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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Elevated dust layers inhibit dissipation of heavy anthropogenic surface air pollution" *by* Zhuang Wang et al.

Anonymous Referee #2

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Comments on "Elevated dust layers inhibit dissipation of heavy anthropogenic surface air pollution" by Wang et al.

Severe winter haze is one of the major environmental issues in China. This is a comprehensive study combining remote sensing observations with three dimensional chemical transport model, which investigated the effect of natural dust on haze formation. The results show that a dust layer frequently exists above the planetary boundary layer (PBL), inhibits dilution of surface pollutants, and aggravates haze pollution. This study provides very important information toward a complete understanding of the formation mechanism of winter haze in China. The impact of dust is not limited to aerosol-PBL interactions, but may also explain the special multiphase chemistry in this region. Overall, this is a very nice study and I'd recommend its publication in ACP after minor revisions.

Major comments:

Snap shot vs full picture

In this version, the authors focused on a few pollution episodes. My question is how representative are these episodes. Since you have collected several month measurement data, I'd suggest you to provide more statistics. For example, are these dust layers always accompanying the haze events, if not, how frequent? How about the rest periods, is there still a dust layer, and what's the mean dust concentration in both bases? The authors mentioned "This stratification is governed by meteorological conditions that strong northwesterly winds usually prevailed in the lower free troposphere, and southerly winds are dominated in the PBL, producing persistent and intense haze pollution." How often do you have such meteorological conditions? Is there any episode with southerly winds both in the PBL and in the free troposphere?

Other comments:

Abstract "here we found that aerosols in North China are typically characterized by a pronounced vertical stratification ..." By saying "typically", do you mean in winter or all seasons?

Abstract "With the accumulation of elevated dust, the proportion of aerosol and trace gas at the surface in the whole column increased." Normally, we talked about accumulation of pollutants only near the surface referrring to the addition of emitted/secondary formation pollutants. For elevated dust (no emission and secondary formation), can you explain how it can be accumulated?

Page 2 line 6 "Accumulation of air pollutants from stationary and transportation sources, accompanied by the explosive increase of new particles under stagnant weather conditions (Guo et al., 2014; Huang et al., 2014), cause PM2.5 (particle mass less than 2.5 μm in diameter) concentrations to increase several–fold within a few hours." The explosive increase is not caused by accumulation by the transport

(Zheng et al. 2015). The new particles normally refer to sub-10 nm particles, while during severe haze event particles are $\sim$ 100 nm. The multiphase chemical formation (Cheng et al. 2016) is also an important pathway for the haze formation and should be included here.

Equation 3 "... and OIN are nitrate, sulfate, ammonium ..", What of nitrate? Concentration, mass, or?

Equation 4, "1. without considering the influence of dust (dust_off), that is, the effects of dust on radiation transfer and meteorology were ignored; 2. with consideration of the effect of dust (dust_on)," It is not clear how the two numerical experiments were carried out. According to these descriptions, the dust_off case is performed without considering the effects of dust on radiation and meteorology. But without considering dust and without considering the effect of dust are different. Also it is not clear how comes equation 4 because the difference between these two OINs may also be caused by the feedbacks on meteorological conditions on OINs other than dust. Why you cannot directly calculate dust composition from your model?

Page 6 equation 7 and 8, here you calculated the change of turbulence exchange coefficient, how about convection/advection, which is also important for pollutant transport?

Page 7 "had peak mass concentrations greater than 500 μg m-3." Mass concentration of what? Dust, PM2.5?

Page 8 line 7"The average EXT355 in the upper lidar layer during the weak southerly wind conditions was 1.00 km-1, which is clearly higher than that during the winds from Gobi 15 desert (0.66 km-1) and sparsely populated northern mountain areas (0.38 km-1)." Could you explain why during southerly wind conditions, the EXT355 in the upper layer is even higher? Since the other pollutants lead to a thicker/high abundance layer, will it have a stronger effect on the haze events, compared to the dust case (from Gobi desert and northern mountain areas)?

Page 8, line 17 "which is conducive to the accumulation and explosive growth of aerosols in the lower and upper lidar layers.", here again, there is no explosive growth due to chemical processes, and the apparent explosion is mainly caused by fast transition of air masses (Zheng et al. 2015).

Page 8 line 28 "During HPI 1, the upper dust layer formed slightly later than the accumulation of the anthropogenic aerosols in the lower lidar layer (Fig.3)." So?

Page 9 line 16, " The two parallel simulations, dust_on and dust_off, well reproduced the spatial and temporal variations of dust concentration at CWBF (Fig. 8 and Fig. 9)." How can dust_off well reproduced the dust concentration?

Section 3.3, I thought you may use dust_on and dust_off case to analyze the impact of dust, but the relevant discussion in the section is rather limited and vague. For example, "Consequently, dust–meteorology interactions result in more stagnant conditions, with the turbulent exchange coefficient within the PBL falling by over 60%. Similarly, a significant decrease in PBL height was also attributable to the stable stratification (Fig. 11c and 11d).", what did you define the dust-meteorology interactions? How did you calculate the change of PBL and turbulence? Based on comparison between different periods/stages or between the two scenarios (dust_on and dust_off)? The 60% reduction of turbulent exchange coefficient seems to be a large effect, but the change of NO2 and aerosol concentrations seem to be small. Can you also calculate the percentage change due to dust in analogy to the absolute change in Figure 10.

Reference:

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Cheng, Y., Zheng, G., Wei, C., Mu, Q., Zheng, B., Wang, Z., Gao, M., Zhang, Q., He, K., Carmichael, G., Poschl, U., and Su, H.: Reactive nitrogen chemistry in aerosol water as a source of sulfate during haze events in China, Sci. Adv., 2, 10.1126/sciadv.1601530, 2016.

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