Projects

Astro Pi Flight Data Analysis

Do strange, unexplained things happen on the International Space Station?

Step 1 Introduction

In this project you will analyse real data, captured by either of the two Astro Pi Flight Units onboard the International Space Station, to learn about Life in Space and Life.

You will:

- Load Comma Separated Values (CSV) (https://en.wikipedia.org/wiki/Comma-separated_values) into a spreadsheet application.
- Display the loaded data in a graphical format.
- Look for anomalies in the data, and try to form rational conclusions about those data points.

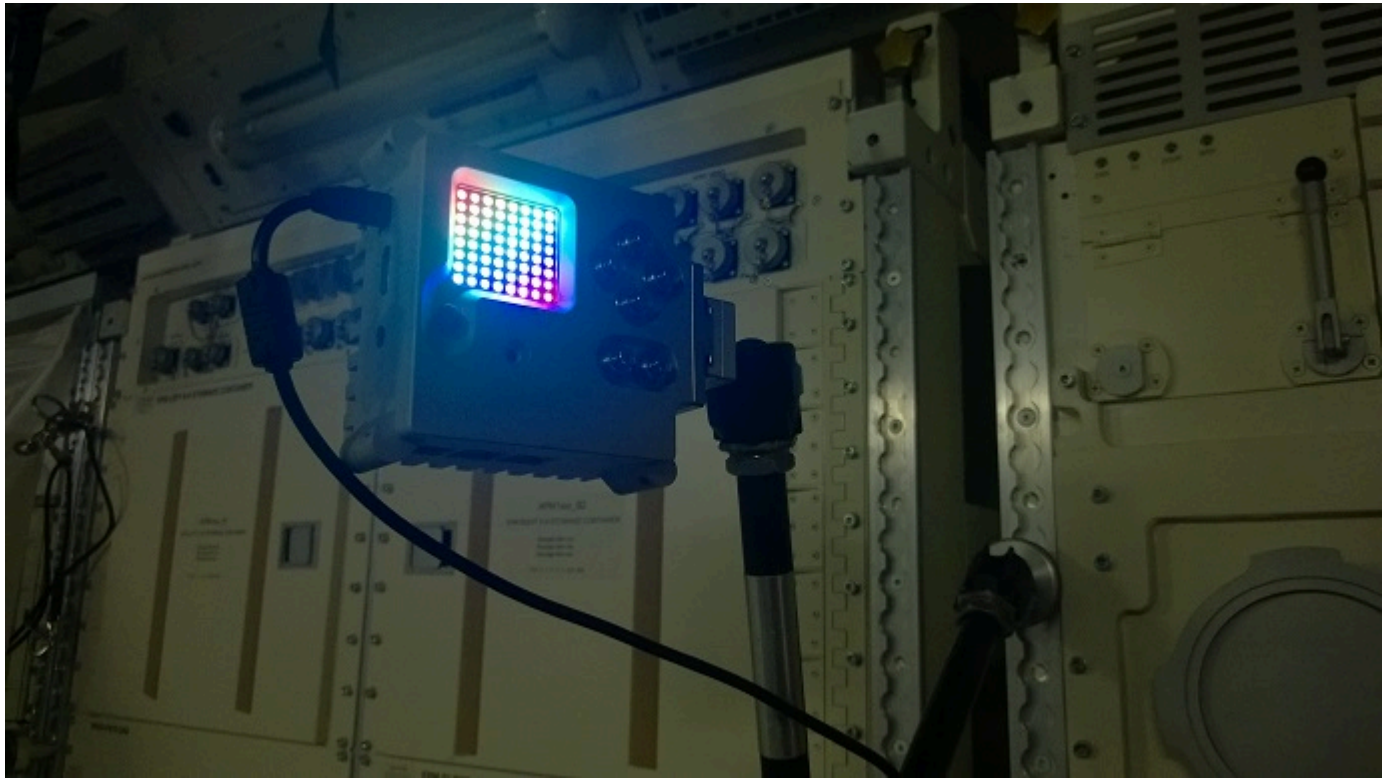
You will need

As a minimum, you will need spreadsheet software. A list of some of the most common is below:

- Microsoft Excel (https://www.microsoft.com/en-us/microsoft-365/excel) (Windows and macOS)
- LibreOffice Calc (https://www.libreoffice.org/) (Windows, macOS and Linux)
- Numbers (https://www.apple.com/uk/numbers/) (macOS)
- Google Sheets (sheets.google.com) (Web based)

Follow the instructions for your operating system to install the software.

Step 2 CSV files



If you have completed the **Sense HAT data logger** (https://projects.raspberrypi.org/en/projects/sense-hat-data-logger/) project you will finish with a large Comma Seperated Value (CSV) file, ready to be looked at.

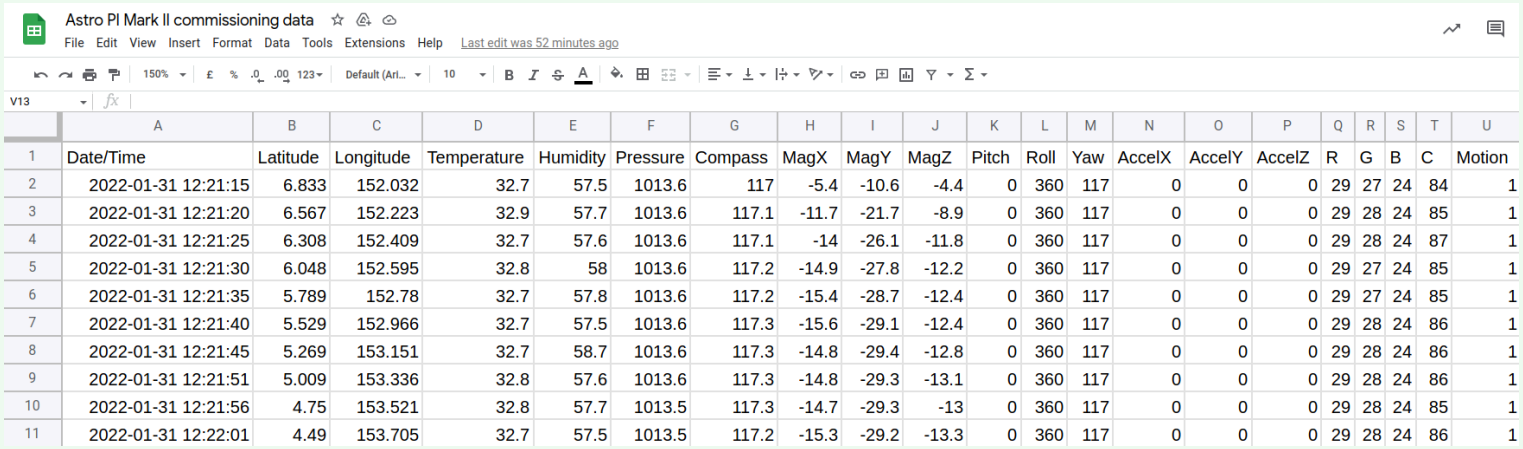
Alternatively you might have completed the **Astro Pi Mission Space Lab** (https://astro-pi.org/mission-space-lab/guidelines/life-in-space) challenge and have a CSV to analyse once your data has been returned from the International Space Station.

What's in a CSV files?

To make the data in a CSV easy to read and analyse, it can be opened using a spreadsheet application. The example below uses Google Sheets, but the process is similar for other applications.

Download this CSV file (https://github.com/raspberrypilearning/astro-pi-flight-data-analysis/raw/master/en/resources/Astro%20PI%20Mark%20II%20commissioning%20data%20-%20IR.csv), which contains data captured from one of the flight units onboard the ISS.

Use your spreadsheet application to **Open** or **Import** the downloaded file. You should see something like this:



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U
1	Date/Time	Latitude	Longitude	Temperature	Humidity	Pressure	Compass	MagX	MagY	MagZ	Pitch	Roll	Yaw	AccelX	AccelY	AccelZ	R	G	B	C	Motion
2	2022-01-31 12:21:15	6.833	152.032	32.7	57.5	1013.6	117	-5.4	-10.6	-4.4	0	360	117	0	0	0	29	27	24	84	1
3	2022-01-31 12:21:20	6.567	152.223	32.9	57.7	1013.6	117.1	-11.7	-21.7	-8.9	0	360	117	0	0	0	29	28	24	85	1
4	2022-01-31 12:21:25	6.308	152.409	32.7	57.6	1013.6	117.1	-14	-26.1	-11.8	0	360	117	0	0	0	29	28	24	87	1
5	2022-01-31 12:21:30	6.048	152.595	32.8	58	1013.6	117.2	-14.9	-27.8	-12.2	0	360	117	0	0	0	29	27	24	85	1
6	2022-01-31 12:21:35	5.789	152.78	32.7	57.8	1013.6	117.2	-15.4	-28.7	-12.4	0	360	117	0	0	0	29	27	24	85	1
7	2022-01-31 12:21:40	5.529	152.966	32.7	57.5	1013.6	117.3	-15.6	-29.1	-12.4	0	360	117	0	0	0	29	28	24	86	1
8	2022-01-31 12:21:45	5.269	153.151	32.7	58.7	1013.6	117.3	-14.8	-29.4	-12.8	0	360	117	0	0	0	29	28	24	86	1
9	2022-01-31 12:21:51	5.009	153.336	32.8	57.6	1013.6	117.3	-14.8	-29.3	-13.1	0	360	117	0	0	0	29	28	24	86	1
10	2022-01-31 12:21:56	4.75	153.521	32.8	57.7	1013.5	117.3	-14.7	-29.3	-13	0	360	117	0	0	0	29	28	24	85	1
11	2022-01-31 12:22:01	4.49	153.705	32.7	57.5	1013.5	117.2	-15.3	-29.2	-13.3	0	360	117	0	0	0	29	28	24	86	1

If you wanted to collect motion data for the Astro Pi Flight Unit, then have a look at the collapsed section below.

Flight unit PIR +

What do the headings mean +

There is an excellent guide to help you understand the sensors here (https://projects.raspberrypi.org/en/projects/getting-started-with-the-sense-hat) if you need to familiarise yourself.

Step 3 Analyse the data

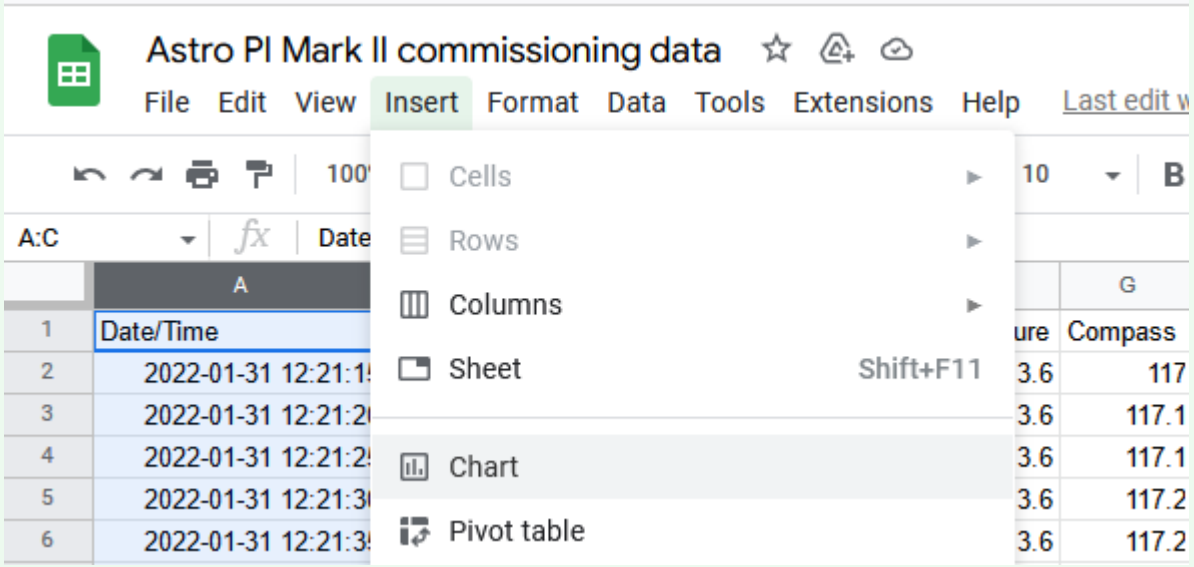
The easiest way to analyse the data is to draw some graphs, and then look for patterns or anomolies that you might find.

You can select columns of data in a spreadsheet and then use that data to draw a graph.

Select the columns of data that you want to graph.

	A	B	C
1	Date/Time	Latitude	Longitude
2	2022-01-31 12:21:15	6.833	152.032
3	2022-01-31 12:21:20	6.567	152.223
4	2022-01-31 12:21:25	6.308	152.409
5	2022-01-31 12:21:30	6.048	152.595
6	2022-01-31 12:21:35	5.789	152.78
7	2022-01-31 12:21:40	5.529	152.966
8	2022-01-31 12:21:45	5.269	153.151
9	2022-01-31 12:21:51	5.009	153.336
10	2022-01-31 12:21:56	4.75	153.521
11	2022-01-31 12:22:01	4.49	153.705
12	2022-01-31 12:22:06	4.229	153.89

From the **Insert** menu select **Chart**



Use the **Chart editor** to change the **X-axis** and **Series** of the chart. In this case the X-axis has been changed to **Date/Time** and the **Latitude** and **Longitude** are being plotted along the **Y-axis**.

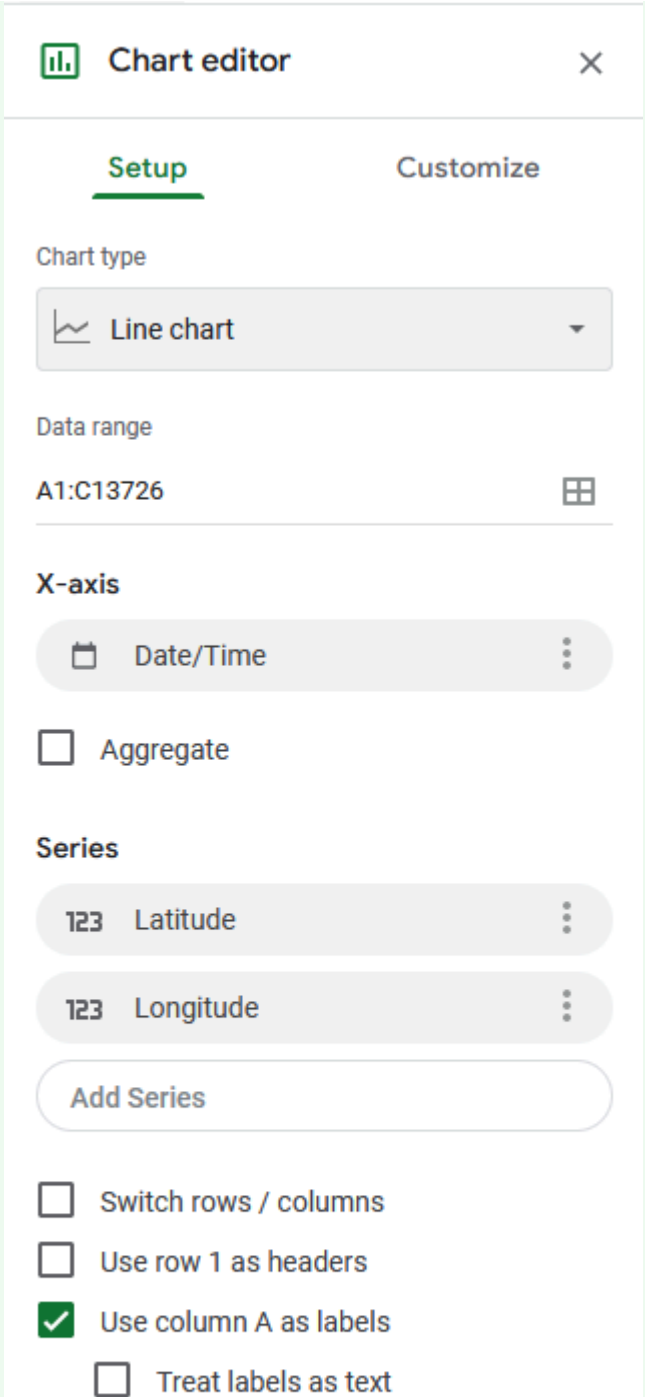
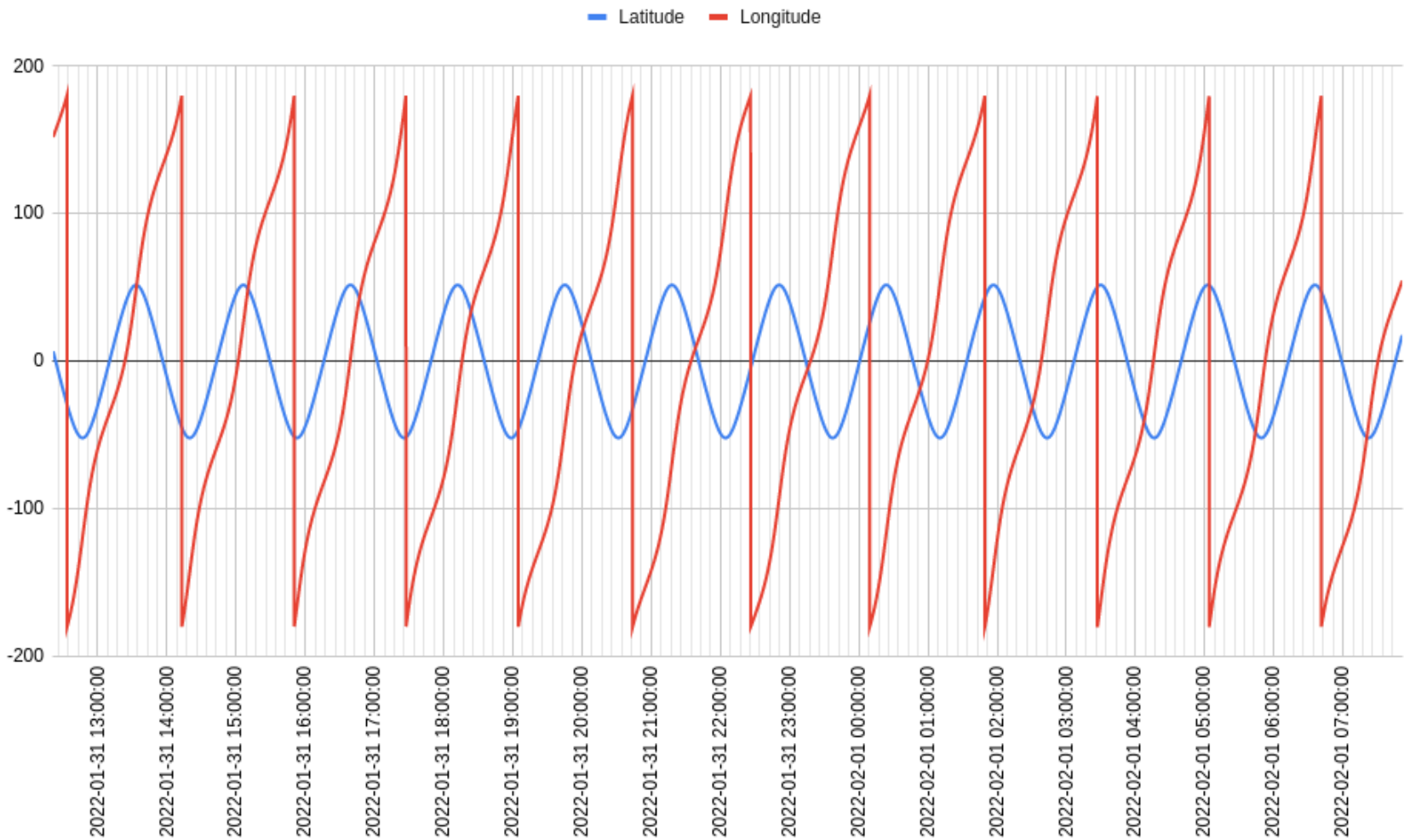


Chart editor
Setup
Customize
Chart type
Line chart
Data range
A1:C13726
X-axis
Date/Time
Aggregate
Series
123 Latitude
123 Longitude
Add Series
Switch rows / columns
Use row 1 as headers
Use column A as labels
Treat labels as text

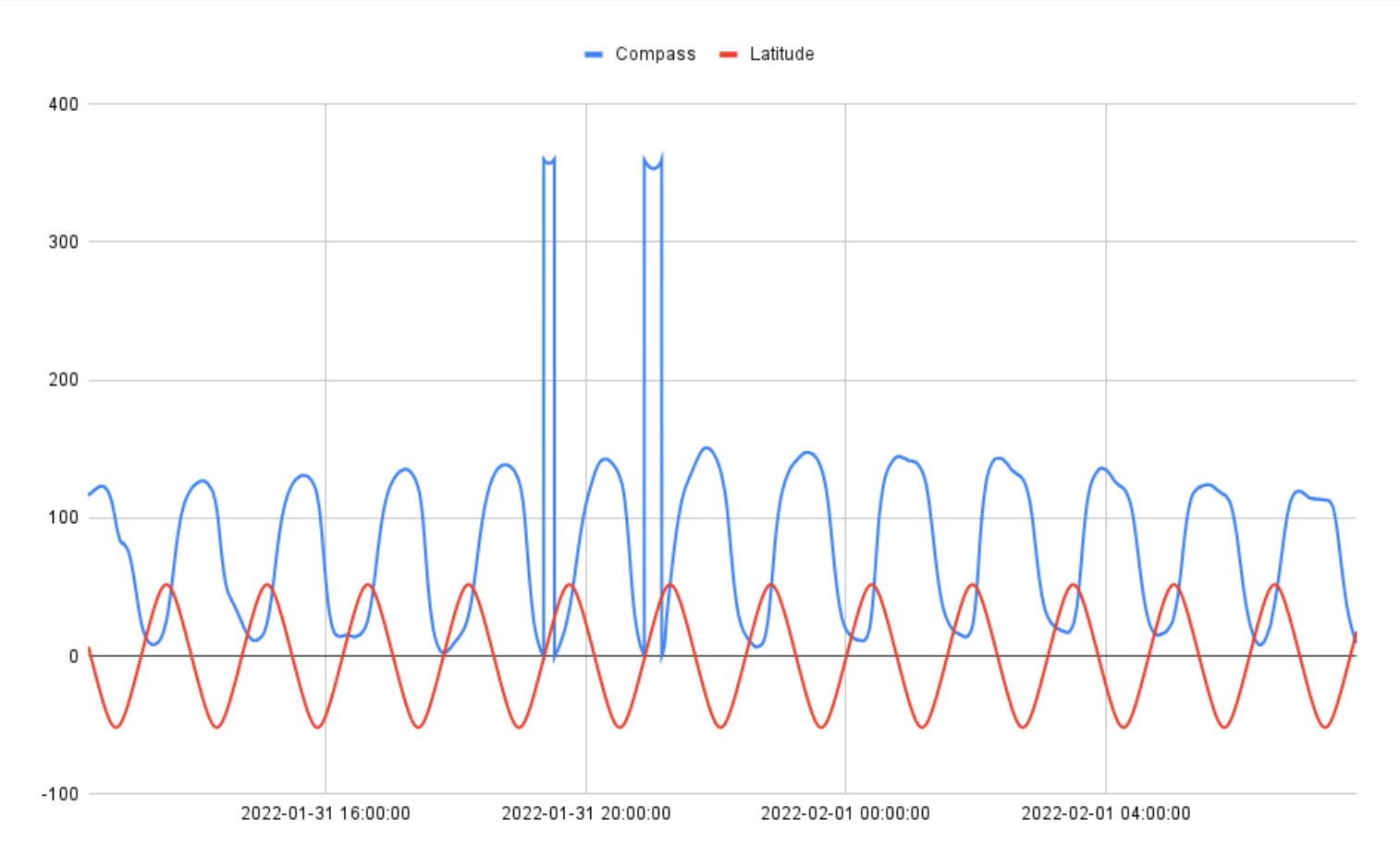
This is the result from the data used so far.



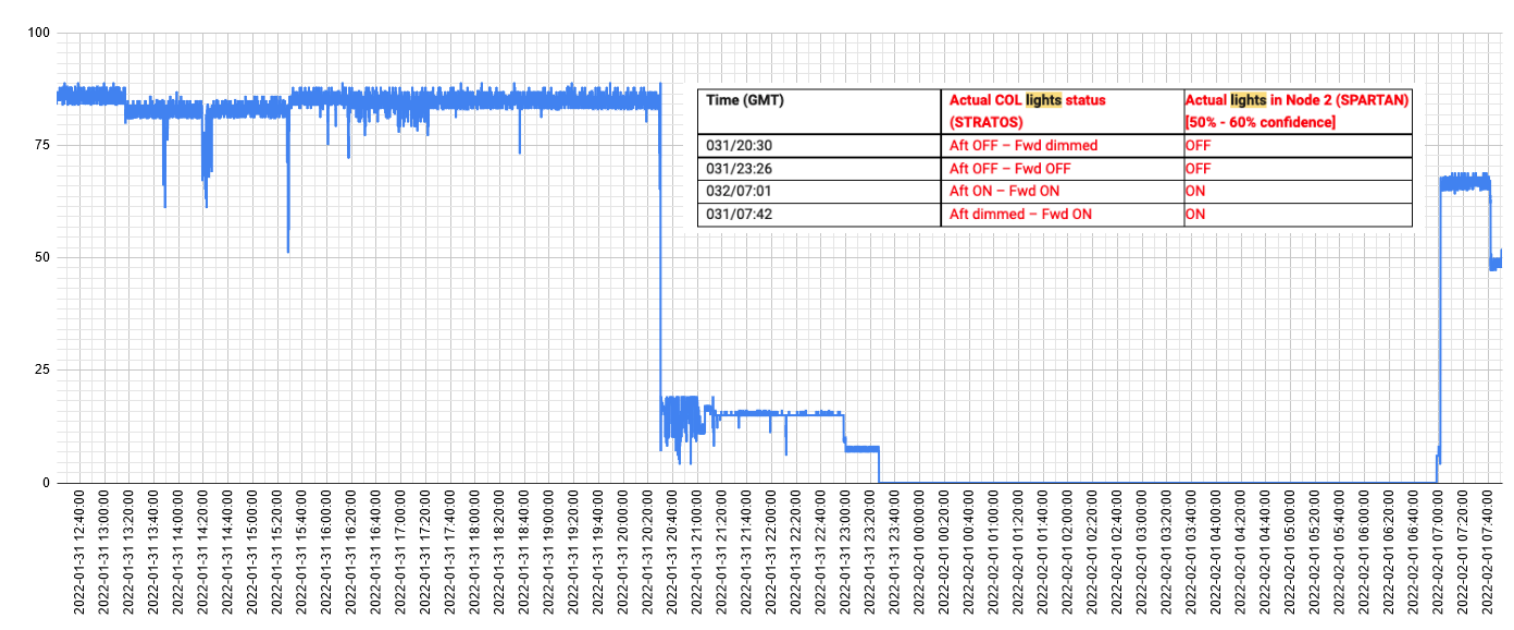
You can clearly see cyclical orbit of the ISS in this graph and by fine tuning the time axis, use it to calculate that the ISS orbits the planet about once every 90 minutes.

Experiment with looking at the data, comparing different sets compared each other or over time.

This is a comparison of the **latitude** and **compass** readings. Although there is a very expected cyclical cycle between latitude and magnetic north readings as the the ISS gets closer and further away from the North Pole, there are two distinct anomalies in the data. These could be due to a technical error, or might be more interesting and worthy of investigation.



This is a graph using the colour sensor that correlates with when the crew dimmed the lights on the ISS.



Time (GMT)	Actual COL lights status (STRATOS)	Actual lights in Node 2 (SPARTAN) [50% - 60% confidence]
031/20:30	Aft OFF – Fwd dimmed	OFF
031/23:26	Aft OFF – Fwd OFF	OFF
032/07:01	Aft ON – Fwd ON	ON
031/07:42	Aft dimmed – Fwd ON	ON

Python also has a graph plotting library called **matplotlib** (http://matplotlib.org/), which can be used to make great-looking graphs. Have a look at the guide here (https://github.com/raspberrypilearning/astro-pi-flight-data-analysis/blob/master/graphing.md) to get started.

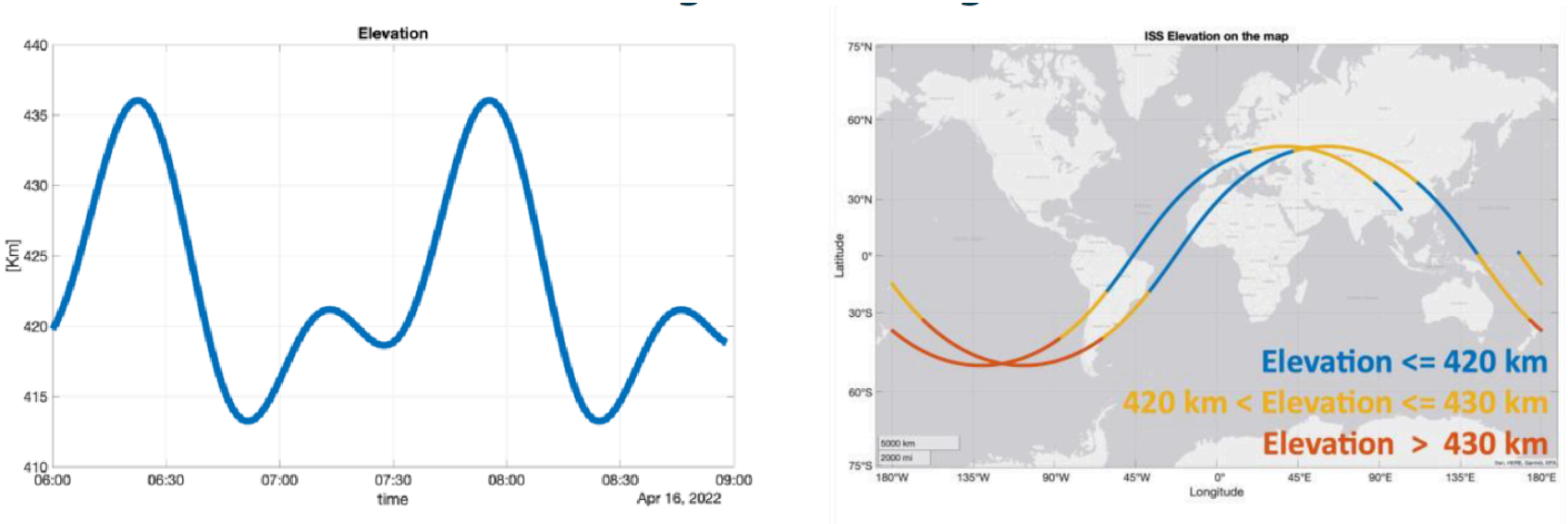


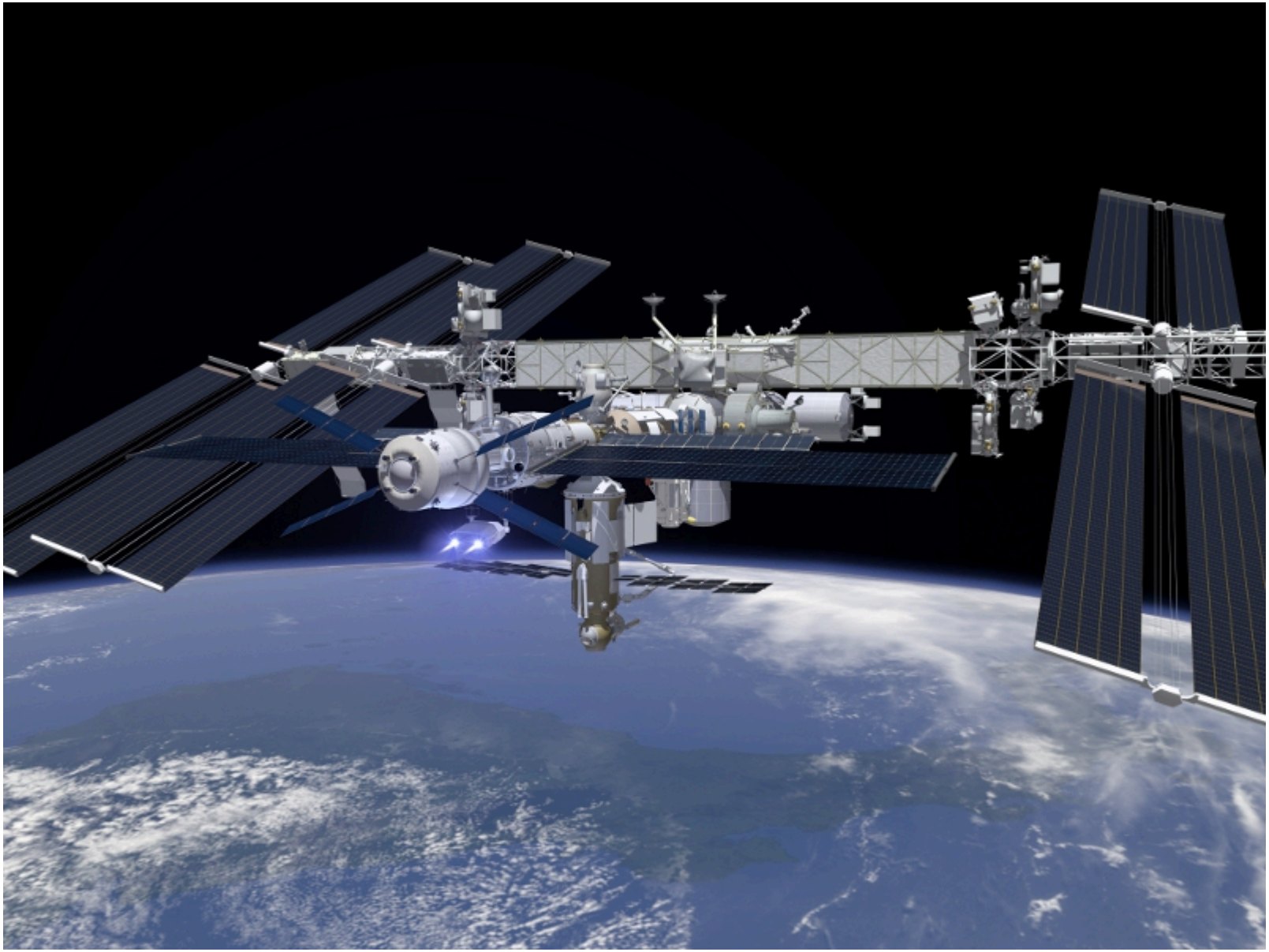
Figure 1: ISS Elevation (left) and discretized ISS Elevation on the map (right).

Step 4 What to look for

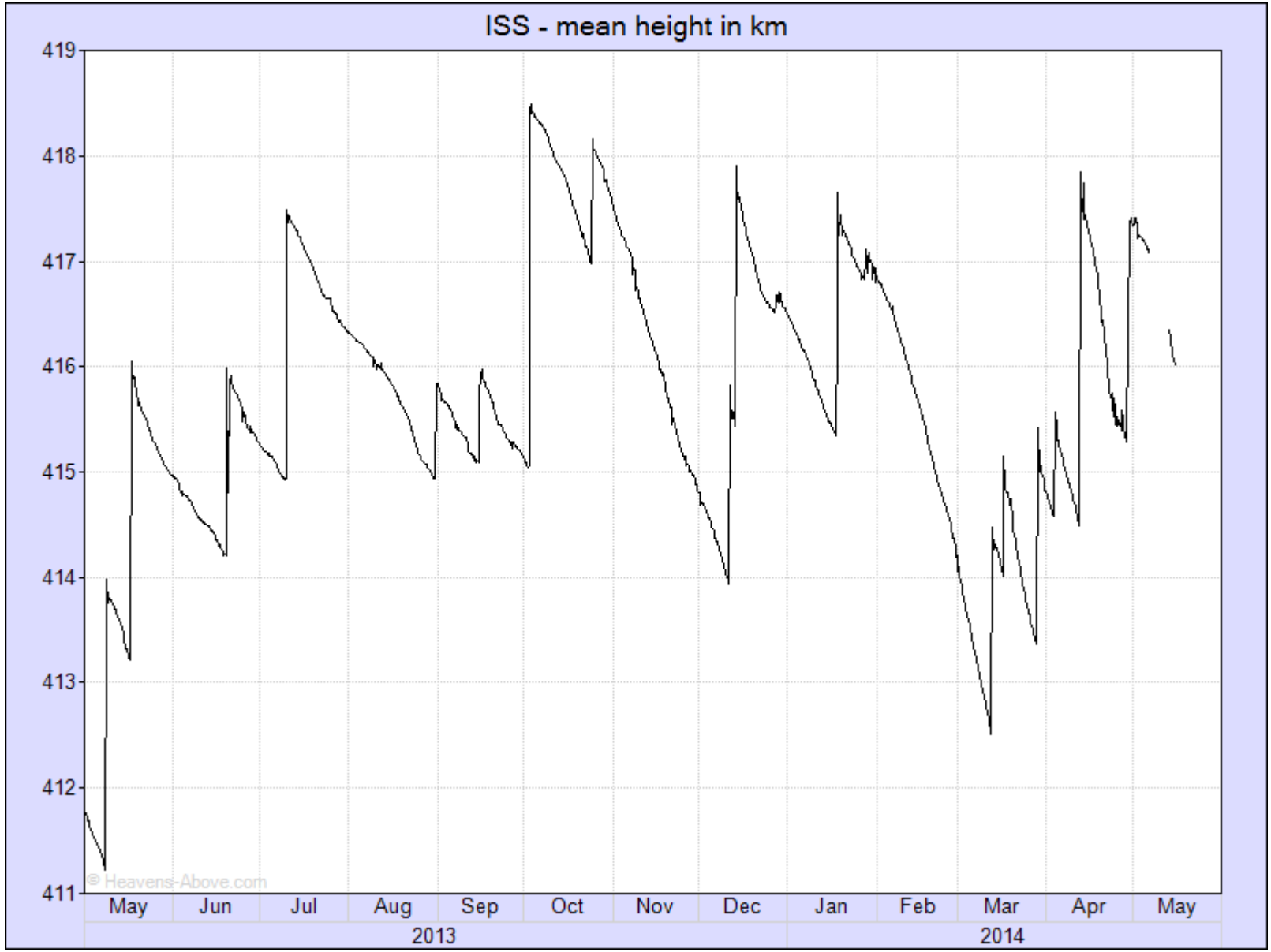
There are a many patterns and anomolies that you could look for, when trying to discover interesting events that might affect the lives of astronauts on the ISS. One such event that might be of interest is the ISS re-boost

The ISS is always losing 50 to 100 metres of altitude per day, and if left unchecked it would eventually re-enter the atmosphere and burn up like a meteorite! This happens because the ISS is in low Earth orbit (LEO), and even at an altitude of 400 km there is still a tiny amount of atmosphere present. That air creates drag on the ISS, which causes its orbit to slowly decay over time.

To avoid it burning up on re-entry the ISS is given a re-boost by a docked spacecraft. A reboost fires the thrusters for a while to increase the altitude by the desired amount.



The graph below shows time on the horizontal axis, and the altitude of the ISS in kilometres on the vertical. You can see that, every now and again, the altitude jumps back up. These are the reboosts and you can see they happen in a somewhat irregular way.



The Astro Pi cannot measure altitude from inside the ISS, so this is not part of the CSV data. However, when an ISS reboost occurs the Pi can detect the force of **acceleration** being applied by the spacecraft thrusters. In microgravity, the accelerometer X, Y and Z axes should always read close to zero Gs. However, at least one or two axes will detect some force when the thrusters are being fired.

The crew say that they can feel when a reboost is happening, so the Sense HAT accelerometer (https://github.com/raspberrypilearning/astro-pi-guide/blob/master/sensors/movement.md) should definitely detect it. Therefore, you should be able to work out when the ISS reboosts occurred and how long they lasted. Go here (http://www.heavens-above.com/IssHeight.aspx) for the latest altitude graph; you may be able to correlate this with the data in the CSV files.

If you are entering the Astro Pi challenge, you need to be aware that you only have a three hour time period in which your experiment will run, and the date and time that your experiment will start can not be predicted. This should factor into what data you choose to collect.