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Annual cycle of Antarctic Baseline Aerosol: A Benchmark for Natural Aerosol Processes

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An ongoing challenge in attributing anthropogenic climate change is to distinguish anthropogenic and natural changes of atmospheric composition, e.g. concerning atmospheric aerosol and its climate effects. Aerosol properties measured at pristine locations, to the extend they still exist, can serve as a climate model benchmark for verifying the representation of natural aerosol processes in the model.

To this end, a recent study (Fiebig et al., 2013) investigates the annual cycle of the baseline aerosol observed at the atmospheric observatory of the Norwegian Antarctic research station Troll (Queen Maud Land, 72.0166 S, 2.5333 E, 1309 m a.s.l.). The aerosol monitoring program at Troll observatory includes the aerosol scattering coefficient at 450, 550, and 700 nm wavelength, and the particle number size distribution (PNSD, 0.03 μm $< D_p <$ 0.8 μm) (Hansen et al., 2009). The time series of both instruments, collected since Feb. 2007, show a distinct annual cycle of the aerosol properties associated with baseline air masses, i.e. those not corresponding to peaks of any origin. Comparison of the aerosol scattering coefficient measured by nephelometer and calculated from the DMPS measurements by Mie-theory assuming an $(NH_4)_2SO_4$ composition show a correlation coefficient of $\sim$ 0.8, confirming a common origin of both annual cycles. The same annual cycle in baseline aerosol scattering coefficient and particle number concentration / size distribution as found at Troll can be detected in corresponding data collected at South Pole and Dome C atmospheric observatories. This shows that the annual cycle of baseline aerosol properties at Troll isn't a local phenomenon, but common to Central Antarctic baseline air masses. Using backward plume calculation by the Lagrangian transport model FLEXPART, as well as ground-level ozone data collected at Troll, it is demonstrated that the air masses associated with baseline aerosol loadings at Troll originate from the free troposphere an lower stratospheric region and descend over the Antarctic continent. The Antarctic summer PNSD is dominated by particles with diameters $<$ 100 nm. Particles in this size range are recently formed from the gas-phase, and this despite the absence of external sources of condensible gases. Further, the aerosol property annual cycle includes a cycle of total aerosol particle volume. FLEXPART is used to calculate the integral solar irradiance the baseline air masses received prior to arriving at Troll. It is demonstrated that the total particle volume in Antarctic baseline aerosol is linearly correlated with the integral insolation the aerosol received on its transport pathway. It is shown also that the photo-oxidative production of particle volume is mostly limited by photo-oxidative capacity, not availability of aerosol precursor gases.

Given the large spatial extend and temporal stability of the observed annual cycle in the Antarctic baseline aerosol, it is proposed to use this annual cycle as benchmark test for natural aerosol processes in climate models, thus improving the distinction between natural and anthropogenic aerosol. Further research is proposed to investigate the correlation between solar irradiance and production of aerosol volume, and whether this correlation can be used also in other atmospheric compartments.

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References

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