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Observational and numerical study of the nocturnal stratification evolution of the lower troposphere after a sea-breeze day

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The structure of the lower troposphere and vertical ozone concentrations have been studied in a post-sea-breeze atmosphere and over an industrialized coastal area of the North Sea. During this campaign, ground-based remote sensing systems (lidar and sodar) were deployed over the city of Dunkerque, in the North of France, together with surface meteorological and air quality network stations. The measurements were interpreted by means of simulations of non-hydrostatic atmospheric model MESO-NH.

After the sunset, the structure of the lower troposphere changed considerably and became increasingly complex. We observed a multiple-layer structure between 200 m and 400 m with high ozone concentrations. The mechanism of this phenomenon has been deduced from numerical simulations.

In the middle of the night, the change of the synoptic wind direction resulted in a ramification of the advective atmospheric boundary-layer into two different residual layers. Above the gravity current, an air mass consisting in horizontal multilayer structures was observed at an altitude between 400 m and 800 m. The numerical simulations revealed a relationship between these structures and the vertical profiles of meteorological parameters such as wind speed, water vapour mixing ratio and potential temperature. The origins of these structures were obtained by means of Lagrangian backtrajectories of passive tracers.

Simultaneously a stable double-layer structure has been detected by the lidar, near the ground, from the surface to 200 m. This structure persisted until the morning and inhibited the development of the mixing layer. We showed that a presence of the double-layer structure may lead to high pollution concentrations near the surface at night in the industrialized coastal area.