natESM

DKRZ DEUTSCHES KLIMARECHENZENTRUM

JÜLICH Forschungszentrum | JÜLICH SUPERCOMPUTING CENTRE

DKK Deutsches Klima Konsortium

Federal Ministry of Education and Research

Sprint 11

Results and challenges experienced during the modLSMcoup sprint

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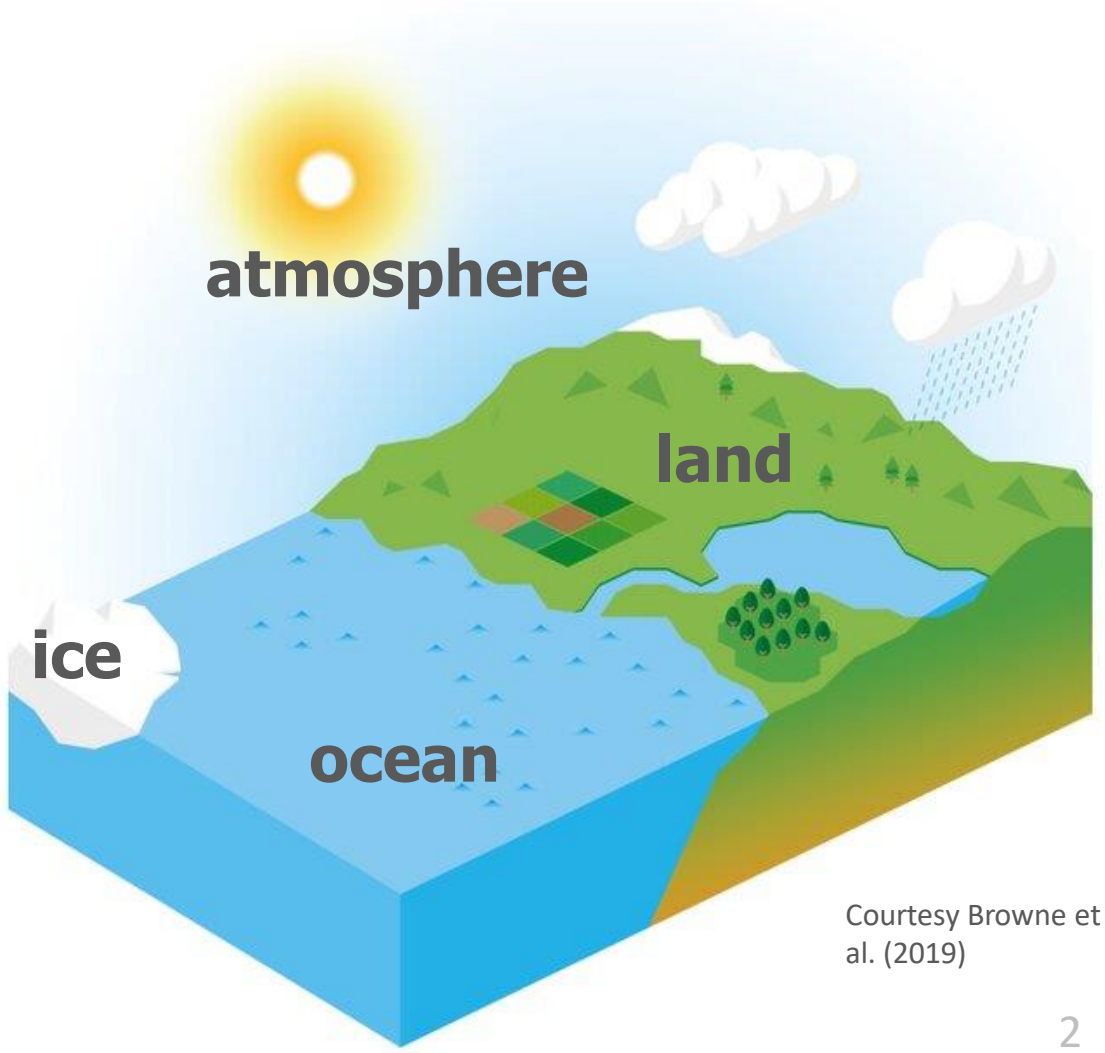
Modular LSM coupling - Aim of the Sprint

Aim of the sprint

- Develop a proof-of-concept for modular coupling of the land surface model (LSM) with the atmosphere by the mean of the YAC coupler

Tailoring to the needs of users

- Different LSMs offer varying degrees of complexity
- Possibility to include multivariate land surface heterogeneity



Courtesy Browne et al. (2019)

Coupling configuration – Sequential coupling

Sequential execution

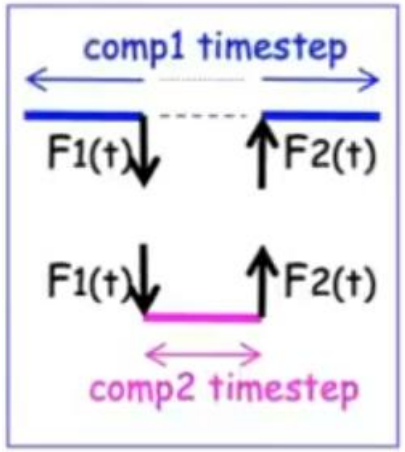
on the same set of cores in one executable

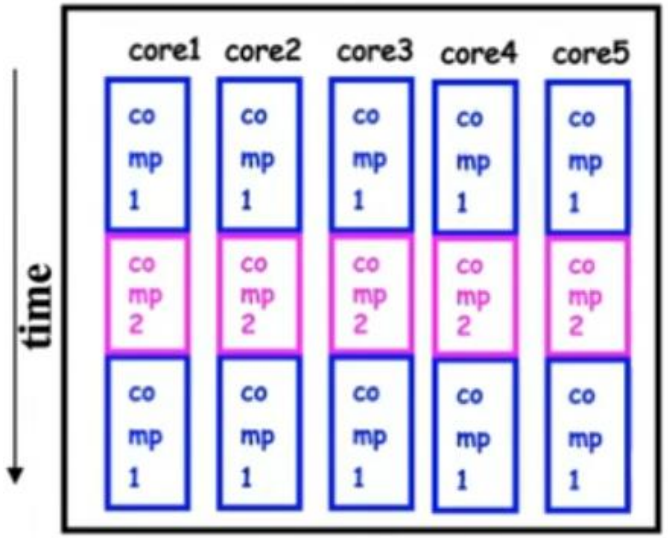
+ Efficient coupling exchange through memory

+ Optimal for load balancing
  (if efficient on the same number of cores)

- No flexibility in coupling algorithm

e.g. atmos. – land coupling in ICON

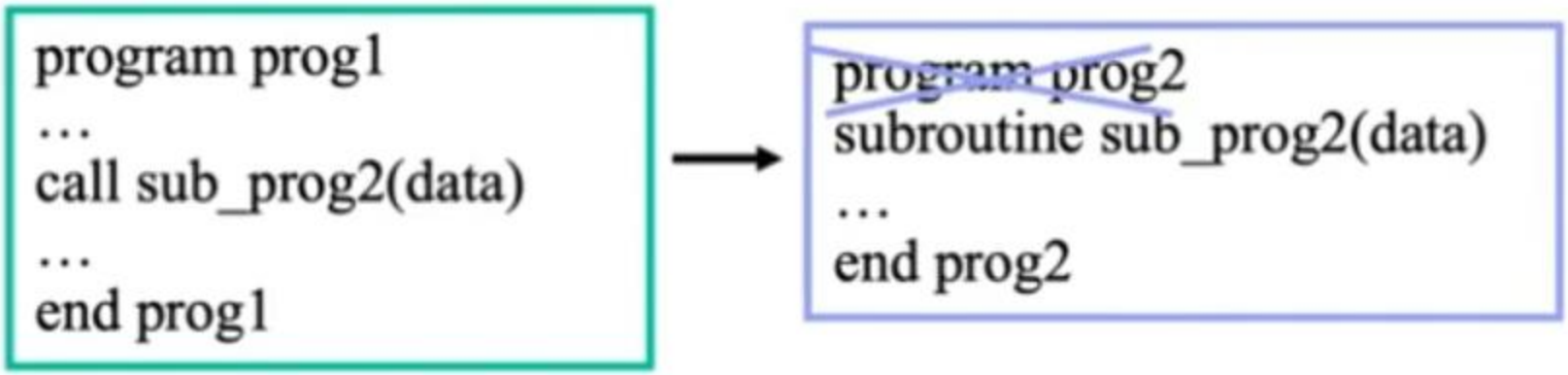




Slide-courtesy Valcke (2020)

Coupling technical solutions

Subroutine coupling



+ Efficient (memory exchange)
+ One executable: easier to debug / for the OS
+ Sequential execution

- Not flexible (coupling algorithm hard coded)
- No use of generic transformations/interpolations
- No heterogeneous computing

Slide-courtesy Valcke (2020)

Coupling configuration – Concurrent coupling

Concurrent execution

on different sets of cores within

one executable or separate executables

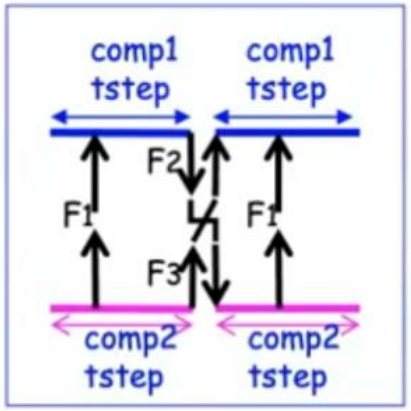
+ Additional level of parallelism

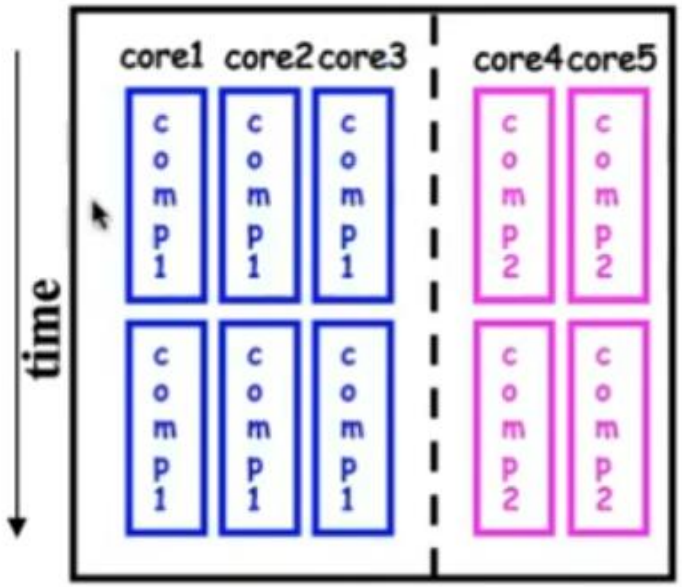
+ Flexible coupling algorithm

- Less efficient coupling exchanges as components mights be on different nodes (no shared memory)

- Harder load balancing

e.g. atmos. – ocean coupling in ICON

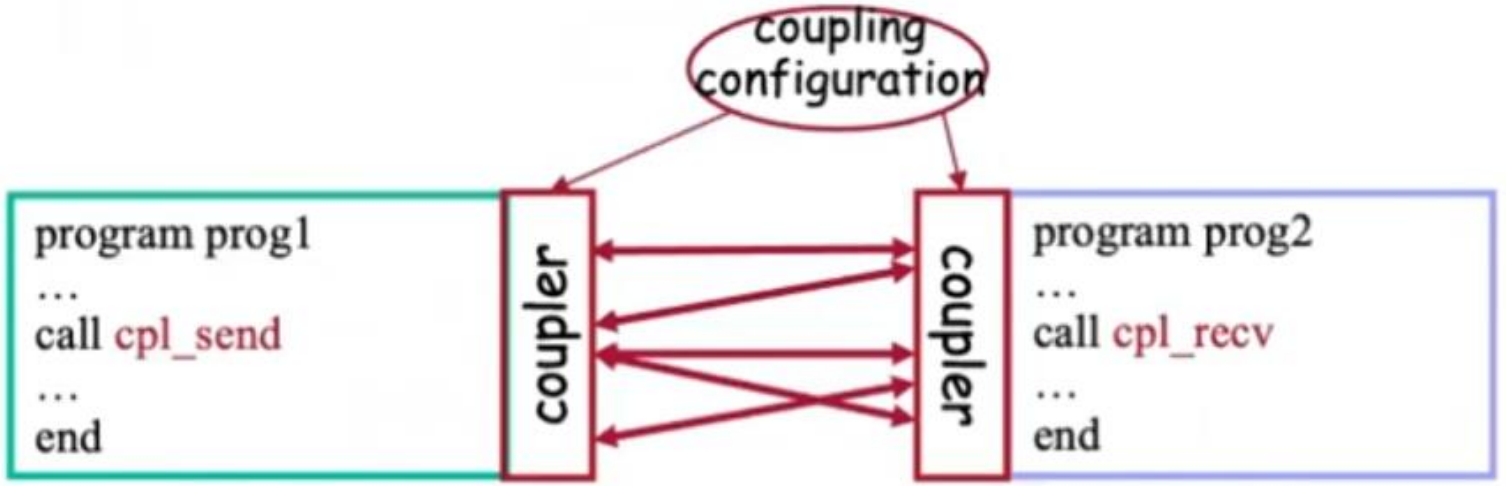




Slide-courtesy Valcke (2020)

Coupling technical solutions

Use of coupling library / external coupling



+ Usage of heterogeneous computing
+ Sequential and concurrent coupling
+ Use of generic transformations regridding
+ Porting of existing code

- Efficiency
- Multi-executable: harder to debug, manage for the OS

Slide-courtesy Valcke (2020)

General information – ModLSMCoup

Sprint aim: Proof-of-concept for modular LSM coupling

Tasks - Modular land surface model (LSM) coupling

- External coupling approach
- Use of ICON’s coupler of choice Yet Another Coupler (YAC)

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1) Concept

Develop coupling concept

4 weeks

- Creation of short concept on modular coupling of land surface models

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2) Implementation

Implementation of coupling

22 weeks

- Implementation of the YAC coupler into the ICON-LSM interface as a demonstrator (example eCLM)

Working plan

time

1) Concept

Develop coupling concept

i. Getting familiar with the code and coupling concepts
ii. Write document about coupling concept for LSM coupling

2) Implementation

Demonstrator of LSM coupling

Implementation of the YAC coupler into the ICON-LSM interface as a demonstrator (example eCLM)

i. Implementation of coupling procedure in ICON
ii. Creation of dwarf land surface model mimicking LSM
iii. Creation of test case for YAC coupling
iv. Test of ICON-YAC-DwarfLSM
v. Implementation of coupling procedure for full fledged land surface model (example eCLM)
vi. Performance testing of coupled system
vii. Demonstrator of MSA

Results – Coupling concept

Brief report for generic design suggestion

- Open for discussion
- Building on existing document
  “Land-atmosphere coupling” (Schlemmer et al., 2023)
- Suggestion:
  - Interface layer, selection of
    coupled variables LSM (interchangeable)
  - Inclusion of mediator if necessary
  - Move tile-approach to LSM with support to for tiled exchange coefficients / surface fluxes (allowing blending height above sfc)

https://gitlab.dkrz.de/b38038/modLSM-coupling-concept

Challenges –
Course of action was clear, details mattered

Procedure

- Take already existing ICON-eCLM with external coupler OASIS3-MCT and use it as a blueprint for the ICON-YAC-eCLM coupling
- Functions between coupler quite similar

Details that mattered

- Grid definition in YAC (obvious)
- Time management
- Coupling time step
- Automatic receive count

Challenges

Porting of the test case

- Issues in linking YAC in DwarfLSM at JUWELS-Cluster (JSC)
- DwarfLSM based on YAC-Tutorial contained newer YAC version than used ICON version (newest release at that time)
- Hetjob does not work at JUWELS-cluster. Solved with multiprog-file.

Restructuring of YAC coupling mechanism

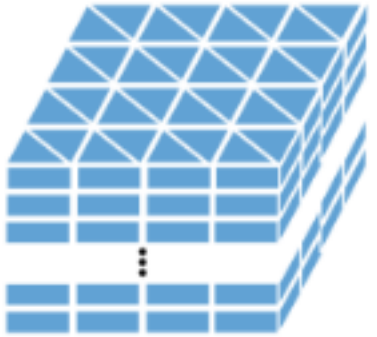
- ICON coupling code was refactored (improved) during the sprint
- Restructuring from a component centric coupling to a general purpose coupling structure

Results – Setup test case ICON-YAC-DwarfLSM

Idealized diurnal cycle

	ICON	DwarfLSM
Time step	10 s	600 s
Sim. time	24 hours	
Coupl. ts.	600 s	
Grid spacing	2 km	2 km
Init.	Tnlev=290K dT/dH=6K/km rh_sfc=80%	homogeneous

ICON



DwarfLSM

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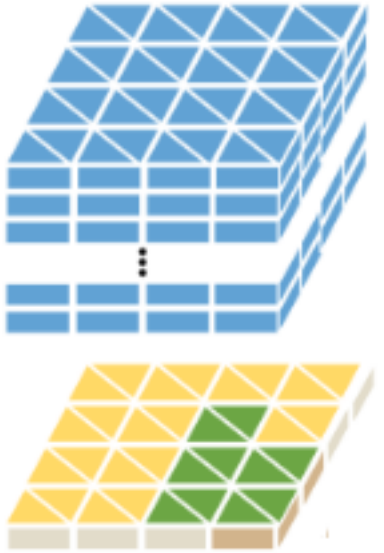
ICON

DwarfLSM



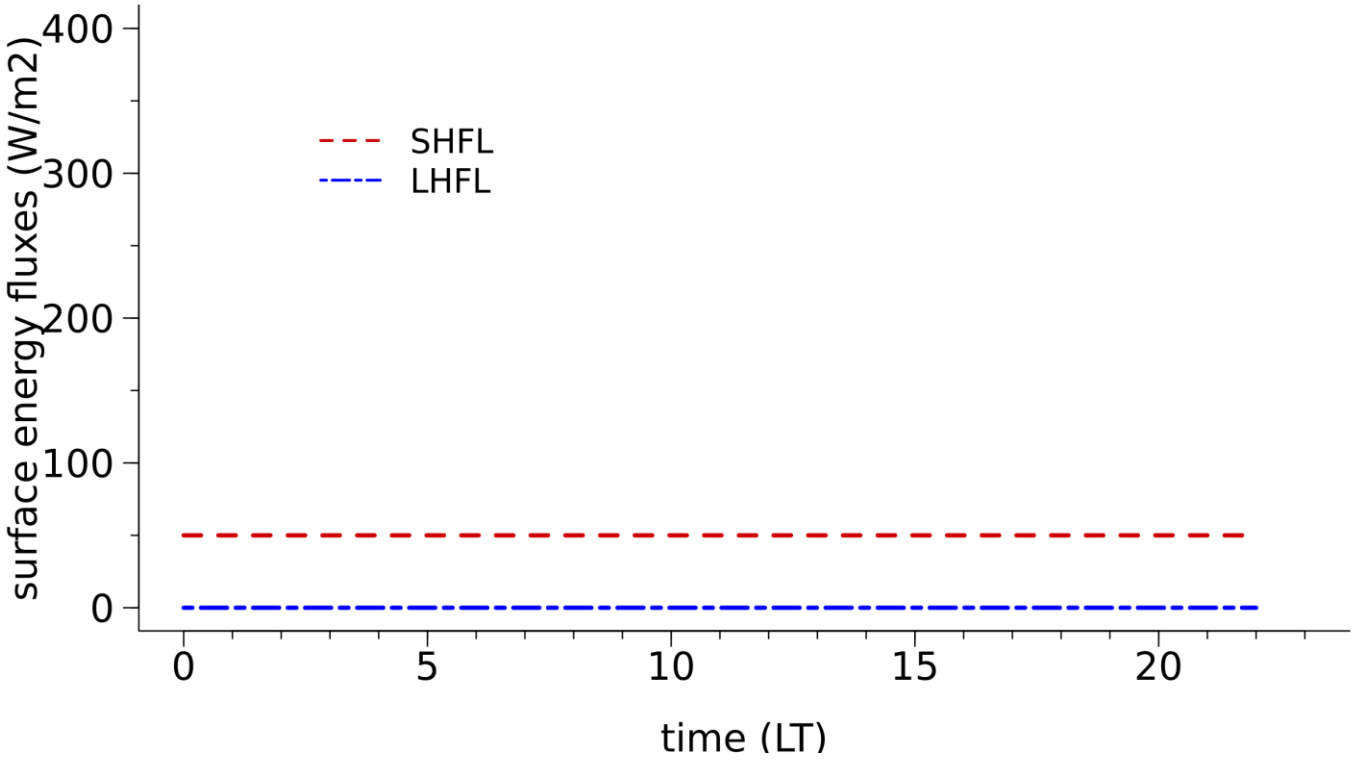
i) Constant value

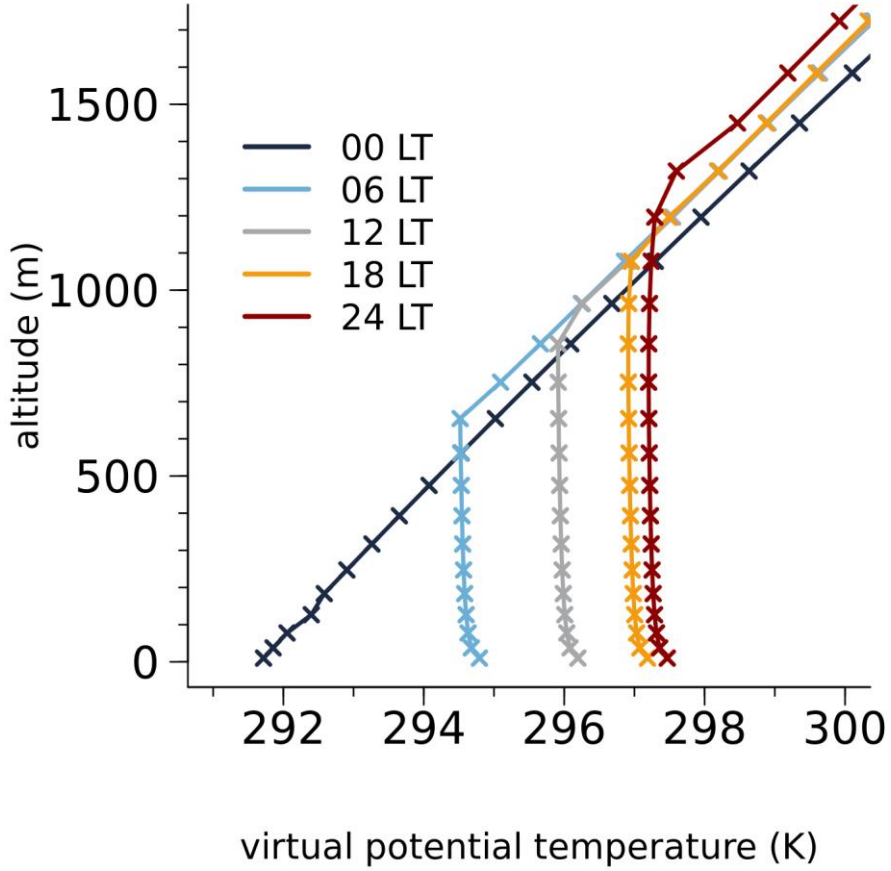
- Albedo 30%
- t_g = 300 K
- shfl_s=50 W/m2
- lhfl_s=umfl_s=vmfl_s= 0 W/m2

ii) LSM feedback

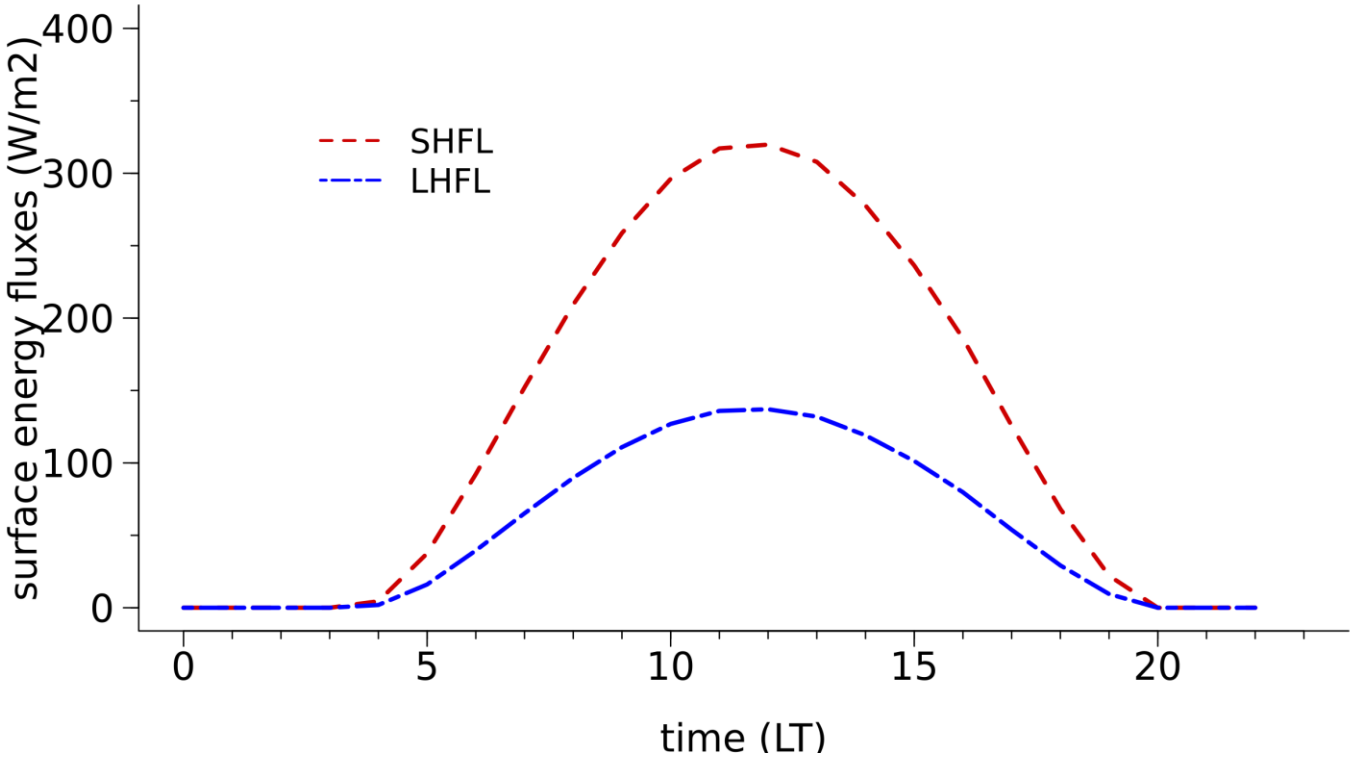
- Albedo 30%
- t_g follows t_nlev
- Ghf 20% of Rnet
- Fixed bowen ratio 2.3

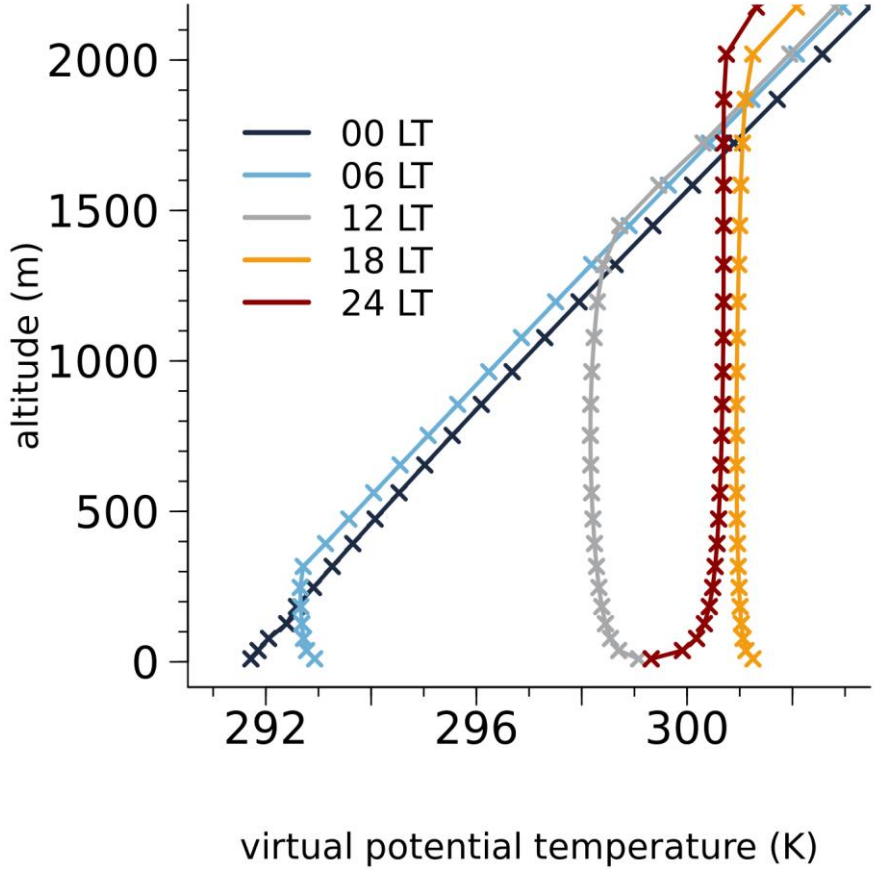
Results – i) Constant value coupling





Results – ii) LSM feedback





demonstrates the proof of concept for a modular land surface coupling

Outlook & open questions

Outlook

- Implementation of full-fledged LSM coupling (example eCLM)

Open questions

- Integration with TMX

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Coupling concept

https://gitlab.dkrz.de/b380388/modLSM-coupling-concept

Sprint repository

https://gitlab.dkrz.de/b380388/icon-fork/-/tree/natesm/modlsmcoup

Test-case with DwarfLSM repository

https://gitlab.dkrz.de/b380388/natesm_ideal-ccs-snwp_icon

Special thanks to Moritz Hanke, Jan Weinkämmerer, Linda Schlemmer and Rainer Schnur!

References

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