Leaf and stem: oak transpiration at BIFoR FACE

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Acknowledgements Thanks to BIFoR Ops. Team: Nick Harper, Kris M Hart, Peter Miles, Giulio Curioni, Gael Denny, Robert Grzesik, Anna Gardner (2016-7) Gary McClean (2018) & Tom Downes. Stefan Krause & Rob MacKenzie are supervisors

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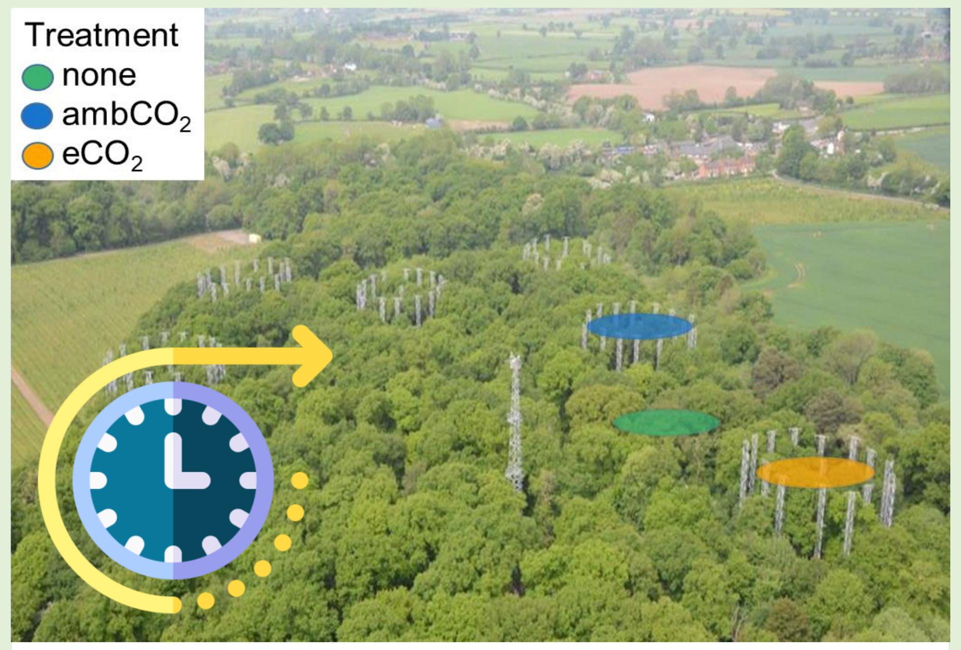
Q1: How does elevated CO_2 influence daily leaf level transpiration?

1 Introduction

Birmingham Institute of Forest Research FACE facility is the project site for this tree-centred plant hydraulic research.



Baseline 2015/16 **eCO_2** 2017-2026

Free-Air Carbon-dioxide Enrichment (FACE)

3 no-infrastructure ambient air (natural/ ghost arrays)

3 ambient-air infrastructure FACE rings

3 treatments of +150 ppmv CO_2

https://www.birmingham.ac.uk/research/bifor/face/index.aspx

2 Leaf measures

Canopy Access System (CAS) used to access top canopy of selected oaks throughout the treatment season April to October using:

Porometer - stomatal conductance

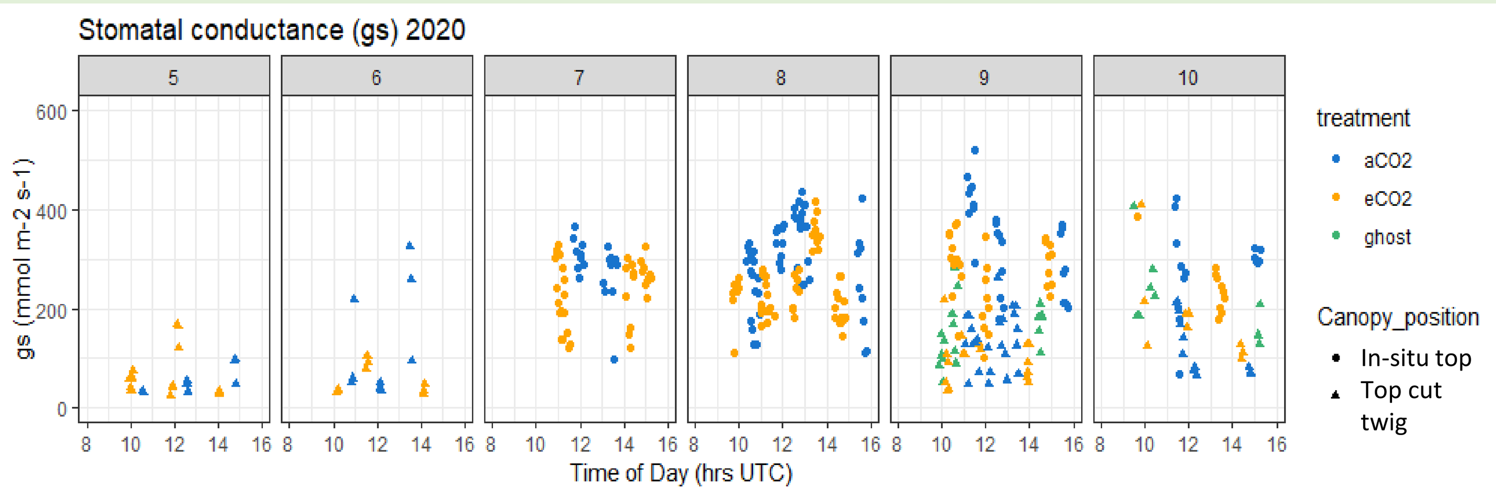
Infrared thermometer -Leaf temperature

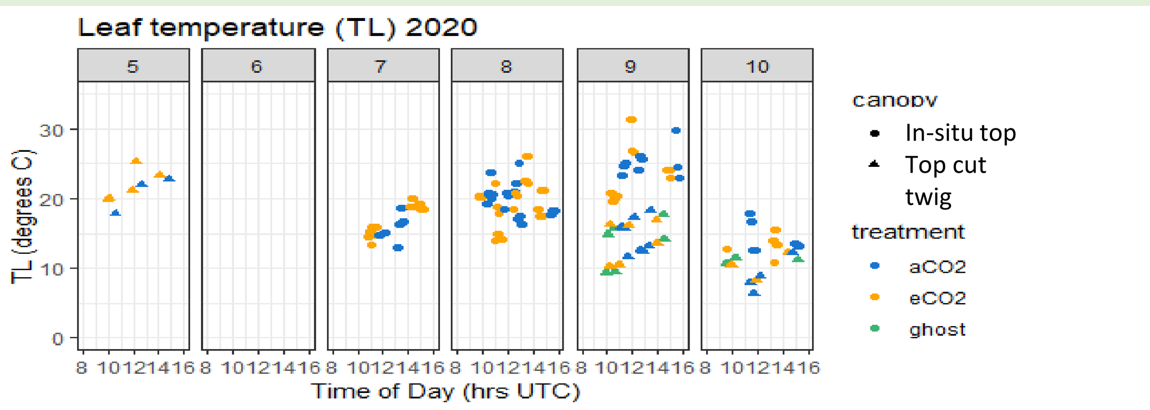
3 Leaf Results

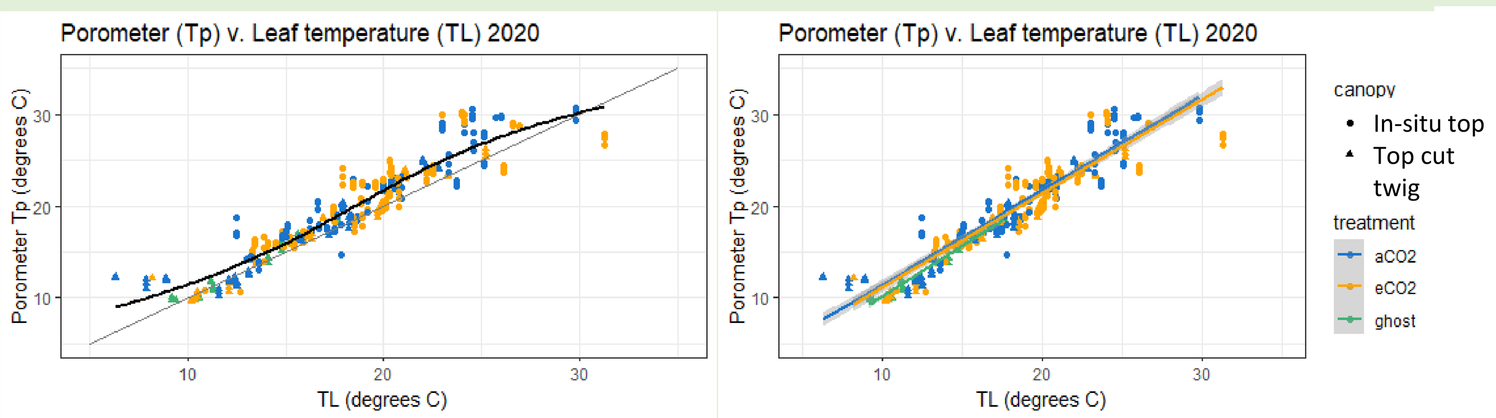
From August 2019 to July 2021 campaigns in the canopy in treatment season produced cut-twig and in-situ stomatal conductance and abaxial leaf temperature data from 3 top canopy leaves of each oak (one per array). Covid-19 pandemic restricted researcher access in early months of 2020. Stomatal conductance results for 2020 are presented pooled for each month.

Confounding factors
- vapour pressure deficit
- air temp
- precipitation
- sun/ shade
- stomatal density
- wind

Leaf temperature was measured prior to each porometer measurement. Comparison with internal porometer temperature results illustrates the limitations and non linearities.







4 Leaf discussion

There are no noticeable differences between eCO_2 and aCO_2 stomatal conductance results from first visualisation. Ghost (no-infrastructure control) results are mainly from cut-twig

Q2: Is peak daily leaf transpiration synchronised between oak trees and with stem sap flux dynamics?

S2 Stem measures

Diurnal tree canopy transpiration is estimated using xylem sap flux data even during cloudy days

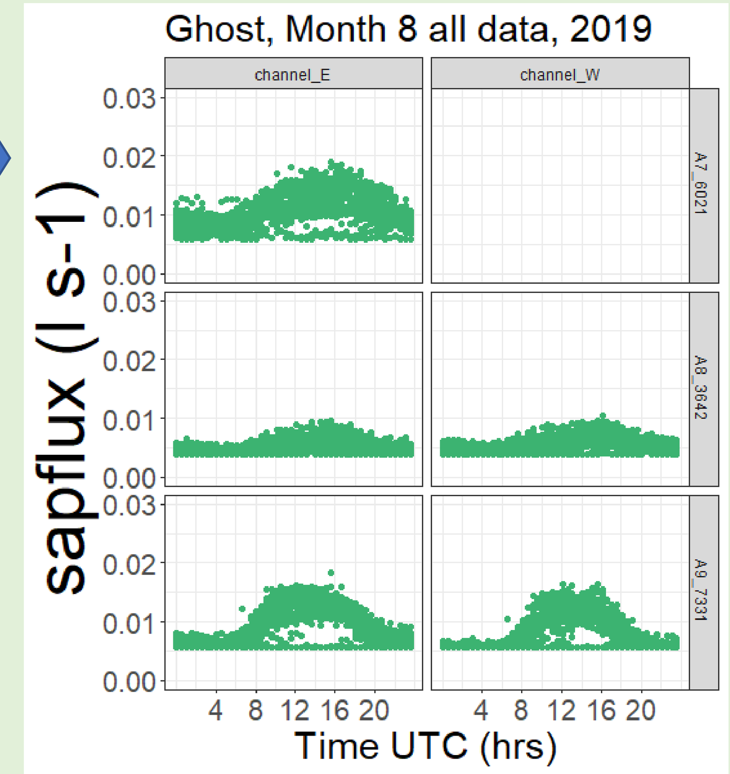
Xylem sap data – oaks

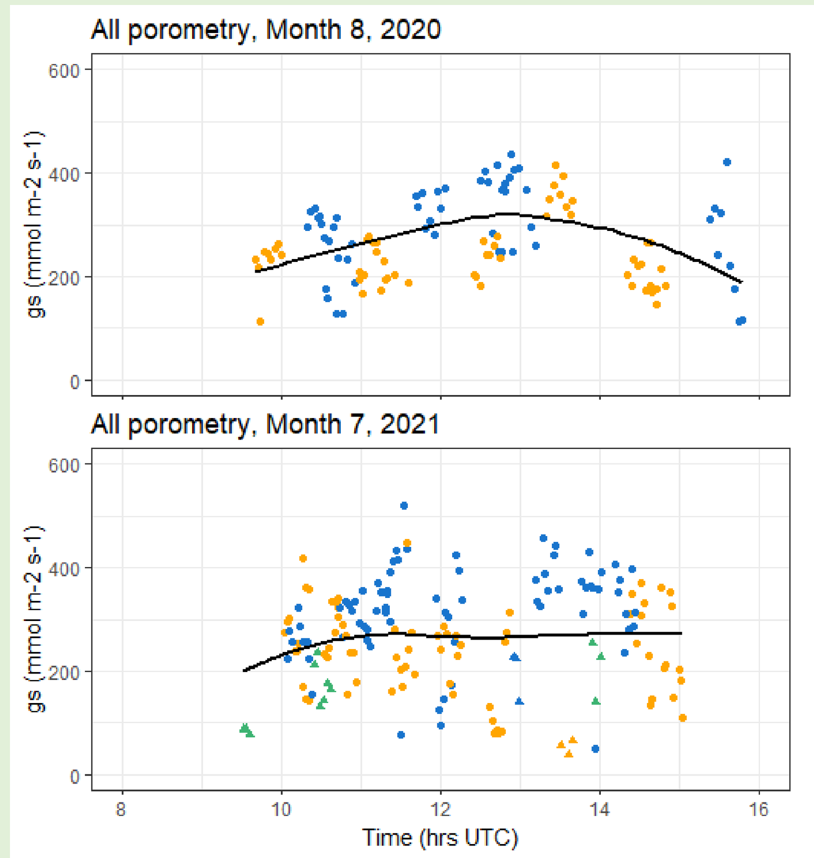
Whole tree daylight water usage *TWU* (litres) calculated across active xylem cross-sectional area, using the modified weighted average method (Hatton, 1990).

S3 Stem Results

Diurnal tree canopy transpiration is estimated using xylem sap flux data even during cloudy days. We see that the shape of diurnal sap flux is synchronsed between trees.

Tree water usage (*TWU*) is driven by solar radiation diurnally and varies by tree size so can be normalised (TWU_N) is separately reported for years 2017-2021 (Quick et al. – in prep). Comparison of trees' TWU_N under different treatments shows seasonal trends are similar and that there may be effects introduced by the infrastructure.





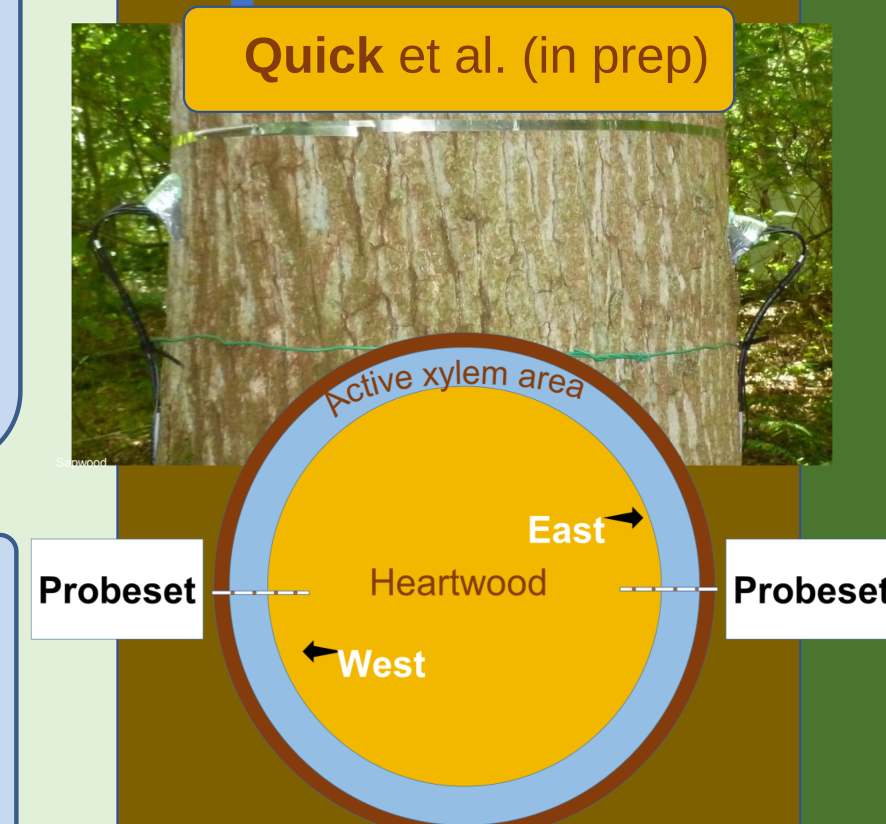
S4 Leaf - Stem Discussion

Comparison of results from leaf and stem tree-based data requires careful normalization. When considering synchronisation, each day is unique in confounding factors such as wind, solar radiation and air temperature.

Findings here indicate very similar diurnal patterns for eCO_2 and aCO_2 at leaf level. Statistical analysis and modelling should provide more rugged conclusions.

Peak time of day for stem sap flux is consistently around midday UTC. There is a wider variation in time of day for peak stomatal conductance.

Quick et al. (in prep)



5 Conclusion and Next steps

In oak transpiration is similar under eCO_2 and aCO_2

- *Stomatal conductance data will be converted to leaf transpiration.*
- *Extract sap flux from specific trees/ days to compare with leaf transpiration.*
- *Leaf-air temperature differentials will be explored.*

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MacKenzie, A. R., Krause, S ..., Quick, S. E., ... (2021). BIFoR FACE: Water–soil–vegetation–atmosphere data from a temperate deciduous forest catchment, including under elevated CO2. *Hydrological Processes*, *35*(3), e14096 https://doi.org/https://doi.org/10.1002/hyp.14096

Hart, et al. (2019) Characteristics of Free Air Carbon Dioxide Enrichment of a Northern Temperate Mature Forest. *Glob Change Biol.* doi:10.1111/gcb.14786