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a case-study comparison from Denmark and Argentina

Sander, Lasse; Kabuth, Alina Kristin

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I just can't put my finger on it!

Approaching coastal lagoon systems from remotely sensed data.
- A case-study comparison from Denmark and Argentina

Lasse Sander[1,2 ‡] & Alina Kristin Kabuth[1]

[1]Department of Geosciences and Natural Resource Management, University of Copenhagen, Denmark
[2]Geological Survey of Denmark and Greenland (GEUS)
[‡]Presenting author, **email: las@geo.ku.dk**

"You can only discover what you have already imagined"
Gastón Bachelard, seen in "Museum of Man and the Sea", Puerto Madryn, Argentina

Abstract

How much geomorphology and process understanding can we get out of SRTM and Landsat data? It seems a trivial thing: The topic is clear, the methods defined, but… how to decide on where to start our fieldwork at a place we have never been to? Is the locality apt to answer our research question or are there better ones? The availability of geodata is highly variable worldwide, stretching from existing and accessible data to downright *scarcity*. The freely available SRTM and Landsat datasets cover most mid- to low-latitude localities at reasonable resolutions. In a few examples we show here, that despite data quality issues of basic open-access data, we can to some degree place our "best guess" on firm grounds.

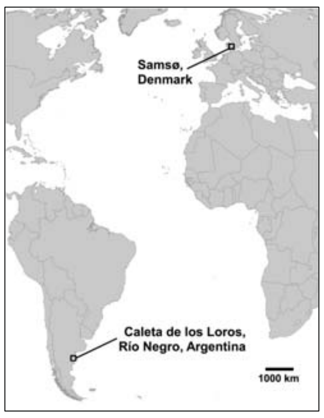


Fig. 1: Location of field sites

Introduction

At two distant localities (Fig. 1) we approached the same question: To what extend do beach ridge and lagoon systems in regressive environments preserve information on Holocene sea-level. Even though most of the hard data on coastal evolution and sea-level will be based on core log information and dating, the bulk background information of our conceptual approach was derived from remotely sensed survey data. The quality and availability of geodata is highly variable between the two sites.

Methods

The available geodata was analyzed with standard methods in Geographic Information Systems (GIS). For both sites, sources of visual surface information (orthophotos, satellite images, Google Earth) and a digital elevation model were used (Tab. 1 for details). Ground-truthing was conducted in the field and supplemented with surface and core samples. GPS RTK transects were measured for the Argentinean case to assess the model error.

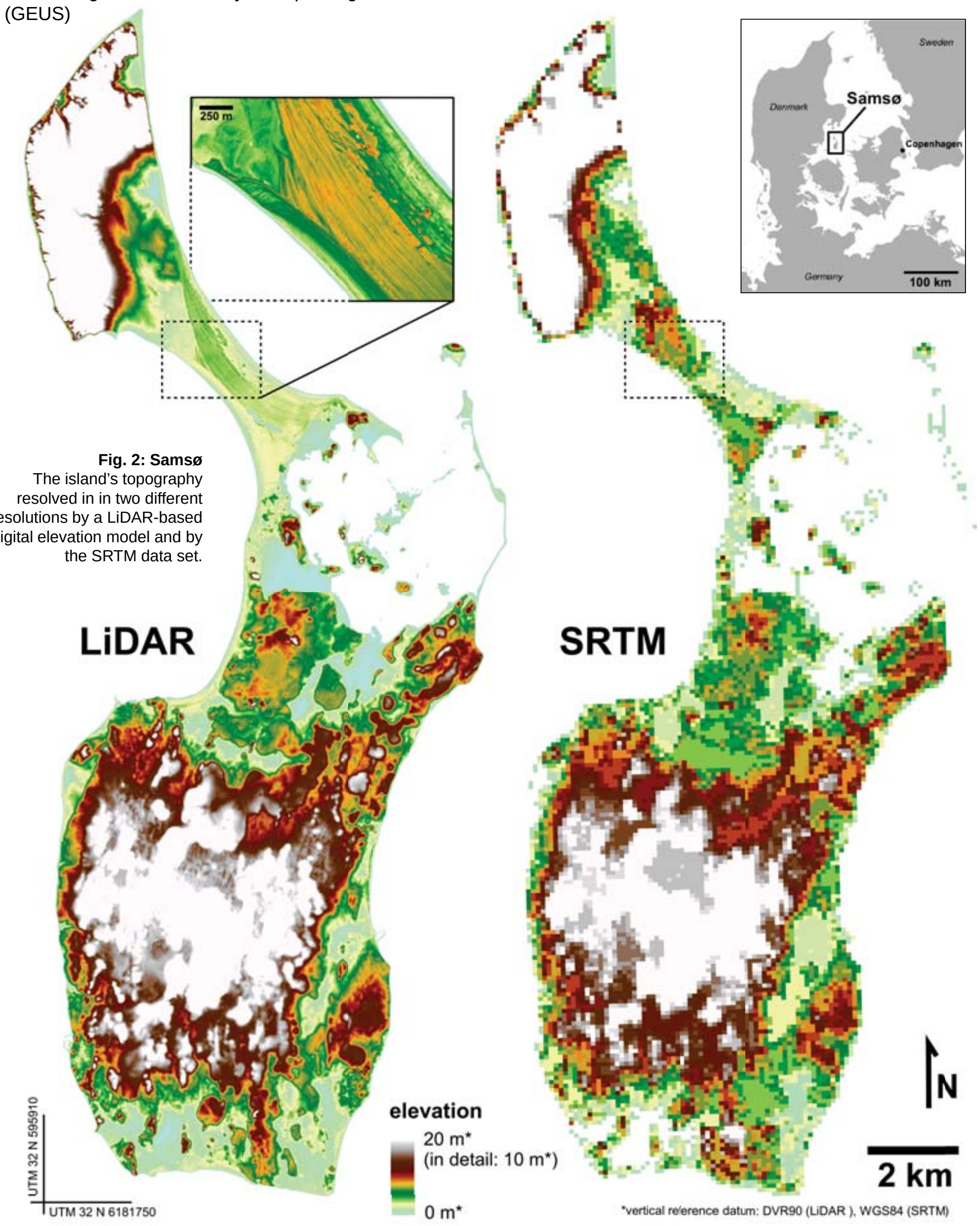


Fig. 2: Samsø
The island's topography resolved in in two different resolutions by a LiDAR-based digital elevation model and by the SRTM data set.

<u>Samsø, Denmark</u>

The island of Samsø is located in the southern Kattegat Sea, Denmark. The area experienced a period of rapid transgression during the early Atlantic, and sea level was since characterized by a forced regression. Samsø is located on a hummocky push moraine of late Weichselian age. Holocene marine deposits are encountered in lagoons, small barriers and spits as well as in an extensive beach ridge system. The southern Kattegat is a microtidal environment (TR ~0.3 m), however marked variations of water level occur with meteorological conditions. The wave energy at exposed locations is low to intermediate. The climate is humid temperate with approx. 530 mm/yr precipitation (Köppen: Dfb).

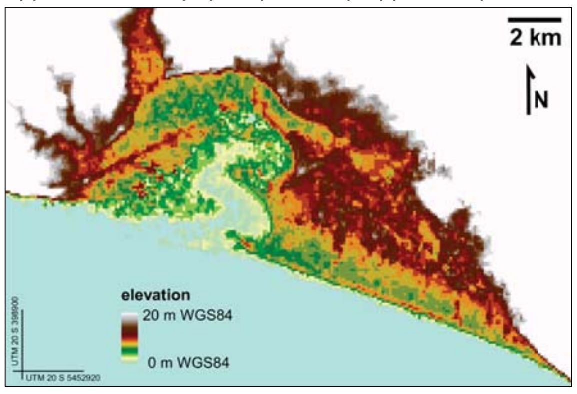


Fig. 3: Elevation model of Caleta de los Loros lagoon
The SRTM elevation model resolves key elements of the lagoons morphology like cliffs or foredune rigdges as well as the general characteristics of the local topography. Twith the help of satellite imagery, the dataset thus allows to read out some first hints on the lagoons Holocene evolution and sea-level

Fig. 4: Main morphological units of Caleta de los Loros interpreted from SRTM and Landsat data
Fine structures, like the recurved tip of a spit, vegetated tidal flats or beach ridges are resolved in this Landsat 7-4-2 false color composite. If the morphology is visible, we can make an educated guess on the processes in operation! Landsat timeseries allows to approximate e.g. dune migration rates (~10 m/yr) and show dynamic elements of the system (e.g. channels or bars).

<u>Caleta de los Loros, Río Negro, Argentina</u>

The Argentinean site is located on the northern shores of San Matías Gulf, north-eastern Patagonia. The highstand of the mid-Holocene transgression was reached at about 7000 yrs BP. Sea-level was since characterized by a continuous to stepped regression possibly with marked drops at ~6000 yrs BP and ~2500 yrs BP (Schellmann & Radtke 2010). The lagoon is located in a ria-like embay-ment in a stretch of cliffed equilibrium coastline. The cliffs are constituted by layers of Pleistocene and Miocene sand and gravel deposits of mostly fluvial origin. Caleta de los Loros experiences macrotidal conditions (TR ~6 m) with low wave energy. The lagoon is located in a winter-cold steppe climate (Köppen: BSk) with an average annual precipitation of roughly 300 mm/yr.

Results and observations

When comparing the elevation models of Samsø (Fig. 2) we observe that both allow a similar interpretation of the coastal evolution since the mid-Holocene transgression. The overall morphology of the island can be determined; lagoons and moraine cliffs can be identified. However, the elevation of the beach ridge system, connecting the northern and the southern part of the island, is exaggerated due to forestry. A similar problem occurs in smaller basins, where fens and carrs formed. These localities are of high interest for sea-level reconstruction. Aridity in Patagonia determines that vegetation is of minor importance there. The gently sloping beach ridge system can be identified and shows a reasonable correlation with the measured GPS RTK data (Fig. 5). Even though SRTM values deviate considerably (±2 to ±5 m), the general trends agree. Dunes (moving at ~10 m/yr) can be identified on the Landsat images and an error in the SRTM interpretation (due to dune migration) can thus be avoided. Drift aligned beach ridges detected in the GPS RTK transect are also visible on the Landsat image (Fig.4; Fig. 5, right side). It is thus reasonable to assume that the same applies other places as well (Fig. 4, detail).

Table 1: Available geodata for the two field sites

	Samsø	Description	Caleta de los Loros (& Samsø)	Description
Elevation data	LiDAR DEM	1,6x1,6 m resolution, actual surface elevation model	SRTM DEM	90x90 m resolution, digital terrain model with unknown vertical error
Surface characteristics	orthophotos	Max. resolution= 12,5 x 12,5 cm, available since the 1950s (uneven intervals, variable resolution)	Landsat	30x30 m (60x60m for Landsat TM) resolution, few images from between 1972 to 2009.
Maps	Topographical (1:25.000 or higher), historical, geologic, geomorphologic, pedologic, etc.		Topographic map from the 1970s (1:200.000)	
Other	GIS data on bathymetry, protected areas, land use, property, etc.		Google Earth, obscure data (e.g. NASA astronaut areal photography)	

Conclusion

Despite the low resolution it is possible to obtain valuable information from SRTM and Landsat data for the development of working hypotheses, which were shown to be in agreement with in-field observations and measurements. Under both scenarios it was possible to set up a satisfying coring campaign yielding promising results. Both datasets can be especially handy wherever access to geodata or maps at higher resolution is restricted or costly. Nevertheless, free access to high resolution geodata would make it easier to pin-point sites of interest and reduce the amount of strenuous fieldwork (footwork!)

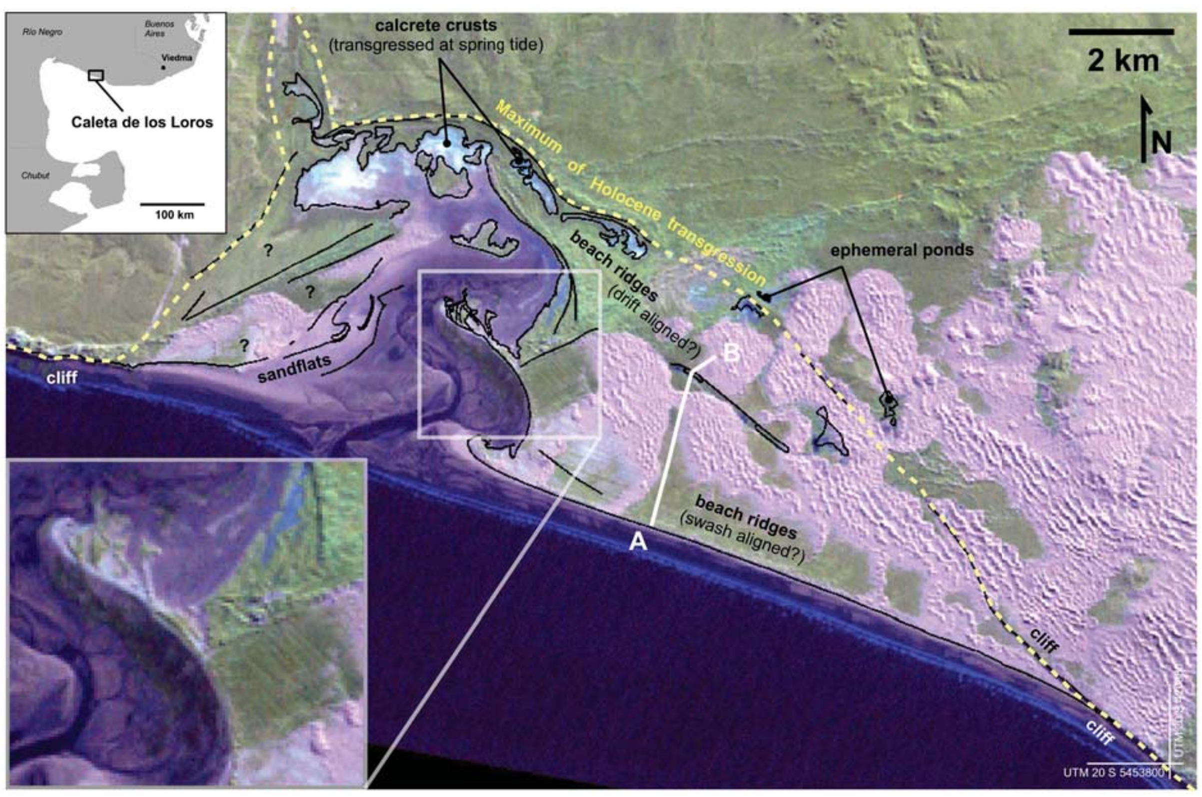
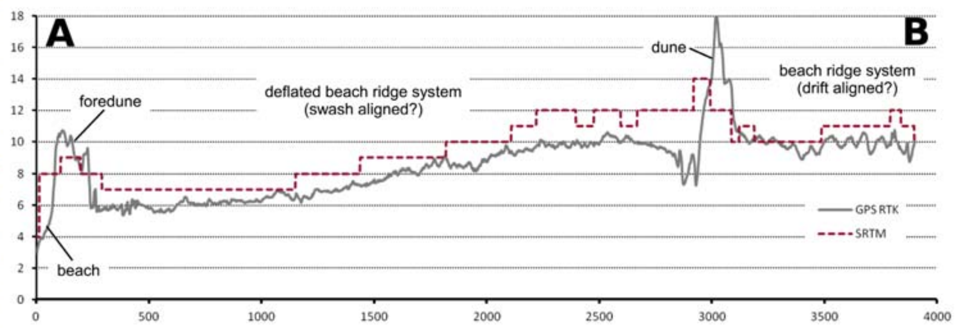


Fig 5: GPS RTK data vs. SRTM elevation
The overall trend detected in a GPS RTK transect (vert. error ± 10 cm) measured across the beach ridge system east of Caleta de los Loros (see Fig. 4, A-B) can be reproduced in the SRTM elevation model.



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Abbreviations

DEM: Digital Elevation Model
DTM: Digital Terrain Model
DVR90: Danish Vertical Reference 1990, Danish national datum
GIS: Geographic Information System
GPS RTK: Global Positioning System Real Time Kinematic
LiDAR: Light Detection And Ranging
SRTM: Shuttle Radar Topography Mission
TR: Tidal Range

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