

Appendix 1

Identified Topics & Knowledge Gaps

At the 2024 MERGE Annual Meeting our members discussed and identified the following knowledge gaps within the three topics of the meeting.

Machine learning (ML)

- Where machine learning can be (further) developed:
 - Now limited capacity to extrapolate
 - Active exploration of areas where we lack data
 - Feedback between data acquisition and modelling
 - Causality, there are recent ML methods that can test for causality.
 - Sensitivity analysis constraints
 - Projects or testbeds who are already using different pathways/technologies of AI in their research or are planning to apply them, from Random Forest to Deep Learning.

Linking small and large models

How to deal with computational time (regional & global models), and/or dealing with time scales relevant to different processes in coupled models

Humans and society in the climate system

- Social Climate Models (SCMs) could eventually replace IAMs, projects that try out coupling to society and with some kind of human boundary would be interesting to develop and test.
- Emission-driven ESMs will be more standard in CMIP7
- It is claimed that SCMs, by superseding the SSP framework, could eventually reduce the uncertainties in future climate projections. If so, it would be good if MERGE was well placed to contribute to the development and analysis of SCMs in future
- Analysis if the models gain credibility by adding more layers of complexity as well as discussions (workshop) around more freedom in the models make simulations more difficult to compare, as opposed to standard scenario-driven simulations.

Examples of how MERGE members could contribute to these topics:

- In a Social Climate Model (SCM), MERGE could contribute with detailed descriptions of climate extremes and how these influence people and ecosystems (e.g. crop yields), but also how wildfires and BVOC emissions influence air quality – all of which could influence the Cognition and Behavioural Response aspects detailed in Beckage et al.
- Funded SCM-related ideas are encouraged to include a high-level workshop or seminar with international speakers to explore the potential of SCMs and for MERGE contributions to them. Note that MERGE researchers already collaborate with Brian Beckage.
- Mathematicians could apply dynamical systems theory to analyse simpler SCMs
- The creation of an Short Project with the aim to initiate regular activities, discussions and work with linking models, ex webinars or seminarserie.
- Projects in which heuristic/empirical parameterizations, components or models are identified as candidates to be replaced with neural networks instead since these will be faster and can include some amount of physics, e.g. in LPJ-GUESS and aerosol models
- Projects in which SMHI data or ICOS/ACTRIS data are used in a ML setting.
- SPs with connection to ELLIIT, eSENCE are encouraged, through common interests/ finding common ground with Machine learning/AI