Beach erosion of Sitia bay, Crete, under the long-term effects of waves

F. Karathanasi¹,², K. Belibassakis¹

¹School of Naval Architecture & Marine Engineering, National Technical University of Athens
²Institute of Oceanography, Hellenic Centre for Marine Research

‘MIKE POWERED BY DHI’ 2019: Sea, coast, harbors & structures
10 April 2019
Presentation outline

1. Study area
2. Data sources
3. Preliminary study - Methodology
4. Simulation results
5. Conclusions
Study area

Sitia Bay (Lasithi, Crete)
- Increasing coastal tourism
- Intensive coastal development

Preliminary study
- Wave field and sediment transport study for:
  - 2 wave scenarios
  - 3 different seabed topographies

Methodology
Study of coastal erosion due to the long-term wave action by reducing computational time
Study area

Coastal characteristics

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Length</td>
<td>2 km</td>
</tr>
<tr>
<td>Width (max)</td>
<td>35 m</td>
</tr>
</tbody>
</table>

Granulometric composition

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth &lt;1.5m</td>
<td>(d_{50}=0.65–0.85)mm</td>
</tr>
<tr>
<td>East part</td>
<td>Beach rocks (up to 1.5m)</td>
</tr>
</tbody>
</table>
Study area

$\theta_w$: ~60% from NW-N

$H_S > 2m$: ~2% from N
Data sources

Bathymetry data

- Digitized maps from the Hellenic Navy Hydrographic Service
- EMODnet (~230 m)

Wave data ($H_s, T_s, \theta_w$)

ERA-Interim/WAM (offshore points)

Model simulation

MIKE21 Coupled model FM (SW, HD, ST)
Preliminary study

Wave scenarios for the simulation of flow and wave fields

<table>
<thead>
<tr>
<th>Wave scenario</th>
<th>(H_S) [m]</th>
<th>(T_e) [s]</th>
<th>(\theta_w) [deg]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scenario 1</td>
<td>0.75</td>
<td>4.50</td>
<td>352.50</td>
</tr>
<tr>
<td>Scenario 2</td>
<td>2.66</td>
<td>6.77</td>
<td>3.85</td>
</tr>
</tbody>
</table>

**Bivariate probability density function of \((H_S, T_{10})\) (Nearshore)**

Statistical Parameter

<table>
<thead>
<tr>
<th>(H_S)</th>
<th>(T_{10})</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Value</td>
<td>0.54</td>
</tr>
<tr>
<td>Stand. Dev</td>
<td>0.07</td>
</tr>
<tr>
<td>Var. Coeff</td>
<td>1.34</td>
</tr>
<tr>
<td>Skew Coeff</td>
<td>1.06</td>
</tr>
<tr>
<td>Kurt Coeff</td>
<td>3.52</td>
</tr>
<tr>
<td>Sample Min</td>
<td>0.00</td>
</tr>
<tr>
<td>Sample Max</td>
<td>4.40</td>
</tr>
</tbody>
</table>

Parameters of Analytic PDF

<table>
<thead>
<tr>
<th>KDE</th>
<th>Inr</th>
<th>Inr</th>
</tr>
</thead>
<tbody>
<tr>
<td>LogN</td>
<td>(x \leq 0)</td>
<td>(x &gt; 0)</td>
</tr>
</tbody>
</table>

\(x = H_S, T_{10}\)
Preliminary study

Seabed topography scenarios for the simulation of flow and wave fields

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Current situation</td>
</tr>
<tr>
<td>2</td>
<td>Submerged breakwaters</td>
</tr>
<tr>
<td>3</td>
<td>Port extension</td>
</tr>
</tbody>
</table>

"ΠΛΑΙΣΙΟ ΕΡΓΩΝ ΑΝΑΠΤΥΞΗΣ (MASTER PLAN) ΔΙΜΕΝΑ ΣΗΤΕΙΑΣ"
(Πηγή: sitiapress.gr)

IACM-FORTH, Deliverable A2, 2015
Simulation results
Scenario 1-2 (top) & Scenario 1-3 (bottom)
Simulation results

Scenario 2-2 (top) & Scenario 2-3 (bottom)
Methodology

✓ **Scope:** Examine coastal erosion in terms of the accumulative wave action by reducing computational time

✓ **How:** Reduce the size of the wave input data with sets of representative wave conditions based on specific criteria

✓ **Criterion:** Initiation of grain motion

✓ **Categories:** Over-critical and sub-critical wave conditions

Methodology

\[ \theta^* = \frac{u_{sw}^2}{(s-1)gd_{50}} \]

Timeseries of \( H_s, T_p, \theta_m \) at \( P_{cd} \) and \( P_{mn} \)

Calculate bottom orbital velocity, bed shear stress, wave shear velocity at \( P_{cd} \)

Yes

Extract over-critical values of \( H_s, T_p \) at \( P_{cd} \)

Identify over-critical values of \( H_s, T_p \) at \( P_{mn,m} \) based on the same timestep of previous step

No

Grouping of over-critical values of \( H_s, T_p \) at \( P_{mn,m} \) and calculation of \( \theta_m \) for each class

Calculate rates of bed level change with MIKE21 CFM for over-critical classes

Calculate bed level at various locations with Eq. (10)
Results
Results
Results
Conclusions

✓ The bed level slope at western locations indicates accretion while the eastern locations exhibit high negative slope, implying erosion patterns. Overall, this behaviour coincides quite satisfactorily with the real situation.

✓ The results of the proposed methodology compared to the ones obtained from utilizing the entire time series of the available wave data present similar trends (differences under 7%).

✓ The proposed technique can be considered as a useful tool for reducing considerably computational cost.

✓ BUT: Sources of uncertainties (e.g. bottom orbital velocity, mean rate estimation) and “ideal” case study.
Thank you!

Email: flora@mail.ntua.gr