

Interactive comment on “The impact of human activity on anthropogenic dust emission over global semi-arid regions” by X. Guan et al.

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We are grateful for the reviewers' useful advice and comments. They helped us greatly to improve this paper. Our point-by-point responses to the reviewers' comments are listed as follows.

General comments:

It is known that human activities have impacts on anthropogenic aerosol emissions, but few studies analyze this problem because there are many contributing factors and technical constraints. The authors of this paper employ a state-of-the-art algorithm to distinguish human-induced dust aerosols from CALIPSO satellite observations, and study the relationship between anthropogenic dust burden and population density (growth rate) over various land covers. This paper deserves to be published, but several prob-

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lems need to be addressed. More discussion, analysis, and references are considered necessary to be added to better support the conclusions.

Part 1:

Major issues:

(1)The title is better changed to “The relationship between anthropogenic dust emission and human activity over global semi-arid regions”. The reason for the suggested title change is that the authors barely discussed about the “impacts” but the “relationship”. In addition, more in-depth analysis about why such a relationship exists between anthropogenic dust and human activity.

Response: Thank you for your suggestion. The title has been changed to “The relationship between anthropogenic dust emission and human activity over global semi-arid regions.” The revised manuscript has also included more description and discussion on the relationship between anthropogenic dust and human activity.

(2)The abstract should be revised in order to better reflect the content of this manuscript. The authors should add the temporal ranges of the data used, otherwise the values (i.e. population growth rate, dust burden, etc.) will be meaningless.

Response: We appreciated this suggestion, the abstract has been revised and the temporal range of data used has also been introduced in the revised manuscript.

(3)The introduction part is also deemed insufficient. First, not enough references are provided to support the acclaims. For example, in page 1, line 24-26: “The economic policy of most developing countries is an extensive economic model. This type of economic policy always results in a lower efficiency of resource use.” Three is no explanation of what is “extensive economic model”. And there is no support (reference or evidence) of why this model “always” results in a lower efficiency of resource use. Similar problems also exit in the manuscript, such as page 1, line 20-22; Also, Page 7, line 15-17: the authors need to add some supporting references to prove that “semi-

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arid areas have fragile eco-system to support large population” and that “semi-arid area are sensitive to natural change and human activities”.

Second, there is not enough discussion of the previous studies about the human impact on anthropogenic dust emission. That is, how do different human activities (i.e. agriculture practice, water use, and industrial practice) practically impact the generation/distribution of anthropogenic dust? This is a critical point in order to understand the variations of human-dust relationship in various regions.

Response: The introduction has been revised, and the questions have been replied separately as below.

(a) in page 1, line 24-26: “The economic policy of most developing countries is an extensive economic model. This type of economic policy always results in a lower efficiency of resource use.” There is no explanation of what is “extensive economic model”.

Response: “Extensive economy” is a type of economic growth that depends on high consumption of material resources and energy to a great extent. Its explanation has been added in the revised manuscript.

(b) And there is no support (reference or evidence) of why this model “always” results in a lower efficiency of resource use.

Response: The related references have been added in the revised manuscript. Currently, the high economic growth depends on high consumption of material resources and energy to a great extent, which is a kind of extensive economic growth mode and inevitably encounters the restriction of population, resources, energy, and the pressure of environment, facing a “bottleneck” of the limited resources.

(c) Similar problems also exist in the manuscript, such as page 1, line 20-22;

Response: Similar problems have been fixed in the revised manuscript.

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(d) Also, Page 7, line 15-17: the authors need to add some supporting references to prove that “semi-arid areas have fragile eco-system to support large population” and that “semi-arid area are sensitive to natural change and human activities”.

Response: More references related to “the semi-arid areas that have fragile ecosystem to support large population” and “the semi-arid area that are sensitive to natural change and human activities” have been added in the revised manuscript.

(e) Second, there is not enough discussion of the previous studies about the human impact on anthropogenic dust emission. That is, how do different human activities (i.e. agriculture practice, water use, and industrial practice) practically impact the generation/distribution of anthropogenic dust? This is a critical point in order to understand the variations of human-dust relationship in various regions.

Response: Thank you for your suggestion. The discussion about human impact on anthropogenic dust emission has been revised. More references about the influence of different human activities on anthropogenic dust have been added in the revised manuscript.

(4) Since the four semi-arid regions, namely East China, India, North America, and North Africa, are selected for in-depth study, why the relationships between anthropogenic dust and population index in these regions are not investigated/provided? It is also helpful to show the anthropogenic dust column burden changes as a function of population density in the four regions (Figure 12). These regional evidences are crucial to support the authors’ arguments and thus should be added.

Response: Thanks for your insightful suggestions. The revised manuscript includes the description and discussion over the four typical semi-arid regions, which cover both the relationship between anthropogenic dust and population density, and the relationship between anthropogenic dust and population change. According to your suggestion, we added Figure 1 in the revised manuscript to illustrate the relationship between anthropogenic dust aerosol and population density in the four typical semi-arid

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regions. Four different semi-arid regions perform different relationships between population density and anthropogenic dust. More description and discussion about the relationship between anthropogenic dust and population density have been stated in the revised manuscript.

(5) A major problem with this manuscript is quite a few arguments/conclusions derived from the analysis are not considered fully supported by the evidences provided. For instance, in Page 6, line 11-16: the authors argue that the difference in anthropogenic dust in different seasons could be due to the difference in human activities (especially agriculture activities). And, agricultural activities are claimed to be most frequent in summer. Then, why and how do agriculture activities impact the most in summer? Similarly, in Page 7, line 27-29: please explain how the difference in population growth rate closely relates with economic status? In page 8, line 31-33: please explain more about why “the land type experiences more human activities, the more anthropogenic dust aerosol will be produced”? How do you figure out the human activity frequencies?

Response: In order to reply the question well, it has been divided into three parts.

(a) For instance, in Page 6, line 11-16: the authors argue that the difference in anthropogenic dust in different seasons could be due to the difference in human activities (especially agriculture activities). And, agricultural activities are claimed to be most frequent in summer. Then, why and how do agriculture activities impact the most in summer?

Response: Spring and summer have the highest anthropogenic dust, which was a conclusion from Huang et al. (2015). They compared the global seasonal distribution of total dust optical depth and found that “the total anthropogenic dust column burden (DCB) is greater in spring and summer than in autumn and winter. This difference is most significant in arid and semi-arid regions. ” Summer always has more human activities than the other seasons, both in day and night. It has longer day and indirect induced an increase frequency of human activities.

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(b) Similarly, in Page 7, line 27-29: please explain how the difference in population growth rate closely relates with economic status?

Response: Population change reflects the economic status to some extent. For the distribution of economic development in the world, the more developed countries have low population change are, even negative growth; the developing countries usually has positive population growth. It depends on the economic status and style, such as the extensive economic development depends on high consumption of material resources and energy to a great extent; it requires a great number of labor to support development of industries. However, in the developed countries, the high level industrialization needs much less people who has the technology to handle the machines to finish the project that used to need much more people. Therefore, the economic status has the ability to change population growth.

(c) In page 8, line 31-33: please explain more about why “the land type experiences more human activities, the more anthropogenic dust aerosol will be produced”? How do you figure out the human activity frequencies?

Response: Anthropogenic dust aerosol is a type of dust aerosol; it is most originated from exposed land, especially in semi-arid region. Anthropogenic dust aerosol is a result of human activities. According to its sources, anthropogenic dust originates mainly from agricultural practices (harvesting, ploughing, overgrazing), changes in surface water (e.g., shrinking of the Caspian and Aral Sea, Owens Lake), and also from urban practices (e.g., construction), and industrial practices (e.g., cement production, transport) (Prospero et al., 2002). The sentence of “the land type experiences more human activities, the more anthropogenic dust aerosol will be produced” is also been changed to “the land type experiences more human activities, the more anthropogenic dust aerosol may be produced”. And Population density and population change have been included in to measure human activities.

(6) Population density and population change are taken as measurement of human

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activities. They have a positive relationship with anthropogenic dust in the global semi-arid region. It is better if you use one figure to show the relationship of anthropogenic dust with population density and population change. In addition, what's the advantage and disadvantage of taking human population density (and variation) as surrogates of human activities? What is the expected impact on the results?

Response: Thanks for these insightful suggestions. First, the figures that show the relationship of anthropogenic dust with population density and population change have been combined to one figure. Second, the relationships of anthropogenic dust with population density and population change have been re-organized in the revised manuscript. As we stated in answering the previous question, population and population change have been used as an index of human activities. As an index of human activities, it has both merit and shortcoming. Population-related index has a close relationship with economic development; it is also a result of government policy. However, it has a limitation of scale. Its limitation also can be found in the comparison of four typical semi-arid regions. The traditional agriculture is the most suitable for using the population index, as most people has been limited in the agriculture. The population and its change can greatly impact on anthropogenic dust, which is been greatly reflected in semi-arid region of India. In the semi-arid region of India, traditional agriculture dominated the economic body in selected area, the agriculture anthropogenic dust aerosol exhibited close relations with population density and population change.

Part 2:

final problem is with the language. A detail check of the mistakes in grammar and sentence structure is highly recommended.

Minor problems:

(1) Page 1, line 25:"always" is better changed to "frequently"

Response: Done.

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(2) Page 1, line 28: "anthropogenic effect on emission"-emission of what? Aerosols?

Response: It has been revised as "anthropogenic effect on aerosol emission."

(3) Page 2, line 8: "these regions are ..." should be "where they are ..."

Response: Done

(4) Page 2, line 12: "soils distributed by human activities" should be "soil distributed by human activities"

Response: Done.

(5) Page 2, line 14: "global dust cycle, historical and possible future changes" should be "global dust cycle, as well as historical and possible future changes"

Response: Done.

(6) Page 2, line 29: "a study of human activity on anthropogenic dust column burden" should be "a study the impact of human activity on anthropogenic dust column burden"

Response: Done.

(7) Page 2, line 33-34: "and investigated its relationship with human activities" should be "and its relationship with human activities is investigated"

Response: Done.

(8) Page 3, line 20: what is "population layer"?

Response: It has been changed to "population" to avoid misunderstanding.

(9) Page 3, line 24: what is the unit of "population density"?

Response: the unit of population density is persons km⁻²

(10) Page 3, line 26: section "2.3 Anthropogenic dust detection data" is better changed to "2.3 Dust detection data"

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Response: Done.

(11) Page 4, line 30: what is “|CAD|>70”? what does it mean?

Response: CAD is cloud aerosol discrimination. |CAD|>70 is a threshold for dust extinction coefficient for the highest confidence level.

(12) Page 5, line 5: “the dust density of dust” should be “the density of dust”

Response: Done.

(13) Page 5, line 7: “This method does not only modify” should be “This method not only modifies”

Response: Done.

(14) Page 5, line 10: “detection” should be “detecting”

Response: Done.

(15) Page 5, line 25: “... regional anthropogenic dust ... of globe” should be “... global anthropogenic dust ...” – I think Figure 2 is the global (not regional) average of anthropogenic dust burden, isn't it?

Response: Done. Figure 2 is the global anthropogenic dust burden.

(16) Page 6, line 9: it's better to add a legend for Figure 3.

Response: The legend for Figure 3 has been added in the revised manuscript.

(17) Page 6, line 12: “that may be a result of ” should be “which may be because”

Response: Done.

(18) Page 6, line 28: what do you mean by “emission effect”?

Response: “Emission effect” has been changed to “radiative effect.”

(19) Page 6, line 34: “differing” should be “different”

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Response: Done.

(20) Page 7, line 15: “that are difficult” should be “that is difficult”

Response: Done.

(21) Page 8, line 8;11: please pay attention to the sentence structure. You may consider separate it into several short sentences.

Response: Thanks. This sentence has been separated into several short ones that are easy to understand.

(22) Page 8, line 23: “rear population” should be “rare population”?

Response: Done.

(23) Page 8, line 27: what is “cropland mosaics”?

Response: Cropland mosaic is a mosaic of less than 60 percentages of cropland in the landscape. Its definition has been added in the revised manuscript.

(24) Page 8, line 29: “is remain unchanged” should be “remains unchanged”

Response: Done.

(25) Page 9, line 3: “starts obvious increase” should be “shows obvious increase”

Response: Done.

(26) Page 9, line 4: “make significant effect in production of anthropogenic dust” should be “have significant effect on anthropogenic dust production”

Response: Done.

(27) Page 9, line 9: “the sensitive of” should be “the sensitivity of”

Response: Done.

(28) Page 9, line 10 “appears obvious increasing” should be “shows obvious increase”

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Response: Done.

(29) Page 9, line 14: “benefit in production of ...” should be “contribute to production of ...”

Response: Done.

(30) Page 9, line 15: “It found that ...” should be “It is found that ...”

Response: Done.

(31) Page 9, line 21: “correlated to ...” should be “correlated with ...”

Response: Done.

(32) Page 9, line 25: “on study the influence of ...” should be “to study the influence of ...”

Response: Done.

(33) Page 17, figure 2 caption: although “AI” is defined in the text, it is still better to give “aridity index (AI)” here for readers who only view the figures.

Response: The description of AI has been added in the place for readers to follow the manuscript easily.

Reference:

(1) Huang, J., Liu, J., Chen, B., and Nasiri, S. L.: Detection of anthropogenic dust using CALIPSO lidar measurements, *Atmos. Chem. Phys.*, 15, 11653–11655, doi:10.5194/acp-15-11653-2015, 2015.

(2) Prospero, J. M., Ginoux, P., Torres, O., Nicholson, S. E., and Gill, T. E.: Environmental characterization of global sources of atmospheric soil dust identified with the Nimbus 7 Total Ozone Mapping Spectrometer (TOMS) absorbing aerosol product, *Rev. Geophys.*, 40, 2-1–2-31, doi:10.1029/2000RG000095, 2002.

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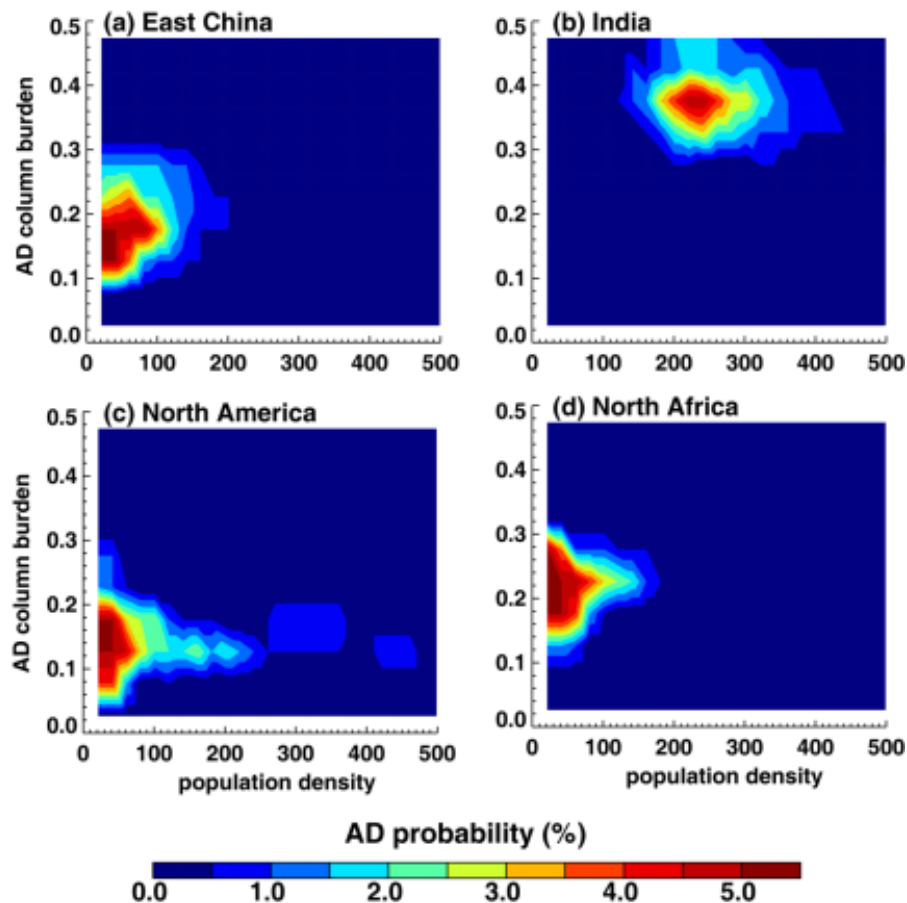


Fig. 1. Anthropogenic dust probability distributions of semi-arid regions in (a) East China, (b) India, (c) North America, (d) North Africa

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