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TAKING THE PULSE OF OUR PLANET FROM SPACE

Mapping Aboveground Biomass and Carbon in Salt Marshes across the Contiguous United States

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Goddard SPACE FLIGHT CENTER

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Salt marsh

Environment commonalities

- Tidally inundated
- Low energy
- Salinity

Variation

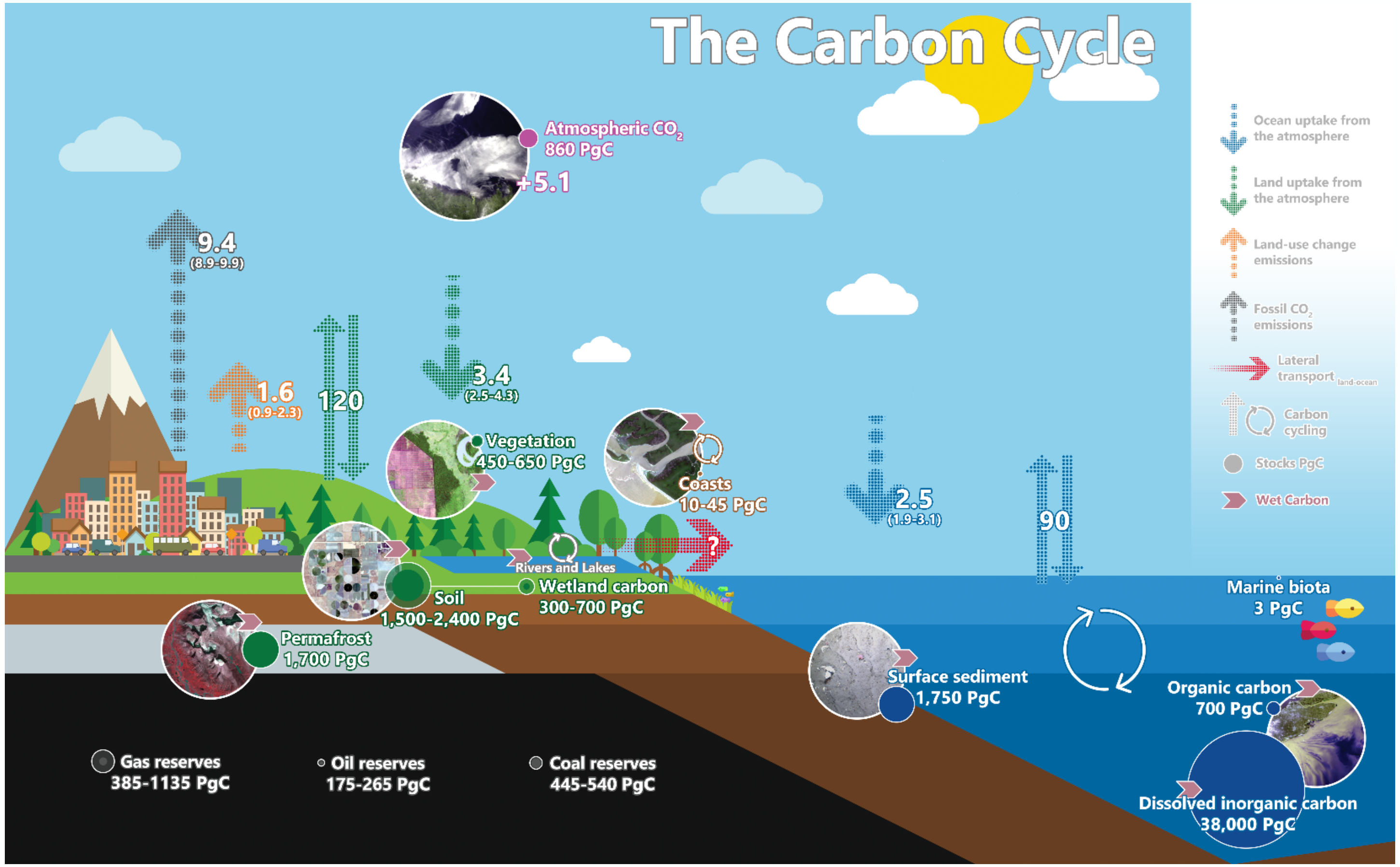
- Tidal characteristics
- Climate
- Soil
- Hydrology
- Sediment
- Fauna
- Regional sea level

Salt marsh significance

- Salt marsh
  - Carbon sequestration
  - Nursery habitat
  - Water quality (denitrification and filtering of pollutants)
  - Wave attenuation
- Approximately $10,000 per hectare
  - Tidal mudflats $1,942 per hectare (Barbier *et al*. 2011)

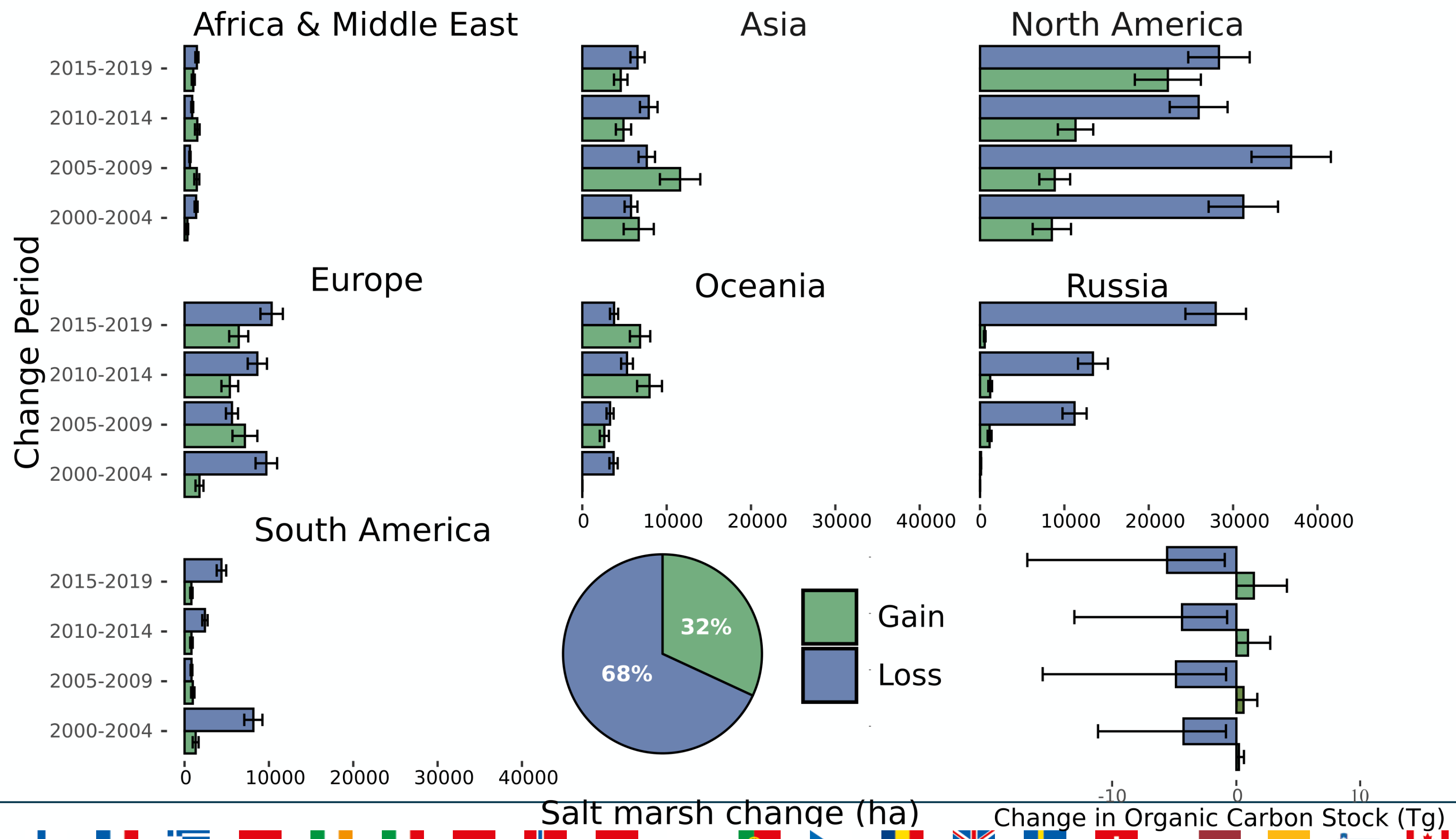
Salt marsh carbon

- In the CONUS, 75% of blue carbon is found within estuarine emergent wetlands (Hinson et al. 2017).
- Carbon burial
  - Estimated
    - 4.8±0.5 – 87.2±9.6 Tg C yr^{-1} (Mcleod et al. 2011)



Status and change – coastal wetlands

- Historic Wetland losses since 1700 AD are estimated to be as high as 87% (Davidson 2014)

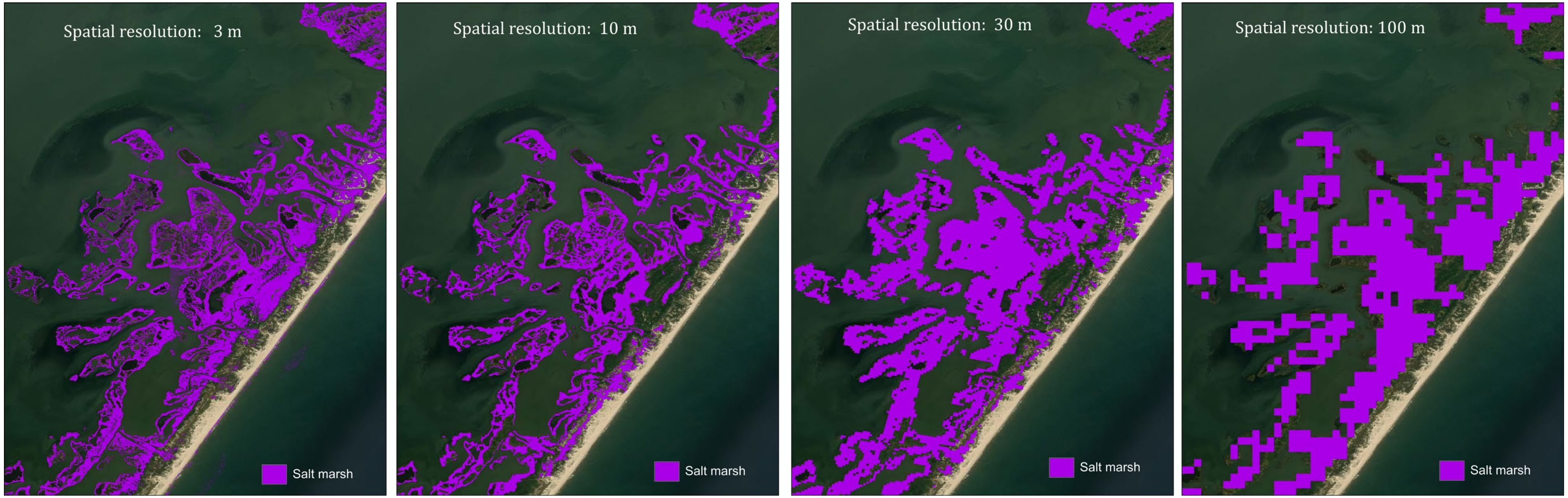


Science questions

What is the distribution of salt marsh aboveground biomass across the CONUS?
What drives this variation (climate, geomorphology, direct anthropogenic change, sea level rise)?

Data outputs

Update salt marsh extent to 2020 and 10 m spatial resolution
CONUS wide map of aboveground biomass

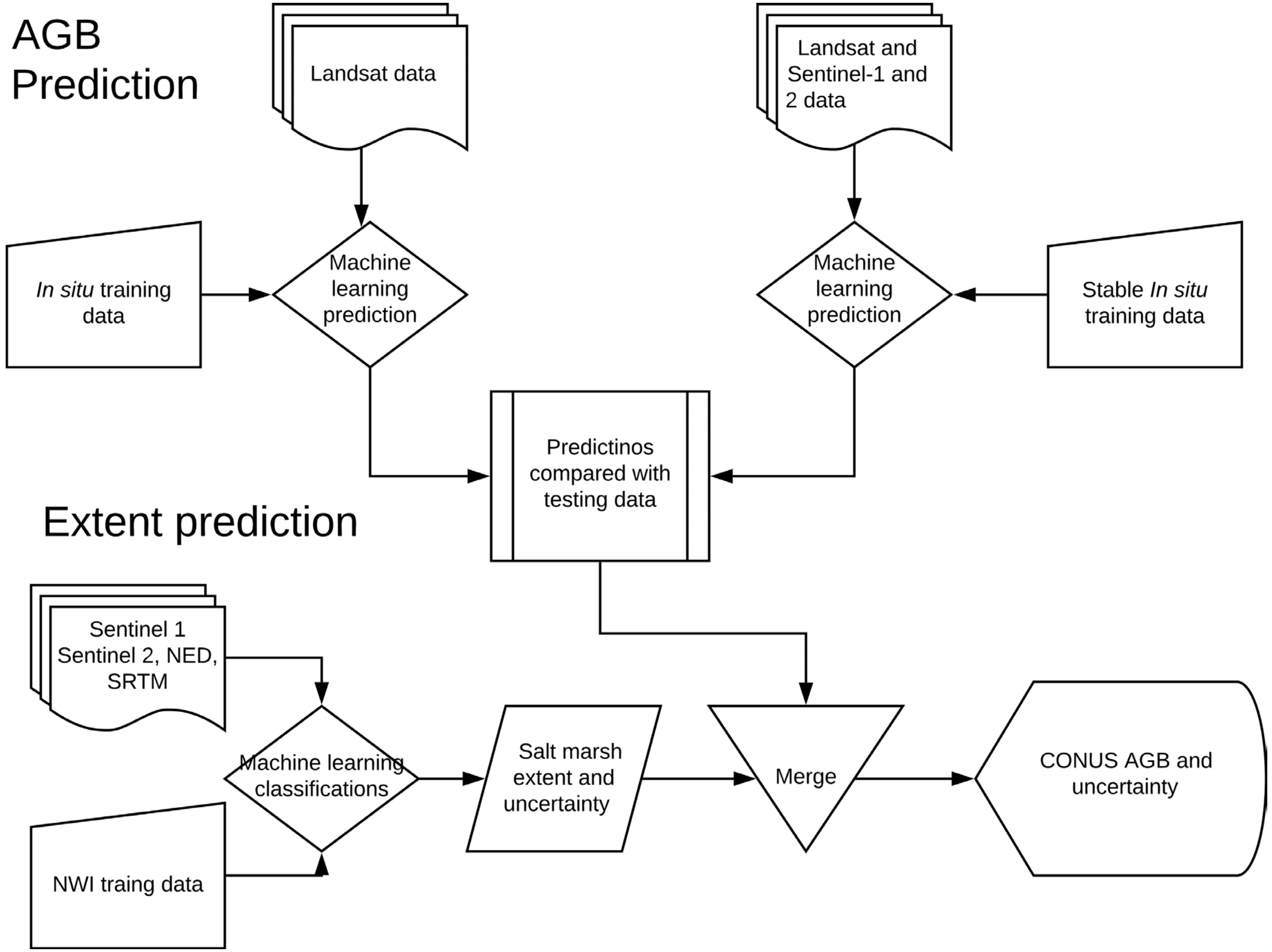


AGB prediction

- 3 machine learning algorithms (xgboost, random forest, SVM), 2 Scales 10 and 30 m, and stable vs complete training dataset
- Hypertuned
- Evaluated with test data from two sites, one completely unused in training

Extent prediction:

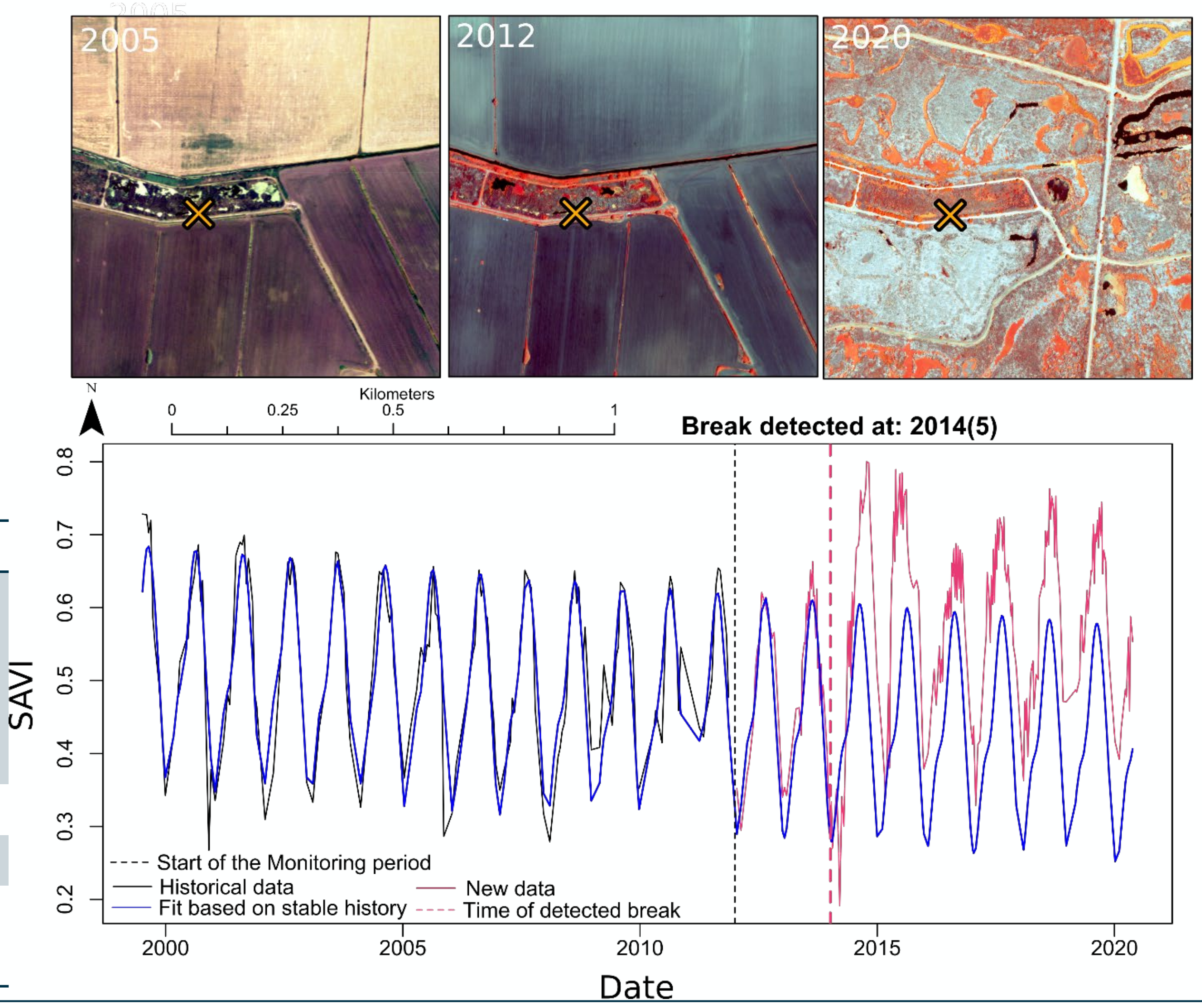
- Three machine learning algorithms – estimate spatially a low, medium and high extent
- Confidence interval and accuracy following methods of Olofosson et al. (2014)



Time series stability – AGB results

- All training data from Byrd et al. 2018 were evaluated for time series stability.
- Two metrics of stability trend following biomass samples and breaks for additive season and trend (BFAST)
- Absolute trends of 0.05 were then analyzed with BFAST finding all these experienced a break following data collection.
- Two AGB models were trained and compared using

Training set		Georgia		Plum Island, MA	
		Validation (n =158)	Site Validation (n =8)	Validation Type 1 (n=17)	Validation Type 2 (n=17)
	n	RMSE	RMSE	RMSE	RMSE
Stable	723	**301.0**	**107.33**	373.04	**221.5**
Complete	984	326.1	194.2	**344.5**	232.3

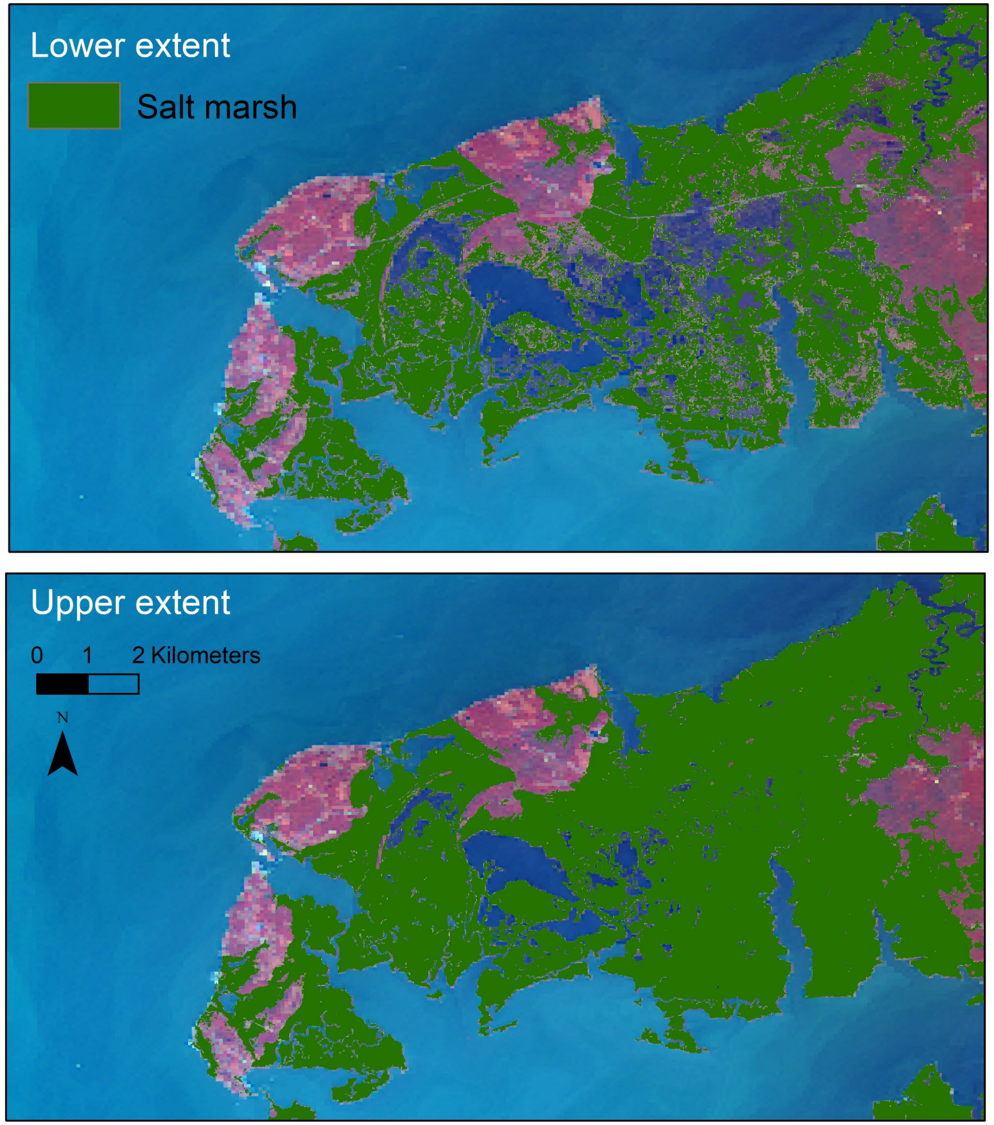


Overall accuracy: 96.3%

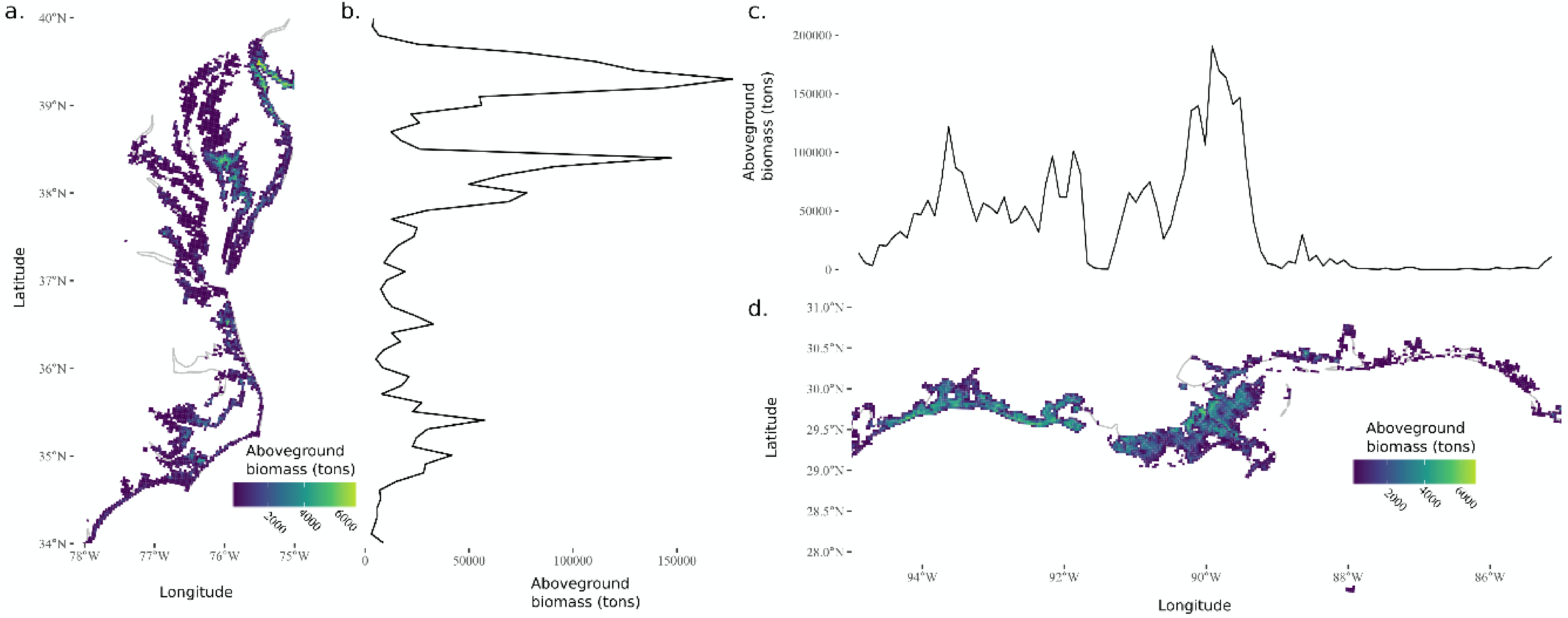
CONUS extent: 14,491 ± 1,736.75 km^2

Uncertainty from accuracy assessment: 3175.6 km^2

Uncertainty from machine learning: 3473.5 km^2



CONUS Aboveground biomass



Aboveground biomass (2015-2020)

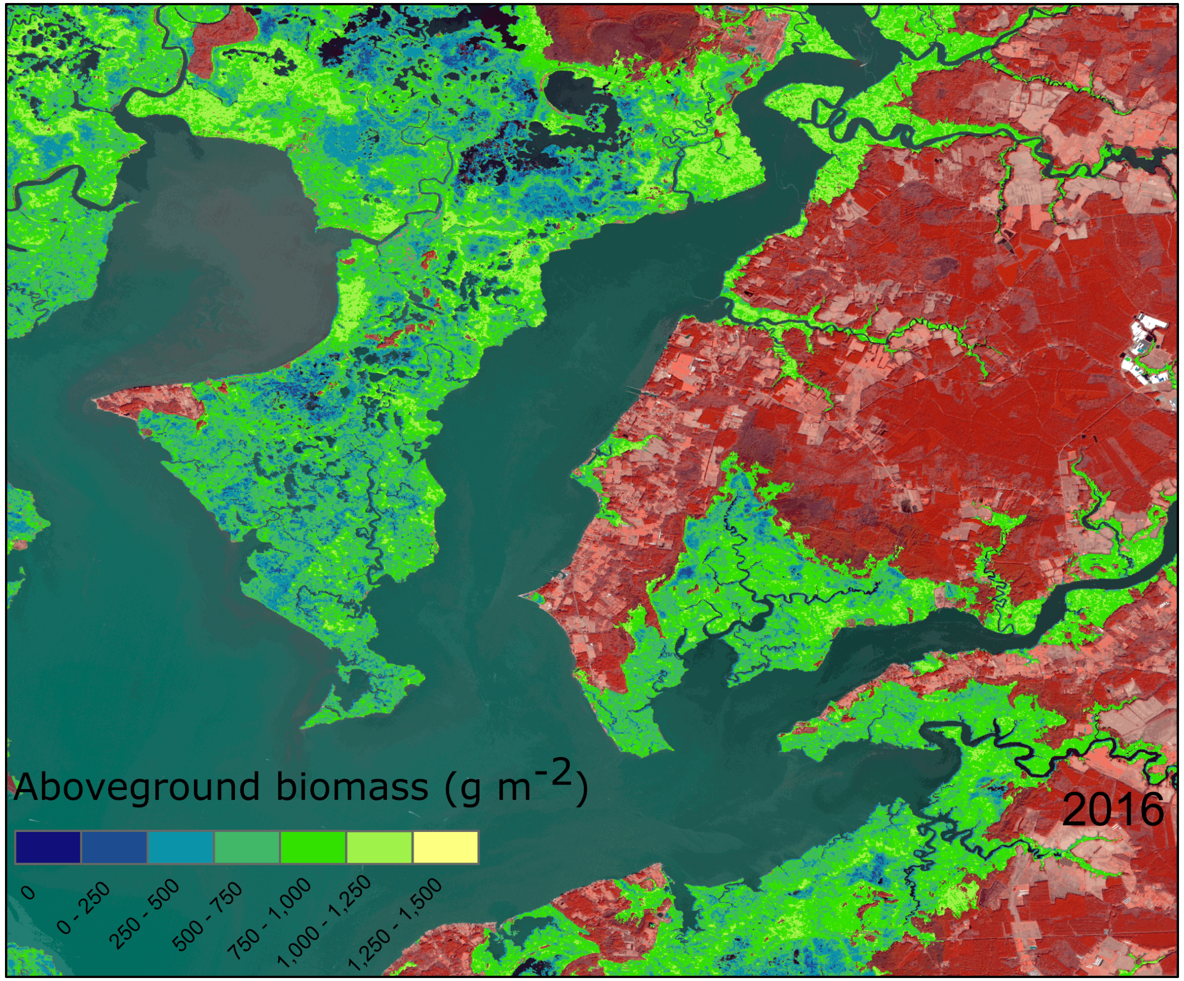
esa

Total AGB

8.32 (7.15-9.35) Tg

Average Carbon

255.7 g C m^2

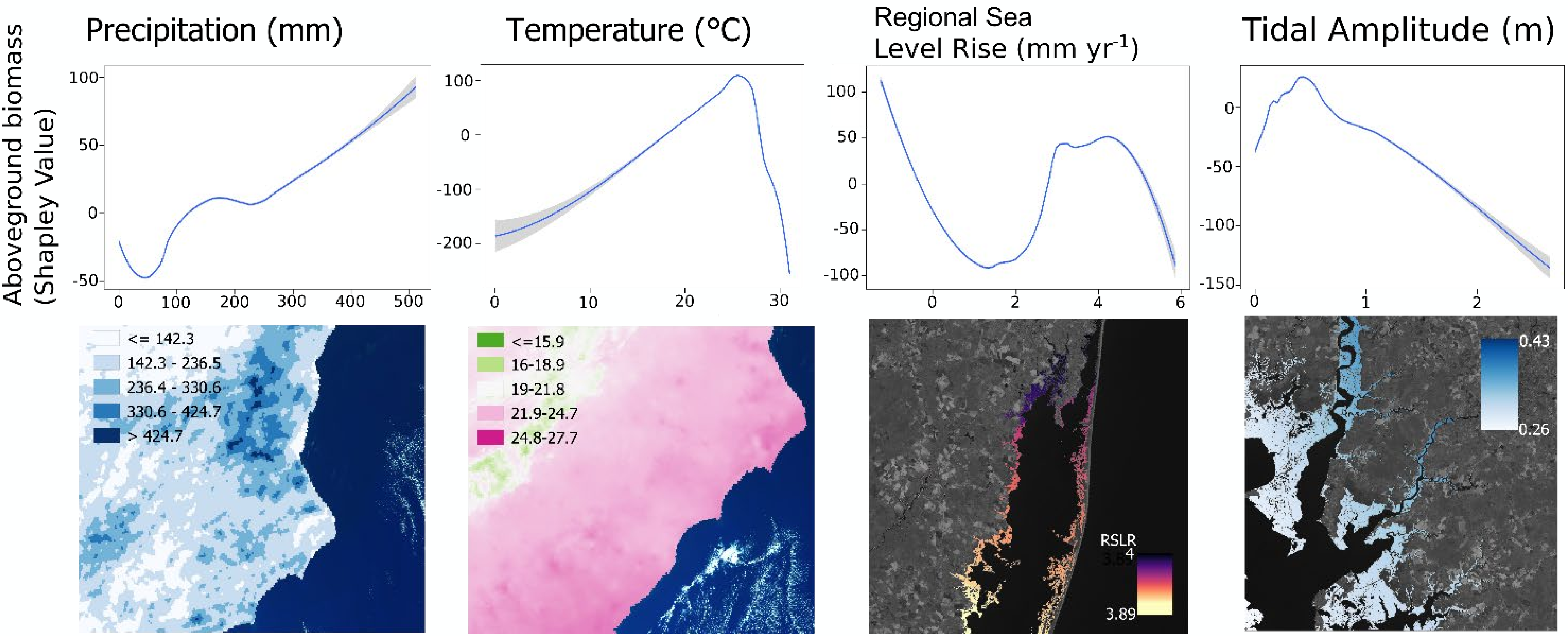


Analysis of AGB drivers

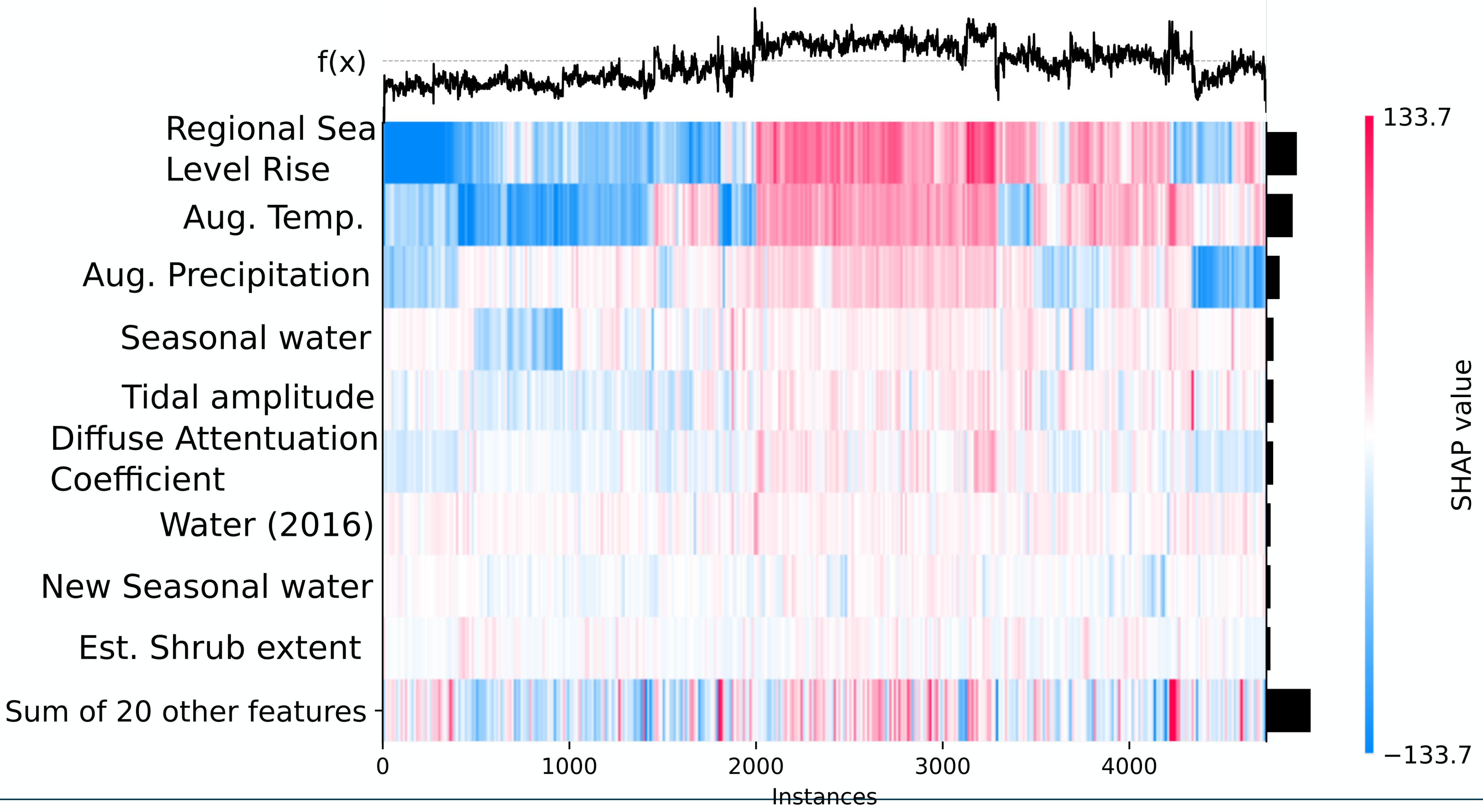
- Average AGB in 3 x 3 km
- Machine learning model (xgboost)
- Shapley calculated and analyzed to determine drivers of AGB across the CONUS.

Data Type	Variable	Resolution	Sensor	Source
Climate	August Temp/Precipitation	250 m	NA	PRISM Climate Data
Tidal/Elevation	Relative tidal elevation, tidal amplitude, RSLR	30 m	Various LiDAR	Holmquist and Windham-Myers 2021
Water	Seasonal, Water, New Seasonal	30 m	Landsat	Pekel et al. 2016
Land cover	NLCD classes	30 m	Landsat	Wickham et al. 2021
Ocean Color	Diffuse Attenuation Coefficient, Chlorophyll	750 m	VIIRS	NOAA CoastWatch/OceanWatch

Major Drivers Aboveground biomass



East coast drivers of aboveground biomass



Takeaways:

In salt marsh AGB was 8.32 (7.15-9.35) Tg in 2020

The 10 m spatial resolution allows for finer scale determination of these loss areas and repeat monitoring

Machine learning uncertainty can be derived spatially informing management and carbon monitoring

RSLR – between 3-5 mm yr^{-1} increase AGB but rates >5 mm yr^{-1} reduced AGB

AGB response to climate and RSLR suggest that these ecosystems response to climate change will be complex

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