

Response to minor comments: Stability dependent increases in liquid water with droplet number in the Arctic

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In addition to the edits detailed below in response to the reviewers' comments, we have fixed two typos in the original manuscript which stated that the enhancement and offset in high and low LTS conditions were calculated as 9% and 51% respectively, when they were in fact 8% and 43% (the values of the slopes quoted were correct). Please note that the line numbers referenced below when discussing where edits have been made correspond to the new manuscript.

5 1 Response to Report 1

1. Although they have been answered in the Response, it would be nice to include following discussion in the manuscript:

1) why the breakdown of LWP-AOD relationship is important; 2) LWP-Nd relationships and their dependencies on q and LTS are valid in different seasons; 3) Nd-LWP sensitivity as a function of LTS and cloud-top humidity q is valid for q taken at different vertical levels.

10 1) The text surrounding the decomposition into the N_d -LWP and N_d -AOD components around line 70 has been rewritten to include some of the discussion included in the response to reviewers.

2) We have included mention of the robustness of the relationship in different seasons on line 238 of the new manuscript.

3) Reference to analysis done at different vertical levels is made at line 221.

15 **2. Line 334: "The effects of these LWP changes to the longwave effect, which dominates in non-summer months, is expected to be weaker as changes in longwave downwelling radiation are more strongly controlled by cloud fraction as Arctic clouds in non-summer months typically have LWP greater than 30 g m⁻² and therefore act as black-body radiators (Shupe and Intrieri, 2004; Huang et al., 2017, 2019)." This sentence is too long and hard to follow. Please considering rephrase it.**

We thank the reviewer for the suggestion, and the sentence has been rephrased at line 347 of the new manuscript.

20 2 Response to Report 2

Minor comment: Section 2: On the answer to the reviews, the authors mentioned the uncertainty (on response to reviewer 1), 2)), and I acknowledge the clarifications. Unfortunately, I was hoping for a quantification on the remaining uncertainties: a plot or a range on the uncertainties on τ_c and r_e , or retrieved uncertainties on LWP and N_d . I am sure that the different methods decreased the uncertainty but I am still wondering what the remaining uncertainties are.

25 We thank the reviewer for their comments, but unfortunately a full understanding of the correlated errors in N_d and LWP generated by uncertainties in r_e and τ_c are beyond the scope of this work. As we don't have a good idea of how uncertain r_e and τ_c are in the Arctic, we are unable to analyse the impact of the correlated errors on N_d and LWP. However, in an attempt to understand how these uncertainties may impact our estimate of the offset or enhancement of the Twomey effect, we have used the AMSR-E 2D histograms from the supplementary information and applied the method described in section 3.3. AMSR-E
30 removes the correlated errors between N_d and LWP and therefore offers some constraints (although it has its own errors and uncertainties). In high LTS conditions, the AMSR-E LWP adjustments imply a 13% enhancement of the Twomey effect (slope of +0.05), and under low LTS conditions, an offset of 10% (slope of -0.04). This has been included at line 311 of the new manuscript.

Technical corrections:

- 35
- I.36: "whereas satellite-based satellite studies" -> "whereas satellite-based studies"
 - I. 129: "Dong et al. (2016) saw also saw" -> "Dong et al. (2016) saw also"
 - I.216: "(Coopman et al., 2016) found" -> "Coopman et al. (2016) found"

We thank you for pointing out these errors, they have been corrected in the new manuscript.

Supplementary figures: I find great the addition of the supplementary figures but some of them are not referenced in
40 **the main article (Figure S2 and S4). It would be beneficial to reference them in the main article because they support the author's statistics. Supplementary figures: Figure S5 is referenced before Figure S3 in the main article.**

The order of the figures in the supplementary information has been changed so they now appear in the order they are referenced in the text. Figure S2 is now mentioned at line 175, and Figure S4 is now referenced at line 213.

3 Response to Report 3

45 **I have no further comments on the paper. I only note minor grammatical issues in the Figure 6 caption and line 357.**

We thank the reviewer for their attention to detail and we have changed the caption of Figure 6 for clarity.