

# Why climate models BUG biologists

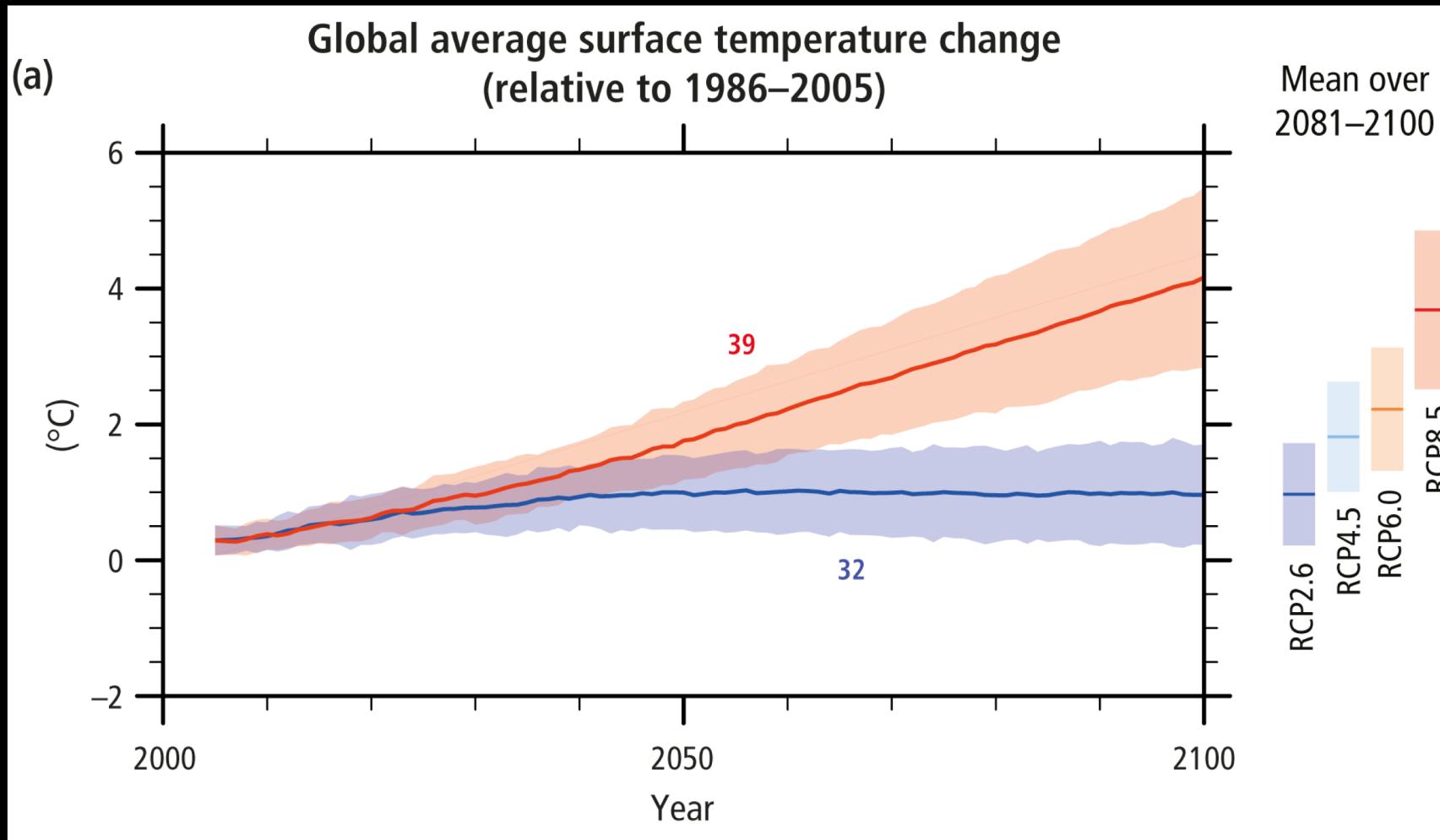


Nick Smith

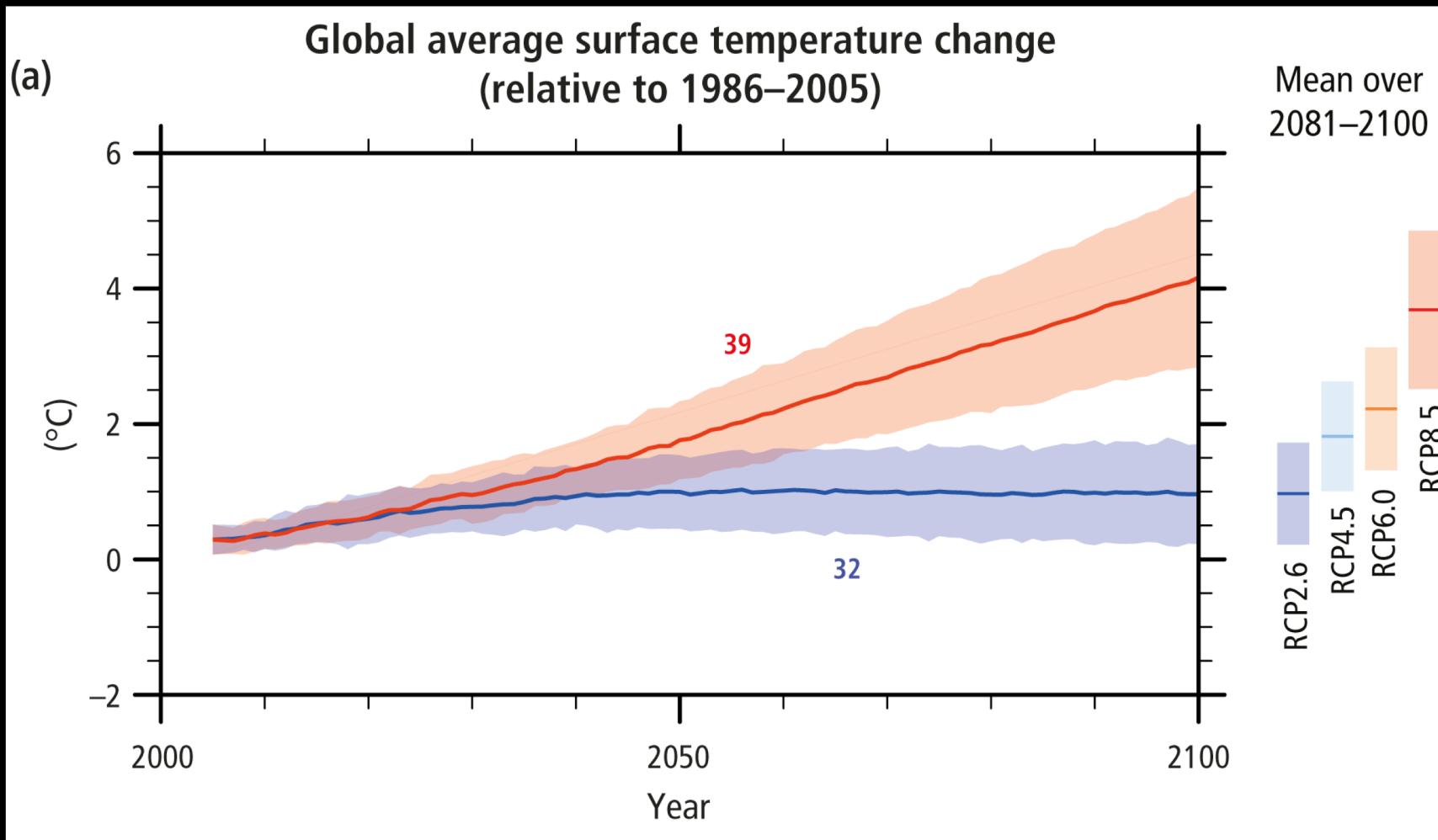
BUGS

March 30, 2019

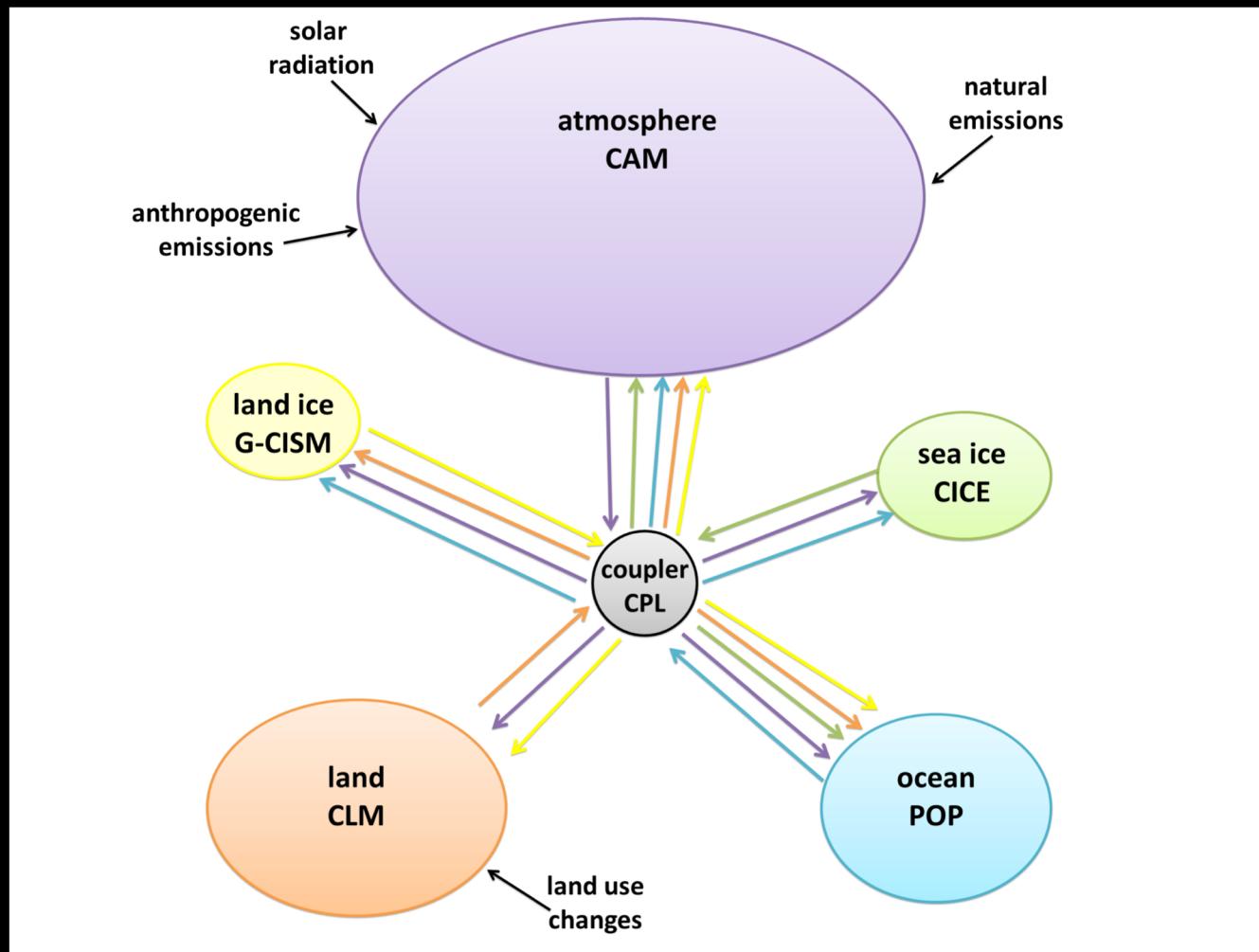
# The world is projected to war 4°C by 2100



# Says who?



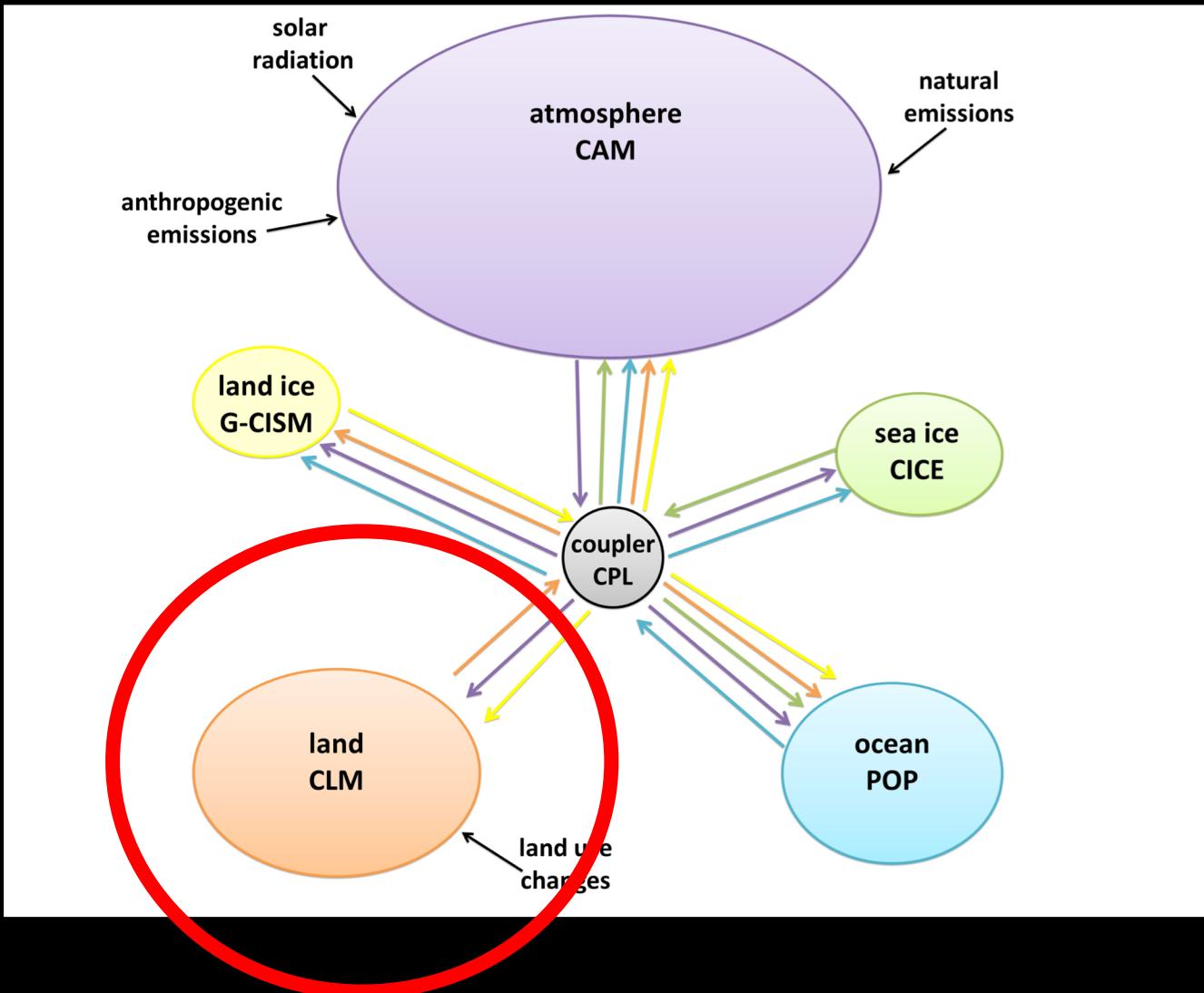
# Earth System Models



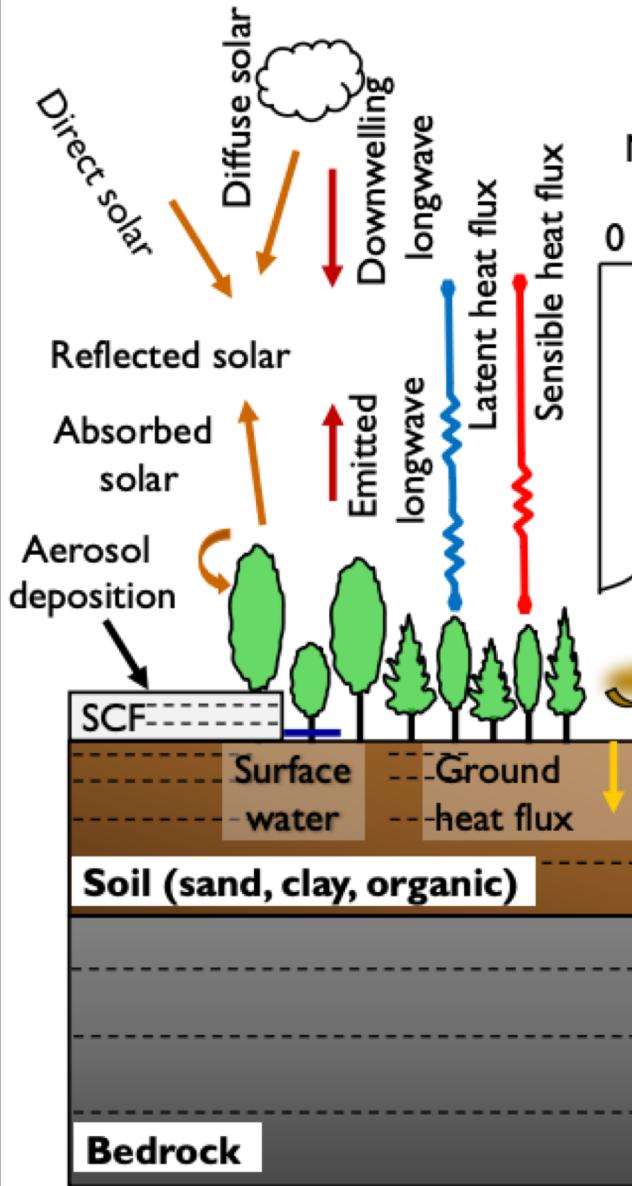
Why do Biologists care?

# Why do Biologists care?

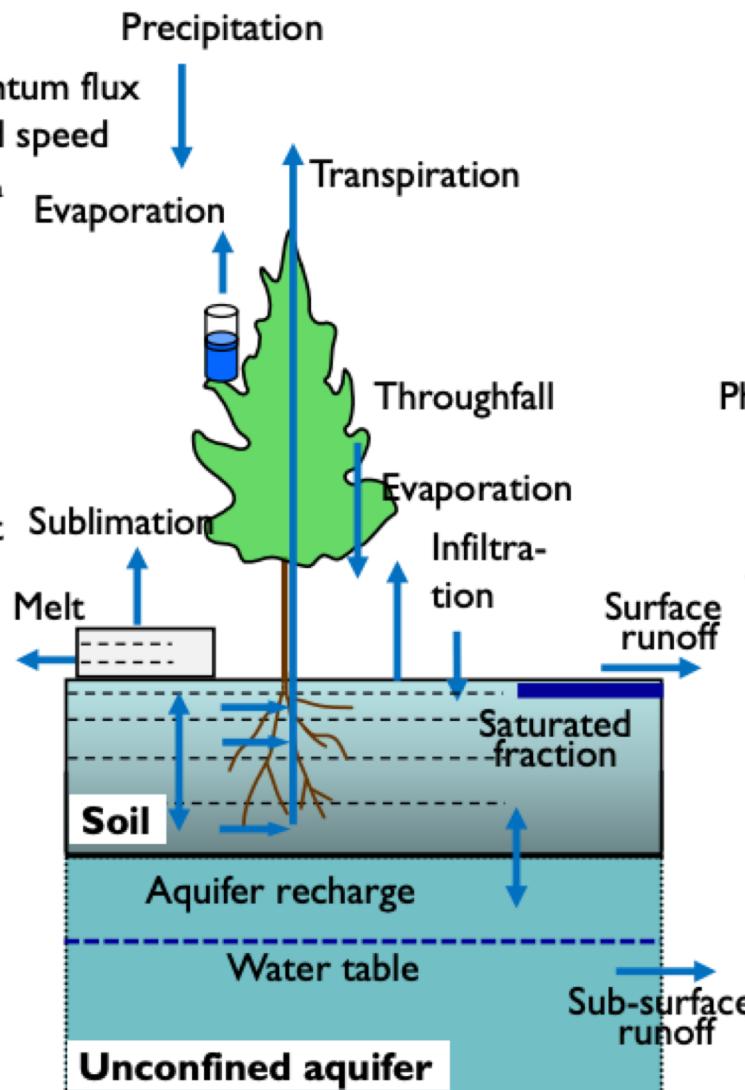
1. There is a lot of Biology in ESMs



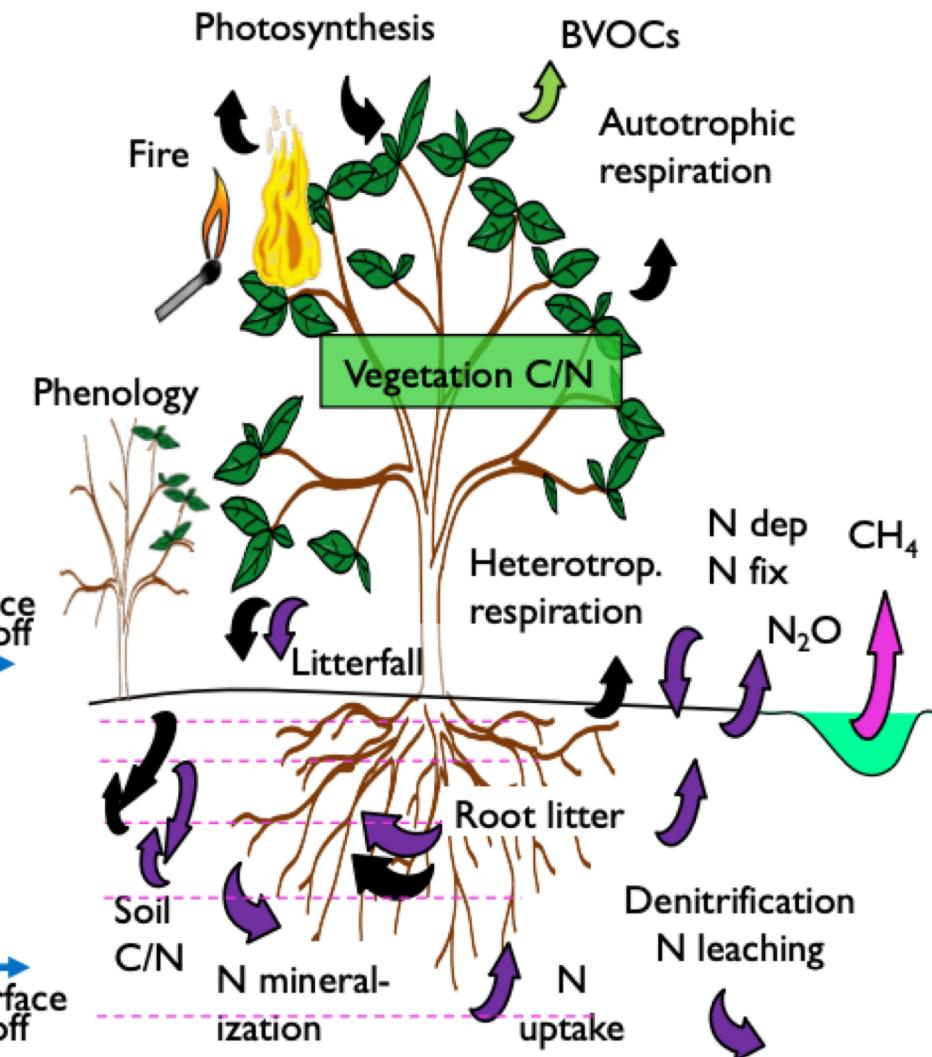
## Surface energy fluxes



## Hydrology



## Biogeochemical cycles



# Why do Biologists care?

1. There is a lot of Biology in ESMs
  - And that Biology matters!

Photosynthesis  
120 PgC/yr



Soil microbial  
respiration  
60 PgC/yr



Fossil fuel burning  
<10 PgC/yr



# Why do Biologists care?

1. There is a lot of Biology in ESMs
  - And that Biology matters!
2. There is a lot of Biology missing from ESMs

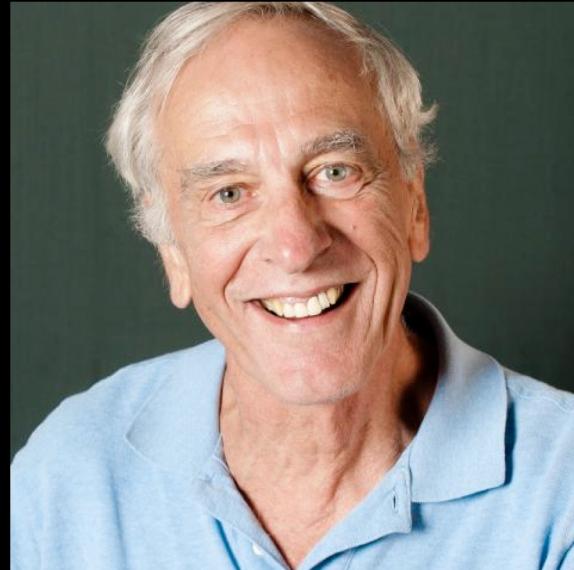
# 1980's: plant models are developed

## A Biochemical Model of Photosynthetic CO<sub>2</sub> Assimilation in Leaves of C<sub>3</sub> Species

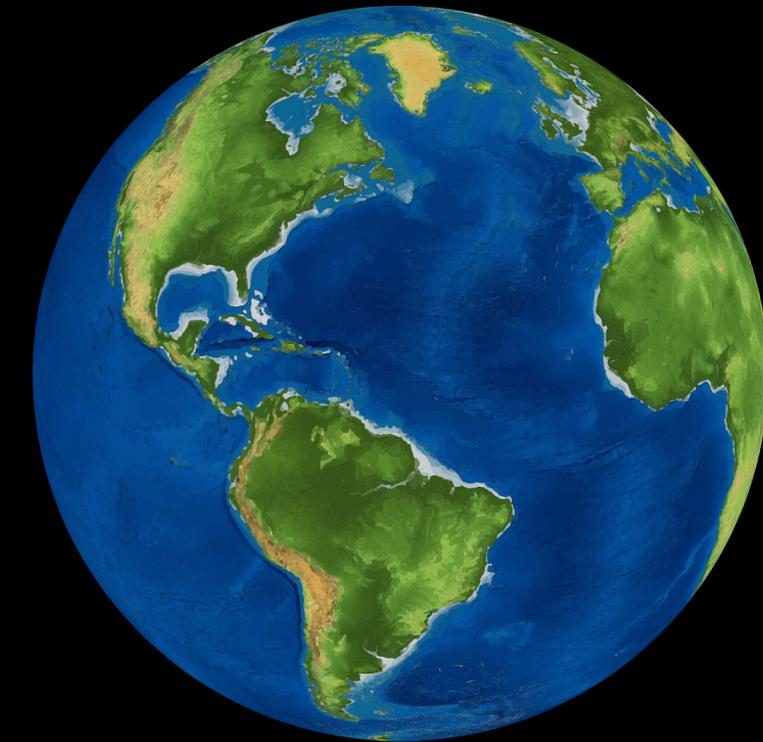
G.D. Farquhar<sup>1</sup>, S. von Caemmerer<sup>1</sup>, and J.A. Berry<sup>2</sup>

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

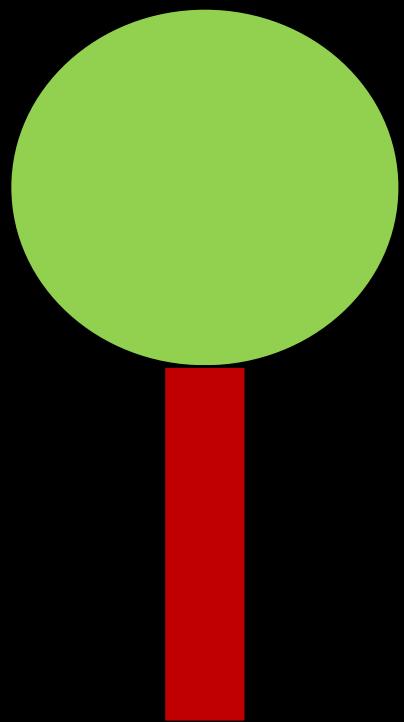
<sup>2</sup> Carnegie Institution of Washington, Department of Plant Biology, Stanford, Cal. 94305, USA



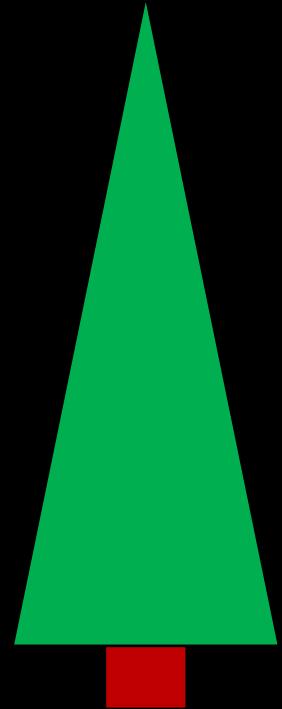
90's to 2000's: spinach world!



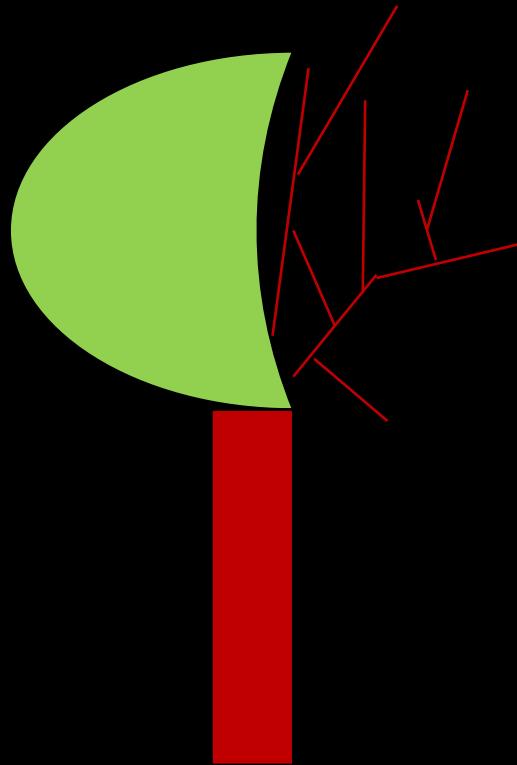
2000's: 5 – 10 plant “types”



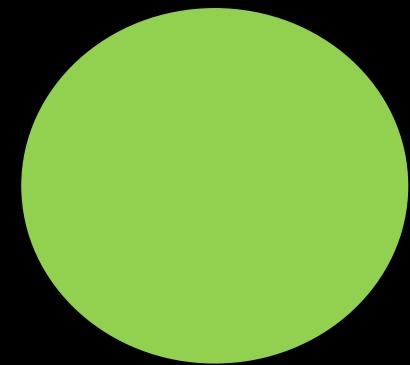
Broadleaf tree



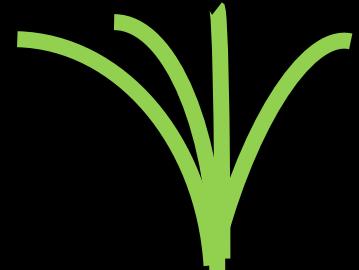
Needleleaf tree



Deciduous tree



Shrub



Grass

# 2010's: "Smart" plants

With time, plants will acclimate to environmental perturbations, such as elevated temperature and CO<sub>2</sub>.



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<sub>2</sub>**

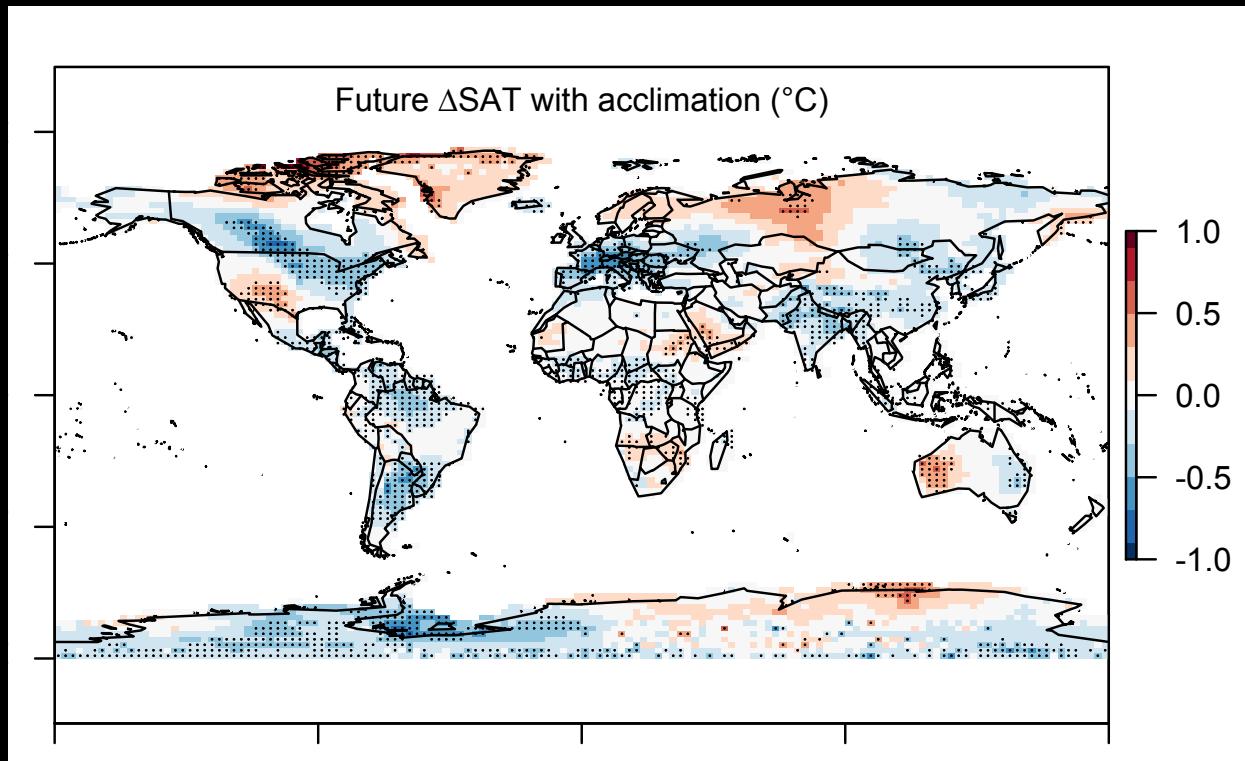
NICHOLAS G SMITH\* and JEFFREY S DUKES\*†

# Why do Biologists care?

1. There is a lot of Biology in ESMs
  - And that Biology matters!
2. There is a lot of Biology missing from ESMs
  - ...which may or may not matter

# 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

Key Points:

- We assessed the biophysical influence of photosynthetic

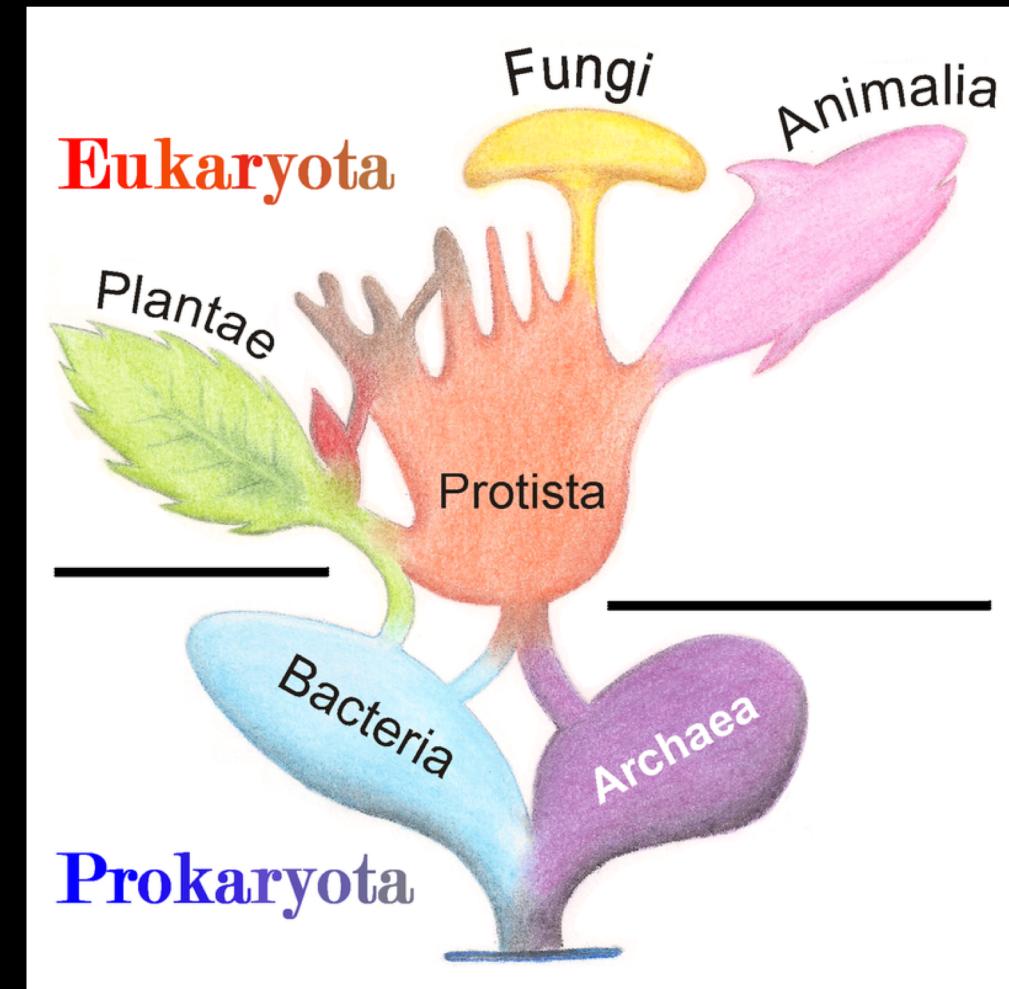
Nicholas G. Smith<sup>1,2,3,4</sup> , Danica Lombardozzi<sup>5</sup>, Ahmed Tawfik<sup>3</sup> , Gordon Bonan<sup>5</sup>, and Jeffrey S. Dukes<sup>1,2,3</sup>

# Biology in ESMs

- Plant “types”
  - Photosynthesis, respiration, transpiration, nutrient cycling
- “Living” soils
  - Respiration, nutrient cycling
- Humans
  - Not really doing any biology directly; mostly just burning fossil fuels and changing land use

# Biology missing from ESMs

- Individual species
- Animals, bacteria, fungi
- Reproduction



Which leads to...

Models should this important  
process that I measured!



**Nina Buchmann** @NinaBuchmann1 · 9 Jul 2018

so the conclusions are: CO<sub>2</sub> fertilization is in reality small because respiration but also water and nutrient limitations kick in. This calls for more biogeochemical interactions to be considered in models to get plant responses right. And emergent properties within ecosystems !!

**Nick Smith** @nick\_greg\_smith

Nice review by @MirindiDusenge out in @NewPhyt : "Plant carbon metabolism and climate change: elevated CO<sub>2</sub> and temperature impacts on photosynthesis, photorespiration and respiration" #toReadPile  
[nph.onlinelibrary.wiley.com/doi/full/10.1111/nph.14811](http://nph.onlinelibrary.wiley.com/doi/full/10.1111/nph.14811)...



1



3



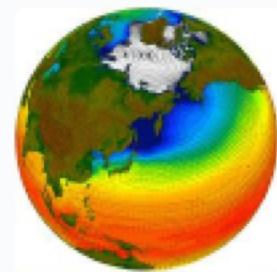
I'm convinced, what do I need to  
know to get my Biology in an  
ESM?



Search or jump to...



Pull requests Issues Marketplace Explore



# Earth System Community Modeling Portal

<https://escomp.github.io/>

**Repositories** 21

**People** 2

**Projects** 0

## Pinned repositories



**cesm**  
The Community Earth System Model

● Python

★ 59

ψ 40



**ctsm**  
Community Terrestrial Systems Model (includes  
the Community Land Model of CESM)

● Fortran

★ 82

ψ 77

<https://github.com/ESCOMP>

A word of caution  
(alternatively: why biologists BUG  
climate modelers)



**Nick Smith**  
@nick\_greg\_smith

Replying to [@NinaBuchmann1](#)

Well I think we need to be careful about adding in interactions for uncertain processes into our predictive models. Even many leaf processes (e.g. acclimation) rely on uncertain statistical parameters b/c of poor mechanistic understanding. Larger scale processes are likely worse!

12:25 PM - 9 Jul 2018

CESM > 1.5 million lines of code