Project: **1311**

Project title: **The importance of upper-troposphere aerosol formation for low- and mid-troposphere aerosol concentrations**

Principal investigator: **Anna Possner**

Allocation period: **2023-07-01 to 2024-06-30**

Resources utilization report

Table 1: Overview of project resources during the allocation period from 2022-07-01 to 2023-06-30. All entries are given in Node hours.

Category	Amount
Granted	17′051
Consumed (until 2023-04-14)	10′294
Expired	2′495
Remaining	4′262

The granted resources were used to perform global and regional simulations with idealized tracers to study the transport of upper tropospheric aerosols originated within the tropics. The resources were partitioned between data preprocessing, model setup, experiments, and postprocessing. Most of the granted resources were used up to the moment of requesting resources for the next allocation period. The expiration of 2′495 node hours was due to difficulties encountered during the implementation of the wet scavenging parameterization, which caused a delay in the planned schedule. Nevertheless, a significant part of the first phase of the four-years-long project was accomplished via the performance and analysis of 10-years-long, transport-only simulations, as detailed below.

ICON simulations

Global and regional ICON simulation were performed in parallel to represent the transport of idealized tracers from the tropical upper troposphere to other regions in the globe. Four domains were used with resolutions ranging from 80 km to 10 km. The configuration of these domains is shown in Fig. 1. The outer domain is intended to analyze the transport of tracers all over the globe, while the innermost domain is intended to better represent transport mechanisms over the Amazon forest, in view of recent findings highlighting the intense particle source over that region.

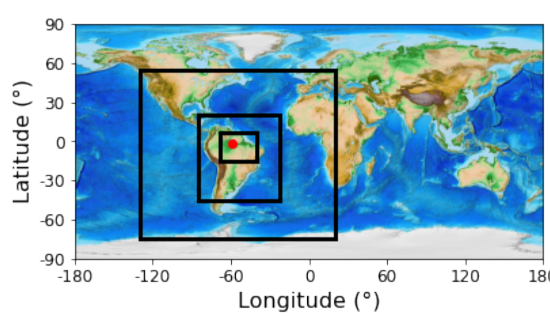

Figure 1: Configuration of the spatial domains to be used in the ICON simulations

The tracer forcing strategy is illustrated in Fig. 2. Defining tracer sources this way guaranteed that the maximum value of the tracer mixing ratio within the forcing region increased linearly with time (although step-wise, i.e., maintained constant during each calendar day), as necessary to apply the age-of-air approach. To minimize advection errors associated with the occurrence of steep gradients in the tracer fields, a Gaussian relaxation was included in the forcing term.

If only resolved advection is considered, and neglecting numerical diffusion and dispersion during advection calculations, the age of the air at a certain point of the domain is given approximately ($\pm \sim 0.5$ days) by the difference between the average mixing ratio within the forcing region at the current time step, and the mixing ratio of the tracer at the point in question.

Figure 3 shows examples of the postprocessed data based on the ICON simulations performed. The top panels show histograms of the age of the air in different region and pressure levels, for different elapsed times (i.e., maximum age of the air considered), taking as a reference the 304$^{\text{th}}$ simulation day. The bottom pannels show 10-months time series of the mean age of the air in each region. Such analyses are useful to characterize the transport time-scales and contrasts between regions and levels in the atmosphere regarding its exposure to the influence of upper tropospheric particles. For example, Fig. 3 suggests that transport from the upper troposphere to levels as low as 700 hPa takes typically $\sim 3-4$ weeks, while it takes typically $\sim 11-12$ weeks for even lower levels, if wet scavenging is neglected. Also, the simulations indicate a potential for little ($<\sim 2$ weeks) seasonal differences in transport time scales for the Globe, the Tropics and the Amazon region.

Region	**Forcing**
Tropics	$F = \frac{t}{86400} - 1 + \exp\left(-\frac{(p-250)^2}{50^2} - \frac{lat^2}{20^2}\right)$
Amazon	$F = \frac{t}{86400} - 1 + \exp\left(-\frac{(p-250)^2}{50^2} - \frac{lat^2}{20^2} - \frac{(lon+59)^2}{20^2}\right)$
Atlantic	$F = \frac{t}{86400} - 1 + \exp\left(-\frac{(p-250)^2}{50^2} - \frac{lat^2}{20^2} - \frac{(lon-0)^2}{60^2}\right)$
Pacific	$F = \frac{t}{86400} - 1 + \exp\left(-\frac{(p-250)^2}{50^2} - \frac{lat^2}{20^2} - \frac{(lon-(-120))^2}{60^2}\right)$

t: time (s)
p: pressure (hPa)
lat: latitude (^{o})
lon: longitude (^{o})

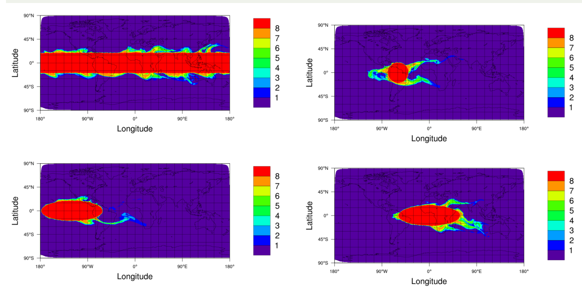

Figure 2: Mathematical definition of the tracers forcing (top) and examples of the tracers on simulation day 10$^{\text{th}}$, at 250 hPa (four bottom panels).

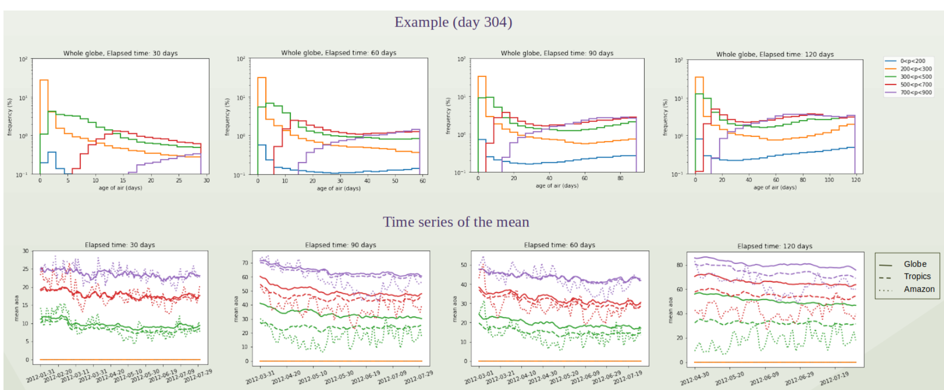

Figure 3: Histograms of the age of the air on simulation day 304$^{\text{th}}$ (top) and time series of the mean age of the air (bottom) for different reference days, elapsed times, region and level.

Next steps

The next step of this research will involve completing the implementation of the wet scavening parameterization and performing the corresponding experiments. Later (not included in the next allocation period), complexity levels will be added by incorporating dry deposition and sedimentation. At last, the full life cycle of the aerosol will be represented (after nucleated), including aerosol mechanisms.