

To Anonymous Referee #2

We appreciate your review of the manuscript we submitted to the ACP journal. Your detailed opinions, comments, and suggestions were helpful in the revision of our manuscript. The authors have added new datasets to the manuscript. We hope the revised version is more comprehensive and describes the DRAGON-Japan and -Osaka networks with greater clarity to the readers. Detailed replies to your comments and suggestions are included below. Our sincerest thanks once again.

With best regards,

Itaru Sano

General Comment

Authors analyzed the data obtained by the fields campaign DRAGON-Japan and DRAGON-Osaka, which are network of ground-based sun- photometers, and tried to discuss the long-range transboundary aerosol. The data obtained during the fields campaign DRAGON-Japan and DRAGON-Osaka are very valuable to understand the aerosol optical properties and the transportation process of aerosols in the region of East Asia. However, there are some unclear points in the manuscript. The authors need to show more data in order to draw the definitive conclusions. Although the manuscript includes some important data, however, the quality is not sufficient in the current state to be directly published.

Specific comments

Replies to specific comments are included in the following pages.

#1

Page 1 Line 1

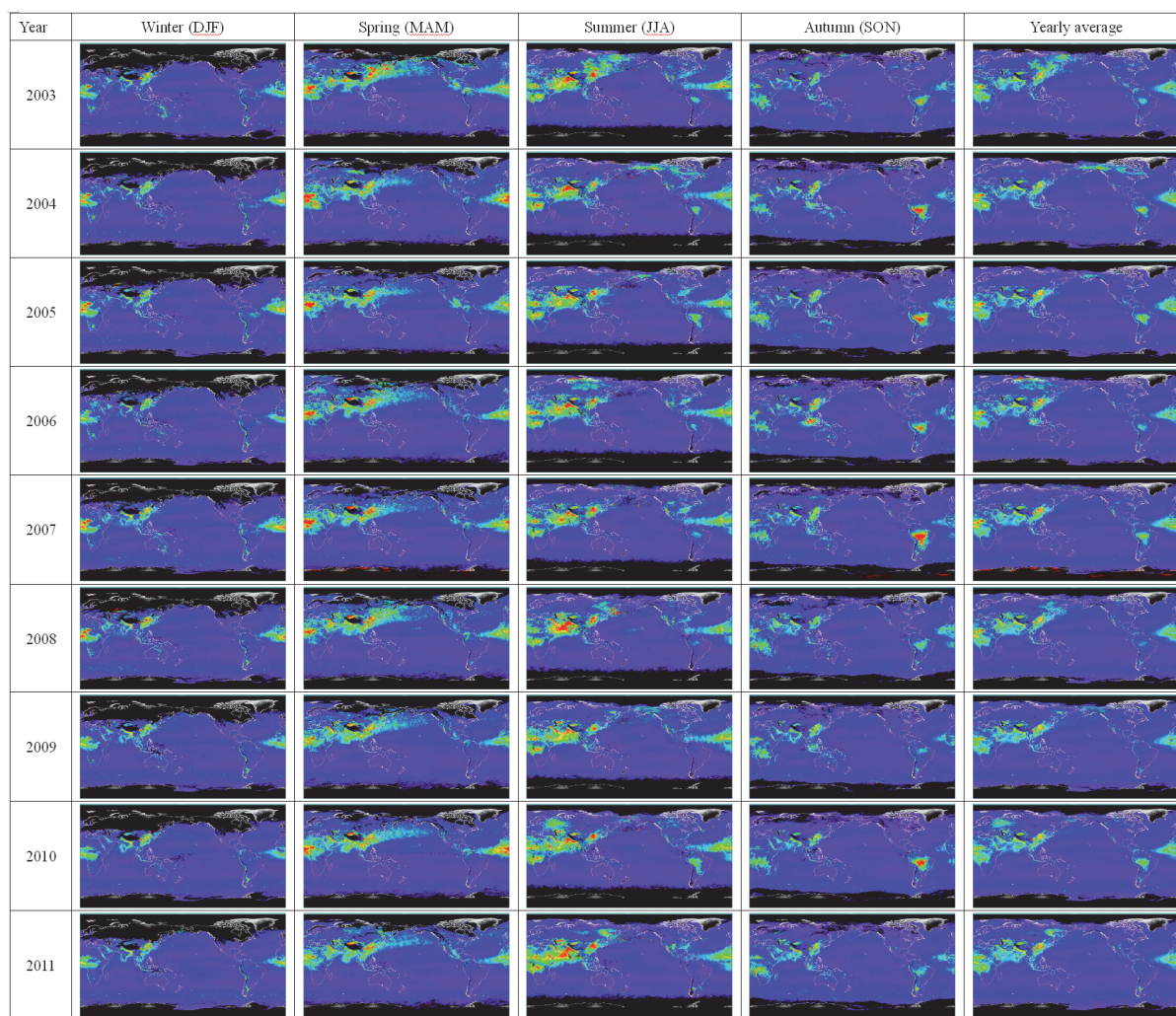
“The amount of long-range transboundary (LRT) aerosols over Japan is increasing due to growing anthropogenic emissions from the east Eurasian continent.”

Is this true? The aerosol optical thickness is flat or slightly decreasing in Japan area after 2000. If true, please cite references in the text.

Author’s reply

The authors investigated the AOT trend around Japan based on AOT (550 nm) distribution maps of yearly averages. Four season-average maps were created for the years from 2003 to 2011, which are classified based on MODIS/Aqua level 2 aerosol products (MYD04) collection 5 (see figure below). The yearly average indicates that the AOT around Japan varies from year to year. Considering these AOT features, the sentence has been changed to

“Aerosol mass concentrations are affected by local emissions as well as long-range transboundary (LRT) aerosols.” (Page 1, Lines 15-16)



#2

Page 2 Line 31 to 33

“In spring in East Asia, large desert dust particles are frequently observed from February to May. The Asian dust events result in a lower AE. At the same time, dust events bring a larger amount of particles with a high AOT. Such turbid conditions continue until August even after the Asian dust season has ended.”

From Fig.1, I cannot find neither “...large desert dust particles are frequently observed from February to May” and “dust events bring a larger amount of particles with a high AOT”.

This figure does not show the frequency of dust events. If the authors show the scatter plot of aerosol optical thickness and AE, we might see the frequency of dust events and a large amount of particles during dust event. When does Asian dust season end?

Author's reply

In compliance with your suggestion, a new figure has been included. The figure shows a scatter plot of the monthly average of AOT and Angstrom exponents. Additionally, the target period has been extended from 2001 to 2014. It can be seen in Fig. 1 that dust particles do affect the AE, i.e., low Angstrom exponent values and high AOT are apparent from March to May.

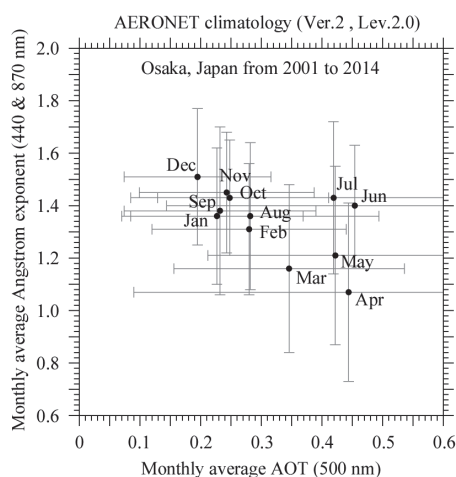


Figure 1

Thus, the manuscript has been revised as:

“The AOT-AE relationship shows that aerosols over Osaka can be classified into three groups. The first group is represented as low AOT and high AE, found in fall and winter. The averaged AOT in this group is less than 0.25 at 500 nm. On the contrary, the high AOT-low AE group appears in spring (March to May). Sano et al. (2003) presented the AOT-AE relationship found in results of aerosol measurements in the spring of 2001. At that time, high AOT-low AE events were frequently measured at several places in Japan due to Asian dust events; long term measurements imply the causal feature of this second group is the dust event. The third group is seen in June and July as high AOT-high AE. ”

(Page 3, Lines 23-30)

Further, regarding your question, most of the dust particles over Japan were observed in the spring. However, weak dust signals were observed throughout the year by analyzing LIDAR depolarization ratios, e.g.

<http://www-lidar.nies.go.jp/Osaka/archives/160810-160814.png>.

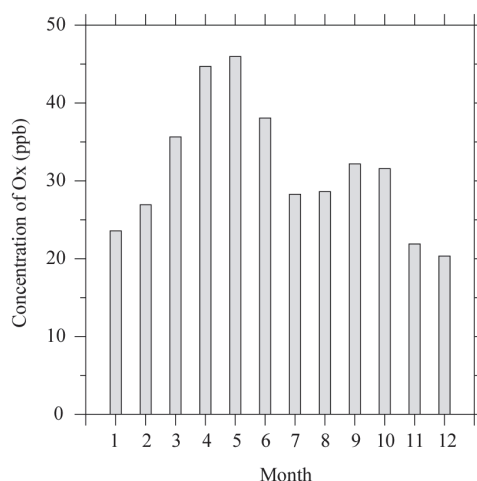
#3

Page 3 line 1 to 2

“With respect to aerosols in summer time, we assume the following three conditions: a high oxidant (Ox) level from local and transboundary emissions, high temperature, and strong solar incident light, . . .” I think that the conditions in May and June are also high oxidant level, high temperature, and strong solar incident light.

Author's reply

The authors have studied Ox levels from 2008 to 2013 obtained by the Japanese environmental monitoring system (Atmospheric Environmental Regional Observation System : AEROS : <http://soramame.taiki.go.jp/>). The concentrations of Ox in May and June were compared to those in July. We therefore concluded that the high Ox was not the only factor responsible for the high AOT. Kaneyasu et al. 2005 have proposed that the weather system and topography are the two factors that lead to high aerosol concentration in Japan in the early summer.



Thus, the manuscript has been revised as:

“AEROS presents high concentrations of Ox in April and May that subsequently decrease in June and July. This suggests that other reasons explain the relationship of high AOT-high AE in summer in Japan. Kaneyasu et al. (2005) have reported that events of high concentrations of suspended particulate matter (SPM) occurred through the stagnation of air exchange in Tokyo due to topography and the seasonal rain front (called the Baiu front in Japan).” (Lines 2-6 in Page 4)

Kaneyasu, N., Suzuki, M., Sugimoto, N., Matsui, I., and Shimizu, A.: Meteorological structures during the extensive aerosol pollution in the rainy season of Japan—A case study of 1997 July event— (in Japanese), J. Aerosol Res., 20, 313–322, doi: 10.11203/jar.20.313, 2005.

#4

Page 3 line 6 to 7

“It is possible that spring is the best season to investigate the contribution from China of long-range transboundary (LRT) aerosols over Japan.” Why the spring is the best season? In spring season, the aerosol characteristics are changing with the passage of synoptic disturbance. The synoptic scale disturbance periodically passed over the Japan area. In this situation, the air mass originating in both the continent and Japan area pass over the observation site in Japan. When we interpret the observational results, the contributions of air mass from the continent and Japan area to the optical thickness must be divided.

Author’s reply

The revised figure 1 indicates that high concentrations of LRT aerosols are likelier to occur in the spring. A high concentration level ($AOT_{440} > 0.3$) is needed to apply the results of Dubovik's retrieval, which gives us the optical properties of aerosols. The MODIS results, which are mentioned in the first reply, show that high AOT over Japan was observed in MAM (March, April, and May). The AOT pattern extends over the North Pacific Ocean. Considering these factors, the measurements were taken in the spring.

We were unable to completely differentiate between the LRT aerosols and local aerosols obtained from the AOT results. We therefore assumed that the contribution of local aerosols were high on low AOT days ($AOT < 0.3$), and those of LRT aerosols were high on turbid days ($AOT \geq 0.3$).

Considering these factors, we changed the following sentence from:

“It is possible that spring is the best season to investigate the contribution from China of long-range transboundary (LRT) aerosols over Japan.”

to:

“It is possible that spring is the best season to investigate long-range transboundary (LRT) aerosols, including anthropogenic particles and Asian dusts.” (Page 4, Lines 7-9)

#5

Page 4 line 4 to 5

“It is easily understood from Fig. 3 that the AOT values decrease with longitude. In other words, western Japan exhibits higher AOT than eastern Japan.” It is not easily understood western Japan exhibits higher AOT than eastern Japan. Because the standard deviation at each site is large. Therefore, the difference is not significant statistically. Furthermore, if the authors are interested in LRT aerosol, the LRT aerosol and locally emitted one should be distinguished.

Author's reply

The authors redrew figure 3, which now shows the temporal change of AOT (500 nm) measurement during the observation period from March to May. Each filled square represents the hourly average AOT. We also deleted the sentence

“It is easily understood from Fig. 3 that the AOT values decrease with longitude. In other words, western Japan exhibits higher AOT than eastern Japan.”

from the manuscript as per your suggestion. We were unable to estimate the exact fraction of LRT aerosols involved in the measurements. However, several peaks in the AOT time series trend might represent the LRT aerosols.

The following sentences are also inserted:

“Figure 3 shows a time series of hourly average AOT at 500 nm during DRAGON-Japan. ” (Page 5, Line 18)

“Each average value of AOT and its standard deviation are represented by a red line with a value, and gray shading, respectively. ” (Page 5, Lines 22-24)

“Note that the lowest value denoted by a blue line around 0.1–0.2 might be the usual local AOT value at all sites. Fukuoka is a million city, which releases a large volume of local emissions. However, two higher values in the middle of April and May imply the results of influence by transported aerosols. ” (Page 6, Lines 3-6)

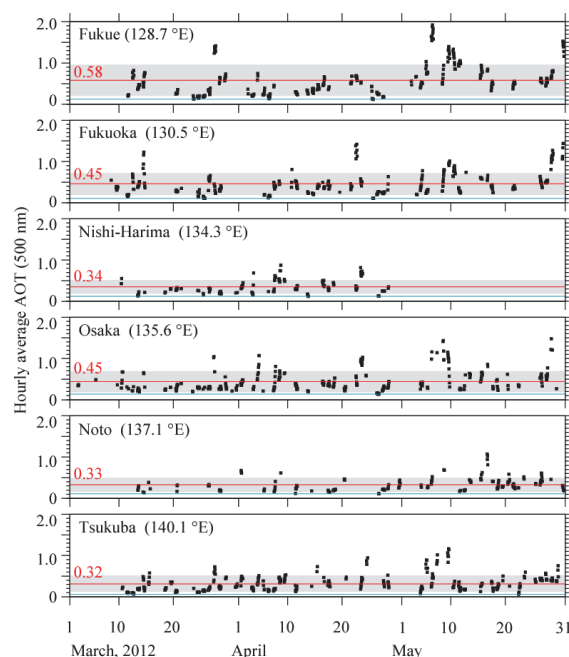


Figure 3. Temporal variation of AOT at a wavelength of 500 nm during the DRAGON-Japan period. Measurements were taken at Fukue Island, Fukuoka, Nishi-Harima, Osaka, Noto, and Tsukuba (see Fig. 2). The error bars (shaded gray) represent standard deviation at each site. Red lines represent average values at each site.

#6

Page 5 line 19

Why do the authors not show the data of mountain sites in Fig. 5?

Author's reply

The authors have included the results obtained from the mountain sites (Fig. 5) and have rewritten paragraphs 3 to 6 in section 3.1 (Page 8 and 9).

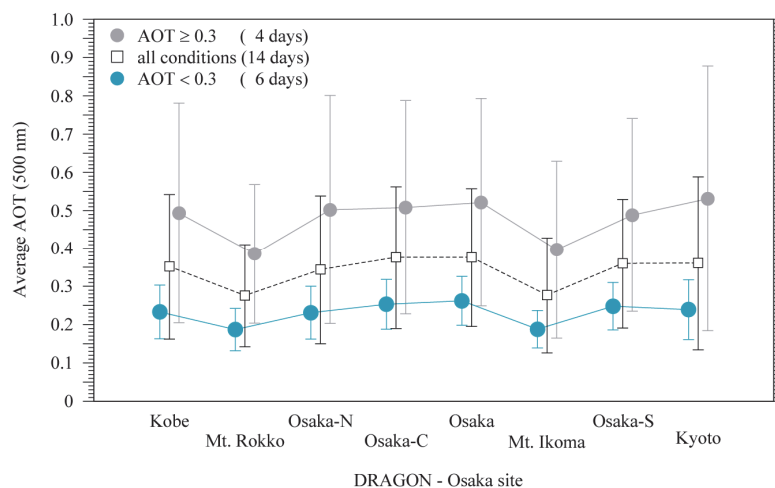


Figure 5. Daily average values of AOT (500 nm) at each site, classified into three cases, namely: turbid days (AOT ≥ 0.3) denoted by solid gray circles, moderate days (AOT < 0.3) by light blue circles, and the values obtained during the DRAGON period by white squares. The error bars represent the standard deviation.

#7

Page 6 line 1 to 14

The differences of AOT from 0.01 to 0.03 are small. I do not think that it is possible to discuss the difference of local emission.

Author's reply

The authors have incorporated additional sample values and have inserted average values instead of the values on the days with the lowest and the highest concentrations, in an effort to reduce errors in the evaluation of atmospheric conditions. The total average is also included. Thus, the new Fig. 5 exhibits three kinds of results.

- 1) the average of low AOT days ($\text{AOT} < 0.3$)
- 2) the average of high AOT days ($\text{AOT} \geq 0.3$)
- 3) The total average (including 1 and 2, as well as other days)

The authors also discuss the localization of AOT with lower level atmospheric conditions by using AOT_city site values – the AOT_mountain_site values. This estimates the values of AOT below mountain altitudes, which are probably related to local emission.

Considering these results, the authors still have a discussion on the localization within the DRAGON-Osaka results. (from line 26 in Page 8 to line 12 in Page 9)

#8

Page 6 line 14

“the measurements on the 27th represent the intrinsic local emissions of aerosols.”

This conclusion is not clear. The more explanation is necessary.

Author's reply

The authors have replaced the value of April 27 with an average measurement value. Further, as per your suggestion advising us to include the mountain dataset, new discussion topics, particularly regarding lower level AOT, have been added. The details have already been discussed in detail in the previous (#7) reply.

#9

Page 9 line 6 to 17.

Figure 8 is minute. I hope that the authors extract the data in May 4 and 5 from Fig. 8 and draw again it. LIDER system was installed only at Osaka site. From Fig. 8, we can get information on the vertical structure of aerosol just above Osaka site and we cannot get information on the horizontal distribution of aerosol. Therefore, Fig.8 does not explain the difference among Osaka, Osaka-C and Osaka-S. From Fig. 8a, we can get information on structure of aerosol extinction coefficient, but it is not quantitative. I recommend that the authors estimate the optical thickness below and above 500m height from Lider data.

Author's reply

The authors have redrawn figure 7 to include the AOT at mountain sites. As per your suggestion, two kinds of extinctions (Ext_0 - 630 m, Ext_0 - 6 km), which were obtained from the AD-Net LIDAR, are presented as dashed and solid lines on the lidar's backscatter coefficient image (see Fig. 8).

(See also line from 21 in Page 12 to line 5 in Page 13)

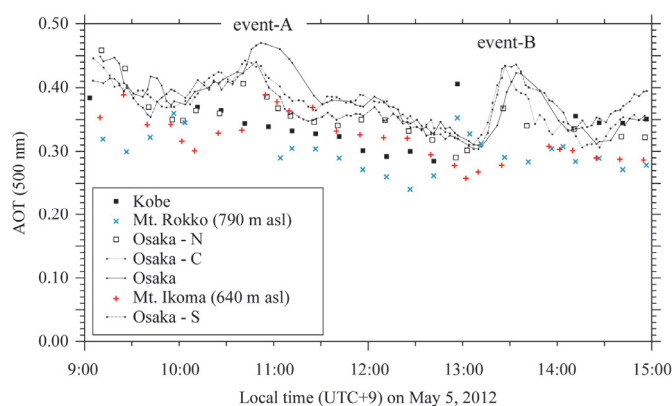


Figure 7.

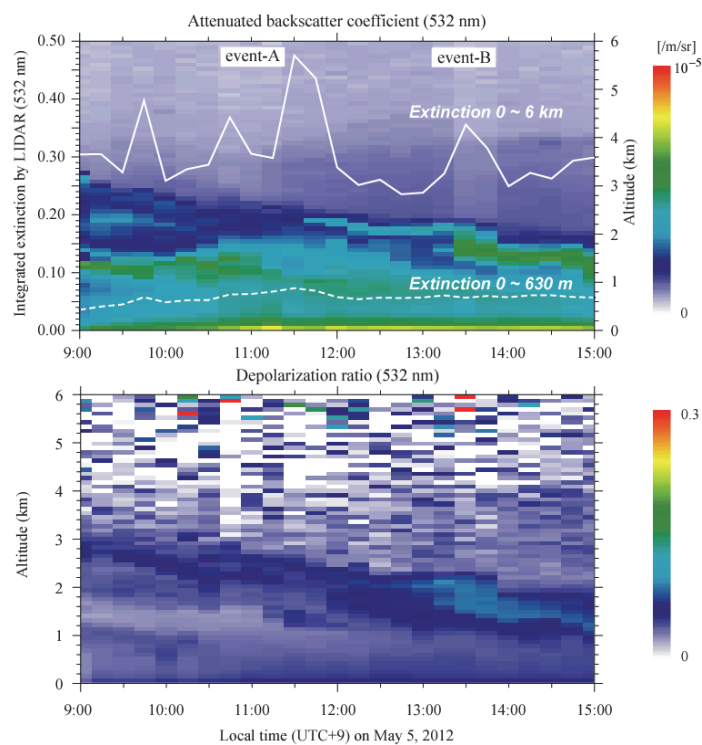


Figure 8.

#10 Page 10 line 3
What do the authors mean by the ward “transition”? Is the word “transition” appropriate?
Author’s reply
The authors have replaced the word “transition” with "movement". (Page 13, line 12)