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Patterns of Moving Brazilian Coastal Dunes

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Abstract: The satellite images of Google Earth show an interesting feature of some coastal dunes of Brazil. They are leaving, during their motion, some "footprints" behind, which are sedimentary patterns. In this manner, it is possible to follow year after year the motion of such dunes.
Keywords: Dune motion, Satellite images, Google Earth, GIMP, Image processing.

Sand dunes exist in arid and coastal regions of the world, created by the wind which is moving and depositing sand. When winds are blowing in a prevailing direction, dunes can move of several meters in a year, with a rate depending on their size and on environmental conditions [1]. Let us note that recent studies on sand dunes are increasingly addressing the problem of dune stability in relation to climate changes [2-5].

It is very important to note that coastal dunes, such as those of Brazil, can differ considerably from the desert dunes [6]. Brazilian coastal dunes are created under an environment rich of humidity and with heavy rainfall, and the roots of plants growing on dunes contribute to their features [6]. In any case, coastal dunes can move, as we can see from the time series of satellite images provided by Google Earth. Moreover, in these images, we can note that the Brazilian coastal dunes are showing an interesting feature. They are leaving "footprints" behind, during their motion. As discussed in [7], for a large active dune-field of the eastern portion of the Maranhão coast, the observed patterns on the soil are formed due to seasonal phenomena. During the wet season, interdune plains are flooded and the soil is reworked by intermittent drainages; during the dry season, the deposits formed by the drainages and interdune lakes become temporary internal sedimentary sources for the system [7].

Here, we will give some examples of these sedimentary patterns in Google Earth images. Before their discussion, let us remember that a time series of satellite images can help us in remote monitoring of the motion of dunes, as demonstrated in some recent papers [8-11]. In the given references, we have investigated in particular the motion of barchans. In general, a surveying of dunes requires large length and time scales; it can be easily made by the satellites working in the visible range and by those equipped to determine the local environmental conditions. Maps obtained from the data recorded by such satellites are available from NOAA federal agency [12]. Such remote surveying method can substitute a local monitoring. As detailed in [10], to obtain data concerning the motion of dunes from the satellite images we can use GIMP, the GNU Image Manipulation Program.

We can apply GIMP to the Google Earth satellite images for studying the coastal dunes of Brazil too.

Since these dunes are leaving footprints behind, which are noticeably evidencing their motion, we can follow them year after year. Let us note that Brazilian dunes have been discussed in several other references, for instance [13-18]. [13] reports of local investigation of the dunes of Jericoacoara. Let us start from Jericoacoara then, a small fishing village, "mecca" of windsurfing and kitesurfing, in Ceará, Brazil. In the Figures 1 and 2, we can see some dunes: each figure is giving two images from a time series of Google Earth.

Figure 1: Dunes of Jericoacoara.

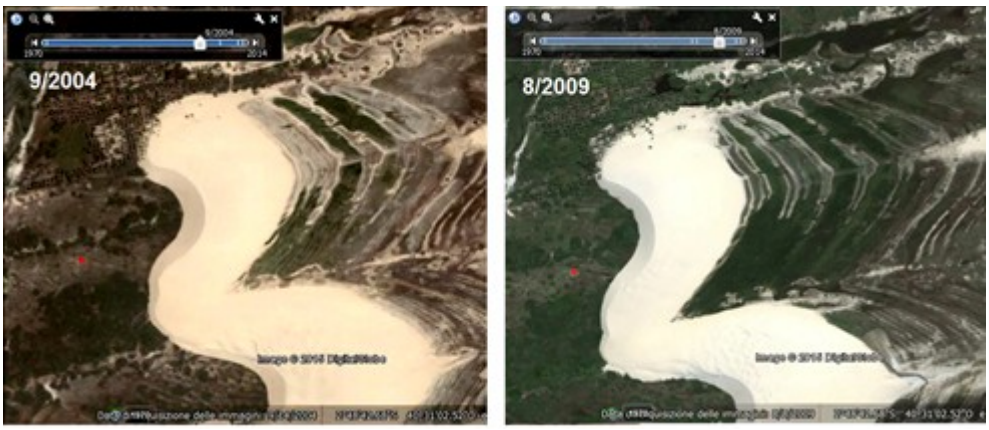

Figure 2: Detail from Figure 1.

As we did in the Ref.10, where the method is discussed in detail, we can measure the motion of a dune, comparing satellite images. Here, we apply the same method of [10], to show the "footprints", which dunes yearly create. This is shown in the Figure 3; the dune is clearly leaving some traces on the soil, consequence of seasonal effects [7]. We created Figure 3 from two layers adjusted with GIMP Retinex filtering (for a discussion of GIMP Retinex, see please [19,20]). The red line marks the position of the toe of the dune in 2009, whereas the white lines mark its position in the previous years: these lines are marking the footprints of the dune.

Figure 3: We can easily compare the motion of the dune, using the two images of Figure 2. In this case, we used GIMP to create an image from two layers adjusted with Retinex filtering. Red line marks the position of the toe of the dune in 2009, whereas white lines mark its position in the previous years. Note the "footprints" of the dune.

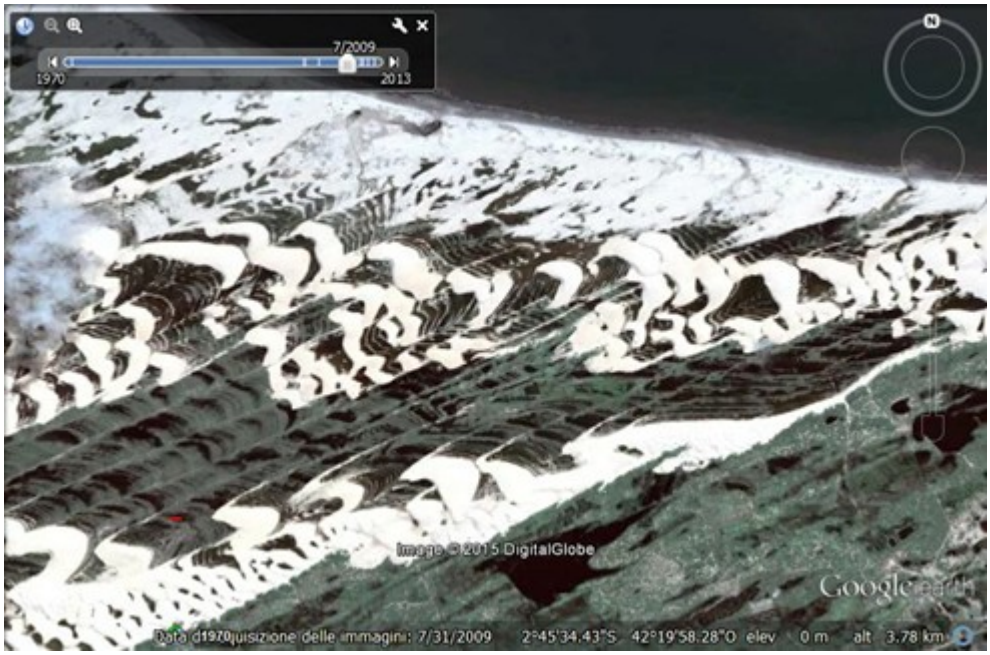

Figure 4: Dunes and their footprints of another coastal region of Brazil, near Tutoia.

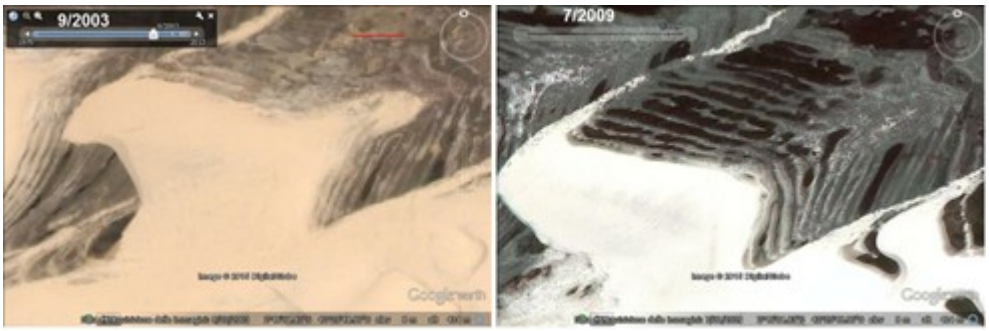

Figure 5: Detail of Figure 4. We can see two images from the time-series of Google Earth, dated 9/2003 and 7/2009. Note the footprints behind the dune.

Footprints are not limited to the dunes of Jericoacoara. If we follow the Brazilian coast on Google Earth we can easily see them. We have, for instance, those of Tutoia dunes, analysed in Ref.7. In the Figure 4, some dunes of this location are shown. In the Figures 5 and 6, the satellite images evidence that it is possible to follow year after year the motion of the dunes. If the distance of footprints changes, we can obtain information on the variation of their migration rate.

Figure 6: In this figure, we used GIMP to create an image from two layers adjusted with Retinex filtering. Red line marks the position of the toe of the dune in 2003, whereas blue line mark its position in 2009

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After the publication of this paper, Haim Tsoar was so kind to send me a copy of one of his papers on Brazilian Coastal Dunes. In it, the reader can find detailed data and models of these dunes. Moreover, the reader can find an analysis of dune in Fig.3, given from QuickBird satellite images ranging from September 2003 to September 2004. Here the reference:
Levin Noam; Haim Tsoar, Hans Jürgen Herrmann; Luis P. Maia; V. Claudino?Sales (2009). "Modelling the formation of residual dune ridges behind barchan dunes in North?east Brazil." Sedimentology 56, no. 6, pages 1623-1641.

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