How to calculate and understand emissions

✓ Timo Roschier / 2023

Emissions and Air Quality

- Local air quality is based on four components:
  - Long range transportation
  - Local emissions
  - Local weather conditions (micrometeorology)
  - Human behavior
- Many local sources:
  - Traffic (cars, busses, heavy vehicles)
  - Industry, Factories
  - Construction sites
  - Households (wood burning, coal)
  - Power plants
  - Photonucleation
  - Biogenic sources
  - Transformation into Secondary parameters
  - Resuspension

Main components

- Gases
  - NO_2, Nitrogen dioxide
  - CO, Carbon monoxide
  - O_3, Ozone
  - SO_2, Sulphur dioxide
- Particulate Matter
  - $PM_{2.5}$, Particles ≤ 2.5µm
  - PM_{10}, Particles ≤ 10µm
  - (Coarse Particles: 2.5µm - 10µm)
  - Ultrafine particles UFP: ≤ 1µm)

New parameters coming:

- BC, Black Carbon
- LDSA, Lung deposited Surface Area
- PNC, Particle Number Count, Particulates per cubic centimeter

Emissions and concentrations

- Emissions sources are usually very local
- Estimation of total emissions are based on measurements
  - Source of emission (traffic, construction, etc.)
  - Type of emission (single shot, short, long, …)
  - Behavior of emission (deposition, expanding, …)
  - (Height of the emission: surface, low height, …)
  - Emission component (gas, particles)
  - (Atmospheric stability and mixing: plume shape)
- Measurements must be in as optimal place as possible: Traffic and city measurements aside of a road (like in the picture)
- Locally emissions can be estimated based on concentration measurements in correlation with conditions
- Measured concentration is also related to site environment: in street canyon concentrations are higher than in open area.

Emission scenarios

- Emissions are not constant
  - Diurnal properties: Rush hours, Quiet nights
  - Weekly properties: Workdays, weekends
  - Monthly and yearly properties: Holiday seasons, vacation season, special events
- Measured concentrations can differ from emissions: weather conditions – ventilation efficiency
  - Question of ground level ventilation
  - In inversion/stabile conditions, concentrations are higher when mixing is not happening
  - Otherwise, deep mixing making concentrations lower.

From reactive mode (Observations) to proactive mode (Forecasting)

- Measurements tell concentrations only on-site location – does not what are concentrations between sensors.
- Vaisala's Hyperlocal Air Quality Forecast model has capability to create analysis of conditions within a City based on long range air quality transportation, weather forecasts and latest observations
- Forecasting is possible by iterating emission inventories and scenarios to match with observations. (Statistical methods, machine learning, trad. Dispersion modelling, etc.)
- But: Human behavior can't be fully solved. (like random changes in traffic due Olympics, Football World Cup, etc.)
- Air Quality is highly local – like forecasting precipitation into street corners
- Therefore 100% accuracy cannot bee reached.
- If actions are made in a city based on forecasts, successful activities make forecast to fail.

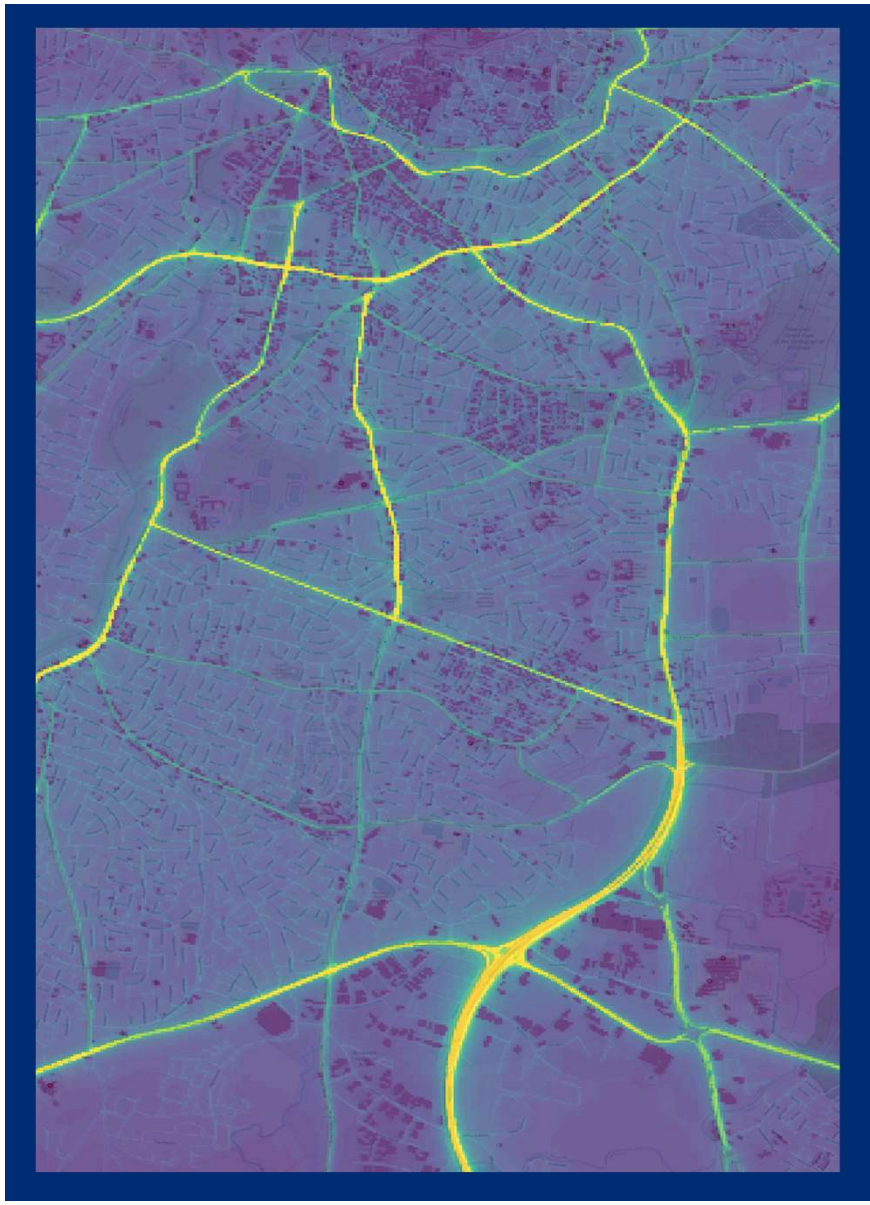
Estimating emissions in Vaisala Hyperlocal Air Quality Forecast

- Modelling activities:
  - Human behavior as statistical scenarios
    - Traffic scenarios: workday/weekend daily variation, weekly variation, for different vehicles
  - Weather related activities from weather forecast
    - Coefficients: bad weather increase car traffic
  - Weather conditions to increase or decrease concentrations.
    - Coefficients: Power plant and household wood burning emissions are based on temperature
- Additional needs – GIS data:
  - Land use maps with building height, population density maps, accurate street maps, etc.

Emission inventories and modelling

How to create reliable forecasts:

- Create environmental description for the model domain
- Create emission maps for each hour in the past and to the future
- Get background concentrations from Regional Air Quality model
- Do data fusion with weather data
- Iterative learning process: Adjust against observations and recognize changed emission levels.



Summary

- Emissions are very local: therefore, air quality measurements are more vulnerable to bad siting than weather measurements: must be located in optimal places, especially if goal is to catch emissions.
- Emissions are varying from hour to hour and day to day. Statistical approach only way to understand emissions.
- Combining emission statistics, background concentrations, weather conditions and real time observations with high resolution GIS data only way to get accurate information of Air Quality within Cities.

Vaisala.com
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