Project1_Assg

July 2, 2021

[694]:
```
import numpy as np
import requests as reqs
import pandas as pd
import bs4
from bs4 import BeautifulSoup as soup
import datetime as dt
import matplotlib.pyplot as plt
import matplotlib.dates as pltdate
```

1 Part 1: Data scraping and preparating

2 Step 1: scrape your competitor's Data

[695]:
```
#(2) Use reqs to get the url
sp_we_liv = reqs.get("https://cmsc320.github.io/files/top-50-solar-flares.html")
```

[696]:
```
#(3 & 4) Extract the text, read and parse the data using soup
sp_we_liv_txt = soup(sp_we_liv.text, "html.parser")
```

[697]:
```
#(5) Use prettify() to view the content and find the appropriate table
print(sp_we_liv_txt.prettify()[:256])
```

```
<!DOCTYPE html>
<html class="fontawesome-i2svg-active fontawesome-i2svg-complete" lang="en">
 <head>
  <meta content="text/html; charset=utf-8" http-equiv="content-type"/>
  <title>
   Top 50 solar flares | Solar activity | SpaceWeatherLive.com
  </title>
```

[698]:
```
#(6) Use find() to save the aforementioned table as a variable
sp_we_liv_table = sp_we_liv_txt.find("table", {"class":"table table-striped␣
↪table-responsive-md"})
print(sp_we_liv_table.text)
```

```
RegionStartMaximumEnd1X28+2003/11/04048619:2919:5320:06 MovieView
archive2X20+2001/04/02939321:3221:5122:03 MovieView
```

archive3X17.2+2003/10/28048609:5111:1011:24 MovieView
archive4X17+2005/09/07080817:1717:4018:03 MovieView
archive5X14.42001/04/15941513:1913:5013:55 MovieView
archive6X102003/10/29048620:3720:4921:01 MovieView
archive7X9.41997/11/06810011:4911:5512:01 MovieView
archive8X9.32017/09/06267311:5312:0212:10 MovieView
archive9X92006/12/05093010:1810:3510:45 MovieView
archive10X8.32003/11/02048617:0317:2517:39 MovieView
archive11X8.22017/09/10267315:3516:0616:31 MovieView
archive12X7.12005/01/20072006:3607:0107:26 MovieView
archive13X6.92011/08/09126307:4808:0508:08 MovieView
archive14X6.52006/12/06093018:2918:4719:00 MovieView
archive15X6.22005/09/09080819:1320:0420:36 MovieView
archive16X6.22001/12/13973314:2014:3014:35 MovieView
archive17X5.72000/07/14907710:0310:2410:43 MovieView
archive18X5.62001/04/06941519:1019:2119:31 MovieView
archive19X5.42012/03/07142900:0200:2400:40 MovieView
archive20X5.42005/09/08080820:5221:0621:17 MovieView
archive21X5.42003/10/23048608:1908:3508:49 MovieView
archive22X5.32001/08/25959116:2316:4517:04 MovieView
archive23X4.92014/02/25199000:3900:4901:03 MovieView
archive24X4.91998/08/18830722:1022:1922:28View
archive25X4.82002/07/23003900:1800:3500:47 MovieView
archive26X42000/11/26923616:3416:4816:56 MovieView
archive27X3.92003/11/03048809:4309:5510:19 MovieView
archive28X3.91998/08/19830721:3521:4521:50View
archive29X3.82005/01/17072006:5909:5210:07 MovieView
archive30X3.71998/11/22838406:3006:4206:49 MovieView
archive31X3.62005/09/09080809:4209:5910:08 MovieView
archive32X3.62004/07/16064913:4913:5514:01 MovieView
archive33X3.62003/05/28036500:1700:2700:39 MovieView
archive34X3.42006/12/13093002:1402:4002:57 MovieView
archive35X3.42001/12/28976720:0220:4521:32 MovieView
archive36X3.32013/11/05189022:0722:1222:15 MovieView
archive37X3.32002/07/20003921:0421:3021:54 MovieView
archive38X3.31998/11/28839504:5405:5206:13 MovieView
archive39X3.22013/05/14174800:0001:1101:20 MovieView
archive40X3.12014/10/24219221:0721:4122:13 MovieView
archive41X3.12002/08/24006900:4901:1201:31 MovieView
archive42X32002/07/15003019:5920:0820:14 MovieView
archive43X2.82013/05/13174815:4816:0516:16 MovieView
archive44X2.82001/12/11973307:5808:0808:14 MovieView
archive45X2.81998/08/18830708:1408:2408:32View
archive46X2.72015/05/05233922:0522:1122:15 MovieView
archive47X2.72003/11/03048801:0901:3001:45 MovieView
archive48X2.71998/05/06821007:5808:0908:20 MovieView
archive49X2.62005/01/15072022:2523:0223:31 MovieView
archive50X2.62001/09/24963209:3210:3811:09 MovieView archive

[699]:
```
#(7) Use pandas to read in the HTML file to SWL table
sp_we_liv = pd.read_html(sp_we_liv_table.prettify(), flavor="bs4")[0]
sp_we_liv.head(10)
```

[699]:
```
   Unnamed: 0 Unnamed: 1  Unnamed: 2  Region  Start Maximum    End  \
0           1       X28+  2003/11/04     486  19:29   19:53  20:06
1           2       X20+  2001/04/02    9393  21:32   21:51  22:03
2           3     X17.2+  2003/10/28     486  09:51   11:10  11:24
3           4       X17+  2005/09/07     808  17:17   17:40  18:03
4           5      X14.4  2001/04/15    9415  13:19   13:50  13:55
5           6        X10  2003/10/29     486  20:37   20:49  21:01
6           7       X9.4  1997/11/06    8100  11:49   11:55  12:01
7           8       X9.3  2017/09/06    2673  11:53   12:02  12:10
8           9         X9  2006/12/05     930  10:18   10:35  10:45
9          10       X8.3  2003/11/02     486  17:03   17:25  17:39

           Unnamed: 7
0  Movie  View archive
1  Movie  View archive
2  Movie  View archive
3  Movie  View archive
4  Movie  View archive
5  Movie  View archive
6  Movie  View archive
7  Movie  View archive
8  Movie  View archive
9  Movie  View archive
```

[700]:
```
#(8) Set the names of the SWL table
sp_we_liv = sp_we_liv.rename(columns={'Unnamed: 0':'rank', 'Unnamed: 1':
 ↪'x_class',                                   'Unnamed: 2':'date',␣
 ↪'Region':'region',
                                        'Start':'start_time', 'Maximum':
 ↪'max_time',                                  'End':'end_time',␣
 ↪'Unnamed: 7':'movie'})
sp_we_liv.head(10)
```

[700]:
```
   rank x_class        date  region start_time max_time end_time  \
0     1    X28+  2003/11/04     486      19:29    19:53    20:06
1     2    X20+  2001/04/02    9393      21:32    21:51    22:03
2     3  X17.2+  2003/10/28     486      09:51    11:10    11:24
3     4    X17+  2005/09/07     808      17:17    17:40    18:03
4     5   X14.4  2001/04/15    9415      13:19    13:50    13:55
5     6     X10  2003/10/29     486      20:37    20:49    21:01
6     7    X9.4  1997/11/06    8100      11:49    11:55    12:01
7     8    X9.3  2017/09/06    2673      11:53    12:02    12:10
8     9      X9  2006/12/05     930      10:18    10:35    10:45
```

```
9    10     X8.3  2003/11/02     486       17:03     17:25     17:39

                  movie
0  Movie  View archive
1  Movie  View archive
2  Movie  View archive
3  Movie  View archive
4  Movie  View archive
5  Movie  View archive
6  Movie  View archive
7  Movie  View archive
8  Movie  View archive
9  Movie  View archive
```

3 Step 2: Tidy the top 50 solar flare data

[701]:
```python
# (1) Drop the last column of the table
sp_we_liv = sp_we_liv.drop('movie', axis=1)
sp_we_liv.head(10)
```

[701]:

	rank	x_class	date	region	start_time	max_time	end_time
0	1	X28+	2003/11/04	486	19:29	19:53	20:06
1	2	X20+	2001/04/02	9393	21:32	21:51	22:03
2	3	X17.2+	2003/10/28	486	09:51	11:10	11:24
3	4	X17+	2005/09/07	808	17:17	17:40	18:03
4	5	X14.4	2001/04/15	9415	13:19	13:50	13:55
5	6	X10	2003/10/29	486	20:37	20:49	21:01
6	7	X9.4	1997/11/06	8100	11:49	11:55	12:01
7	8	X9.3	2017/09/06	2673	11:53	12:02	12:10
8	9	X9	2006/12/05	930	10:18	10:35	10:45
9	10	X8.3	2003/11/02	486	17:03	17:25	17:39

[702]:
```python
#(2 & 3) Use datetime import to combine and update the value
# date--->start_time
# date--->max_time
# date--->end_time
# into three datetime columns
start_time_col = []
max_time_col = []
end_time_col = []

# for loop in table
for index, row in sp_we_liv.iterrows():
    new_date = row['date'].split('/')
    date = dt.date(int(new_date[0]), int(new_date[1]), int(new_date[2]))
```

```
    #satrt_time column combine
    # date--->start_time
    new_start_time = row['start_time'].split(':')
    start_time = dt.time(int(new_start_time[0]), int(new_start_time[1]))

    # max_time column combine
    # date--->max_time
    new_maximum_time = row['max_time'].split(':')
    maximum_time = dt.time(int(new_maximum_time[0]), int(new_maximum_time[1]))

    # end_time_column combine
    # end_time_col = []
    new_end_time = row['end_time'].split(':')
    end_time = dt.time(int(new_end_time[0]), int(new_end_time[1]))

    #append the combine data into the array
    start_time_col.append(dt.datetime.combine(date, start_time))
    max_time_col.append(dt.datetime.combine(date, maximum_time))
    end_time_col.append(dt.datetime.combine(date, end_time))

# drop and insert the new ones
#from end_time to start_time to date--->max_time
sp_we_liv = sp_we_liv.drop('end_time', axis=1).drop('max_time', axis=1).
 ↪drop('start_time', axis=1).drop('date', axis=1)
sp_we_liv.insert(loc=2, column='end_datetime', value=end_time_col)
sp_we_liv.insert(loc=2, column='max_datetime', value=max_time_col)
sp_we_liv.insert(loc=2, column='start_datetime', value=start_time_col)

#print the first 10 rows
sp_we_liv.head(10)
```

[702]:

```
   rank x_class      start_datetime        max_datetime        end_datetime  \
0     1    X28+ 2003-11-04 19:29:00 2003-11-04 19:53:00 2003-11-04 20:06:00
1     2    X20+ 2001-04-02 21:32:00 2001-04-02 21:51:00 2001-04-02 22:03:00
2     3  X17.2+ 2003-10-28 09:51:00 2003-10-28 11:10:00 2003-10-28 11:24:00
3     4    X17+ 2005-09-07 17:17:00 2005-09-07 17:40:00 2005-09-07 18:03:00
4     5   X14.4 2001-04-15 13:19:00 2001-04-15 13:50:00 2001-04-15 13:55:00
5     6     X10 2003-10-29 20:37:00 2003-10-29 20:49:00 2003-10-29 21:01:00
6     7    X9.4 1997-11-06 11:49:00 1997-11-06 11:55:00 1997-11-06 12:01:00
7     8    X9.3 2017-09-06 11:53:00 2017-09-06 12:02:00 2017-09-06 12:10:00
8     9      X9 2006-12-05 10:18:00 2006-12-05 10:35:00 2006-12-05 10:45:00
9    10    X8.3 2003-11-02 17:03:00 2003-11-02 17:25:00 2003-11-02 17:39:00

  region
0    486
1   9393
2    486
```

```
3      808
4     9415
5      486
6     8100
7     2673
8      930
9      486
```

[703]:
```
# (4) Set region code '-' as NaN
sp_we_liv = sp_we_liv.replace('-', np.NaN)
sp_we_liv.head(10)
```

[703]:
```
   rank x_class      start_datetime        max_datetime        end_datetime  \
0     1    X28+ 2003-11-04 19:29:00 2003-11-04 19:53:00 2003-11-04 20:06:00
1     2    X20+ 2001-04-02 21:32:00 2001-04-02 21:51:00 2001-04-02 22:03:00
2     3  X17.2+ 2003-10-28 09:51:00 2003-10-28 11:10:00 2003-10-28 11:24:00
3     4    X17+ 2005-09-07 17:17:00 2005-09-07 17:40:00 2005-09-07 18:03:00
4     5   X14.4 2001-04-15 13:19:00 2001-04-15 13:50:00 2001-04-15 13:55:00
5     6     X10 2003-10-29 20:37:00 2003-10-29 20:49:00 2003-10-29 21:01:00
6     7    X9.4 1997-11-06 11:49:00 1997-11-06 11:55:00 1997-11-06 12:01:00
7     8    X9.3 2017-09-06 11:53:00 2017-09-06 12:02:00 2017-09-06 12:10:00
8     9      X9 2006-12-05 10:18:00 2006-12-05 10:35:00 2006-12-05 10:45:00
9    10    X8.3 2003-11-02 17:03:00 2003-11-02 17:25:00 2003-11-02 17:39:00

   region
0     486
1    9393
2     486
3     808
4    9415
5     486
6    8100
7    2673
8     930
9     486
```

4 Step 3: Scrape the NASA data

[704]:
```
# Scrape the data from the NASA url
nasa_data = reqs.get('http://www.hcbravo.org/IntroDataSci/misc/waves_type2.
↪html')
print(nasa_data.text[:400])
```

```
<html><body>
<h2>Wind/WAVES type II bursts and CMEs</h2>
<a href="waves_type2_description.htm">A Brief Description</a>
<pre>
```

```
NOTE: List includes DH type II bursts observed by Wind spacecraft,
but after STEREO launch on Oct 2006 the start and end times and
frequencies of bursts are determined using both Wind and STEREO
observations

================================================================
```

[705]:

```python
#(Task 1) Use soup to read from the nasa url and parse
nasa_txt = soup(nasa_data.text, "html.parser")
print(nasa_txt.prettify()[:147])
```

```
<html>
 <body>
  <h2>
   Wind/WAVES type II bursts and CMEs
  </h2>
  <a href="waves_type2_description.htm">
   A Brief Description
  </a>
  <pre>
```

[706]:

```python
# Show this beautiful table with Dh type II, Flare, CME with Plots
# by using find()
nasa_html = nasa_txt.find("pre")
print(nasa_html.getText()[:995])
```

```
NOTE: List includes DH type II bursts observed by Wind spacecraft,
but after STEREO launch on Oct 2006 the start and end times and
frequencies of bursts are determined using both Wind and STEREO
observations

=================================================================================
=================
                DH Type II                             Flare                    CME
-----------------------------------------   -----------------
--------------------------   Plots
Start             End           Frequency     Loc    NOAA  Imp     Date   Time CPA
Width  Spd
(1)        (2)    (3)    (4)    (5)     (6)     (7)     (8)   (9)     (10)   (11)  (12)
(13) (14)   (15)
=================================================================================
=================
1997/04/01 14:00 04/01 14:15  8000   4000   S25E16  8026 M1.3   04/01 15:18   74
79  312   PHTX
1997/04/07 14:30 04/07 17:30 11000   1000   S28E19  8027 C6.8   04/07 14:27 Halo
360  878   PHTX
```

[707]:
```
# Using splitline to get the text and show the next 10 rows from previous table
nasa_line = nasa_html.getText().splitlines()
nasa_line = nasa_line[12:-2]
nasa_line[0:5]
```

[707]:
```
['1997/04/01 14:00 04/01 14:15  8000  4000   S25E16  8026 M1.3   04/01 15:18
74   79  312   PHTX',
 '1997/04/07 14:30 04/07 17:30 11000  1000   S28E19  8027 C6.8   04/07 14:27
Halo  360  878   PHTX',
 '1997/05/12 05:15 05/14 16:00 12000    80   N21W08  8038 C1.3   05/12 05:30
Halo  360  464   PHTX',
 '1997/05/21 20:20 05/21 22:00  5000   500   N05W12  8040 M1.3   05/21 21:00
263  165  296   PHTX',
 '1997/09/23 21:53 09/23 22:16  6000  2000   S29E25  8088 C1.4   09/23 22:02
133  155  712   PHTX']
```

[708]:
```
# Use split to see what will be in each column of nasa table
# Separate each line of text into a data row
#like satrt_date, start_time, end_date...
nasa_line[0].split()
```

[708]:
```
['1997/04/01',
 '14:00',
 '04/01',
 '14:15',
 '8000',
 '4000',
 'S25E16',
 '8026',
 'M1.3',
 '04/01',
 '15:18',
 '74',
 '79',
 '312',
 'PHTX']
```

[709]:
```
#(1 & 2) Create a DataFrame at this point so be use later
# Chose appropriate names for columns
nasa = pd.DataFrame()
lines = []
for line in nasa_line: # for loop into table
    lines.append(line.split()[:14]) #append then to nasa for 14 lines split
nasa = nasa.append(lines)
nasa.columns = ["Start Date", "Start Time", "End Date", "End Time", "Start␣
↪Frequency",
```

```
                 "End Frequency", "Flare Location", "Flare Region", "Flare␣
↪Classification",
                 "CME Date", "CME Time", "CME Angle", "CME Width", "CME Speed"]
#Show table
nasa.head(10)
```

[709]:

	Start Date	Start Time	End Date	End Time	Start Frequency	End Frequency
0	1997/04/01	14:00	04/01	14:15	8000	4000
1	1997/04/07	14:30	04/07	17:30	11000	1000
2	1997/05/12	05:15	05/14	16:00	12000	80
3	1997/05/21	20:20	05/21	22:00	5000	500
4	1997/09/23	21:53	09/23	22:16	6000	2000
5	1997/11/03	05:15	11/03	12:00	14000	250
6	1997/11/03	10:30	11/03	11:30	14000	5000
7	1997/11/04	06:00	11/05	04:30	14000	100
8	1997/11/06	12:20	11/07	08:30	14000	100
9	1997/11/27	13:30	11/27	14:00	14000	7000

	Flare Location	Flare Region	Flare Classification	CME Date	CME Time
0	S25E16	8026	M1.3	04/01	15:18
1	S28E19	8027	C6.8	04/07	14:27
2	N21W08	8038	C1.3	05/12	05:30
3	N05W12	8040	M1.3	05/21	21:00
4	S29E25	8088	C1.4	09/23	22:02
5	S20W13	8100	C8.6	11/03	05:28
6	S16W21	8100	M4.2	11/03	11:11
7	S14W33	8100	X2.1	11/04	06:10
8	S18W63	8100	X9.4	11/06	12:10
9	N17E63	8113	X2.6	11/27	13:56

	CME Angle	CME Width	CME Speed
0	74	79	312
1	Halo	360	878
2	Halo	360	464
3	263	165	296
4	133	155	712
5	240	109	227
6	233	122	352
7	Halo	360	785
8	Halo	360	1556
9	98	91	441

5 Step 4: Tidy up the nasa table

[710]:
```
nasa = pd.DataFrame()
lines = []
for line in nasa_line: # for loop into table
    lines.append(line.split()[:15]) #append then to nasa for 14 lines split
nasa = nasa.append(lines)
nasa.columns = ["Start Date", "Start Time", "End Date", "End Time", "Start␣
↪Frequency",
                "End Frequency", "Flare Location", "Flare Region", "Flare␣
↪Classification",
                "CME Date", "CME Time", "CME Angle", "CME Width", "CME Speed",␣
↪"plot"]
nasa.head(10)
```

[710]:

	Start Date	Start Time	End Date	End Time	Start Frequency	End Frequency
0	1997/04/01	14:00	04/01	14:15	8000	4000
1	1997/04/07	14:30	04/07	17:30	11000	1000
2	1997/05/12	05:15	05/14	16:00	12000	80
3	1997/05/21	20:20	05/21	22:00	5000	500
4	1997/09/23	21:53	09/23	22:16	6000	2000
5	1997/11/03	05:15	11/03	12:00	14000	250
6	1997/11/03	10:30	11/03	11:30	14000	5000
7	1997/11/04	06:00	11/05	04:30	14000	100
8	1997/11/06	12:20	11/07	08:30	14000	100
9	1997/11/27	13:30	11/27	14:00	14000	7000

	Flare Location	Flare Region	Flare Classification	CME Date	CME Time
0	S25E16	8026	M1.3	04/01	15:18
1	S28E19	8027	C6.8	04/07	14:27
2	N21W08	8038	C1.3	05/12	05:30
3	N05W12	8040	M1.3	05/21	21:00
4	S29E25	8088	C1.4	09/23	22:02
5	S20W13	8100	C8.6	11/03	05:28
6	S16W21	8100	M4.2	11/03	11:11
7	S14W33	8100	X2.1	11/04	06:10
8	S18W63	8100	X9.4	11/06	12:10
9	N17E63	8113	X2.6	11/27	13:56

	CME Angle	CME Width	CME Speed	plot
0	74	79	312	PHTX
1	Halo	360	878	PHTX
2	Halo	360	464	PHTX
3	263	165	296	PHTX
4	133	155	712	PHTX
5	240	109	227	PHTX
6	233	122	352	PHTX

```
7       Halo       360        785  PHTX
8       Halo       360       1556  PHTX
9         98        91        441  PHTX
```

[711]:

```
#(1) Recode any missing entries as NaN
nasa = nasa.replace(['------', '----', '--/--', '--:--'], np.NAN)
nasa['Flare Classification'] = nasa['Flare Classification'].replace('FILA', np.
 ↪NAN)
nasa.head(10)
```

[711]:

```
   Start Date Start Time End Date End Time Start Frequency End Frequency  \
0  1997/04/01      14:00    04/01    14:15            8000          4000
1  1997/04/07      14:30    04/07    17:30           11000          1000
2  1997/05/12      05:15    05/14    16:00           12000            80
3  1997/05/21      20:20    05/21    22:00            5000           500
4  1997/09/23      21:53    09/23    22:16            6000          2000
5  1997/11/03      05:15    11/03    12:00           14000           250
6  1997/11/03      10:30    11/03    11:30           14000          5000
7  1997/11/04      06:00    11/05    04:30           14000           100
8  1997/11/06      12:20    11/07    08:30           14000           100
9  1997/11/27      13:30    11/27    14:00           14000          7000

  Flare Location Flare Region Flare Classification CME Date CME Time  \
0         S25E16         8026                 M1.3    04/01    15:18
1         S28E19         8027                 C6.8    04/07    14:27
2         N21W08         8038                 C1.3    05/12    05:30
3         N05W12         8040                 M1.3    05/21    21:00
4         S29E25         8088                 C1.4    09/23    22:02
5         S20W13         8100                 C8.6    11/03    05:28
6         S16W21         8100                 M4.2    11/03    11:11
7         S14W33         8100                 X2.1    11/04    06:10
8         S18W63         8100                 X9.4    11/06    12:10
9         N17E63         8113                 X2.6    11/27    13:56

  CME Angle CME Width CME Speed  plot
0        74        79       312  PHTX
1      Halo       360       878  PHTX
2      Halo       360       464  PHTX
3       263       165       296  PHTX
4       133       155       712  PHTX
5       240       109       227  PHTX
6       233       122       352  PHTX
7      Halo       360       785  PHTX
8      Halo       360      1556  PHTX
9        98        91       441  PHTX
```

[712]:
```python
# (2) Create a new column that indicates if a row corresponds to a halo flares␣
↪or not
nasa.insert(loc=15, column='Halo', value=np.where(nasa['CME Angle'] == 'Halo',␣
↪True, False))
# a replace Halo entries in the cme_angle column as NaN
nasa = nasa.replace('Halo', np.NaN)
#show this beautiful table
nasa.head(10)
```

[712]:

	Start Date	Start Time	End Date	End Time	Start Frequency	End Frequency
0	1997/04/01	14:00	04/01	14:15	8000	4000
1	1997/04/07	14:30	04/07	17:30	11000	1000
2	1997/05/12	05:15	05/14	16:00	12000	80
3	1997/05/21	20:20	05/21	22:00	5000	500
4	1997/09/23	21:53	09/23	22:16	6000	2000
5	1997/11/03	05:15	11/03	12:00	14000	250
6	1997/11/03	10:30	11/03	11:30	14000	5000
7	1997/11/04	06:00	11/05	04:30	14000	100
8	1997/11/06	12:20	11/07	08:30	14000	100
9	1997/11/27	13:30	11/27	14:00	14000	7000

	Flare Location	Flare Region	Flare Classification	CME Date	CME Time
0	S25E16	8026	M1.3	04/01	15:18
1	S28E19	8027	C6.8	04/07	14:27
2	N21W08	8038	C1.3	05/12	05:30
3	N05W12	8040	M1.3	05/21	21:00
4	S29E25	8088	C1.4	09/23	22:02
5	S20W13	8100	C8.6	11/03	05:28
6	S16W21	8100	M4.2	11/03	11:11
7	S14W33	8100	X2.1	11/04	06:10
8	S18W63	8100	X9.4	11/06	12:10
9	N17E63	8113	X2.6	11/27	13:56

	CME Angle	CME Width	CME Speed	plot	Halo
0	74	79	312	PHTX	False
1	NaN	360	878	PHTX	True
2	NaN	360	464	PHTX	True
3	263	165	296	PHTX	False
4	133	155	712	PHTX	False
5	240	109	227	PHTX	False
6	233	122	352	PHTX	False
7	NaN	360	785	PHTX	True
8	NaN	360	1556	PHTX	True
9	98	91	441	PHTX	False

[713]:
```python
#(3) Create a new column that indicate if width is as lower bound and remove
# any non-numeric part of width column
```

```
nasa.insert(loc=16, column='Lower Bound', value=[isinstance(x, str) and x[0] ==
 ↪'>' for x in nasa['CME Width']])
nasa['CME Width'] = [x[1:] if isinstance(x, str) and x[0] == '>' else x for x
 ↪in nasa['CME Width']]
nasa.head(10)
```

[713]:

```
  Start Date Start Time End Date End Time Start Frequency End Frequency  \
0 1997/04/01      14:00    04/01    14:15            8000          4000
1 1997/04/07      14:30    04/07    17:30           11000          1000
2 1997/05/12      05:15    05/14    16:00           12000            80
3 1997/05/21      20:20    05/21    22:00            5000           500
4 1997/09/23      21:53    09/23    22:16            6000          2000
5 1997/11/03      05:15    11/03    12:00           14000           250
6 1997/11/03      10:30    11/03    11:30           14000          5000
7 1997/11/04      06:00    11/05    04:30           14000           100
8 1997/11/06      12:20    11/07    08:30           14000           100
9 1997/11/27      13:30    11/27    14:00           14000          7000

 Flare Location Flare Region Flare Classification CME Date CME Time  \
0        S25E16         8026                 M1.3    04/01    15:18
1        S28E19         8027                 C6.8    04/07    14:27
2        N21W08         8038                 C1.3    05/12    05:30
3        N05W12         8040                 M1.3    05/21    21:00
4        S29E25         8088                 C1.4    09/23    22:02
5        S20W13         8100                 C8.6    11/03    05:28
6        S16W21         8100                 M4.2    11/03    11:11
7        S14W33         8100                 X2.1    11/04    06:10
8        S18W63         8100                 X9.4    11/06    12:10
9        N17E63         8113                 X2.6    11/27    13:56

 CME Angle CME Width CME Speed  plot   Halo  Lower Bound
0        74        79       312  PHTX  False        False
1       NaN       360       878  PHTX   True        False
2       NaN       360       464  PHTX   True        False
3       263       165       296  PHTX  False        False
4       133       155       712  PHTX  False        False
5       240       109       227  PHTX  False        False
6       233       122       352  PHTX  False        False
7       NaN       360       785  PHTX   True        False
8       NaN       360      1556  PHTX   True        False
9        98        91       441  PHTX  False        False
```

[714]:

```
#(4) Combine date and time columns for
#date & Time----> start_dateTime
#date & Time----> end_dateTime
#date & Time----> cme_dateTime
nasa_start_times = []
```

```
nasa_end_times = []
nasa_cme_times = []
# split the Start date & Time
for index, row in nasa.iterrows():
    start_time_str = row['Start Time'].split(':')
    start_date_str = row['Start Date'].split('/')
    #date & Time----> start_dateTime combine
    start_time = dt.time(int(start_time_str[0]), int(start_time_str[1]))
    start_date = dt.date(int(start_date_str[0]), int(start_date_str[1]),␣
 ↪int(start_date_str[2]))
    #date & Time----> end_dateTime combine
    end_time_str = row['End Time'].split(':')
    end_date_str = row['End Date'].split('/')
    end_date = dt.date(int(start_date_str[0]), int(end_date_str[0]),␣
 ↪int(end_date_str[1]))

    if int(end_time_str[0]) >= 0:
        end_time_str[0] = int(end_time_str[0]) % 24
        end_date + dt.timedelta(days=1)

    end_time = dt.time(int(end_time_str[0]), int(end_time_str[1]))
    #appending start and end time n date
    nasa_start_times.append(dt.datetime.combine(start_date, start_time))
    nasa_end_times.append(dt.datetime.combine(end_date, end_time))

    if isinstance(row['CME Time'], str) and isinstance(row['CME Date'], str):
        cme_time_str = row['CME Time'].split(':')
        cme_date_str = row['CME Date'].split('/')
        #date & Time----> cme_dateTime combine
        cme_time = dt.time(int(cme_time_str[0]), int(cme_time_str[1]))
        cme_date = dt.date(int(start_date_str[0]), int(cme_date_str[0]),␣
 ↪int(cme_date_str[0]))
        #appending cme date n time
        nasa_cme_times.append(dt.datetime.combine(cme_date, cme_time))
    else:
        nasa_cme_times.append(np.NAN)
#droping old columns and inserting the combine ones
nasa = nasa.drop('End Time', axis=1).drop('Start Time', axis=1).drop('End␣
 ↪Date', axis=1).drop('Start Date', axis=1)
nasa = nasa.drop('CME Time', axis=1).drop('CME Date', axis=1)
nasa.insert(loc=3, column='CME DateTime', value=nasa_cme_times)
nasa.insert(loc=0, column='End DateTime', value=nasa_end_times)
nasa.insert(loc=0, column='Start DateTime', value=nasa_start_times)
#show the beautiful table
nasa.head(1)
```

[714]:
```
       Start DateTime        End DateTime Start Frequency End Frequency  \
0 1997-04-01 14:00:00 1997-04-01 14:15:00            8000          4000

  Flare Location        CME DateTime Flare Region Flare Classification  \
0         S25E16 1997-04-04 15:18:00         8026                 M1.3

  CME Angle CME Width CME Speed  plot   Halo  Lower Bound
0        74        79       312  PHTX  False        False
```

[715]:
```python
#The output of this step should looks like this
nasa_tidy = nasa.rename(columns={'Start DateTime':'start_datetime',
                                  'End DateTime':'end_datetime',
 ↪                                                    'Start Frequency':
 ↪'start_frequency',
                                  'End Frequency':'end_frequency',
                                  'Flare Location':'flare_location',
                                  'Flare Region':'flare_region',
                                  'Flare Classification':'importance',
                                  'CME DateTime':'cme_datetime',
                                  'CME Angle':'cpa', 'CME Width':'width', 'CME
 ↪Speed':'speed',
                                  'Halo':'is_halo', 'Lower Bound':
 ↪'width_lower_bound'
                                  })
nasa_tidy.head(10)
```

[715]:
```
       start_datetime        end_datetime start_frequency end_frequency  \
0 1997-04-01 14:00:00 1997-04-01 14:15:00            8000          4000
1 1997-04-07 14:30:00 1997-04-07 17:30:00           11000          1000
2 1997-05-12 05:15:00 1997-05-14 16:00:00           12000            80
3 1997-05-21 20:20:00 1997-05-21 22:00:00            5000           500
4 1997-09-23 21:53:00 1997-09-23 22:16:00            6000          2000
5 1997-11-03 05:15:00 1997-11-03 12:00:00           14000           250
6 1997-11-03 10:30:00 1997-11-03 11:30:00           14000          5000
7 1997-11-04 06:00:00 1997-11-05 04:30:00           14000           100
8 1997-11-06 12:20:00 1997-11-07 08:30:00           14000           100
9 1997-11-27 13:30:00 1997-11-27 14:00:00           14000          7000

  flare_location        cme_datetime flare_region importance  cpa width speed  \
0         S25E16 1997-04-04 15:18:00         8026       M1.3   74    79   312
1         S28E19 1997-04-04 14:27:00         8027       C6.8  NaN   360   878
2         N21W08 1997-05-05 05:30:00         8038       C1.3  NaN   360   464
3         N05W12 1997-05-05 21:00:00         8040       M1.3  263   165   296
4         S29E25 1997-09-09 22:02:00         8088       C1.4  133   155   712
5         S20W13 1997-11-11 05:28:00         8100       C8.6  240   109   227
6         S16W21 1997-11-11 11:11:00         8100       M4.2  233   122   352
7         S14W33 1997-11-11 06:10:00         8100       X2.1  NaN   360   785
```

```
8         S18W63 1997-11-11 12:10:00         8100        X9.4  NaN   360  1556
9         N17E63 1997-11-11 13:56:00         8113        X2.6   98    91   441

   plot  is_halo  width_lower_bound
0  PHTX    False              False
1  PHTX     True              False
2  PHTX     True              False
3  PHTX    False              False
4  PHTX    False              False
5  PHTX    False              False
6  PHTX    False              False
7  PHTX     True              False
8  PHTX     True              False
9  PHTX    False              False
```

6 Part 2: Analysis

7 Question 1: Replication

[716]:
```
# The top 50 solar flare base on their classification using data fron nasa
# Use their magnitude
def magnitude(x):
    if isinstance(x, float) and np.isnan(x):
        return 0

    #Remove non alphanumerical component from data
    if x[-1] == '+':
        x = x[:-1]

    #Calculate magnitude, ex. X4.5 -> 4.5*10^4
    return (10**({'A':0,'B':1,'C':2,'M':3,'X':4}[x[0]]))*float(x[1:])

#The last 50 rows of the sorted data represent the 50 largest flares by␣
↪magnitude.
# pip install -U pandas (to be able to use key)
nasa_top_sf = nasa.sort_values(by=['Flare Classification'], key=lambda x: x.
↪map(magnitude)).tail(50)
#show table
nasa_top_sf.head(10)
```

[716]:
```
          Start DateTime        End DateTime Start Frequency End Frequency  \
49  1999-10-14 09:10:00 1999-10-14 10:00:00           14000          4000
191 2002-07-18 07:55:00 2002-07-18 08:45:00           14000          1500
102 2000-11-24 22:24:00 2000-11-24 22:36:00            4000          3000
104 2000-11-25 19:00:00 2000-11-25 19:35:00            6000          2000
287 2005-01-17 09:25:00 2005-01-17 16:00:00           14000            30
```

```
100 2000-11-24 05:10:00 2000-11-24 15:00:00           14000             100
127 2001-04-12 10:20:00 2001-04-12 10:40:00           14000            7000
276 2004-11-07 16:25:00 2004-11-08 20:00:00           14000              60
362 2011-09-06 22:30:00 2011-09-07 15:40:00           16000             150
421 2013-10-25 15:08:00 2013-10-25 22:32:00           16000             200

    Flare Location        CME DateTime Flare Region Flare Classification  \
49          N11E32 1999-10-10 09:26:00         8731                 X1.8
191         N19W30 2002-07-07 08:06:00        10030                 X1.8
102         N21W14 2000-11-11 22:06:00         9236                 X1.8
104         N20W23 2000-11-11 19:31:00         9236                 X1.9
287         N15W25 2005-01-01 09:30:00        10720                 X2.0
100         N20W05 2000-11-11 05:30:00         9236                 X2.0
127         S19W43 2001-04-04 10:31:00         9415                 X2.0
276         N09W17 2004-11-11 16:54:00        10696                 X2.0
362         N14W18 2011-09-09 23:05:00        11283                 X2.1
421         S06E69 2013-10-10 15:12:00        11882                 X2.1

    CME Angle CME Width CME Speed  plot  Halo  Lower Bound
49        NaN       360      1250  PHTX  True        False
191       NaN       360      1099  PHTX  True        False
102       NaN       360      1005  PHTX  True        False
104       NaN       360       671  PHTX  True        False
287       NaN       360      2094  PHTX  True        False
100       NaN       360      1289  PHTX  True        False
127       NaN       360      1184  PHTX  True        False
276       NaN       360      1759  PHTX  True        False
362       NaN       360       575  PHTX  True        False
421       NaN       360      1081  PHTX  True        False
```

[717]:

```
# Recall the SWL table
sp_we_liv.head(10)
```

[717]:

```
   rank x_class      start_datetime        max_datetime        end_datetime  \
0     1    X28+ 2003-11-04 19:29:00 2003-11-04 19:53:00 2003-11-04 20:06:00
1     2    X20+ 2001-04-02 21:32:00 2001-04-02 21:51:00 2001-04-02 22:03:00
2     3  X17.2+ 2003-10-28 09:51:00 2003-10-28 11:10:00 2003-10-28 11:24:00
3     4    X17+ 2005-09-07 17:17:00 2005-09-07 17:40:00 2005-09-07 18:03:00
4     5   X14.4 2001-04-15 13:19:00 2001-04-15 13:50:00 2001-04-15 13:55:00
5     6     X10 2003-10-29 20:37:00 2003-10-29 20:49:00 2003-10-29 21:01:00
6     7    X9.4 1997-11-06 11:49:00 1997-11-06 11:55:00 1997-11-06 12:01:00
7     8    X9.3 2017-09-06 11:53:00 2017-09-06 12:02:00 2017-09-06 12:10:00
8     9      X9 2006-12-05 10:18:00 2006-12-05 10:35:00 2006-12-05 10:45:00
9    10    X8.3 2003-11-02 17:03:00 2003-11-02 17:25:00 2003-11-02 17:39:00

   region
0     486
```

```
1    9393
2     486
3     808
4    9415
5     486
6    8100
7    2673
8     930
9     486
```

8 Interpretation of nasa_top_sf and the sp_we_liv table

The magnitude from the SpaceWeatherLive(SWL) is quite significant. Compare to the ones from NASA I can say that SWL magnitudes are smaller than NASA's

9 Question 2: Inetgration

Use of three aspects to see if a flare exist in both SWL and NASA A flare is function closely matched if there exists an entry in nasa table the given flare begins within 4 hours and flare has magnitude +-10% and and also shares its region data with the nasa entry.

[718]:
```
#A close enough match is tuple function of
# a possible match, the number of criteria
def close_enough(swl_row):
    matches = []
    #for loop in reach the nasa_top_sf elem
    for i, row in nasa_top_sf.iterrows():
        n = (abs((row[0]-swl_row[2]).total_seconds()) < 14400)*1 + \
        (abs(np.log10(magnitude(row[7])/magnitude(swl_row[1]))) < np.log10(1.
 ↪1))*1 + \
        (int(row[6]) % 10000 == int(swl_row[5]))*1

        if n >= 2:
            matches.append((i, n))

    matches.sort(key=lambda x: x[1], reverse=True)
    #if match then return the list
    #else return -1
    if len(matches) == 0:
        return -1
    else:
        return matches

matched = [close_enough(row) for i, row in sp_we_liv.iterrows()]
#insert match into the table
sp_we_liv.insert(loc=6, column='Matched', value=matched)
```

```
sp_we_liv.head(10)
```

[718]:

```
   rank x_class      start_datetime         max_datetime         end_datetime  \
0     1    X28+ 2003-11-04 19:29:00 2003-11-04 19:53:00 2003-11-04 20:06:00
1     2    X20+ 2001-04-02 21:32:00 2001-04-02 21:51:00 2001-04-02 22:03:00
2     3  X17.2+ 2003-10-28 09:51:00 2003-10-28 11:10:00 2003-10-28 11:24:00
3     4    X17+ 2005-09-07 17:17:00 2005-09-07 17:40:00 2005-09-07 18:03:00
4     5   X14.4 2001-04-15 13:19:00 2001-04-15 13:50:00 2001-04-15 13:55:00
5     6     X10 2003-10-29 20:37:00 2003-10-29 20:49:00 2003-10-29 21:01:00
6     7    X9.4 1997-11-06 11:49:00 1997-11-06 11:55:00 1997-11-06 12:01:00
7     8    X9.3 2017-09-06 11:53:00 2017-09-06 12:02:00 2017-09-06 12:10:00
8     9      X9 2006-12-05 10:18:00 2006-12-05 10:35:00 2006-12-05 10:45:00
9    10    X8.3 2003-11-02 17:03:00 2003-11-02 17:25:00 2003-11-02 17:39:00

   region     Matched
0     486  [(242, 3)]
1    9393  [(119, 3)]
2     486  [(234, 3)]
3     808          -1
4    9415  [(128, 3)]
5     486  [(235, 3)]
6    8100    [(8, 3)]
7    2673          -1
8     930  [(330, 3)]
9     486  [(238, 3)]
```

[719]:

```
# For each of the top 50 solar flares in the SpaceWeatherLive data
# find the best matching row from the NASA data
best_match = [-1 if isinstance(x, int) else x[0][0] for x in␣
 ↪sp_we_liv['Matched']]
sp_we_liv.insert(loc=7, column='Best Match', value=best_match)
sp_we_liv.head(10)
```

[719]:

```
   rank x_class      start_datetime         max_datetime         end_datetime  \
0     1    X28+ 2003-11-04 19:29:00 2003-11-04 19:53:00 2003-11-04 20:06:00
1     2    X20+ 2001-04-02 21:32:00 2001-04-02 21:51:00 2001-04-02 22:03:00
2     3  X17.2+ 2003-10-28 09:51:00 2003-10-28 11:10:00 2003-10-28 11:24:00
3     4    X17+ 2005-09-07 17:17:00 2005-09-07 17:40:00 2005-09-07 18:03:00
4     5   X14.4 2001-04-15 13:19:00 2001-04-15 13:50:00 2001-04-15 13:55:00
5     6     X10 2003-10-29 20:37:00 2003-10-29 20:49:00 2003-10-29 21:01:00
6     7    X9.4 1997-11-06 11:49:00 1997-11-06 11:55:00 1997-11-06 12:01:00
7     8    X9.3 2017-09-06 11:53:00 2017-09-06 12:02:00 2017-09-06 12:10:00
8     9      X9 2006-12-05 10:18:00 2006-12-05 10:35:00 2006-12-05 10:45:00
9    10    X8.3 2003-11-02 17:03:00 2003-11-02 17:25:00 2003-11-02 17:39:00

   region     Matched  Best Match
0     486  [(242, 3)]         242
```

```
1    9393  [(119, 3)]         119
2     486  [(234, 3)]         234
3     808          -1          -1
4    9415  [(128, 3)]         128
5     486  [(235, 3)]         235
6    8100    [(8, 3)]           8
7    2673          -1          -1
8     930  [(330, 3)]         330
9     486  [(238, 3)]         238
```

[720]:

```
#checking for a possible ties break
#they are all unique so no ties break
sp_we_liv['Best Match'].value_counts()
```

[720]:

```
-1      18
 289     1
 444     1
 123     1
 106     1
 376     1
 119     1
 202     1
 242     1
 240     1
 239     1
 238     1
 235     1
 234     1
 360     1
 290     1
 162     1
 19      1
 128     1
 286     1
 405     1
 404     1
 83      1
 144     1
 334     1
 333     1
 223     1
 330     1
 137     1
 8       1
 195     1
 194     1
 319     1
```

```
Name: Best Match, dtype: int64
```

[721]:
```
#Ranking the top 50 in nasa table base on their flare classification column
ranks = [np.NAN] * len(nasa.index)
for i, row in sp_we_liv.iterrows():
    if not row[7] == -1:
        ranks[row[7]] = row[0]

nasa.insert(loc=13, column='Rank', value=ranks)
# ranking by flare classification
nasa_top_sf = nasa.sort_values(by=['Flare Classification'], key=lambda x: x.
↪map(magnitude)).tail(50)

nasa_top_sf.head(10)
```

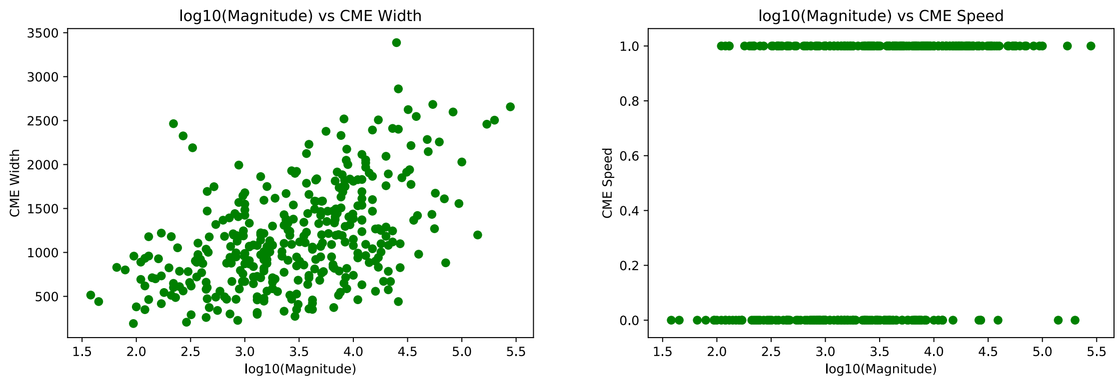
[721]:
```
          Start DateTime        End DateTime Start Frequency End Frequency  \
49  1999-10-14 09:10:00 1999-10-14 10:00:00           14000          4000
191 2002-07-18 07:55:00 2002-07-18 08:45:00           14000          1500
102 2000-11-24 22:24:00 2000-11-24 22:36:00            4000          3000
104 2000-11-25 19:00:00 2000-11-25 19:35:00            6000          2000
287 2005-01-17 09:25:00 2005-01-17 16:00:00           14000            30
100 2000-11-24 05:10:00 2000-11-24 15:00:00           14000           100
127 2001-04-12 10:20:00 2001-04-12 10:40:00           14000          7000
276 2004-11-07 16:25:00 2004-11-08 20:00:00           14000            60
362 2011-09-06 22:30:00 2011-09-07 15:40:00           16000           150
421 2013-10-25 15:08:00 2013-10-25 22:32:00           16000           200

    Flare Location        CME DateTime Flare Region Flare Classification  \
49          N11E32 1999-10-10 09:26:00         8731                 X1.8
191         N19W30 2002-07-07 08:06:00        10030                 X1.8
102         N21W14 2000-11-11 22:06:00         9236                 X1.8
104         N20W23 2000-11-11 19:31:00         9236                 X1.9
287         N15W25 2005-01-01 09:30:00        10720                 X2.0
100         N20W05 2000-11-11 05:30:00         9236                 X2.0
127         S19W43 2001-04-04 10:31:00         9415                 X2.0
276         N09W17 2004-11-11 16:54:00        10696                 X2.0
362         N14W18 2011-09-09 23:05:00        11283                 X2.1
421         S06E69 2013-10-10 15:12:00        11882                 X2.1

    CME Angle CME Width CME Speed  plot  Halo  Rank  Lower Bound
49        NaN       360      1250  PHTX  True   NaN        False
191       NaN       360      1099  PHTX  True   NaN        False
102       NaN       360      1005  PHTX  True   NaN        False
104       NaN       360       671  PHTX  True   NaN        False
287       NaN       360      2094  PHTX  True   NaN        False
100       NaN       360      1289  PHTX  True   NaN        False
127       NaN       360      1184  PHTX  True   NaN        False
```

```
276        NaN       360       1759  PHTX  True   NaN         False
362        NaN       360        575  PHTX  True   NaN         False
421        NaN       360       1081  PHTX  True   NaN         False
```

10 Question 3: Analysis

I will plot the logarithm in base 10 of the magnitude of individual observations vs their CME Width and CME Speed respectively.

[722]:
```
#(1 & 3) Plot attributes in the NASA dataset (e.g., starting or ending␣
↪frequencies, flare height or width) over time. Use graphical elements (e.g.
↪, text or points) to indicate flares in the top 50 classification.
nasa = nasa.replace('360h', '360')

magnitudes = []
widths = []
speeds = []

for index, row in nasa.iterrows():
    if magnitude(row[7]) == 0 or np.isnan(float(row[10])) or np.
↪isnan(float(row[12])):
        continue
    magnitudes.append(np.log10(magnitude(row[7])))
    widths.append(float(row[10]))
    speeds.append(float(row[12]))

fig, ax = plt.subplots(1, 2)

fig.tight_layout()

ax[0].scatter(magnitudes, widths, color='g')
ax[0].set_title('log10(Magnitude) vs CME Width')
ax[0].set_ylabel('CME Width')
ax[0].set_xlabel('log10(Magnitude)')

ax[1].scatter(magnitudes, speeds, color='g')
ax[1].set_title('log10(Magnitude) vs CME Speed')
ax[1].set_ylabel('CME Speed')
ax[1].set_xlabel('log10(Magnitude)')

plt.subplots_adjust(right = 2)
```

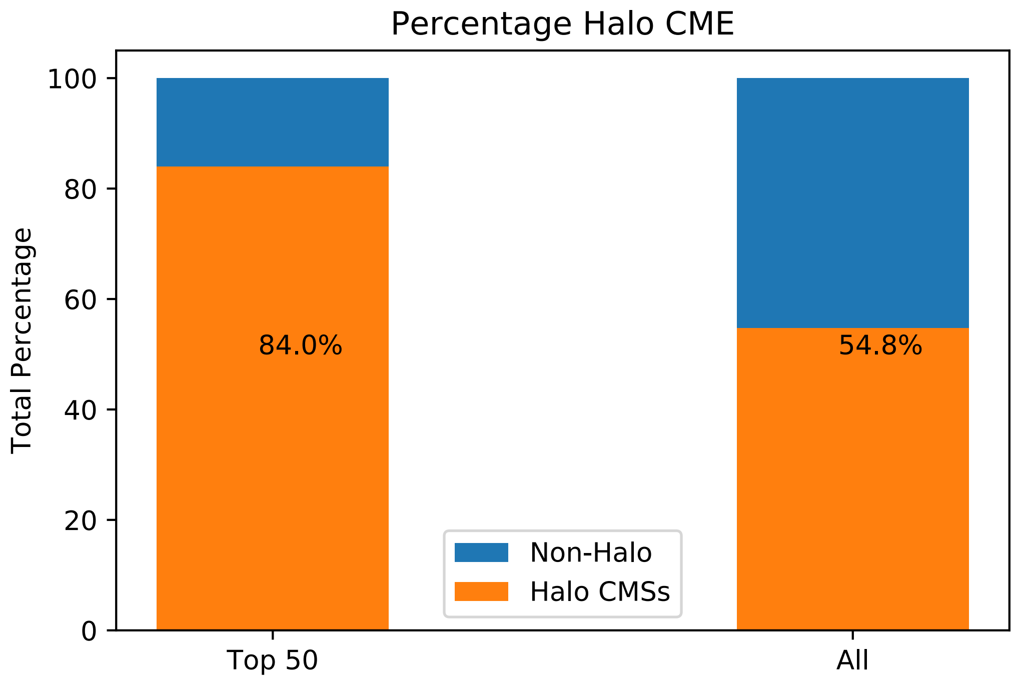


11 Interpretation

First Graph: We can corralation between log10 and CMEs width. They cluster in time

Second Graph: There is absolutely no corralation between both.

[723]:
```
#(2) You can make a barplot that compares the number (or proportion) of Halo␣
↪CMEs in the top 50 flares vs. the dataset as a whole.
labels = 'Top 50', 'All'

fig, ax = plt.subplots()
halo_prop = [nasa_top_sf['Halo'].value_counts()[True]/50 * 100, nasa['Halo'].
↪value_counts()[True]/len(nasa.index) * 100]
n_halo_prop = [nasa_top_sf['Halo'].value_counts()[False]/50 * 100, nasa['Halo'].
↪value_counts()[False]/len(nasa.index) * 100]

ax.bar(labels, n_halo_prop, .4, bottom=halo_prop, label='Non-Halo')
ax.bar(labels, halo_prop, .4, label='Halo CMSs')

ax.set_ylabel('Total Percentage')
ax.set_title('Percentage Halo CME')
ax.legend()
ax.text(-.025,50, '%.1f%%' % halo_prop[0])
ax.text(0.975,50, '%.1f%%' % halo_prop[1])

plt.show()
```



12 Interpretation

Top 50 CMEs from NASA has higher percentage(84%) and proportion than the dataset in hole only (54%) percentage.

13 The end of project 1