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Sand Dunes Moving in the Nili Patera Caldera on Mars

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Abstract: Recently, it was discovered that the sand dunes on Mars are moving. This important result was obtained by means of some high resolution HiRISE images, recorded three years apart, of the dunes in the Nili Patera caldera. Here we compare an image HiRISE of 2007 with an image of 1999 recorded by the Mars Global Surveyor. Using Gimp, a GNU image processing software, to enhance the images, we can see and measure the motion of the dunes during a longer period of time.

Keywords: Google Mars, Dune motion, Satellite images, HiRISE, Mars Reconnaissance Orbiter, Mars Global Surveyor, GIMP, Image processing.

1. Introduction

While sand dunes on Earth are known to be landforms created and moved by the prevailing winds, it is only recently that the dunes on Mars have been recognized as moving objects. This result has been achieved by means of the images coming from the satellites orbiting on Mars. The images allow seeing how the Martian dunes change due to the Martian winds of its tiny atmosphere. Moreover, as remarked in [1], in a few months the NASA's Curiosity rover will explore a dune field on the terrain of Gale Crater. These dunes which are surrounding the Aeolis Mons, the central peak of the crater, have been studied by the researchers from the SETI Institute [2]. They discovered that these dunes are influenced by winds causing them to move at a rate of about 0.4 m/yr. To investigate this motion the researchers used images from the High Resolution Imaging Science Experiment (HiRISE), the camera onboard the Mars Reconnaissance Orbiter [3]. The researchers evidenced also the sand motion in the Herschel Crater and on the Nili Patera caldera on Mars [4,5].

The dunes in the Nili Patera caldera have been also the subject of another publication [6]. In this paper, it is discussed the relevant question of whether the dunes and wind erosion, seen on the Martian landforms, are current processes. In [6], the authors present the measurements of the migration rate of sand ripples and dune lee fronts at the Nili Patera dune field. They show that these dunes have their bulk composed of mobile sand and that the dunes have unexpectedly high sand fluxes, similar to those in the Victoria Valley, Antarctica. As a result, the rates of landscape modification on Mars and Earth are similar. Two images three years apart are given at Ref.7, showing the motion of a dune of the Nili Patera dune field.

Here we will discuss the image processing of an image from HiRISE and of an older image from the camera of the Mars Global Surveyor to investigate the dune motion in the Nili Patera caldera. We will see that using a suitable tool, such as GIMP, the GNU image processing software , we can enhance the images and compare them to measure the motion on a longer time interval. Using the Google Earth (on Mars) we can evaluate the distances. Then, if images of the same place are available in the two collections, Mars Global Surveyor and HiRISE, this approach can be repeated to see the landform modifications.

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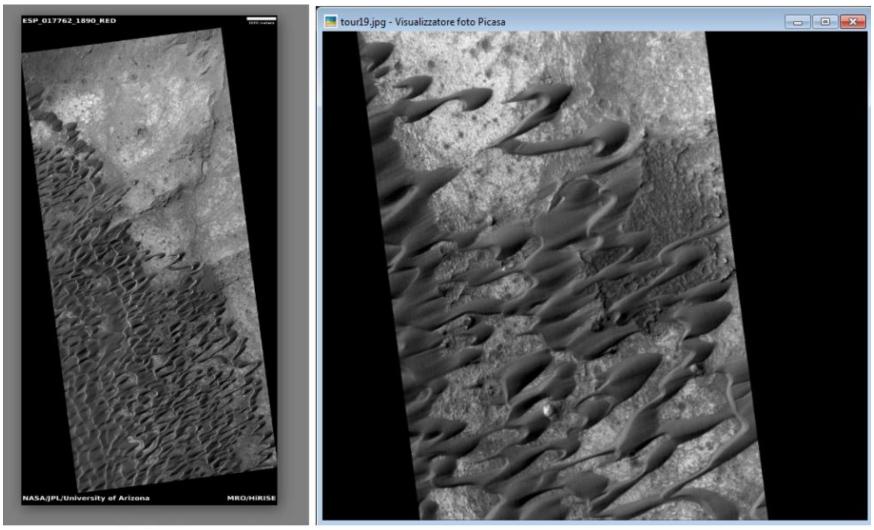

HiRISE on 13 October 2007 ***Mars Global Surveyor on March 11, 1999***

Fig.1 – The images of the Nili Patera dune field that we use here for the study of the moving dunes on Mars.

2. HiRISE image

In Ref.8, where the image on the left in Figure 1 is proposed and discussed, it is told that it is showing a set of dark sand dunes within the northeastern edge of the dune field in Nili Patera, which is a volcanic caldera in the region of the Syrtis Major on Mars. The surface beneath the dunes is an ancient lava flow, showing some cracks probably formed when the lava cooled. Many of these cracks are dark for the sand inside them. The dark color of the sand suggests a basaltic composition. The dunes have a crescent shape, and therefore they are defined as "barchans" in analogy with the dunes on Earth. "The horns of the barchans point in the downwind direction, indicating that the predominant surface winds in this region blew from the east-northeast" [8]. The HiRISE image is able to show the small ripples on the dune surface, showing "that the winds in this region have not only blown the barchans across the lava plain, but also modified the dunes themselves". The acquisition date of the image was 13 October 2007 (for more details, see Ref.8).

3. Mars Global Surveyor image

In Ref.9 we can find an image with a part of the same dune field in Nili Patera caldera taken by the Mars Orbiter Camera on the Mars Global Surveyor spacecraft on March 11, 1999 (portion of Mars Orbiter Camera image FHA-00451, NASA/JPL/Malin Space Science, reproduced in the Figure 1). It was the first day of the regular mapping phase of the mission. According to Ref.9, the crescent shape of the dunes is a result of a locally limited sand supply and indicates that the sand-driving winds blew across this region from the upper right to the lower left. The dunes are darker than their surroundings, suggesting that at least here the sand particles consist of dark materials. Some of the individual dunes are more than 70 meters high [9].

4. Image comparison and dune motion

Let us try to compare the images in order to see the motion of the dunes. Of course, the recent high resolution images provide a precise observation [7]. However, if we can use the images in the Figure 1, which have a lower resolution, we can investigate a larger interval of time to see how the dunes are moving. The image processing tool used here is GIMP, the GNU manipulator for images. In particular, it is used to select the dunes and adjust brightness and contrast. In some recent papers [10,11], we have used GIMP to see the motion of dunes on Earth, obtaining good results, quite interesting for the analysis of images freely available on the web. Here, in the following images (Figures 2-4) some dunes of the Nili Patera caldera field are shown: on the left, the image of 1999 and on the right the HiRISE of 2007.

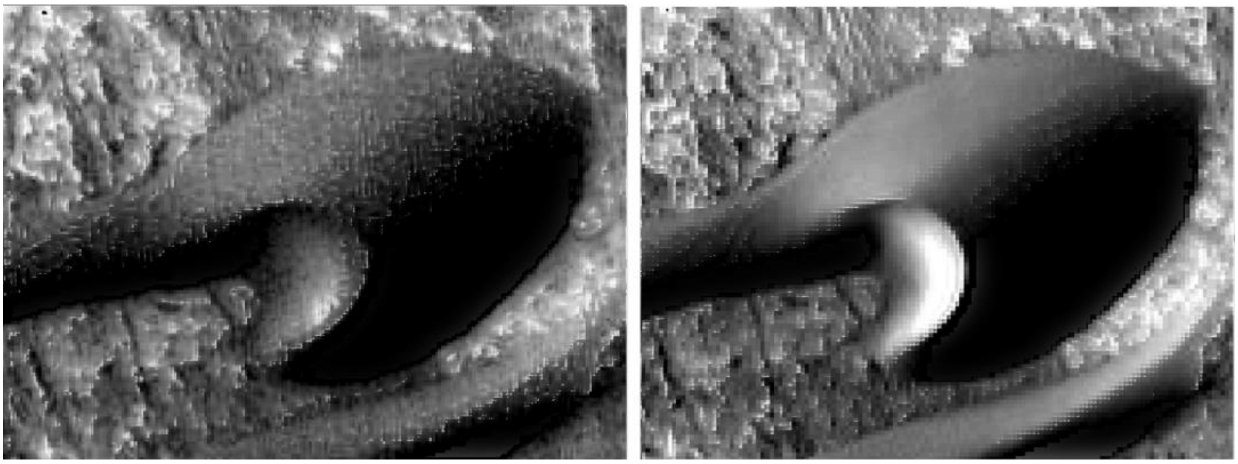

Fig.2 - Mars Orbiter Camera (1999) on the left and HiRISE on the right (2007). The image of 1999 has a lower resolution.

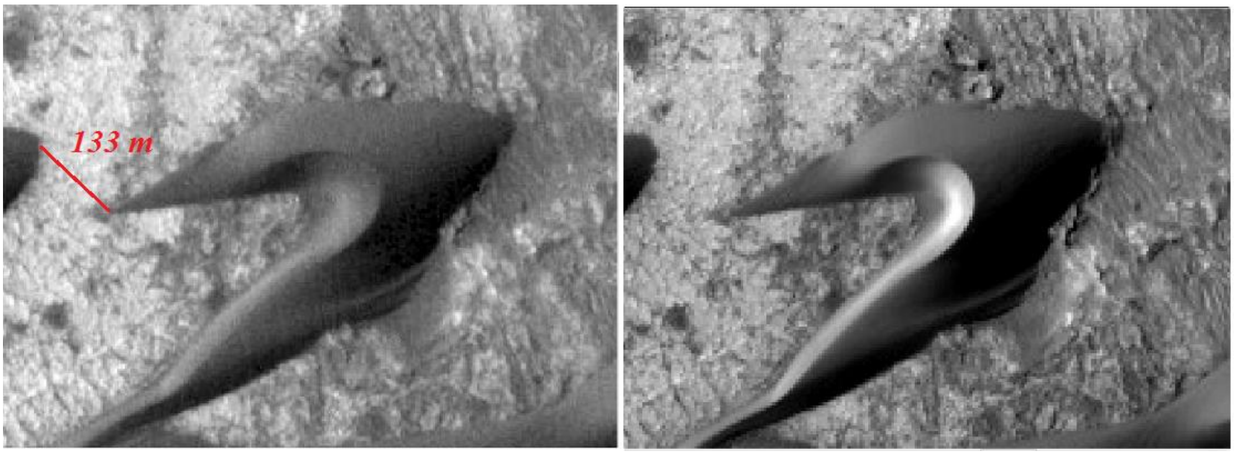

Fig.3 - Mars Orbiter Camera (1999) on the left and HiRISE on the right (2007). Note the displacement of the toe of the dune. Using Google Earth (on Mars) we can measure with its ruler the distance shown in the figure.

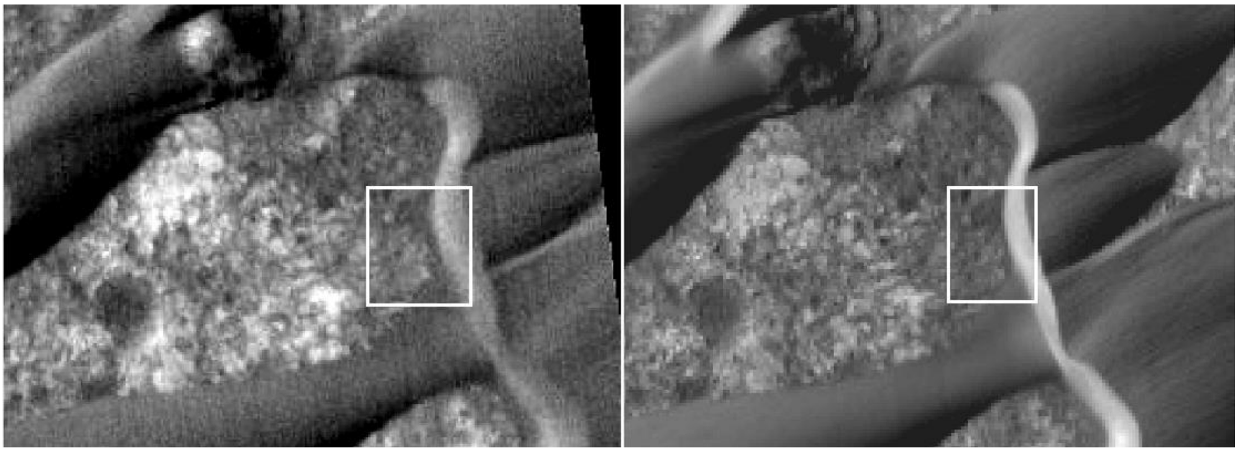

Fig.4 - Mars Orbiter Camera (1999) on the left and HiRISE on the right (2007). Note the displacement of the dune with respect to the two small bright dots.

Let us consider the barchan in the Figure 3. We can have a rough estimation of the displacement considering the toe of the dune. Let us mark it and a reference point on the two images and then copy these details on a GIMP image. After, we can use the GIMP ruler (having a compass as icon) to measure the distance from the tip of the dune and the reference point. We have 40 px for the image of 1999 and 47 px for the image of 2007. Then the difference is 7 px; the segment which corresponds to 133 meters is of 89 px. It means that the displacement was of about 10 meters in eight years (see the Figure 5). This speed seems large, however, as we have seen in [10,11], the speed of the dune depends inversely on its size and then small dunes move faster than the large ones.

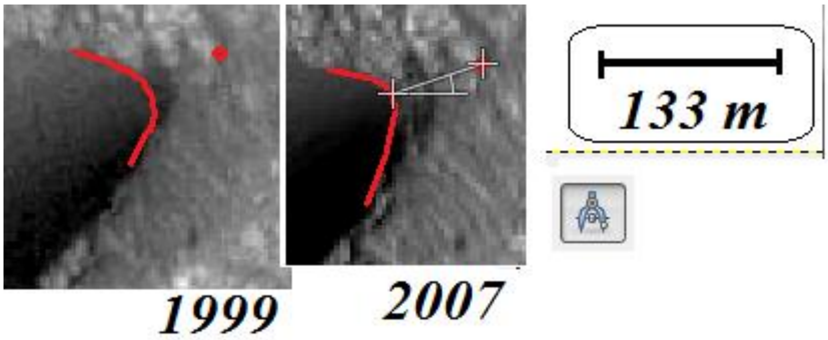

Figure 5 – Using GIMP we can have an estimation of the motion of the dune.

Here we have discussed a simple image processing to compare a HiRISE image and a Mars Global Surveyor image, and investigate the dune motion in the Nili Patera caldera on a period of eight years. Due to the low resolution of the image of 1999, it is difficult to evaluate the displacement of all the dunes of this field. However, for the smaller dunes, which are expected to move faster, we observed a displacement of several meters. We can conclude that, also in the case of low resolution images, we can have information on the motion of dunes and then, when images of the same place are available from the two collections, Mars Global Surveyor and HiRISE, this approach can be repeated to see any landform modification.

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