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A QUANTITATIVE EVALUATION OF EROSIVE AND ACCRETIONAL SECTIONS ALONG THE BELGIAN COAST IN THE PERIOD 1978-1990

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1. COASTAL EVOLUTION

Coastal morphodynamics are extremely complex as they are simultaneously commanded by processes of erosion, transport and deposition by current, wave, tide, wind and seepage, each of them varying locally and temporarilly in intensity and direction, so that direct and residual effects over varying time spans may be quite different. Moreover, they are characterized by a combination of different short term, medium term and "long term" components. We do not intend to discuss them at length neither to treat geological aspects of coastal genesis and evolution nor to comment on temporary states of dynamic equilibrium that possibly can be reached.
The results of a detailed but qualitative monitoring of the behaviour of the sandy, megatidal, runnel and ridge type beaches along the Belgian coast during the period 1982-1987 are shown in figure 1. This map of the residual shoreline displacement, used as criterium for beach erosion, shows that along the Belgian coast several sections of residual erosion or residual accretion are following each other. Some of them are related to coastal management; some however are undoubtly of a natural origin. De Moor 1979, 1991b) has proven that since the 60's the section Bredene-De Haan corresponds to an erosive megaprotuberance. This consists of a longer term coastal dynamics component, embracing a coastal section of a few kilometer length and characterized by a residual erosion continuing over several decades, changing in intensity and sweeping slowly the coastline in the direction of the residual current, so that it locally presents a longer term cyclic character (estimated in that case at about 50-70 years) and is followed by an accretional phase. Inside the erosive megaprotuberance storm effects seem to be more devastating. Visual monitoring of the coastal evolution in the Bredene-De Haan area during the period 1955-91 proved that the erosion progressed to the east, reaching De Haan itself around 1980. Since 1990 it touched another 2 km east of De Haan, while

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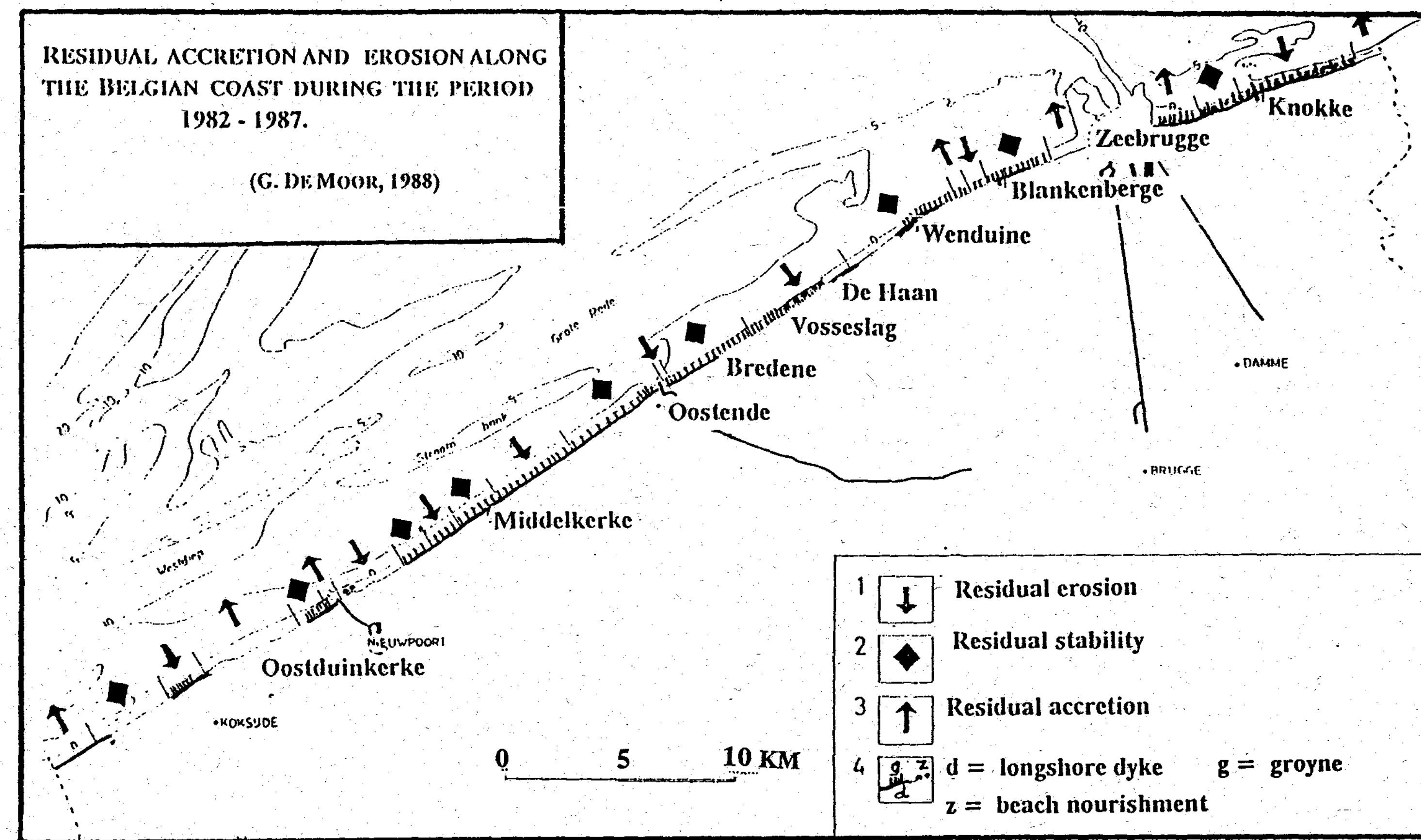


Fig. 1. Evolution of the Belgian coast line during the period 1982-1987.

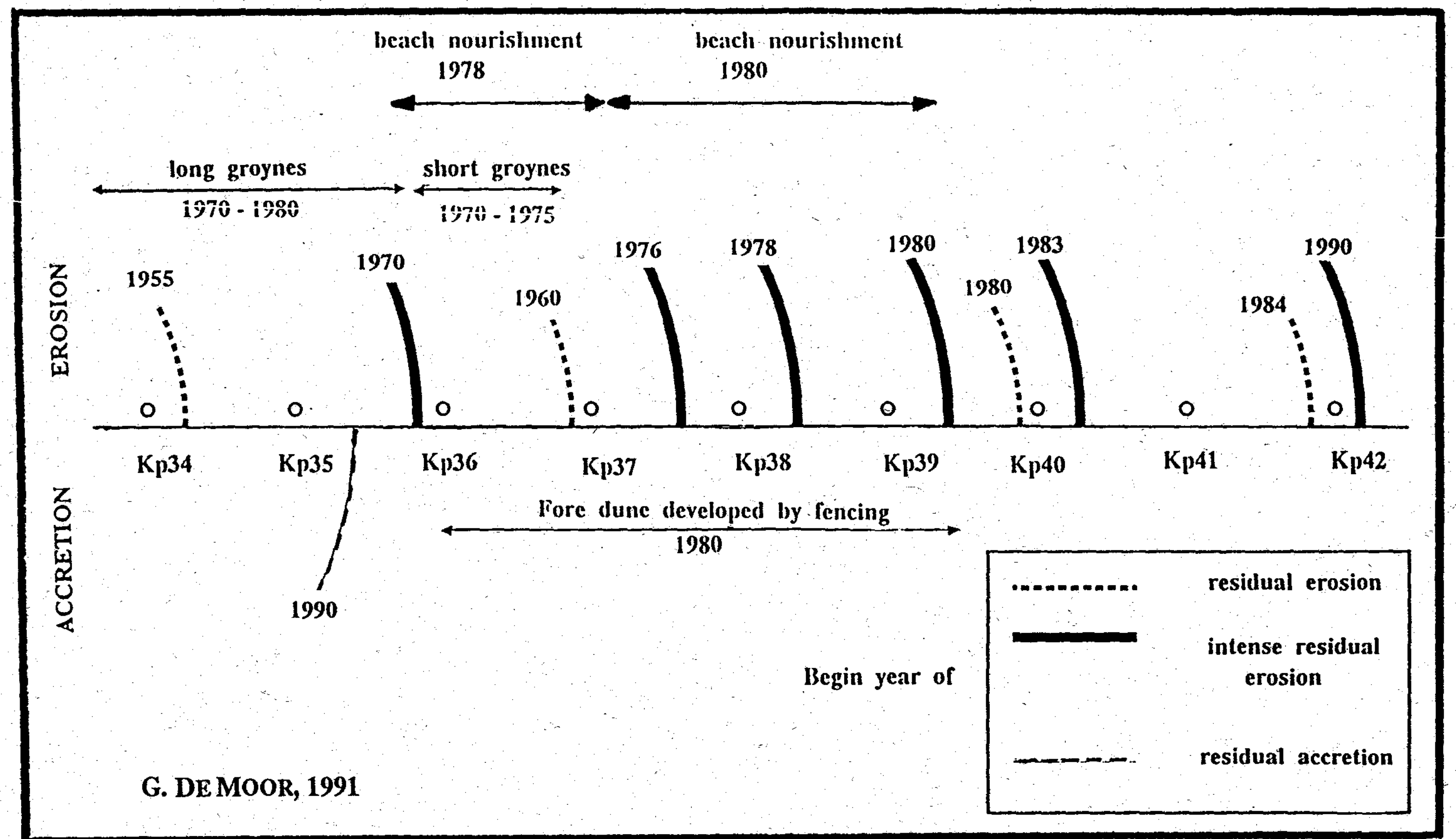


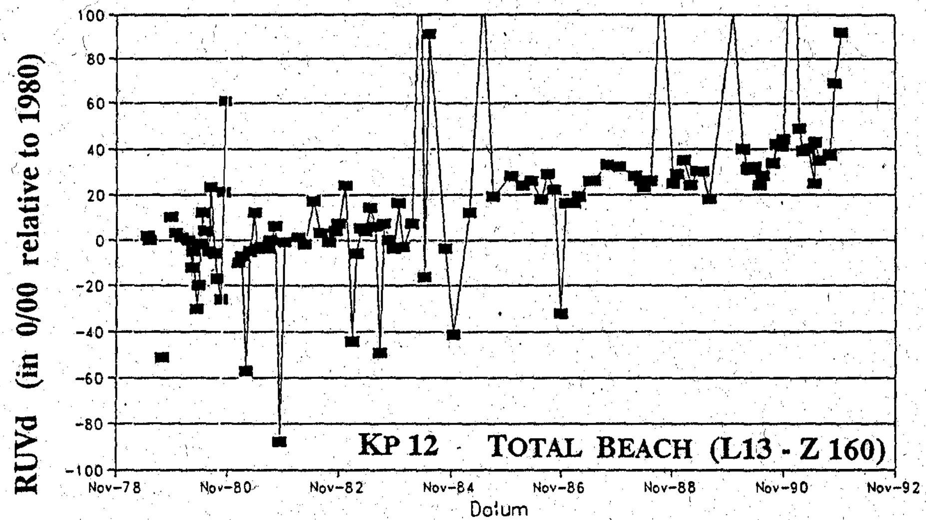
Fig. 2. Schematic outline of the displacement of the front of residual accretation and erosion of beach and dune face in the coastal section Bredene-De Haan during 1955-1990.

at its western tail stabilization and even accretion started, burying parts of defence structures (fig. 2).

2. COASTAL MONITORING BY VOLUMETRIC DATA COLLECTION

Objective description of the local beach evolution, comparison of beach behaviour in different locations and research for causal relationships and prognosis of further evolution cannot be fulfilled without the use of a numerical parameter for the beach condition and its follow up by a sequential monitoring with an adequate frequency, yielding a numerical time series signal available for statistical analysis. Moreover erosion means loss of material within a morphological entity and is not necessarily indicated by shoreline displacements or merely by absolute surface lowering.
The basic numerical parameter is the absolute unit volume of the beach measured by detailed beach profiling in a fixed station. This geomorphological approach assesses beach dynamics not by direct monitoring of particle or bedform motion, but using residual effects of their multidirectional displacements during successive phases of erosion and deposition. Time series are obtained by sequential profiling with a frequency adaptable to causal conditions (e.g. storms).
The absolute unit volume (AUV in m^3/m) of a beach or a beach section in a profiling station corresponds to the volume defined by the vertical cross section along the rectilinear transversal beach profile delimited by a vertical at the begin and another at the end of the profile (or its section) and by its intersection with an horizontal plane situated at a fixed depth below a local elevation datum, and further by an equal cross section at 1 m parallel to the former. Limits of the total beach are defined by the SLW line and by the dune front convexity at a fixed date. Beach profiling was carried out with a 3 m step. Volumetric computations were performed with the programme SPEV (G. De Moor, 1987). As the size of the beaches is varying, comparison of volumetric data is only meaningful after normation of the AUV in relation to a reference volume specific for each profiling station, and corresponding to an annual mean. This yields the relative unit volume (RUV in ‰).
The absolute unit volume difference (AUVd) accounts for the value of the reference volumes themselves. This parameter corresponds to the difference between the momentaneous AUV, and that at a former reference date or corresponding to a mean value for a fixed period. For similar reasons as mentioned before, a relative unit volume difference (RUVd) is to be calculated.
Figures 3, 4 and 5 show UVd time series for Oostduinkerke (KP 12)*, a

* KP XX=reference pole at XX kilometer east of the French border along the Belgian coast.



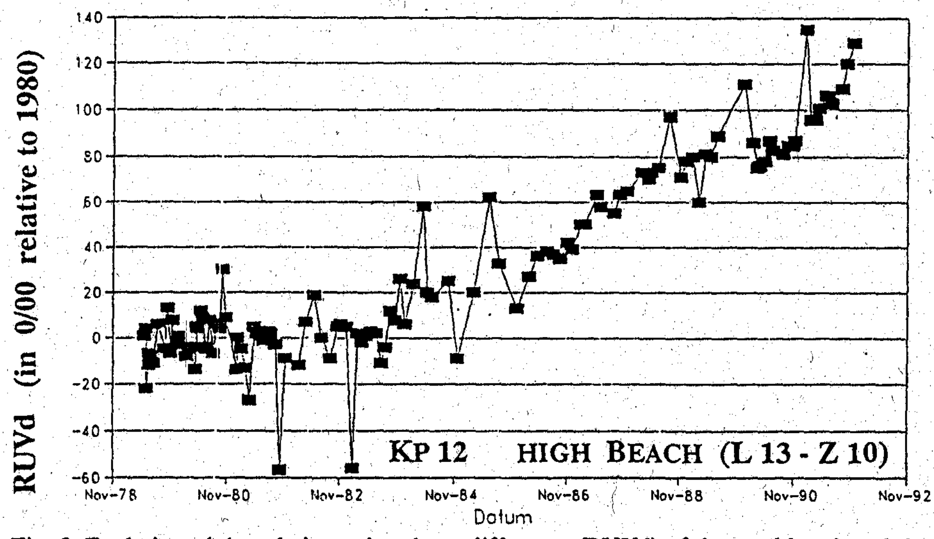


Fig. 3. Evolution of the relative unit volume difference (RUVd) of the total beach and the high beach at Oostduinkerke (Kp12) in 1979-91.

station in an accretional zone; for Klemskerke-Vosseslag (KP 37), a station in an erosional zone with defence structures; and for Vlissegem (KP 42), a station without defence structures in a zone that recently became erosive. They confirm the simultaneous occurrence of different morphodynamical beach types along a uniform coast and the shifting of the megaproturberance. Volumetric monitoring for the last years shows a slight increase west of KP

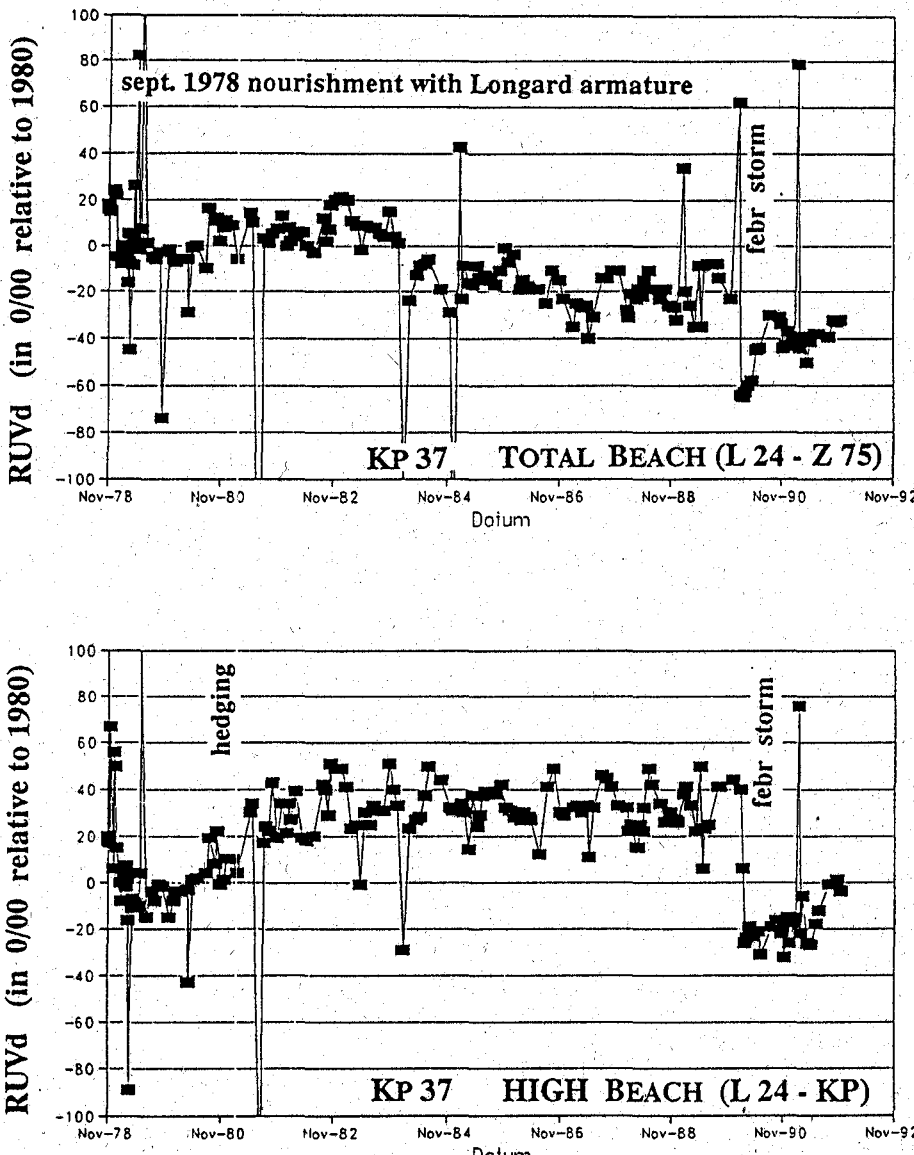


Fig. 4. Evolution of the relative unit volume difference (RUVd) of the total beach and of the high beach at Klemskerke-Vosseslag (Kp 37) in 1978-91.

36 and increasing erosion between KP 39 and KP 42. Such time series allow to formulate short term perspectives by trend analysis (G. De Moor, 1991[a])

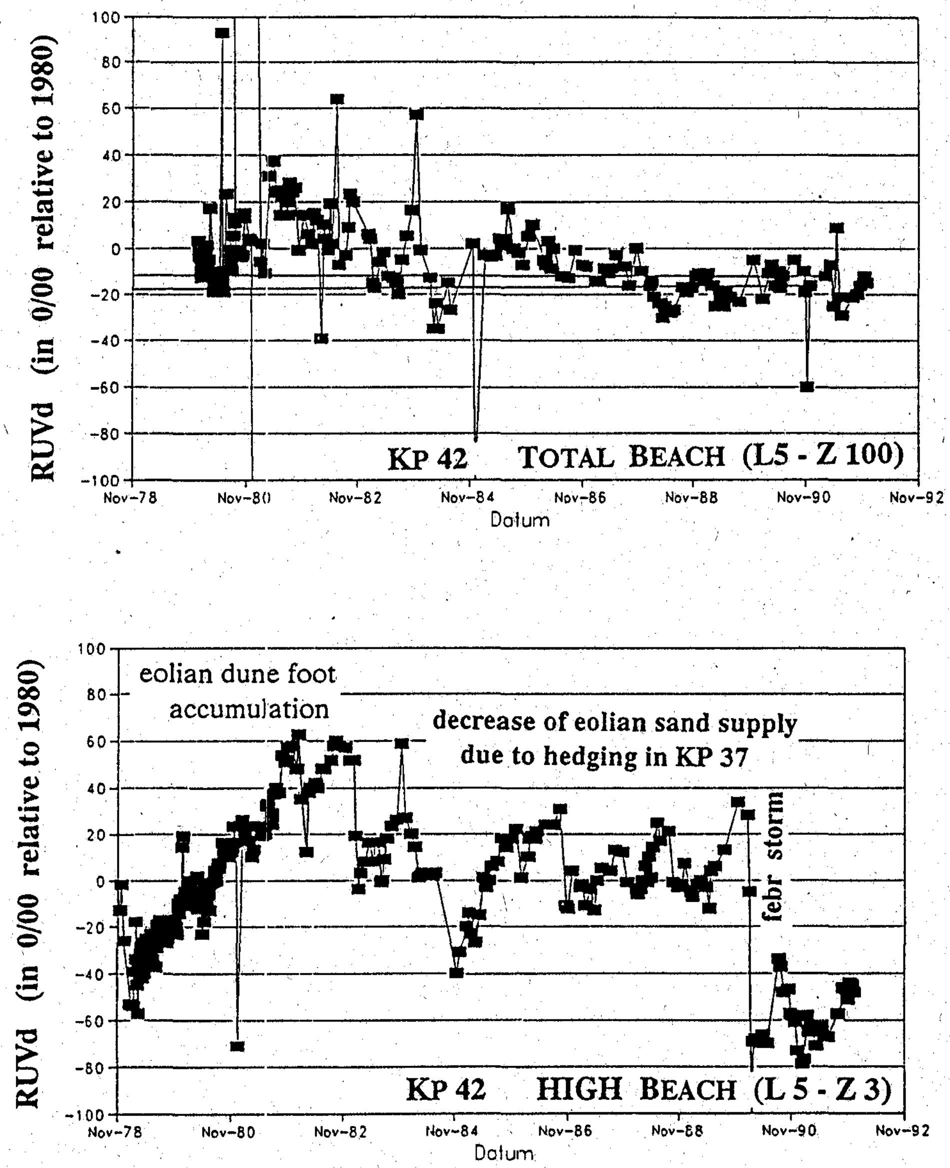
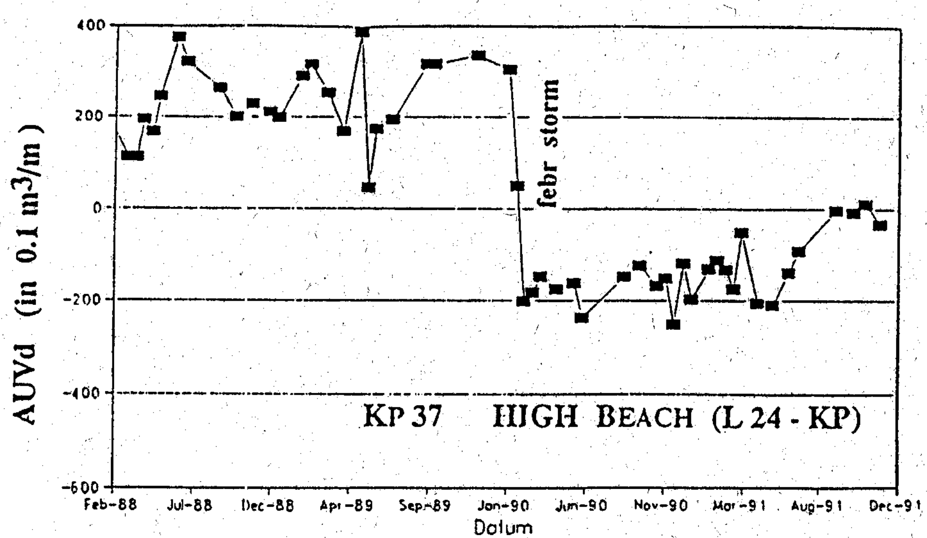


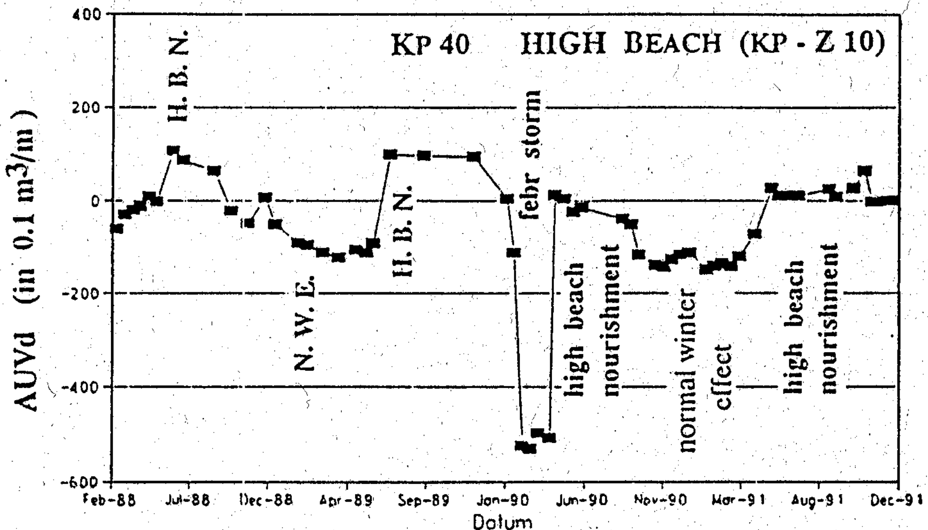
Fig. 5. Evolution of the relative unit volume differences (RUVd) of the total beach and of the highe beach at Vlissegem (Kp 42) in 1978-91.

3. COASTAL DEFENCE

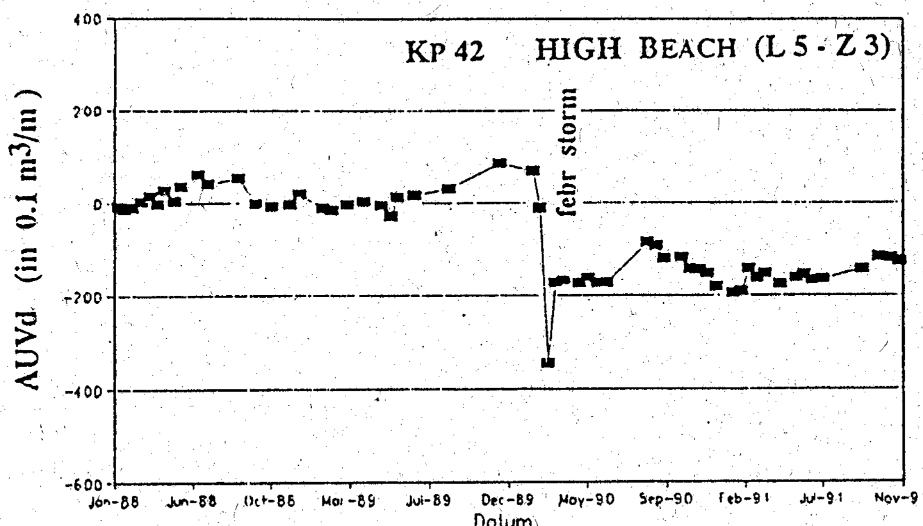
The time series for KP 37 corresponds to the evolution of a station in a coastal section where strong erosion has been counteracted by coastal defence. Since 1976 the erosion in the area Bredene-De Haan became severe. In 1976-78 a series of winter storms caused a mean annual retreat of the dune face



KP 37 HIGH BEACH (L 24 - KP)
febr storm
AUVd (in 0.1 m3/m)
Datum



KP 40 HIGH BEACH (KP - Z 10)
H. B. N.
N. W. E.
H. B. N.
febr storm
high beach nourishment
normal winter effect
high beach nourishment
AUVd (in 0.1 m3/m)
Datum



KP 42 HIGH BEACH (L 5 - Z 3)
febr storm
AUVd (in 0.1 m3/m)
Datum

estimated at 4-5 m. In 1970-78 numereous groynes were constructed over a distance of 4 km west of Klemskerke-Vosseslag, without stopping the erosion.

In 1978 an important beach nourishment (about 1.000.000 m^3 sand) with Longard armouring was put on the high and medium parts of the beach over a distance of 2 km between KP 35 and KP 37 (G. De Moor, 1979[b]). In the first months there was a quick reinstallment of the runnel and ridge morphology, followed up by the exhumation of the sandtubes, by deep pitting of the central part of the beach and by the development of a high water line cliff that gradually advanced by wave attack. Meanwhile, more to the east, between KP 37 and KP 39, erosion continued as well, causing the exhumation of old defence structures (dating from an earlier 1910 erosional megaproturberance, meanwhile covered by accretion) and, for the first time, provoking dune face cliffing in KP 39 in 1979.

In 1980 the beach nourishment was extended to the east over 2.5 km between KP 37 and the west side of the De Haan waterfront, necessitating another sand supply of about 1.000.000 m^3. Since 1980 erosion of the nourishment went on, although the highest part remained more save, with the exception of the section near KP 39.

In 1980 a beach fencing was put on the higher part of the beach nourishment between KP 36 and De Haan. It caused fixation of the aeolian sand transport, formation of a fore dune edged by a seaward rim, a slow down of the retreat rate of the high water line cliff (fig. 4), but also a decrease of aeolian sand supply on the high beach in De Haan , leewards of the prevailing wind.

Since 1990 winter beach erosion in De Haan itself became so important that in april-may 1992 an extensive beach nourishment (800.000 m^3) between KP 39 and KP 41 became necessary to provide a high beach practicable by tourists.

4. STORM IMPACTS

UVd-time series for stations inside and outside the Bredene-De Haan section, prove that direct and residual storm effects were much more important inside the erosional megaprotuberance. UVd-time series for KP 37, KP 40, KP 42, all situated inside the megaprotuberance, show severe losses and a slow or merely a partial recovery even after more than 1 year (fig. 6). UVd-times

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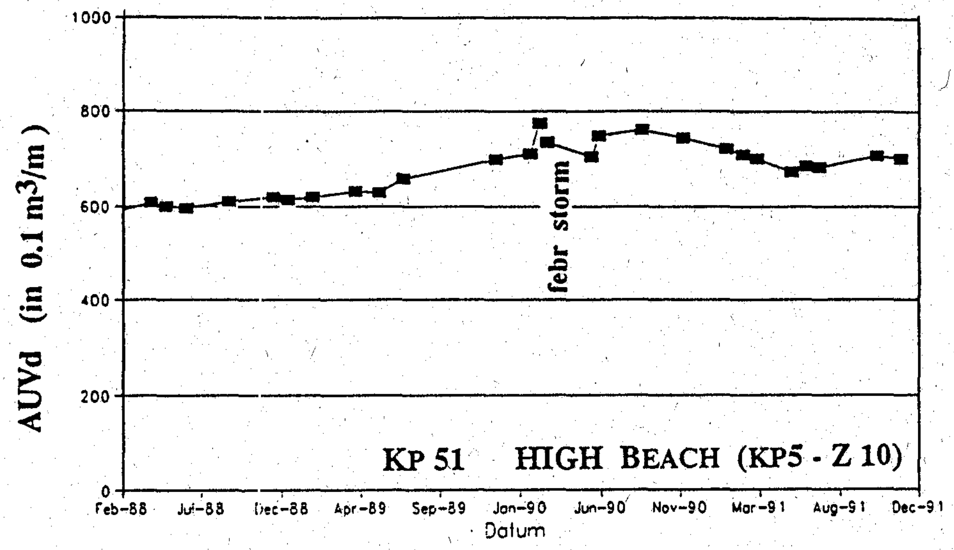
Fig. 6. Evolution of the absolute unit volume difference (AUVd) of the high beach at Klemskerke-Vosseslag (KP 37), at De Haan (KP 40) and at Vlissegem (KP 42) in 1988-91. The three stations are located inside the Bredene-De Haan megaprotuberance. The impact of the february 1990 storms is striking. Partial recovery in KP 40 is mainly due to spring high beach nourishment.



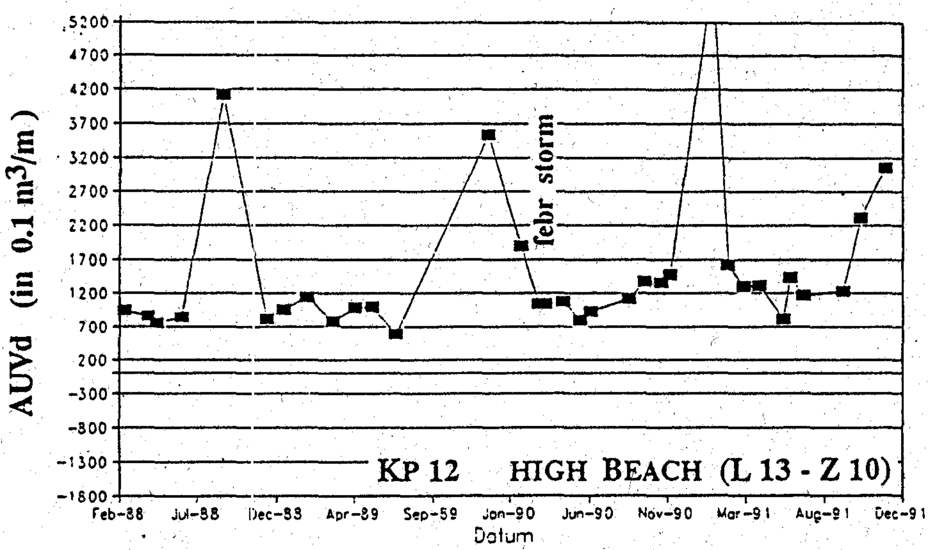


Fig. 7. Evolution of the absolute unit volume difference (AUVd) of the high beach at Oostduinkerke (KP 12) and at Zeebrugge-West (KP 51) in 1988-91. The two stations are located outside a megaprotuberance. In both stations the high beach is partly hedged for eolian sand transport fixation. In Zeebrugge the accretion is mostly conditionned by break-water effect upstream flood peak current direction.

series for KP 12 and KP 51, both situated outside an erosive megaprotuberance, show little direct storm damage, quick beach restoration and resumption of the accretion (fig. 7).

The effect of the winter storms of February 1990 illustrate the areal differen-

ciation of the immediate and the residual s y
short and uniform coast. Tide and wave da ic
conditions along the coast during the stor es
neither in storm characteristics, nor in de d-
ered as a main cause for the differenciatio

[illegible]

5. CONCLUSIONS

Erosional and accretional megaprotuberances are alternating along the Belgian coast. They are slowly shifting to the east, in the direction of the dominant flood peak current. Various small scale and short term beach processes are acting within the megaprotuberance. Storm events seem to be one of the short term events that discontinuously enhance the evolution of the erosional megaprotuberance and its coast sweeping displacement. Coastal defence structures are not altering markedly the phenomenon on a durable way.

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