Focus on Nature-based Solutions Toward Sustainability

Environmental Research Letters
Deadline: March 31st, 2024

Guest Editors

Xu Yue, *Nanjing University of Information Science and Technology, China*
Ge Sun, *USDA Forest Service, USA*
Mariska te Beest, *Utrecht University, Netherlands*
Jun Zhang, *Netherlands Organization for Applied Scientific Research, Netherlands*
Maricar Aguilos, *North Carolina State University, USA*
Xianglan Li, *Beijing Normal University, China*
Jintai Lin, *Peking University, China*

- Responses of diverse ecosystems to the climate, environment, and societal changes.
- The role of NbS in enhancing land carbon sink strength and improving water quality and quantity, and other ecosystem services.
- State of art in integrating cross-site and long-term measurements and modeling of ecosystem fluxes.
- Advances in big data fusion, modeling, and integration technology through ESM and machine learnings.
- The economical and societal benefits of NbS in context of ecosystem functions and dynamics.
- Mechanistic understanding of coupling human and nature systems through the lens of climate, environment, and ecosystem interactions.

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- 9 articles published
- 5 articles accepted
- 7 revised articles in peer review
- 8 original articles in peer review
- 5 articles rejected (following peer review)
- **11 articles agreed for submission – delayed**

20-25 papers are expected to be published in ERL focus issue

Most papers are contributed by USCCC members and their students

第20届中美碳联盟年会

20th Annual Conference for USCCC

南京信息工程大学

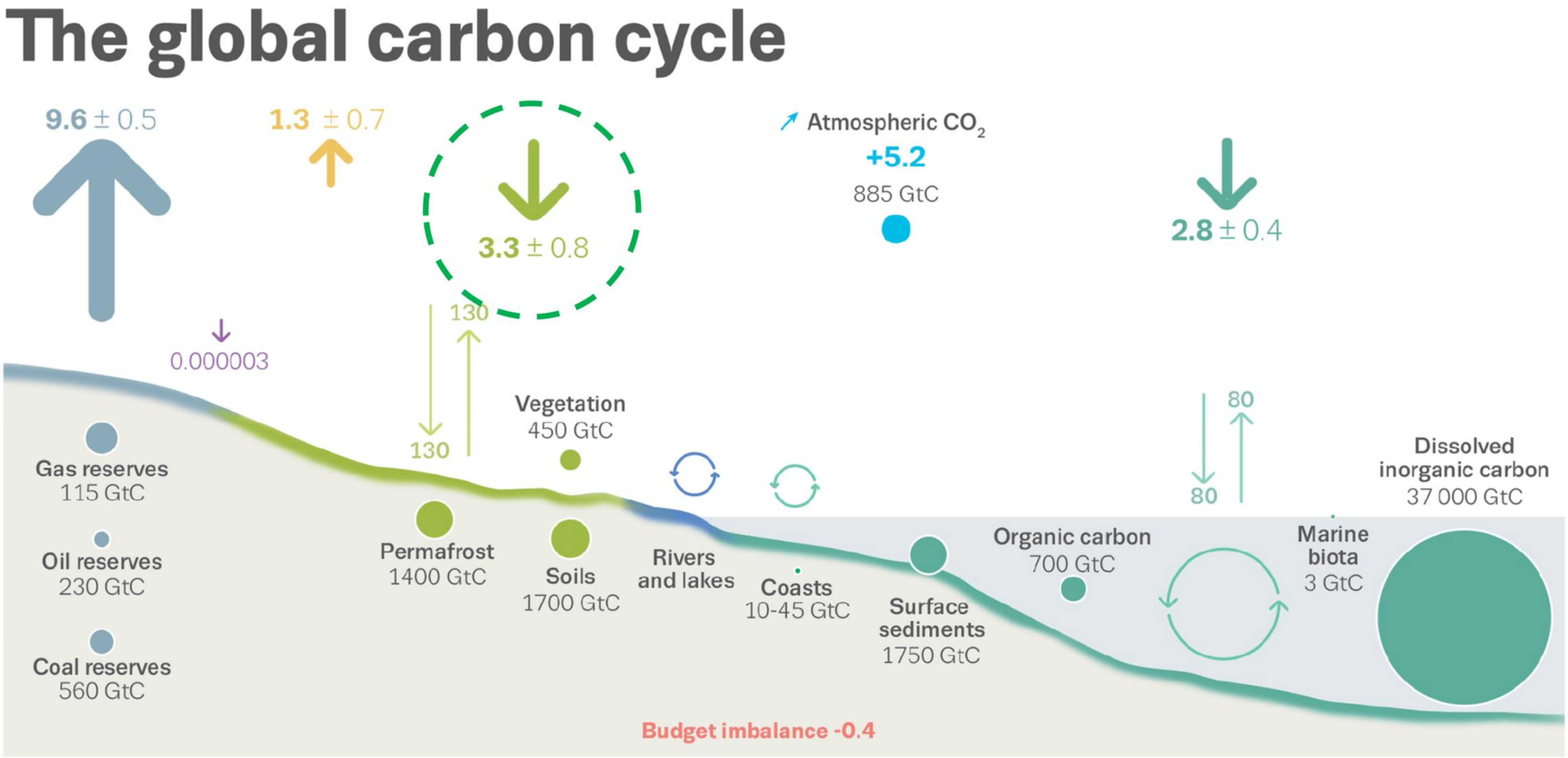
Nanjing University of Information Science & Technology

Large potential of strengthening the land carbon sink in China through anthropogenic interventions

Xu Yue（乐旭）

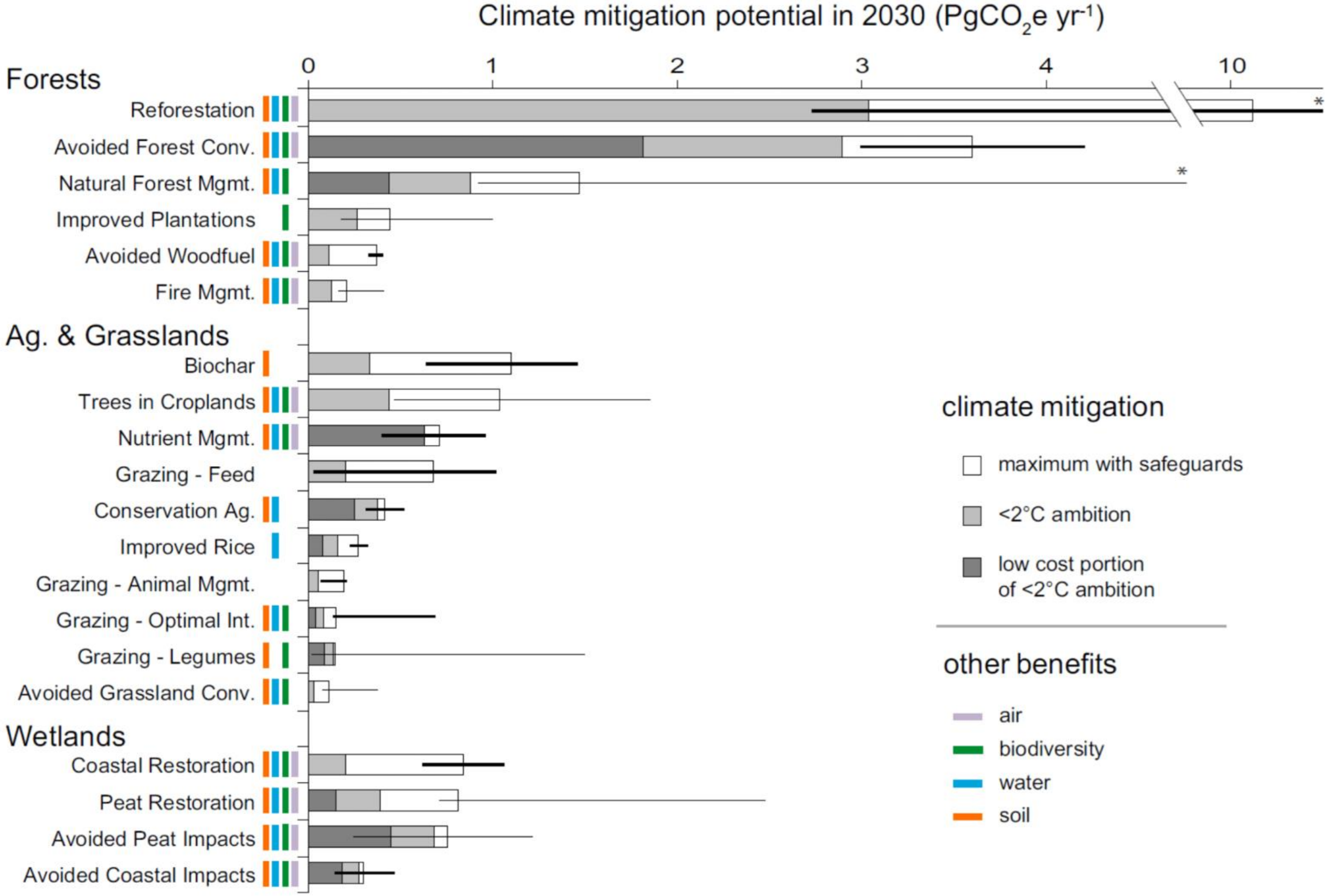
July 17th, Xining

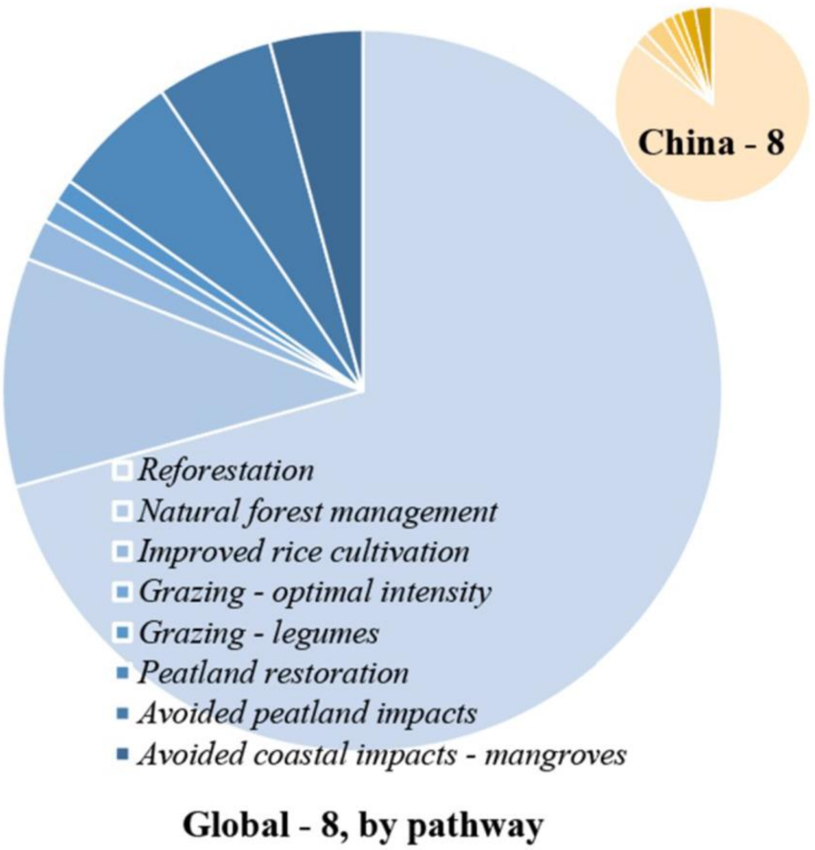
Ecosystem is the largest land carbon sink



Friedlingstein et al. (2023)

Reforestation has the largest potential of increasing C sink



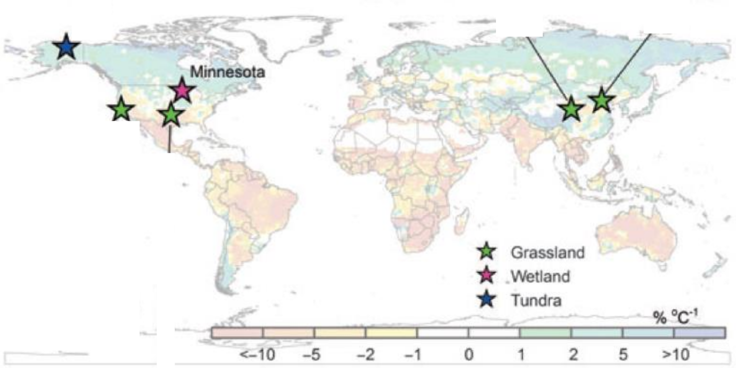


Griscom et al. (2017)

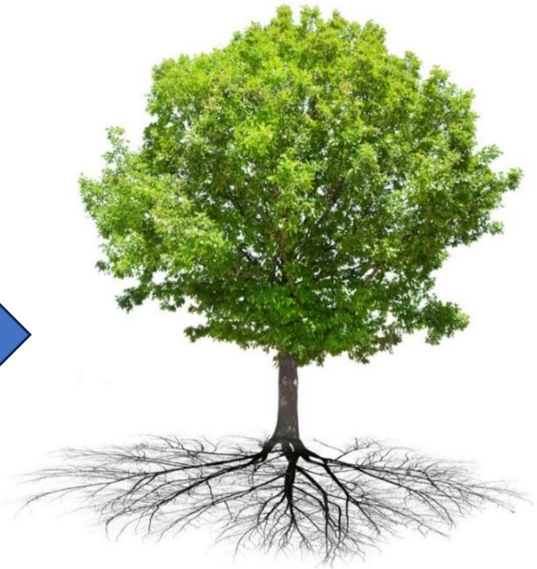
Qin et al. (2021)

Land carbon uptake is constrained by environment and climate

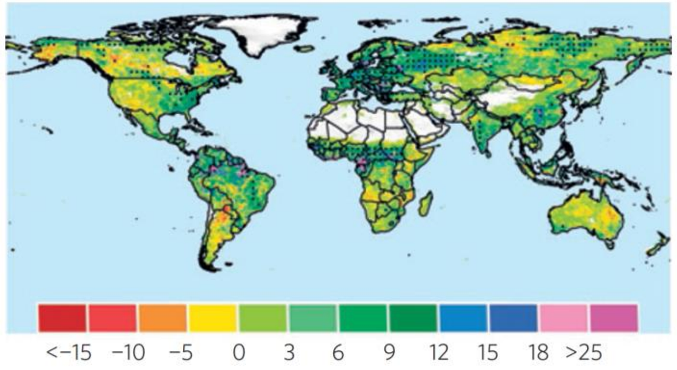
Nonlinear response to Tair



(Piao et al. *GCB*, 2013)

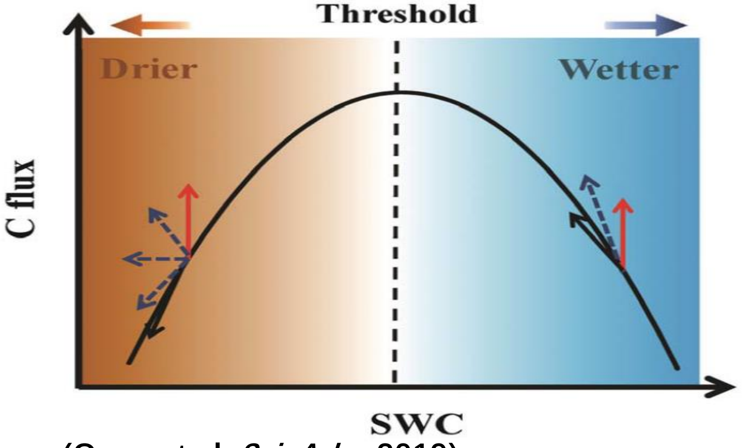


CO_2 fertilization



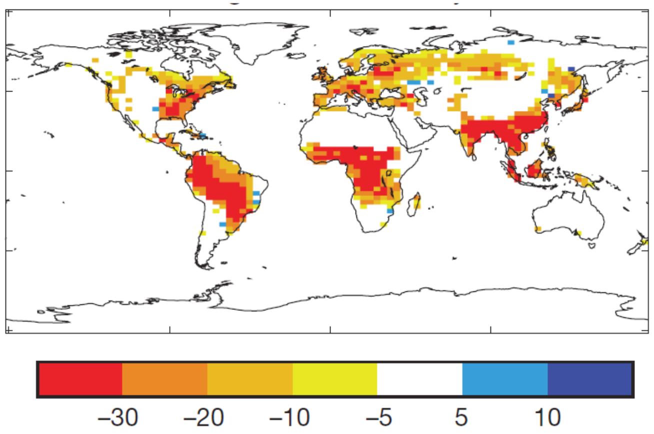
(Zhu et al. *Nat. Clim. Change* 2016)

Nonlinear response to Wsoil



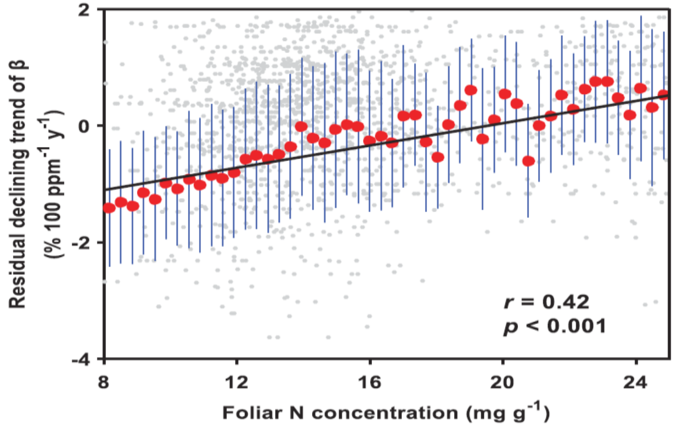
(Quan et al. *Sci. Adv.*, 2019)

Ozone deposition



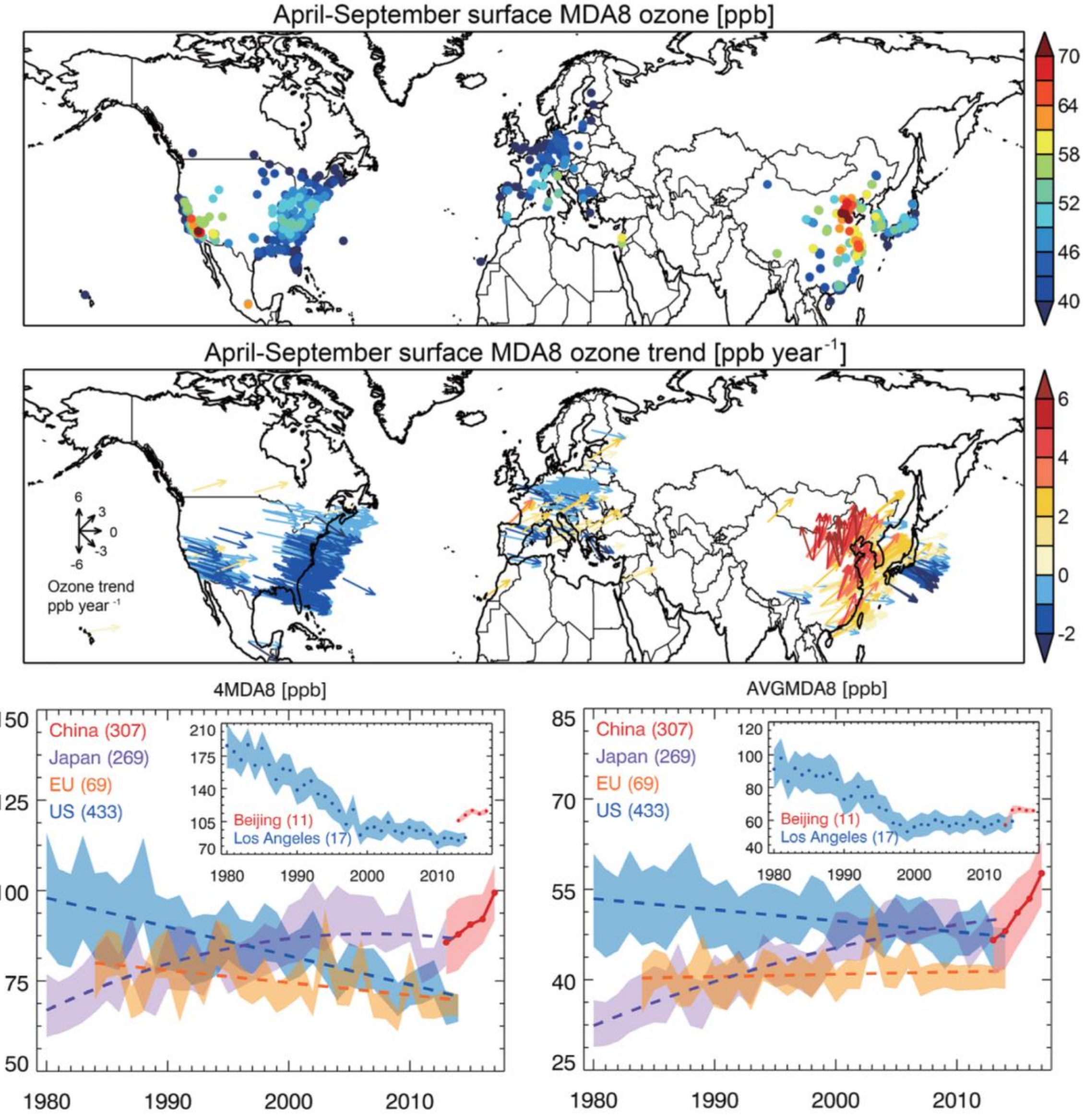
(Sitch et al. *Nature*, 2007)

Nitrogen deposition



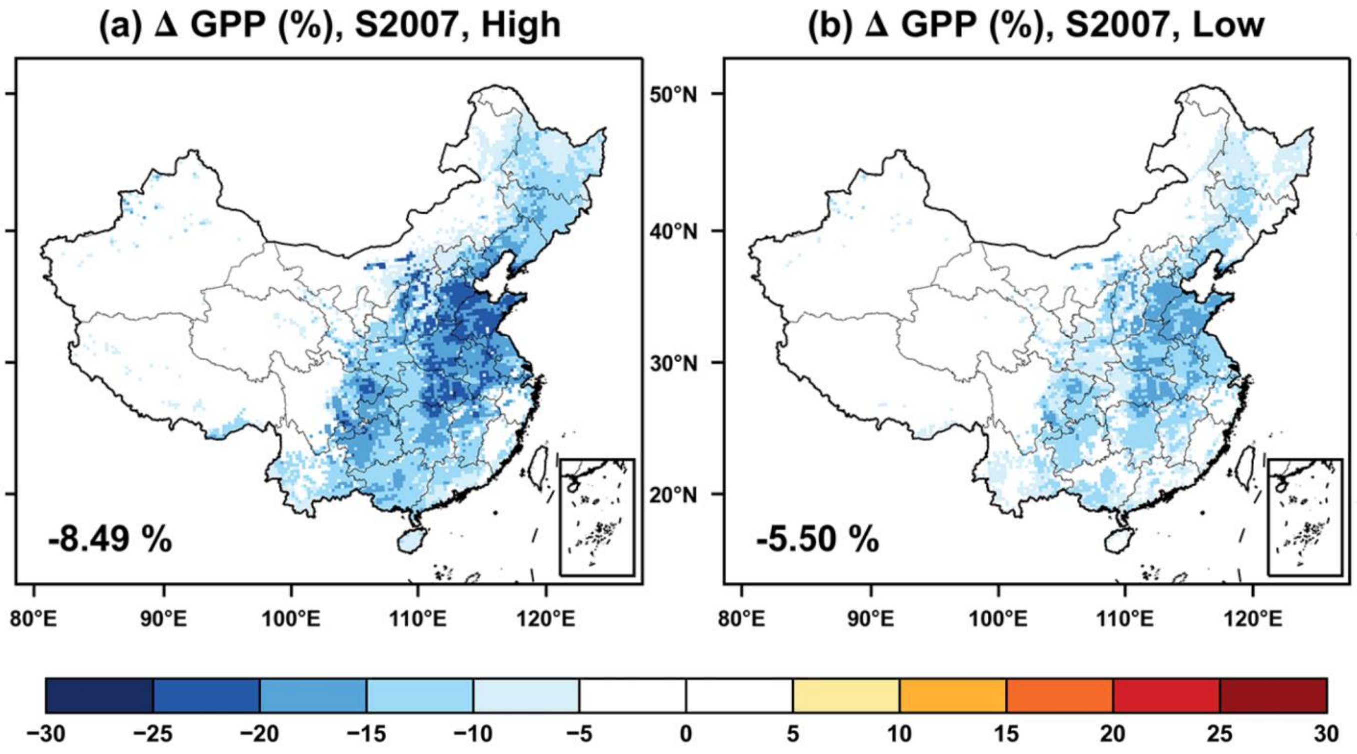
(Wang et al. *Science*, 2020)

High ozone dampens carbon sink in China



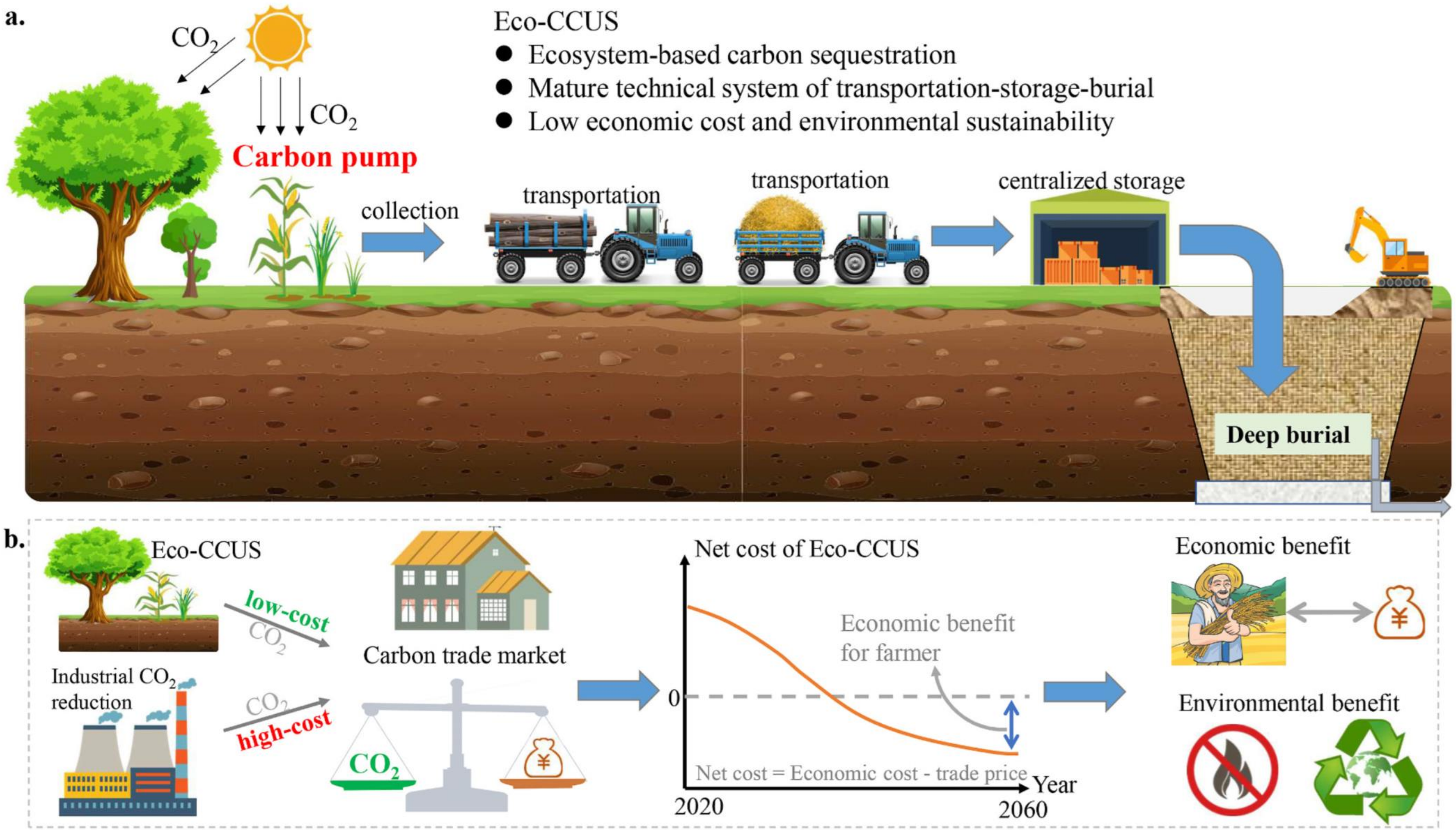
(Lu et al. 2018, 2020)

- ❑ **Ozone pollution is rising in China**
- ❑ **Ozone damages plant photosynthesis, reducing ecosystem productivity and crop yield**



(Cao et al. 2024)

Litter removal helps promote land carbon sink

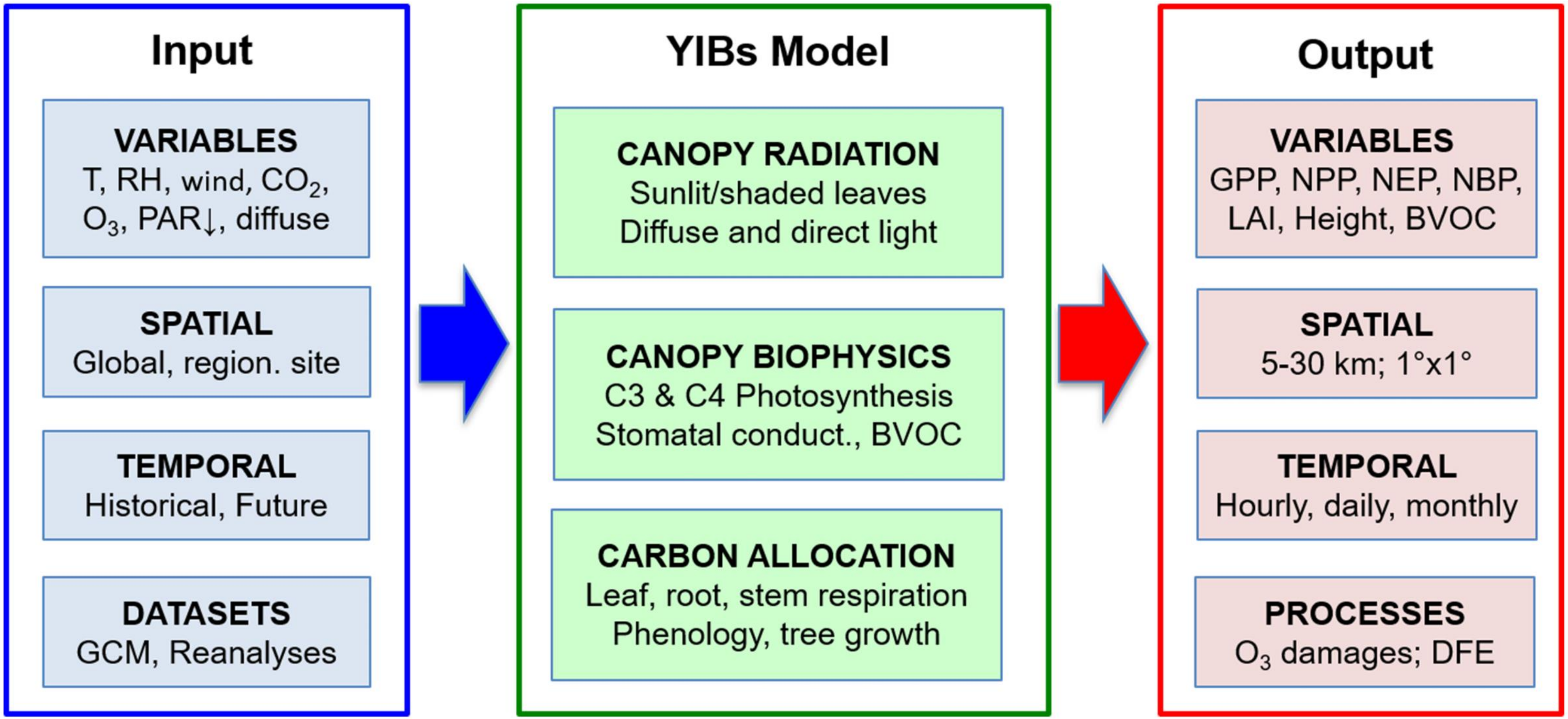


Li et al. (2023)

Questions

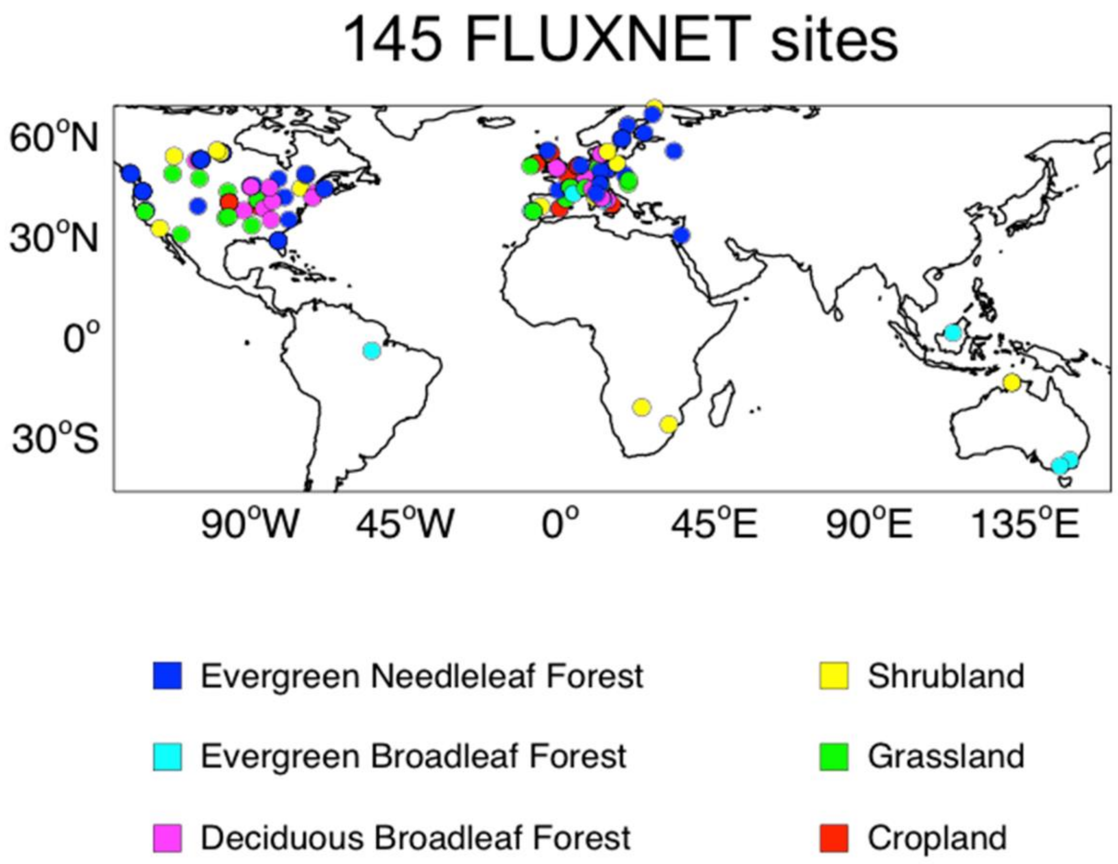
- **How the carbon sink in China responds to the future changes in climate and environment?**
- **To what extent will carbon sink increases with anthropogenic interventions? (Reforestation, O_3 control, litter removal)**

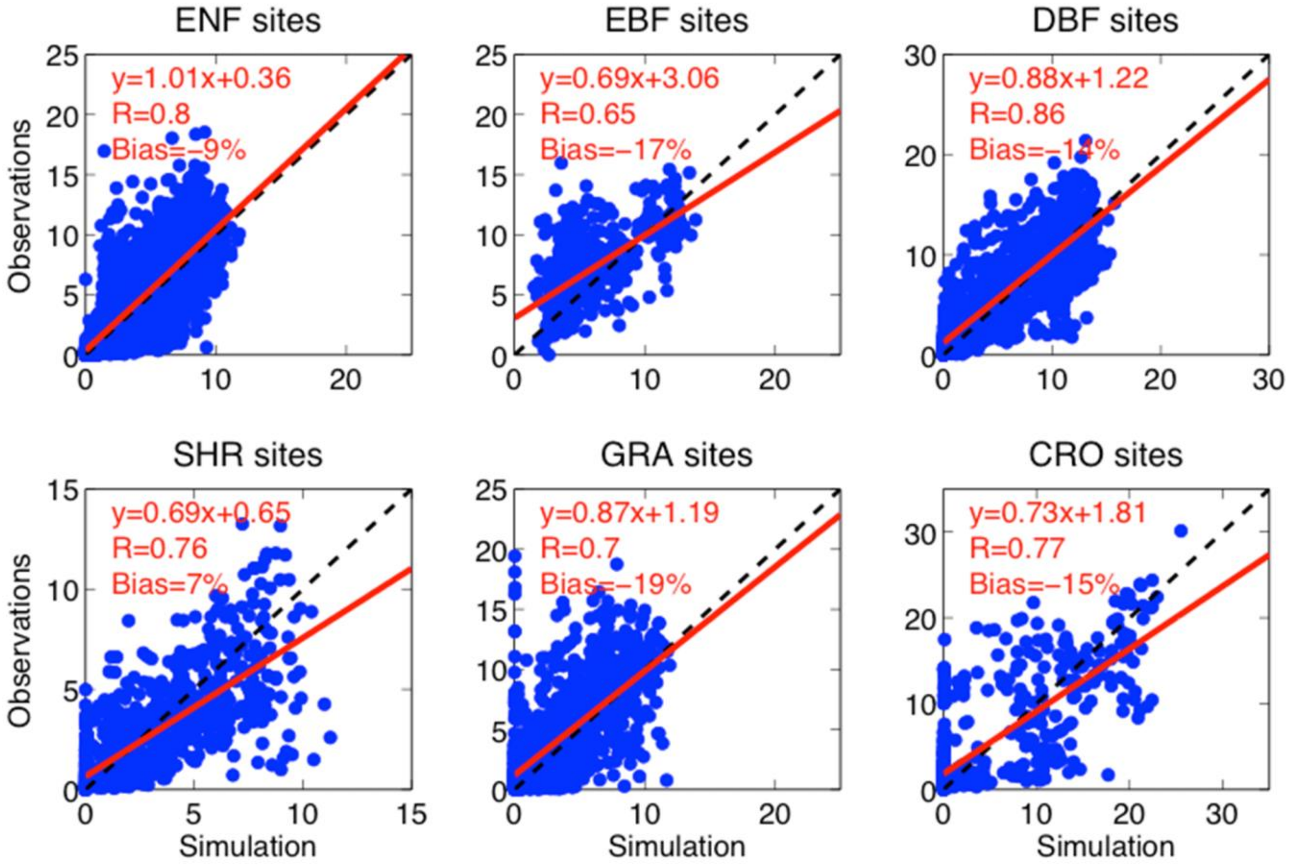
Yale Interactive terrestrial Biosphere Model (YIBs)



(Yue and Unger, 2014; 2015; Yue et al., 2015a, 2015b, 2017a, 2017b, 2020, 2021)

YIBs model evaluations

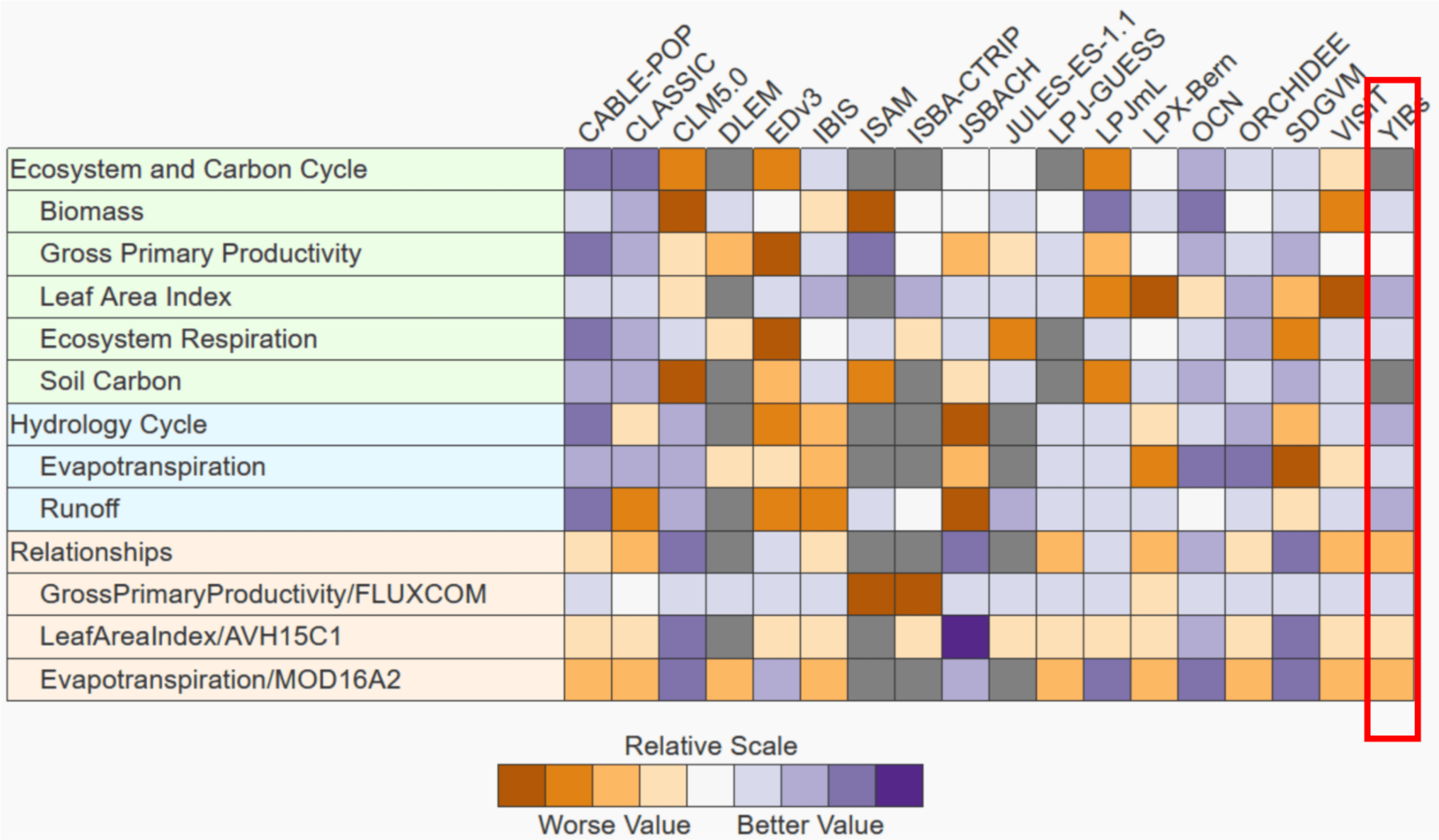




☐ **The model shows good performance at individual sites**

(Yue and Unger, 2015)

YIBs model evaluations



□ **The model shows good performance in global carbon and water fluxes**

(Friedlingstein, et al., 2023)

Ozone vegetation damage in model

Sitch et al. (2007) scheme

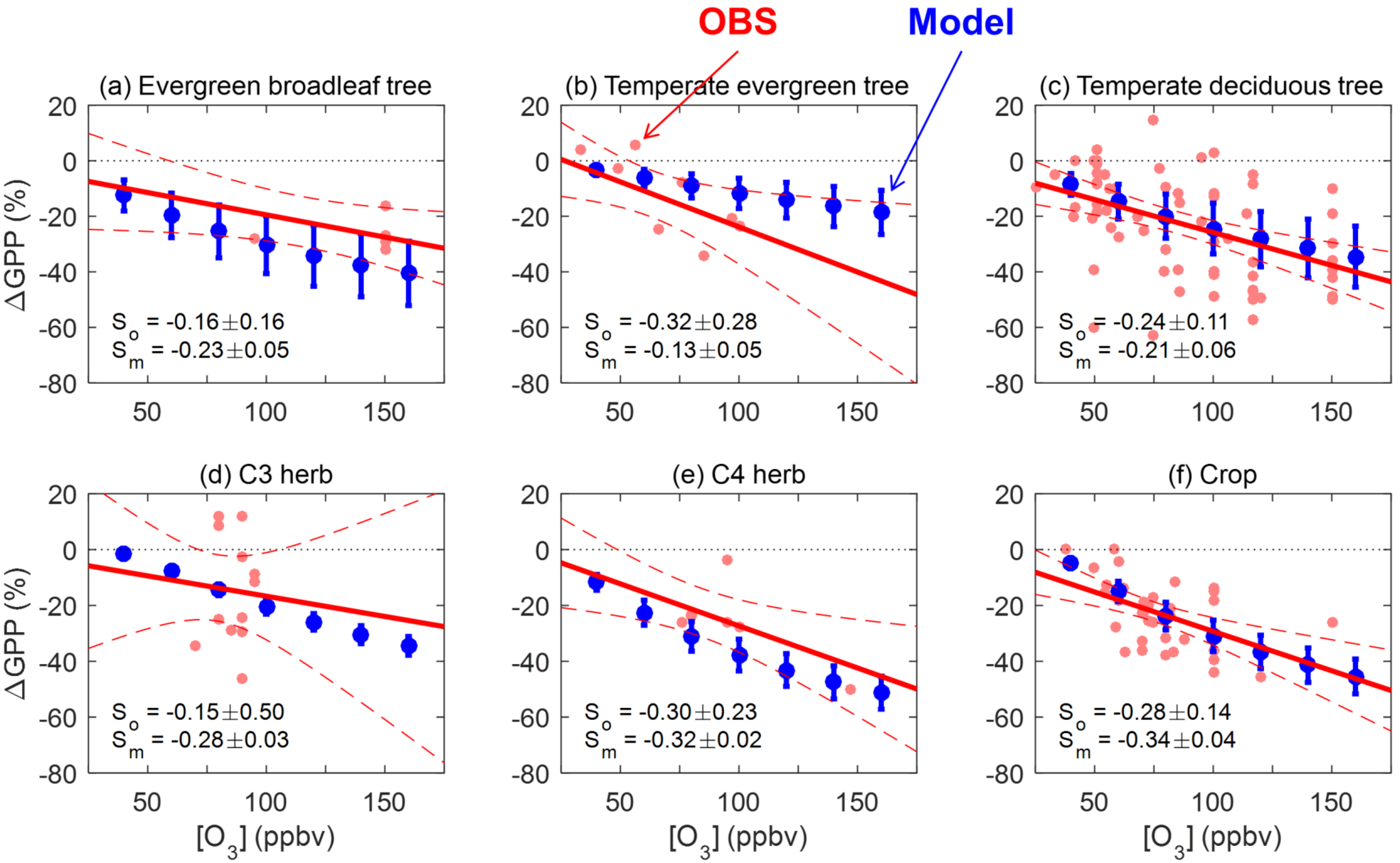
$$A' = F \cdot A_{net}$$

$$F = 1 - a \cdot U_{>O3T}$$

$$U_{>O3T} = \max[(F_{O3} - O3T), 0]$$

$$F_{O3} = \frac{[O_3]}{r_b + \kappa \cdot r_s'}$$

$$r_s' = \frac{1}{g_s'} = \frac{1}{F \cdot g_s}$$

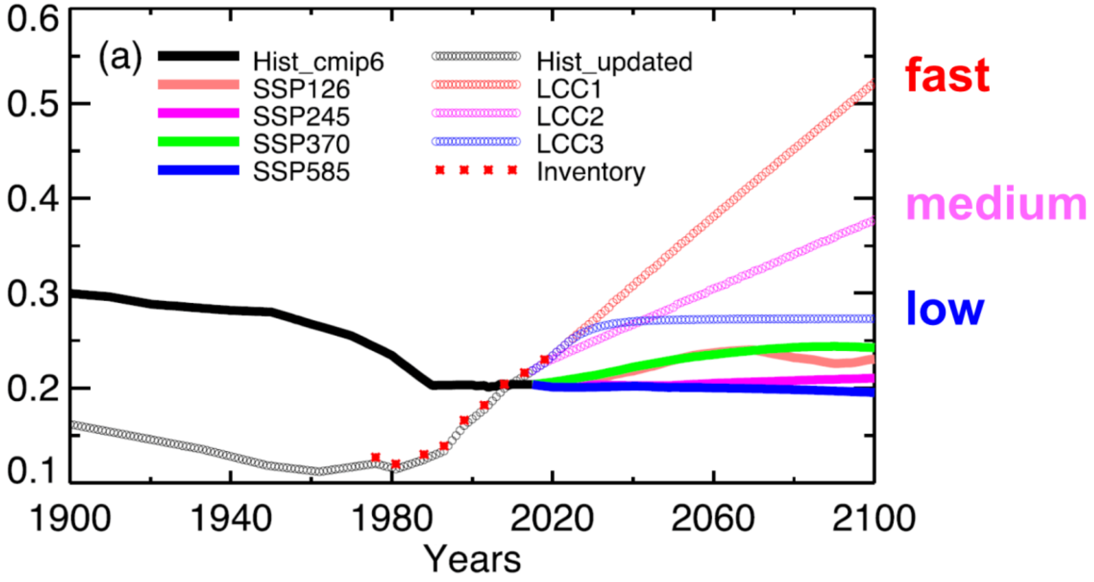


(Yue* & Unger., *NC* 2018)

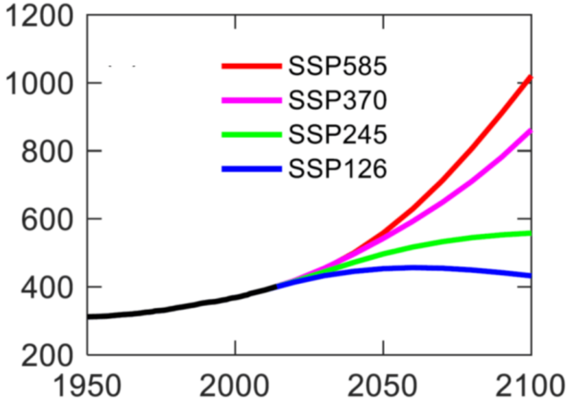
Sensitivity experiments

- A total of 18 groups, isolating effects of CO_2, O_3, LCC, litter removal, and climate change
- Each group has 16×4 runs (Climate from 16 models under 4 SSP scenarios)
- Each run spans 250 years
- Hourly time step at 1°×1°

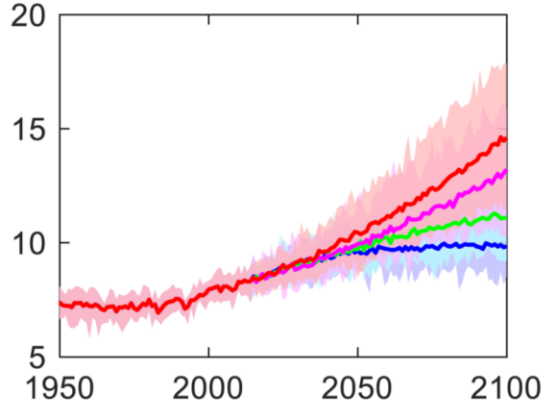
Land cover (3 cases)



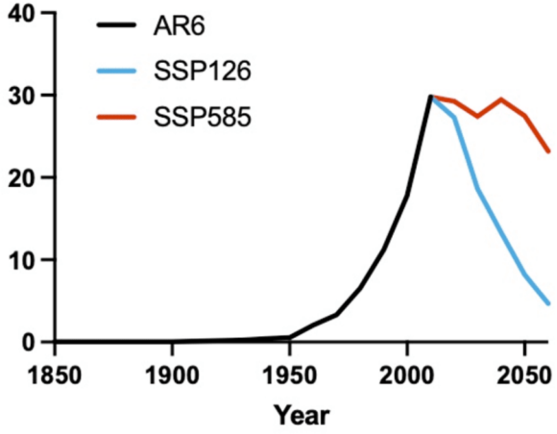
CO_2 (4 SSPs)



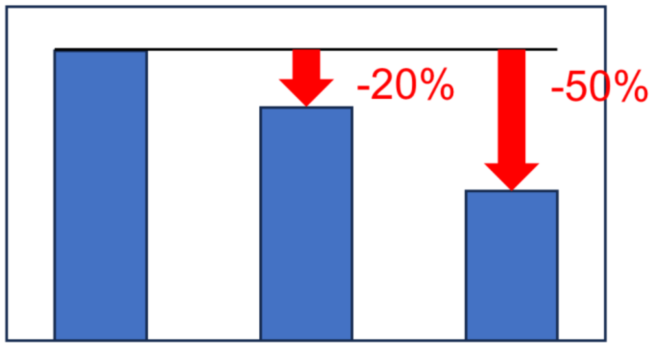
Climate (16 models)



NO_x emissions



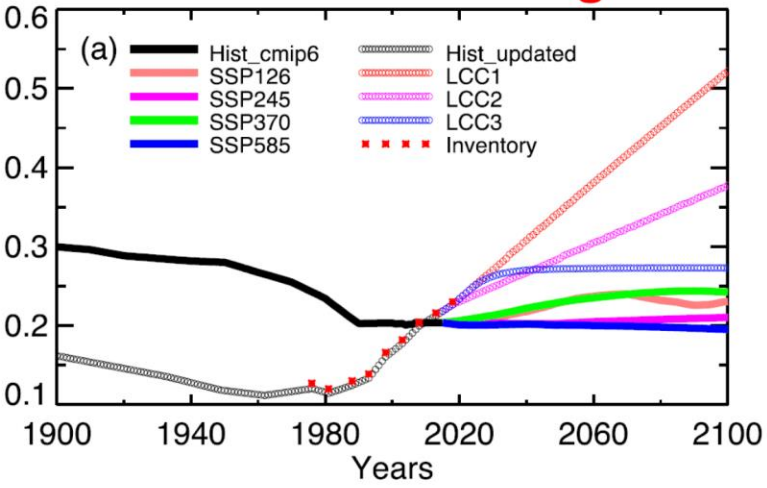
Litter removal



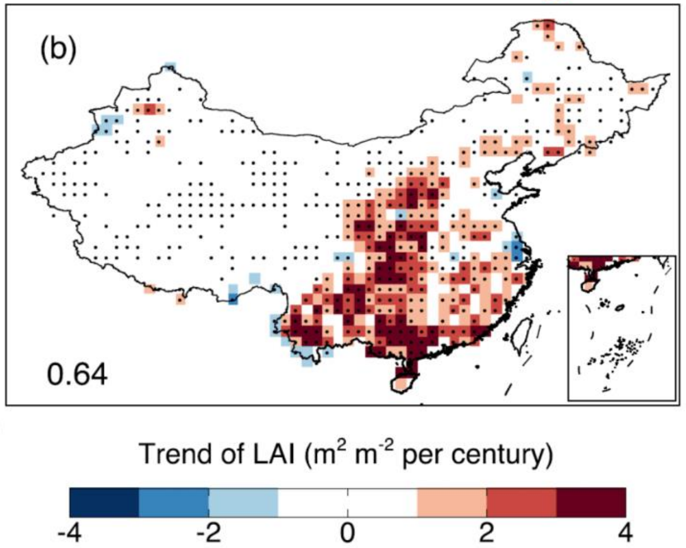
(Yue et al., *Sci. Bull.* in press)

Afforestation dominates the greenness in China

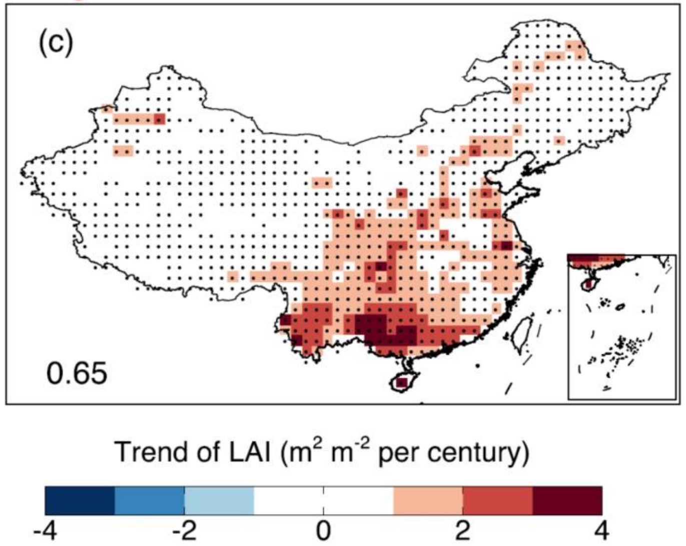
Land cover change



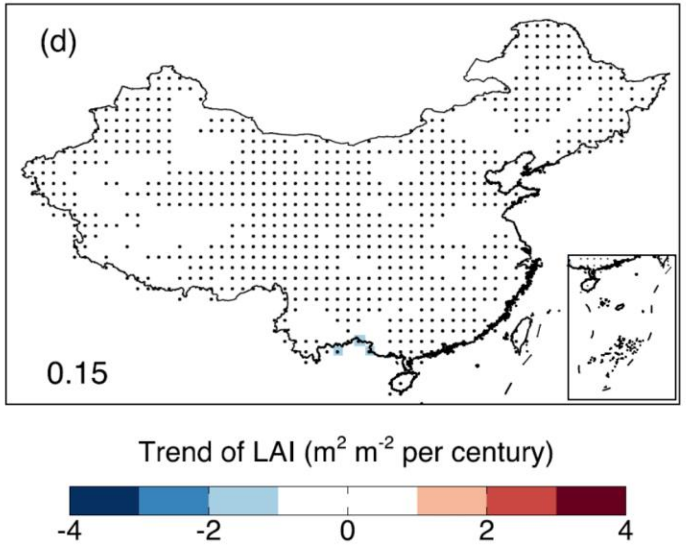
Observed LAI change



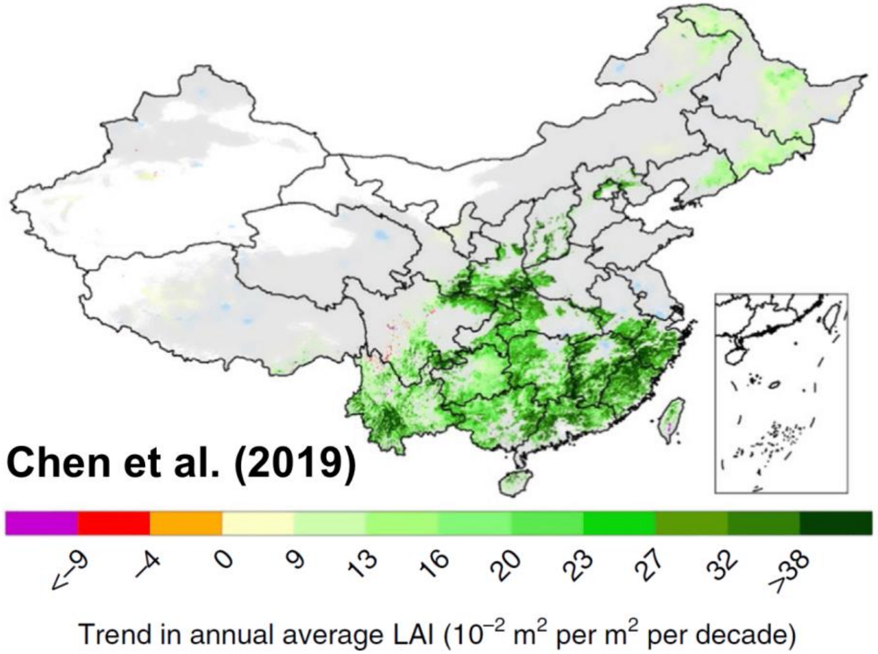
Adjusted LCC simulations



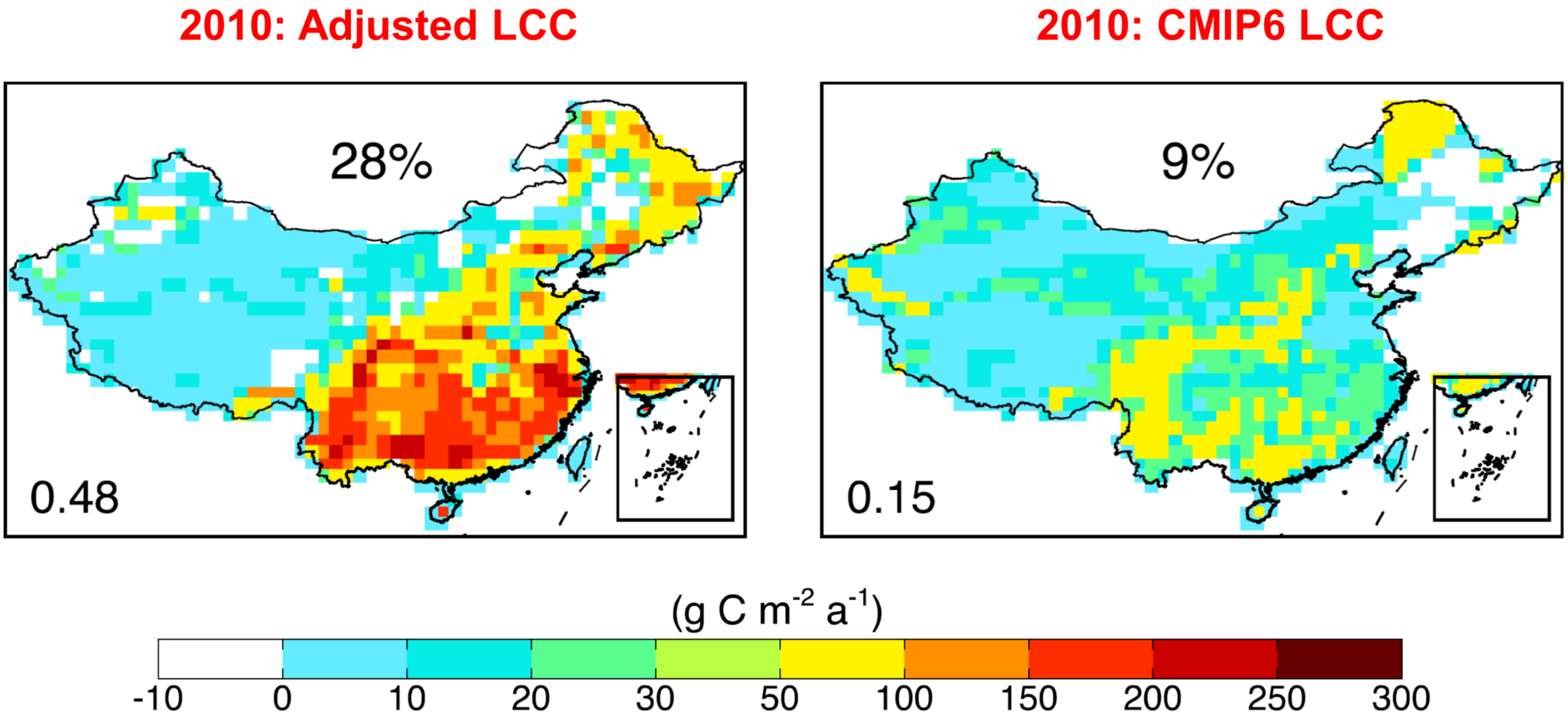
CMIP6 LCC simulations



- ☐ **Observations revealed increasing trend of LAI in the past 2 decades**
- ☐ **Simulations with adjusted LCC could reproduce observed LAI trend**
- ☐ **Simulations with CMIP6 LCC failed to capture the observed LAI trend**

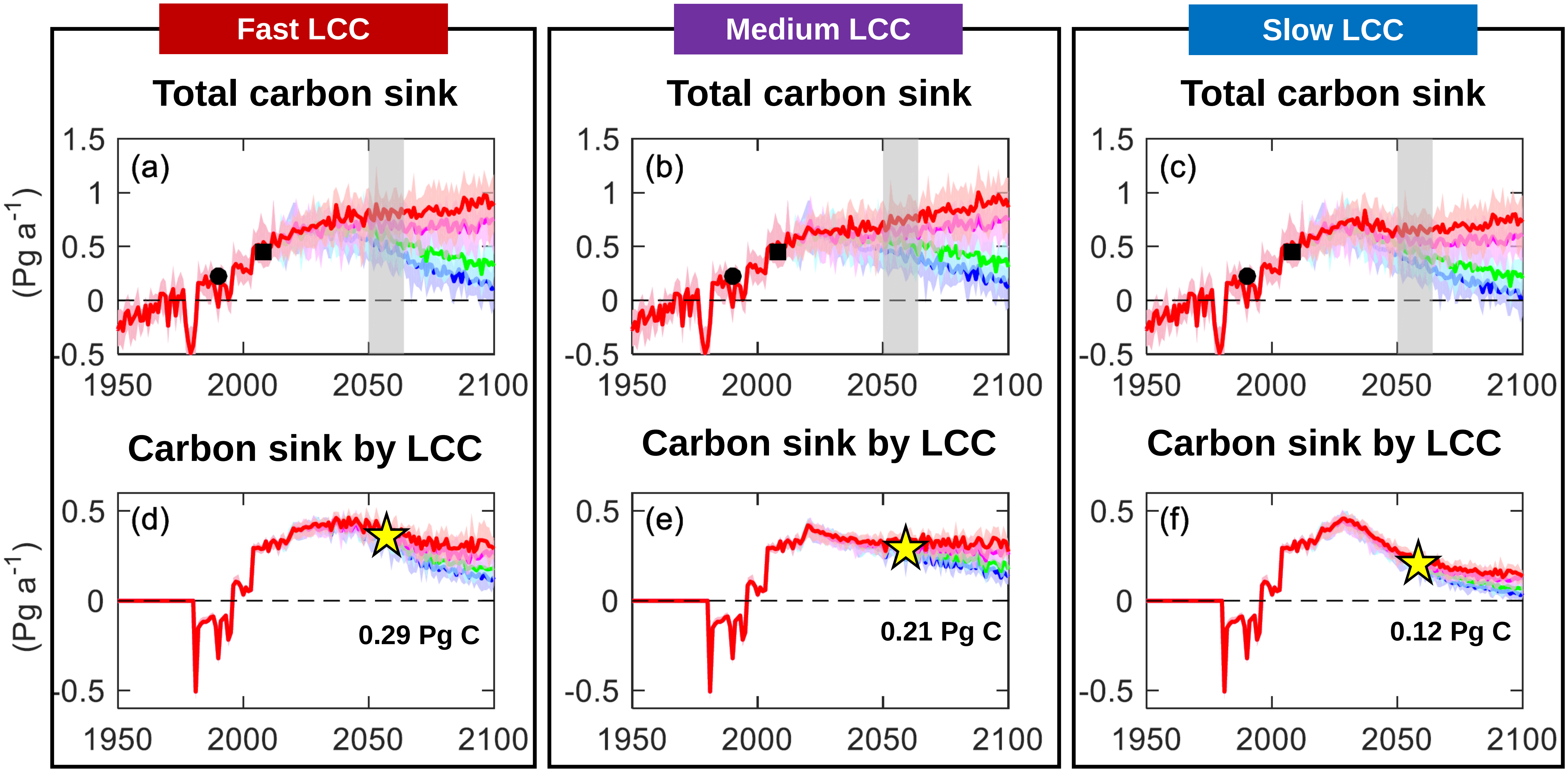


Afforestation enhances present-day carbon sink in China

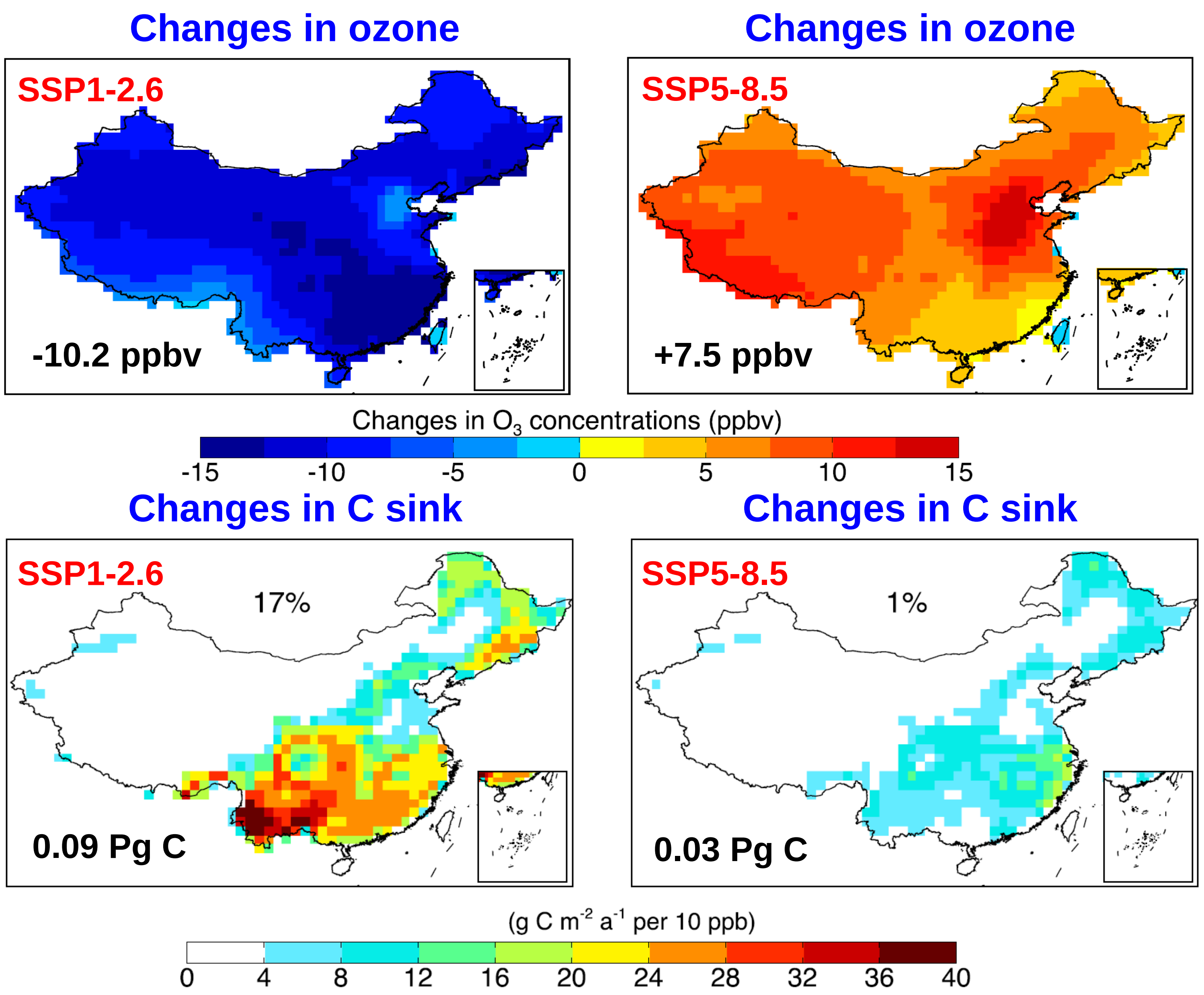


(Yue et al., *Sci. Bull.* in press)

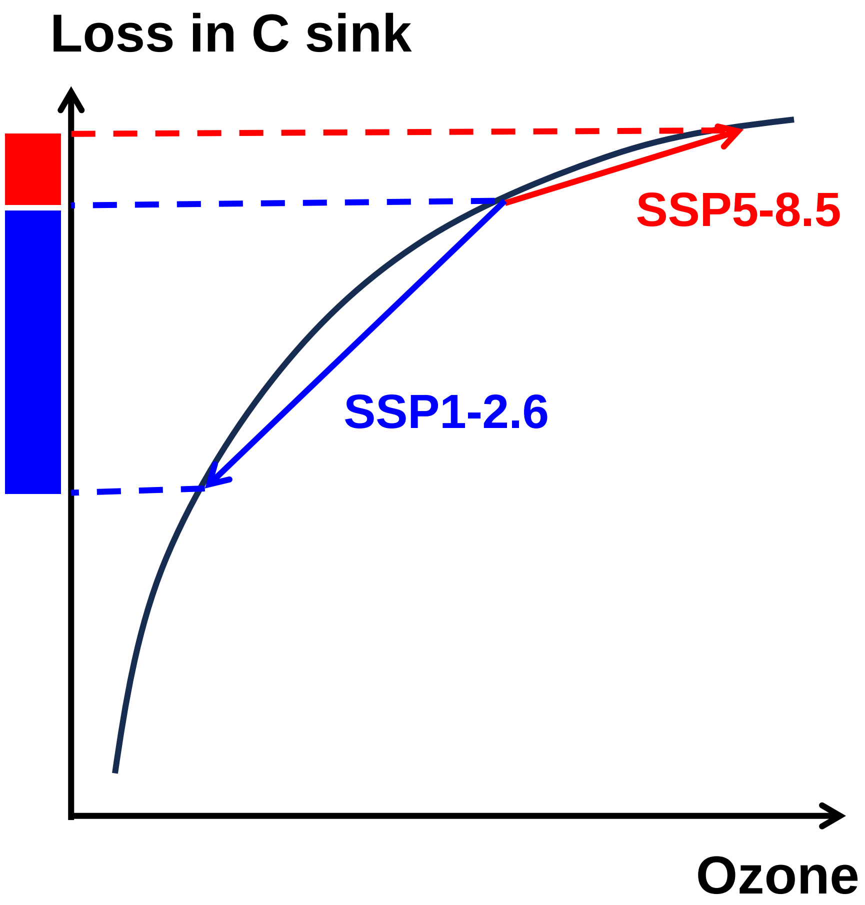
Changes in carbon sink by afforestation



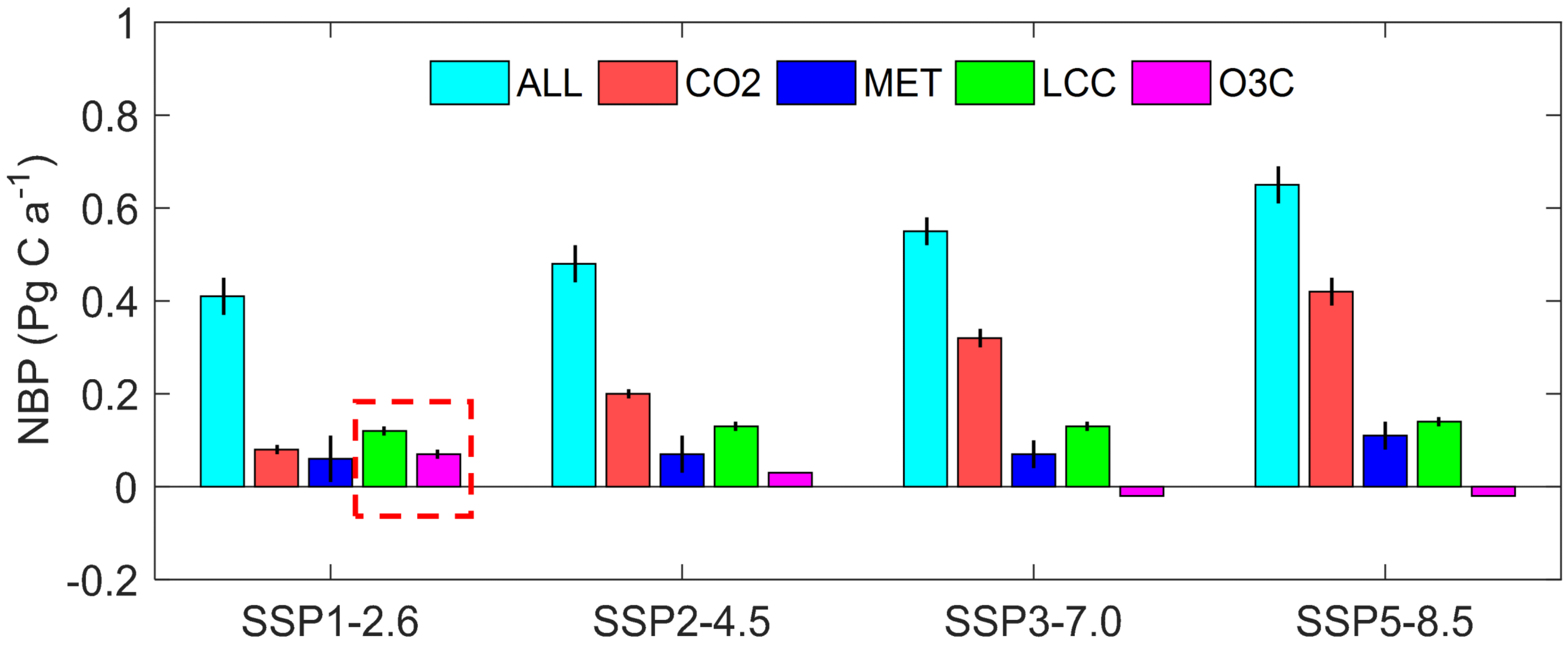
Contributions to carbon sink by ozone control



- The larger benefit for carbon sink with deeper cut in ozone



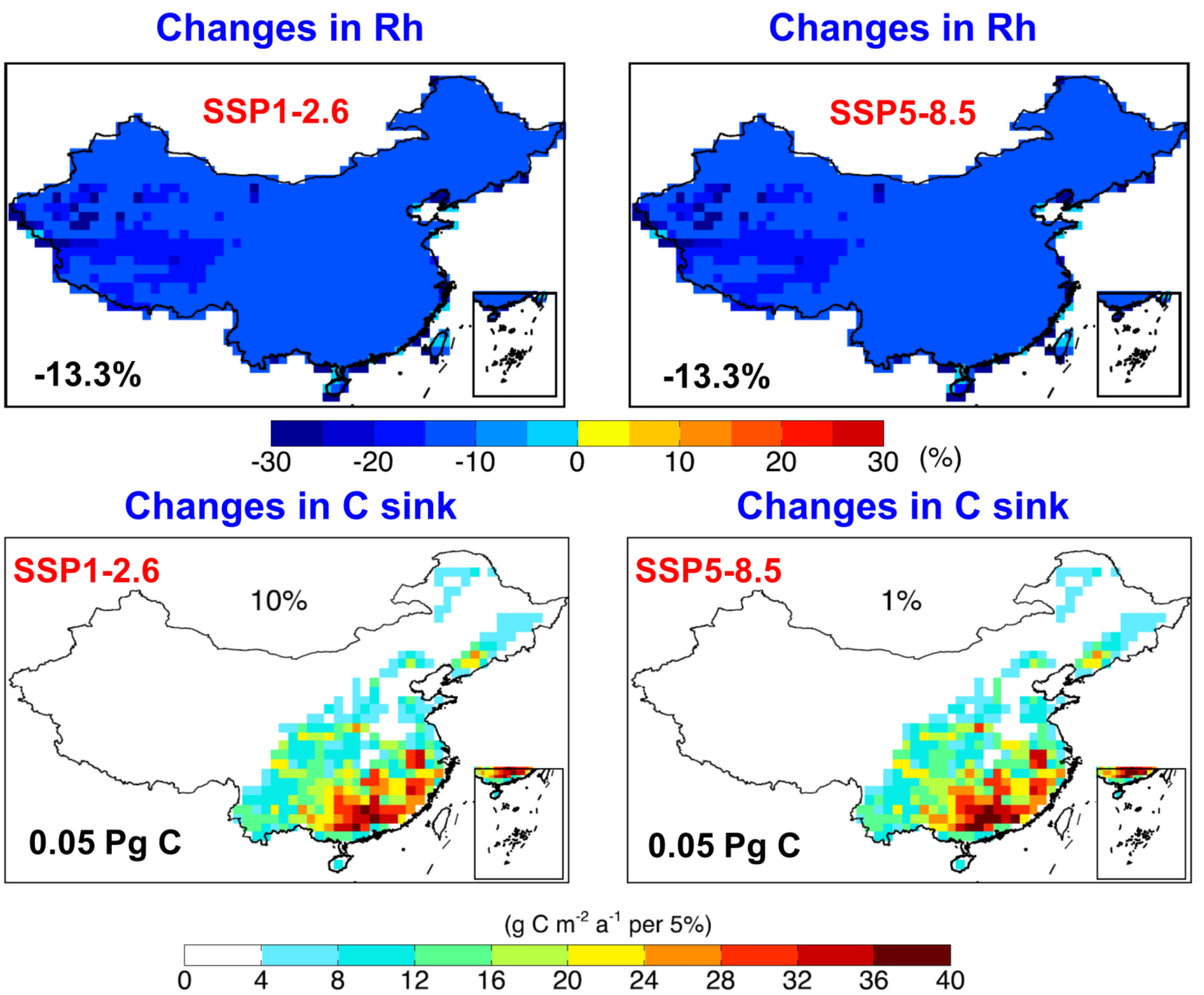
Comparisons of different drivers to carbon sink



- **The cost for 90% cut of NO_x is \$65B, leading to a carbon gain of 2.06 PgC due to ozone reduction, equivalent of \$8.6 per ton CO_2**
- **The cost of afforestation is \$50-100 per ton CO_2**

(Yue et al., *Sci. Bull.* in press)

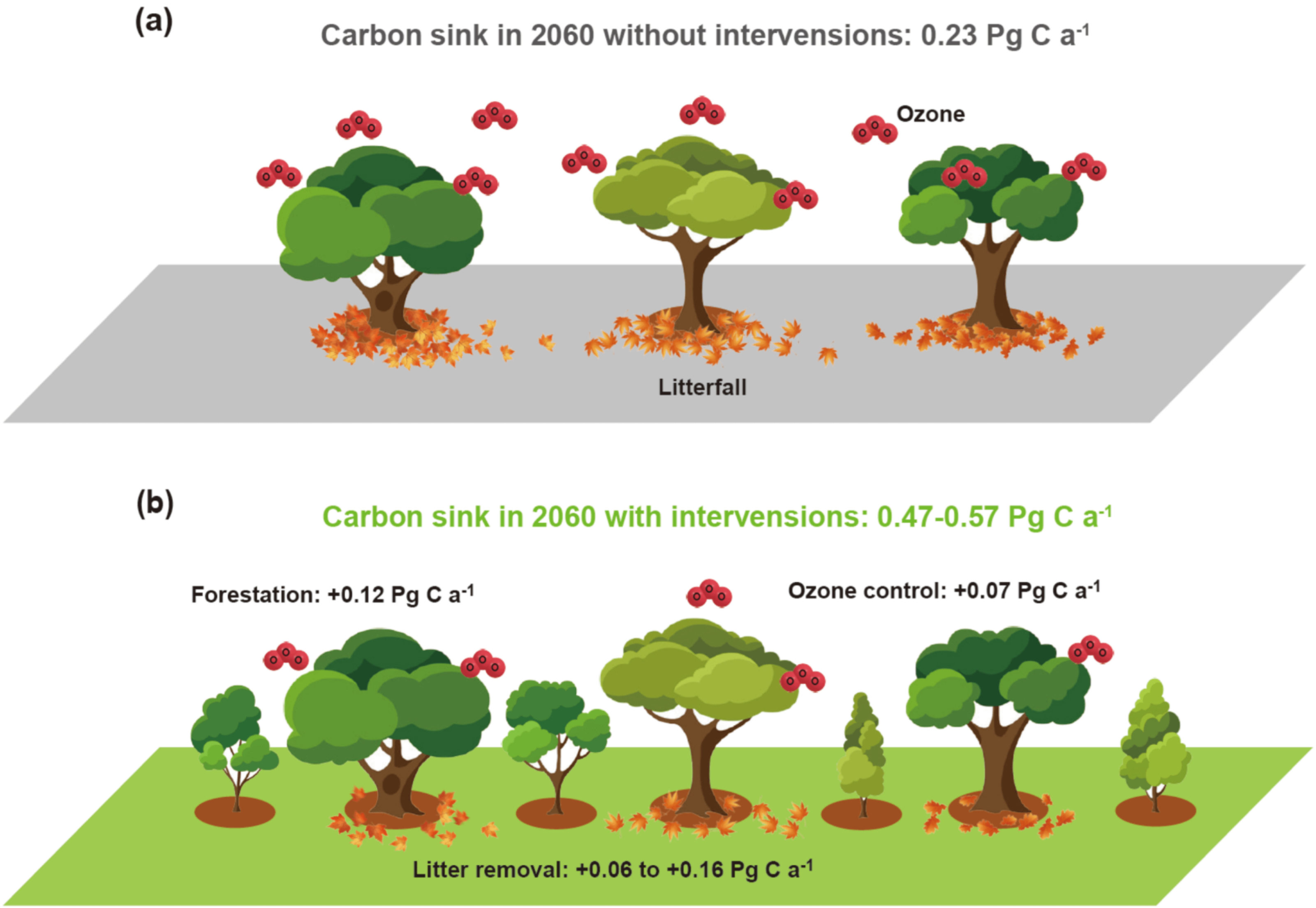
Contributions to carbon sink by litter removal



- ☐ **Litter removal decreases soil respiration, and enhances carbon sink**
- ☐ **The effect of litter removal is insensitive to climate scenarios and LCC**
- ☐ **We suggest to remove only the litterfall on planted forest**

(Yue et al., *Sci. Bull.* in press)

Conclusions



For SSP1-2.6 scenario:

- ☐ **By 2060, the carbon sink is only 0.23 Pg C a^{-1} if no interventions**
- ☐ **This sink enhances to 0.47-0.57 Pg C a^{-1} with proper human interventions, offsetting 90-110% of the residue carbon emissions**
- ☐ **Reforestation: 0.12 Pg C a^{-1}**
  Ozone control: 0.07 Pg C a^{-1}
  20% litter removal: 0.06-0.16 Pg C a^{-1}

(Yue et al., *Sci. Bull.* in press)

Thank you!

For more information:

Yue, X., Zhou, H., Cao, Y., Liao, H., Lu, X., Yu, Z., Yuan, W., Liu, Z., Sitch, S., Knauer, J., and Wang, H.: Large potential of strengthening the land carbon sink in China through anthropogenic interventions, *Science Bulletin*, in press, 2024.

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