Quantifying global terrestrial photosynthesis is essential to understanding the global carbon cycle and the climate system. Remote sensing has played a pivotal role in advancing our understanding of photosynthesis from leaf to global scale...

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What is global photosynthesis? History, uncertainties and opportunities

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BRIGHT SIDE:
Carbon uptake can be reasonably well estimated under steady conditions

P=APAR x LUE
P=ETR=(PRI, SIF), SIF=NIRv P x Fyield
Hyperspectral
etc.

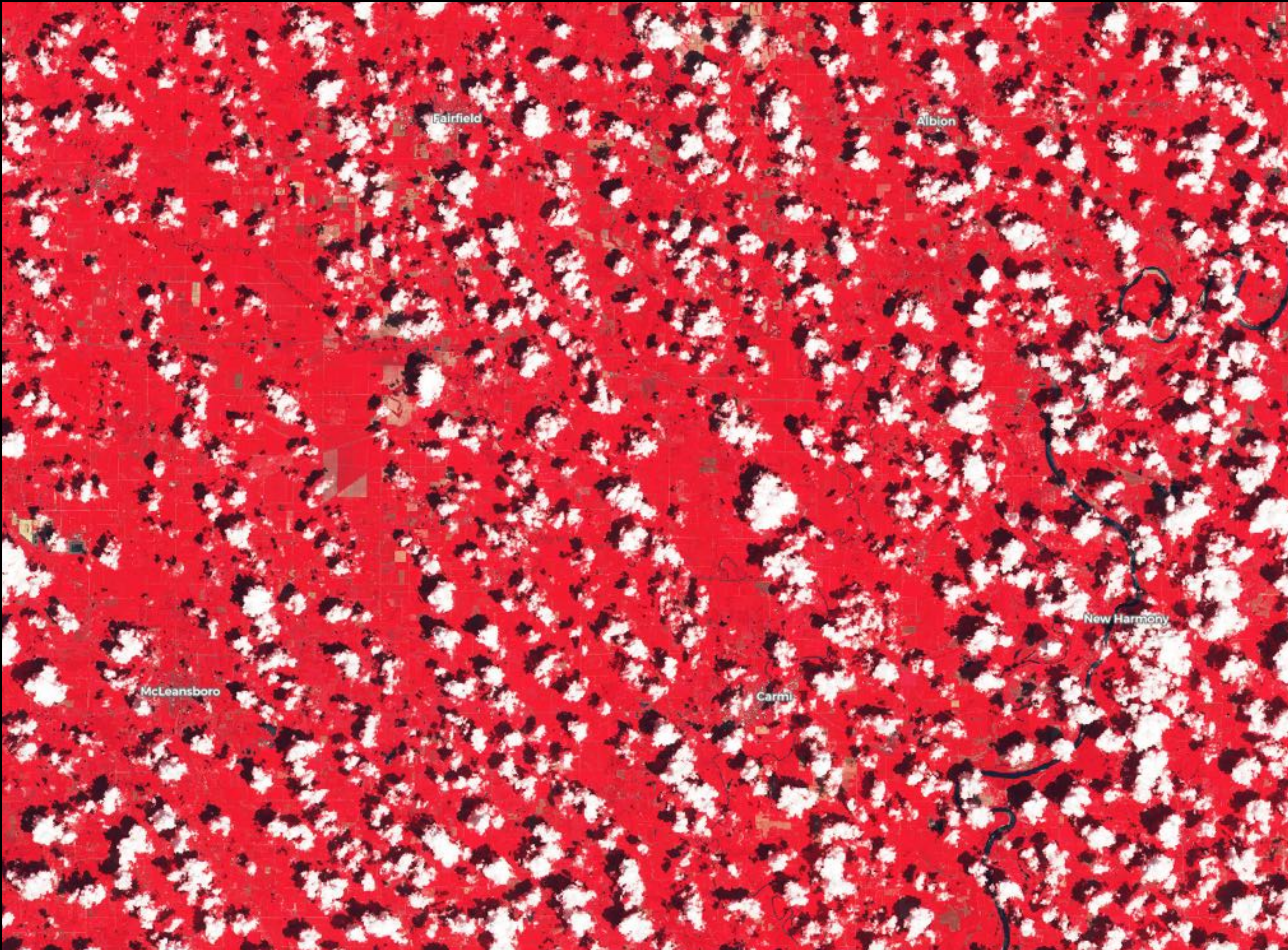
DARK SIDE:
Photosynthesis is everything but steady-state in the real world

THE DARK SIDE

Content:

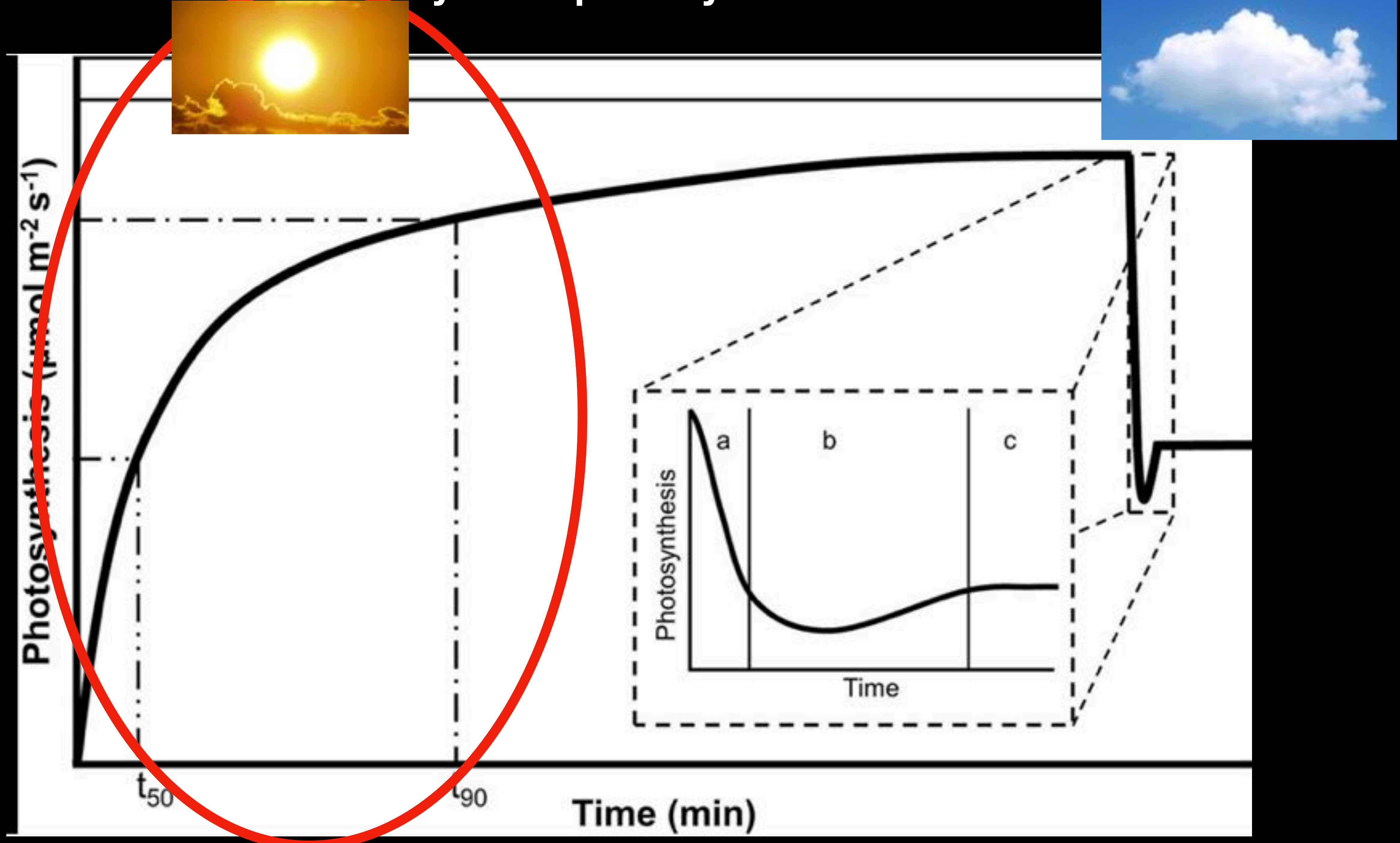
- **Light fluctuations (stomatal conductance and NPQ-relaxation)**
- **CO2 fluctuations (vertical and horizontal CO2-gradients in the field)**

- **Measurement issues (GPP & Reco)**
- **Photosynthesis & Growth paradigms**

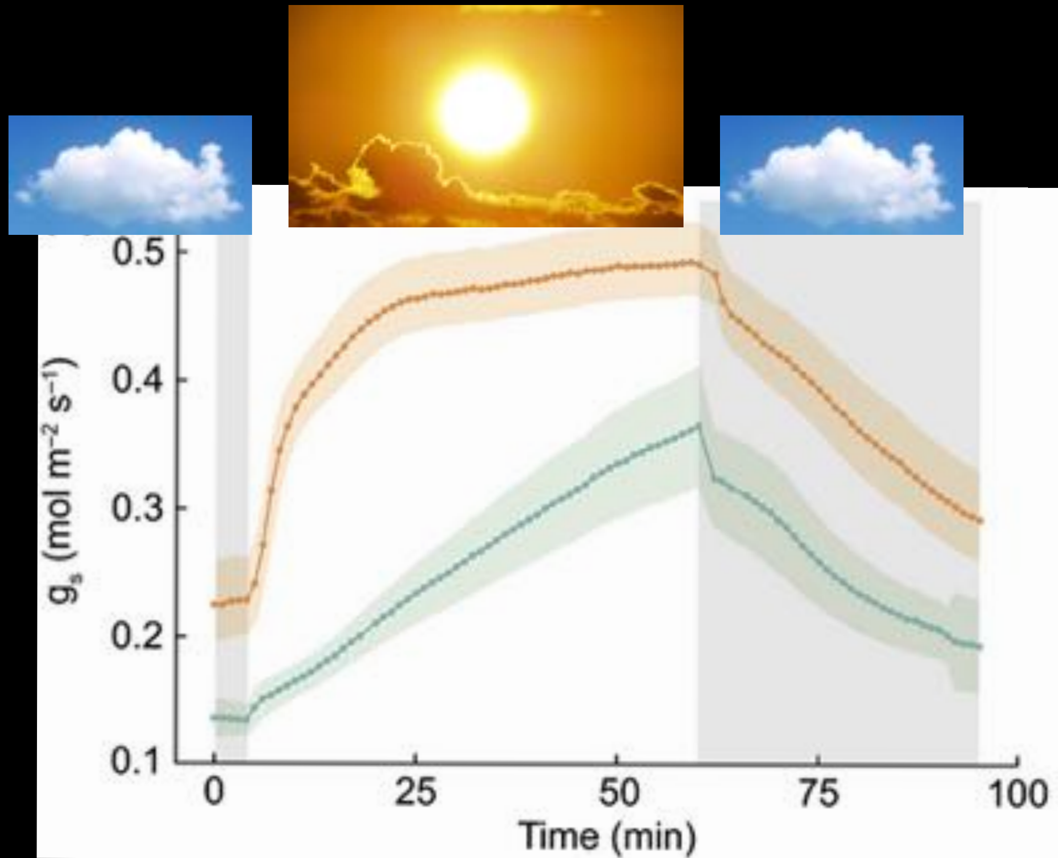

Fairfield
Albion
New Harmony
McLeansboro
Carmi


Dynamic photosynthesis

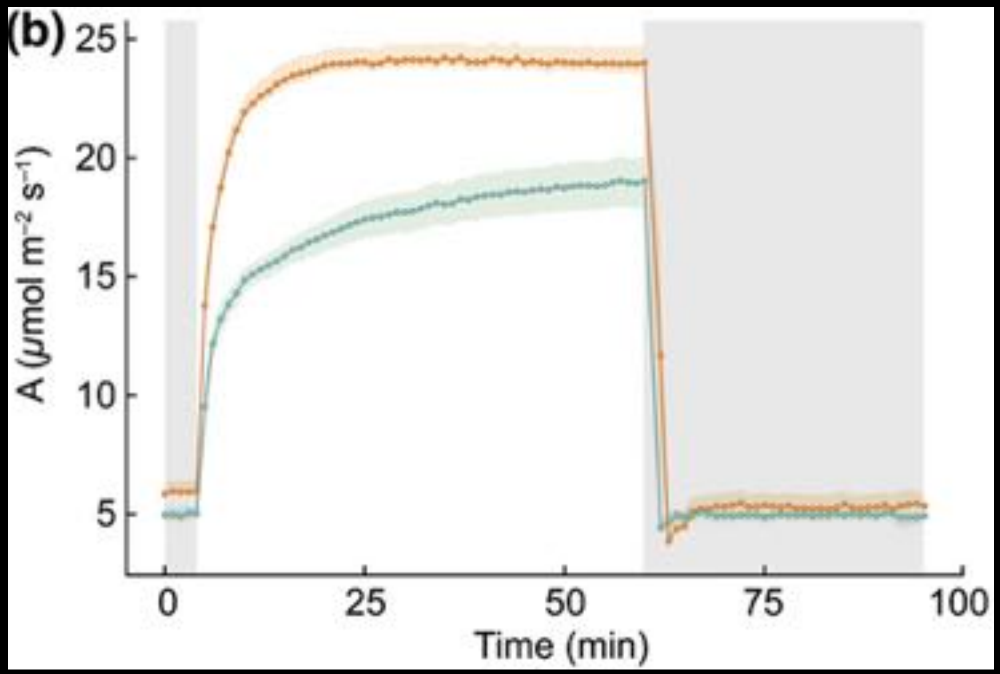
Dynamic photosynthesis



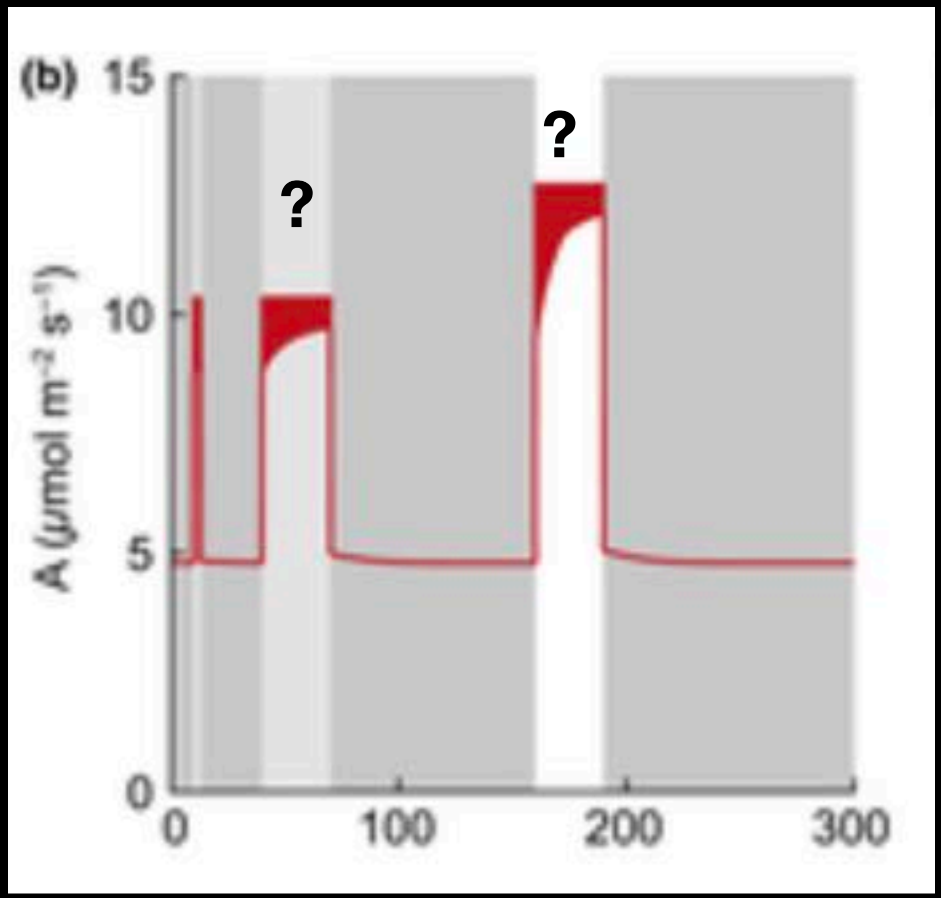
I. Speedy stomata



Stomatal conductance



Net CO2 exchange



Tansley insight

Speedy stomata, photosynthesis and plant water use efficiency

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Contents

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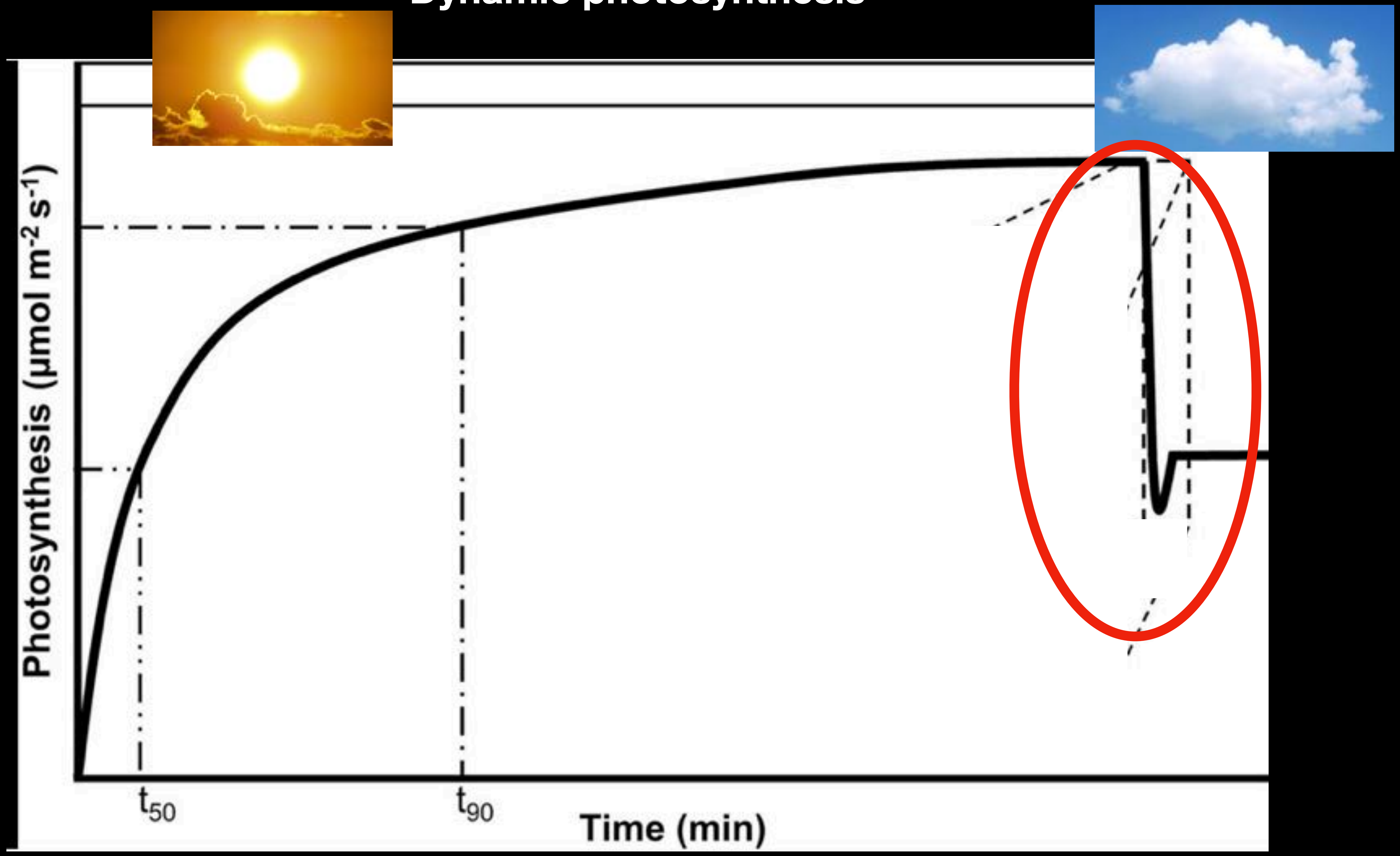
Summary

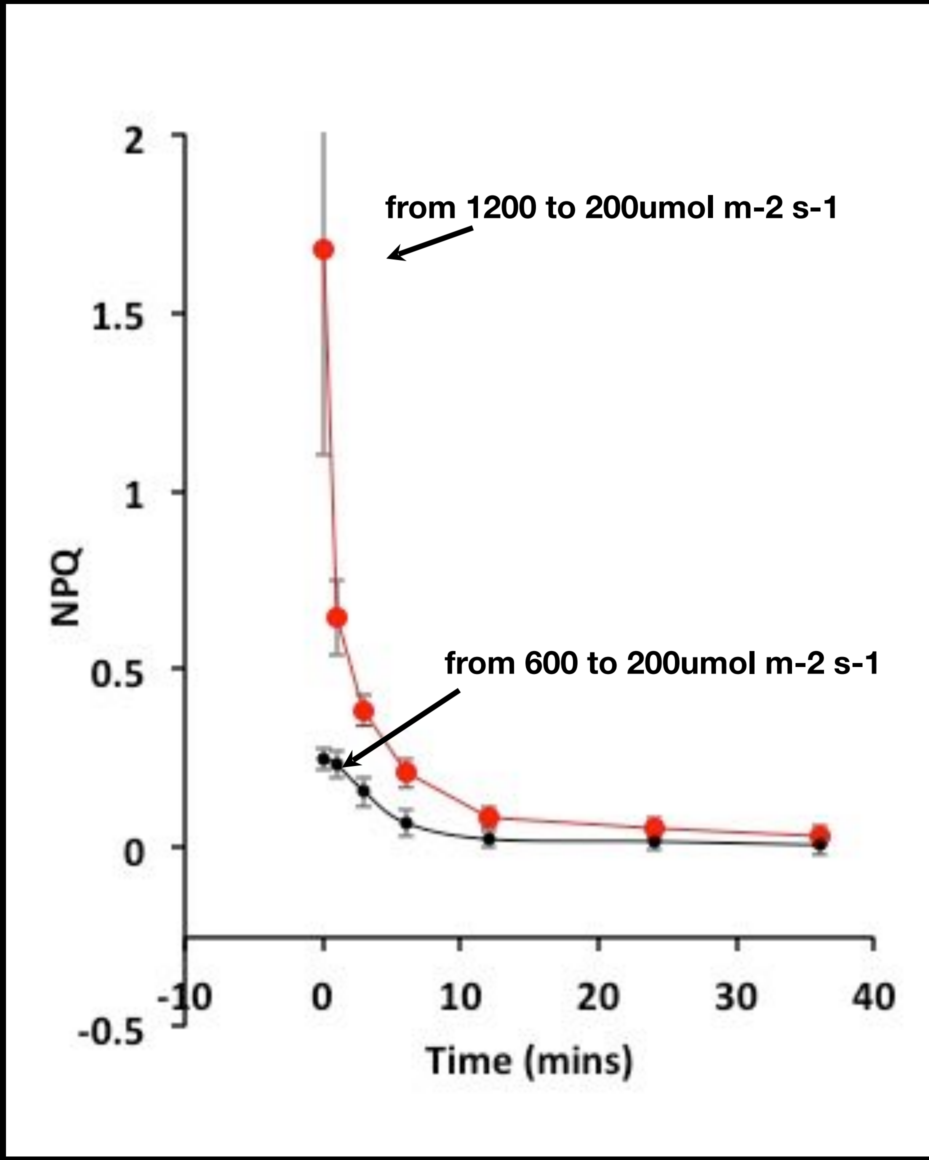
Stomatal movements control CO_2 uptake for photosynthesis and water loss through transpiration, and therefore play a key role in plant productivity and water use efficiency. The

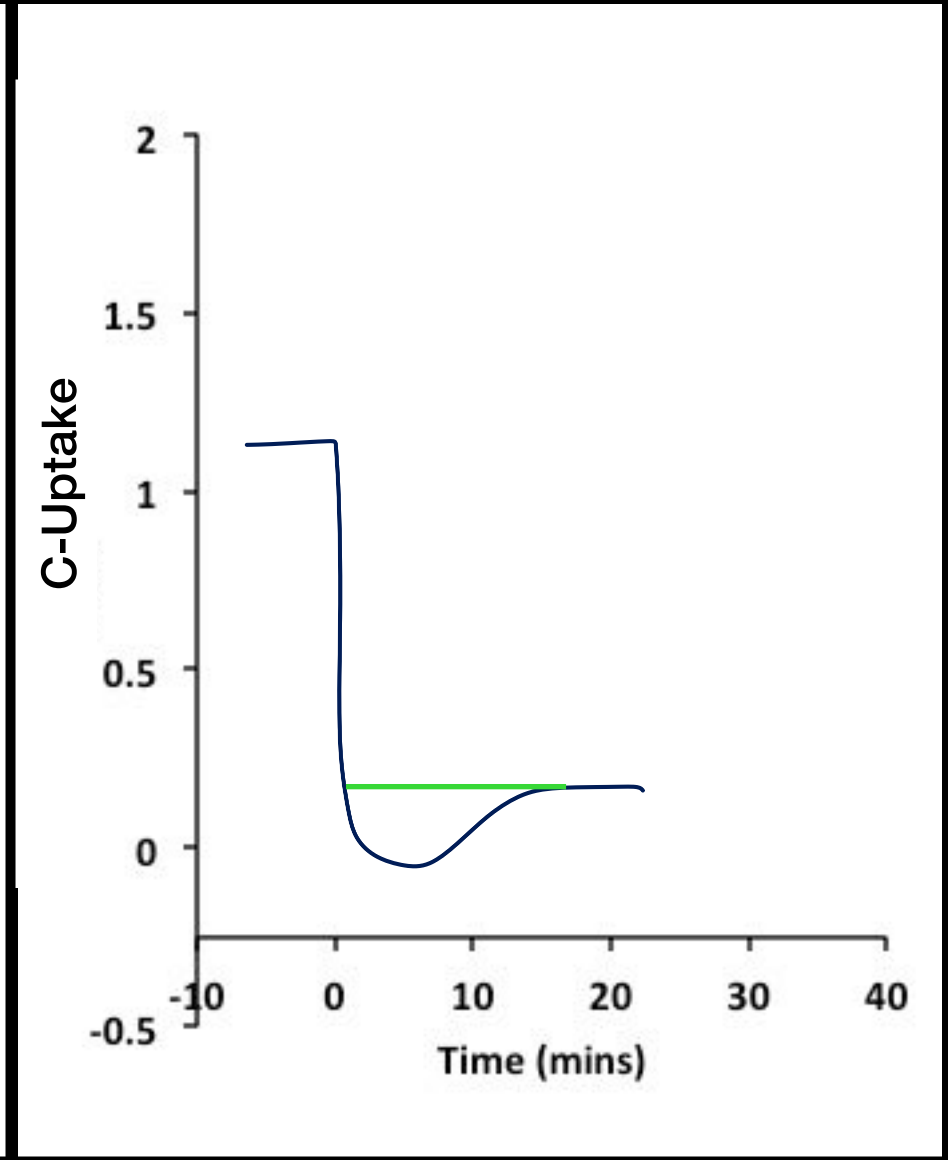
II. Photoprotection (NPQ) relaxation

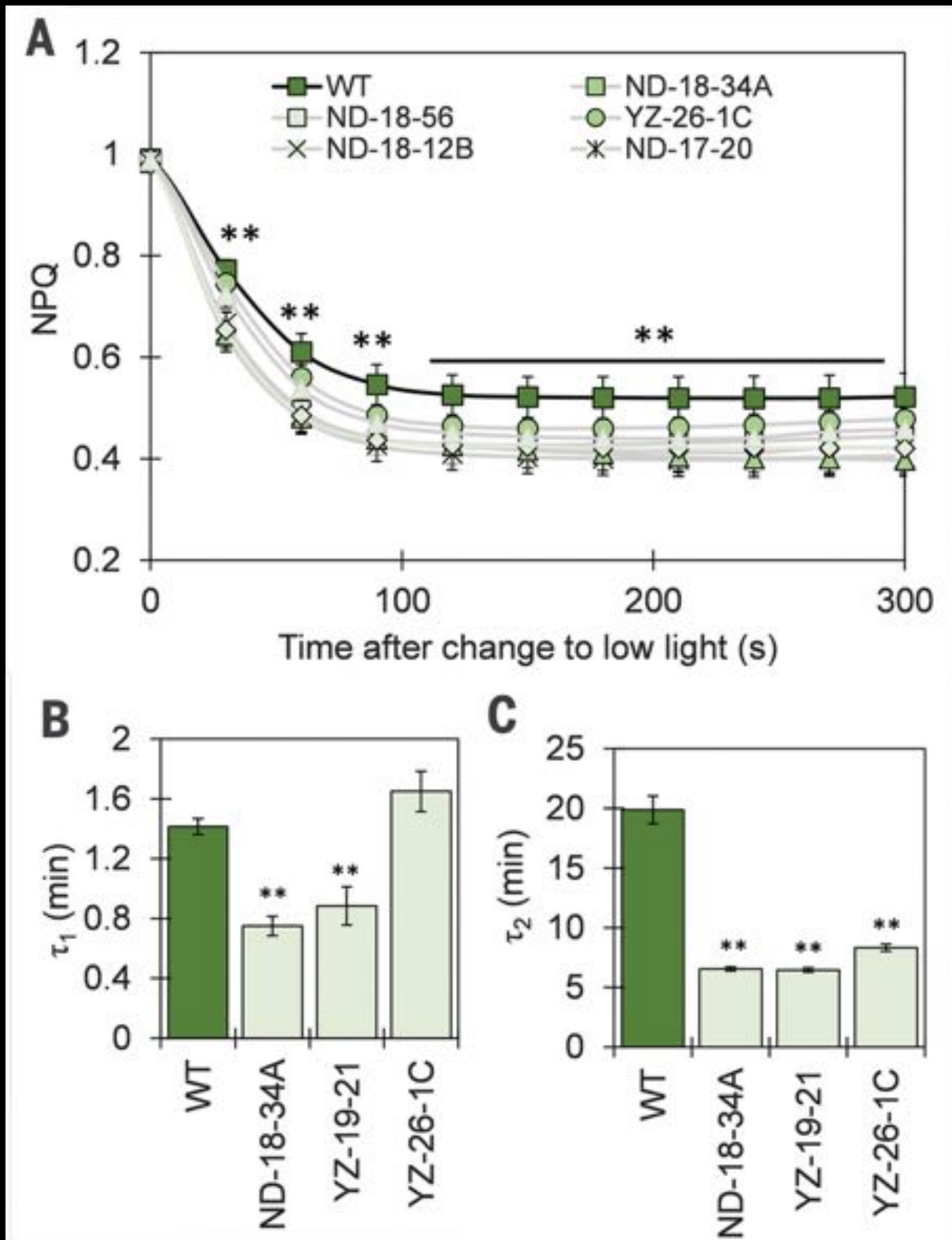
Dynamic photosynthesis

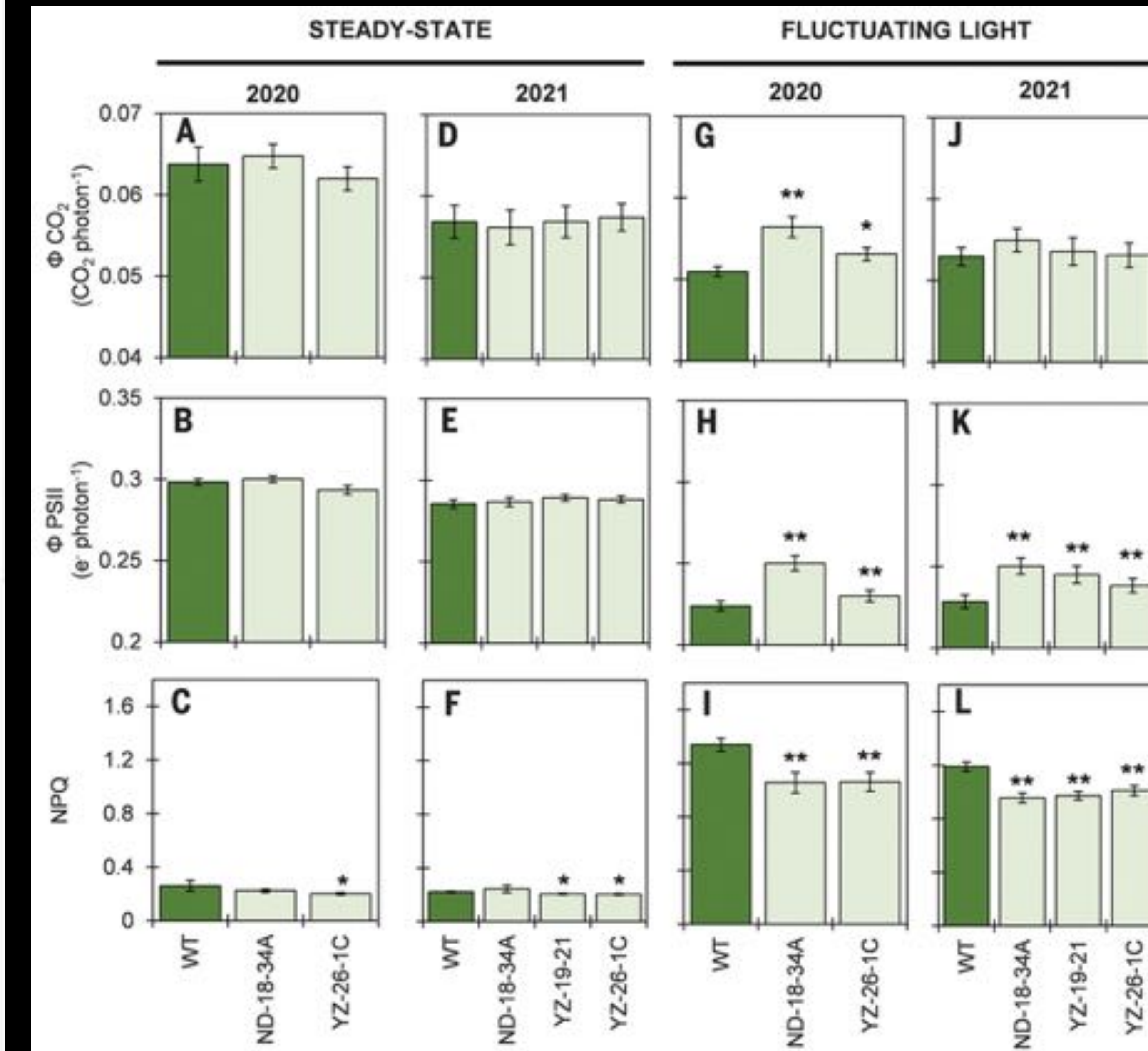


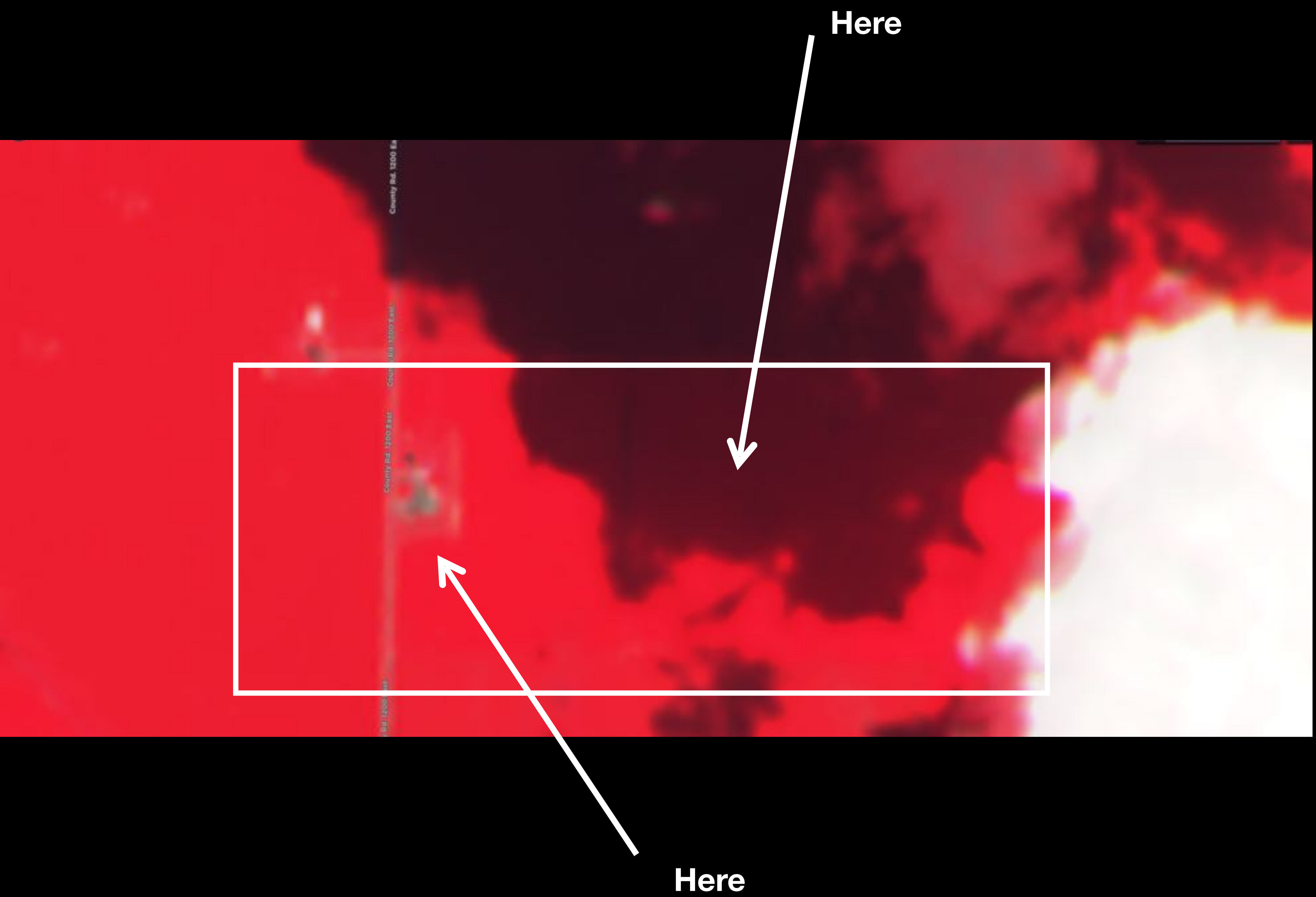
NPQ relaxation






A
1.2
1
0.8
0.6
0.4
0.2
NPQ
WT
ND-18-34A
ND-18-56
YZ-26-1C
ND-18-12B
ND-17-20
**
**
**
**
0
100
200
300
Time after change to low light (s)
B
2
1.6
1.2
0.8
0.4
0
τ1 (min)
**
**
WT
ND-18-34A
YZ-19-21
YZ-26-1C
C
25
20
15
10
5
0
τ2 (min)
**
**
**
WT
ND-18-34A
YZ-19-21
YZ-26-1C


STEADY-STATE
FLUCTUATING LIGHT
2020
2021
2020
2021
A
D
G
J
0.07
0.06
0.05
0.04
Φ CO2 (CO2 photon⁻¹)
**
*
B
E
H
K
0.35
0.3
0.25
0.2
Φ PSII (e⁻ photon⁻¹)
**
**
**
**
**
C
F
I
L
1.6
1.2
0.8
0.4
0
NPQ
*
*
*
**
**
**
**
**
WT
ND-18-34A
YZ-26-1C
WT
ND-18-34A
YZ-19-21
YZ-26-1C
WT
ND-18-34A
YZ-26-1C
WT
ND-18-34A
YZ-19-21
YZ-26-1C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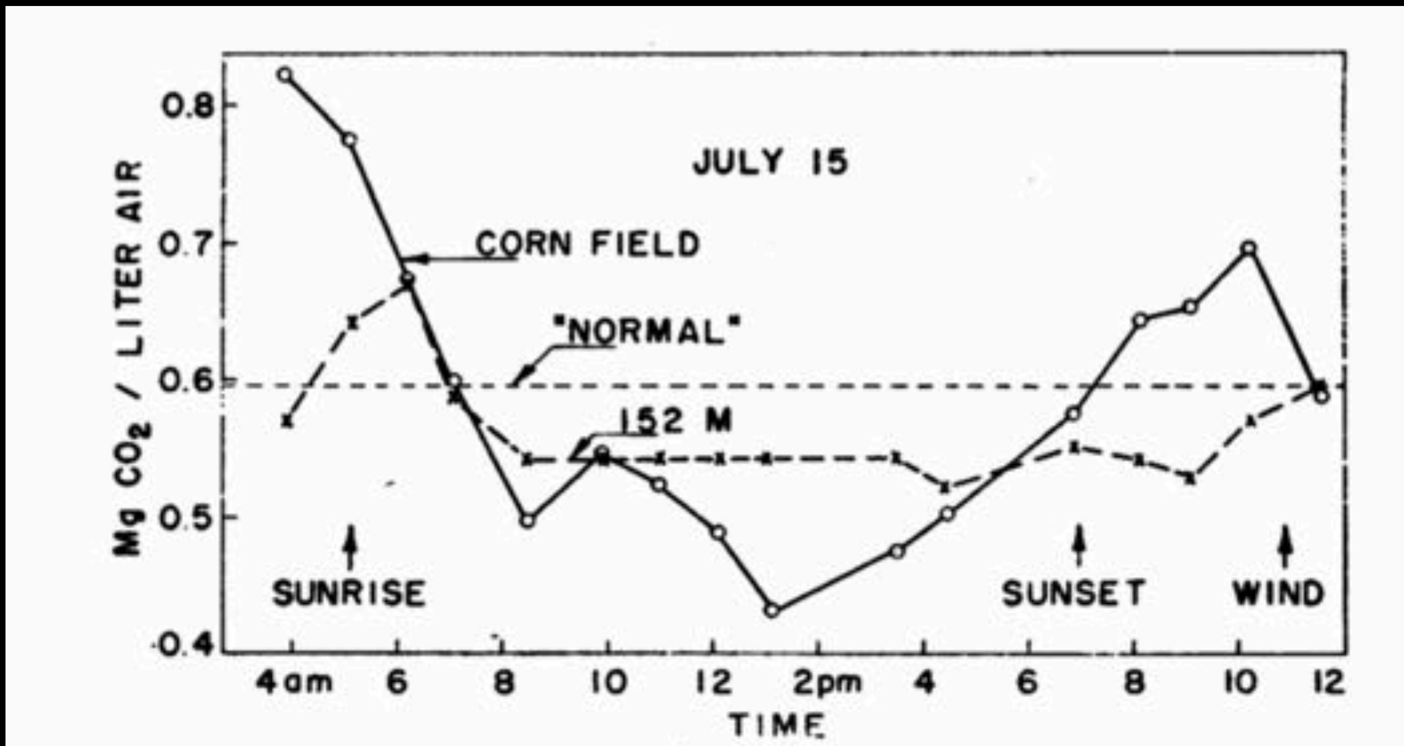
Here

III. [CO_2] fluctuations



Discussion and Summary

The daytime decrease in the CO_2 content of the air among plants carrying on active photosynthesis has been confirmed and shown to extend, with some lag, to a height of 152 m or 500 ft. A typical fluctuation in the CO_2 content at 152 m was 0.03 % at night, decreasing to 0.027 % during the day. With winds of 5 mph or more the CO_2 content of the air in a corn field sampled at a height of 1 m, was nearly the same as that at the 152 m level, but on still days and nights a maximum variation of 0.02 % has been observed; from 0.041 % at night to 0.021 % during active photosynthesis. Since the equilibrium CO_2 level at which net photosynthesis becomes zero is in the neighborhood of 0.01 % (21) such marked drops

THE CARBON DIOXIDE CONTENT OF FIELD AIR [1,2]

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Studies of the CO_2 content of the air have been published over the last 200 years. Stepanova (20) gives 229 abstracts in her 1952 review, without including several extensive studies published in botanical journals or any work in which CO_2 measurements were incidental to studies of photosynthesis, soil respiration, etc. Although DeSaussure (7) showed diurnal variations in the CO_2 content of field air as early as 1816, and correctly interpreted them as due principally to photosynthesis and respiration, one 1952 paper is listed as an endeavor to clarify the disputed point of whether the CO_2 content of the air is constant or variable.

The point is of more than academic interest, for Böhning (3), Chapman and Loomis (5), Decker (6) and Thomas and Hill (21) have shown that photosynthesis varies directly with the CO_2 concentration at levels present in the field. Normal CO_2 is generally considered to be 0.03 volume percent, which is 300 ppm or 0.594 mg/liter of air at sea level and 0° C. Glueckauf (9) believes, however, that the average concentration is increasing with the utilization of oil and coal, and is now above 330 ppm. Balloon and rocket flights have shown that the volume percentage of CO_2 is essentially uniform to heights of at least 70 km or 42 miles (9). A value of 0.029 ± .002 % at 72,000 ft was reported by the Explorer II ascent (17). Atmos-

the CO_2 content of field air
thesis in Iowa averaging 25

[1] Received May 12, 1954.
[2] Journal paper No. J-2521
Experiment Station, Ames, Iow

[3,4] Present addresses: Dep

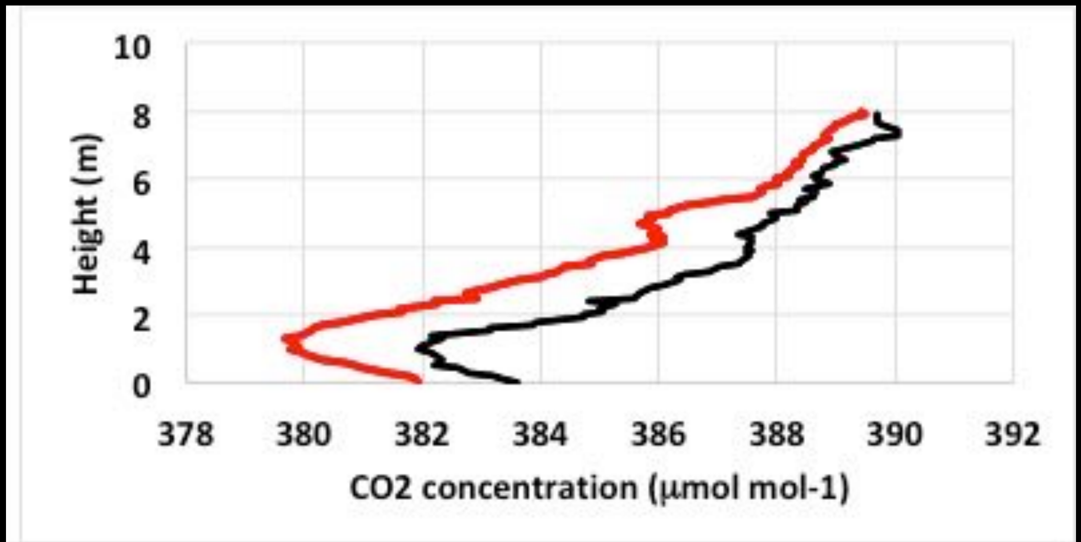
centrations. Similar changes have been reported recently by other workers (4, 11, 15, 16, 22, 25). Chapman (4) found less fluctuation in the CO_2 content of the air in a dryland field at Alliance, in western Nebraska, than had been reported for Ames, Iowa. He assumed that the lower soil organic matter, moisture and temperature reduced the build-up of free CO_2 at night, and that the generally more sparse vegetation resulted in less utilization during the day. Results in Palestine (16) were similar to those in Iowa, but analyses at Milano, Italy (22) showed a considerable increase in average CO_2 content of the air in the summer. The daytime drop during the summer was of the same magnitude as that in Iowa.

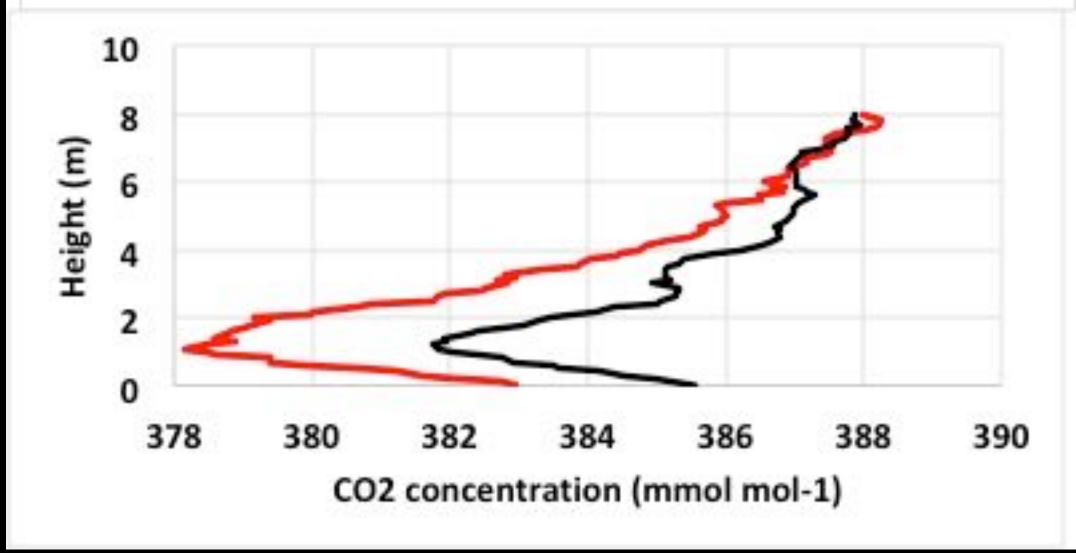
Verduin and Loomis (24) noted that the low daytime CO_2 at ground level was not increased appreciably by winds of moderate velocity, thus raising the question of stratification and limited mixing of surface air with higher levels. In the summer of 1952 the opportunity arose of using the Iowa State College television tower for continuous sampling of air at a moderate height in comparison with analyses from an adjoining corn field.

Methods

A modification of Heinicke's method (10) described by Chapman and Loomis (5) was used. Five lines of 3/16 inch I.D. copper tubing were connected ...orption towers. These lines sampled the ... 1 m above the ground and about 20 m ...order of a large corn field; (b) 1 m in the ...area, a grass plot about 40 by 60 m ...rounded by corn; (c) 10 m above the ...the tower; (d) 30 m on the tower, and ...at the base of the transmitting antenna on ... Manometers and thermometers were in... air lines just ahead of the flow meters to ...ta for correcting apparent air volumes. ...e differences were small; pressure drops ...resistance varied between about 10 and 50 ...

Corn field, summer 2018





Conclusions from THE DARK SIDE:

- Dynamic photosynthesis is relatively poorly studied, but is extremely important

- **They may be driven by a number of processes of biological but also physical nature**

- **The measurement of "true photosynthesis" in the field is difficult and knowledge of ETR alone cannot help in some instances in separating carboxylation and oxygenation**

- **This does not certainly negates the critical importance of estimating ETR under quasi steady-conditions but it is always good to know that things may not be so simple**

Thanks for your attention !!