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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Observed Trends of Clouds and Precipitation (1983–2009): Implications for Their Cause(s)" *by* Xiang Zhong et al.

Anonymous Referee #3

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Review of Zhong et al. 2020

The authors present two analyses concerning trends in clouds and rainfall. One uses global, satellite-observed cloud and precipitation data to show that cloud cover and precipitation trends are consistent with an expanding tropical belt. The other looks at surface-observed clouds and rain rates in China to show that light, stratiform rain and overcast clouds are declining while convective rain associated with more broken clouds is relatively more common. These results are consistent with prior work showing a widening tropical belt and a trade-off from stratiform precipitation in favor of convective precipitation.

The work addresses some very large and interesting problems using a fairly simple and easy to understand method, which is commendable. The quality and presentation of the manuscript is high and the work presents great value to the community. There are a few places where the analysis needs a bit more rigor, especially regarding the removal of long-term variation from timeseries in the correlation analysis. It is crucial that we know that the correlations we see are due to interannual variations and not due to coinciding trends. If the authors can do this bit of extra work, the results will be significantly more robust.

Major comments:

There is talk of a widening Hadley cell, and the results do hint at this, but I would love to see a bit more rigor in 1) defining what your data show as the tropical belt, maybe with a zonal mean plot showing the mean clouds/precipitation for latitude zones, then 2) showing the mean trends for the same zones. You could do this globally, or for a specific region between longitude bounds.

I'm not completely convinced by the trend/correlation analysis discussed in Figure 3 and the associated tables. Specifically, I'm concerned that linear trends in timeseries being correlated may occur coincidentally and that this could be driving much of the signal in Figure 3. The authors need to show that the relationships between global temperature and regional variations in cloud cover and precipitation are consistent when the linear trends (or long-term variability with very few independent data points) are removed. This removal could be done either by detrending the time series or by filtering out a 5-year or 10-year running mean. The maps showing significant relationships after this filtering will more clearly show how year-year global temperature variations interact with year-year cloud and precipitation variations. Basically, the idea is that if temperature is actually driving cloud and precip changes, then the relationship should be apparent on both decadal and yearly timescales. To aid in this, you could also show a few time series plots for some significant regions as an example, showing that year-year temperature and cloud variations are similar, most importantly by adding a temperature plot to Figure 2.

Line 105 & 106: Can you clarify this? It sounds like you mean that you chose stations that have consistent reporting throughout the year. Can you also clarify whether observation timing throughout the diurnal cycle remains consistent for those years? Are you excluding any night data if lunar illumination is insufficient, or can you show that interannual variation of daytime data is equivalent to night?

Minor comments:

Line 49: I think you may be referring to Eastman, Warren, and Hahn (2011) that uses ocean observations. The 2013 paper is only concerned with land stations.

Can you list the grid spacing of all data? The precip data is 2.5x2.5 and it appears that the clouds are at that resolution as well? The spacing itself appears appropriate, with little spurious-looking noise in the contour plots.

I think you need one more sentence describing the Norris and Evan empirical method for removing spurious trends, something like: "by removing anomalous cloud variability within individual grid boxes shown to be associated with artifact factor anomalies", which is (somewhat lazily) adapted from their abstract.

Figure 1: It's frustrating that the contours of total precipitation aren't plotted in the mid-latitude storm tracks, but the trends seem to be plotted in these regions. Can you explain this discrepancy, or better yet, plot the climatological average precipitation in the regions where you plot the trends? There appear to be some regions, especially the N Atlantic where precip contours vanish. The chosen contour interval may not be sensitive enough to show variability in many regions, which is why there aren't contours plotted. Could you tighten the interval for total precip values below 900? This would really aid the paper since the southern ocean storm track and N Atlantic also appear to have a significant precipitation trends.

Figure 5: Can you provide numbers that show what these bins mean? What intensity

of rain occurs in bin 10, for instance? Line 198 says bins are 'equal'. Does this mean equal number of obs per bin, or equal ranges of rain rate within each bin?

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