Analysis of the dust events in Hafr al Batin (KSA)

Customer : Test

Author: Etienne Wey

Date: 13 July 2017

Outline

Outline 2
Introduction - methodology 3
General information from publications 4
Dust frequency analysis 6
Dust period length analysis 8
Analysis of the number of dust events 9
Dust hours * PM10 concentration analysis 11
Conclusion 12

Introduction - methodology

Customer wants to understand the frequency of sand storms and dust events near Hafr al Batin airport site in KSA. This knowledge is important in order to better assess the needs for the cleaning frequency of the PV panels of the future solar plant at this location.

Site name: Hafr al Batin Airport
Latitude: 28.3167(decimal degrees)
Longitude: 46.1333 (decimal degrees)
Elevation: 362 (meters)

The analysis of the dust events frequency, length and strength is based on the hourly METAR data available for the airport, covering the period from 01/01/2007 to 31/12/2016 (with missing data for all year 2008).

We have exploited the visibility and weather codes from the METAR information.

Weather codes DU (dust), BL DU (blowing dust), DS (dust storm), SA (sand), BL SA (blowing sand), SS (sand storm) and HZ (dust haze) are associated with a "dust" event.

Visibility lower than 10 km is used to compute an estimate of the PM10 concentration based on the regression formulas:

$$C = e^{(8.75-0.58D_V)} \qquad D_v < 3.5 \text{ km}$$

$$C = 4589.80 D_v^{-1.35} \qquad 20 \text{ km} \geq D_v \geq 3.5 \text{ km}$$

C is expressed in $\mu g/m^3$
D_v is the visibility in km

This is a regression formula from the following paper:
Song, Z., J. Wang, and S. Wang (2007), Quantitative classification of northeast Asian dust events, J. Geophys. Res., 112,
D04211, doi:10.1029/2006JD007048

The figure 1 shows the location of the airports with METAR data over KSA (from https://mesonet.agron.iastate.edu/ASOS/) which gives an idea of the data coverage available for this country. This web site gives access to the automatic METAR stations data, which is available since 2007 for the all the airport sites, up to now and can be downloaded from the site.

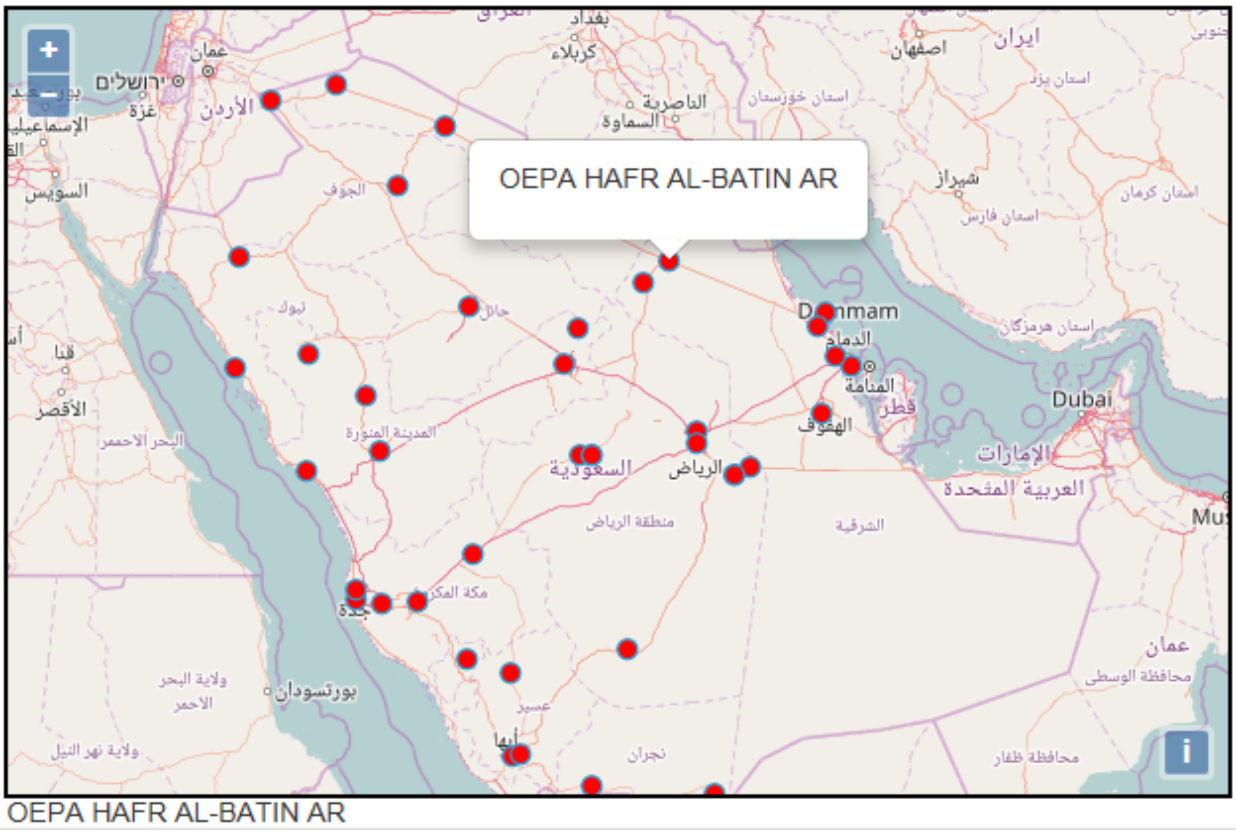

Figure 1 : Map of the METAR station (airports) locations in KSA

General information from publications

We have analyzed the available publications and documents on the dust events analysis for the region of interest. Most of the dust events are generated from silt, clay or fine sand zones:

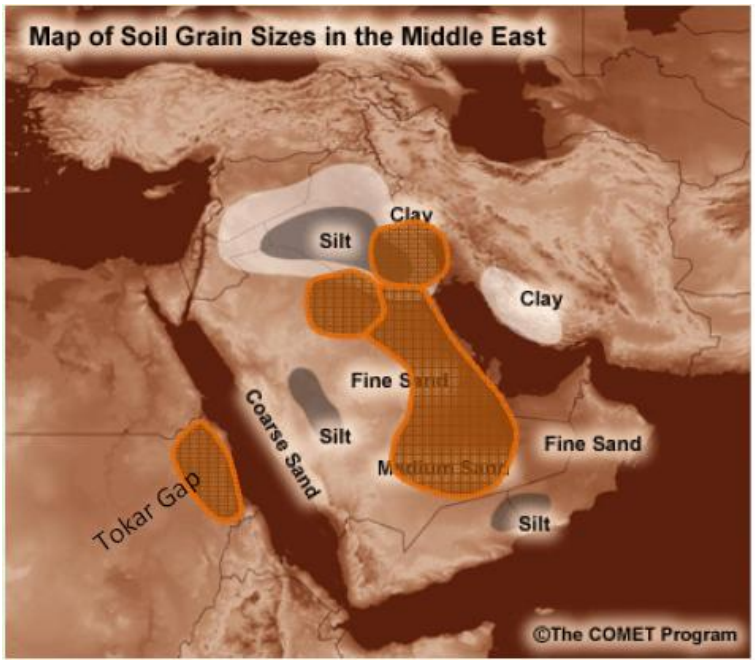

Figure 2: Locations of dust events origins with type of soil

Notaro and al. have analyzed the main origins of the dust events for different locations in KSA.

Notaro, M., F. Alkolibi, E. Fadda, and F. Bakhrjy (2013), Trajectory analysis of Saudi Arabian dust storms, J. Geophys. Res. Atmos., 118, 6028–6043, doi:10.1002/jgrd.50346.

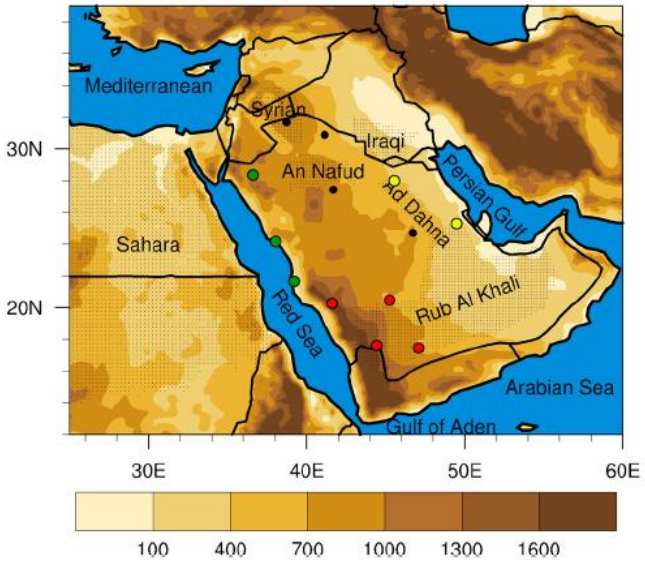

Figure 3: Main deserts zones generating dust events in KSA (from Notaro and al.)

In their paper, Notaro and al. have classified the main dust events origins for all the stations located with colored circles in Figure 3. Red, green, and yellow dots indicate stations with dust sources primarily from the Rub Al Khali, Sahara, and Iraqi Deserts, respectively. The six primary desert regions (Sahara, Rub Al Khali, An Nafud, Ad Dahna, Syrian, and Iraqi) are labeled and identified with small dots.

For the Hafr al Batin station (yellow dot), the percentage of the dust storms origins is as follow:

17% Rub Al Khali, 28% AdDahna, 15% An Nafud, 20% Sahara, 60% Iraqi and 24% Syrian

For the region of interest (yellow dots), most of the strong dust events (over 80%) are originating from the Iraqi and Syrian silt plains:

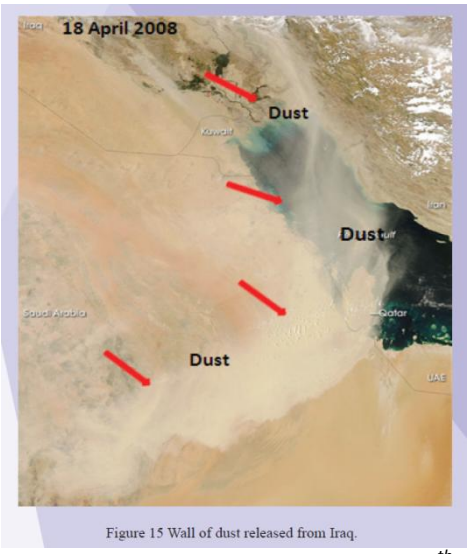

Figure 4: Dust event from Iraq on April 18th 2008

Dust frequency analysis

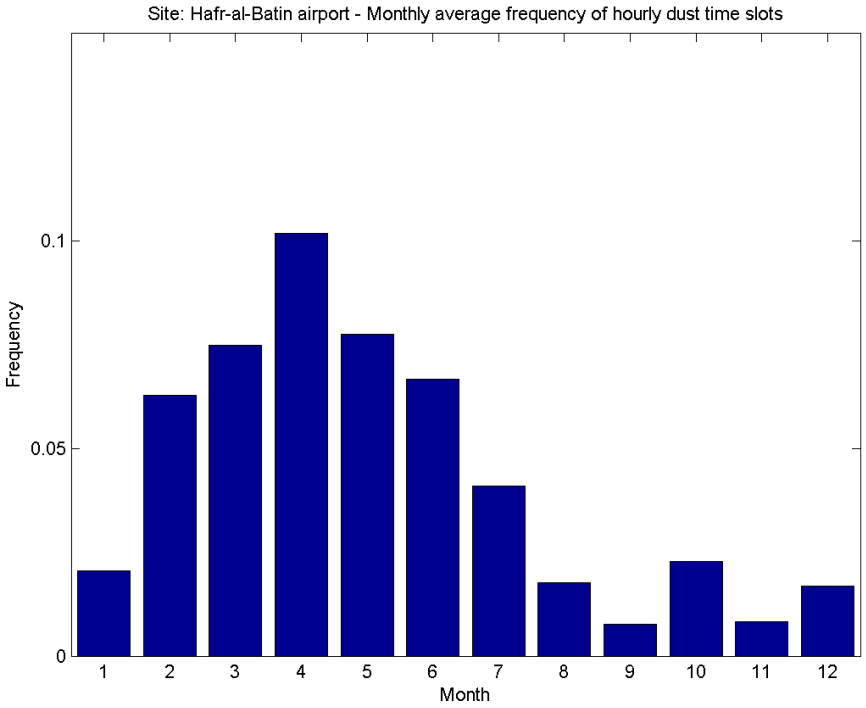

Figure 5: Average frequency of dust events per month from 2007 to 2016

For Hafr al Batin, it is clearly visible that the frequency is at its maximum from February to June. Up to 10% of the hourly time slots are dusty in April.

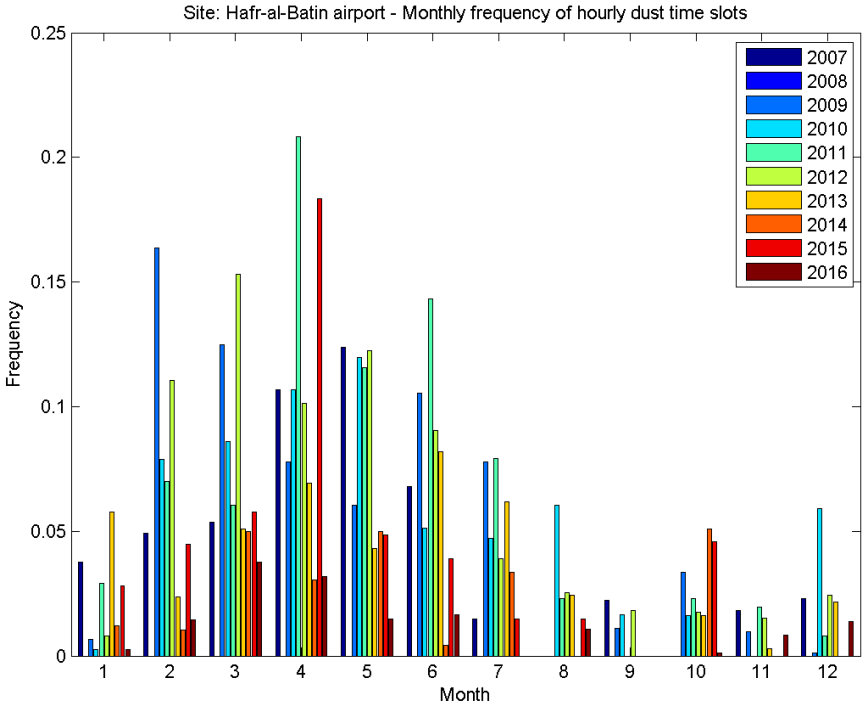

Figure 6: Frequency of dust events per month for all years

For Hafr al Batin, it is also clearly visible that the frequency is at its maximum from February to May for most years. The yearly variability is nevertheless important. In 2012, 20% of the time was dusty in April. It seems that the period 2009-2012 has a higher number of dust slots than 2013-2016.

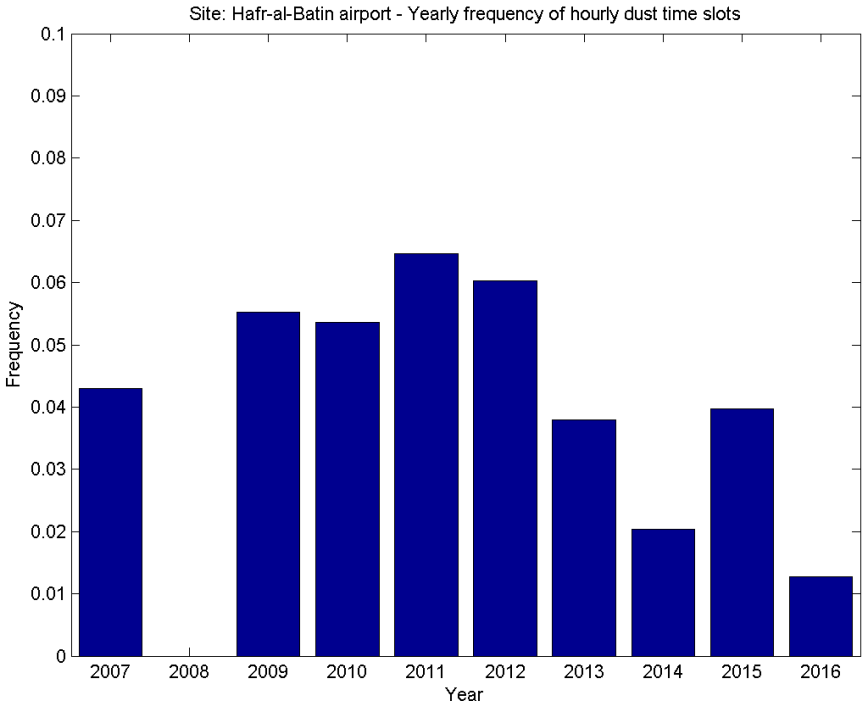

Figure 7: Average frequency of dust events per years

From figure 7 it is confirmed that the annual frequency of dust events is lower after 2012.

Dust period length analysis

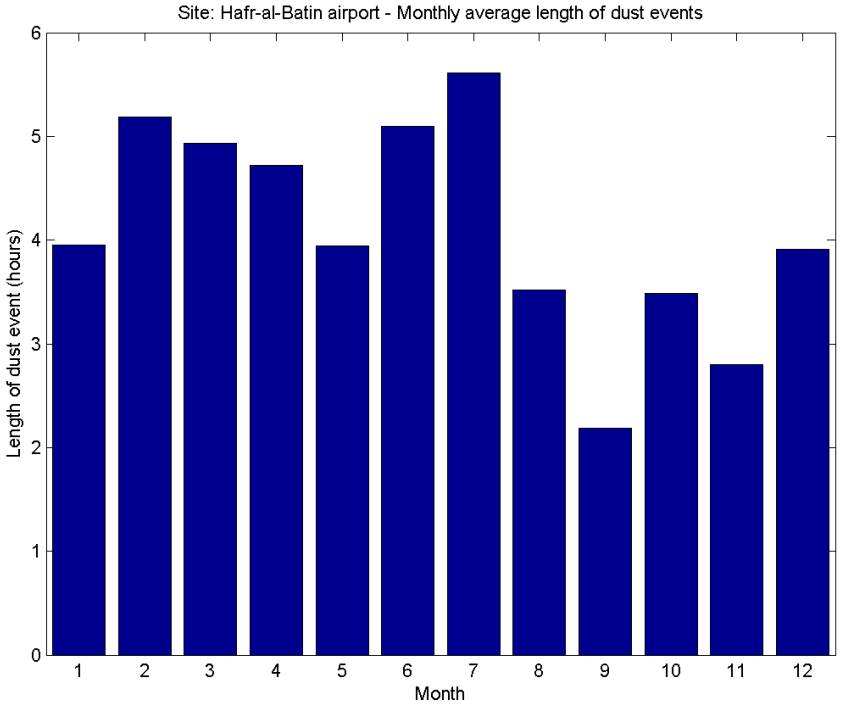

Figure 8: Average length of dust events per month from 2007 to 2016

No very clear pattern can be derived from the monthly average of dust events length.

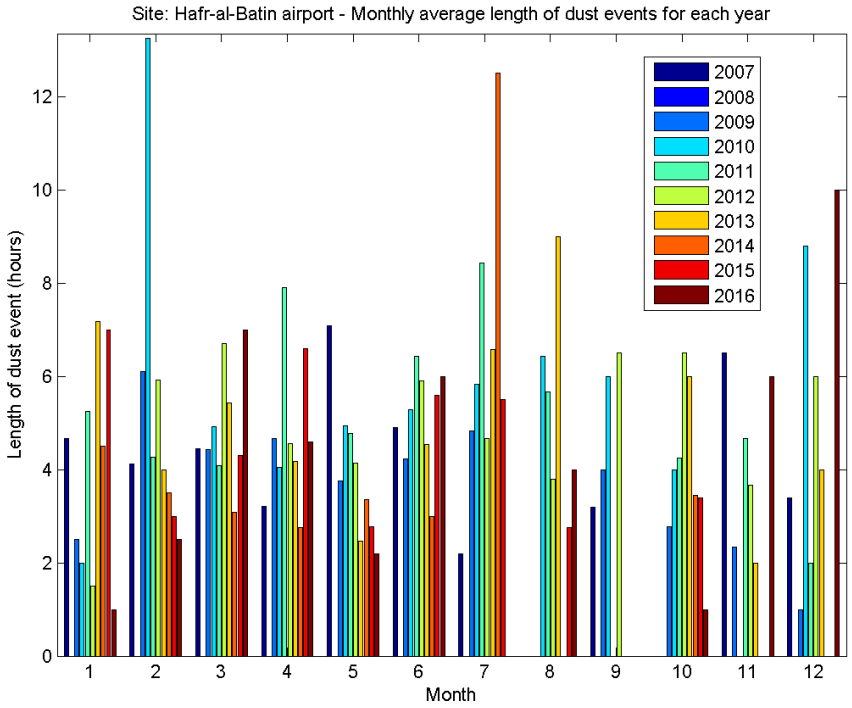

Figure 9: Length of dust events per month for all years

The average length of dust events for each month of all years is also not showing anything very conclusive, except that occasionally, for a few months, the average duration of the dust events can be quite long.

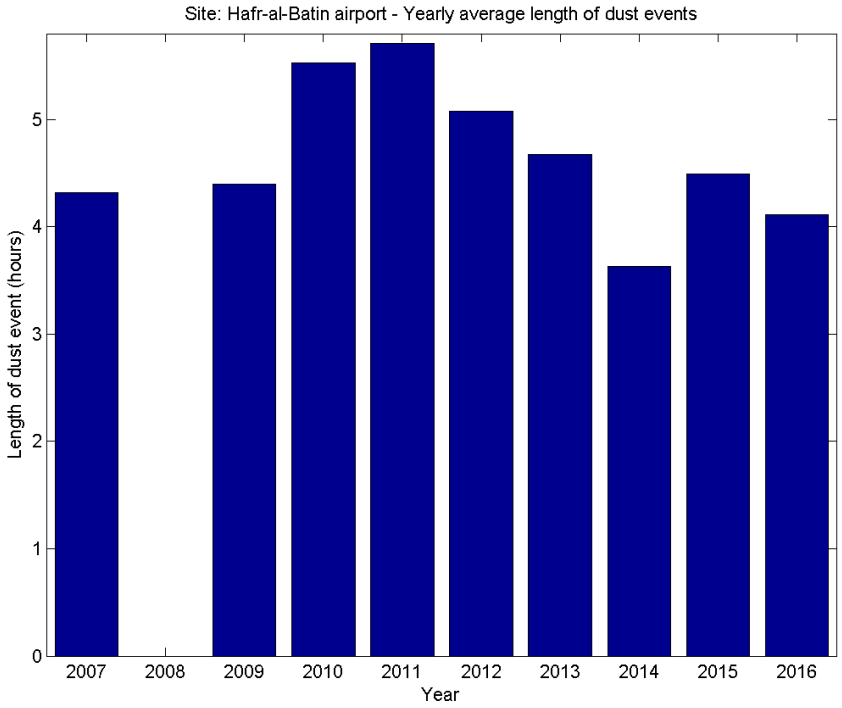

Figure 10: Average length of dust events per years

From Figure 10, yearly average length of dust events no further information can be derived.

Analysis of the number of dust events

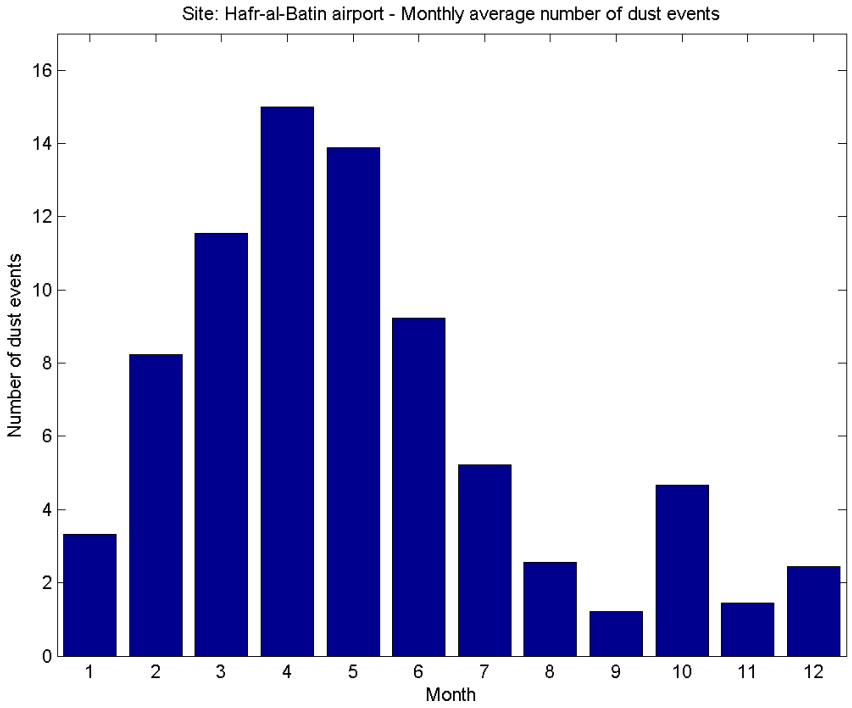

Figure 11: Average number of dust events per month from 2007 to 2016

That number of dust events is at its maximum from February to June (up to 15 dust events in a month!).

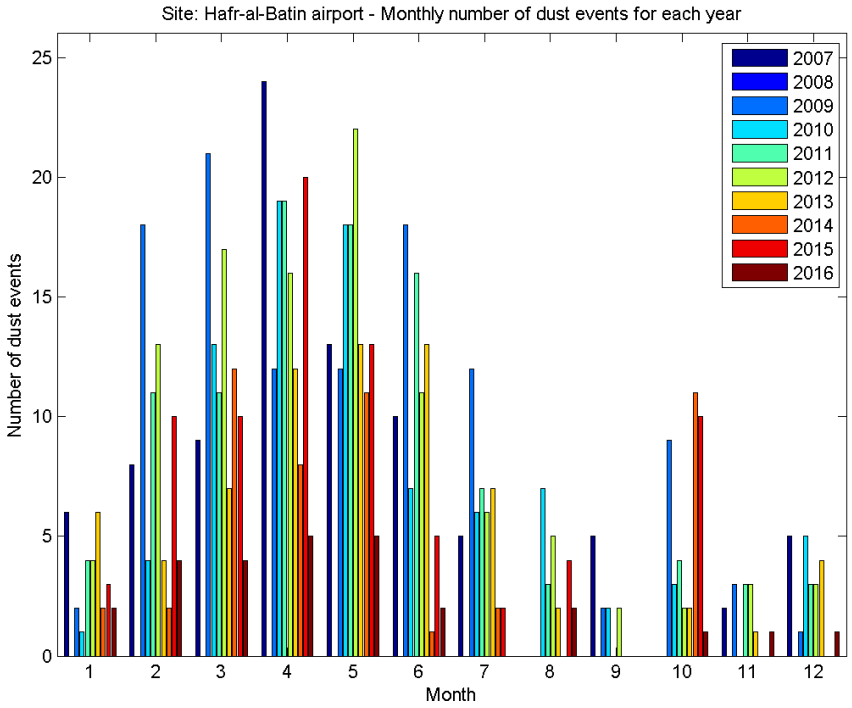

Figure 12: Number of dust events per month for all years

The conclusions drawn from Figure 11 are shown again in Figure 12 for the months of all years.

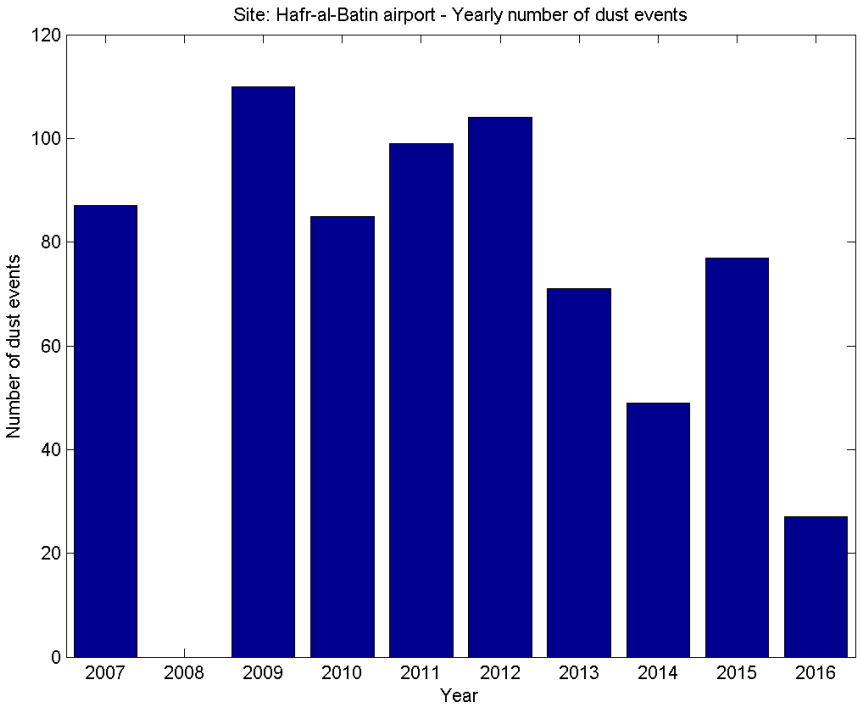

Figure 13: Number of dust events per years

From Figure 13 it can be seen that the annual average number of dust events reached 110 in 2009 and was quite low in 2016.

Dust hours * PM10 concentration analysis

These data are obtained from the summarization for each month of the dust hours multiplied by the PM10 concentration derived from the visibility. The results are expressed in "mg/m^3 * hours".

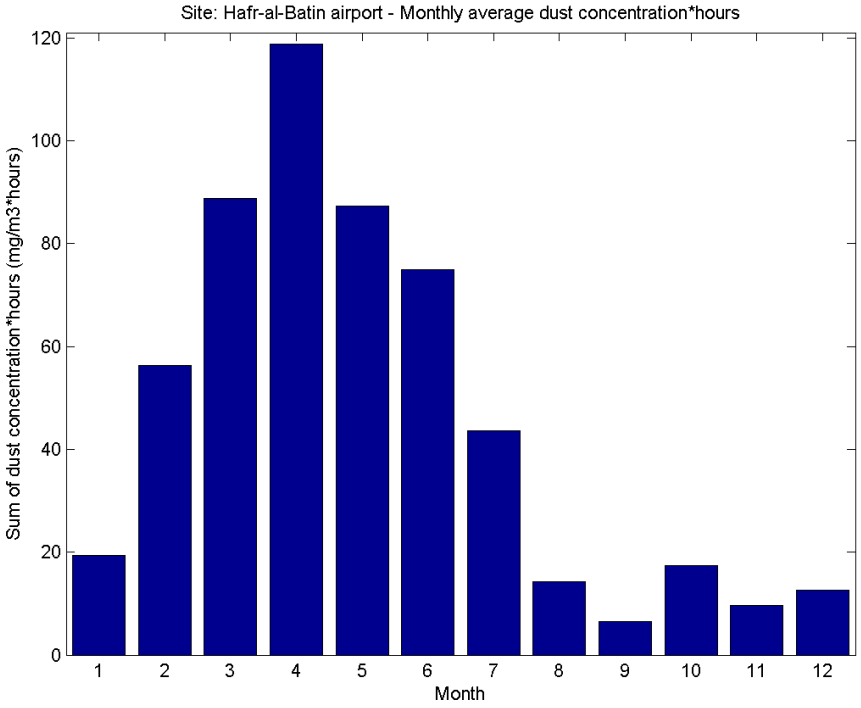

Figure 14: Average sum of dust concentration per month from 2007 to 2016

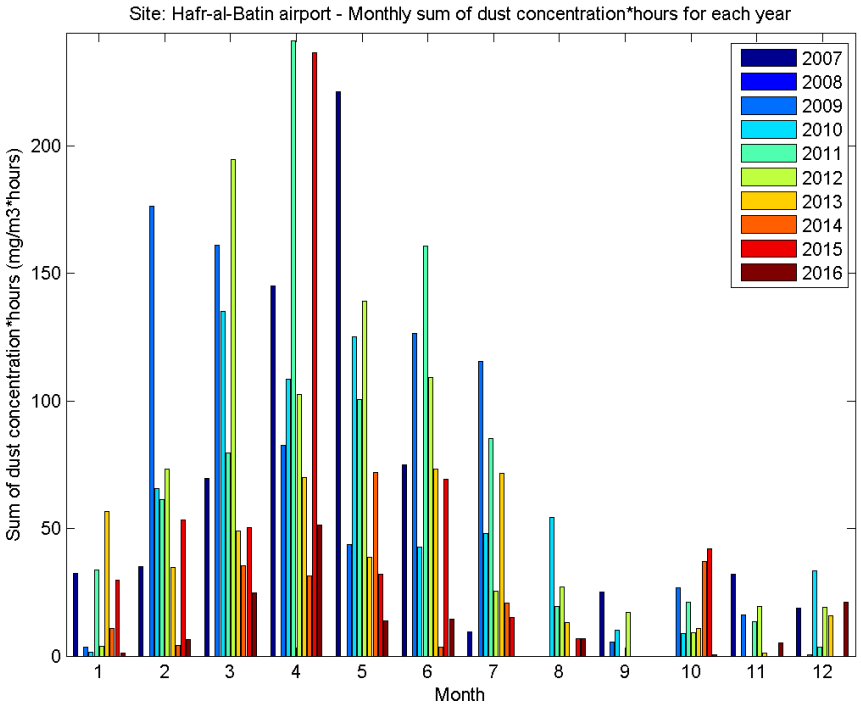

Figure 15: Sum of dust concentration per month for all years

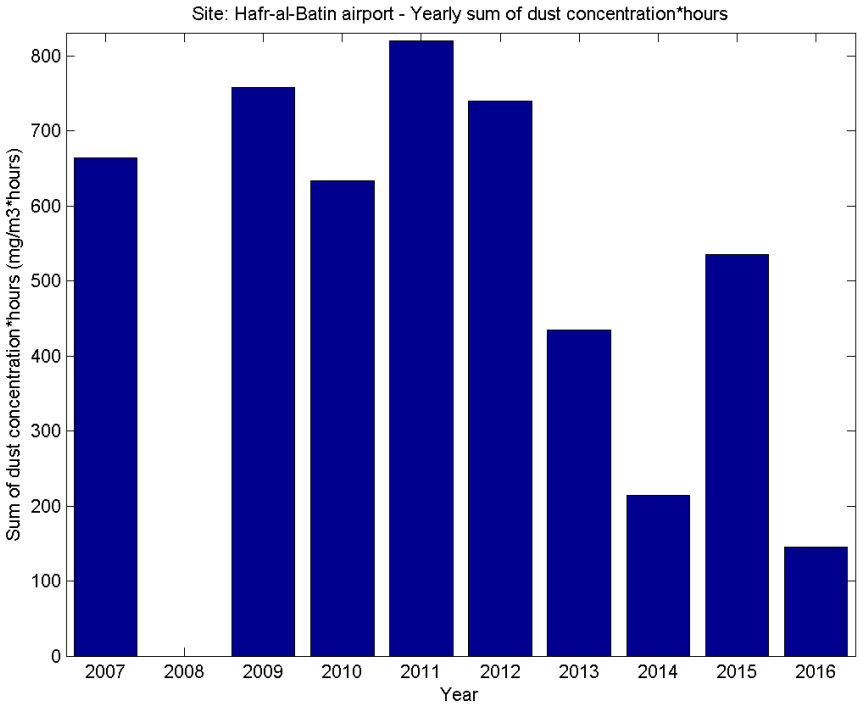

Figure 16: Average sum of dust concentration per years

In Figures 14 to 16, it is clearly shown that the summarization of the dust concentration (obtained from the visibility) multiplied by the value of dust hours is possibly the most interesting data to examine. It shows clearly the peak in dust from February to June with a peak in April. It shows also the high variability for the 2007-2016 period and the decrease in the dust events severity after 2016 with a minimum in 2016.

Conclusion

The number of hours of dust is very important for the site, with a peak in the spring season and certainly a need to clean often any solar installation.

The dust concentration * dust hours values is the most relevant parameter (with the dust frequency as the second best one) to study a location or to compare it with another location.