

Interactive comment on “Mixing of dust and NH₃ observed globally over anthropogenic dust sources” by P. Ginoux et al.

Anonymous Referee #2

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The manuscript is well written, and studies NH₃-dust mixing in the atmosphere through, for the first time, a combined use of the direct measurements of the two from space, i.e., dust retrieved from MODIS Deep-Blue and NH₃ retrieved from IASI. It is shown that dust and NH₃ are well collocated in the anthropogenic source. Based upon AERONET data, the authors find that coating of NH₄ salt particles decrease the mass extinction efficiency MEE of coarse mode anthropogenic dust, but has little impact on MEE for fine mode; the latter is more regulated by the dust mineral composition or absorption. The research topic, method, and conclusion are interesting, and merit for publication. However, the manuscript as now it stands, needs a minor revision to acknowledge some important caveats in the analysis, as well as add more discussion in the interpretation of the results.

1. Both IASI NH₃ and MODIS DB dust datasets contain little information about their vertical profile. In some cases, the good match between column quantities may not be a good indicator of strong mixing between the two. The authors should discuss and elaborate on this topic, possibly in the beginning of Section 4. It is noted that both NH₃ and dust can be transported more than 0.25 degree (the gridbox size used in the analysis) within 1 day. It is unclear how the transport can affect the results presented in section 5. Dust can be uplifted well above the boundary layer. While NH₃ often is thought to reside in the boundary layer, some modeling studies with support from aircraft data also show that considerable amount of NH₃ might be in the middle troposphere as well, depending on the region and season. See some discussion and references from the following paper:

Wang, J., A. A. Hoffmann, R. Park, D. J. Jacob, and S. T. Martin (2008), Global distribution of solid and aqueous sulfate aerosols: effect of the hysteresis of particle phase transitions, *J. Geophys. Res.*, 113, D11206, doi:10.1029/2007JD009367.

2. Section 6.1. Although references are given, some more description of why coating on coarse particles make the MEE smaller can be helpful for the later interpretation of the results. Since coating will increase particle hygroscopicity and decrease (increase) the real (imaginary) part of refractive index, which factor will dominate the change of MEE? In addition, is this MEE normalized to the mass of dust, or the total mass of dust + dry or wet coating materials?

3. About AERONET inversion datasets. To have reliable inversion, AERONET AOD should be higher than certain value. Have the authors considered that in the analysis? This should not be a question, since the inversion algorithm developer O. Dubovik is a coauthor here. However, this at least should be mentioned in the text. Also, some discussion on the accuracy of AERONET-derived MEE and k in fine/coarse mode will be useful to address the readers' curiosity.

4. Authors found 'a surprise' that FMEE doesn't change below or above the deli-

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quesce point (80%), and thus interpret that FMEE has weak dependence on hygroscopic growth. The interpretation here is not accurate. Fine mode particles such as sulfate certainly has a strong dependence on hygroscopic growth or size. The point here is if sulfate are indeed coated with dust, and if yes, how much is the sulfate. Because of hysteresis effect, sulfate can be (a) in the solid phase below delinquency RH, and hence not coating with dust, and/or (b) in aqueous phase and hence no clear distinction of FMEE for RH from 75-85%. Finally, with dust inside, the coated sulfate may have lower deliquesce point. In reality, these three scenarios can act together (see references below) and thus smear the effect of hygroscopicity on scattering. It remains uncertain how much fraction of dust inside sulfate particles will not affect the dependence of sulfate scattering on RH. The following references might be relevant to the topics here.

Martin, S. T., T. Rosenoern, Q. Chen, and D. R. Collins (2008), Phase changes of ambient particles in the Southern Great Plains of Oklahoma, *Geophys. Res. Lett.*, 35, L22801, doi:10.1029/2008GL035650.

Martin, S. T. (2000), Phase transitions of aqueous atmospheric particles, *Chem. Rev.*, 100, 3403–3453, doi:10.1021/cr990034t.

5. Some more discussion of the implication of this study can be useful. What are the implications of the difference of optical properties between anthropogenic and natural coarse mode particles to the chemistry transport model, and/or satellite/ground-based remote sensing of dust particles?

Minor comments: Page 12504, Line 5: “globally, we found 22% of dust burden collocated with NH₃”. It is not clear what you mean by ‘collocate here’? Do you use any threshold for NH₃ amount in the calculation?

Page 12505, Line 15, in addition to (NH₄)₂SO₄ and (NH₄)HSO₄, sulfate can also in form of (NH₄)₃H(SO₄)₂.

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Page 12515, please be specific about what aerosol properties are “mostly sensitive to change in scattering and absorption properties rather than size”. The MEE with respect to the dry sulfate particle mass is sensitive to the particle size (hygroscopic growth).

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