C06 The importance of upper troposphere aerosol transport and processing for low- and mid-troposphere aerosol concentrations

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Motivation

- New particle formation (NPF) of organics in the free troposphere impacts low-troposphere (LT) cloud-condensation nuclei (CCN) concentrations.
- NPF in the upper troposphere (UT) could occur independently of anthropogenic emissions.

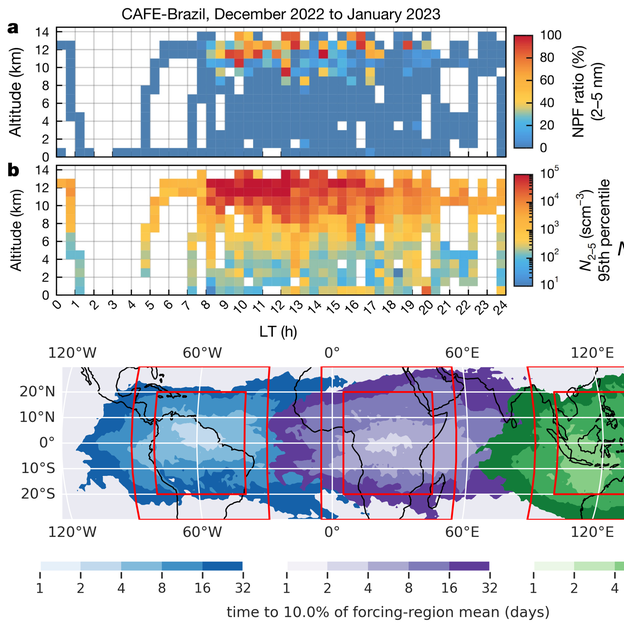

*Figure 1: Diurnal cycle of 11-flight composite for **a** frequency of NPF occurrence and **b** $N_{2\text{-}5}$ concentrations (bins: 1km by 30min).*

Figure 2: Mean time to reach 10% of mean forcing region value at 500 hPa for Amazon, Africa, and Maritime Continent tracers.

Collaborations within TPChange

- A03 joint work package on downward transport in CAFE-BRAZIL case study
- C07 jointly designed climate experiments and model diagnostics applicable to MESSy
- C08 shared analysis on impact of convection representation on downward transport
- Z03 sensitivity exploration of ORACLE at cold temperatures of the UT & evaluation of generalised tagging in MESSy

Education:
Vieira Fischer (ongiong). MSc Thesis. GUF.

Results from phase I

CAFE-BRAZIL campaign activities

- new tool for online flight planning support
- analysis of contact to preceding convection prior to particle nucleation events
  - **Curtius et al., Nature, 2024**
- script for satellite-based air mass trajectories (Hernandez Pardo doi:10.5281/zenodo.10498508) and data set (Hernandez Pardo, doi: 10.5281/zenodo.7906798)

global transport analysis

- tracers from UT source region (200 - 300 hPa) reach 10% of initial value concentration in less than 7 days
- injection height dominant source of uncertainty of transport time scales over uncertainties from parametrised transport or particle size (20 - 100 nm range)

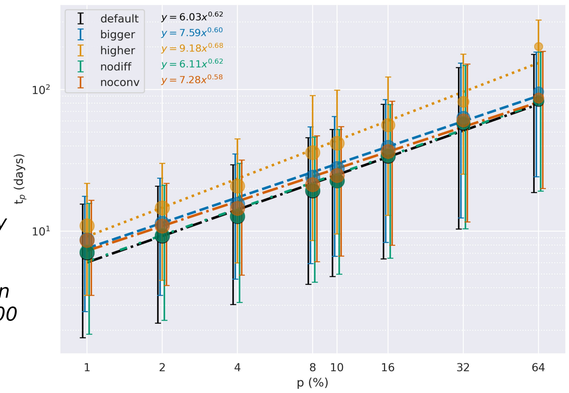

Figure 3: Sensitivity experiments of the mean time to threshold p of mean forcing region at 500 hPa for Amazon tracer.

Hernandez Pardo et al., subm. ACP

downdraft modelling

- Cloud-edge downdrafts (primarily mechanically forced) compensate 10-30% of updraft mass flux in growing cumuli

Hernandez Pardo et al., JGR, 2025

CAFE-BRAZIL model intercomparison

- submission and initial evaluation of km-scale case study for model intercomparison (in final stage)

Research plan phase II

Main goal: Quantify the contribution of UT NPF to tropical mid- and low-troposphere climatological CCN concentrations and to the tropical anthropogenic aerosol-cloud-radiative forcing.

objectives

- O1: Quantify the UT NPF contribution to tropical LT CCN concentrations in the pre-industrial, present-day, and end-of-century atmosphere.
- O2: Quantify the impact of UT NPF on tropical aerosol-cloud-radiative forcing.
- O3: Assess the impact of the model resolution on the downward transport in the upper and mid-troposphere in convection-permitting and convection-parametrising simulations.

methods

- O1 and O2: global 10-year timeslice simulations with EMAC for three climatological periods in coordination with C07
- O3: likely mesoscale (1-80 km) MECO(n) simulations in coordination with A03

milestones

M1 (March 2027)
sensitivity analysis & scenario design completed

M3 (June 2029)
impact of convection representation on downward transport timescales completed

01/2026 — 06/2029

M2 (June 2028)
climatological runs and CCN budget analysis and radiative forcing completed