

Interactive comment on “Identification of Atmospheric Transport and Dispersion of Asian Dust Storms” by Raegyung Ha et al.

Y. Yu

yongjaeyu@cnu.ac.kr

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Our response to referee’s comments are listed as Red (Referee 1) and Blue (Referee 2) in a marked pdf file.

Attached files include

- (1) Manuscript revised: Manuscript-Revision 2.pdf
- (2) Response to comments: Response to Referee 2.pdf

Please also note the supplement to this comment:

<http://www.nat-hazards-earth-syst-sci-discuss.net/nhess-2016-400/nhess-2016-400-SC2-supplement.pdf>

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Interactive comment on Nat. Hazards Earth Syst. Sci. Discuss., doi:10.5194/nhess-2016-400, 2017.

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List of Revision

Our response to referee's comments are listed as Red (Referee 1) and Blue (Referee 2) in a marked pdf file.

Blue (Referee 2)

(Referee 2's Comment 1) This paper presents a short work on the identification of Asian dust storms outbreaks (ADS) affecting Korea. The period from January 2003 to August 2015 is analysed, and a total of 743 ADS affecting Korea are identified by means of Lagrangian trajectories. The HYSPLIT model is used to compute backtrajectories reaching the area of study at 1000, 1500 and 2000 m. This information is combined with observations of PM10 dust concentrations at 4 representative sites located in Korea. The main problem with the present version of the manuscript is that right now is a technical brief report. The analysis conducted are not scientifically sounding. There are some misunderstandings in the manuscript: the authors confuse the definition of concentration with density, presenting measurements of PM10 dust air concentration as dust densities.

(Response to Referee 2's Comment 1)

It is true that we measured "PM10 dust air concentration" not the "dust density".

(Revisions according to Referee 2's Comment 1)

Throughout the text, we have revised manuscripts accordingly.

"dust density" to "PM10 dust air concentration"
"mean dust density" to "mean of PM10 (PM10_{mean})"
"median dust density" to "median of PM10 (PM10_{median})"

(Referee 2's Comment 2) The lack of a Conclusion sections is a clear indication about the limitation of the analysis presented in this work.

(Response to Referee 2's Comment 2)

We have added a new section for "Conclusion".

(Revisions according to Referee 2's Comment 2)

From Line 27 of Page 6 to Line 12 of Page 7

1. The present study dealt with the Asian dust storms (ADS) outbreaks affecting Korea from January 2003 to August 2015. A total of 743 ADS air parcel backward trajectories reaching to Korea were identified by means of Lagrangian integrated trajectory (HYSPLIT) at three different ending altitudes at 1000, 1500, and 2000 m.
2. In all four stations where ADS was monitored, we found that ADS occurrence rate was increased recently. Such increase of ADS occurrence was statistically significant in 99.9 % confidence level regardless of the threshold time divide of 1997/98 or 2000/01.
3. Monthly variation of ADS occurrence was definitely non-uniform, as ADS was mostly concentrated

Fig. 1.

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in colder seasons of winters and springs. Instead, ADS events rarely occurred from June to September.

4. Majorities of ADS events are azimuthally confined in narrow intervals of 290–340° on angle histograms, indicating that northwesterly distribution of dust transport was prominent. Such angular dependence of ADS occurrence agrees well with the higher PM10 dust air concentration from the northwest.

5. We propose that the total amount of cumulative PM10 discharge was rather constant over time in Korea, as there is an inverse correlation between ADS occurrence and PM10 dust air concentration. Such constant PM10 flux allows weaker PM10 concentration for longer transport, and vice versa."

Fig. 2.

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Red (Referee 1)

(Referee 1's Comment 1)

The backward trajectory of each dust storm was calculated using HYSPLIT. But there is no description of HYSPLIT and its advantages and disadvantages, except for a short sentence on P.2. Many readers of NHSS are probably not familiar with HYSPLIT, a free downloadable model from the NOAA website, and will appreciate having some background information on the model.

(Response to Referee 1's Comment 1)

For a broader audience, a brief introduction to "HYSPLIT" is necessary.

We have added five new sentences.

(Revisions according to Referee 1's Comment 1)

Lines 21-31, Page 2

"In the present study, we trace the air parcel trajectories of ADS using the hybrid single particle Lagrangian integrated trajectory (HYSPLIT) model (Draxler and Hess, 1998). The HYSPLIT has evolved from the earliest model in 1982 (Draxler and Taylor, 1982) from modelling long-range air parcel trajectories into simulations of pollutant transportation, dispersion, and deposition over global scales. As an open source, the HYSPLIT is available on the Web through the ARL READY system (<http://ready.arl.noaa.gov/HYSPLIT.php>), operated by the National Oceanic and Atmospheric Administration (NOAA) Air Resource Laboratory (ARL). The HYSPLIT model requires the meteorological data and vertical movement of atmospheric circulation as input, and it displays the analysis of the simulation outputs (Stein et al., 2015). One great advantage of using the Lagrangian HYSPLIT is that both forward and backward trajectories are available with local or global airflow patterns to interpret the transport of pollutants. The HYSPLIT model is continuously evolving to cope with turbulent mixing process and to incorporate higher temporal frequency data available from the meteorological data (Stein et al., 2015)."

(Referee 1's Comment 2) *The study mentions that the trajectories of air transport at altitudes of 1000, 1500, and 2000 m were traced and shows the trajectories in Fig. 1b. But after Fig. 1b, there is no more mention of these different altitudes. Are they involved in subsequent analysis?*

(Response to Referee 1's Comment 2)

Air transport at three different altitudes were handled independently.

We have added three new sentences.

(Revisions according to Referee 1's Comment 2)

Lines 1-5, Page 6

"The HYSPLIT backward trajectories at different altitudes of 1000 m, 1500 m, and 2000 m were counted as individual path in the present study. They do not show a meaningful difference statistically, implying that atmospheric turbulent mixing was minimal. Such directional consistency for different altitudes of the HYSPLIT model might result from the relatively low and flat geographic conditions. For instance, both eastern China and western Korea are low in elevation, with bridging shallow Yellow Sea which extends 900 km in North-South directions and 700 km in East-West directions."

Fig. 3.

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(Referee 1's Comment 3) *In the Introduction, the authors explain that ADS contain "surface minerals of natural origin (e.g., weathered soils) as well as pollutants of anthropogenic origin such as black carbon, heavy metals, and sulfates." But in the Discussion, the authors seem to identify the desertification of the Gobi and Taklamakan deserts as the main cause of the recent increase of ADS. Can pollutants of anthropogenic origin, such as from coal burning and industrial plants, be another reason for the increase?*

(Response to Referee 1's Comment 3)

Influence of anthropogenic particulate matters is now included.

We have added three new sentences.

(Revisions according to Referee 1's Comment 3)

Lines 21-25, Page 5

"In addition to natural pedogenic enhancement, we cannot ignore the contribution of anthropogenic particulate matters supplied by fossil fuel combustion, coal burning and industrial plants. Although anthropogenic particulate matters represent only 5-30% of ADS volumetrically, they are harmful as they have a strong tendency to react with heavy metals preferentially. Considering on-going demand for the fossil-fuel combustion, it is reasonable to suggest that pollutants of anthropogenic origin are also responsible for the increase of ADS."

(Referee 1's Comment 4) *The Discussion concentrates on the results from the four stations in South Korea. Are there studies from other countries such as Japan and Taiwan to support the findings of the study on the recent increase and seasonality of ADS?*

(Response to Referee 1's Comment 4)

Seasonality of Asian Dust Storm in other neighboring countries are included in discussion.

We have added two new sentences.

(Revisions according to Referee 1's Comment 4)

Lines 6-8, Page 5

"Occurrence of more frequent ADS and its seasonality was also documented in neighboring countries including Japan and Taiwan (Yang, 2002; Watanabe et al., 2011; Chien et al., 2012; Kimura, 2012). Then, it can be understood that seasonal variation of ADS is a local, natural phenomenon in Eastern part of Asia."

Fig. 4.

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