Impact of Non-Uniform CO_2 Concentration on Terrestrial Carbon Uptake

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Introduction

Prediction of the terrestrial carbon (C) uptake in the 21st century remains highly uncertain (Friedlingstein et al., 2013; Arora et al.,2020), and one of the main sources of this uncertainty is our incomplete understanding of plant production and terrestrial respiration owing to the spatial variation of the regulation of atmospheric carbon dioxide (CO_2).

Methods

We employed two different CO_2 datasets to simulate the C flux in BNU-ESM with a fully interactive C cycle. BNU-ESM operates with a spatial resolution of 2.81° × 2.81°.

Table 1. Summary of Simulations Including CO_2 Data

Name	Experiments	Time span	CO_2 concentrations
A1	Uniform	1850–2005	Without spatial variations
A2	Uniform	2006–2100	Without spatial variations
B1	Non-uniform	1850–2005	Spatial variations
B2	Non-uniform	2006–2100	Spatial variations
B3	Non-uniform	2006–2100	Without spatial variations in the radiative process, with spatial variations in the physiological process
B4	Non-uniform	2006–2100	Without spatial variations in the physiological process

Conclusions

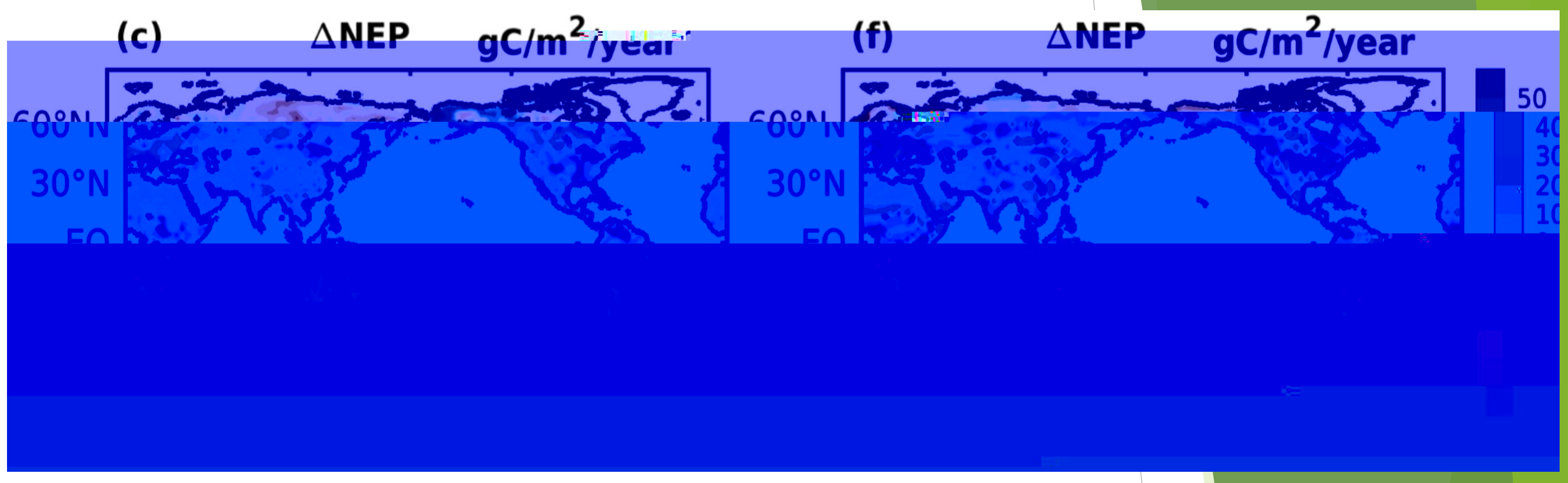
Our findings call for more attention to be paid to the influence of spatial variations in CO_2 concentration– particularly in the Northern Hemisphere – to better constrain the projected C uptake under future conditions.

It highlights the fundamental importance of non-uniform CO_2 in determining the pattern, response, and magnitude of C uptake through to 2100.

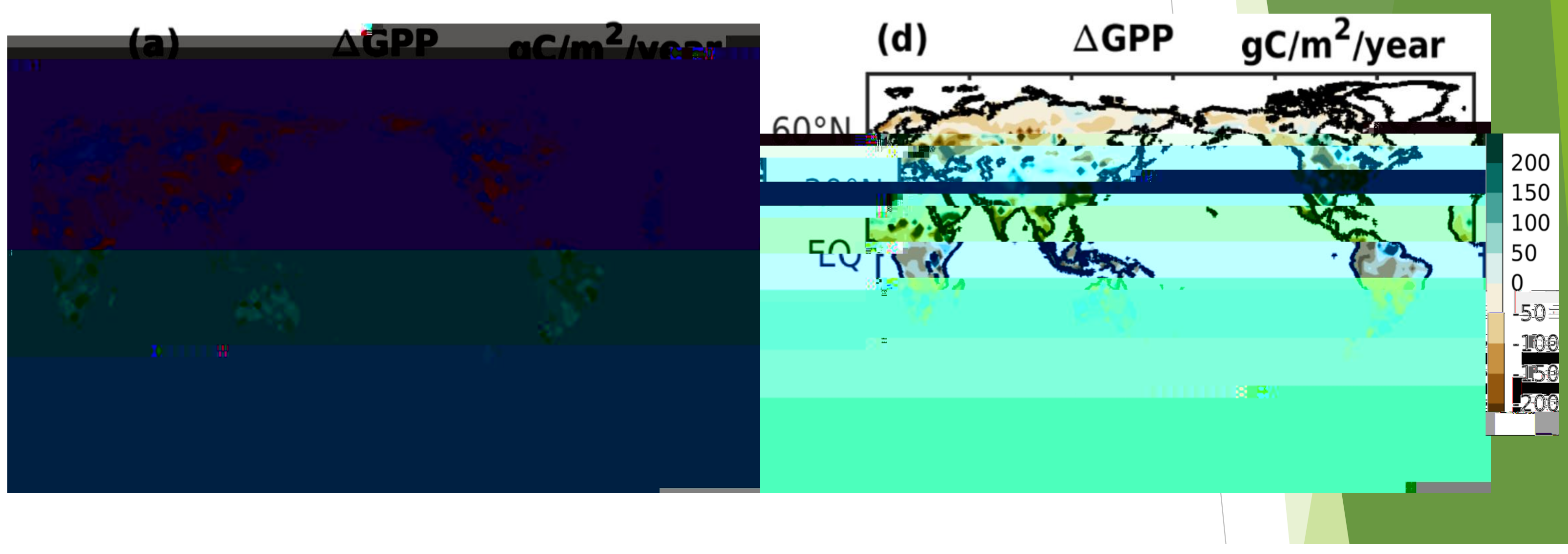
In the future, an additional decrease in C uptake within Chinese terrestrial ecosystems is projected, attributed to the limitation of phosphorus availability.

Results

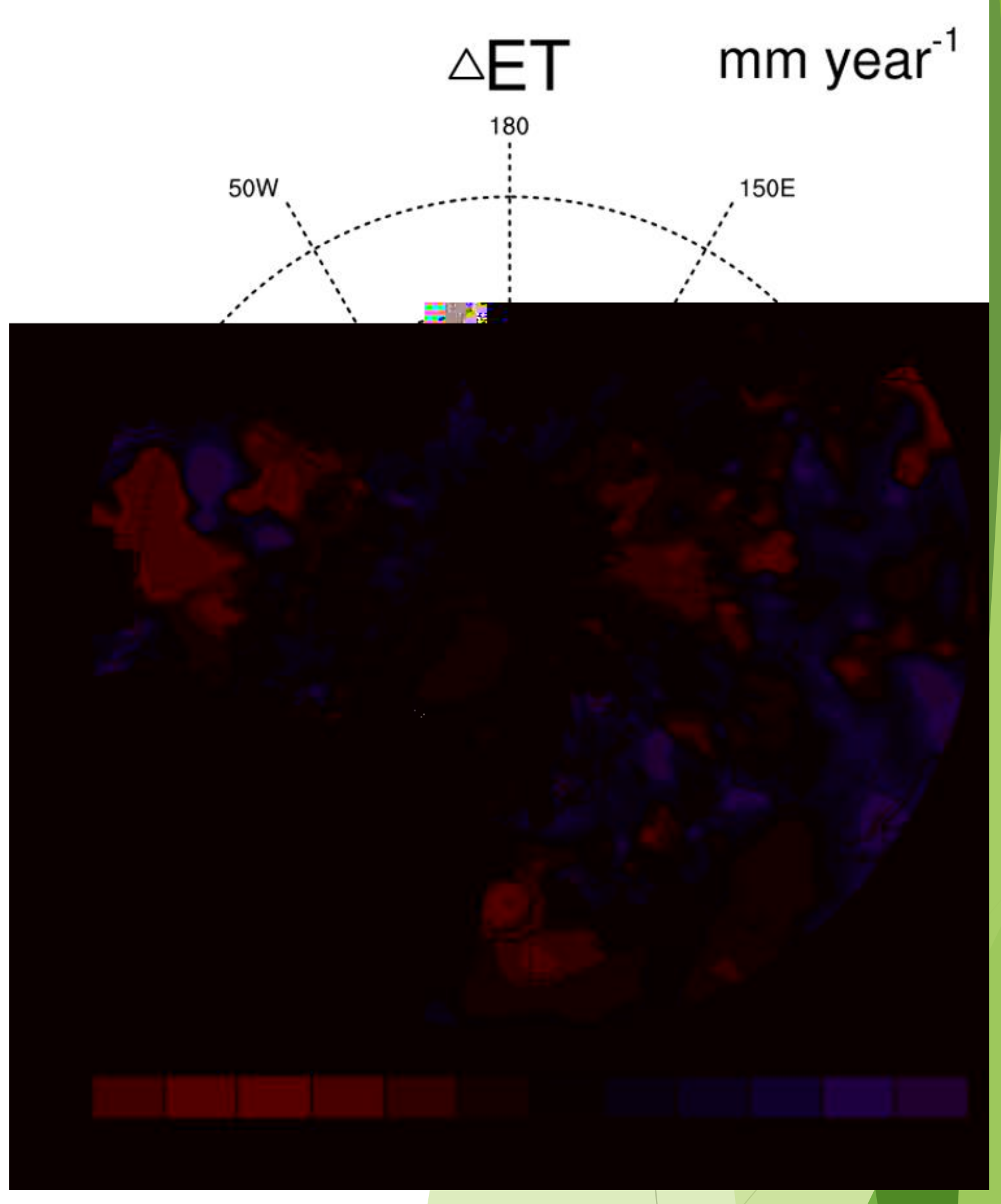
The global reduction in NEP under future conditions caused by the effect of non-uniform CO_2 was estimated to be 0.51 Pg C yr^{-1}, or -19% under future conditions of 2071–2100.

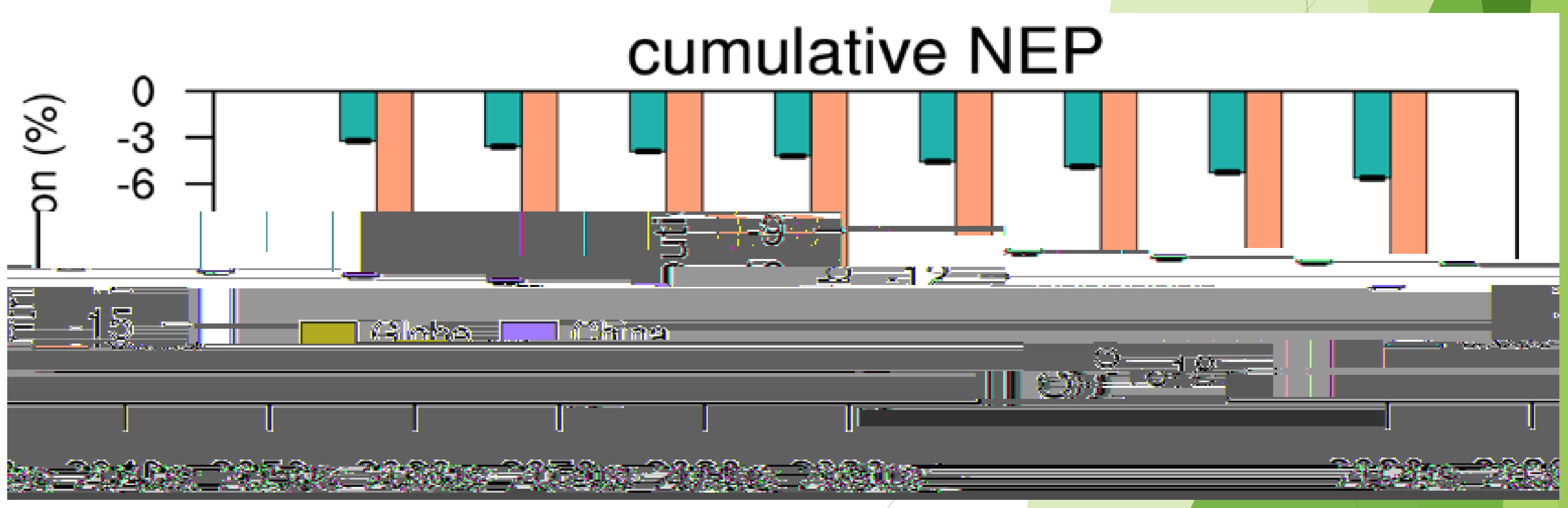


A reduction in NEP was estimated, especially in eastern Asia and eastern North America, caused by the non-uniform CO_2 effect that was mainly driven by decreases of GPP.



The spatial gradient of NEP in North America, Eastern Asia and Europe is related to spatial precipitation distribution. The higher sensible heat flux and reduction in ET likely make the reductions in convective precipitation considering spatial variations in CO_2 concentrations.





When accounting for the phosphorus cycle by the 2030s, it can lead to an additional reduction of 15.1% in NEP in China.

References

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