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Assessing coastal dune rehabilitation using very high resolution digital elevation models: an example from Leffrinckoucke, northern France

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Abstract

A part of the dune restoration zone in Leffrinckoucke (northern France) was monitored using high resolution DEMs from 1999 to 2001. Maps comparison shows regular dune growth in the fence-equipped area. Volume computation and statistical analysis confirm the accretional trend detected from map analysis and enable a quantitative assessment of the efficiency of the fences and brushwood barriers.

Keywords: Dunes rehabilitation; Topographic survey; Digital Elevation Models; Volume computation; Statistical analysis; Leffrinckoucke, France.

Study area

Until the early 1990s, much of the coast between Dunkirk and the Belgian border (Fig. 1) suffered severe erosion involving dune blowouts and breaches and bluffs cut into the dunes.

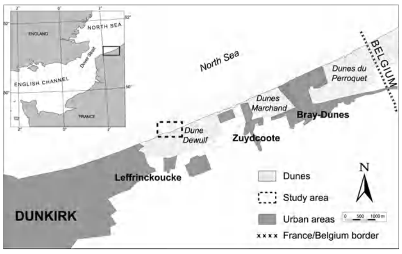

Fig. 1. Location of study area.

This coast is presently in a state of stability. Since 1997, dune restoration has been undertaken by the "Conseil Général du Nord" (Departmental authorities) and the "Conservatoire du Littoral". This restoration scheme has focused on a large blowout in Leffrinckoucke, and has involved the use of longshore oriented sand fences, cross-shore oriented brushwood barriers and the planting of *Ammophila arenaria*. The monitored sector reported in this study is a part of the rehabilitation zone, and comprises the upper beach, and the dune front and crest.

Methodology

From September 1999 to October 2001, very high resolution topographic surveys were carried out every 2 months and half on average over a 25x30m sector using an electronic total station (Leica TC600), Vanhée (2002). An average of 708 data points were collected each time (*i.e.* ≈ 1 point per m^2). This dataset was used to create nine Digital Elevation Models (Fig. 2) from which nine comparison maps were computed (Andrews *et al.*, 2002; Rebêlo *et al.*, 2002). Eight maps were generated following subtraction of one DEM from the next one and represent topographic changes between two surveys (Fig. 3).

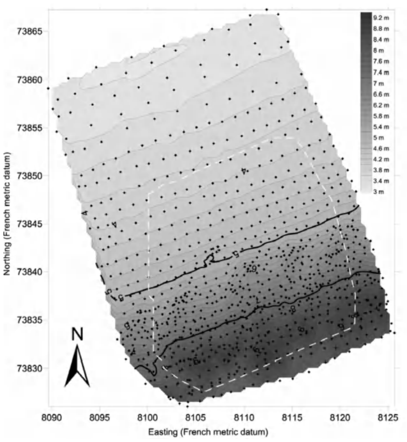

Fig. 2. Example of DEM (elevations are relative to French datum, bold lines represent the 5 and 7.5m contours, dots indicate measurement points, white dashed line indicates comparison zone).

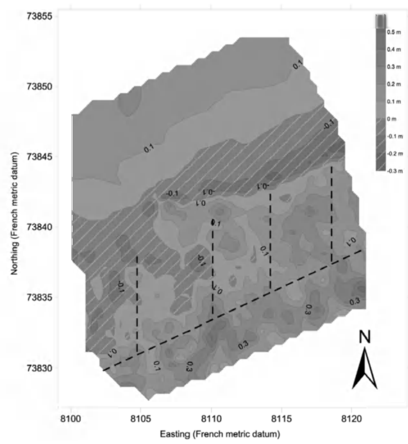

Fig. 3. Example of a comparison of two DEMs (April and October 2001). Dashed lines represent sand fences and brushwood barriers. Positive values express accretion, negative values erosion.

The last map was produced by comparing the first and the last DEMs and hence represents the total topographic changes for the complete survey period. These maps show regular dune growth in the fence-equipped area (dune front and crest). The DEMs were divided into three sub-zones (upper beach, dune front and crest) for computing volume changes, using the 5 and 7.5m contours (relative to French elevation datum) as limits (Vanhée *et al.*, 2001).

Results

Calculations of global and partial volumes were carried out and then statistically synthesized (Fig. 4 and Table I). Means and Standard Deviations were used to calculate variation coefficients (St.Dev. divided by Mean), which can be interpreted as a measurement of evolution regularity (low value = regular, highest value = irregular). Slopes are the b parameter of a linear equation (y = bx + a), indicating value of daily evolution (in m^3). R (Bravais-Pearson correlation coefficient) expresses the trend intensity (varying between –1 = strong negative relation and 1 = strong positive relation).

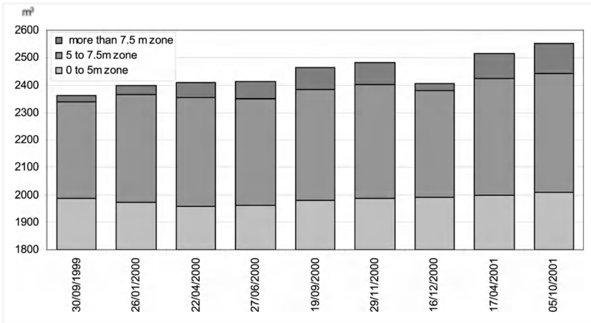

Fig. 4. Volumes of the three sectors at each date of measurement.

Table I. Main statistical parameters used in data analysis (calculated using raw volume data)

	Mean (m^3)	St Dev (m^3)	Variation coef.	Slope (b)	R
0 to 5 m	1982.61	16.71	0.01	0.05	0.69
5 to 7.5 m	399.44	23.21	0.06	0.09	0.88
more than 7.5 m	62.70	30.57	0.49	0.11	0.80
Total	2444.75	61.65	0.03	0.25	0.91

Fig. 4 shows that the lower zone (upper beach from 0 to 5m) of the DEM suffered little erosion at the beginning of the study and then experienced very mild accretion. This sector shows the most regular evolution (Table I: variation coef. = 0.01), but also the slowest (b = 0.05 r = 0.69) of the three sectors.

The dune front (5 to 7.5m) and crest (more than 7.5m) accreted less regularly but more rapidly than the upper beach (variation coef.= 0.06 and 0.49, b = 0.09 and 0.11). It is important to note that the 0.49 variation coefficient for the dune crest is due to erosion between November and December 2000. These results not only confirm the accretional trend detected from map analysis, but enable a quantitative assessment of the efficiency of the fences and brushwood barriers.

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