# Integrating satellite observations, sensor networks, and models to improve monitoring of algal blooms in UK lakes and reservoirs

Peter D. Hunter
Associate Professor of Earth Observation
Scotland's International Environment Centre, University of Stirling

# Blooms, nutrients & climate

- **Harmful algal blooms occur annually throughout the UK**

- **Main drivers are nutrients and climate**

- **Blooms pose risks to water security and health**

- Can we use remote sensing to improve detection and monitoring of blooms?
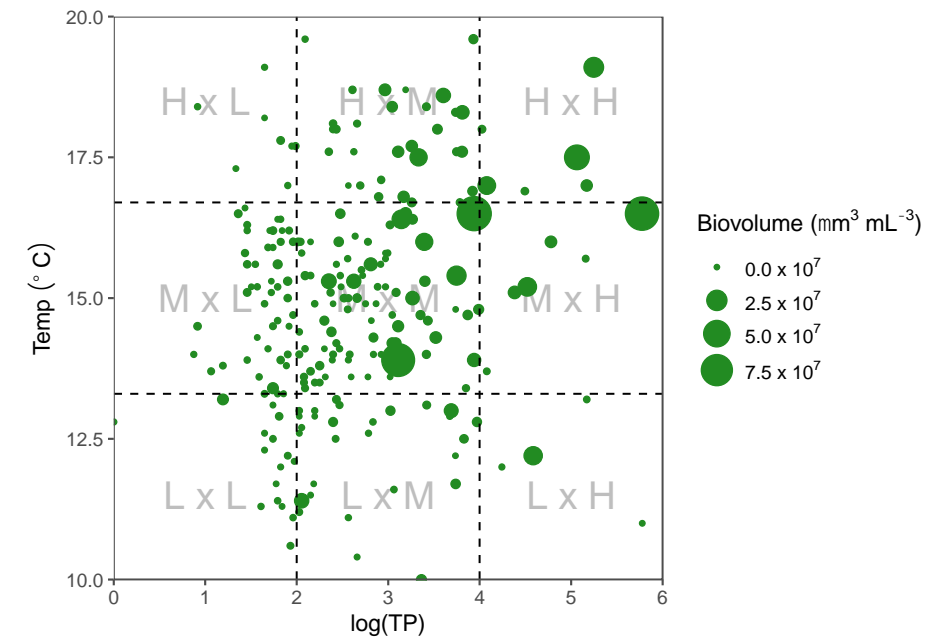
Effect of TP and temperature on cyanobacteria biovolume (data courtesy of SEPA)

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UK Lakes Observatory (UKLO)

- **Pilot operational service providing satellite chlorophyll estimates for UK (England & Scotland)**

- **Weekly aggregated chlorophyll product derived from Sentinel-2a/b MSI**
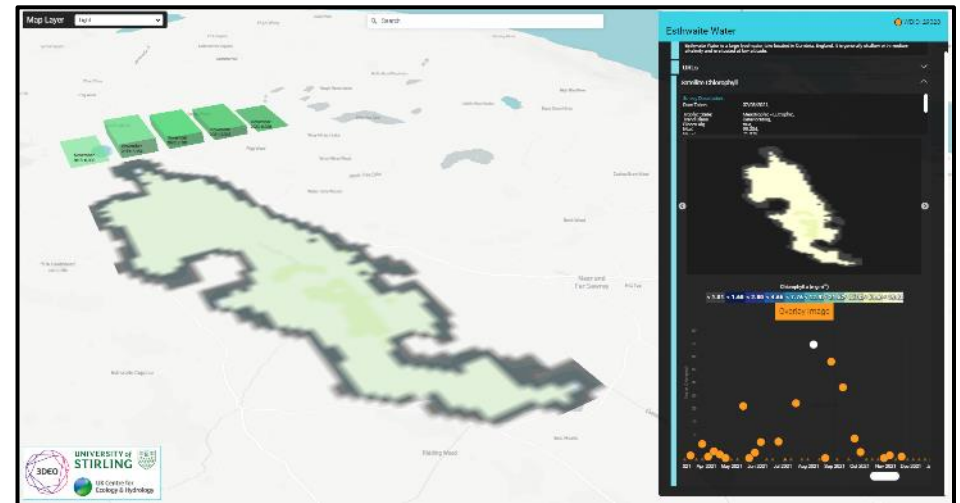
- **Data visualised on dedicated web platform**
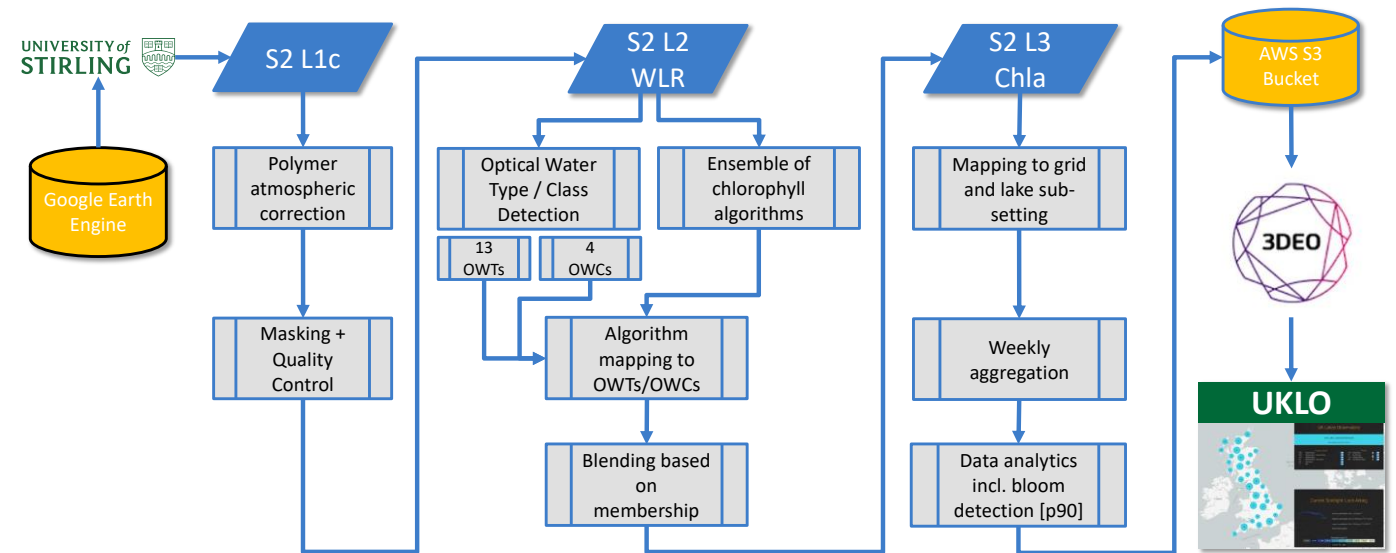
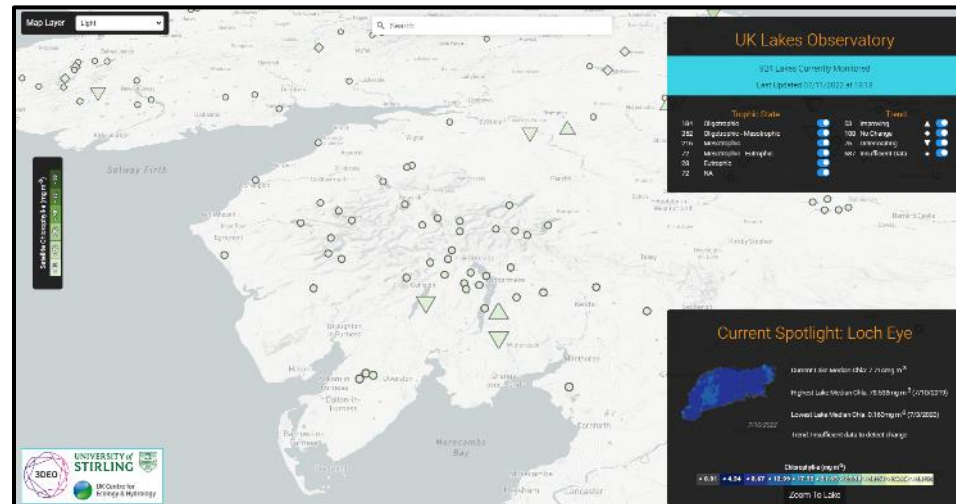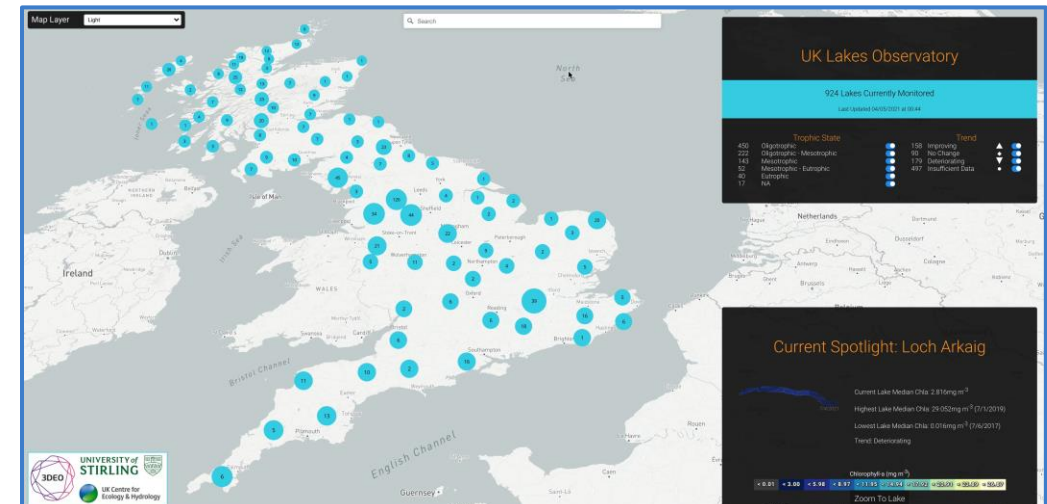UK Lakes Observatory (UKLO) processing chain [v.1.0]

UKLO Web Platform
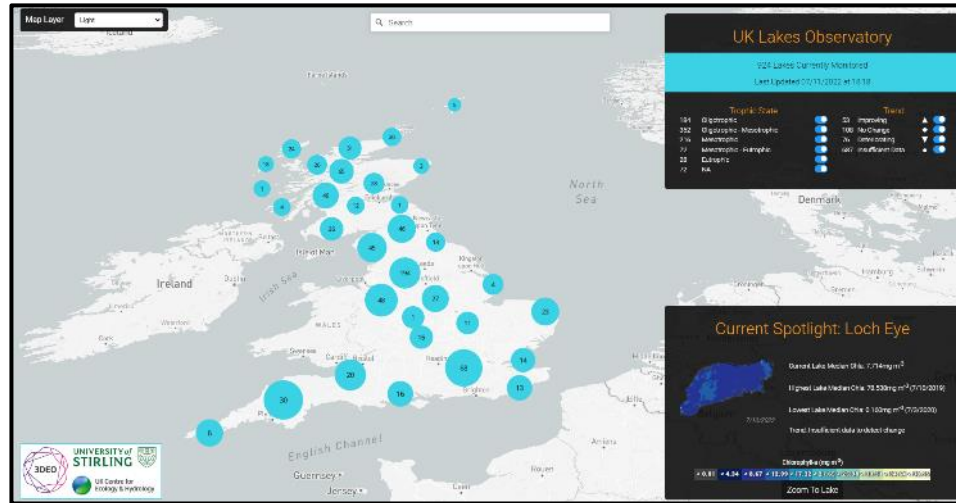
Lakes with available data

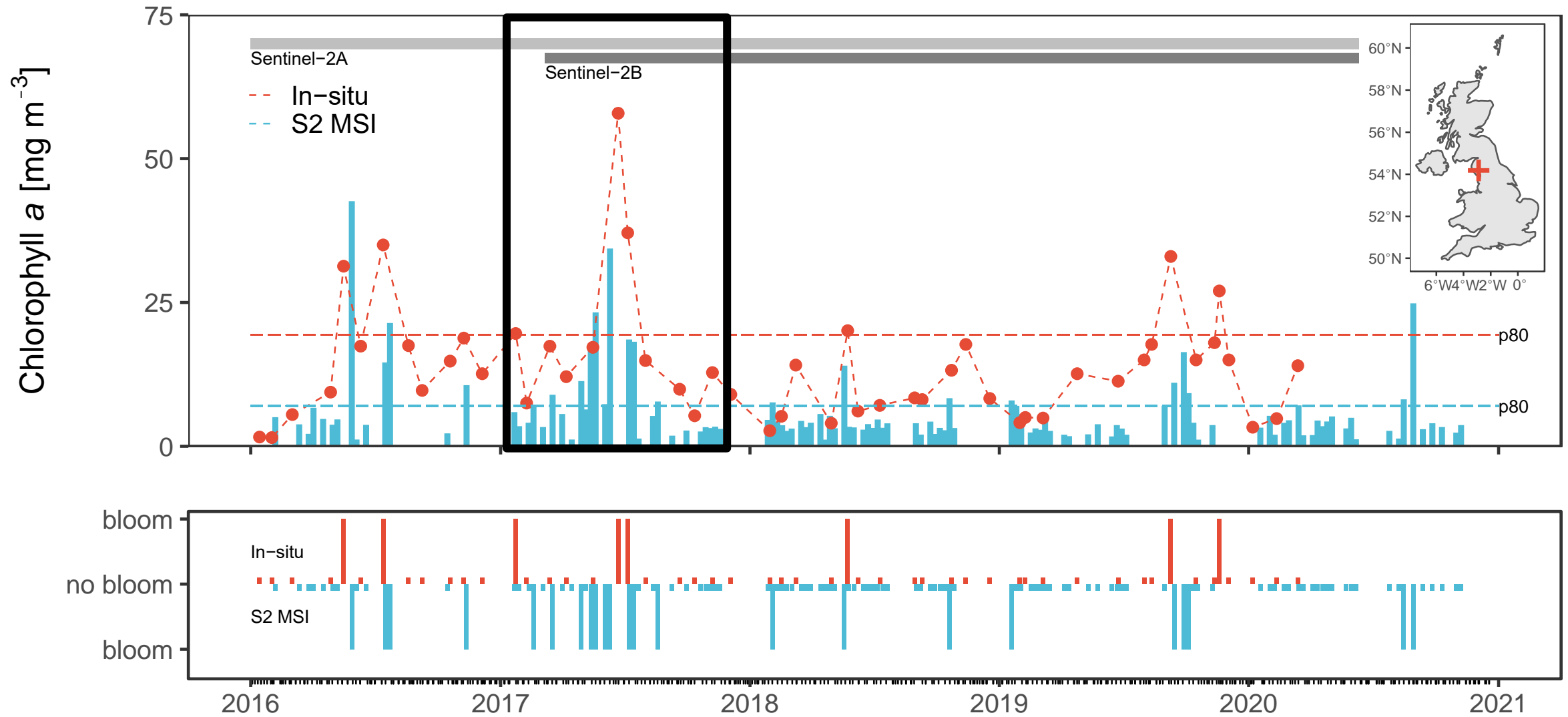**Time-series data for an individual lake (Esthwaite)**

Current status and trend (last week's Chl)

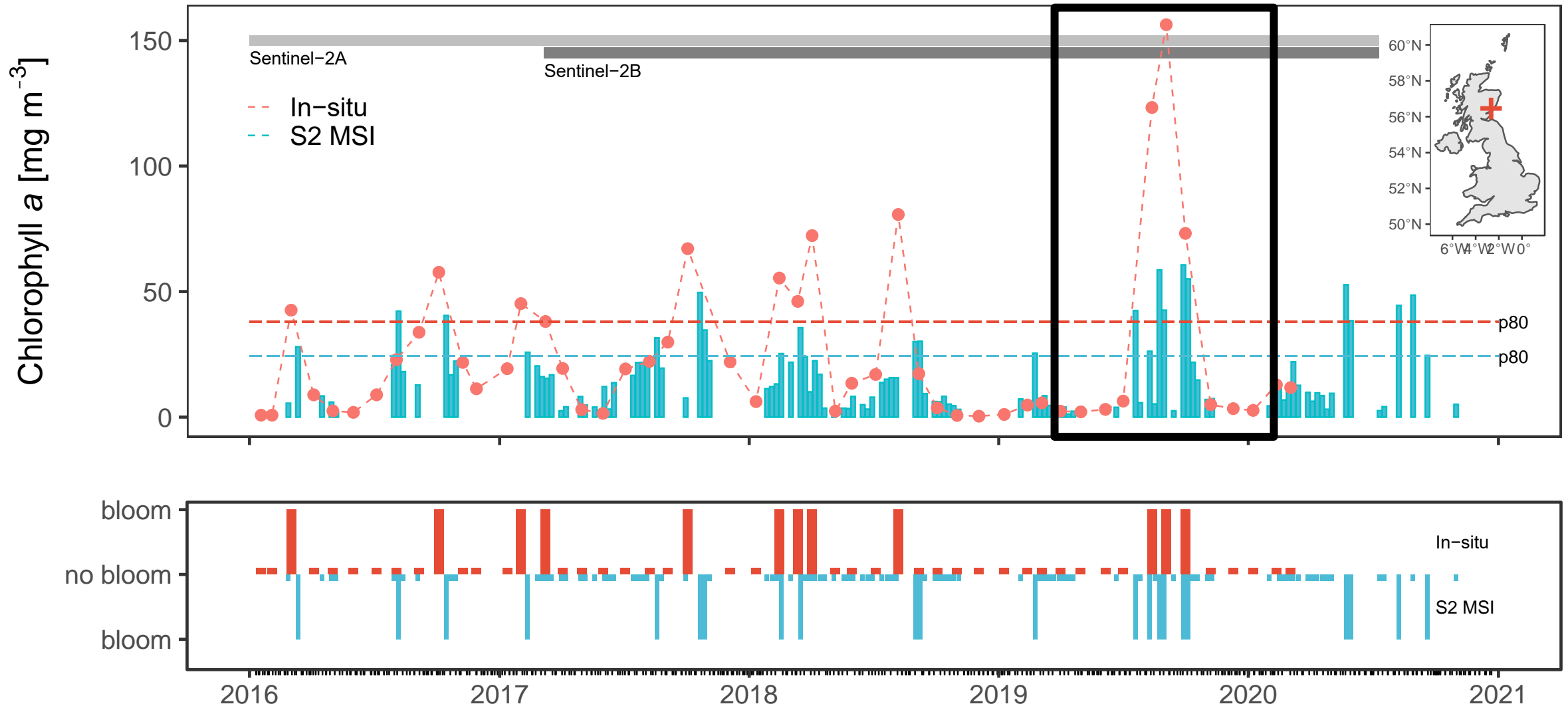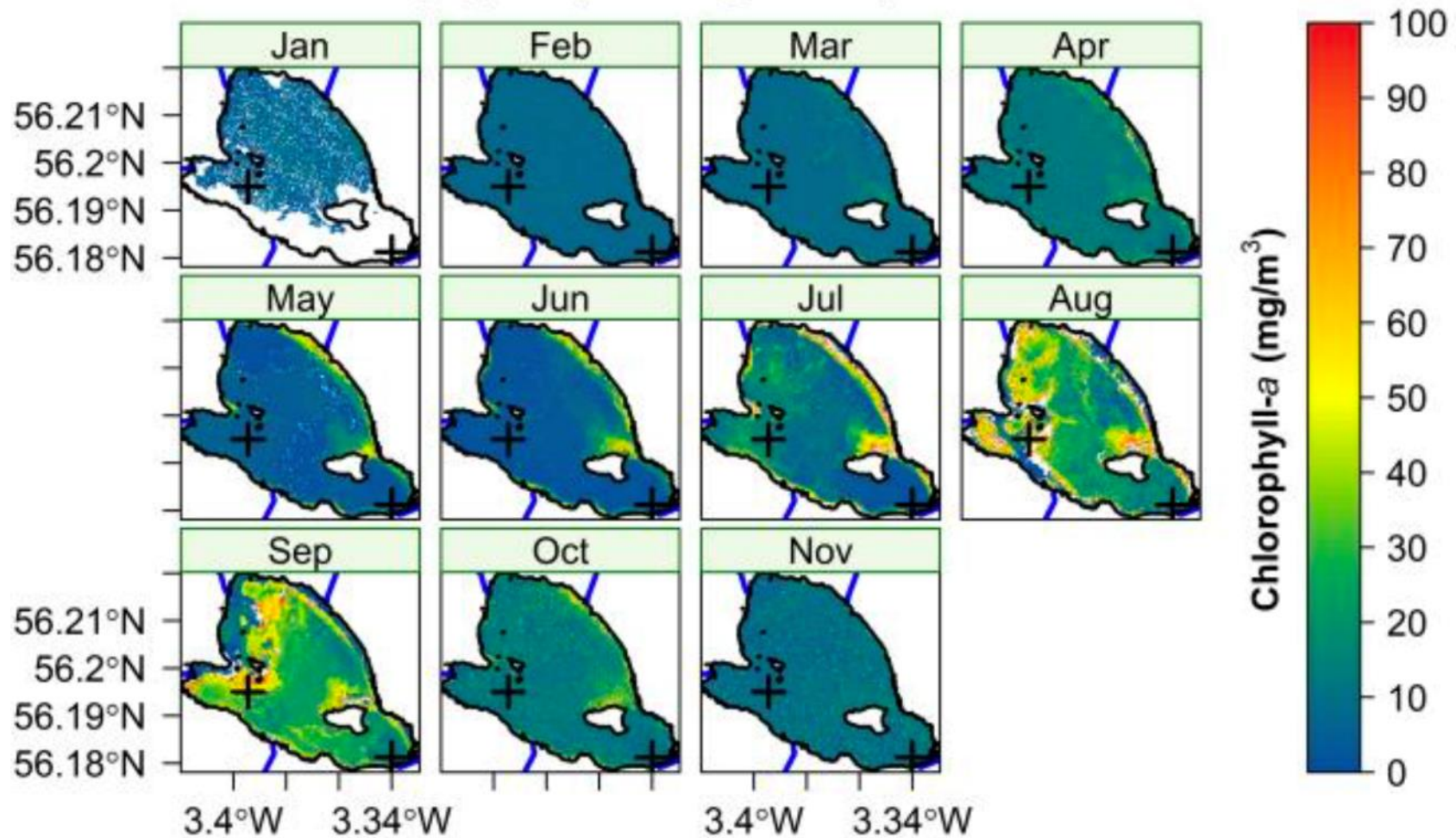**Video walk-through**

Esthwaite Water validation

Monitoring data courtesy of UKCEH

Loch Leven validation

Monitoring data courtesy of UKCEH

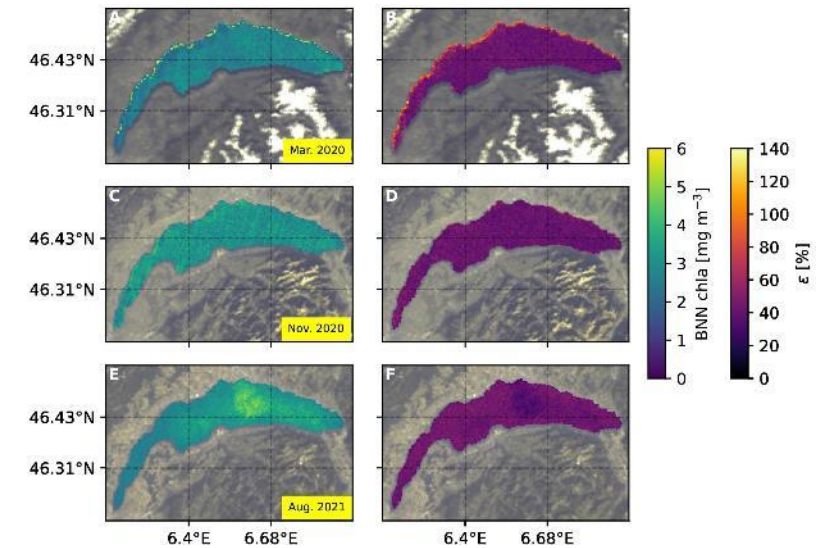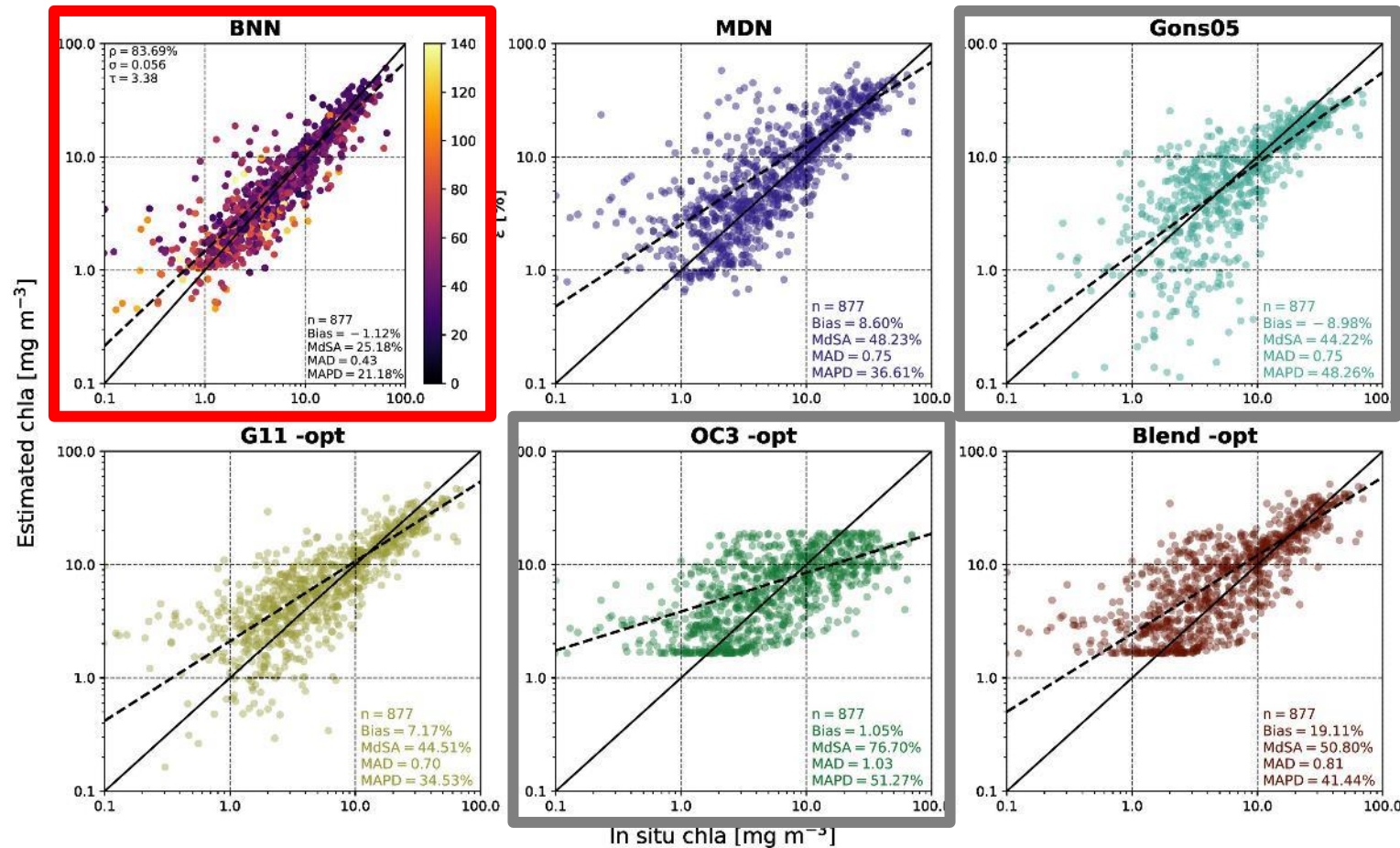# Loch Leven validation

Monthly mean chlorophyll in Loch Leven
during 2021 (Credit: Kieran O'Reilly)

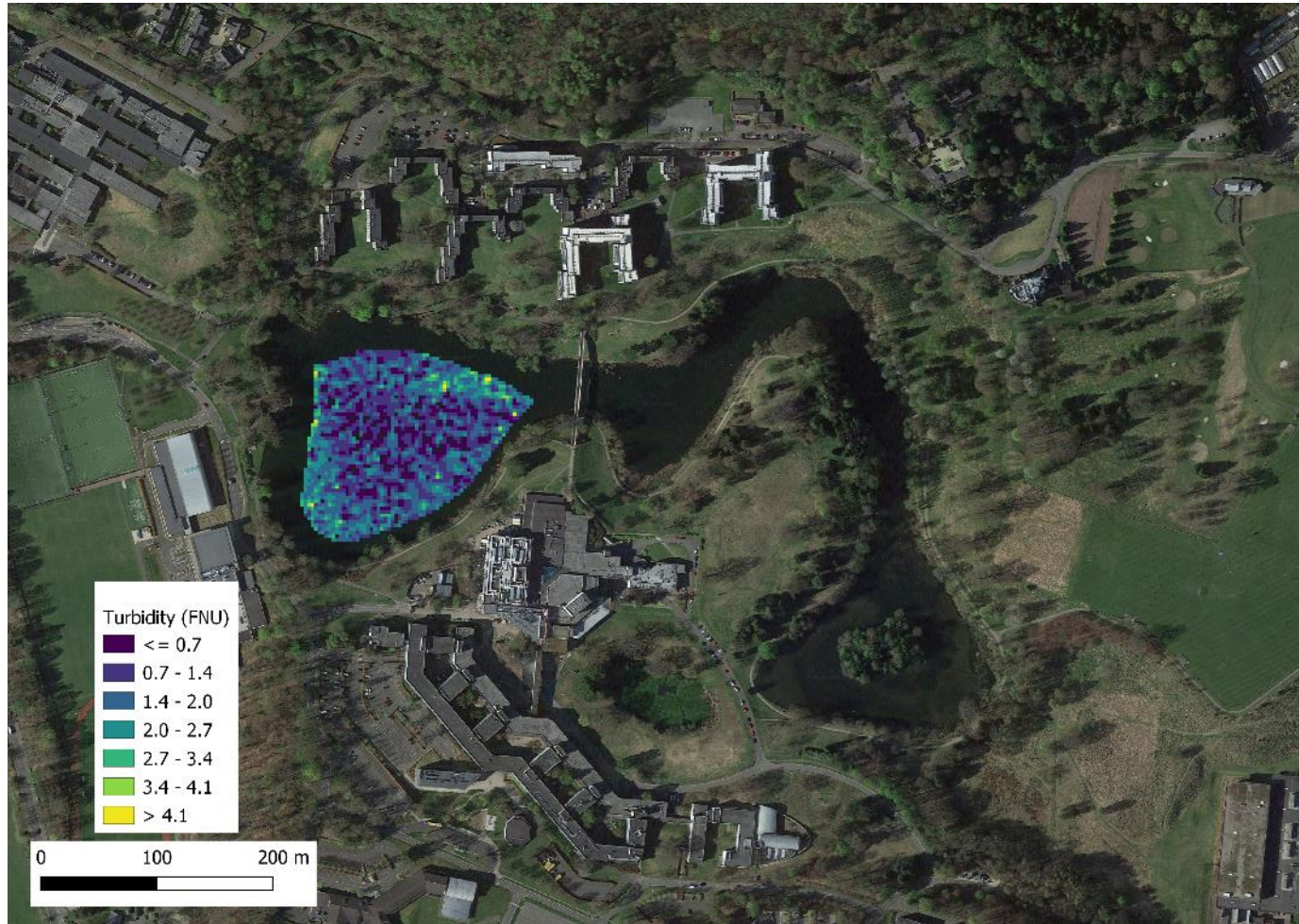# UKLO improvements: Bayesian neural networks

Werther et al. (2022) Remote Sensing of Environment, 283, Art. No.: 113295. https://doi.org/10.1016/j.rse.2022.113295

Estimation of chlorophyll in lakes worldwide using Bayesian neural networks (BNNs; red box) versus existing (UKLO) methods (grey boxes)

UKLO improvements: PlanetLabs SuperDoves

Example turbidity product derived from SuperDove data acquired over Airthrey Loch (University of Stirling campus). Credit: Daniel Beckmann.

- **Planet SuperDove cubesats**

- **8 spectral bands with 3.7 m spatial resolution**

- **44 SuperDoves (plus ~200 Dove-C/-R) provide daily data globally**
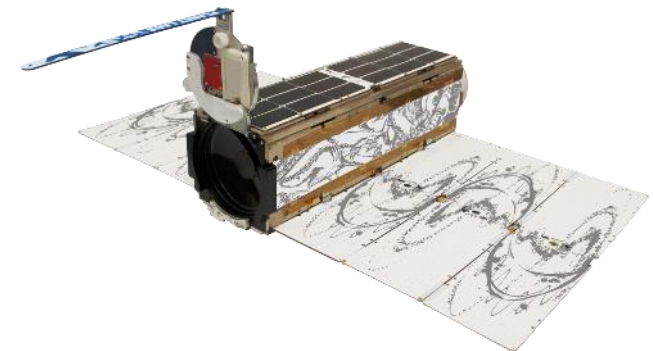
UKLO improvements: water temperature

- **Satellite Vu constellation of 7 satellites (launching 2023 on SpaceX)**

- **Mid-infrared imager (3.4 - 5.0 μm) with 3.5 m spatial resolution**
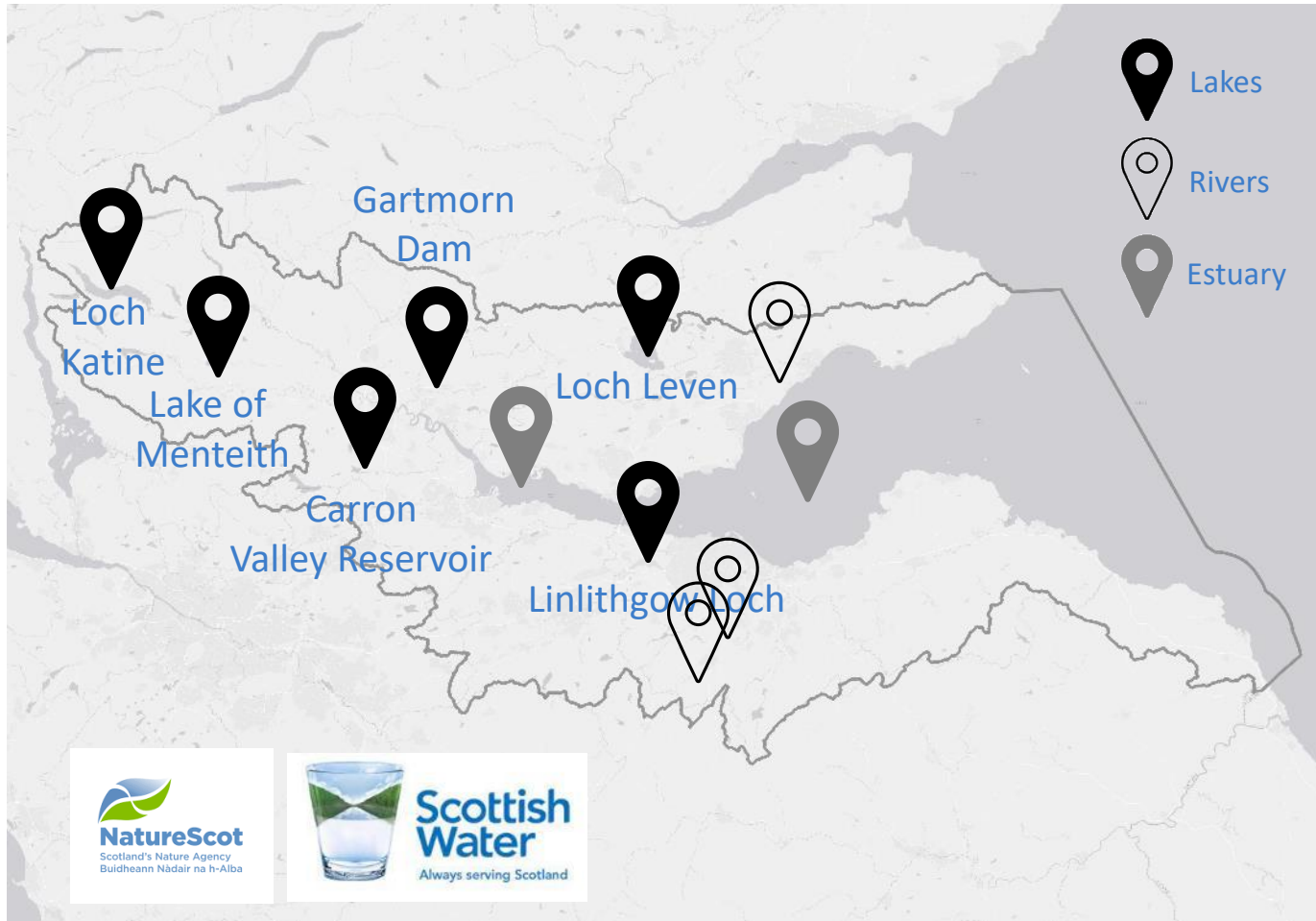
- **< 2K sensitivity (improved with ground calibration)**

- **Up to 20 images per day globally (day/night)**

Water temperature on the River Almond (Scotland) near the East Calder WWTW. Data: Satellite Vu

Forth-ERA digital observatory

Lakes

Rivers

Estuary

Loch Katrine

Gartmorn Dam

Lake of Menteith

Loch Leven

Carron Valley Reservoir

Linlithgow Loch

NatureScot
Scotland's Nature Agency
Buidheann Nàdair na h-Alba

Scottish Water
Always serving Scotland

https://bit.ly/ScotlandsInternationalEnvironmentCentre

- **Network of water quality buoys and sensors on lakes, rivers and Forth estuary**

- **Real-time data telemetry and web visualisation**

Forecasting with models

- **Developing models for forecasting blooms and testing climate scenarios**

- **1-dimensional General Lake Model and Aquatic Ecosystem Dynamics (GLM-AED)**

- **Model calibrated and validated for Esthwaite Water (2016-2020)**

- **Model improvement via assimilation of sensor/satellite data**

Input data courtesy of UKCEH and EA
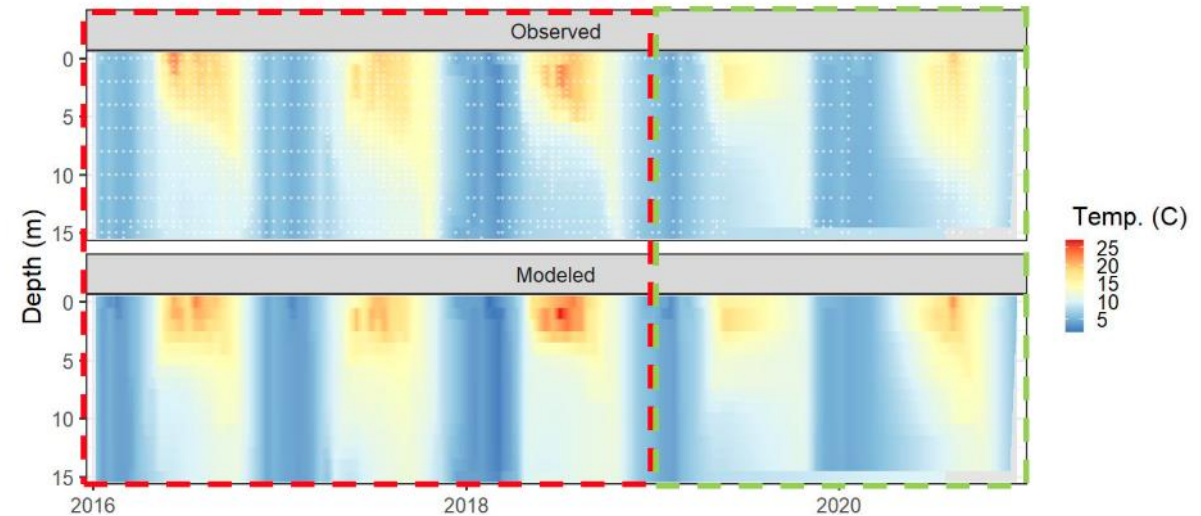
Temperature (credit: Maud Siebers)
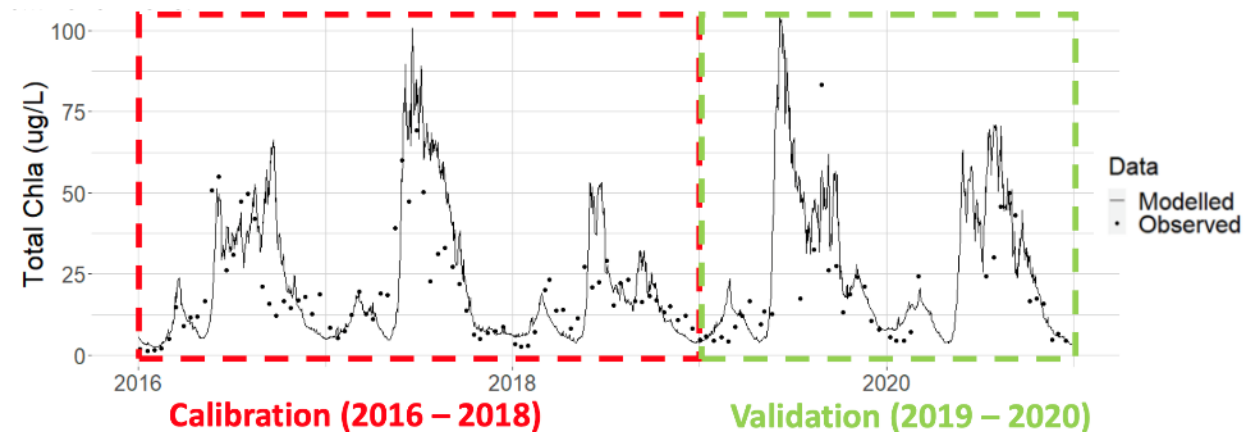
Calibration (2016 – 2018)   **Validation (2019 – 2020)**

Chlorophyll (credit: Maud Siebers)

Summary

- Operational monitoring of algal blooms from space now achievable

- Upcoming missions will further extend capabilities

- Complements long-term monitoring programmes, sensor networks, and citizen science

- Potential to combine with models to produce forecasts

Algal bloom on Gartmorn Dam, Clackmannanshire

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Thank you

Peter D. Hunter
Forth-ERA Science Director &
Associate Professor of Earth Observation
Scotland's International Environment Centre
University of Stirling

t   +44 1786 466538
e   p.d.hunter@stir.ac.uk
w www.stir.ac.uk

@drpeterhunter

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