Datascience Laboratory
Lightning Hotspots on Earth

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Fall Semester,2021

1 Introduction

"Earth's lightning flash frequency has been an object of interest and study for decades." [3] This phenomena was analysed in [3], where they used 16 years of data, combining Tropical Rainfall Measuring Mission (TRMM) Lightning Imaging Sensor (LIS). Nowadays the International Space Station (ISS) has LIS installed, which provided the data [2] for this analysis.

The data is in a HDF-4 file format, which is a scientific hierarchical data format used by NASA. The ISS LIS is being analysed by a special algorithm, which uses the individual brightened pixel of the sensor to categorize the events into different groups. For this analysis, the 'lightning' field will be used. The HDF-4 file format is considered outdated, thus a conversion to HDF-5 is needed.

In the end, with the recorded lightnings, the 2020 year's data will be used and will be compared to another dataset (wind) to give insight and explanation to the existence of lightning hotspots on Earth.

2 Analysis

2.1 Preprocessing the data

2.1.1 LIS ISS Data

Generally, even the 'lightning' group in the HDF-5 files contain many fields that is unneeded for the analysis. For us, only the location and the time is needed. Rather then accessing each file every time to gather information, collecting the previously mentioned data into one file is beneficial. This in the end speeds up the analysis of the data set.

Time [s]	Longitude [°]	Latitude [°]
8.520277489147690535e+08	-1.664173583984375e+02	-9.797150611877441e+00
...	...	...

Table 1: The structure of the simplified output. The time field is seconds counted from 1993/01/01 00:00:00.0

There are two type of data sets available on [2]: a Quality and a No Quality controlled version is kept. For this analysis, I will use the No Quality controlled data set. This means that the output of the simple algorithm used to categorize the brightened pixels into different groups will be used.

The sensor has a 6-8km spatial resolution, while it covers Earth's surface from -54° to 54° in latitude and from -180 to 180 in longitude.

2.1.2 Historical Wind Data

This data will be used to explain why these hotspots exists on a given location. This data was provided by [4]. It is a file format, netCDF, and their data is recorded by every day at 4 different times: 00:00, 06:00, 12:00, 18:00. As this source mentions, this dataset should be used for observations only. They recorded the u and v (azimuthal and polar direction projection of the wind vector w) and is measured in m/s.

3 Results

3.1 Locating the hotspots

Using the simplified output, we can quickly get 2D histogram that can be utilized for locating the hotspots. The problem is that each bin usually surrounded by much smaller bins, thus it not that easy to locate these hotspots. I used Gaussian smoothing on the histogram and located that hotspots afterwards.
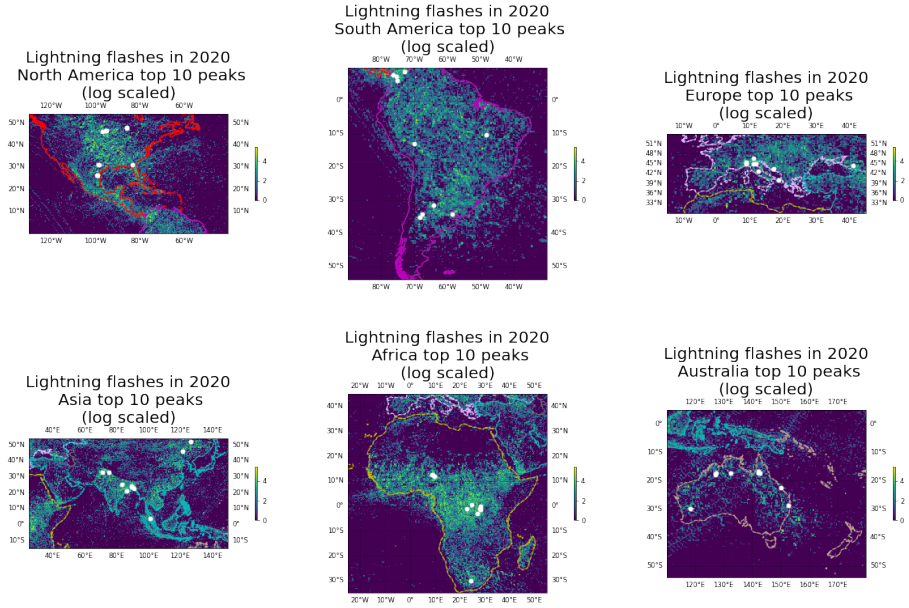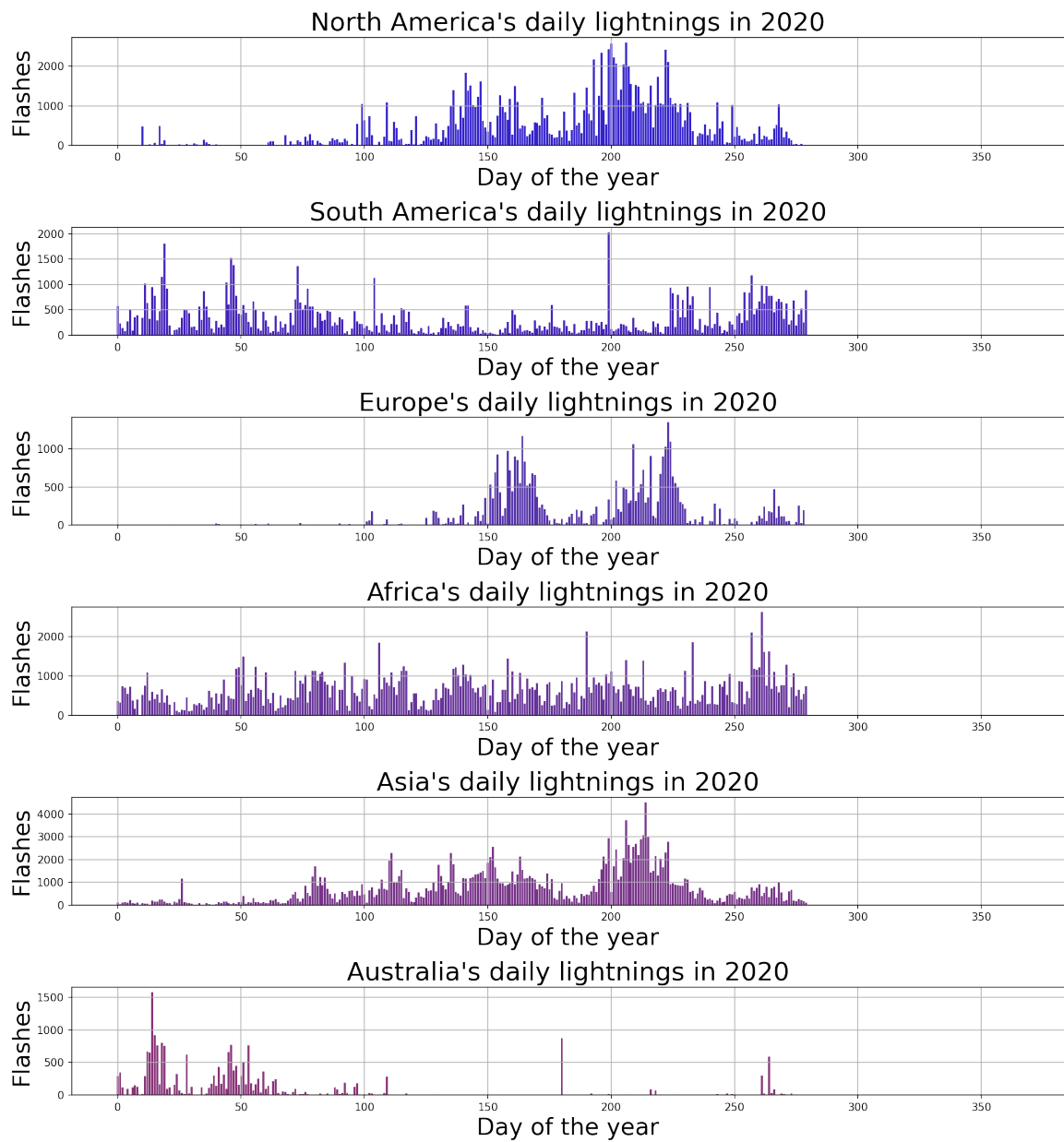

Figure 1: Locating the hotspots. The white dots are the location of the hotspot for each continent.

My assumption is that these locations have higher annual rainfall, and from experience we know that there will be lightnings when it rains, but rain comes with a lower wind speed, thus these areas could have lower wind speeds compared to their surrounding. But the wind speed and direction changes even during the day and due to this, a seasonal analysis is recommended.

North America's daily lightnings in 2020

South America's daily lightnings in 2020

Europe's daily lightnings in 2020

Africa's daily lightnings in 2020

Asia's daily lightnings in 2020
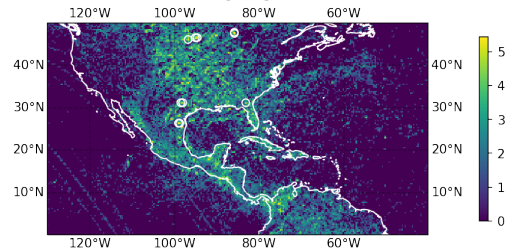
Australia's daily lightnings in 2020

4

With this, we can choose the day that ha the most lightnings. The results are the following (the shown figures are logarithmic scaled):
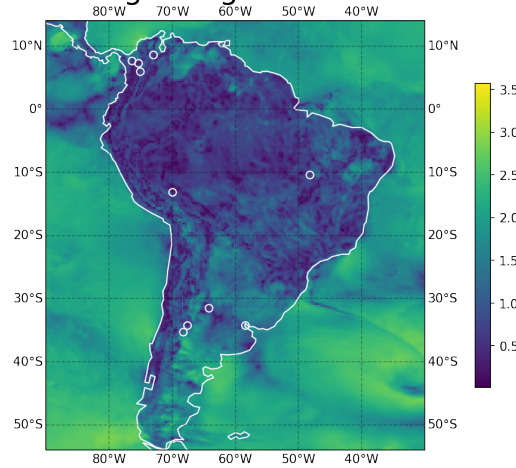
Earth Wind data on the day of
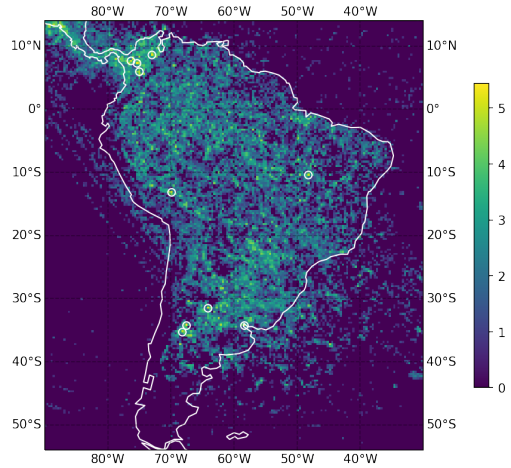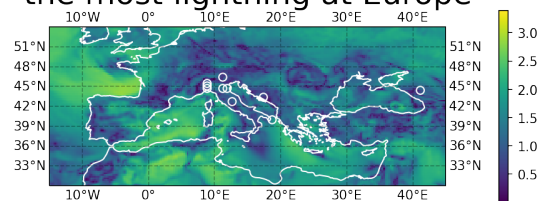the most lightning at North America
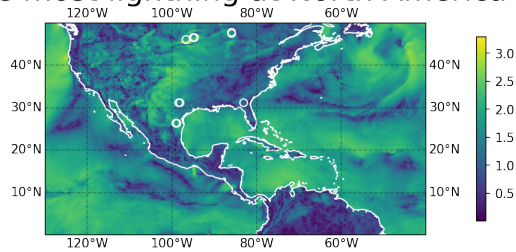
Lightning Flashes at North America
2020

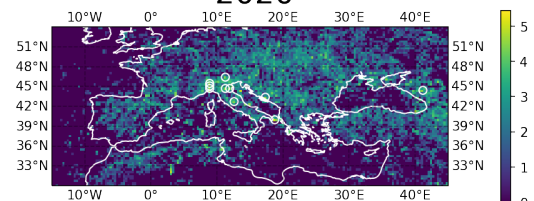Earth Wind data on the day of
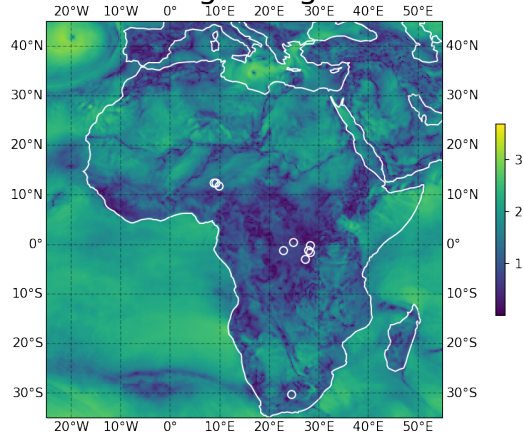the most lightning at South America

Lightning Flashes at South America
2020

Earth Wind data on the day of
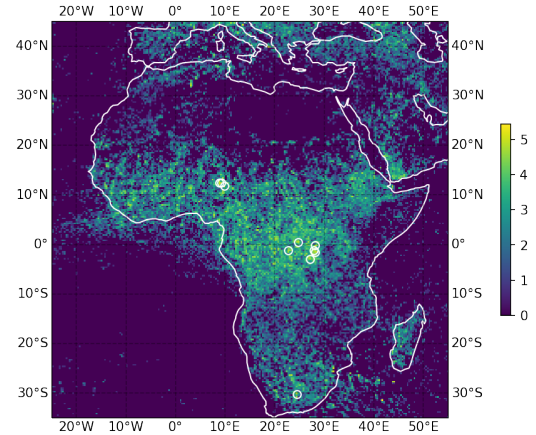the most lightning at Europe
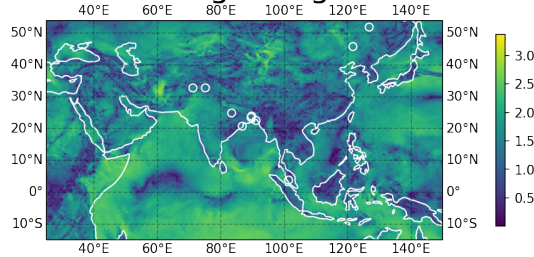
Lightning Flashes at Europe
2020

Earth Wind data on the day of
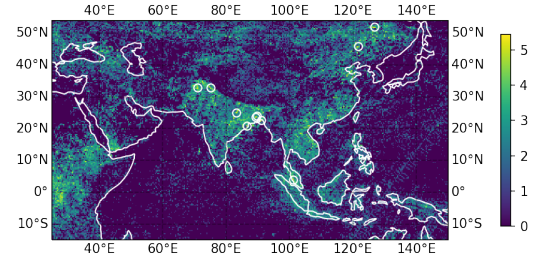the most lightning at Africa
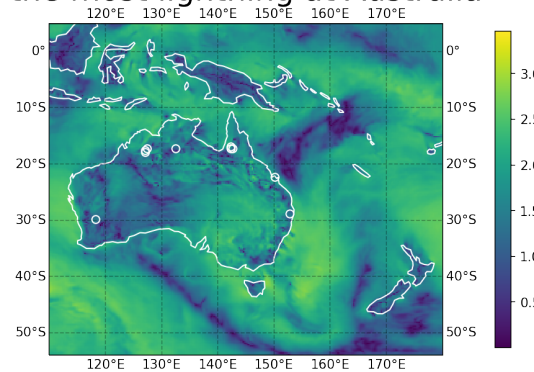

Lightning Flashes at Africa
2020

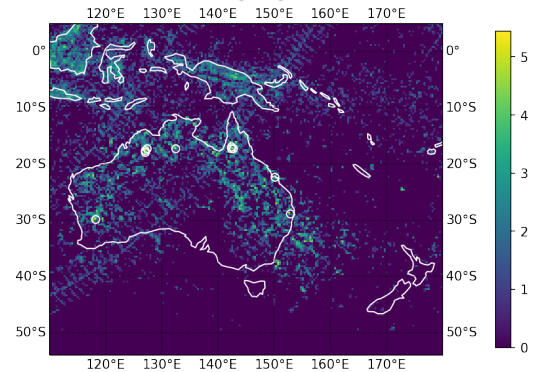Earth Wind data on the day of
the most lightning at Asia

Lightning Flashes at Asia
2020

Earth Wind data on the day of
the most lightning at Australia

Lightning Flashes at Australia
2020

Most of the hotspots does come from a location that has a lower windspeed, which means that my assumption is correct, but not sufficient to determine the location of the hotspot, meaning that more variables may need to give a more precise result.

References

[1] Github repository. https://github.com/AdamGTaylor/ELTE_mod_comp_2021.

[2] LIS ISS Data. https://ghrc.nsstc.nasa.gov/lightning/data/data_lis_iss.html.

[3] Rachel I. Albrecht, Steven J. Goodman, Dennis E. Buechler, Richard J. Blakeslee, and Hugh J. Christian. Where are the lightning hotspots on earth?

[4] Carl A. Mears, Joel Scott, Frank J. Wentz, Lucrezia Ricciardulli, S. Mark Leidner, Ross Hoffman, and Robert Atlas. A near-real-time version of the cross-calibrated multiplatform (ccmp) ocean surface wind velocity data set. https://data.remss.com/ccmp/v02.1.NRT/.