Atmos. Chem. Phys. Discuss.,
https://doi.org/10.5194/acp-2017-887-RC2, 2017

Atmospheric Chemistry and Physics
Discussions

Interactive comment on "Estimating precipitation susceptibility in warm marine clouds using multi-sensor aerosol and cloud products from A-Train satellites" *by* Heming Bai et al.

Anonymous Referee #2

Received and published: 11 November 2017

In various studies, the precipitation susceptibility metric has been used to quantify the effect of aerosols on the precipitation in both models and observations and to indicate the strength of the cloud lifetime effect. The present article examines how observationally-based estimates of the precipitation susceptibility metric vary depending on the various dataset and analysis choices. Previous attempts to provide an observational constraint on the precipitation susceptibility metric have led to different strengths in susceptibility and also in different behaviors of the susceptibility. The study contributes to the existing literature by attempting to reconcile those differences by examining a wide range of data and analysis choices in the same framework, which might help answer why different studies have arrived at different susceptibility estimates. The

authors examine the sensitivity of the susceptibility metric to the choice of aerosol proxy, precipitation characteristic (intensity, probability of precipitation (POP), or mean precipitation), stability regime, liquid water path retrieval, precipitation retrieval, and precipitation threshold. After examining the whole range of sensitivities, the authors conclude that SPOP has the least amount of spread that arises from the choice of liquid water path and precipitation data product. The authors also find strong sensitivities in the choice of stability regime and in whether aerosol index (AI) or the cloud droplet number concentration (CDNC) is used as the aerosol proxy.

The study is a substantial contribution to the existing literature by providing a comprehensive examination of the possible source of discrepancies that can arise when trying to estimate the precipitation susceptibility based on satellite retrievals. The manuscript methodically goes through the different choices that can be made, and assesses their impact on the value and behavior of the metric. There are a couple issues with the paper that I would like to see the authors address. First, the authors mention in the introduction of how estimates from Wang et al. (2012), Terai et al. (2015), and Michibata et al. (2016) differ in the magnitude of the SPOP metric. Although it appears that the use of AI or CDNC is the largest source of the discrepancy, I expected to see the authors discuss more thoroughly how the effect of the choice of aerosol proxy compares with effect of the choice of precipitation dataset and threshold. I had also expected a similar discussion that folds in the results from Sorroshiaan et al. (2009) on both the magnitude of the susceptibility, as well as the behavior of the susceptibility. Second, statistical confidence limits to the susceptibilities should be provided to determine how the statistical uncertainties compare with the other dataset/methodology uncertainties that are examined in the study. The confidence intervals would help inform whether the choice of datasets significantly change the susceptibility estimates or not. Overall, the manuscript has a clear scientific question, uses analyses that address the question, and is well organized. I do not consider the main issues that I have to be major. Therefore, I recommend that the manuscript be published after the following comments and issues have been addressed.

Main comments and issues

1) The uncertainties in the susceptibility estimates should be reported in all the figures and graphs. The 95% confidence intervals can be calculated from the standard deviation of the regression or using bootstrapping techniques. The statistical uncertainties will help the author substantiate some of the statements within the manuscript that say whether or not various choices significantly change the susceptibilities.

2) Given that the main purpose of the study is to examine how the various choices have led to differences in the susceptibility that are reported in the literature, the authors should provide more discussion on how this study helps to reconcile existing differences. In particular, the authors should do their best to identify likely reasons why the estimates in the previous studies have differed (if they do). For example, there are differences in the magnitude of the susceptibility (e.g., Wang et al., 2012 versus Terai et al., 2015). There are also differences in the behavior of susceptibility (monotonic decrease versus increase and then decrease).

3) The authors seem to argue for the use of SPOP as a metric to quantify aerosol-cloud-precipitation interactions due to SPOP having a smaller range of possible values, based on different LWP and precipitation rate retrievals (Fig. 14). There is less discussion on the advantages and disadvantages of using CDNC or AI as a metric and also a lack of discussion on how the threshold (rain vs. drizzle) can significantly change SPOP values. Given that the authors have examined a wide range of potential sources that lead to differences in susceptibility estimates, it would be informative for the readers to have the authors synthesize their findings and discuss what should be considered in future attempts to try to observationally constrain precipitation susceptibility or attempts to compare susceptibilities from models and from observations.

Minor comments

P2 L3: "Susceptibility is an inherent property of the aerosol-cloud system." – This is an interesting statement, but it is also vague. Does the statement mean that susceptibility

doesn't change with cloud condition? Or aerosol condition? Should they be robust to differences in measurement platform, etc.?

P5 L32: ". . . selected in close proximity of clouds pixels." What exact criteria is used to determine how close aerosol retrievals must be to be used in the study?

P6 L23: replace "significant" with "significantly"

P6 L25: What is the spatial resolution of the precipitation data? Is it at the footprint level? In general, how are pairs of LWP, precipitation rate, and aerosol proxy combined? Are they all combined at the footprint of the precipitation rate? Is the coarsest footprint used for the comparison?

P7 L15: Provide some indication of statistical uncertainty in the estimates in Fig. 1. See main comment 1. Also, it would be informative to indicate the 0 value with a dotted or gray line, because values below that line will indicate that increases in aerosols/cloud droplets lead to more precipitation.

P7 L22-24: The turning point is very slight. The confidence intervals will be helpful in determining how significant the peak is.

P7 L29: To show that the fluctuations in the mean are small compared to noise, the interquartile range (between 25th percentile and 75th percentile) can be shown.

P7 L29: Also, because the AI vs. CDNC relationship takes the form d ln(CDNC)/d ln(AI) and because it looks like the AI has a lognormal distribution, it might be better to plot the x-axis in log-scale.

P8 L4-5: The differences in dlnCDNC/dlnAI between the different stability regimes is interesting, in particular, the lack of sensitivity (or negative sensitivity at high LWPs). Are these differences significant? Do the authors have an explanation as to why the stability affects the sensitivity?

P8 L16: The subtle differences in Fig 4 are hard to see because of the large y-axis range. I can understand the choice to try to keep the same axis range across different figures, but in this case, I would suggest narrowing the range to allow the reader to discern any differences.

P8 L26-28: Is there a reason why we would rely more heavily on and prefer MODIS AI rather than CALIPSO AI?

P9 L2-7: This is one case where confidence intervals can show that the SPOP estimates are not significantly affected by the choice of LWP retrievals, whereas the SI and SR estimate are significantly affected.

P9 L26: Data is plural, so it should be "... when data are binned..."

P10 L11: Although the axis labels show this, the figure caption to Figure 9 should indicate the difference between the top row and the bottom row.

P10 L26-28: What is the impact on SR if SPOP increases and SI decreases with increases in the threshold?

P10 L31: "more significant" should be replaced with "larger", because significant has a particular meaning in the literature (statistical significance), and to state more significant would require examining the confidence intervals.

P11 L28: "sigh" should be replaced by "sign"

P14 L5: Insert "by increases in AI or CDNC" between "readily suppressed" and "in warm clouds"

P14 L5-6: Taken at face value, this statement is counterintuitive, isn't it? Wouldn't we expect rainfall, which is more dependent on accretion than on autoconversion, to have a weaker dependence to CDNC?

P14 L14: Replace "value" with "values"

P14 L14-18: Are these results consistent with existing conceptual frameworks (such as

those based on LES) on how stability affects aerosol-cloud-precipitation interactions? Are there LES studies that have addressed how stability might affect susceptibility?

Interactive comment on Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2017-887, 2017.