LIGHTNING CORRELATION WITH ENVIRONMENTAL VARIABLES USING THE TRMM LIS

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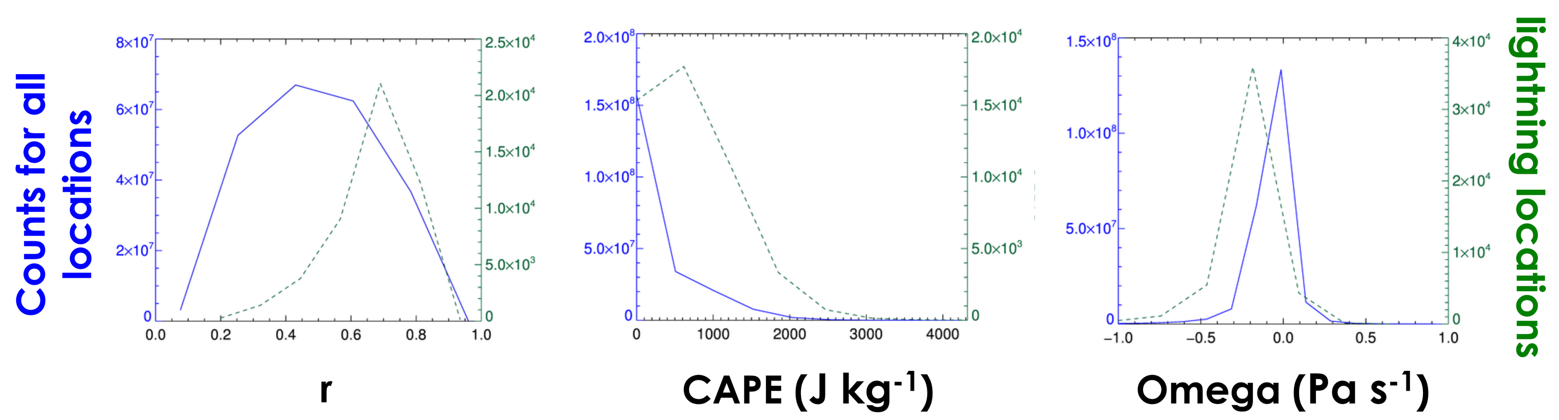
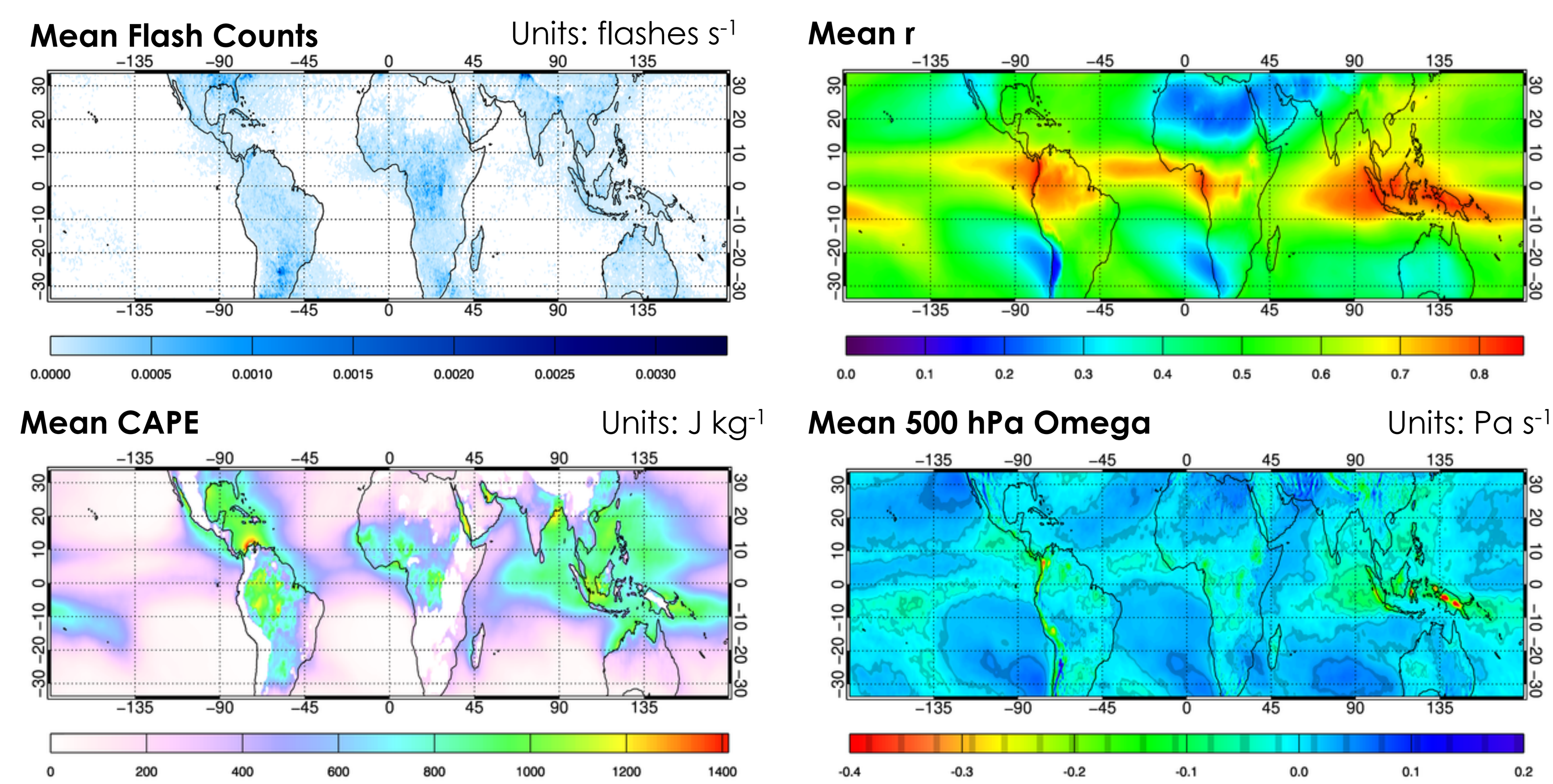
MOTIVATION

Lightning has significant societal impacts and knowing the relationships between lightning production and environmental variables can be highly beneficial for its predictability. Many studies have used the Tropical Rainfall Measuring Mission (TRMM) Lightning Imaging Sensor (LIS) to observe thunderstorms across the globe. However, environmental variables are sparingly accounted for in most lightning studies. Some model lightning parameterizations utilize convective available potential energy (CAPE) (e.g., Lopez 2016), but few have accounted for multiple environmental variables (Stolz et al. 2017 is a notable exception). This study aims to more clearly reconcile the relationships between lightning and environmental variables, such as CAPE, column saturation fraction (r) and large-scale rising motion (500 hPa omega). The plots below show significant differences between lightning conditions and the general tropical environment and help to motivate this study.

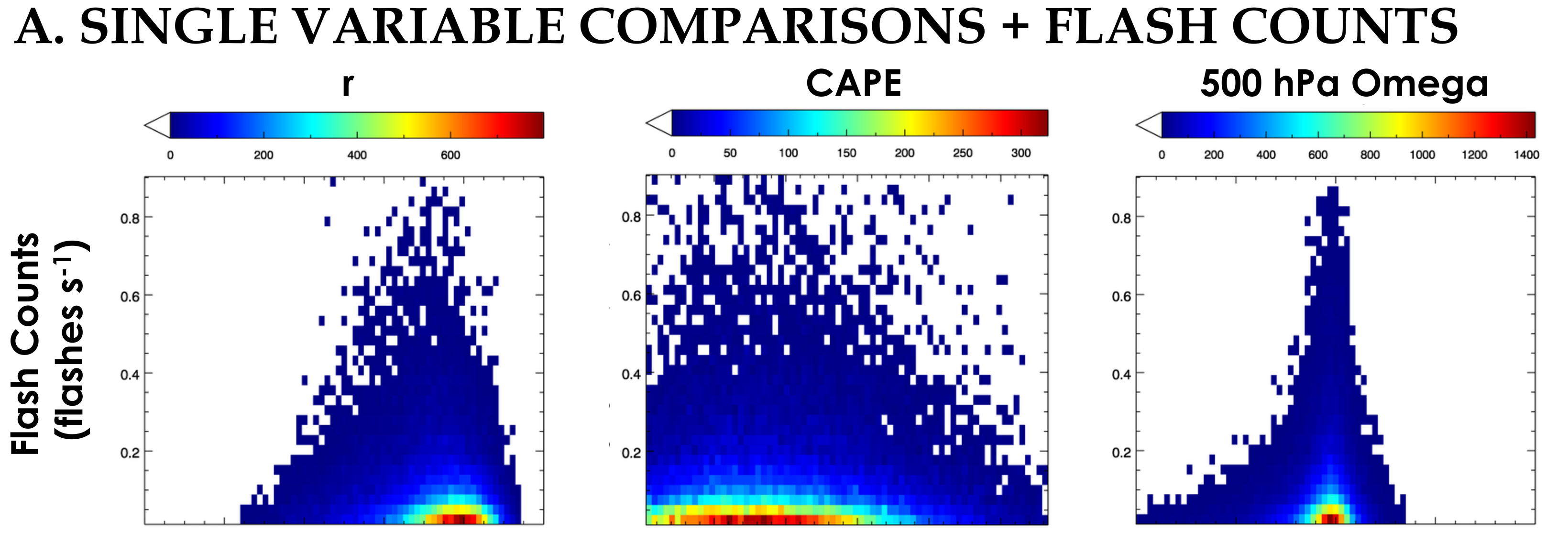


DATA

Environmental variables are derived from MERRA2 reanalysis data and lightning flash data are obtained from the TRMM LIS. Data was binned into 3-hour time periods over 0.5° grids. We have created a climatology of average flash rates from 1998 to 2014. For the remainder of this study, we have chosen to use 1998 as a base year, as the highest flash rates were observed during this year. The mean maps for 1998 below suggest potentially predictive relationships between lightning occurrence and r, CAPE and 500 hPa omega.

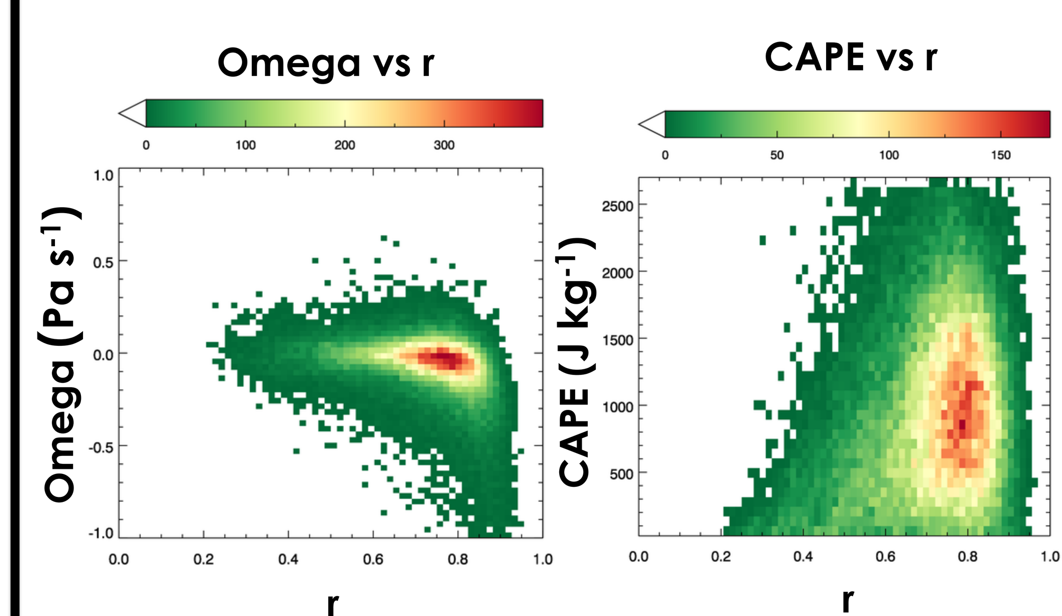


A. SINGLE VARIABLE COMPARISONS + FLASH COUNTS



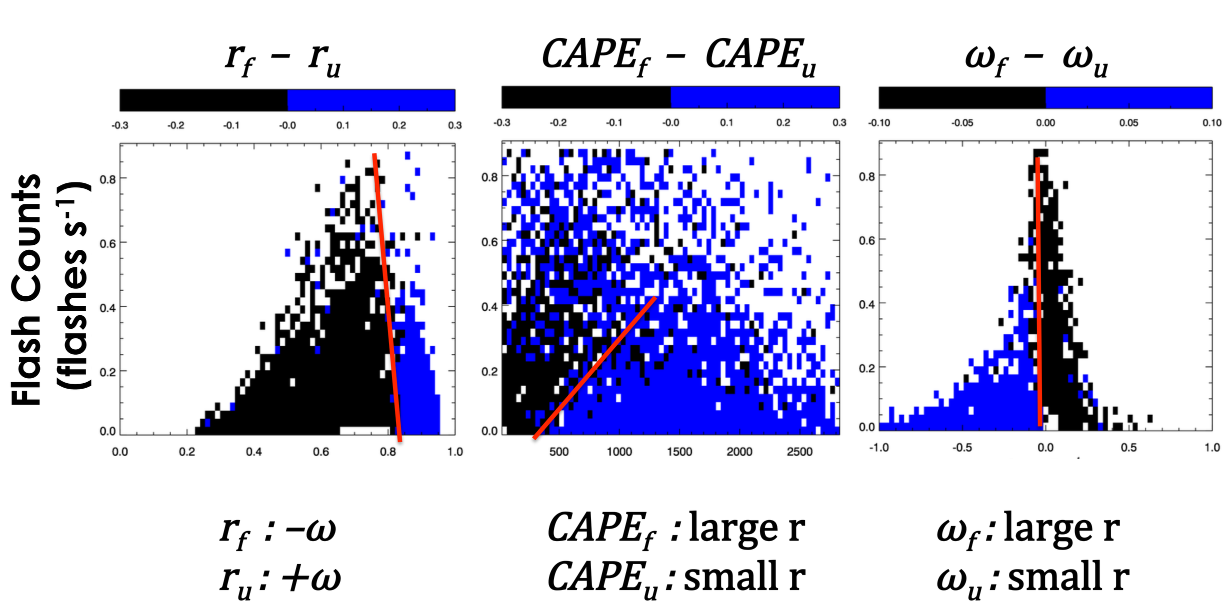
- Column saturation fraction is the best predictor of flash counts - the higher the r value, the higher the flash counts
- Moderate CAPE is associated with the highest flash counts
- Omega at 500 hPa is generally a weak predictor of flash rate

B. DOUBLE VARIABLE COMPARISONS + LIGHTNING OCCURENCE



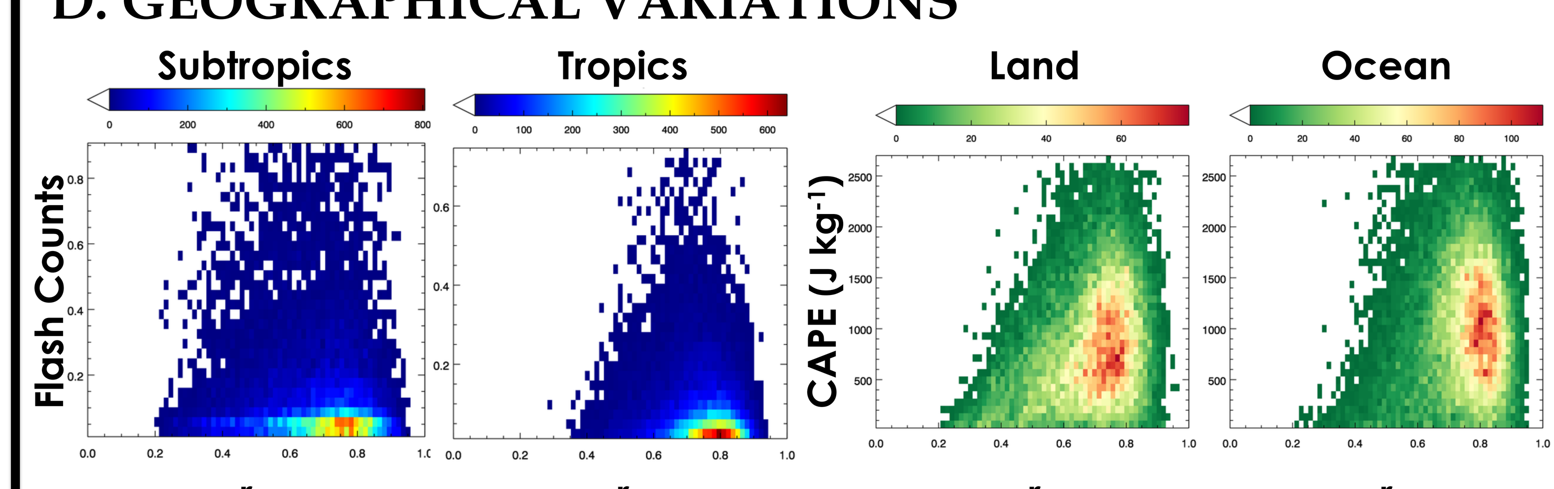
- Lightning at large r occurs in conjunction with larger negative omega
- Lightning is more likely to occur when there is high r & moderate CAPE

C. DOUBLE VARIABLE COMPARIONS + FLASH COUNTS



- r is a better predictor of higher flash counts when accounting for omega
- CAPE and omega show improvement when accounting for r

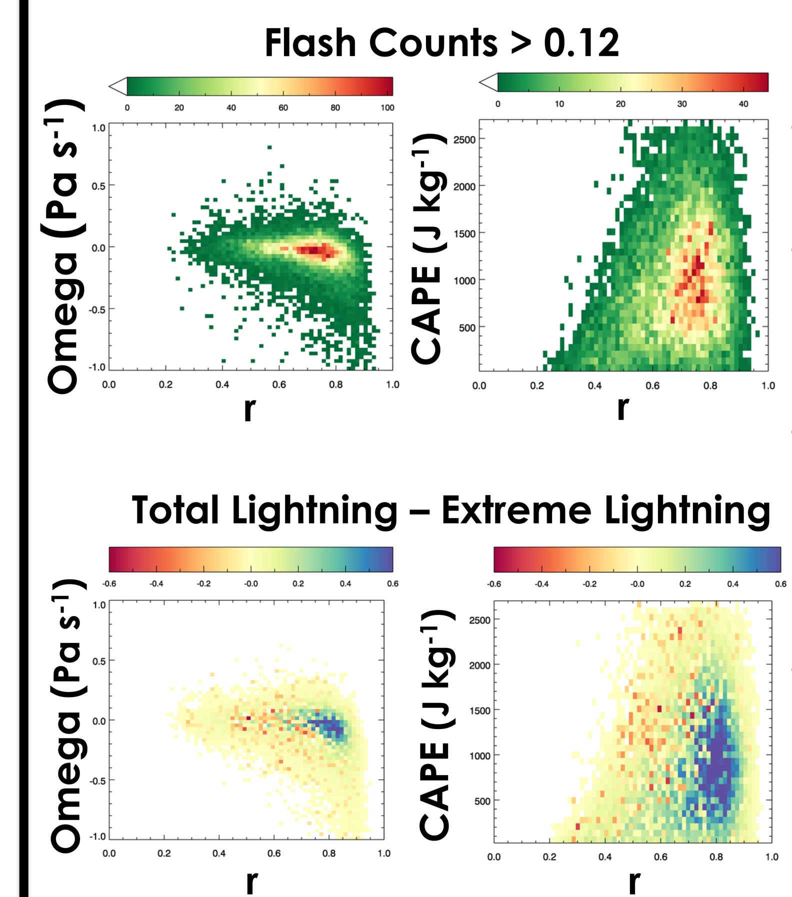
D. GEOGRAPHICAL VARIATIONS



- Lightning occurs at higher values of r in the tropics
- Over ocean, the CAPE and r relationship discussed previously holds true; however, over land, lightning occurs for lower CAPE and lower r

E. EXTREME LIGHTNING

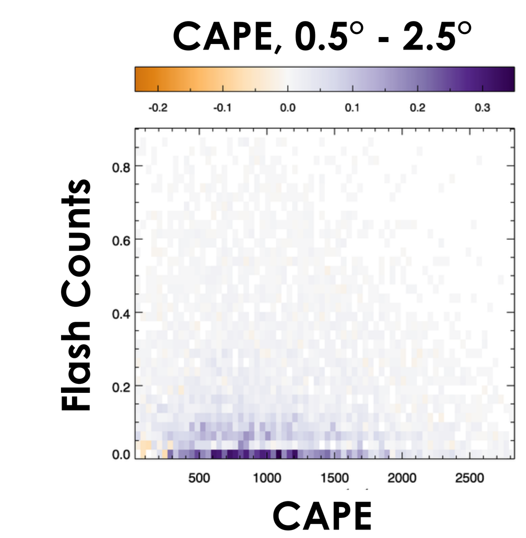
The majority of lightning occurs at flash counts less than 0.1 flashes s^{-1}.



- We have taken flash counts for the last quartile (> 0.12 flashes s^{-1})
- Relationships discussed previously generally hold for our "extreme lightning" cases
- The difference between all lightning and the last quartile shows the biggest difference in omega/r at high r but 0 omega
- The biggest CAPE/r difference occurs at high r and low to moderate CAPE

F. RESOLUTION

- Lastly, we compared our results on 2.5° and 0.5° grids
- Our results did not change for r and 500-hPa omega
- For CAPE, we see a shift in predictability of lightning to higher values of CAPE for finer resolutions



CONCLUSIONS

- There are promising predictive relationships between environmental variables and lightning using TRMM LIS observations and reanalysis fields, although predictors can vary over land and ocean and between the tropics and subtropics
- The best predictor, by itself, is column saturation fraction because of its strong link to the existence of organized convection
- Best predictors together are CAPE vs r and 500 hPa omega vs r because of the added dynamical information
- The ability to discern extreme lightning events from large-scale environmental variables is less clear, but it appears that the omega/r relationship is stronger for extreme lightning cases, where the CAPE/r relationship is weaker
- Higher resolutions are only beneficial when comparing CAPE and lightning

FUTURE WORK

- Explore different methods for calculating CAPE, replicate work with wind shear, and study seasonal and interannual variability
- Analyze these relationships in global climate models as they may be helpful in improving lightning parameterizations

AKNOWLEDGEMENTS

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