CMSC6950 COURSE PROJECT

WINDROSE APPLICATION

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Windrose Application

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Abstract

Wind rose is a graphic tool to describe the wind speed and direction distribution at a particular location. In this project, wind data of St. John's processed by Numpy and Pandas, wind rose was plotted by Matplotlib. After five different plots were analysed, the result indicated that most wind in St. John's is from northwest and southeast, and the average wind speed is range from 0.05 m/s to 19.62 m/s, which will be useful for environmental research and infrastructure construction.

List of Figures

1.1 An example wind rose (Roubeyrie and Celles, 2018) 1
1.2 URL generation of CSV data file 2
1.3 Project workflow 2

2.1 The first several lines of raw wind data 3
2.2 Dataframe after adjustment 4
2.3 Dataframe with speed on x and y axis respectively 5
2.4 The first several lines of processed data 5

3.1 Wind speed distribution, St. John's, 2019-2020 6
3.2 Wind rose like a stacked histogram with normed results, St. John's, 2019-2020 7
3.3 Another stacked histogram representation, not normed, with bins limits, St. John's, 2019-2020 7
3.4 A wind rose in filled representation, with a controled colormap, St. John's, 2019-2020 8
3.5 A wind rose in filled representation, with contours, St. John's, 2019-2020 8

Contents

1 Introduction **1**
- 1.1 Wind rose . . . 1
- 1.2 Data source . . . 1
- 1.3 Analysis workflow . . . 2

2 Data Management and Analysis **3**
- 2.1 Data process by Pandas . . . 3
  - 2.1.1 Read raw data . . . 3
  - 2.1.2 Adjust data format . . . 3
  - 2.1.3 Generate speed data on x and y axis respectively . . . 4
- 2.2 Remove none and zero values . . . 4

3 Data Visualization **6**
- 3.1 Cartesian coordinate system plot . . . 6
  - 3.1.1 A basic scatter plot with transparency . . . 6
- 3.2 Wind rose plot . . . 6
  - 3.2.1 Wind rose like a stacked histogram with normed results . . . 6
  - 3.2.2 Another stacked histogram representation, not normed . . . 7
  - 3.2.3 A wind rose in filled representation, with a controled colormap . . . 7
  - 3.2.4 A wind rose in filled representation, with contours . . . 8

4 Conclusion **9**

Chapter 1

Introduction

1.1 Wind rose

A wind rose is a graphic tool used by meteorologists to give a succinct view of how wind speed and direction are typically distributed at a particular location. Historically, wind roses were predecessors of the compass rose, as there was no differentiation between a cardinal direction and the wind which blew from such a direction(Wikipedia, 2020).

Using a polar coordinate system of gridding, the frequency of winds over a time period is plotted by wind direction, with color bands showing wind speed ranges. The direction of the longest spoke shows the wind direction with the greatest frequency as shown below.

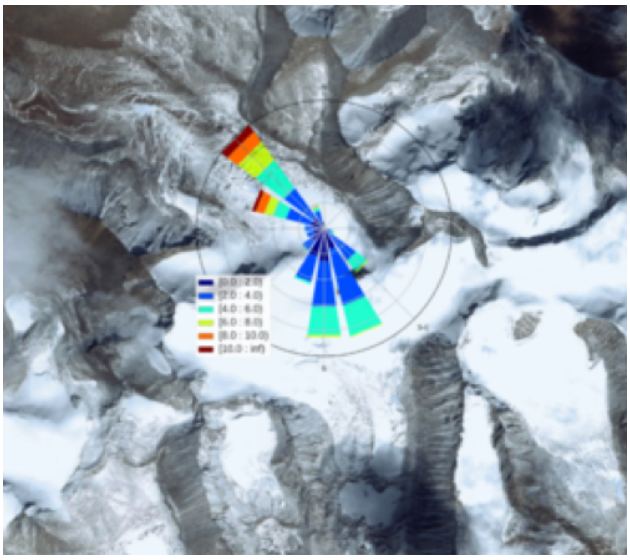

Figure 1.1: An example wind rose (Roubeyrie and Celles, 2018)

1.2 Data source

The wind data of St. John's was obtained directly from the SmartAtlantic Alliance which is an initiative of the Fisheries and Marine Institute of Memorial University of Newfoundland's Centre for Applied Ocean Technology (CTec) and the Centre for Ocean Ventures and Entrepreneurship (COVE) of Halifax.

The URL of CSV data file was generated from their website as the figure shown below.

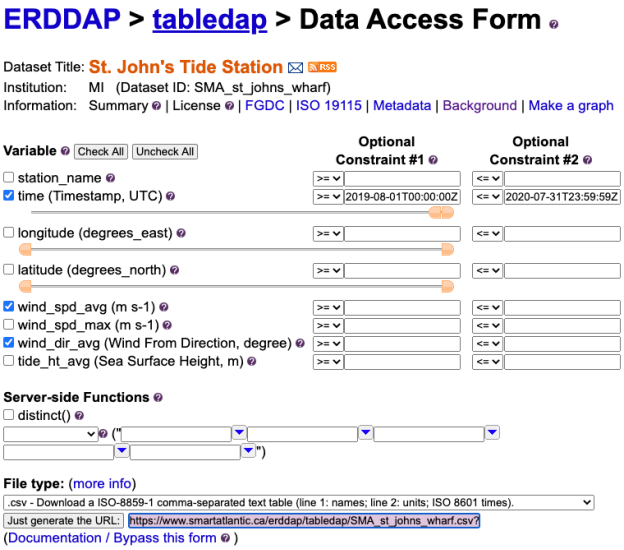

Figure 1.2: URL generation of CSV data file

In this project, the information of timestamp, wind speed and wind direction in the last 365 days (from 1 August 2019 to 31 July 2020) was collected and used to plot wind rose.

1.3 Analysis workflow

This project was implemented by four main steps as shown in the figure below.

After collecting the raw wind data, it was processed by the tools from python package Numpy and Pandas. The details of what processes have been done will be discussed in the next chapter.

The processed wind data was used to implement the visualization and five different graphs were drew with python package Matplotlib tools.

As plotting the graphs, the wind distribution of St. John's reflected from the images was also discussed.

Figure 1.3: Project workflow

Chapter 2

Data Management and Analysis

In this chapter the raw wind data was downloaded, processed and regenerated for plotting.

2.1 Data process by Pandas

2.1.1 Read raw data

The raw data that imported to a dataframe by `pandas.read_csv` from the URL generated before has a size of 44338 rows × 3 columns. The first several lines were shown in figure below.

time	wind_spd_avg	wind_dir_avg
UTC	m s-1	degree
2020-07-01T00:00:00Z	0.679688	290.47
2020-07-01T00:01:00Z	0.637097	222.557
2020-07-01T00:02:00Z	0.578125	207.777
2020-07-01T00:03:00Z	0.545806	204.016
2020-07-01T00:04:01Z	0.977188	161.322
2020-07-01T00:05:01Z	1.04781	225.731
2020-07-01T00:06:01Z	0.5625	202.616
2020-07-01T00:07:01Z	0.468125	184.795
2020-07-01T00:08:01Z	0.712258	186.317
2020-07-01T00:09:01Z	1.00281	232.78
2020-07-01T00:10:01Z	0.581875	205.769
2020-07-01T00:11:01Z	1.05097	241.721

Figure 2.1: The first several lines of raw wind data

2.1.2 Adjust data format

The right two columns were renamed to “speed” and “direction” by `pandas.DataFrame.rename` and the left one column was set to the index of the dataframe by `pandas.DataFrame.set_index`. Then the second row

which is the unit was removed by `pandas.DataFrame.drop`. The dataframe type was converted to float64 by `pandas.DataFrame.astype` for the following calculations.

After the adjustment, the dataframe was more clear as shown in figure below.

time	speed	direction
2020-07-01T00:00:00Z	0.679688	290.470
2020-07-01T00:01:00Z	0.637097	222.557
2020-07-01T00:02:00Z	0.578125	207.777
2020-07-01T00:03:00Z	0.545806	204.016
2020-07-01T00:04:01Z	0.977188	161.322
...	...	...
2020-07-31T23:55:28Z	2.592190	147.109
2020-07-31T23:56:29Z	2.531870	150.540
2020-07-31T23:57:29Z	2.435940	153.876
2020-07-31T23:58:29Z	2.241870	156.218
2020-07-31T23:59:29Z	2.308750	158.763

Figure 2.2: Dataframe after adjustment

2.1.3 Generate speed data on x and y axis respectively

The wind speed on x and y axis was calculated by the following functions:

$$Speed_x = speed \times \sin(direction \times \pi/180)$$
$$Speed_y = speed \times \cos(direction \times \pi/180)$$

After the generation, there were two more columns in the dataframe as shown in figure 2.3 below.

2.2 Remove none and zero values

A python function called `clean_df` was generated to remove the none and zero values. After that, a new CSV file was generated by `pandas.DataFrame.to_csv` as shown in figure 2.4 below.

time	speed	direction	speed_x	speed_y
2019-08-01T00:00:00Z	1.24719	329.669	-0.629824	1.076478
2019-08-01T00:01:01Z	1.70781	309.479	-1.318186	1.085818
2019-08-01T00:02:00Z	1.29188	309.120	-1.002274	0.815107
2019-08-01T00:03:00Z	1.26156	312.453	-0.930818	0.851534
2019-08-01T00:04:01Z	2.24500	352.753	-0.283200	2.227066
...	...	...	...	...
2020-07-31T23:55:28Z	2.59219	147.109	1.407669	-2.176675
2020-07-31T23:56:29Z	2.53187	150.540	1.245214	-2.204497
2020-07-31T23:57:29Z	2.43594	153.876	1.072582	-2.187092
2020-07-31T23:58:29Z	2.24187	156.218	0.904052	-2.051505
2020-07-31T23:59:29Z	2.30875	158.763	0.836291	-2.151963

Figure 2.3: Dataframe with speed on x and y axis respectively

time	speed	direction	speed_x	speed_y
2019-08-01T00:00:00Z	1.24719	329.669	-0.6298243297825940	1.076477686584310
2019-08-01T00:01:01Z	1.70781	309.479	-1.3181862412512300	1.0858176778243900
2019-08-01T00:02:00Z	1.29188	309.12	-1.0022743672811500	0.8151073715107530
2019-08-01T00:03:00Z	1.26156	312.453	-0.9308184277629640	0.851534314127671
2019-08-01T00:04:01Z	2.245	352.753	-0.28320007719808200	2.2270659434051300
2019-08-01T00:05:01Z	2.48406	347.019	-0.5579892523968590	2.4205788724620400
2019-08-01T00:06:01Z	2.62438	326.72	-1.440078747724010	2.193978938995010
2019-08-01T00:07:01Z	2.86844	316.006	-1.992369768265790	2.0635917086721700
2019-08-01T00:08:01Z	3.81156	306.208	-3.0754633004790100	2.251558376104600
2019-08-01T00:09:01Z	2.34156	336.586	-0.930470681294521	2.14875022858668
2019-08-01T00:10:02Z	2.15156	318.62	-1.4222887097739700	1.6144055437372300
2019-08-01T00:11:02Z	2.52063	348.289	-0.5116256024646310	2.4681602135604400
2019-08-01T00:12:02Z	1.39313	327.49	-0.7487332601199210	1.174823264193470
2019-08-01T00:13:02Z	2.4671	321.362	-1.5404517715864600	1.9270679151021500
2019-08-01T00:14:02Z	3.39094	318.243	-2.2582738374057700	2.5295599140737100

Figure 2.4: The first several lines of processed data

Chapter 3

Data Visualization

In this chapter five plots were analysed in order to summary the wind distribution of St. John's.

3.1 Cartesian coordinate system plot

3.1.1 A basic scatter plot with transparency

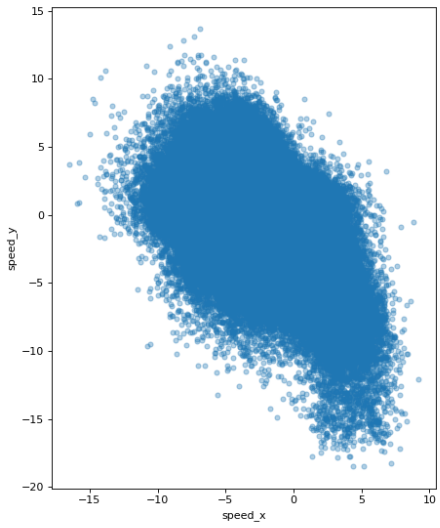

Figure 3.1: Wind speed distribution, St. John's, 2019-2020

The figure above indicated that the wind speed on X axis ranged from about -15 m/s to 8 m/s, on Y axis ranged from about -17 m/s to 12 m/s in the last whole year.

3.2 Wind rose plot

3.2.1 Wind rose like a stacked histogram with normed results

The wind rose below indicated that most wind directions are northwest and southeast and account for over 50 percent.

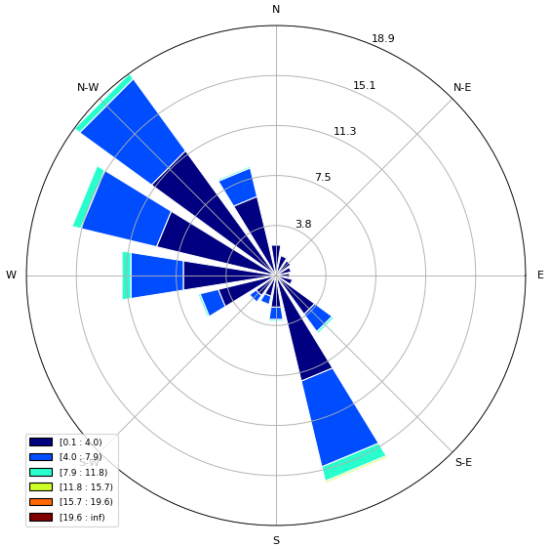

Figure 3.2: Wind rose like a stacked histogram with normed results, St. John's, 2019-2020

3.2.2 Another stacked histogram representation, not normed

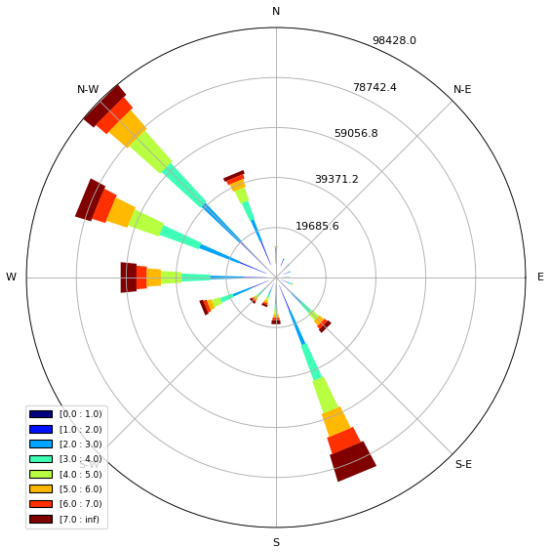

Figure 3.3: Another stacked histogram representation, not normed, with bins limits, St. John's, 2019-2020

For the second figure above, the bins limit was set from 0 to 7 which is 8 in total.

3.2.3 A wind rose in filled representation, with a controled colormap

Compared to the two figures above, this wind rose is more consecutive. Wind speed information can be obtain from any point in this figure.

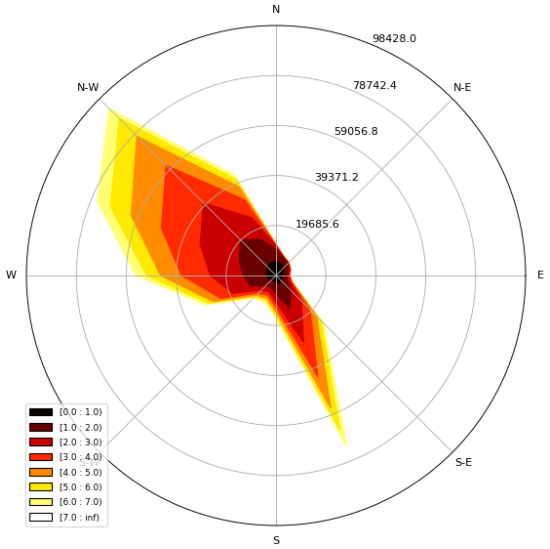

Figure 3.4: A wind rose in filled representation, with a controled colormap, St. John's, 2019-2020

3.2.4 A wind rose in filled representation, with contours

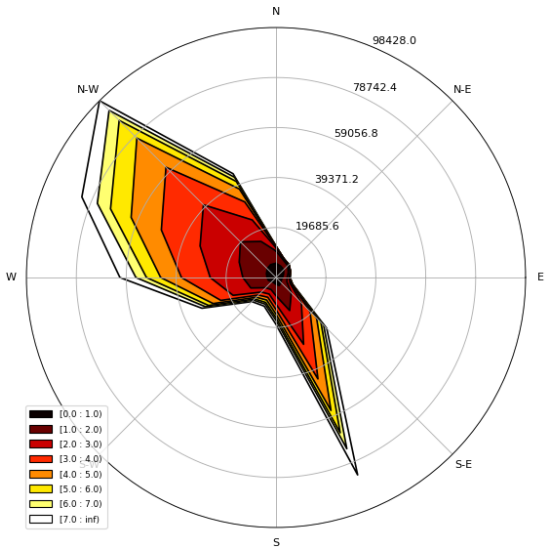

Figure 3.5: A wind rose in filled representation, with contours, St. John's, 2019-2020

After adding the contours, the wind rose was visualized better.

Chapter 4

Conclusion

The graph results showed that more than 50 percent wind in St. John's was from northwest and southeast in the last year. The maximum average wind speed was 19.62 m/s, while the minimum average wind speed is 0.05 m/s. The wind direction and speed may change with season changed which will be explored in the future studies.

Bibliography

Roubeyrie, L. & Celles, S. (2018). Windrose: A python matplotlib, numpy library to manage wind and pollution data, draw windrose. *Journal of Open Source Software*, *3*(29), 268. doi:10.21105/joss.00268

Wikipedia. (2020). Wind rose. https://en.wikipedia.org.