

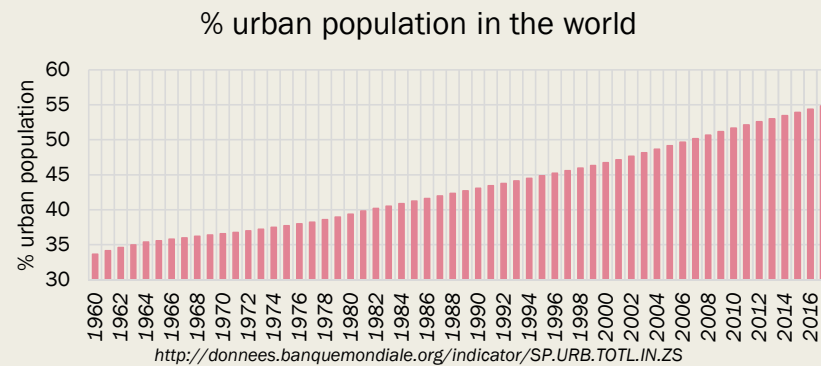
# DEVELOPMENT OF A NEW INDEX FOR URBAN AIR QUALITY AS AN URBAN DESIGN TOOL

FALZONE C. – Researcher  
ROMAIN AC. – Professor

*Sensing of Atmospheres and Monitoring  
University of Liege*

# Introduction

## World urban population growing every year



## Higher activity for a given area

- Traffic
- Heating



depositphoto



<https://thetravelcrew.files.wordpress.com/2012/06/liege.gif>



<https://maison-monde.com/petites-cheminees-toits-de-paris/>

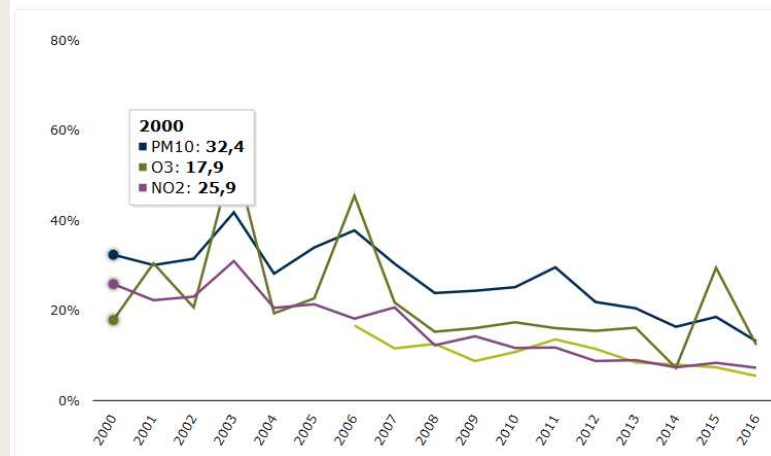
# Introduction

## Air quality (urban) impacts human health

### Effects:

- Irritation of the respiratory tract
- Head aches
- Eyes irritation
- Lung cancer
- ...

Figure 1. EU urban population exposed to air pollutant concentrations above selected air quality standards of the EU Air Quality Directive



### Outdoor air quality in urban areas

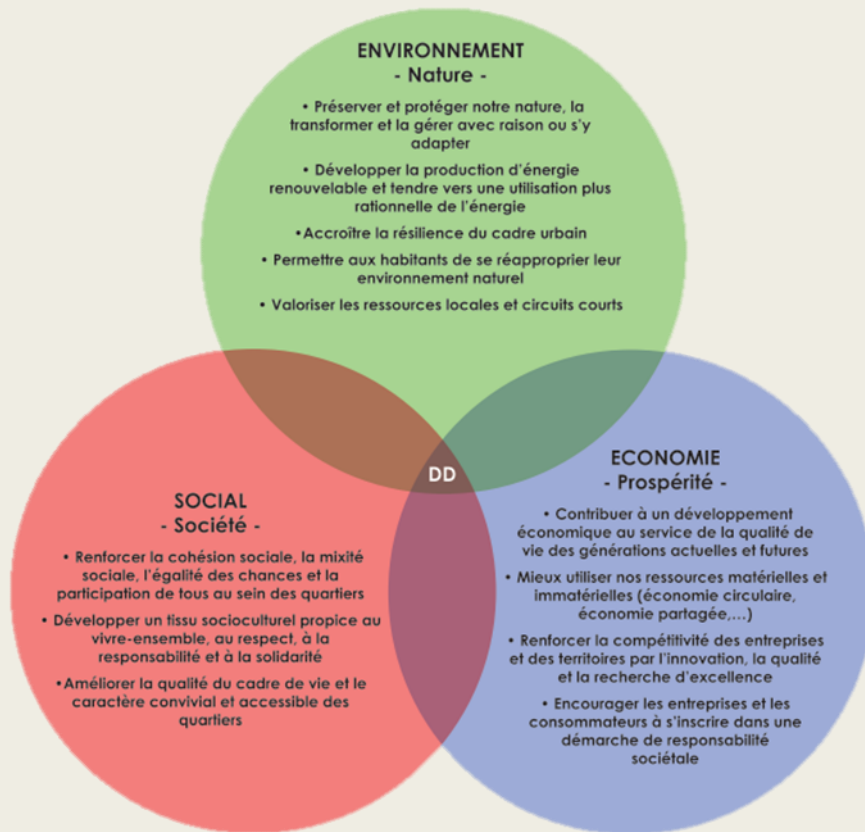
Briefing — Published 29 Nov 2018 — Last modified 08 May 2019 — 16 min read

*“In conclusion, for particles and nitrogen dioxide, the proportion of the urban population in the EU exposed to levels above the EU air quality standards and to the WHO guidelines has been decreasing while the trend for ozone is unclear because of the high fluctuations over time. However, because of the widespread exceedance levels in urban areas it is unlikely that the air quality standards for these pollutants will be met by 2020 across the EU, while achieving air quality in line with the WHO guidelines is much further away (except for NO<sub>2</sub> for which the EU standard and the WHO guidelines are the same).*

*Effective air quality policies require action and cooperation at global, European, national and local levels, which must reach across most economic sectors and engage the public (EEA, 2018a). This has been recognised by the European Commission in its latest Communication ‘Clean Air for all’ (EC, 2018). Holistic solutions must be found that involve technological development, structural changes — including the optimisation of infrastructures and sustainable urban planning — and behavioural changes. These will be necessary to deliver a level of air quality across the EU that is more conducive to the protection of human health (EEA, 2016).”*

# Introduction

## Development of eco-neighbourhood



[http://spw.wallonie.be/dgo4/site\\_colloques/QuartiersNouveaux/assets/documents/referentielQN.pdf](http://spw.wallonie.be/dgo4/site_colloques/QuartiersNouveaux/assets/documents/referentielQN.pdf)

grand angle | antisèche

## C'EST QUOI, UN ÉCOQUARTIER?

Les villes ont jusqu'au 16 mai pour se porter candidates au label EcoQuartier, qui récompense **les projets d'aménagement respectueux de l'environnement et offrant un meilleur cadre de vie.**

Lancée en 2008, la démarche EcoQuartier dispose depuis 2012 d'un **label national EcoQuartier**, décerné par le ministère du Logement. L'Etat ne fixe pas un cahier des charges contraignant, mais juge chaque projet au cas par cas.

### LE RESPECT DE L'ENVIRONNEMENT

La construction sur des zones naturelles ou agricoles est évitée.

Un maximum de logements sont situés à moins de 500 mètres des transports en commun.

Une part de l'électricité est issue de sources d'énergie renouvelable.

De nombreuses surfaces sont végétalisées, notamment les toitures.

Pour mieux gérer les ordures, un maximum de logements sont situés à moins de 200 mètres d'un point d'apport volontaire des déchets.



### UN MEILLEUR CADRE DE VIE

Le quartier propose des logements sociaux intégrés au site.

Les bâtiments accueillent des logements, mais aussi des bureaux et des commerces.

Le nombre de mètres carrés d'espaces verts et d'espaces publics (école, médiathèque, etc.) par habitant est élevé.

Un maximum de logements sont raccordés à Internet haut débit, par exemple à la fibre optique.

### LE SAVIEZ-VOUS ?

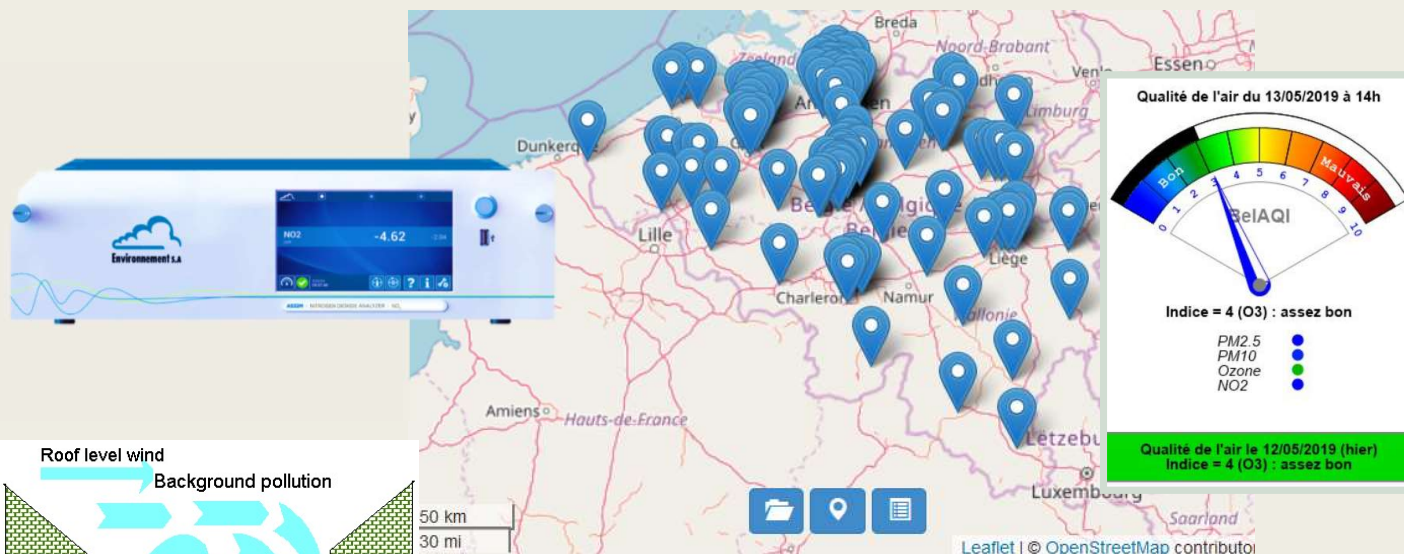
Déjà 12 quartiers en France métropolitaine (soit 18 313 logements) ont obtenu le label EcoQuartier et 32 devraient le recevoir d'ici deux ans. Sur les 12 déjà labellisés, 10 sont gérés par des partenariats entre collectivités et bailleurs privés, 2 par la commune.



# Introduction

## Air quality monitoring

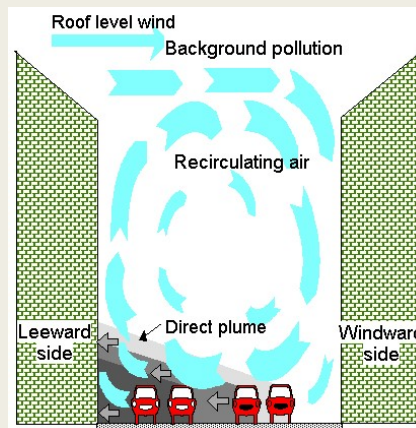
- Telemetric network
  - Analysers
- BelAQI (Belgium)
  - $\text{NO}_2$ ;  $\text{O}_3$ ;  $\text{PM}_{10}$ ;  $\text{PM}_{2.5}$



## Quid local pollution ?



<https://i.pinimg.com/736x/4e/69/0d/4e690dc5653d23bf59b13db42add9094.jpg>

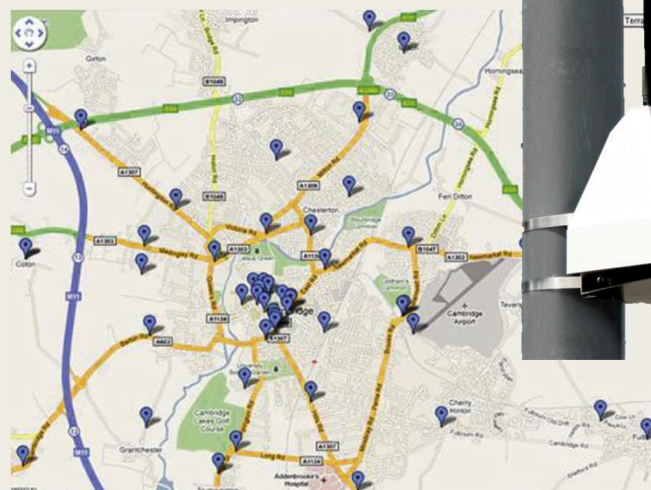


<http://ibis.geog.ubc.ca/courses/geob370/students/class13/bho/>

# Introduction

## Solutions

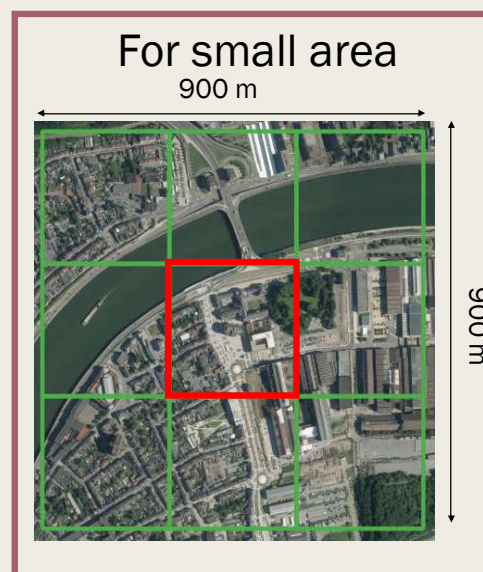
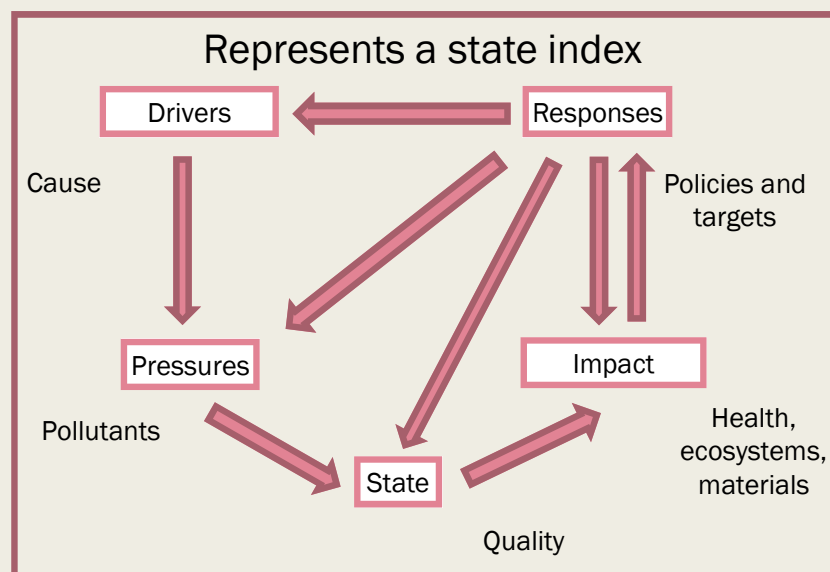
- Low-cost sensors
  - Electrochemical sensors
  - Optical sensors
  - ...
- Low-cost sensors network
  - Multi-sensors platform



*M.I. Mead et al. / Atmospheric Environment 70 (2013) p.186-203*

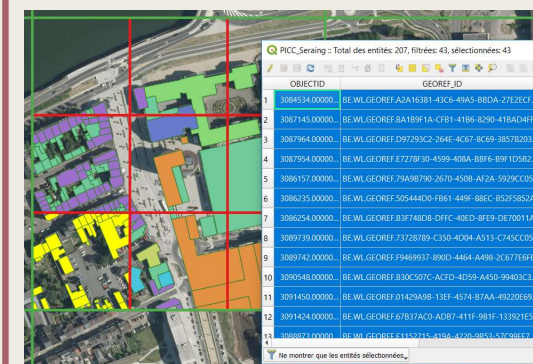
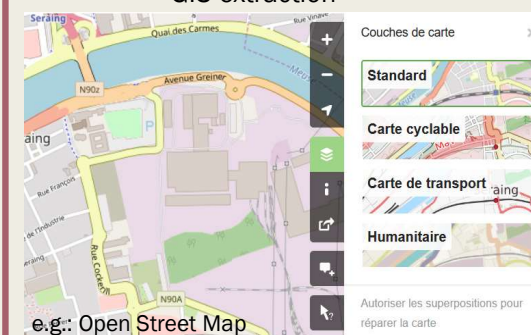
# Objective

## Development of an air quality state index

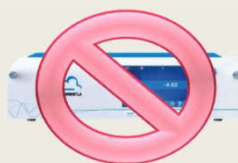


## Built on an open access database

- Internet
- GIS extraction



Independent of the pollutant measurement at short term

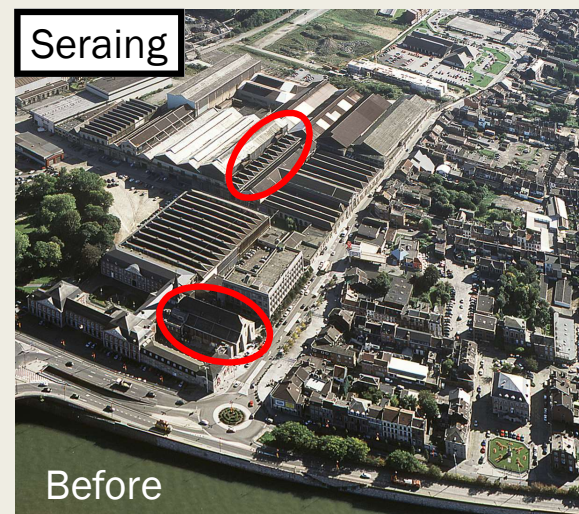
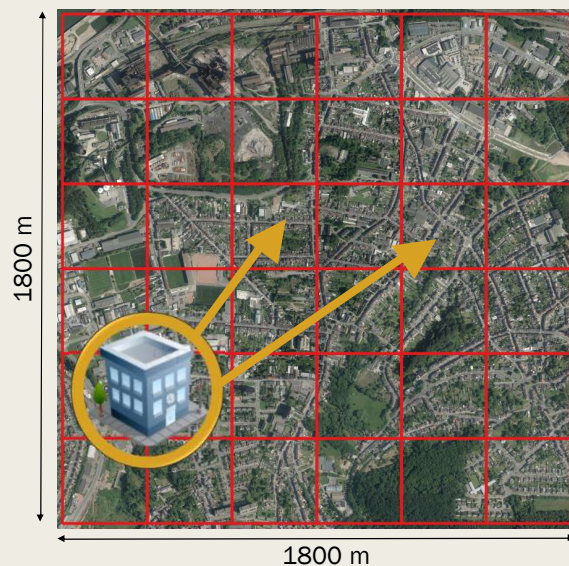




# Objective

## Applications

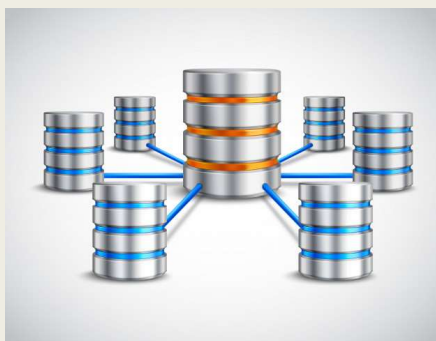
- Chose a place for a new urban project
- Comparison of a site over time





# Material

## Open access database



- WalOnMap (Projet Informatique de Cartographie Continue)
- BelAQI
- Industrial emissions (IED)
- GIS calculation (e.g.: area)
- List of carcinogenic pollutants (IARC)

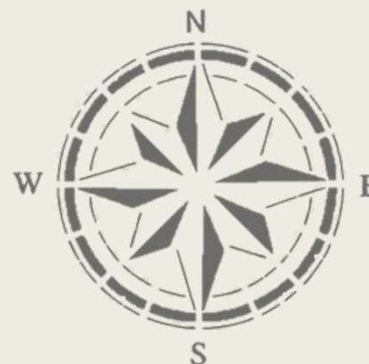
## Software



- QGIS (v3.6.0)
- Access 2016
- Rstudio (v3.4.1)
- Elyx3D
- Envi-MET (v4.4.2)

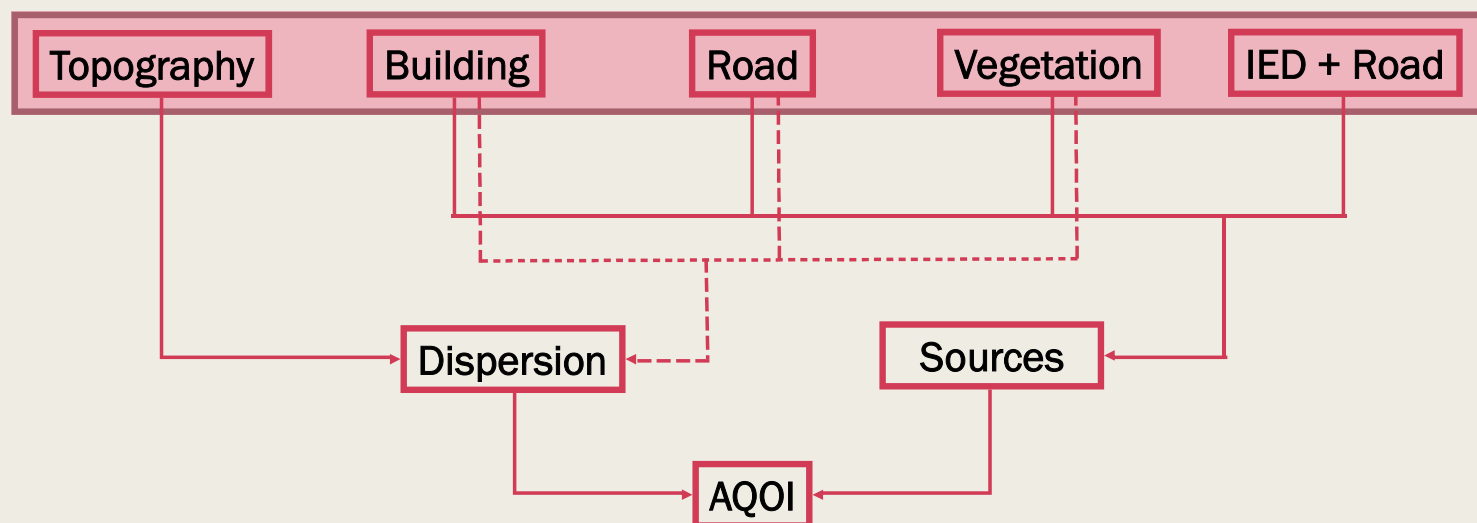
# Results - AQOI

## Structure



Each parameter interacts with the wind direction

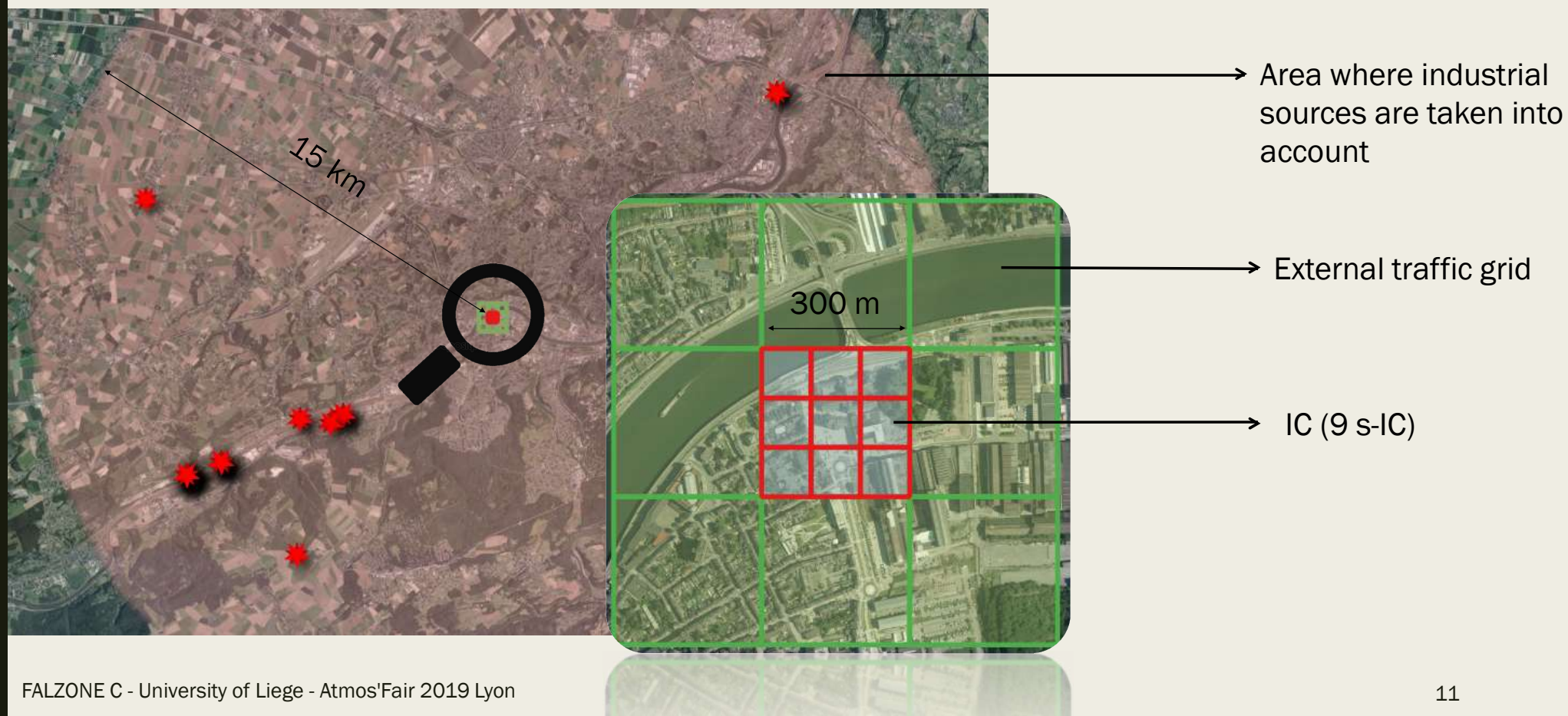
Parameters composed by variables



AQOI :  
Air Quality Observed Index

# Results - AQOI

Study area:



# Results - AQOI

## First step:

- Inventory of features
  - Observed variables (e.g.)



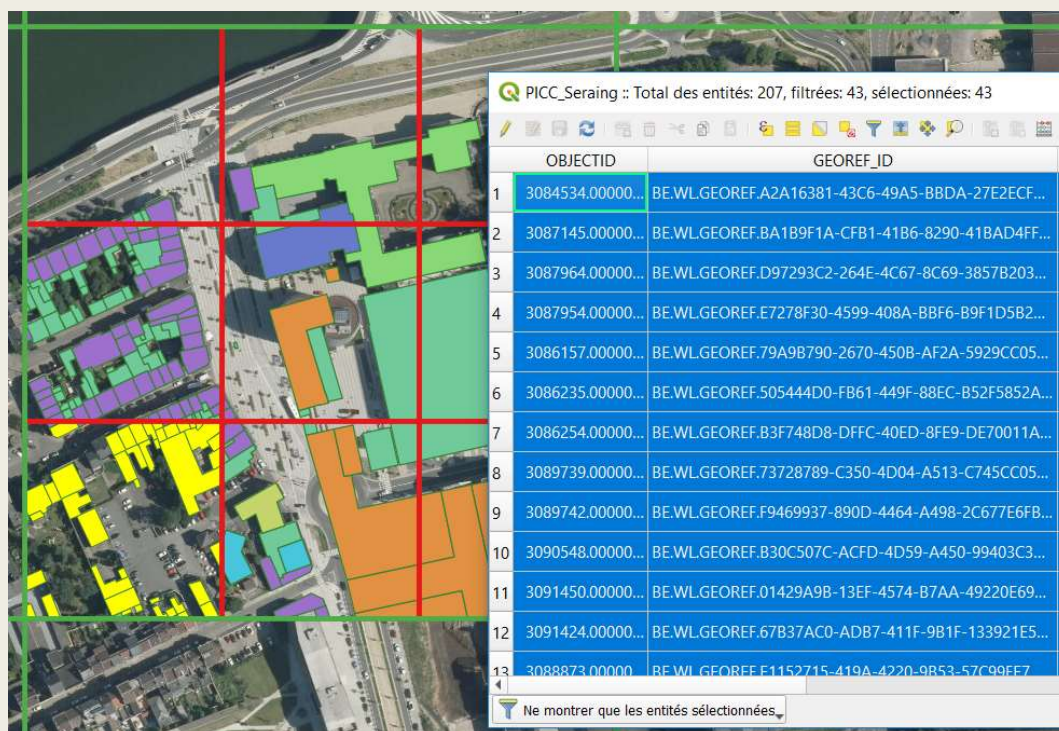
*Seraing (Liège, Belgium) – pilot site for EcoCityTools project*



# Results - AQOI

## Second step:

- GIS extraction
  - Referenced variables (e.g.)



« Le PICC reprend selon leurs coordonnées x, y, z, avec une précision inférieure à 25 cm, tous les éléments identifiables du paysage wallon :

- Bâtiments et ouvrages d'art ;
- Équipements (taques, poteaux, pylônes, etc.);
- Réseau ferroviaire ;
- Réseau hydrographique ;
- Occupation du sol (arbres isolés, lisières, terrains de sport, etc.) ;
- Éléments du relief (talus, etc.) ;
- Voiries (axes, bords, trottoirs, etc.).

Depuis décembre 2014, le PICC couvre toute la Wallonie. »

<http://geoportail.wallonie.be/catalogue/b795de68-726c-4bdf-a62a-a42686aa5b6f.html>

# Results - AQOI

## Third step:

- Listing of proxy variables

Metric



e.g. Dimension

Absence / presence



e.g. Green wall

Listing

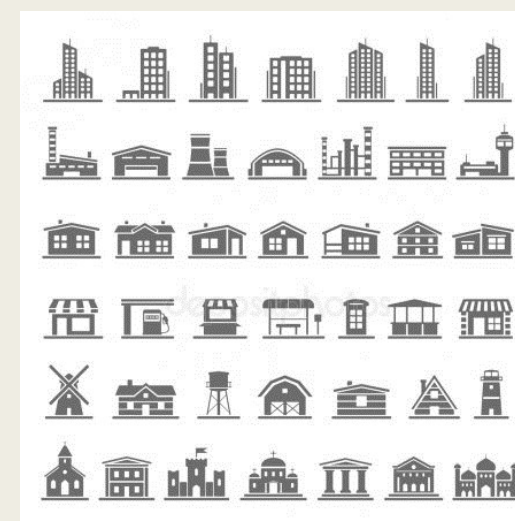


Position

- North
- East
- West
- South
- ...

e.g. Position in IC

Listing with classification



e.g. Building affectation

Images : Depositphotos

# Results – AQOI







## *Topography Parameter*

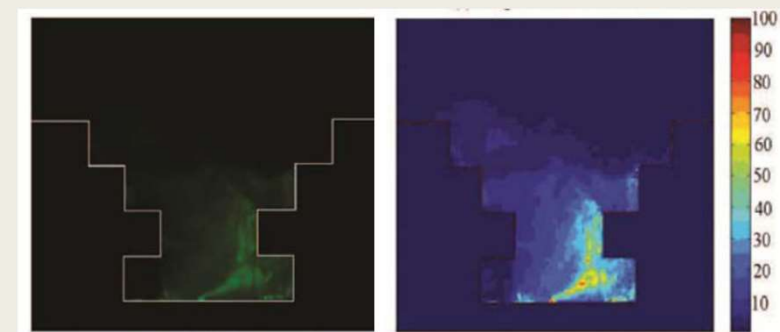
Variables	Type	Examples
Relief	☹️ 😐 😊	<i>Pollutants concentration is different between top and bottom of a valley</i>
Waterway	✅ ❌	<i>River traffic</i>



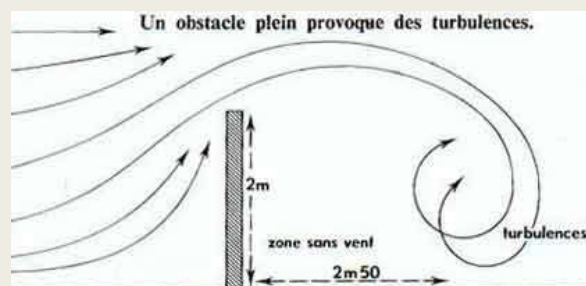
# Results – AQOI

## Building parameter

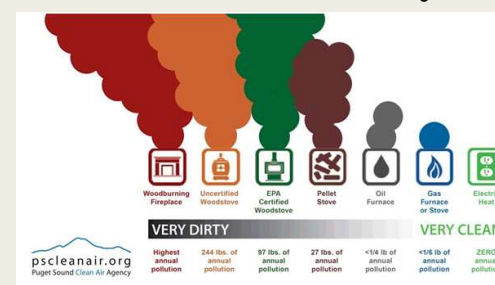
Variables	Type	Examples
Affectation		More traffic for a hospital than for a house
Position in IC		Wind from the North coupled with a building located in the North IC → Pollutants stay out of the IC Wind from the North coupled with a building located in the South IC → Pollutants stay in the IC
Height		Screen effect affected
Heating system		Wood emits more PM than gas
Green wall		Local action
Gallery		Pollutants trap



Y-d. Huang and al. / Journal of Hydrodynamics 28 (2016) p.801-810




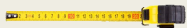



<http://arrosiers-secateurs.com/Protection-contre-le-vent-dans-un>



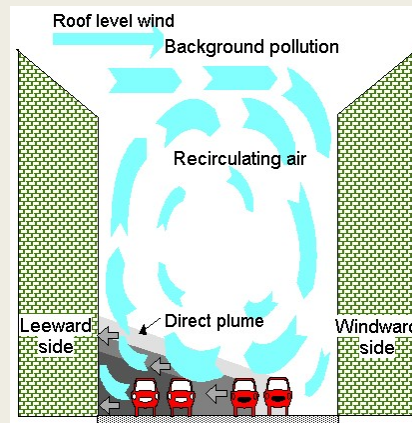


# Results – AQOI

## Road Parameter

Variables	Type	Examples
Width		$H/W \approx 1$ regular canyon
Height		$H/W \approx 1$ regular canyon
Orientation		<p>Wind from the North coupled with a street facing North → Pollutants are driven off the street</p> <p>Wind from the North coupled with a street facing East → Pollutants remain on the street</p>
Classes		Higher traffic density on a national highway than on a residential street
Stop		Stopped vehicles emit pollutants over a longer period of time

S. Vardoulakis et al. / Atmospheric Environment 37 (2003) 155–182



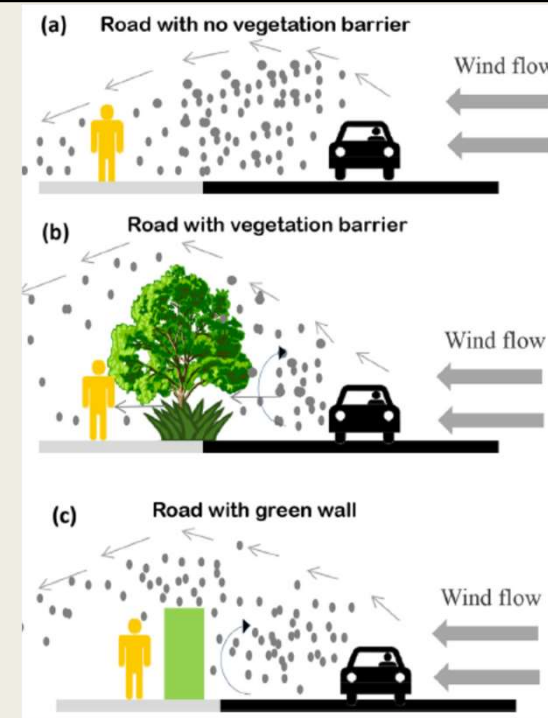
# Results – AQOI

## Vegetation Parameter

Variables	Type	Examples
Type	☹️ 😐 😊	Local depollution by trees ; Agriculture contribution to pollution
Canopy	☹️ 😐 😊	Large canopy traps pollutants under the tree
Disposition	☹️ 😐 😊	No screen effect for a single tree while for grouped trees yes
Height	📏	Screen effect affected
Deciduous leaf	✅ ❌	The leaves act on the environment
Position in IC	☹️ 😐 😊	Same as building parameter
Orientation	☹️ 😐 😊	Wind from the North coupled West-East linear disposition → Screen effect Wind from the West coupled West-East linear disposition → No Screen effect
Allergenicity	☹️ 😐 😊	Birch is more allergenic than beech



FALZONE C - University of Liege - Atmos'Fair 2019 Lyon

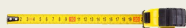






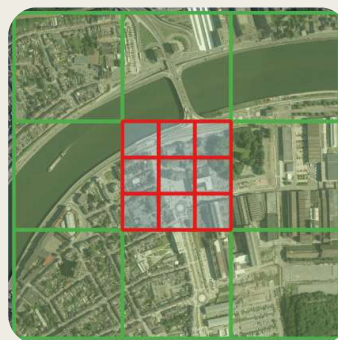
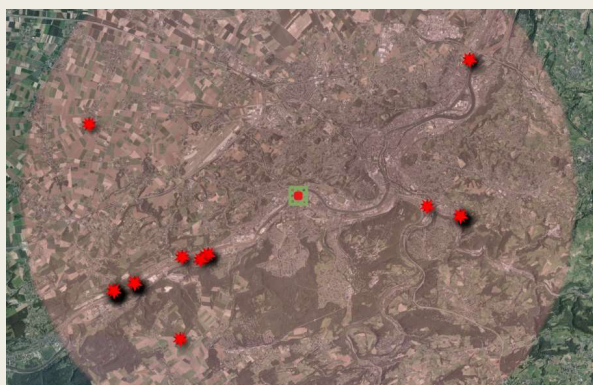
K.V. Abhijith et al. / Atmospheric Environment 162 (2017) 71-86



# Results – AQOI

## External sources Parameter

Variables	Type	Examples
IED - Distance from IC		An industry located 15 km away will be less likely to impact the IC than an industry located 500 m away
IED - Pollutants emitted		Not all emitted pollutants have the same impact on health; some are carcinogenic (cf. IARC)
IED – Quantity of pollutants		The quantity emitted impacts health
Road - Orientation		<p>Wind from the North coupled with a street facing North → Pollutants are driven off the street</p> <p>Wind from the North coupled with a street facing East → Pollutants remain on the street</p>
Road - Position around IC		<p>Wind from the North coupled with a North facing street located North of IC → Pollutants enter the IC</p> <p>Wind from the North coupled with a North facing street located South of IC → Pollutants don't go in the IC</p>



# Conclusions and perspectives

## Done

## In progress

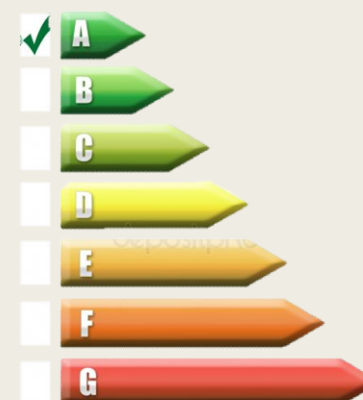
### Variables

- Identification based on
  - Data relevance
  - Accessibility # Low-cost
- Values determined according to the impact on air pollution

### Parameters

- Clustering of variables
  - Easy encoding
  - Used for urban planning
- Values
  - Matrix of interaction between several variables

- Integration of parameters to calculate AQOI
- Build a classification based on worst and best situation for each parameters
- Validation
  - By measurement of pollutants integrated over a long period of time
- Optimisation based on the validation results
- Integration into GIS through heat map





EcoCityTools Project



Funding: Wallon Region



# Thank you for your attention