Suivi de la pollution de l’air à l’aide de capteurs pour une meilleures compréhension de son impact sur la santé

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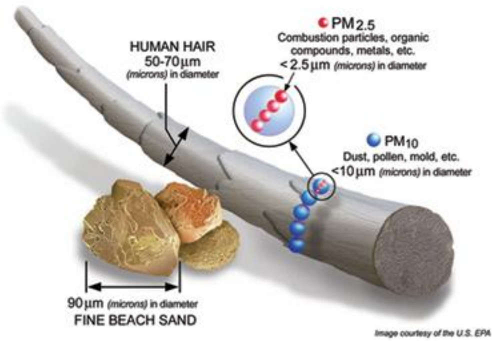
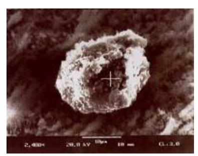
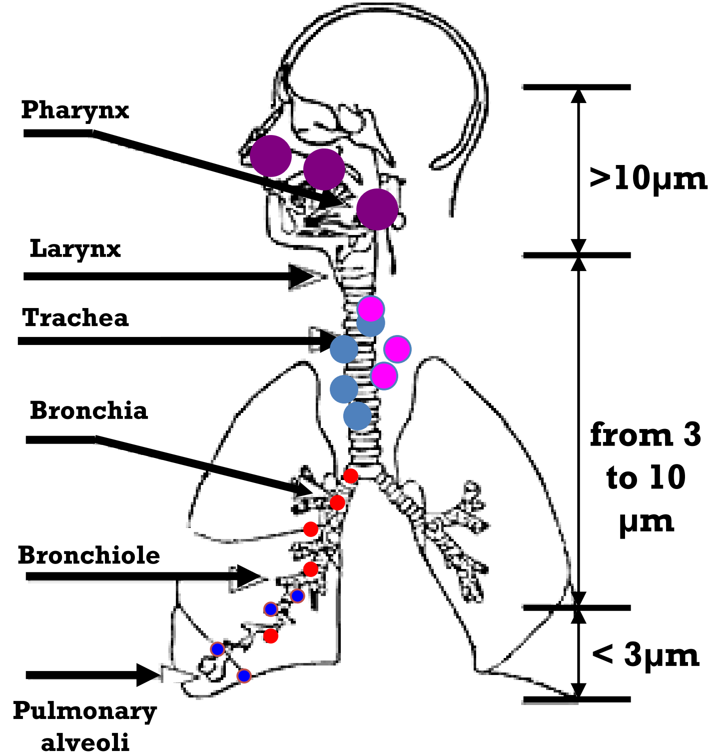
Collaborative Work by Many!

Outline

Particulate matter penetration







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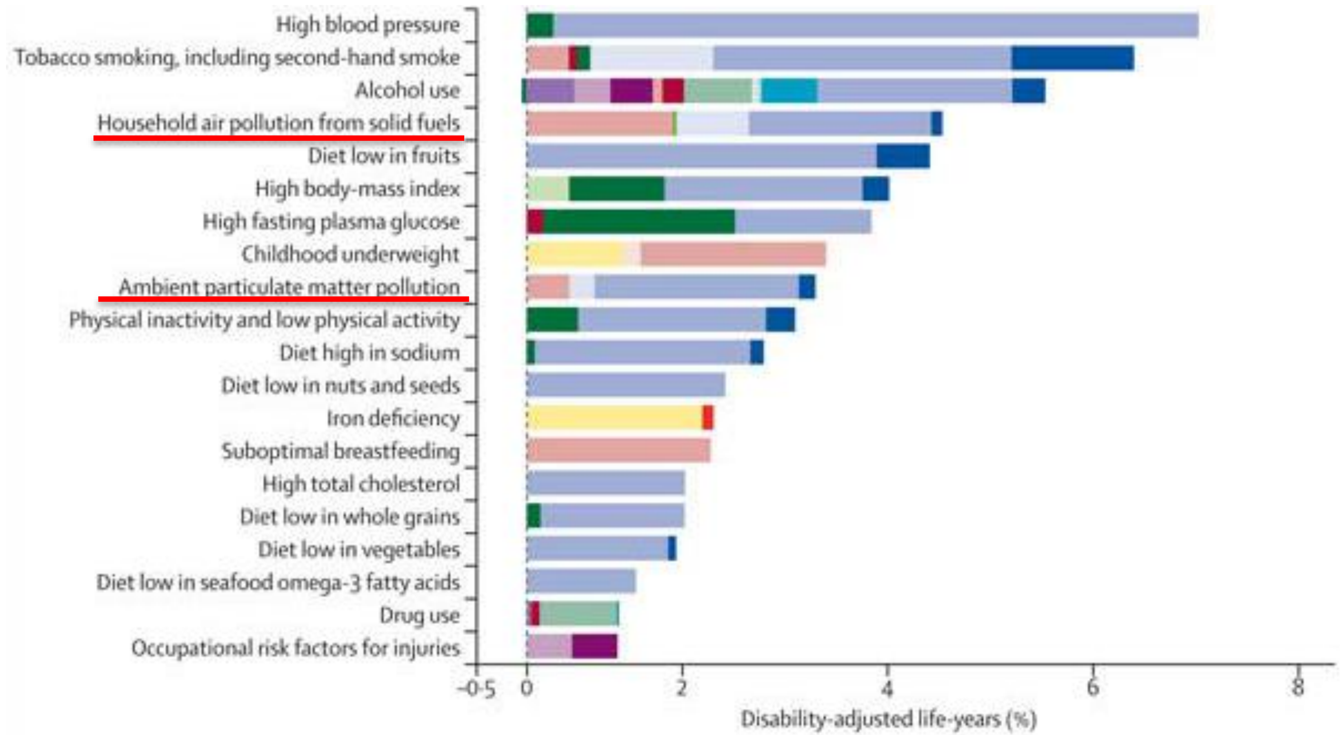
Global Burden of Disease 2010



DALYs= sum of years lived with disability [YLD] and years of life lost [YLL]

http://www.healthmetricsandevaluation.org/
Lancet 2012

LETTER

doi:10.1038/nature15371

The contribution of outdoor air pollution sources to premature mortality on a global scale

J. Lelieveld[1,2], J. S. Evans[3,4], M. Fnais[5], D. Giannadaki[2] & A. Pozzer[1]

Assessment of the global burden of disease is based on epidemiological cohort studies that connect premature mortality to a wide range of causes[1–5], including the long-term health impacts of ozone and fine particulate matter with a diameter smaller than 2.5 micrometres ($PM_{2.5}$)[3–9]. It has proved difficult to quantify premature mortality related to air pollution, notably in regions where air quality is not monitored, and also because the toxicity of particles from various sources may vary[10]. Here we use a global atmospheric chemistry model to investigate the link between premature mortality and seven emission source categories in urban and rural environments. In accord with the global burden of disease for 2010 (ref. 5), we calculate that outdoor air pollution, mostly by $PM_{2.5}$, leads to 3.3 (95 per cent confidence interval 1.61–4.81) million premature deaths per year worldwide, predominantly in Asia. We primarily assume that all particles are equally toxic[5], but also include a sensitivity study that accounts for differential toxicity. We find that emissions from residential energy use such as heating and cooking, prevalent in India and China, have the largest impact on premature mortality globally, being even more dominant if carbonaceous particles are assumed to be most toxic. Whereas in much of the USA and in a few other countries emissions from traffic and power generation are important, in eastern USA, Europe, Russia and East Asia agricultural emissions make the largest relative contribution to $PM_{2.5}$, with the estimate of overall health impact depending on assumptions regarding particle toxicity. Model projections based on a business-as-usual emission scenario indicate that the contribution of outdoor air pollution to premature mortality could double by 2050.

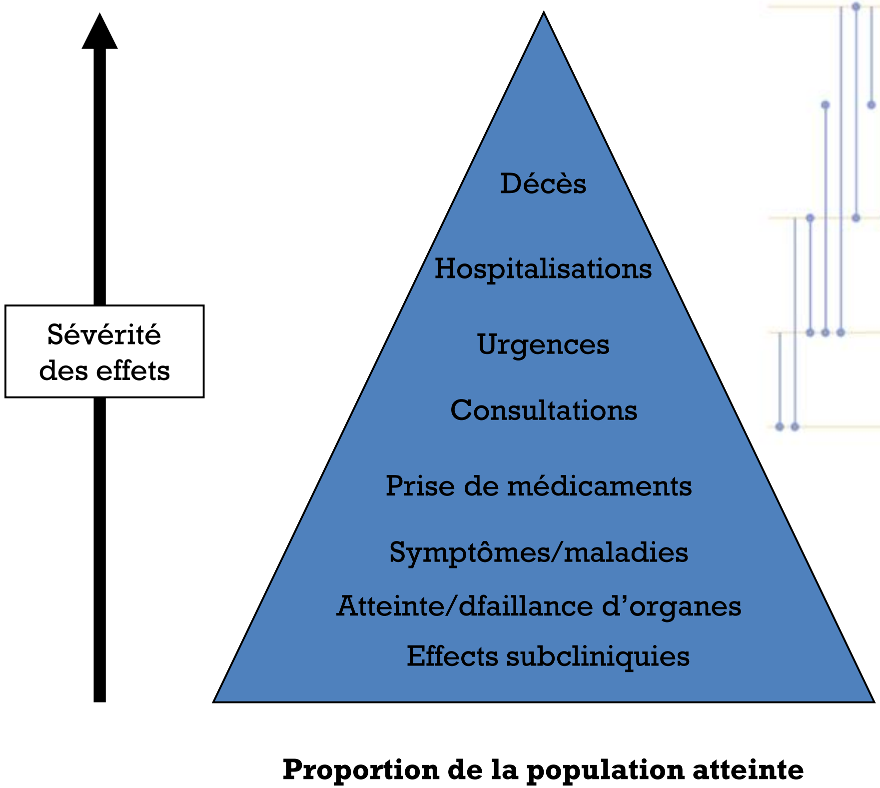
Table 1 | Premature mortality related to $PM_{2.5}$ and O_3 for the population <5 and ≥30 years old

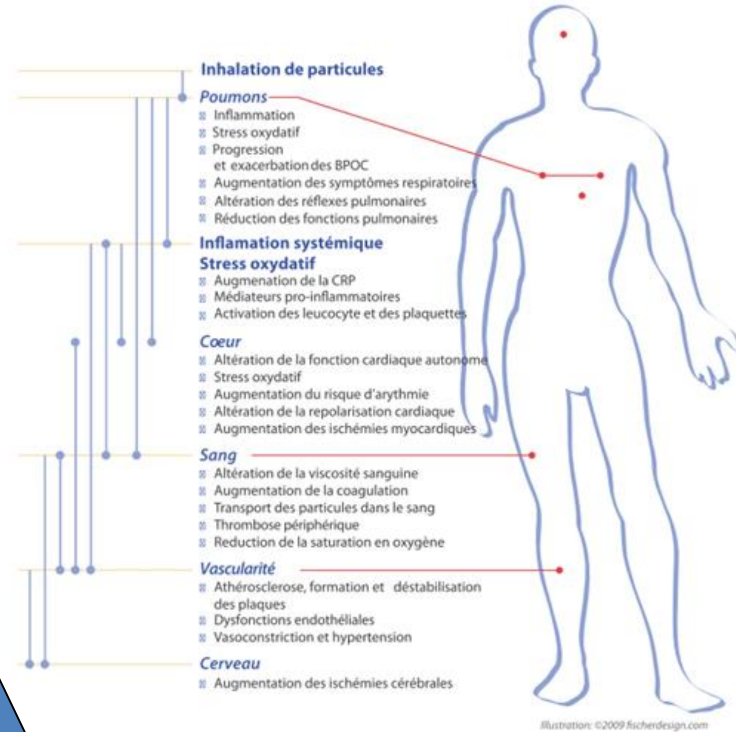
WHO region	Year	Population (×10[6])	Mortality attributable to air pollution (deaths × 10[3])						
			$PM_{2.5}$					O_3	Total
			ALRI < 5 yr	IHD ≥ 30 yr	CEV ≥ 30 yr	COPD ≥ 30 yr	LC ≥ 30 yr	COPD ≥ 30 yr	
Africa	2010	809	90	55	77	11	2	2	237
	2050	1,807	158	185	262	38	5	12	660
Americas	2010	930	0	44	8	4	7	5	68
	2050	1,191	0	75	15	7	11	11	119
Eastern Mediterranean	2010	602	56	115	86	12	5	12	286
	2050	1,021	66	321	246	37	13	40	723
Europe	2010	867	1	239	95	13	27	6	381
	2050	886	1	307	156	18	37	11	530
Southeast Asia	2010	1,762	64	327	250	124	15	82	862
	2050	2,332	104	865	807	419	48	227	2,470
Western Pacific	2010	1,812	19	299	794	209	107	35	1,463
	2050	1,861	16	413	1,120	309	155	57	2,070
World	2010	6,783	230	1,079	1,311	374	161	142	3,297
	2050	9,098	346	2,166	2,604	828	270	358	6,572

Regions are defined by the World Health Organization, see Extended Data Table 1. Results for 2050 are based on a business-as-usual scenario.

Lilieveld, Nature 2015

Effets sanitaires de la pollution atmosphérique (PM) (court terme et long terme)





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Effets à CT sur la mortalité

results of two collaborative projects conducted in 90 cities in the USA (National Morbidity Mortality Air Pollution Study; NMMAPS) and in 29 cities in Europe (Air Pollution Health Effects Approach; APHEA-II) have been reported. In the American cities, where annual average concentrations of PM_{10} ranged 23–46 $\mu g \cdot m^{-3}$, a 0.27% increase in total mortality and a 0.69% increase in cardiorespiratory mortality were detected for a 10 $\mu g \cdot m^{-3}$ increase in PM_{10} [14]. There was no evidence of a threshold and the effects were linear even at low levels of concentration. In the European study, based on the most extensive database available in Europe and covering a large range of PM_{10} concentrations, the risk estimate for overall mortality was 0.6% per increase of 10 $\mu g \cdot m^{-3}$ in PM_{10} [15] and was 0.76% per 10 $\mu g \cdot m^{-3}$ PM_{10} for cardiovascular mortality

Annesi-Maesano et al, ERJ 2007

USA: augmentation de 0.27% et 0.69% dans la mortalité journalière totale et cardiorespiratoire pour une augmentation de 10 µg/m³ de PM_{10}

APHEA II: augmentation de 0.6% dans la mortalité journalière totale pour une augmentation de 10 µg/m³ de PM_{10}

L'homme

Effects on LT mortality

that mortality increases due to long-term, low-level exposure to PM was provided by the Harvard Six Cities study [2]. These findings were confirmed in the long-term follow-up (1982–1998) of the American Cancer Society (ACS) II cohort, consisting of ~500,000 adults from metropolitan areas throughout the USA [3, 4]. In the latter study, each 10 $\mu g \cdot m^{-3}$ elevation in $PM_{2.5}$ was associated with approximately a 6, 9 and 14% increased risk of all-cause cardiopulmonary and lung cancer mortality, respectively. A recent report from Los Angeles [5], which included a large proportion of the ACS II cohort from that area, has indicated that a more refined method for assessing exposure produces a higher risk estimate of mortality increase (17% increase; 95% confidence interval 5–30%) for an increase of 10 $\mu g \cdot m^{-3}$ in $PM_{2.5}$. Well-conducted

Annesi-Maesano et al, ERJ 2007

ACS II: augmentation de 6, 9, 14% du risque de mortalité toutes causes, cardiorespiratoires et par cancer pour une augmentation de 10 $\mu g/m^3$ des $PM_{2.5}$

ACS II revu: augmentation de 17% du risque de mortalité toutes causes pour une augmentation de 10 $\mu g/m^3$ des $PM_{2.5}$

L'homme

RATIONALE

- Importance of:
  - Monitoring individual exposure
  - Have detailed local Data
  - Realtime Monitoring for specific diseases

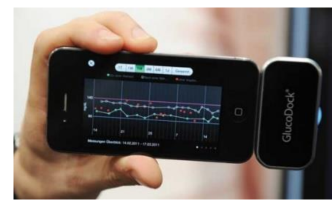
Exploring individual exposure

Different levels

Global/local level

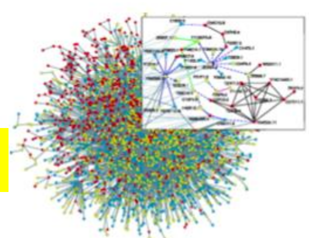
data

Individual remote sensors



data

Biomarkers (omics, etc.) (DOSE)



data

Precision in the exposure

OUTDOORS / INDOORS 1.XII.2015

Major steps

Individual remote sensors

The key to monitor the "cumulative exposure assessment" is convenience, weight, validity/reliability of data collected, low-noise, and non-interference from the wearer and personal activities. Ideally a sensor system should have the following characteristics:

1. Portable and unobtrusive to the wearer;
2. "Low-cost", i.e. such that widespread deployment of sensors is a practical proposition;
3. Able to collect, store and transmit high-time resolution data;
4. Useable by a non-scientifically trained person, a
minimally engage with the sensor system to collect the data
5. Connected to the internet so that collected data can
researchers and users;
6. Constructed to predefined quality assurance and
specifications, including:
   a. Sufficient sensitivity and specificity to allow u
and
   b. Reliable so that it can be used repeatedly and w

Cherrie et al.
Env Int (in press)

Targeted stressors:

- Localisation
- Physical activity
- Air quality
- T and Hum
- Noise
- Food…
- 3 potential candidates

Pollution is Local:

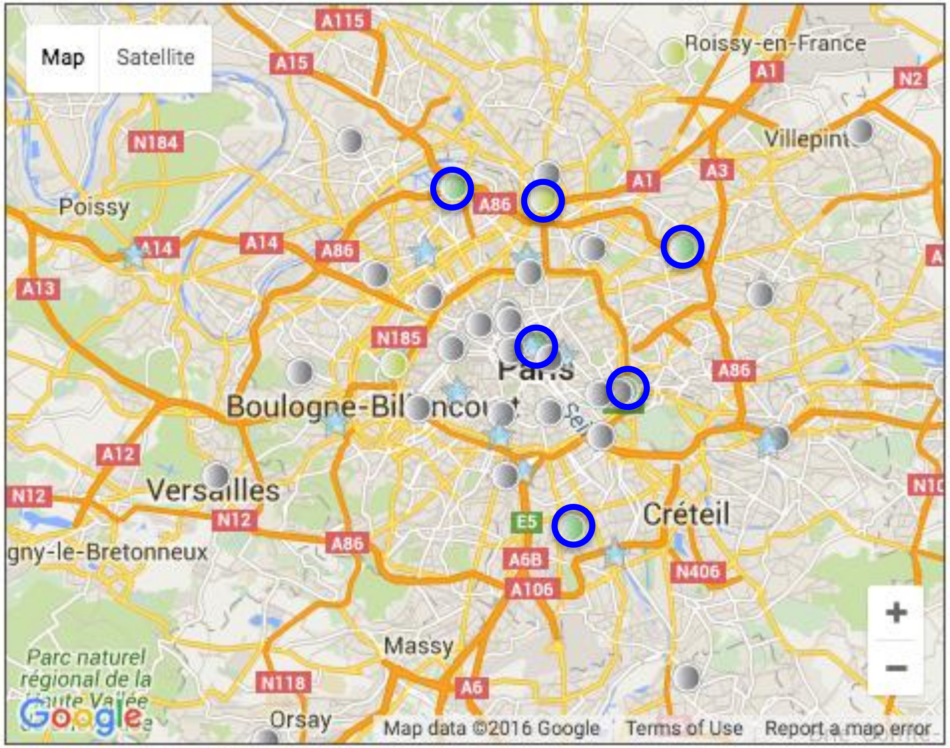
Local Dynamics are hard to measure from few scattered stations

Hi oral

res

- A ined
  w
  – s and
- Pe can
  au atial-
  te
  – mous
  lly.

▸ Monitoring station network



Select a station: Select a station

Pollutants

- Global index
- Nitrogen dioxide (NO2)
- Ozone (O3)
- Particulate matter (PM10)
- Particulate matter (PM2.5)

Legend :

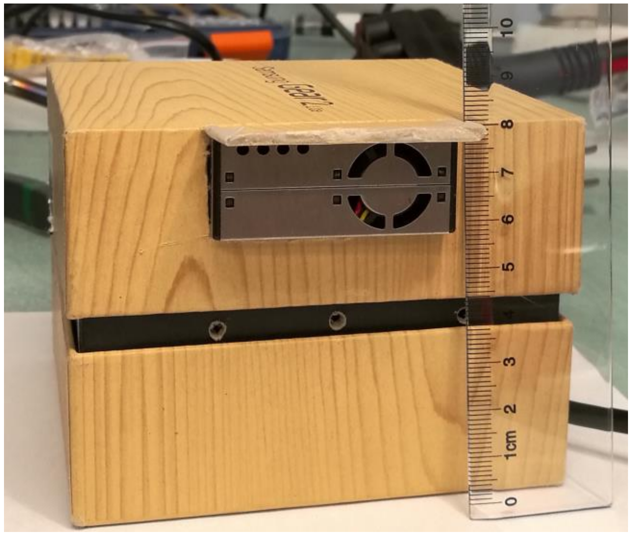
Pollution	index
Very high >100	
High [75-100]	
Medium [50-75]	
Low [25-50]	
Very low [0-25]	
Index non calculated	
Non-permanent station	

The station colours reflect the state of the air quality measured based on the index calculation grid. If the global index or sub-index requested is not calculated, the station will appear in grey.
Feel free to click on a station to find further information about the measurements or see:

▸ Station data

Outline

Sensor



8cm

10cm

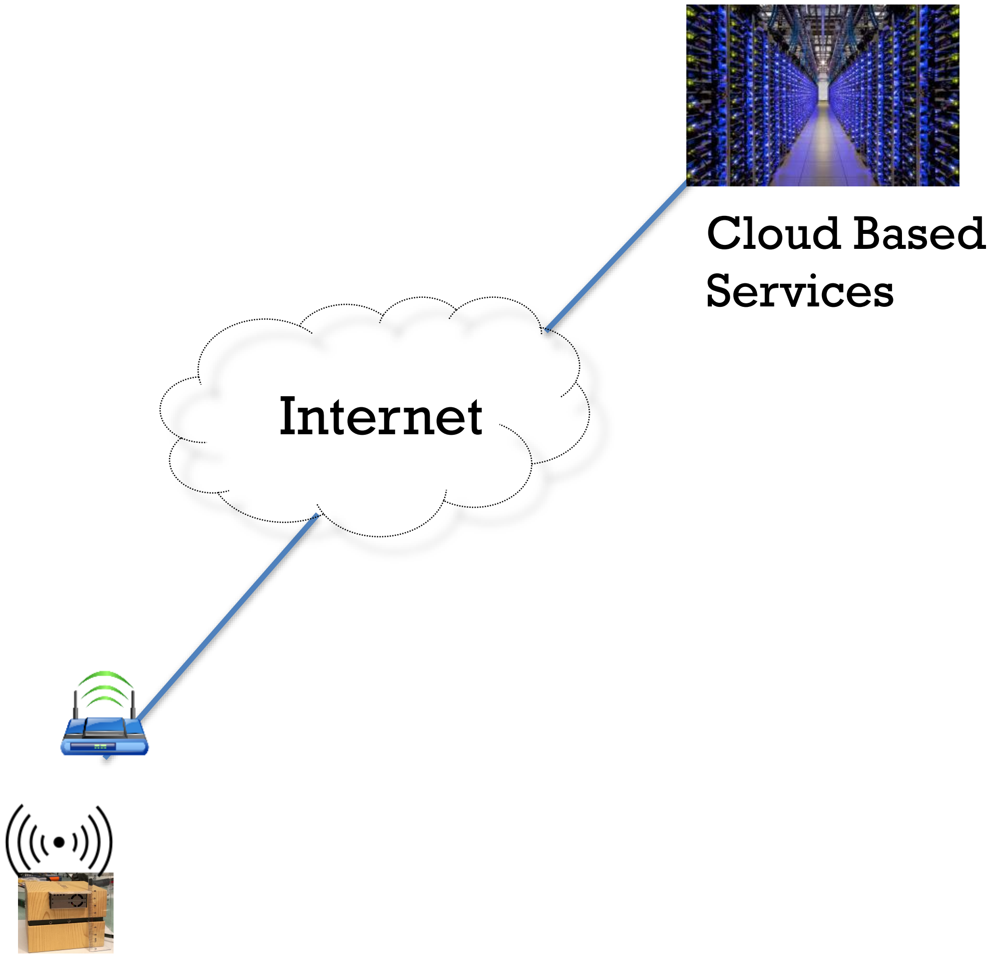
10.5cm

- Can be reduced in size by a factor of 1/3 roughly
- 90Hrs x Charge @ 1 sample/minute; 1 Upload/5min

On the Scale

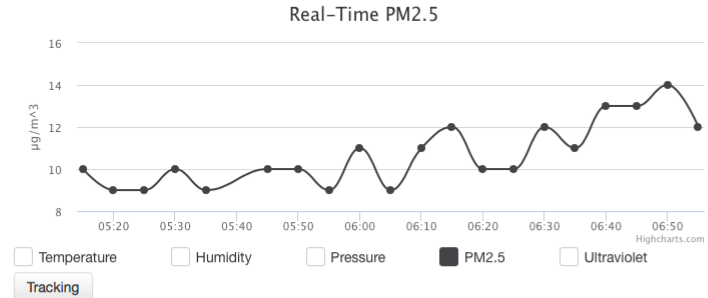
- **350g Total**
  - 100g Battery→??
  - 100g Box →50g

Server Side



Last Updated

2016-01-16 13:55:00



Temperature

4.8°C

Relative Humidity

71.3%

Air Pressure

1018.1hPa

Bat. Voltage

2980mV

Ultraviolet

0 mV

Last Human Motion

No Data

Current Human Motion

Not detected

PM 2.5

12µg/m^3

Air Quality

Good

Geo. Location

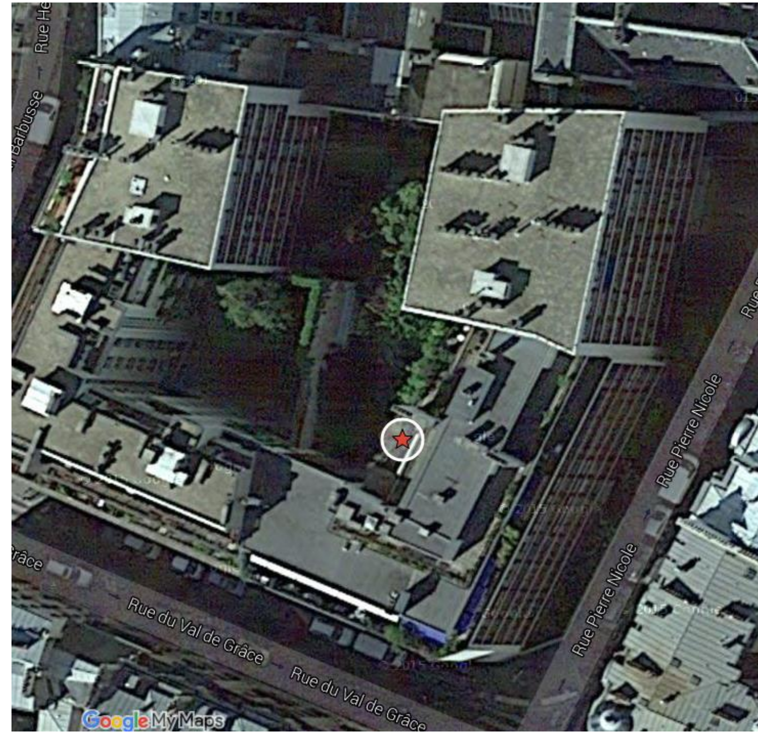
48.841087N,2.339393E

Outline

1. ~~Introduction~~
2. ~~Sensor~~
3. Preliminary Evaluation
4. Current Activities
5. Planned Evolutions

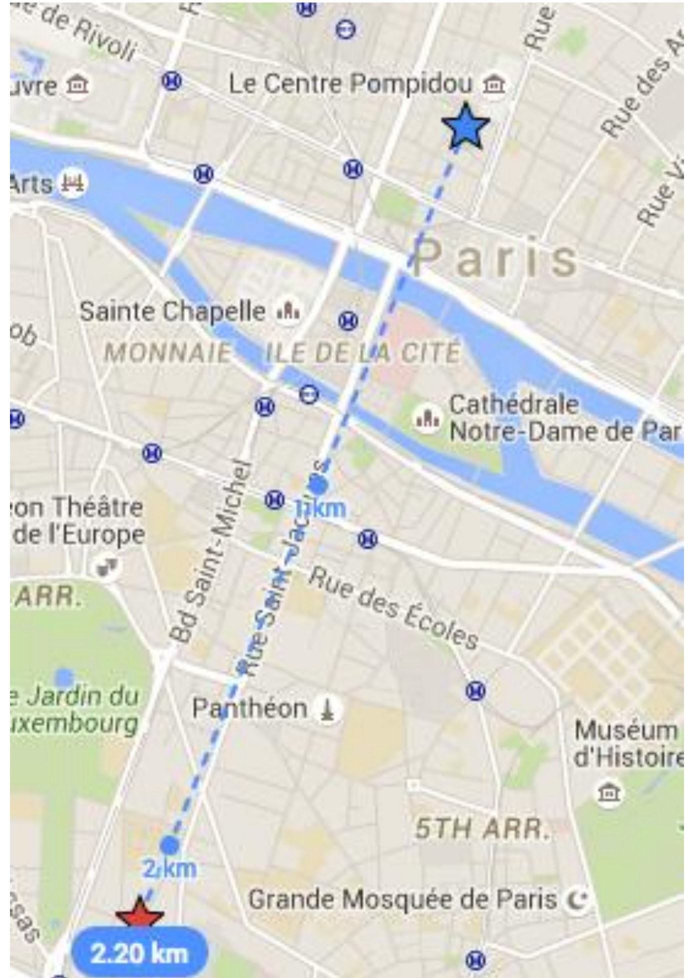
Location, Location, Location

Place Igor Stravinsky
Inlet: 3.5m
Data: Airparif
Station: PA04C



12 Rue du Val de Grace
Inlet: ~ 25m (5^{th} Floor)
Data: Sensor
Station: S3

...Location...



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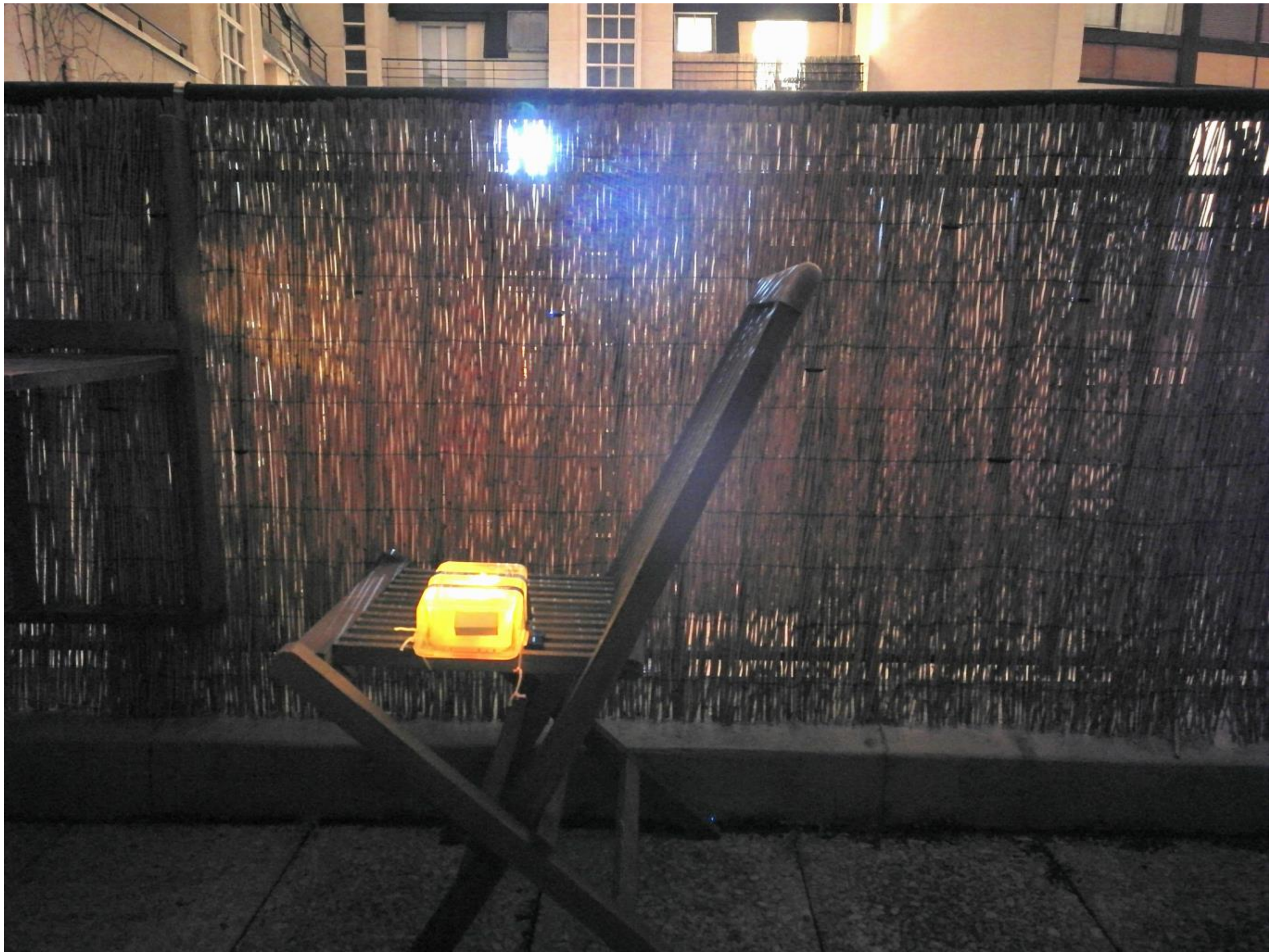
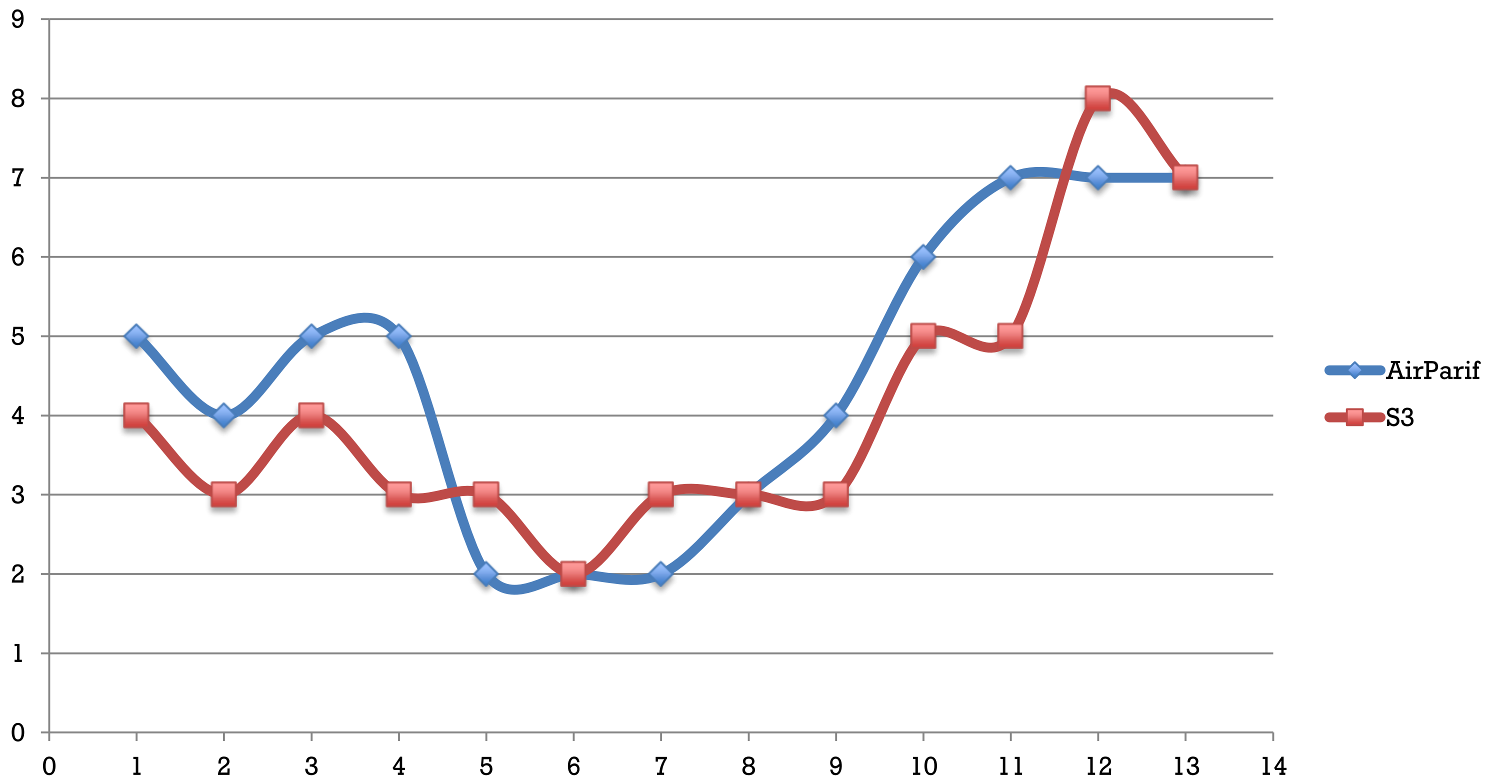
…. Location… Again..

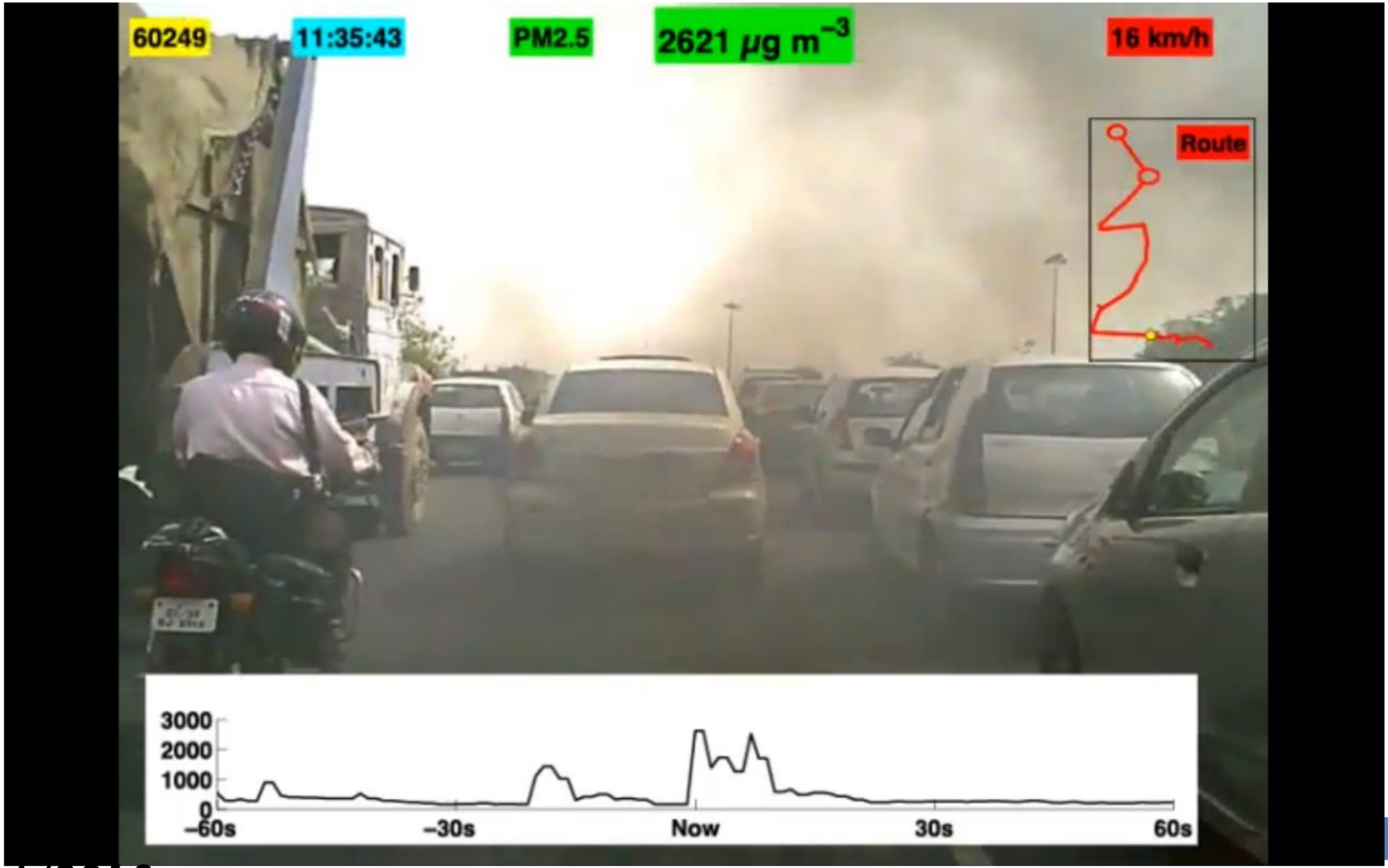


Quick and Dirty Comparison



Jan. 15, 2016

One example


60249
11:35:43
PM2.5
2621 μg m-3
16 km/h
Route
3000
2000
1000
0
-60s
-30s
Now
30s
60s

Outline

UPMC SORBONNE UNIVERSITÉS

Current Activities

- Sensor Cross-Calibration
  - At INSERM
  - In House @ LISA
- Sensor Development
  - VOC
  - NOX
  - Size Reduction
- At scale deployment in Thailand
  - With INSEARM and AIT

Outline

Planned Evolutions

- Optimizations
  - Physical: Size, Duration
  - Communications:
    - VHF /UHF Radio for Thailand Exp.
    - Protocol Design and Robustness
    - Cloud Based Control (i.e. increasing/decreasing sensing frequency)
- Data Intelligence (Tensor Flow or similar) in the back-end
  - Data driven control loop
  - Cumulative intelligence information flow

Projects using remote sensors (INSERM & UPMC) to assess health impact of air pollution

- EU FP7-ENV HEALS Health and Environment-wide Associations based on Large population Surveys, THE LARGEST RESEARCH PROJECT IN EUROPE ON ENVIRONMENT AND HEALTH (www,heals-eu.eu)
- SEA HAZEMON (Thaïlande)
- Eu FP7-ENV DACCIWA
- ICARE
- PID93

MERCI

G. Pau – I. Annesi-Maesano

Institut Pierre Louis d'Épidémiologie et de Santé Publique
Pierre Louis Institute of Epidemiology and Public Health
Pierre Louis (French physician, 1787-1872) contributed to the development of epidemiology