Interactive comment on “Limited production of sulfate and nitrate on front-associated dust storm particles moving from desert to distant populated areas in northwestern China” by Feng Wu et al.

General comments:

A number of laboratory and field studies have proved that Asian dust particles readily promoted the formation of sulfate and nitrate when the lofted dust plumes transported across urban areas under high RH and elevated levels of reactive trace gases (i.e. SO_2, NOx, O_3 and OH radicals). This would significantly alter the physical and chemical properties of dust aerosol and subsequent climate change on regional scale.

The authors carried out a series of particle samplings at the Tengger desert (06:30–15:00 BST on April 24, 2014) and downwind Xi’an city (07:00–19:00 BST on May 1, 2014) during two independent dust storms. Combination of HYSPLIT backward trajectories model and CFORS simulation, they showed that the two dust events originated from the same source regions and had similar transport routes. They compared the concentrations and mass fraction of chemical components (i.e. sulfate, nitrate, ammonia, and elemental ratios) in dust particles at two sites during the prefrontal, frontal, and postfrontal air parcels, and indicated that the production of sulfate and nitrate on front-associated dust particles was limited when the dust moved from desert sources to populated areas in northwest China. The result of this manuscript seems to be reasonable in spite of limited in-situ sampling data, which is completely different from the other previous studies. Different scientific viewpoints should be encouraged to promote the understanding of interplay between mineral dust and atmospheric chemistry. Therefore, I recommend this manuscript is accepted and published in the journal of ACP after some revisions.

Specific comments:

1. **Abstract**, Page 2, lines 12–14: “The significant sulfate and nitrate reported in

dust-associated samples in previous studies were more likely produced on locally-emitted and urban mineral particles or from soil-derived sulfate rather than being produced via chemical conversions on desert dust particles."

Conclusion, Page 11, lines 2–4: "Significant sulfate and nitrate in dust storm periods in China reported in previous studies were likely produced on locally-emitted and urban mineral particles, in addition to soil-derived sulfate, and they were unlikely produced via chemical conversions on dust particles from deserts."

Comment: I think there is no enough evidence for the manuscript to demonstrate this conclusion. Because the dry condition (RH<40%) and low mass concentrations of trace gases (i.e. SO_2 and NO_2) were observed in Xi'an during the dust-storm episode, which didn't favor the formation of sulfate and nitrate on the surface of mineral particles. However, these are only a few cases. The authors didn't show the results when dust storm transported across the other polluted areas with high RH conditions and high levels of trace gases.

2. Page 4, lines 21–22: "This sample collection ensured that mineral particles collected on the filters were dust particles from the desert and there should be no influence of anthropogenic pollutants from the village or the city considered in the samples."

Comment: The evidence provided by this manuscript could not fully support this sentence. Please reconsider again.

3. Page 6, lines 15–17: "The cold fronts are the boundaries between the local or regional anthropogenic-polluted air and the long-distance transported air because the movement of air on a synoptic scale is approximately adiabatic, i.e. the air is hardly mixed with thermodynamically-different air it meets."

Comment: I don't agree with this viewpoint about "the air is hardly mixed with thermodynamically-different air it meets". In terms of meteorology, the warm and humid air mass is readily lifted and the weather process (e.g., strong wind and cooling weather, rainfall or snow) often changes dramatically on the border of frontal system

when a cold front passes over. As shown in Figure 2a, the RH increased sharply from 40% at 13:00 BST to 100% at 16:00 BST, which indicated clearly that a rainfall or snow process took place at Tengger desert (also see Page 4, line 15 and Table 1). The cold fronts are dominated and accompanied strong winds intensify the diffusions of local air pollutants.

4. Page 7, lines 26–33: "At the desert site, NO_3^- concentration in dust samples was 4-6 μgm^{-3} and the average was 5 μgm^{-3}. The relative amount of NO_3^- range between 0.11% and 0.12%, and the average was 0.12%. …Right after the passage of the cold front (the first sample in the postfrontal air), the concentration of NO_3^- was 0.9 μgm^{-3} and it occupied 0.2% of the aerosol mass. The relative amount in this sample was about twice of that in the desert samples although it was the lowest in the samples at Xi'an site, indicating that nitrate had been produced on dust particles during their travel to Xi'an."

Comment: At the Tengger desert site, NO_3^- concentration in dust samples was 4-6 μgm^{-3} (with the average value and fraction of 5 μgm^{-3} and 0.12%), which were much larger than that at Xi'an after the cold front (~0.9 μgm^{-3}, with the mass fraction ~0.2%). The higher mass fraction of NO_3^- at Xi'an was ascribed to the low concentration of TSP (total suspended particulates, ~420 μgm^{-3}), and the TSP concentration in Tengger desert site was about 5000 μgm^{-3}. Although the relative amount of NO_3^- at Xi'an was about twice of that in the desert samples, it couldn't indicate that nitrate had been produced on dust particles during their travel to Xi'an. Please explain this.

5. Page 18, Table 2; Page 19, Table 3: The authors sampled the concentrations of TSP (total suspended particulates) and analyzed the chemical components (i.e. sulfate, nitrate, and ammonia) in TSP at the Tengger desert and Xi'an sites.

Comment: Please explain why did you sample the concentrations of TSP, instead of PM_{10} or $PM_{2.5}$. It is well known that most of the coarse-size dust particles (radii > 10 μm) generally settle near the source region on account of large gravitational

deposition velocity, whereas the finer dust particles (radii < 10 μm) are transported more efficiently to the downstream areas. And the concentrations of TSP (meaning coarse-size particle with radii>10 μm) in Xi'an city should include the local source emissions (e.g., engines of vehicles, road dust, and construction dust; Page 4, lines 27-29) that increases the TSP concentrations, but may decrease the relative mass fraction of sulfate, nitrate, and ammonia. Inferred from Page 6, Lines 1-7, the mass concentrations of TSP and sulfate are about 425 μgm^{-3} and 17 μgm^{-3} at Xi'an before the dust arrival (i.e. prefrontal air). In the postfrontal air, the mass concentrations of sulfate are 3.8, 3.5, and 3.4 μgm^{-3}, respectively, right after, two hour after, and four hours after the passage of cold front (means slight variations), whereas the corresponding TSP concentrations are 422, 318, and 189 μgm^{-3} (shows large variations). Clearly, relative mass fractions of sulfate reduce.

Minor comments:

1. **Abstract**, Page 2, lines 3–4: "but the production was very inefficient in other studies."

Comment: Please give the quoted literature.

2. Page 3, line 8: "RH"

Comment: Change to "relative humidity (RH)"

3. Page 10, line 4: "mineral/TSP ratios"

Comment: Change to "mineral/TSP (total suspended particulates) ratios"