Prediction for coastal flooding at Delaware Bay under climate change conditions

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Summary

Potential flooding is investigated at Cumberland and Cape May, New Jersey, under projected relative sea level rise (RSLR) and storm surge conditions. The 3D FVCOM is coupled with a 2D shallow water model, the latter being used to predict the hydrodynamics of flooding in the near-shore and over land. Predictions are made for the years 2020, 2060 and 2100 for regular and storm conditions. The model results indicate a large inundation region during storms and impacts on transportation, businesses and residences.

I. Objective

The prediction of flooding due to RSLR under normal and storm conditions in the New Jersey counties of Cape May and Cumberland.

II. Study Area

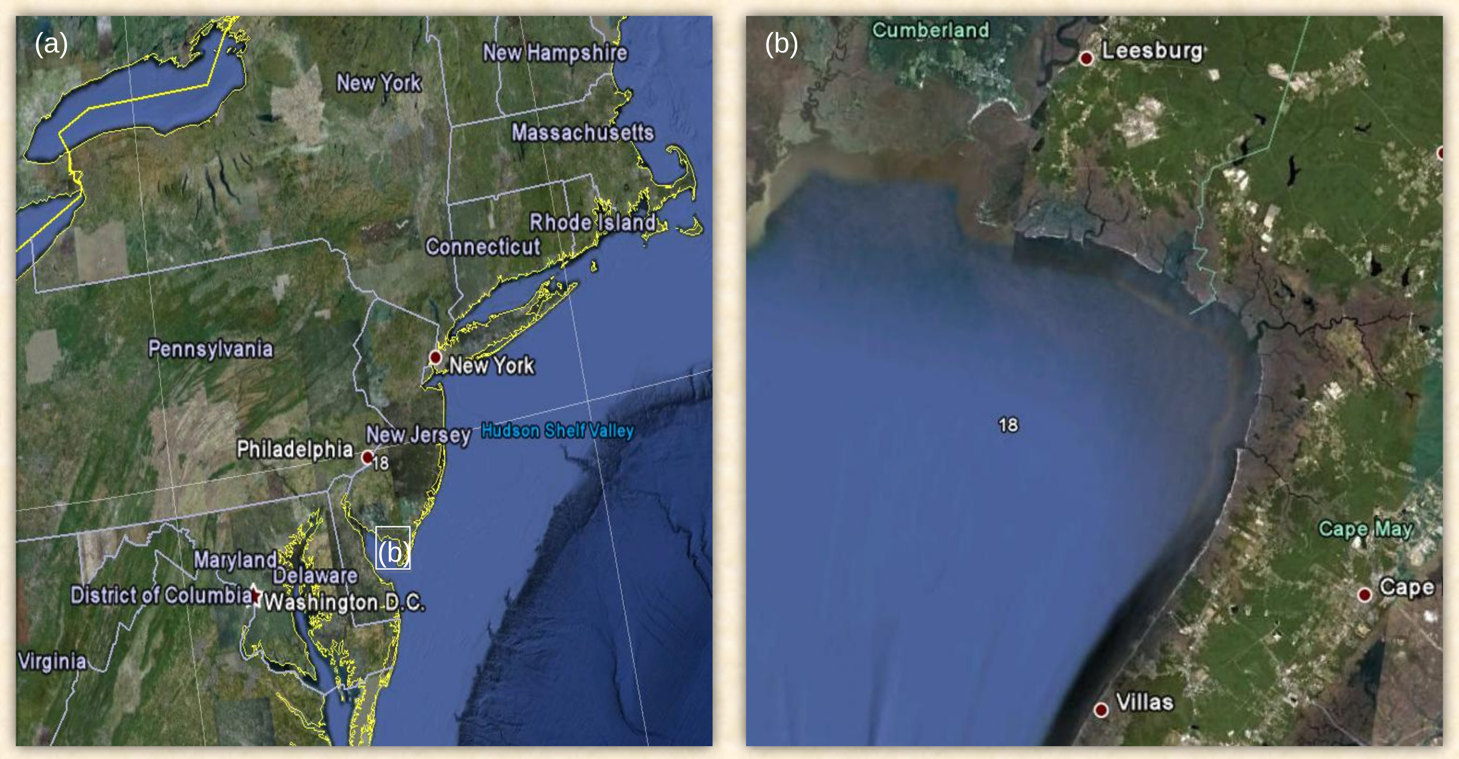

Figure 1. (a) Location of study region on the US east coast. (b) Close-up of study region.

III. Models

FVCOM
- 3D incompressible geophysical fluid dynamics equations.
- Finite volume method, triangular mesh in horizontal direction, sigma coordinates in vertical direction

SWM
- 2D shallow water equations
- Finite volume method, triangle mesh

Coupling
- Coupling between shallow water model (SWM) and internal mode of FVCOM
- Patched overset grids
- Advantages: 1) saving of CPU time. 2) capture storm surge bore.

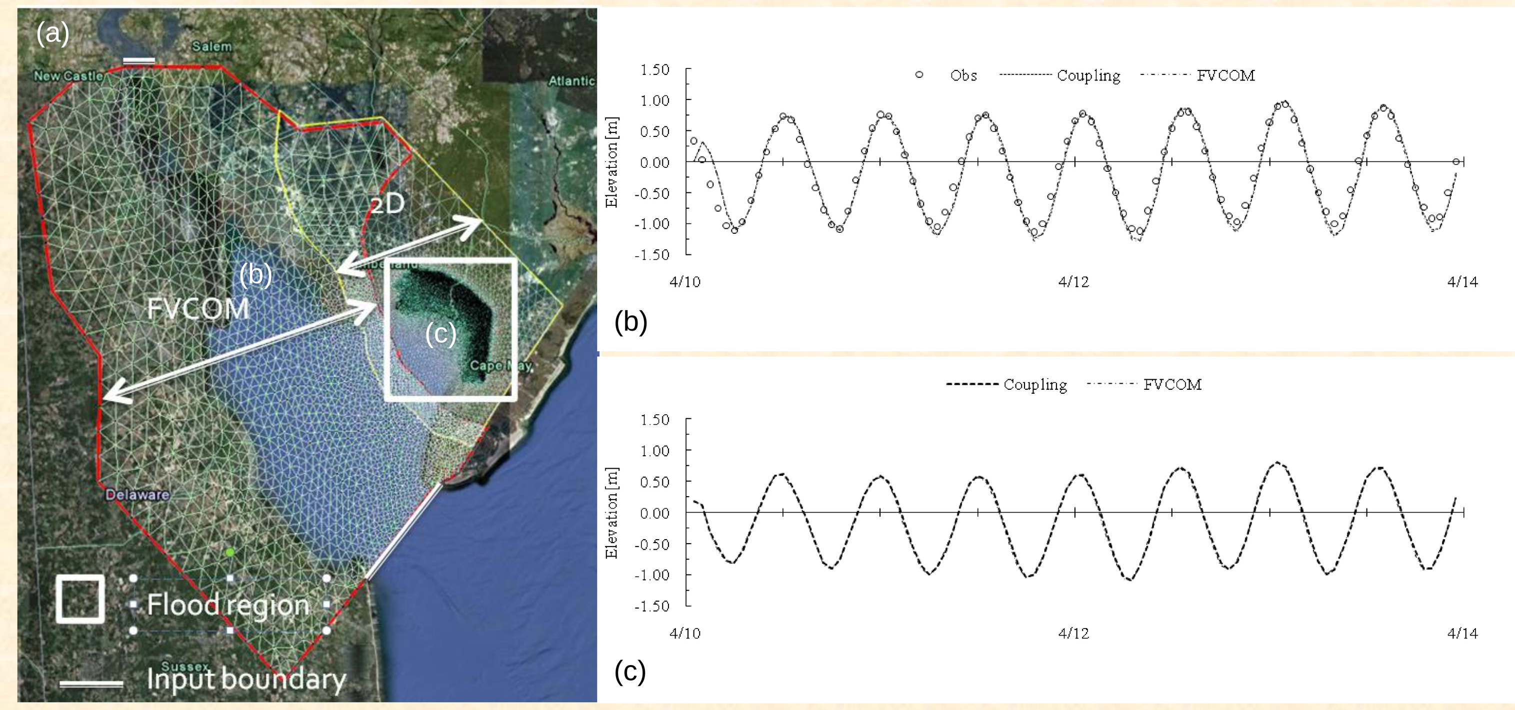

Figure 2. FVCOM/SWM provides same quality results but uses less computation time in comparison of FVCOM. The former uses 4h18m, and the latter uses 23h19min for simulation of 24hrs process. (a) The mesh, boundaries and coupling region of the FVCOM and SWM models.(b) Calibration results at Ship John Shoal for FVCOM and the coupled models. (c) Comparison of FVCOM and the coupled models at a point inside the SWM model region.

IV. General and Climate Change Condition input

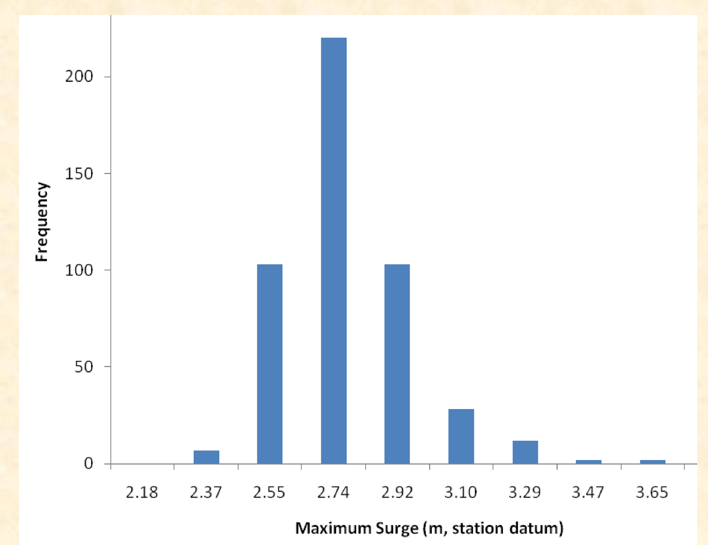

Figure 3. Frequency analysis of water elevation over a 40 year time period indicates a lognormal distribution. The station datum is 1.652 m below NAVD88.

T (Years)	SWE (NAVD88, m)
10	1.63
50	1.79
90	1.84

Table 1. Results of frequency analysis: Storm water elevation (SWE) at return period T. The February 1998 nor'easter is used to drive the model.

$$K_T = \frac{w - 2.515517 + 0.802853w + 0.010328w^2}{1 + 1.432788w + 0.189269w^2 + 0.001308w^3}$$

$$w = \left[\ln\left(\frac{1}{p^2}\right)\right]^{\frac{1}{2}}, \text{ for } p \le 0.5$$

$$y_T = \mu_y + K_T\sigma_y$$

$$x_T = e^{y_T}$$

T – return period
p – exceedence probability
K_T – frequency factor
μ - mean
σ – standard deviation
x – normal water elevation
y – lognormal water elevation

Time (years)	Global SLR [m] IPCC2007	Cape May RSLR [m]
2020	0.04	0.09
2060	0.19	0.42
2100	0.345	0.76

Table 2. Estimated RSLR at Cape May. Estimate is derived from station data and IPCC 2007, SRES A1B projections.

- Manning values are assigned based on NLCD1992 and values provided in literature.
- NOAA's VDATUM tool was used to convert NGDC data to NAVD88 datum.
- Lidar data has ± 0.13 m accuracy at the 95% confidence interval.

IV. Results

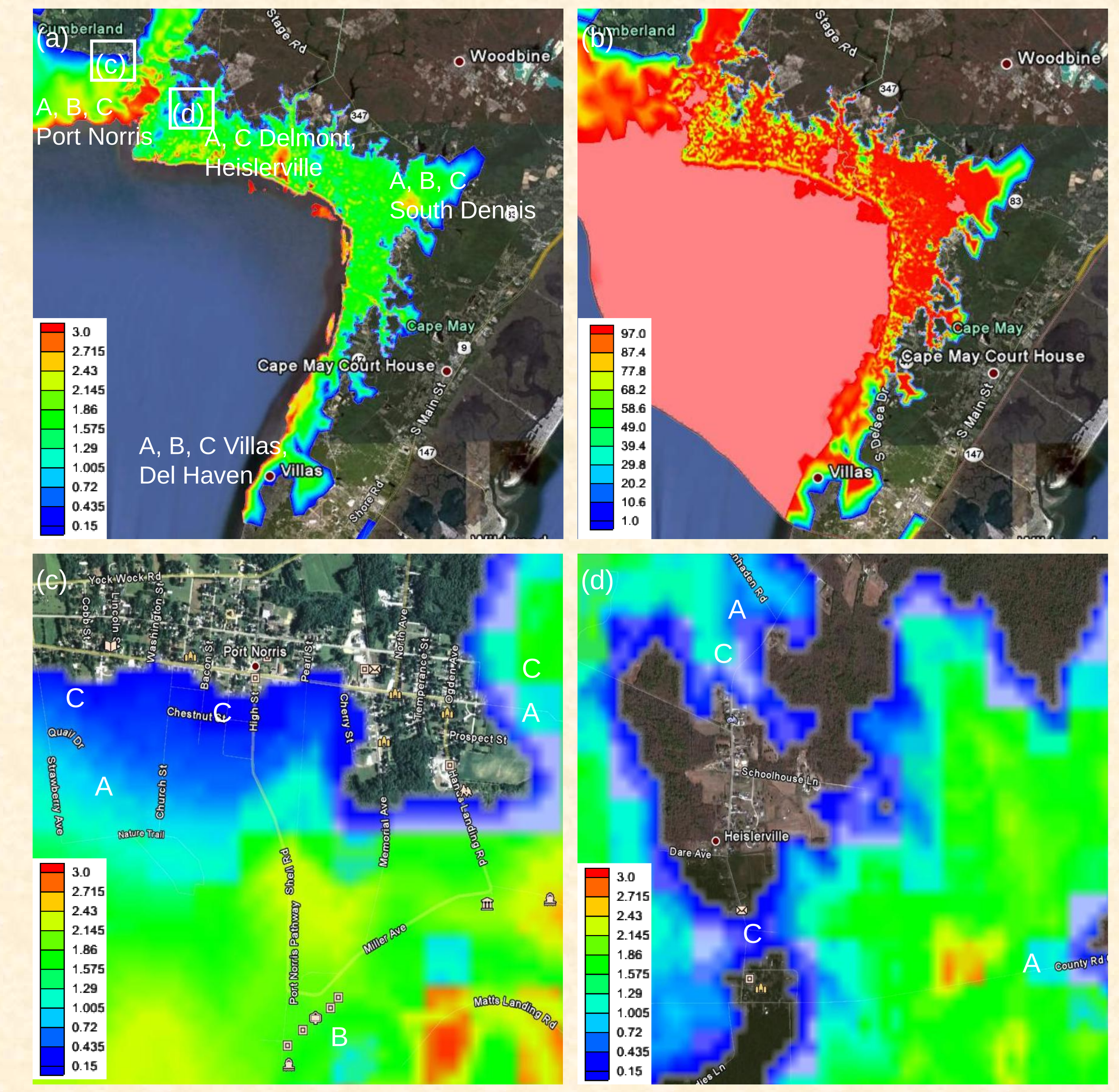

Figure 5. Results for the year 2060 (SLR = 0.42 m, T = 50 years). Flooded roads (A), businesses (B) and residences (C) are shown. Water elevation contours are shown in meters ((a),(c),(d)) and water residency time in hours (b) out 97 hours. Figures (c) and (d) are close-ups of Port Norris and Heislerville.

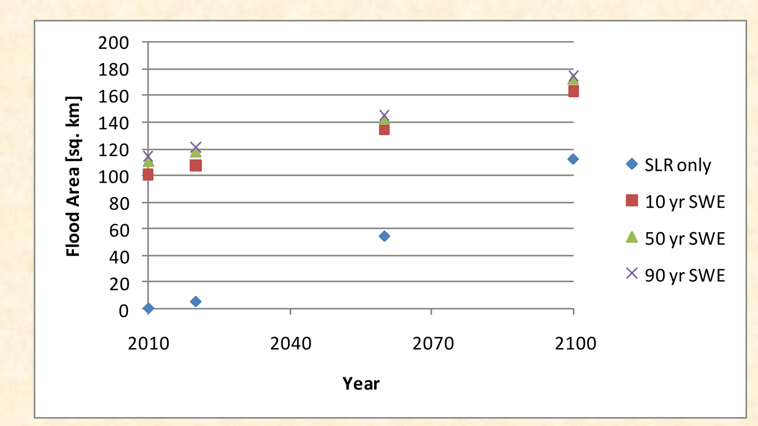

Figure 7. Flood area extent in the year 2010, 2020, 2060 and 2100 for a storm-water-elevation (SWE) return period of 0, 10, 50 and 90 years.

Concluding Remarks

1) RSLR, even under normal weather conditions will cause significant inundation.
2) Transportation, businesses and residences will be affected in the medium term.

References:

Tang, Wu, Cheng, Kraatz. AGU Fall Meeting, San Francisco, CA (2010).

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