Investigation of the environmental impact of annual sea level rise variability on the deltaic landscape evolution in estuarine environments

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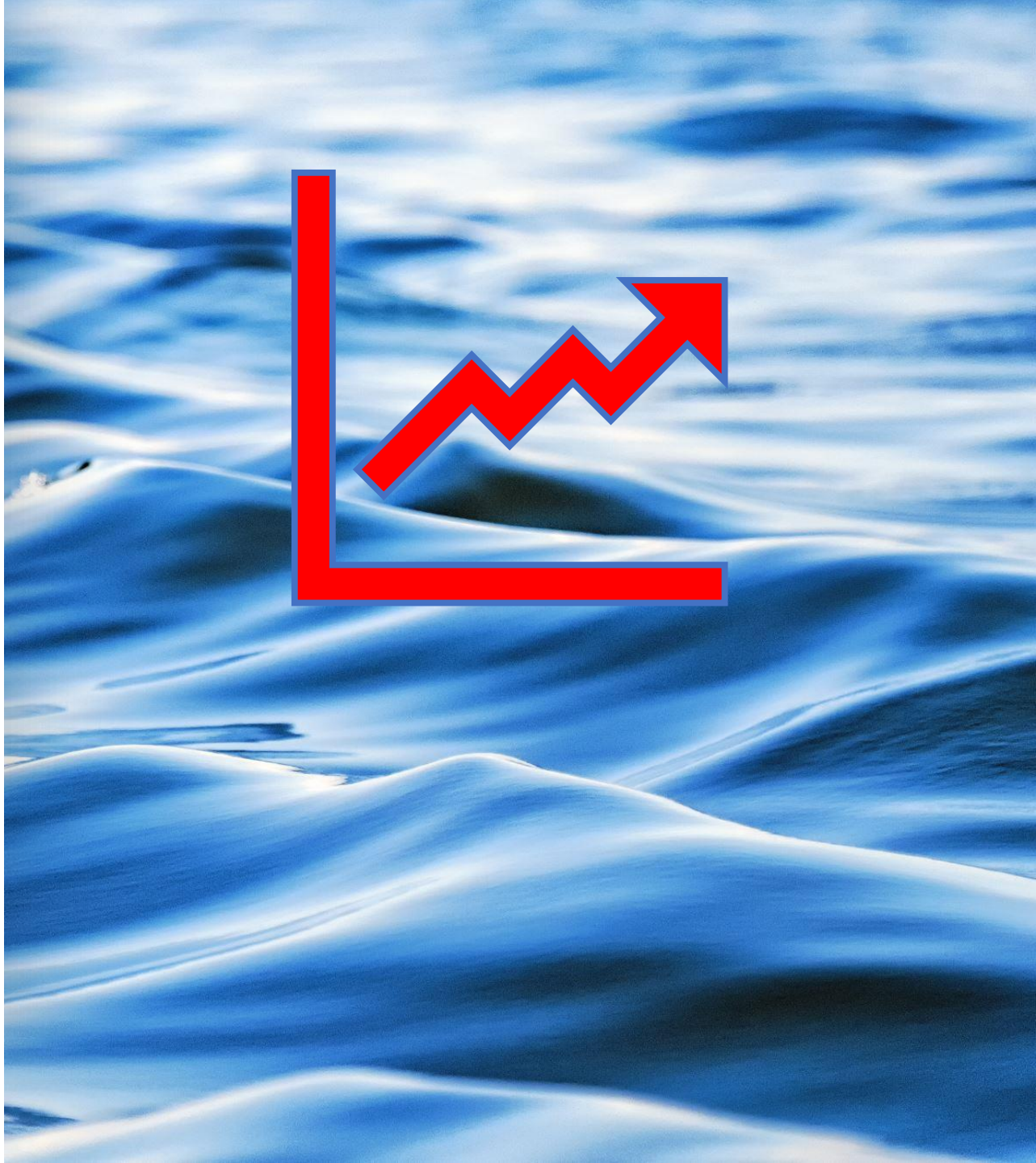
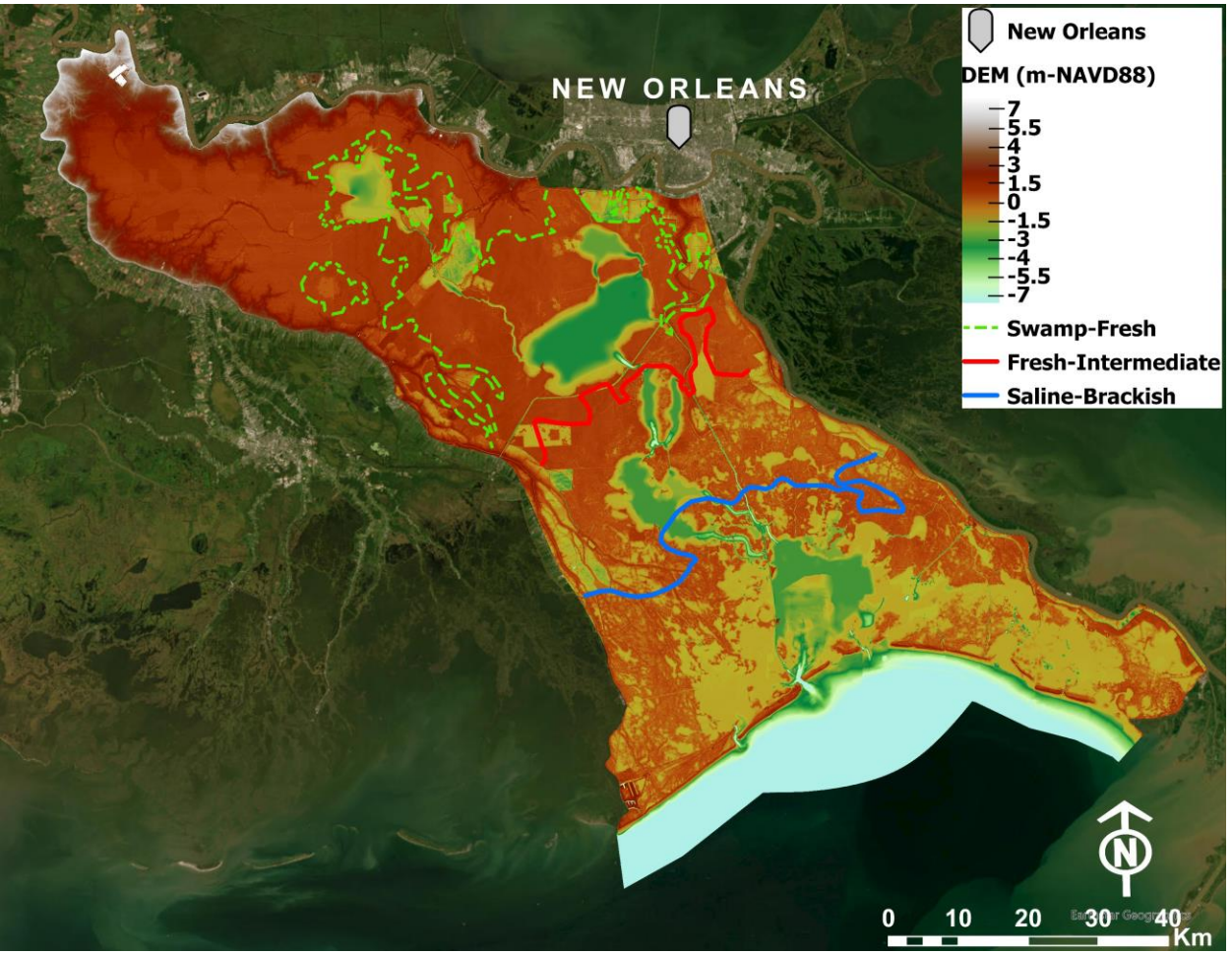
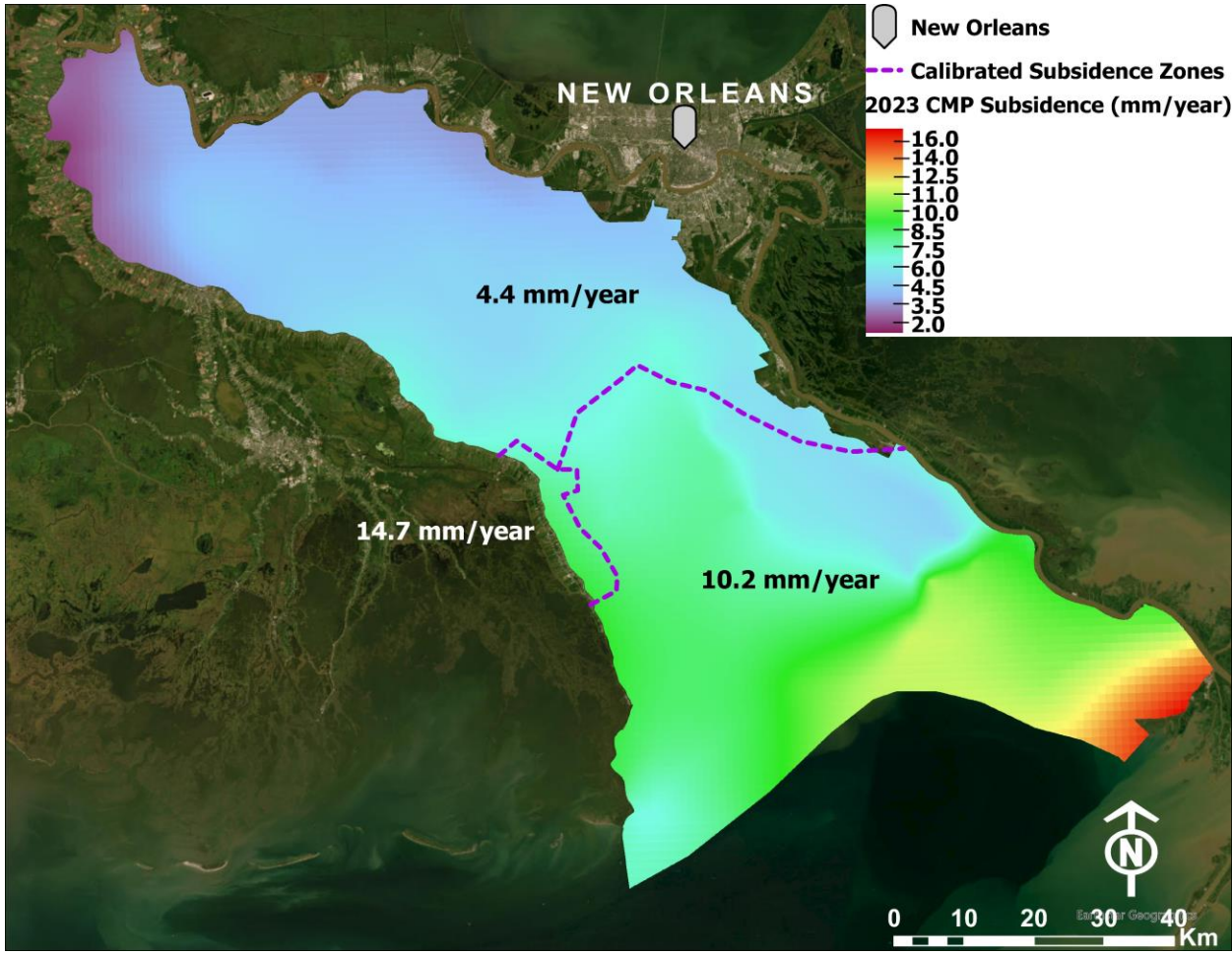
Introduction and Study Objective

- Most planning and feasibility efforts simplify sea level rise (SLR) as a smooth curve to represent the impact of long-term increase in sea level
- Annual variability in SL can significantly impact these dynamic ecosystems
- This study explores the impact of the annual SL variability on land loss in coastal ecosystems
- We explored three SLR estimates (2 m, 1.1 m, and 0.6 m by 2100) along with various annual variability estimates



Study Area


NEW ORLEANS
New Orleans
DEM (m-NAVD88)
7
5.5
4
3
1.5
0
-1.5
-3
-4
-5.5
-7
Swamp-Fresh
Fresh-Intermediate
Saline-Brackish
N
0 10 20 30 40
Km


NEW ORLEANS
New Orleans
Calibrated Subsidence Zones
2023 CMP Subsidence (mm/year)
16.0
14.0
12.5
11.0
10.0
8.5
7.5
6.0
4.5
3.5
2.0
4.4 mm/year
14.7 mm/year
10.2 mm/year
N
0 10 20 30 40
Km

Simplified Biophysical Model

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Development and application of a simplified biophysical model to study deltaic and coastal ecosystems

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Toward understanding the hydrologic, ecologic and community flooding implications of coastal restoration strategies: Sediment diversions

Ahmed M. Khalifa [a,*], Ehab A. Meselhe [a], Kelin Hu [a], Denise Reed [b], Rachel Rhode [c], Natalie L. Snider [d]

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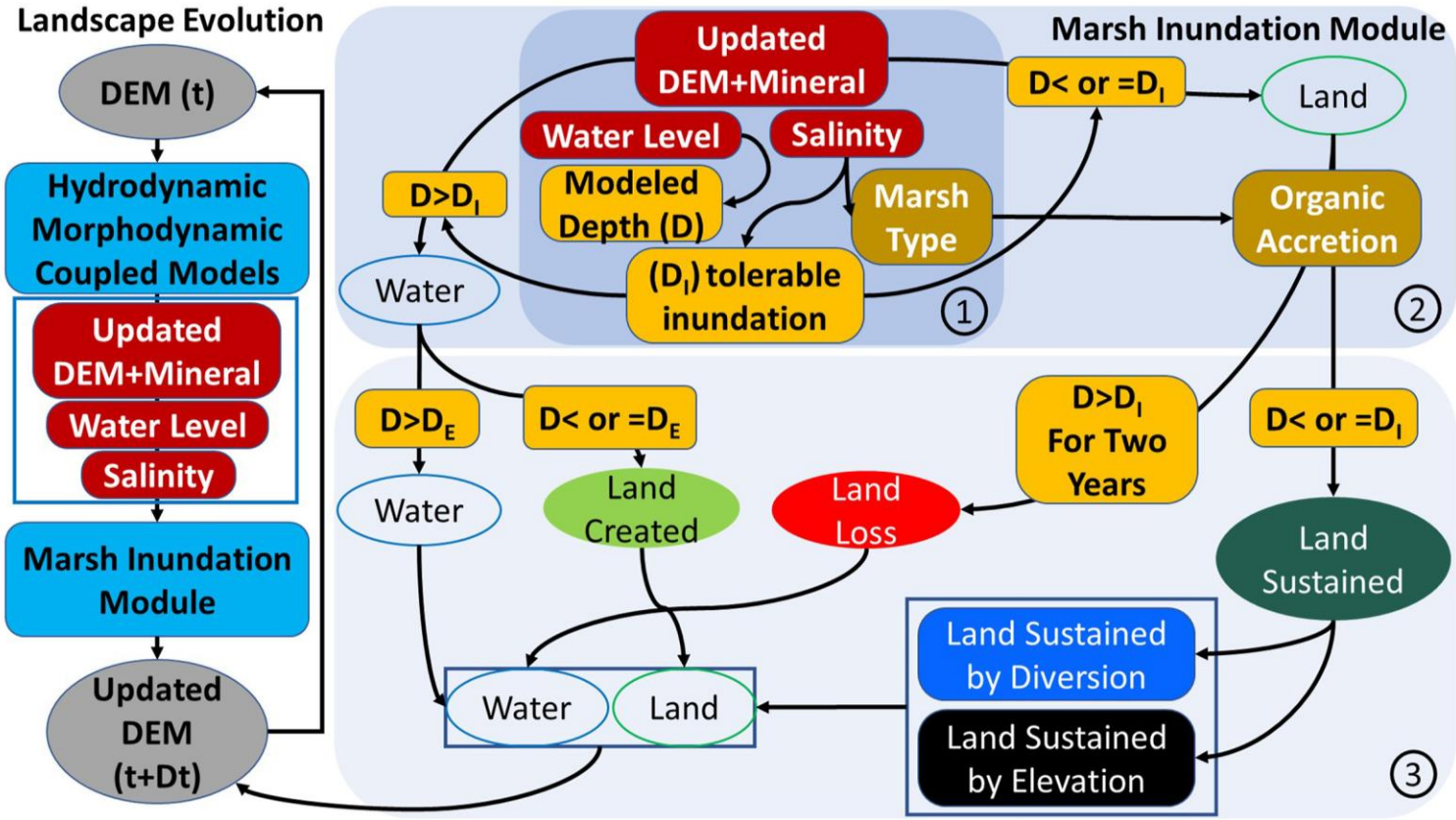
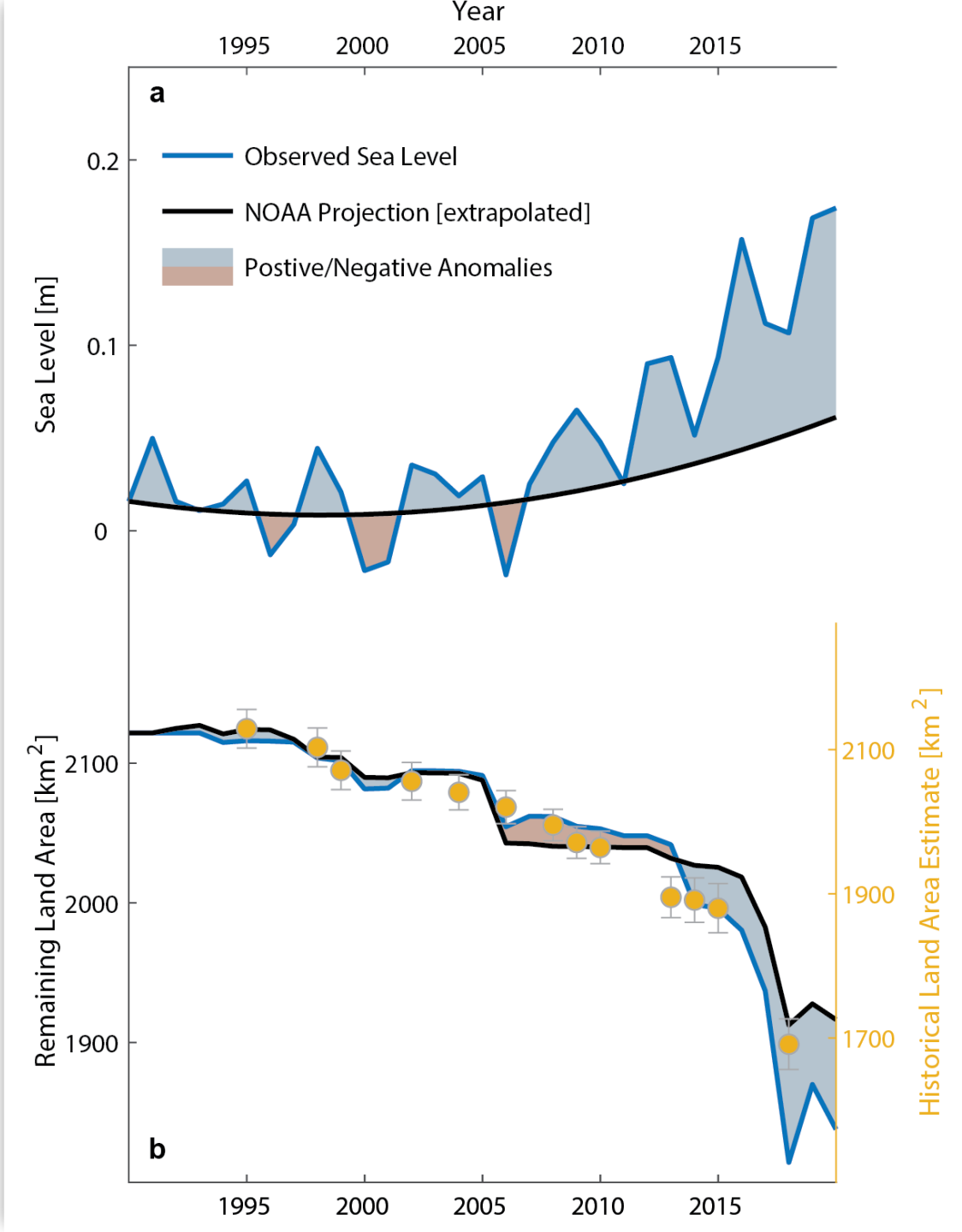
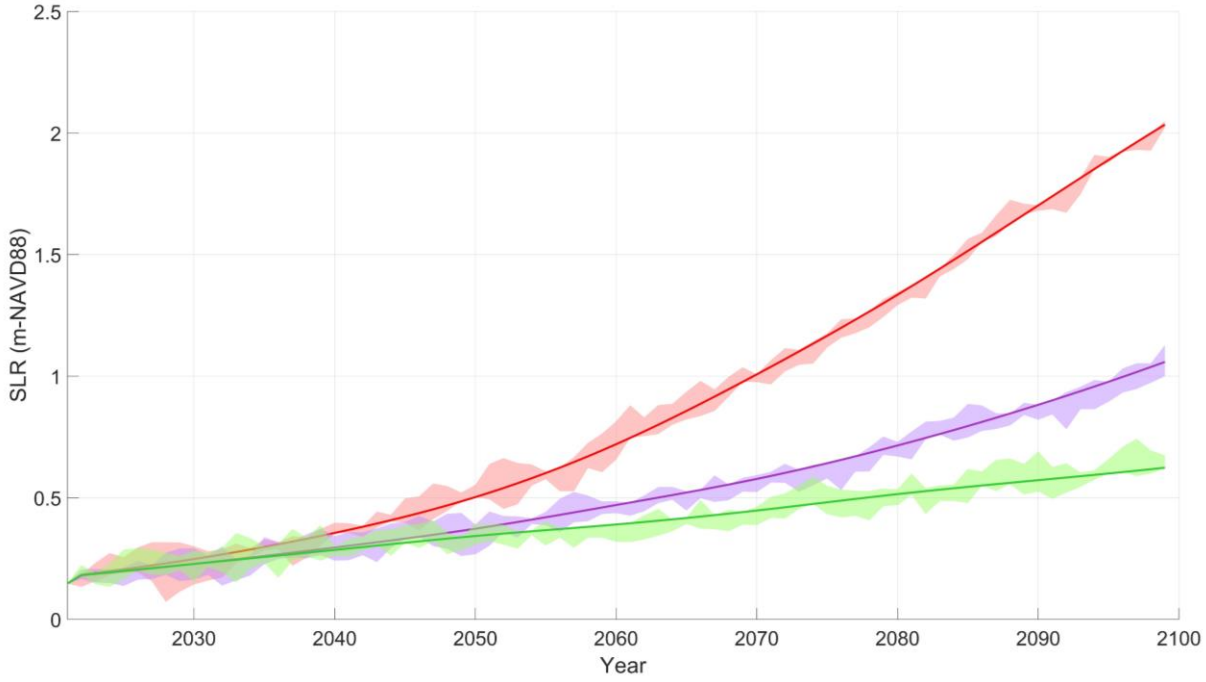


Impact of SL Variability on Barataria Land Change

- Observed sea level between 1990 and 2020 for Grand Isle, Louisiana compared to NOAA projection
- Impact of SL variability is evident in the response of land change to the accelerated/decelerated rates
- Hindcast of wetland loss using the observed Grand Isle record (blue line) versus the NOAA projection (black line).

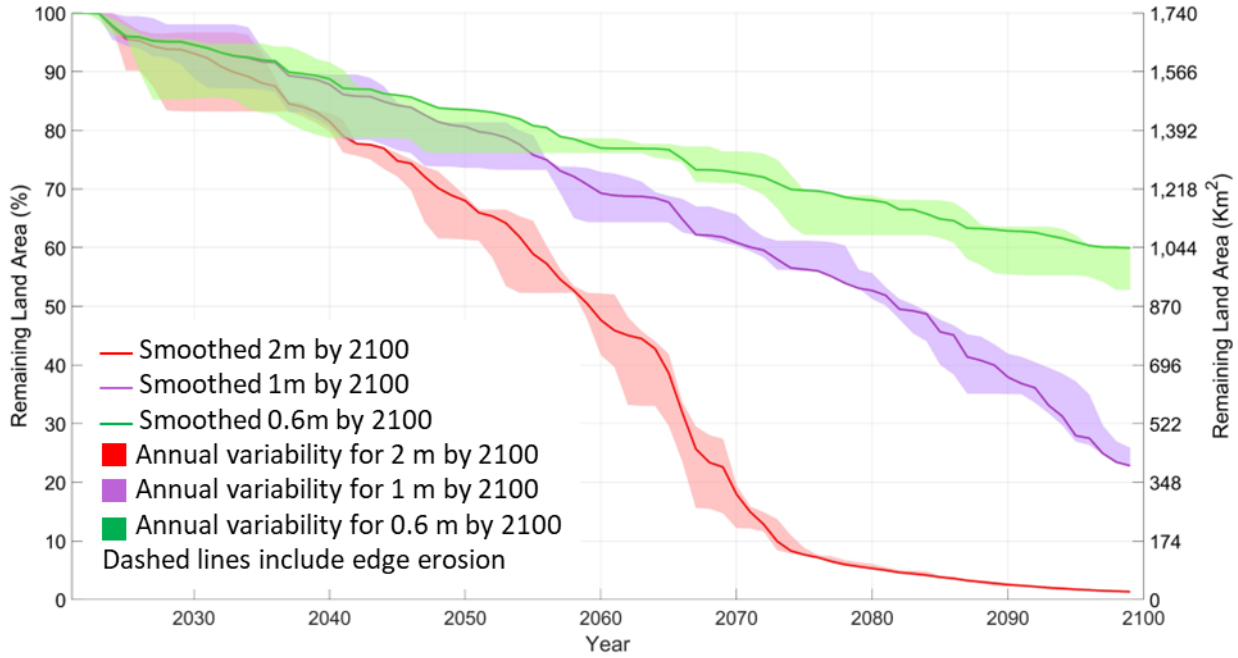


Projected SLR and Annual Variability Scenarios

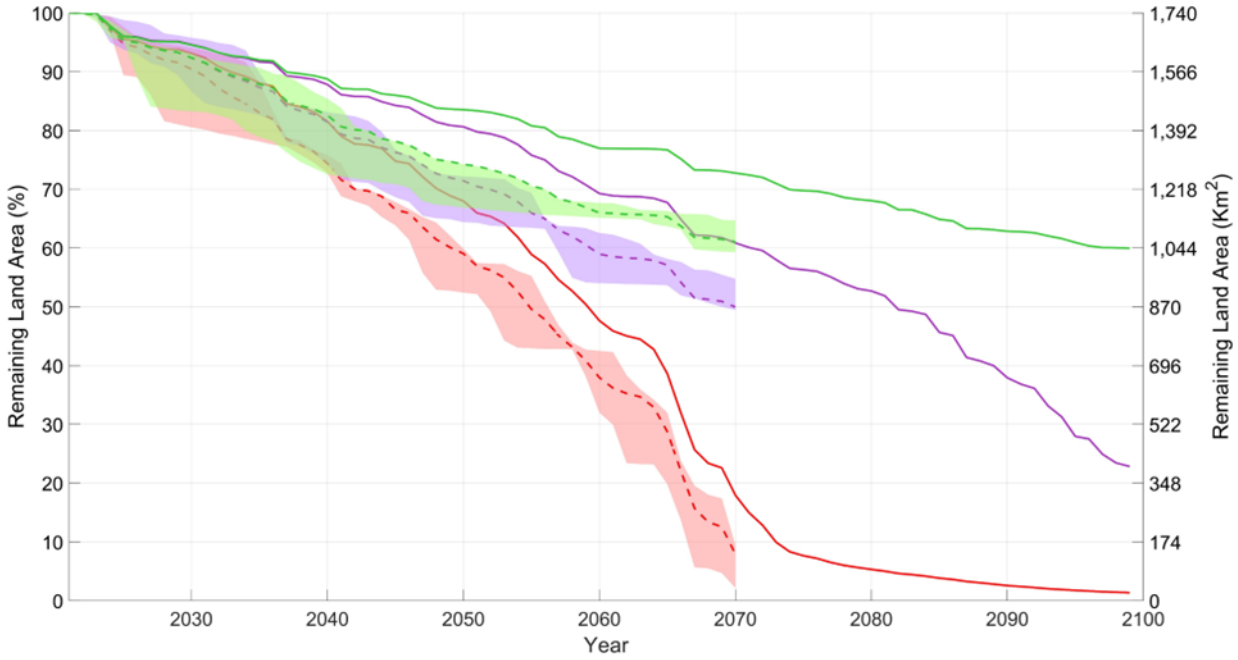


- Superimposed regional randomizations of the regional SL variability (colored shaded bounds).
- 0.6 m by 2100
- 1 m by 2100
- 2 m by 2100

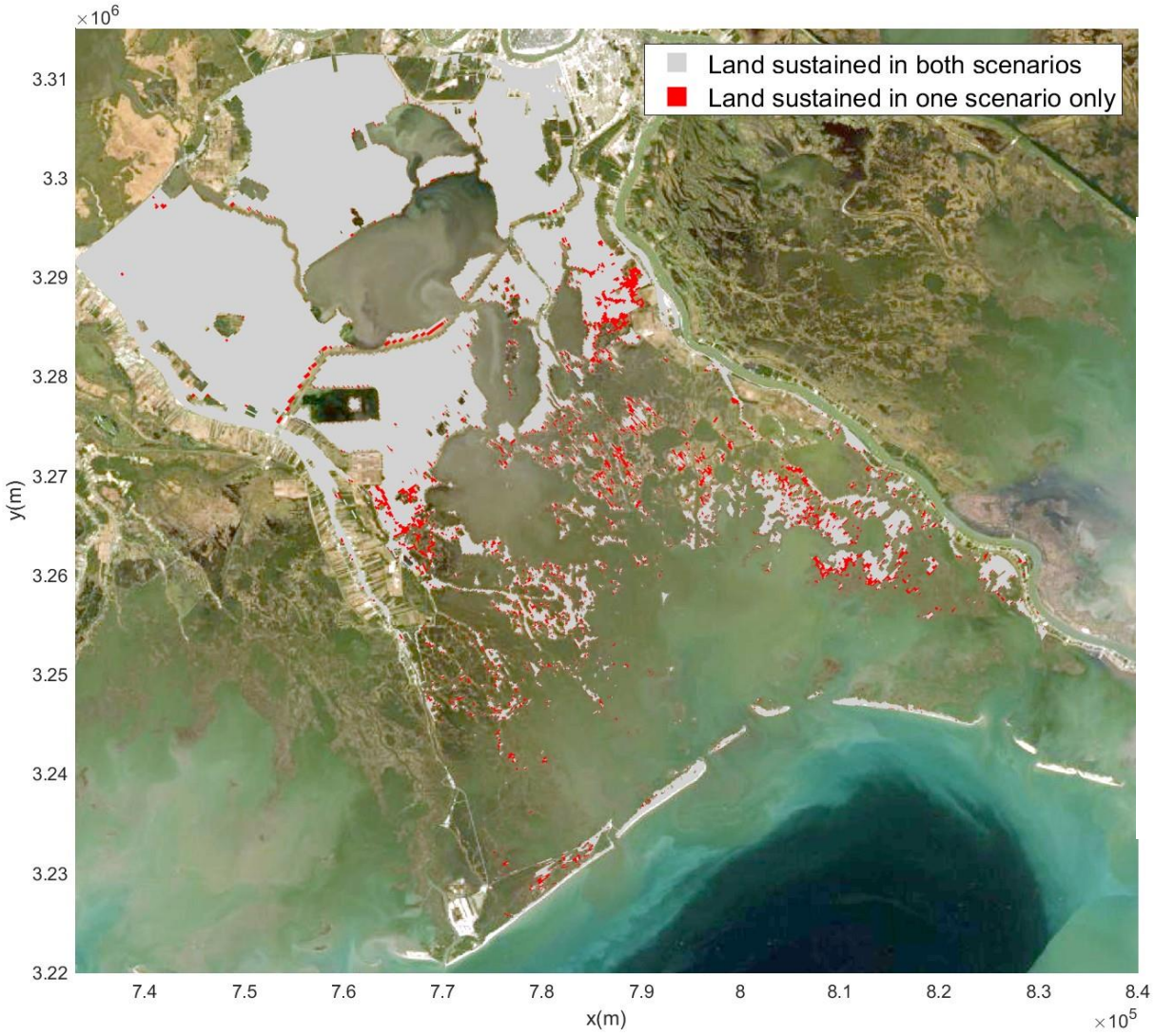
Landscape Change Under SLR Scenarios

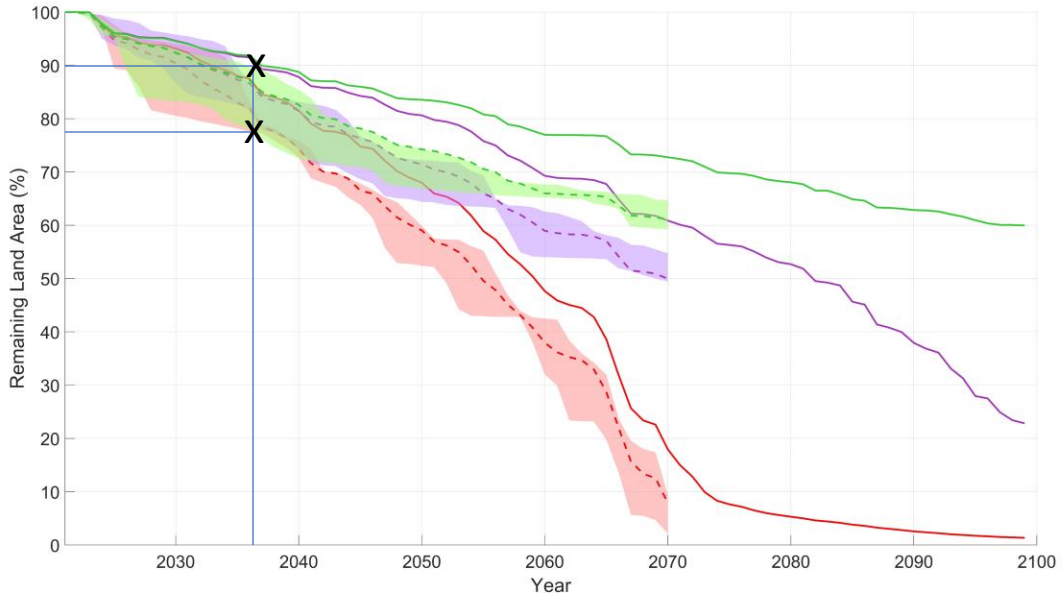


- Land change projections in Barataria using the smoothed and the regionally randomized SLR rate
- Impact of marsh edge erosion based on Reed et. al., (2020) is superimposed

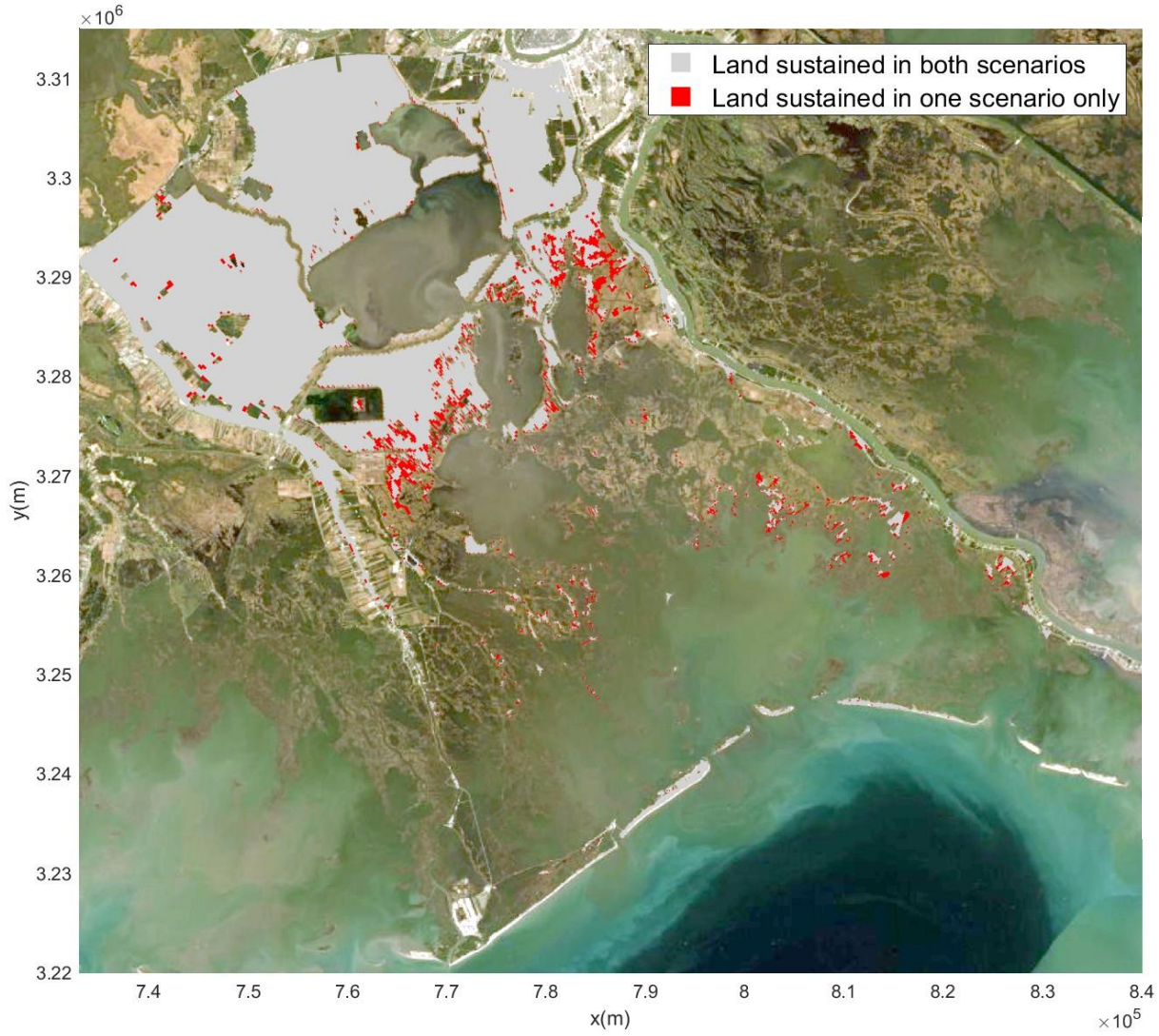


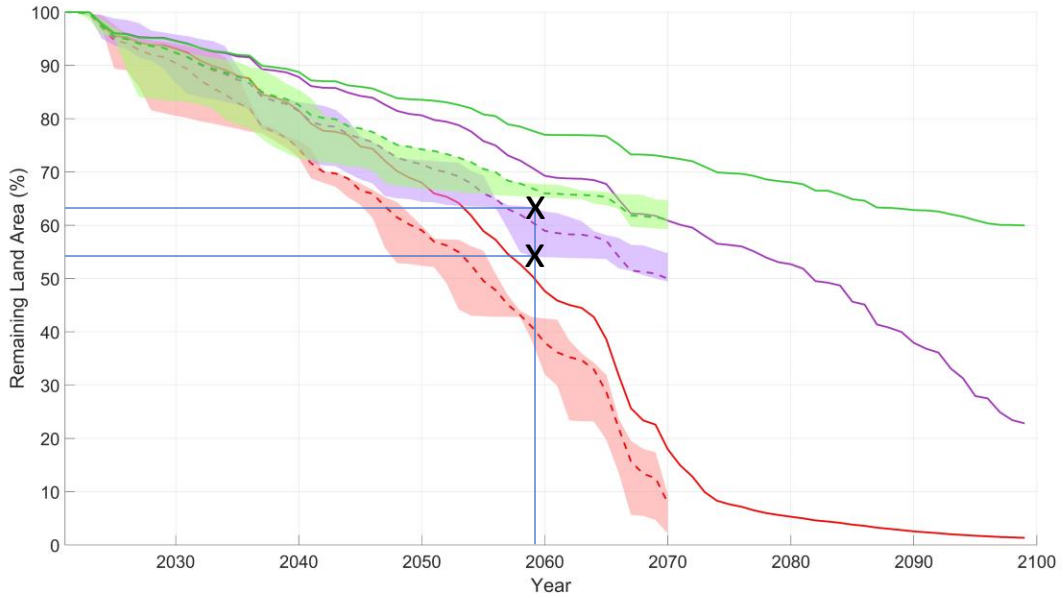
Land Change Comparison (0.6 m by 2100 at 2036)



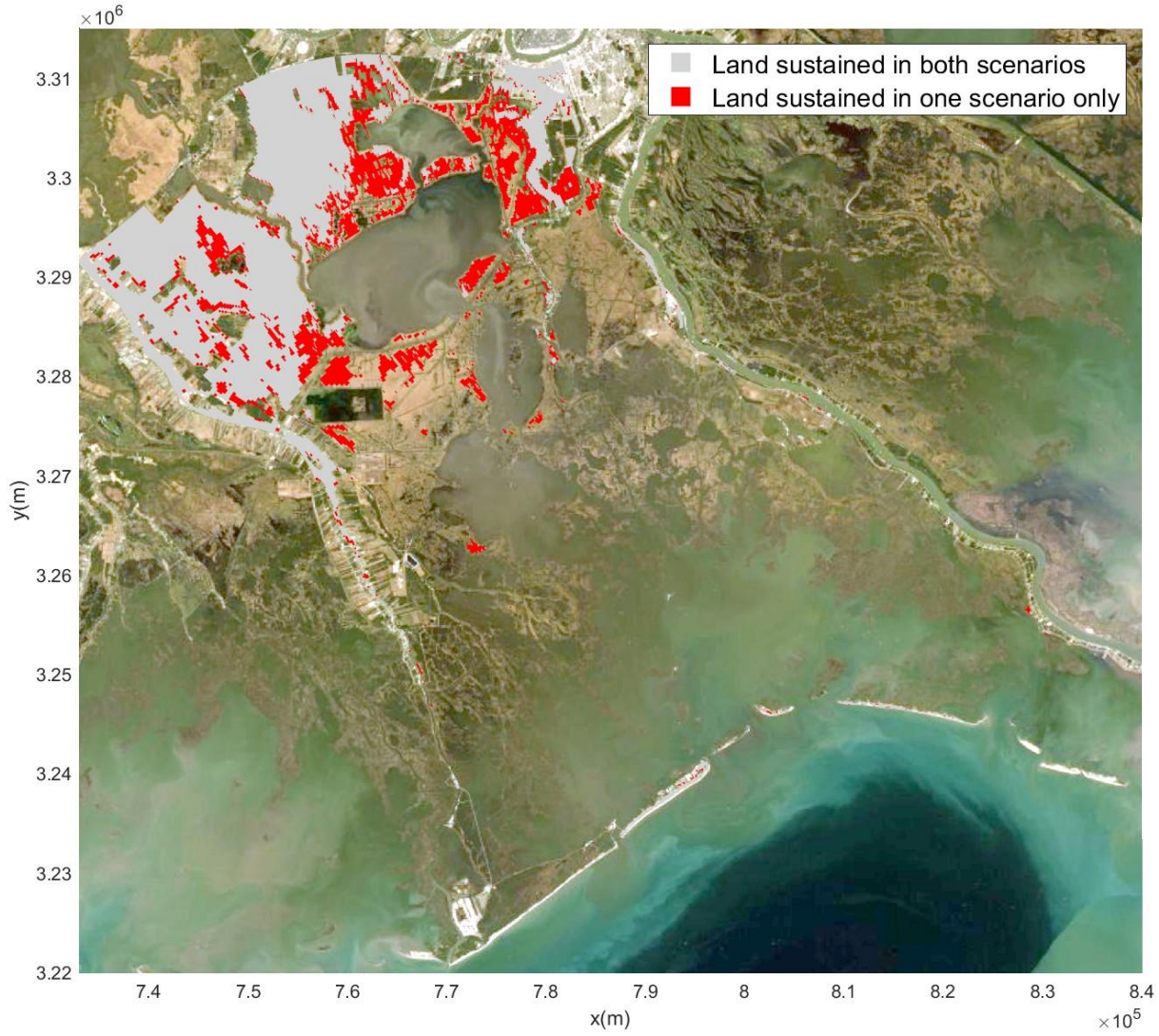


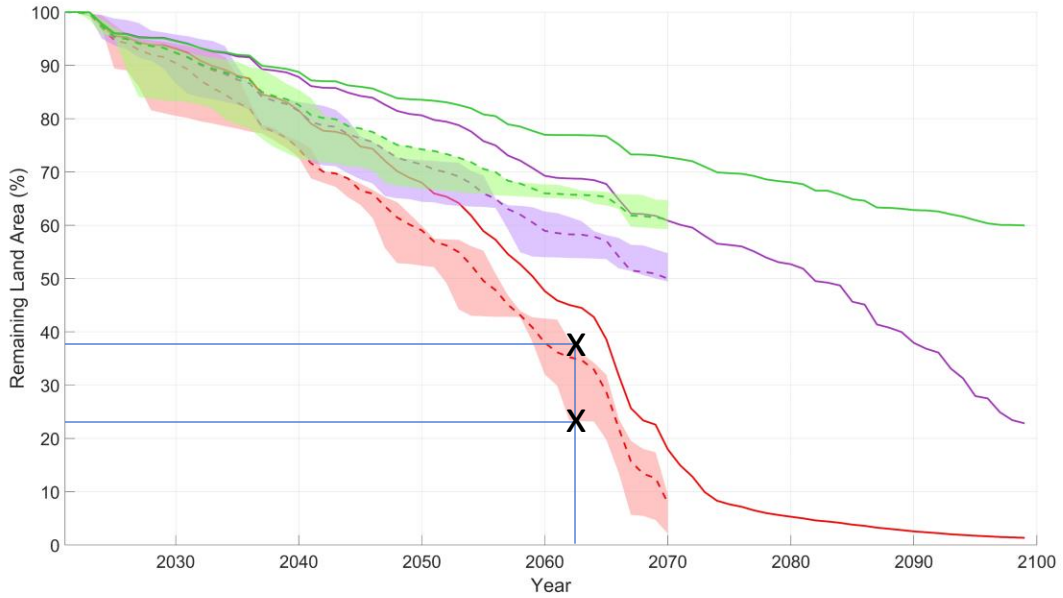
Land Change Comparison (1 m by 2100 at 2059)

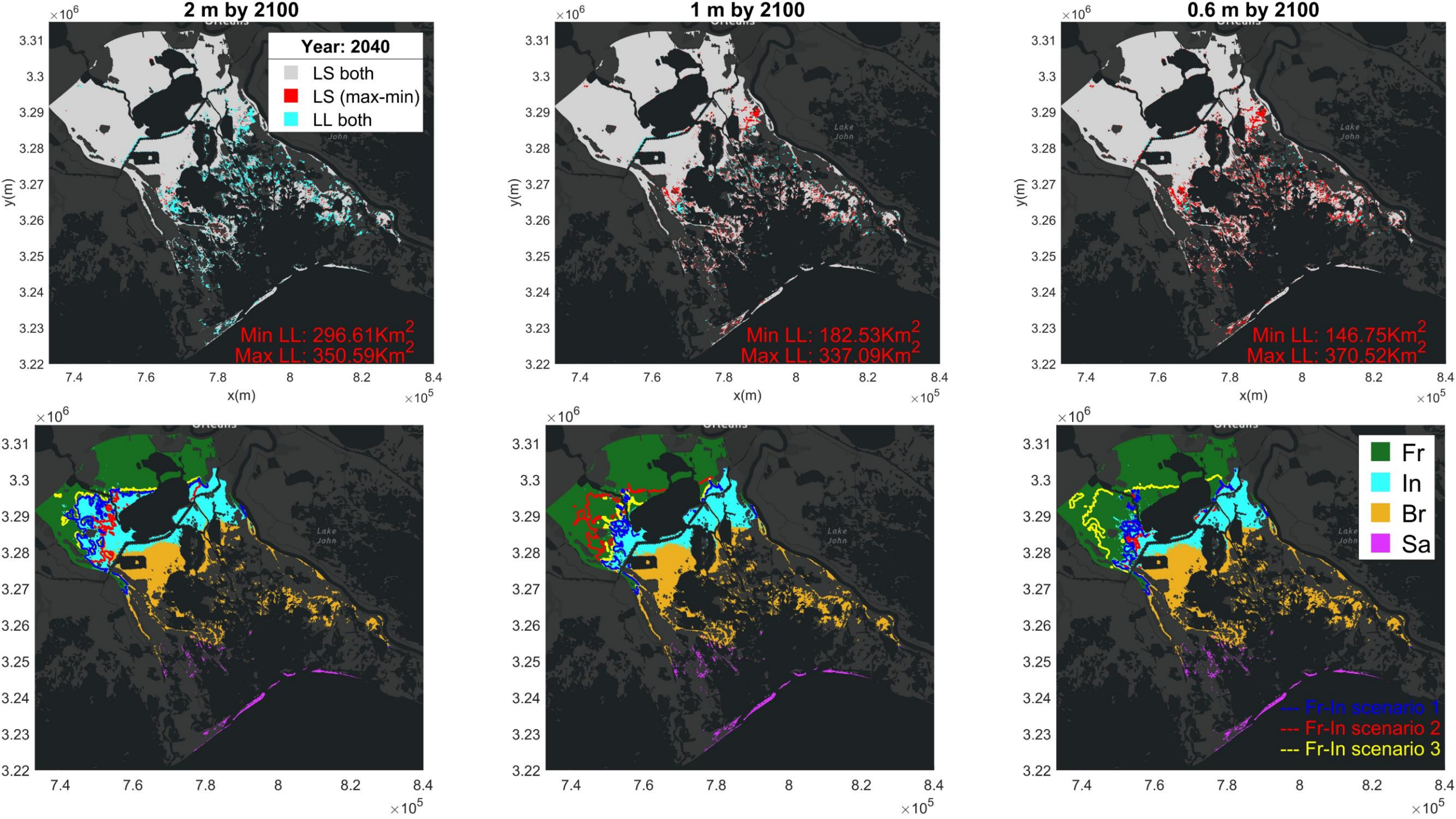


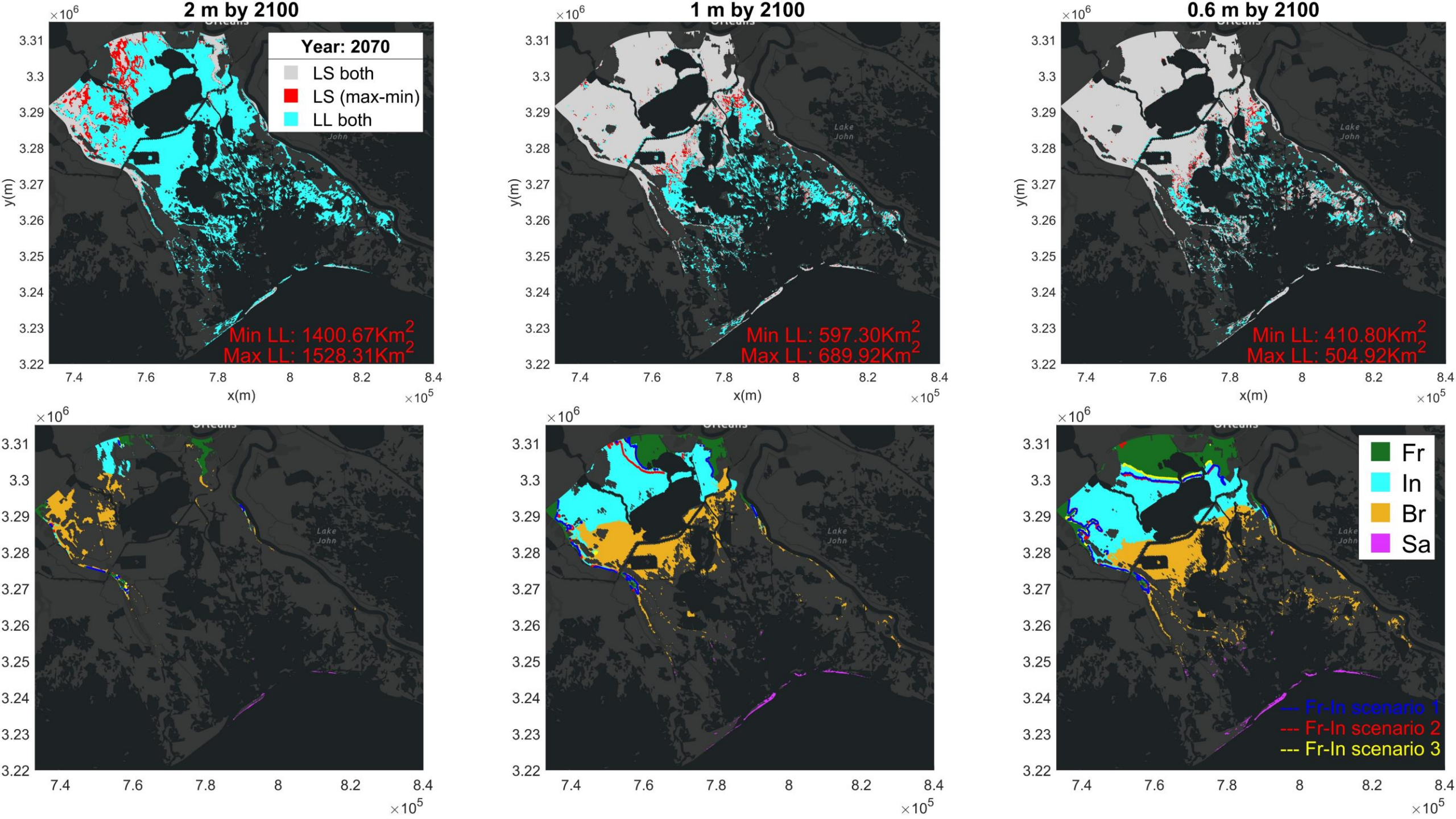


Land Change Comparison (2 m by 2100 at 2062)






2 m by 2100
1 m by 2100
0.6 m by 2100
Year: 2040
LS both
LS (max-min)
LL both
Min LL: 296.61Km2
Max LL: 350.59Km2
Min LL: 182.53Km2
Max LL: 337.09Km2
Min LL: 146.75Km2
Max LL: 370.52Km2
Fr
In
Br
Sa
--- Fr-In scenario 1
--- Fr-In scenario 2
--- Fr-In scenario 3
x(m)
y(m)
Lake John


2 m by 2100
1 m by 2100
0.6 m by 2100
Year: 2070
LS both
LS (max-min)
LL both
Min LL: 1400.67Km2
Max LL: 1528.31Km2
Min LL: 597.30Km2
Max LL: 689.92Km2
Min LL: 410.80Km2
Max LL: 504.92Km2
Fr
In
Br
Sa
--- Fr-In scenario 1
--- Fr-In scenario 2
--- Fr-In scenario 3
Lake John
x(m)
y(m)
×10^6
×10^5

Closing Remarks

- Our results underscore the critical need to consider SL variability in coastal planning and management strategies to mitigate the impacts of rising sea levels.
- While at the turn of the century the impact of the annual variability on land change is overshadowed by the SLR projection, the near term (decadal) implications are often substantial
- In the Barataria example, the SL variability results in a range of 50, 155, and 255 Square Kilometer (13, 38, and 55 thousand acres) respectively for the 2-m, 1-m and 0.6-m SLR.
- The annual variability typically impact the most vulnerable sites within a coastal ecosystem – critical to identify those for a planning effort
- The annual variability also highlights the conversion of marsh to open water and the difficulty in recovery from acceleration episodes – i.e. a high acceleration period followed by a deceleration period is NOT equivalent to an average rate

Tulane