Observations of life cycles of global mesoscale convective systems

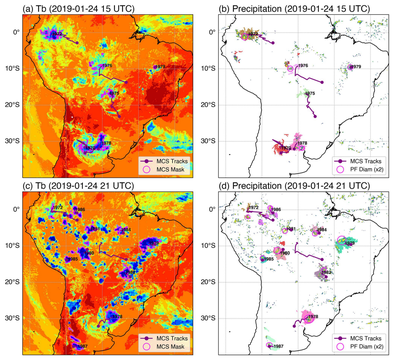
Alyssa Shih and Steve Nesbitt
Department of Climate, Meteorology and Atmospheric Sciences, University of Illinois at Urbana Champaign

Introduction

Mesoscale convective systems (MCSs) play a vital role in the global hydrologic cycle, bringing over half of all annual precipitation to some areas of the world. This study aims to quantify and compare life cycles of land, oceanic, and coastal MCSs as well as identify areas of explosive MCS growth.

Data

Data were obtained from Feng et al. (2022)[1], which used the open-sourced feature tracking software PyFLEXTRKR to identify MCSs from geostationary satellite data. The dataset spans from 2000 to 2020 and includes systems from 60N to 60S. 713,382 MCSs are included in the dataset. MCS features are quantified every hour.



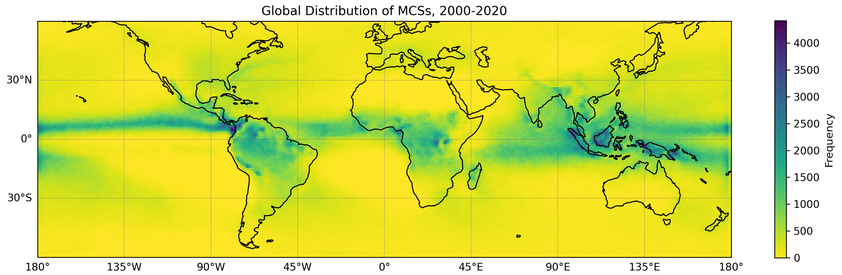
Example of MCS tracking from Feng et al. (2022)[1]. Magenta colorings in (a) and shadings in (b) show MCS masks, while purple lines show MCS tracks.

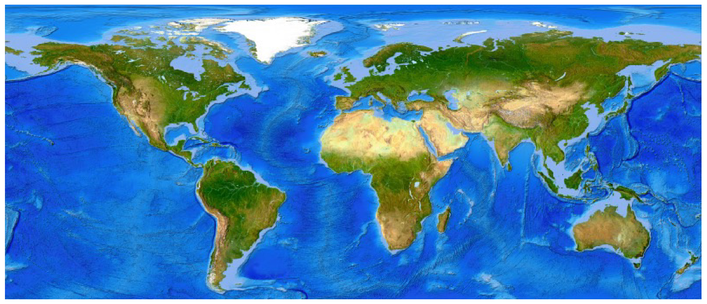
Methods

Mean area was used to find average growth rate. MCSs were sorted into land, oceanic, and coastal by determining if each track was over land or ocean at every time in its lifecycle. Land classification was done with the python module global-land-mask. If a track traveled over both land and ocean, it was deemed a coastal MCS. Categorization by latitude was done by considering all MCSs that initiated between 0º and 23.5º in both hemispheres as tropical, 23.5° and 30° as subtropical, and greater than 30° as midlatitude.

$$\text{growth rate} = \frac{\text{area}(t-1) - \text{area}(0)}{t}$$

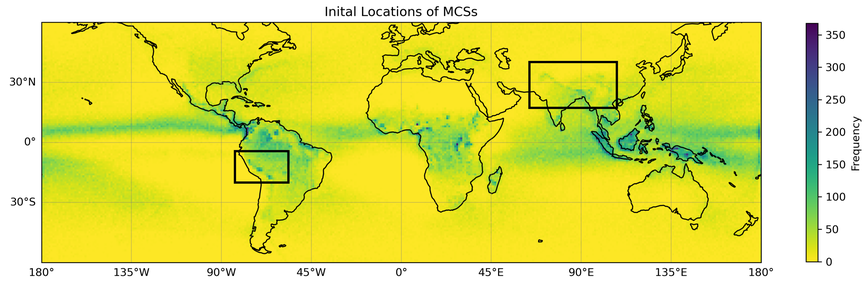
Where are MCSs in the world?



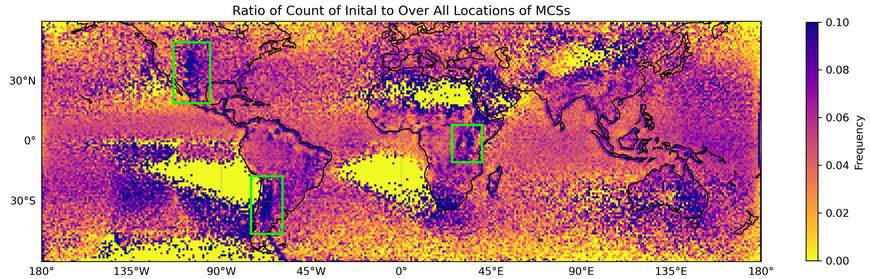


MCSs are primarily distributed around the Inter-Tropical Convergence Zone (ITCZ) and near significant topography over land.

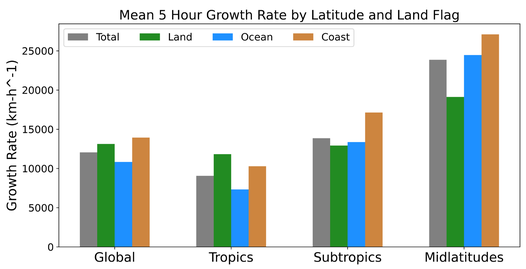
Where do MCSs form?



MCS formation near significant topography



How does growth compare by latitude?

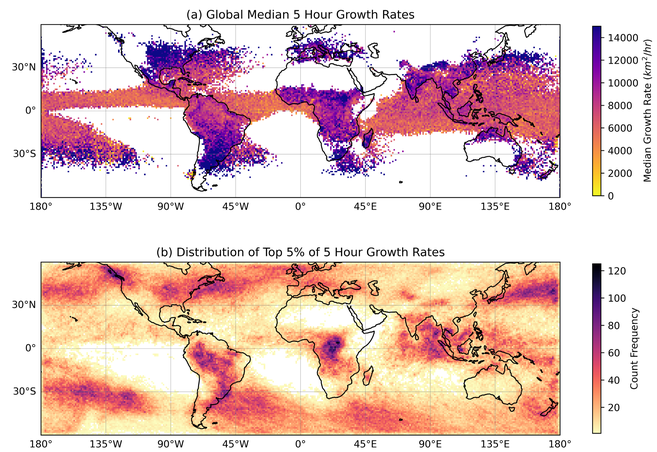


Fastest MCS cloud top growth occurs in the midlatitudes for all land classifications.

Coastal MCSs grow fastest within the subtropics and midlatitudes, but not the tropics.

Tropical oceanic MCSs grow slowest on average while coastal midlatitude MCSs grow the fastest of all storms globally.

How does land affect growth rate?



MCSs near significant topography, have the highest median 5-hour growth rates and dominate MCSs with explosive top 5% growth.

Equatorial oceanic MCSs, though common, exhibit relatively low growth rates. A cluster of top 5% MCSs center around the Bay of Bengal.

Conclusions

MCSs initiate near significant topography, especially along mountain ranges. Coastal and land MCSs growth rates outpace oceanic storms. The most explosive 5% growth rates occur around significant topography both over land and over the oceans.

Future Work

Future research will focus on linking environmental variables to categorical differences in 5-hour growth rate. Continued study will also aim to include core and precipitation field growth rates.

References

[1]Feng, Z., Hardin, J., Barnes, H. C., Li, J., Leung, L. R., Varble, A., & Zhang, Z. (2022). PyFLEXTRKR: a Flexible Feature Tracking Python Software for Convective Cloud Analysis. EGUsphere, 1-29.

Acknowledgements

This study is based upon work done by Zhe Feng.

Contact: ashih4@illinois.edu