AIRTEC-CM NEWS, JUNE 2020

https://airtec-cm.es/

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IN THIS ISSUE:

Welcome letter from the Project coordinator

Welcome to the first edition of the AIRTEC-CM newsletter. AIRTEC-CM (urban air quality and climate change integral assessment) is a scientific programme funded by the Directorate General for Universities and Research of the Greater Madrid Region (S2018/EMT-4329) and the European Union. In this issue we present the project and show some results from the first year of work.

This research programme builds on two previous projects: AIRBIOTA-CM; ("to know and model biological urban air pollution, atmospheric biota") and TECNAIRE-CM ("innovative techniques for the assessment and improvement of urban air quality, anthropogenic pollution"). The main objective of this collaborative research is to understand the interactions, synergies and interdependencies among biotic and abiotic agents in the urban atmosphere along with meteorological factors in a climate changing scenario in the Greater Madrid region.

The Consortium is integrated by:

- Technical University of Madrid (UPM)
- Energy, Environment and Technological Research Centre (CIEMAT)
- Complutense University of Madrid (UCM)
- Spanish National Research Council (CSIC)
- Health Research Institute. Hospital Clínico San Carlos in Madrid
- Local administrations (air quality service of Madrid City Council and Greater Madrid Region)
- Associate companies

It is expected that this research project will eventually provide policy makers in the area of air quality, climate change and public health with the information and technology needed to design overarching strategies able to minimize the negative impacts related to atmospheric pollution, one of the main environmental concerns that cities worldwide face today.

AIRTEC-CM aims to consolidate and strengthen atmospheric research activities in the region in cooperation with the wider scientific community. Beyond scientific outcomes we hope that our work can contribute to rise awareness and to involve all relevant stakeholders in this challenging endeavour towards cleaner and healthier cities.

Rafael Borge
AIRTEC-CM coordinator

Introducing the AIRTEC project

www.airtec-cm.org

AIRTEC-CM intends to improve our understanding of the interactions of complex atmospheric phenomena that are ultimately relevant for exposure to air pollution and related risks for citizens. On the one hand, we further delve into monitoring and modeling techniques needed to depict emission, dispersion and physicochemical transformation of pollutants in our cities. On the other, we continue to work in the characterization of biotic elements in our atmosphere (pollen, bacteria and fungi among others) that may have significant implications from the public health perspective too. In addition, we try to provide a better view of their interdependencies and their links with weather, something particularly important in a context of rapidly changing climate.

This is a very novel approach and it is expected to produce a significant impact, considering both the scientific dimension of the project and the applicability and practical interest of the investigation proposed. Our consortium gathers a wide range of scientist and technicians from very different areas of engineering, natural sciences and health related disciplines that work together to explain how anthropogenic pollutants interacts with biotic agents and how both depend on the chemical composition of the atmosphere and meteorological processes. In addition, AIRTEC-CM includes several companies, organisms and other groups and researchers with complementary scientific expertise.

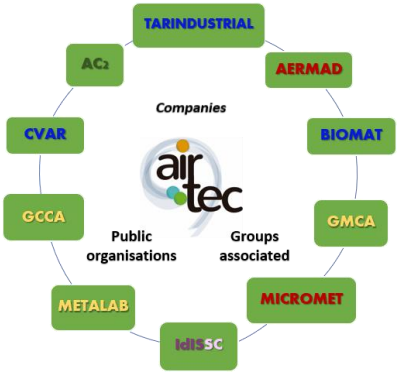
To achieve this general goal, the participants share, revise and harmonize measurements from previous projects and carry out additional experimental campaigns to fill relevant gaps of information in order to produce the extensive databases required to support these comprehensive spatio-temporal analyses. These measurements include conventional and novel techniques such low-cost sensors or 2D/3D observations from optical remote sensing devices as well as sampling from moving vehicles and flying drones. Both outdoor and indoor air quality data will be collected in these experimental campaigns. All these measurements will be complemented with the results with numerical simulations suitable to compare, explain and reproduce the observations.

AIRTEC-CM combine state of the science air quality models to achieve a consistent representation of the multiple temporal and spatial scales involved relevant to urban air quality: from the global scale to the street scale. Furthermore, indoor air quality simulations will be done to let us understand the implications of outdoor air quality inside buildings and public transportation means. This information will be instrumental to describe the full exposure cycle of people living in urban areas and thus, to propose better informed, scientifically sound policies and measures. Special attention will be paid to the study of atmospheric dynamics to anticipate the outcome of potential emission abatement measures, not only over regulated pollutants that promote such air quality plans, but to the comprehensive response of the main health relevant biotic and abiotic components of the atmosphere.

This will provide the necessary basis to identify optimal strategies to improve urban air quality considering their implications for climate change too. To do so, we also propose to study how all these atmospheric interactions may evolve in the future in the prospect of different climate change scenarios as well as potential mitigation and adaptation options specifically for the Madrid region. AIRTEC-CM intends to bring this knowledge and developments to society and to make a real impact on citizens wellbeing. For that we will work in close cooperation with local administrations to co-create harmonized strategies to tackle both air quality and climate change issues.

The consortium

The consortium is integrated by ten research groups from two public universities and three public research institutions as well as two public administrations, and several companies



TARINDUSTRIAL

Technical University of Madrid (UPM)

The Technical University of Madrid (UPM) is the oldest and largest Spanish technical university, with more than 4,000 faculty members, around 38,000 undergraduate students and 6,000 postgraduates in 21 Schools of study including most of engineering disciplines. The Industrial Engineers' School dates from 1809 and is host to the UPM research group on Environmental Technologies and Industrial Resources (**TARINDUSTRIAL**), framework for the research activities of the participants involved in this project.

This group has promoted and participated in tens of R&D projects, mainly in the air quality modelling field, funded by public administrations (national, regional and local) as well as private companies including the development and analysis of atmospheric emissions, impact assessment studies and Life-Cicle-Assessment (LCA) studies. Within the research group on Environmental Technologies and Industrial Resources, the Laboratory of Environmental modelling has a long experience in the assessment of air quality via multiscale modelling techniques including on-line models as well as model inventory development and integration for both anthropogenic and biogenic sources.

UPM

BIO-MAT

Technical University of Madrid (UPM)

The Research Group on Bioengineering and Materials **BIO-MAT** was created in 1986, at the Industrial Engineers' School of the Technical University of Madrid (ETSII-UPM), focusing its research lines on the interaction between materials and microorganisms, so its main activity has always been linked to the environmental and industrial applications: Biofilms, Biofouling, Microbial Corrosion, Biodeterioration, Biodegradation and Bioremediation, Molecular Microbiology and Biotechnology, Nanotechnology, Biomaterials and New Materials and Behavior of Materials in Service.

The BIO-MAT Group is composed of a multidisciplinary team of engineers, chemists, physicists and biologists with extensive experience in Microbiology and Biotechnology. Some of its members belong to the Boards of Directors of the SEM (Spanish Society for Microbiology) and the IBBS (International Biodeterioration and Biodegradation Society).

CVAR

Technical University of Madrid (CAR-UPM)

Computer Vision and Aerial Robotics CVAR – is a Research Group at CAR-UPM whose activities are oriented to two main objectives:

UAV autonomous complex missions using on board sensors (i.e. vision and LIDAR) and computing to fly in environments where GPS is not available (e.g. indoors) or where GPS doesn't provide enough accuracy (e.g. industrial inspection and/or maneuvers close to obstacles). We have our own open source framework for operating autonomous our missions www.aerostack.org .

Autonomous image/video recognition and detection using Machine Learning, e.g. DL, as well as Image Processing techniques, mainly used for aerial images an also for other kind of images. Reinforcement Learning for controlling UAV is also one of our main research topics, based on both direct visual info and pose estimation. Some of our projects can be seen in www.vimeo.com/vision4uav

The consortium

AER-MAD
Complutense University of Madrid (UCM)

AER-MAD belongs to the consolidated research group of the UCM Aerobiology, which has been developing its research in this field since 1994. It integrates 5 UCM researchers and three external members who actively collaborate in the work of the group, since they belong to the PALINOCAM Network and are responsible for the management of this Network in the field of public health. In the last ten years, in addition to basic and applied research in Aerobiology, it has worked on the development of short and medium term prediction systems for various aerobiological parameters, for the most clinically relevant aeroallergens, and on the possible impacts of climate change on them. Finally, as part of the AIRBIOTA-CM Project, it has participated in the study of atmospheric biological particles using emerging technologies in molecular biology.

UCM

MICROMET
Complutense University of Madrid (UCM)

The **MICROMET** group belongs to the UCM consolidated Research group "Micrometeorology and Climate Variability" which was founded in 2005, being actually integrated by 24 members (including 6 permanent University Professors). This consolidated group has published in the last six years more than 60 papers in different peer-reviewed international journals and has presented more than 100 contributions to Conferences and Workshops. Moreover it has been granted with 12 research projects (MINECO, UE, etc), and since 2008, ten PhDs have been presented and more than 25 MSc projects have been supervised within the 'Meteorology and Geophysics' Master. This group brings to the project its experience in boundary layer meteorology processes and atmospheric turbulence, key issues in the air quality research.

GMCA
Research Centre for Energy Environment and Technology (CIEMAT)

GMCA Group is a National benchmark for simulation of air quality, with over 20 years experience and leadership of the thematic network on Air Pollution Modelling (RETEMCA).

GMCA aims to deepen the understanding of the processes of air pollution. Pollution processes are being modelled on several scales to supplement the experimental approach to characterization. Work is ongoing in development and improvement of emission, meteorological and dispersion models, as well as computerized pollution prediction and control systems. All of this makes it possible to provide technical assistance to government and private companies in air quality assessment, control, prediction and improvement.

It includes projects aimed at developing atmospheric models at different scales and their practical application in the investigation of the processes of air pollutants and the air quality assessment, monitoring, prediction and abatement.

GCCA
Research Centre for Energy Environment and Technology (CIEMAT)

This group is hosted by the Atmospheric Pollution Characterization Unit belonging to the Department of Environment of CIEMAT (Center for Research on Energy, Environment and Technology). The research team is highly skilled in techniques of measurement and analysis of a wide variety of ambient parameters related to atmospheric pollution and meteorology. This capacity allows the group to address different issues related to the experimental characterization of atmospheric pollutants, in some cases through novel and state of art techniques (SMPS, HTDMA, ACSM, DOAS, LIDAR) which provide nonstandard parameters and a deep knowledge on processes involved in the formation and transformation of pollutants in the atmosphere.

The consortium

CIEMAT

AC2 - CSIC

Spanish National Research Council

The Atmospheric Chemistry and Climate group (**AC2**) belongs to CSIC's Institute of Physical Chemistry Rocasolano (IQFR), and its research is focused on the role of atmospheric composition and chemistry in the climate system. The goals of the group are to explore and analyse the interactions between natural and anthropogenic emissions, and the biosphere, as well as the numerical description, through mathematical models, of the variables involved. Within this scientific framework, AC2 provides an integrated research approach combining atmospheric measurements (satellite and ground-based), modelling (microphysical to global chemistry-climate) and laboratory studies (photochemistry).

H. Clínico San Carlos

METALAB

Research Centre for Energy Environment and Technology (CIEMAT)

This laboratory belongs to the Department of Environment of CIEMAT (Center for Research on Energy, Environment and Technology). **METALAB** is at charge of the atmospheric aerosol and the gas pollutant characterization, being able to study their physical and chemical properties. To this aim, it is possible to determine the aerosol particle mass and number concentration (High-volume samplers, TEOM and particle counters), the mass distribution (cascade impactors), the particle size distribution (SMPS and optical devices), the particle hygroscopic properties (HTDMA), the chemical composition (ACSM) and the optical properties (nephelometers, aethalometers, ceilometers…). About the gas pollutants a DOAS (Differential Optical Absortion Spectrometry) is used at CIEMAT site together with monitors for NO_x, O_3, VOCs,… At the same time, portable sensors are available to perform field campaigns.

CSIC

IdISSC

Health Research Institute

The Vascular Biology Group at the Health Research Institute of the Hospital Clínico San Carlos is a multidisciplinary group whose main area of investigation is the identification of the molecular mechanisms of the cardiovascular disease, mainly the inflammatory process associated to atherosclerosis and heart failure, as well as the identification of new therapeutic approaches.

The goal of this group will be to study the relationship between air pollution and the gut microbiota and its implication in the development of the cardiovascular disease.

Management committee

TARINDUSTRIAL

Rafael Borge leads the Laboratory of Environmental Modelling at the Department of Chemical and Environmental Engineering of the Technical University of Madrid (UPM).

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Associate professor at this same University and Visiting Scientist at the Harvard, School of Public Health he runs courses on environmental engineering, air quality and environmental modeling. He holds a degree on Forestry and Environmental Engineering and a Ph.D. on atmospheric modeling from UPM (2006).

Adolfo Narros PhD in Analytical Chemistry at the Complutense University of Madrid. Associate Professor in the Industrial Engineering School of the Technical University of Madrid. Main research area is Environmental Chemical Analysis.

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AERMAD

Adela M. Gutiérrez Bustillo is a full-time Professor of Botany at the Department of Pharmacology, Botany at Pharmacognosy and Botany at the Faculty of Pharmacy, at Universidad Complutense in Madrid (UCM).

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From 1993 the basic and applied research in Aerobiology has been her priority. She is the Technical Director of the Madrid´s Autonomous aerobiological net PALINOCAM, focusing her investigation on the analysis of aerobiological information for descriptive purposes, on performing predictive models for atmospheric pollen and on the study of palynological trends.

AC2 - CSIC

Alfonso Saiz-Lopez studied Chemistry in Ciudad Real, Spain. In 2005 he received his Ph D degree in Atmospheric Physical Chemistry at the University of East Anglia, focused on absorption spectroscopy for atmospheric measurement and marine boundary layer halogen chemistry. After a brief postdoctoral stay at the University of Leeds, he was a NASA Postdoctoral Scholar at the Jet Propulsion Laboratory and Research Associate at the Harvard-Smithsonian Center for Astrophysics. Since 2009, he is a Senior Research Scientist at the Spanish National Research Council (CSIC) and an Affiliate Scientist at the NCAR.

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BIO-MAT

Ana M. García is the Head of the Research Group on Bioengineering and Materials (BIO-MAT) at the Technical University of Madrid (UPM). She holds a B.Sc. in Biological Sciences from the Universidad Complutense de Madrid and a PhD from the UPM.

Her main research line is the interaction between microorganisms and materials in the industrial and environmental area. She has been involved in more than 30 projects including private and government-funded, as well as consultancies and contracts with private companies. Currently, she is an Associate Professor at the UPM.

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CVAR

Pascual Campoy is Full Professor on Automatics at the Universidad Politécnica Madrid UPM (Spain) where he lectures on Control, Machine Learning and Computer Vision. He has been visiting professor TUDelft (NL) from 2014 to 2019, at Tong Ji (Shanghai-China) in 2013 and Q.U.T. (Australia) 2011.

He is leading the Research Group on "Computer Vision and Aerial Robotics" at UPM. within the Centre of Automatics and Robotics (C.A.R.), whose activities are aimed at increasing the autonomy of the Unmanned Aerial Vehicles (UAV) by exploiting the powerful sensor of Vision, using cutting-edge technologies in Image Processing, Control and Artificial Intelligence.

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GCCA

Begoña Artíñano is Head of the Atmospheric Pollution Characterization Unit at CIEMAT and responsible of the Climate Change Programme of this public research organism.

She has more than 30 year of experience in atmospheric sciences, in the fields of meteorology, micrometeorology and atmospheric pollution. During the last 15 years, she has focused her activity on particulate matter/atmospheric aerosol field (air pollution assessment and study of microphysical and chemical aerosol properties). She has leaded or participated in more than 50 research projects on these areas focused on urban and industrial emissions and their air quality and climate change impact.

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Management committee

GMCA

Fernando Martín obtained his PhD in Atmospheric Modelling in 1988 in the Complutense University of Madrid, where he was Assistant Professor in the Atmospheric Physics Department from 1989 to 1991.

Since 1991 he has worked in the Research Centre for Energy, Environment and Technology (CIEMAT) as scientist. He is the Head of the Atmospheric Pollution Division of CIEMAT.

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METALAB

Francisco J. Gómez Moreno is graduated in Chemistry and PhD in Physics. He currently works at the Unit of Atmospheric Pollution and POC at CIEMAT. He has 27 years of experience in the field of aerosol.

Behavior, the last 13 applied in air pollution. Since 2003 he is involved in the area of atmospheric pollution: secondary aerosol formation, aerosol size distribution and their hygroscopic properties. He worked previously in developing instrumentation to characterize aerosols and in validation of filtration systems.

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MICROMET

Carlos Yagüe obtained his BSc degree in Physics at the Complutense University of Madrid (UCM) in 1988, and after a scholarship for postgraduate studies at the University of Cambridge (UK) in 1990 obtained his PhD in 1993 at UCM.

From 1992 to 1996 he was an assistant lecturer on atmospheric physics and in 1996 he joined the National Meteorological Service (AEMET) working as operational forecaster as well as researcher. Since 2003 he was Associate Professor at the Complutense University and from 2019 Full-Professor at the Department of Physics of the Earth and Astrophysics at UCM. carlos@ucm.es

IdISSC

Dulcenombre Gómez Garre obtained her BSc degree in Biology at the *Autónoma University of Madrid* in 1989 and her PhD with Honors in Molecular Biology at the same university in 1995. Since 2007 she leads the Laboratory of Vascular Biology

Research and Microbiota of the Health Research Institute of the Hospital Clínico San Carlos in Madrid (IdISSC). She is more than 25 years experienced in molecular mechanisms of cardiovascular diseases. She has published over 60 original publications and has participated in 30 research projects. She is reviewer of several scientific journal and of EIT Health Innovation Projects.

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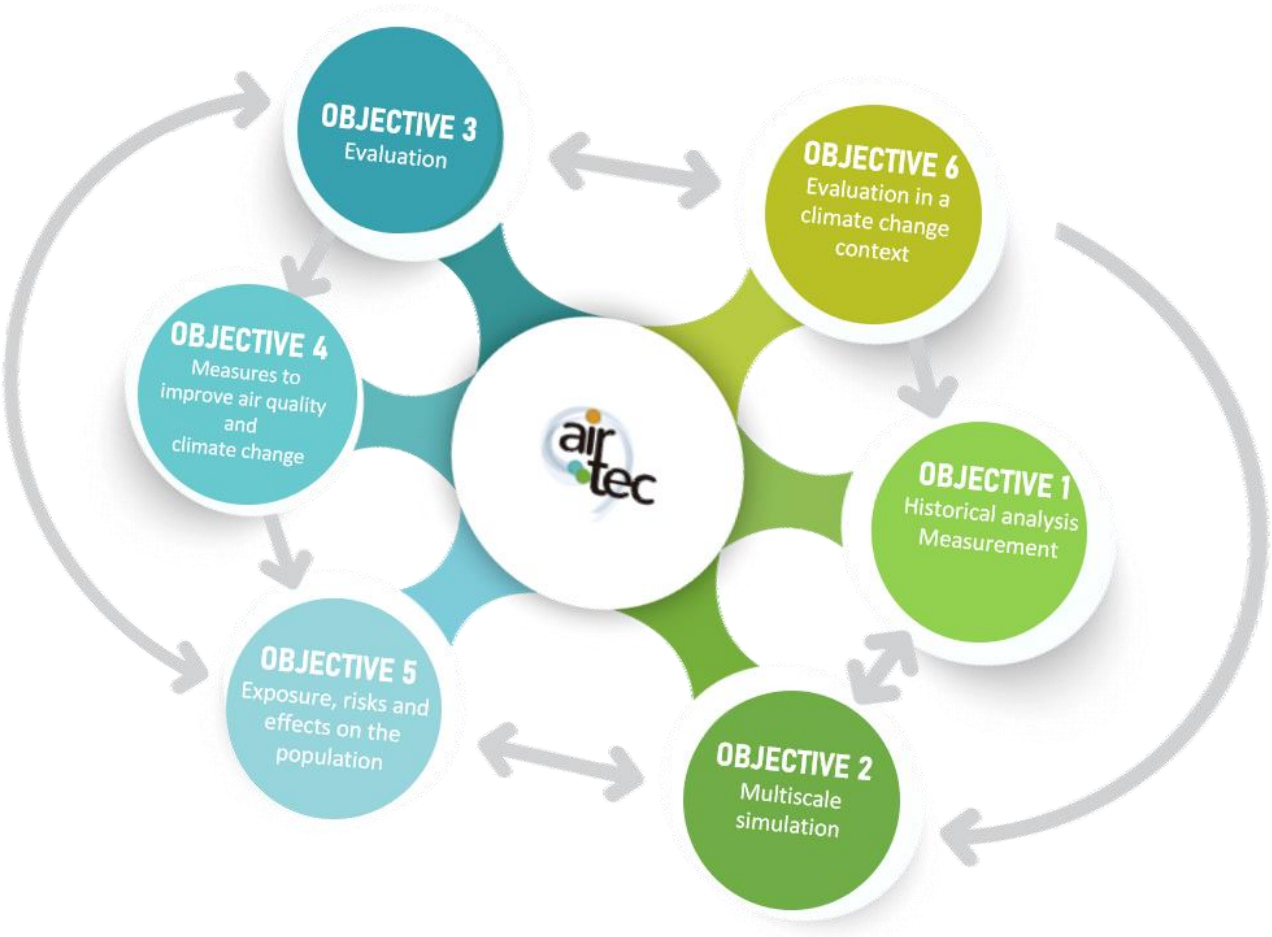
AIRTEC-CM Scientific and Technical Committee, november 2019

Objectives and Working program

OBJECTIVES



- 1. HISTORICAL ANALYSIS AND MEASUREMENT
- 2. MULTISCALE SIMULATION
- 3. EVALUATION
- 4. MEASUREMENT TO IMPROVE AIR QUALITY AND CLIMATE CHANGE
- 5. EXPOSURE, RISKS AND EFFECTS ON THE POPULATION
- 6. EVALUATION IN A CLIMATE CHANGE CONTEXT

Objectives and Working program

"The activity to develop the research objectives in the first year has focused on the ETSII experimental campaign"

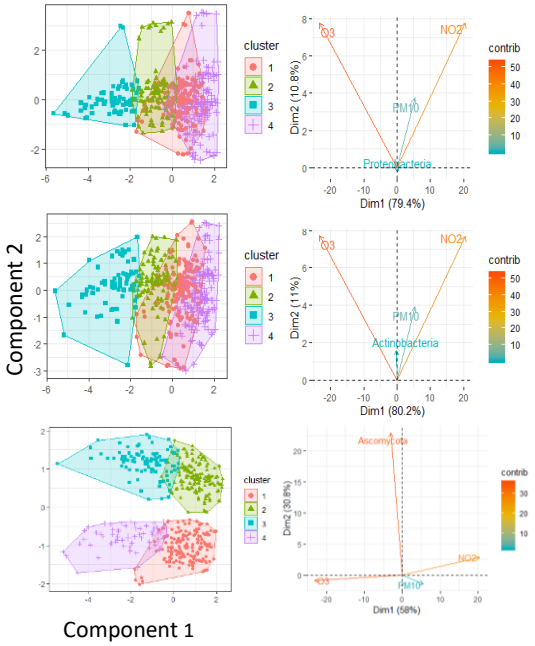
OBJECTIVE 1

Historical analysis measurement. Historical analysis and measurement to characterize the interactions between the biological, physical and chemical characteristics of the atmosphere

1. **Analysis of historical data available under different methodologies.**

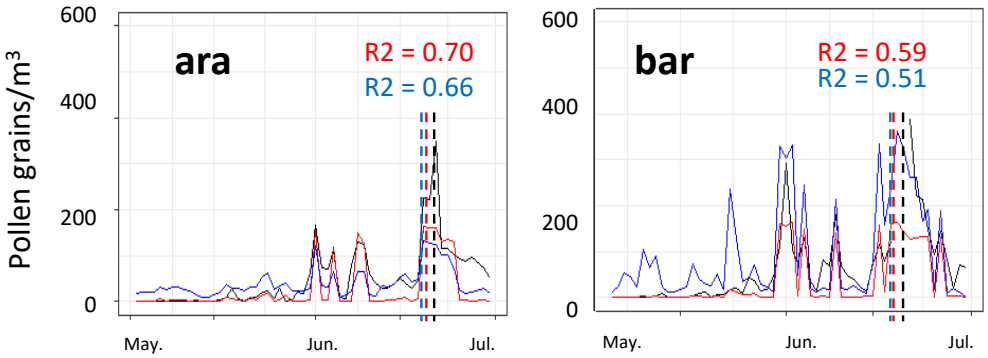
A common exploitation of previous results (air quality, meteorology and biotic parameter databases) was conducted to investigate correlations and interactions between biotic (bacteria, fungi and pollen) and abiotic (NO_x, O_3, PM…) agents for various spatial and temporal scales, identifying and characterizing specific phenomena, like:

- ✓ African dust outbreaks among others.
- ✓ Biotic/Abiotic relationships. A methodology to analyse the data including descriptive statistics, k-means unsupervised clustering, hypotheses contrast test, and modelling with Generalised Additive Models (GAMs) was developed. The right figure shows the output of the k-means clustering using the abiotic variables as clustering factors as an example. A good separation into four clusters was achieved for the fungi phyllum Ascomycota, revealing that some relationships should exist and hence must be further studied.



Cluster plot (left) and PCA biplot (right) using the relative abundances of each phylum and air quality features (daily average concentration of NO_2, O_3 and PM_{10}.

✓ Allergenic pollen peaks prediction. As a first work, an ensemble including Artificial Neural Networks (ANNs) and Light Gradient Boosting models (LGBMs) was applied to predict the Olea pollen concentration. The figure below shows the Olea time-series along with the predictions from the models including the entire time-series Olea pollen concentrations and the moment of the peaks.



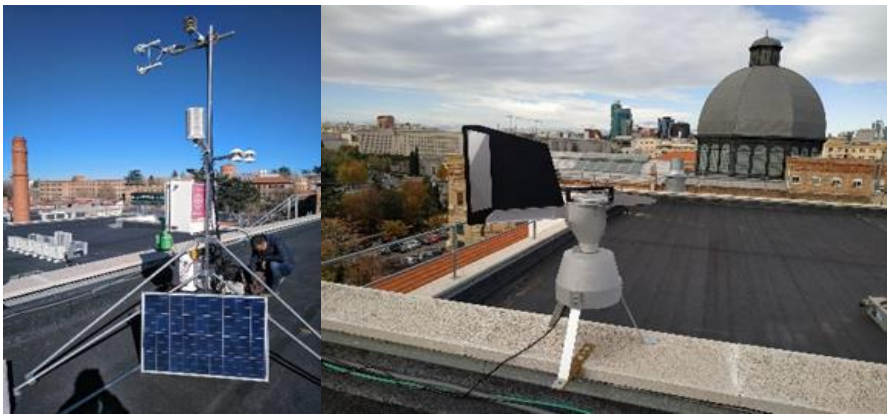
Time series of observed Olea concentration (black line) and the predictions of the ensembles LightGBM (red line) and ANN (blue line) at Aranjuez (ara) and Barajas (bar) in the year 2018. The predicted peak_PS from the models are displayed as vertical lines.

Objectives and Working program

2. Continuous/spot sampling, through a weather station and a Hirst type volumetric trap at the ETSII

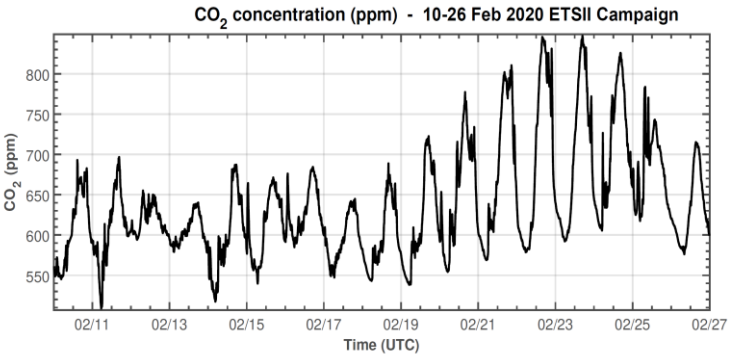
In addition to the bacteria and fungi records collected during 2015-2017, a Hirst type volumetric trap was installed at the ETSII (UPM) and air samples have been taken since May 2019 to identify biological particles. These biological data will be enriched with weather information (temperature, relative air humidity, wind speed and direction) from a meteorological station located close to the sampling point.

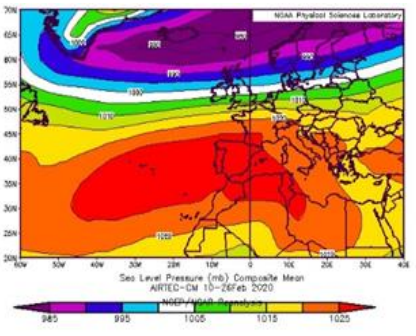
Additional information regarding air quality can be obtained from nearby measurement stations such as the one located in Paseo de la Castellana, about 50 m from the ETSII. Altogether, very precise data on biological, physicochemical, and meteorological variables at the sampling point will be acquired.



Meteorological station (left) and Hirst-trap (right) on the rooftop of the ETSII.

✓ CO_2 monitoring by means of a portable meteorological station installed at the ETSII





CO_2 monitoring winter campaign, where the maximum concentrations are attained during a high stability anticyclonic period (left) and composite surface pressure map during the field campaign (right).

Objectives and Working program

3. **Experimental, measurement campaigns to complement existing data and fill gaps in information needed to obtain such correlations**

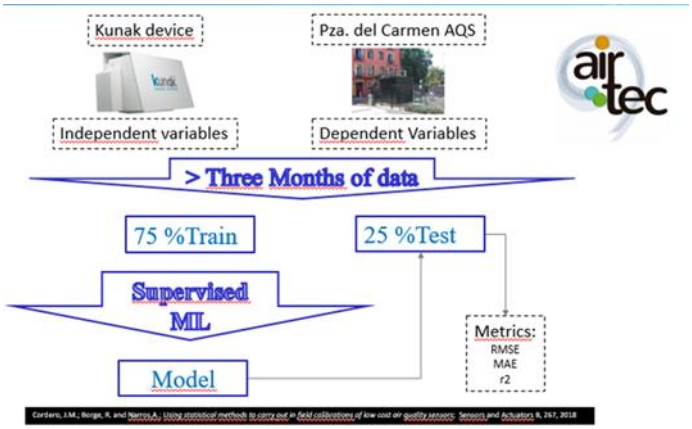
   ❖ **Calibration campaign at Plaza del Carmen air quality station**

   8 Eco Controller from Automated Devices air quality electrochemical sensors (NO_2, O_3 from Membrapor), like the one shown in figure below, and 1 Kunak KA-10 also fitted with electrochemical sensors (NO, NO_2, O_3, SO_2, CO from Alphasense) data were collected along three months from October 2019 to December 2019 for the development of self-calibration algorithms

Sensors in the Plaza del Carmen air quality station (AQS)

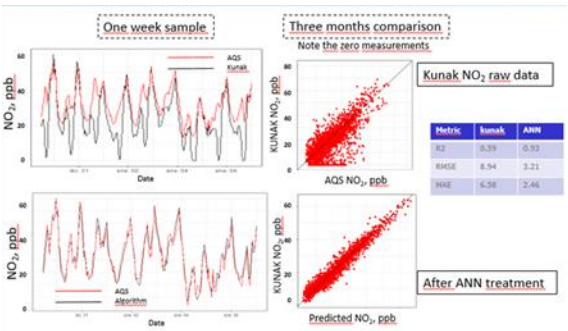
Automated Devices Eco Controller air quality sensors

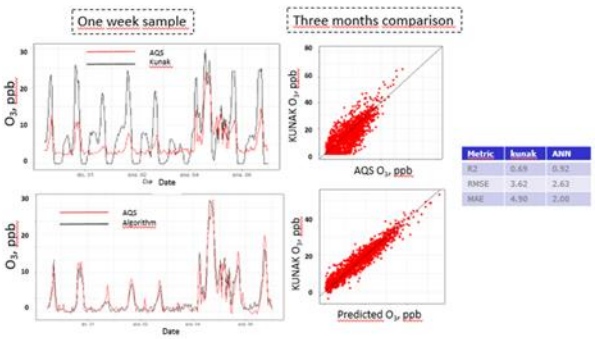
Kunak A-10 device and cloud software



Data post-processing based on machine learning algorithms

The Eco Controllers and the KUNAK devices were calibrated previously following a machine learning algorithm. Eco Controllers did not have a preliminary processing by the proprietary and hence only electric signals not directly comparable to AQS were given. Satisfactory results regarding the calibration of the NO_2 and O_3 sensors for the KUNAK device are illustrated below.



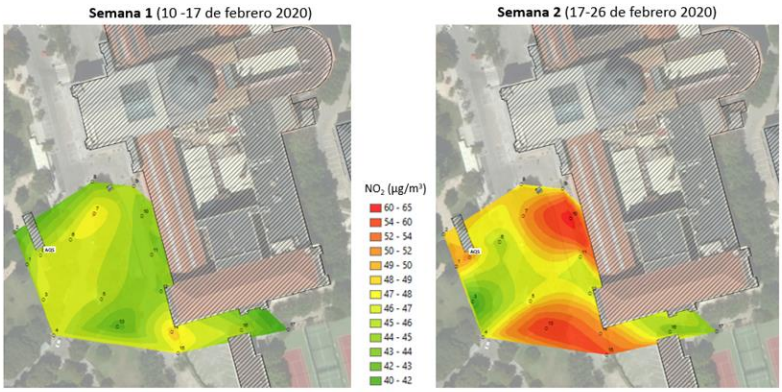


Calibration of the O_3 sensor in the Kunak device

Objectives and Working program

❖ Indoor-outdoor campaign

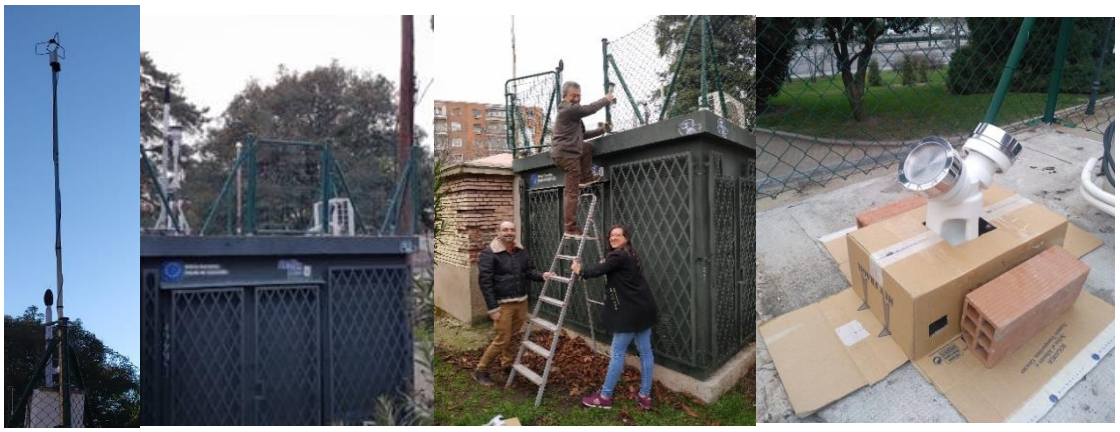
The Winter experimental Campaign at the ETSII, has been carried out from the 10th to the 26th of February 2020. Up to 17 passive sampling tubes were deployed around the ETSII at the points shown to provide high-resolution 1-week maps to characterize specific indoor/outdoor exchange rates



NO_2 concentration maps around the ETSII from the passive tubes data

Passive sampling tubes locations around the ETSII

Biological particles were also collected in a daily routine during the winter campaign using a DUO SAS Super 360 air sampler (right side picture in the figure below) in order to study the indoor and outdoor relationships.



Sonic anemometer and DUO-SAS sampler at Castellana Air Quality Station (AQS) rooftop.

Indoor (within a room inside the ETSII) and outdoor pollution levels were measured regarding the following species;

- PM_{10}, $PM_{2,5}$, PM_1, NO_2 and black carbon

Indoor pollution monitoring (GRIMM365)

Objectives and Working program

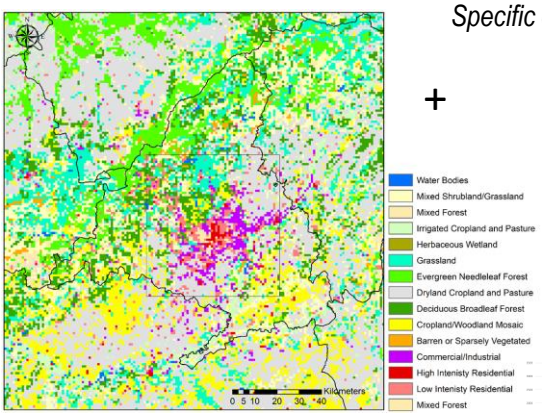
OBJECTIVE 2

Air quality multiscale simulation

1. Development of emissions inventories
2. Mesoscale simulation
3. Microscale simulation

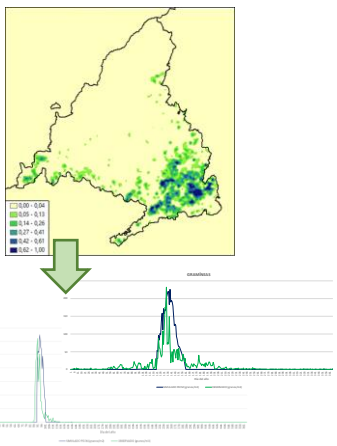
This objective brings together an important part of the simulation work at the regional, local and microscale level, including indoor environments in order to understand the dynamics of air pollution with support other activities

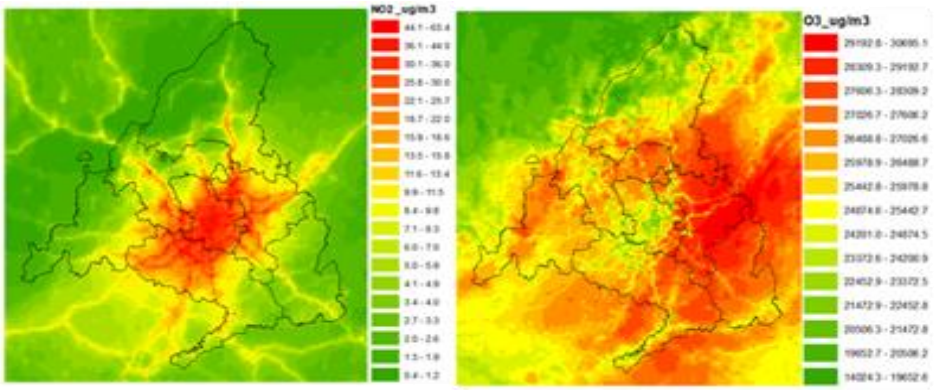
1. During the first year, emission inventories have been revised and chemical speciation profiles updated, including the information needed to include halogen chemistry in our mesoscale simulations. As for biogenic emissions, land uses and vegetal species definition have been improved for a better estimation of natural VOCs and pollen.
The conceptual framework for pollen integration in the mesoscale chemical-transport model has been developed



1 km² land use of the Greater Madrid Region modelling domain

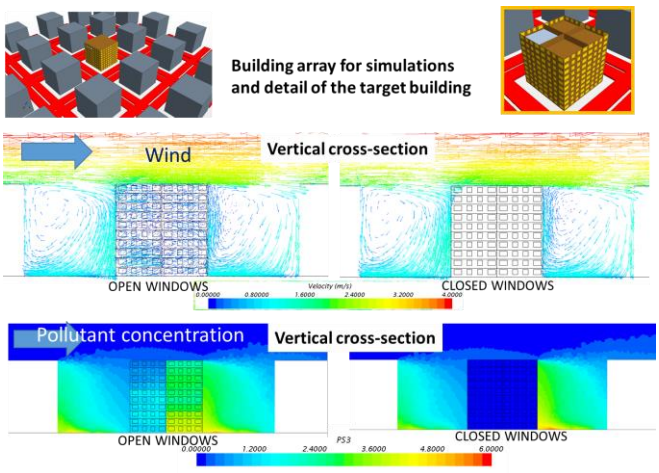
Specific distribution of allergenic species





2. Mesoscale air quality simulations made to support objectives 1, 4 and 6 (WRF-SMOKE-CMAQ modelling system)

NO_2 annual mean (left) and O_3 AOT40 (right)



3. CFD modeling is being used to simulate the atmospheric pollution in the surroundings and inside a building located in the center of an ideal building array with the aim to understand how the outdoor pollutants are coming inside the buildings. This is a simplified scenario. Real cases corresponding to measuring campaigns will be also simulated.

Wind flow and pollutant distribution for the cases of all windows closed and all windows opened

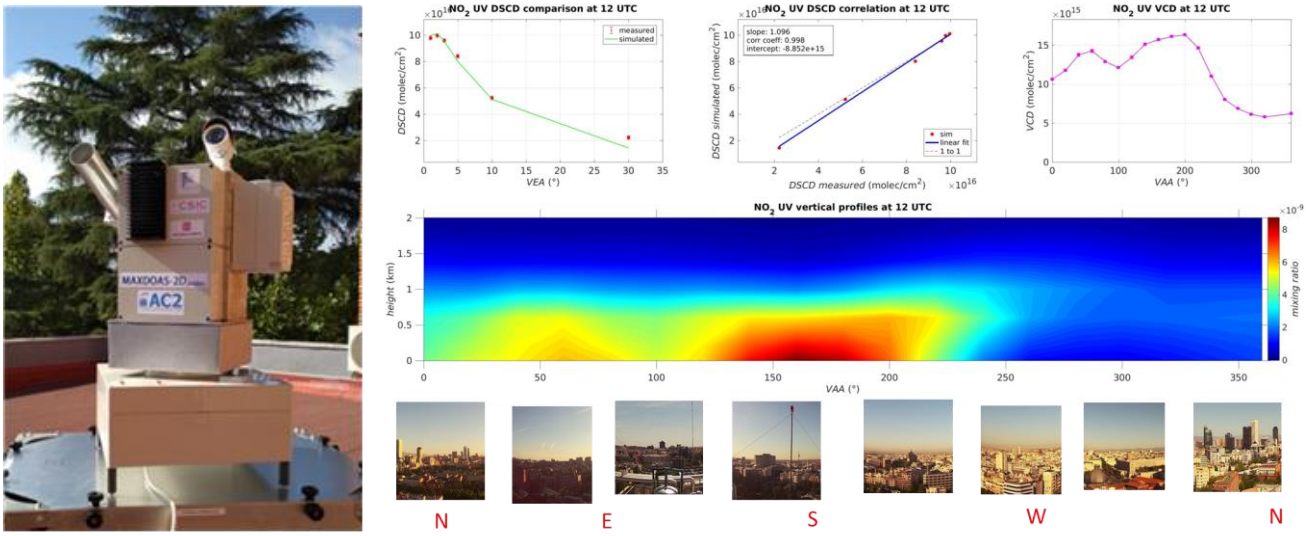
Objectives and Working program

OBJECTIVE 3

Evaluation

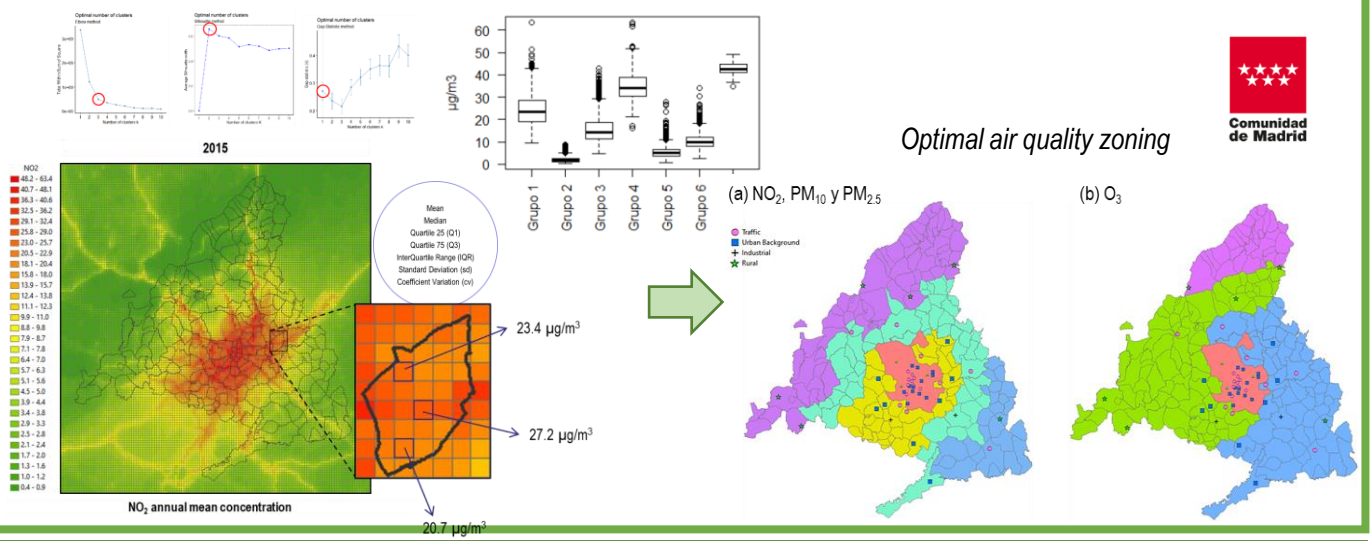
The activity within this objective aims at the integration of various data sources to evaluate the simulations to be performed within the project (1). On the other hand, it aims to evaluate air quality monitoring strategies in order to contribute to their harmonization and improvement, both in terms of biotic and abiotic compounds (2).

1. A MAXDOAS-2D device based on the atmosphere absorbance is being used to measure the vertical profiles of different pollutants (NO_2, O_3…) given a Viewing Azimuth Angle (VAA). In order to do this, the spectral absorptions produced within the solar spectra due to the presence of these trace gases in the atmosphere is analyzed.



The MAXDOAS-2D instrument (left) and NO_2 concentration at 12 UTC

2. AIRTEC-CM developed a novel methodology to define zones to control and manage air quality required by the European Air Quality Directive (AQD) (2008/50/EU). We reproduced all relevant indicators according to the legislation (NO_2, $PM_{2.5}$, PM_{10} and O_3) from an annual mesoscale air quality model run with 1 km^2 resolution to characterize all the municipalities in the Madrid region. Then, we applied a k-means clustering algorithm to identify municipalities with similar air quality features that could conform homogeneous zones.



Objectives and Working program

OBJECTIVE 4

Measures to improve air quality and climate change

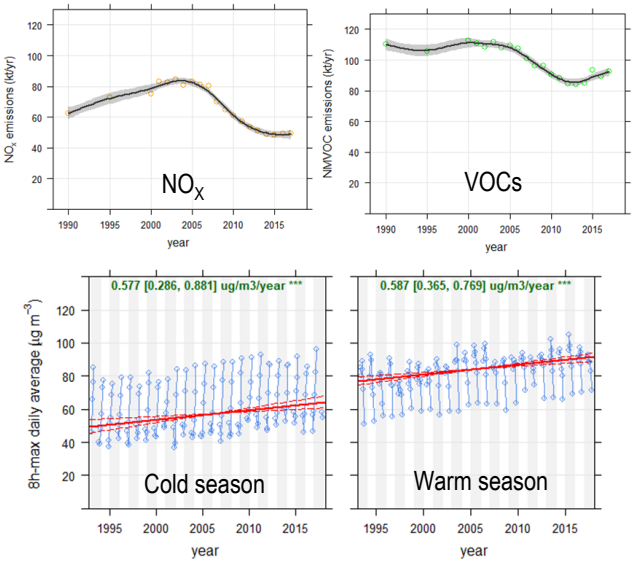
This objective aims at generate relevant information in order to develop improvement plans for urban areas of the Community of Madrid, integrating and harmonizing air quality and climate change goals..

1. Analysis of atmospheric photochemical dynamics (both from the analysis of historic records and from a modelling perspective
2. Analysis of local policies and measures to improve air quality and climate change.

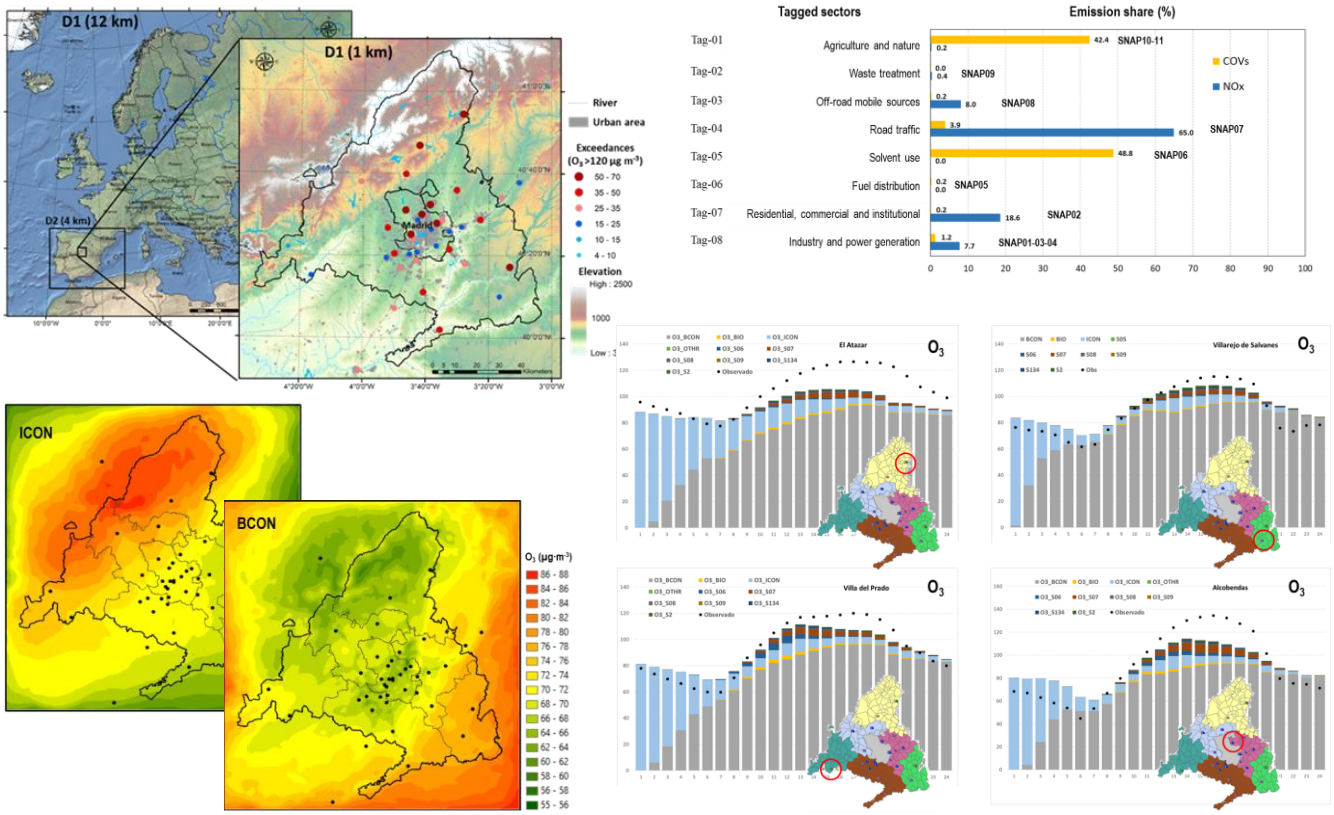
Short lived climate pollutants (SLCP) are particularly interesting to integrate air quality and climate change policies. We have analyzed the trends and influence of weather on ozone trends.

On the other hand, we have looked into the formation processes and emission source apportionment through the Integrated Source Apportionment Method (ISAM) to identify the contributions to summer ground-level O_3 in the Madrid region

Emission trends in the Madrid Greater Region (CM official inventory)



Aggregated O_3 trends in Madrid Greater Region



Modelling domains and observational dataset (top left), tagged sectors (top right), average contribution from initial and boundary conditions (bottom left) and detailed averaged source contribution at selected locations (bottom right)

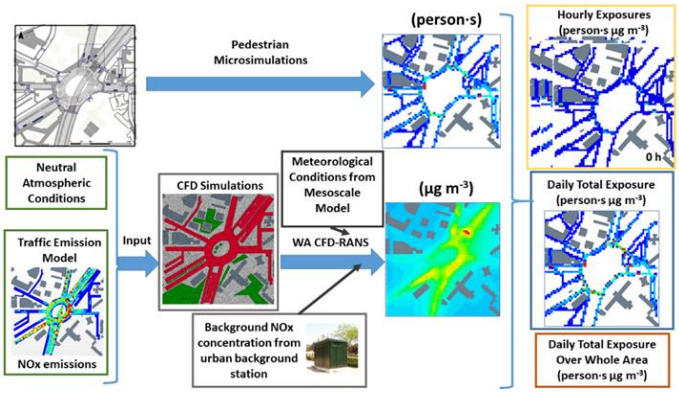
Objectives and Working program

OBJECTIVE 5

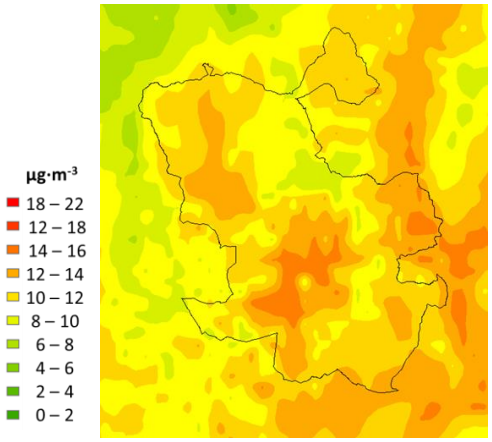
Exposure, risks and effects on the population

The work under objective 5 is devoted to the development of new methods to assess population exposure and to provide better links with health risks. We intend to explore different tools, datasets and methodologies to improve our understanding of overall exposure to air pollution at different spatial and temporal scales.

Computation of the very high resolution pedestrian exposure to atmospheric pollution: in order to quantify in detail, the pedestrian exposure to air pollutants (NOx) in an urban traffic hot spot, high spatial resolution concentration maps based on CFD simulations are combined with the pedestrian flows estimates obtained by VISSIM-VISWALK microsimulations (also used to compute very high resolution emissions from traffic). This is a novel very high-resolution exposure methodology addressing the important challenge to evaluate the health impacts of air pollution.



Scheme of the very high-resolution exposure assessment methodology



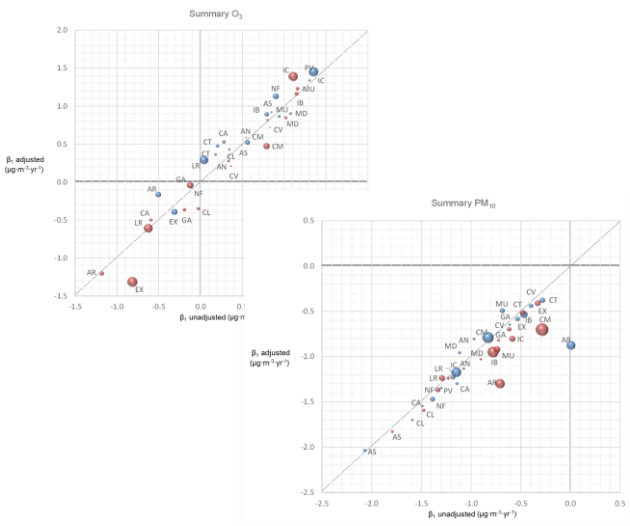
To understand the exposure at a larger temporal (several years) and spatial scale (the complete typical daily mobility patterns) of citizens we are estimating spatial-temporal PM distribution applying linear mixed effects models fed with relevant proxies and high resolution satellite data (MAIAC).
This information may be combined with personal mobility patterns (from massive data such as cell phone information) or data for specific cohorts (e.g. patients from Hospital Clínico San Carlos)

Satellite-derived 2015 $PM_{2.5}$ annual mean concentration

OBJECTIVE 6

Evaluation in a climate change context

Dynamic downscaling to provide high-resolution local scenarios under representative climate pathways will be performed within this objective and future-year simulations will be done to understand the role of likely weather changes in the atmospheric dynamics and its impact on plans and strategies.
As a starting point we have performed a statistical analysis over 30 years of 1-hour air quality data to isolate the effect of weather changes on observed trends. We used generalized additive models (GAMs) to disentangle the influence of recent weather changes on air pollution. This information provides a reference regarding likely future trends and implications for emission abatement strategies.



Weather penalties for O_3 and PM_{10} in different regions of Spain over the 1993-2017 period

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In progress:

"Statistical analysis of the relationships between atmospheric microorganisms and abiotic factors in Madrid" Cordero JM., Núñez A., García A.M, Borge R.

"Predicting the Olea pollen concentration with a machine learning algorithm ensemble". Cordero JM., Narros A., Gutiérrez-Bustillo AM., de la Paz, D., Borge R.

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