# STUDY OF THE SAHARAN DUST TRANSPORT EVENTS IN THE REGION OF MEDITERRANEAN

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## AERONET Stations

**Table 1** The AERONET sites selected across the Mediterranean basin region

| Site | Latitude | Longitude | Altitude (m) |
|---|---|---|---|
| **Arcachon** | N 44º 39’ 50’’ | W 01º 09’ 46’’ | 11 |
| **Autilla** | N 41º 59’’ 49’’ | W 04º 36’ 10’’ | 873 |
| **Granada** | N 37º 09’ 50’’ | W 03º 36’ 18’’ | 680 |
| **Venice** | N 45º 10’ 15’’ | E 12º 30’ 28’’ | 10 |
| **Rome_Tor_Vergata** | N 41º 50’ 24’’ | E 12º 38’ 49’’ | 130 |
| **Messina** | N 38º 11’ 44’’ | E 15º 34’ 01’’ | 15 |
| **Thessaloniki** | N 40º 37’ 38’’ | E 22º 57’ 36’’ | 60 |
| **Athens-NOA** | N 37º 59’ 16’’ | E 23º 46’ 30’’ | 130 |
| **Forth_Crete** | N 35º 19’ 58’’ | E 25º 16’ 55’’ | 20 |

**Fig. 1.** Geographical locations overview of AERONET stations , considered within this study: 1) Arcachon, 2) Autilla, 3) Granada, 4) Venice, 5) Rome, 6) Messina, 7) Thessaloniki, 8) Athens and 9) Forth-Crete

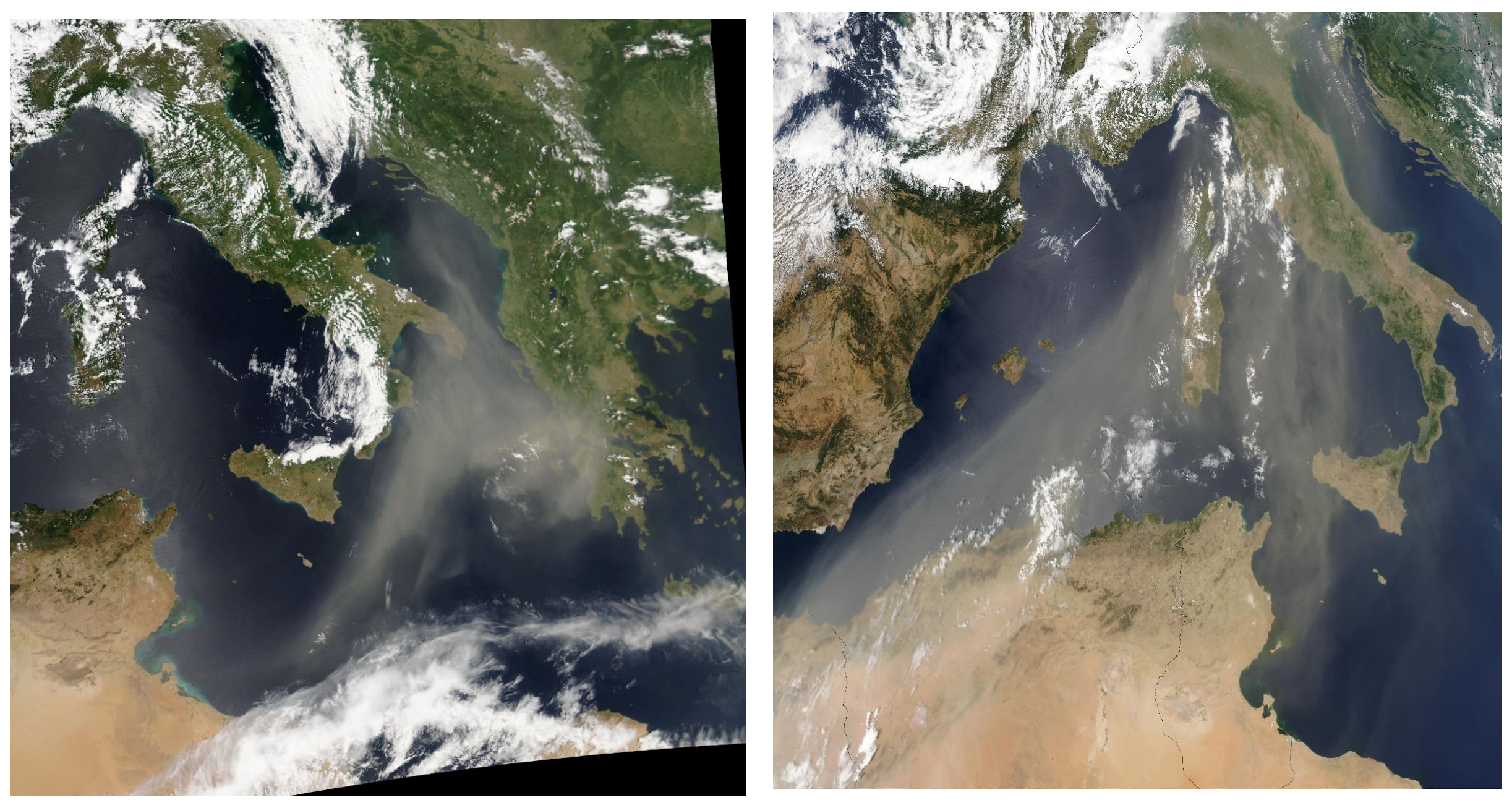

**Fig. 2**. Satellite photos that depicted, dust episodes in the Mediterranean area

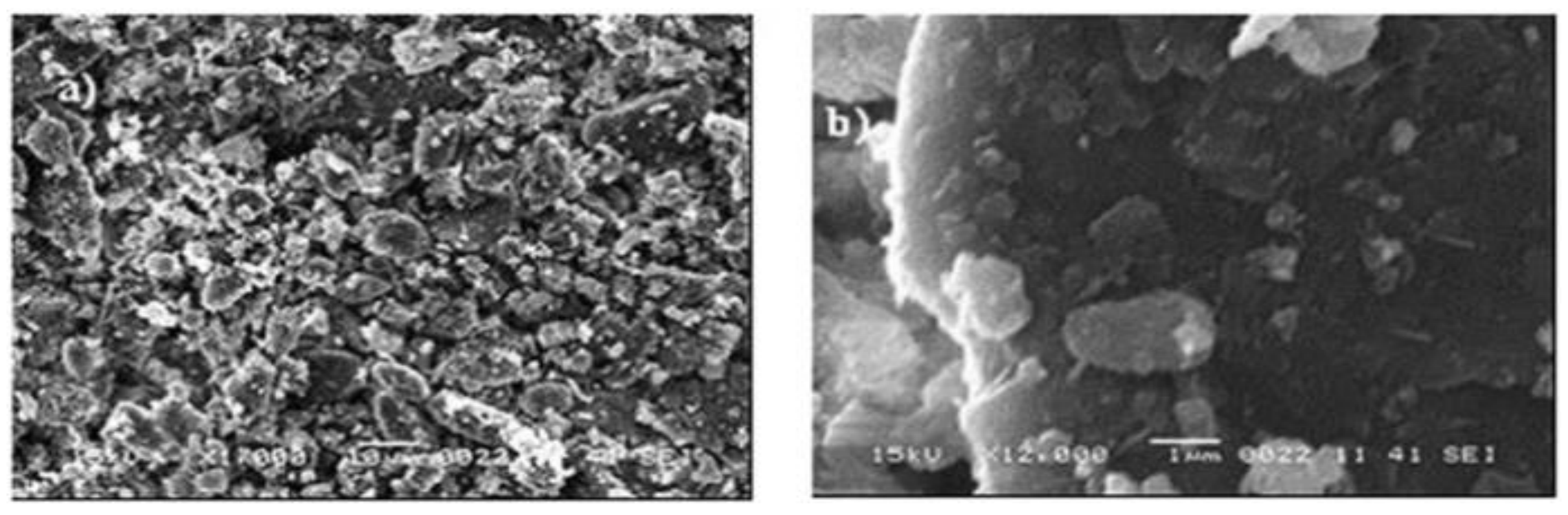

**Fig 3**. Scanning electron micrograph of Sahara dust (**a**) various sizes of dust particles and (**b**) small dust particles adhering to the surface of large dust particles.

## Abstract

North Africa and particularly the Sahara desert is a significant source region of mineral dust. Studies conducted in the past few decades have clearly shown that throughout the year, large amounts of dust, mobilized by wind, can be transported across the Mediterranean and Europe, affecting the air quality in these regions. The present study examines the temporal and spatial variability of Saharan dust transport events in selected Mediterranean cities. The analysis is carried out using data of Angstrom exponent of aerosol optical depth, measured with CIMEL sun photometers of the worldwide network AERONET in the selected Mediterranean cities.

## Data and Methodology

**Fig 6.** The CIMEL sun photometer

The AErosol RObotic NETwork (AERONET) is a worldwide network of installed CIMEL sun-sky radiometers (following similar protocols) obtaining sunphotometric observations in more than 1000 locations of the planet. Sun-photometer measurements provide total-column information on the atmospheric content of aerosols due to their scattering characteristics at specific wavelengths to which the instrument is sensitive. Besides information on the total atmospheric aerosol load, different types of aerosols can be distinguished due to their size and optical properties. Taking the ratio between the AODs at wavelength $\lambda_1$= 440 nm and $\lambda_2$= 675 nm, the Angstrom exponent, α, can be derived, which provides the spectral dependence of the AOD in the visible domain. Several authors have discussed how the spectral variation of the Angstrom exponent can provide further information about the aerosol size distribution. According to Moulin et al. (1997) small or even negative values of α are found for large particles, such as sea salt or desert aerosols. The AERONET sites for this study were selected in a way, so that the spatial variability of Saharan dust transport events can be distinguished (i.e. three sites in the Eastern, three in the central and three in the Western region of the Mediterranean) as shown in Table 1. In this study, a day is considered dusty if there are at least two observations of $\alpha \le 0.7$ during the day. However, we also take into account the case, where at least one observation of $\alpha \le 0.7$ can characterize a dust day. The analysis includes only data of stations with a sufficient number of observations during the sampling period.

## Results and Discussion

### ❖ Seasonal Variability

- **Eastern Mediterranean:** All three sites have a dominant peak of dust events in spring and a secondary in autumn. These peaks are the result of two factors, (i) the Sharav Cyclones, as they transfer Saharan dust to the Eastern Mediterranean region in spring and (ii) dust from sources in the Middle East that is transported to the Mediterranean in autumn. A minimum is observed at all three stations in August.
- **Central Mediterranean:** The two main features that influence the transport of dust from Africa into Europe and particularly into Italy is the trough that emanates from the Icelandic low southward, and the subtropical high. We can notice a clear peak during spring and a minimum in late summer at Messina station, which is in agreement with the meteorological conditions that take place in the region of South Italy (Sharav Cyclones). In regions with higher latitude (i.e. Rome and Venice) a significant reduction in the frequency of dust events is observed and as a result no seasonal pattern can be distinguished with certainty.

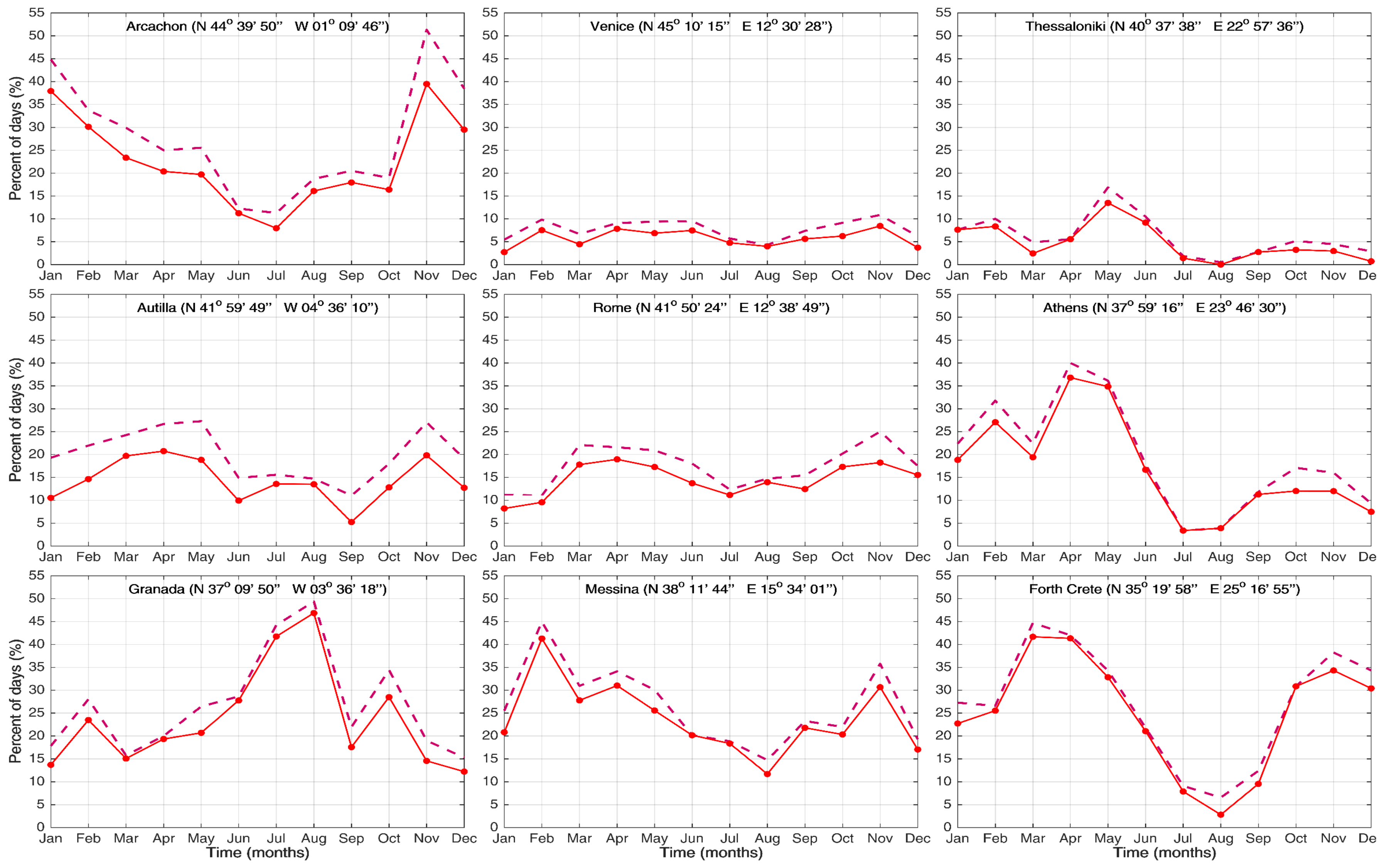

**Fig. 4.** Seasonal frequency of occurrence of desert dust events (percent of dusty days over the total number of observation days) A day is considered dusty if **(a)** there are at least two observations of (solid line), **(b)** at least one observation (dashed line) during the day

- **Western Mediterranean**: At the station of Granada, desert dust episodes are more frequent, as expected, in August and July, because the intrusion of air masses coming from the Sahara desert is direct as a result of the short distance between the two regions. At higher latitude and specifically at the Autilla site, the frequency of episodes is significantly lower than Granada. However, frequent episodes are observed throughout the year when we would normally not expect intense transport of dust. Also, at Arcachon station the percent of days with low Angstrom exponent values is higher in winter and autumn. These maritime regions are directly affected by atmospheric aerosols originating from the Atlantic Ocean and are transported by pressure systems.

### ❖ Inter-annual Variability:

Fig. 5 presents the inter-annual variation of Mediterranean desert dust episodes. It seems that there is no clear temporal pattern in any of the selected sites. However, 2010 seems to be a year of intense dust transport events across the entire region, as most of the sites show local maxima in the frequency of the observed episodes.

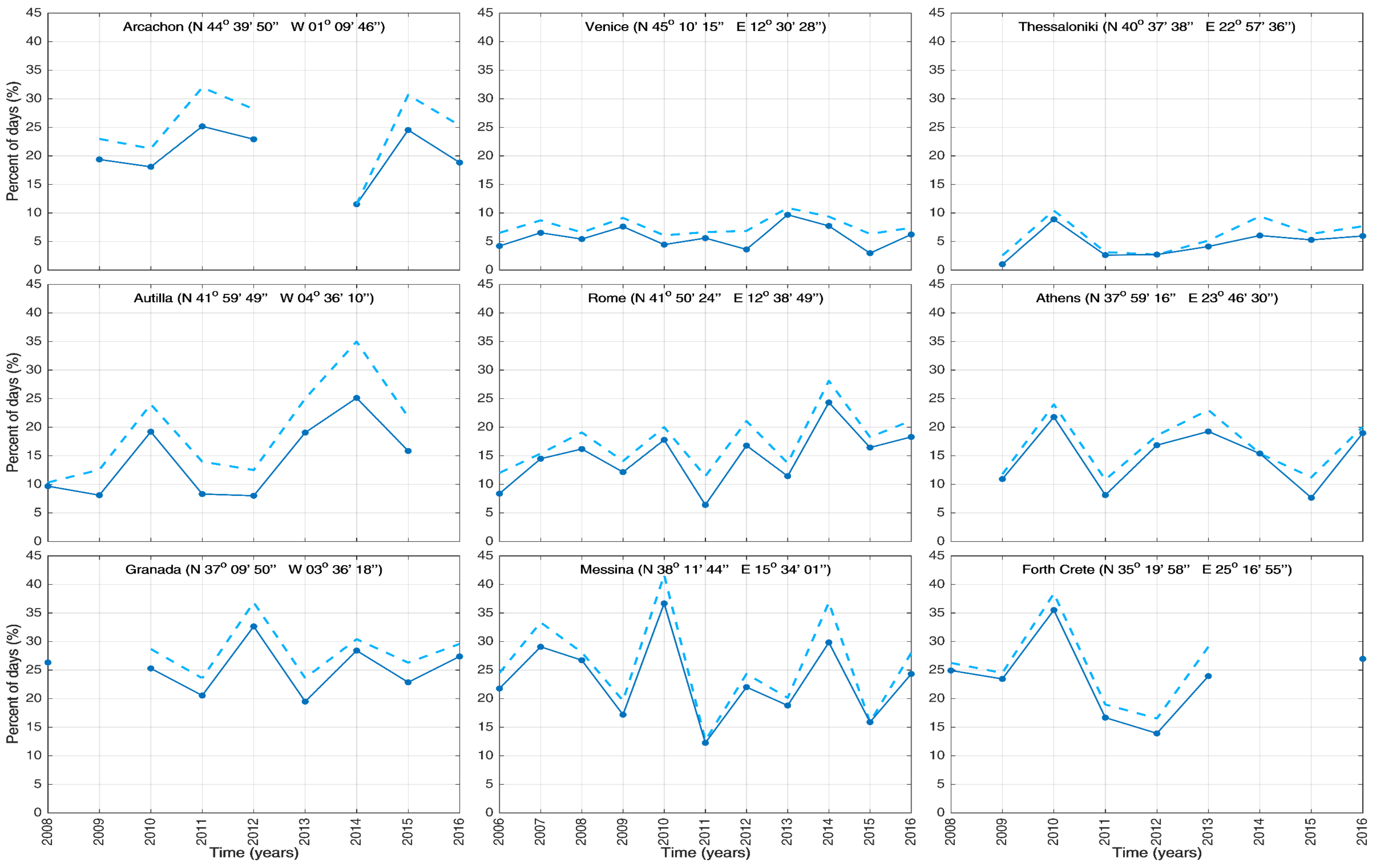

**Fig. 5.** Inter-annual frequency of occurrence of desert dust events (percent of dusty days over the total number of observation days). A day is considered dusty if (a) there are at least two observations of (solid line), (b) at least one observation (dashed line) during the day

## Conclusions

- There is a clear and predominant latitudinal gradient, with frequencies of desert dust episodes decreasing from South to North, as the distance from the North African desert areas increases.
- African dust outbreaks across the Mediterranean occur in different seasons and are caused by synoptic scale meteorological conditions. Intricate and slow-moving transport mechanisms dominate African dust occurrence, higher in summer, in the Western Mediterranean. On the contrary, conventional meteorological mechanisms (low pressure systems) provoke a rapid transport of dust towards the Eastern Mediterranean, usually from autumn to spring. An intermediate situation occurs in the central part of the basin.
- There is no clear inter-annual (year-to-year) pattern in any of the selected sites. However, 2010 seems to be a year of intense dust transport events across the entire region, as most of the sites show local maxima in the frequency of the observed episodes.

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