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Atmospheric Chemistry and Physics Discussions

Interactive comment on "The evolution of microphysical and optical properties of an A380 contrail in the vortex phase" *by* J.-F. Gayet et al.

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General Remarks

The Pi Nephelometer (PN) is a unique instrument that provides detailed information on the scattering phase function of cloud particles. Clouds that are dominated by small droplets and ice crystals are particularly well suited for measurements with this instrument. In general, I think that this study provides a useful contribution to what is still a very small data set of in situ measurements in contrails. Before transitioning from the discussion stage, however, I recommend that a number of modification/additions be made to make it a more readable manuscript whose results are more clearly stated within the context of what is still not understood with respect to contrail formation and evolution.

Recommended Edits

It seems to me that this paper was submitted prematurely. I draw this conclusion on the basis of small but numerous grammatical disconnects throughout the manuscript. This made it difficult for me to follow, at times, the train of thought by the authors. It is my opinion that it is the responsibility of all the co-authors to read carefully the paper that they have agreed to associate with their name. There are thirteen authors on this paper. With so many contributors I expected a more concise manuscript. As a reviewer I would much rather focus on the technical and scientific issues rather than be handicapped by confusing choice of words or missing fragments of sentences. I will only point out the most blatant omissions in my following observations.

Introduction

I think that a more clear description is needed of where this study fits with previously published results. In particular, although a brief description is given of other studies, it is never directly discussed why more measurements are needed or why the current study adds anything to the body of knowledge on contrail science. It seems to me to be a major oversight to not use the BAMS special issue on contrails as the basis for explaining why more information is needed on contrail particle formation and evolution. Without this type of discussion in the introduction, as well as in the concluding remarks, the reader is left wondering how these measurements advance the science.

2.1 Contrail particle probes

First of all, the title of the section is odd as it reads as if the particle probes are part of the contrail. Suggest removing the adjective "Contrail" and just entitle the section "Particle Probes".

Secondly, I recommend that the term "Optical equivalent diameter" be used instead of "diameter" to make it quite clear the type of size parameter being defined. This can be clarified farther on when discussing the use of T-matrix to redefine the size bins. It is

probably OK to then use “diameter” from this point on once there is no ambiguity in its usage.

In lines 92 and 93, it is more correct to say that the sampling volume is defined by the cross sectional area of the beam multiplied by the distance traveled during the sample period.

I am completely mystified by the explanation in the section encompassed by lines 114-129. If the way in which the size channels are grouped is essential to the interpretation of the data then a much better description of what is being done is needed here. The relationship between Mie ambiguities and particle shape is not at all clear to me. I am fairly well versed in the Mie ambiguities with respect to spherical particles, refractive index, size and collection angle but don’t understand what the authors mean when they talk about shape information from the PN. The FSSP-300 is a 30 channel instrument so when the discussion is about 8 and 9 channel rebinning with different upper thresholds I am unable to decipher their meaning. I am supposed to know these things so if I can’t unravel the meaning I doubt other will either.

When calculating extinction coefficients from the FSSP-300 size distributions are you assuming spherical ice crystals? What type of uncertainty is associated with these derived values?

2.2 Trace Gas Instruments

Line 168, what is a PFA?

Observations Why is effective diameter being used rather than some more definitive parameter to track particle growth like median volume diameter? If effective diameter is going to be used, then define how it is calculated and the estimated uncertainties. The usual definition has it proportional to the ratio of liquid water content to extinction, both are parameters that are likely to have large uncertainties for aspherical particles.

Lines 224-228: Why is it surprising that NOy and ice crystal concentration are not

correlated. It seems to me that their production and removal processes and time scales are quite different. I am uncomfortable with trying to explain the lack of correlation with plume inhomogeneities. I think a discussion of the physio-chemical processes involved with the crystals and gases is needed in order to explain the lack of correlation. Using plume inhomogeneities is rather frail, in my opinion.

Line 274 – What does “reliable values” mean? Do you mean, if we assume that these are reliable values? In the previous sentence you say these values can’t be representative. Why not just compute averages and standard deviations?

Line 277 – What does it mean to say “maximum values from 340-360, for example? Where are maximum values being defined?

Line 279 – Reiterating my previous question about the use of effective diameter instead of a more physically relevant diameter, if the purpose is to examine particle growth, what is the justification for using effective diameter?

Lines 309-324 - I am rather confused by the discussion in this section. There might be a problem of grammar use but it is not clear to me what is being discussed here. The measurements indicate quasi-spherical particles and it seems that the objective here is to explain why they are quasi spherical. It is my understanding that ice formation in contrails is likely a result of homogeneous freezing of water droplets. If that is the case, and if the sampling is only a few hundred seconds after contrail formation, why can’t these still be spherical ice? There are lab studies (Golina et al., for example) that show that frozen droplet remain spherical for up to 20 minutes after they freeze. Why does sublimation need to be used here to explain the spherical shape?

Line 364 – Why is a refractive index of 1.29 the starting point? I was under the impression that 1.31 is the refractive index for ice, at least at the wavelength of the PN.

Line 377 – Given that laboratory and theoretical studies have shown that small water droplets freeze slower than larger, how robust is this assumption of ice fraction the

same over all sizes.

Line 389 - Please expand on this derivation. It seems that this is a circular calculation and will always provide an excellent fit? You get size distribution from the phase function but derive phase function from the derived size distribution? This needs a lot more clarification.

Line 417 - I don't understand what this means? Why split between oblate and prolate. What does this accomplish?

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