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Improvements of SIMAIR with support vector regression, SVR

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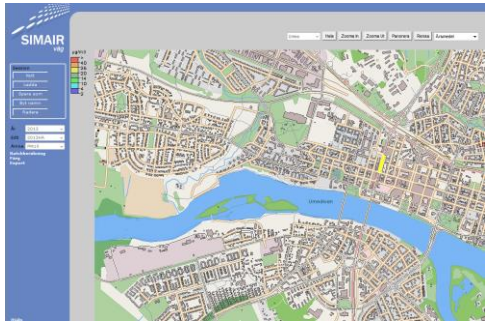
SIMAIR – Swedish national Air Quality model system

Web-based Air Quality model tool

- Can be used by all municipalities and cities in Sweden.
- Simple user interface.
- Fast calculations.
- Applications for road traffic and small-scale residential wood combustion.

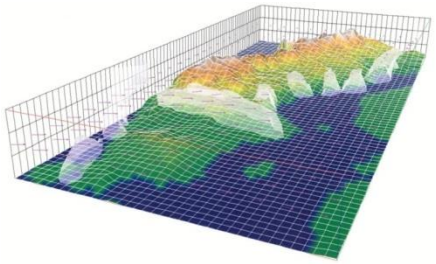


http://www.smhi.se/tema/SIMAIR

SIMAIR - coupled model system

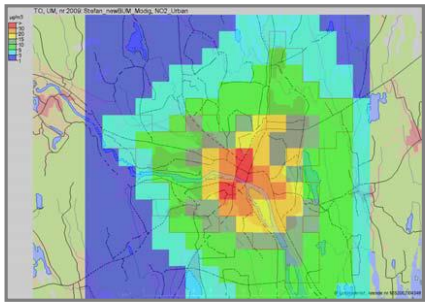
Regional scale

- MATCH: Multi-scale Atmospheric Transport and Chemistry Model
- 44 km x 44 km (Europe)



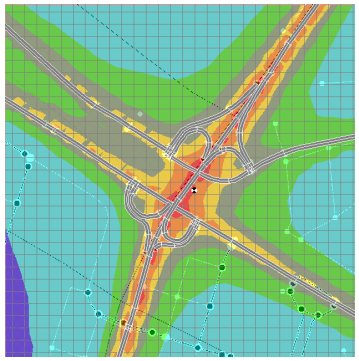
Urban scale

- BUM – back-trajectory model + Gaussian model
- 1 km x 1 km



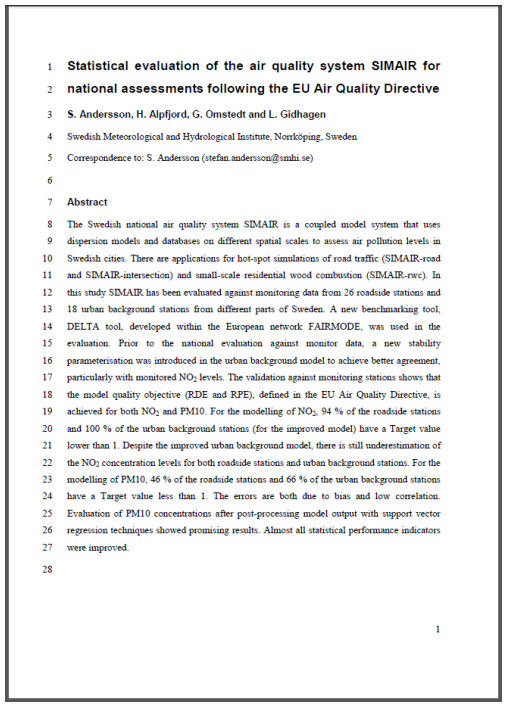
Local scale

- OSPM (street canyon)
- Open road
- Dispersion
- 25 m x 25 m



Statistical evaluation of SIMAIR

- Paper submitted 2015 to ACP.
- Validation including Delta-tool.
- Evaluation of statistical post-processing technique; support vector regression, SVR.



Statistical evaluation of the air quality system SIMAIR for national assessments following the EU Air Quality Directive

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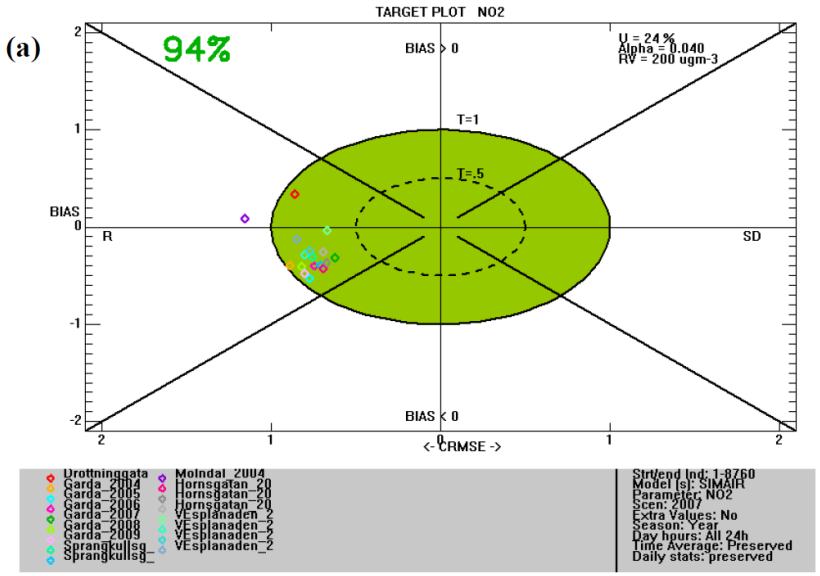
Abstract

The Swedish national air quality system SIMAIR is a coupled model system that uses dispersion models and databases on different spatial scales to assess air pollution levels in Swedish cities. There are applications for hot-spot simulations of road traffic (SIMAIR-road and SIMAIR-intersection) and small-scale residential wood combustion (SIMAIR-rwc). In this study SIMAIR has been evaluated against monitoring data from 26 roadside stations and 18 urban background stations from different parts of Sweden. A new benchmarking tool, DELTA tool, developed within the European network FAIRMODE, was used in the evaluation. Prior to the national evaluation against monitor data, a new stability parameterisation was introduced in the urban background model to achieve better agreement, particularly with monitored NO_2 levels. The validation against monitoring stations shows that the model quality objective (RDE and RPE), defined in the EU Air Quality Directive, is achieved for both NO_2 and PM10. For the modelling of NO_2, 94 % of the roadside stations and 100 % of the urban background stations (for the improved model) have a Target value lower than 1. Despite the improved urban background model, there is still underestimation of the NO_2 concentration levels for both roadside stations and urban background stations. For the modelling of PM10, 46 % of the roadside stations and 66 % of the urban background stations have a Target value less than 1. The errors are both due to bias and low correlation. Evaluation of PM10 concentrations after post-processing model output with support vector regression techniques showed promising results. Almost all statistical performance indicators were improved.



Data fusion using Support Vector Regression (SVR)

- Aim: To implement a method for statistical post-processing of dispersion model output from SIMAIR.
- The compound examined is PM10.
- The statistical method is developed based on data from Hornsgatan in Stockholm 2007-2009. Validation using data from Umeå and Gothenburg.
- Two years used as evaluation set, one year as validation set

Hornsgatan in Stockholm

- Yearly daily average of 28 000 vehicles
- One of the streets in Sweden with the highest concentrations of PM10

Gårda in Gothenburg

- Yearly daily average of 90 000 vehicles

Västra Esplanaden in Umeå

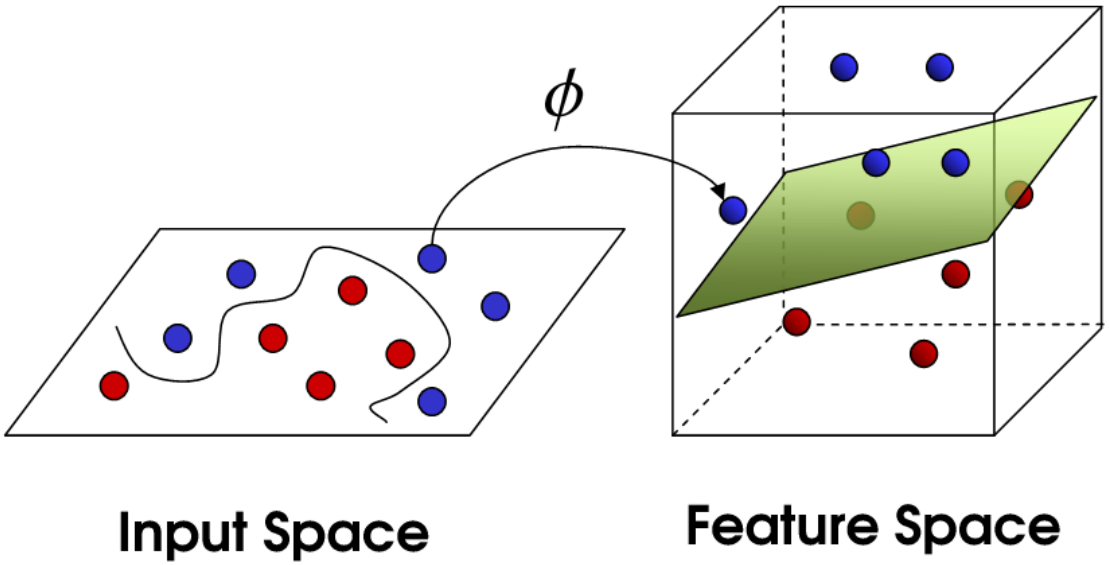
- Yearly daily average of 24 000 vehicles
- Problems with inversions

Support Vector Regression

- Data fusion methods are completely statistical, do not take physical or chemical laws into account.
- Support Vector Regression can be used for both linear and non-linear regression.
- Does not assume normally distributed residuals nor constant variance.

Support Vector Regression

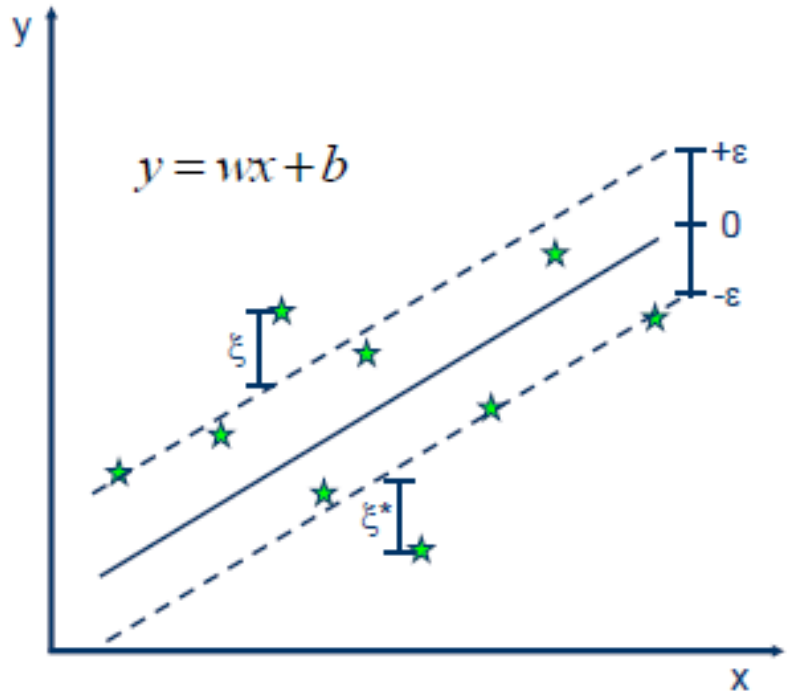
- SVR is a form of supervised machine learning.
  - Training using examples
  - Prediction – input data are given values based on training
- Input data is transformed to a higher dimensional space where a linear regression is performed
- The transformation uses kernels (here radial basis functions)



Source: http://stackoverflow.com/questions/9480605/what-is-the-relation-between-the-number-of-support-vectors-and-training-data-and

Support Vector Regression

- Minimisation is based on both complexity and residual size. Overfitting is avoided.
- The optimisation problem:



• Minimize:

$$\frac{1}{2}\|w\|^2 + C\sum_{i=1}^{N}\left(\xi_i + \xi_i^*\right)$$

• Constraints:

$$y_i - wx_i - b \le \varepsilon + \xi_i$$

$$wx_i + b - y_i \le \varepsilon + \xi_i^*$$

$$\xi_i, \xi_i^* \ge 0$$

Source: http://www.saedsayad.com/support_vector_machine_reg.htm

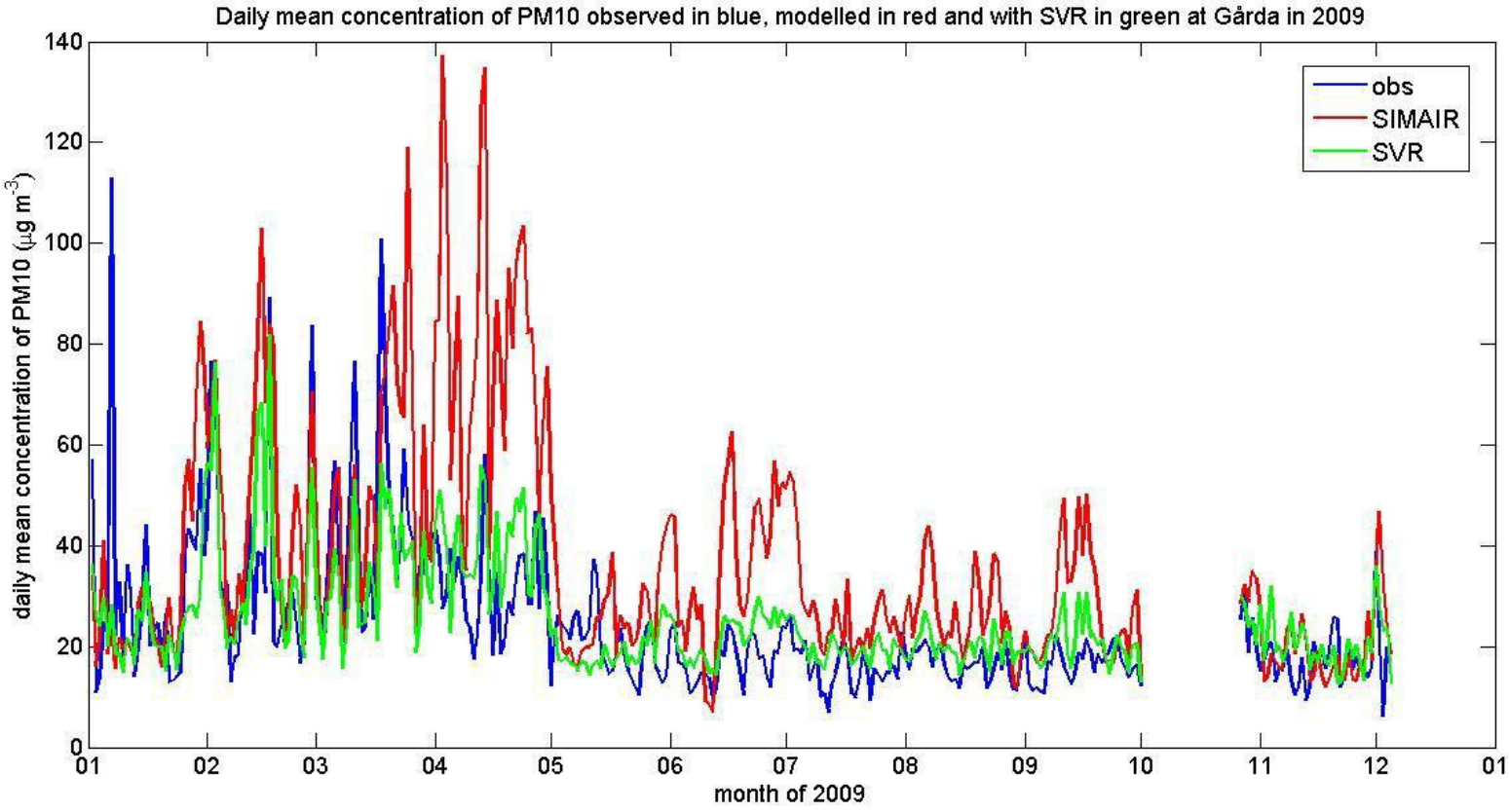
Explanatory variables

- Modelled concentration of PM10 (local and urban background), number of vehicles
- Meteorological: precipitation (exponentially filtered), humidity, wind direction, temperature difference during the day, accumulated global irradiance
- Indicators of day/night and season

Results from Gårda in 2009

	Observations	SIMAIR model	SVR
Yearly mean ($\mu g/m^3$)	23.7	37.0	24.8
90-percentile daily mean ($\mu g/m^3$)	39.3	70.3	39.3
Days > 50 $\mu g/m^3$	15	68	15
RPE %		56	5.6
RDE %		33	3.0
r daily mean		0.60	0.76
r hourly		0.43	0.57
RMSE daily mean ($\mu g/m^3$)		15.0	6.49
RSME hourly ($\mu g/m^3$)		29.5	18.3

Results from Gårda in 2009



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Conclusions

- The SVR method shows promising results for correcting SIMAIR calculations
- It is important that training data are representative for the period to be predicted
- Independent observation data for validation
- Useful tool for model evaluation
- Future extensions – use the method for sites without measurements by training on adjacent locations?