European Network on New Sensing Technologies for Air Pollution Control and Environmental Sustainability - *EuNetAir*

COST Action TD1105

Final Meeting at PRAGUE (CZ), 5-7 October 2016

New Sensing Technologies for Air Quality Monitoring

Action Start date: 01/07/2012 - Action End date: 15/11/2016 - EXTENSION: 15/11/2016

AIR QUALITY NETWORKS: LESSONS LEARNED, CURRENT STATUS AND FUTURE OPPORTUNITIES

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cost
EUROPEAN COOPERATION IN SCIENCE AND TECHNOLOGY

EuNetAir
European Network on New Sensing Technologies for Air-Pollution Control and Environmental Sustainability

COST is supported by the EU Framework Programme

European Science Foundation
ESF provides the COST Office through a European Commission contract

We will discuss:

Sensor performance

AQ Network requirements

Validation

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Air Quality Monitoring Networks

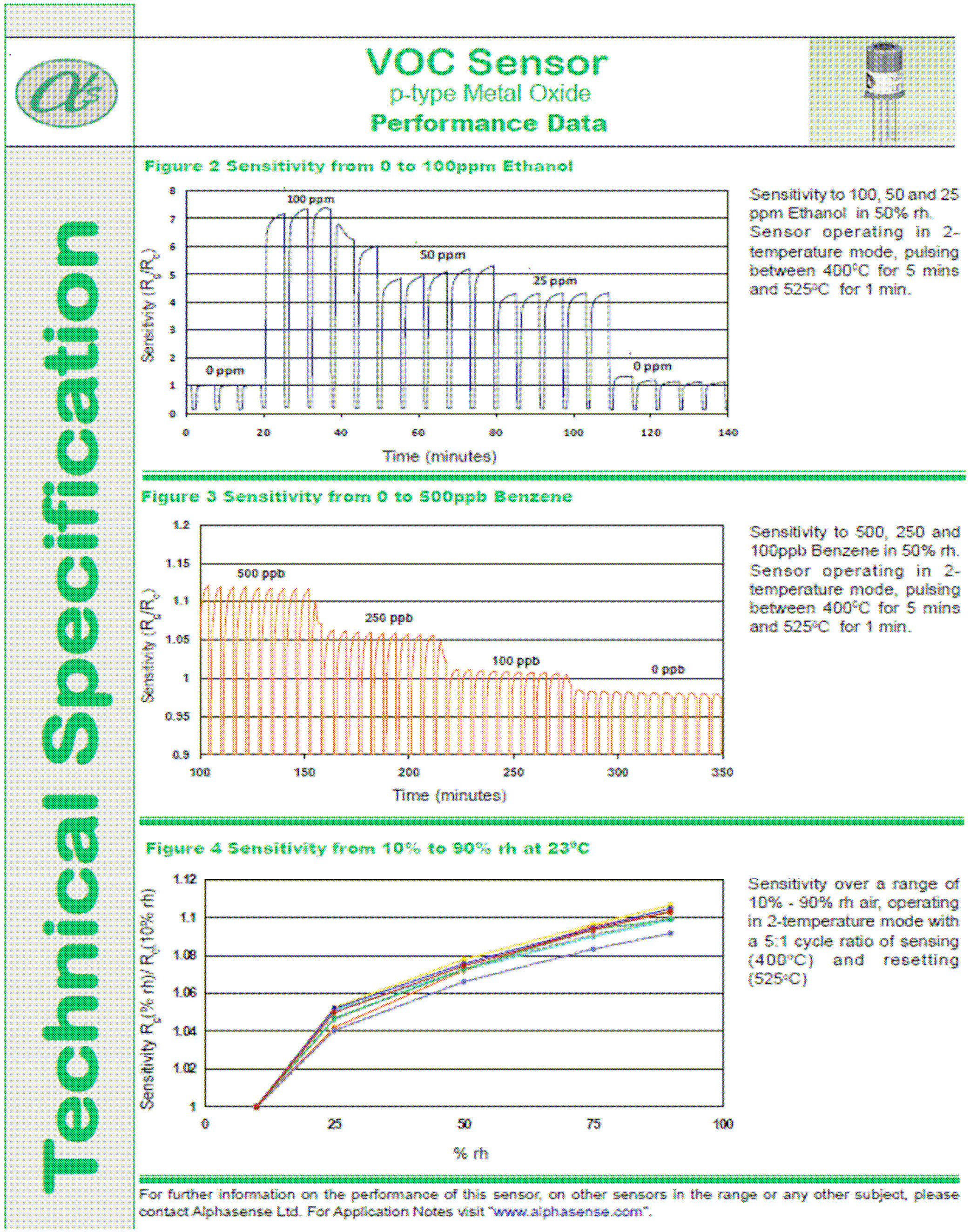
Examples of miniature air quality sensors

Electrochemical	NO_2, NO, CO, O_3, SO_2
Spectroscopic	CO_2, CH_4
Photo-ionisation	SVOCs
Optical particulates	BC, PM_{10}, $PM_{2.5}$, PM_1
Metal Oxides	SVOCs

Metal Oxides: alternatives to PIDs for VOCs

n-types have fundamental problems: rh and baseline drift; p-types are more stable and insensitive to humidity

Filters are the key to selectivity



VOC Sensor

p-type Metal Oxide

Performance Data

Figure 2 Sensitivity from 0 to 100ppm Ethanol

Sensitivity to 100, 50 and 25 ppm Ethanol in 50% rh. Sensor operating in 2-temperature mode, pulsing between 400°C for 5 mins and 525°C for 1 min.

Figure 3 Sensitivity from 0 to 500ppb Benzene

Sensitivity to 500, 250 and 100ppb Benzene in 50% rh. Sensor operating in 2-temperature mode, pulsing between 400°C for 5 mins and 525°C for 1 min.

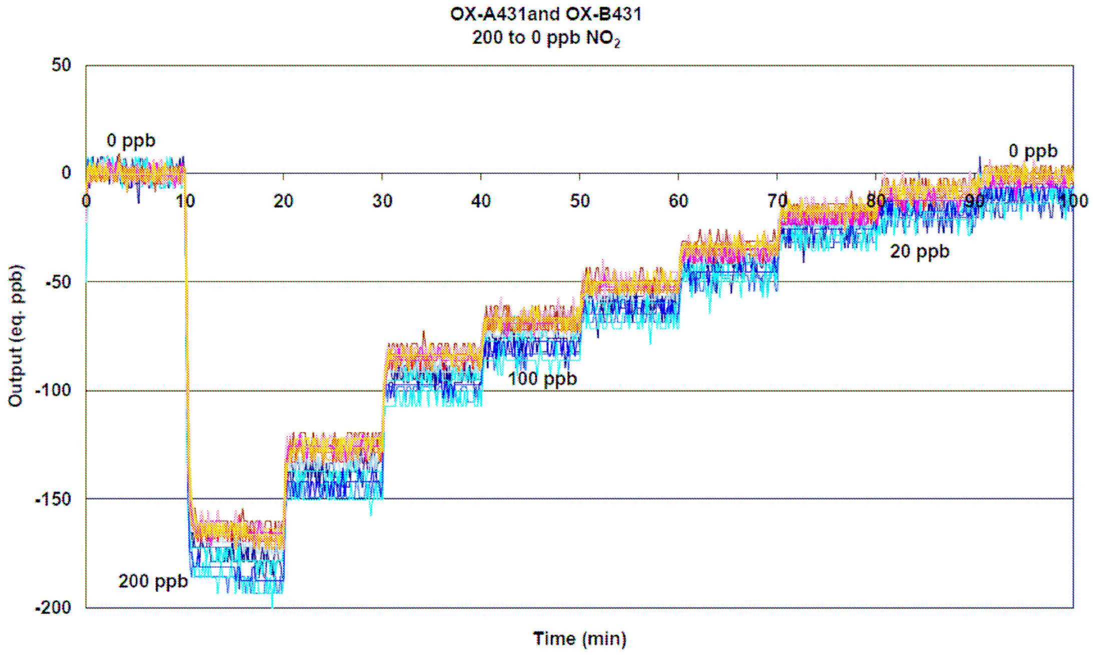
Figure 4 Sensitivity from 10% to 90% rh at 23°C

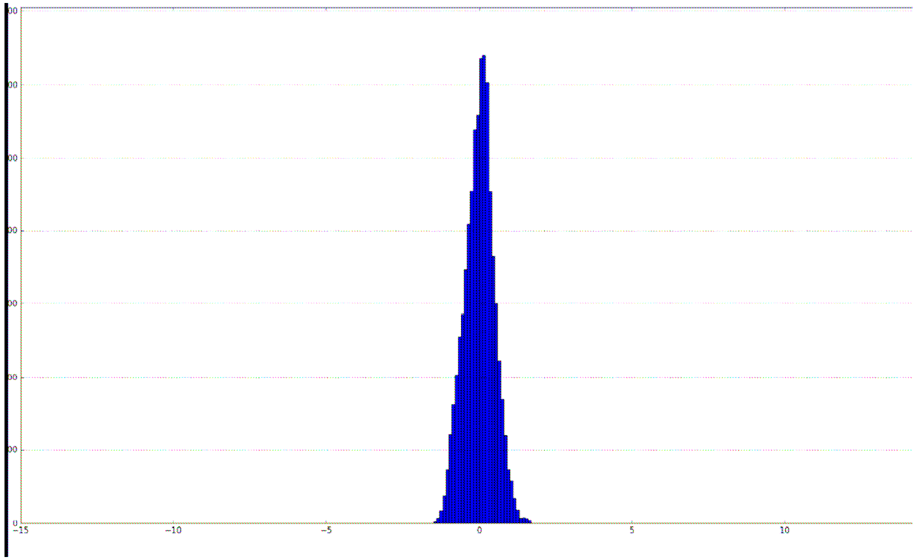
Sensitivity over a range of 10% - 90% rh air, operating in 2-temperature mode with a 5:1 cycle ratio of sensing (400°C) and resetting (525°C)

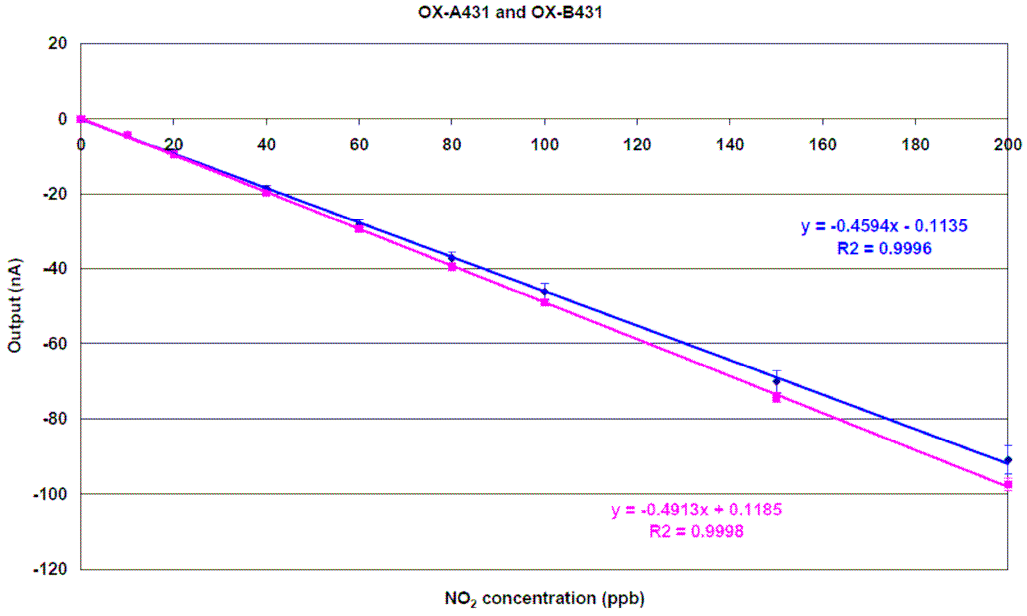
For further information on the performance of this sensor, on other sensors in the range or any other subject, please contact Alphasense Ltd. For Application Notes visit "www.alphasense.com".

Electrochemical cells are linear

LoD: 1 to 5 ppb, depending on the sensors and electronics

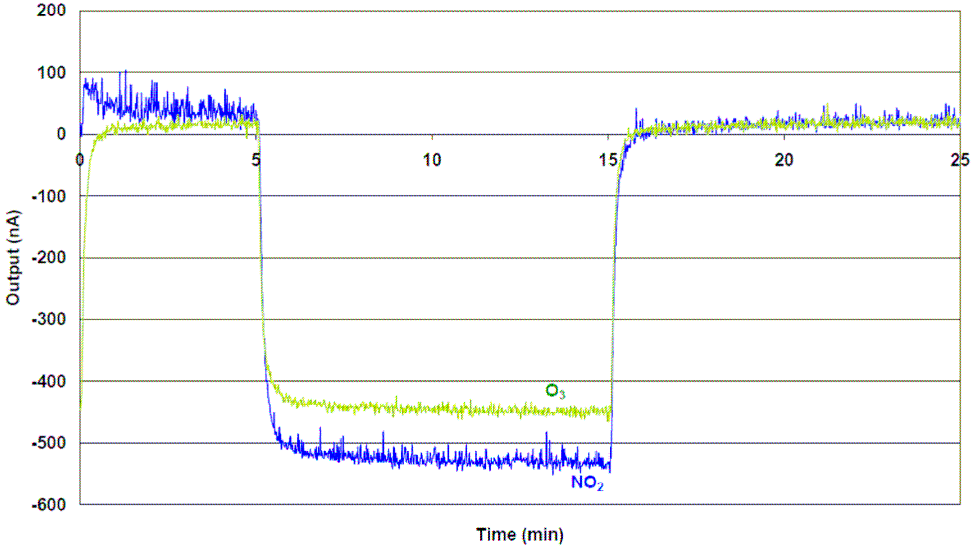




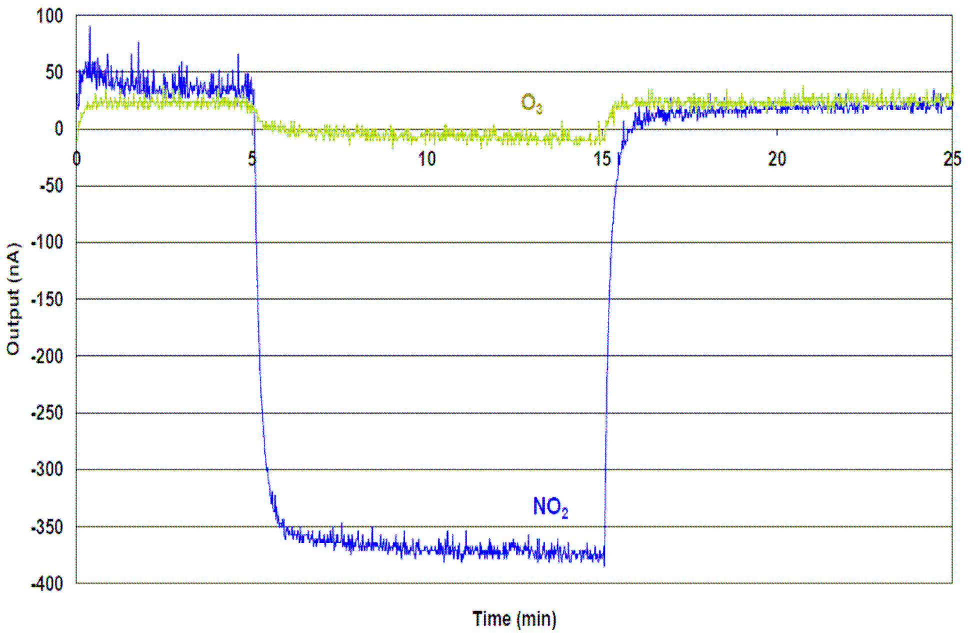


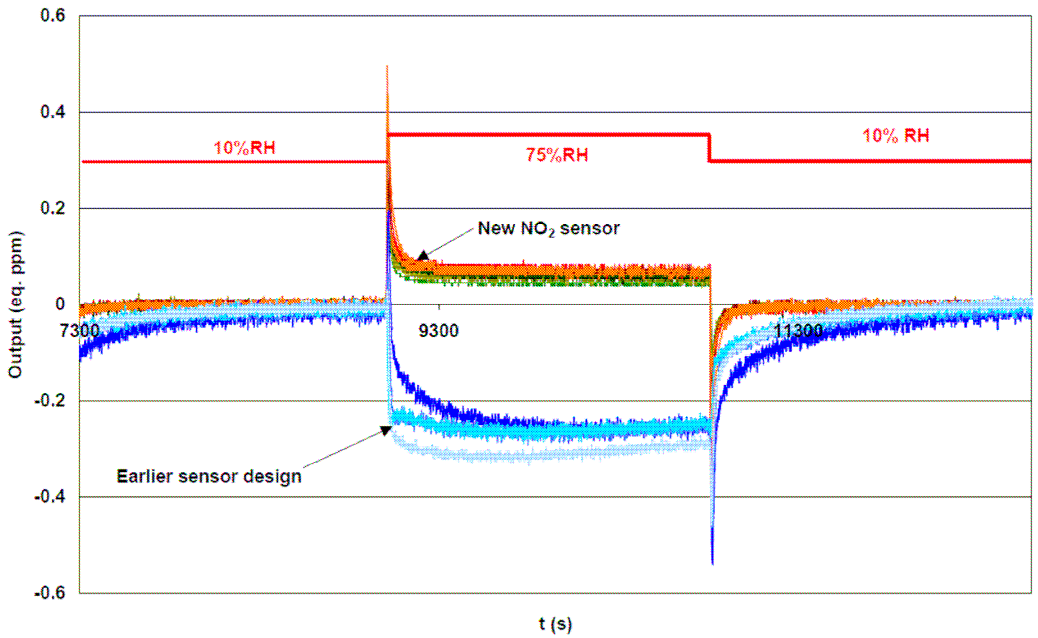
We can now separate O_3 from NO_2 and humidity transient response is improved

OX-B431 resdponse to 1 ppm O_3 and NO_2

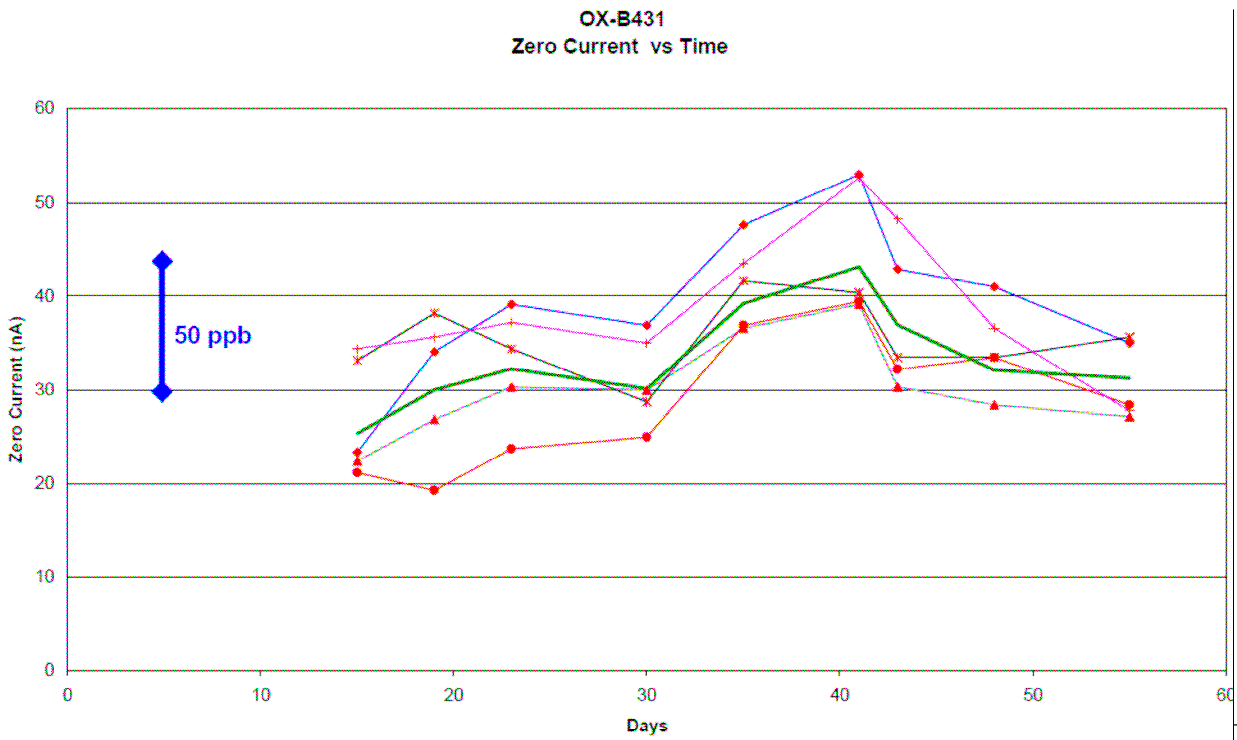


NO2-B43F to 1 ppm NO_2 and O_3



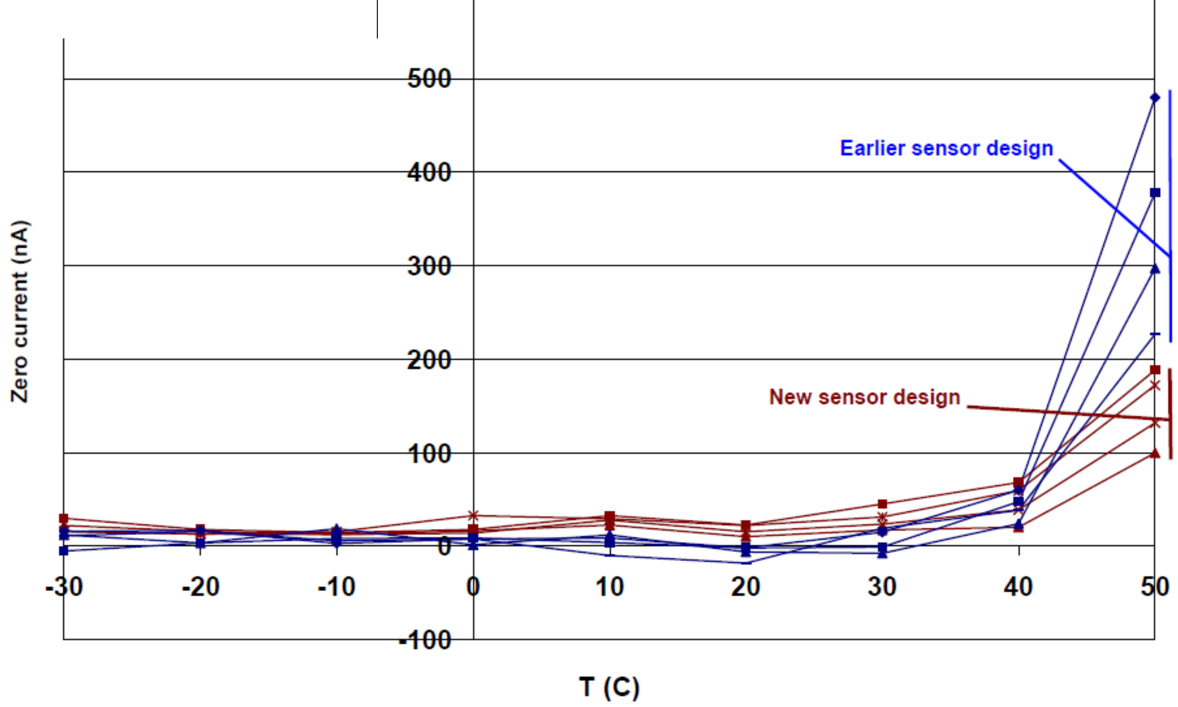


Improved NO_2/ O_3



better stability

better zero current



Types of Air Quality Networks

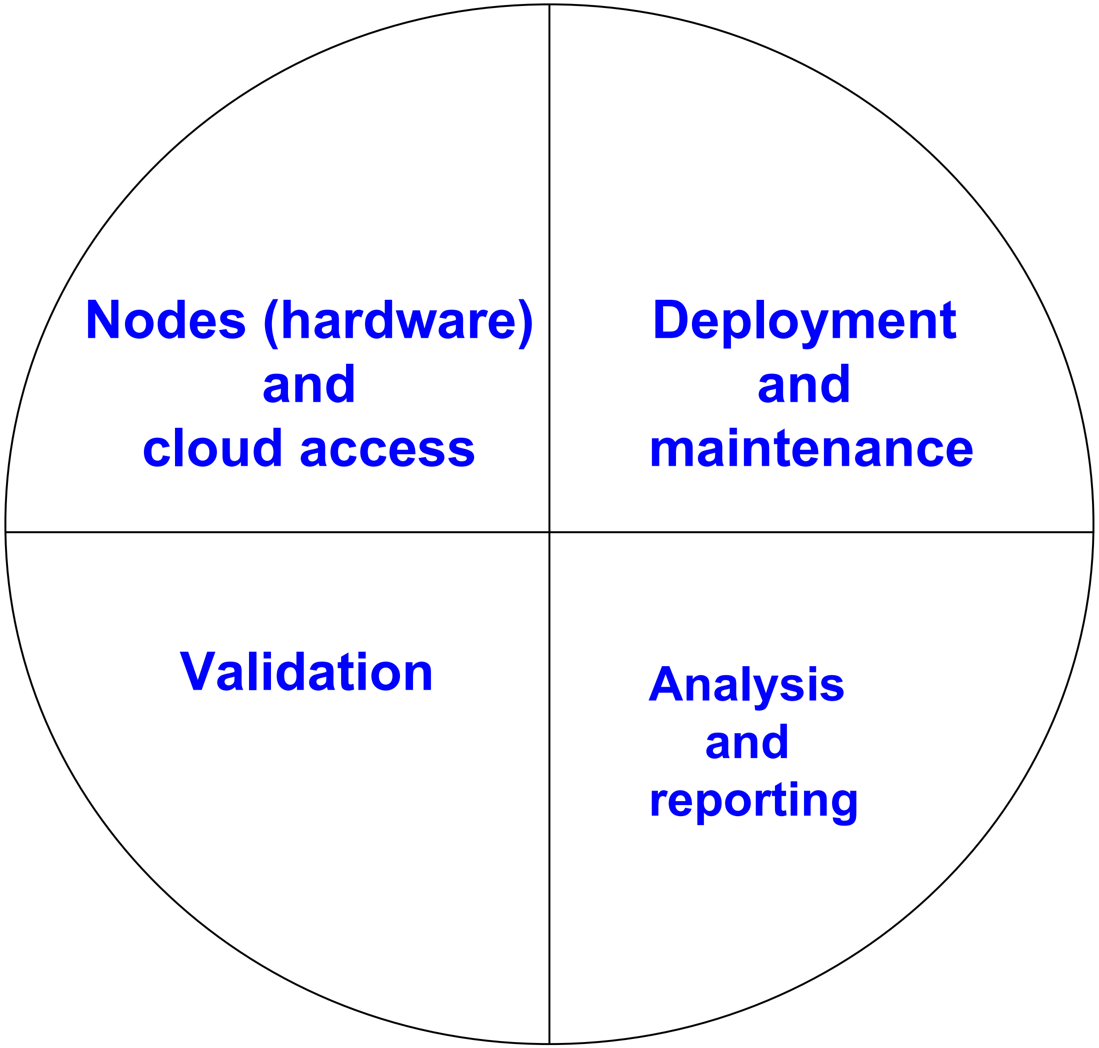
Fixed site: 50 to 5,000 nodes per city- *best calibration options*

Mobile: trams, buses, special cars- *no power problems, but a moving platform*

Personal: rapid mapping of the city, citizens make local pollution maps- *hardest to validate*

Wearable: a fitbit that measures gases, particulates- *a technology challenge*

Managing a fixed site AQ Network



Nodes (hardware)
and
cloud access

Deployment
and
maintenance

Validation

Analysis
and
reporting

Air Quality Monitoring Networks

Can Africa and Asia afford it?

TOTAL $

Stage 1 (initial review)	
Initial AQ review: 6 nodes, analysis, report	$100,000
Stage 2 (full deployment)	
Each node: $1,500 to $3,000 x 100 nodes	150-300,000
Deployment, maintenance, cloud- 3 yrs	300,000
Validation, analysis, apps, reports	250,000
	TOTAL < 1M$

Differences between lab calibration and field testing

IMPORTANT

Lab: controlled environment, degrees of freedom are known

Good correlation and **Bayesian networks** work well

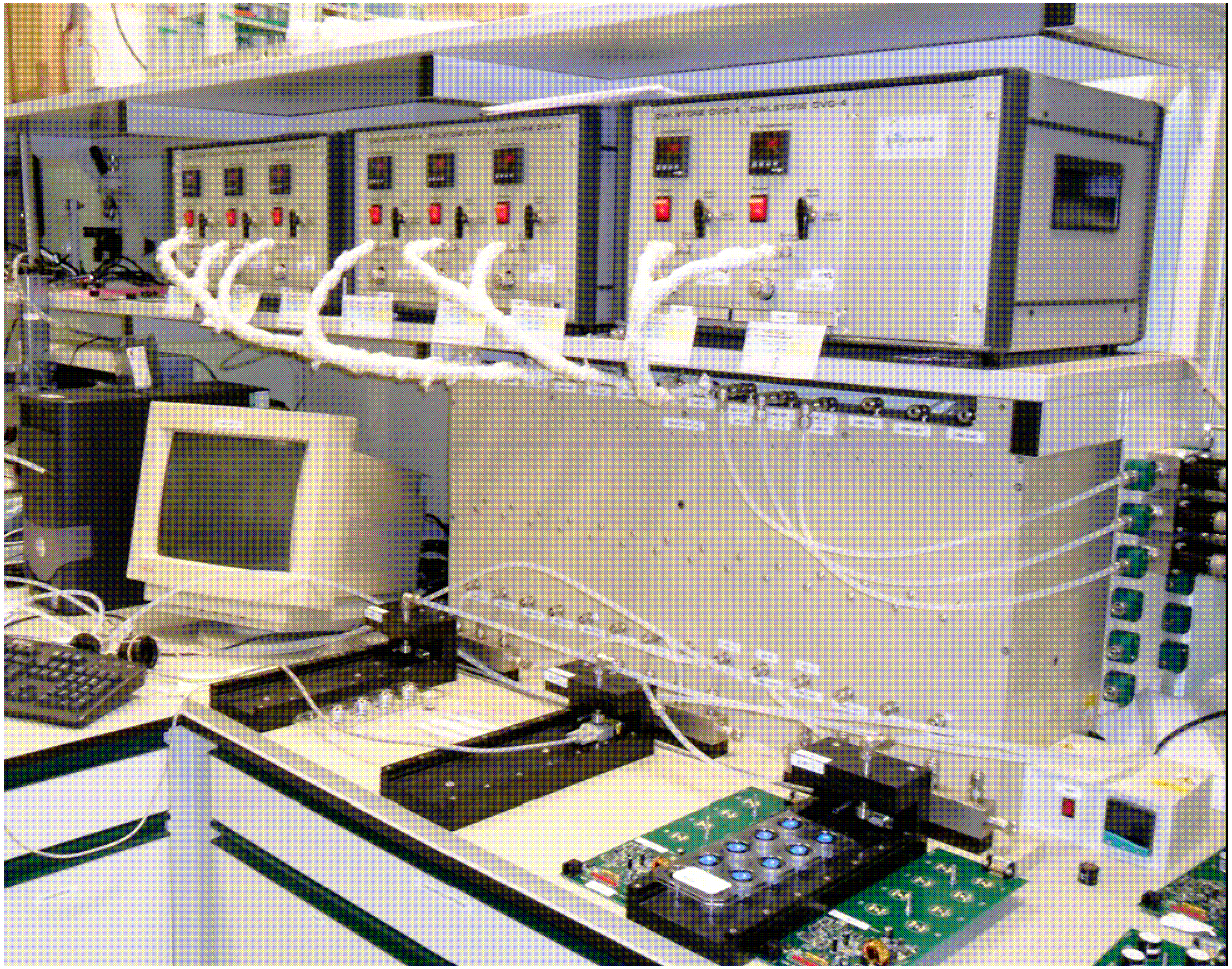
Field: more degrees of freedom, no control of the variables

Need to go to **machine learning/ Deep Belief Networks** (G Hinton 2007)

Alphasense gas testing system

120 gas bottles
130 DMFCs
2 km micropolished SS316 gas lines

Automated 8 channel permeation tube system

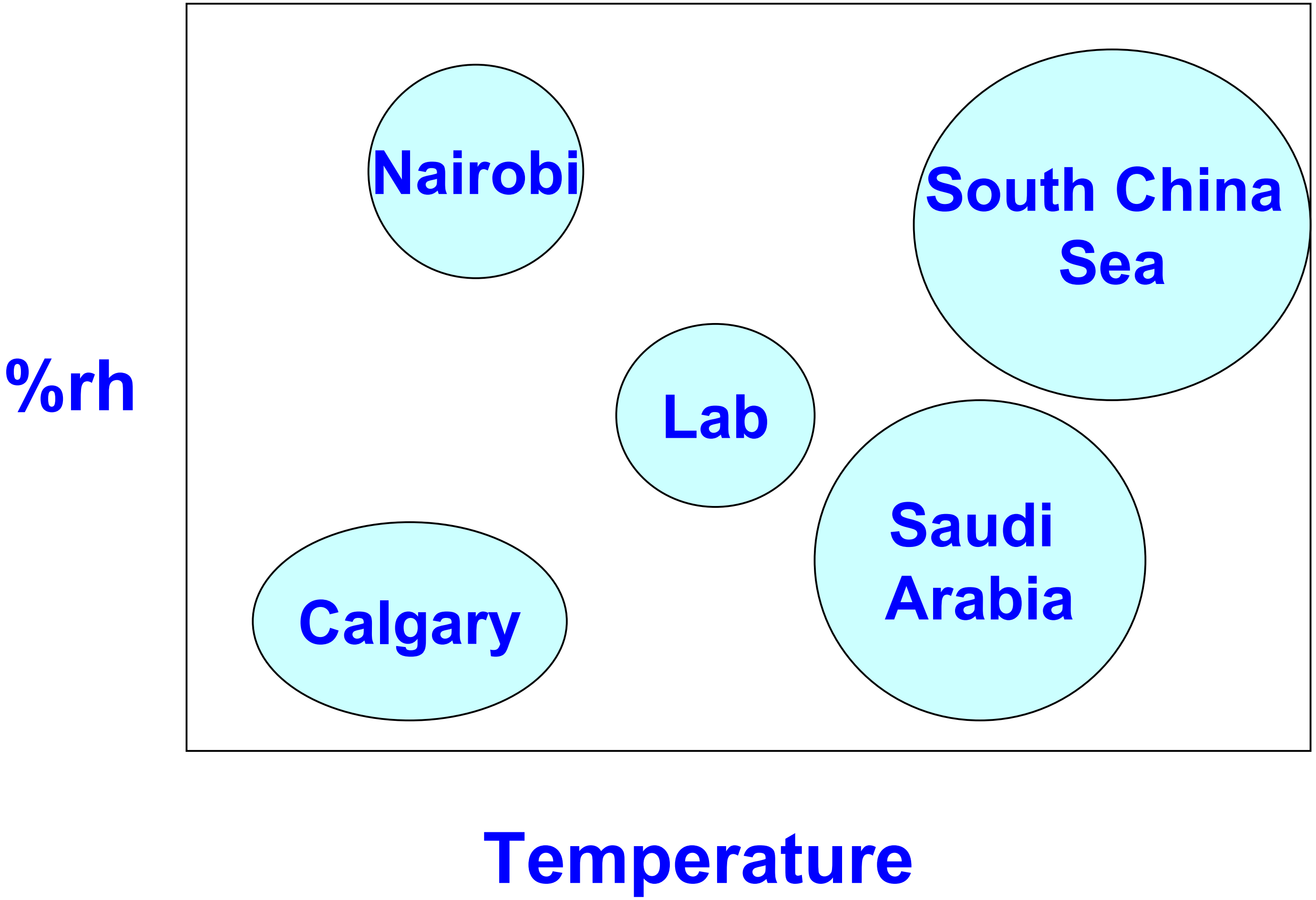


Validating AQ Networks in the field

Overcoming problems and using the network to reduce errors/ improve accuracy

Temperature variations
Long term sensor drift
Interfering gases and particulates
Temperature and humidity transients
Diurnal and seasonal variations

From the Equator to the Arctic



Lessons we have learned

- Air quality is transient, so **sample every 10 to 60 seconds** to separate background and local sources
- Relative change in air quality is not difficult to monitor: **absolute concentration** is the challenge; and-absolute baseline concentration is the most important (and the most challenging)
- **Use your chemistry.** Analyse diurnal patterns, consider the role of photochemistry and beware of $NO/NO_2/O_3$ reactions
- **Co-location** is the secret to in-field calibration of mobile networks and long term fixed sites.
- No sensor is perfect- use chemistry-based maths to **deconvolve interfering gases**
- Get the **electronics** right, so you do not have to worry about noisy data
- Combine data from **multiple sensors** for a complete picture
- **Anemometers** are very useful tools to separate local and background pollution sources

AQM

Conclusions

AQ Network

Fixed site low cost Air Quality networks are here. But- they do not replace AQMs.

PM and NO_2 sensors now work to requirement- finally!

Validation is our next step. Co-location and good network management are needed

Mobile and personal AQ points are being tested- needed to complement fixed sites and for healthcare

Wearables are still in the future

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