AQsensor – Air Quality sensing for estimation and control traffic emission

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Outlines

- Introduction
- Project ideas
- Research approach and activities
- Further perspectives

Introduction

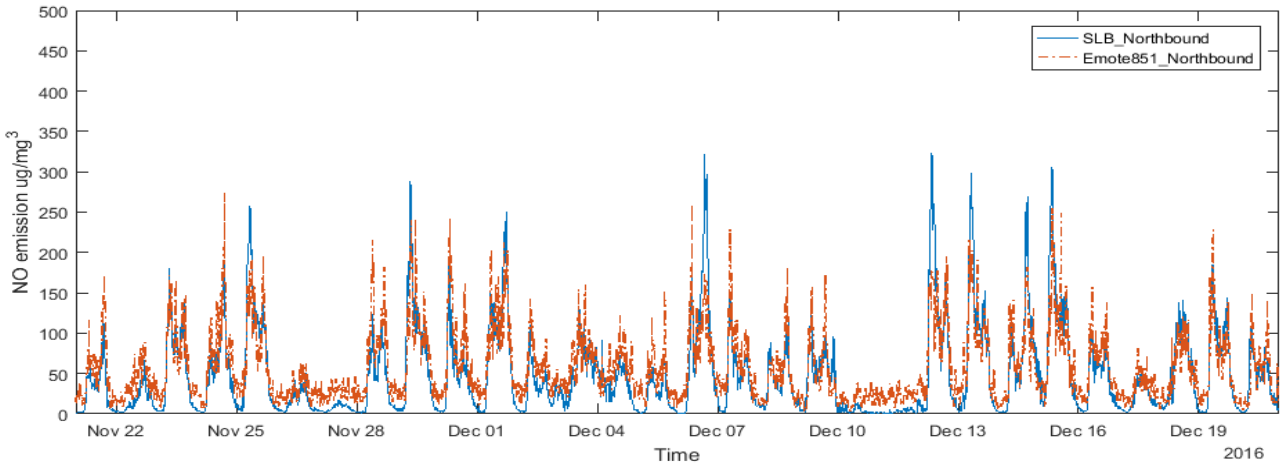
- Air pollution is one of the leading causes of mortality worldwide
  - Short-term exposure -> acute respiratory infection etc.
  - Long-term exposure -> lung cancer, heart disease etc.
- Air quality health index (AQHI) is a new tool to report public exposure to air pollutants
  - Obligatory to let the public know the AQ and health risks in EU
  - AQHI is going to be reported from 2021 in Stockholm
- Road traffic emission is dominant source in urban
  - Monitor and estimate traffic air pollutants
  - Design traffic management measures

Project Idea

- Traffic Emission
  - Complicated to estimate (vehicle model, type, engine, exhaust treatment etc.)
  - Impossible to measure directly
- Air Pollution Measurement
  - Precision stations (expensive complicated measurement equipment, big and intrusive)
  - Electrical Chemical Sensor (ECS) has been fast developed as one type of cheap sensors that can be used for Air Pollution Measurement (small, power-efficient, easily form an IoT network with wireless communication)
  - ECS can help intensify the measurement in space and can be potential used for traffic environment studies

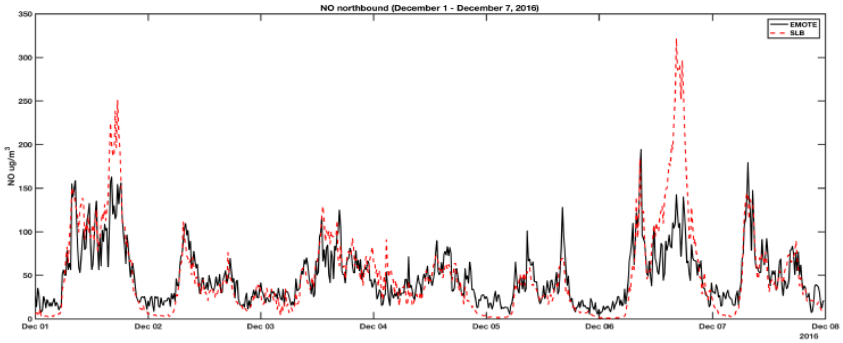
Pre-Study

- Sensors installation
  - KTH Campus (hardware and software)
  - E4 - dispersion (2016)
  - E18 – comparison (2017-2018)

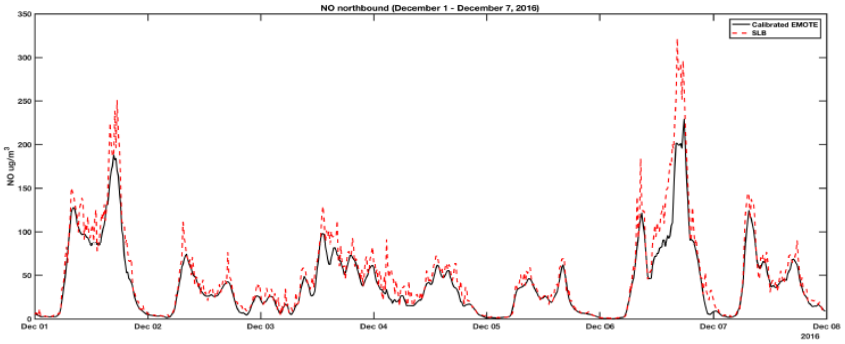


Pre-study

- ECS can capture the air pollutant profile but cannot precisely capture the amplitude in many cases
- Each individual ECS will have to be calibrated according to precision equipment
- We applied DL tools to calibrate the ECS sensors, and the suggested process requires some calibration effort (every six months)



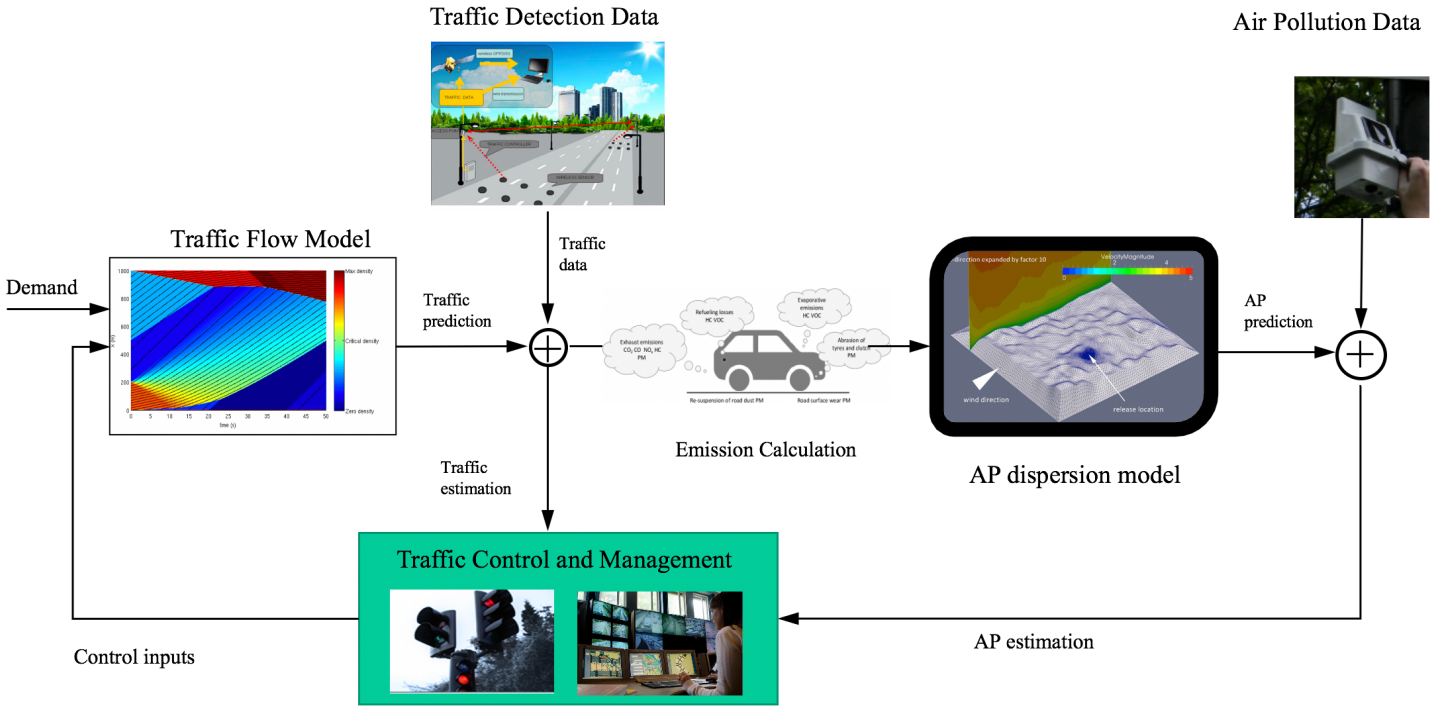
(a) EMOTE NO VS. SLB NO



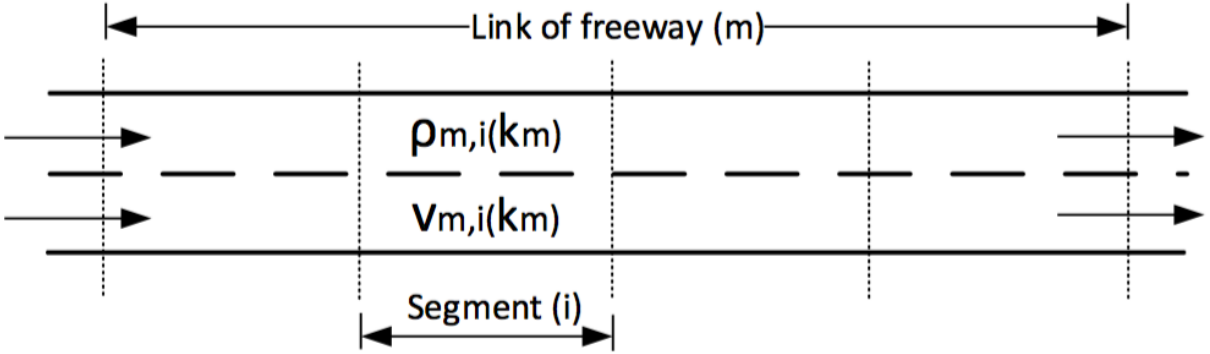
(b) Calibrated NO VS. SLB NO

Objectives and approaches

- To improve air pollution estimation for road-side emissions using Air Quality data as feedback information;
- To integrate traffic flow model and AQ model as well as AQ measurement in the analysis of traffic-induced emissions at road-sides;
- To apply the integrated model for mitigating traffic emissions by traffic management and control measures



Methodology: Macroscopic Traffic Flow Model

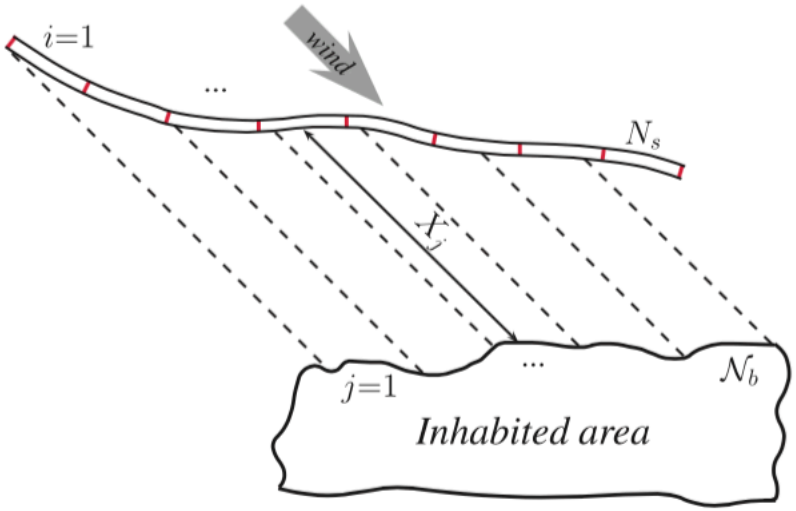


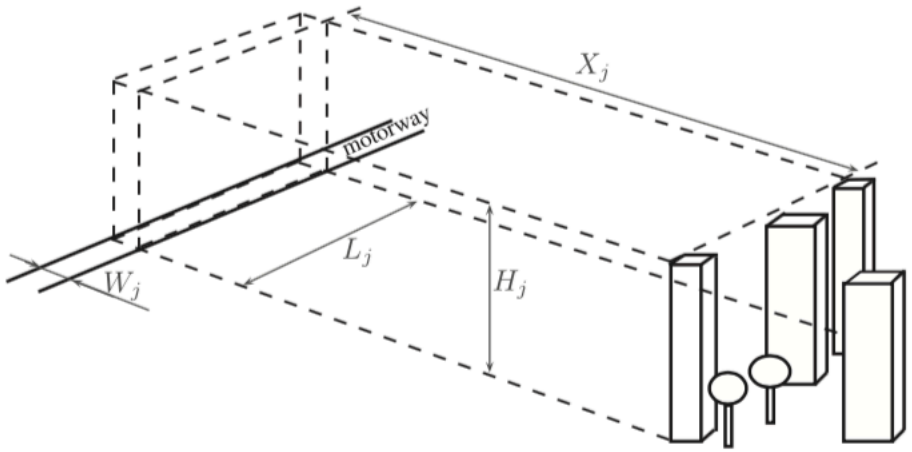
Consider a homogeneous traffic flow in a road element; according to the conservation law,

$$\frac{dn(t)}{dt} = Q_a(x,t) - Q_a(x+\Delta x,t) \approx \frac{\partial \rho_a(x,t)}{\partial t}\Delta x$$

$$\boxed{\frac{\partial \rho_a}{\partial t} + \frac{\partial(\rho_a V)}{\partial x} = 0} \quad \text{or} \quad \boxed{\frac{\partial \rho_a}{\partial t} + \frac{\partial Q_a}{\partial x} = 0}$$

Methodology: Air Pollution Model





- Emission is dispersed along channels
- Each channel is cuboid within which line-source emission from road segment will transport and disperse
- Air pollution dispersion will be described by conservation law in each channel:

$$\frac{ds_i^p(x_i,t)}{dt} = \phi_i^p(x_i,t) - \psi_i^p(x_i,t) - d_i^p(x_i,t)$$

inflow outflow dispersion

Case Study on E4S

Further Perspective

- To deliver
  - Integrated computational model for traffic-induced air pollution estimation at roadside (with case of E4S)
  - Design principle for optimal speed limit control that considers air pollution as one objective
- Further perspectives
  - Parallelize the computational code for more efficiency (in collaboration with KTH PDC)
  - Data-driven approach can be used or combined to support traffic and air pollution estimation process (collaboration with SLB)
  - Promote the method for real application in collaboration with public organization