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The Ozone Budget of the Berlin-Plume

Starting position

The local change of ozone mixing ratios is determined by the processes of advection, turbulent diffusion, chemical transformation and deposition. The typical magnitude of all these processes is ±10 ppb ozone per hour for central European emission- and weather situations. Discussing the quality of ozone predictions by Chemistry-Transport-Models (CTMs) means, not only looking on the total change of ozone mixing ratios, but to examine the contributions of the single processes on that local change.

Project aim

Determination of processes characterising the change of the local ozone mixing ratio inside and outside an urban plume in order to evaluate the quality of ozone predictions by CTMs.

Method

During the Berlin-Ozone-Experiment 'BERLIOZ' in summer 1998 ground-based and airborne measurements of meteorological and chemical parameters were made windward of Berlin, over and in the lee of the city. The contributions of advection, turbulent diffusion as well as the local change of the ozone mixing ratios were calculated using data measured during boundary layer stratification of different stability on horizontal measuring paths parallel to the mean wind in heights of 370 m, 680 m and 990 m asl upstream and downstream of Berlin. The chemical transformation is seen to be the residuum of the measured processes.

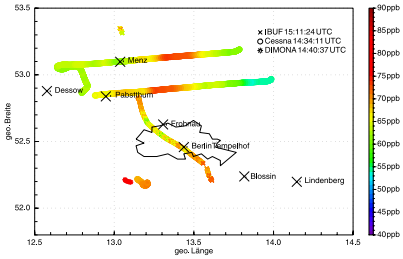
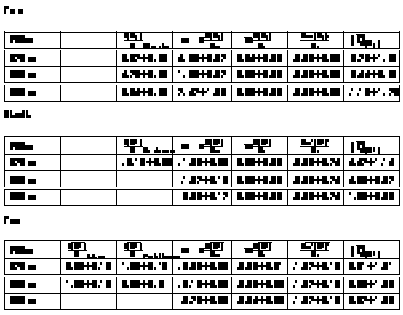


Fig. 1: Ozone mixing ratio measurements by three aircraft in the area of Berlin between 300 and 500 m asl in the afternoon of July 20, 1998.



Tab. 1: Components of the ozone budget at three levels in the area of Berlin (windward/Luv, city/Stadt, and lee/Lee) on July 20, 1998 at 14.30 UTC. The results were calculated with the budget method.

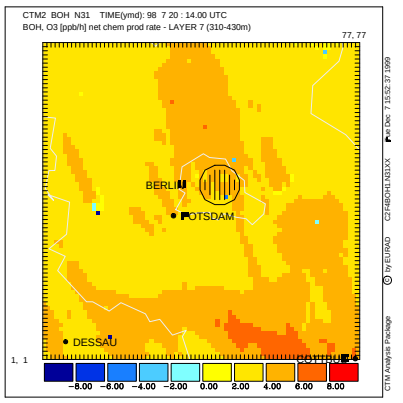


Fig. 2: Ozone production rates in the area of Berlin on July 20, 1998, at 14 UTC between 310 and 430 m agl, calculated by Memmesheimer, Universität zu Köln, using the EURAD model.

Results

Between 13 and 16 UTC on July 20, 1998, with southerly winds an ozone plume developed in the lee of Berlin about 30 to 70 km north of the city. While 55 ppb ozone where detected at the windward side, about 70 ppb were measured in the plume within the 1500 m high mixing layer (Fig. 1).

Upstream the city an increase of ozone of 5.4 ppb h^{-1} is calculated, caused by horizontal advection of 4.5 ppb h^{-1} in the lower 1000 m of the atmosphere. Mean vertical transport, turbulent diffusion and production of ozone are very small (Tab. 1).

Over the city, the change of ozone is near zero. Negative advection of -1.0 ppb h^{-1} and downward turbulent diffusion of -2.7 ppb h^{-1} are compensated by a production rate of 3.5 ppb h^{-1}.

On the lee side of the city a local increase of ozone of 1.8 ppb h^{-1} is detected, resulting from negative advection of -3.6 ppb h^{-1} and negative turbulent diffusion of - 1.1 ppb h^{-1}, which both are overcompensated by an ozone production of 6.5 ppb h^{-1}.

This production rate agrees well with the value of 7.5 ppb h^{-1} calculated by Mihelcic, FZJ, for the Papsthum ground station at the western edge of the ozone plume.

Numerical simulations with EURAD by Memmesheimer (Fig. 2), result in values of about 4 to 6 ppb h^{-1} ozone production between 230 and 720 m agl at 14 UTC within the plume. Over the city production rates of 0 to 4 ppb h^{-1} are calculated while at the windward side the production rate is about 2 ppb h^{-1}.