Combining Earth Observation and Machine Learning for Cyanobacterial Bloom Forecasting

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Motivation

- Cyanobacteria (blue-green algae) can be toxic and scum-forming, posing a risk to ecosystems and public health
- Continued anthropogenic eutrophication (nutrient enrichment of water bodies) and climate change will likely lead to more frequent and severe cyanobacterial blooms in many areas

Previous Work

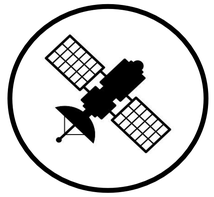
- Earth Observation (EO) data has been demonstrated to be effective at monitoring chlorophyll-a (chl-a) concentrations as a proxy for phytoplankton
- This has potential to allow for widespread monitoring of algal blooms but can only inform bloom management in a retrospective way

The Aim: Cyanobacterial Bloom Forecasting

- Forecasting cyanobacterial blooms is highly desirable to provide pre-warning to society and enable management processes to be activated in advance
- Previous forecasting attempts have typically focused on lakes and reservoirs that are regularly monitored, but there is a need for a monitoring and prediction methodology that is applicable to many more lakes than this

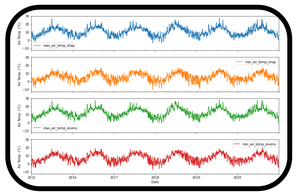
Satellite Remote Sensing

- Data from ESA Sentinel-2 and Planet Super-Doves
- Can estimate chl-a or phycocyanin concentration as a proxy for cyanobacteria



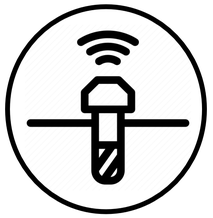
Meteorological Data

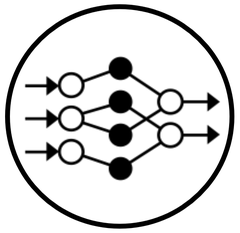
- Data from weather stations and forecasts
- E.g. precipitation, wind speed, air temp.



Automated In-situ Sensors

- In-situ reflectance data will be used to calibrate and validate EO data
- Other sensors (eg. water temperature, fluorescence) may be used for monitoring





Data Driven Modelling

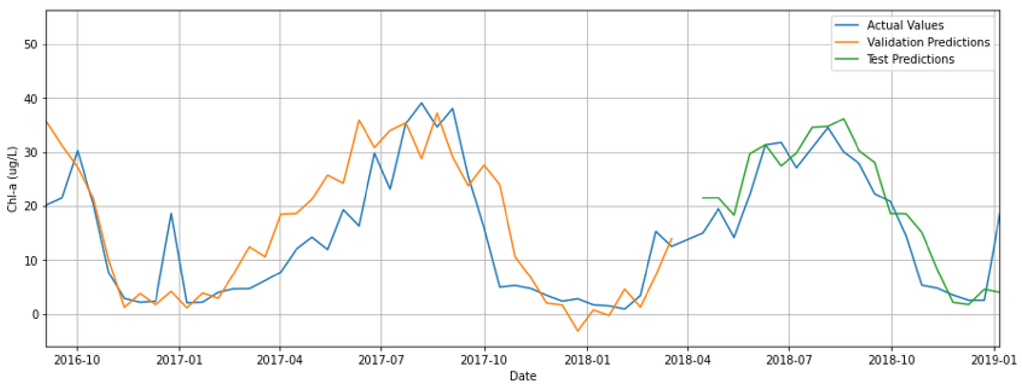
- Machine learning models (eg. Neural networks, LSTM, SVM, random forest)
- Training on historical data from multiple lakes
- Potential to investigate coherence of blooms between multiple lakes, which may allow for forecast performance improvements

Short-term Bloom Forecasts

- Forecasts for chl-a concentration and bloom likelihood, up to 2 weeks into the future
- Initial forecast validation using hind-casting, looking to implement a real-time forecast
- Possibility to investigate forecasting taste & odour issues associated with cyanobacterial blooms

Cyanobacterial bloom in Airthrey Loch (University of Stirling) and close-up of Anabaena, a common cyanobacteria genus (Wikipedia)

Blelham Tarn: *forecasting chl-a 2 weeks ahead using a convolutional neural network*



Model input data*: air temperature; water temperature at multiple depths; chl-a from water sampling; secchi depth; daily precipitation; humidity*

Preliminary Results

- Trained various chl-a forecast models using historical data from Blelham Tarn in the Lake District
- Benchmarking using 'persistence' forecast (predicts no change in chl-a over the 2 week forecast period)
- Convolutional neural networks appear to be able to anticipate rises in chl-a (ie. the onset of algal blooms) 2 weeks in advance

Next Steps

- Incorporating satellite data into forecast models
- Creating 'smarter' benchmarking procedures
- Expanding forecasts to multiple lakes
- Using high-frequency sensor data to track bloom formation