Mission Space Lab Phase 4 Report

Team Name: Space Wombats

Chosen theme: Life on Earth

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Introduction

Climate change has increased the frequency and extent of wildfires all around the world which is something countries with low rainfall like ours are most concerned with and the main reason we've chosen wildfire tracking as a research topic.

Satellite fire monitoring helps visualizing the impact on ecosystems as well as assessing smoke and carbon emissions into the atmosphere. At a smaller scale, tracking allows communities to take better care of its natural resources.

To find out if affordable tools like a Raspberry Pi and the NoIR camera module are a viable means of keeping an eye on the environment our team intended to spot wildfire areas using NDVI techniques on pictures taken by AstroPi's near-infrared camera and subsequently estimate gross burnt area.

NDVI (Normalized Difference Vegetation Index) takes advantage of the fact that healthy vegetation mostly absorbs blue and red light and reflects green and infrared. A camera that doesn't block IR fitted with a blue filter that gets rid of green light let us examine the ratio between blue and IR amounts thus sorting areas according to photosynthetic activity. In that regard, burnt areas should stand out against their surroundings.

Method

Our code had the NoIR camera taking pictures with the blue filter on about every 10 seconds and logging corresponding coordinates into a csv file as well as into picture's EXIF data. Pictures were taken at maximum resolution (2592x1944) and saved in jpeg format.

In order to save storage space and skip night pictures the code tested for day or night before shooting. This was achieved by using the PyEphem astronomy library to measure the height of the sun above horizon for the location ISS was passing over.

Once we got the data we run reverse_geocoder library on csv file to get locations from coordinates so as to start looking for suitable areas. Since reverse_geocoder results are inaccurate, we plot the ISS path during our experiment as well (Fig-1).

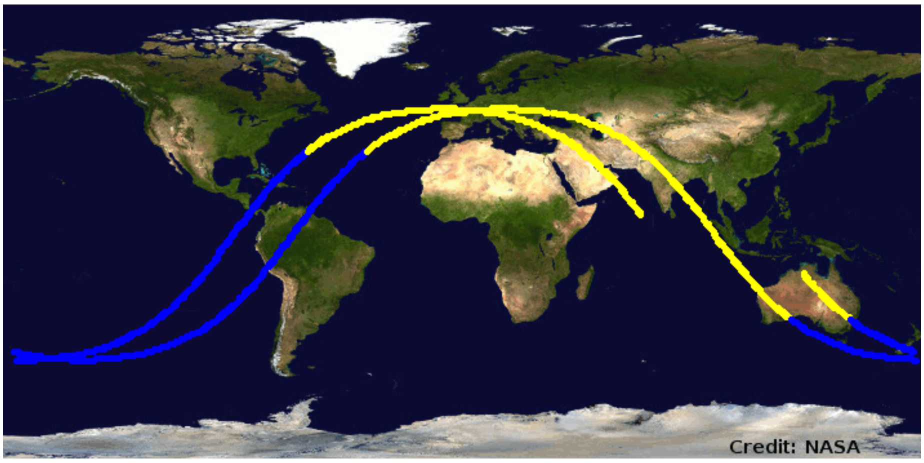


Fig-1: ISS path for Space Wombats (yellow dots are for day and blue for night)

Next, we looked for recent fire occurrences in areas within ISS path. For that we used Global Forest Watch Fires and NASA World View on-line services (Fig-2).

In order to highlight affected areas we then performed NDVI analysis on the selected images with the on-line tool INFRAGRAM by Public Lab.

Finally we estimated the burnt area in pixels with ImageJ image processing software for which we had to work out the area covered by a single pixel.

Results

Fortunately, we had ISS passing over Chernobyl area (23rd April) which had recently had the biggest fires ever recorded in the exclusion zone. In fact thin smoke can still be seen on the AstoPi's picture (Fig-3).

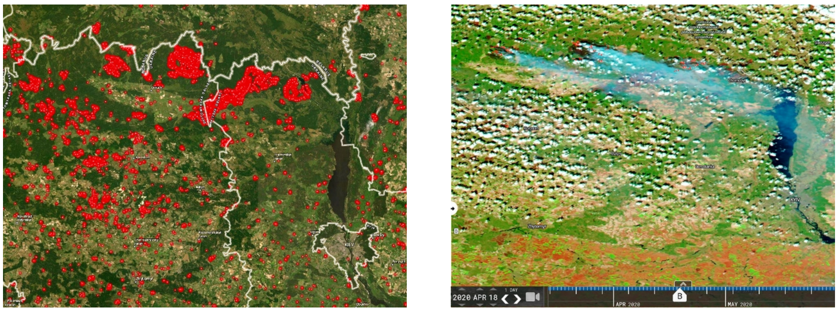


Fig-2: Global Forest Watch active fire detections (VIIRS) and NASA Worldview images (AQUA / MODIS, corrected reflectance bands 7-2-1)

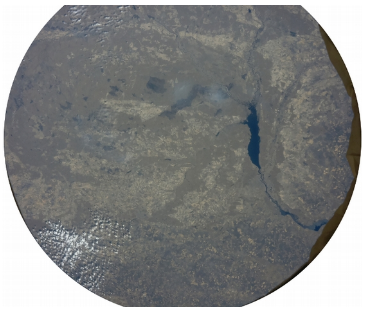


Fig-3: AstroPi's picture of Chernobyl and its surroundings

On those images we used the INFRAGRAM tool which performs NDVI calculation on every pixel and returns a greyscale image which can then be false colored (Fig-4).

$$NDVI = \frac{(NIR - B)}{(NIR + B)}$$

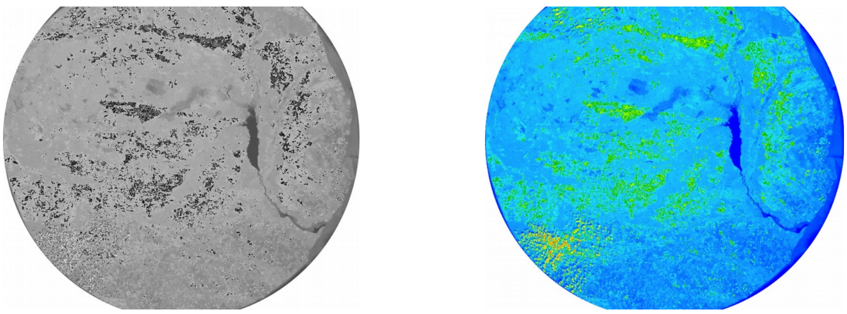


Fig-4: NDVI equation, greyscale and false color NDVI images

In a close comparison the resulting dark highlighted areas on NDVI image match those of NASA Worldview almost perfectly (Fig-5).

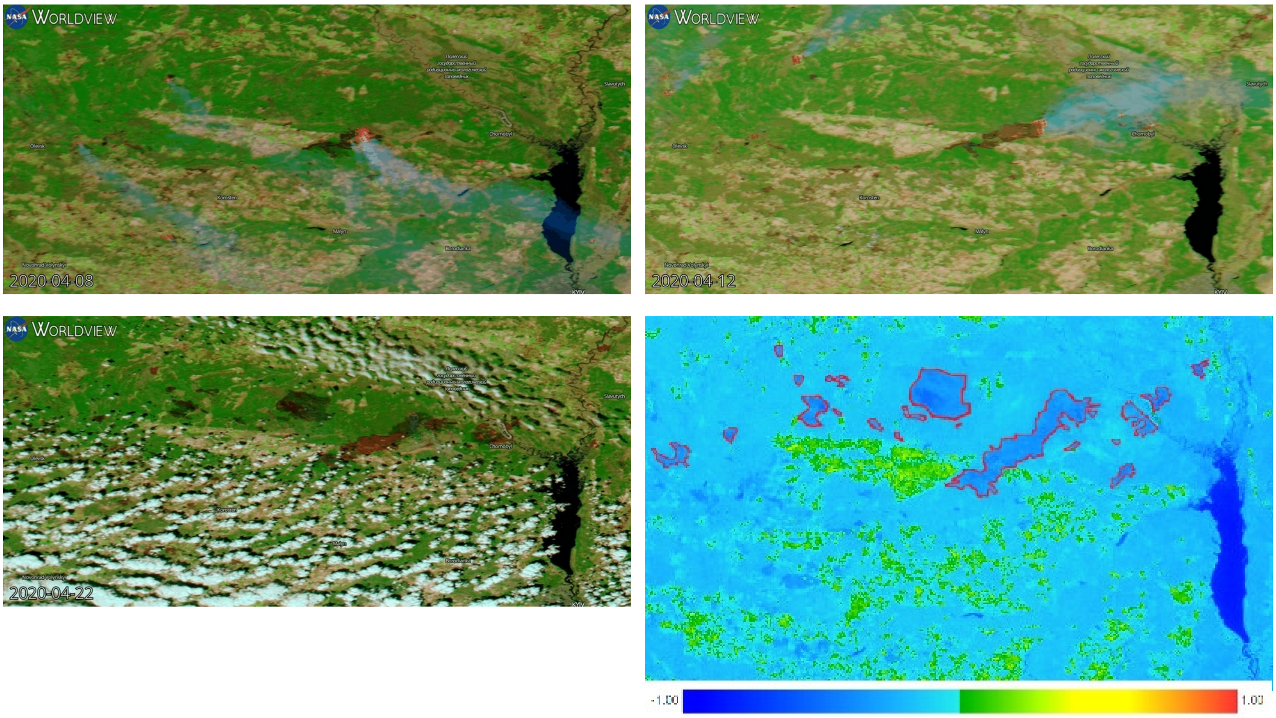
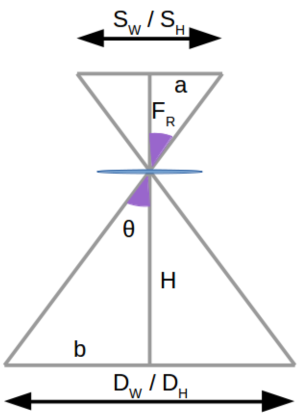


Fig-5: Fire evolution from NASA Worldview (AQUA / MODIS, corrected reflectance bands 7-2-1 and Fires and Thermal Anomalies band) and NDVI results

Next we estimated the area covered by a single pixel, based on the ground sampling distance method (Fig-6).



S_W (sensor width) =3,76mm

F_R (Focal range) = 3,6mm

H (ISS height) ~ 418750m

D_W(distance covered in width direction)

Equally:

S_H (sensor height) =2,74mm

F_R(Focal length) = 3,6mm

D_H(distance covered in height direction)

I_W (image width) = 2592 px

I_H (image height) = 1944 px

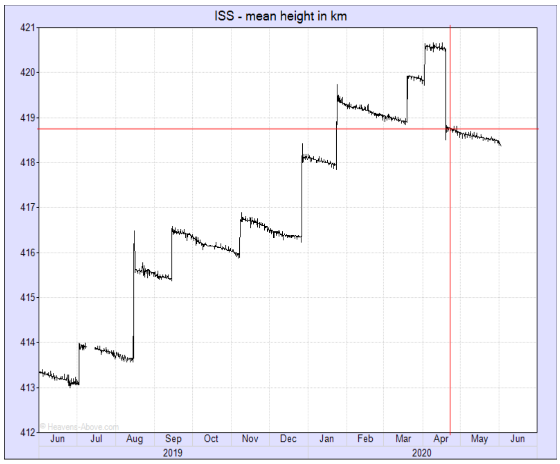


Fig-6: Ground sampling distance drawing with corresponding data and ISS height according to heavens-above.com

$$\tan(\theta) = \frac{a}{F_R} = \frac{b}{H} \rightarrow \frac{2 \cdot a}{F_R} = \frac{2 \cdot b}{H} \rightarrow \frac{S_W}{F_R} = \frac{D_W}{H} \rightarrow \rightarrow \rightarrow D_W = \frac{H \cdot S_W}{F_R}$$

$$D_W = \frac{H \cdot S_W}{F_R} \rightarrow \frac{418750\ m \cdot 3{,}76\ mmm}{3{,}6\ mm} = 437361\ m \qquad \frac{D_W}{I_W} \rightarrow \frac{437361\ m}{2592\ px} = 168{,}73\ \frac{m}{px}$$

$$D_H = \frac{H \cdot S_H}{F_R} \rightarrow \frac{418750\ m \cdot 2{,}74\ mmm}{3{,}6\ mm} = 318715\ m \qquad \frac{D_H}{I_H} \rightarrow \frac{318715\ m}{1944\ px} = 163{,}95\ \frac{m}{px}$$

Which results in 168,73 x 163,95 = **27633m² per pixel**.

Finally, we used ImageJ image processing software from NIH to find total area in pixels which turned out to be **[4549 pixels]**[1] (Fig-7) that is equal to **12584 hectares** which is a value that falls close to the 11500 hectares some media mentioned.

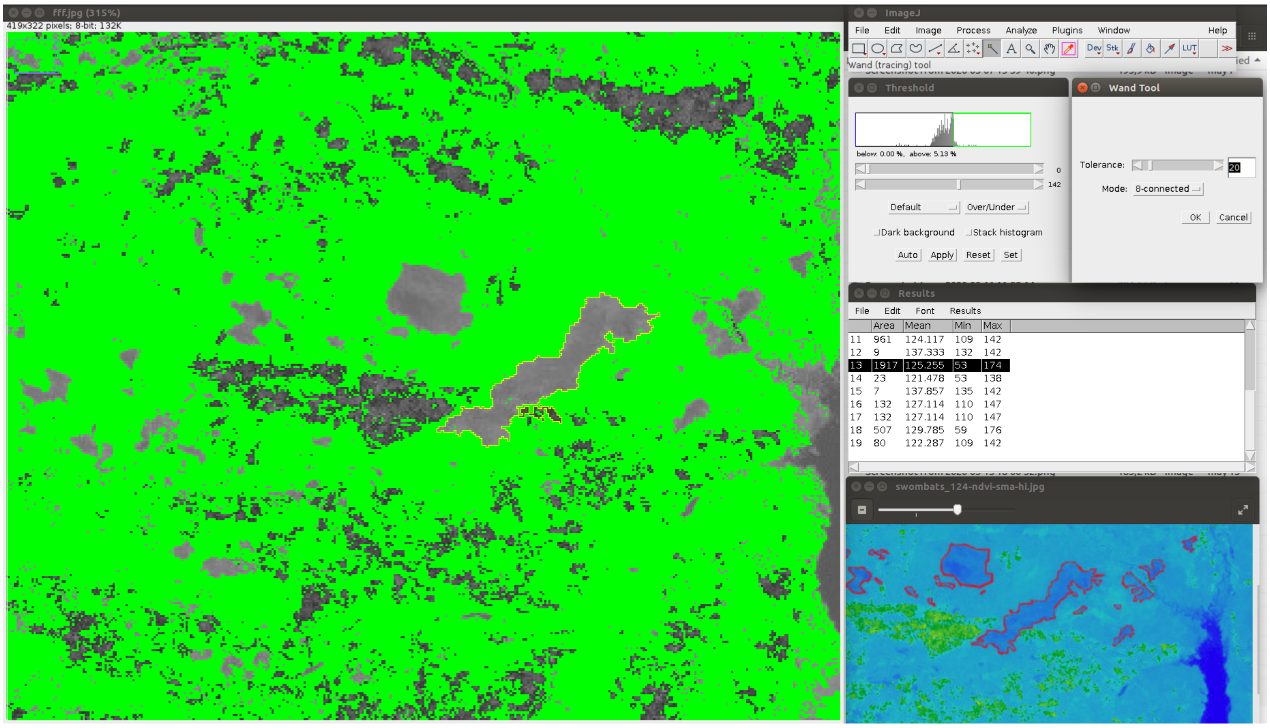


Fig-7: Pixel counting with ImageJ software

Conclusion

Even though NDVI results far surpassed our expectations, we have to take into account that burn scars were very recent and clearly visible. It would be interesting to reproduce this measurements let's say in six months time to see how much recognizable burnt areas still are.

Regarding area measurements, the method used to work out pixel dimensions makes some assumptions such as Earth is flat, camera is vertically facing Earth's surface and that there are no significant differences in relief. These factors could account for the difference between our value an that from the media (11500 ha).

All in all though, results were pretty good and let us say that Raspberry Pi and the NoIR camera (with blue filter) with the aid of aerial means such as drones or weather balloons constitute a feasible means for communities to watch over their natural resources.

Finally, we would like to thank ESA and RaspberryPi for giving us such an amazing opportunity as well as NASA, Public Lab, Global Forest Watch, heavens-above.com and National Institutes of Health (NIH) for making their tools available.

And also many thanks to Josep Palau for his mentoring through this challenge.

Project data and code can be found at

https://github.com/jpalau-edu/AstroPi1920/tree/master/SpaceWombats

1 Total amount of pixels in areas highlighted in Fig-05 (from left to right). We've limited measurements to the areas that burnt from April 1st to April 23rd.