Plants in the Climate System

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Why do people care about plants?

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Why do people care about plants?






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But plants also affect climate!

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Plant influence on climate

1. Carbon uptake
2. Evapotranspiration (energy transfer)
3. Albedo (surface color)

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Plant influence on climate

1. Carbon uptake
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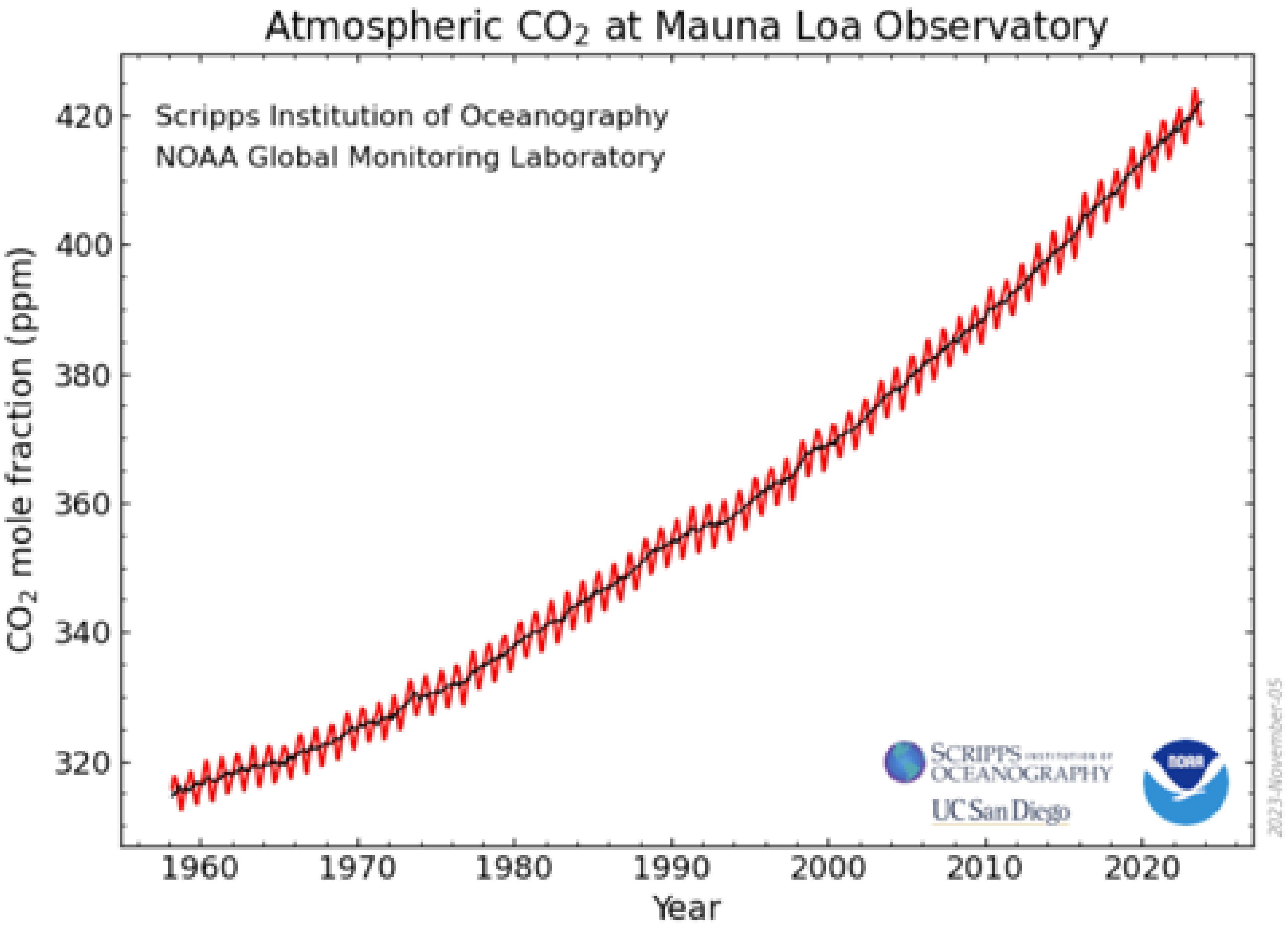

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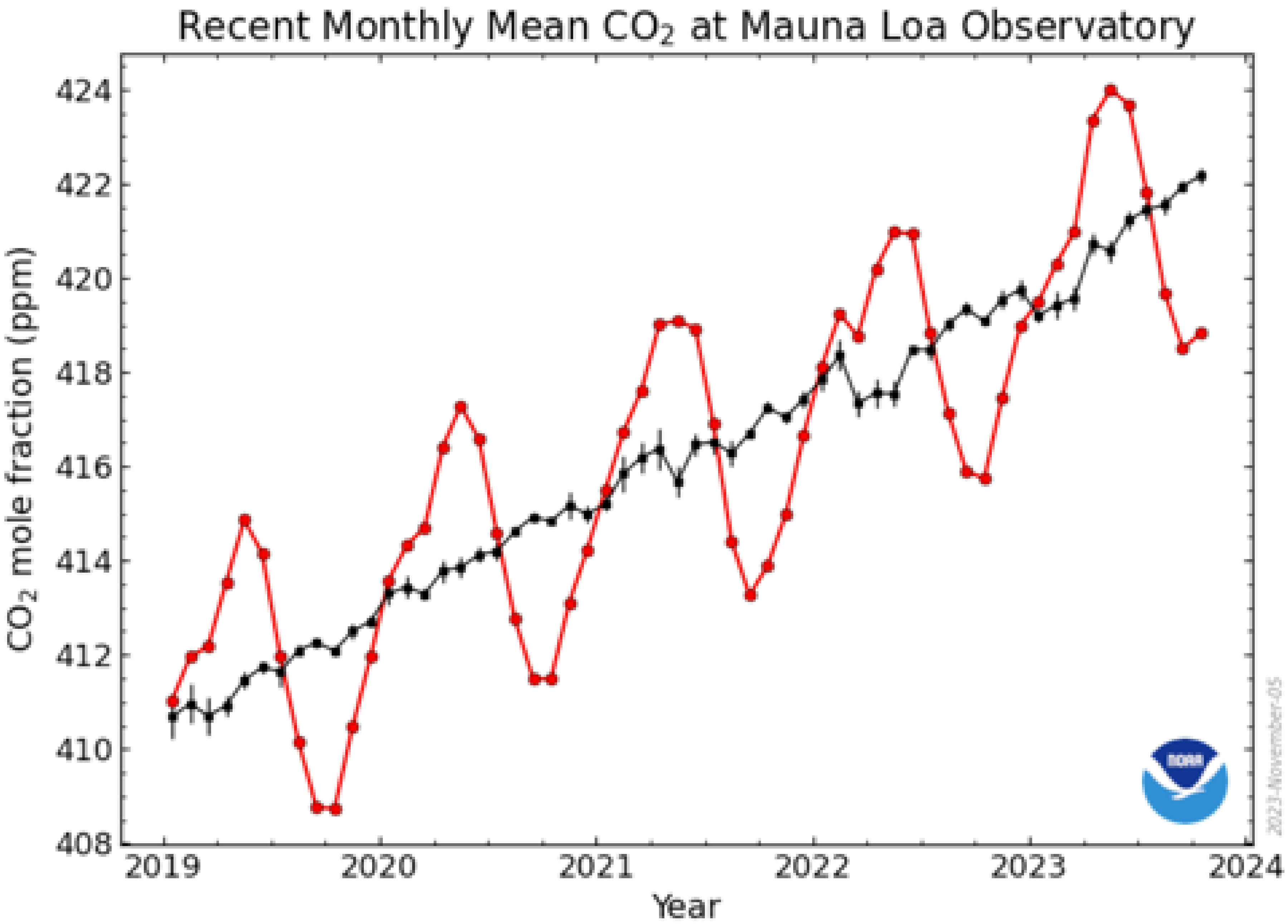

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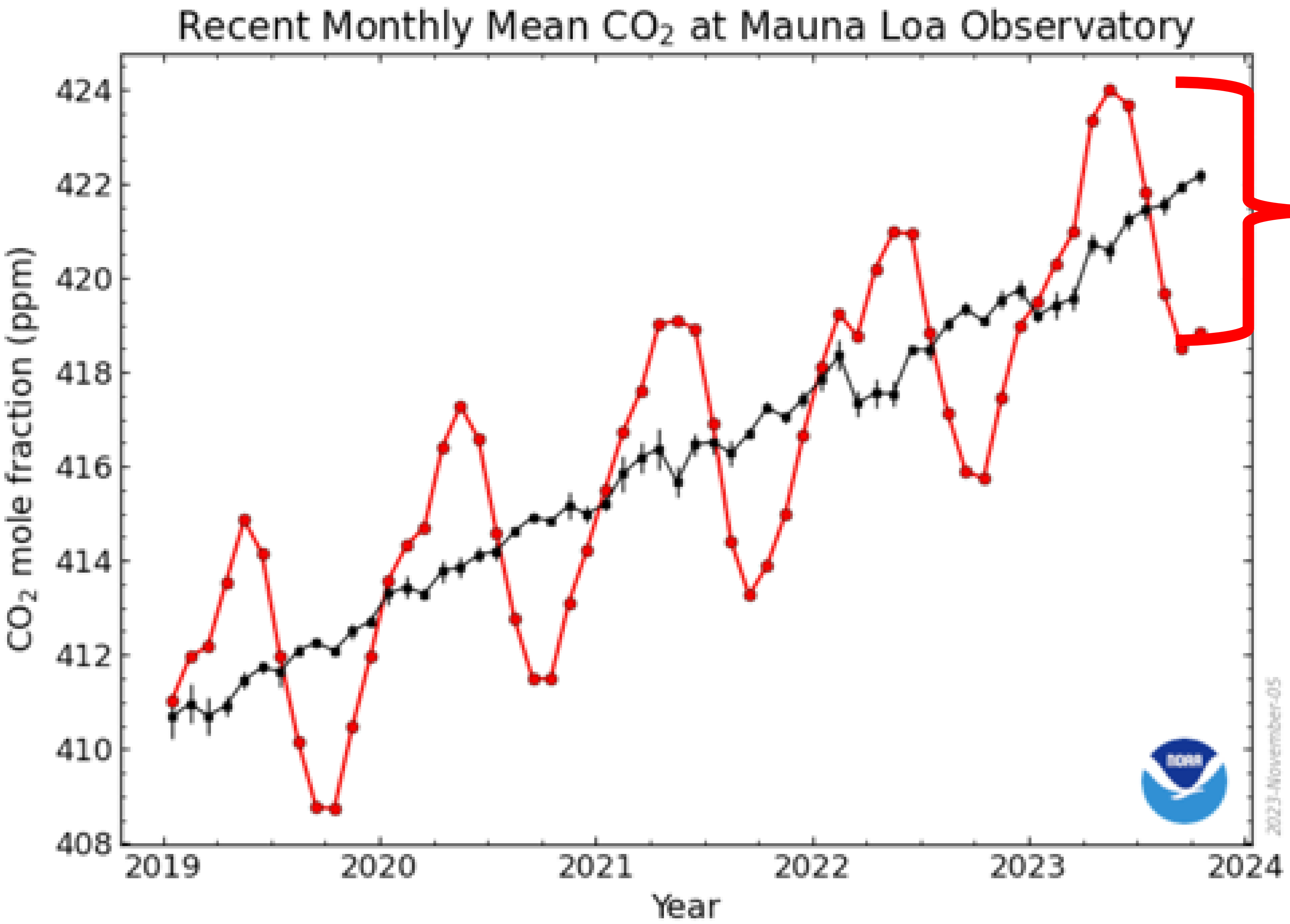

Plants!

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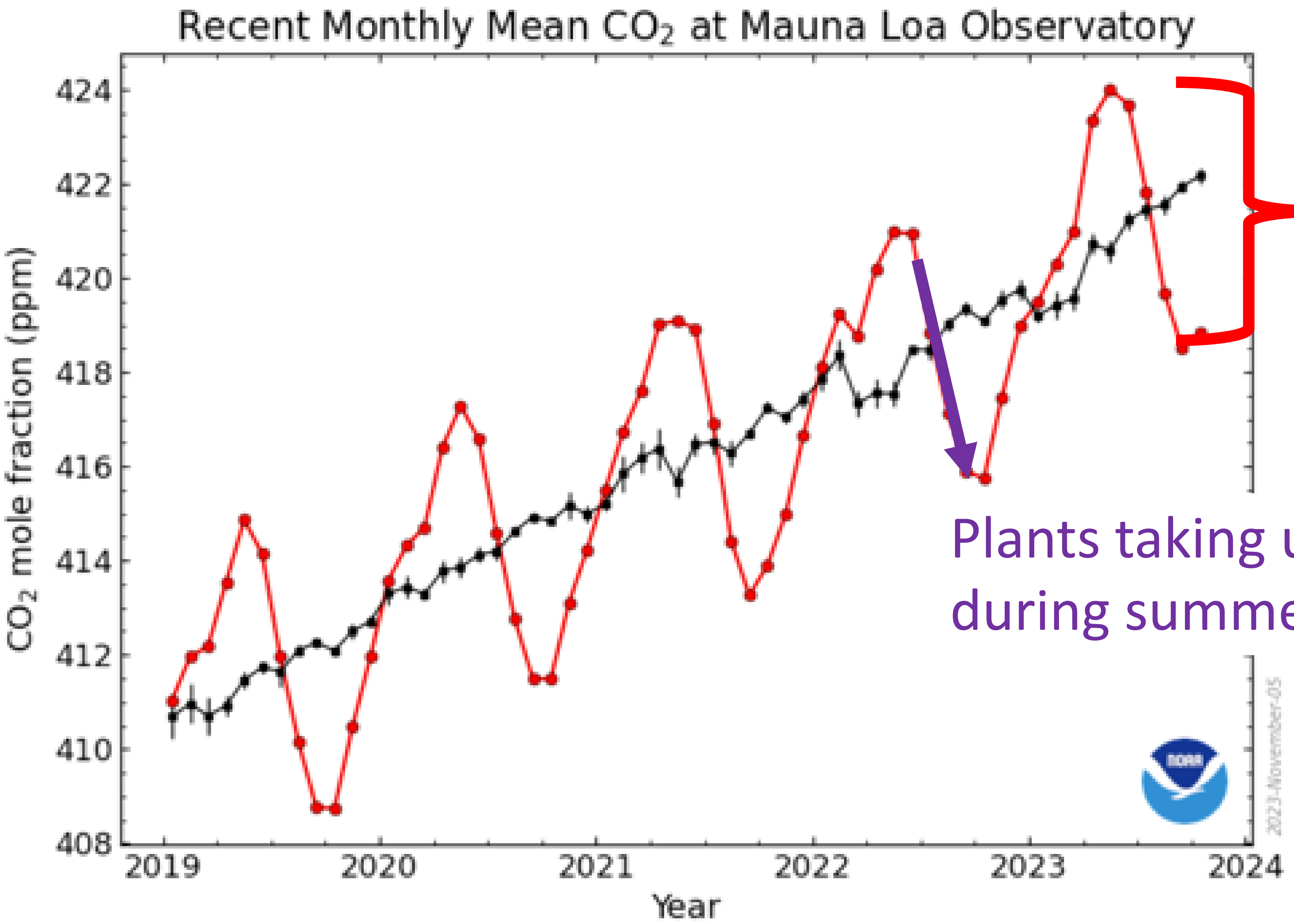

Plants!

Plants taking up CO_2 during summer

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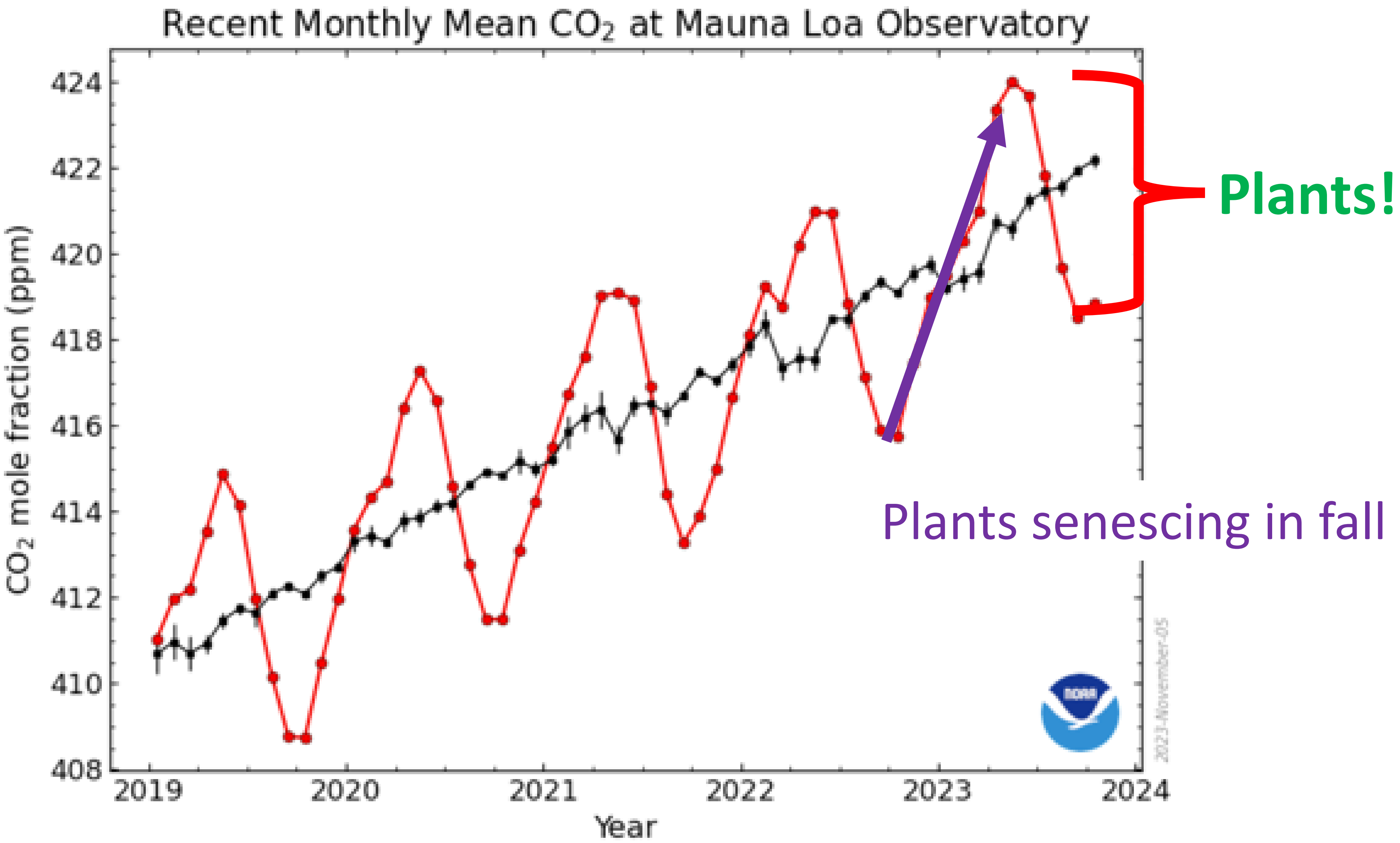

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Plant influence on climate

1. Carbon uptake
2. Evapotranspiration (energy transfer)
3. Albedo (surface color)

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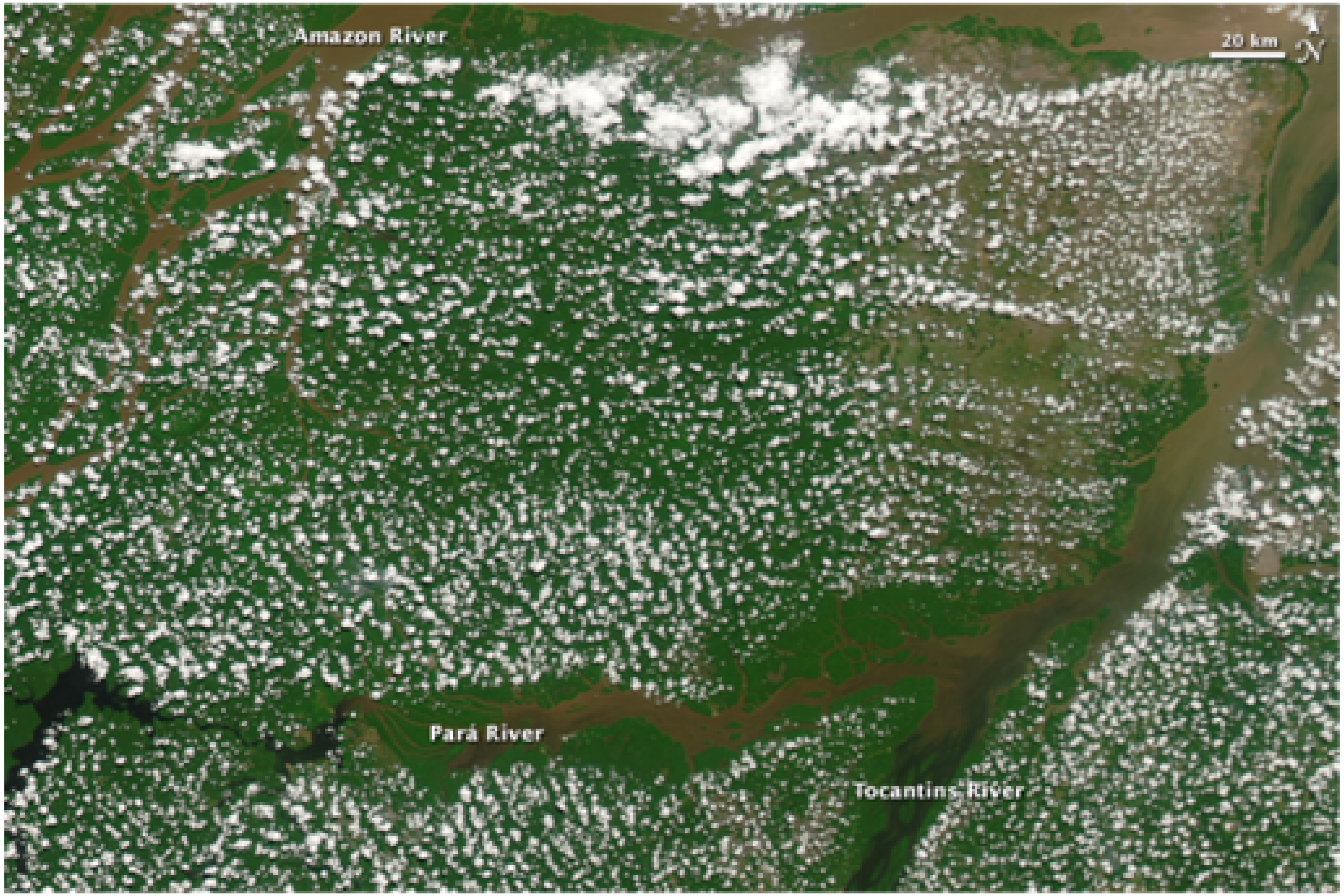
Plants influence surface energy fluxes



Transpiration cools the land surface

NASA

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Plant influence on climate

1. Carbon uptake
2. Evapotranspiration (energy transfer)
3. Albedo (surface color)

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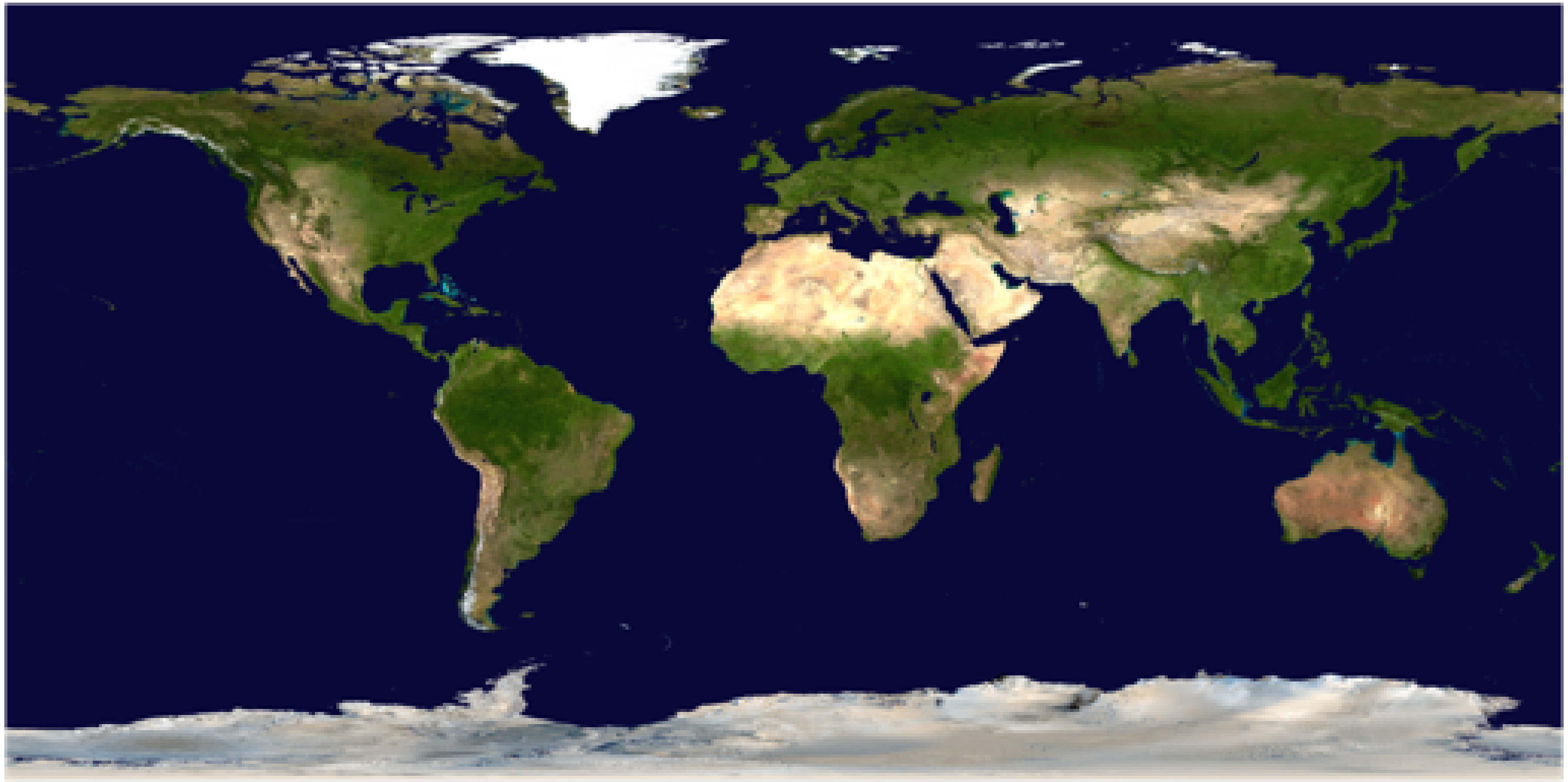
Plants influence Earth’s color



Darker = more energy absorbed = warmer

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So, to know climate, we need to model plants

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So, to know climate, we need to model plants

$$\rightarrow \quad f\,(X, Y, Z)$$

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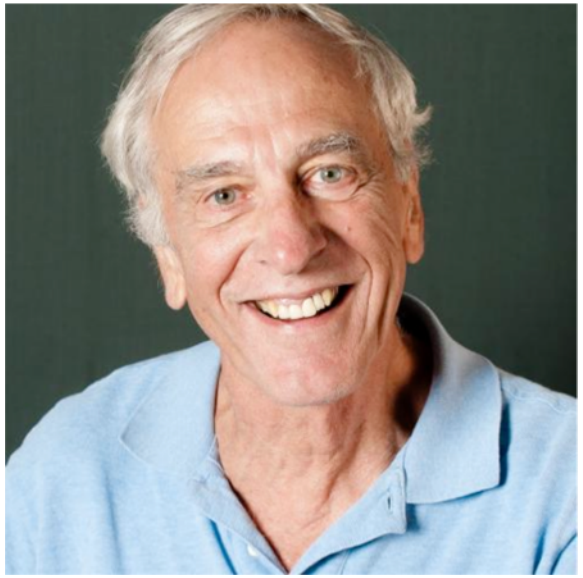
1980's: plant models are developed

A Biochemical Model of Photosynthetic CO_2 Assimilation in Leaves of C_3 Species

G.D. Farquhar[1], S. von Caemmerer[1], and J.A. Berry[2]

[1] Department of Environmental Biology, Research School of Biological Sciences, Australian National University, P.O. Box 475, Canberra City ACT 2601, Australia and

[2] Carnegie Institution of Washington, Department of Plant Biology, Stanford, Cal. 94305, USA



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90's to 2000's: spinach world!

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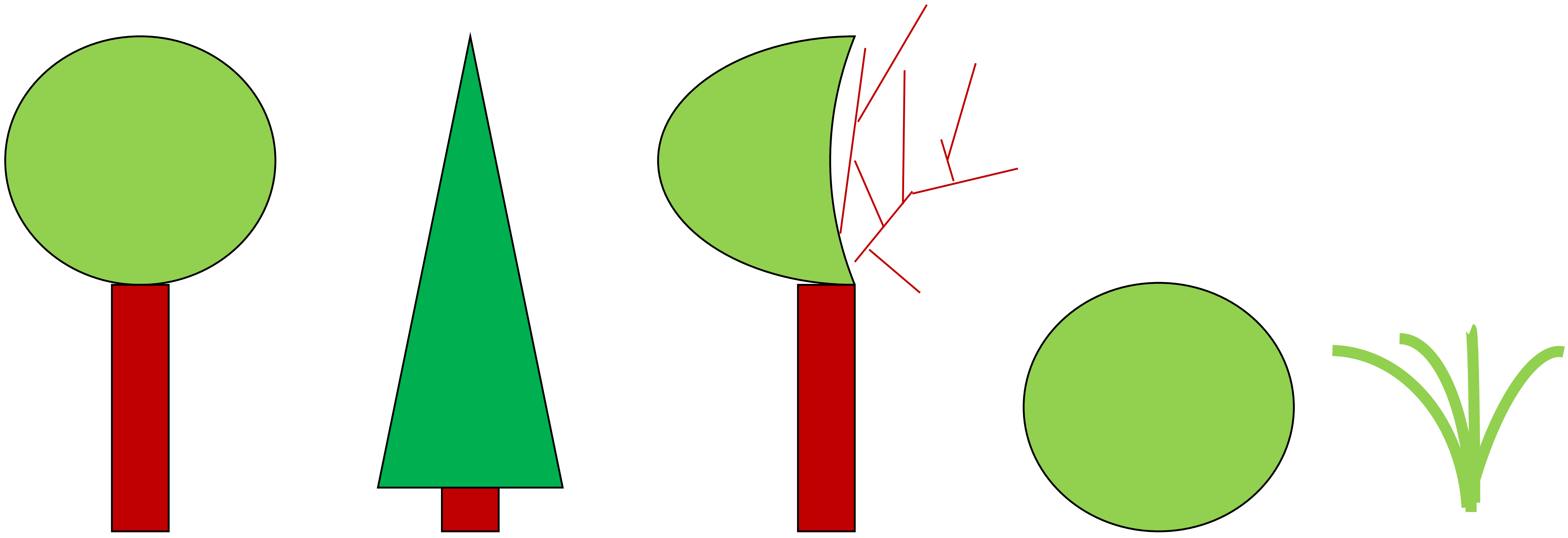
2000’s: 5 – 10 plant “types”



Broadleaf tree | Needleleaf tree | Deciduous tree | Shrub | Grass

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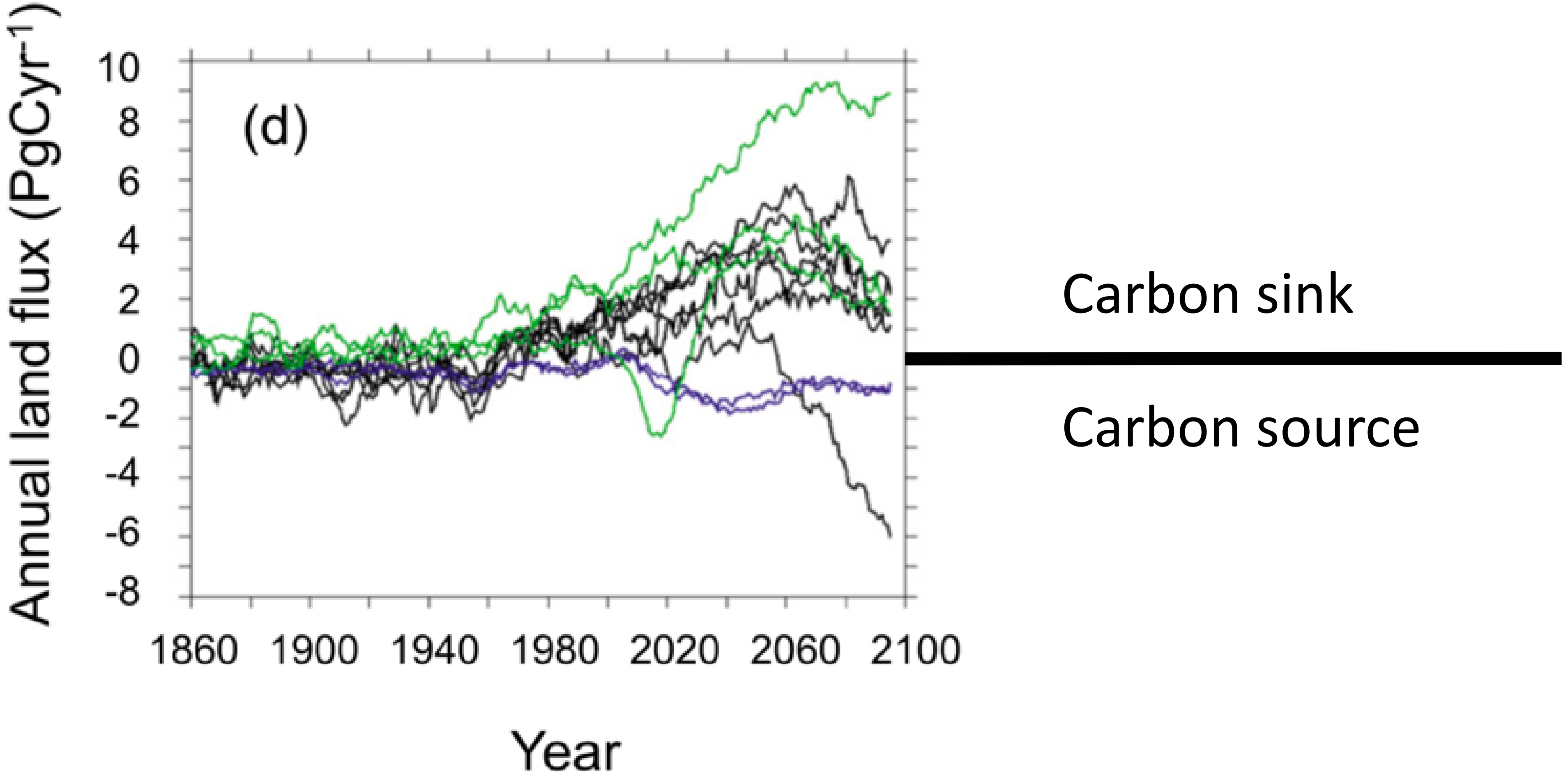
…but the models still vary



Friedlingstein et al. (2014)

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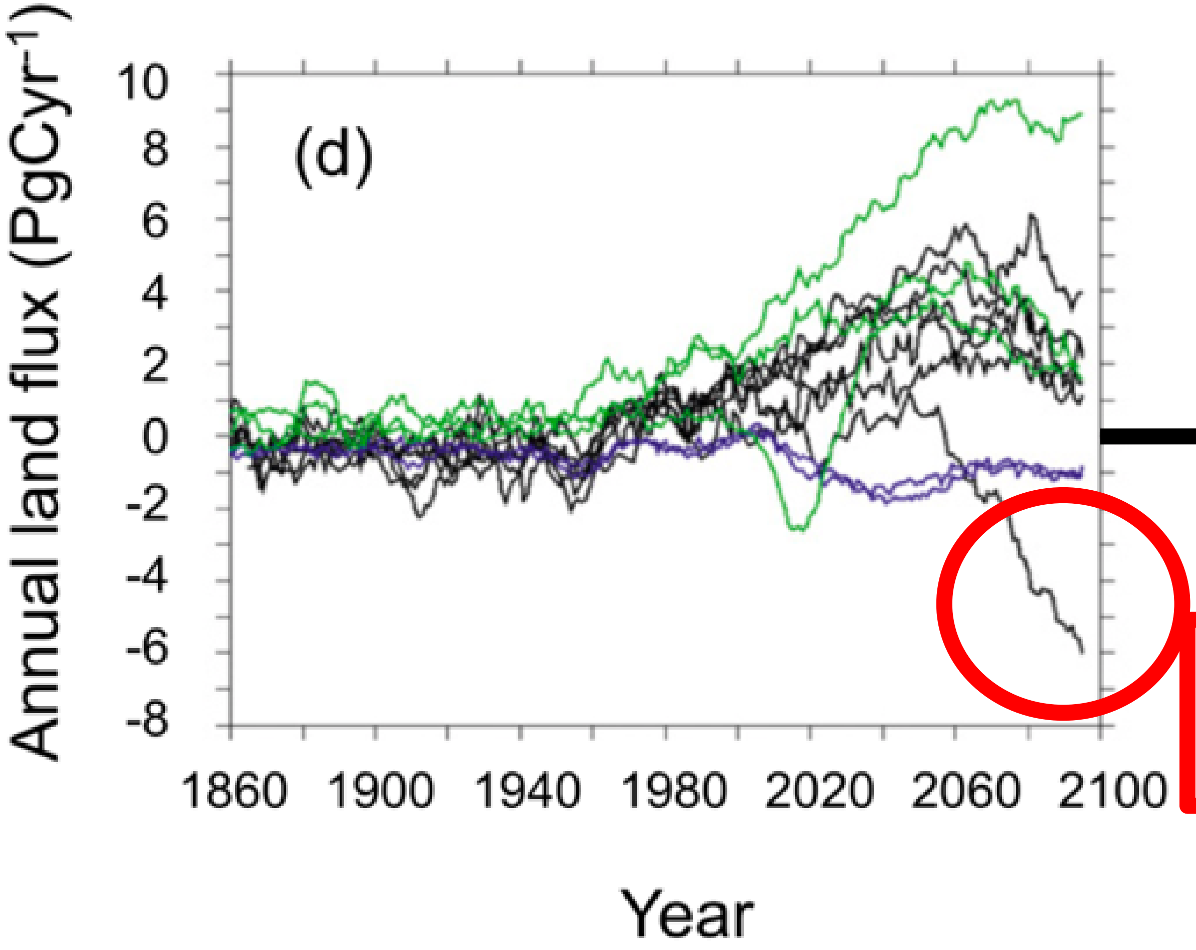
And some make scary predictions!



Carbon sink

Carbon source

The Amazon Dieback Scenario

BY JUSTIN GILLIS OCTOBER 7, 2011 3:31 PM

Friedlingstein et al. (2014); New York Times

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Dumb plants

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2010's: "Smart" plants

With time, plants will acclimate to environmental perturbations, such as elevated temperature and CO_2.

Global Change Biology

Global Change Biology (2013) **19**, 45–63, doi: 10.1111/j.1365-2486.2012.02797.x

REVIEW

Plant respiration and photosynthesis in global-scale models: incorporating acclimation to temperature and CO_2

NICHOLAS G SMITH* and JEFFREY S DUKES*†

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2010's: "Smart" plants

Acclimation reduces plant sensitivity to climate.

nature climate change

LETTERS

PUBLISHED ONLINE: 7 DECEMBER 2015 | DOI: 10.1038/NCLIMATE2878

Foliar temperature acclimation reduces simulated carbon sensitivity to climate

Nicholas G. Smith[1*], Sergey L. Malyshev[2], Elena Shevliakova[2], Jens Kattge[3,4] and Jeffrey S. Dukes[1,5]

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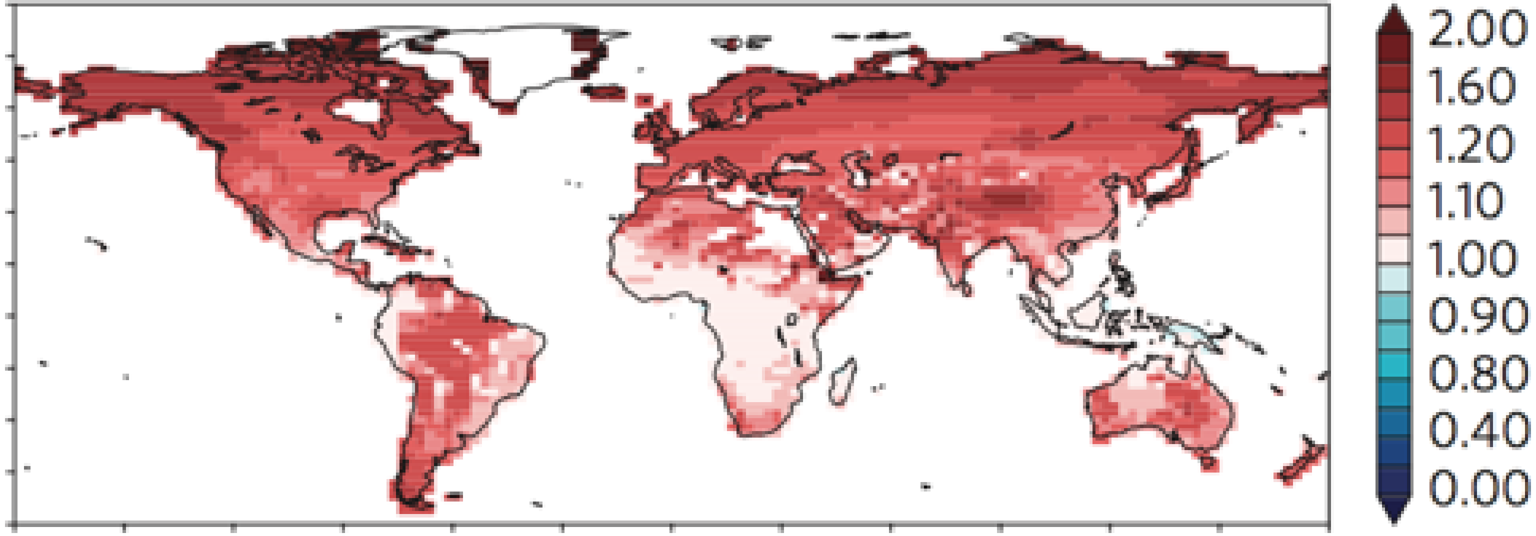
2010's: "Smart" plants

Acclimation reduces plant sensitivity to climate, which increases future carbon uptake (no Amazon dieback).



Effect of acclimation on future photosynthetic capacity (μmol m^{-2} s^{-1}).
Note: 1: no change; >1: increase; <1: decrease

nature climate change
LETTERS
PUBLISHED ONLINE: 7 DECEMBER 2015 | DOI: 10.1038/NCLIMATE2878

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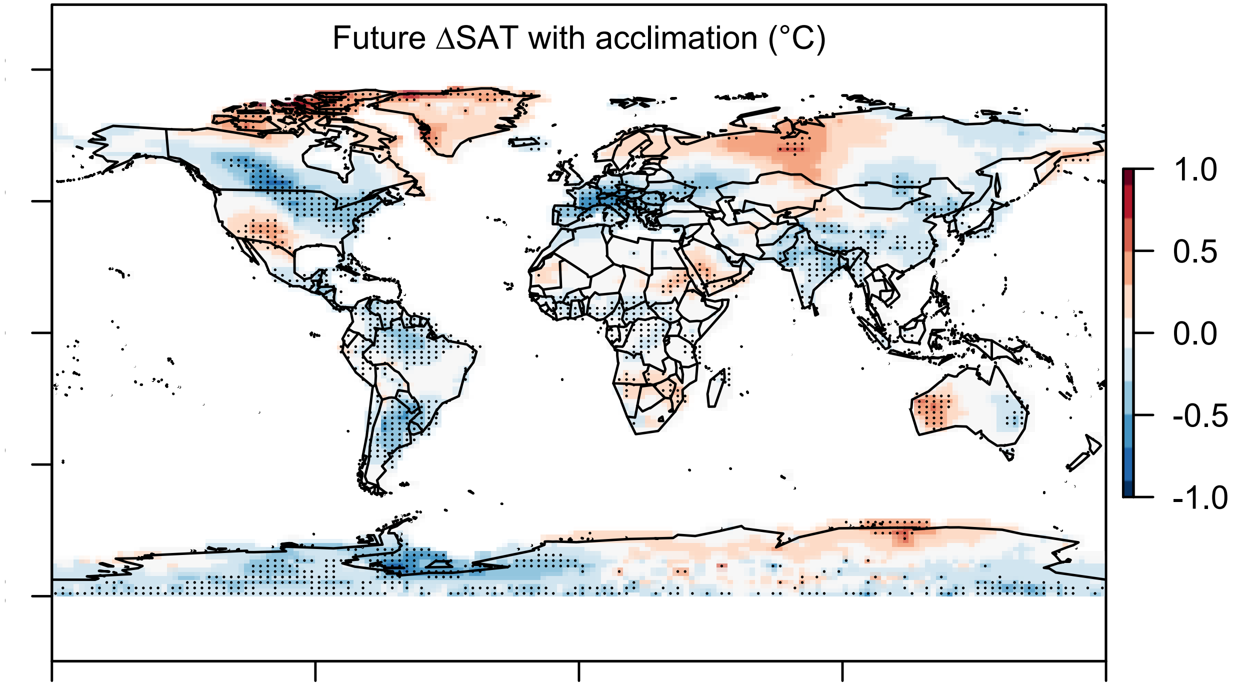
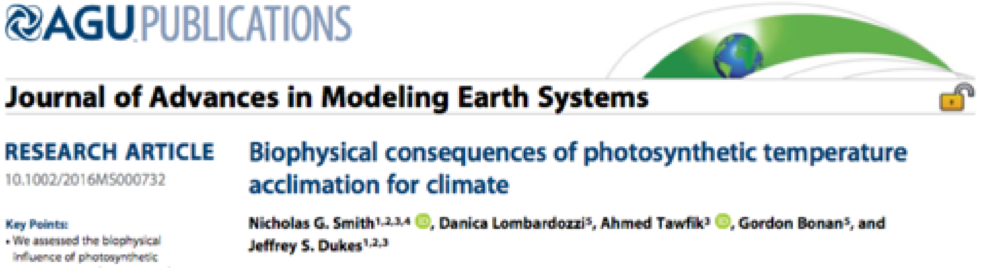
2010's: "Smart" plants

Acclimation reduces plant sensitivity to climate, which increases future evaporative cooling.




AGU PUBLICATIONS

Journal of Advances in Modeling Earth Systems

RESEARCH ARTICLE

10.1002/2016MS000732

Biophysical consequences of photosynthetic temperature acclimation for climate

Nicholas G. Smith[1,2,3,4], Danica Lombardozzi[5], Ahmed Tawfik[3], Gordon Bonan[5], and Jeffrey S. Dukes[1,2,3]

Key Points:

- We assessed the biophysical influence of photosynthetic

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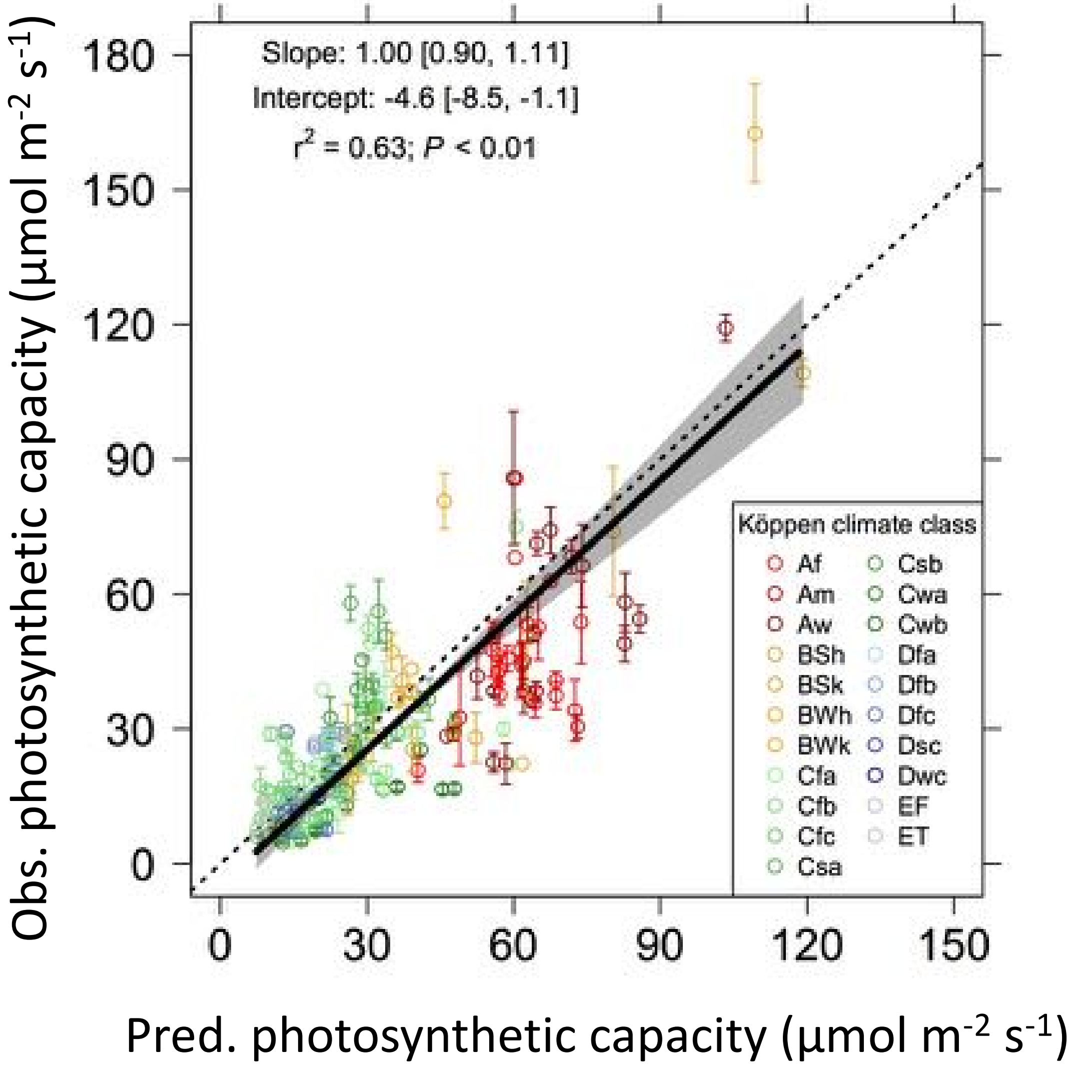
2010's: "Smart" plants

A theoretical model of acclimation to everything!

- Temperature
- CO_2
- Light
- Moisture



Smith et al. (in review)

… but how do humans fit in?

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2020’s: adding in the human dimension

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2020’s: adding in the human dimension

Example: What happens when you plant cover crops?

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2020’s: adding in the human dimension

Example: What happens when you plant cover crops?

1. Increase carbon uptake (cooling)

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2020's: adding in the human dimension

Example: What happens when you plant cover crops?

1. Increase carbon uptake (cooling)
2. Increase evapotranspiration (cooling)

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2020's: adding in the human dimension

Example: What happens when you plant cover crops?

1. Increase carbon uptake (cooling)
2. Increase evapotranspiration (cooling)
3. Change energy reflection/albedo (warming/cooling)

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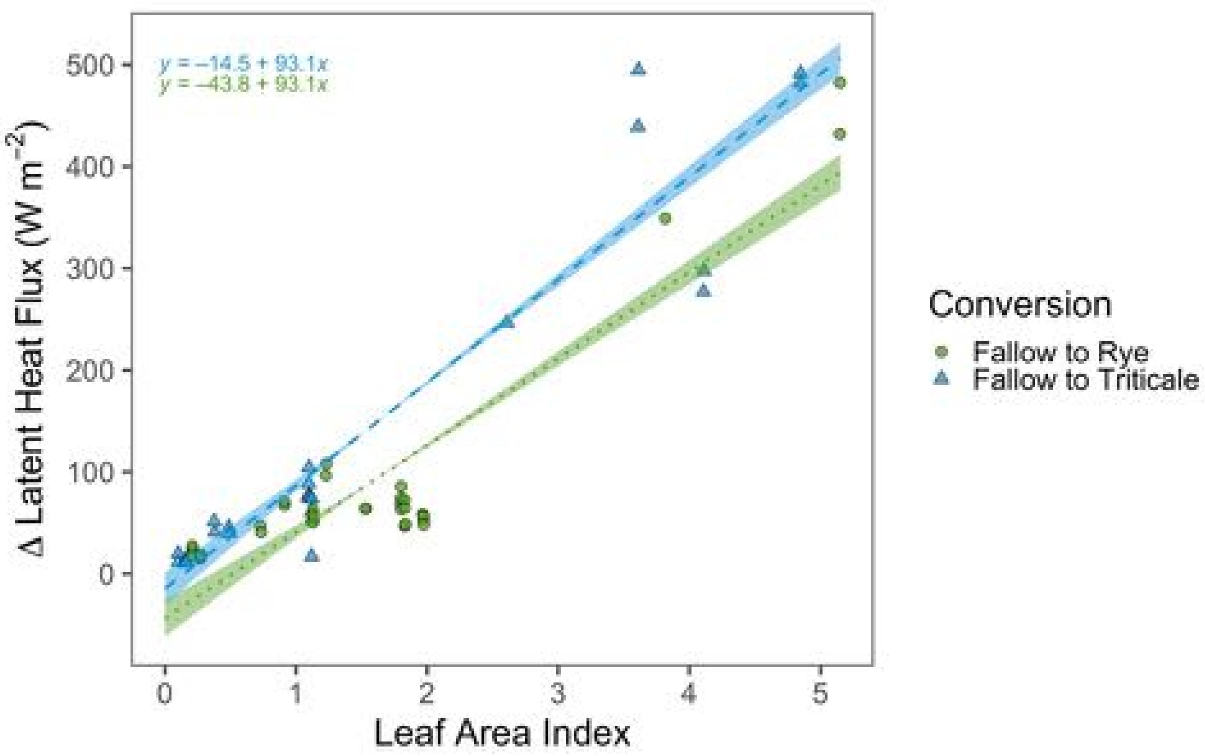
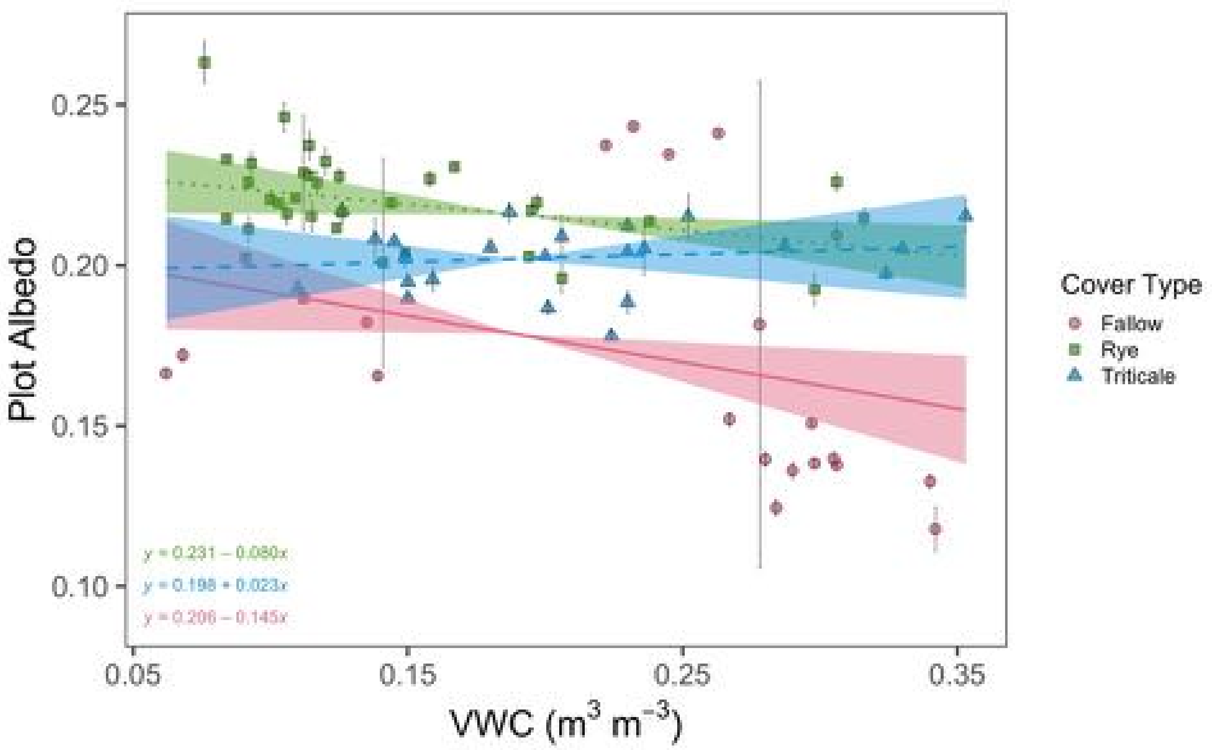
2020's: adding in the human dimension





McNellis et al. (accepted)

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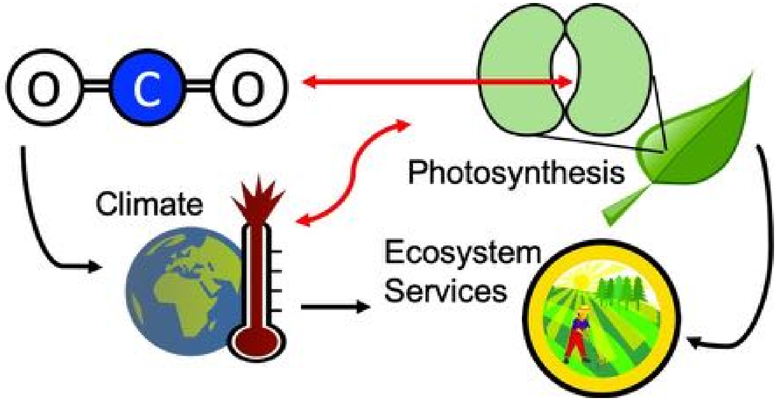
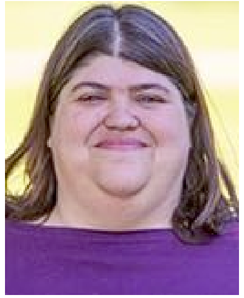
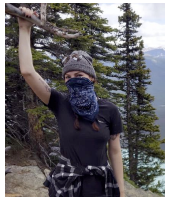
Smith Ecophysiology Lab at TTU

- How do plants respond and feedback to climate over large spatial and temporal scales?
- How is human activity modifying plant-climate feedbacks?
- Can we build robust, reliable models to represent these responses?

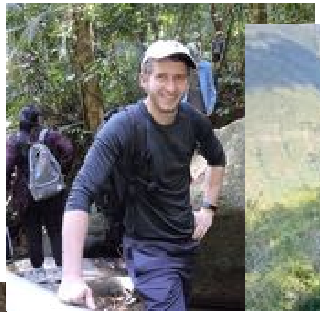
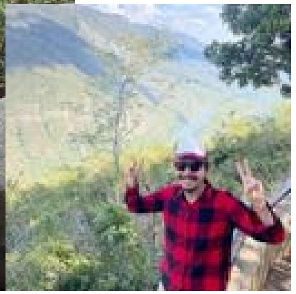










Presentation available at:
www.github.com/SmithEcophysLab/seminar/2023_sbtg

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