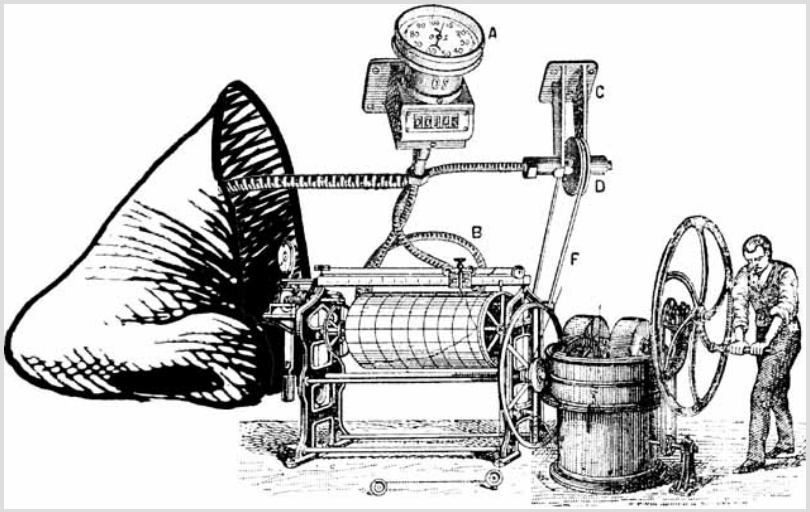
Université de Liège

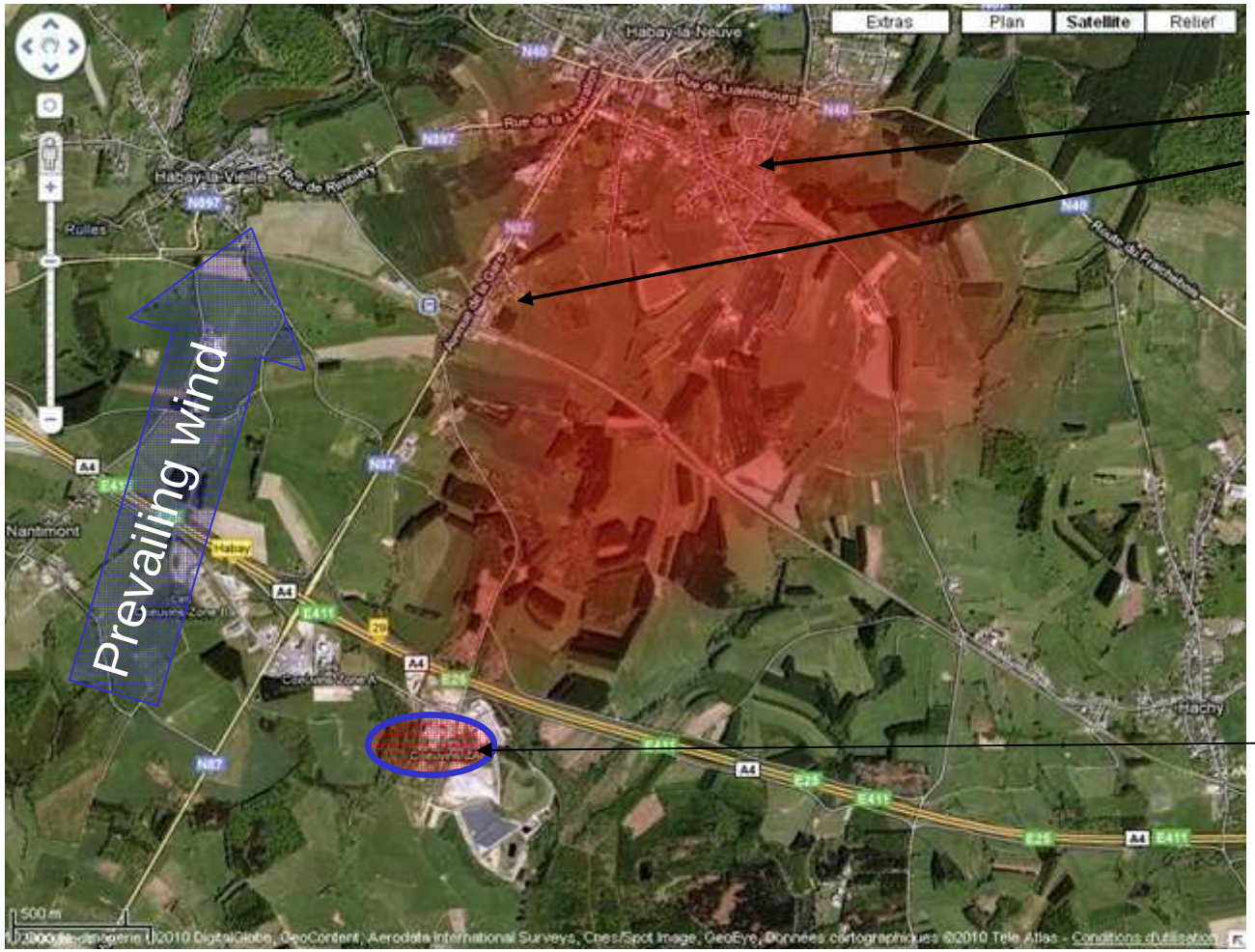
Arlon campus environnement

E-nose development to predict odour annoyance in a receptor site



CEMAGREF, Novembre 2010

1 – Intro



Inhabitants exposition

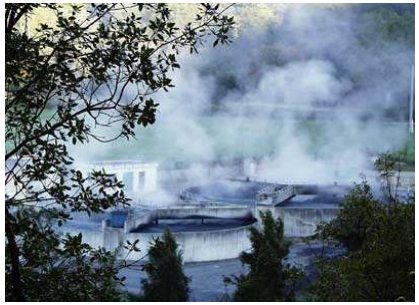
ANNOYANCE

Odour emission

POLLUTION

Pollution

Generation of gaseous mixture gazeux



odour emission

Transport & dispersion

Chemical evolution: nature and concentration

Exposition

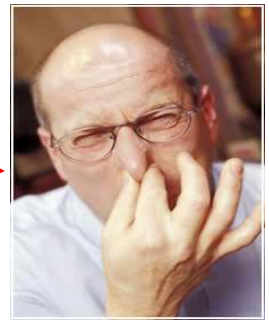
≠ variables→ ≠ measurement approaches

Annoyance

complaint

annoyance

Detection & perception



incomfort

1 – Intro

Sampling

Olfactory pollution metrology

Sensorial techniques		Electronic nose	Analytical techniques
Dynamic olfactometry (concentration)	Hedonic character		Identification/quantification of compounds
Percentiles evaluation (concentration + frequency)	Emission factors (concentration, odour rate,distance)		…
Sniffing team method (concentration, odour rate)	**population survey (neighbour panel)**		
Intensity measurement	Measurement grid		

1 – Intro

Sensorial

Chemical

E-nose

Complementary techniques

For instance

Prediction of odour taking into account the chemical composition! BE CAREFUL

correlation « chemical composition – odour » is not a straight-line!

odour Mixture ≠ sum of single odorant

There are **Synergy and Inhibition** interactions between molecules

For odour perception,

1 + 2 = 4

1 + 2 = 2

and

1+2 ≠ 3

→ Chemical analysis alone insufficient to evaluate odour

2 – E-nose: environmental application "odour"

Presentation

= Array of chemical sensors with overlapping sensitivities

+

Pattern recognition techniques

→ Able to detect and recognise single or complex gaseous mixture (for instance odour one)

Device includes three major parts:

- *Sample delivery system* (pump, mass flow meter, filter, "pre-concentration",

- *Detection system*: reactive part of the device sensor array

  different kind of chemical sensors (often metal oxide sensors): each are sensitive to volatile compunds but with their own selectivity

  Hr and T sensors

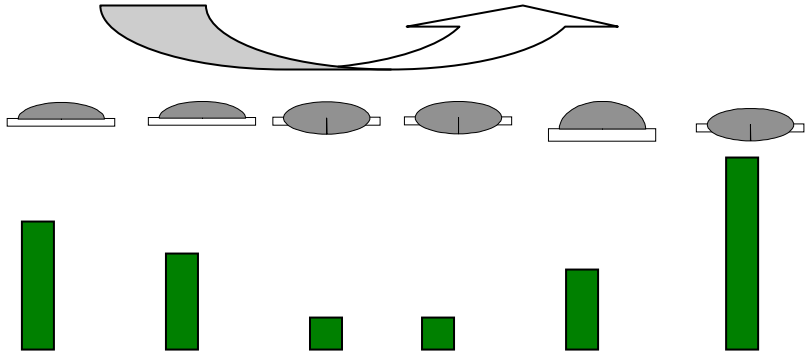
- *Computing part*: data treatment, control system

2 – E-nose: environmental application "odour"

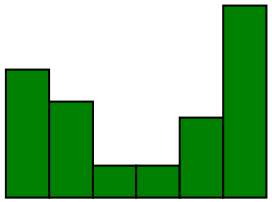
Principle

Odour (j)

Sensors (i)



ΔK_{ij}



Pattern

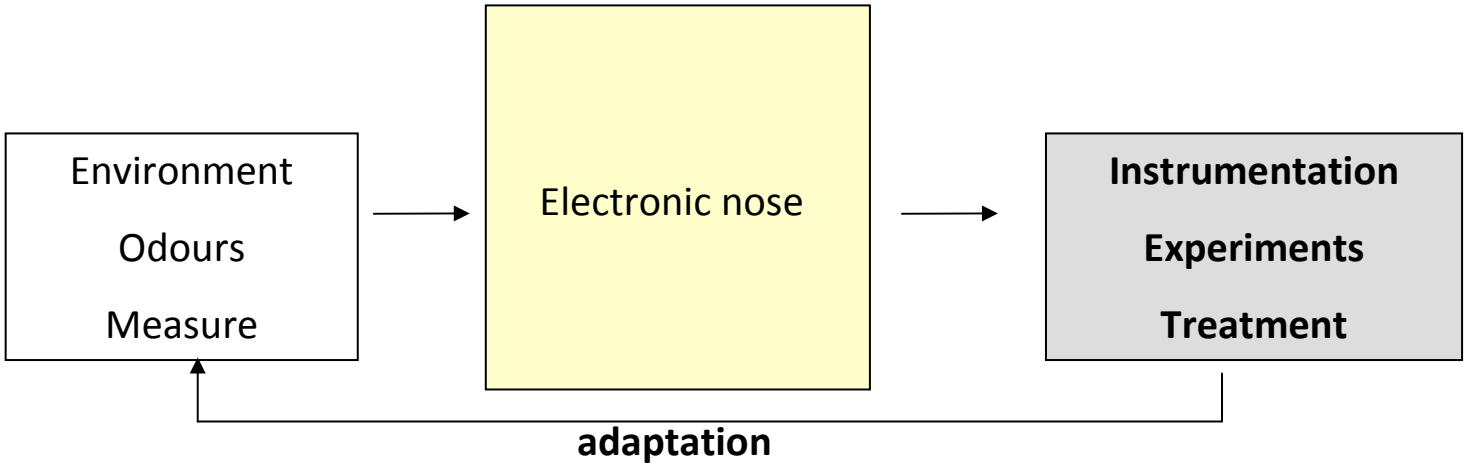
Compost?

Pattern Recognition techniques (PARC)

3 – e-nose to predict annoyance

Our « philosophy»

Development of the “e-nose” instrument considering the application

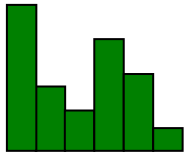


2 – E-nose: environmental application "odour"

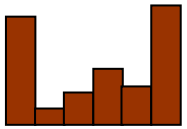
<u>To identify a mixture</u>: LEARNING phase of the various patterns (database development)

the input signals are put in relationship with the odour sources, and the membership in a specific group is known

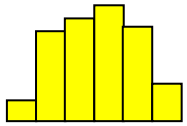
<u>Field sampling→lab measurement</u>



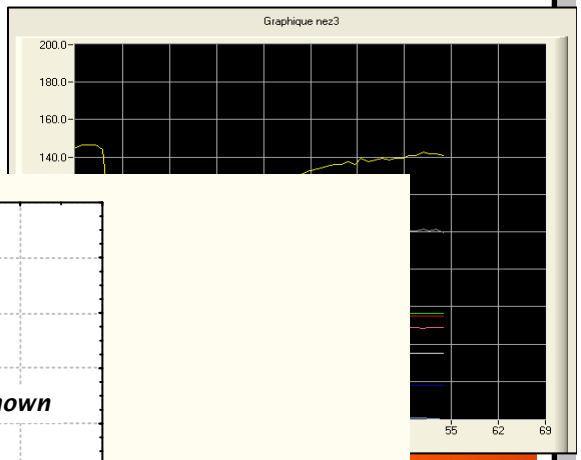
=compost

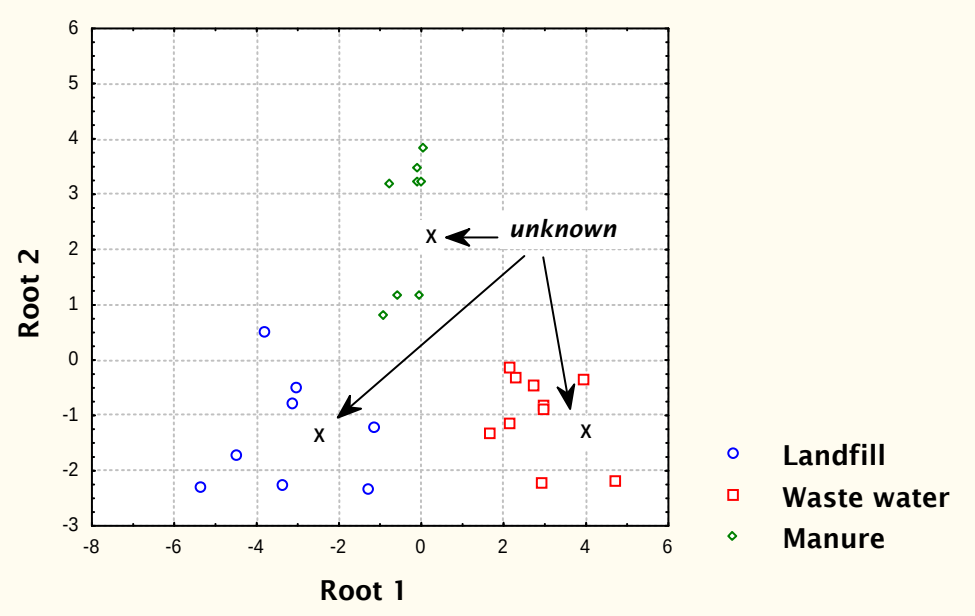


=fresh organic waste



=biogas

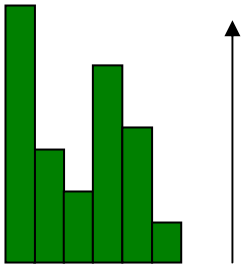




<u>Or Field measurement</u>

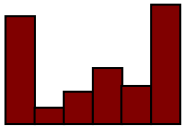
2 – E-nose: environmental application "odour"

To quantify the odour (like a calibration)



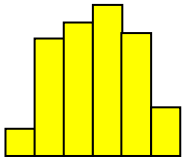
=compost

500000 uo/m3



=fresh organic waste

3000 uo/m3

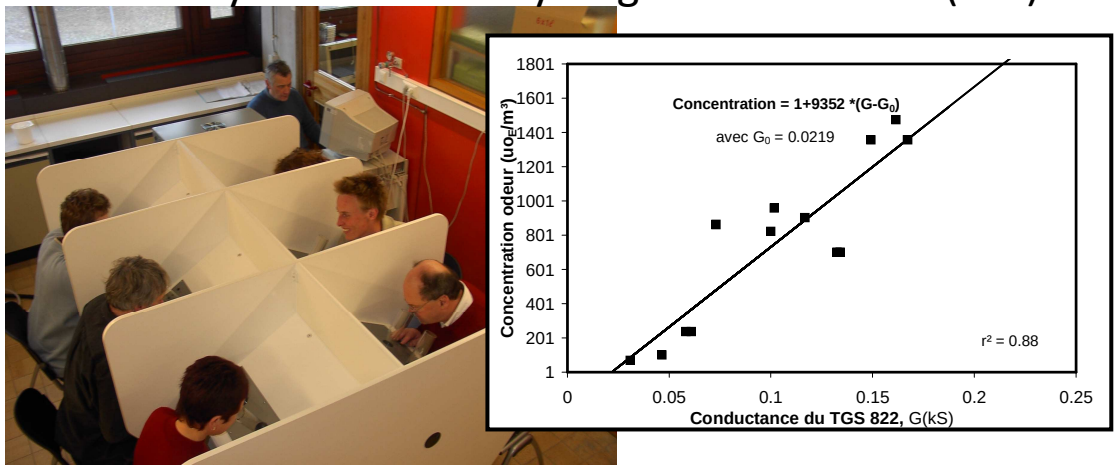


=biogas

10000 uo/m3

Field sampling-lab measurement:

olfactometry + sensors array: regression models (PLS)



Or

Field measurement:

sniffing team + dispersion models:

correlation with field e-nose

2 – E-nose: environmental application "odour"

Some data treatment tools

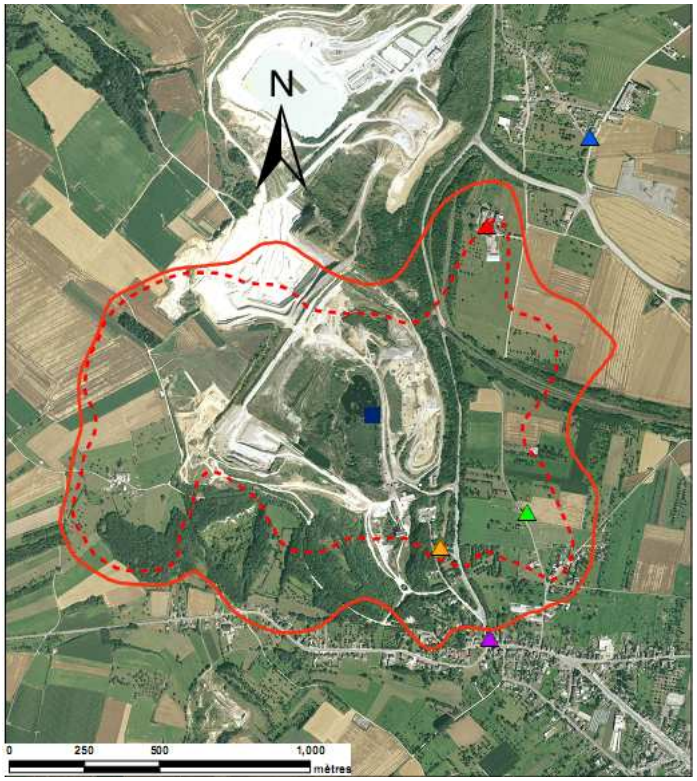
- Multivariate techniques (PARC)
  - Supervised or not
  - Linear : PCA LDA MLR PLS (rarely no linear techniques-ANN-)
  - Simple Bayes classifiers (Mahalanobis LDA)

- Univariate techniques
  - Linear regression
  - Simple algorithms (multiplicative or additive)
  - Statistic (i.e. : threshold evaluation)

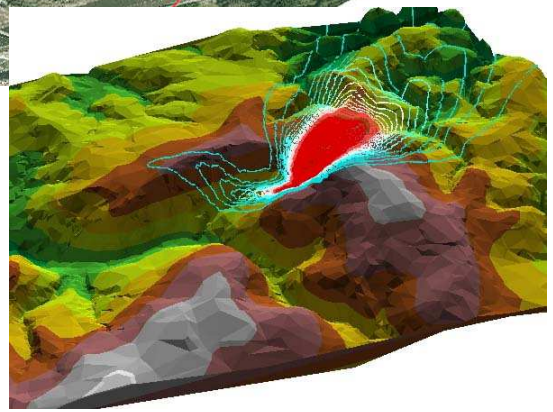
2 – E-nose: environmental application “odour”

Some data treatment tools

Modelling 2D



Modelling 3D



Percentiles: C98(1 hour): 1 ou/m3 delimitates an ellipse

outside: below1 uo during **more than 98%** of the time

inside: below1 uo during **less than 98%** of the time

2 – E-nose: environmental application "odour"

E-nose in comparison to usual approaches

	÷ **sensorial approaches**	÷ **chemical techniques**
+	«Objectivity » No need of human presence Continuous measurement (night) : -Variation detection -Recording and archiving -Real time, …	Global measurement Chemical composition ≠ Odour Continuous measurement
-	- response to chemical composition (odorant and non odorant compounds) - correlation with sensorial techniques - external variables influence -detection limit of metal oxide sensors in the field around 200 uo/m³(higher than human detection)	- no specific to compounds -Weaker accuracy - no chemical analyses -

3 – E-nose to predict annoyance

Challenge

Our research team considers:

- **FIDOR (integrating index)**
  - **F**requency: + F is elevated, more it is painful
  - **I**ntensity≈ odour concentration
  - **D**uration: continuous period of odour perception
  - **O**ffensiveness≈ odour description (compost, biogas,…)
  - **R**eceptor: location (wind direction, residential or industrial …)

- **odour perception in the neighbouring**
  - **dispersion models** (weather conditions and topographic elements)
  - **validation by sniffing team and/or local resident survey**

3 – E-nose to predict annoyance

Our last instrument: FIDOR*

Algorithms developed to estimate olfactive annoyance by odour measurement

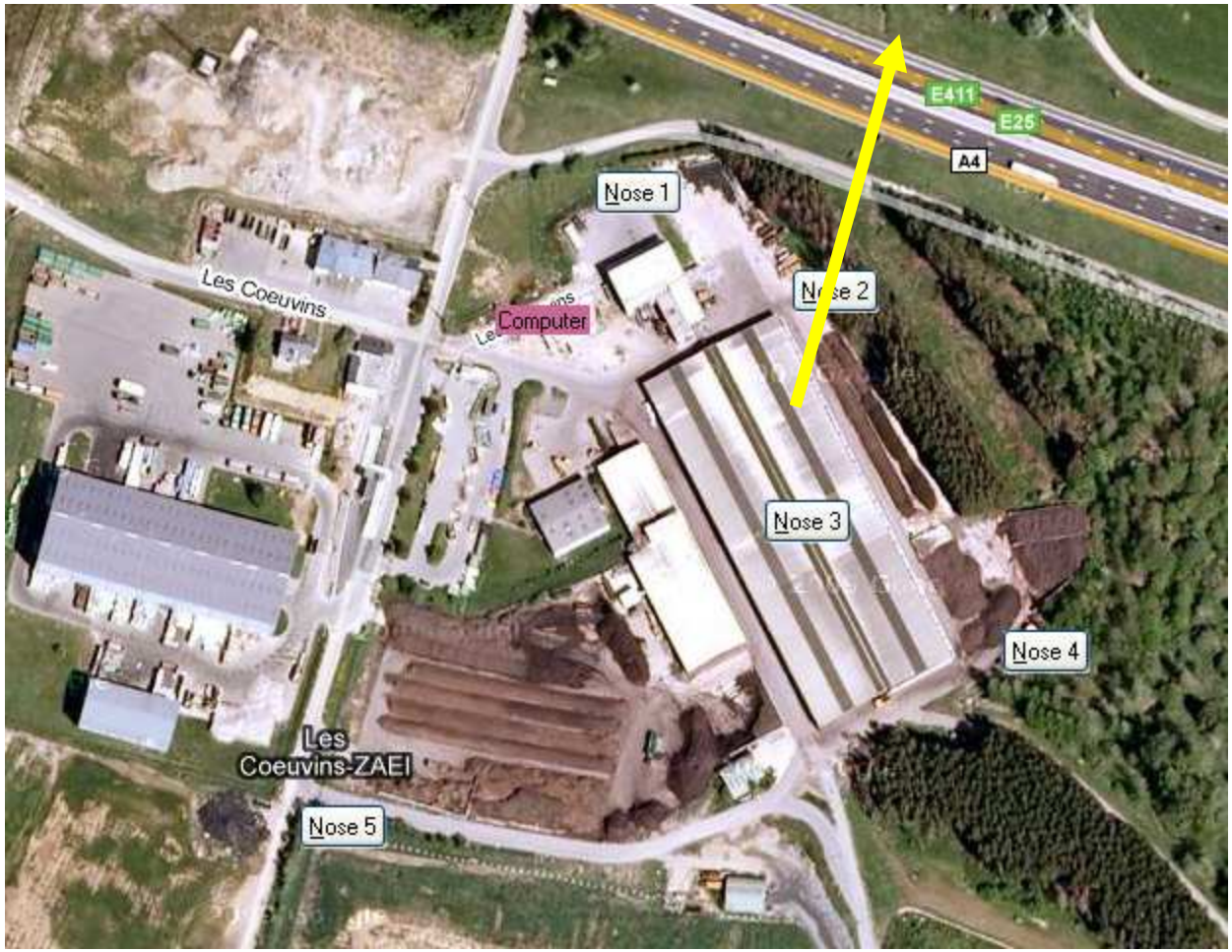
Estimation of FIDOR index: **F**requency
Intensity
Duration
Offensiveness
Receptor

*A-C Romain these
License to Odometric

3 – E-nose to predict annoyance

In use, on a landfill site since spring 2009

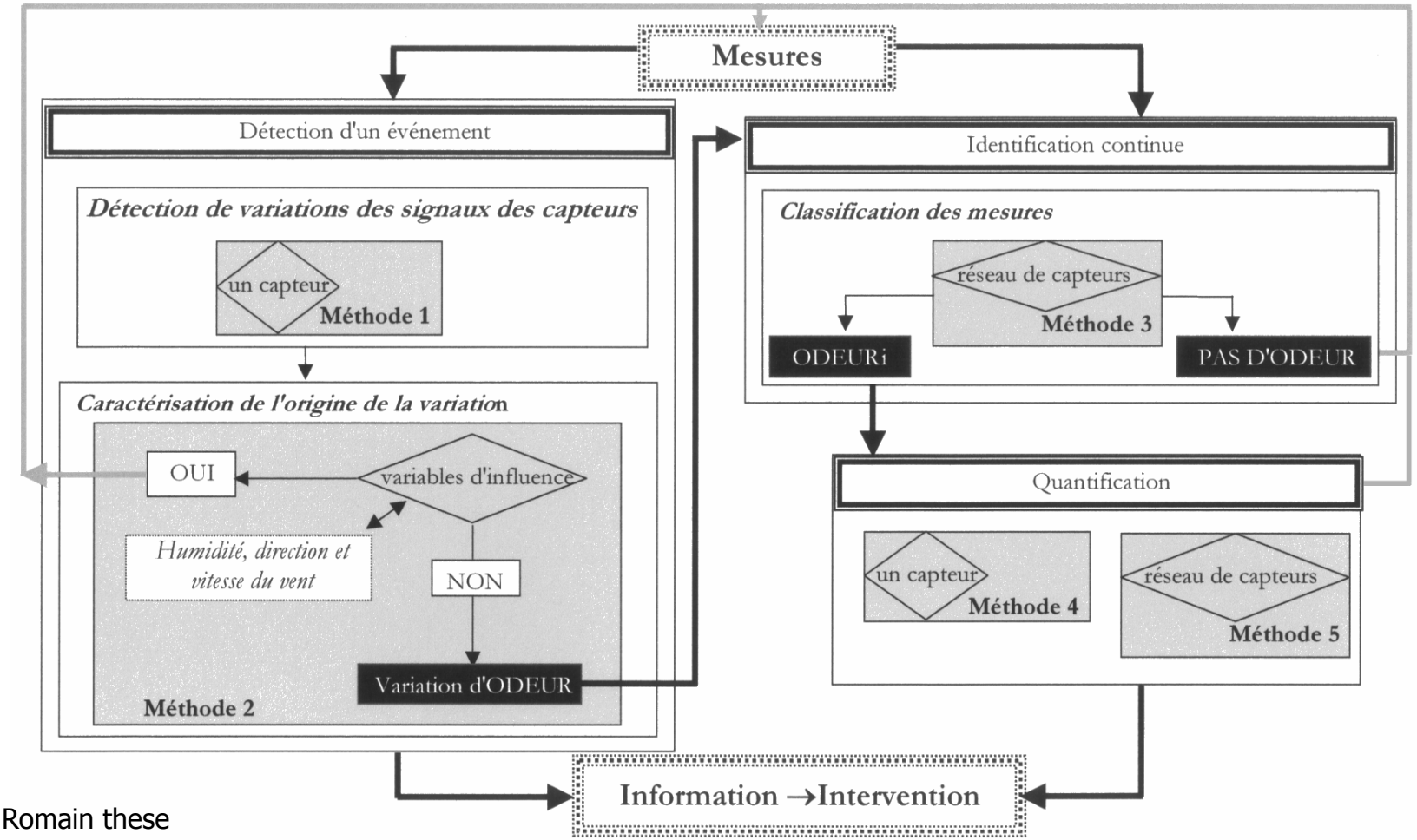
Network of 5 e-noses on the site



3 – E-nose to predict annoyance

3 – E-nose to predict annoyance

Algorithm FIDOR*:

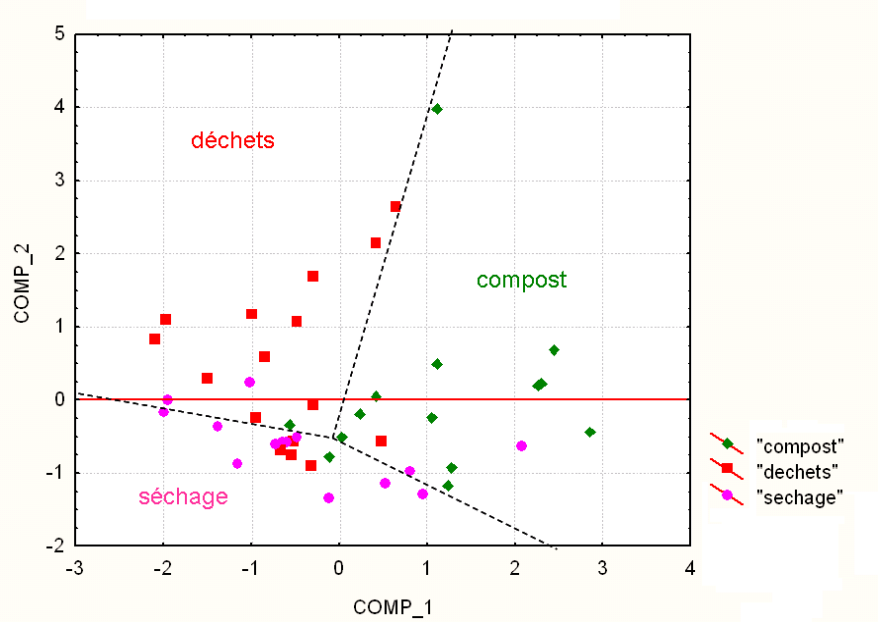


*A-C Romain these

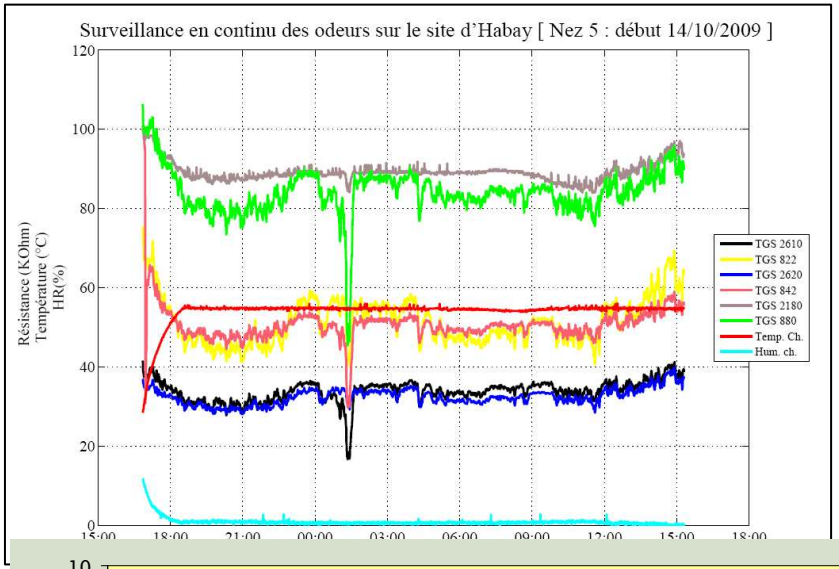
License to Odometric

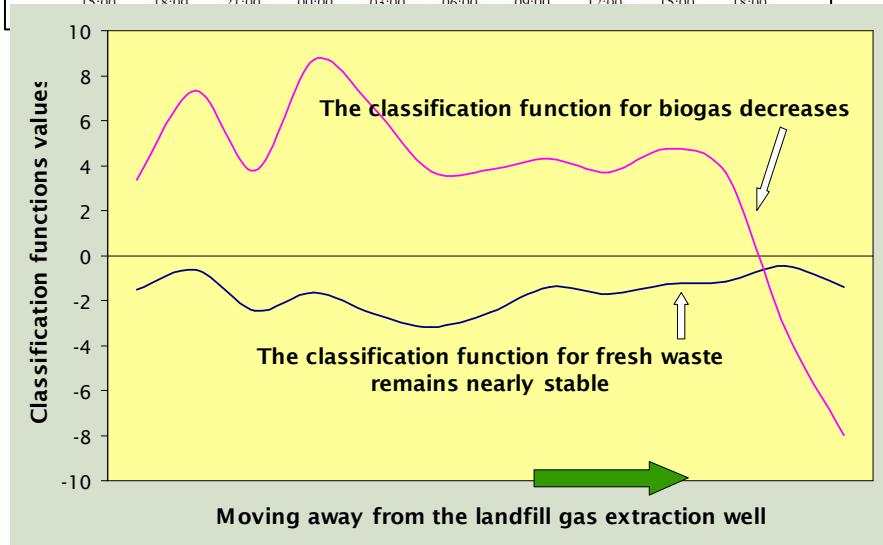
3 – E-nose to predict annoyance

FIDOR



Continuous monitoring

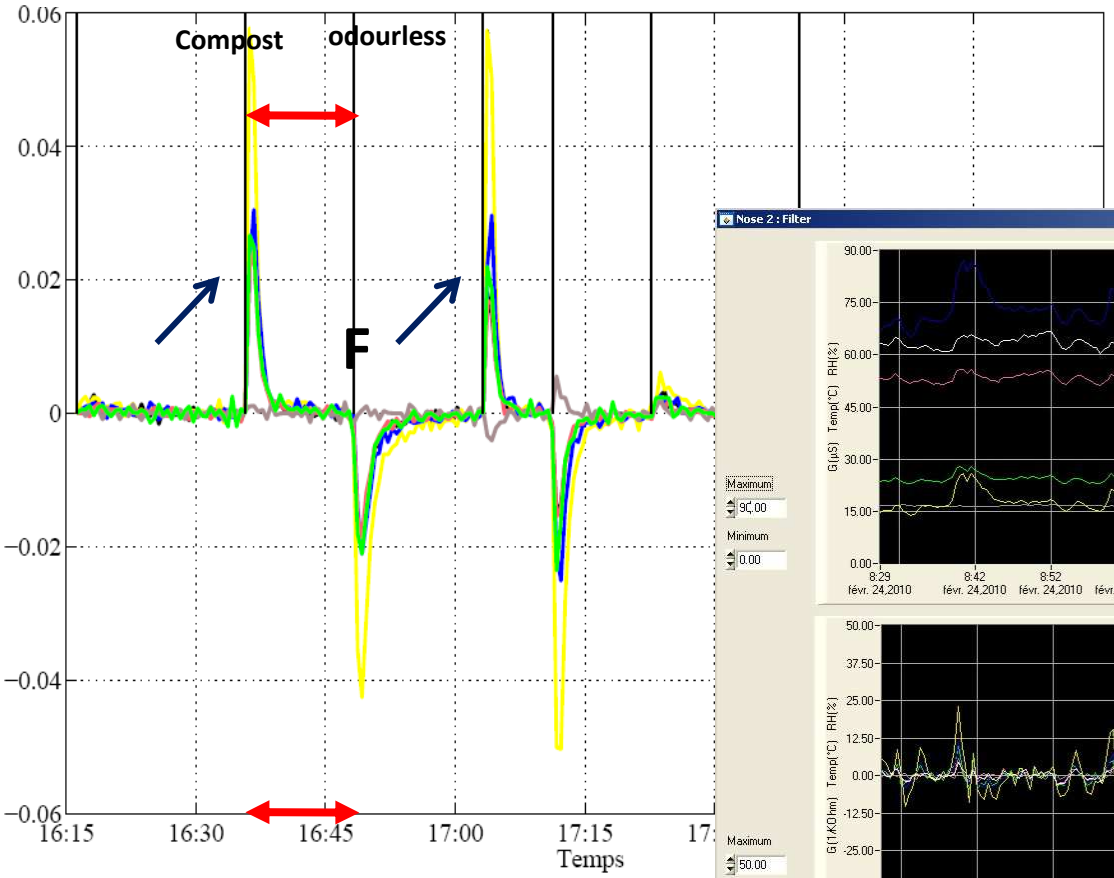


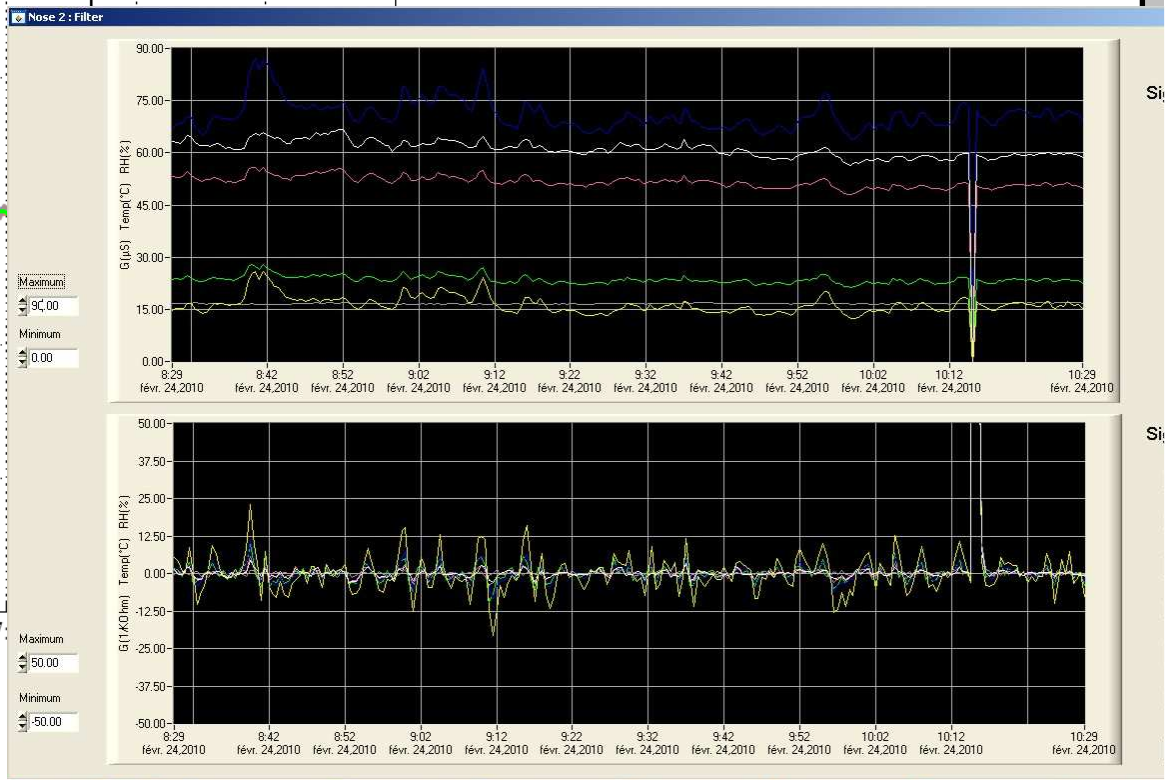


3 – E-nose to predict annoyance

FIDOR

Odour monitoring (30/06/2009) Nose 1





3 – E-nose to predict annoyance

General analysis

Temperature (°C) 3.2

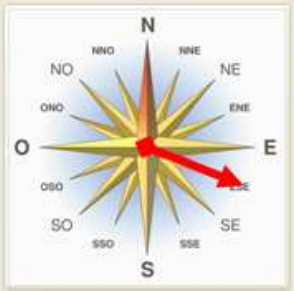
Wind Speed (m/s) 2.4

R. Hum. (%) 86

Wind Direction ESE

Barometer (hPa) 1013

Distance (m) and direction of the odor'smelling. 333

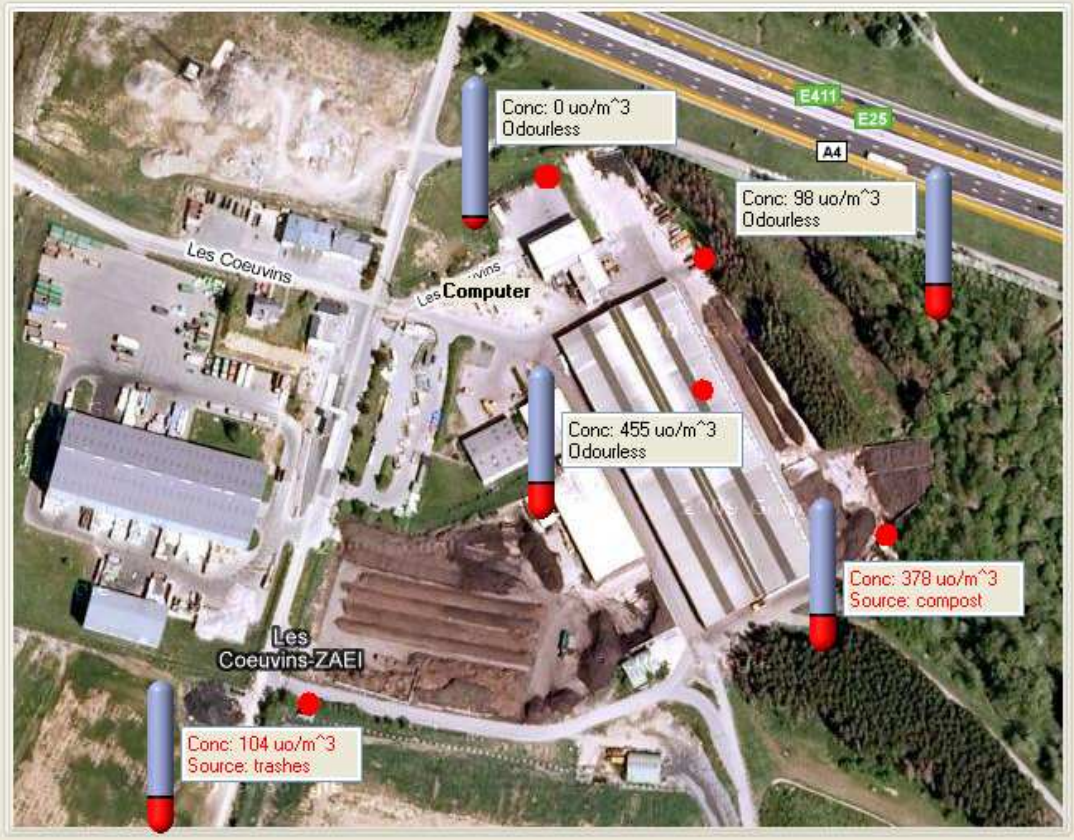


Mean wind Speed (m/s) 2.0

Absolute Humidity (g/m³) 4.1

Solar radiation (W/m²) 631

Unstable



02-11-2010 11:00 : Nose 2 : Signal decreasing.
02-11-2010 11:00 : Nose 3 : Signal decreasing.
02-11-2010 11:00 : Nose 5 : Signal increasing.
02-11-2010 11:01 : Nose 1 : Signal decreasing.
02-11-2010 11:01 : Nose 4 : Signal increasing.
02-11-2010 11:01 : Nose 5 : Signal decreasing.
02-11-2010 11:01 : Nose 4 : Signal decreasing.
02-11-2010 11:02 : Nose 1 : Signal increasing.
02-11-2010 11:02 : Nose 2 : Signal increasing.
02-11-2010 11:02 : Nose 3 : Signal increasing.

Number of events the last six hours	Nose 1	Nose 2	Nose 3	Nose 4	Nose 5
	0	0	0	0	0

3 – E-nose to predict annoyance

F I D O R

To predict in real time odour exposition and annoyance, R is fundamental

relationship between:

- **measurement of odour on the site, by an array of e-noses**
- **exposition**

→ distance of perception thanks to dispersion models (***input data=odour rate,*** **ou/s??**)

At present,

search the best models between e-noses signals and odour concentration in the neighbourhood

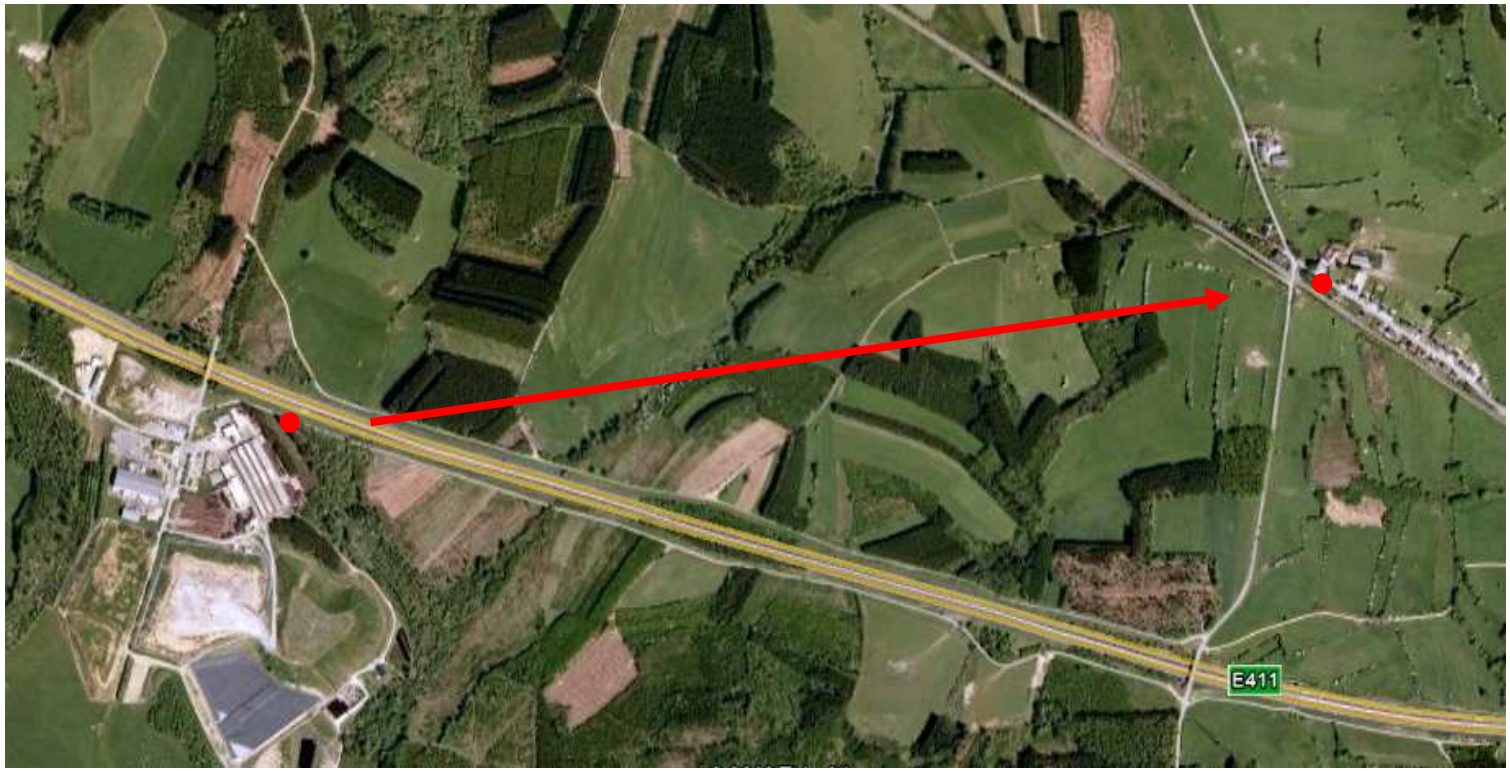
1. Local resident survey
2. A nose at the periphery of the site + a portable nose
3. Sniffing team

Optimisation of quantification and identification models

Validation step

3 – E-nose to predict annoyance

FIDOR



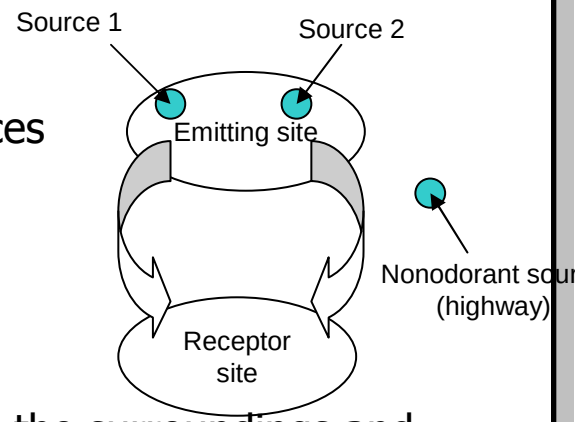
4 – Conclusions

E-nose to predict annoyance: Under development

- Improvement of the FIDOR located in the receptor site (first results under interpretation-with wind direction, other pollution sources**):** "Odometric"

- Understanding the relationships chemical composition-odour to improve e-nose models development

- These in progress to study the ability to discriminate two sources



- Local resident survey: "Odometric"

- Improvement of learning phase (ie. odour samples collected in the surroundings and not on the sources)

- **…**

4 – Conclusions

Applications

- Controlling a processing system or sampling
- odour-causing process control
- Information: authorities, resident, industrial
  real time+archiving
- real time estimation of immission in the vicinity
- check of efficacy of new processes
- assist in correct application of reglementation:
  ie « objectivity » of the complaints, monitoring of fluctuating emissions

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