Assessing submerged aquatic vegetation blue carbon in the Chesapeake Bay from high resolution satellite imagery

Victoria Hill (vhill@odu.edu), Richard Zimmerman

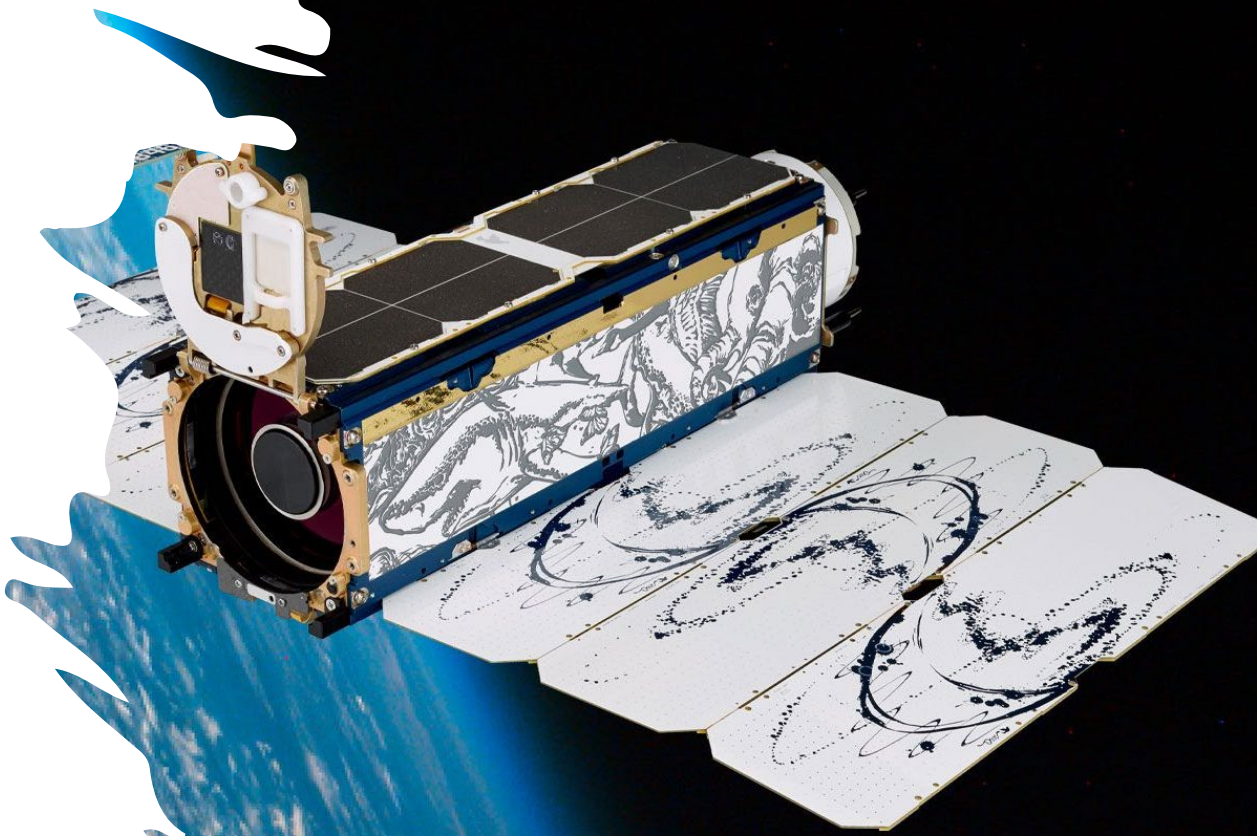
Department of Ocean and Earth Sciences.

Old Dominion University, Norfolk. Virginia. USA

The Opportunity – Satellite Remote Sensing

- Planet now operates >200 cubesats
  - 8 spectral (color) bands
  - 3 m ground resolution (nadir)
  - Radiometrically calibrated
  - Atmospherically corrected
  - Harmonized to ESA Sentinel
  - Daily coverage eliminates tasking logistics
- Can satellite remote sensing replace or at least augment aerial surveys?
- Can we generate quantitative data for Blue Carbon estimates and biogeochemical modeling?

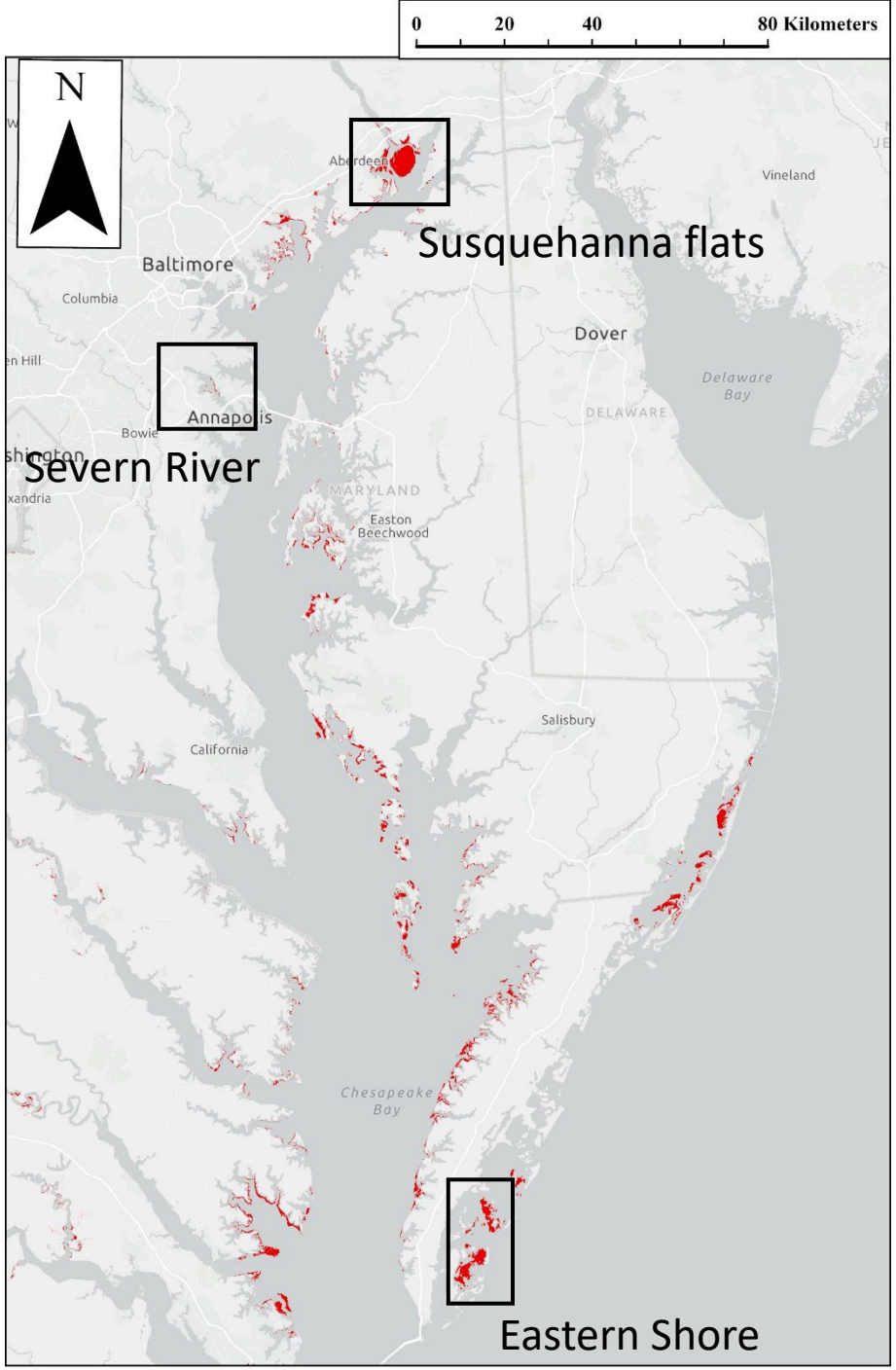
- freely available for research



- www.planet.com

Mapping SAV with Planet imagery

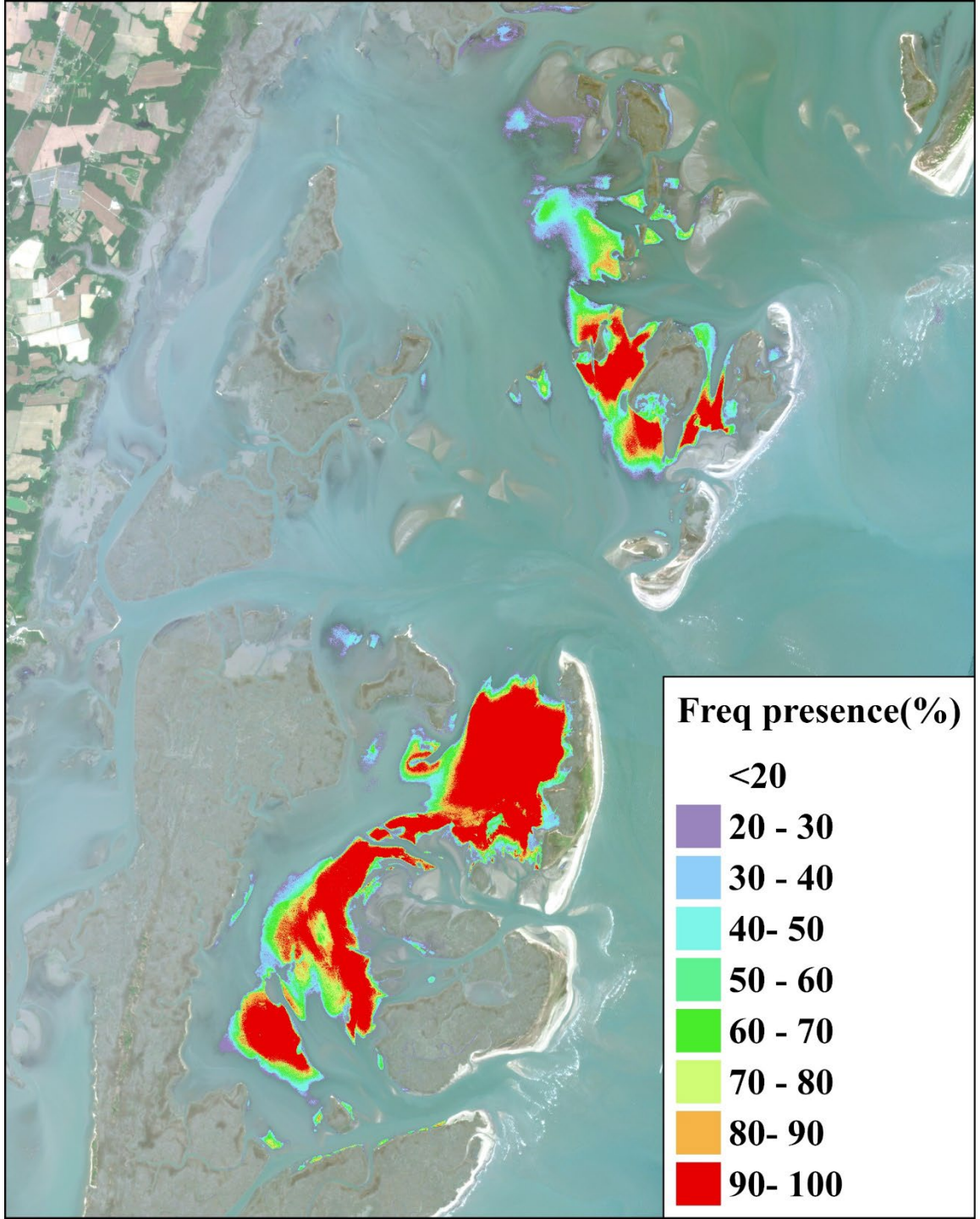
- Eastern Shore
  - Oceanic coastal lagoons. Polyhaline.
  - extensively restored meadow of *Zostera marina* (eelgrass).
- Severn River
  - Mesohaline central bay
  - Mixed species beds, *Zannichellia palustris* (Horned Pond weed), *Ruppia maritima* (Widgeongrass), *Potamogeton perfoliatus* (*Redhead*)
- Susquehanna Flats oligohaline upper Bay
  - Oligohaline upper bay
  - large stable meadow of *Vallisneria americana* (water-celery) and other freshwater spp.



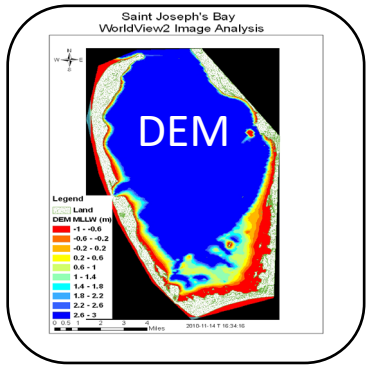
VGIN, Esri, TomTom, Garmin, SafeGraph, FAO, METI/NASA, USGS, EPA, NPS, USFWS

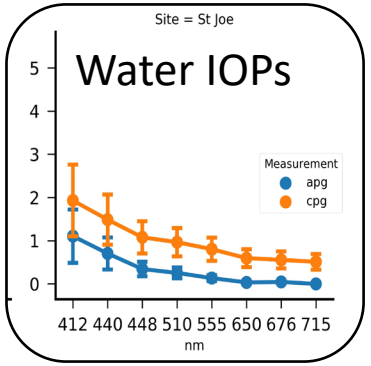
Mapping SAV distribution and density

- Planet passes every day, often multiple passes from different sensors.
- Supervised classification is used to map SAV on all viable images.
- Use all the classified images and generate product that is percent presence – number of times that a pixel was identified as SAV.
- **Produce seasonal maps.**



From distribution to Leaf Area Index

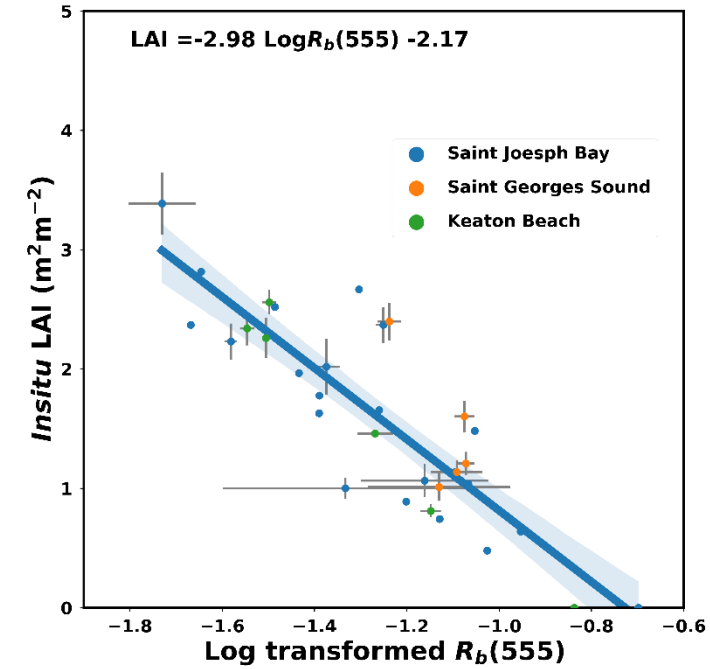




- ***Atmospherically corrected*** R_{rs} from imagery
- $Q_b = E_u(z_b)/L_u(z_b) = \pi$
- K_{Lu} & K_d from *Hydrolight* using measured IOPs
- Water depth, DEM + tide

$$R_b = \frac{R_{rs} Q_b}{t} \frac{\exp\left[-K_{Lu} z_b\right]}{\exp\left(K_d z_b\right)}$$

- z_b – bottom depth from acoustic survey
- t – air/sea transmittance of $L_u(0.54)$



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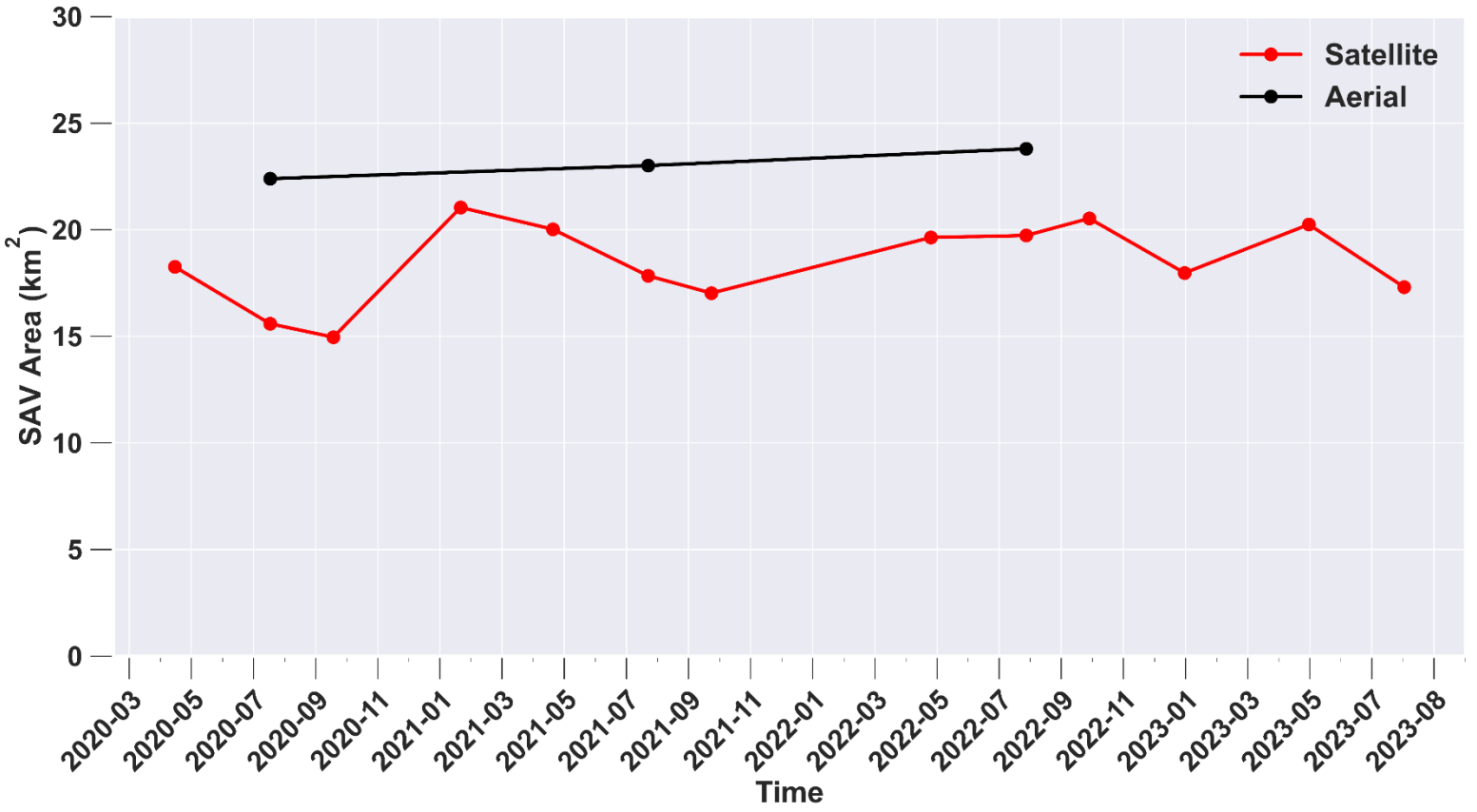
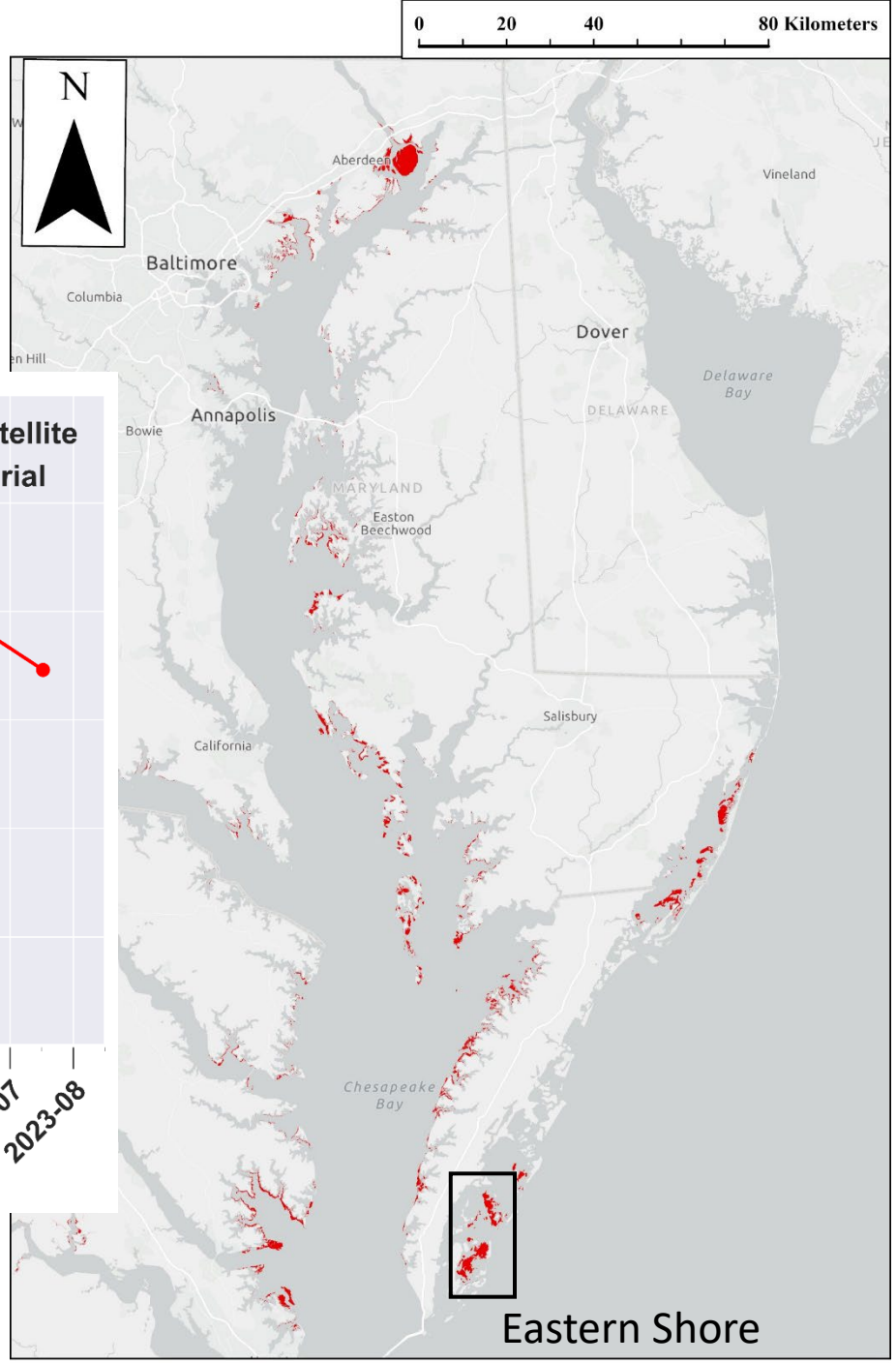
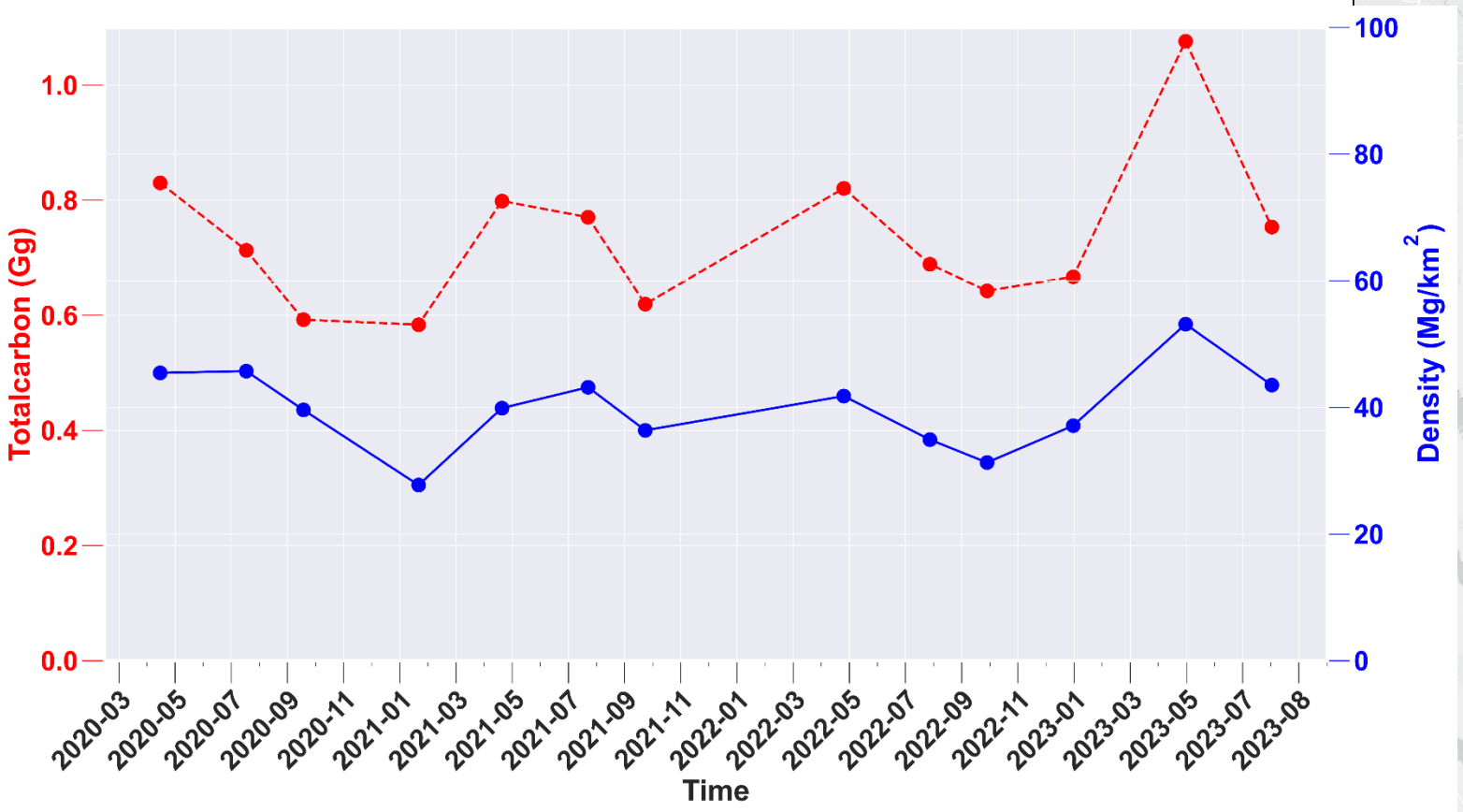
Dierssen, H., R. Zimmerman, R. Leathers, T. Downes, and C. Davis. 2003. Remote sensing of seagrass and bathymetry in the Bahamas Banks using high resolution airborne imagery. Limnol. Oceangr. **48: 444-455.**

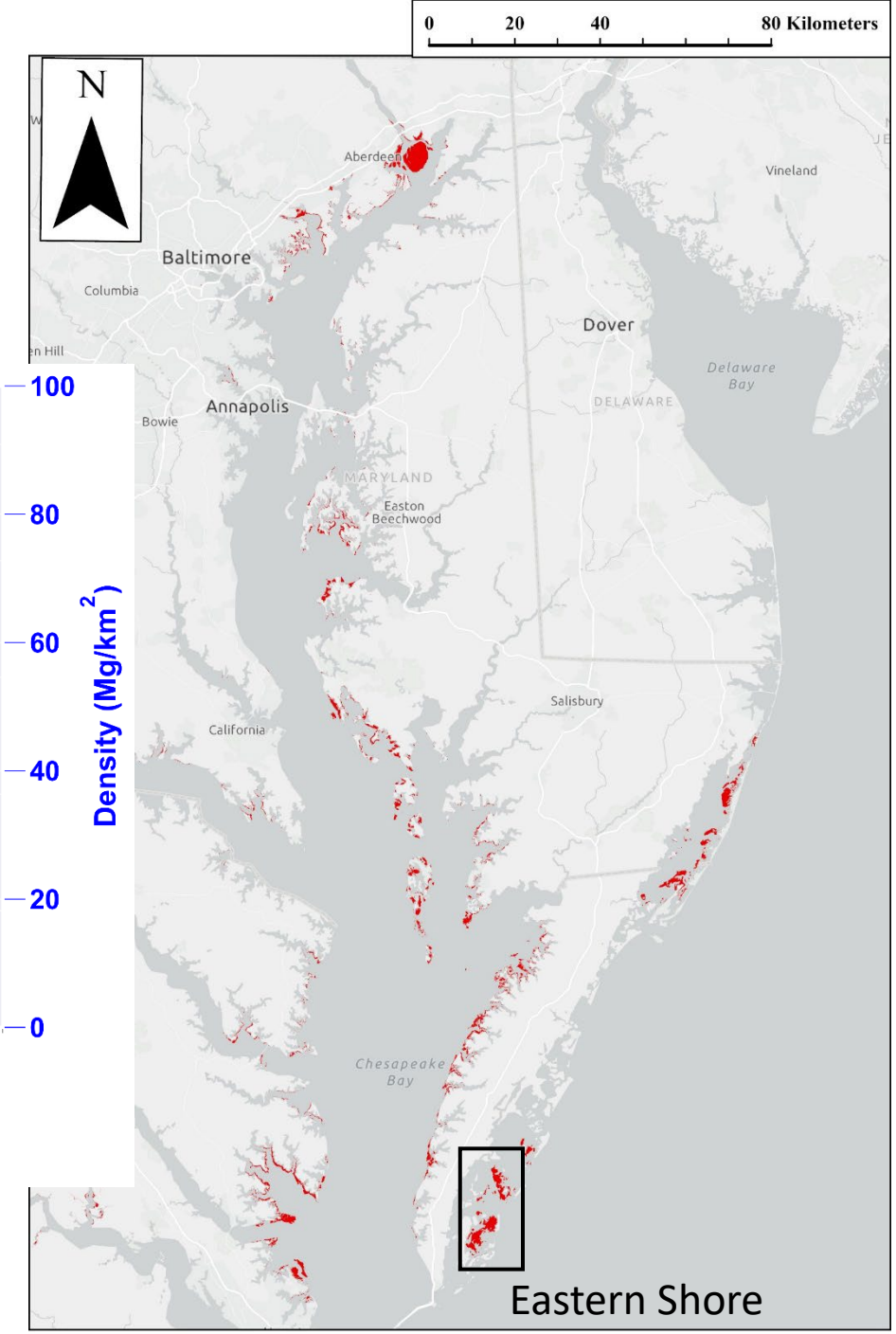
Eastern Shore: A modest upward trend and weak seasonal variation in SAV area





Eastern Shore: A weak seasonal signal in carbon.





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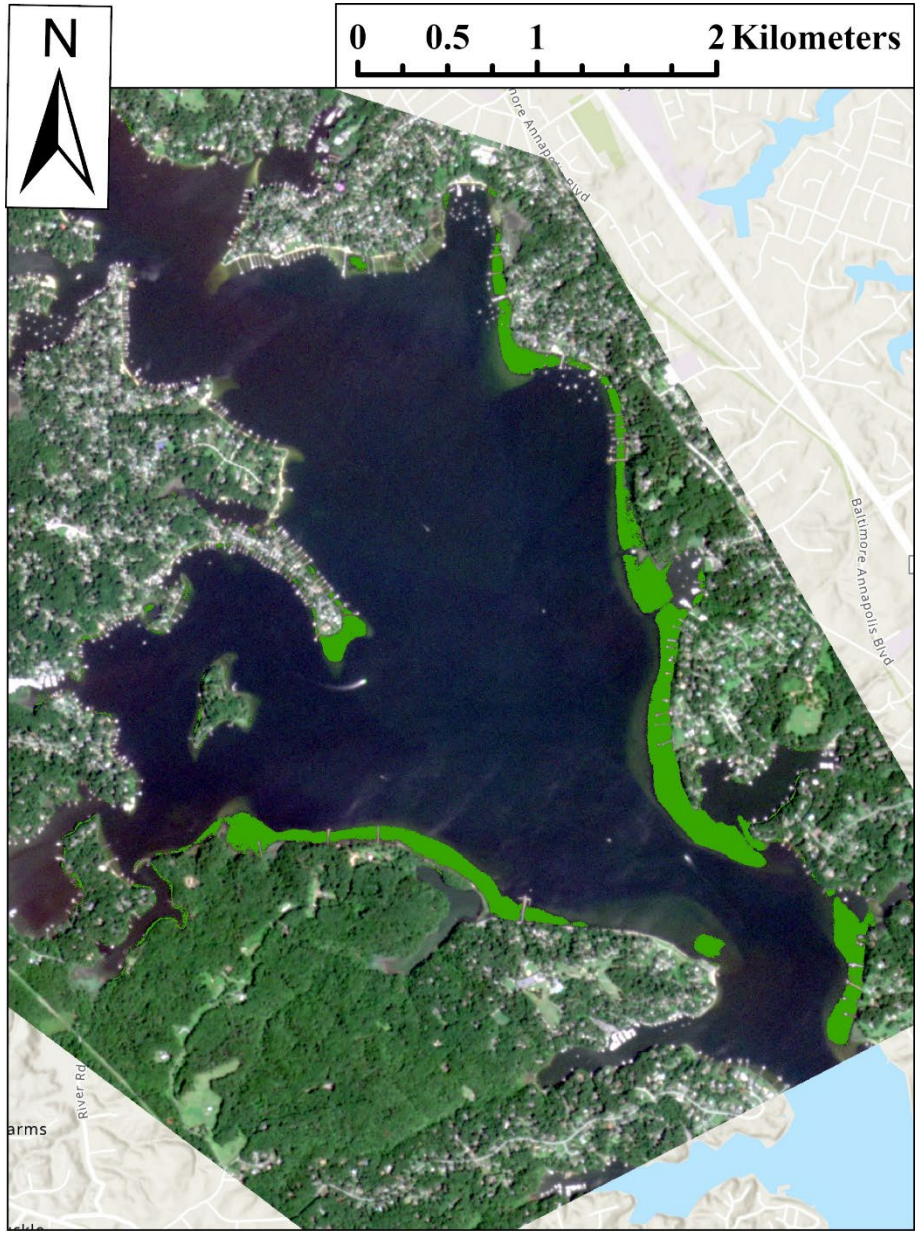
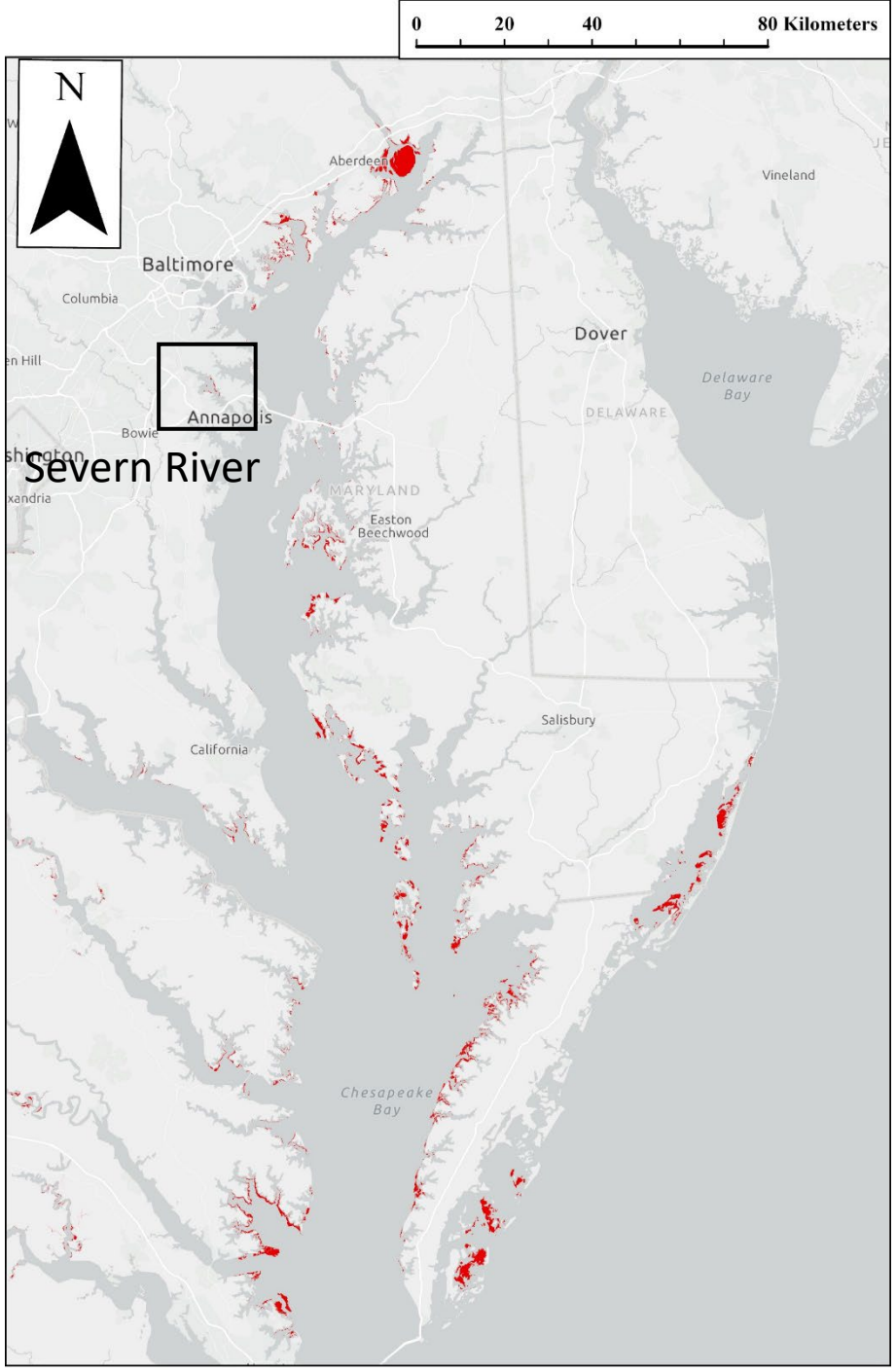
Severn River: Dense continuous SAV beds.





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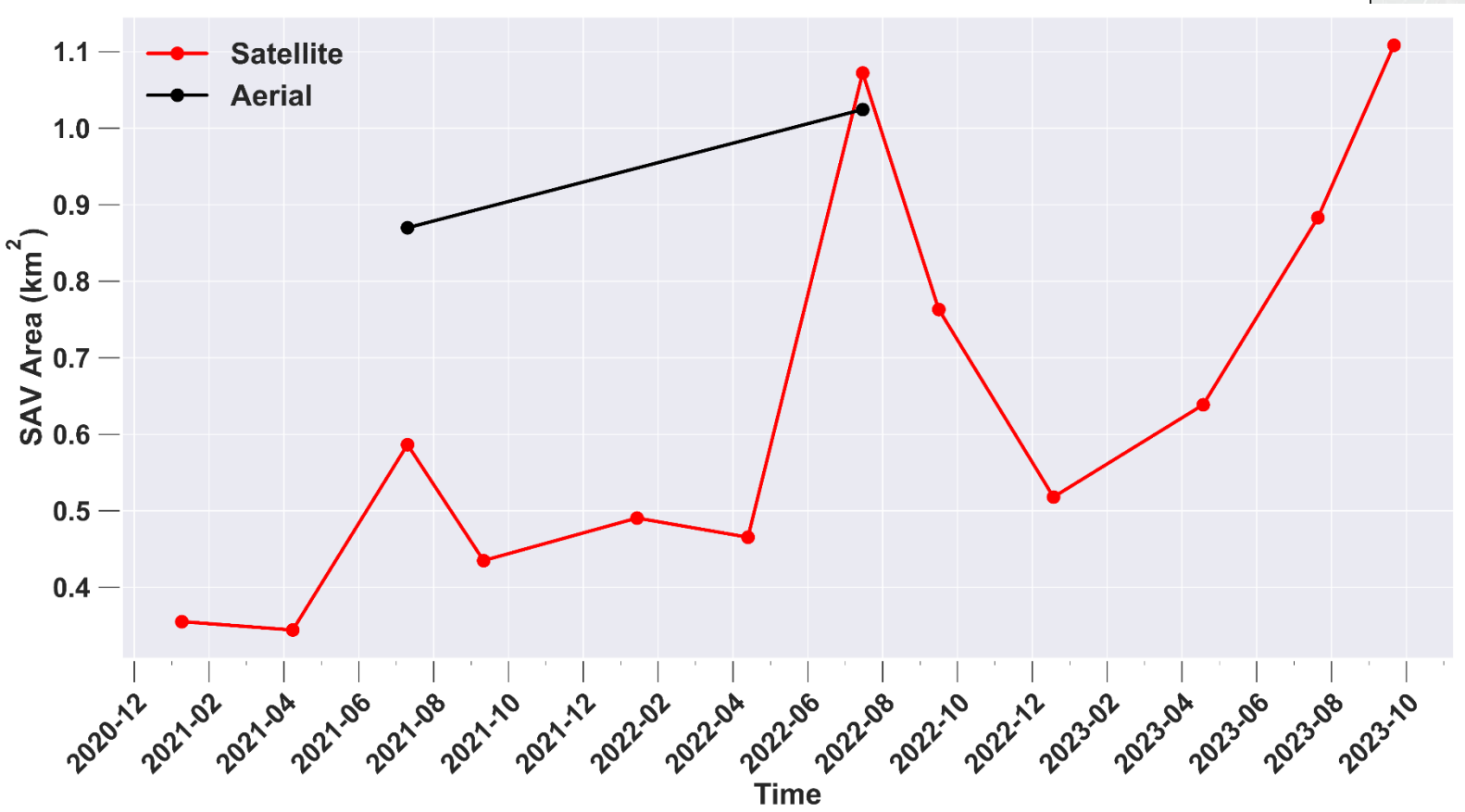
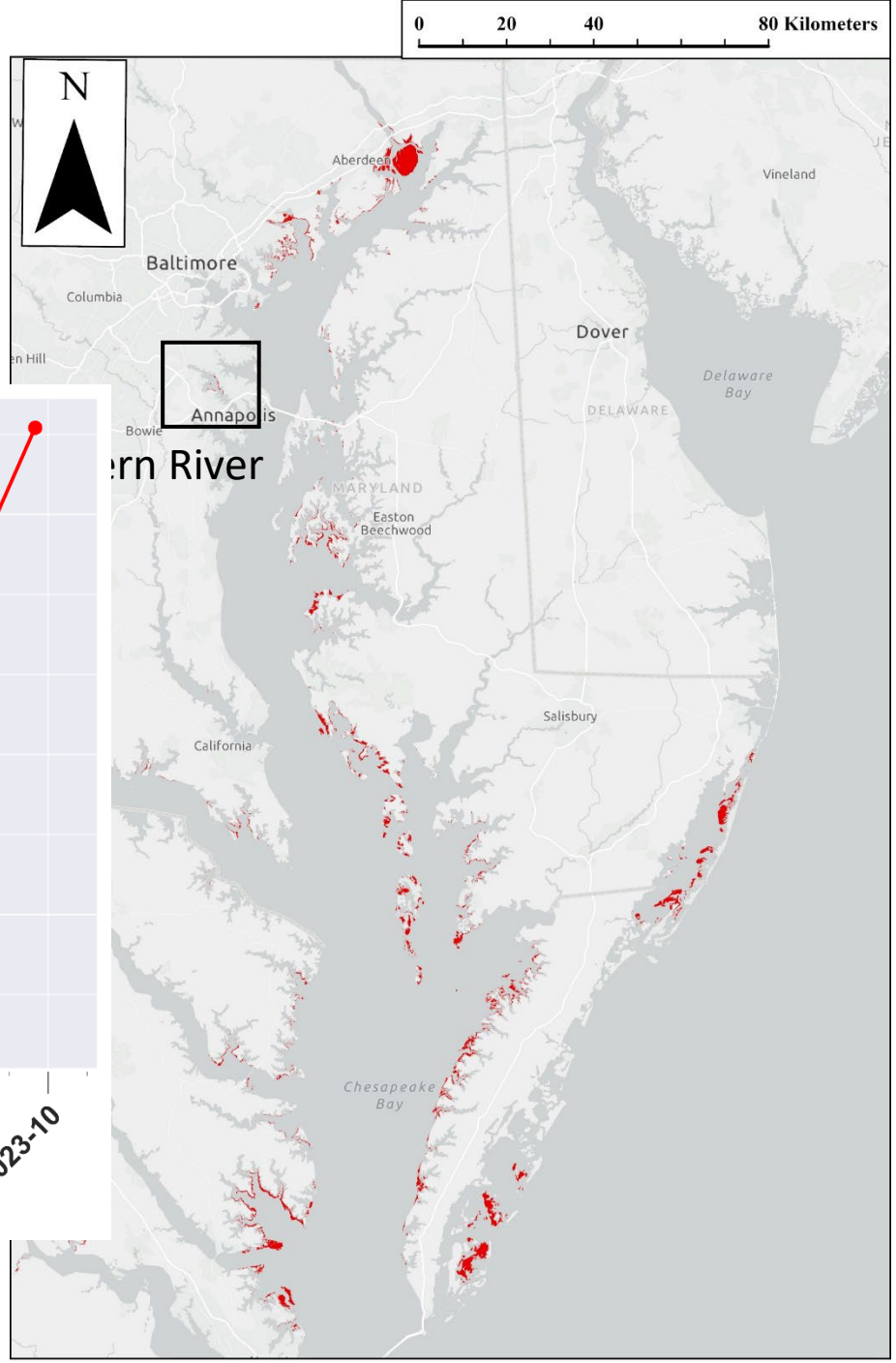
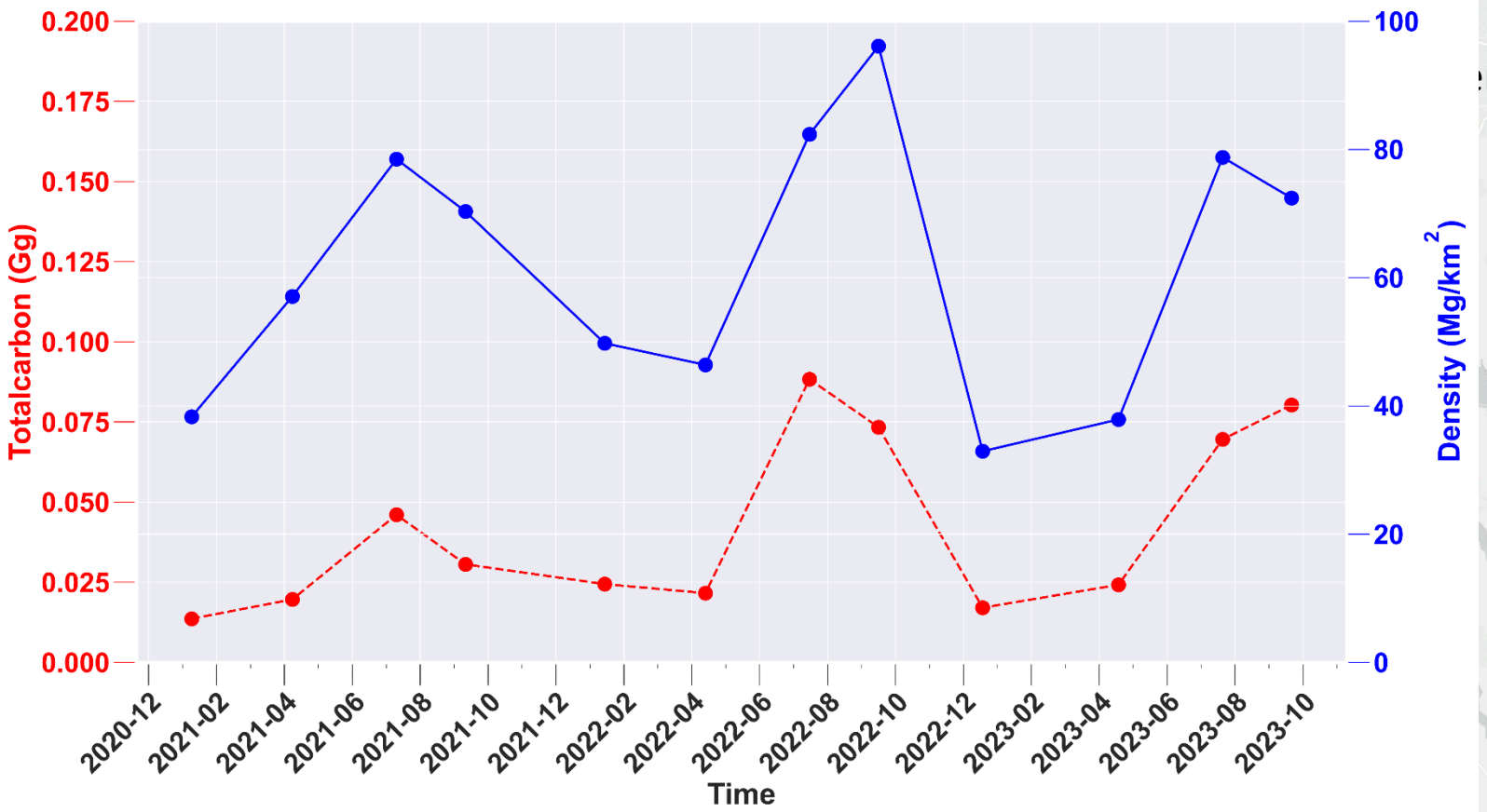
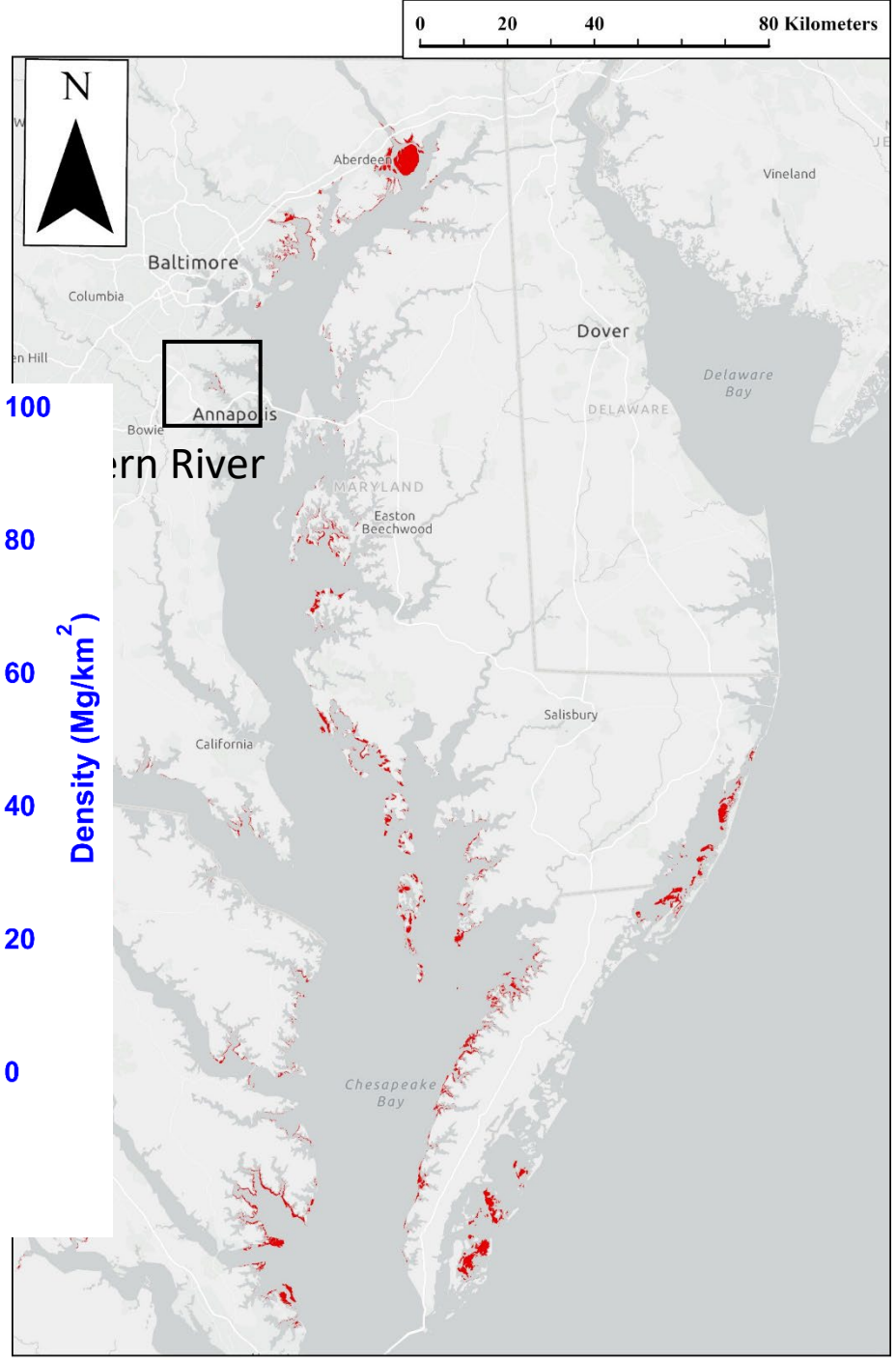
Severn River: Stronger seasonal signal





Severn River: Stronger seasonal signal in carbon and density





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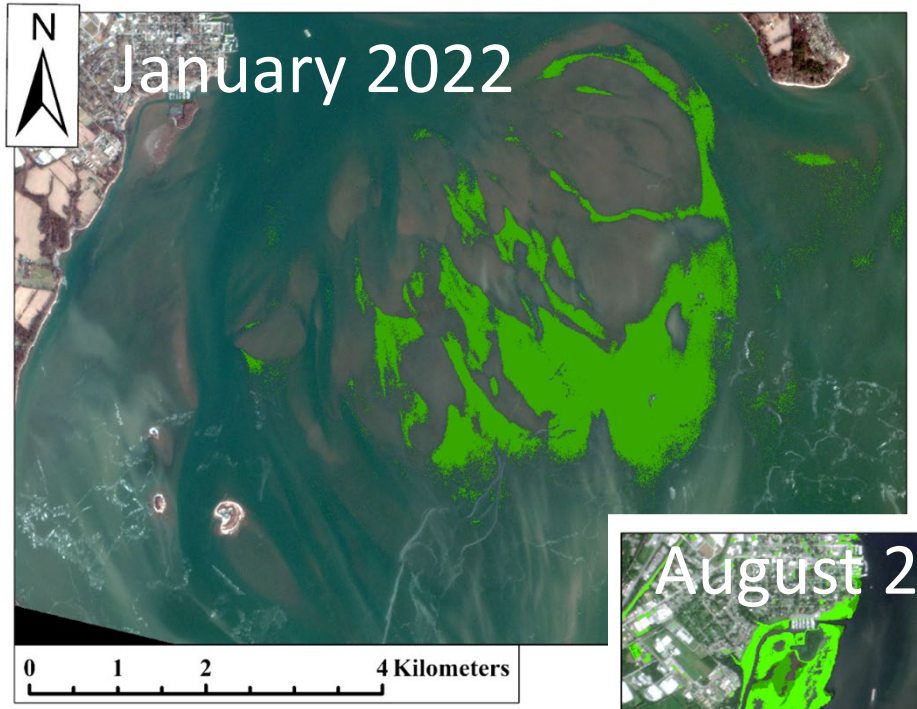
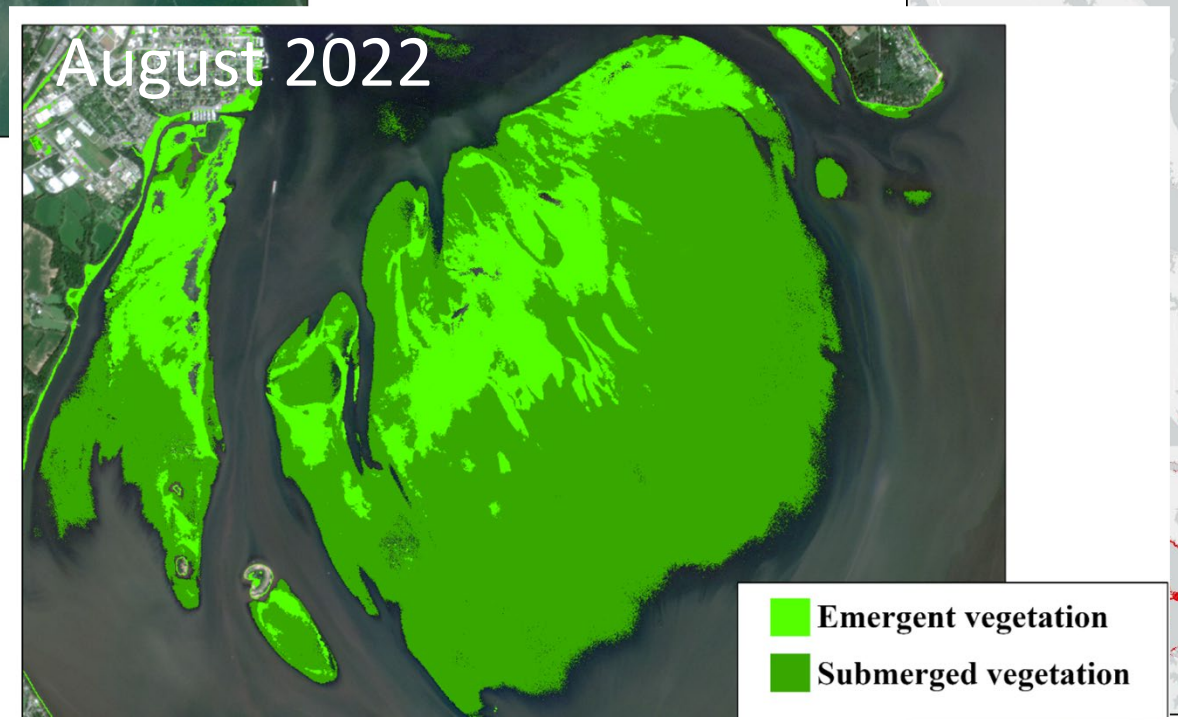
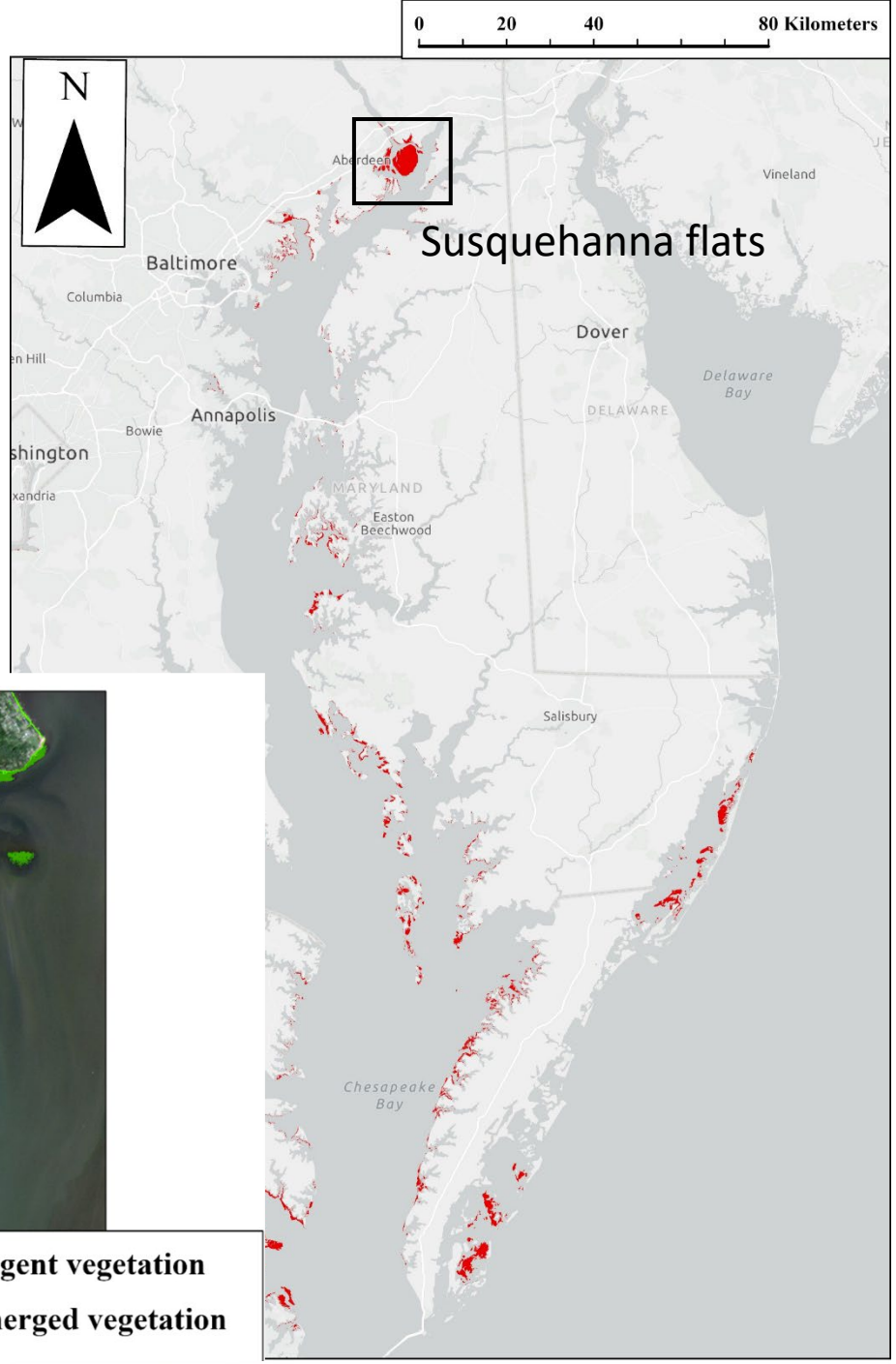
Susquehanna Flats







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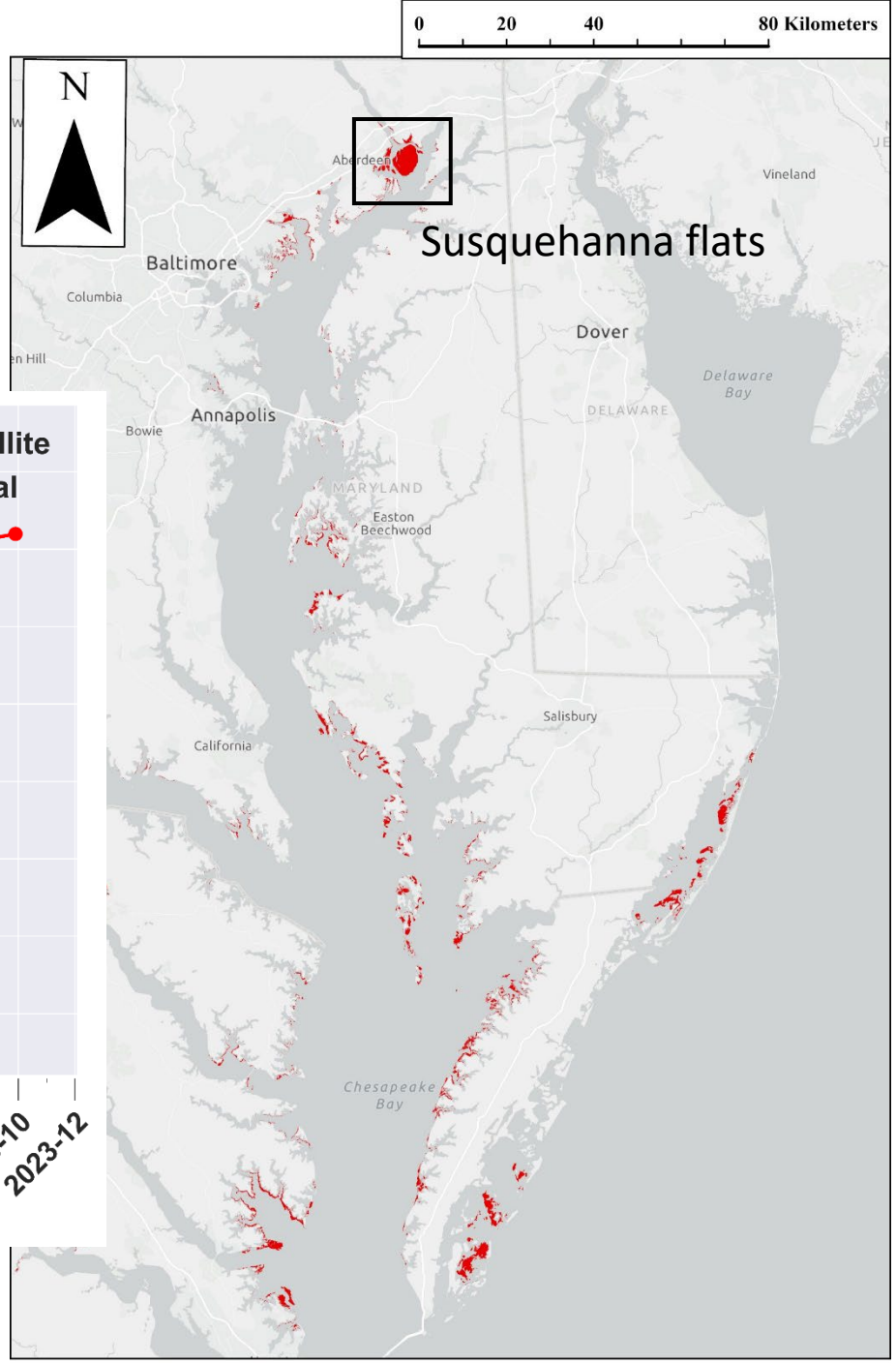
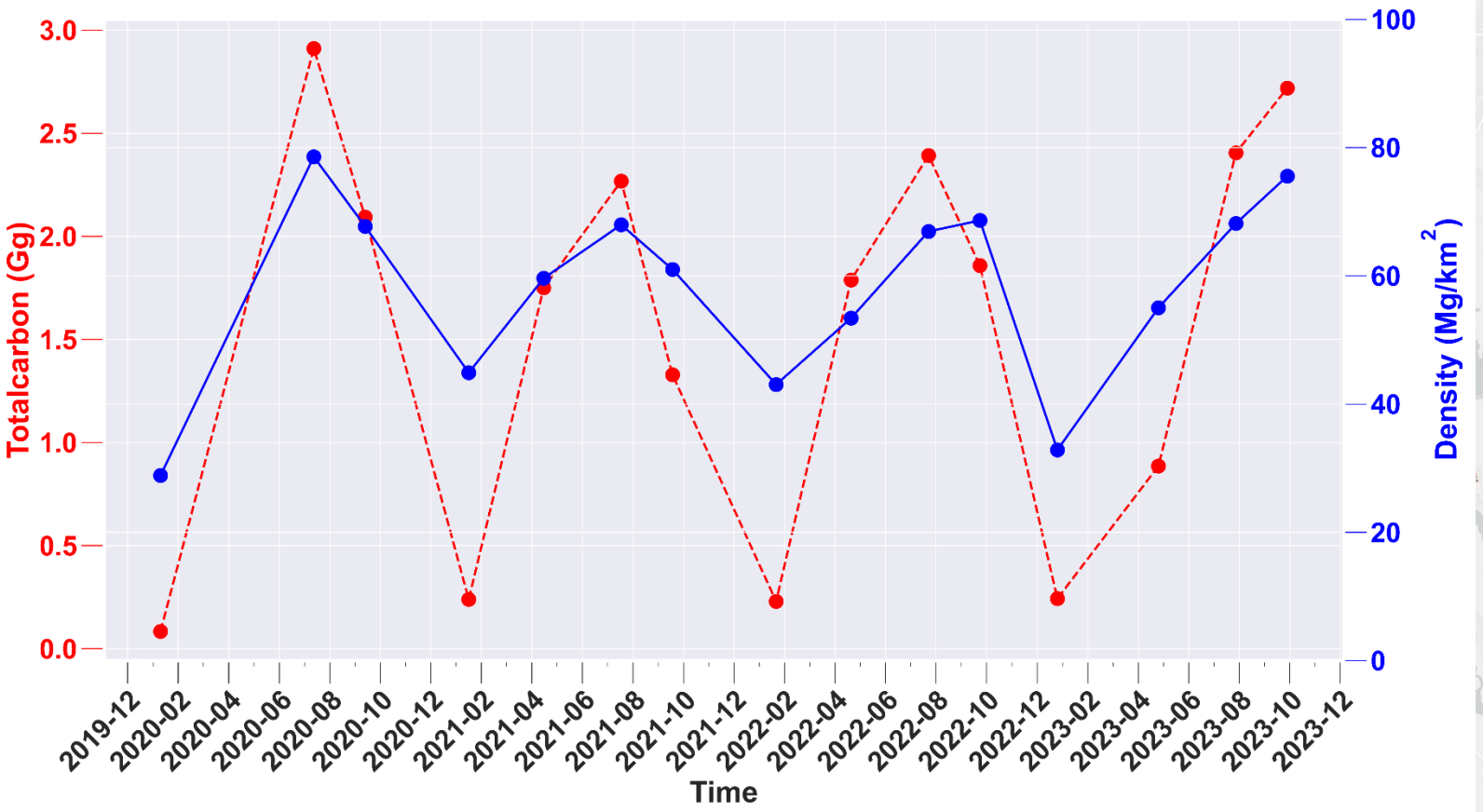
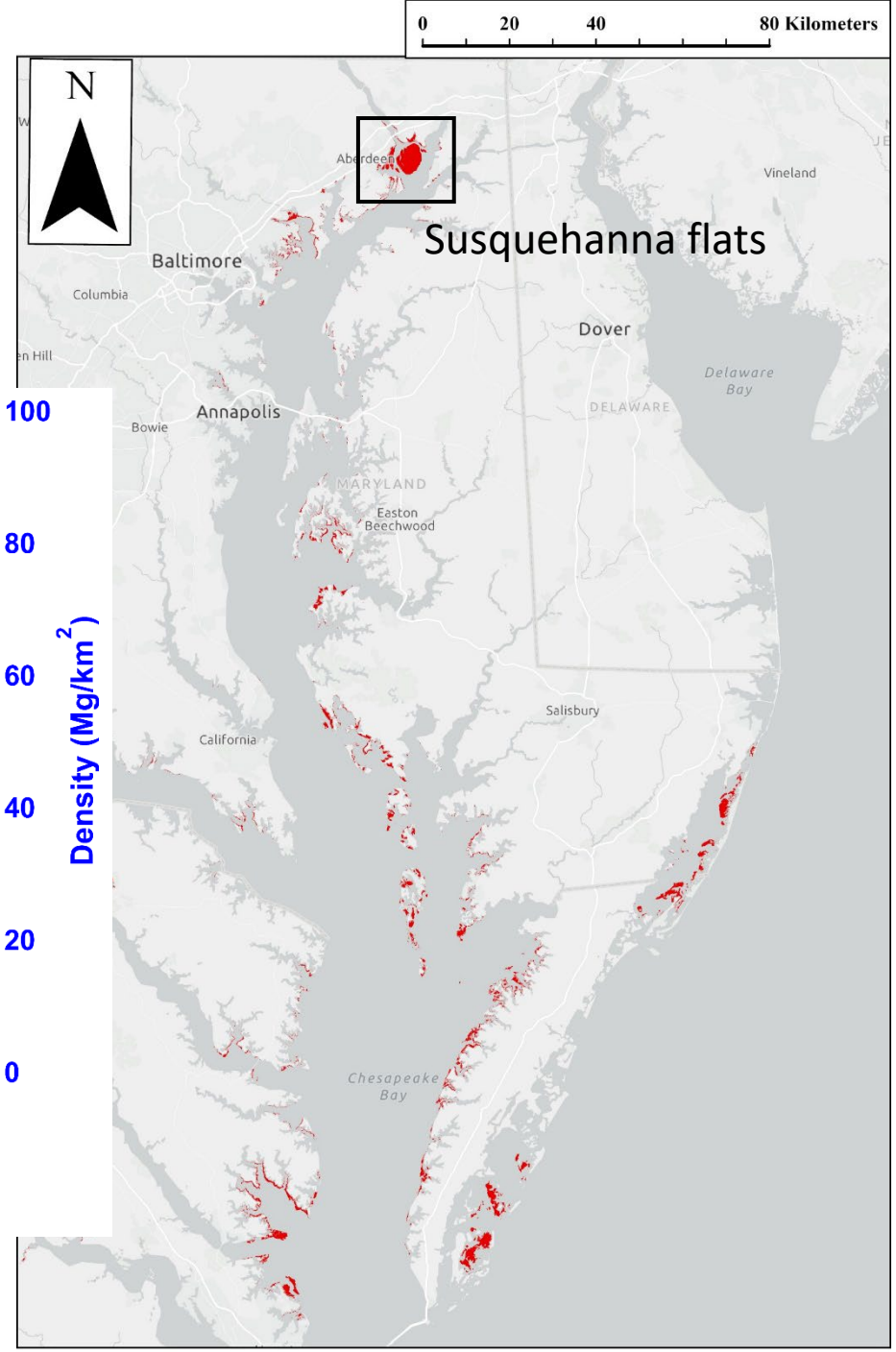
Susquehanna Flats: Extreme seasonality



Susquehanna Flats: Winter SAV carbon drops to > 10% of summer.



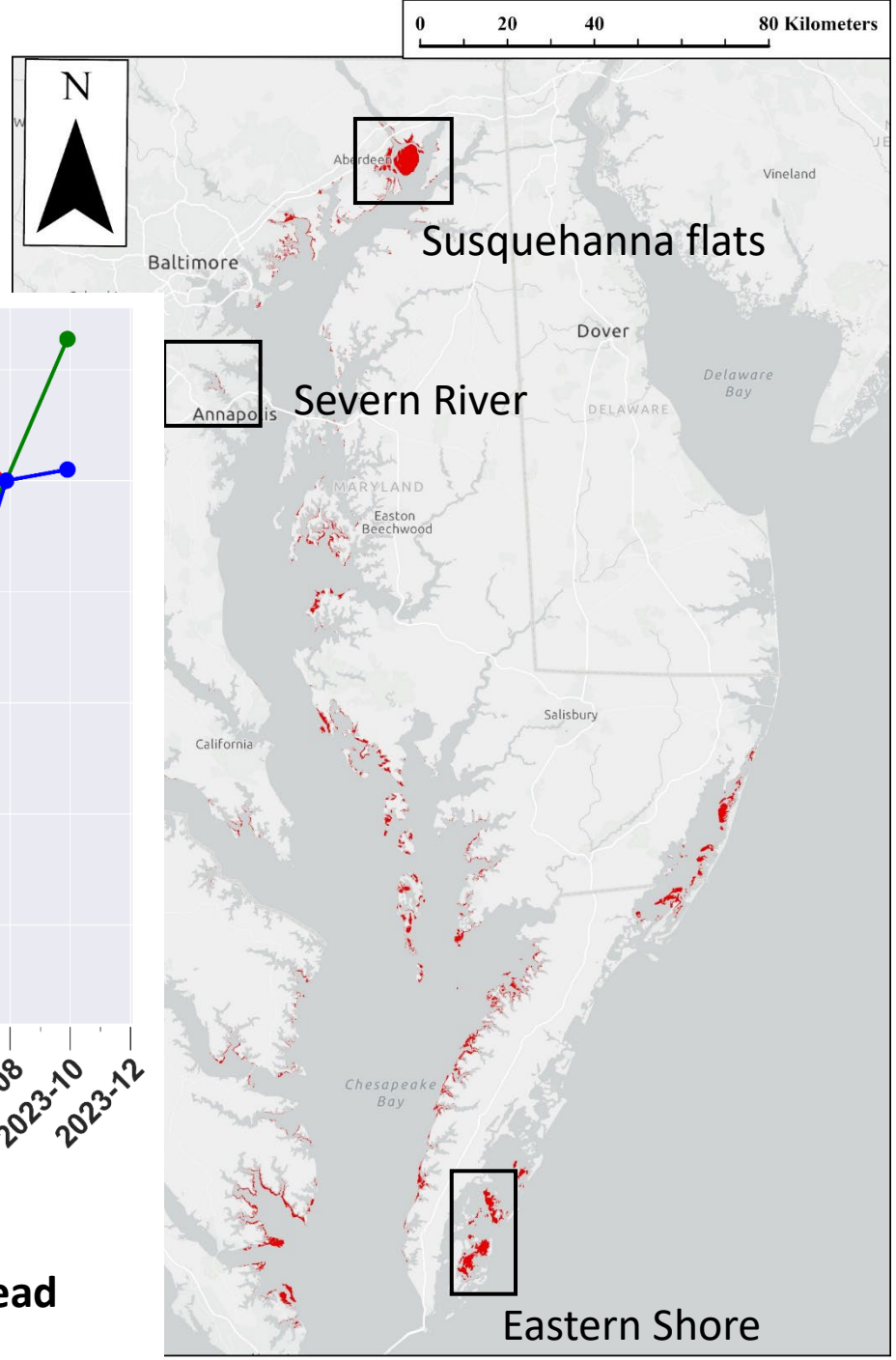


Seasonality increases with decreasing salinity

Eastern Shore: Eelgrass

Severn River: Horned pondweed, Widgeongrass, Redhead

Susquehanna flats: Wild celery, plus others



Annual carbon cycling

Eastern shore: Eelgrass

- Standing biomass ~ 0.5 Gg
- Above ground biomass turns over ~ 6 times per year (every 8 to 10 weeks)
- Carbon loss per year ~ 3 Gg

Severn River: mesohaline species

- Biomass decrease summer to winter = 0.08 Gg
- Above ground biomass turns over ??????
- Carbon loss per year ~ 0.08 Gg

Susquehanna Flats

- Biomass decrease summer to winter = ~3 Gg
- Above ground biomass turns over ?????? Once per year?
- Carbon loss per year ~ 3 Gg

Do Susquehanna Flats and Eastern Shore have same annual carbon cycling of above ground biomass??
Where does the carbon go?

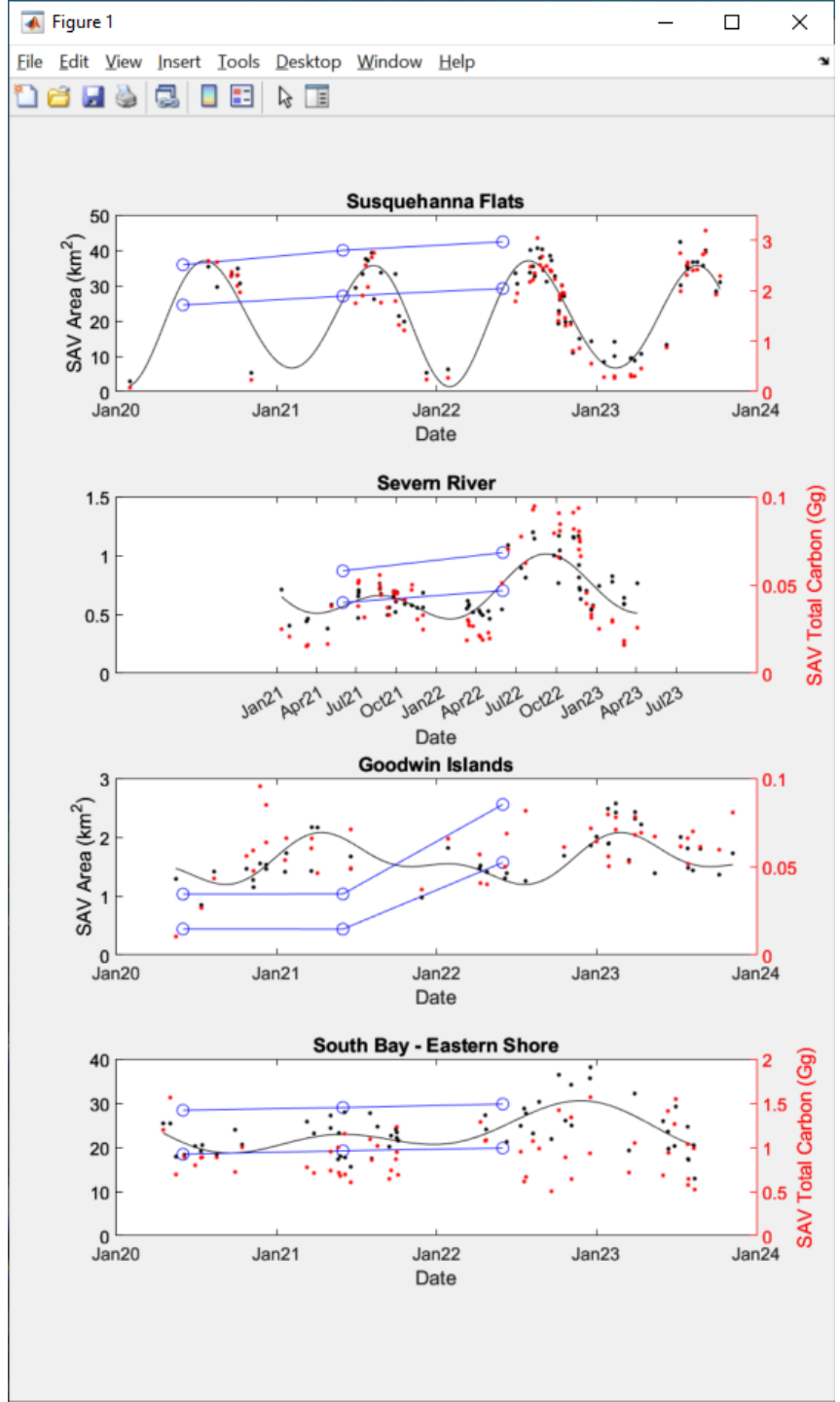


Figure 1
File Edit View Insert Tools Desktop Window Help
Susquehanna Flats
SAV Area (km2)
Jan20 Jan21 Jan22 Jan23 Jan24
Date
Severn River
SAV Total Carbon (Gg)
Jan21 Apr21 Jul21 Oct21 Jan22 Apr22 Jul22 Oct22 Jan23 Apr23 Jul23
Date
Goodwin Islands
SAV Area (km2)
Jan20 Jan21 Jan22 Jan23 Jan24
Date
South Bay - Eastern Shore
SAV Total Carbon (Gg)
Jan20 Jan21 Jan22 Jan23 Jan24
Date

Conclusions

- **Commercial high-resolution satellites provide sufficient spatial & temporal coverage to assess Chesapeake Bay SAV on scales not previously attainable**
- **Automated workflow allows for rapid processing of imagery to quantify temporal patterns**
- **Eelgrass abundance on Eastern Shore shows low seasonal variation and slow expansion.**
  - **above ground biomass turns over ~ 6 times per year (every 8 to 10 weeks)**
- **Mesohaline SAV (many spp.) in Severn River shows more seasonal variation, most abundant in summer and biomass density 2X that of eelgrass.**
  - **Rate of biomass turnover is unknown.**
- **Oligohaline SAV (many spp.) in Susquehanna Flats show extreme seasonal variation, with maximum densities similar to Mesohaline SAV – both 2X eelgrass.**
  - **Biomass clearly turns over at least once per year.**
- **<u>What is the role of these SAV populations in the coastal carbon cycle?</u>**