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Vertical distribution of atmospheric constituents above complex terrain - Influence of a mesoscale system

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Measurements in and above the planetary boundary layer (PBL) are essential to fully understand the exchange and transport processes between the PBL and the free troposphere (FT). Here we discuss the impact of a mesoscale system on the local trace gas and particle distribution above the PBL over hilly terrain.
During the field campaign PARADE (PArticles and RAdicals: Diel observations of the impact of urban and biogenic Emissions) in August and September 2011 measurements were conducted at the Taunus Observatory on Mount “Kleiner Feldberg (KF)” (825 m asl.), about 20 km northwest of Frankfurt am Main in Germany. For the vertical composition of the lowest 3000 m, high-resolution measurements were performed using 174 radio soundings. The measurements are complemented by continuous boundary layer observations of a ceilometer and a variety of reactive tracers (CO, NO_x, O_3, VOCs) on the mountain top. In addition, aircraft measurements of CO_2, CO, O_3, temperature, humidity and aerosol number concentration and size distribution were performed during the first week of September.
The PBL height varied during the measurement campaign between 1 and 2.5 km. The variations are due to very changeable weather, synoptic fronts as well as local phenomena such as low clouds and fog. The analysis of the data from different instruments shows good agreement in determining the boundary layer height under windless high pressure conditions, as well as with certain restrictions on cloudy and windy days. Based on the PBL investigation, the aircraft-based trace gas measurements were used to identify transport and exchange processes between the free atmosphere and the boundary layer, additionally supported with high-resolution backward-trajectories initialized every 10 seconds along the flight track, based on the wind fields from the COSMO-EU model.
On 2 September 2011 we observed an enhanced particle number concentration and low ozone in the free troposphere at two flights around KF. Local transport can be excluded, in contrast, the origin of the trajectories shows, that the probed air masses were lifted from the ground over mid-France about 24 hours prior to the measurements. We conclude that this uplift is related to the passage of a warm front.