UTILIZING A TERRESTRIAL LASER SCANNER TO ASSESS THE EVOLUTION OF AN UNDEVELOPED BEACH

KELSI SCHWIND
MICHAEL J. STAREK
JAKE BERRYHILL
ALISTAIR LORD
It is necessary to document beach evolution over time to effectively implement coastal zone management practices.

Remote sensing techniques have been widely applied to study coastal processes and evolution:

- Traditional surveying methods are labor and time intensive.
- More data can be captured using remote sensing.
- Terrestrial laser scanning can be a time effective and cost-effective alternative to traditional land surveying or aerial lidar methods.
STUDY SITE

- Apalachicola National Estuarine Research Reserve (ANERR) in Apalachicola, Florida
  - Little St. George Island
  - 9 miles of protected and undeveloped, gulf-facing beach
DATA COLLECTION

- Data collection began in mid-March, 2016
  - One TLS survey per beach site each year
  - 2 scans per site – merged and georeferenced

- Riegl VZ-400 terrestrial laser scanner (TLS)
  - Ground-based, tripod platform
  - Up to 122,000 measurements per second
  - Nikon d800 camera used to capture RGB values

Distance = Speed x time
DATA COLLECTION

- Target points
  - Five, cylindrical targets measured with a Trimble R8S GNSS System
  - Minimum of 60 observations per target

- RTK GPS ground control points
  - Trimble R8S GNSS System
  - Minimum of 5 observations per point
  - At least 50 points per site
GENERATION OF TLS 3D POINT CLOUDS

- Riegl software outputs a raw point cloud in RiScan Pro
- RiScan Pro, lastools, and QT Modeler were used to filter for noise
- Resulting point clouds displayed by RGB and elevation values
GENERATION OF POINT CLOUDS

Filtered R41 2016 point cloud depicted by elevation – over 26 million points
GENERATION OF DIGITAL ELEVATION MODELS

- Lastools: clip, classify, output 5 cm DEMs
  - Triangulation, ‘kill’ method to avoid heavy interpolation of sparse data
  - Can generate contour and slope maps from the data
  - Lastools → powerful processing
DEM VERTICAL ACCURACY

- DEM vertical accuracy compared to the RTK GPS control points for site
  - Differences of elevation in dune and vegetated areas are greater than that of the beach when compared to the RTK GPS control points
    - Occlusion, difficulty penetrating vegetation to obtain true ground points
    - R41 was the most vegetated site

---

<table>
<thead>
<tr>
<th>Site Number</th>
<th>Mean Difference</th>
<th>RMSE</th>
</tr>
</thead>
<tbody>
<tr>
<td>D341</td>
<td>0.041</td>
<td>0.053</td>
</tr>
<tr>
<td>R29</td>
<td>0.038</td>
<td>0.061</td>
</tr>
<tr>
<td>R41</td>
<td>0.064</td>
<td>0.094</td>
</tr>
</tbody>
</table>

Mid-March 2016 TLS survey accuracy (m)

<table>
<thead>
<tr>
<th>Accuracy</th>
<th>Mean Difference</th>
<th>RMSE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beach</td>
<td>0.024</td>
<td>0.030</td>
</tr>
<tr>
<td>Dunes and Vegetation</td>
<td>0.116</td>
<td>0.144</td>
</tr>
</tbody>
</table>

Accuracy of the R41 mid-March 2016 comparison of the beach versus dune and vegetated surface (m)
VOLUMETRIC CHANGE ANALYSIS

- Quantification of sediment change using ArcMap
  - Allows you to assess beach evolution over time
  - Negative values erosion and positive values represent accretion
  - Average loss of 3.78 cm$^3$ per cubic yard

Comparison of R29 mid-March 2016 and R29 mid-March 2017 TLS scanning data
CROSS SECTION PROFILE ANALYSIS

- Cross sections generated in QT Modeler using historical transects

- Will compare current TLS data to historical traditional survey data at the ANERR study sites since 1973 to assess their evolution over time
CROSS SECTION PROFILE ANALYSIS

- Cross sections generated in QT Modeler using historical transects

Graph showing elevation changes over distance from origin for Dunes and Exposed Beach areas.

- Red line: Mid-march D341 2016 Elevation
- Green line: Mid-march D341 2017 Elevation
CROSS SECTION PROFILE ANALYSIS

- Cross sections generated in QT Modeler using historical transects

![Graph showing cross sections with Dunes and Exposed Beach labeled.]

- Origin

Distance from origin (m)

Elevation NAVD88 (m)

- Mid-march R41 2016 Elevation
- Mid-march R41 2017 Elevation
CONCLUSION

- TLS powerful tool for producing localized data to monitor beach evolution over time
  - Dense data source
  - Prone to occlusion from terrain and vegetation
    - More accurate on the exposed beach
  - Can be very precise and accurate, but accuracy will depend on the georeferencing technique employed
CURRENT AND FUTURE WORK

- Generation of UAS-SfM DEMs from concurrent aerial flights
  - Can it generate as accurate point clouds and DEMs using photogrammetric techniques?
  - What features can or cannot be observed in this data vs TLS data?
- TLS and UAS surveying is being used for routine monitoring of beach and wash over sites here locally on Mustang Island and North Padre Island
  - Developed processing workflows from this work are being used to generate more accurate elevation products from the data for coastal zone monitoring
CURRENT AND FUTURE WORK

- Compare historical transect field survey data to look at profile evolution over time and compare with TLS observations for recent data
- Impacts of Hurricane Michael on ANERR
  - Comparison of UAS data obtained pre-Michael to airborne lidar obtained by USACE post-Michael
  - DEM to DEM comparison to assess beach changes from this event
  - Predict the vulnerability to this beach to future events using this data and vulnerability indices
THANK YOU!

Kelsi Schwind
Graduate Research Assistant
Texas A&M University – Corpus Christi, Coastal and Marine System Sciences
Kelsi.Schwind@tamucc.edu