CASPA 2019

Session 2 : Capteurs - Données

LE PROJET OPENSENSE

JEAN-PAUL CALBIMONTE PÉREZ

OpenSense
Crowdsourcing for High-resolution Air Quality Sensing

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@jpcik

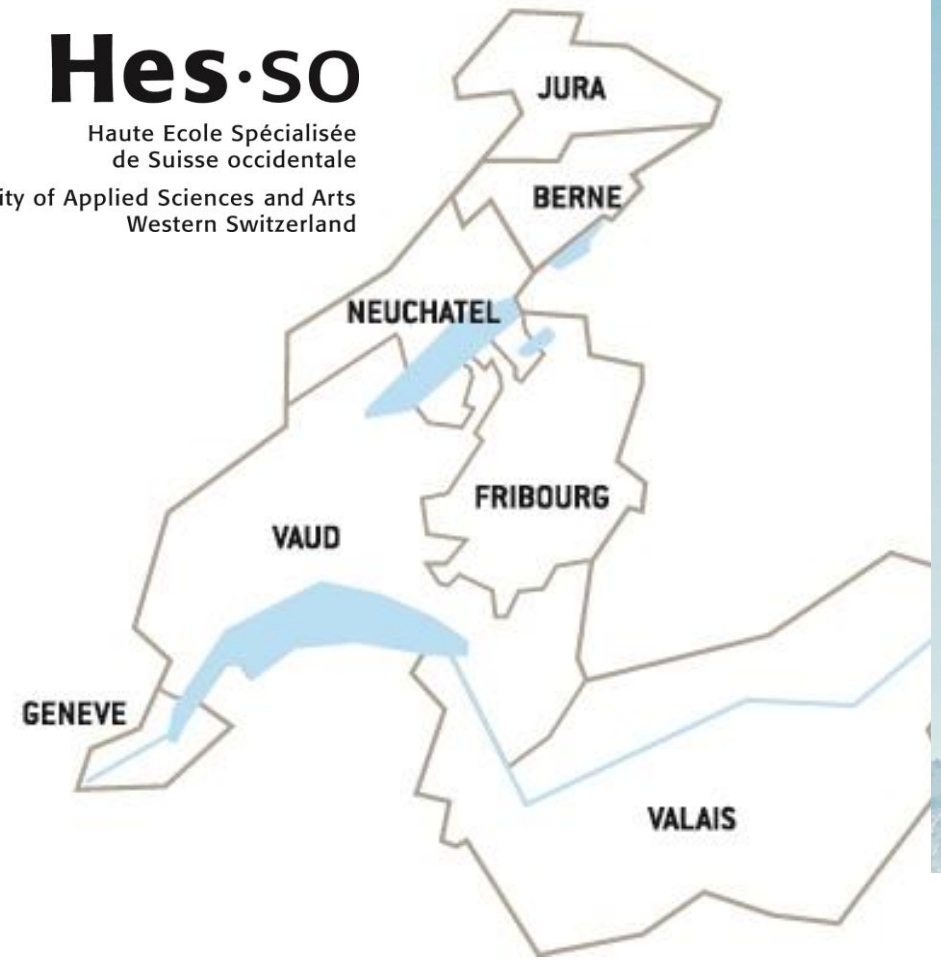
Colloque National Capteurs et Sciences Participatives (CASPA)

Paris, April 2019

HES-SO:

University of Applied Sciences and Arts Western Switzerland

Hes·so
Haute Ecole Spécialisée
de Suisse occidentale
University of Applied Sciences and Arts
Western Switzerland



Institute of Information Systems

HES-SO Valais-Wallis

nano-tera.ch

OpenSense II

Sensing the air we breath

CHUV EMPA IST Institut universitaire romand de Santé au Travail ETH Zürich EPFL ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

FNSNF

nano-tera.ch

140 Projects funded overall

50 Swiss research institutions involved

1200 Researchers

310 PhD students involved overall

The Nano-Tera initiative:

Collaborative research, bridging traditional disciplines

→ electrical engineering
→ bio-medical sciences
→ computer/communication sciences

Areas:

→ implantable/wearable systems
→ ambient/environment systems
→ energy systems.

Phase I	Phase II
RTD 2009-2013	RTD 2013-2017
↓	↓
OpenSense I	OpenSense II

Air pollution in urban areas is a **global concern**

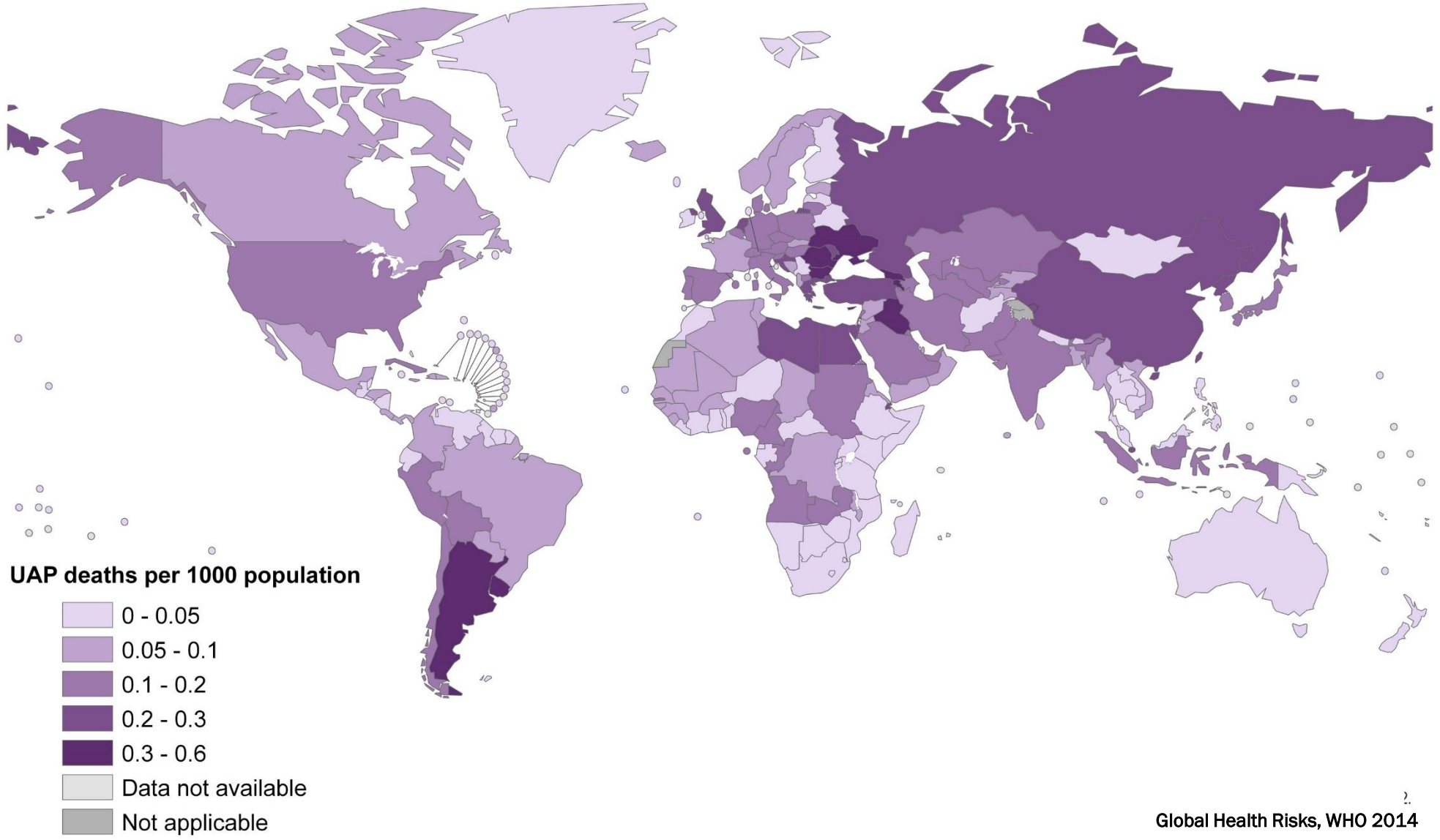
- affects quality of life and health
- urban population is increasing

Air pollution is highly **location- and time-dependent**

- traffic chokepoints
- rush hours
- urban canyons
- industrial installations and activities

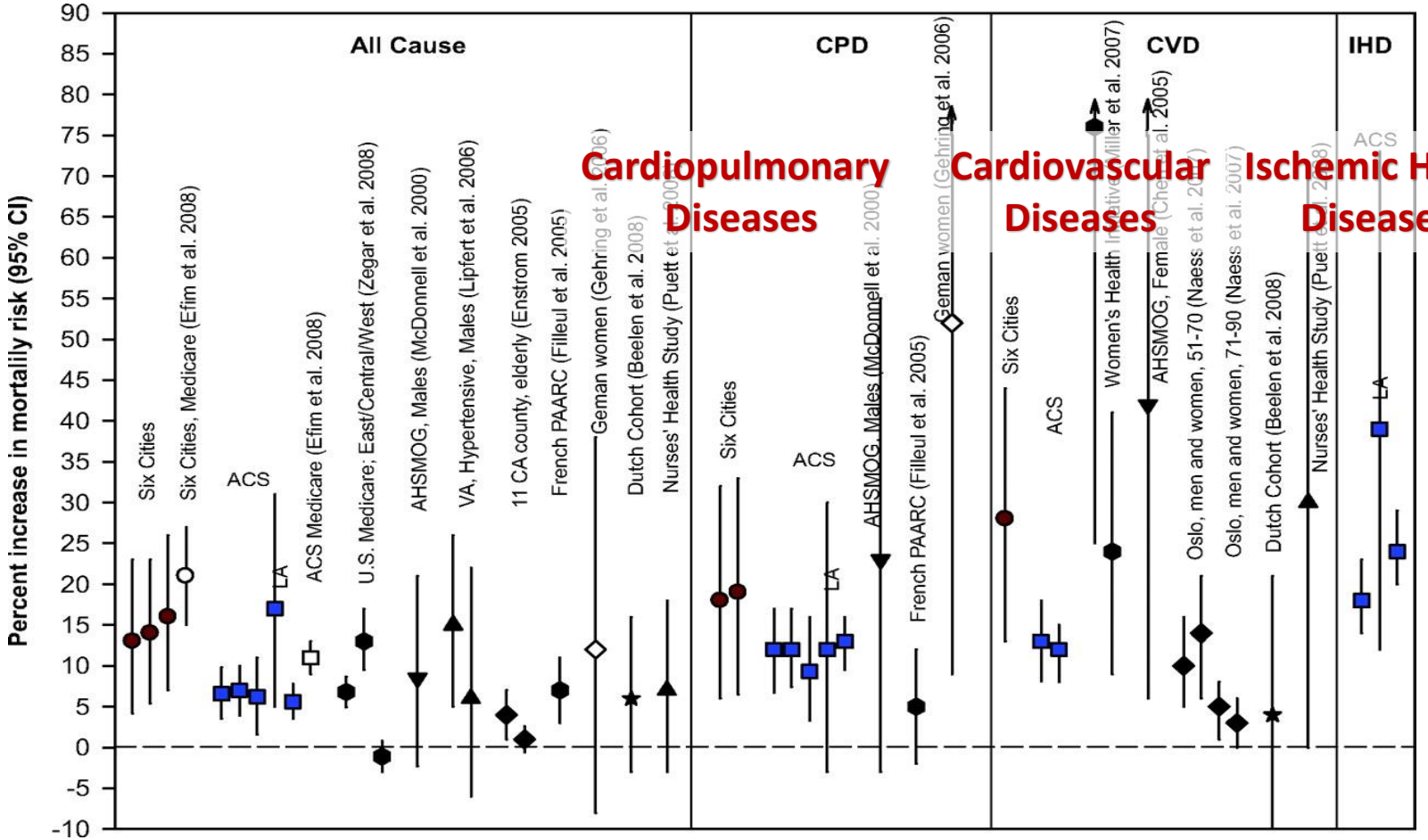
Air pollution monitoring today

- **Sparse, stationary** and expensive stations
- Spatial interpolation with **mesoscale** models (1km^2)



Global Health Risks, WHO 2014

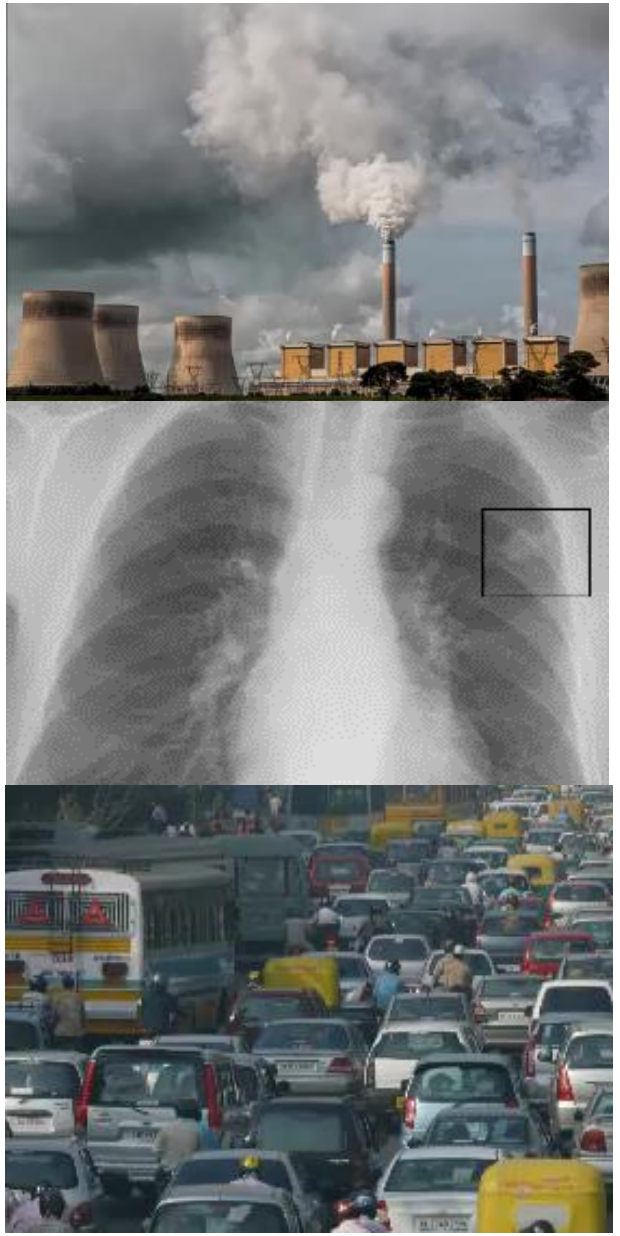
5% (2.6 million) of all deaths are caused by urban air pollution



Cardiopulmonary Diseases

Cardiovascular Diseases

Ischemic Heart Diseases



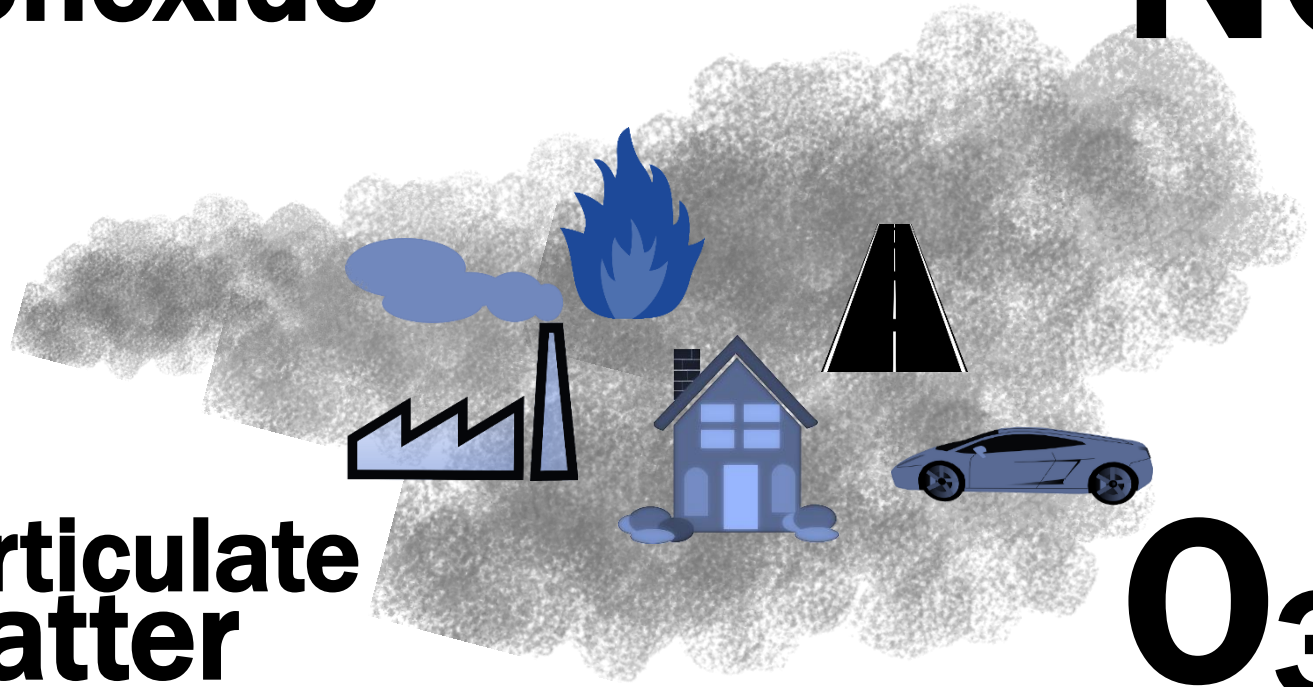
Health studies have shown the link between pollution and cardiovascular mortality

cardiovascular & respiratory morbidity
negative effects on nervous system

CO carbon monoxide

respiratory morbidity
airway hyperresponsiveness

NO_x nitrogen dioxide monoxide



PM particulate matter

aggravation pulmonary &
cardiovascular condition

O_3 ozone

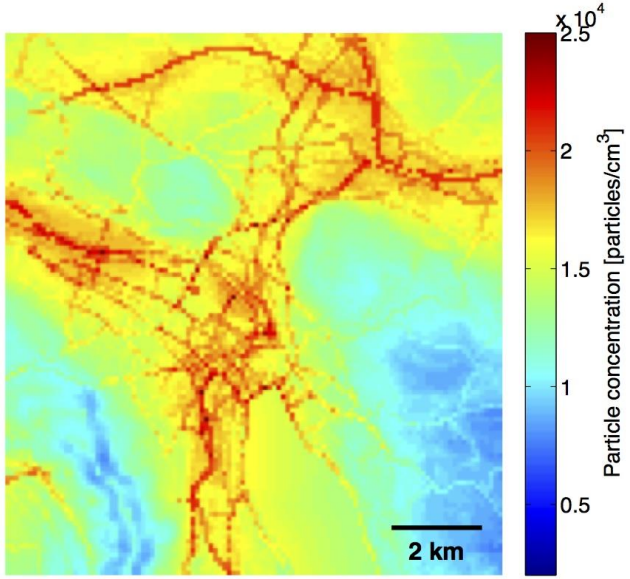
harmful to living organisms
decreased lung function
lung inflammation

Urbain Air Pollutants

Objectives in Air Pollution Monitoring

Officials

- environmental engineers: location of pollution sources
- municipalities: creating incentives to reduce environmental footprint
- public health studies



Citizens

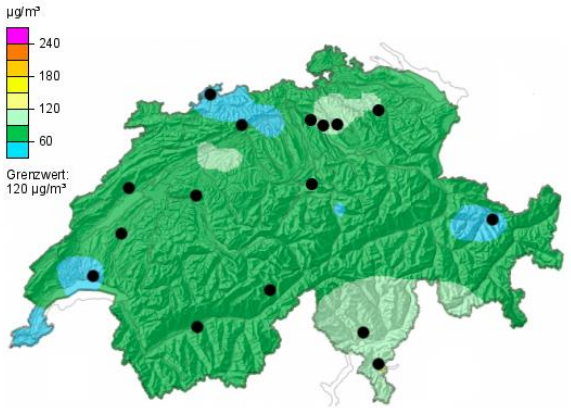
- advice for outside activities
- assessment of long-term exposure
- pollution maps

Accurate **location-dependent** and **real-time** information on air pollution is needed

*OpenSense ultra fine particle levels map in Zürich during winter months

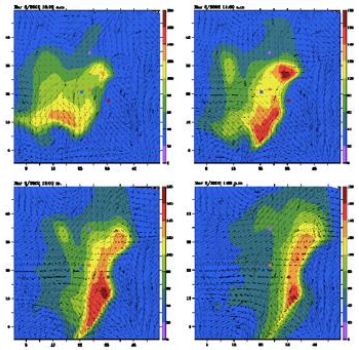
Monitoring Today*

Stationary and
expensive stations

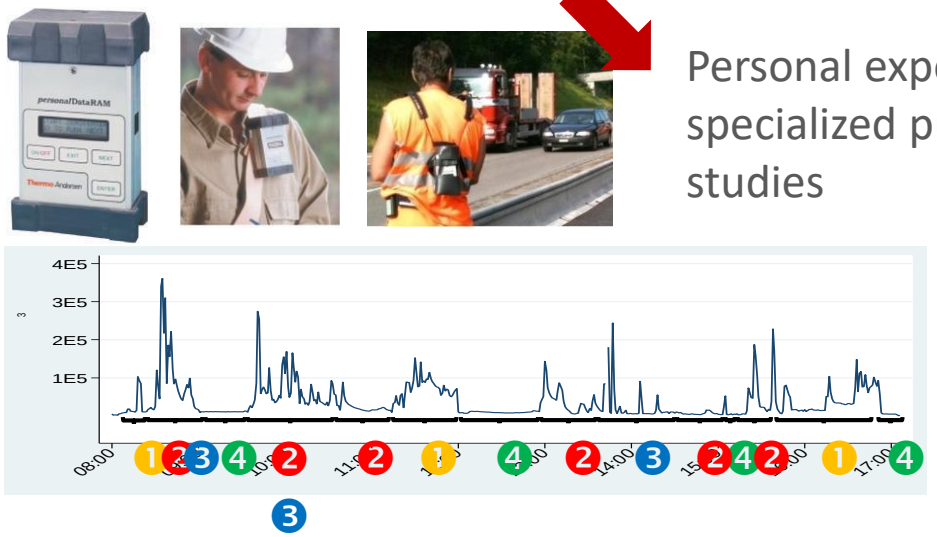


Sparse sensor network (Nabel)

Expensive mobile
high fidelity equipment



Coarse models
(mesoscale = 1km^2)



Personal exposure with
specialized punctual
studies

1 Garage
2 Vehicle
3 Road
4 Indoor

*sort of…
Sensing tehcnology changes rapidly

OpenSense I

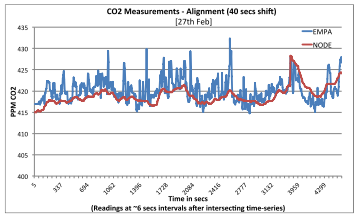
2009-2013

OpenSense:

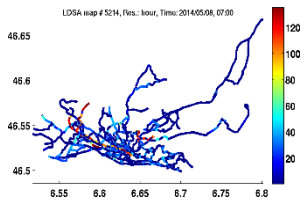
producing dense measurements in the domain of air pollution monitoring using mobile measurement stations and aiming at long-term measurements.

Air Quality Products & Applications

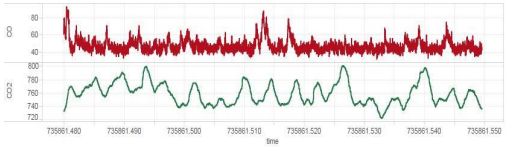
Temporal Spatial Aggregations



Pollution Maps



Air Pollutants Time Series

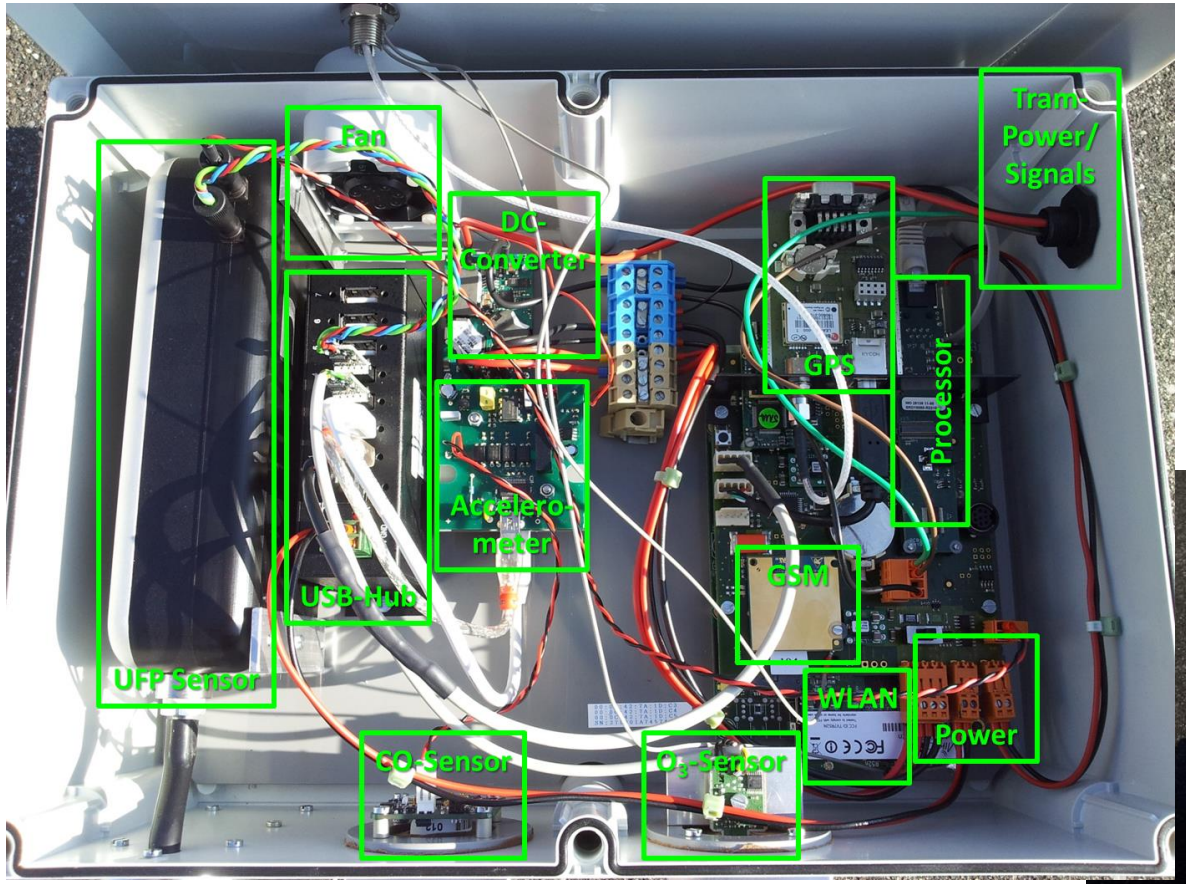


Raw Data Acquisition

Reference station

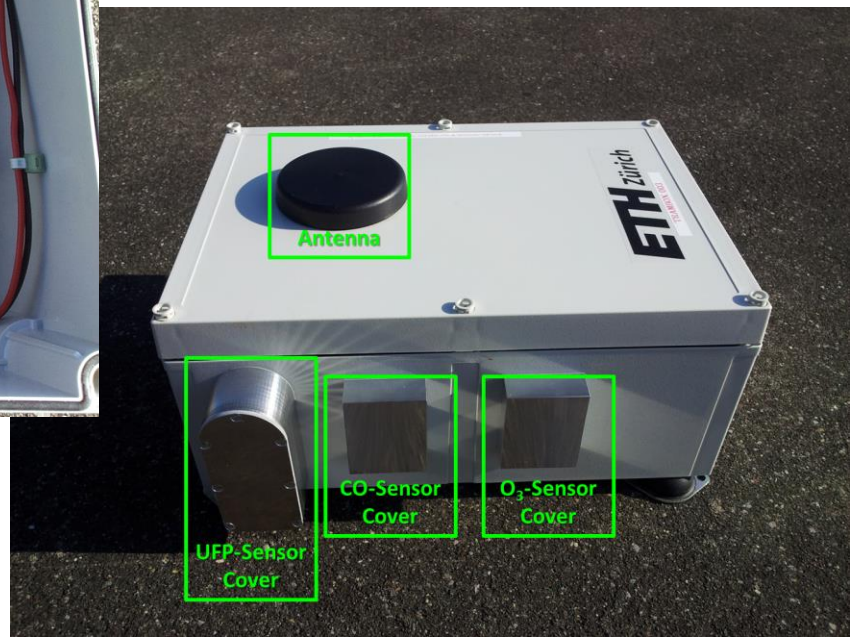
Public transportation

Crowd sensing



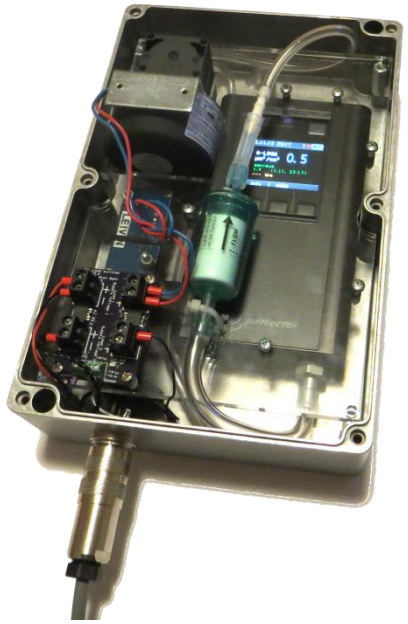
Inside the OpenSense Zurich node

Installation on top of VBZ Cobra tram



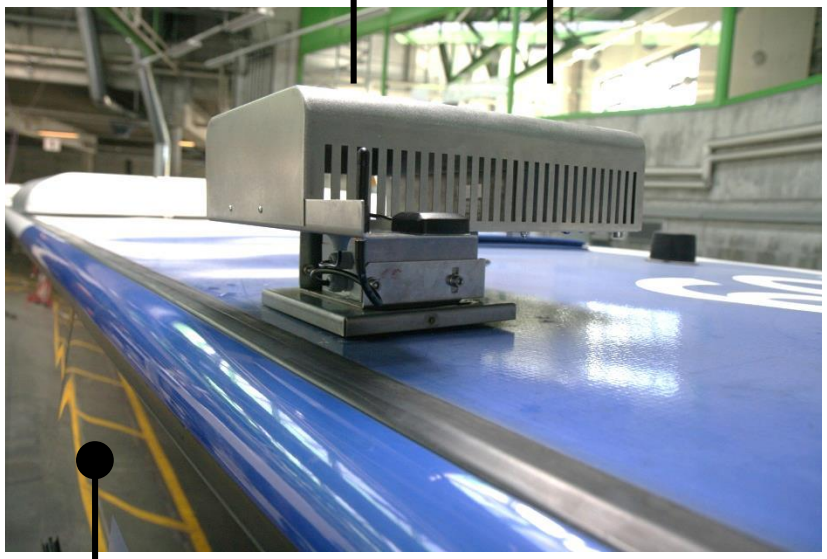
OpenSense Zurich node

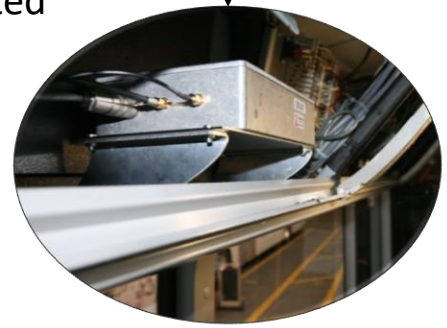
OpenSense Zurich Node

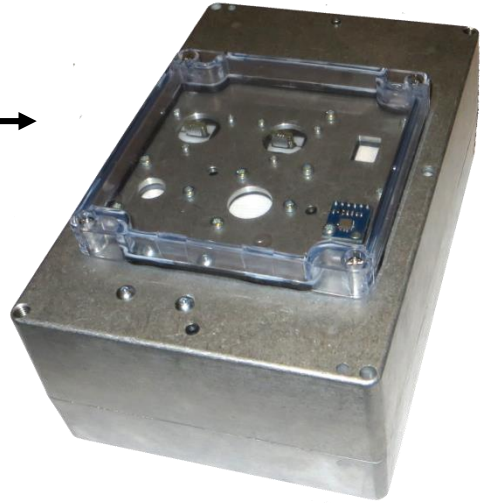


Particle sampling module

- Ultrafine particle measurements using Naneos Partector
- Measures directly lung-deposited surface area







Gas sampling module

- CO, NO_2, O_3, CO_2, temperature & relative humidity
- Hybrid active sniffer/closed chamber sampling operation
- Enables absolute concentration mobile measurements

Enhanced localization & logger

- mounted inside bus
- Fused GPS, gyro and vehicle speedpulses
- Accurate sample geolocation even in difficult urban landscapes
- GPRS communication

OpenSense Lausanne Node

[Aberer et al., MDM 2007]

data.opensense.ethz.ch

Data Storage/Access: GSN

Environment

Citizens

Infrastructure

ICT

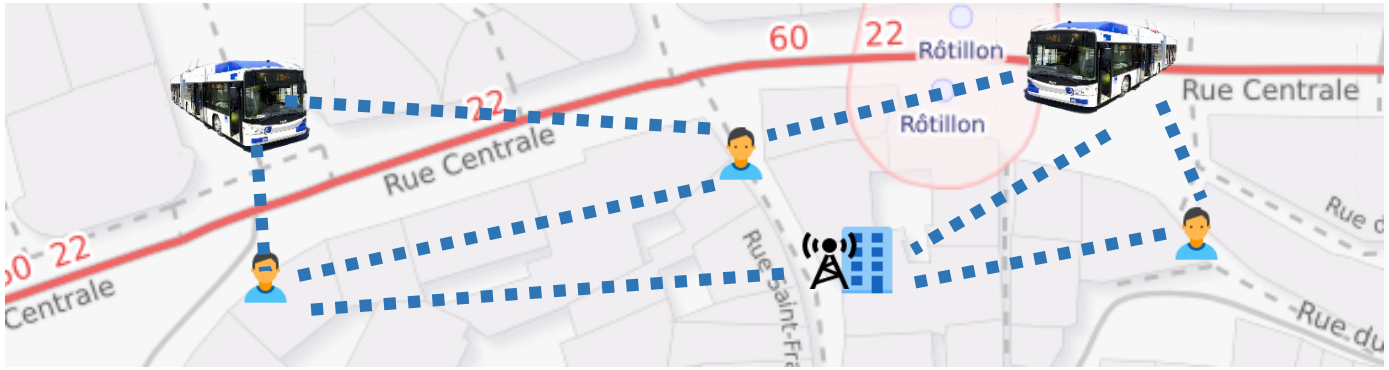
Physical

Business

Social

Mobility

Smart City

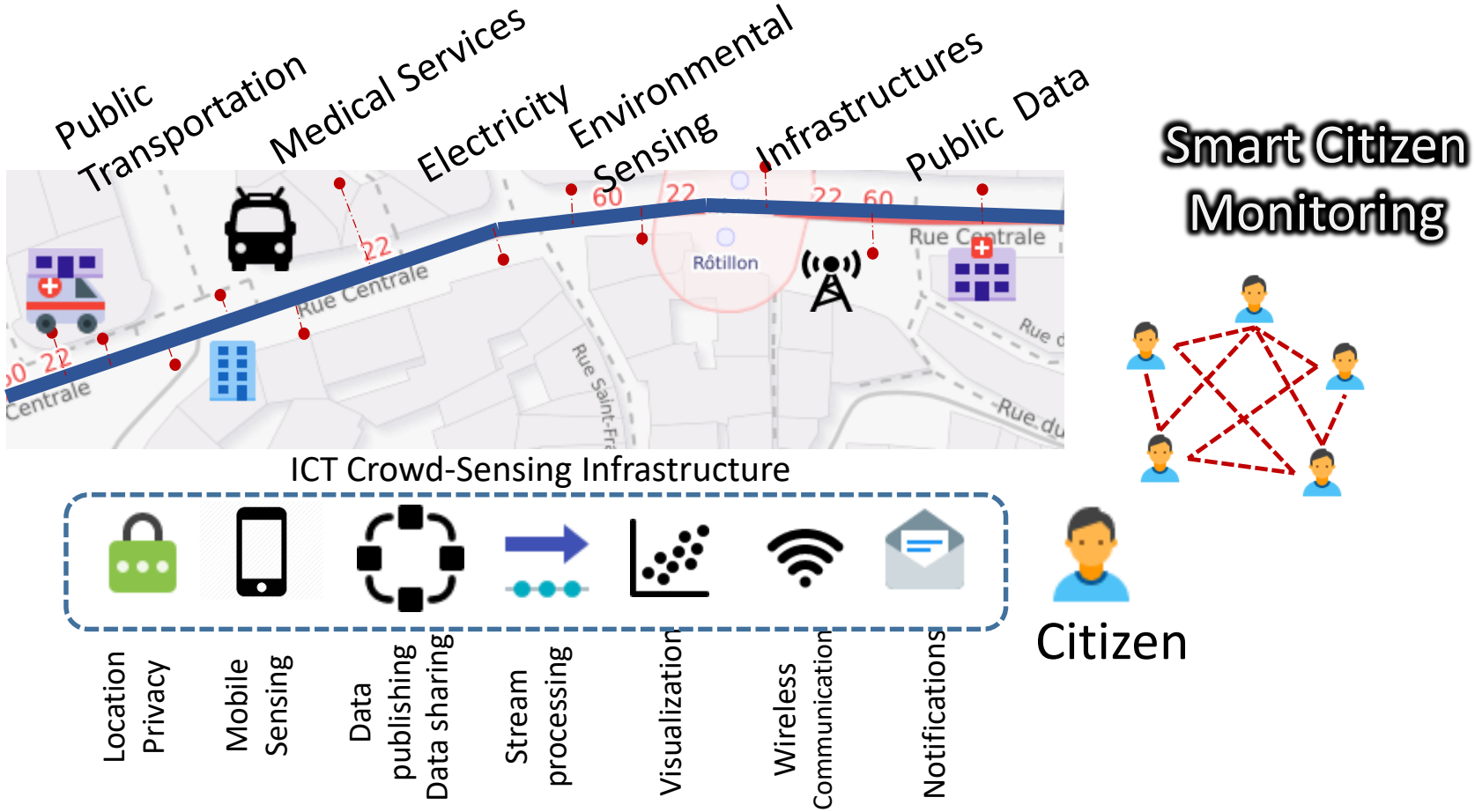


Multimodal monitoring City

Sensors in Public Transportation

Monitoring stations

Toward self-monitoring smart cities



Calbimonte et al. 2017. Toward self-monitoring smart cities: the OpenSense2 approach. *Informatik Spektrum.*

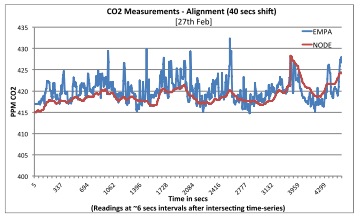
OpenSense II

2013-2017

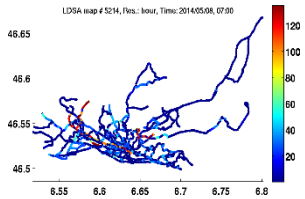
OpenSense II

Air Quality Products & Applications

Temporal Spatial Aggregations



Pollution Maps

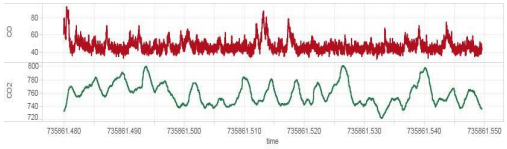


Pollution Models

Air Quality recommendations

Health Studies

Air Pollutants Time Series



Raw Data Acquisition

Reference station

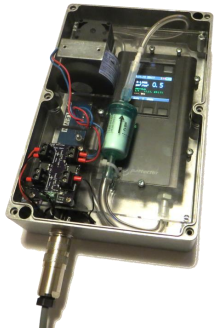
Public transportation

Crowd sensing

Coordination mechanisms

Privacy

Sensing platform



10 streetcars in Zurich & 10 buses in Lausanne

- CO, NO_2, O_3, CO_2, UFP, temperature, humidity
- Localization: GNSS for trams, GNSS fusioned with odometry and stop information for buses
- Communication: GPRS

OpenSense II Deployments

On top of "LuftiBus"

- Since March 2013, covers whole Switzerland

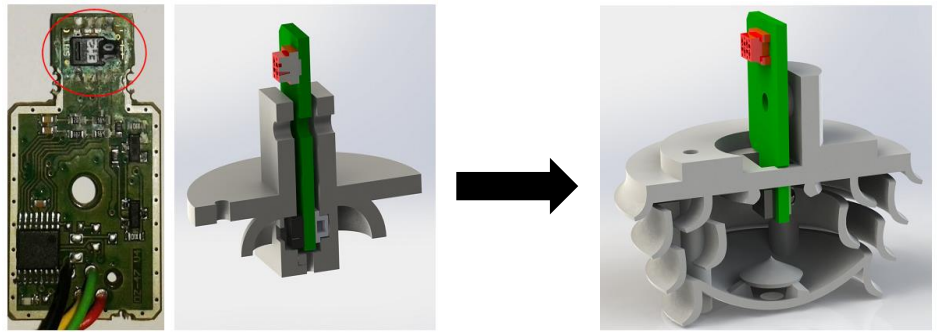
On top of C-Zero electric vehicle

- 100% electric, flexible mobility
- system test bed, targeted investigation tool

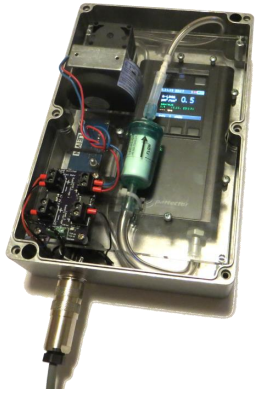
At NABEL stations in Dübendorf & Lausanne

- Stations run by EMPA
- Calibration and sensor drift evaluation
- Testing new sensors

Sensing Platform Upgrades



Lausanne deployment – Upgraded mask design for solving O_3 sensor corrosion problem; improves long-term stability of this sensory modality

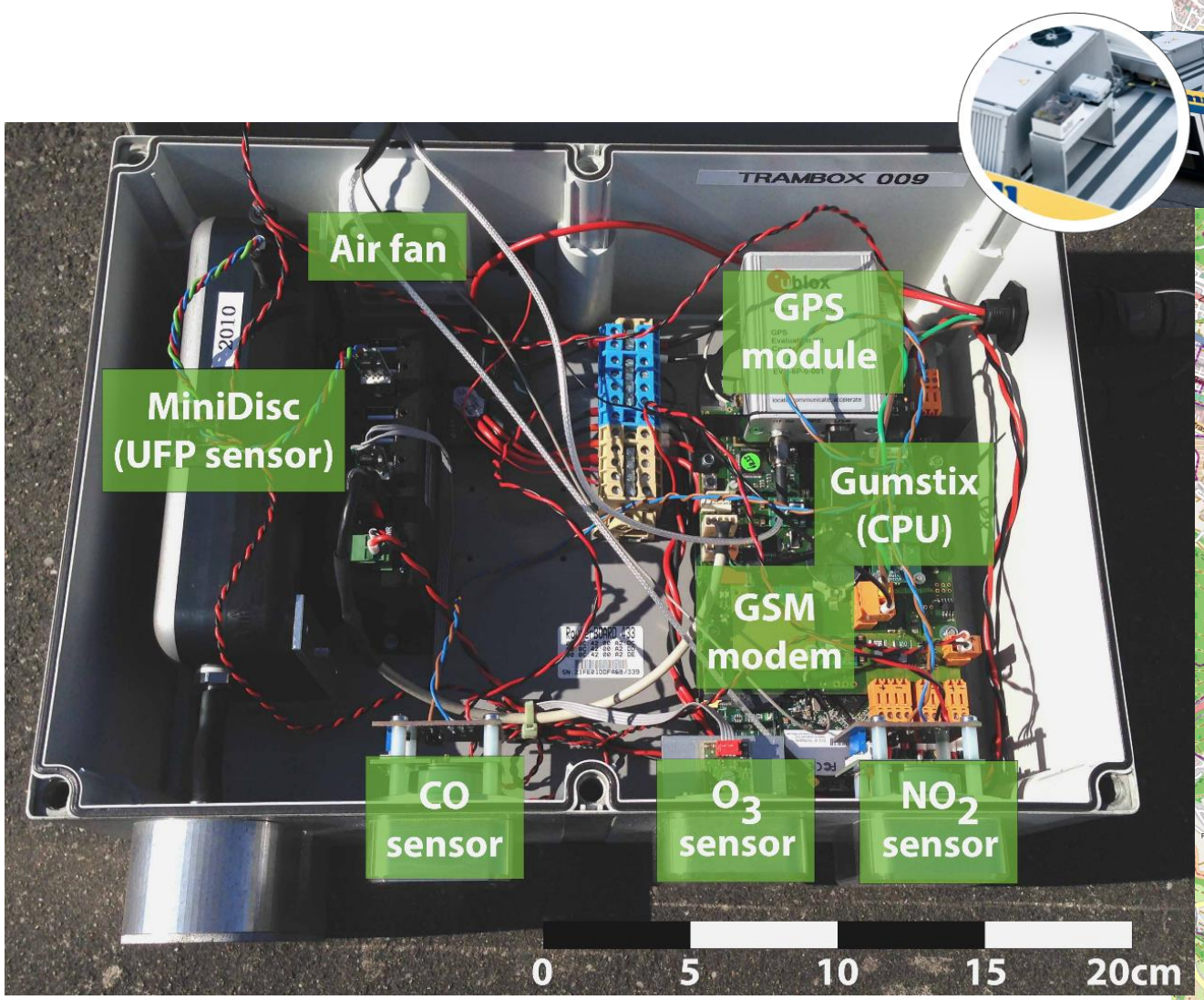


Lausanne deployment - Upgraded flow pre-processing and humidity control for Partector devices (UFP detectors)**;** improves long term stability and effective operational duty cycle of the instrument

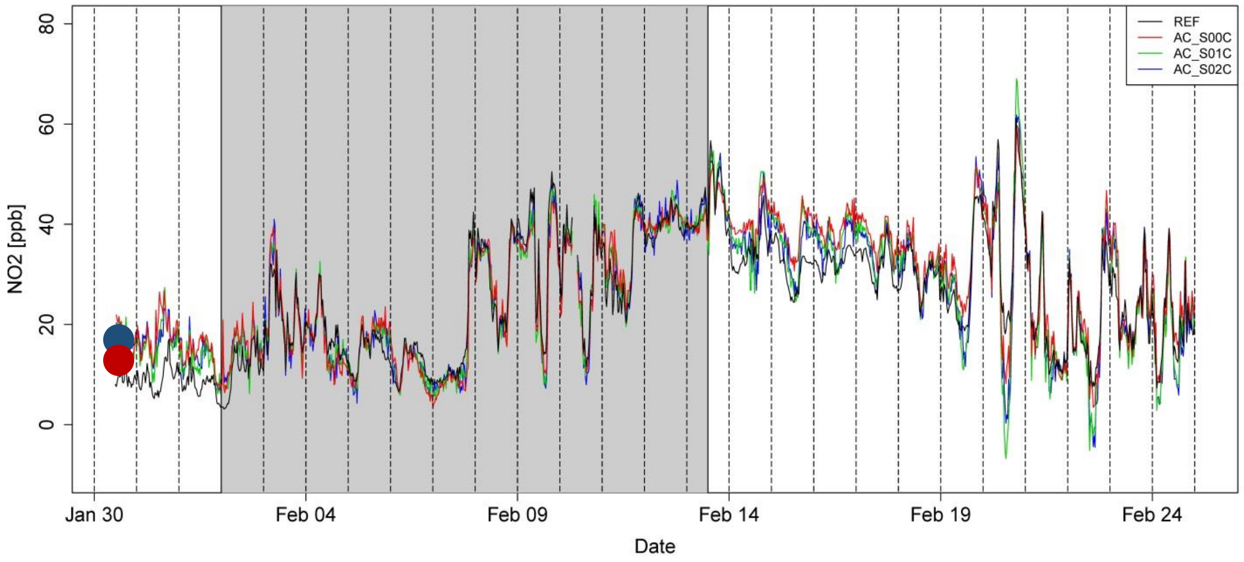
Zurich deployment – EMPA: new, high-quality nodes for static operation by DecentLab GmbH (spin-off of EMPA Measure NO_2, O_3, T and H: increasing the spatial density of calibration points for mobile nodes in the city of Zurich

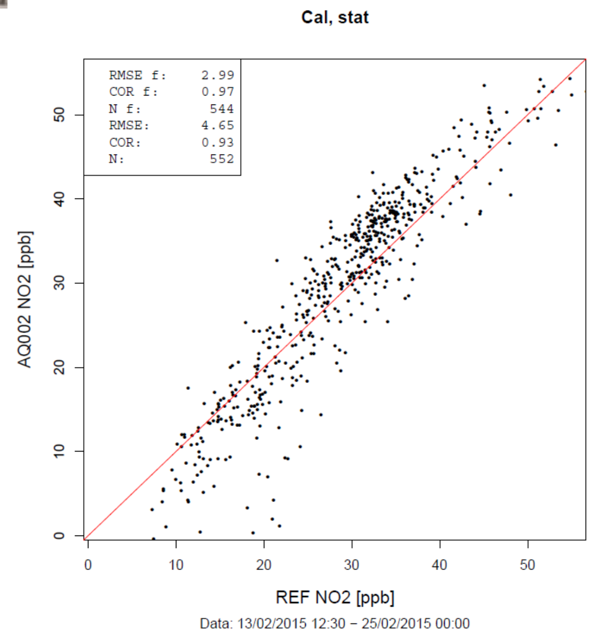
naneos particle solutions gmbh

decentLab



Zürich: 10 sensor nodes updated: O_3, NO_2, CO, UFP, GSM, GPS





EMPA/Decentlab: 2 sensor nodes (Aircubes): 2x O_3, 3x NO_2

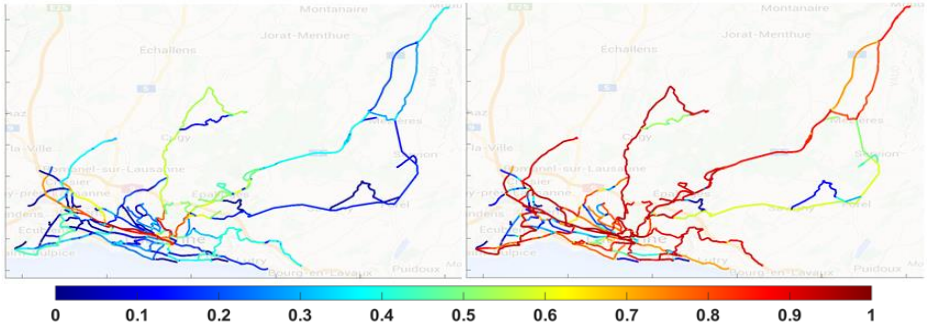
EMPA/Decentlab: comparison of results with reference

Lausanne: 10 sensor nodes upgraded: O_3, NO_2, CO, UFP, GSM, GPS

Network coverage analysis

- coverage of the network dynamically changes over time
- data-driven probabilistic coverage of street segments of Lausanne
- measurements are assigned to road segments using a route matching algorithm

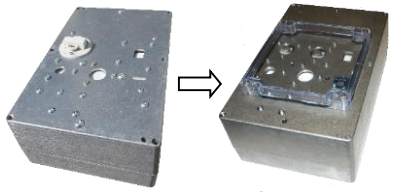
[Arfire et al., SenSys'15, submitted]

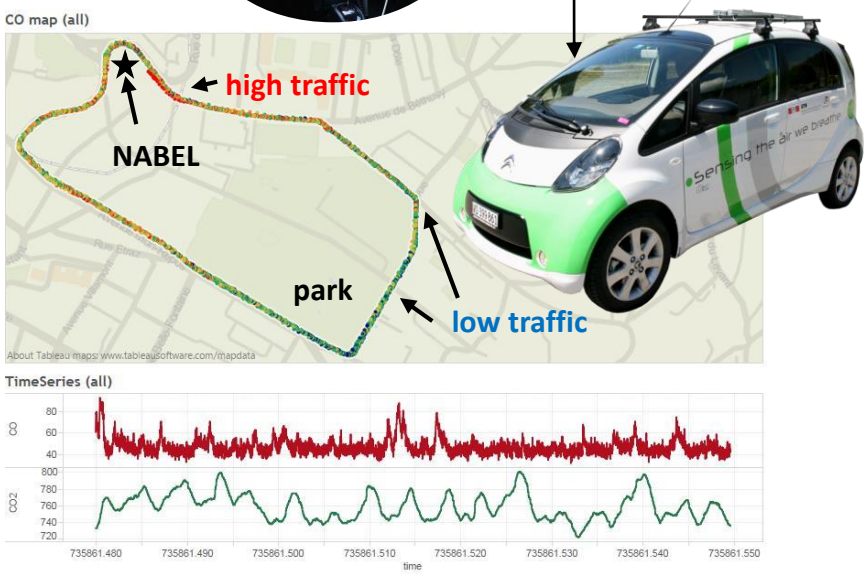


Daily (left) and weekly (right) probability of coverage of street segments in Lausanne

Advanced sampling systems

- electric car node used for studying impact of mobility on measurements
- testing in parallel novel sampling systems

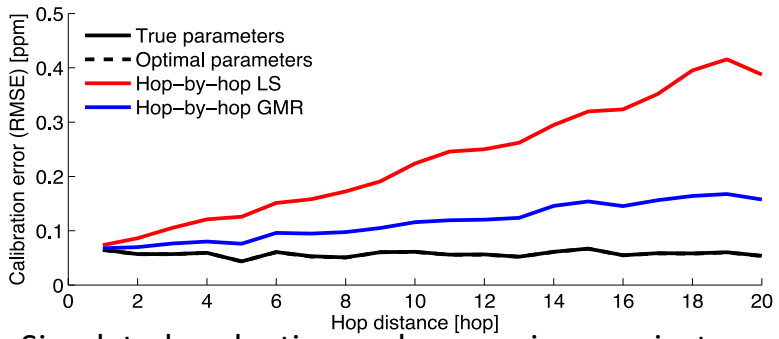




Mobility modeling and sampling strategies

Hop-by-hop GMR algorithm

- Calibrates network of noisy, unstable sensors
- Leverages meeting points between any pair of sensors
- Based on Geometric Mean Regression (GMR)
  - No regression dilution problem (no calibration bias)
  - Low error-accumulation over multiple hops
  - Resistant against sensor noise



Simulated evaluation and comparison against standard methods

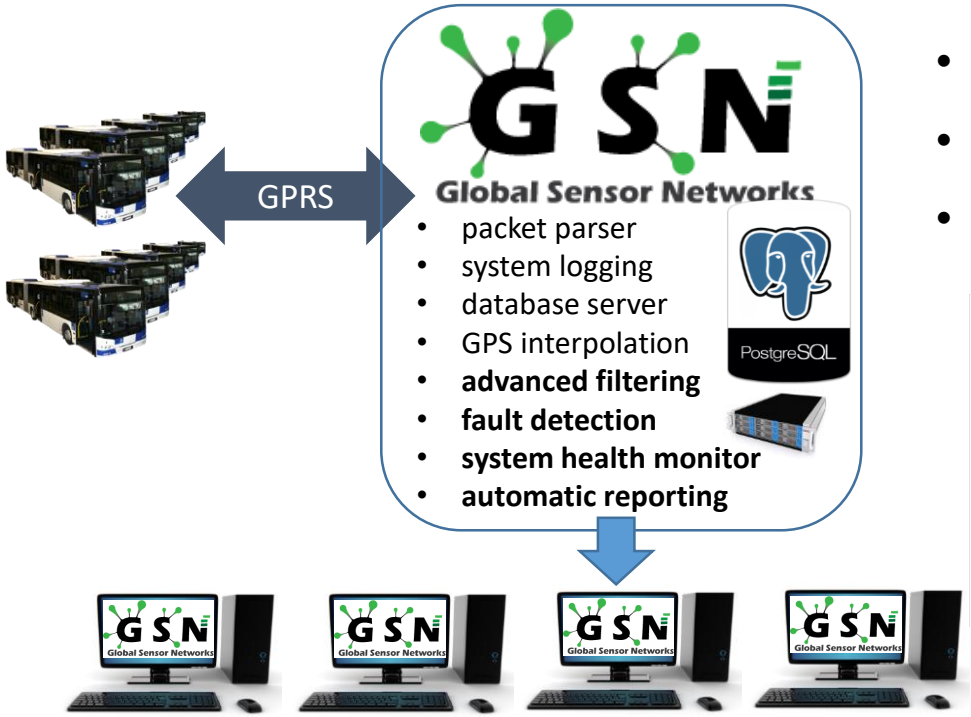
Data set	Measurements [in millions]	Periodic calibration error [RMSE]
Temperature	2.7	1.6 °C
Ozone (O_3)	2.1	9.8 ppb
Carbon monoxide (CO)	8.5	0.08 ppm

Evaluation on OpenSense data set obtained with Zurich deployment

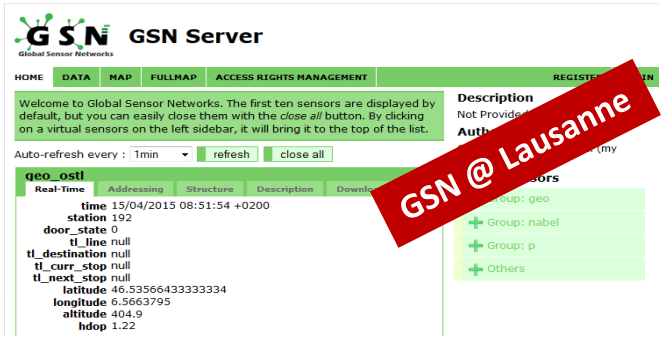
[O. Saukh, D. Hasenfratz, L. Thiele, *Reducing Multi-Hop Calibration Errors in Mobile Sensor Networks, IPSN'15]*

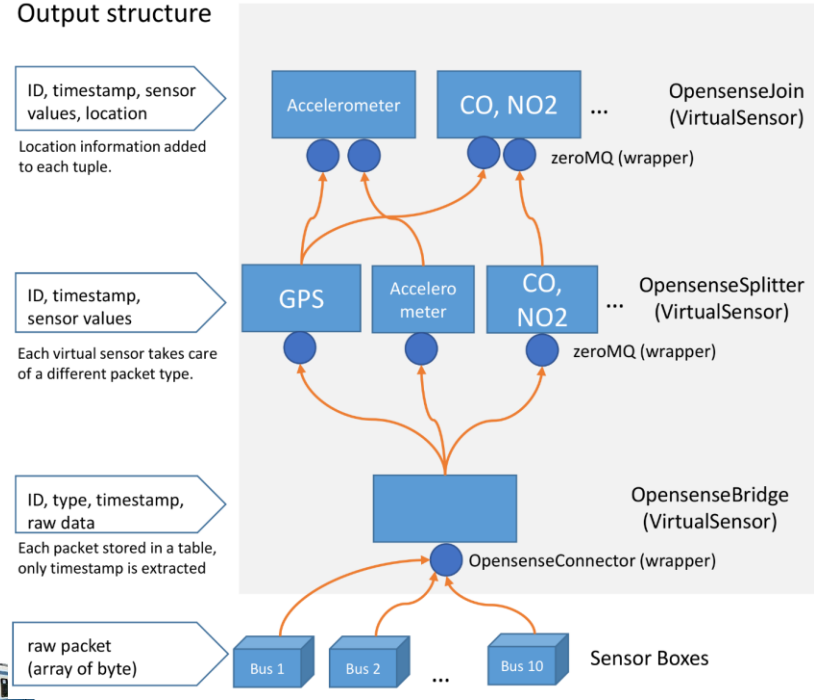
Balz Maag, Olga Saukh, David Hasenfratz, and Lothar Thiele, Pre-Deployment Testing, Augmentation and Calibration of Cross-Sensitive Sensors. EWSN 2016

Multi-Hop Calibration: quality assurance



- Unified **data acquisition** process
- **Web data** access/filter/download
- Sensor data archiving
- Sensor data search
- **Time series** processing





J.-P. Calbimonte, J. Eberle and K. Aberer, Semantic Data Layers in Air Quality Monitoring for Smarter Cities. S4SC 2015, at ISWC 2015, Oct 2015
- T. Guo, J.-P. Calbimonte, H. Zhuang and K. Aberer, SigCO: Mining Significant Correlations via a Distributed Real-time Computation Engine, In IEEE BigData 2015, Oct 2015.

Sensing Software Platform: GSN Backend

Global Sensor Networks

OpenSense Deployments

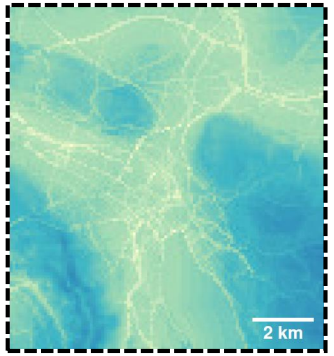
Trams Zurich

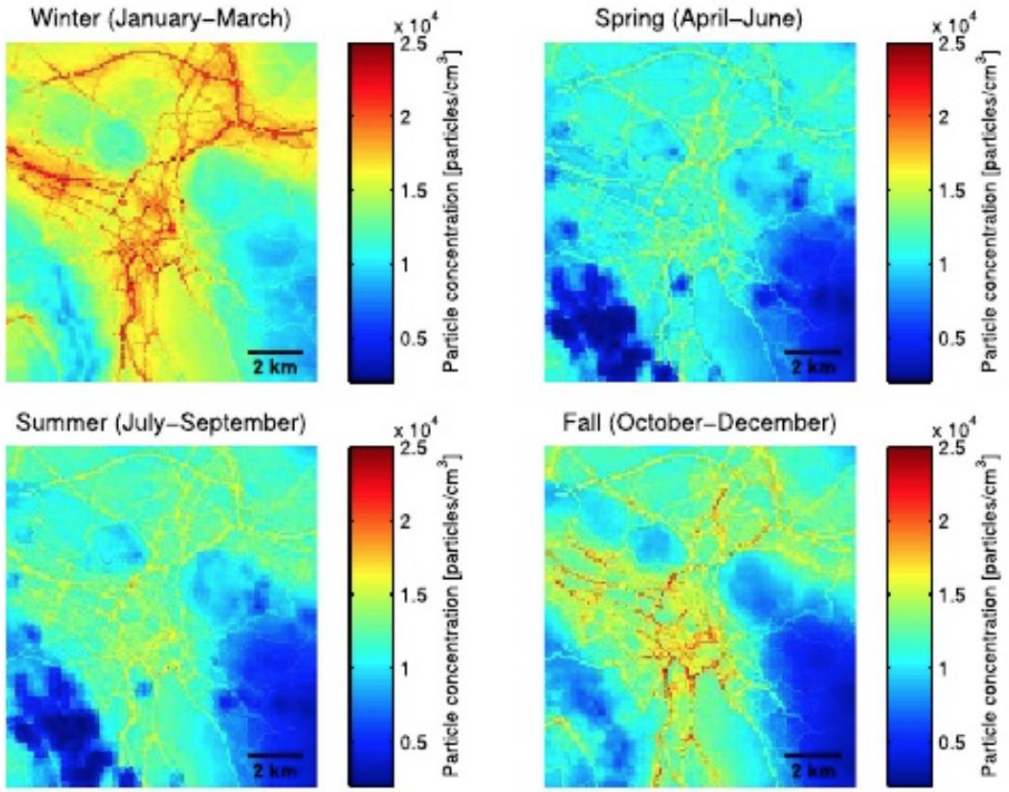
Sensing modality	Sampling rate	# of measurements
Particulate Matter (PM)	5s	> 80 millions
Ozone (O_3)	30s	> 21 millions
Carbon-Monoxide (CO)	10s	> 52 millions
Nitrogen-Dioxide (NO_2)	10s	> 52 millions
Temperature (T) & Humidity (RH)	30s	> 42 millions

Buses Lausanne

Sensing modality	Sampling rate	# of measurements
LDSA (PM)	1 s	> 203 millions
[CO, NO_2, CO_2]	5 s	> 101 millions
[O_3, T, RH]	5 s	> 71 millions
GPS fix	1 s	> 325 millions
[odometer, accelerometer]	0.25 s	> 1352 millions
vehicle context info	event-driven	> 14 millions

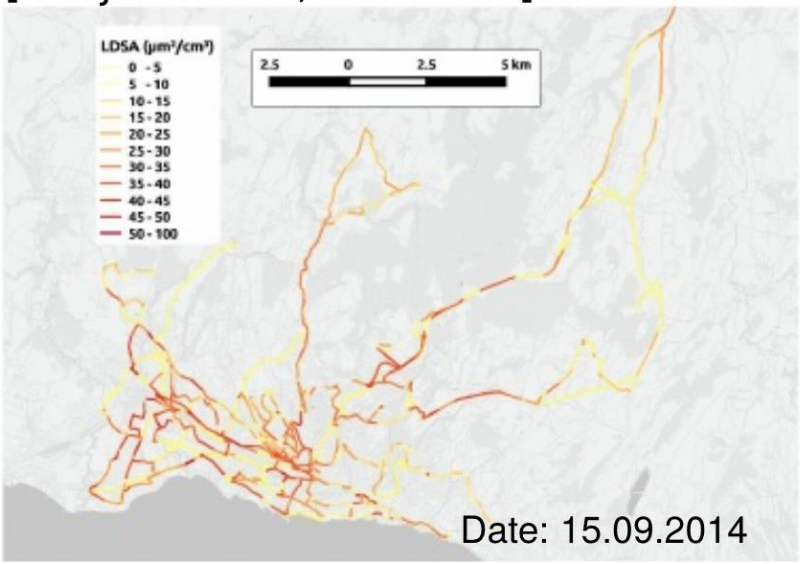
Building pollution maps





Zurich, quarterly data, 100x100 m grid-based tessellation; linear regression model using land-use and traffic data as explanatory variables

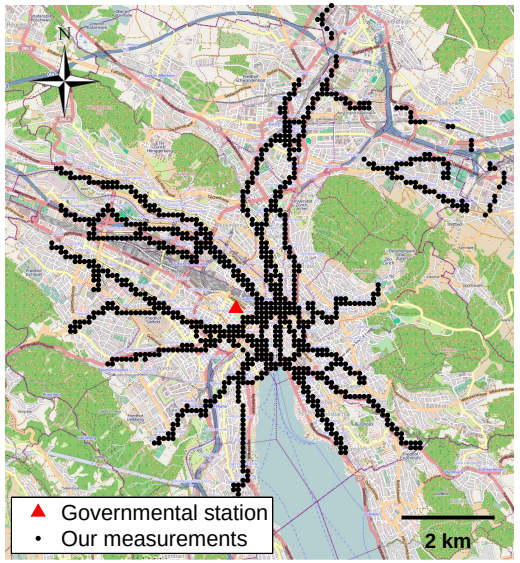
Lausanne, daily data, street-based tessellation; ANN with deep learning model using land-use, traffic and weather data as explanatory variables
[Marjovi et al., EWSN'17]

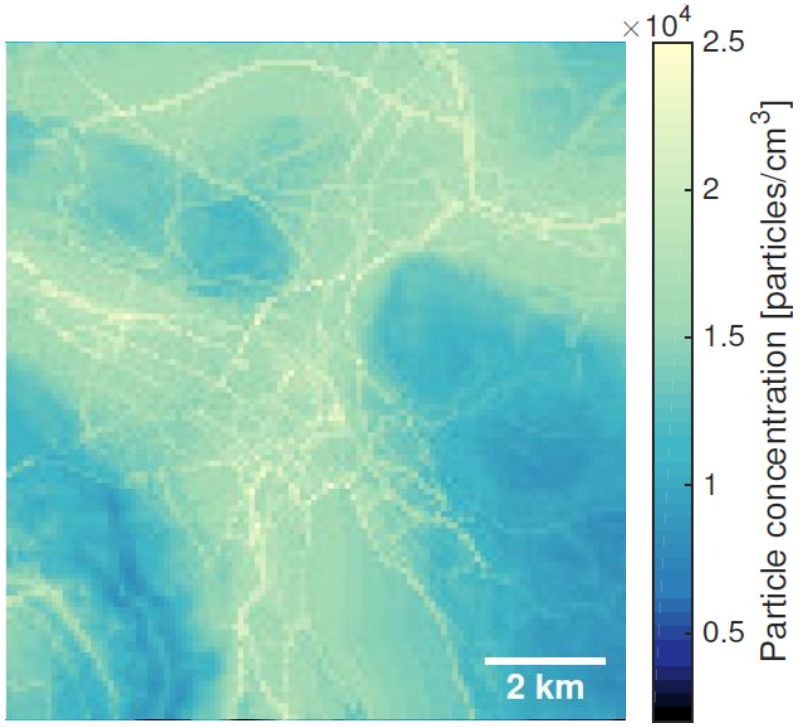


Zurich

Lausanne

Generation of data-driven pollution maps





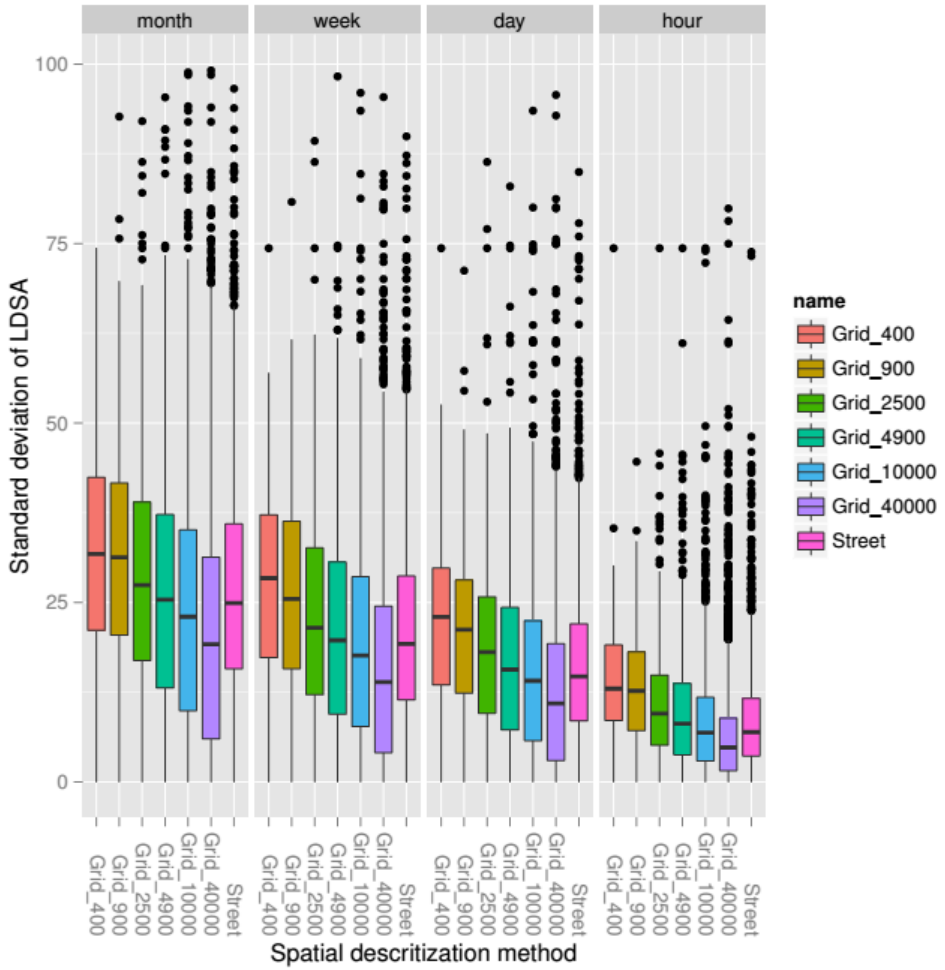
Processing steps:

Raw data → Data filtering & calibration → Data validation → **LUR model** → Pollution map → Map validation

- M.D. Mueller, D. Hasenfratz, O. Saukh, M. Fierz, Ch. Hueglin, Highly resolved ultrafine particle number concentration maps for the city of Zurich, Switzerland. International Symposium on Ultrafine Particles, May 2015
- M.D. Mueller, D. Hasenfratz, O. Saukh, M. Fierz, Ch. Hueglin, Mapping of ultrafine particle concentrations with high spatial and temporal resolution in the city of Zurich, Switzerland, European Aerosol Conference, Sept. 2015.

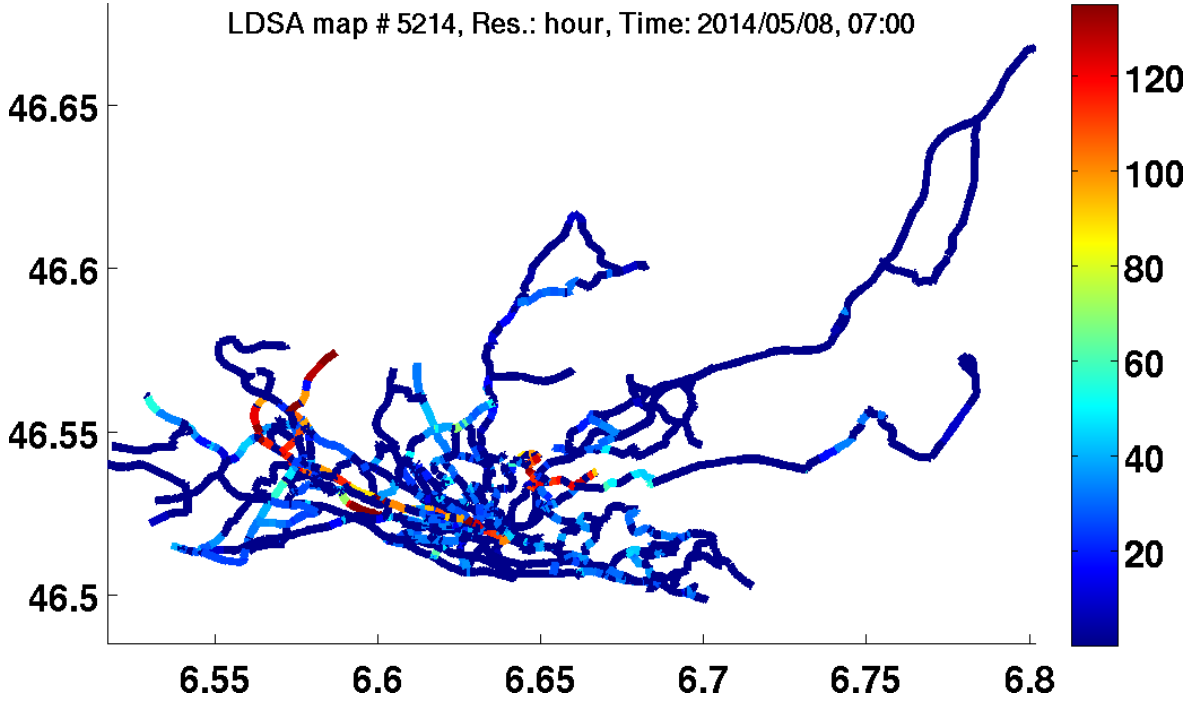
From raw measurements to fine-grained pollution maps

Street segment-based space discretization better suited than grid-based



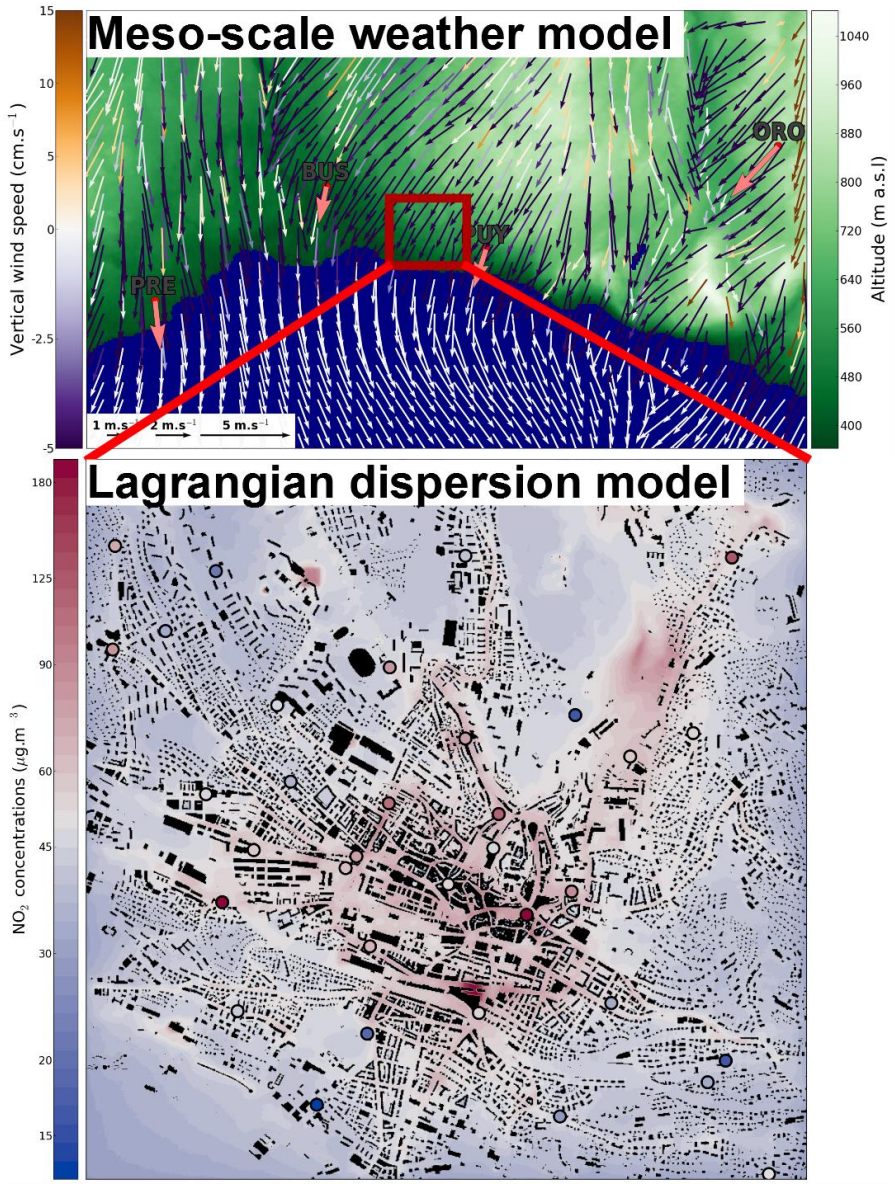
Types of models considered so far:

- Log-linear regression (NABEL station & meteorological explanatory variables only)
- Network-based log-linear regression (explanatory variables + measurements on other segments)
- Probabilistic Graphical Model (see picture)



- A. Marjovi, A. Arfire, and A. Martinoli, High Resolution Air Pollution Maps in Urban Environments Using Mobile Sensor Networks, (DCOSS), June 2015.

Mobility modeling & Sampling strategies: pollution mapping



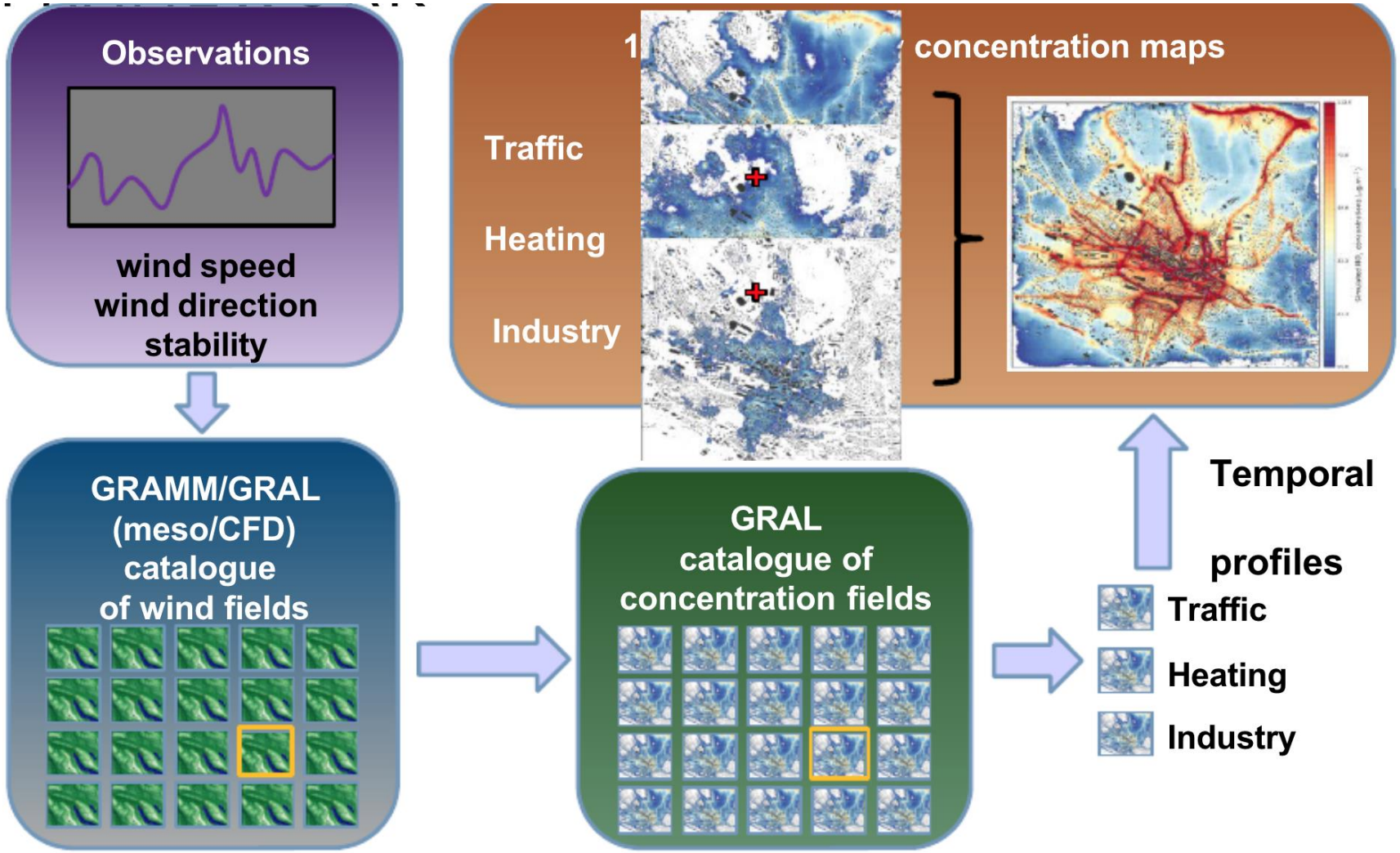
Setup

- GRAMM (Graz Mesoscale Model): mesoscale flow simulations for city region (100 m resolution) accounting for topography and land use
- GRAL (Graz Lagrangian Model): flow and air pollutant dispersion simulations at building resolving scale (5 m) for city area forced by GRAMM meteorological data

Achievements

- Successful setup for Lausanne, including preparation of emissions and other inputs
- Hourly maps for NO_2 pollution generated, good match with observations
- Background NO_2 from nearby rural sites
- Ported to Linux cluster, improved data pre- & post-processing

Air pollution dispersion modeling: GRAMM/GRAL

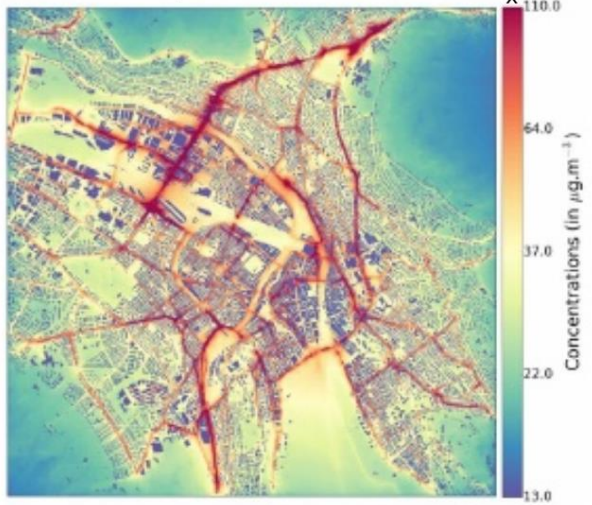


- A. Berchet, D. Brunner, K. Zink, A. Arfire, A. Martinoli, L. Emmenegger, High-resolution air pollution modeling for urban environments in support of dense multi-platform networks, European Geosciences Union General Assembly, April 2015.

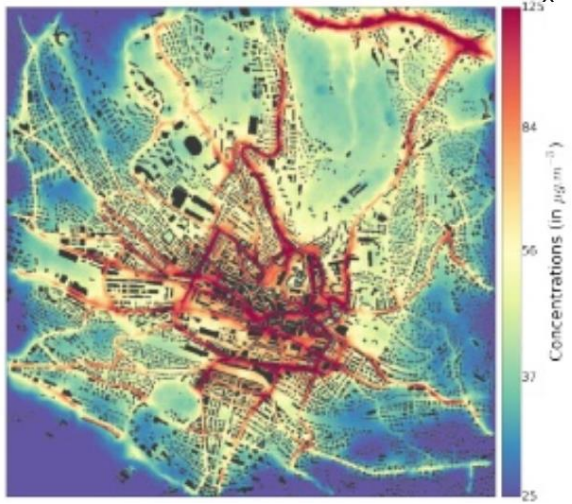
- A. Berchet, K. Zink, D. Brunner, L. Emmenegger, Assessing spatial and temporal variability of air quality at the city scale using building-resolving dispersion modelling,Physmod 2015 international workshop. September 2015.

Air pollution dispersion modeling: GRAMM/GRAL

Zurich, annual mean NO_x

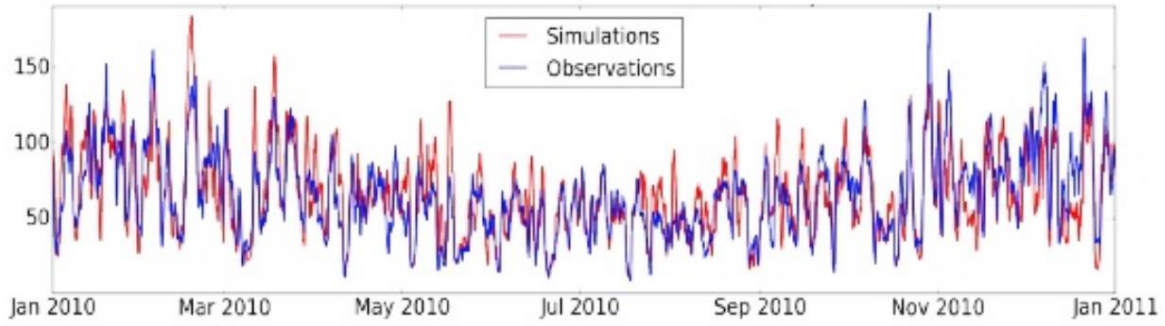


Lausanne, annual mean NO_x



- 5 m resolution, hourly output, 0-30 m above ground level
- Evaluation with in situ measurements:
  - Bias < 10%
  - Correlation > 0.7 for hourly concentrations
  - Correlation > 0.8 for daily averages

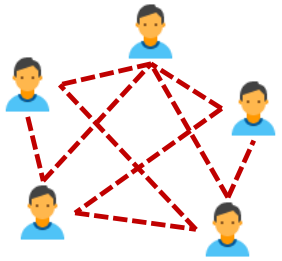
Comparison with NABEL NO_x measurements in Lausanne



- K. Zink, A. Berchet, D. Brunner, L. Emmenegger, Simulating air pollution at the city scale- Swiss Geoscience Meeting 2015, Basel, Switzerland, November 2015.

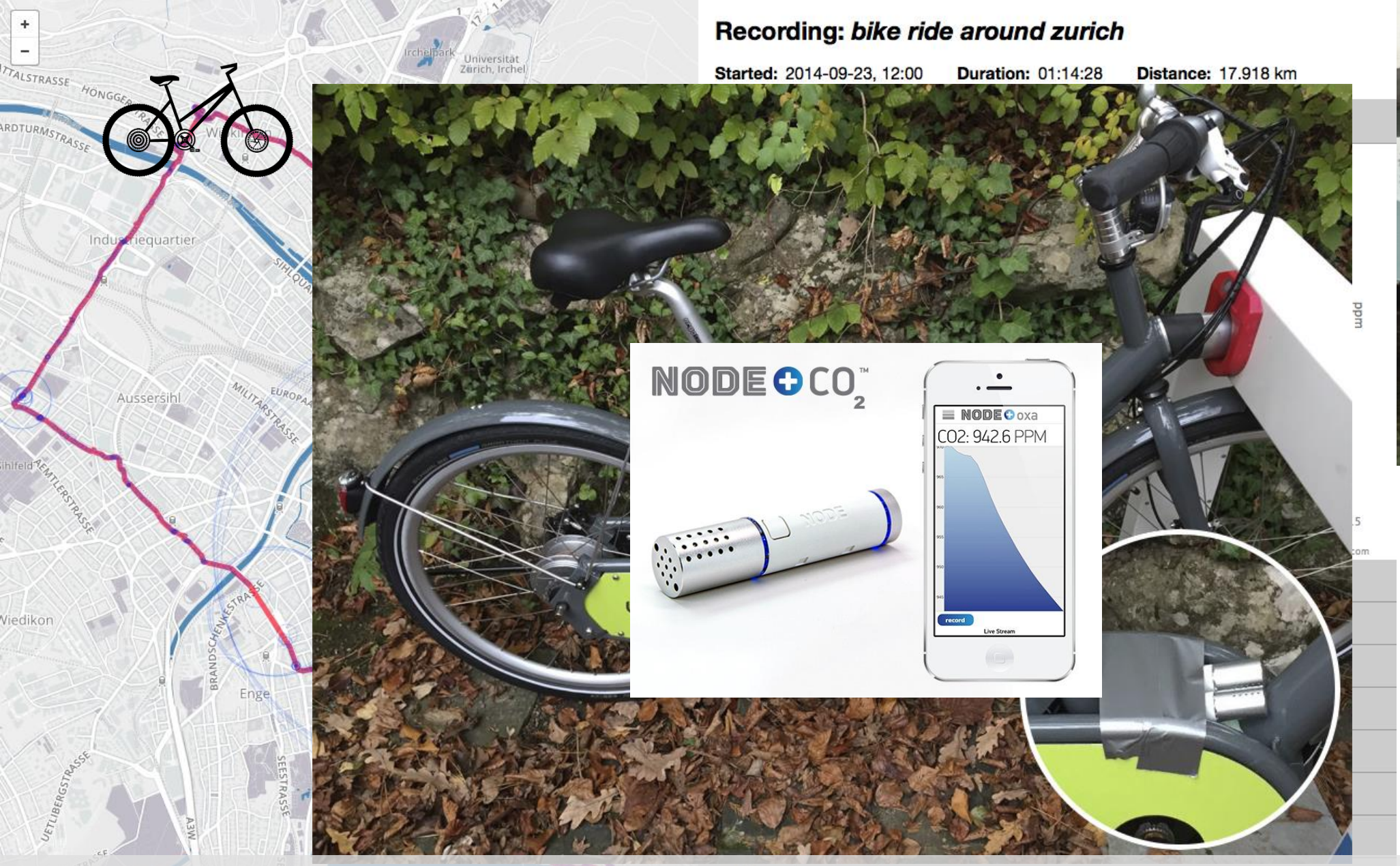
Multi-year simulations of Nox and PM10: Lausanne & Zurich

Crowdsensing



n.m. new sensing paradigm that empowers **ordinary citizens to contribute data** collected or generated from their mobile devices with the aim to measure a phenomena of common interest.

Bin Guo; Zhiwen Yu; Xingshe Zhou; Daqing Zhang, "From participatory sensing to Mobile Crowd Sensing," *PERCOM Workshops, 2014*



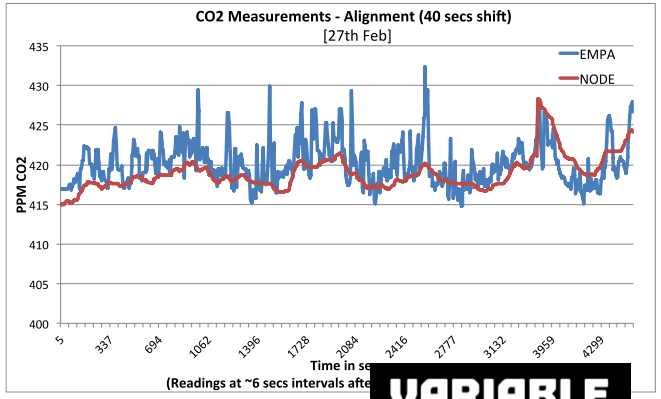
A test: public bikes equipped with CO/CO_2 sensors

NODE device explored by LAS

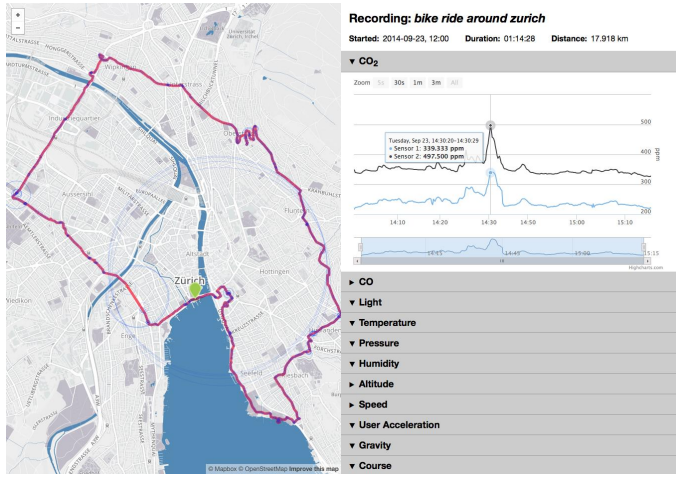
- Under 500 CHF(base module + two gas sensors)
- Lightweight and works via Bluetooth communication with a smartphone
- Can be easily mounted on a bike/car or kept in user's pocket
- Built a prototype of sensing platform with NODE sensors mounted on bikes

Data quality testing of NODE devices at EMPA

- Collected CO and CO2 recordings over two days
- Reference measurements provided by EMPA
- Promising quality for CO2 while issues with CO sensors



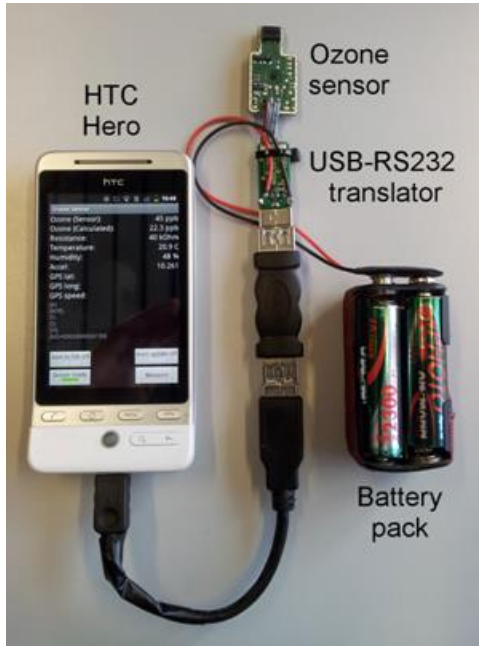
VARIABLE



ElectricFeel

Study: NODE devices as a potential crowdsensing platform

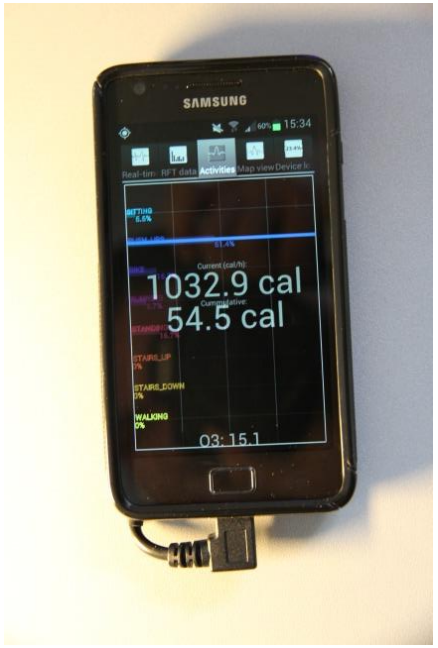
Zurich prototype



Smartphone connected to ozone sensor
and various application software for Android

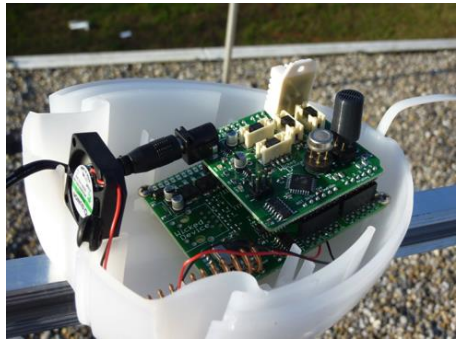
[Hasenfratz et al., Mobile Sensing 2012]

Lausanne prototype



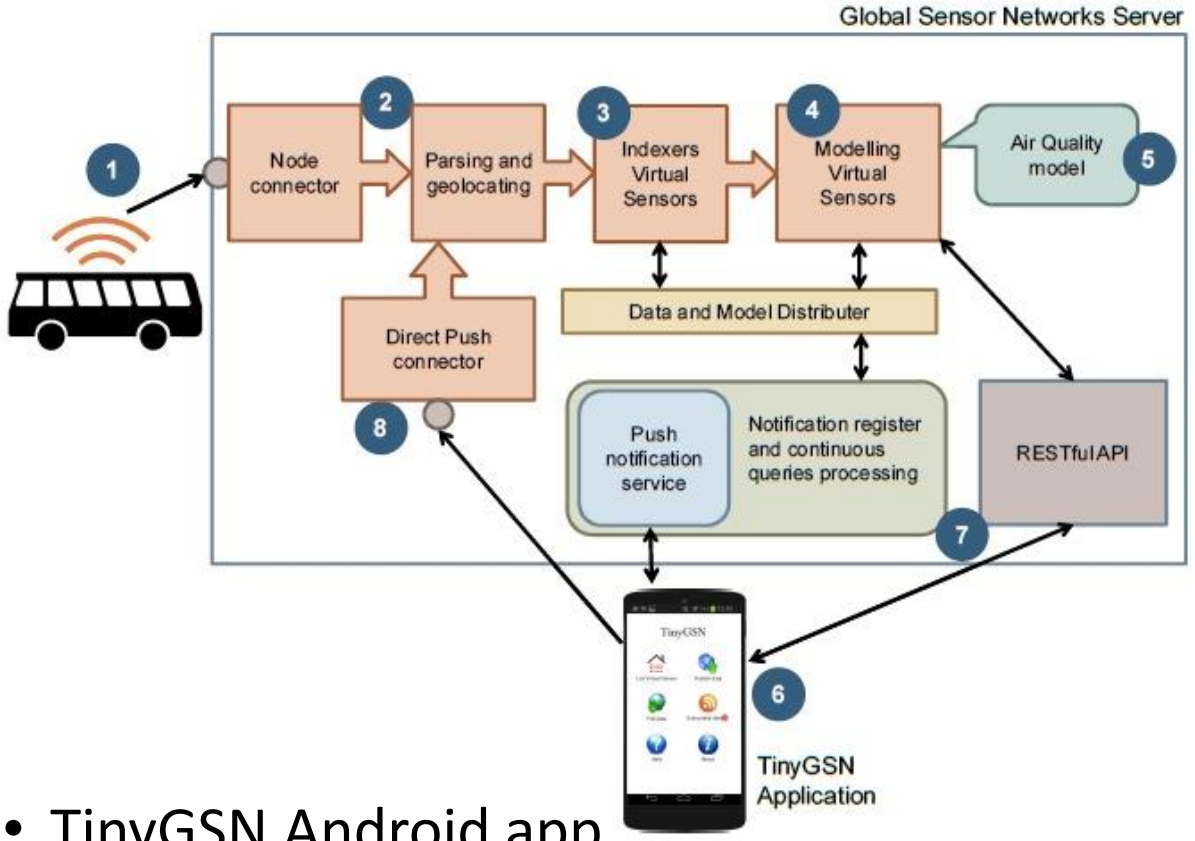
[Predic et al., PerCom'13]

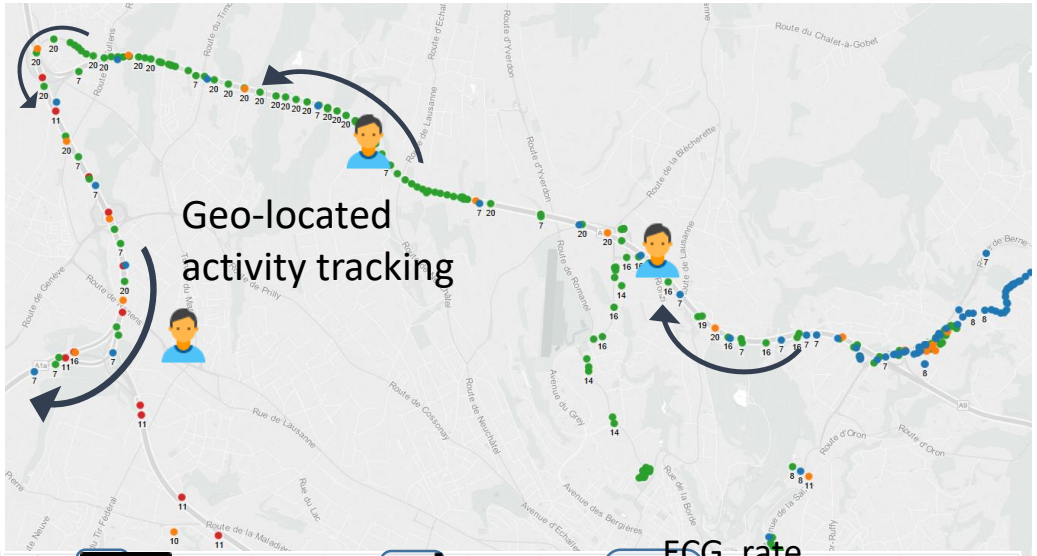
AirQualityEgg

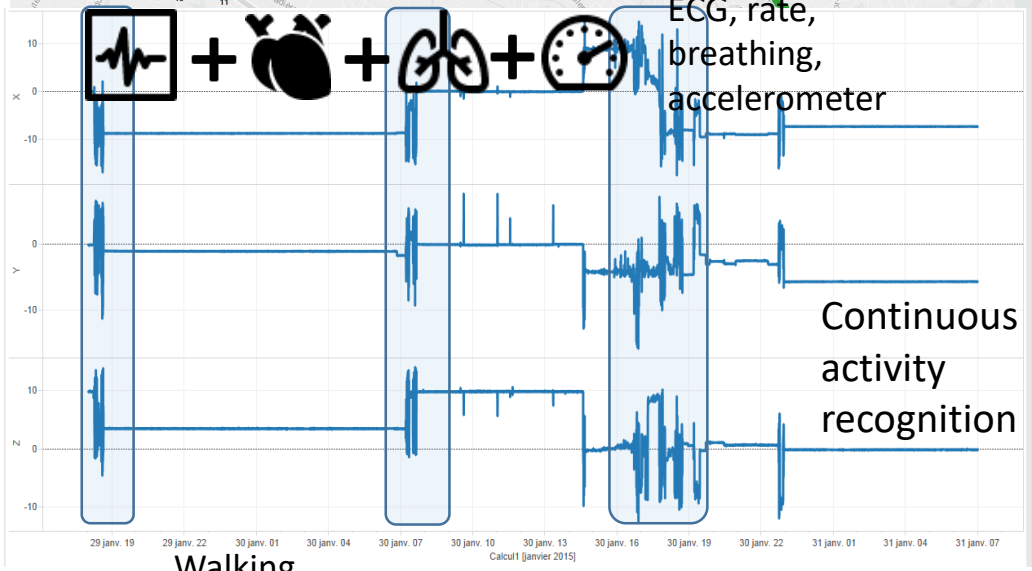


Low-cost devices for home deployment (calibration tests at the NABEL station in Dübendorf)

Crowdsensing platforms: proof-of-concept and prototypes

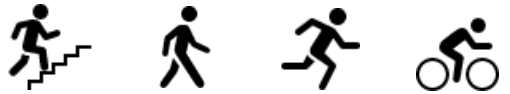






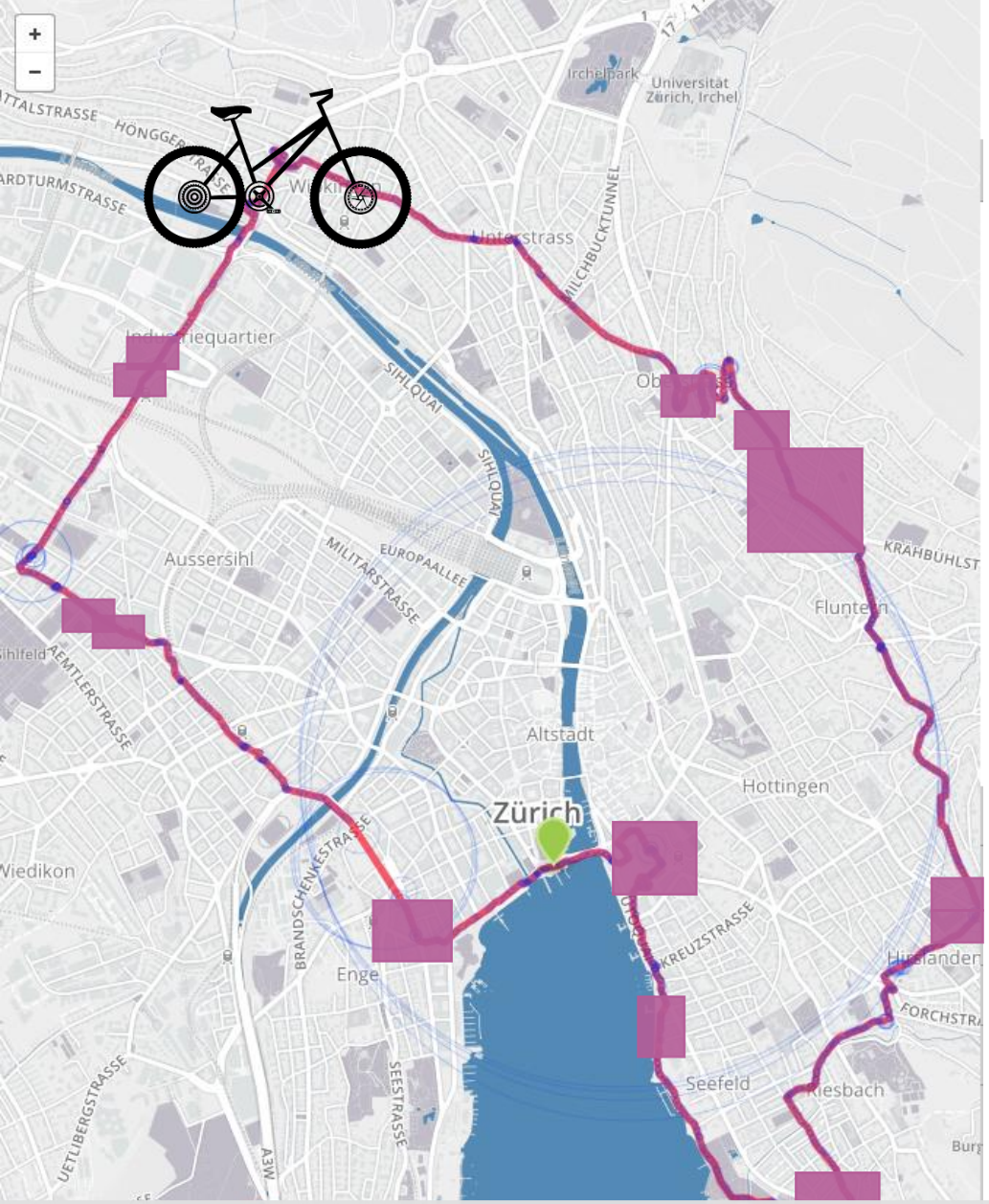
- TinyGSN Android app
  - GSN principles (wrapper, virtual sensors)
- Field Experiments:
  - Collecting location, also accelerometer/gyroscope
  - Goal: 24h of recording with one battery charge
  - running a controlled experiment

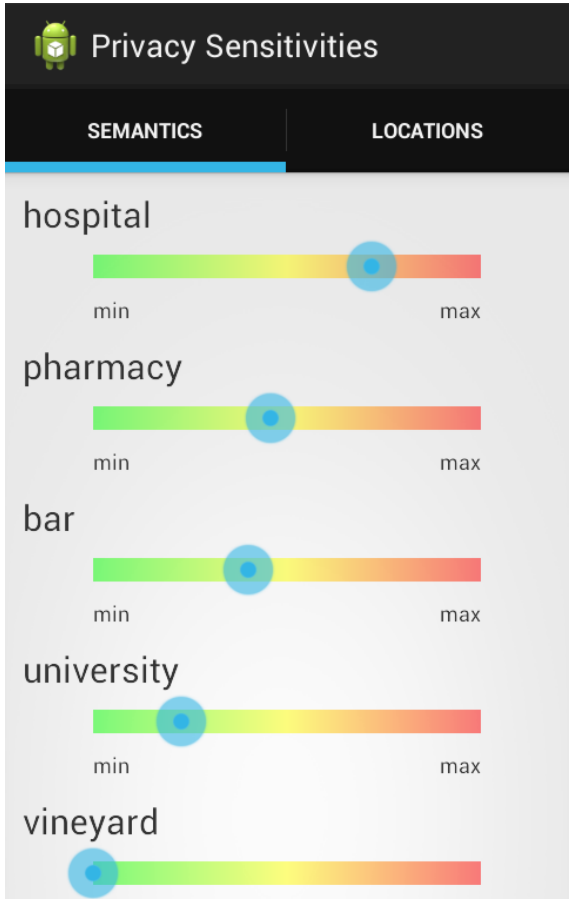
Walking
Running
Biking, etc.

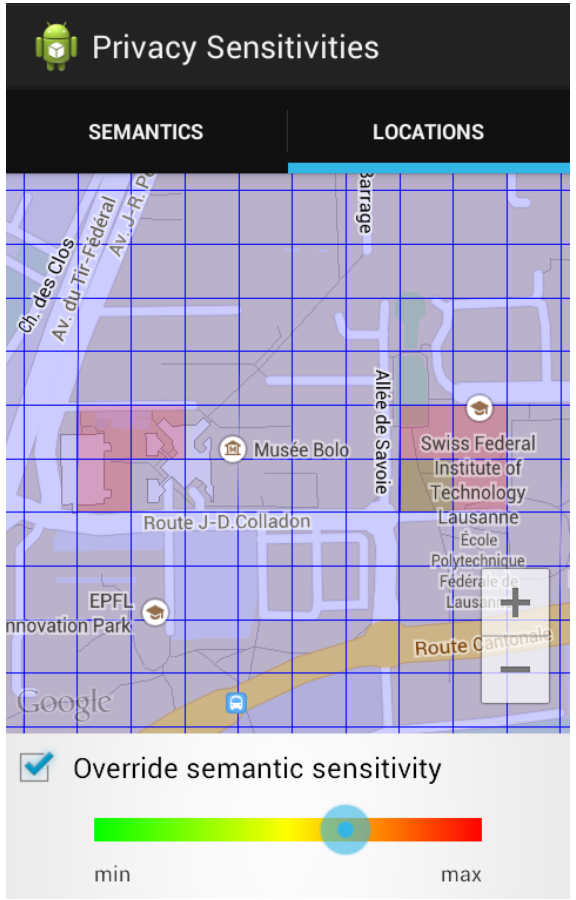


Humans as sensors: TinyGSN mobile activity sensing

Privacy of the Crowd at Risk







Semantic and Sensitivity Aware Location Privacy Protection for the Internet of Things.B Agir, JP Calbimonte, K Aberer - PrivOn@ ISWC, 2014

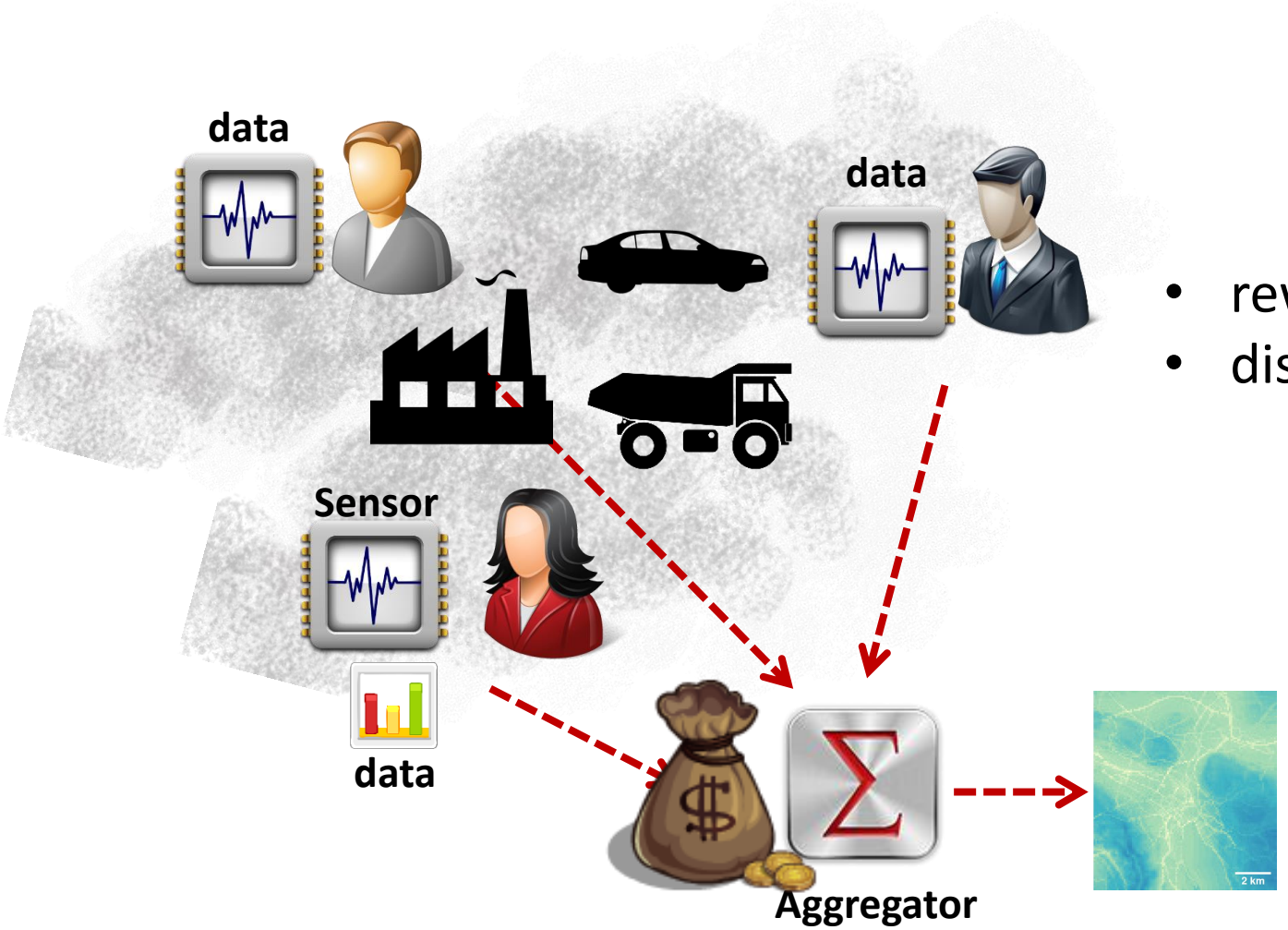
Cloaking of location is used to protect sensitive locations' privacy.

How to get high-quality data from the crowd?

- G. Radanovic, and B. Faltings, Incentive Schemes for Participatory Sensing. AAMAS 2015.

- G. Radanovic, and B. Faltings, Incentives for Subjective Evaluations with Private Beliefs. AAAI 2015

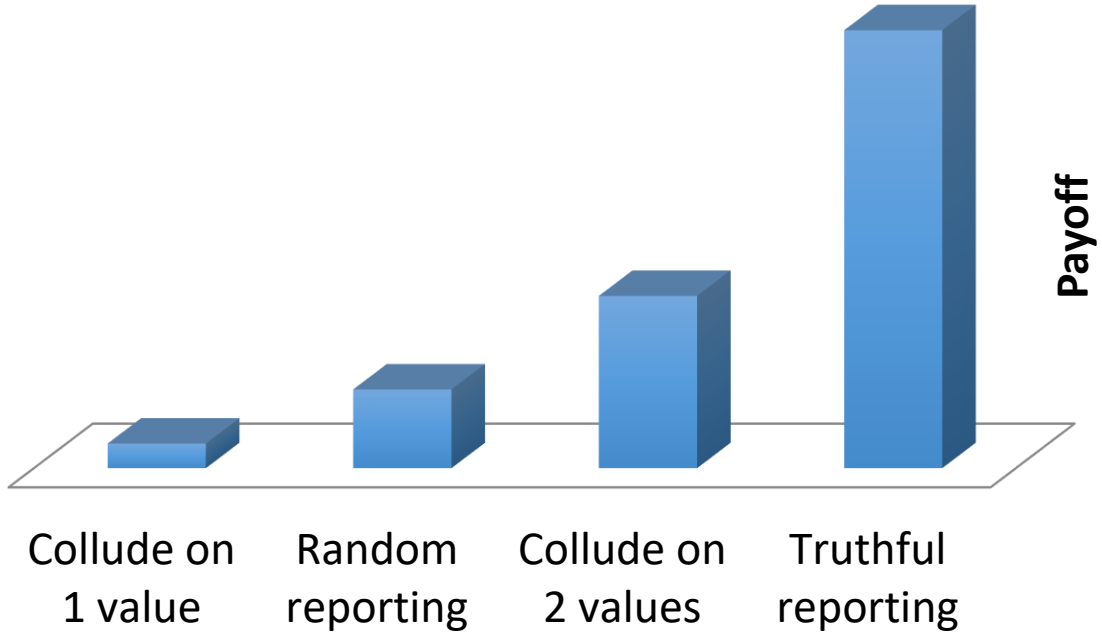
How to encourage truthful reporting?



Participants contribute their data for a reward

Peer Truth Serum

- rewards more ‘surprisingly common’ reports
- discourages colluding and random reporting



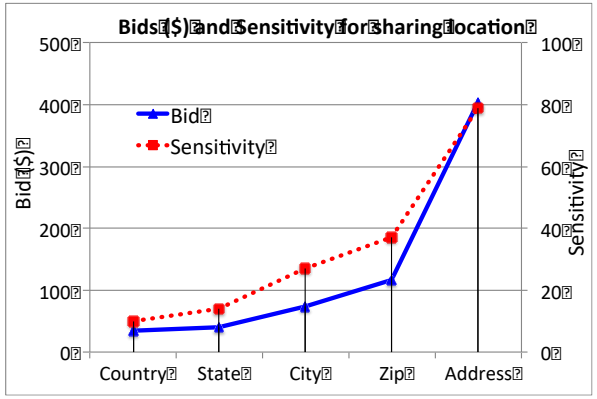
Peer Truth Serum for crowdsourcing participation

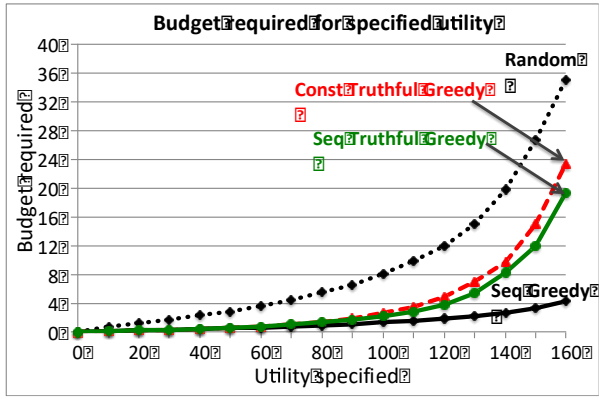
Incentives for data gathering [Singla & Krause, HCOMP'13]

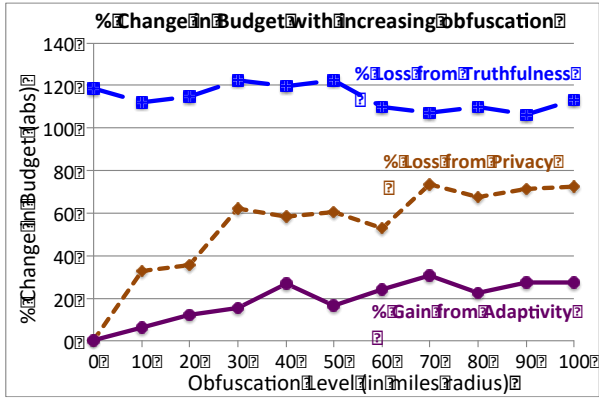
- How to valuate and negotiate access to private information of strategic agents?
- Main contribution: Privacy-aware, adaptive, truthful mechanism with monetary incentives to compensate for information shared

Case study of air quality monitoring [Singla & Krause, HCOMP'13]

- Simulation studies, with data collected from survey





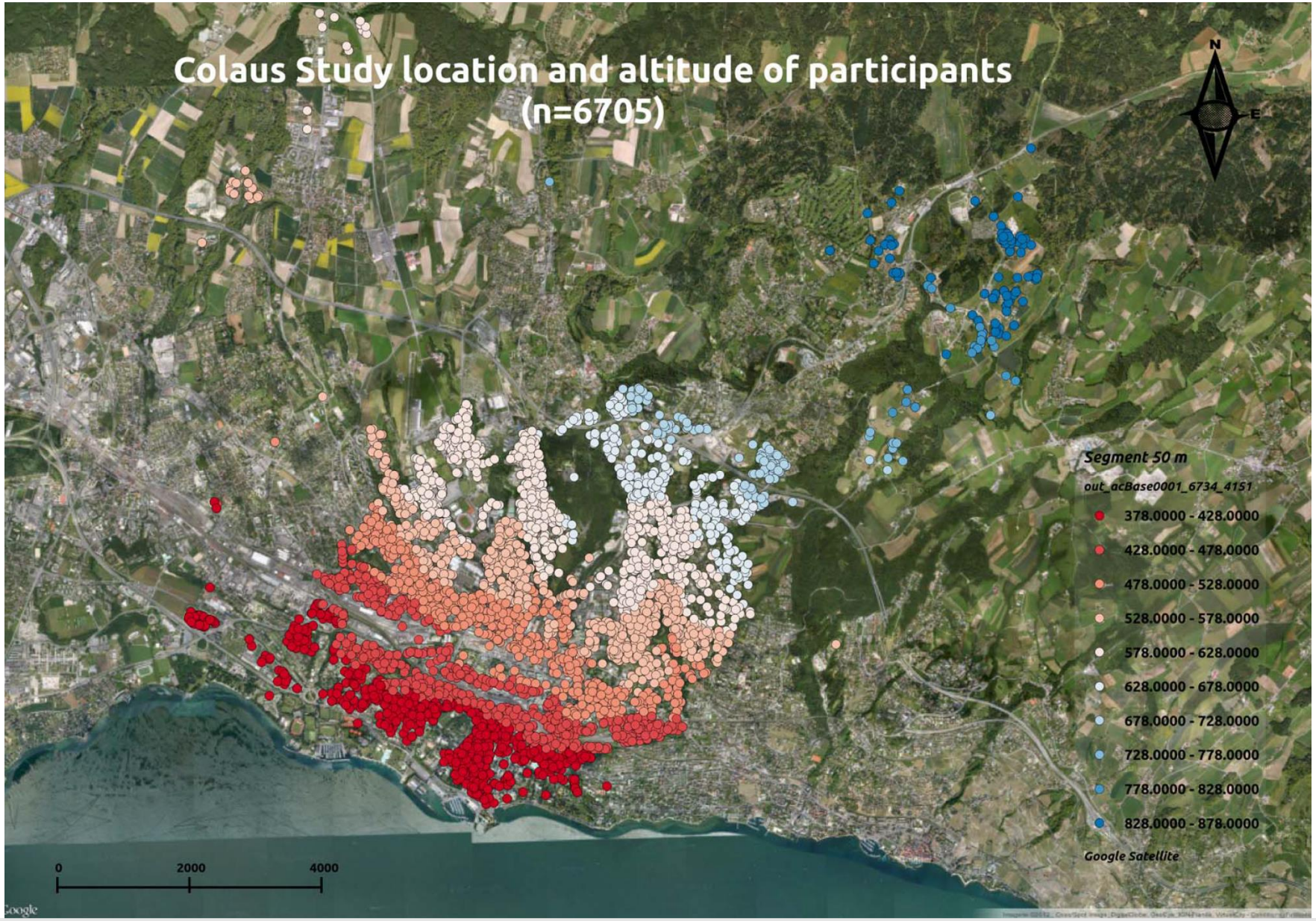


Gaussian Process (GP) models of air quality phenomenon

- Scaling up the existing GP models of air quality, developed as part of OpenSense
- Extending the models with new features

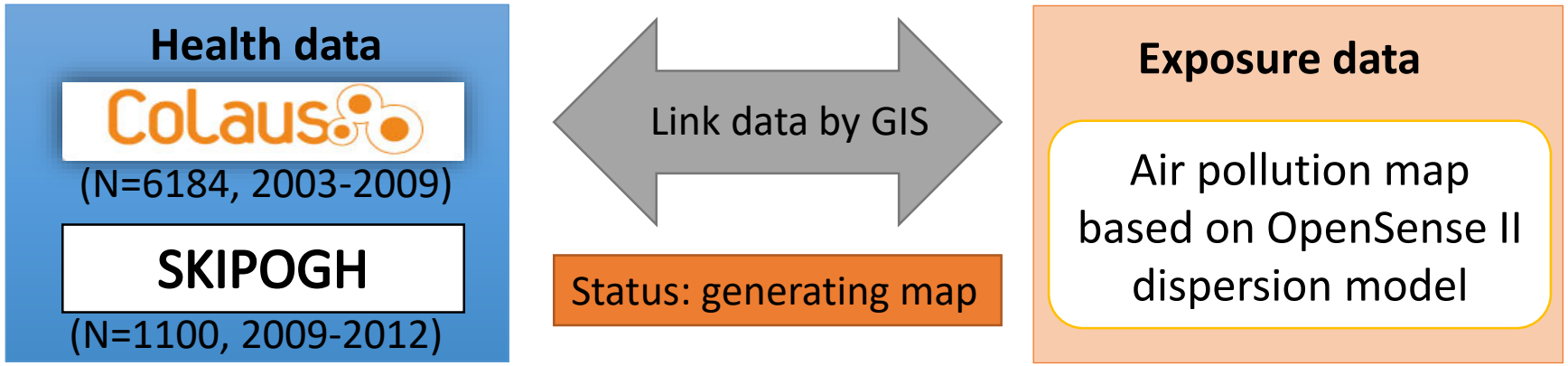
Privacy and incentives in sensor selection

Health studies



Goal: estimate the health effects of long-term exposure to air pollution

Generate Individual-level long-term exposure data



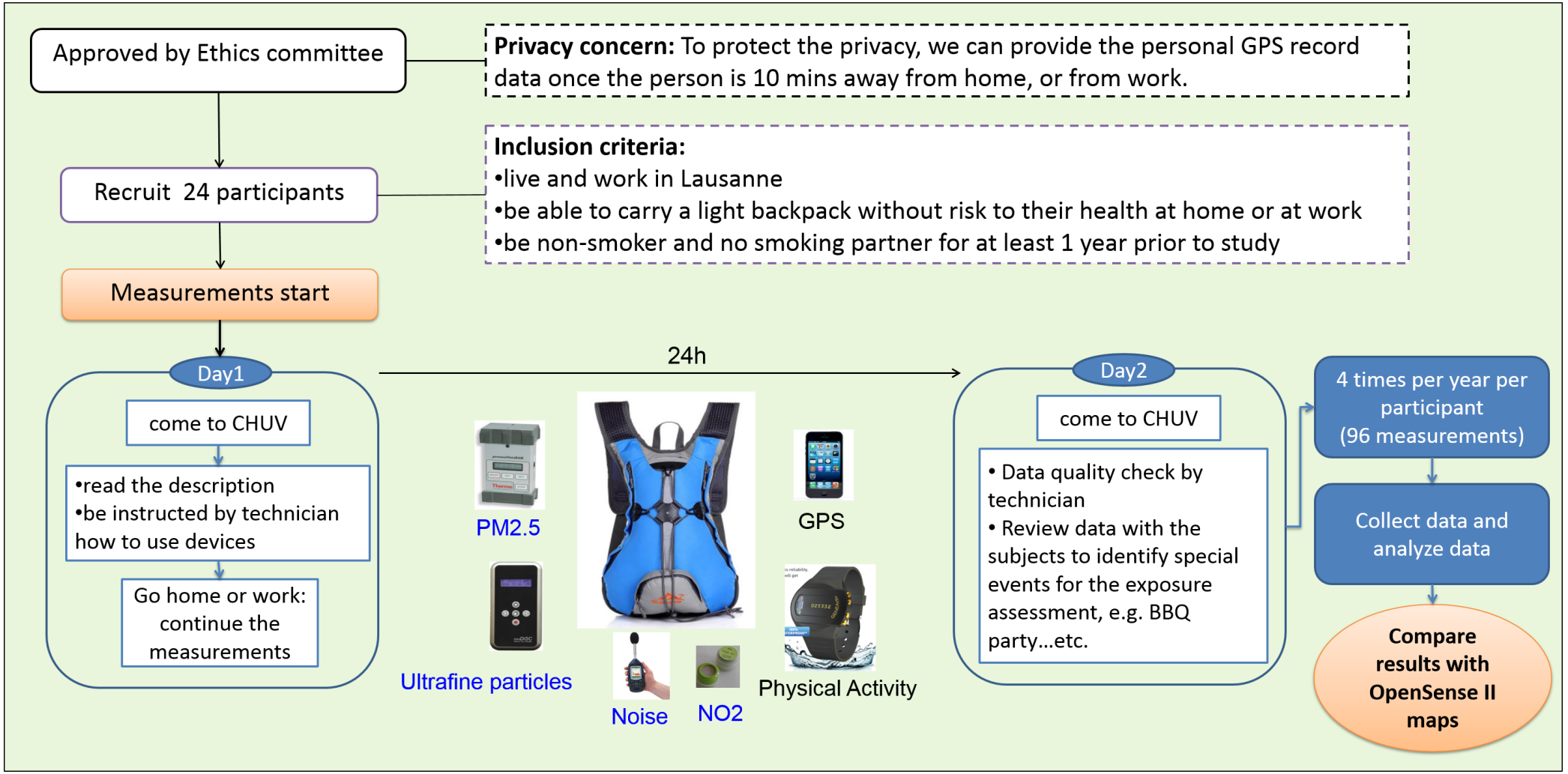
Papers on associations of air pollution with blood pressure and renal function

- Air pollution and blood pressure
  Colaus (N=6184) and Bus Santé (N=5605)

  [Tsai et al., Journal of Hypertension, 2015]
  - Positive associations of pulse pressure and systolic blood pressure with short-term exposure to PM10.
  - Stronger associations were observed when outdoor temperature was above 5°C.
- Air pollution and renal function and related phenotypes
  CoLaus (N=6184) and SKIPOGH (N=1100)
  - An association of increased PM10 levels with increased levels of a selected urinary protein among women, not among men.

Impact of Air pollution on Human Health

Design of a pilot study about physical activity on exposure to air pollution



Report on recommendation

Once the pilot study is complete, we will send the volunteers recommendation reports

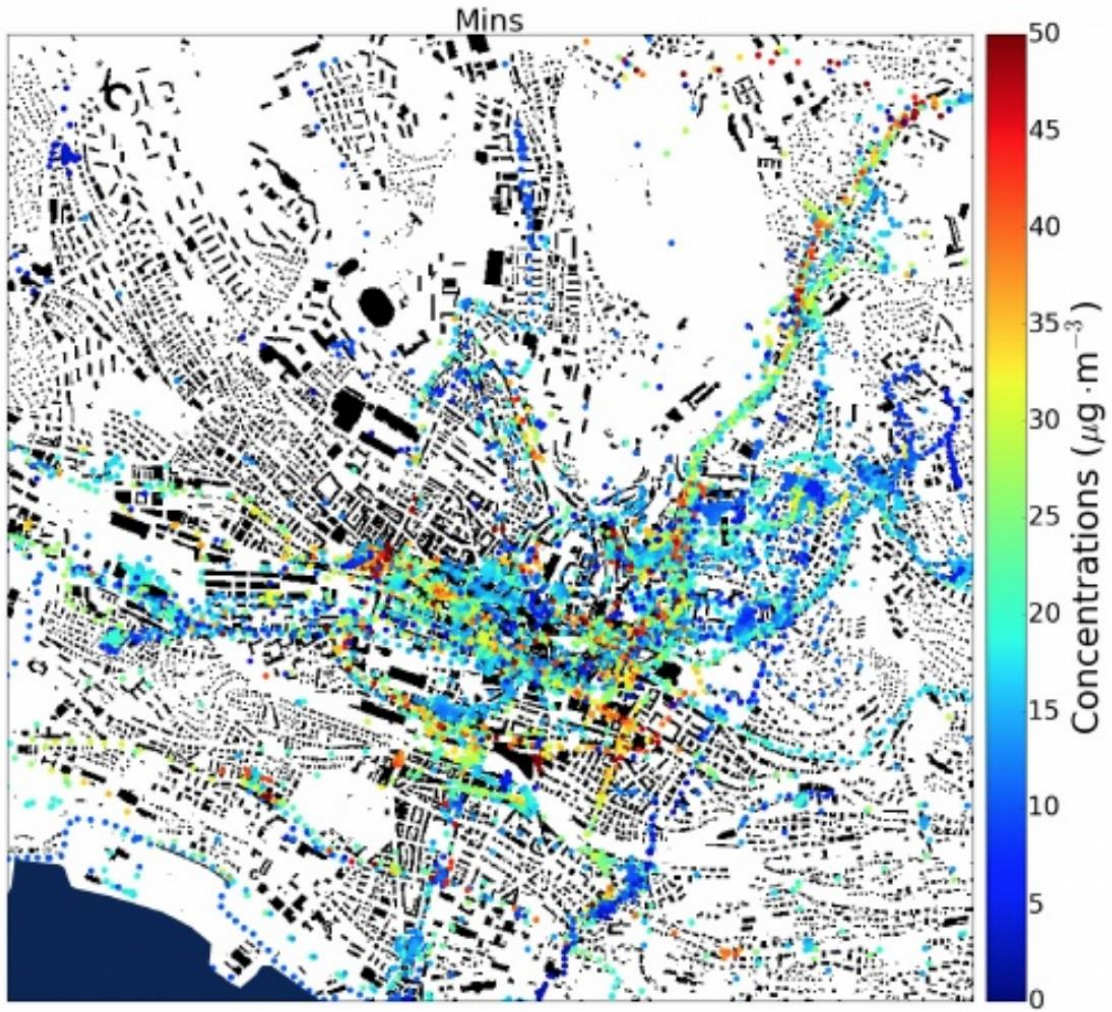
Pilot study on Physical activity vs. Air pollution exposure

The participants carry a backpack with the following sensors:

Backpack Devices

Parameter	Instrument
Personal PM2.5	Personal aerosol monitor
Ultrafine PM	Ultrafine particle counter
Noise	Class 1 sound meter
CO	Electrochemical sensor
Ozone	Diffusive sampler
NO2	Diffusive sampler

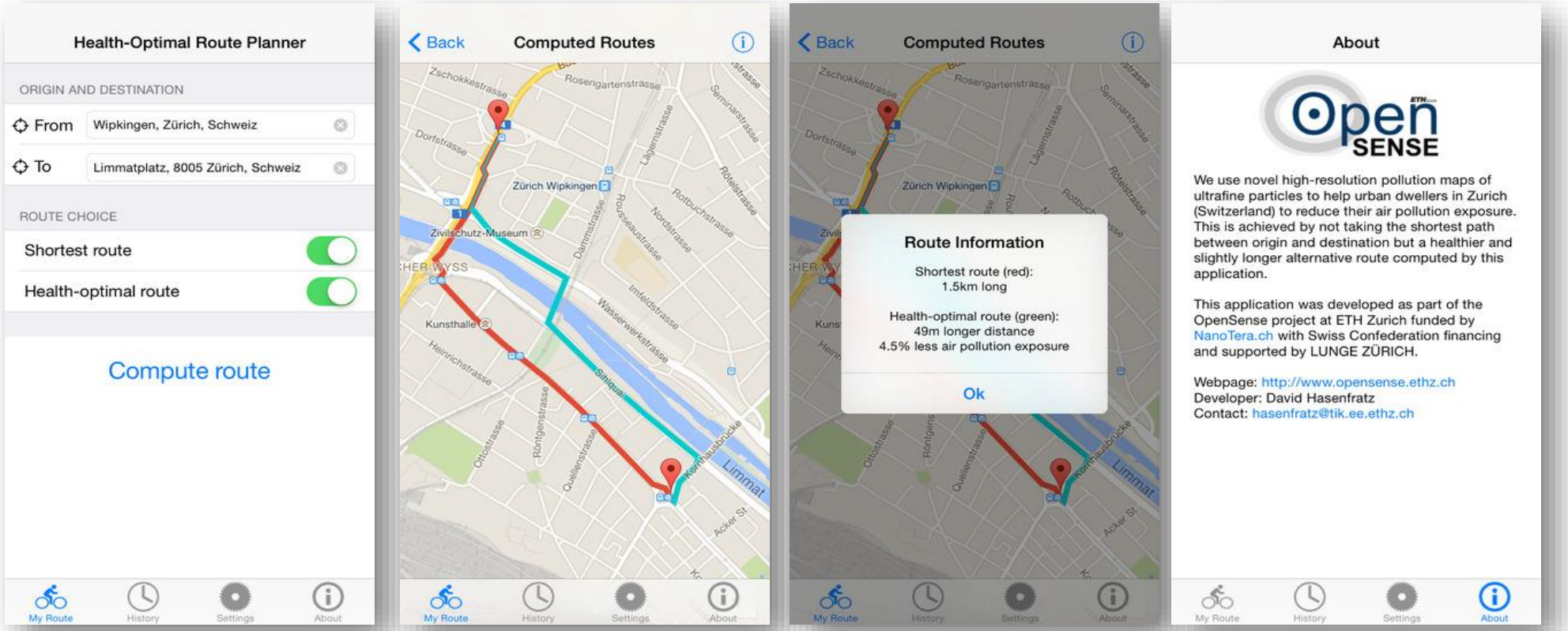
+ Global position and activity diary



Modeled hourly PM10 concentrations on the participants trajectories

Closing the loop: Applications

Uses UFP pollution maps developed in OpenSense to compute healthy routes for pedestrians and cyclists in Zurich



[D. Hasenfratz, T. Arn, I. de Concini, O. Saukh, L. Thiele, *Demo-Abstract: Health-Optimal Routing in Urban Areas, IPSN'15]*

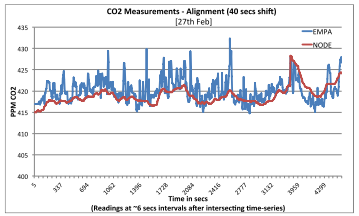
hRouting: Health Optimal Route Planner

Sensing the air we breath...

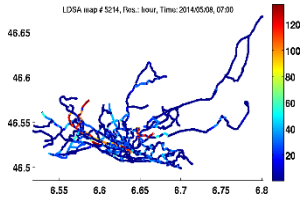
OpenSense II

Air Quality Products & Applications

Temporal Spatial Aggregations



Pollution Maps

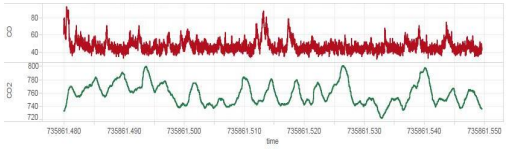


Pollution Models

Air Quality recommendations

Health Studies

Air Pollutants Time Series



Raw Data Acquisition

Reference station

Public transportation

Crowd sensing

Coordination mechanisms

Privacy

Company	Business area	Collaboration form
TL	Transportation in Lausanne	In-kind, hosting sensor on vehicles and providing technical assistance
VBZ	Transportation in Zürich	In-kind, hosting sensor on vehicles and providing technical assistance
Naneos	Particle detection	In-kind, providing partially customized UFP detectors and technical assistance
DecentLab	Sensor networks	In-kind, providing customized static nodes and partner in the Gateway project CarboSense
ElectricFeel	Bike network provider	In-kind, provider of e-bikes for Zurich deployment
PSA	Car manufacturer	In-kind, provider of e-vehicle for the Lausanne deployment
SGX SensorTech	Gas sensing	In-kind, providing sensor samples and test facilities for sensory systems
Swisscom	Communication	Partner in the Gateway project

Supported by Industry, Government and Research

Entity	Business	Sector	Country
CSEM	Swiss private, non-profit R&D company	Industry/gov.	Switzerland
InfoTeam	Software Engineering	Industry	Switzerland
La Poste	Transportation and mail company	Industry	Switzerland
LNI Schmidlin	Gas mixers, generators, and calibration devices	Industry	Switzerland
SensorScope	Sensor networks	industry	Switzerland
Seres Environment	Online analysis of water and air quality	Industry	Switzerland
Anaximen	Air quality monitoring	Industry	France
Digicore Systems	Software Engineering	Industry	U.K.
IBM	IT and Smarter Cities	Industry	India
Origins	Air quality monitoring	Industry	China
Perkin Elmer	Environmental monitoring and detection solutions	Industry	Canada
Wicked Devices	Air quality monitoring	Industry	U.S.A.
Swiss TPH	Air pollution and health studies (SAPALDIA)	Government	Switzerland
UGZ	Air quality and health in Zürich	Government	Switzerland
DSE	Environnemental protection in Lausanne	Government	Switzerland
FOEN	Federal Office for the Environment	Government	Switzerland
De Meter Stichting	The Dutch Measurement Foundation	Government	The Netherlands

Supported by Industry, Government and Research

Zürich

Umstrittener Plan
EU-Kommissionschef Jean-Claude Juncker will mit einem neuen Investitionsplan das Wachstum in Europa ankurbeln. SEITE 27

Gewalt in der Küche
In französischen Restaurantküchen ist Gewalt keine Seltenheit. Nun wollen Spitzenköche dem einen Riegel schieben. SEITE 36

Trams messen Luftqualität

Am Feinstaub vorbei

von Reto Scherrer / 14.1.2014, 05:30 Uhr

Dereinst sollen für die Stadt Zürich Karten verfügbar sein, au[illegible] könnten etwa Sportler ihre Trainingsroute am Feinstaub vorbei planen. Dafür sammelt die ETH mithilfe von VBZ-Trams derzeit Daten.

1 KOMMENTAR

Kostenlose ETH-App lotst Jogger zu Zürichs «gesündesten» Wegen

Ja zur Siedlung Hornbach
WOHNBAU Die geplante städtische Siedlung Hornbach

Les bus aident aussi à mesurer la qualité de l'air

Actuellement, dix bus diesel Neoplan parcourent le réseau munis de capteurs qui mesurent la qualité de l'air en ville. Yves Regamey, responsable de la mise à disposition du

Bhumibol 88-ja

her Monarcl
Machtinsti

Bossart / vor 2 Stu

s für Literatur
ausgezeich

Blick

Home News Sport People Ratgeber Life Gesundheit Virtual Reality Auto Star des Tages Services

Technik

Sensoren an Trams liefern Karte der Zürcher Luftverschmutzung

ZÜRICH - ZH - Seit zwei Jahren sammeln an zehn Zürcher Trams installierte Messstationen Daten zur Luftverschmutzung in Zürich. Diese haben Forscher der ETH Zürich ausgewertet. Sie stellen nun erstmals detaillierte Karten der Ozon- und Feinstaubbelastung in der Stadt vor.

Challenges

Gare à la pollution souterraine

L'air que respirent les voyageurs, en particulier dans les souterrains, contient bien plus de particules fines que les noeuds routiers. La gare de Zurich est très concernée.

Data quality and curation

Applying theoretical crowdsensing models $(\xi\varphi)^2$

Failure and Noise handling

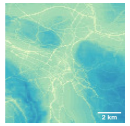
Incentives for participatory sensing

Semantic Layers of sensor data

Privacy protection in crowdsensing

Personalized health recommendations

Reliable crowdsensing platforms



Integration of air quality models and sensing

nano-tera.ch

OpenSense II

Sensing the air we breath

CHUV EMPA IST Institut universitaire romand de Santé au Travail ETH Zürich EPFL ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

PI: Alcherio Martinoli, EPFL.

Co-PIs: Karl Aberer, EPFL
Boi Faltings, EPFL
Andreas Krause, ETH Zürich
Lothar Thiele, ETH Zürich
Lukas Emmenegger, EMPA
Murielle Bochud, CHUV
Michael Riediker, IST

FNSNF

Thank you!

OpenSense II Team

Extras

Tsai et al. Particle and Fibre Toxicology 2012, 9:24
http://www.particleandfibretoxicology.com/content/9/1/24

PARTICLE AND FIBRE TOXICOLOGY

RESEARCH Open Access

Effects of particulate matter on inflammatory markers in the general adult population

Dai-Hua Tsai[1,2], Nadia Amyai[3], Pedro Marques-Vidal[1], Jia-Lin Wang[2], Michael Riediker[4], Vincent Mooser[5], Fred Paccaud[1], Gerard Waeber[3], Peter Vollenweider[3] and Murielle Bochud[1*]

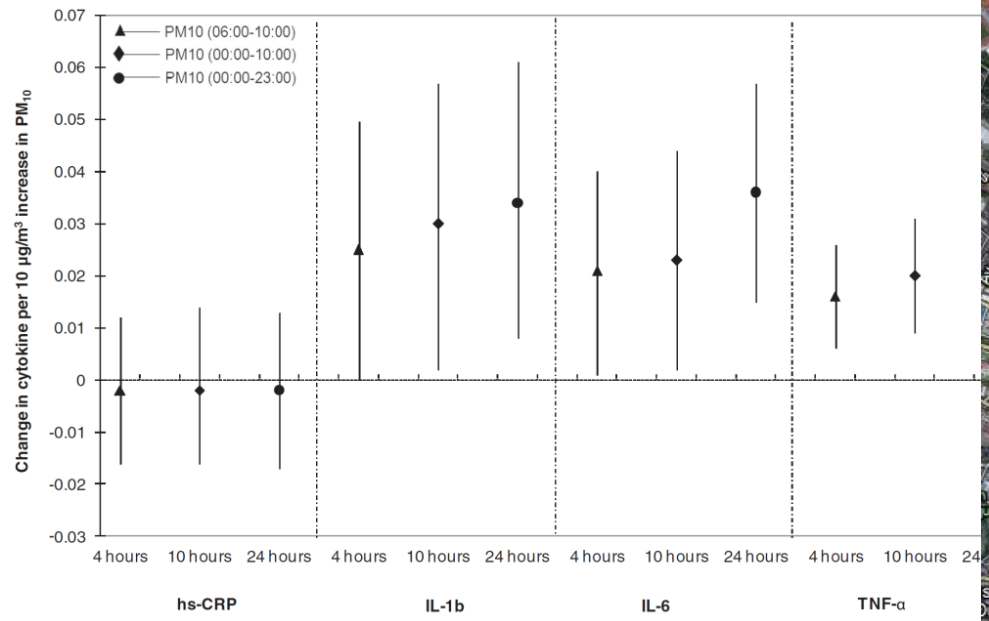
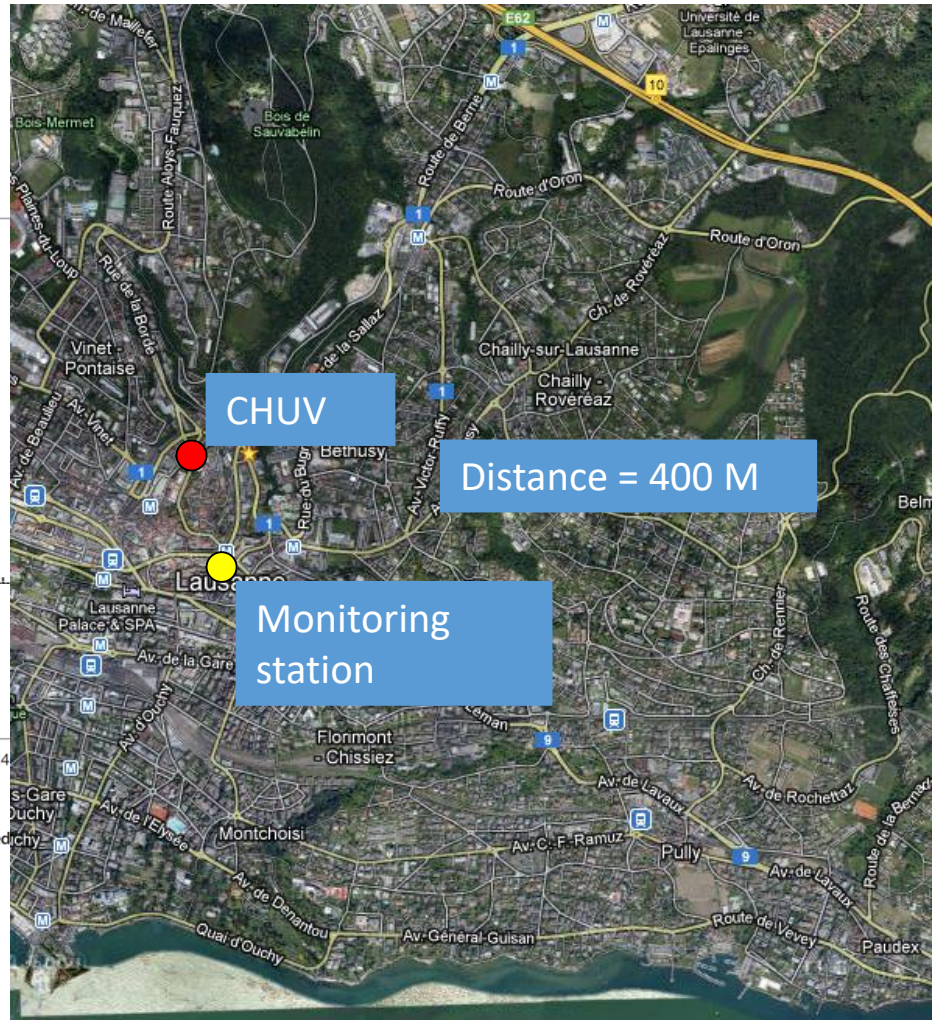
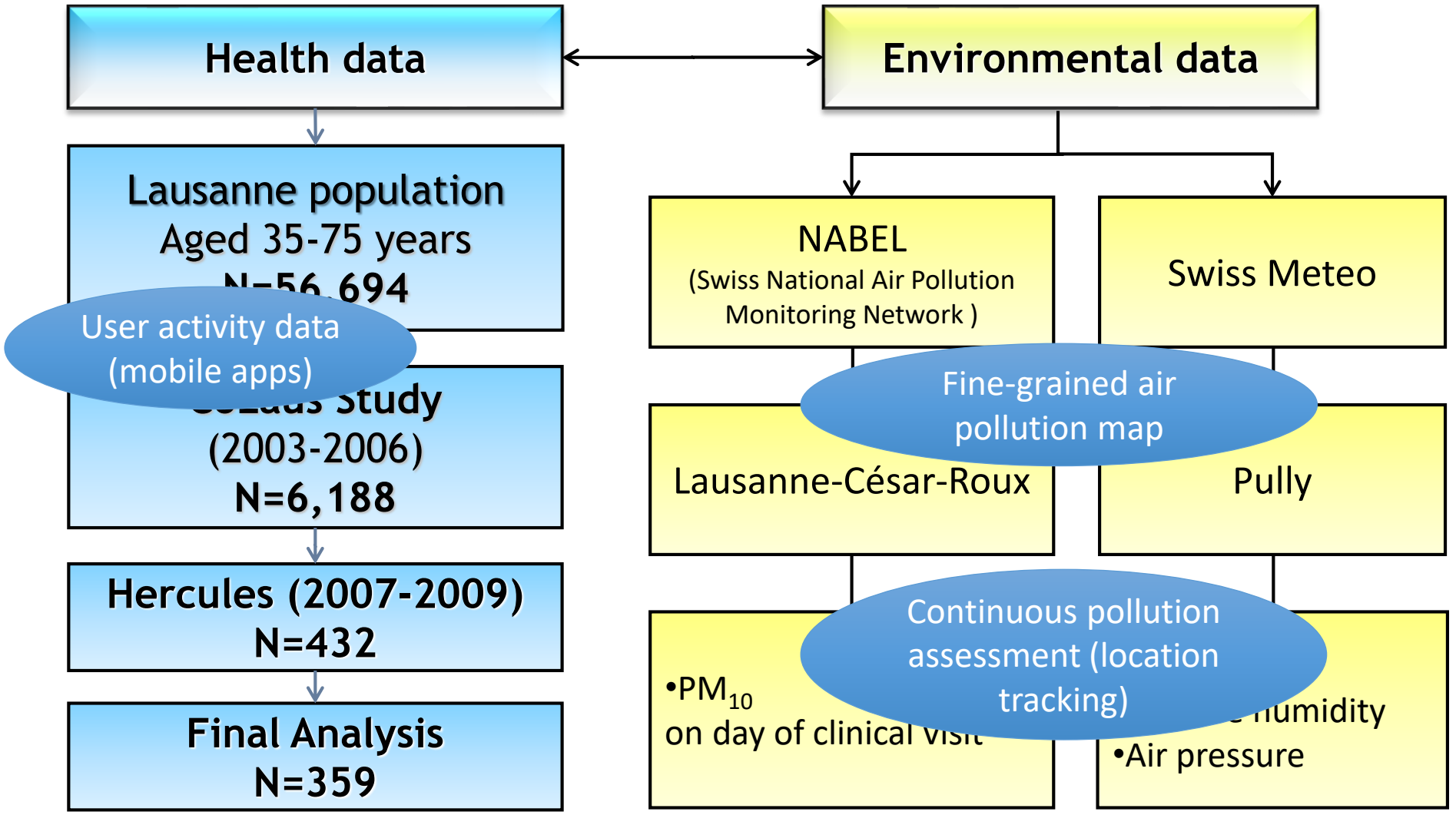


Figure 2 Association between different time-averaged PM_{10} concentrations and log-transformed inflammatory markers (adjusted effects).

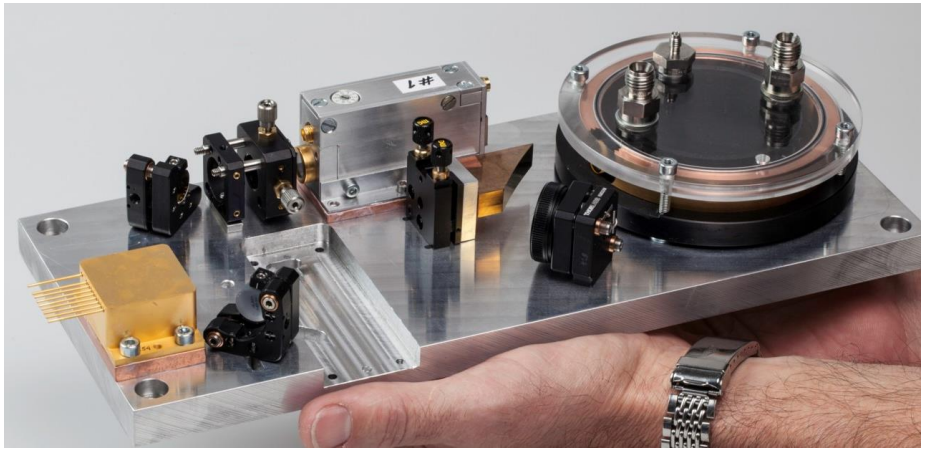


In CoLaus (N=6000) short-term (0h-24h) exposure to higher PM10 was associated with higher blood levels of inflammatory markers

Augmenting the available datasets

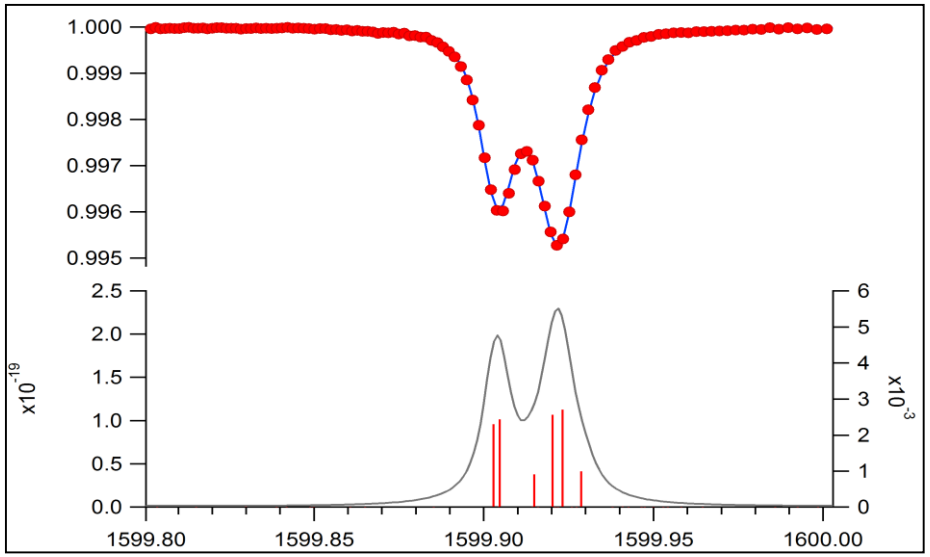


IRSENS prototype on Zürich tram



Prototype MIR gas sensor platform based on QC laser for high-precision atmospheric measurements

Joye et al., Analyst, 2013
Tuzson et al, Physics Letters, 2013



Spectra of NO_2 at 1 ppb mixing ratio
Measured (top) and simulated (bottom)

Tuzson et al, Atm. Meas. Techn., 2013

EMPA

Ultrafine Particles (UFPs)

Nanoscale particles with a diameter less than 100 nanometers

- Most countries do not have restrictions
- Probably **more severe health implications** than PM_{10} or $PM_{2.5}$
- Lack of epidemiological due to
  - High cost of monitoring equipment
  - Lack of spatially resolved exposure data
  - Lack of reliable dispersion models

MiniDisc (Miniature diffusion size classifier):

- First compact UFP measurement device suitable for mobile measurements

Naneos Partector

- Currently the most compact UFP measurement device

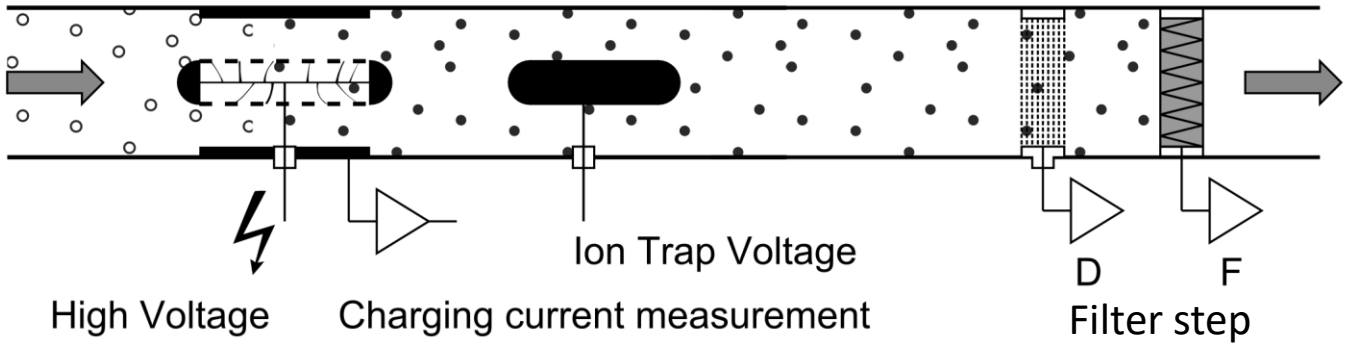
naneos particle solutions gmbh

Fachhochschule Nordwestschweiz

MiniDiSC (Miniature Diffusion Size Classifier)

- PM10, PM2.5 (diameter < 10µm and 2.5µm)
- Ultrafine particle size: 30 – 100 nm
- MiniDiSC measures particle count, particle average size, and lungs area coverage
- Developed at the FHNW by Dr. Martin Fierz
- Portable device (670g, 8h battery), temporal resolution 20Hz

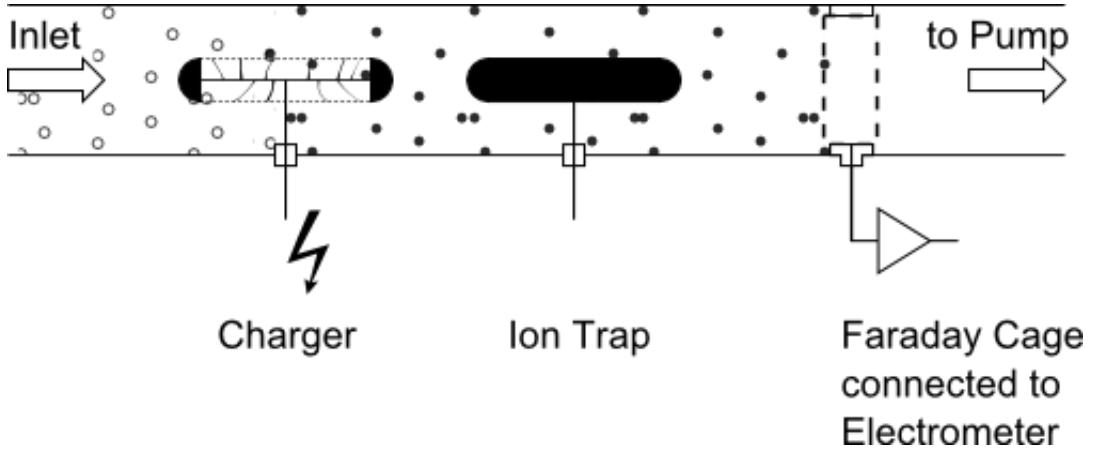
MiniDiSC measurement procedure:



PARTECTOR

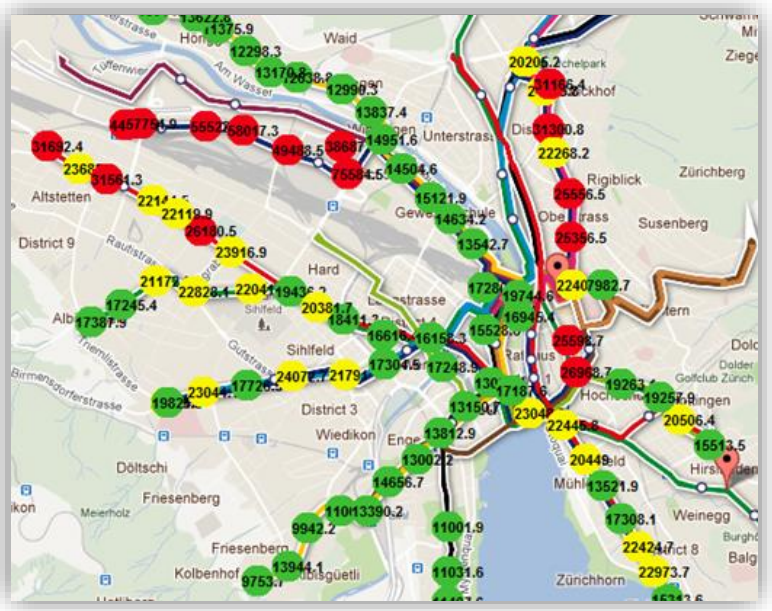
- LDSA (Lung Deposited Surface Area) instrument
- Extremely wide size range (10nm – 10 µm) and concentration range ("universal" instrument)
- Developed at the FHNW by Dr. Martin Fierz
- Very simple instrument – no filters
- no filter necessary ⇨ no exchanges ⇨ little maintenance (suitable for long term deployments)
- Smaller than miniDiSC (300 cm^3 /460g, 10h battery)

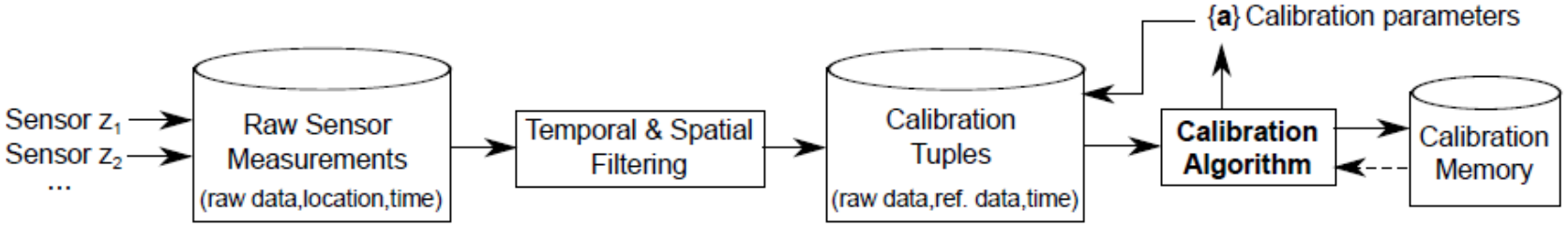
Partector measurement procedure:



Calibration Procedure

- Gas sensor drift (aging) -> periodic recalibration needed
- Gas sensors are installed on mobile vehicles
- Few expensive reference stations within city limits
- Two recipes:
  - Calibration upon rendezvous of mobile vehicles and references
  - Passing of calibration data from vehicle to vehicle: Multi-hop Calibration



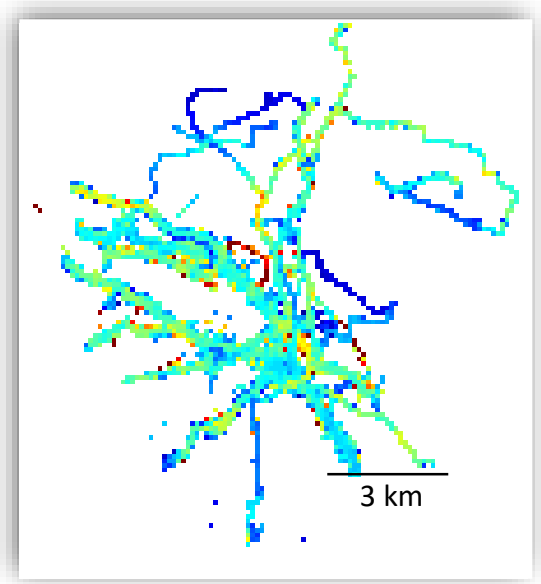


[Hasenfratz et al., EWSN 2012]

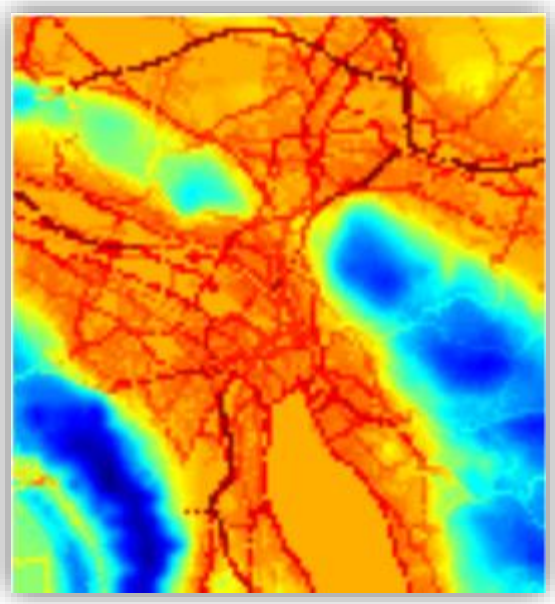
EMPA

OSTLUFT

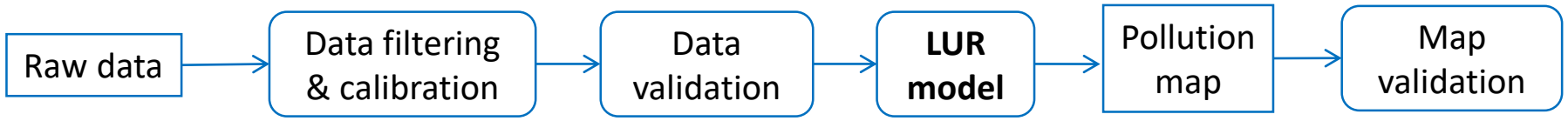
Primary Model Use: Pollution Maps



Single measurements

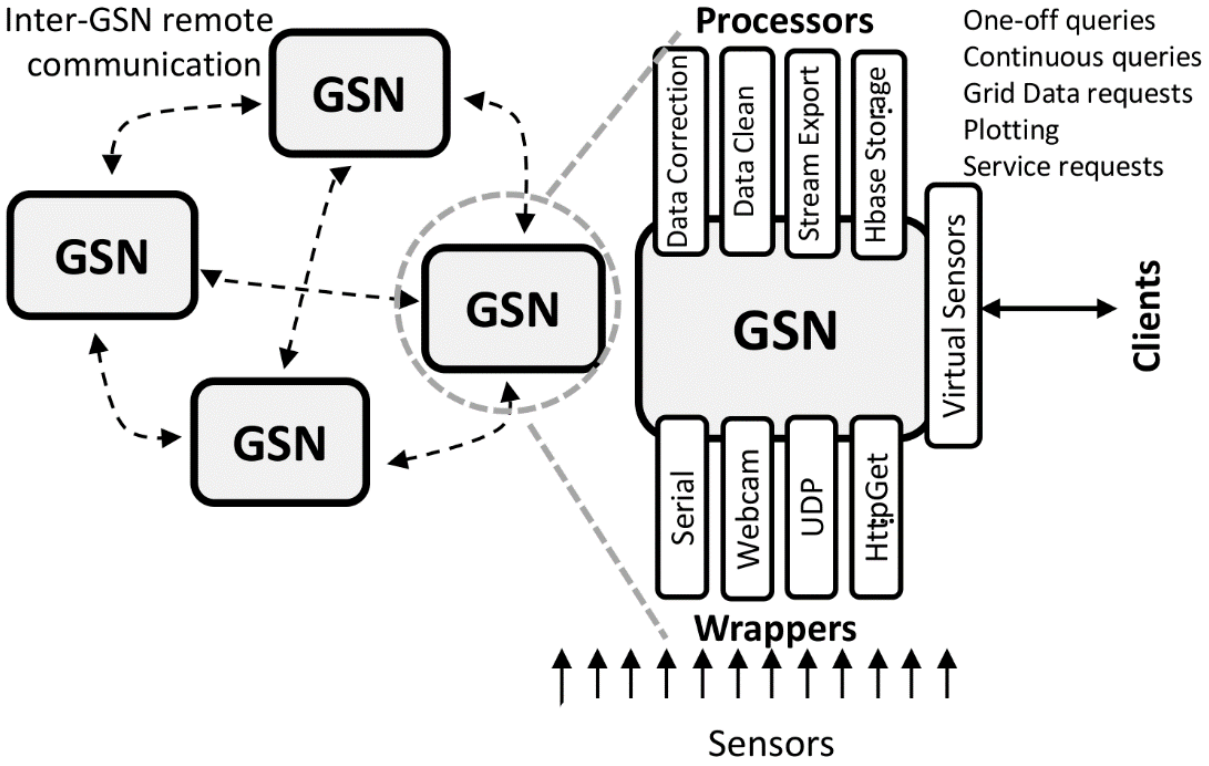


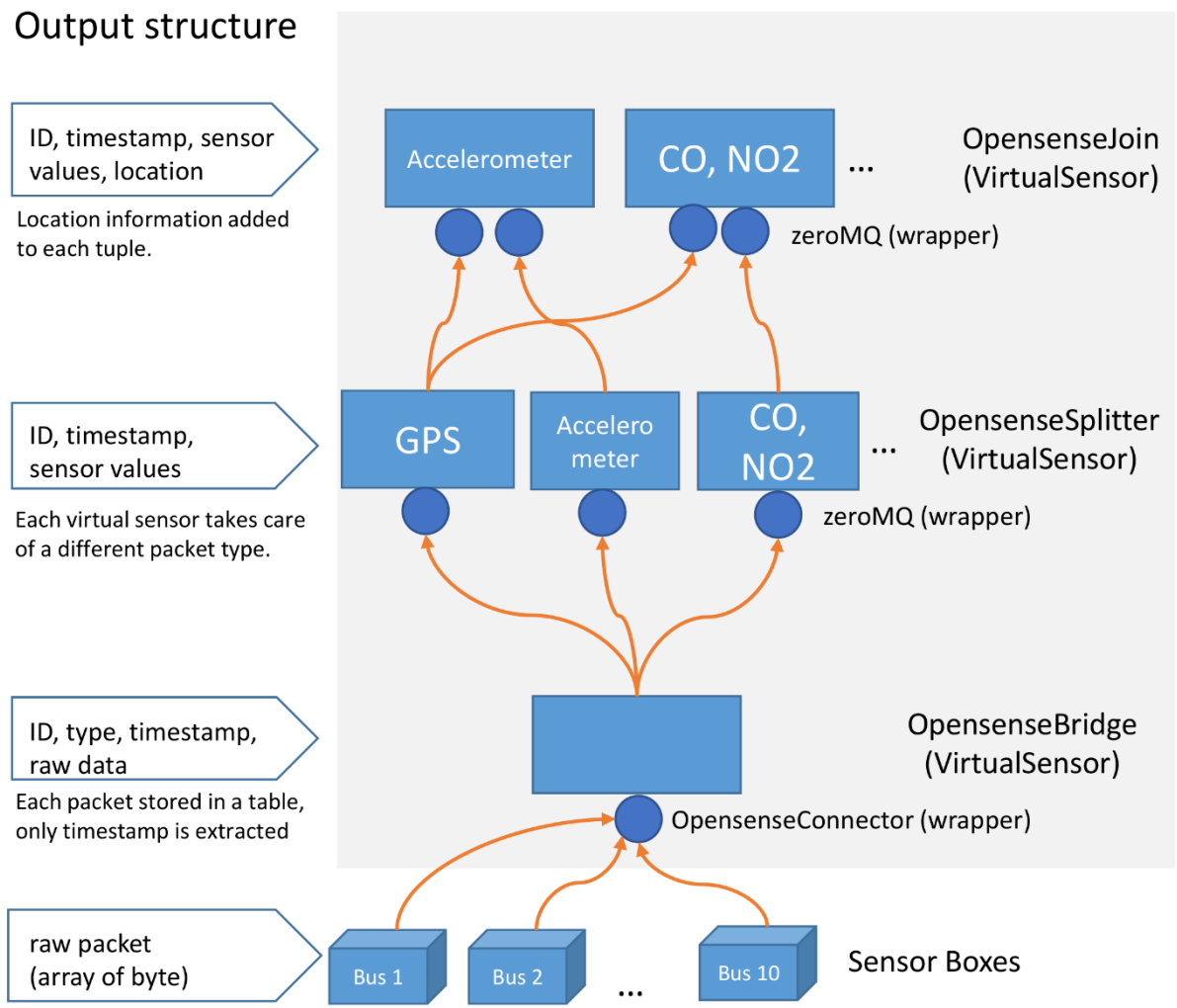
Micro-scale pollution map



Land-Use Regression models

GSN: Global Sensor Networks





https://github.com/LSIR/gsn

SSN Ontology