Novel Sensor Applications for Air Quality Measurements

Report from the recent 12th International Conference on Air Quality, 2020

Professor Nicolas Moussiopoulos

Laboratory of Heat Transfer and Environmental Engineering
School of Mechanical Engineering, Aristotle University of Thessaloniki

Concluding events of the project “Smart Air Quality Network” (SAQN)
Augsburg, 23-24 September 2020


ARISTOTLE UNIVERSITY THESSALONIKI
12 TH INTERANTIONA CONFERENCE
AIR QUALITY SCIENCE & APPLICATION
ONLINE CONFERENCE
2020
University of Hertfordshire UH

Special Session – Sensors, Crowd Sourcing and AQ Model Simulations 1/2

Name	TITLE
F. Barmpas	INTERPETING MEASUREMENTS FROM AIR QUALITY SENSOR NETWORKS: DATA ASSIMILATION AND PHYSICAL MODELLING
M. Mueller	CITY-SCALE GEOSPATIAL DISTRIBUTION OF CO2 BASED ON A DENSE SENSOR NETWORK
V. Voss	ASSESMENT OF HETEROGENITY OF AIR POLLUTION WITHIN AN URBAN CANOPY
J. Allard	HIGH-RESOLUTION MAPPING OF URBAN AIR QUALITY BASED ON LOW-COST SENSORS AND NEURAL NETWORK MODEL: APPLICATION TO GRENOBLE CITY, FRANCE
B. Heinold	ASSESSING THE SPATIO-TEMPORAL DISTRIBUTION OF URBAN AIR PULLUTANTS – AN INTEGRATED SYSTEM BASED ON CROWDSENSING WITH MOBILE SENSORS AND MULTI-SCALE MODELLING
M. Otalora	CHALLENGES IN THE ASSIMILATION OF MOBILE MICRO SENSORS DATA FOR URBAN AIR QUALITY – ANALYSIS OF A PARIS CASE STUDY
D. Sarigiannis	AIR POLLUTION EXPOSURE MANAGEMENT AT THE CITY LEVEL – THE ICARUS APPROACH
M. Karl	EVALUATION OF A CITY-SCALE FORECAST SYSTEM FOR AIR QUALITY IN HAMBURG
V. Binas	HIGHLY SENSITIVE, LOW COST AND PRINTABLE SENSORS FOR AIR QUALITY CONTROL
E. Saltas	CONTAMINATION ISSUES OF AUTOMOTIVE EXHAUST SENSORS: EFFECT OF AMMONIA AND ASH ON THE RESISTIVE SOOT SENSOR
A. Samad	ASSESSING THE PERFORMANCE OF LOW-COST AIR QUALITY GAS SENSORS UNDER CONTROLLED VARIATION OF RELATIVE HUMIDITY AND AIR TEMPERATURE
E. Ibarrola-Ulzurrun	LOW COST SENSOR BEHAVIOUR ASSESMENT: DEALING WITH LONG-TERM DRIFTS
L. Emmenegger	ENVIRONMENTAL TRACE GAS SENSING USING QUANTUM CASCADE LASERS
U. Uhrner	INNOVATIVE USE OF SENSOR DATA TO IMPROVE SPATIOTEMPORAL EMISSION INVENTORIES
J. Werhahn	AIR QUALITY SIMULATIONS IN AN URBAN AREA WITHIN A SMART AIR QUALITY NETWORK BY THE LARGE EDDY SIMULATION MODEL PALM-4U

Special Session – Sensors, Crowd Sourcing and AQ Model Simulations 2/2

Short presentations:

Name	**TITLE**
V. Voss	ATMOSPHERIC MODEL DATA (ATMODAT) - CREATION OF A MODEL DATA STANDARD FOR OBSTACLE RESOLVING MODELS
I. Zyrichidou	CITY-WIDE AIR QUALITY MEASUREMENT SYSTEM BASED ON IOT NETWORK
I. Zyrichidou	DEPLOYMENT OF COST-EFFECTIVE SENSORS FOR AIR QUALITY MONITORING BY CITIZENS IN THE REGION OF THESSALONIKI
H. Omidvarborna	PERFORMANCE EVALUATION OF LOW-COST SENSORS INSIDE AN ‘ENVILUTIONTM’ CHAMBER

What has been achieved so far regarding the use of low-cost sensors?

- Fundamental changes, as far as air quality detection is concerned:
  - Everybody can measure air pollutants
  - Data platforms collect enormous amounts of data and new data products are provided for users
  - Installation on board of UAVs makes these platforms extremely interesting for air quality management
  - Citizens can recognise dangerous areas for health and conclude personal health protection measures
- Development of user oriented data services and enhancement of citizen information about air pollution and climate change.

AIRTHINGS Project: Aims and Objectives

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AIM:

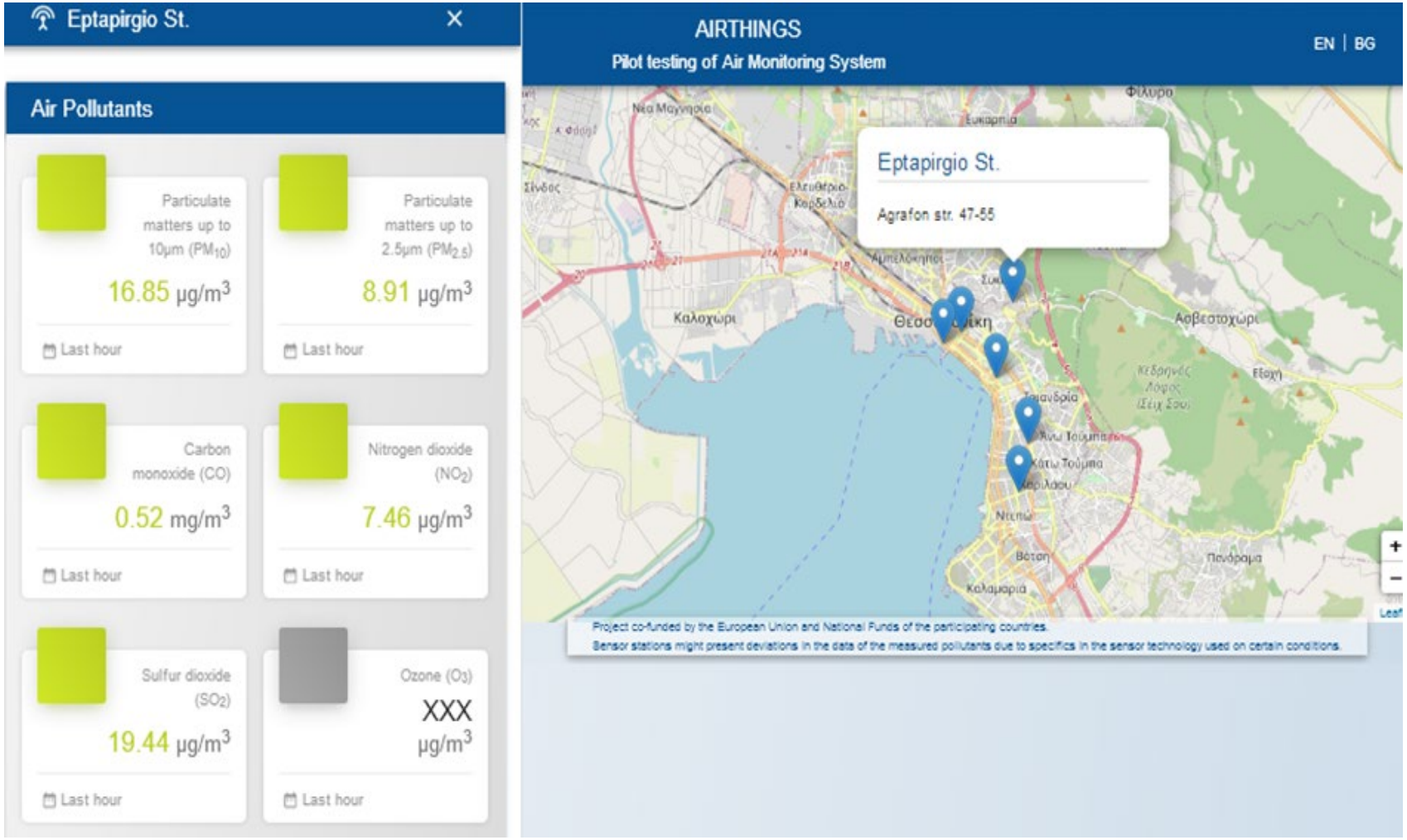
To leverage emerging technologies by deploying Internet of Things (IoT) intelligent air quality measuring sensors and enable information driven decisions to be taken by public authorities, citizens and industries.

Main objectives:

- ❑**Deploy IoT sensors in five cities** to provide real-time data through a network of connected cities jointly monitoring air quality, in a cloud based "Open data" system with predictive analytics, **numerical modelling** and advanced machine learning capabilities
- ❑Formulate city specific **guidelines and methodologies** for air quality monitoring
- ❑To interface the IoT sensors with **state of the art numerical models and databases**
- ❑To establish a common **policy framework** for the reduction of regional pollutants

Interreg Balkan-Mediterranean AIRTHINGS

AIRTHINGS Project: Implementation in Thessaloniki



- Installation of 22 smart ambient IoT sensors providing real-time data of air quality
- Integration in a web-based Open-Data Platform
- Interfacing between the Open-Data Platform and an improved model-based Air Quality Management System (AQMS)
  - ✓ Deployment of the coupled modelling system MEMICO (MEMO/MARS + MIMO)
  - ✓ Integration of a real-time Data Assimilation Module
  - ✓ Validation and verification of the enhanced system

How to assess measured data quality and model simulations results?

- Sufficient experience with the evaluation of sensors and associated networks
- Ongoing activities to standardize a protocol for sensor evaluation. This is required for data products (e.g. personal air pollution exposure), as well as for applications (e.g. traffic management).

What science challenges remain (including why they are important)?

- Need for sensors to detect all air pollutants including UFP and PSD, while also GHG levels should be monitored
- Ways to link sensor networks to existing measurement data

How important are crowd sourcing, big data analyses and data assimilation?

- QA/QC methods on the basis of big data analyses already exist in theory. Adequate methods for real life applications are to be selected and combined. Crowd sourcing will help identifying the application potential of air quality data. Data assimilation (DA) is found to considerably improve air quality forecasts.

What science challenges remain (including why they are important)?

- Rather than the measurements, suitable combinations of them with the application of crowd sourcing, big data analyses and DA is the basis for new data products requested by the citizen.

In which areas and for which tasks are measured data applied?

- Citizens get personal exposure data, and they learn the location of risk areas, as well as of least polluted areas (for outdoor activities).
- Local authorities are informed about hot spots and are supported for efficient road traffic and air quality management.
- Sensor data are combined with ground-based and remote sensing information, providing also useful hints re. indoor air pollution.

What science challenges remain (including why they are important)?

- Further development of methods for integrating observations by different platforms, as well as the assessment of simulation results will lead to novel application areas.

How can sensor data support urban air quality modelling?

- Measurements of meteorological variables and of emission related quantities are necessary for highly resolved numerical simulations.
- Monitored network data, with the suitable temporal and spatial resolution, are a prerequisite for dispersion model evaluation.
- Concepts for the sensor number in networks and for the detection of boundary and background conditions, as well as suitable network configurations are being developed.

What science challenges remain (including why they are important)?

- For highly resolved numerical simulations it will be essential to have reliable online input and evaluation data, processed with suitable algorithms from the area of machine learning and AI.

How can citizens access data on pollution levels and personal exposure, as well as air quality forecasts?

- Citizen science supports their sensibility for air quality and personal health protection. Alerted in view of the health impacts of air pollution, citizens are prepared to have an active role in detecting (partially conducting own measurements) air quality.
- In the era of digital transformation, citizens can have easy access (primarily via the Internet) to information re. the current air quality situation, but also to forecasts for the future.
- Air Quality Management Systems allow investigating the impact of various future emission scenarios on air quality and consequently the effects of different public health policies on personal exposure.

DEVELOPMENT OF AN ADAPTABLE AIR QUALITY MANAGEMENT SYSTEM FOR SUPPORTING URBAN-SCALE ASSESSMENT IN EUROPE

Objective: To modify an existing integrated Air Quality Management System (AQMS), originally developed by LHTEE, in order to provide an adaptable air quality modelling platform for urban-scale applications in Europe, which will support air quality assessment and decision making.

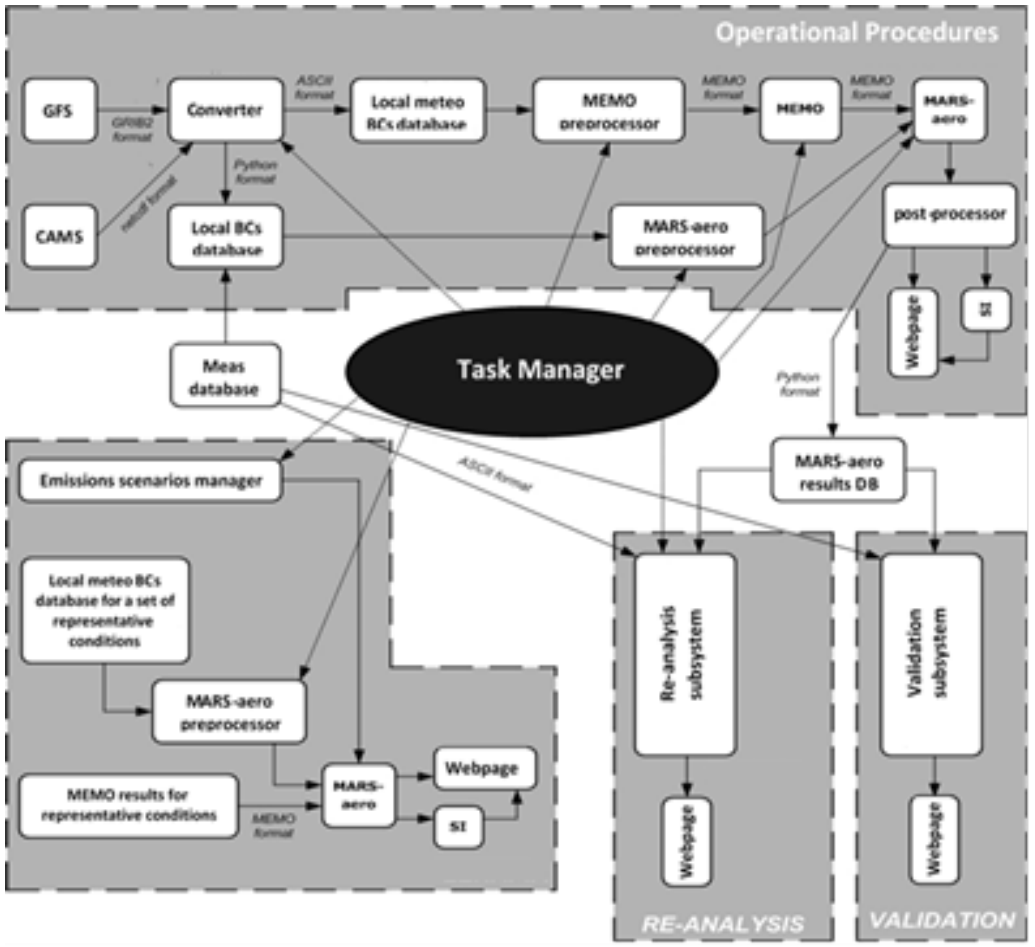
Service contract with KIT/TM, collaboratively implemented by AUTH/LHTEE and KIT/TECO

AQMS structure and implementation

➢The AQMS consists of a model system performing advanced meteorological and photochemical model simulations in two parallel operational modes (Moussiopoulos et al., 2012)

➢**Implementation plan:**

- ✓ Development of adapted computational core and user interface for supporting the mesoscale wind field model GRAM and the Lagrangian dispersion model GRAL.
- ✓ Specification of functional parameters and programming interface, implementation of the operational management and book-keeping code.
- ✓ Test application of the new modelling system for the functional verification of the system, also incorporating user feedback.
- ✓ Validation through comparison with monitoring data.



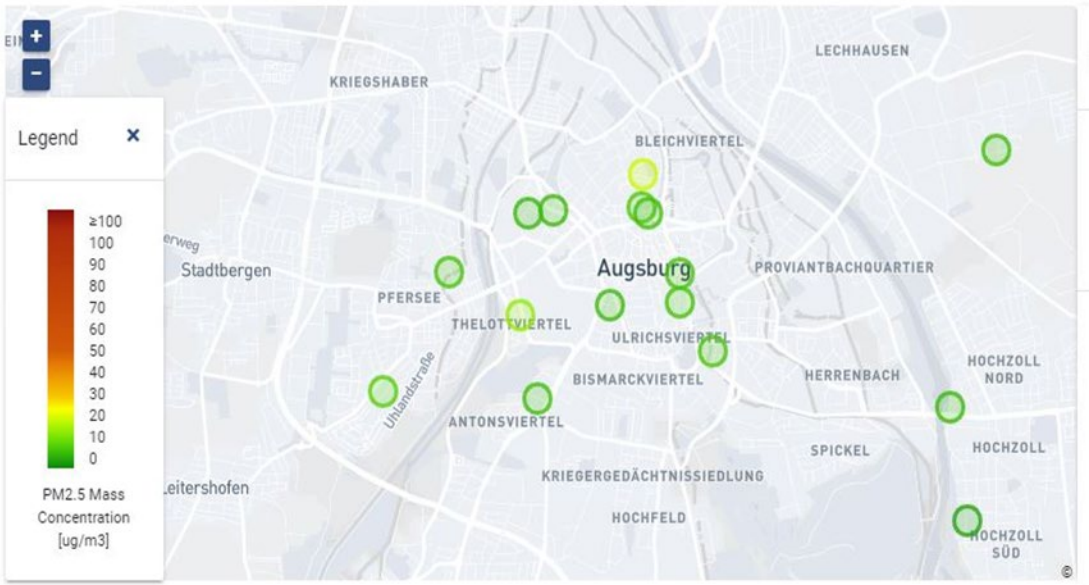
AQMS: architecture and interfacing

Moussiopoulos N, Douros I, Tsegas G, Kleanthous S, Chourdakis E (2012) An air quality management system for policy support in Cyprus. Hindawi Publishing Corporation, Advances in Meteorology 2012, doi:10.1155/2012/959280.

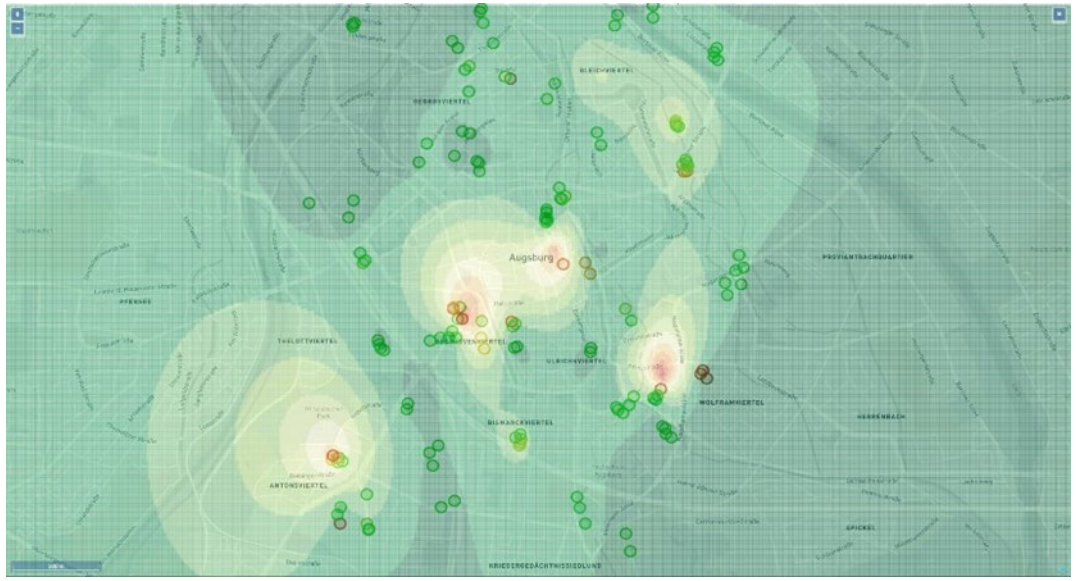
Improved AQMS highlights

- The new AQMS version constitutes an evolutionary improvement towards a **model-independent, adaptable system** for the preparation and management of meteorological and air quality simulations.
- An off-line (non-real time) module provides support for air quality related assessment and decision making, based on **custom emission scenarios**.
- Individual models and **multiple scenarios** can be incorporated with little effort using a minimal interfacing layer.
- Results of the operational calculations can be reviewed and visualised via a **user-friendly web page**.
- The capabilities offered by the AQMS for producing high quality assessments of air quality, are expected to be a **valuable aid to the authorities** towards compliance with the relevant EU standards.

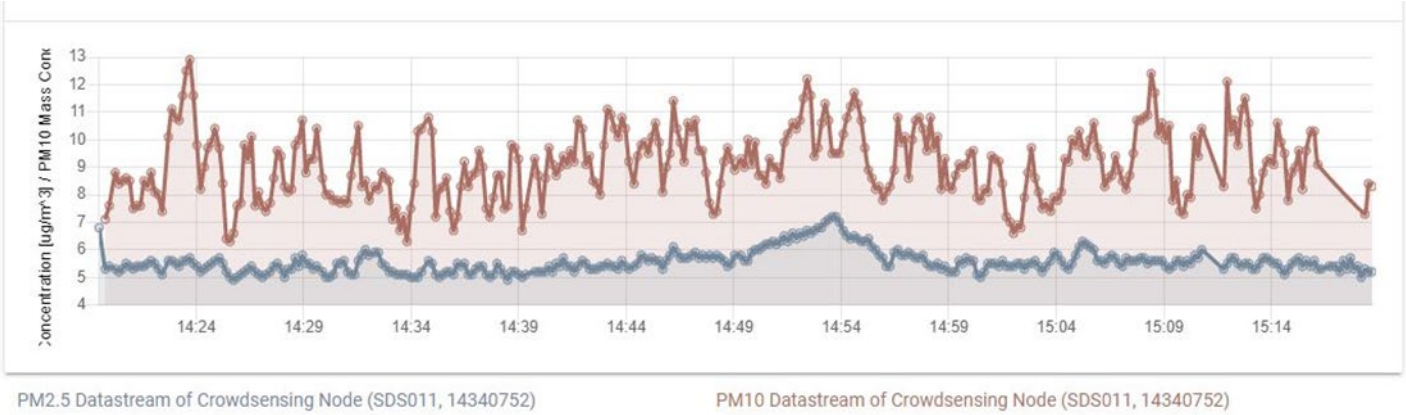
Dynamic Presentation Layers



Dynamic mapping layer (Open Street Map) with observations overlay



Analysis layer using guided interpolation (kriging) over a subset of observations



Custom views of measurements and model results

Conclusion

- New monitoring networks (including low-cost sensors) combined with high resolution (both in space and time) air quality model simulations lead to reliable personal air pollution exposure data.
- Citizen science provides new data sources, new data products and thus new data applications, while- most importantly - supporting sensibility for air quality and personal health protection.
- Local authorities and relevant stakeholders should ensure that this development is of a long-term character.
- All agencies responsible for air quality monitoring should commit themselves to co-operate intensively on various topics, e.g. in the area of standardisation of new sensors and networks.

Thank you for your attention!

moussio@auth.gr

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