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# COMPARABILITY OF MOBILE SENSOR BOUNDARY LAYER MEASUREMENTS WITH LAGRANGIAN PARTICLE MODELLING

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**Summary**

Airborne meteorological and air quality measurements have been collected by a SkyArrow/ERA aircraft flying around a waste incinerator. The fast-response instruments equipping the airplane allowed to monitor the buoyant plume dispersion up to a height of about 500m a.g.l. Relying on a sound emission estimate based on data provided by the incinerator continuous emission monitoring system (CEMS), the atmospheric dispersion of pollutants was reconstructed through the application of a Lagrangian particle model. The model satisfactorily simulated the plume track and its horizontal dispersion, while concentration peaks where underestimated, highlighting problems in comparing nearly-instantaneous measurements with model estimates representative of longer time averages. Difficulties arising from the interpretation of fast moving sampling and its comparison with boundary layer models are discussed and possible approaches to address the problem are proposed.

**Introduction**

The use of moving sensors to probe meteorological variables and pollutants concentration in the atmosphere are rapidly spreading thanks to the availability of lightweight and low-cost measuring devices. Moreover, the possibilities offered by unmanned aerial vehicles and small airplanes make airborne monitoring affordable for local air quality investigations. The need to analyse pollutant concentration variability along the aircraft track however limits the applicable time-averaging period to few seconds. This approach, in principle, does not guarantee the comparability of mobile sensors measurements with ground based monitors providing hourly average measurements (e.g. Mylne and Mason, 1991) and with dispersion models based on Reynolds averaging or on the statistical description of the atmospheric turbulence. Possible discrepancies are expected to be larger with increasing instability in the atmospheric boundary layer, when the time scales of the largest turbulent eddies increase to the order of one hour. The problem has been investigated through a case study where $CO_2$ airborne measurements have been compared with the Lagrangian particle model SPRAY results.

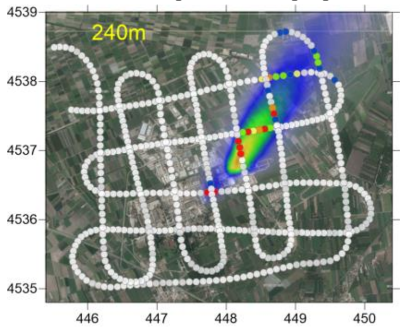


*Fig.1 $CO_2$ (ppm) modelled concentration fields compared with aircraft measurements at about 240m a.g.l. on 27/07/2016*

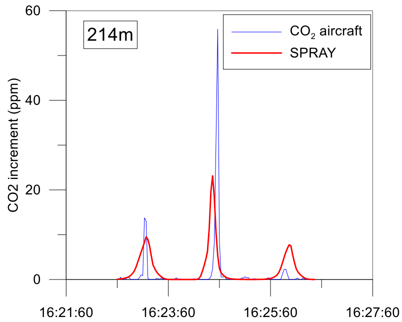


*Fig.2 Comparison of modelled and measured concentrations along the flight track on 05/07/2016 at about 214m a.g.l.*

**Methodology and Results**

An advanced monitoring program set up to assess the environmental impact of a waste incinerator allowed to collect airborne meteorological and pollutants measurements by means of a SkyArrow/ERA airplane. The aircraft equipment included high frequency sensors measuring wind components, temperature and $CO_2$ concentration at 50 Hz frequency. The flights plan has been finalised to monitor the buoyant plume dispersion in the area surrounding the incinerator stack up to a height of about 500m a.g.l., while ancillary profiles up to 1500 a.g.l. were performed to complete the boundary layer diagnostic. Preliminary analyses of measured $CO_2$ concentrations indicated 2s as the proper time averaging period to identify the incinerator footprint along the aircraft trajectory. Local meteorology was diagnostically reconstructed from aircraft measurements and pollutants emissions were estimated on the basis of data acquired by the incinerator continuous emission monitoring system. The Lagrangian model satisfactorily described the plume track and its horizontal dispersion at all the heights covered by the flights (Fig. 1). Measured peaks were identified but often underestimated (Fig. 2) and significant concentration values were detected at heights above those predicted by model simulation and by the expected plume rise. High concentration detected by the airplane over limited space areas at elevated height could be attributed to the transport of updrafts occurring in convective conditions.

**Conclusions**

The model well described the plume trajectory, while underestimated peak measured concentrations. A generalisation of the peak-to-mean concentration ratio, usually applied to estimate surface sources fluctuations, seems necessary to compare model results with short-time averages provided by moving sensors and to obtain longer time average concentration estimates from those measurements. Alternatively, LES techniques could be applied to reconstruct the observed concentration values.

**References**

Mylne K.R., Mason P.J. 1991. Concentration fluctuation measurements in a dispersing plume at a range of up to 1000m. Q. J. R. Meteorol. Soc. 117, 177-206.