

## Environmental impacts on human health during a Saharan episode at Crete Island, Greece

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### Abstract

The objective of this study is to examine the relationship of the environmental variability (weather and particulate air pollution conditions) with cardiovascular and respiratory syndromes, in Heraklion city at the northern part of Crete Island, during a Saharan dust episode on March, 22-23 2008. Daily counts of admissions for cardiovascular and respiratory syndromes were obtained from the two main hospitals in Heraklion. The corresponding daily meteorological parameters, such as maximum and minimum air temperature, relative humidity, wind speed, cloudiness and atmospheric pressure, from the meteorological station of Heraklion (Hellenic National Meteorological Service), were manipulated in multivariate analyses. Besides, the bioclimatic conditions expressed by the Physiologically Equivalent Temperature (PET), based on the energy balance models of the human body, are analyzed. Dust concentrations were derived from the SKIRON forecast model of the University of Athens.

The findings showed that the respiratory admissions were 3-fold than the mean daily admissions on the same day of the emergence of the Saharan dust episode (key day). The admissions concerning the cardiovascular syndromes did not appear any significant change. The analysis of the bioclimatic conditions on the key day revealed that thermal stress existed and this may be attributed mainly to the geomorphology of the island which is responsible for extreme weather conditions.

### 1. Introduction

Changes in the frequencies of extreme heat and cold and the profile of local or transboundary air pollution and aeroallergens would directly affect human health. These environmental changes are caused in specific cases by miscellaneous phenomena, such as Föhn winds - hot and dry winds - associated with extreme bioclimatic conditions and Saharan dust transport. Crete Island (Fig. 1), being in the Southeastern Mediterranean basin is affected by frequent Saharan dust episodes, resulting in very high particulate matter (PM) concentrations, which are associated with either short or long term effects on human health.

Long-term particulate matter exposure is connected with accelerated heart and lung disease because it contributes to pulmonary and systemic oxidative stress, inflammation, subclinical chronic inflammatory lung injury, atherosclerosis and increased risk of ischemic heart disease and death (Pope et al., 2004; Souza et al., 1998). But besides the problem of exposure to PM over a long period (months or years), exposures from minutes to hours or days can also affect heart and lung function.

Short term exposures result in: increased rates of myocardial infarction associated with hospital admissions or death (Pope et al., 2006; Peters et al., 2001; Sullivan et al., 2005), heart rate disturbances such as paroxysmal atrial fibrillation or other arrhythmias (Lipsett et al., 2006; Rich et al., 2006; Grigoropoulos et al., 2009) and reduced lung function with episodes of acute asthma and bronchitis (Ho et al., 2007; Nastos, 2008; Monteil et al., 2009). Many studies have shown that short-term increase in mean daily levels of PM may also precipitate acute cardiac decompensation leading to hospitalization, especially in patients with ischemic heart disease (Wellenius et al., 2005).



Fig. 1: Crete Island, Greece. Heraklion city is indicated by a rectangular frame

The present study evaluates the role of short-term increases of dust concentrations in daily counts of admissions for cardiovascular and respiratory syndromes at the wider area of Heraklion, Crete Island, Greece, during a Saharan dust episode on March, 22-23 2008.

## 2. Data and Analysis

Daily counts of admissions for cardiovascular (acute coronary syndrome, arrhythmia, decompensation of heart failure) and respiratory (pulmonary infection, acute exacerbation of chronic obstructive pulmonary disease, acute asthma crisis and syncope-presyncope) syndromes were obtained from the two main hospitals in Heraklion, during March-April 2008. The corresponding daily meteorological parameters, such as maximum and minimum air temperature, air humidity, wind speed, cloudiness and atmospheric pressure, were acquired from the meteorological station of Heraklion (Hellenic National Meteorological Service). Besides, the bioclimatic conditions expressed by the Physiologically Equivalent Temperature (PET), based on the energy balance models of the human body, are analyzed (Matzarakis et al., 1999). Dust concentrations were derived from the SKIRON forecast model of the University of Athens, while daily composite anomalies (reference period: 1968-1996) of the air temperature and vector wind from the middle to the lower atmospheric levels (500hPa – mean sea level) on March, 23 2008, calculated from the reanalysis datasets of the National Centers for Environmental Prediction/National Center for Atmospheric Research (NCEP/NCAR) (Kalnay et al., 1996).

### 3. Results and Discussion

The examined Saharan dust episode affected Crete Island firstly at noon on March, 22 2009 and became more appreciable the next day, as it is depicted in Fig. 2, where the aerosol optical thickness, the dust concentration ( $\mu\text{g m}^{-3}$ ) at 10 m and the dry deposition ( $\text{mg m}^{-2}$ ) over the wider area of Heraklion are presented from the SKIRON forecast model of the University of Athens.

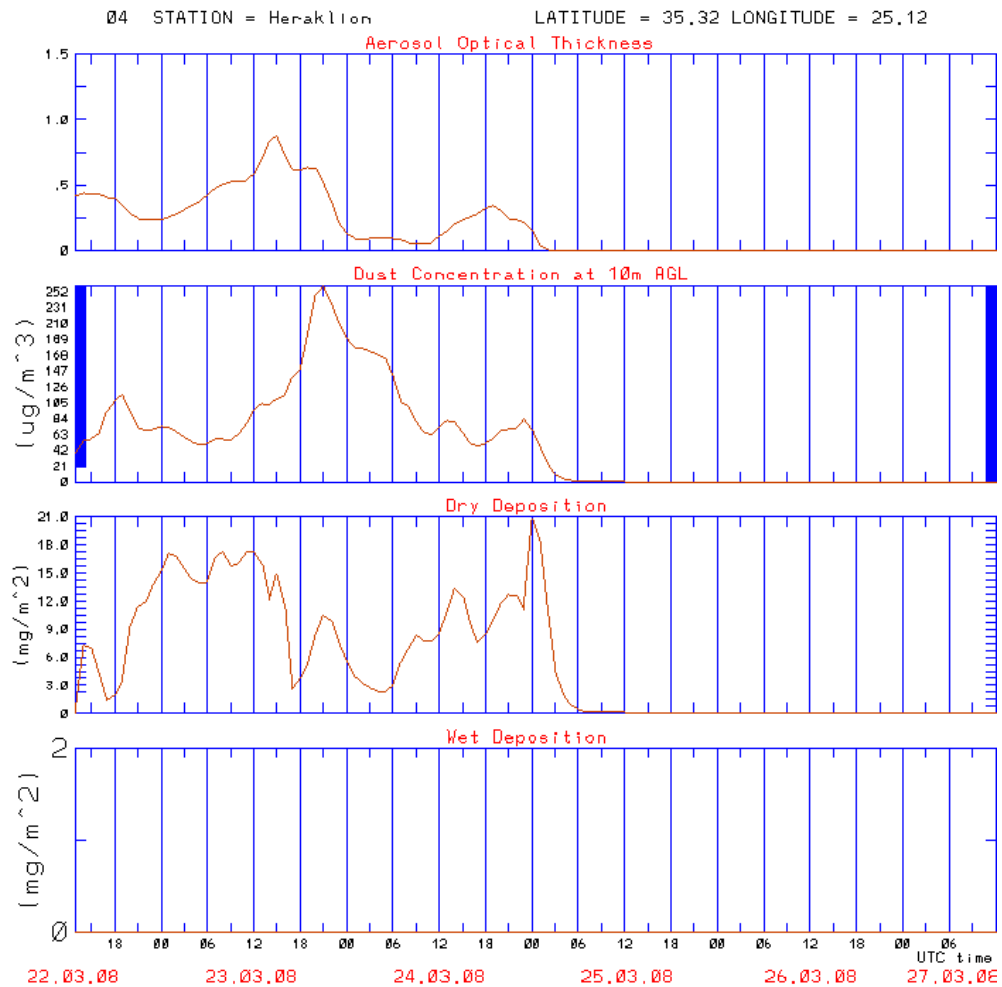


Fig. 2: Output (dustgram) from SKIRON forecast model of the University of Athens, concerning aerosol optical thickness, dust concentration at 10m, dry and wet deposition over Heraklion, Crete on March, 22-27 2008

High values of dust concentrations ( $252 \mu\text{g m}^{-3}$ ) appeared over the city causing an asphyxiating environment. Moreover, the south-eastern wind blow was the main factor for extreme bioclimatic conditions, which could be attributed to the Föhn phenomenon, a normal situation under these synoptic conditions.

The daily composite anomaly (reference period: 1968-1996) of the air temperature from the middle to the lower atmospheric levels (500hPa – mean sea level) on March, 23 2008 (Fig. 3) revealed that positive anomalies ( $\sim +5 \text{ }^\circ\text{C}$  at the 500hPa isobaric level,  $\sim +12 \text{ }^\circ\text{C}$  at the 850 hPa isobaric level,  $\sim +7^\circ\text{C}$  at surface) appear. Additionally, high positive daily composite anomalies of south-eastern winds ( $\sim +25 \text{ m/s}$  at the 500 hPa isobar-

ic level,  $\sim +17$  m/s at the 850 hPa isobaric level,  $\sim +10$  m/s at surface) show the strong transport of Saharan dust over Crete area.

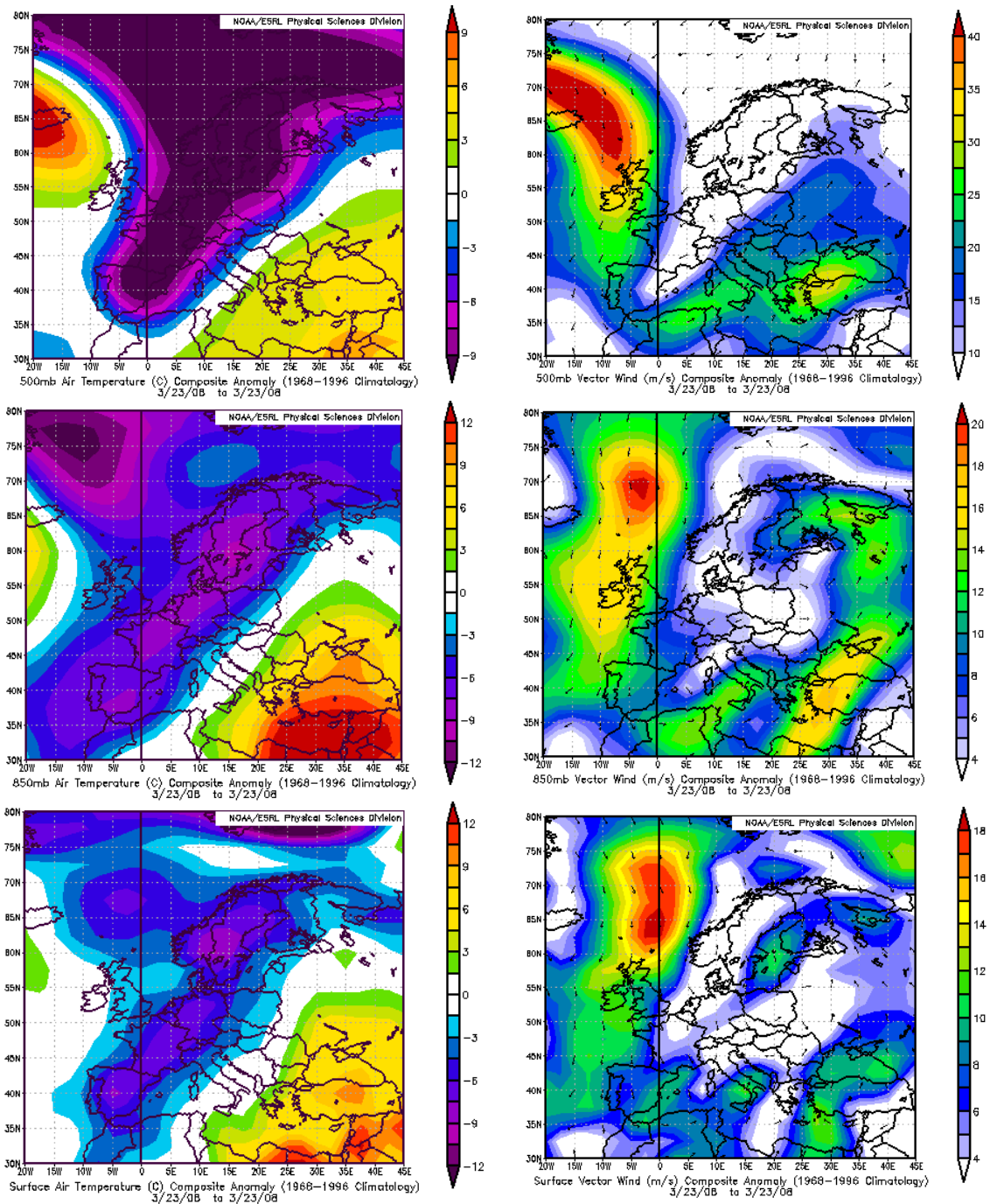


Fig. 3: Daily composite anomalies (reference period: 1968-1996) of air temperature (left graphs) and vector wind (right graphs) for 500 hPa level (upper graphs), 850hPa level (middle graphs) and surface (lower graphs) on March, 23 2008, calculated from the NCEP/NCAR reanalysis data

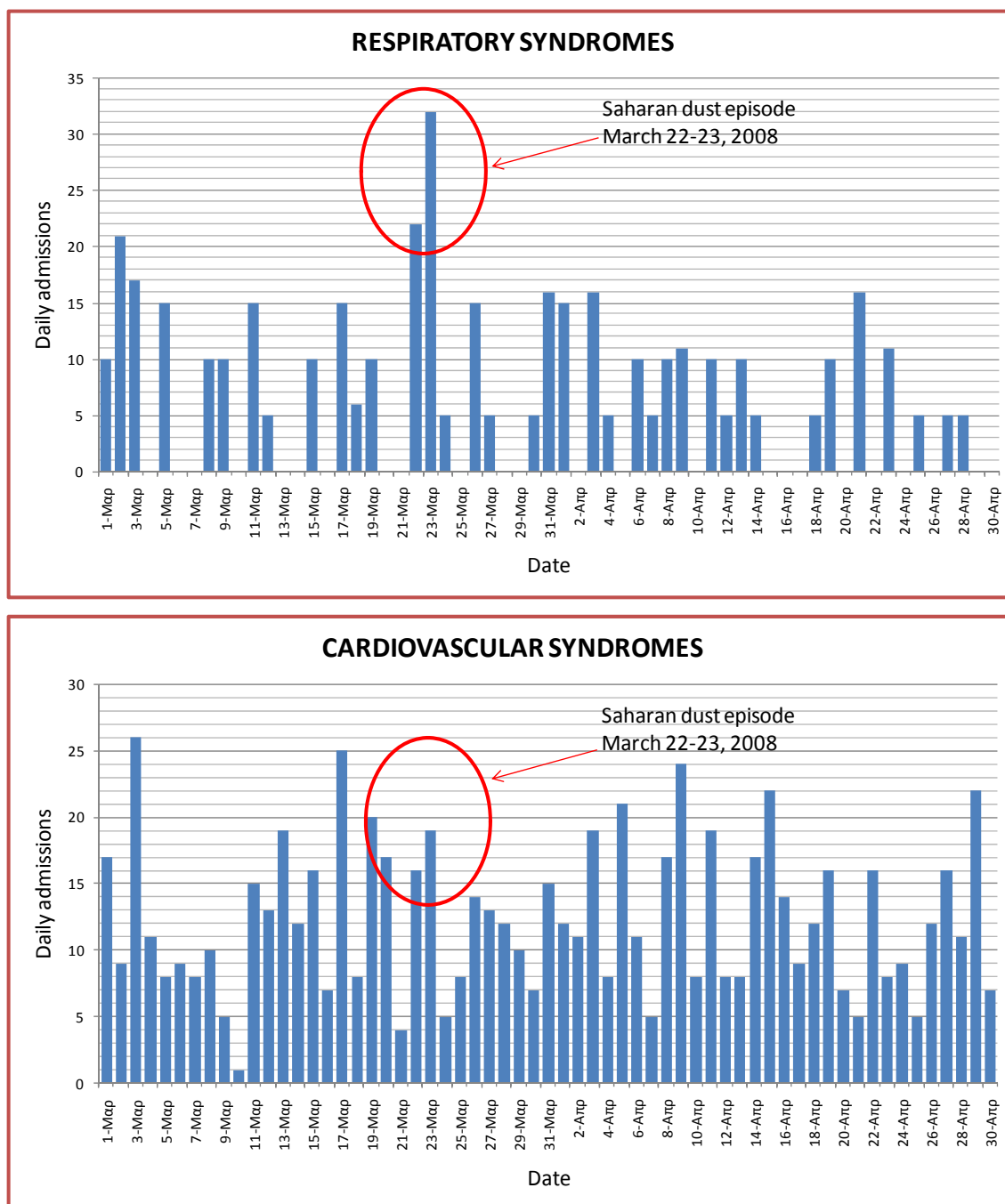


Fig. 4: Daily admissions concerning respiratory (upper graph) and cardiovascular (lower graph) syndromes at Heraklion, Crete Island, in March-April 2008

As far as the bioclimatic conditions are concerned, the physiologically equivalent temperature (PET), estimated from RAYMAN model (Matzarakis et al., 2007), reached 29.3 °C at 13:00 UTC on March, 23 2008, giving evidence of moderate heat stress at the beginning of Spring season, when Saharan dust episodes are more frequent (Kosmopoulos et al., 2008).

The daily counts of admissions for cardiovascular and respiratory syndromes, which were obtained from the two main hospitals in Heraklion city, are depicted in Fig. 4. It is clear the impact of the Saharan dust episode in the increased incidence of respiratory

syndromes, giving evidence that high dust concentrations, which are associated with high PMs concentrations (Mitsakou et al., 2008), trigger respiratory syndromes outbreak. The daily counts were approximately 5-fold than the mean daily counts (6.6 admissions) on the same day of the emergence of the Saharan dust episode. On the other hand, it seemed not to be any significant increase in the cardiovascular syndromes attributed to the Saharan episode. Cardiovascular syndromes appeared high variability within the examined period.

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### 5. Conclusions

The Saharan dust episode on March, 22-23 2009 affected Crete Island, Greece, establishing moderate heat stress bioclimatic conditions and increased dust concentrations over Heraklion city (case study). These outdoor factors linked to respiratory syndromes outbreak, while cardiovascular syndromes were not associated with high dust concentrations resulted from Saharan episode.

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