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An operational urban scale air quality forecast system

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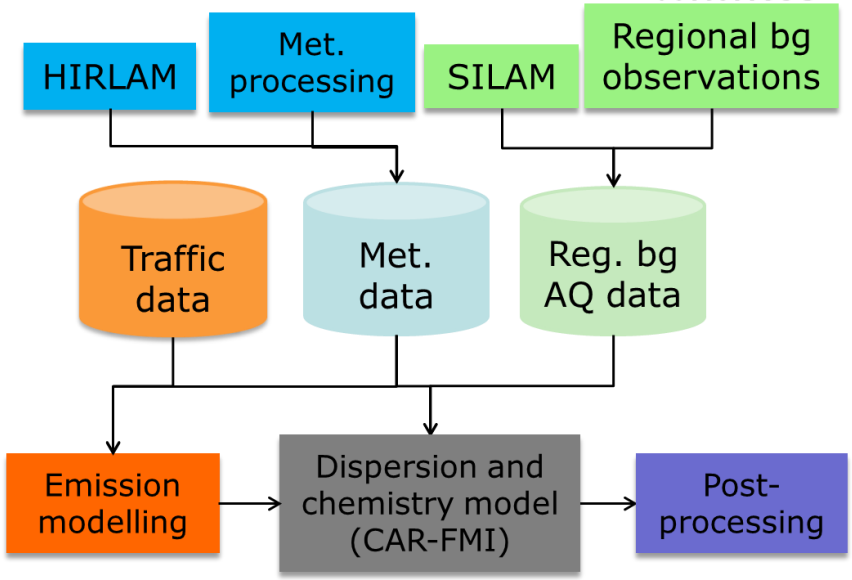
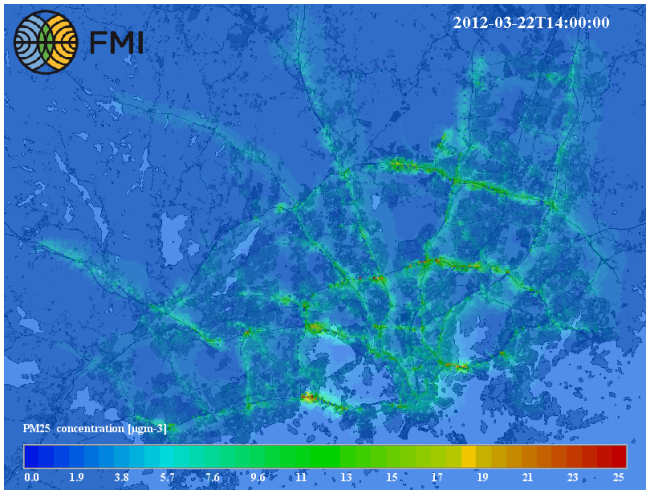
Background

- Aim
  - Information and planning tool for authorities
  - Information and warnings for public about high air pollution
- Requirements
  - Series of models from emission modelling and meteorological forecasting to dispersion of pollutants
  - Data retrieval and processing tools
  - Operational forecasting
  - Web interface for results

Urban air quality forecast system at FMI

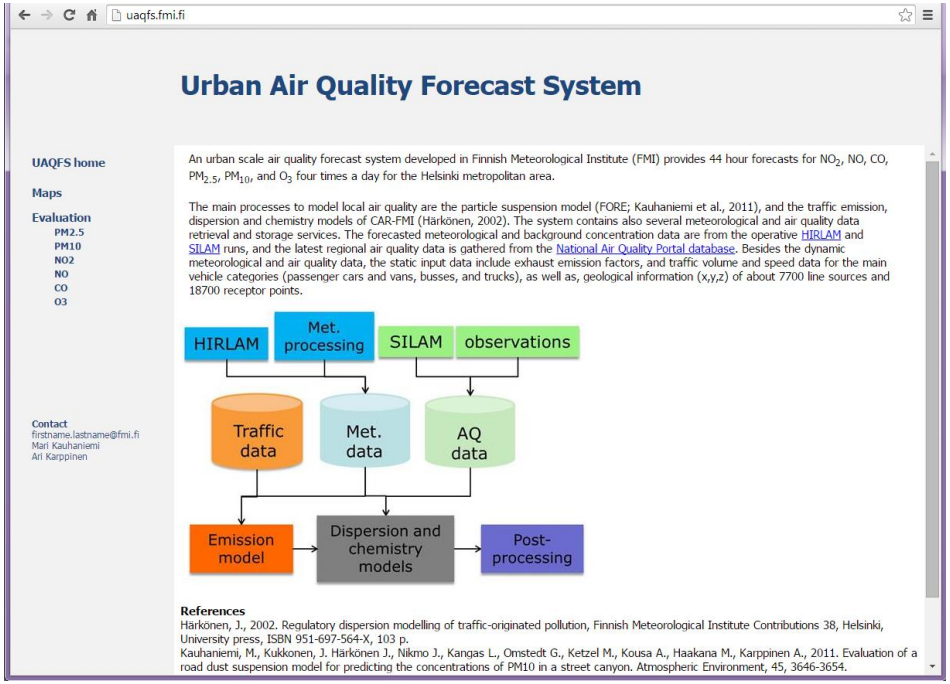
- Includes
  - Meteorological and air quality data retrieval
  - Models for emission, chemistry, and dispersion (FORE, CAR-FMI)
- Limitations
  - Considers only road traffic emissions
- Output
  - 44 hour forecast four times a day (02, 08, 14, and 20 local time)
  - NO2, NO, CO, O3, PM2.5, and PM10
  - Domain is the Helsinki metropolitan area (40 km x 30 km; grid size 50-500 m)



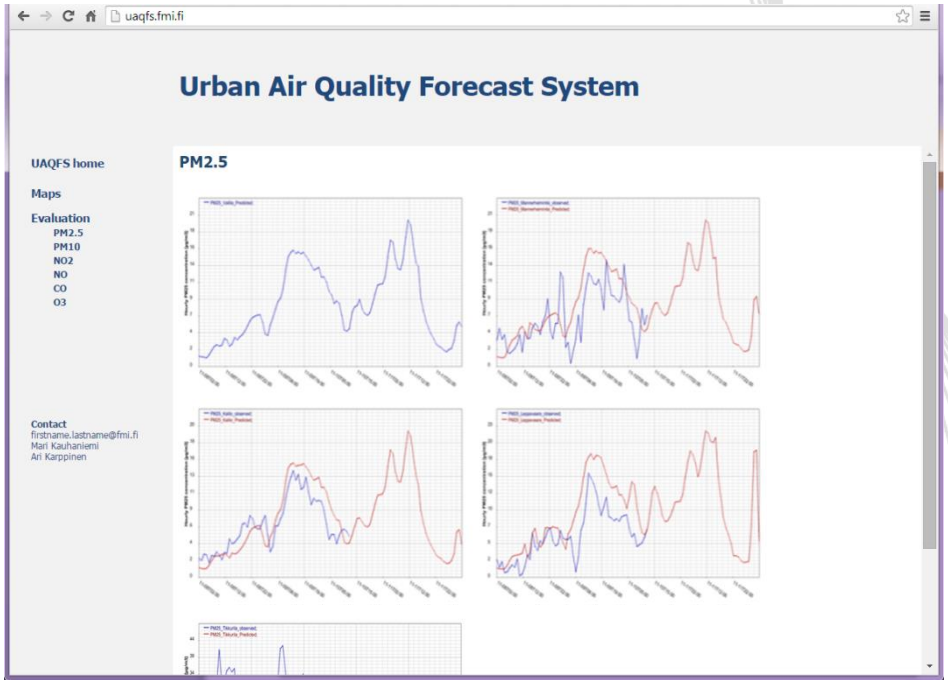


Urban air quality forecast system at FMI

- Real-time results shown on website uaqfs.fmi.fi



Description of the system.



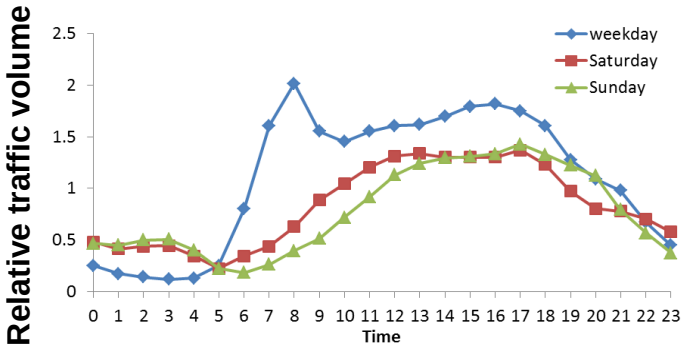
Example of model evaluation.

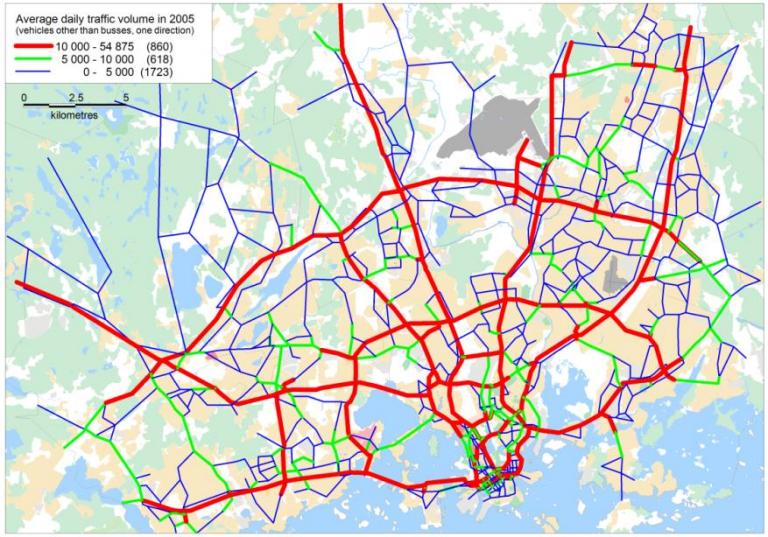
Dispersion and chemistry model (CAR-FMI)

- Contaminants in the Air from a Road (Härkönen, 2002)
- Traffic-originated pollution from an open road network
- Includes
  - Gaussian plume dispersion
  - Dry deposition of particles
  - Discrete parcel method for NO-O3-NO2 chemistry
  - Traffic-induced turbulence
- Evaluated e.g. by
  - NO2: Levitin et al., 2005, Kukkonen et al., 2001, Kousa et al., 2001, Karppinen et al., 2000
  - PM2.5: Kauhaniemi et al., 2008, Tiitta et al., 2002
  - PM2.5 and NO2: Sokhi et al., 2008

Traffic emission modelling

- Exhaust emission factors for NOx, CO, PM2.5
  - National estimates
- Non-exhaust emission factors for PM10
  - Road dust emission model (FORE)
- Traffic data (EMME-2 model)
  - Traffic volume
  - Travel speed (for exhausts)





Road dust emission model (FORE)

- Forecasting Of Road dust Emissions (Kauhaniemi et al., 2011)
- Based on PM emission model of SMHI (Omstedt et al., 2005)
- Considers
  - Moisture content of the road surface.
  - Particles from the wear of pavement due to tyres and traction sand.
- Not included
  - Emissions from brake, tyre, and clutch.
  - Dependencies of emissions on vehicle speed or fleet composition.
  - Influence of salting, dust binding, ploughing, and cleaning.
- Output
  - The emission factor of road wear and traction sand for all traffic in µg/veh/m.

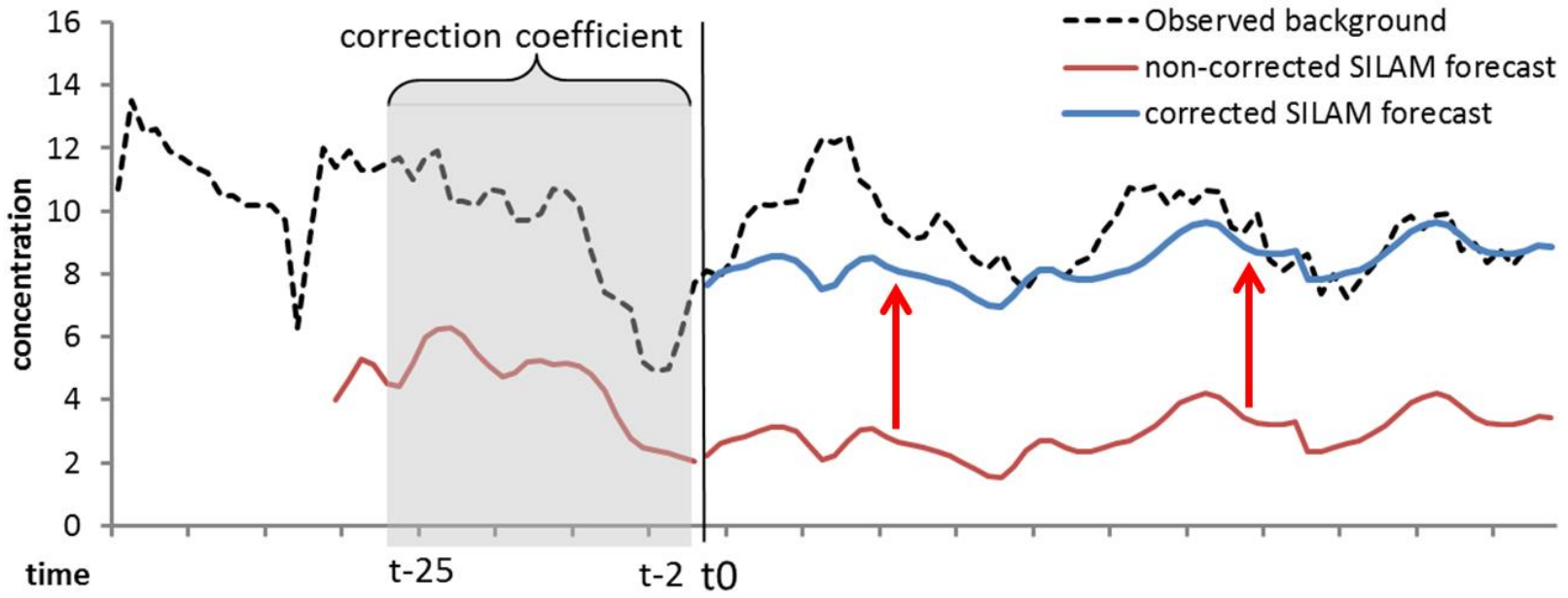
Meteorological and regional background AQ data

- Meteorological forecasts from HIRLAM
  - High resolution limited area model
  - 54 h forecast
  - four times a day (at 00, 06, 12, 18 UTC)

- Background air quality forecasts from SILAM
  - System for integrated modelling of atmospheric composition
  - 72 h forecast
  - one time a day (at 02 UTC)

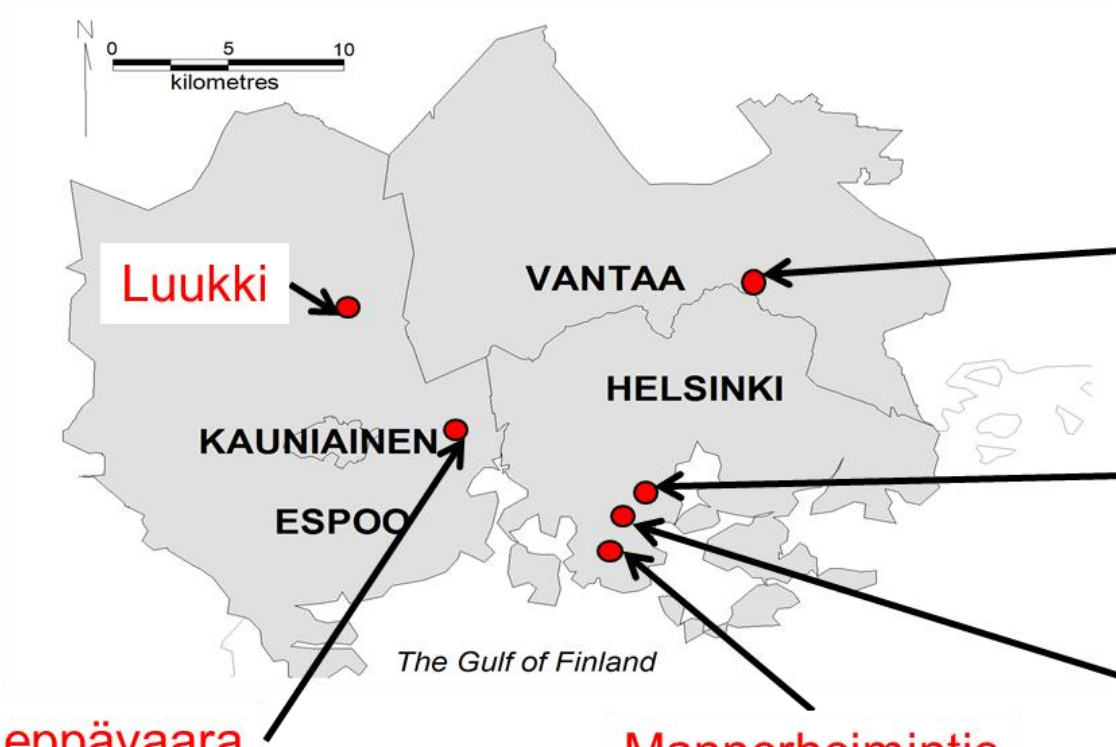
Correction of predicted background air quality

- The level of forecasted background concentrations is corrected with regional background air quality observations.



AQF start time t0 = 02, 08, 14, and 20 local time

AQ measurement sites used for model evaluation



Tikkurila

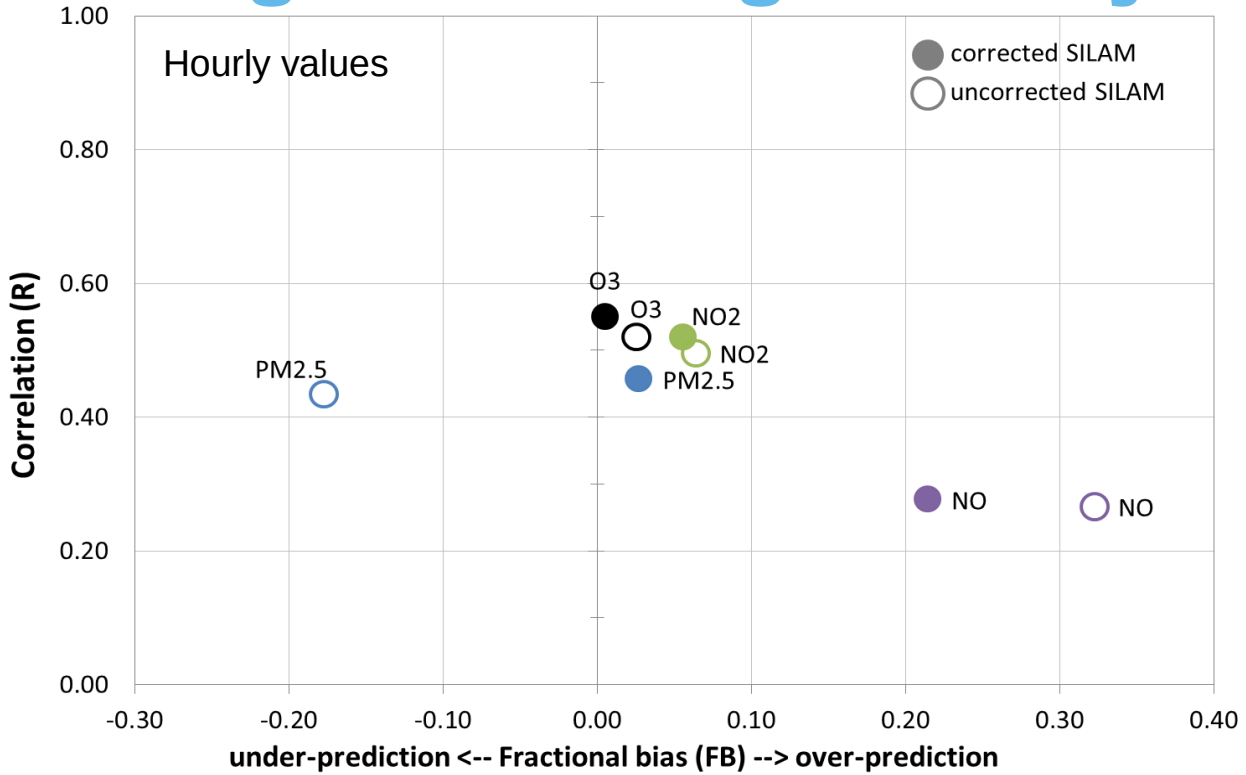
Vallila

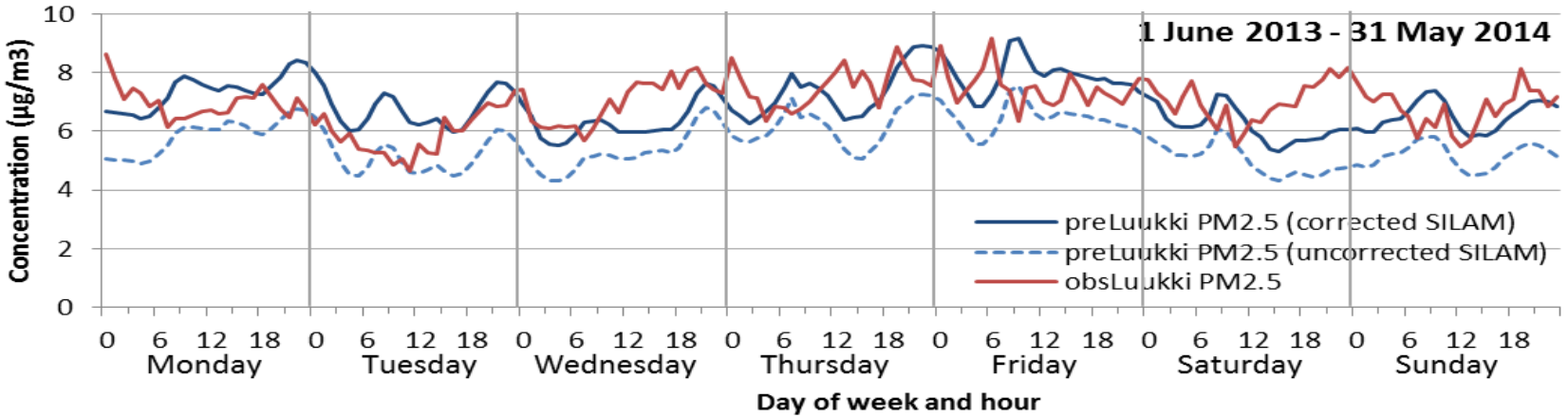
Leppävaara

Mannerheimintie

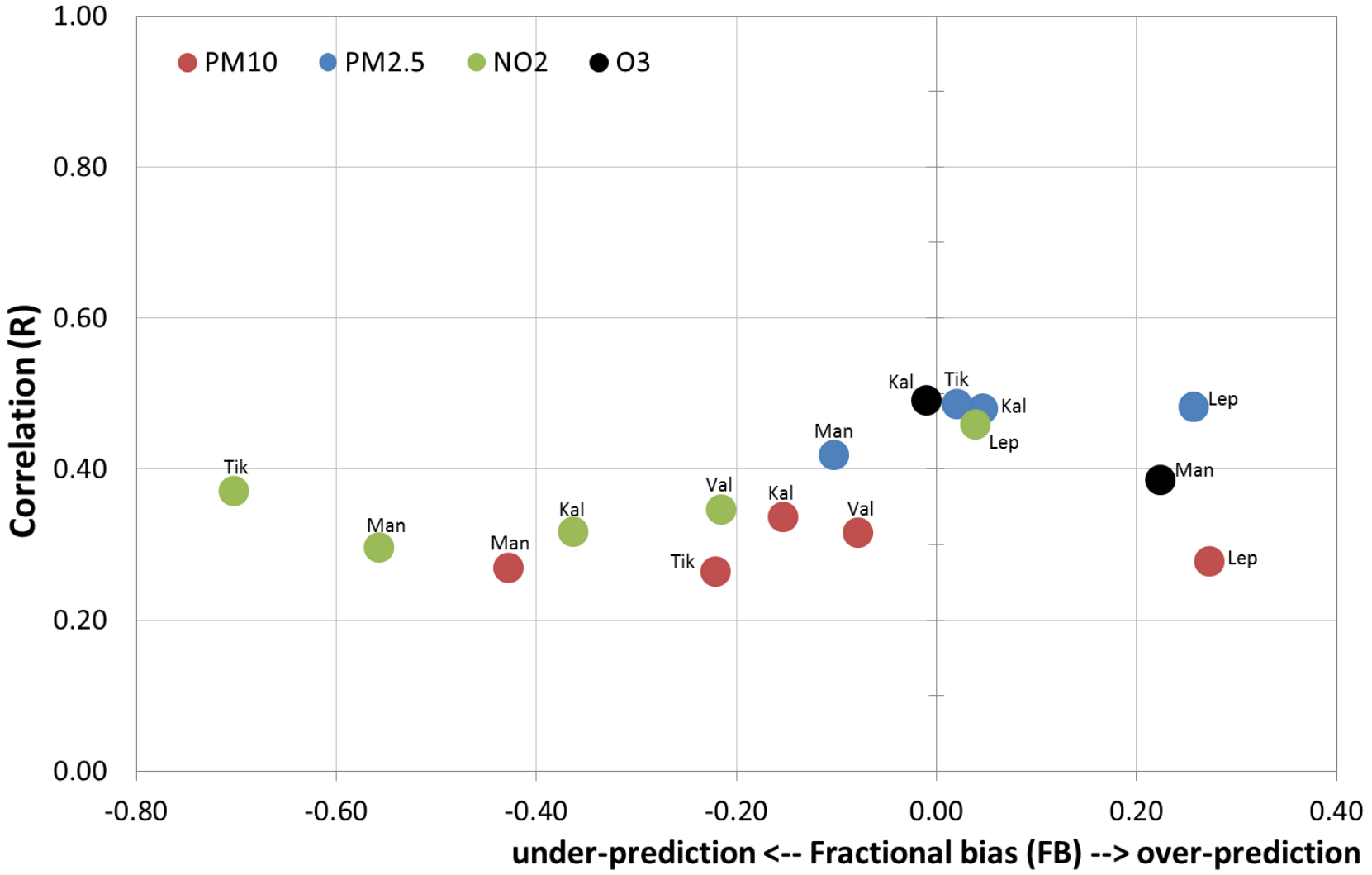
Kallio

Results: Regional background by SILAM

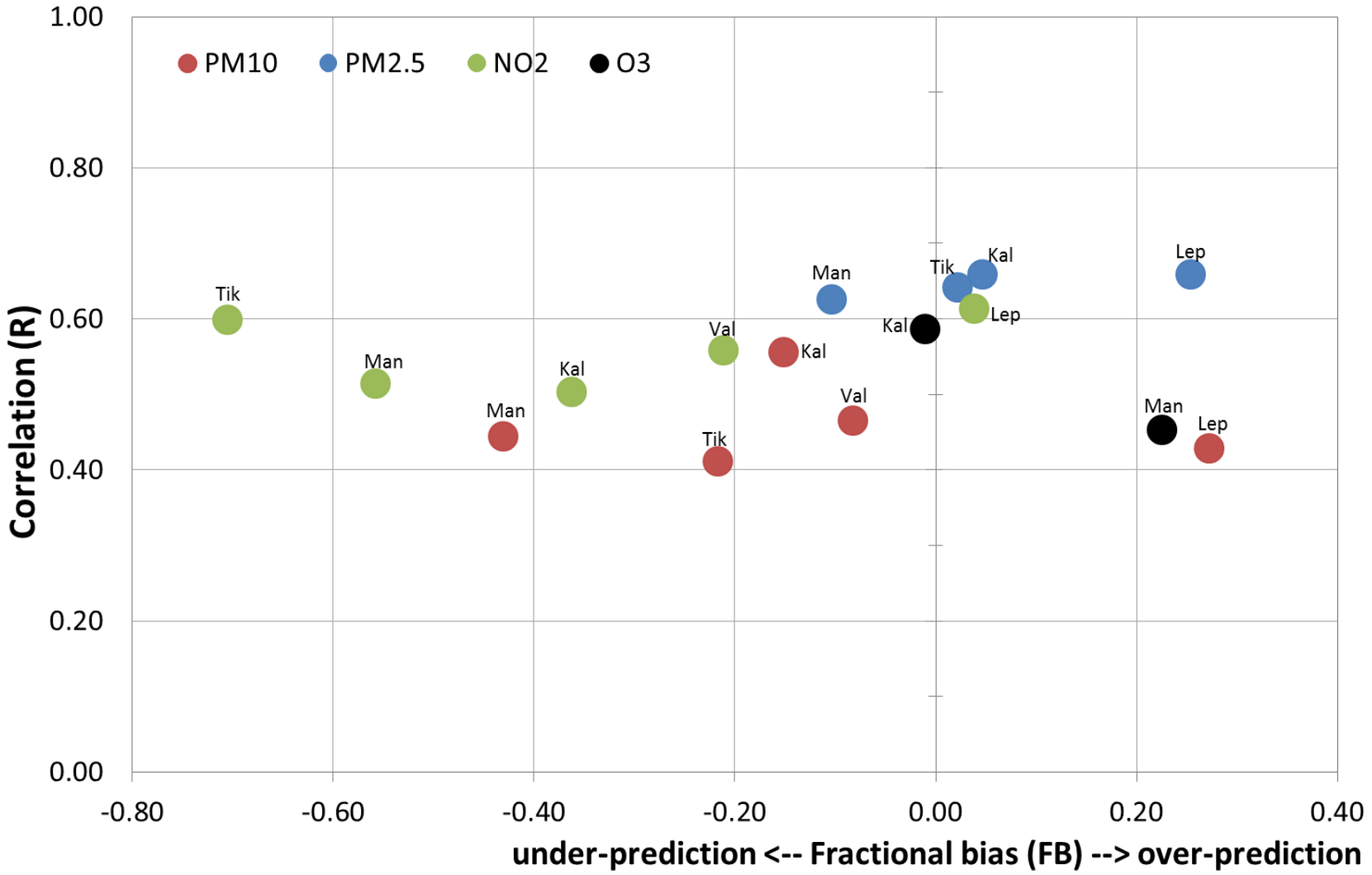




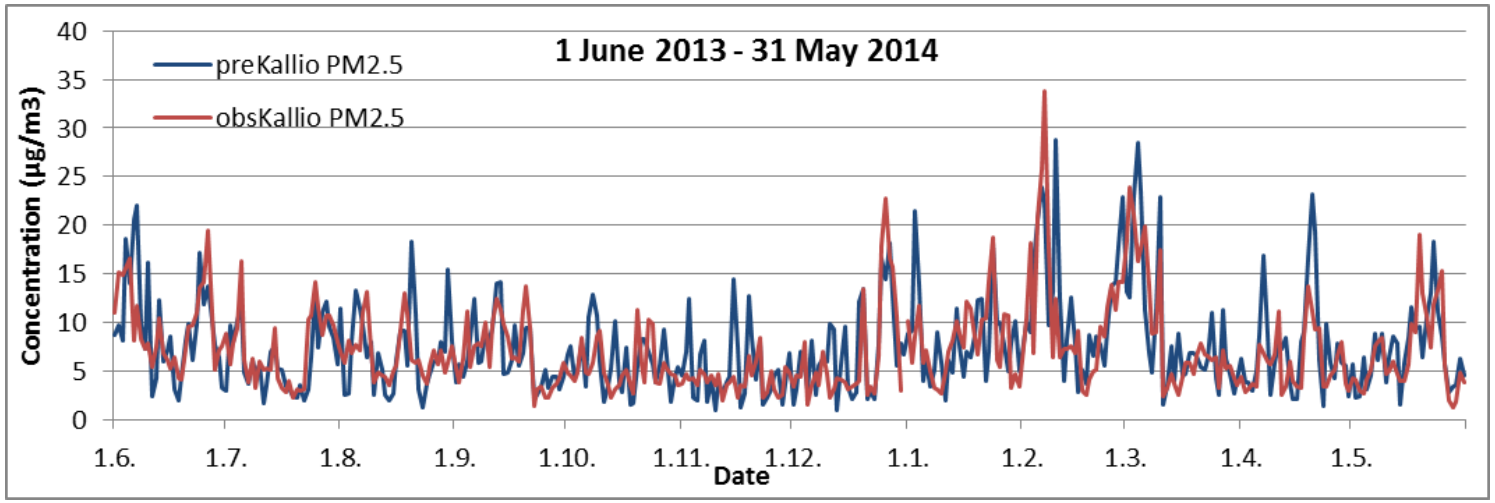
Results: Hourly values summary

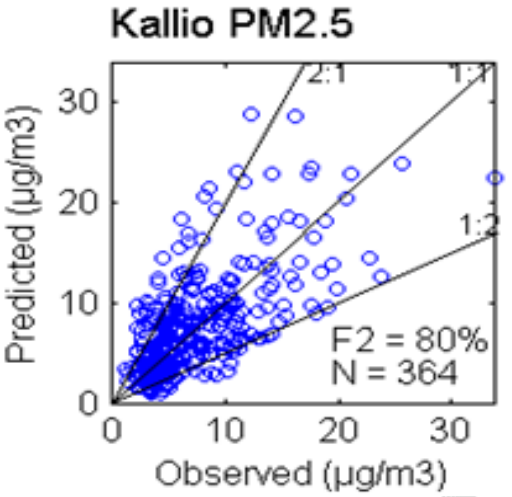


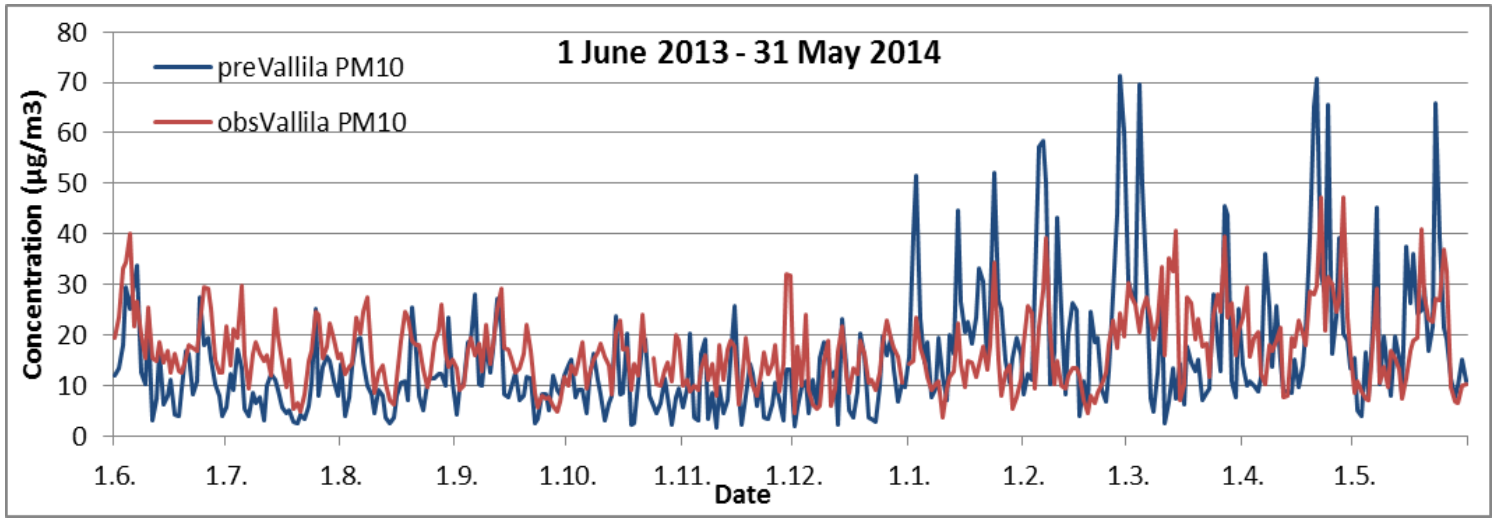
Results: Daily values summary

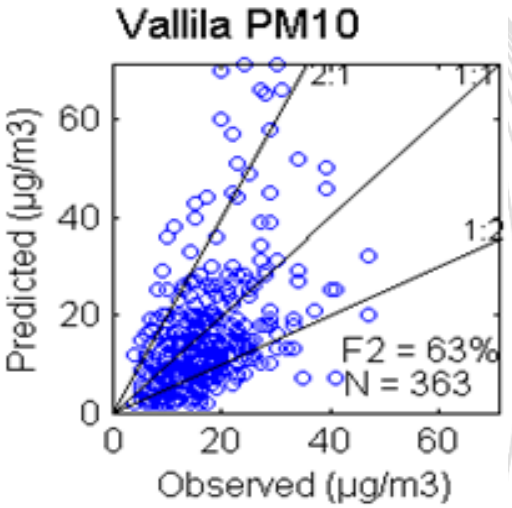


Results: Daily averaged PM2.5 and PM10

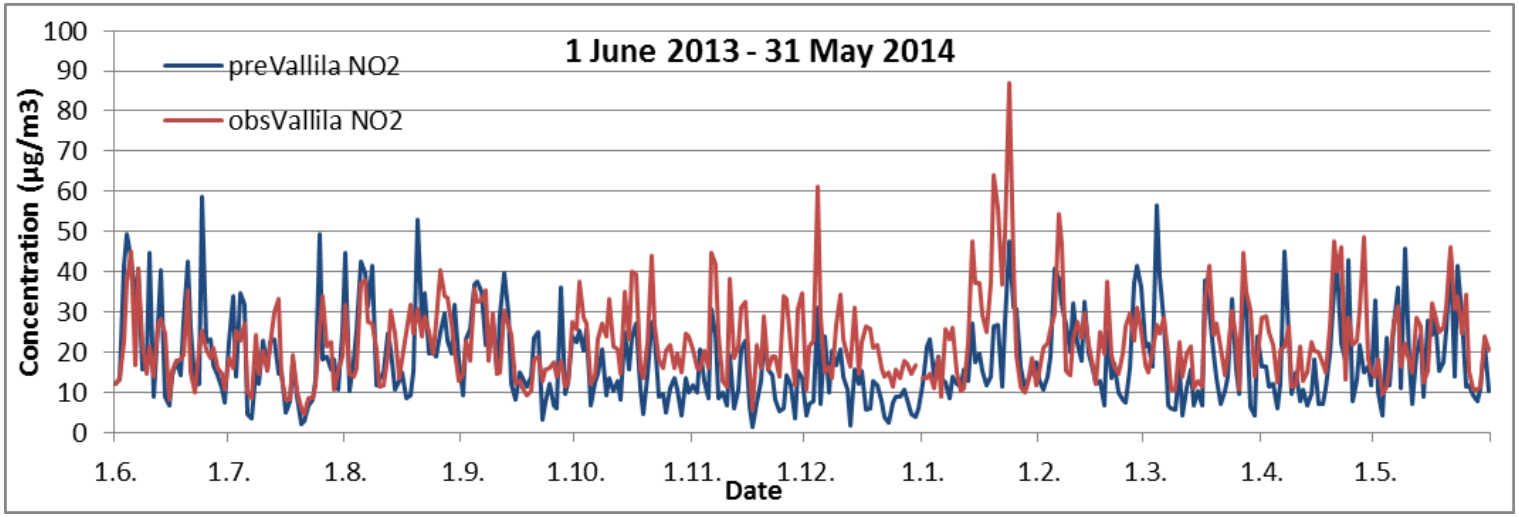


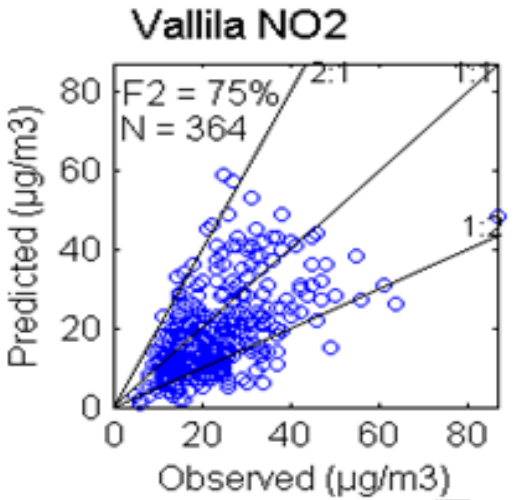


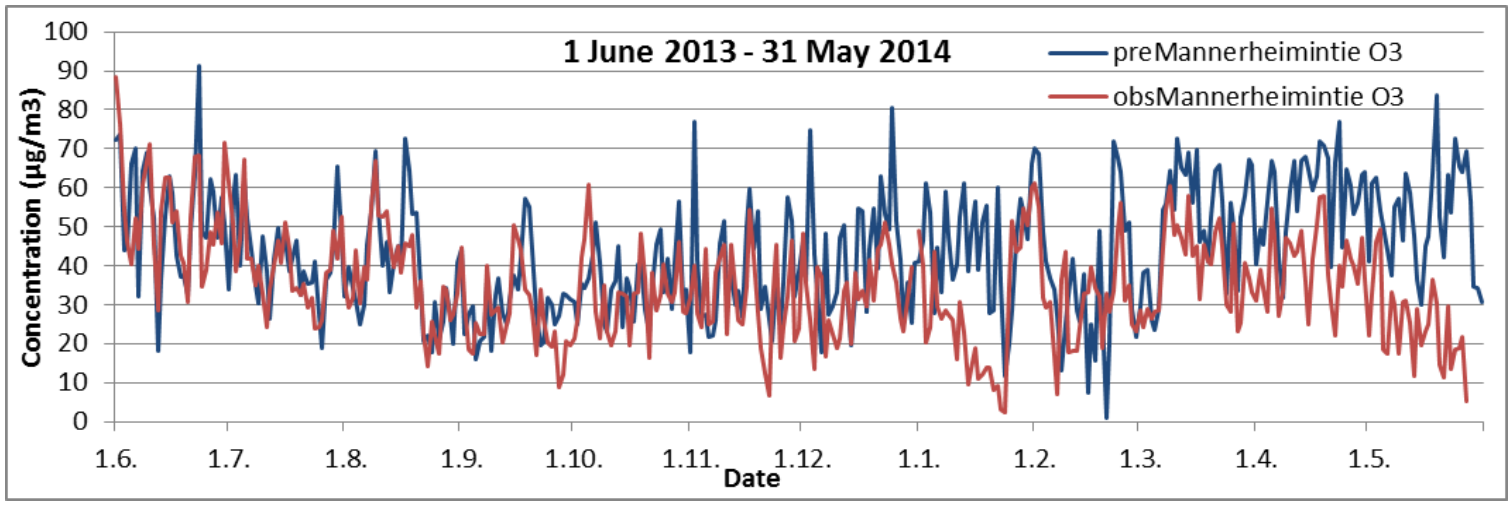


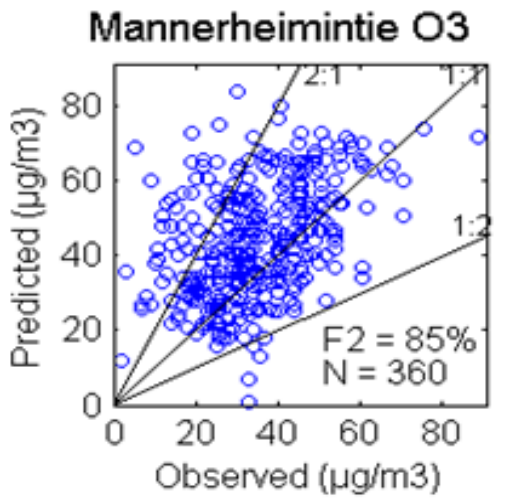


Results: Daily averaged NO2 and O3









Conclusions

- Accuracy of AQ forecasting system regarding daily values for t+24 forecast data:
  - PM2.5: fairly good
  - PM10, NO2 and O3: moderate
- PM2.5 usually somewhat over-predicted and NO2 and PM10 under-predicted.
- Correlation regarding daily values is better than for hourly values.

Challenges and further work

- Forecasting urban meteorology
  - Stability, precipitation, …
- Forecasting of regional background concentrations
- Emission and traffic data up-to-date as possible
- PM10 modelling
  - Road dust emission model
- Other
  - Street canyons,… other emission sources e.g. small scale combustion?

References

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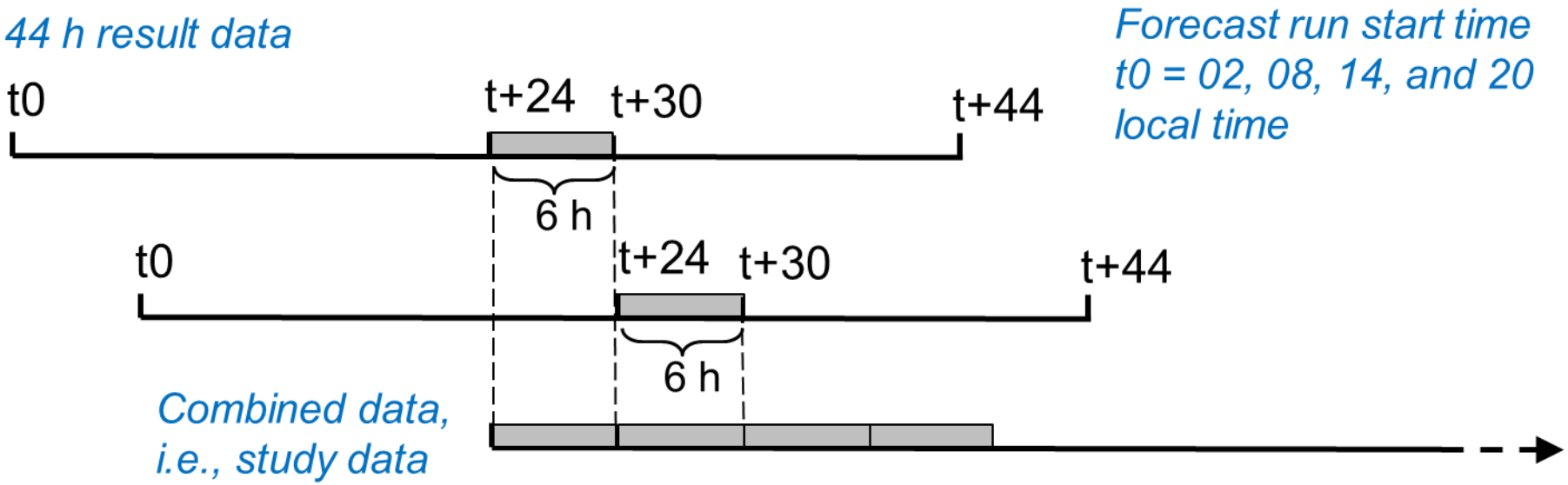
Tiitta P., Raunemaa T., Tissari J., Yli-Tuomi T. Leskinen A., Kukkonen J., Härkönen J., Karppinen A., 2002. Measurements and modelling of PM2.5 concentrations near a major road in Kuopio, Finland. Atm Env 36, 4057-4068.

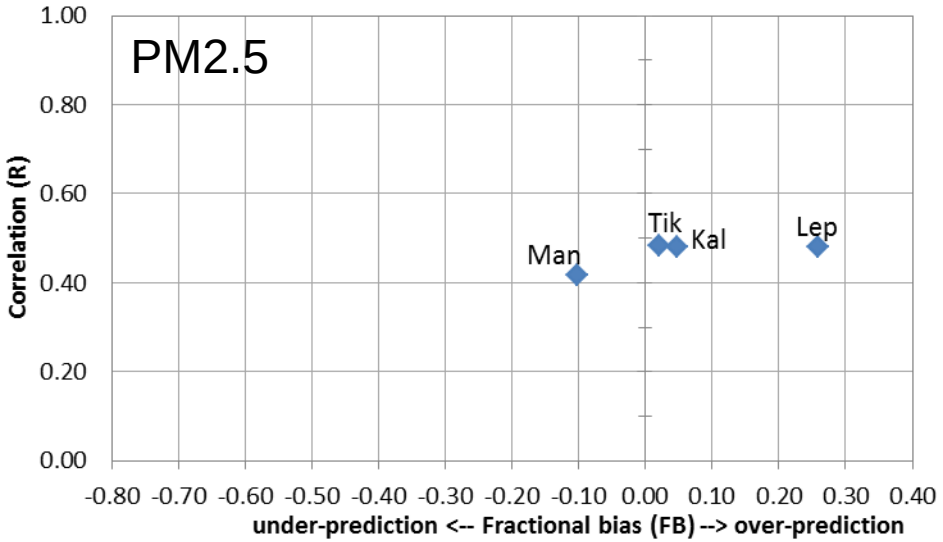
Thank you!

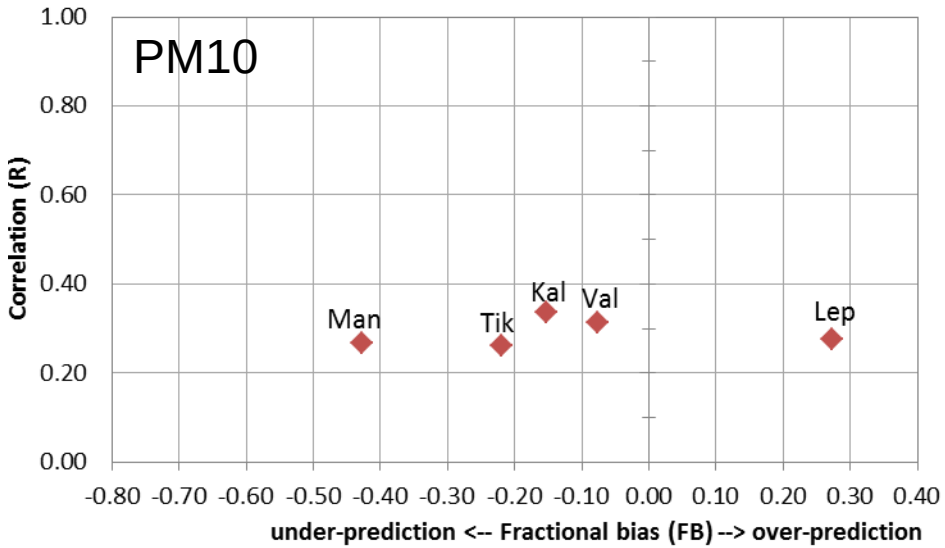
System performance study

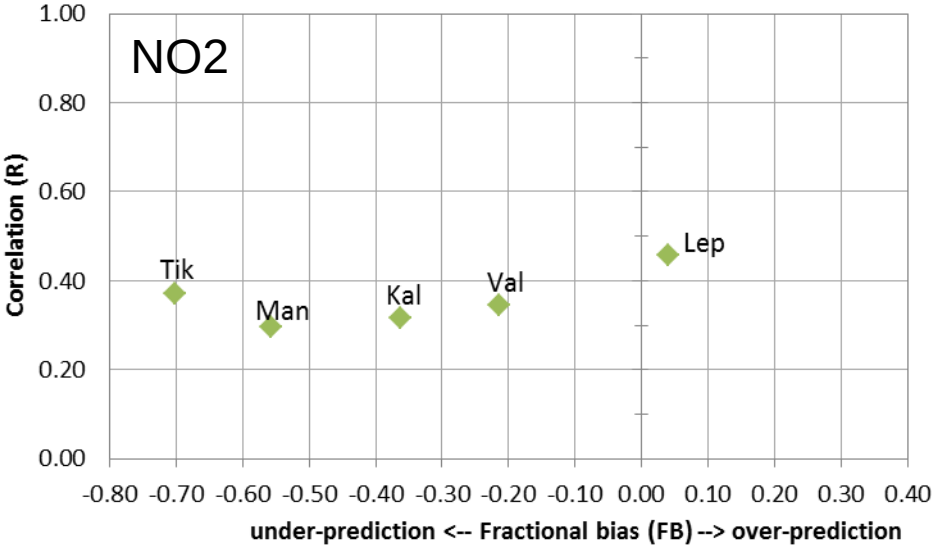
- 24 h forecast of PM2.5, PM10, NO2, O3 concentrations
- Values t+24 … t+30 picked from each result file and combined together for one time series.
- Time period: 1 June 2013 to 31 May 2014

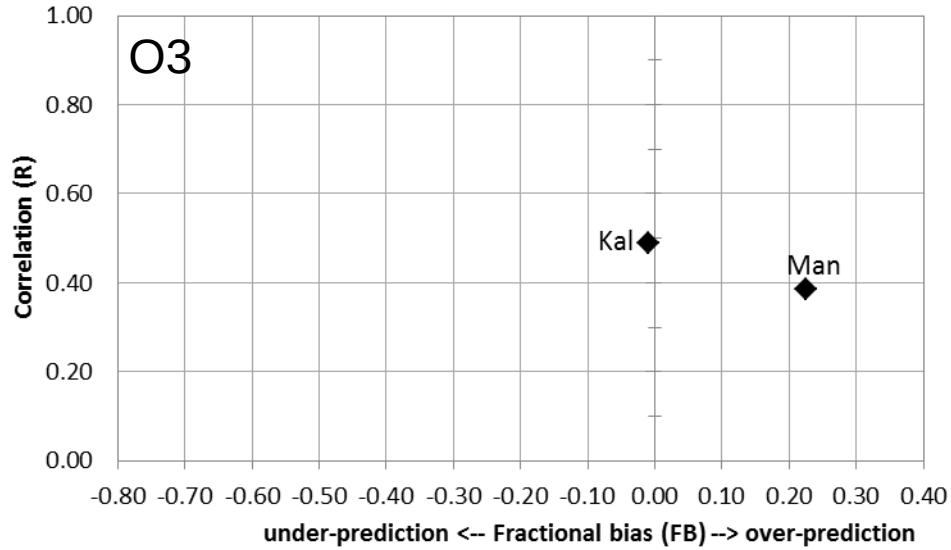


Results: Hourly values



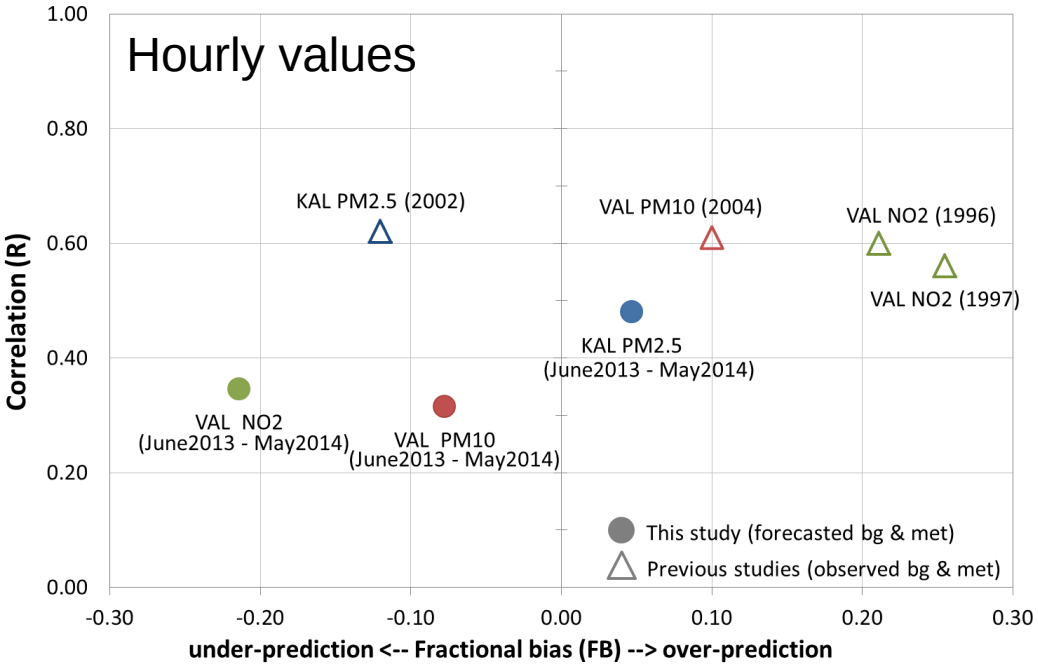


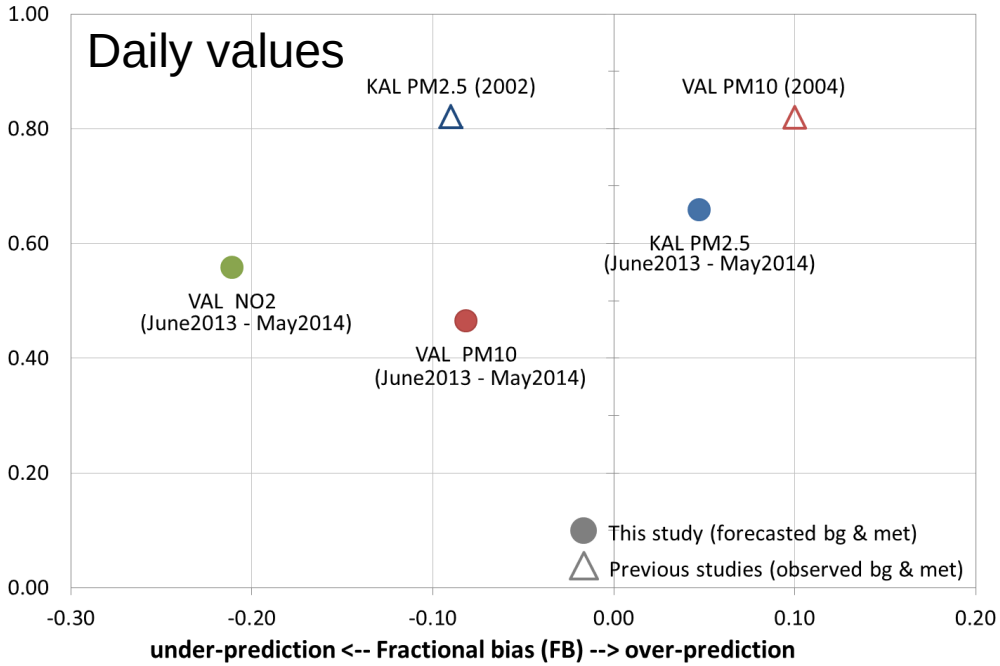




Comparison with previous studies with observed bg and met data

NOTE! Not directly comparable with this study.





- **VALLILA NO2 (1996, 1997):** Evaluation of modelling system with observed met. (MPP-FMI) and regional background data, emi. from stationary sources included (Kousa et al., 2001)
- **KALLIO PM2.5 (2002):** Modelling system with observed met. (MPP-FMI) and regional background data, non exh. emi. included by coefficient (Kauhaniemi et al., 2008)
- **VALLILA PM10 (2004):** Modelling system with observed met. (MPP-FMI) and regional background data, road dust emi. Included