# Intro to Python and Pandas

*DataFrames for Data Science*

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October 15, 2025

# Background

⚠ We assume that you all followed Guy Simpson’s Python crash course

`pandas`: A **package** for data manipulation and analysis handling **structured data**

- **Reading/writing data** from common formats (CSV, Excel, JSON, etc.)
- Handling **missing data**
- **Filtering**, **sorting**, **reshaping** and **grouping** data
- **Aggregating** data (sum, mean, count, etc.)
- **Time series support** (date ranges, frequency conversions)
- **Statistical operations**

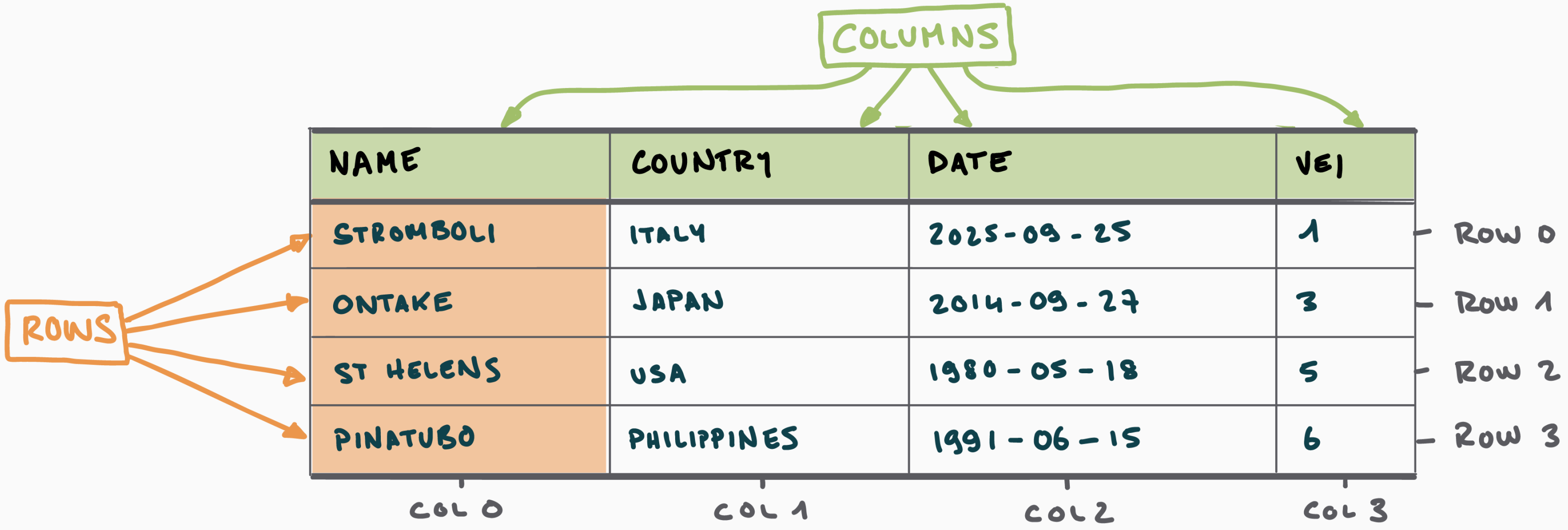
# Today's objectives

Understand what is a `pandas` DataFrame and its basic anatomy

- How to load data in a DataFrame
- How to access data → *query by label/position*
- How to filter data → *comparison and logical operators*
- How to rearrange data → *sorting values*
- How to operate on data → *arithmetic and string operations*

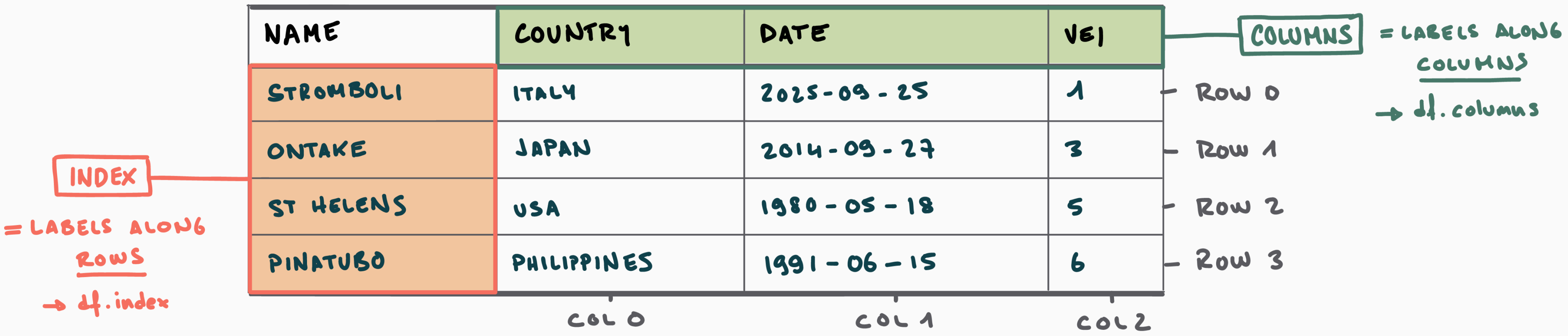
# Introduction to pandas

# Anatomy of a DataFrame



| NAME | COUNTRY | DATE | VEI |
|---|---|---|---|
| STROMBOLI | ITALY | 2025-09-25 | 1 |
| ONTAKE | JAPAN | 2014-09-27 | 3 |
| ST HELENS | USA | 1980-05-18 | 5 |
| PINATUBO | PHILIPPINES | 1991-06-15 | 6 |

# Anatomy of a DataFrame



| NAME | COUNTRY | DATE | VEI |
|---|---|---|---|
| STROMBOLI | ITALY | 2025-09-25 | 1 |
| ONTAKE | JAPAN | 2014-09-27 | 3 |
| ST HELENS | USA | 1980-05-18 | 5 |
| PINATUBO | PHILIPPINES | 1991-06-15 | 6 |

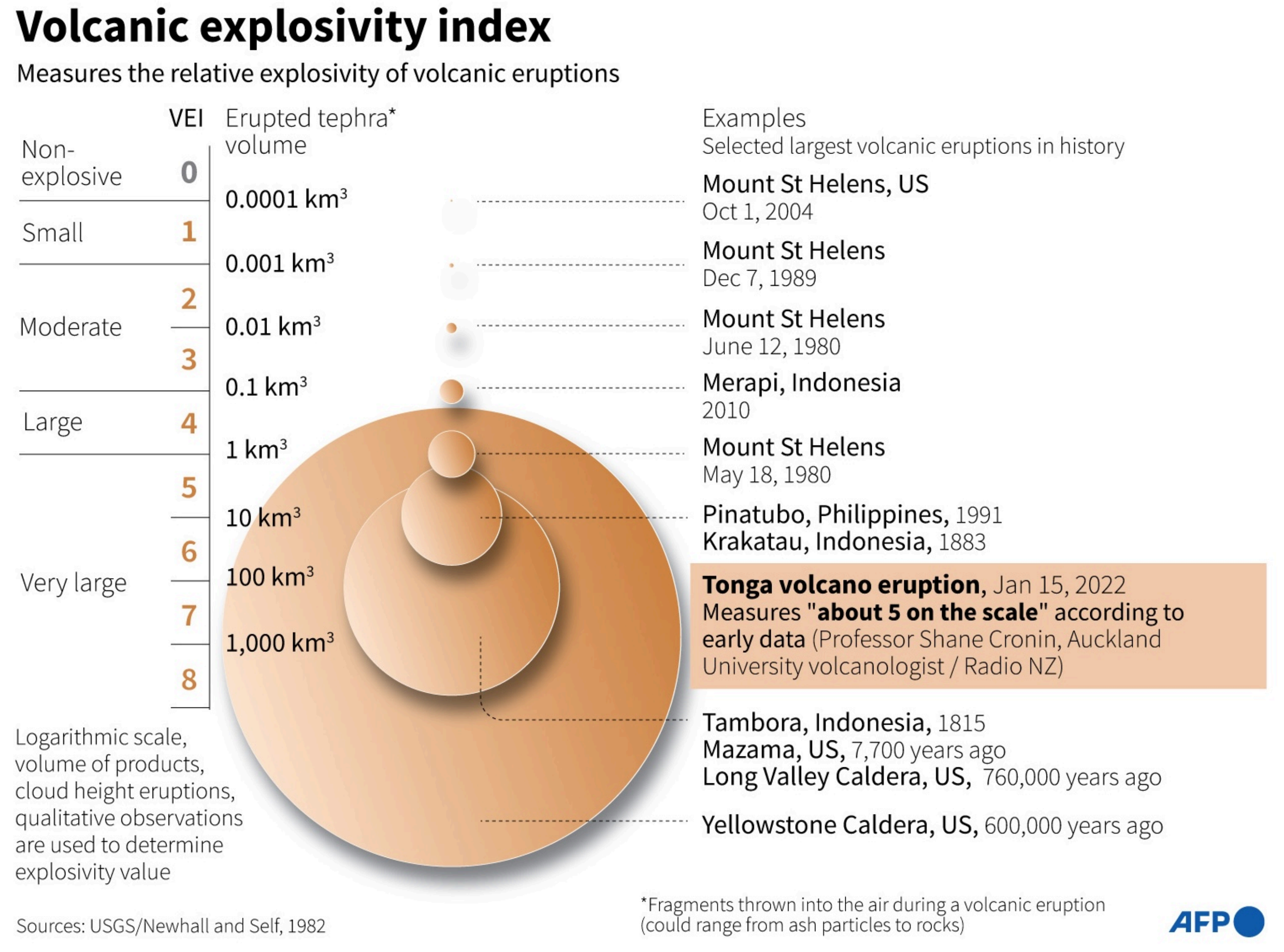
# Data structure

# The dataset

Synthetic dataset of **selected volcanic eruptions** → first 5 rows:

| Name | Country | Date | VEI | Latitude | Longitude |
|---|---|---|---:|---:|---:|
| St. Helens | USA | 1980-05-18 | 5 | 46.1914 | -122.196 |
| Pinatubo | Philippines | 1991-04-02 | 6 | 15.1501 | 120.347 |
| El Chichón | Mexico | 1982-03-28 | 5 | 17.3559 | -93.2233 |
| Galunggung | Indonesia | 1982-04-05 | 4 | -7.2567 | 108.077 |
| Nevado del Ruiz | Colombia | 1985-11-13 | 3 | 4.895 | -75.322 |

# Volcanic explosivity index (VEI)



## Volcanic explosivity index

Measures the relative explosivity of volcanic eruptions

Examples
Selected largest volcanic eruptions in history

Mount St Helens, US
Oct 1, 2004

Mount St Helens
Dec 7, 1989

Mount St Helens
June 12, 1980

Merapi, Indonesia
2010

Mount St Helens
May 18, 1980

Pinatubo, Philippines, 1991
Krakatau, Indonesia, 1883

**Tonga volcano eruption**, Jan 15, 2022
Measures "**about 5 on the scale**" according to early data (Professor Shane Cronin, Auckland University volcanologist / Radio NZ)

Tambora, Indonesia, 1815
Mazama, US, 7,700 years ago
Long Valley Caldera, US, 760,000 years ago

Yellowstone Caldera, US, 600,000 years ago

Logarithmic scale, volume of products, cloud height eruptions, qualitative observations are used to determine explosivity value

*Fragments thrown into the air during a volcanic eruption (could range from ash particles to rocks)

Sources: USGS/Newhall and Self, 1982

# Setting up the notebook

- We start by importing the pandas library
- We import it under the name pd - which is faster to type!

```python
# Import the required packages
import pandas as pd
```

# Setting up the notebook

- We then load the specified data with the `pd.read_csv()` function
- This returns a DataFrame object in a variable named `df`

```python
# Import the required packages
import pandas as pd

# Read the data
df = pd.read_csv('https://raw.githubusercontent.com/ELSTE-Master/Data-Science/main/Data/dummy_v
```

# Setting up the notebook

- We print some data for inspection with `df.head()`
- The functions are now directly called from the DataFrame `df` object

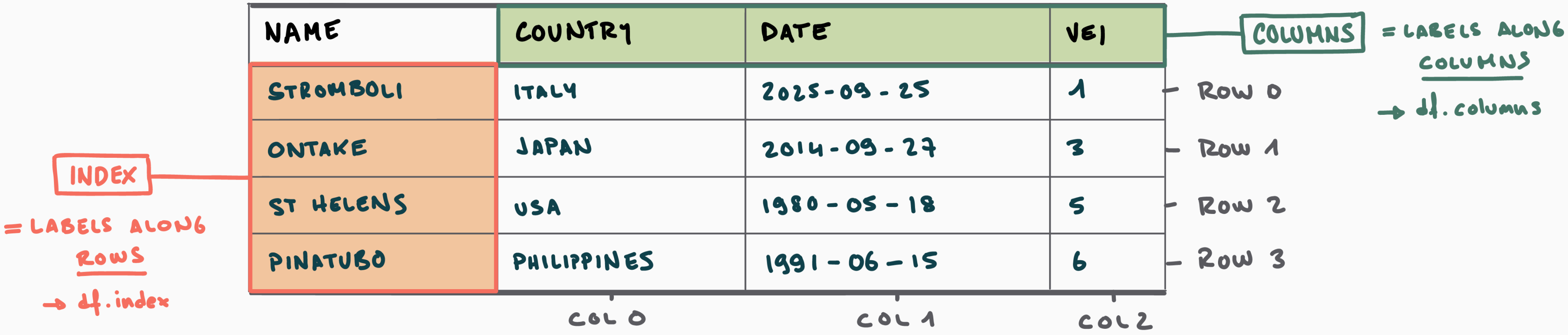
```python
# Import the required packages
import pandas as pd

# Read the data
df = pd.read_csv('https://raw.githubusercontent.com/ELSTE-Master/Data-Science/main/Data/dummy_v

# Show the first 3 rows
df.head(3)
```

| | Name | Country | Date | VEI | Latitude | Longitude |
|---|---|---|---|---|---|---|
| 0 | St. Helens | USA | 1980-05-18 | 5 | 46.1914 | -122.1956 |
| 1 | Pinatubo | Philippines | 1991-04-02 | 6 | 15.1501 | 120.3465 |
| 2 | El Chichón | Mexico | 1982-03-28 | 5 | 17.3559 | -93.2233 |

# Setting the index



| NAME | COUNTRY | DATE | VEI |
|---|---|---|---|
| STROMBOLI | ITALY | 2025-09-25 | 1 |
| ONTAKE | JAPAN | 2014-09-27 | 3 |
| ST HELENS | USA | 1980-05-18 | 5 |
| PINATUBO | PHILIPPINES | 1991-06-15 | 6 |

# Setting the index

- …for now, the index (→ **the first column)** is an *integer*
- This might be acceptable in datasets where the *label* is not important

```python
# Show the first 3 rows
df.head(3)
```

| | Name | Country | Date | VEI | Latitude | Longitude |
|---|---|---|---|---|---|---|
| 0 | St. Helens | USA | 1980-05-18 | 5 | 46.1914 | -122.1956 |
| 1 | Pinatubo | Philippines | 1991-04-02 | 6 | 15.1501 | 120.3465 |
| 2 | El Chichón | Mexico | 1982-03-28 | 5 | 17.3559 | -93.2233 |

# Setting the index

- Here we want to access the data using the **name of the volcano**
- We **set the index** using `set_index()`

```python
# Set the index to the 'Name' column
df = df.set_index('Name')

# Show the first 3 rows
df.head(3)
```

| | Country | Date | VEI | Latitude | Longitude |
|---|---|---|---|---|---|
| **Name** | | | | | |
| St. Helens | USA | 1980-05-18 | 5 | 46.1914 | -122.1956 |
| Pinatubo | Philippines | 1991-04-02 | 6 | 15.1501 | 120.3465 |
| El Chichón | Mexico | 1982-03-28 | 5 | 17.3559 | -93.2233 |

# Exploring data

- Here are some **basic functions** to review the structure of the dataset:

| Function | Description |
|---|---|
| `df.head()` | Prints the *first* 5 rows of the DataFrame. |
| `df.tail()` | Prints the *last* 5 rows of the DataFrame. |
| `df.info()` | Displays some info about the DataFrame, including the number of rows (*entries*) and columns. |
| `df.shape` | Returns a list containing the number of rows and columns of the DataFrame. |
| `df.index` | Returns a list containing the index along the *rows* of the DataFrame. |
| `df.columns` | Returns a list containing the index along the *columns* of the DataFrame. |

### Functions vs attributes

- **Functions** have parentheses → they **compute** something on `df`
- **Attributes** do *not* have parentheses → they store some **parameter** related to `df`

# Sorting data

- Sorting numerical, datetime or strings using `.sort_values`
- Importance of documentation to understand arguments

```python
df.sort_values('VEI').head() # Sort volcanoes by VEI in ascending number
```

| | Country | Date | VEI | Latitude | Longitude |
|---|---|---|---|---|---|
| **Name** | | | | | |
| Nyiragongo | DR Congo | 2021-05-22 | 1 | -1.5200 | 29.2500 |
| Ontake | Japan | 2014-09-27 | 2 | 35.5149 | 137.4781 |
| Etna | Italy | 2021-03-16 | 2 | 37.7510 | 15.0044 |
| Merapi | Indonesia | 2023-12-03 | 2 | -7.5407 | 110.4457 |
| Kīlauea | USA | 2018-05-03 | 2 | 19.4194 | -155.2811 |

# Sorting data

- Sorting numerical, datetime or strings using `.sort_values`
- Importance of documentation to understand arguments

```
df.sort_values('VEI').head() # Sort volcanoes by VEI in ascending number
df.sort_values('Date', ascending=False).head() # Sort volcanoes by eruption dates from recent t
```

| | Country | Date | VEI | Latitude | Longitude |
|---|---|---|---|---|---|
| **Name** | | | | | |
| Merapi | Indonesia | 2023-12-03 | 2 | -7.5407 | 110.4457 |
| Cleveland | USA | 2023-05-23 | 3 | 52.8250 | -169.9444 |
| Sinabung | Indonesia | 2023-02-13 | 3 | 3.1719 | 98.3925 |
| Nyiragongo | DR Congo | 2021-05-22 | 1 | -1.5200 | 29.2500 |
| La Soufrière | Saint Vincent | 2021-04-09 | 4 | 13.2833 | -61.3875 |

# Sorting data

- Sorting numerical, datetime or strings using `.sort_values`
- Importance of documentation to understand arguments

```python
df.sort_values('VEI').head() # Sort volcanoes by VEI in ascending number
df.sort_values('Date', ascending=False).head() # Sort volcanoes by eruption dates from recent t
df.sort_values('Country').head() # Also works on strings to sort alphabetically
```

| Name | Country | Date | VEI | Latitude | Longitude |
|---|---|---|---|---|---|
| Calbuco | Chile | 2015-04-22 | 4 | -41.2972 | -72.6097 |
| Nevado del Ruiz | Colombia | 1985-11-13 | 3 | 4.8950 | -75.3220 |
| Nyiragongo | DR Congo | 2021-05-22 | 1 | -1.5200 | 29.2500 |
| Eyjafjallajökull | Iceland | 2010-04-14 | 4 | 63.6333 | -19.6111 |
| Galunggung | Indonesia | 1982-04-05 | 4 | -7.2567 | 108.0771 |

# Sorting data

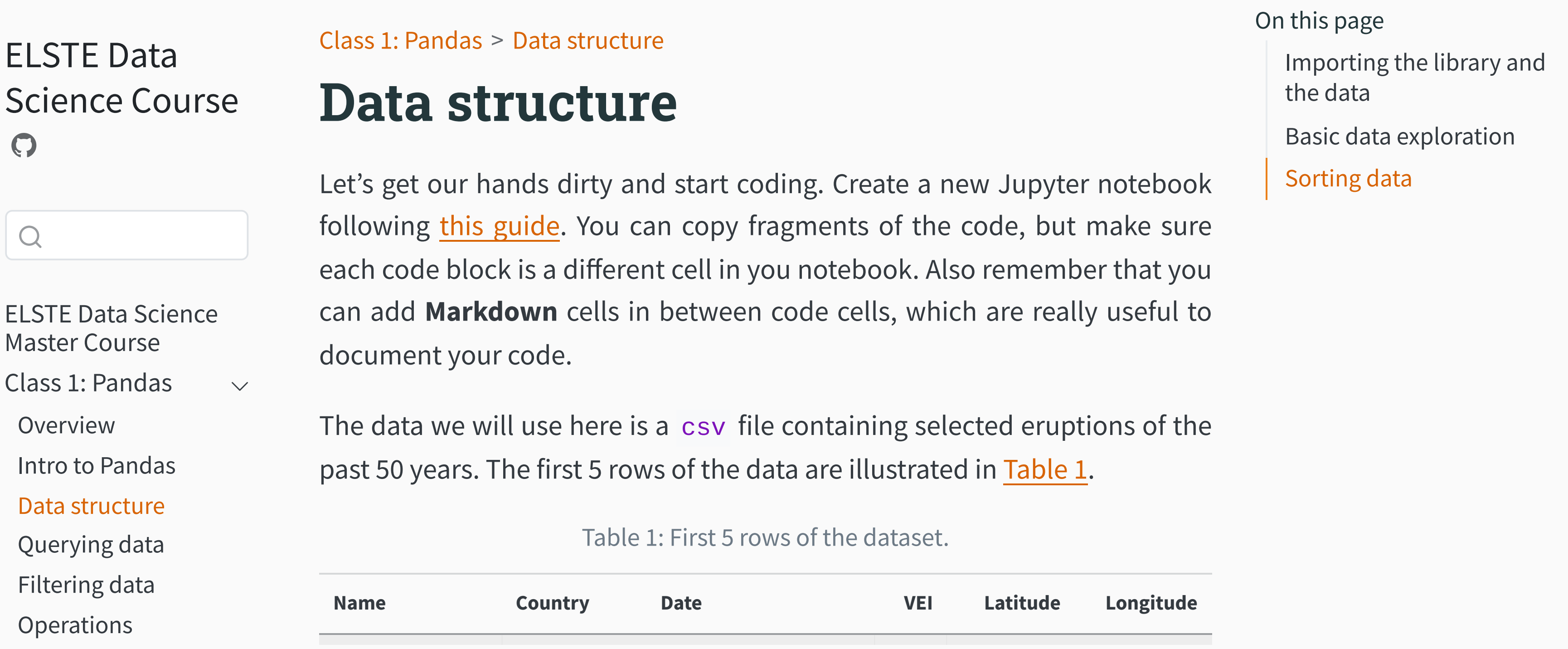
- Sorting numerical, datetime or strings using `.sort_values`
- Importance of **documentation** to understand arguments

```python
df.sort_values('VEI').head() # Sort volcanoes by VEI in ascending number
df.sort_values('Date', ascending=False).head() # Sort volcanoes by eruption dates from recent t
df.sort_values('Country').head() # Also works on strings to sort alphabetically
df.sort_values(['Latitude', 'Longitude']).head() # Sorting using multiple columns
```

| | Country | Date | VEI | Latitude | Longitude |
|---|---|---|---|---|---|
| **Name** | | | | | |
| Calbuco | Chile | 2015-04-22 | 4 | -41.2972 | -72.6097 |
| Agung | Indonesia | 2017-11-21 | 3 | -8.3422 | 115.5083 |
| Merapi | Indonesia | 2023-12-03 | 2 | -7.5407 | 110.4457 |
| Galunggung | Indonesia | 1982-04-05 | 4 | -7.2567 | 108.0771 |
| Tavurvur | Papua New Guinea | 2014-08-29 | 3 | -4.3494 | 152.2847 |

# Your turn!

- Go to https://elste-master.github.io/Data-Science/
  - → Class 1 > Data Structure



## Data structure

Let’s get our hands dirty and start coding. Create a new Jupyter notebook following this guide. You can copy fragments of the code, but make sure each code block is a different cell in you notebook. Also remember that you can add **Markdown** cells in between code cells, which are really useful to document your code.

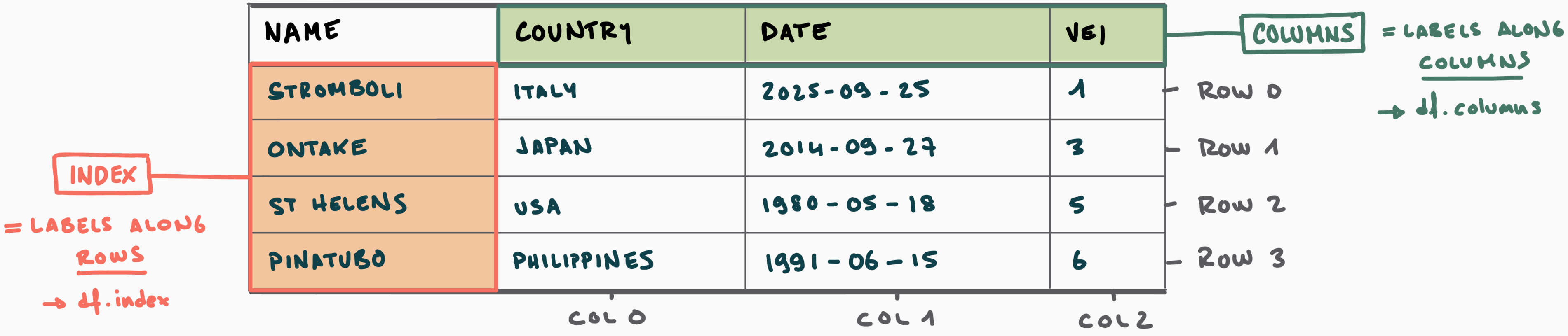
The data we will use here is a `csv` file containing selected eruptions of the past 50 years. The first 5 rows of the data are illustrated in Table 1.

Table 1: First 5 rows of the dataset.

| Name | Country | Date | VEI | Latitude | Longitude |
|---|---|---|---|---|---|

# Querying data

# Accessing data in a DataFrame



| NAME | COUNTRY | DATE | VEI |
|---|---|---|---|
| STROMBOLI | ITALY | 2025-09-25 | 1 |
| ONTAKE | JAPAN | 2014-09-27 | 3 |
| ST HELENS | USA | 1980-05-18 | 5 |
| PINATUBO | PHILIPPINES | 1991-06-15 | 6 |

# Accessing data in a DataFrame

**Option 1**: label-based indexing

- Use the labels of **index** and **columns** to retrieve data
- Function to use: `df.loc`

# Accessing data in a DataFrame

**Option 2**: position-based indexing

- Use the positions of **index** and **columns** to retrieve data
- Function to use: `df.iloc`

# Label-based indexing: Rows

- **Query a row** with `.loc` → Use **square brackets** `[ ]`
  - → Query the *row* for which the *index label* is `Calbuco`
  - → Returns all *columns*

# Label-based indexing: Rows

- **Query multiple rows** with `.loc`
  - → Query the *rows* for which the *index labels* are `Calbuco` or `Taal`
  - → Returns all *columns*

# Label-based indexing: Columns

- **Query columns**
  - → Query the *columns* for which the *column labels* are `Country` or `VEI`
  - → Returns all *rows*

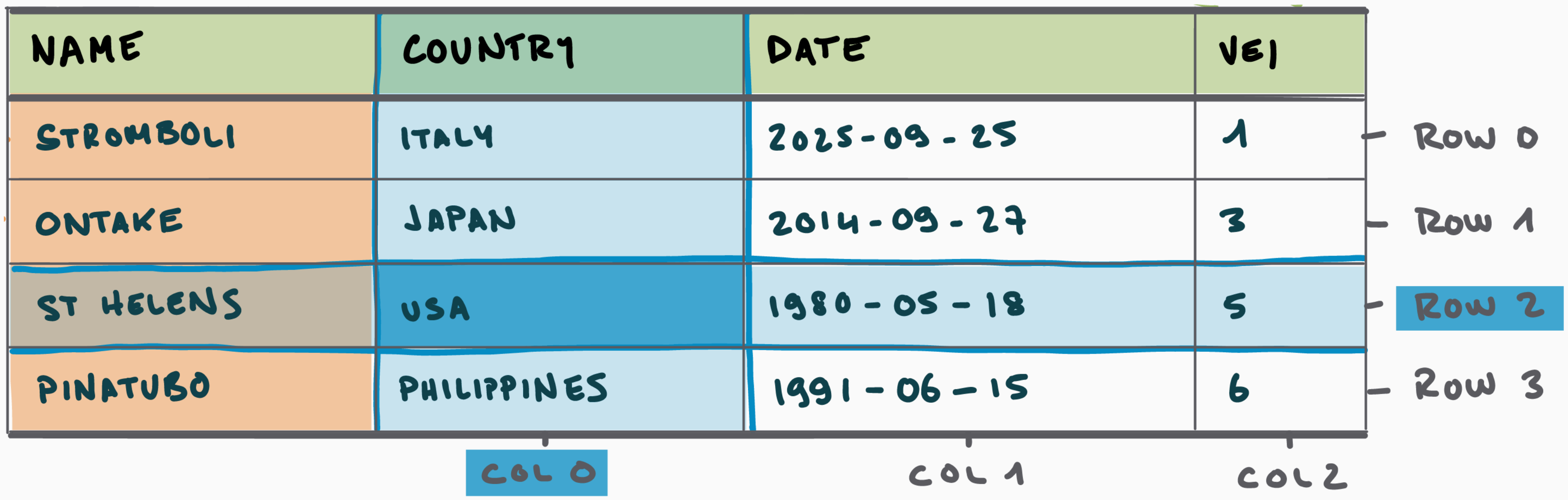
# Label-based indexing: Rows and Columns

- Again, choice on whether to use `.loc` to query columns

# Position-based indexing

- Use **positions** instead of **labels**

df.iloc [2,0] → USA



| NAME | COUNTRY | DATE | VEI |
|---|---|---|---|
| STROMBOLI | ITALY | 2025-09-25 | 1 |
| ONTAKE | JAPAN | 2014-09-27 | 3 |
| ST HELENS | USA | 1980-05-18 | 5 |
| PINATUBO | PHILIPPINES | 1991-06-15 | 6 |

# Position-based indexing: Rows

- **Query a row** with `.iloc`

  → Returns all *columns*

# Position-based indexing: Rows

- Query rows from the end:
- Example:
  - → Get the **last 5 rows** of the DataFrame:

```
df.iloc[-5:]
```

| | Country | Date | VEI | Latitude | Longitude |
|---|---|---|---|---|---|
| **Name** | | | | | |
| La Soufrière | Saint Vincent | 2021-04-09 | 4 | 13.2833 | -61.3875 |
| Calbuco | Chile | 2015-04-22 | 4 | -41.2972 | -72.6097 |
| St. Augustine | USA | 2006-03-27 | 3 | 57.8819 | -155.5611 |
| Eyjafjallajökull | Iceland | 2010-04-14 | 4 | 63.6333 | -19.6111 |
| Cleveland | USA | 2023-05-23 | 3 | 52.8250 | -169.9444 |

# Position-based and label-based queries

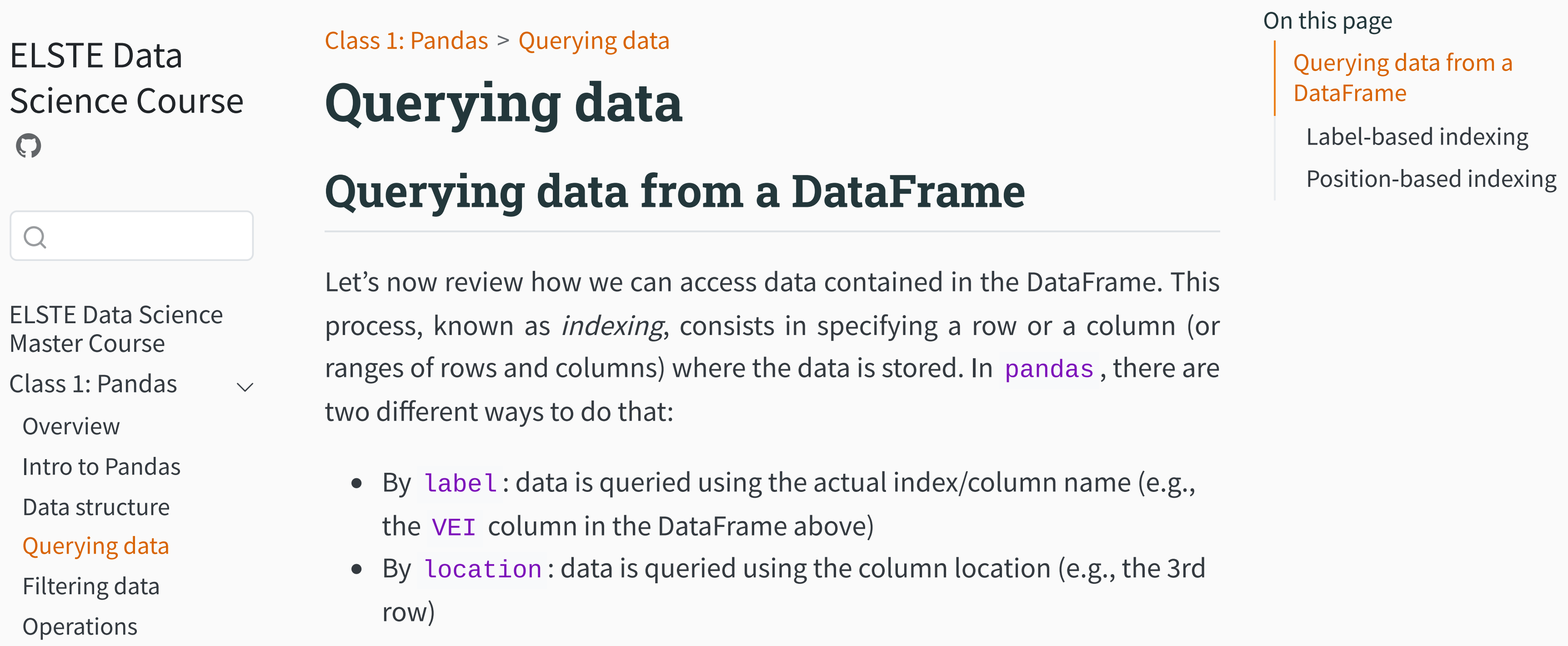
- Mix position-based and label-based indexing:
  - → **Rows** → *labels*
  - → **Columns** → *positions*

```python
df.iloc[0:5][['Country', 'VEI']]
```

| | Country | VEI |
|---|---|---|
| **Name** | | |
| St. Helens | USA | 5 |
| Pinatubo | Philippines | 6 |
| El Chichón | Mexico | 5 |
| Galunggung | Indonesia | 4 |
| Nevado del Ruiz | Colombia | 3 |

# Your turn!

- Go to https://elste-master.github.io/Data-Science/
  → Class 1 > Querying data



ELSTE Data Science Course

ELSTE Data Science Master Course
Class 1: Pandas
Overview
Intro to Pandas
Data structure
Querying data
Filtering data
Operations

Class 1: Pandas > Querying data

# Querying data

## Querying data from a DataFrame

Let's now review how we can access data contained in the DataFrame. This process, known as *indexing*, consists in specifying a row or a column (or ranges of rows and columns) where the data is stored. In `pandas`, there are two different ways to do that:

- By `label`: data is queried using the actual index/column name (e.g., the `VEI` column in the DataFrame above)
- By `location`: data is queried using the column location (e.g., the 3rd row)

On this page
Querying data from a DataFrame
Label-based indexing
Position-based indexing

# Filtering data

# Boolean indexing

- **Filtering** data with boolean indexing

  → Returns either `True` or `False` depending on whether the **condition** is satisfied

# Boolean indexing: Example

- Query all volcanoes where `VEI == 4`

# Boolean indexing: Strings

- **Filtering** also works with strings
  - → Use **string comparison** operations

- **Example**:

```python
df.loc[df['Country'] == 'Indonesia']
```

| | Country | Date | VEI | Latitude | Longitude |
|---|---|---|---|---|---|
| **Name** | | | | | |
| Galunggung | Indonesia | 1982-04-05 | 4 | -7.2567 | 108.0771 |
| Merapi | Indonesia | 2023-12-03 | 2 | -7.5407 | 110.4457 |
| Agung | Indonesia | 2017-11-21 | 3 | -8.3422 | 115.5083 |
| Sinabung | Indonesia | 2023-02-13 | 3 | 3.1719 | 98.3925 |

# Boolean indexing: Strings

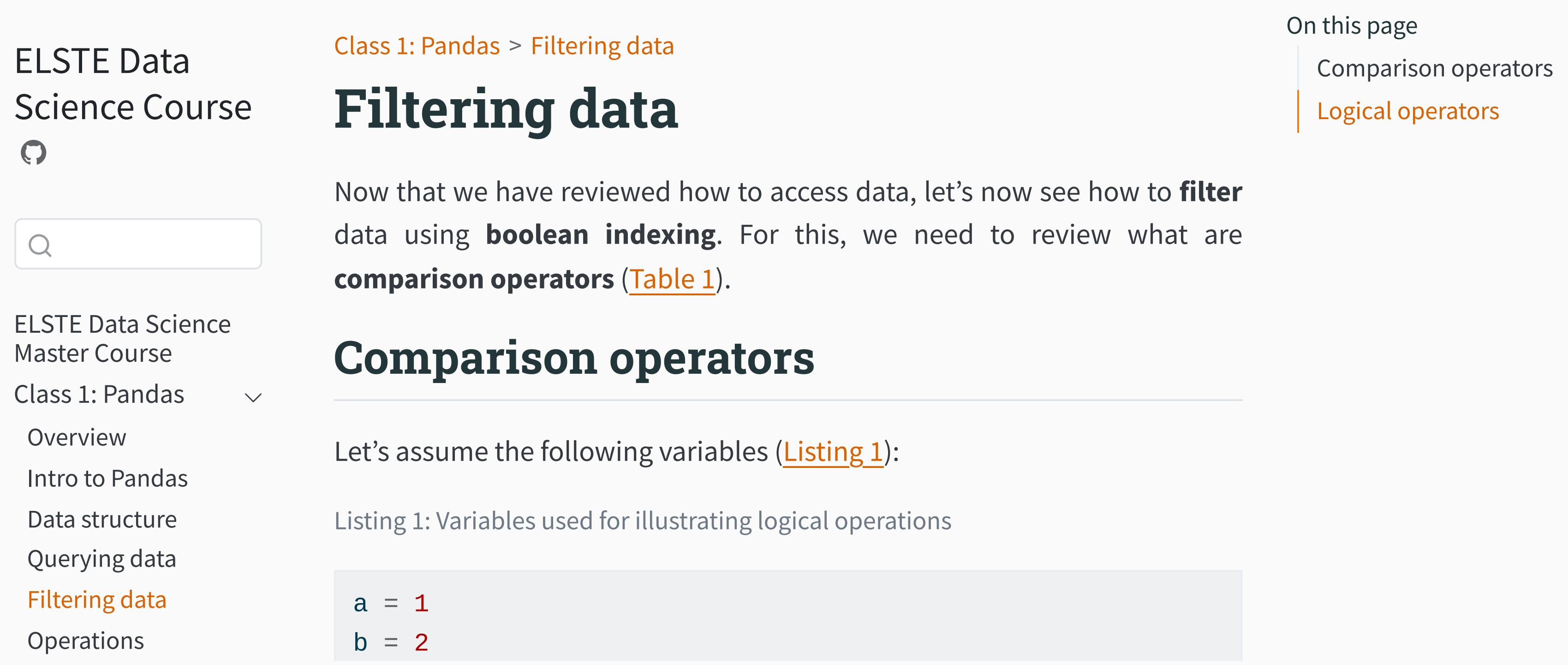
- **Filtering** also works with strings
  - → Use **string comparison** operations

- **String comparison operators**:

| Operation | Example | Description |
|---|---|---|
| contains | `df['Name'].str.contains('Soufrière')` | Checks if each string contains a substring |
| startswith | `df['Name'].str.startswith('E')` | Checks if each string starts with a substring |
| endswith | `df['Name'].str.endswith('o')` | Checks if each string ends with a substring |

# Your turn!

- Go to https://elste-master.github.io/Data-Science/
  → Class 1 > Filtering data



ELSTE Data Science Course

ELSTE Data Science Master Course

Class 1: Pandas

Overview

Intro to Pandas

Data structure

Querying data

Filtering data

Operations

Class 1: Pandas > Filtering data

# Filtering data

Now that we have reviewed how to access data, let’s now see how to **filter** data using **boolean indexing**. For this, we need to review what are **comparison operators** (Table 1).

## Comparison operators

Let’s assume the following variables (Listing 1):

Listing 1: Variables used for illustrating logical operations

```
a = 1
b = 2
```

On this page

Comparison operators

Logical operators

# Operations

# Data management operations

- Common data management functions for pandas columns:

| Operation | Example | Description |
|---|---|---|
| Round | `df['VEI'].round(1)` | Rounds values to the specified number of decimals |
| Floor | `df['VEI'].apply(np.floor)` | Rounds values down to the nearest integer |
| Ceil | `df['VEI'].apply(np.ceil)` | Rounds values up to the nearest integer |
| Absolute value | `df['VEI'].abs()` | Returns the absolute value of each element |
| Fill missing | `df['VEI'].fillna(0)` | Replaces missing values with a specified value |

# Arithmetic operations

- Arithmetic operations on parts of the DataFrame (→ *columns*) using native Python arithmetic operators

| Operation | Symbol | Example | Description |
|---|---|---|---|
| Addition | `+` | `df['VEI'] + 1` | Adds a value to each element |
| Subtraction | `-` | `df['VEI'] - 1` | Subtracts a value from each element |
| Multiplication | `*` | `df['VEI'] * 2` | Multiplies each element by a value |
| Division | `/` | `df['VEI'] / 2` | Divides each element by a value |
| Exponentiation | `**` | `df['VEI'] ** 2` | Raises each element to a power |
| Modulo | `%` | `df['VEI'] % 2` | Remainder after division for each element |

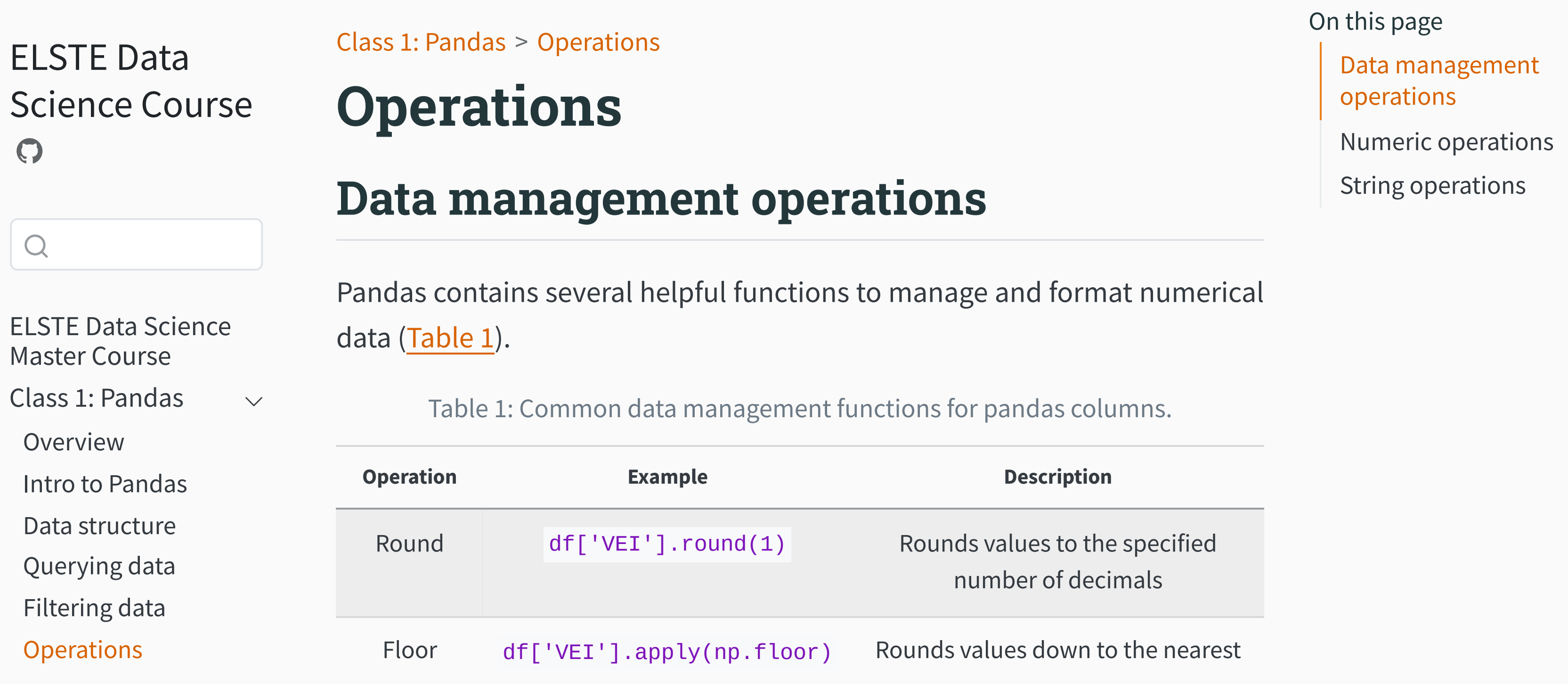
# Expanded arithmetic operations

- The range of arithmetic operations can be expanded using `numpy`

| Operation | Symbol | Example | Description |
|---|---|---|---|
| Exponentiation | `np.power` | `np.power(df['VEI'], 2)` | Element-wise exponentiation |
| Square root | `np.sqrt` | `np.sqrt(df['VEI'])` | Element-wise square root |
| Logarithm (base e) | `np.log` | `np.log(df['VEI'])` | Element-wise natural logarithm |
| Logarithm (base 10) | `np.log10` | `np.log10(df['VEI'])` | Element-wise base-10 logarithm |
| Exponential | `np.exp` | `np.exp(df['VEI'])` | Element-wise exponential (e^x) |

# Your turn!

- Go to https://elste-master.github.io/Data-Science/
  - → Class 1 > Operations



# Operations

## Data management operations

Pandas contains several helpful functions to manage and format numerical data (Table 1).

Table 1: Common data management functions for pandas columns.

| Operation | Example | Description |
|---|---|---|
| Round | `df['VEI'].round(1)` | Rounds values to the specified number of decimals |
| Floor | `df['VEI'].apply(np.floor)` | Rounds values down to the nearest |