Project Title

The importance of upper troposphere aerosol formation for low- and mid-troposphere aerosol concentrations

Project Leader/Project Administrator:

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Several field campaigns within the tropics (Andreae et al., 2018; Williamson et al., 2019) have demonstrated on a regional scale that upper-troposphere new-particle formation may contribute, or even dominate, low- and mid-troposphere cloud condensation nuclei concentrations. Williamson et al. (2019) showed using staircase flight observations obtained during AToM 1 and 2 that this could be the case generally throughout the tropics and sub-tropics. However, a clear source-apportionment and in-depth analysis of the relevant transport time-scales and mechanisms could not be obtained in the observations, or the associated numerical model experiments utilizing coupled aerosol-chemistry models of full complexity.

Thus, despite strong empirical evidence, we lack an in-depth, process-based analysis of downward aerosol transport at a global scale. In particular, the air mass history and thus the potential influence of lateral detrainment of pre-existing particles and condensable vapors remains unexplored. It is also unclear to which heights aerosol budgets are dominated by particles nucleated in the upper troposphere (UT) which grew upon descent, and from which heights boundary-layer-sourced particles also contribute. In addition, substantial (up to an order of magnitude) uncertainties are associated with new particle formation rates, condensation and coagulation growth rates, wet-removal efficiencies of condensable vapors and particles, particle transport mechanisms and characteristic transport timescales (Kanakidou et al., 2005). Williamson et al. (2019) showed that new particle formation seems to occur relatively homogeneously throughout the UT within the tropics. Yet it remains unclear whether low- and mid-trophosphere aerosol budgets are homogeneously impacted by UT-sourced particles throughout the tropics and whether this impact is limited to the tropics due to transport, chemical, or microphysical constraints.

Using the atmosphere-only version of the "Icosahedral Nonhydrostatic Weather and Climate Model" (ICON) we will assess the horizontal and vertical transport of newly-formed UT particles using idealized tracer experiments. This will allow us to clearly identify regions of increased exposure to secondary upper troposphere particles, before addressing these processes within a full-complexity modeling framework.

<u>References:</u>

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Kanakidou, M., J. Seinfeld, S. Pandis, I. Barnes, F. Dentener, M. Facchini, R. Van Dingenen, et al. (2005): Organic aerosol and global climate modelling: a review. ATMOSPHERIC CHEMISTRY AND PHYSICS 5, 1053–1123. doi: {10.5194/acp-5-1053-2005}.

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