Harmful algal bloom monitoring (from space!)

ALBERTA INNOVATES

September 12, 2023

ALMS Alberta Lake Management Society

Alberta Health Services

Pigeon Lake Watershed Association

Alberta Government

ABMI Alberta Biodiversity Monitoring Institute

Associated Engineering

Environment and Climate Change Canada / Environnement et Changement climatique Canada

Lac La Biche County welcoming by nature.

University of Alberta

What am I going to talk about?

Presentation Objectives

- Briefly introduce the ABMI
- Describe the VERY COOL algal bloom monitoring project
- Seek your input with a Dotmocracy activity

About the ABMI

Mission

We track changes in Alberta's wildlife and their habitats from border to border, and provide ongoing, relevant, scientifically credible information on Alberta's living resources. For Alberta's land-use decision makers. For Albertans.

Operating Principles

- Independent
- Scientifically credible
- Relevant and Accessible
- Transparent

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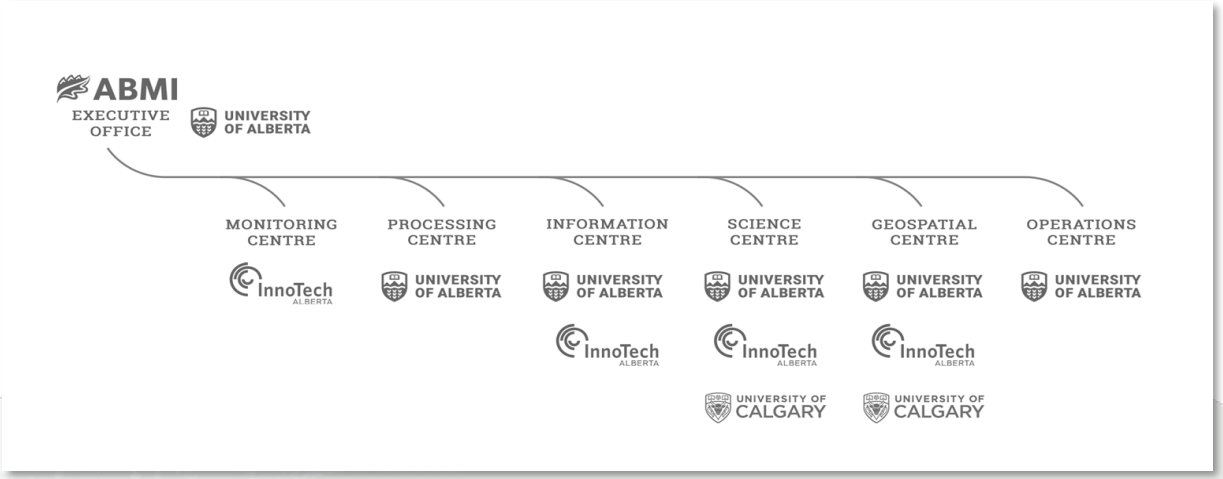
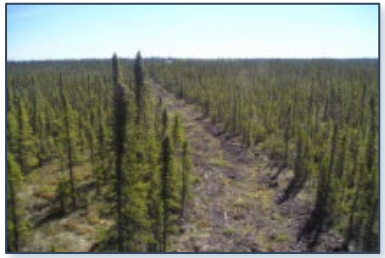
Our Organization

- 6 Centres
- ~70 Staff and associates
- 50-70 additional season staff



What we do

Species Monitoring



Footprint/Land-use Monitoring

Landcover/Habitat Monitoring (EO Insights)

Data Management, Quality Assurance, Standards

Knowledge Translation and Outreach

Practical Application of Science

Project introduction

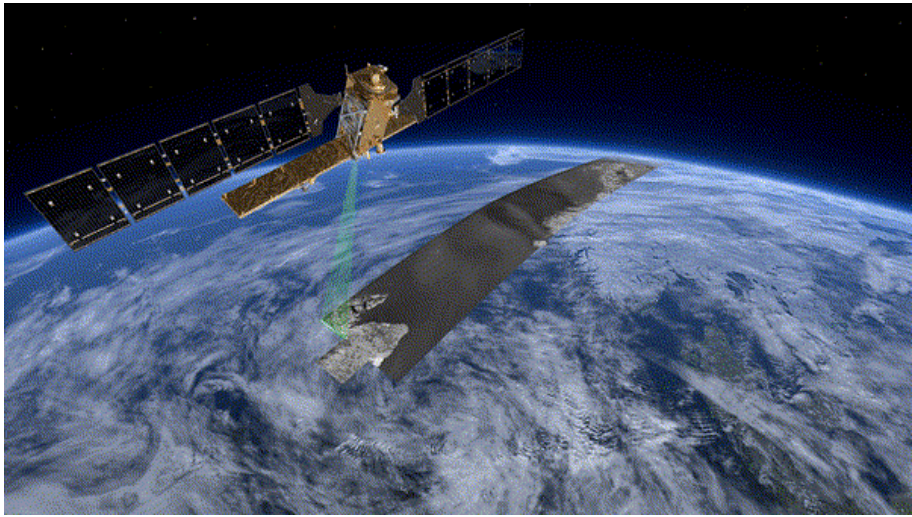
1. Collaborative project:
    - Funded by Alberta Innovates
    - Collaborators:
        - The University of Alberta,
        - the Alberta Lake Management Society,
        - The Alberta Biodiversity Monitoring Institute,
        - Alberta Health, Alberta Health Services,
        - Environment and Climate Change Canada,
        - Alberta Environment and Protected Areas,
        - Associated Environmental Consultants Inc.,
        - the Pigeon Lake Watershed Association,
        - Lac La Biche County,
        - and the Wabamun Watershed Management Council.

Project introduction

1. The plan:
    - Collect water samples from 6 lakes with varying levels of blooms to calibrate satellite data (Nakamun, Ethel, Pigeon, Wabamun, Sylvan, and Lac La Biche)
        - **20-40 per visit depending on lake size**
    - Collect satellite images taken at the same time as water samples
    - Create a predictive model for blooms using the satellite images and water samples
    - Apply the model to an online mapping application, freely available to anyone, which helps users see if there is likely to be a bloom on their lake of interest in "near real time" or not, and to look at historical blooms.

Intro to Earth observation/satellite data

- European Space Agency Copernicus programme
- Open access data from Satellite constellations 2016 and onward
- Satellites named Sentinel-1, -2, -3, etc
    - Sentinel-2 and -3 are useful for water quality monitoring
- Google Earth Engine hosts all this data on their servers and and allows users to process it for their applications



Google Earth Engine

Monitoring algal blooms from space

- Use Sentinel-2 and Sentinel-3 satellite data to monitor algal blooms in lakes across the province
- Nakamun, Ethel, Pigeon, Wabamun, Sylvan, and Lac La Biche

The Satellites

Sentinel 2A & 2B

- Open Source Data
- 20 m Pixels
- Thirteen Spectral Bands including Red Edge
- Overpass every ~5 days
- Data starts 2015 for S2-A, 2017 for S2-B

Sentinel 3A & 3B

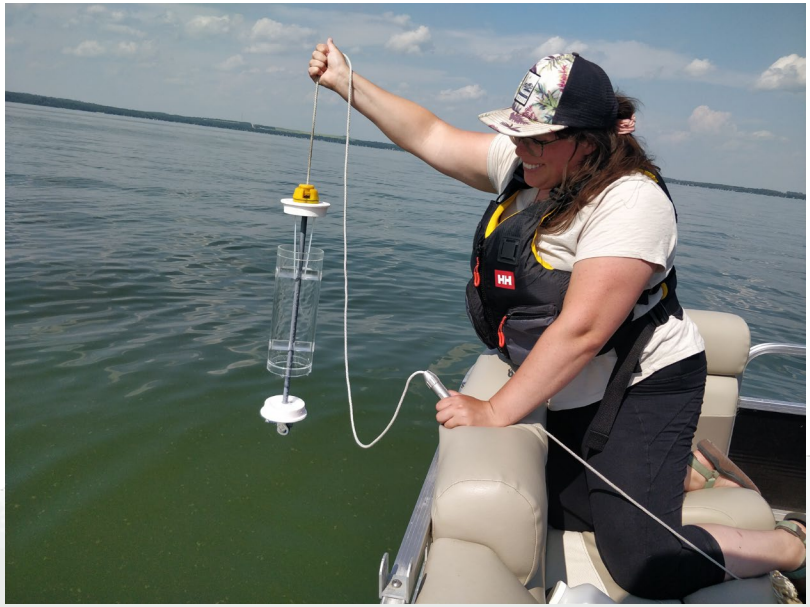
- Open Source Data
- 300 m Pixels
- OLCI sensor has 21 spectral bands including Red Edge
- Overpass almost every day
- Data starts 2016 for S-3A, 2018 for S-3B

Collection of water samples:

ALMS, EPA, PLWA, WWMC, County of Lac la Biche

Calibrate satellite data

- Cloud free days



Analysis of water samples– Rolf Vinebrook's lab

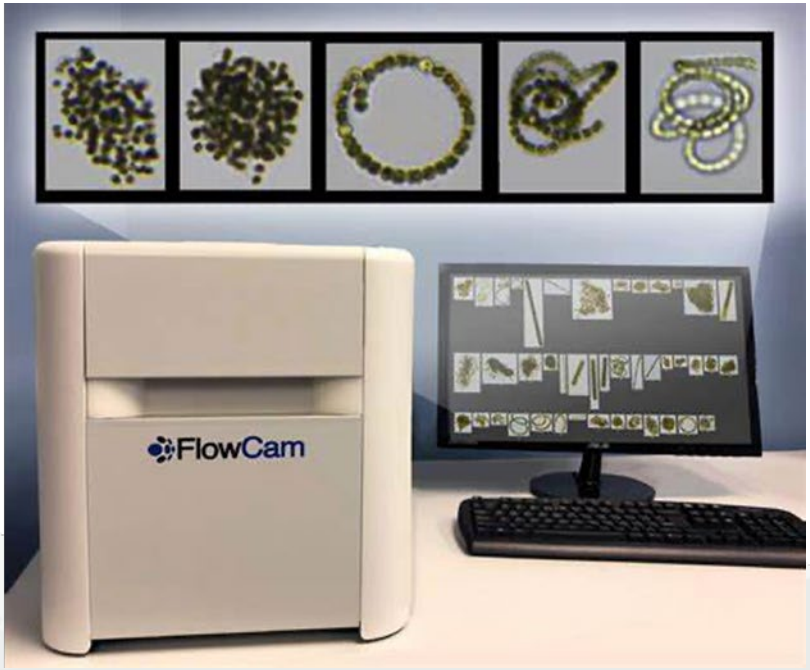
High Performance Liquid Chromatography

HPLC used to measure chlorophyll and taxonomically diagnostic cyanobacterial pigments in lake water samples

Analysis of water samples– Rolf Vinebrook's lab

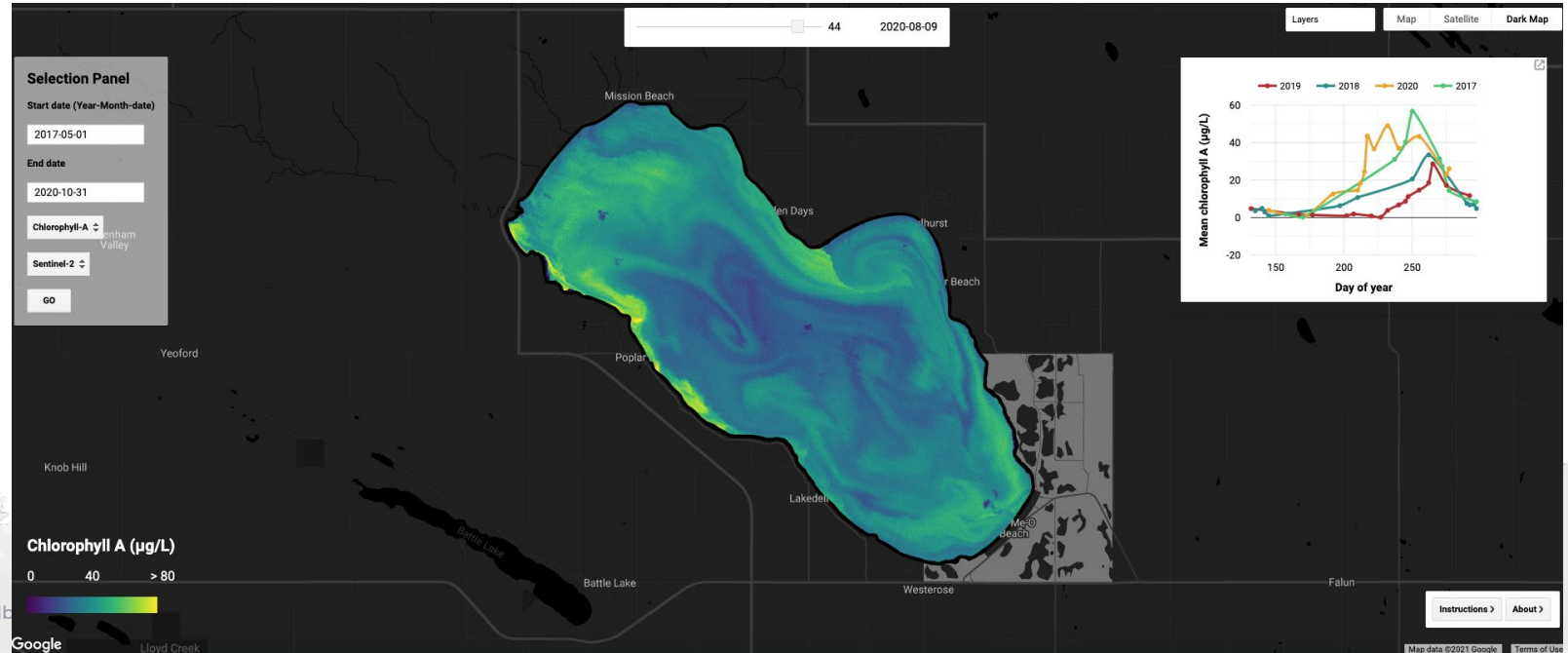
Advanced Flow Cytometry (FlowCam)

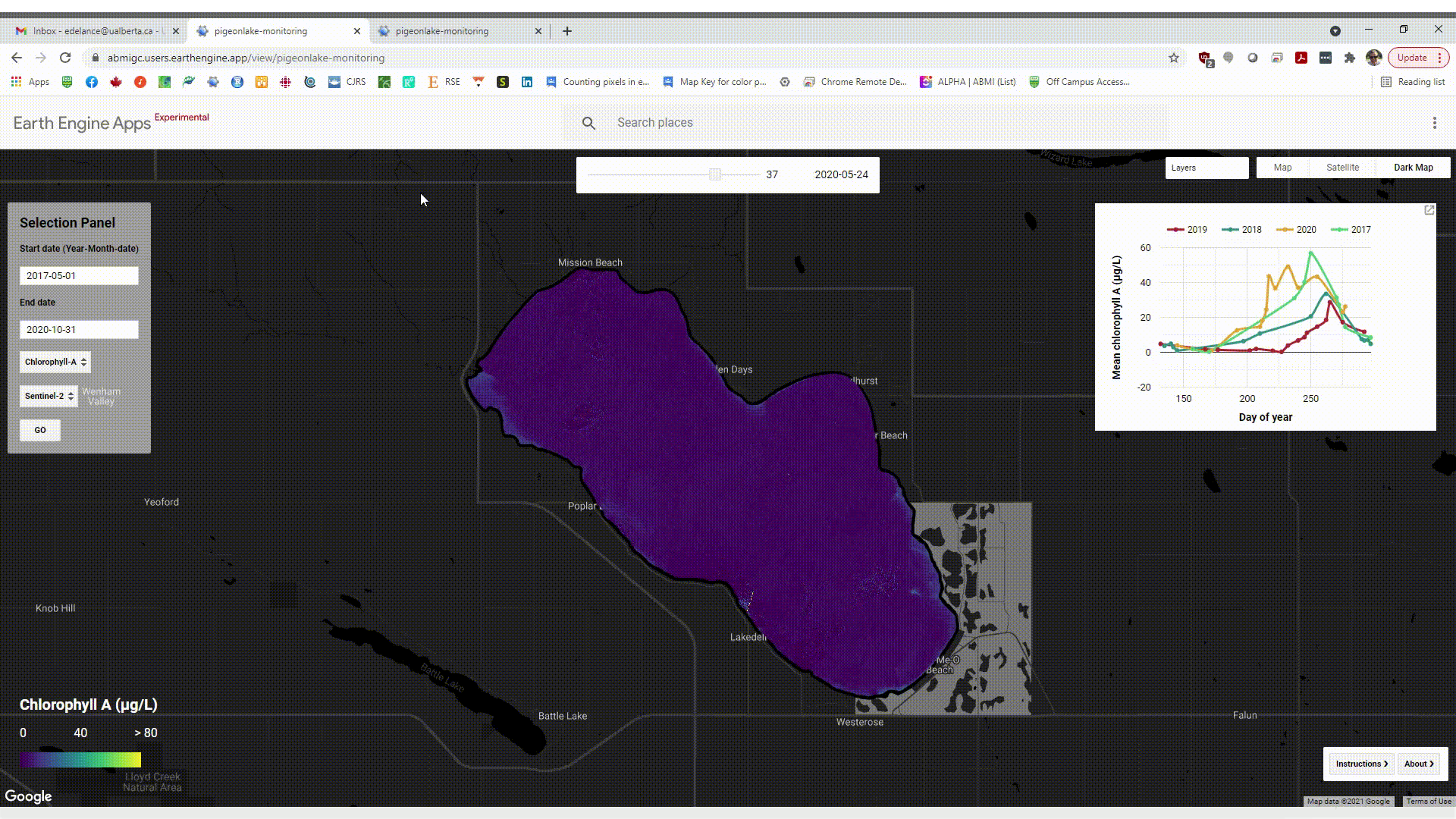
A FlowCam is used to detect and create a quantitative collage of all cyanobacteria contained in lake water



Web application

- Beta version of interactive web application
- Hosted on Google Earth Engine
- Allows users to select dates, satellites, and outputs
- Will allow for near real time (day after) viewing of chlorophyll-*a* concentrations in Pigeon Lake




Earth Engine Apps
Experimental
Search places
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2020-05-24
Layers
Map
Satellite
Dark Map
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Start date (Year-Month-date)
2017-05-01
End date
2020-10-31
Chlorophyll-A
Sentinel-2
GO
2019
2018
2020
2017
Mean chlorophyll A (µg/L)
Day of year
Mission Beach
Yeoford
Poplar
Knob Hill
Battle Lake
Westerose
Falun
Chlorophyll A (µg/L)
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Instructions
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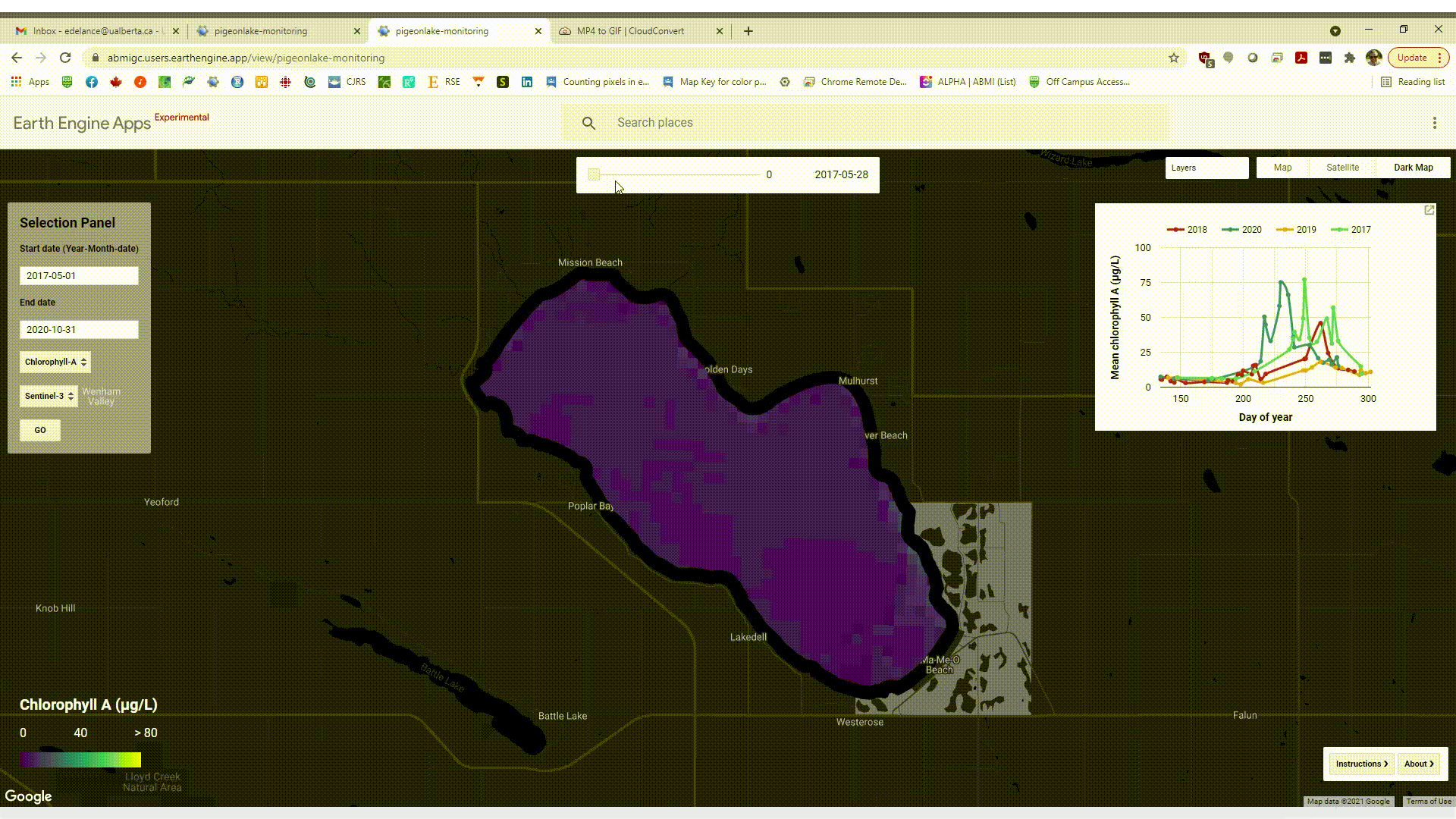
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Update
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Lloyd Creek Natural Area
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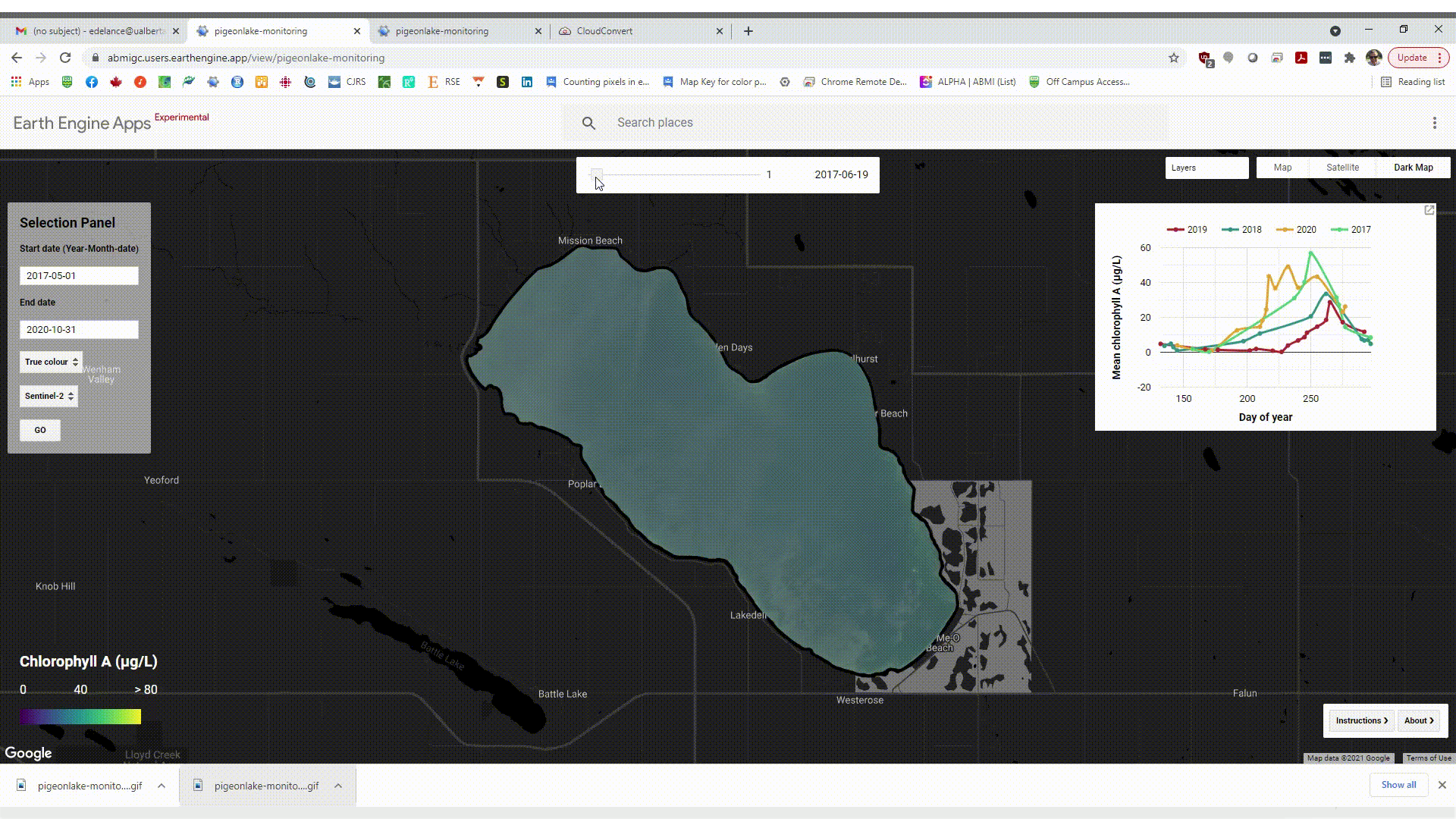
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Sentinel-2
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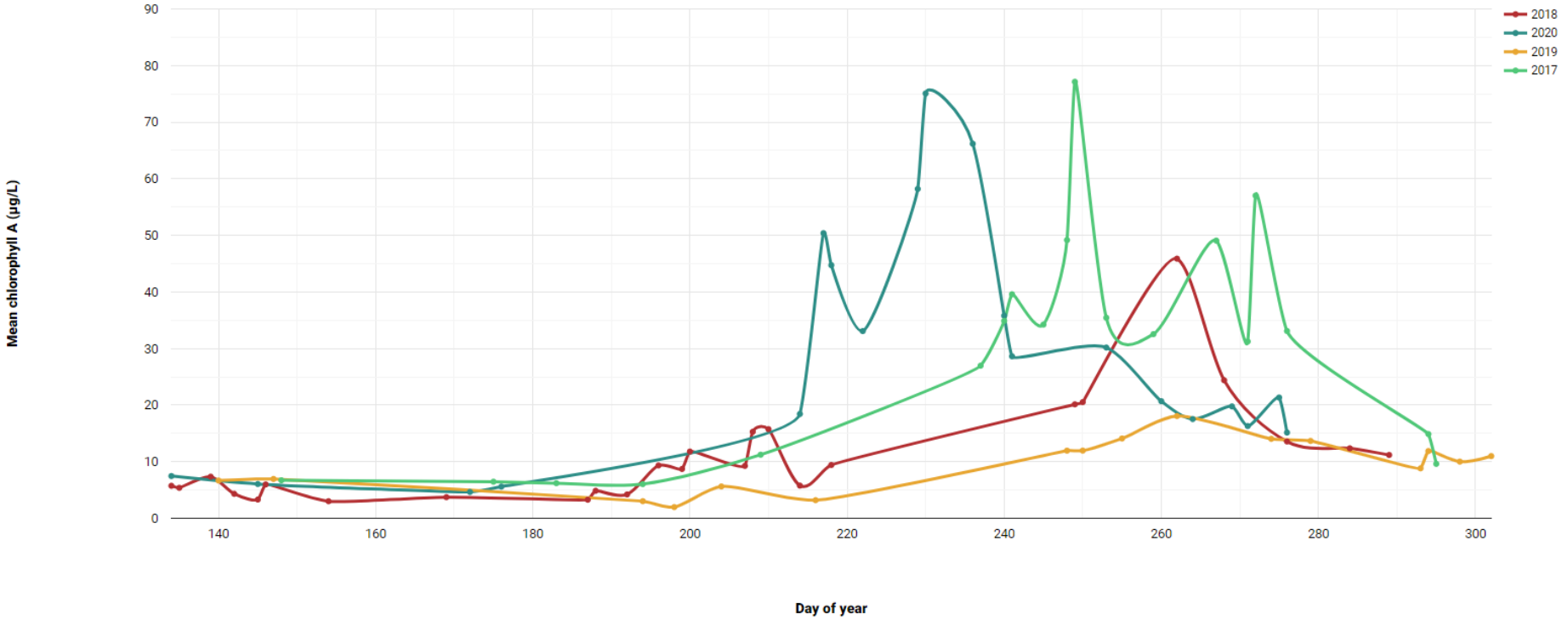
Time series chart



Historical Reconstruction

Taking a comprehensive look at older satellite datasets in conjunction with past chl-*a* samples to see what we can say about historic trends in Alberta

- AEP: 38 Sentinel Lakes, goes back to 1980's
- ALMS LakeWatch: 18 lakes, goes back to early 2000's
- AH bloom monitoring: 35 lakes, goes back to 2012
- Landsat and MERIS are examples of satellites that have been used historically to monitor algal blooms in other research

Landsat 4, 5, 7, 8, 9

- 30 m Pixels
- Bands in visible, NIR, SWIR – but no red edge
- Overpass every 16days
- Landsat 4 started 1982, Landsat 8 & 9 continue today

EnviSat – MERIS

- 300 m Pixels
- Precursor to Sentinel-3
- 15 spectral bands including Red Edge
- Overpass every 35 days
- Data 2002 - 2011

The EOLakeWatch Bloom Indicators

EOLakeWatch is an algal bloom monitoring program for Lake Winnipeg, Lake of the Woods, and Lake Erie run by ECCC (Govt of Canada)

EOLakeWatch uses a 14 day rolling average of images.

Calculates indicators using a 10 ug/L threshold, including

Daily Lake-Wide Algal Bloom Indices

Bloom Extent	Bloom Severity
Bloom Intensity	Bloom Duration

The EOLakeWatch Bloom Indicators

EOLakeWatch is an algal bloom monitoring program for Lake Winnipeg, Lake of the Woods, and Lake Erie run by ECCC (Govt of Canada)

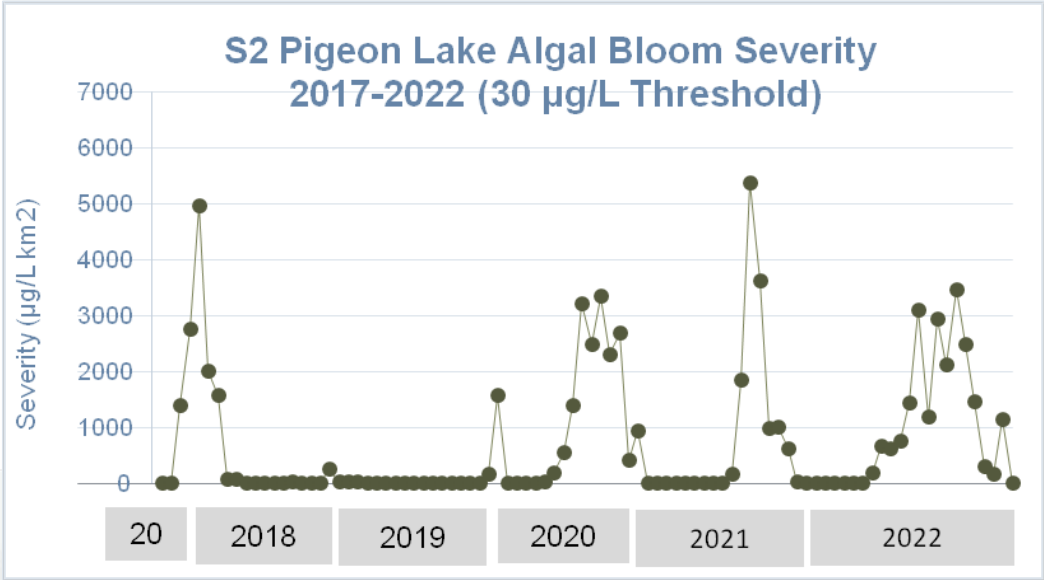
Pigeon threshold set to 30 ug/L.

Intensity = mean chl-*a* above threshold averaged over lake

Extent = percent of lake with bloom above threshold

Severity = Intensity X Extent

Duration = Length of time a given pixel is above threshold



New directions?

Under current funding (until 2025)

1. Release full version of web application applied to 5 more lakes
2. Using historical data to discover long term trends in 6 lakes (1984-present)
3. Using environmental data to develop a predictive model for blooms.

Future funding opportunities

- Expand to more lakes
- Improve the web app
- Expand communications about blooms
- ….?

Project Timeline

2023

- Sampling 6 lakes three times in the open water season
- Buoy deployment (Pigeon, Nakamun, Ethel)
- Selection of archived data
- Model validation

2024

- Sampling 6 lakes three times in the open water season
- Buoy deployment (Pigeon, Nakamun, Ethel)
- Evaluation of additional satellites
- Model validation
- Trend analysis

2025

- Design, development, testing of web application.

We need your input! - Dotmocracy Activity!

We are releasing an updated version of the web app and want to know what features are most important to you to be included.

- Vote for the features and development ideas you feel are most important to the web app with the 5 stickers shared with you on the table
- Fill out sticky notes to answer the open ended questions on the wall about the app.
- The results of this activity will inform the development of this app.

Online version of the activity available here: https://www.surveymonkey.com/r/algalbloomapp

We need your input! - Dotmocracy Activity!

DESIGN/FORMATTING

- the default landing page is set to the latest satellite image
- Ability to visualize a side by side of algal blooms at the same lake on different years
- Ability to visualize a side by side of algal blooms at different lakes at the same time

ANALYSIS

- Ability to download a gif of the time series of the algal bloom
- Ability to download image files of algal blooms
- Ability to generate graphs of seasonal summaries
- Ability to do trend analysis of bloom extent, duration, severity, or intensity over time
- Annual reporting which details seasonal summaries and trends
- Email notification system
- Ability to download raw data from the tool

DATA INCLUSIONS

- Human Footprint
- Hydrology Layers
- Historical images (example: current vs. archived blooms)

Thanks to Alberta Innovates and all the collaborators!