Transport and chemical conversion of air pollutants under convective conditions – Results of the COPS-TRACKS campaign

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Introduction:
In July 2007, the COPS-TRACKS campaign (Transport and Chemical Conversion in Convective Systems) was carried out in southwestern Germany in order to study the transport of atmospheric trace gases and aerosols under convective conditions. During TRACKS, the dilution of air pollutants around Karlsruhe, a city with moderate anthropogenic emissions, has been detected by coordinated measurements of ground based stations and different airborne platforms. We show results of measurements by the DO 128 (TU Braunschweig/IMK Karlsruhe), completed by a model simulation of COSMO-ART.

Measurement performance:
- Day of investigation: July 25, 2007
- Weather conditions: high pressure situation with 1/8 cloudiness and a maximum temperature of about 24°C. Wind from westerly directions between 3 ms⁻¹ and 8 ms⁻¹.
- In the lee of Karlsruhe, three aircraft and a zeppelin flew between 13:20 UTC and 17:40 UTC inside the convective boundary layer.
- The anthropogenic emissions of air pollutants mainly result from traffic and industry.

The correlation of O₃ and CO is split for the near and the remote lee area (Fig. 3), the borderline is set to 20 km away from the city emission sources (Fig. 2).

The regional model COSMO-ART:
- Horizontal resolution: 2.8 km. Start of simulation at 24/07/07, 0:00 UTC.
- Nested run: start with COSMO-ART in 14 km coarse grid resolution.
- Initial and boundary conditions for the coarse grid run were provided by GME (meteorology) and MOZART (chemistry).
- COSMO-ART shows relative high NOₓ values in north-east of France, reaching also the environment of Karlsruhe (Fig. 4).
- Positive correlation of O₃ and CO in the remote lee area: R² = 0.4, ΔO₃/ΔCO = 0.05 (Fig. 5).

Comparison of COSMO-ART and measurement data:
- Modelled O₃ concentrations are in the same magnitude as measured. However, eastward of Karlsruhe a tongue-shaped area shows O₃ concentrations ≈ 7 ppb lower than measured (Fig. 7).
- The O₃/CO-correlation of COSMO-ART is less distinctive than in the measurements.
- Modelled CO concentrations are higher than measured with an offset by about 35 ppb.
- Ozone precursors like NOₓ and CO are transported from France into the lee area of Karlsruhe (Fig. 4 and 7).

Summary - a case study:
- Moderate convective summer day » no significant city plume of Karlsruhe identifiable.
- In the near lee area of Karlsruhe no significant correlation between O₃ and CO » local emission sources determine the chemical conversion processes.
- In the remote lee area (distance to Karlsruhe = 20 km) a significant positive correlation between O₃ and CO » long distance transport of ozone precursors predominates local emission sources.
- Transport of NOₓ and CO enriched air masses from northeast of France to Karlsruhe.
- In complex terrain (Upper Rhine Valley), the predominance of either local chemical conversion or transport processes can even change at short distances inside the convective boundary layer.
- COSMO-ART is able to reproduce fine structures in gas distributions, but partly with slight temporal or local displacements (ozone).
- COSMO-ART combines information of the regional scale with highly resolved local effects » important tool for understanding measured trace gas distributions in complex terrain.

References:

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