Project:	**1174**
Project title:	**Regional Effects of Absorbing Aerosols and Biomass Burning**
Former Project title:	*Effects of Absorbing Aerosols on Cloud Cover over Germany*
Project lead:	**Dr. Fabian Senf (TROPOS)**
Allocation period:	**1.7.2023 - 30.6.2024**

Overview

The project is dedicated to the research question how the presence of absorbing aerosol such as black carbon changes the atmospheric state including clouds. Aerosol-mediated changes in the atmosphere occur at rather short time scales compared to other climatic changes, and thus appear to be mainly independent of near-surface temperature changes. Therefore, the changes in the atmospheric state due to aerosol absorption are assigned to the so-called rapid adjustments to aerosol-radiation interactions (ARI) - formerly known as semi-direct effects - which together with the direct (or instantaneous) radiative forcing of aerosol can be combined to the effective radiative forcing.

Resource Utilization

At the time this report was written, approximately 40% of the granted computing resources were being used by project members, while 60% expired unused. Resources were mainly used by F. Senf (PI) and by one PhD student. Thanks to the very easy-to-use interface to DKRZ Jupyterhub, an important part of the work and therefore used resources was put into the scientific analysis of the generated simulation data.

Scientific Results

Continuing the work from the last allocation period, the bb1174 project dealt with the question of how aerosols influence the adjustment processes in the cloudy atmosphere through their interaction with atmospheric radiation. We are happy to report the computational resources supported the finalization of a master's thesis at the University Leipzig (Käpplinger, 2023) at the end o the last allocation period. The thesis documents how different ICON versions and how differently chosen radiation schemes respond to perturbations in aerosol absorption and scattering characteristics. The ICON simulations were done at hectometer horizontal grid spacing applying the so-called LEM pathway. However, the problem with the unrealistic fluctuations (mentioned in the last report) could not be solved in the current allocation period, which is why the originally planned perturbation runs were postponed further. The problems most likely originate from the calculation of the turbulent diffusion coefficient and will be investigated in detail in the future as soon as human resources permit.

Moreover, the compute project bb1174 supported the scientific analysis of the impacts of the extreme Australian wildfires (simulations were conducted with resources from bb1004). Devastating wildfires spread across Australia at the turn of the year between 2019 and 2020. As a result of the extreme fire heat and the favorable meteorological conditions, deep pyro-convective clouds formed,

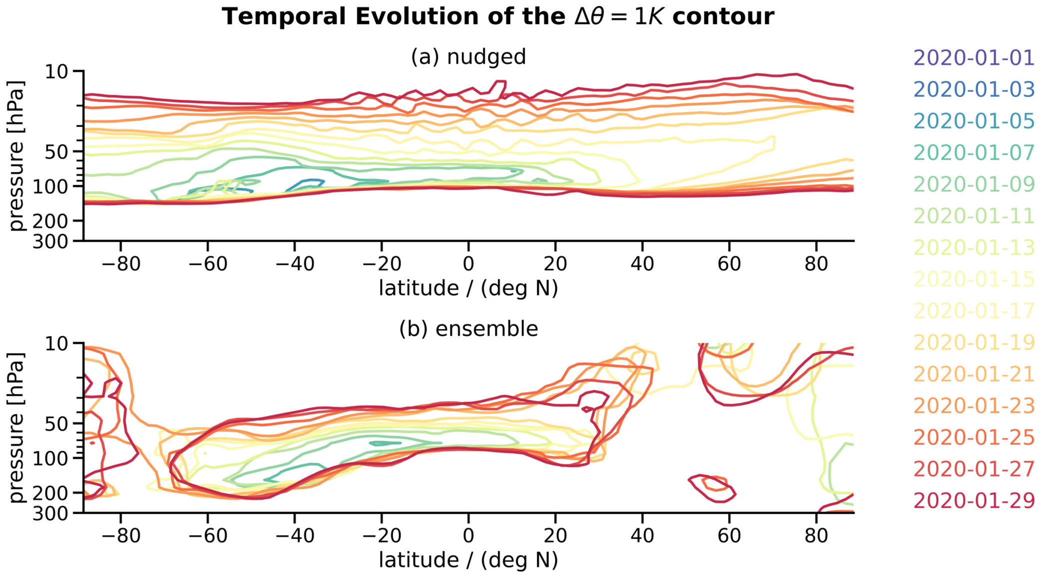

Figure 1: Temperature perturbation due to Australian wildfires simulated with ECHAM-HAM. (a) Nudged and (b) ensemble simulation are compared. The time of the 1-K θ-contour is color-coded, see Senf et al. (2023) for more detail.

which enabled efficient transport of the smoke aerosol into the lower stratosphere. This allowed the smoke to spread across the entire Southern hemisphere and had an impact similar to that of the last major volcanic eruptions. However, since the smoke aerosol not only scattered sunlight back into space, but also absorbed it, scientifically exciting and climate-relevant aerosol-induced adjustments emerged, which we published in Senf et al. (2023). As an example, the zonally averaged temperature perturbation due to stratospheric wildfire smoke is shown in Fig. 1. It is positive due to the absorption of solar radiation and spreads towards the tropics due to exciting interactions with the global circulation. It is therefore evident that the global effects of Australian smoke must be considered as part of the effective radiative forcing in a similar way to the local adjustments caused by absorbing aerosol as studied earlier in this project.

During the allocation period, we further redirected our science focus towards the effects of wildfires. We have successfully acquired funding for this and have started work on a PhD research topic with the help of the resources available in bb1174. We will realign and generalize the bb1174 project accordingly for the next allocation period in order to take these aspects into account.

References

Käpplinger, H., 2023: Simulation of rapid adjustments to aerosol-radiation interactions over land with ICON. Masterthesis, University of Leipzig.

Senf, F., B. Heinold, A. Kubin, J. Müller, R. Schrödner, and I. Tegen, 2023: How the extreme 2019–2020 australian wildfires affected global circulation and adjustments. *Atmos. Chem. Phys.*, **23 (15)**, 8939–8958, doi:10.5194/acp-23-8939-2023, URL https://acp.copernicus.org/articles/23/8939/2023/.