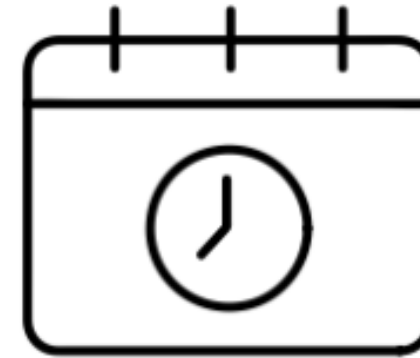


Data range constraints



Out of range movie ratings



Subscription dates in the future

Uniformity

Column	Unit
Temperature	32°C is also 89.6°F
Weight	70 Kg is also 11 st.
Date	26-11-2019 is also 26, November, 2019
Money	100\$ is also 10763.90¥

An example

```
temperatures = pd.read_csv('temperature.csv')  
temperatures.head()
```

	Date	Temperature
0	03.03.19	14.0
1	04.03.19	15.0
2	05.03.19	18.0
3	06.03.19	16.0
4	07.03.19	62.6

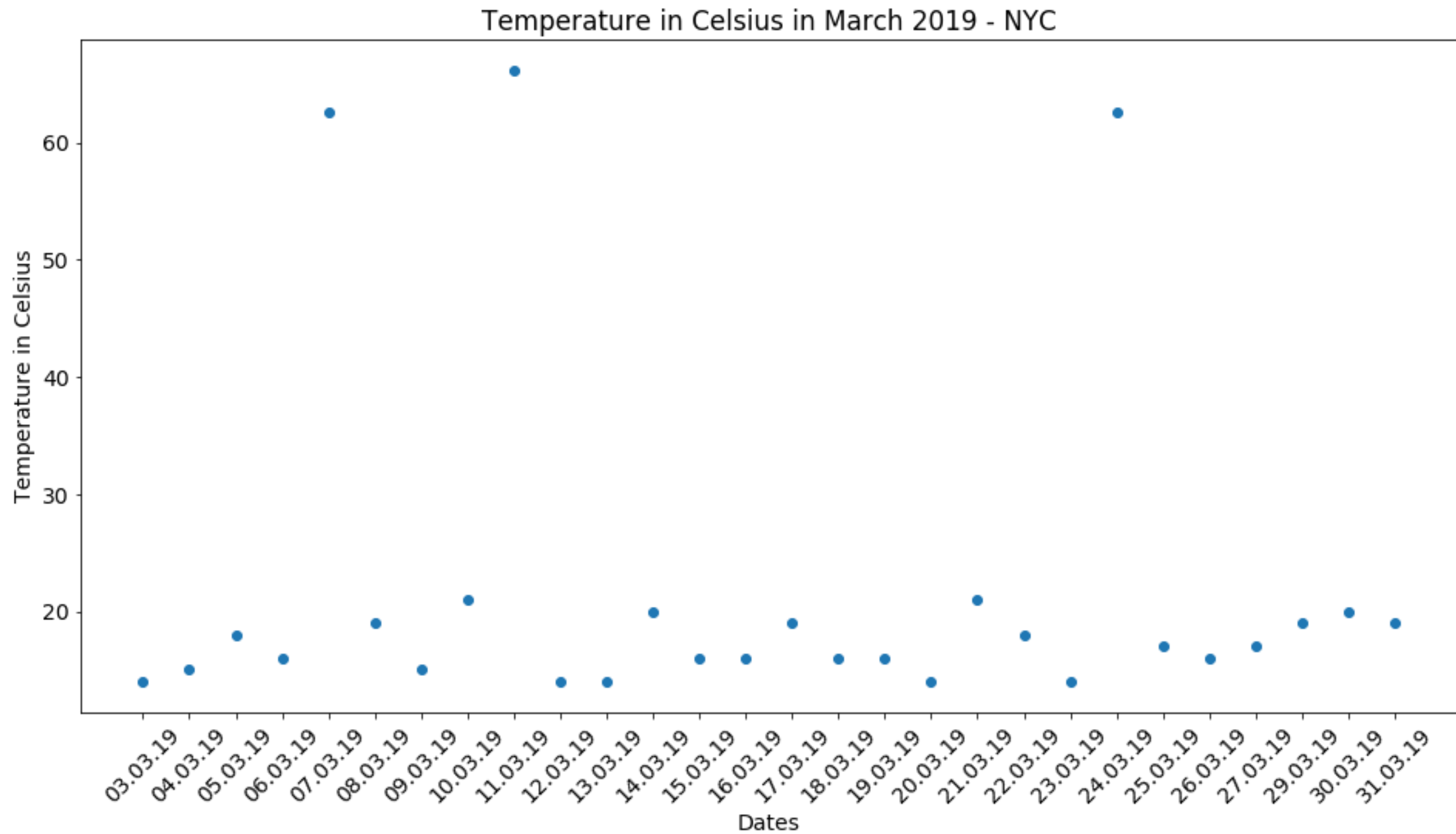
An example

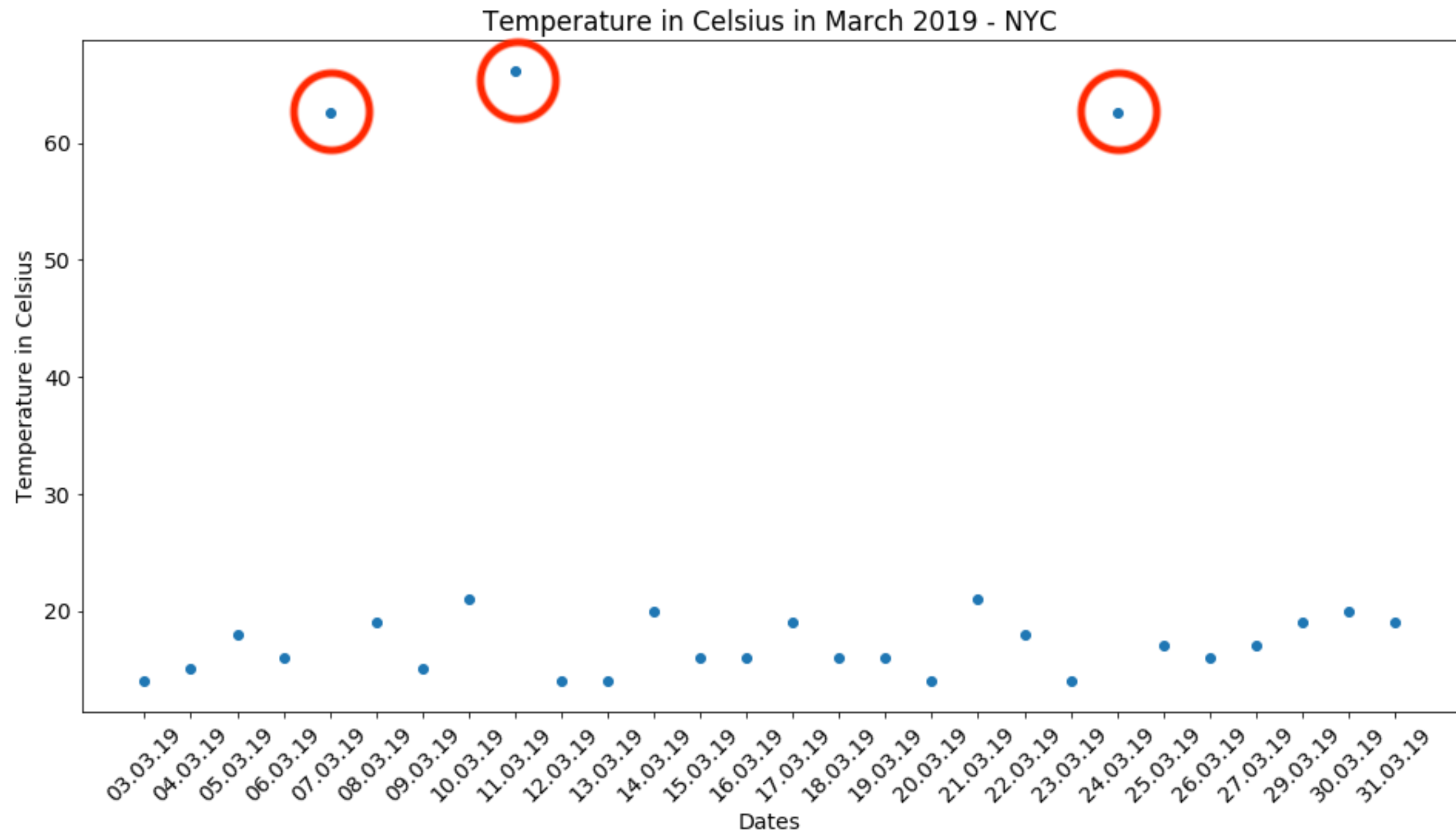
```
temperatures = pd.read_csv('temperature.csv')  
temperatures.head()
```

	Date	Temperature	
0	03.03.19	14.0	
1	04.03.19	15.0	
2	05.03.19	18.0	
3	06.03.19	16.0	
4	07.03.19	62.6	<--

An example

```
# Import matplotlib
import matplotlib.pyplot as plt
# Create scatter plot
plt.scatter(x = 'Date', y = 'Temperature', data = temperatures)
# Create title, xlabel and ylabel
plt.title('Temperature in Celsius March 2019 - NYC')
plt.xlabel('Dates')
plt.ylabel('Temperature in Celsius')
# Show plot
plt.show()
```





Treating temperature data

$$C = (F - 32) \times \frac{5}{9}$$

```
temp_fah = temperatures.loc[temperatures['Temperature'] > 40, 'Temperature']  
temp_cels = (temp_fah - 32) * (5/9)  
temperatures.loc[temperatures['Temperature'] > 40, 'Temperature'] = temp_cels
```

```
# Assert conversion is correct  
assert temperatures['Temperature'].max() < 40
```


Treating date data

```
birthdays.head()
```

```
      Birthday First name Last name
0      27/27/19      Rowan    Nunez
1      03-29-19     Brynn     Yang
2  March 3rd, 2019    Sophia   Reilly
3      24-03-19     Deacon   Prince
4      06-03-19   Griffith     Neal
```

Treating date data

```
birthdays.head()
```

	Birthday	First name	Last name	
0	27/27/19	Rowan	Nunez	??
1	03-29-19	Brynn	Yang	MM-DD-YY
2	March 3rd, 2019	Sophia	Reilly	Month Day, YYYY
3	24-03-19	Deacon	Prince	
4	06-03-19	Griffith	Neal	

Datetime formatting

`datetime` is useful for representing dates

Date	<code>datetime</code> format
25-12-2019	<code>%d-%m-%Y</code>
December 25th 2019	<code>%c</code>
12-25-2019	<code>%m-%d-%Y</code>
...	...

`pandas.to_datetime()`

- Can recognize most formats automatically
- Sometimes fails with erroneous or unrecognizable formats

Treating date data

```
# Converts to datetime - but won't work!
birthdays['Birthday'] = pd.to_datetime(birthdays['Birthday'])
```

```
ValueError: month must be in 1..12
```

```
# Will work!
birthdays['Birthday'] = pd.to_datetime(birthdays['Birthday'],
                                       # Attempt to infer format of each date
                                       infer_datetime_format=True,
                                       # Return NA for rows where conversion failed
                                       errors = 'coerce')
```

Treating date data

```
birthdays.head()
```

```
   Birthday First name Last name
0         NaT      Rowan   Nunez
1 2019-03-29    Brynn    Yang
2 2019-03-03    Sophia  Reilly
3 2019-03-24    Deacon  Prince
4 2019-06-03  Griffith    Neal
```

Treating date data

```
birthdays['Birthday'] = birthdays['Birthday'].dt.strftime("%d-%m-%Y")
birthdays.head()
```

	Birthday	First name	Last name
0	NaT	Rowan	Nunez
1	29-03-2019	Brynn	Yang
2	03-03-2019	Sophia	Reilly
3	24-03-2019	Deacon	Prince
4	03-06-2019	Griffith	Neal

Treating ambiguous date data

Is 2019-03-08 in August or March?

- Convert to NA and treat accordingly
- Infer format by understanding data source
- Infer format by understanding previous and subsequent data in DataFrame

Motivation

```
import pandas as pd
```

```
flights = pd.read_csv('flights.csv')  
flights.head()
```

	flight_number	economy_class	business_class	first_class	total_passengers
0	DL140	100	60	40	200
1	BA248	130	100	70	300
2	MEA124	100	50	50	200
3	AFR939	140	70	90	300
4	TKA101	130	100	20	250

Cross field validation

*The use of **multiple** fields in a dataset to sanity check data integrity*

	flight_number	economy_class	business_class	first_class	total_passengers		row wise sum Axis = 1
0	DL140	100	+	60	+	40	= 200
1	BA248	130	+	100	+	70	= 300
2	MEA124	100	+	50	+	50	= 200
3	AFR939	140	+	70	+	90	= 300
4	TKA101	130	+	100	+	20	= 250

By Defult its 0(column)

```
sum_classes = flights[['economy_class', 'business_class', 'first_class']].sum(axis = 1)
passenger_equ = sum_classes == flights['total_passengers']
# Find and filter out rows with inconsistent passenger totals
inconsistent_pass = flights[~passenger_equ]
consistent_pass = flights[passenger_equ]
```

Cross field validation

```
users.head()
```

	user_id	Age	Birthday
0	32985	22	1998-03-02
1	94387	27	1993-12-04
2	34236	42	1978-11-24
3	12551	31	1989-01-03
4	55212	18	2002-07-02

Cross field validation

```
import pandas as pd
import datetime as dt

# Convert to datetime and get today's date
users['Birthday'] = pd.to_datetime(users['Birthday'])
today = dt.date.today()

# For each row in the Birthday column, calculate year difference
age_manual = today.year - users['Birthday'].dt.year

# Find instances where ages match
age_equ = age_manual == users['Age']

# Find and filter out rows with inconsistent age
inconsistent_age = users[~age_equ]
consistent_age = users[age_equ]
```

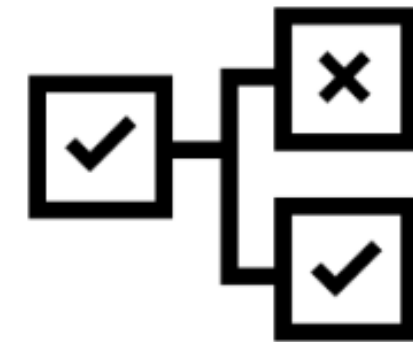
What to do when we catch inconsistencies?



*Dropping
Data*



*Set to missing
and impute*

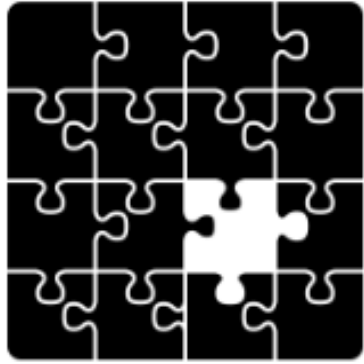


*Apply rules from
domain knowledge*

Let's practice!

CLEANING DATA IN PYTHON

What is missing data?



Occurs when no data value is stored for a variable in an observation

Can be represented as `NA` , `nan` , `0` , `.` ...

Technical error

Human error

Airquality example

```
import pandas as pd
airquality = pd.read_csv('airquality.csv')
print(airquality)
```

	Date	Temperature	CO2
987	20/04/2004	16.8	0.0
2119	07/06/2004	18.7	0.8
2451	20/06/2004	-40.0	NaN
1984	01/06/2004	19.6	1.8
8299	19/02/2005	11.2	1.2
...

Airquality example

```
import pandas as pd
airquality = pd.read_csv('airquality.csv')
print(airquality)
```

	Date	Temperature	CO2	
987	20/04/2004	16.8	0.0	
2119	07/06/2004	18.7	0.8	
2451	20/06/2004	-40.0	NaN	<--
1984	01/06/2004	19.6	1.8	
8299	19/02/2005	11.2	1.2	
...	

Airquality example

```
# Return missing values  
airquality.isna()
```

	Date	Temperature	CO2
987	False	False	False
2119	False	False	False
2451	False	False	True
1984	False	False	False
8299	False	False	False

Airquality example

```
# Get summary of missingness
```

```
airquality.isna().sum()
```

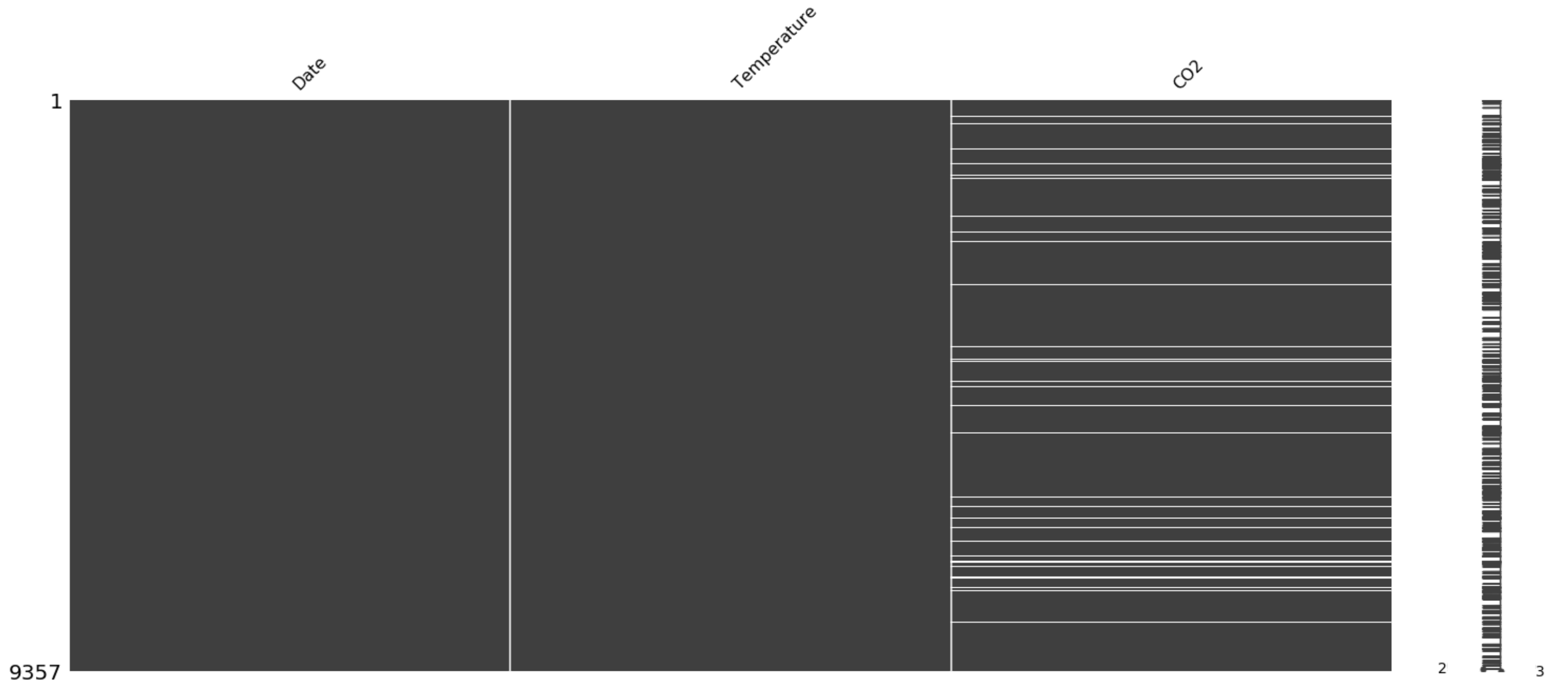
Method Chaining

```
Date          0
Temperature    0
CO2           366
dtype: int64
```

Missingno

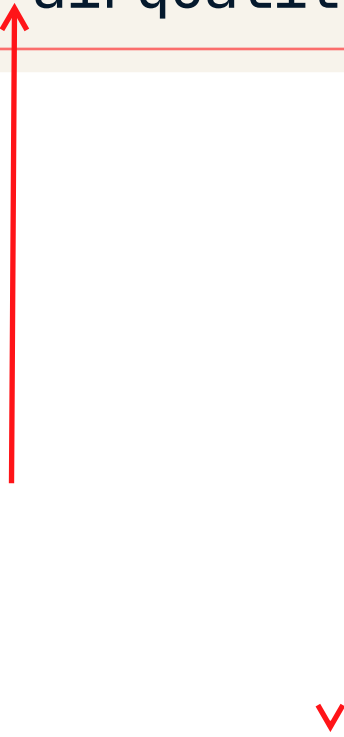
Useful package for visualizing and understanding missing data

```
import missingno as msno
import matplotlib.pyplot as plt
# Visualize missingness
msno.matrix(airquality)
plt.show()
```



Airquality example

```
# Isolate missing and complete values aside  
missing = airquality[airquality['CO2'].isna()]  
complete = airquality[~airquality['CO2'].isna()]
```



Airquality example

```
# Describe complete DataFramee
complete.describe()
```

	Temperature	CO2
count	8991.000000	8991.000000
mean	18.317829	1.739584
std	8.832116	1.537580
min	-1.900000	0.000000
...
max	44.600000	11.900000

```
# Describe missing DataFramee
missing.describe()
```

	Temperature	CO2
count	366.000000	0.0
mean	-39.655738	NaN
std	5.988716	NaN
min	-49.000000	NaN
...
max	-30.000000	NaN

Airquality example

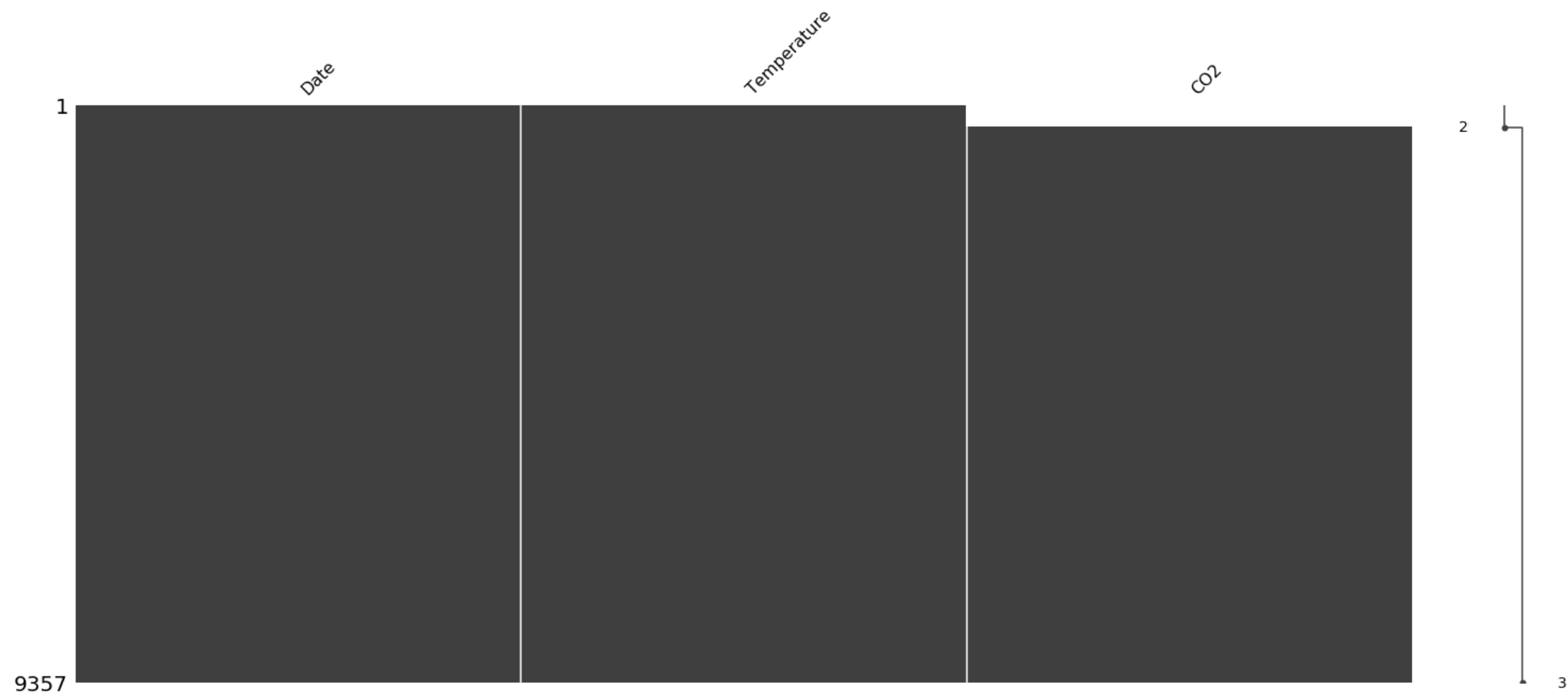
```
# Describe complete DataFramee
complete.describe()
```

	Temperature	CO2
count	8991.000000	8991.000000
mean	18.317829	1.739584
std	8.832116	1.537580
min	-1.900000	0.000000
...
max	44.600000	11.900000

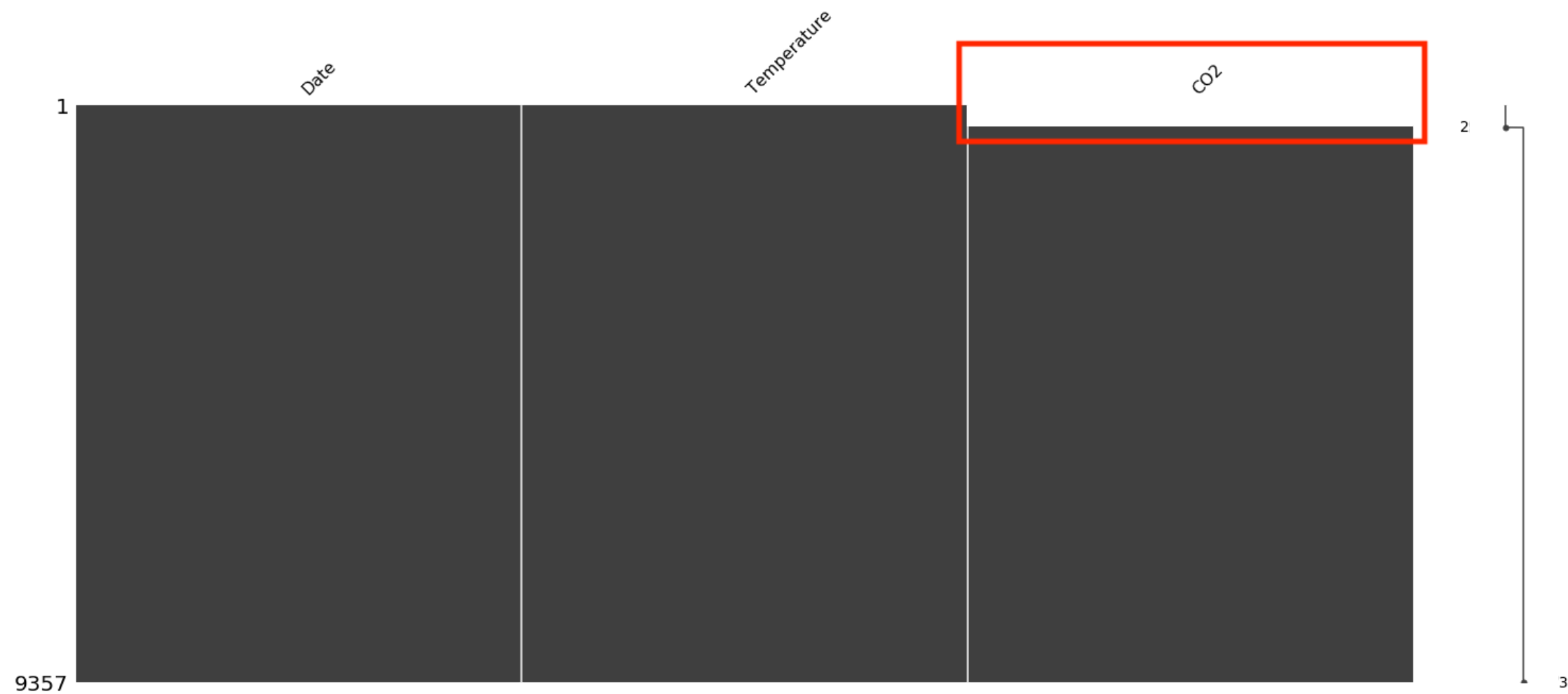
```
# Describe missing DataFramee
missing.describe()
```

	Temperature	CO2	
count	366.000000	0.0	
mean	-39.655738	NaN	<--
std	5.988716	NaN	
min	-49.000000	NaN	<--
...	
max	-30.000000	NaN	<--

```
sorted_airquality = airquality.sort_values(by = 'Temperature')  
msno.matrix(sorted_airquality)  
plt.show()
```




```
sorted_airquality = airquality.sort_values(by = 'Temperature')  
msno.matrix(sorted_airquality)  
plt.show()
```



Missingness types



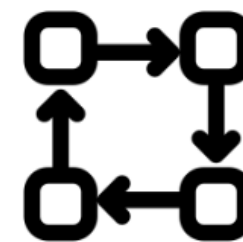
*Missing Completely
at Random*

(MCAR)



*Missing at
Random*

(MAR)



*Missing Not at
Random*

(MNAR)

Missingness types



***Missing Completely
at Random***

(MCAR)

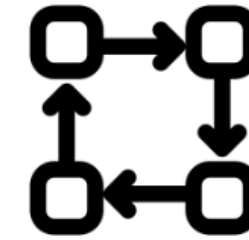
*No systematic relationship
between missing data and
other values*

*Data entry errors when
inputting data*



***Missing at
Random***

(MAR)



***Missing Not at
Random***

(MNAR)

Missingness types



**Missing Completely
at Random**

(MCAR)

*No systematic relationship
between missing data and
other values*

*Data entry errors when
inputting data*

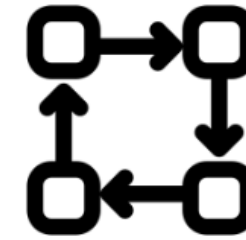


**Missing at
Random**

(MAR)

*Systematic relationship
between missing data and
other observed values*

*Missing ozone data for high
temperatures*



**Missing Not at
Random**

(MNAR)

Missingness types



**Missing Completely
at Random**

(MCAR)

*No systematic relationship
between missing data and
other values*

*Data entry errors when
inputting data*

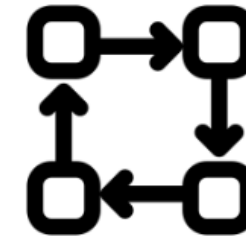


**Missing at
Random**

(MAR)

*Systematic relationship
between missing data and
other observed values*

*Missing ozone data for high
temperatures*



**Missing Not at
Random**

(MNAR)

*Systematic relationship
between missing data and
unobserved values*

*Missing temperature values for
high temperatures*

How to deal with missing data?

Simple approaches:

1. Drop missing data
2. Impute with statistical measures (*mean, median, mode..*)

More complex approaches:

1. Imputing using an algorithmic approach
2. Impute with machine learning models

Dealing with missing data

```
airquality.head()
```

	Date	Temperature	CO2
0	05/03/2005	8.5	2.5
1	23/08/2004	21.8	0.0
2	18/02/2005	6.3	1.0
3	08/02/2005	-31.0	NaN
4	13/03/2005	19.9	0.1

Dropping missing values

```
# Drop missing values
airquality_dropped = airquality.dropna(subset = ['CO2'])
airquality_dropped.head()
```

	Date	Temperature	CO2
0	05/03/2005	8.5	2.5
1	23/08/2004	21.8	0.0
2	18/02/2005	6.3	1.0
4	13/03/2005	19.9	0.1
5	02/04/2005	17.0	0.8

Replacing with statistical measures

```
co2_mean = airquality['CO2'].mean()
airquality_imputed = airquality.fillna({'CO2': co2_mean})
airquality_imputed.head()
```

dict

	Date	Temperature	CO2
0	05/03/2005	8.5	2.500000
1	23/08/2004	21.8	0.000000
2	18/02/2005	6.3	1.000000
3	08/02/2005	-31.0	1.739584
4	13/03/2005	19.9	0.100000

Let's practice!

CLEANING DATA IN PYTHON