The Role of Wind in Longshore Currents

Carolina Burnette and William Dally

University of North Florida, Jacksonville, FL
10 years of data
Field data collection

* Spessard Holland North Beach Park - Melbourne Beach

**Acoustic Doppler Current Profiler (ADCP)**

- Installed offshore ≈ 610 m at a mean depth 8.5 m depth (9/2001 – 10/2011)
- Current speed and direction measured over the water column (Δz = 0.3m).

**Anemometer**

- Mounted to a 10 m tall tower on the dune (9/2002 – 10/2008)
- Wind speed and direction
Motivation

FSBPA – 2015
Montoya and Dally (JCR in press)

<table>
<thead>
<tr>
<th>Year</th>
<th>Average $S_{xy}$ (N/m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001</td>
<td>-11.4</td>
</tr>
<tr>
<td>2002</td>
<td>-10.3</td>
</tr>
<tr>
<td>2003</td>
<td>-4.22</td>
</tr>
<tr>
<td>2004</td>
<td>-13.4</td>
</tr>
<tr>
<td>2005</td>
<td>0.09</td>
</tr>
<tr>
<td>2006</td>
<td>8.79</td>
</tr>
<tr>
<td>2007</td>
<td>-5.5</td>
</tr>
<tr>
<td>2008</td>
<td>-31</td>
</tr>
<tr>
<td>2009</td>
<td>11</td>
</tr>
<tr>
<td>2010</td>
<td>-16.2</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td><strong>-7.22</strong></td>
</tr>
</tbody>
</table>

Histogram of radiation stress ($S_{xy}$) integrated from fully directional 2D ($f, \theta$) spectra
Mean Vertical Profile of Longshore Current

- **January (Winter)**
  - Elevation above bottom (m)
  - Average current speed (m/sec)

- **March (Spring)**
  - Elevation above bottom (m)
  - Average current speed (m/sec)

- **June (Summer)**
  - Elevation above bottom (m)
  - Average current speed (m/sec)

- **September (Fall)**
  - Elevation above bottom (m)
  - Average current speed (m/sec)
Empirical Orthogonal Function Analysis (EOF)

<table>
<thead>
<tr>
<th>Year</th>
<th>Cross-shore Eigenfunctions</th>
<th>Longshore Eigenfunctions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Eigenvalues variance</td>
<td>Eigenvalues cumulative variance</td>
</tr>
<tr>
<td>2002</td>
<td>94.80</td>
<td>94.80</td>
</tr>
<tr>
<td></td>
<td>4.40</td>
<td>99.20</td>
</tr>
<tr>
<td></td>
<td>0.50</td>
<td>99.70</td>
</tr>
<tr>
<td>2003</td>
<td>94</td>
<td>94.00</td>
</tr>
<tr>
<td></td>
<td>5.2</td>
<td>99.20</td>
</tr>
<tr>
<td></td>
<td>0.6</td>
<td>99.80</td>
</tr>
<tr>
<td>2004</td>
<td>95.3</td>
<td>95.30</td>
</tr>
<tr>
<td></td>
<td>4.1</td>
<td>99.40</td>
</tr>
<tr>
<td></td>
<td>0.4</td>
<td>99.80</td>
</tr>
<tr>
<td>2005</td>
<td>90</td>
<td>90.00</td>
</tr>
<tr>
<td></td>
<td>5.7</td>
<td>95.70</td>
</tr>
<tr>
<td></td>
<td>3.2</td>
<td>98.90</td>
</tr>
<tr>
<td>2007</td>
<td>94.6</td>
<td>94.60</td>
</tr>
<tr>
<td></td>
<td>4.7</td>
<td>99.30</td>
</tr>
<tr>
<td></td>
<td>0.6</td>
<td>99.90</td>
</tr>
</tbody>
</table>
The first spatial Eigenfunctions of the cross-shore and the longshore components represent the vast majority of the variability each year.
First Longshore Temporal Functions

2004 Longshore First Temporal Function [PC1]

2004 Vertically Averaged Longshore Current

R=0.99
First Cross-Shore Temporal Functions

2004 Cross-shore First Temporal Function [-PC1]

2004 Vertically Averaged Cross-shore Current

R=0.95
Weekly running average of longshore current and longshore wind stress

Correlation = 0.78
<table>
<thead>
<tr>
<th>Year</th>
<th>Longshore Wind stress</th>
<th>Cross-shore Wind stress</th>
</tr>
</thead>
<tbody>
<tr>
<td>2002</td>
<td>-21.1</td>
<td>-179.8</td>
</tr>
<tr>
<td>2003</td>
<td>-92.8</td>
<td>-505.8</td>
</tr>
<tr>
<td>2004</td>
<td>13.5</td>
<td>-473.5</td>
</tr>
<tr>
<td>2005</td>
<td>-33.2</td>
<td>-516.4</td>
</tr>
<tr>
<td>2007</td>
<td>59.7</td>
<td>-207.2</td>
</tr>
<tr>
<td>Net</td>
<td><strong>-73.8</strong></td>
<td><strong>-1882.6</strong></td>
</tr>
</tbody>
</table>
Year | Volume Flux from bin 2 to 26 | Volume Flux from bottom to bin 1 | Total Volume Flux
--- | --- | --- | ---
2002 | 1791.20 | -494.68 | 1296.52
2003 | -2782.44 | -2284.82 | -5067.25
2004 | 9535.14 | -867.33 | 8667.82
2005 | 5158.76 | -1037.18 | 4121.59
2007 | 1323.50 | -795.95 | 527.55
Net | 15026.17 | -5479.95 | 9546.22

**Longshore Volume Flux**

**Mean Longshore Currents**

- **South**
- **North**

**Graphical Representation:**
- **Elevation above bottom (m)**
- **Current velocity (m/sec)**
- **Years represented:**
  - 2002
  - 2003
  - 2004
  - 2005
  - 2007

**Legend:**
- Green: 2002
- Blue: 2003
- Black: 2004
- Red: 2005
- Pink: 2007
Year | Cross-shore Volume Flux [m²/sec]
--- | ---
2002 | -493.83 | 369.84 | -123.98
2003 | 235.75 | 191.56 | 427.31
2004 | 39.63 | 414.53 | 454.16
2005 | -426.97 | 118.53 | -308.44
2007 | -3463.11? | 325.11 | -3138.01
Net | -4108.53 | 1419.57 | -2688.95
Longshore Current Vs. Longshore Wind Speed

![Graph showing correlation coefficient over time, with two sets of data points: blue for the average of lower 3 bins and red for the average of upper 3 bins.](image)
Cross-shore Current Vs. Cross-shore Wind Speed

The graph shows the correlation coefficient over time, with data points for each year from January 2003 to January 2007. The correlation coefficient values range from -1 to 1.

- **Red dots**: Avg. of upper 3 bins
- **Blue dots**: Avg. of lower 3 bins
Conclusions

- Longshore currents measured outside the surf zone are highly correlated with the measured longshore component of the wind.
- Most of the longshore wind influence is in the upper 20% of the water column.
- Strong seasonality in both direction and intensity of the longshore current.
- The first spatial and temporal eigenfunctions account for 98% of the variation in the longshore current and 95% of the variation of the cross-shore current.
- Although the net longshore surface currents for the five years are directed towards the north, at the bottom of the water column it appears that the mean longshore currents are to the south.
Future Work

* Examine correlation of storm waves (i.e. $H_s \geq 1.75 \text{ m}$) with the longshore current.

* Look more closely for a mass flux balance in the cross-shore direction.

* Add additional years using wind data from Port Canaveral.
Thanks