Authors Response to Referee Comments on "In-Situ Measurements of Cloud Microphysical and Aerosol properties during the Breakup of Stratocumulus Cloud Layers in Cold Air Outbreaks over the North Atlantic"

We thank the referees for their useful comments on the manuscript. The responses to these points are detailed below.

Response to Anonymous Referee #1

Specific Comments

1. The section labelling has been corrected.

2. The PCASP Size is the median particle size that we calculated from the particle size distributions (PSDs) measured by the PCASP instrument, which is described in the instrumentation section. We also calculated the percentiles for the same from the PSDs to give a measure of the variability in the aerosol properties.

Response to Anonymous Referee #2

Specific Comments

1. The ice number concentrations within the Sc clouds were generally a few per litre at most. This has now been stated in the text.

2. The low concentration is now stated as with Specific Comment #1

3. Double period corrected

4. We do focus on microphysical processes but have tried to provide a thorough overview of the different processes involved in the development of the Sc cloud layer. This has been detailed at the end of the introduction on page 4 lines 20 – 31.

5. We compared measurements from multiple different instruments in this paper and generally we found very good agreement between the measurements. We acknowledge the difficulty in instrument inter-comparisons but we found this to be a valuable thing to do as it helped us confirm that there is consistency in the measurements across a range of techniques.

6. Shattering on instrument inlets is a well-known phenomenon (e.g. Korolev et al. 2011). Some of the instruments were fitted with anti-shatter tips to reduce the number of shattered particles. However not all shattered particles can be removed in this way so we also used Inter-Arrival Time (IAT) Analysis to identify and remove particles with short inter-arrival times, which are likely produced by shattering on probe housing (e.g. Crosier et al. 2011).

7. As with Specific Comment #6 we carefully removed any shattering artefacts through IAT Analysis.

8. We have added a statement to the paper – 'We found agreement between the Total Water Content (TWC) Probes LWC and the Cloud Droplet Probe (CDP) LWC to be in good agreement for all cases. The r2 values for these comparisons were 0.86, 0.86, 0.93 and 0.66 respectively. The lower r2 value for the final case was due to an instrument issue that was identified using this inter-comparison approach. This further supports our thoughts in

Specific Comment #5 that inter-comparisons are useful for identifying potential problems. Below is an example figure of one inter-comparison between instruments.

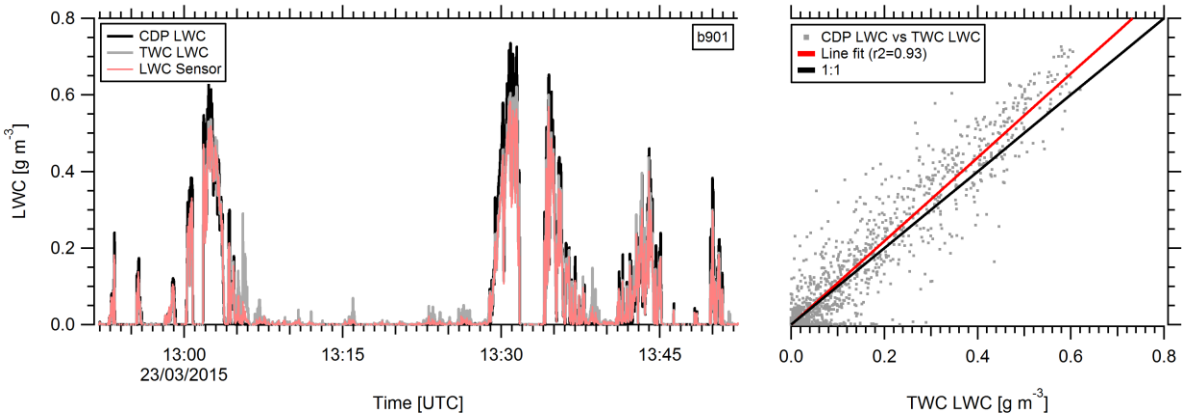

Figure. 1. *An inter comparison time series between the CDP, TWC and LWC Sensor (left panel) and a scatter of CDP and LWC vs TWC LWC (right panel)*

9. Yes, the size threshold is pixels, the size value in the manuscript is a representation of the approximate particle size threshold using a pixel threshold of 50.

10. This has been altered in the manuscript.

11. The strength of a cold air outbreak is very sensitive to the time of year and also any given synoptic situation. Our inter-case variability was quite wide, but we saw similar outcomes in each case.

12. The profiles were selected by the flight pattern carried out by the aircraft. The approach was to fly saw tooth profiles through the Sc layers towards the open cellular region. In each case we tried to make as many measurements as possible within the cloud layers and the results of these profiles are presented for example in figures 6, 10 and 13. The variability is also presented to try and give some information on whether any trends were in excess of the variability.

13**.** If we were to compare cases as a function of altitude we don't feel normalised altitude would be an advantage as the altitude range the cloud layers spanned were similar in all cases.

14. The median value is quoted in the manuscript but we have added 25th and 75th percentile where appropriate for added information.

15. This information has been added

16. We aren't aware of a widely used index or strength indicator for the types of events described in the manuscript. The ECMWF ERA-5 Reanalysis products in figure 2 show some properties that can be used to infer the strength of a cold air outbreak. Mean Sea level Pressure (MSLP), 10m wind speed, 2 m temperatures and Sea Surface temperatures (SSTs) are all included in this figure.

17. The profiles were selected to try and represent the Sc cloud within the cloudy boundary layer and the changes that took place closer to the transition. Although we selected these by eye the data presented in figures 6, 10 and 13 show all data for all profiles to avoid any bias.

18. This has been changed in the text.

19. The figure has imagery superimposed on each particle size distribution from the individual cases, not just from a single case.

20. You are absolutely correct, we do not know for certain that dust is the INP active in this case, we can only make the suggestion based on our current understanding of studies into the different INP species active at different temperatures.

21. The imagery for each case is shown in figure 7 alongside the particle size distributions for the cases. However we have added a new figure 8 to provide more imagery from the cases.

22. We have included new figure 16 that shows data from the cases plotted on the same x axis (distance from breakup). We think this was a valuable suggestion and has helped show the cases that have some consistency with each other (cases 1 and 3) together with the case that had some differences. We have also improved the discussion section.

23. The Particles Size Distributions show the cases and the increasing amounts of larger drizzle sized particles closer to the breakup. We put the PSDs side by side so that the reader can compare the different cases.

24. The data and time captions have been added.

25. As in Specific Comment #23 we have the PSDs to represent the increasing drizzle size.