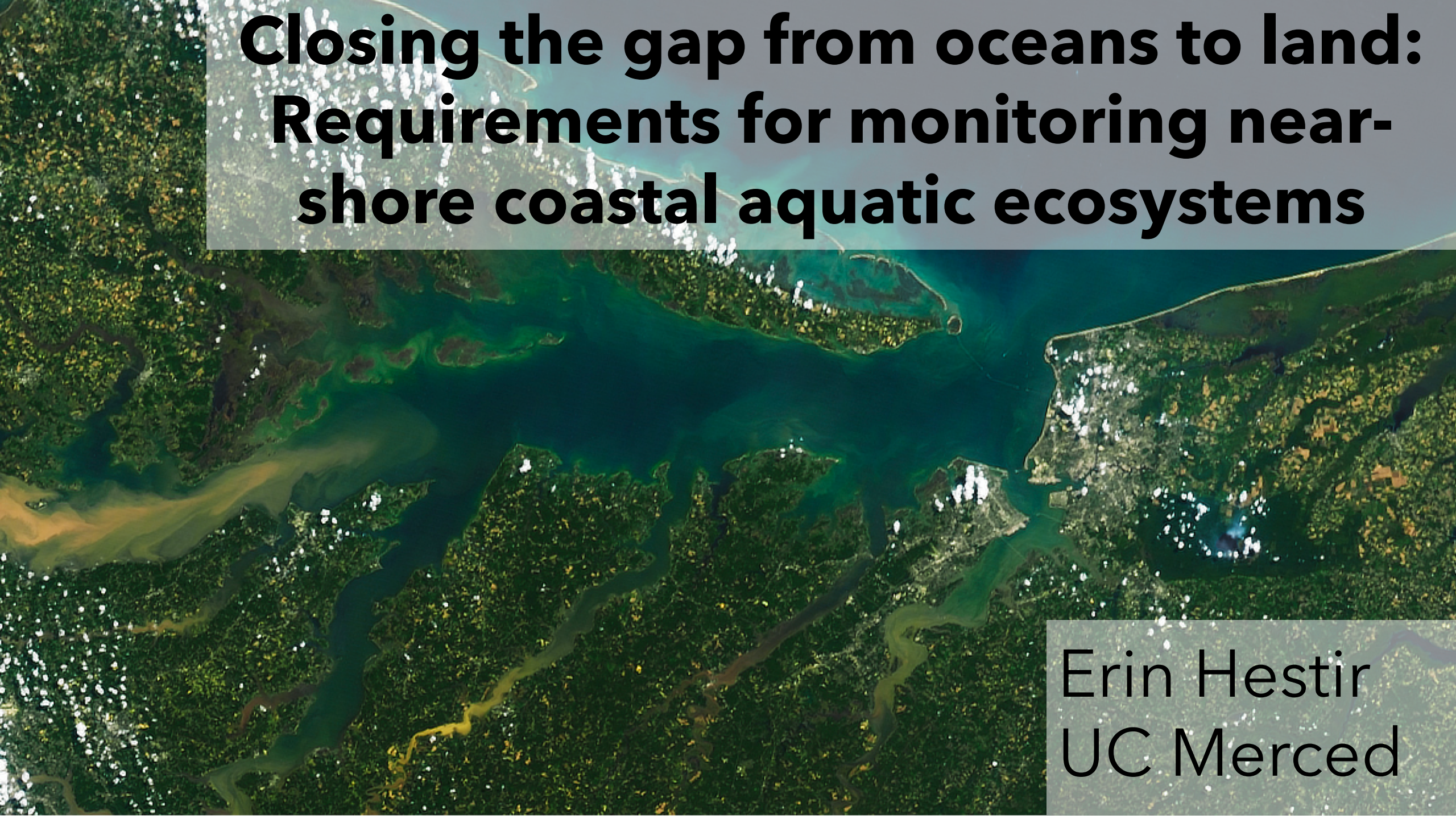
Closing the gap from oceans to land: Requirements for monitoring near-shore coastal aquatic ecosystems



Erin Hestir
UC Merced

From Arboreal to Benthic Communities:
The ABCs of land-to-ocean biodiversity observations

LOBO

Land to Ocean Biodiversity Observations

Michelle Gierach
Ryan Pavlick
Phil Townsend
Rob Green
David Schimel
Natasha Stavros
Christine Lee
David Thompson
Bo-Cai Gao

Frank Muller-Karger
Kevin Turpie
Lola Fatoyinbo-Agueh
Evelyn Gaiser

Coastal ecosystems are some of the most productive and diverse places in the world

30% of total oceanic production

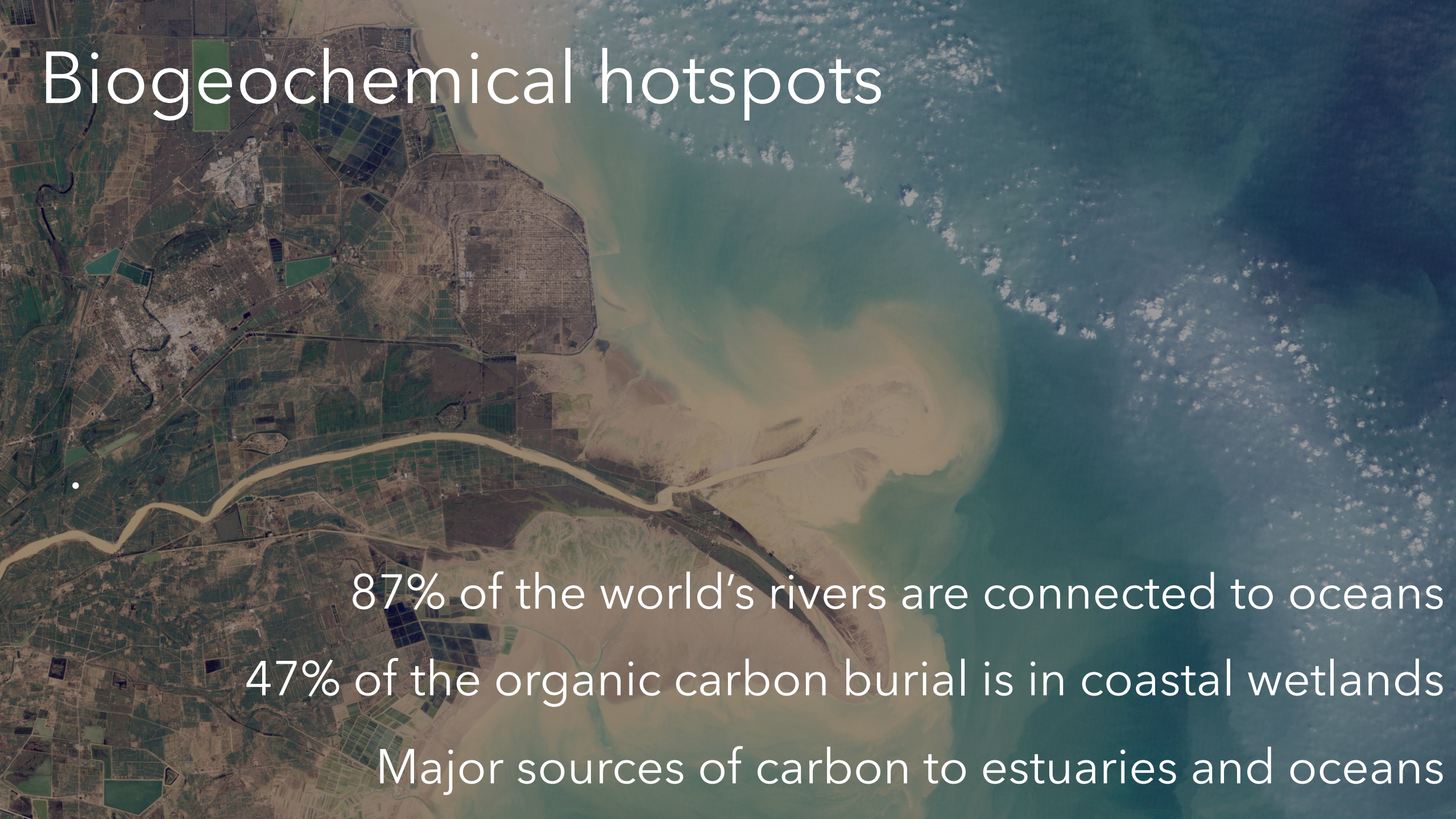
90% of global fish production

More than 100,000 animal species

Over 80% of all marine fish species

Over 20% of bird species

Biogeochemical hotspots



87% of the world’s rivers are connected to oceans

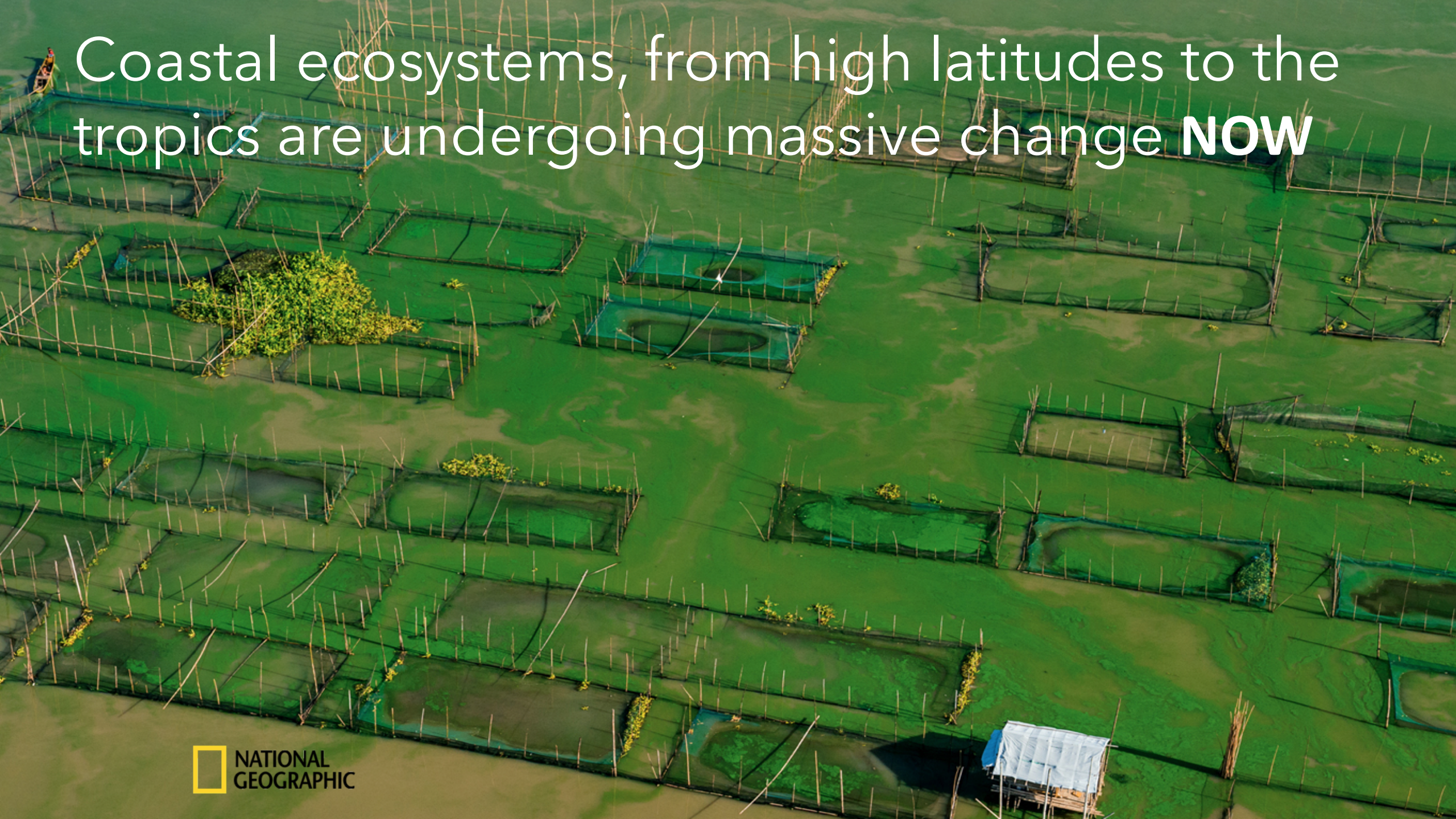
47% of the organic carbon burial is in coastal wetlands

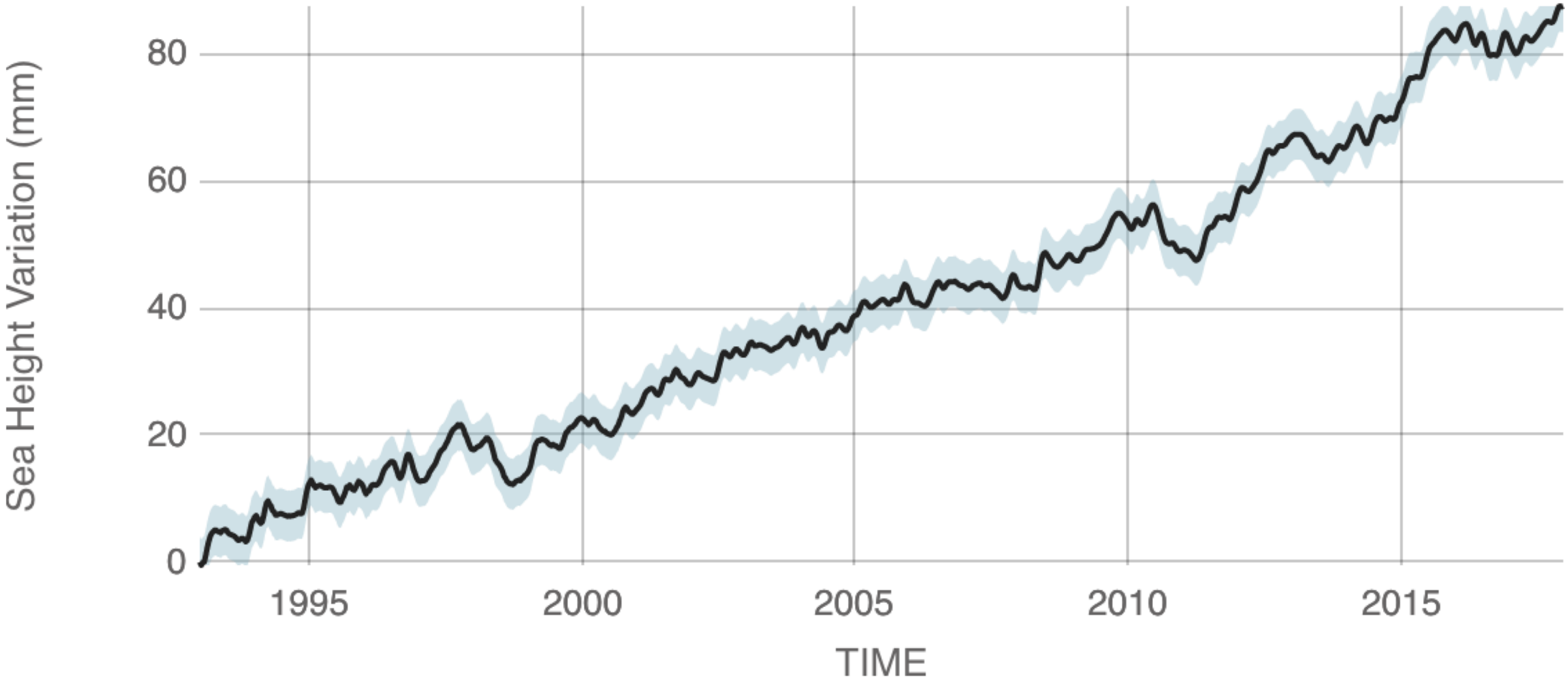
Major sources of carbon to estuaries and oceans

Our life and economy depend on healthy coastal ecosystems


Chesapeake Bay Program


OLD BAY
SEASONING


Coastal ecosystems, from high latitudes to the tropics are undergoing massive change **NOW**
NATIONAL GEOGRAPHIC



[Nasa.climate.gov]


VICE News

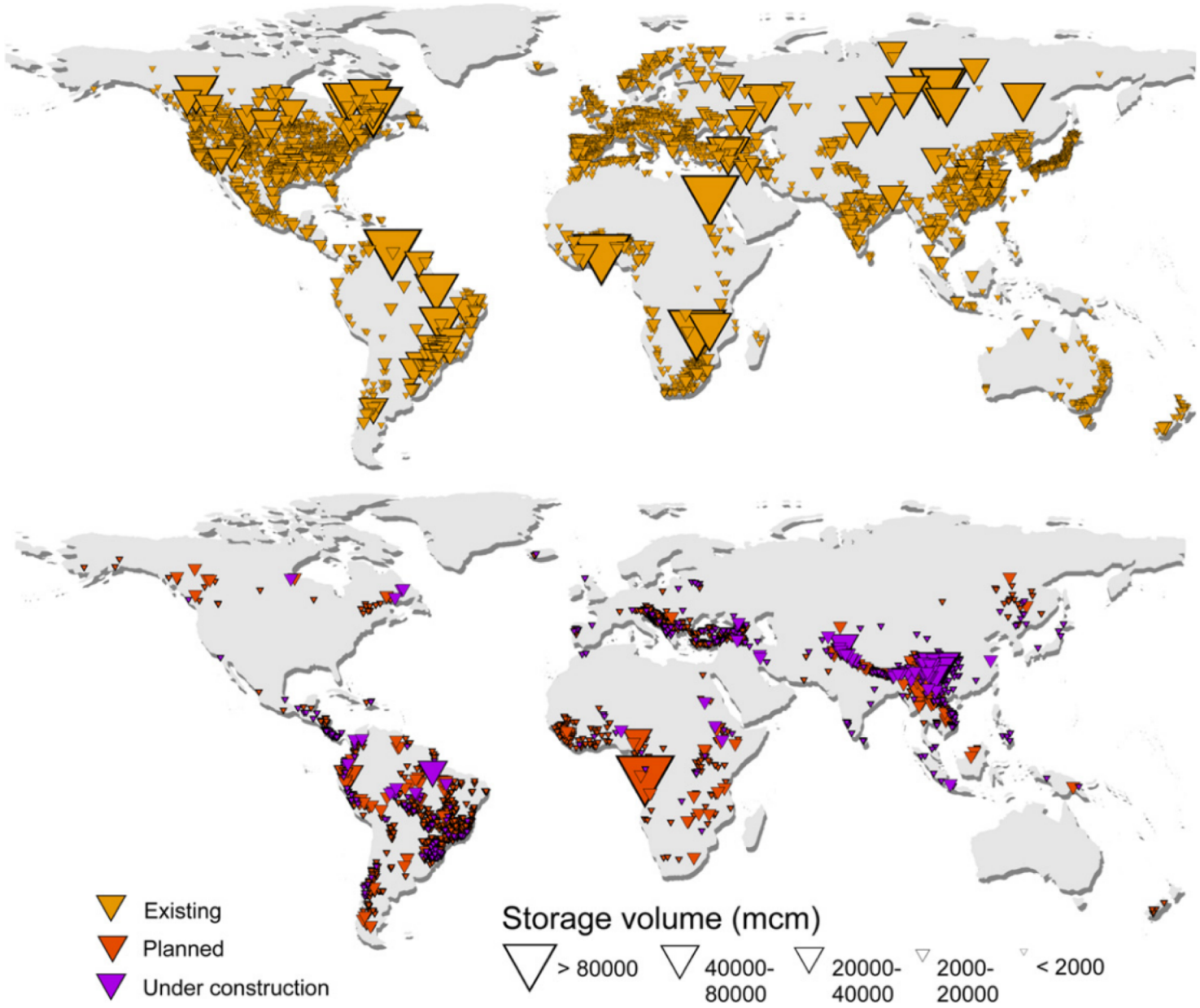
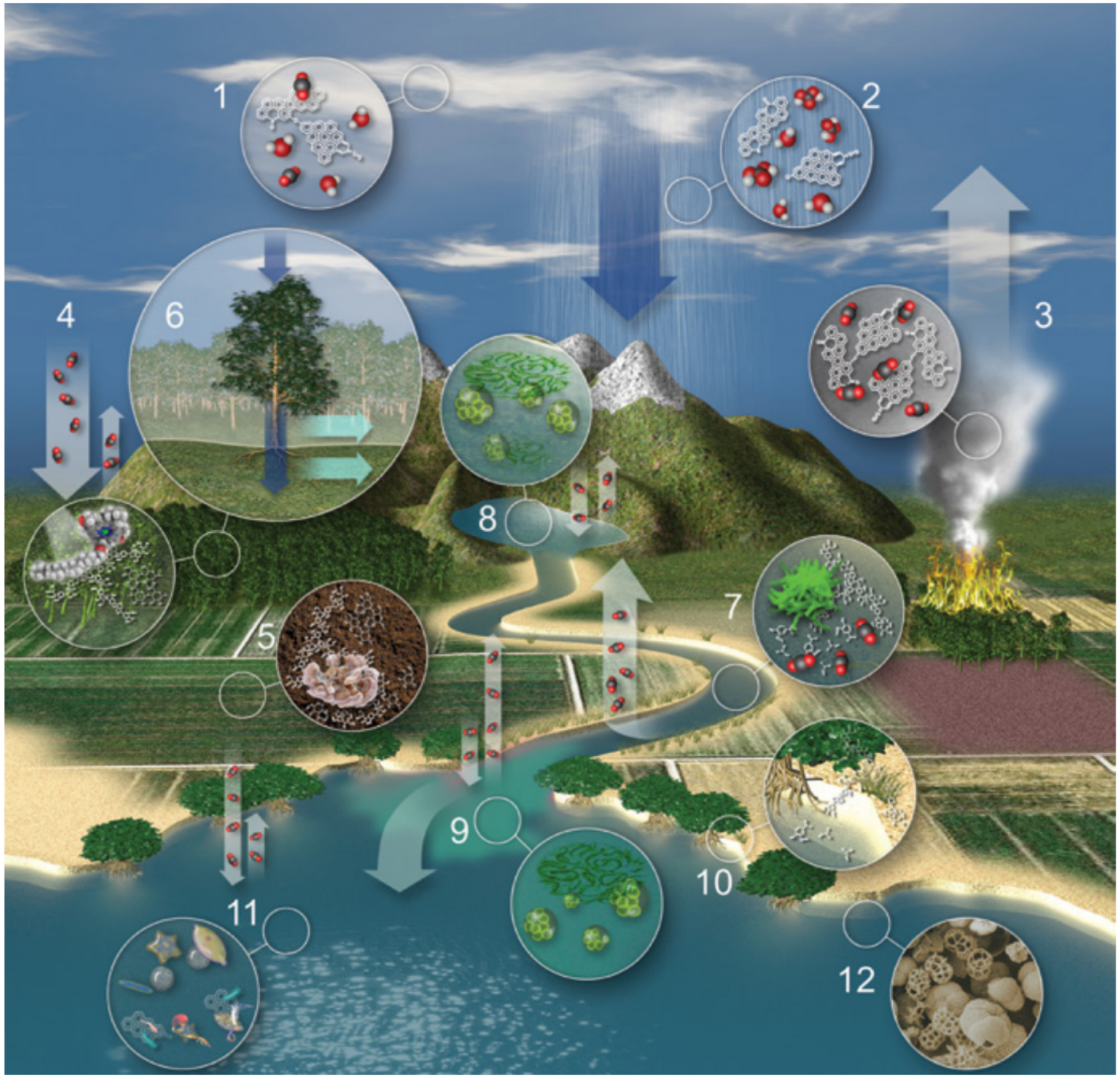


Figure 1. Overview of existing dams (GRanD, Lehner *et al* 2011) and planned and under construction future dams (Zarfl *et al* 2014) by storage volume class (volumes in million cubic meters from Lehner *et al* 2011 and own estimates).

50% of the world's runoff has been diverted

Günther Grill et al 2015 Environ. Res. Lett.

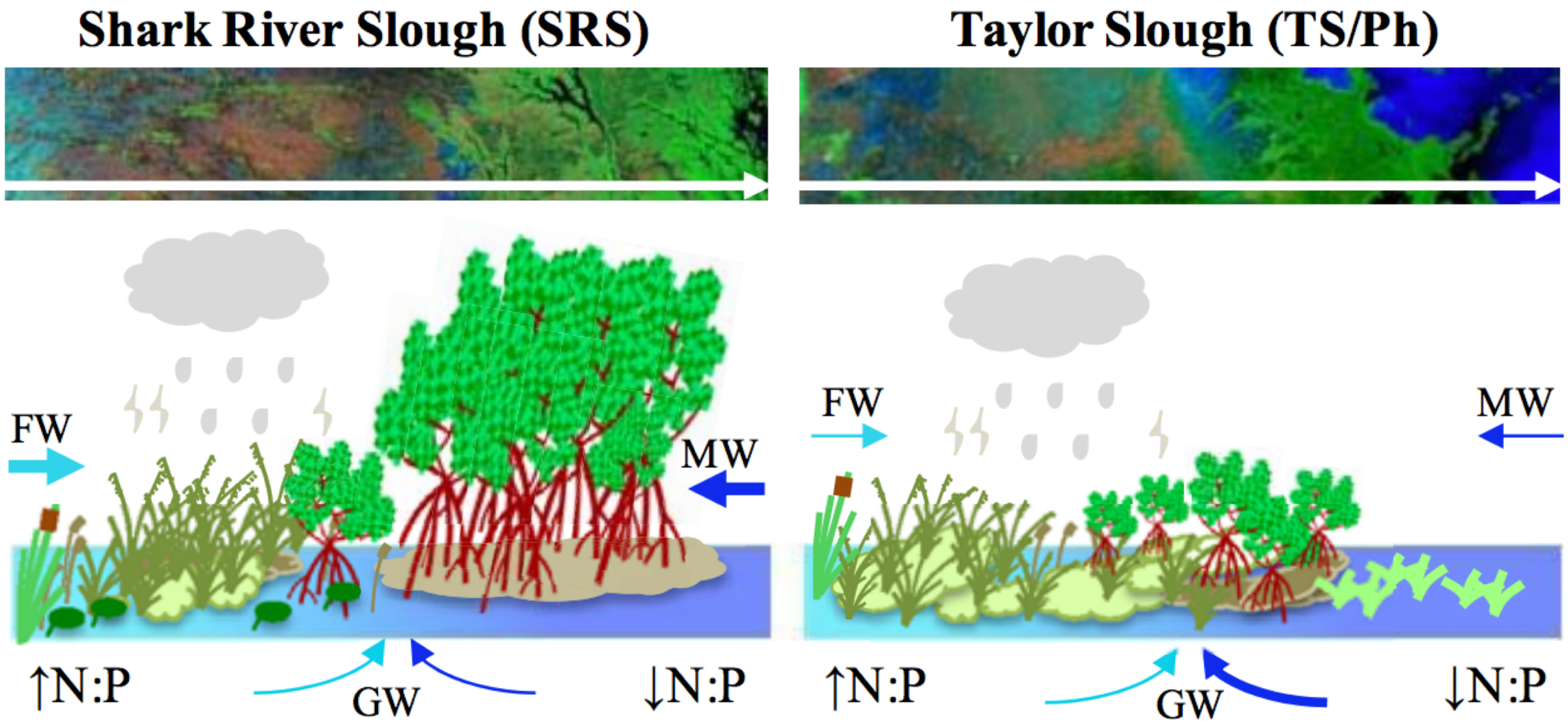


Water drives biogeochemical cycling across the land to ocean continuum

Plant traits and vegetation dynamics control hydrology and geomorphology, and regulate microbial and soil biogeochemical processes.

Where carbon goes when water flows: carbon cycling across the aquatic continuum. Ward et al. 2017

The balance of fresh-marine water determines fundamental ecosystem structure and shape of the coastal gradient



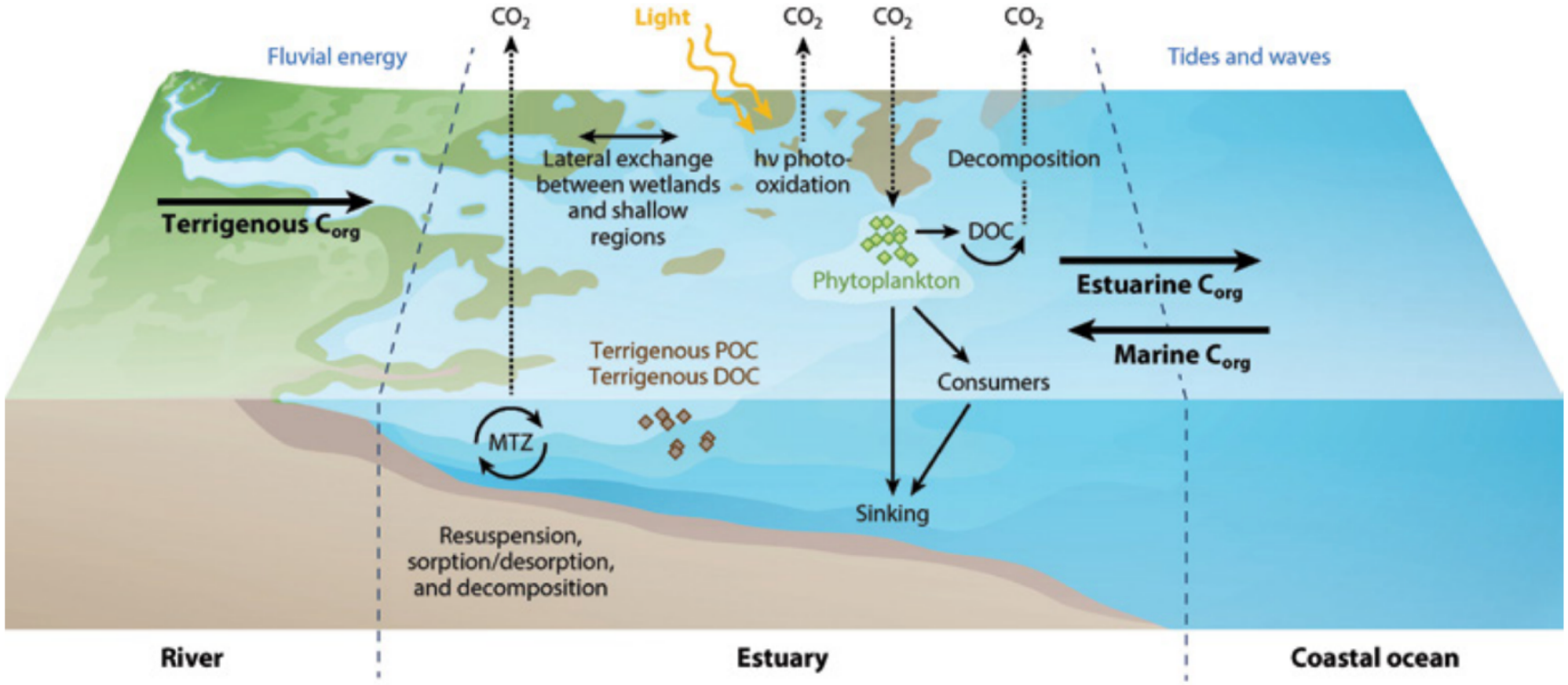
E-1: What are the structure, function, and biodiversity of Earth’s ecosystems, and how and why are they changing in time and space?

E-3: What are the fluxes (of carbon, water, nutrients, and energy) *within* ecosystems, and how and why are they changing?

Coasts are transition zones.
Flows occur between *and* within.

E-2: What are the fluxes (of carbon, water, nutrients, and energy) *between* ecosystems and the atmosphere, the ocean and the solid Earth, and how and why are they changing?

Coastal ecosystems at the terrestrial-aquatic interface are poorly represented by global models



Canuel, E. A., and A. K. Hardison. 2016. Annual Review of Marine Science

Remote sensing enables us to consider land and adjacent marine ecosystems as part of a **continuum**

Florida Coastal Everglades Long Term Ecological Research Program

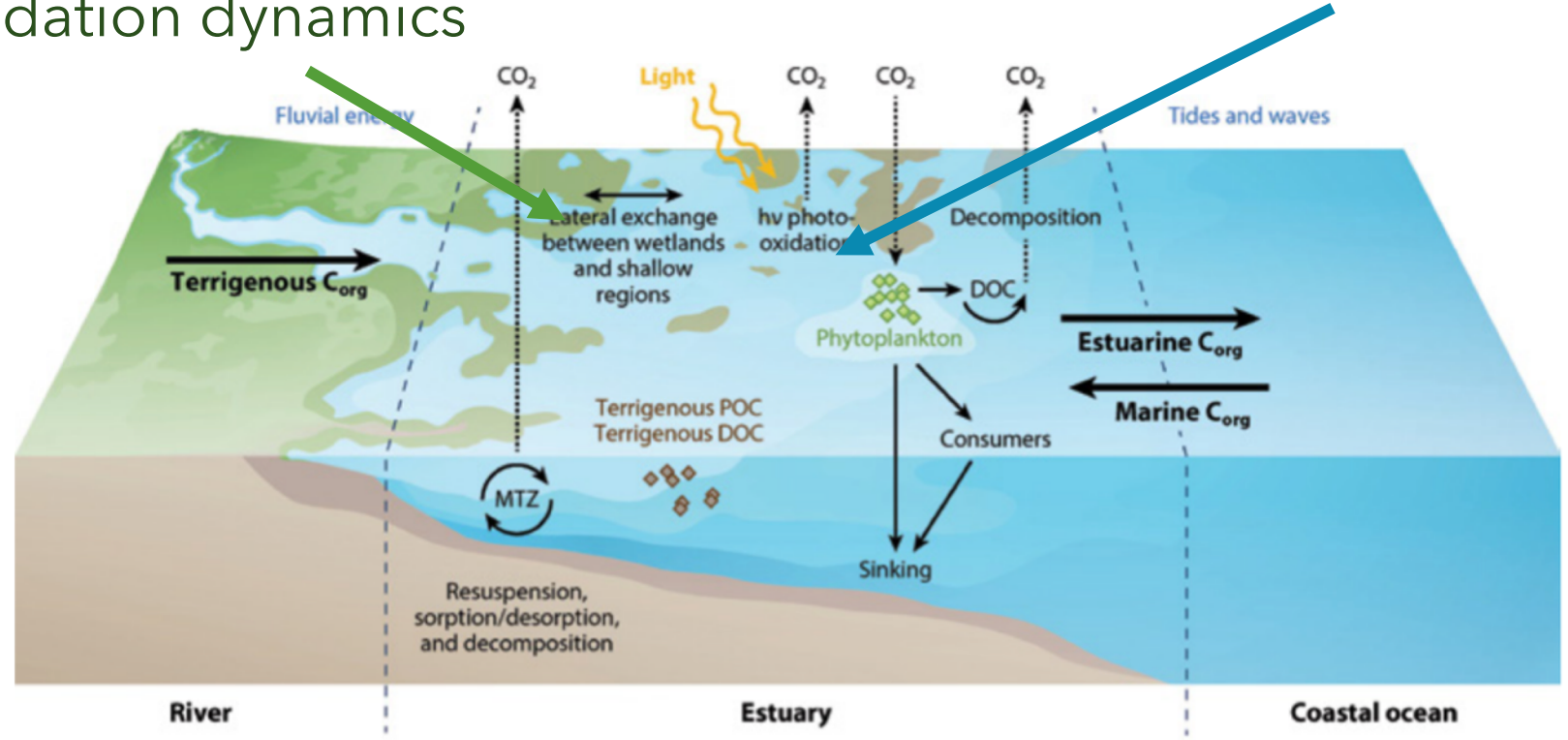
Measurement requirements

Vegetation

- Plant/macro-algal composition & distribution
- Vegetation dynamics
- Plant functional traits
- Inundation dynamics

Aquatic biogeochemistry & water quality

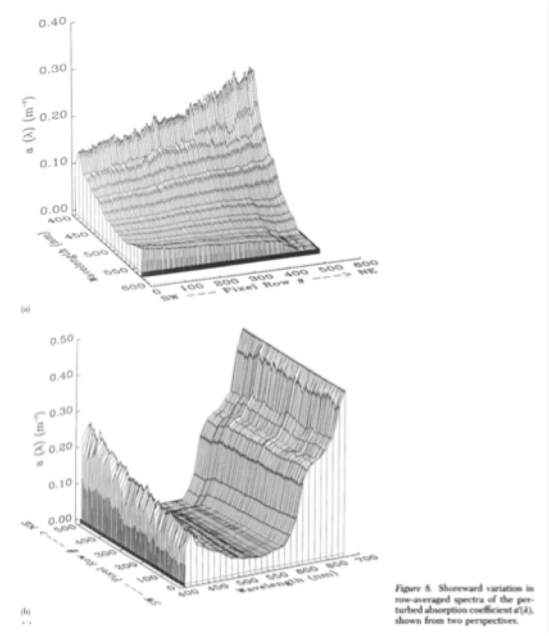
- Phytoplankton biomass
- Dissolved & particulate organic carbon
- Suspended sediments
- Underwater light environment



Canuel, E. A., and A. K. Hardison. 2016. Annual Review of Marine Science

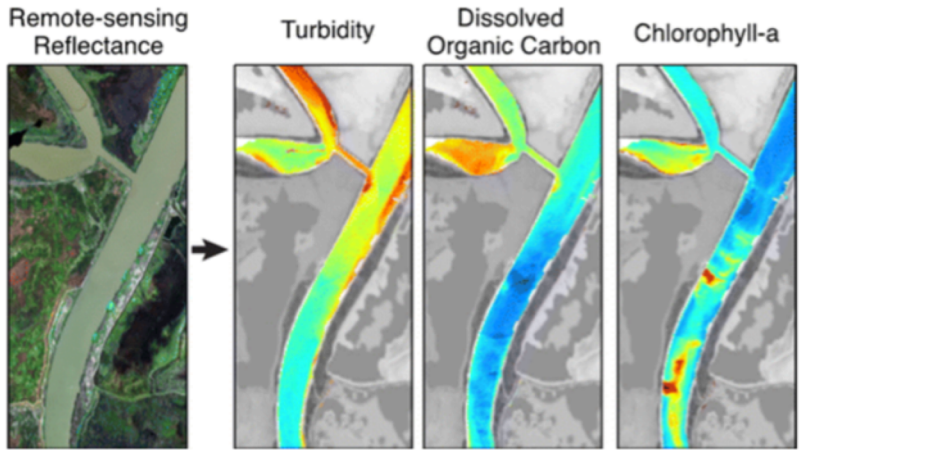
We've been doing this for a long time.

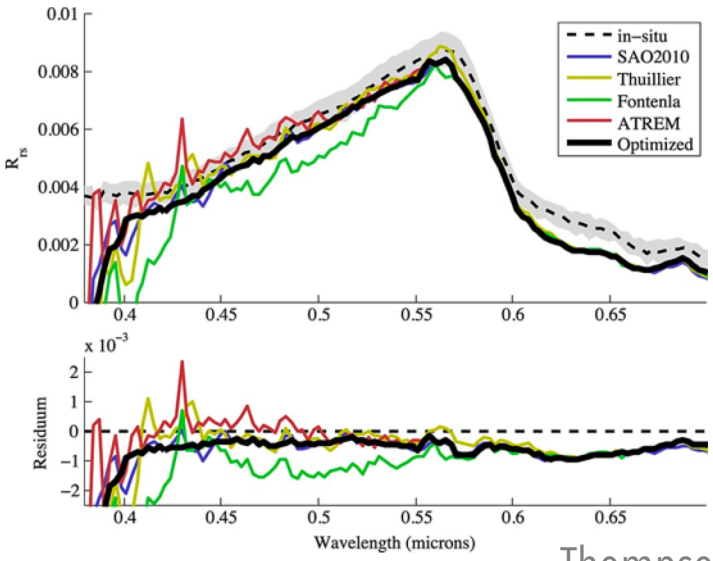
(And we've gotten really good at it)



Carder et al. 1993

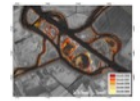
~25 years





Thompson et al. 2015

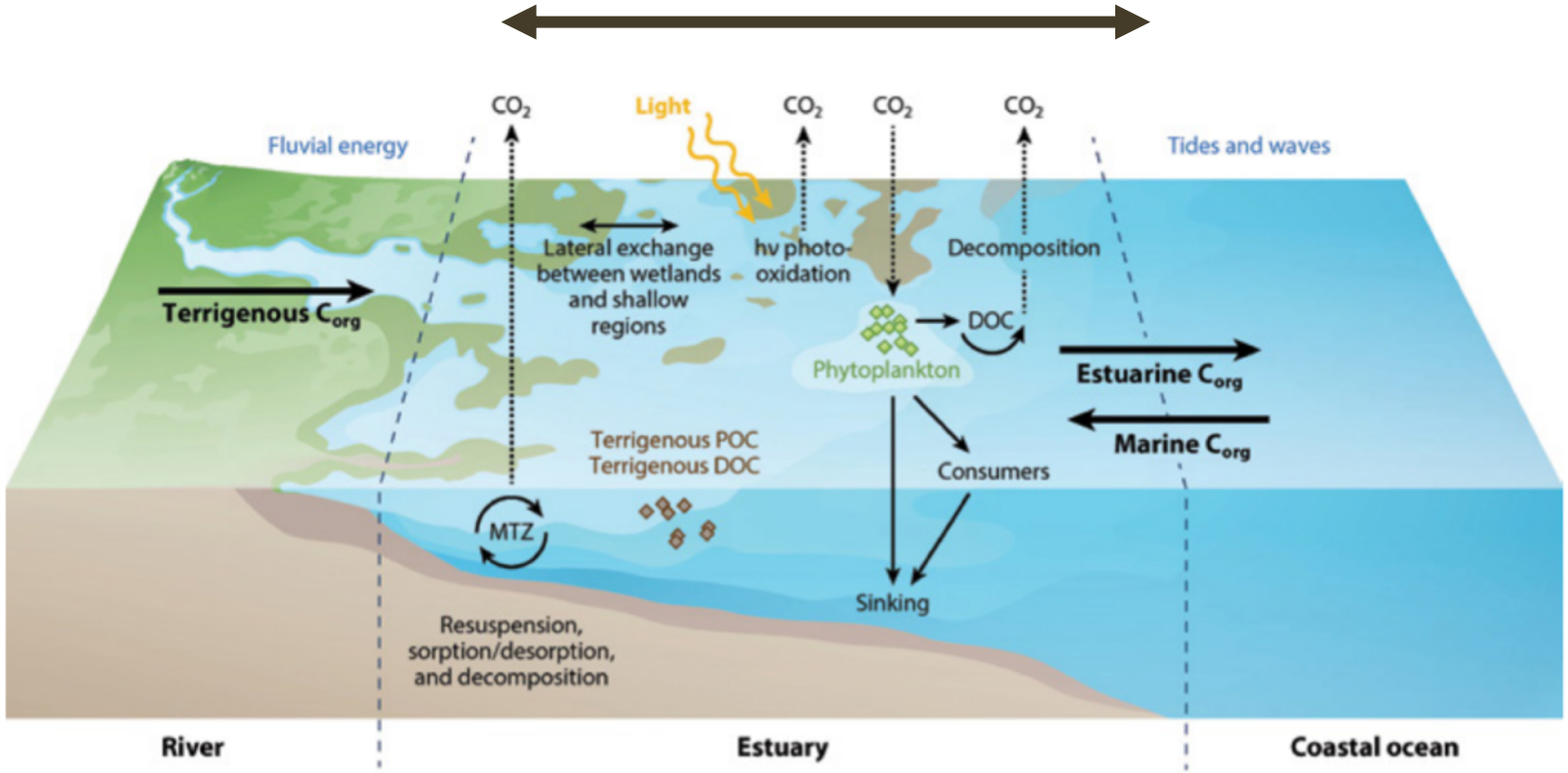
Fichot et al. 2016



Santos et al. 2016

Observation requirements

Spatial & spectral complexity at the interface
Measure across the interface from land to water
Measure water column (dark) close to land (bright)
Resolve tidally driven processes
Characterize change across systems dominated by the anthropogenic signal



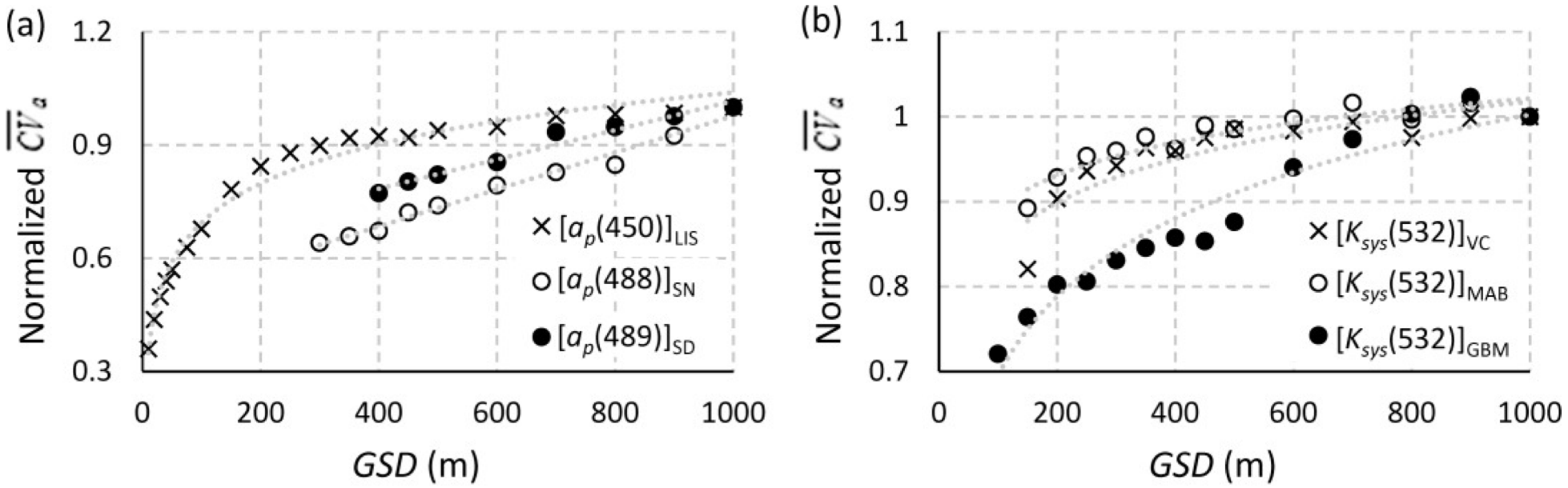
Canuel, E. A., and A. K. Hardison. 2016. Annual Review of Marine Science

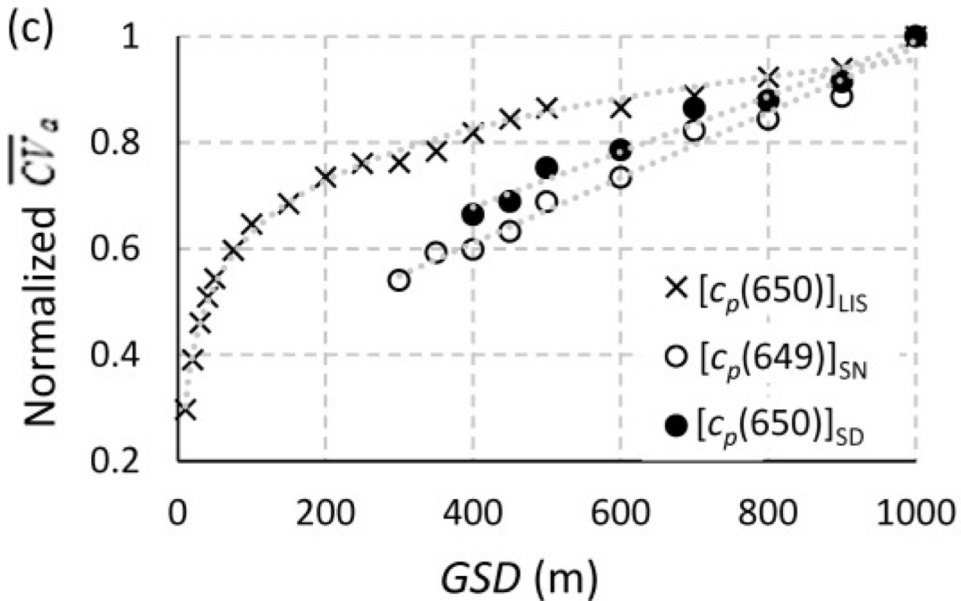
Observation strategy: *H4 sensing*

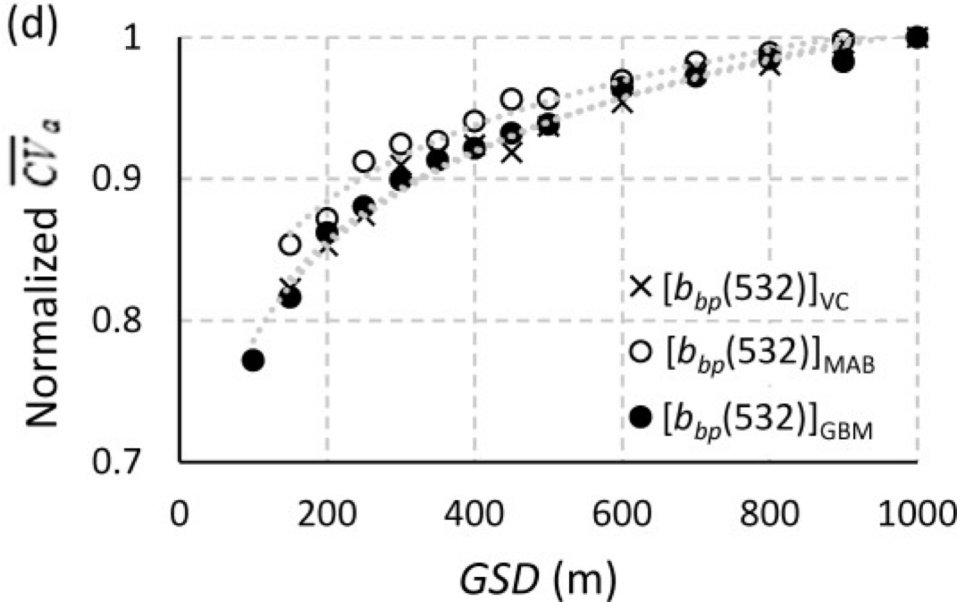
1. High spatial resolution
2. High spectral resolution
3. High radiometric quality
4. High temporal resolution

Everglades Backcountry (1), NPS Photo

Spatial Resolution



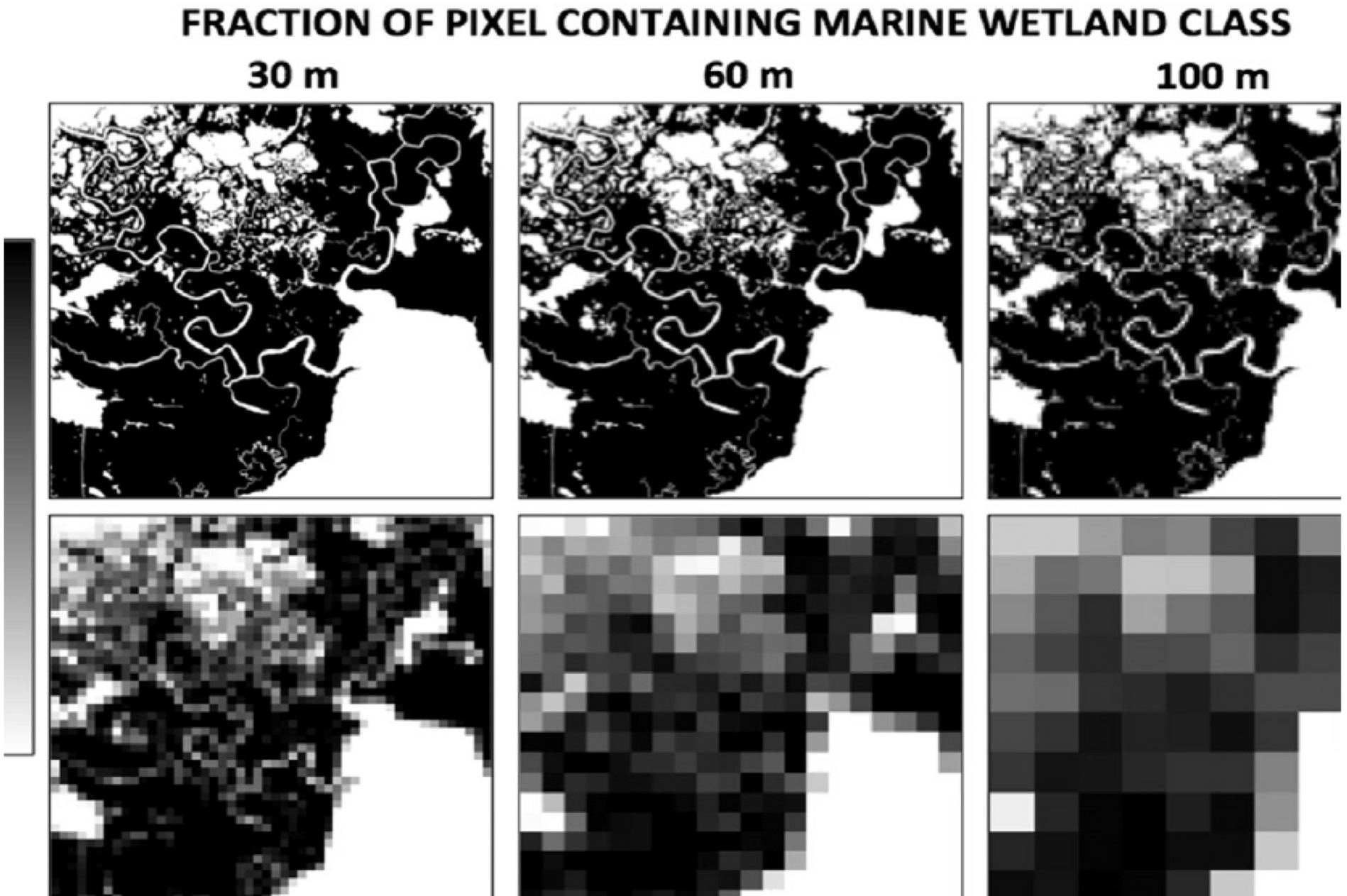




Water
<100 m

[Moses et al. 2016]

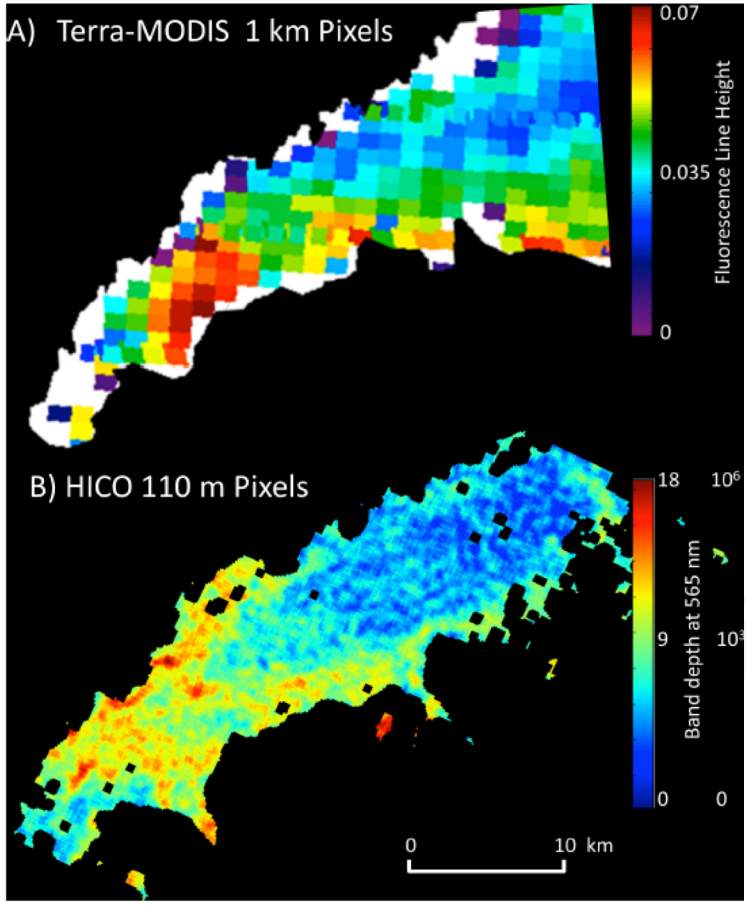
Spatial Resolution

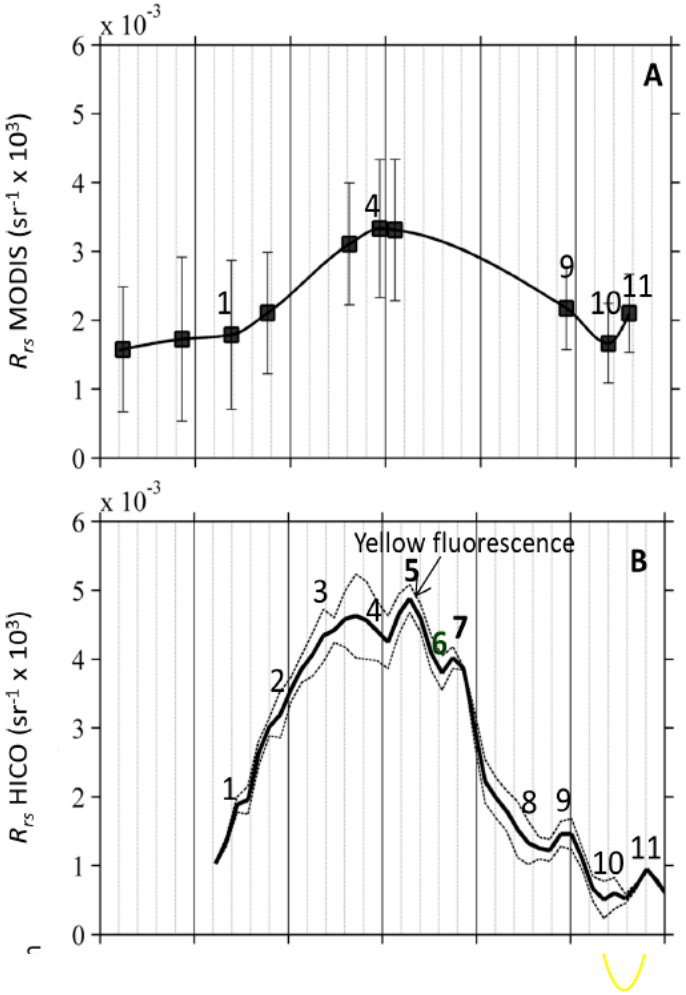


Land
< 60 m

[Turpie et al. 2015]

Spectral Resolution

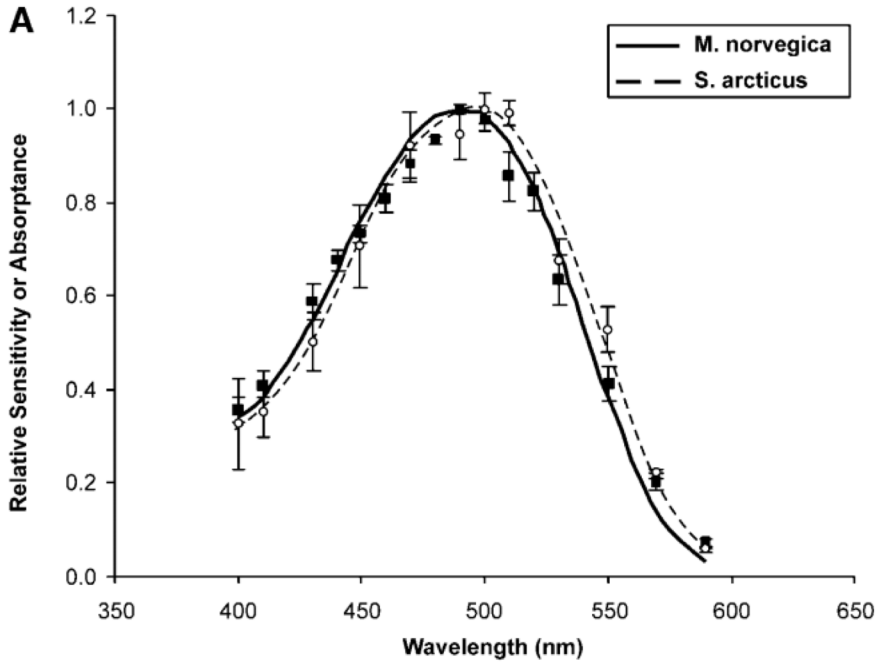




HICO shows *Mesodinium rubrum* bloom because it has fluorescence information provided by hyperspectral data

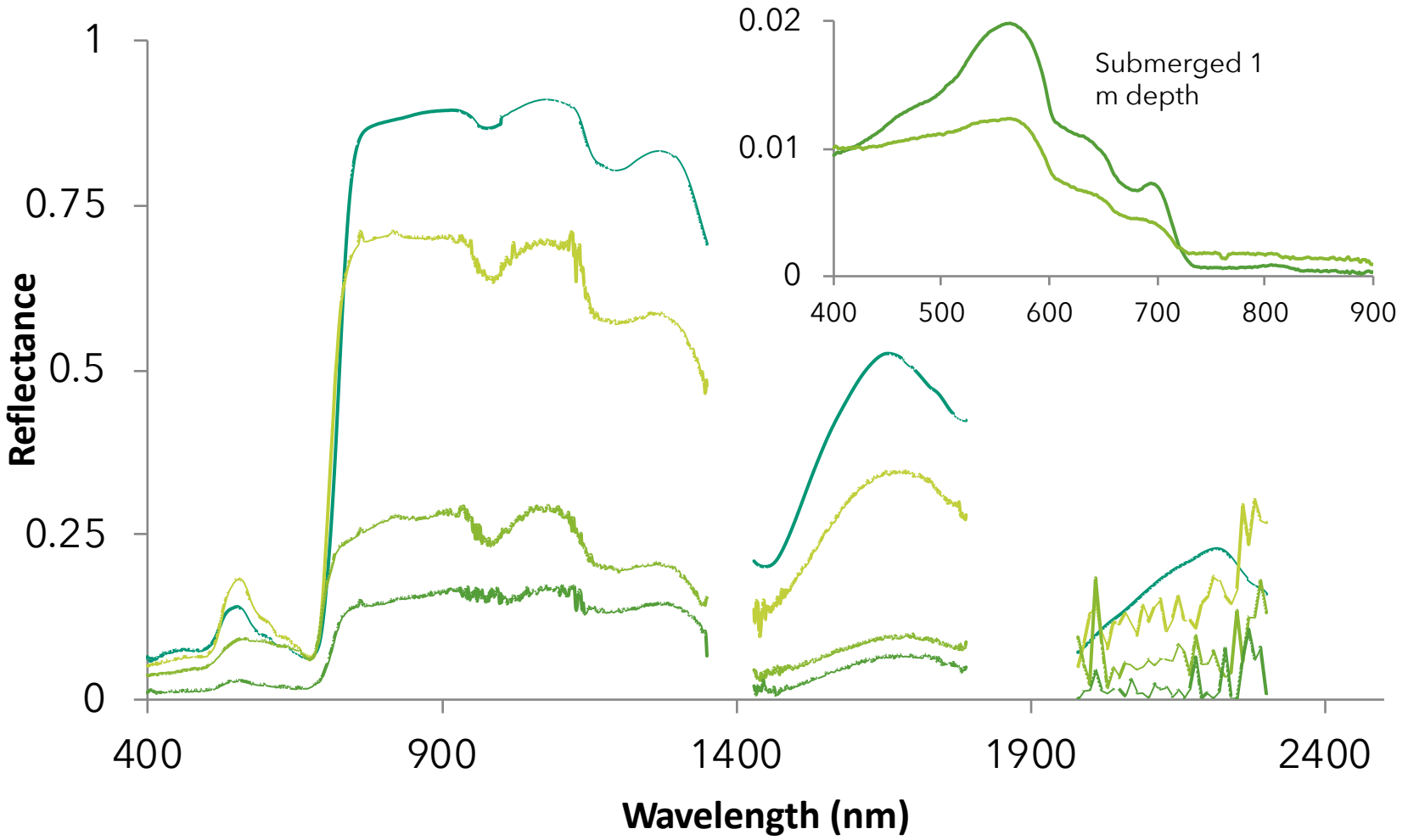
Dierssen et al. 2015

Water
VNIR + SWIR bands<10 nm



Widder and Frank 2001

Spectral Resolution

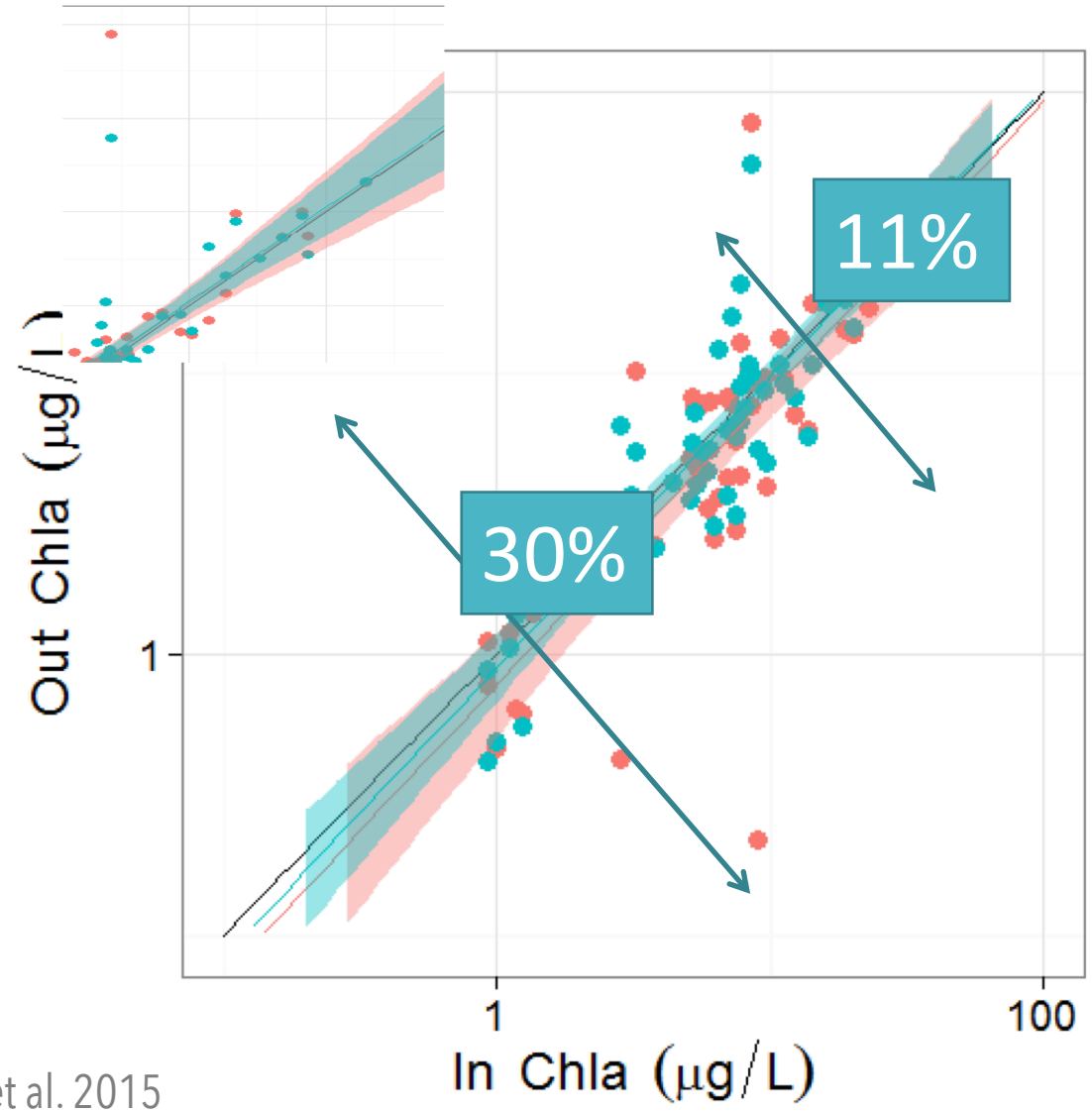


Land
Vis-NIR-SWIR
<10 nm

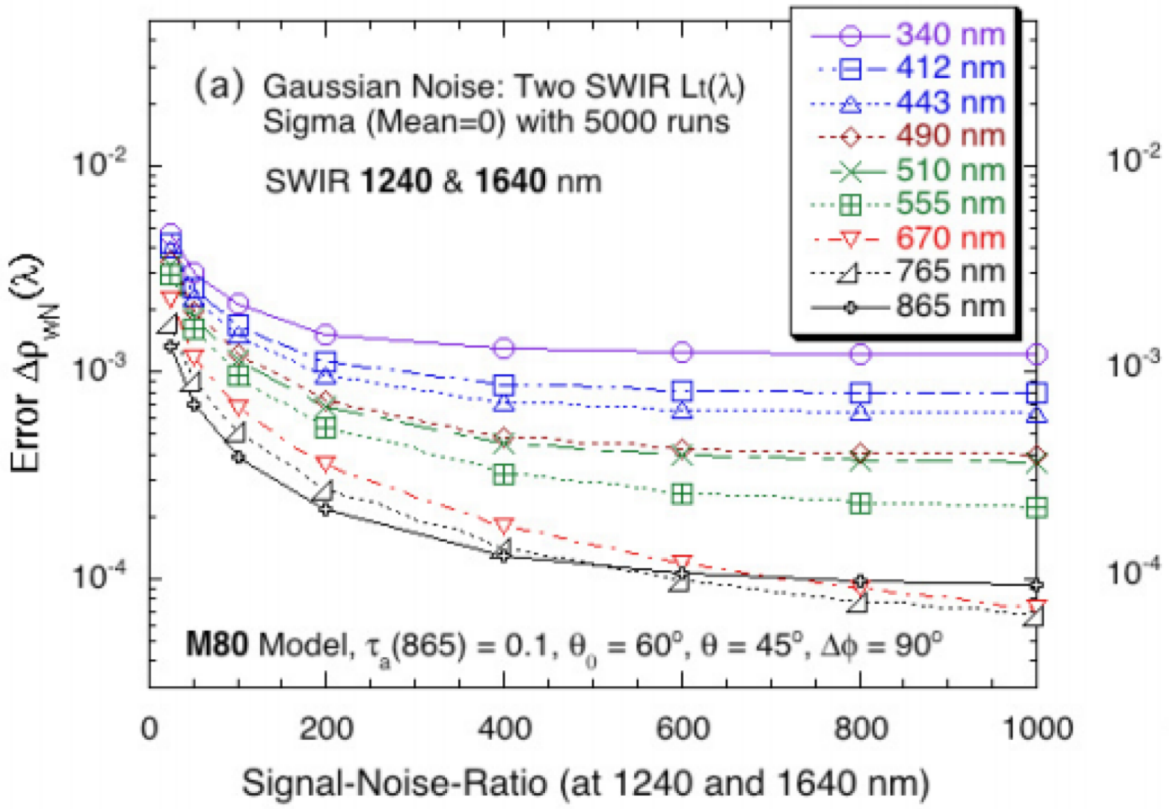
[Hestir et al. 2015]

Radiometric Resolution

Driven by Water
Vis < 800
NIR < 200
SWIR< 100



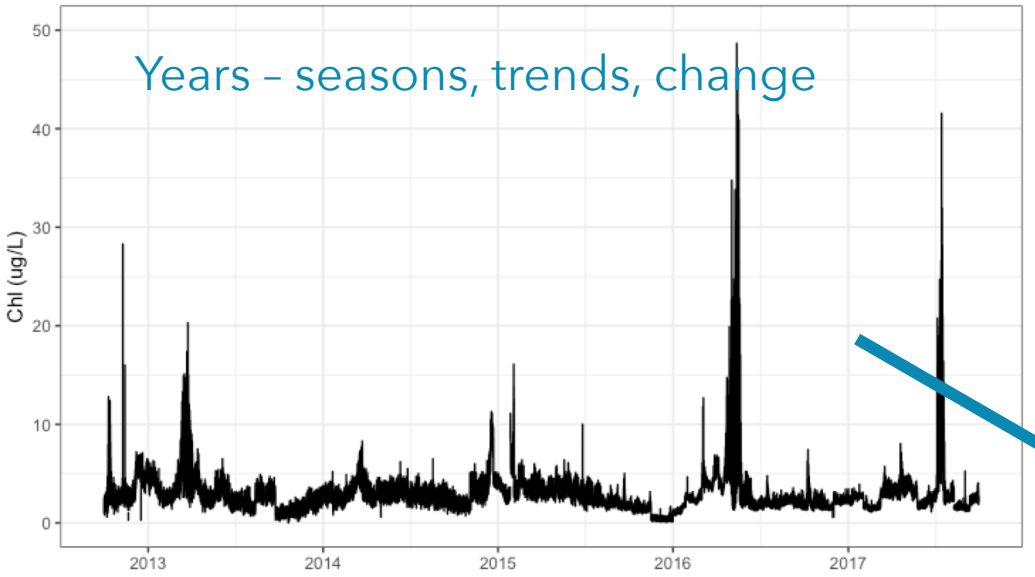
Hestir et al. 2015

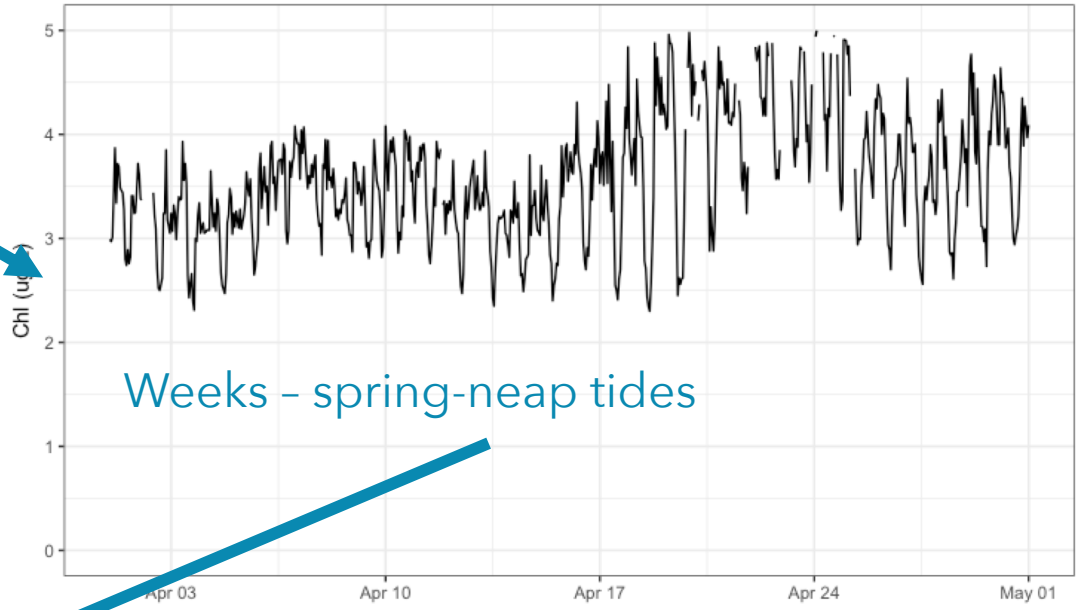


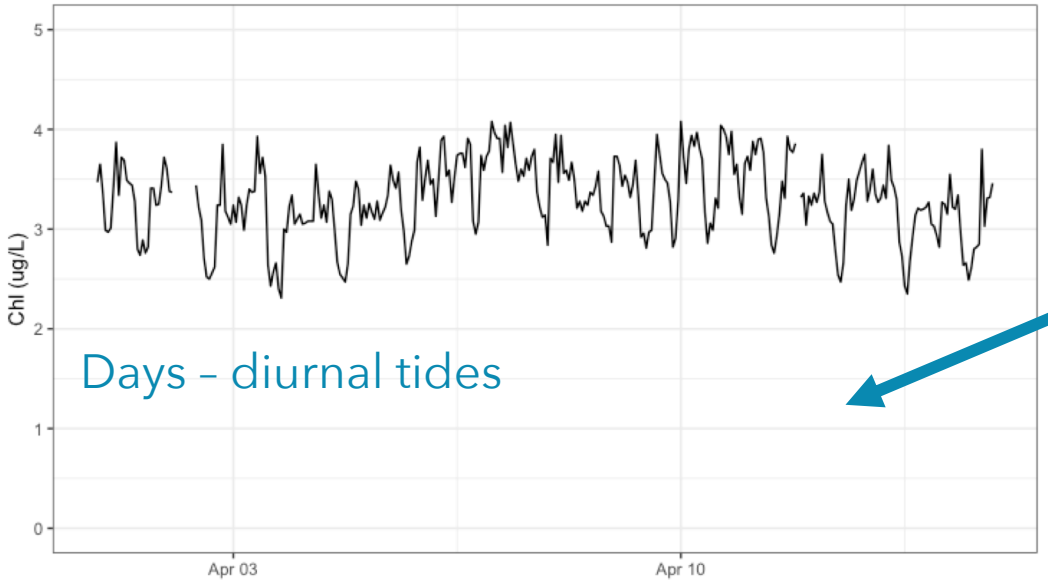
Wang & Gordon 2018

Temporal Resolution

Driven by the interface & change
Trends – Decades
Seasons - Years
Spring-neap tide ~ 14 days
Clouds ~ 1 day cloud-free frequency

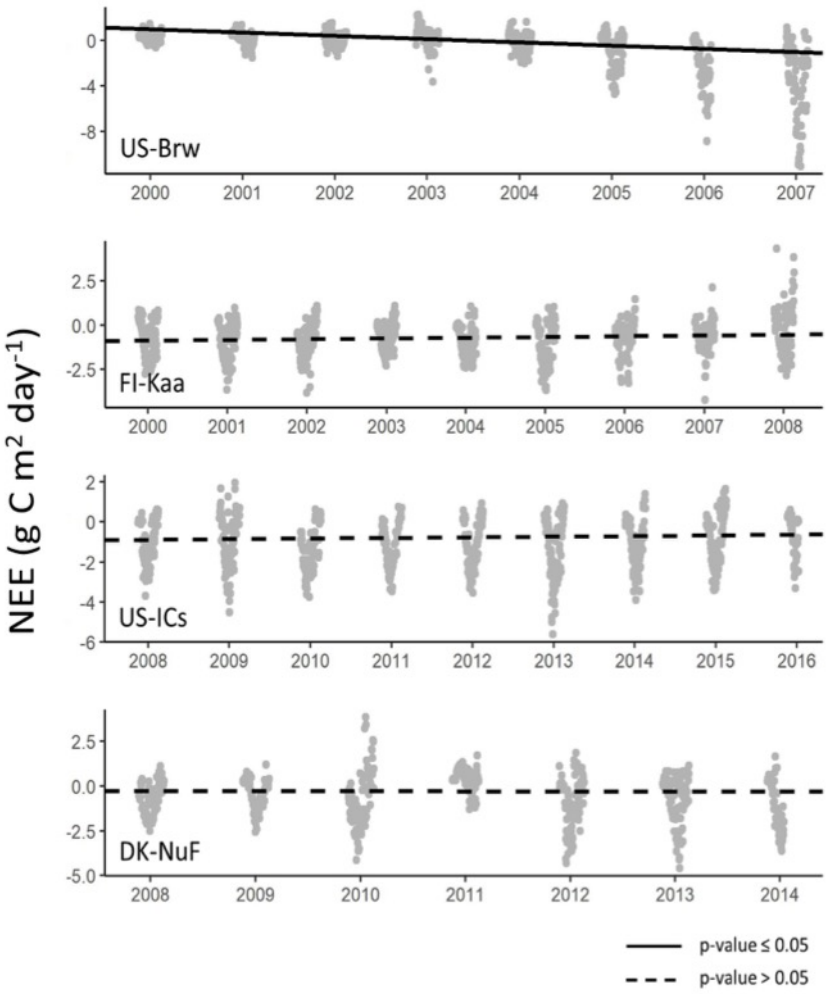






Mission Duration

Human and climate-relevant records are required for change



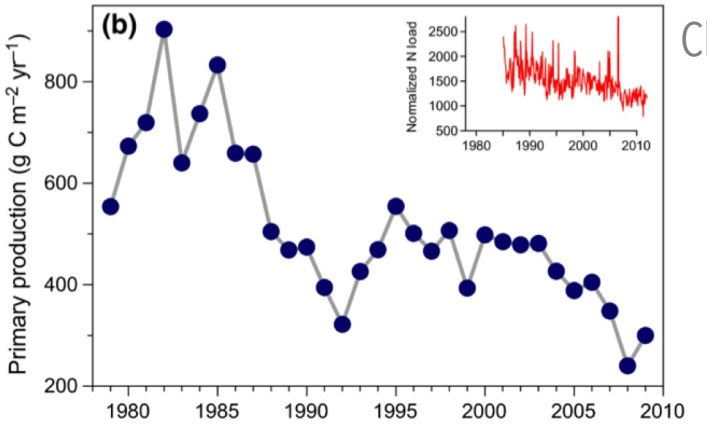
7 years

24 years

36 years

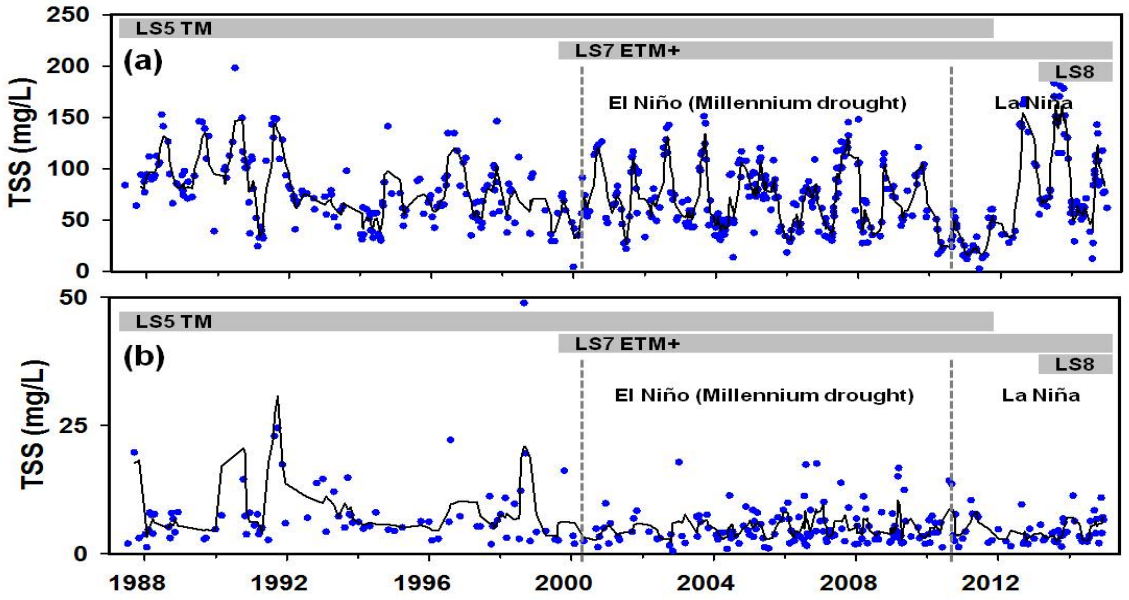
>100 years

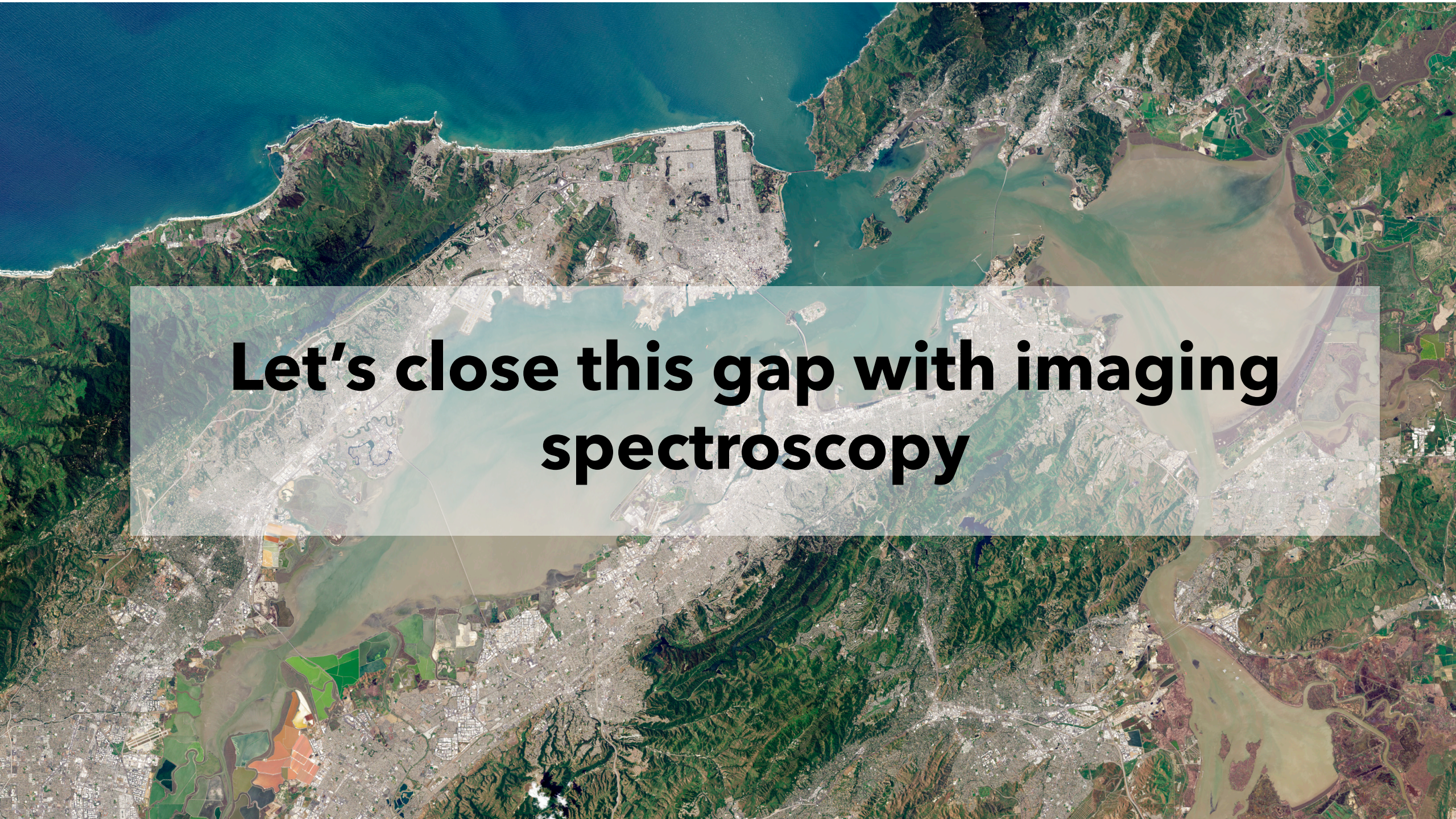
Amanatides & Hestir *submitted*



Cloern et al. 2016

Lymburner et al. 2016





Let’s close this gap with imaging spectroscopy