Effect of the Covid-19 pandemic on the air-transportation network

Jorin Graham, Department of Physics

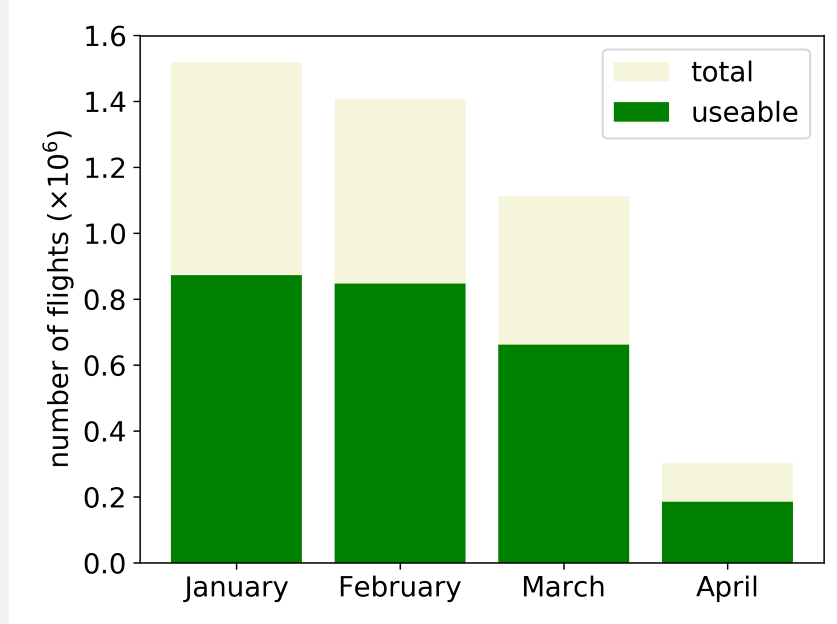
Summary

In order to determine the effect of the Covid-19 pandemic on the air-transportation network, I create air-transportation networks for the months of January and April 2020. There is a clear decrease in the number of flights, especially for moderately-sized airports. However, my analysis failed to unveil any major topological differences between the networks.

Data collection and processing

Data source: Airplanes occasionally transmit information about their position. OpenSky Network is a project to collect and store data from these transmissions. They provide access to cleaned data for the first several months of 2020 which includes the ICAO airport codes of the source and destination airports. I discarded data points that did not report both origin and destination

Network construction: I used airports as nodes and connected two airports with an edge if there was a record of a flight between them. I assigned each edge a weight equal to the number flights over that edge. Information about direction was discarded to produce an undirected network.



Number of flights recorded in the data from OpenSky Network for the first four months of 2020. Only some of the flights (shown in green) had both origin and destination information. This was the data I used to construct the networks.

origin	destination
YMML	YSSY

A sample of the data used to construct the networks.

Key assumptions: The effects of the pandemic on January's network is small while the effects on April's network is large. Any large differences between the two networks are likely due to the pandemic and not to other factors such as seasonal variation.

Some brief metrics

Number of shared airports	2024
Number of shared routes	8173

Most of the airports in April's network also appear in January's network. However, only around 2/3 of the routes in April's network appear in January's network.

	January	April
Number of airports (nodes)	3949	2467
Number of unique routes (edges)	26666	12250
Global clustering coefficient	0.16	0.17
Average path length	3	3

The number of airports and unique routes in April's network are smaller than those in January's network. However, some other global metrics are similar.

Conclusion

It seems unlikely that the Covid-19 pandemic did not majorly influence the structure of the air-transportation network. Analysis of other network features might reveal differences not uncovered here. For example, some initial exploration of the community structure indicated that April's network is more fragmented than January's network.

References

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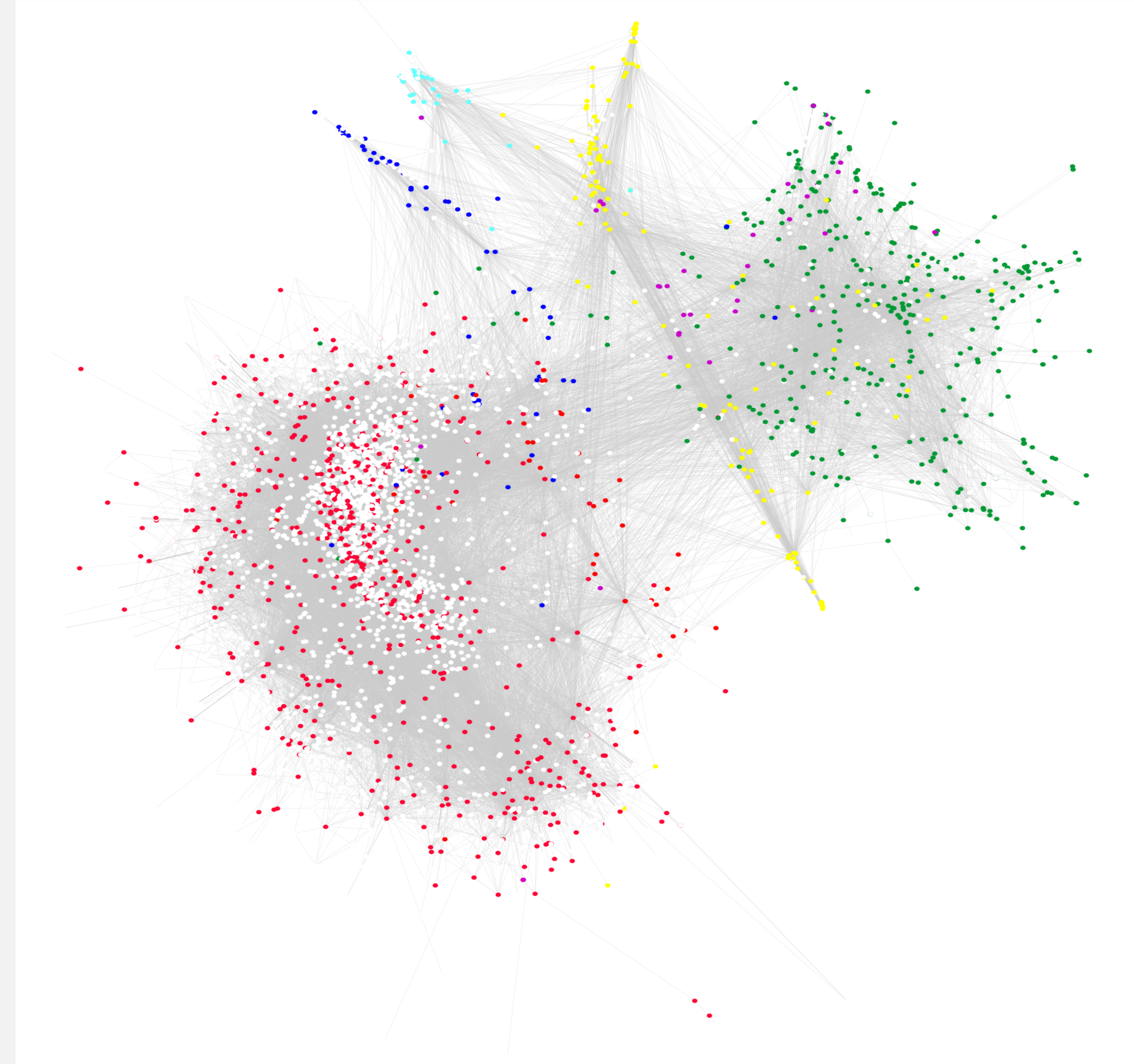
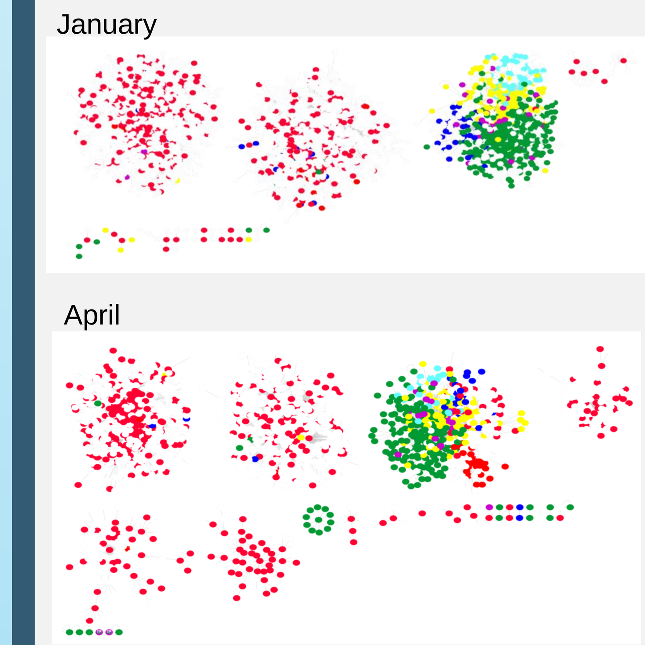
January



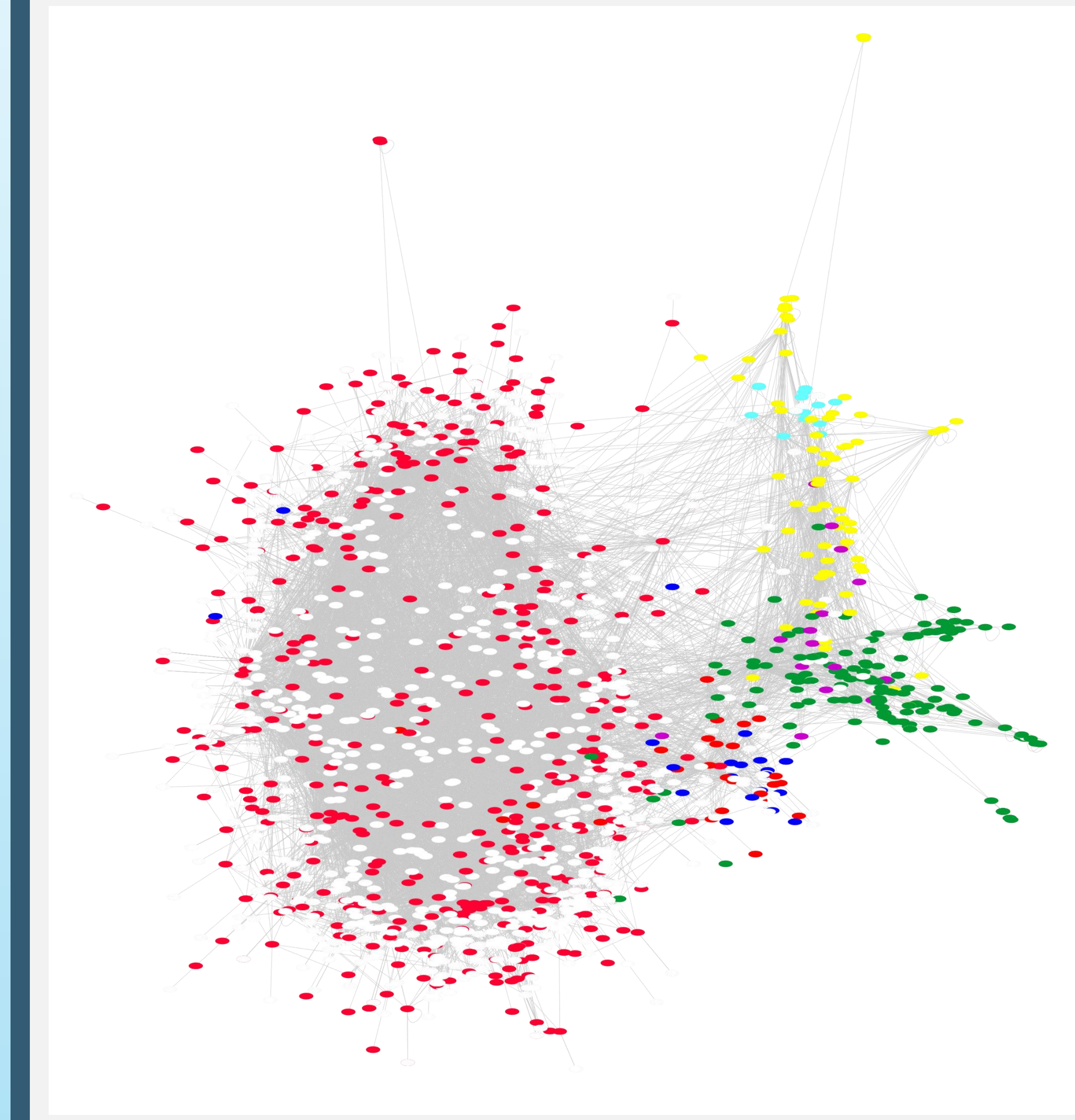
Color code

Red: North America
Green: Europe
Yellow: Asia, Middle East
Dark blue: South America, Central America, Caribbean
Light blue: Australia, New Zealand
Purple: Africa, others
White: No country identification

Communities

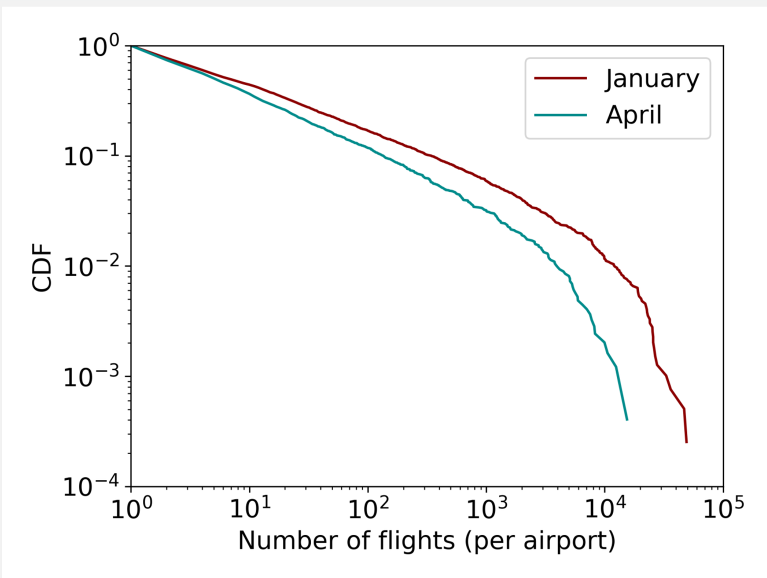


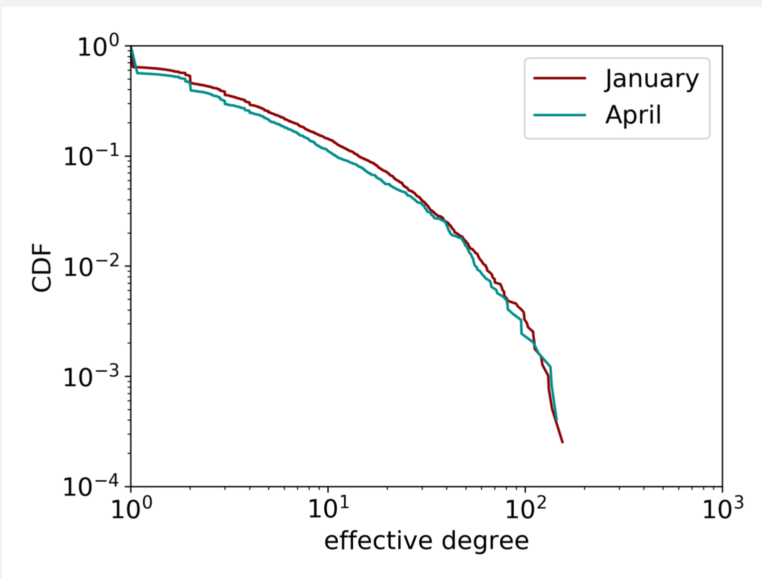
April



Results

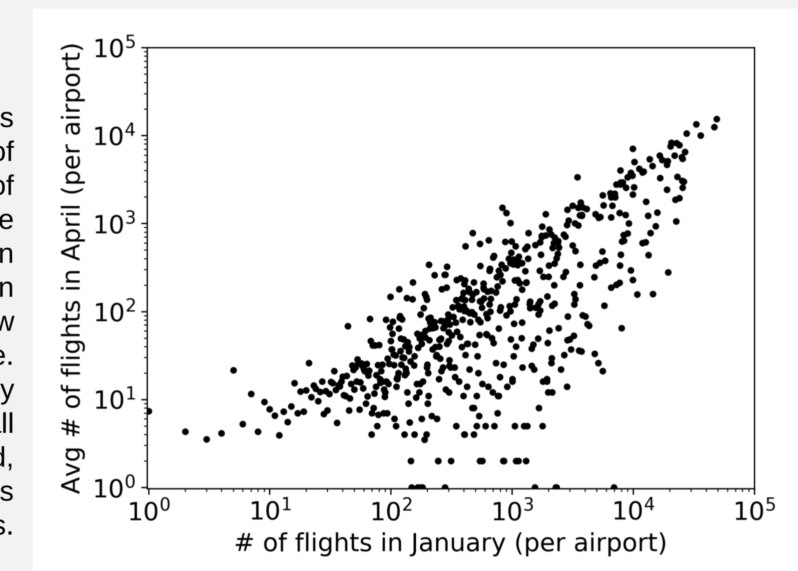
Complementary cumulative weighted degree distribution function. The weighted degree of an airport is the number of flights connecting to that airport. The distribution seems to follow a power law with a cutoff. The exponent of the power law is about 1.5. The distribution for April is slightly steeper than for January, but not significantly different.

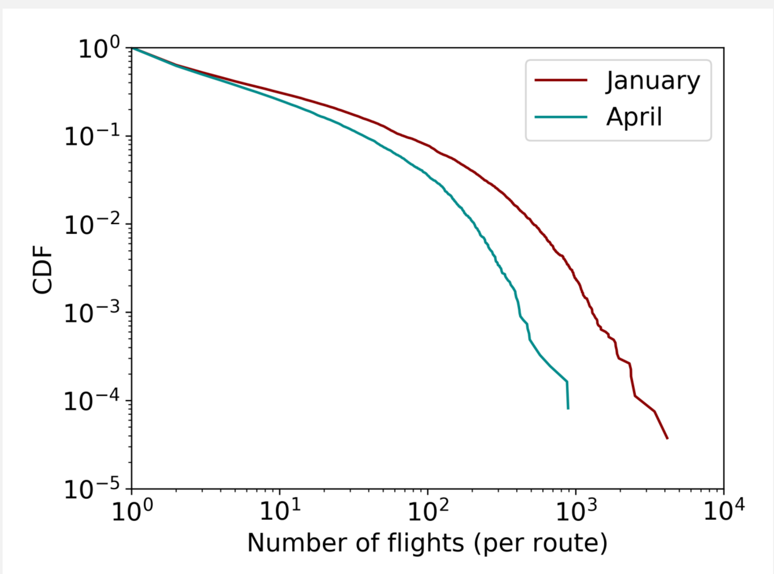




Complementary cumulative effective degree distribution function. The distributions for January and April are very similar.

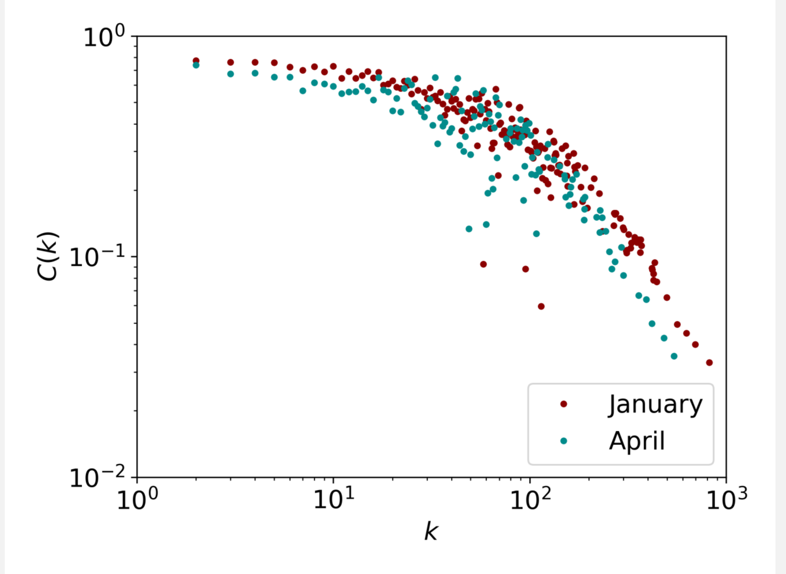
Correlation between number of flights in January and April. For each set of airports with a certain number of flights in January, I found the average number of flights for the same set in April. The correlation displays an upper bound that follows a power law with exponent slightly less than one. However, some airports, especially those of moderate size, fall significantly below this upper bound, indicating a major reduction in flights at some airports.

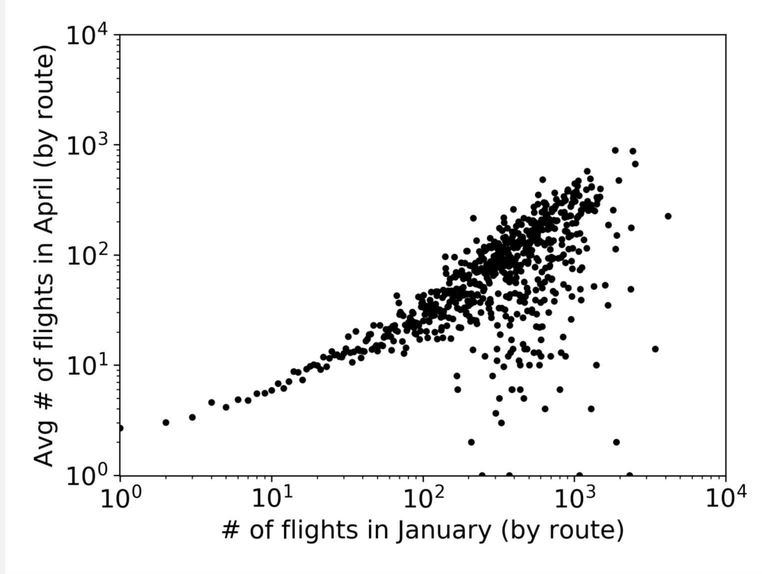




Complementary cumulative edge weight distribution function. The weight of an edge is the number of flights travelling along that edge. The distribution seems to follow a power law with a cutoff. The distribution for April is slightly steeper than for January, but not significantly different.

Clustering coefficient as a function of unweighted degree. The unweighted degree of an airport is the number of routes connecting to the airport. The clustering coefficient functions for January and April are very similar.





Correlation between number of flights in January and April. For each route with a certain number of flights in January, I found the average number of flights for the same set in April. There is a pronounced reduction in the number of flights per route, especially for moderately trafficked routes.