Astronomy and Python

Using coding activities to teach astronomy

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https://forms.gle/C1hXshdmpwuZkMQB9

Dimitrios

Teacher in the UK (RQT)

- General Science (Physics Specialism)

- Astronomy Module for BTEC Applied Science

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

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Teaching with Notebooks

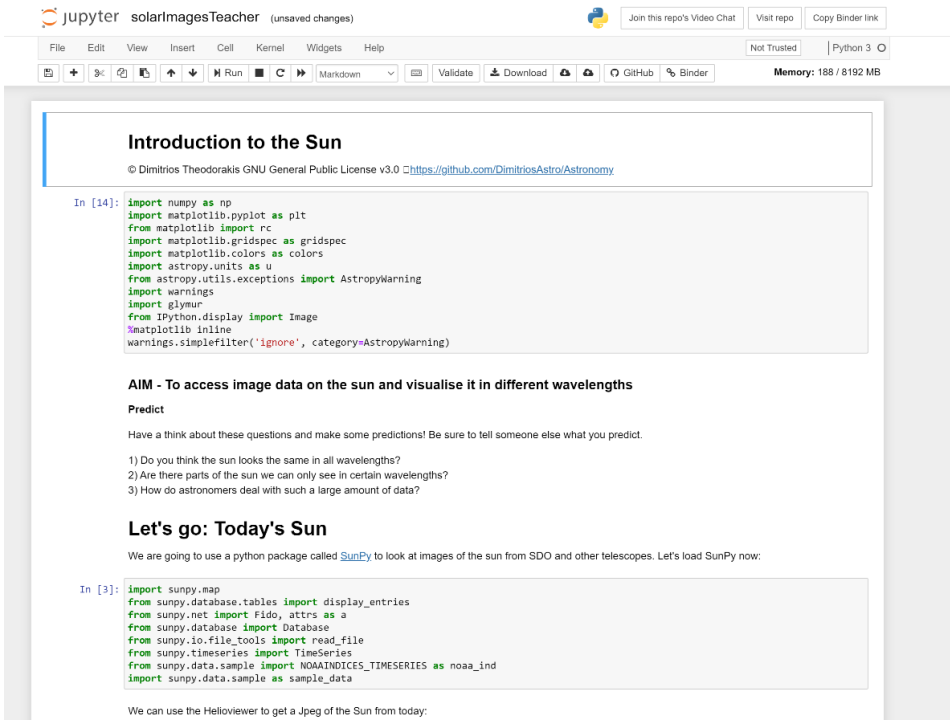
Online – suitable for virtual learning

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



The Jupyter Notebook

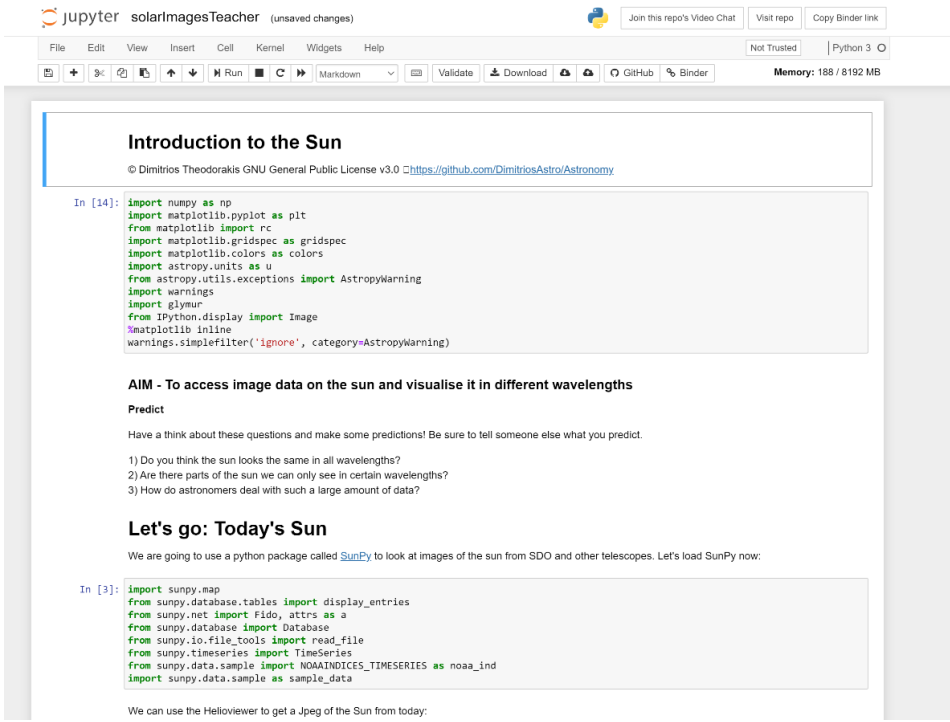
Jupyter – Interactive data science online and in many languages

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



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

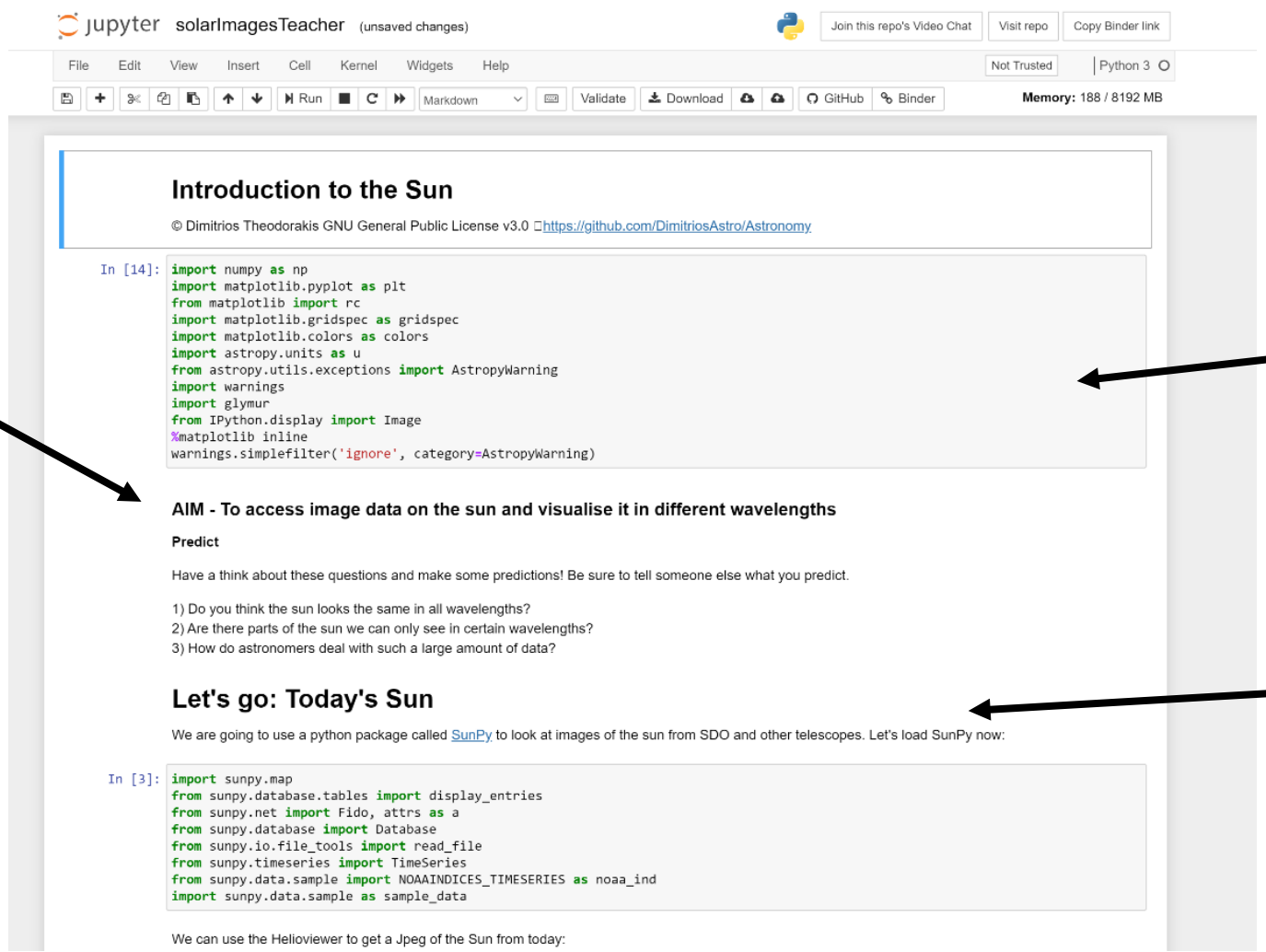
(**+2** coding challenges)

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**



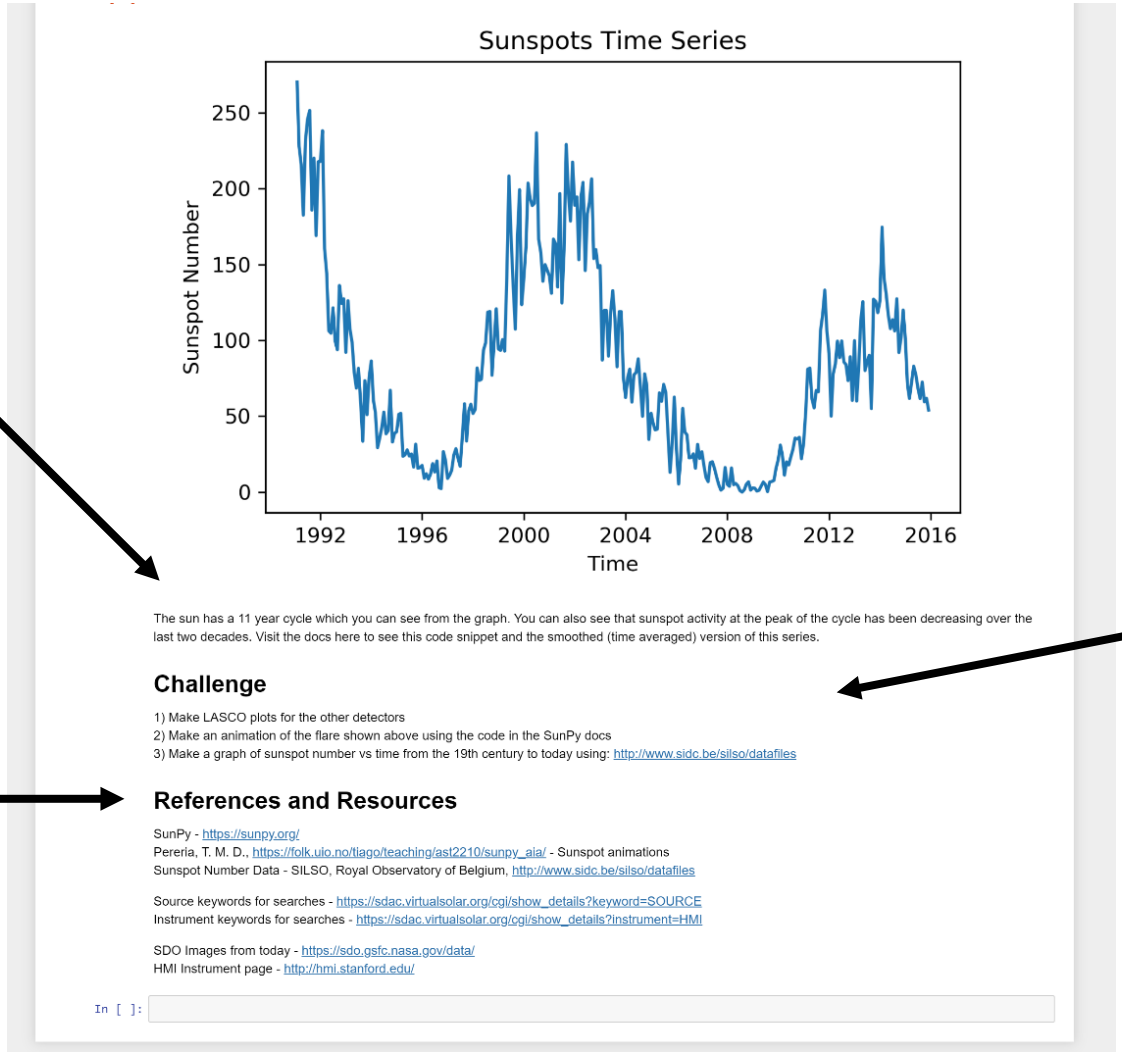
Most activities have some requirements to import first

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

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:

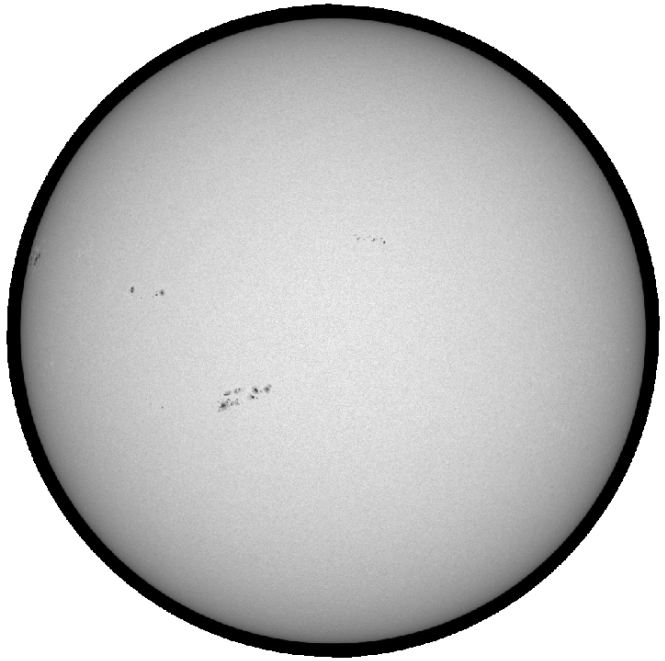
- Example live notebook
- How to upload the files I sent to jupyter.org/try
- Breakout rooms so you can try one of the activities I sent via email
- Final 5-10 mins back to round up and ask questions

Example LIVE Notebook

https://github.com/astroDimitrios/Astronomy/tree/master/Code/AstPy-6%20Sunspots

AstPy-6 Sunspots

- Identification of sunspots in SDO HMI continuum images
- Calculation of the sidereal and synodic rotation periods of the sun
- Automatic identification and tracking of sunspots using SunPy (challenge)



Where next?

I will continue to make more notebooks!

It would be great if this became a community project!

Be sure to email me 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.

https://forms.gle/hN3429sc4hjvt5iL6