

Interactive comment on “Significant variations of trace gas composition and aerosol properties at Mt. Cimone during air mass transport from North Africa – contributions from wildfire emissions and mineral dust” by P. Cristofanelli et al.

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The authors are very grateful to Referee3 for the interesting comments. Here you can find the answers to the questions and the comments proposed.

Major comments: *While the analysis of the event is sound in itself and leaves little space for discussion of the processes controlling the observed concentrations, the authors do not spend enough time on the question of how important such events are for the Mediterranean region. Only the introduction and the last paragraph of the*

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manuscript try to highlight the importance of such transport events in a very general manner. In this context it would be very valuable to discuss the frequency of Sahara dust and biomass burning events at the site but also at other sites in the region. What is special about the event reported here is the combination of concurrent transport of dust and biomass burning emissions, but how frequent are such events and can you really assume that increased dust transport due to ongoing and future desertification and increased biomass burning will go hand in hand for extended periods of time?

Following the referee suggestions, in the revised version of the paper we will further discuss about the frequency of mineral dust outbreaks and BB product transport to the Mediterranean basin (Discussion section): “During the drought periods that frequently affect the Mediterranean basin (particularly during the summer months), BB products can be often found to affect the Mediterranean basin (Sciare et al., 2003; Pace et al., 2005; Cristofanelli et al., 2006; Pace et al., 2006). In particular, by analysing the behaviour of fine light absorbing aerosol in the central Mediterranean during summer 2003, Pace et al. (2005) estimated that the particles emitted by the forest fires on South Europe produce an increase in heating rate as large as 2.8 K/day at the altitude of the aerosol layer, probably also affecting the atmospheric circulation by increasing the atmospheric stability. It is well known that also mineral dust plays an important role on the climatic system (e.g. Forster et al., 2007) and the importance of Saharan dust as source of mineral aerosol for the Mediterranean basin is indicated by several investigations. In fact, during a 11-year investigation (1983-1994) Moulin et al., (1997) reported 16 Saharan dust events per year over Western Mediterranean. Recent results from EARLINET (European Aerosol Research Lidar Network) showed that, depending on the geographical location, over the Mediterranean basin from 12 to 35 days per year can be affected by Saharan dust outbreaks (Papayannis et al., 2008). Similar results were presented by Marinoni et al. (2008) who identified an average of 40 days per year as influenced by Saharan dust events at CMN and by Collaud Coen et al. (2004) who found 48 dust events from March 2001 – December 2002 at the Jungfrauoch alpine station.” It should be noted that this paper represent the first investigation about an

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episode of mixed dust/BB product transport from North Africa to Mt. Cimone (see answer 9 to referee 2). As it is expected that North Africa and the Mediterranean basin will probably experience more frequent and severe droughts in the near future (Christensen et al., 2007; IPCC, 2007), mineral dust and BB product transport (and their concurrent occurrence) might gain further importance in the next future, as sources of atmospheric compounds able to exert an influence on the regional climate and on the tropospheric composition over South Europe/Mediterranean basin. However, as will be reported in the revised manuscript, “to better clarify the potential role of this classes of events (mineral dust transport, BB product transport as well as concurring BB product and mineral dust transport) in influencing systematically the composition of the troposphere over the Mediterranean region, a multi-year climatological investigation appears as an important step.” We accept the referee suggestion to decrease the number of citations (in particular, along the introduction). These changes will be introduced in the final version of the paper.

Minor Comments

The official GAW ID of Monte Cimone is CMN. Why do you use MTC?

In the revised version we will use the official GAW acronym “CMN”

*The use of FLEXTRA trajectories is mentioned in the methods section but in the result-
sonly BOLAM trajectories are discussed. Did you not use FLEXTRA at all? How do
these very differently derived trajectories compare?*

Please, see the answer 3, referee2

*P 7830, L 10: As for many other high altitude observatories worldwide I would suggest
that you don't consider your day-time measurements as being free tropospheric. The
mountain venting regime prevailing during summer day-time hours certainly destroys
the free tropospheric character of the observations as you yourself show later on, while
the night-time measurements might still represent free tropospheric conditions. Please*

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rephrase this introductory statement.

In the section 2.1, it was clearly stated that “The CMN measurements are considered representative for the baseline conditions of the Mediterranean free troposphere (Bona-soni et al., 2000; Fischer et al., 2003), even if during the warm months an influence of boundary layer air can be detected due to convective processes and mountain breeze regime (Fischer et al., 2003; Van Dingenen, 2005)”

P 7830, L 12f: "The accuracy and quality ... " change "are guaranteed" to "were". Also specify the GAW requirements and mention your external reference scale.

We will add to the revised paper a reference describing GAW sampling procedures for surface ozone sampling (WMO, 2002). The ozone analyser working at CMN is traced back to EMPA (Swiss Federal Laboratories for Materials Testing and Research) SRP15 Standard Reference Photometer.

World Meteorological Organization (WMO), Global Atmospheric Watch measurement guide. Tech. Deoc. 1073, GAW Rep. 143, Geneva, Switzerland, 2002.

P 7833 f: Trajectory description: You mention that you started clusters of backtrajectories centred around the location of MTC. According to the manuscript you used a box with an extension of 2 degrees in East-West direction but with only 0.5 degrees in the North-South direction. Explain the wider East-West extent. Furthermore, give the pressure level of the model surface at MTC and the difference to the average station pressure level.

We have chosen a cluster starting from a rectangular grid covering the Apennines region to have a cross section orthogonal to the average atmospheric flux (see figure 8, 30/08 at 6 UTC). This with the aim of: - to evaluate the sensitivity of the trajectories with respect to the longitude that is a potential source of error - to evaluate how the transport varies at different locations of the Apennines and where it occurs. The analysis shows that the transport pattern is uniform over longitude and that the transport estimate is

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slightly sensitive to the positioning the origin of back trajectories and that Mt. Cimone location can be in fact considered as representative of the whole Apennines ridge. The model works on hybrid-coordinate levels and the pressure of the first level (some meters above the ground) is around 850 hPa. Further details on the orography treatment and its effect on the flow are provided in the references. This latter information will be added to the revised version of the paper.

P 7834: Here you use ER as abbreviation for enhancement ratio, while in the abstract you used it for emission ratio. I guess in the context of your study it should always be enhancement ratio!

OK

P 7834, L 25: FLEXTRA is often driven by ECMWF analysis fields with a grid resolution of 1 by 1. Why did you use 1.25?

Right! This was a typing mistake!

P 7834: At which altitude or pressure level did you initialize the FLEXTRA calculations? From the total number of cases I assume that you used several initial altitudes

We considered FLEXTRA back-trajectories at the CMN altitude (2200 m a.s.l.). The number of trajectories here reported referred to the total number of trajectories available for summer 2007 (4 back-trajectories for 92 days: 368 back-trajectories in total).

P 7836, L 5: Could you mark the selected background level measurements in Figure 1? The figure gives the impression that a number of measurements (especially at the beginning of the period) represent clean, background conditions.

We will add to the revised manuscript the figure 1 revised following the referee suggestions (see below).

P 7836, L 11: Would it be possible to include the dust mobilization temporal development over Northern Africa as obtained from the NAAPS simulations in Fig 5 in parallel

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to the fire count development?

NAAPS results and dust mobilization can be seen at the NRL web-site (<http://www.nrlmry.navy.mil/>). Here we will add to Fig. 5 (Fig. 4 in the revised manuscript and Fig. 2 in this reply) the behaviour of the OMI Aerosol index averaged over a North Africa region (latitude 30N/25N longitude -10E/10E) comprising Morocco, Algeria and Mauritania but excluding the wildfire emission area. The sentence on page 7836 (line 9-14) will be changed as following: "These conditions favoured the transport of mineral dust from the Sahara, as confirmed by the high coarse particle concentrations ($>1.0 \text{ cm}^{-3}$) recorded at CMN (Fig. 1) from 25 to 30 August 2007. Although OPC measurements were not available at CMN for the onset of the transport event, the NAAPS simulations (not shown) indicated that dust mobilized over Algeria, Morocco and Mauritania reached Southern Europe and Northern Italy, starting from 23 August 2007. The mobilization of mineral dust over Sahara desert was confirmed also by the OMI measurements, showing high values of Aerosol Index over this area (Fig. 4) (data courtesy by NASA/GSFC and University of Maryland and Goddard Earth Sciences Data and Information Services Center)."

P 7838, L 27: Which fit technique did you use? Did you consider uncertainties in both x and y as recommended by Parrish et al. 1998.

To calculate the fitting parameter we used a fitting model taking into account only the uncertainties in the y variables (single sided linear regression). As noted by Parrish et al. (1998) this can yield less steep slopes than using a method considering measurement uncertainties in both variables. Thus, our results can be considered as a lower limit for enhancement ratios. However, as reported by Henne et al. (2008), it should be noted that differences between the two methodologies are small for cases with large correlation coefficient. In fact, we calculated the regression slopes also by using the RMA techniques and, due to the rather high R^2 observed, we obtain only relatively small increases of the slope coefficients (the highest variation was observed for the $N_{\text{fine}}\text{-CO}$ regression during the BB plume transport, when the regression slope

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increased from 1.15 to 1.40). Nevertheless, we decided to retain the slopes obtained by the former linear fitting technique both to provide a “conservative” ER estimate as well as to make an easier comparison with ERs by earlier works which were calculated by single sided linear regression. These information will be reported in the “Discussion and conclusions: ”However, following Henne et al. (2008), it should be noted that since the regression slopes deduced by the “scatter technique” were obtained by applying an ordinary least squares regression, the obtained ERs can be underestimated. For this reason, we also calculated regression slopes by using the Reduced Major Axis (RMA) techniques, accounting for errors in both the x and the y-variable. Nevertheless, due to the rather high R2 only slight increases of regression slopes (and ERs) were calculated both for the pollution and the BB events. In particular, by considering the RMA technique, the O3/CO ER calculated by the “scatter” technique increase to 0.22 ppbv/ppbv.”

P 7840, L 20: How were the average travel times calculated? Did you consider multiple intersections with fire pixels at different times on the trajectory and different fire intensities (fire counts are not directly proportional to CO emissions!)?

As reported in the paper, the travel time is calculated from the last active fire pixel encountered by the back-trajectories before leaving the North Africa. The authors are aware of the fact that number fire are not proportional to CO emissions, however it can provide information about the geographical extension (and thus, indirectly, about “intensity”) and locations of wildfires.

P 7845, L 19: I would not conclude that the age of the air-mass is confirmed by the ER study. Since ER will be largely determined by the emission ratio NO2 to CO and this varies largely between wild fires, the event analysed here only adds to the range of reported ER, but its ER should not be used to estimate the age of the plume. Your trajectory analysis is certainly more precise in determining the age of the plume. Simply remove "in good agreement with the ER analysis" from the sentence.

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OK

P 7845-46: To my knowledge, there is at least one other case of an advected biomass burning from northern Africa reported in the literature (Henne et al., ACP, 2008, 3119-3139.) which reports dO_3/dCO of 0.23 for a plume age of 3.7 days. However, this plume was traced back to savannah burning and not to the coast.

The results by this paper have been added to Fig. 11

Table 1: Background Selection, Mean O3: I assume this should read 6x ppbv ?

Yes, this is 61 ppbv

Fig 1 and 6: These figures repeat each other. I suggest to combine them by showing a single plot with the parameters and selected periods in Fig 6 but for the extended time section of Fig 1 and for 30 min averages only.

We decided to leave both Fig. 1 and Fig. 6. In fact, we think that the Fig. 6 (1-min time resolution) permits to show in a very effective way the changes of air-mass properties related with the mountain wind system and the transport from North Africa.

Fig 2: If the dots represent 5th and 95th percentile they should not be called outliers! Simply write: the dots represent the 5th and 95th percentile.

OK

Fig 3: It is not possible to identify the vectors for the lower plot. The scale for the wind vectors is also not given.

Figure 3 will be redrawn in the revised manuscript.

Fig 4: It would help to identify area of the MODIS image if you could display its extension on a map of the Mediterranean in a small insert at the upper left corner of the image.

The map will be inserted in the revised manuscript.

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Fig 7: Please add if the scatter plots are based on 1 or 30 minute aggregates.

On 30-minutes aggregation, as will be reported in the revised manuscript.

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9, C1726–C1736, 2009

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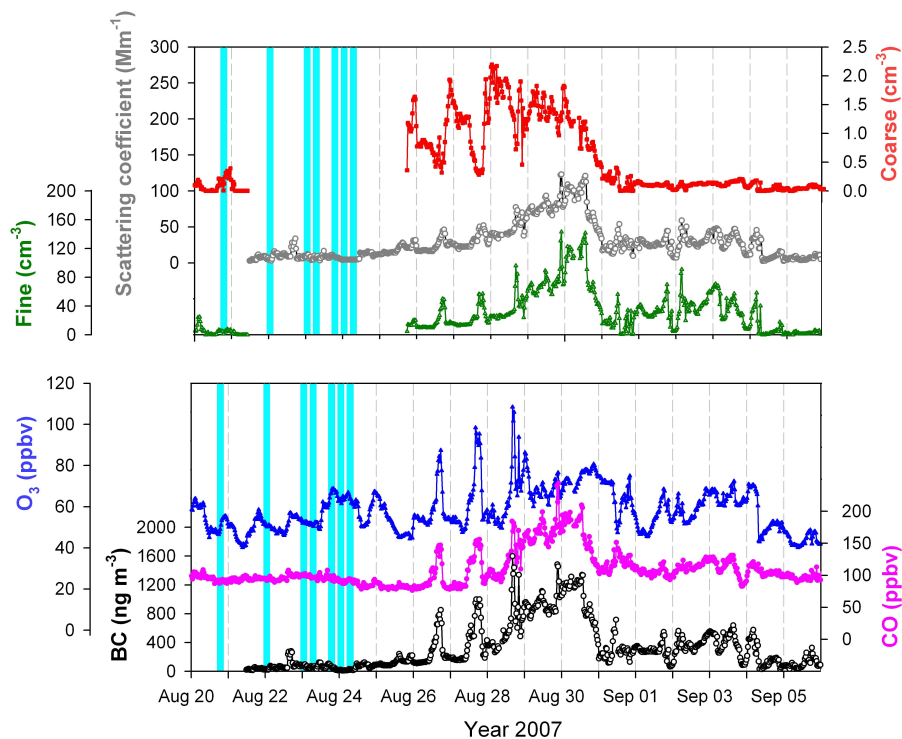


Fig. 1. Mt. Cimone: 20 August – 5 September 2007. The cyan bars indicate the periods characterised by summer background conditions as defined in the section 2.4.

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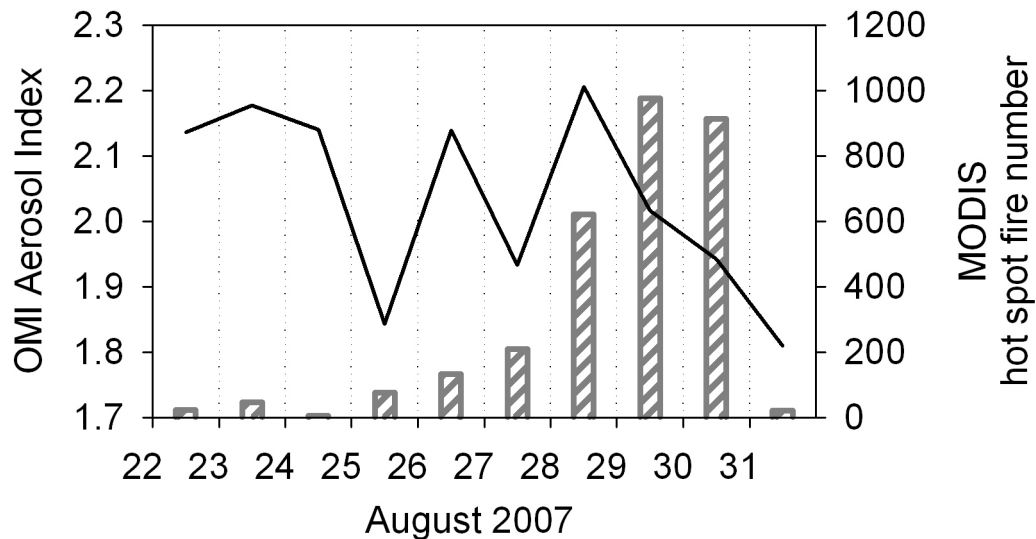


Fig. 2. Figure 4: Daily values of OMI Aerosol Index averaged over the Sahara desert (left y-axis) and daily number of MODIS hot spot fire (right y-axis) detected over the North African coastlines

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