REQUEST FOR AN EMI R&D PROJECT 2027–2029

MEMBER STATE: GERMANY

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Project Title: Forecasting and Validation of Aircraft Field Campaigns

To make changes to an existing project please submit an amended version of the original form

If this is a continuation of an existing project, please state the computer project account assigned previously.	**SP** DESCAN	
Starting year: (A project can have a duration of up to 3 years, agreed at the beginning of the project.)	2027	
Would you accept support for 1 year only, if necessary?	YES ☐	NO ☒

Computer resources required for project year:		**2027**	**2028**	**2029**
High Performance Computing Facility	[SBU]	500000	500000	500000
Graphics Processing Unit Cluster-A	[GBU]			
Graphics Processing Unit Cluster-B	[GBU]			
Accumulated data storage (total archive volume)[2]	[GB]	100	100	100

[1] The Principal Investigator will act as contact person for this Special Project and, in particular, will be asked to register the project, provide annual progress reports of the project's activities, etc.
[2] These figures refer to data archived in ECFS and MARS. If e.g. you archive x GB in year one and y GB in year two and don't delete anything you need to request x + y GB for the second project year etc.
[3]The number of vGPU is referred to the equivalent number of virtualized vGPUs with 8GB memory.

EWC resources required for project year:		2027	2028	2029
Number of vCPUs	[#]	24	24	24
Total memory	[GB]	350	350	350
Storage	[GB]	1000	1000	1000
Number of vGPUs[3]	[#]	2	2	2

Continue overleaf.

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Extended abstract

This project aims at combining high-resolution ground-based and airborne observations with IFS operational forecasts and analyses, with reanalyses, and with results from numerical modelling. The base of our measurements are airborne in-situ observations of the atmospheric wind and temperature in the upper troposphere and lower stratosphere as well as ground-based and airborne remote-sensing observations of wind, temperature, and humidity. These measurements have been and will be collected during international field campaigns using the German research aircraft DLR Falcon and the High-Altitude and Long-Range Research Aircraft (HALO). At our DLR Institute of Atmospheric Physics, we have been using the ECMWF's operational IFS forecasts for years. The fast and trustworthy access to operational forecasts provided by the ECMWF ensures a high degree of reliability when planning the challenging flights during daily campaign operations. Another equally important aspect is the analysis of the measurements. Here, the various products of the IFS are helpful in interpreting the data and in identifying biases in forecasts and analyses. ECMWF benefits from model validation efforts using campaign data to improve its modelling system. The use of IFS data in this project over the coming years will focus on five areas, which are briefly explained below.

(1) **Analysis of turbulence observations by HALO and comparison with CAT diagnostics implemented at the ECMWF**

In Dörnbrack et al. (2022), we compared the in-situ flight-level turbulence observations during the SouthTRAC campaign with the CAT index as implemented in the current operational IFS forecasts (Bechtold et al., 2021). IFS products were also used in a recent case study by Gisinger et al. (2024) investigating the severe convectively induced turbulence encounter by Singapore Airline Flight SQ321 over Myanmar on 21 May 2024. In the coming years, the comparison and validation of the IFS CAT index will be extended to other aircraft campaigns of HALO, where similar turbulence data are available in different geographical regions of the world, see for example Dörnbrack et al. (2026). In addition to these comparisons, the spread of the CAT predictions in the IFS ensemble will be evaluated. Focus is also on forecast evaluation for recent severe turbulence events of commercial airliners. Thereby convectively induced events are of special interest.

(2) **Analysis of boundary layer and tropopause-near humidity**

Comparison of airborne lidar water vapor observations with ERA5 enabled Krüger et al. (2022) to identify the vertical structure of a lower-stratospheric moist bias associated with a cold bias that degrades the IFS's forecast skill. Observation-space analyses further showed that radiosondes improve sharpness and altitude of the midlatitude tropopause (Krüger et al. 2024). Using a similar approach, we demonstrated systematic lower-tropospheric wind and humidity biases likely linked to latent heat fluxes (Schäfler et al. 2024). Boundary layer and tropopause humidity transport were a primary objective of the North Atlantic Waveguide, Dry Intrusion, and Downstream Impact Campaign (NAWDIC) in 2026. In the coming years, these NAWDIC observations will be used to validate the recently implemented stratospheric humidity assimilation in the IFS, as well as to evaluate boundary-layer representation and related processes in moisture source regions.

(3) **WAVEGUIDE**

Campaigns on atmospheric gravity waves (in the past e.g. GWLCYCLE I&II, DEEPWAVE, SouthTRAC) using a combination of ground-based and airborne observations benefit from IFS analysis and forecast products in various ways. First, for identifying situations of interest that are investigated in an intense observation period and for flight planning and flight track design (Bauer et al.,2022) during the campaign itself. An example is a mountain wave event with conditions allowing wave propagation deeply into the stratosphere (Kaifler et al., 2025). Second, for post-campaign (e.g. Dörnbrack et al., 2020) and long-term data analysis (e.g. Gisinger et al., 2022, Binder et al., 2026). In Gisinger et al. (2022) the analysis and interpretation of the results benefited from the possibility of special IFS runs with an inactive sponge layer. The simultaneous display of ground-based lidar observations with ERA5 vertical profiles and horizontal maps (Binder et al., 2026) helps to put the point-observations into a broader context and allows the identification of interesting cases for future more detailed studies.

For the upcoming WAVEGUIDE campaign, which studies non-orographic and orographic gravity waves over the Atlantic, Europe, and polar latitudes with airborne observations on HALO in November/December 2026, the IFS forecasts will be again used for campaign planning. Afterwards, gravity wave activity and wave properties in the troposphere and middle atmosphere in the observations and in IFS data will be analyzed. In addition, high-quality turbulence data at flight level will be available for CAT forecast evaluation.

(4) **CONTRAIL studies**

During the recent years, measurements of contrails and contrail cirrus clouds behind aircraft burning alternative fuels have been conducted aboard of the DLR Falcon. Contrail cirrus clouds are a possible main contributor to the climate forcing from aviation. These special in-flight observations behind A321neo aircraft with lean-burn engines require a meticulous flight planning and a wealth of experience in order to predict ice supersaturated regions in the upper troposphere and lower stratosphere. For this purpose, the IFS's operational forecasts were used to visualize the temperature threshold required for the formation of contrails and persistent contrails. The analysis of these measurements led to some influential publications, e.g. Dischl et al. (2024, 2025), Harlaß et al. (2024), Märkl et al. (2024), and Voigt et al. (2026). For the next HALO campaign AEROCLOUD in July-October 2027, these forecasts will be provided for regions over middle Europe and North America.

(5) **High altitude platform (HAP) mission support**

In the past years, DLR designed and built a HAP (DLR, 2025) and for future operations precise forecasts of the atmospheric conditions in the troposphere and lower stratosphere are needed. Being a light-weight solar powered aircraft, a successful HAP flight to stratospheric altitudes relies on low wind speeds and minimum atmospheric turbulence. Especially at the surface during takeoff and landing and in the troposphere and lower stratosphere during ascent and decent. Full access in real-time to IFS forecast products including not only the troposphere but also the stratosphere is crucial for identifying flight windows where save operations for takeoff/ascent and decent/landing are possible. The ensemble forecast dataset is used to quantify the (un)certainty of the local forecasts under different synoptic regimes. Taking into account the turbulence/CAT forecasts shall further minimize the risk of HAP crashing due to dangerous atmospheric conditions.

References (bold letters refer to members of the current project)

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