Discovery and Access of Elevation Data: The Impacts on DEM Development and Inundation Modeling

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DEM for modeling

Since tsunamis are strongly affected by variations in coastal relief, a carefully constructed digital elevation model (DEM) of the coastal zone is critical to inundation modeling and forecasting tsunami inundation. DEMs are a required input to inundation models which are a critical component in the development of inundation maps and, ultimately, evacuation maps.

Accurate DEMs help prevent over or under evacuation during events and enable efficient use of emergency funds and staff.

For over a decade, our group has been developing a range of DEM products serving not only NOAA’s tsunami program but in support of hurricane forecast/warning and coastal flooding research and operations.
DEM s created from current, accurate, and resolution appropriate source data support the development of tsunami inundation mapping products that further support clear, consistent evacuation products. We rely on other agencies, whether federal, state, regional, or non-governmental to provide us access to elevation data. Discoverability and timely access to these data enable us to develop the best DEM products and ultimately help modelers provide the most accurate estimations of coastal inundation.
Major problem for DEM development is source data discovery and access. High resolution lidar for coastal areas is hard to find or not available for our use. Agencies that may have collected these data often do not have public (online) access or catalog information so we may not know about it. News reports, scientific journal articles, and technical briefs have listed various elevation data but contact information and details about the dataset itself are not specified or discoverable.

Goal is to find supporting elevation data that has been collected recently and is accurate and is of high enough resolution to minimize interpolation. “Resolution” based on the required level needed by model to create appropriate or desired results.
It is not possible to create highly accurate DEMs from low resolution, sparse, or otherwise low quality source data.


https://www.nrc.gov/docs/ML1635/ML16357A270.pdf

Image source:
Example, inadequate source data for Belize is impacting modeling results. Specifically, if the source data has vertical errors of ~ 5m in some locations and the overall elevation of much of the city is in a 5 m range, that does not lend itself to accurate modeling. *Use of control points is not a substitute for good data.*

<table>
<thead>
<tr>
<th></th>
<th>Pre-correction</th>
<th>Post-correction</th>
<th>Max flooded area</th>
<th>Pre-correction</th>
<th>Post-correction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max amplitude</td>
<td>128 cm</td>
<td>160 cm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Min amplitude</td>
<td>-93 cm</td>
<td>-110 cm</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Max flooded area</td>
<td>0.28 km²</td>
<td>5.74 km²</td>
<td></td>
<td></td>
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<tr>
<td>Max current</td>
<td>6.8 kts</td>
<td>6.9 kts</td>
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Accurate DEMs help prevent over or under evacuation during events and enable efficient use of emergency funds and staff.
Possible Solution to Data Sharing Challenges

Conduct a regional workshop(s) to train local experts on how to develop and/or update DEMs when:

- new topographic/bathymetric surveys are conducted
- data access is granted by partner agencies and/or private institutions

Training Goals: Attendees learn how to process and evaluate coastal topographic and bathymetric data, and develop individual coastal relief models for use in regional tsunami inundation studies.

Process bathymetric, topographic and shoreline data with select open source and proprietary GIS software.

- Evaluate and edit data.
- Develop coastal digital elevation models (DEMs) using gridding algorithms.
- Evaluate DEMs.
- Document DEM development.
- Gain a broad understanding of DEM accuracy and uncertainty.
- Learn what is required from the DEM to produce community inundation maps.

DEM Staff lead a DEM development workshop hosted by Ocean Networks Canada in 2016 and again in 2019. This workshop provided participants from Canadian government agencies and regional stakeholders with instruction on developing high resolution seamless coastal DEMs. Knowledge gained from this training will provide input for development of Canadian national guidelines for coastal flooding projects and is part of the west coast demonstration study of the Canadian Safety and Security Program, Coastal Flood Mitigation Canada Project led by Natural Resources Canada. Refer to IOC Digital Elevation Model Development Workshop proposal for details.
QUESTIONS?

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Next two slides highlight current research and development of ancillary DEM products supporting use and providing additional information for modeling.
Spatial Metadata

- Future data products to enhance value of DEMs *(In Progress)*
  - **Spatial Metadata**
  - **Vertical Uncertainty**
- **Spatial Metadata** provides users with information on input elevation data used in the DEM development.
- Important information includes:
  - Collection agency
  - Date of the data collection
  - Instrumentation (lidar, sonar, satellite, etc.)
- **Vertical Uncertainty** provides users with quantitative estimate of quality of the DEM values.
- DEM quality can vary across space:
  - Integration of different data (e.g., old vs. new technologies)
  - Terrain (e.g., flat or sloped)
  - Interpolation (estimating elevations in areas of no data)

Example of Spatial Metadata Product in SW Florida, United States
Total Vertical Uncertainty estimates from the combination of source data set uncertainty and additional uncertainty due to interpolation where there are no measurements. The total uncertainty varies across space, primarily as a result of the input data sets. Some areas have high quality measurements with modern technology like lidar, and these areas have low vertical uncertainty estimates.

Source uncertainty estimates includes different data set instrumentations (e.g., lidar vs. sonar), different data densities (number of measurements in a DEM grid cell), and terrain variance (flat or sloped terrain).

Interpolation uncertainty is modeled as a function of distance to the nearest measurement. Areas farther away from measurements have larger interpolation uncertainty.