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Interactive comment on "Ice crystal number concentration estimates from lidar-radar satellite remote sensing. Part 1: Method and evaluation" *by* Odran Sourdeval et al.

Anonymous Referee #1

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Referee #2 has stated that the first two size-bins (5-15 μm and 15-25 μm) of the 2D-S probe should not be used to compare against this DARDAR-LIM retrieval since these bins are not reliable (i.e. have too much uncertainty). It should be noted that the FSSP 100 or FSSP 300 sample particles in the size range 3.0–30 or 0.6–40 μm diameter, respectively, and that typically 90% of the total N (ice particle number concentration) is sampled over this size-range (Krämer et al., 2009, ACP). The smaller size-bins of the 2D-S probe generally measure higher ice particle number concentrations such that N(D)1 > N(D)2, where N(D)1 corresponds to N between 5-15 μm and N(D)2 corresponds to N between 15-25 μm. Even if future 2D-S probe improvements show that N(D)1 < N(D)2, the concentration N(D) in these two bins is not zero, and N(D)1 plus

N(D)2 could easily be higher in number concentration than PSD defined by the larger size-bins of the 2D-S probe. Thus, throwing out the first two 2D-S bins is unlikely to improve the accuracy of 2D-S measurements of N. Furthermore, if the first two 2D-S bins are omitted, what would be the purpose of comparing DARDAR-LIM N retrievals with 2D-S measurements?

On the other hand, such comparisons may be meaningful. In collaboration with SPEC, Inc. (the company that invented the 2D-S probe), our group has analyzed comparisons of FSSP and 2D-S measurements of ice particle size distributions (PSDs) during the SPARTICUS field campaign. PSD sampling times ranged from 1.0 to 5.0 minutes, with a mean sampling time of 2.65 $\pm$ 1.35 minutes. Ten 2D-S/FSSP paired PSD comparisons were found where the agreement between these probes was relatively good (but far from perfect) for D > 15 μm; PSD were relatively narrow in 8 of the 10 pairs. The 2D-S ratio N(D)1/N(D)2 was estimated for cirrus clouds based on the FSSP bins that corresponded with 2D-S bins 1 and 2 [i.e. N(D)1 and N(D)2]. On average, this ratio was 0.42, ranging in value from 0.22 to 1.3. While the FSSP generally measured lower concentrations for N(D)1, the FSSP consistently measured higher (or roughly equal) concentrations for N(D)2, relative to the 2D-S probe. Based on this analysis, N(D)2 is not over predicted by the 2D-S probe.

There are uncertainties and limiting factors associated with all of the ice PSD probes, and it can be argued that agreement in the 5-to-35 μm range cannot be expected to be better than a factor of two, partly due to the small sample volumes and their uncertainties at these sizes (e.g. Cotton et al., 2013, QJRMS). Perhaps expecting satellite retrievals of N to agree with aircraft probe measurements of N within a factor of two is misguided (e.g. comment 17 from Referee #2), given the probe and retrieval uncertainties. Satellite retrievals of N arguably have more uncertainties than the in situ measurements do, and in this referee's opinion, their value is not in capturing the absolute magnitude of N, but it is in revealing how N varies as a function of latitude, season, surface type, etc. Much can be learned from these relative differences in N, and while it is optimal when retrieved N agrees closely with in situ N, the scientific community should not be denied valuable information concerning these relative differences when differences between retrieved and in situ N exceed standards applied to probe performance.

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