3. Model Setup and verification

Meso-NH is a non-hydrostatic mesoscale model, jointly developed by Météo-France, the French National Weather Service, and the Laboratoire d’Aérologie (http://meso.meteo.fr). A description of the standard version of Meso-NH may be found in Lefèvre et al. (1998). The model is used here with grid nests in the standard configuration, with several parameterizations: FISBA surface scheme, urban surface scheme, ECMWF radiation scheme. 3D turbulence for low horizontal resolution fields. 3D turbulence and large-eddy simulation mode for the highest horizontal resolution field. The initial and boundary conditions as well as the sea-surface temperature were initialized from the meteorological archive of ARPEGE model outputs. The model inputs are the prognostic variables, initiated with large-scale models. These variables are the wind components, the potential temperature and the mass mixing ratio of the water vapor, and the surface and rain field. The surface turbulent fluxes of heat, moisture and momentum were calculated with the help of transfer coefficients that depend on the wind and the surface stability.

The detailed description of simulations can be found in Talbot et al. (2007). The simulations were done with three nest models (see Fig. 2), starting from September 15, 12:00 UTC to September 16, 12:00 UTC. The largest domain with low horizontal resolution (10km) covers the north of France, south-eastern England and part of Belgium, and spreads over 400km from north to south and 400km from east to west. The second domain is centered on the northern part of the Nord - Pas-de-Calais region and has a 2.5km resolution covering a 120km by 200km area. In our study, the sea-breeze phenomenon corresponds to the local development of a near-surface wind. The domain of highest horizontal resolution (500m) was modelled on Dunkerque with 50 by 50 grid mesh points and a 2-s timestep. The vertical grids included 50 levels up to 8,800m a.s.l. with a first level at 30m. The studied area is extremely flat; the maximum altitude in the local topography of the 500m resolution domain does not exceed 30m a.s.l.

To simulate the pollution transport two techniques were employed - passive tracers and Lagrangean parcels. The first allows to simulate the effect of the pollution transport and dispersion, while the second one helps to draw the Lagrangean trajectories from the background winds to find the source of pollution and to analyze the origin of air mass.

Model outputs was verified by the available in-situ and remote sensing data (fig. 3, 4 and 5). At fig. 3 we present a comparison of simulated temperature and humidity with meteorological ground stations data in Graveline. The model error is comparable with difference between the measurements of monostationary sondes and the available atmospheric layers derived by lidar. The wind time-height section for the whole period of simulation is presented at fig. 4a below. This data was brought into comparison with available sodar measurements (see fig. 4b). In the regions above 200m, where the model understimates the wind speed, the sodar measuring errors are also significant. Finally, the conclusion of the done, that the model sufficiently reproduces the local dynamics.

6. Conclusions and perspectives

The model results and the measurements identify an increase of turbulence and maximal vertical ascents in the vicinity of the sea-breeze front (fig. 5a, 6a and 6b). The sea breeze abruptly reduced the mixing layer depth from AABL at 1,000-1,100 m to the TBL depth at 90m (fig. 5a). Both the TBL and the AABL heights were strongly dependent on the presence of the TBL (fig. 5b, c), which decreased continuously until its disappearance at night. The top of the TBL was characterized by loss of water vapor and high potential temperature gradient. The altitude of high values of humidity predicted by the Mesoc-NH model corresponded to the gravity-current (GC) top observed by the lidar. The TBL trapped and mixed the pollutants emitted from the ground, while the gravity current transported this air mass horizontally inland (fig. 6a). The sea-breeze front is determined by the model. After the sunset, the structure of the lower troposphere changed considerably and became increasingly complex. We have observed two residual layers (RL1 & RL2), heterogeneous layers (HL1 & HL2) and a double structure layer located near the ground (SSL & SUL). This double layer structure may play a significant role in the development of the mixing layer and influence the accumulation near ground of primary pollutants.

References

