Developing a New Winter Wheat Crop in JULES-Crop

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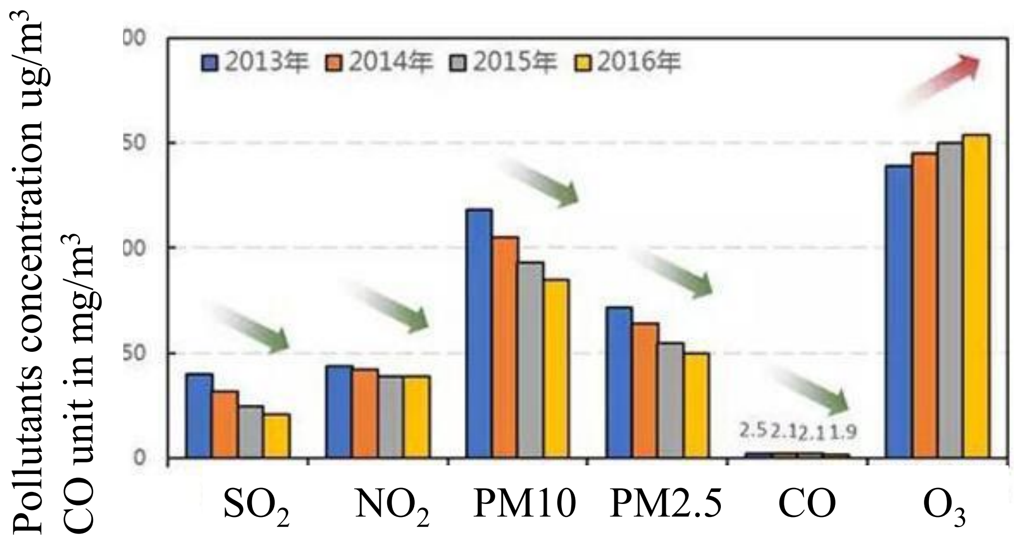
7 – 11th September JULES Science Meeting

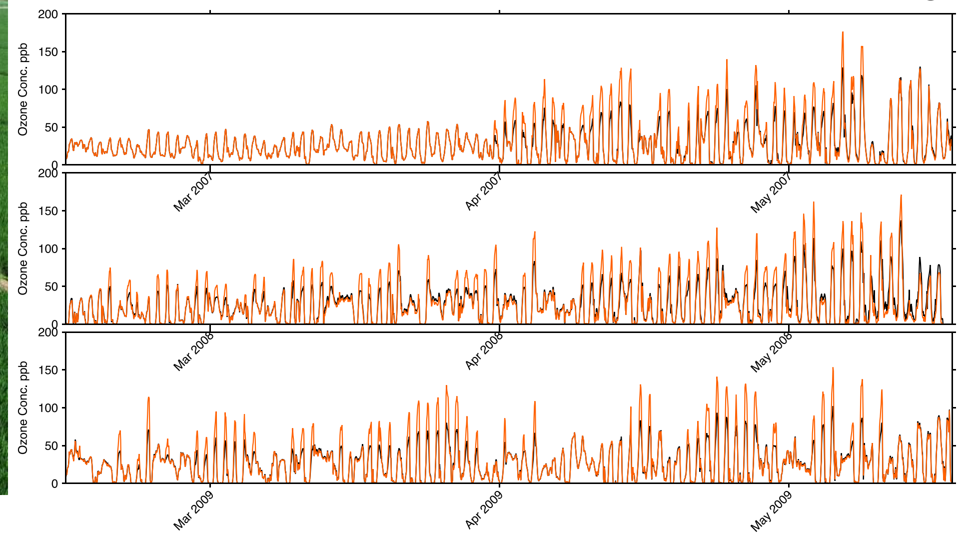
Ozone in China



2013-2016 6 major pollutants for 74 cities over China.

FACE-O3 Experiment

Black – Ambient O_3
Orange – Elevated O_3

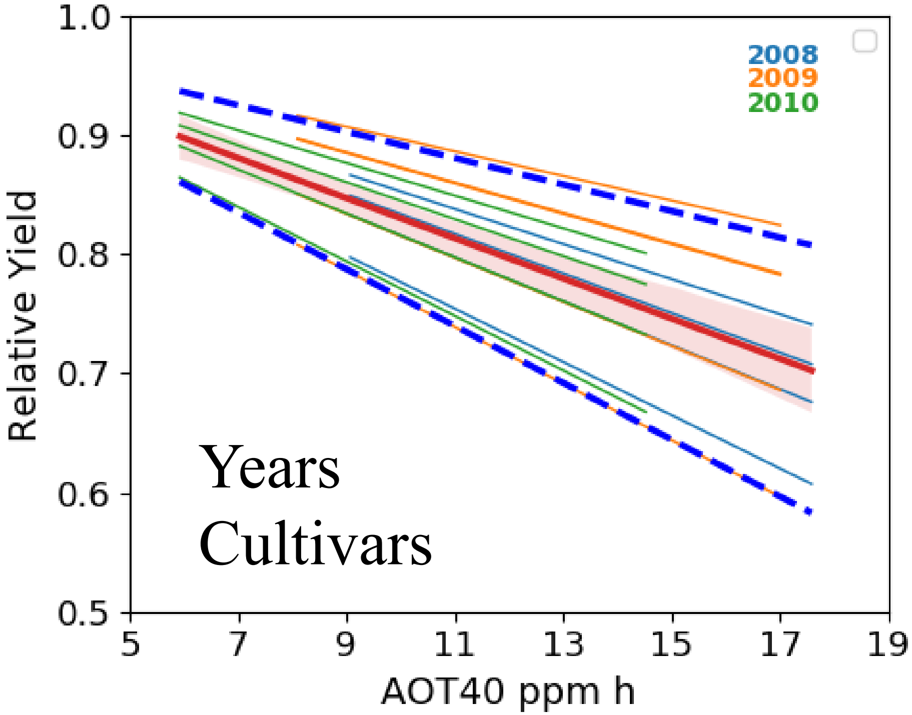


Location: Xiaoji town, Jiangdu county, Jiangsu Province, China (119°42′0″ E, 32°35′5″ N)

- Target E-O_3 is 50% more than A-O_3
- four replicates for each O_3 level
- Plots were separated from each other at least 70m (avoid cross-contamination)

Sensitivity of yield to cultivars and ozone

Observed RY vs Ozone (AOT40)



$$A_{net} = A_P F$$

$$F = 1 - a * max[F_{O3} - F_{O3crit}, 0.0]$$

Vcmax

➢**Calibration:** FACE LI-COR measurements (Winter wheat)

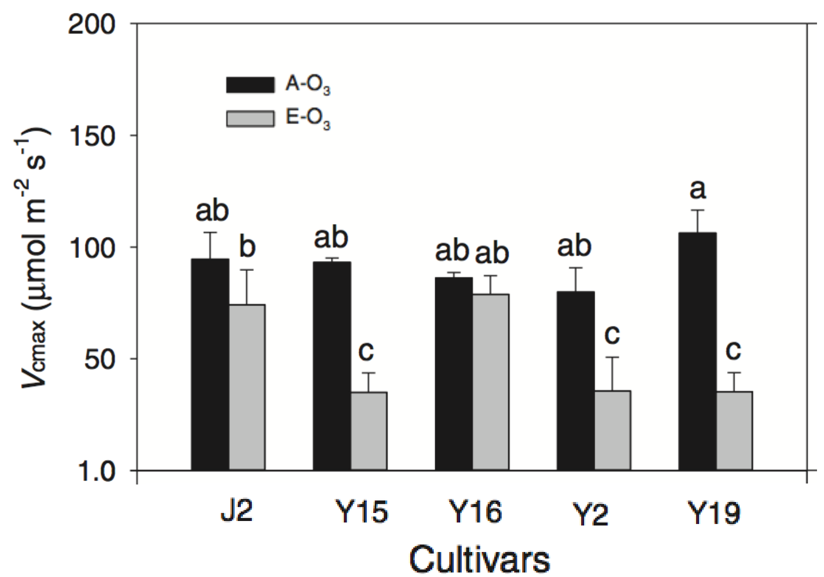
$$Max\ rate\ of\ carboxylation = quantum\ efficiency * top\ leaf\ [N]$$
$$Vc_{max} = \mathrm{neff} * \mathrm{nl0}$$

Vcmax (umol m^{-2} s^{-1})	BET-Tr	BET-Te	BDT	NET	NDT	C_3	C_4	Esh	DSh	Wheat	Soybean	Maize	Rice
neff	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0004	0.0008	0.0008	0.0008	0.0008	0.0004	0.0008
n10	0.046	0.046	0.046	0.033	0.033	0.073	0.06	0.06	0.06	0.073	0.073	0.06	0.073
JULES Vcmax (umol m-2s-1)	36.8	36.8	36.8	26.4	26.4	58.4	24	48	48	58.4	58.4	24	58.4
TRY database Vcmax	55	61.5	41-57	62.5-62.6	39.1	78.2	51.6	61.7	54	100.7	100.7	100.7	100.7

Table 1 PFT (plant functional type)-specific photosynthetic parameters. V_{cmax25}^{kattge} is the realized V_{cmax25} values obtained from Kattge et al. (2009); f_1(N) is the prescribed nitrogen limitation factor used in CLM4.5, while f_2(N) is from CLM4.0; and V_{cmax25}^{opt}, which represents the potential values for V_{cmax25}, is given by $V_{cmax25}^{opt} = V_{cmax25}^{kattge} / f_2(N)$.

Plant functional type	V_{cmax25}^{kattge}	f_1(N)	f_2(N)	V_{cmax25}^{opt}
Needleleaf evergreen tree, temperate	62.5	1	0.72	86.8
Needleleaf evergreen tree, boreal	62.6	1	0.78	80.2
Needleleaf deciduous tree, boreal	39.1	1	0.79	49.5
Broadleaf evergreen tree, tropical	55.0	1	0.83	66.3
Broadleaf evergreen tree, temperate	61.5	1	0.71	86.8
Broadleaf deciduous tree, tropical	41.0	1	0.66	62.1
Broadleaf deciduous tree, temperate	57.7	1	0.64	90.1
Broadleaf deciduous tree, boreal	57.7	1	0.70	82.4
Broadleaf evergreen shrub, temperate	61.7	1	0.62	99.5
Broadleaf deciduous shrub, temperate	54.0	1	0.60	90.0
Broadleaf deciduous shrub, boreal	54.0	1	0.76	71.0
C3 grass, arctic	78.2	1	0.68	115.0
C3 grass	78.2	1	0.61	128.1
C4 grass	51.6	1	0.64	80.6
Crop	100.7	1	0.61	165.1

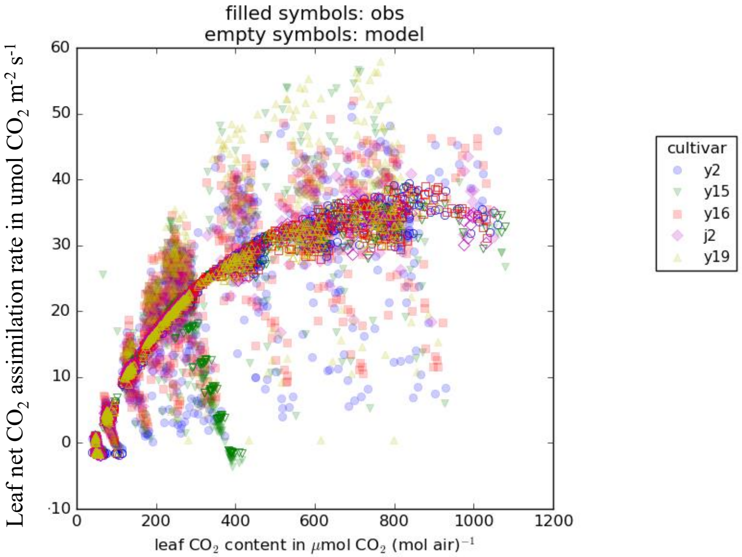
TRY – a global database of plant traits



The maximum carboxylation (Vcmax) measurement at the mid-grain filling stage under ambient [O3] and elevated [O3] (Feng et al., 2016)

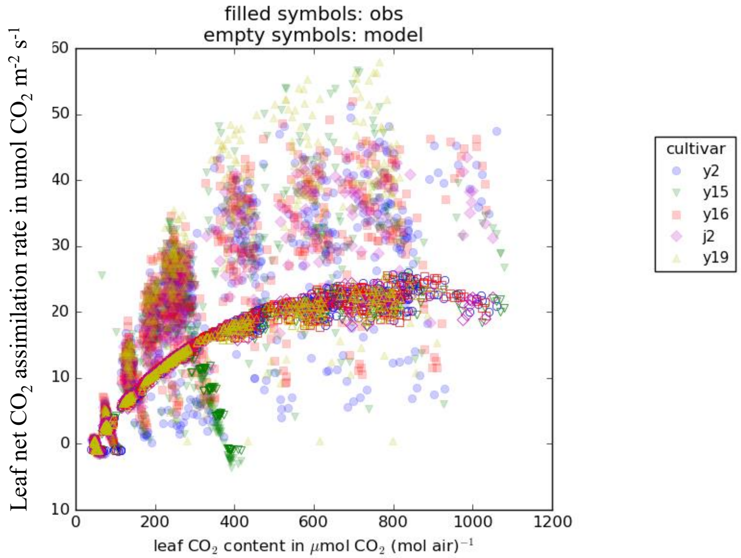
Calibrated A-Ci plot

Calibrated



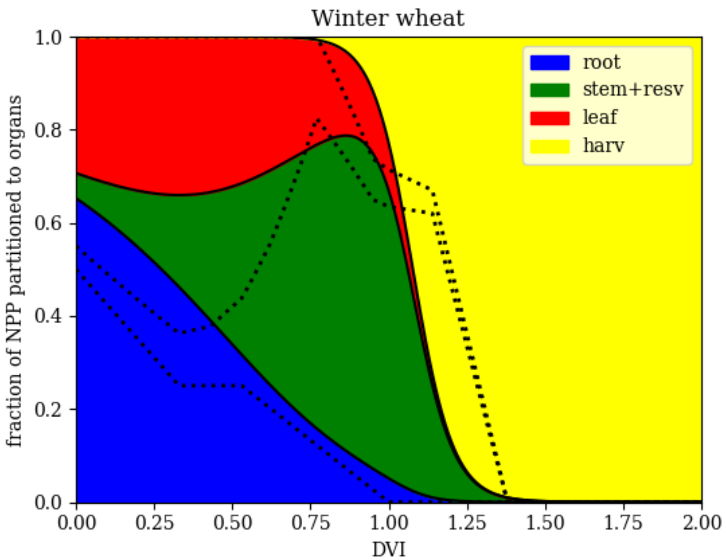
date(dd/mm/year)	Treatment	Tleaf	Ci	Photo	Cond	Trmmol	VpdL
24052008	F1-Y16-A	27.08	523	11.1	0.296	3.21	1.09
24052008	F1-Y16-A	27.11	714	12.2	0.301	3.28	1.09
24052008	F1-Y16-A	27.21	903	13.2	0.295	3.27	1.11
24052008							
24052008	F3-Y2-C	27.51	320	3.48	0.109	1.37	1.23
24052008	F3-Y2-C	27.49	261	2.19	0.111	1.39	1.23
24052008	F3-Y2-C	27.5	177	1.32	0.116	1.44	1.22
24052008	F3-Y2-C	27.57	95.5	0.0642	0.113	1.43	1.24
24052008	F3-Y2-C	27.63	65.1		0.114	1.45	1.25

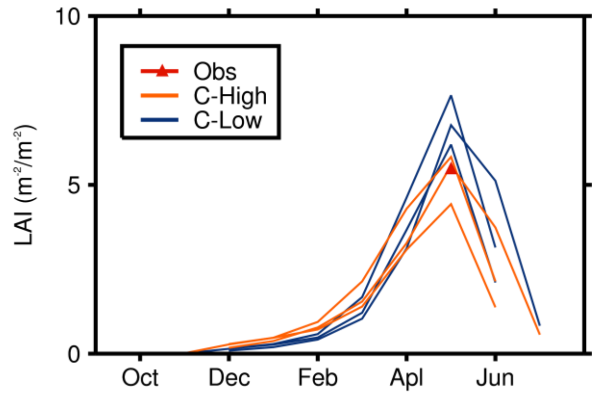
Default



	Calibrated	Default
neff	1.2E-3	8.00E-4
nl0	0.083	0.073
Vcmax	95.78	58.4

Calibration





$$L = \frac{C_{\mathrm{leaf}}}{f_{\mathrm{C}}}\mathrm{SLA}$$

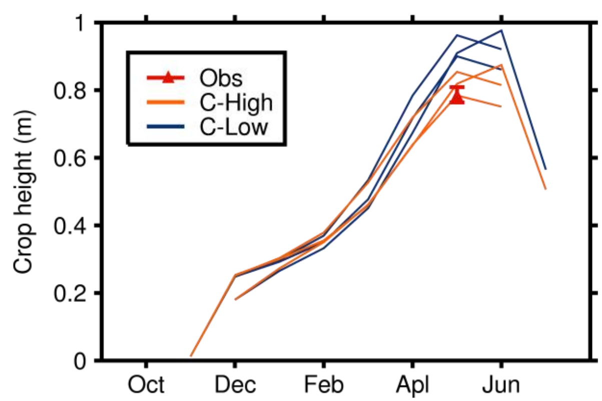
$$\mathrm{SLA} = \gamma\,(\mathrm{DVI} + 0.06)^{\delta}$$

$$p_{\mathrm{root}} = \frac{e^{\alpha_{\mathrm{root}} + (\beta_{\mathrm{root}}\mathrm{DVI})}}{e^{\alpha_{\mathrm{root}} + (\beta_{\mathrm{root}}\mathrm{DVI})} + e^{\alpha_{\mathrm{stem}} + (\beta_{\mathrm{stem}}\mathrm{DVI})} + e^{\alpha_{\mathrm{leaf}} + (\beta_{\mathrm{leaf}}\mathrm{DVI})} + 1},$$

$$p_{\mathrm{stem}} = \frac{e^{\alpha_{\mathrm{stem}} + (\beta_{\mathrm{stem}}\mathrm{DVI})}}{e^{\alpha_{\mathrm{root}} + (\beta_{\mathrm{root}}\mathrm{DVI})} + e^{\alpha_{\mathrm{stem}} + (\beta_{\mathrm{stem}}\mathrm{DVI})} + e^{\alpha_{\mathrm{leaf}} + (\beta_{\mathrm{leaf}}\mathrm{DVI})} + 1},$$

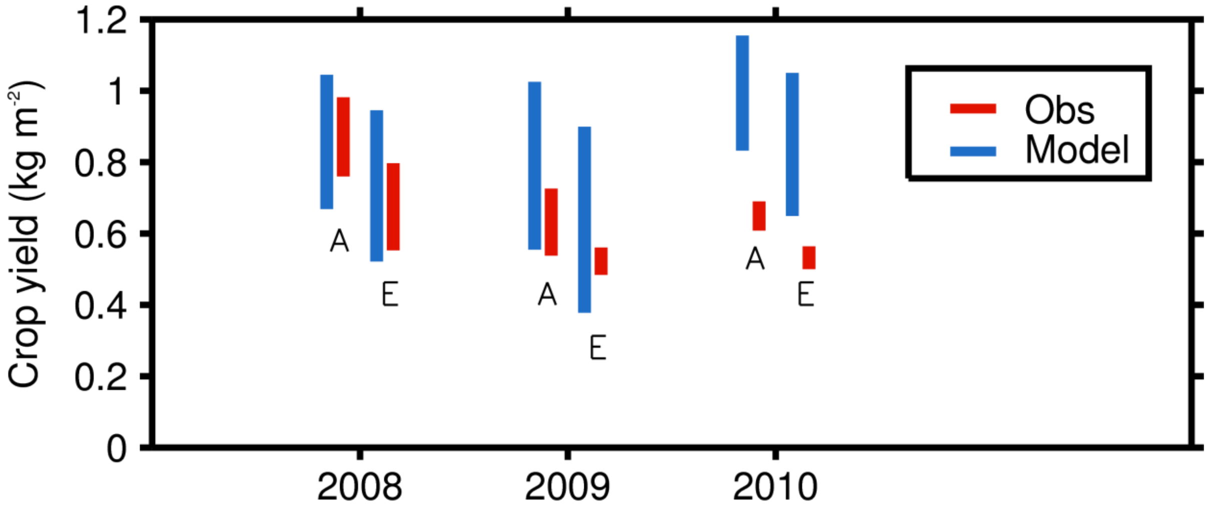
$$p_{\mathrm{leaf}} = \frac{e^{\alpha_{\mathrm{leaf}} + (\beta_{\mathrm{leaf}}\mathrm{DVI})}}{e^{\alpha_{\mathrm{root}} + (\beta_{\mathrm{root}}\mathrm{DVI})} + e^{\alpha_{\mathrm{stem}} + (\beta_{\mathrm{stem}}\mathrm{DVI})} + e^{\alpha_{\mathrm{leaf}} + (\beta_{\mathrm{leaf}}\mathrm{DVI})} + 1},$$

$$p_{\mathrm{harv}} = \frac{1}{e^{\alpha_{\mathrm{root}} + (\beta_{\mathrm{root}}\mathrm{DVI})} + e^{\alpha_{\mathrm{stem}} + (\beta_{\mathrm{stem}}\mathrm{DVI})} + e^{\alpha_{\mathrm{leaf}} + (\beta_{\mathrm{leaf}}\mathrm{DVI})} + 1},$$



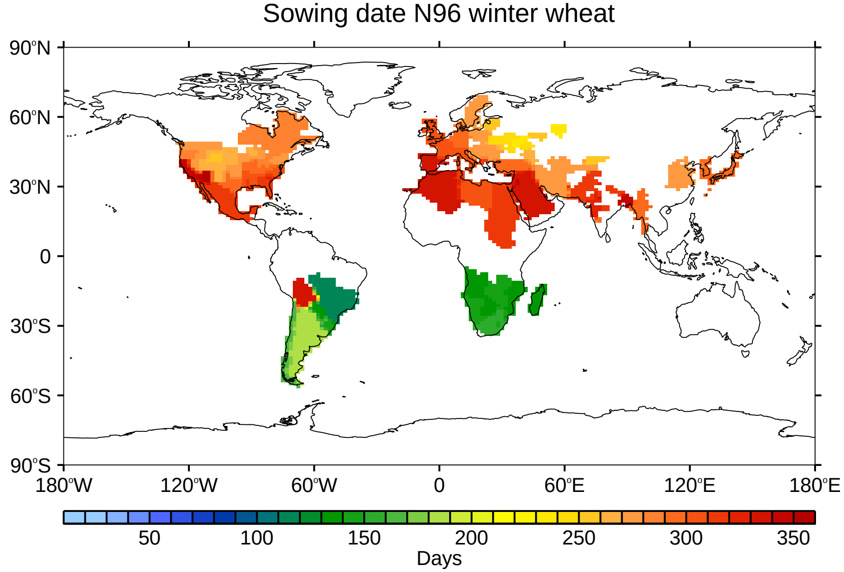
$$h = \kappa\left(\frac{C_{\mathrm{stem}}}{f_{\mathrm{C}}}\right)^{\lambda}.$$

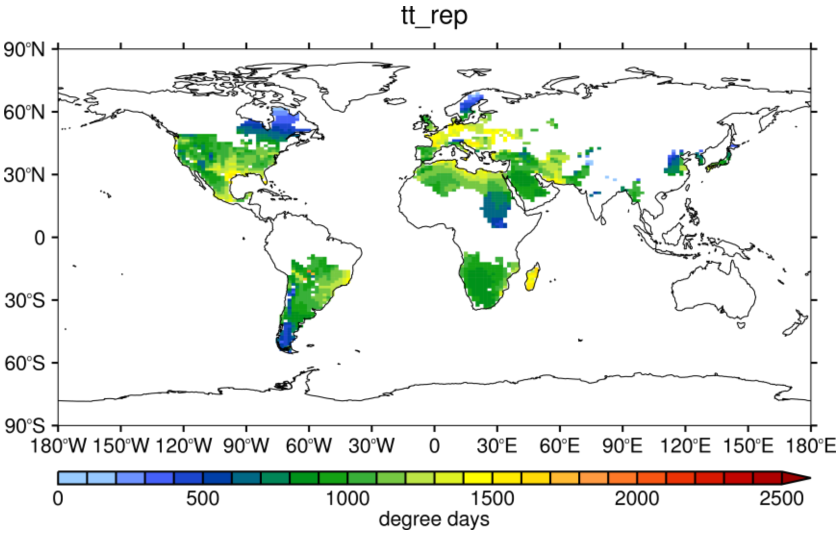
Calibration - Yield



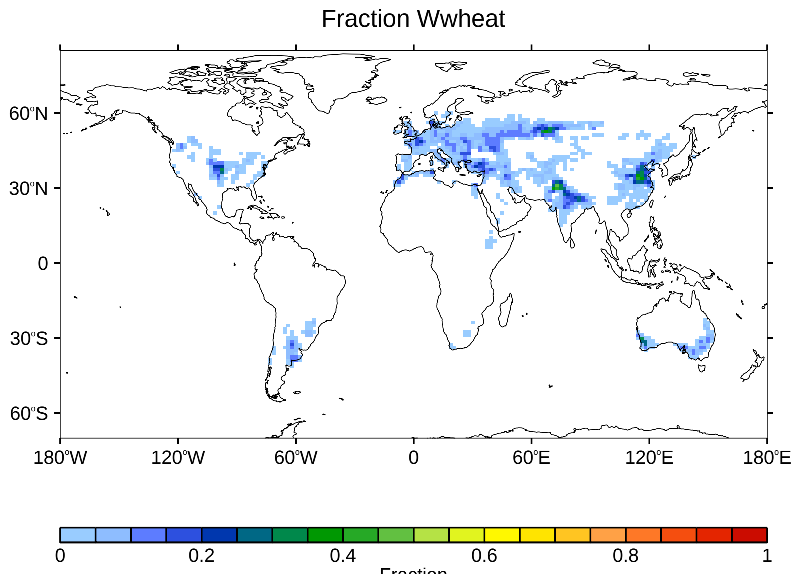
Winter wheat harvested area – MIRCA2000

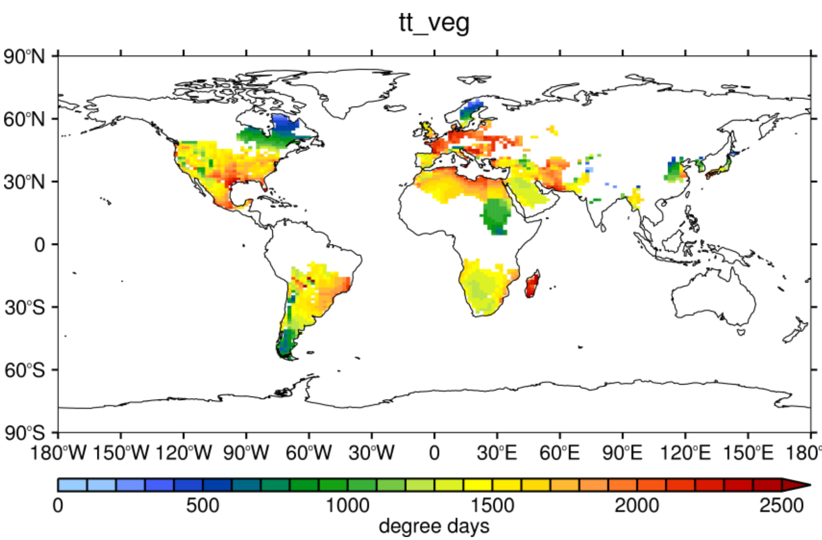
MIRCA2000 resolution





N96

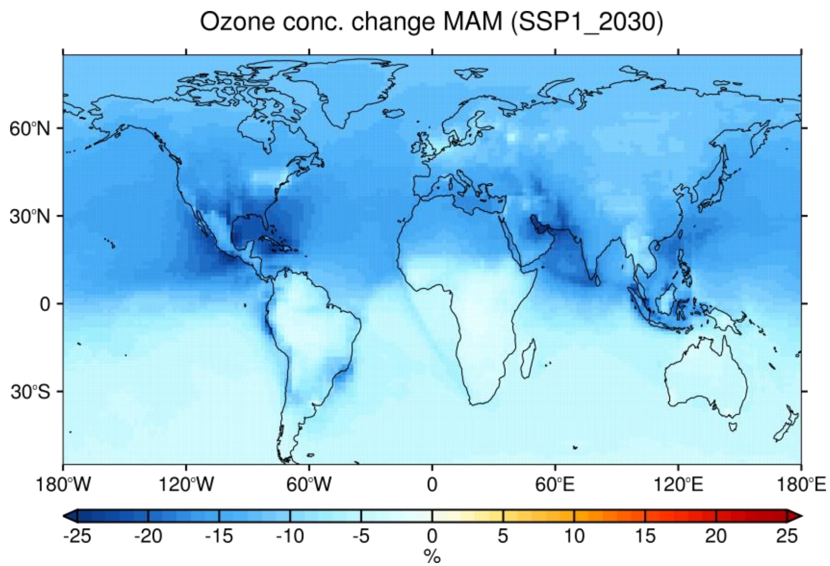


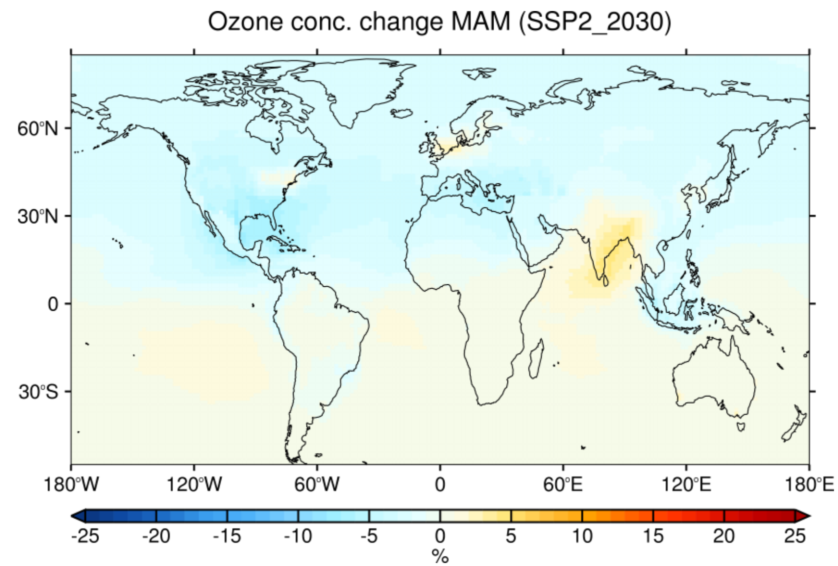


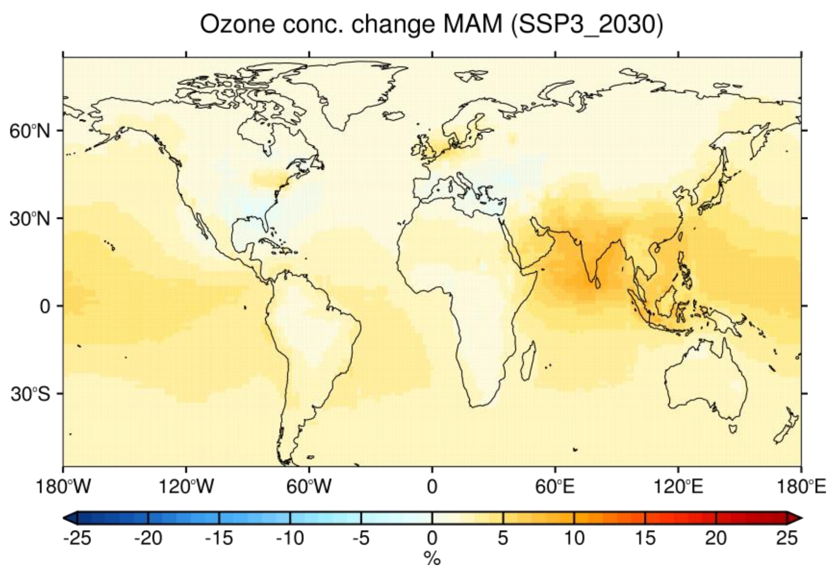
Shared Socioeconomic Pathways (SSPs)

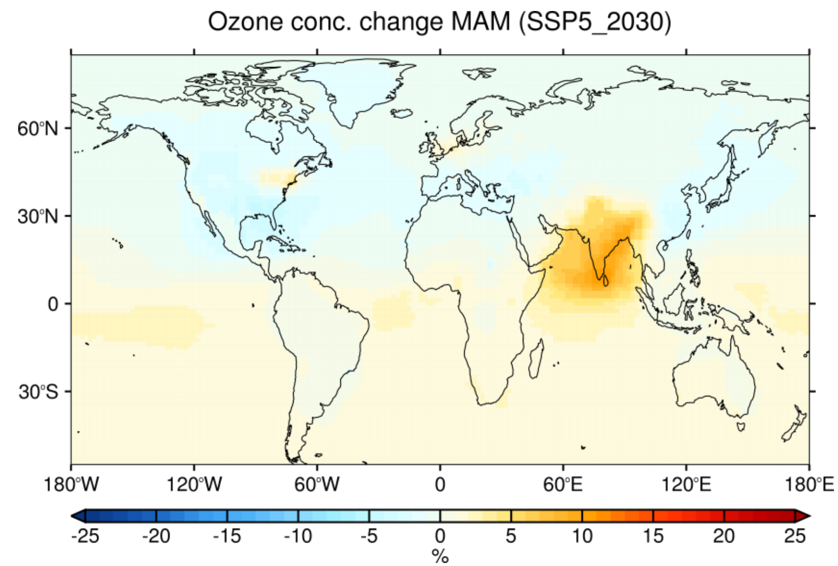
SSP1	The Green Approach World shifts toward a more sustainable path of inclusive development and respecting the environmental
SSP2	Continue on the same path The world follows a path in which social, economic, and technological trends do not shift markedly from historical patterns
SSP3	Increased degradation Slow economic development, increased interest in regional identity, weak global institutions and barriers to trade particularly in energy and resources. Ineffective at tackling environmental concerns.
SSP5	Fossil-fueled development Strong economic success with energy intensive lifestyles driving high fossil-fuel usage. Competitive integrated global markets but only local approaches to environmental issues.

AQP – Ozone Conc. Mar/Apr/May (2030)









JULES simulation of yield change for 2010

JULES output results

AVE	Percentage $Y_{O3}-Y_{noO3}$	Abs Mg ha^{-1} $Y_{O3}-Y_{noO3}$
AVE	-35.24	-4.37
High	-46.44	-5.18
Low	-26.31	-3.30

FACE-O3 experiment results:
Yield reduction (i.e. $Y_{O3}-Y_{noO3}$)
-34.7% to -12.8%

JULES projections of yield change

2030

Cultivar effect

Pathway	Yield Change (%)		
	High	Low	Ave
SSP1	17.92	7.95	12.47
SSP2	2.35	1.19	1.62
SSP3	-5.38	-2.78	-3.84
SSP5	3.15	1.61	2.37

Pathway effect

Future work:
JULES-crop and FACE-O3 rice

if you want to be involved, contact h.yang@greenwich.ac.uk

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