THE INFLUENCE OF AEROSOL PROCESSES IN VEHICULAR EXHAUST PLUMES:

MODEL EVALUATION AGAINST THE DATA FROM A ROADSIDE MEASUREMENT CAMPAIGN

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Introduction

- Previous work
  - Pohjola, M A, Pirjola, L, Kukkonen, J, Kulmala, M. 2003. Modelling of the influence of aerosol processes for the dispersion of vehicular exhaust plumes in street environment. Atmospheric Environment, 37, 3. pp.339-351.

    Focus was on the importance of various aerosol processes

- This study: the evaluation of model predictions with measurements

The approach

Measured meteorological data

Measured traffic flow

Measured urban background concentrations

Measured exhaust aerosol number distributions and compositions

Meteorological pre-processing model MPP-FMI

The roadside emission and dispersion model CAR-FMI

Aerosol process model MONO32

Mobile laboratory van measurements: aerosol number concentrations

Model predictions of aerosol number concentrations, and composition

Mobile laboratory

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for SMPS
- silicagel airdryer
- particle filter

ELPI
7 nm -10 um

SMPS
- DMA
- UCPC

UCPC

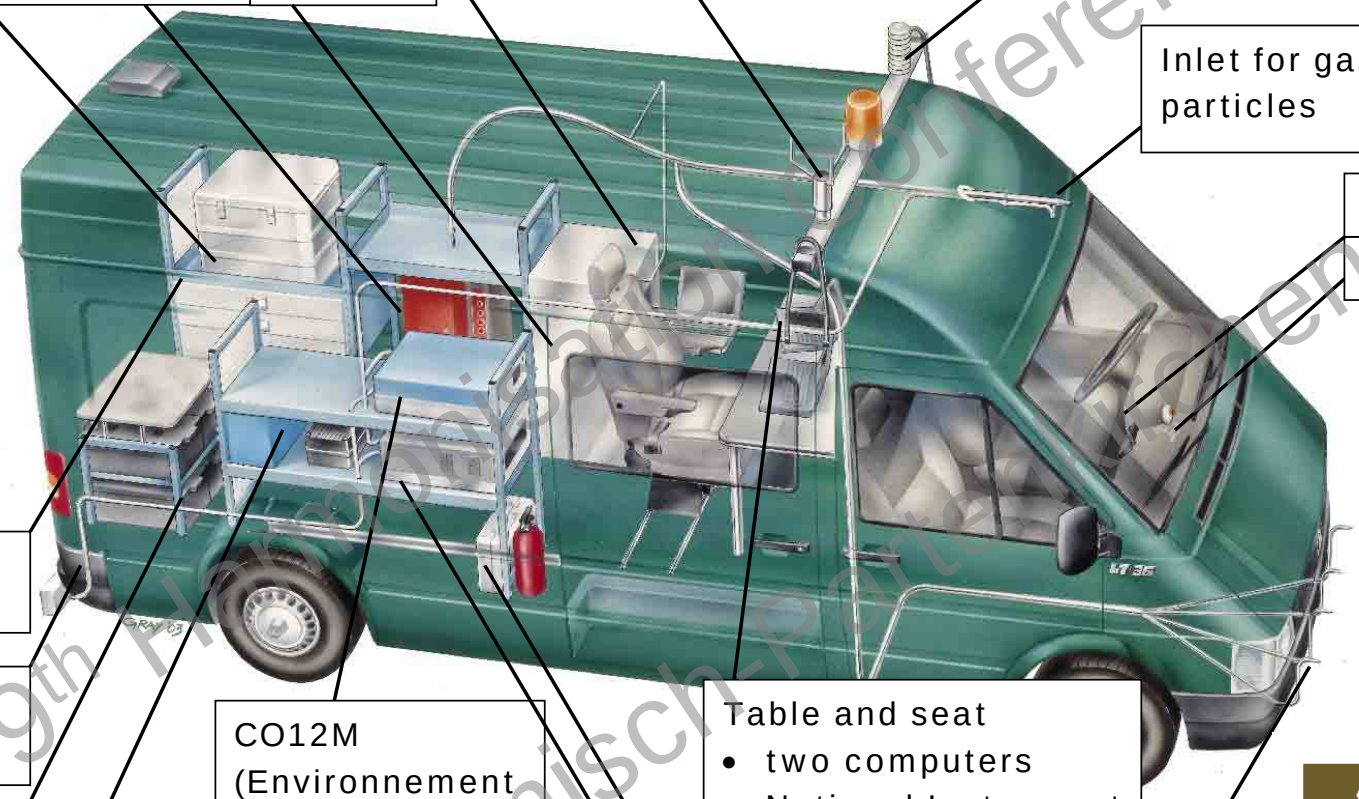
VAISALA WAS425AH –wind sensor
- wind speed
- wind direction

VAISALA HMP45A sensors
- relative humidity
- air temperature

Inlet for gases and particles

Garmin GPS V

Video camera



Tools

Outlet for analysers

Batteries

Victron energy Phoenix multi-inverter

CO12M (Environnement S.A) CO -analyser

APNA-360 (Horiba), NO, NO_2 and NO_X -

Table and seat
- two computers
- National Instrument connector block

Gilian Gilibrator 2, for flow measurements

Inlets for chasing

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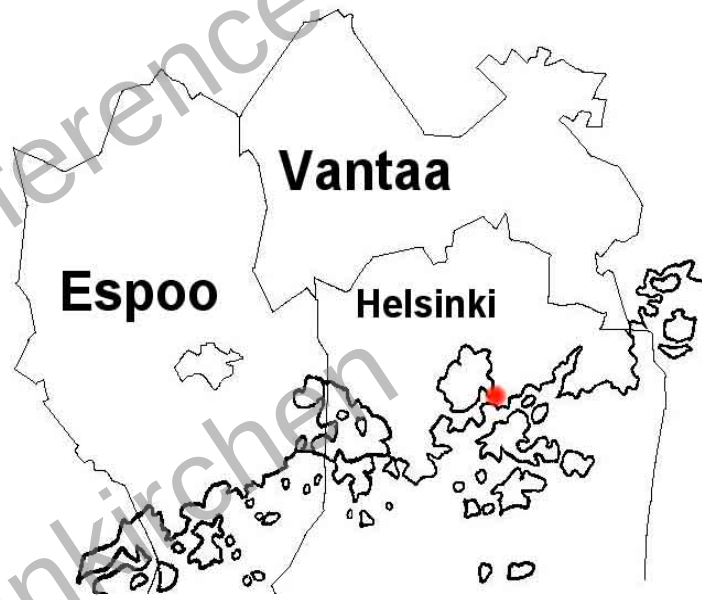
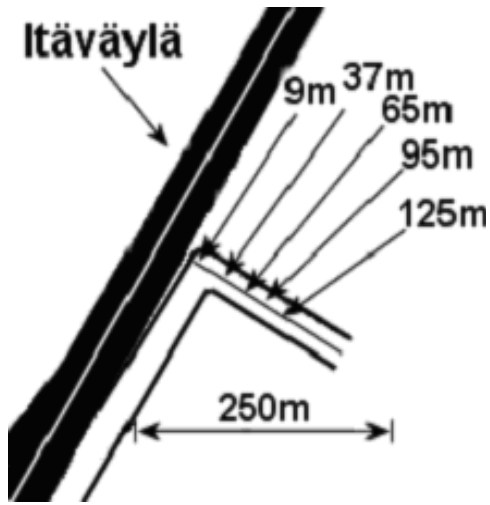
The measurement campaign

- Particle size distribution measurement at a height of 2.4 m:
  - Electrical Low Pressure Impactor: 0,07 nm – 10 μm (aerodynamic diameter)
  - Scanning Mobility Particle Sizer: 3 – 50 nm (mobility diameter)
  - Condensation Particle Counter: total number concentration of particles larger than 3 nm
- Met measurements at a height of 3.4 m:
  - Relative wind speed & direction
  - Temperature, relative humidity
- Global Positioning System:
  - Van speed, driving route





CAR-FMI

- Contaminants in the Air from a Road - Finnish Meteorological Institute
- Model includes an emission model, a dispersion model and statistical analysis of the computed time series of concentrations.
- Model utilises the meteorological input data evaluated with the meteorological pre-processing model MPP-FMI.
- The dispersion equation is based on an analytic solution of the Gaussian diffusion equation for a finite line source

* Härkönen, J., Valkonen, E., Kukkonen, J., Rantakrans, E., Jalkanen, L. and Lahtinen, K., 1995. An operational dispersion model for predicting pollution from a road. International Journal of Environment and Pollution, Vol. 5, Nos. 4-6, 602-610.

Aerosol process model MONO32

- Lagrangian box model under clear sky conditions
- Gas-phase chemistry and aerosol dynamics
- Binary H_2SO_4-H_2O or ternary H_2SO_4-H_2O-NH_3 nucleation
- Multicomponent condensation of H_2SO_4, H_2O, organic vapour (soluble, partly soluble, insoluble)
- Coagulation
- Dry deposition

MONO32

- MONOdisperse representation for particle size distribution:
  - nucleation mode 1 nm < d < 20 nm
  - Aitken mode 20 nm < d < 100 nm
  - accumulation mode 100 nm < d < 2.5 μm
  - coarse mode d > 2.5 μm
- All particles in a mode have the same composition (internally mixed particles)
- 4 variables for number concentrations, 7 variables for mass concentrations (sulphuric acid, ammonium sulphate, ammonium nitrate, OC, EC, sea salt, mineral dust) per mode

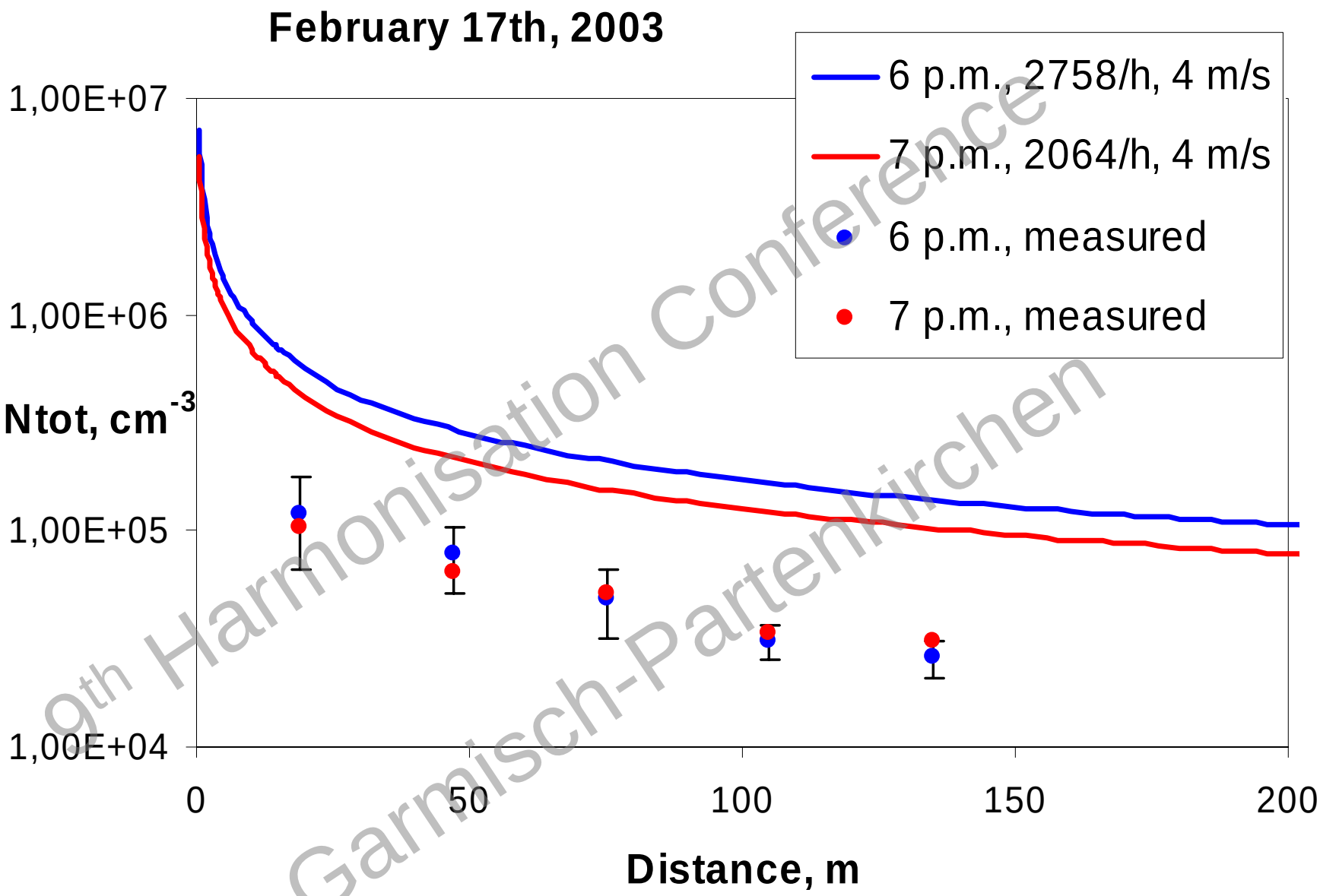
⇒ 32 variables

- As particles in a mode grow by condensation and coagulation and their size approaches that of the larger mode: mode merging

Evaluation of model predictions against measured data

- Measurements (resolution 10 min) for the time period
  February 17 – 20, 2003
  - We have selected periods, at which the wind was about perpendicular to the road (northwest), and then used the corresponding hourly averages (13 cases)
  - Weekdays from Monday to Thursday

- At distances smaller than 10 m from the road edge, we utilised an extrapolation of the CAR-FMI predictions
- The measured total number of particles was compared to the corresponding predicted values



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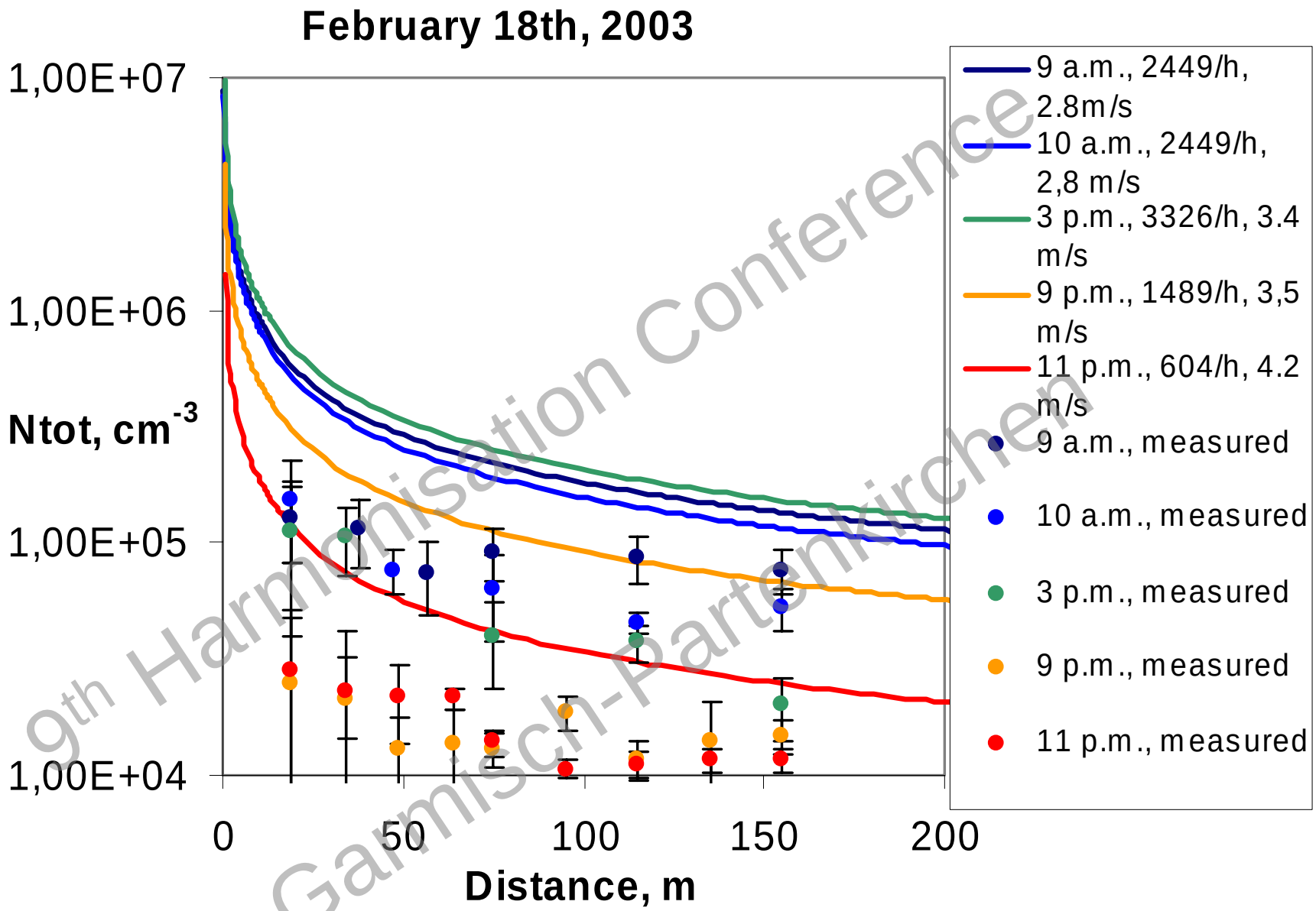

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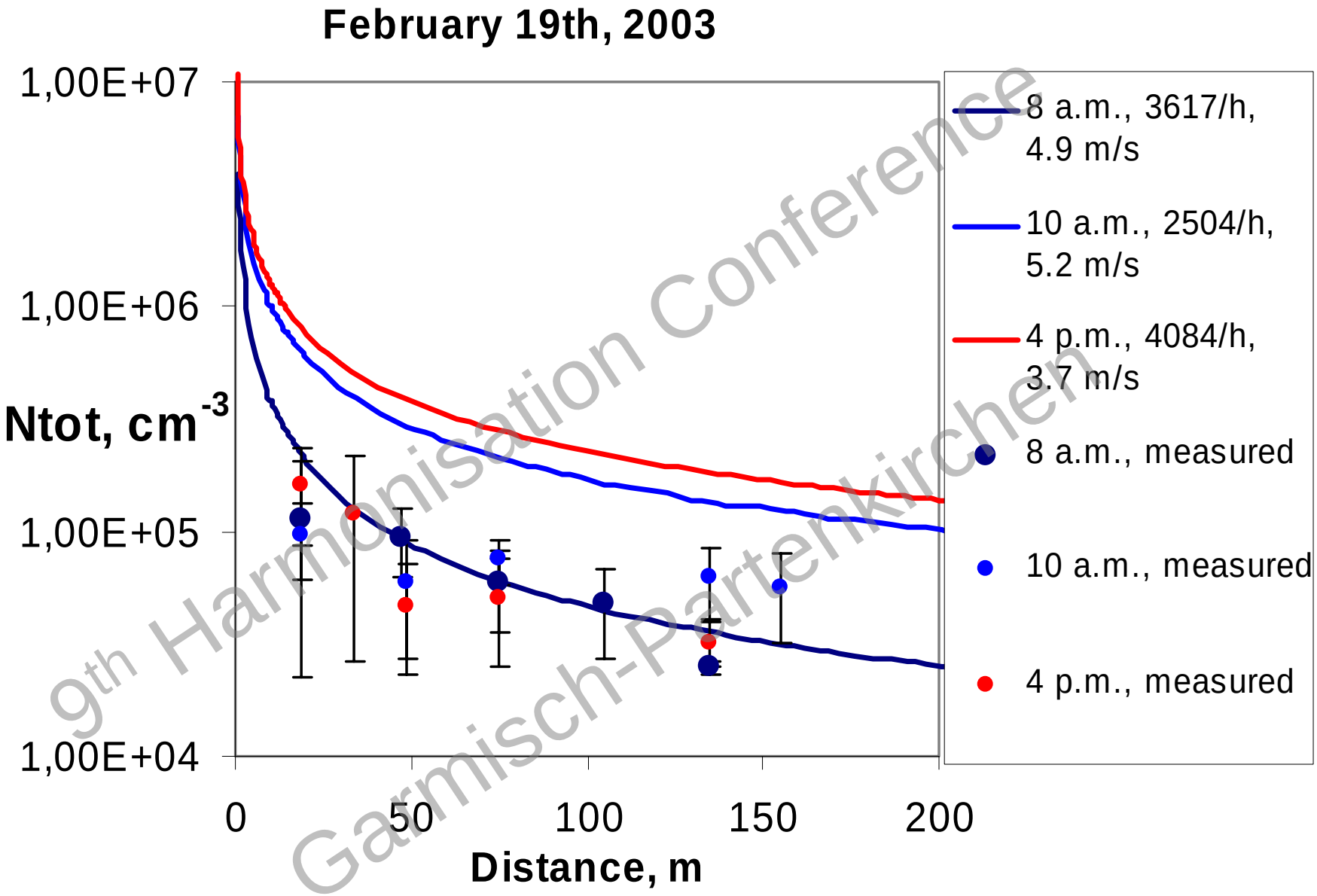
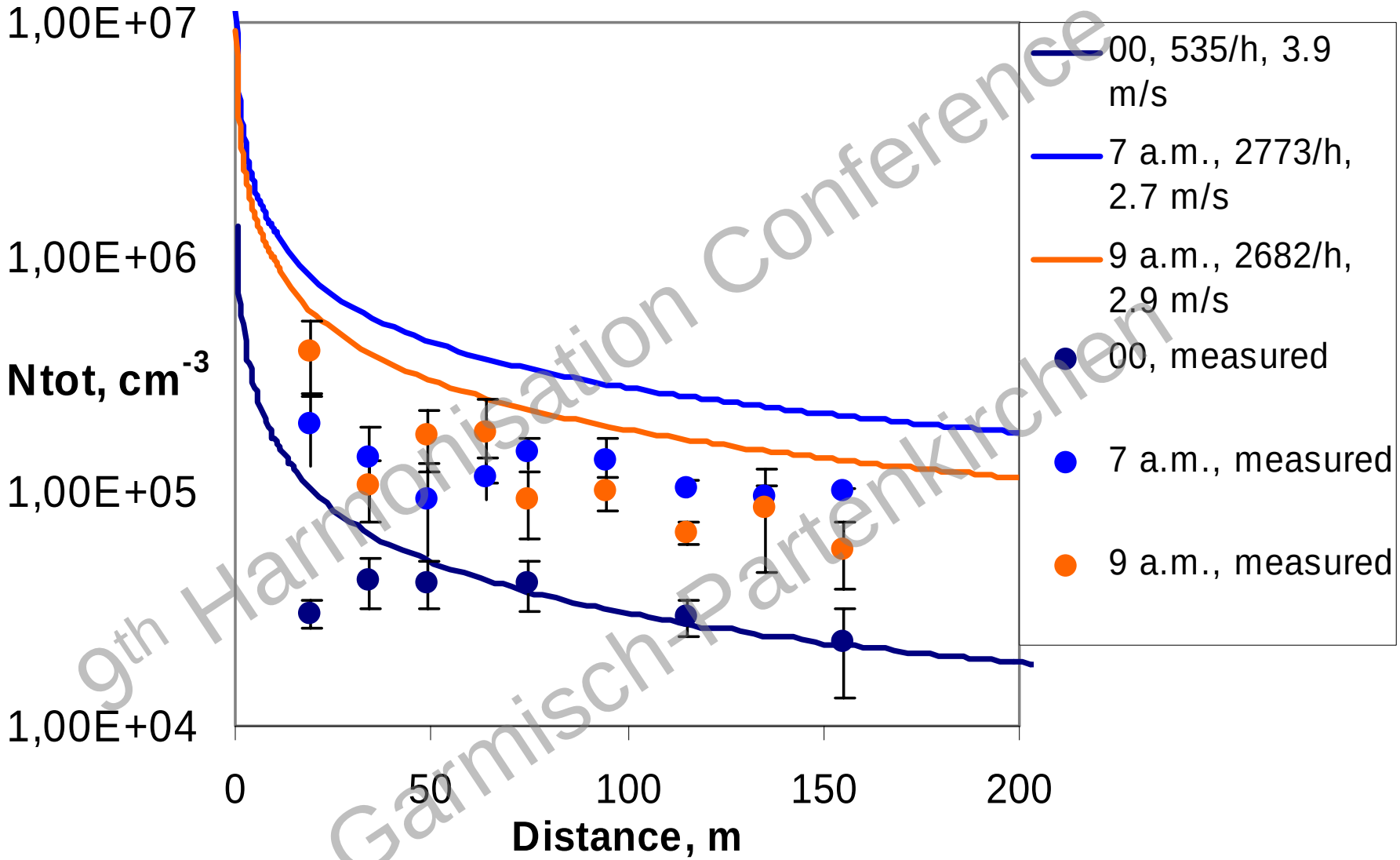
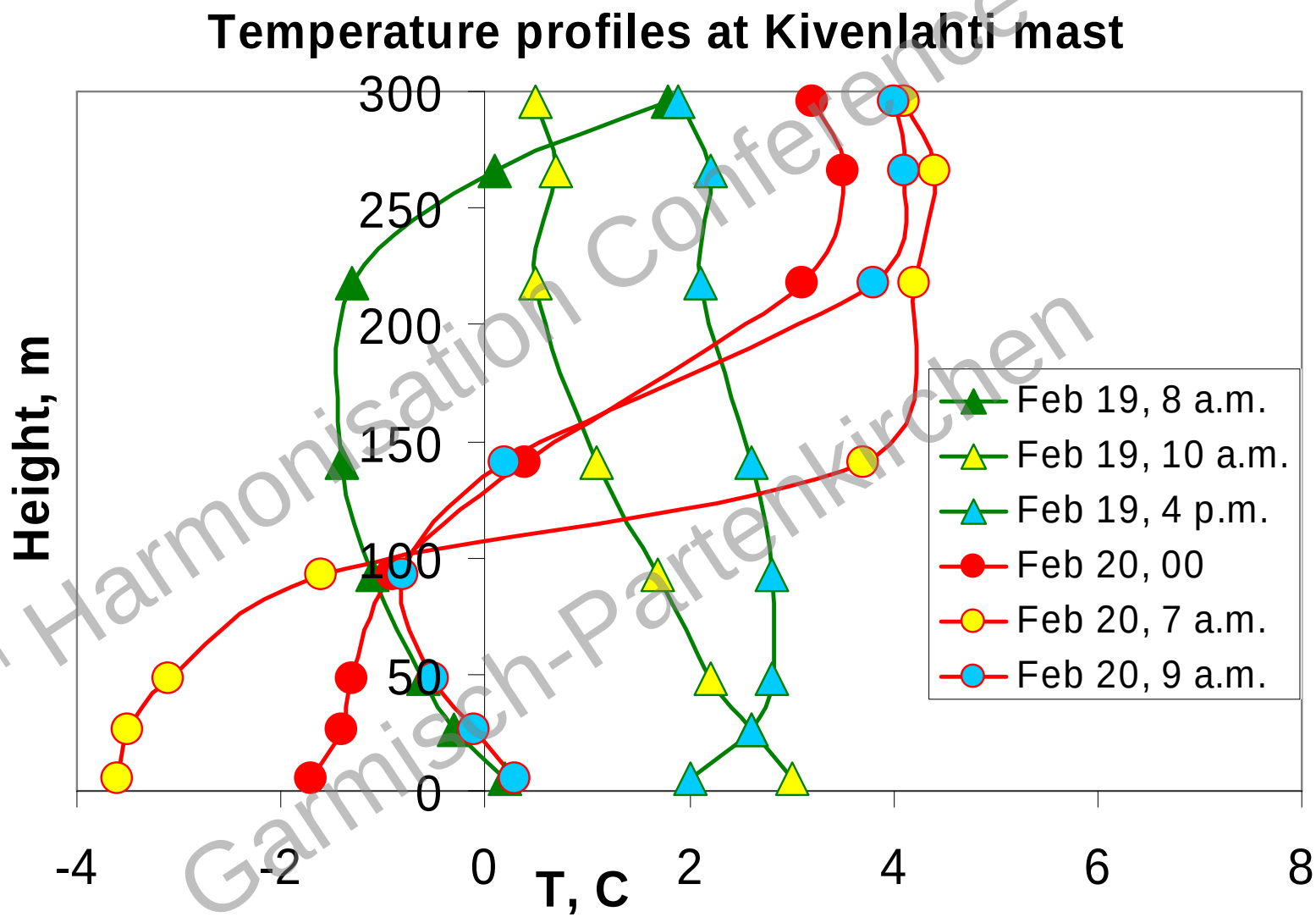


February 20th, 2003



Meteorology during the measurement campaign



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Conclusions

- In a street scale, atmospheric dispersion is the most important factor regarding particulate matter concentrations (both number and mass concentrations); e.g., Pohjola et al., 2003
- The predicted concentrations showed the same dependencies as the measured data (in terms of the distance and the relative concentration values); however, the measured total number concentrations were substantially overpredicted in most cases
- The inaccuracies of the predictions were probably caused by the following:
  - Particulate matter emissions are most likely overestimated (as no up-to-date emission data was available that would contain simultaneously measured number concentration and chemical composition)
  - The dispersion of pollution originated from the two lanes to both directions should be modelled in more detail
  - Traffic volume varied ± 30 % during the time periods considered (hourly)

Future work

- analysis of importance of different aerosol processes in the 1-200 m distance scale
  - condensation, coagulation
  - aerosol number concentrations in the size modes
  - aerosol composition in the size modes
  - aerosol radii in the size modes

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