SEMINAR *SEAL Team — Exploring Robotics — Remote Sensing*

Scale analysis

Direct interpretation of satellite images

Laurent Beaudoin & Loïca Avanthey
EPITA

For these direct photo-interpretation exercises, it is advisable to use the free and open-source Gimp software to answer the questions.

1 2004 Indian Ocean tsunami

This first set of images (Figure 1 page 1) was taken by the **Quickbird satellite** which flew over the coast of Sri Lanka during the tsunami of December 26, 2004. As often for the study of **natural disasters**, we compare the images taken during or just after the event, that is to say the **crisis situation** (`tsunami_XA` images), with the **normal situation** (`tsunami_XB` images).

These pairs of "before-after" images are taken under comparable geometric conditions (same spatial resolution), therefore any geometric information extracted from the normal situation is valid for the crisis situation.

The images have been cropped to focus on the event, the crop sizes are not quite equivalent, but it does not change the resolution (pixel size).

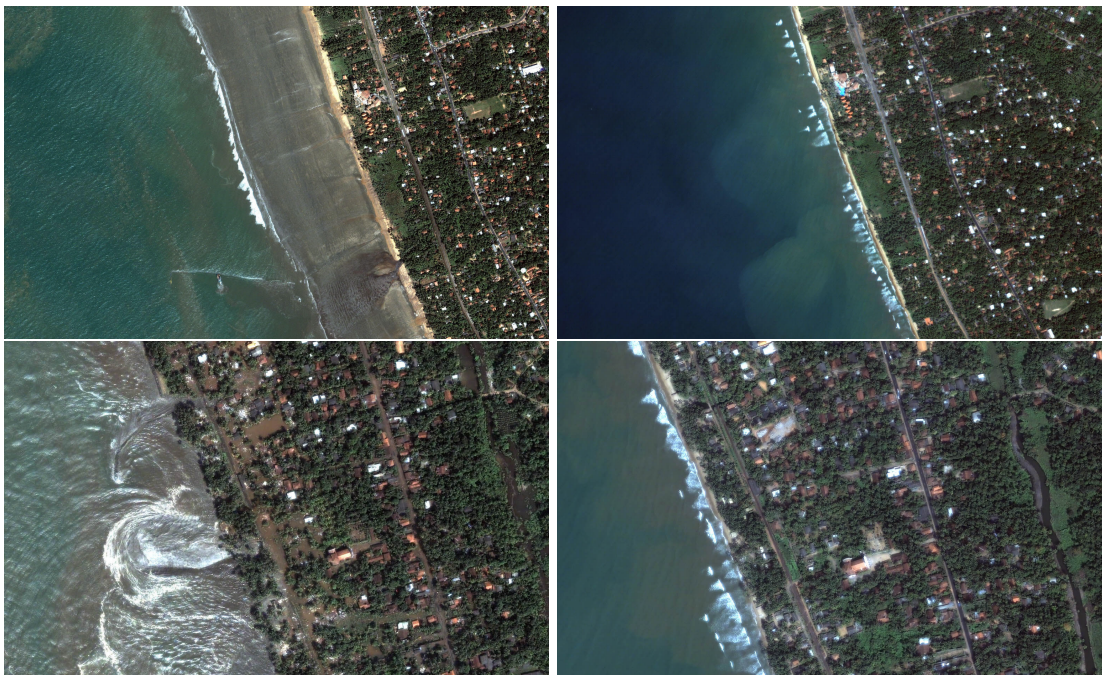

Figure 1 – *Images of the December 26, 2004 tsunami. The images on the left are taken during the crisis and those on the right in normal situations (almost a year before).*

QUESTION 1

Observe the images of the **normal situation** for each couple. From the **elements** represented there, determine their **resolution**, i.e. the **physical size** in meters represented by **one pixel**.

The measuring tool represented by a **compass** will be of great help (see Tools tab).

QUESTION 2

Measure the **average distance** in meters of the **withdrawal from the sea** on the **crisis image** `tsunami_1A`.

QUESTION 3

Assuming that the wave line on the `tsunami_1A` **crisis image** corresponds to a normal **depth** of **10 meters** and assuming that the **depth profile** on the discovered area is **linear** up to 0 meters, determine the **volume of water that has withdrawn** on the image, in number of **Olympic swimming pools** (size of $50 \times 25 \times 2$ meters) ?

QUESTION 4

At what **point** in the crisis does the **situation** in the image `tsunami_2A` **correspond** ? Why ?

QUESTION 5

Estimate the **size** of the **swirls of water** on the **crisis image** `tsunami_2A`.

2 The disappearance of the Aral Sea

The **disappearance** of the **Aral Sea** (Central Asia), which was the **fourth largest lake** in the world, is happening at an extremely **rapid rate**, as can be seen in the images taken over a few decades by the **Landsat satellites** (figure 2 page 2).

Figure 2 – *Images of the disappearance of the Aral Sea. From left to right, the shoots date from 1973, 1987, 1999 and 2014.*

QUESTION 6

Estimate the **spatial resolution (GSD)** in kilometers of this image set.

QUESTION 7

Estimate the **area** occupied by the Aral Sea (therefore the number of dark pixels) for each date and **draw** the **curve** having the area in km^2 on the ordinate and the date on the abscissa.

Gimp's **color tab options** will be of great help

From this curve :

QUESTION 8

Estimate the average **area loss per year** in km^2.

QUESTION 9

Knowing that Paris has an area of 105 km^2, **how many "Paris" are lost per year** by the Aral Sea ?

QUESTION 10

What is the **percentage of disappearance** in 2014 compared to 1973 ?

QUESTION 11

When would the Aral Sea **theoretically disappear** from this information alone ?

Fortunately, actions have been taken to **halt the process**. It is not yet won, but the water has **come back a little** since 2014, as we can see on the images of the figure 3 page 3

Figure 3 – *The Aral Sea seen by the Terra satellite in 2017 and by the Landsat satellite in 2018.*

3 The pyramids of Giza

This exercise and the next one on the bridges of San Francisco (see page 4) are similar, do the one you like the most !

The great pyramids of Giza are impressive, even when viewed from space (figure 4 page 4).

QUESTION 12

Estimate the **resolution** from the **elements** present on the image. For information, the **Sphynx** has for real dimensions 74 m in length, 14 m for its maximum width and 20 m in height. Can **other elements** help you **confirm** your estimate ?

QUESTION 13

Quickbird satellite images are announced at a **resolution** of 1 m. Is this the result you find **experimentally** ? Why ?

QUESTION 14

Estimate the **dimensions** at the **base** of **each pyramid** and check the **quality** of your estimates with **ground truth** (around 230 m per side for Khufu, 215 m for Kephren and 105 m for Mykerinos).

QUESTION 15

Knowing that at the **time** of the shooting, the **height of the sun** is approximately 40 degrees, what is the **height of the pyramids** of Cheops, Kephren, Mykerinos and the **height of the Sphynx** ?

Figure 4 – *Image of the Giza pyramids taken by the Quickbird satellite.*

4 The bridges of San Francisco

It is always wise to be **wary of the information** that we collect, even when it comes from **official sources** as shown in the figure 5 page 5.

QUESTION 16

This bridge is advertised as the **Golden Gate Bridge**. Your **verdict** ?

QUESTION 17

Looking at the **bridge pier**, what is the **elevation of the sun** from the horizon ?

QUESTION 18

Give an estimate of the **height** of the **big tower** at the beginning of the road leading to the bridge knowing that the **height** of the **bridge pier** is 160 m. **Check** by searching the web for the **name** of the tower and **compare** with your **estimate**.

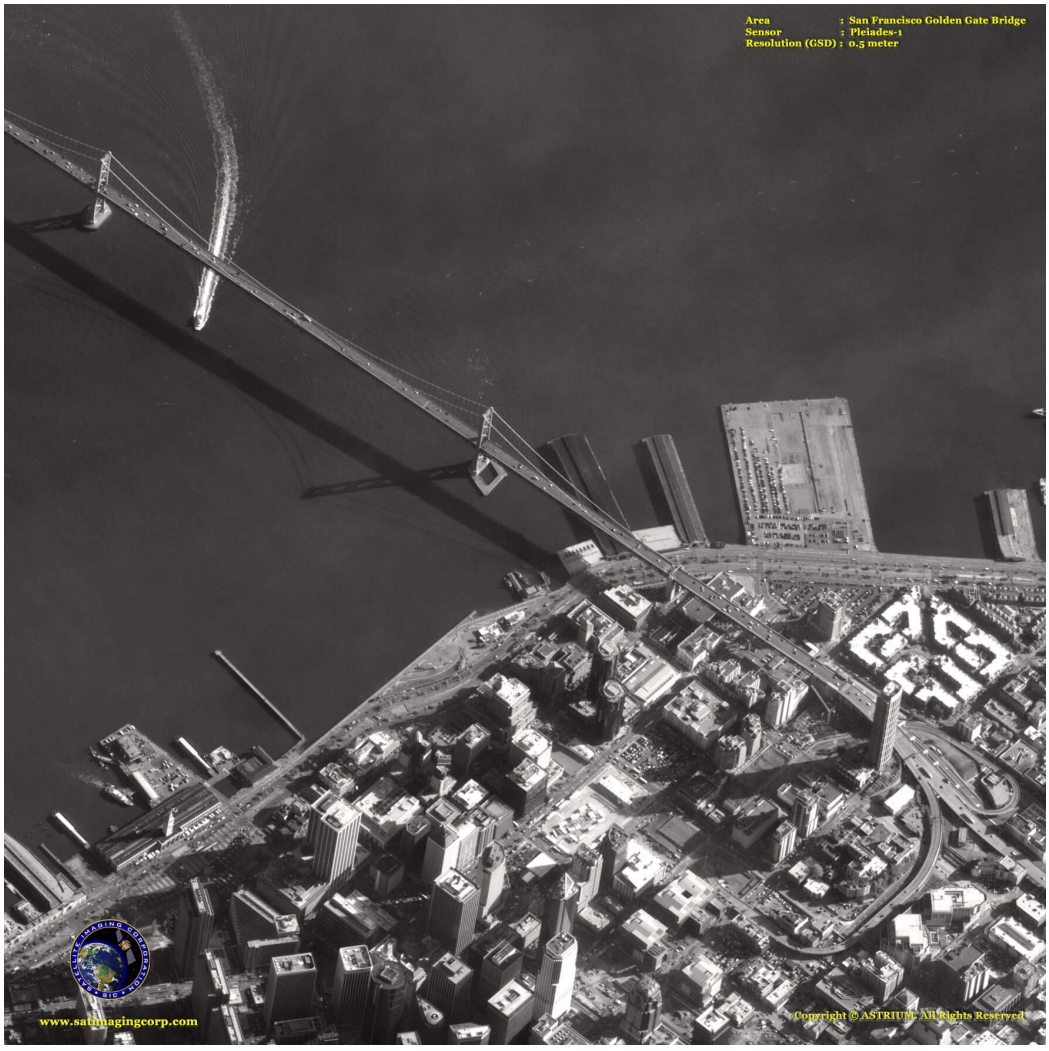

Figure 5 – *Image of a San Francisco bridge by the Pleïade satellite.*