Application of the Sea Level Affecting Marshes Model (SLAMM) to Connecticut's Shoreline

Coastal marshes are dynamic ecosystems that provide significant ecological and economic value. Located at the margin between land and water, they are also among the most susceptible ecosystems to climate change, especially accelerated rates of sea-level rise (SLR). Similarly, public infrastructure near coastal waters are increasingly susceptible to flooding in a rising sea.

To help identify the potential responses of coastal marshes and infrastructure to sea level rise, Warren Pinnacle Consulting, Inc. (WPC), the Northeast Regional Ocean Council (NROC), and the Connecticut Department of Energy and Environmental Protection (CT DEEP) applied the Sea Level Affecting Marshes Model (SLAMM version 6) to Connecticut's coast. This 2016 application of SLAMM updates a previous 2014 effort that includes new SLR scenarios ranging from 0.38 meters to 1.9 meters from the base year (2002) to year 2100. Also included in the current model run are new environmental factors such as tidal muting of select areas due to flow constrictions, marsh collapse, enhanced hydraulic connectivity and more current elevation data. This application of SLAMM also provides new data on the effects of tidal and storm surge flooding on roads and other infrastructure.

The SLAMM project data can help support environmental planning efforts by identifying potential future locations of new coastal marsh currently occupied by undeveloped dry upland, how current coastal high marsh/low marsh composition ratios are expected to change and how changes in the frequency of tidal and storm surge road flooding can inform infrastructure resilience planning. For the purposes of the data presented here, coastal marsh is defined as low marsh (regularly-flooded marsh), high marsh (irregularly-flooded marsh), undeveloped dry land recently converted to marsh (transitional or scrub-shrub marsh), and tidal-fresh marsh. Model output is presented as either deterministic or probabilistic (likelihood) results.

Deterministic results predict future land cover type (e.g., coastal marsh, intertidal flat, open water, flooded developed land, etc.) and flooding under specific SLR scenarios for each modeled time step (Year 2025, 2040, 2055, 2070 2085, 2100) using discrete data (e.g., marsh accretion rate, tide range, marsh surface elevation, road centerline elevation, etc.)

SLR Scenarios and Projections Used**					
Time Interval	**Low (mm)**	**Low-Medium (mm)**	**Medium (mm)**	**High-Medium (mm)**	**High (mm)**
2002	0	0	0	0	0
2025	51	102	152	203	254
2055	203	279	406	533	762
2085	330	457	737	991	1473
2100	381	559	914	1270	1905

** values for 2070 were interpolated from above time-steps and projections that are based upon *New York City Panel on Climate Change, 2015 Report Chapter 2*, in *Annals of New York Academy of Sciences* 13326 (2015) 36-44 (2015)

Probabilistic or likelihood results are presented to address uncertainty inherent to the SLAMM model's input variables to quantify the level of confidence in model results. SLAMM's uncertainty analysis module uses Monte-Carlo simulations to produce several hundred model iterations based upon variation in key model input values (e.g., sea level rise, marsh accretion rates, tidal range, marsh surface elevation) randomly drawn from distributions to represent model uncertainty. Each model realization represents one possible future condition for the studied area. All model realizations are then assembled into probability distributions reflecting the effect of data model uncertainties on prediction results. These probability distributions can be summarized in a single map, such as the 'percent likelihood of a coastal marsh' at a given date. Unlike deterministic results, probabilistic or likelihood results are not reported according to any single SLR scenario since all SLR rates were considered in producing predicted outcomes, with some SLR rates weighted as being more likely to occur than others. Likelihood results are reported based upon percent likelihood (1%-100%) of a predicted outcome or landcover type (e.g., coastal marsh) occurring.

SLAMM provides the following datalayers:

Probabilistic/Likelihood Results (at each time step: 2025, 2040, 2055, 2070, 2085, 2100):

Data Layer	Description*
Likelihood_coastal_high_marsh	Likelihood that area is high marsh
Likelihood_coastal_low_marsh	Likelihood that area is low marsh
Likelihood_coastal_marsh	Likelihood that area is coastal marsh (high/low)
Likelihood_coastal_marsh_new	Likelihood that area that was initially not tidal marsh is coastal marsh
Likelihood_developed_flooded	Likelihood that existing developed land is flooded at least every 30 days
Likelihood_developed_flooded_new	Likelihood that area not predicted to flood under initial conditions will flood at least every 30 days
Likelihood_HydraulicConnection_InitialConditions	– Likelihood at time of initial conditions that an area that is not connected to tidal water but that could potentially accommodate tidal-marsh establishment if connected, for example by using hydraulic structures (culverts, ditches, etc.)
Likelihood_HydraulicConnection	Likelihood that an area that is not connected to tidal water but that could potentially accommodate tidal-marsh establishment if connected, for example by using hydraulic structures (culverts, ditches, etc.)
Likelihood_land_to_open_water	Likelihood of an area that is not water at low tide (MLLW) will become open water at that tide on a given time step

Deterministic results (provided at each time step 2025, 2040, 2055, 2070, 2085, 2100):

Data Layer	Description*
Model_results_1-Low	Predicted land cover types [e.g., regularly-flooded (low) marsh; developed flooded land, tidal flat, etc.] under low SLR scenario
Model_results_2-Low-Medium	Predicted land cover types . . . under low-medium SLR scenario
Model_results_3-Medium	Predicted land cover types . . . under medium SLR scenario
Model_results_4-High-Medium	Predicted land cover types . . . under high-medium SLR scenario
Model_results_5-High	Predicted land cover types . . . under high SLR scenario
InundationFreq_InitialConditions	Frequency that land is flooded at base year
InundationFreq_1-Low	Frequency that area is flooded under low SLR scenario
InundationFreq_2-Low-Medium	Frequency area is flooded under low-medium SLR scenario
InundationFreq_3-Medium	Frequency area is flooded under medium SLR scenario
InundationFreq_4-High-Medium	Frequency area is flooded under high-medium SLR scenario
InundationFreq_5-High	Frequency area is flooded under high SLR scenario
InundationFreq_CTDESP_roads_justwet	Locations and frequencies of flooded roadway segments

* Consult data layer’s metadata for a complete description.