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Morphological Impacts and COastal Risks induced by Extreme storm events

Climate change presents unprecedented societal, agricultural and industrial challenges that must be addressed by developed nations in the near future. Increasingly, civil society and politicians are recognizing that past scientific predictions of climate change are now a reality and that changes are occurring at a rate faster than previously imagined.

The role of extreme storm in generating risk scenarios

Both the EU and The United Nations are now taking seriously the predicted climate change scenarios of the IPCC. Of particular relevance to Integrated Coastal Zone Management is the predicted increase in the intensity and frequency of powerful storm events characterised by larger peak wind speeds and consequently largerwaves.

Engineering has usually been favoured in the past as the best option for disaster mitigation at the coast. However, most engineering works are constrained by economics, and a compromise is sought between the potential threat to lives and property and the resources available for design and construction. Furthermore, the design of structures is based on predicted extreme events which themselves are subject to uncertainty, especially in a rapidly changing global climate. The huge damage to the city of New Orleans by Hurricane Katrina illustrates clearly what can go wrong when the engineering design is subjected to forcing beyond its design limits and when civil evacuation and management plans fail.

THE MICORE PROJECT

The MICORE project will provide the knowledge necessary to assess the present day risks and to study the economic and social impact of future severe storm events. The project will also develop operational predictive tools in support of emergency response to storm events. Together, these elements will have an important strategic impact on the safety of the people living in coastal areas. The project will also investigate with stakeholders and end-users the possibilities of producing EU-wide guidelines for a viable and reliable risk mitigation strategy. MICORE will produce an up-to-date data base for each partner country that will include: an historical review of storms; an inventory of data related to the forcing signals; quantification of the morphological response of coastal systems to storms and to sequences of storms; an assessment of socio-economic impact; a description of existing civil protection schemes and interventions.

THE MICORE APPROACH

The general aim of the project is to develop and demonstrate online tools for reliable predictions of the morphological impact of marine storm events in support of civil protection mitigation strategies. The project is specifically targeted to contribute to the development of probabilistic mapping of the morphological impact of marine storms and to the production of early warning and information systems to support long-term disaster reduction.

A review of historical storms that had a significant morphological impact on a representative number of sensitive European coastal stretches is taking place using published and non-published databases. The regional coastlines are selected according to wave exposure, tidal regime and socio-economical pressures. All data will be compiled into a homogeneous database of occurrence, including information on the characteristics of the storms, their morphological impacts, the damages caused on society, the Civil Protection schemes implemented after the events.

Monitoring of nine selected case-study sites is taking place for a period of one year to collect new data sets of bathymetry and topography using state-of-the-art technology (Lidar, ARGUS, Radar, DGPS). The impact of the storms on living and non-living resources is being assessed using low-cost portable GIS methods and undertaking post-damage assessments. Numerical models of storm-induced morphological changes are being tested and developed, using commercial packages and developing a new open-source code. The models will be linked to wave and surge forecasting models to set-up a real-time warning system and to implement its usage within Civil Protection agencies. The most important end-product of the project will be the production of an operational warning system with defined thresholds (Storm Impact Indicators) for the prediction of major morphological changes and flooding events. The uncertainty involved in the use of these indicators is a sensitive issue for decision-makers. Dealing with uncertainty will be an important topic to be developed within MICORE will be.

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Where we are testing our approach

The study sites of the MICORE Project
Their diversity encompasses the different coastal environments that can be found along European coastlines

1	Italy	Lido di Dante Lido di Classe	Natural with dunes, river mouths - defended coastline, infrastructures, high touristic value, microtidal	8 km
2	Portugal	Praia de Faro	Barrier-islands, dunes, overwashes, inlets, high touristic value, infrastructures, mesotidal	8 km
3	Spain	La Victoria Camposoto Beach	Urban beach, high touristic value, defended coastline, infrastructures - natural sand spit with dunes, overwashes, river mouth, salt marsh, touristic value, mesotidal	10 km
4	France	Lido of Sète to Marseillan	Low barrier island, dunes, high touristic value, defended coastline, infrastructures, microtidal	13 km
5	United Kingdom	Eastern Irish Sea	Macrotidal site with high occupation and touristic value, high value infrastructure, coastal defences, sand dunes, tidal flats, mud flats, salt marsh and estuaries	40 km
6	The Netherlands	Egmond	Nourished beach, dunes, high touristic value, mesotidal	5 km
7	Belgium	Mariakerke	Wide dissipative urban beach regularly nourished, infrastructures, defended coastline, high touristic value, macrotidal	11 km
8	Poland	Dziwnow Spit	Sand spit with low dunes; river mouth, protected coastline, nourishments to protect infrastructures, high touristic value, non-tidal	15 km
9	Bulgaria	Kamchia Shkorpilovtsi	Open beach on the Black Sea, dunes, river mouths, touristic value, non-tidal	13 km

The specific objectives

1 To undertake a review of historical marine storms that had a significant impact on a representative number of sensitive European regional coastlines. The diverse range of coastal regions of the European Union is selected according to wave exposure, tidal regime and socio-economical pressures.

2 To collate data related to occurrence of significative extreme events and socio-economic impacts in a database. Parameters will include:
- characteristics of the storms: wind and wave measurements, wave hindcasts, tide measurements, surge computations;
- morphological impacts including pre- and post-storm beach profiles, presence of dune overwashing/overtopping, damage to coastal structures;
- socio-economic impact including cost of reconstruction, loss of lives and property, dune reconstruction and beach replenishment;
- civil protection schemes, implementation of warning systems and preparation of hazard and vulnerability maps;
- competent authorities and statutory bodies and voluntary organisations for warnings

3 To undertake monitoring of nine European case study sites for a period of 1 year with the following aims:
- to collect new data sets of bathymetry and topography using state-of-the-art technology (Lidar, ARGUS, Radar, DGPS); to simultaneously measure the forcing agents (wind and waves, tides, surges) that trigger the events;
- to map the impact of the storms on living and non-living resources using portable GIS methods.

4 To test and develop reliable methods for numerical modelling of storm-induced morphological changes for the following purposes:
- to test the predictive capability of wave and surge hindcast models routinely used by end users in each region of interest;
- to link morphological models with wave hindcast models;
- to evaluate the accuracy of off-the-shelf morphological models for prediction of extreme erosion hot-spots;
- to test and develop a new open-source morphological model for the prediction of storm impacts.

5 To set-up real-time warning systems and to implement their use within Civil Protection agencies with the aim of:
- linking morphological models with wave hindcast models;
- preparing early warning protocols;
- developing an expert system in support of long-term disaster reduction including timely disaster relief operations.

6 To disseminate results to end users at national, European and International levels through:
- a series of non-technical workshops;
- production of a multilanguage report;
- production of a storm impact video-clips;
- implementation of an interactive website with Web-GIS technology.

WORKPACKAGES

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WP1 Historical storms

The main objective is to review the state-of-the-art for each site, producing an historical review of storms, collecting all data such as the forcing signals (wind, waves, water levels), the morphological response, the socio-economic impact and the civil protection schemes of interventions and other mitigation measures (e.g. relocation of people and activities).

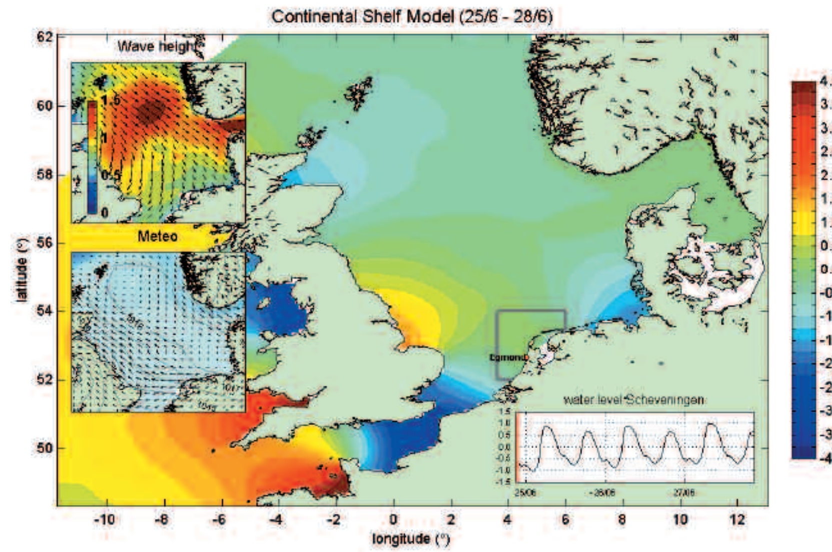
WP2 Data standards

The objective of this workpackage is to takein, store, process and disseminate physical data for each pilot site (bathymetries, waves, tides etc.) in a form convenient for the assessment of storm risk along the European coastlines. To promote in- and external cooperation MICORE adopts the approaches and standards proposed by OpenEarth the open source initiative for working with data, models and tools. (http://openearth.deltares.nl)

WP3 Site monitoring

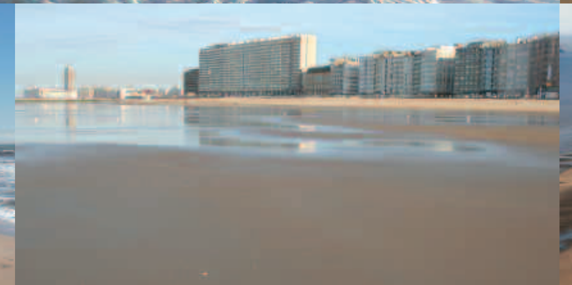
Intensive monitoring of critical stretches of coastline at each site is taking place, according to the identification of risk priorities identified from the study of past events. In addition to the measurement of physical parameters during the storms (e.g. waves, tides, beach profiles), surveys are undertaken to identify points of damage to structures or dune breaching. Waves and tides are measured using existing networks of gauges and/or new stations specifically installed for the project. An important aspect is the use of real-time wave and tide datasets, for the planning of surveys immediately after the high energy events. Morphologies are studied using in-situ techniques and airborne surveys.



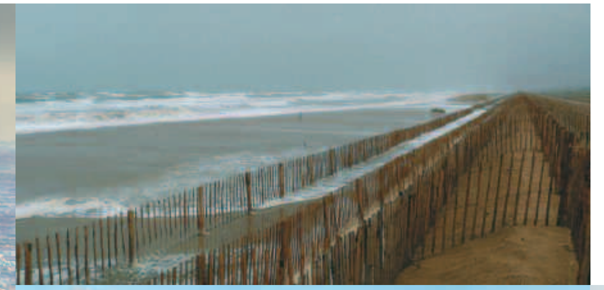
Example of an operational chain for the Dutch coast (predictions centered on the Egmond Site-NL)





WP4 Modelling

A major aim is to test wheter new and off-the-shelf models are able to predict coastal changes after major storms. A new model (X-beach) will be used to predict coastal changes generated by high energy events. The model will be a useful mean for European countries to produce predictions of storm impacts on beaches considering all the information available. The new model will be relevant to many different conditions observed along European coastlines, so that it will be suitable for countries facing the Atlantic Ocean as well as for countries facing the Mediterranean Sea or the Black Sea. A Morphological Impact Threshold will be defined to know which are and will be the hydrodynamic and morphological conditions that lead to a coastal disaster or to damage to coastal structures and sensitive ecological environments.



WP5 Warning system development

The MICORE Consortium will produce early warning protocols that will include all the variables relating to coastal risk as it is defined in WP1, data archiving protocols defined in WP2 and model predictions from WP4. End-users will be strongly involved in this part of the project. The main output of the project will be site-specific operational warning systems to be used for Civil Protection purposes. An additional output will be risk maps that could be used by public authorities as well as private stakeholders for strategic planning and mitigation purposes.


WP6 Dissemination and exploitation

All stakeholders at regional and national level will participate to local meetings. A multi-language report will be produced. The dissemination will also include workshops for end-users to illustrate the definition of risk for each site and the critical areas. Moreover, the new warning system will be presented together with a training session to tell end-users how to use the outputs. A web site with a Web-GIS will be produced in order to upload on the Internet the Project outputs such as risk maps, descriptions of areas at risk and available datasets. (www.micore.eu)

WP7 Project management

WP7 consists in the management activities of the project and the general administration of financial issues within the project. This task is performed by combining Scientific Leadership by the Coordinator (University of Ferrara) with Quality Assured management procedures by partner Consorzio Ferrara Ricerche.

The apparent increase in the proportion of very intense storms since 1970 in some regions is much larger than simulated by current models for that period.

According to the IPCC Summary Report to Policy Makers published on 2 February 2007