Introduction to Instrumental Odour Monitoring Systems

Drone-based Odour Monitoring

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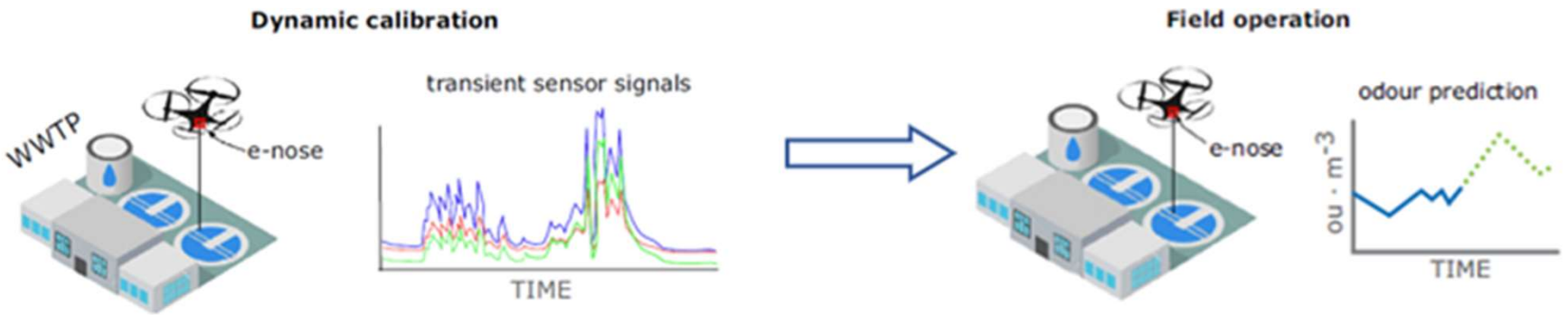
Outline

- **Instrumental Odour Monitoring Systems: Open problems**
- **Standards for IOMS**
- **Drone based environmental monitoring**

Instrumental Odour Monitoring Systems (IOMS)

- **IOMS are chemical sensing systems able to provide odour metrics in real time.**
  - Odour detection
  - Odour concentration estimation
  - Odour class / Odour source
- **IOMS definition is technology agnostic**
- **IOMS are expected to work continuosly in field conditions without human intervention.**

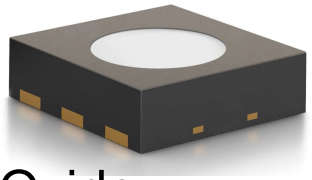
- **Often IOMS are known as Electronic Noses ('enoses')**



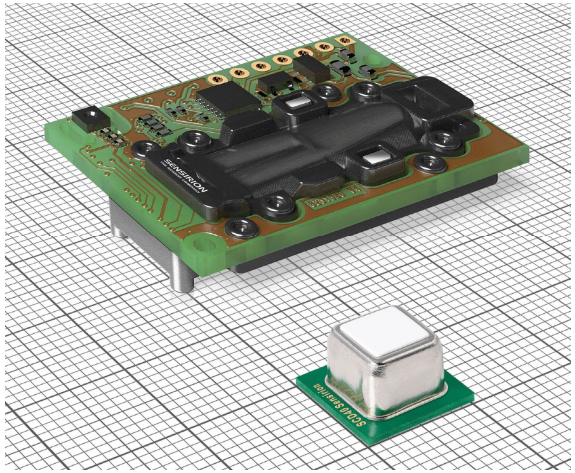
Technologies for Gas Sensing

Electrochemical

Photoionization

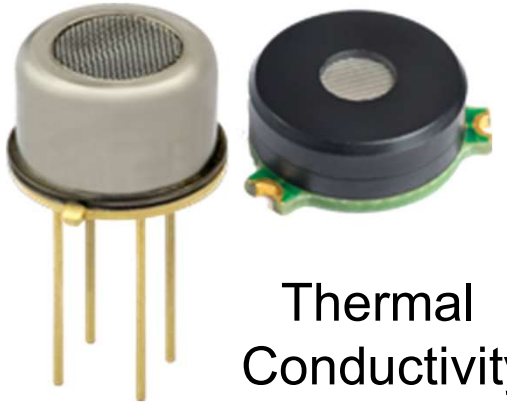


Metal Oxide



NDIR
Photoacoustics

IMS



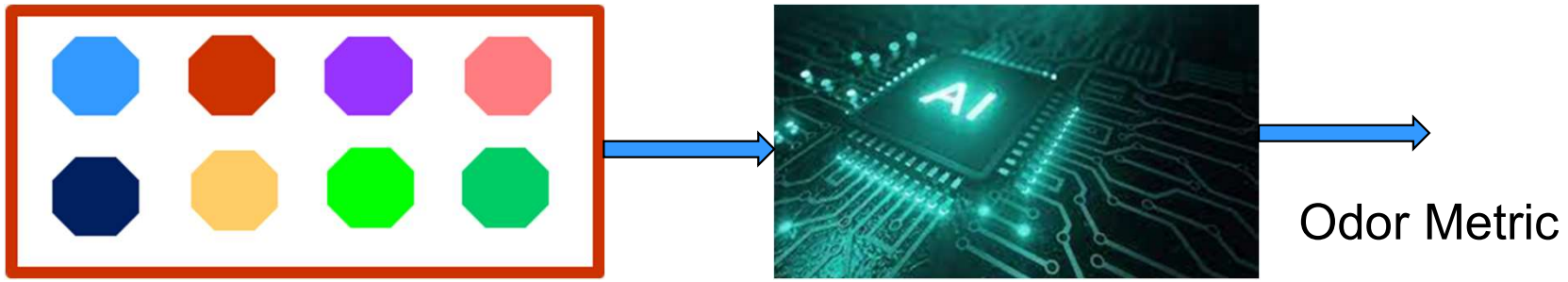
Thermal
Conductivity

Catalytic

TDLAS

Open problems in Machine Olfaction

- **Mimicking Human Perception….What is an odour?**
- **Odor (smell, scent, aroma….):**
  - *"sensation perceived by means of the olfactory organ in sniffing certain volatile substances" (CEN TC246/ WG41)*
- **Environmental odours are very complex with hundreds of compounds:**
  - The perception of odours as complex mixtures of odorants maybe modified by sinergy, and antogonist effects.
- **Sensors do not respond to odours, they respond to gas/volatile compounds**

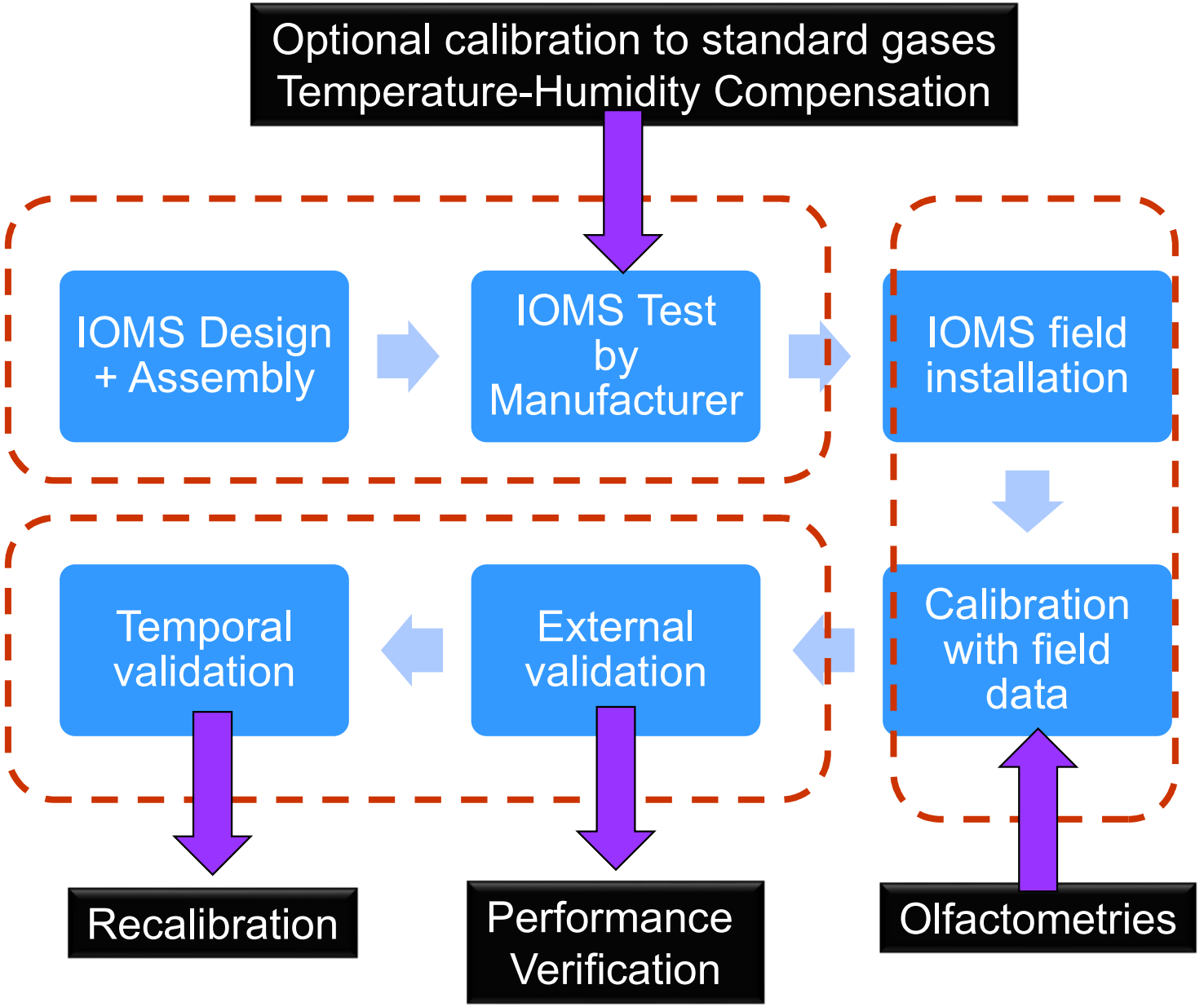


Due to the complexity of odour emissions system calibration requires a large number of calibration points

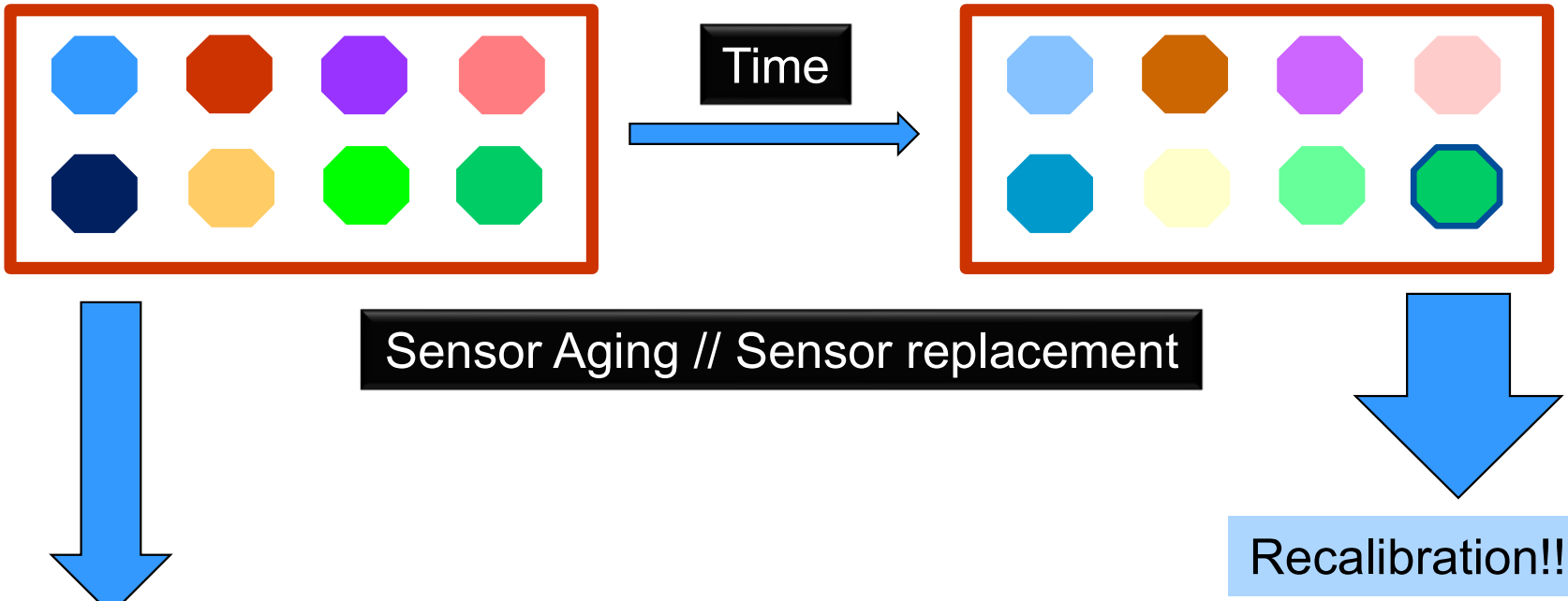
Difficulties for IOMS

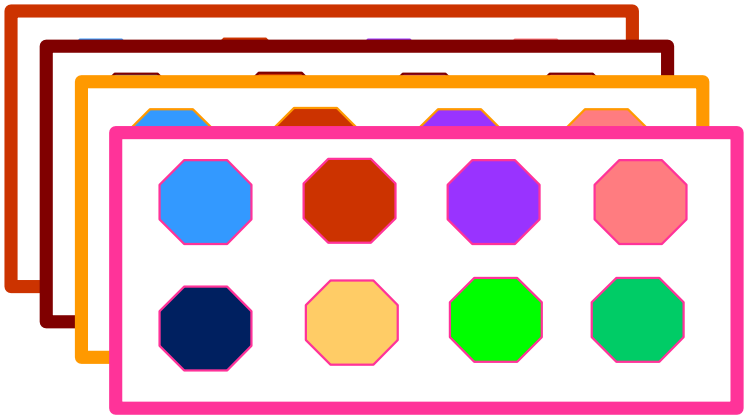
- **Complexity and variability of the odorous emissions**
- **Costly calibration process involving human panels**
- **Requirement of Individual calibration**
  - Plant specific
  - Instrument specific
- **Stability problems**
- **Lack of standard methods**

IOMS Calibration & Validation process



IOMS Deployment problems





Deployment to other similar plants even with identical units requires **re-tuning**

The severety of retuning depends on:
emision similarities
sensor tolerances.

Standards

Code	Country	Env Odours?	Principle	Highligths	Cons
NTA9055: 2012	NL	✓	Defines and Recomends	Historical value	Too vague
VDI35183: 2018	GER	✗	Minimum requirements	Complete Considers different applications Defines: Differentiation, Identification, Quantification Proposes test with standard gases	Minimum requirements fixed. Evaluation of uncertainty not defined
UNI 11761: 2019	ITA	✓	Performance verification	Defines: Detection, Identification, Quantification Proposes a method to quantify uncertainty Defines three level for testing	Not validated Comparison with EN13725 unclear
CEN TC264/WG41	Europe	✓	Performance verification?	Defines: Detection, Identification, Quantification Two level testing: Lab/Field Focuses on verification	Work on progress since 2015 Not validated
IEEE SA P2520	Global	✗	Minimum requirements?	Defines: Detection, Identification, Quantification Defines mínimum requirements for triangular tests on selected VOCs as baseline performance testing	Early stage of development Many parts, most have not started yet.

Adapted from Cipriano & Capelli, Biosensors, 2019

The SNIFFIRDRONE Project

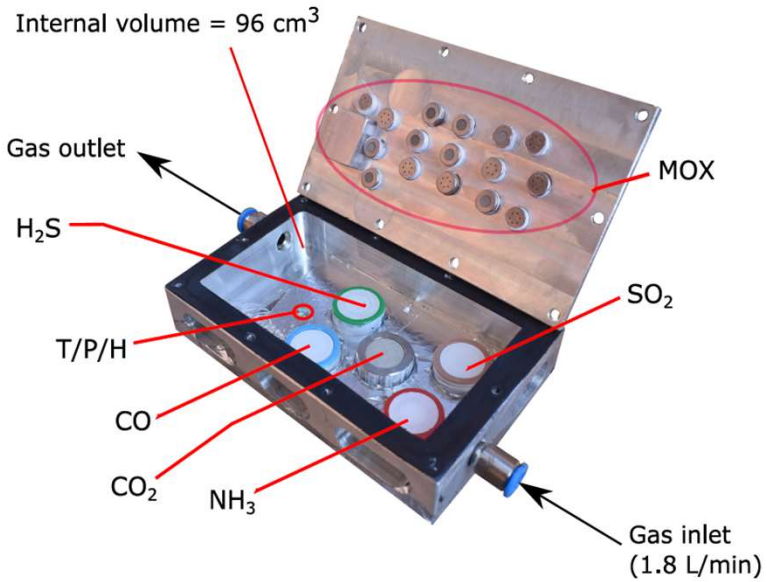
Main goals:

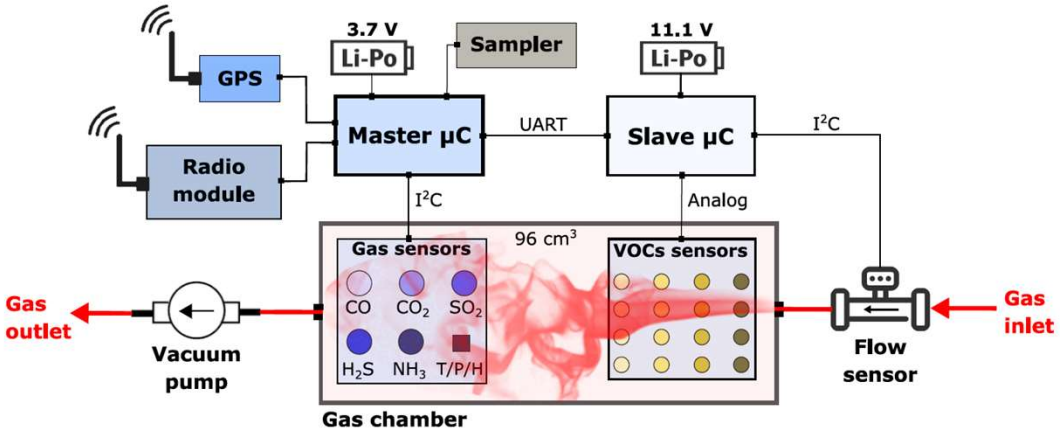
Increase TRL level of Drone based Odour Monitoring.

Explore results in other waste processing plants

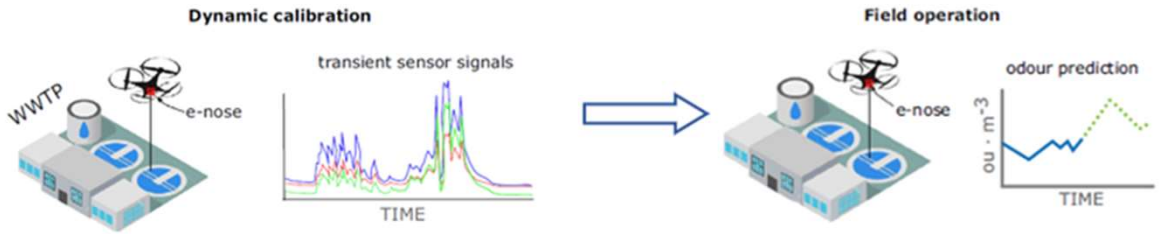
Include in the unit a Novel LED Absorption Spectroscopy unit operating in NIR and MIR.

RHINOS Electronic Nose





Sample collection in flying conditions
Simultaneous collection of bag
Ans sensor signals

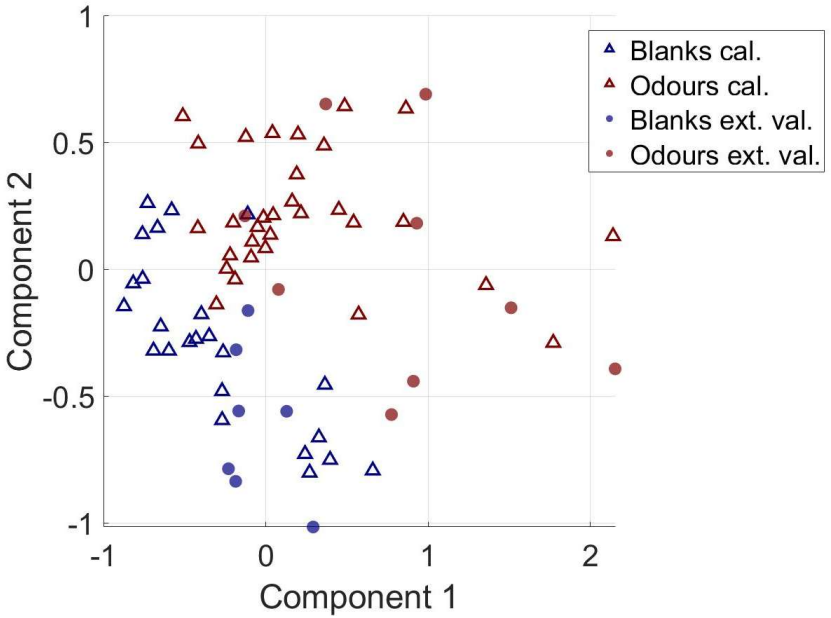


System Optimization for Odour Detection

System validation for odor detection
Odurs between 100 OuE/m3 – 10.000 OuE/m3

Array	Balanced Classification Rate	AUC
Optimized sensor configuration	97%	0.97
NH_3 (Best Single Sensor)	72%	0.83

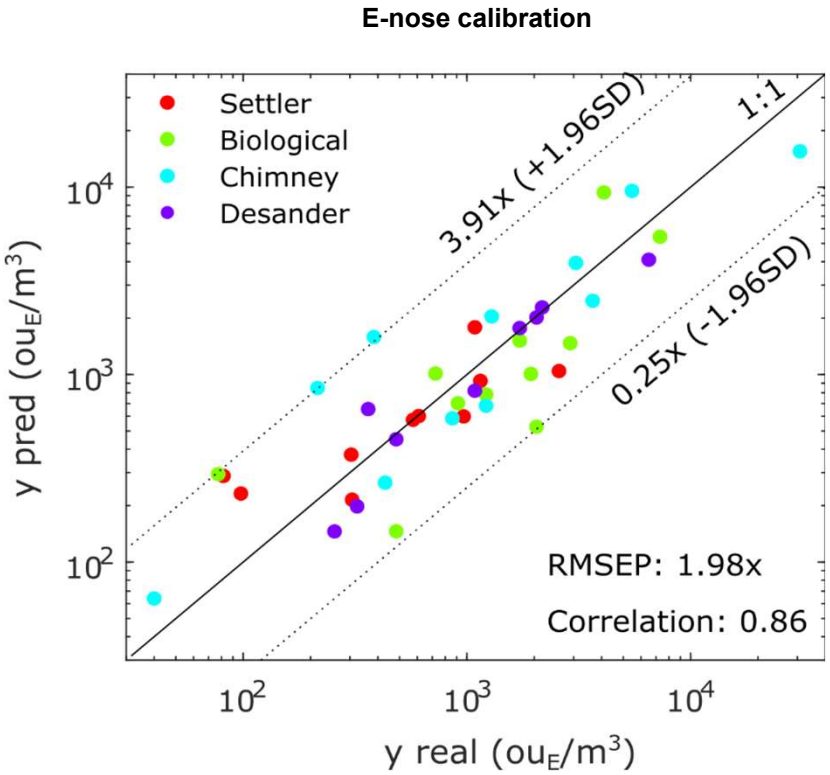
Scoreplot example



N=71 Samples, 40 odours, 31 blanks

Validation in a Waste Water Treatment Plant

- Example of application of Bland Altman:
  - Electronic Nose mounted on a drone
  - N=40 Validation samples
  - 4 days of measurement spanning a month



Bland Altman (95% CI) k=2

Upper LoA	3.91
Bias	0.99
Lower LoA	0.25

Optimal results with 2 EC + 2 MOX

Summary

- **The reference method is Dynamic Olfactometry (EN13725) but:**
  - Infrequent, Expensive, Spatially Sparse

- **IOMS need sufficient calibration points to learn the relationship between sensor responses and perception.**

- **Performance verification by standard methods may help to overcome barriers to widespread application**

- **Methodologies for system recalibration and calibration transfer require more validation**

- **IOMS on drone can be an interesting alternative to maximize mobility and obtain odour maps over the plant.**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