Project: **1368**

Project title: **nextGEMS aerosols**

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Summary

Aerosols strongly influence Earth's climate as they scatter and absorb radiation and serve as nuclei for cloud droplets and ice crystals. New Earth system models that run at kilometer resolutions allow us to examine long-standing questions related to these interactions. To perform kilometer-scale simulations with the Earth system model ICON-MPIM, we developed the one-moment aerosol module HAM-lite. HAM-lite was derived from the two-moment module HAM. Like in HAM, aerosols are represented as an ensemble of log-normal modes. Unlike in HAM, aerosol sizes and compositions are prescribed, which reduces the computational costs significantly.

Aerosol-cloud interactions and aerosol forcing

To assess the impact of anthropogenic aerosols, we performed two simulations with different emission scenarios. The first simulations incorporates anthropogenic and wildfire emissions, whereas the second simulation incorporates only wildfire emissions. The anthropogenic emissions were taken from the Community Emissions Data System (CEDS), and the wildfire emissions were taken from the Global Fire Assimilation System (GFAS). In both simulations, the sea surface temperature and sea ice were prescribed with the boundary conditions of AMIP. Based on these two scenarios, we analyzed how anthropogenic aerosols interact with radiation and clouds over one year.

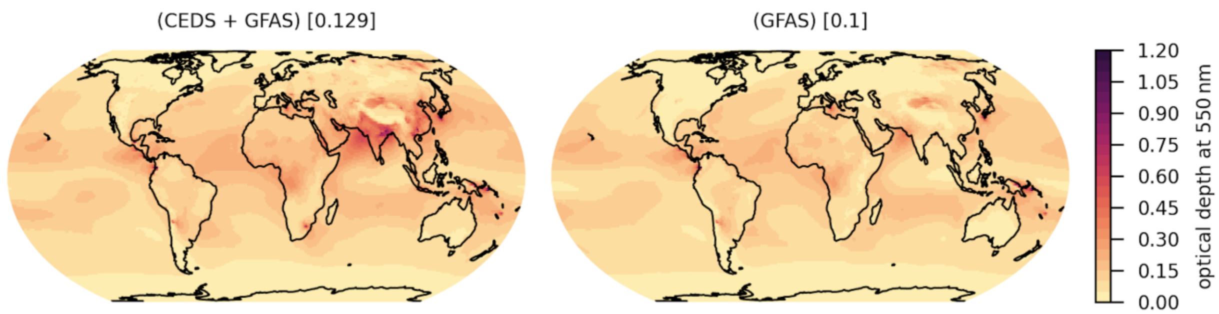

Figure 1: Aerosol optical depth at 550 nm of the two simulations with ICON-HAM-lite averaged over February 2020 to January 2021.

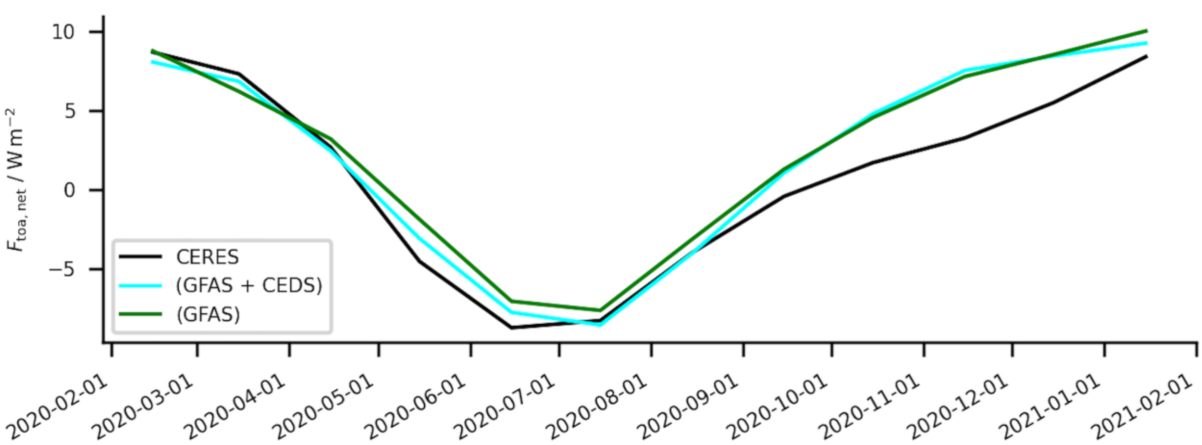

Figure 2: Top-of-atmosphere radiation balance of the two simulations with ICON-HAM-lite and of CERES-EBAF from February 2020 to January 2021.

Dust generation and transport in continental-scale storm

Haboob dust storms, formed by the cold pool outflow from moist convection, play a significant role in global dust emissions. However, they are largely absent in current global climate models, as most do not explicitly resolve convection processes, leading to considerable inaccuracies in modeling global dust and its impacts. Therefore, the global influence of haboobs on the dust cycle and the Earth system remains poorly understood. With the advent of kilometer-scale Earth system models, there is a unique opportunity to unveil the global haboob behavior and advance our understanding of their impacts.

A preliminary one-year model simulation was conducted globally at a 5 km resolution including online dust simulation. A haboob detection algorithm was developed and applied to track haboobs, allowing us to analyze their global characteristics and variability. This includes their spatial distribution, seasonal and diurnal cycles, duration, and size. Additionally, the contribution of haboobs to global dust emissions was evaluated. This study offers what is, to our knowledge, the first comprehensive analysis of haboobs on a global scale, shedding light on their critical role in the global dust cycle.

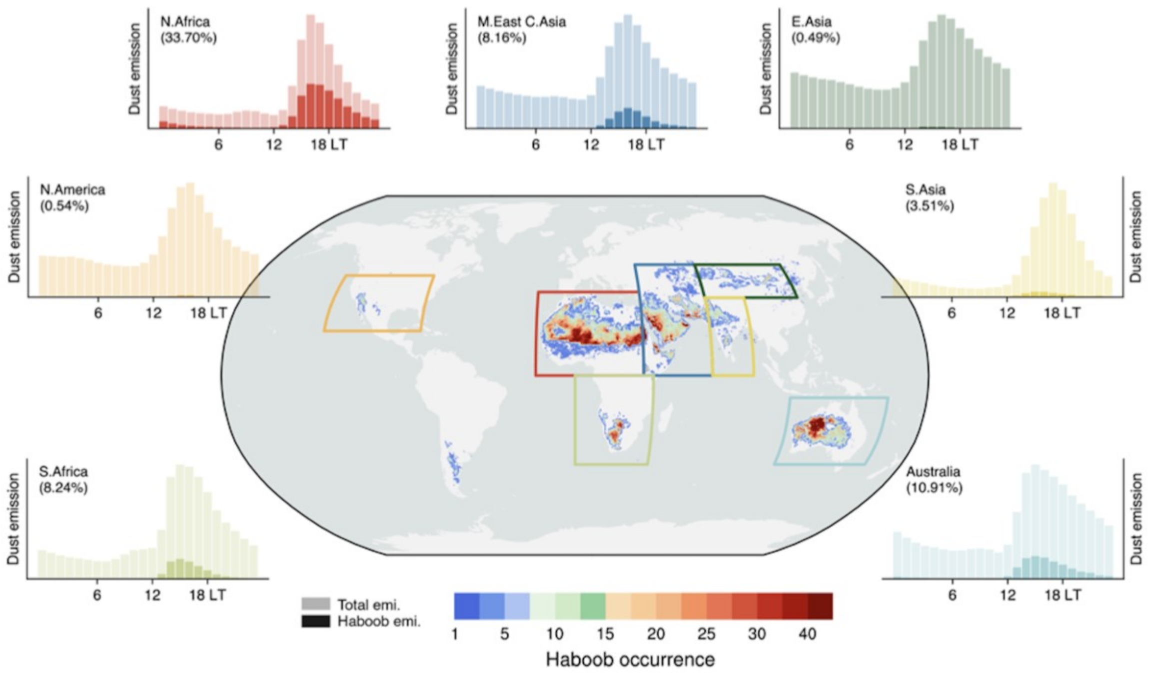

Figure 3: Global map of haboob occurrence and bar plots of dust emissions at local time for different regions averaged over February 2020 to January 2021 (preliminary results). Light bars show total emissions and dark bars shows emission from haboobs.

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