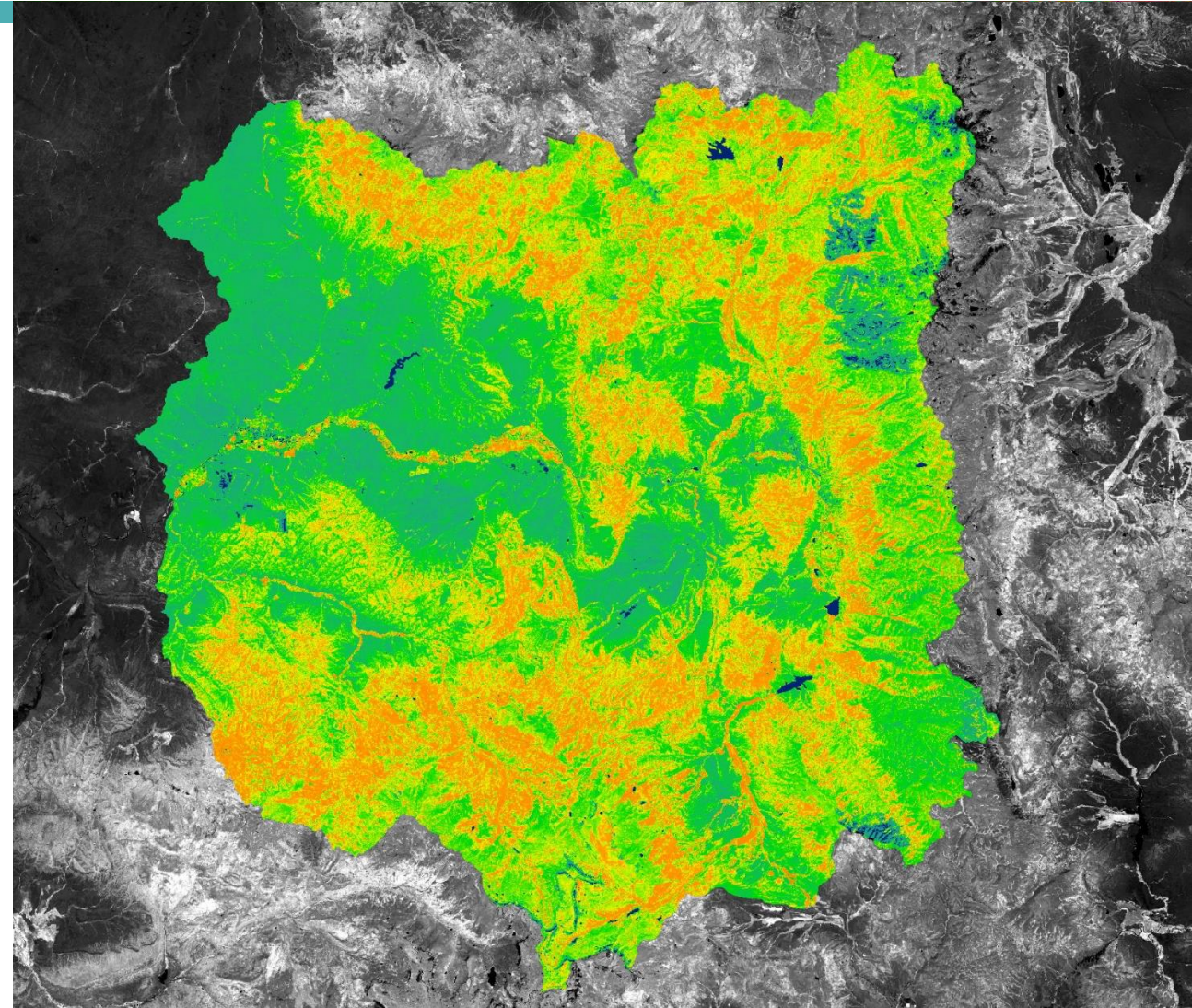




Yampa Water Resources

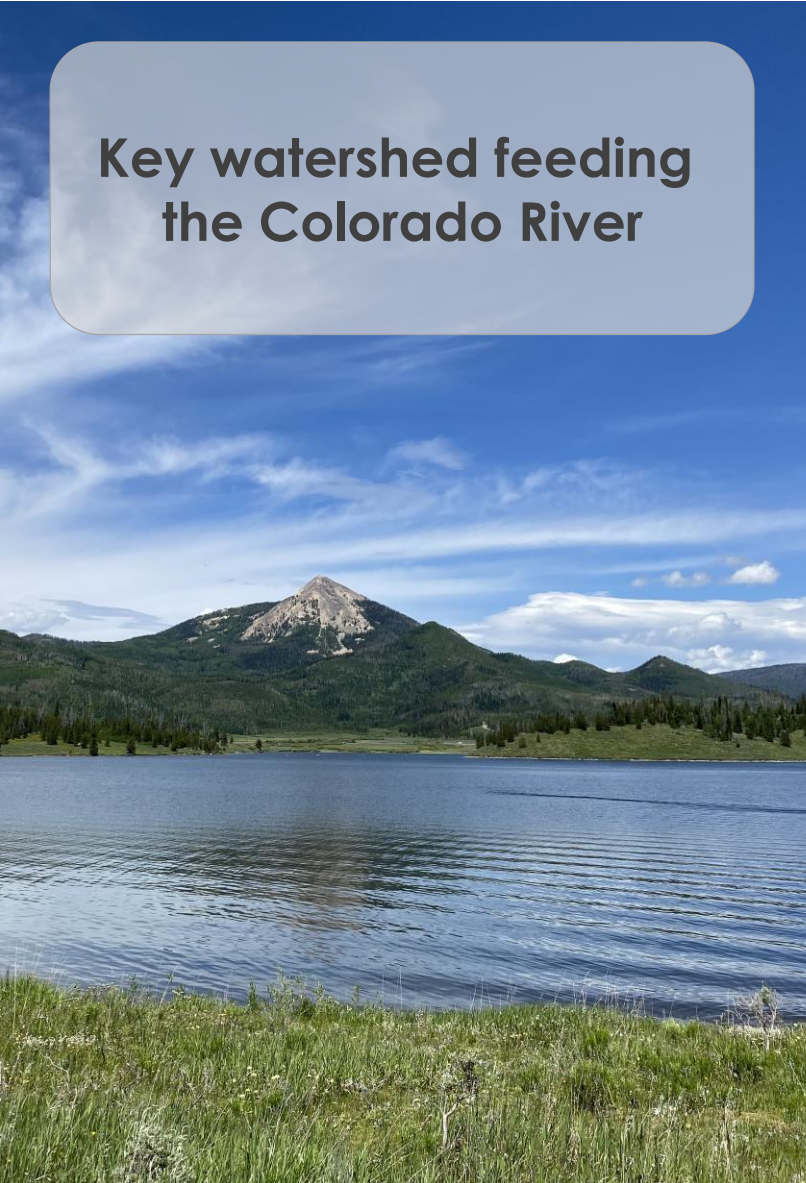
Monitoring Water Quality and Evaluating
Potential Drivers of Algal Blooms in the Upper
Yampa River Watershed

Ethan Gates
Morgan Guttman
Samrin Sauda
Erin Weitzel

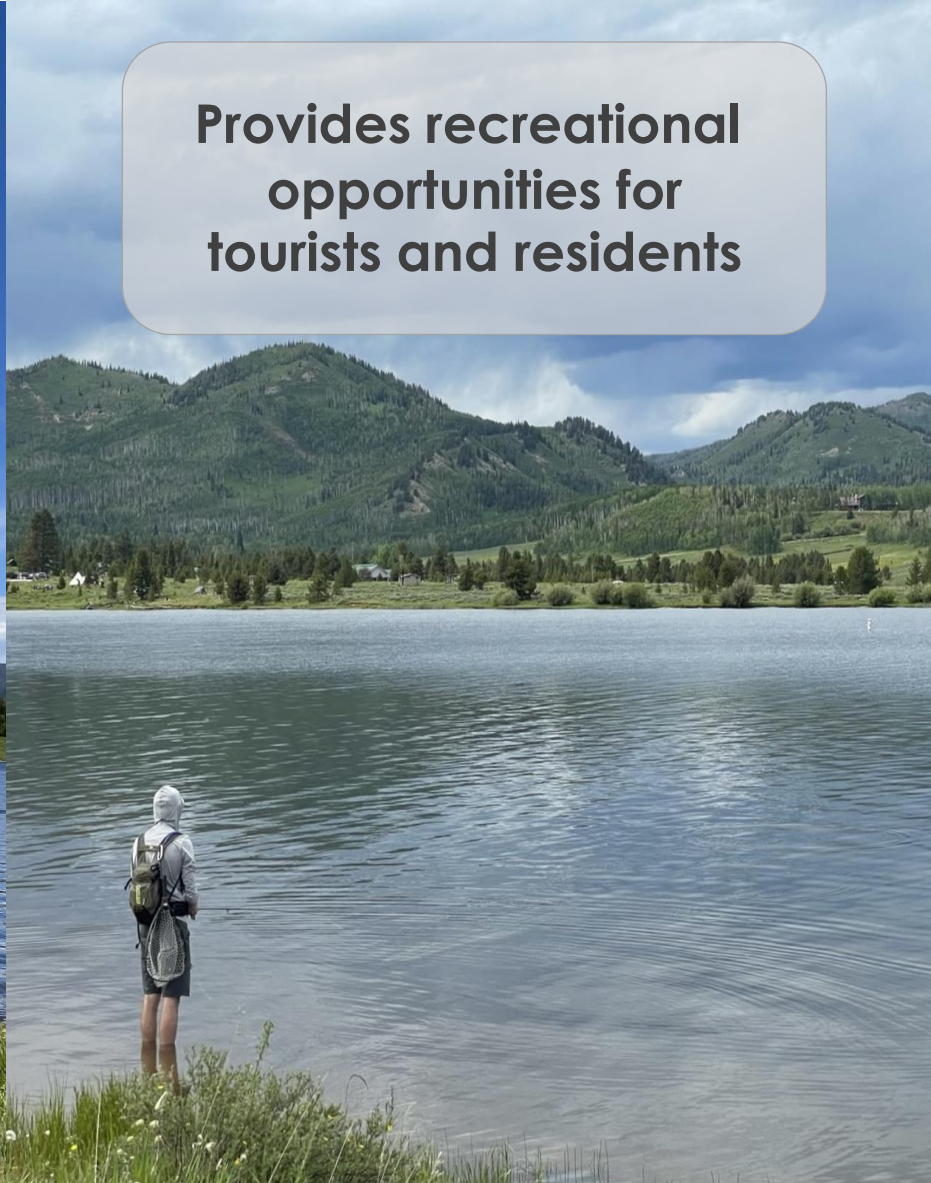


Background

**Key watershed feeding
the Colorado River**



**Provides recreational
opportunities for
tourists and residents**



**Low productivity lakes
sensitive to change**

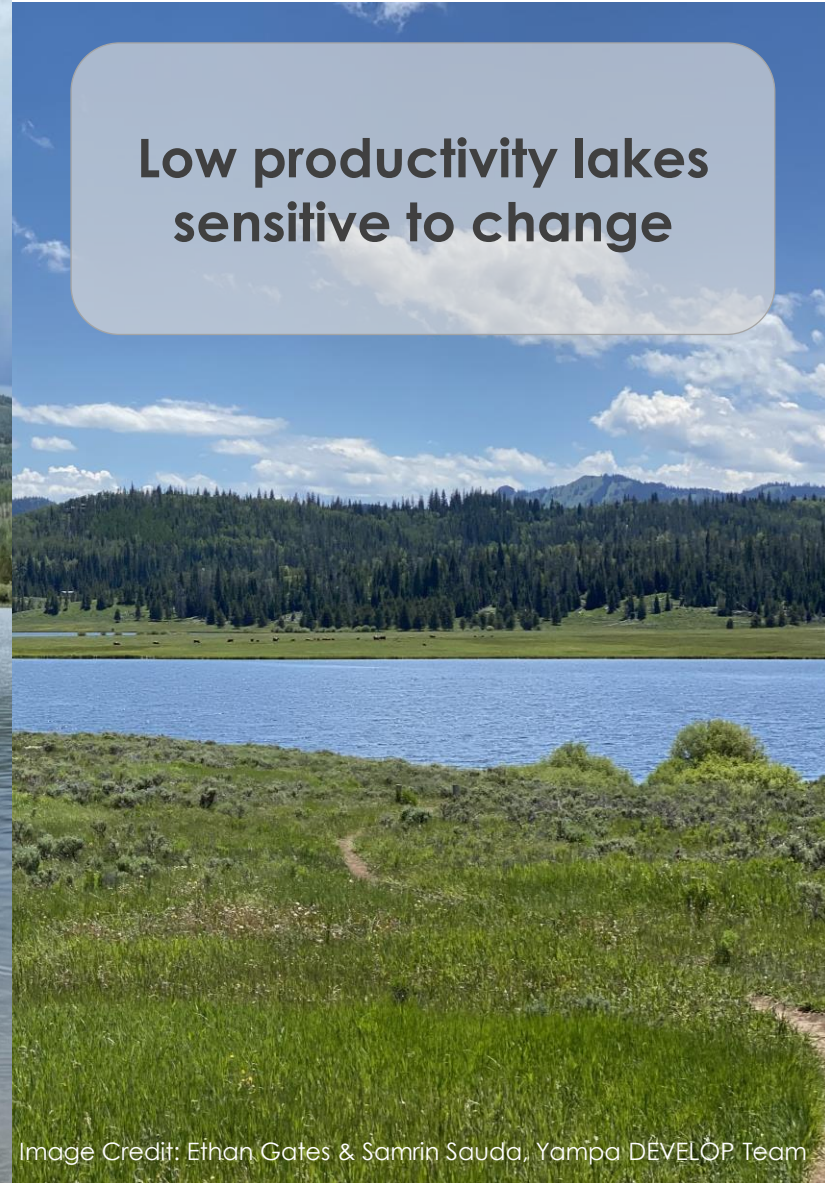
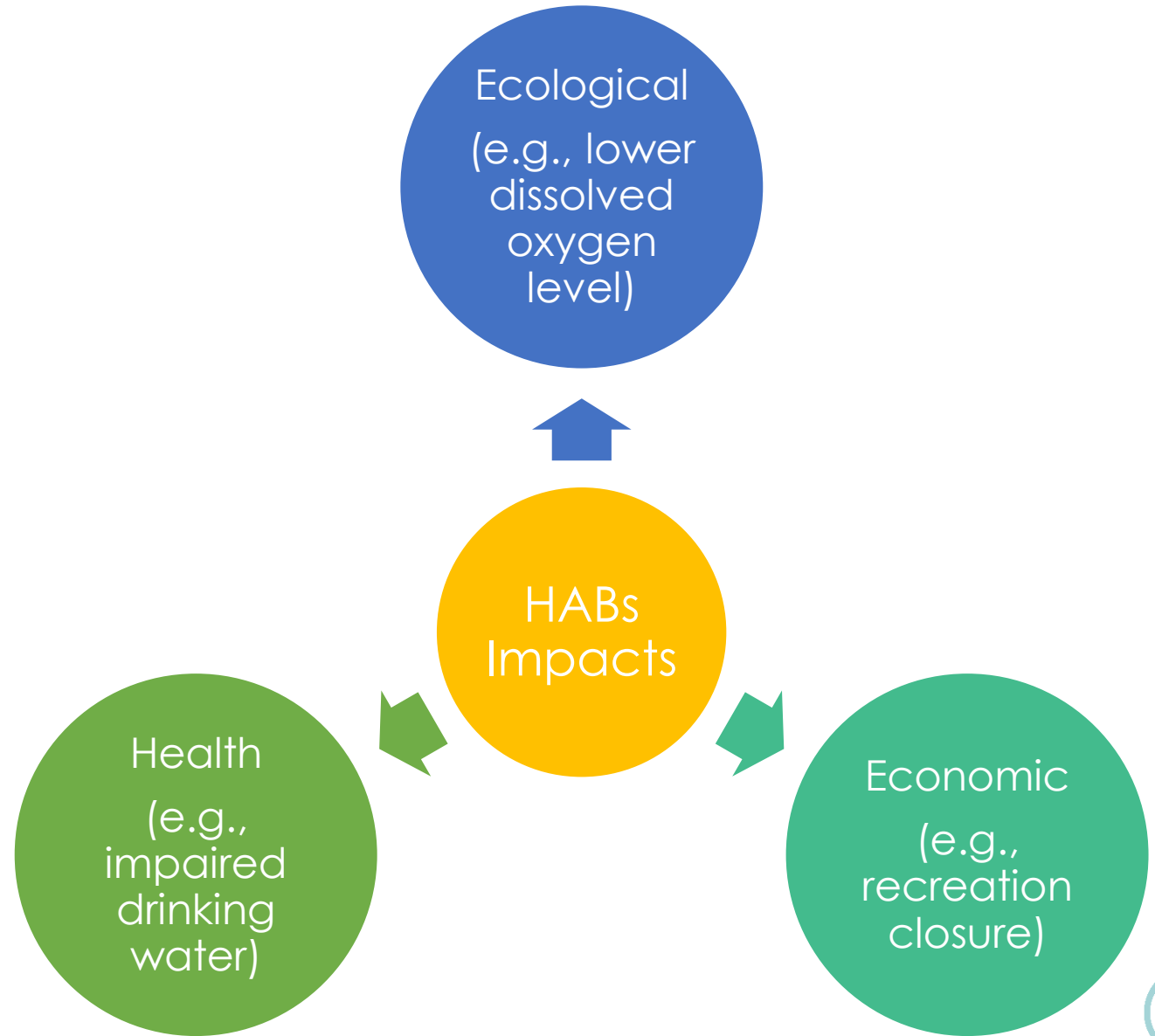


Image Credit: Ethan Gates & Samrin Sauda, Yampa DEVELOP Team

Community Concerns

- ▶ **Blue-green** algae → Cyanotoxins
- ▶ Exposure symptoms can include:
 - ▶ Nausea
 - ▶ Vomiting
 - ▶ Abdominal pain
 - ▶ Liver damage
 - ▶ Neurological issues



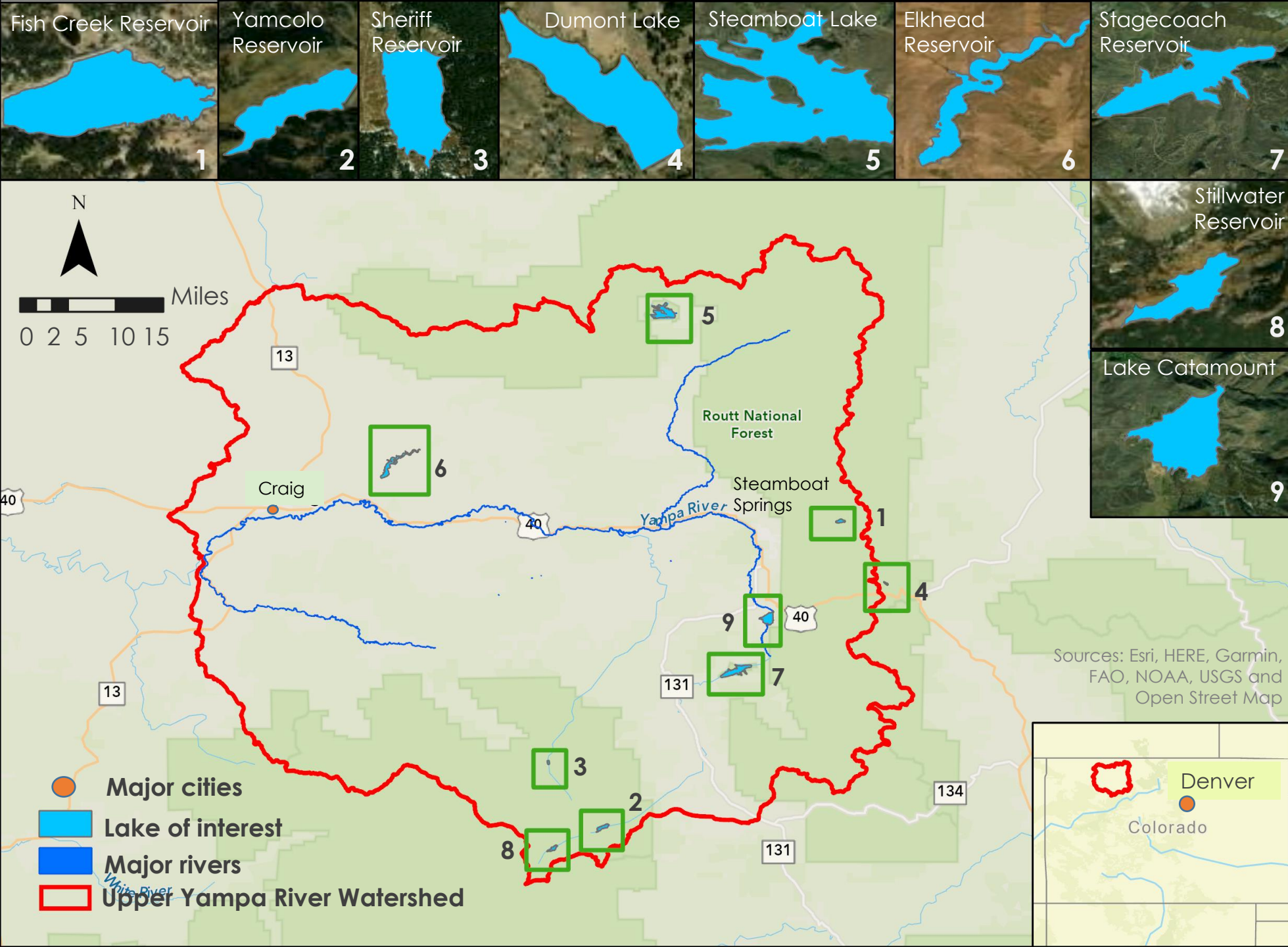


Figure 1. Study area map showing Yampa river and our areas of interest.



Objectives



Analyze trends
in water quality over
time and fill historical
data gaps



Assess viability
of remote sensing to
monitor water quality
in the UYRB



Partners

- ▶ Upper Yampa Water Conservancy District (UYWCD)
- ▶ Colorado State University (CSU)
- ▶ CSU Agricultural Water Quality Program (AWQP)



Image Credit: Erin Weitzel, Yampa DEVELOP Team



Methodology

ACQUIRING DATA



Algal bloom
season



Mask cloud &
snow cover



Ancillary Data



- USGS Water Quality Data
- Stagecoach Park Temperature Data

PROCESSING

Spectral bands



- Greenness
- Temperature

Spectral indices



- Apparent Visible Wavelength (AVW)
- Broad Wavelength Algae Index (BWAi)

VISUALIZING

Maps



- True Color
- Spectral bands
- Spectral indices

Plots



- Spectral bands
- Spectral indices

ANALYZING

Trends



- Correlation between indices
- Bloom extent

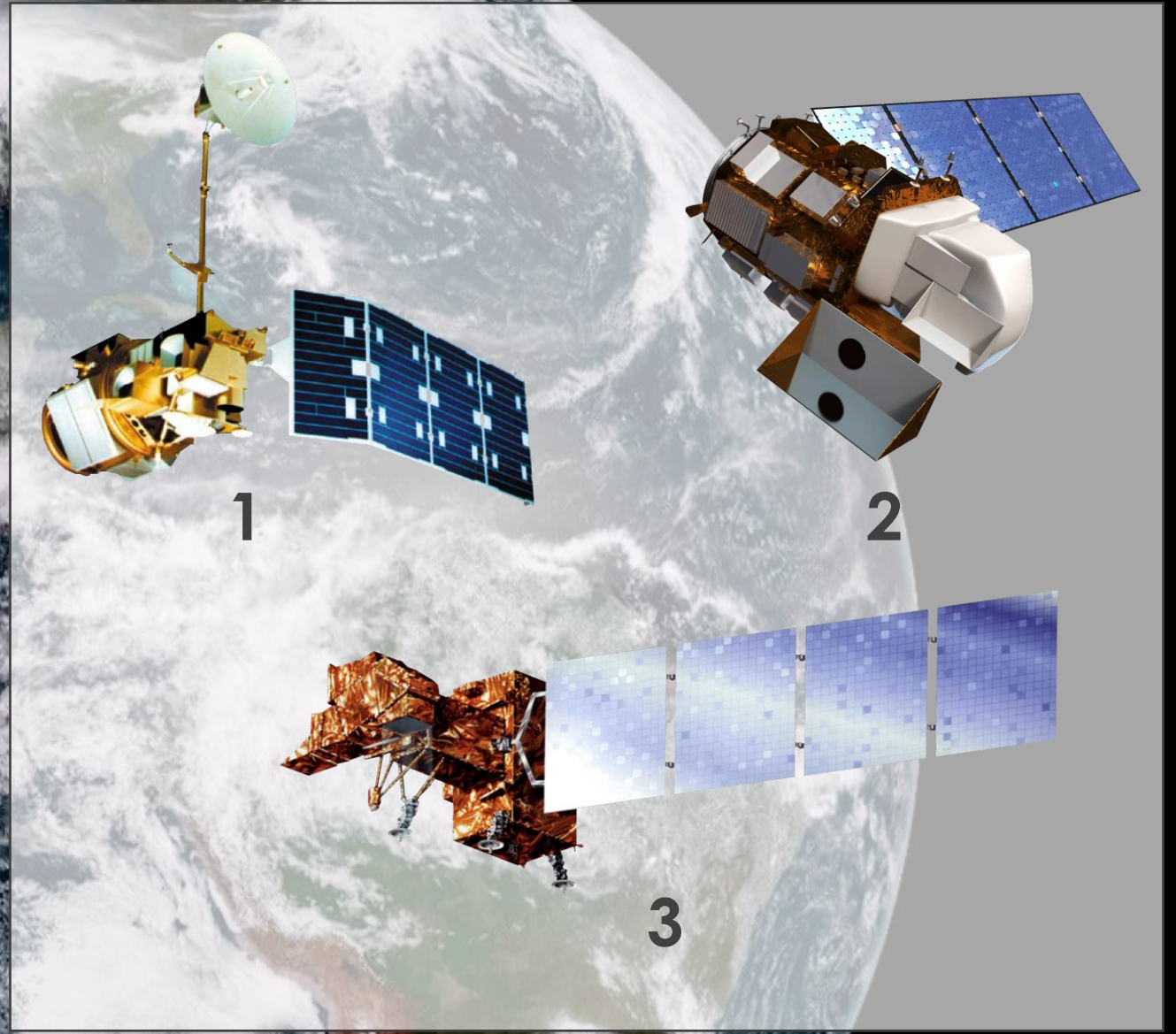
Validity of Results



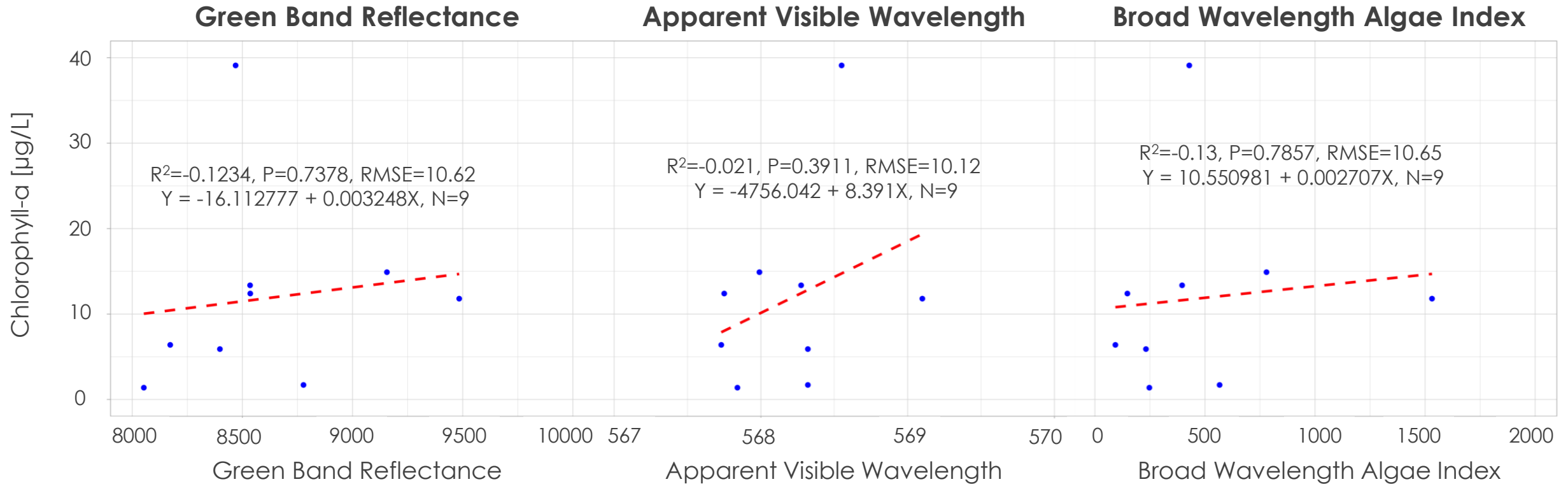
- Confusion matrix
- In-situ data comparisons

NASA EO's

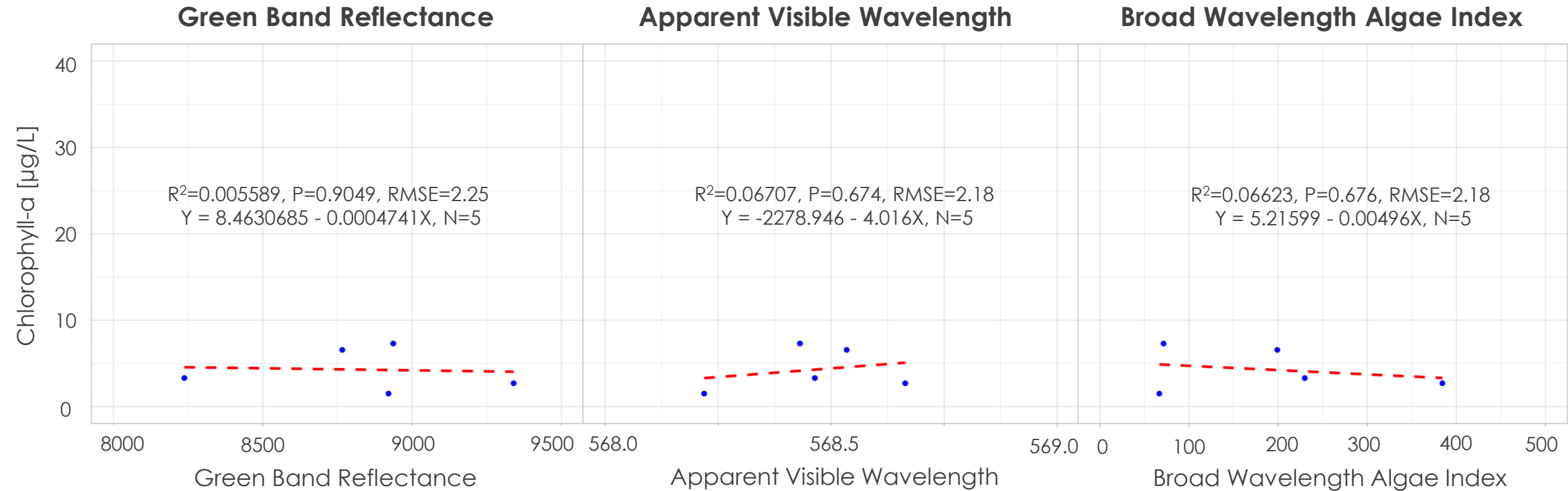
- ▶ (1) Landsat 5 Thematic Mapper (TM)
- ▶ (2) Landsat 8 Operational Land Imager (OLI)
- ▶ (3) Landsat 7 Enhanced Thematic Mapper Plus (ETM+)



Results – Stagecoach Reservoir Evaluation

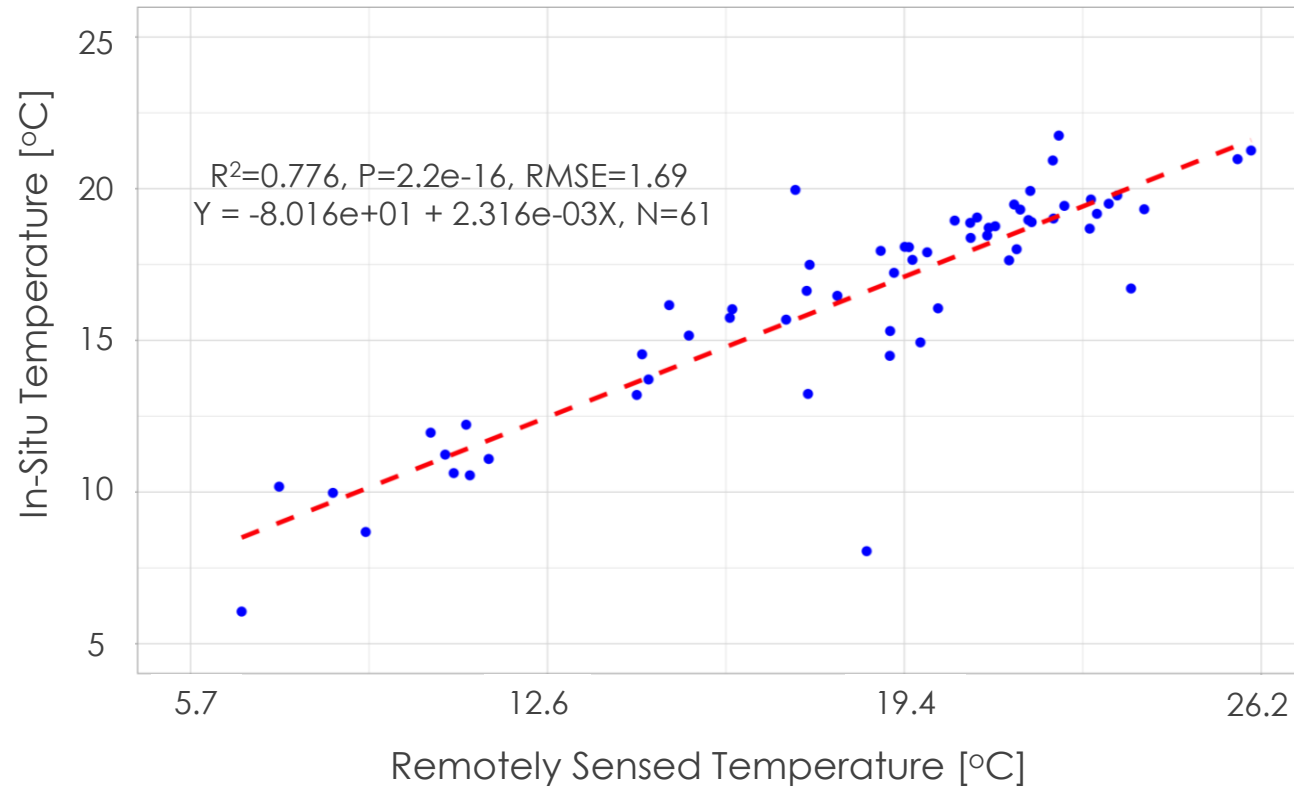


Results – Steamboat Lake Evaluation

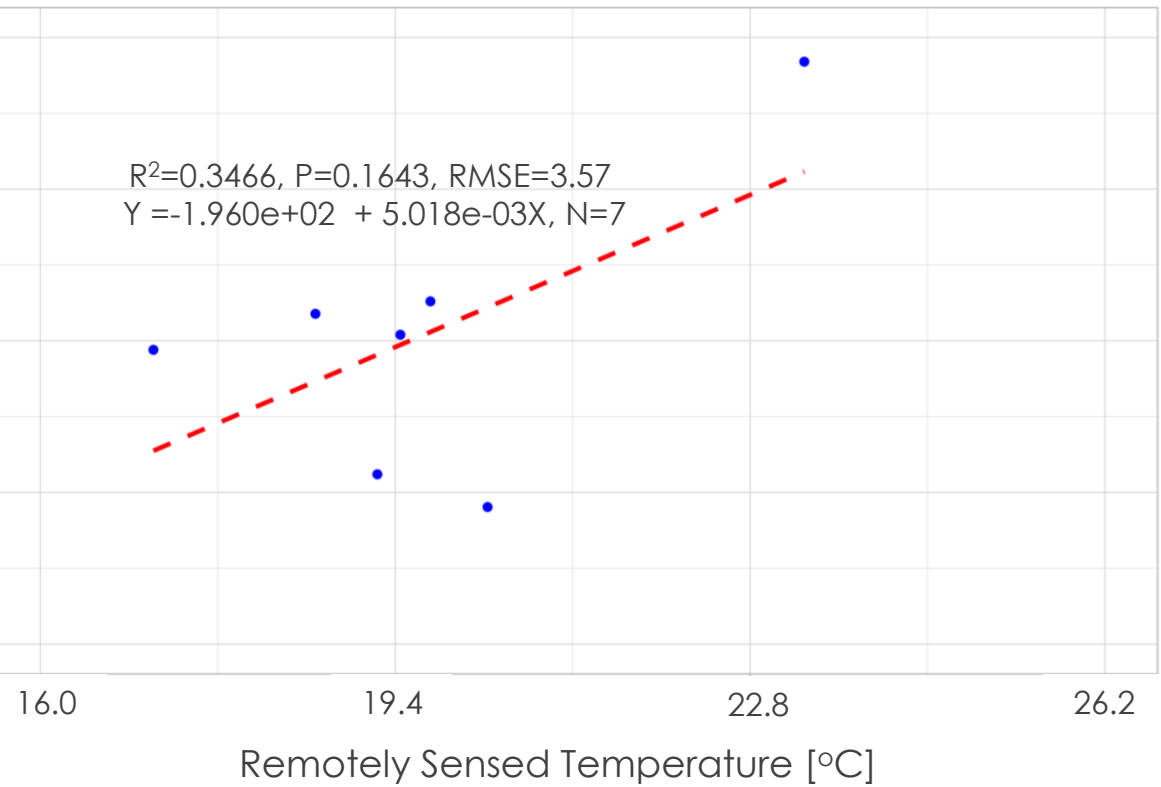


Results – Lake Temperature Evaluation

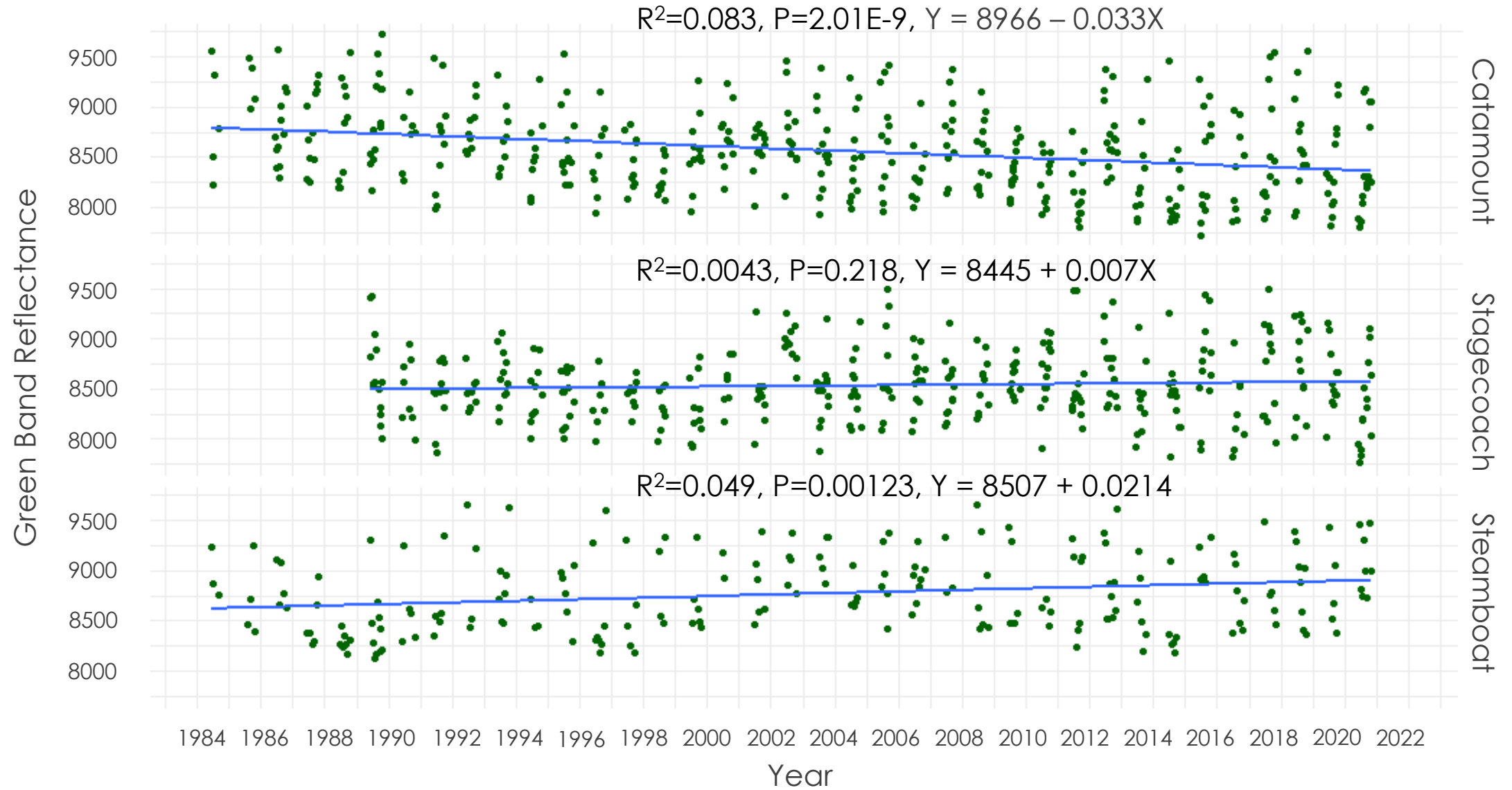
Stagecoach Reservoir Temperature Evaluation



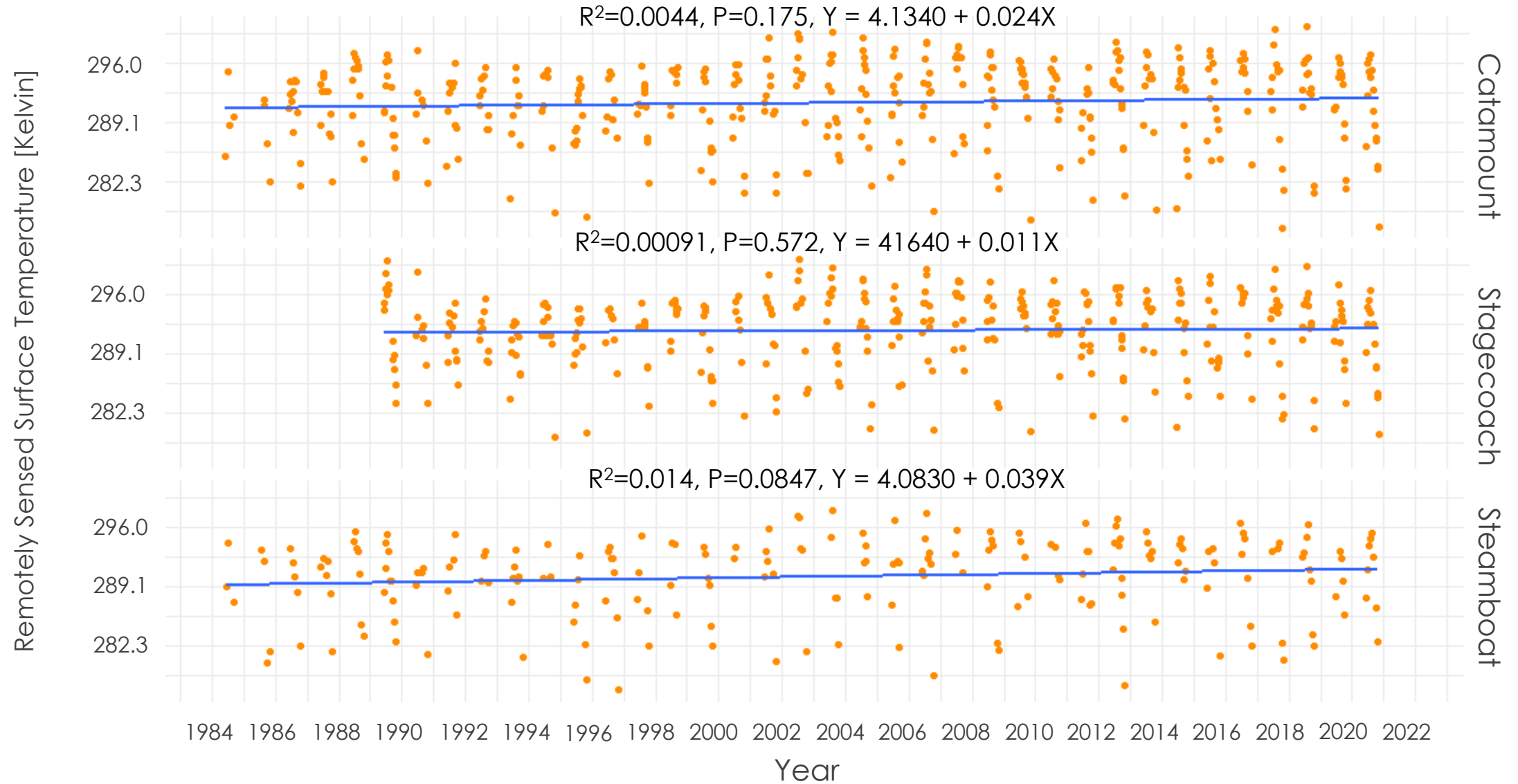
Steamboat Lake Temperature Evaluation



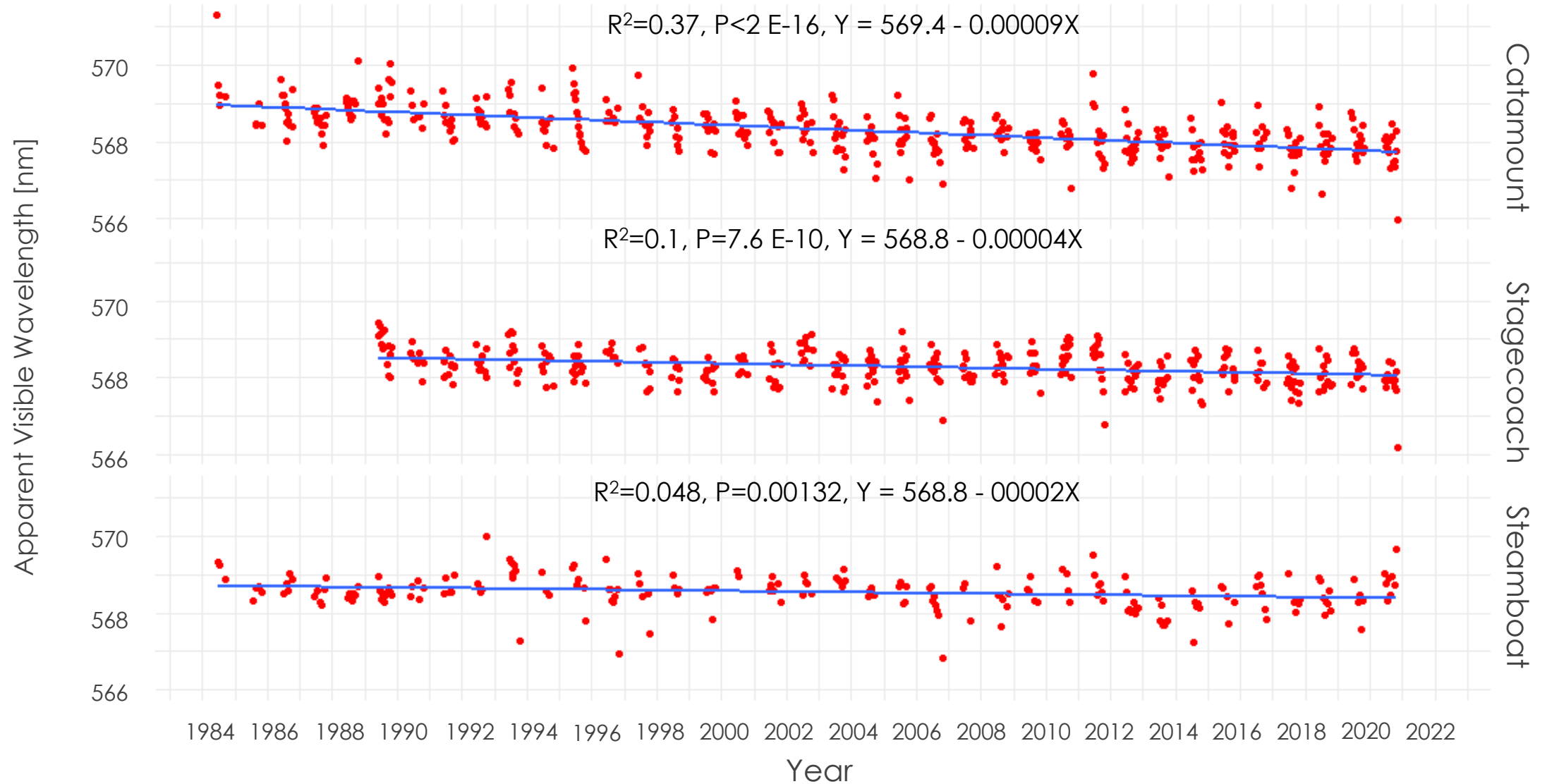
Results – Green Band Reflectance



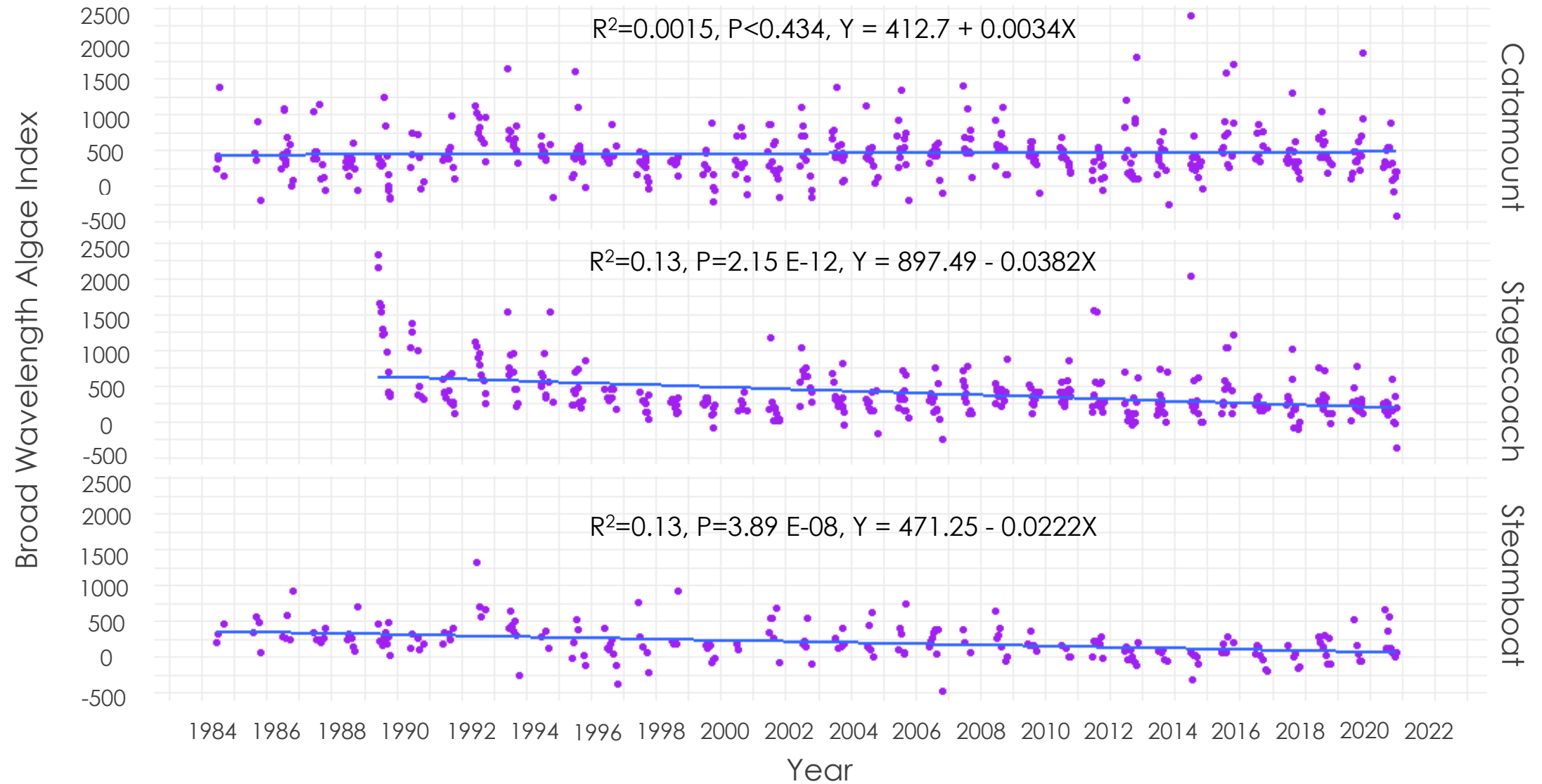
Results – Surface Temperature



Results – Apparent Visible Wavelength

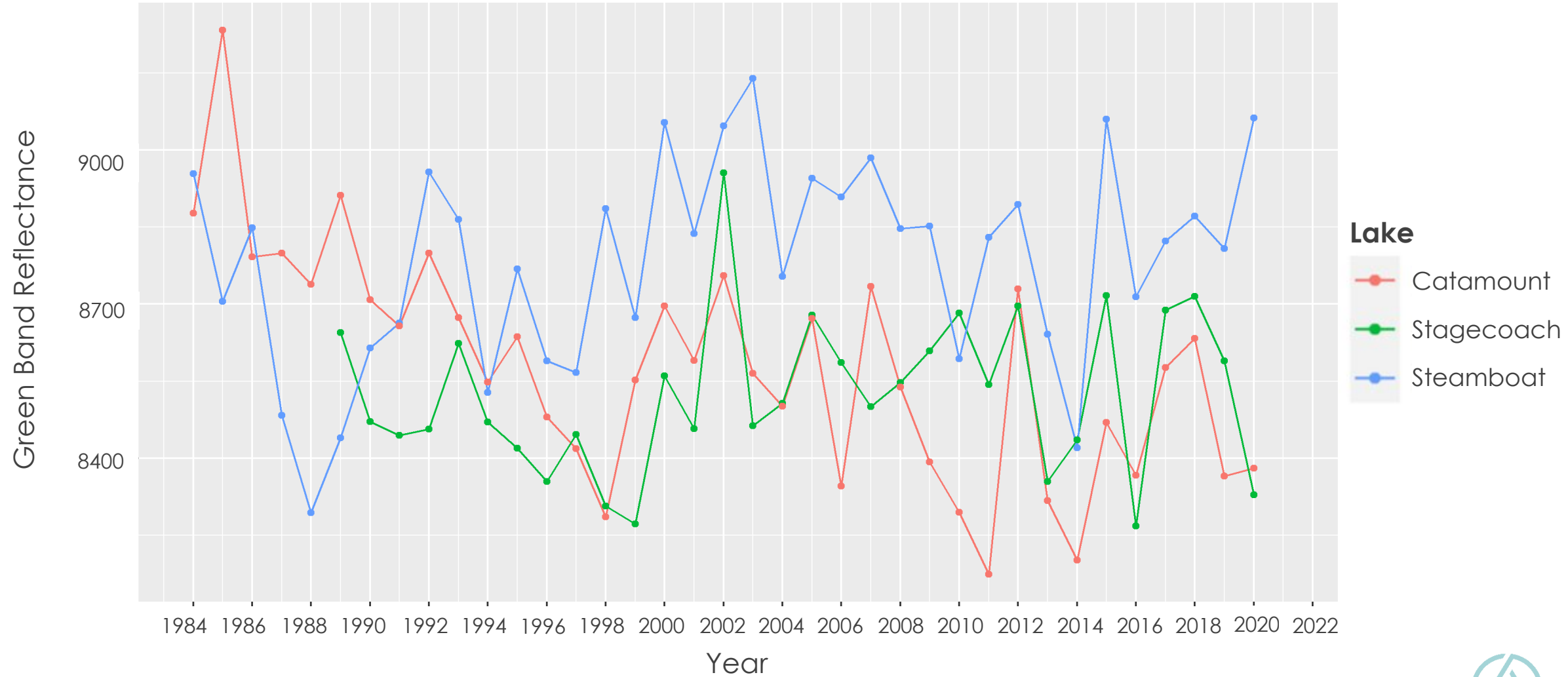


Results – Broad Wavelength Algae Index



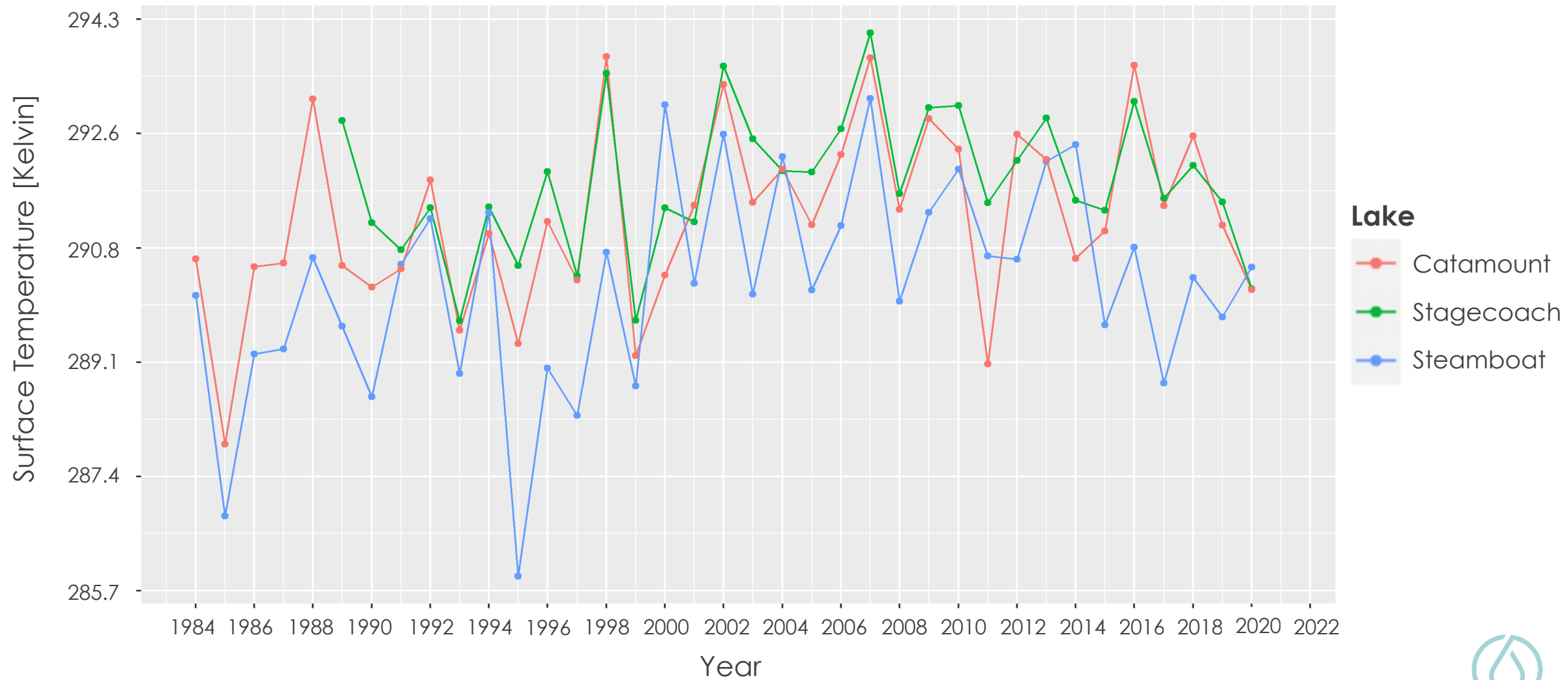
Results

June-October Yearly Averages of Green Band Reflectance



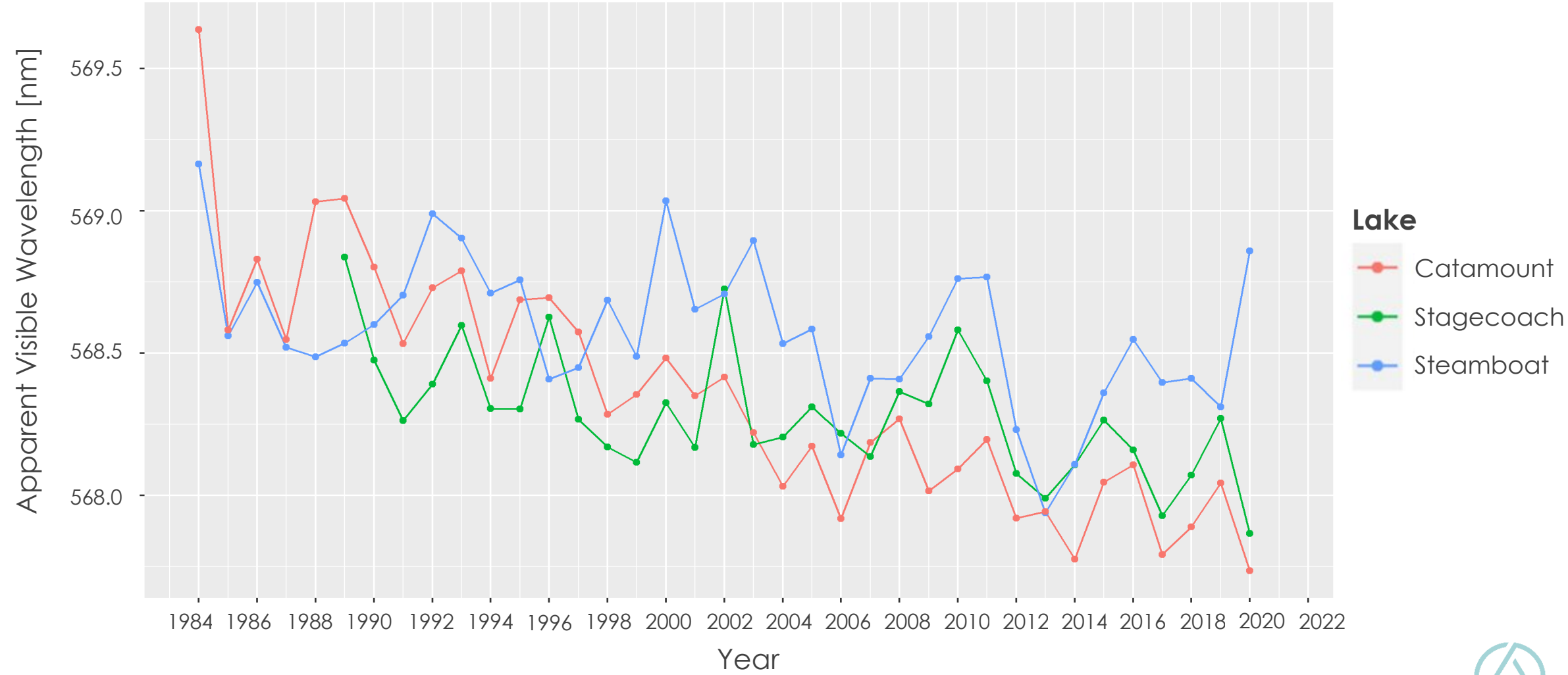
Results

June-October Yearly Averages of Remotely Sensed Surface Temperature

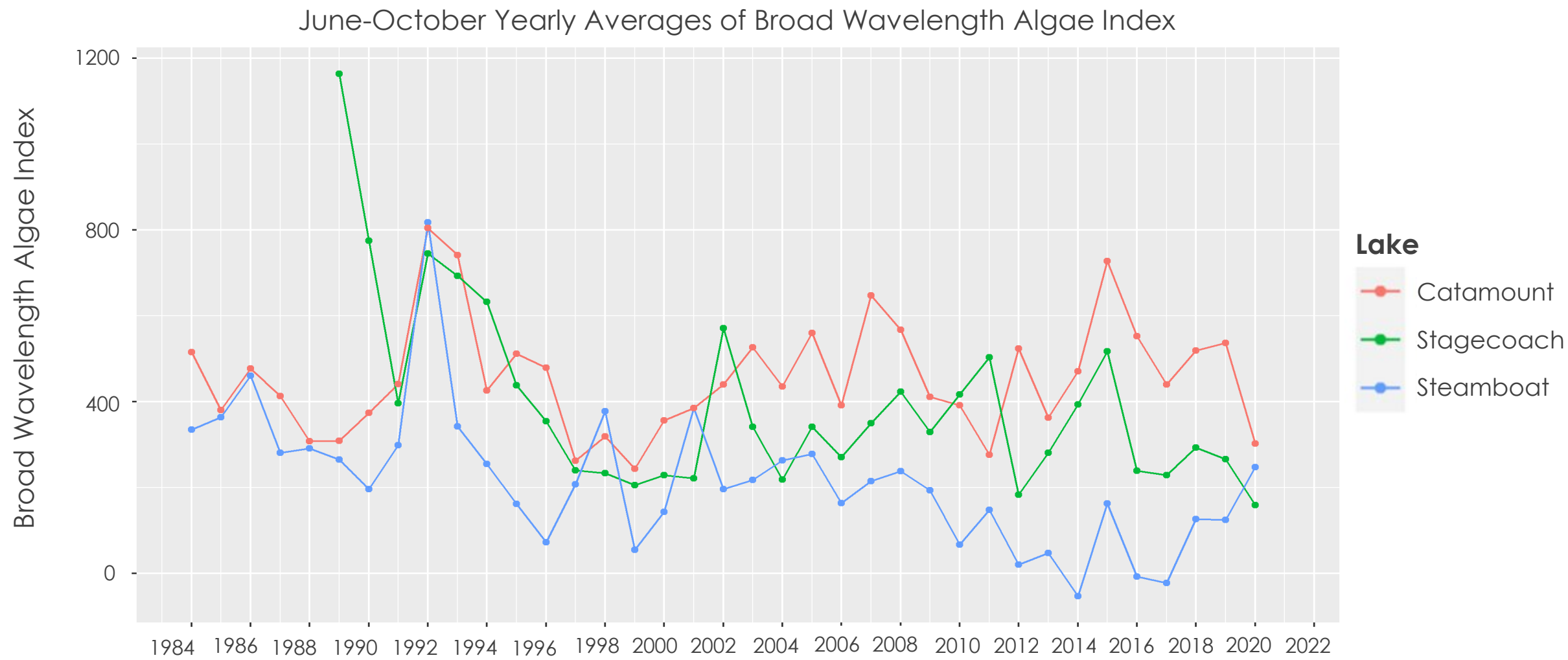


Results

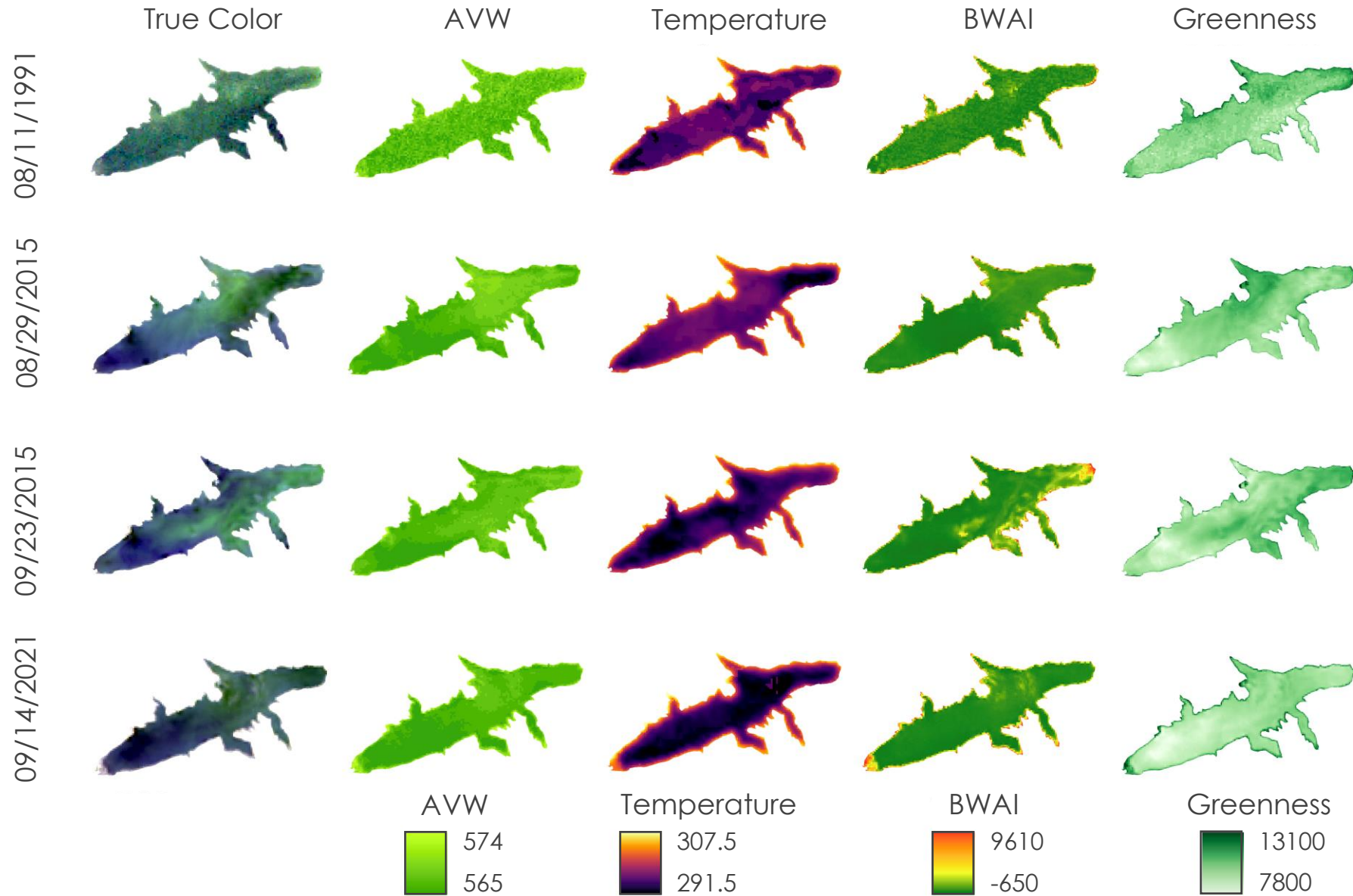
June-October Yearly Averages of Apparent Visible Wavelength



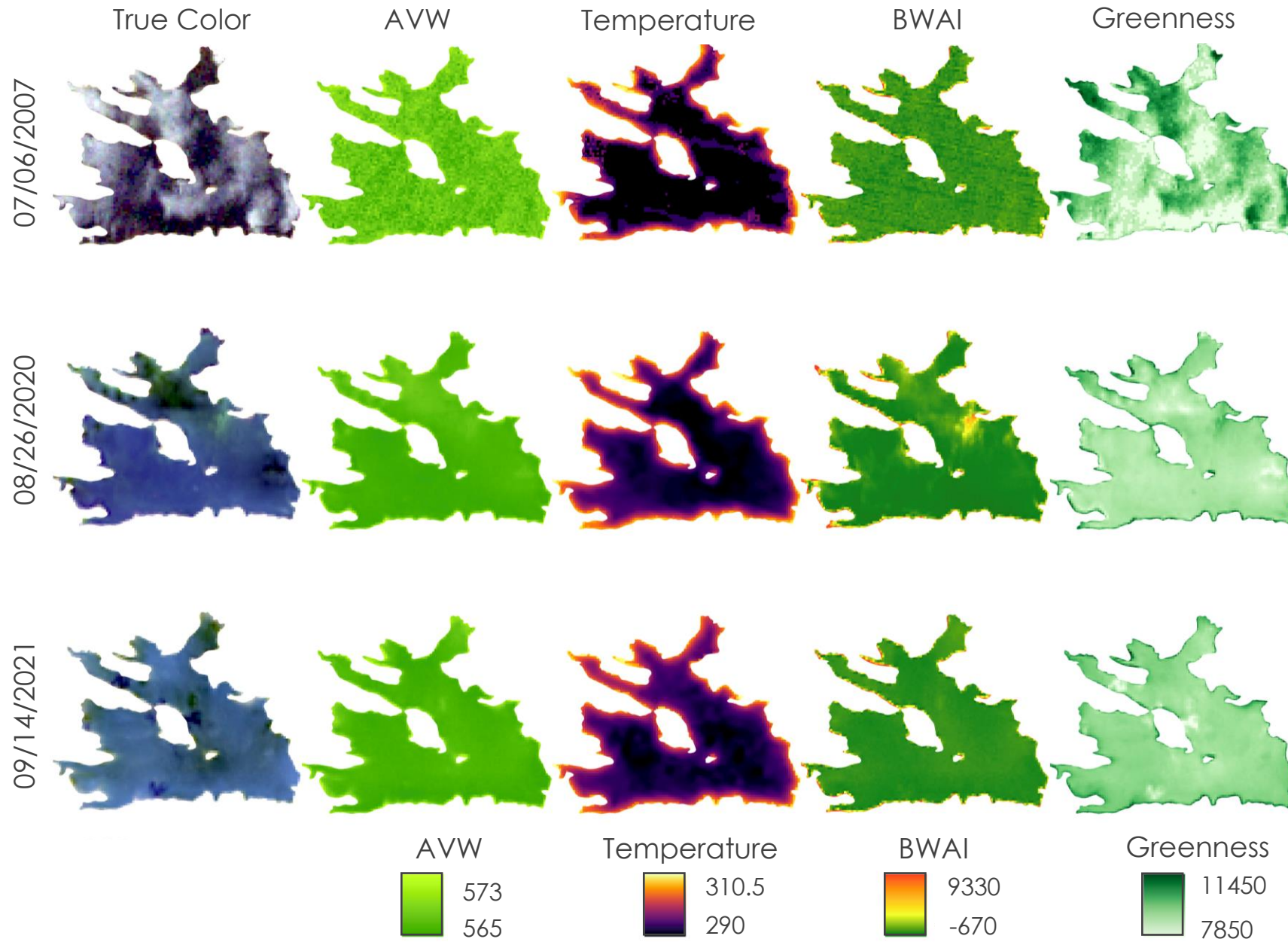
Results



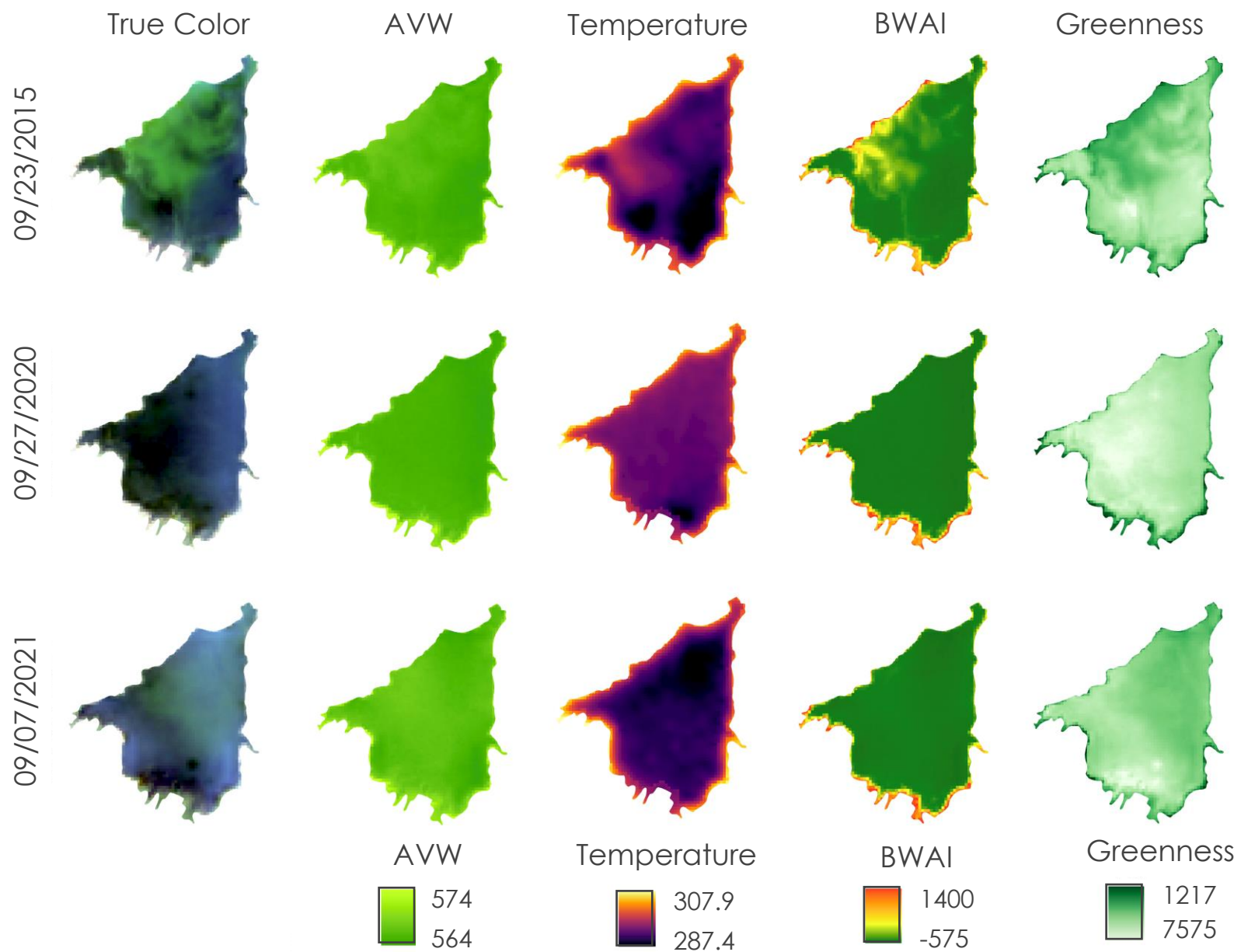
Stagecoach Reservoir Change Map



Steamboat Lake Change Map



Lake Catamount Change Map



Conclusions

- ▶ **Fill historical data gaps**

- ▶ Constructed time series plots of lake color and temperature from 1984 to 2021 for 9 waterbodies of interest and maps for 3 lakes of interest

- ▶ **Assess viability of remote sensing to monitor water quality**

- ▶ Lack of significant evaluation data makes it difficult to assess viability of using remote sensing to monitor water quality
- ▶ Strong correlation between remotely sensed temperature and in-situ temperature

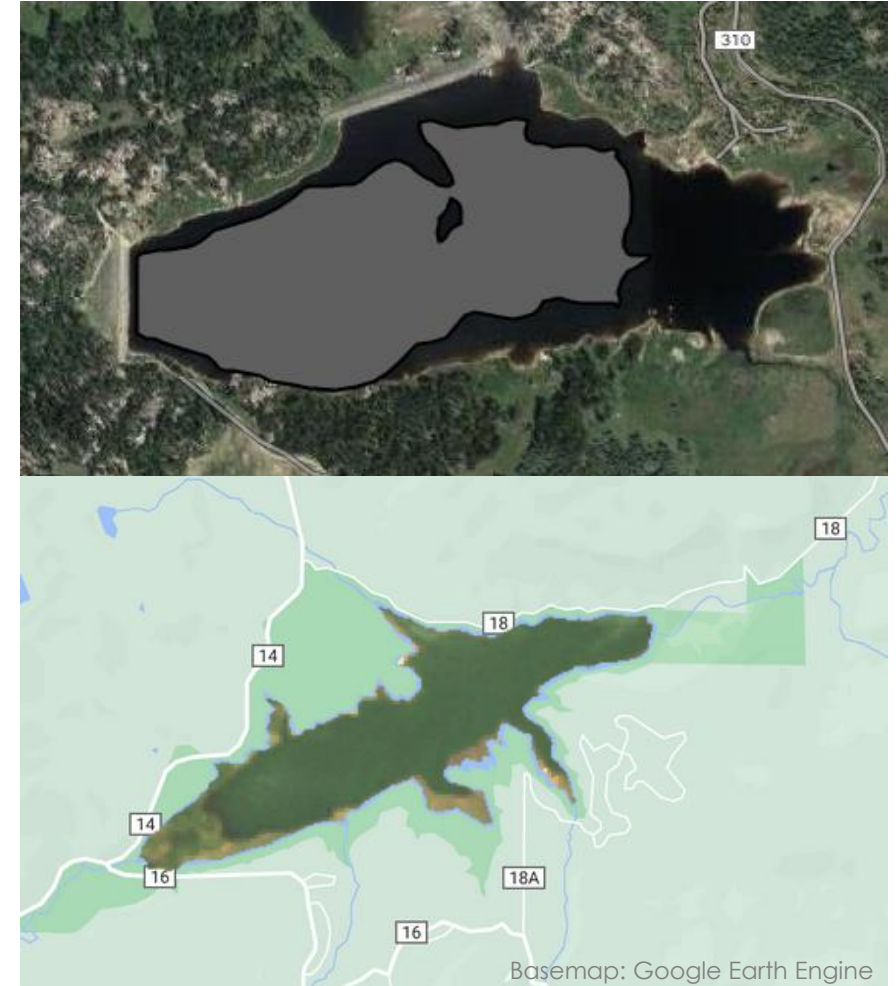
- ▶ **Analyze trends in water quality over time**

- ▶ Mixed trends were found among the 3 lakes for the AVW, BWAI, and green band timeseries



Errors & Uncertainties

- ▶ Extremely limited amount of in-situ data made evaluations difficult
- ▶ Cloud masking was imperfect – some cloudy pixels were not masked out, leading to erroneous values for greenness, temperature, etc.
- ▶ Imagery was clipped to static lake shapefiles, sometimes including land pixels or leaving out usable water pixels
- ▶ Averaging pixel values over lake extent may have missed some of the signal as algae is often concentrated in specific areas



Future Work

- ▶ Consider if factors such as land use, climate change, lake depth, lake elevation, or season have an impact on algal blooms
- ▶ Utilize Random Forest modeling to assess relationships between algal blooms and potential drivers
- ▶ Analyze how alternative satellites and sensors impact the observed results and trends
- ▶ Evaluate and interpret the trends observed in the AVW results
- ▶ Collect water quality samples on a regular interval for more extensive in-situ data
- ▶ Average pixels in specific regions of the lakes (e.g., shallow vs. deep areas)



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- ▶ Lyn Halliday, Collaborator, Upper Yampa Water Conservancy District

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- ▶ Nick Young, CSU

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- ▶ Ryan Hammock, NASA DEVELOP Arizona – Tempe

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