Update on Research at Cornell

Fires in the CCSM

- Sylvia Kloster, Natalie Mahowald, Jim Randerson

Motivation

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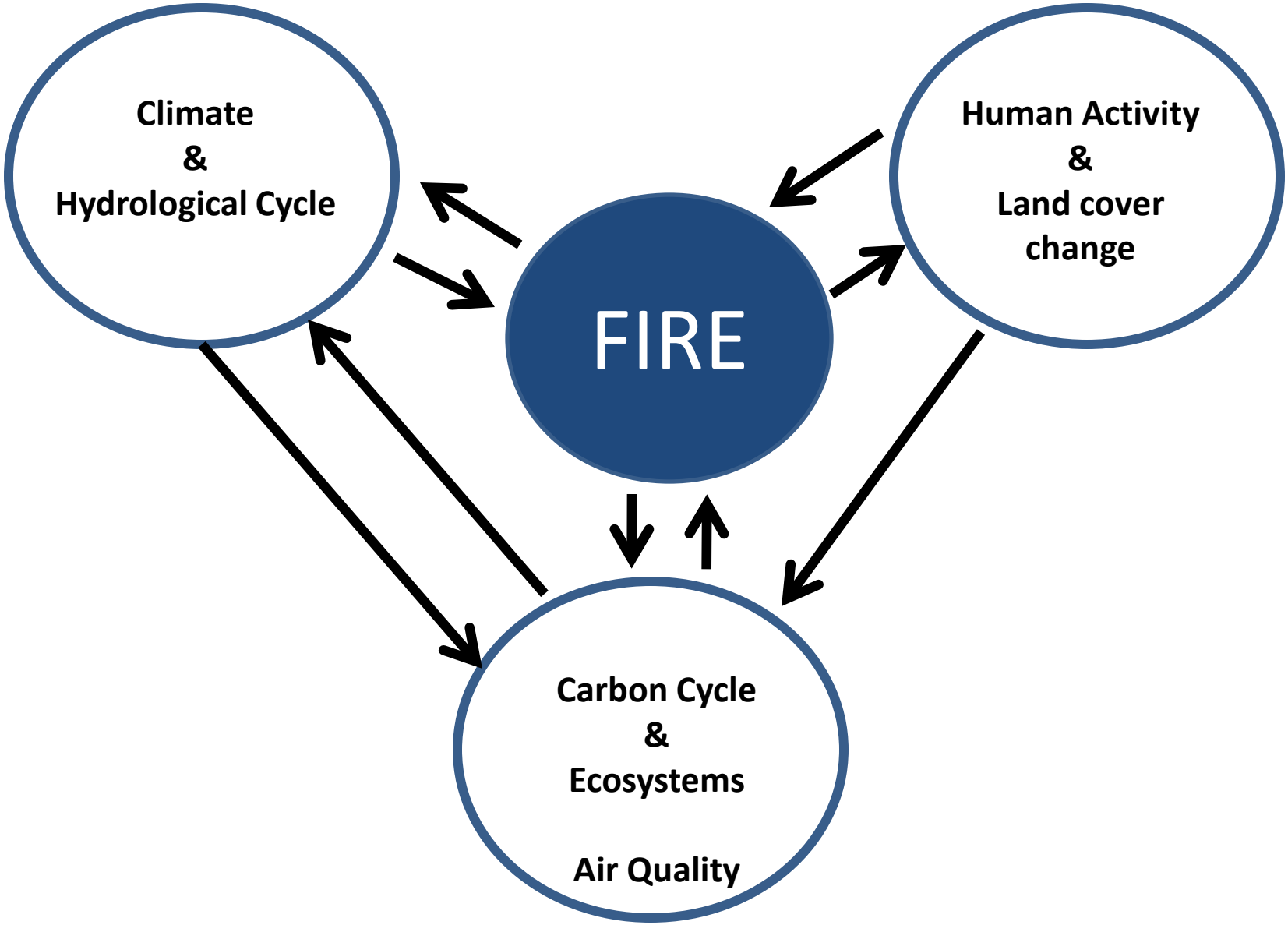
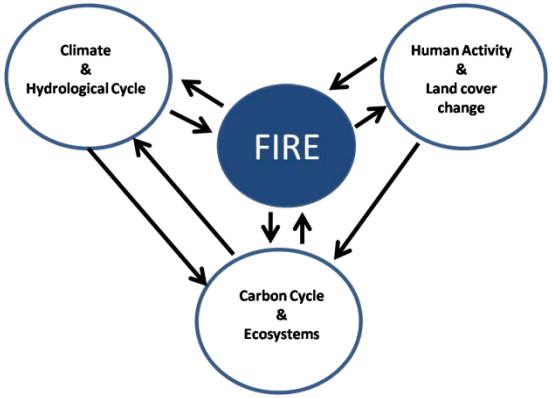
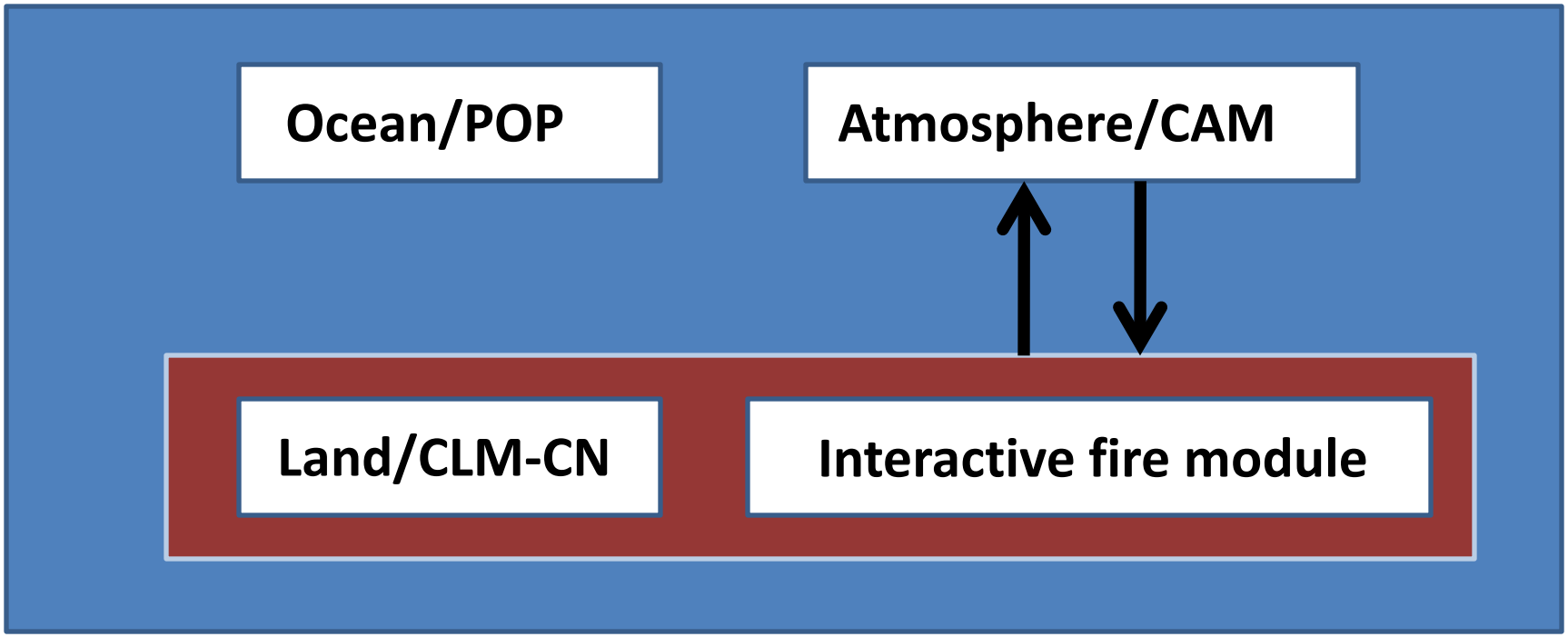


Model



Community Climate System Model
CCSM



Model

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Interactive fire module within CLM-CN:

A: Thonicke et al. (2001)

- developed for LPJ
- fire probability is simulated as a function of soil moisture and biomass
- empirical approach relating annual fire season length to annual area burned

B: Arora and Boer (2004)

- developed for CTEM
- fire probability is simulated as a function of soil moisture, biomass and ignition (lightning, human)
- area burned is simulated as a function of wind speed and soil moisture

•Results:

• pre-industrial spin-up simulation forcing CLM-CN with NCEP data (1948-1972)

CLM-CN area burned (Pre-Industrial)

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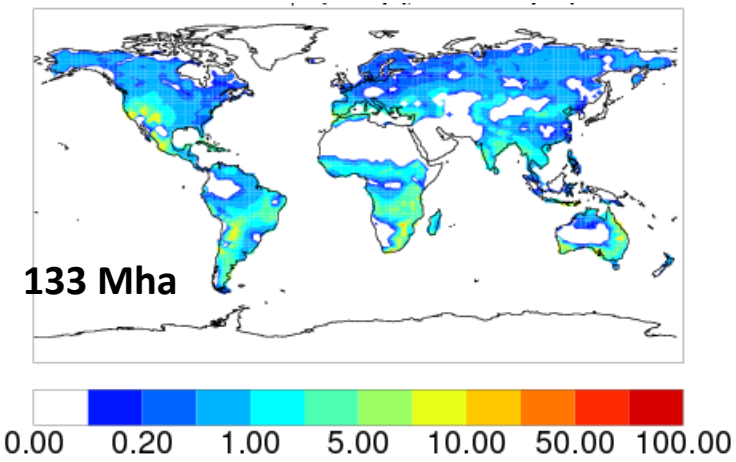
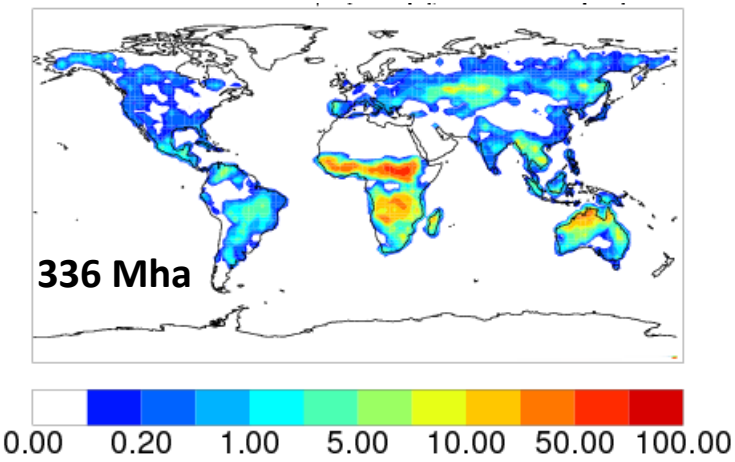
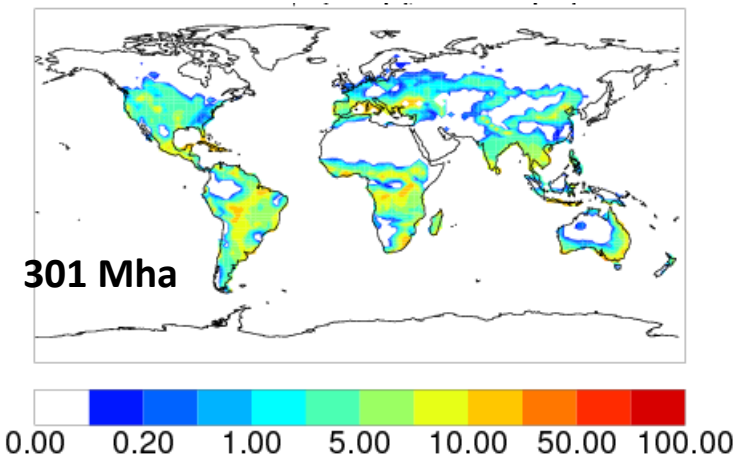
CLM – CN Thonicke et al. 2001



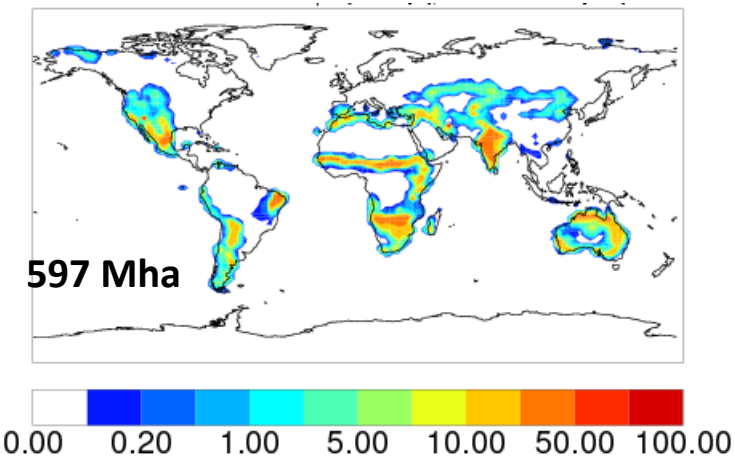
GFEDv2 (van der Werf et al., 2006)



CLM – CN Arora and Boer 2005



RETRO (Schulz et al., 2008) Reg-Firm



CLM-CN Carbon Emissions (Pre-Industrial)

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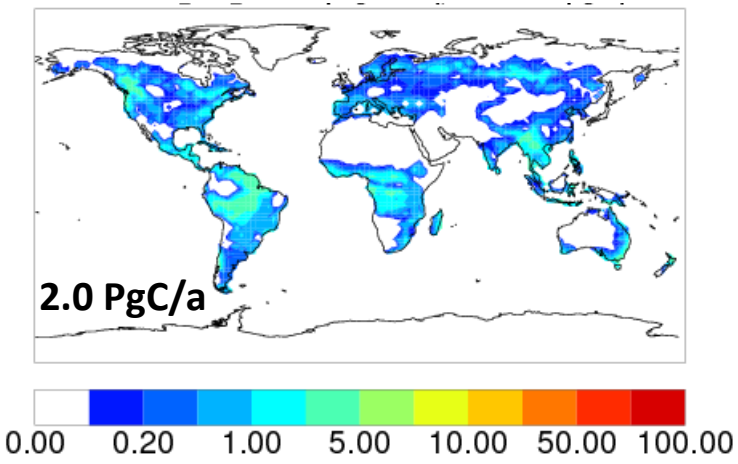
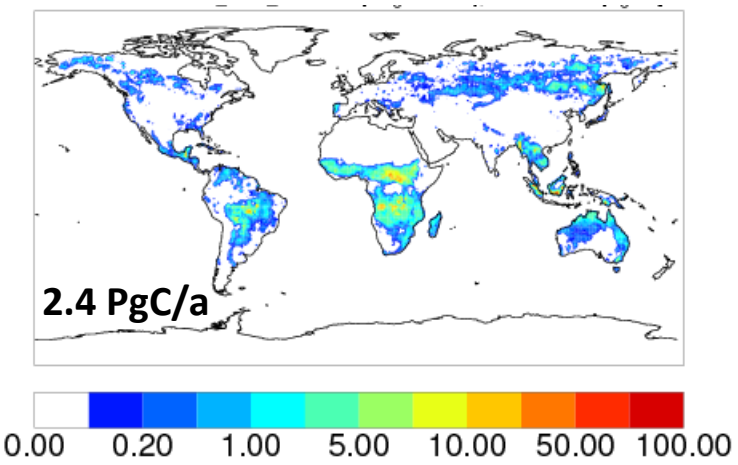
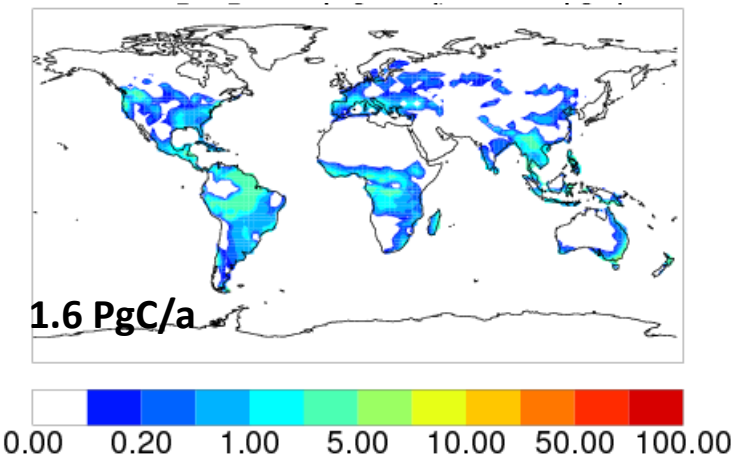
CLM – CN Thonicke et al. 2001



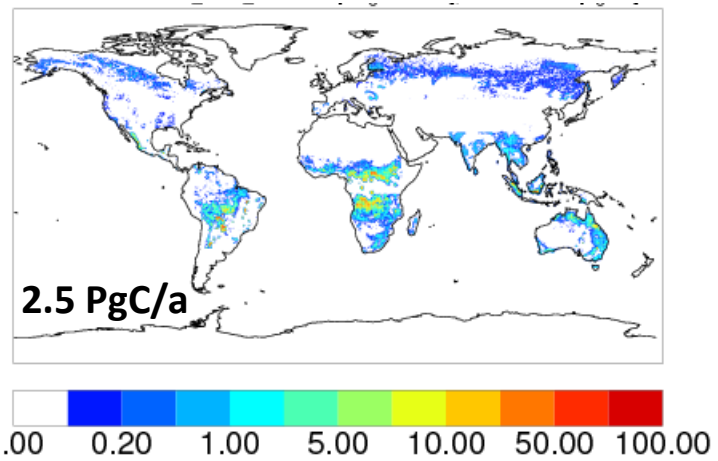
GFEDv2 (van der Werf et al., 2006)



CLM – CN Arora and Boer 2005



RETRO (Schulz et al., 2008)



Trace gas and aerosol emissions

Cornell University

Emission of trace gases and aerosols by a fire simulated in CLM-CN every time step and send to the coupler

$$E_i(t) = EC(t)\frac{EF(i)}{EF(CO_2)+EF(CO)}$$

EC = Emission of carbon

EF(i) = Emission factor for species i (Andreae and Merlet, 2001, Andreae pers. comm.) – function of land cover (savanna, tropical forest, extratropical forest)

	C	CO_2	CO	CH_4	H_2	NO_x	OC	BC
CLM-CN Thonicke et al. 2001	2020	6764	361	18.0	8.73	9.87	22.29	2.24
CLM-CN Arora and Boer 2005	1612	5426	280	13.6	6.56	7.88	16.91	1.78
GFEDv2	2424	8774	427	21	10.5	12.1	23.5	2.82
RETRO	2540	8659	417	20.45	9.42	18.3	22.4	2.72

[Tg(species)/year]

Other emissions considered in CLM-CN:
NHMC, N_2O, PM2.5, TPM, TC, SO_2

Next Steps

1. implement deforestation fires using George Hurtt dataset on land use change

   - land use change results in fire emissions in regions with high fire probabilities as simulated in the fire algorithm

   - the seasonality of fire emissions from land use change is driven by the fire probability as simulated in the fire algorithm

2. Improve the fire algorithm by comparison with GFEDv2

   -Transient offline simulation into the period of satellite observations (1997-2006)

   - Account for deforestation fires in the model as these are "seen" by the GFED observations

3. Coupled CCSM simulation to assess the overall role of fires in the Earth System, including the effect of trace species emissions and aerosol emissions by fires on climate.

Impact of Ozone on Climate

- Danica Lombardozzi, Jed Sparks

Ozone

GDP

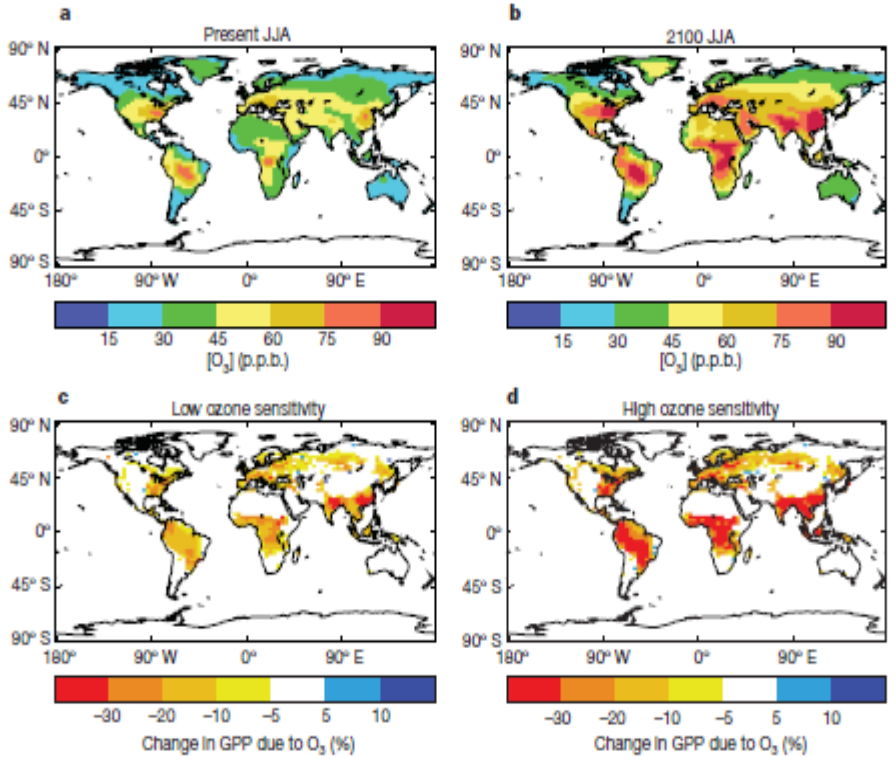
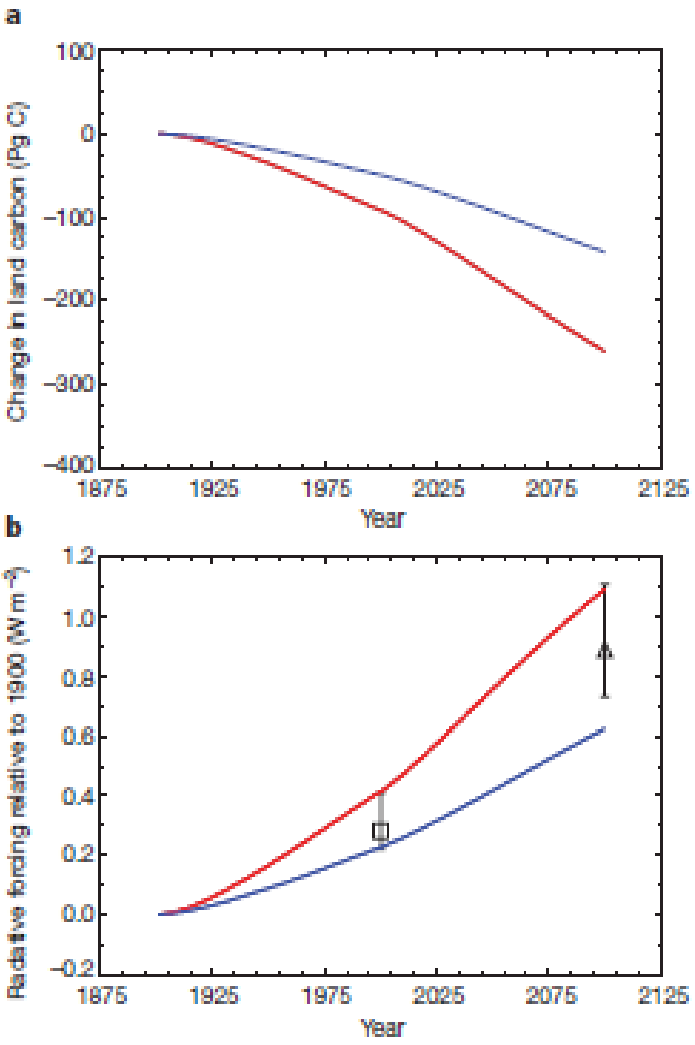


Figure 1 | Temporal changes of modelled ozone concentrations and gross primary productivity. **a**, **b**, Modelled diurnal (24-h) mean surface [O_3] in p.p.b. averaged over June, July and August (JJA) for the present day (**a**) and the year 2100 under the SRES A2 emissions scenario (**b**). **c**, **d**, Simulated percentage change in gross primary productivity (GPP) between 1901 and 2100 due to O_3 effects at fixed pre-industrial atmospheric [CO_2] for 'low' (**c**) and 'high' (**d**) ozone plant sensitivity.

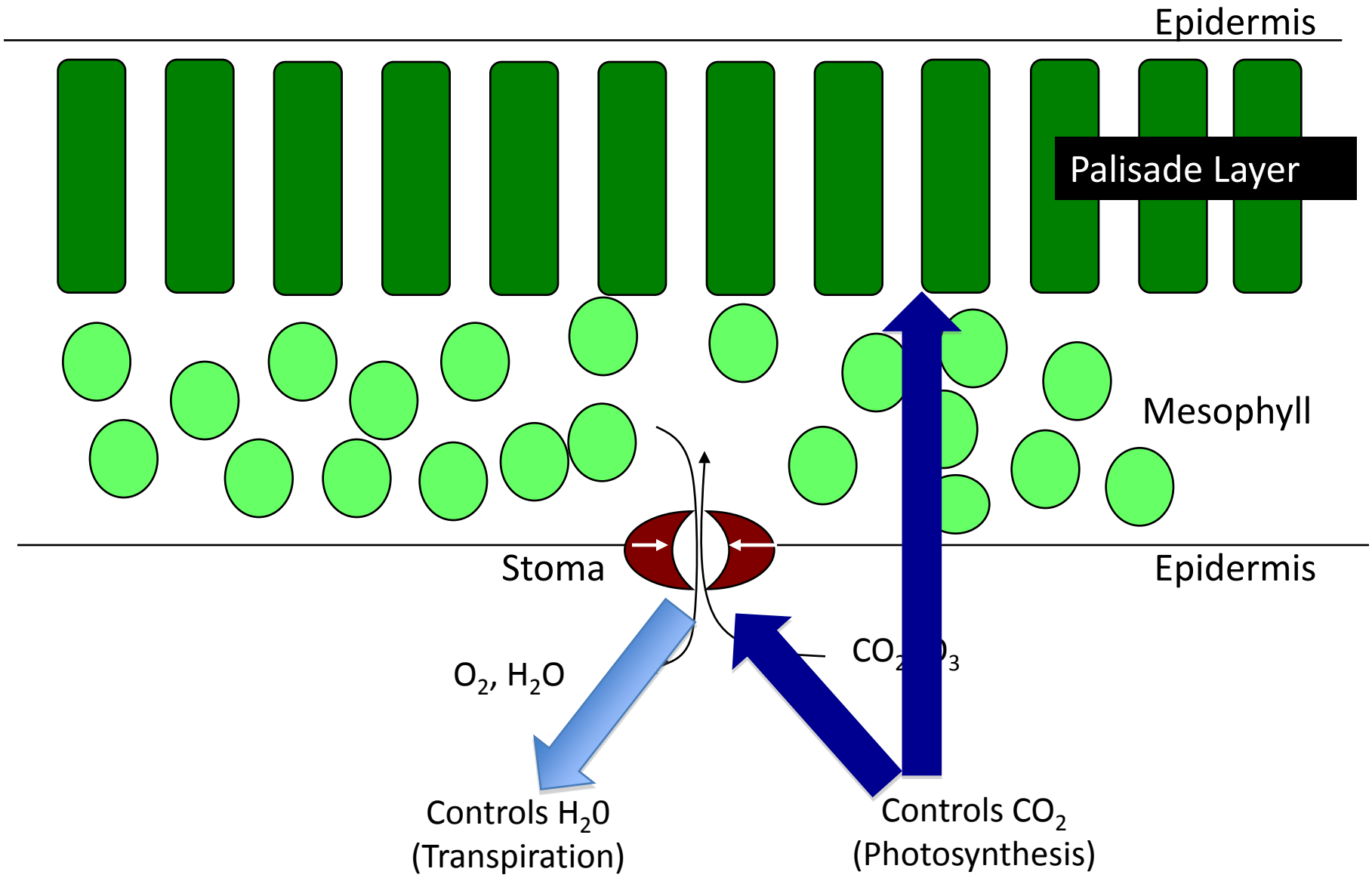
Stich et al.



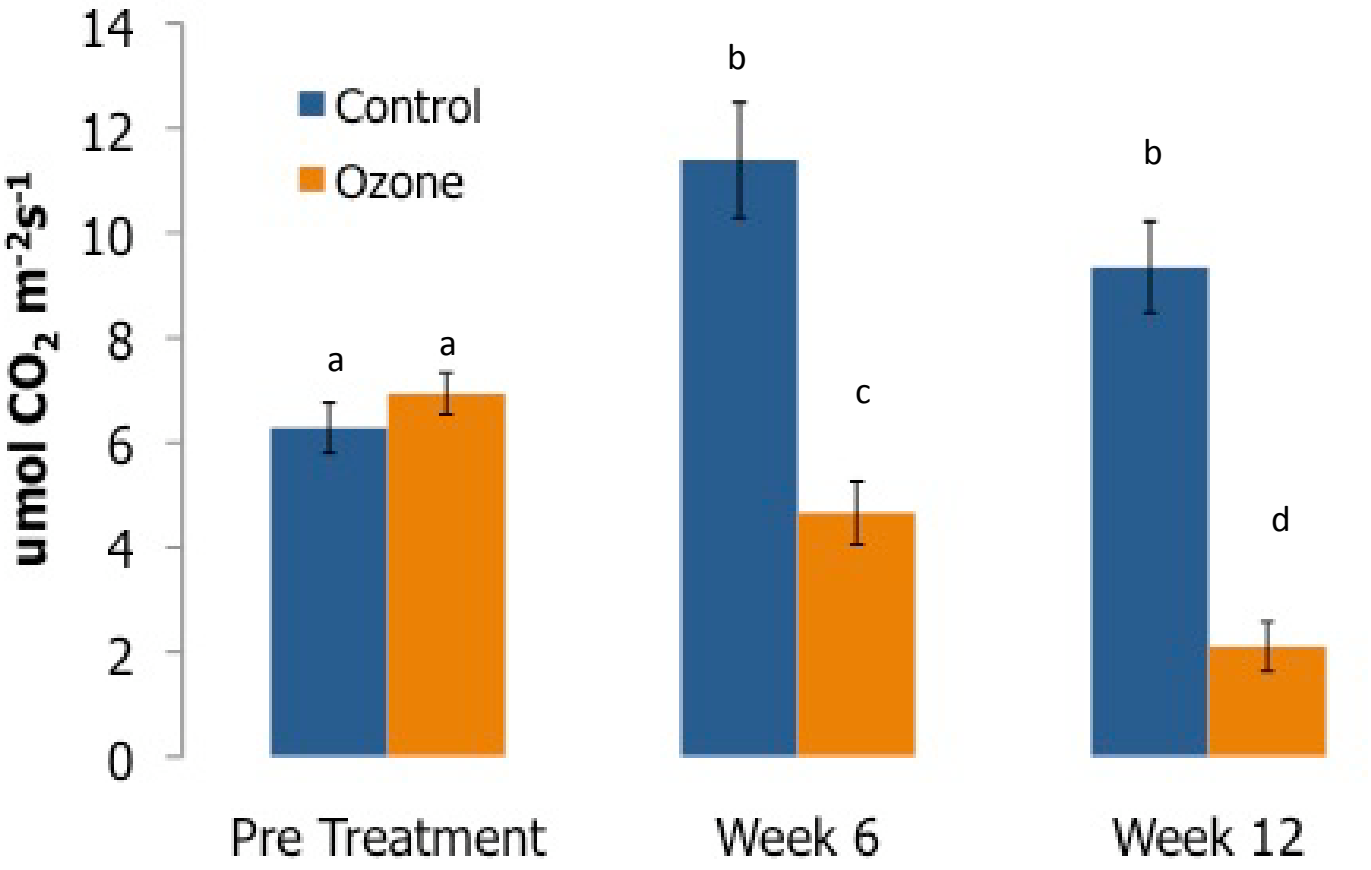
Change in Land Carbon

Change in Radiative Forcing Due to Ozone Change

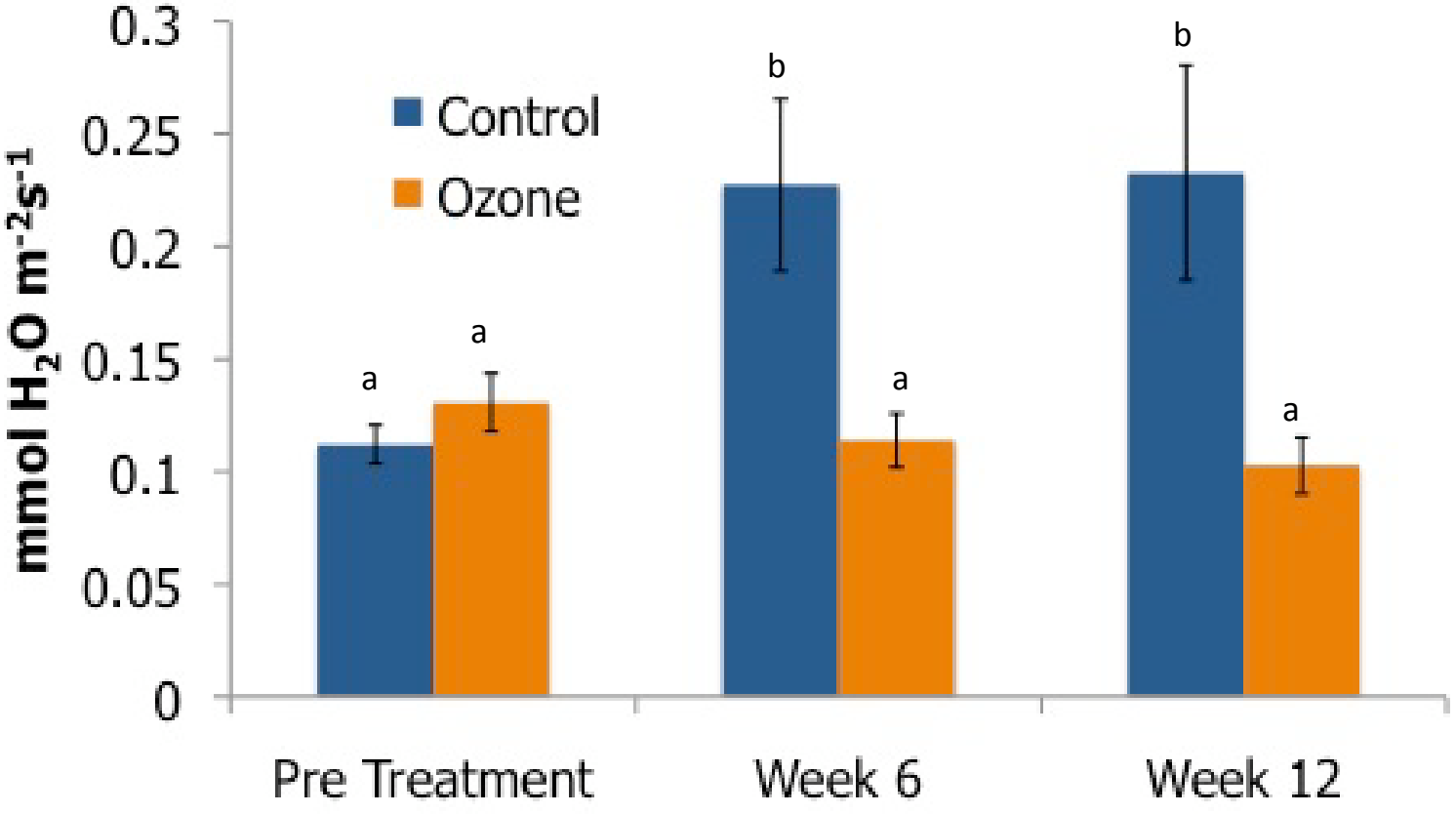
Stich et al.

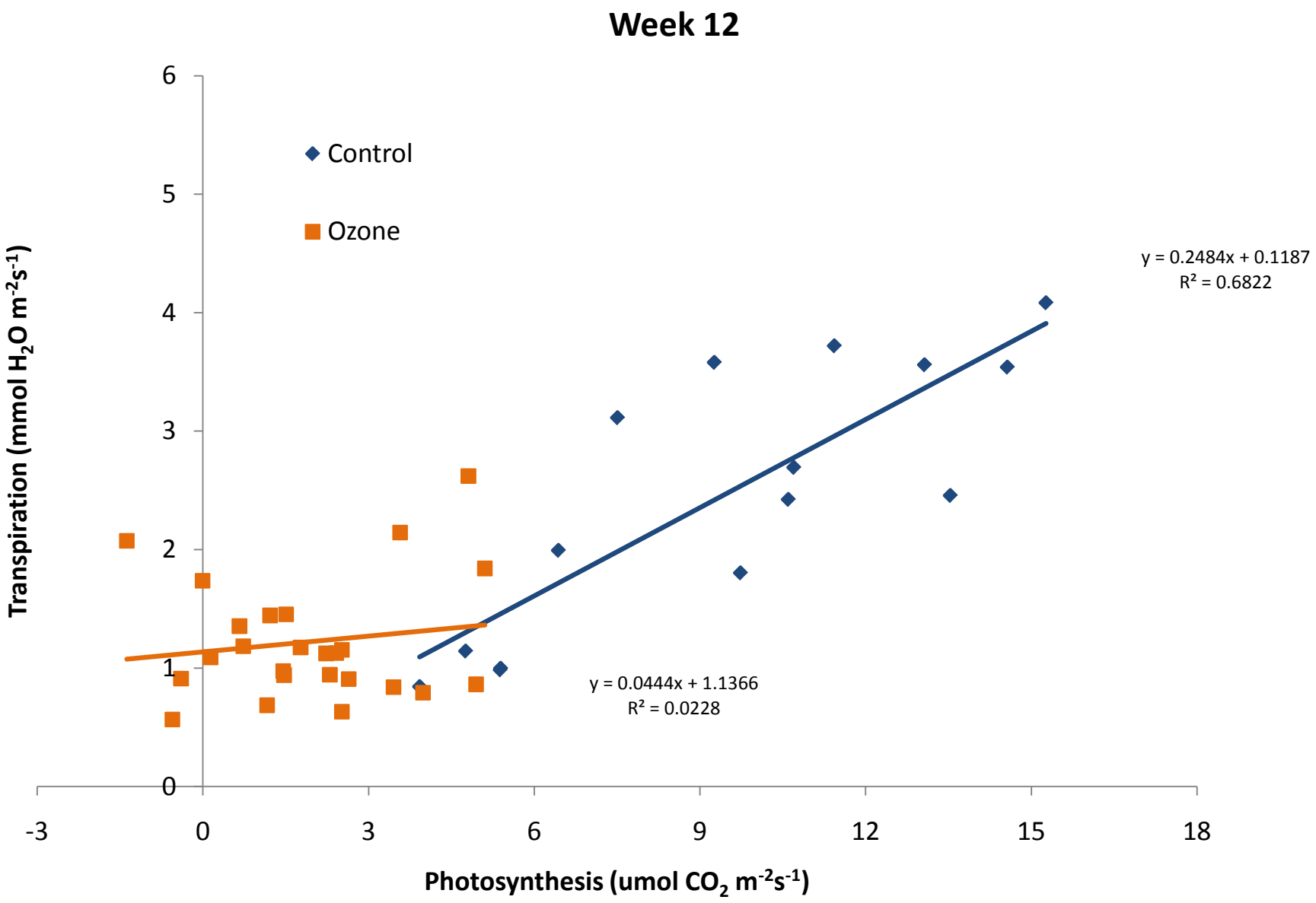

Epidermis
Palisade Layer
Mesophyll
Stoma
Epidermis
O_2, H_2O
Controls H_20
(Transpiration)
Controls CO_2
(Photosynthesis)

Instantaneous Photosynthesis



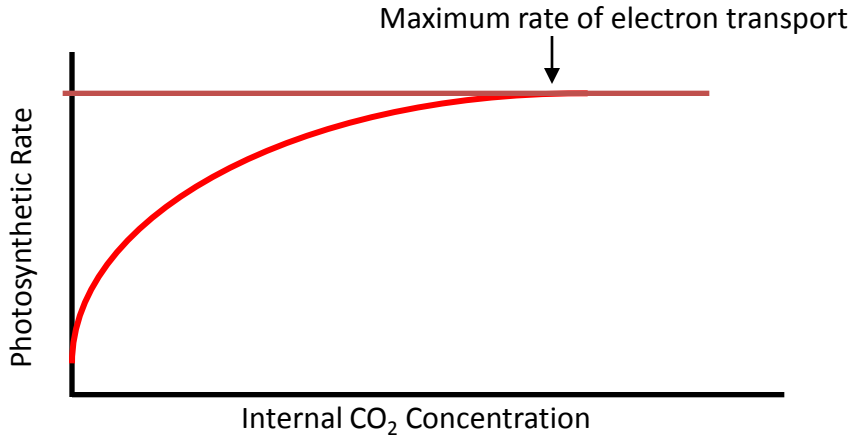
Instantaneous Conductance




Week 12
Control
Ozone
y = 0.2484x + 0.1187
R² = 0.6822
y = 0.0444x + 1.1366
R² = 0.0228
Transpiration (mmol H2O m-2s-1)
Photosynthesis (umol CO2 m-2s-1)
0
1
2
3
4
5
6
-3
0
3
6
9
12
15
18

Parameterizing CLM: Photosynthesis

1. Photosynthesis (A_{max}) = min (w_j,w_c,w_e) calculcated



Parameterizing CLM: Conductance

2. 1/resistance = $(A_{max}/[CO2]_s)$ x (e_s/e_i) x P_{atm} + b
Calculated from photosynthess

- **Change**: to Jarvis equation, which doesn't use A_{max}

Other Projects

- Methane emission model (D. Lawrence, B. Riley)
  - Based loosely on Rita Wania's thesis (which is an advance over the Walters and other models).
  - Sean Swenson is working on the wetland distribution
  - Advertising for a post-doc to evaluate within CAM
- Flying Leap for Nitrogen (pending funding)