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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Observation of ENSO linked changes in the tropical Atlantic cloud vertical distribution using 14 years of MODIS observations" *by* Nils Madenach et al.

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Our general response

We would like to thank reviewer 1 for reading our manuscript. We deeply regret that reviewer 1 does not consider our study insightful and the manuscript a useful contribution to the literature. Reviewer 1 does not provide specific comments on textual or technical parts in the paper. However, broader criticism on result interpretation and our linkage to large-scale/ENSO dynamics is given. The main point that we take to heart is that the scientific contribution of this study is not coming through in the paper, according to reviewer 1. Therefore, we would like to take the opportunity to argue why we consider

our study and manuscript a useful contribution to the literature by responding to the main points given by reviewer 1 as well as suggesting first adjustments, thanks to the comments of reviewer 1, to make sure that our points are insightful for everyone and, most importantly, to clarify the take-home message of the manuscript.

Our specific response

"If the authors are trying to make a more insightful point than "ENSO induces vertical motion anomalies over the Tropical Atlantic, which affects the amount of high clouds there", it is not coming through in the paper. If this is their point, then it does not rise to the level of a scientific contribution worthy of publication in this journal."

The main point of the manuscript was not to show that ENSO induces vertical motion anomalies over the TA, which affects the amount of high clouds. We are well aware that the general dynamic mechanisms of ENSO and its effect on TA ocean-atmosphere system are well described in literature. Within our work we have cited several studies discussing this. However, there are many (related) mechanisms, e.g., the response of the TA ocean-atmosphere system to a warming climate, its effect on cloud radiative forcing, convective self-aggregation, that are not well understood and quantified yet. We argue that the data and tools used within this work can contribute to this field of research. What we consider the main scientific contribution of this work is the quantification of changes in cloud properties in the TA using climatologies computed from well-established multi-annual MODIS satellite observations and at the same time being able to clearly relate the observed anomalies to (model) large-scale dynamics, and in particular, ENSO events. It would be much appreciated if reviewer 1 could provide studies/publications where satellite-observed cloud changes in the TA and their relation to large-scale dynamics have been quantified in a way that they are also useful for model studies (e.g. evaluation). If so, we would be very thankful and our study would be another contribution to this field of research, if not, we would add new measures to this field of research. In the Summary and Conclusion we state that ENSO events could serve as a large experiment for climate warming. In the future we expect a warm-

ing, possibly giving rise to similar changes in SST/water vapor/dynamics/clouds in the TA as is the case in the ENSO events in our investigated time period. We show that the satellite cloud observations of the type we used can provide an excellent tool to analyze and quantify the impact of a changing climate on clouds in the TA. To clarify our main points, we suggest several adjustments. Regarding the title, we acknowledge that it was somewhat misleading and suggest to change it from:

Observation of ENSO linked changes in the tropical Atlantic cloud vertical distribution using 14 years of MODIS observations to: Quantification of ENSO linked changes in the tropical Atlantic cloud vertical distribution using 14 years of satellite observations

Furthermore, in the Abstract, Introduction and Summary and Conclusion we will rephrase several lines to clearly emphasize that this study is about quantifying changes in satellite-observed cloud fraction and height and linking observed anomalies to large-scale dynamics/ENSO Events and not about explaining the well-known ENSO dynamics and their impact on TA.

“It is clear from the very high correlation between high cloud fraction (HC) and cloud top height (CTH) that both are simply measures of the relative amount of high clouds, which makes sense intuitively but is not particularly insightful.”

Despite the fact that with MODIS it is not possible to vertically resolve clouds, using vertically resolved cloud cover, even if coarse and limited in specific situations, shows the potential of passive imagers for large-scale analysis of possible changes in the cloud vertical distribution and linking those changes to large-scale dynamics using other observations or model data. We show that the observed anomalies in the mean CTH are mainly driven by changes in the HCF and not by changes in the CTH itself, emphasizing the importance of using vertically resolved cloud cover or, in a next step, cloud types. The new insight from our study is not the change in the (high) cloud amount, but the quantification of the change in the (high) cloud amount using satellite observations. It is well-known that climate models still struggle with the correct modelling of

cloud vertical distributions, also for the TA region, giving extra importance to satellite observations, which provide cloud observations for long time periods and large spatial scales. In particular, the satellite-observed cloud anomalies and their linkage to ENSO events serve as a powerful tool to investigate and quantify the impact of a changing climate on clouds in the TA.

“I see no value in interpreting these as trends as opposed to variations in high cloud amount governed largely by variations in ascent.”

We acknowledge that the use of the word trend is a bit tricky in this case. We never intended the meaning of a climatological trend. By using the two time periods and looking at temporal changes, we rather want to quantify changes due to transitions between two states. The two time periods have been chosen such that the impact of two opposite ENSO events on satellite-observed cloud properties in the TA could be quantified, mimicking possible transitions/changes due to a changing climate. In this study the use of the word trend is misleading and we will rather change to using the word transition. We will further clarify the idea behind analyzing using two time periods.

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