# Effects of elevated $CO_2$ and nitrogen limitation on stomatal conductance in CLM-CN (Preliminary experiments)

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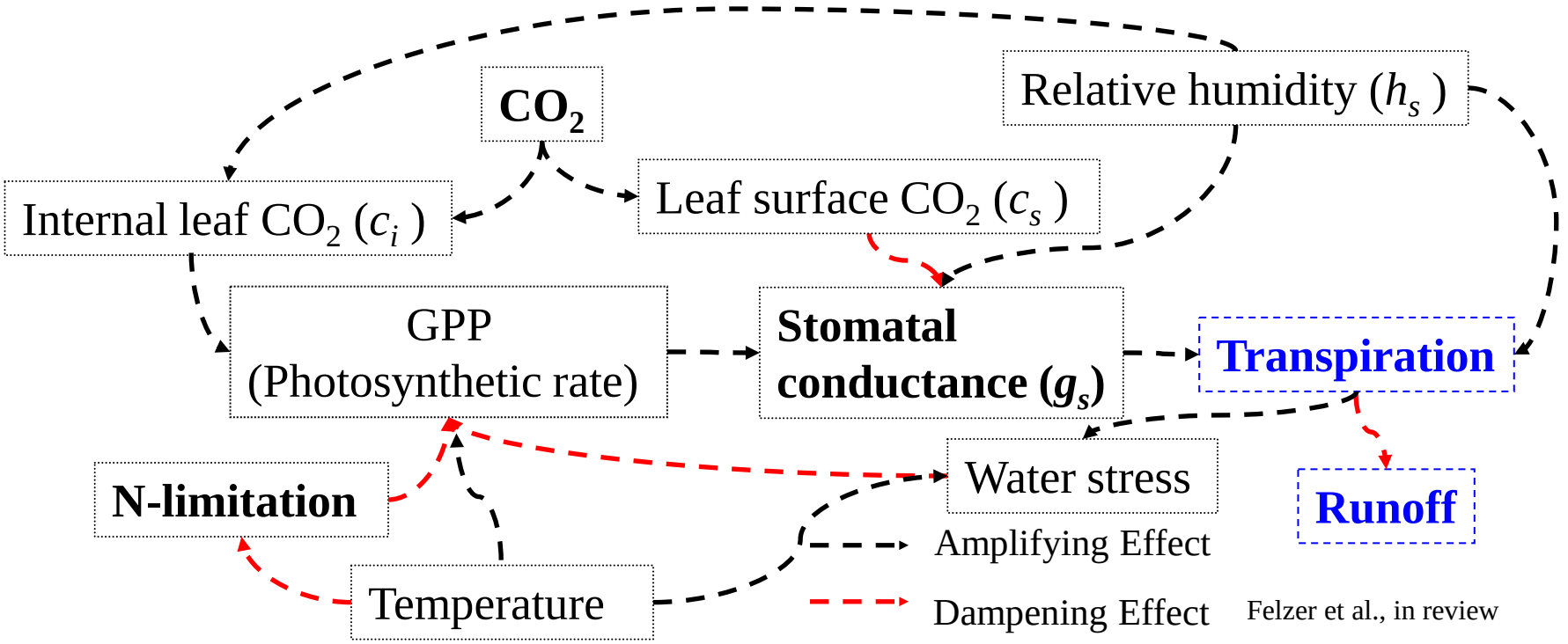
# Carbon-Nitrogen-Water coupling through leaf's stomata




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 $A$ : $CO_2$ assimilation rate

$h_s$ : Relative humidity $c_s$ : $CO_2$ concentration at the leaf surface

*GPP*: Gross Primary Productivity

# In current CLM-CN

- Stomatal resistance from Ball-Berry model
  : Stomata subroutine within CanopyFluxesMod in biogeophys
- Nitrogen limitation from carbon and nitrogen allocation
  : CNAllocationMod in biogeochem

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

- In CNAllocationMod, total gross photosynthesis (GPP) is coming from CanopyFluxesMod, then it's scaled by nitrogen limitation.

✓ The photosynthesis used to control stomatal conductance in CLM-CN is not affected by the GPP downregulated by nitrogen limitation.

# Modifications of CLM-CN model (in progress)

We are incorporating “CNAllocationMod” into “Stomata subroutine” within CanopyFluxesMod.

1. Calculate photosynthesis
2. GPP before downregulation
3. Nitrogen demand, availability, and limitation
4. Downregulate GPP due to nitrogen limitation
5. Update photosynthesis using the downregulated GPP
6. Stomatal resistance
7. Transpiration and runoff

# Experimental design: Initial conditions

- CESM CAM-CLM CN: “Compset E” includes CLM-CN with the prognostic atmosphere and sea ice, but slab ocean model under future Representative Concentration Pathway scenarios.

- **Initial model experiments**

1. E1850CN (30-yr equilibrium run)
   : Pre-industrial fully active ice and som ocean, with CN
2. E20TRCN: 1850-2005 transient run starting with a reference from 1
3. E2005CN: 30-yr equilibrium run starting from 2

➢ **Control run**
E21RCPCN: 2005-2100 transient run starting from 3 with RCPs

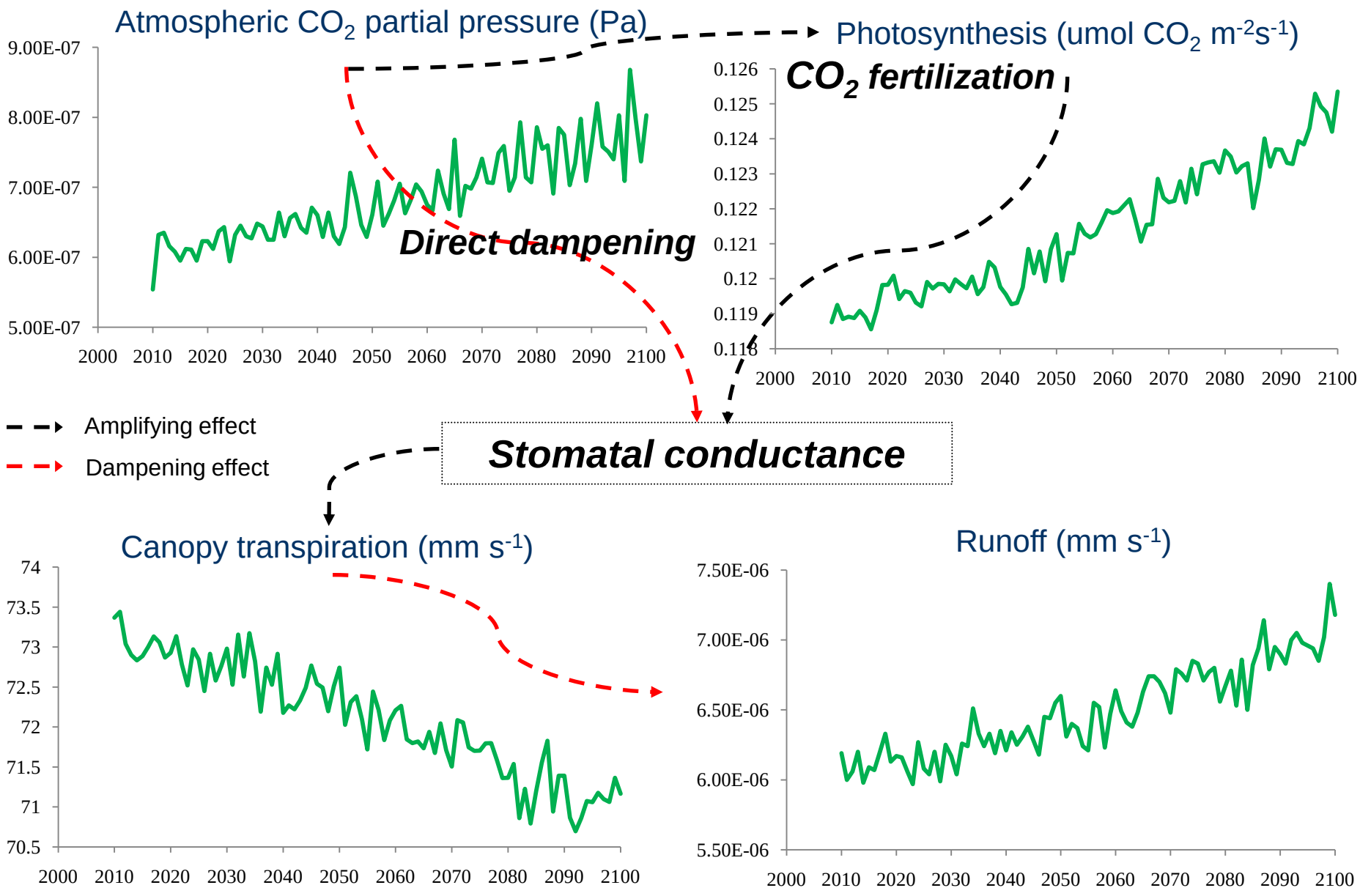
RCP scenarios- New scenarios for the next IPCC and beyond (Moss et al. 2010)
: RCP 8.5- close to the radiative forcing from SRES A1F1 (higher than SRES A2)
RCP 4.5- very close to SRES B1
(personal communication with Jerry Meehl)

# Experimental design

| | Elevated $CO_2$ → Stomata | Nitrogen limitation on GPP in Stomata |
|---|---|---|
| Control run (E21RCPCN) | Yes | No |

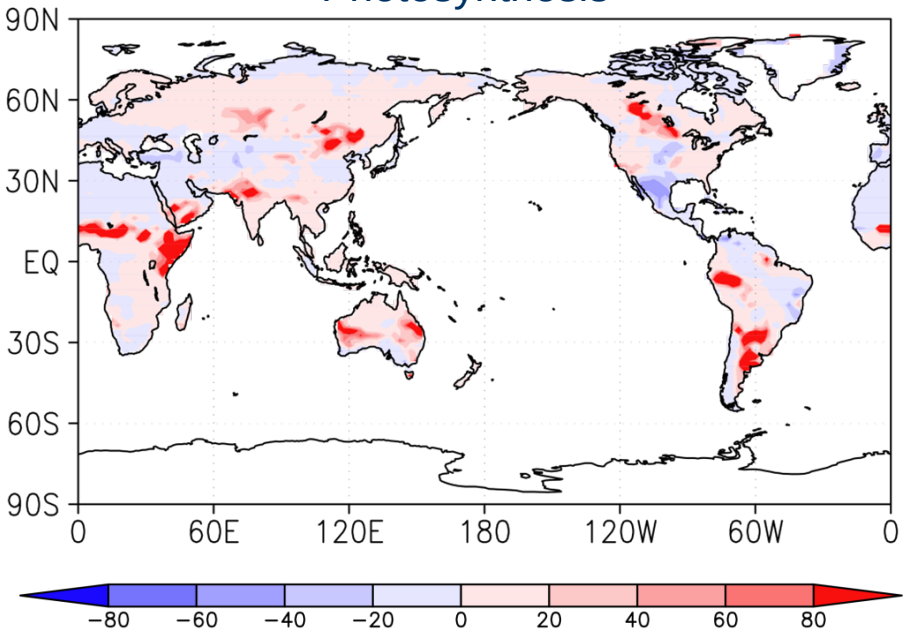
- All model runs will be performed using both RCP 8.5 and 4.5 scenarios.

# **Preliminary results:** Elevated $CO_2$ effects during 21th century (RCP8.5)

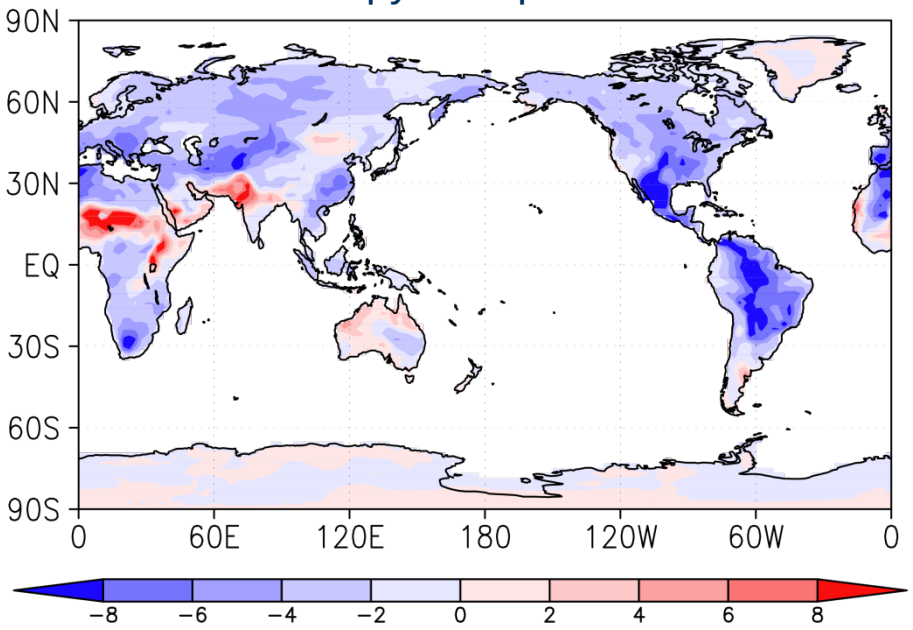


# **Preliminary results:** Elevated $CO_2$ effects during 21th century (RCP8.5)

Photosynthesis




Canopy transpiration




Differences between late (2071-2100 mean) and early (2010-2039 mean) 21th century (%)

# Expected results

Effects of elevated $CO_2$ and N-limitation on stomatal conductance and the resulting evapotranspiration and runoff

- Biogeochemical and biogeophysical feedbacks

# Questions and comments


**Thank you !**

# Why are carbon-nitrogen interactions in stomata important?

Vitousek and Howarth (1991); Thornton et al. (2007 and 2009); Sokolov et al. (2008); Felzer et al. (2009 and in review)

- Nitrogen limitation reduces GPP increase due to elevated $CO_2$, so $CO_2$ fertilization not as strong.

- Nitrogen dynamics is more sensitive to warming, as warming leads to increased net nitrogen mineralization and therefore increases GPP.

# Preliminary results: Difference between constant CO2 and control runs

## Model evaluation

To examine if the model outputs from the modified CLM-CN version can improve the reproduction of the observed conditions
e.g. runoff from Global Soil Wetness Project 2 (GSWP-2)