Lancaster Environment Centre | Lancaster University

Modelling the effect of the 2018 summer heatwave and drought on isoprene emissions in a UK woodland

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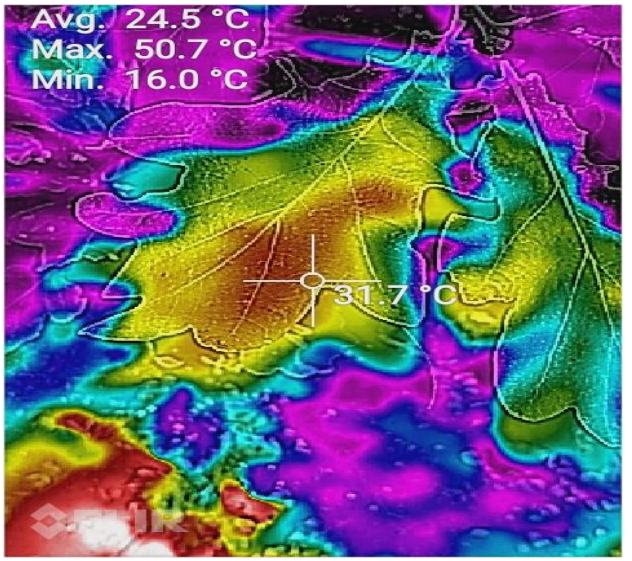

JULES Science Meeting 2019

University of Edinburgh

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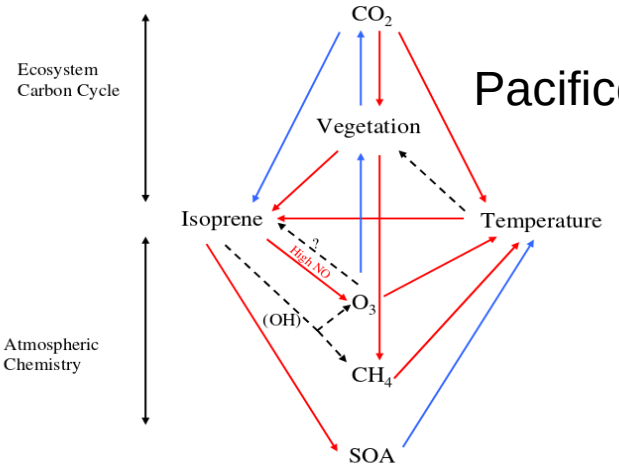
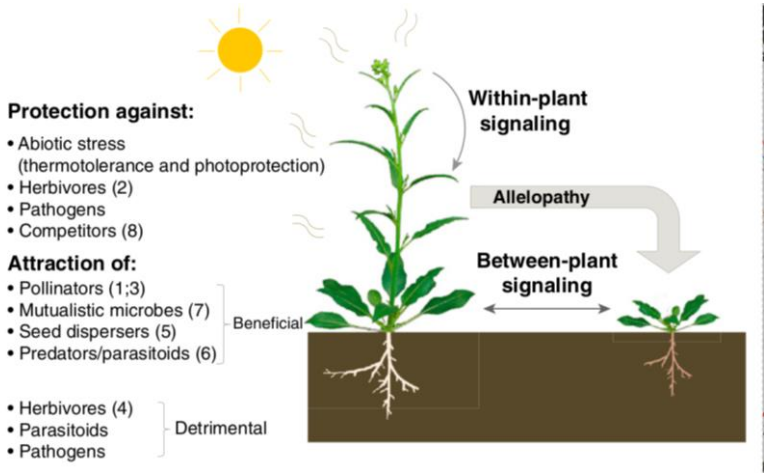
Introduction

- Isoprene is the most abundant bVOC emitted by terrestrial vegetation.
- It is important for atmospheric chemistry and composition due to its high reactivity rates
- Emission rates are highly dependent on environmental factors
- Reasons for emissions include protection from biotic and abiotic stress, inter-plant communication and attarction of pollinators



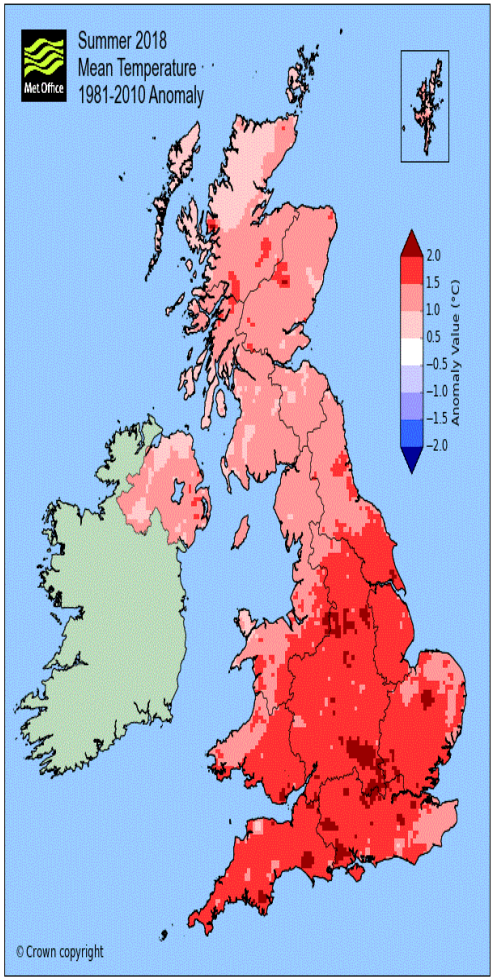
Pacifico et al., 2009

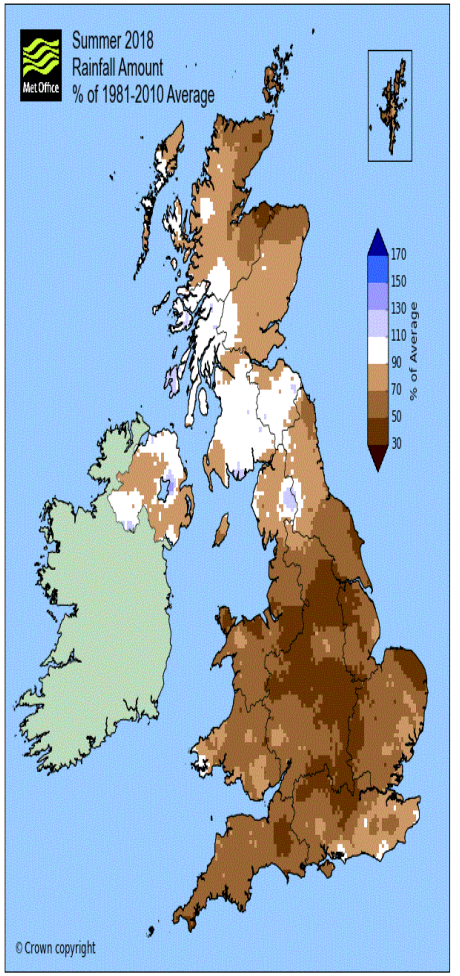
Baldwin, 2010



Introduction cont ...

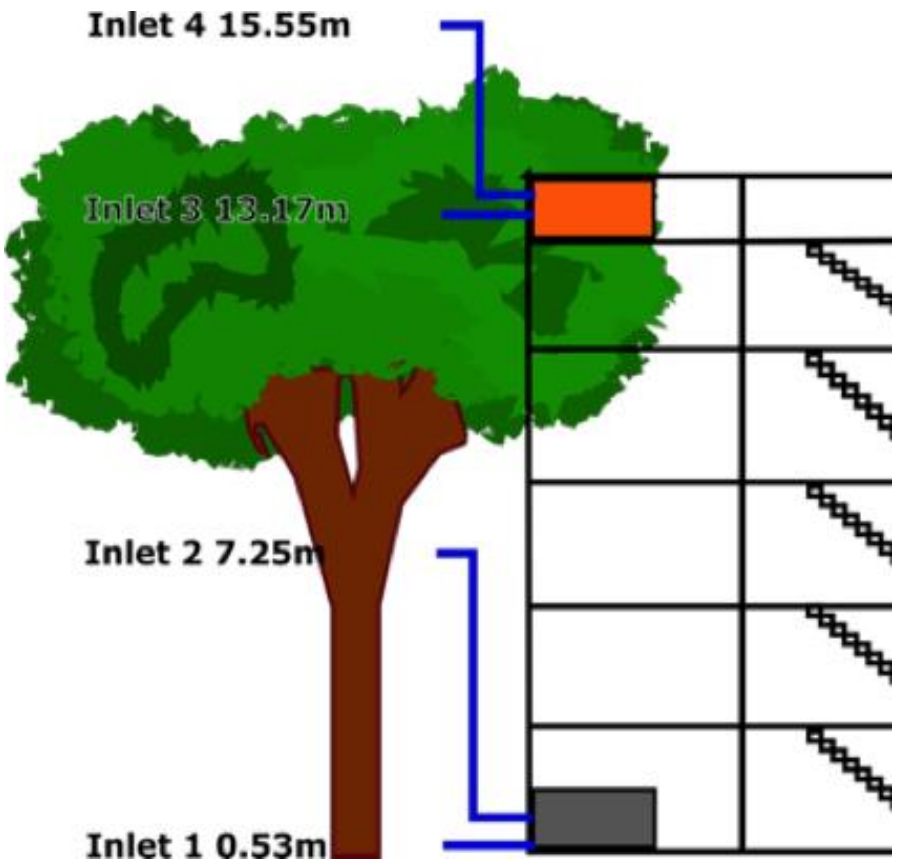
- UK and most of northern Europe experienced drought and heatwave in the summer of 2018
- Met Office declared a heatwave 22nd June 2018 to the 8th August in the South of England.
- Mean temperature was 2^{o}C above the 1981 to 2010 average across the UK
- For Wytham Woods, mean temperature was 3^{o}C above the 1991-2015 average for the same period.
- These changes in weather were expected to have impacts on bVOC emissions across the UK.



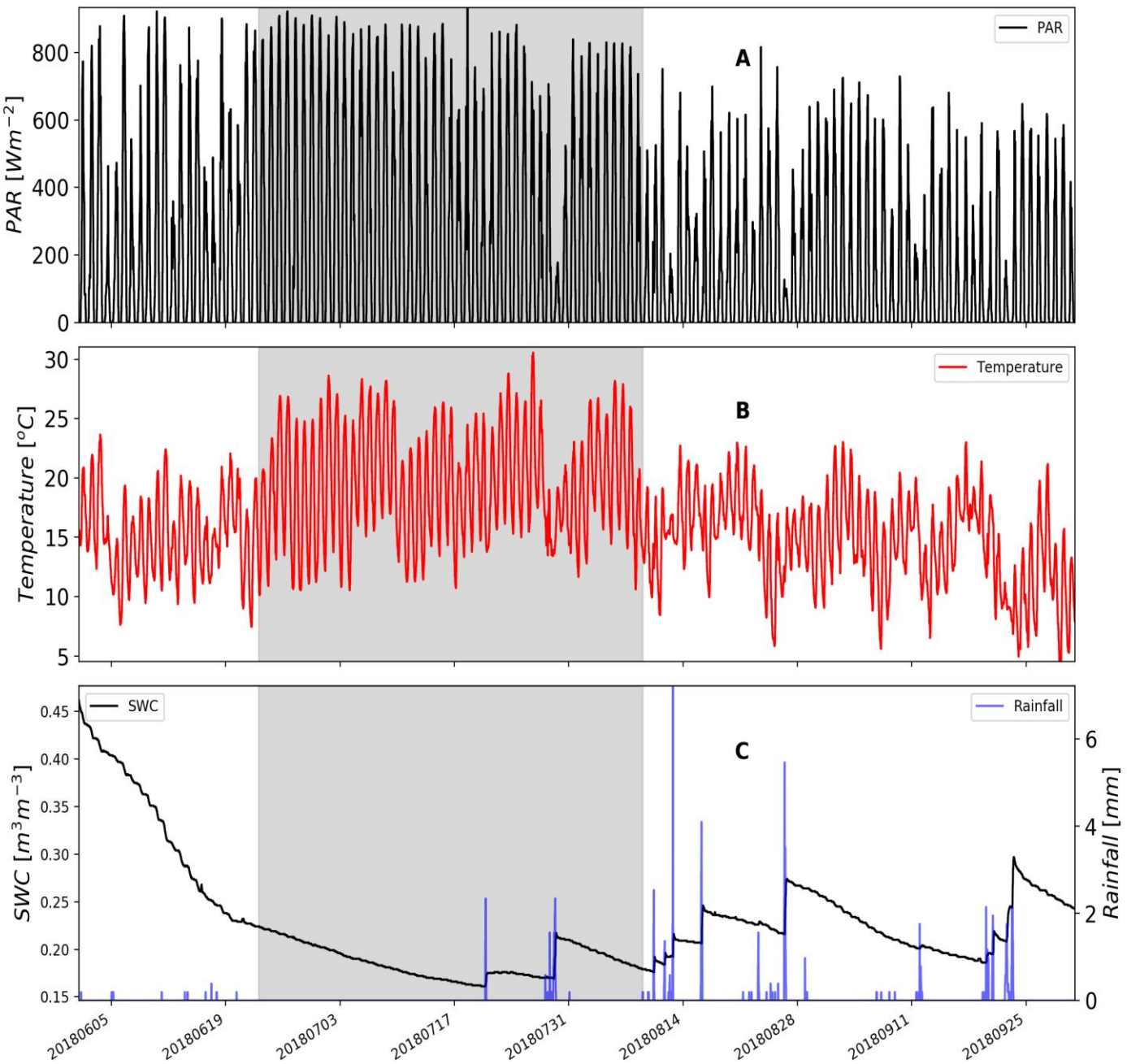


Observation Campaign and Study Area

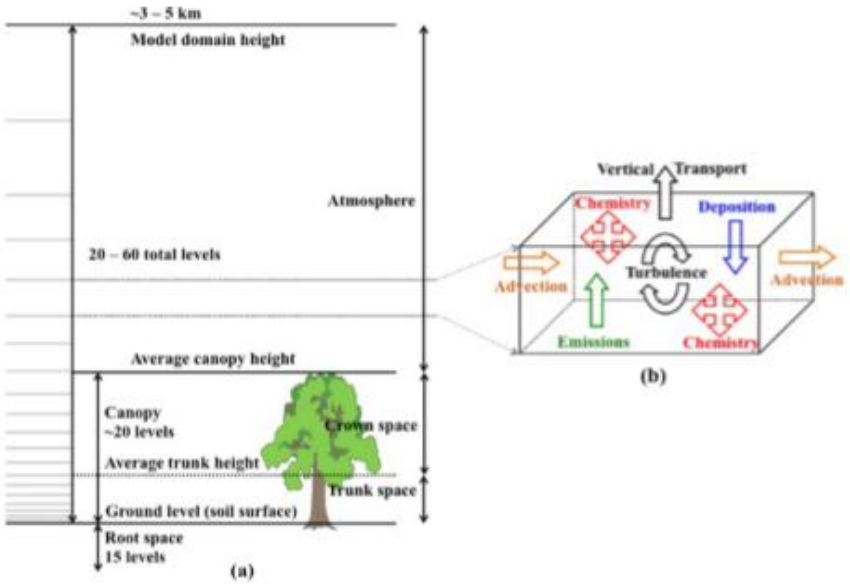
- Wytham Woods located in Oxfordshire, UK)
- mixed temperate woodland dominated by Oak, Ash, Sycamore
- Oak is the dominant isoprene emitter in the forest
- Measurements of isoprene were made as part of the WIsDOM campaign from May to October 2018.
- Observations made at 4 levels in the Canopy
- Meteorological data was obtained from an Automatic Weather Station 200m away from measurement site.



Heatwave-Drought Meteorology



Modelling Study (FORCAsT model)



A schematic of the FORCAsT column model. Each level within the column is a box model incorporating the processes involved in canopy–atmosphere exchange of energy and mass appropriate for that level.

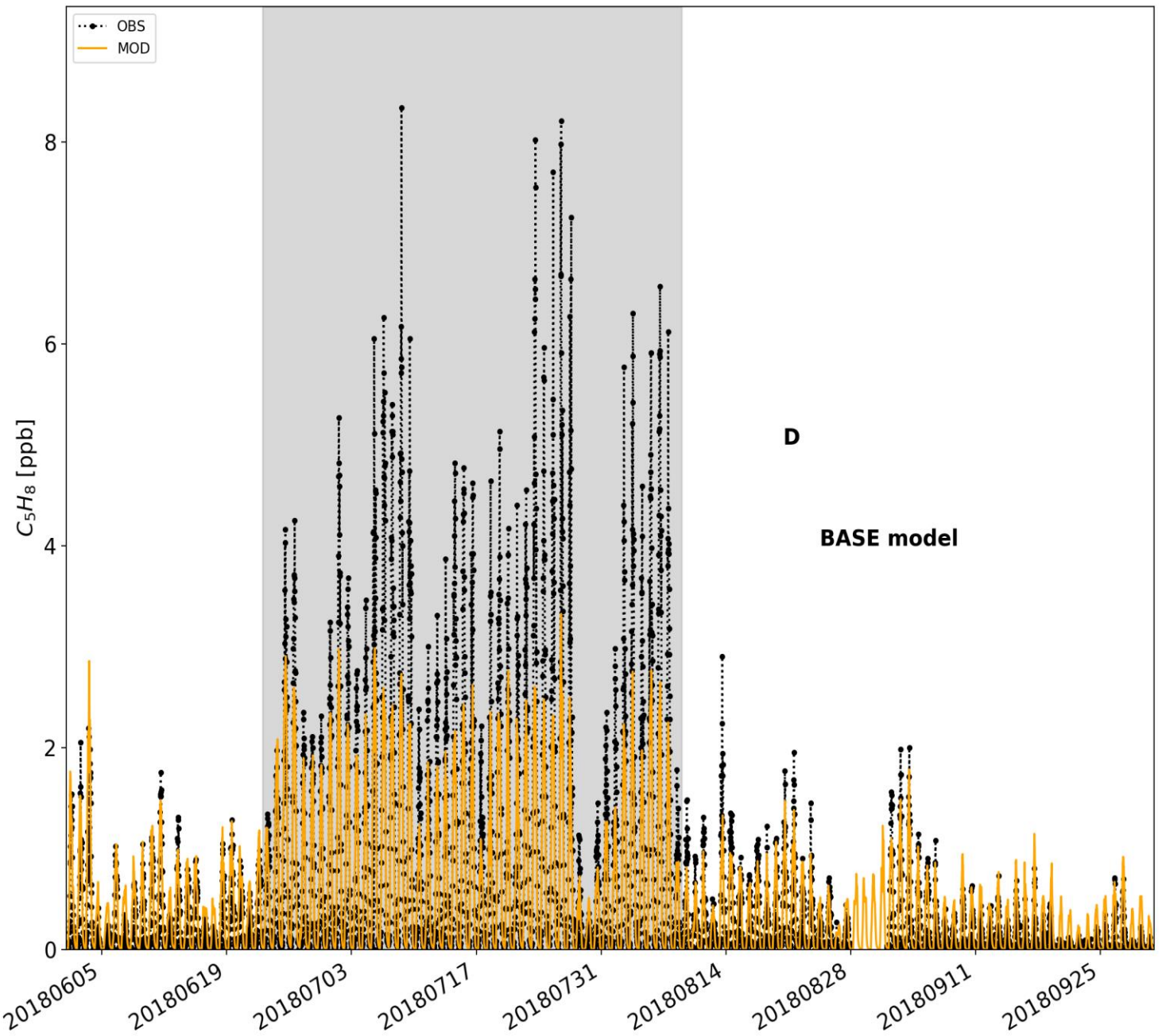
- FORCAsT 1-D Model is used in the study
- BVOC emissions based on Guenther et al., 1995

$$ER = LAI \cdot \varepsilon \cdot \gamma_{iso}$$

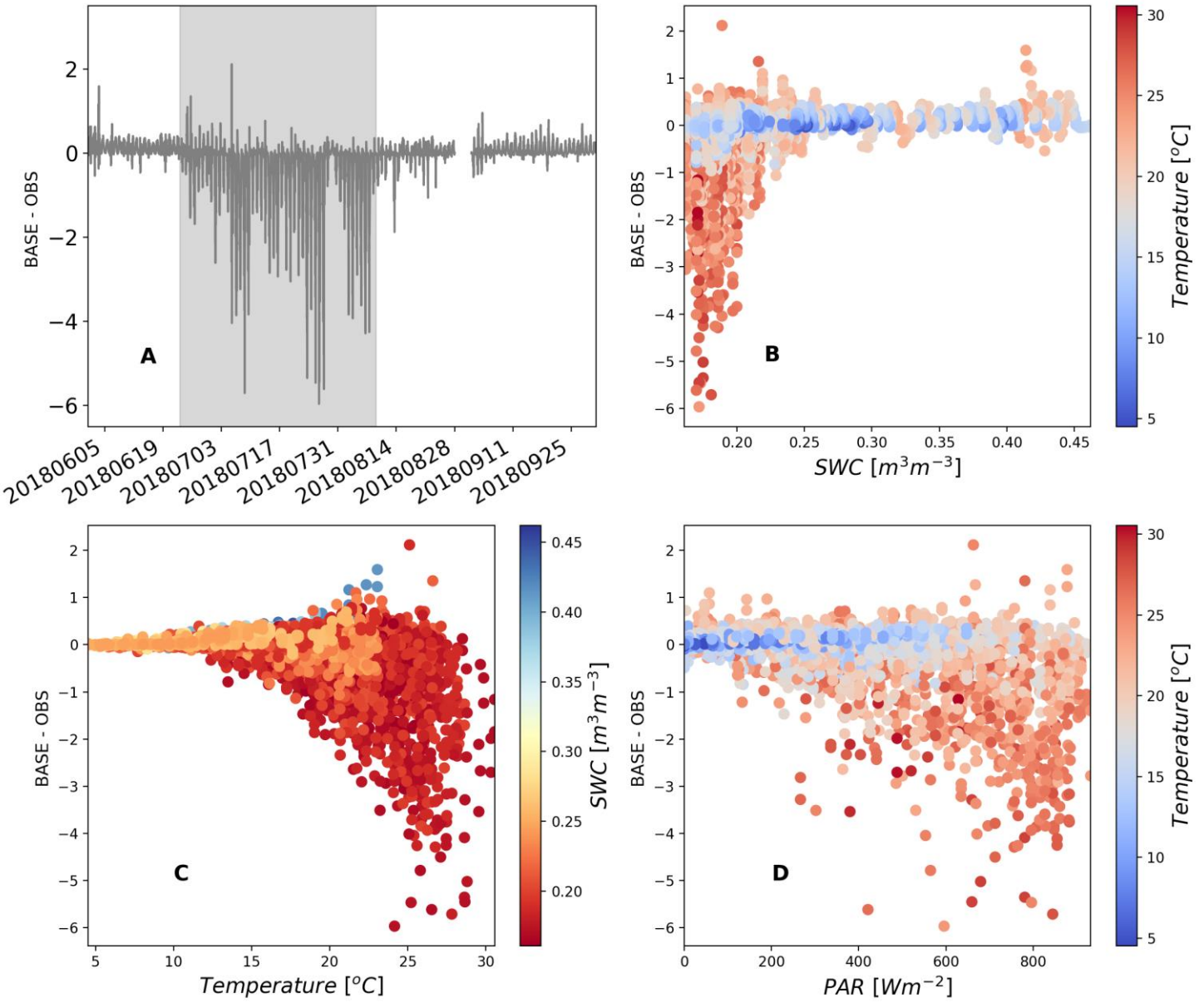
$$\gamma_{iso} = C_L C_T$$

- Model was driven with observed meteorology
- Simulations cover the period Jun 01 – Sep 30

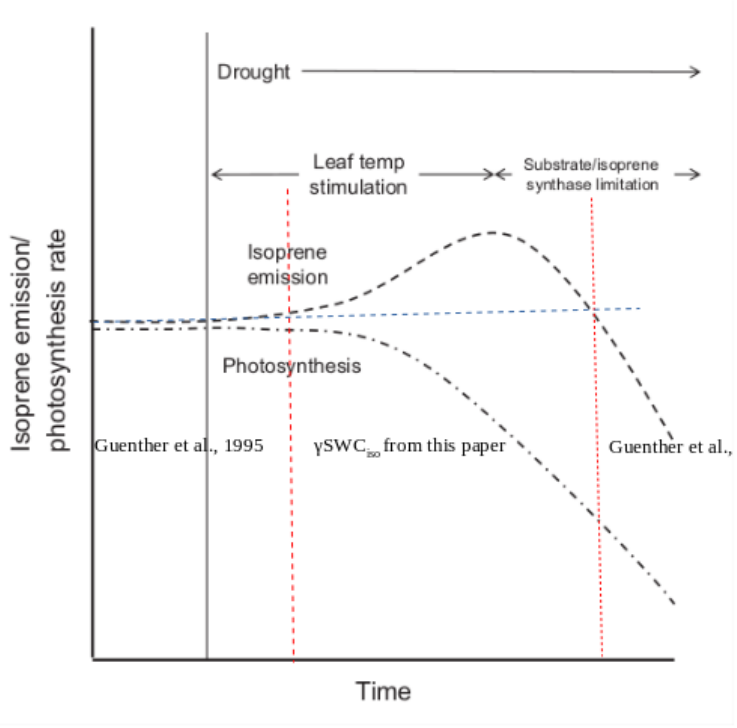
BASE Model Results



BASE Model Results



Further Modelling Experiments



Niinemets, 2010; Potosnak et al., 2014

$ER = LAI \cdot \varepsilon \cdot \gamma_{iso}$

$\gamma_{iso} = \gamma_{iso} \cdot \gamma_{x}$

BASE + T

$$\gamma T_{iso} = \frac{(T - T_{mean})}{(T_x - T_{mean})}$$

BASE+SW

$$\gamma SWC_{iso} = \left[\frac{(\theta - \theta w)}{(\theta c - \theta w)}\right]^{q}$$

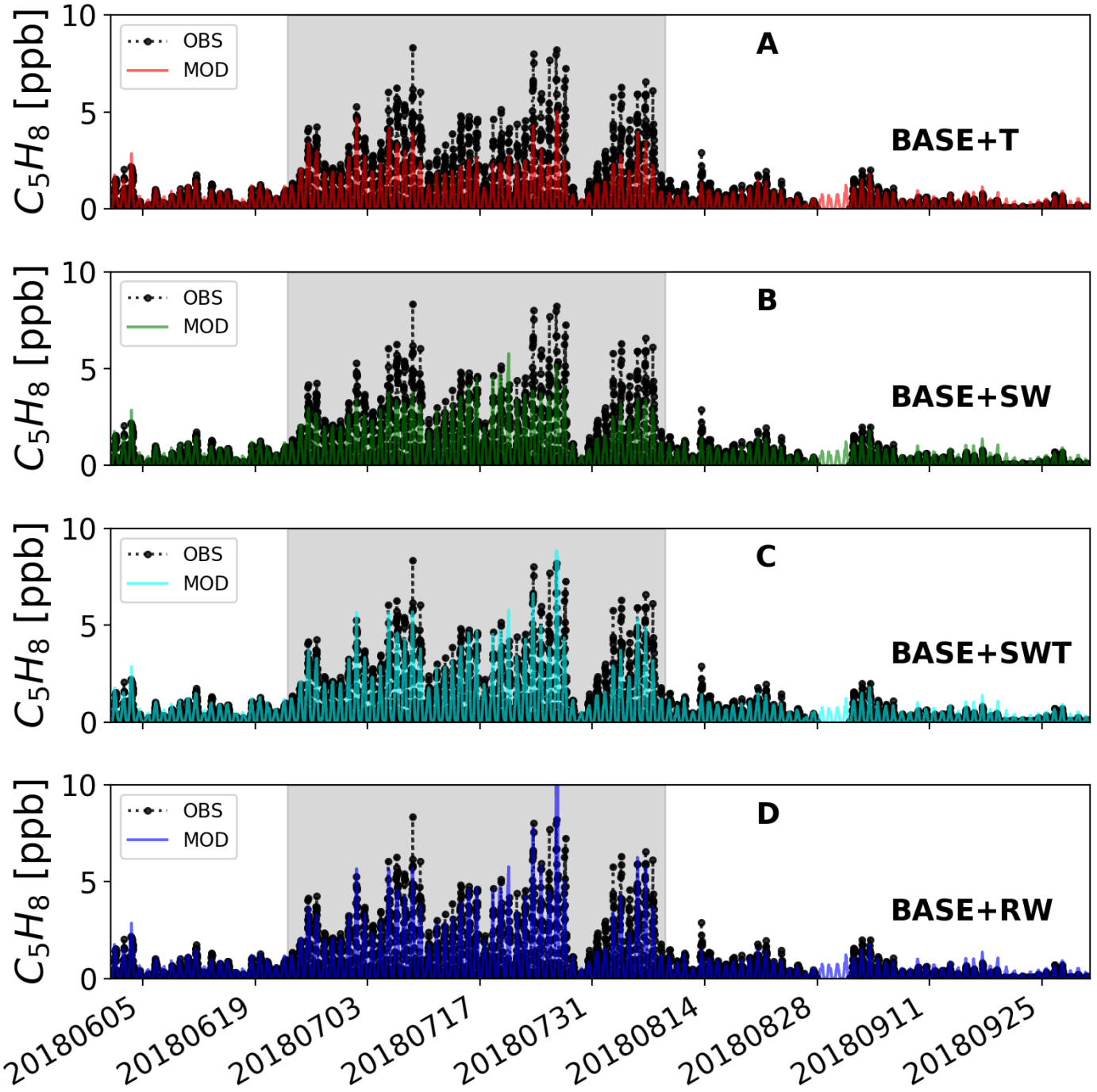
BASE +SWT

$$\gamma SWCiso = \left[\frac{(\theta - \theta w)}{(\theta c - \theta w)}\right]^{q} * \left[\frac{(T - T_{mean})}{(T_x - T_{mean})}\right]$$

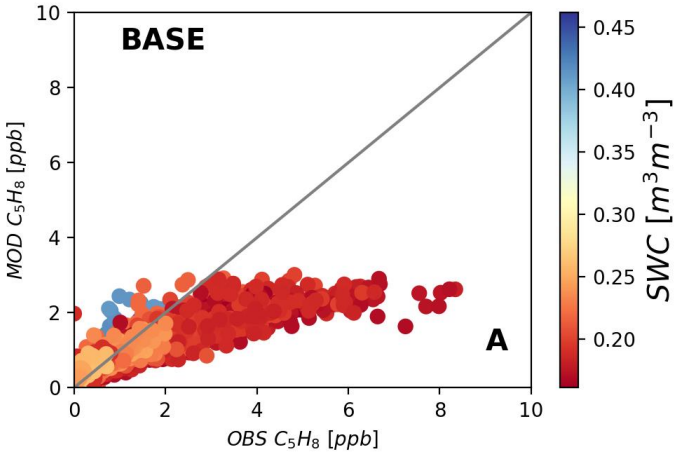
BASE +RW

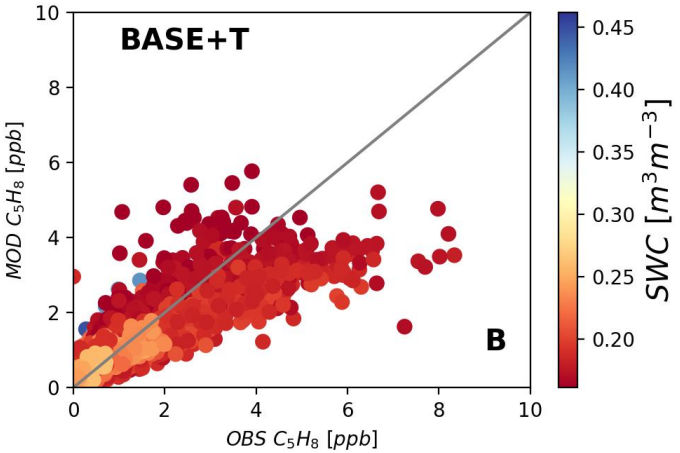
$$\gamma SWCiso = \left[\frac{(\theta - \theta w)}{(\theta c - \theta w)}\right]^{q} * \left[\frac{(T - T_{mean})}{(T_x - T_{mean})}\right] * f_{swc}$$

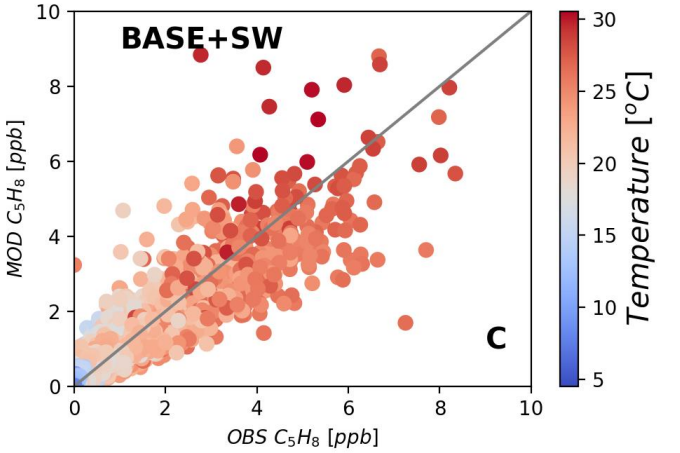
Results of Experiment

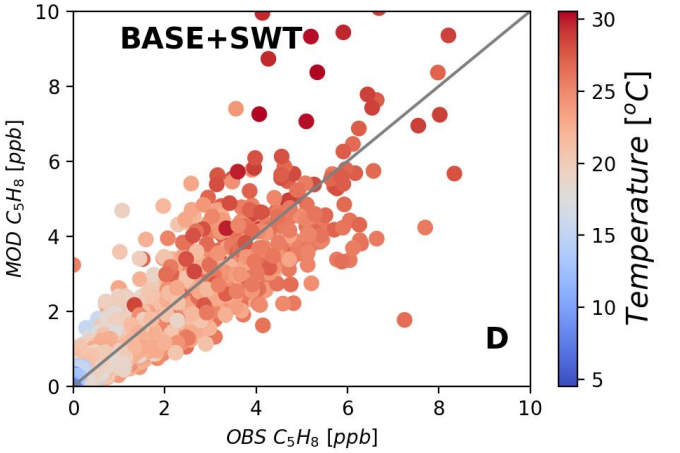


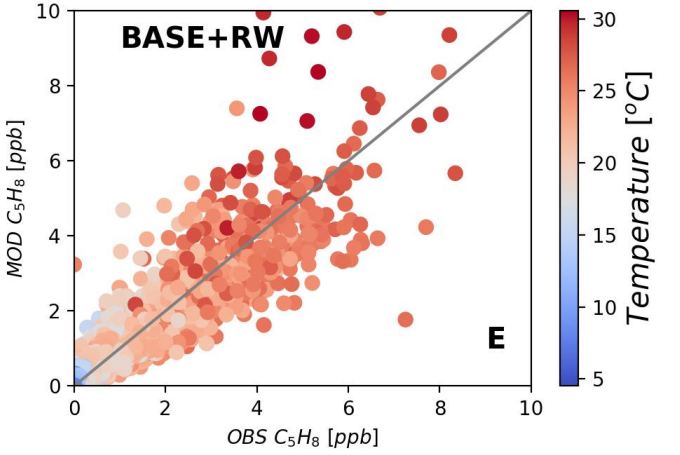
Results cont...



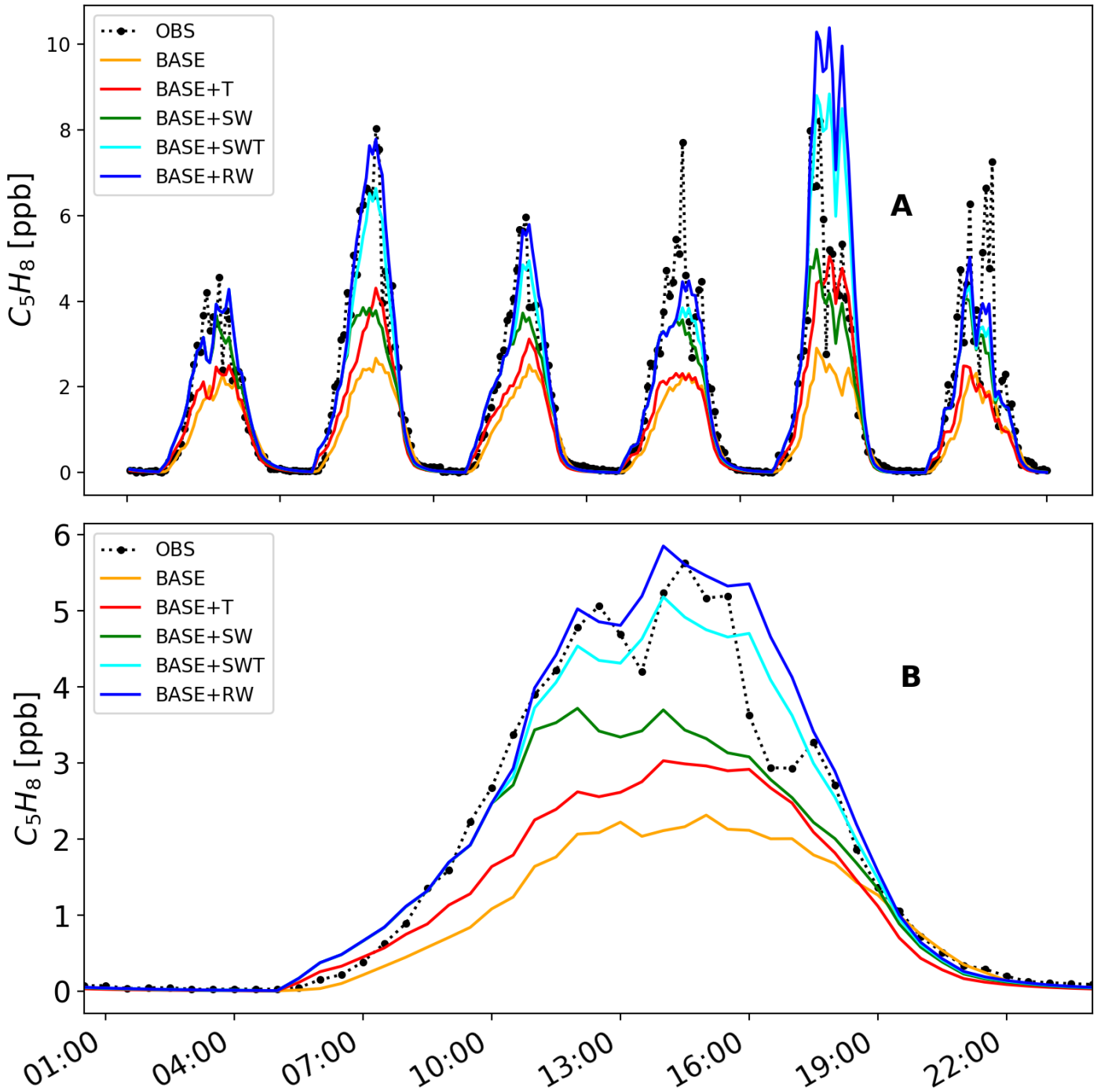








Results cont…



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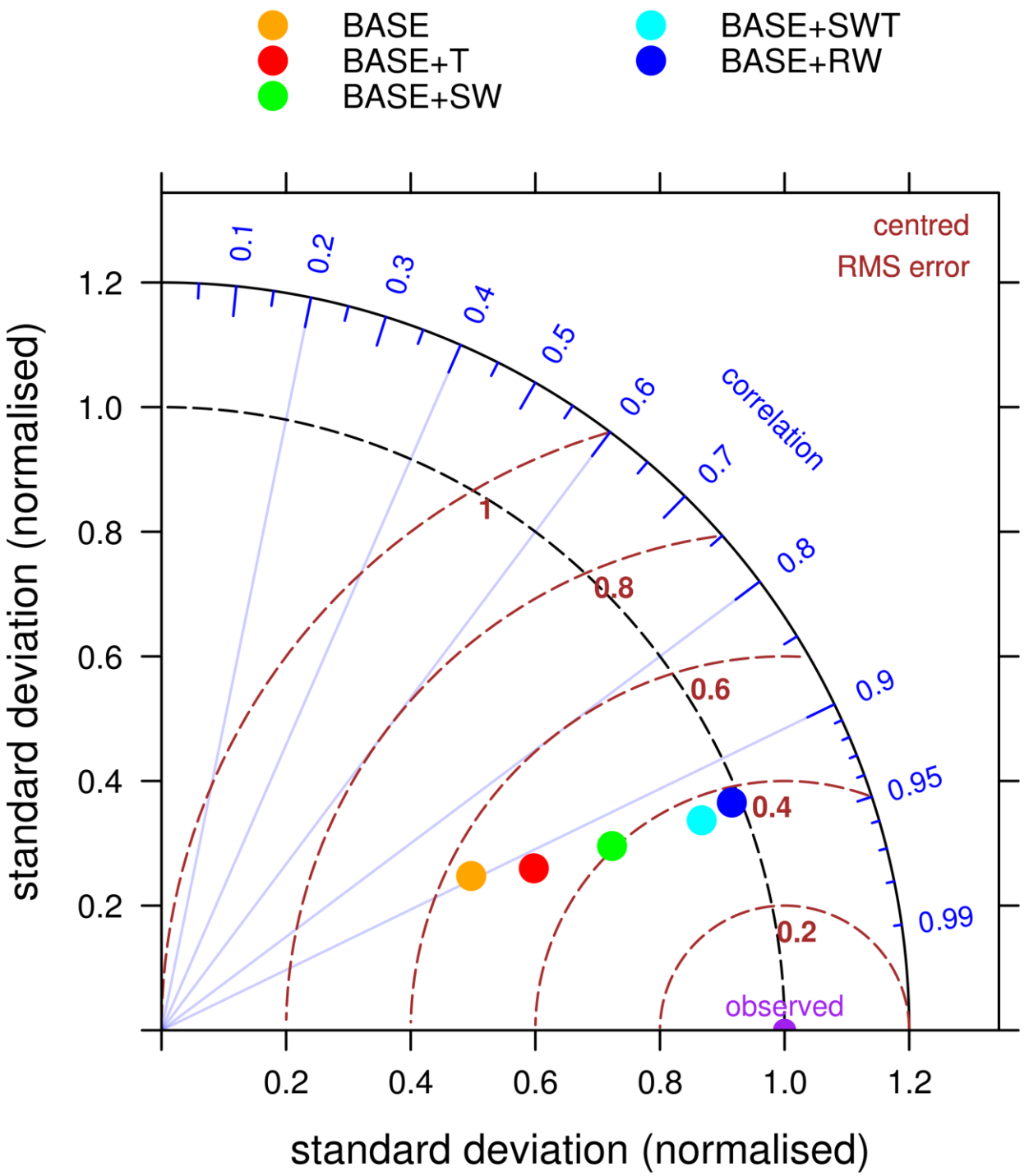

Summary

- The heatwave-drought of 2018 increased isoprene emissions/concentrations at Wytham by ~400%
- Emissions algorithm reproduces observed concentrations before and after the heatwave-drought but underestimate by ~40% during heatwave-drought
- Soil moisture and temperature stress algorithm improves model reproduction of observed concentrations