This paper is touching an ongoing effort in the dust modeling community to better characterize the anthropogenic part of dust emission. I want to address some major issues with their methodology as well as incorrect statements. Human activities may contribute directly to dust emission through traffic, off-road vehicles, construction or some industry such as cement factory. They can also disturb soils due to agricultural practice or overgrazing. In a study published in 2012 in Reviews of Geophysics with my co-authors we estimated dust emission from agriculture based on MODIS Deep Blue satellite products at 0.1o resolution. The present study is pretty much following our methodology but with different input datasets.

As their datasets have different grid resolution and they did not describe which grid is considered for the final product, I have to assume that the values they reported are on the coarser grid or $1^o x1^o$.

Thank you so much for your suggestions. We carefully read your paper published by Reviews of Geophysics in 2012. We think that you did a great work for developing anthropogenic dust in the study. Your paper was cited many times in our articles. We really thank you for suggesting these valuable suggestions. We will try to explain your comments and suggestions as follows:

At present, the uncertainty of determining anthropogenic dust sources and constructing dust emission schemes has led to larger biases in the estimations of anthropogenic dust emissions. This research has noted that simulated anthropogenic dust contributions to the total dust loading mass have ranged from 10% to 60%. In the introduction, we proposed three key reasons for such large uncertainties as follows: "First, lacking of observation constraints on estimations of anthropogenic dust; Second, neglecting the influence of dynamic land surface in the anthropogenic dust emission; Third, neglecting the direct anthropogenic dust emissions induced by human activities."

To fully consider the mechanisms of anthropogenic dust emissions, we hope to develop and construct both "indirect" and "direct" anthropogenic dust emission schemes in the study. Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations (CALIPSO) retrievals based on Huang et al. (2015) were used to constrain the simulations at the global scale. We think it may be some new ideas for simulating anthropogenic dust.

The spatial resolution of indirect anthropogenic dust emissions was determined by the surface bareness at 0.5°×0.5° resolution. As for direct anthropogenic dust emissions, the spatial resolution depended on the resolution of the CNLI (Compounded Nighttime Light Index) which was at 1°×1° resolution. Therefore, the spatial resolution of indirect and direct anthropogenic dust emissions was 0.5°×0.5° and 1°×1° resolution, respectively.

The spatial resolution of simulations at the global scale would be limited due to the limit of input datasets. We utilized land cover datasets developed by Meiyappan et al. (2012) in the simulations. This land cover dataset which merged the Historical Database of the Global Environment (HYDE 3.1), wood harvest data, and urban land data, is to provide estimates of historical land-cover change at the global scales. It incorporates 28 types of land cover, including 16 types of natural land cover (e.g., forests, grasslands, shrubs, etc.) and 12 types of land cover disturbed by human activities (e.g., secondary forests, croplands, pasturelands, and urban environments) (Table 2 in the manuscript). It noted that the datasets provided percentage of different land covers within a grid at 0.5°×0.5° resolution. In this study, we included C_4 croplands and C_4 pasturelands as potential indirect anthropogenic dust sources (Figure 1b and 1c). Therefore, we took the proportion of C_4 croplands and C_4 pasturelands within a grid into consideration in the indirect dust emission scheme in this study. In addition, urbanization, population density, and economic development were coupled in the direct anthropogenic dust emission scheme. Among them, the CNLI (Compounded Nighttime Light Index) with valid range from 0 to 1 represents the proportion of urbanization within a grid showing significantly regional characteristics (Zhuo et al., 2003). Thus, the spatial resolution of direct anthropogenic dust emissions set by 1°×1° was reasonable enough to reflect the spatial characteristics of direct anthropogenic dust.

Although the spatial resolutions of indirect and direct anthropogenic dust emissions we set were a bit coarse, the simulation results could generally capture the spatial distributions of anthropogenic dust emissions at the global scale under the constrain of observations retrieved by CALIPSO. As your suggestions, we will further simulate anthropogenic dust with a higher resolution in the further work.

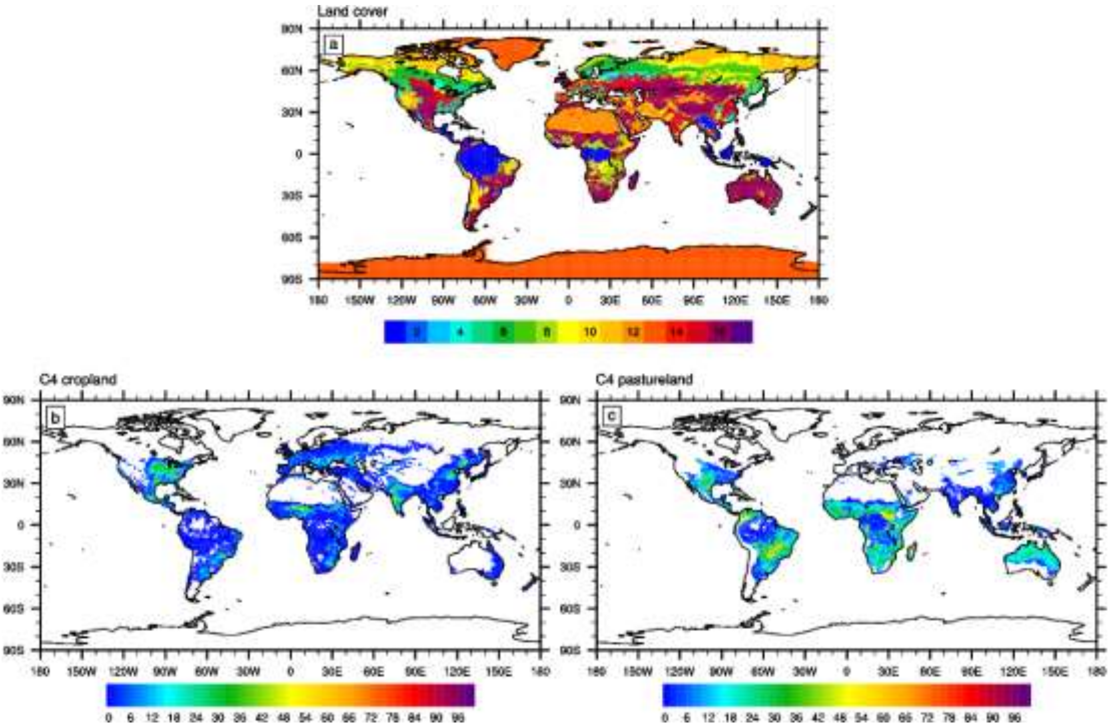

Figure 1. Spatial distribution of land cover from Meiyappan and Jain (2012) and the percentages of C_4 croplands and C_4 pasturelands within a grid at 0.5 °×0.5 ° resolution from 2007 to 2010.

In our 2012 work, we showed that major uncertainties arise from selecting the threshold of wind erosion, and to a lesser extend to the minimum fraction of land use required to attribute an anthropogenic origin. This last uncertainty is much more critical in the present study due to their coarser (100 times) resolution. The first uncertainty is brushed aside in the present study, as they used a fixed value globally and for all surface conditions without providing any justification or making sensitivity study.

We agreed with your opinion. The threshold of wind erosion is a key parameter in the emission process as the vital part in dust emission schemes. It remains a debate about the determination of threshold wind speed in the anthropogenic dust source regions (Xi and Sokolik, 2016). Ginoux et al. (2012) and Stanellet et al. (2014)

pointed out that the increased threshold velocity in pastureland and cropland could reflect the effects of soil conservation practices while Tegen et al. (2004) and Xi et al. (2015b) reduced the erosion threshold velocity for cultivated soils because human disturbances make the soil more susceptible to erosion.

We think that human disturbances including ploughing, trampling, rolling by wheels could break down the original structure of soils, such as crust, caking or aggregate, resulting in generating more erodible particles and decreasing the threshold wind speed. What's more, over-grazing can lead to the reduction of coverage of vegetation, changing the soil surface texture and thus increasing the wind erosion and land degradation (Okin and Gillette, 2001). Neff et al. (2008) also pointed out that the 500% increasing of dust sediments in the west of America can be attributed to the expansion of over-grazing in the 1990s. Munkhtsetseg et al. (2017) investigated the effects of trampling of domestic animals on anthropogenic dust emissions, concluding that with the increasing intensities of trampling, the erosion rates of soil particles would be more severe significantly.

Xi et al. (2015b, 2016) chose u_t = 6.5 m s^{-1}, because the value has been widely used in Tegen and Fung (1995), Uno et al. (2001), and Takemura et al. (2009). In addition, your 2012 work noted that "we impose u_t = 6 and 10 m s^{-1} for smooth (natural and hydrologic sources) and vegetated (agriculture or range) surfaces, respectively. These values correspond to the range of values (6.5 to 13 m s^{-1}) reported by Helgren and Prospero (1987) for Western Sahara." Therefore, we chose u_t = 6.5 m s^{-1} that is the smallest threshold wind speed within the range of you provided in Ginoux et al. (2012) and Helgren and Praspero (1987). Some more related details or supplement has added in our manuscripts.

Concerning the formulation of the direct anthropogenic emission, the authors propose without justification an empirical economical formula, which depends on population density, urbanization, and economic development. How dust emission from traffic, construction or cement factory is related to these factors are not justified or explained.

Thank you for your suggestions. We constructed the direct anthropogenic dust emission scheme based on the STIRPAT model (the stochastic impacts by regression on population (P), affluence (A), and technology (T)). The STIRPAT model is a mutual developed environmental-stress model, has been widely used to simulate air pollution, gases emissions or the change of cultivated lands induced by human activities (Dietz and Rosa, 1997; Soulé and DeHart, 1998; Shi, 2003; and York et al., 2003; Wang et al., 2008) and it can reflect the effects of driving forces on a variety of environmental impacts.

Direct anthropogenic dust emissions are derived from direct human influences such as urban activities, industrial activities (e.g., construction, cement production, and transportation). It has a strong dependence on environmental impacts such as the intensities of human endeavors, urbanization, policies, etc (Huang et al., 2015; Guan et al., 2016). Therefore, we utilized the STIRAPT model to construct our direct anthropogenic dust emission scheme.

In the direct anthropogenic dust emission scheme, we retained the population density in the model formula because anthropogenic dust loadings can increase significantly when the population density is more than 90 people per square kilometer (people km^{-2}) (Guan et al., 2016). Munkhtsetseg et al. (2017) also investigated the effects of trampling of domestic animals on anthropogenic dust emissions, concluding that with the increase of livestock number, the erosion rates of soil particles would be more severe significantly. Moreover, anthropogenic dust emissions in developed countries are smaller than that those in developing countries, because incomplete industrial structures, city construction projects, and less restrictive environmental regulations have quite significant impacts on developing countries such as China and India, thereby increasing the possibility potential for the emission of anthropogenic dust particles into the atmosphere in these regions. Accordingly, the environmental policies for emission reduction in developed countries, such as those in Europe and North America, also restrain restricts anthropogenic dust emissions (Huang et al., 2015). Therefore, the CNLI representing the urbanization proportion within a grid developed by Zhuo et al. (2003) was used to describe the urbanization level and was introduced into the STIRPAT model. To reflect the developmental level of a region, we further put the Engel's Coefficient (EC) into the STIRPAT model. Some more related details or supplement has added in our manuscripts.

On the other hand, there is a long list of studies related to in-situ measurements, and modeling of dust generated by traffic on paved and unpaved road ways. They only need to type "dust traffic" with Google Scholar to get more than 60k results.

As you said, "they only need to type "dust traffic" with Google Scholar to get more than 60k results". This is a powerful proof that direct anthropogenic dust such as dust traffic should not be ignored. To fully consider the mechanisms of anthropogenic dust emissions, it is necessary to develop and construct both "indirect" and "direct" anthropogenic dust emission schemes in the study.

As for fugitive road dust, it is one of crucial components of direct anthropogenic dust. It is mainly derived from dust depositions, mud carried by vehicles, construction, bioclastic, bare soil roads and so on, which can be entrained into the air by the movements of vehicles (Patra et al., 2006; Abu-Allaban et al., 2003; Kuhns et al., 2003). The fugitive road is not included in the direct anthropogenic dust emission schemes in the manuscript. Therefore, in the next step, we are constructing the emission inventories of road dust at the global scale. Some more related details or supplement has added in our manuscripts.

I found a few statements which are unfounded and incorrect:

1. "Ground observations can not capture the anthropogenic dust emission well because observed dust loading is a mixture of natural dust and anthropogenic dust." (Lines 123 to 125). This is incorrect. Ginoux et al. (Atm. Chem. Phys., 2012) showed that anthropogenic dust from agriculture is often mixed with ammonia and has a distinctive optical signature observed with AERONET sun photometers.

Thank you for your correction. We will cite your reference.

2. "However, their retrieval method was only applicable over bright surfaces ..." (lines 130-131). This is incorrect. MODIS Deep Blue aerosol products used by Ginoux et al (Rev. Geophys. 2012) are provided daily globally (except for gaps between orbits in equatorial regions) over land except over snow, under clouds, and during radiometric calibration.

Thank you for your correction.

3. "... and was unable to properly exclude natural dust aerosols..." This is incorrect as shown by Ginoux et al. (Atm. Chem. Phys., 2012) where they collocated dust and NH3 plumes over agricultural areas using 2 distinct satellite instruments.

Thank you for your correction.

4. "Observations have shown that anthropogenic dust mass loading is stronger than natural dust loading in densely populated regions with a high level of human activity." (Lines 161 and 162). I am unaware of any data showing such results. To the contrary, AERONET sun photometer data don't show any increasing trend of coarse mode optical depth over big cities but surely an increase of fine mode aerosol optical depth.

We think anthropogenic dust mass loading is stronger than natural dust loading in densely populated regions with a high level of human activities in some developing countries such as India and China. It is because the seasonal variations of natural dust are significantly. Moreover, the magnitude of natural dust during the long-term transport deposited in the urban is smaller. But the direct anthrophonic dust mass loading induced by direct human activities such as city constructions, cement production, transportation, always occurred in the urban of developing countries in the whole year.

5. "For example, anthropogenic dusts accounts for more than 91.8% and 76.1% of the total dust loading in east China and India, respectively (Huang et.al., 2015)." (Lines 163 to 165). If I understand this correctly, it means that the Taklimakan and Mongolian deserts are negligible source of dust. This goes against common knowledge.

Thank you for your suggestions. Maybe you misunderstood this meaning of the sentence. The Taklimakan and Mongolian deserts dominate the dust concentrations over East Asia especially in China. Compared with transport of dust particles from Taklimakan Desert and Gobi Desert over the East of China, anthropogenic dust accounts for more than 91.8% of the total dust loading (natural dust + anthropogenic dust).

6. "To isolate the role of meteorology from the land surface effects, Marsham et al. (2011) simplified the dust emission scheme developed by Marticorena and Bergametti (1995). The scheme neglected differences from using wind speed at 10 m rather than at threshold velocity (Marsham et al., 2011). Instead, they substituted the threshold wind velocity by a constant of 7 m s−1. Although this approach neglected the second order effects of stability and roughness, it is a simple and easy method to better quantify the effects of meteorology on dust emissions at global scale over long time periods (Cakmur et al., 2004)." (Lines 189 to 196). These 3 sentences are really unclear, but if I understand correctly they suggest using a constant threshold of wind erosion because atmospheric stability as well as surface roughness can be neglected. This contradicts what they formulate above, that is to say to include vegetation changes as key parameter. Vegetation cover is the main roughness element on the surface.

These three sentences just described the simplified dust emission scheme proposed by Marsham et al. (2011). Marsham et al. (2011) simplified the MB dust emission scheme to simulate African dust, and Evan et al. (2016, Nature) also employed this simplified dust emission scheme to simulate African Dust over the Northern Tropical Atlantic. They both chose the 7 m s^{-1} value as threshold wind speed of natural dust in their simulations. We further improved this simplified MB dust emission scheme by coupling a dynamic dust source function constructed by NDVI and topographical features according to Kim et al. (2013) to reflect the effects of dynamic of anthropogenic dust source regions owing to the growth and wither of vegetation.

7. "Therefore we used the simplified dust emission scheme by Marticorena and Bergametti (1995)..." (Lines 201-202). I got quite confused here as Marticorena and Bergametti (1995) have developed one of the most sophisticated schemes.

Here the "simplified" MB dust emission scheme was proposed by Marsham et al. (2011), not the MB dust emission scheme itself. Marsham et al. (2011) isolated the role of meteorology from the land surface effects. Although this approach neglected the second order effects of stability and roughness, it is a simple and easy method to better quantify the effects of meteorology on dust emissions at global scale over long time periods. Evan et al. (2016, Nature) also used this simplified dust emission scheme to investigate the African dust and obtained well results. Therefore, the simplified MB dust emissions scheme was employed to simulate the indirect anthropogenic dust emissions in this study.

8. "Here, we chose ut = 6.5 m s^{-1} according to Tegen et al. (2004) because human disturbances make the soil more susceptible to erosion." (Lines 211 to 213). This is incorrect. Tegen and co-authors used 6.5 m/s for undisturbed soils but scaled it down for disturbed soils.

Thank you for your correction. It should be "*we chose ut = 6.5 m s^{-1} according to Tegen and Fung (1995) and Xi et al. (2016) because human disturbances make the soil more susceptible to erosion.*". In fact, as illustrated in Tegen and Fung (1995) and Xi et al. (2016), they both utilized u_t=6.5 m s^{-1} to simulate anthropogenic dust emissions. Especially, Xi et al. (2016) utilized TF dust emission scheme to simulate anthropogenic dust emissions over agricultural lands in Central Asia and used u_t = 6.5 m s^{-1} the same with Tegen and Fung (1995), Uno et al. (2011) and Takemura et al. (2009), obtaining well simulation results compared with other dust emission schemes. Moreover, as you said, Tegen et al. (2004) noted that the threshold wind speed for disturbed soils should be decreased. However, all this proves pointed out that u_t for cultivated soils should be decreased because human disturbances make the soil more susceptible to erosion.

What's more, as noted in Ginoux et al. (2012), the valid range of threshold wind speed for dust emissions was from 6.5 to 13 m s^{-1}. As we considered that human activities can destroyed the original structures of soils such as crust, the soil particles are easily uplifting compared with undisturbed land covers, the smallest value of threshold wind speed range of anthropogenic dust emissions from Helgren and Praspero (1987), and Ginoux et al. (2012) is chosen in our study.

9. "..high vales of soil moisture were excluded" (line 270). What do you consider a high value for soil moisture? Where did you get such fields? Same for snow cover, where did you get the fields and what maximum value did you use?

The soil moisture datasets are derived from Global Land Data Assimilation System (GLDAS) driven by NOAH. The snow cover datasets were from MODIS. We considered the 0-10 cm soil moisture and snow cover had the significant effects on dust emission. Areas with soil moisture higher than 25 kg m^{-2} or snow cover higher than 10% were removed.