulator.

In order to calculate the observational coverage, the forecast time closest to the time of the flight is chosen, because an interpolation between two different forecast times may lead to a smearing of gradients. The model data fields are linearly interpolated in the vertical to the Doppler lidar resolution of 100 m for the calculation of the 2D map. For the vertical cross-section, the model data are also interpolated horizontally using a bi-linear interpolation to every point of the respective flight track.

With the interpolated data fields, the cloud extinction (α_{cl}) is computed using the assumptions on the extinction per mass unit of cloud ice water from Baum². In order to determine the backscatter β with help of the extinction α , the lidar ratio $S = \alpha / \beta$ is used. The lidar ratio for ice clouds is utilized as proposed by Wilkinson et al. 2008. The extinction and backscatter per mass unit of cloud liquid water is calculated with a Mie theory code by C. Emde (DLR). In addition, sub-grid scale clouds are considered by means of a random number and ECMWF cloud cover data.

Concerning the aerosol extinction (α_{aer}), the correlation with the relative humidity is taken from Tardif 2002 and the assumptions on the extinction per mass unit of aerosol are taken from Reddy et al. 2005. Since the aerosol extinction is available for 550 nm (λ_0) instead of 2 μm (λ), the Angström coefficient δ is used to calculate the corresponding extinction. The Angström coefficient as well as the lidar ratio of the aerosol particles are taken from Mueller et al. 2007 for sea salt and dust and from Cattral et al. 2005 for organic matter, black carbon and sulphates. The obtained extinction and backscatter are then used to compute the received power $P_r(R)$ with help of the lidar equation as denoted in Fig.1. The calculation is performed iteratively from 600 m beneath the aircraft to the ground to account for the attenuation of the lidar signal between the aircraft and the respective range gate.

An empirical probability for a valid wind measurement at a certain received power was determined from observations in previous field campaigns (COPS 2007 and IPY-THORPEX 2008). These observations were also used to estimate the system coefficient (k) in the lidar equation. The lidar coverage is calculated from the simulated received power and the empirical probability for a valid wind measurement. Fig. 3 shows an example of the horizontal map for a sample flight track during the typhoon Fitow on 5 September 2007.

² Baum, B. A.: http://www.ssec.wisc.edu/~baum/Cirrus/Solar_Spectral_Models.html

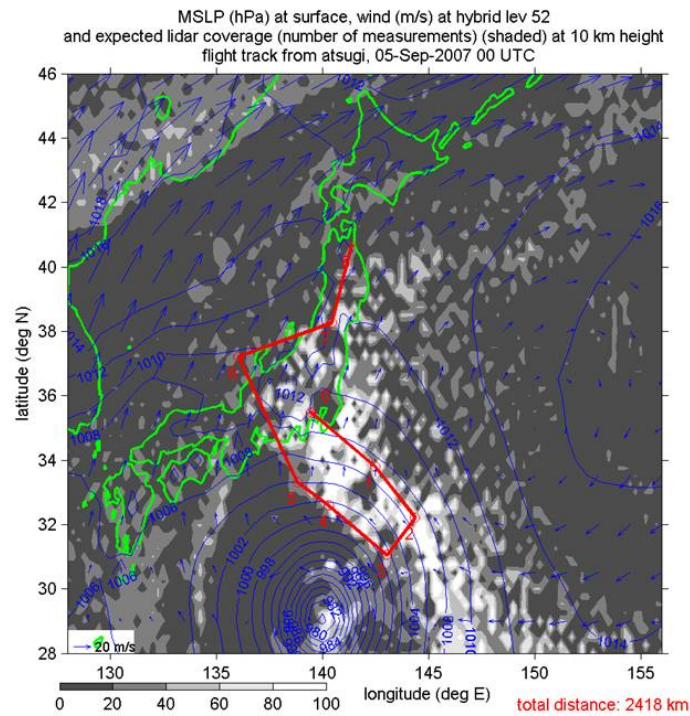


Fig. 3: Map of simulated Doppler lidar observational coverage at a flight level of 10 km for the typhoon Fitow on 5 September 2007 00 UTC. The greyscale depicts the number of lidar observations per vertical profile.

(b) Support of airborne field campaign in 2008

The above mentioned tools were used for mission support during the campaigns POLARCAR-GRACE (July 2008, <http://www.pa.op.dlr.de/polarcat/>), T-PARC, and CONCERT (October/November 2008, <http://www.pa.op.dlr.de/CONCERT/>). Meteorological forecasts were prepared from ECMWF data and used to guide the aircraft operations. Access to the restricted parts of the web pages that contain the ECMWF data is available upon request. The LAGRANTO model was run in order to compute the expected movement of air masses for Lagrangian flight experiments.

(c) Development of an integrated mission support system

Major work has been performed assessing a requirement analysis and an investigation of suitable technologies for implementing an integrated mission support system (IMSS). The current situation of techniques employed for mission support was analysed, a survey of available technologies was created, and a concept for the implementation of an IMSS was prepared. Lacking user interface interactivity and data interoperability issues currently pose major restrictions on the current flight planning work flow. Such problems are not only present at DLR, but other research facilities including NASA, NCAR or EUFAR encounter similar issues. Our objective is using ECMWF forecast data in an integrated environment for the operational

- interactive visualisation and data exploration,
- interactive analyses,
- interactive flight route planning and optimisation,
- communication of the results, and
- monitoring of aircraft and instrument data during the flights

to facilitate the flight planning process. We investigated scientific visualisation and data processing systems, flight planning systems, and geographic information systems. Particular focus has been laid on the Open Geospatial Consortium's (OGC) web services.

We attended the ECMWF workshop on the use of OGC web services in meteorology in November 2008 and are in contact with the ECMWF graphics section regarding the possible use of next generation ECMWF visualisation software (Magics++, Metview 4) for our purposes. One scenario for implementing the MSS includes the usage of Magics++ in a web service environment. A final decision on our implementation strategy will be made within the coming weeks (July/August 2009).

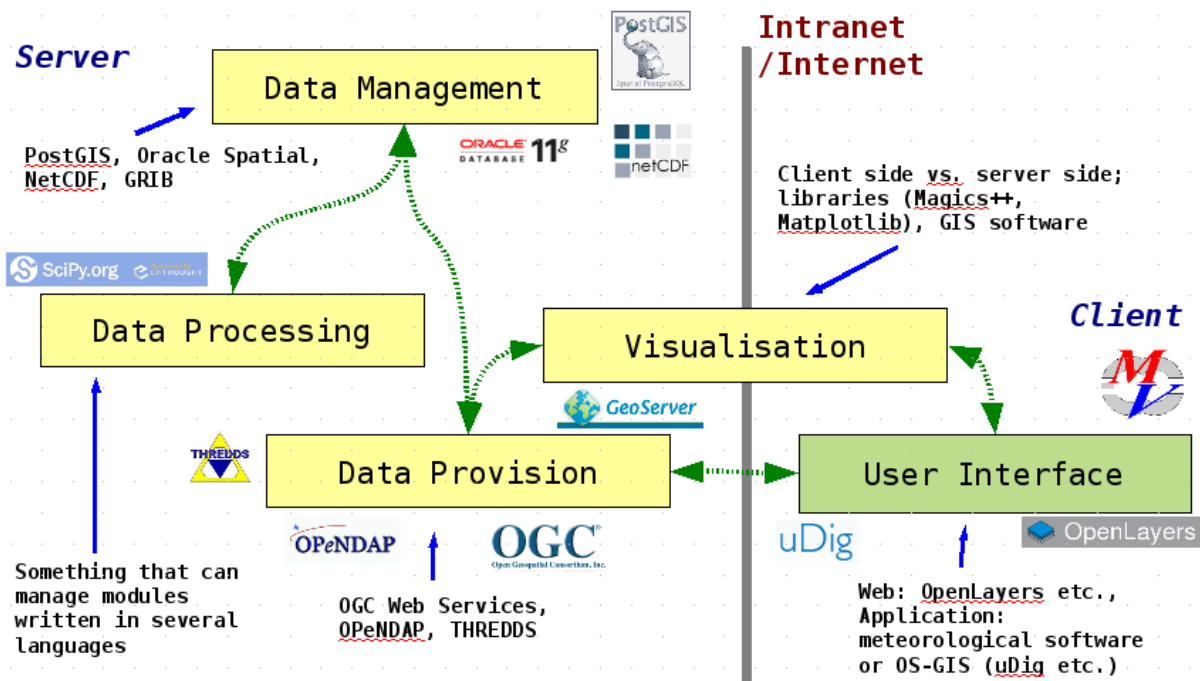


Fig. 4: Some suitable software products for elements of the IMSS.

A wiki page has been created for the ongoing documentation of project-related matters. As mentioned above, the web page access is available upon request.

List of publications/reports from the project with complete references

Summary of plans for the continuation of the project

(10 lines max)

- support of the first HALO demonstration missions in 2009/2010
- design and development of the HALO mission support system