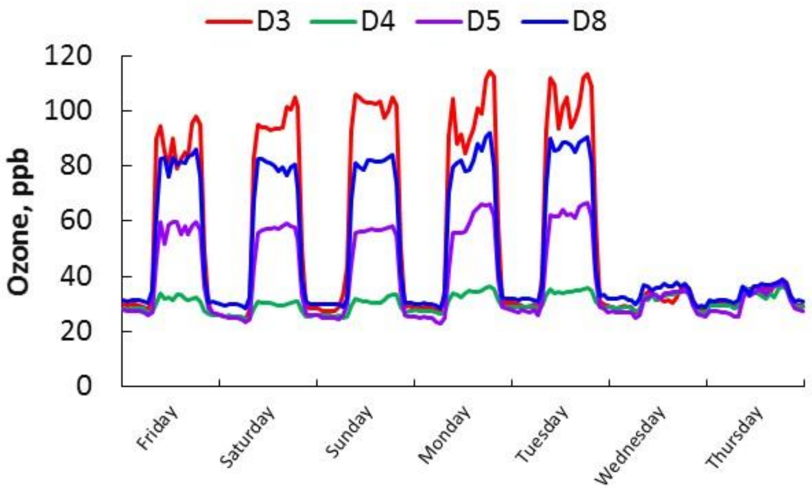
RESPONSE OF EUROPEAN WHEAT TO OZONE AND DROUGHT, AND APPLICATIONS FOR CROP MODELLING

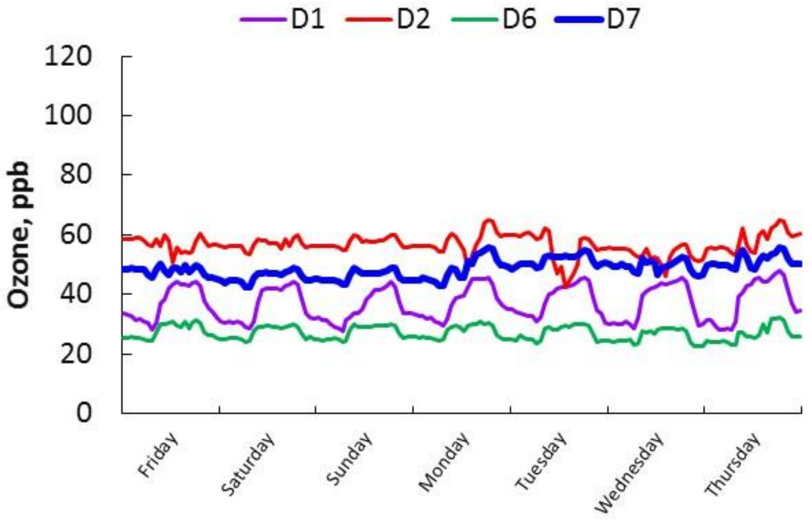
Steph Osborne, Gina Mills, Felicity Hayes, Katrina Sharps, Harry Harmens, Patrick Büker, Lisa Emberson

Centre for Ecology & Hydrology NATURAL ENVIRONMENT RESEARCH COUNCIL
SEI
UNIVERSITY of York
NERC SCIENCE OF THE ENVIRONMENT

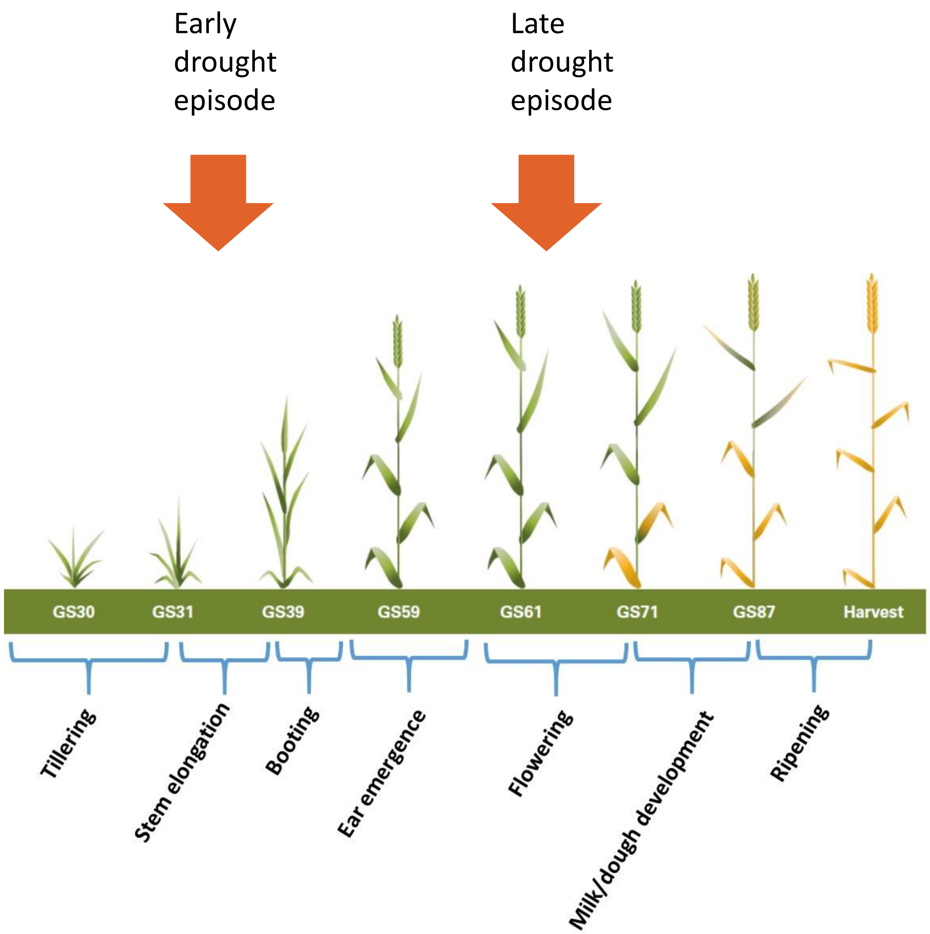
2015 Bangor O_3-wheat – two parallel experiments:

1. What is the response of wheat to O_3 exposure supplied as a peak or background profile?





2. What is the effect of an early and late drought event on wheat, and do drought and O_3 interact?

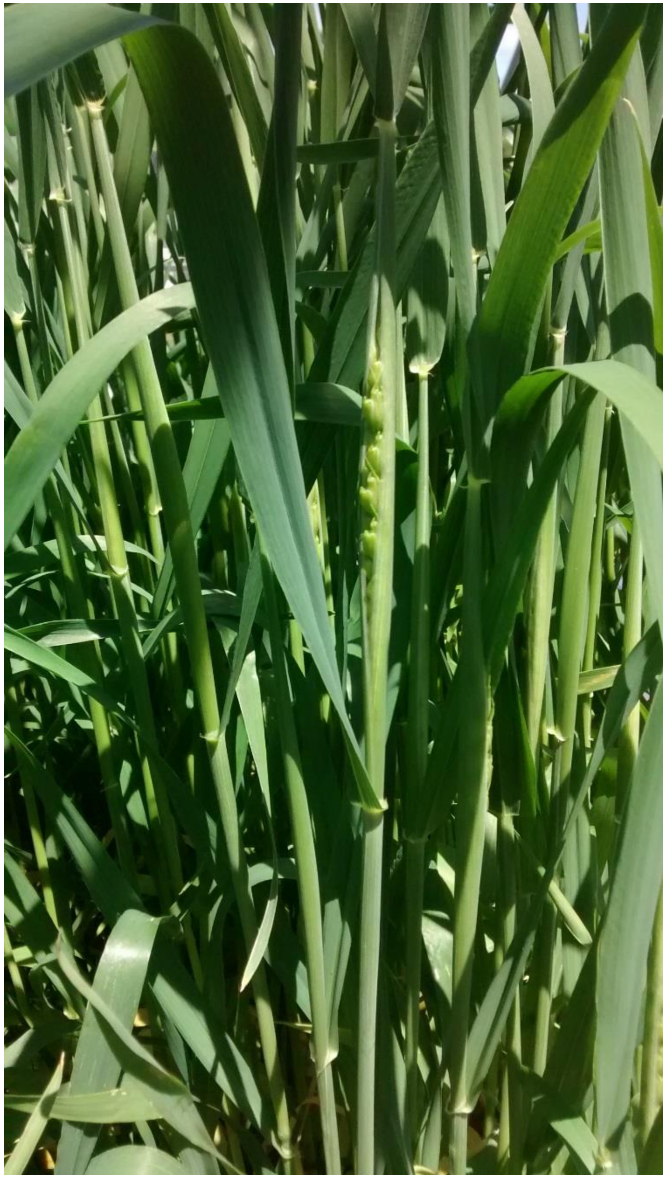


Drought/O_3 interaction experiment – research questions

1. **What would be the individual effects of ozone and drought on the yield and physiology of wheat?**

2. **Does the timing of the drought event affect the yield/physiology response – early versus late?**

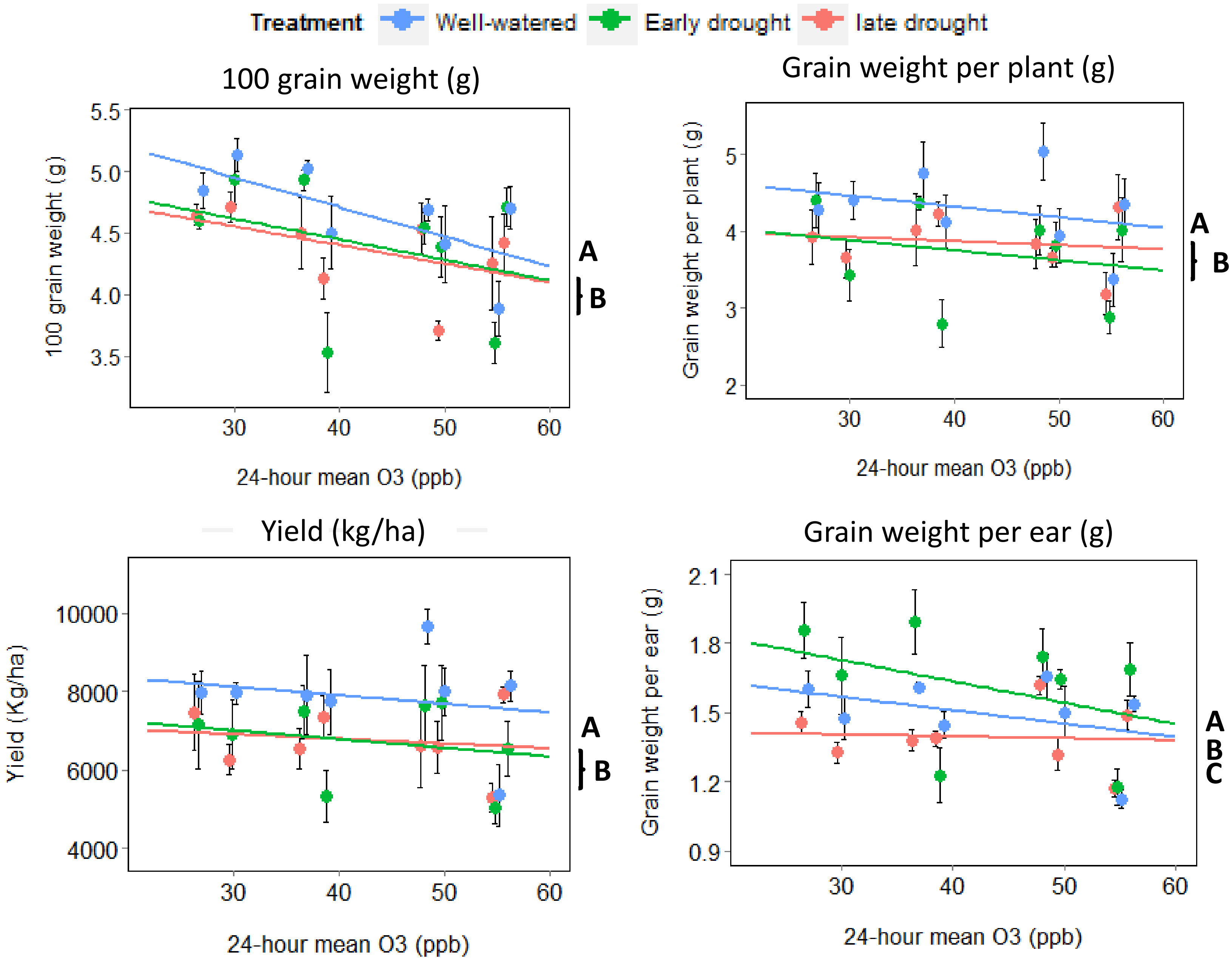
3. **Can we observe an interaction between the combined stresses of O_3 and drought?**



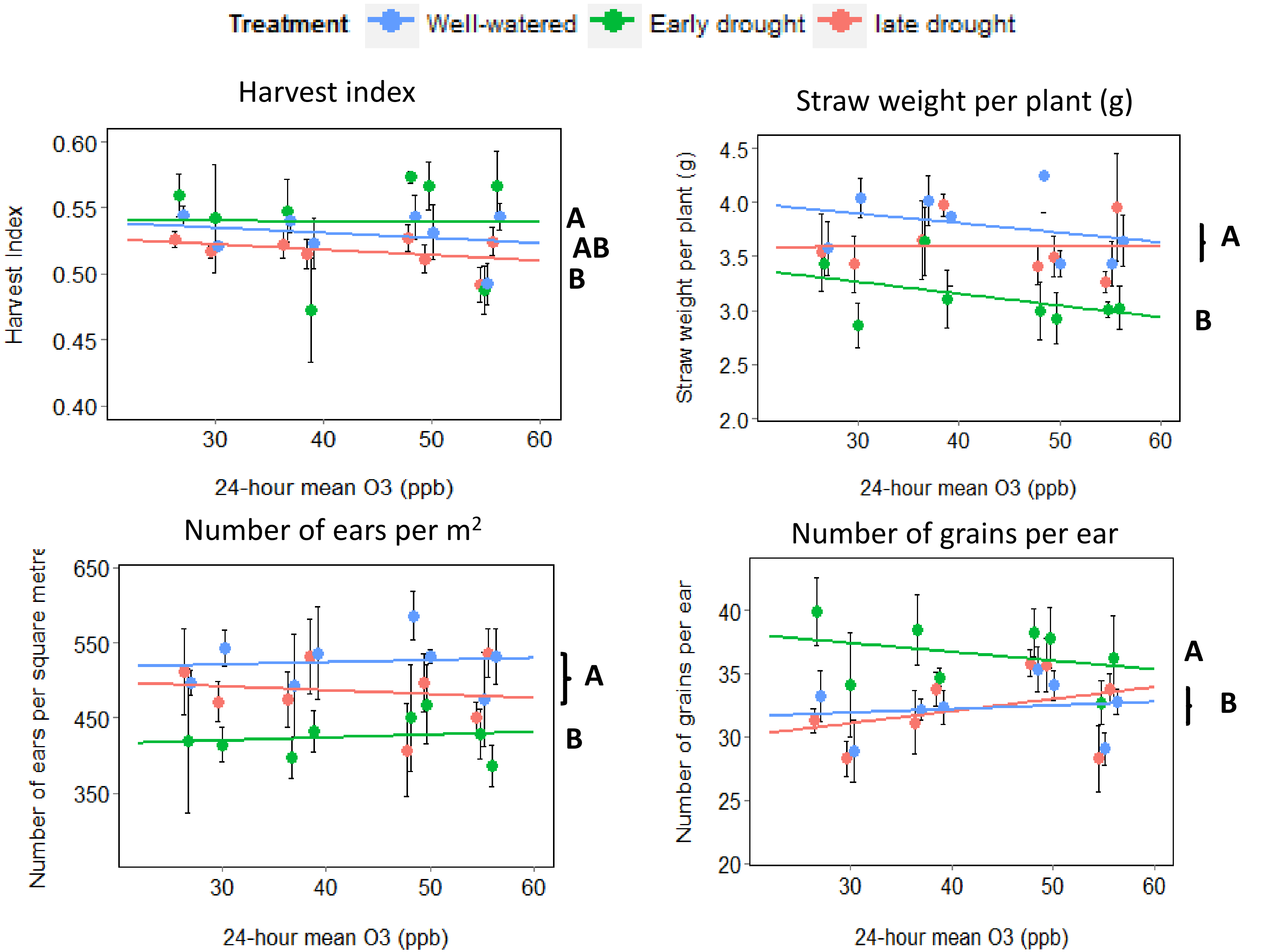
Experimental design

- Cultivar “Mulika”
- 8 solardomes
- 3 watering regimes per dome:
  - well-watered
  - early drought episode, May
  - late drought episode, July
- 4 pots per watering regime. 32-40 wheat plants per pot
- Physiological measurements in May, June and July, in four domes (two low, two high O_3)
- Growth stage assessments throughout the season
- Model selection in R to test for main effects and interactions of drought and O_3

Results – harvest variables



Results – harvest variables continued



Harvest variables - conclusions

- Both drought episodes reduced yield by a similar amount (early drought = - 14%, late drought = -16%).

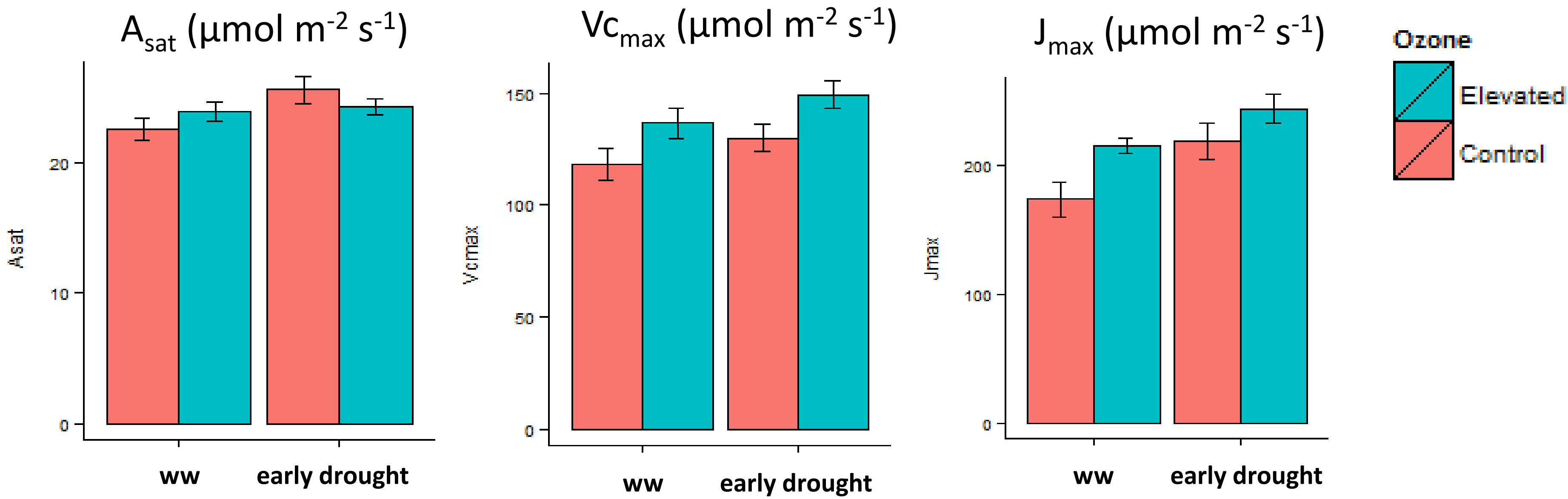
- Mechanism of yield reduction differed according to the timing of the drought:
  - Late drought reduced weight of individual grains
  - Early drought reduced the number of ears and individual weight of grains, but boosted the number of grains per ear

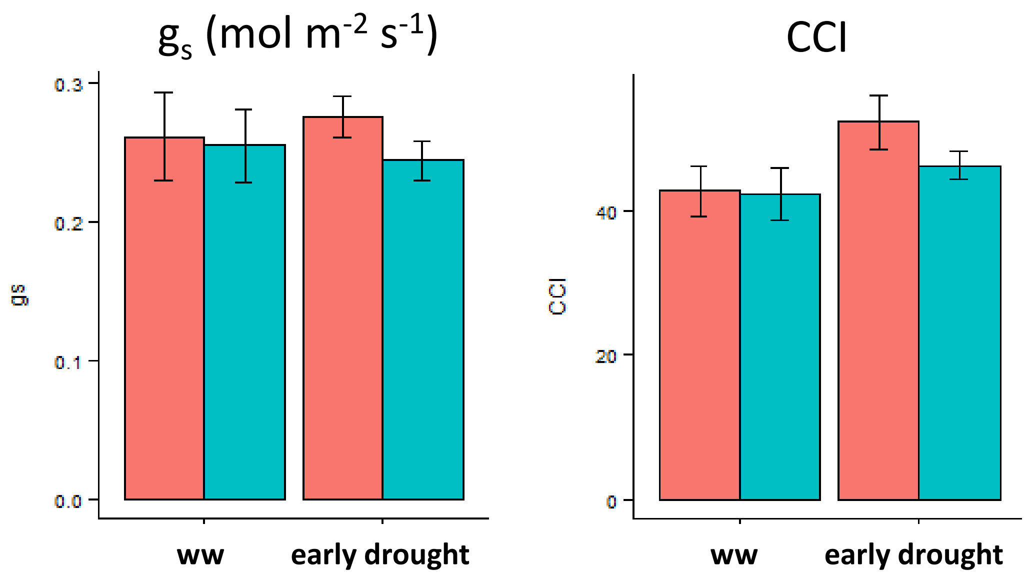
- A short (10 days) drought event can have a significant effect on yield in European wheat

- Ozone exposure does not appear to protect against, or exacerbate, the effects of drought; drought does not protect against the effects of O_3

- Would be interesting to repeat analysis with AOT40 and flux O_3 metrics, to take into account the difference in exposure related to the peak/background experimental design

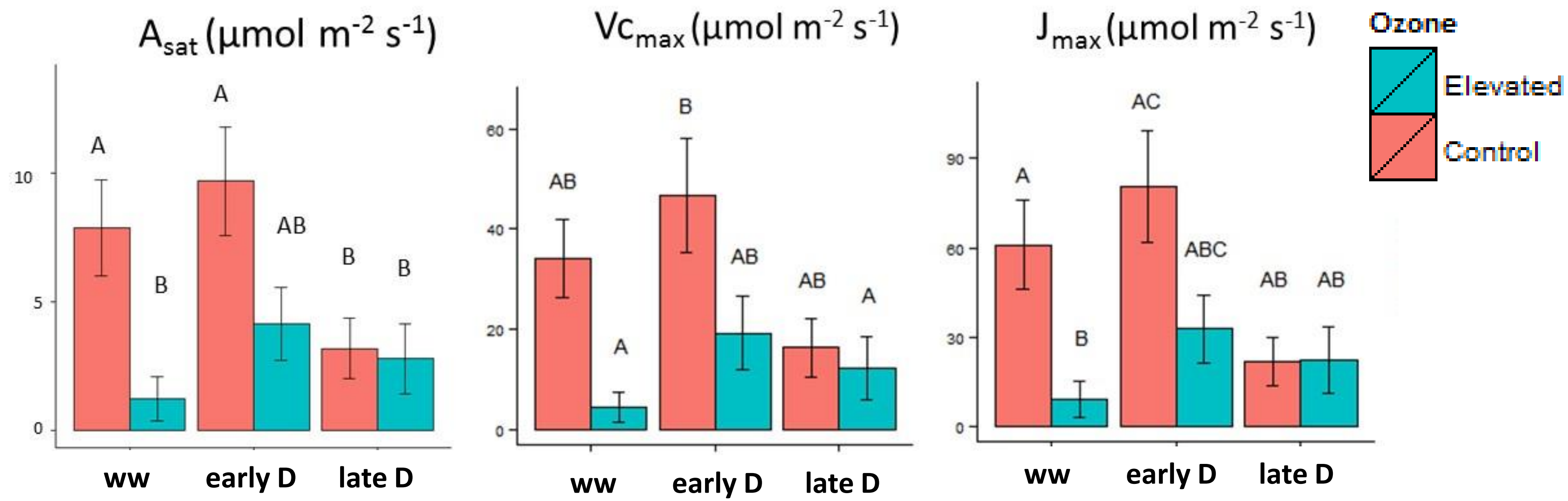
Results – physiological parameters, June timepoint

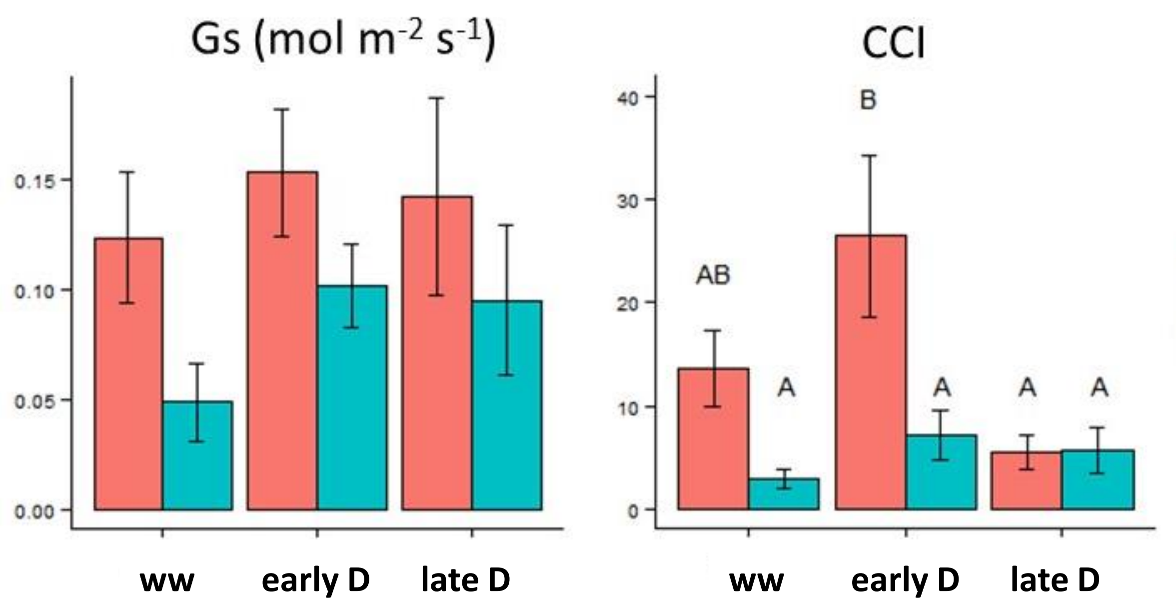




- Differences across treatments are small; most not statistically significant
- Higher Vc_{max} and J_{max} in elevated ozone treatment
- Higher J_{max} in early drought treatment – possibly related to higher CCI?

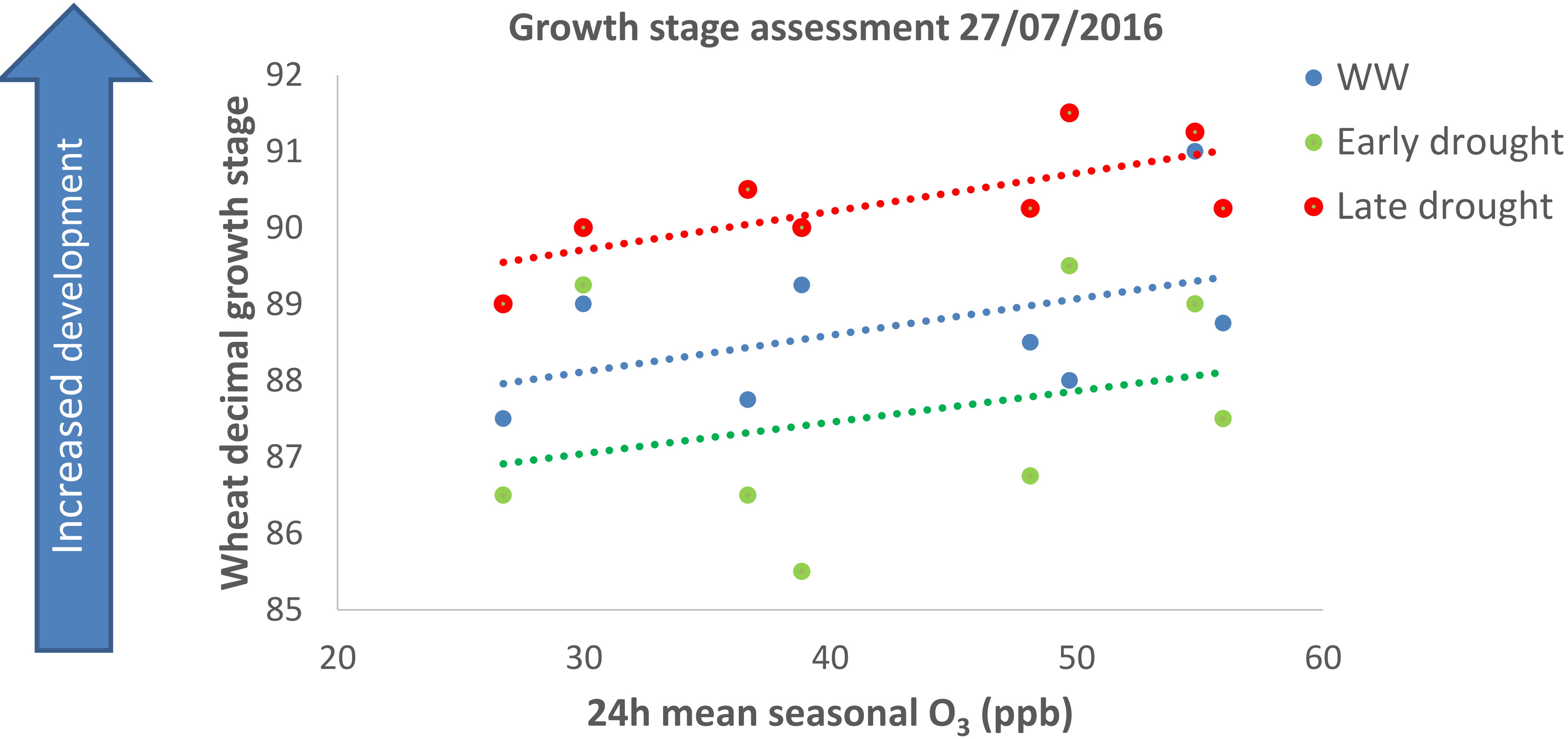
Results – physiological parameters, July timepoint





- Strong differences
- Drought a significant factor in most models – highest parameter values in early drought treatment
- Strong O_3 effect (ww, early drought)
- O_3 reduces conductance
- Photosynthetic parameters correlate most closely with CCI, not g_s

Can looking at growth stage progression help us interpret our results?



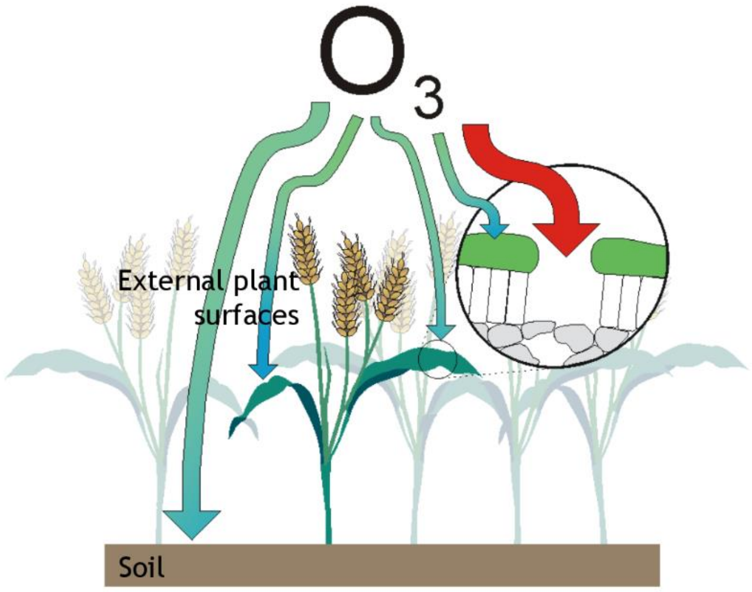
- Significant effect of O_3 on growth stage progression ($p = 0.04$)
- Significant effect of drought on growth stage progression ($p = 0.0002$)
- High O_3 and late drought episode accelerated progression; early drought slowed progression

Physiology results - Conclusions

- Few differences in June; a number of differences between treatments apparent in July
- Measured A_{sat} follows same pattern as V_{cmax}, J_{max} and CCI, but not g_s
- Ozone seen to reduce stomatal conductance in the July data
- Effect of drought and O_3 on growth stage progression/senescence may have driven the patterns we observed in physiology – supported by the Chlorophyll Content Index and growth stage results

Next stages: Application of physiology data in DO_3SE development

- New DO_3SE formulation in development which will incorporate O_3 effects on photosynthesis (short and long-term) into the calculation of flux
- O_3 will influence rate of photosynthesis by modifying the activity of Rubisco (Vc_{max})
- Will simulate photosynthesis, conductance, assimilated carbon
- Species/cultivar-specific parameterisation via the parameters Vc_{max}, J_{max}, R_d, gsto_0, m



Multiplicative
(Jarvis; Emberson, 2000 etc..)

$$g_{sto} = g_{max} [\min(f_{phen}, f_{O3})] * f_{light} * \max\{f_{min}, (f_{temp} * f_{VPD} * f_{SWP})\}$$

Photosynthesis-based
(Farquhar, 1980 & Leuning, 1990)

$$g_{sto} = g_{sto.0} + m.\frac{A_{net}.h_s}{c_s}$$

Data collection for DO_3SE parameterisation: Varanasi, India, Feb 2016

- Parameterisation for European wheat cultivar using Mulika Parameters, Bangor 2015

- Parameterisation for Indian cultivar “HD-3118”, using parameters measured in Feb 2016

- Possibility of converting assimilated carbon output to yield using allocation ratios

- Part of a wider project to integrate the effects of O_3, N, H_2O, CO_2 and climate extremes in estimates of O_3 damage (CiXPAG)

Thank you for listening!

stepo@ceh.ac.uk

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