Analysis of urban air quality in 6 European cities by lower cost sensors, lagrangian urban dispersion modelling and traffic flow modelling: the TRAFAIR project

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(AND MANY MORE OTHER COLLABORATORS)



Our reasoning

Using low-cost air quality sensors coupled with air pollution models to both report current air pollution and forecast air pollution at urban-scale

> All sensor units used include a cell for each of the 4 monitored pollutant: **NO**, **NO**₂, **O**₃ and **CO**. RH and T sensor is also included.

GRAL (Graz Lagrangian Model) is a free and open source **lagrangian particle dispersion** model, suitable for urban (microscale) simulation.

The model uses local weather and emission data and its result is evaluated based on the TRAFAIR sensors network and AQM.



Decentia

http://lampz.tugraz.at/~gral/index.php/2-uncategorised/1-description#

Sensor approach



TRAFAIR is based in

- Italy: Pisa, Livorno, Firenze, Modena
- Spain: Santiago de Compostela, Zaragoza



In total, **54 low cost air pollution sensor** units are deployed in TRAFAIR = **216 measuring cells**: 25 <u>AirCubes</u>, 3 <u>Kunak</u>, 3 <u>Libellium</u> and 21 AIRQino (custom by <u>CNR-IBE</u>)



Sensors are calibrated by co-location to a reference station (AQM) and applying a hybrid model: **Random Forest + linear regression** for extrapolation beyond the calibration range



Data collected every 2 min and sent by LoRawan network to a central DB. Data by AQM collected every 1 - 15 min

Periods of recurrent co-location at AQM for calibration







via Villa d'Oro
 piazza Grande
 piazza Manzor

via Pavia

via A. Volta
Parco Ferra

) Policlinico

Ring Road

ARPAE AOM

Sensor

LORaWAN Gateways

locations

in Modena

MASA

Example of calibration performance for Low Cost Sensors (LCS) for Modena

- Correlation of AQM vs LCS for NO_2 and O_3 (10-minute time resolution)
- Red bars: co-location data over the same period used for both calibration and validation (benchmark)
- White bars: validation based on "temporal re-location" (calibr. and valid. periods differ)



LCS accuracy & precision

Variability of the LCS + calibration protocol estimate for each concentration bin observed by the AQM (i.e. reference)

- Black dot: LCS median value for the bin
- Black vertical line: range of the 90% LCS estimate
- Blue solid line: the 1-1 line
- Orange dashed line: 15% uncertainty
- Green dashed line: 25% uncertainty

The graph is used to assess the reliability of the LCS + calibration protocol at different levels At ~35 μ g m⁻³ the LCS stabilizes and performs satisfactorily.



GRAL approach



Tailored NO_x traffic emissions by SUMO traffic model + EEA emission factors for the local fleet



Tailored domestic heating emissions by local inventory + building location and ancillary data (e.g. neighborhood-resolved natural gas consumption)



48 hrs local weather forecast for each city (by <u>WRF</u> or <u>COSMO</u>)



GRAL ran at microscale only: 4m x 4m cells domain over the whole city. Buildings as obstacles included.

GRAL 48hrs forecast service of NO_x running daily on local HPC in each city



GRAL performance assessment based on the <u>FAIRMODE</u> guidelines

Santiago de compostela 5-6/May/2020

GRAL - SCQ NOx



Zaragoza





Example of GRAL results for Modena (index for 1 month of simu.)

1st day of forecast





GMT time

GRAL

OBS

150











Conclusions

Measurements

- Short term co-location periods for calibration provide adequate results. However, further co-location periods are needed in different seasons
- No clear sensor degradation was observed in the different calibration periods
- The comparison of results is challenging because over different seasons (meteorology, anthropogenic emissions). A further temporal relocation will be performed in summer 2021
- Calibration over periods of lower absolute levels exhibits lower performance, both for NO and O_3

Visit <u>http://trafair.ue</u>



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Modeling

- The GRAL performance in modelling NO_x concentrations at urban traffic sites captures the daily pollution pattern and can be considered quite good
- Simulated concentrations generally underestimate levels at urban background, but their performance is in line according to benchmarks suggested by FAIRMODE
- Further improvement regarding traffic simulations are planned in order to accurately describe traffic fluxes in minor roads distant from the city centres. GRAL concentrations in suburban areas will benefit by these enhancements

