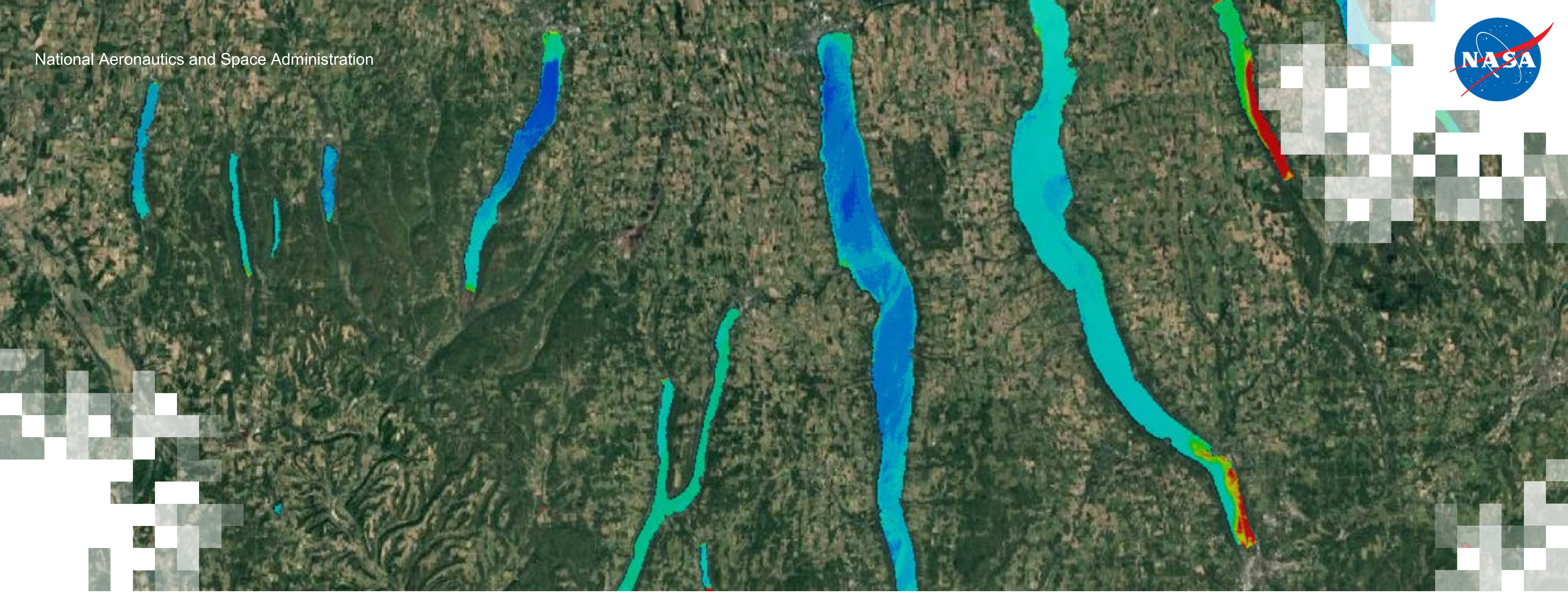
National Aeronautics and Space Administration

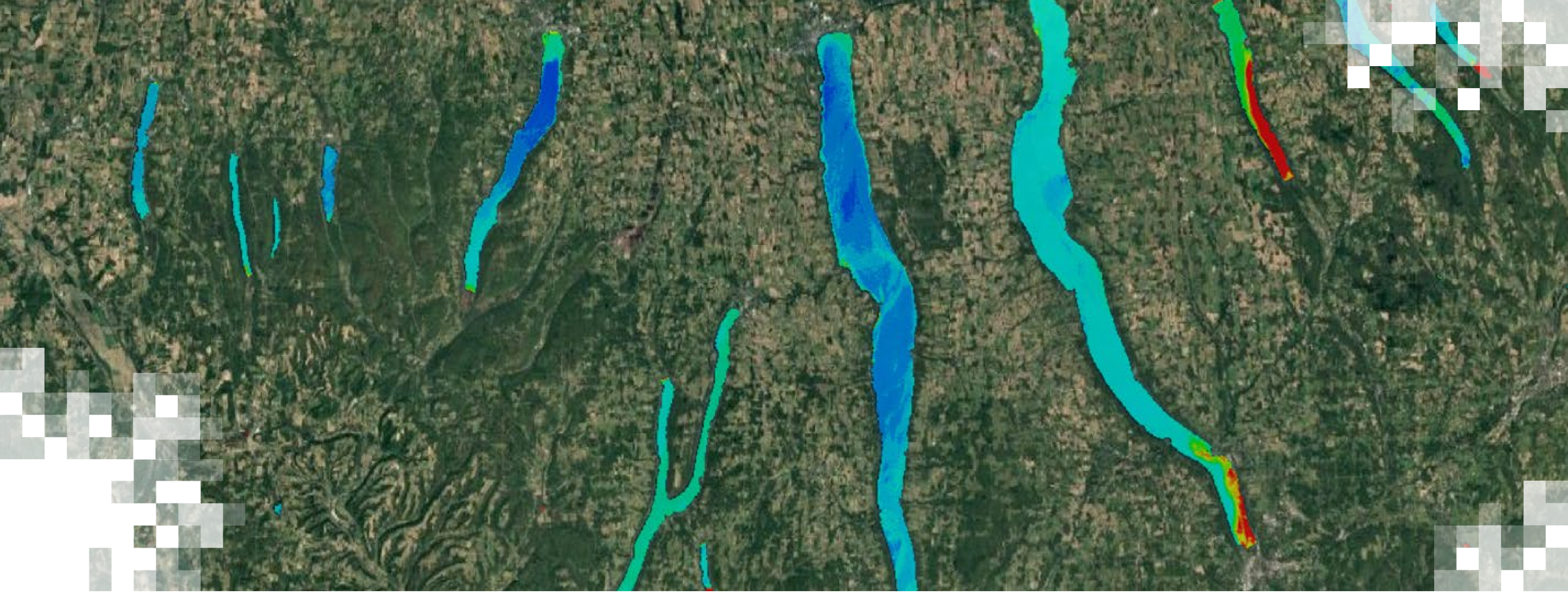


Monitoring Water Quality in Lakes and Coastal Regions Using STREAM

Part 1: Introduction and Demonstration of Satellite-based Tool for Rapid Evaluation of Aquatic EnvironMents (STREAM)

Amita Mehta (GESTAR II, NASA Goddard Space Flight Center (GSFC)), William Wainwright (SSAI, NASA GSFC)

February 10, 2026



About ARSET

About ARSET

- **ARSET provides accessible, relevant, and cost-free training on remote sensing satellites, sensors, methods, and tools.**
- Trainings include a variety of applications of satellite data and are tailored to audiences with a variety of experience levels.

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CLIMATE & RESILIENCE

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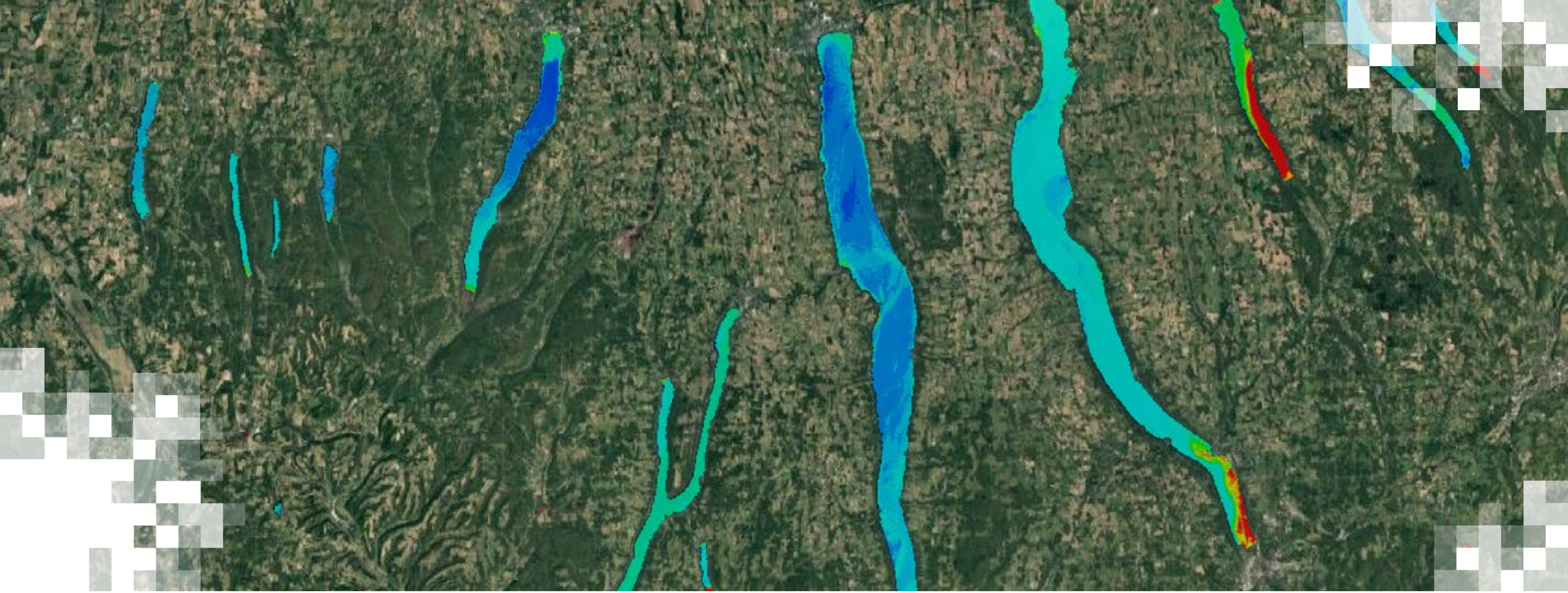
About ARSET Trainings

- Online or in-person
- Live and instructor-led or asynchronous and self-paced
- Cost-free
- Bilingual and multilingual options
- Only use open-source software and data
- Accommodate differing levels of expertise

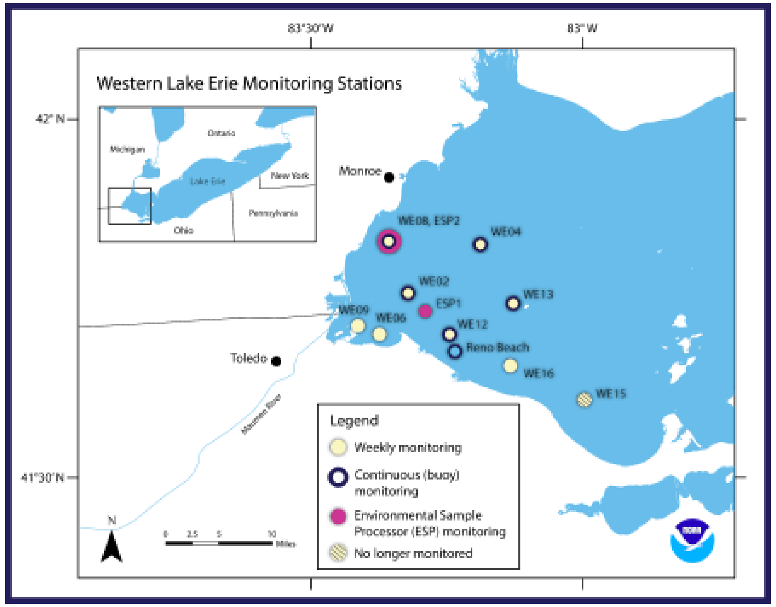
- Visit the ARSET website to learn more.



Monitoring Water Quality in Lakes and Coastal Regions Using STREAM Overview

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.

Satellites and Sensors for Water Quality Monitoring

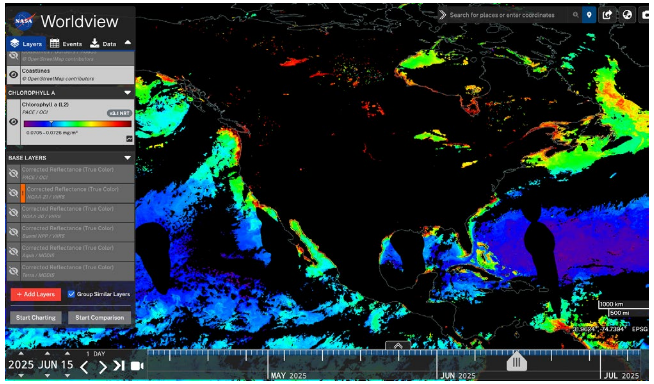
Satellites Orbits	Sensors	Spectral Measurements	Temporal Coverage, Observation Time, and Resolution	Spatial Coverage and Resolution
Landsat 8 Landsat 9 polar	TIRS, OLI TIRS-2, OLI-2	Visible, Near IR, Middle IR, Thermal IR	2/2013 – Present 11/2021– Present 10:30 am/pm local time 16 Day	Global Swath: 136 km 30 m
Terra Aqua Polar	MODIS	Visible, Near IR, Middle IR, Thermal IR	12/1999 – Present (10:30 am/pm) 4/2002 – Present (13:30 am/pm) 1-2 Days	Global Swath: 2330 km 250 m to 1 km
SNPP JPSS polar	VIIRS	Visible, Near IR, Middle IR, Thermal IR	10/28 2011– Present 11/18 2017 – Present 11/10 2022 – Present 1:30 am/pm local time 12 Hours	Global Swath: 3040 km 375 m, 750 m
Sentinel 2A Sentinel 2B & 2C Polar	MSI	Visible, Near IR	6/23/2025 – Present 3/7/2017– Present 10:30 am/pm 5 Day	Global Swath: 290 km 10 m, 20 m, 30 m
Sentinel 3A & 3B Polar	OLCI	Visible, Near IR	2/16/2016-Presenet 4/25/2018-Present 10 am/pm, 1 to 2 Days	Global Swath: 1270 km 300 m
PACE Polar	OCI	Visible, Near IR, Shortwave IR	2/8/2024 –Present 1 AM/PM 1 to 2 Days	Global Swath: ~2500 km 1 km

Existing Water Quality Training and Application

Selected ARSET Trainings on Remote Sensing of Water Quality:

- Introduction to PACE Hyperspectral Observations for Water Quality Monitoring
- Monitoring Water Quality of Inland Lakes using Remote Sensing
- Monitoring Coastal and Estuarine Water Quality: Transitioning from MODIS to VIIRS
- Monitoring Coastal and Estuarine Water Quality Using Remote Sensing and In Situ Data

- These previous ARSET trainings focused on water quality data available at relatively low resolution: from 250 m to 1 km.
- Higher resolution (20 to 30 m) water quality data, not readily available, had to be to derived by using algorithms developed from satellite data and in-situ measurements.

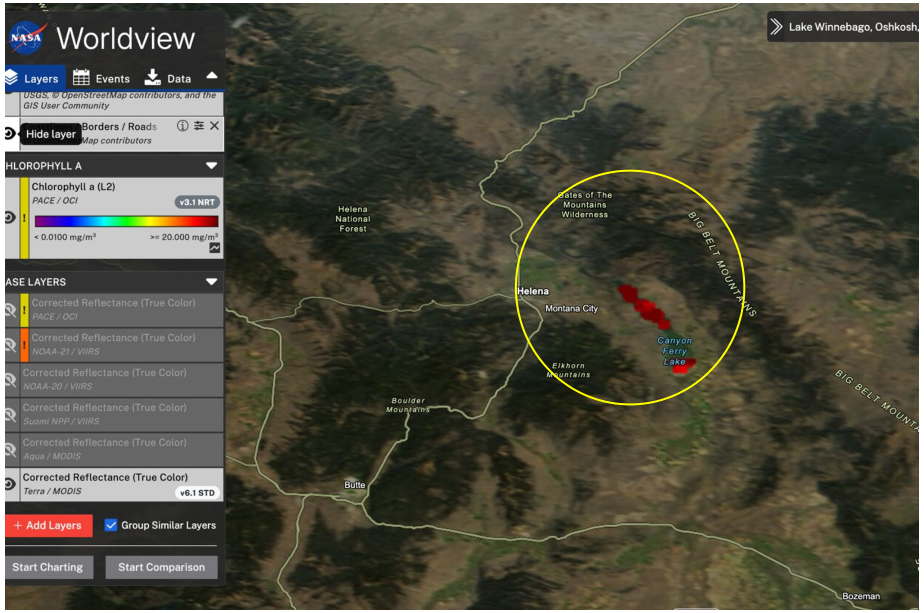


Chlorophyll-a concentration from PACE-OCI at 1 km resolution, adequate for open oceans and large water bodies, but can not resolve smaller inland lakes.

NASA Worldview

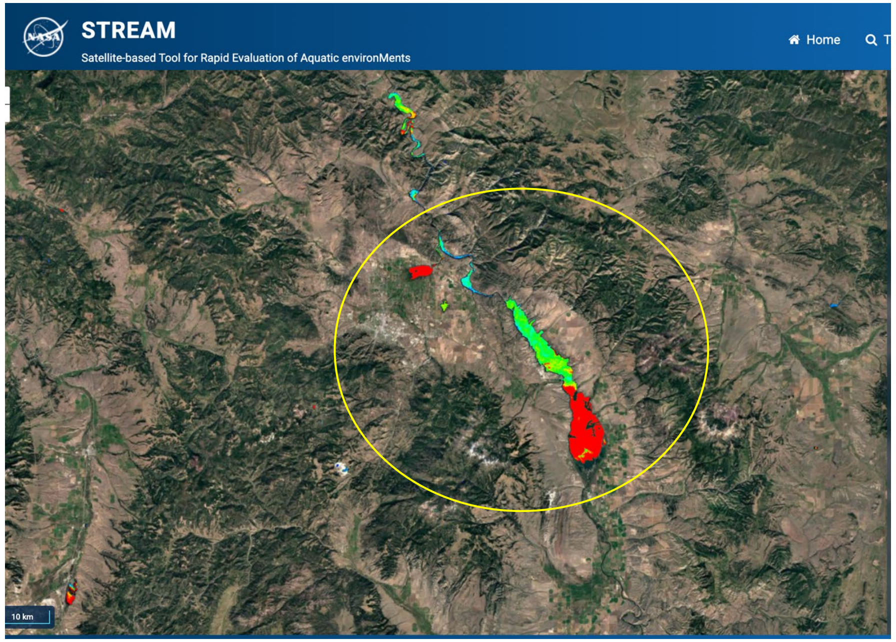
Why use STREAM for Water Quality Monitoring?

- Interactive web tool and API enabling monitoring of water quality in near-real time since 2024
- 20-30 m spatial resolution
  - Smaller water bodies are resolved in STREAM (size > 100 m^2)
  - Inland lakes and coastal waters (U.S. and selected countries)
- Derives water quality parameters via open-source model



PACE OCI (1 km)

Chlorophyll-a concentration in Lake Canyon Ferry (Montana) from PACE OCI and Sentinel-2.



Sentinel 2 MSI (20 m)

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.

Prerequisites

- [Fundamentals of Remote Sensing]
- [ARSET - Monitoring Water Quality of Inland Lakes using Remote Sensing]

Training Outline

Part 1

Introduction and Demonstration of STREAM

February 10, 2026

Part 2

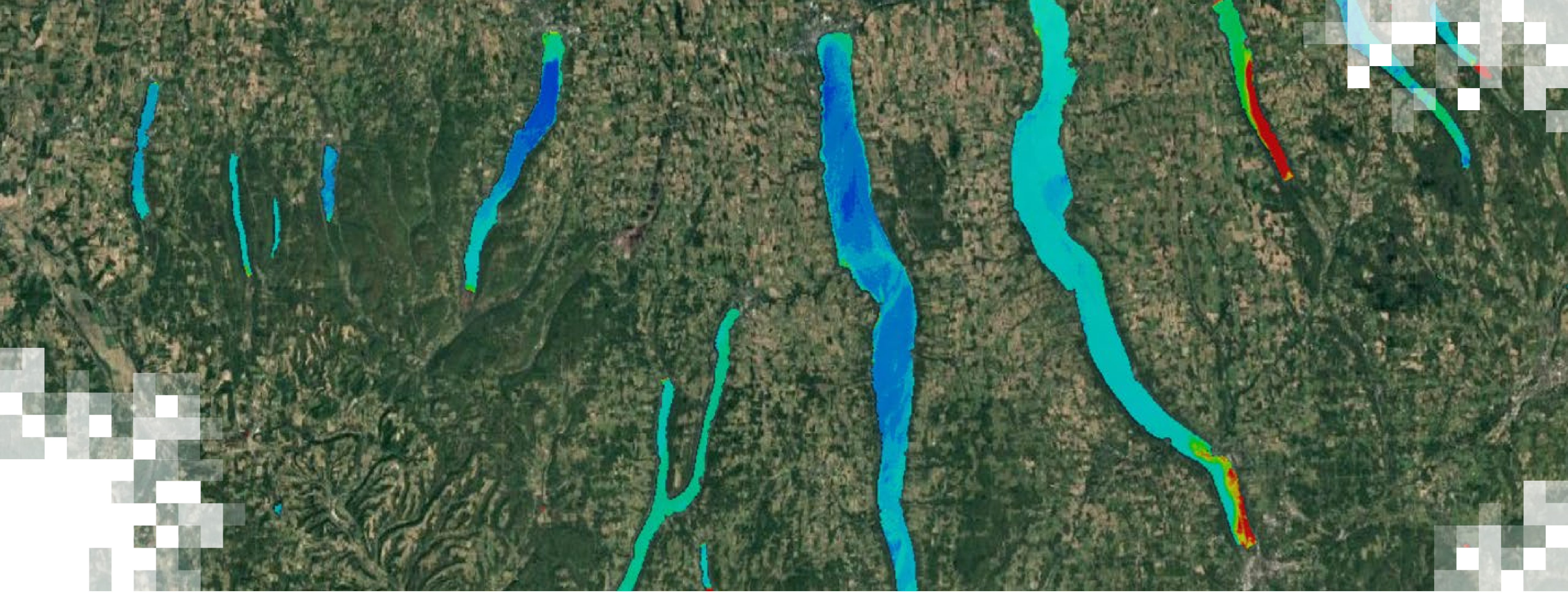
Introduction to a Machine Learning Model to Estimate Water Quality Parameters Based on Satellite Observations

February 17, 2026

Homework

Opens February 17 – Due March 10 – Posted on Training Webpage

A certificate of completion will be awarded to those who attend all live sessions and complete the homework assignment(s) before the given due date.



Part 1
Introduction and Demonstration of STREAM

Part 1 Objectives

By the end of Part 1, participants will be able to:

- Identify features of STREAM website and API for selection and display of water quality parameters for selected lakes/coastal areas.
- Recognize how to download water quality parameters using STREAM API.
- Recognize how to display maps and time series of chlorophyll-a concentration, Secchi disk depth, and total suspended solids for selected lakes/coastal areas.

Part 1 Outline

- Overview of STREAM
- Demonstration:
  - Making maps of water quality parameters using STREAM web tool
  - Making time series of water quality parameters using STREAM API and QGIS

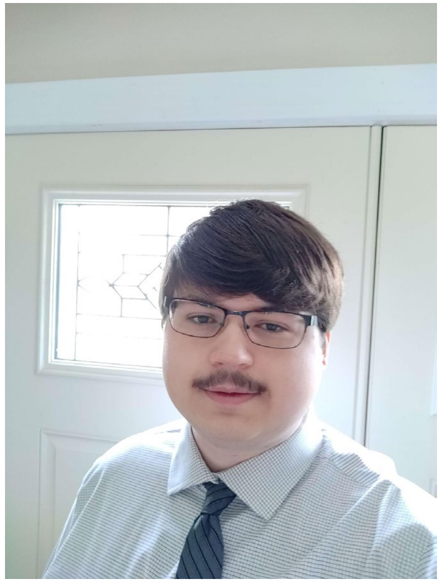
How to Ask Questions

- Please put your questions in the Questions box and we will address them at the end of the webinar.
- Feel free to enter your questions as we go. We will try to get to all of the questions during the Q&A session after the webinar.
- The remainder of the questions will be answered in the Q&A document, which will be posted to the training website about a week after the training.

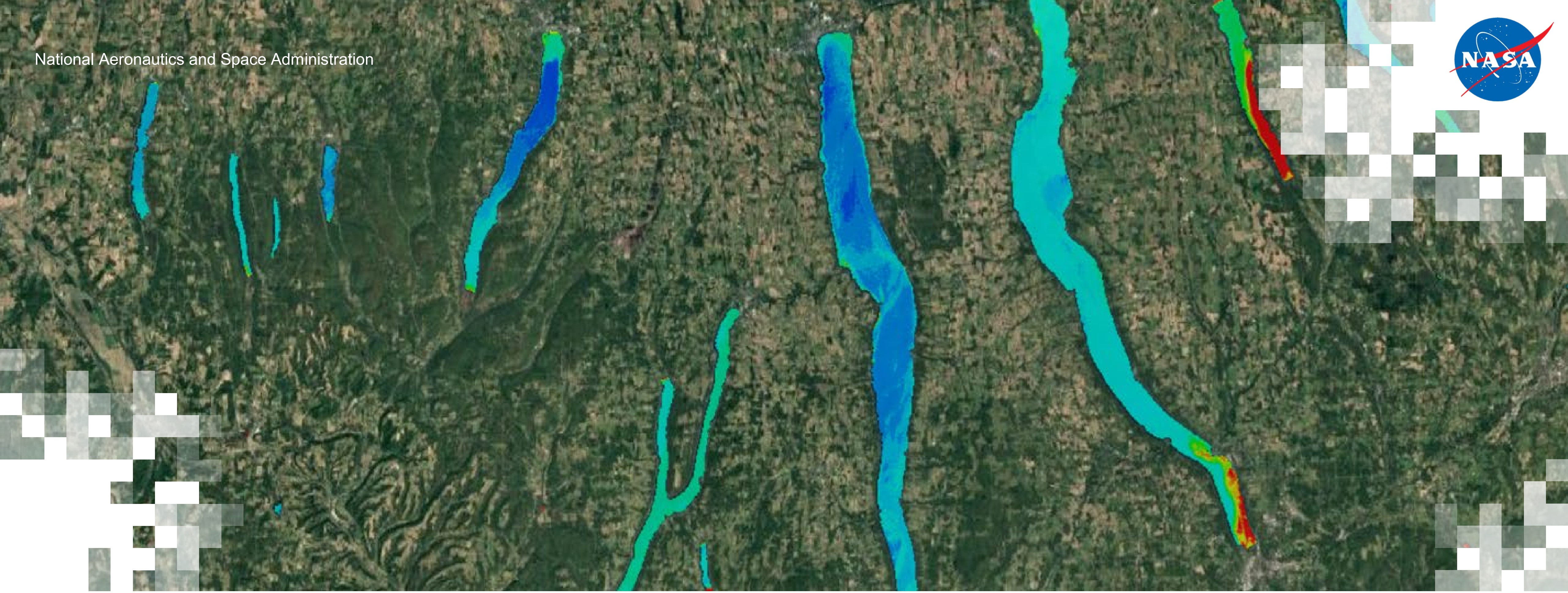
Part 1 – Trainer

William Wainwright

Senior Scientific Programmer
NASA-GSFC 619, SSAI



National Aeronautics and Space Administration



Monitoring Water Quality in Lakes and Coastal Regions Using STREAM

Part 1: Introduction and Demonstration of STREAM

William Wainwright (SSAI, NASA GSFC), Akash Ashapure (Affiliation), & Navid Golpayegani (Affiliation), Ryan O'Shea (Affiliation), Arun Saranathan (Affiliation)

February 10, 2026

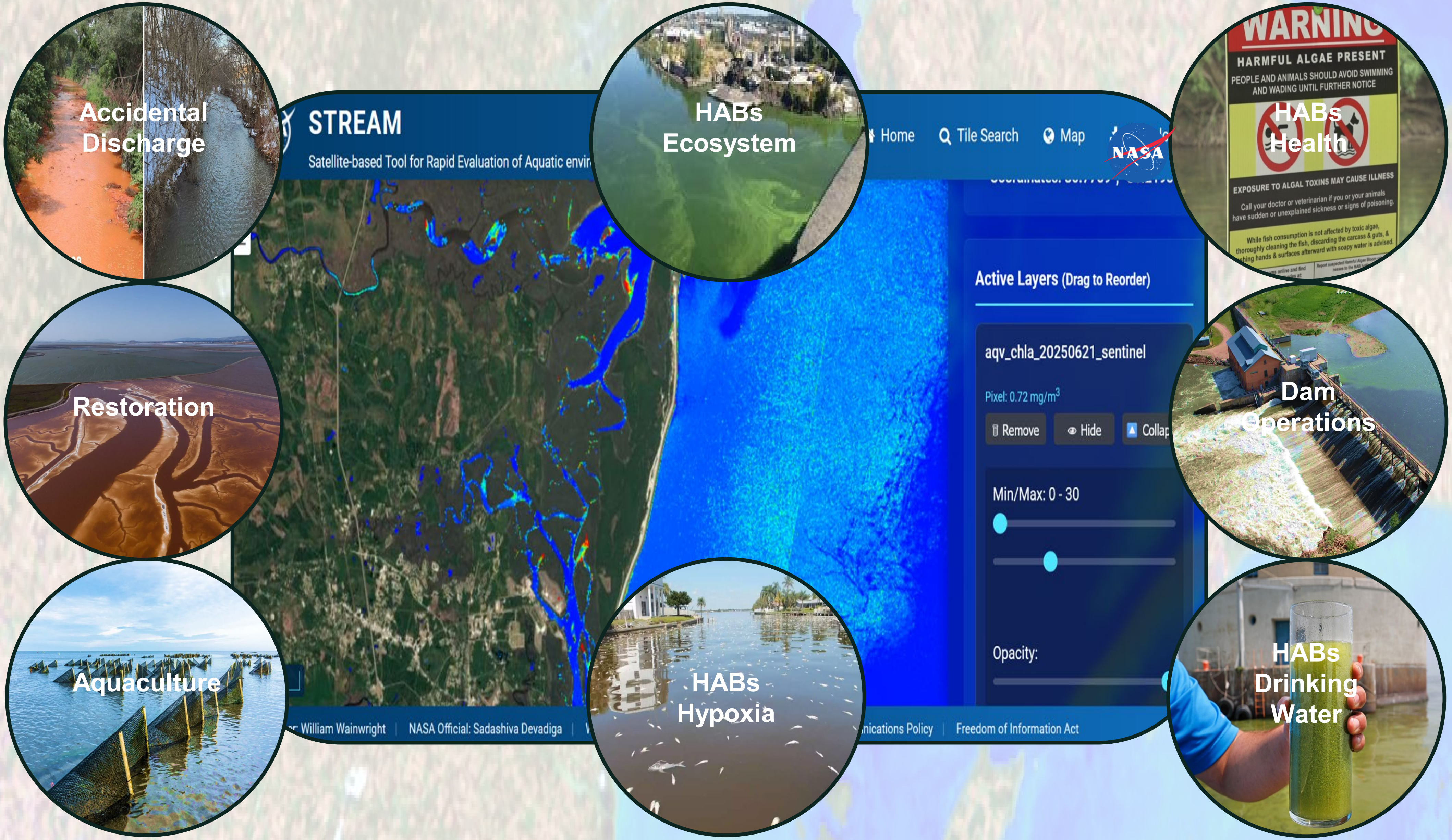
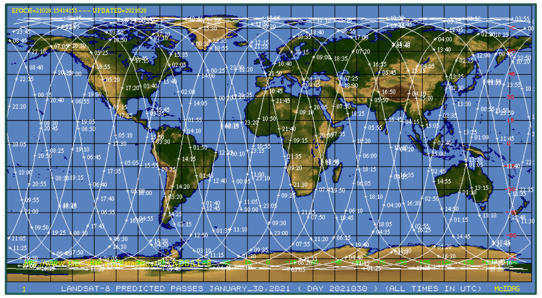
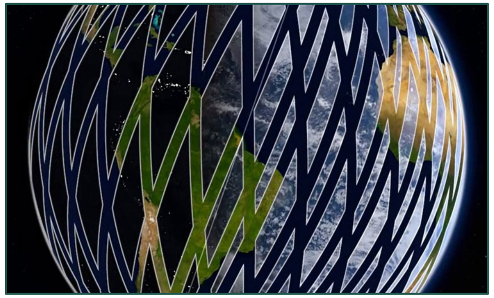


Photo credit: PA Dept. of Environmental Protection; LA Times. San Francisco salt pond A12; Fish kill in March in Cocoa Beach. NY Times; NY Times. Flip bags containing oysters in Cape Cod Bay; Ohio EPA; American Whitewater/Hydropower; Virginia Department of Health; USDA Natural Resources Conservation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

Satellites and Sensors Applied within STREAM



Landsat 8 & Landsat 9



Sentinel-2 A, B, & C

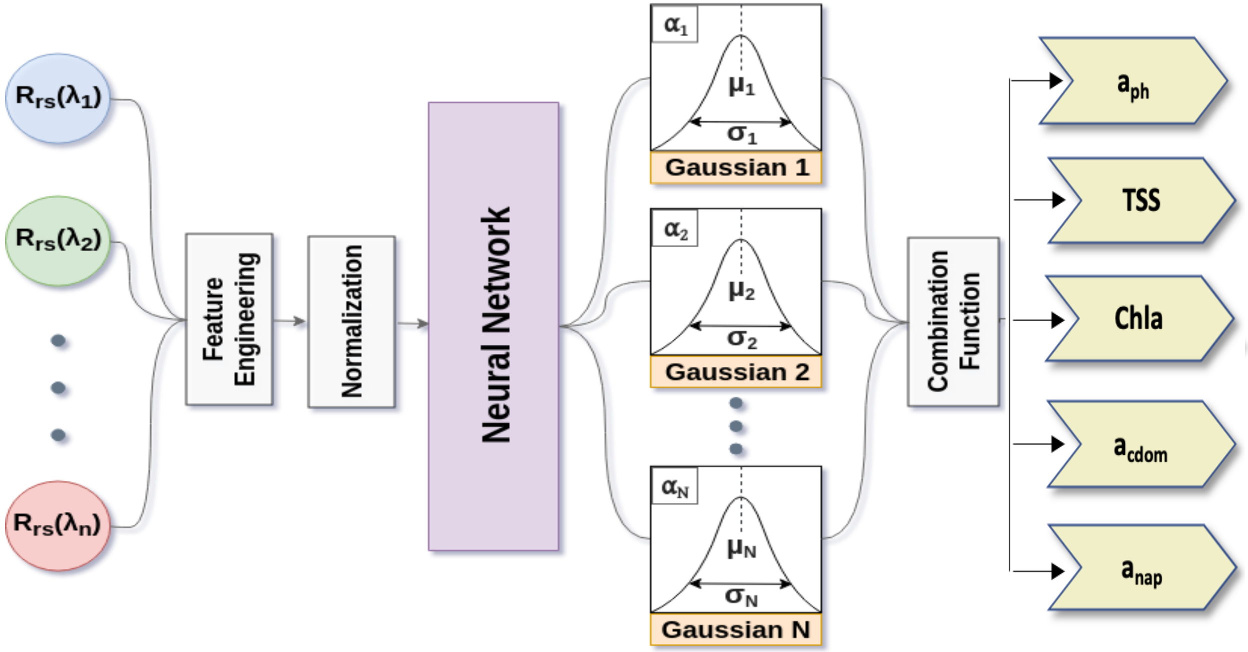
- All are polar orbiting satellites with different swath widths and revisit times.

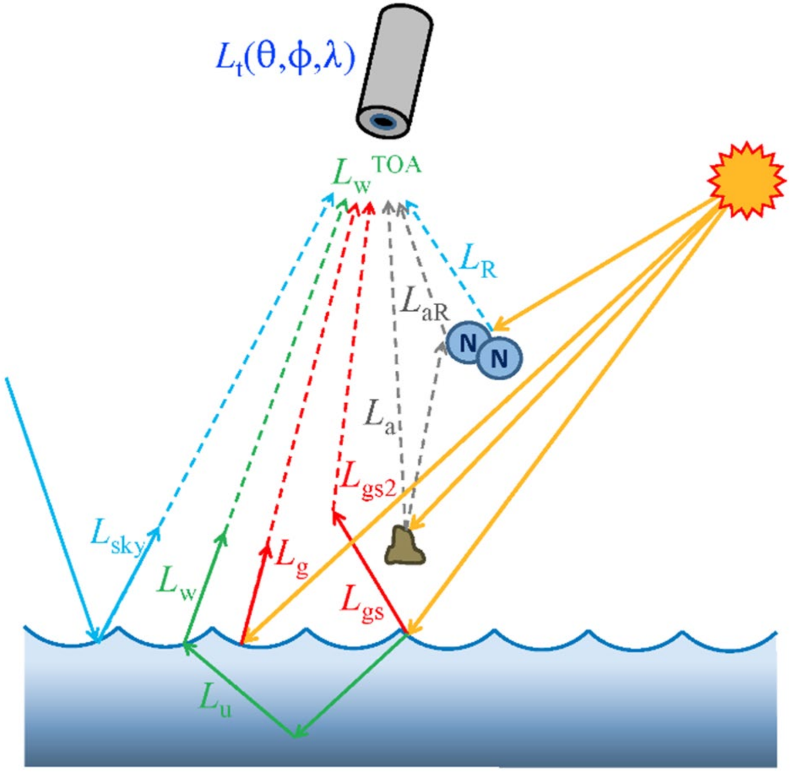
- Landsat 9 (9/27/2021 – Present)
- Landsat 8 (2/1/2013 – Present)
- Sentinel-2A (6/23/2015 – Present)
- Sentinel-2B (3/7/2017 – Present)
- Sentinel-2C (9/5/2024 - Present)

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

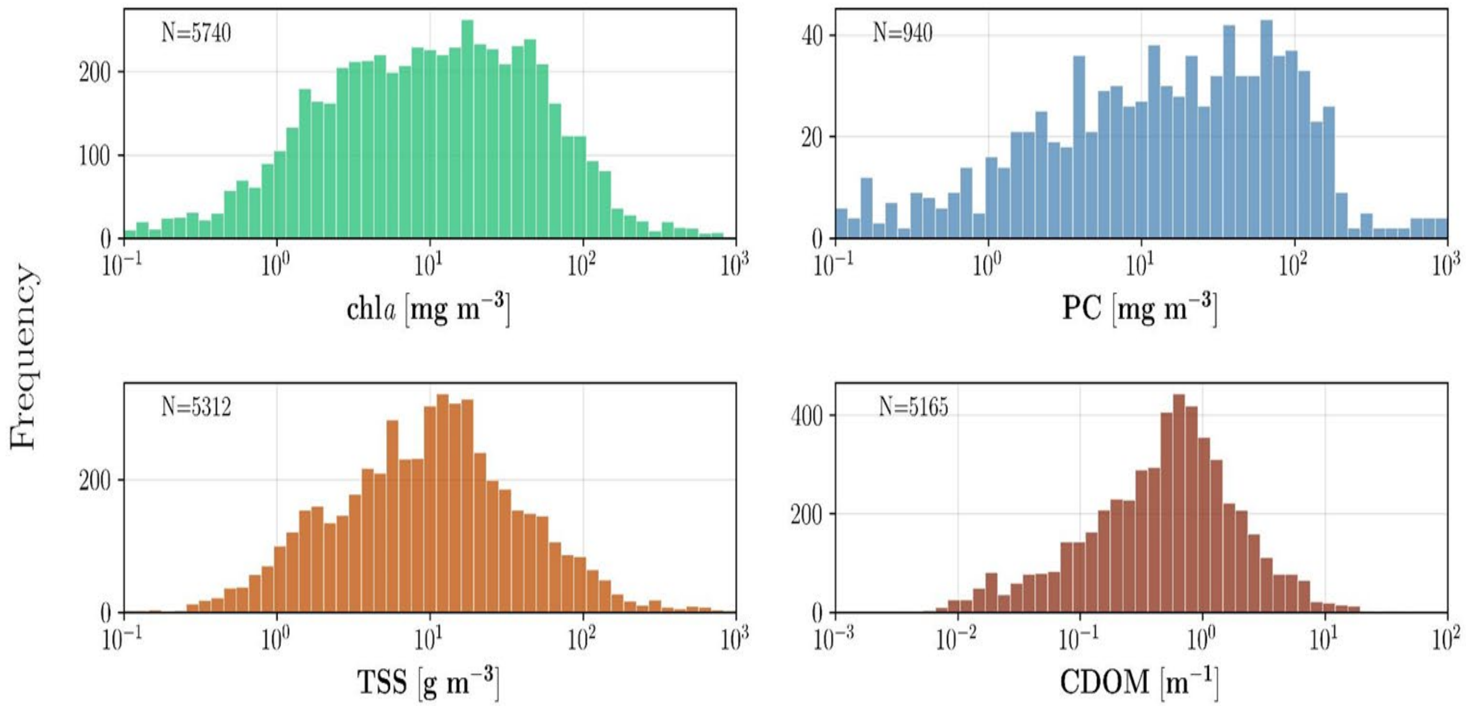
- Over 7500 hyperspectral RRS
  - 1nm intervals from 350-900nm
- Coastal and inland water bodies
- Co-located in-situ water quality indicators
- Over 25 years of temporal coverage

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:

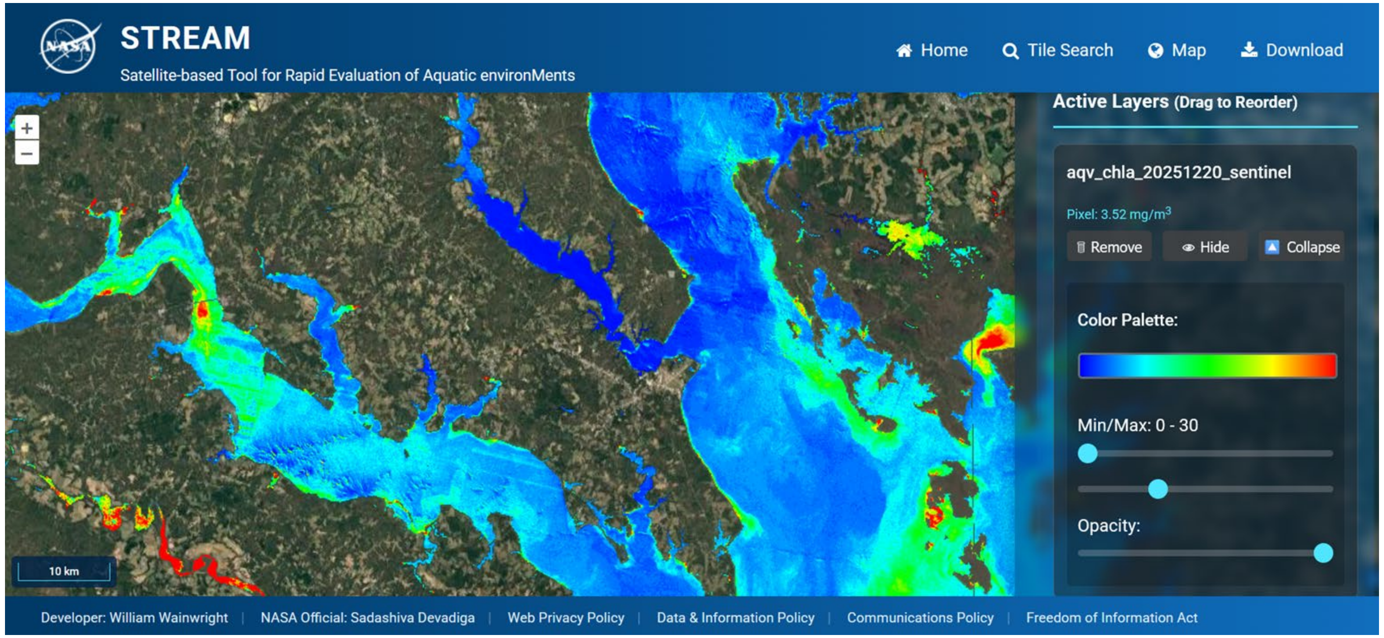
- Aerosol Robotic Network-Ocean Color

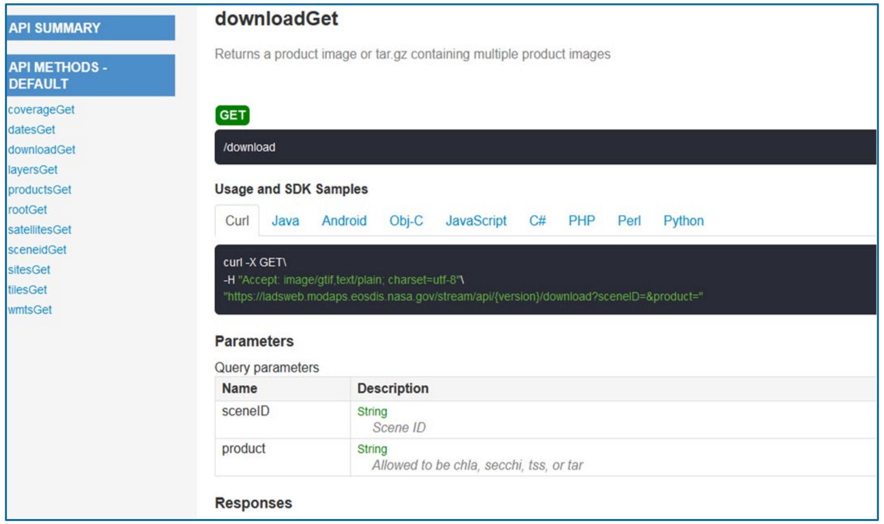


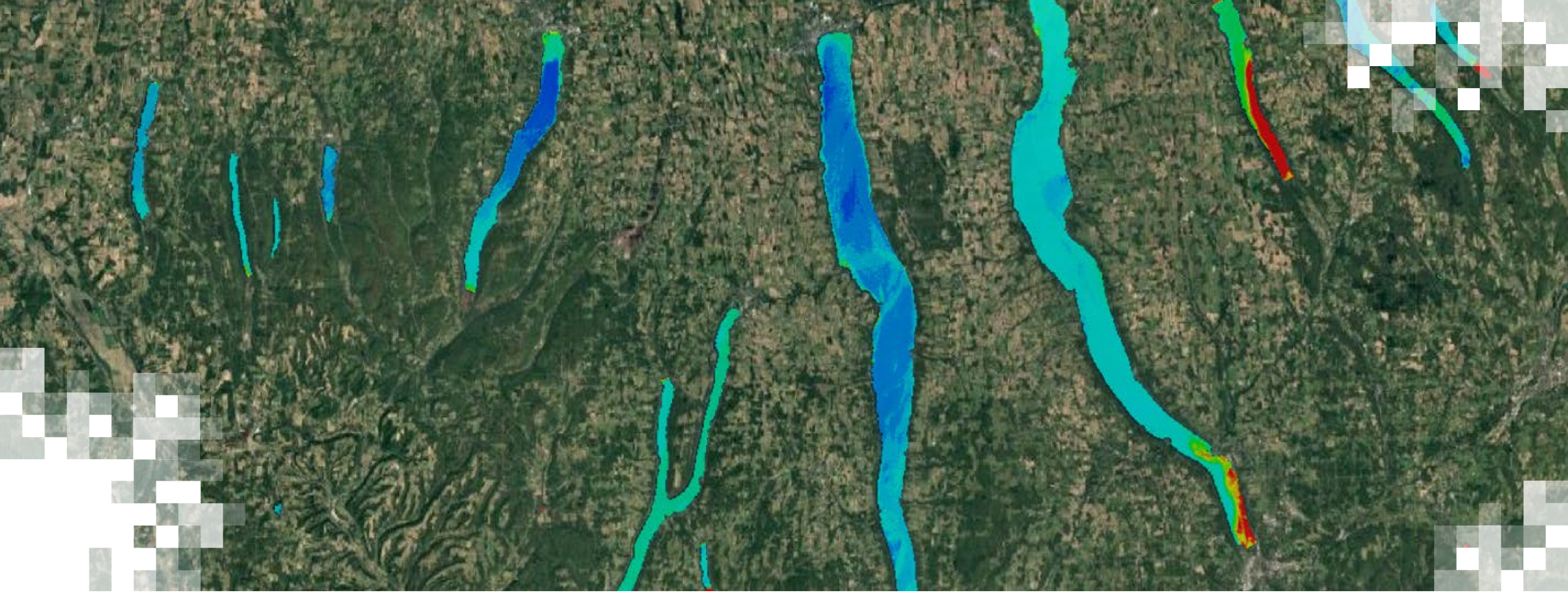
O'Shea et al. 2023 (Remote Sensing of Environment)

Website & API

- Interactive map
  - OpenLayers
  - WMTS tile service
- Archive of daily processing
  - June 2024 – Present
  - CONUS, Hawaii, Alaska
  - Select regions outside US
- RESTful API
  - Documentation included
  - Query and download







Demonstration:
Maps and Time Series of Water Quality Parameters using QGIS

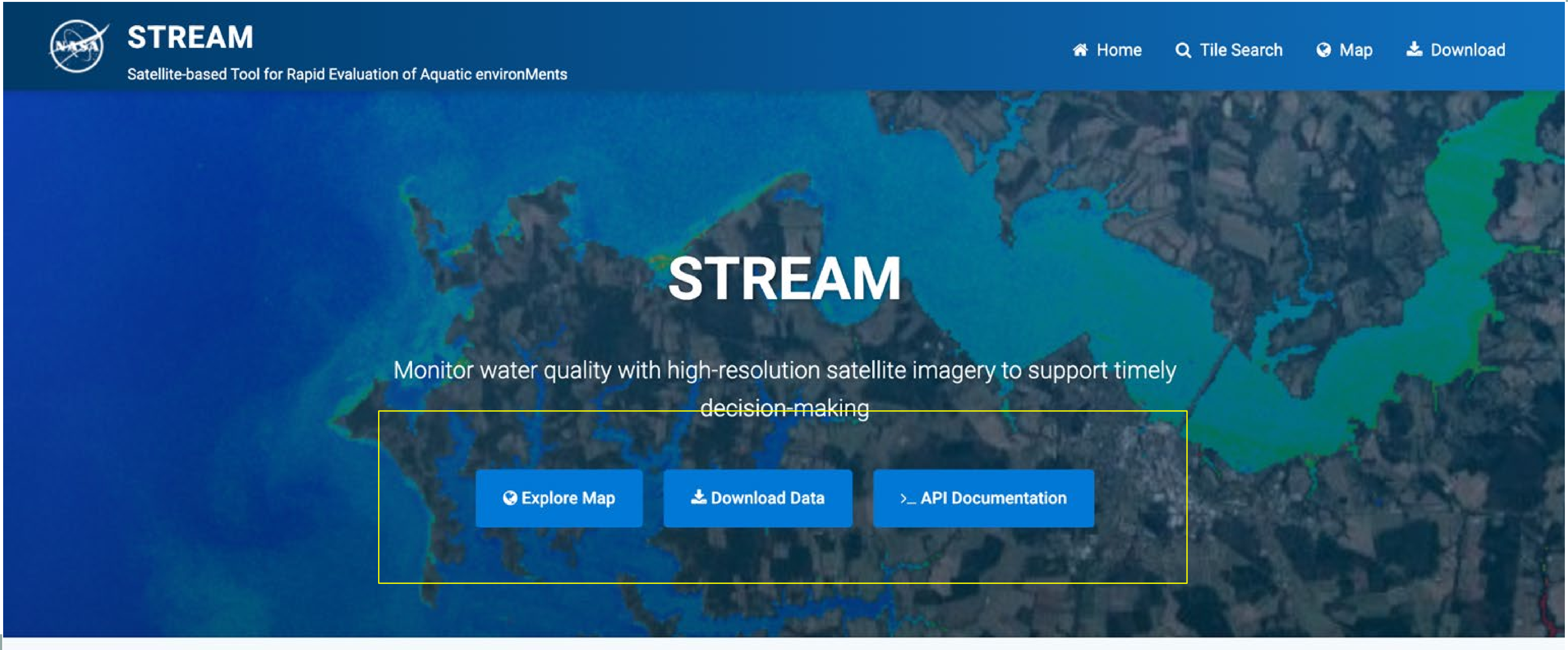
Demonstration Outline

- STREAM web tool functionality to map water quality parameters
- STREAM API to download multiple water quality images for a selected water body
- Making time series of water quality parameters for the selected area using QGIS
- Case Study:
  - Monitor water quality in Pyramid Lake (Nevada)

Photograph of Pyramid Lake taken from International Space Station

Image: NASA Earth Observatory

STREAM Web Tool



Marge Beaver | Photography Plus
Grand River

USGS
science for a changing world

NASA

ACKNOWLEDGEMENT

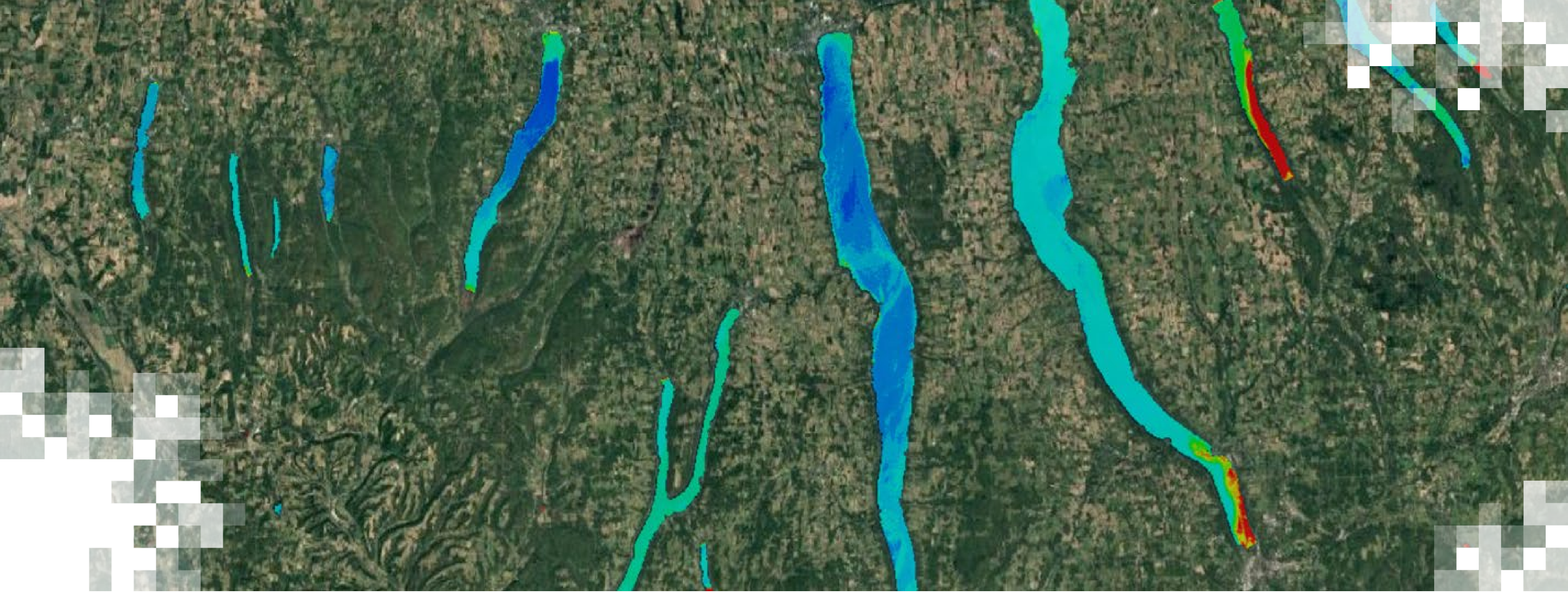
United States Geological Survey
Landsat Science Team

NASA Earth Science Programs
Ocean Biology and Biogeochemistry
Remote Sensing of Water Quality
PACE Science and Applications Team
EMIT Science and Applications Team
Commercial Small Satellite Data Acquisition
Applied Sciences, Sustainable Development Goals

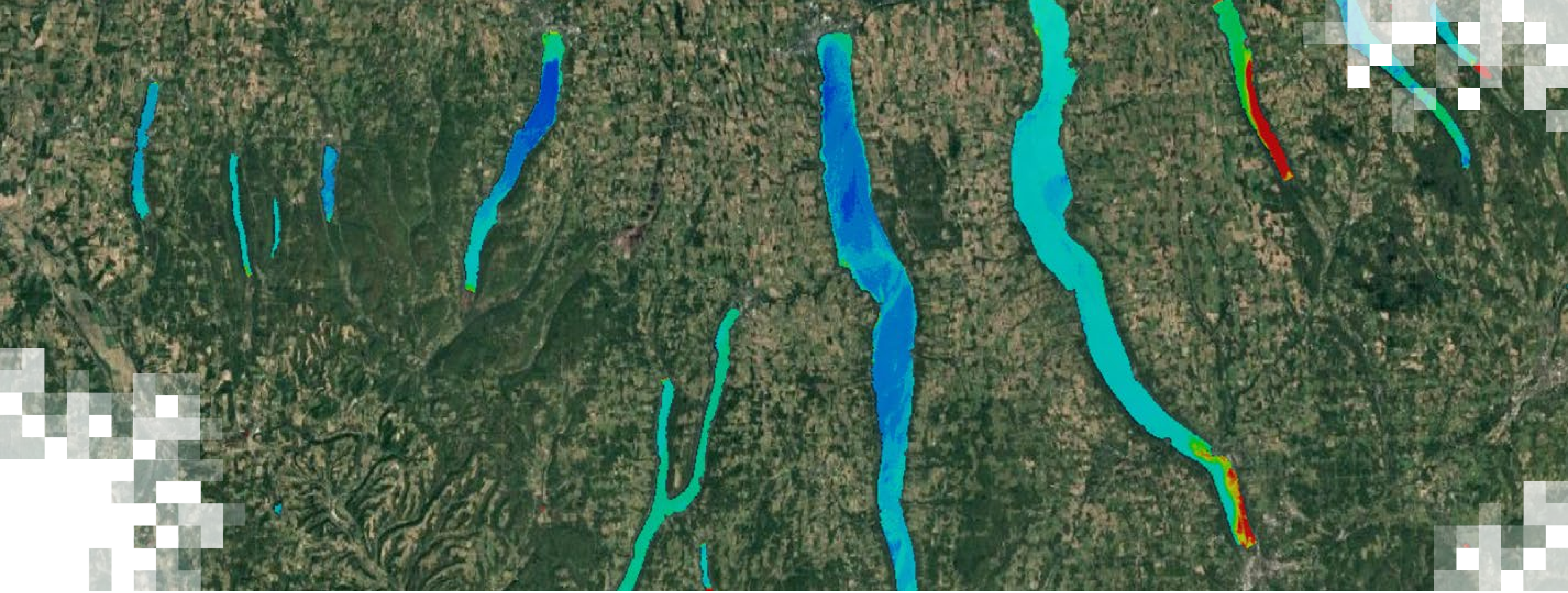
Try STREAM Yourself!

NASA STREAM water quality

SSAI



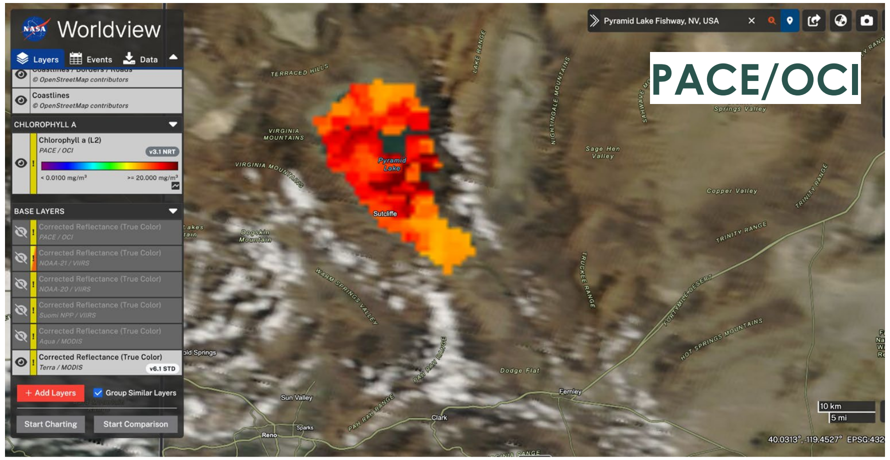
Demonstration:
Making Time Series of Water Quality Parameters using STREAM and QGIS
Locations: Pyramid Lake and Chesapeake Bay

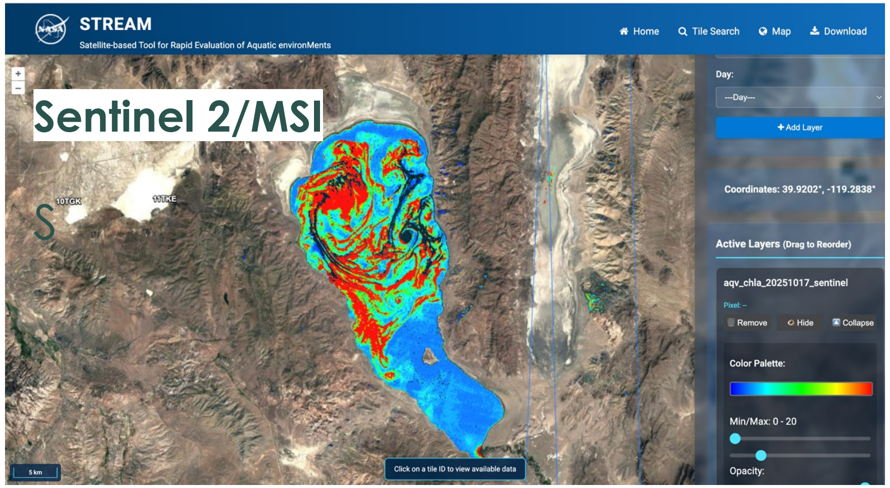


Summary

Summary

- Background, overview, and demonstration of 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 20m to 30 m spatial resolution
  - API allows search and download of multiple images of an area of interest
- Example of selection of the water quality parameters in areas of interest using STREAM:
  - Map the water quality parameters
  - Access and download multiple water quality data using the STREAM API
  - Make time series of area-averaged water quality parameters using QGIS





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

Looking Ahead to Part 2

- Introduction to a machine learning model to estimate water quality parameters based on satellite observations

Homework and Certificates

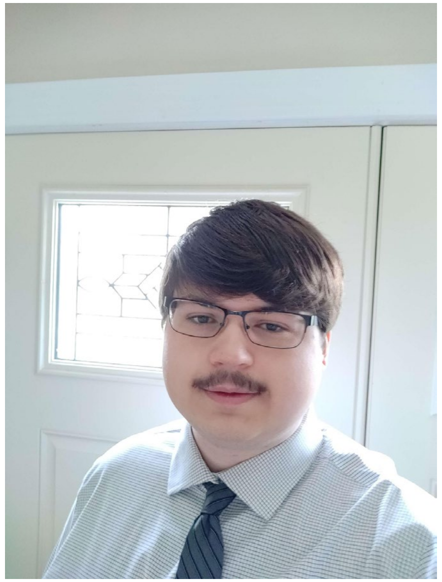
- **Homework:**
  - One homework assignment
  - Opens on 02/17/2026
  - Access from the training webpage
  - Answers must be submitted via Google Forms
  - **Due by 03/10/2026**

- **Certificate of Completion:**
  - Attend all live webinars (attendance is recorded automatically)
  - Complete the homework assignment by the deadline
  - You will receive a certificate via email approximately two months after completion of the course.

Acknowledgements

William Wainwright

Senior Scientific Programmer
NASA-GSFC 619, SSAI



Resources

- STREAM
- STREAM API
- ARSET: QGIS Download and Install
- Install experimental plugin in QGIS: Dymaxionlabs → Raster analysis → Zonal statistics (multiband)
- Introduction to Git video

Acronyms

- JPSS: Joint Polar Satellite Syetem
- MODIS: Moderate Resolution Imaging Spectroradiometer
- MSI: Multispectral Imager
- OCI: Ocean Color Instrument
- OLCI: Ocean and Land Color Instrument
- OLI/OLI2: Operational Land Imager
- PACE: Plankton Aerosol, Coud, ocean Ecosystem
- SNPP: Soumi National Polar-orbiting Satellite
- TIRS/TIRS2: Thermal Infrared Sensor
- VIIRS: Visible Infrared Imaging Radiometer Suite

Contact Information

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  - Amita.v.mehta@nasa.gov
- William Wainwright
  - Wiiliam.wainwright@nasa.gov

- ARSET Website
- ARSET YouTube

For questions, comments, or to share how you have applied our trainings to your work or studies, email nasa.arset@gmail.com.

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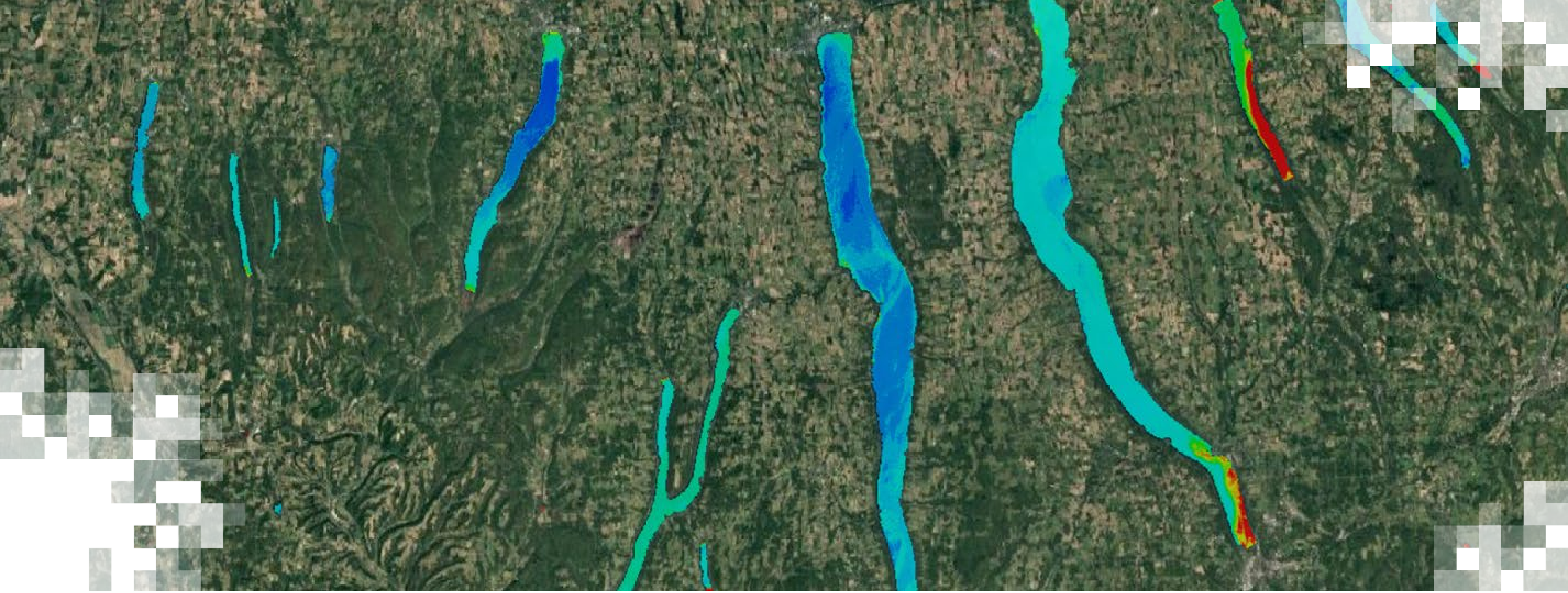
1. Send an email with no subject line to arset-join@lists.nasa.gov.
2. Follow the instructions sent in response.

Thank You!



Appendix
Install QGIS

Install QGIS and Zonal Statistics (multiband) Plugin

- **Install QGIS:**

  ARSET: QGIS Download and Install

Install Zonal Statistics (multiband) Plugin:

- Go to Zonal Statistics for Multiband Rasters – QGIS plugin for more instruction
- **Add plugins repository**
- To install this plugin, you need to add our **QGIS Repository** first. Go to **Plugins -> Manage and Install Plugins**.
- On the **Settings** tab, enable **Show also experimental plugins**, and add a repository named Dymaxion Labs with the following URL:

  https://dymaxionlabs.github.io/qgis-repository/plugins.xml
- After that, press **Reload all repositories** button to load our plugins index into QGIS.
- **Install plugin**
- Finally, go to Plugins -> Manage and Install Plugins, and in All or Not Installed tabs, search for **Zonal Statistics for Multiband Rasters**. Click Install plugin.