Use of Modeling Tools for Assessing Future Flood Risk

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Use of Modeling Tools for Assessing Future Flood Risk

Presented by
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THE ISSUE

Many communities understand flood risk from FEMA products.

FEMA does not consider changing landscape or climate.

In the coastal zone, FEMA separates tidal and upland processes.

Storm surge does not include precipitation.

Where and how much does this matter?
NUMERICAL EXPERIMENTS

Our research is exploring how sensitive coastal flood risk is to:

- Sea Level Rise
- Precipitation
- Upland riverine flow

We are exploring these interactions by using computer simulation
FEMA MODELS

• One of the main missions is to inform flood risk
• NFIP
  • Develop Flood Insurance Rate Map (FIRM)
  • FIRM represents “present conditions”
  • Data goes stale as landscape changes and/or if there are meteorological changes
• FEMA periodically updates FIRM with latest tools
• Update of Eastern Shore VA
• Funded development and validation (2011-2012)
ADCIRC and SWAN

**ADCIRC**
Calculates water surface elevation and currents

**SWAN**
Is a spectral wave model that computes energy for a range of wave lengths

- Codes share the same input (mesh, winds, etc.)
- Codes are dynamically coupled (run at the same time) to integrate evolution of surge and waves
- Captures wind-wave-surge interactions
- State of the art algorithm runs on massively parallel supercomputers
SUPERCOMPUTING ASSET

Athos

- 84 HP SL160z G6 servers
- Dual Six-Core Intel Nehalem processors - 996 total cores
- 24 GB RAM - 1992 GB total RAM
- 160 GB disk - 13280 GB total disk
- Infiniband connectivity
Hurricane Track

Tidal Boundary Conditions
FEMA COASTAL FLOODING MAPPING

Historical surge/wave data is sparse
FEMA COASTAL FLOODING MAPPING

- Simulates thousands of hypothetical hurricane scenarios
- Ensemble represents a “synthetic history”
STRATEGY

LEVERAGE previous work with FEMA model development and creating synthetic storms.

ADD precipitation or sea level rise estimate

RE-RUN selected storms

COMPUTE spatial variability of differences

INFORM FEMA methodology
PRECIPITATION

- On-going DHS funded research with UNF
- Compiled statistics of rain patterns
- Modified the ADCRIC code to include rain
- Use several synthetic storms to look at the difference
- Where does it matter?
FINDINGS SPECIFICALLY FOR HAMPTON ROADS

Rainfall offshore is influenced by sea surface temperature and storm size.

Timing of rainfall slightly lags in closest proximity of storm center passage.

Precipitation is concentrated in a 24-hour interval centered on the point of closest approach.

Storm track is the primary discriminator of both the duration and intensity of rainfall in storms.
PRECEPITATION MODEL

\[ I = 1.14 + 0.12\Delta P \text{ for } r \leq R_{\text{max}} \]

\[ I = (1.14 + 0.12\Delta P) \cdot \exp\left[ -0.3 \cdot \left( \frac{r - R_{\text{max}}}{R_{\text{max}}} \right) \right] \text{ for } r > R_{\text{max}} \]

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Unit</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>( I )</td>
<td>[mm/hr]</td>
<td>Rainfall intensity</td>
</tr>
<tr>
<td>( \Delta P )</td>
<td>[mbar]</td>
<td>Pressure deficit (difference between standard atmospheric and local pressures)</td>
</tr>
<tr>
<td>( r )</td>
<td>[km]</td>
<td>Distance from center of storm to location</td>
</tr>
<tr>
<td>( R_{\text{max}} )</td>
<td>[km]</td>
<td>Radius of maximum wind speed</td>
</tr>
</tbody>
</table>

* Lonfat, Marks, and Chen (2004)
RAINFALL CONTRIBUTION

Storm 002

Storm 003
RAINFALL CONTRIBUTION

Storm 002

Storm 003
SEA LEVEL RISE

Simulation of the several storm scenarios at different sea levels

These sea-level rise projections are based on the 2012 National Climate Assessment and have been customized for Virginia by the Virginia Institute of Marine Science.

The “high” scenario is based on the upper end of projections from semi-empirical models using statistical relationships in global observations of sea level and air temperature. This is currently seen as the most likely scenario by scientists.

Because of the complexity of the storm surge modeling process, only the “high” scenario was modeled for two future time periods: 2040 and 2065.
Run 001  -> BP1_dp2r3b1c1h1l1
Run 002  -> NCR_dp2r1b1c2h3l1
Run 003  -> NCR_dp3r2b1c2h2l1
Run 004  -> NCR_dp3r2b1c2h3l1
Run 005  -> NCR_dp3r3b1c2h2l1
Run 006  -> VAR_dp1r1b1c2h2l1
Run 007  -> VAR_dp1r1b1c2h3l1
Run 008  -> VAR_dp1r2b1c2h1l1
Run 009  -> VAR_dp2r1b1c1h1l1
Run 010  -> VAR_dp2r1b1c2h4l1
Run 011  -> VAR_dp2r2b1c2h2l1
Run 012  -> VAR_dp2r2b1c2h2l1
Run 013  -> VAR_dp3r1b1c1h1l1
Run 014  -> VAR_dp3r1b1c2h1l1
Run 015  -> VAR_dp3r1b1c2h2l1
Run 016  -> VAR_dp3r3b1c2h5l1
CURRENT CONDITIONS
2065 LESS CURRENT
SUMMARY

We are developing tools to improve the next generation of FEMA mapping.

SLR can cause amplification due to topography.

The bathtub approach is not valid everywhere.

Precipitation and river flows need to be considered.

The spatial extent of these effects can be accurately defined.
Thank You for your time and attention