Monitoring of UFPs in a site affected by biomass burning

C.Collaveri[1], F.Dini[1], D.Dalle Mura[1], R.Fruzzetti[1], E.Bini[1], S.Fortunato[1], M.Rosato[1], B.P. Andreini[1]

[1]CRTQA Regional Centre of Air Quality – ARPAT Environmental Protection Agency of Tuscany Region

Presenting author email: f.dini@arpat.toscana.it

ARPAT Agenzia regionale per la protezione ambientale della Toscana

Sistema Nazionale per la Protezione dell'Ambiente

Regione Toscana

EAC 2025

Poster PO1:235 Lecce, 31 agosto- 5 settembre 2025

Introduction

This study is part of a screening monitoring of a subregion of Tuscany for UFP (***see poster ID: 956 / PO3: 154***). It describes results of the monitoring at the site of LU-Capannori affected by a large amount of biomass burning emissions. A portable size distribution instrument that gives number particle concentrations in 13 dimensional classes form 10 nm to 365 nm was used (TSI 3910). The aim of the study is to characterize the granulometric distribution according to the source, in particular the biomass burning. This work is the starting point for the definition of the new regional network according to the criteria of the new air quality Directive [1].

Materials and method

The instrumentation employed only allows short periods of monitoring, therefore each campaign has been contextualized meteorologically with respect to the winter of 2025 . Monitoring campaigns were made in four different short periods of the winter 2025 from January to March.

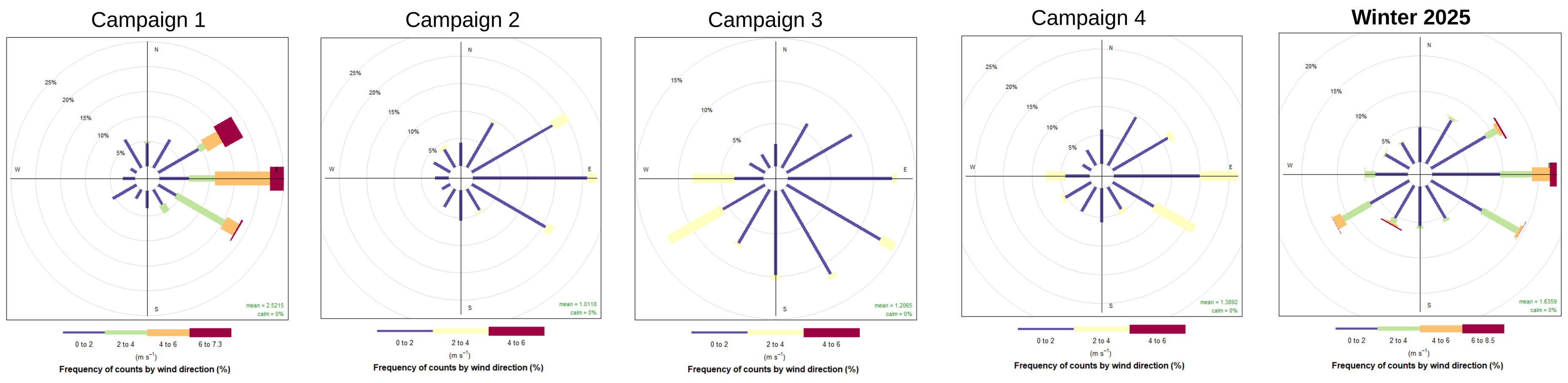
For each campaign a meteorological analisys was made with particular reference to:

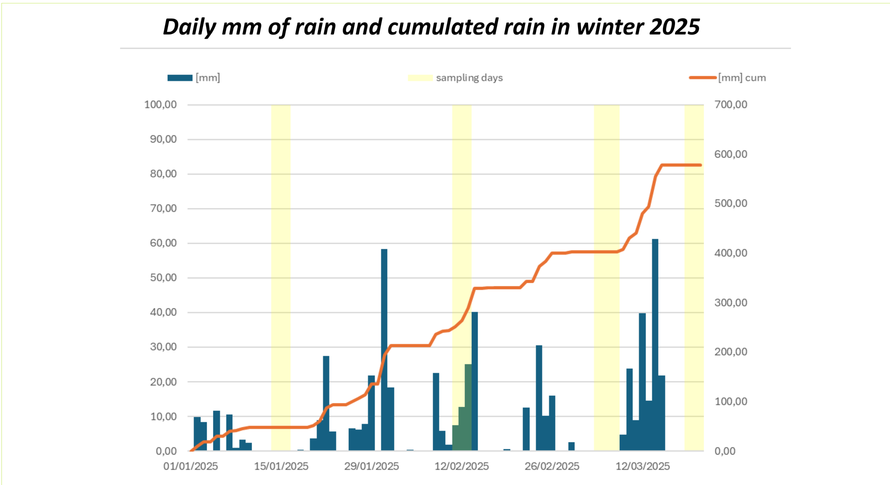
- temperature (connected to emissions from domestic heating),
- rain and wind (direction and speed) for possible conditions favorable to the dispersion of pollutants

Also the natural radiation, a parameter daily measured by the PM10 monitoring system (SWAM DC), which results well correlated with daily PM10, was considered as an approximative indication of the mean mixing capacity of the atmosphere in each day.
Meteorological data are from the meteorological network of Regional Idrological Service (SIR) [2].
Other pollution data are collected by the monitoring station instrumentation. In particular: OPSIS SM200 for hourly PM10, PM2.5, PM1, PN, T, P, U%; SWAM DC for daily PM10 and PM2.5, Aethalometer AE33 Magee Scientific for Black Carbon, API T200 for NO, NO_2 and API T100 for SO_2 [3].

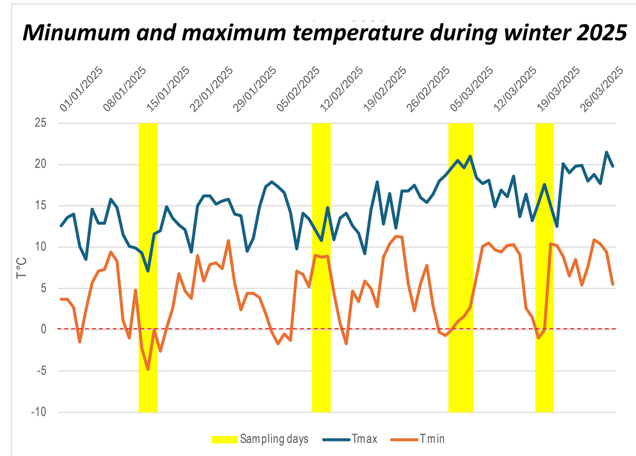
Meteorological analysis

During the four campaigns all the meteorological situations of the winter occurred and were taken into account.
Comparison of the windrose relative to the whole winter 2025 with windroses relative to each campaign

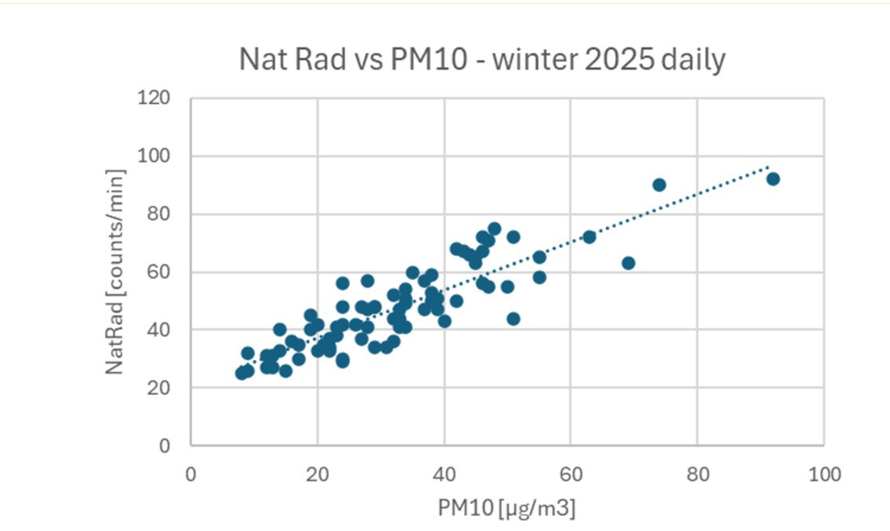


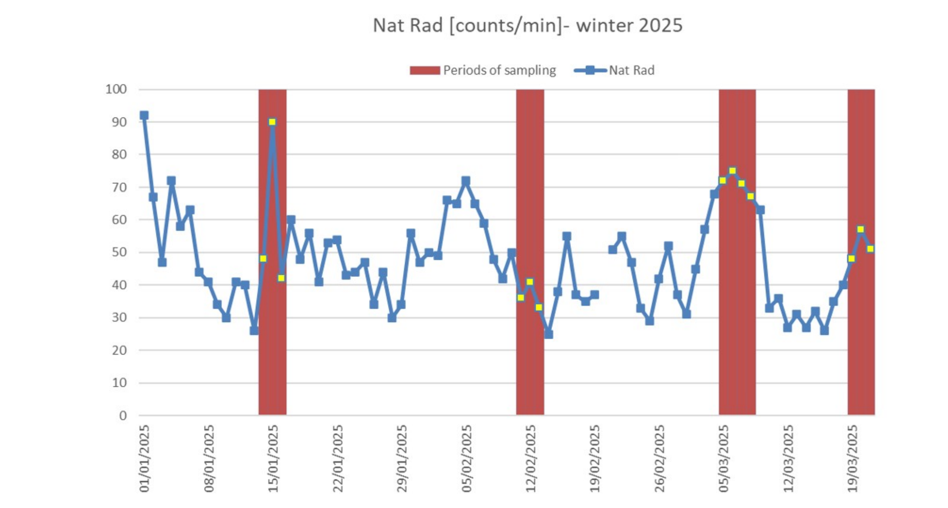


In the whole winter the total amount of rain was of 577,4 mm distributed in 6 distinct episodes approximately continuative. One of these episodes includes a sampling period from 11 to 13 Febbruary with an amount of 45 mm rain fallen.



Minimum temperature below 0°C were registered on 14/01, 15/01, 19/03. The two sampling periods in March have very low minimum temperatures (0 and -1 °C respectively) so domestic heating is present, also if, maximum temperatures above 15 °C and greater number of daylight hours, positively affect measured levels.

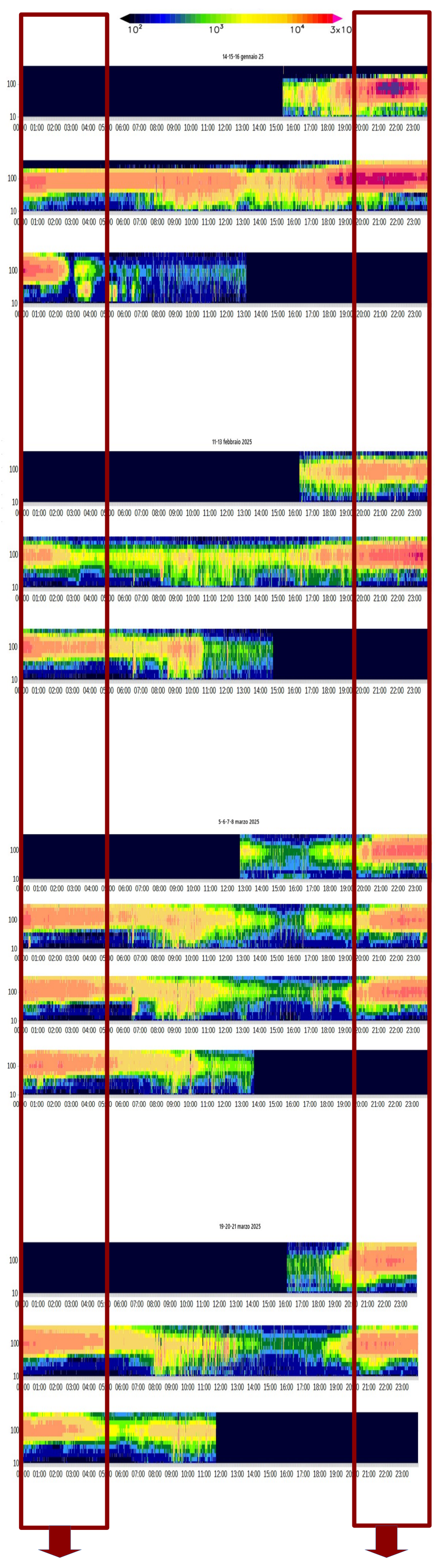




Natural radiation measured on PM10 filters gives an approximate idea of the stability conditions of the atmosphere. This parameter is well correlated with PM10. During sampling days different stability conditions occurred with natural radiation varying from 90 counts/min (the second higher value in the whole winter) on the 15/01 and a minimum of 36 counts/min on the 11/02. The only sampling days of lower stability were the ones on Febbruary, that were also the rainy days. Also the March campaigns have higher values of natural radiation compared to surrounding days.

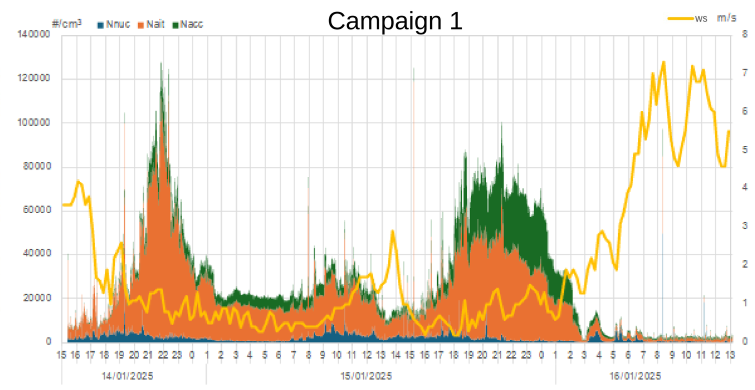
Measured data

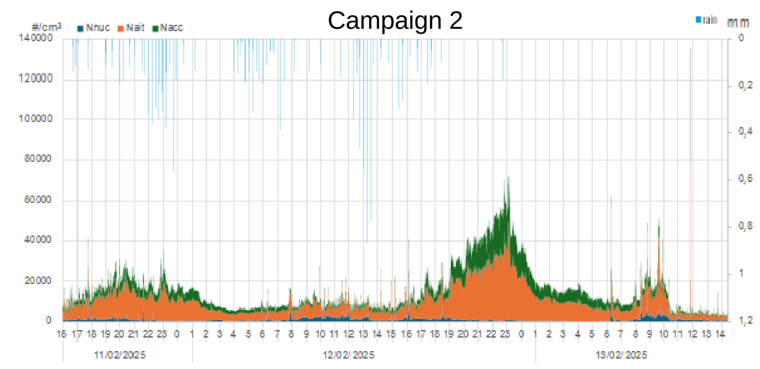
Daily DN/Dlog(Dp) graphs

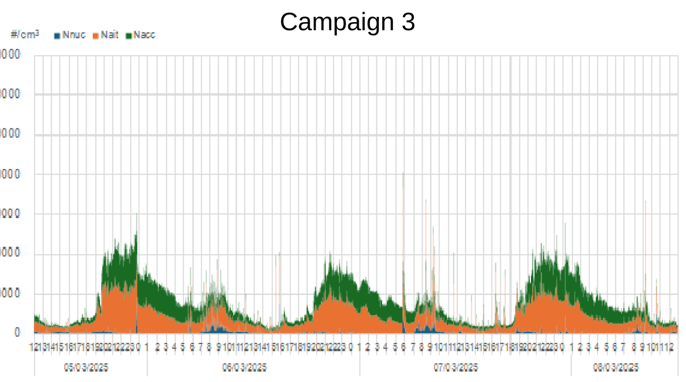


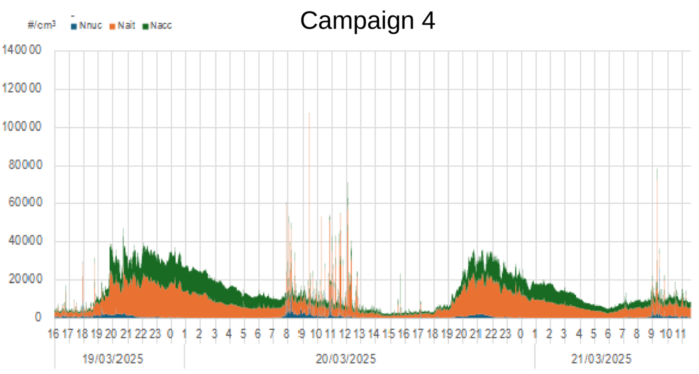
NIGHT PEAKS ALWAYS PRESENT

Trends of total particles per campaign splitted in the 3 modes (nucleation, Aitken, accumulation)









Reference values established by **WHO for the total number of particle** are **10.000 N/cm³** as daily mean and **20.000 N/cm³** for hourly mean [4]

In the January campaign night peaks reach very important levels in term of number of particle. The 24-hour averaged value is always above 30.000 N/cm³ and 69% of the hourly averages are above the WHO reference value of 20.000 N/cm³.
When the wind rises above 3 m/s levels drastically decrese below 10.000 N/cm³

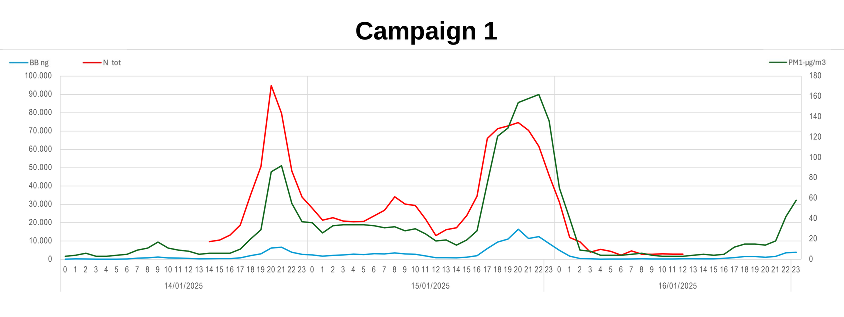
In the February campaign, it is clearly visible the effect of the rain on the nighttime peak between the 11th and 12th when levels are about half the ones of the following night.
These days also had mild temperatures with slight difference between minima and maxima and lower stability (see meteorological analisys); also these elements favour greater dispersion of pollutants.

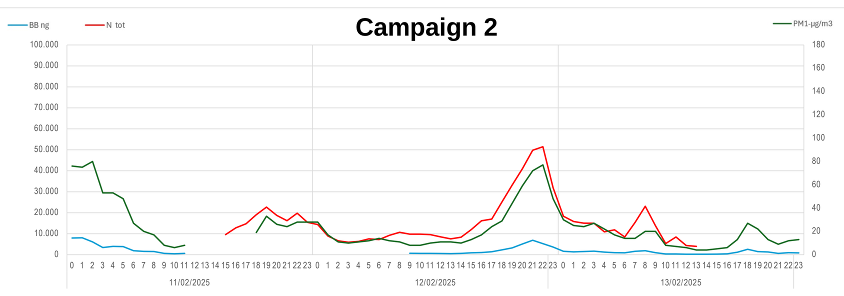
At the beginning of March peaks maxima are about 40.000 N/cm³. The hourly mean values over 20.000 N/cm³ are 25/74 and the mean level of the campaigns was 17.340 N/cm³.

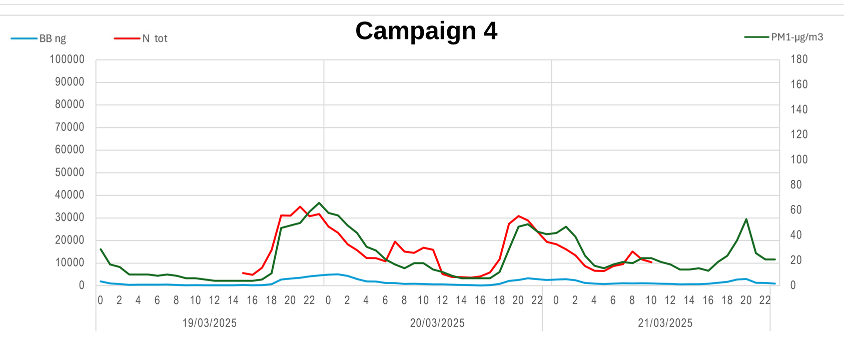
At the end of March peaks maxima are still about 40.000 N/cm³ with a campaign mean of 15.700 N/cm³ and 11/44 hourly mean above 20.00 N/cm³

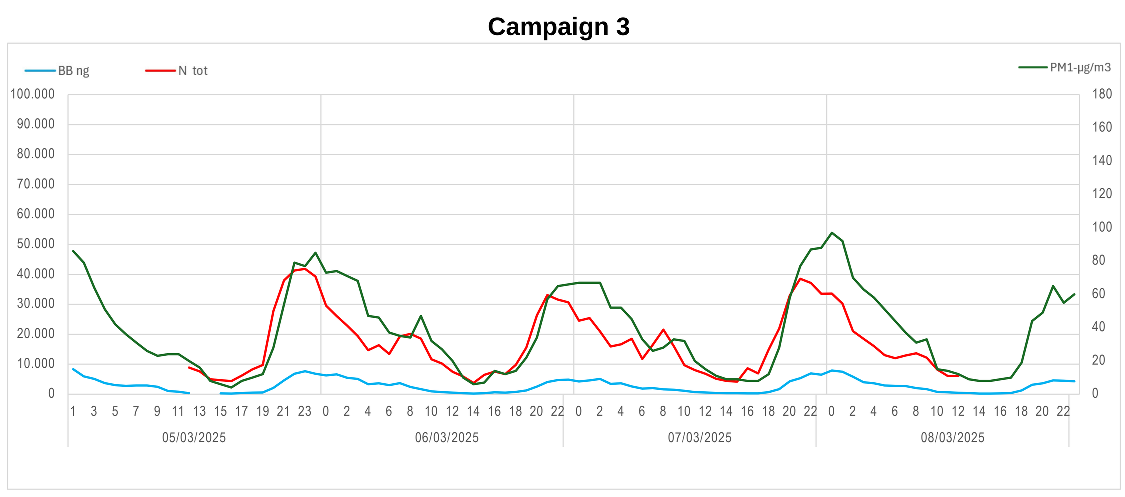
Results and discussion

In the site of Capannori PM on hourly basis and Black carbon are also monitored, with the estimate of fraction coming from biomass burning (BB). So, it was possible to establish a correlation between the contribution of biomass burning and the size distribution of particles.







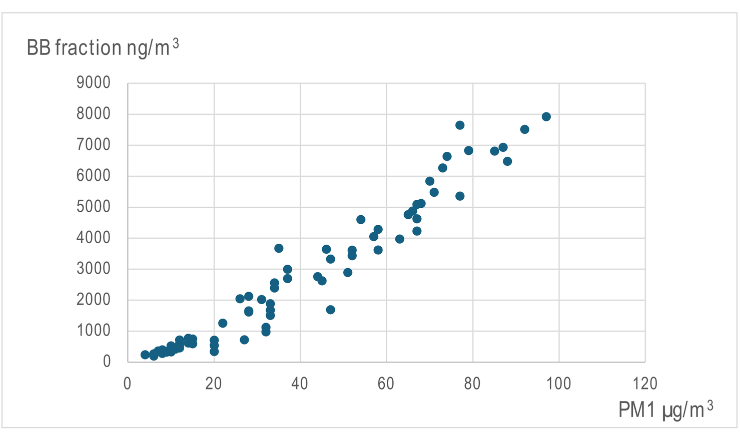


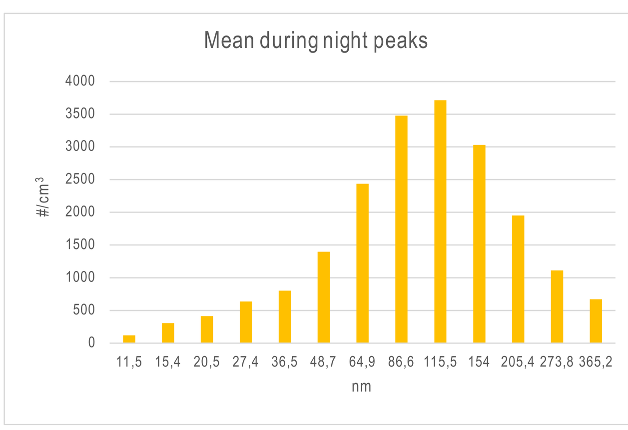
	11,5	15,4	20,5	27,4	36,5	48,7	64,9	86,6	115,5	154	205,4	273,8	365,2	tot	SO2	NO2	NO	BC6	PN	PM1	PM2.5	PM10	P	T	U%
11,5	1,00	0,72	0,32	0,33	0,39	0,29	0,16	0,07	0,00	-0,06	-0,16	-0,20	-0,21	0,12	0,02	0,09	0,17	0,00	-0,09	-0,07	-0,07	-0,02	0,04	0,03	-0,16
15,4	0,72	1,00	0,76	0,52	0,44	0,32	0,20	0,13	0,08	0,01	-0,11	-0,18	-0,21	0,21	0,04	0,23	0,29	0,09	-0,03	-0,01	0,00	0,06	0,02	-0,06	-0,11
20,5	0,32	0,76	1,00	0,86	0,65	0,37	0,21	0,15	0,12	0,08	-0,01	-0,09	-0,12	0,30	0,05	0,29	0,30	0,16	0,05	0,06	0,07	0,13	-0,01	-0,12	-0,03
27,4	0,33	0,52	0,86	1,00	0,87	0,52	0,27	0,15	0,10	0,05	-0,04	-0,11	-0,12	0,32	0,04	0,25	0,25	0,12	0,02	0,03	0,04	0,09	0,00	-0,10	-0,04
36,5	0,39	0,44	0,65	0,87	1,00	0,83	0,56	0,36	0,23	0,11	-0,09	-0,16	-0,16	0,47	0,02	0,25	0,22	0,12	0,04	0,05	0,06	0,10	0,04	-0,12	-0,06
48,7	0,29	0,32	0,37	0,52	0,83	1,00	0,91	0,75	0,61	0,44	0,13	0,01	-0,04	0,76	0,03	0,35	0,28	0,34	0,31	0,33	0,33	0,35	0,04	-0,29	0,07
64,9	0,16	0,20	0,21	0,27	0,56	0,91	1,00	0,96	0,87	0,73	0,40	0,23	0,13	0,91	0,05	0,45	0,36	0,54	0,57	0,58	0,58	0,57	0,02	-0,43	0,22
86,6	0,07	0,13	0,15	0,15	0,36	0,75	0,96	1,00	0,97	0,88	0,60	0,40	0,26	0,96	0,07	0,50	0,41	0,66	0,72	0,73	0,73	0,71	-0,01	-0,51	0,31
115,5	0,00	0,08	0,12	0,10	0,23	0,61	0,87	0,97	1,00	0,96	0,74	0,54	0,39	0,96	0,09	0,53	0,44	0,74	0,81	0,82	0,82	0,79	-0,03	-0,55	0,38
154	-0,06	0,01	0,08	0,05	0,11	0,44	0,73	0,88	0,96	1,00	0,89	0,72	0,56	0,91	0,11	0,56	0,45	0,79	0,90	0,90	0,90	0,86	-0,05	-0,56	0,46
205,4	-0,16	-0,11	-0,01	-0,04	-0,09	0,13	0,40	0,60	0,74	0,89	1,00	0,93	0,80	0,71	0,13	0,52	0,38	0,75	0,89	0,89	0,88	0,84	-0,07	-0,48	0,51
273,8	-0,20	-0,18	-0,09	-0,11	-0,16	0,01	0,23	0,40	0,54	0,72	0,93	1,00	0,95	0,54	0,12	0,44	0,20	0,62	0,81	0,79	0,78	0,72	-0,06	-0,39	0,53
365,2	-0,21	-0,21	-0,12	-0,12	-0,16	-0,04	0,13	0,26	0,39	0,56	0,80	0,95	1,00	0,41	0,09	0,40	0,06	0,48	0,69	0,66	0,66	0,60	-0,04	-0,36	0,55
tot	0,12	0,21	0,30	0,32	0,47	0,76	0,91	0,96	0,96	0,91	0,71	0,54	0,41	1,00	0,10	0,58	0,46	0,73	0,79	0,80	0,80	0,78	-0,02	-0,54	0,37
SO2	0,02	0,04	0,05	0,04	0,02	0,03	0,05	0,07	0,09	0,11	0,13	0,12	0,09	0,10	1,00	0,16	0,20	0,18	0,15	0,15	0,16	0,18	-0,13	0,00	0,03
NO2	0,09	0,23	0,29	0,25	0,25	0,35	0,45	0,50	0,53	0,56	0,52	0,44	0,40	0,58	0,16	1,00	0,56	0,71	0,65	0,64	0,65	0,70	-0,10	-0,41	0,39
NO	0,17	0,29	0,30	0,25	0,22	0,28	0,36	0,41	0,44	0,45	0,38	0,20	0,06	0,46	0,20	0,56	1,00	0,66	0,45	0,48	0,50	0,60	-0,14	-0,40	0,23
BC6	0,00	0,09	0,16	0,12	0,12	0,34	0,54	0,66	0,74	0,79	0,75	0,62	0,48	0,73	0,18	0,71	0,66	1,00	0,87	0,88	0,89	0,89	-0,12	-0,49	0,43
PN	-0,09	-0,03	0,05	0,02	0,04	0,31	0,57	0,72	0,81	0,90	0,89	0,81	0,69	0,79	0,15	0,65	0,45	0,87	1,00	1,00	1,00	0,95	-0,14	-0,53	0,53
PM1	-0,07	-0,01	0,06	0,03	0,05	0,33	0,58	0,73	0,82	0,90	0,89	0,79	0,66	0,80	0,15	0,64	0,48	0,88	1,00	1,00	1,00	0,96	-0,14	-0,53	0,51
PM2.5	-0,07	0,00	0,07	0,04	0,06	0,33	0,58	0,73	0,82	0,90	0,88	0,78	0,66	0,80	0,16	0,65	0,50	0,89	1,00	1,00	1,00	0,97	-0,14	-0,53	0,51
PM10	-0,02	0,06	0,13	0,09	0,10	0,35	0,57	0,71	0,79	0,86	0,84	0,72	0,60	0,78	0,18	0,70	0,60	0,89	0,95	0,96	0,97	1,00	-0,15	-0,52	0,50
P	0,04	0,02	-0,01	0,00	0,04	0,04	0,02	-0,01	-0,03	-0,05	-0,07	-0,06	-0,04	-0,02	-0,13	-0,10	-0,14	-0,12	-0,14	-0,14	-0,14	-0,15	1,00	-0,07	0,05
T	0,03	-0,06	-0,12	-0,10	-0,12	-0,29	-0,43	-0,51	-0,55	-0,56	-0,48	-0,39	-0,36	-0,54	0,00	-0,41	-0,40	-0,49	-0,53	-0,53	-0,53	-0,52	-0,07	1,00	-0,74
U%	-0,16	-0,11	-0,03	-0,04	-0,06	0,07	0,22	0,31	0,38	0,46	0,51	0,53	0,55	0,37	0,03	0,39	0,23	0,43	0,53	0,51	0,51	0,50	0,05	-0,74	1,00

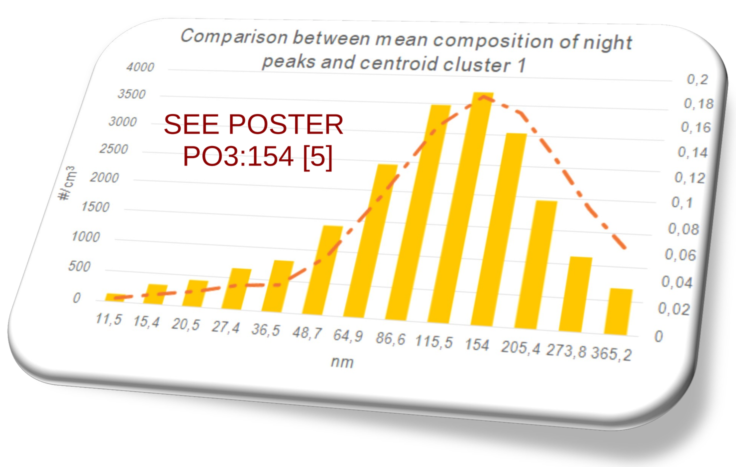
Moreover, in the same periods of sampling data per minute were collected for : total black carbon (BC6), PM10, PM2.5, PM1 and gaseous pollutant: NO, NO_2, SO_2.
In the correlation table Pearson correlation coefficients between all the species are shown. As can be seen, total number of particle is most determined by classes in the **Aitken** and **accumulation** mode. It is also evident the correlation of these classes with Black Carbon, PM and Particle Number (PN) measured by the OPC.
Slighter correlation of Nitrogen Oxides always related to the same dimensional classes.
Temperatures are anticorrelated with PM levels, and number of nanoparticles and microparticles, as expected.
The humidity shows a moderate correlation with PM and nanoparticles focused on the higher size classes.

During night peaks the most contributing mode of particles is the **Aitken** mode from approximately 50 to 100 nm. With the exception of the peak in the night between 14/01 and 15/01 the other peaks show high correlation between PM and the fraction of black carbon due to biomass burning.
The most correlated class with PM1 is the 154 nm. The temporal development of the peaks is approximately from 7:00 PM to 6:00 AM the following day, varying according to the campaigns. In the first campaign, the night peaks are longer; as winter approaches spring with longer days, the night peaks decrease not only in intensity but also in duration.
Two different phases can be distinguished with different distribution among dimensional classes:
- evening hours when domestic heating is on, and fresh particles of lower diameter are still present
- night hours when particles in the **nucleation** mode are negligible in number

Mean composition calculated for night peaks is given below







Conclusions

Each campaign has peculiar characteristics due to the specific meteorologic conditions and emission levels of those days, but each one reveals that levels of UFPs, in site affected by biomass burning, are much higher than the recommended values of WHO as hourly and daily values.

The temporal evolution and the correlation with other pollutants related to biomass burning demonstrate that this source is the one that most contributes to exceeding the WHO reference values.

REFERENCES

[1] DIRECTIVE (EU) 2024/2881 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on ambient air quality and cleaner air for Europe
[2] https://sir.toscana.it/
[3] https://www.arpat.toscana.it/temi-ambientali/aria/qualita-aria/rete_monitoraggio/scheda_stazione/LU-CAPANNORI
[4] "WHO global air quality guidelines: Particulate matter ($PM_{2.5}$ and PM_{10}), ozone, nitrogen dioxide, sulfur dioxide and carbon monoxide", 2021 https://www.who.int/publications/i/item/9789240034228
[5] EAC 2025, PO3:154 Monitoring of size distribution of ultrafine particles in Tuscany Region.