Measurements of UV Aerosol Optical Depth in the French Southern Alps

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Aerosol Optical Depth Measurements

- Objectives
- Station and Instruments
- Method, Data, and Uncertainties
- Results: Annual Variations
- Summary and conclusions

Objectives

Using the UV irradiance measurements performed routinely at the Briançon station since several years:

- build a climatology of aerosol in a clean unpolluted area (a French southern Alpine valey at moderate altitude)

- detect the possible cases of turbidity:
    - desert dust crossing the Mediterranean Sea
    - particles from forest fires in the South

Station and Instruments

The station is located in Briançon (44.9°N, 6.65°E), at the altitude of 1310 m asl, in a sunny and dry valey

Spectroradiometer characteristics

Monochromator	JobinYvon HD10	Bentham DM150
Spectral range	280-450nm	290-400nm
Step	0.5 nm	0.5 nm
Resolution FWHM	0.75 nm	0.80 nm
Sampling frequency	15 min	30 min
Cosine error	<5% at SZA=75°	<5%at SZA=75°
Threshold	10^{-6} $Wm^{-2} nm^{-1}$	10^{-5} $Wm^{-2} nm^{-1}$

Method, Uncertainties, Data

Method

Alternately, measure of global (Glo),and, with a shadower, of diffuse (Dif) irradiance. The direct measured irradiance derives as Dir_{mes}=Glo-Dif

Direct irradiance without aerosol is computed (Dir_{cal}), using:

- the extraterrestrial ATLAS 3 spectrum,

- the Rayleigh scattering for a mid-latitude standard atmosphere at Briançon altitude,

- the ozone total amount from TOMS at Briançon site

The aerosol optical depth (AOD) is given as:

$\tau_{aer} = \ln(Dir_{cal}/Dir_{mes})/m_r$, where m_r is the relative airmass

Uncertainties

The uncertainty on Dir_{mes} is due to the instrument calibration uncertainty, estimated to 5%, for wavelengths larger than 320 nm, and SZA smaller than 75°.

For short wavelengths and very low sun, the signal becomes small and the uncertainty on measurements strongly increases. To be on the safe side, we have limited our analysis to wavelengths larger than 330 nm and to SZAs smaller than 75°.

On Dir_{cal}, the uncertainty is due to 3 causes:

- an uncertainty of 2% on the ATLAS extraterrestrial flux

- an uncertainty on the molecular optical depth, of about 2%; this leads to an absolute error on τ_{aer} smaller than 0.02 at 330 nm, and decreasing at larger wavelengths

- an uncertainty on the ozone optical depth, due mainly to the uncertainty on the ozone amount; on TOMS data, it is estimated to 2%; the impact on τ_{aer} can be very large at short wavelengths. This is another reason for limiting our analysis at 330 nm.

Combining the various uncorrelated errors, we estimate roughly $\Delta\tau_{aer}$=0.05

Data analyzed:

3 years (2003, 2004, 2005), with available data for 179 cloudless days

The two instruments have operated simultaneously during 53 clear days, in 2004 and 2005

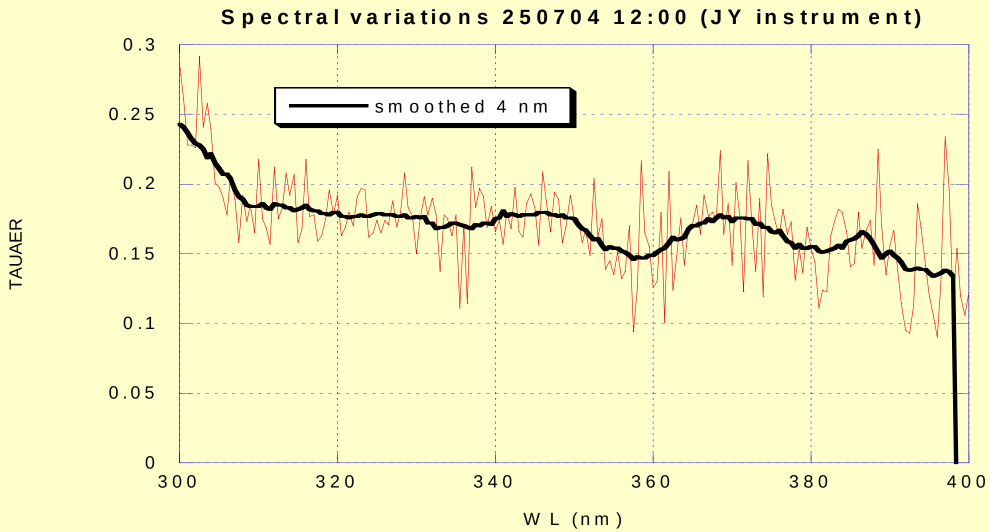
The differences τ(BE)-τ(JY) oscillate between -0.053 and +0.060, with rms=0.030; BE values are generally larger in summer, and smaller in winter than JY values.

Example of result: spectral variation

Rapid oscillations due to wavelength misalignement

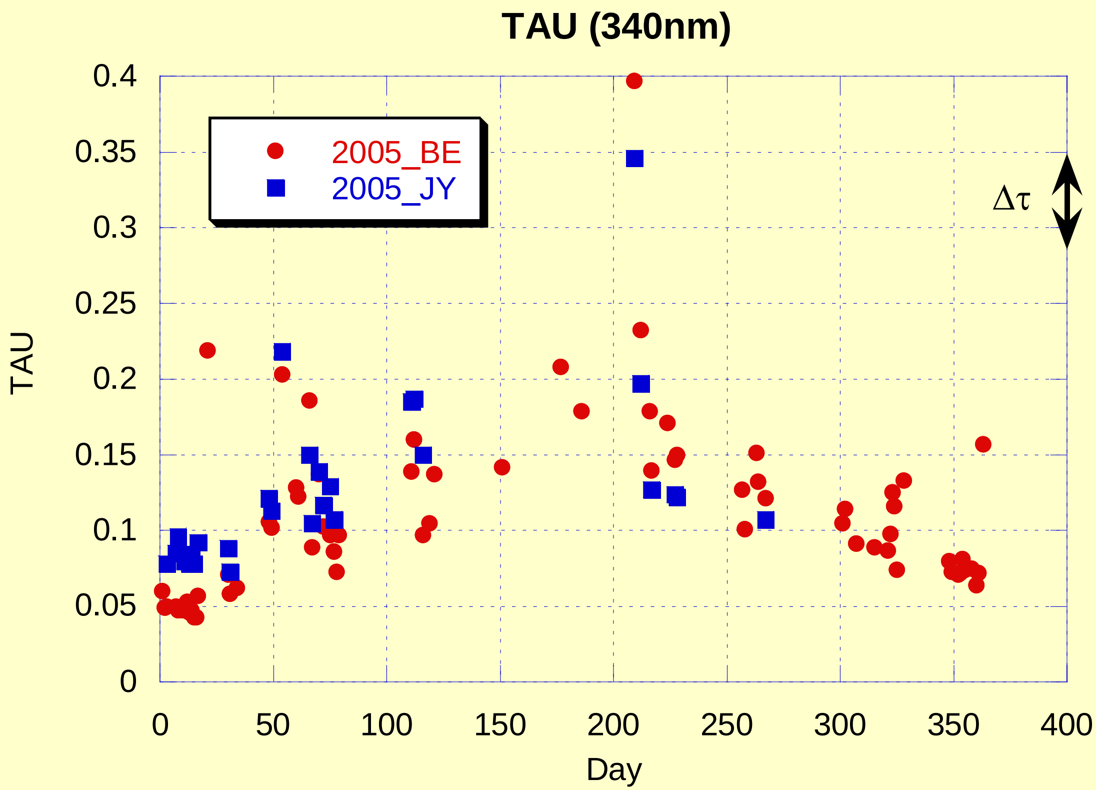
After smoothing (4 nm), large remaining oscillations (same order as uncertainty). Explained by wavelength dependent calibration error ?

Very weak increase toward short wavelength

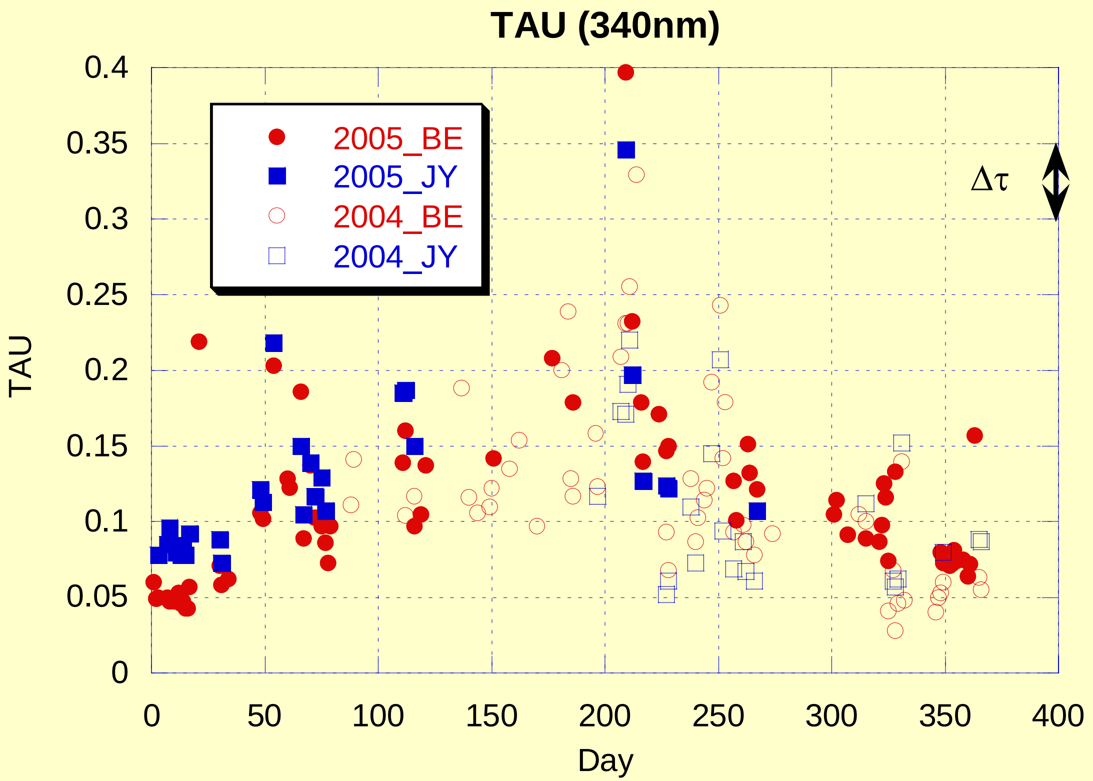


Most of the analysis concerns 340 and 380 nm (channels of the CIMEL photometer)

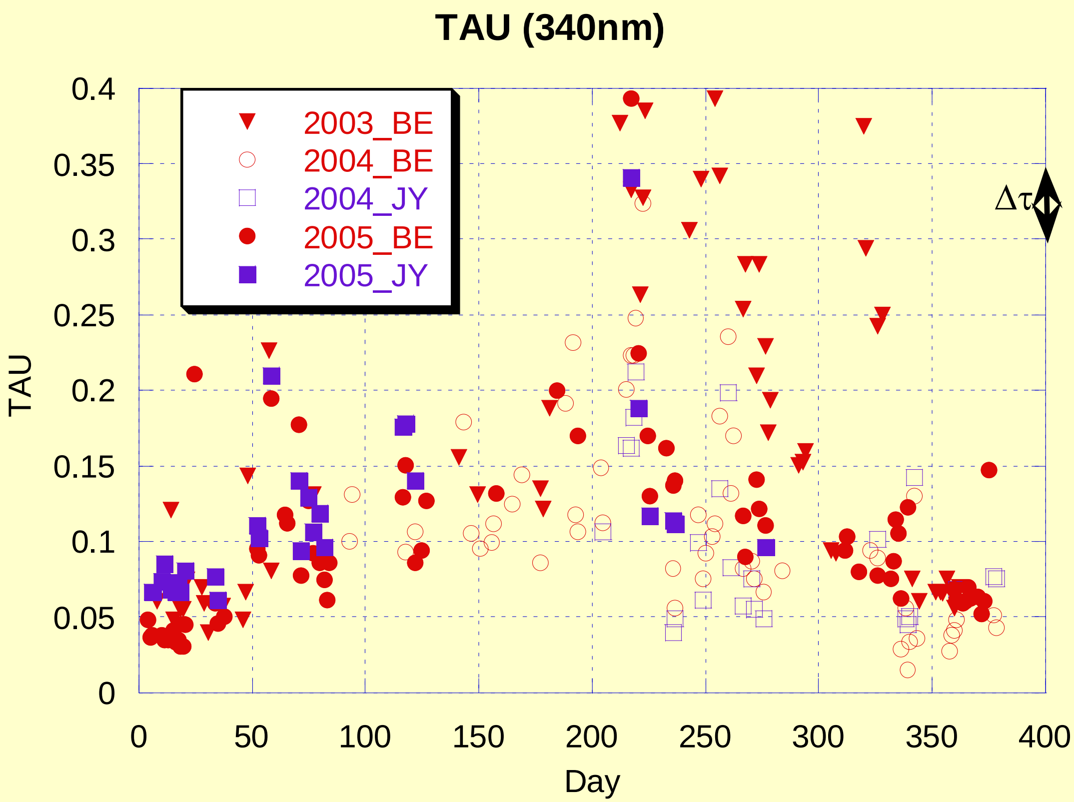
Annual Variations



Annual Variations



Annual Variations



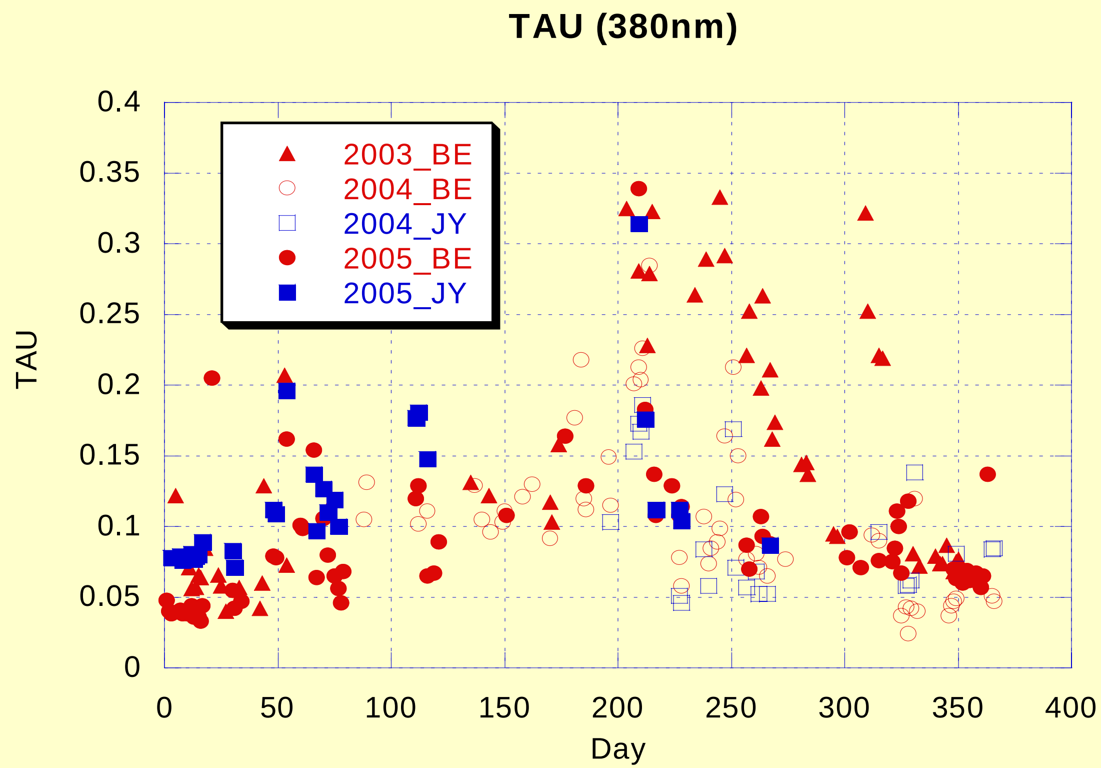
Summer 2003 presents high values; it was a very hot summer

Statistical results for τ (340)

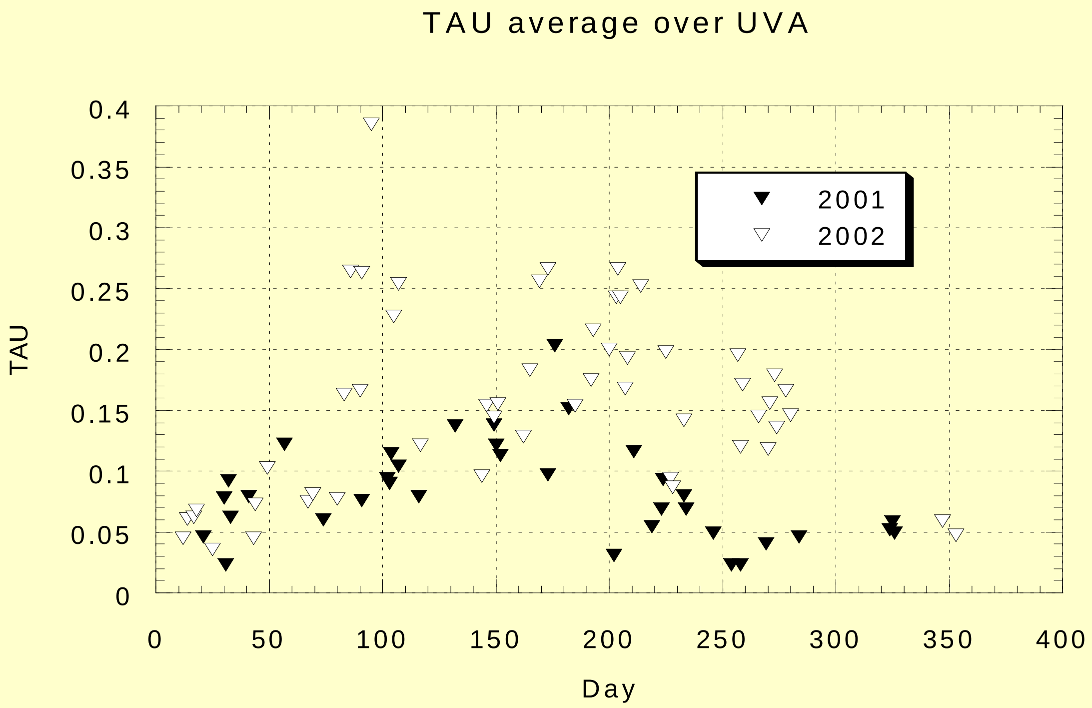
3 Years 2 Instruments

Period	Point Number	Mean	rms	std
January-February	51	0.086	0.097	0.046
March-April	28	0.125	0.129	0.030
May-June	16	0.147	0.151	0.035
July-August	44	0.194	0.217	0.097
September-Oct.	40	0.156	0.175	0.079
November-Dec.	53	0.097	0.116	0.065

Annual Variations at 380 nm

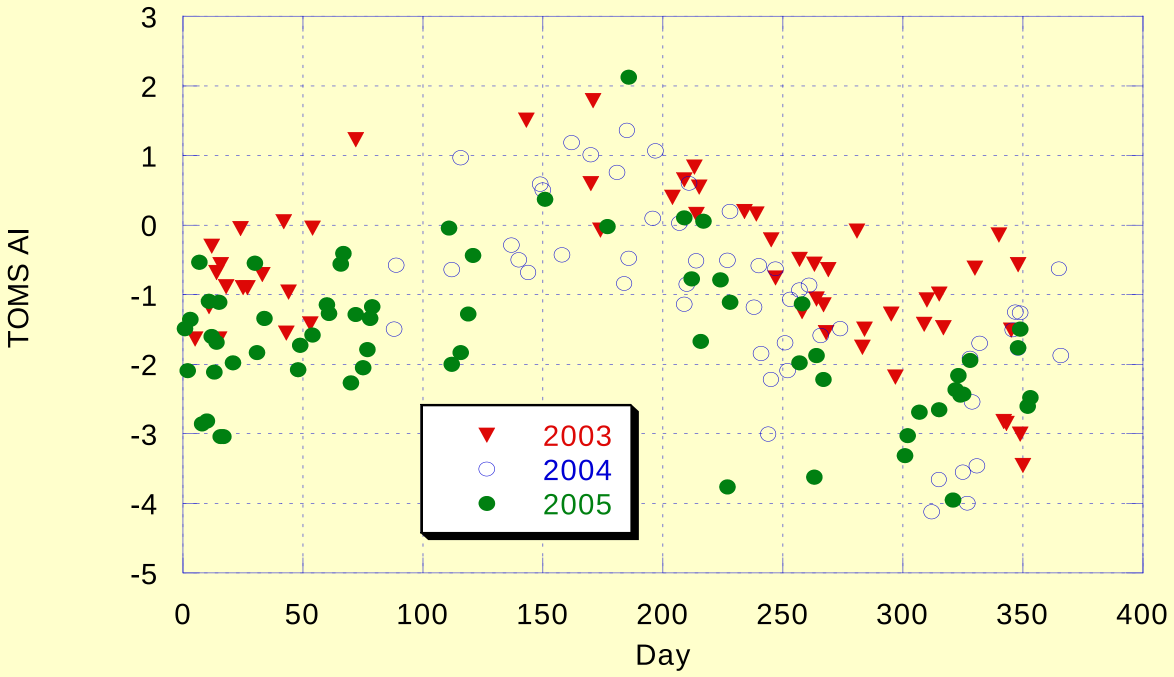


Comparison to previous results

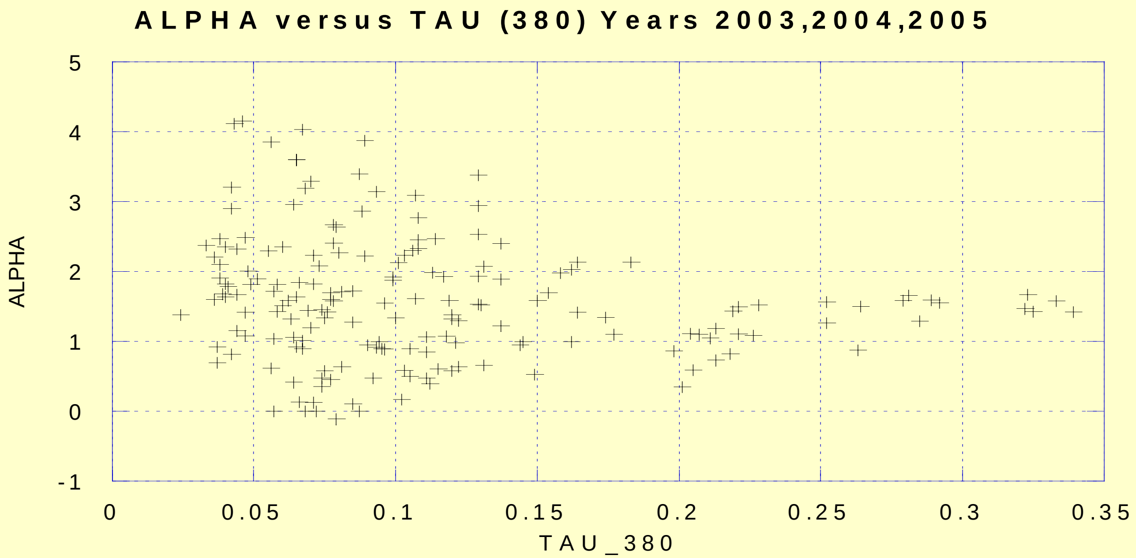


Lenoble, de La Casinière, Cabot, Applied Optics, 2004,43, 3133-3139

TOMS Aerosol Index (cloudless days)



Angström coefficient defined between 340-380 nm



	Tau<0.2	Tau>0.2
mean	1.65	1.26
rms	1.89	1.31
std	0.94	0.35

Summary

Routine measurements of Global and Diffuse UV irradiances at Briançon station (1310m asl) have been used to retrieve Direct irradiance and Aerosol Optical Depth, for cloudless days.

Data of three years (2003, 2004, 2005) are analyzed. The results agree with results of a preliminary analysis for the years 2001-2002.

Major results for 5 years:

- the atmosphere is very clear in winter
  UV AOD between 0.05 and 0.1

- the turbidity increases slowly in spring, starting
  end of February, with AOD around 0.2-0.3
  in mid summer, some values reaching 0.4

- similar behaviour for all years, with somewhat
  higher values in late summer (August-
  September) for the year is 2003

How to explain the systematic annual variation

- dry soil producing dust in summer ? (in winter the ground is covered by snow)

- pollen in spring ?

- other vegetation particles in summer ?

Could the few high peaks (around 0.4) be related to specific events (transport of desert dust or biomass burning particles) ?