Project: **1395**

Project title: **Numerical modelling for transport research**

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Report period: **2025-11-01 to 2026-10-31**

Experiment "Response model gas phase"

In the DLR project MoDa, we develop the climate response model TransClim for land transport and shipping emissions, targeting the gas phase effects in this experiment. A series of training simulations with EMAC are conducted here, using QCTM mode in T42L90 resolution with TAGGING. We perform perturbed parameter ensemble (PPE) simulations, in which we apply 33 different combinations of the most relevant species' emission rates from land transport or international shipping in specified regions.

For the current reporting period, our goal was to investigate subregions of the global ocean for more targeted applications of TransClim. However, due to a problematic signal-to-noise ratio in the corresponding aerosol effect simulations (see report on the sister project 1393), we skipped the regional simulations here and conducted a set of simulations for global shipping under "clean" background conditions instead. For this ensemble, we applied anthropogenic "background" (i.e., non-shipping) emissions projected for 2050 under the SSP1-1.9 scenario (as developed for IPCC report AR6).

In addition, we are running ensembles for land transport under present-day (2015) background conditions, targeting all land regions. This shift in priorities with respect to the planning for the last resource request stems from changes in project requirements. Eight such simulation ensembles have been completed in the current reporting period and two further ones are currently running. We plan to use up as much of the remaining granted resources (three further ensembles) as possible until the end of the year, but the downtime in late August/early September and the very long queuing times since then have increased the total simulation completion times considerably.

Work on the publications of and on TransClim was delayed, so that this is again a plan for 2027.

Experiment "Hydrogen: Chemistry and radiation"

This experiment is part of the EU-funded project HYway that aims to reduce the uncertainties associated with the climate effects of increased H_2 use. Since October 2025, we performed and processed six sensitivity time slice simulations under 2019 climatic conditions, and processed the output of the control simulation. The sensitivity simulation with perturbed global CH_4 surface concentration is used to derive the methane feedback factor for our EMAC configuration, which enters the H_2 global warming potential (GWP) derivation from the simulation with perturbed H_2 emissions. Details of this method are currently written up as a HYway deliverable and a journal publication is also planned. The four regional perturbation simulations will be used in the same way to determine the variability of the GWP. Due to limited resources available to the HYway partners and limited expected scientific insight, the perturbation in the tropics was removed from the simulation protocol.

The planned simulations with perturbations to H_2 emissions and CH_4 surface concentrations in the low-OH and high-OH atmospheres were delayed due to late modifications to the simulation protocol. Spin-up simulations for both are currently running and will be used for both the control and the perturbation simulations once they reach a chemical equilibrium. We do not expect all the simulations to finish during the remainder of the year, so that we also request resources for these for 2027.

So far, the 50 TiB of output of the simulations conducted as part of this experiment has not been archived. This is one of the two main reasons for the current under-usage of the granted archive space. We will start the archival soon, since the processed data has now been made available to the HYway project partners, and we want to avoid to archive large amounts of data towards the year's end.

Several publications that will include results from this year's simulations in the present experiment are

currently being prepared or planned by the HYway project partners.

Experiment “Hydrogen: soil sink”

An accurate simulation of present and future H_2 emission effects on the atmosphere and the climate requires a dynamic representation of the main H_2 sink, namely the soil sink. Therefore, we tested and tuned the recently introduced H_2 soil sink parameterization in EMAC in T42 resolution. This requires the use of the land-surface (sub)model JSBACH, which had so far only been evaluated in T63 resolution. Through comparisons with the previously used soil properties from the submodel SURFACE and with observational data, we ensured that JSBACH also produces reasonable output in T42 resolution. The planned implementation of additional H_2 soil sink parametrizations to allow for an intercomparison and choice of the best-performing one for our model configuration were delayed because we discovered and helped fix a bug in the JSBACH submodel. A second round of soil parameter evaluation followed, and the additional soil sink parameterizations are currently being implemented. We still expect to finish this task and the associated test simulations within 2026. The planned radiation tuning of the JSBACH-enabled configuration was carried out as part of the following experiment, but the planned transient simulation from preindustrial to present time had to be postponed to the next allocation period due to the bug-induced delay.

Experiment “Hydrogen: future scenarios”

As part of the DLR project CLEANLIEST, we planned a set of transient projection simulations with EMAC to investigate the climate impact of a prospective hydrogen-based transport system. The experiment requires a thoroughly tuned model configuration with respect to the radiation balance. Although we decided on a different approach to the tuning than what we had in mind when we submitted the May request, and could thus cut the required computing time from 100’000 node-h to about 10’000 node-h, this also meant that we could only run the required simulations in sequence. Thus, it took us until October to reach a satisfactory radiation balance. At the moment, the spin-up for the production simulations is running. As soon as it reaches the year 2025, all other proposed simulations can be started. We therefore request the computing time again for the upcoming allocation period, since we do expect to neither start nor finish all planned simulations this year. In summary, this explains most of the under-usage of our granted computing time in the third quarter of 2026, and it is also the second major reason for the under-usage of our granted archive space, as only a few of the estimated 612 TiB of data have materialized so far. In line with the suggestion of sharing resources between work packages from a prior review of this project, about 12’000 node-h of the “freed” resources were used to make up for cuts in the requested resources of a “neighbor” project (1361).

Experiment “Data: Response model aerosol”

Further analysis of the PPE method versus our former linearized approach to derive the aerosol response to transport emission variations from EMAC simulations showed that the new method is superior. We therefore no longer need to keep the old data in Levante storage.

Experiment “Data: Global NO_x source uncertainties and their effects on O_3”

Findings from this experiment were presented in the form of posters at two conferences during the current reporting period. It became clear that an additional simulation is required to further support or reject our hypotheses on the reasons for the changes that we detected between the original and the updated EMAC QCTM configurations. The aim is to perform this simulation during the next allocation period, and to publish a journal article documenting the comparison results.