Investigating The Conditions for Lightning Formation in The Gulf Stream

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Background

Atmospheric Science is a relatively new field with a wealth of interesting problems needing to be solved. This research aims to answer the following:

How does an ocean current, such as the Gulf Stream, affect lightning formation?

More specifically, is there a correlation between a strong/warm ocean current and increased lightning activity? Are there any identifiable factors that can allow us to predict a “double-band” of lightning?

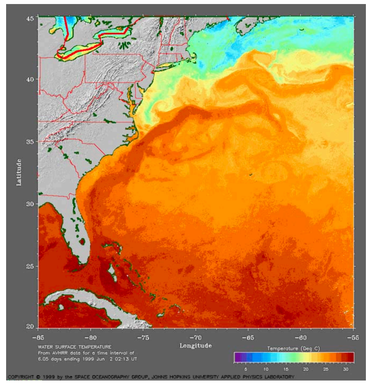

Figure 1 - A temperature map of the Gulf Stream [1]

Methodology

Using lightning data from the GOES-GML instrument and atmospheric reanalysis data from ERA5 the average sea surface temperature was calculated and plotted against the number of lightning events over the Gulf Stream region.

An algorithm to detect double-band events was developed. There are **3 stages**:

1) Scan the lightning event data over a given area and calculate a **probability distribution** for lightning being found within that region.
2) T**ry to fit 3 cases to this distribution**: constant probability (flat), normally distributed (gaussian) or a double normal distribution (bimodal).
3) Compute a **regression value** from the fit data and use this to determine the best fit.

This was repeated over the entire region for every hour of 2018. An example is shown in Fig 2.

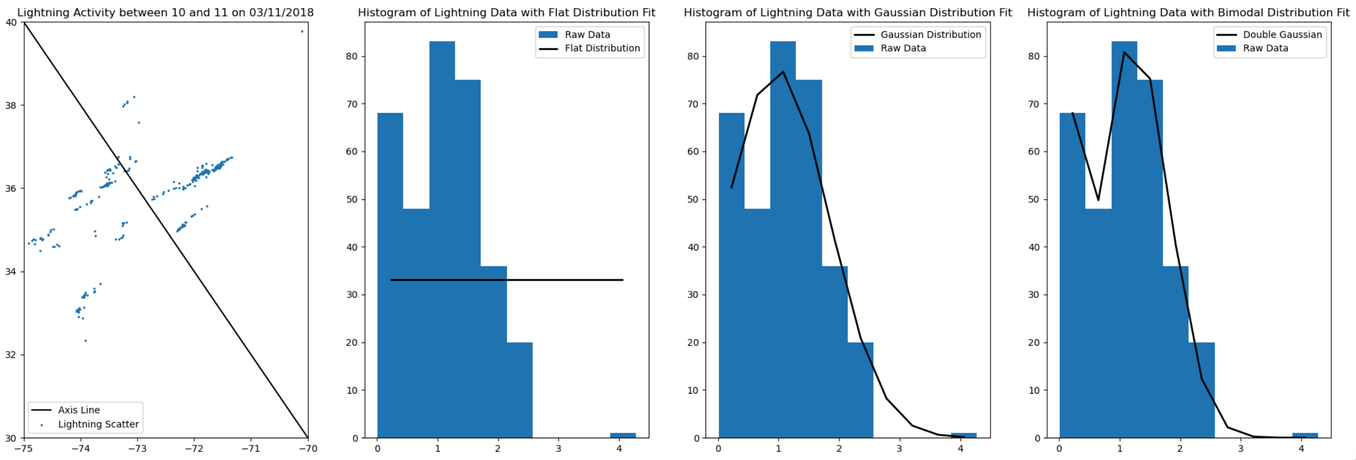

Figure 2 - An example of the algorithm fits between 10am and 11am on 03/11/2018

Results

It was found that:

- If the **average SST in a given region was higher** the **number of lightning events would also be larger** (Fig 3.).
- Lightning **double-bands were primarily found during the summer months** (Fig 4.) with approximately 57% of double-bands found in June, July and August.
- Double-bands were typically had a **region of negative PV** lagging behind the bands (Fig 5.).

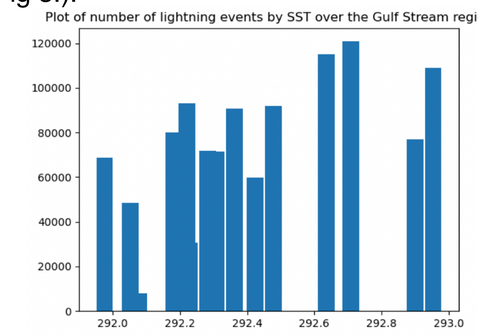

Figure 3 - A plot of lightning detections in 2018

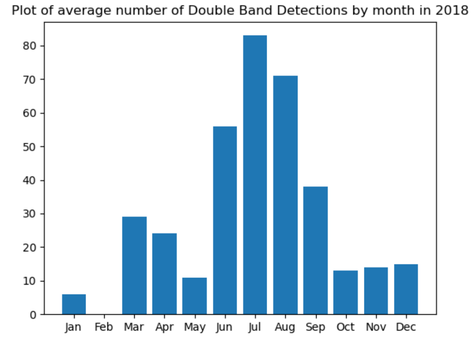

Figure 4 - A plot of double-band detections in 2018

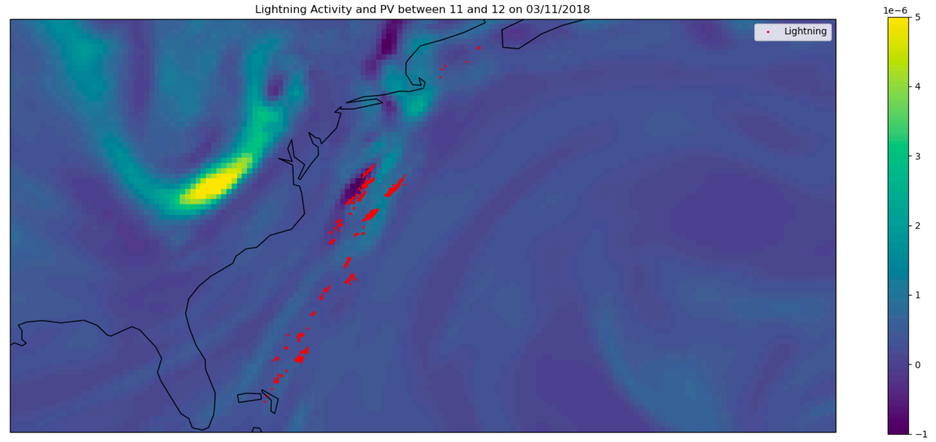

Figure 5 - An example of a double-band with a lagging region of negative PV

Conclusions

Taken together the results **support previous research** [2][3] about lightning formation processes. There is **strong evidence** that warm ocean currents have a **significant** impact on lightning formation, and there are some factors that are **good predictors** that lightning events are likely to occur (such as a local updraft, high cloud water ice content, strong precipitation, etc.). These factors are also **well supported by previous research** [4].

References

1. https://archive.bigelow.org/virtual/sst_sub1.html
2. Sheldon, L., Czaja, A., Vannière, B., Morcrette, C., Sohet, B., Casado, M., & Smith, D. (2017). A ‘warm path’ for Gulf Stream–troposphere interactions. Tellus A: Dynamic Meteorology and Oceanography, 69(1), 1299397. https://doi.org/10.1080/16000870.2017.1299397
3. Albrecht, R. I., Goodman, S. J., Buechler, D. E., Blakeslee, R. J., & Christian, H. J. (2016). Where Are the Lightning Hotspots on Earth? Bulletin of the American Meteorological Society, 97(11), 2051–2068. https://doi.org/10.1175/bams-d-14-00193.1
4. Dash, J. G., Mason, B. L., & Wettlaufer, J. S. (2001). Theory of charge and mass transfer in ice-ice collisions. Journal of Geophysical Research: Atmospheres, 106(D17), 20395–20402. https://doi.org/10.1029/2001jd900109