Mission Space Lab Phase 4 report outline

AstroPi to make awesome 3D movies of Clouds and Earth

Team name: Pantheon

Chosen theme: Life on Earth

Organisation name: Sainte-Geneviève

Country: France

1. Introduction

The objective was to take 3d photos of the Earth to tweet photos from the ISS like Thomas Pesquet @Thom_astro, but in 3D, to distinguish the altitudes of the relief and of the clouds to categorize the clouds thanks to their altitude.

We took high resolution photos with different time intervals (around 20 seconds) during the day. We reconstructed stereographic images.

We were able to distinguish Cirrus from Cumulus by distinguishing several cloud heights. We were also able to observe the height of the clouds above the relief, just above, or kilometers higher and the relief of the mountains was apparent with an accuracy of the order of a hundred meters of altitude.

The precision of the photos made it possible to see human constructions such as the 170m wide Suez Canal (2 pixels width on pictures) or the 28m wide Antirion and Rio bridge (1 pixel slightly brighter).

We were able to make 3D videos, which give the impression of literally jumping on the ground through the layers of clouds.

2. Method

We took photos of the earth at the highest possible resolution with Astropi v2022 : [cam = PiCamera() cam.resolution = (4056, 3040)] every 18 to 23 seconds during days to get pictures corresponding to the right eye and the left eye, and be able then to see 3D pictures.

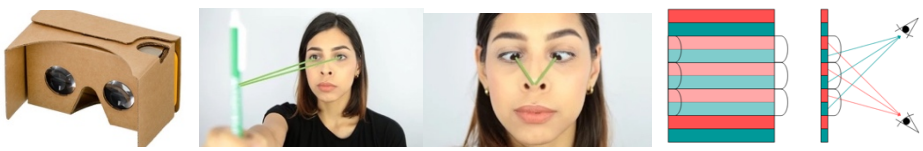

Figure 1: Several techniques allow to see images in 3d. Here are a few. Left: using a virtual reality headset; center: squinting while looking at the right and left images until you mentally superimpose them; right displaying the images behind Fresnel lenses.

To see and analyse pictures, the advantage of cross-eye is that it is instant during development without requiring any tool. The disadvantage is that the images cannot be further apart than the distance between the eyes, which is less than 10 cm wide.

For this reason, we have developed a web page in JavaScript that zooms in on 3D images in order to be able to enlarge images and see the details, while keeping the small difference of about ten centimeters between the images. the animations can be seen either with the cross-eye technique or with a cardboard helmet.

See https://sergi5.com/astropi for HD pictures, movies and interactive JavaScript tool to zoom on 3d images.

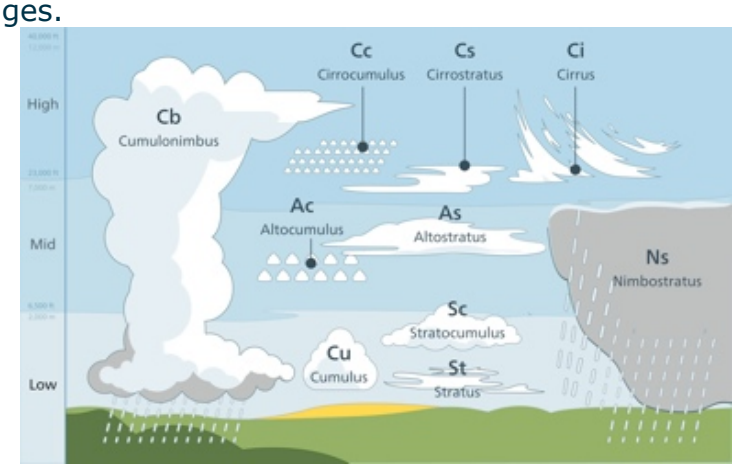

Figure 2: The most used method to distinguish between clouds, land and sea is by color. Altitude gives better results and distinguishes between low, medium and high clouds altitude, corresponding to Stratus, Altus and Cirrus clouds.

3. Experiment results

*Figure 3: **Left**: each green spot represents a photo taken. Above America while it was night, we took less pictures to optimize disk space. **Middle:** we can see the Nile river in Africa, a thin green band along the river with desert around that emphasize the importance of unsalted water on earth, and the Suez Canal.*
***Right:** is a closeup of the Suez Canal the left line was dug in 1869 and the right line doubled the speed dug in 2015. Each has a width of 55 meters and 2 pixels, that give about **1 pixel per 30 meters**.*

416 Pictures were taken starting on the 10yh of May 2022 near Australia and ended 2h58 minutes later above Madagascar with a delay of 18, 20 or 23 seconds between each picture during day and 120 seconds during night. Actually, night was not only over USA but also over France and the majority of Spain and the delay between night (black) picture and day (well exposed picture) was only 1 minute.

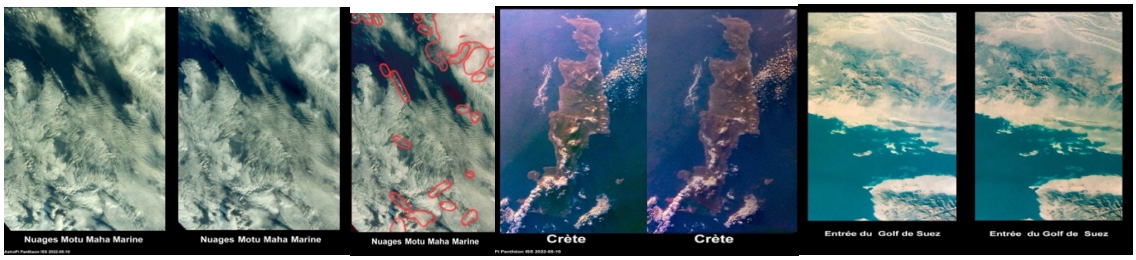

Figure 4: ***Left****: clouds over the Motu Maha Marine, of the south of New Zealand. Without stereoscopic pictures, it is difficult or impossible to distinct clouds and their altitude. Thanks to 3d, (third picture) we can spot in red the clouds that are a layer above the others.*
Center*: The Crete Island in Greece. In the middle the Mount Psiloritis 2456m and at the top the Mont Dicté 2148m that clouds not more than twice above seem to touch, and on the bottom the clouds are attached to the Mount Patchnès 2453m under the clouds.*
Right*: The entry of the Suez golf in the red sea. In the middle we see Gamasa and Hurghada islands and sand bellow (-10m) the level of the sea (-50m): this is the Ras Mohamed Nature Reserve paradise of scuba. At the bottom the Mont Sinaï at 2285m in Egypte and on top the Gabal Shayeb El-Banat (2187m) where Porphyrites was extracted during Romanian empire.*

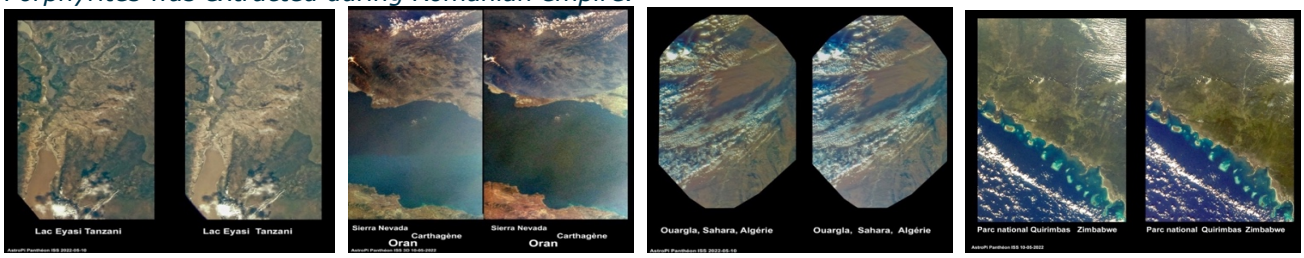

Figure 5: ***Left****: The salty lake Eyasi (1000m) is part of the Great Rift. The right plateau is 900 above with the Maswa Reserve (dark green). Some white spots on the edge of the lake is salt, whereas other white spot are clouds above.*
Center Left*: Spain at the top with the Hoya de Huescar surrounded by mountains and the Sierra Nevada mountain and snow on the left edge and clouds in the north, and Africa at the bottom with the lake of Sebkha near the city of Oran limited in the north by Murdjajo mountain (430m) and the Tessala mountain (1061m) on the south.*
Center Right*: Ouargla located in the Sahara desert in Algéria. It rains 4 times less than in Paris and mostly in may and October, and we see clouds above (picture taken 10th of May).*
Right*:Quirimbas islands in Zimbabwe facing Madagascar. Some clouds above Macomia village On the left, some clouds along the shore.*

Figure 6: ***Left****: Albert Lake separates Uganda on the left and on the right the Democratic Republic of the Congo. It is part of the Great Rift. 160km long and 30km width. On the right edge of the lake clouds are attached to the mountain that is 1500m above the lake (2100m), in the middle of the right edge and the top of the right top right corner of the lake and bottom right corner of the lake. On the top right of the picture, clouds at high altitude above the Okapi Wildlife Reserve. Thomas Pesquet took a flat picture of the lake https://twitter.com/Thom_astro/status/1392390492709601280 a year before.*
Center*: on the top right, the land is the Peloponnese in Greece, a peninsula on which humans have built a second road on a bridge that we can see on the top left corner between Antirion and Rio (2252m distance) built in 2004 it was the world's longest cable-stayed deck over the sea, 28m width). In 2005 a lightning strike melt one of its cable. Clouds are thin over the Peloponnese, but over the sea (-5000m), clouds are thick from low to high altitude.*
Right*:This is the Zouar Volcano in Tchat. It is made of a black the pic Toussidé (3315m) and the white Trou au Natron due to Welded crystals (1500m). Low altitude clouds on the right and high-altitude clouds on the left can be seen. The Ehi Sunni crater (2820m) at the bottom left. These Tibesti mountains is the highest point of Sahara and more wet.*

4. Learnings

Our Panthéon team brings together students from two schools: Louis-le-Grand Highschool and Henri IV Middle School in Paris from 12 to 15 years old. To carry out the project, it was necessary to bring together or develop various skills: programming in JavaScript and python which correspond to computer club skills, social network skills to disseminate knowledge, geoscience and meteorology skills provided by the fact that the establishment trains volunteer students for the Initiation to Aeronautics Certificate.

Next time we will allow more time for the analysis of the results, because the time has been absorbed for the first qualitative analysis of the very rich results. We plan to analyse the results quantitatively with AI at the beginning of the school year between September and November 2022.

5. Conclusion

We expected to distinguish cloud altitudes, and the results exceeded our expectations in terms of accuracy. The mountains of a few hundred meters stand out and the beauty of the landscapes as the one of the earth in 3D are fascinating. The spatial detail allows to have a resolution of the order of 30 meters.

Standing on the shoulders of giants (Gigantum umeris insidentes): we succeeded in producing fascinating 3D movies of earth and clouds, far beyond the flat tweets produced from the ISS by the Thomas Pesquet astronaut a year earlier (https://sergi5.com/astropi); captivating films, which we love to see again and again in an almost hypnotic way.

The data is very rich and further quantitative analysis can be conducted in the future using stereoscopic to grayscale depth picture algorithms using AI to quantify proportions clouds as a function of their altitude.