Project: 1471

Project title: Scale interaction in Land-Atmosphere feedback - Land-Atmosphere Feedback Initiative (LAFI)

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Report period: 2025-01-01 to 2025-12-31

Overview

The scientific objective of this project is to improve our understanding of how processes linked to land-atmosphere interactions are represented in ESMs, and the dependence of these interactions on the resolution at which the models are operated. As a part of the DFG-funded project 'Land Atmosphere Feedback Initiative', it contributes to a joint effort to understand and quantify land-atmosphere feedback through synergistic observations and simulations. For the year 2025, our target was to: (a) initialize ICON with IFS forecasts, which is required for making the output comparable to the other models in LAFI using IFS forecasts as the initial conditions, (b) Conduct simulations using ICON-NWP and JSBACH4 with full functionality of vegetation processes. While we managed to accomplish our first objective, additional time was spent setting up benchmark runs and learning how to use ICON before further progress towards realizing ICON-JSBACH simulations can be made.

ICON-TERRA as an initial benchmark

As a starting point for our LAFI PhD study (D. Jyoti) and to become familiar with the ICON framework, ICON-TERRA was used as a benchmark for future simulations. This choice was based on the previous studies of the principal investigator using this configuration (Sakradzija et al., 2025) as well as the availability of observational data from the previous observational campaign (Field Experiment on submesoscale spatio-temporal variability in Lindenberg – FESSTVaL, Hohenegger et al., 2023). These observations are used to evaluate the performance of ICON in different configurations and using different forcing data. In this initial stage, ICON was used in NWP mode, coupled with TERRA, and forced by the ICON operational analysis and forecasts, covering grid resolutions from about 5 km to 78 m. Once the PhD student successfully reproduced the simulations from the FESSTVaL campaign, we introduced the forcing based on the IFS operational analysis and forecasts.

Initialization with IFS

The initialization of ICON using IFS analysis and forecasts can be straightforward with direct access to the DWD or ECMWF computing systems. However, working at a university we do not have such access and could not use the scripts provided with ICON directly, such as `icon/scripts/preprocessing/mars4icon_smi`. As a result, the PhD student had to learn how to manually process the IFS files by reformatting and converting the dimensions and units of the needed variables. After successfully preparing the initial and lateral boundary conditions based on the IFS, simulations for the FESSTVaL region were conducted for the test day (17.06.2021) to compare the model performance using the new IFS input files with the previous setup. We found that our new setup performs reasonably well (Figure 1) when compared to the observations and previous simulations from FESSTVaL. The simulations were not resource-intensive at this point, as the highest resolution used was 2.5 km for a limited-area domain over Germany.

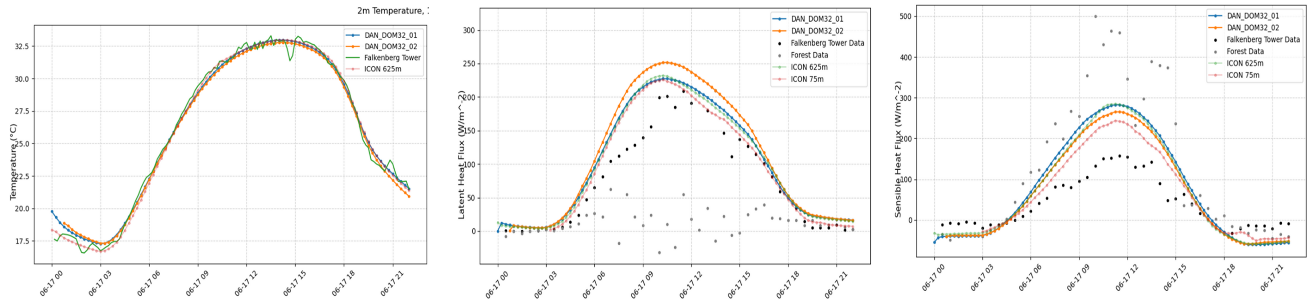

Figure 1. Results from ICON simulations forced with IFS (DAN_DOM32_(domain)'), compared with previous ICON simulations and observations from the FESSTVaL campaign for temperature at 2 m(left), latent heat flux(center) and sensible heat flux(right) on June 17, 2021.

While the model was able to represent diurnal temperature and relative humidity variations very well compared to previous ICON simulations and observations, we found that the nested domains from the third nest onwards tended to overestimate evapotranspiration (latent heat flux) and underestimate temperatures near the surface. This tendency was stronger with each finer nest. We plan to address this issue before the end of this year. In addition, we plan to introduce higher resolutions and approach the large eddy scales (~75 m), for which we will run a nested setup using five nests with successively refined resolution. As a result, we expect to utilize much more of the allocated resources for this year than we could have until this point. Resource utilization was lower than expected in the previous quarters, predominantly due to delays in setting up ICON in a limited area region using IFS forecasts.

ICON-JSBACH

Once we determine the cause of the resolution dependency in surface turbulent fluxes and successfully reproduce the sub-km-resolution benchmark simulations, we plan to switch to our target ICON setup, ICON-NWP-JSBACH, following its current development at Deutscher Wetterdienst. In preparation for these runs, we have already created the initial and boundary conditions files required to initialize JSBACH. Due to the very high resolutions at which we aim to conduct our runs, we need to prepare these initial files from the EXTPAR data for the ICON grids. The spatial resolution of the soil and land-surface input data for most variables is not fine enough for sub-km runs. We are therefore also exploring the SoilGrids data for use in ICON. The example shown in figure 2 demonstrates the difference in resolution between the soil type data currently used in EXTPAR and the one available in SoilGrids.

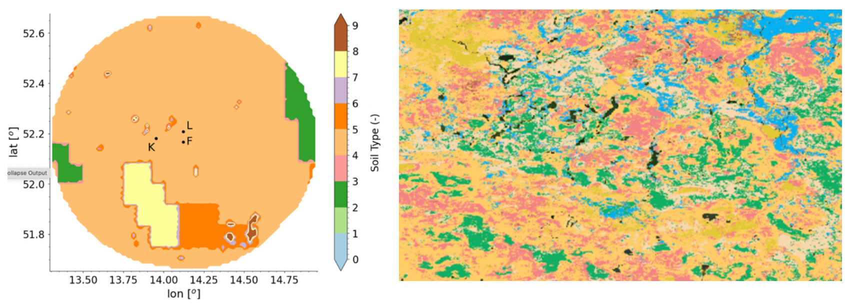

Figure 2: An example of the differences in the maps of soil types from EXTPAR (left, interpolated to ~320 m resolution) and those from SoilGrids in approx. the same region (right, at 250 m resolution). Different colormaps are used for the two plots.

1. Sakradzija, M., Ahlgrimm, M., Beyrich, F., Heerwaarden, C., Päschke, E., Görsdorf, U. et al., 2025: Where numerical weather prediction meets large-eddy simulations in a convective boundary layer during the FESSTVaL field experiment. Quarterly Journal of the Royal Meteorological Society, e70037. https://doi.org/10.1002/qj.70037

2. Hohenegger, C., Ament, F., Beyrich, F., et al. including M. Sakradzija, 2023: FESSTVaL: the Field Experiment on Submesoscale Spatio-Temporal Variability in Lindenberg, *Bull. Amer. Meteor. Soc.*, 104, E1875-E1892, https://doi.org/10.1175/BAMS-D-21-0330.1.