Can regular, long-term monitoring of lakes improve short-term machine learning forecasts for algal blooms?

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The need for short-term algal bloom forecasts:

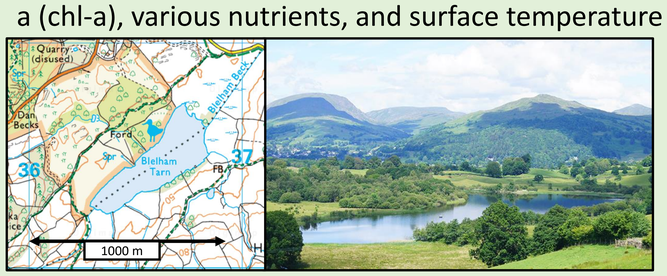
- Some algae (e.g. blue-green / cyanobacteria) can produce toxins harmful to human health and ecosystems
- Allow acting early to prevent drinking water supply issues
- Give warning to wild swimmers and dog walkers
- Further our understanding of aquatic ecosystems

The Research Question:

- Machine learning (ML) models have the potential to be used to forecast algal blooms in the short-term
- ML approaches typically require large training data-sets, which may mean that regular monitoring is required for many years to create reliable forecasts
- Here, we ask the questions:
  - **Does increasing the number of training years available always improve performance?**
  - **Do long-term changes in the behavior of algal blooms make older data less useful for training ML models?**

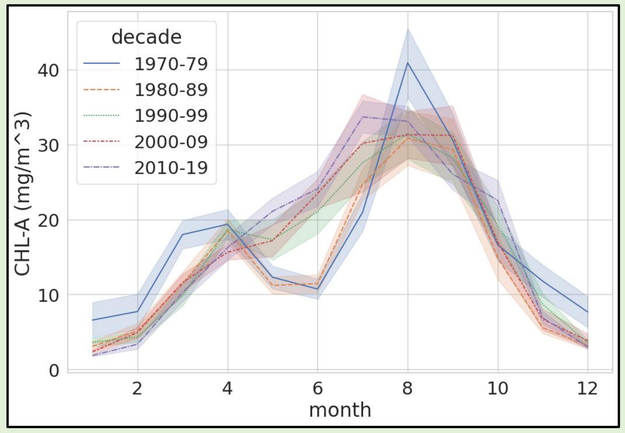
Study Site

- **Blelham Tarn,** English Lake District
- Eutrophic, suffers blue-green algal blooms in summer
- Sampled fortnightly by CEH (previously FBA)
- For this study, we use 47 years data, including chlorophyll-a (chl-a), various nutrients, and surface temperature



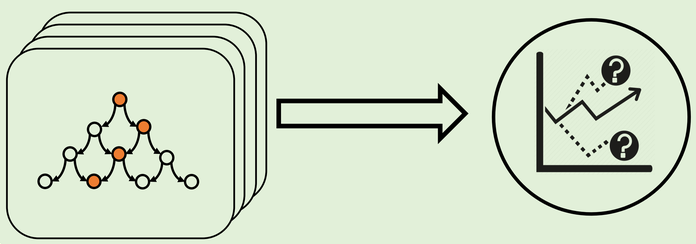
Long-term bloom history

- Decadal trends in the annual chl-a cycle suggest that in the 1970/80s there were clearly defined separate spring and summer blooms
- In more recent years, the spring and summer blooms are less separable,
- This change may suggest that older data is less useful for training ML models to predict recent blooms



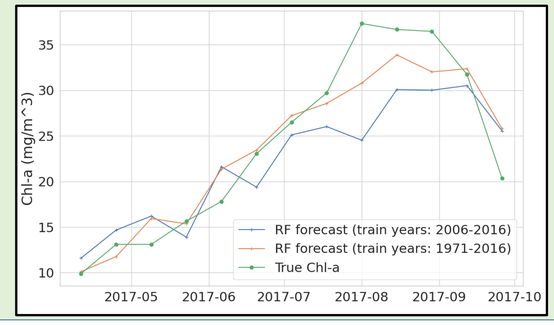
ML Model: *Random Forest (RF)*

- RF is a well-established ML approach which uses an ensemble of decision trees to make predictions
- **Input data:** all measurements from the last 4 weeks
- **Forecast:** Chl-a 2 weeks in the future



Forecasting Blooms in summer 2017

- A RF model trained with 45 years of data outperforms a RF model trained with 11 years data (as well as a persistence forecast benchmark model)
- The shape is good, but peaks in chl-a are consistently under-estimated



Does increasing the number of training years improve performance?

- Multiple RFs were trained on various sets of randomly selected training years
- **Increasing the number of training years generally improves performance**, but with significant variations between test years
- Further work required to investigate **some cases where adding additional training years reduces performance**