Running the SILAM model comparatively with ECMWF and HIRLAM meteorological fields - a case study in Lapland

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This modelling study is based on the aerosol measurement campaign carried out in April-May 2003 in the Värriö monitoring station in Finland, Eastern Lapland, close to the border with Russia (Ruuskanen *et al.*, 2004), 67°46'N, 29°35'E.

On the generally low aerosol background of Arctic spring a few pollution episodes were observed (Figure 1). There we will focus to the highest of them, up to 30 mg/m^3 of PM10 at May 2-3.

First, the SILAM model (Sofiev *et al.*, 2006) was applied in adjoint mode to identify the sources of pollution. It was found that the aerosol peak of May 2-3 most probably originated from the Nikel metallurgy factory at Kola Peninsula, Russia, about 200 km North from Värriö. Then SILAM was applied in direct mode comparatively with ECMWF and HIRLAM (FMI) meteorological datasets (EMEP emission data on sulphate and PM). The well-tested Lagrangian kernel (version 3.7) and new Eulerian kernel (test version 4.0 released late 2006, heavily under construction) of SILAM were applied with both datasets, thus producing four comparative runs.

In large scale the concentration patterns produced in all four runs were rather similar, but some differences concerning the May 2-3 peak appeared critical for local measurement-modelling comparison (see Figure 2):

- the Lagrangian plume with ECMWF data missed the monitoring station;
- the Lagrangian plume with HIRLAM data matched the monitoring station;
- the Eulerian plume with ECMWF data matched the monitoring station;
- the Eulerian plume with HIRLAM data missed the monitoring station.

Surface-level concentration maps of sulphate computed with (Lagrangian) SILAM 3.7 are presented in Figure 3. The run with ECMWF data set gives a narrow plume directly to south from Nikel, which misses the Värriö site just by one grid cell (20 km). The run with HIRLAM data forces the plume to pass first to South-South-West and then, after the turn of wind, over to east over Värriö.

In general, the Eulerian scheme (version 4) produced much wider horizontal spread than the Lagrangian one (Figure 4), despite the higher concentration peaks. The run with ECMWF data putted the sulphate cloud directly to Värriö, but HIRLAM meteodata forced it to go eastwards and miss Värriö

Differences were found in vertical spread as well. In the Lagrangian run (Figure 5) the concentration fields in the lower free troposphere followed the surface-level concentrations in general, but in Eulerian case (Figure 6) the higher-level modelled concentrations were much lower (in agreement with high surface concentrations) and runs with the ECMWF and the HIRLAM data gave the plumes propagating in almost opposite directions in respect to each other.

The reasons of large differences are under research yet. The weather situation during the May 2-3 peak was complicated due to a high-pressure system with centre located close to the monitoring site. Thus, wind was weak, changing rapidly in space and time. In such conditions small discrepancies in both meteorological fields and ways to treat these in the dispersion model become essential.

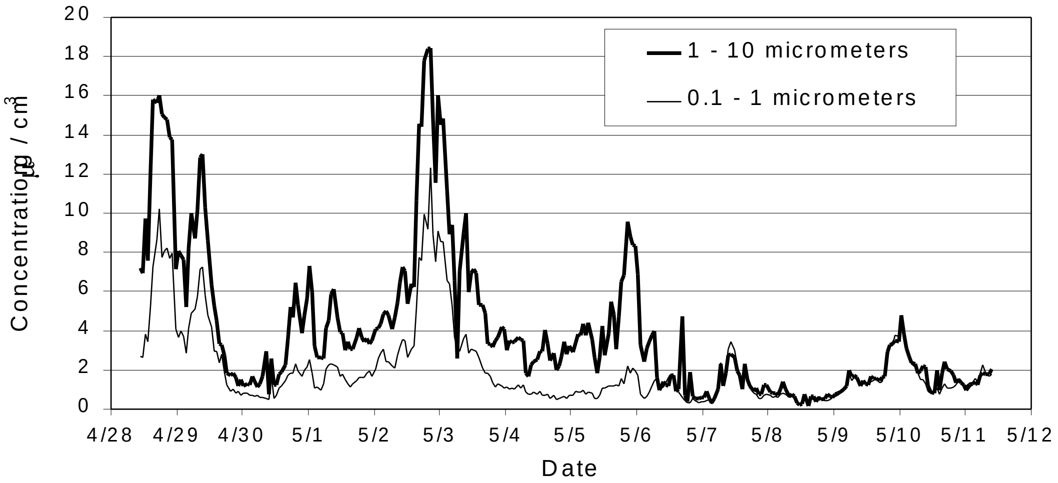

Figure 1. Measured surface-level concentrations of PM10 and PM1 in Värriö, 2003.

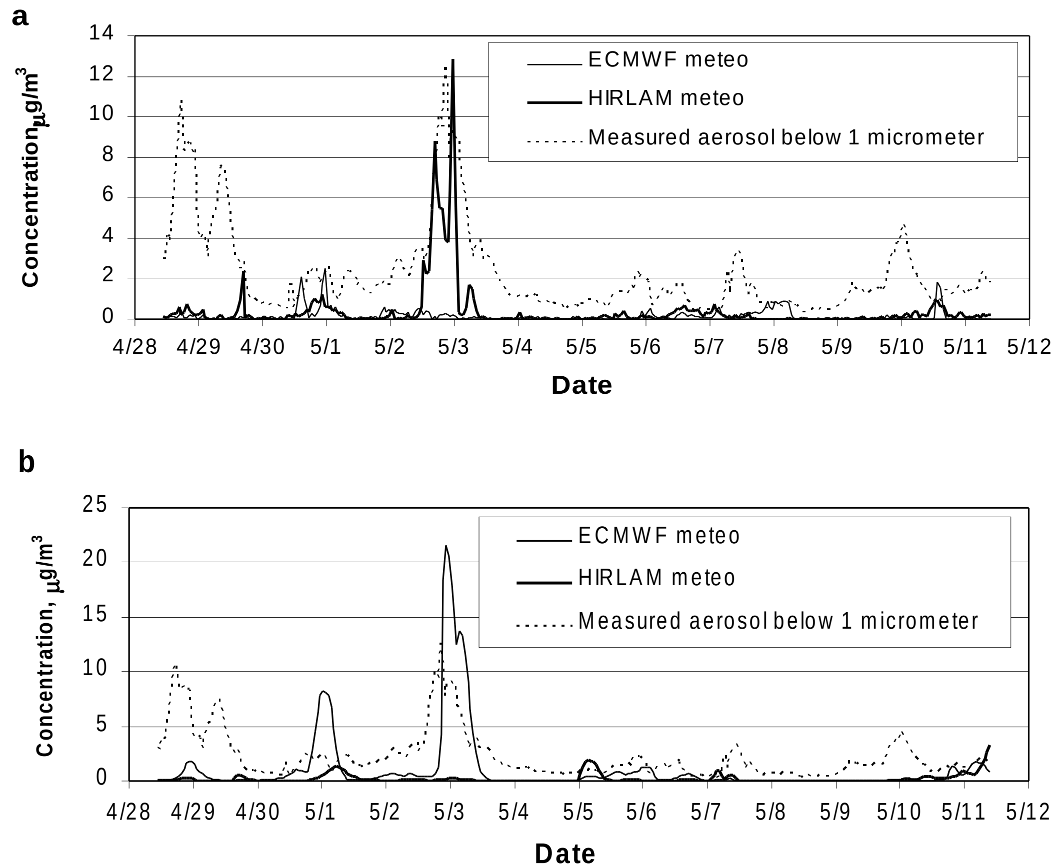

Figure 2. Surface-level concentrations of sulphate in Värriö, modelled with SILAM 3.7 (a) and SILAM 4 (b) with ECMWF and HIRLAM meteorological input, compared to the measured concentrations of aerosol particles with diameter below 1 m.

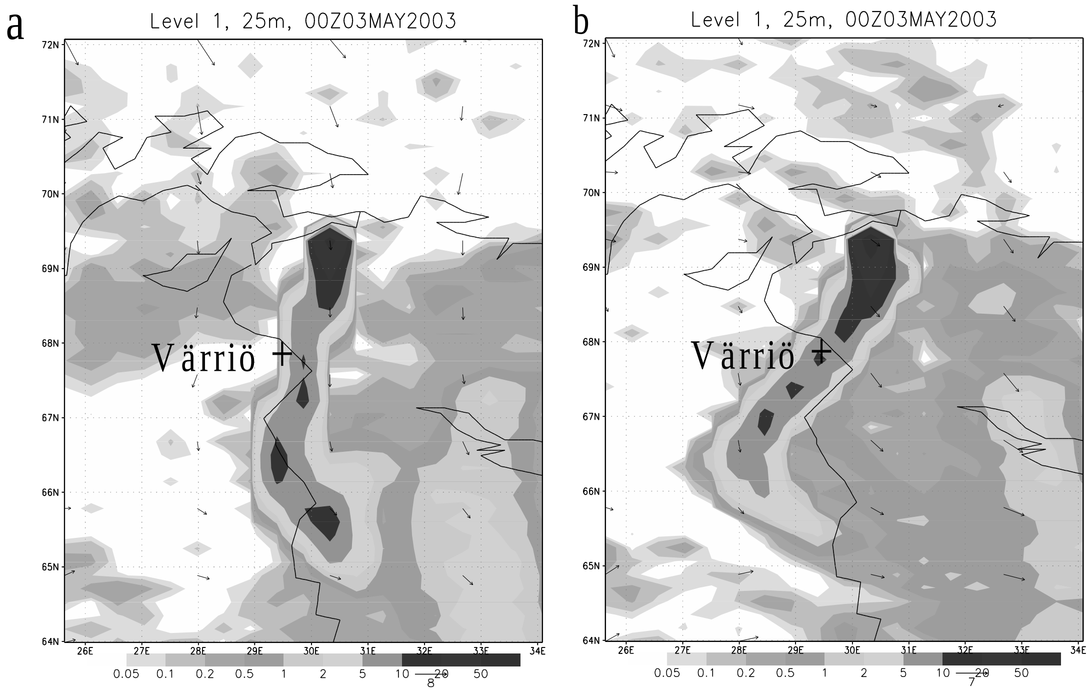

Figure 3. Surface-level concentration fields of sulphate, 0:00 at May 3, 2003, calculated with Lagrangian SILAM 3.7: a) with ECMWF meteorological fields, b) with HIRLAM (FMI) meteorological fields. Arrows – wind at 25 m.

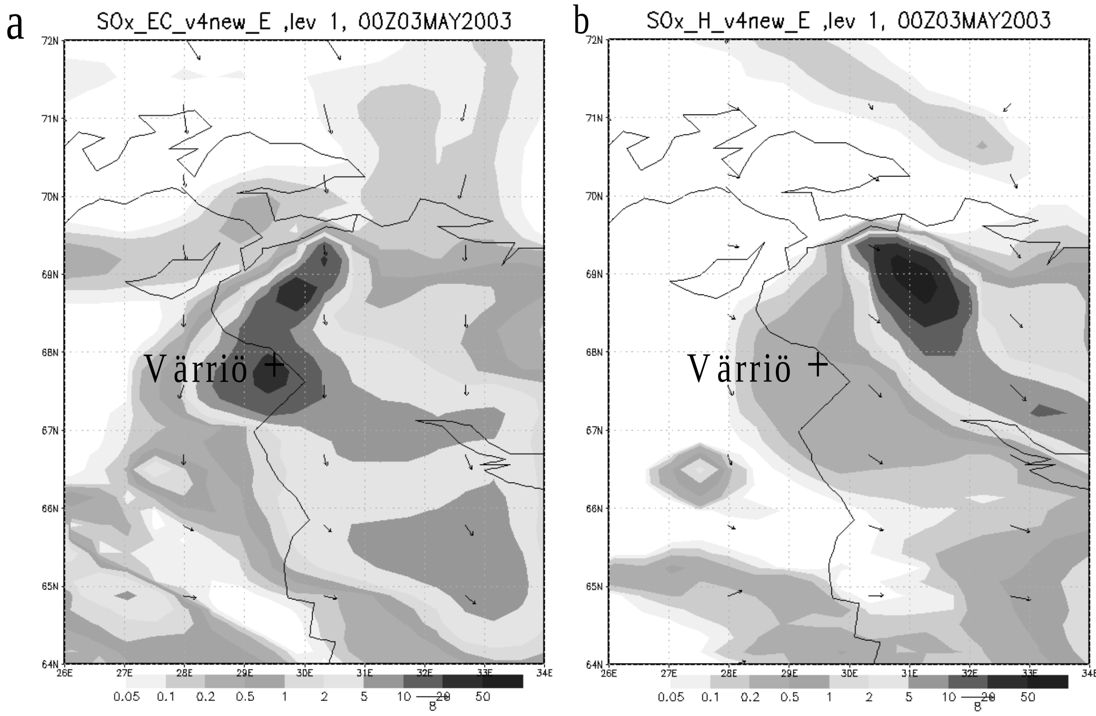

Figure 4. Surface-level concentration fields of sulphate, 0:00 at May 3, 2003,

calculated with Eulerian SILAM 4: a) with ECMWF meteorological fields, b) with HIRLAM (FMI) meteorological fields. Arrows – wind at 25 m.

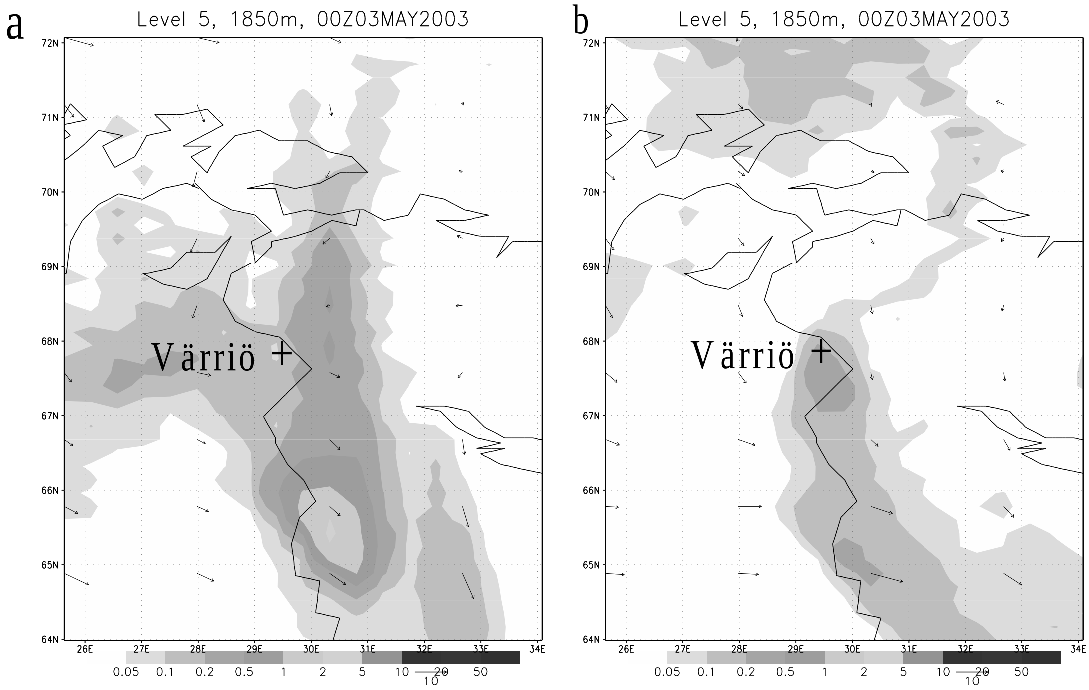

Figure 5. 1850 m fields of sulphate, 0:00 at May 3, 2003, calculated with Lagrangian SILAM 3.7: a) with ECMWF meteorological fields, b) with HIRLAM (FMI) meteorological fields. Arrows – wind at 1850 m.

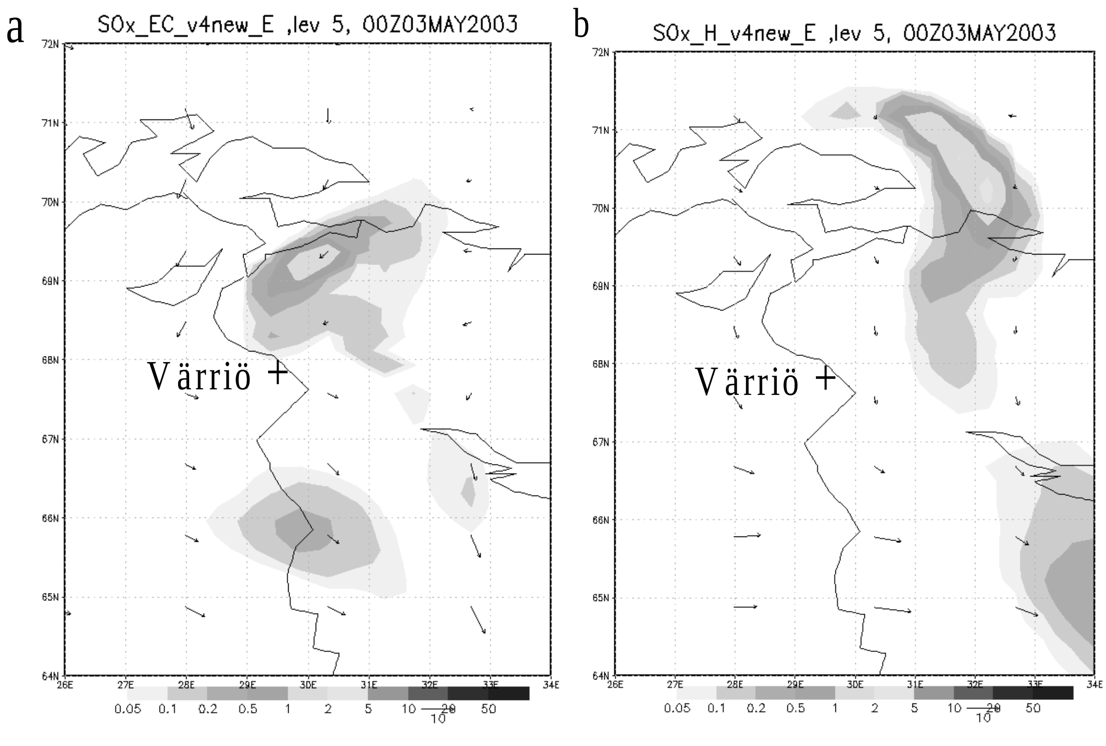

Figure 6. 1850 m fields of sulphate, 0:00 at May 3, 2003, calculated with Eulerian SILAM 4: a) with ECMWF meteorological fields, b) with HIRLAM (FMI) meteorological fields. Arrows – wind at 1850 m.

We learn from this exercise that both nearly correct and severely wrong predictions for a single-point measurement can be done by several ways. Moreover, interaction between a NWP and an AQ model produces non-linear effects for the accuracy of end results.

References

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