Forecasting blue carbon in tidal marshes: The balance between carbon sequestration and methane emissions

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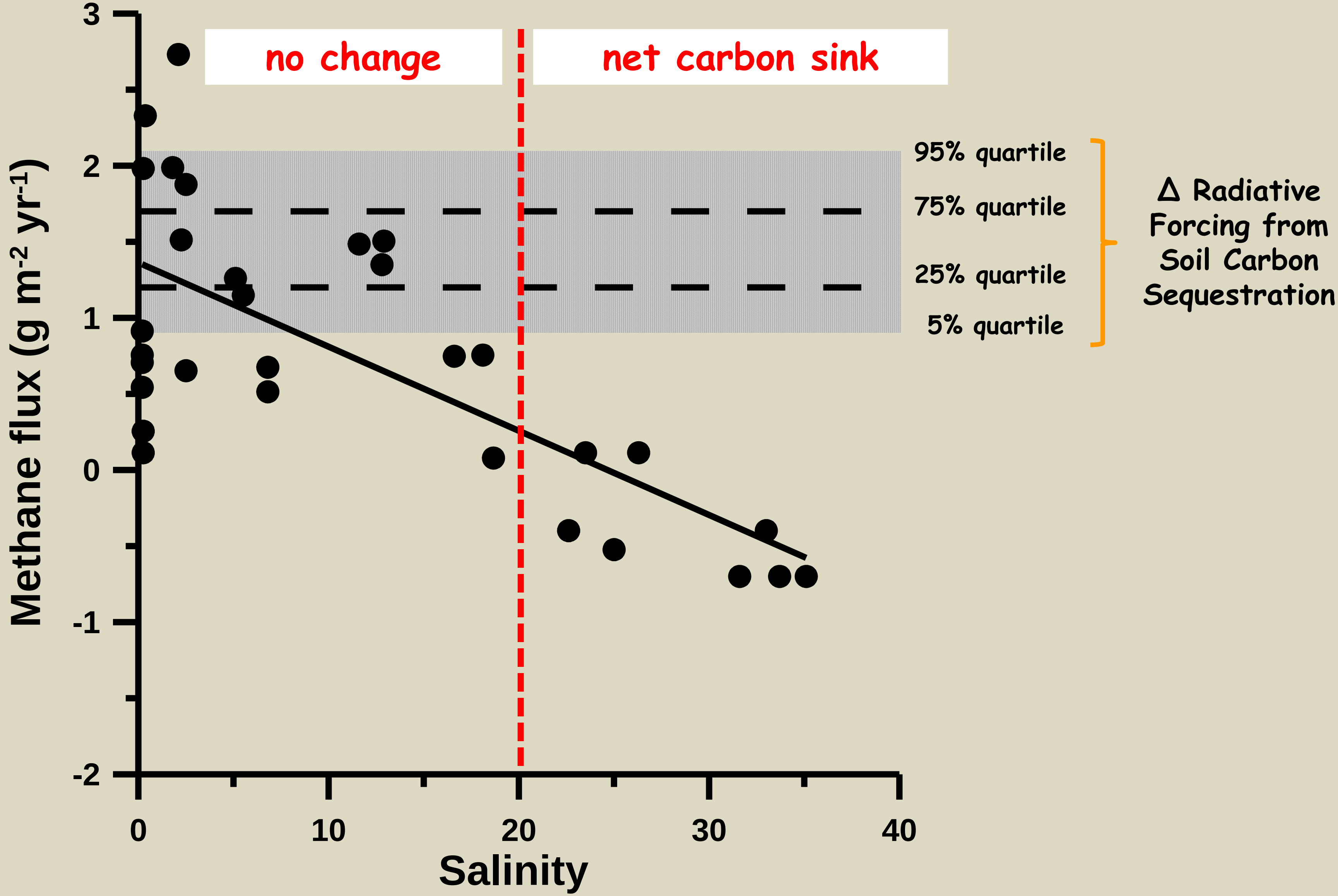
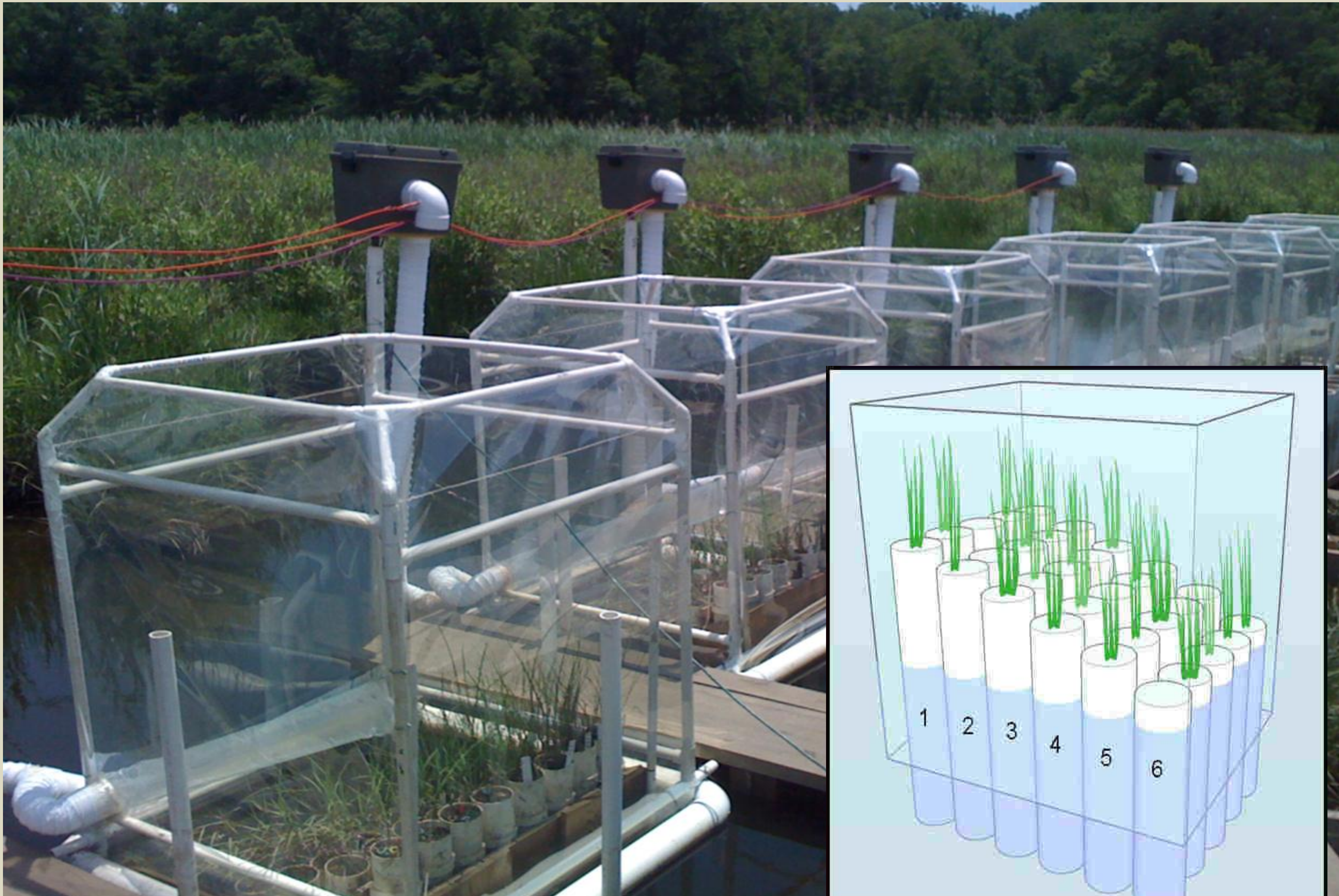
Climate Benefits of Sequestration Offset by Methane

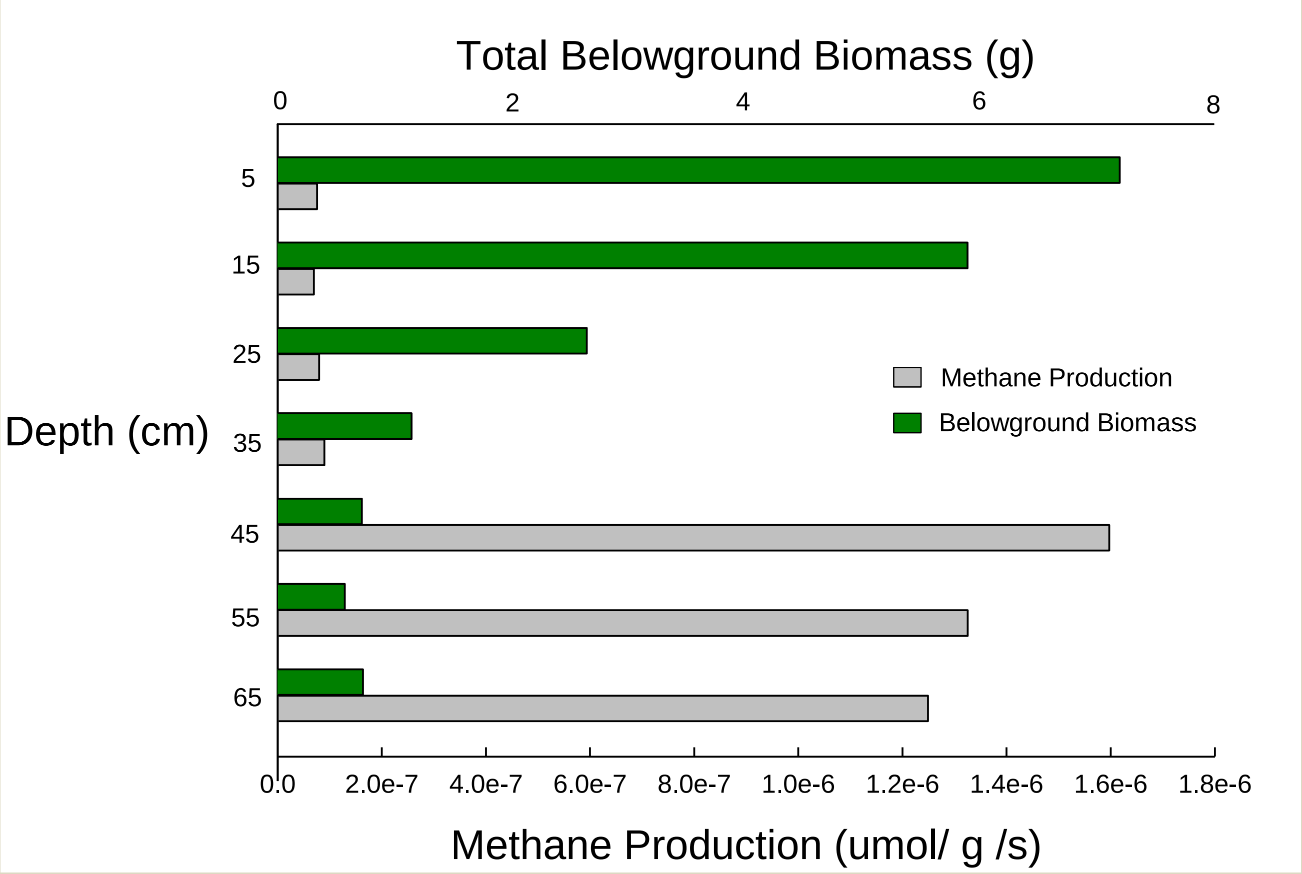


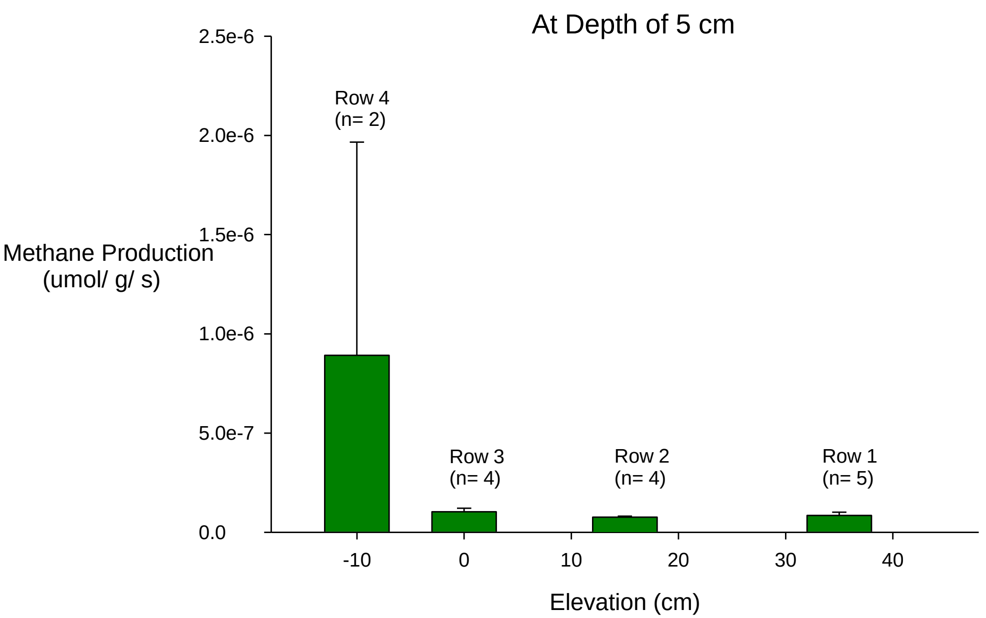
Hoffenberger, Needelman & Megonigal, 2010

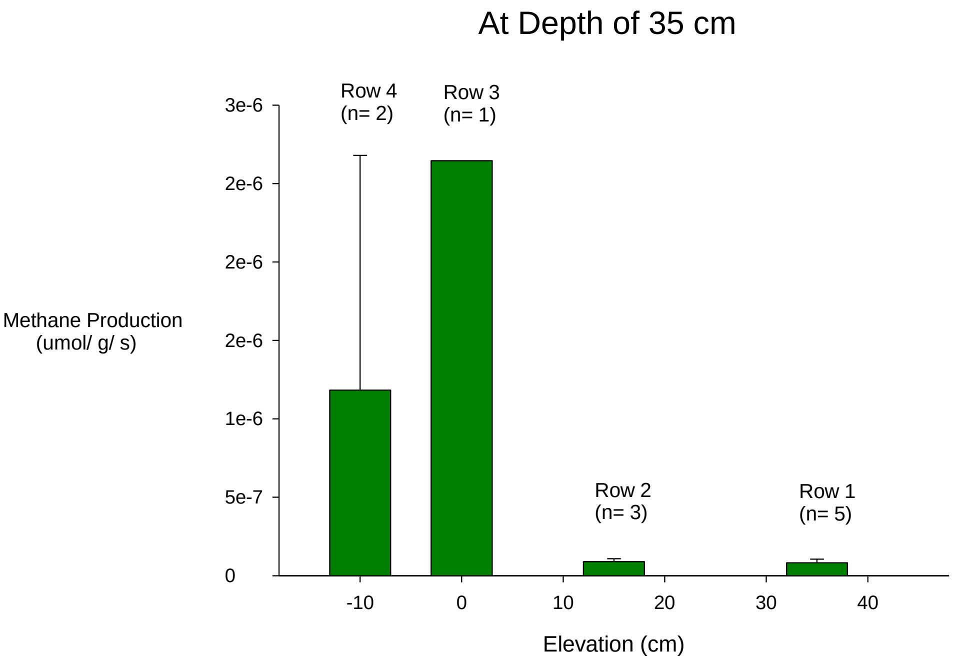
Marsh organs like they can only do at SERC



Typical Results: Note that there may be a threshold depth below which CH_4 production occurs – related to dewatering?







1. CH_4 production was greater at depth (e.g. 35 cm > 5 cm).
2. CH_4 production was greater in organ rows that were lower in elevation (e.g. -10 cm elevation > 35 cm elevation).

The results suggest there is a threshold inundation frequency across which methanogenesis is either “on” or “off”.

Features of Methane Emissions Submodel

1. Leverages existing parameters of MEM, adding just one new parameter.

2. Methanogenesis occurs only when depth is less that D* (40% inundation time).

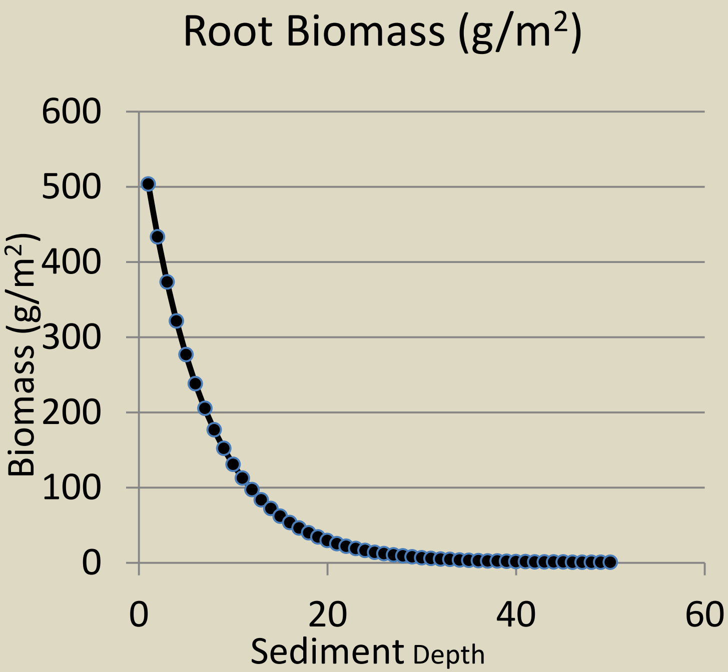
3. Methanogenesis is a constant fraction (4%) of root litter (i.e. labile carbon) decay. This fraction is the CH_4 yield coefficient.

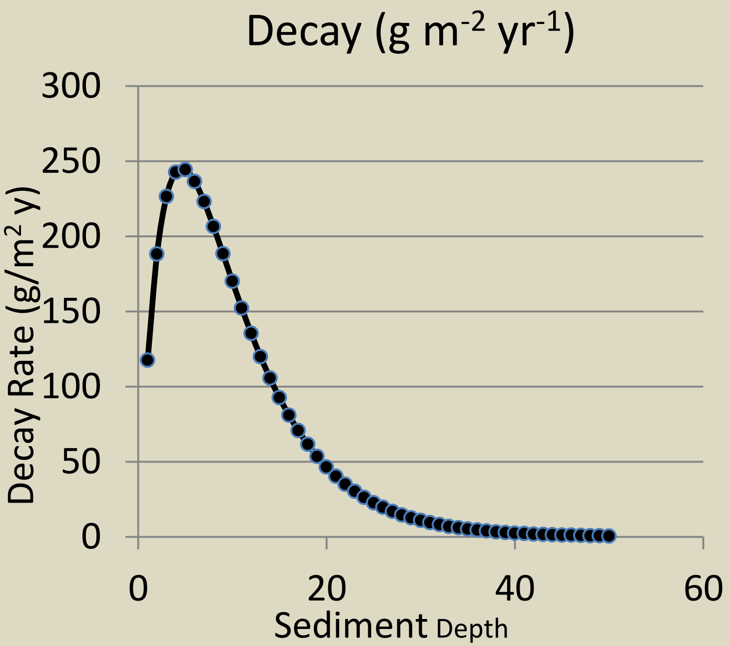
4. The CH_4 yield coefficient incorporates many processes including competition for TEAs and CH_4 oxidation.

5. Yield coefficient was adjusted so that modeled emissions at one sea level matched observed.

6. This gives an integrated rate of 26.4 g C m^{-2} yr^{-1}.

We modeled the root distribution as an exponential distribution. The total decay was proportional to root turnover and a specific decay rate. This is the resulting decay rate when the RS ratio is 4, the turnover is 1/yr, the decay rate of -0.3/yr, and the 95% rooting depth is 20 cm.

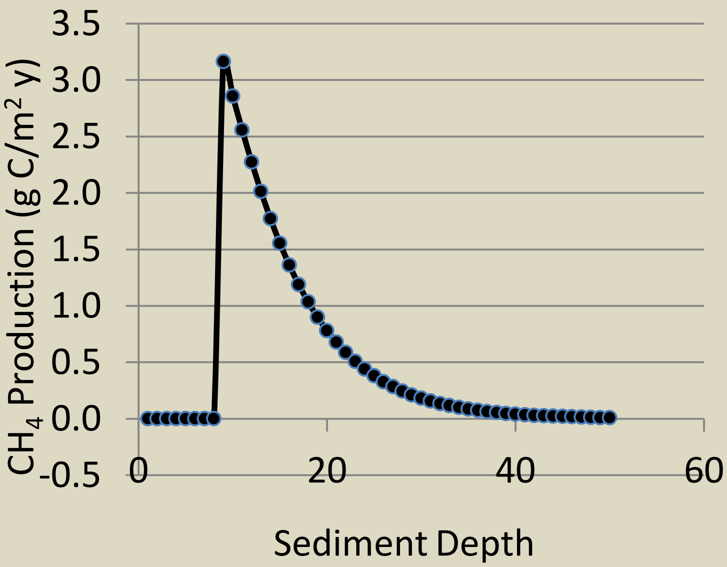




Two alternative models of methanogenesis – takes into account the saturation of sediment. It depends on relative elevation, depth, and tidal amplitude.

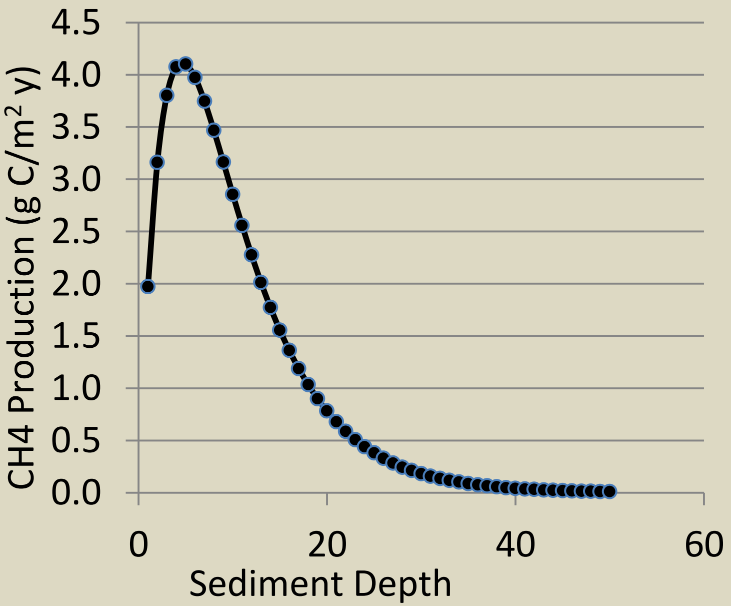
Threshold Model

1. Methanogensis occurs only when depth is less that D*
This gives an integrated rate of 26 g C m^{-2} yr^{-1}.



Proportionality Model

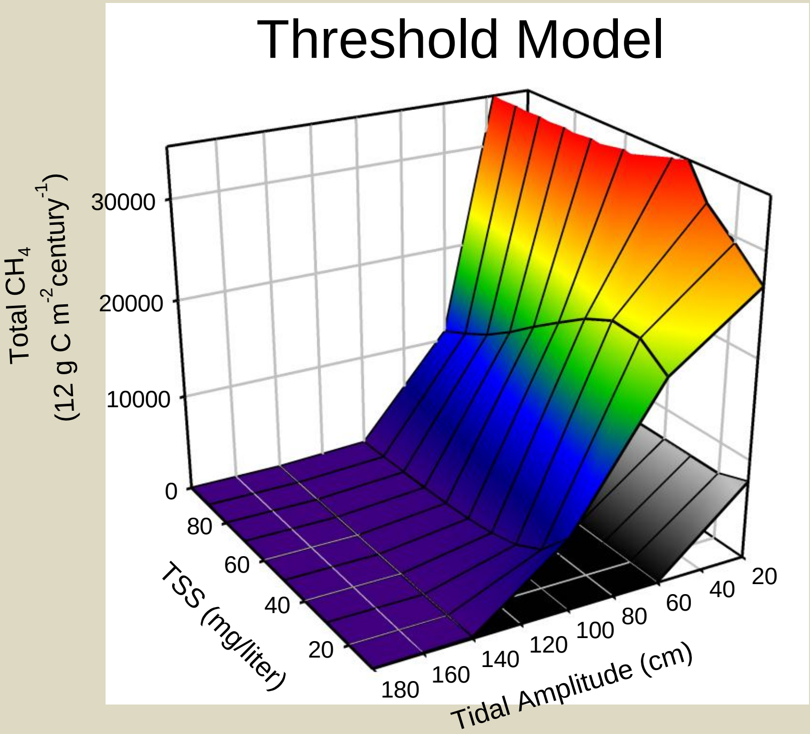
2. Methanogensis occurs only during the time that a given depth is saturated (i.e. in proportion to inundation time).

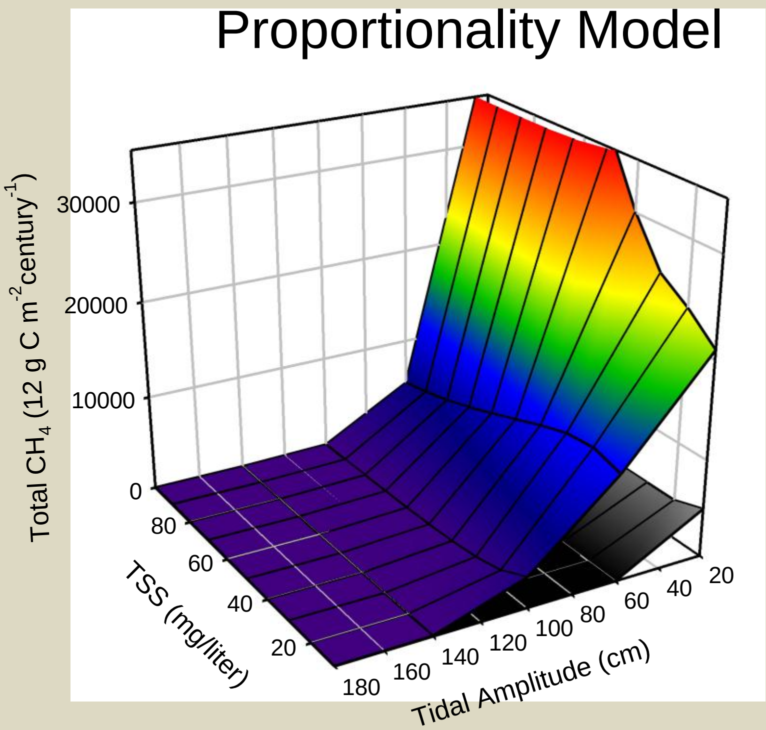


Predicted Century-Level Methane Production

MEM was run for different combinations of TSS and tidal amplitude for two sea-level rise scenarios.

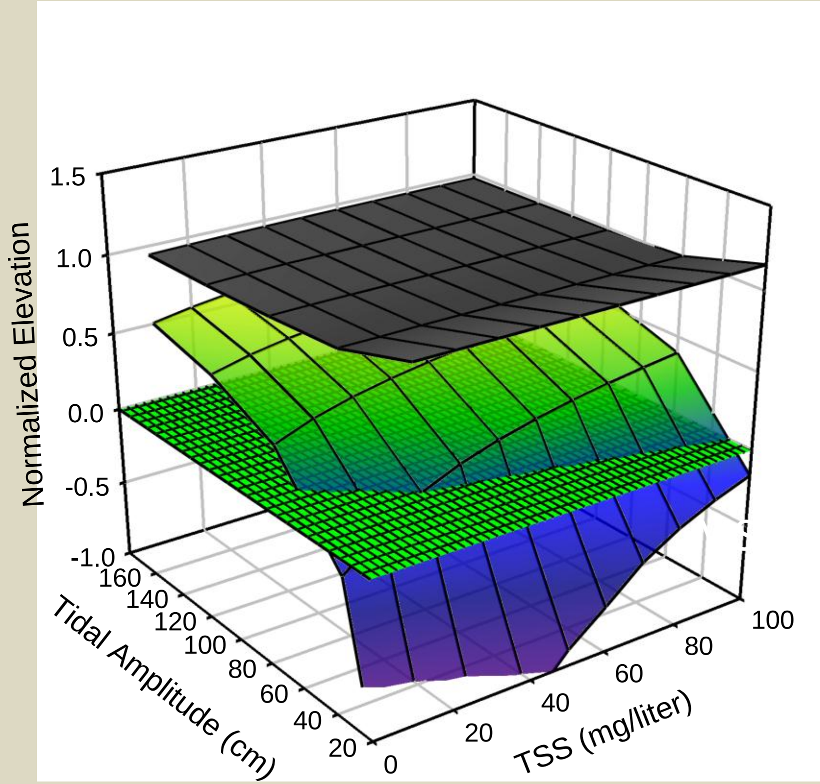
The equilibrium CH_4 production at constant SLR = 0.5 mm/yr (grey surface) and following 100 yr of accelerating sea level to 1 m (color surface).

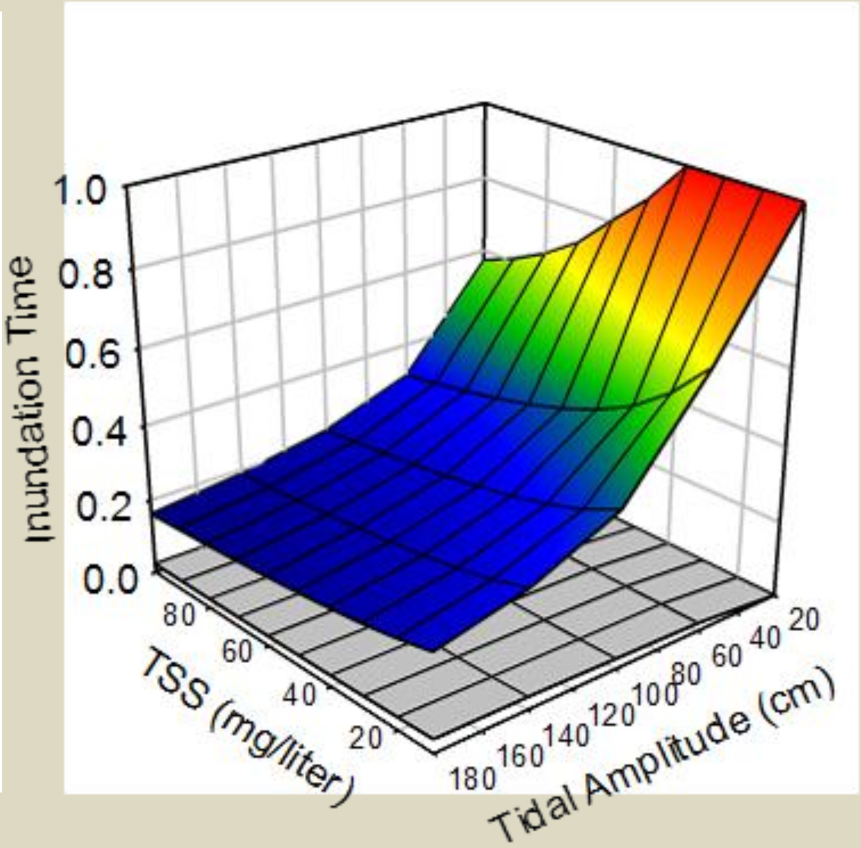




Why is CH_4 production sensitive to tidal amplitude?

The equilibrium, normalized marsh elevation (left) and inundation time (right) at constant SLR =0.5 mm/yr (grey surface) and following 100 yr of accelerating sea level to 1 m (color surface).

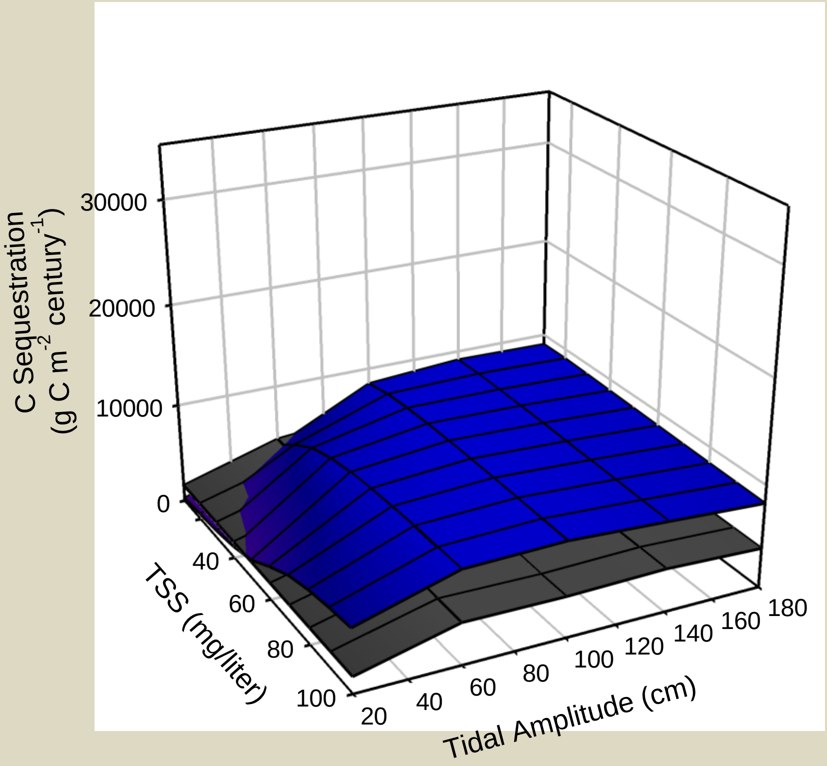




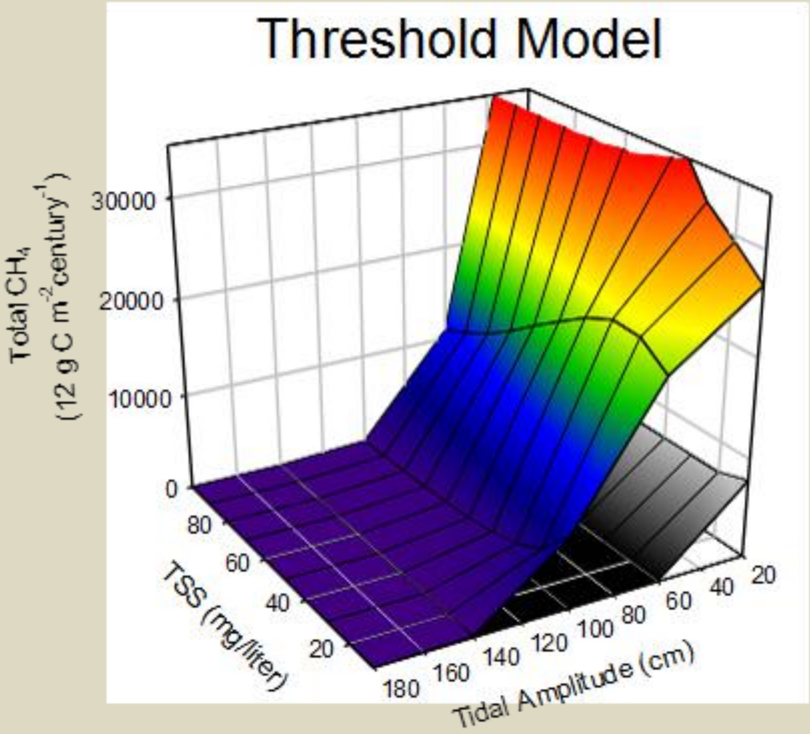
Normalized elevation = (marsh elevation – MSL)/(MHW-MSL)

Equilibrium rates of C sequestration and CH_4 emissions at constant SLR =0.5 mm/yr (grey surface) and following 100 yr of accelerating sea level to 1 m (color surface).

Century Level
C Sequestration Rate



Century Level
CH_4 Emissions (CO_2 Equivalent)



Conclusions

1. Methane emissions are far more important in microtidal than in macrotidal estuaries.
2. C-sequestration is more important in macrotidal than in microtidal estuaries and will increase with an acceleration in SLR, at least over the next century.
3. Methane emissions will surpass C-sequestration in microtidal estuaries with accelerating SLR over the next century, resulting in positive feedback.

Caveats

1. The refractory fraction of organic production is invariant
2. The RS ratio and root turnover rate are invariant
3. CH_4 yield was invariant and calibrated for a single brackish marsh.
4. Salinity is constant

Acknowledgements

We thank

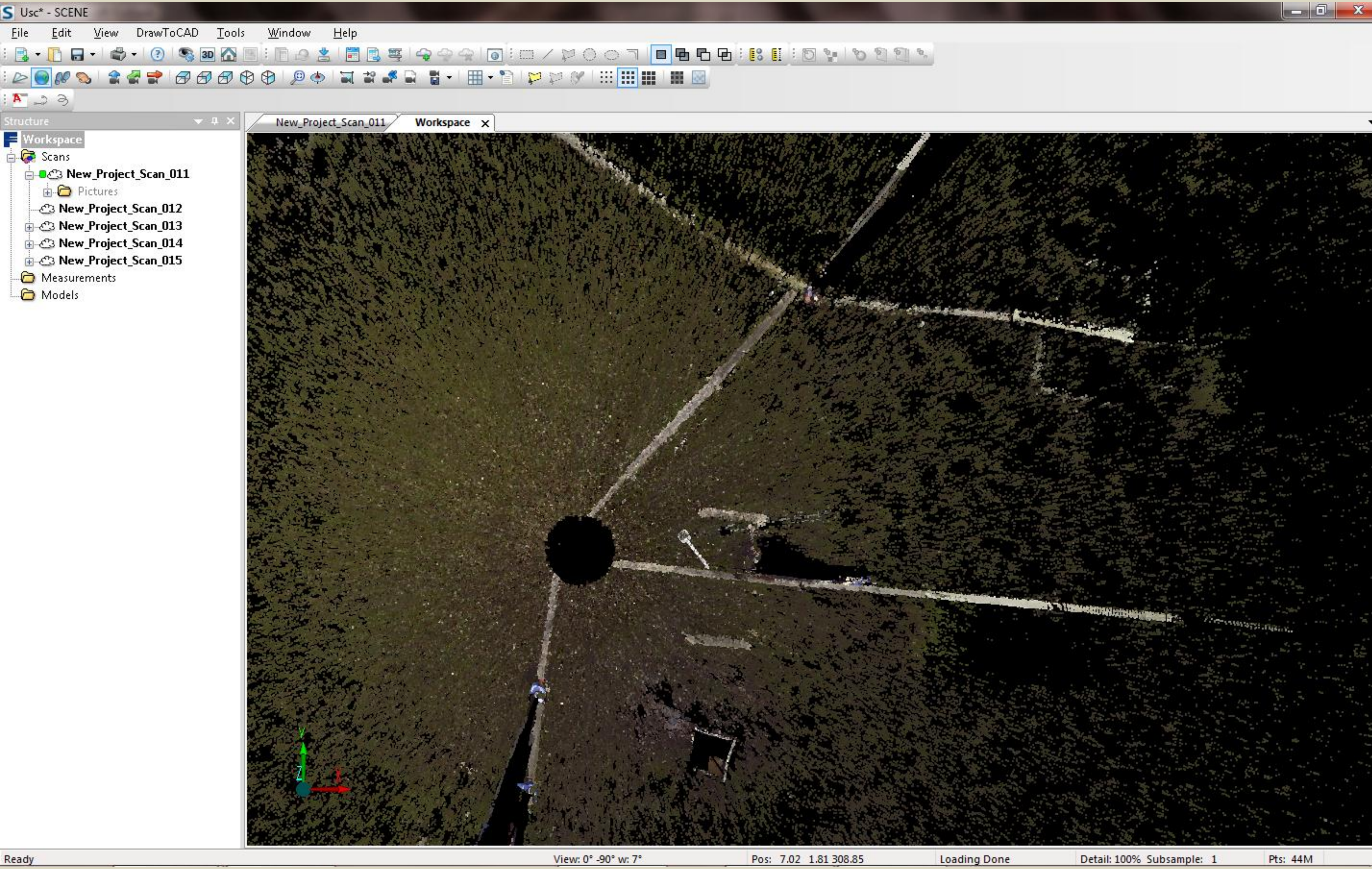
Adam Langley
Tom Mozdzer
and Karen Sundberg for their invaluable assistance

and

NSF

The only agency that will pay you to watch grass grow

A 3-D scan of North Inlet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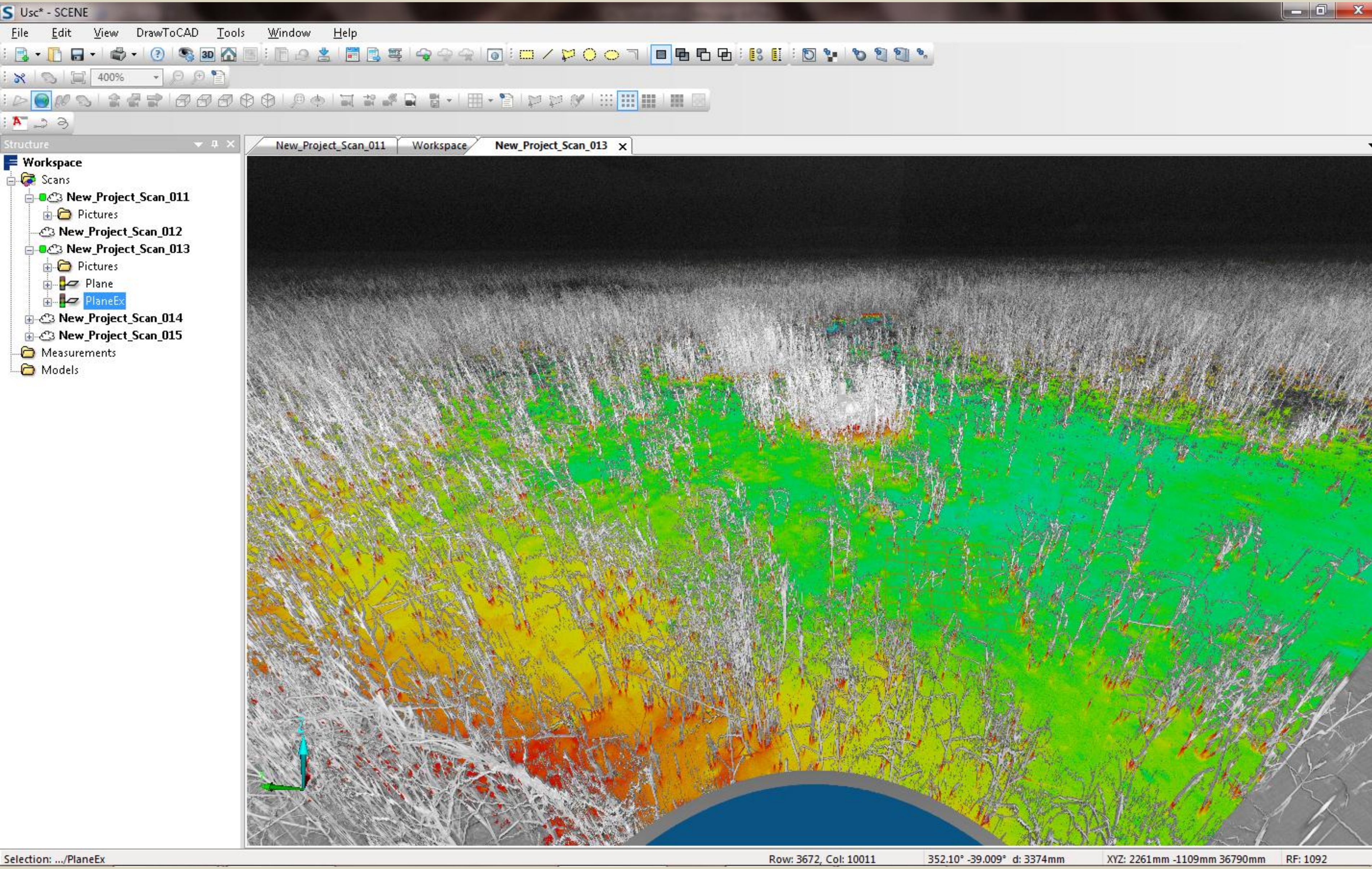
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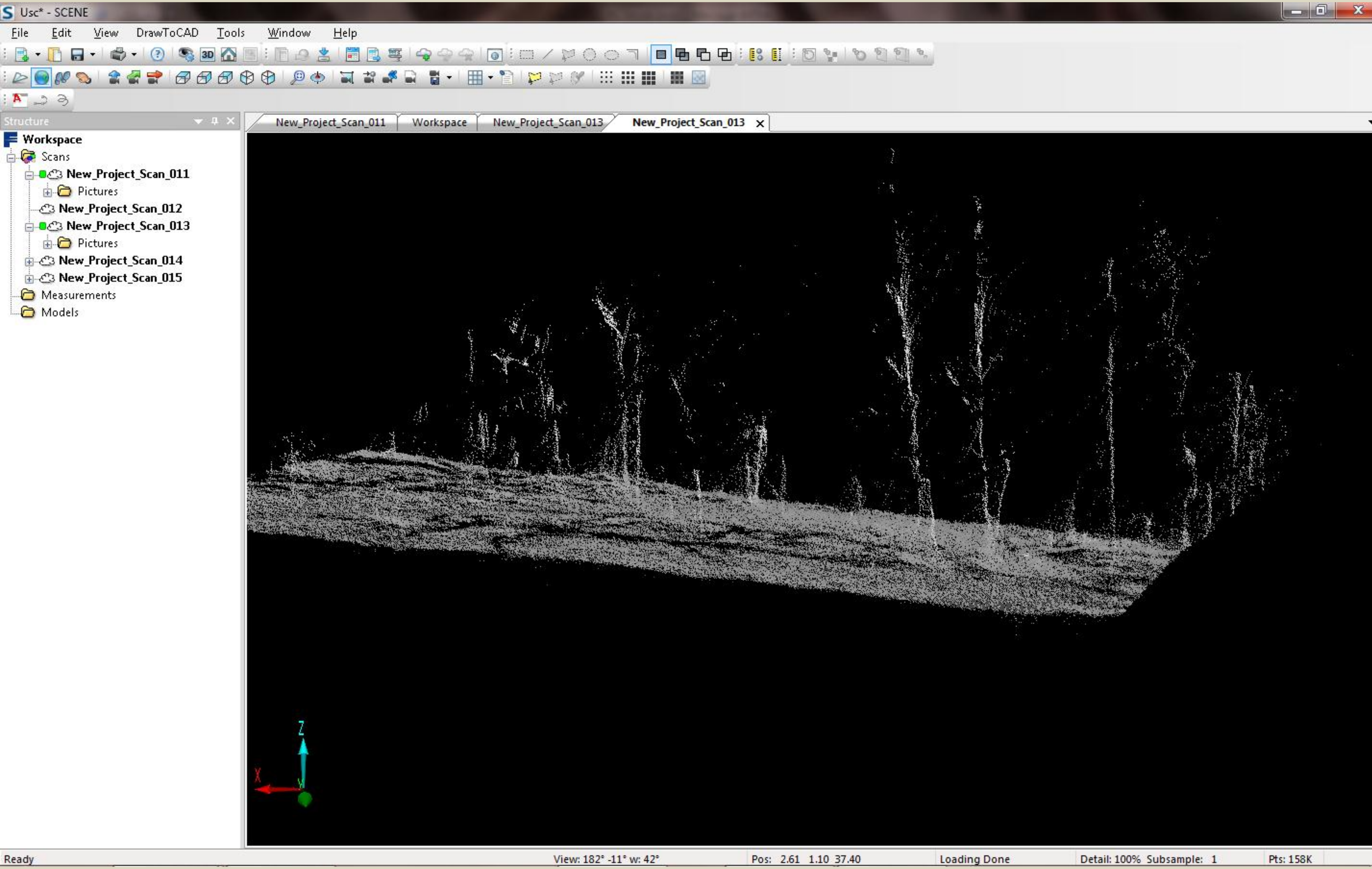
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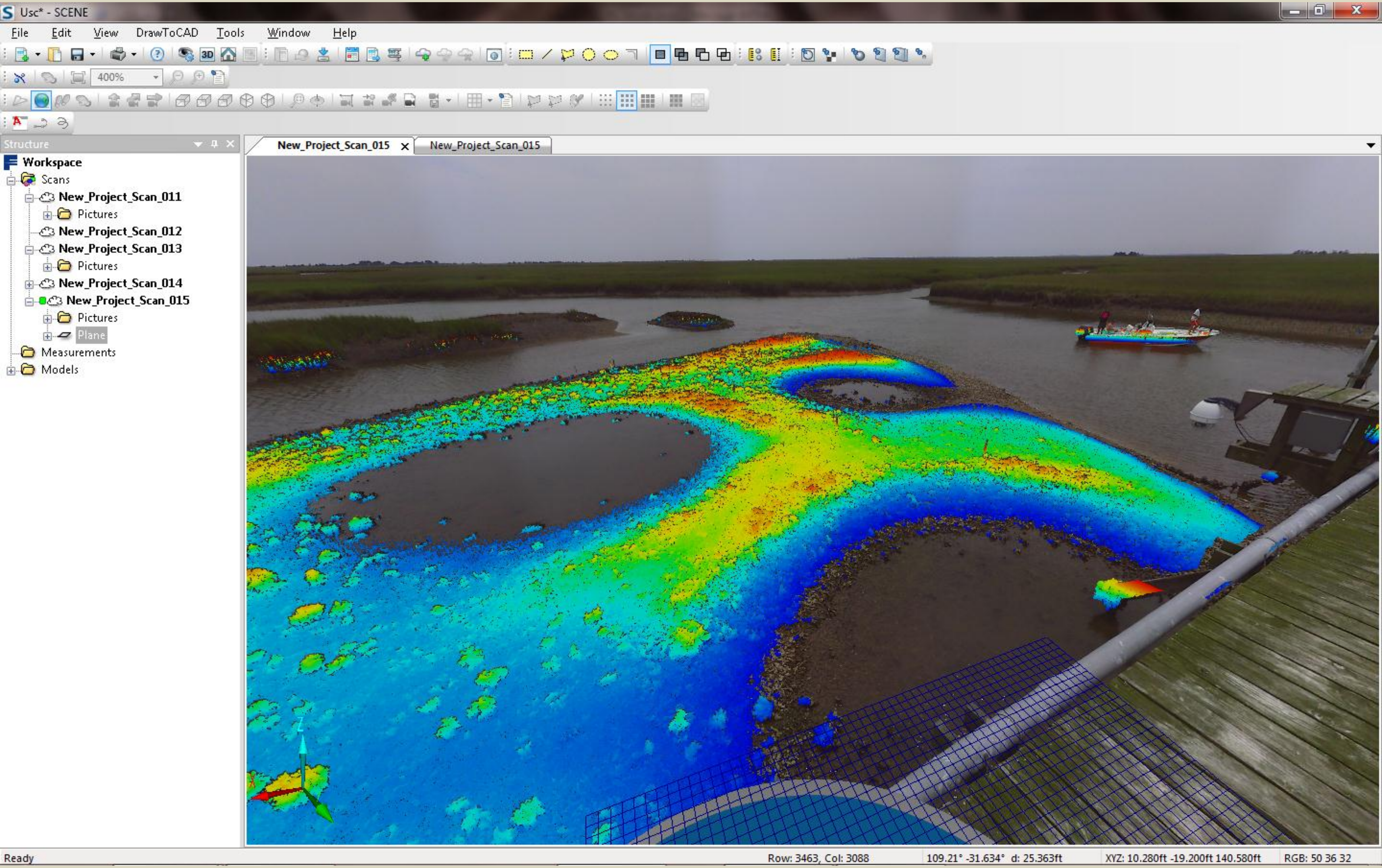
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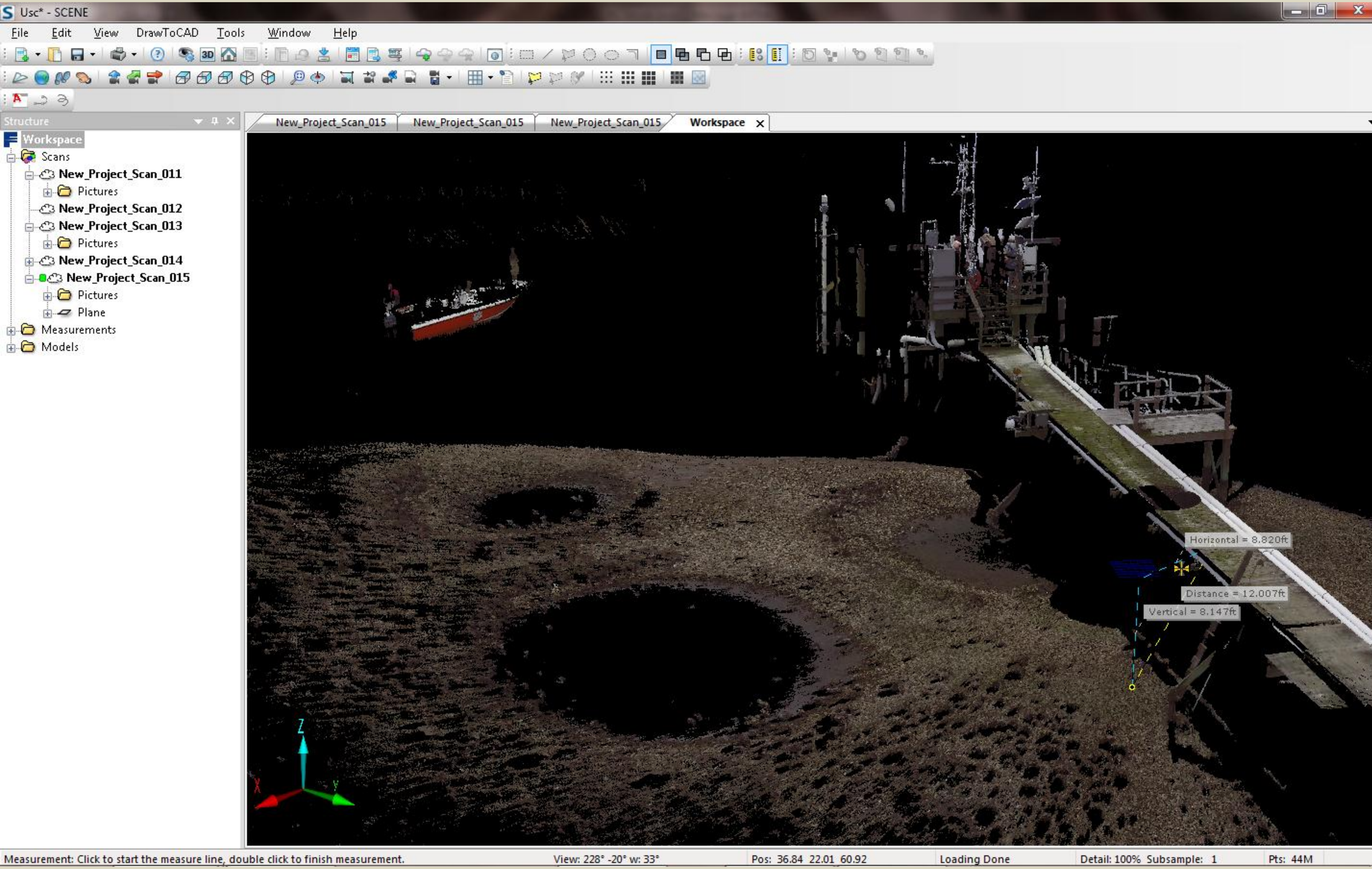
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