Project: **1070**

Project title: **ARIA**

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Report period: **2022-01-01 to 2022-12-31**

The ARIA numerical experiments on Mistral and Levante in 2022 are separated in three groups. The progress of each group is outlined below.

1- Surface fluxes of aerosols

Vegetation fires emit various gases and particles that can get transported to remote area and affect the atmospheres radiative budget and the air quality and therefore the human health. The transport is dependent on different factors; one factor is the emission height that is a large uncertainty. So far, ICON-ART calculated the emission height through a 1D-plume rise model, which is developed for climate models. We aim to simulate emission and transport on a finer resolution and therefore use large eddy simulations to calculate the fire caused dynamic changes. Using satellite observation as a benchmark, we aim to improve this set-up so that ICON-ART can reproduce the injection heights more precisely. This includes the release of moisture by the fire, which can cause additional convection due to latent heat release. Further, the implementation of fire radiative power as additional heat release can lift the emission plume. Furthermore, aerosol radiative effects can affect the plume height. Biomass burning particles, especially black carbon particles, absorb solar radiation efficiently, potentially lifting the plume further. To quantify this effect, we study the Australian bushfires in 2019/2020 and outline the effect of moisture release, radiative heat release and radiation on the biomass burning aerosol transport.

Sea salt is one of the main natural aerosols that affect the climate and chemistry of the marine atmosphere. Beside interactions with radiation and clouds, sea salt is a source of halogens and provide a large surface area for heterogeneous reactions, thereby affecting atmospheric chemistry. Despite their importance, sea salt aerosols remain one of the most poorly constrained aerosols in terms of their surface fluxes (emission, wet/dry deposition) and atmospheric burdens. We have performed multi-year simulations with ICON-ART to identify the key mechanisms that control the surface fluxes of sea salt. We have been able to reproduce the global budgets for emission and atmospheric burdens reported in the literature (Fig. 1). Next steps focus on the role of the aging processes on the lifetime and optical properties of sea salt.

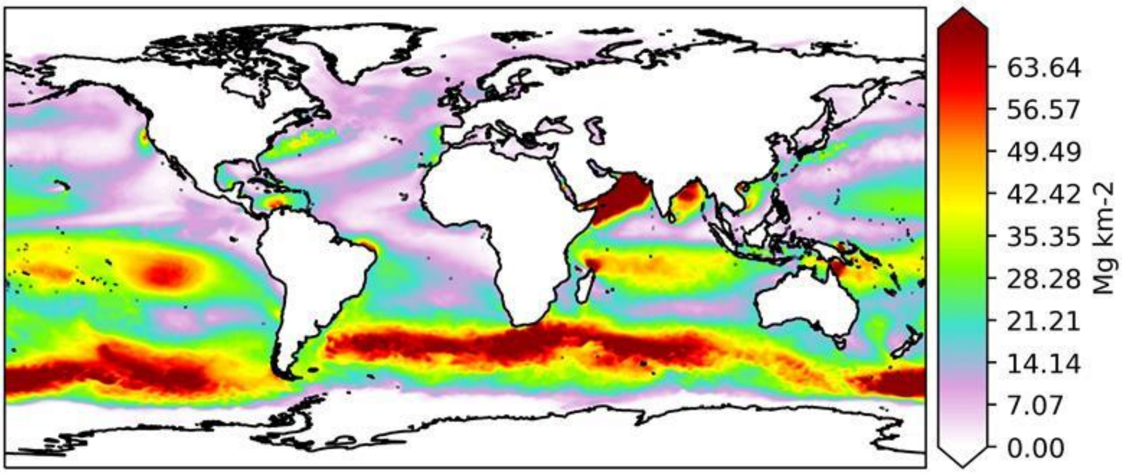

Figure 1: Annual emission flux of sea salt from ICON-ART simulations.

2- Mixing and aging of aerosols

The aerosol dispersion forecasting systems that are used for operational forecasting nowadays only consider externally mixed aerosols. In the real atmosphere, however, due to aerosol dynamic processes (nucleation, condensation, and coagulation) and chemical reactions, the mixing state of aerosols is internally mixed. We implemented a new aerosol dynamics module

(AERODYN) in ICON-ART to account for such processes. The first simulations focused on volcanic eruptions as natural experiments. The results show that the interplay of aerosol dynamics, chemistry and aerosol-radiation interactions controls the evolution and transport of the plume. Moreover, within the PermaStrom project the mixing of dust and sea salt is simulated successfully (Fig. 2). The first results confirm that water absorption enhances the removal of sea salt aerosols significantly.

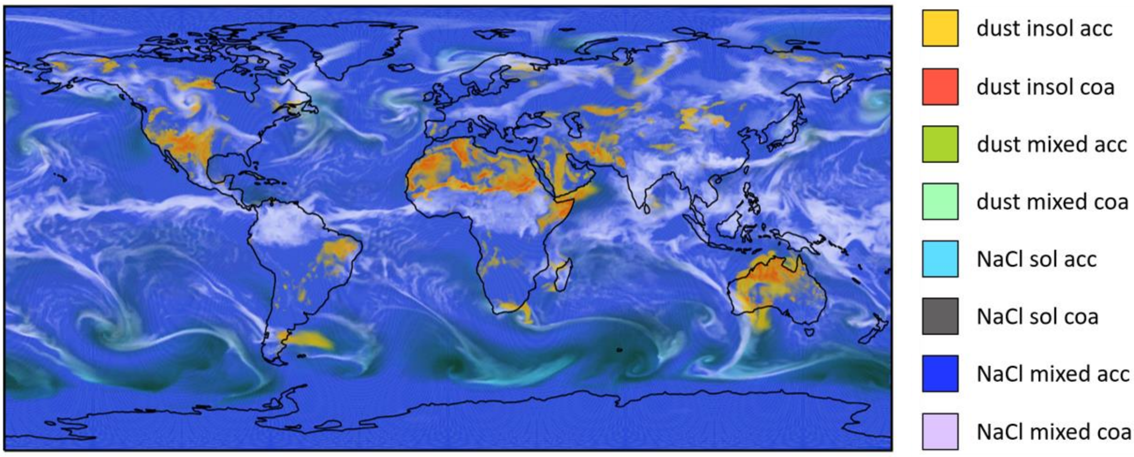

Figure 2: Global simulation of mixed dust and sea salt

3- Aerosol-radiation-cloud interactions

Aerosol particles act as cloud condensation nuclei (CCN) and/or ice nuclei (IN) and therefore directly affect the formation and the properties of clouds. A high aerosol number concentration leads to the formation of more and smaller droplets or ice particles compared to a smaller number concentration. Therefore, the aerosol concentration has a direct impact on the clouds' hydrometeor spectrum. This in turn affects the clouds' properties, e.g. regarding its radiation interaction or precipitation behavior. Additionally, concerning supercooled clouds, the droplet spectrum may influence the safety of passing aircraft. This is because supercooled water instantaneously freezes when impinging on the aircrafts surface combined with the differing droplet impingement efficiencies depending on its size. We developed ICON-ART to represent the aerosol loads and its impact on hydrometeor spectra more accurately, which is crucial for understanding icing properties of clouds and in forecasting the aircraft icing hazards. The results obtained from high resolution LAM simulation show very good agreement with the observations.

Problems:

After the official launch of Levente, we had several issues in migration of the code, data and configurations. Most importantly installation and running ICON-ART took several weeks. Thus, we were not able to use our computation time in the first two quarters.

We also observed in several simulation the dependency of the results on the number of nodes. We are working on DKRZ support to understand and solve the problem.

References:

Bruckert, J., Hoshyaripour, G. A., Horváth, Á., Muser, L., Prata, F. J., Hoose, C., and Vogel, B.: Online treatment of eruption dynamics improves the volcanic ash and SO2 dispersion forecast: case of the Raikoke 2019 eruption, Atmos. Chem. Phys. 2022.