DGPS AND GIS USED AS TOOLS FOR THE ANALYSIS AND MODELLING OF BEACH RIDGES ON THE BRAZILIAN SOUTH COAST

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ABSTRACT

The beach ridges are prolonged accumulations, in general of sandy composition, disposed parallel to the ancient shoreline and separated to each other by depressions. They are formed by the action of storm waves, currents and in a lesser extend by tides, constituting progradation zones. The portion of beach ridges studied is an increment in the shoreline accumulated in the last 40 years, that correspond the succession of these ridges, inserted by narrow and prolonged marshy strips, covered by typical vegetation, or small ponds, where the altitudes vary between 0.78 a 3.85m. This coastal plain area is located in Paraná State, Brazil (25^o 34-30'S; 48^o 20-25'W).

The studied area shoreline has typical variations of outlet of bays. Certain sections of the beach show a progress of approximately 700m in 40 years, with medium progress of 17,5 m/year.

Studies for the preservation of these beach ridges are of great importance because it is the last and well preserved "restinga" (sand dune vegetation) of the coast on state of Paraná, and it also represents an important stop point for resting and feeding of migratory birds.

With the purpose of obtaining information that allowed the construction of a digital elevation model and of thematic maps of the area, several field survey were accomplished using DGPS Ashtech Realiance Decimeter package. Firstly, the mapping of the area contour and drainage mesh was accomplished. Later on, 48 profiles of perpendicular points to the shoreline were made. For each point the data obtained by DGPS, including observed data relief morphology was stored. These data were post-processed on the Reliance processor software and the points that did not have inferior accuracy to 0,5 m were discarded. For the whole study area, 2.2 km^2, were obtained a total of 933 points.

The data were worked in the SPANS GIS, generating a digital elevation model using the triangulation method and a resolution of 6.4 m. Morphology forms maps were also generated, using the Voronoi method for the data interpolation.

In spite of the great morphologic diversity of this environment type, the obtained results were satisfactory. The digital elevation model did not resulted in a faithful reconstruction of all the features of the area. This is due to the small variation in the height of the features, being close to the limit of the resolution reached by DGPS in the altitude (0,5 m). However, it characterized the main ridges and swales, obtaining a good concordance with the morphology forms maps.

This survey type was efficient for the characterization of small areas, even having little altimetric variation of its relief morphology. The information generated by this survey will be of great usefulness for the understanding, planning and monitoring of this ecosystem.

1. INTRODUCTION

The inlets are met on the transition between the protected environment of the estuaries and the open sea. These geomorphological forms are subjected to a complex interaction of natural agents like: tides, tide currents, meteorological variables, waves and drift currents.

It is very common at these areas the formation of beach ridges that, according to Suguio (1998), consist on elongated depositional forms, in general with sandy composition, with parallel disposition to the palaeoshorelines and separated one from the other by swales. It is formed by storm waves activity, currents, and

smaller influence of tides, constituting progradation littoral zones. When composed by fine sand it may occur superficial aeolic rework creating the dune ridges.

Beach ridges are important on the coastal zone because they protect against storm waves that reach the coast. It is common in many places the removal of these environments for the construction of houses, this act has many times as a consequence the beginning of coastal erosive processes.

This study represents the begin of diagnostic studies, modeling and management of one of the last areas of beach ridges from Paraná coast – Brazil. For such study, were used techniques of spatial analysis based on GIS.

2. STUDY AREA

The studied area consists on a portion of 2.2 km^2 of beach ridges located at the South mouth of the estuary of the Bay of Paranaguá – Paraná – Brazil, on the co-ordinates 25º34-30'S; 48º20-25'W (Figure 1). This portion of beach ridges is an area where a strong progradation of its coastline has occurred, representing a typical situation of bays outlets, where the adjustment to the energy supplied by the dynamical variables, as waves, tides, currents and winds is very fast. According to Soares *et al.* (1997), certain sectors show an advancement of approximately 700m in 40 years, with averaged advancement of 17,5 m/year.

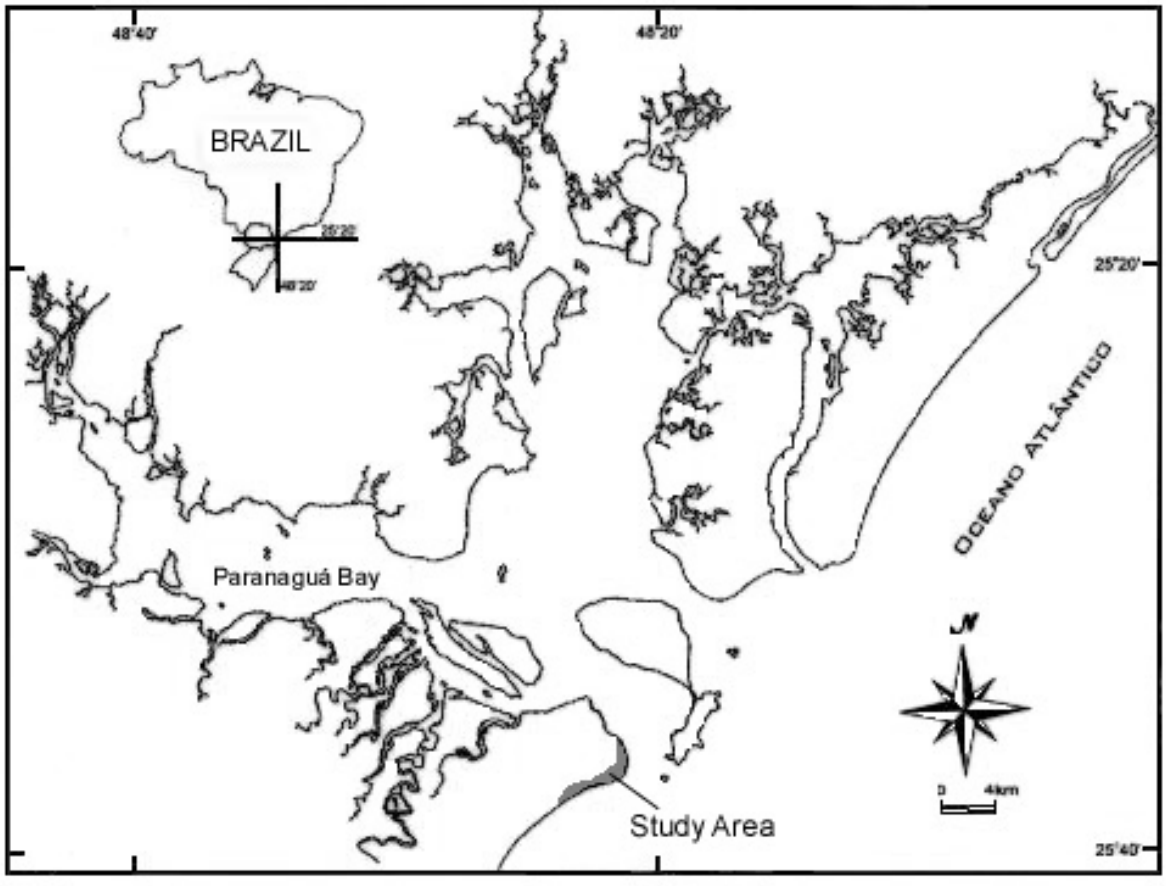

Figure 1. Study area location

Besides its role as a protection system against the invasion of the sea during storms, this area has ecological importance for being as an important rest stop point and feeding for migratory birds.

3. THE LOCAL BEACH RIDGE SYSTEM'S FUNCTIONING

The morphological structure of the area had its origin from the interaction Land-Sea-Atmosphere that occurs at this site, mainly from the movement of sediments brought by the littoral drift coming from the South. Part of this drift, when passing by the region, meets a hydraulic barrier formed by the mouth of the Bay of Paranaguá, these currents loose energy, causing the deposition of these sediments. By this way, it is basically formed by the deposition of beach ridges, built from this recent material coming from the littoral drifts.

The system works mainly due to the associations that occur between the morphological structure, hydrological regime, and atmospheric regime. The swamps and swampy regions have their expansion and retraction determined by the hydrological system, which is regulated by the rain regime and tides dynamic. This acts on the mode of direct intrusion and contact of the sea water with the underground water.

This means that the functioning of this environment in centered on the entrance and exit of water and sediments from this system. During the rainy period, that occurs during summer, the functioning of the interactions shows to be more intense, what causes several changes on the physical and chemical structures of this environment.

4. METHODOLOGY

The study was done in three parts: 1) field data sampling; 2) post-processing of GPS data; and 3) processing and analysis at GIS.

The field data were sampled with a DGPS Reliance Super C/A (Geodesic) Ashtech, firstly concentrating on the mapping of the contour and of the draining system of the area, walking around. After this, it was defined the punctual sampling mesh that consisted of 48 profiles perpendicularly to the coastline (Figure 2). And at each sampled point the characteristics of soil moisture level and morphological form were wrote down. The geographical co-ordinates and altitude were collected by DGPS, being the receiver (base) situated in a Portobrás geodesic landmark. The altitude values are not related to the sea level, they correspond to the altitude relative to the geodesic landmark. The GPS sample taxa was of 1 second with acquisition time to the point of 1 minute. The distance between the points of the same profile was determined by the variation of ground characteristics, what means that, if there was a dune it was taken a point on the base of the dune, one at the top, and another on the posterior base.

In order to remove inaccuracies from the field data due to the random degradation (S4) a post-processing differential was made. The processing used was the decimeter processing that use carrier phase of the L1 satellite signal. After this, the points that showed an error bigger than 0,5m were discharged at the longitudes and latitudes, and bigger than 0,2m at altitude. A total of 933 points were used.

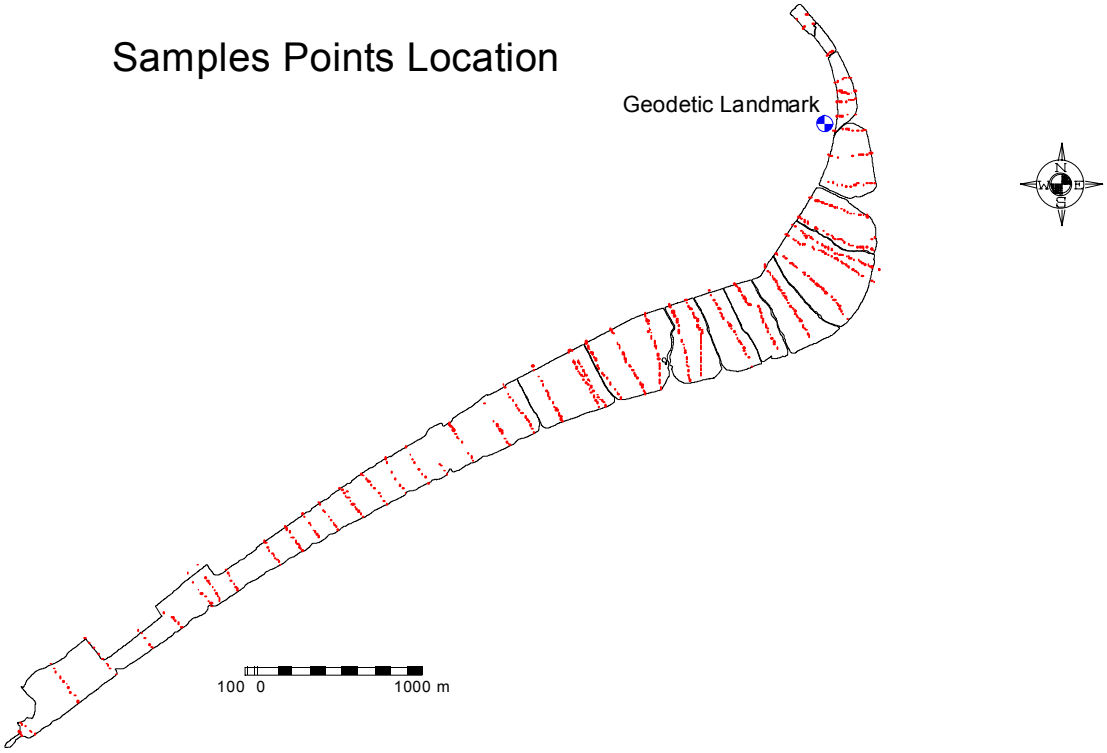

Figure 2. Sampling mesh and geodetic landmark location

Finally, the data were analyzed at GIS Spans. With the data of altimetry it was generated a digital model of elevation by the method of triangulation weighted average of Z-values. This surface model applies a weight inversely proportional to the distance of the center of the quad cell from the three vertices of the plane in the TIN. The filtering policy used was the maximum Z-value/Location, that determines the maximum Z-value and its location. Due to the little altimetric variation (0.78 a 3.85m) it was restricted to 5 classes of altimetry, being this posteriori converted to the format raster with spatial resolution of 6.4 meters. It was also applied a filter of Gaussian convolution 3x3. With the morphological forms information it was generated a thematic map utilizing the Thiessen method of polygons (Voronoi) with a resolution of 6,4 meters. Thiessen polygons contain only a single point, and have the useful property that any location within a polygon is closer (in Euclidean distance) to the associated point to any of the neighboring points (Bonham-Carter, 1994).

5. RESULTS AND DISCUSSION

Figure 3 shows the digital elevation model, where it is possible to observe that the highest altitudes are shown represented by the portion further from the estuary mouth and by strips of high altimetrics parallel to the coastline located both at the system of dune ridges as at the system of inner ridges. The altitudes diminish with the proximity of the mouth of the estuary being possible to observe the smallest altitudes on the portion of the beach ridge that is almost inside the estuary. This occurs, according to Duarte & Lessa (1996), due to the almost null incidence of waves on the inner part of the estuary in relation to the portion facing the open sea, fact that impedes the elevation of the terraces because of the low wave incidence.

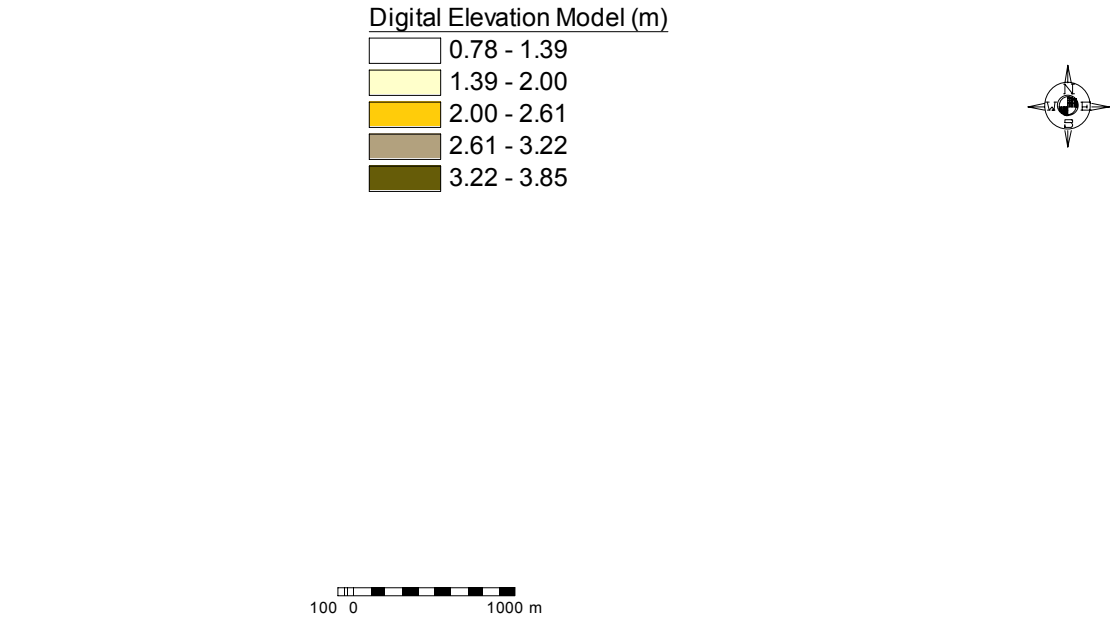

Figure 3. Digital elevation model map

According to the map of geomorphological forms (Figure 4), the distribution of the area confers two main zones of geomorphological forms, being one represented by dune ridges fields and inner ridges, and another by the prairies that occur mostly at SW of the area. A third geomorphological form found, even thought in low quantity, are small swamp areas constantly flooded, distributed along the whole area.

The ridges fields appear in the zone closest to the estuary, being these related to the great availability of sediments found at this place due to the occurrence of an ebb tidal delta adjacent to the place.

Inside the fields are: a dune ridge frontal system and a system of inner ridges. The first one with physical contact with the sea. This zone is the one that suffers more transformation, because its morphology is reworked several times by the waves and the wind, in a short period of time. The second represents a set of inner ridges and swales with parallel alignment to the coastline being as records of old frontal systems on a progradation process.

Most of the prairies are located, on the zone further than the estuary mouth, showing a small frontal system of dune ridges followed by long plain area, associated in few places to embankments executed by urban implementations. The prairies also appear behind and intercalated to the system of inner ridges, but in smaller quantity.

The map analysis and the field observations show a big swampy area, separated from the sea by a dune ridge system, that spreads and retracts determined by the hydrological system, which is regulated by the rain regime. During the rainy period, the swamps overflow causing the formation of great swamps that grow by the swales and by the low regions, utilizing as relief valve of this additional quantity of water the draining channels, being these dry by the time of the smallest precipitation indexes. The dune ridges system, except for few sites, is not suffering inundation during the whole year, neither are few prairie regions.

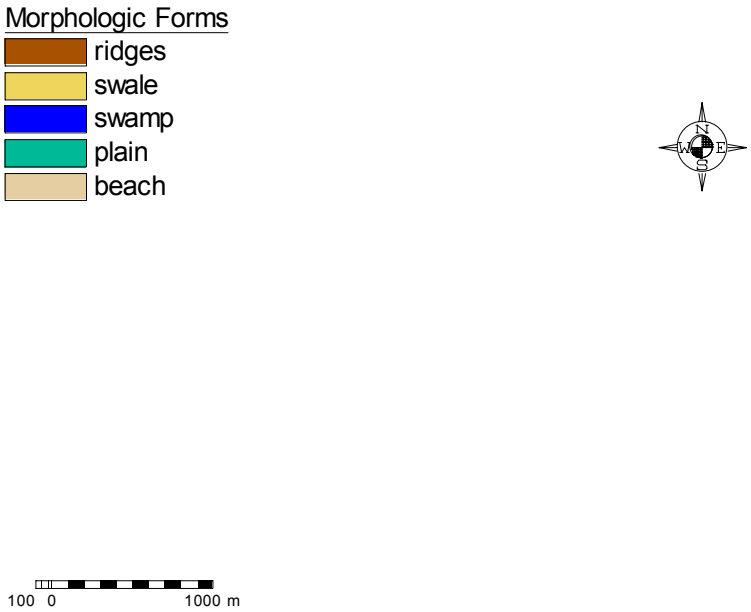

Figure 4. Morphologic forms map

In spite of the big irregularity of the relief, the relative altimetry values, gotten by DGPS together with the post-processing decimeter, the model generated seems to be faithful to reality. Being possible the visualization of the main forms. This is due to the alignment preferably transversal of the forms in relation to the profiles, and to the great quantity of sampled sites.

Thiessen method showed to be useful on the analysis of the forms, indicating the presence and orientation of smaller ridges, not visible on the digital elevation model.

6. CONCLUSION

The small altimetry variability, the reduced scale, and the complexity of the ridges distribution were limiting parameters present at the beach ridges, and that could not be well characterized by the proposed method. However, the use of DGPS and spatial analysis techniques based on GIS showed potential for diagnostic and analysis of coastal environments, like beach ridges.

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