Sprint 2

Challenges and results experienced during the ICON-mHM-YAC sprint

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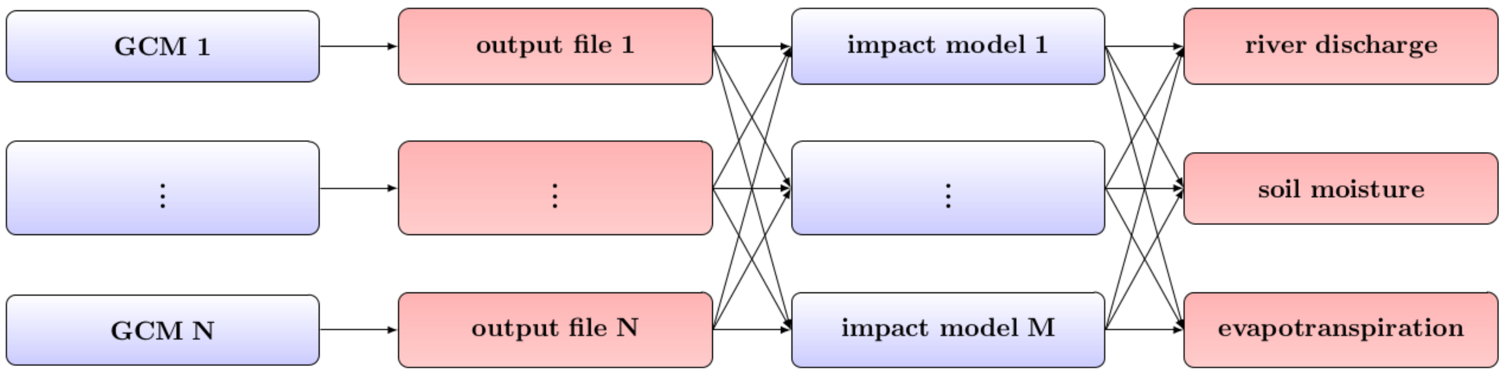
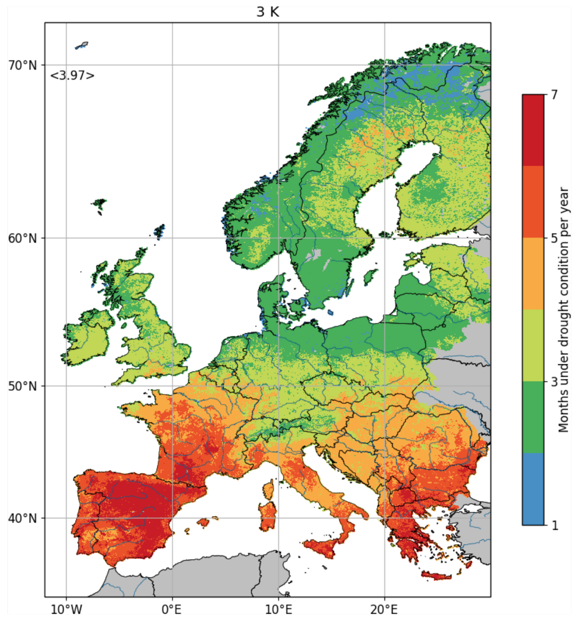
General information: Overview and Scope

Coupling via files.

Climate model ensemble | Impact models | Output variable

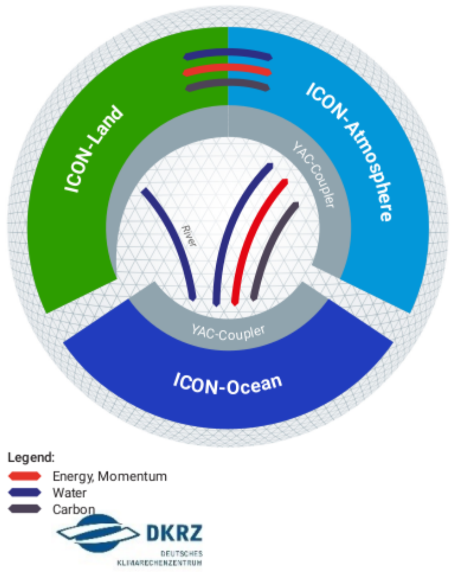




Samaniego and Thober et al., 2018 (NCC)

Coupling via memory

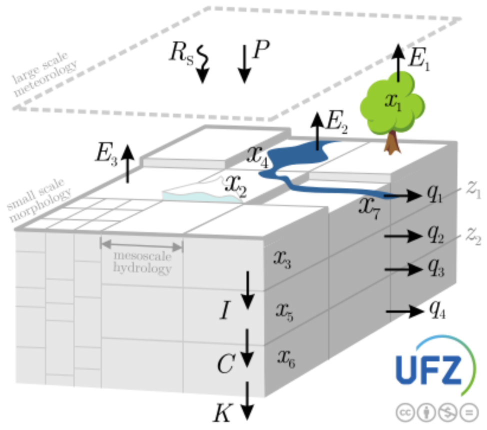
ICON



YAC

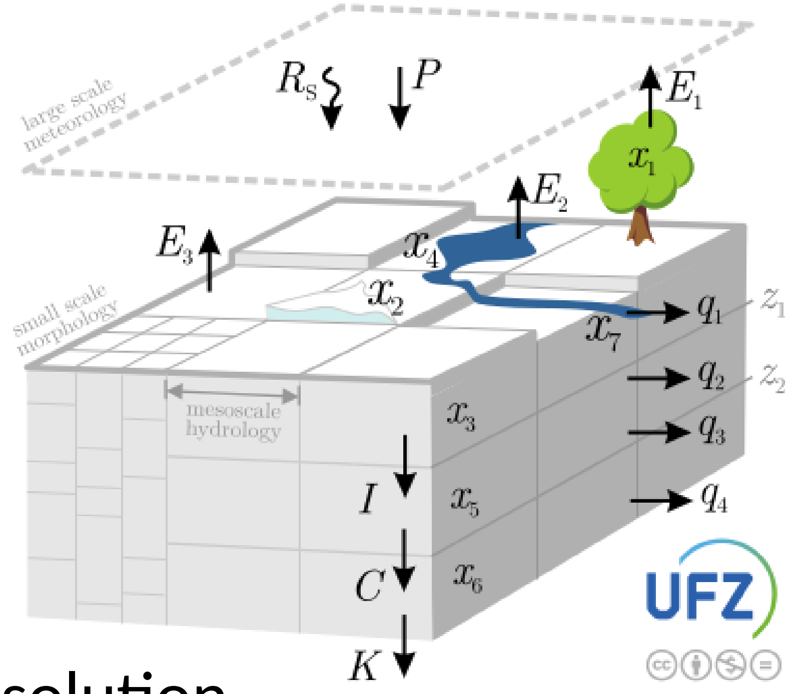
Precipitation, 2-m air Temperature, humidity, Downward radiation

mHM



General information:
The mesoscale hydrologic model (mHM)

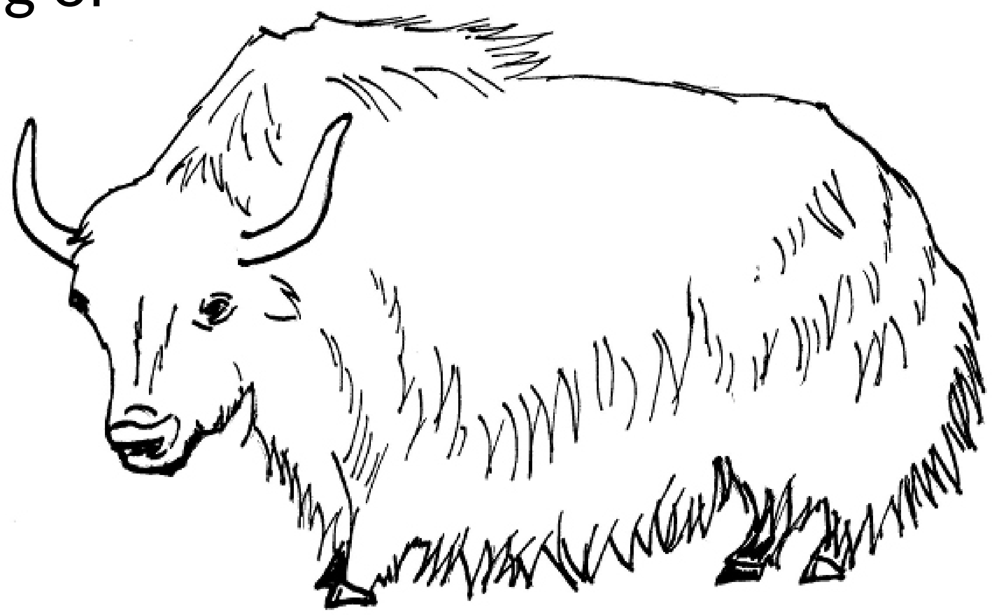
- spatially explicit distributed hydrologic model on grid cells
- accounts for a variety of processes
  (e.g., runoff, PET, discharges, flood routing)
- driven by hourly or daily meteorological forcings
  (e.g., precipitation, temperature)
- utilizes observable basin physical characteristics
  (e.g., soil-, geological properties)
- main feature of mHM is the approach to estimate parameters at the target resolution based on high resolution physiographic land surface descriptors (MPR)



https://mhm-ufz.org

General information:
Yet Another Coupler (YAC)

- developed at DKRZ
- lightweight software library to realise coupling of Earth system model components
- two-dimensional neighborhood search, interpolation, and communication for the coupling between any two models
- efficient and fully parallelized
- supports unstructured and block-structured numerical grids



https://dkrz-sw.gitlab-pages.dkrz.de/yac

Hanke and Redler et al., 2016 (GMD)

Work description

1) Provide overview of YAC to mHM core developers (RSE)
2) Provide mHM overview to ICON-YAC core developers (UFZ)
3) Identify mHM source code modificatios necessary for YAC coupling (UFZ/RSE)
4) Implement mHM code modifications (UFZ)
5) Create dummy component that reads default input meteorology and passes it to mHM (RSE)
6) Conduct mHM default simulation coupled to dummy component using YAC (RSE)
7) Validate mHM default simulation (UFZ)

1) Discuss simulation experiment to conduct coupled ICON-mHM simulation (UFZ/RSE)
2) Adapt ICON initialisation to allow external models
3) Modify ICON-ESM to provide required variables to mHM via YAC (RSE)
4) Provide mHM setup for simulation experiment (UFZ)
5) Conduct coupled ICON mHM simulations (RSE)

Results

toy_atm.c

```c
{
  double *point_set_data[1];
  double **collection_data[1] = {point_set_data};

  point_set_data[0] = tavg;
  yac_cput(tavg_field_id, nlev, collection_data, &info, &err);
}
```

coupling.xml

```xml
<!--tavg-->
<transient_couple transient_id="2">
        <source component_ref="2" transient_grid_ref="2"/>
        <target                   transient_grid_ref="2"/>
        <timestep>
                <source>24</source>
                <target>1</target>
                <coupling_period operation="accumulate">24</coupling_period>
                <source_timelag>0</source_timelag>
                <target_timelag>0</target_timelag>
        </timestep>
```

Meteo

- tavg
- pre
- ...

YAC

mhm_driver_yac.f90

```fortran
  ! Loop over time
  TimeLoop: do while(.not. time_loop_finished)

    call coupling_mhm_recv_meteo(L1_pre_yac, L1_tavg_yac, L1_pet_yac, L1_tmin_yac, L1_tmax_yac, &
                                 L1_netrad_yac, L1_absvappress_yac, L1_windspeed_yac)
    select case (processMatrix(5, 1))
      case(-1 : 0)
        call mhm_interface_run_do_time_step(L1_pre_yac=L1_pre_yac, L1_tavg_yac=L1_tavg_yac, &
                                            L1_pet_yac=L1_pet_yac)
```

- Created new driver for mHM-YAC coupling
- Replace meteorological data in every time-step
- New development in mHM: “meteo-handler“ to either read from interface or file

Results

ICON

```
! ------------------------------
!  Send land surface temperature - coupling with hydrology model
!   field_id(15) represents "mean_land_surface_temperature"
!
CALL yac_fput ( field_id(15), nbr_hor_cells, no_arr, &
                buffer(1:nbr_hor_cells,1:no_arr), info, ierror )
```

Meteo
- tavg
- pre
- ...

YAC

coupling.xml

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mhm_driver_yac.f90

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    select case (processMatrix(5, 1))
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        call mhm_interface_run_do_time_step(L1_pre_yac=L1_pre_yac, L1_tavg_yac=L1_tavg_yac, &
                                            L1_pet_yac=L1_pet_yac)
```

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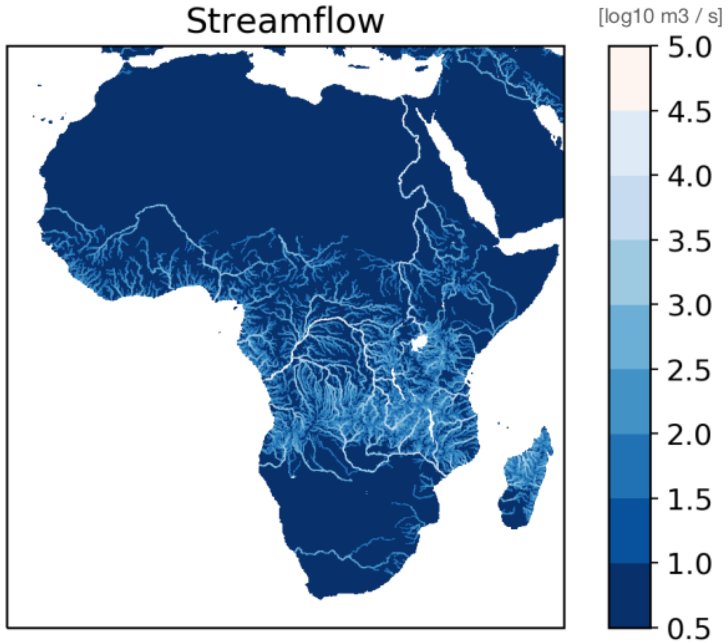
Results

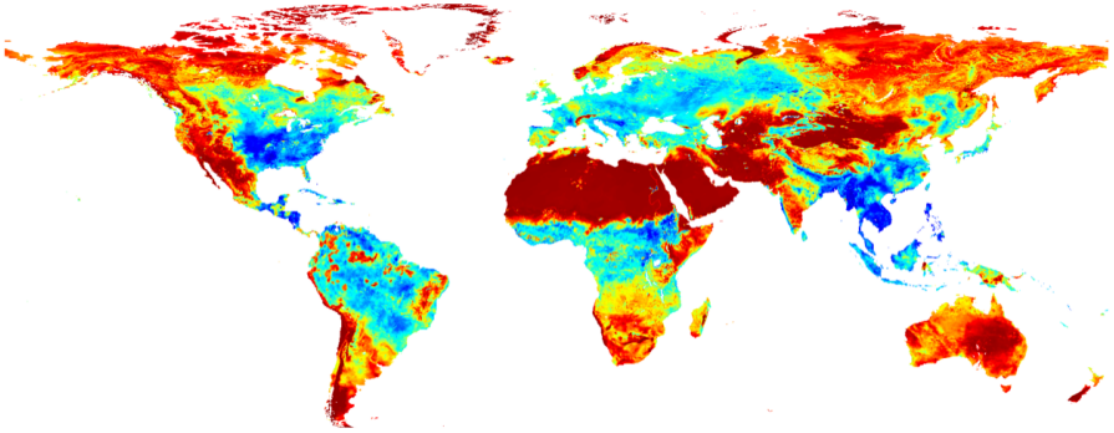
- YAC sends data from ICON to mHM
- Proof of concept: 2 days simulation

YAC



YAC

mHM



ET

- 0,1° global setup
- 20.01.2020 – 22.01.2020

Experiences & Challenges

- All required technical expertise was well represented
  - Implementation of YAC interface went smooth
  - All involved developers were highly commited
  - We made a successful run within *one* sprint
- Executing a coupled simulation of ICON and mHM is challenging
  - Executing modeller needs to have knowledge of configuring ***both*** models ***and*** the coupler
  - Simple overview on the components is not enough to run a successful coupling
- Administrative challenges:
  - Unclear project management practices for sprint members
  - Are there guidelines from natESM?

Outlook & open questions

- There was no in-depth scientific evaluation of the coupling
  - Research projects could focus on the Ahr flood event:
    - How would the forecast of such an event profit from an online coupling that would allow the usage of higher resolved temporal data?
- Outlook
  - Obtain further funding for scientific projects making use of the coupling
  - mHM will get a new „meteo-handler“ to make couplings like these easier

Thank you for your attention!

References

- Samaniego L., Kumar, R., and Attinger, S. (2010): Multiscale parameter regionalization of a grid-based hydrologic model at the mesoscale. Water Resour. Res., 46, W05523, https://doi.org/10.1029/2008WR007327
- Kumar, R., Samaniego, L., and Attinger, S. (2013): Implications of distributed hydrologic model parameterization on water fluxes at multiple scales and locations, Water Resour. Res., 49, https://doi.org/10.1029/2012WR012195
- Samaniego, L., Thober, S., Kumar, R. et al. (2018): Anthropogenic warming exacerbates European soil moisture droughts. Nature Clim Change 8, 421–426, https://doi.org/10.1038/s41558-018-0138-5
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- Wan, H., Giorgetta, M. A., Zängl, G.et al. (2013): The ICON-1.2 hydrostatic atmospheric dynamical core on triangular grids – Part 1: Formulation and performance of the baseline version, Geosci. Model Dev., 6, 735–763, https://doi.org/10.5194/gmd-6-735-2013