Wave climate from spectra and its impact on Longshore Sediment Transport

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**MOTIVATION**

Longshore Sediment Transport (LST) is strong involved in most of shoreline changes at medium-term (i.e from month to decades).

LST is governed by wave climate.

Apply state of the art approaches of wave climatology to enhance LST assessment.
Approches of wave climatology used:

Long-term wave systems. Portilla et al. (2015)

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\[
\begin{align*}
\text{TN} &= \text{the number of spectra} \\
J_T &= \text{the number of partitions of the spectrum at instant } T \\
LST_{\text{system}} &= f(H_{\text{system}}, T_{\text{system}}, D_{\text{system}})
\end{align*}
\]
Approaches of wave climatology used:

Maximum correlation with wind velocity projected in the azimuth. Jiang & Mu 201.

\[ \text{CORRmax} = \max \{ \text{corr}(H_{\text{system } t}, V_{\text{wp } t - \tau}) \} \]
Case study:
Case study:

Solari et al. (2018) highlights the relevance of LST for coastal sediment budget in the Uruguayan Atlantic coast.
**Database:** Uruguayan wave hindcast. Alonso & Solari xxxx (under revision)

**Model:**
WAVEWATCH III® 5.16. Multi-grid mode.
Two-way nesting. 5 regular grids.
Sin+Sds --> ST4

**Forcings:**
CFSR winds ~0.31° for all the grids.
TELEMAC water levels 2′ for high Rank grids (Green and yellow)
TELEMAC currents 1′ for high Rank grids (Green and yellow)

**Period:** 1985 – 2016.
**Time resolution:** 1 h

Global (1.25° x 1°)
South Atlantic (0.5° x 0.5°)
Methodology:

1) Wave spectral partition.
   Watershed algorithm (Meyer (1994), available in Matlab), filtering systems with Hs < 0.25 m.

2) Long-term wave systems identification.
   Partition of the bivariate distribution of (T,D), filtering systems with frequency of occurrence < 50 h / year.

3) LST_{system} and LST estimations and identification of the most relevant.
   CERC formula improved by Mil-homens et al. (2013)

4) Exploration of the Long-term wave systems most relevant for LST.
   Region of origin, Sea fraction, Statistics of (H,T, D)

5) Analysis of the variability of LST_{system}
   Annual cycle, inter-annual variations and correlation with climate indexes.
Results:
Results:

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B3

- B3 A
- B3 B
- B3 C
- B3 D
- B3 E

Hours/Year $\times 10^4$

LST per sys. / LST gross

Frequency of occurrence (%)

B3 E

B3 C

B3 A

B3 B

B3 D
Results:
Results:

[Graphs and diagrams showing wave climate from spectra and its impact on longshore sediment transport.]
Results:

Easterly long-term wave system ($E_{WS}$)
Results:

Southerly long-term wave system ($S_{ws}$)
Results:

<table>
<thead>
<tr>
<th></th>
<th>Hours / year</th>
<th>$H_{\text{mean}}$ (m)</th>
<th>$H_{\text{std}}$ (m)</th>
<th>$H_{\text{max}}$ (m)</th>
<th>Sea (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$E_{WS}$</td>
<td>6634.8</td>
<td>0.88</td>
<td>0.55</td>
<td>6.14</td>
<td>16.1%</td>
</tr>
<tr>
<td>$S_{WS}$</td>
<td>6730.7</td>
<td>0.97</td>
<td>0.69</td>
<td>6.6</td>
<td>18.7%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>$T_{\text{mean}}$ (S)</th>
<th>$T_{\text{range}}$ (S)</th>
<th>$D_{\text{mean}}$ (°)</th>
<th>$D_{\text{range}}$ (°)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$E_{WS}$</td>
<td>8.3</td>
<td>[4 – 12]</td>
<td>88</td>
<td>[60 120]</td>
</tr>
<tr>
<td>$S_{WS}$</td>
<td>9.2</td>
<td>[3 – 19]</td>
<td>178</td>
<td>[150 240]</td>
</tr>
</tbody>
</table>

Hanson & Phillips (2001)
Results:

Annual cycle

- LST$_{net}$
- EWS LST$_{system}$
- SWS LST$_{system}$
Results:

Inter-annual variability

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Results:

Inter-annual variability

![Graph showing inter-annual variability of LST, EWS LST, and SWS LST over different seasons (JFM, AMJ, JAS, OND).]
Results:

Inter-annual variability

[Graphs showing inter-annual variability for different seasons (JFM, AMJ, JAS, OND). Each graph compares LST, EWS LST, and SWS LST with net and system trends over the years 1985-2015.]
Results:

Correlation with climate indexes

![Correlation with Niño 3.4](image1)

![Correlation with AAO](image2)
Results:
Results:
Results:

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2nd International Workshop on Waves, Storm Surges and Coastal Hazards
Conclusions:

• The two wave systems with highest capacity to transport sediment along the Uruguayan Atlantic coast were identified and characterized.

  \[EWS \text{ and } SWS. \text{ They transport sediment in opposite directions.}\]

• The Maximum correlation with wind projection on the azimuth allows to identify the generation zones of these systems.

  \[Future \text{ met-ocean work will focus there in order to improve data for coastal morphodynamics studies in the Uruguayan Atlantic coast.}\]

• The \(LST_{\text{system}}\) approach shows to be able to provide a good insight into LST dynamics.

  \[Annual \text{ cycle of the EWS and SWS are out of phase, acentuating the amplitude of the anual cycle of } LST_{\text{net}}.\]

  \[Larger \text{ peaks on seasonal } LST_{\text{net}} \text{ are associated with ESW.}\]

  \[Negative \text{ (transport to the northeast) trends on seasonal transport are observed on JAS and OND associated with both systems.}\]

  \[Significant \text{ correlation with climate indexes are obtained comparing seasonal transport and } LST_{\text{system}}. \text{ (}LST_{\text{ESE}} \text{ with Niño 3.4 and } LST_{\text{SSE}} \text{ with AAO).}\]
References:


Thanks for your attention!

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https://www.fing.edu.uy/imfia/congresos/latwaves/

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