Teaching Astronomy with Python

Using coding activities to teach astronomy

Dimitrios Theodorakis

Dimitrios

Teacher in the UK (RQT)

- General Science (Physics Specialism)

- Astronomy Module for BTEC Applied Science

@AstroDimitrios astrodimitrios.github.io

https://www.youtube.com/channel/UCf8Sg-cgLNubyCM5Em8eDZg/

https://github.com/astroDimitrios/Astronomy

astrodimitrios@gmail.com

Teaching with Notebooks

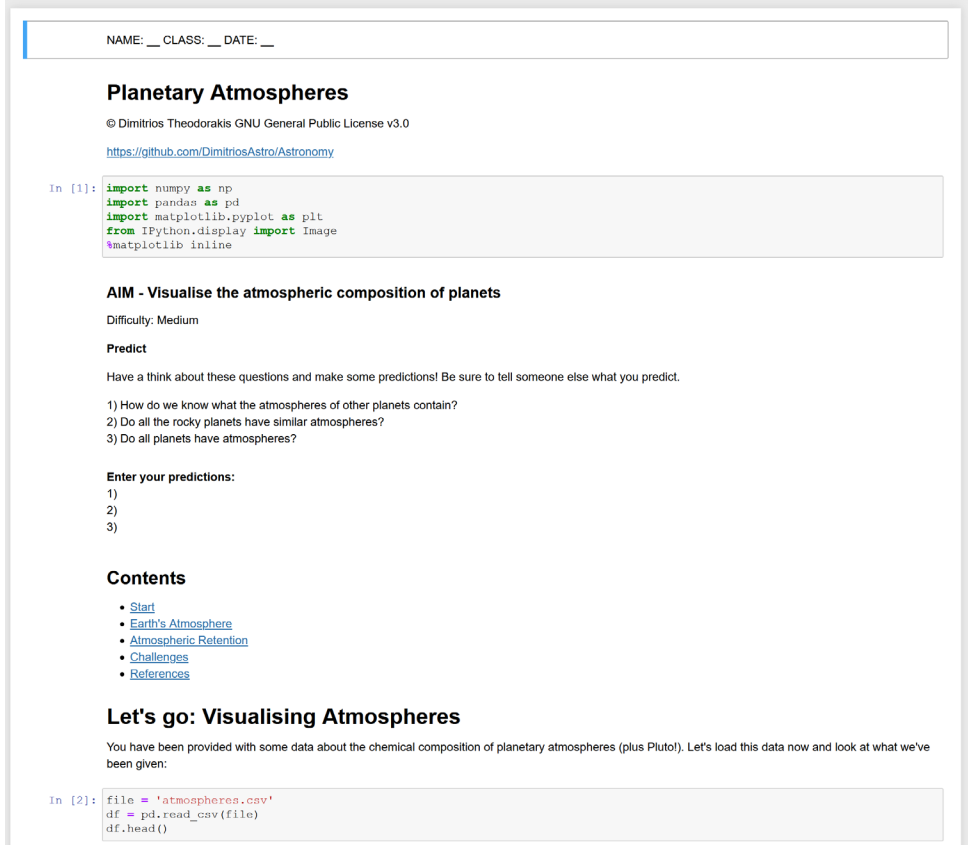
Online – suitable for virtual learning

Free – open source software and activities

Integrates a **new skill** into students learning

Provides **interactivity** where no standard physical activity exists

Brings **astronomical data** into the classroom



NAME: __ CLASS: __ DATE: __

Planetary Atmospheres

© Dimitrios Theodorakis GNU General Public License v3.0

https://github.com/DimitriosAstro/Astronomy

In [1]:
```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
from IPython.display import Image
%matplotlib inline
```

AIM - Visualise the atmospheric composition of planets

Difficulty: Medium

Predict

Have a think about these questions and make some predictions! Be sure to tell someone else what you predict.

1) How do we know what the atmospheres of other planets contain?
2) Do all the rocky planets have similar atmospheres?
3) Do all planets have atmospheres?

Enter your predictions:
1)
2)
3)

Contents

- Start
- Earth's Atmosphere
- Atmospheric Retention
- Challenges
- References

Let's go: Visualising Atmospheres

You have been provided with some data about the chemical composition of planetary atmospheres (plus Pluto!). Let's load this data now and look at what we've been given:

In [2]:
```
file = 'atmospheres.csv'
df = pd.read_csv(file)
df.head()
```

The Jupyter Notebook

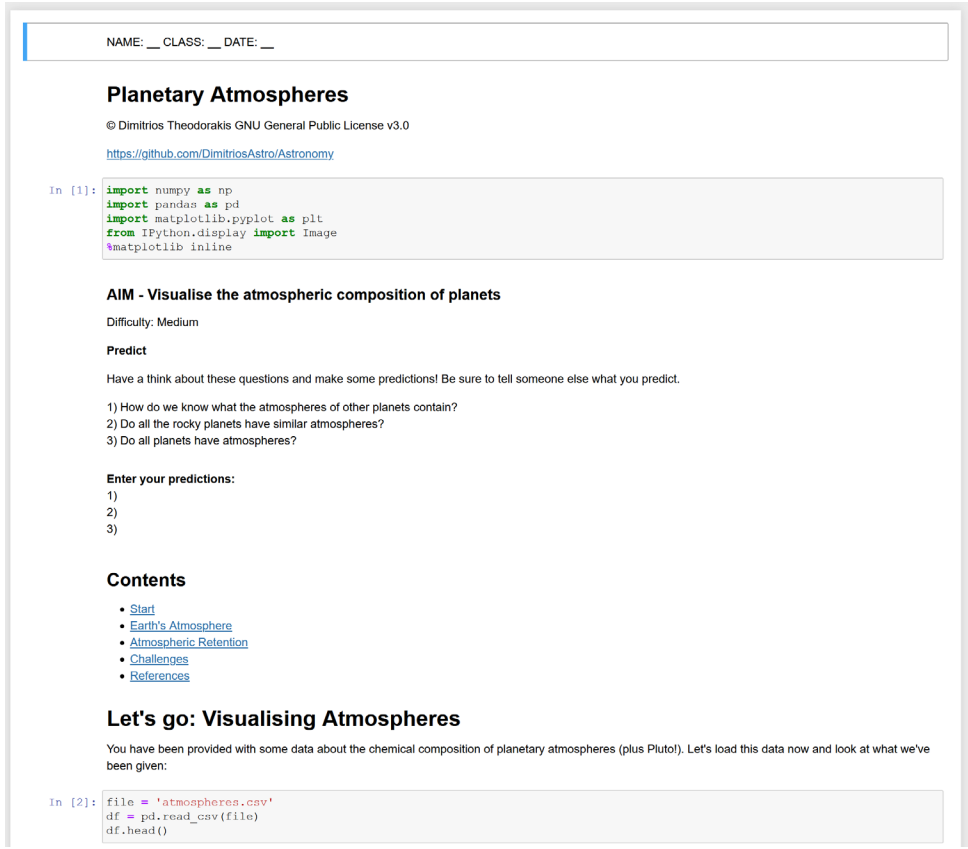
Jupyter – Interactive data science online and in many languages

My notebooks are in **Python 3** – widely used by astronomers

Support for the **Markdown** markup language, **LaTeX**, and **Html**.

Can be run **free online:** https://jupyter.org/try
Or through Google with Colab or Microsoft with Codespaces

Docs:
https://jupyter-notebook.readthedocs.io/en/stable/notebook.html



NAME: __ CLASS: __ DATE: __

Planetary Atmospheres

© Dimitrios Theodorakis GNU General Public License v3.0

https://github.com/DimitriosAstro/Astronomy

In [1]:
```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
from IPython.display import Image
%matplotlib inline
```

AIM - Visualise the atmospheric composition of planets

Difficulty: Medium

Predict

Have a think about these questions and make some predictions! Be sure to tell someone else what you predict.

1) How do we know what the atmospheres of other planets contain?
2) Do all the rocky planets have similar atmospheres?
3) Do all planets have atmospheres?

Enter your predictions:
1)
2)
3)

Contents

Let's go: Visualising Atmospheres

You have been provided with some data about the chemical composition of planetary atmospheres (plus Pluto!). Let's load this data now and look at what we've been given:

In [2]:
```
file = 'atmospheres.csv'
df = pd.read_csv(file)
df.head()
```

My Notebooks

2 intro activities (**1**&**2**)

12 main activities

Some focus solely on visualisation and others just maths – most are a mix. Teacher version includes answers.

1.5 – 2 hours each

(**+3** coding challenges)

Can all be seen in **Binder**:
https://mybinder.org/v2/gh/DimitriosAstro/Astronomy/master?filepath=Code

AstPy Number	Description	Data Files	Comments
1	Intro to Python and Numpy		
2	Challenge: Bouncing Balls		Bit harder than intro - adds plotting + animation.
3	Stellar Fusion	Nuclear masses and binding energies (csv)	Binding energy anim and calcs including coulomb potential well.
4	Solar Images	Various SDO HMI and AIA FITS	Getting and potting SDO/SOHO Images.
5	Solar Radiation		Blackbody rad, Wien's law etc. Effective temperature of planets.
6	Sunspots	SDO HMI Fits	Calculation of solar rotation period (interactive and automatic). Sunspot identification and sunspot tracking (automatic).
7	Lunar Surface	LOLA DEM, LOLA Raw Topographic Data for Catalan Crater	Annotating your image of the moon from a telescope. Calculating resolution, crater heights and diameters. Comparing to Lunar Reconnaissance Orbiter (LRO) and Lunar Orbiter Laser Altimeter (LOLA) data.
8	Planets	Orbital data, density, radius, mass etc.	Comparing planets by looking at data from the NASA Planetary Factsheet such as mass and radius etc. Looking briefly at exoplanet detection and observational bias.
9	Planetary Interiors	Structure of the planets csv and chemcial composition of the Earth csvs.	Visualising the interiors of planets, visualise the chemical composition of the Earth's interior.
10	Planetary Atmospheres	Chemical composition of planetary atmospheres. Exobase altitudes and temperatures (with escape velocities).	Visualising and comparing the chemical composition of planetary atmospheres. Calculating whether a planet can hold onto a gas using escape velocities and kinetic theory.
11	Earth's Heat	Geothermal gradient data and pressure data.	Visualise the thermal gradient of the Earth. Model the geotherm of the lithosphere. Calculate energy transfer via conduction and latent heat.
12	Earth's Atmosphere	Data to construct the international standard atmosphere (ISA) model.	Visualising the temperature, pressure, density, and speed of sound variation with altitude using the ISA model.
13	Martian Surface		COMING SOON!
14	Planetary Rings	Data on the ring structure for all gas giants and data on their moons.	Visualising the ring structure of Saturn and the other gas giants. Calculating roche limits for some moons.
15	Ring Dynamics	Data on Saturns moons.	Visualising the Roche limit with an N-body simulation. Calculating the locations of mean-motion resonances. Looking at bending and density waves, and the effects of shepherd moons.

Example Notebook

All activities start with the **AIM** and some **Predictions**

Most activities have some requirements to import first

Activity starts at **Let's go:**

NAME: __ CLASS: __ DATE: __

Planetary Atmospheres

https://github.com/DimitriosAstro/Astronomy

In [1]:
```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
from IPython.display import Image
%matplotlib inline
```

AIM - Visualise the atmospheric composition of planets

Difficulty: Medium

Predict

Have a think about these questions and make some predictions! Be sure to tell someone else what you predict.

1) How do we know what the atmospheres of other planets contain?
2) Do all the rocky planets have similar atmospheres?
3) Do all planets have atmospheres?

Enter your predictions:
1)
2)
3)

Contents

Let's go: Visualising Atmospheres

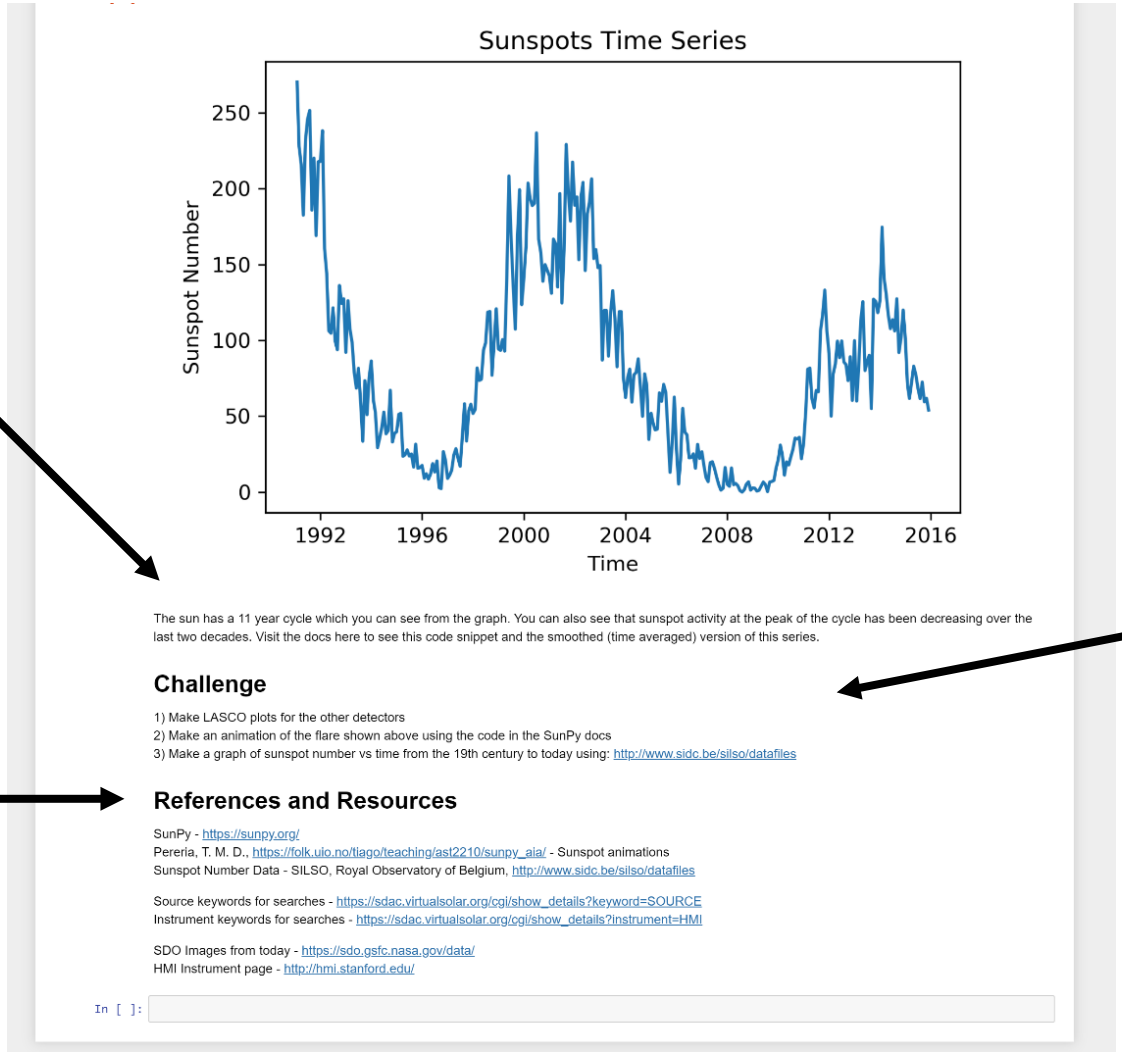
You have been provided with some data about the chemical composition of planetary atmospheres (plus Pluto!). Let's load this data now and look at what we've been given:

In [2]:
```
file = 'atmospheres.csv'
df = pd.read_csv(file)
df.head()
```

Example Notebook

Final Comments often with suggestions on where to go next for more info

References and Resources



Challenge activity suggestions

Could be used as an assessment

Easy to hard

Improvements

- Add space for students to write answers (make sure Q's have numbers)
- Place for student name and class
- Add contents at the top to make navigation easier
- Add inline images using HTML where possible
- Difficulty rating for activities?

PLAN:

- Example live notebook
- How to upload the files I sent to jupyter.org/try
- Breakout rooms so you can try one of the activities
- Final 5-10 mins back to round up and ask questions

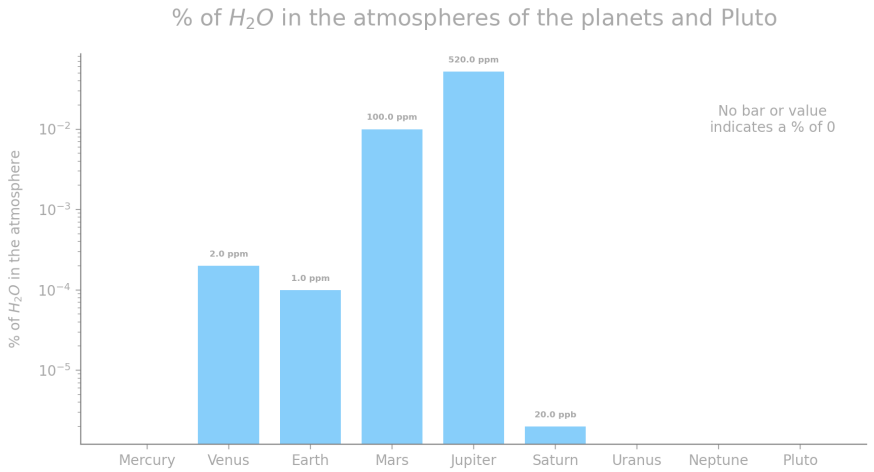
All the activities you see today have been updated with these improvements!

Example LIVE Notebook

https://github.com/astroDimitrios/Astronomy/tree/master/Code/AstPy-10%20Planetary%20Atmospheres

AstPy-10 Planetary Atmospheres

- Visualise the chemical composition of planetary atmospheres
- Compare the atmospheres of planets
- Calculate whether a planet can retain certain gases



Where next?

I will continue to make more notebooks! (+improve old ones)

It would be great if this became a community project!

Be sure to email – astrodimitrios@gmail.com
or join our gitter - https://gitter.im/Astronomy-Python-Notebooks/
if you're interested in:

- Making notebooks
- Using/testing notebooks in your classroom
- Translating notebooks
- Want to chat about astronomy and python!

Any Questions?

Thanks! Don’t forget to star my GitHub repo
and follow me on Twitter and YouTube.