Forest response to elevated CO_2 from UAV-based measurements of Solar Induced Fluorescence

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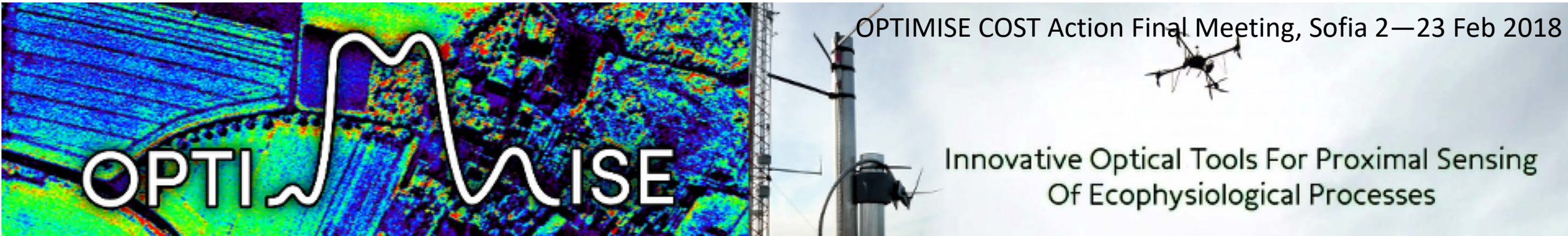


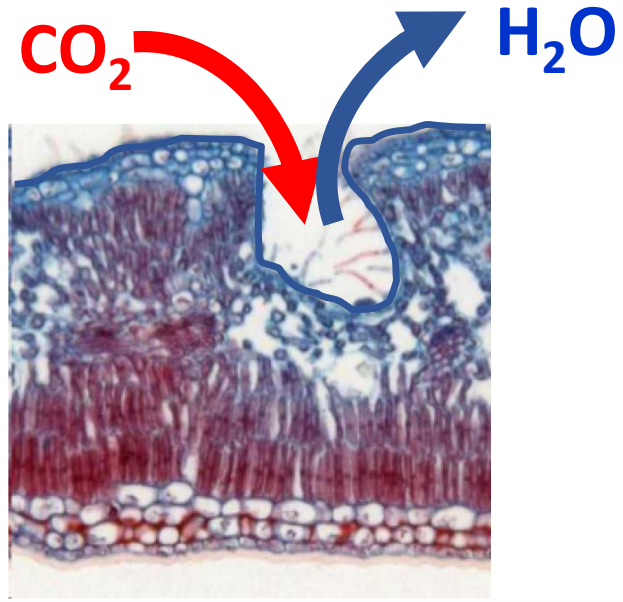
Motivation

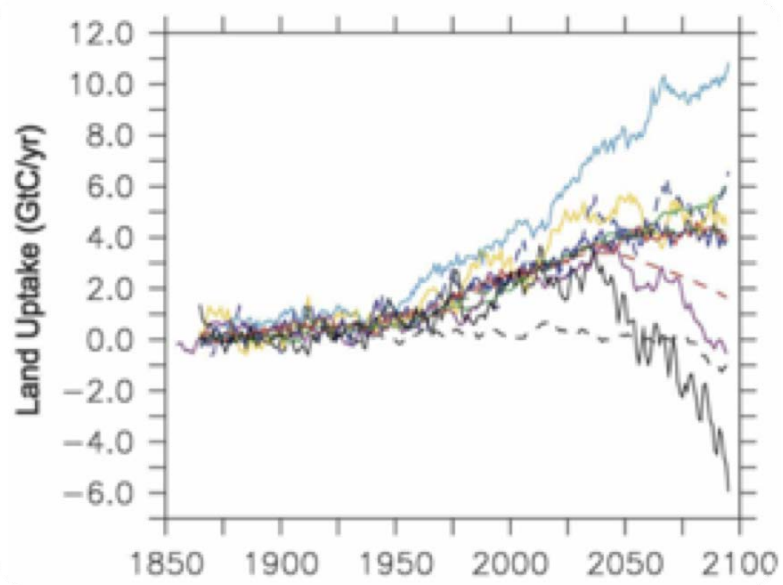
Increasing atmospheric CO_2 will have wide reaching consequences for the biosphere

- carbon cycle and hydrological cycle impacts

Significant model divergence in photosynthesis under future scenarios

Experimental data on ecosystem responses to elevated CO_2 comes from FACE sites





FACE: Free-Air CO_2 Enrichment

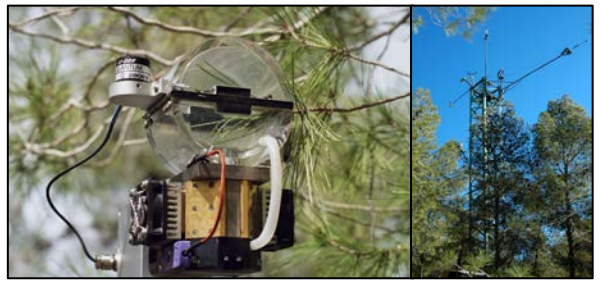
Field-based manipulation experiment to investigate ecosystem response to elevated CO_2

Fumigation of ecosystem patches with CO_2 to simulate mid-century concentrations (550 ppm)

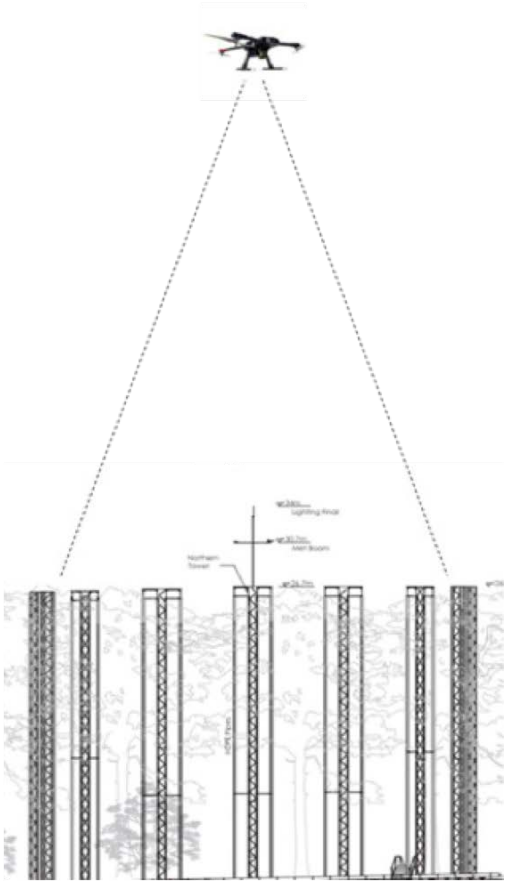
Mature forests under represented in FACE studies

Birmingham Institute of Forest Research (BIFoR) FACE site:
Established in 2017 in mature oak woodland near Birmingham, UK

Canopy-level photosynthesis at ‘ring-level’: new opportunities in SIF?



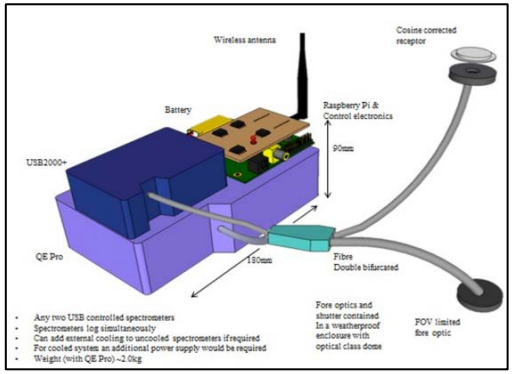
Limitations of existing methods:
operate at scales too small (chamber measurements) or too large (eddy covariance) for arrays (30 m diam)



UAV-based SIF measurements provide a new opportunity for measurements of photosynthetic responses to eCO_2:
integrated, replicated

Initial campaign, September 2017

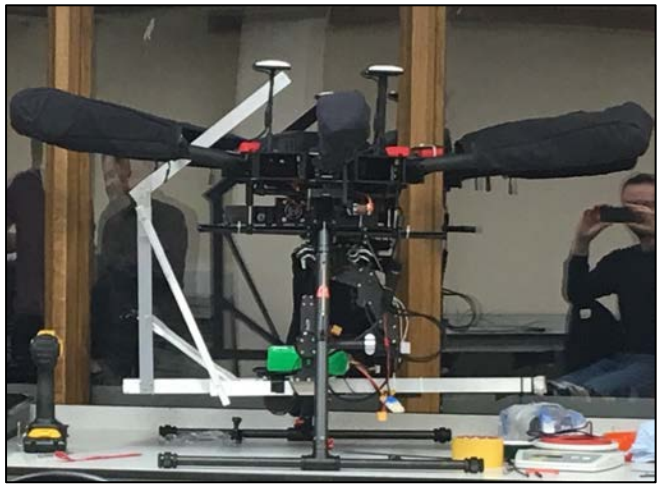
- Piccolo Doppio dual-field-of view spectrometer system (Ocean Optics FLAME + QEPro)
- Matrice 600 Pro UAV
- Parrot Sequoia multispectral sensor
- 360˚ and GoPro cameras
- Total weight ~15 kg



Four flights in the day;

each ring measured at least once

Bespoke gimbal



BIFOR FACE Sept 2017 360

155 views

4 0 SHARE

Dr Rick Thomas
Published on 22 Sep 2017

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Click and drag to look around this 360 taken during a flight test of a spectrometer above the BIFOR FACE site - see http://www.birmingham.ac.uk/research/... for more information about the FACE experiment.

Ancillary measurements

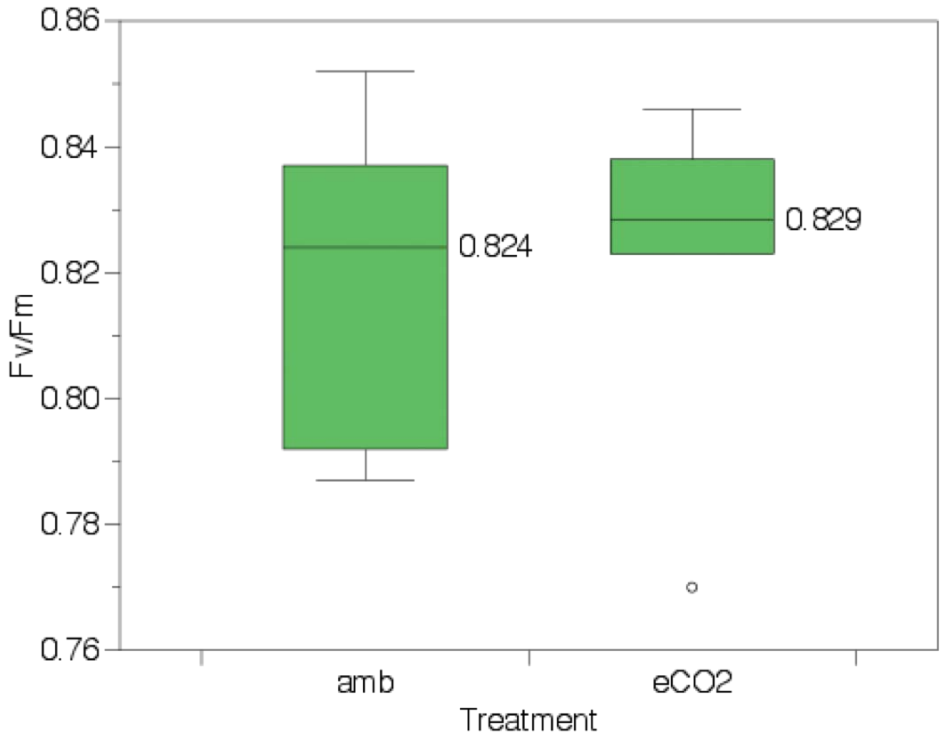
Leaf-level gas exchange and chl fluorescence
(LiCor phs systems, Opti-Science fluorimeter

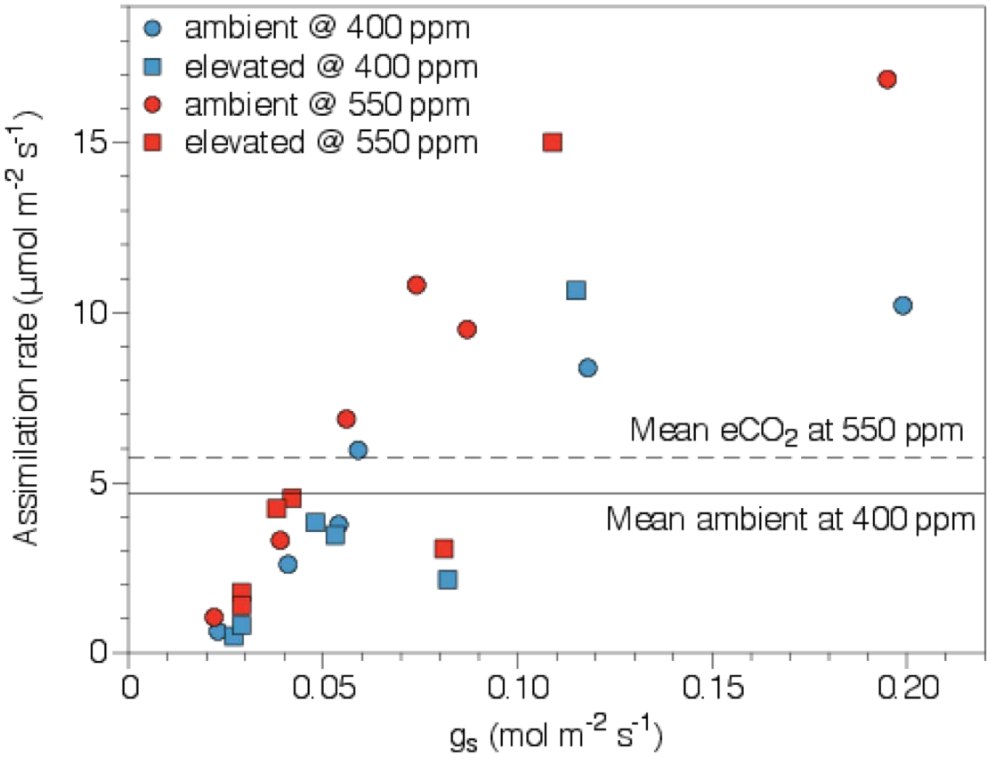
Fluorescence spectra
(FluoWat leaf clip, FLAME spectrometer)

Range of meteorological and physiological data collected at the site

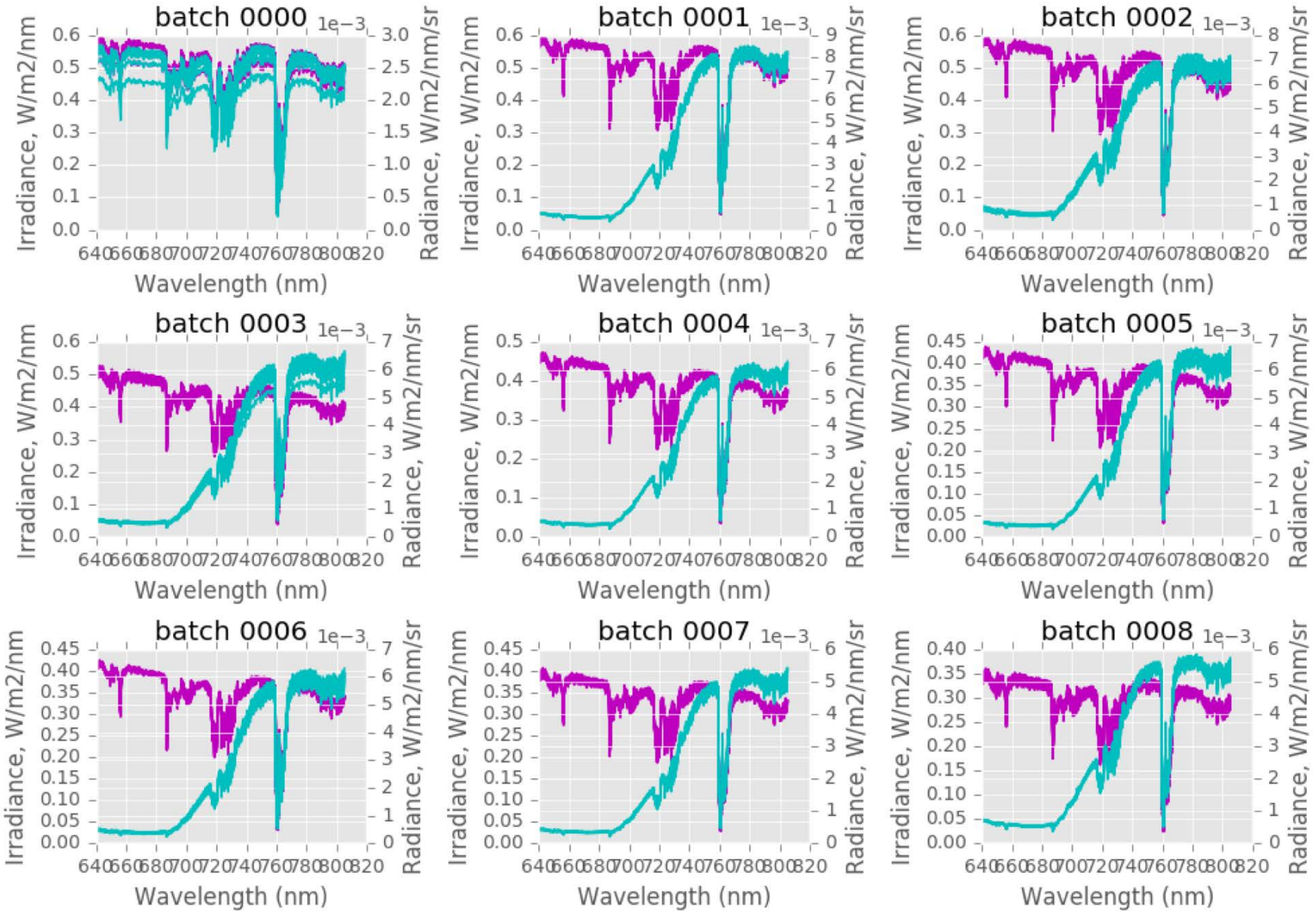
Physiological results

- No difference in maximal (dark-adapted) photosynthetic efficiency between treatments
- Increase in photosynthesis under elevated CO_2; response ratio (1.2) consistent with other studies
- Stomatal conductance was limiting (end of season)

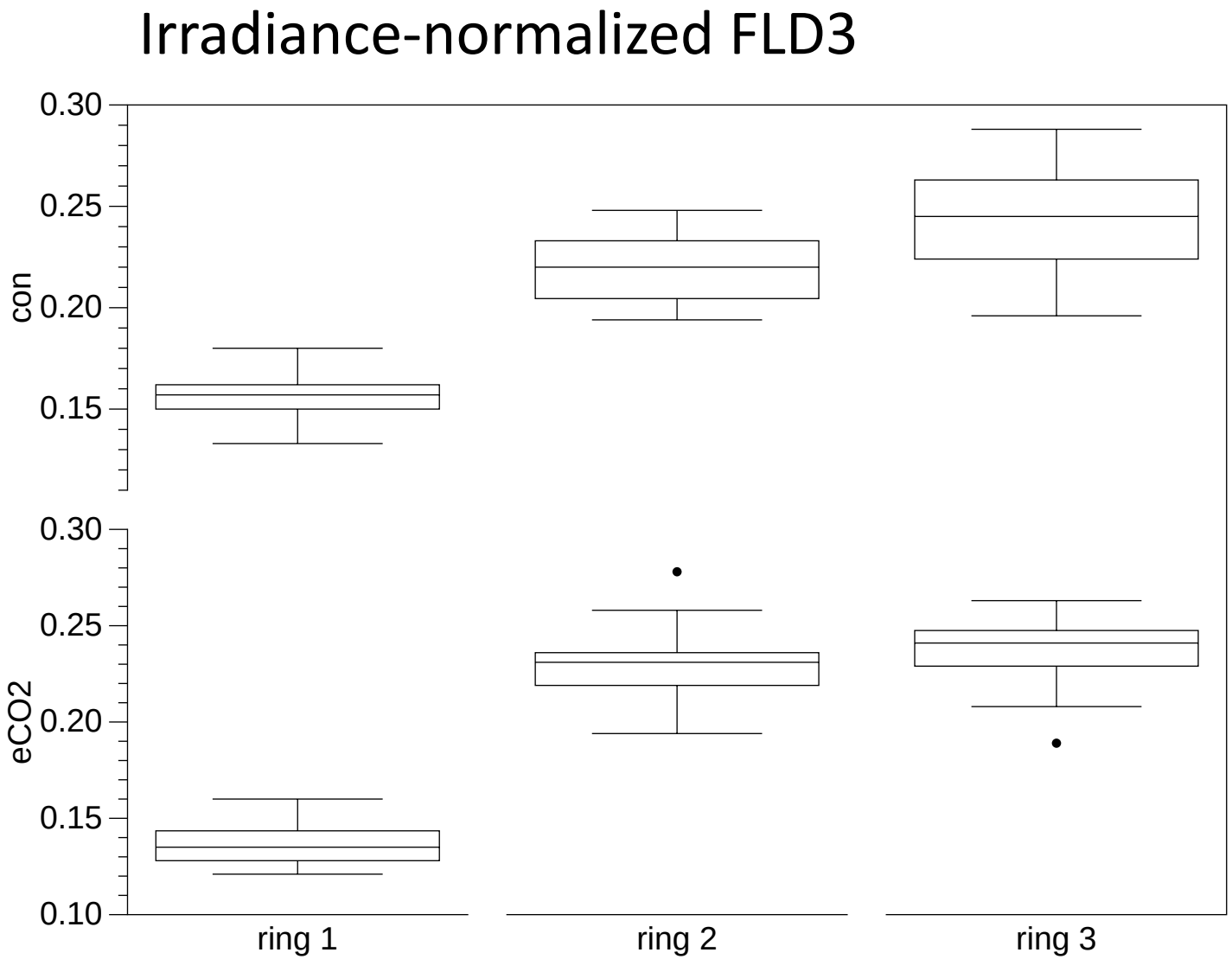




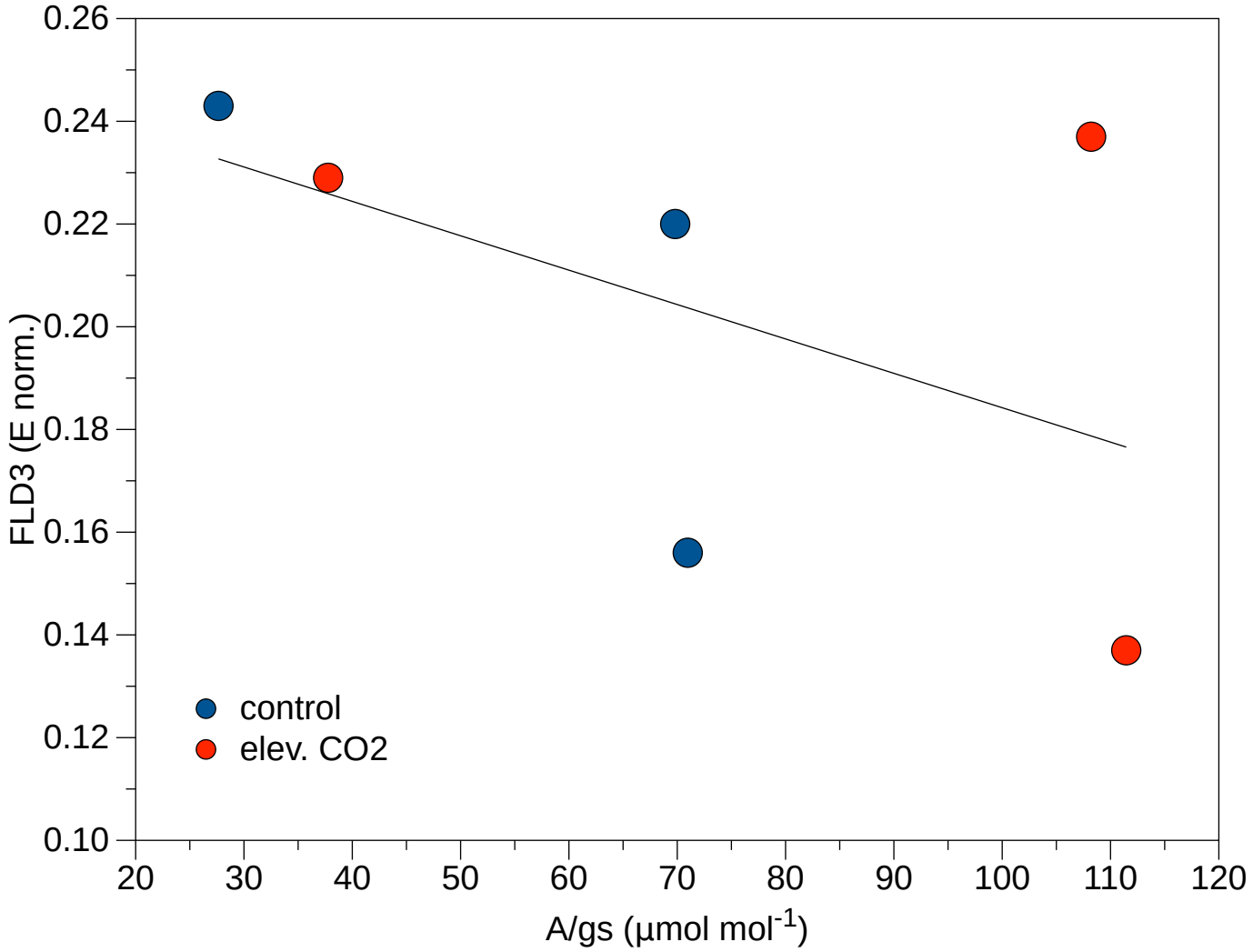
Spectra from one flight



SIF estimates

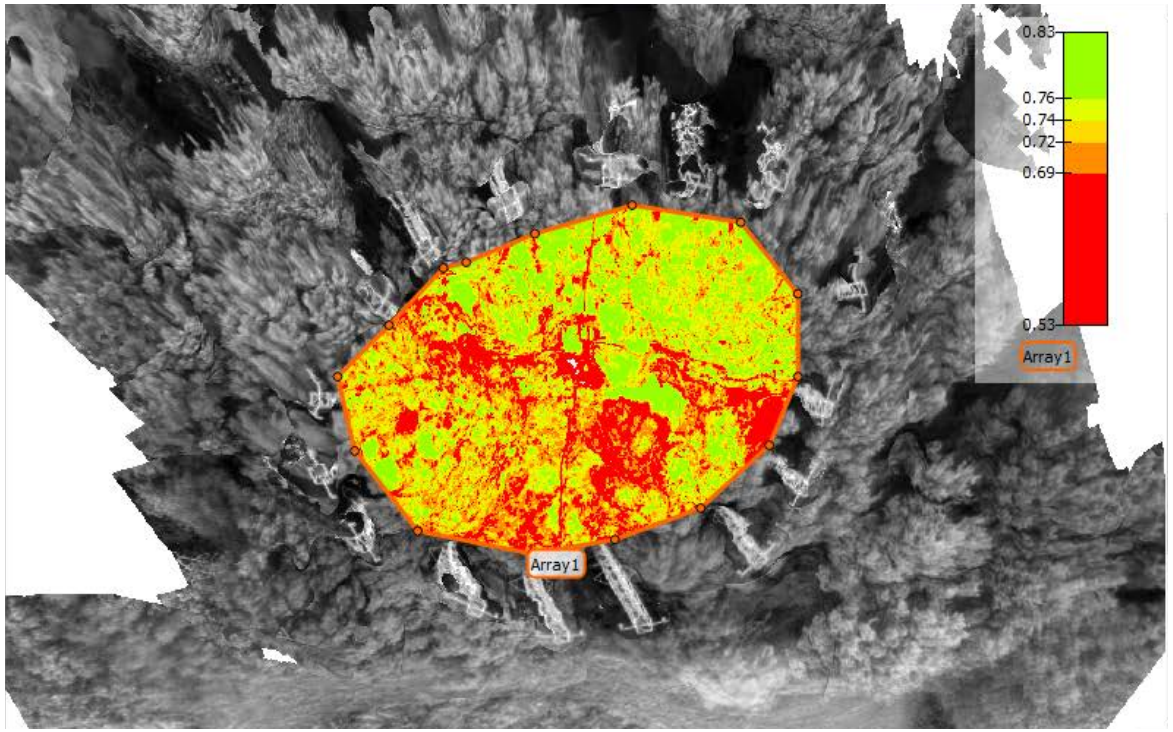


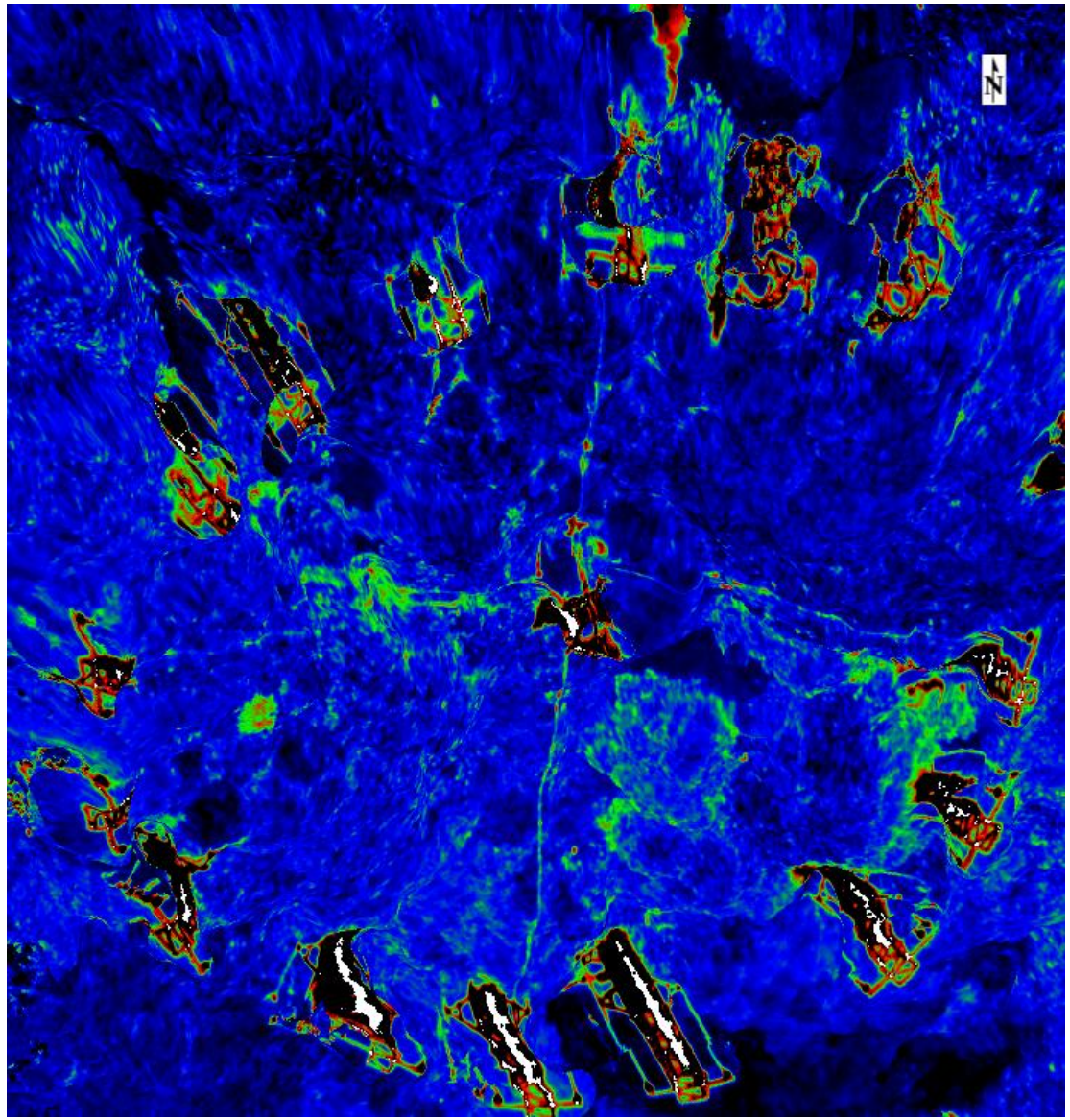
Relationship (or not) with physiology



Sources of variation: NDVI

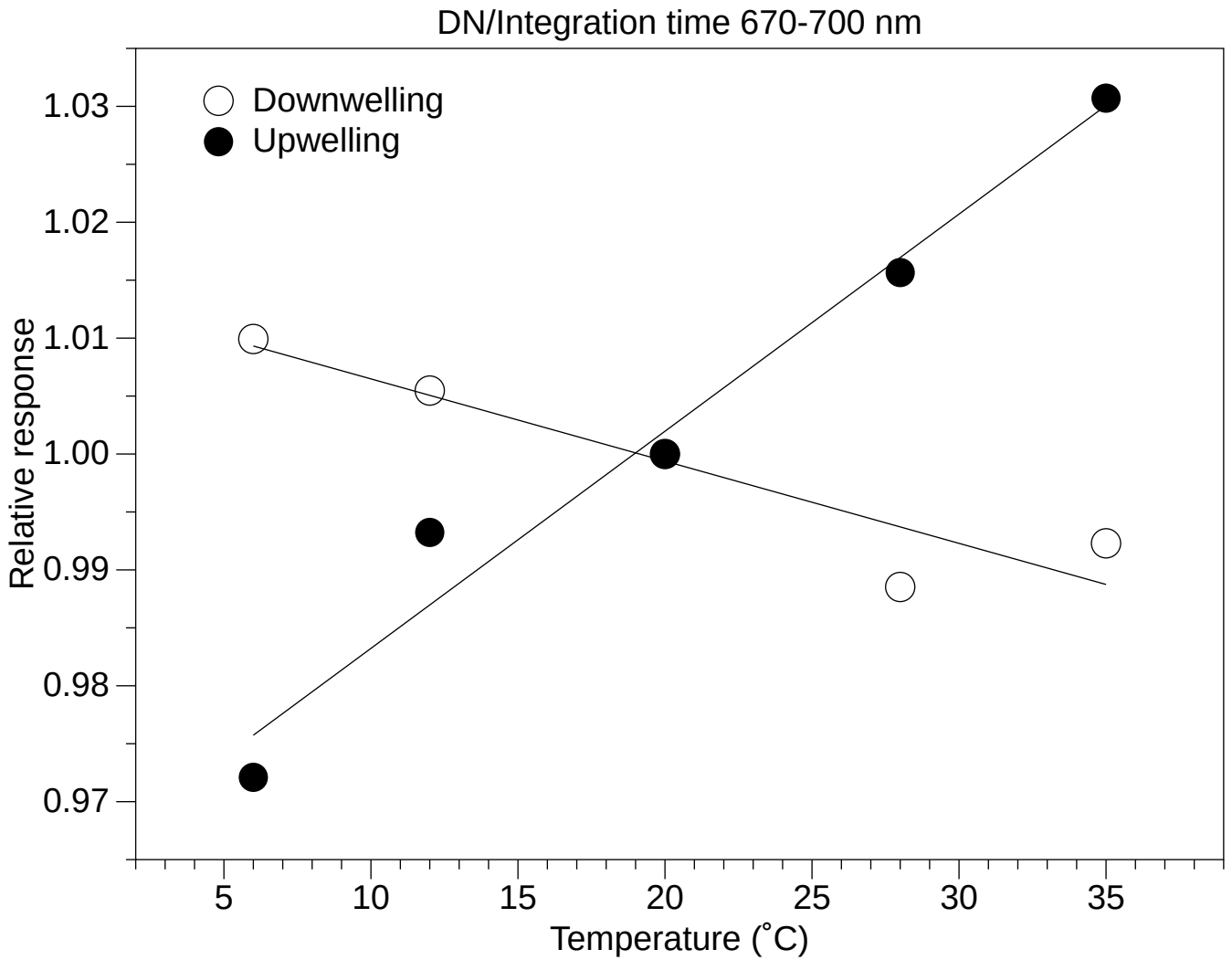
Processing of Parrot Sequioa Multispectral Camera data (RGB, Red, NIR, Red Edge).





Influence of temperature on the system

Measurements in a controlled environment chamber (lamp temperature constant)



Summary

Successful campaign to test the feasibility of UAV-based SIF measurements at large–scale field manipulation experiment to understand ecosystem response to global change processes

seasonal variation, response to stress and extreme events

Analysis and processing of data is ongoing, and will help refine and improve future experimental protocols

- ring-sized flight validation targets, positioning, heights

Collection of air and ground-based physiological data will be essential to develop an understanding of the variations in SIF before routine use of SIF alone (eg thermal imaging)

Characterisation of system response to temperature might be important for that extra precision required