Embedding iCOASST

Using morphological modelling to guide decision-making at the coast

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An academic NERC-funded project from 2012–2016 that developed a number of independent tools and models linked within a ‘system-level’ framework

- Coastal & Estuarine System Mapping (CESM)
- ESTEEM
- Meso-I
- SCAPE+
- ASMITA+
- Unalinea+
- Pilot demonstrations of model ‘compositions’
- Data-driven modelling evaluation
- Coastal State Indicator (CSI) evaluation
Funded by the Environment Agency (2016-2017) to:

- **Disseminate** iCOASST-specific outputs and knowledge
- **Evaluate** the **usability** of iCOASST outputs
- **Support** coastal managers and engineers in understanding how morphological modelling can best support decision-making
- **Provide** **guidance** on the range of morphological models and tools available, and their capacity to answer key questions
- **Investigate** the potential **added value** from one of the pilot ‘compositions’ by linking the outputs to the NAFRA model of coastal flood risk
Who is the guide for?

Coastal Modellers

Coastal Managers

Coastal Engineers
Framework Details

Introduction

This section describes the different components of the iCOASST Framework and how they are related. While all these components are useful in their own right, the iCOASST approach is that by linking them, better analysis and new insights becomes possible.

The iCOASST Framework is underpinned by qualitative mapping that describe Coastal and Estuarine Systems Mapping. A new CESM methodology demonstrated in the pilot sites.

The CESM describes the landform components and their interrelationship. Landform models are required to represent these components. iCOASST used both existing models developed in previous research and new landform behaviour models. These landforms are valuable in their own right and can also be coupled to form model compositions of the pilot sites.

The shallow seabed is often ignored in coastal modelling, but this simplification is often in appropriate. In iCOASST well-validated Coastal Area Models were used to understand potential sediment fluxes between the seabed and shoreline, as well as indirect effects such as wave sheltering by shallow areas such as sand banks.
## Evaluating iCOASST

### Embedding iCOASST Into Practice: Model Evaluations

<table>
<thead>
<tr>
<th>Model name</th>
<th>ASMITA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Evaluation date</td>
<td>November 2016</td>
</tr>
<tr>
<td>Version of model and operating system used</td>
<td>ASMITA V1.3, openMI wrapped, requires Matlab 2008 or newer and MS Excel [test run with 2016a].</td>
</tr>
<tr>
<td>Model filename</td>
<td>V1.0_asmita_lite_openMI_jan2017_2.zip</td>
</tr>
<tr>
<td>Manual filename and date</td>
<td>Asmita Lite Manual v1.0 (February 2010)</td>
</tr>
<tr>
<td>Version of windows used for the evaluation</td>
<td>Windows 7 Enterprise Version, 64 bit</td>
</tr>
</tbody>
</table>

### Scoring

<table>
<thead>
<tr>
<th>Score</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Not met / Unsatisfactory / Inappropriate</td>
</tr>
<tr>
<td>0.5</td>
<td>Partially met / appropriate in some aspects</td>
</tr>
<tr>
<td>1</td>
<td>Yes / met / Satisfactory / Appropriate</td>
</tr>
</tbody>
</table>

| Evaluation not relevant for the user type |

February 2017

<table>
<thead>
<tr>
<th>Score (0.0 / 0.5 / 1)</th>
<th>Comment</th>
</tr>
</thead>
</table>

### Evaluation Questions

1. **Does the model run successfully with the data provided?**
   - For User Type 1: 1
   - For User Type 2: 1
   - For User Type 3: 1
   - **Comment:** The model runs successfully after one line in the source code needed commenting out. The results match those given in the example results.

2. **Is information provided in the Manual on the operation system required and prerequisites in terms of software?**
   - For User Type 1: 0
   - For User Type 2: 0
   - For User Type 3: 0
   - **Comment:** These are not discussed in the user manual. Someone familiar with modelling might think to look in the referenced extra reading.

3. **Is model calibration/validation discussed in the Manual?**
   - For User Type 1: 0
   - For User Type 2: 0
   - For User Type 3: 0
   - **Comment:** No, there are no sections covering errors within the manual. Matlab provides information on the error location within the source code.

4. **Are potential errors and bugs dealt with in the manual?**
   - For User Type 1: 0.5
   - For User Type 2: 0.5
   - **Comment:** The results are provided in an easy to use Excel worksheet including headings. The user manual contains a list of the output variables so that they can be cross-referenced.

5. **Are the output file headings explained in the Manual?**
   - For User Type 1: 1
   - For User Type 2: 1
   - For User Type 3: 1
   - **Comment:** Yes, by changing the number of each element within the steering file. The model ran successfully.

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Dissemination

20 March 2018

Embedding iCOASST

The iCOASST Project has produced a number of tools and models. While each of these is useful in their own right, the strength of the iCOASST approach is by linking these separate elements, better analysis and new insights become possible. The iCOASST framework demonstrates how the individual components can be linked to achieve a system-level understanding of long-term coastal change.

Who is iCOASST for?

Many of the outputs of the iCOASST project will be of primary interest to the coastal modellers community. However, a key aim of the current work is embedding iCOASST into practice. This is being undertaken by HR Wallingford and funded by the Environment Agency, DEFRA and Welsh Government through the joint Coastal and Estuarine Empirical Risk Management (CEERM) Research and Development programme. The aim is to encourage communication between the academic community and coastal practitioners. It is hoped that this will ultimately benefit from improved understanding of coastal processes and the implications for future management. An end user focus guide (to be made available on-line by late 2017) is being developed to help achieve this.

www.healingford.com
Coastal morphological modelling for decision makers

Guidance structure

- **Chapter 1** Introduction
- **Chapter 2** Using coastal morphological models to represent coastal processes
- **Chapter 3** The morphological modelling framework
- **Chapter 4** Coastal morphological models
- **Chapter 5** Using models to support coastal management decisions

Guidance themes

- Understand the link between morphological change and decision making at the coast
- Understand the questions that may need to be answered
- Understand the processes operating at the site
- Understand how morphological models can help quantify the rate and extent of likely coastal change
- Understand the needs, constraints and uncertainties associated with the modelling approach
- Understand how to ensure the outputs are robust
- Understand what information to ask for and/or communicate to give confidence in model outputs
- Understand the range of different model types and their suitability in terms of helping answer the coastal management question
Predicting change...

Historical context

Identification of key issues

Understanding processes

Data analysis

Expert interpretation

Morphological modelling

Input to decision makers

Stakeholders
The complexity of scale

FACTORS INFLUENCING COASTAL PROCESSES

Temporal scale
- 1 century
- 1 decade
- 1 year
- 1 month
- 1 week
- 1 day
- 1 hour
- 1 sec

Spatial scale
- 1mm
- 1cm
- 1m
- 10m
- 100m
- 1km
- 10km
- 100km

MORPHOLOGICAL FEATURES
- Shore platform
- Dune accretion
- Beach recovery
- Coastal changes
- Dune erosion
- Cliff erosion
- Beach lowering/beach width
- Breaching
-noteq

IMPACTS
- Scale range relevant to Coastal Managers
- Coastal Erosion
- Coastal Inundation
What we want help in understanding…

- Natural trends in coastal geometry
- Impacts of climatic change
- Impacts of coastal structures
- Impacts of management practices
- Impacts of extreme storms
- How well the coast might recover
- Impacts of estuarial change
- Relationship between coastal change and flood risk
### Which model to answer which question?

#### Table 5.1 Using models to help understand beach morphological change

<table>
<thead>
<tr>
<th>Model type</th>
<th>Sub-type</th>
<th>Limitations</th>
<th>Past/ Now rate</th>
<th>Future prediction</th>
<th>Under different management scenario</th>
<th>Under different climate related changes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coastal and estuarine system mapping</td>
<td></td>
<td>Needs long-term and well timed beach surveys</td>
<td></td>
<td></td>
<td>(Assuming same trend)</td>
<td></td>
</tr>
<tr>
<td>Geomorphological data analysis</td>
<td>HIA</td>
<td>Identifies net change between successive datasets, not the scale of variability over shorter timescales.</td>
<td></td>
<td></td>
<td>(Assuming same trend)</td>
<td>(assuming the effect of the scenario a priori)</td>
</tr>
<tr>
<td></td>
<td>SBA</td>
<td></td>
<td></td>
<td></td>
<td>(Assuming same trend)</td>
<td>(assuming the effect of the scenario a priori)</td>
</tr>
<tr>
<td>Data driven models</td>
<td>PCA</td>
<td>Good historical record is required (typically 10 years of 6-monthly beach surveys and time series of measured or hindcast wave conditions)</td>
<td></td>
<td></td>
<td>(Assuming same trend)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>CCA</td>
<td></td>
<td></td>
<td></td>
<td>(Assuming same trend)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ANN</td>
<td></td>
<td></td>
<td></td>
<td>(Assuming same trend)</td>
<td></td>
</tr>
<tr>
<td>Parametric models</td>
<td>Equilibrium</td>
<td>Constant wave conditions and single grain size. Limited to validity range</td>
<td></td>
<td></td>
<td>(only for certain structures)</td>
<td>(assuming the effect of the scenario a priori)</td>
</tr>
<tr>
<td></td>
<td>Change of state</td>
<td></td>
<td></td>
<td></td>
<td>ST</td>
<td>ST</td>
</tr>
<tr>
<td>Process based – shoreline change</td>
<td>One-line</td>
<td>Assumes straight beach. Longshore transport as main cause</td>
<td>LT</td>
<td>LT</td>
<td>LT</td>
<td>SLR by Brunn rule (1)</td>
</tr>
<tr>
<td>Process based – profile models</td>
<td></td>
<td>No beach recovery. No overwash/breaching</td>
<td>ST</td>
<td>ST</td>
<td>ST (different models deal with different structures)</td>
<td>ST</td>
</tr>
<tr>
<td>Process based – coastal area models</td>
<td></td>
<td>Need techniques for LT predictions. Processes at beach not well represented.</td>
<td></td>
<td></td>
<td>(depending on the management scenario)</td>
<td></td>
</tr>
<tr>
<td>Behaviour based models</td>
<td></td>
<td>Limited to model the aspects of the coastal/estuarine issues which the model has been developed for</td>
<td></td>
<td></td>
<td>SLR by Brunn rule (1)</td>
<td></td>
</tr>
</tbody>
</table>

Legend: LT: Long-term, ST: Short-term; (1)SLR by Brunn rule, which has been challenged by several authors (see main text for explanation)
Defining triggers for action

Modelled ‘indicators’ can help:

- Set short term and long-term objectives
- Optimise the monitoring and data collection strategy
- Support more robust decision-making – often through ‘trigger’ thresholds
Flood risk models tend to be constructed with a static bathymetry.

- Changes in bathymetry
- Changes in the waves and water levels
- Changes in structure beach toe level
- Changes in the waves and water levels
- Changes in the cross-sectional area of a beach
- Water depth at the structure
- Shore platform protection performance
- Increased risk of cliff erosion
- Ability of barrier to withstand breaching
- Changes in the cross-sectional area and beach crest height of a barrier beach
- Overtopping rate & stability of the structure toe itself
- Ability to survive a storm without breaching
- Changes in the cross-sectional area of a dune
- Probability of cliff failure
Tyndall study (Dawson et al, 2007)

Decreasing levels of cliff protection
iCOASST pilot study

No morphological change, medium SLR

Full morphological change in response to medium SLR

Full morphological change in response to coastal management interventions and medium SLR