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Atmospheric Chemistry and Physics Discussions

# *Interactive comment on* "Increase in the Frequency of Tropical Deep Convective Clouds with Global Warming" *by* Hartmut H. Aumann et al.

**Anonymous Referee #2**

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Review of 'Increase in the frequency of tropical deep convective clouds with global warming' by H. H. Aumann and co-authors for consideration in ACP.

In this manuscript the authors take observations of tropical deep convective clouds (DCC), roughly reaching the tropopause, and relate their occurrence to the underlying SSTs. Using data from the period 2003-2016 they find that the likelihood distribution of DCC shifts to warmer SSTs slower than the tropical mean SST at a rate of about 0.5 K/K. This means that in the warmer years a larger area is covered with DCC. The authors extrapolate this to the future using SST distribution change projected using climate models, to yield the main result of the study that there might be a 50 percent increase in the occurrence of DCC.

The result is challenging both because models do not seem to reproduce the behavior,



and because there seems to be little theoretical grounds for this. All other things equal, in a warmer climate the largest storms are expected to increase their precipitation with Clausius-Clapeyron, i.e. about 7 percent per Kelvin. If we assume DCC are such storms, then their frequency of occurrence would have to decrease slightly because to total precipitation is bound by radiative cooling which gives only 2-3 percent per Kelvin increase. There could, of course, be a shift from other types of precipitation to DCC, but I doubt it could change this fast, and would argue that there are simpler explanations for the statistical result.

The first is purely methodological. In figure 2 regression is used to fit a line to the data points, the result has a slope of about 0.5 K/K. Linear regression is usually used when one variable is much less noisy than the other, placing the less noisy variable on the x-axis. Judging from the even/odd days pairs there does seem to be a bit more noise in the "SST at 1/2 peak" than the tropical mean SST, but it is by far not dominant and it further cannot explain deviations from the line. In this case it is better to use a total least squares method (sometimes orthogonal linear regression). This will probably yield a slope that is indistinguishable from 1 K/K. Probably Matlab does not have this capability out of the box, but there is help to be found on the internet. The authors might also simply try to invert the order of regression variables, and then invert the slope back again, which will probably yield slopes » 1 K/K.

The second is conceptual. In the same figure 2 it is obvious that most of the signal contributing to the slope of about 0.5 K/K comes from the two warm years with tropical mean SST of about 299.6 K. These, I assume, are 2015 and 2016 which were El Nino years. The distribution of SST is quite different in years with El Nino compared to normal years, and it is quite different from that of global warming as predicted by climate models, in that the warmest SSTs from the warm pool region are spread out eastward such that deep convection can occur over a larger area. Perhaps then it is not surprising that the 1/2 peak DCC distribution is not moving to warmer SSTs as fast as the tropical mean, since the warmest SSTs are not warming substantially during El

Nino.

Overall, the physical concepts, the linear statistical assumption and data underlying this study and used to project into the future leaves much to be desired, and I fear the found signal is pure artefact. I can therefore not recommend publication of this study. I therefore also refrain from going into details with the weak presentation, language and problematic referencing to the literature.

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