Manuscript Review

Observations of microphysical properties and radiative effects of a contrail cirrus outbreak over the North Atlantic

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The authors have improved somewhat upon their first effort and partially addressed my previous concerns; however, there remain a number of issues that must be rectified before I can recommend publication. These issues are all related to how the measurements are processed and interpreted from the CAS-POL and CIP, lack of a proper error analysis, and the failure to use the full capabilities of these instruments to distinguish contrail cirrus from cirrus.

1) The criteria that is used to distinguish contrail cirrus from regular cirrus puzzles me, i.e. it appears that only the relative concentrations of NO and Nice, from the CAS and CIP) are used to discriminate the two types of cirrus. Previous studies, e.g. Järvinen et al. (2016) and Nichman et al (2016) has discussed how the CAS-POL polarization detection is sensitive to the shape of the small ice crystals, and the authors in the present paper also allude to the shape of ice crystals as sensitive to the type of cirrus, and yet neither the polarization ratio from the lidar or the CAS-POL is used to further separate the types of cirrus. Is this because this approach was tried but unsuccessful?

2) Unless I didn't interpret what was written correctly, it appears that the CAS measurements below 3 µm are not used in the analysis. I assume the thinking is that particles smaller than 3 µm must be aerosol particles, not ice crystals. Whereas that might be a reasonable assumption, from contrail studies that I participated in during the early 1990s, we found that there were significant concentrations of contrail ice crystals smaller than 3 µm (Baumgardner et al., 1998). Similar studies by Kuhn et al. (1996), using the predecessor of the CAS-POL, also documented high concentrations of very small crystals. Then Kleine et al. (2018) also used a CAS-POL over the full size range to detect the smallest ice crystals. Hence, I want to see a reanalysis of the cloud passes using the full range of the CAS-POL since I hypothesize that the difference in contrail cirrus and cirrus will become much more distinct if you are only using number concentration. At the same time, I also hypothesize that the effective radius, Re, will also be much smaller in the contrail cirrus and provide a much more clear separation between regions with contrail cirrus and those without, particularly if you use the particle by particle data to identify fine scale entrainment and mixing.

3) The use of Kleine et al, (2018) to define the uncertainty in size derivation as ±16% is valid for very small contrail crystals, but not for other crystals. As seen in the figure below, derived from Baumgardner et al., 2016, the uncertainty can be as much as ±50% due to asymmetries in shape. Given that the current study ignores shape as a

parameter in defining cirrus types, this uncertainty is unimportant; however, when comparing Re between contrail and non-contrail cirrus, it becomes important. In addition, the derivation of IWC will be very uncertain when you propagate this uncertainty in the calculation of IWC from the CAS size distribution. The derived IWC will exceed ±100%. Hence, since the N, Re and IWC are incorporated in the radiatice transfer models, these uncertainties will need to be discussed in the model results.

4) In section 4.1 (not 4.2 as is stated earlier in the manuscript), the radiative model uses an aggregate of ice crystals rather than a more reasonable mix of likely habits. If the average shape was aggregated crystals, where is the evidence from the CIP, which most certainly can identify such aggregates. Before I am willing to accept this very questionable simplification, I want to see a sensitivity study that show how changing the assumed crystal shapes impacts the resulting radiative fluxes. Likewise, I want to see how the estimated uncertainties in Re and IWC impact the flux calculations.

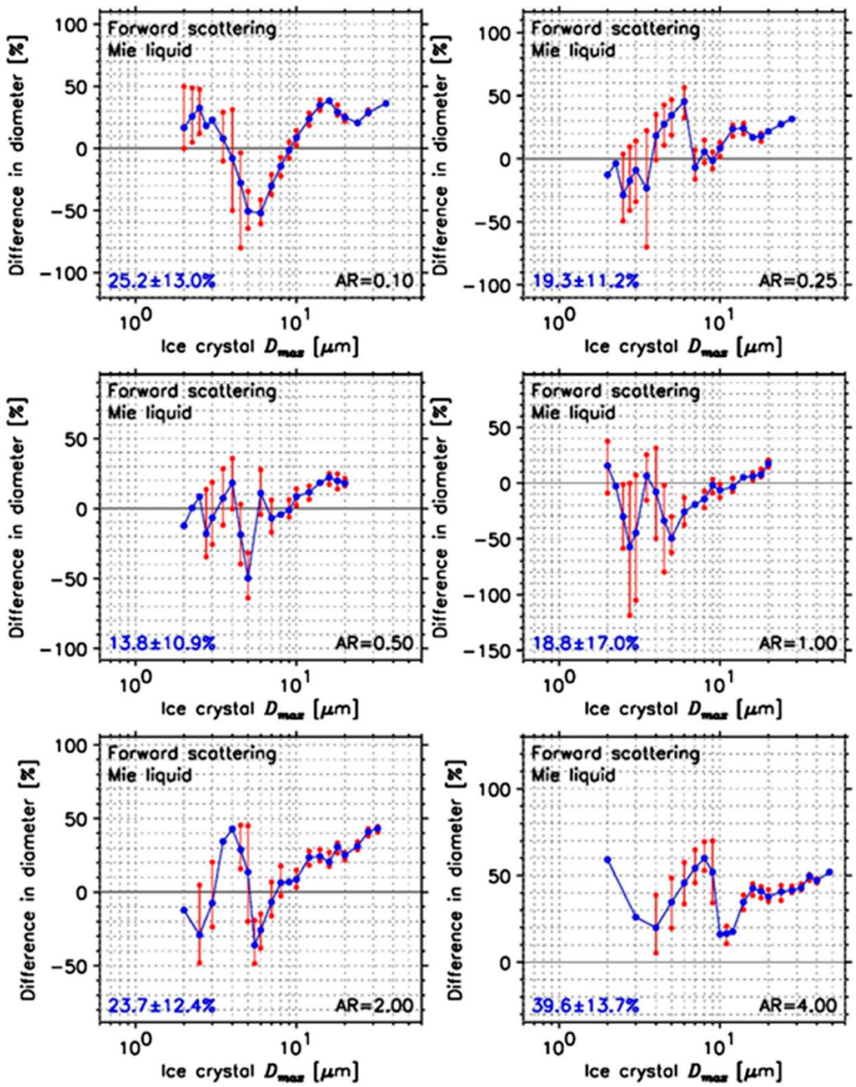

FIG. 9-3. The percent difference between the maximum dimension of hexagonal ice crystals and the dimension that would be derived from Mie scattering is shown as a function of the maximum dimension for different ARs.

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