Project: **893**

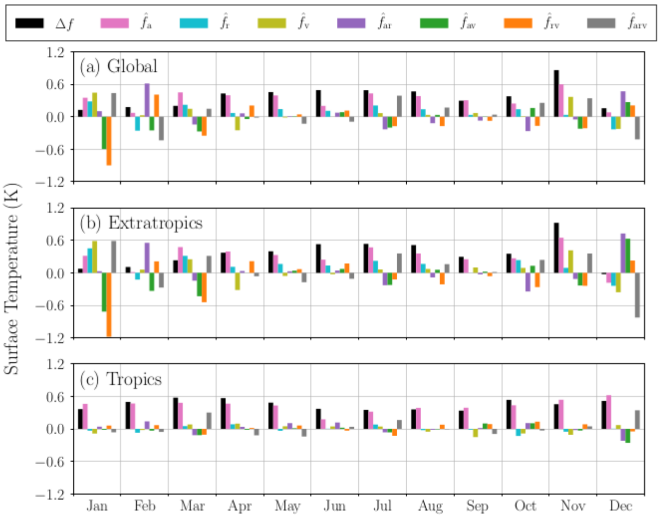
Project title: **Convection and Clouds in Earth System Modelling**

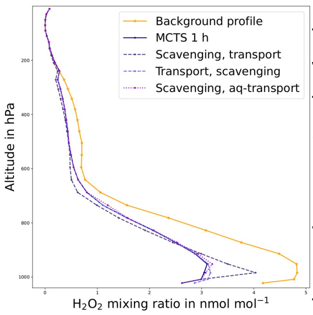
Principal investigator: **Holger Tost**

Report period: **2024-11-01 to 2025-10-31**

In the current allocation period more resources than granted have been utilised on Levante profiting from a non-100% usage of other users and projects.

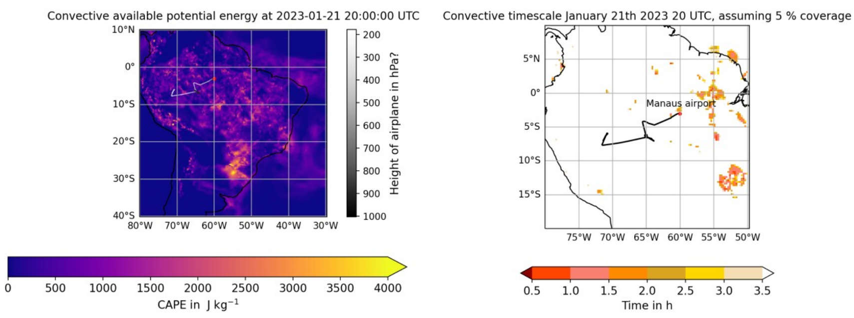
The majority of the resources have been utilised in projects and activities of the CRC TPChange, i.e., the requested WP VI. Within the project, WP I as a continuous workpackage has required some resources for test simulations, version control tests, bugfix tests. For WP II simulations have been conducted which include the feedback of the vegetation scheme LPJ/GUESS within the EMAC model, utilising the MESSy infrastructure. A set of 8 simulations for a factor-separation-method have been performed, allowing to analyse the feedback of the albedo, roughness length and vegetation properties on the climate state. This is displayed in the figure on the right hand side, which depicts the individual contributions of the three parameters mentioned above, as well as their interactions, to analyse compensating and amplification effects. This analysis is included in a master thesis and will potentially be published in a scientific paper. Due to shortening of the requested resources WP III has not been conducted.





WP IV is still ongoing (3D implementation), but the single column model is fully functional. An example is shown in the picture to the left, depicting a vertical profile of H_2O_2 mixing ratios differentiating the impact of separated transport, scavenging and multiphase chemistry from a joint process description. For WP V only minor test simulations have been conducted and some technical implementations have already been prepared, representing the basis for a new project in the second phase of the CRC TPChange (C08), which analyses different representations of convection and convective transport for the composition of the UTLS making use of the ICON/MESSy scheme (rated: very good to excellent).

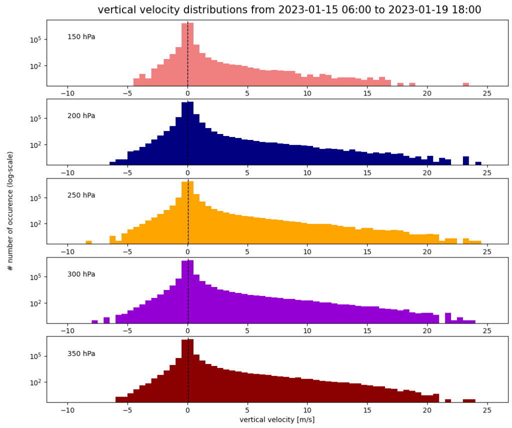
As mentioned in the beginning most of the ressources have been used to conducted global to regional scale simulations within WP VI, all related to individual project of the CRC TPChange. One aspect has been on mixing of air masses by Clear Air Turbulence (CAT) in the upper troposphere / lower stratosphere (UTLS) region (project B01 of TPChange). Even though the main production simulations have been conducted elsewhere, some tests have also been made on Levante. The mixing of air masses by CAT has the consequence that the tracer gradients in the UTLS are reduced, which finally has impacts on the radiation budget in the UTLS. A corresponding manuscript and part of a PhD thesis is close to submission.



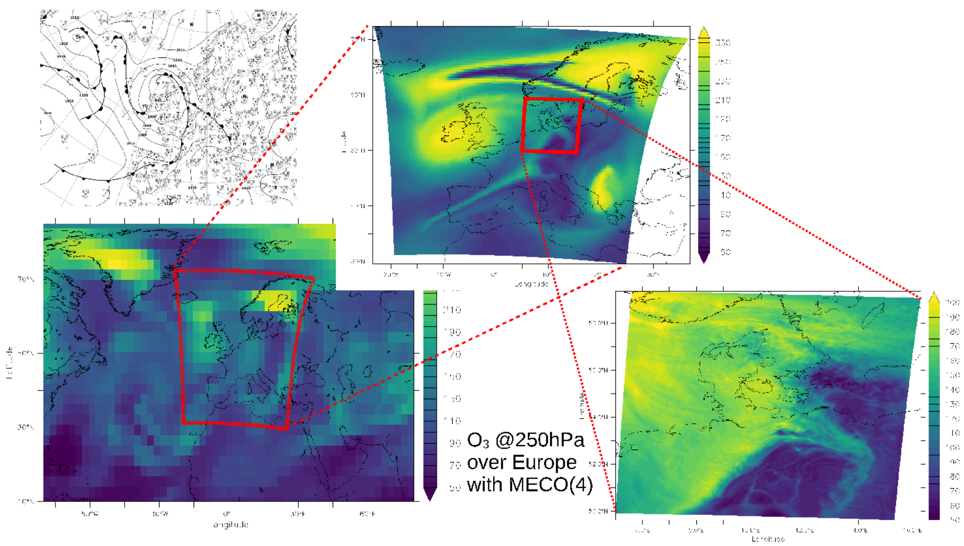
(a) (b)

In a second project of TPChange (A03), dealing with aerosol nucleation in the UTLS over South America during the CAFE-Brazil campaign, we have conducted global to regional scale simulations with the nested model system MECO(n) down to convection resolving grid width to analyse the transport times (especially in convection) of near surface emitted tracers such as volatile organic compounds into the UTLS, and relate this transport time to the chemical lifetime of the compounds. Depicted on the previous page are on the left side the diagnosed CAPE over South America in addition to a flight track from the CAFE-Brazil mission and on the right hand side the associated convective transport times, which allow for a rapid uplift of air masses in the eastern part of the domain both by isolated convection as well as larger organised systems.

Additionally, we analysed the explicitly resolved vertical motion (see figure on the right) from the high resolution domain in terms of their frequency distributions to a) determine the role and frequency of deep convection, b) the transport time depicted above, c) the role of regional versus larger scale mass transport (e.g., whether the mean velocity over the domain is close to zero) and d) the role of downward motion transporting either UTLS air to layers below and transporting convectively lifted air masses downwards again. This simulation has been part of a PhD project, and the analysis and follow-up simulations will continue into the second phase of the CRC (currently unpublished results).



Further work has been placed in radiation calculations of the effects of UTLS aerosol (project C07). A manuscript is currently in preparation (Tost et al., in prep.) which shows effects of enhanced and weakened UTLS extinction on the global radiation budget, building upon the results from the previous allocation period, but required an additional simulation.



A majority of the CPU time has been consumed by a full chemistry simulation with the MECO(n) system for the TPEx campaign (project B01, Z01) of TPChange. Especially, the chemistry on the high resolution nests has been computationally expensive, but allowed for a good comparison of the flights over Europe and the combination of meteorological and chemical impacts on the chemical UTLS composition. Not all the data from the simulations have yet been finally analysed, but an example is provided here (unpublished result). The picture depicts the UTLS ozone distribution at 250hPa in the different MECO(n) instances for a frontal passage event over Germany and the enhanced ozone values after the cold front (lower tropopause) and the enhanced O_3 at the warm front, indicating exchange between stratosphere and troposphere. Aerosol particles will be analysed in the potentially upcoming second phase of TPChange. The interaction of direct observations, model sampling on the flight tracks and Lagrangian backward trajectory information (not shown here) allows for an improved holistic analysis and interpretation of the atmospheric state and composition by taking local, regional and larger-scale processes and effects into account. However, it also poses challenges in case of non-perfect location agreement between model and observations and the comparability of the involved data sets.