

BreakOutGroups

Theme I: Scoping the strategy

Summary of discussion, Theme I: Yellow Group

I) Components of Earth System:

- Wide range of spatial and temporal scales
 - cm – to global
 - paleo – present – short range - climate scenarios
- Large spectrum of available model components
 - Physical representation & modelling approaches
 - regional and global approaches
- Scientific question/application determines
 - Selection of needed scales and components / model
- E.g. ,deep' earth processes
 - needed for paleo processes but not present day

II) Components of Earth system modelling:

- All geophysical components
- Anthropogenic influence – and consequences for humans & society

Disagreement:

- Is socio-economic modelling part of the earth system?
- Effects of use of / on available natural resources

Exploitation of data (in-situ & remote sensing)

- Model analysis & diagnostics & verification
- Data assimilation
- Inverse modelling
- Definition of boundary fields
(function of completeness of earth system model)

Opportunities & risks of a national strategy

Opportunities

- Enhanced scientific interaction and exchange
 - Stimulating development of new hypotheses and ideas
- Increased transparency and information exchange (expertise, ongoing studies)
- Sharing of numerical methods and implementation
- Shared software and evaluation tools
 - benefit esp. to small groups/universities
 - enables open development
- Encourages platform independent software / programming
- Targeted and increased weight of requirements for hardware developers
- Increased visibility of Germany and participating institutes
- Increased international cooperation and competitiveness
- Application to teaching & training

Increased efficiency

Crucial to get it right

- Governance of strategy and its implementation
 - Communication and cooperation structure

- Finances
 - Channeling of funding, i.e. efficient spending
 - Risk: exclusion of unconventional/new ideas

- Concepts for transfer of results into society / decisions

- Design of overall structure / code setup
 - Usability
 - User support
 - Modularity (user guidance critical)

Risks

- Reduced diversity of ideas / developments
- Insufficient clarity for / knowledge of users
- Limits flexibility in international collaboration
- „Lock in“ (closed community)

Summary of discussion, Theme I / part 2: Yellow Group

Question: (1) Long-term vision

- **Dual strategy for overall ESM modelling addressing:**
 - Natural climate
 - Overarching questions (including anthropogenic interaction)

- **Understanding of the earth system**
 - Both the natural and human systems and their interactions
 - Prediction of earth system
 - Research supporting informed decisions on question relevant for society

- **Open discussion of agendas & interests of contributing groups for defining the strategy**
 - Independent external evaluation, moderation and guidance

- **Key guiding principles**
 - Transparency, openness, flexibility and inclusiveness
 - of decision, governance and collaboration
 - Shared and coordinated activities in development across members of community (technical, structural, evaluation, applications)
 - ‚Open development‘
 - **Development of common tools (diagnostic, verification)**

- **Evolving strategy under changing conditions and progress of work**

Question: (2) Short-term (5 yr) goals

- Definition and harmonization of interfaces
 - Possibility to test different model components/modelling approaches in overall system
 - Necessary modularization needs careful design

- Modelling of natural climate
 - Further development and inclusion of all needed components (e.g. verified ice model for long term simulations)
 - Guidance on requirements to be met by simulations/model components
 - E.g. closure of energy and mass budgets/cycles
 - E.g. evaluation & validation against available observations
 - Guidance on needed additional observations
 - Modelling informed observations

Additional aspects to be considered (influencing short term and long term work)

- Technical/hardware: further development of new system structure and necessary adaptations of code and systems
- Software development: support in software engineering, HPC, HPDA, and numerics transitions, mapping of the future technologies on earth system development
 - ‚Sustainability plans‘

Issues needing clarification / contentious issues:

- Components to be included additionally to modelling of natural climate
- Framework for choosing appropriate models / modelling approaches for individual components (e.g. atmosphere)
- Compartments & processes to be included (depending on different perspectives)
- Different criteria to consider for choice/inclusion of model components:
 - scientific/algorithmic
 - practical aspects: usability for wider group
- Needed and desired governance structure

Theme 1: „Scoping the strategy“, Green BG

Opportunities and Risks

Opportunities

- Collaborative platform (scientific and/or infrastructure) can provide synergies
- Address challenge of information technology
- Reduce duplication
- Achieve more coherence and transparency
- Chance for better cooperation among ESM scientists and with stakeholders
- Chance for better incorporation of observations
- Address science questions that cannot be addressed today
- Chance for better models (conservation of energy, water, mass, momentum; seamless simulations)

Risks

- Encompass everything and achieve little (depends on definition of ES)
- not enough commitment and support (example: COSMOS)
- Enforcing too much coherence may limit innovation
- Goals of this group are diverse

Theme 1: „Scoping the strategy“, Green BG

Short-term goals & Long-term vision

Needs further discussion

- Scope of this initiative - Do we limit this initiative to the physics/biogeochemistry of the Earth system or go beyond (e.g. impacts)?
- Do we limit us to climate or include Earth system functioning unrelated to climate/weather?
- What level should a common platform have (sharing scientific expertise or technical framework?)
- Identify unifying questions

Short-term goals

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Long-term vision

...

Theme 1: „Scoping the strategy“, Green BG

Expectations

- We had COSMOS 10 years ago (on a smaller scale) which hasn't worked
- Important to identify who is doing what with which resources
- define a platform/framework of working together (defining common research interests, sharing of tools and expertise)
- What we are discussing here should go beyond climate and weather (e.g. coastal system dynamics)?
- Improve scientific understanding through improvement and extension of modelling tools
- We should go beyond ESMs e.g. towards agent-based simulations (coupled in a way to ESMs)
- Depending on the question the ESM to be used may be very different
- It's worthwhile to work together if there is a common goal (e.g. improve predictive skill, quantify uncertainties?, improve process understanding)
- Achieve an integrative software environment keeping an eye on HPC requirements
- Find a way to develop and maintain complex infrastructure related to ESMs while remaining innovative
- Not feasible to come up with a single ESMs that satisfies all purposes and disciplines;
- identify where how we define ESM and where we cut (is humanity part of an ESM?)
- Tackle the question how we can make scientific use of HPC without the individual scientists having to deal with all technical aspects; support infrastructure is important
- Process (towards a national ESM strategy) should be bottom-up
- Approach should be inclusive
- Expectations need to be clearly identified; at the moment the term ESM is not sufficiently defined
- Risk that the approach becomes too broad and is not ambitious enough
- We need to define clear goals to get this initiative flying (stay with physical part; not go to impacts)
- Coordinated effort, speak with one voice to the rest of the world (e.g. within the IPCC process)
- Right now too many parallel efforts (e.g. chemistry, CMIP)
- Good strategy is to have a common scientific question/goal
- Are current models able to conserve energy, water and mass?
- Observations need to be included in an ESM strategy
- Need one overarching goals plus sub-goals for different disciplines
- Risk that the commitment may be too low to succeed

Short-term goals & Long-term vision

Short-term goals

- Brief overview on existing German ESM activities (there are already activities for elements of the system)
- Identify the ESM needs in view of the existing science goals and future challenges (not start from a blank page)
- Investigate different possibilities for an ESM strategy (joint infrastructure or joint core models)
- Identify challenges for ESM arising technology
- Identify challenges for improving integration of observations and models

Long-term vision

- National integrative framework on ESM that fosters progress in fields that are not yet (satisfactorily) covered in „classical“ ESMs
- Striving for a seamless ESM system (should cover time scales from weather to climate, spatial scales from regional to global and interactions between different compartments)
- There is no agreement on the degree of convergence towards an ESM system: one core system vs. fostering diversity; however the group sees a value in striving for more coordination
- System should be open to contributions from different groups
- Need to develop a complex infrastructure for long-term use
- Possible science goals: understanding of the ES, predictive capability of the ES, improving the skill of ESMs, closing cycles, coupling across compartments; community is broad; answer questions of societal relevance

Scoping the Strategy

Report of the Red Group

agreement:

- no restriction to climate modelling; complexity of model system depends on specific scientific goal

disagreement:

- starting from tools and infrastructure or from research questions?
- do we need a modular system?

1) Which opportunities and risks arise from a national strategy?

risks:

- loss of diversity & visibility
- increase of uncertainty due to increase of complexity
- increase of (technical) complexity
- issue: flexible vs. most sophisticated model system

Scoping the Strategy

Report of the Red Group

1) Which opportunities and risks arise from a national strategy?

opportunities:

- synergies in use of resources
- broadening of fields of expertise (disciplines, scales, methods, ...)
- more effective use of expert knowledge
- advancement of know-how transfer
 - coordinated data management
- large effort necessary for coordination, communication, and scientific exchange
- identification of necessary degree of scientific diversity
- coordination of adaptation to rapidly changing HPC architectures
but: a flexible system can probably not be a state-of-the-art system
or use HPC structures in an optimal way

Scoping the Strategy

Report of the Red Group

Agreement: ESMs comprise all compartments from the deep Earth to the top of the atmosphere

TBD: Earth System Modelling vs. Climate System Modelling

Areas with need for coordination → a common modelling strategy:

- Infrastructure and resources:

How to manage infrastructure efficiently?

software & hardware management; source code adaptation to hardware;
→ technical support to free more resources for science;

readability; model interfaces; human and computing resources; data management
interfaces to observational data (evaluation, DA);

Quality management: open source (source codes, output, tools, ...)

- Governance: new topics, merging/ adding modules

- Science: atmospheric chemistry; climate-chemistry interactions;
implementation of hydro-geological components;
post-processing; state-of-the-art data analyses

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Scoping the Strategy

Report of the Red Group

Areas with need for coordination → a common modelling strategy:

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- Education: promotion of young scientists
- Artificial intelligence / data science
- => How can these areas be efficiently coordinated? (-> afternoon sessions)

Scoping the Strategy

Report of the Red Group

2) What are potential short-term (5 years) goals and what is the long-term vision of the strategy?

- development of tools and common infrastructures
- development of a flexible/modular model system (not necessarily plug 'n play)
- identification of infrastructural needs:
where does the scientific infrastructure not work for us
- bridging spatial and temporal scales where dynamics of sub-systems interact

Scoping the Strategy

Report of the Blue Group

What is the benefit of a national strategy?

- Efficiency, new possibilities, synergy of resources
- Enhanced interaction, community building, developing joint goals
- Chance to step from climate modelling towards impacts and consequences
- Validated and robust system
- Education and outreach, attract young scientists to the field
- Opportunities, new technologies and techniques, exascale and data science

Scoping the Strategy

Report of the Blue Group

What is an earth system model?

- Consensus: Broad in scope, but uneven in implementation
- Consensus on included components (broad view):
 - Weather and climate
 - Impacts and consequences
 - Interaction with mankind
 - Ocean, sea ice, solid earth,
 - Include high-res option
 - Data assimilation and observation operators for validation
 - Global and regional modelling
 - Common interfaces
 - Common framework, HPC, software, data base,
 -
- Simple flexible system versus sophisticated complex system?
- Joint system or joint modelling framework?
- Include methods for model output or just modelling components

Scoping the Strategy

Report of the Blue Group

Short-term goals

- Align existing strategies
- Realignment of existing funding streams (BMBF, HGF, DFG etc.), BMBF can coordinate

Challenges and risks

- Balance of flexibility versus efficiency
- Losing variety, developing a big beast, lack of flexibility
- May concentrate funding on certain institutions and validated ideas while hindering completely new approaches
- Risk of pleasing everybody and having no effect. Broad versus focused...
- There should be validated and recommended options

Scoping the Strategy

Report of the Blue Group

Strategy that enables to answer the questions posted by society, science and decision makers

Long-term vision

- ESM system / framework, integrated, seamless, coherent, flexible, open, accessible, easy to use, sustainable structure, competitive, serving the community, competitive on international level, brings together community
- Open window for new groups and science
- Coherent modelling framework
- Avoiding duplication of efforts
- Coordinated efforts in ESM
- Federated system

Potential short-term (5 year) goals

- Develop few validated standard configurations (within flexible framework)
- ESM ready for exascale computing
- Nucleus for flexible ESM framework
- Formats for engaging with community, community building, keep momentum
- Teaching and outreach
- Establish public data accessibility, common data base

Scoping the Strategy

Report of the Blue Group

Next steps

- Decide on / install governance (task 1)
- Building infrastructures (task 2)
- Commitments for sustainability (task 3)
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- Install working groups for strategy and technical aspects?
(sharp terms of reference)
- WG: To define options and requirements
- WG: Define technical options, feasibility and realistic goals
- WG: Flexibility versus performance /efficiency
-
- Wiki/website to inform larger community?

Theme II: Towards a national strategy – How? Why?

Session II: Towards a National Strategy – “How? Who?”

Yellow Group

Short term (5 yrs) goals?

- establish an **internationally leading ESM system** (coupled across Earth system compartments), and develop a few validated configurations
- development of **innovative modular framework**
- develop innovative plan for full integration of processes from further sectors (e.g., socio-economic) (= towards long-term vision) **“climate and beyond”**
- contribute to a **strong European ESM research and service infrastructure**

What themes for task groups?

- **Steering – Coordination:**
 - **Implementation** (of the strategy, governance?)
 - **Strategy process** (framework, time-line)
 - Strategic Aspects of
 - Financial and technical **resources**
 - **Education** (all levels), communication, outreach
 - **Vision development** (participatory and continual)
 - **Advisory board**, international contacts (esp. European dimension), evaluation metrics (of the strategy)

Themes for task groups (continued)

- **Modeling framework**

- **Inventory**/ current status of modeling activities/goals (who?, what?, what for?) in Germany
- **Assessment and prioritisation** of models/components for further development
- **Task Groups**: development of thematic models/ components (e.g., clouds, land surface, ice-sheets, hydrology, hydrogeology, air quality, anthroposphere, atmosphere, ocean, ...)
- ESMs for **regional systems**

Themes for task groups (continued)

- Model/component **interfaces and coupling** (flexible, extendable)
- Concepts and development of components for exchange with **diverse observation networks / data-bases** (for initialisation, assimilation and evaluation)
- **User interfaces**; usability in education and training
- long-term **technical user support**
- Model/system **evaluation and benchmarking** (HPDA)
- **Modeling infrastructure**:
 - Open development: version control, documentation
 - HPC, software engineering and numerics,
 - hardware issues

Breakout group session II “Towards a National Strategy”:

- Possible pathways of how the initiative **will achieve its overarching goals and objectives**, formulated during the first BG session
- **Options for implementation** (including tentative schedule and partner contributions).

identify specific areas where there is consensus among the participants and areas where there is disagreement.

Suggesting proposal on future ideas/evolving goal/research/projects

Need for observations

Possible pathways

- **Stick to the suggestions from BG1**
- **Support the steering committee mandate** to assist along the pathway of implementing a national strategy → assure scientific diversity in ESM community
- Addressing diversity of point of views: **Forming Working Groups** on sub-topics/"streams" before next workshop → Identify different "streams"/"focus groups"/"interfaces between modules/observations"
- Agreement on convergence and coordination → needs further discussion (in working groups?)! Sustaining diversity but bring together expertise and competence (framework)

Options for implementation

- Account for technical challenges that need to be addressed
- Participate in national AND international platforms, developer groups (e.g., NEMO platform)
- Identify missing components and interfaces in ESM on a national level
- Share motivation for running the chosen ESM (open access, maintenance, teaching, applicability, community & support, ...); National strategy as a “scientific attractor” → **identify motivation** for participating
- Networking with international strategies; participate in international model development strategies/networks → **identify connections** (key national vs. key international model components)
- Further topics for working groups to be defined (task for 2nd session)
- Phrase scientific goals that clearly would benefit from a national strategy

Working Groups

Working and contributing towards identification of scientific goals:

(1) Earth System Models – part a

- **Inventory:** Which models and modules are available? Scalability? Strength / Weakness?
- **Diversity:** Which level of diversity is desirable? Diversity in available models not equally distributed across all component of the ES. Affordable level of diversity (cost of tuning; interaction between modules)
- **Missing/limiting parts:** Opportunity to develop novel modules

(2) Earth System Models – part b

- **Interfaces:** Defining standards
- **Documentation:** defining (and following) standards
- **Portability:** Running on various computing architectures
- Technical **scalability**
- **Data storage and access**

Working Groups

(3) Strategies for Validation & Verification

- Identification of suitable observations and reconstructions; making most out of it
- Data assimilation
- Model performance / model verification for all configurations and coupled systems
- Using process understanding for the strategies
- Quality Management, development of verification strategies

(4) Education & Training

- Generation of new generation of code developers
- Sustaining knowledge
- Going beyond "applying models"

(5) Strategies for improving process understanding

- Observing system design

None of the working groups will start from scratch and are encouraged to consider previous work.

How to achieve the goals?

- Further discussion needed to define problem domains and associated model systems
 - Suggested working definition from this group:
 - processes and interactions effecting exchanges of energy, water, and substances within and between atmosphere, ocean, cryosphere, biosphere, and solid earth on timescales from minutes* to millennia
- Long term stewardship of the strategy and associated model(s) (acceptance/sustainability)
 - Governance
- Measures for success are needed

* Actually seconds

Options for implementation

- Form working groups
 - (topics from blue)
 - And governance
- Study how existing model consortia do their governance
 - COSMO, CESM, CLM, EMAC, NEMO, ...
- Some desirable characteristics of governance:
 - External review (advisory board)
 - Balance between centralised/decentralised
 - Alignment of interests and motivations
 - Clear roles and responsibilities
 - Steering body (or multiple steering bodies)
 - Ensures quality control
 - Decides what code goes into the standard model
 - Defines standard configurations
 - Freedom to pursue own development without disturbing other groups (branch/fork)
- Dedicated scientific programmers
 - Service-oriented
 - Essential part of the infrastructure

Working groups / timeline

- Preliminary vision (guiding principles for all working groups) by **December 2018**
 - From steering committee
- Clear terms of reference and list of potential participants for each group
 - Steering committee (**December 2018**)
 - With feedback from institutions (**January 2019**)
- 3-4 working groups constituted by **January 2019**
 - 6-10 people each
 - Mix of expertise/experience/seniority
 - Inclusive/representative of all partners
- Recommendations from WGs by **June 2019**
- Steering committee synthesis of recommendations, “final” vision
- 2nd workshop **September 2019**

Working group topics

- Scope
 - Definition of requirements
 - Based on input collected from participating institutions
 - Key experiments including scientific objectives
 - Screening/identification/recommendation of components and configurations
 - Potential timeline for future developments
- Governance
 - (Previous input from the red group (slide 2))
- Technical challenges / best practices
 - Infrastructural requirements
 - Modularity, efficiency, and upgradability

Working groups (**who?**)

- WG1: Components and configurations
- WG2: Governance/structure, involvement and commitment
- WG3: ~~Define technical options, feasibility and realistic goals: Technical implementation~~
Model independent infrastructure

WG2: Governance/structure, involvement and commitment

- Terms of reference:
 - Study how existing model consortia do their governance (COSMO, CESM, CLM, EMAC, NEMO,...)
 - What does the structure need to be responsible for?
 - **How to come to decisions?**
 - How should it be structured (steering committee, SAB, funding agencies,...?)
 - Who needs to be involved? Level? For example: Key users, BMBF, science organisations (MPG, HGF, Leibniz, DFG), federal states, BMVI, BMWi, BMU, Universities,
 - How to reach commitments enabling sustainable structures?
- **Who?**
 - **Proposition from bottom, from those who will be governed, they should suggest a structure that would serve them best**
 - **Maybe as a second step: Include high-level stakeholders, people who decide on the money may determine the government structure**

WG3: Model independent infrastructure

- **Terms of reference:**
 - Define technical options, feasibility and realistic goals
 - Modularity, flexibility (vs. Performance?), easy-to-use interfaces
 - support of future model component development/incorporation
 - E.g.: DSL, IO, parallelization, pre-postprocessing, workflow, online diagnostics, visualization
- **Who: „hands-on-people“ who do the work, computer scientist**

Further discussion in the group

- Glossary
- **Don't forget the science → it should drive, investment now with delayed return**
- **Timeline is missing**
- **Discussion/interaction between the four groups would have required more time**
- **We are going home with little we have decided**