

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

COST Action TD1105

## WGs and MC Meeting at LINKÖPING, 3 - 5 June 2015

Action Start date: 01/07/2012 - Action End date: 30/06/2016

Year 3: 1 July 2014 - 30 June 2015 (*Ongoing Action*)

## MOX SENSOR PLATFORM IN OUTDOOR ODOR NUISANCE MONITORING



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 **cost**  
EUROPEAN COOPERATION IN SCIENCE AND TECHNOLOGY



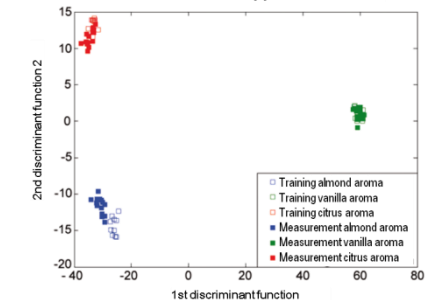
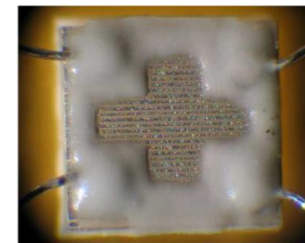
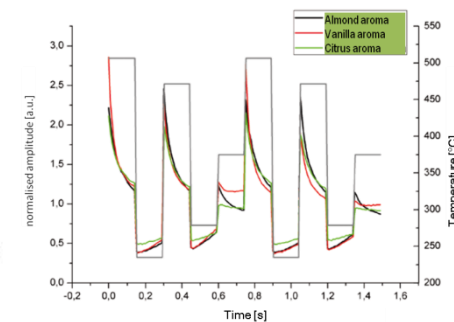
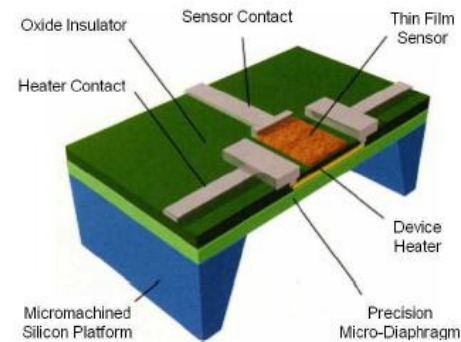
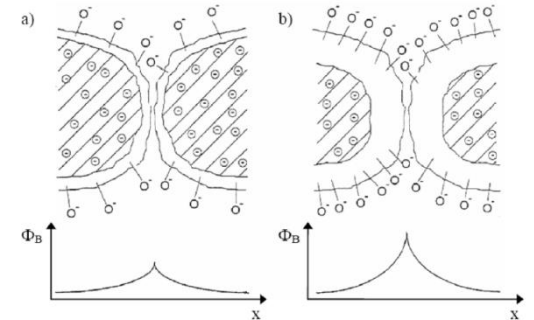
# Background of 3S GmbH

- **Spin-off company founded 2006**  
originally by members of Prof. Andreas Schütze's lab for measurement technology at Saarland University (USAAR)
- Most developments based on **MOX sensor technology**, combining USAAR and own research
- Main commercial fields of application:
  - **Leakage** detection
  - **Odour** assessment
- **Providing hardware systems for research**
  - at USAAR
  - in VOC-IDS / SENSIndoor (IAQ)



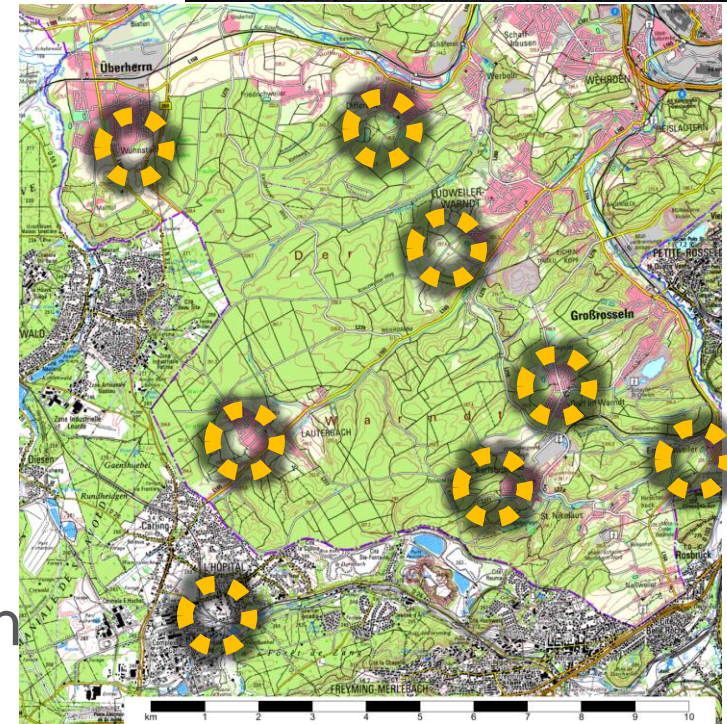
# Temperature cycled MOX sensors

- Metal oxide gas sensors: working principle redox reactions with surface adsorbed oxygen  
→ unspecific, **broadband** reaction
- Temperature dependency can be used for “thermal spectroscopy”  
→ **selectivity**
- Transient behaviour most interesting, current research shows vast increase in **sensitivity**
- Temperature cycle results in response pattern  
→ **pattern recognition** correlates reaction with substances / odours



# Context and objectives for outdoor device

- Can temperature cycled MOX sensors be used for “immission” monitoring?
- Odor nuisance reported by residents
- Sensor network for objective monitoring with sufficient time and location resolution
- “Immission” means:
  - Small concentrations
  - Climate parameters influence transport from emission site to immission location
  - Strong local disturbance



# Outdoor device

- Modular electronics from IAQ

- MOX sensors:
  - 1 thick film ceramic type
  - 1 thin film on micromachined Si platform

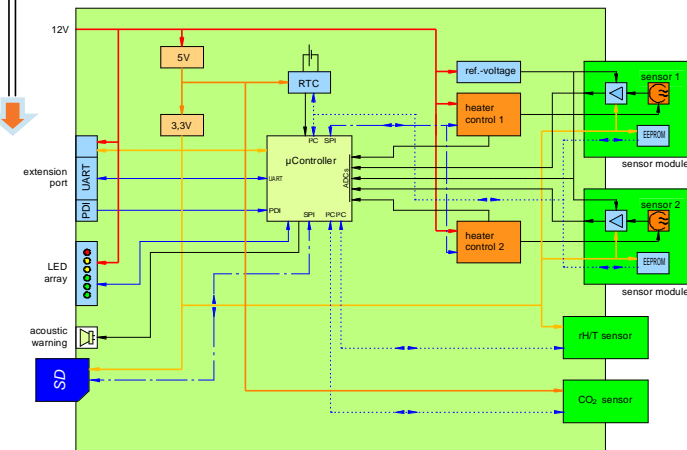
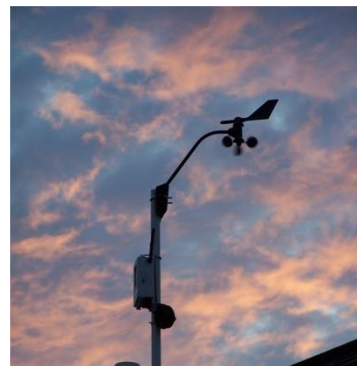
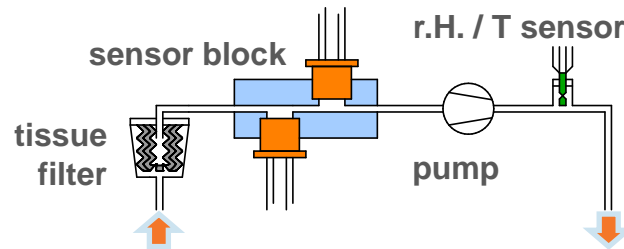
- r.H./T sensor

- Outdoor adaptation

- Rugged housing

- Pumped system

- Energy and expansion options



# Installations on site



Differten



Ludweiler

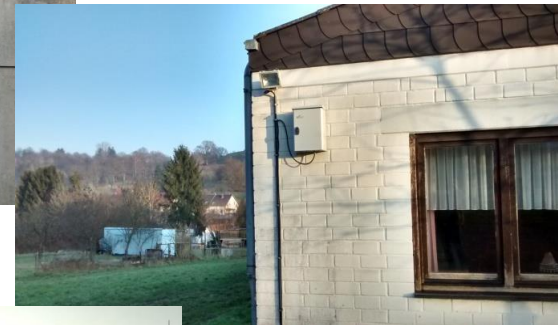


Emmersweiler

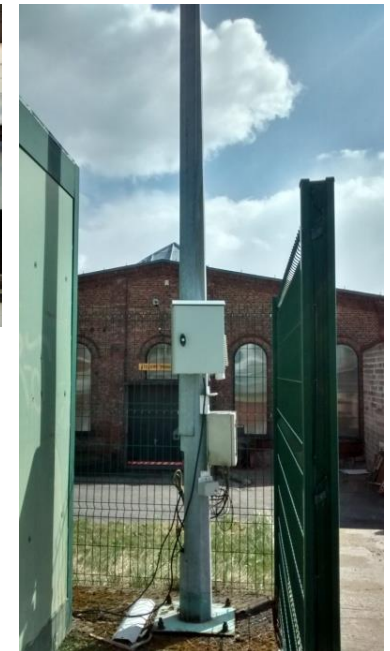


Überherrn

Dorf im Warndt



Karlsbrunn



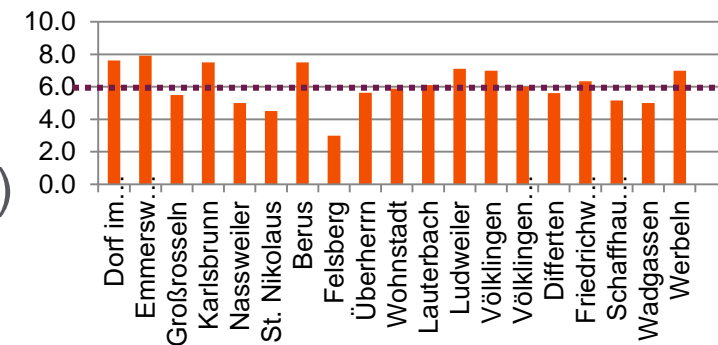
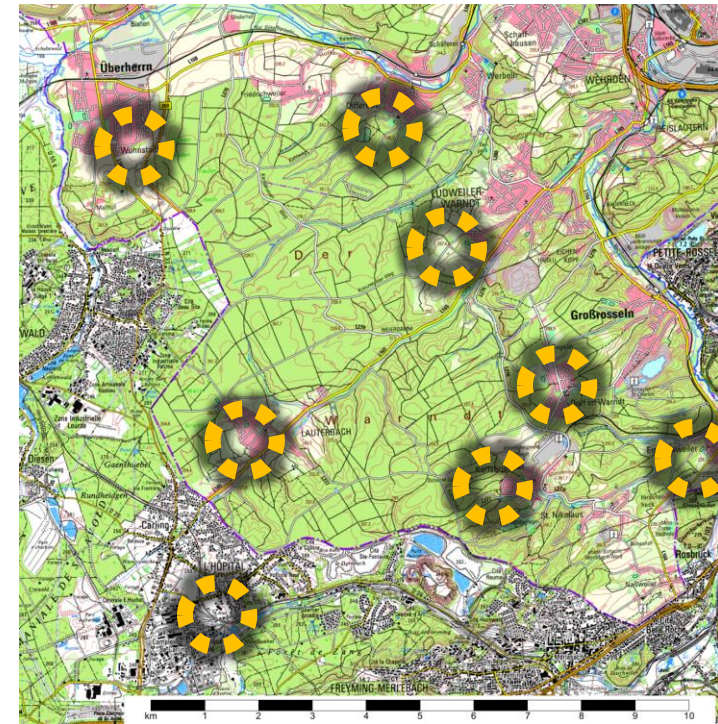
L'Hôpital

Lauterbach

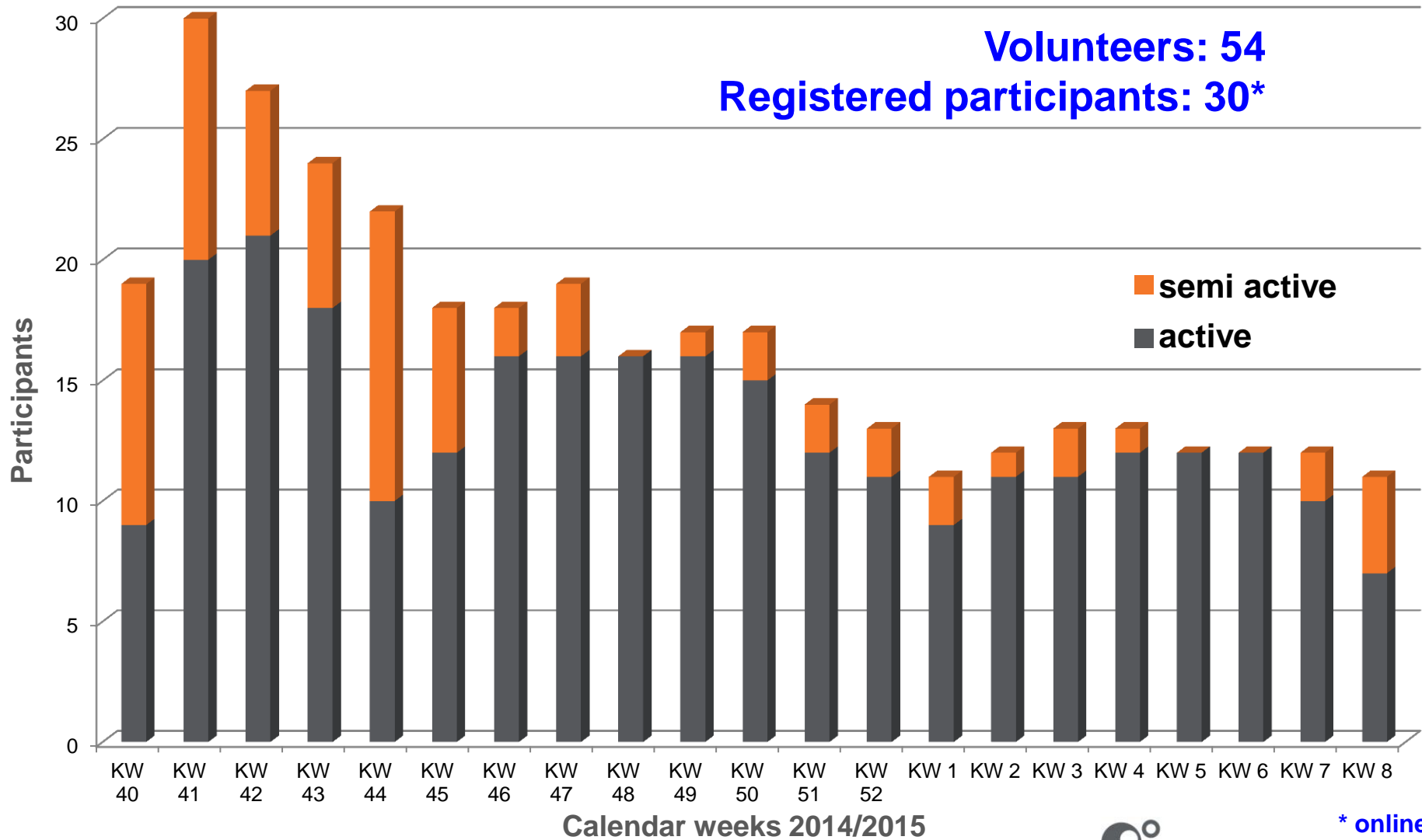


# Human odour panel

- **First step: Questionnaire campaign**
  - 171 participants
  - 7 severely impacted villages
- **Second step: Odour survey**
  - 35 participants
  - Online form provided by Odometric SA
  - Feedback on odor type, intensity, nuisance with time and location
- **Other information taken into account**
  - Climate (meteo networks and local wind data)
  - Official German and French measurement stations



# Human odor panel – Participation





# Human odour panel – reported odors

Place	No. Participants	Expected reports**	No. Reports	Wind direction				Kind of odor report									
				All reports		pungent		Wind direction SW									
				SW	Other	SW	Other	Sum „pungent“	1	2	3	4	5	6	Other odor	„plastics“	No odor
Berus	3	618	232	123	109	0	3	0	0	0	0	0	0	0	2	24	97
Bous	1	206	159	81	78	1	0	1	0	0	1	0	0	0	23	0	57
Differten*	4	824	714	388	326	39	32	39	8	14	15	0	2	0	77	6	266
Dorf im Warndt*	4	824	410	194	216	23	12	23	0	5	10	2	2	4	34	0	137
Emmersweiler*	5	1030	217	102	115	8	15	8	0	0	2	1	4	1	4	4	86
Friedrichweiler	1	206	131	61	70	8	6	8	1	3	1	2	1	0	9	4	40
Großrosseln	1	206	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1
Karlsbrunn*	4	824	383	191	192	21	12	21	3	4	6	5	3	0	17	0	153
Lauterbach*	4 (1)	824 (206)	127 (769)	68 (306)	59 (463)	3 (306)	2 (463)	3 (306)	0 (0)	0 (0)	1 (0)	2 (0)	0 (0)	0 (0)	8 (0)	1 (0)	56 (0)
Ludweiler	2	412	209	111	98	2	0	2	0	0	2	0	0	0	1	0	108
Wadgassen	2	412	169	85	84	0	0	0	0	0	0	0	0	0	0	0	85
Werbeln	1	206	14	7	7	2	2	2	0	0	1	0	1	0	4	1	0
Überherrn-Wohnstadt*	3	618	339	190	149	5	11	5	0	1	4	0	0	0	16	3	166
<b>SUMS***</b>	<b>35</b>	<b>7210</b>	<b>3105</b>	<b>1602</b>	<b>1503</b>	<b>112</b>	<b>95</b>	<b>112</b>	<b>12</b>	<b>27</b>	<b>43</b>	<b>12</b>	<b>13</b>	<b>5</b>	<b>195</b>	<b>43</b>	<b>1252</b>

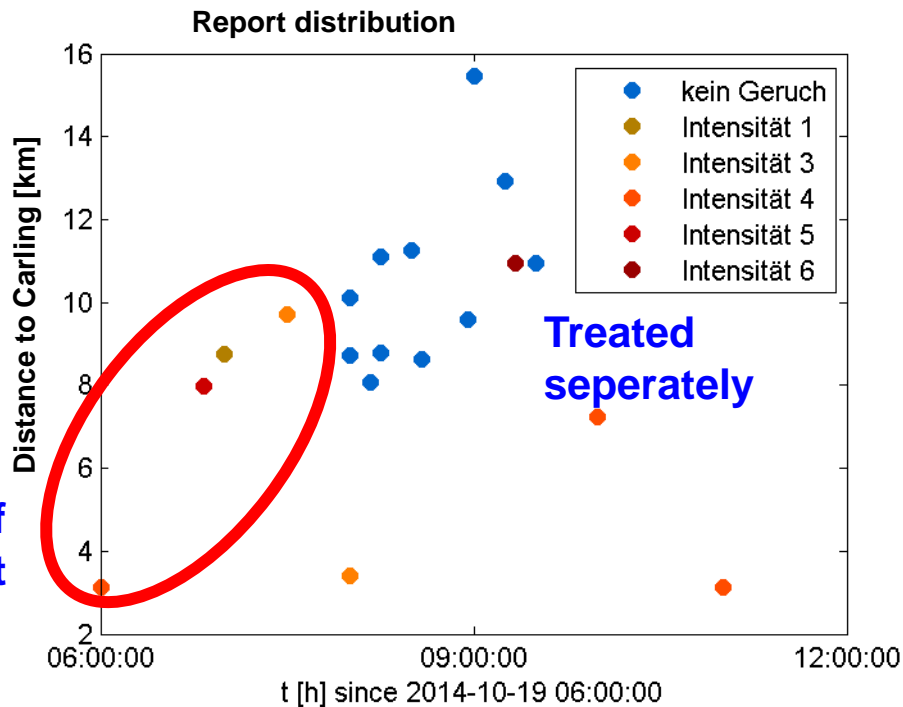
\* Placewith OCO installed; \*\* 01.10.2014 – 11.01.2015 = 103 days; \*\*\* without local peculiarity at Lauterbach

**Intensity: 1: barely perceptible; 2: low; 3: distinct; 4: high; 5: very high; 6: unbearable**

# Human odour panel – search for odor events

## Screening for relevant time intervals

- Necessary because of vast amount of data
- Either: Many reports of intense odor (target event) with temporal and spatial connection
- Or: „no odor“- reports only (zero event)



## Reports

- total number = 3105, 207 “pungent“
- Windrichtung SW = 1605
- pungent with wind direction SW = 112

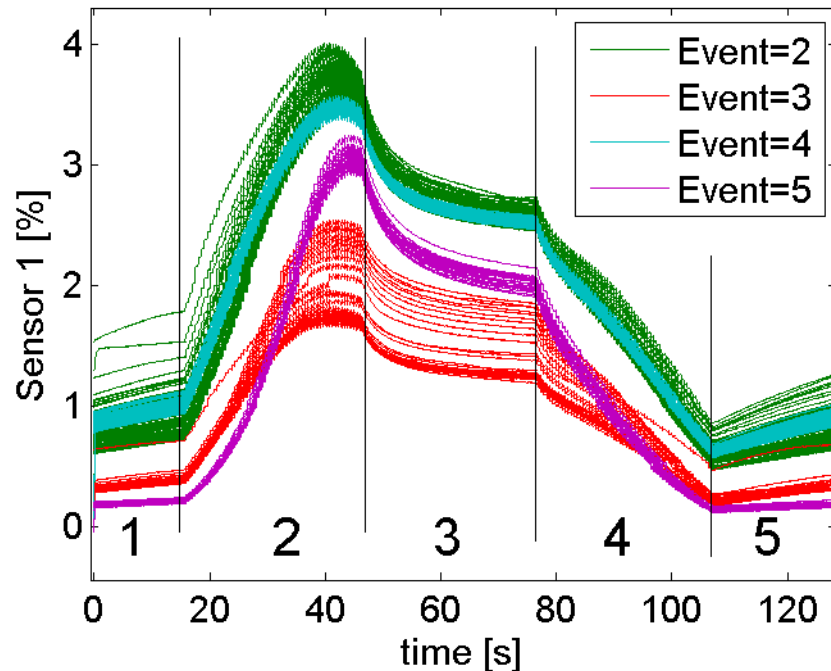
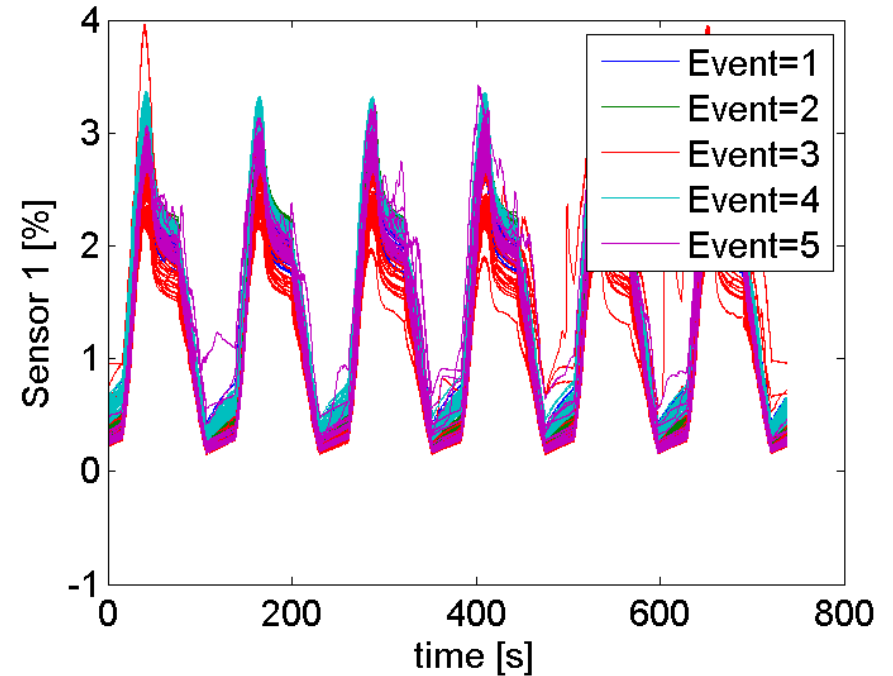
## Found „events“

- 3 odor events
    - 2 „target odor“ (=Carling)
    - 1 „other odor“
  - 2 zero events (more exist)
- Basis for sensor data analysis

# Sensor data treatment

**Aim: Separation of events**

- 1: Other odor
- 2: Zero event
- 3: Target event
- 4: Zero event
- 5: Target event

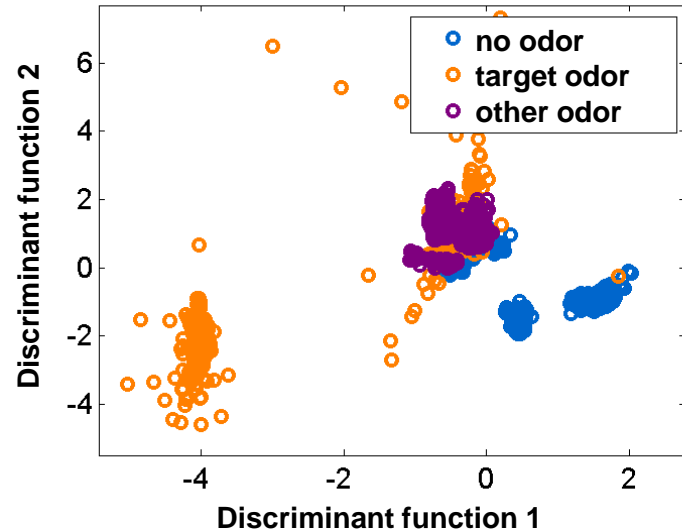


**Features from each temperature cycle interval**

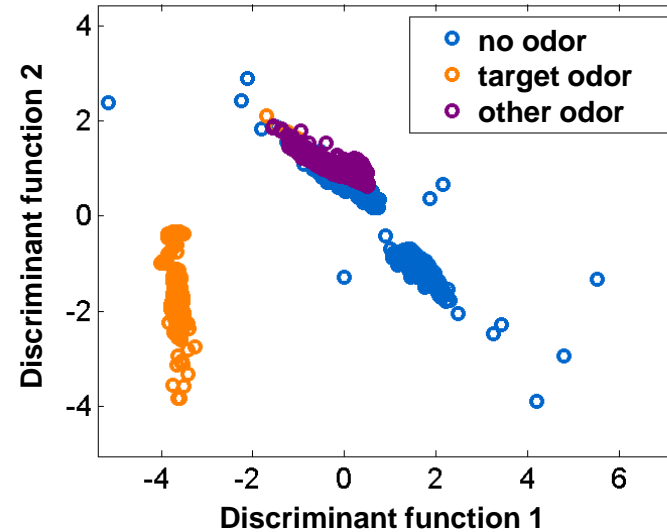
- mean
- slope

# LDA mapping of events

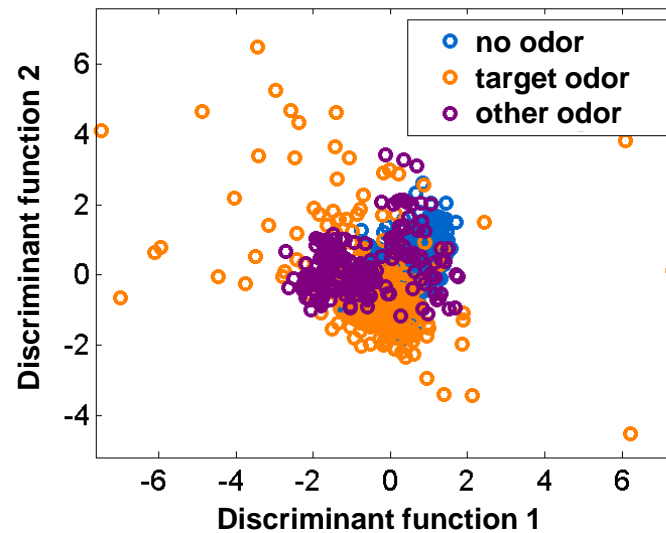
Dorf im Warndt (sensor type B)



Karlsbrunn (sensor type B)

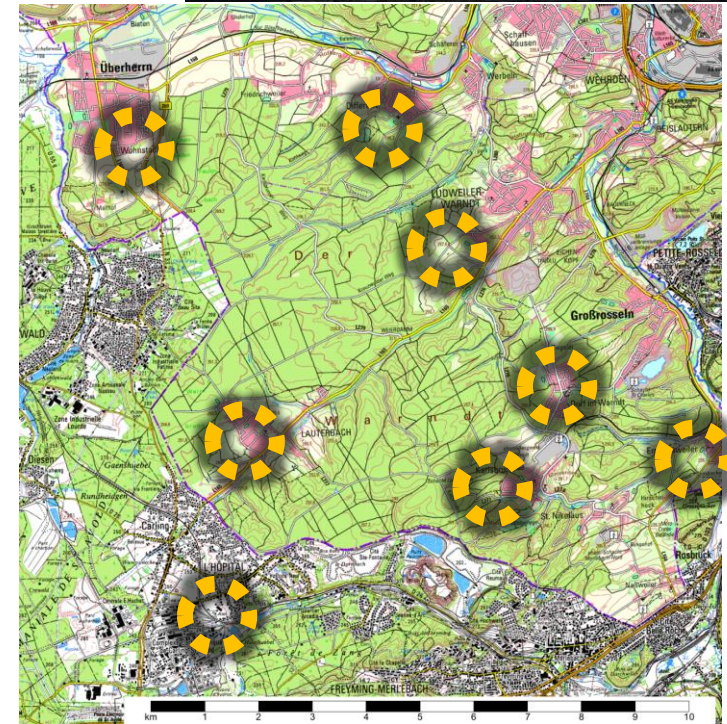


Dorf im Warndt  
(sensor type A)



# Results in context of Warndt project

- Separation could be performed.
- But: Sparse events do not hold enough reference information to build a stable algorithm
- Second phase (April to July 2015)
  - More devices
    - Emission measurement
  - More participants
    - Aim: More reference data for better proof-of-concept



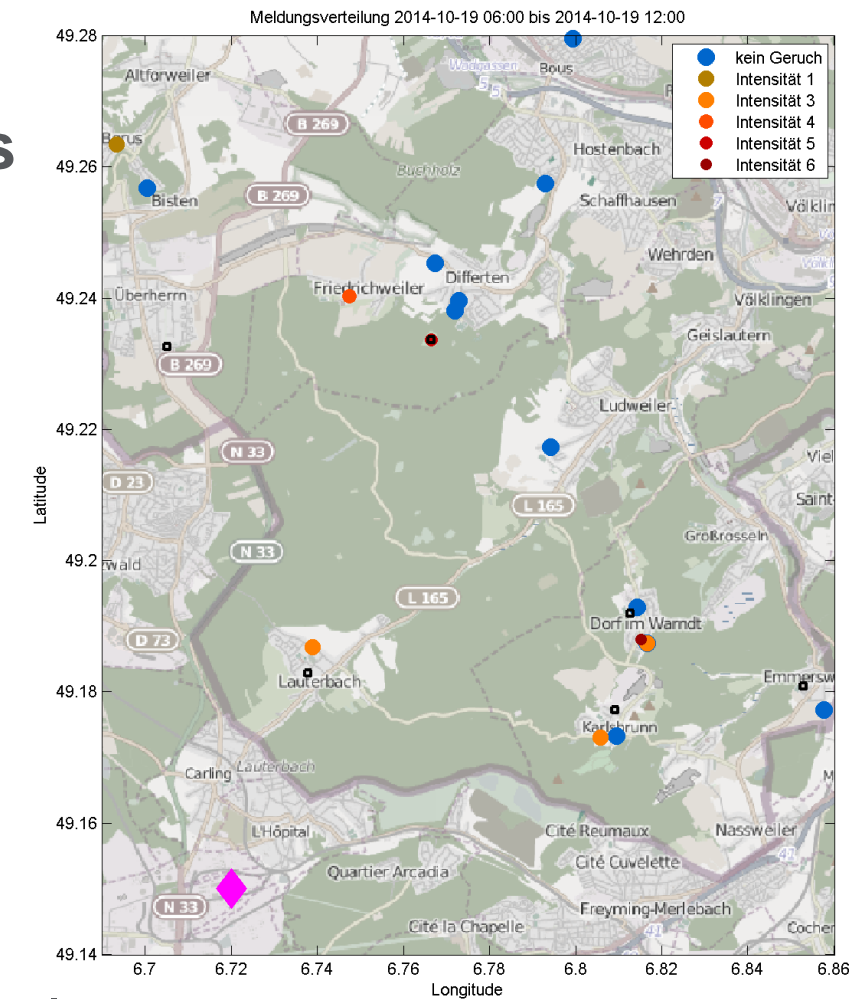
# Results regarding sensor system

- **Not one single system failure since October**
- 24/7 operation throughout the winter months
  - No alterations apart from periodic filter exchange
  - Adaptation of temperature cycle via SD config
- Next steps in development
  - Remote access (3G wireless)
  - Additional sensors for special use cases (EC cells, other technologies, e.g. in research partnerships)
  - Dilution unit for emission use
  - Sampling unit



# Outlook: Data interfacing

- Online odor information for customers and integrated services
- Better accessibility
  - Graphic representation
  - Data interface
- Short-term objective
  - Central data processing of complex odor information at 3S
- Long-term objective
  - Adaptation to GIS standard protocol



ground map (c) OpenStreetMap Contributors