Technical integration pathways and interface requirements in natESM

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What we'll cover

What tools and techniques are there for integration?

| ComIn | YAXT | | Direct Integration | FABM |

What has already been done using these tools and techniques?

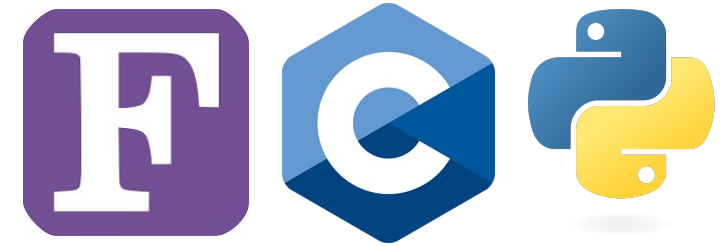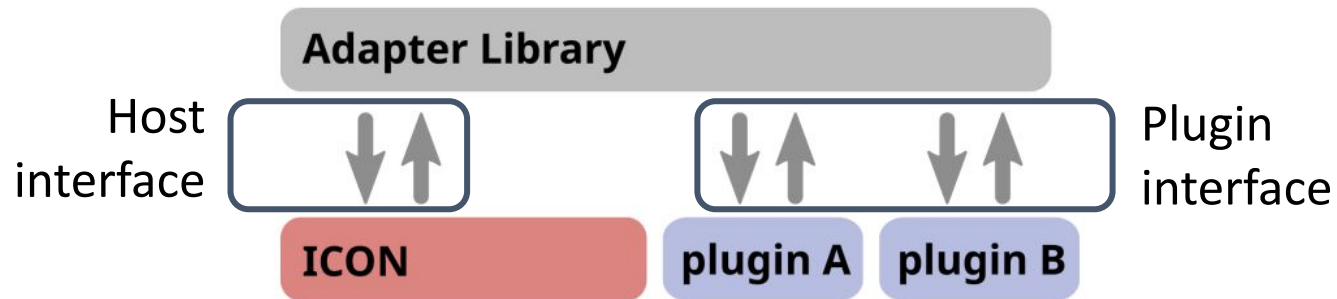| MESSy-ComIn -ICON | HAMOCC -ICON-O | ICON-YAC- mHM | CLEO | LAGOOn | REcoM-FABM |

What tools and techniques are there for integration?

ComIn

- The ICON Community Interface (ComIn) allows 3rd-party applications to connect with ICON

- Offers access to **ICON data and entry points** for user-defined callbacks


- Plugin subroutines are executed **BY ICON processes**

- ComIn currently only offers entry points for ICON-A

ComIn
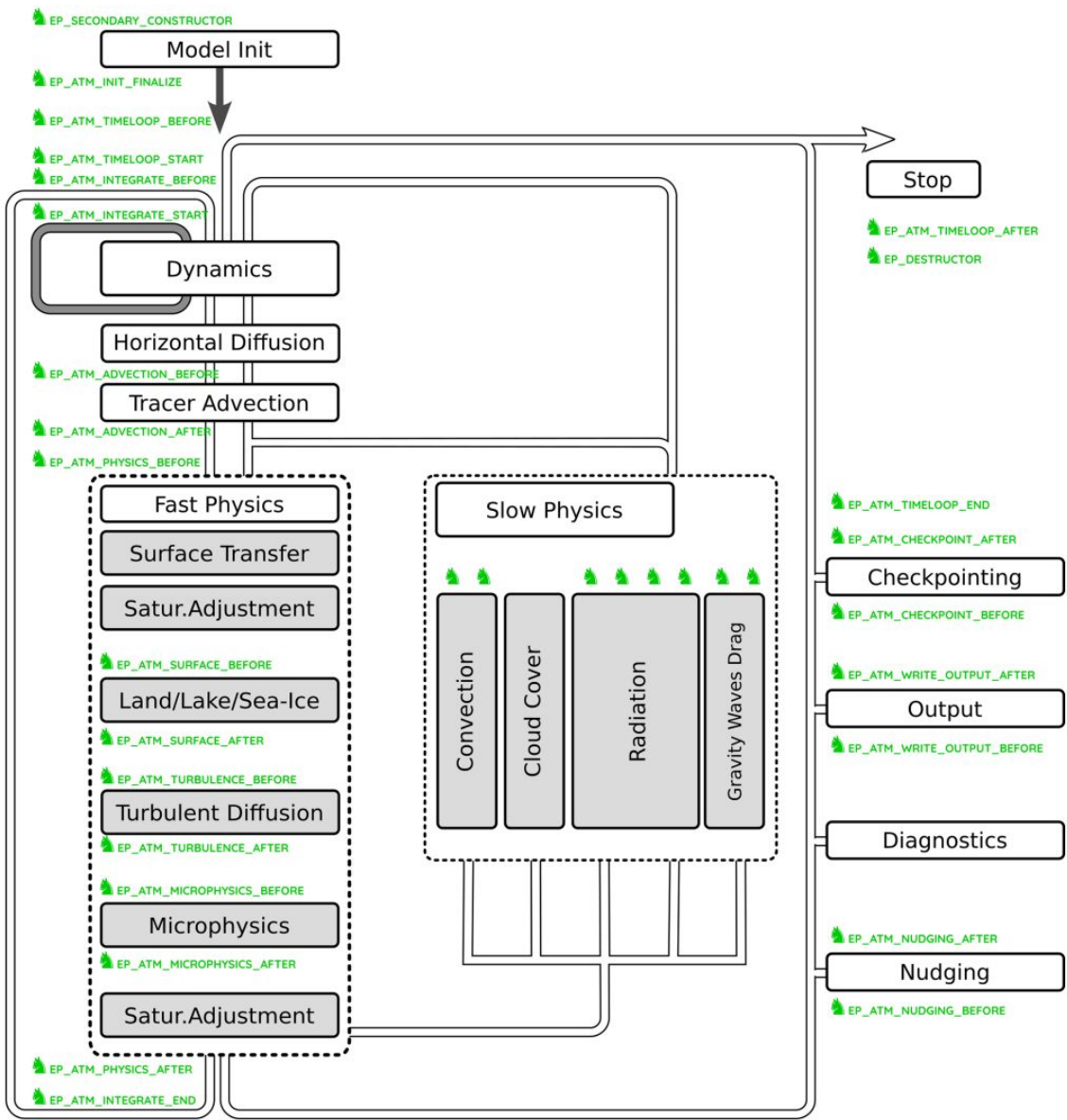
YAXT

- Yet Another eXchange Tool (YAXT) is a library created to facilitate data exchanges

- It is built on top of MPI and simplifies redistribution of data between two sets of processes

- Operates on a lower level than YAC, has no concept of grid or interpolation

- Useful to integrate two models that share the same grid

YAC

- Yet Another Coupler (YAC) is a coupling library that handles data exchanges between models

- Provides **interpolation** between different model grids

- Each model runs on its own independent set of processes

- **Multi-language** and **flexible** interface for different uses
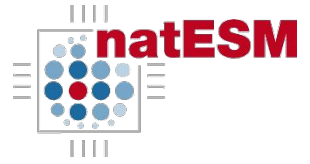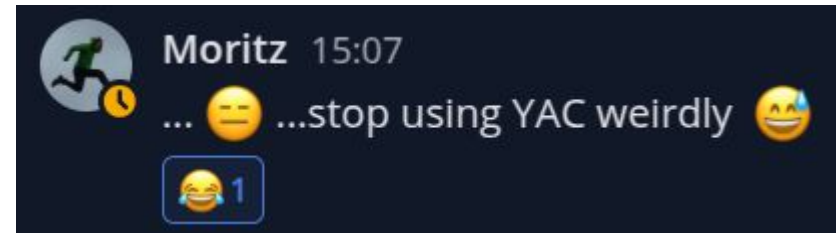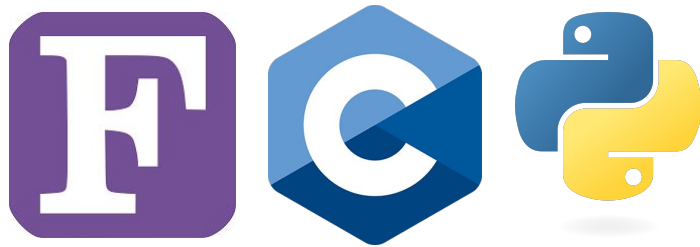

- Great documentation and support

FABM

- The Framework for Aquatic Biogeochemical Models (FABM) creates a bridge between hydrodynamics and biogeochemistry models
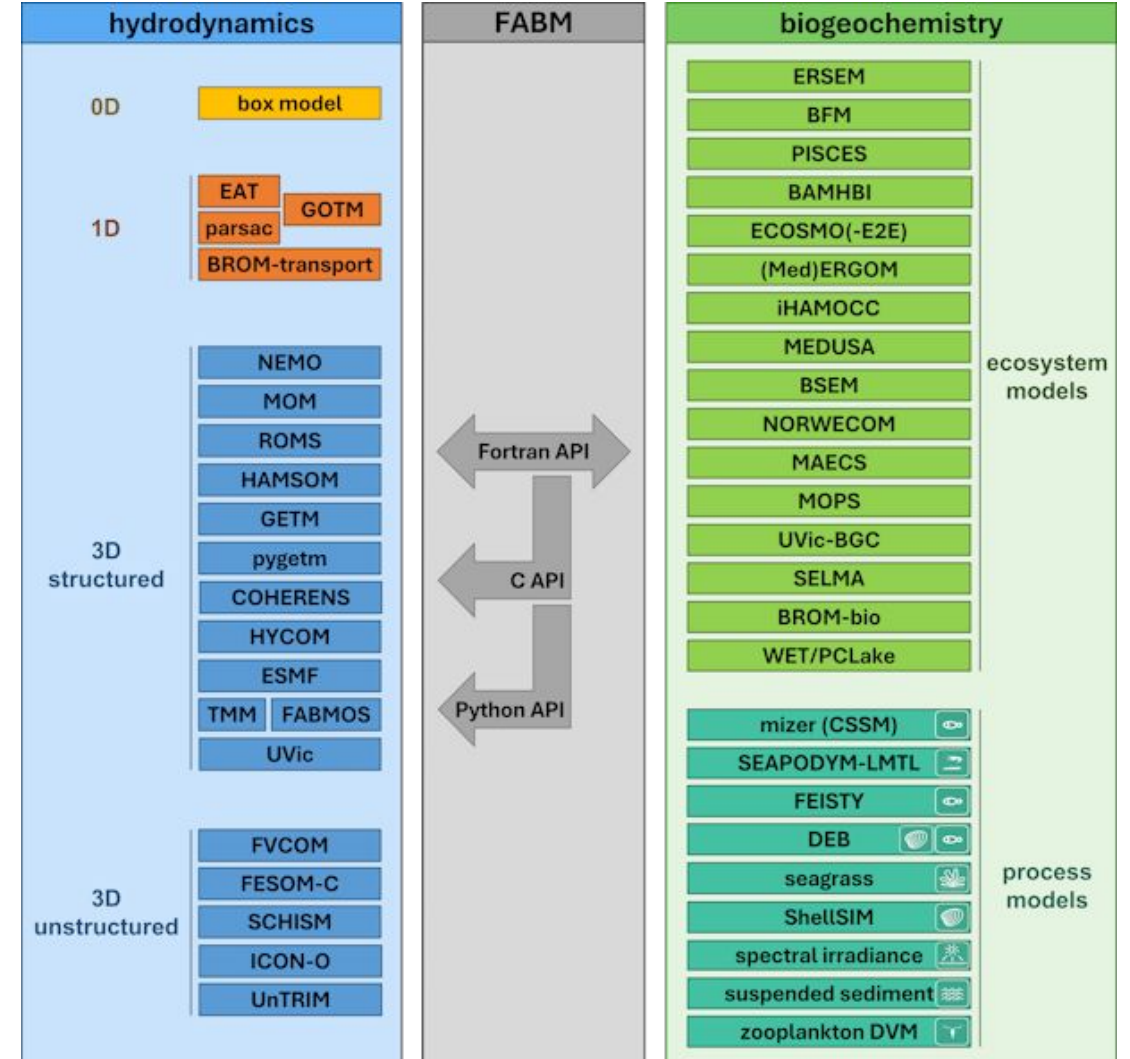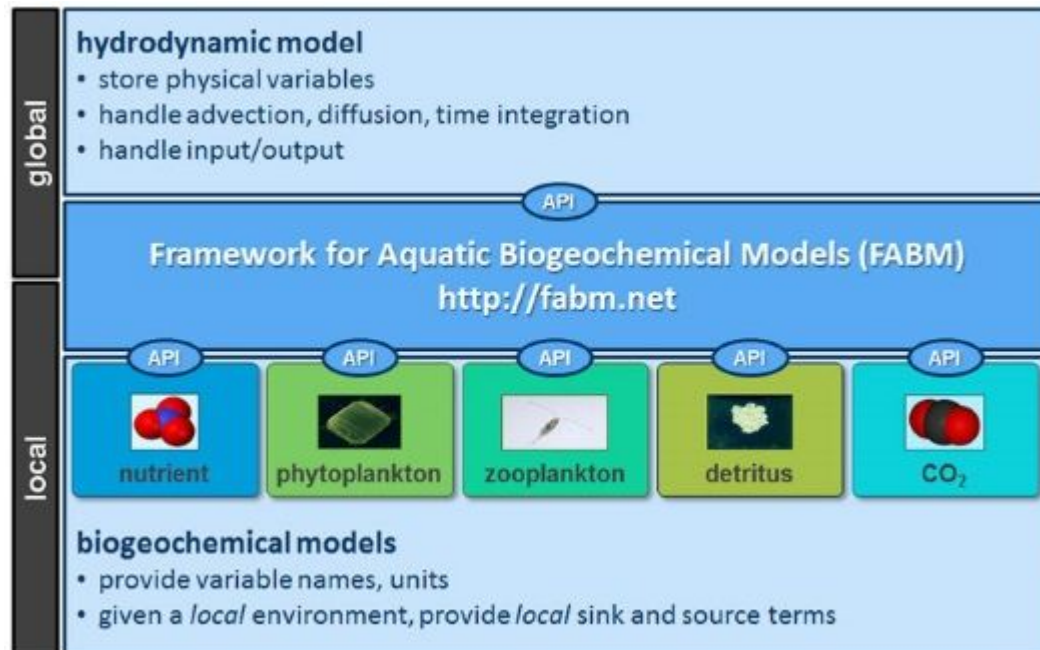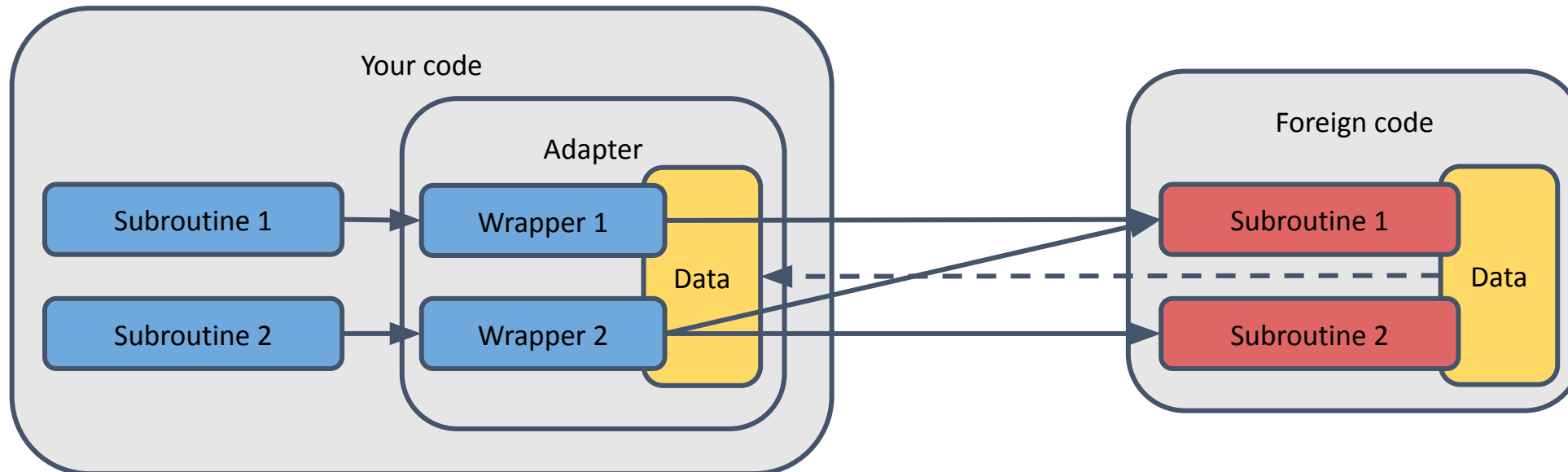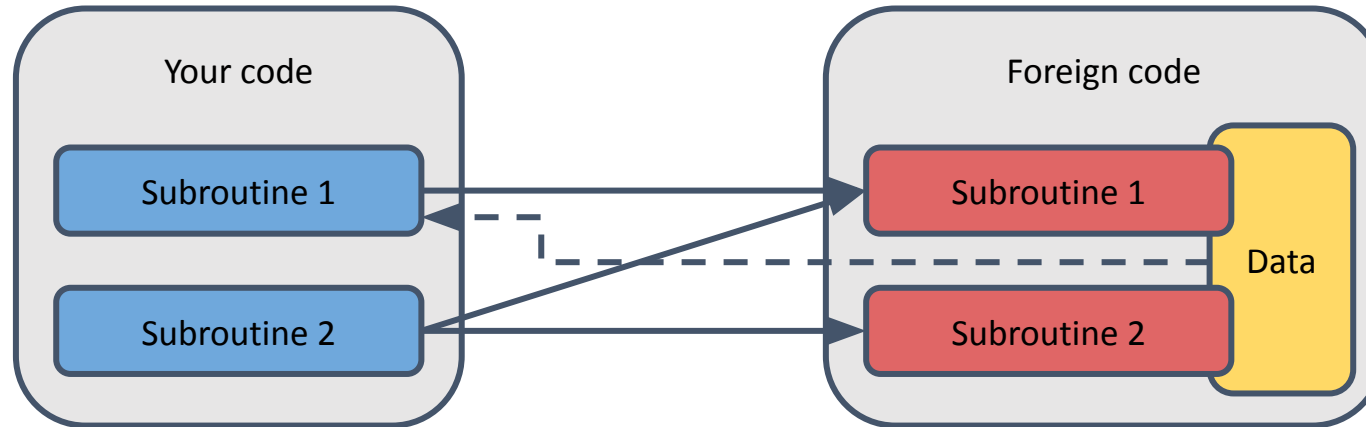
Direct integration

- Direct integration here means directly using subroutines and data structures from another model or exposing them on your own

- Makes the most sense if the model being integrated offers an interface for doing so

- If there is no well-defined interface, it comes with hurdles:
  - Keeping up with new versions and managing the code becomes more complicated
  - Requires adhoc build integrations with the foreign code
  - Since internal subroutines and data are accessed, changes can be frequent and more significant
  - Updating the version of the integrated model usually requires multiple manual changes
  - Specific changes may be required, which demand patches or other workarounds

Direct integration - When importing

- Shield your code from foreign changes with adapters

- This goes both for subroutines and data

- How necessary and effective it is depends on the characteristics of what is being integrated

- Think carefully about the actual reality of your code, avoid the "abstraction paradox"

Direct integration - When importing
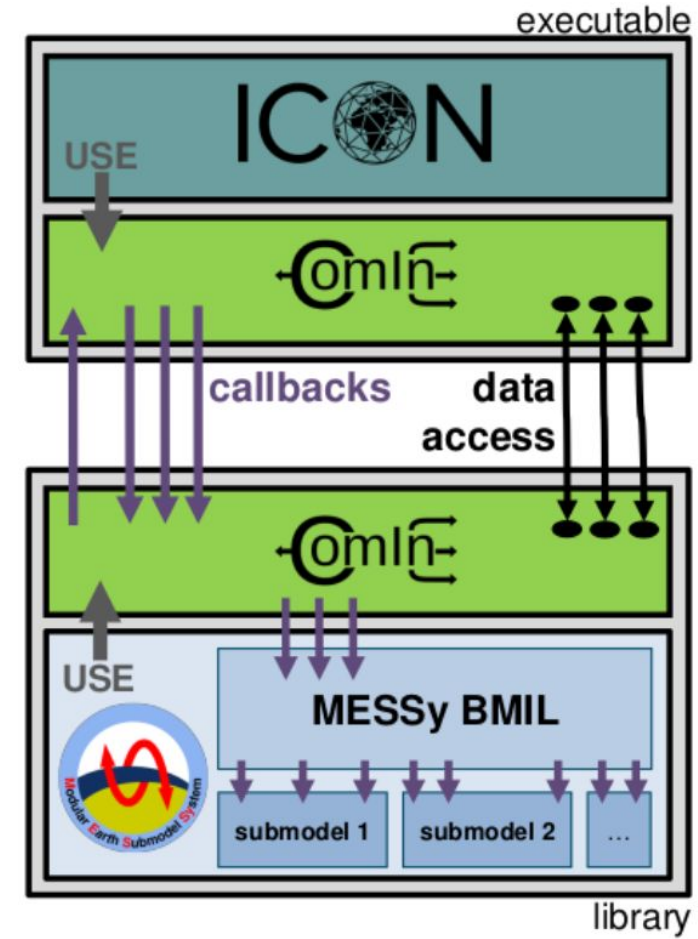
Your code

Subroutine 1

Subroutine 2

Foreign code

Subroutine 1

Data

Subroutine 2

Your code

Subroutine 1

Subroutine 2

Adapter

Wrapper 1

Data

Wrapper 2

Foreign code

Subroutine 1

Data

Subroutine 2

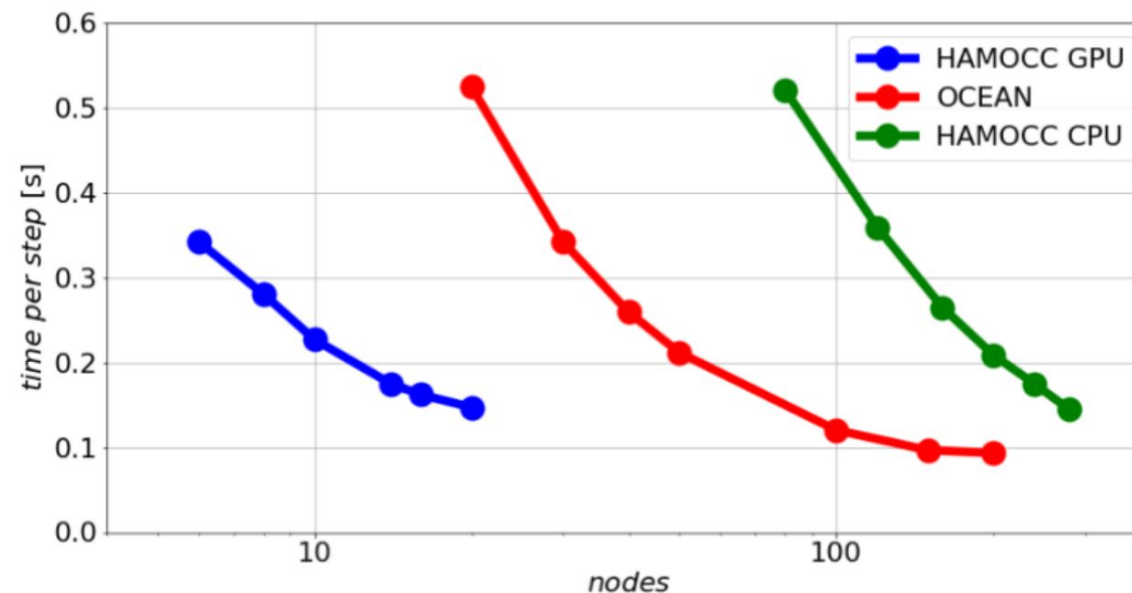**What has already been done using these tools and techniques?**

MESSy ComIn plugin for ICON
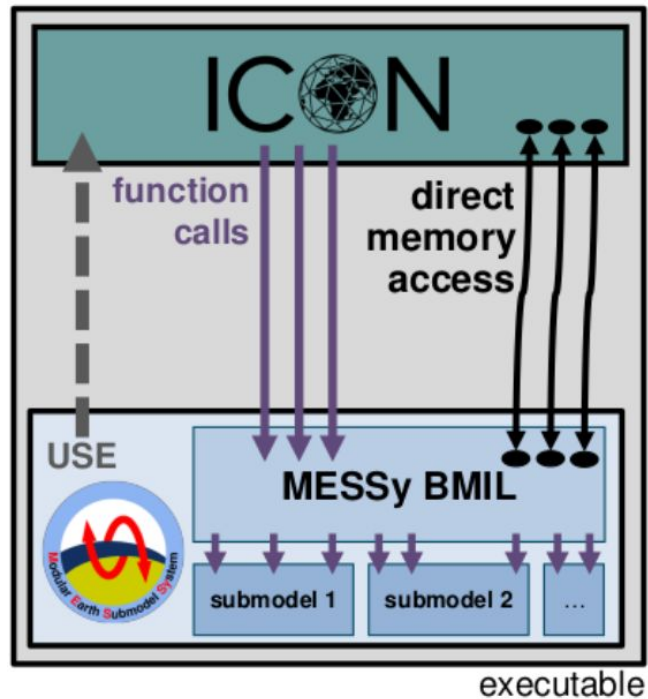
Concurrent HAMOCC on GPU with YAXT

- HAMOCC and ICON-O concurrent execution using YAXT

- Porting of subroutines for GPU execution

- Optimizations done for better performance

- Outlines possibilities of more efficient execution setups

Coupling of mHM and ICON-A

- mHM is a hydrology model also employed for impact modelling

- Implementation of the coupling interface into mHM

- Extension of the coupling interface in ICON to support hydrologic models

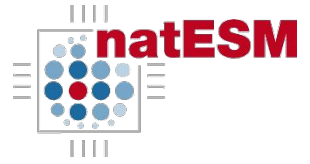- Successful proof of concept coupled run

CLEO coupling with ICON
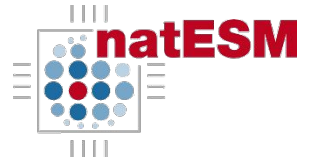
- CLEO is a C++ library for Super-Droplet Model (SDM) cloud microphysics

- Sprint for implementing two-way coupling with ICON

- Coupling infrastructure implemented in CLEO and extended in ICON

- One-way coupling technically implemented, two-way coupling ongoing

- Prompted discussions on the generalization of microphysics interfaces in ICON

# A Lagrangian toolkit for the natESM strategy (LAGOOn)

- **CLaMS** (Fortran) and **MPTRAC** (C) are two Lagrangian trajectory models part of natESM

- Consolidation and interoperability of the code from the two models

- Use of GPU-ready advection from MPTRAC into CLaMS

- First steps towards the creation of a toolkit for Lagrangian transport modelling

REcoM integration into FABM (upcoming)
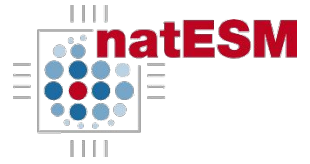
- REcoM is currently integrated into FESOM with direct inline calls

- The planned sprint aims at including REcoM into FABM to generalize its utilization

- Updated calls to REcoM may be added back into FESOM to account for the new setup

- The sprint is planned to start still this year

Summary
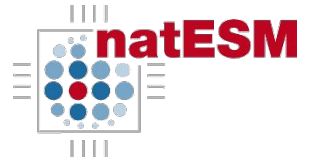
- There are many tools and techniques for integration between ESM models

- The best approach will depend on the characteristics of the model and restrictions

- Often work on technical integration brings **benefits beyond the initial goals**

- Many successful integrations have been supported by natESM

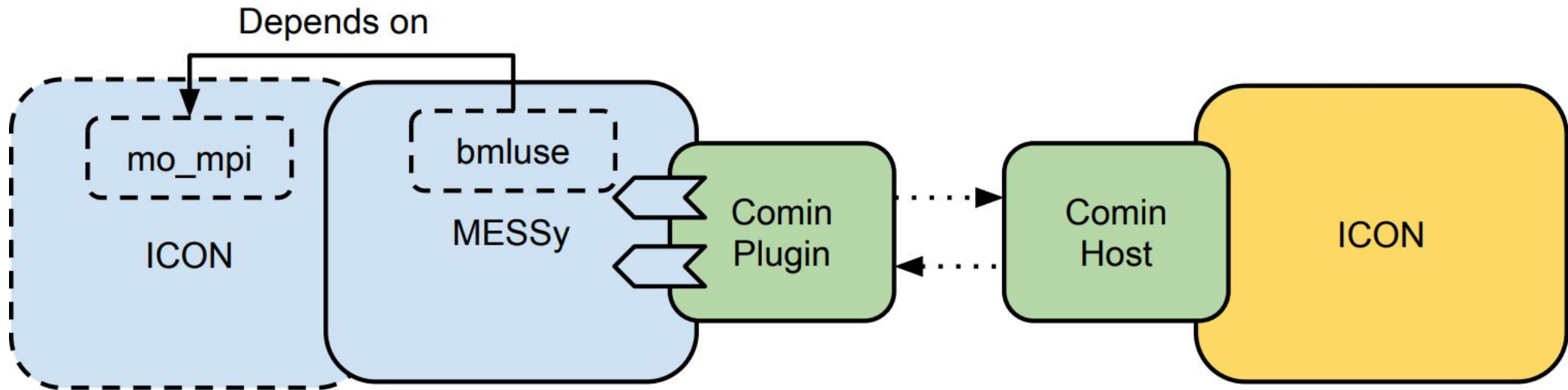- Be it ComIn, YAC or others, we are happy to discuss and support your integration ideas
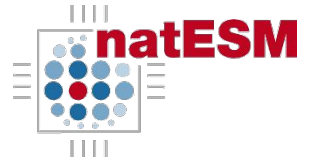
Thank you for your attention!

More info at nat-esm.de

Contact me via loch@dkrz.de

MESSy ComIn plugin for ICON

Intermediate ComIn ICON/MESSy integration

MESSy ComIn plugin for ICON

- A ComIn plugin has been created for the full execution of MESSy

- Technically all hardcoded ICON dependencies have been removed from MESSy

- MESSy-ComIn-ICON setup has been created and needs scientific validation

- First example and reference for the creation of complex ComIn plugins