Chronic ozone exposure changes plant physiology: implications for climate

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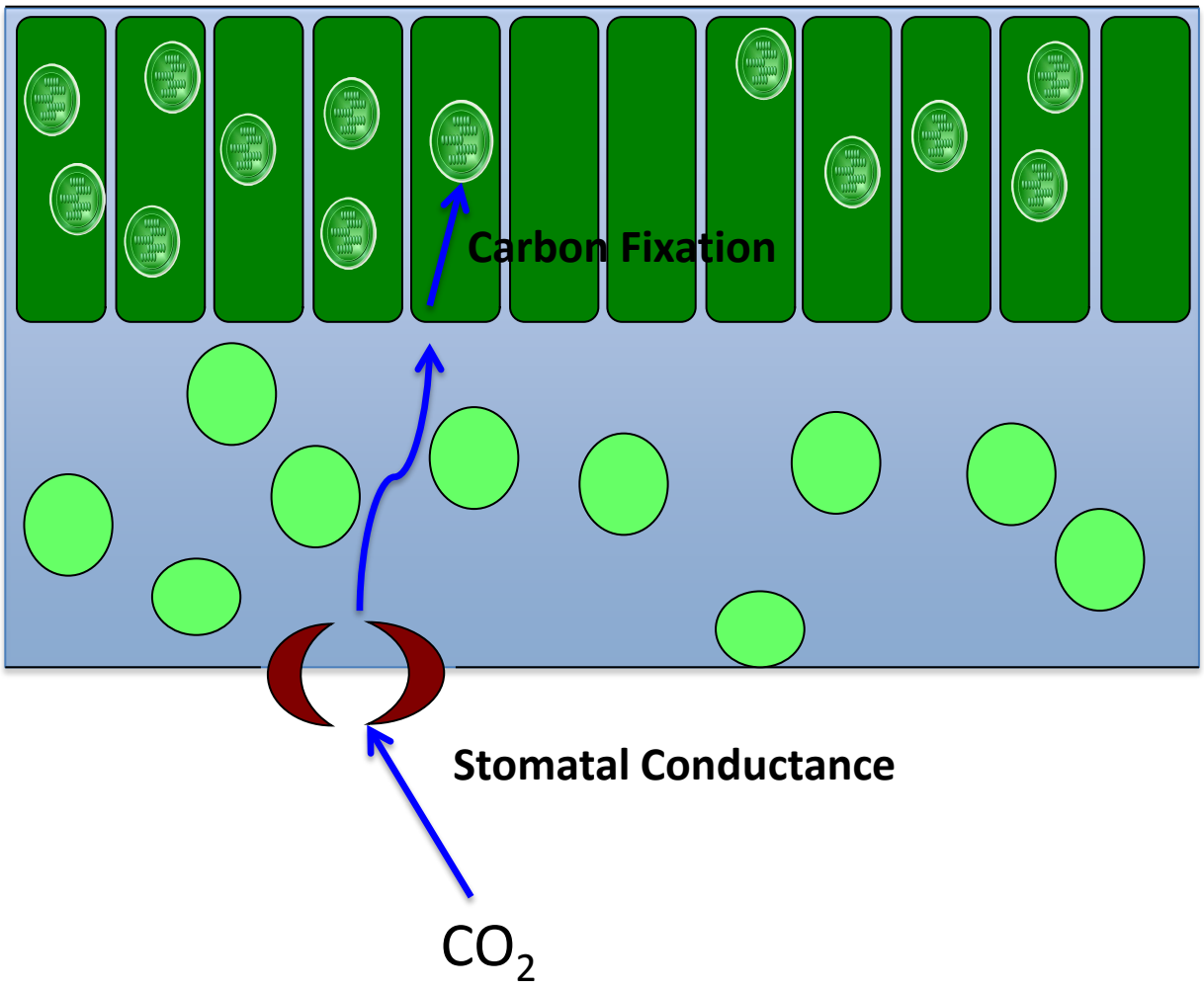
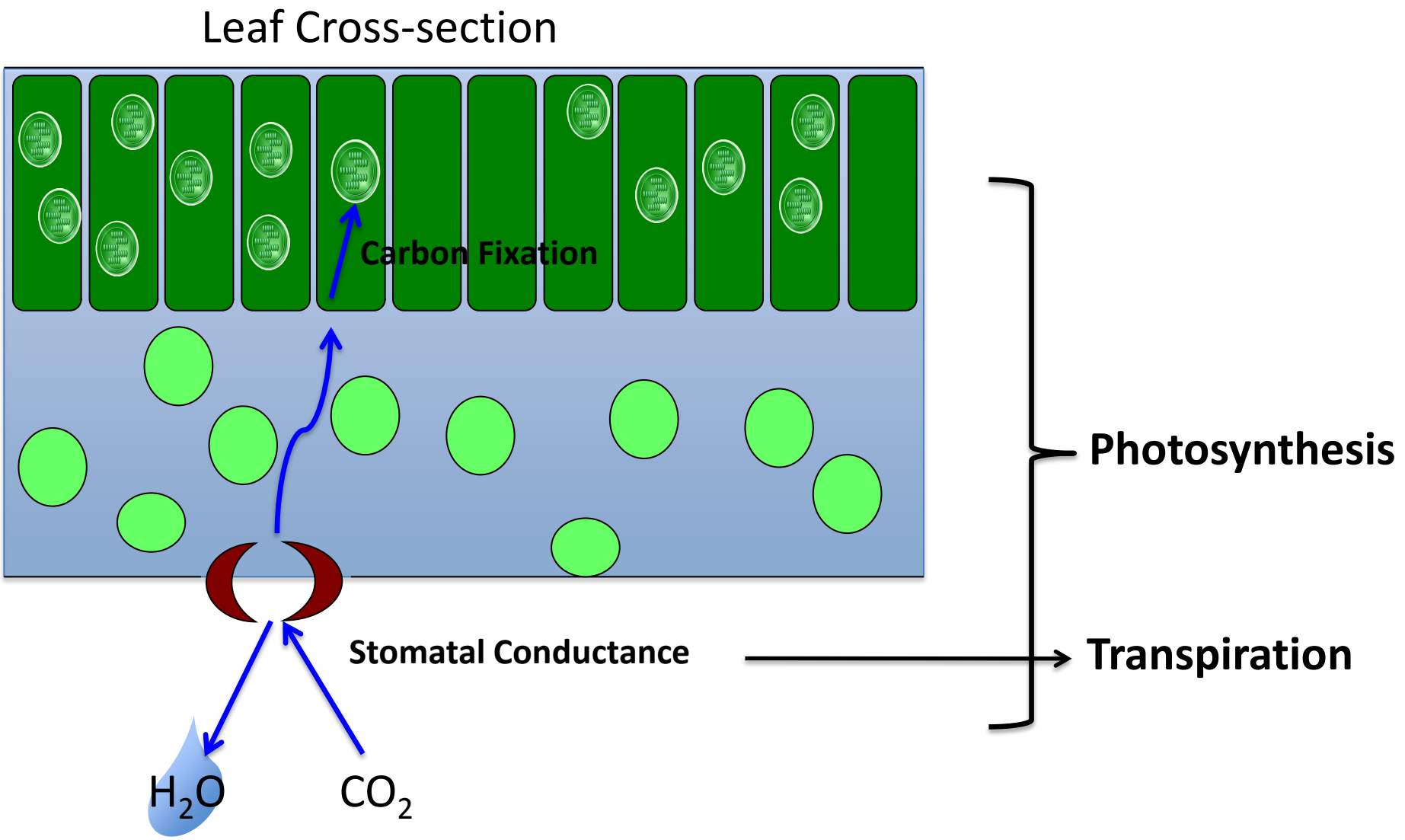
Gordon Bonan • NCAR
Sam Levis • NCAR
Peter Hess • Cornell University

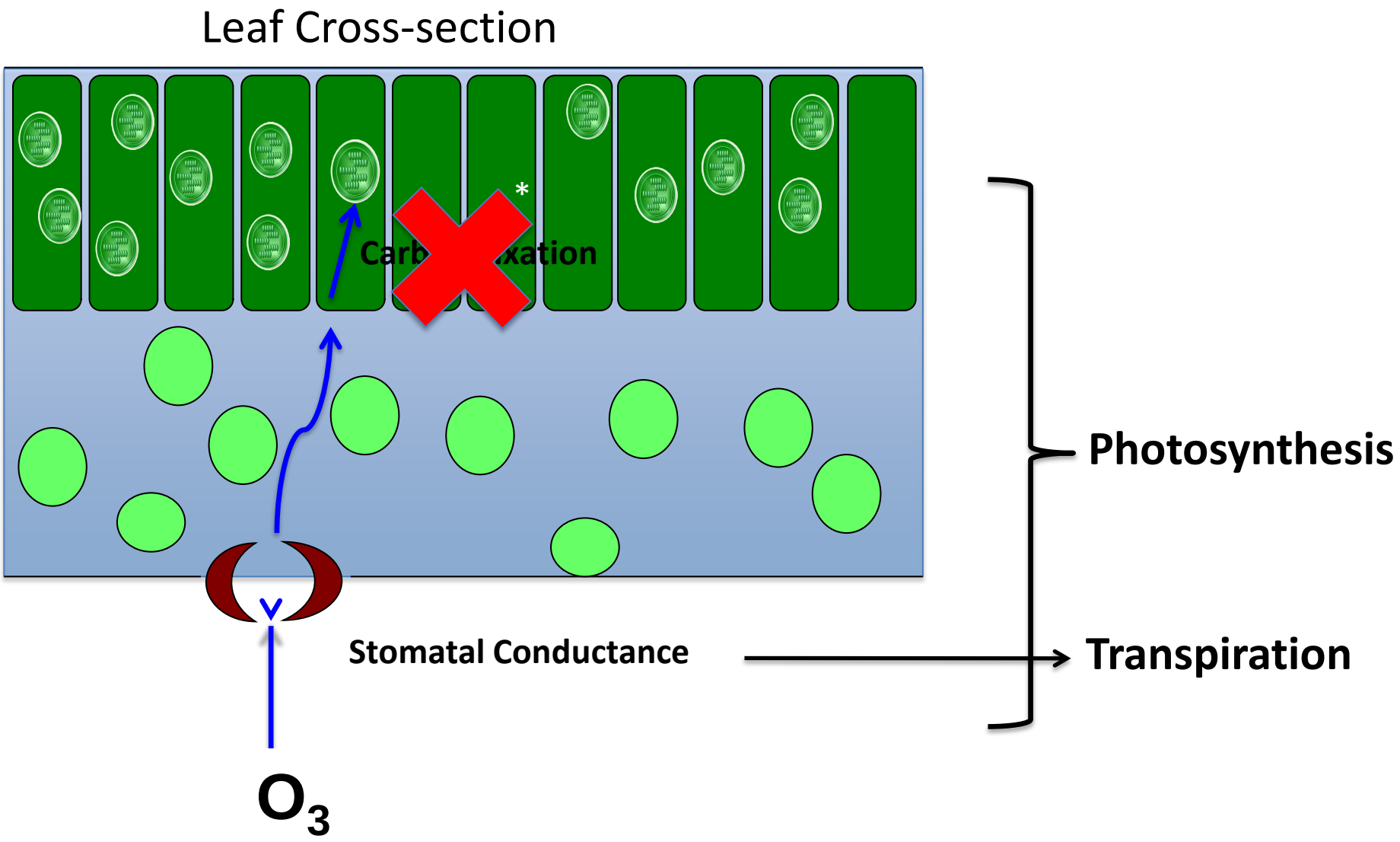
Visible O_3 damage on tulip poplar leaf

Leaf Cross-section

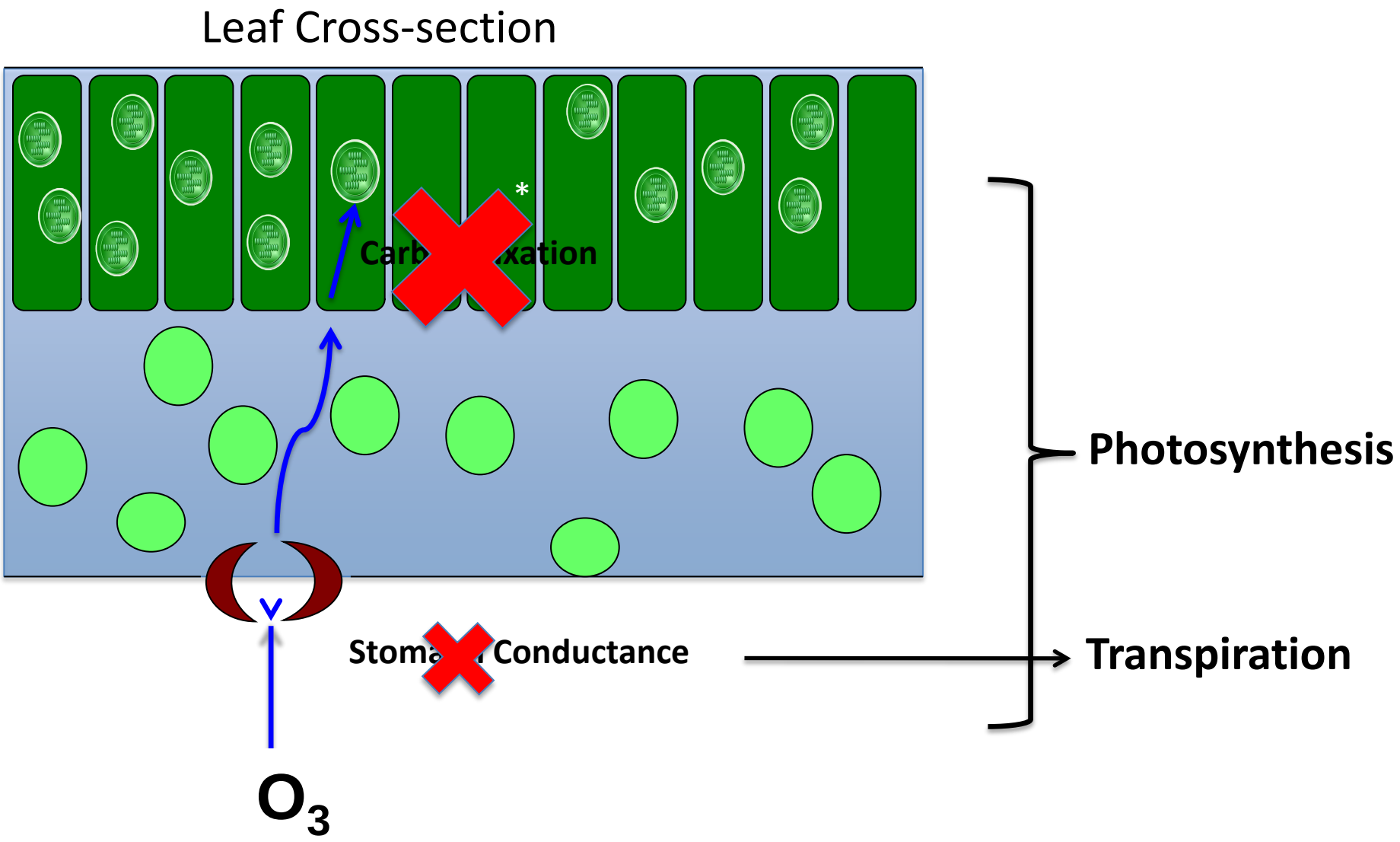


Photosynthesis


Leaf Cross-section
Carbon Fixation
Photosynthesis
Stomatal Conductance
Transpiration
H_2O
CO_2



* Bortier et al. 2000, *New Phtyol*; Francini et al. 2007, *Environ Exp Bot*; Fiscus et al. 1997, *J. Exp Bot*; Heagle et al. 1996 *J. Environ Qual*; Noormets et al. 2001, *Plant Cell Environ*; Sharma et al. 2003, *Ekologia*



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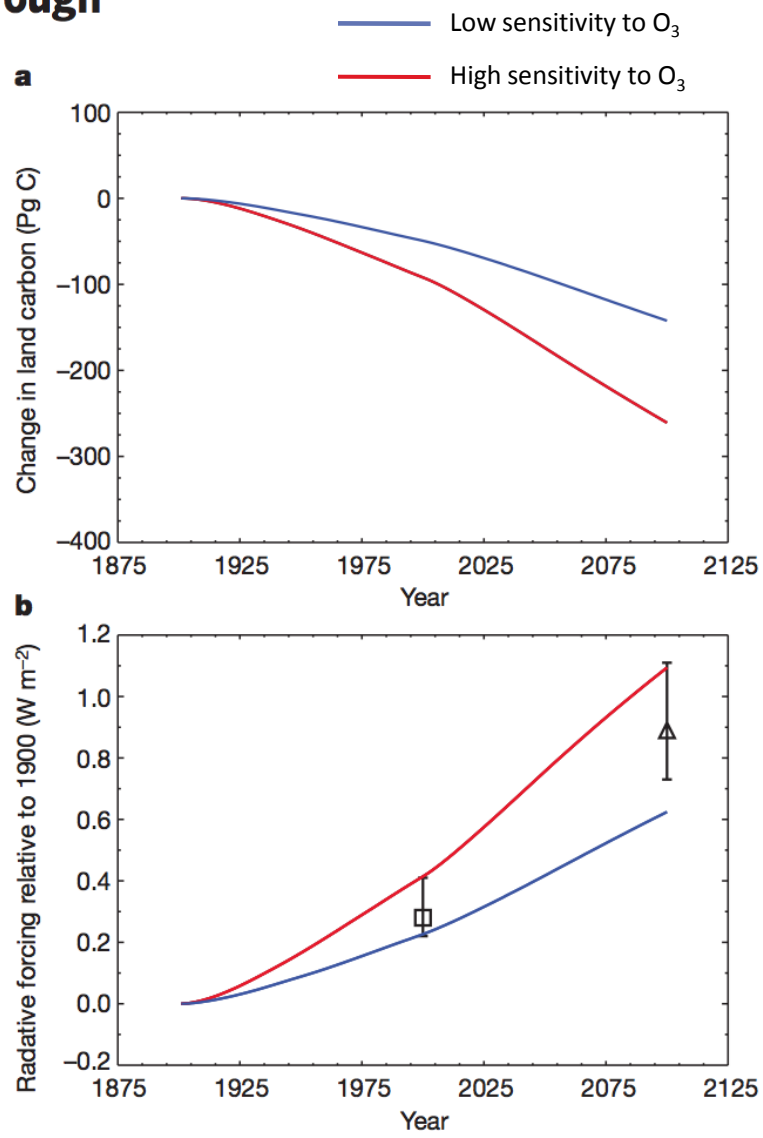
LETTERS

Indirect radiative forcing of climate change through ozone effects on the land-carbon sink

S. Sitch[1], P. M. Cox[3], W. J. Collins[4] & C. Huntingford[2]



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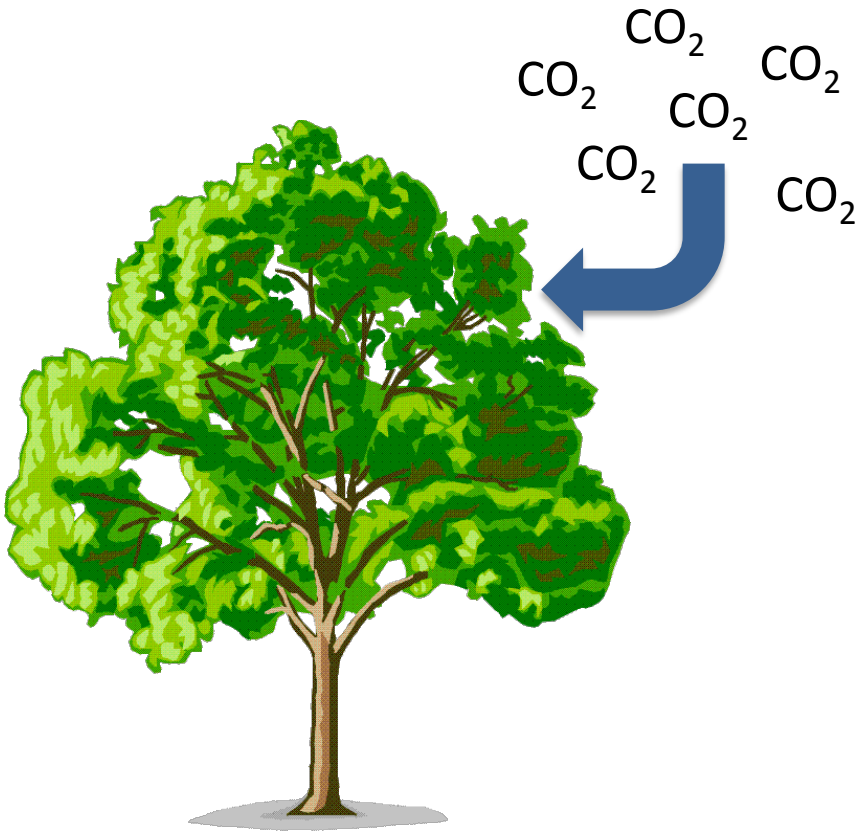
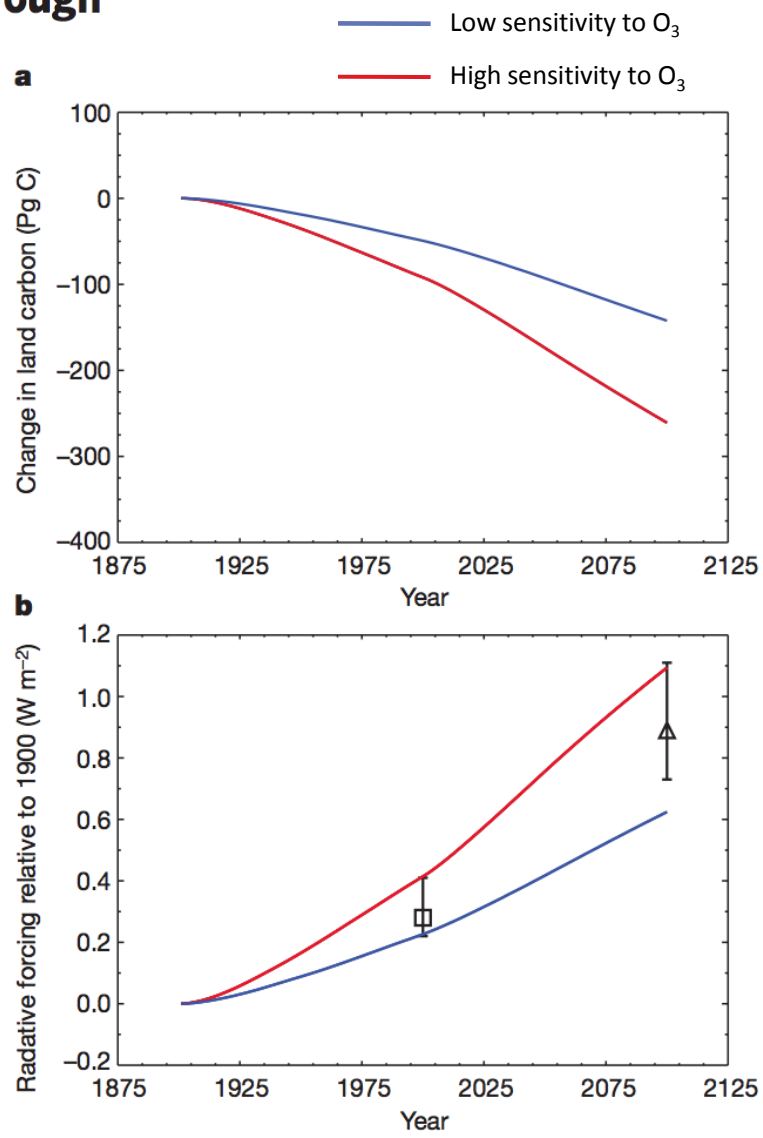
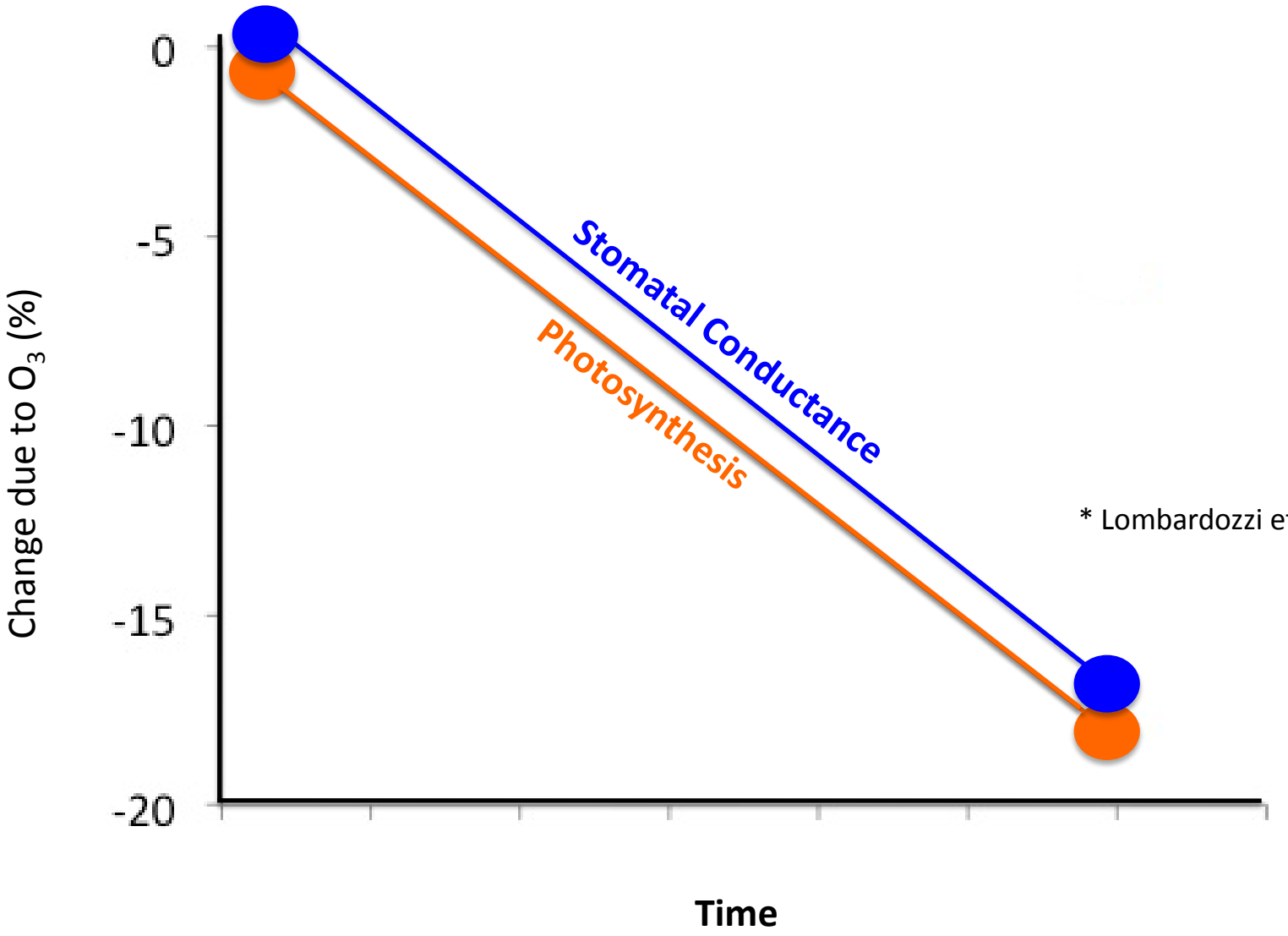
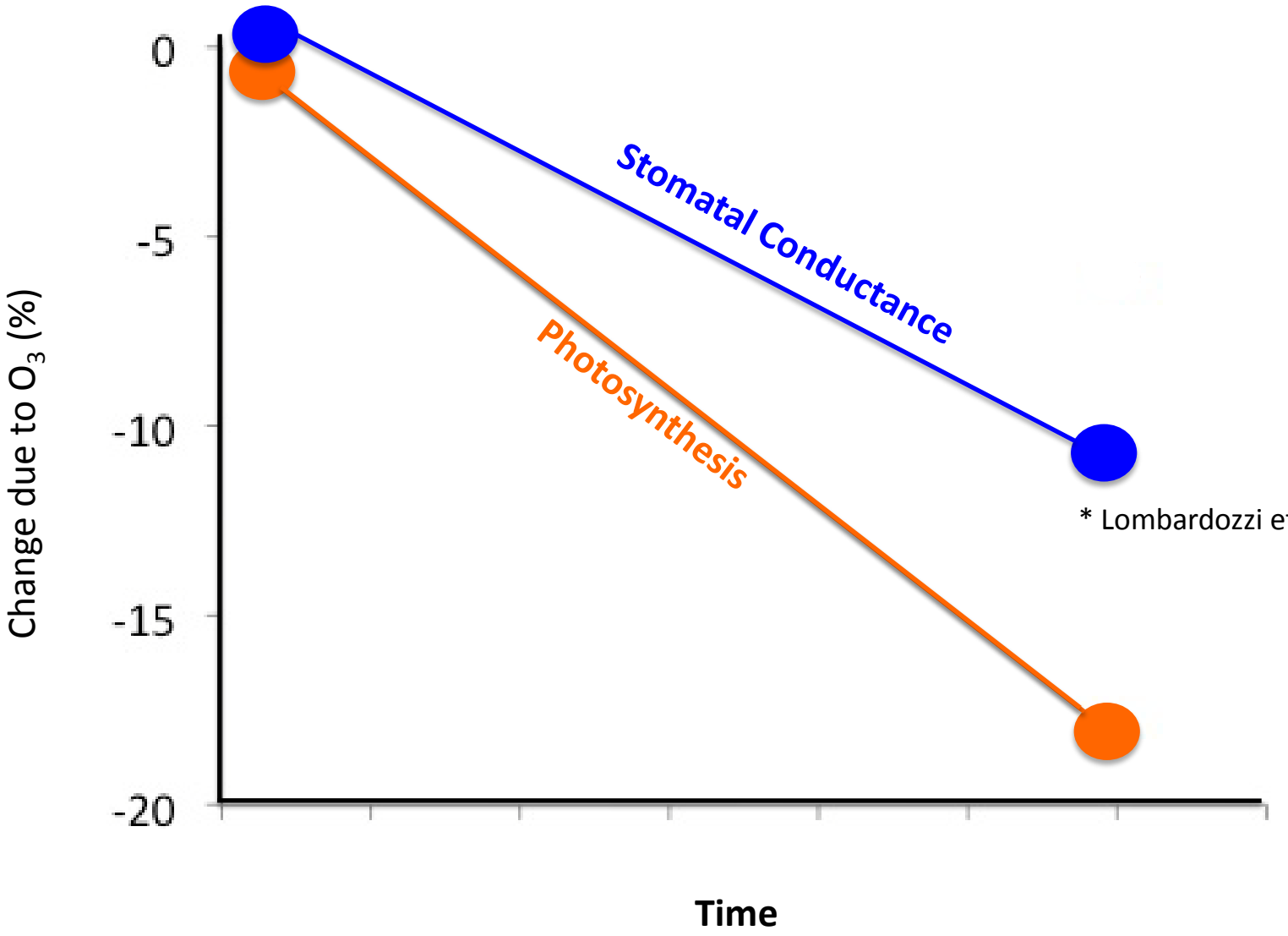






* Lombardozzi et al., submitted *BGS*



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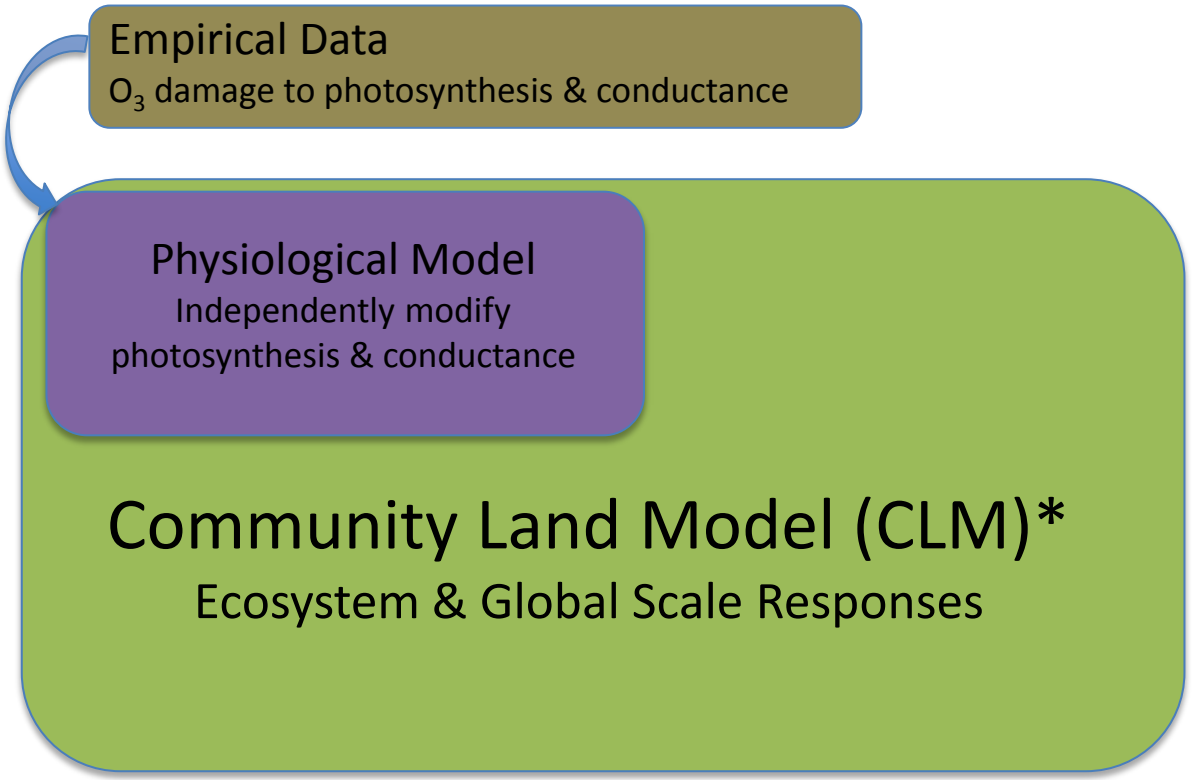
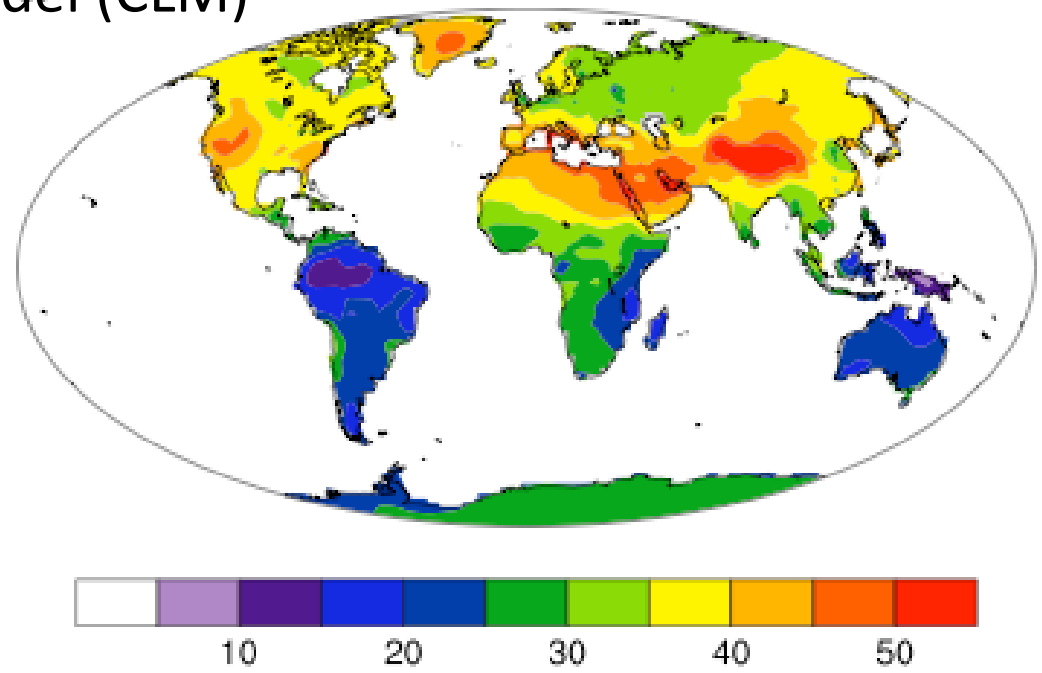


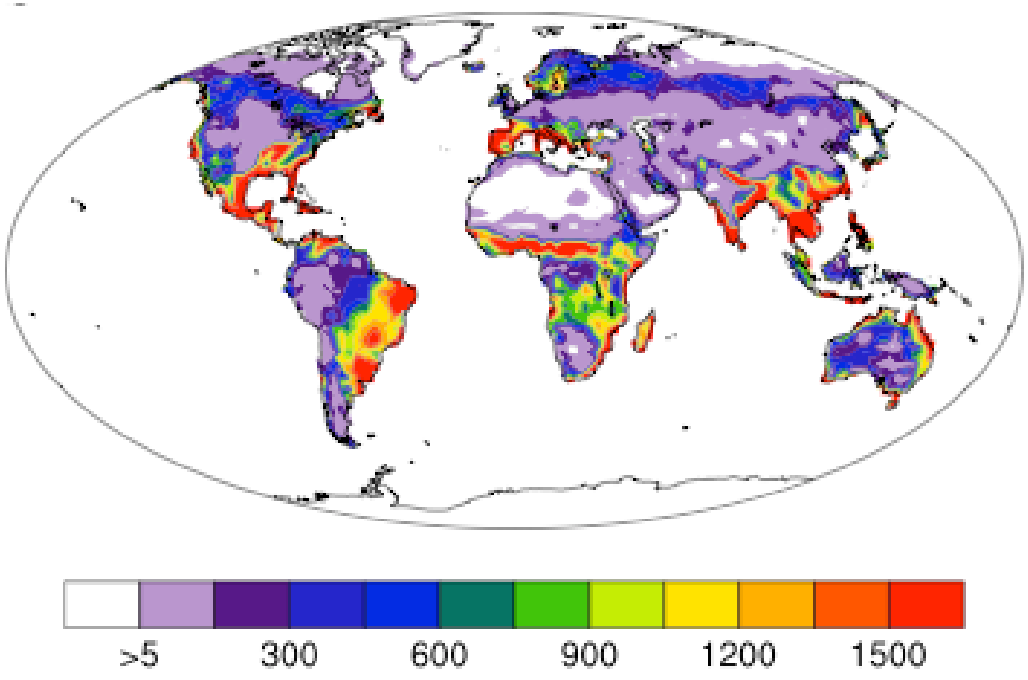
* Developed by NCAR and used in IPCC reports

Results: Community Land Model (CLM)

$[O_3]$ (ppb)



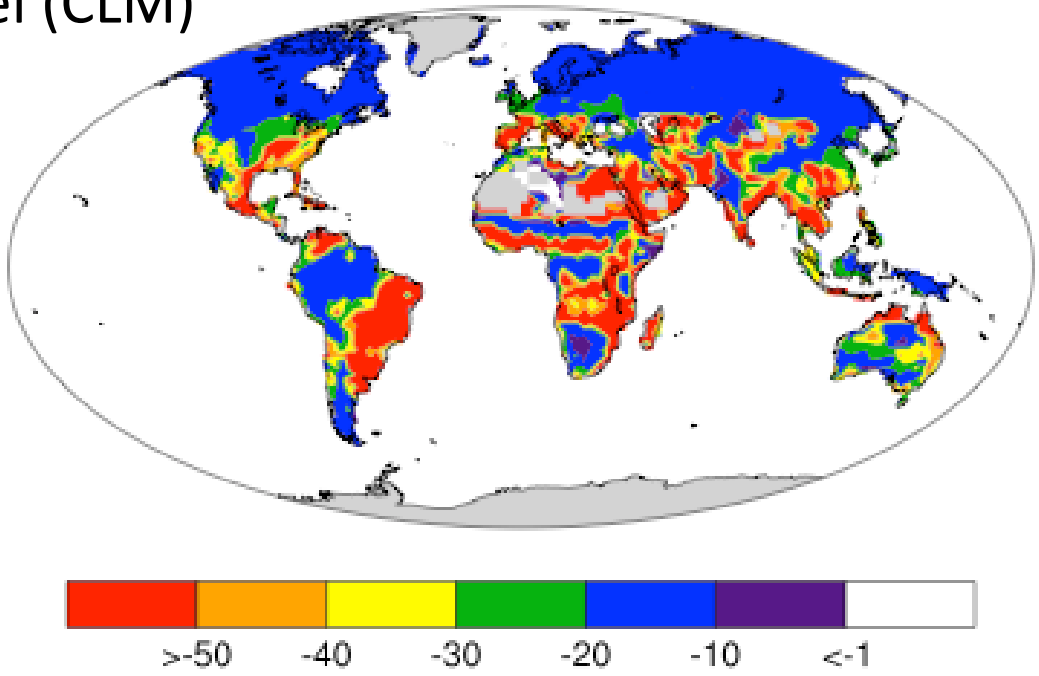
Cumulative O_3 Uptake (mmol O_3 m^{-2})



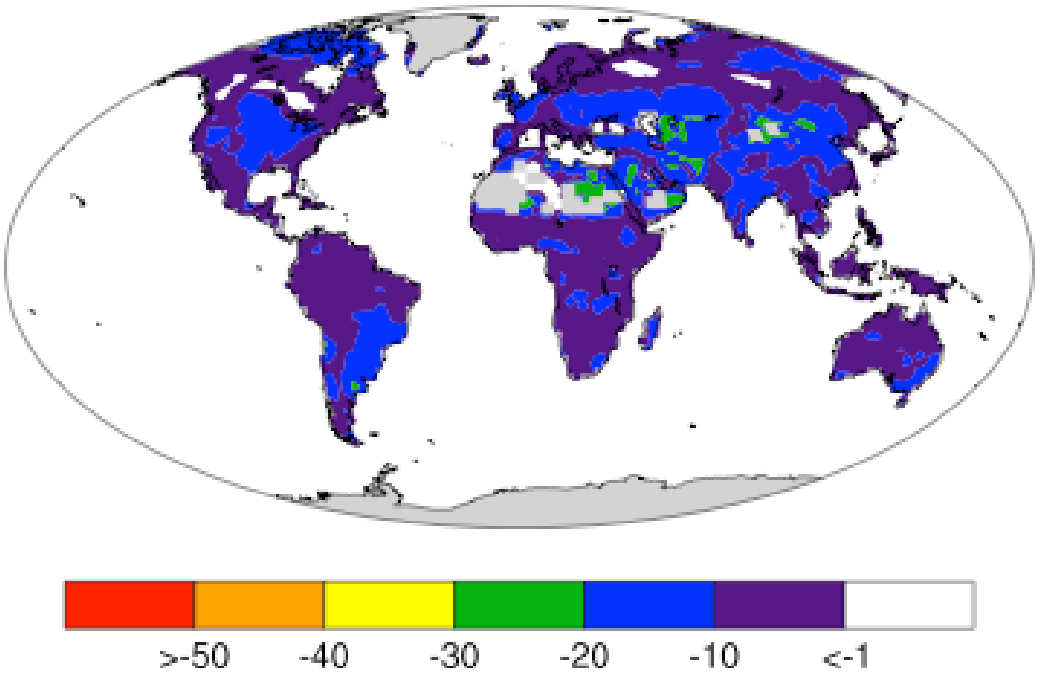
Lombardozzi et al., in prep for *J. Climate*

Results: Community Land Model (CLM)

Change in **GPP** due to O_3 (%)



Change in **transpiration** due to O_3 (%)



Lombardozzi et al., in prep for *J. Climate*

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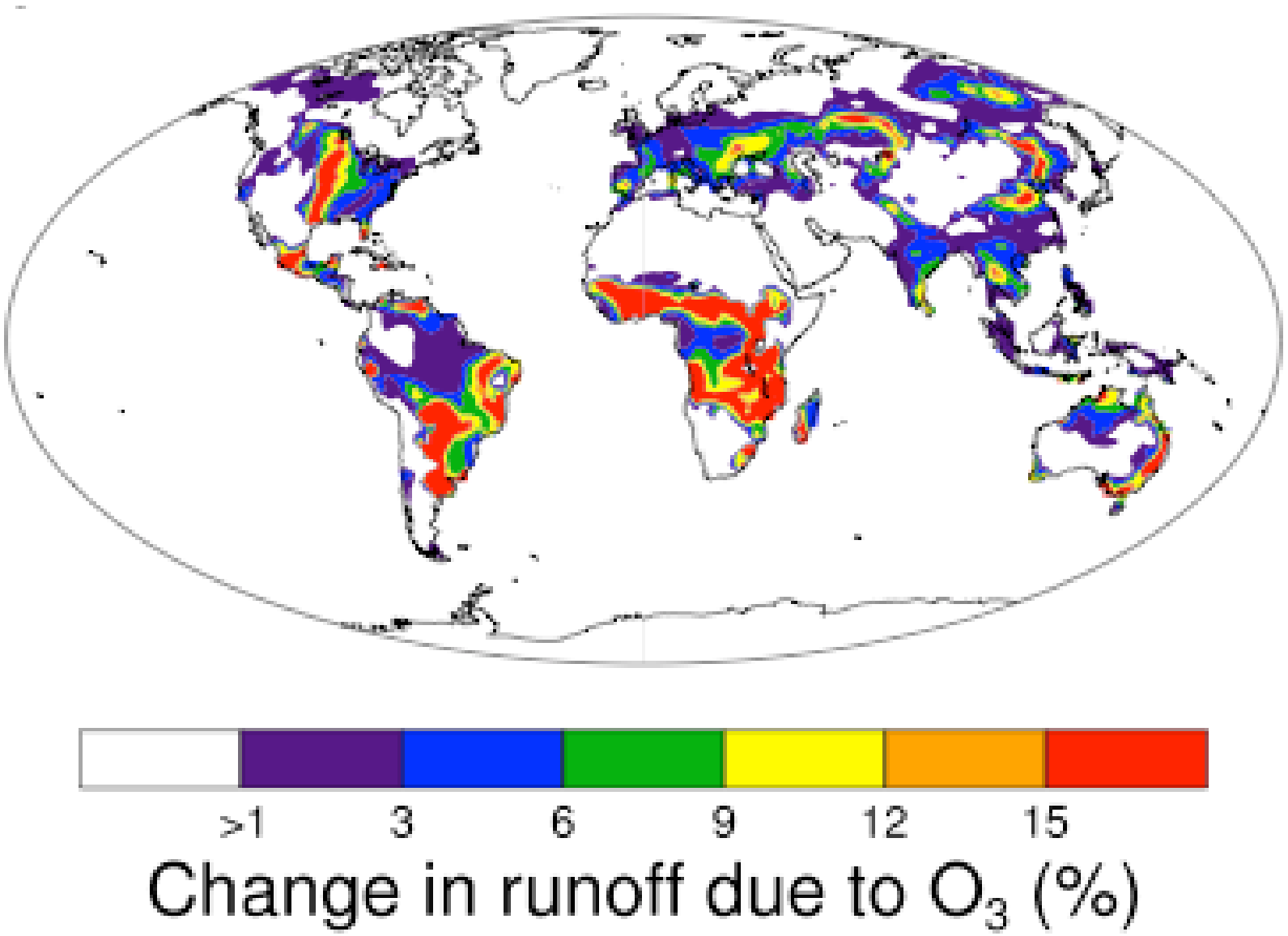

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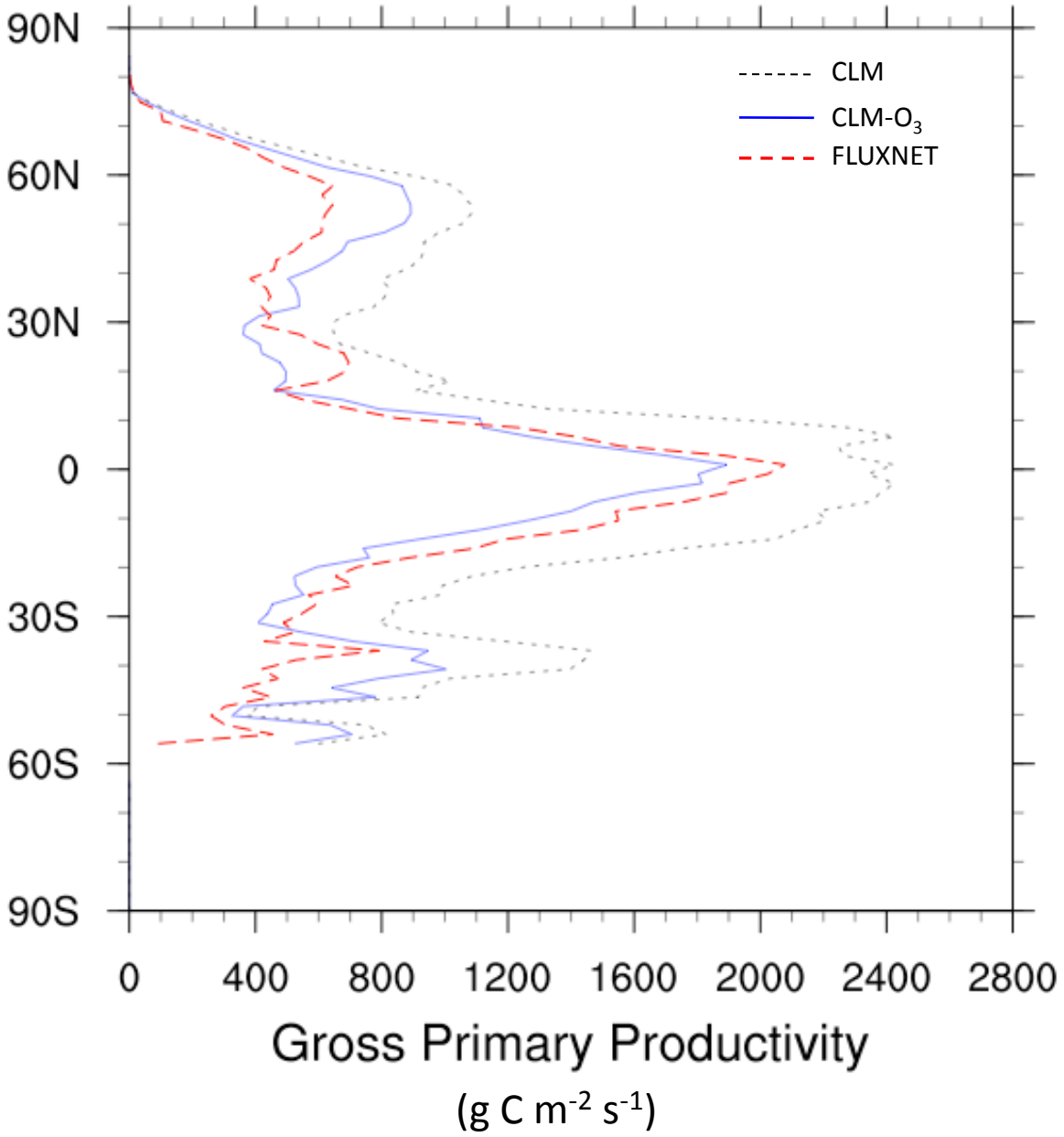
Results: Comparison between CLM and FLUXNET



Key Points & Future Work:

- O_3 decreases global GPP more than transpiration
- O_3 changes hydrology

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- O_3 decreases global GPP more than transpiration
- O_3 changes hydrology

How does O_3 change precipitation?

How does O_3 change surface temperatures?

Are the effects of O_3 changed by increased [CO_2], temperatures or plant nitrogen availability?

Acknowledgements

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Jed Sparks


Gordon Bonan


Sam Levis


Peter Hess

Other Contributors


Sparks Lab


Keith Oleson


Natalie Mahowald


Christy Goodale

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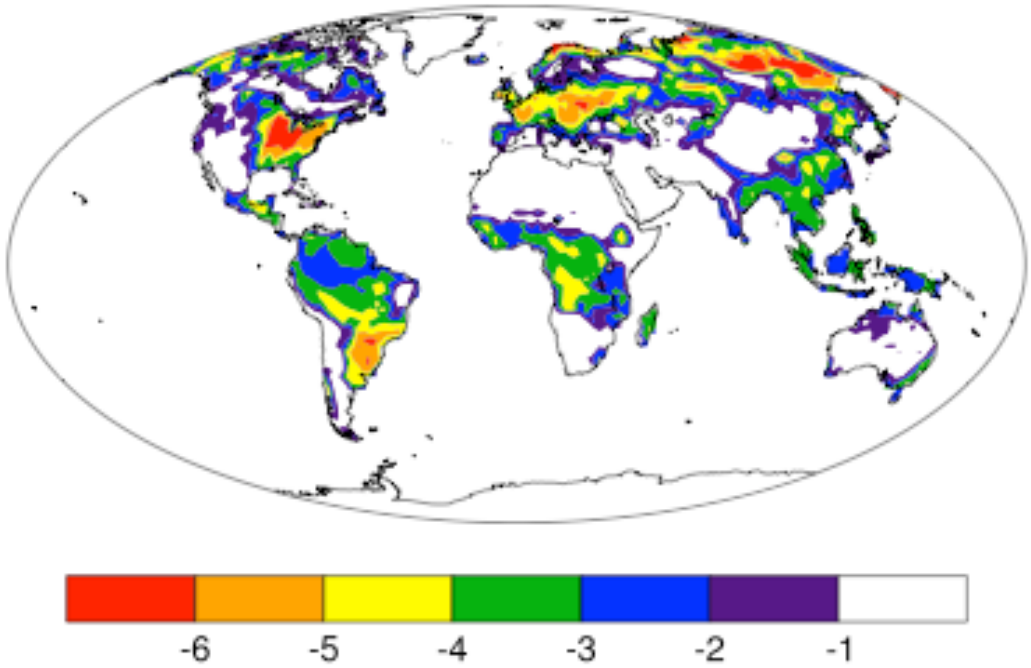
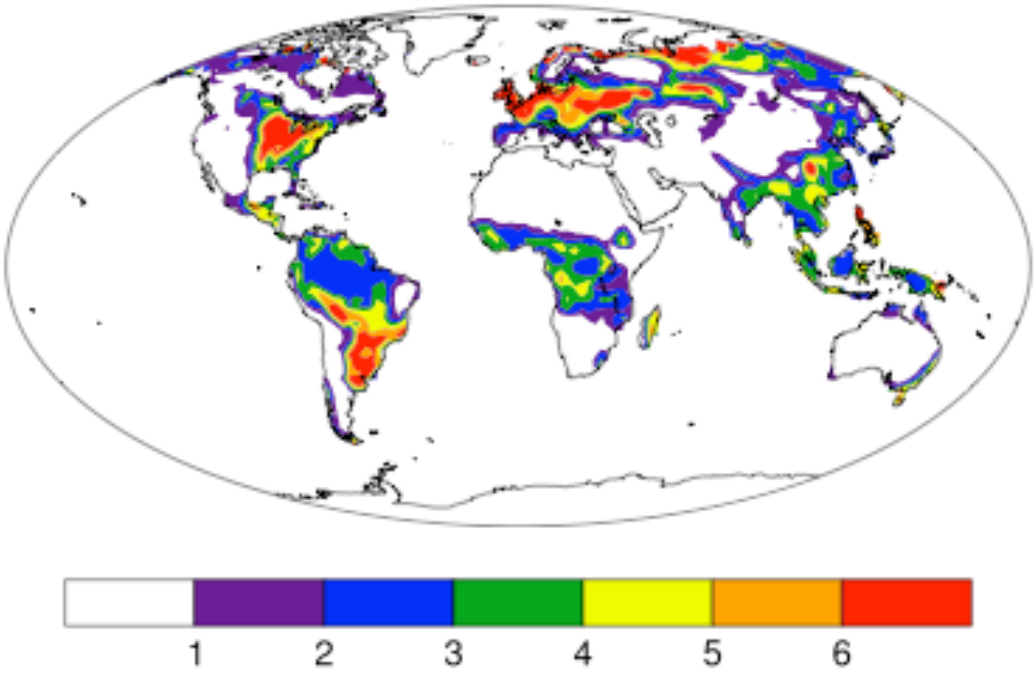
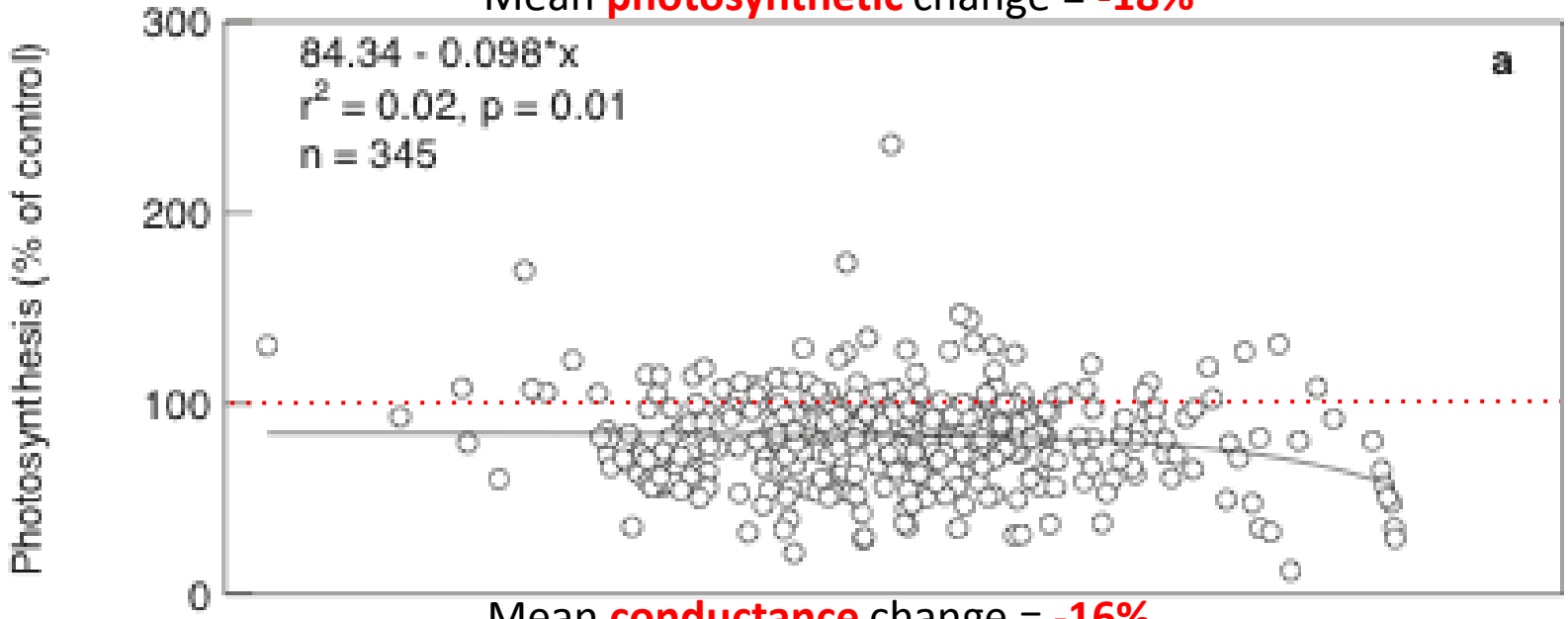
Change in **latent** heat flux due to O_3 (%)



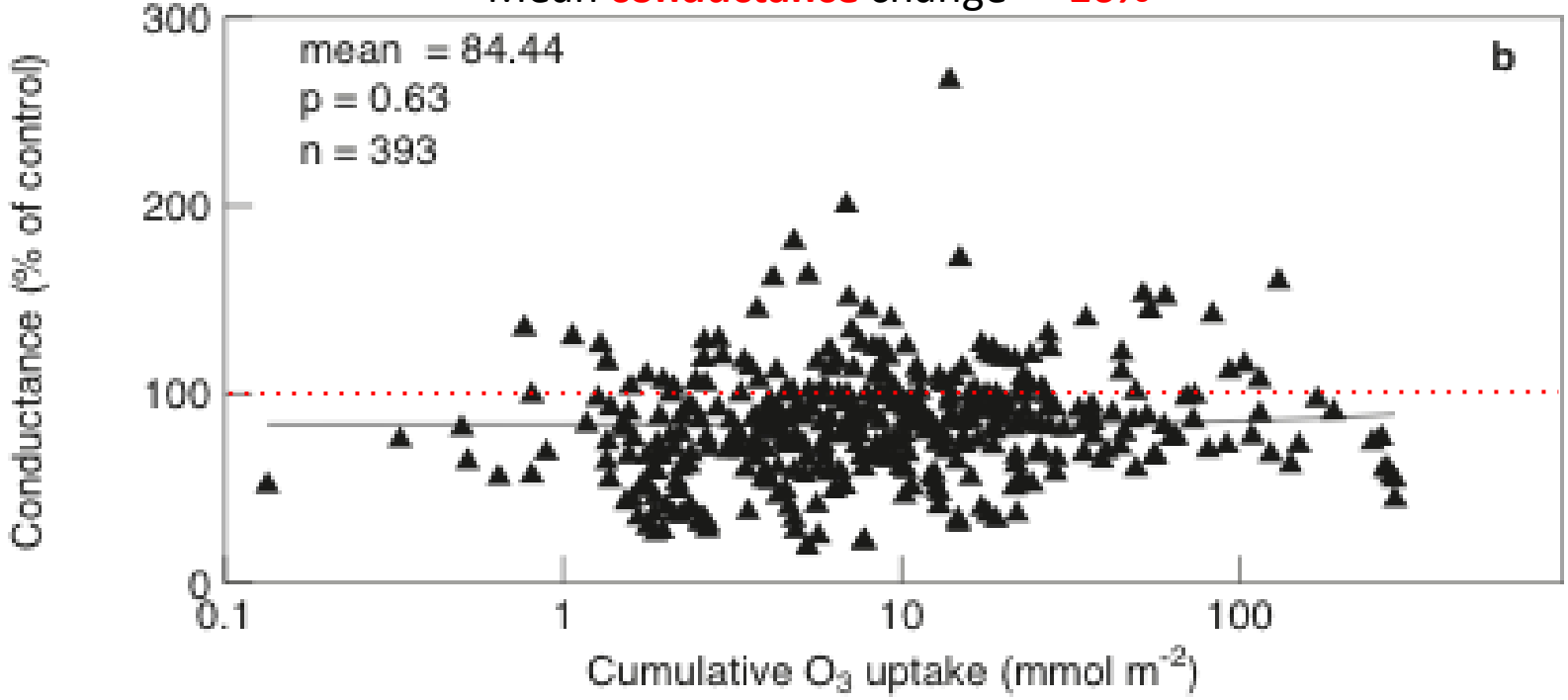
Change in **sensible** heat flux due to O_3 (%)



Mean **photosynthetic** change = **-18%** *

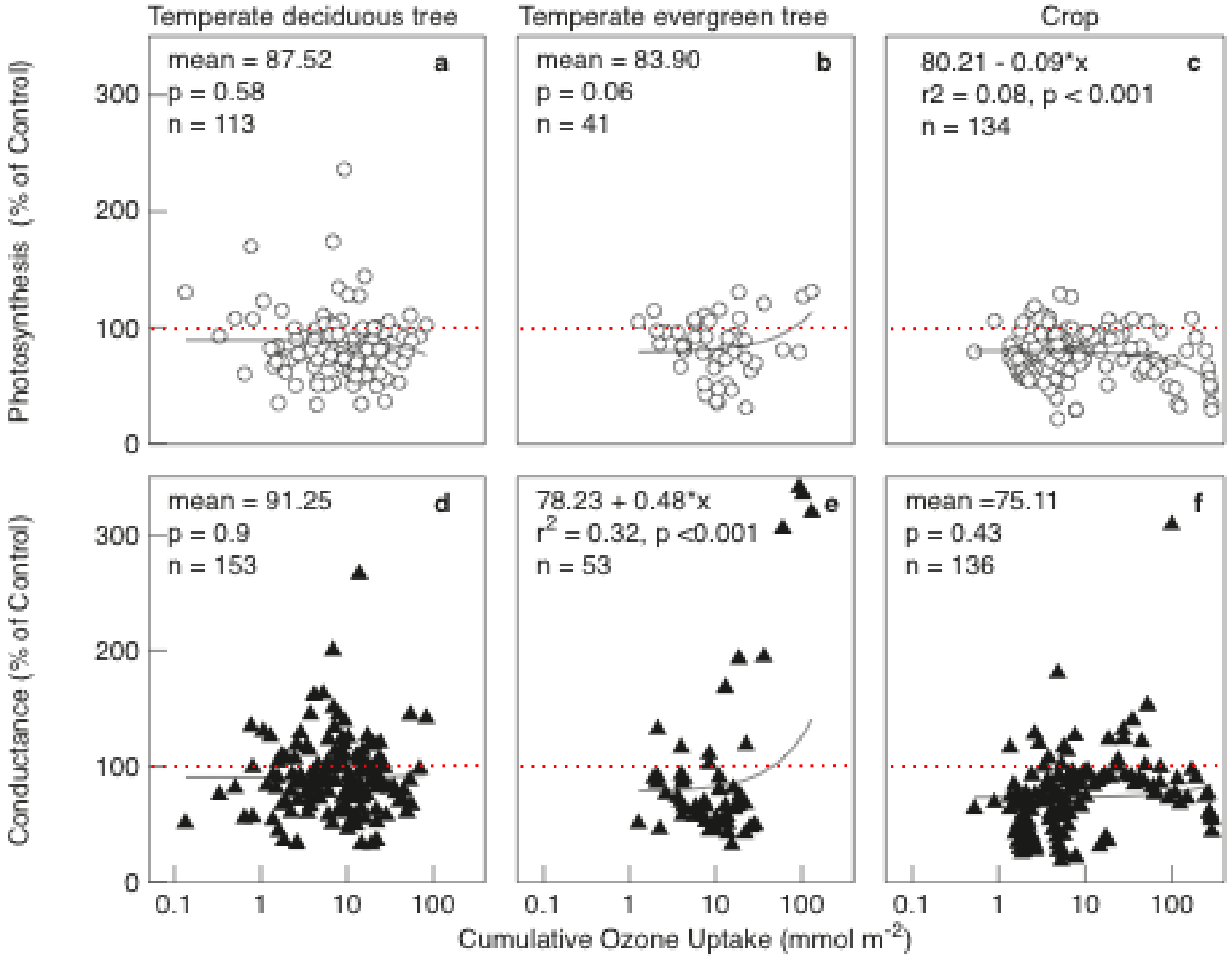


Mean **conductance** change = **-16%**



* Similar to Wittig et al. 2007, *Plant Cell Environ*; Feng et al. 2008 *GCB*; Morgan et al. 2003, *Plant Cell Environ*

Lombardozzi et al. (2013). Submitted to *BGS*



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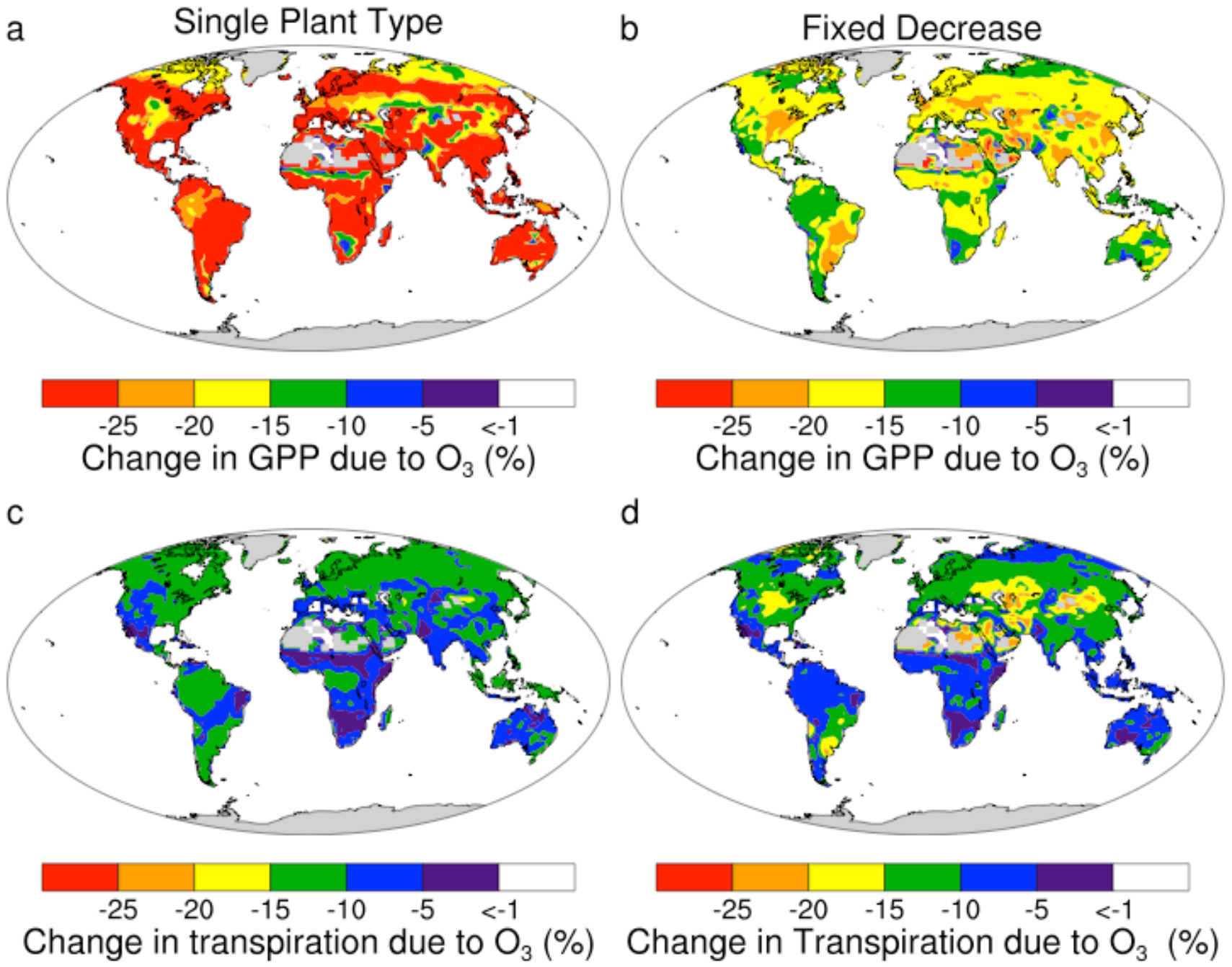
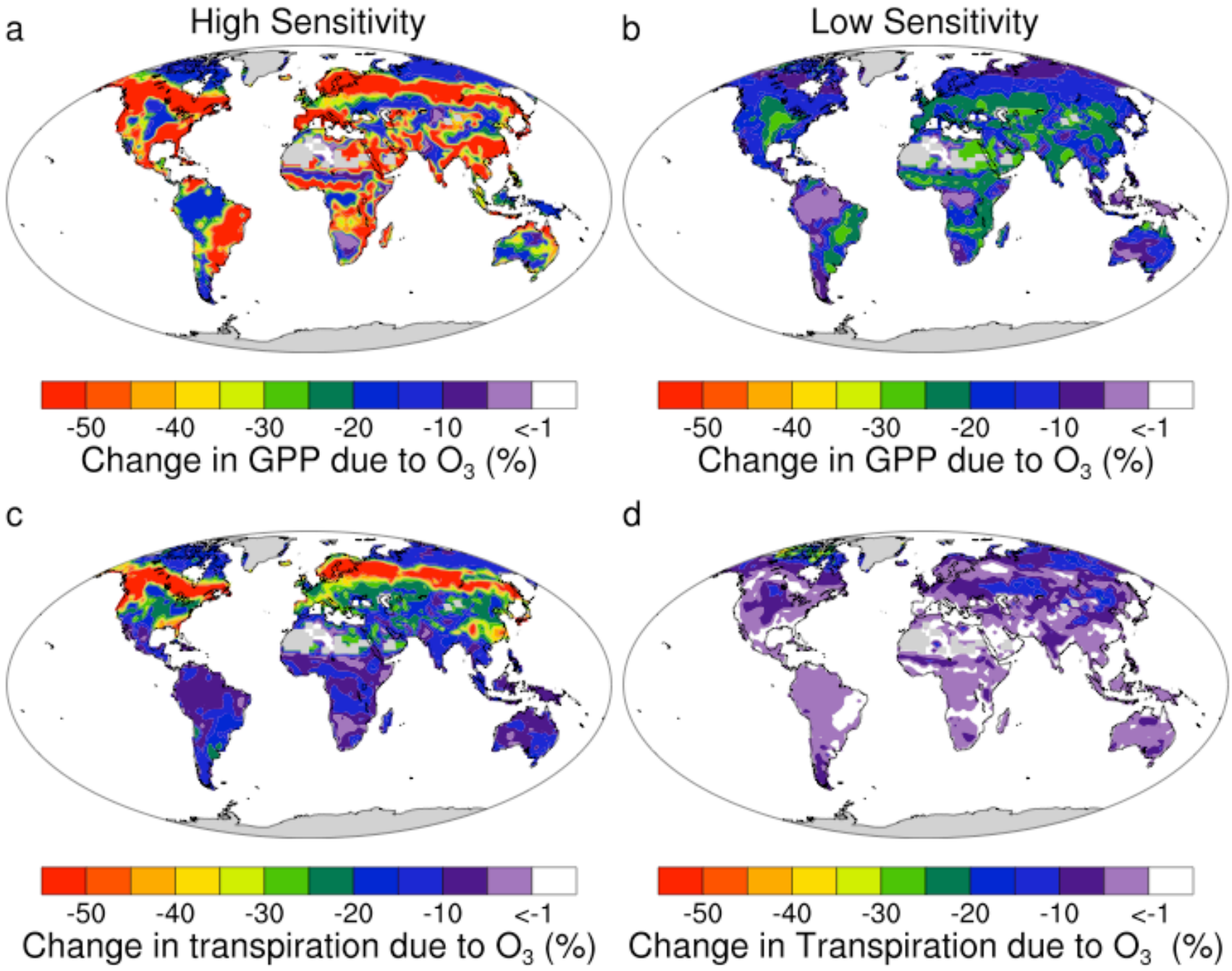
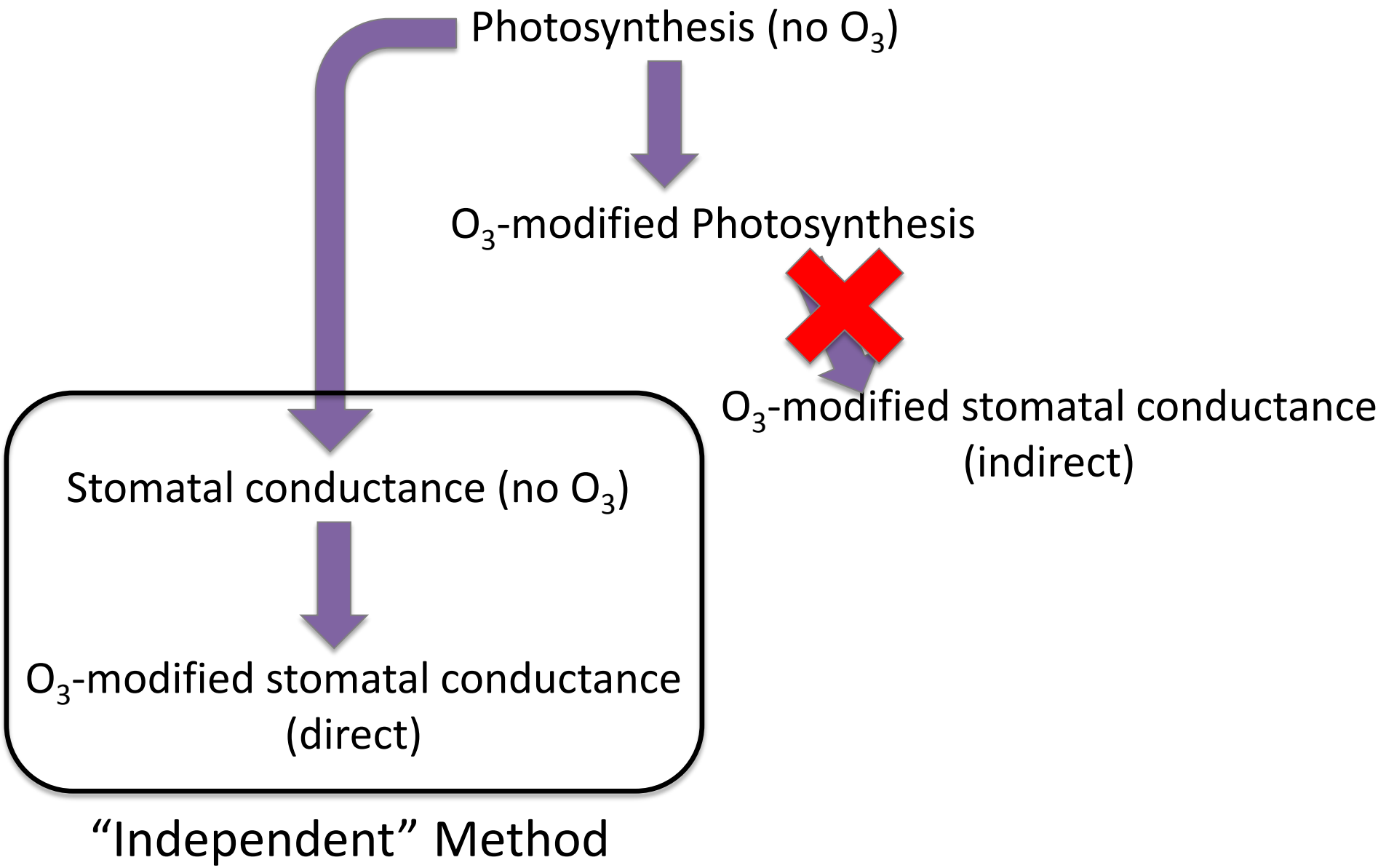

a
Single Plant Type
b
Fixed Decrease
-25 -20 -15 -10 -5 <-1
Change in GPP due to O_3 (%)
-25 -20 -15 -10 -5 <-1
Change in GPP due to O_3 (%)
c
d
-25 -20 -15 -10 -5 <-1
Change in transpiration due to O_3 (%)
-25 -20 -15 -10 -5 <-1
Change in Transpiration due to O_3 (%)


a
High Sensitivity
b
Low Sensitivity
-50 -40 -30 -20 -10 <-1
Change in GPP due to O_3 (%)
-50 -40 -30 -20 -10 <-1
Change in GPP due to O_3 (%)
c
d
-50 -40 -30 -20 -10 <-1
Change in transpiration due to O_3 (%)
-50 -40 -30 -20 -10 <-1
Change in Transpiration due to O_3 (%)

Community Land Model (CLM)*



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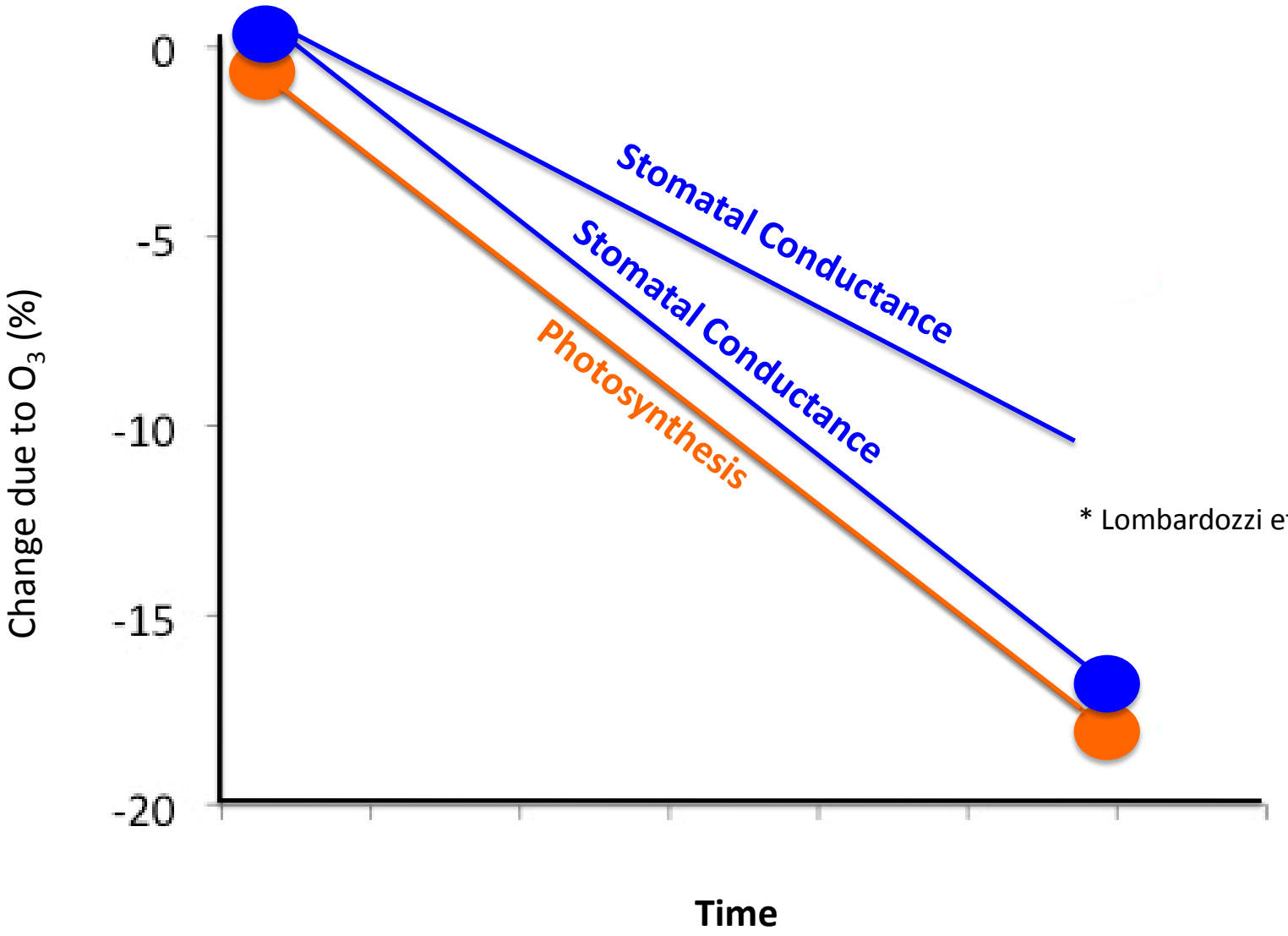

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