Project: **677**

Project title: **Model development and support for the MESSy system (FZJ-ICE-3 part)**

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Report period: **2025-11-01 to 2026-10-31**

The computing time request for 2026 code developments was subdivided into four subprojects:

1. Reimplementation of MESSy into ICON via the ComIn library

   In preparation of the first release of Community Interface (ComIn) for ICON, which ensures stable interfaces (released October 7th, 2026, merged into ICON release October 15th, 2026), ComIn has undergone some interface changes to which the MESSy code was adapted within this project. Furthermore, to enable the access and the modification of the wind components, the ComIn has been expanded to include the required descriptive data. Especially, interpolation coefficients required for the interpolation of the edge normal wind defined in ICON to the at cell mid-points defined zonal and meridional wind components usually used by MESSy submodels, were implemented in ComIn. Additionally, a small ComIn plugin has been written to test this implementation.

   There are still some important steps missing until MESSy is fully functional as a ComIn plugin. The most complex part is the coupling of the prognostic variables which differ between ICON and MESSy. While MESSy submodels usually use the zonal / meridional winds (u,v) and temperature (t), ICON uses the prognostic variables edge normal wind (v_n), the Exner pressure (Π) and the potential virtual temperature (Θ_v). To allow bidirectional data exchange and feedback, firstly, algorithms for conversions between these variables are required. Secondly, a complex logic needs to be established about when which feedback to ICON is possible, as at least in the NWP physics of ICON, u,v, and t are used and changed, instead of Π and Θ_v. Therefore, it needs to be ensured, that at all entry points the MESSy submodels change the currently “valid” variable, or a tendency of the respective variable. A first implementation of this exists, however, it does not work correctly. Debugging of this implementation is still ongoing.

   As this final coupling step is still missing, no progress was achieved in terms of integration of additional needs of MESSy and other plugins into the ICON model. Simply because the merge request have not been issued until we are sure that we integrated everything that is required by MESSy.

2. Further development w.r.t. porting MESSy to GPUs

   Not much progess has been archieved in this subpart of the project, as this has the lowest priority of the listed projects here. However, an infrastructure component dealing with the host-device copies for the base model has been updated to be usable with the current ComIn implementation. At the ESiWACE3 hackathon at JSC (October 20-22,2026), first tests with the ICON model on GPUs and MESSy in mixed CPU/GPU have been performed on JUPITER and Levante. The preparation for the hackathon was mostly performed on Levante, but mostly with another accounting project.

3. I/O-Server development

   a. Revision of IMPORT-GRID

   In the framework of a natESM sprint an IMPORT server has been developed to replace the infrastructure submodel IMPORT_GRID, which, especially for ICON, shows a very bad performance and no scaling.

   While the data exchange and regridding via YAC and the revision of the handling of MPMD setups in MESSy, was mainly handled by the RSE from DKRZ (using his own projects computing time), the computing time project 677 covered

   - the further processing of the exchanged and horizontally regridded data on the MESSy model side (e.g., further processing of metadata sent by the server, memory allocation, implementation of vertical integration, a very simple time-interpolation scheme)

- The automatic detection and calculation of the imported grid from the meta-data available in the netCDF file. This was achieved within a Seminararbeit of a MaTSE Bachelor student.
- The implementation and first test of different time reconstructions schemes for the timely aggregated input data (MaTSE Bachelor Thesis, October 2026, unfortunately not publicly available)
- Tests to run the IMPORT server with the COSMO model and the MECO(n) system have been performed, including the respectively required code changes.

The new IMPORT server does work well, however, some features covered by IMPORT_GRID still need to be implemented. Therefore, the development of the IMPORT server will continue in 2027.

b. Extension and tests of MESSy Output- and Import-Server

This work needs to be shifted to 2027 due to the following reasons:

- Our priority is to enable all features available in IMPORT_GRID also in the IMPORT server.
- At the end of the natESM sprint addressing the IMPORT server, we became aware, that running the IMPORT and the OUTPUT server at the same time requires the implementation of two YAC instances (at least for externally nested setups).
- The OUTPUT server in its current implementation does not have the required features to fully replace the direct CHANNEL netCDF output. Therefore, we decided, that we will apply for a further natESM sprint, to implement the same approach as was implemented into PISM during another natESM sprint by Wilton Loch (DKRZ).

4. (Part of) the User Support for MESSy

A considerable number of User Support requests / bug reports have been processed in 2026. Explaining these in detail would go beyond the scope of this report, but they could be checked in the MESSy GitLab at DKRZ. Some major parts were

- In preparation for the MESSy open-source release, several MESSy submodels have been cleaned up (including runtime tests for binary identical results bevor/after cleanup).
- The MESSy chemistry submodel MECCA has been enabled for CLaMS tracers in setups using CLaMS as base model and in setup coupling EMAC and CLaMS.
- Code changes required as preparation for the integration of YAXT into the MESSy infrastructure submodel CHANNEL have been introduced.

Literature:

Diepenthal, Niklas: Implementierung und Analyse konservativer Verfahren zur Rekonstruktion des zeitlichen Verlaufs von zeitlich gemittelten Chemie-Klima-Modellranddaten, Bachelor Thesis, FH Aachen, submitted. (Will be findable via JUSER data base in future).