

Interactive comment on “A pervasive and persistent Asian dust event over North America during spring 2010: lidar and sunphotometer observations” by P. Cottle et al.

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AC: The reviewer raises several valid points about the structure of the article, the readability of some of the figures, and the need for several points of additional clarification on methods and results. The reviewer’s main concern is the authors’ “inference of chemical ageing of the dust in the free troposphere in transit across the North American continent” hasn’t “convinced me that their observations support that conclusion”. This important and valid point has been taken into consideration with the focus of the conclusions section revised to avoid overstating the results. We acknowledge that further work is required to examine the process of chemical aging in continental dust

C13243

transit. However, the focus and major contribution of this submission remains the description of the unusual spatial and temporal persistence of this event and the addition of high-resolution data showing the vertical distribution and dynamics of the layers involved. Additionally, the authors wish to thank the reviewer for bringing an excellent new study to our attention. The observations of Liu et.al. provide a valuable context to observations in this article. The paper has been added as a reference and the results and conclusions sections modified to include support from their observations.

The authors address each of the reviewer’s specific points individually below:

RC: The discussion of HYSPLIT simulations is a bit unclear. Ref: “back trajectories in 6 h intervals” - does 6 h refer to the time resolution of the met. data used (plausible), or the time step used (less plausible)? What is the time step and order of accuracy of the scheme used?

AC: The 6 hour intervals refer to the start times for the trajectories (i.e. for a given 24-hour period, trajectories were originated at hours 00, 06, 12 and 18). As to the time step for the individual back trajectories, the step size was 1 hour. The text has been rewritten to clarify this point.

RC: I don’t see any reference to Figs. 1 and 2. First reference to a figure is to Fig.3.

AC: References to the first two figures have been added.

RC: p.30598, line 14: “Based on lidar observations” It would seem more logical to present the lidar observations (Figs. 4-6) before showing the model results that are used to interpret them.

AC: The authors have relocated the section on NAAPS and HYSPLIT Model Results so that it now follows the CORALNet and AERONET results.

RC: Figure 3: The changes in orientation (e.g. from 3a – 3c) and different projection of the HYSPLIT maps compared with the NAAPS maps is not helpful. Also, the color scale used for the NAAPS maps lacks sufficient contrast for the reader to locate peak

C13244

values over North America.

AC: The authors agree that the different map projections and the NAAPS colour scheme are less than ideal. Unfortunately, these are the result of limitations of the modelling software and cannot be modified without a substantial amount of effort. Despite the drawbacks to this method, the authors feel that with careful inspection of the figure, the relevant information is discernible. In order to further clarify the image, the authors have added a red ellipse to each projection roughly encircling the source regions and a red star indicating the location where back trajectories were originated.

RC: p.30600, line 24: what is "heterogeneous" about the "mixing with other aerosols."

AC: Quite correct. The word heterogeneous is redundant and has been removed

RC: p.30601, lines 13-18: What's the meteorological context for this short-lived surface dust event, e.g. subsidence behind a cold front? This deduced impact on local air quality would be strengthened with some aerosol chemistry observations from ground sites, e.g. Whistler.

AC: This event coincided with subsidence associated with a ridge of high pressure. The brevity of the subsidence event was due to a frontal passage on 25 March. Lidar observations showing a relatively short-lived period of elevated dust concentrations near the ground are in agreement with NAAPS time-height sections taken at Cheeka Peak for the days in question (see attached figure). At ground level the event was also accompanied by modest increases in PM10 concentrations to a maximum of 28 mgm-3 at Vancouver International Airport (and elsewhere in the region), which further support the observation of increased impact on local air quality. Mention of the meteorological context and the elevated PM concentrations have been added to the text of the article.

RC: p.30603, lines 5-11, 16-19., and p.30607, lines 19-22: Chemical ageing of the dust associated with coating by acid pollutants (in the Asian airstream) should have tailed off (surface saturation) before the dust reaches North America (The Tang et al., and Li

C13245

et al., papers concern uptake over East Asia). Can you definitively connect the dust observed over Egbert to the dust observed over Vancouver? That would seem critical to asserting some sort of additional "chemical ageing" in transit across the continent. Liu et al., (2012) show variability in particulate depolarization ratios in transpacific dust plumes, attributed to different Asian source regions. Do the trajectory calculations suggest that the dusts observed at Vancouver and Egbert originate from the same or from different source regions? Reference: Liu, Z., et al., Transpacific transport and evolution of the optical properties of Asian dust, *J. Quart. Spect. Rad. Transf.*, 11 (2013) 24-33.

AC: Upon careful reading of the Liu article, the authors feel that Liu et.al.'s observations of spatial variation of depolarization ratios for dust from Asian sources are consistent with our observations regarding the Egbert lidar data. As the reviewer points out, Liu et.al. observe a significant variation in Particle Depolarization Ratios (PDR) between the two main source regions of China (0.34 +/- 0.07 for the Tarim Basin and 0.28 +/- 0.06 for the Gobi desert), but they also show CALIPSO PDR measurements that reveal little statistically significant variation among 6 of the 7 overpasses reported (see Fig. 4 and associated discussion on pp.28-29). The one exception to this is Overpass 1, taken just off the coast of Japan where Liu et.al. posit that increased mixing from fine-mode sources caused a further net reduction in PDR (p.28). Based on their GEOS-Chem results (Figs. 2a, 3a) and wind vector model (Fig. 8) it is reasonable to conclude that the dust-rich layers from the source regions are likely to have mixed with each other as well as with fine-mode aerosols originating from the industrial centers of eastern China, Korea and Japan, homogenizing and reducing the observed PDR of the layers seen over the Pacific. As a result, it is not really possible to distinguish the relative influence of dust from individual source regions once the layers reach North America. They do not specifically address the continued mixing that occurs as these layers pass over North America. Notably they point out on page 28 that although dust from Asia was observed by the HSRL lidar in Langley, VA on April 22; observations that coincide with the Egbert lidar observations, these results were not part of the Liu article. However,

C13246

the authors believe it is reasonable to assert that the lower observed mean Volume Depolarization Ratio (VDR) of the dusty layers seen over Egbert is likely the result of a higher relative concentration of fine-mode aerosols in those layers than in those observed in Vancouver, even if changes due to chemical ageing have dropped off. This is also seen in Liu et.al. Figure 7 a. showing 5-year averages of PDR from layers identified by CALIPSO as dust and polluted dust, where the values show a weak dropping trend from West to East over Canada. Of course there is a distinct difference between PDR and VDR (as demonstrated in Liu Fig. 6) but the general trends in depolarization would still be consistent.

In order to address these important distinctions between chemical ageing and layer mixing, and to avoid any implication that the layers seen in Egbert are necessarily the same ones seen in Vancouver, the authors have made the following changes to the article:

- 1) More precise language has been included distinguishing between volume and particle depolarization ratios
- 2) Mentions of chemical ageing have been replaced with the more likely scenario of external mixing of dust layers with other fine mode aerosols
- 3) Language has been clarified to reflect that although the layers of dust in Egbert and Vancouver were likely to have both come from the source regions of Asia, the individual layers observed in Egbert may well be different than those that passed over Vancouver. The primary observation in this regard pertains to the difference between the observed VDR of layers that had been transported across North America as compared to those that had only reached the West Coast.

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C13247

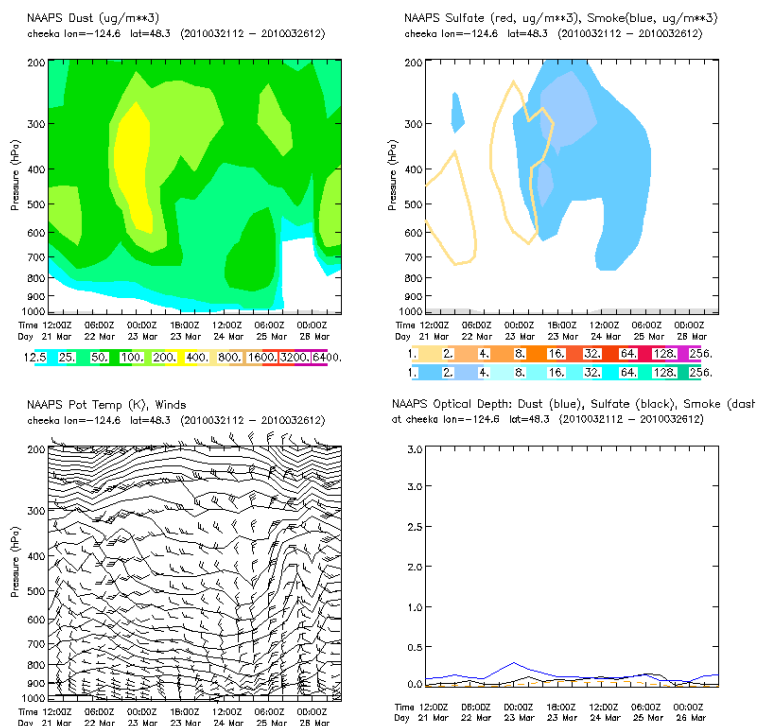


Fig. 1. NAAPS time-height sections for Cheeka Peak, WA from 21 – 26 March, 2010 showing subsidence and high dust concentrations near the surface on 24 March, 2010.

C13248