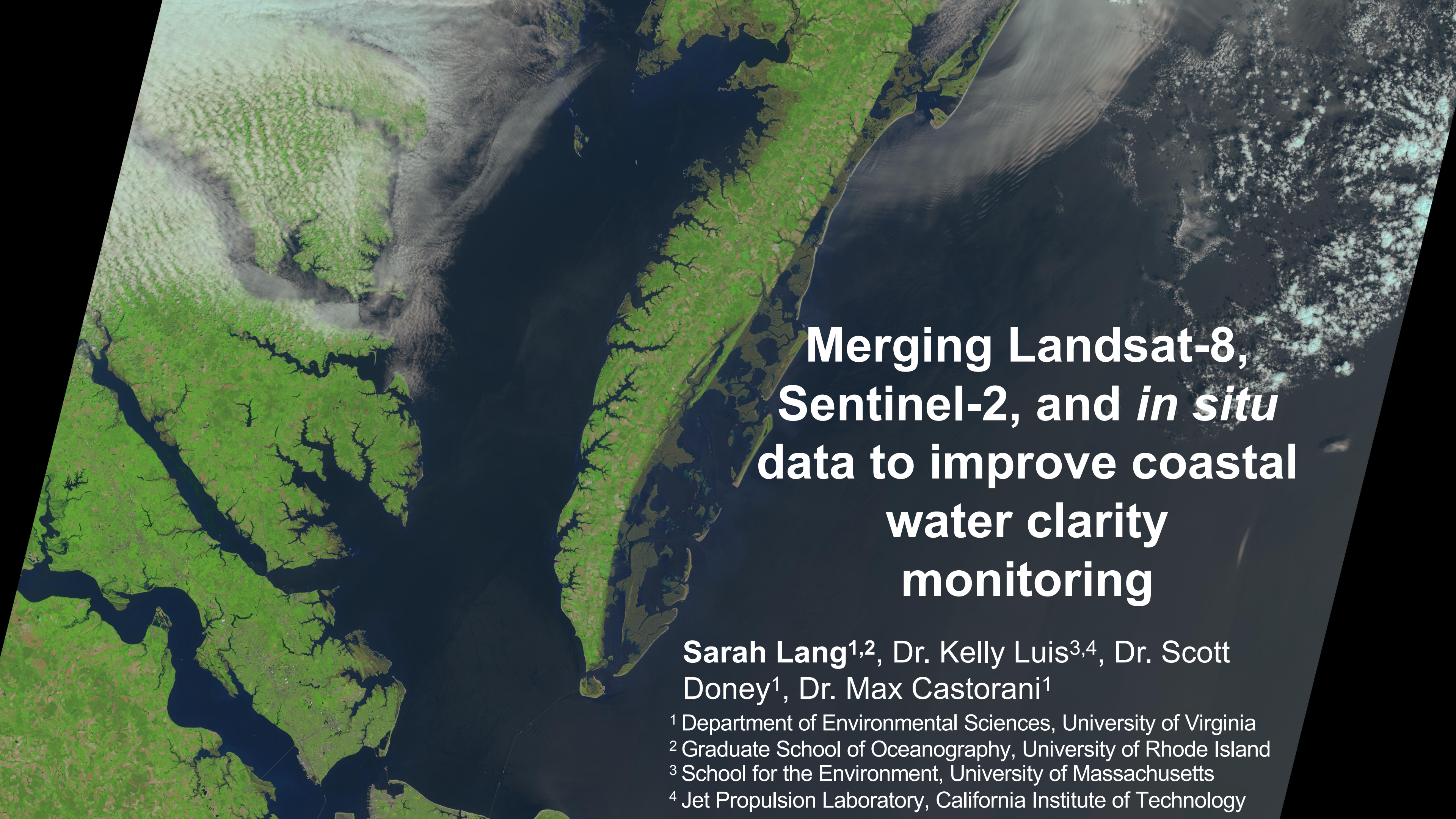

Merging Landsat-8, Sentinel-2, and *in situ* data to improve coastal water clarity monitoring

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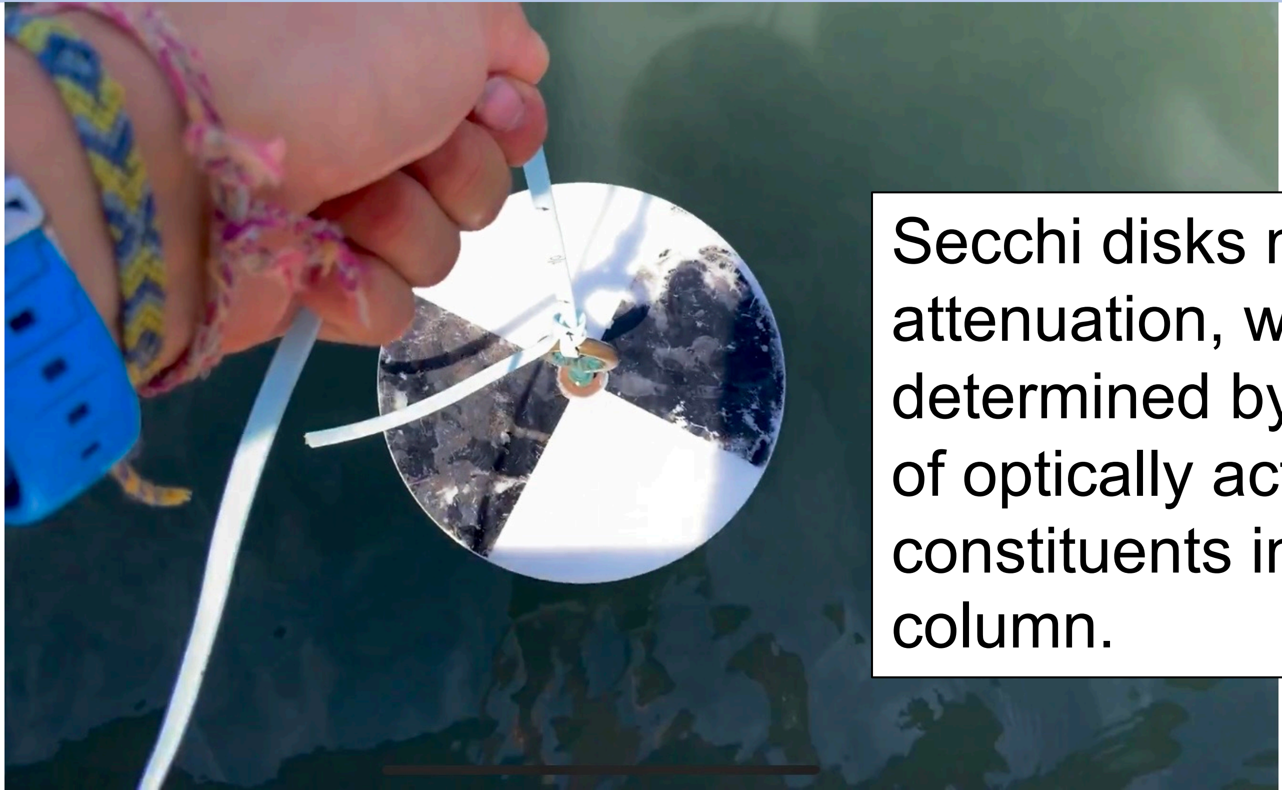
Overview

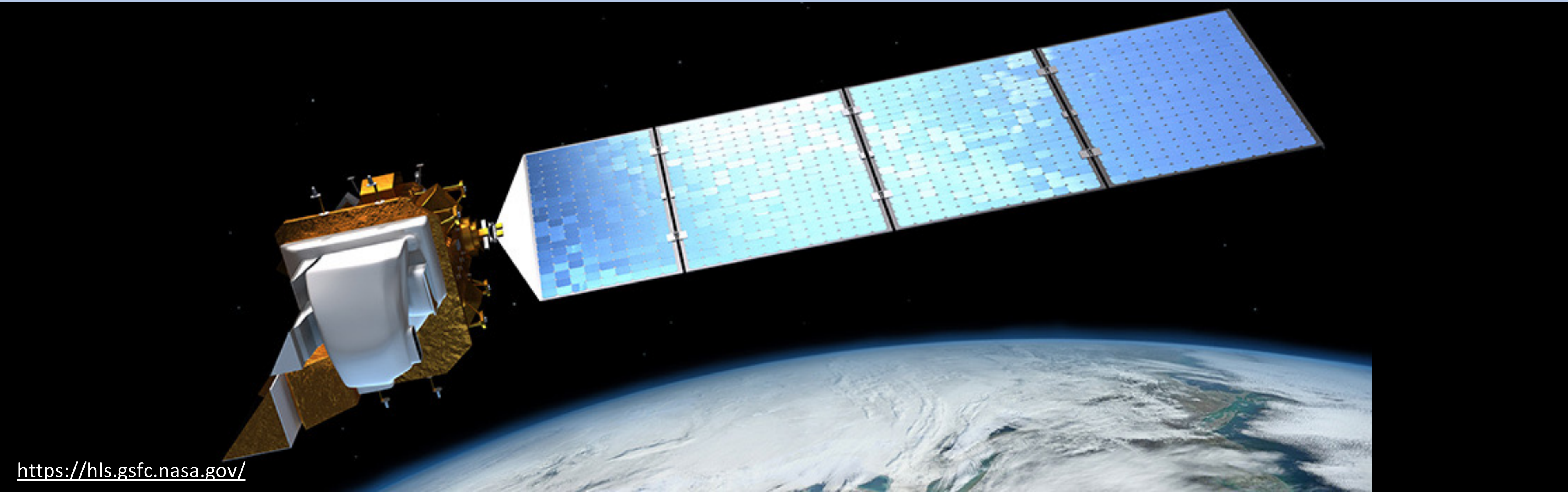
- Introduction to ocean color algorithms and water clarity applications
- Methods for creating a satellite water clarity product using *in situ* observations
- Recommendations for Chesapeake Bay

In situ measurements cannot fully capture variability alone.



Secchi disks measure light attenuation, which is determined by the amount of optically active constituents in the water column.

Coupling remotely-sensed satellite measurements with *in situ* measurements could provide a more complete understanding of water clarity changes and drivers in coastal ecosystems.



https://hls.gsfc.nasa.gov/

Ocean color algorithms can estimate useful biogeochemical parameters.

Level 1 Reflectance data

↓ Atmospheric Correction

$R_{rs}(443)$, $R_{rs}(482)$, $R_{rs}(561)$, $R_{rs}(655)$

↓ Quasi-Analytical Algorithm

Inherent Optical Properties

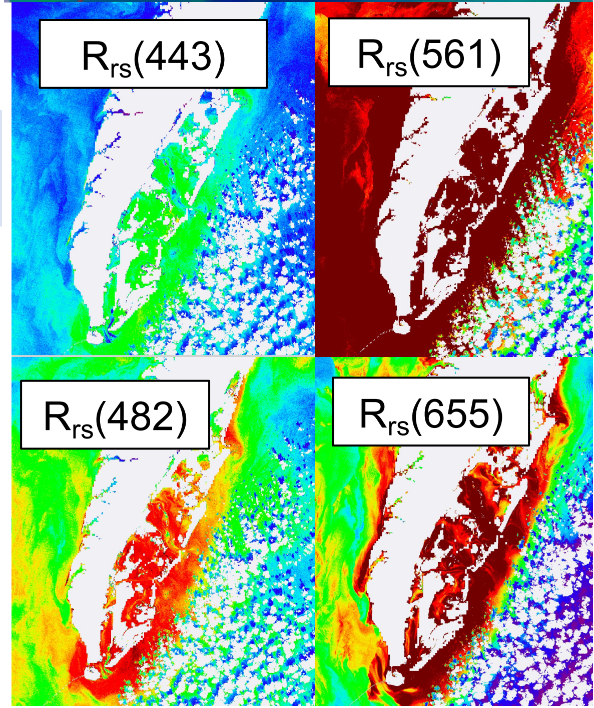
↓ Lee et al. (2005, 2015, 2016) K_d model

Light Attenuation

↓ Lee et al. 2016 Z_{SD} model

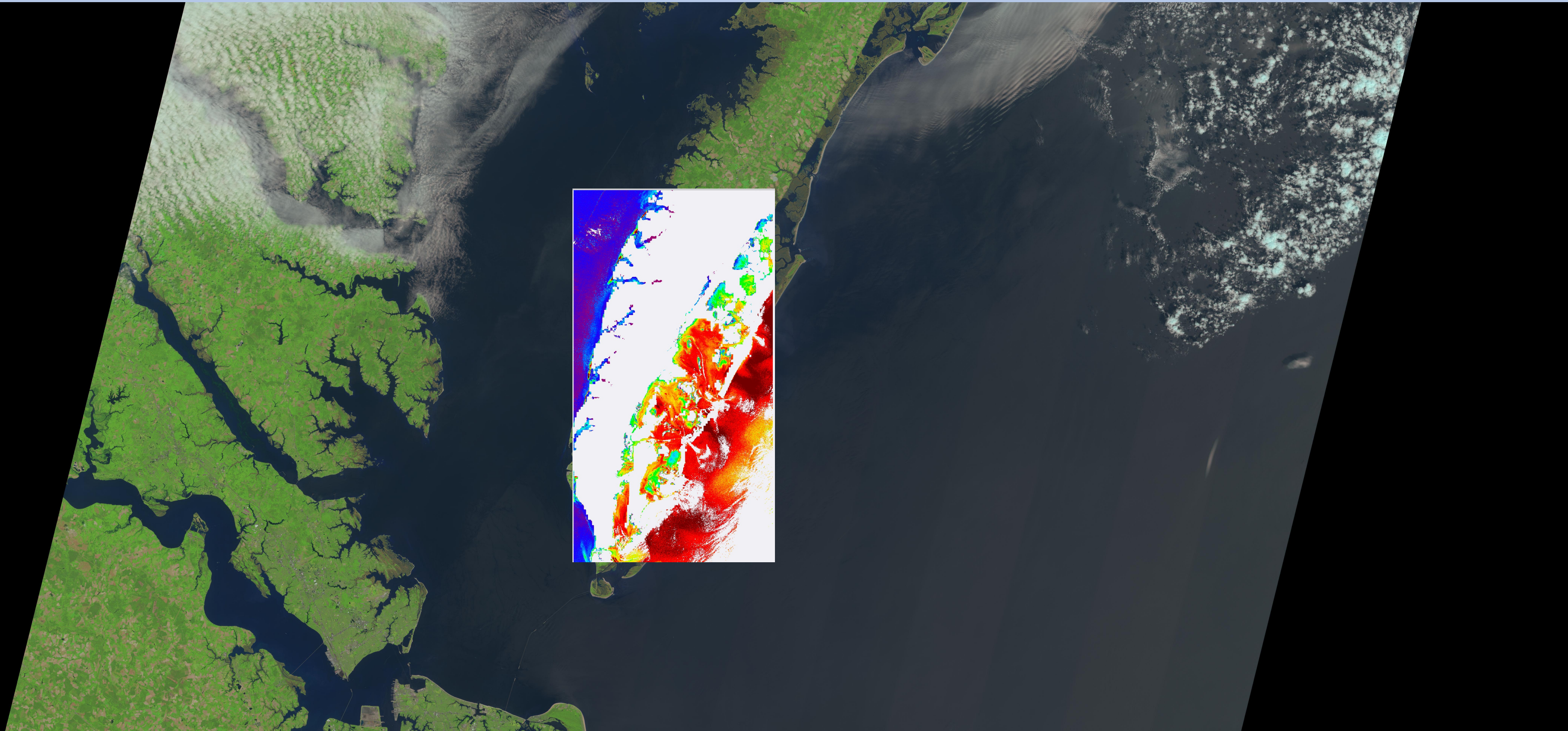
Secchi disk depth ($Z_{SD,sat}$)

$$Z_{SD,sat} = \frac{1}{2.5Min(K_d^{tr})} \ln\left(\frac{0.14 - R_{rs}^{tr}}{0.013}\right)$$

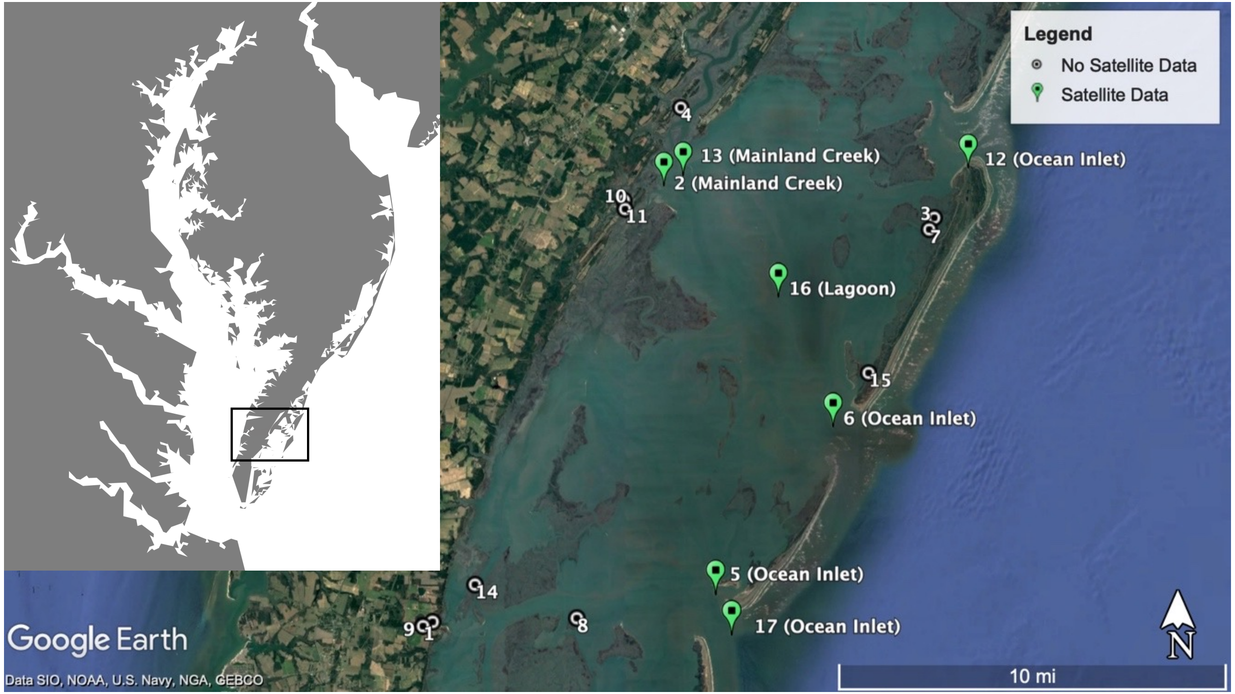


11/9/2019 Landsat-8 Image

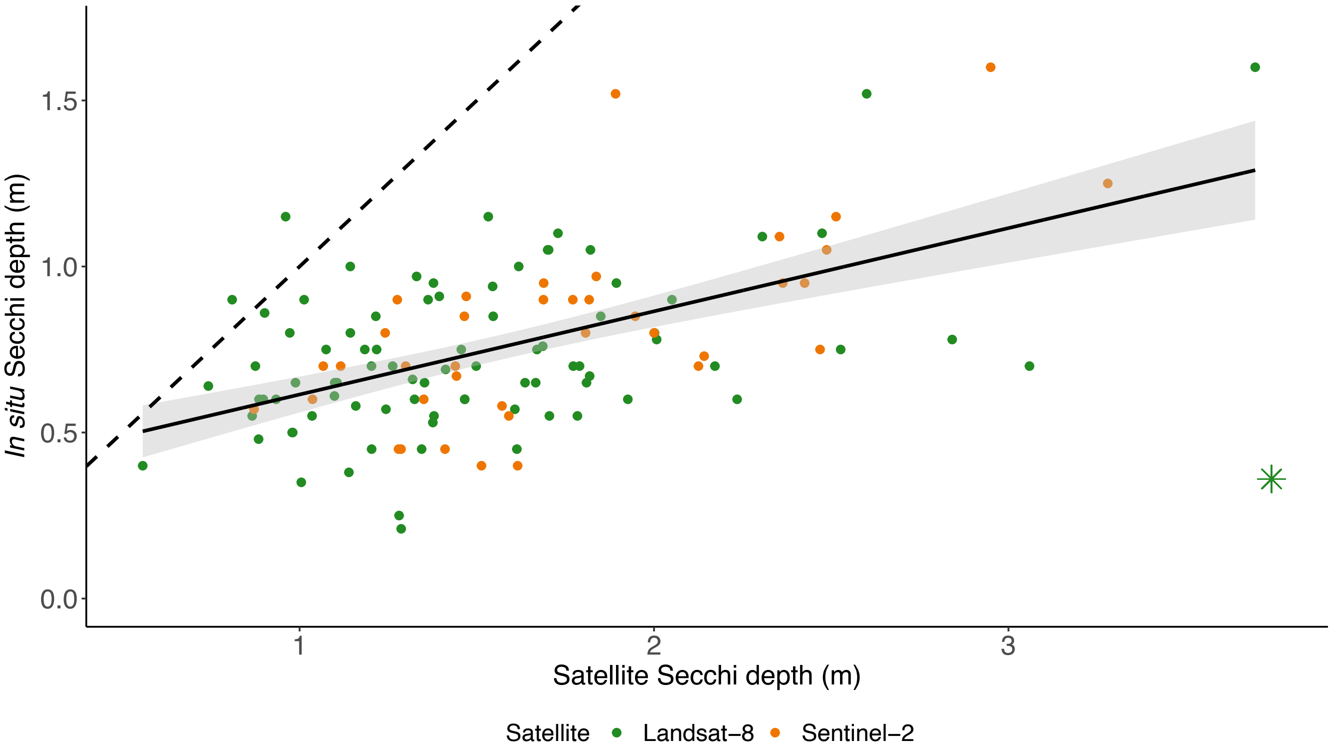
Coastal oceans introduce unique challenges for remote sensing.



Extensive *in situ* water quality data from the Virginia Coast Reserve LTER provide an opportunity to evaluate satellite ocean color algorithms.



The satellite algorithm overestimated Secchi depths relative to their corresponding *in situ* values.

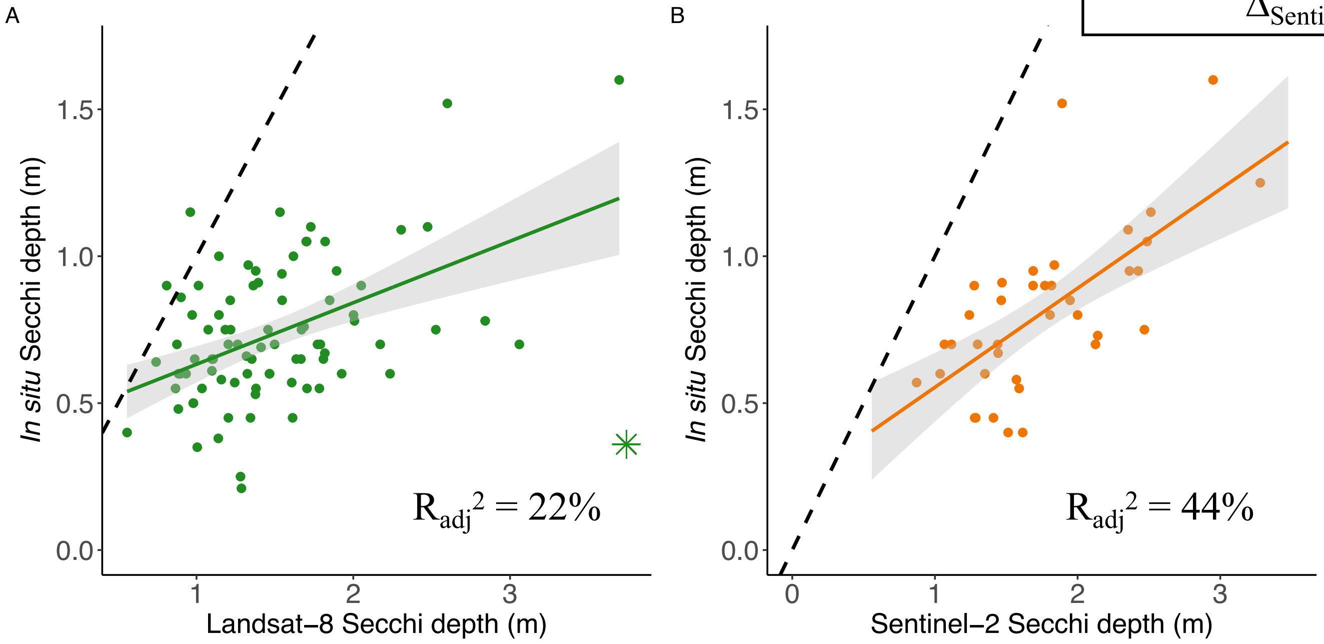


Our model can describe **31%** of variation in *in situ* measurements.

$$Z_{SD,model} = 0.21\,Z_{SD,sat} + 0.42 + \Delta$$

$$\Delta_{\mathrm{Landsat}} = 0$$

$$\Delta_{\mathrm{Sentinel}} = 0.13\;Z_{SD,sat} - 0.21$$



The model improved estimates from bio-optical algorithms that overpredicted water clarity.

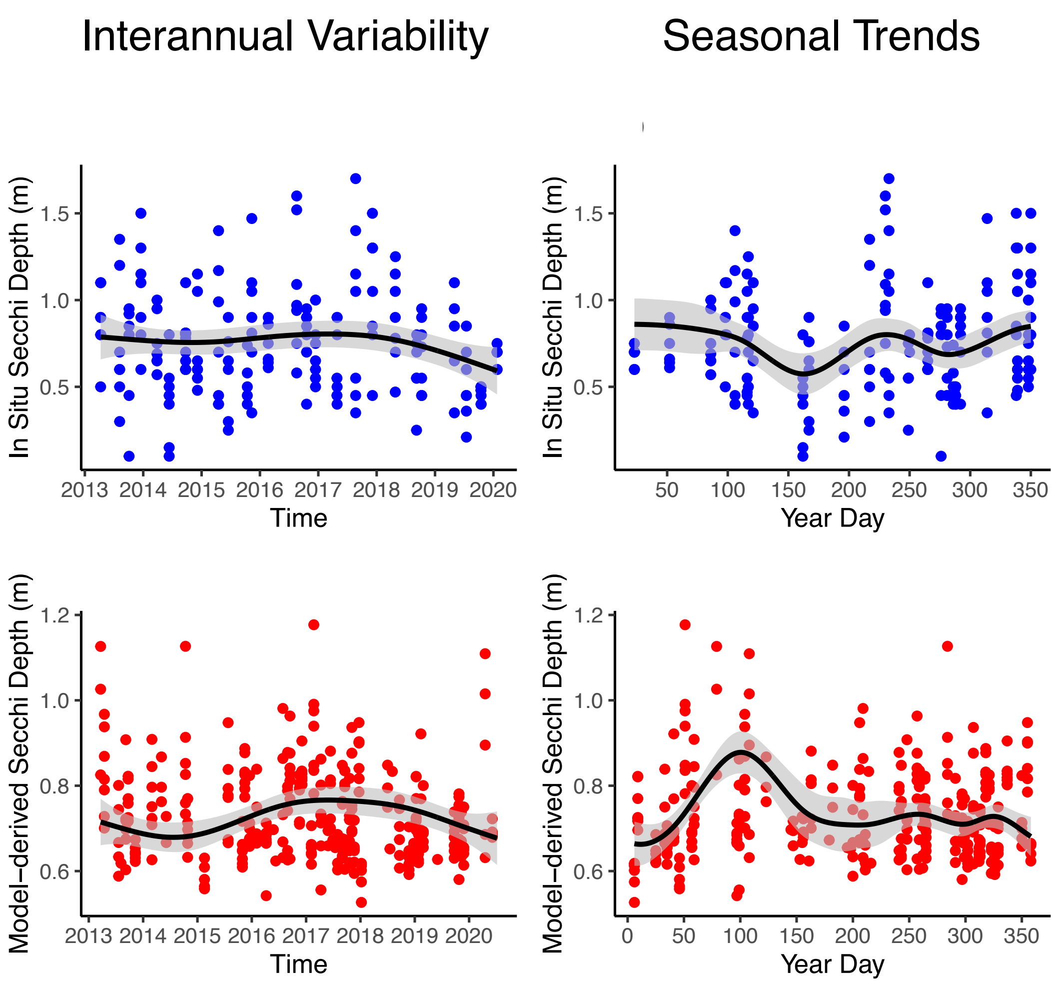
$$RMSE = \sqrt{\frac{1}{n}\sum_{i=1}^{n}\left(x_{model,i} - x_{in\,situ,i}\right)^2}$$

Unadjusted: RMSE = 0.94 m
Adjusted: RMSE = 0.21 m

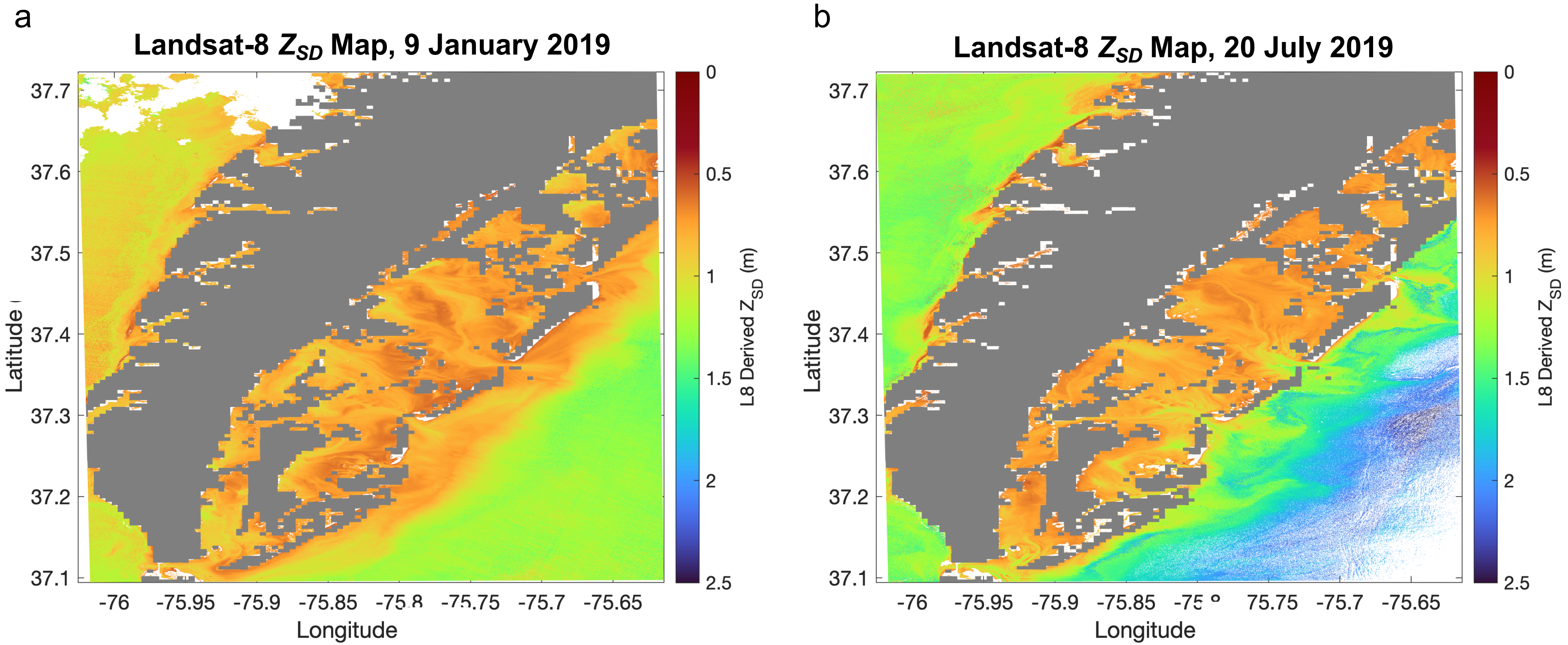
$$MAPD = \frac{1}{n}\sum_{i=1}^{n}\left|\frac{x_{model,i} - x_{in\,situ,i}}{x_{in\,situ,i}}\right| \times 100\%$$

Unadjusted: MAPD = 120%
Adjusted: MAPD = 25%

It is crucial to couple *in situ* observations with satellite observations to understand and predict changes in water clarity.



Satellites capture spatial patterns unresolved by point measurements.



Our product:

1. Increases the spatiotemporal scope of *in situ* water clarity data
2. Improves estimates from bio-optical algorithms that overpredicted water clarity
3. Decreases errors associated with Landsat-8/Sentinel-2 differences

How we are improving this product:

- Reprocessing satellite imagery with improved code
- Decreasing match-up period (± 1 day)

SeaDAS processing guide available on my github:
https://github.com**/ocean-slang/SeaDAS**

Chesapeake Bay recommendations

- Create a satellite product harmonious with a long term *in situ* dataset
- Apply our methodology with ±1 day window, expand as needed
- Atmospheric correction – C2RCC (Windle et al., 2022)
- Drones

Thank you!

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Water quality parameters were strongly seasonal, with peaks in various parameters co-occurring with a seasonal minimum in Secchi depth.