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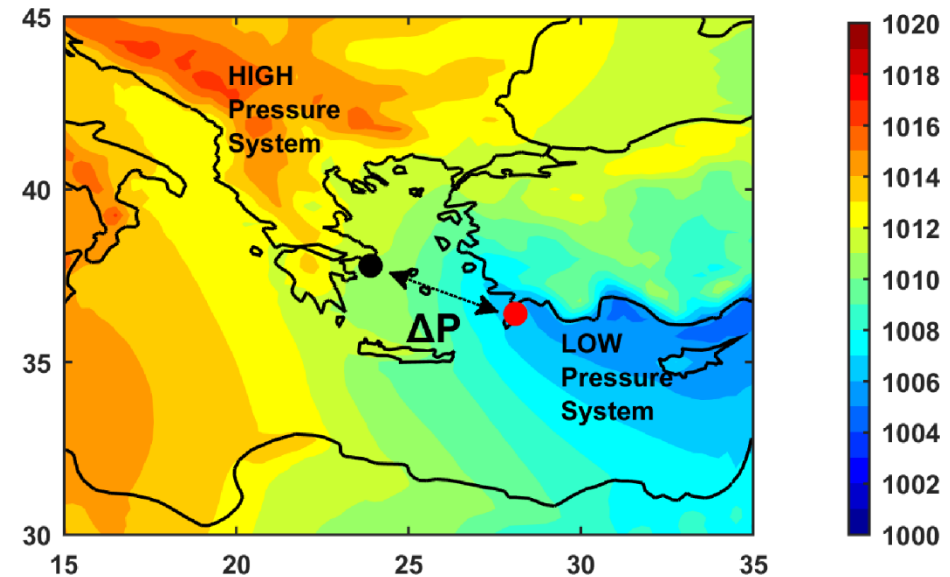1–15 Dec 2022

ΗΛΕΚΤΡΟΝ

The air quality and the influence of Etesians on pollution levels in the Rhodes city, the case of July 2022

Dr. Ioannis Logothetis*, Christina Antonopoulou, Georgios Zisopoulos,

Dr. Adamantios Mitsotakis, Dr. Panagiotis Grammelis

*Corresponding author: logothetis@certh.gr (I.L.)

Outline

- Introduction

- Data and Methods

- Results
  - Daily mean and diurnal variation of concentration of pollutants in Rhodes city.
  - The Etesian regime during July 2022
  - The impact of Etesians on the concentration of pollutants

- Conclusions

- The poor air quality increases the environmental danger and affects human health (*Sillmann et al., 2021*).

- The traffic emissions and pollution episodes degrades the air quality over the cultural center of the Rhodes city (*Logothetis et al., 2022*).

- The dominant atmospheric circulation over the Aegean Sea is the northern sector winds (Etesian winds) that affects sailing and variation of pollution levels over eastern Mediterranean (*Dafka et al., 2016; Logothetis et al. 2019*)
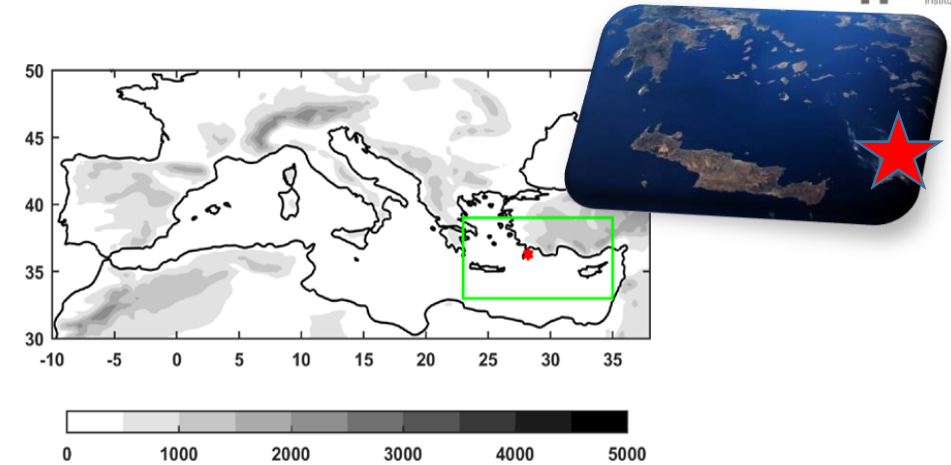

Fig 1: Mediterranean topography. The green box indicates the region of southeastern Mediterranean and the red star indicates the city of Rhodes (Source: Logothetis et al, 2022, Proceedings of the 7th World Congress on Civil, Structural, and Environmental Engineering, Paper No. ICEPTP 181)

In July 2022 intense northern sector winds blew over the Aegean Sea affecting the tourist activities and sailing over the Aegean basin.

The Objectives of this study are to investigate:
- The variability of pollutants' concentrations (PM_{10}, NO_2, O_3 and SO_2) and
- The impact of strengthening of low tropospheric circulation of July 2022 on the pollution level of Rhodes city.

- Recordings from the **Haz-Scanner™ model HIM-6000** air quality monitoring station (AQMS) located in the center of Rhodes City are used.

- **Recordings include**:
  - Concentration of: PM10, NO2, SO2 and O3.
  - Meteorological factors temperature (T), relative humidity (RH), wind speed (WS) and wind direction (Wdir).

Fig 1. The AQMS. The location of AQMS in the center of the city of Rhodes. The red star indicates the position of mobile air quality monitoring station. *(Source: Logothetis et al, 2022, Proceedings of the 7th World Congress on Civil, Structural, and Environmental Engineering, Paper No. ICEPTP 181)*

- **Mean Sea Level Pressure (MSLP)** hourly data available **from ERA5** in the frame of ECMWF

> ➢ **Our analysis focuses on July 2022 because it presents high-frequency and stronger northern sector winds than the normal conditions.**

- **Discomfort index (DI)** is calculated following the equation:

$$DI(°C) = T - 0.55 * (1 - 0.01 * RH) * (T - 14.5),$$ *(Poupkou et al. 2011)*

To define the frequency and strength of the Etesians:
- The difference between the pressure in the region of Elliniko (Attica) and Rhodes, using MSLP data (*Dafka et al., 2016*) from ERA5 during July 2022 (hereafter ΔP), is calculated over Aegean Sea (Fig.).

Etesians day classification: A day is classified as Etesian day when the ΔP is larger/equal to the median of the positive values of the ΔP distribution.
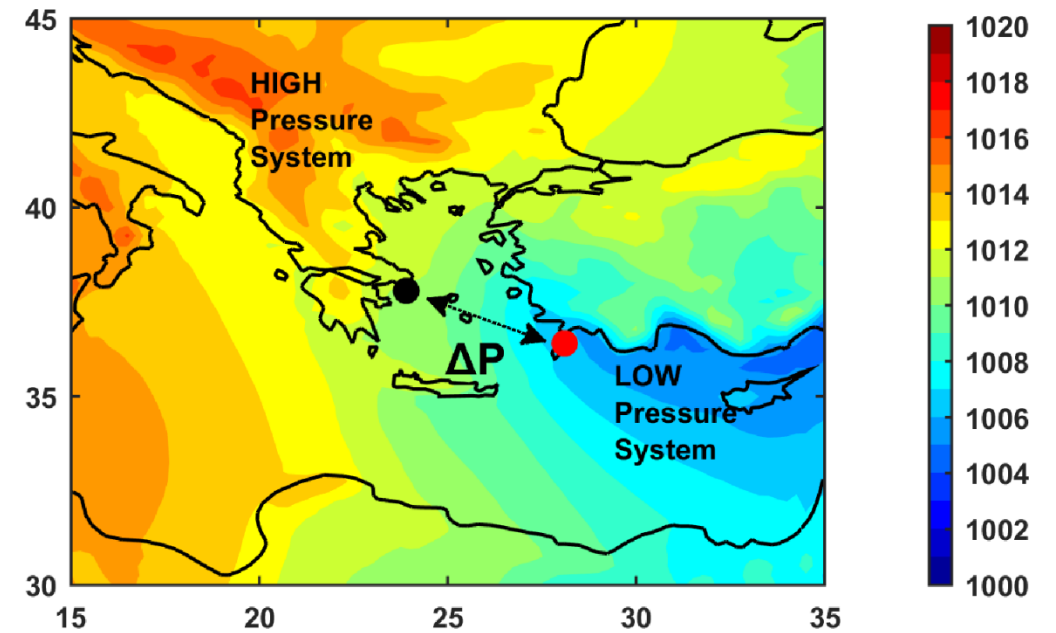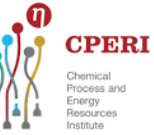

Fig 2. Map of the composite mean July MSLP (hPa) for the period from 1980 to 2022. The black/ red points show the location of Elliniko (Attica)/ Rhodes. Also the location of High and Low pressure system is presented.

- To study the changes in the Etesian flow of 2022, compared to period 1980-2022, the **composite difference map** of MSLP over the spatial window 15°-35°E, 30°-45°N is constructed.

- To investigate the **diurnal changes of ΔP** between two periods, diurnal variation of ΔP is also calculated.

- In order to study the spatiotemporal variability of MSLP and its relation with the level of pollution in the region of Rhodes, the three dominant mode of **Empirical Orthogonal Functions (EOFs) and Principal Components (PCs) of MSLP** over eastern Mediterranean are calculated and the corresponding maps are constructed.

- The concentration of pollutants is maximized during the hours with high traffic activity.
    - The maximum concentration of NO_2 and O_3 → during the afternoon and midnight hours.
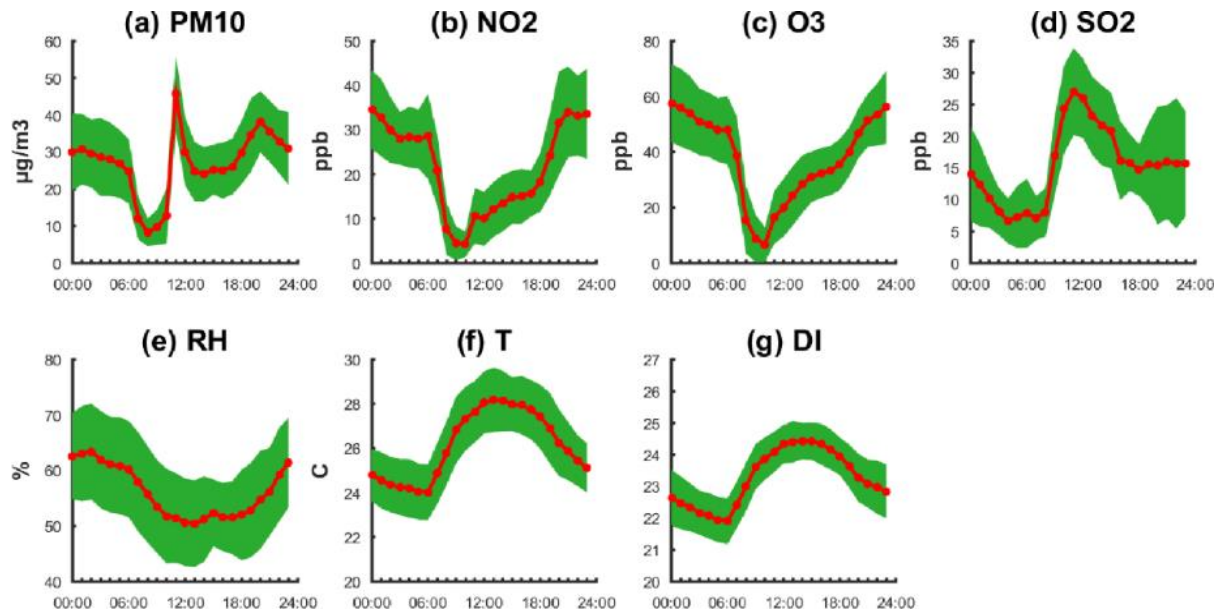   - The concentration of PM10 presents the maximum hourly values → afternoon and early morning hours.

- The DI values vary between 22 and 25 → a significant percentage of population feels discomfort
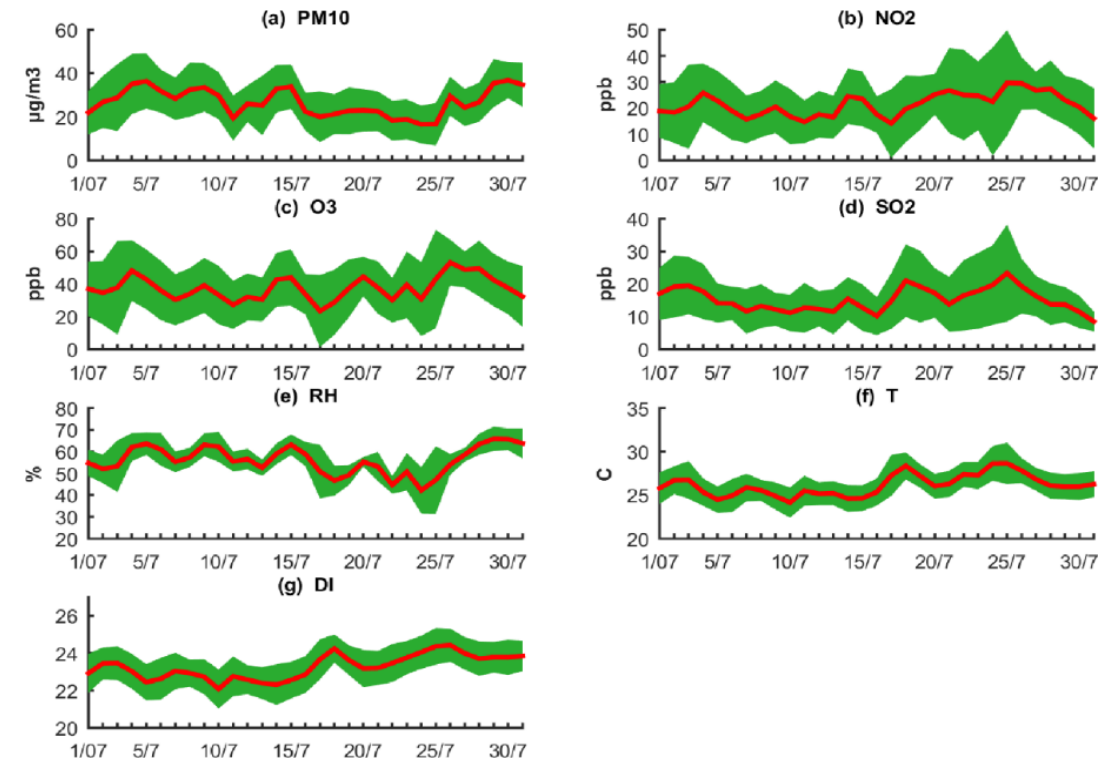

Fig 3. Diurnal variation for **(a-d)** the concentration of PM_{10}, NO_2, O_3 and SO_2, **(e,f)** meteorological factors (RH,T) and **(g)** discomfort index (DI) for the center of Rhodes city during July 2022. The red line shows the daily mean value and the green area denotes the mean value plus/ minus one standard deviation.

Fig 4. Daily mean variation for **(a-d)** the concentration of PM_{10}, NO_2, O_3 and SO_2, **(e,f)** meteorological factors (RH,T) and **(g)** discomfort index (DI) for the center of Rhodes city during July 2022. The red line shows the daily mean value and the green area denotes the mean value plus/ minus one standard deviation.

July (2022) VS (1980 to 2022):

- ΔP was stronger by about 1.8 hP.

- The high pressure center increased and the low pressure center deepened (Fig. 5a)

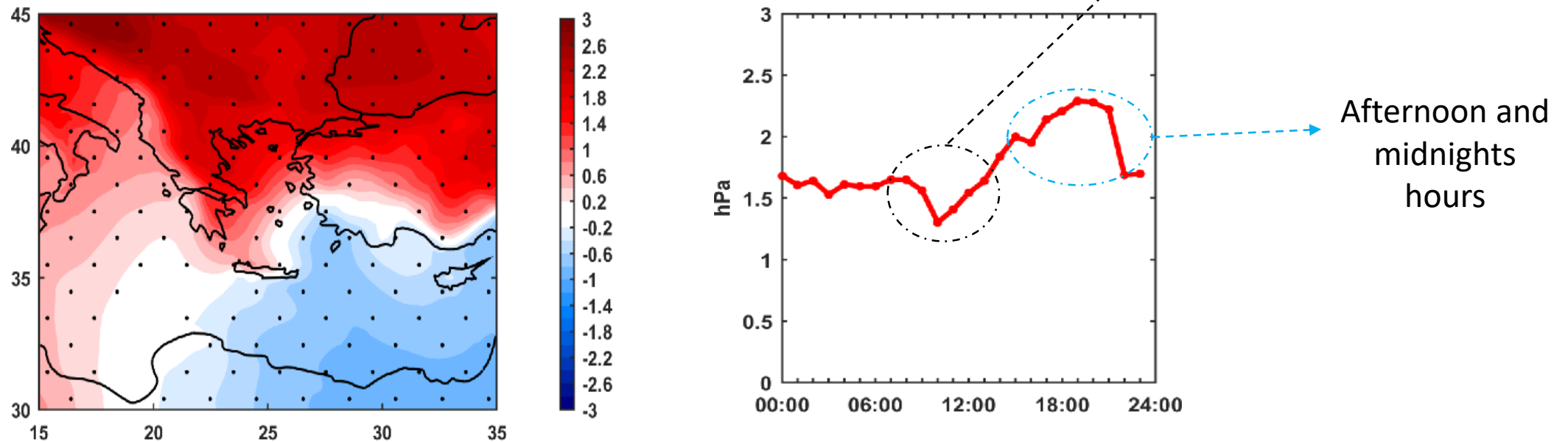- The frequency of Etesian days shows a relative increase about 68%.

Daytime hours

Afternoon and midnights hours

Fig 5. **(a)** Map of the difference between composite mean (July) MSLP (hPa) between 2022 and period from 1980 to 2022 **(b)** Diurnal variation of the difference of (July) pressure gradient over Aegean between 2022 and period from 1980 to 2022.

EOF analysis:

- EOF1 → shows an increase on MSLP over the east Mediterranean (Fig. 6).
- EOF2 and EOF3 → a north – south dipole intensifies the ΔP over Aegean basin (Fig. 6).

❖ (July) 2022 ΔP is high correlated with PC1 (~0.8).

❖ the ΔP is negatively correlated with the concentration of PM_{10}, NO_2 and O_3 (corr. coeff. -0.45, -0.25 and -0.4, respectively).

→ The Etesian flow tends to reduce the pollutants' concentration
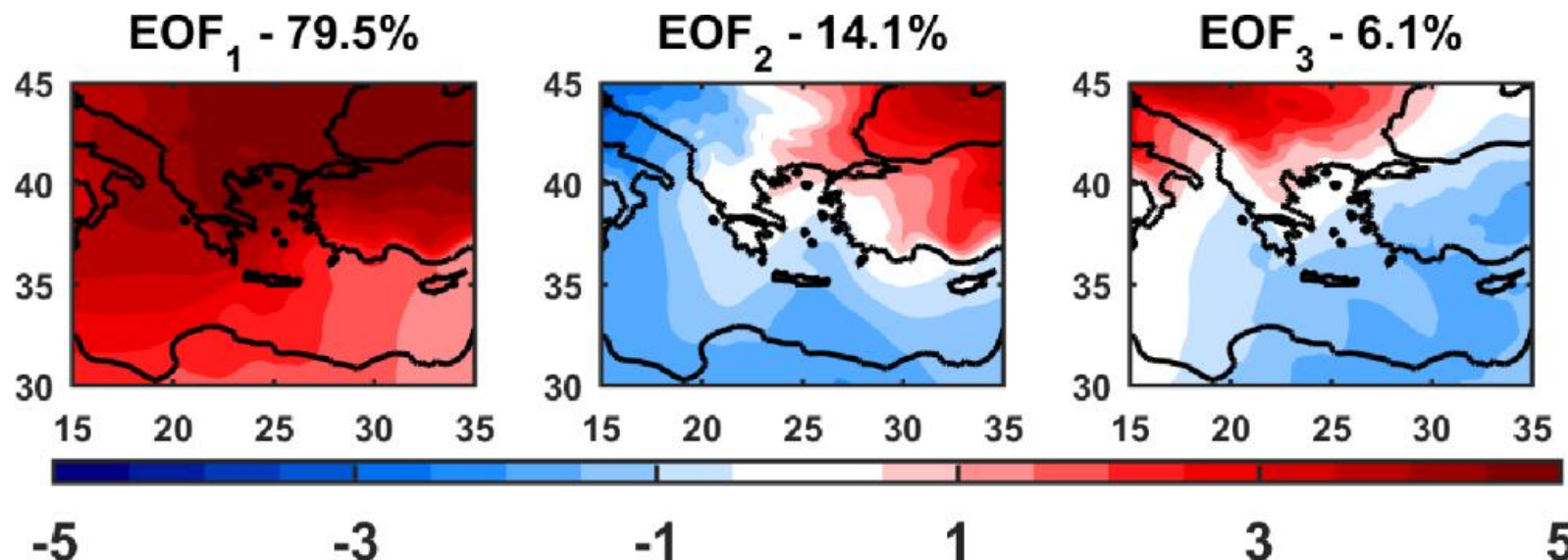

Fig 6. The three dominant EOF modes of MSLP between 15º-35ºE and 30º-45ºN for July 2022. The percentage of the total variance explaining the pattern appears in the title of each subplot.

- The traffic and human activities affect the air quality although the pollution limits do not exceed the thresholds according to 2008/50/EC.

- The discomfort index indicates that in some cases half of the population feels discomfort in the city center of Rhodes.

- The ΔP is negatively related with the concentration of PM_{10}, NO_2 and O_3 showing that the strong and high-frequency Etesians of July 2022 are possibly related to the improved air quality in Rhodes city center.

  - The Etesian flow tends to reduce the pollutants' concentration.

Thank you

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