Project: **1004**

Project title: **Development and evaluation of aerosol processes in ECHAM-HAMMOZ**

Project lead: **Bernd Heinold, Ina Tegen**

Report period: **2019-07-01 to 2020-06-30**

The aim of his project is the on-going evaluation and coordination of further developments of the aerosol model HAM (Versions 2.2, 2.3) in close collaboration with scientists from the HAMMOZ consortium. The well-established global aerosol-chemistry-climate model ECHAM6-HAMMOZ is jointly developed by partners from several European universities and research institutes. The model code is hosted at the ETH Zurich where it is made accessible to the research community; partners include scientists at the Universities of Oxford, Helsinki and Munich, as well as at the German research institutes MPI Hamburg, FZ Jülich, TROPOS and GEOMAR. It simulates the lifecyles of the climate-relevant aerosol species including microphysical transformation processes, and their climate impact. The model system includes the global atmospheric climate model ECHAM, the aerosol-microphysics model HAM, and the atmospheric chemistry model MOZART. The role of TROPOS in this project is to bring together the different aspects of the model development and to test the subsequent modifications in the aerosol distribution resulting from the changes of the aerosol parameterisation.

During the period 07/2019 to 04/2020, the version ECHAM6.3-HAM2.3-MOZ released in February 2017 was used for several applications, including contributing to comparing with measurements of the ATom flight campaigns covering large parts of the Atlantic and Pacific Oceans (Hodzic et al., 2020) as well as the SALTRACE field campaign over the tropical Atlantic (Publication in preparation by A. Walser et al). It should be noted that the publication by Tegen et al (2019) describing the aerosol evaluation in the model is already a 'highly cited paper' in the ISI Web of Science publication database. Ongoing model tests and developments include the tests of the deposition scheme and updates in the sulfate oxidation scheme in HAMMOZ.

Part of the granted computing time was used for simulations of the extreme wild fires in Australia during the 2019/20 fire season. The unusual intensity and distribution of the fires was caused by an extreme drought in central and eastern Australia. Massive smoke plumes were lifted into the upper troposphere and lower stratosphere by pyro-convection. Subsequently the fire aerosol was transported over thousands of kilometres eastward by the prevailing winds, affecting the aerosol conditions throughout the southern hemisphere.

We have started to investigate the transport of the fire aerosol and its impact on the radiation budget by aerosol-climate simulations with the ECHAM6.3-HAM2.3 model at a resolution T63 and 47 vertical levels. Biomass burning emissions are prescribed by current GFAS fire information on a daily basis. For late 2019 and January 2020, the Australian wildfire emissions of e.g. BC aerosol extracted from this dataset are greatly increased compared to emissions averaged for the years 2000-2016 (Figure 1). As the horizontal model resolution is too coarse to explicitly resolve convection, the injection height of the smoke is prescribed at heights between 5 and 15 km and varied in terms of sensitivity studies. The model results for late 2019 and early 2020 are contrasted with smoke results for years with low Australian wildfire emissions. Results for the BC load for January 2020 are shown as an example in Figure 2, together with the difference of BC load compared to January 2019. Elevated BC loads can be identified across the southern mid-latitudes. This has a direct impact on the radiation budget but also cloud formation is affected (not shown).

As a next step, it is planned to thoroughly evaluate the model results with AERONET sun photometer and satellite retrievals, with focus on the representation of the vertical layering, microphysics and lifetime of the fire aerosol. Further model sensitivity studies using different fire emission configurations as well as statistical analysis will be carried out in order to quantify the aerosol-climate impact.

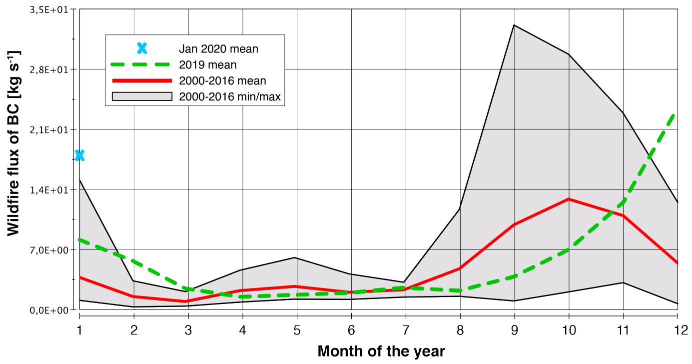

Figure 1: Annual cycle of wildfire emissions of black carbon across Australia. Compared is the monthly-mean area total for the period 2000–2016 with that of the years 2019/2020 from the GFAS fire inventory.

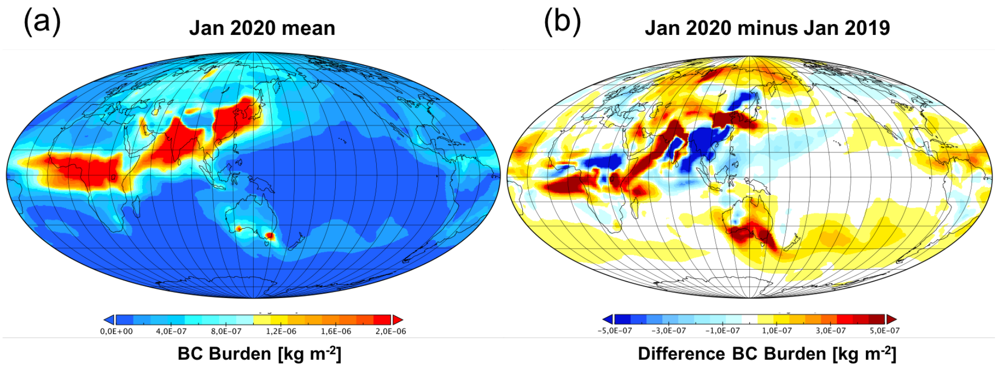

Figure 2*:* Monthly mean burden of black carbon for January 2020 (a) and the difference compared to January 2019 (b) from the ECHAM6.3-HAM2.3 model simulations.

Publications:

Heinold, B., Hoffmann, E., Kubin, A., Schepanski, S., Schacht, J., Schrödner, R., Senf, F., Tegen, I., Villanueva, D., and co-authors, Transport and climate effects of the Australian wildfire plumes during the extreme season 2019/2020 with ECHAM-HAM, Atmos. Chem. Phys. Discuss., in preparation.

Hodzic, A., Campuzano-Jost, P., Bian, H., Chin, M., Colarco, P. R., Day, D. A., Froyd, K. D., Heinold, B., Jo, D. S., Katich, J. M., Kodros, J. K., Nault, B. A., Pierce, J. R., Ray, E., Schacht, J., Schill, G. P., Schroder, J. C., Schwarz, J. P., Sueper, D. T., Tegen, I., Tilmes, S., Tsigaridis, K., Yu, P., and Jimenez, J. L.: Characterization of organic aerosol across the global remote troposphere: a comparison of ATom measurements and global chemistry models, Atmos. Chem. Phys., 20, 4607–4635, https://doi.org/10.5194/acp-20-4607-2020, 2020.

Tegen, I., Neubauer, D., Ferrachat, S., Siegenthaler-Le Drian, C., Bey, I., Schutgens, N., Stier, P., Watson-Parris, D., Stanelle, T., Schmidt, H., Rast, S., Kokkola, H., Schultz, M., Schroeder, S., Daskalakis, N., Barthel, S., Heinold, B., and Lohmann, U.: The global aerosol–climate model ECHAM6.3–HAM2.3 – Part 1: Aerosol evaluation, Geosci. Model Dev., 12, 1643–1677, https://doi.org/10.5194/gmd-12-1643-2019, 2019.