Aircraft-based assessment of relationships between CCN concentration and aerosol optical depth

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Contrary to common assumptions in satellite-based analysis of aerosol-cloud interactions, ∂lnCCN/∂lnAOD is less than unity, i.e., the number concentration of cloud condensation nuclei (CCN) less than doubles as aerosol optical depth (AOD) doubles. This is explained by condensation, coagulation and cloud processing that either drive particles from the Aitken mode to the accumulation mode or separate these two modes. This paper reports on the relationship in local air masses between CCN concentration, aerosol size distribution and light extinction observed during airborne field observations (e.g., ARCTAS, INTEX-B). The CCN-to-local-extinction ratio, when averaged over 1 km distance and sorted by the wavelength dependence of extinction, varies approximately by a factor of 2. This, together with uncertainties in aerosol hygroscopicity, vertical profile and AOD retrievals, challenges AOD-based CCN estimates. However, these large differences in estimated CCN may correspond to a considerably lower uncertainty in cloud drop number concentration (CDNC), given the sublinear response of CDNC to CCN. We discuss implications on the use of visible and near-infrared AOD from nadir-view passive satellite sensors.