Dunes changing their shape The case of the dunes of the Laayoune Sakia El Hamra region

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Amelia Carolina Sparavigna (Department of Applied Science and Technology, Politecnico di Torino)

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Abstract
Sand can create an endlessly moving collection of dunes, drifted by the prevailing winds. However, it can happen that, changing the winds, also the motion and the shape of the dunes change. Here we show an example in the dunes of the Laayoune-Sakia El Hamra region, in the west of Sahara. We can observe that the barchans assume a deformed shape in the satellite images of 2016, images that we can find in the time series of Google Earth. The origin of this deformation is in the change of the prevailing wind.

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Amelia Carolina Sparavigna

Politecnico di Torino, Italy

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Keywords: Sand dunes, Satellite images, Time series, Google Earth.

Dunes are made of sand interacting with the local wind and soil surface. By this complex interaction, the variety of shapes displayed by the dunes arise [1,2]. Moreover, in the case that wind is blowing from a prevailing direction, the dunes migrate. The first studies on the migration rates of dunes were made by field measurements [3,4]. Today, controlled experiments and numerical simulations

had been added to such measurements, to have a better comprehension of the mechanisms of formation and drift of sand dunes [3-13]. As stressed in [14,15], field measurements are fundamental to have information on the specific features of sand composition and environmental conditions.

To estimate the migration rates of dunes, we need measurements made on large length and time scales [2], which are corresponding approximately to 100 m and 1 year. For this reason, in the study of the motion of dunes, we can have a great help from the use of the time series of satellite images, which allow an easy remote measure and control of dunes. Examples are given in [16-20]: in these references we used the time series of Google Earth.

In [20], we investigated some dunes which were studies in [21]. The authors of [21] measured the width and position of more than 5,000 dunes corresponding to four dune field corridors of Morocco and Western Sahara, using the satellite images from Google Earth. Their aim was that of determining the size distribution and structure of the dune fields; therefore, in [21], the motion of the dunes was not discussed in details. However, Google Earth gives us the possibility to investigate their migration rate too: we considered some of these dunes (coordinates 27.387239,-12.607788), giving their motion as a function of their size (Figure 5 in [20]).

Of this location in Western Sahara we have not recent images provided by Google Earth (in [20], we used those recorded in 2005, which are the only images given in the time series). But the dunes which are in northern locations, such as those in the Laayoune-Sakia El Hamra region, are shown in images of 2016. Therefore, here we consider some of the dunes of this region.

The dune field of the Laayoune-Sakia El Hamra region is very interesting, because the recent images of 2016 show that the dunes are changing their shape. This is clearly visible in the Figures 1-4 (the satellite images have been enhanced using GIMP Retinex; about this filter see [22] and references therein). We can suppose that the dunes are changing their shape because of a change in the direction of prevailing wind. In the images of 2012 and 2013, according to the shape of the barchans, the direction of the wind was NNE, but in the images of 2016 the barchans appear deformed by ESE wind (see Figure 5 for the directions).

Let us conclude stressing that the satellite images of 2016 are showing a quite interesting phenomenon, which requires further detailed researches, in particular concerning the direction of the wind. From the deformation of the barchans, it seems that this region of Sahara is subjected to a climate change.

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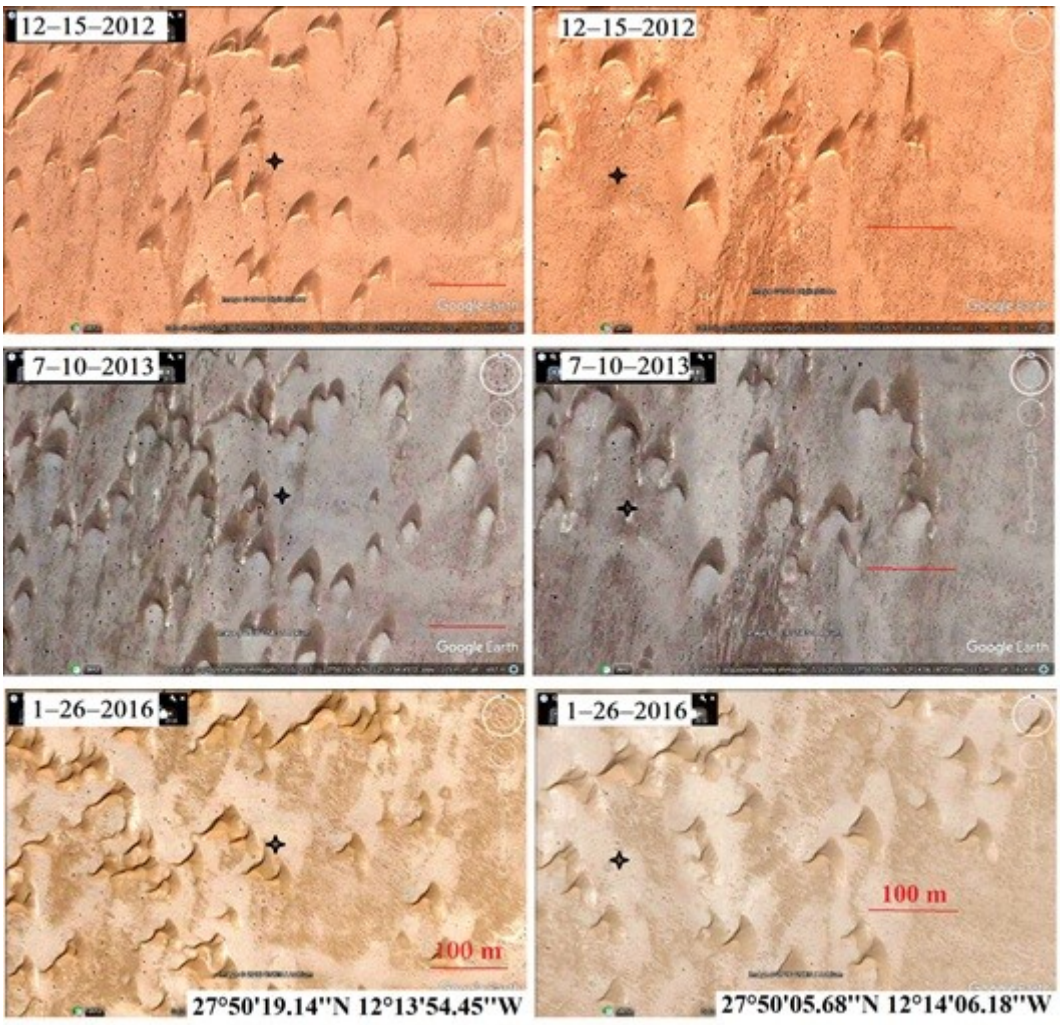

Figure 1: Dunes in the Laayoune-Sakia El Hamra region. Use the black stars as reference points to compare the images. Note from the images of 2016 that the shape of the dunes changed. In the upper and middle images, the prevailing wind was NNE; in the lower image, we see that the prevailing wind changed.

Figure 2: Two barchans in the Laayoune-Sakia El Hamra region. Use the black stars as reference points to compare the images and see the motion of the dunes. They have changed their shape. Note the faint "ghost" image of the previous position and shape of the dunes.

Figure 3: Barchans changed their shapes (the red circle is the reference point). Note the faint "ghost" shapes (marked in red) of the previous position and shape of a dune.

Figure 4: Other barchans (the red circle is the reference point). Here too we can see the faint "ghost" shapes in the image of the right panel.

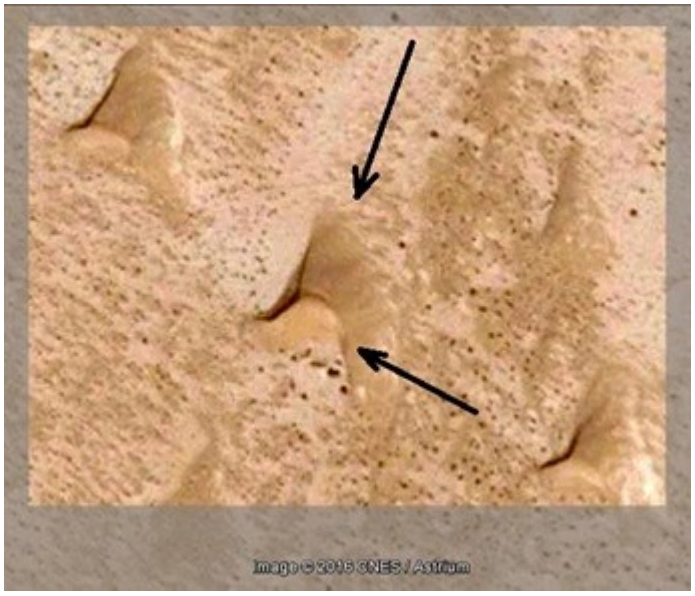

Figure 5: Barchans in 2016, deformed by ESE wind.

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