

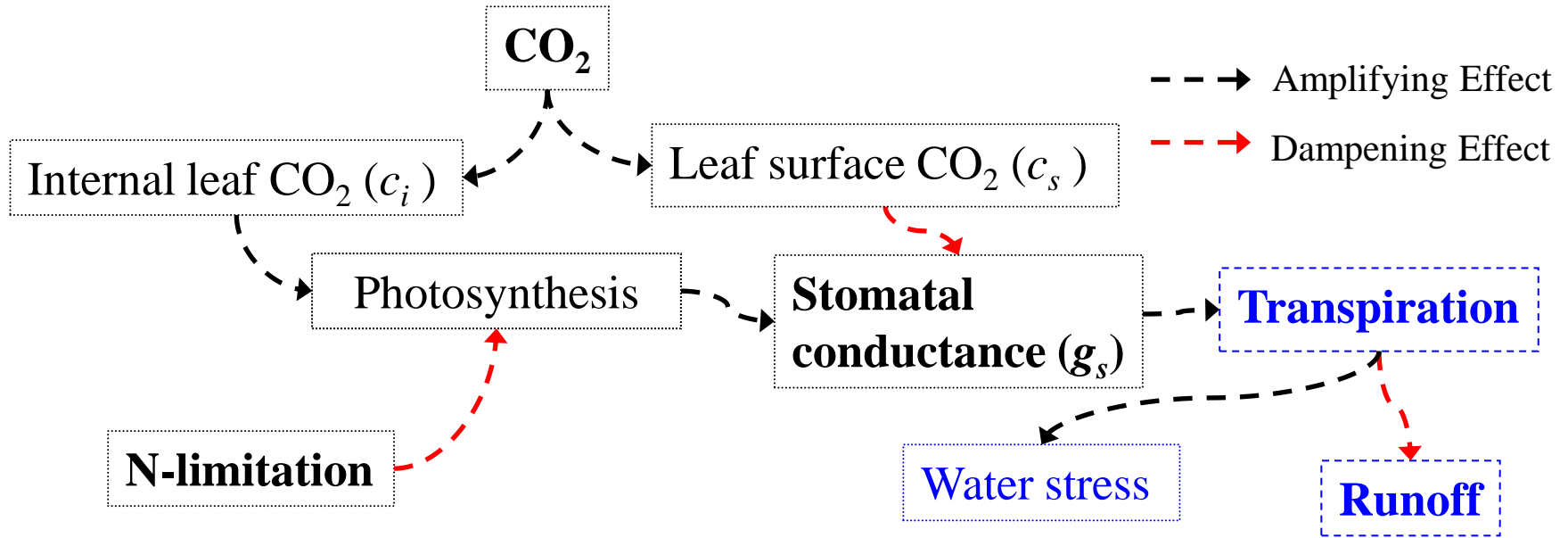


Effects of nitrogen limitation on hydrological processes in CLM4-CN

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Carbon-Nitrogen-Water coupling through leaf's stomata



Ball-Berry Model

(Ball et al., 1987)

$$g_s = k \frac{A h_s}{c_s}$$

g_s : Stomatal conductance

k : Slope constant of the model

A : CO₂ assimilation rate

h_s : Relative humidity

c_s : CO₂ concentration at the leaf surface

GPP: Gross Primary Productivity

- We examine the effects of CO₂ and nitrogen limitation on carbon-nitrogen-water coupling in leaf's stomata and thereby hydrological processes using the Community Land Model with coupled Carbon and Nitrogen cycles (CLM4-CN).

Experimental designs

CESM 1.0.1 CLM 4.0 with coupled carbon and nitrogen (CN):
Stand-alone CLM with Qian atmospheric input data for 1948-1972
and transient CN, aerosol deposition from 1850-2000
and 2000 CO₂ level (*I_1850-2000_CN*)

Initial model experiments *I_1850_CN* (700-yr equilibrium run)

Pre-industrial stand-alone CLM-CN using a reference case

Three sensitivity experiments (151-yr transient runs: 1850-2000)

1. Control (*I8520CN*)
2. Nitrogen limitation (*I8520CN-downregulation*)
3. Constant CO₂ (*I8520CN-constant*)

Approach: downregulation experiment

The stomatal resistance is not linked to the down-regulated GPP by nitrogen limitation.

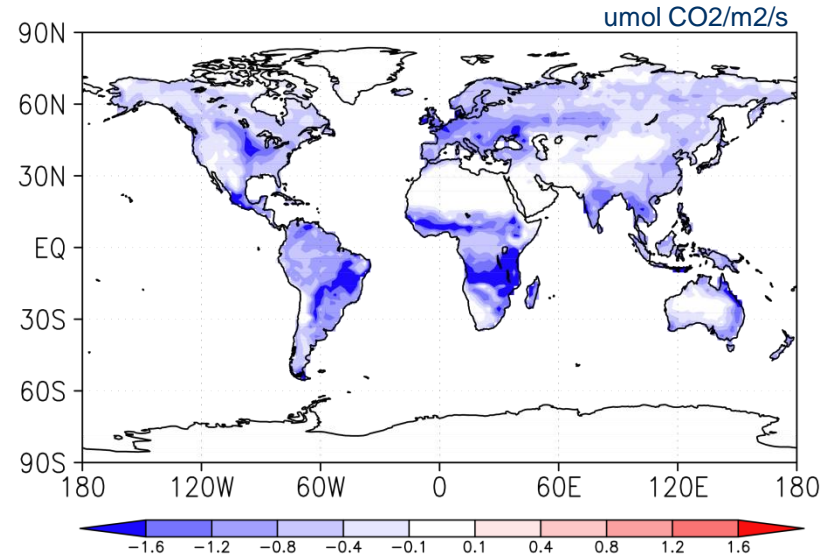
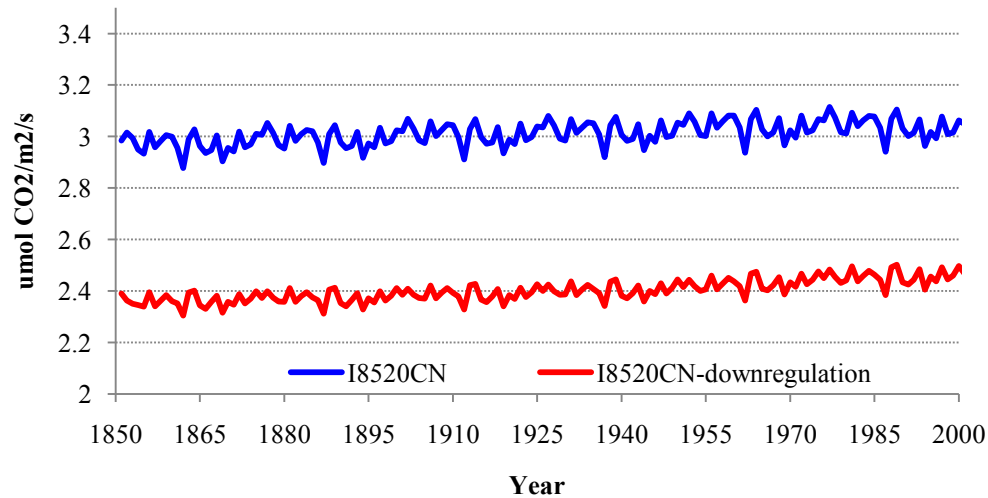
- Total gross photosynthesis (GPP) in CNAllocationMod is coming from CanopyFluxesMod, then it's scaled by nitrogen limitation.
 - The photosynthesis used to control stomatal conductance in current CLM4-CN is not affected by nitrogen limitation.
- We scale “foliage photosynthesis (*psn*)” in stomata subroutine by “fractional reduction in GPP due to nitrogen limitation (*downreg*)” in CNAllocation module from the previous time step.

Nitrogen limitation effects: photosynthesis

Globally averaged annual mean

Downregulation – Control

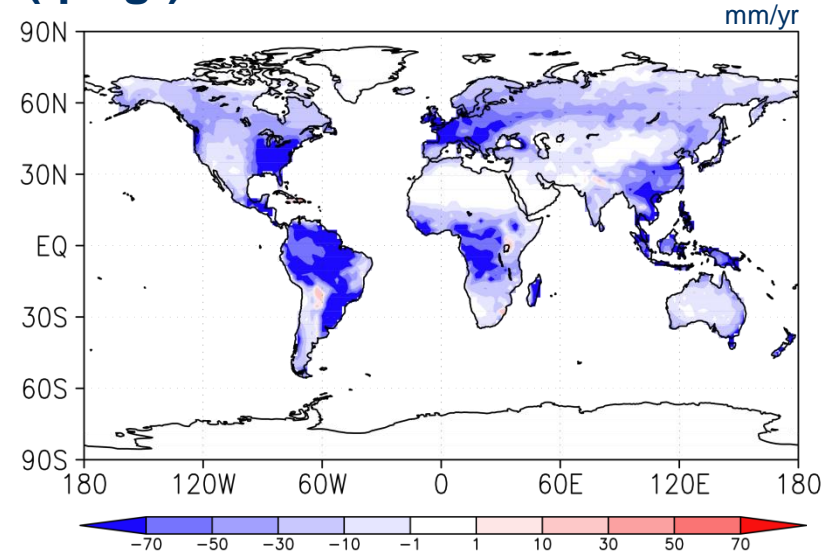
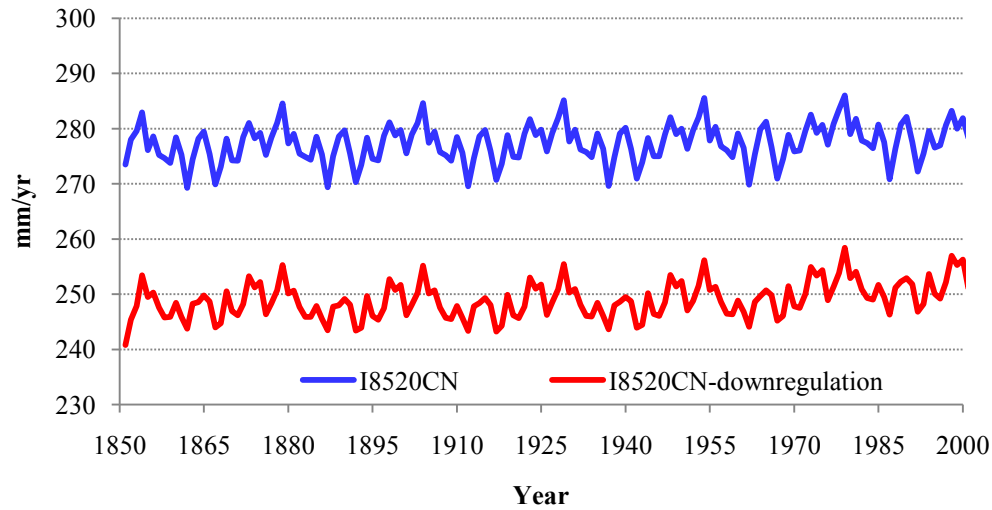
Leaf photosynthesis (psnsun+psnsha)



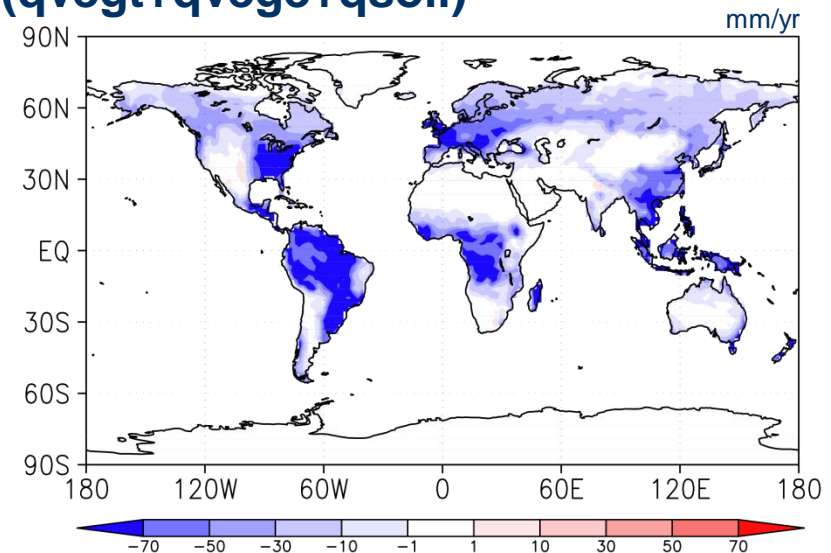
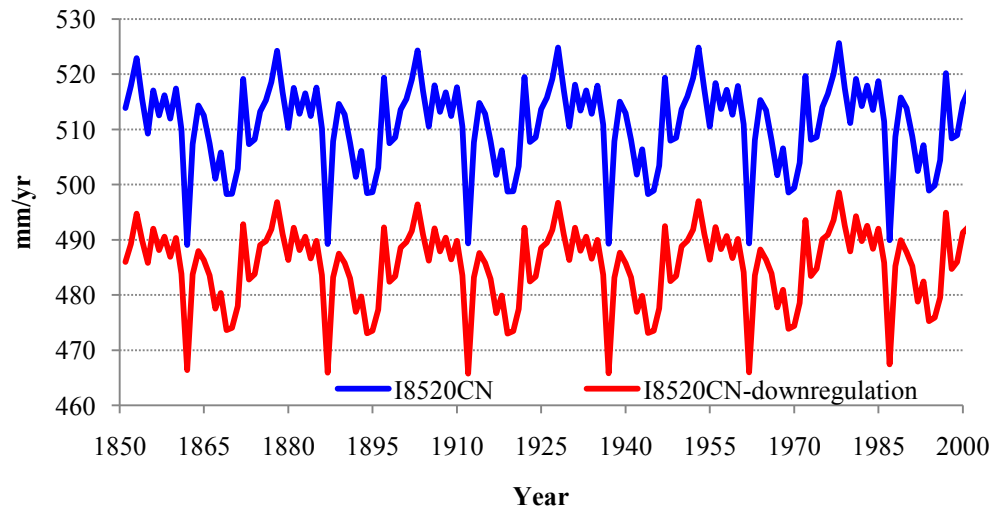
Photosynthesis used in Ball-Berry is lower in the downregulation run.

Nitrogen limitation effects: transpiration and total ET

Canopy transpiration (qvegt)

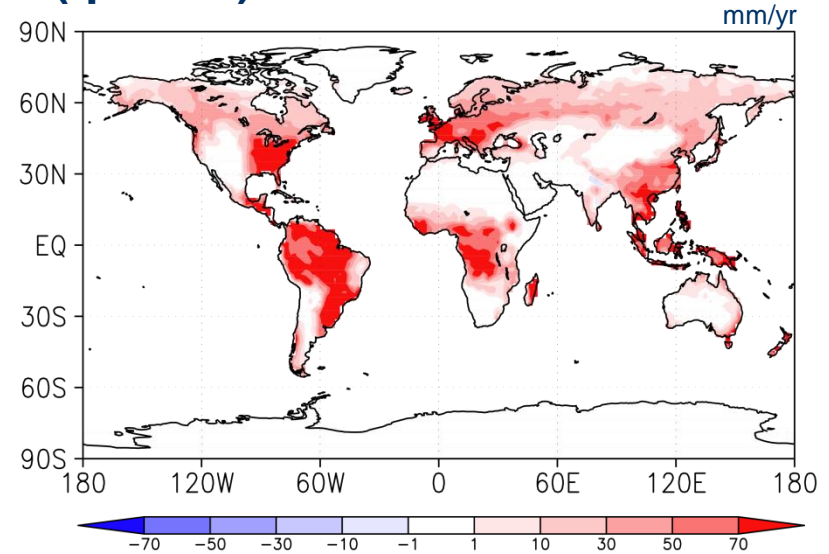
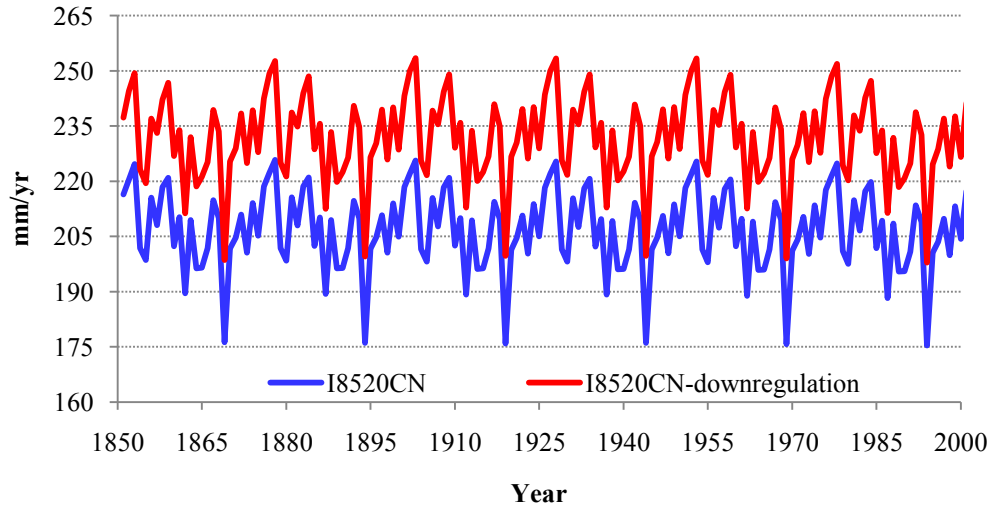


Total evapotranspiration (qvegt+qvege+qsoil)

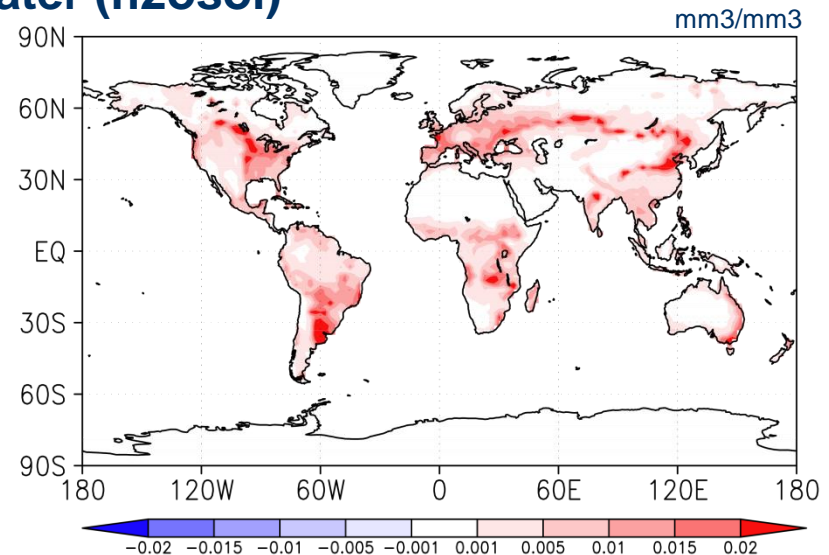
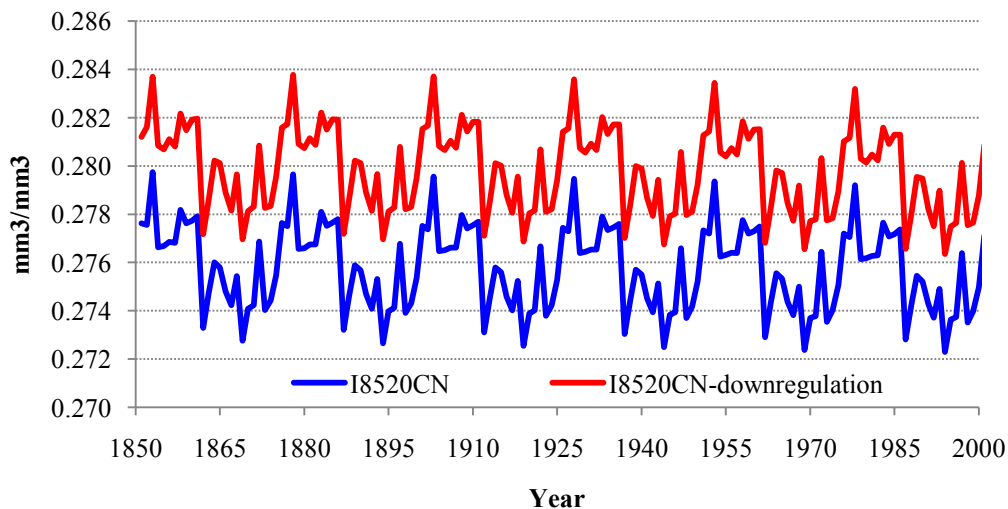


Nitrogen limitation effects: runoff and soil water

Total liquid runoff (qrunoff)

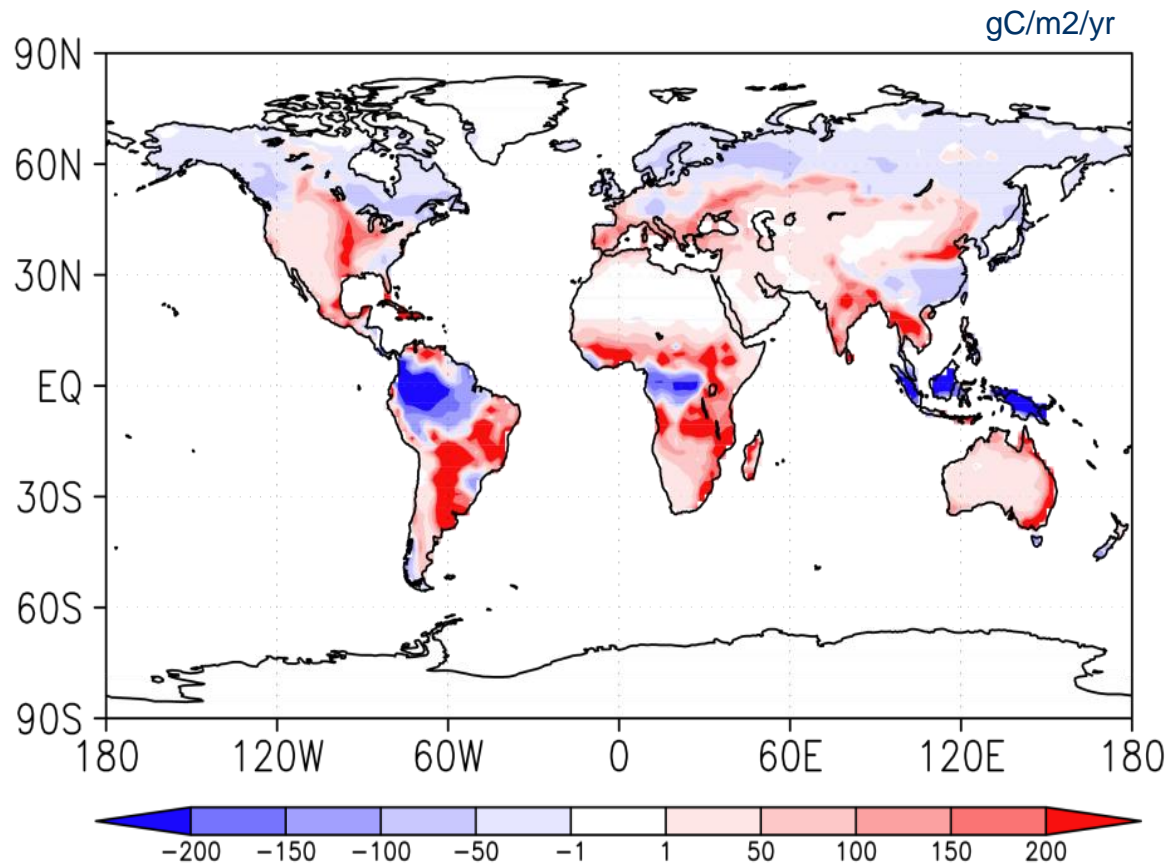


Volumetric soil water (h2soi)



Nitrogen limitation effects: GPP

Downregulation – Control



Conclusions

- Nitrogen limitation in stomata affects hydrological processes through changes in photosynthesis.

Decreasing canopy transpiration and total evapotranspiration

Increasing runoff and soil water

- Decreasing ET and increasing runoff due to nitrogen limitation might improve simulating ET and runoff, which are too high (ET) and too low (runoff) in current CLM4-CN (Lawrence et al., 2011).

Next steps...

- Running stand-alone CLM with “transient historical CO₂ concentration”
- Constant CO₂ experiments one for internal CO₂ (c_i) and another for leaf surface CO₂ (c_s): positive and negative feedback in carbon and water coupling
- Statistical significance test for the differences
- **Evaluating model outputs with observations**
Gridded dataset (EC-MOD data; Xiao et al., 2011) from eddy flux and MODIS data
Site-level data from flux tower measurements
- Is there an improvement in simulating diurnal and seasonal cycles of GPP?



Questions and comments

Thank you!