Next Generation of Air Monitor used for

Odorant Dispersion and Emissions Monitoring System (ODEMS)

Rony Akiki, Brice Hellio - Environnement SA / Cairpol
Youssef Stitou, Patrice Bonnet - ISEO
Didier Buty - Aria Technologies
Stéphane Cariou, Jean-Louis Fanlo - Ecole des Mines d'Ales
Didier Samani - Alliance Environnement
Pierre Michaud – Avensys Solutions

Presentation

- Context
- Need for monitoring
- Current monitoring techniques
- ODEMS Project
  - ODEMS Tool configuration
  - Wireless Sensor Network Deployment
  - Dispersion Model
  - Predictive Tool
- About CairPol Sensors
- Applications
- Conclusion

Context

- Legislation is becoming more and more restrictive

  According to French Environment law L220-2:
  "Constitutes Atmospheric pollution, what is introduced by Man, directly or indirectly where the presence of, in the atmosphere and enclosed spaces, chemical, biological or physical agents which may have a harmful impact on human health and cause olfactory nuisance"

- Up to 20 % of the population is annoyed by diffused environmental odors.

  - Bokowa A.H. and Bokowa A.H., Review of odour legislation, *Chem. Eng.. Transac.* **2010**, *23*, 31-36

Context

- Reduced Sulphur compounds (RSC) are the primary irritants, especially hydrogen sulphide (H_2S) and methanethiol (CH_3SH) because of their high olfactory impact at very low concentrations (a few ppbv) :

Compound	Lowest human olfactory threshold	Smell
H_2S	18 ppbv	Rotten egg
CH_3SH	1 ppbv	Cabbage, garlic
NH_3	5-6 ppmv	Pungent, irritant

- Ammonia (NH_3) is also a compound of concern

- Increasing demand for affordable tools able to monitor these species at very low concentration, ppbv-levels, and their impact around industrial sites.

Source : Devos M., Patte F., Rouault J., Laffort P., Van Gemert L.J., Standardized human olfatory thresholds . IRL Press, Oxford, 1990.

Currently available techniques

Apparatus	Advantages	Inconvenient	Average cost
Lab apparatus (GCs and others)	High sensitivity High accuracy level Highly selective	Not transportable Analysis Time	> $25k
Field analyzers	Sensitivity Good Selectivity Compact (easily transportable) Direct analysis	Temperature Controlled Expensive Frequent calibration needed Low density network	> $15k
Electronic noses	Odor footprint identification	Expensive Poor selectivity Regular calibration needed Low density network	> $25k
Passive samplers	Low cost Selectivity High density network	Integrative indications (> 24h) Diffusive sampling Poor representative measurements	$50 + lab analysis
Cairsens (miniature gas sensors)	Cost effective Good selectivity Continuous monitoring (1 min) Dynamic sampling (more representative) No-calibration (for 1 year) High density network	Selective by category - Reduced Sulphur compounds - Oxidant (O_3 + NO_2 ...) - Reducing gases Limited accuracy	$800-$1000

ODEMS: Odor Dispersion and Emissions Monitoring System

Objective :

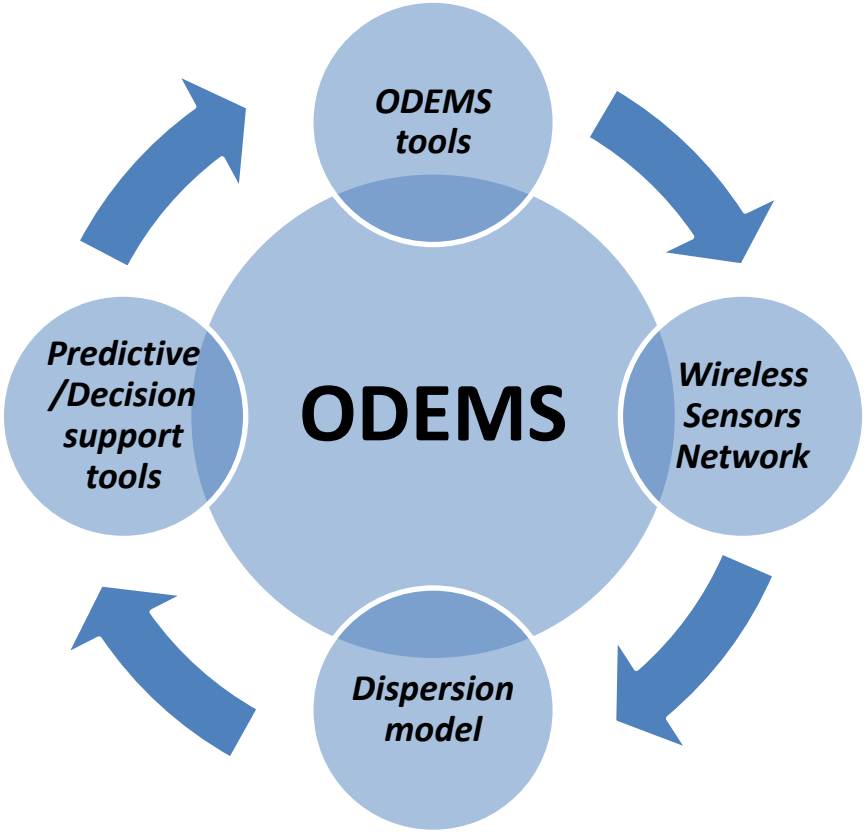
"Measure and predict the odorous emissions of a composting plant activity"

Project phases:

1. Laboratory and field test of the sensors
2. Comparison with dispersion model results
3. On-site test of the complete system

ODEMS : Overview

Number of sensors and positioning optimization tool



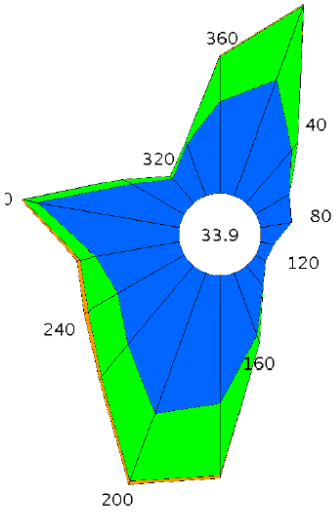
Impact prediction of tasks/activities

Network of H2S and NH3 sensors, with visualization interface

Dispersion calculation (impact on the neighborhood)

Step 1 : ODEMS Tools

- Identification of emissions sources, exclusion areas, neighborhood location.
- Import of a wind rose for this particular site.

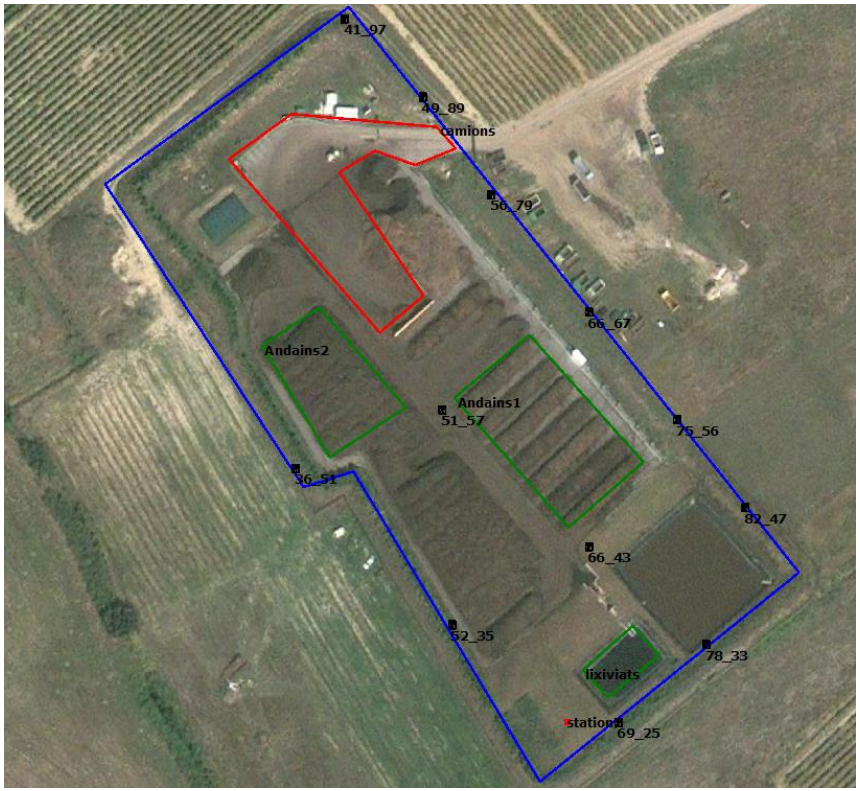


Dir.	[5.0;16.0 [	[16.0; 29.0]	> 29.0 km/h	Total
20	4.7	3.0	+	7.7
40	2.7	0.4	0.0	3.0
60	1.5	+	0.0	1.5
80	1.2	+	0.0	1.2
100	0.5	0.0	0.0	0.5
120	0.4	0.0	0.0	0.4
140	1.0	+	0.0	1.0
160	2.5	0.3	+	2.8
180	4.8	2.8	+	7.7
200	5.6	2.8	0.2	8.6
220	3.9	1.5	0.1	5.6
240	2.9	1.3	0.2	4.4
260	3.2	0.6	0.1	4.0
280	5.4	0.6	+	6.1
300	2.3	0.4	+	2.7
320	1.2	0.1	0.0	1.4
340	2.1	0.1	0.0	2.2
360	3.5	1.7	+	5.2
Total	49.5	15.7	0.9	66.1
[0;5.0 [				33.9

Step 1 : ODEMS Tools

Alternative 1:

- 19 stations (2 sensors)
- Reliability index : 100



Alternative 2:

- 12 stations (2 sensors)
- Reliability index : 78

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Step 2 : Wireless sensors network

Sensors and software implementation :

- Sensors in autonomous stations (Cairnet)
- Software in several layers :
  - ✓Cairmap/Caircloud → *ODEMS*
  - ✓+ Modeling software → *ODEMS Premium*
    - (Aria view/Swift/Spray)
  - ✓+ Predictive package → *ODEMS Platinum*

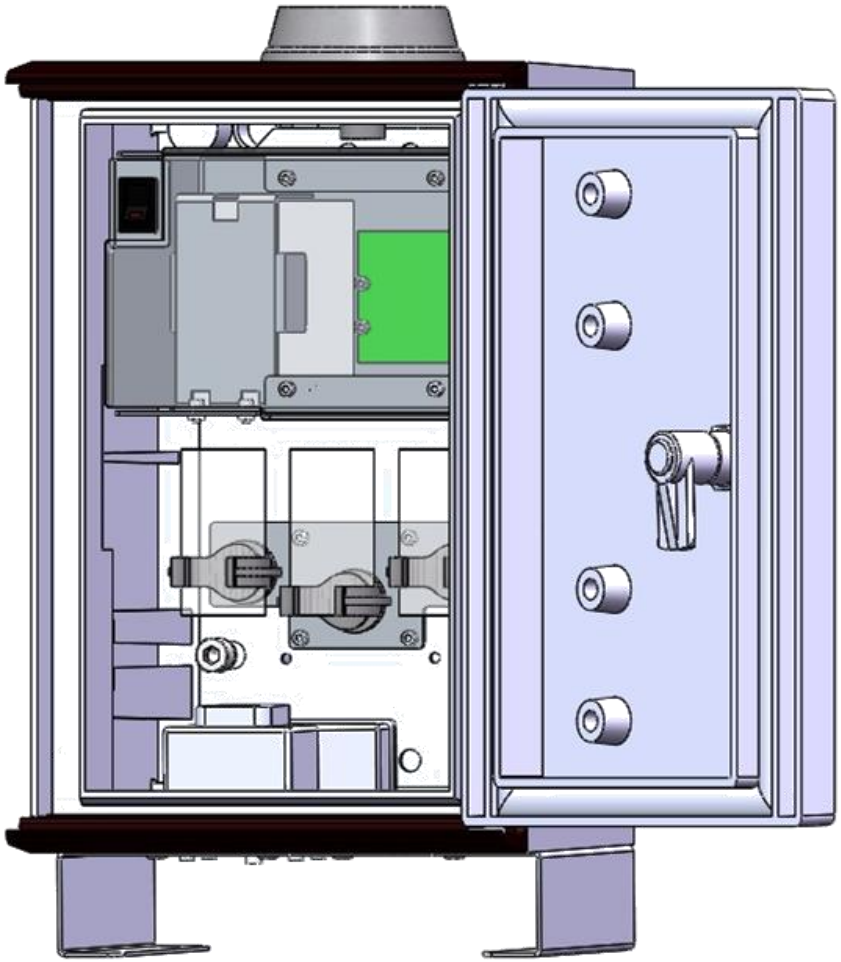
Step 2 : The CairNet System

Cairnet cabinet
- H2S
- NH3
- T° and humidity

Remote communication

Solar panel power assistance where no power is available

Additional information :
- Battery charge
- Solar panel production
- Sensors service life



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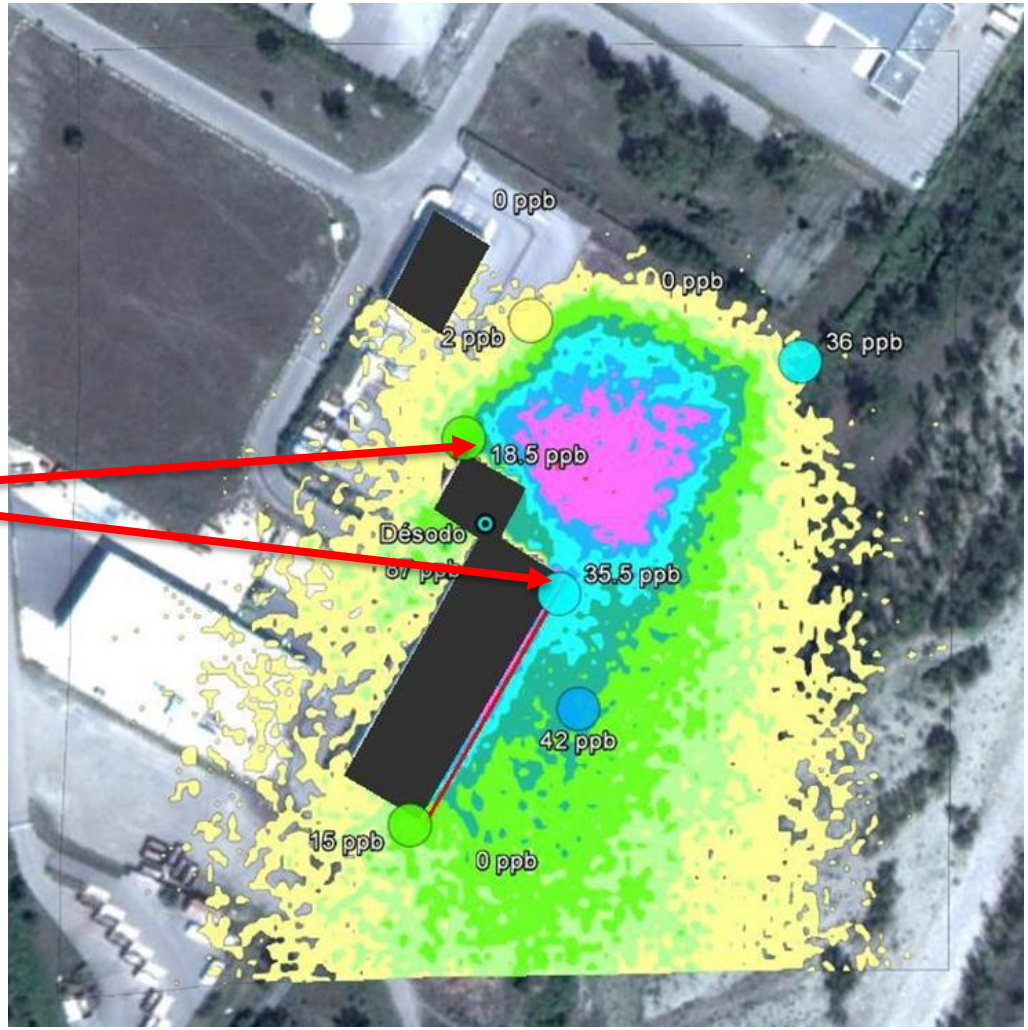
Field test : Compost plant

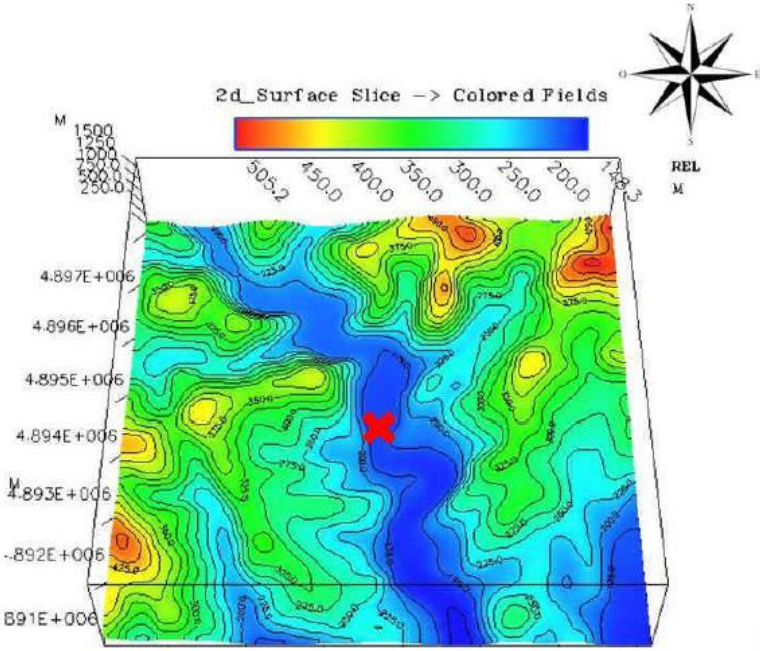
Small scale campaign results for H2S

Values measured by the sensors



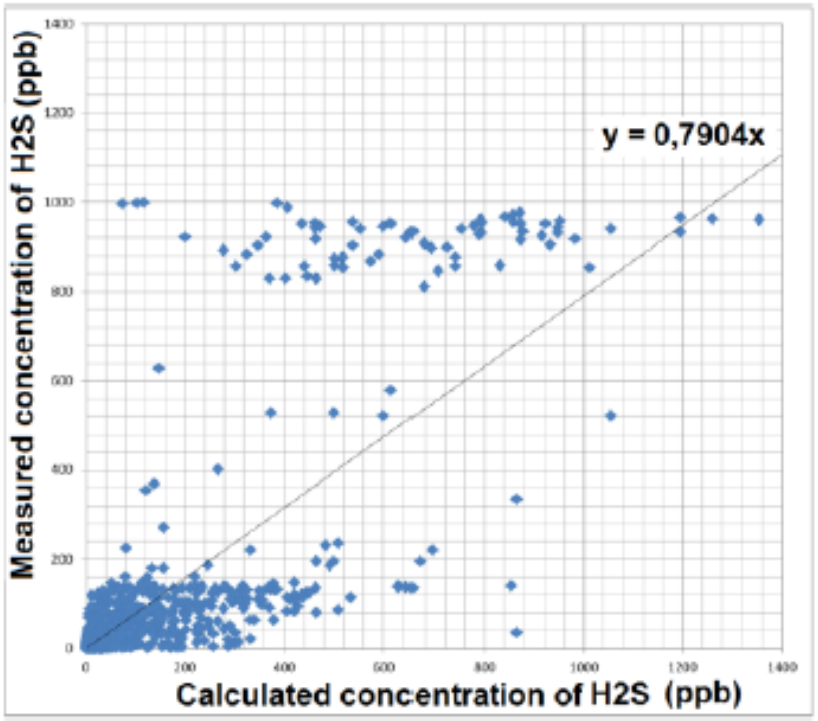
Field test : Compost plant

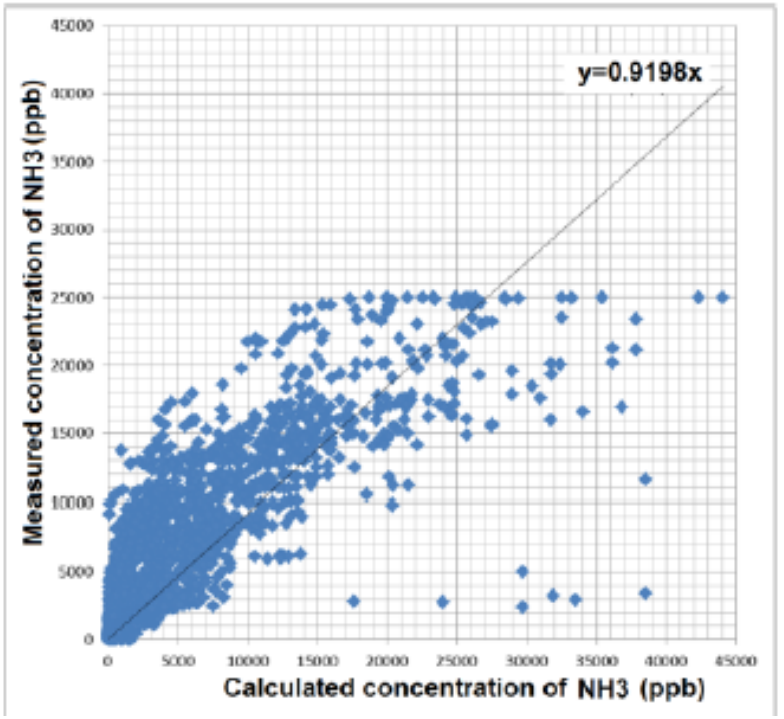
- Particular site, with specific complex topography.
  Installation of 12 sensors (Reliability index : 74%).



Field test : Compost plant

Correlations between measured data and calculated data

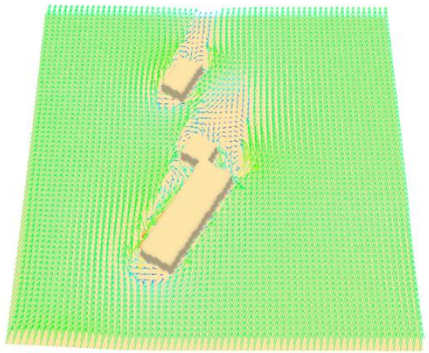


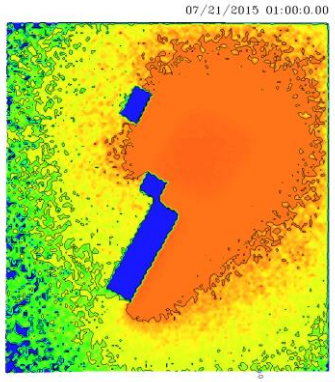


Step 3 : Dispersion model

Combination of 2 calculation modules :

- Wind field model : SWIFT
- Lagrangian particle dispersion mode, 3D : SPRAY



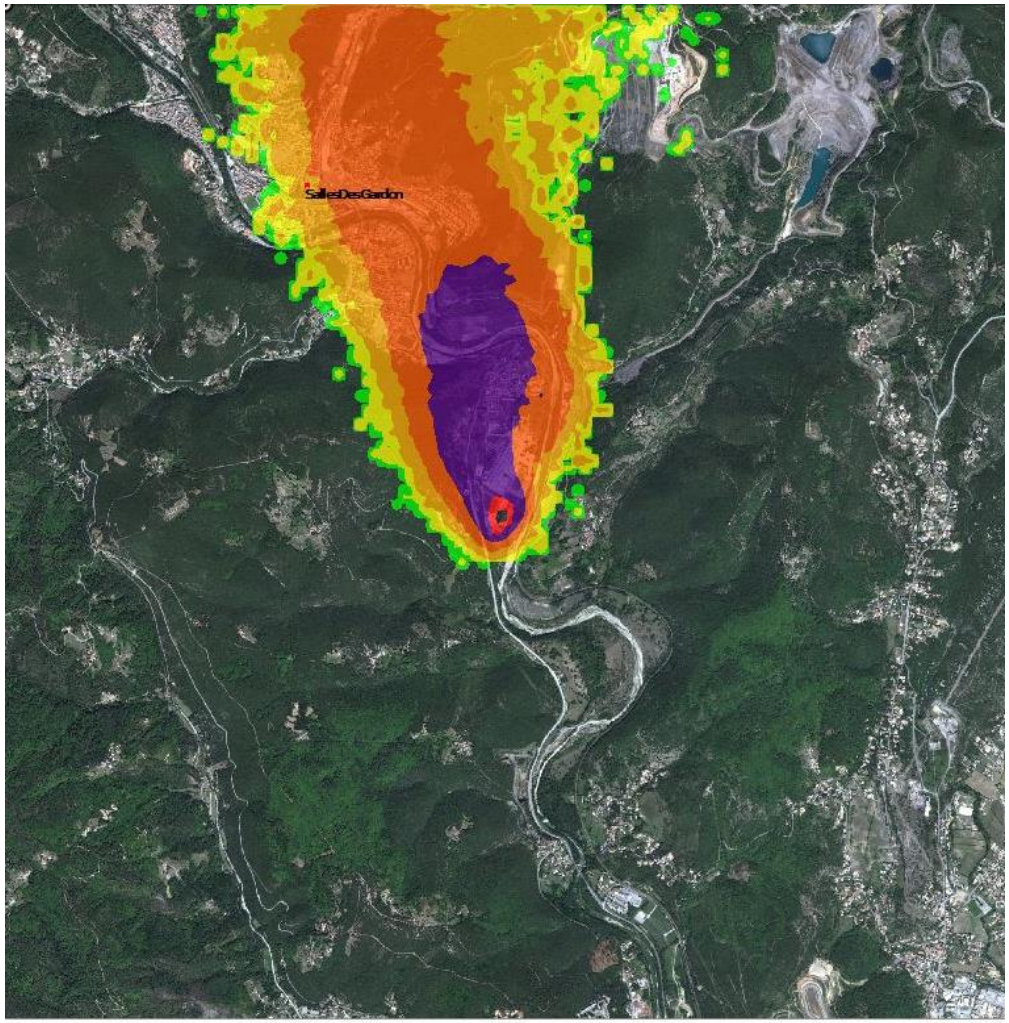


Method :

- Comparison between small scale dispersion based on nominal known emissions and data measured by sensors around the sources.
- Determination of corrective coefficient applied to nominal emissions for final calculation

Step 3 : Dispersion model

Large scale calculation result (NH3)



Step 4 : Predictive tool

Two phases are required :

- Database creation
- Prediction

Scenarios

- Scenario 1
- Scenario 2
- Scenario …

Impact

- Meteorological data
- Sensors measurements data
- Dispersion modeling

Database construction

Step 4 : Predictive tool

Scenario input

Meteorological Conditions

Database dispersion modeling

Prediction

- Odorous graphical dispersion

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Cairsens are Indicators

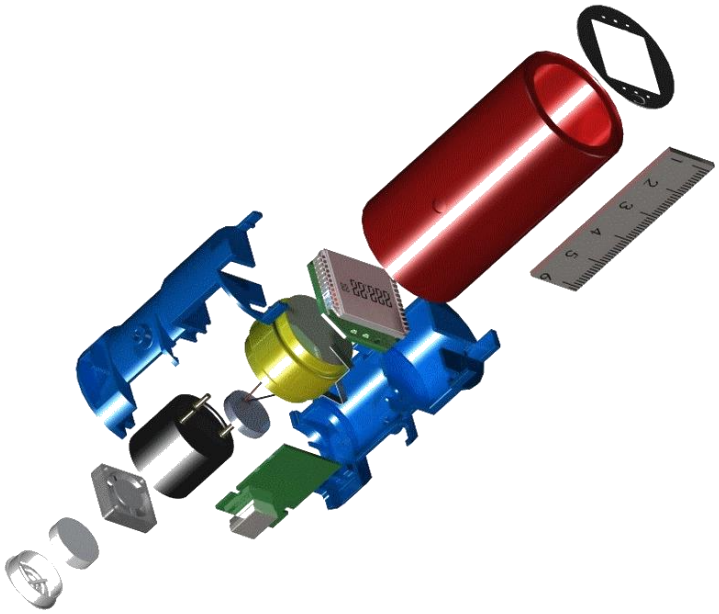
- No **certifications** exist for sensors.

- All our sensors **comply with the European directive** 2008/50/EC, which requires a minimum accuracy level for the different categories of measuring devices for gases :
  - ✓ < +/- 15% for reference devices;
  - ✓ **< +/- 30% for indicators;**
  - ✓ < +/- 75% for estimators.

- Cairpol's sensors are indicators; a **tool** to help users to collect an **indicative information** on air quality, to:
  - Monitor and control industrial sites processes
  - Citizen information purposes
  - Mapping and modelling

Cairsens Technology Overview & Key Features

- Electro-chemical sensor
- Low consumption electronic
  - High sensitivity circuit (nA)
  - Integral data logger
  - USB connection, HMI
- Dynamic air sampling
  - Micro fan with tension stabilization
- Sample conditioning : humidity buffer (patented)



No maintenance, no calibration for 1 year **Miniaturization**

Cost efficient **Accurate and reliable measurement**

Available sensors

Pollutants	Measurement Ranges
O_3/NO_2	0 – 250 ppb
NO_2	0 – 250 ppb
CO	0 – 20 ppm
SO_2	0 – 1000 ppb
H_2S/CH_4S	0 – 1000 ppb / 0 – 20 ppm / 0 – 200 ppm
NH_3	0 – 25 ppm
Formaldehyde / Organic Solvent	0 – 1000 ppb
nM VOC (PID sensor)	0 – 16 ppm
CO_2 (NDIR)	0 – 5000 ppm
PM2.5	Coming soon

Cairtub – for small scale monitoring projects

Stand-alone application :

- Protective housing with internal battery (solar or sector powered)
- Different kind of supports (tri-pod, masts)
- Up to 3 different Cairsens inside

Cost-efficient solution for field tests :

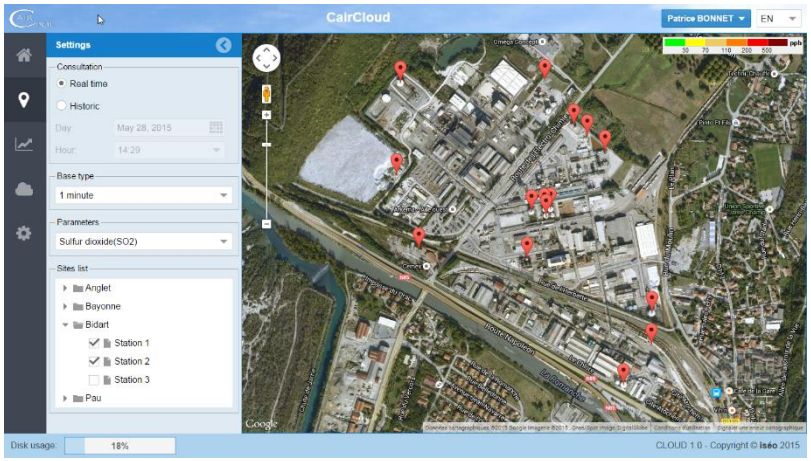
- up to 21 days of study
- **Repeatable**
- Recording of pollutants concentration **dynamically**

Manual data extraction via USB upload, and displayed through our freeware Cairsoft. Possibility to create Excel reports.

Cairnet : the smart network

Continuous, real-time monitoring application :

- Autonomous stations for 1 year : protective housing, battery, solar panel, no data logging limits, no re-calibration
- From limited to widely spread areas (Cellular or Radio communication)
- Measurement at low concentration level (ppb)



Applications examples

Smartcities

Industrial site monitoring

Indoor Air Quality

Cairpol solution

Conclusions

- Qualitative results with a very promising future for this system, for process management applications.
- Cairsens can play a very important role in supporting and increasing spatial resolution of existing systems or used in new systems
- Next steps :
  - Integration of the 4 modules into a user-friendly HMI
  - Validation of the predictive and decision support tools, this phase is ongoing

QUESTIONS ?

Contact :
Pierre Michaud
Mail : pmichaud@avensys.com
Phone : (888) 965-4700
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