Peruvian Transverse Dunes in the Google Earth Images

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Abstract
A sand sea where winds create an endlessly moving collection of long dunes, like waves on the surface of water: this is the landscape of transverse dunes that we can see in Peru by means of satellite images of Google Earth. Here we will show some examples of these dune fields. Keywords: Sand dunes, Transverse dunes, Peru, Barchans, Google Earth. Author: A.C. Sparavigna, DISAT, Politecnico di Torino, Italy.

Introduction

Dunes are hills or ridges made of sand blown by winds, which appear in some arid and coastal regions of the world. Dunes begin to grow when some sand is deposited, because an obstacle is impeding the flow of winds. Over time, sand dunes can grow further or shrink or move, when winds are blowing in a prevailing direction, shifting of several meters in a year.

How dunes form and move is the subject of constant experimental and theoretical researches, which started several decades ago with the pioneering works of Ralph Bagnold [1,2]. In fact, the current studies are increasingly addressing the problem of dune stability in relation to climate changes [3,4]. In nature, dunes cannot move when are stabilized by vegetation, because it reduces the impact of wind. For this reason, it is important to preserve this natural situation, or, alternatively, to create a proper environment for an artificial stabilization by planting vegetation or by using some other materials and measures [5].

When dunes are moving, their motion can be a challenge for human activities. It is therefore important a survey able of giving an estimate of their migration rate. In some recent papers, we have shown how to determine the drift of dunes using the satellite images of Google Earth, in particular its time series [6-9]. In the given references, we have investigated the motion of barchans. These dunes have a crescent shape which is aligned with the wind direction. Barchans are observed in areas where there is a hard ground surface, a moderate supply of sand and a constant wind direction. Besides the crescent one, the dunes can have different shapes, depending on the amount of sand and the blowing of winds [10,11]. For instance, when there is abundant supply of sand and constant wind direction, the transverse dunes are created. These are large dunes that look like sand ripples on a large scale. We will show here some beautiful fields of transverse dunes that we can find in Peru. These dunes move and, as in the case of barchans, we can study their motion using Google Earth.

Moving dunes and time series of Google Earth

A survey able of monitoring the migration of dunes can be obtained by using time series of satellite images. Since the evaluation of migration rates of dunes requires large length and time scales, these time series turn out to be the best resource. Moreover, some of them are freely available in the World Wide Web, such as those collected by Google Earth [6,7].

To obtain information from the satellite images we can use GIMP, the GNU Image Manipulation Program, a program which is freely available on the Web [8]. In this reference we have discussed how some of GIMP features can be applied to study the dunes. To illustrate the method, here we

use the Figure 1: in it we can see two examples from images of Google Earth, showing some barchans in Peru. As discussed in [8], GIMP allows measuring the drift of dunes. In the Figure 2, another example of moving Peruvian barchans is proposed.

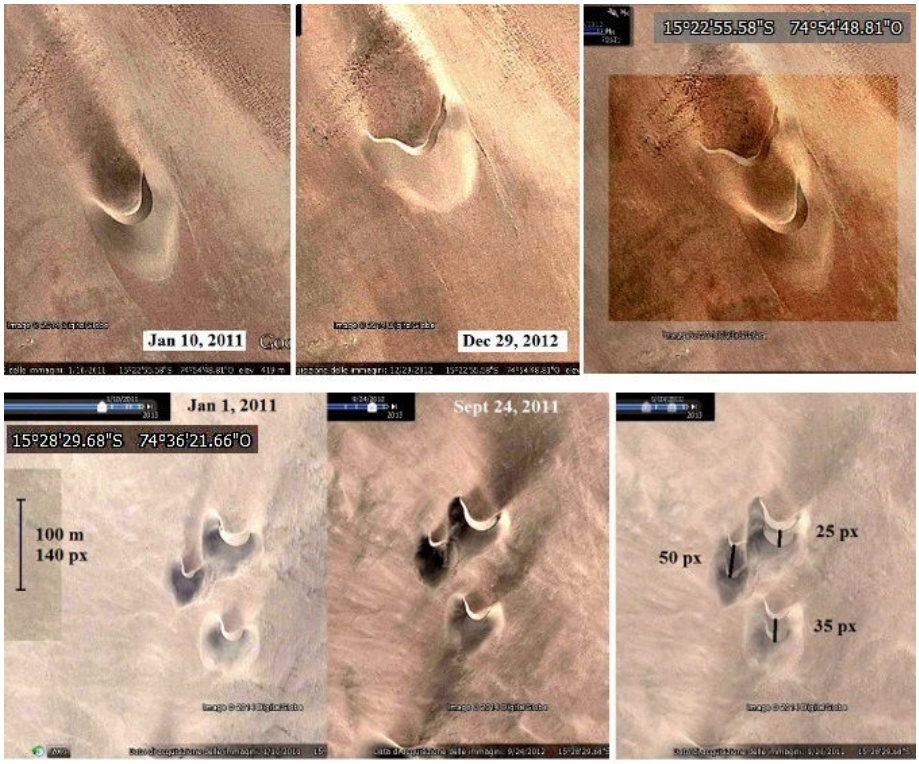


Figure 1 - Moving dunes in the time series of Google Earth images (coordinates: 15°22’55.58’’S, 74°54’48.81’’W, and 15°28’29.68’’S, 74°36’21.66’’W; Courtesy Google Earth). Using GIMP, we can measure the speed of dunes. Two images, recorded at different time, are combined in the same image. In fact, GIMP allows laying an image on the other [8]. Then, using a tool of GIMP, the pair of compasses, we can measure the displacement of dunes in pixels. Since from Google Earth, we know distances on the ground, we can convert pixels in meters. In the image on the right, we can see three dunes, the smaller is moving faster than the other two [1].

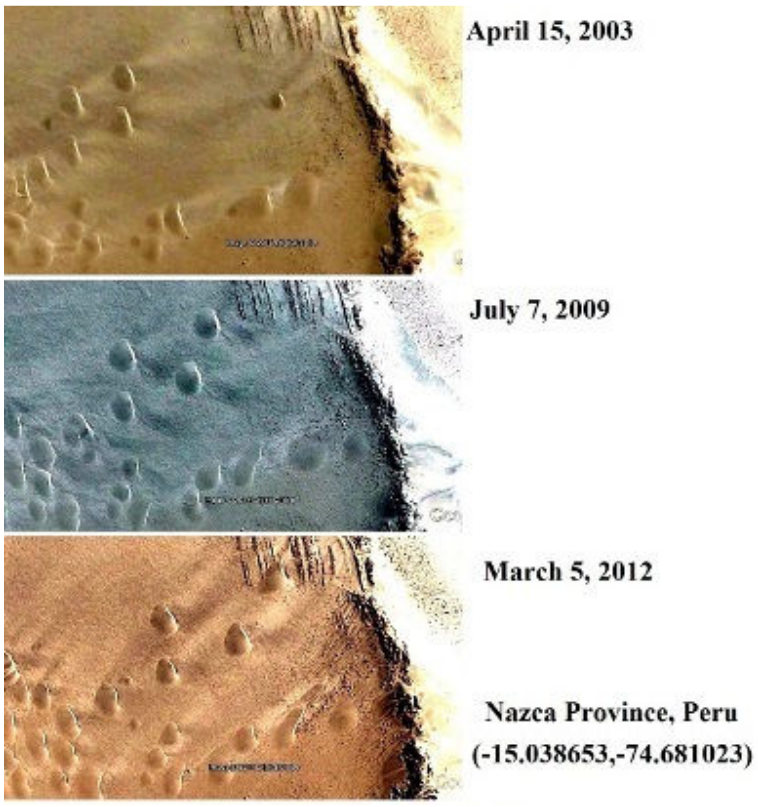


Figure 2 - Another example of moving dunes in the time series of Google Earth images (coordinates: -15.038653,-74.681023, Courtesy Google Earth).

Peruvian transverse dunes

The dunes can have several shapes [12]. Among the others, we have the transverse dunes, which are dunes looking like stripes of sand perpendicular to the direction of the blowing wind. The characteristic form, with gentle windward and steep leeward slopes, is maintained when they migrate. Transverse dunes usually form in the regions where wind is blowing almost constantly from a given direction. Of the other types of dunes, let us just talk about the longitudinal dunes, which are ridges with about the same slope on both sides, elongated in the direction of prevailing winds.

In the previous two figures we have shown examples of barchans. In fact, Google Earth is offering images of beautiful transverse dunes, such as those in the Province of Caraveli, Department of Arequipa, Peru. In the Figure 3, we can see the dunes near Acari: these dunes move as shown by the time series of images. Since the series has several images, we can prepare also a movie (it is available at http://dunes-on-earth.blogspot.it/2014/12/transverse-dunes-of-peru.html). In the Figure 4, it is shown another field of transverse dunes in the same province of Peru; such straight parallel ridges of moving dunes are rare to observe, being a result of the peculiar environment in which the sand moves. The huge sand sea of Caraveli is also producing amazing landscapes, such as that given in Figure 5.

Besides barchans, the proposed images are giving another example of the use of Google Earth in studying the motion of sand dunes. In a study which requires large length and time scales, Google Earth is providing a large amount of data on which we can work.

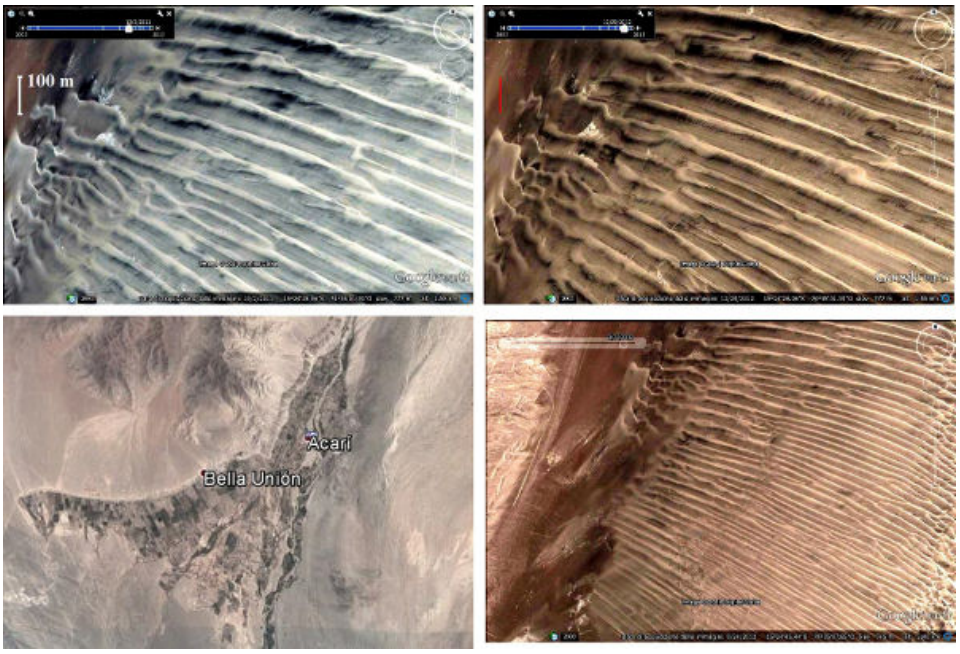
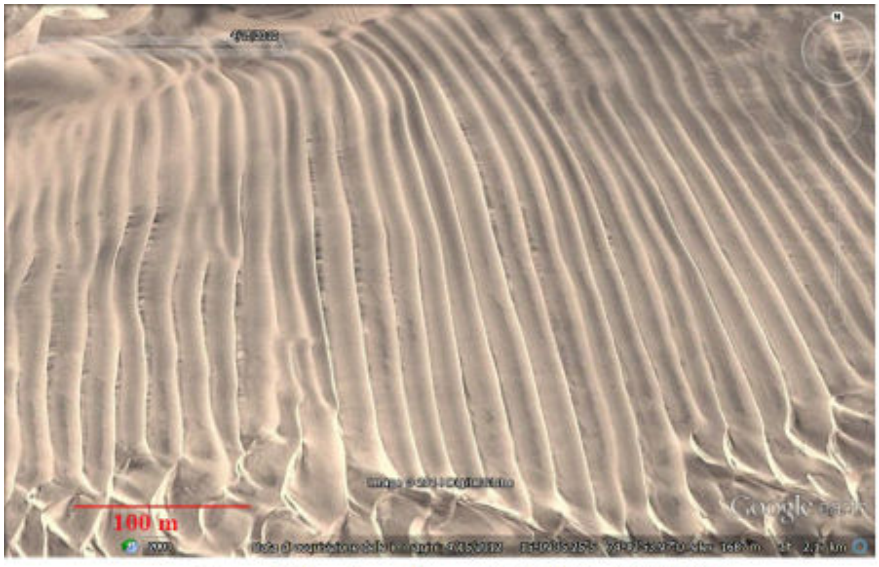


Figure 3 - Transverse dunes look like waves on the surface of water. These dunes appear where there is abundant supply of sand and the direction of winds is constant. In the lower part of the figure, the images are showing the region of Acari and the dune field. In the upper part of it, we can see two images of the Google Earth time series (October 2, 2011, on the left and December 29, 2012, on the right).



Caraveli Province, Peru, -15.159874, -74.715011

Figure 4 - Transverse dunes in the Caraveli Province of Peru. Note the almost perfect alignment

of parallel dunes, which is quite rare to observe.

Figure 5 - Dunes near Colca, Caraveli, Arequipa.

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