the native aerial surveyor

The Potential of µUAS in enhancing/validating SLAMM Model predictions of Sea Level Rise and Coastal Wetland Migration Pathways

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AMERICAN ASSOCIATION of GEOGRAPHERS
ANNUAL MEETING • April 3-7, 2019 • Washington, DC

Introduction: An important challenge in evaluating and predicting coastal salt marsh resources in the face of anticipated Sea Level Rise (SLR) using numerical modeling, is that in many cases, we are at the nexus of potential scalar mismatch scenarios in the application of available data (elevation data, tidal range and descriptions of marsh species zonation - i.e. landcover).

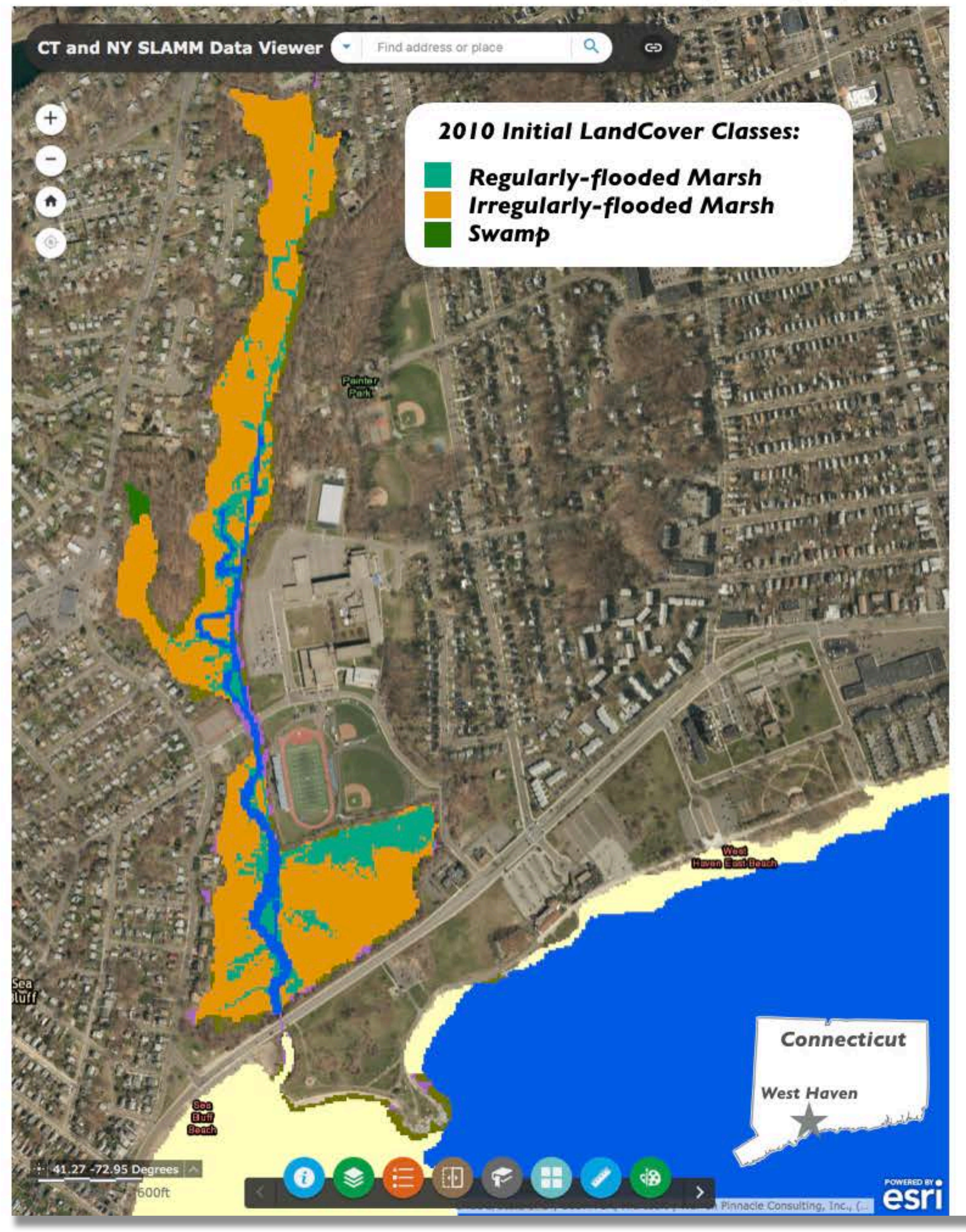
The particular Scale Mis-Match scenario highlighted here is in reference to a widely employed numerical modeling and visualization system known as Sea Level Affecting Marshes Model (SLAMM). In SLAMM I identify potential scale mis-match as a serious challenge in interpreting model results due to imprecise and/or inappropriate scales/resolutions in the remotely sensed data used as model input for resolving the Cove River (West Haven, CT) salt marsh responses to SLR. The data in question are Digital Surface Models (DSM) or elevation models derived from LiDAR, and tidal inundations projected from tide gauges that are miles from the wetland of interest, as well as "assumed marsh landcover classifications" across a wetland complex, based solely on predicted tidal inundation and a generalized knowledge of marsh species' preference for living/thriving at different marsh elevations.

The Coastal Planning, Engineering and Management community, as well as Academicians, need to think more deeply about modeling programs such as SLAMM and it is strongly suggested that decision-making process includes continued on-ground observation, and data gathering using emerging technologies such as micro Unmanned Aerial Systems (µUAS/drones) and Structure from Motion (SfM) mapping and 3D modeling as appropriate alternative (higher resolution) model inputs. (Graves, S.M., 2019)

µUAS/Drone Aerial Imaging/Mapping/Modeling: µUAS/drones have proven to be useful tools for gaining an intermediate aerial perspective on landscapes. They fill an important niche in the overall remote sensing process and provide very high detail imagery and where processed through Structure from Motion (Pix4D software), also yield detailed Digital Surface Models (DSM). At Cove River (Mid-Upper Salt Marsh location ~900m upstream from the river mouth), we have been flying µUAS since the summer of 2015, following the eradication of invasive Phragmites across the wetland complex. After the Invasive Phragmites irradiation across the entire Salt and Fresh Marsh (Autumn 2012), much of the marsh top to-date, remains a mudflat held together by the rotting Phragmites roots. Some limited Spartina Alterniflora have been established along the marsh channel banks, but in many areas the channel banks and marsh top remain un-vegetated. The fear is that without anchoring vegetation, the marsh top and channel margins will destabilize and deflate or collapse. Further, while many species of wetland/shore and wading birds have returned to the Cove River (including osprey, mallards, mergansers, egrets, herons, swans, lesser & greater yellow legs, etc.), a reinvigorated and healthy salt marsh is a long way off.

SLAMM Model Results for Cove River Estuary/Salt & Fresh Marsh

Scale Mis-Match Scenario in full display here: Landcover Classes are mis-identified at the start!



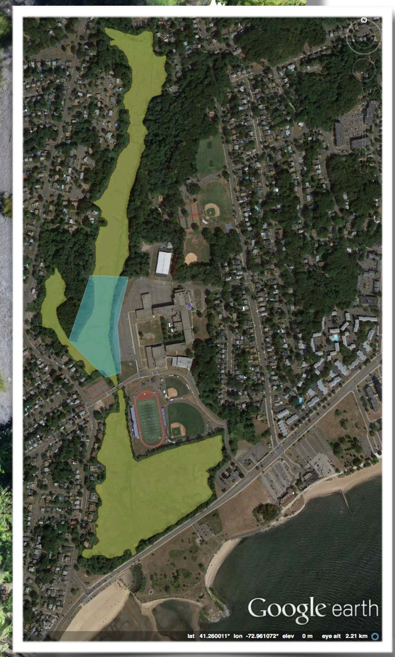
SLAMM Model Characterization of Cove River Wetland Complex Landcover (left) vs. More Detailed Characterization of the Wetland Complex's Actual Landcover by Direct Observation (right). In the "initial model" (left) there is a mis-characterization of the small Inland Fresh Marsh, [B] indicated at right as being of similar composition and elevation as the rest of the Salt Marsh directly to the East. The Model predicts this area will be "regularly flooded" with a rise in Sea Level of ~30-40cm. In reality, this Fresh Marsh stands some 40-50cm above the level of the rest of the Salt Marsh complex and so here does provide some small area of potential upland Salt Marsh migration… at least for a time. In the event of a SLR of ~50-80cm, the entire complex will be deeply inundated and may transition to Mud Flats. Figure from Graves, S.M., 2019.

SLAMM Viewer available @ http://ctdeep.maps.arcgis.com/apps/webappviewer/index.html?id=205df00b30de40c7b84626e4a77fb914

µUAS in Validating/Enhancing SLAMM Modeling: SLAMM (Sea Level Affecting Marshes Model) is a valuable numerical modeling strategy for assessing/predicting future coastal wetland responses and potential upland migration pathways in the face of rising Sea Levels. SLAMM, however need not, and in many cases initially does not employ much direct observation of or field assessment/characterization of actual wetland complexes. Instead it relies upon available Tide Gauge data, and Digital Elevation Models, as well as a generic landcover classification of wetland species based on their predicted distribution over wetland surfaces and across the intertidal zone. While this approach is very valuable in gaining a preliminary understanding of the potential marsh migration avenues where open uplands are present (not impeded by other infrastructure and/or hardened surfaces), significant errors and resolution challenges in some of the data employed (LiDAR-derived DEMs and Tide Data from distant gauges), may result in some important nuances in the areas of most concern being overlooked -or details overgeneralized. This is especially evident when considering smaller and fragmented wetland complexes ~ 25-50 hectares or less.

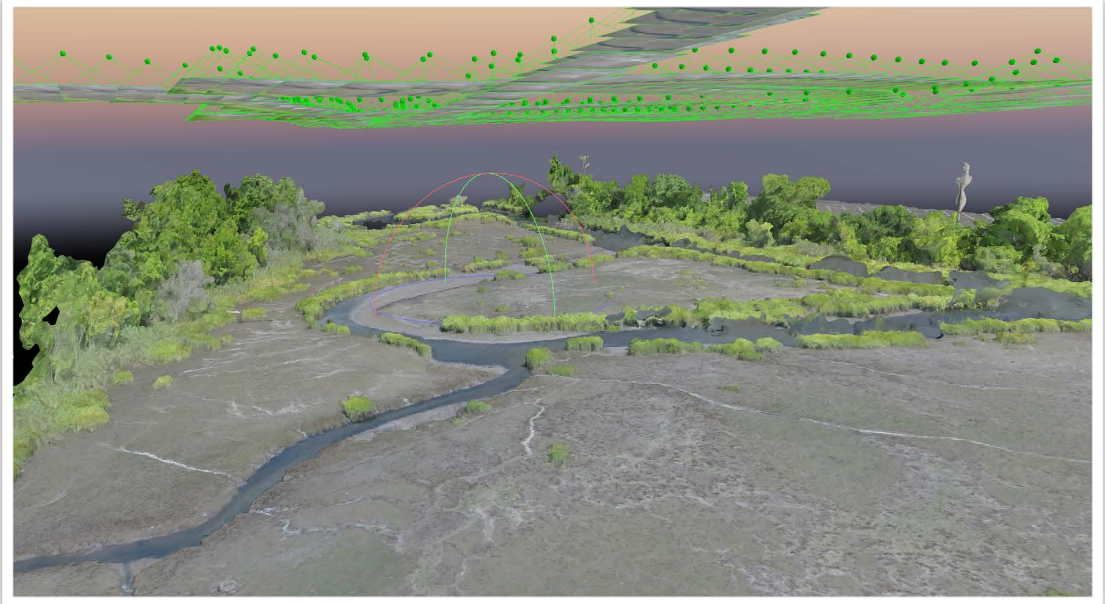
Future Research: As we seek to understand how the marsh changes over time, we continue to document (using µUAS) the vegetation aerial extent, the species present and those colonizing. We also continue combining our aerial photo-mosaics and 3D models of the marsh area with ground-level observations and intend on sampling marsh top and channel bank and trough sediment characteristics. Further, we have occasionally installed marsh top inundation measurement stations (*Marsh Inundation Camera System*). Finally, we plan on making observations of the marsh top and channels through a series of Spring and Neap Tidal cycles, with flow-rate monitoring and Salinity measures at select locales.

µUAS (3D Robotics Solo) flight conducted @ Cove River Historical Site
Upper Mid-Salt Marsh September 28th 2017, Neap High Tide 0.9m @ 1806
µUAS launch location Lat: 41.259840° Lon: -72.961721° Elev: 1.1m (MSL)



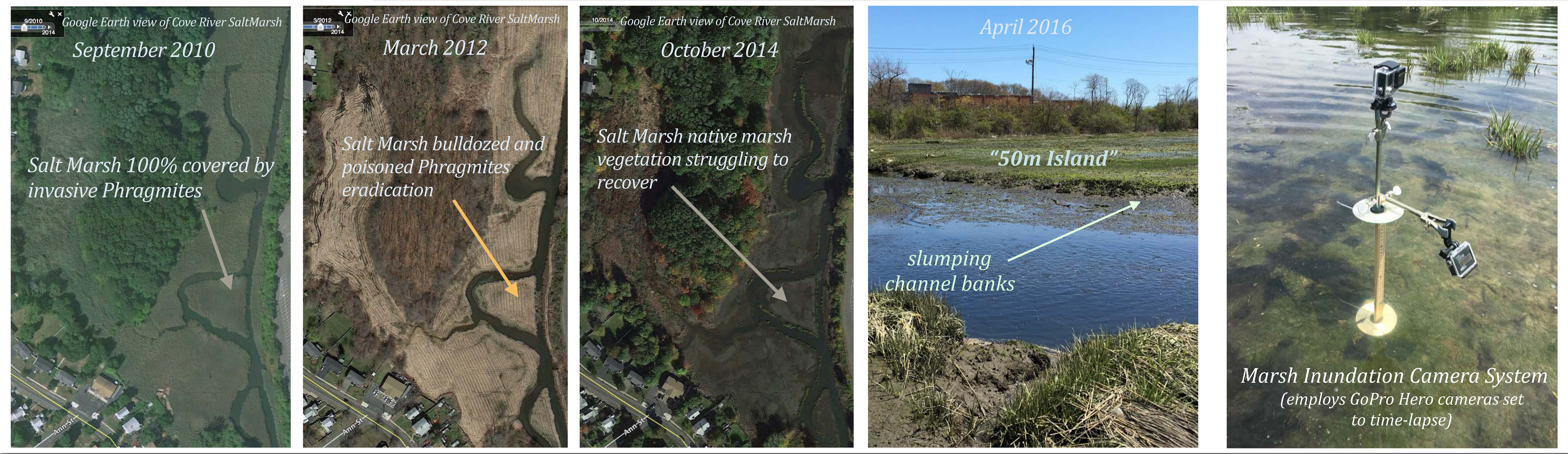
Cove River Wetland Complex, West Haven, CT

Image Mosaic and DSM processed with PIX4D mapper pro



Pix4D map/model rendering with µUAS flight path and camera locations above terrain

µUAS overview of Cove River Mid-Upper Salt Marsh Wetland area September 28th 2017



Recent views of thew Cove River Salt Marsh showing Eradication of Invasive Phragmites, Compromised Marsh, and Marsh Inundation Camera

Panorama of Lower-Mid Cove River Estuary and Salt Marsh (April 16th 2016)

Graves, S.M., 2019, Data & Policy Scale Mismatch in Coastal Systems: the potential for µUAS a new tools for monitoring coastal resilience, in Heidkamp and Morrissey (eds.) Coastal Transitions: Toward Sustainability and Resilience in the Coastal Zone, Routledge Series on Dynamics of Economic Spaces, pg 213-229.