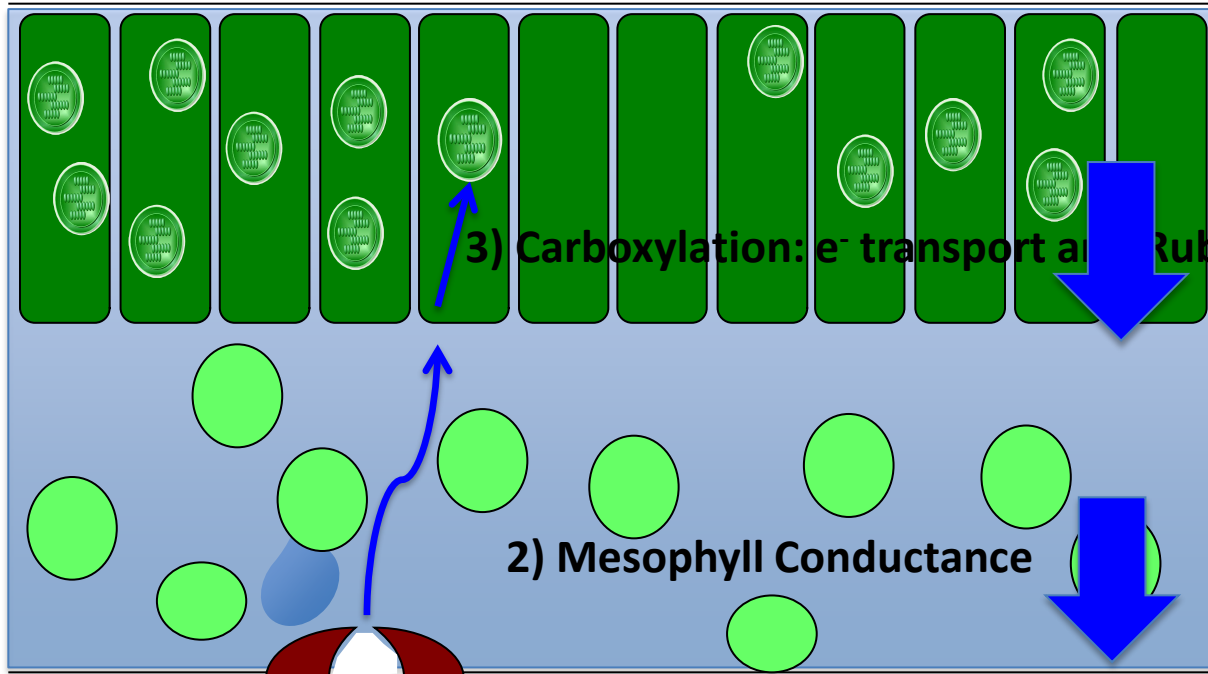


When Physiological Models Fail: Fixing the Ozone Oxidation Problem

An aerial photograph showing a dense green forest in the foreground, with a city skyline visible in the background under a cloudy sky. The skyline includes several prominent skyscrapers, with the tallest one having a distinctive spire.

Danica Lombardozzi, Jed Sparks
Cornell University
Gordon Bonan, Sam Levis
NCAR

Leaf Cross-section



3) Carboxylation: e⁻ transport and Rubisco activity

2) Mesophyll Conductance

1) Stomatal Conductance

Photosynthesis

Transpiration

H_2O

O_3

Ball-Berry Stomatal Conductance

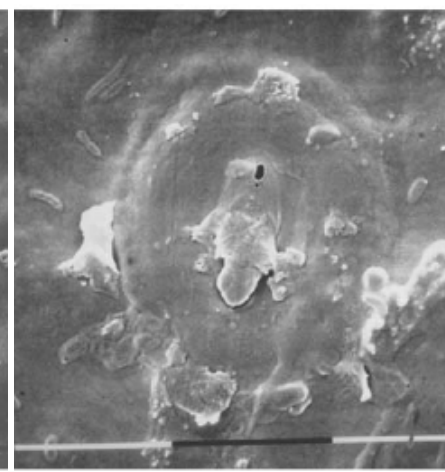
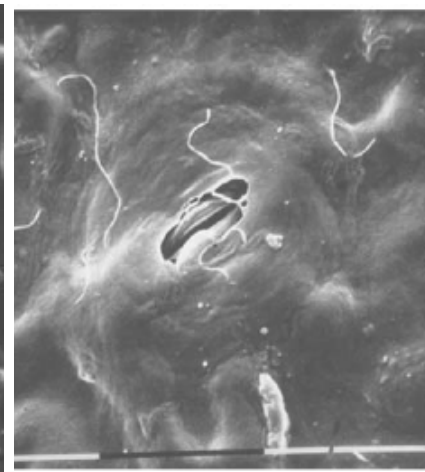
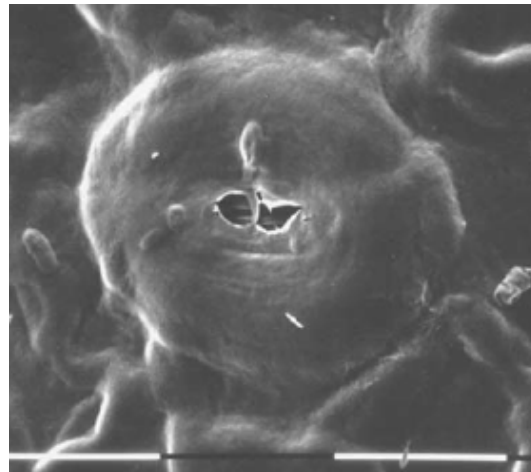
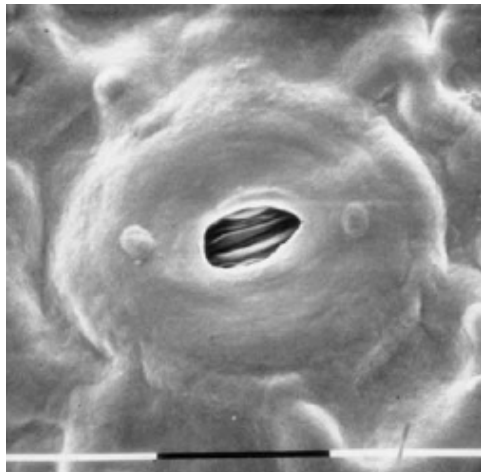
$$g_s = m \frac{\text{Photosynthesis}}{[\text{CO}_2] \text{ @ leaf surface}} \text{RH} + \text{minimum } g_s$$

Healthy stoma

Slightly damaged stoma

Moderately damaged stoma

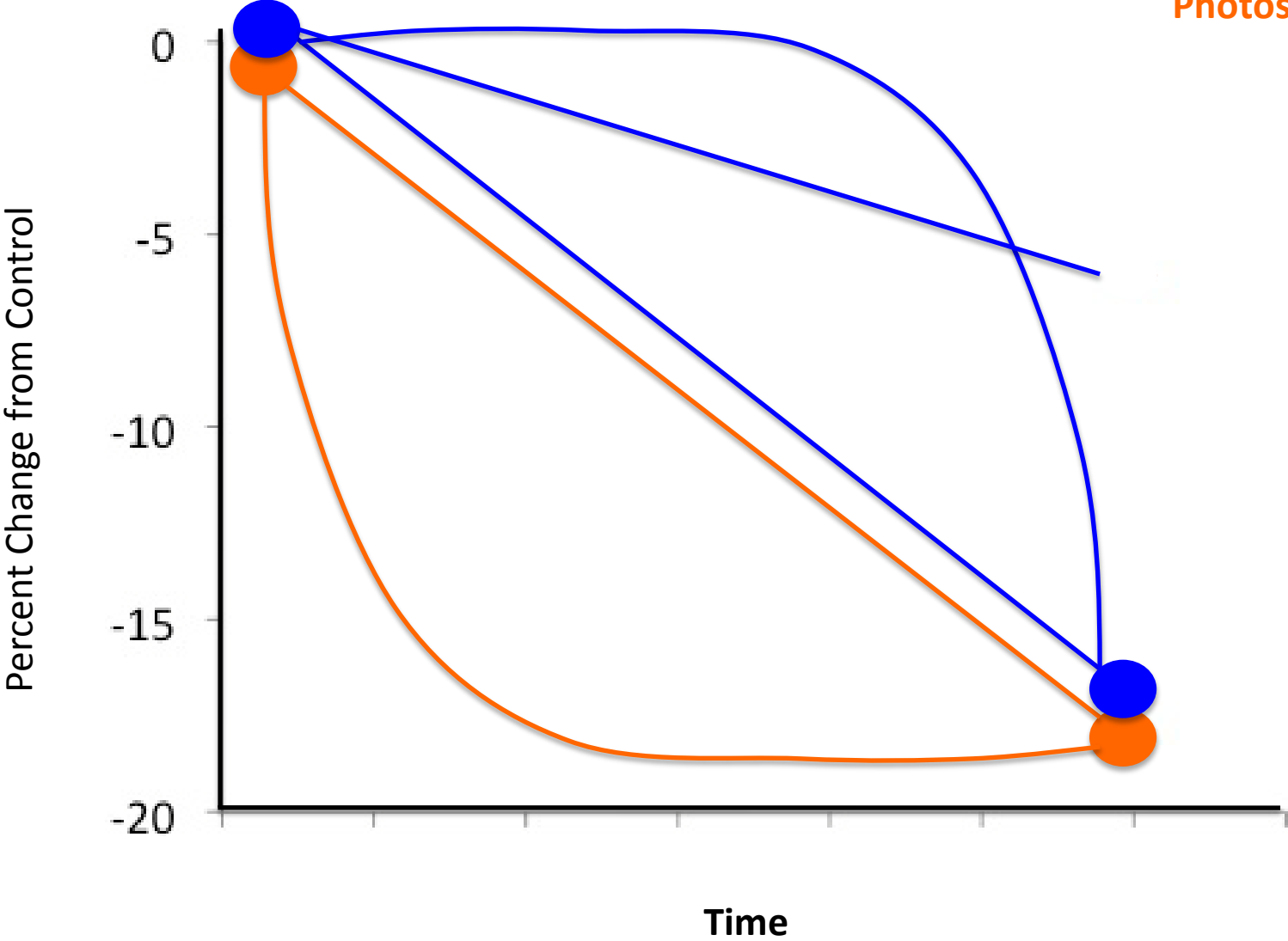
Severely damaged stoma



Images of O₃ damage to stomata from Paoletti et al. 2007

Stomatal Conductance

Photosynthesis



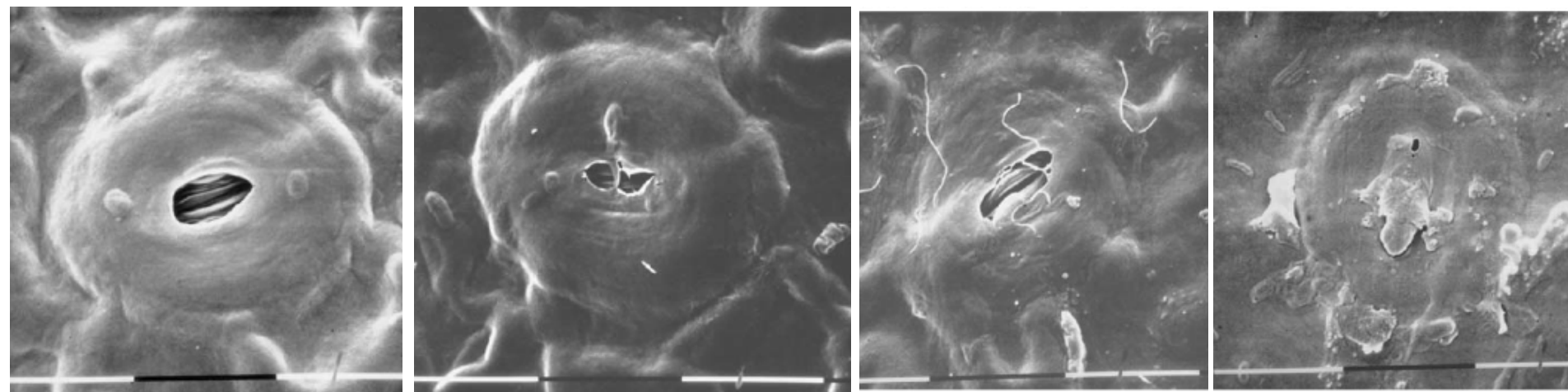
- 1) Calculate optimal photosynthesis
- 2) Modify photosynthesis
- 3) Calculate optimal conductance from optimal photosynthesis
- 4) Modify conductance

Healthy stoma

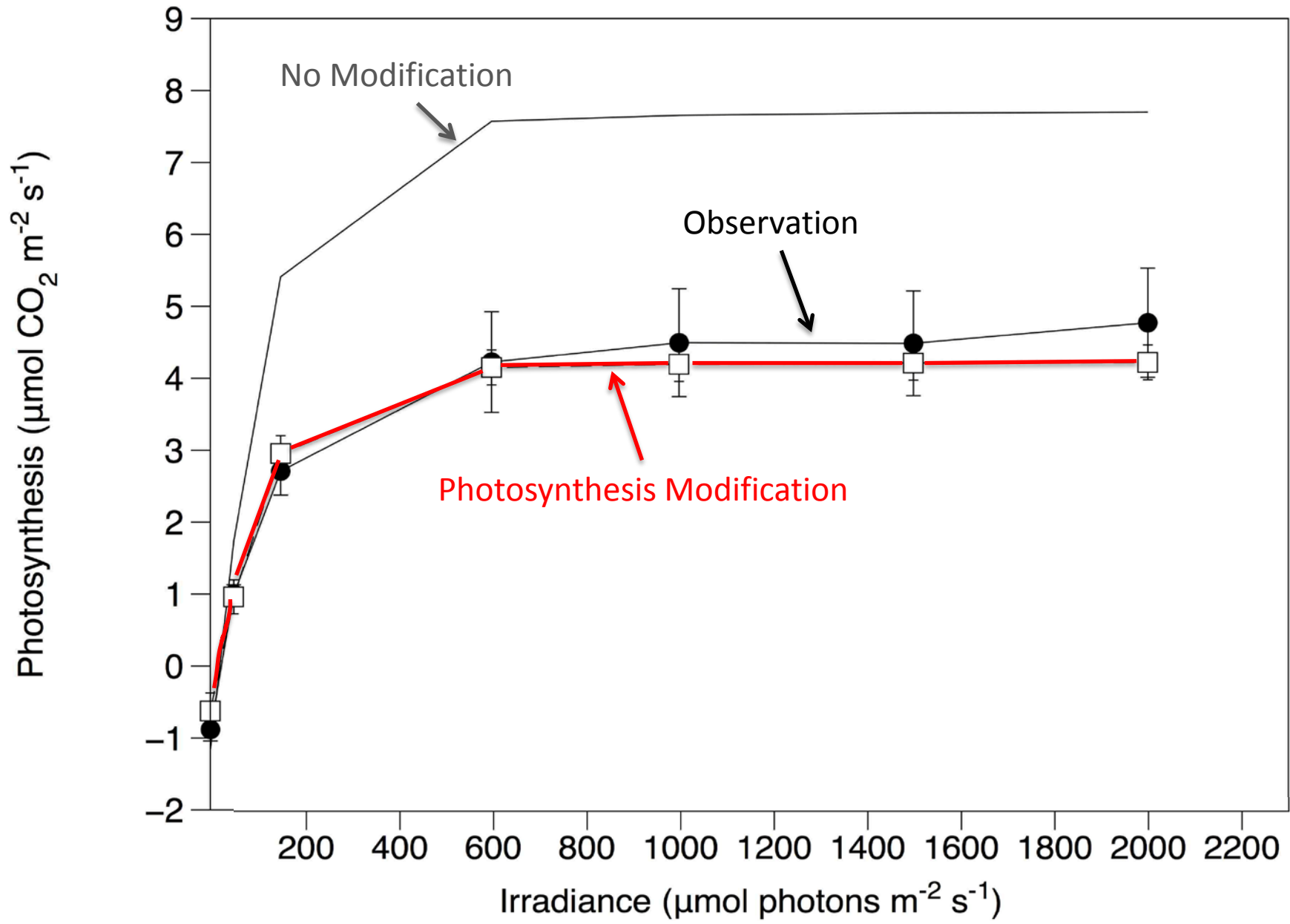
Slightly damaged stoma

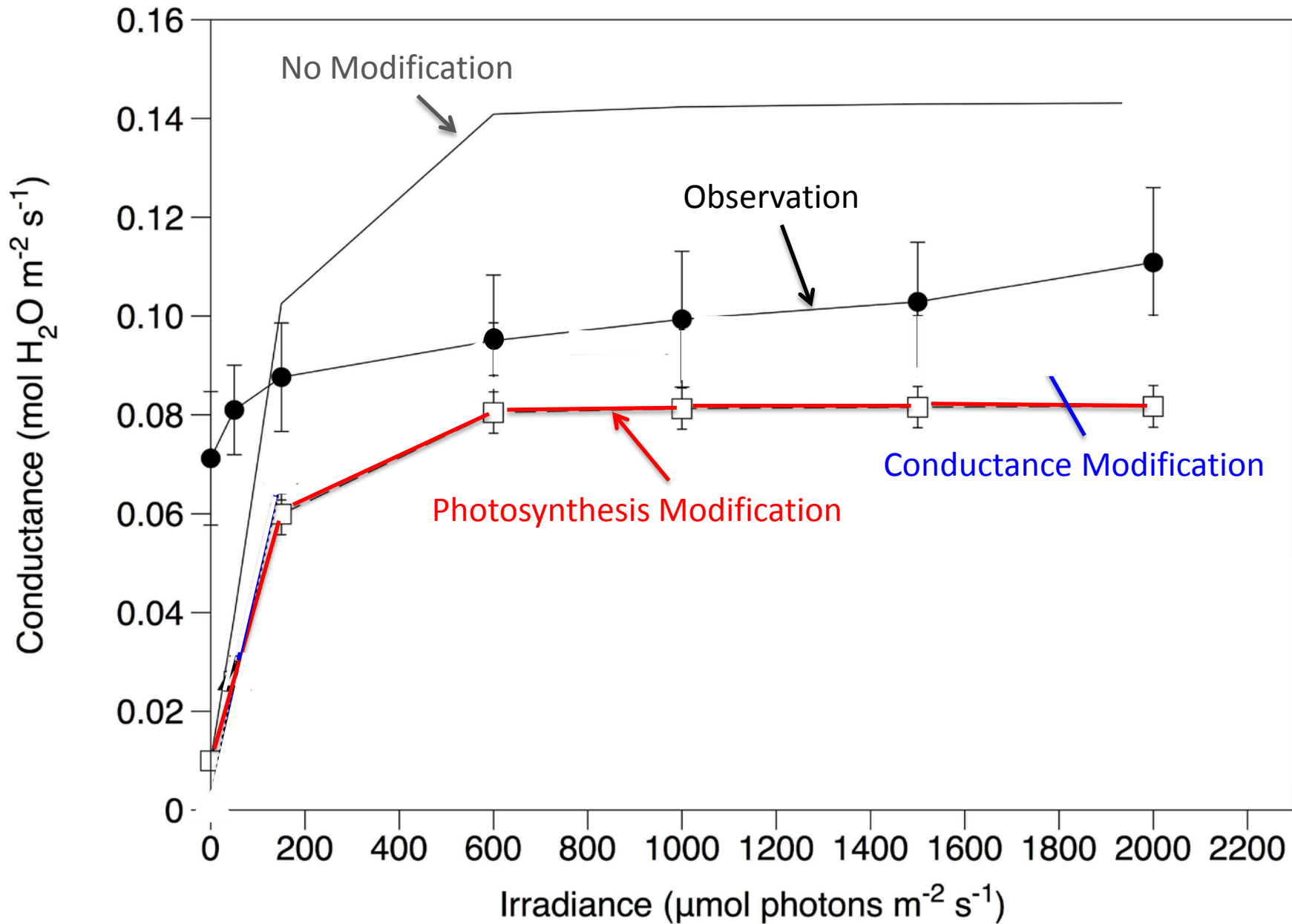
Moderately damaged stoma

Severely damaged stoma



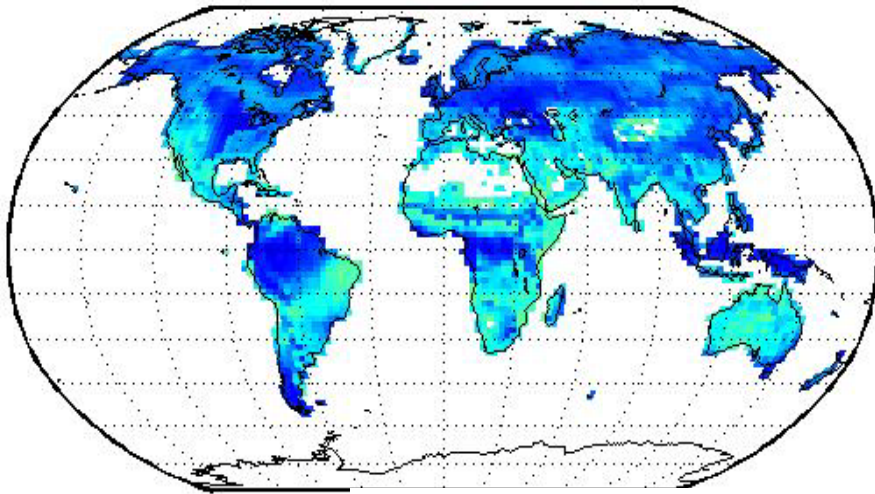
Images of O₃ damage to stomata from Paoletti et al. 2007



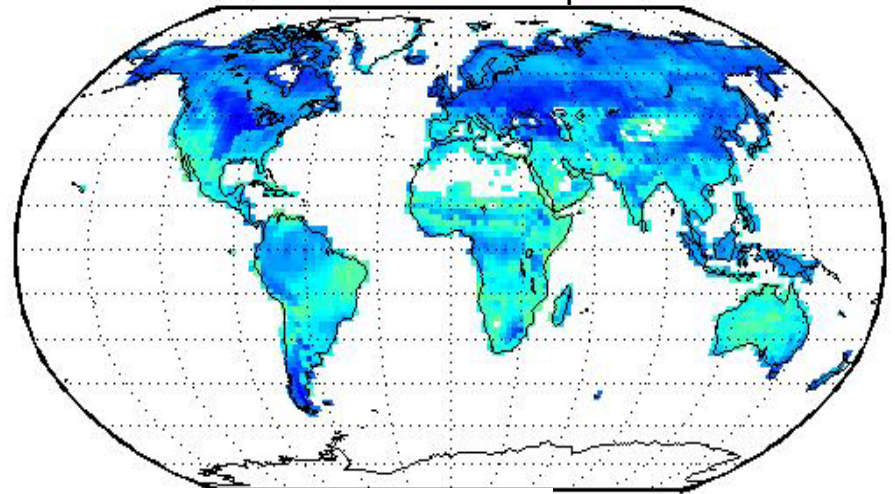


Transpiration

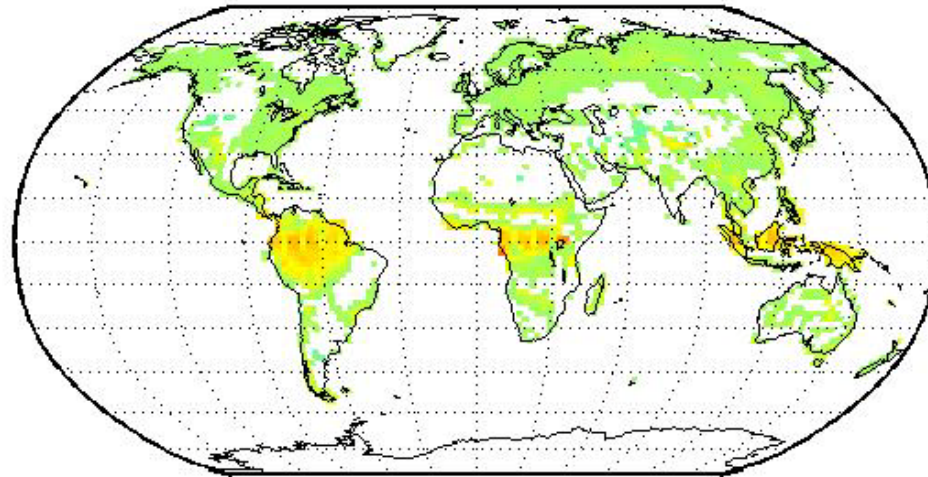
Standard Ball-Berry coupling



New method – uncoupling photosynthesis and stomatal responses



Difference between “new” and “standard” methods

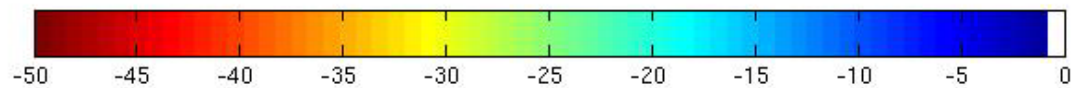
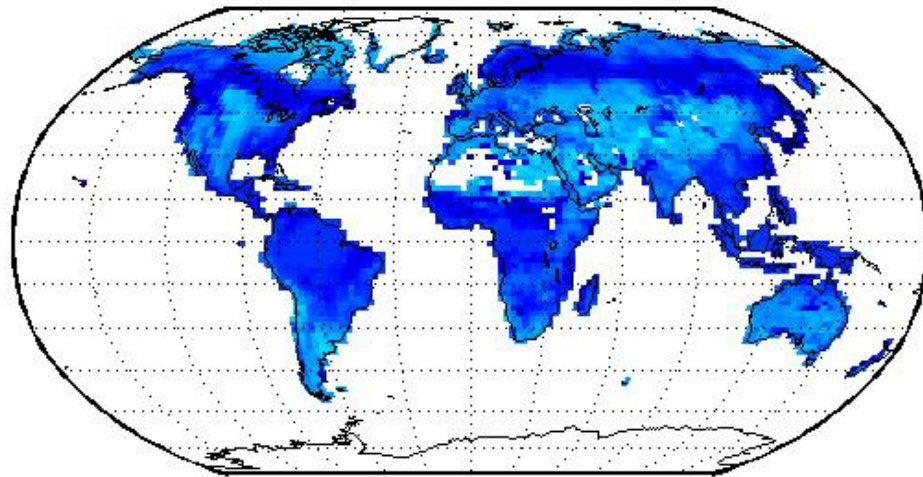


% Change

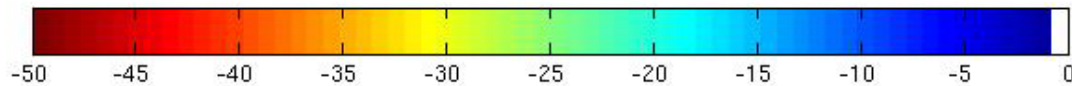
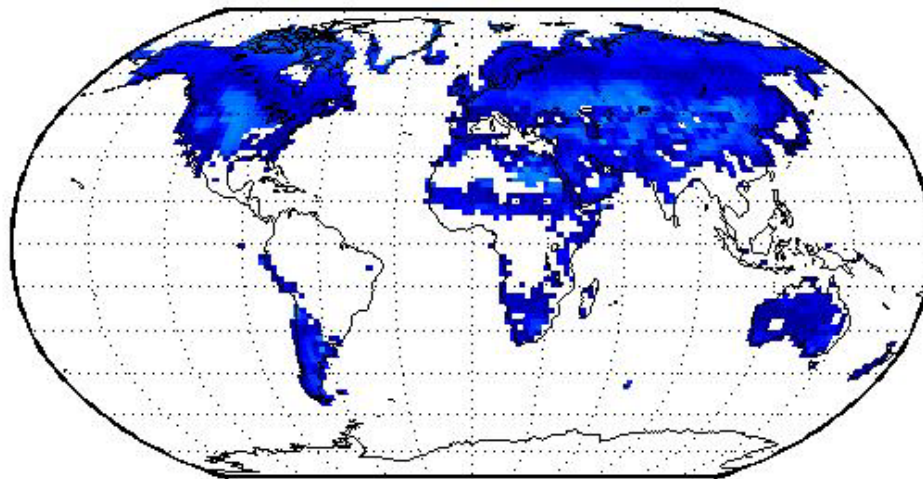
Conclusions

- Directly modifying simulated conductance improves accuracy of physiological model
- Higher transpiration rates when directly modifying conductance compared to standard method
- Predictions of H₂O cycling and climate feedbacks can be improved by changing conductance directly

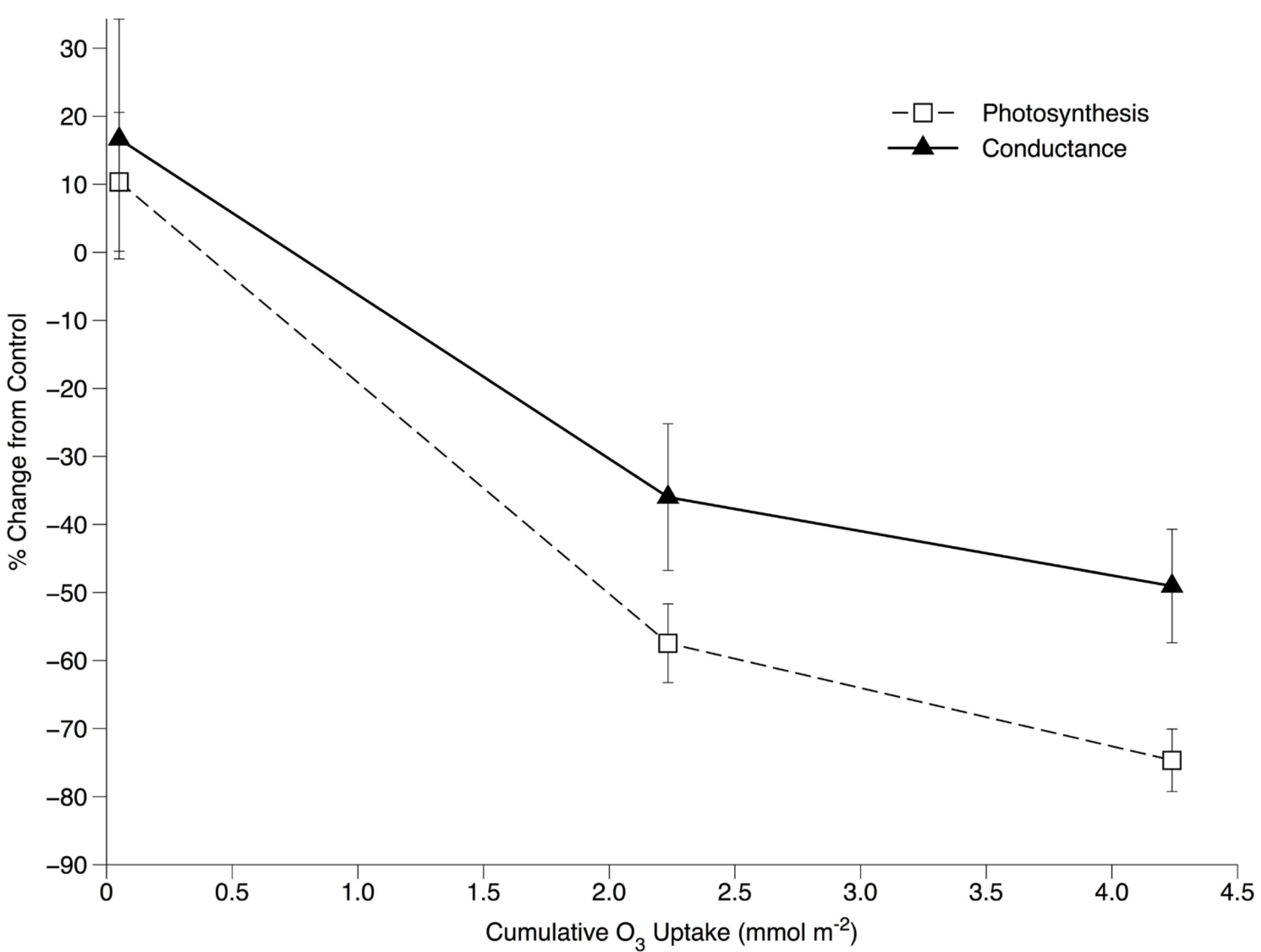


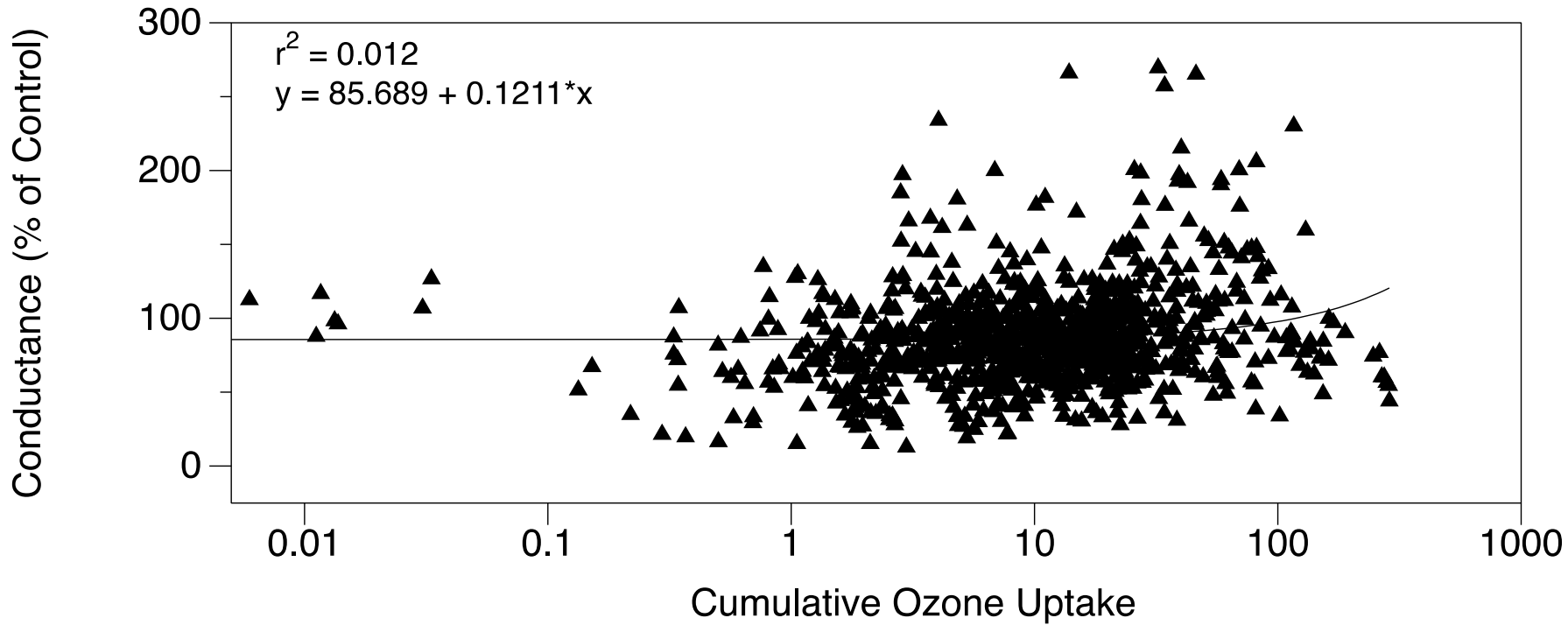
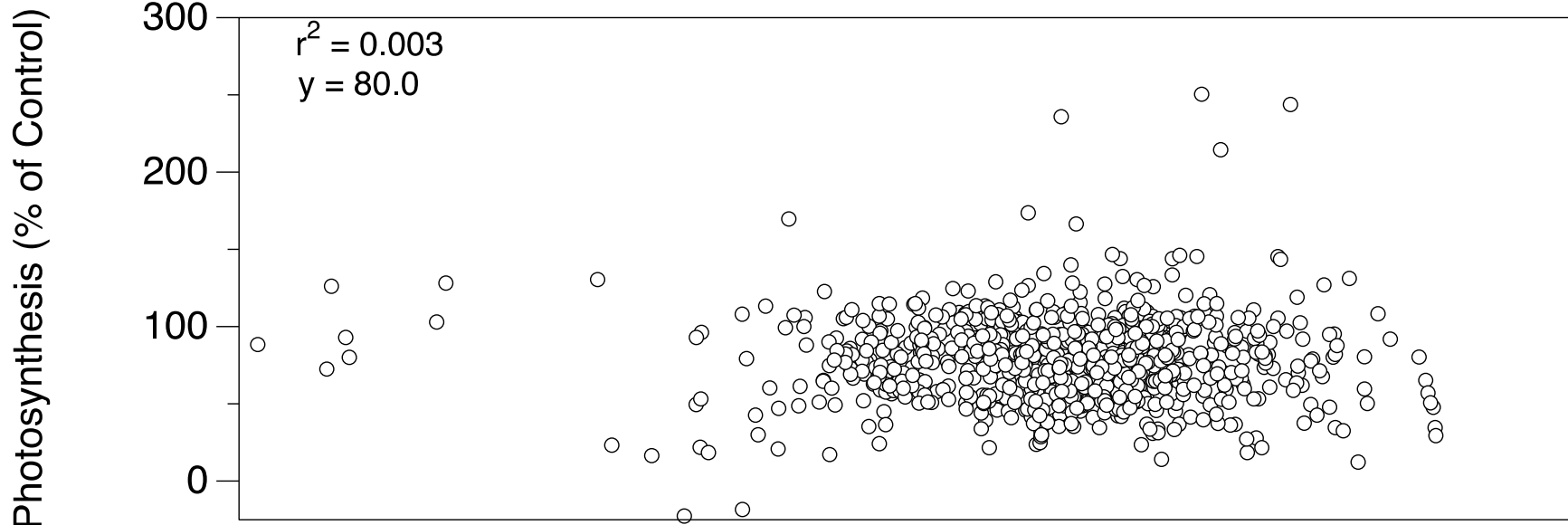


Change in GPP due to O_3 (%)



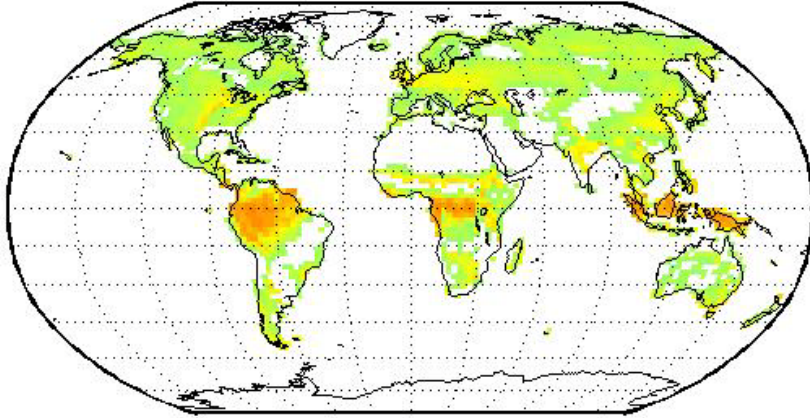
Change in transpiration due to O_3 (%)



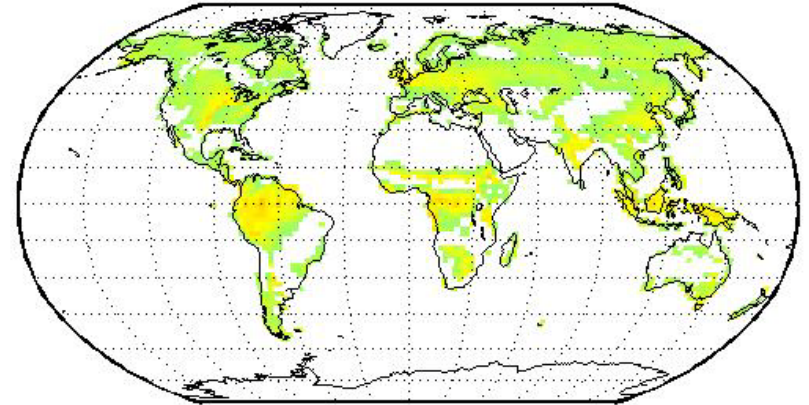


Ozone Uptake

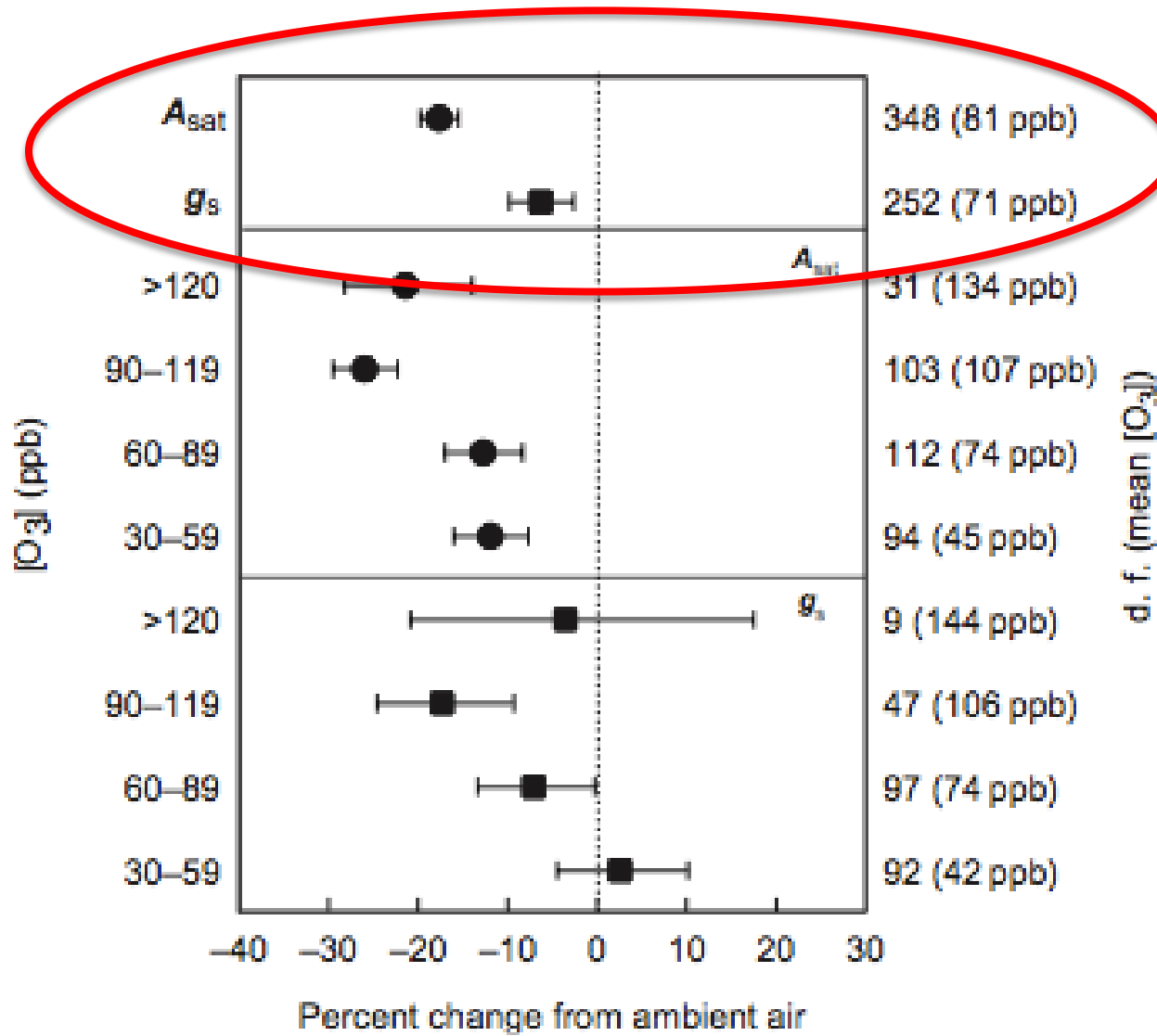
Standard Ball-Berry coupling



New method – uncoupling photosynthesis and stomatal responses



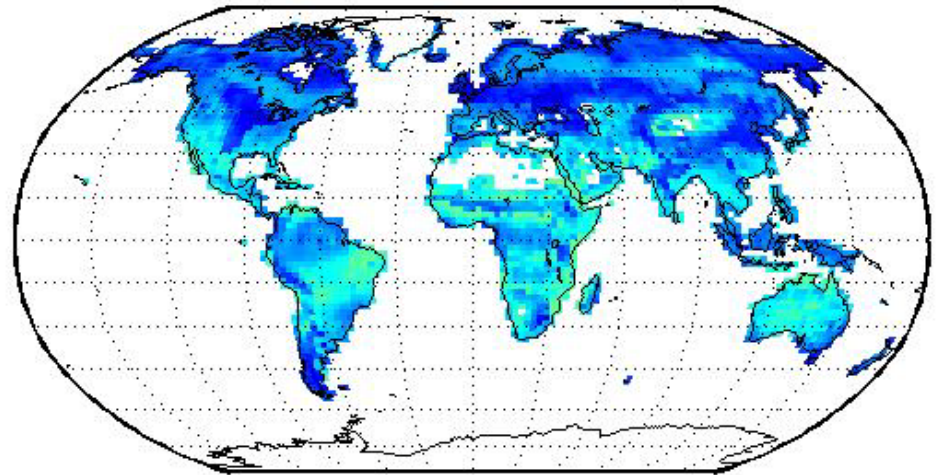
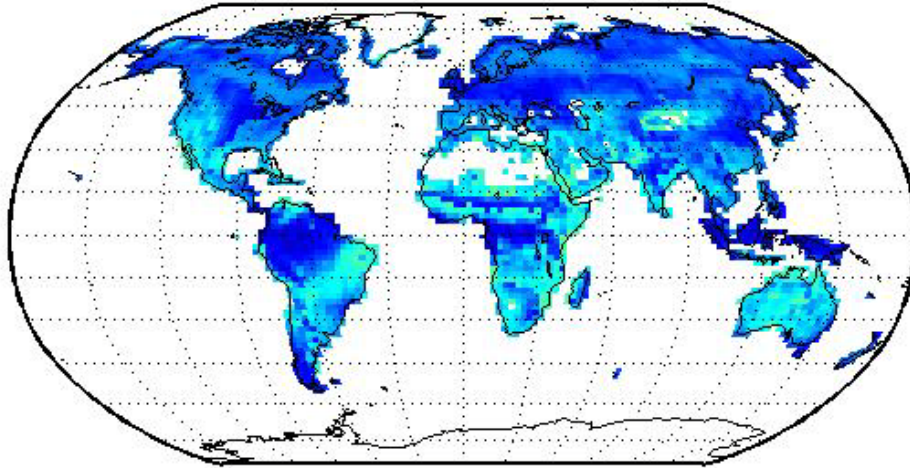
$\text{mmol O}_3 \text{ m}^{-2}$



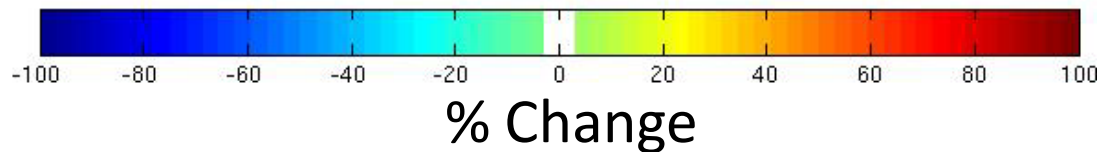
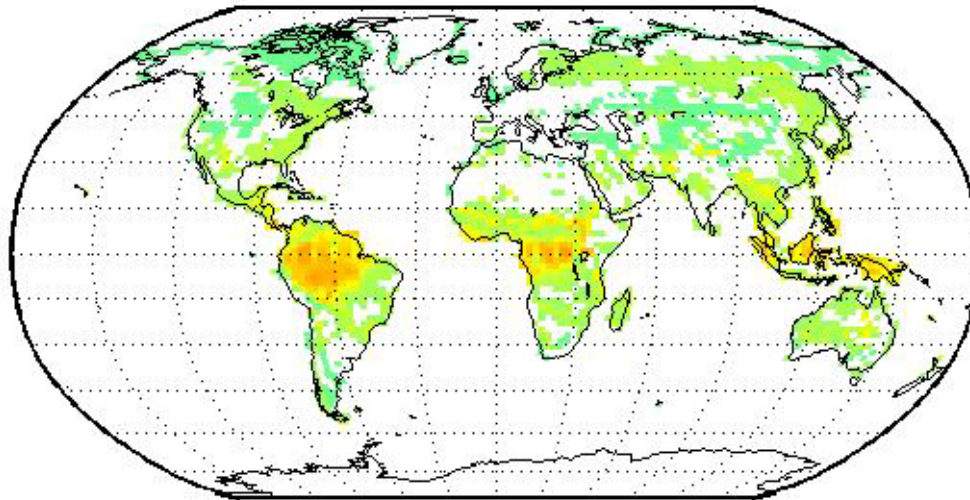
Gross Primary Productivity (GPP)

Standard Ball-Berry coupling

New method – uncoupling photosynthesis and stomatal responses



Difference between “new” and “standard” methods



Category	Categorical Level									
Plant Type	crop (36, 241)	deciduous shrub (2, 14)	evergreen shrub (2, 9)	grasses (C ₃ & C ₄) (2, 9)	herbaceous (4, 50)	deciduous tree (59, 646)	evergreen tree (24, 183)	tropical tree (4, 17)		
Plant Age (years)	< 1 (57, 443)	1 - 5 (60, 662)	> 5 (13, 55)							
Control Air	ambient (35, 349)	charcoal filtered (91, 812)								
Data Confidence	low (66, 461)	medium (49, 582)	high (12, 126)							
Sensitivity	low (72, 293)	medium-low (59, 292)	medium-high (51, 292)	high (33, 292)						
