AIRTEC-CM NEWS, NOVEMBER 2021

https://airtec-cm.es/

UNIÓN EUROPEA
Fondos estructurales
Invertimos en su futuro

Comunidad de Madrid

IN THIS ISSUE:

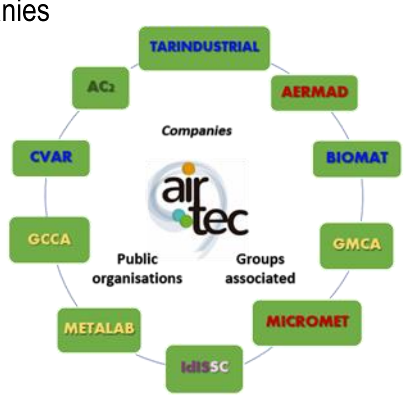
What is the project about? Where are we?

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. We aim at improving our understanding of the interactions, synergies and interdependencies among biotic and abiotic agents in the urban atmosphere along with meteorological factors in a climate changing scenario. The recent outbreak of the Coronavirus disease 2019 (COVID-19, related to the pathogen SARS-CoV-2) highlighted the need for a holistic approach to air quality where chemical and biotic factors are taken into account. Under a wider perspective, the pandemics demonstrated the urgency to intensify our efforts to alleviate the burden of disease of air pollution. At the same, time, the year 2020 provided an unparalleled demonstration of the potential contribution of non-technical measures to abate emissions and thus, improve air quality in urban environments. All research groups within AIRTEC-CM continue to work to meet this challenge.

Consortium

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



Other researchers and companies involved

TARINDUSTRIAL

- Borge García, Rafael (PI and programme coordinator)
- Narros Sierra, Adolfo
- Cordero Días, Jose Maria
- De Andrés Almeida, Juan Manuel
- De la Paz Martín, David
- Jung, Daeun
- Lumbreras Martín, Julio
- Perez Rodriguez, Javier
- Pons Martí, Amalia

AERMAD

- Gutiérrez Bustillo, Adela Monserrat (PI)
- Cervigón Morales, Patricia
- Ferencova, Zuzana
- Rojo Ubeda, Jesús

AC2 - CSIC

- Saiz López, Alfonso (PI)
- Alkorta Osoro, Ibon
- Cuevas Rodriguez, Carlos Alberto
- Lebrón Aguilar, Rosa
- Quintanilla López, Jesús Eduardo
- Serna Ruiz, Jesús Angel

GCCA

- Artíñano Rodriguez de Torres, Begoña (PI)
- Coz Diego, Esther
- Diaz Ramiro, Elias
- Molero, Menéndez, Francisco de Asis,
- Núñez Martí, Lourdes
- Palacios Gomez, Magdalena
- Salvador Martinez, Pedro

BIO-MAT

- García Ruiz, Ana M (PI)
- Núñez Hernández, Andrés

CVAR

- Campoy Cervera, Pascual (PI)
- Molina González, Martín
- Dominguez Cabrerizo, Sergio
- Rodriguez Vázquez, Francisco Javier

GMCA

- Martin Llorente, Fernando (PI)
- Santiago, Jose Luis
- Martilli , Alberto
- Rivas Ramos, Esther

IdISSC

- Gómez Garre, Dulcenombre (PI)
- Abad Cardiel, Maria
- Álvarez de arcaya Vicente, Aranzazu
- Garcia Donaire, Jose Antonio
- Martell Claros, Nieves
- Modrego Martin, Javier
- Ortega Hernández Adriana

METALAB
LABORATORIO RED-374

- Gómez Moreno, Francisco Javier (PI)
- Fernández García, Francisco Javier

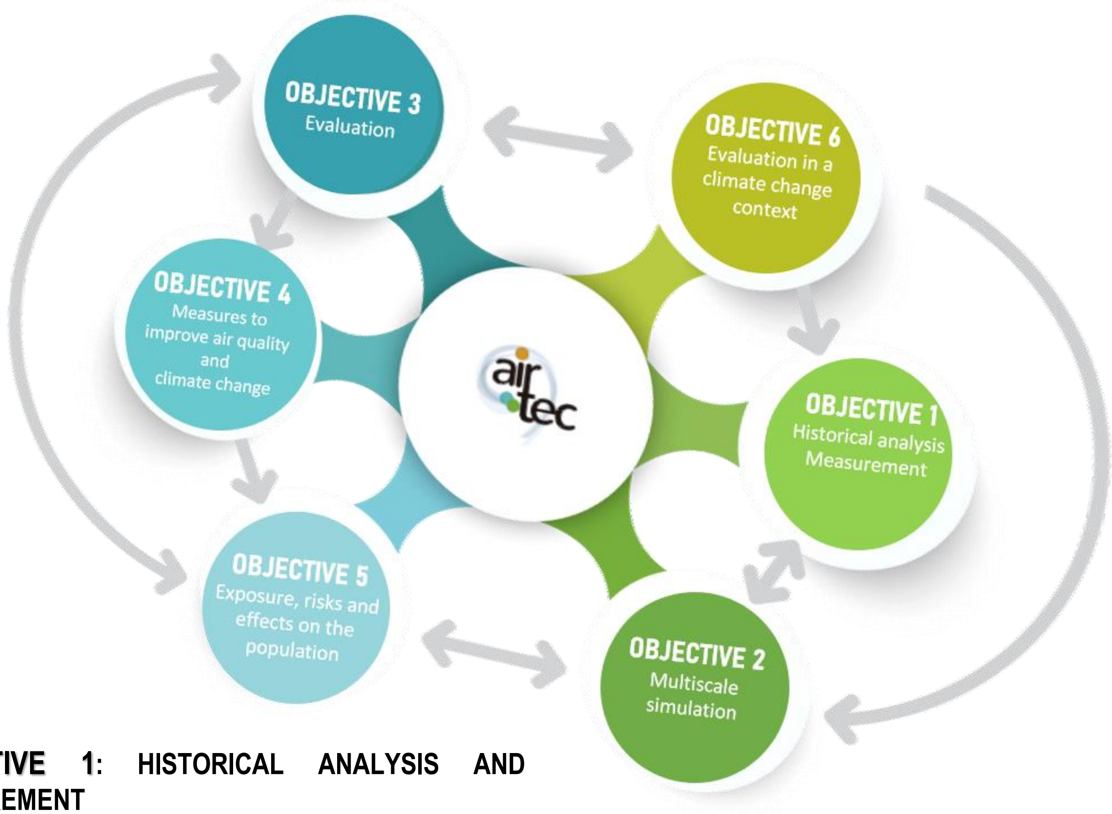
MICROMET

- Yagüe Anguis, Carlos (PI)
- Maqueda Burgos, Gregorio
- Román Cascón, Carlos
- Sastre Marugán, Mariano
- Serrano Mendoza, Encarnación

Companies involved in 2020-21:

Objectives and Working program

OBJECTIVES and RECENT DEVELOPMENTS



OBJECTIVE 1: HISTORICAL ANALYSIS AND MEASUREMENT

1. Analysis of historical data available under different methodologies.

2. Relations between the local-scale meteorology and the concentrations of different pollutants, such as NO_2, or particle matter (PM).

3. Experimental, measurement campaigns to complement existing data and fill gaps in information needed to obtain such correlations at reference sites:

a) ETSII (Winter Campaign, 10th - 26th February 2020, Summer Campaign, 14th June 2021 – 6th July 2021).

b) Hospital (Summer Campaign 23th June-11th July 2020, Winter Campaign, 8th February 2021 – 26th February 2021).

OBJECTIVE 2: MULTISCALE SIMULATION

1. Emission inventory update.
2. Mesoscale simulation. Simulation System update.
3. Microscale simulation.

OBJECTIVE 3: EVALUATION

1. Calibration of KUNAK devices.
2. Assessing WRF meteorology model.
3. Assessing CMAQ Air Quality Model performance

OBJECTIVE 4: MEASUREMENT TO IMPROVE AIR QUALITY AND CLIMATE CHANGE

1. Impact of COVID-19-related restrictions on local emissions.

2. Meteorology-normalized method to estimate the true air pollution reduction during the COVID-lockdown period.

3. Impact of ventilation of indoor and semi indoor environments on SARS-CoV2 dispersion.

4. Source Apportionment assessment to understand potential measures to reduce NO_2, PM and O_3 ambient concentration levels in the Madrid region

OBJECTIVE 5: EXPOSURE, RISKS AND EFFECTS ON THE POPULATION

1. Exposure, risks and effects on the population.

2. Estimating $PM_{2.5}$ concentrations in the city of Madrid in 2015.

OBJECTIVE 6: EVALUATION IN A CLIMATE CHANGE CONTEXT

1. Evaluation in a climate change context (Dynamic downscaling).

Objectives and Working program

OBJECTIVE 1

“The activity to develop the research objectives in the second year has focused on the experimental campaigns”

OBJECTIVE 1

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

Analysis of historical data available under different methodologies.

<u>Evaluation of the influence of different factors determining the microbial composition of the urban atmosphere</u>

The airborne biological particles composition from 11 different sites around the Community of Madrid, with different degree of urbanization and at different seasonal periods along 2 years were analyzed.

As shown in Figure 1, the main bacterial and fungal genera were present in all the locations and seasons with similar contribution. The contribution of the most abundant bacteria was mostly steady along seasons, while the abundance of fungi showed a marked seasonality.

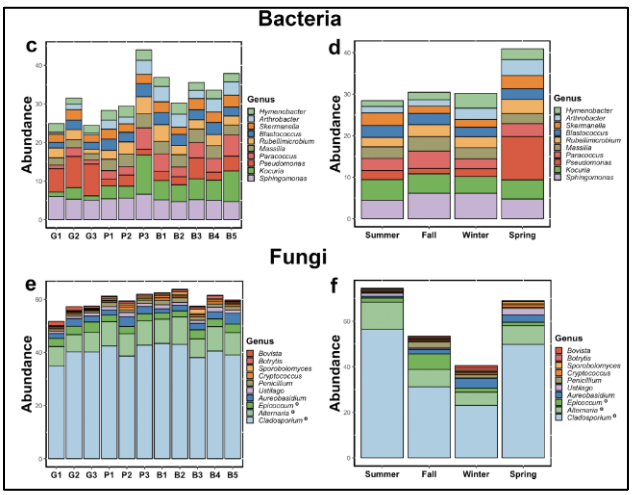


__Figure 1__.Contribution of bacteria (upper panels) and fungi (bottom panels) throughout different locations (left panels) and seasons (right panels) [Núñez et al, 2021]

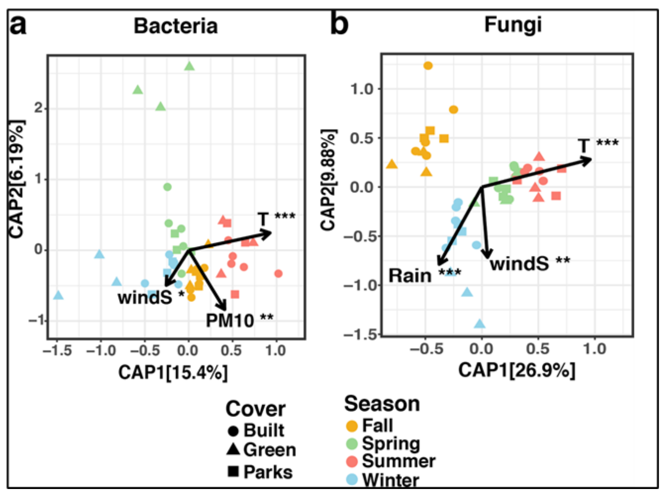


__Figure 2__.Main environmental factors explaining seasonal changes in the airborne microbial composition. [Núñez et al, 2021]

Temperature (T), Wind speed (windS) and Precipitation (Rain) are the most influential environmental factors driving the seasonal changes in the airborne microbial composition and abundance. (Figure 2).

“Microbial communities in the atmosphere of Madrid are very stable at spatial and temporal scales, and they are modulated by meteorological factors, mainly temperature and accumulated rain, associated to seasonal changes. Local sources and the degree of urbanization play a minor role”

Objectives and Working program

OBJECTIVE 1

2. **Relations between the local-scale meteorology and the concentrations of different pollutants, for example NO_2, NO_x ,or particle matter (PM).**

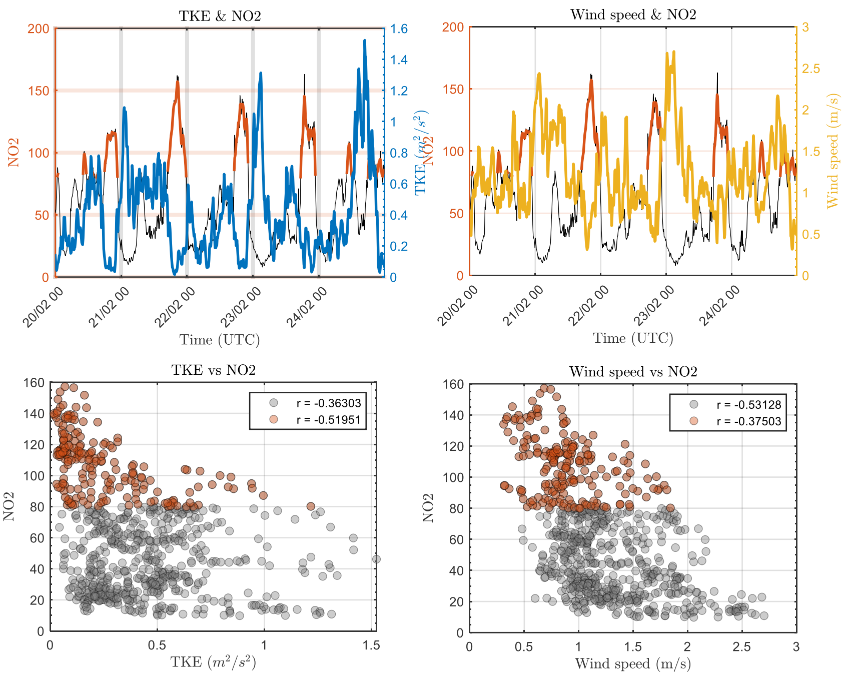


***Figure 3**. Relation between TKE and NO_2 concentration (top and bottom left), Relation between wind speed and NO_2 concentration (top and bottom right).*

The MicroMet Research Group looked into the statistical correlations between wind speed and pollutants concentration during different periods with contrasting characteristic (including Stable Boundary Layer periods: SBL). These correlations are compared with those obtained using some turbulent parameters calculated from sonic anemometers data, which can sample the air at high-frequency (20 data per second). The typical parameters calculated are the turbulent kinetic energy (TKE) or the friction velocity (u*), which include information about the turbulence (the diffusion) in the air, and whose values are typically used in numerical modelling.

Understanding the role of the different scales of the eddies contributing to turbulence (Sensible Heat –SH- for example) is of particular interest to improve our understanding of urban air pollution dynamics.

***Figure 4** Instrumentation monitoring pollution, weather and turbulence..*

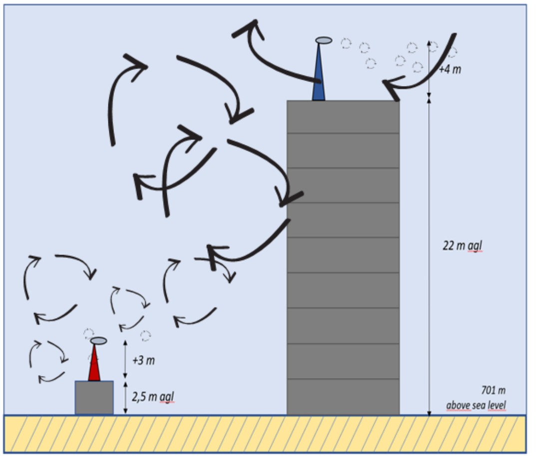


***Figure 5.** Diagram illustrating the two sonic anemometers installed during the ETSII field campaigns, as well as an hypothesis of the eddies distribution.*

Objectives and Working program

OBJECTIVE 1

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

Results from recent Indoor-Outdoor experimental campaigns

a) ETSII I (Winter Campaign, 10th - 26th February 2020)

Biological particles were collected in a daily routine during the campaign using a DUO SAS Super 360 air sampler in order to study the indoor and outdoor relationships.

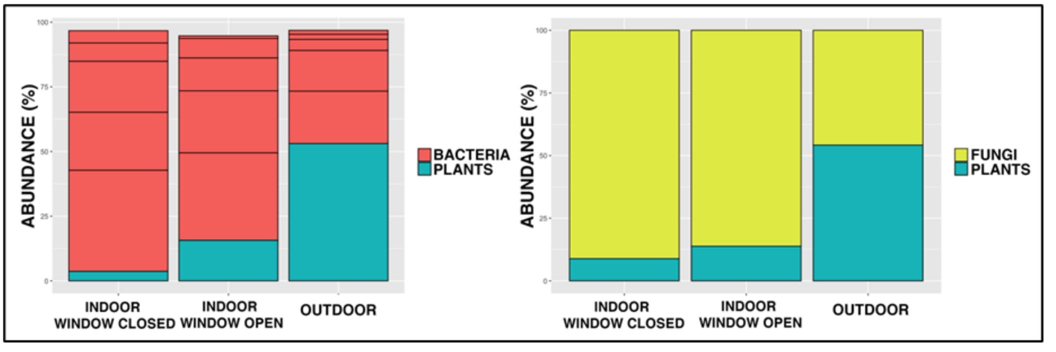


***Figure 6**. Bioaerosols composition (left: Bacteria; right: Fungi) for the different samples collected.*

The biological particle composition showed remarkable differences between the samples collected indoors (Indoor Window Closed) and outdoors (Outdoors) (Figure 6).
Passive ventilation through window opening for two hours was not enough to balance the composition of bioaerosols between indoors and outdoors (Indoor Window Open vs Outdoor, Figure 6).

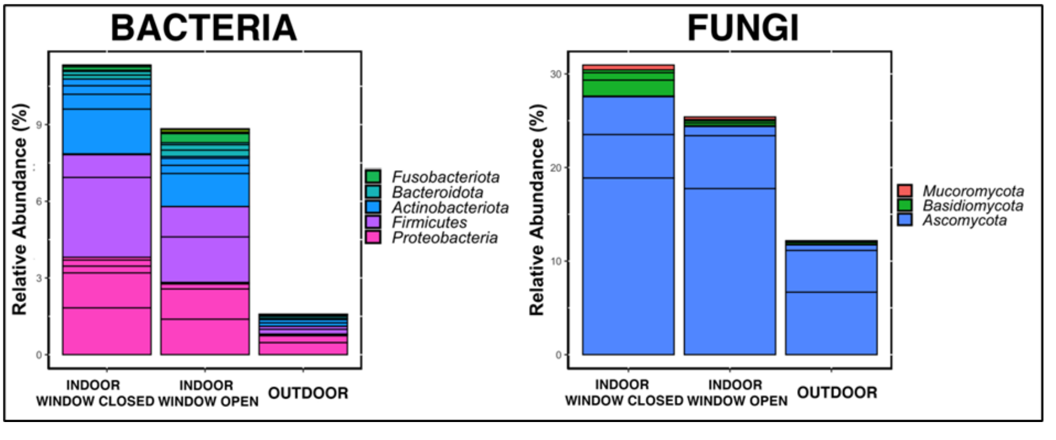


***Figure 7**.Contribution of bacteria (left) or fungi (right) related to human body by type of sample.*

Samples indoor were significantly enriched in human-related bacteria compared to samples outdoor and no effect from the window opening was detected (Figure 7, left). No remarked differences for fungi between indoor and outdoor were observed (Figure 7, right).

"Indoor and outdoor environments have different biological particle composition and natural ventilation through window opening has a low impact on the microbial composition"

Objectives and Working program

OBJECTIVE 1

In order to contrast results of biotic agents, we performed a statistical study with long time series from the AIRTEC-CM field campaigns. MICROMET deployed two sonic anemometers at different heights from the street level, one is located at the terrace of the main building of the Higher Technical School of Industrial Engineering and the other much closer to the street level.

They have performed different tests to check the effect of the processing typically applied for fluxes computation using the eddy covariance data, illustrating the importance of the location of the sensor.

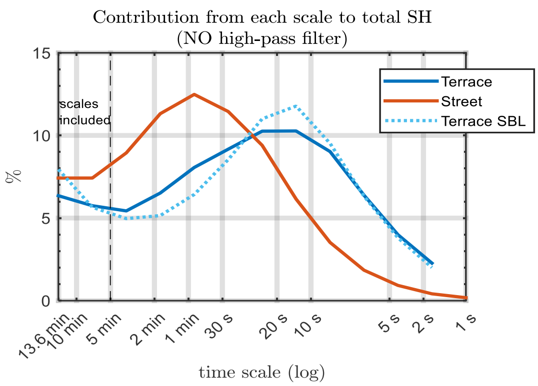


***Figure 8**. Contribution from each scale to total sensible heat flux (SH) NO high-pass filter.*

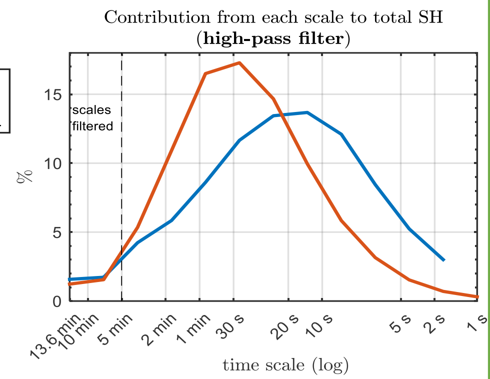


***Figure 9**. Contribution from each scale to total SH. High-pass filter.*

METALAB Group has participated in different experimental campaigns measuring background pollution levels and preparing instruments to be used in different sites during the campaigns. Previously, these instruments were tested and calibrated at the CIEMAT – METALAB facilities (if required).

CPCs were used to measure particle number concentrations. The comparison between CPCs used during the AIRTEC-CM campaigns and a reference instrument can be found in Figure 10. Both instruments show good correlations with the reference, the different slope being caused by slightly different particle size ranges (CPC Magic) or by flow rates fittings (CPC3772).

San Carlos Hospital

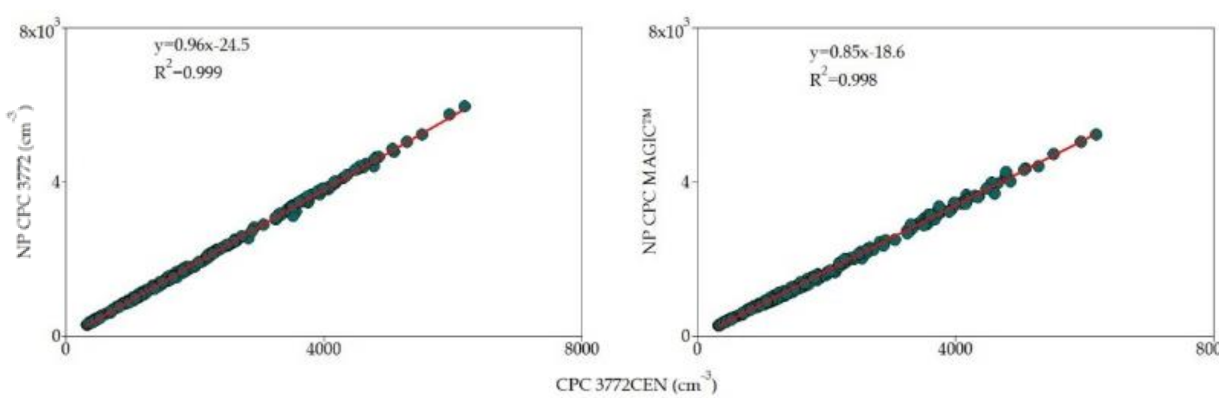


***Figure 10**. Intercomparison of applied CPCs with a reference instrument. Both instruments show good correlations with the reference.*

The microaethalometers used to measure BC in AIRTEC-CM were calibrated by LNE (France) in a cooperation campaign. Instruments used to measure pollutant gases (NO_x, O_3) were calibrated in METALAB with standard concentration gas bottles. Very good responses were obtained for both kinds of instruments during their calibrations. METALAB has also participated in the instruments deployed and maintenance during said campaigns.

Objectives and Working program

OBJECTIVE 1

b) ETSII II (Summer Campaign, 14th June 2021 – 6th July 2021)

The GCCA group participated in two field campaigns carried at the HCSC in winter (February 2021) and in the ETSII in summer (June 2021). A diversity of parameters for gaseous and particle air pollutants were measured in these campaigns. Measurements were performed both indoor and outdoor, with a high number of instruments. Ambient and indoor air pollutant concentrations were characterized during the campaign, during specific scenarios and during experiments especially designed to characterize outdoor/indoor fluxes.

Figure 11. *Field campaign placement and setup.*

Additionally, a microaetholemeter was attached to a UAV/ drone system to perform vertical profiles during flights and document BC evolution (in time and in vertical profile).

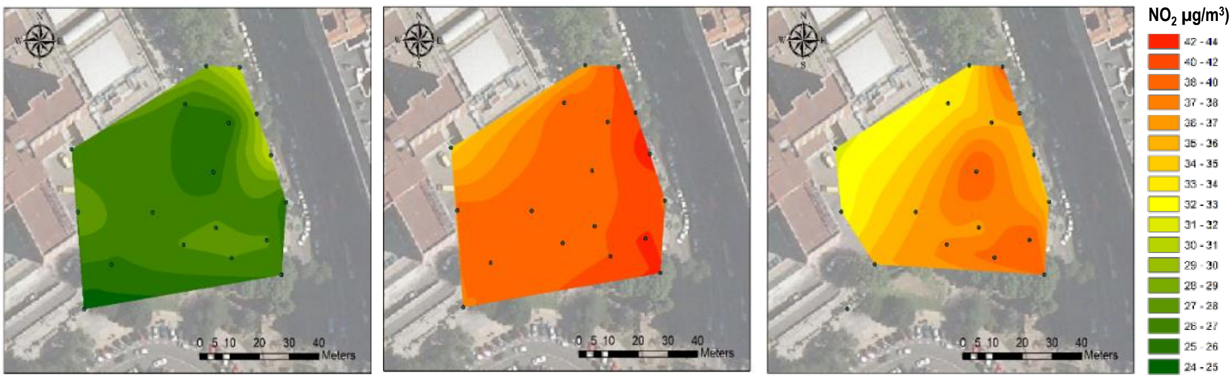
***Figure 12**. UAV with weathr sensors (T, P & HR) and Black Carbon monitor (“BC”) onboard.*

Objectives and Working program

OBJECTIVE 1

c) Hospital II (Winter Campaign, 8th February 2021 – 26th February 2021)

Three weeks of February 2021 were chosen to carry out one of the measuring campaigns inside the AIRTEC Project at the Hospital Clínico San Carlos. The dots reflect the position of the passive tube samplers used for NO_2 weekly-averaged measurement. The first week was characterized by strong winds whose turbulence dispersed the NO_2 and therefore was the week showing the lowest NO_2 concentrations. The other weeks showed higher concentrations close to the road and lower at the proximity of the Hospital walls. A Kunak device was also installed firstly outside a window to perform complementary measurements of NO_2, O_3 and particulate matter (PM_{10}, $PM_{2,5}$ y PM_1). Then, it was co-located with reference instruments of the mobile AQS (deployed by the Madrid City Council) for gathering data for its calibration.



Week 1
8 to 15 February 2021

Week 2
15 to 22 February 2021

Week 3
22 February to 1 March 2021

***Figure 13**. NO_2 concentratarion fields from passive samplers at San Carlos Hospital.*

The effect of the height of the building was also studied collocating passive tube samplers inside and outside the windows of the Hospital at different floors (heights). The results showed that despite the windy conditions generally the concentration was higher at the outside, as could be expected.

***Figure 14.** Madrid City Council mobil air quality station and co-location of Kunak device for calibration.*

	Winter February Campaign 2021		
Place	% Diff outside-inside 1st week	% Diff outside-inside 2nd week	% Diff outside-inside 3rd week
Mezzanine 4ª-5ª	11.8	7.8	4.9
Mezzanine 3ª-4ª	28.9	5.6	1.7
Mezzanine 2ª-3ª	19.6	6.0	1.3
Mezzanine 1ª-2ª	14.0	8.8	-3.4

***Table 1**. Percentual difference between outside and the inside NO_2 concentration of the Hospital at different heights.*

Objectives and Working program

OBJECTIVE 2

Air quality multiscale 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 for other activities.

1. Emission inventory update

The year 2018 was simulated with a four nested domain system, using CB6r3 ae6 as the speciation mechanism.

Europe (27km resolution): the emissions inventory used is EMEP 2018.

- 84 surrogates for spatial disaggregation, by sector and pollutant (CAMS, resolution 6 x 6 km)

Iberian peninsula (9km resolution): the National Inventory of Spain and Portugal + EMEP 2018 have been used.

- 215 area activities and 350 point sources of 76 activities Chemical Speciation (CB6r3 ae6) (>300 profiles).
- Spatial disaggregation (38 surrogates based on spatial coverage CLC2018, JRC 2018, MITMA, etc).

Central Peninsula (3km resolution):

- The National Inventory of Spain was utilized,
- 205 area activities and 85 specific activities (addition of 30 specific focuses),
- For spatial disaggregation, 42 surrogates based on CLC2018 spatial coverage, JRC 2018 and MITMA were used.

Community of Madrid (1km resolution):

- Combination of previous inventories and Chemical **Speciation** (CB6r3 ae6) (> 300 profiles).
- Segregation by fuels within SNAP 02 and SNAP 07 (386 activities in total).
- Spatial disaggregation (40 surrogates).

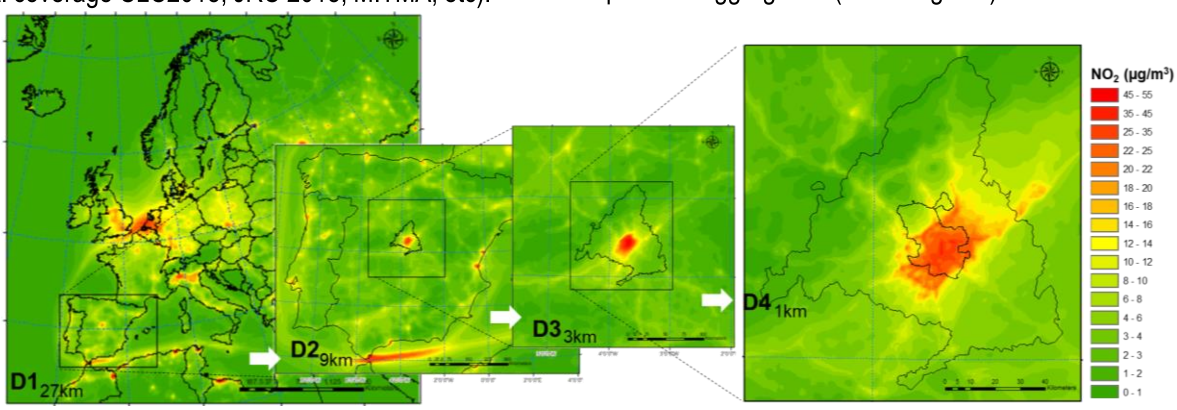


***Figure 15**. Nested domains showing average NO_2 concentration ($\mu g/m^3$)*

2. Simulation System update

All parts of the air quality modeling system have been updated to the latest versions. The new meteorological model (WRFv4.2.1) dates from July 22, 2020. The emissions model used to calculate anthropogenic emissions (SMOKEv4.8.1) dates from January 2021. Regarding biogenic emissions, the latest available version is MEGANv3.1, which dates from 2019. The chemical transport model used is the CMAQ v5.3.2, which dates from October 2020.

To achieve objective 4 and support other objectives, the chemical transport model (CMAQ) calculates source attribution information for user specified ozone and particulate matter precursors.

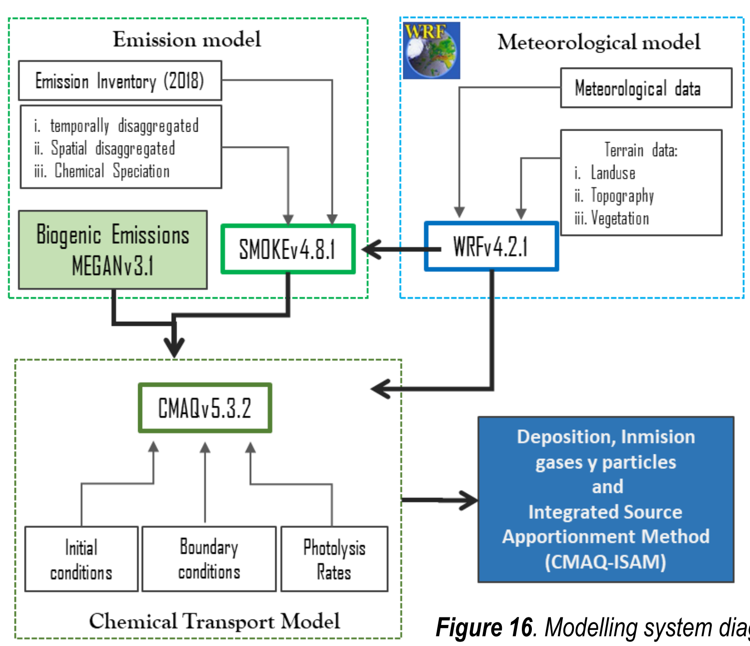


***Figure 16**. Modelling system diagram.*

3. Microscale simulation

CFD modelling has been applied to a target building located in the center of an idealized neighborhood to study airflows and pollutant dispersion from road traffic both indoor and outdoor. The aim of this work is to investigate the influence of external flow patterns on indoor air quality. Coming soon, this aim will be transferred to a real urban setting (corresponding to experimental campaigns): San Carlos Hospital (Madrid).

- ✓ Indoor concentration is dependent on the floor, configuration of open windows and wind direction.
- ✓ Indoor concentration decreases as room floor increases.
- ✓ In some cases, concentration in the lowest floor rooms is larger than the average concentration in the street.

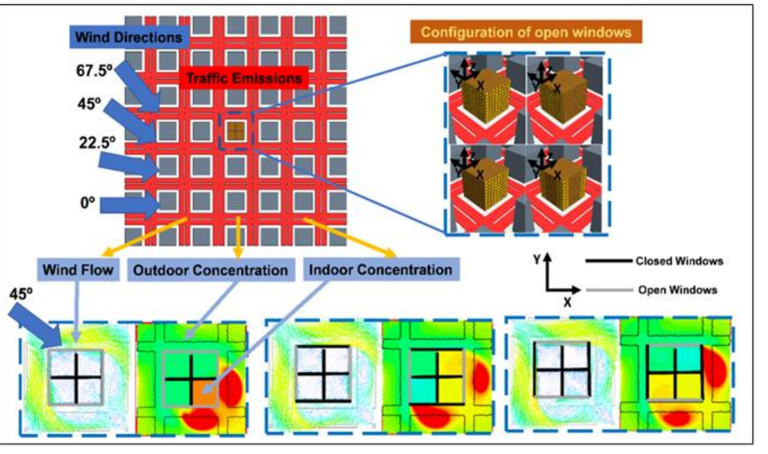


***Figure 17**. Above: Scheme of idealized neighborhood and configuration of open windows of the target building. Below: Wind flow and indoor and outdoor pollutant concentration depending on open windows configuration.*

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. Calibration of low-cost sensors

The device lent by the Kunak company for the AIRTEC-CM measurement campaigns was assessed. Performance and reliability of the data downloaded from the cloud was processed by an algorithm of the proprietary. We could further improve this accuracy by performing a 2-step calibration (refer to Cordero et al., 2018). Looking at the Figures, the time series from NO_2 and O_3 present some zeroes when the RH was low. However, the Artificial Neural Networks (ANN) corrected this effect among others, enhancing r^2 coefficient in 0.23 units for O_3 and in 0.34 units in NO_2. This method provided us with high accurate pollutant measurements with high temporal resolution.

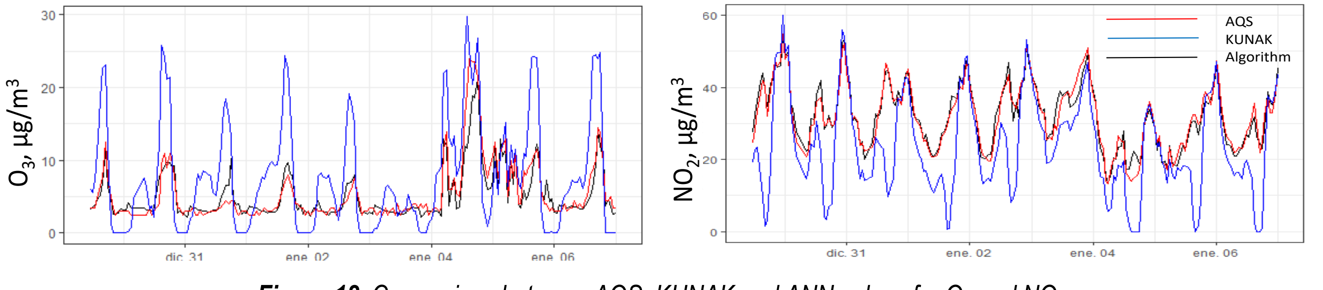


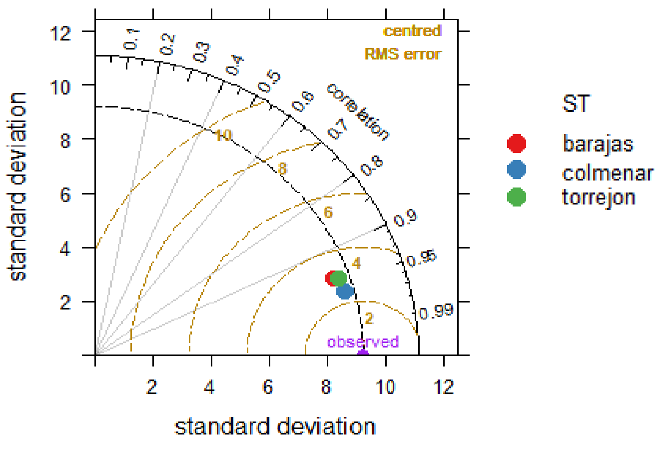
***Figure 18**. Comparison between AQS, KUNAK and ANN values for O_3 and NO_2.*

Metric	Kunak O_3	ANN O_3	Kunak NO_2	ANN NO_2
r^2	0.69	0.92	0.59	0.93
RMSE	6.32	2.76	8.94	3.10
MAE	4.90	2.00	6.58	2.34

***Table 2**. Comparison between AQS, KUNAK and ANN values for O_3 and NO_2.*

2. Assessing WRF meteorology model

An annual simulation for the reference year (2018) was completed. Meteorology was evaluated in the last nested domain with a resolution of 1 km^2. That includes the entire Community of Madrid and some surroundings.
Taylor Diagrams are commonly used to evaluate the model against the observations in atmospheric sciences. Predicted values from the simulation of temperature and wind speed at 10 meters have been evaluated by this method. These results show a correlation above 0.95 for temperature at the tested stations, showing also very low biases and error. For wind speed the results are worse but still good, with a correlation above 0.85 and considerably low errors and biases.



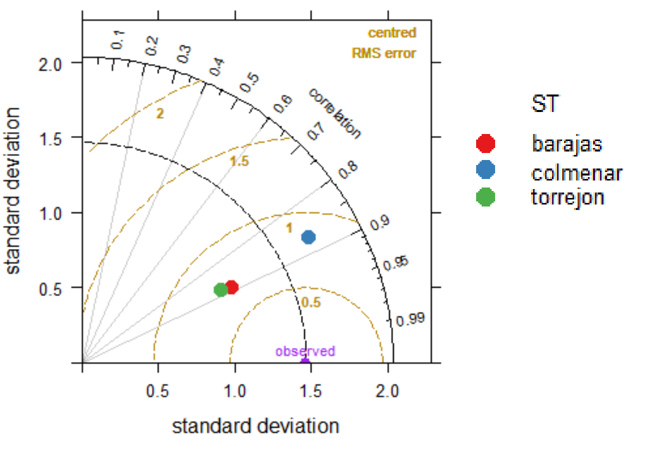


***Figure 19**. Taylor diagram showing a statistical comparison of WRF simulations for temperature (left) and wind speed (right)*

3. Assessing CMAQ Air Quality Model performance

The results shown in the figure belong to the annual simulation of Domain 3, which includes the center of the Iberian Peninsula and provides boundary conditions to the last simulation (domain 4, currently being executed).These results show the time series for NO_2 and O_3 concentration values for the traffic Air Quality Stations (AQS) at the Community of Madrid. As can be seen, in all cases the model captures accurately the absolute values and the timing of the peaks, although it works better in the case of O_3 rather than NO_2.

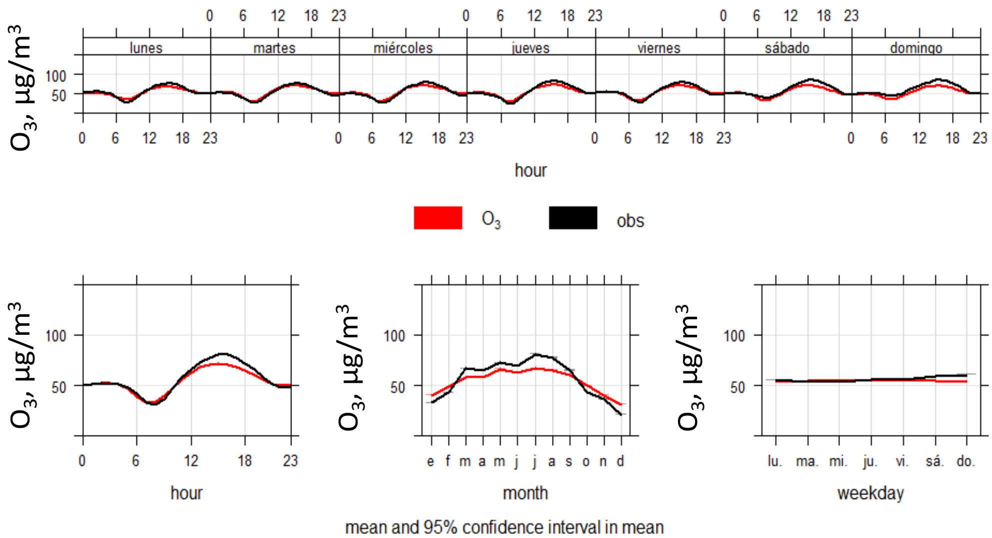


Figure 20. *Comparison between model predicted O_3 concentrations and observed O_3 concentrations.*

In the case of NO_2 the model seems to underpredict the concentrations. This situation has been found as general rule for the rest of AQS.

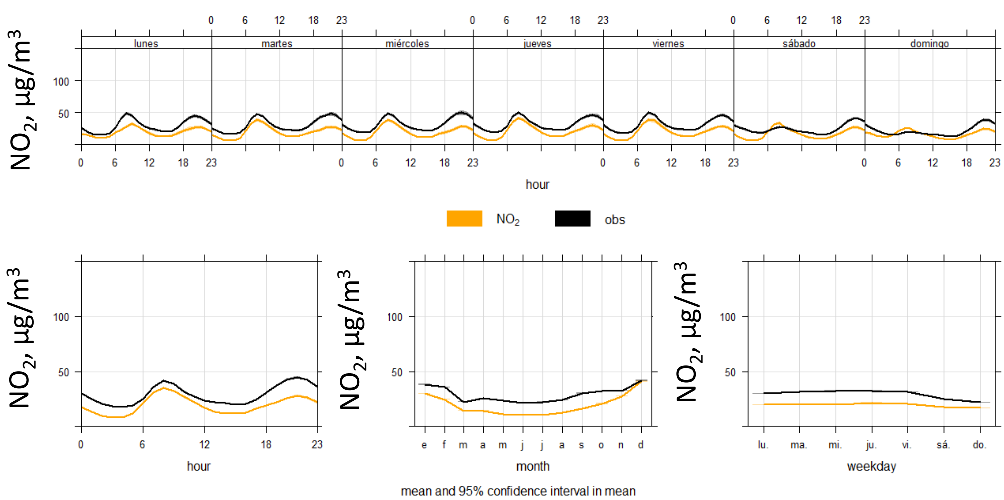


Figure 21. *Comparison between model predicted NO_2 concentrations and observed NO_2 concentrations.*

As seen in the following table, the coefficient of determination (r) was high and errors and biases were low.

Statistics	FAC2	MB (µg/m³)	MGE (µg/m³)	NMB	NMGE	RMSE (µg/m³)	r	COE	IOA	N	Obs_avg (µg/m³)	Pred_avg (µg/m³)
NO_2	0.43	-9.72	16.08	-0.33	0.55	23.46	0.67	0.20	0.60	128069	29.11	19.39
O_3	0.80	-2.20	17.18	-0.04	0.31	21.73	0.77	0.37	0.69	111919	56.15	53.95

Table 3. *Comparison between model predicted NO_2 and O_3 concentrations and observed NO_2 and O_3 concentrations statistics.*

Objectives and Working program

OBJECTIVE 4

1. Impact of COVID-19 related restrictions on local emissions

The outbreak of the Coronavirus disease 2019 (COVID-19, related to the pathogen SARS-CoV-2) was declared as a global pandemic by the WHO on March 11, 2020. Like many other cities worldwide, Madrid implemented a strict lockdown to guarantee social distancing and slow down transmission rates (from March 15th to June 21st). This was an unprecedented demonstration of what non-technical measures could achieve in terms of emissions and air quality improvement as well as a unique experiment to define further abatement measures.

To assess the emission changes, we built two emission scenarios according to the emission computation methodology used in the AIRTEC-CM modelling inventories (Objective 2).
On one hand we estimated a hypothetical one (BAU) that reflects the expected level of emissions within the first half of 2020 if no restrictions were applied. Then, we compiled a detailed inventory using the best available statistics for each relevant sector (road traffic, civil aviation, industry, residential, commercial and institutional) to reflect what actually happened during the lockdown (Actual). Finally, we derived the impact of activity restrictions by comparing both scenarios.

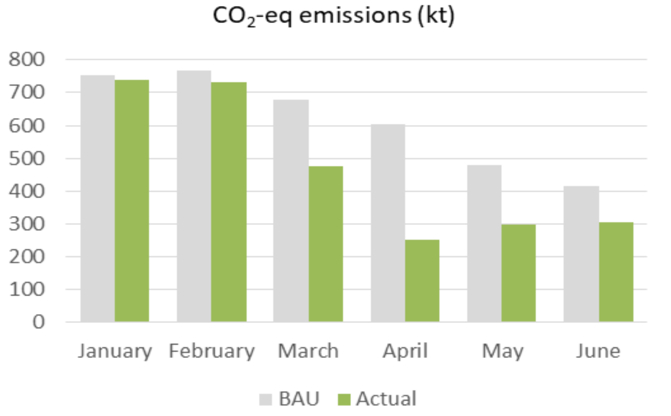


***Figure 22**. Preliminary estimation of CO2-eq emission reductions in Madrid during 2020 lockdown*

Our preliminary findings suggest that the emissions of criteria pollutants such as NO_X or $PM_{2.5}$ were reduced up to 68% and 53% respectively in April 2020. CO_2-eq were reduced up to 58% during that month. Although absolute changes were driven by savings on road traffic (with peak reductions of 75%), the highest relative decrease was found for civil aviation that was virtually halted during April and May.
These emission inventories will support high-resolution air quality simulations to contrast the estimates of air quality improvements based on MLA (example in the following section) and will help testing the accuracy of our multi-scale chemical-transport model under strong emission reductions scenarios.

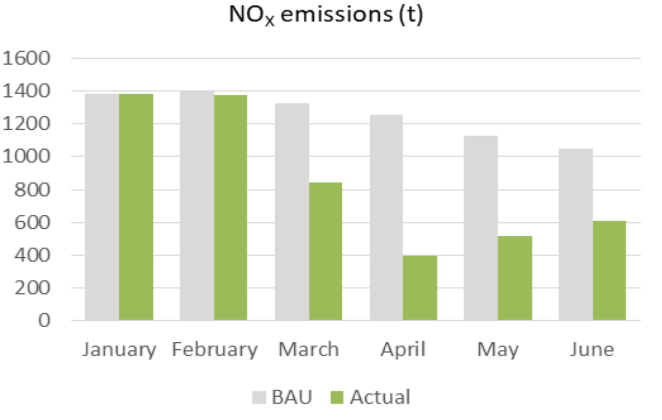


***Figure 23**. Preliminary estimation of NOx emission reductions in Madrid during 2020 lockdown*

Objectives and Working program

OBJECTIVE 4

2. Meteorology-normalized method to estimate the true air pollution reduction during the COVID-lockdown period

Two machine learning algorithms (LigthGBM and XGBoost) were fitted to the past data of air quality using meteorological variables as inputs. This way we obtained a meteorological-normalized prediction when applying the models to the COVID lockdown period, which allowed us to see the true variations. Figure 24 and 25 show the prediction time series from both models, along with the Air Quality Station (AQS) measurements for NO_2 and the traffic type.

A clear reduction in NO_2 concentration can be noticed observing Figure 24, and although a reduction was expected too for O_3, none can be seen in Figure 25. This indicates an interaction with the VOCs regime, and its currently under research.

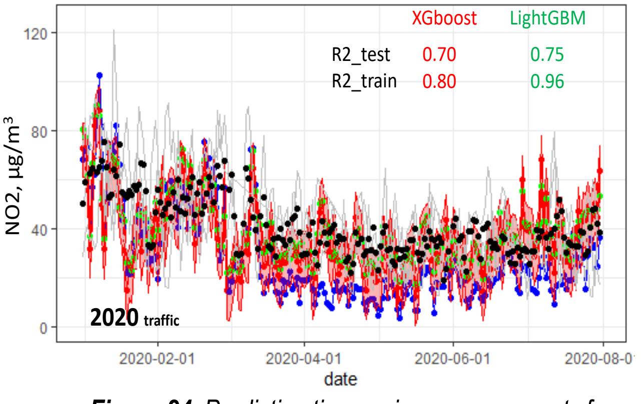


***Figure 24**. Prediction time series measurements for NO_2 and the traffic type.*

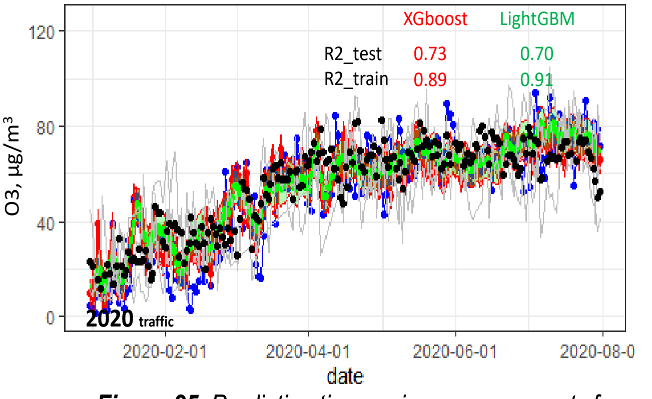
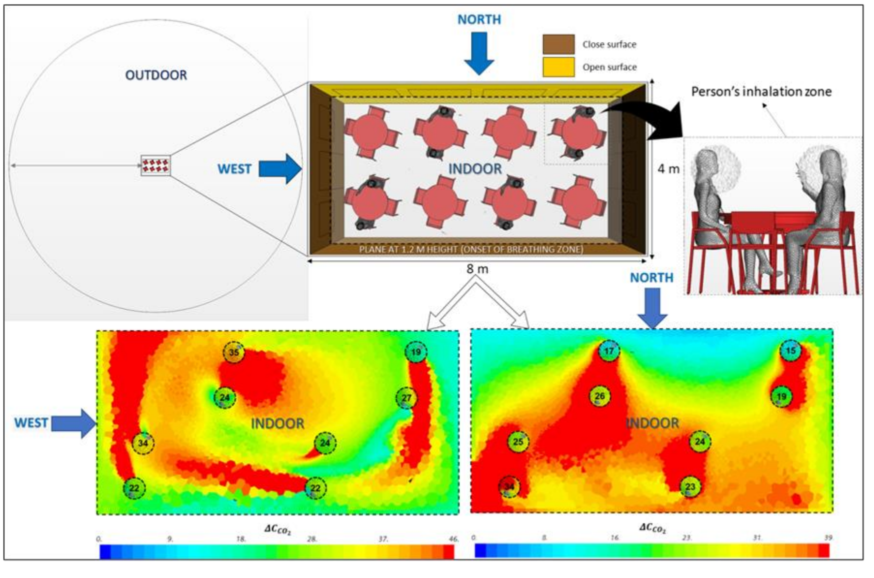


***Figure 25**. Prediction time series measurements for O_3 and the traffic type.*

3. Impact of ventilation of indoor and semi indoor environments on SARS-CoV2 dispersion.



CFD modelling has been used to investigate the relative exposure to SARS-CoV 2 in a set of virtual scenarios representing typical enclosed and semi-enclosed terraces under different outdoor meteorological conditions using indoor CO_2 concentrations as a proxy for risk transmission. This work has been aimed to better understand the airborne transmission of respiratory diseases in shared indoor and semi-indoor environments with natural ventilation to adopt effective people's health protection measures.

***Figure 26**. ΔCO_2 distributions at the onset breathing zone and volume averaged ΔCO_2 incoming to each person from the others (dotted circles) for the semi-enclosed terrace shown in the upper part of the image*

Preliminary recommendations for shared settings may be summarized as:

- To increase the ventilation in order to prevent the short-range airborne transmission, which is higher than the long-range transmission,
- To minimize the impact of potential flow patterns created by the increasing ventilation.

Objectives and Working program

OBJECTIVE 4

4. Source Apportionment

CMAQ-ISAM (Integrated Source Apportionment Method) was used to calculate the information of source attributions for ozone and particulate matter precursors. Ten different sources have been selected based on their importance in relation to the emission of NOX, VOC and PM. In addition, 3 regions (Masks) have been used: Municipality of Madrid, Community of Madrid and outside of Community of Madrid.

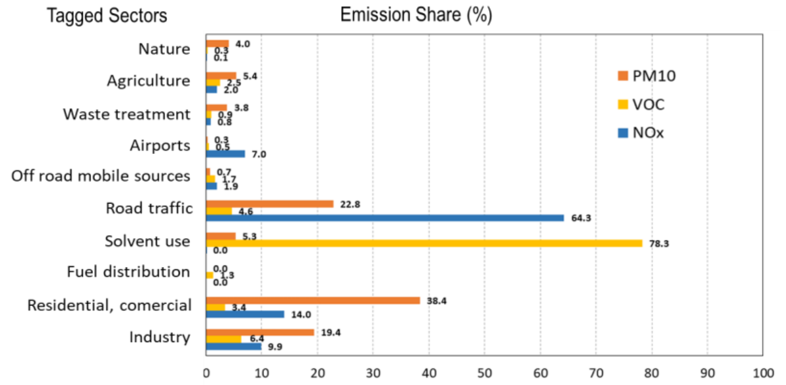


***Figure 27**. Emission share (%) for the different emitting sectors.*

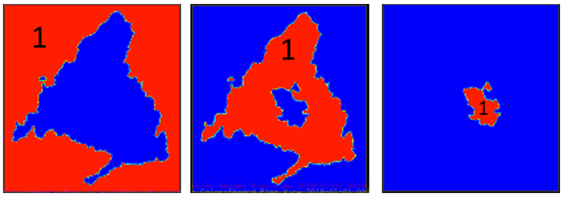


***Figure 28.** Region masks used for Source Apportionment analysis.*

CMAQv5.3.2 includes significant updates to the CMAQ (ISAM) and multiple minor fixes to address issues identified in CMAQv5.3.1. The new CMAQ-ISAM version includes substantial updates to the gas-phase chemistry apportionment algorithms that improves both physical and numerical aspects of the method.

Preliminary analyses show that the most important "source" of Ozone are the boundary conditions (BCON, 41%). The highest contributing sector is road transport (20%) followed by the residential sector is the second in percentage of contribution (18%).

These results are of particular interest for the development of the new Climate Change mitigation and adaptation and regional air quality strategy of the Madrid Region 2021-2030. TARINDUSTRIAL and the Region of Madrid, also a part of AIRTEC-CM are collaborating in a scientific agreement to support the design of this strategic plan. The authors gratefully acknowledge UPM for providing computing resources on Magerit Supercomputer

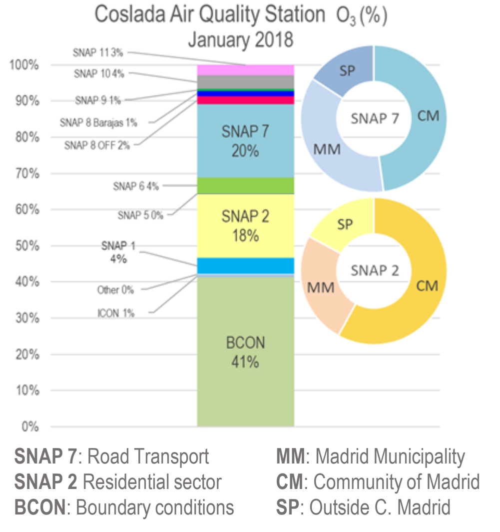


***Figure 29.** Source apportionment O_3 at Coslada air quality station location (%).*

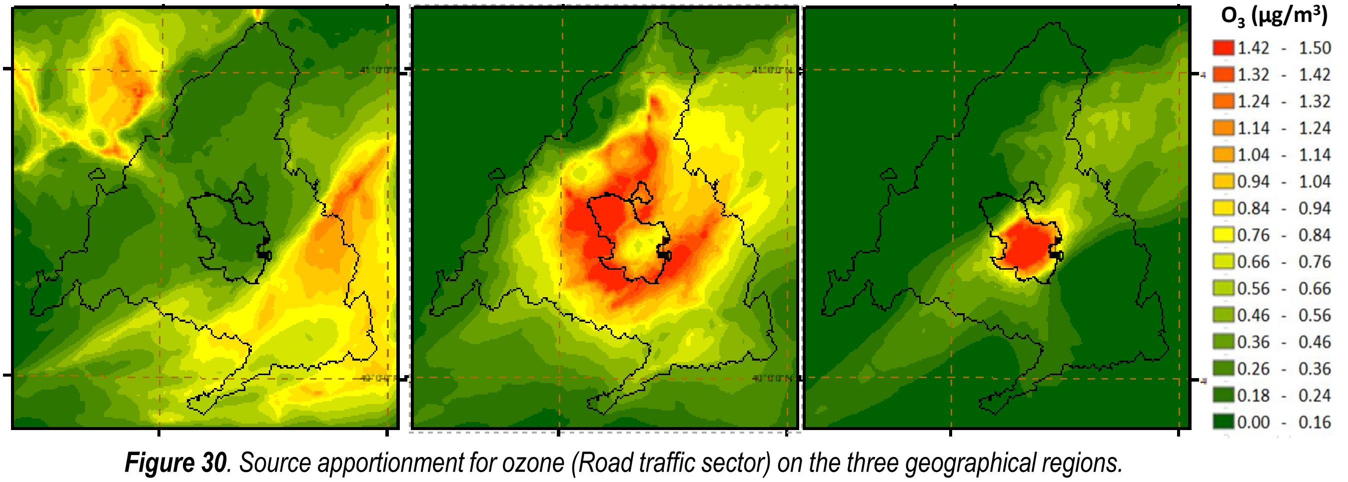


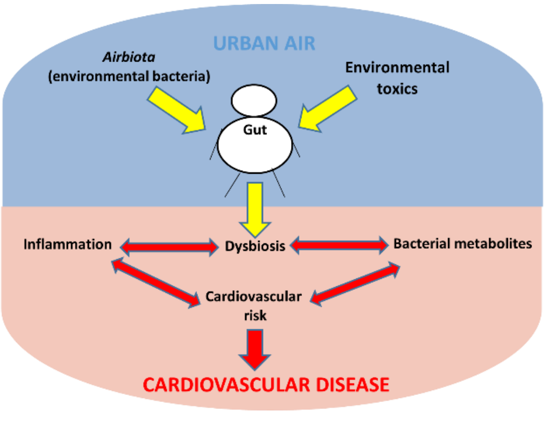
***Figure 30**. Source apportionment for ozone (Road traffic sector) on the three geographical regions.*

Objectives and Working program

OBJECTIVE 5

1. 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.



Cardiovascular diseases (CVD) are a major and prevalent public health problem; consequently, the need for a lifelong treatment for this type of patients arises. The incidence of CVD is not only explained by the presence of traditional risk factors. In fact, there is growing evidence that environmental toxic chemicals and gut microbiota play a role in these pathologies. On the other hand, there are no data about the interaction of bacterial *"aerobiota"* with human health. Based on this background, our main objective is to demonstrate how air toxics and bacterial *aerobiota* influence in the development of CVD, with the possible link being the composition of the gut microbiota and/or some of its metabolites.

At this stage, twenty patients have been recruited. Blood and stool samples are already available to begin their analysis. To assess the environmental exposure of these patients, the methodology proposed by the Harvard University has been adapted to produce a high-resolution $PM_{2.5}$ concentration map based on hybrid models combining surface proxies (population density, traffic, point observations, etc.) with very high resolution satellite data (MAIAC). The results have not yet been published, but are expected to be made available to the scientific community within the next year

2. Estimating ground-level $PM_{2.5}$ concentrations at the Municipality of Madrid in 2015

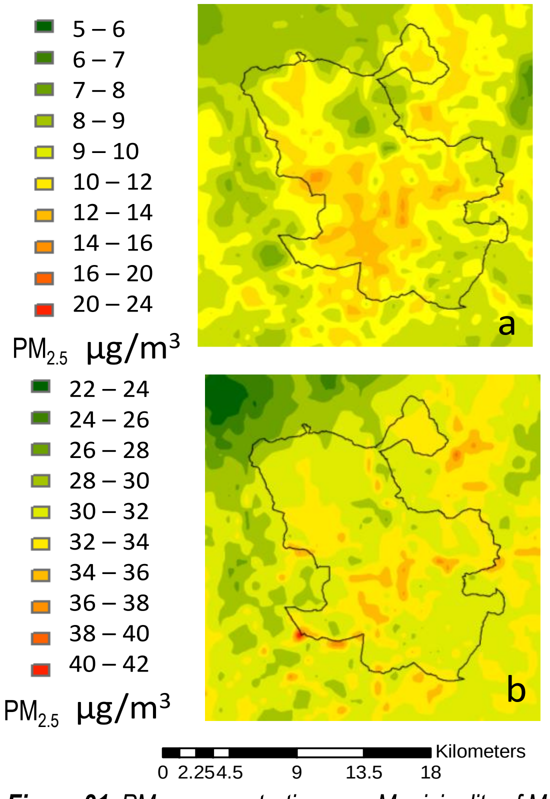


Figure 31. *$PM_{2.5}$ concentration map Municipality of Madrid.*

A 2-step machine learning model based on XGBoost algorithm was designed and applied to calculate in two steps the $PM_{2.5}$ concentrations at the Municipality of Madrid and its surroundings. Among the predicting variables was a selection of spatial, temporal and emission variables. The first step fills the AOD (Atmospheric Optical Depth) missing values, whereas the second step calculates the $PM_{2.5}$ concentrations. Map A shows the yearly averaged $PM_{2.5}$, which has its peak in the city of Madrid and roads as A-6 and A-1. Map B shows the day of highest $PM_{2.5}$ concentration due to a saharian dust advection, reading close to the predicted value of AEMET of 40 µg/m³. Different methods to calculate peoples exposure using this data are currently under study. The results of the 10-fold cross-validation are very encouraging showing very accurate values and very low standard deviations, see **Table 4.**

r^2	**0.80±0.05**
RMSE (µg/m³)	0.46±0.07
MAE (µg/m³)	0.28±0.03

Table 4. *Results of the 10-fold cross-validation*

Objectives and Working program

OBJECTIVE 6

1. Evaluation in a climate change context (Dynamic downscaling)

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.

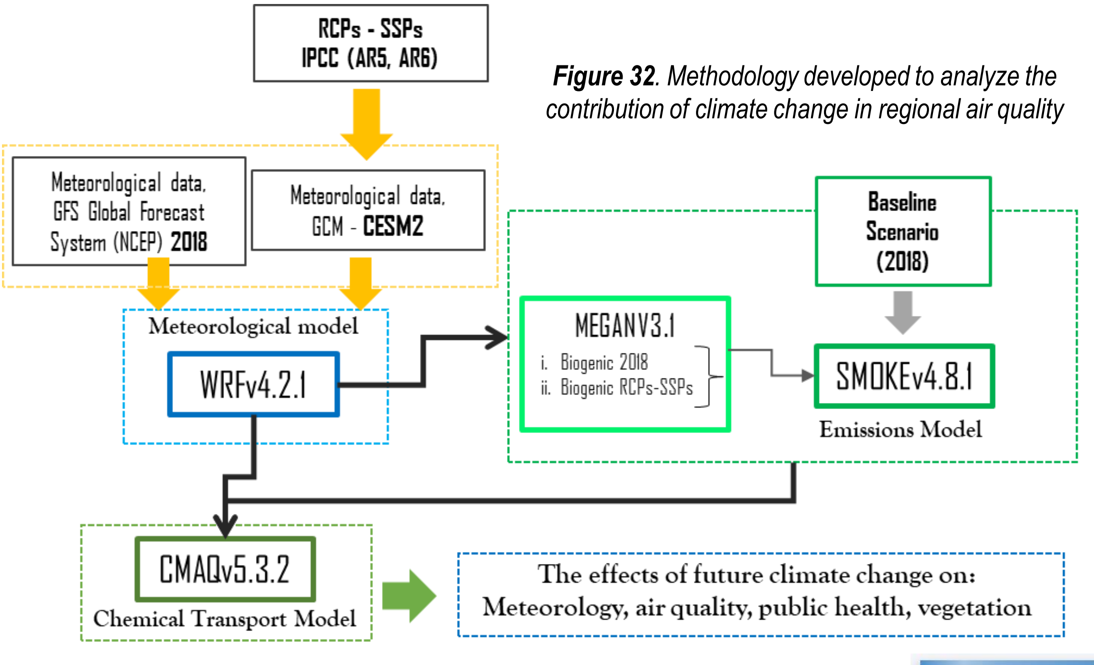
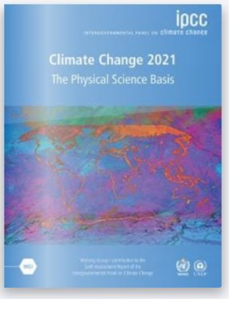


***Figure 32**. Methodology developed to analyze the contribution of climate change in regional air quality*



The employed climatic scenarios will be those of the latest IPCC reports (AR5 and AR6). Currently the RCPs (AR5) scenarios are available for direct use in the regional meteorological model, and the scenarios selected to run are RCP4.5 and RCP8.5. As we continue to work with Representative Concentration Pathways, we will explore the feasibility of initializing our multi-scale modelling system (Objective 2) from the scenarios of the latest Assessment Report (AR6) of the Intergovernmental Panel on Climate Change.

The report "Climate Change 2021. The Physical Science Basis", released on August 2021, introduces the Shared Socioeconomic Pathways (SSP). They reflect different potential combinations of socio-economic responses to climate change in terms of mitigation and adaptation strategies that are associated with global greenhouse gas emissions scenarios and related net radiative forcing (SSP1-1.9, SSP1-2.6, SSP2-4.5, SSP3-7.0 and SSP5-8.5). AIRTEC-CM will focus on the SSP2-4.5 and SSP5-8.5 scenarios, as representative of likely future and extreme climate evolution, respectively.

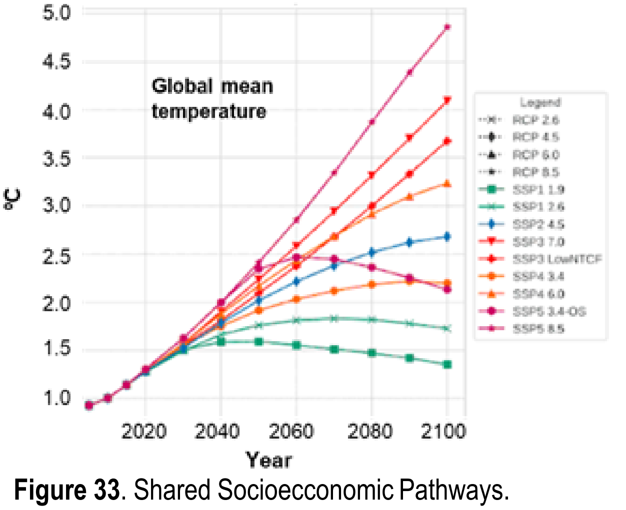


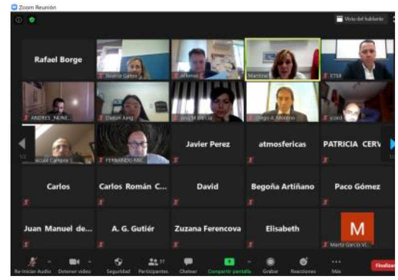
Figure 33. Shared Socioecconomic Pathways.

Dissemination

In addition to the research briefly summarized in this newsletter, regular coordination activities within the Consortium have continued despite COVID-19 restrictions. Face to face interaction is being gradually recovered as sanitary conditions improve.

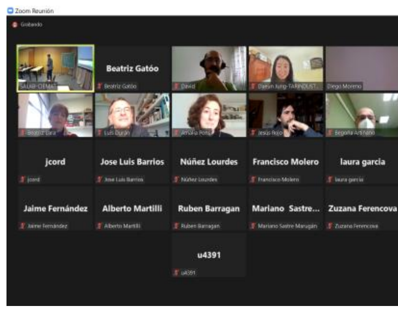
AIRTEC-CM Scientific and Technical

Committee. november 2020



AIRTEC-CM Scientific and Technical

Committee. november 2021



Journal papers 2020-21

- Cordero J.M., Núñez A., García A.M., Borge R. 2021. Assessment and statistical modelling of airborne microorganisms in Madrid. Environmental Pollution. Volume 269-116124. https://doi.org/10.1016/j.envpol.2020.116124
- Núñez A., García A.M., Moreno D.A., Guantes R. 2021. Seasonal changes dominate long-term variability of the urban air microbiome across space and time. Environment International. Volume 150-106423. https://doi.org/10.1016/j.envint.2021.106423
- Santiago J.L., Borge R., Sanchez B., Quaassdorff C., de la Paz D., Martilli A., Rivas E., Martín F. 2021. Estimates of pedestrian exposure to atmospheric pollution using high-resolution modelling in a real traffic hot-spot. Sci Total Environ. Feb 10; 755 (Pt 1): 142475. https://doi.org/10.1016/j.scitotenv.2020.142475
- Sánchez-Parra B., Núñez A., García A.M., Campoy P., Moreno D.A. 2021. Distribution of airborne pollen, fungi and bacteria at four altitudes using high-throughput DNA sequencing. Atmospheric Research. Volume 249-105306. https://doi.org/10.1016/j.atmosres.2020.105306
- Cordero JM., Narros A., Gutiérrez-Bustillo AM., de la Paz, D., Borge R. Predicting the Olea pollen concentration with a machine learning algorithm ensemble. Int J Biometeorol 65, 541–554 (2021). https://doi.org/10.1007/s00484-020-02047-z
- Núñez A., García A.M. Effect of the passive natural ventilation on the bioaerosol in a small room. Building and Environment Volume 207, Part B January 2022, 108438. https://doi.org/10.1016/j.buildenv.2021.108438
- Martilli A., Sanchez B., Domingo Rasilla D., Pappaccogli G., Allende F., Martin F., Roman C., Yagüe C. Simulating the meteorology during persistent Wintertime Thermal Inversions over urban areas. The case of Madrid, Atmospheric Research, volume 263,2021,105789. https://doi.org/10.1016/j.atmosres.2021.105789

In Progress

- Santiago J.L., Rivas E., R. Buccolieri R., Martilli A., Vivanco M. G., Borge R., Gatto E., Martín F. Indoor-outdoor pollutant concentration modelling: A comprehensive urban air quality and exposure assessment.
- Rivas E., Santiago J. L., Martín F., Martilli A.Impact of natural ventilation on exposure to SARS-CoV 2 in indoor/semi-indoor terraces using CO2 concentrations as a proxy. Jung D., Lejarraga I., Borge R., de La Paz D., Cordero JM. Assessment of the Madrid region air quality zoning based on mesoscale modelling and K-means clustering.
- De la Paz D., R. Borge R., Golam Sarwar G.,Cordero JM. Análisis de contribución de fuentes en la formación de Ozone troposférico durante un episodio de alta contaminación en Madrid (Spain).
- Cordero JM., Li J., de la Paz D., Koutraki P., Borge R. Dealing with the difficulties of using AOD to estimate the PM2.5 concentrations at the Municipality of Madrid.
- Cordero JM., Borge R. Meteorological-normalized air quality improvement in the Community of Madrid during the COVID-19 lockdown due to emission changes.

Dissemination

Conferences 2020-2021

- Santiago J.L., Rivas E., R. Buccolieri R., Martilli A., Vivanco M. G., Borge R., Gatto E., Martín F. Towards a Comprehensive Urban Air Quality Modelling and Population Exposure Assessment: Relationship Between Outdoor Pollutant Concentration in Sidewalks and Indoor Pollution Inside Buildings. June 2020.20th International Conference on Harmonization within Atmospheric Dispersion modelling for regulatory purposes. Comunicación Oral.
- Rivas E., Santiago J. L., Martín F., Martilli A. Preliminary study of natural ventilation in indoor/semi-indoor terraces.. 20th International Conference on Harmonization within Atmospheric Dispersion modelling for regulatory purposes. Comunicación Oral.HARMO20. Tartu, Estonia.
- Borge R., Jung D., Lejarraga I., Crespo E., , Ricardo Vargas R., de la Paz D., Cordero JM. A novel modelling-based method for air quality zoning. Application to the Madrid region. 20th International Conference on Harmonization within Atmospheric Dispersion modelling for regulatory purposes. HARMO20.
- Borge R., Indicadores y herramientas para el diseño y seguimiento de ZBE. 3 de mayo 2021. CONAMA 2020 (30 mayo-3 junio 2021), comunicación escrita y panel del proyecto AIRTEC_CM
- Núñez Hernández A., García Ruiz A.M., Moreno Gómez D.A., Guantes Navacerrada R. 2021. Variación espacio-temporal del microbioma del aire urbano. XXVIII Congreso Sociedad Española de Microbiología. 28 de junio al 2 de julio de 2021. Póster
- Yagüe, C., Román-Cascón, C., Ortiz, P., Sastre, M., Maqueda, G., Serrano, E., Artíñano, B., Gómez-Moreno, F.J., Díaz-Ramiro, E., Alonso, E., Fernández, J., Borge, R., Narros, A., Cordero, J.M., García, A.M.4 and Núñez, A. Multi-scale analysis of turbulence data from AIRTEC-CM urban field campaigns in Madrid.September 2021 EMS (European Meteorological Society).
- Cordero J.M. Estimation of $PM_{2.5}$ ambient concentration in Madrid using linear mixed effects models and random forest. 18 – 22 October 2021. Pollution Modelling and its Application (ITM), Barcelona.

Patents

- Método de detección por PCR de la bacteria *Legionella pneumophila* en muestras ambientales y/o clínicas. Inventores: Sánchez Parra B., Núñez Hernández A., Moreno Gómez D.A. 04/03/2021. ES2702117.

Other

- Microbiología de la atmósfera: un ambiente extremo pero no estéril. Núñez Hernández A . XXIV Curso de iniciación a la investigación en microbiología profesor J.R. Villanueva (Albacete, 6-9 de julio de 2021).

Dissemination activities

ETSI Industriales UPM
3 noviembre 2021

semana de la ciencia y la innovación 2021
Una ciencia para los grandes retos de la humanidad
Comunidad de Madrid

¿Como sabemos que contiene el aire que respiramos?

What's in the air we breathe?
AIRTEC researchers showed their work in Science Week to students and the general public.

FOR MORE INFORMATION, PLEASE VISIT OUR WEBSITE
www.airtec-cm.org