Ocean Dynamics (2005) 55: 100–109
DOI 10.1007/s10236-005-0114-2

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Topography and morphodynamics in the German Bight using SAR and optical remote sensing data

Received: 9 July 2004 / Accepted: 9 May 2005 / Published online: 8 September 2005

Abstract Morphological changes in coastal areas, especially in river estuaries, are of high interest in many parts of the world. Satellite data from both optical and radar sensors can help to monitor and investigate these changes. Data from both kinds of sensors being available for up to 30 years now, allow examinations over large timescales, while high resolution sensors developed within the last decade allow increased accuracy. So the creation of digital elevation models (DEMs) of, for example, the wadden sea from a series of satellite images is already possible. ENVISAT, successfully launched on March 1, 2002, continues the line of higher resolution synthetic aperture radar (SAR) imaging sensors with its ASAR instrument and now also allows several polarization modes for better separation of land and water areas. This article gives an overview of sensors and algorithms for waterline determination as well as several applications. Both optical and SAR images are considered. Applications include morphodynamic monitoring studies and DEM generation.

Keywords Waterline · Edge detection · Remote sensing · Morphodynamics · Digital elevation model (DEM) · Coastal area

1 Introduction

Two thirds of the world's population, some four billion people, live in coastal areas. In most cases, their lives depend on the morphological changes of the coast, the sediment transport of the ocean currents. Both erosion and deposition can be a problem: houses near cliffs may fall into the sea, growing river estuaries can cause flooding.

As an exemplar area, the tidal flats of the German Bight, especially the large river estuaries, are studied within this work. Methods are derived to monitor morphodynamics using satellite data from both synthetic aperture radar (SAR) and optical imaging sensors. Applications and possible new developments using ENVISAT and upcoming satellites are given.

The investigation area covers the German North Sea coast between the Netherlands and Denmark. Figure 1 gives an overview of this area. Examples given here cover the regions of the rivers 'Elbe' and 'Eider'. Additional studies on the river 'Weser' and the island 'Sylt' are mentioned.

The core of this article are methods to derive coastlines and waterlines[1] from satellite images of various types (Sect. 2). The waterlines can be used in many ways such as the generation of land/water masks, morphodynamic monitoring or the generation of digital elevation models (DEMs) (Sects. 3.1, 3.2, and 3.3resp.). New developments and ideas for use with ENVISAT, upcoming satellites and enhanced sensor techniques like interferometric SAR are finally given in Sect. 4.

2 Waterline determination

In order to monitor morphodynamic changes of bottom topography, different methods for DEM generation have already been analyzed (Hoja 2000; Niedermeier et al. 2000; Wimmer et al. 2000). One approach is the so-called waterline extraction by image analysis.

Using extracted waterlines, several geoscientific applications can be carried out like identifying morphodynamic changes in bottom topography over a long time span and interpolation of waterlines from data acquired during a short time span into DEMs using

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[1] A waterline is the instantaneous land–water boundary at the time of the imaging process. A coastline or shoreline is the waterline at the highest possible water level.