



Enabling impact. Securing sustainability.

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Germany has excellent models, but fragmented structures

- Increasing HPC complexity (exascale transition) poses huge technical challenges for model developers
- Scientific and technical efficiency require a much higher degree of coordination in ESM development and use
- New developments often are not integrated back into system, preventing portability
- Software-engineering capacity is chronically underfunded and undervalued

Result: Scientific excellence, but limited scalability, portability and adoptability

Before

- Individual optimization
- Short-term, project-based solutions
- Fragmented technical responsibility

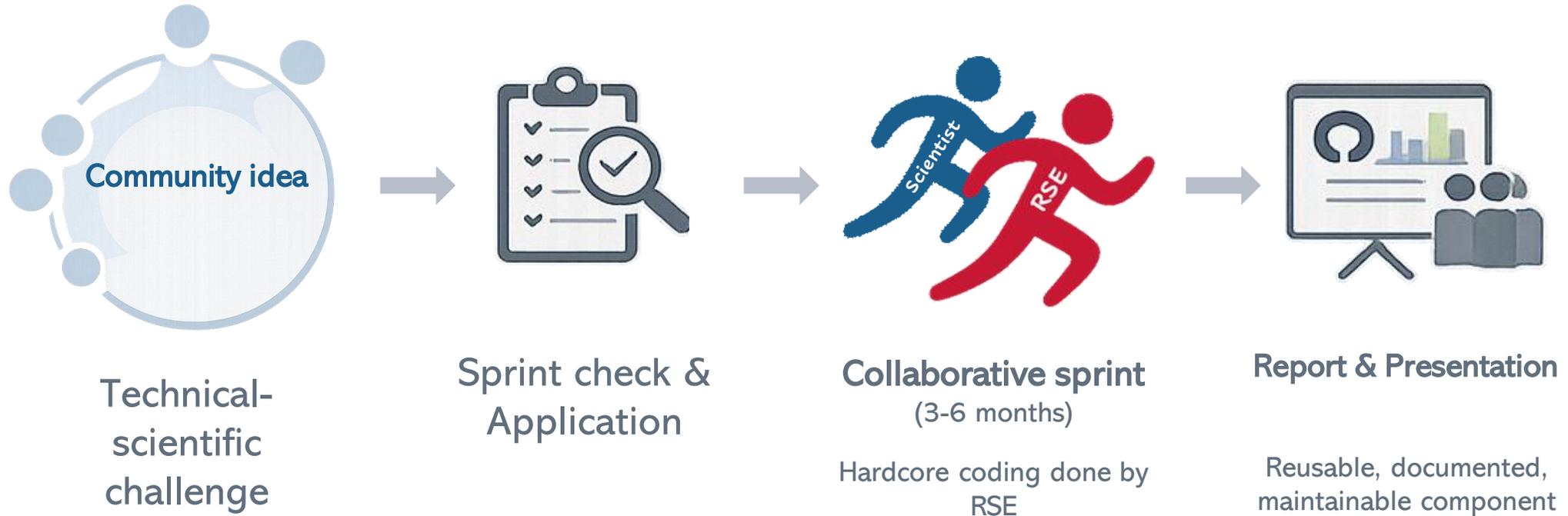


natESM

- Coordinated RSE and sprint-based support system
- Defined technical criteria for integration into natESM and review processes
- Bottom-up community-driven effort

Transform distributed excellence into a coherent national Earth System Modelling system

The sprint model in practice



Professional software engineering allows scientists to focus on science and results in documented, maintained and reusable community-built ESM system

Phase I successfully completed (August 2025)

- ✓ All milestones delivered
- ✓ Sprint framework established
- ✓ Transparent system architecture defined

 20 sprint checks  15 sprints  6 system components

 22 institutions  ~500 community members



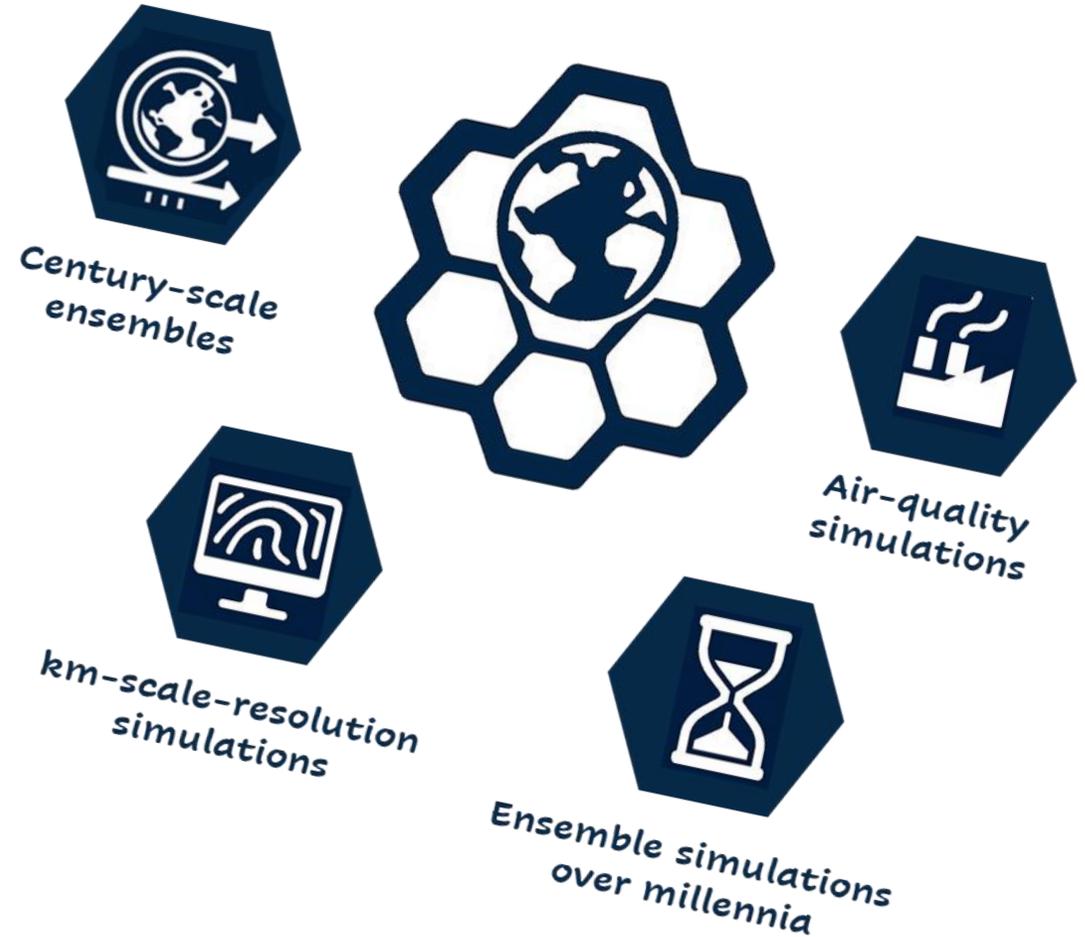
Phase II successfully started (September 2025)

- Focus on integration of further components in particular impact-related ones
- Provision of well-defined configurations
- Expansion of machine-learning capabilities

 5 sprint checks  4 sprints

Scaling the service model

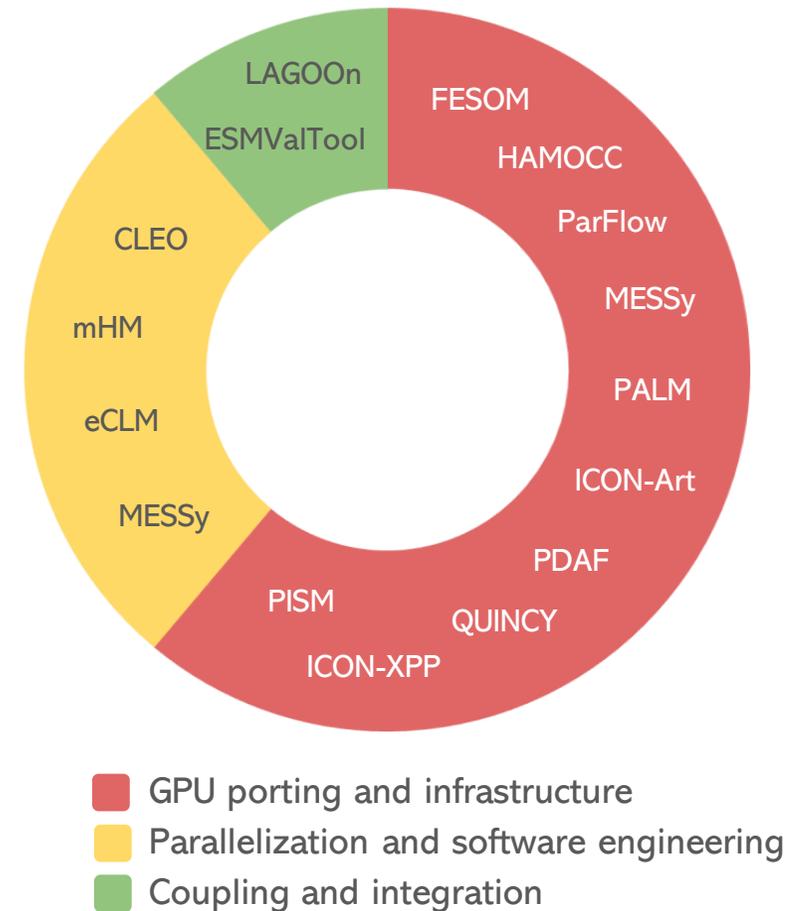
- Expansion to AI and machine learning
- 4 defined model configurations
- 6 RSE positions
- Systematic adaptation to future HPC systems



- 18 sprints completed (6 since last workshop)
- Continued focus on GPU porting, coupling, infrastructure integration
- Cross-institutional collaboration strengthened

Sprints remain our central instrument for sustainable integration into natESM

Goals of completed sprints

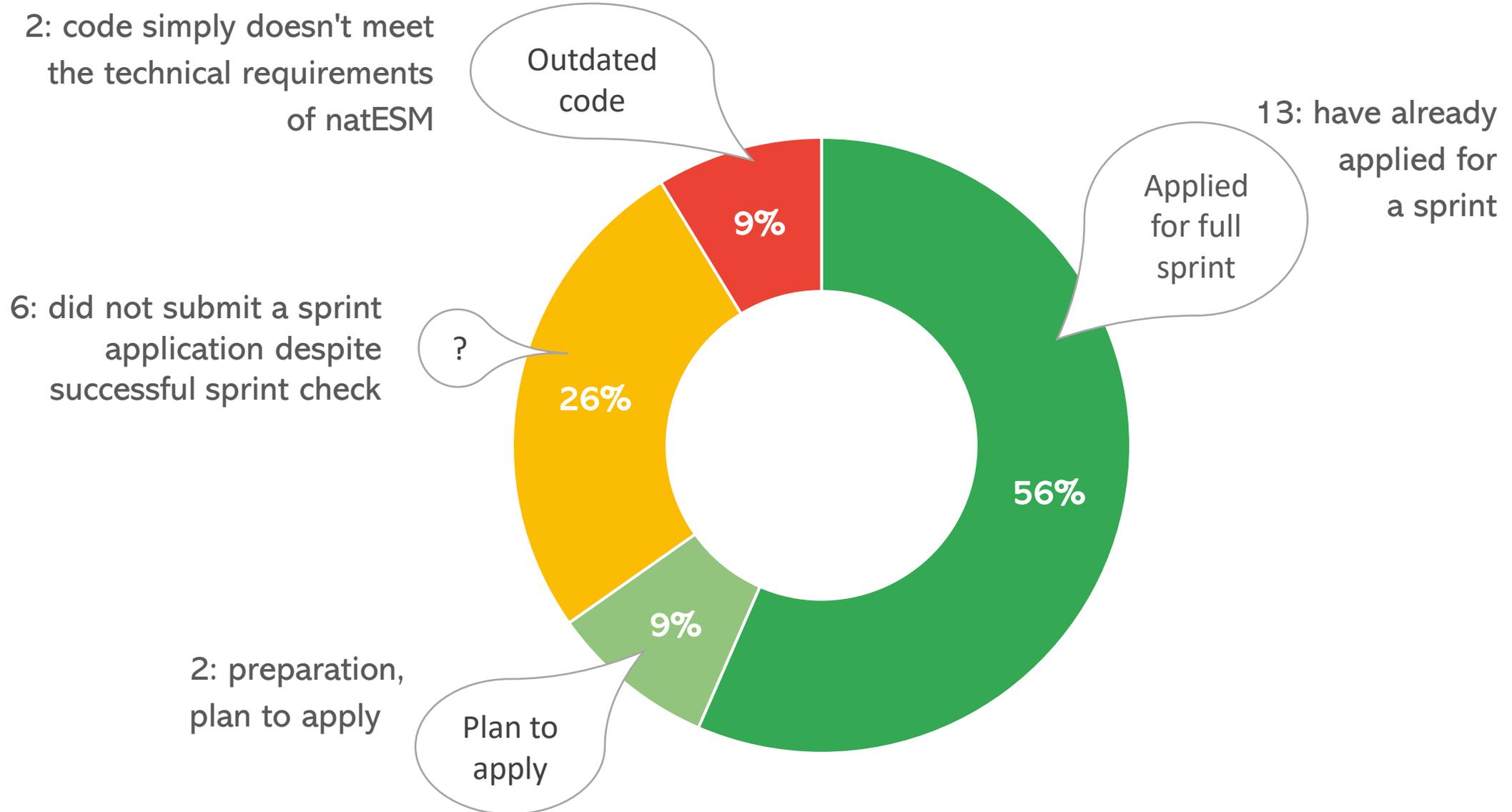


Sprint checks are now fully established

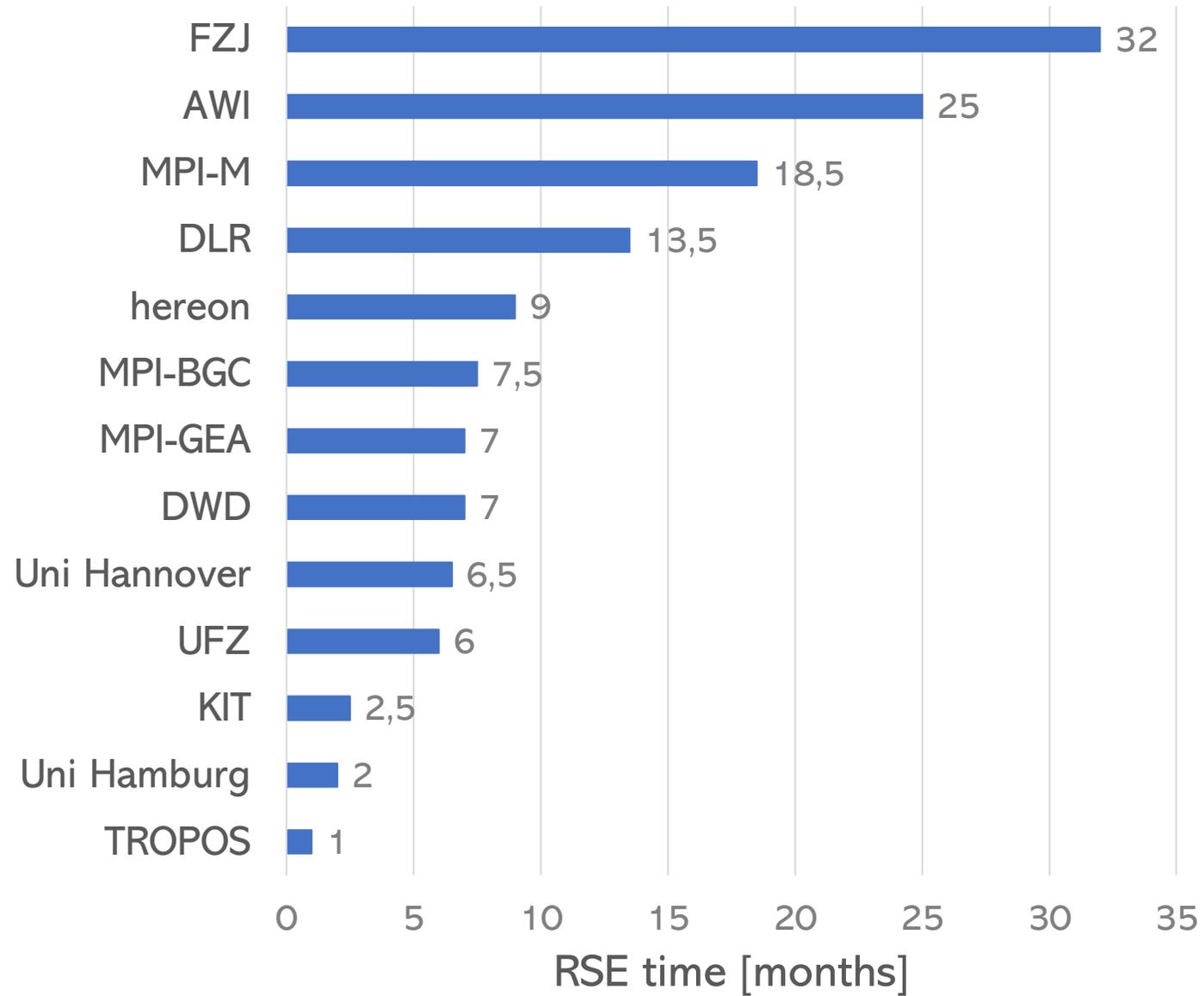
- Standardized evaluation process, applied to wide variety of scientific codes
- Significant RSE effort invested at an early stage
- Careful assessment of sustainability, maintainability, and integration potential
- In most cases, leads to full sprint application
- In some cases, prevents unsustainable investments

Sprint checks are a low-threshold entry point into the sprint process

RSEs have completed 23 sprint checks up to now



RSE time provided to the community so far in months



What we learned from sprints



- Weekly RSE-scientist meetings now mandatory
- Status meeting now required after 1/3 runtime
- Additional status meeting now held towards the end of sprint
- One-year follow-up assessment now performed
- Collaborative sprint report now mandatory

natESM sprint framework is unique and might be a blueprint for other fields

RSE capacity expanding to six

- From March 1: Two RSEs back at JSC
- From April 1: AI-focused RSE at DKRZ
- From April 1 (planned): Additional RSE position
- Full team capacity expected from April

Sustained RSE capacity is the prerequisite for integration, impact, and long-term sustainability

From workshop to working group to implementation pathway

- OBGC Focus Workshop brought together 30 experts across institutions
- **Formation of cross-institutional working group led by Judith Hauck (AWI) and Carsten Lemmen (Hereon)**
- Goal: develop a modular “OBGC box” for integration as natESM extended core component → prerequisite for centennial and paleo configurations
- Evaluation of existing modules for technical and scientific suitability
- **Preparation of coordinated sprint proposals**
- Community-driven, sustainability-oriented integration strategy

This is exactly what focus workshops are meant to achieve: from discussion to coordinated action

System architecture: where we are now

Core

Fundamental models for basic Earth system modeling.
Currently: **ICON-A, ICON-O, FESOM**

Extended Core

Comprehensive models for Earth-system interactions.
Currently: **ICON-Art**



Infrastructure

Tools and interfaces that connect core and extended core components, ensuring seamless functionality.
Currently: **YAC, ComIn**

Impact

Specialized models enabling one-way interactions within the system. Currently: **None so far**

Optional

Community-suggested models for future integration, visible for exploration but not part of the main system.
Currently: **47**



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Today's breakout group

Impact

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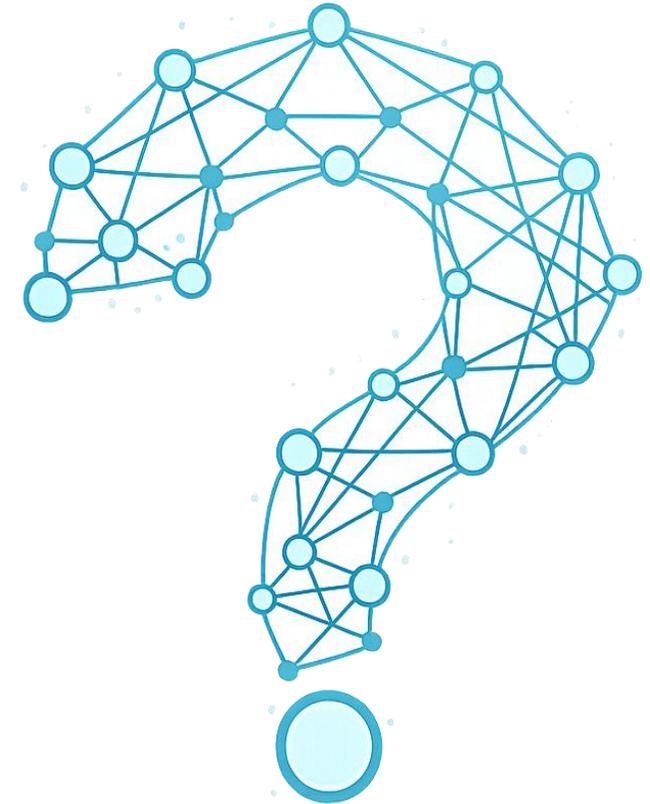
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Impact & AI: entering a new phase

- Dedicated AI-RSE starting April 1 at DKRZ
- Expertise in modern AI frameworks (e.g., PyTorch)
- Embedded within existing AI expertise at DKRZ
- We are beginning to define how AI complements natESM
- Possible future formats: AI-focused sprints

Tomorrow's session marks the start of this exploration





Teaching & outreach

- natESM Master course (University of Cologne)
- Community members presented their components
- Students tested components hands-on
- Valuable feedback on where we need stronger teaching support
- Blueprint for future university collaborations
- Thanks to all who contributed, especially Vera Schemann



Technical trainings

- Regular natESM technical trainings
- 2025 example: ICON course (DWD-led)
- This year's technical training developed by natESM RSE team (planned October)
- GitLab as shared development infrastructure
- Cross-institutional knowledge exchange



Summer School

- 13–19 September 2026, Kiel
- Program under development
- Application process for ECS opens mid-March
- Cross-institutional collaboration

Thanks to all contributors – across institutions and formats

Opportunities for engagement

- Community members: anyone with interest in natESM
- Appreciate user-friendly nature of future natESM capability



Initiate
working groups



Shaping
workshops



Showcase
models



Apply for
sprints



Our goal is to move from project funding to institutional anchoring

- July 31, 2027: milestone report due
- Goal: expand our strategy with a concept for long-term RSE hub
- Requires institutional commitment (Letters of Intent)

The strongest argument for a sustainable anchoring of natESM is active community usage, visible demand, and evidence of the added value delivered to community and institutions through natESM

If we can demonstrate that natESM is needed, it might be sustained