Monitoring Water Quality for Aquaculture using NASA Remote Sensing Observations

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Overview of SRTEAM
[Satellite-based Tool for Rapid Evaluation of Aquatic EnvironMents]

William Wainwright (SSAI, NASA GSFC)

Workshop Agenda

Part 1: Presentations [9:30 to 11:00 AM]

- Introduction to NASA Water Resources Program
- Introduction to Earth Observations for Monitoring Water Quality
  - Fundamentals of Remote Sensing
  - Satellite missions
  - Data products
- **Demonstration**: data access, analysis, and visualization web tools: Worldview
- **Overview of Satellite-based Tool for Rapid Evaluation of Aquatic EnvironMents (STREAM)**
- **Demonstration: data access, analysis, and visualization web tools: STREAM**

Break [11:00 to 11:15 AM]

Part 2: Hands-on Exercises [11:15 AM to 12:15 PM]

- Monitoring coastal and inland WQ parameters for facilitating aquaculture applications using Worldview and STREAM

Summary and Survey [12:15 to 12:30 PM]

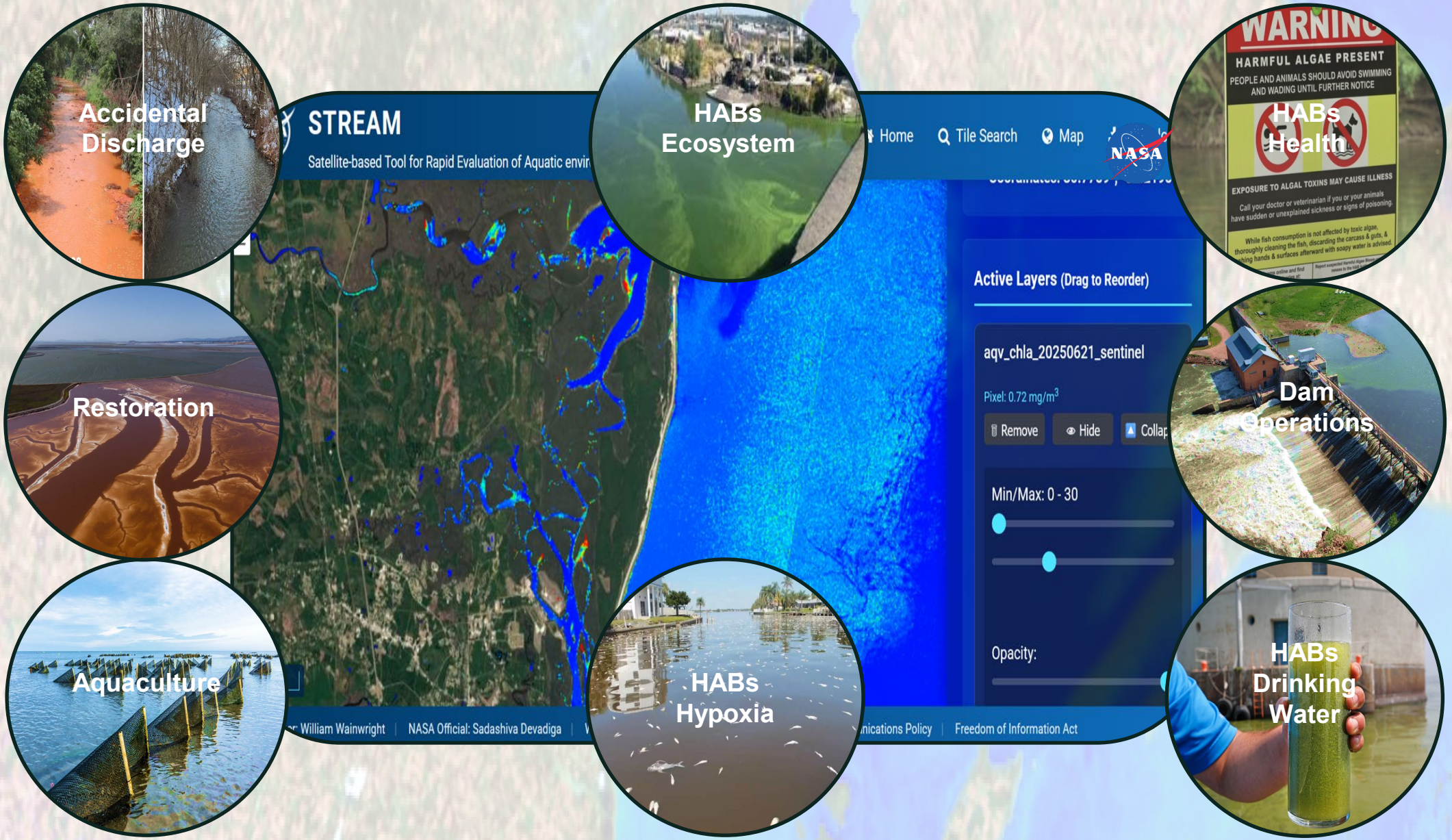
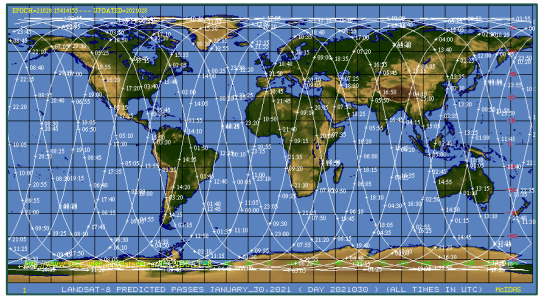


Photo credit: PA Dept. of Environmental Protection; LA Times. San Francisco salt pond A12; Fish kill in March in Cocoa Beach. NY Times; NY Times. Flip bags containing oysters in Cape Cod Bay; Ohio EPA; American Whitewater/Hydropower; Virginia Department of Health; USDA Natural Resources Conservation Services.

Satellites and Sensors Applied within STREAM



Landsat 8 & Landsat 9

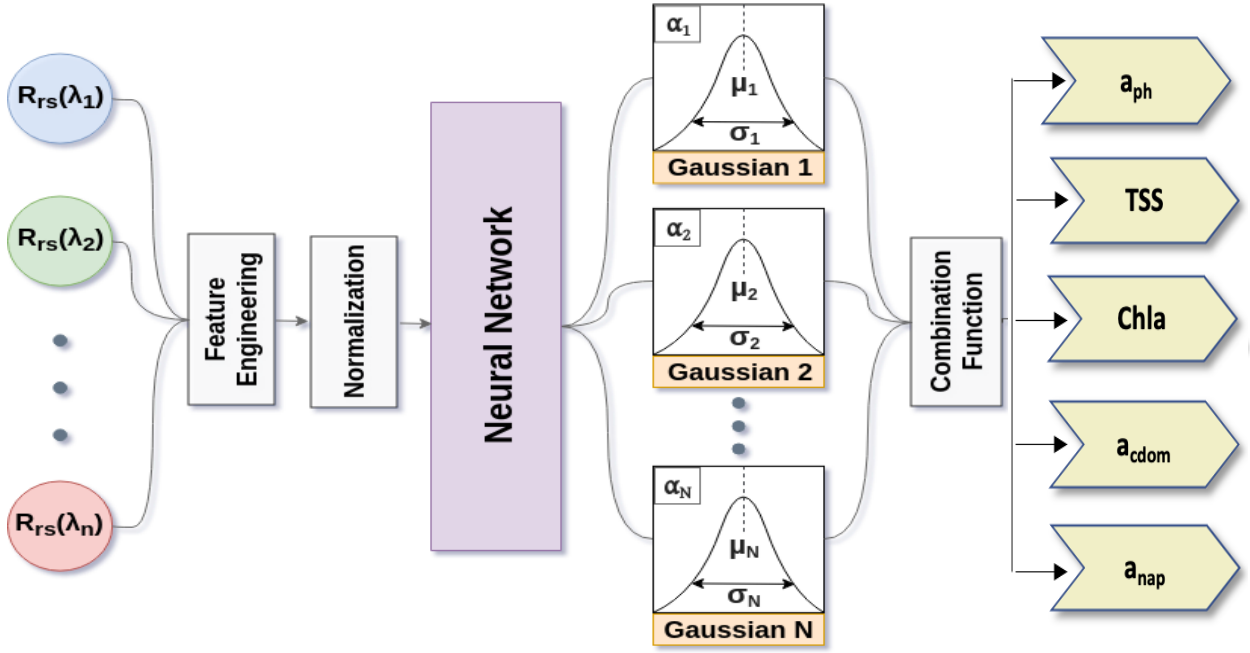
Sentinel-2 A, B, & C

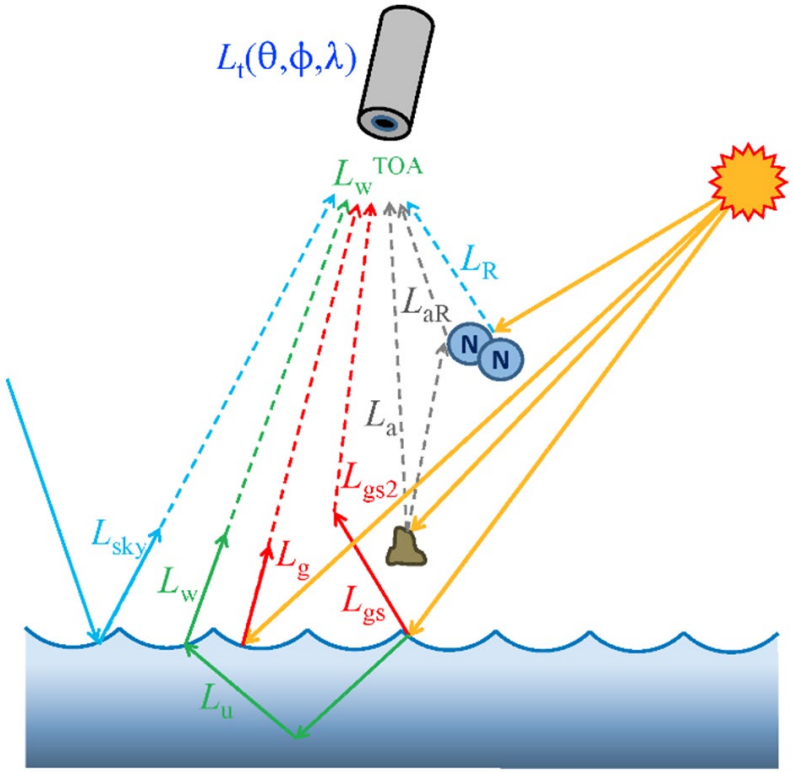
- All are polar orbiting satellites with different swath widths and revisit times.
- Landsat 9 (9/27/2021 – Present)
- Landsat 8 (2/1/2013 – Present)
- Sentinel-2A (6/23/2015 – Present)
- Sentinel-2B (3/7/2017 – Present)
- Sentinel-2C (9/5/2024 - Present)

Satellites	Sensors	Resolution
Landsat 8 & 9	Operational Land Imager (OLI & OLI2)	185 km Swath; 30 m 16-Day Revisit
Sentinel-2A, -2B, and -2C	Multi Spectral Imager (MSI)	290 km Swath; 10 m, 20 m, 60 m; 5-Day Revisit

How STREAM Works

- Mixture density network (MDN)
  - Rayleigh scattering & gaseous absorption
  - Compensate for aerosol with first MDN
  - Retrieve Chla, TSS, and Zsd with second MDN





Validation – GLORIA & AERONET-OC

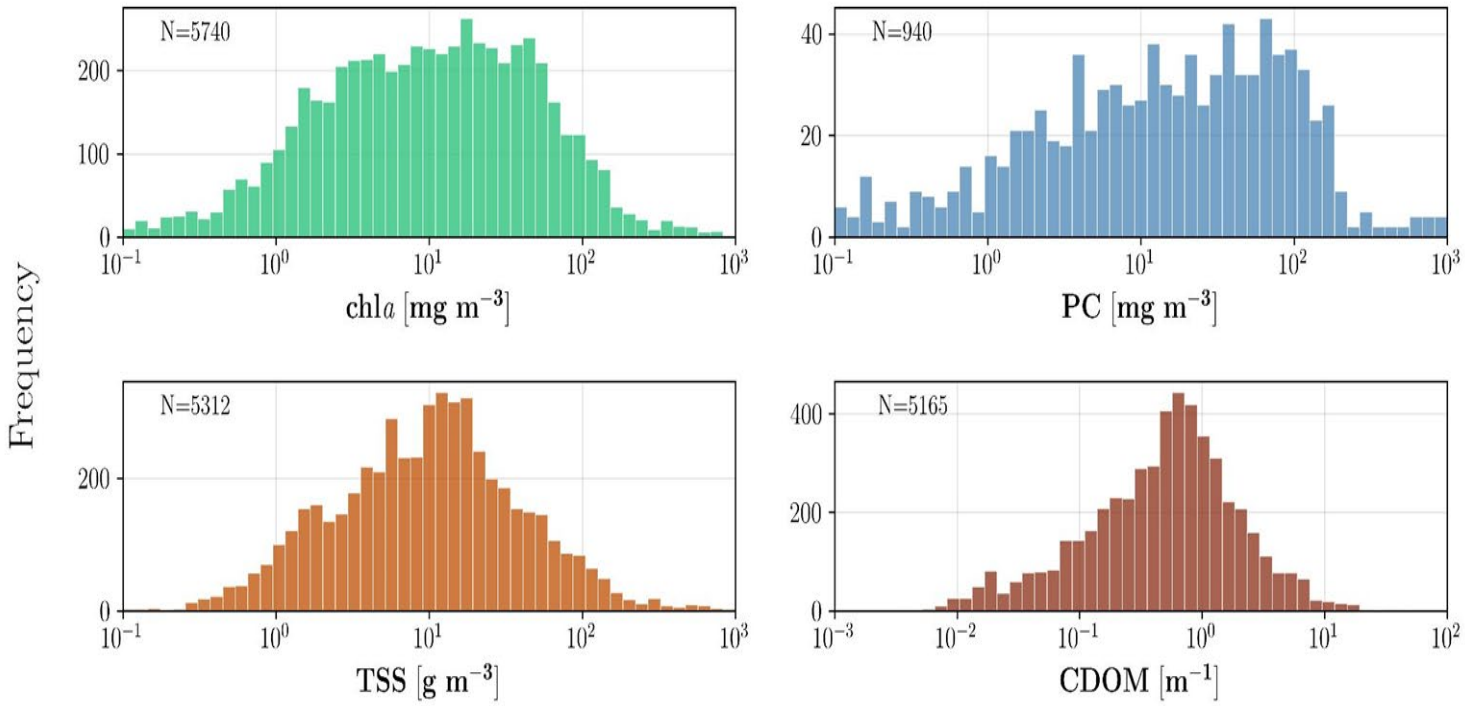
- Over 7500 hyperspectral RRS
  - 1nm intervals from 350-900nm
- Coastal and inland water bodies
- Co-located in-situ water quality indicators
- Over 25 years of temporal coverage

GLORIA:

- Lehmann, M.K., Gurlin, D., Pahlevan, N. et al. GLORIA - A globally representative hyperspectral in situ dataset for optical sensing of water quality. Sci Data 10, 100 (2023). https://doi.org/10.1038/s41597-023-01973-y.
- ARSET Training: Monitoring Water Quality of Inland Lakes using Remote Sensing

AERONET-OC:

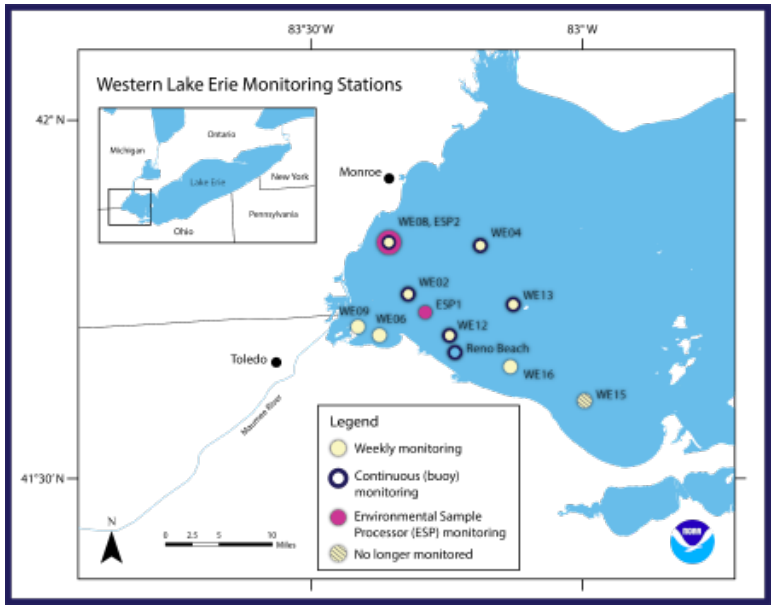
- Aerosol Robotic Network-Ocean Color



O'Shea et al. 2023 (Remote Sensing of Environment)

Why Monitor Water Quality Using Remote Sensing?

- **Monitoring water quality is vital for**:
  - Managing drinking water treatment
  - Public health and ecosystem advisories
  - Assessing health and productivity of freshwater and saltwater fisheries
- Conventional in situ measurements of water quality parameters are expensive and have limited spatial and temporal coverage.
- Remote sensing provides a cost-effective way to assess water quality in thousands of lakes and in coastal waters with improved coverage.



[NOAA Great Lakes Environmental Research Laboratory]

For monitoring harmful algal blooms (HABs), water samples are collected weekly at eight sampling sites and continuously at a few buoys in western Lake Erie.

[NASA Earth Observatory]

Algal bloom observed by Landsat-9 (OLI 2) on August 13, 2024.

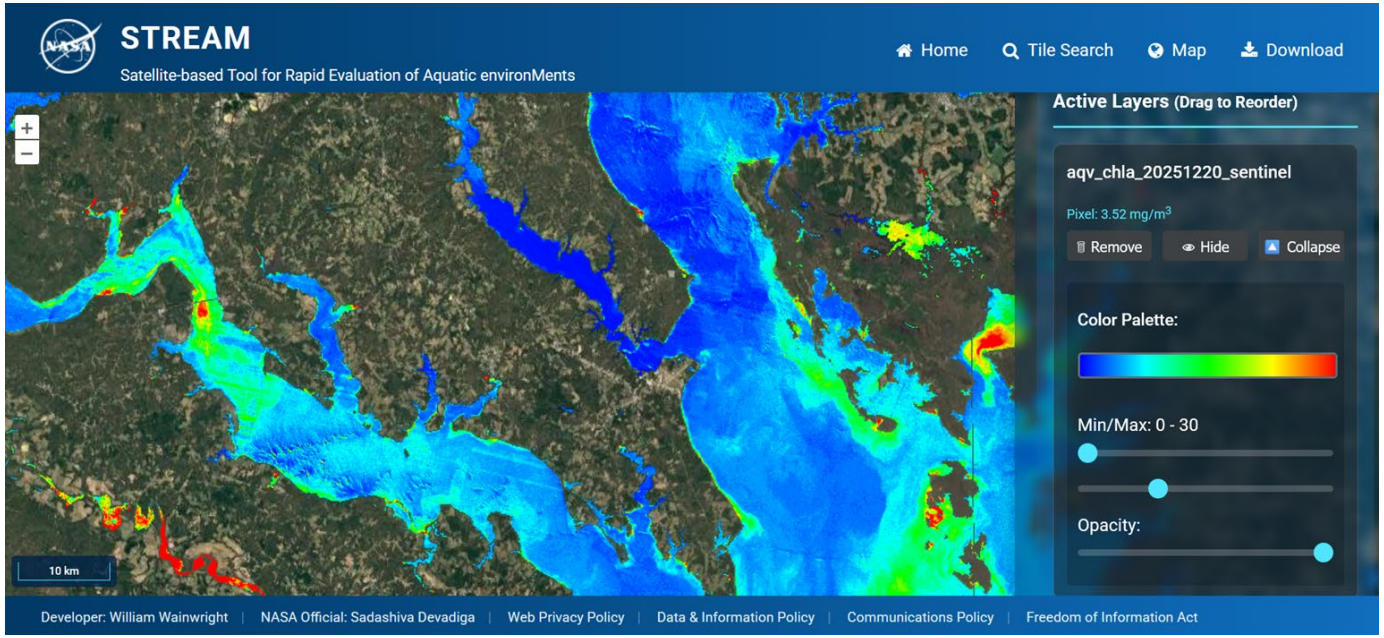
Training Learning Objectives

By the end of this training, participants will be able to:

- Identify the purpose, capabilities, and benefits of the STREAM tool for analyzing inland and coastal water bodies.
- Identify the process to use STREAM to monitor chlorophyll-a concentration, Secchi disk depth, and total suspended solids in lakes and coastal waters.
- Identify the steps to use STREAM API to search and download chlorophyll-a concentration, Secchi disk depth, and total suspended solids data for a specific time period.
- Examine time series of chlorophyll-a concentration, Secchi disk depth, and total suspended solids using QGIS.
- Identify how an open-source machine-learning model based on Mixture Density Network (MDN) enables users to estimate water quality parameters for any inland/coastal water body (greater than 100m x 100m) worldwide.

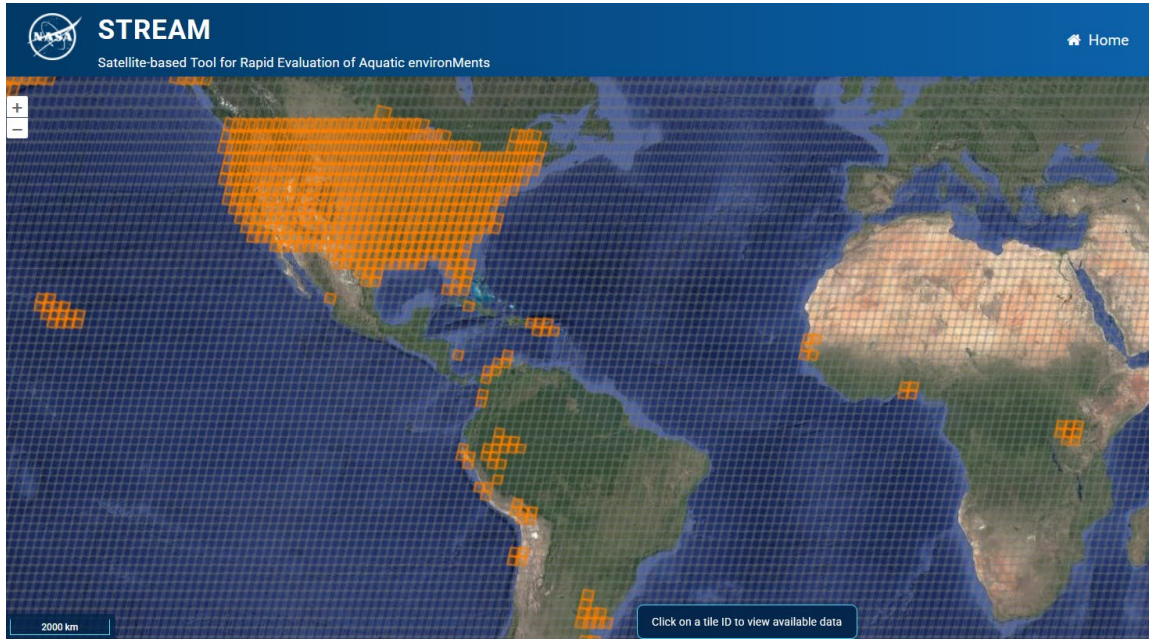
STREAM Website & API

- Interactive map
  - All scenes mosaicked
  - Multiple layers
  - Live readout at cursor
- Archive of daily processing
  - Full resolution GeoTIFs
  - Per-tile basis
- RESTful API
  - Documentation included
  - Query and download
  - Example python script available



STREAM's Coverage

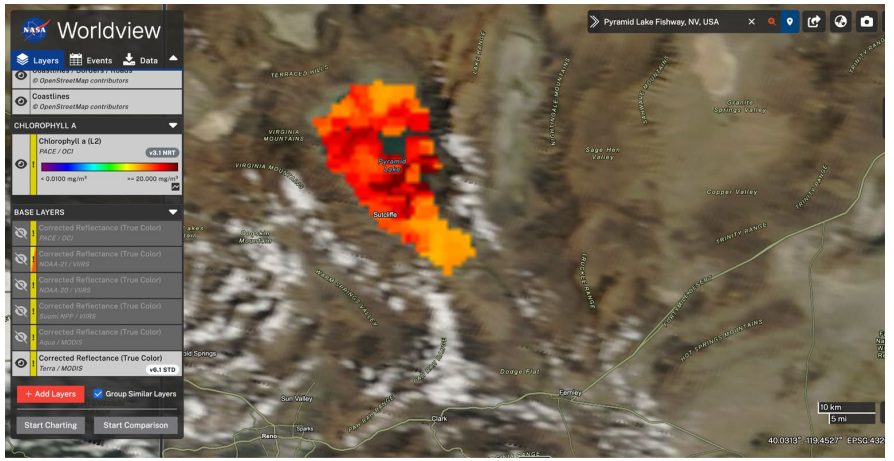
- Daily processing since June 2024
  - Processed overnight/as available
  - Chlorophyll-a, total suspended solids (TSS), Secchi depth, RGB True color composite
- Landsat 8/9 and Sentinel-2
  - Landsat at 30m resolution
  - Sentinel-2 resampled to 20m
- Full coverage of U.S. and additional water bodies in
  - India, South Korea, South Africa, Benin, Ghana, Chile, Uruguay, Peru, Colombia, Mexico, Cuba
- Coming Soon!
  - Sea-surface temperature
  - Time series tools



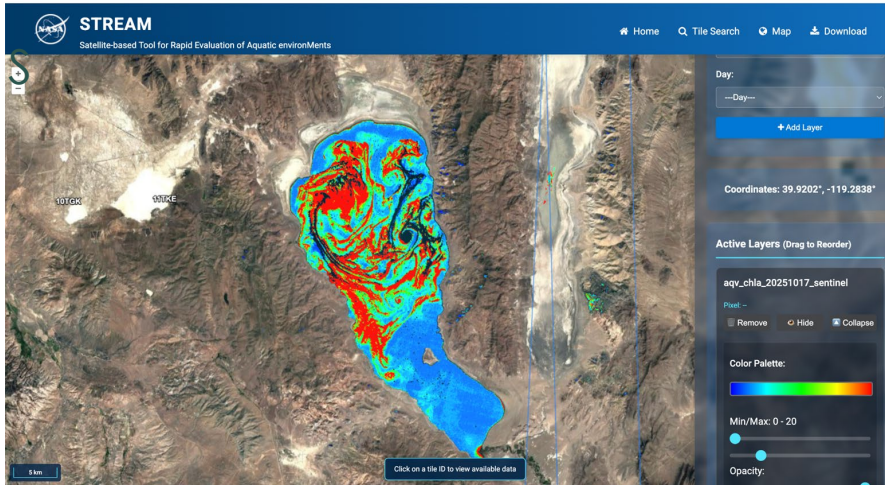
Summary

- STREAM web tool and API:
  - Uses Landsat 8 & 9, and Sentinel 2 a,b, and c to obtain water quality parameters, including chlorophyll a concentration, Total Suspended Solids, and Secchi Disk Depth in coastal estuaries and inland lakes in the US
  - Provides the water quality parameters at 20 m to 30 m spatial resolution
  - API allows search and download of multiple images of an area of interest

PACE/OCI



Sentinel 2/MSI



Chlorophyll-a concentration in Pyramid Lake from PACE/OCI and Sentinel 2/MSI

Data Access, Analysis, and Visualization Web Tool

Demonstration: STREAM