Aerosol measurements in fresh and aged outflow and vertical profiles during DC3 – first results

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Scientific objectives & questions

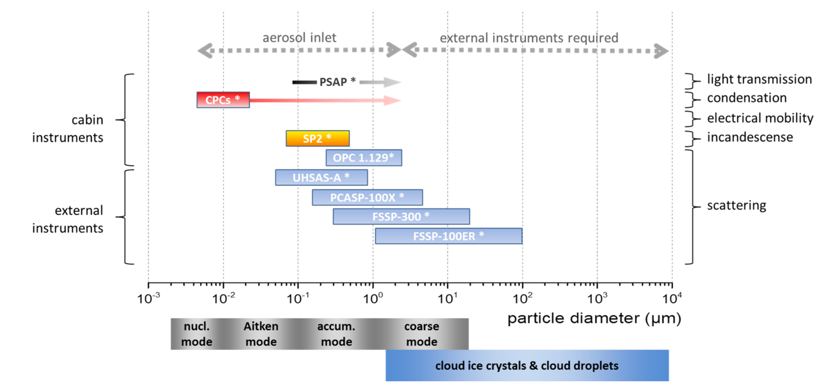
Main objectives

- to characterize **particle properties in the inflow and outflow** of convective cells
- to understand the **vertical redistribution** of air mass and aerosols by convective systems
- to study **particle formation processes** and the **evolution of aerosol** properties (change in size distributions) in the fresh and ageing outflow

Some questions

- How do particle size distributions and mixing state change between inflow and outflow regions?
- How does the pollution level in the boundary layer (inflow region) affect particle properties found in the outflow region?
- Which process dominates outflow aerosol properties?
  - wet removal of particles in the cloud system ("clean" outflow)
  - convective uplift of boundary layer aerosol (pollution signatures in outflow)
- To what extent (and why) does new particle formation occur in the outflow?

DLR Falcon aerosol microphysics instrumentation

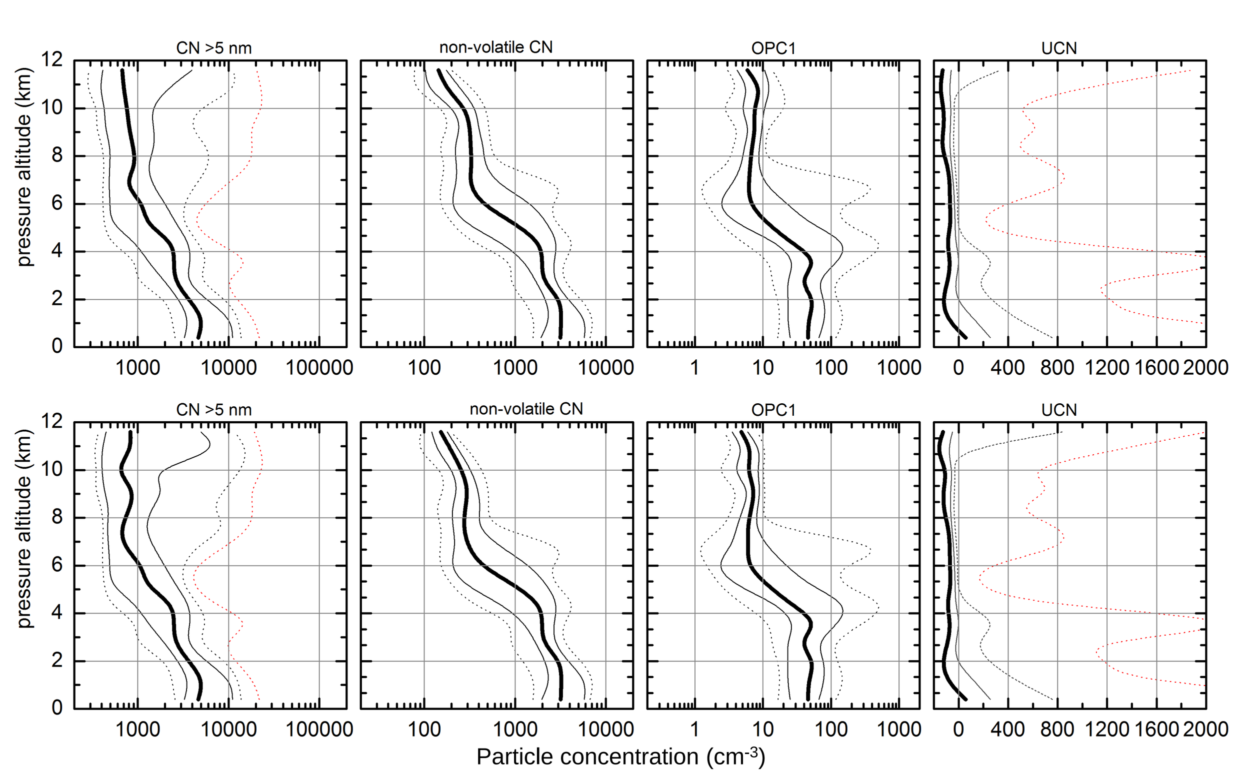


Left: Schematic of size ranges covered by the aerosol in-situ instrumentation onboard the DLR Falcon. Cabin instruments measured behind an isokinetic inlet sampling sub-2.5 µm aerosol.

Additional trace gas instrumentation included measurements of NO, CO, O_3, CO_2, CH_4, SO_2, and volatile organic compounds. Meteorological parameters such as pressure, temperature, humidity, and wind were recorded by the DLR-Falcon.

Target	Instrument
Total number concentration of aerosol particles	**4 x Condensation particle counter** (CPC) size range > 5 nm, >10 nm, total/non-volatile
Size distribution of PM2.5 fraction	**2 x Optical particle counter** (OPC) of type Grimm 1.129 (size range 0.25 - 2 µm), total/non-volatile
Non-volatile fraction	**Thermodenuder** (@ 250 °C) separating volatile/non-volatile matter for CPCs & OPCs
Absorption and BC mass	**3λ-PSAP & SP2**
Particle size distribution of dry aerosol	**UHSAS-A & PCASP-100X** (wing probes) size range 70-700 nm & 140-1000 nm
Size distribution of small ice crystals & coarse aerosol	**FSSP-100-ER** (wing probe) size range 1 - 95 µm in 4 user selectable ranges

Vertical profiles: All local flights & cloud detection



Median: black line, bold; 25%, 75% percentile: black line, thin; 10%, 90% percentile: dashed, black; 99% percentile: dashed, red

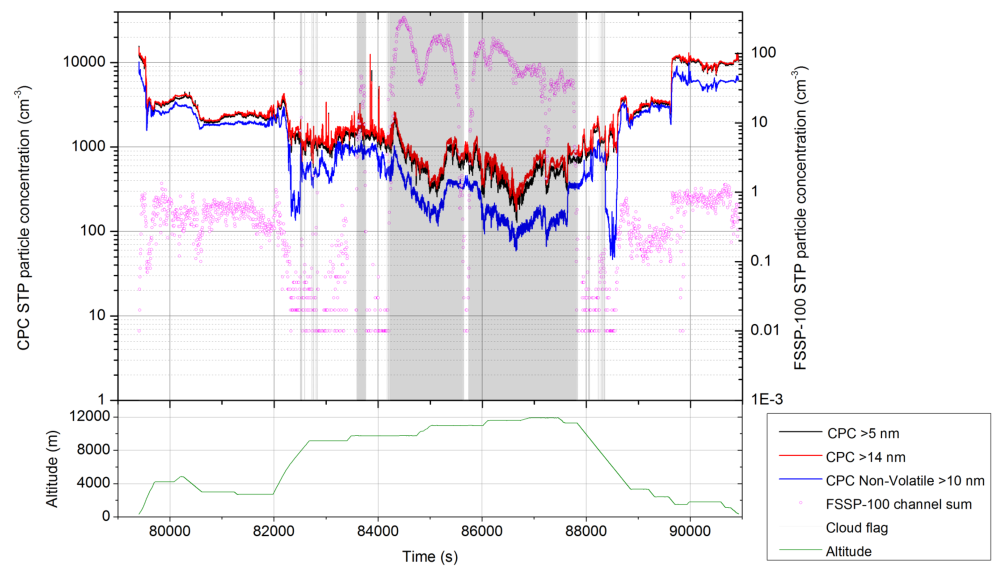
No cloud detection

Sensitive cloud detection <7 km & >1 cm^{-3} >7 km & >0.005 cm^{-3}

- Applied cloud detection method is based on FSSP-100 data for particle sizes >4 µm.
  - Below 7 km: particle concentration > 1 cm^{-3} to avoid detection of BB plumes/polluted air
  - Above 7 km: particle concentration > 0.005 cm^{-3} to exclude thin cirrus clouds
- Optimal method for cloud detection, especially for thin cirrus and the anvil region?

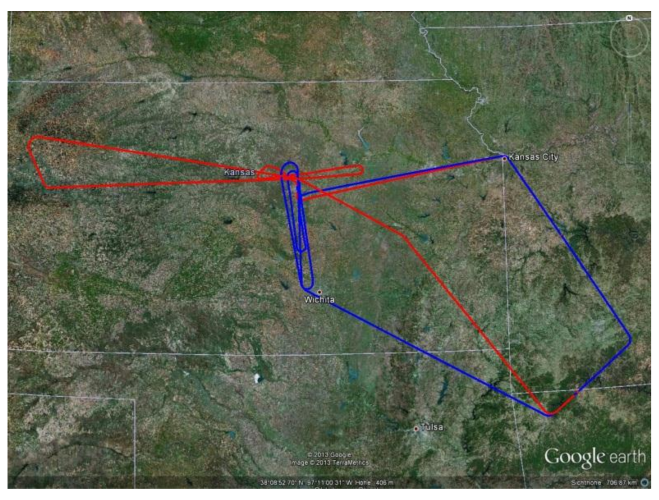
  - Sensitive cloud detection of thin cirrus or haze during climb (left) and descend (right) at 10.6 km altitude on June 8, 2012
- Nucleation events (UCN) detected on the double flight (aged outflow) on June 8, 2012.
- BB plumes enhance particle concentrations between 2 km and 6 km in nearly all 13 local flights.

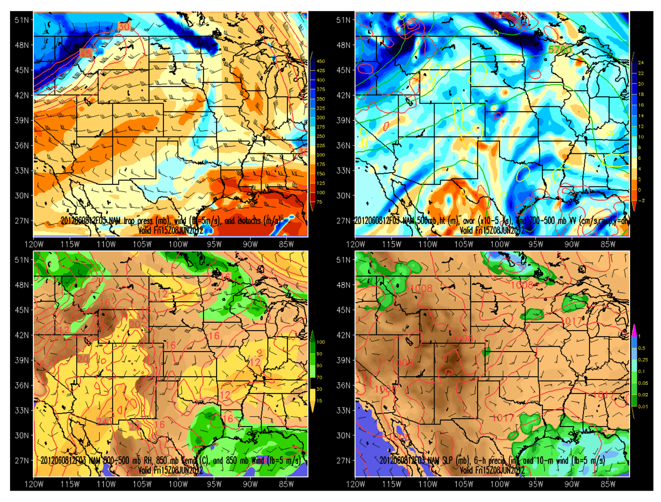
Fresh Outflow of Squall Line June 12, 2012



- Fresh outflow of squall line over the SE border Kansas on June 12, 2012.
- Particle concentrations in fresh outflow are lower than in aged outflow, e.g. flight on June 8, 2012
- Penetration of the anvil and outflow on multiple levels, mostly in clouds (shaded grey) with NO mixing ratios reaching up to 3 ppbv at the highest level at 12 km altitude.
- Measurement of pollution plume originated from Asia between 8 km and 10 km (SO_2, CO_2, CH_4 mixing ratios elevated, but not NO)
- During ascend and descend probing of BB plume below 5 km.

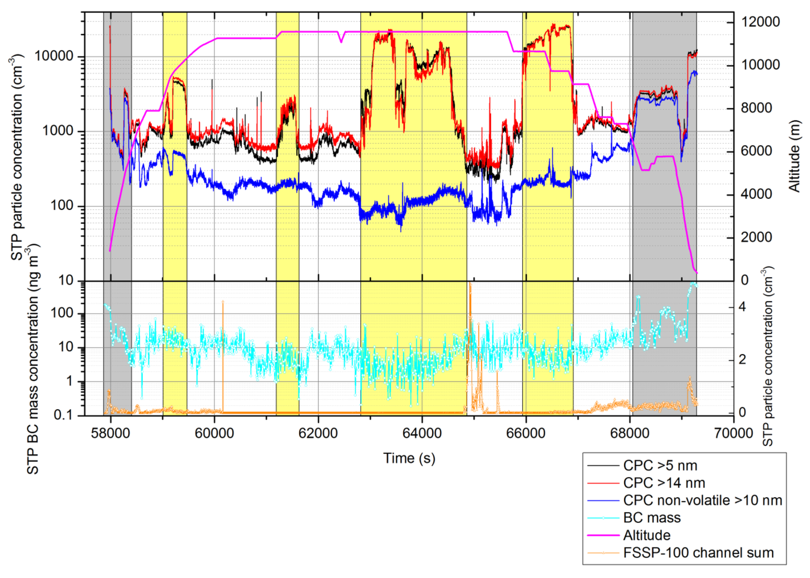
Aged outflow of CO thunderstorms on June 8, 2012

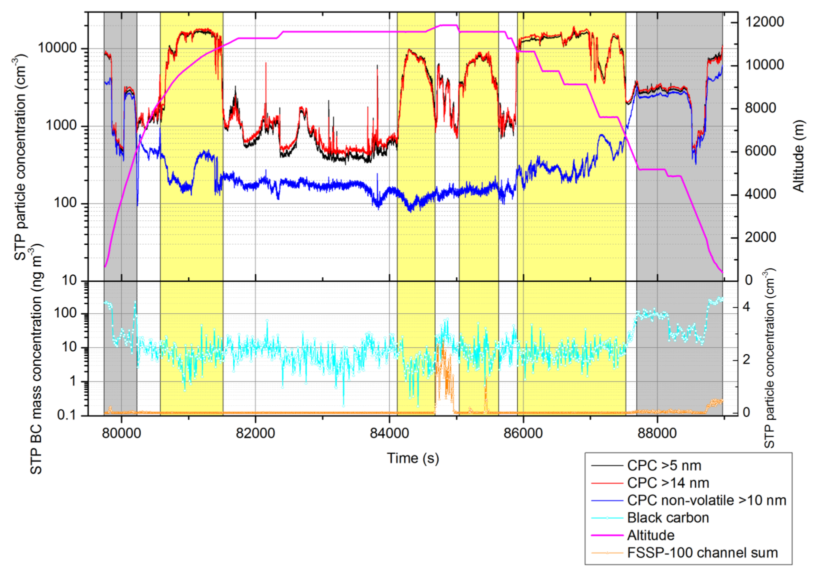


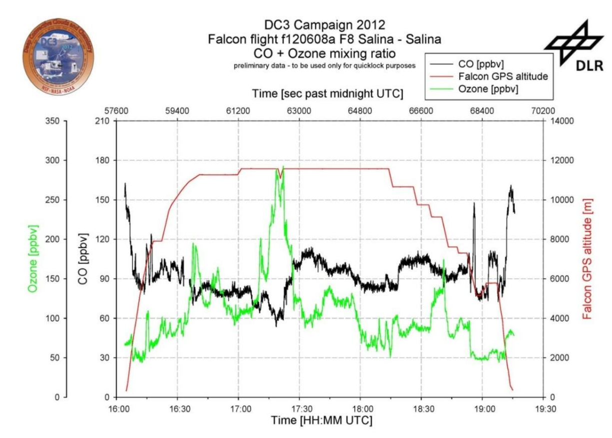


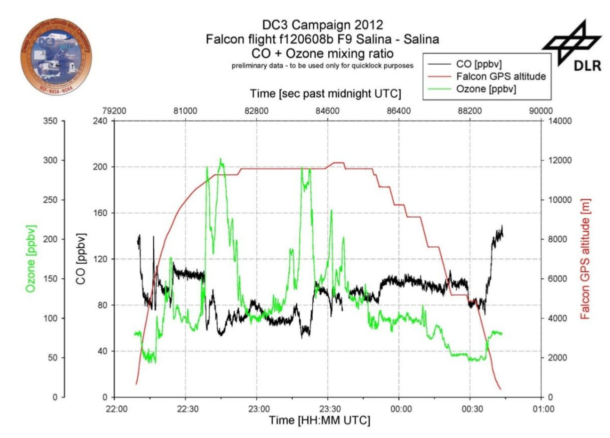
DC3 Field Catalog

Flight tracks of the flights 120608a (red) and 120608b (blue) and NAM forecast composite (valid for June 8, 2012) 15 UTC show a low tropopause moving over Kansas and southerly low level winds.









- Outflow age: 12-18 hours
- The maximum particle mass concentration was measured above 9 km altitude, exceeding the concentrations in BL and BB plume/polluted air layer roughly by a factor of two.
- NO mixing ratios are increased to ~1 ppbv, corresponding to the maximum in particle concentrations around 17:30 UTC (63000 seconds) as well as increased CO mixing ratios up to ~110 ppbv.
- Feature: local maxima of particle concentrations correspond with minima in BC mass concentrations (shaded yellow).
- Trends in the non-volatile particle concentrations and BC mass concentrations look similar.
- Both flights show polluted air with elevated BC mass concentrations as well as high particle concentrations below 6 km (shaded grey). This polluted air layer (age: 24- 36 hours) was probably advected from the Oklahoma region with the southerly low level winds.
- Both flights show the low tropopause with O_3 mixing ratios up to 300 ppbv similar to the NAM forecast.
- Aged outflow particle concentrations exceed fresh outflow particle concentrations.
  → New particle formation?
- The older advected polluted air between 3.7 km and 6 km shows a different chemical composition and lower but stable particle concentrations of ~3000 cm^{-3} in this layer.
  → Not processed by clouds and convection?