EFFECT OF SEA BREEZE REGIME ON AEROSOL OPTICAL PROPERTIES OVER THE CITY OF ROME, ITALY

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PURPOSES

- Detection of sea-breeze phenomena basing on several meteorological variables, such as: wind intensity and direction, water vapour, irradiance, specific humidity and air temperature.
- Identification of characteristic trends basing on local and synoptic scale weather conditions
- Investigation of effects of sea-breeze on physical, optical, chemical, and hygroscopic properties of the urban aerosol

INTRODUCTION

Mesoscale meteorological phenomena, such as sea-land breeze regime, strongly impact meteorological conditions of coastal areas, affecting wind intensity, moisture, heat and momentum fluxes and polluted air masses dispersion. This effect must be considered in order to correct design urban spaces, predict the possible influence of land use change on air pollution and climate change and, consequently, improve the quality of life and urban comfort.

In recent years, it has been shown that the breeze regime does not only affect microclimatic conditions but also air quality in coastal areas, because of the mixing of different types of aerosols and condensable gases. Moreover, the advection of marine, colder and more humid air leads to the decrease of the boundary layer height and, consequently, to the increase of the surface concentration of locally emitted pollutants, that are trapped within the boundary layer itself.

METHOD

In this work, an approach to determine the breeze effect on aerosol in correspondence of the BAQUNIN [1] Super-site urban location, in the centre of Rome, Italy is presented.

The city is about 28 km far from the Tyrrhenian coast and is often exposed to sea-breeze circulation and to extreme aerosol events [2] [3].

In-situ measurements obtained from different remote sensing instruments are used:

- **(i) vertical profile of horizontal wind velocity and direction** by means of SODAR wind profiler;
- **(ii) moisture, air temperature and wind speed** from ground-based meteorological station;
- **(iii) precipitable water, aerosol optical depth (AOD), Ångström exponent (AE)** from sun-photometer CIMEL,
- **(iv) AOD, AE and aerosol size distribution** from POM 01 L Prede sun-sky radiometer,
- **(v) superficial and tropospheric NO_2** amounts from PANDORA spectrometer,
- **(vi) particulate matter ($PM_{2.5}$ and PM_{10}) concentrations** from ground-based air quality station.

REFERENCES

[1] BAQUNIN Boundary-layer Air Quality-analysis Using Network of Instruments, www.baqunin.eu

[2] Petenko I. et al. (2011) "Local circulation diurnal patterns and their relationship with large-scale flows in a coastal area of the Tyrrhenian sea", Boundary-Layer Meteorology, 139:353-366.

[3] Ciardini V. et al. (2012) "Seasonal variability of tropospheric aerosols in Rome", Atmospheric Research, 118:205-214.

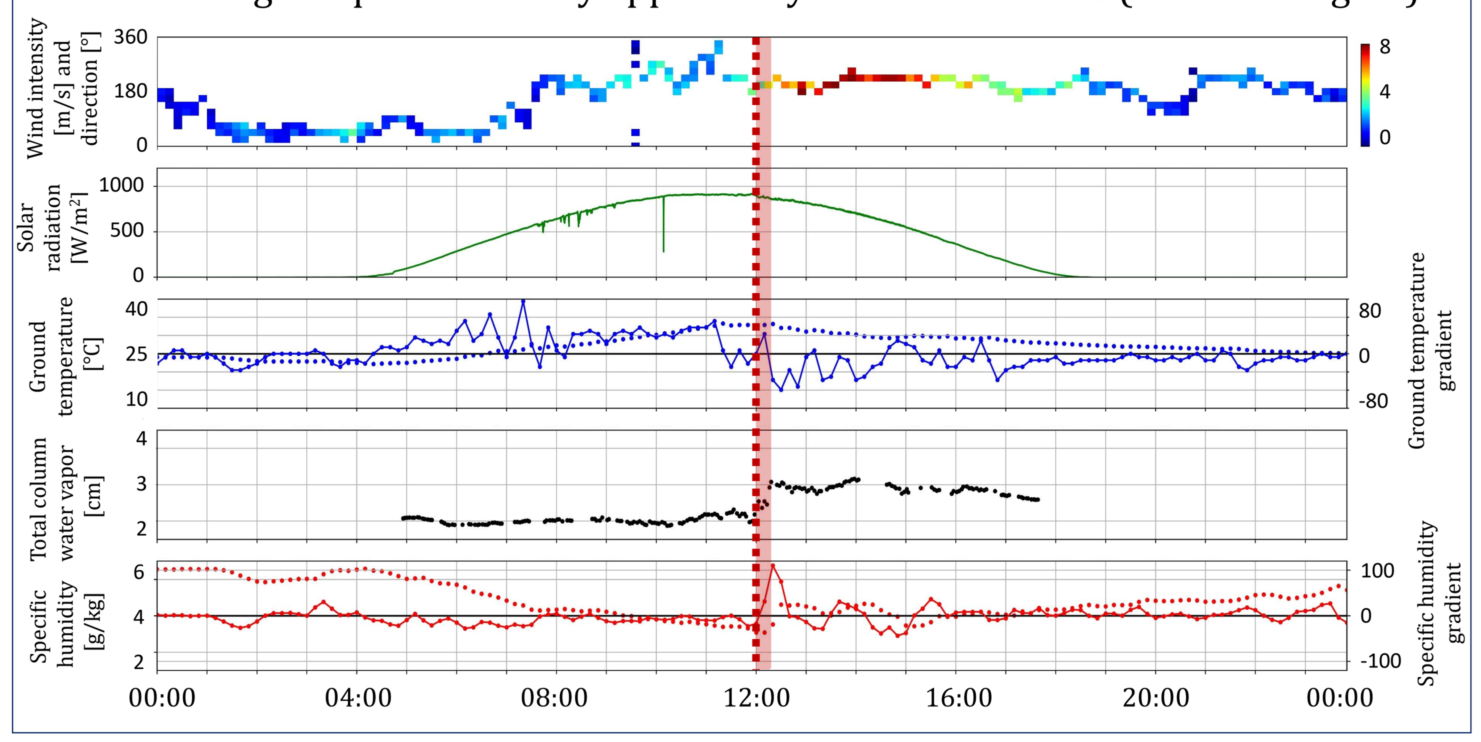
DETECTION OF SEA-BREEZE DAYS

Several criteria have been considered for the detection of the sea-breeze days:

- ❖ warm, clear days with high-pressure systems;
- ❖ change in wind direction and wind intensity some hours after sunrise, with the wind blowing from the sea to the land, perpendicularly to the coastline;
- ❖ increase in specific humidity and simultaneous decrease in the atmospheric temperature, because of cooler, more humid air coming from the sea.

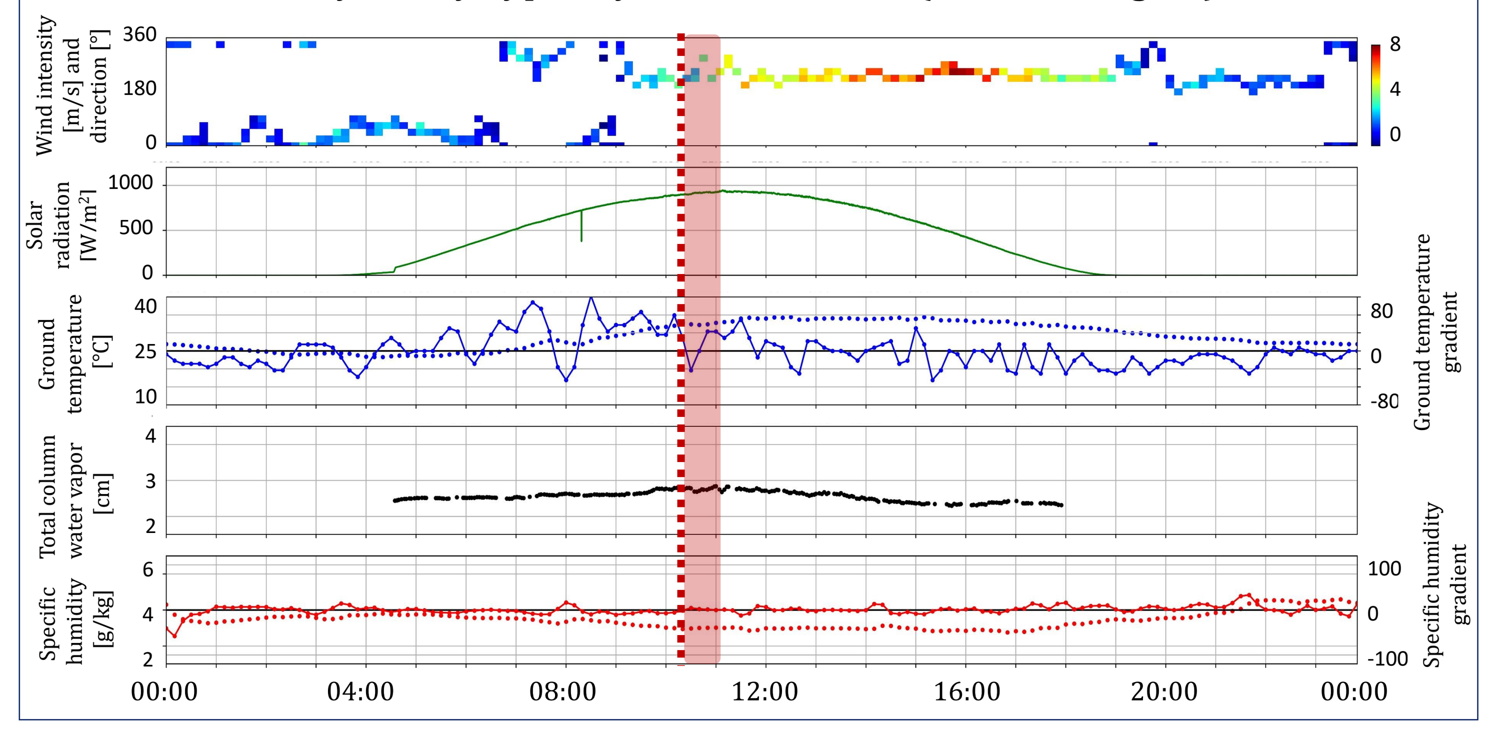
FRONT DAYS

The sea-breeze front (red dotted line) is clearly recognizable and the meteorological quantities vary appreciably in 10-20 minutes (red filled region)



NO FRONT DAYS

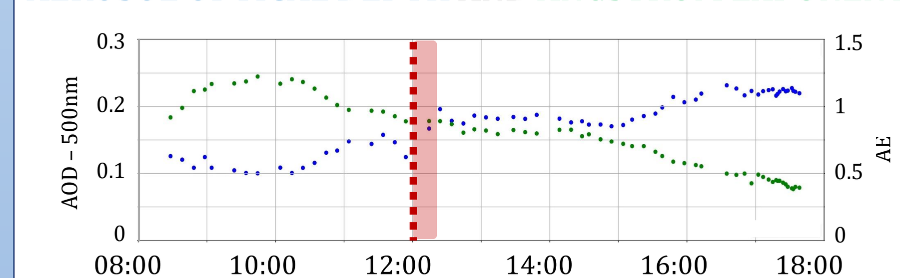
The arrival of the sea-breeze (red dotted line) is gradual and the weather conditions vary slowly, typically in about 1 hour (red filled region)



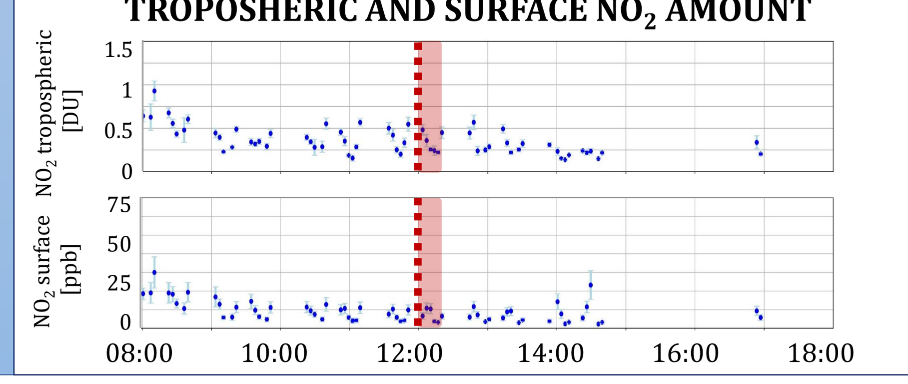
EFFECT ON AEROSOLS AND GASES PROPERTIES

FRONT DAYS

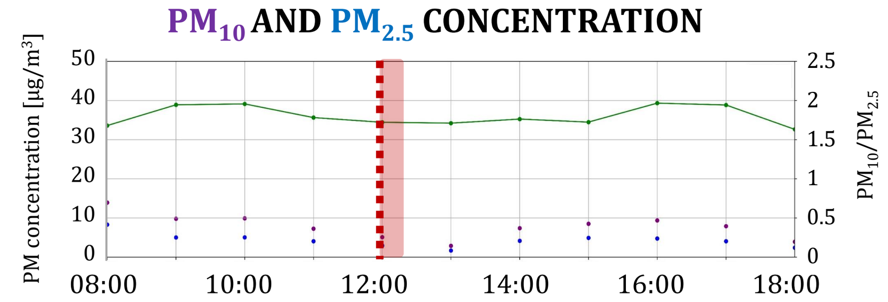
AEROSOL OPTICAL DEPTH AND ÅNGSTRÖM EXPONENT



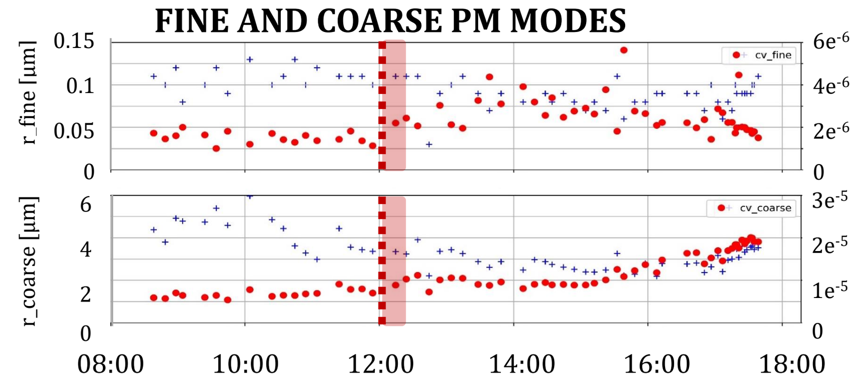
TROPOSPHERIC AND SURFACE NO_2 AMOUNT



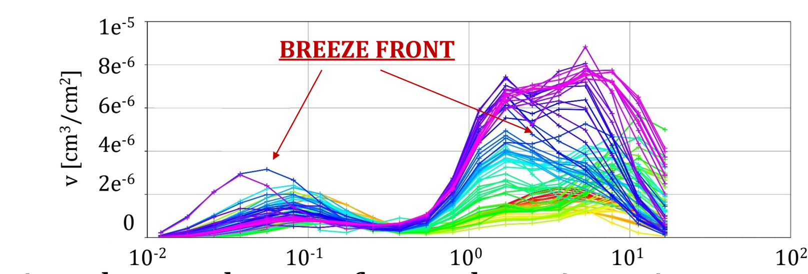
PM_{10} AND $PM_{2.5}$ CONCENTRATION



FINE AND COARSE PM MODES



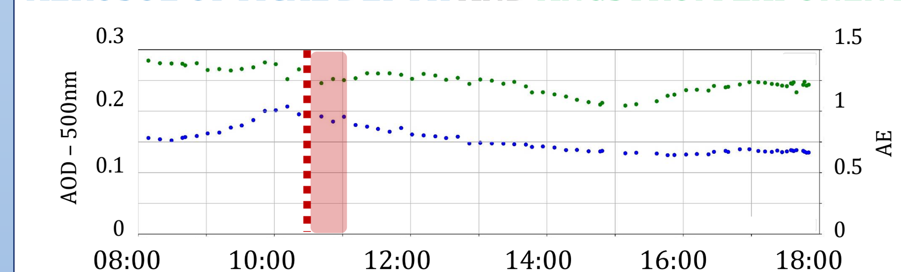
PM SIZE DISTRIBUTION



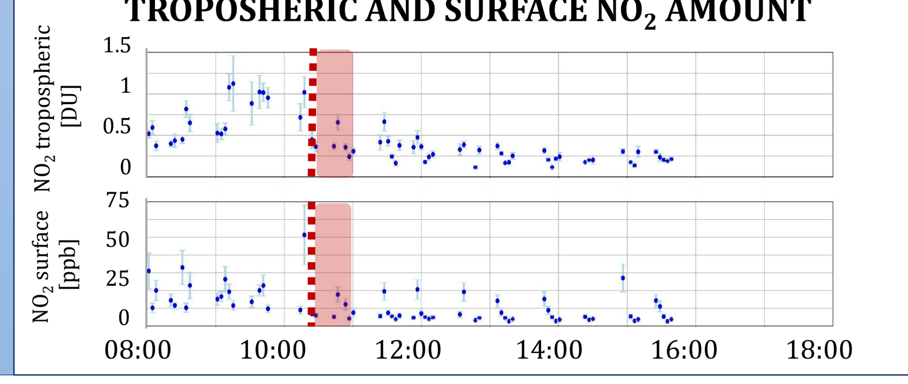
- During the sea-breeze front, there is an increase in AOD
- Tropospheric and surface NO_2 are almost constant
- Aerosol size distribution has a clearly bimodal trend; the fine radius remains constant, the coarse radius increases in terms of volume
- PM concentrations decrease before the sea-breeze front, and increase after the sea-breeze advection

NO FRONT DAYS

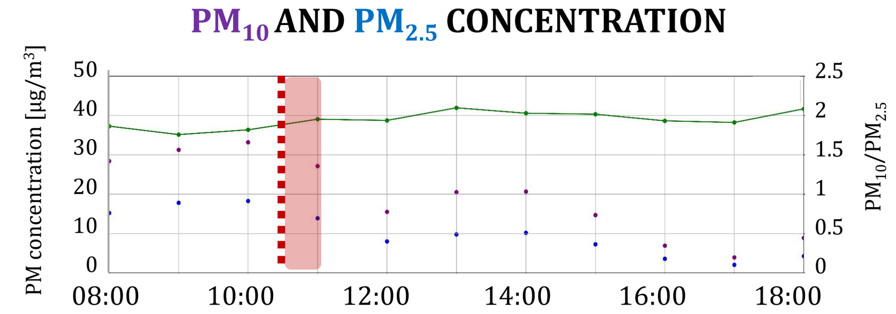
AEROSOL OPTICAL DEPTH AND ÅNGSTRÖM EXPONENT



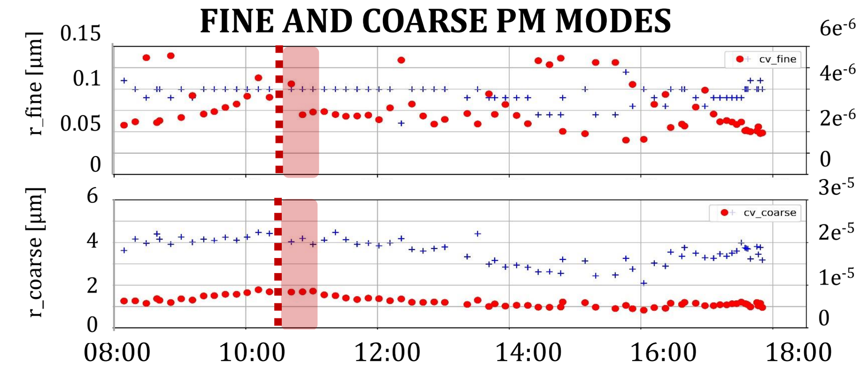
TROPOSPHERIC AND SURFACE NO_2 AMOUNT



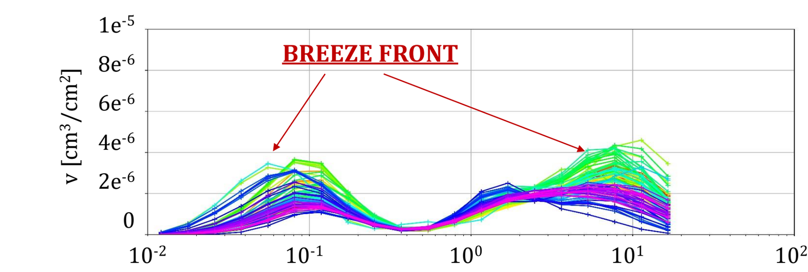
PM_{10} AND $PM_{2.5}$ CONCENTRATION



FINE AND COARSE PM MODES



PM SIZE DISTRIBUTION



- AOD and AE are not affected by the sea-breeze arrival and remain almost constant
- Tropospheric, surface NO_2 and PM decrease: there is dilution of the surface emitted pollutants
- The size distribution does not have a bimodal predominance and a demarcation radius cannot be identified; the fine component decreases, the coarse component remains constant

CONCLUSIONS

The breeze impacts differently on the composition of aerosols and atmospheric gases depending on the intensity and speed of the sea-breeze front.

Preliminary results show that, when the sea-breeze front is well evident, there is an increase in AOD and the aerosol size distribution is clearly bimodal. In this case, the ground-based stations do not give exhaustive indications regarding the aerosol carried by the sea-breeze.

Contrariwise, when the passage of the sea-breeze front is slow and gradual, AOD and AE do not change significantly and the aerosols arriving with the sea-breeze have characteristics similar to those already present. NO_2 and PM decrease and the size distribution is not strongly bimodal.