ELSTE Data science

Some concept of Python coding and statistical inference

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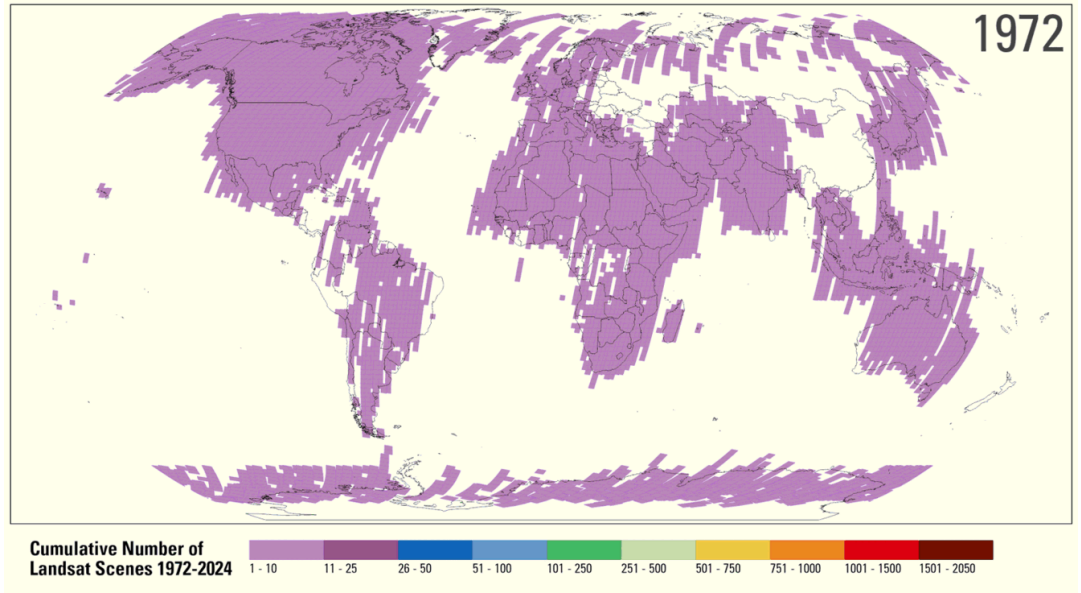
Why this class?

Data deluge: The big EO data landscape



- **Landsat:**
  - → Download: 53 images/day (2001) - 220’000 images/day (2017)
  - → 5 million images of the Earth surface → > 5 PB
- **ESA Sentinel 1 & 2 →** 4.6TB /daily!

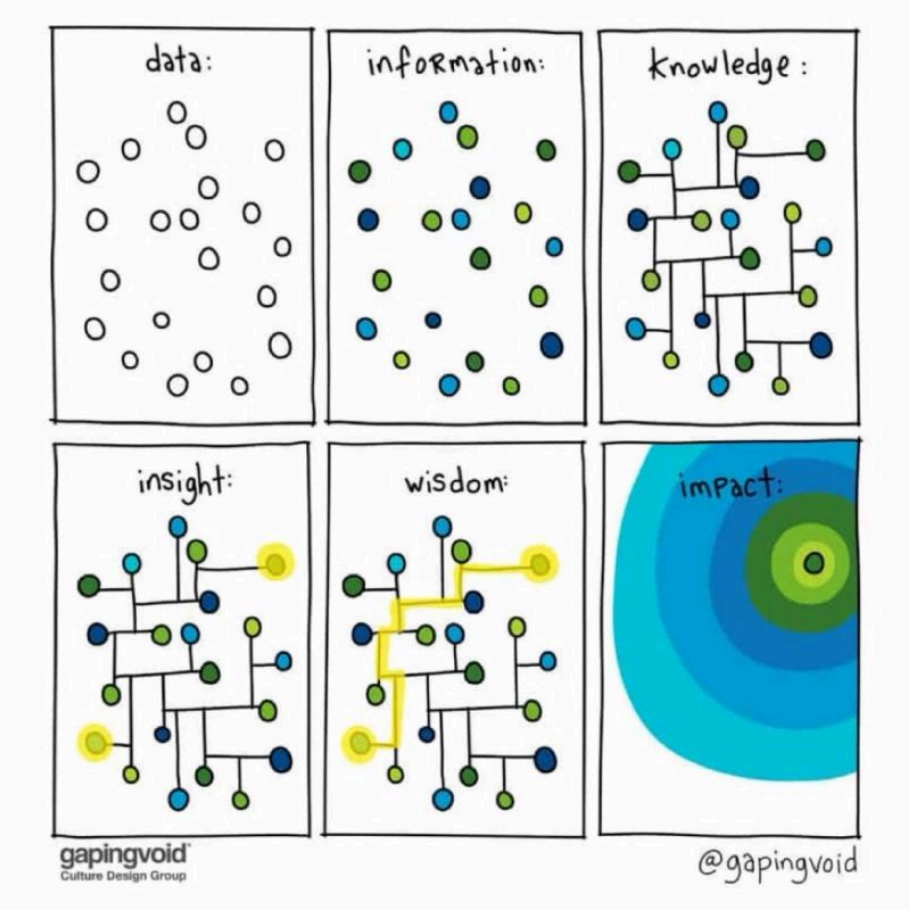
Why this class?

As scientists, we are exposed to:

- Increasing computational power/facilities
- Increasing amount of data

How do we make sense of it all?

- Scientific coding → gateway to scientific data analysis
- Data science → extracting meaningful infomation and insights from data



What is data science

Wikipedia

> Data science is an interdisciplinary academic field that uses statistics, scientific computing, scientific methods, processing, scientific visualization, algorithms and systems to extract or extrapolate knowledge from [...] data.

National Institutes of Standards and Technology

> The field that combines domain expertise, programming skills, and knowledge of mathematics and statistics to extract meaningful insights from data.

Class schedule

- **Fall part at UNIGE**: 6 × 3-h long sessions
- **Assistants**: Simon Thivet, Filippo Salmaso, Lionel Voirol
- **Format**: Theory, live coding and exercises

October 15 and 22

- **Seb** → Intro to data science libraries for Python → `Pandas`, `seaborn`

October 29 and November 5

- **Stéphane** → Intro to statistical method for data inference

November 12 and 19

- Flexible as a function of how we progress
- Exam format to be defined

Class objectives

- Scientific coding and stats often appear daunting
- True, there can be a steep learning curve

Objectives

- **Not** to make you and expert developer / statistician **but**
  - → To help you gain the confidence that you are totally capable of doing it
  - → To make you realise that what you will get in terms of research capabilities is worth the effort!

Get involved!!!

We want this class to be useful for your research!

Try to contextualise the course material to **your research**:

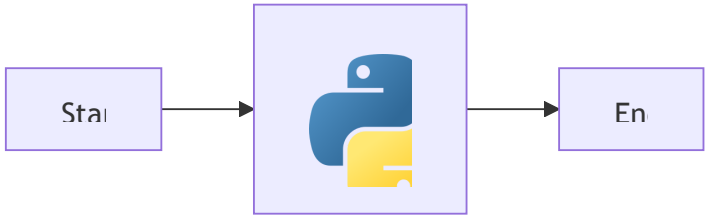
- Do you already have your own datasets you could bring to class?
- Can you use the course to formulate new research questions?
- Do you know any open-access datasets relevant to your fields?
  - → If not, can you find some for the next weeks?

Why coding?

Motivations

- **Example**: A common - but unnecessarily complicated - workflow of many specialised softwares

- **Objective**: Integrate full research workflow in an environment supporting all tasks



Motivations

Motivation 1: Automation

Cotopaxi volcano

- Reconstructing eruption source parameters (ESP) from tephra deposits

  → *How do different measurement methods influence ESP estimates*?

- 40 outcrops
- ~10 samples per outcrop
- ~7 measurement methods per sample

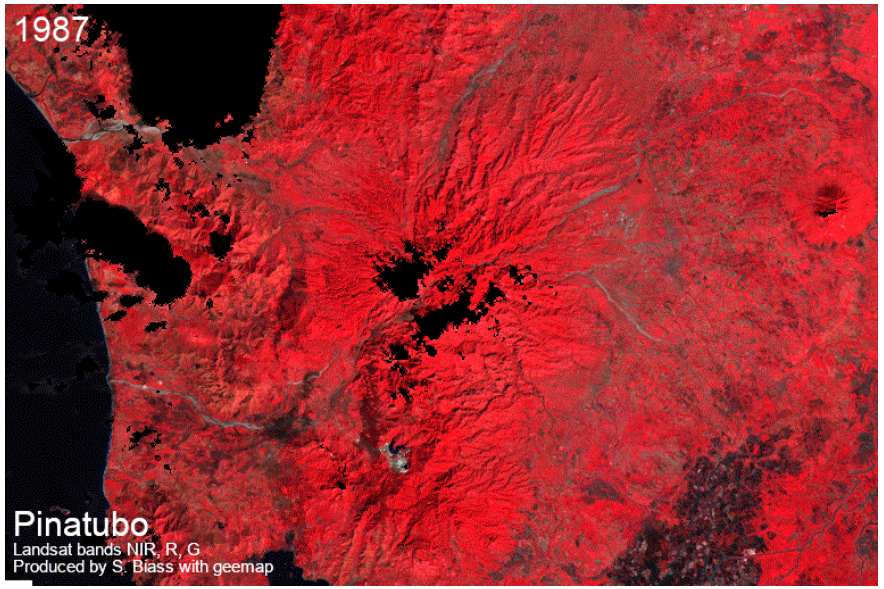
Motivations

Motivation 2: Data analysis

Example 1: Exploit catalogues of big Earth Observation data

- **Revisit big EO catalogues to infer new knowledge**

  → *What controls the impact and recovery of vegetation following eruptions?*

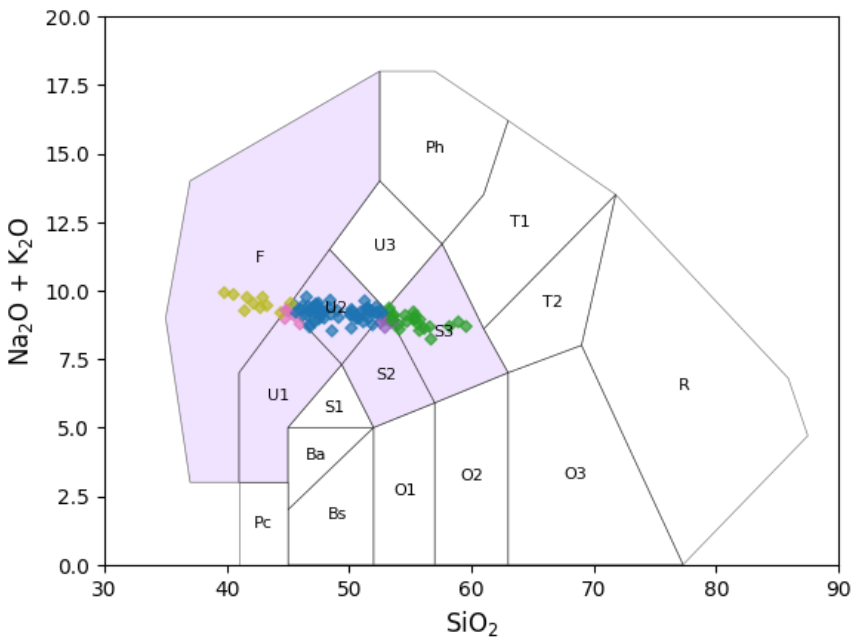


Motivations

Motivation 2: Data analysis

Example 2: Streamline global geochemical analyses

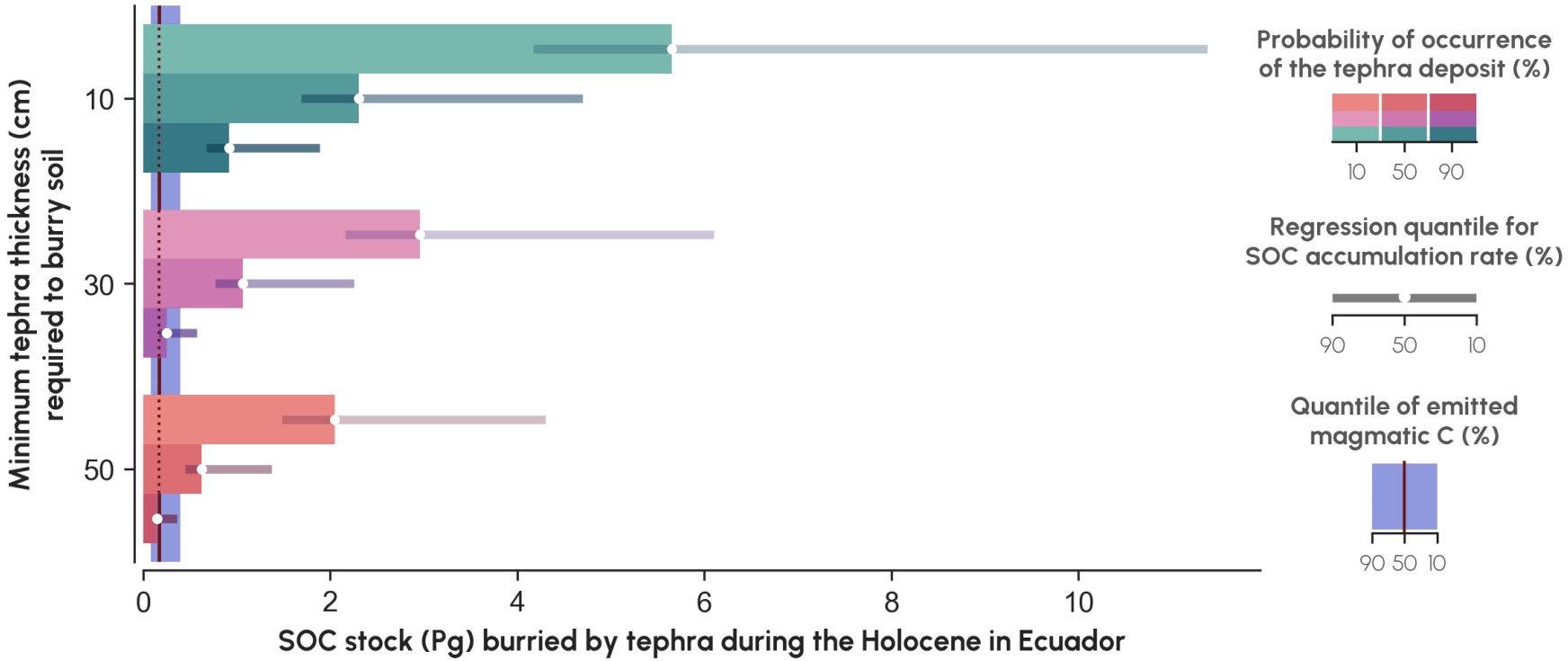
- **Access global databases**
  - → e.g., *Georock* database
- **Automatic dedicated analyses/plots**
  - → e.g., *TAS* diagrams and classification using `pyrolite`



Motivations

Motivation 3: Visualisation

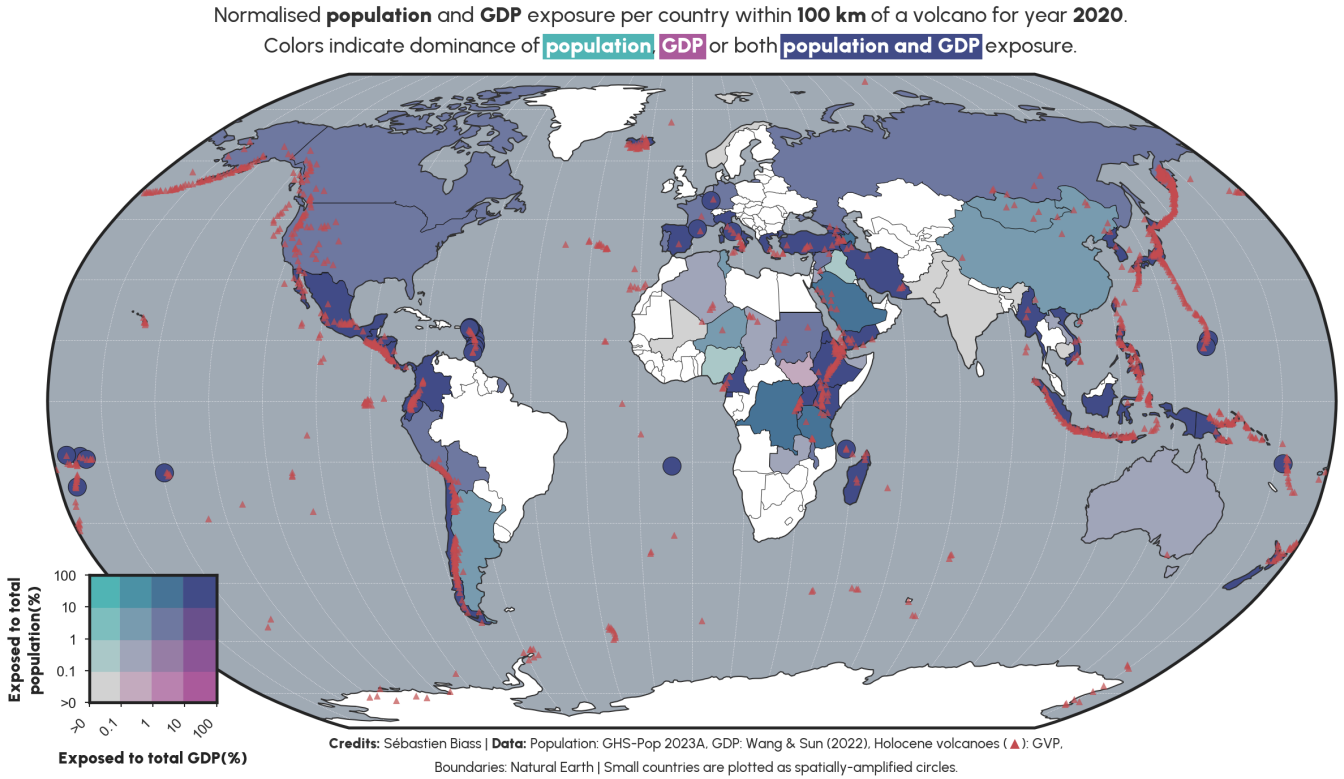
Example 1: In volcanically-active regions, soil burial after explosive eruptions capture more carbon that they emit.



Motivations

Motivation 3: Visualisation

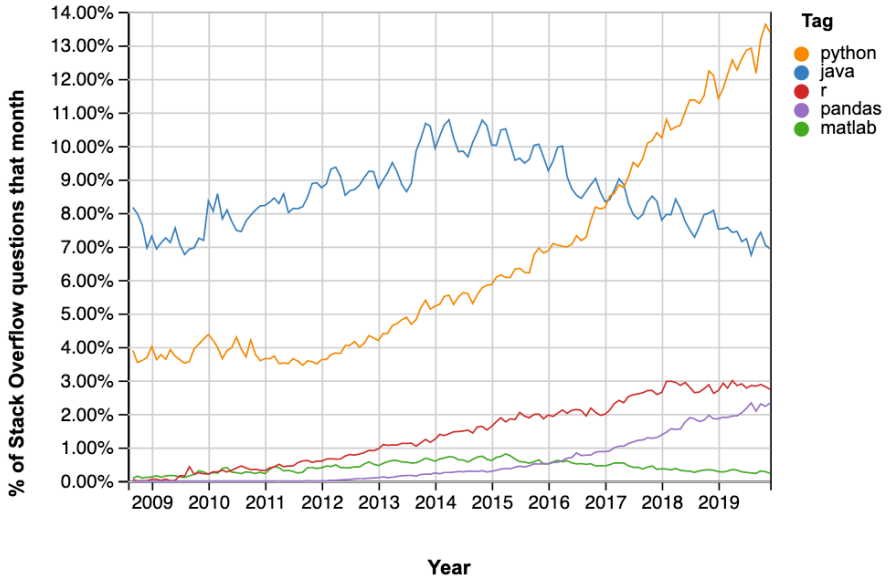
Example 2: In Small Island States, ≥90% of population and GDP is exposed to volcanic hazards.



Why Python?

Python's advantages [1]

1. **Free**
2. **Open source**
   - Not dependent on any company
   - Large online community
3. **Old** → stable (started in 1991)
4. **Very** popular in science
5. Relatively easy to learn



1. Inspired by the School of Oceanography at University of Washington

What is Python

High-level computing language

- Compiled → doesn't directly speak to the computer, but is *interpreted* by another language
  - → Usually slower, but much, much easier to use!

Modular

- Python is composed of a *core* of functions complemented by wide ecosystem of specialized packages for specific tasks
  - → A function is a bit of code to perform a **specific task**
  - → A module is a collection of **functions**
  - → A package is composed by multiple **modules**

An example of packages, modules and functions

In the code below, we first load the necessary packages and libraries:

- `matplotlib` is the main **visualisation** package used in Python
- `pyplot` is a module of `matplotlib` that provides easy-to-use functions for **plotting** data
- `figure` is a function of `pyplot` and is the main function to prepare a plot

```
# Import the packages and modules
from matplotlib import pyplot as plt
# Set up a figure for plotting
plt.figure(...)
```

How to use Python

Option 1: Your own computer

- Requires some setup
- No internet connection required
- Slow if computer is slow
- All data stored on your own computer

> **Environment manager!**
>
> Make sure to install an **environment manager** → e.g. Miniconda

Option 2: On the cloud → Google Collab

- No setup required
- No internet connection required
- Decent speed, free as long as Google says it is free
- All data stored on your own computer

How to run Python

3 main ways to run Python…

1. Run Python `.py` scripts from the command line → *deprecated*
2. Run blocks of code from within a Python `.py` script using `ipykernel` → **similar behaviour to R/Matlab**
3. Use **Jupyter Notebooks** in `.ipynb` files

…in two different environments

1. Dedicated software: VSCode, PyCharm, Spyder
2. Web browser: JupyterLab

Get started

- Follow the guide
- Start a new Jupyter Notebook

Let’s get coding

Background

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

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

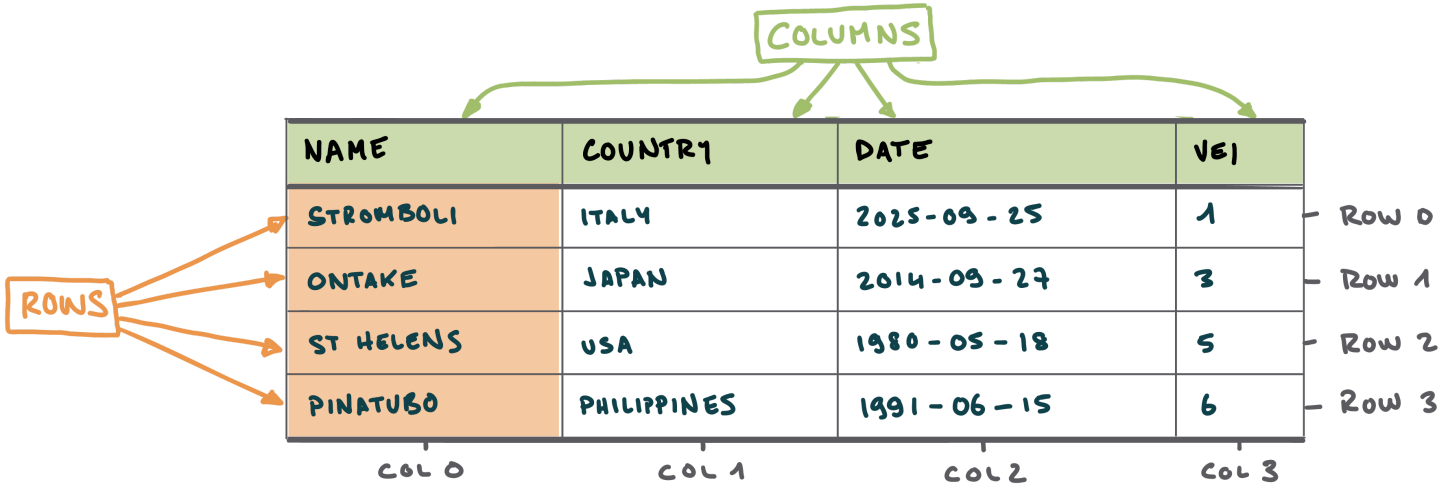
- **Reading/writing data** from common formats (CSV, Excel, JSON, etc.)
- Handling **missing data**
- **Filtering**, **sorting**, **reshaping** and **grouping** data
- **Aggregating** data (sum, mean, count, etc.)
- **Time series support** (date ranges, frequency conversions)
- **Statistical operations**

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*

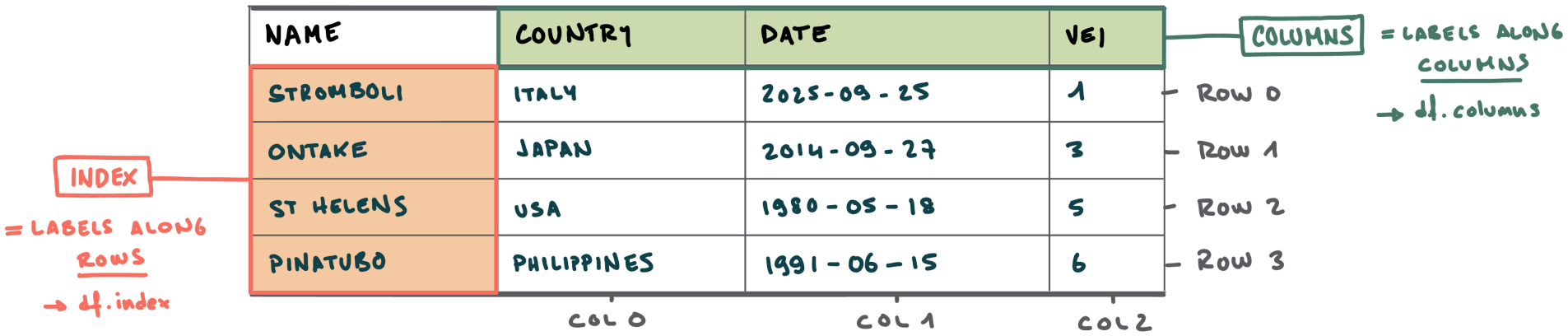
Anatomy of a DataFrame



- Similar to *Excel* → contains *tabular data* composed of rows and columns

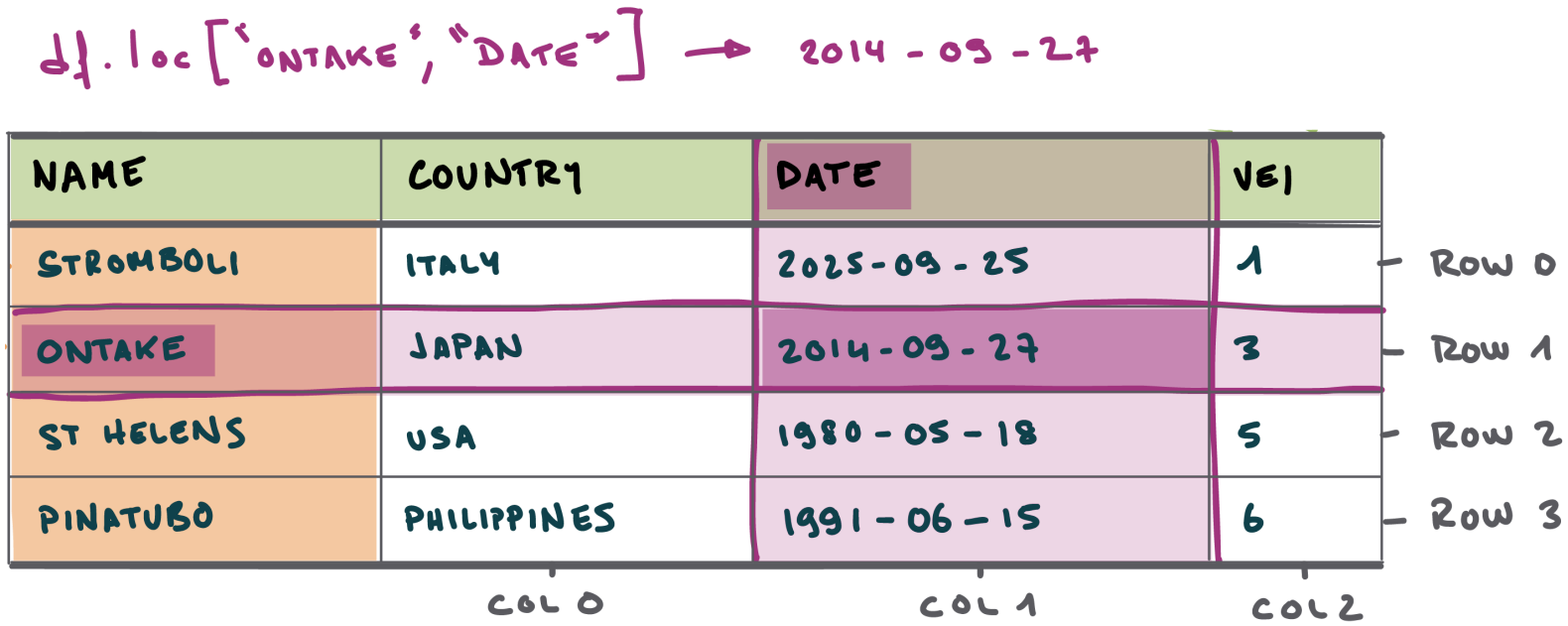
- In *Excel*:
  - → **Rows** are accessed using *numbers*
  - → **Columns** are accessed using *letters*

Anatomy of a DataFrame



- Unlike *Excel*, **rows** and **columns** can be labelled
  - → Index refers to the label of the **rows**. In the *index*, **values are usually unique** - meaning that each entry has a different label.
  - → Column refers to the label of - logically - the **columns**

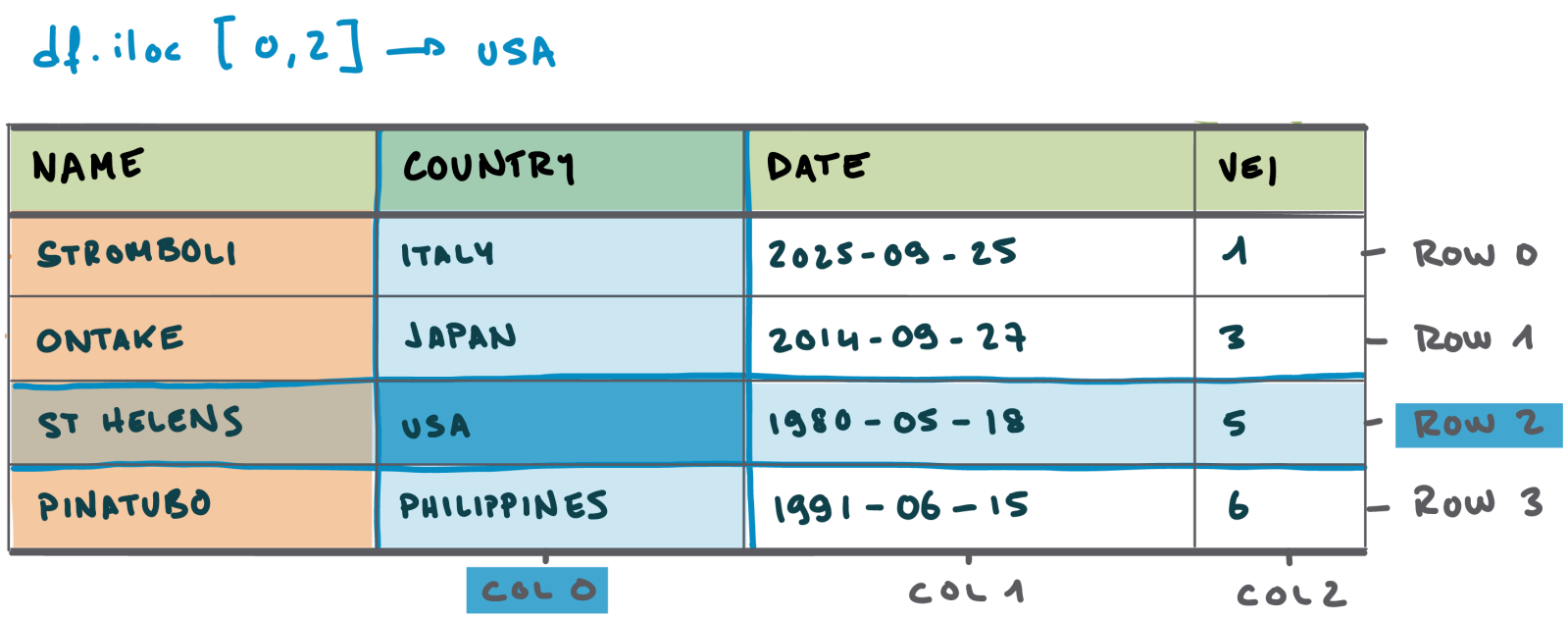
Accessing data in a DataFrame



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`