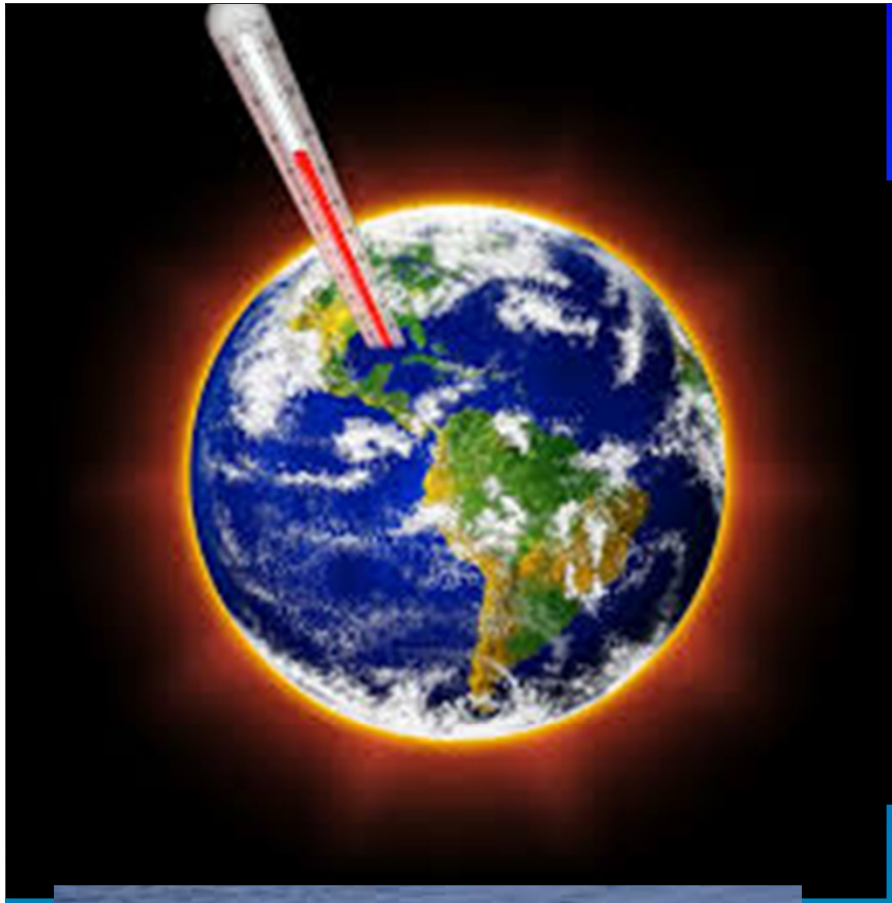
The Optimal Atmospheric CO_2 Concentration For the Growth of Winter Wheat (*Triticum aestivum*)

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Agri-2015, July 13-15, Beijing

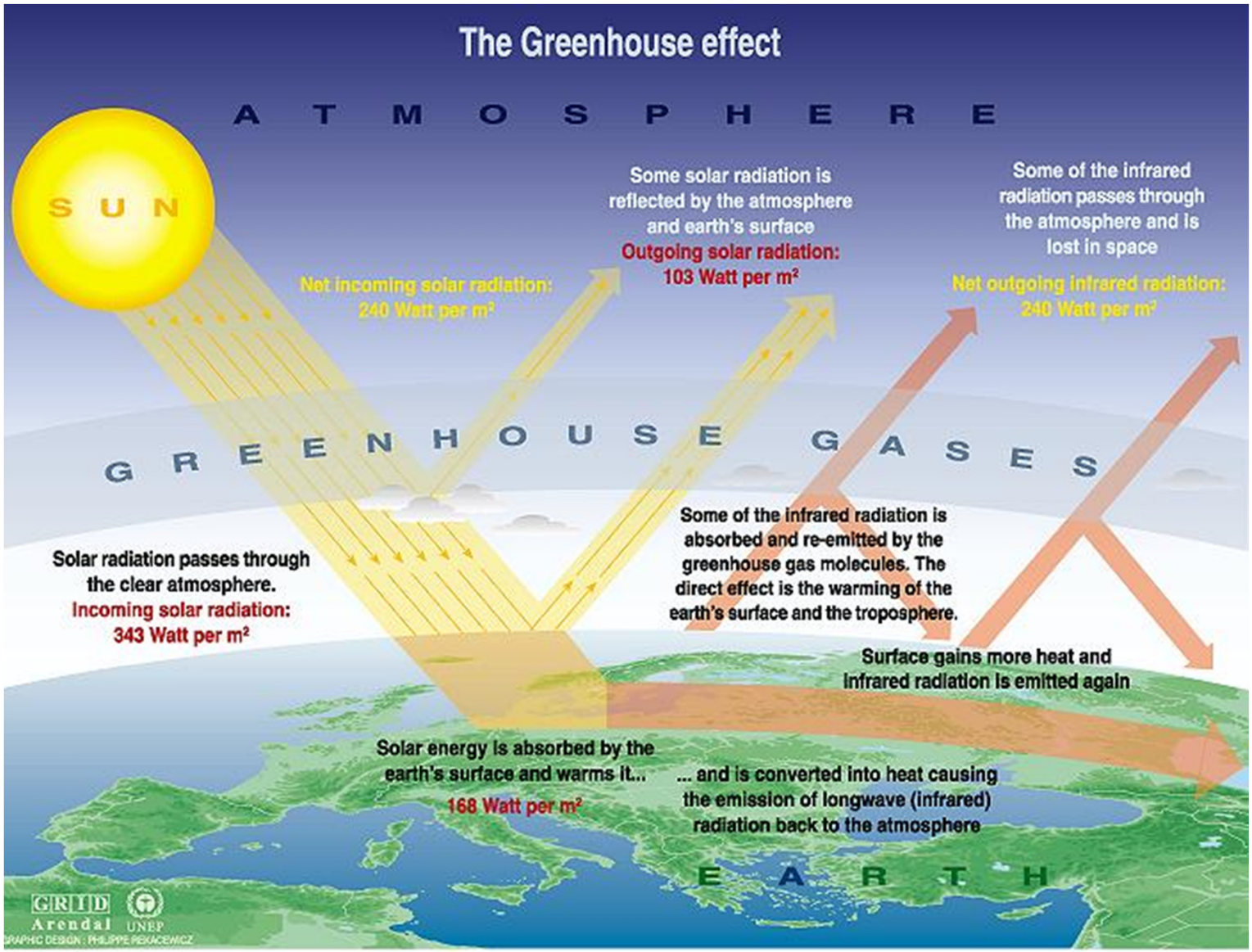






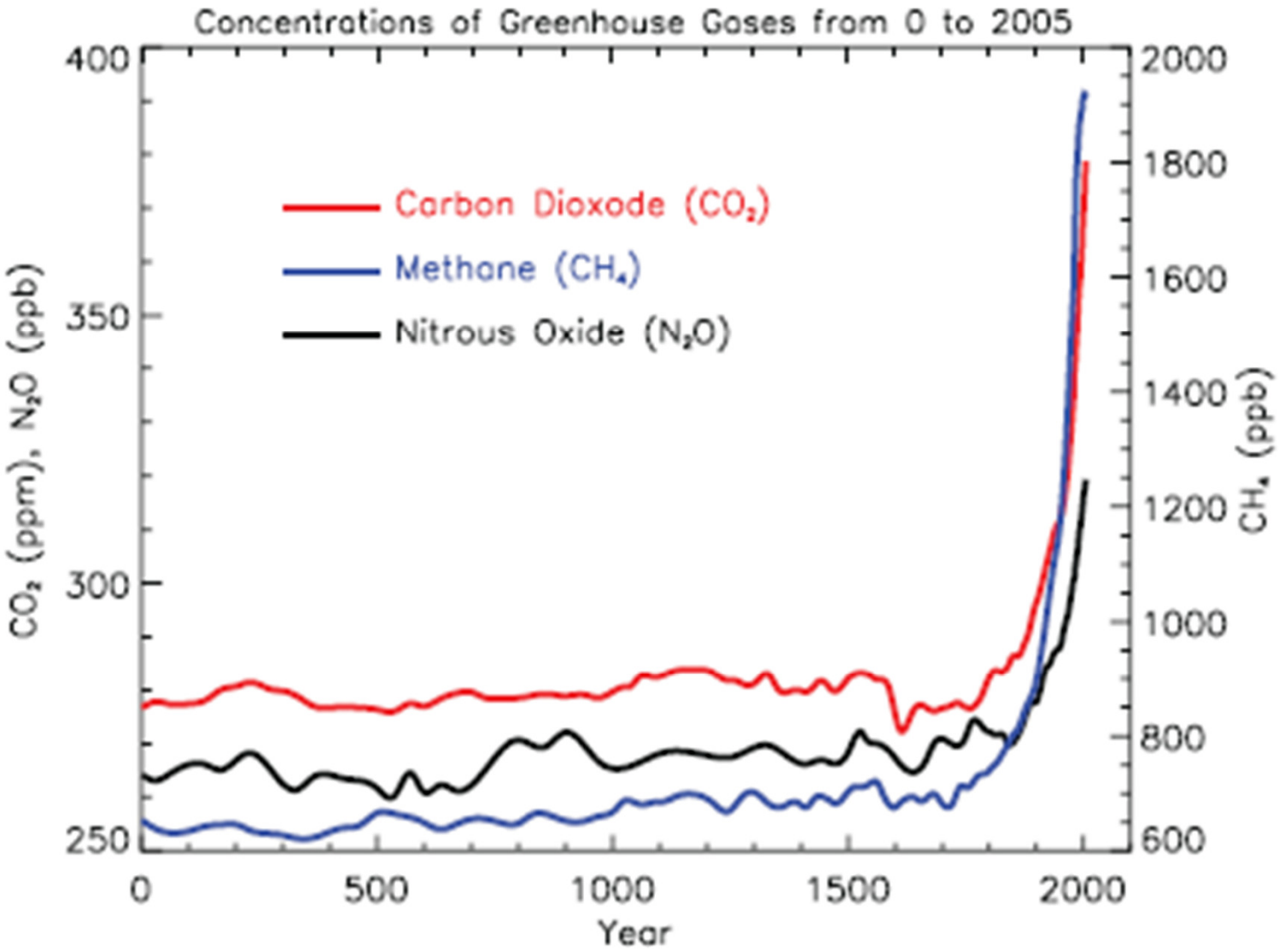


The Greenhouse Effect



Sources: Okanagan university college in Canada, Department of geography, University of Oxford, school of geography; United States Environmental Protection Agency (EPA), Washington; Climate change 1995, The science of climate change, contribution of working group 1 to the second assessment report of the intergovernmental panel on climate change, UNEP and WMO, Cambridge university press, 1996.

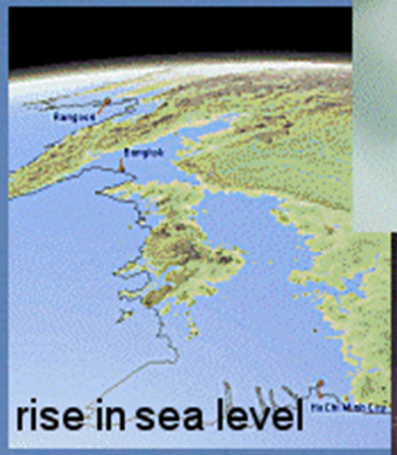
Greenhouse Gasses (Big 3!)

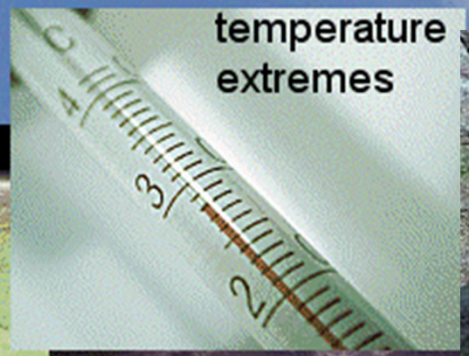


FAQ 2.1, Figure 1. *Atmospheric concentrations of important long-lived green*

Climate Change Impacts


















biodiversity

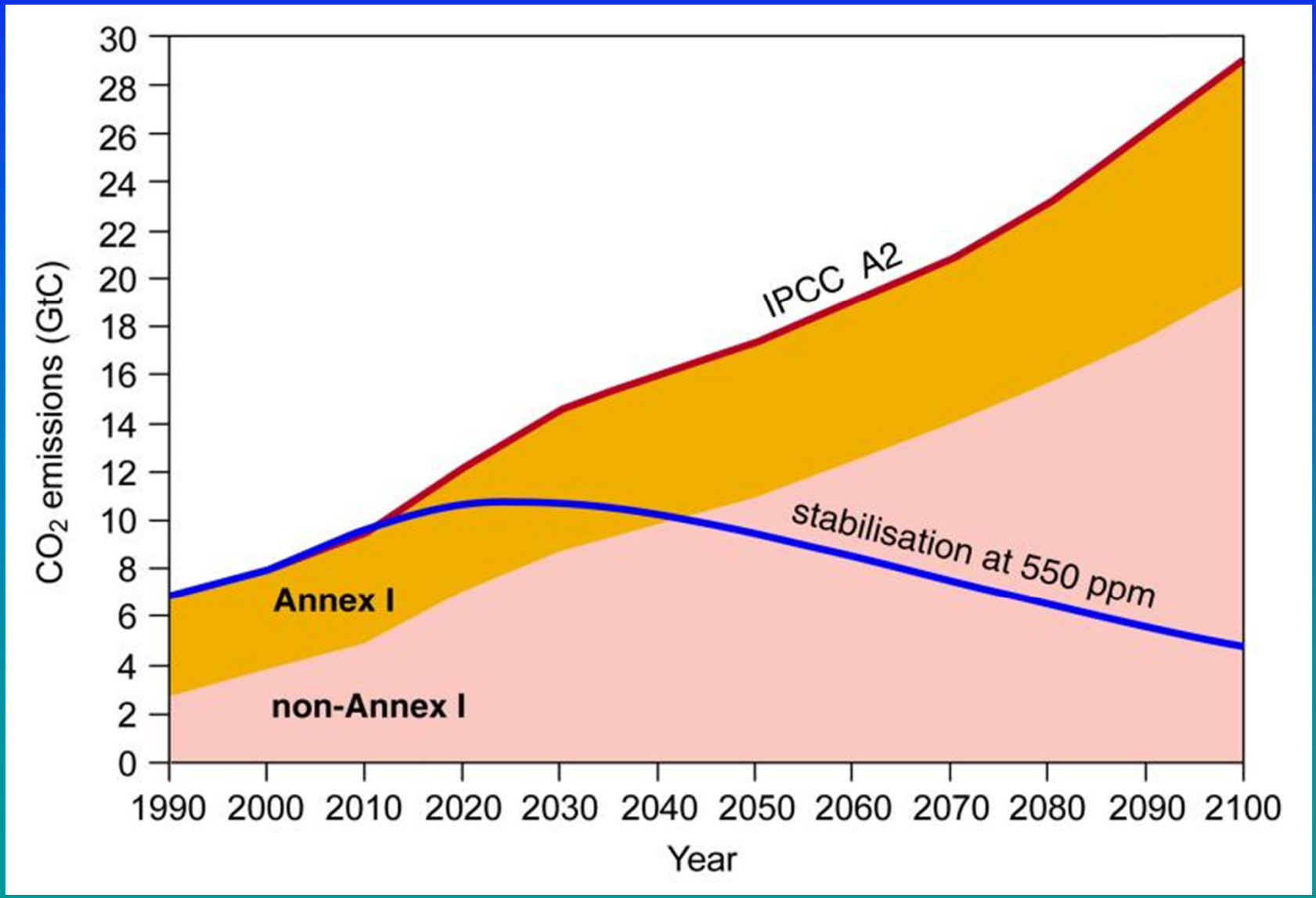

disease


starvation

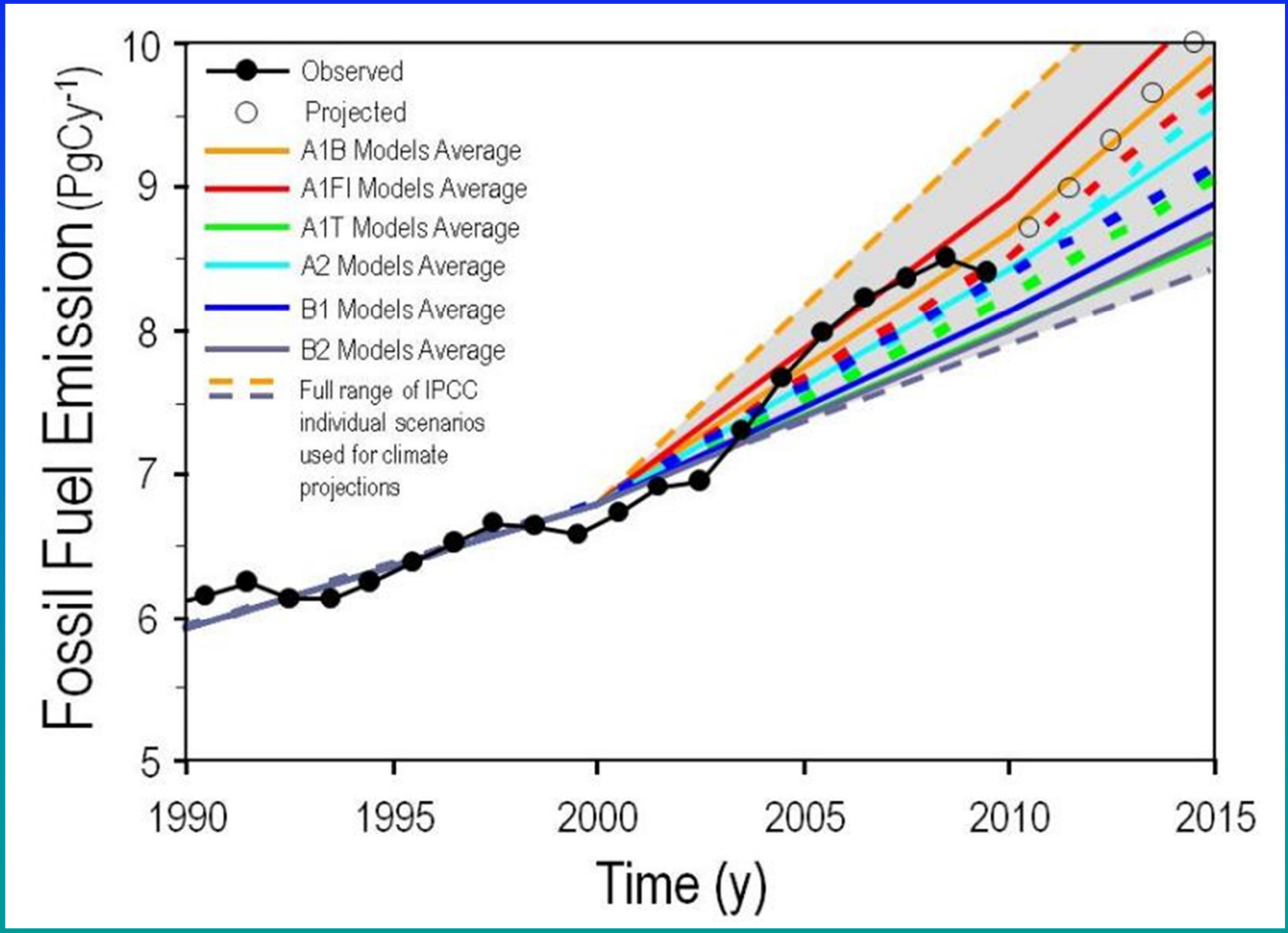

water


coastal areas

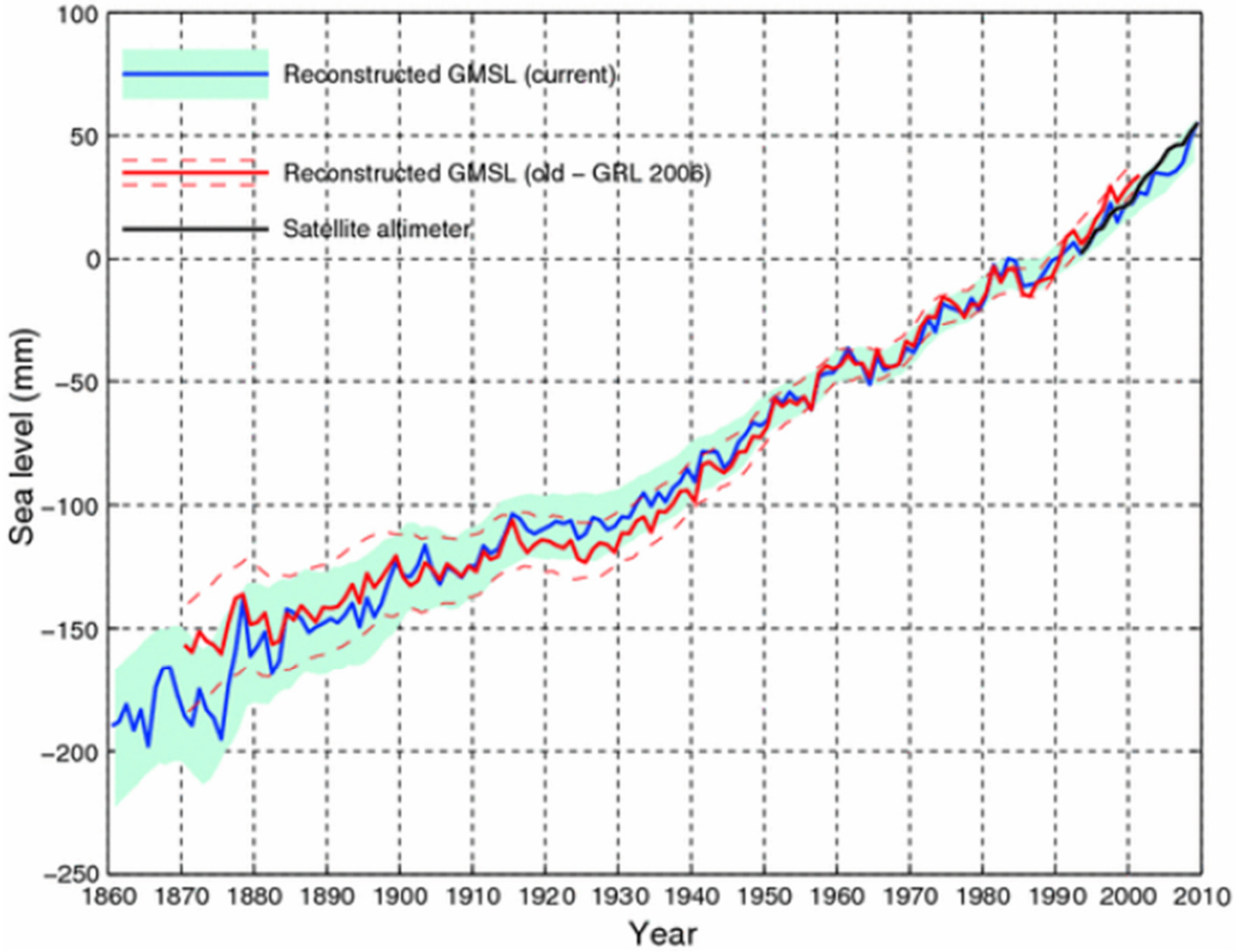
The HUGE climate challenge !!!



CO_2 Emissions from Fossil Burning

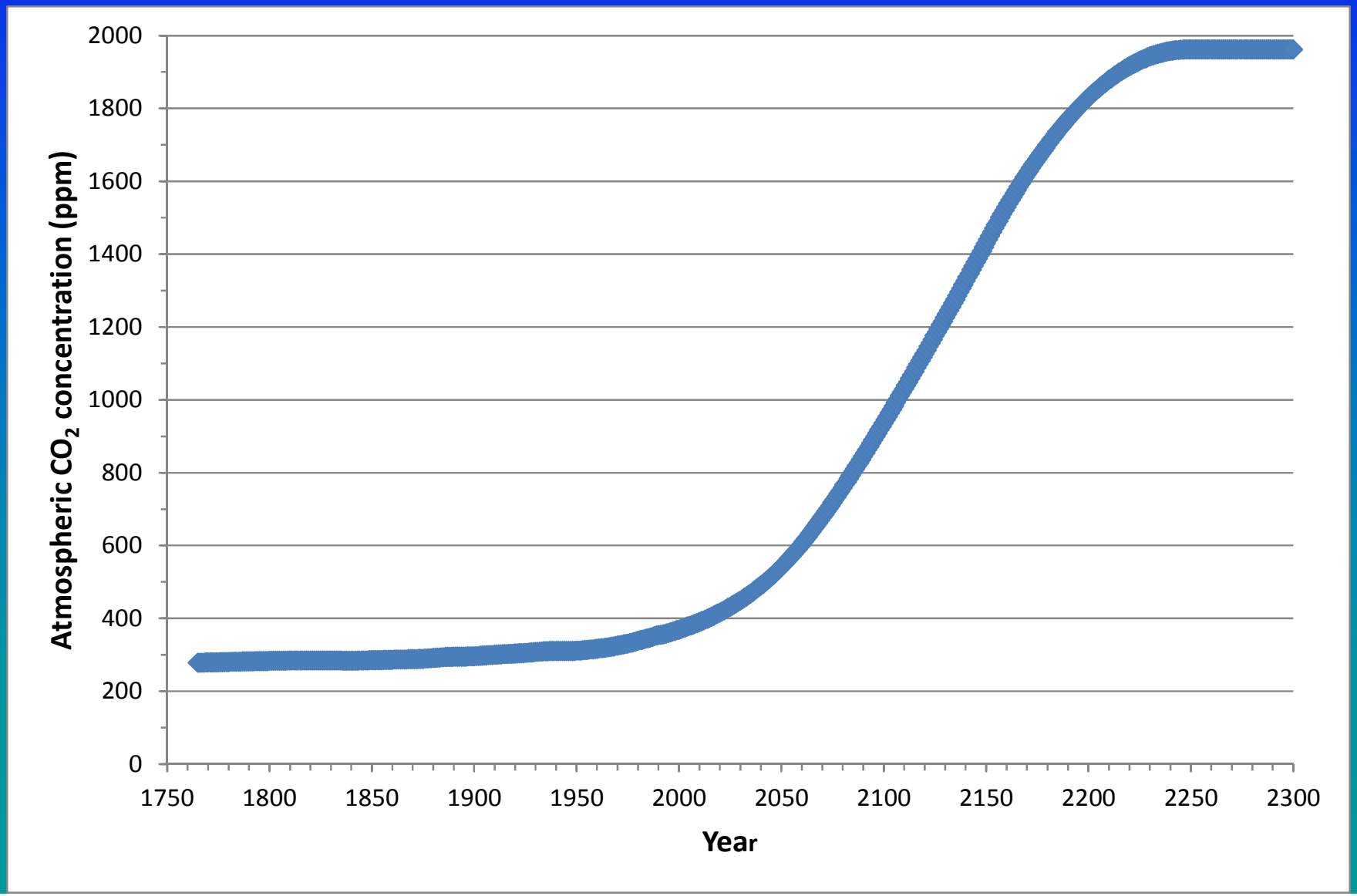


Projections of Sea Level Rising



Source: Church and White (2011).

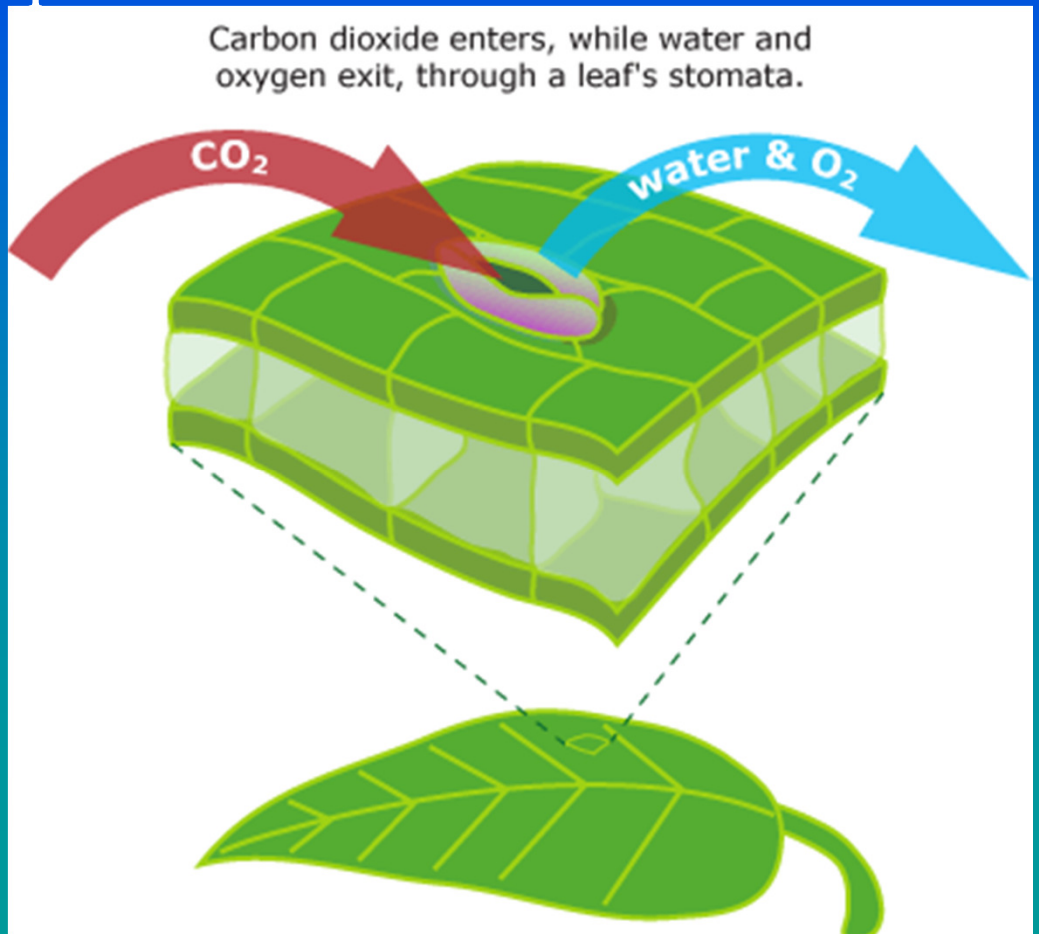
Atmospheric CO_2 concentration: Past, present and future (Data from CMIP5-RCP8.5) of IPCC-AR5)



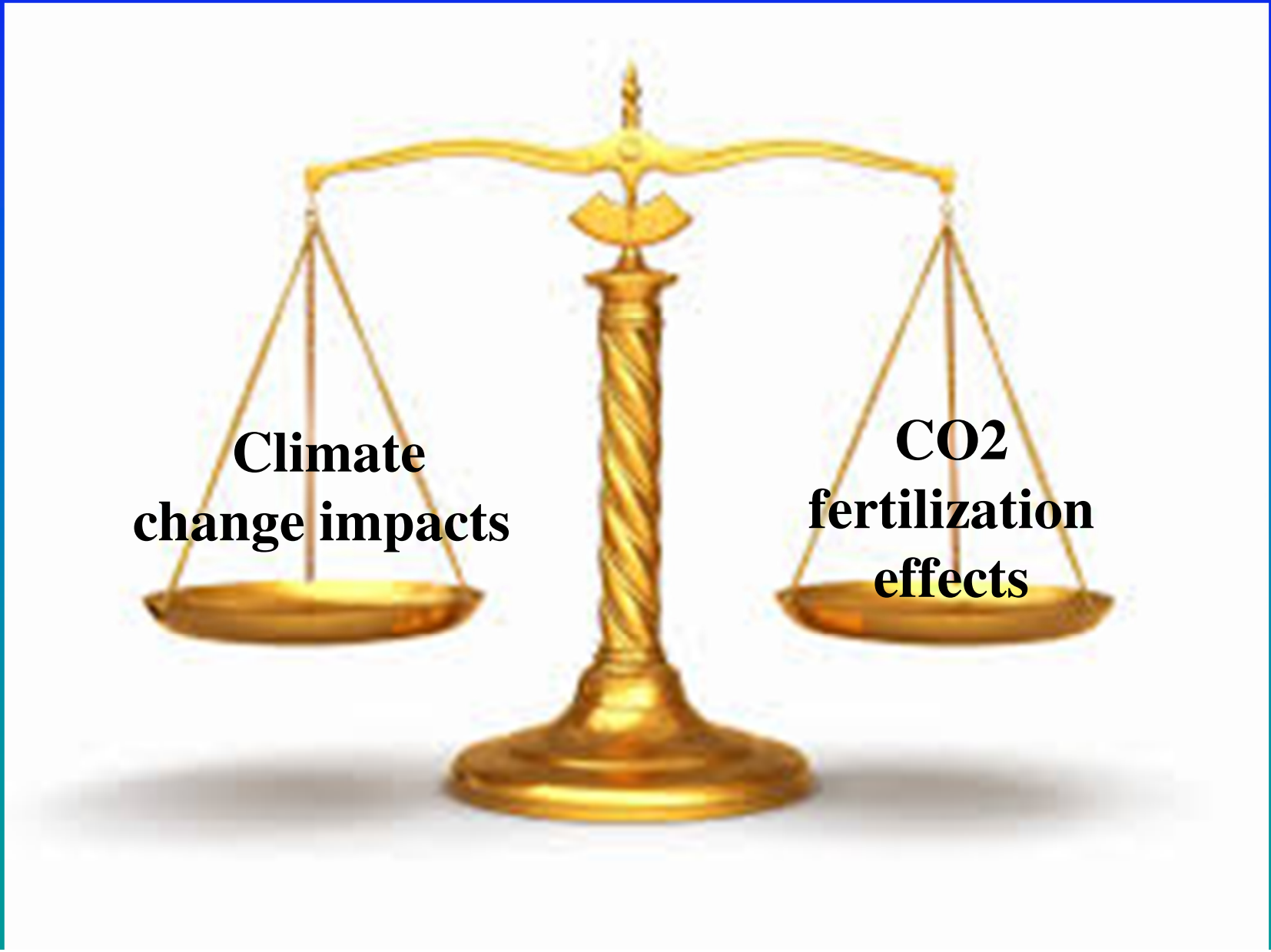
CO2 fertilization Effect: Food for Plants

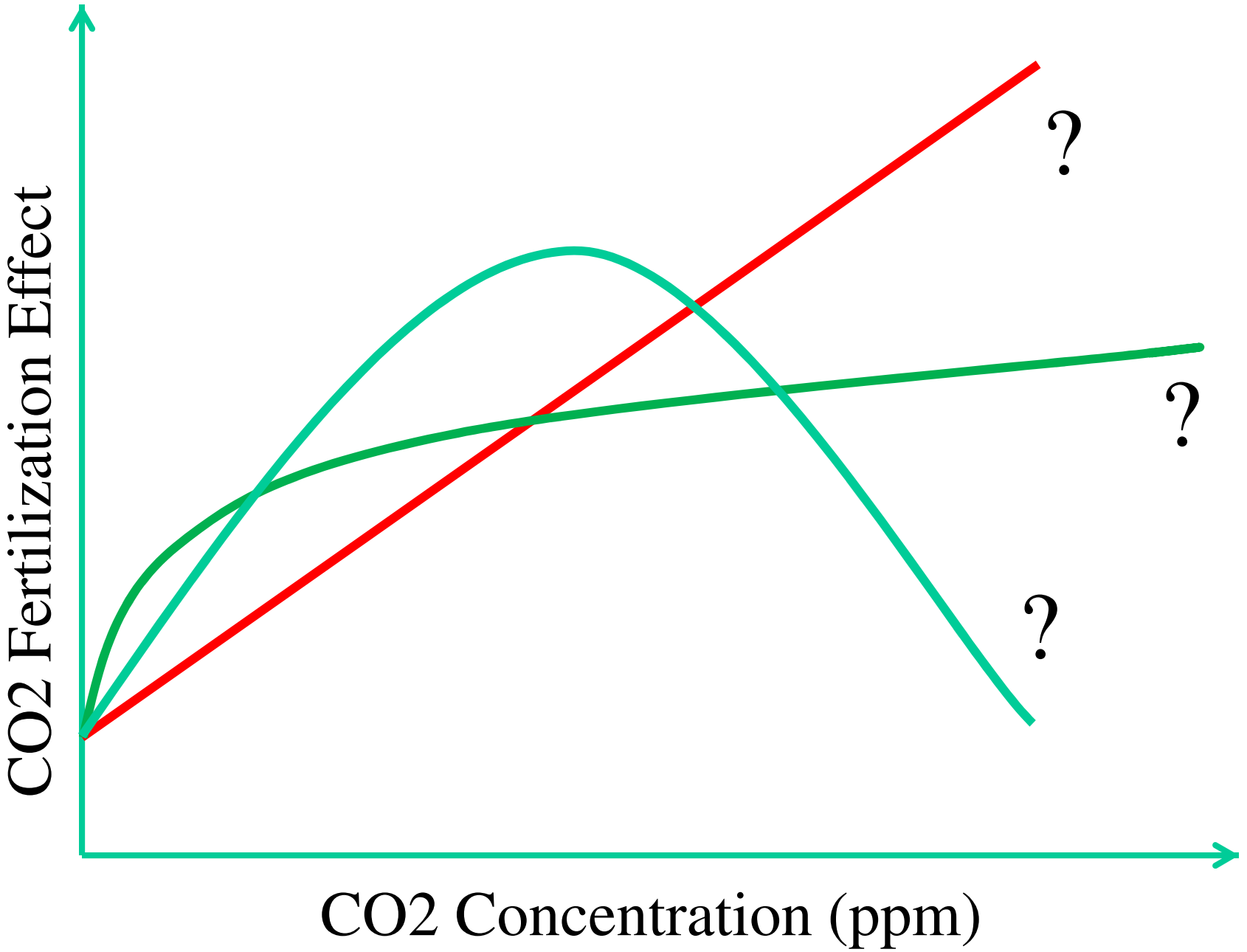
$$CO_2 + H_2O \underset{\text{Respiration}}{\overset{\text{Photosynthesis}}{\rightleftharpoons}} (CH_2O)_n + O_2$$

- Raw material for photosynthesis
- Higher CO2 concentration higher reaction rate
- Confirmed by experiments and models

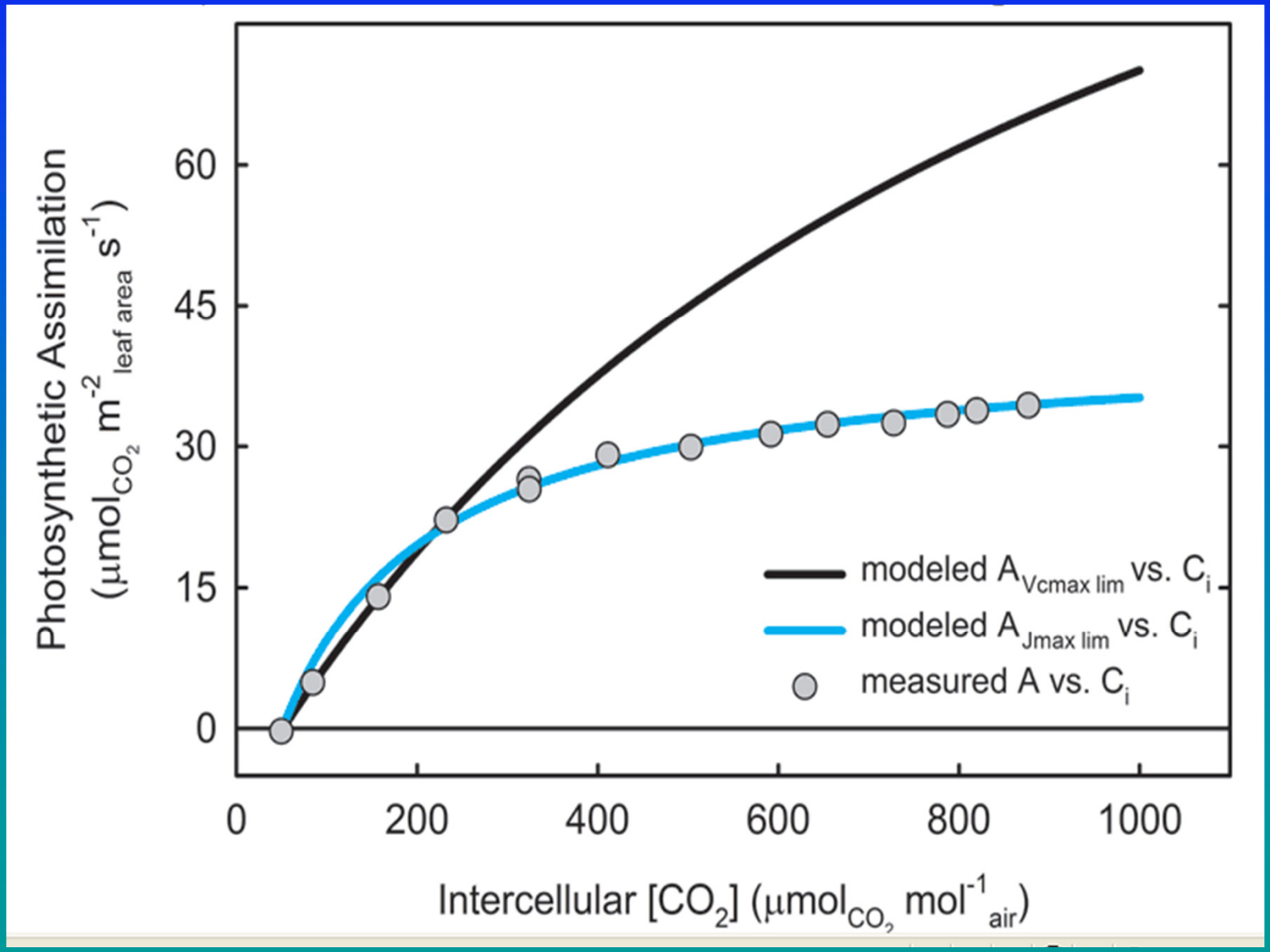


Net Impacts




CO2 Fertilization Effect
?
?
?
CO2 Concentration (ppm)

CO2 fertilization saturation Effect



CO2 Fertilization Effect

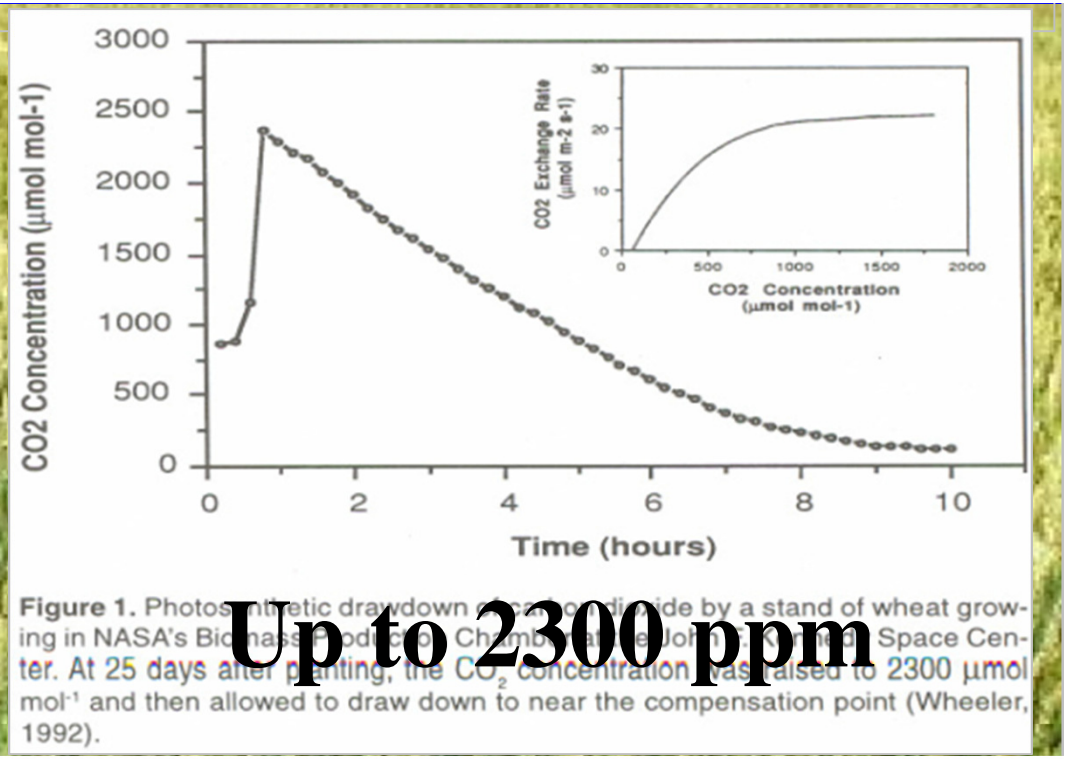
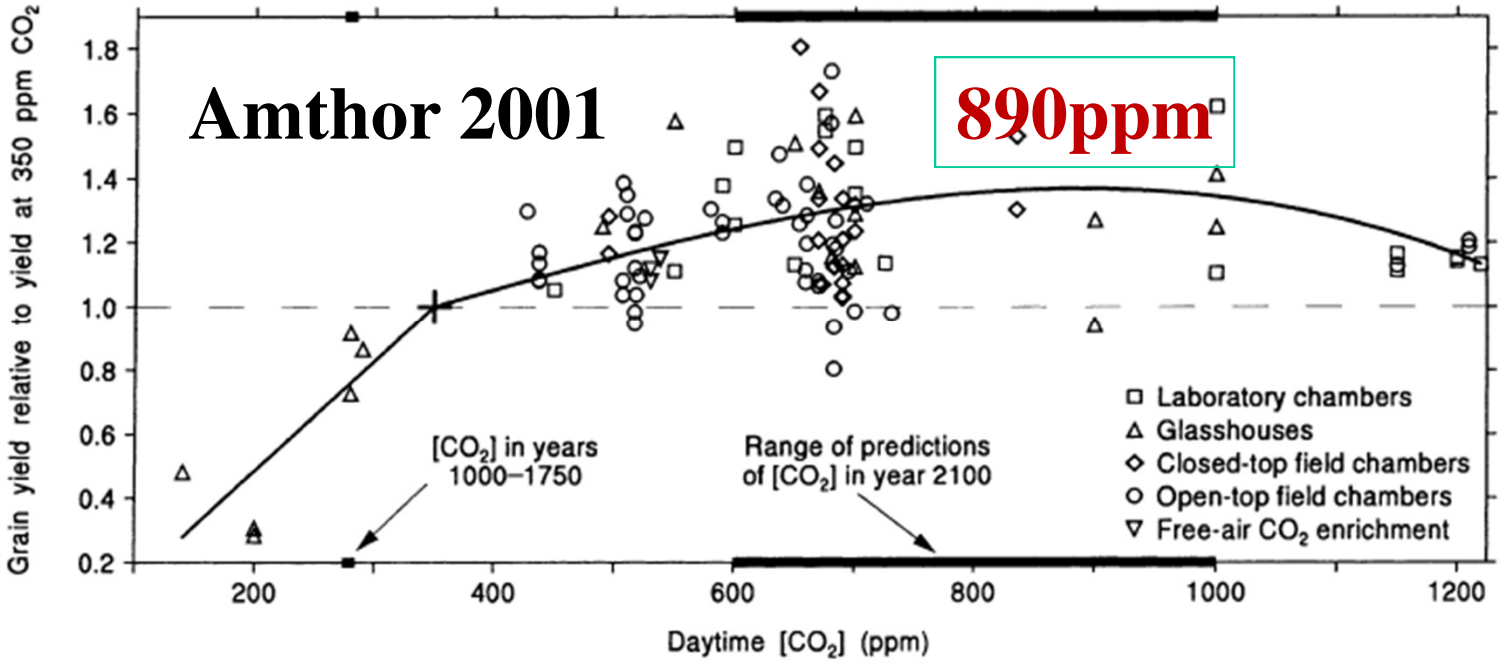


Figure 1. Photosynthetic drawdown of carbon dioxide by a stand of wheat growing in NASA's Biomass Production Chamber at Johnson Space Center. At 25 days after planting, the CO_2 concentration was raised to 2300 µmol mol^{-1} and then allowed to draw down to near the compensation point (Wheeler, 1992).

Up to 2300 ppm





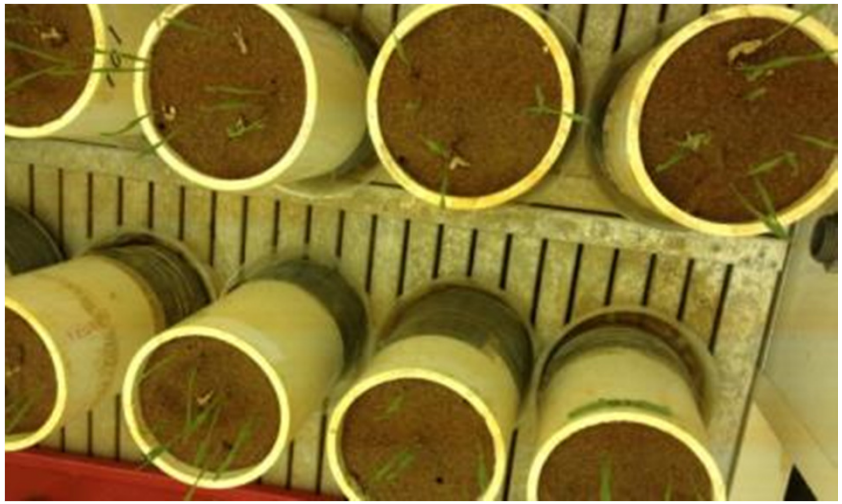
Environmental Growth Chamber



PVC pipe wrapped with duct tape on dish



Plants after germination (1 week)



Plants After Germination (2 weeks) 8 pots in each chamber

CO_2 Controlling System

Five growth chambers with CO_2 concentration regulated to 400, 600, 800, 1000, and 1200 ppm with CO_2 tanks (high purity 99.99%)





Growth chamber control loop

Other Environmental Factors

- Temperature: 21°C
- Humidity: 60-70%
- Light intensity: 1000 µmol m^{-2} s^{-1} PAR, 6am-8pm
- Soil type: fritted clay
- Water amount: 200 ml/pot, watered every other day
- Water type: plain tap water
- Fertilization: half-strength Hoagland's solution once weekly

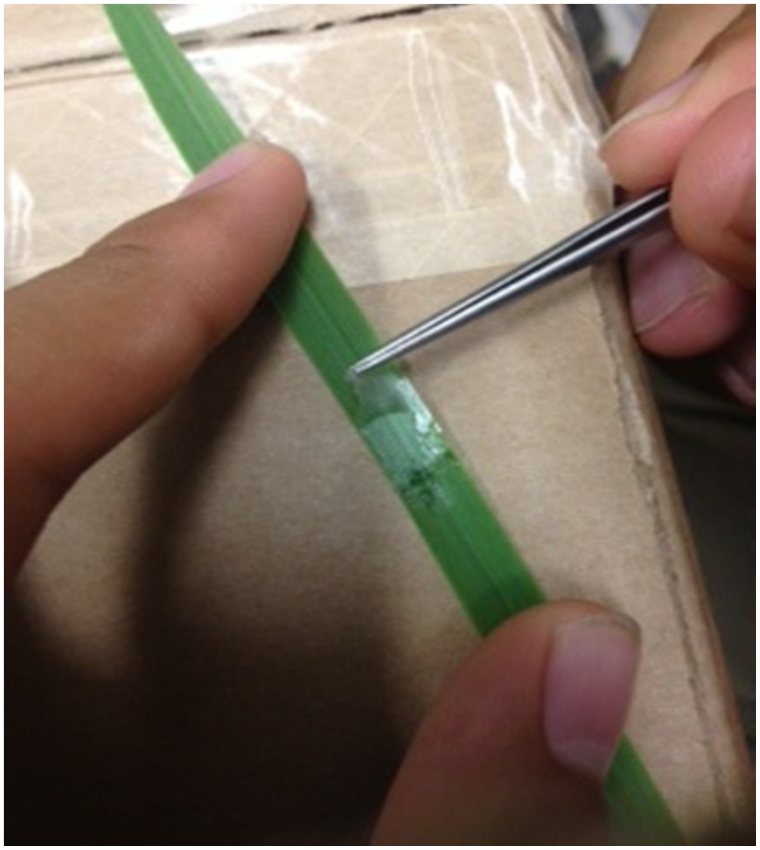




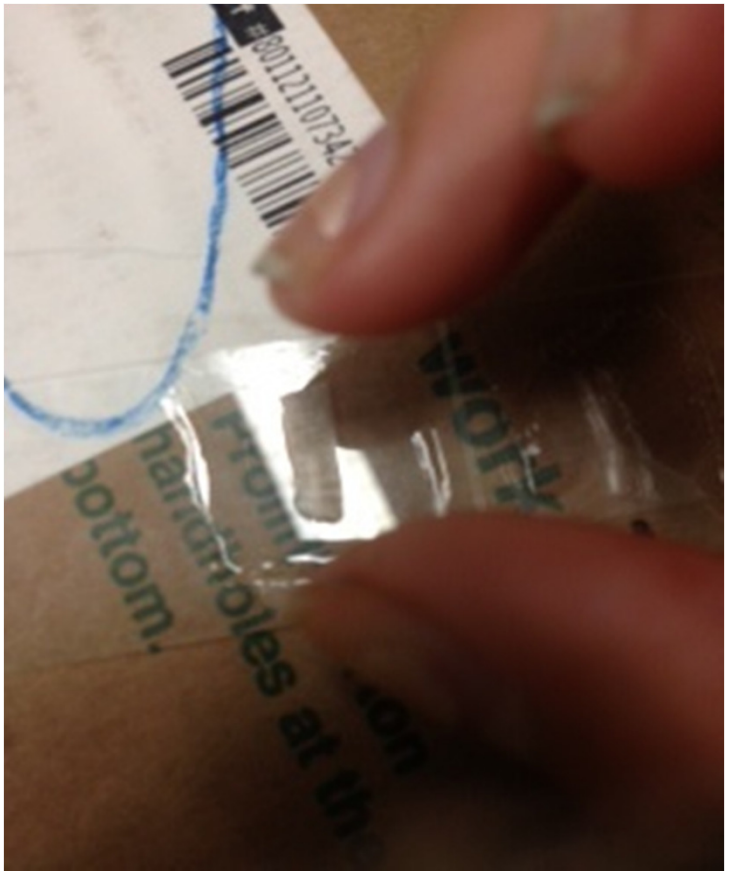




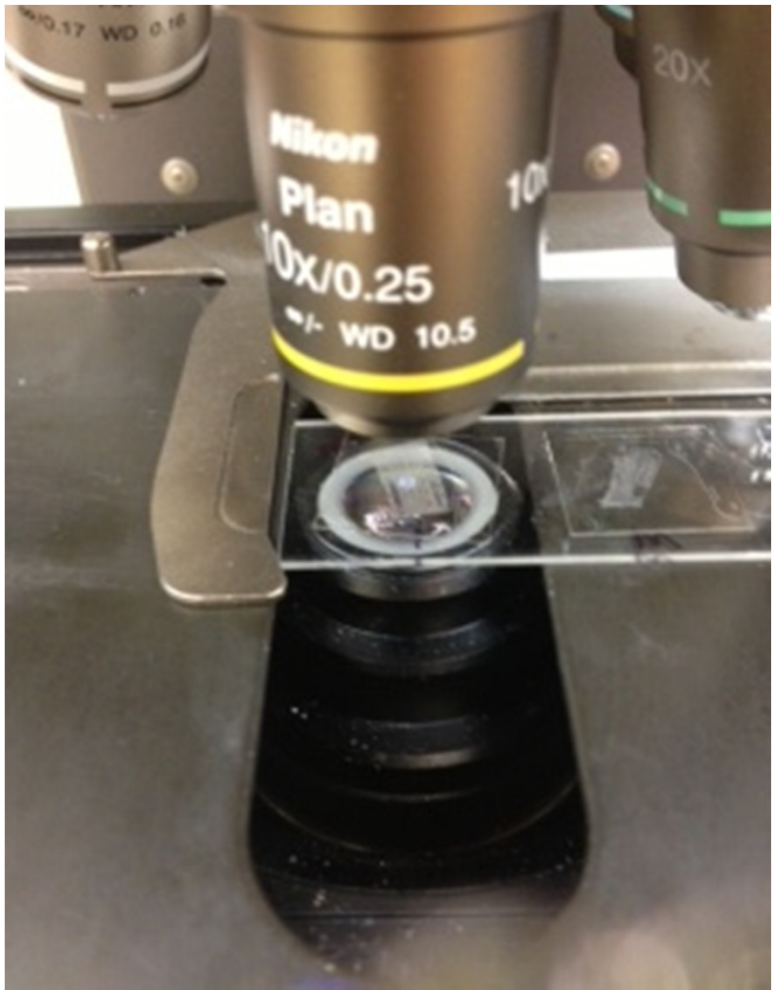
Plants After Germination (2 Weeks)



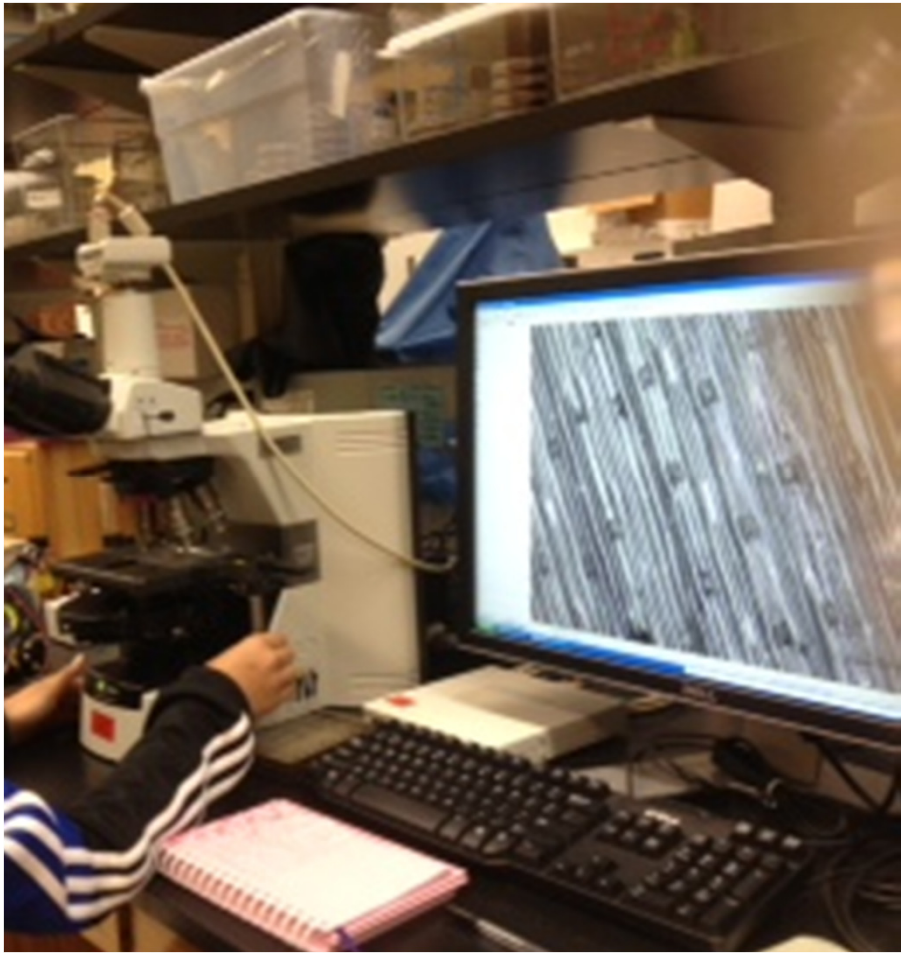
Nail varnish mold peeled off with tweezers

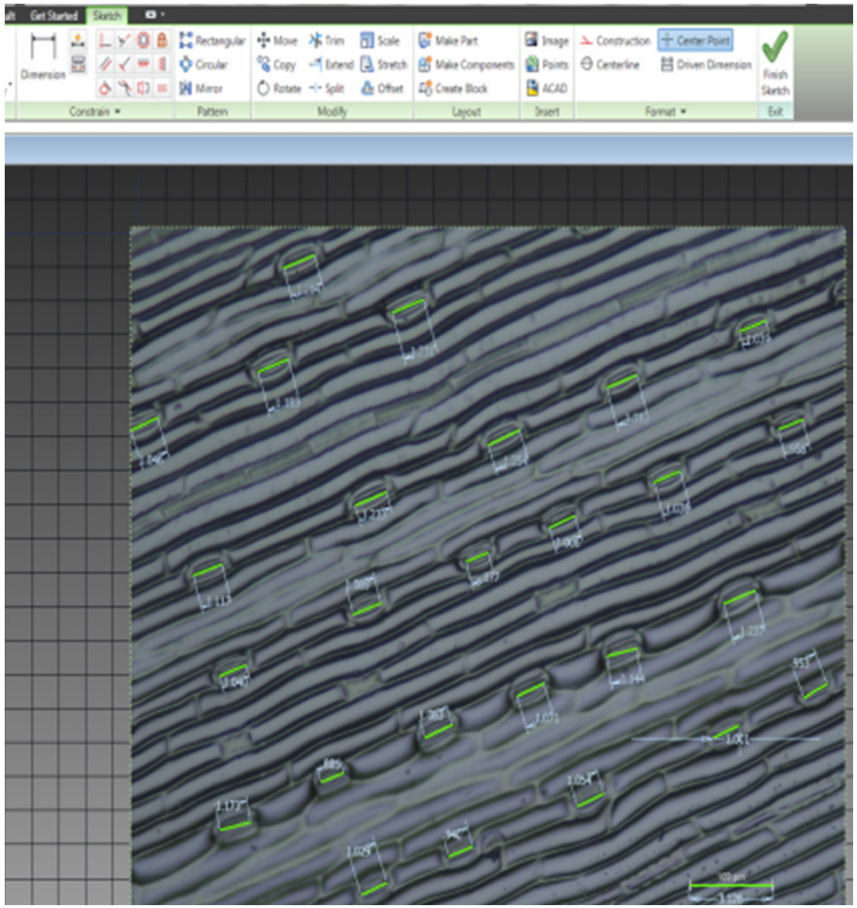


Nail varnish mold is mounted onto clear microslide

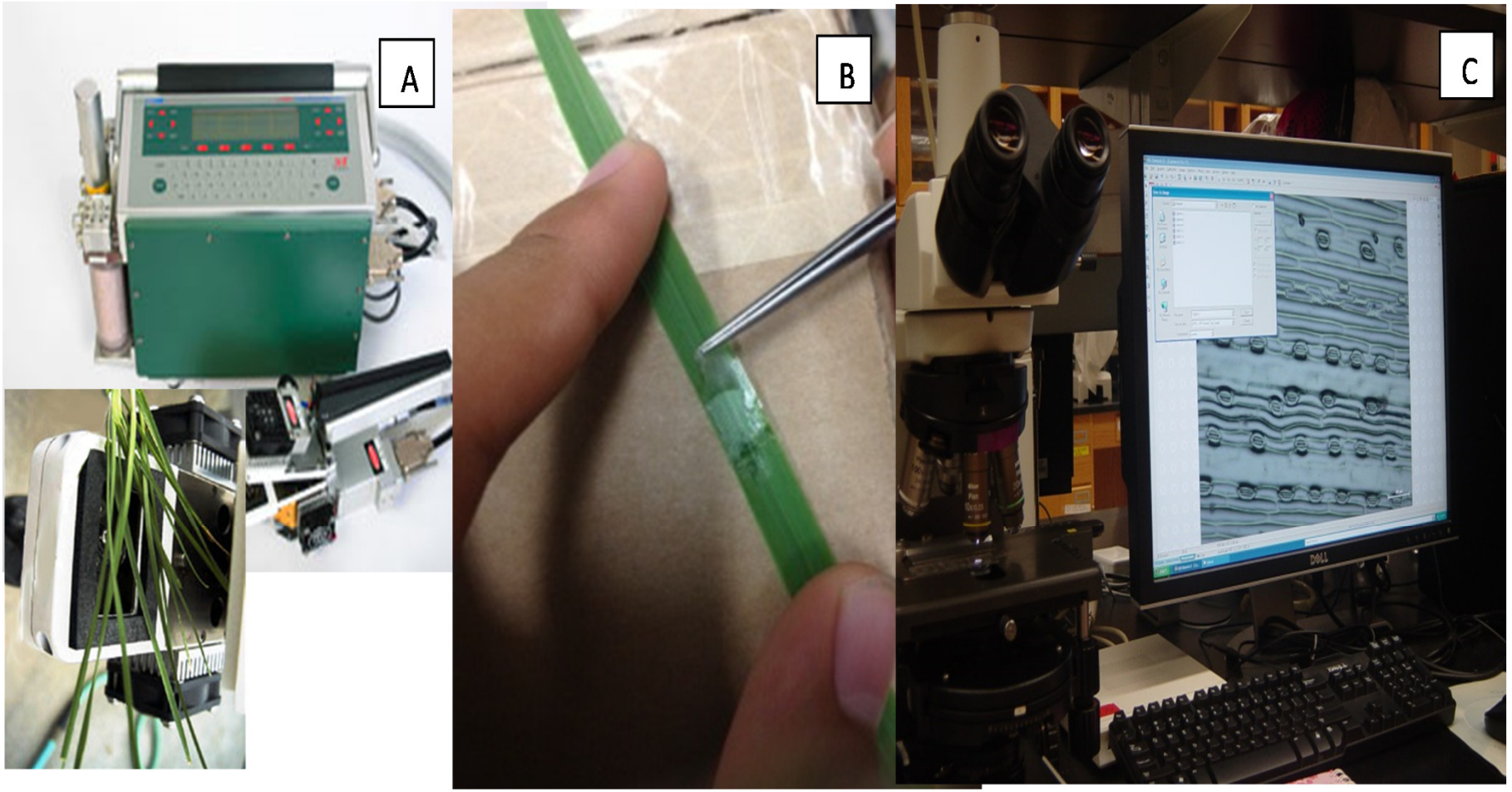


Slide under Nikon Eclipse 80i Microscope





Picture in Autodesk Inventor where stomata lengths are traced with Line Tool and dimensioned


A
B
C









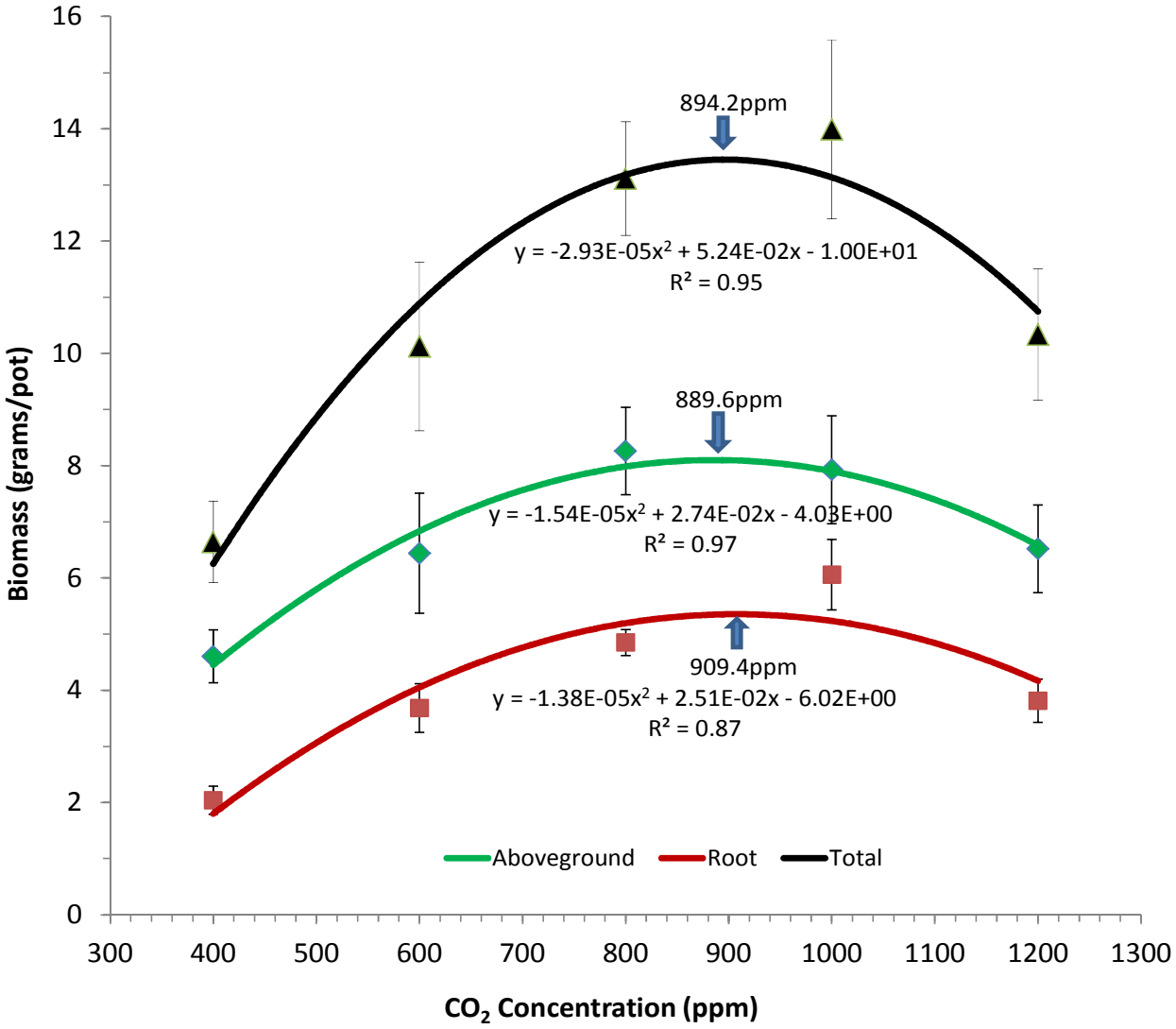
Thelco Laboratory Oven used to dry plant leaves



Laboratory oven settings and values

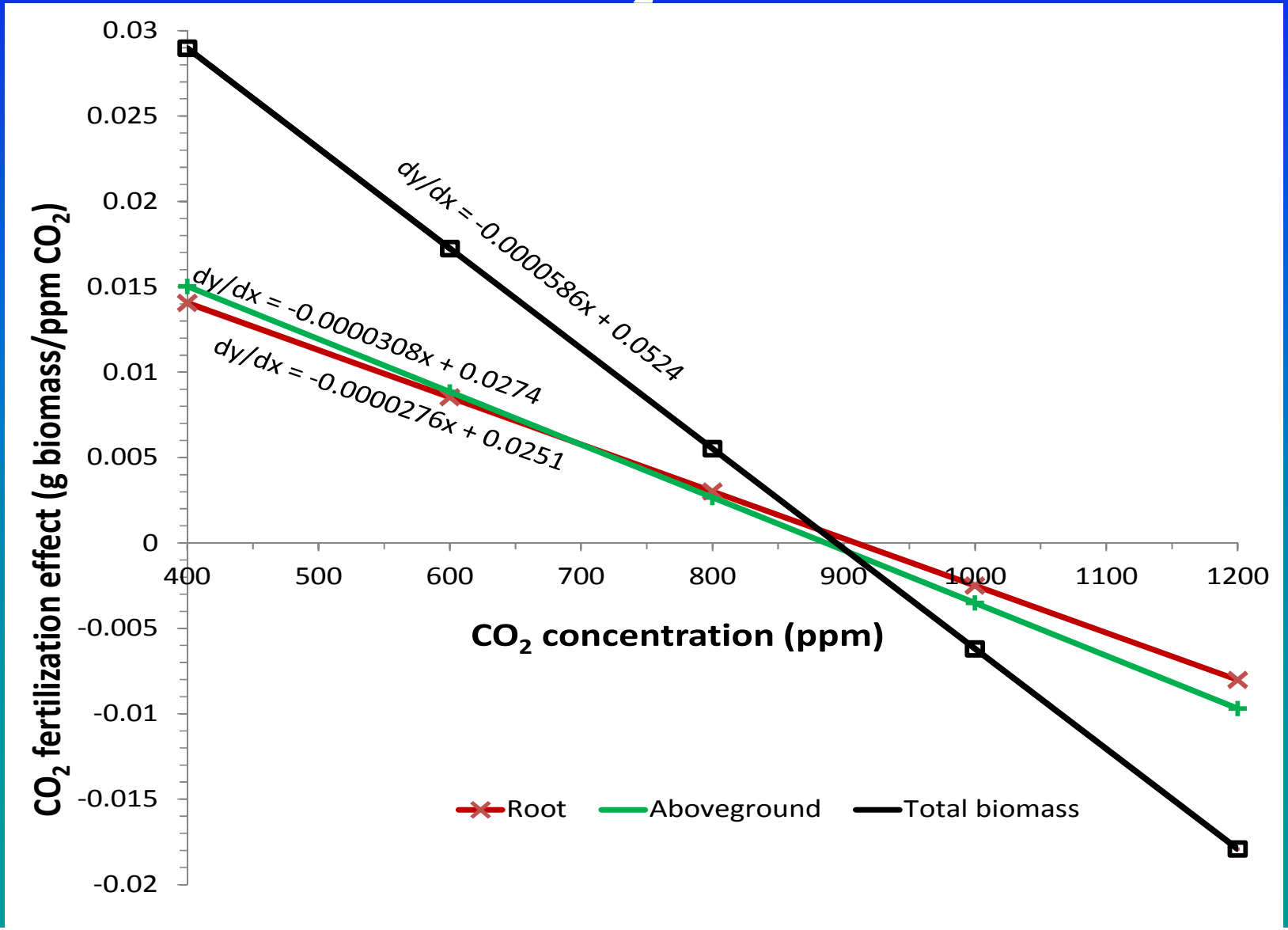


Effects of CO_2 enrichment on biomass growth of winter wheat

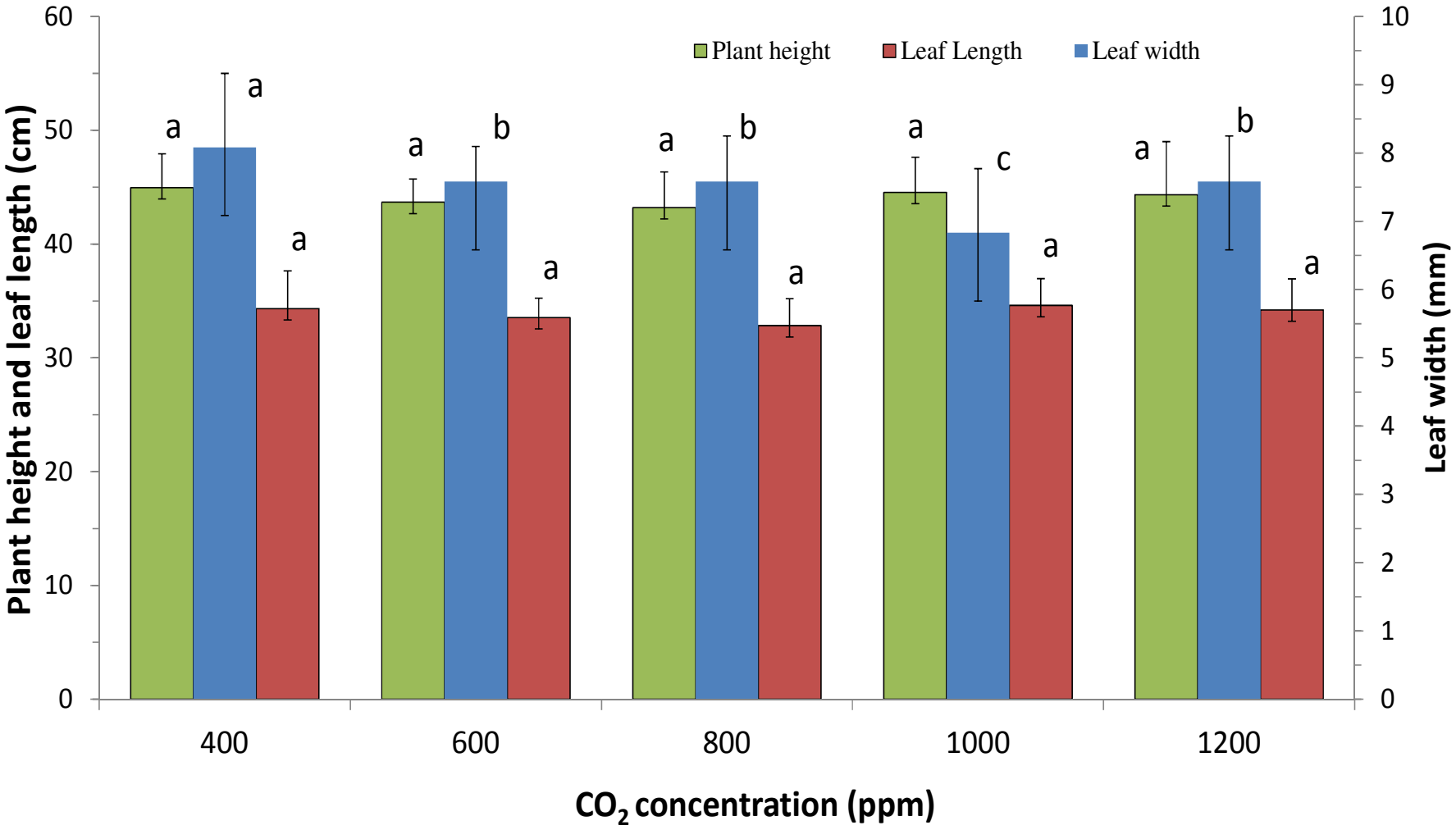


Xu 2015, J. Plant Physiology

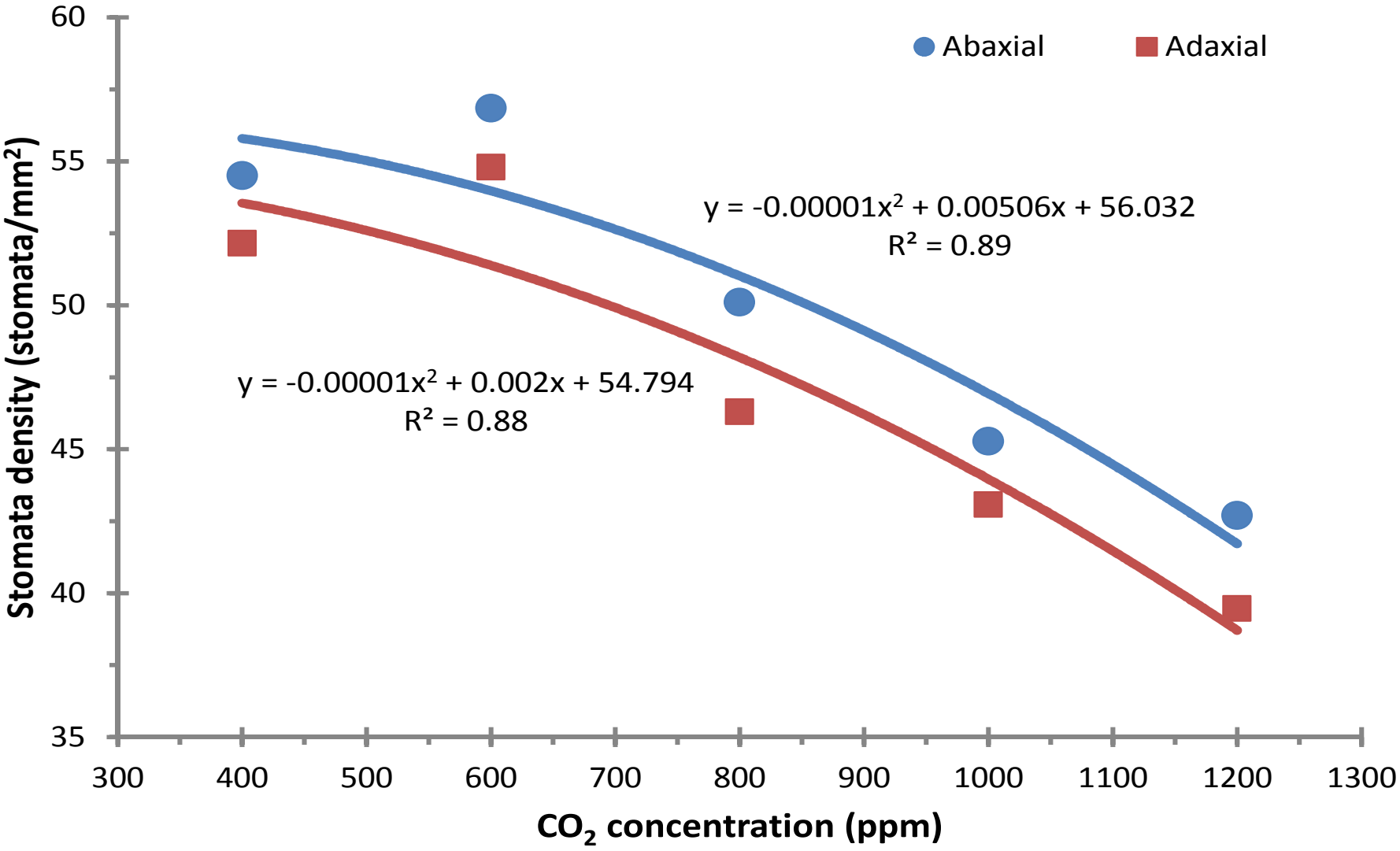
Diminishing of CO_2 fertilization effect with the increase of CO_2 concentration



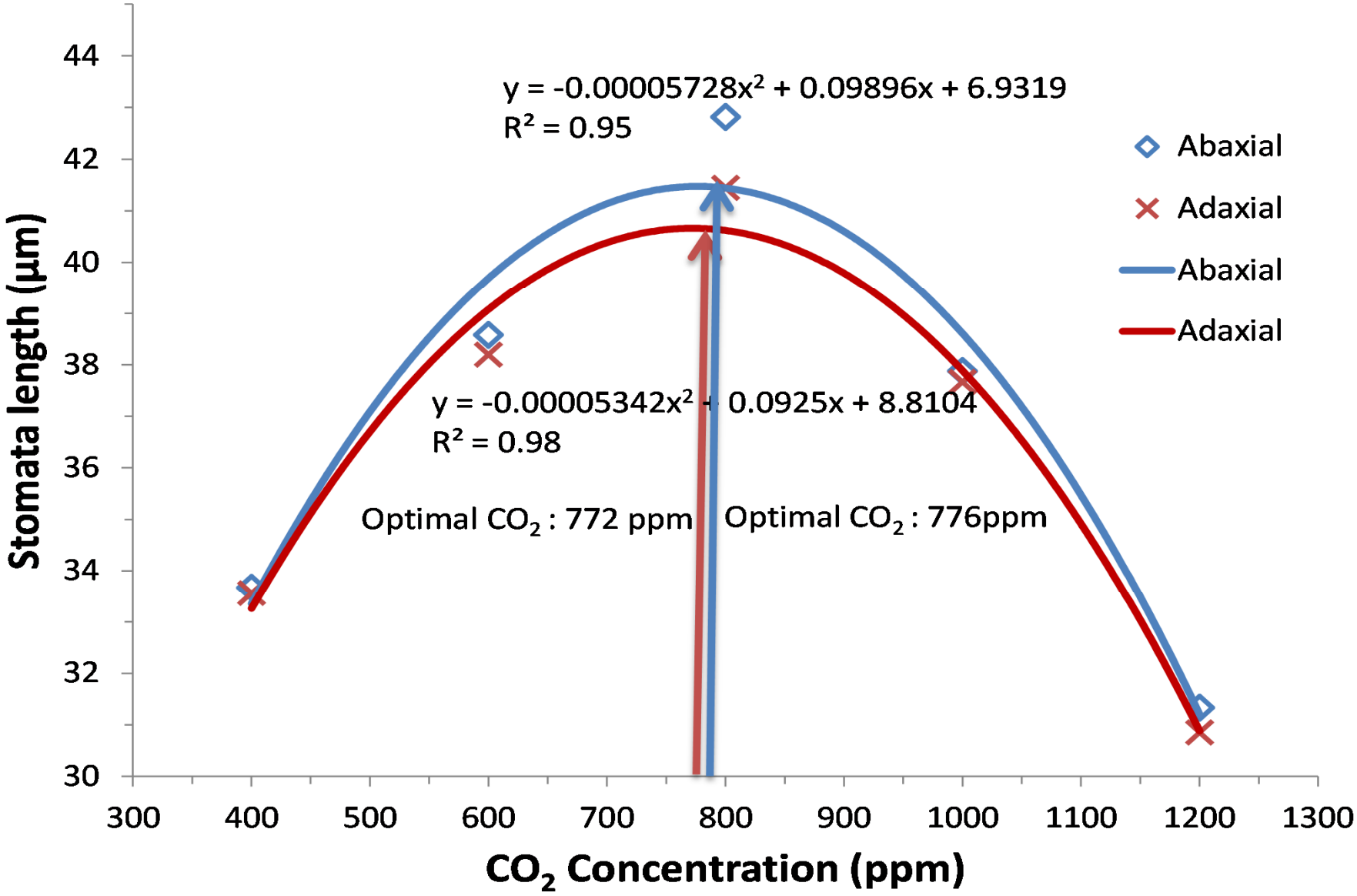
CO_2effects on plant height and leaf characteristics of winter wheat



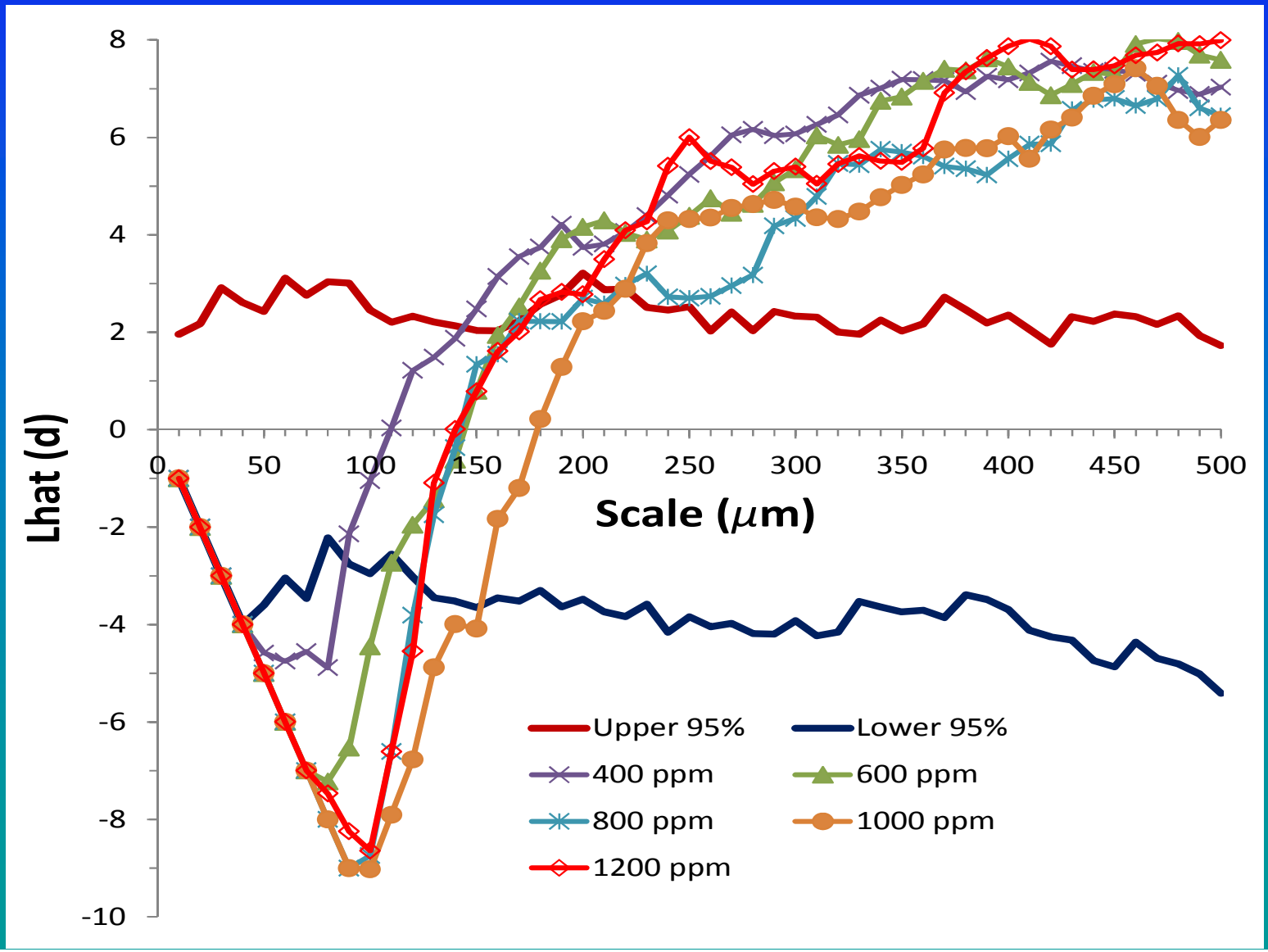
CO_2 effects on leaf stomatal density



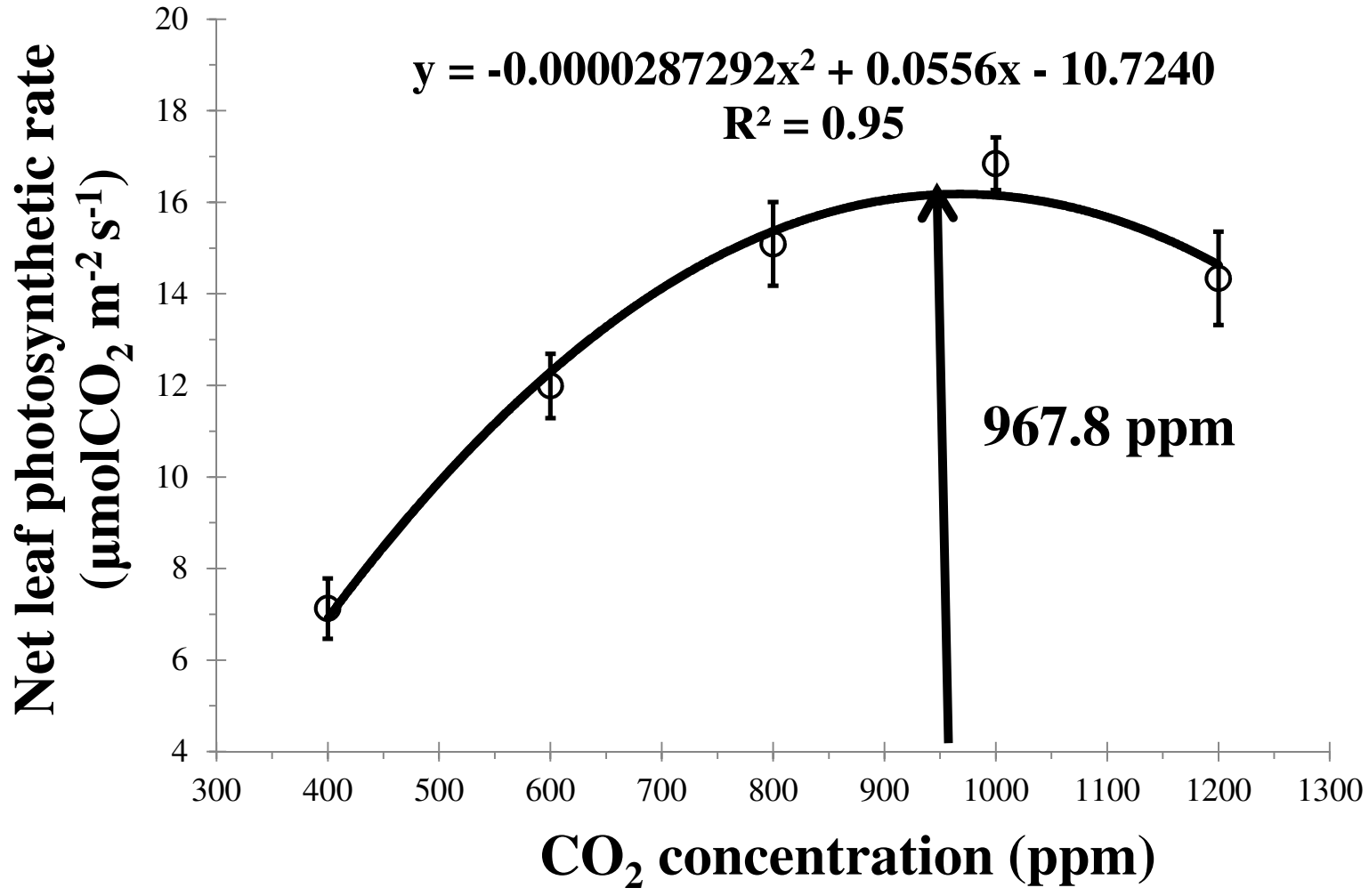
CO_2 effects on adaxial and abaxial stomata length



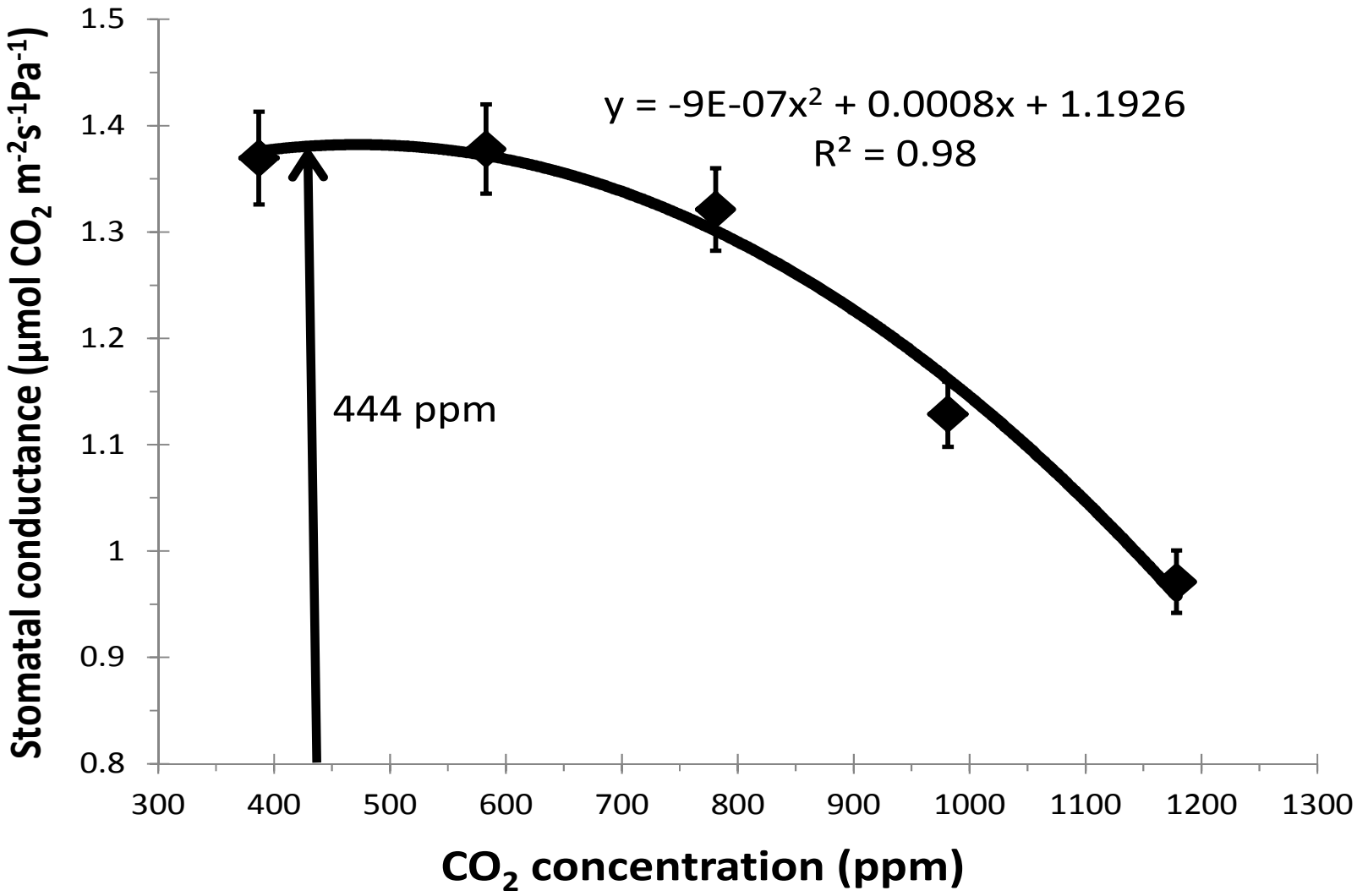
CO2 Effects on the Spatial Pattern of Stomatal Distribution on Leaf Surfaces



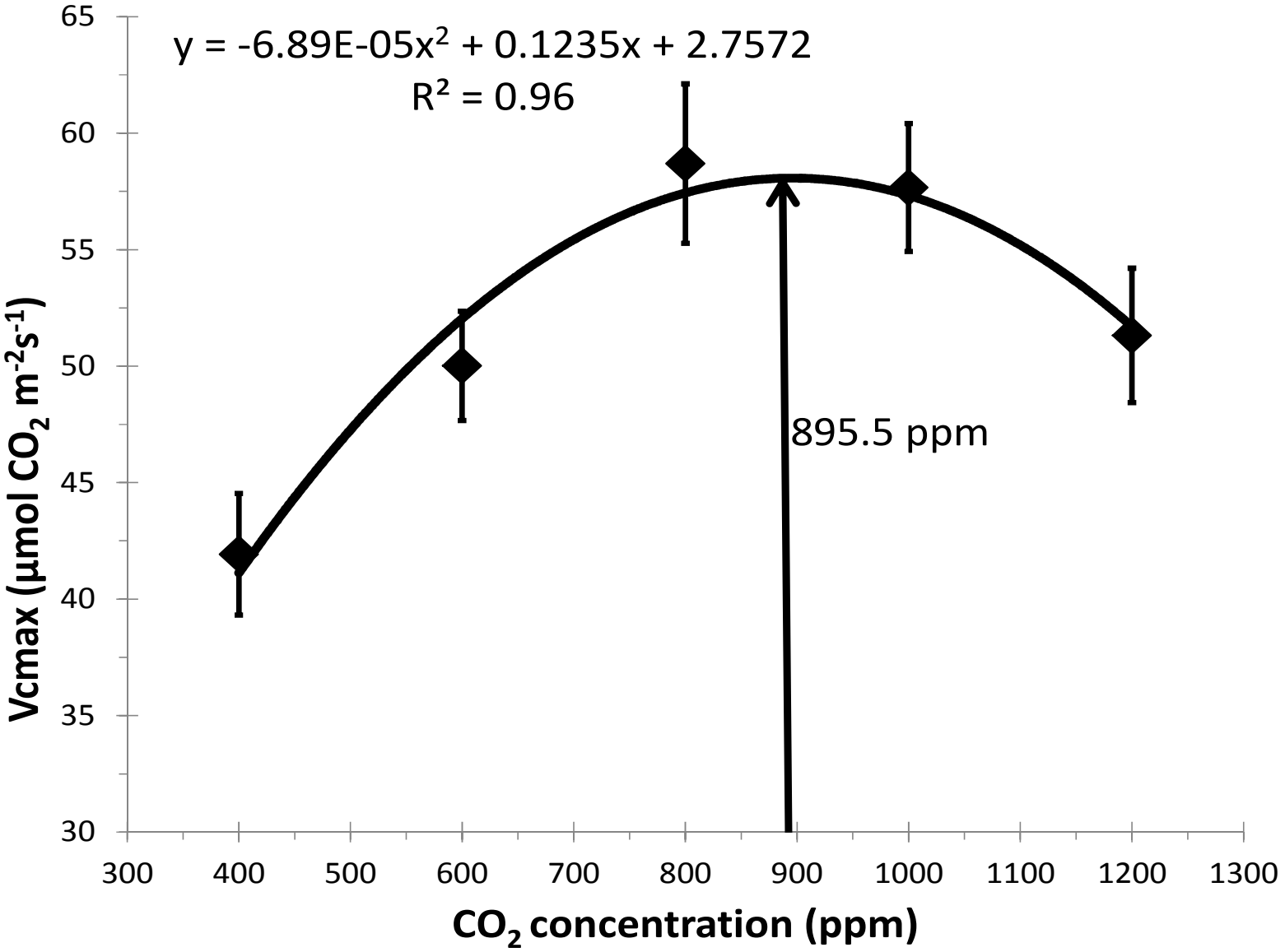
CO_2 effects on net leaf photosynthetic rate under growth CO_2 concentrations



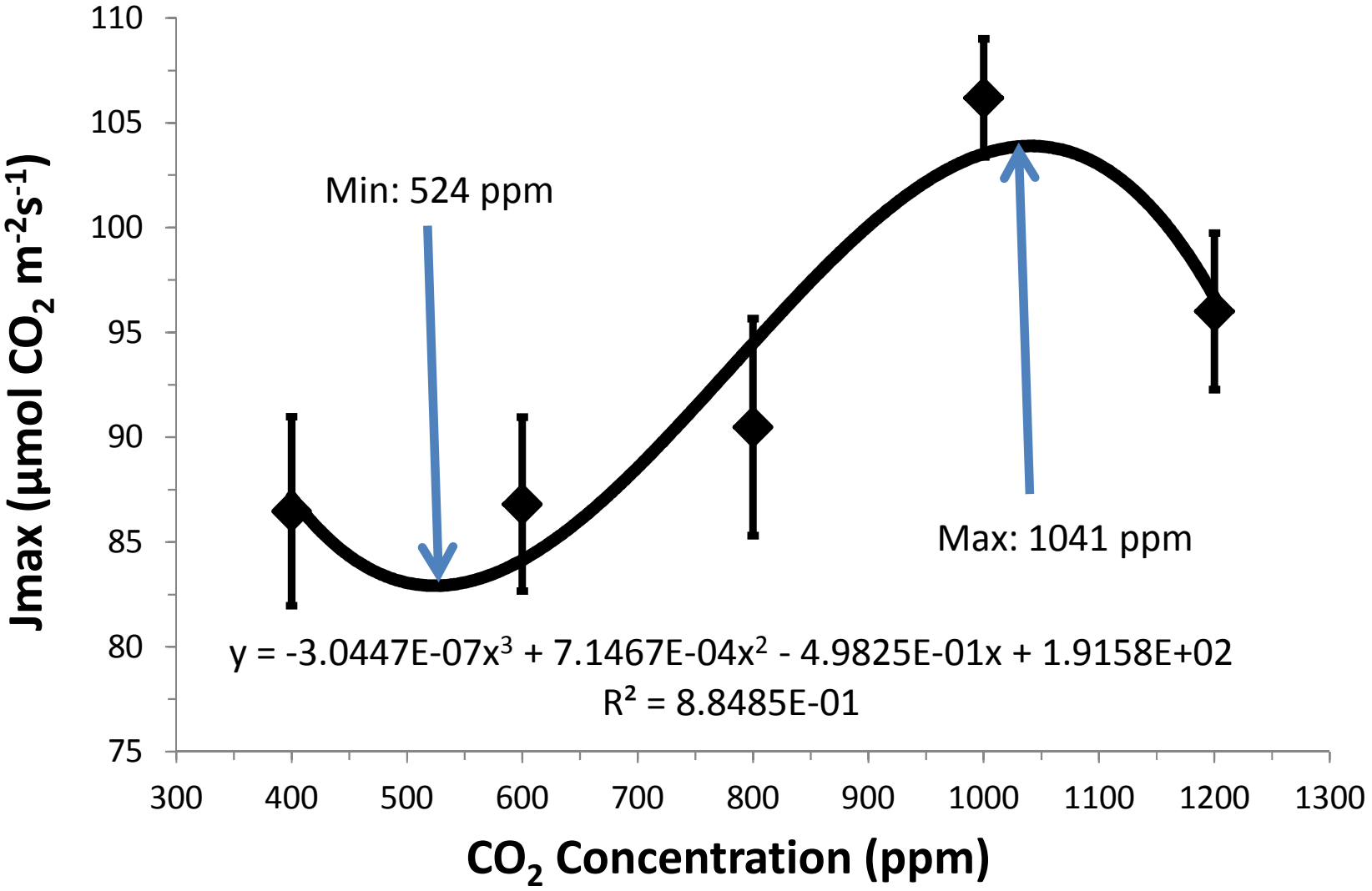
CO_2 effects on stomatal conductance measured under growth CO_2 concentrations



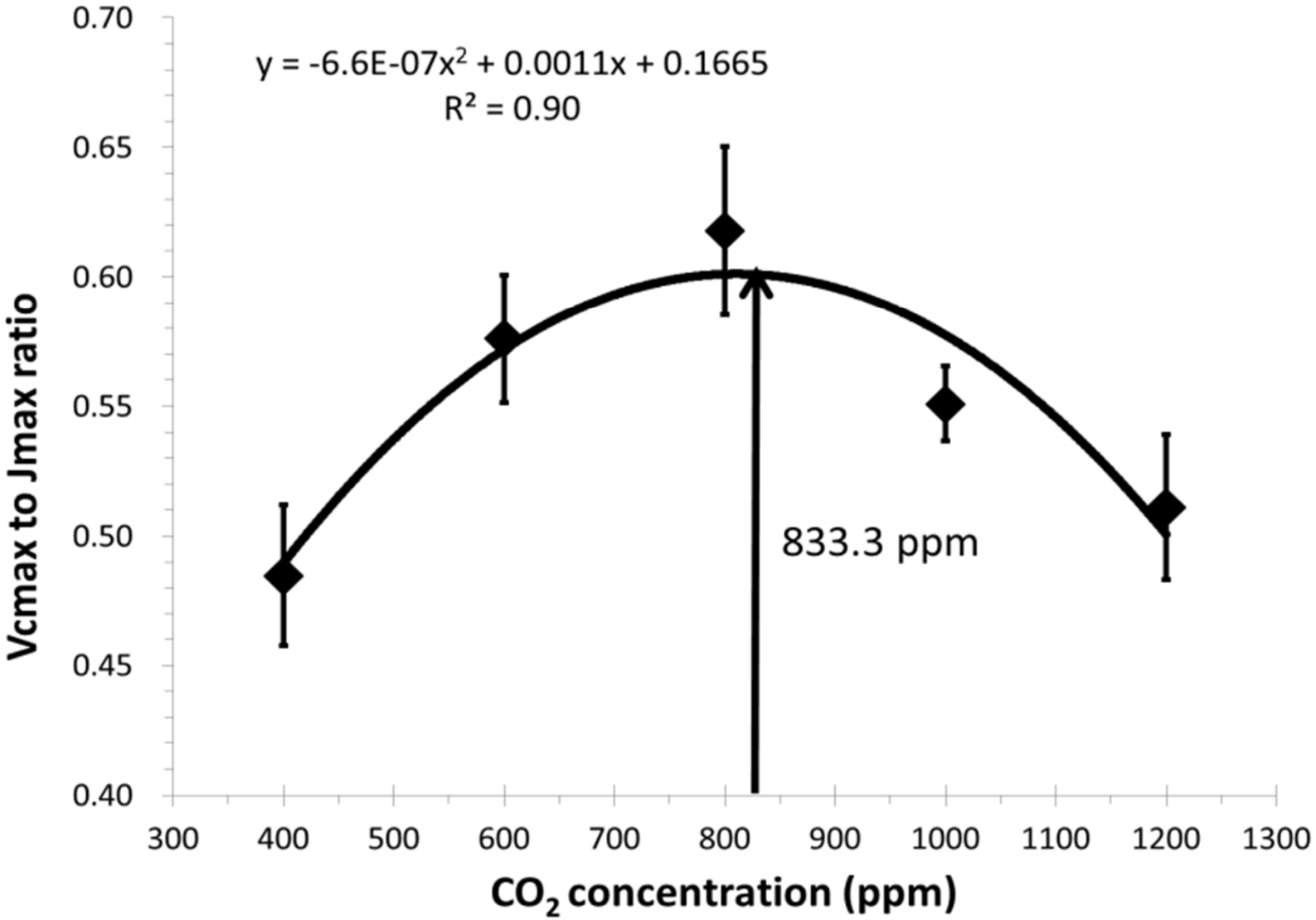
CO_2 effects on the maximum carboxylation rate (Vcmax)



CO_2 effects on the maximum electron transport rate (Jmax)



CO_2 effects on the ratio of Vcmax to Jmax (Vcmax/Jmax)



Conclusions

1. Initial increase in atmospheric CO_2 concentration dramatically enhanced winter wheat growth through the CO_2 fertilization effect before reaching an optimum of about 900 ppm;
2. Further increase in CO2 concentration beyond this concentration substantially decreased the plant growth;
3. Elevating CO2 concentration not only reduced stomatal density, length and conductance, but also changed the spatial distribution pattern of stomata on leaves, leading to more regular patterns.

Acknowledgements

Drs. Bingru Huang and Yali Song

Drs. Patrick Burgess and Yunpu Zheng

USDA-INFA ISE


THANK YOU !
谢谢!



