



Sprint documentation #2

ICON-mHM-YAC Sprint

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1 Summary

The focus of the sprint was to overcome the limitation of offline coupling of impact models to Global Climate Models (GCMs), specifically coupling the ICON-ESM to the mesoscale Hydrologic Model (mHM, mhm-ufz.org) through YAC library. We found that it is crucial that for the coupled ICON-YAC-mHM run, model experts from both ICON and mHM contribute so that a meaningful simulation can be performed. At the end of the sprint, we were successful in setting up a real coupled ICON-mHM simulation for demonstration purposes.

2 General information

Start and end date:	12.07.22 – 15.01.23
Intended period:	6 months
Responsible RSE:	Enrico Degregori (DKRZ)
Responsible scientist:	Stephan Thober (UFZ)

3 Sprint objectives

The ICON-ESM and the mHM impact model are ideal candidates to investigate the impact of the online coupling because of two reasons. First, ICON uses the YAC coupling library, which facilitates the coupling of different components (e.g., atmosphere and ocean). Second, mHM has a highly modularized source code that allows the usage of YAC to enable the coupling to ICON with a reasonable number of resources.

4 Procedure and insights

4.1 Technical Approach / procedure

The work of the sprint was separated into two parts. First, YAC was integrated into the mHM, supporting both curvilinear and regular grids. As a first development step, an input data reader was created that reads the mHM input files and provides the data to mHM via YAC. The first validation uses the input files of an mHM experiment so the coupling does not involve any interpolation and bit-identical results can be obtained compared with the default mHM executable. A second validation uses global data input files and then the interpolated data are sent to the regional mHM grid through YAC.

During the second part of the sprint, a coupling interface was implemented in ICON for hydrologic models, and it was tested coupling the ICON atmosphere (amip experiment) with a toy mHM experiment.

Finally, the script for the final coupled ICON-mHM run was prepared based on the two standalone experiments and adding the xml file required by the YAC library.

4.2 General Insights

The coupling of two models through YAC requires an interface on each model where the coupling is initialized defining the model grid, a mask and the fields to be exchanged, then during the time loop the interpolated data are sent/received. This means that the integration of YAC is rather straightforward because the MPI communication and the interpolation is managed by the library. Internally, the YAC library provides a tool to visualize the weights generated internally for the interpolation of each field to validate the coupling.

The coupling can be configured at runtime defining an xml file where the fields to be exchanged are defined together with the interpolation method, the coupling period operation, and the coupling time lag for each field.

When two models run concurrently, it is usually required to find a good load-balancing to avoid waste of computational resources. In this case, the mHM does not have MPI parallelization so there is no flexibility in terms of load balancing.

However, it is crucial that for the coupled ICON-YAC-mHM run, model experts from both ICON and mHM contribute so that a meaningful simulation can be performed.

5 Results

The following results were achieved during the sprint:

- integration of YAC library in mHM and extensive validation with dummy components
- extension of coupling period operations in YAC library (performed by YAC developers)
- interface for hydrologic models coupling in ICON and validation with mHM toy model

The outcome of the sprint was to set up a real ICON-mHM coupled simulation for demonstration purposes. This setup is focusing on the period which covered the Ahr flooding event (14/15 July 2021) and had also severe floods in China in the same period.

6 Conclusions and Outlook

The current setup allows to couple mHM with the fully coupled ICON-ESM and it also allows to couple ICON with different instances of mHM. These different configurations still need to be tested.

The future step is about allowing online coupling with other external models. Any environmental model that requires the same meteorological input as mHM requires no work on ICON and YAC to be coupled, but only needs the YAC calls to be integrated. Here, the development in mHM serves as a blueprint.

For models requiring different variables as mHM, one-way coupling is rather straightforward because it does not involve any feedback on the ESM. Two-way coupling requires further investigations from domain scientists and was beyond the scope of this sprint.

7 References

A full documentation can be found on UFZ Gitlab: <https://git.ufz.de/natesm/mhm/-/wikis/home>.

Unfortunately, it was not possible to have open access to the sprint development and related wiki. Please get in contact with Sebastian Müller (sebastian.mueller@ufz.de) to get access to the full documentation.