natESM

DKRZ DEUTSCHES KLIMARECHENZENTRUM

JÜLICH Forschungszentrum | JÜLICH SUPERCOMPUTING CENTRE

DKK Deutsches Klima Konsortium

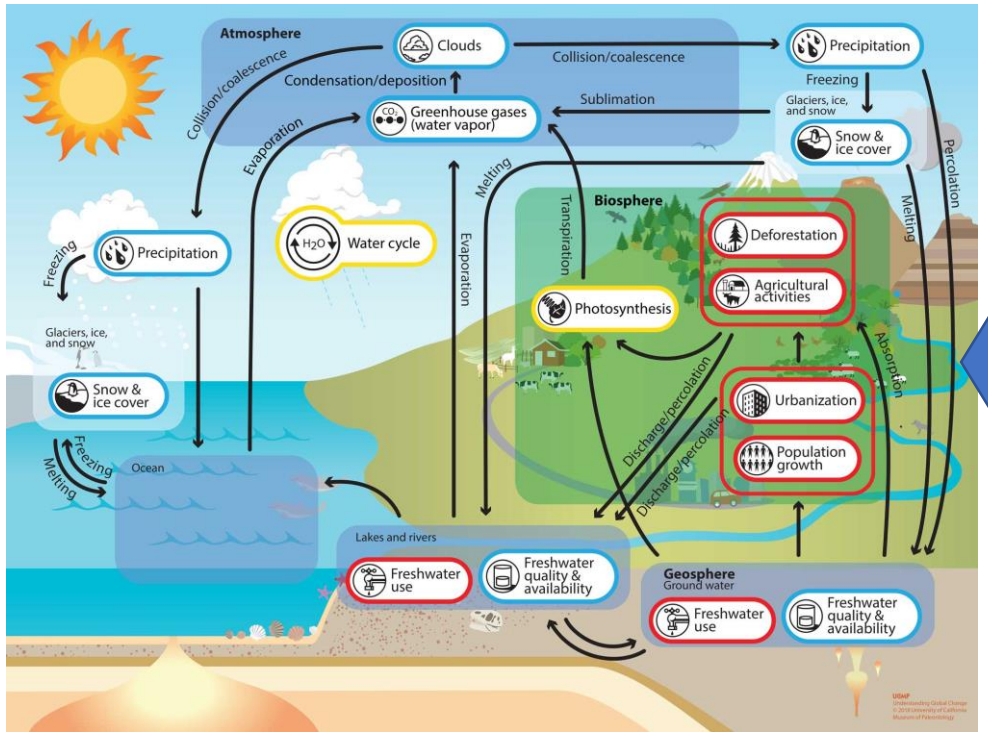
Federal Ministry of Education and Research

Community Workshop 2025

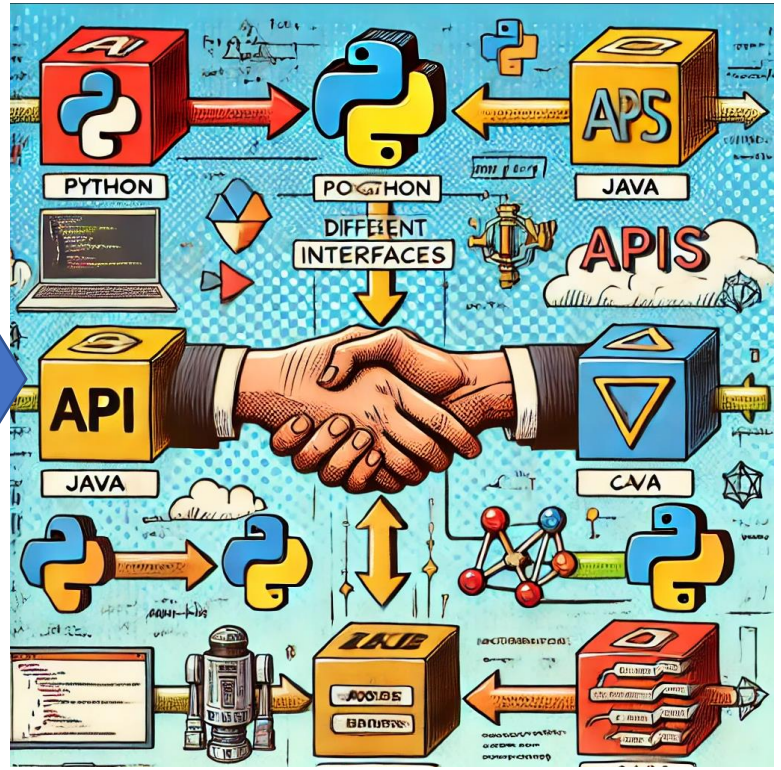
Using well-defined interfaces to improve EarthSystemModelling

Hendryk Bockelmann (DKRZ)

Why should we care about interfaces?



Probably a need for translation

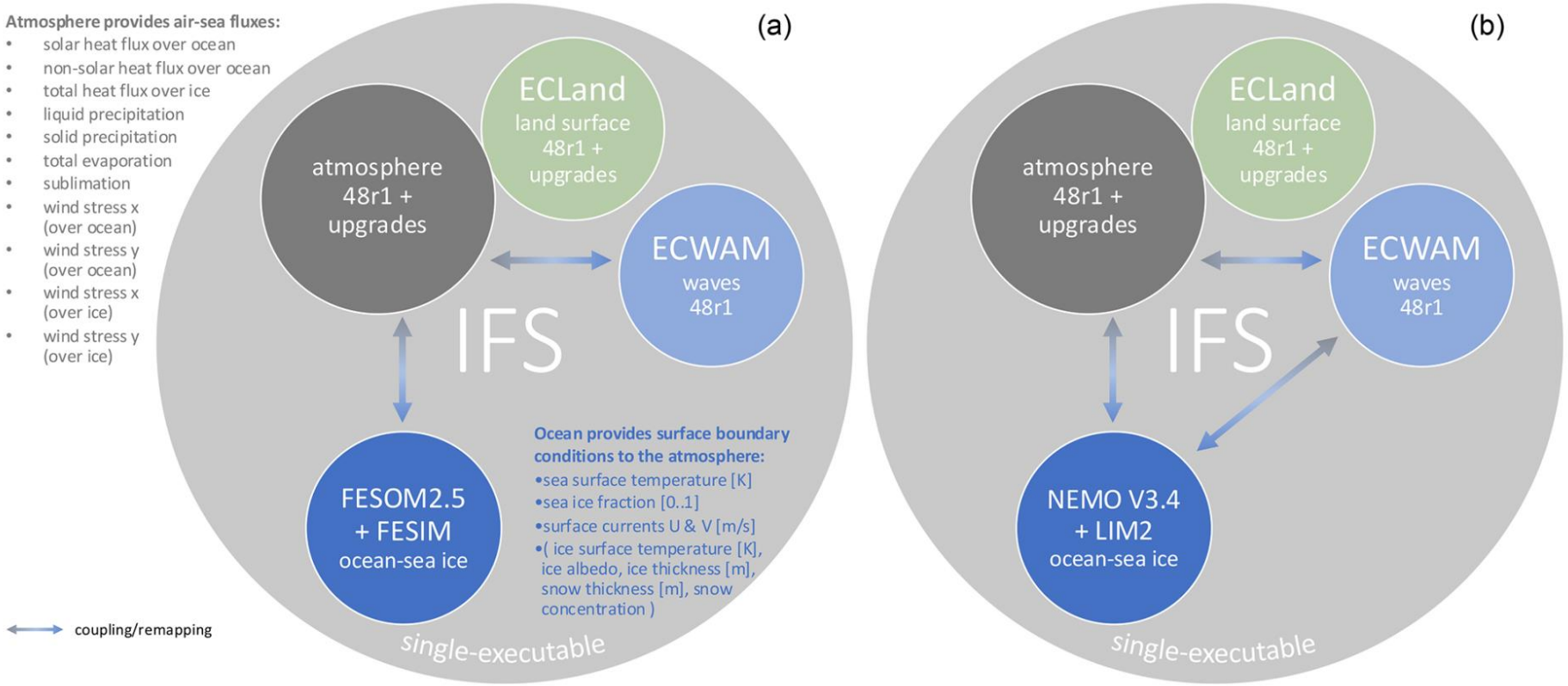


AI generated image

Scientists view on different Earth System components

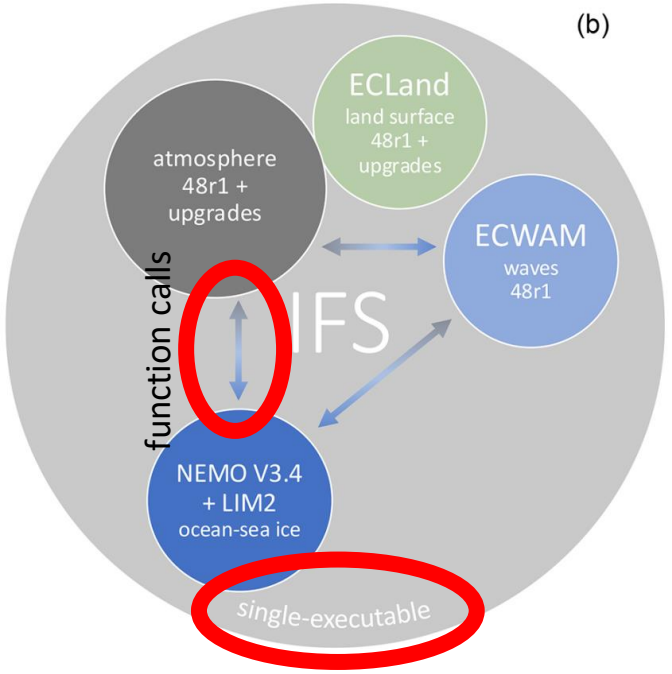
Computer science understanding of interfaces

A possible way …



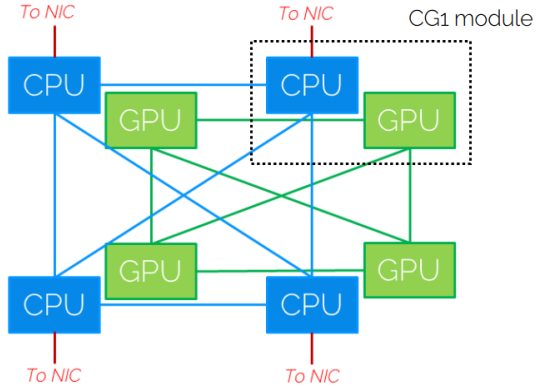
Coupling of the Integrated Forecasting System (IFS) components in (a) IFS-FESOM and (b) IFS-NEMO in nextGEMS configurations. [Thomas Rackow et al, Multi-year simulations at kilometre scale with the Integrated Forecasting System coupled to FESOM2.5 and NEMOv3.4, Geosci. Model Dev., 18, 33–69, https://doi.org/10.5194/gmd-18-33-2025, 2025]

… and its implications

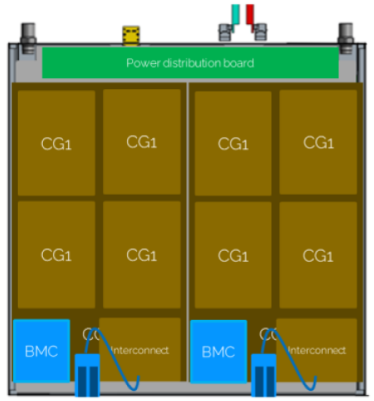


How to map efficiently?

Logical



Physical

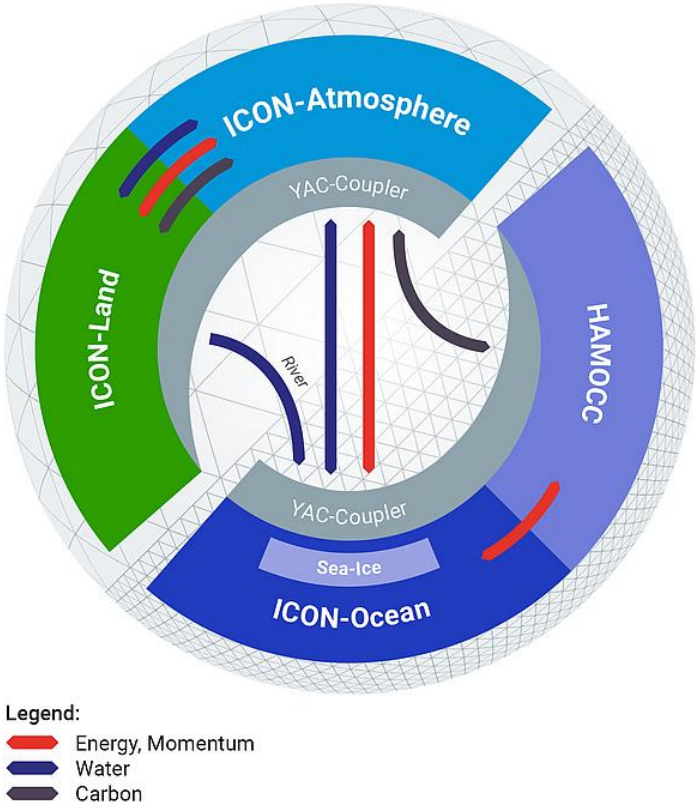


BullSequana X3515-HMQ Compute Blade by Eviden
(aka the JUPITER nodes)

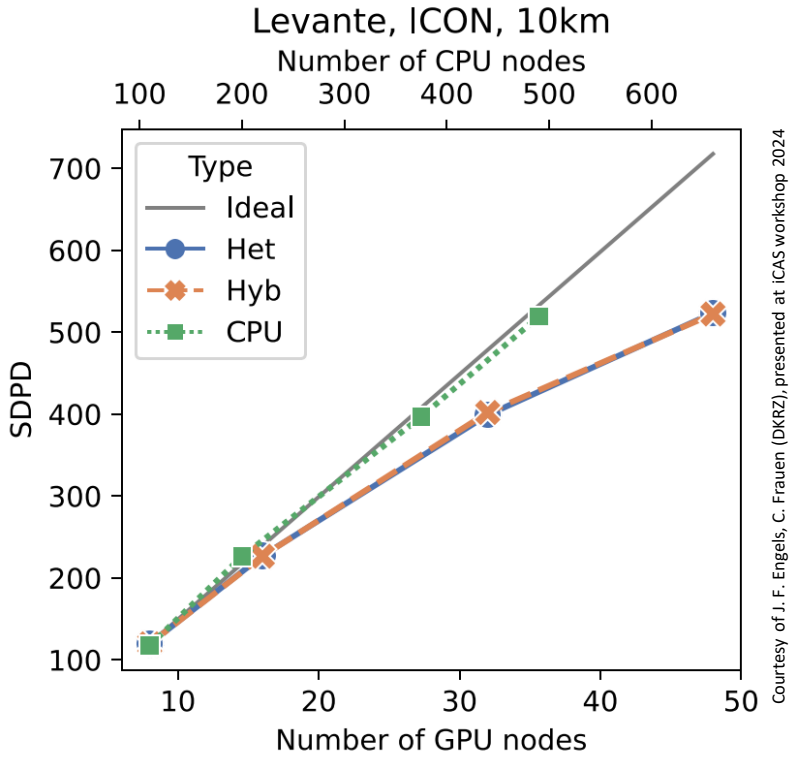
A different approach in ICON

Coupling using YAC library

Aiming for independent components



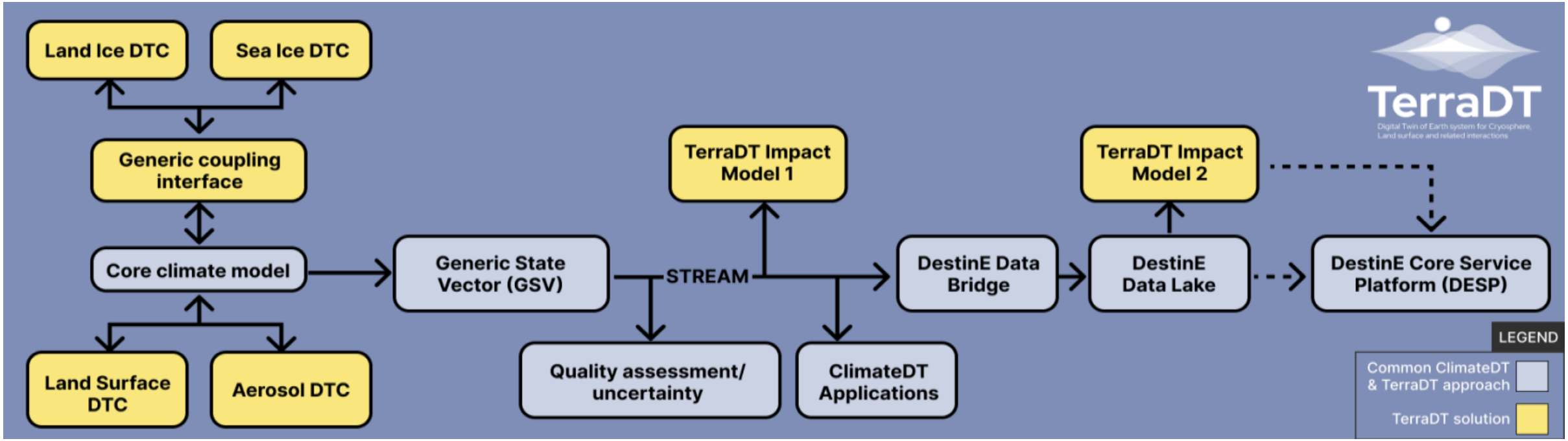
J. Jungclaus, et al (2022). The ICON Earth System Model Version 1.0. Journal of Advances in Modeling Earth Systems. 14. 10.1029/2021MS002813.



Courtesy of J. F. Engels, C. Frauen (DKRZ), presented at ICAS workshop 2024

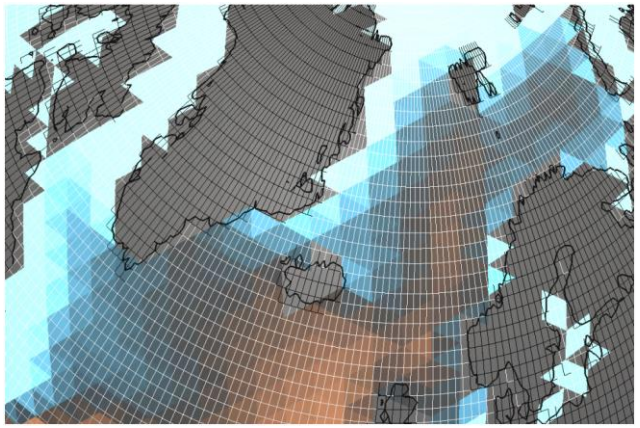
- Allows for concurrency
- Mapping on hybrid nodes makes dedicated CPU nodes redundant

Other activities



- TerraDT introduces a modular approach with standard interfaces
- Enabling easy integration of new components and enhancing scalability, interoperability, and interactivity of the DestinE infrastructure
- Of course, different models or applications need different interfaces.

Different types of interfaces for different needs



I. Classical coupling

- External models can use different grids
- Library takes care of interpolation
- Independent of core climate model because coupler is standalone library

II. Direct hook into core climate model

- External components register callback functions at predefined entry points
- Fields are defined on the native grid and data are accessed through the library
- Tight integration (aka direct access to data)

Different types of interfaces for different needs

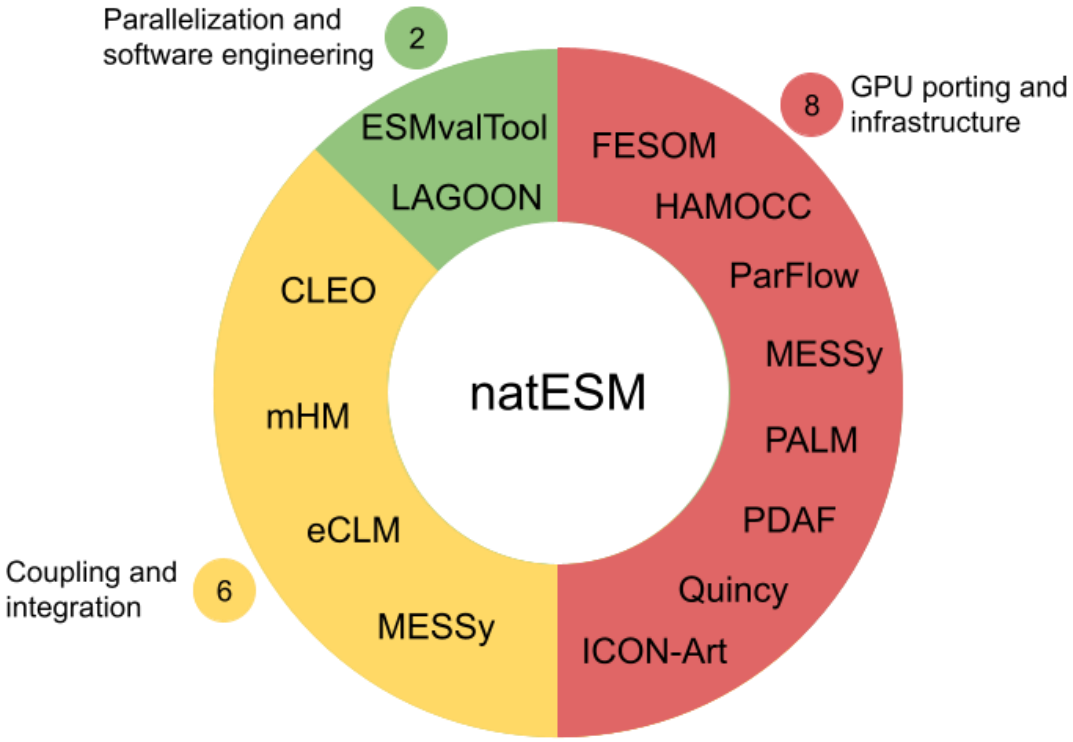
III. Using “stream” vector

- External models read the whole state information of a core climate model while it is running
- No feedback, just using the state for downstream (but realtime) apps

IV. Using curated data

- Community wide agreed data is provided via catalogues
- Usually for inter comparison
- No feedback and often slow access or reduced data

How natESM has helped the community so far



- GPU porting (aka preparing for Exascale) was driving motivation in the beginning
- Increasing number of requests for connection of models
- natESM adopted strategy to define infrastructure components which are supported

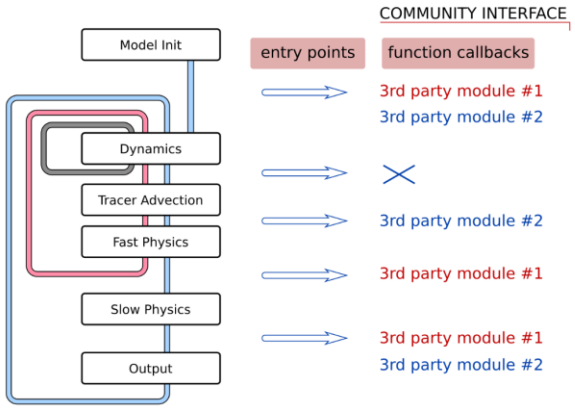
How natESM has helped the community so far

I. Classical coupling via YAC

mHM coupled to ICON

modular coupling of land surface at the example of eCLM

Coupling CLEO (superdroplet model) to ICON



II. Direct hook into ICON using ComIn

MESSy-ComIn integration into ICON

III. Using “stream” vector

Not yet but probably within natESM phase2 when considering ML

IV. Using curated data … no topic so far for natESM

Guiding questions for the following BOG

1. What kind of interfaces should be supported and which are missing?

   ⇒ We will start with an introduction of current approaches in YAC, ComIn, MESSy

2. Defining a “guideline to interfaces”

   ⇒ When to use a coupler?

   ⇒ When to use ComIn?

   ⇒ Are there cases that absolutely require direct implementation into core models?

3. Should natESM take care of data products needed for offline (aka input/output) coupling?

   ⇒ Will ML (or data analysis in general) change the scene? When?