陆地生态系统植被生产力及碳汇对降水的非对称性响应

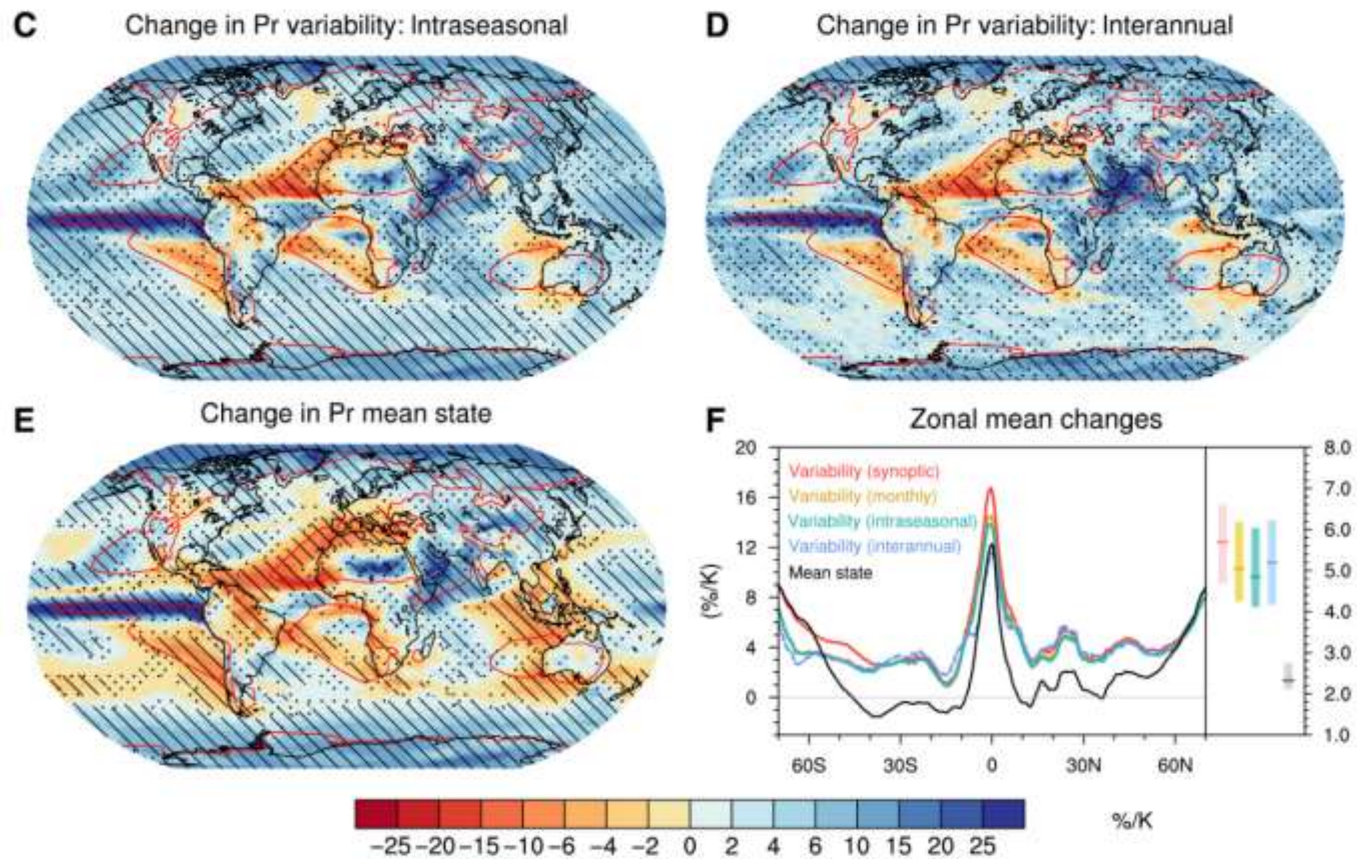
胡中民

海南大学

呼伦贝尔, 2024.8.21-22

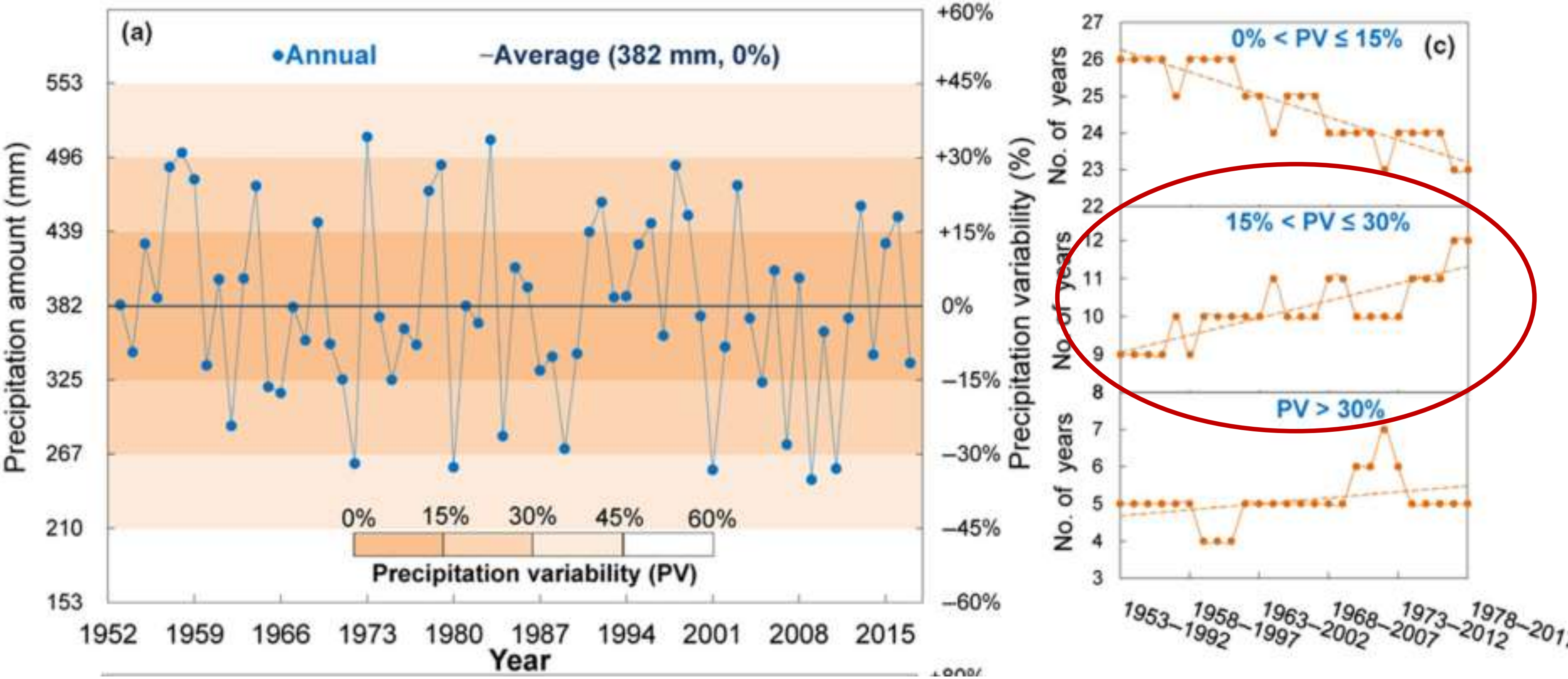
Background: Global precipitation variability is increasing

- Global warming intensifies the water cycle, leading to higher precipitation variability



Zhang et al., 2015, Science advances

- In temporal, precipitation variation also showed an increasing trend, especially in arid regions



Ru et al., 2021, Functional Ecology

How global terrestrial ecosystem carbon sink respond to increasing global precipitation variability?

Increased or decreased ?

- **It is difficult to assess the effects of increasing precipitation variation on carbon sink directly with experiments.**

- **There are very few precipitation variation experiments in the world.**

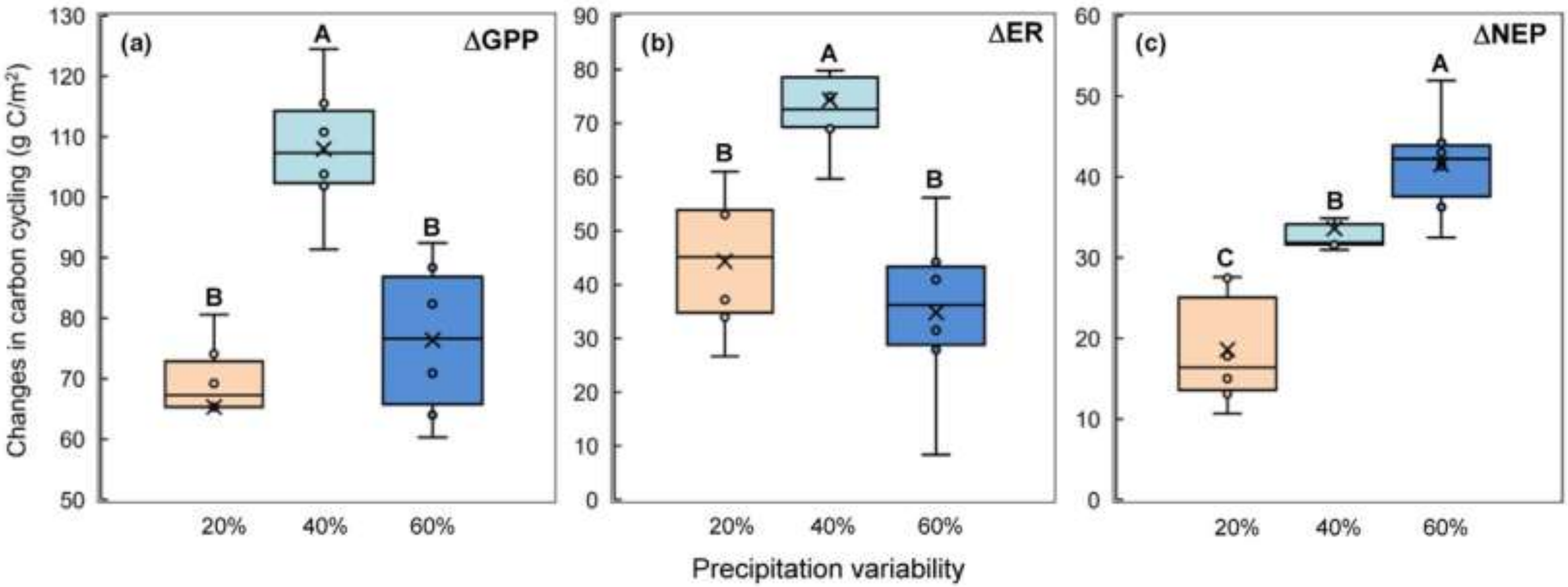
基于控制实验的案例研究

RESEARCH ARTICLE

Functional Ecology BRITISH ECOLOGICAL SOCIETY

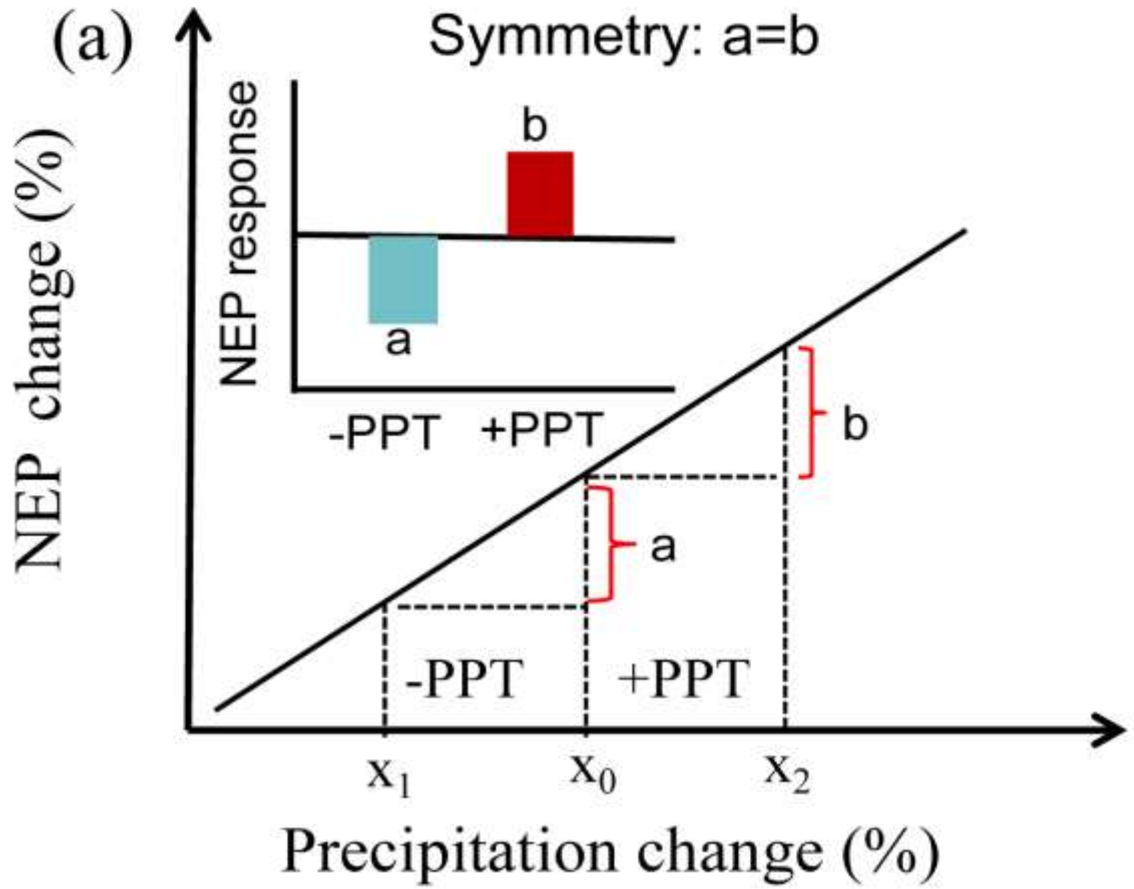
Increased interannual precipitation variability enhances the carbon sink in a semi-arid grassland

Jingyi Ru[1] | Shiqiang Wan[1] | Dafeng Hui[2] | Jian Song[1] | Jing Wang[1]

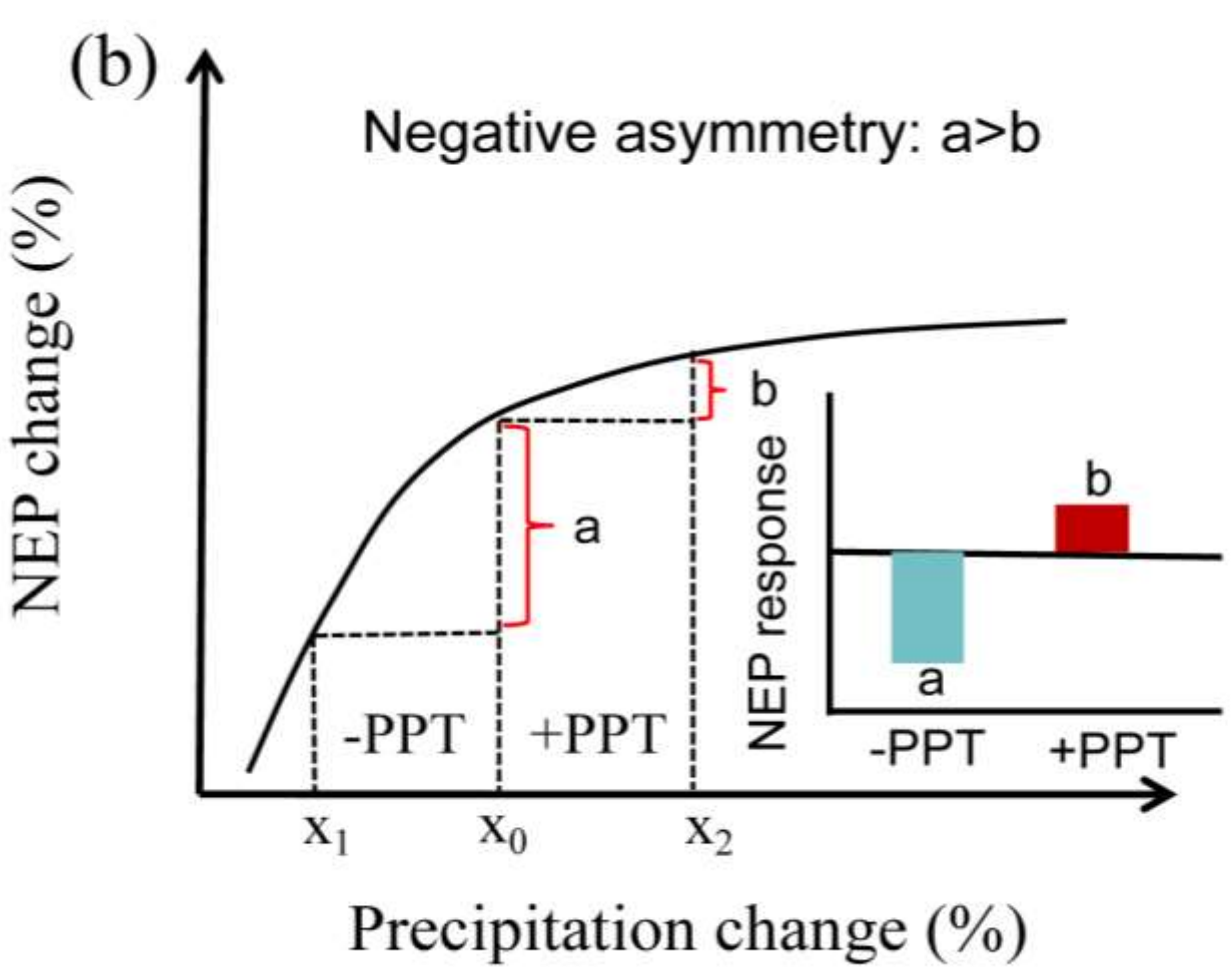


How about the other ecosystems in the world?

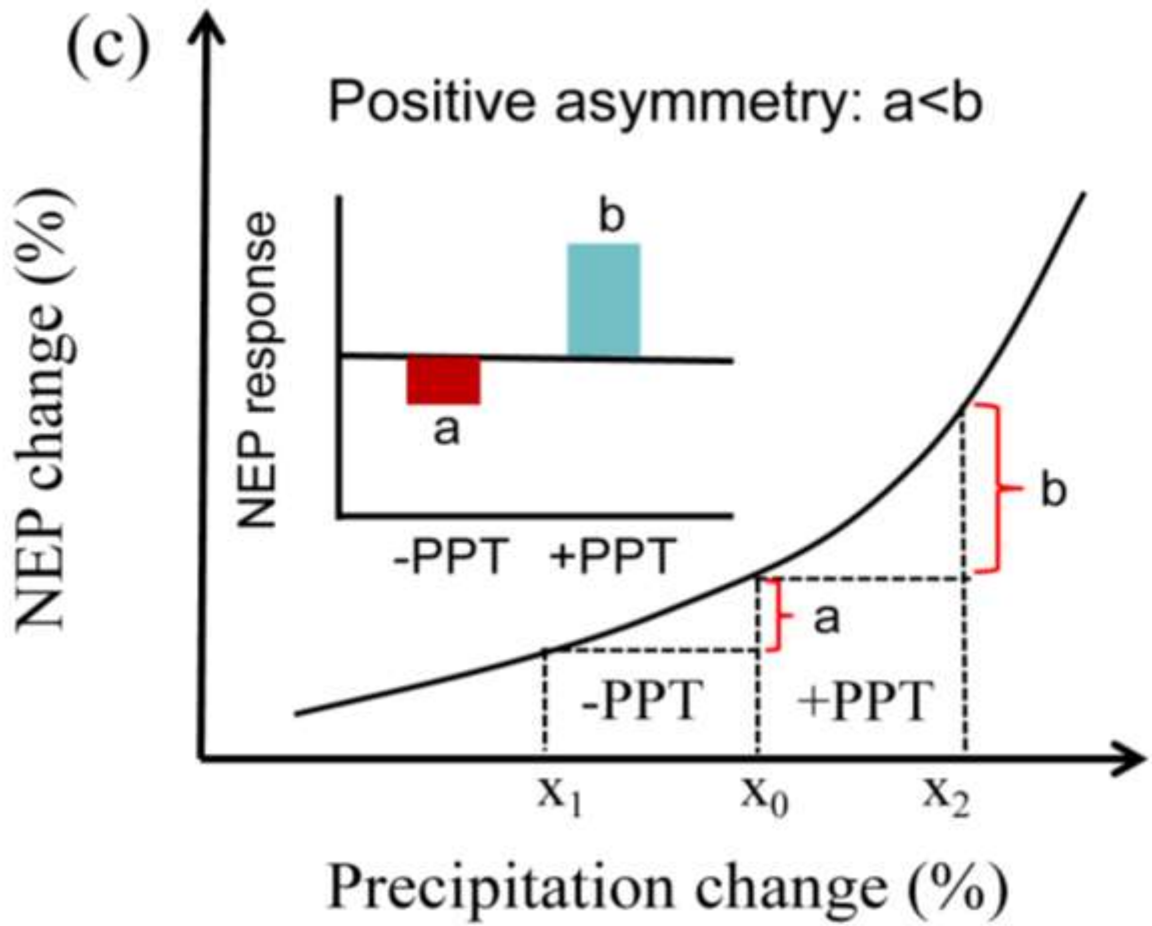
Precipitation variability on ecosystem carbon budget depend on the exact form of the relationship between precipitation and the ecosystem carbon budget



Case 1 No impact, pulse=decline



Case2 Negative impact, pulse < decline



Case3 Positive impact, pulse > decline

Some evidence from meta-analysis

Global Change Biology

PRIMARY RESEARCH ARTICLE

Asymmetric responses of primary productivity to precipitation extremes: A synthesis of grassland precipitation manipulation experiments

Kevin R. Wilcox, Zheng Shi, Laureano A. Gherardi, Nathan P. Lemoine, Sally E. Koerner, David L. Hoover, Edward Bork, Kerry M. Byrne, James Cahill Jr., Scott L. Collins, Sarah Evans ... See all authors

First published: 02 April 2017 | https://doi

Contents lists available at ScienceDirect

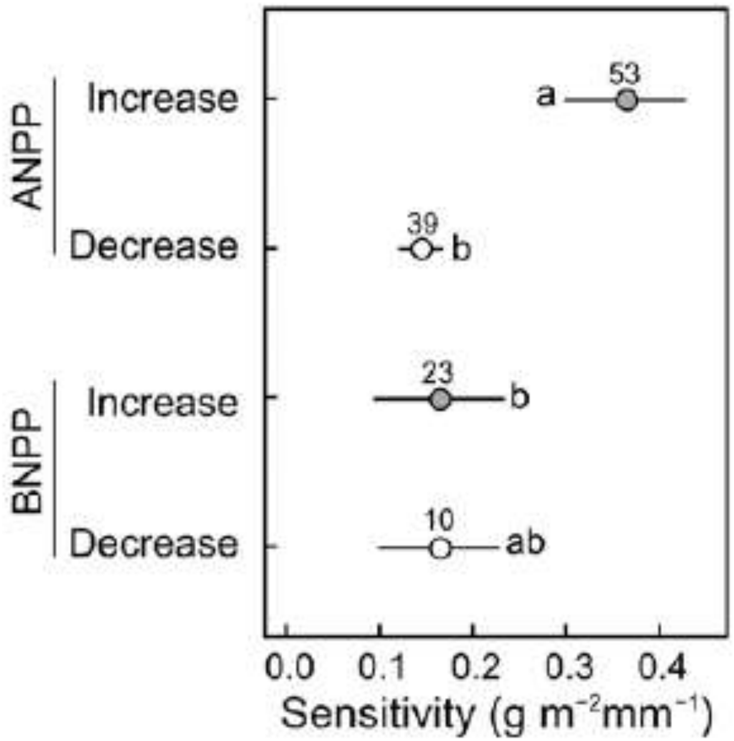
ELSEVIER

Science of the Total Environment

journal homepage: www.elsevier.com/locate/scitotenv

Global evidence on the asymmetric response of gross primary productivity to interannual precipitation changes

Yiheng Wang [a,b], Jingfeng Xiao [c], Xing Li [d], Shuli Niu [a,b,*]



Asymmetric response of productivity to changes in precipitation

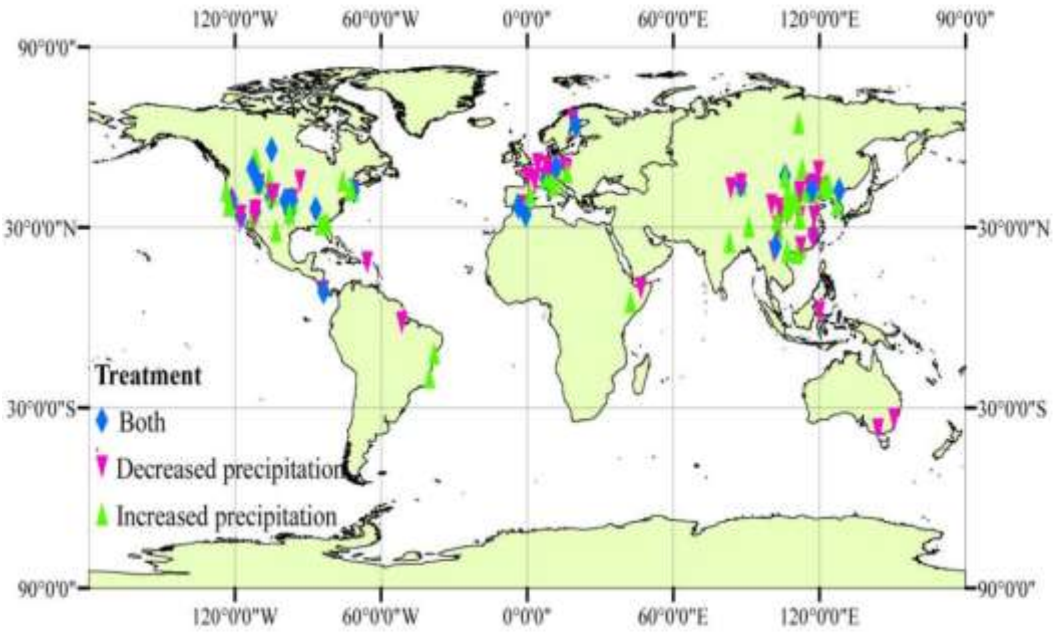
Three scenarios in GPP and ER response would cause positive AS in NEP

NEP=GPP-ER

（1）GPP主导(wet)	+	++	+
（2）ER主导(dry)	+	-	--
（3）共同决定	+	+	-

We need quantify the degree of asymmetry of GPP and ER, independently.

Methods: Meta analysis + Models (Trendy models) + Remote Sensing Data (SIF)



➢ **Meta analysis**

- 145 papers with 800 paired
- Grouped into arid areas (MAP<500 mm) and humid areas (MAP>500 mm).

➢ **Global SIF products**

CSIF, 0.05° 4-day, 2000-2018

➢ **TRENDY models**

Six models for 0.5°： DLEM、ISAM、LPJ-wsl，ORCHIDEE、 VEGAS、 VISIT

- **Calculation of the asymmetry index**

$$\mathrm{AS} = \frac{IP}{DP}$$

IP： Increased percentage in ANPP, BNPP, R_s and NEP corresponding to 40 % increased in precipitation

DP： Decreased percentage in ANPP, BNPP, R_s and NEP corresponding to 40 % reduction in precipitation

Note: AS=1 is symmetry, AS>1 positive asymmetry, and AS<1 represents negative asymmetry.

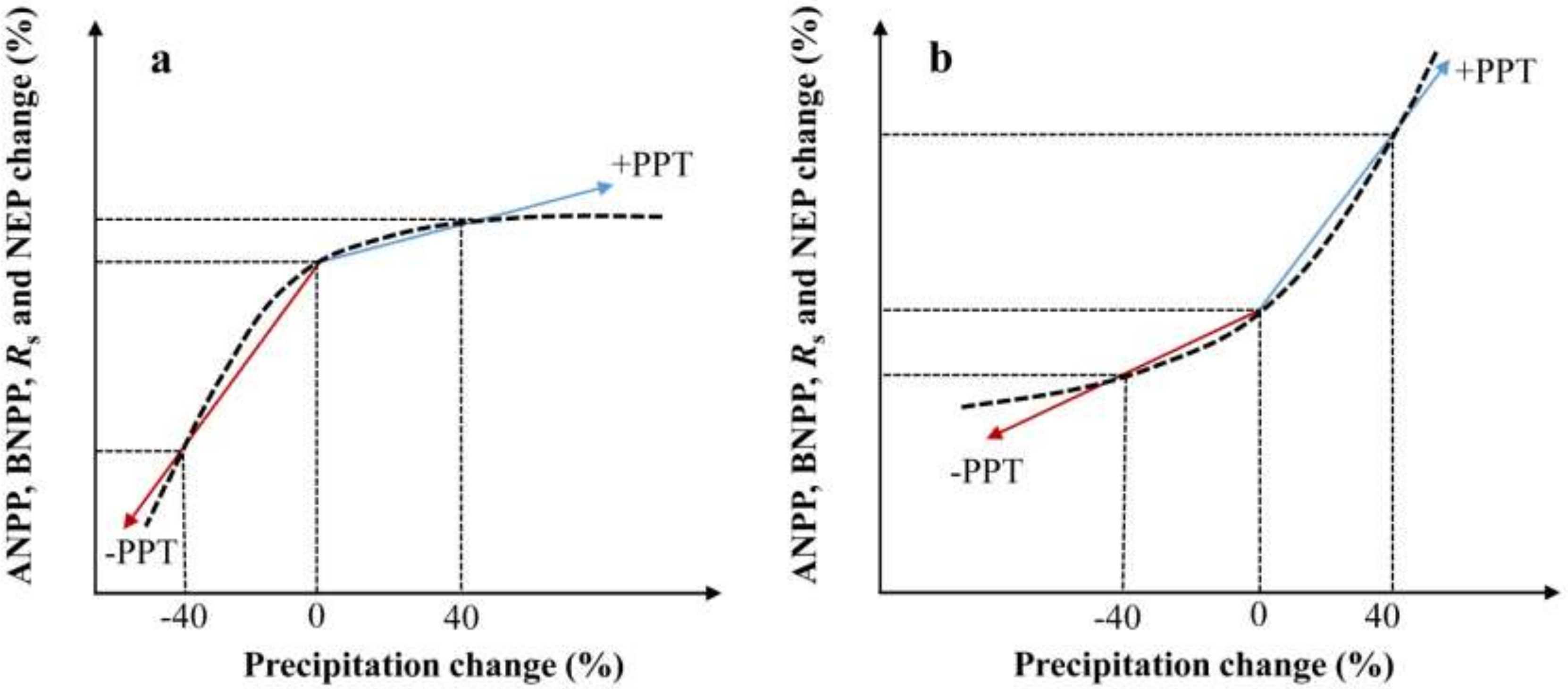
Normalization

$$\overline{X}_{NT} = \overline{X_C} + \frac{\overline{X_T} - \overline{X_C}}{P_c} \times 40\%$$

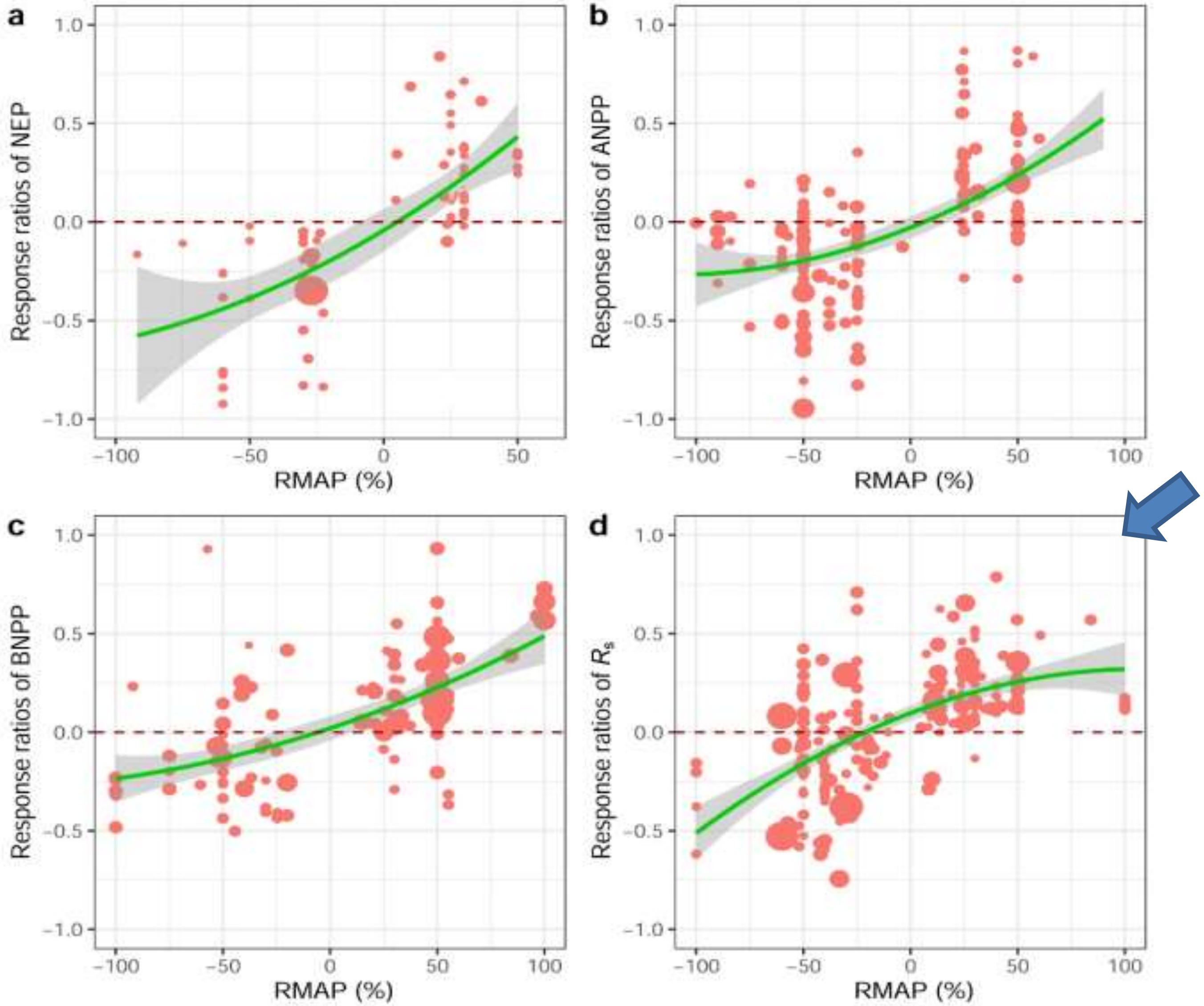
$\overline{X}_{NT}$: the normalized value under 40% above or below the MAP；

P_c :Percentage change in precipitation;

$\overline{X}_T$: Treatment group； $\overline{X}_C$: control group

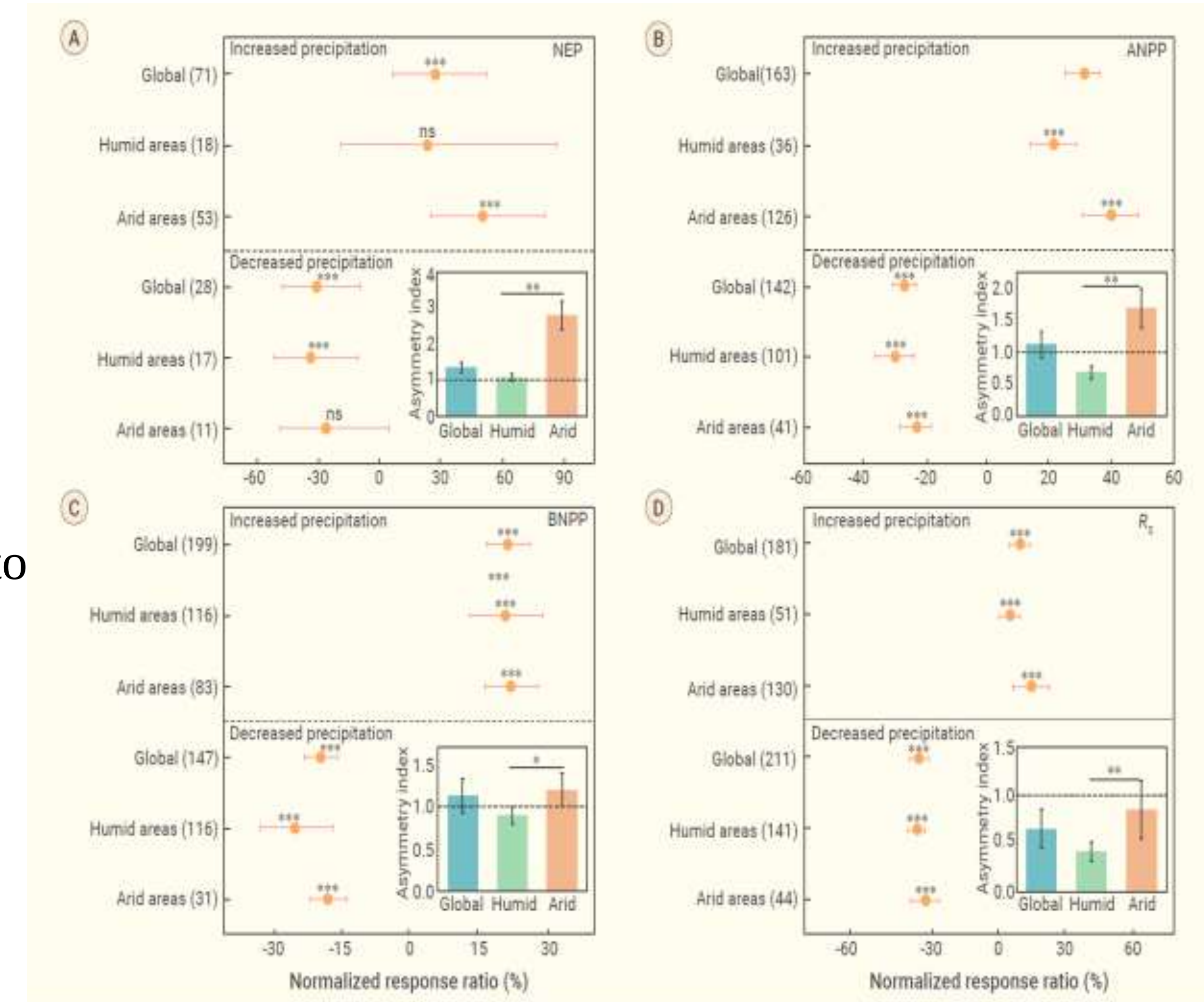


Results: Relationships between changes in precipitation and carbon fluxes



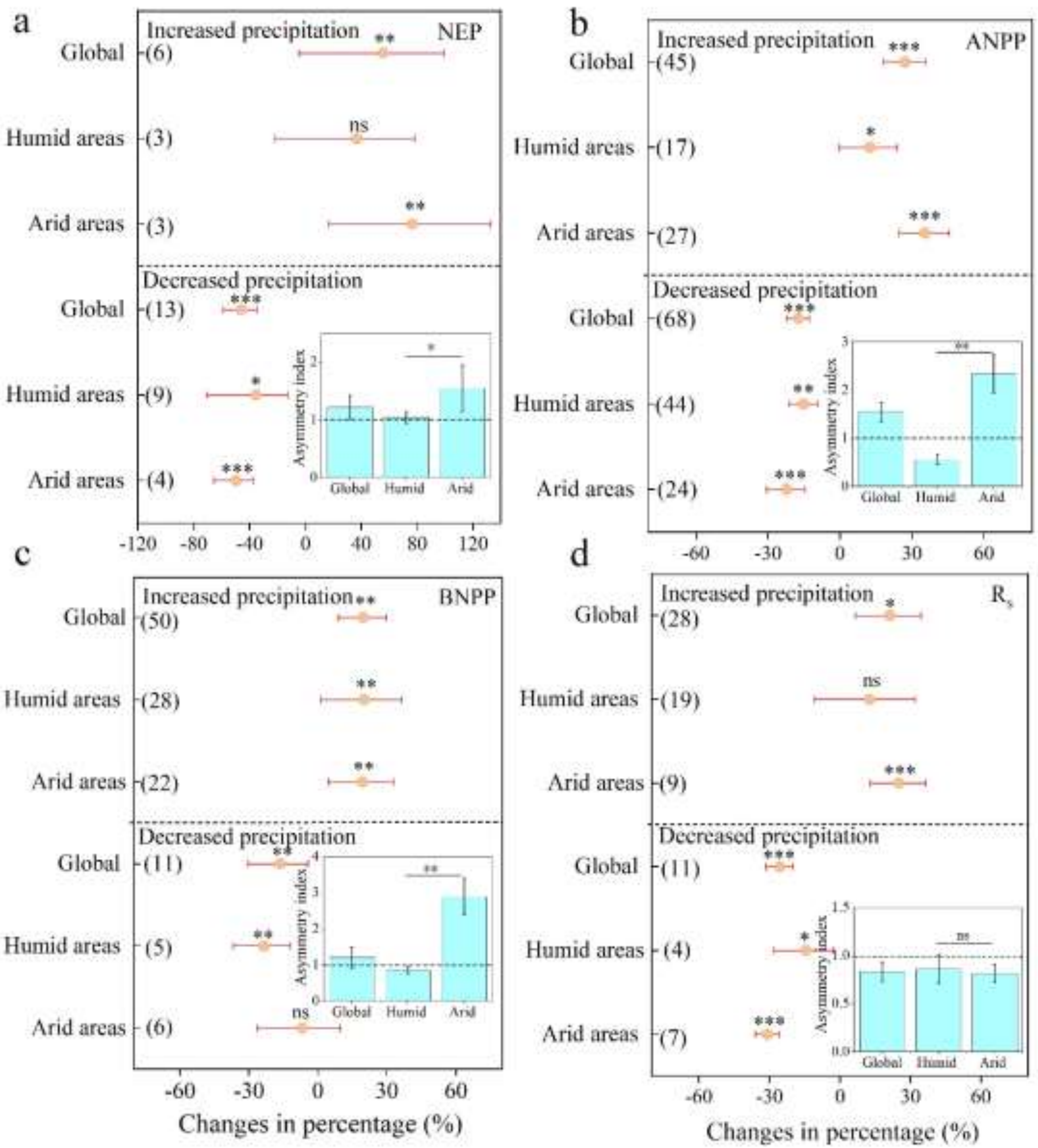
Asymmetric responses of carbon fluxes to normalized precipitation changes

- NEP, ANPP and BNPP display positive asymmetric responses to precipitation changes
- R_s display negatively asymmetric in response to precipitation changes
- Arid VS humid regions



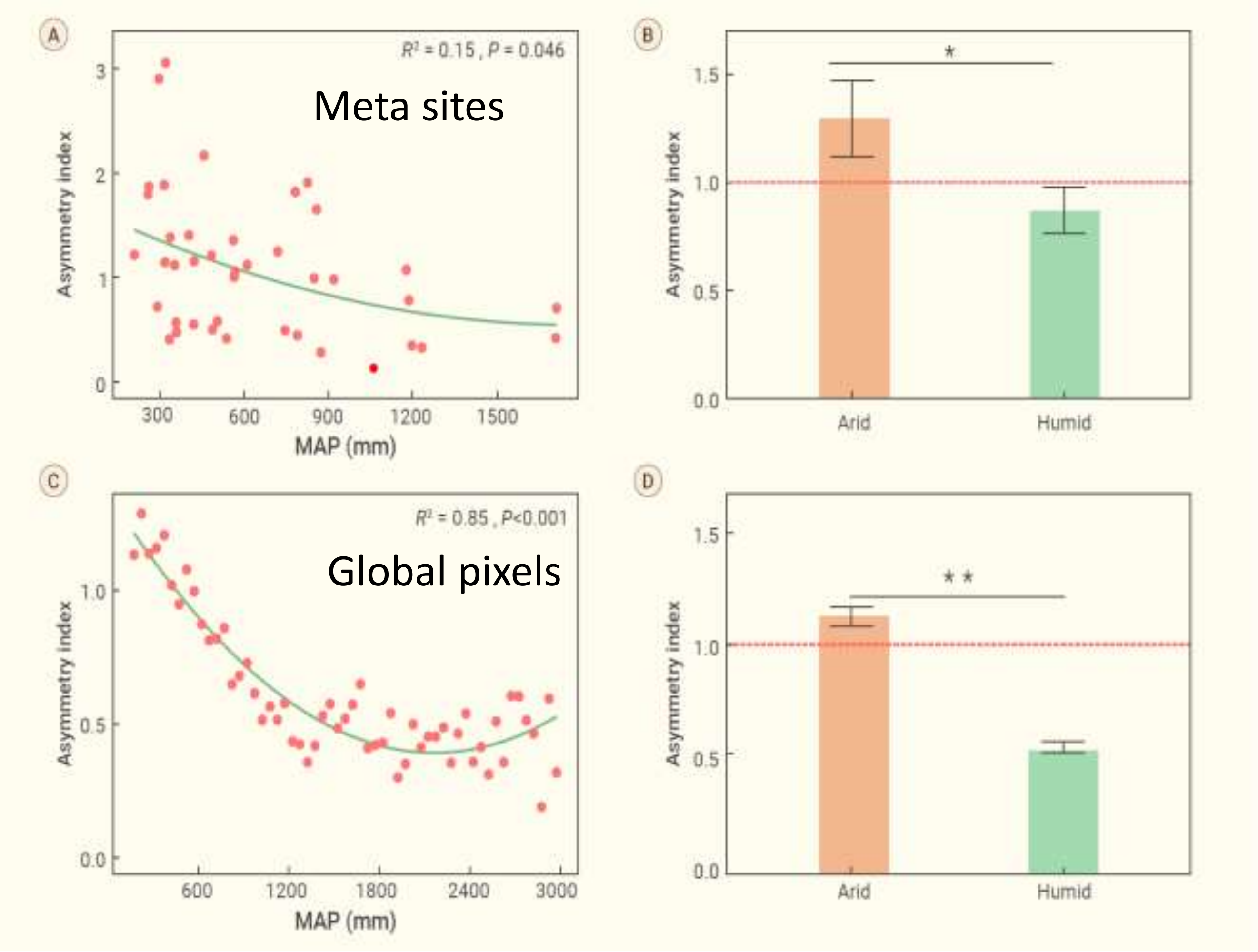
using only the 40-50% precipitation change treatments

- Consistent with normalized results



Asymmetric response of SIF

- Asymmetric index showed a decreasing trend with MAP
- Arid > Humid

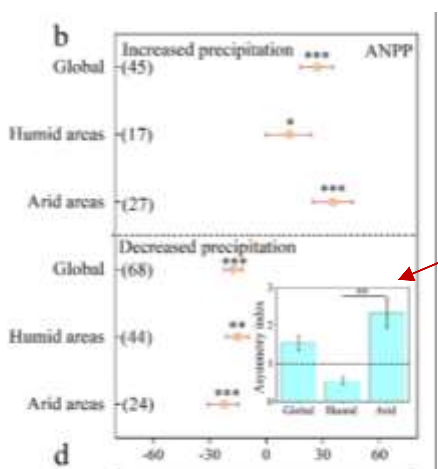


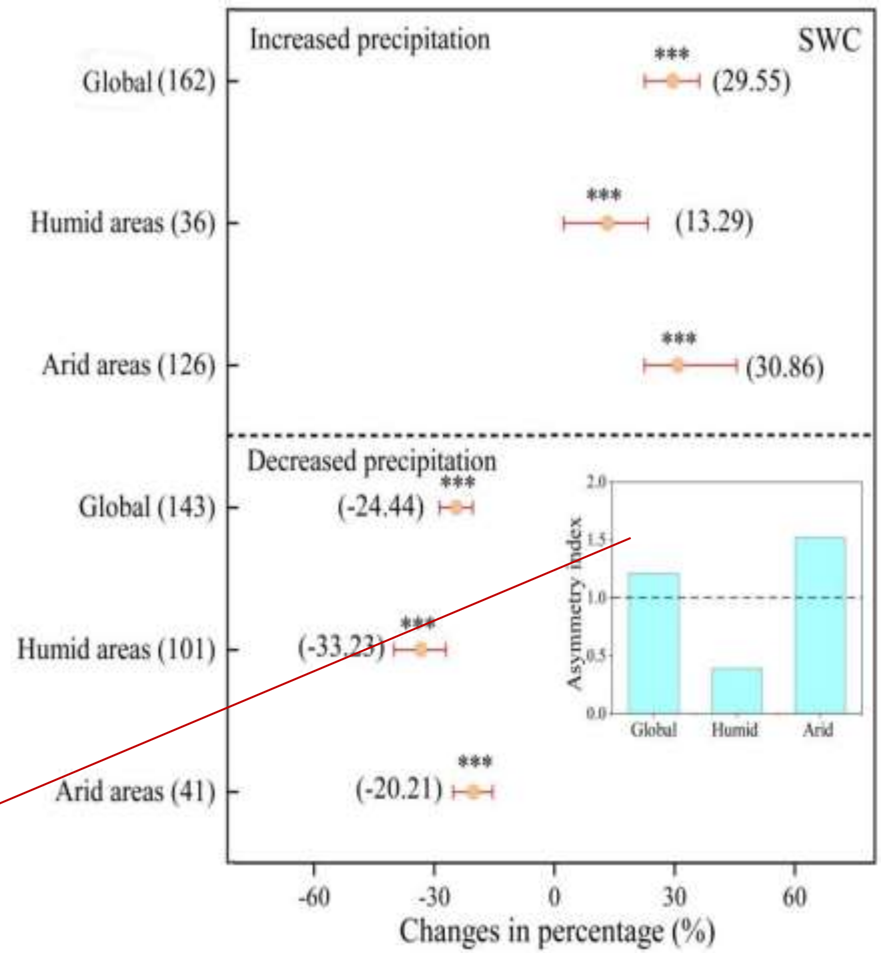
Asymmetric response of SWC

➢ **Consistent with ANPP response to changes in precipitation**

- SWC display a positive asymmetry in response to precipitation change

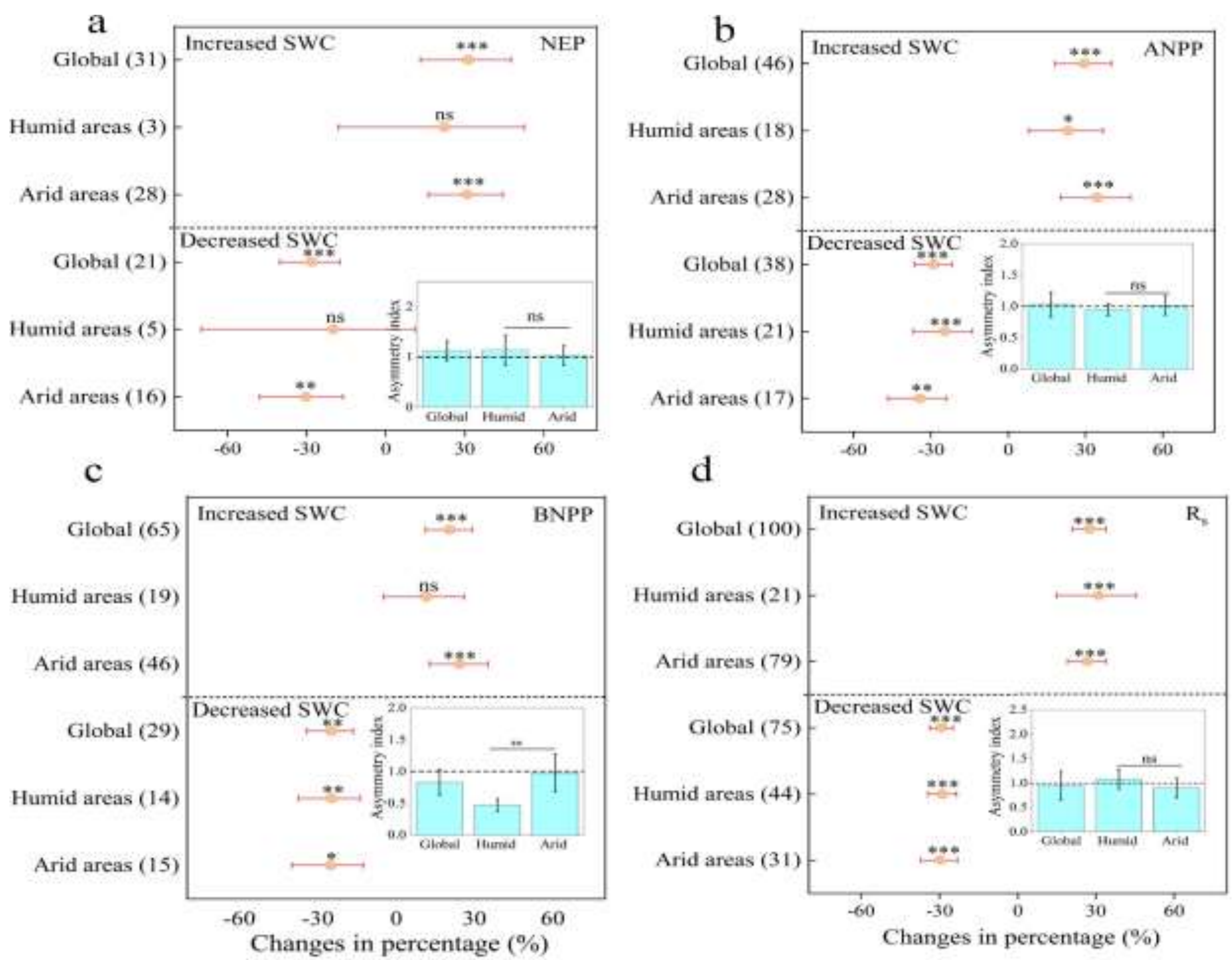
- Positive asymmetry in arid areas, negative asymmetry in humid areas





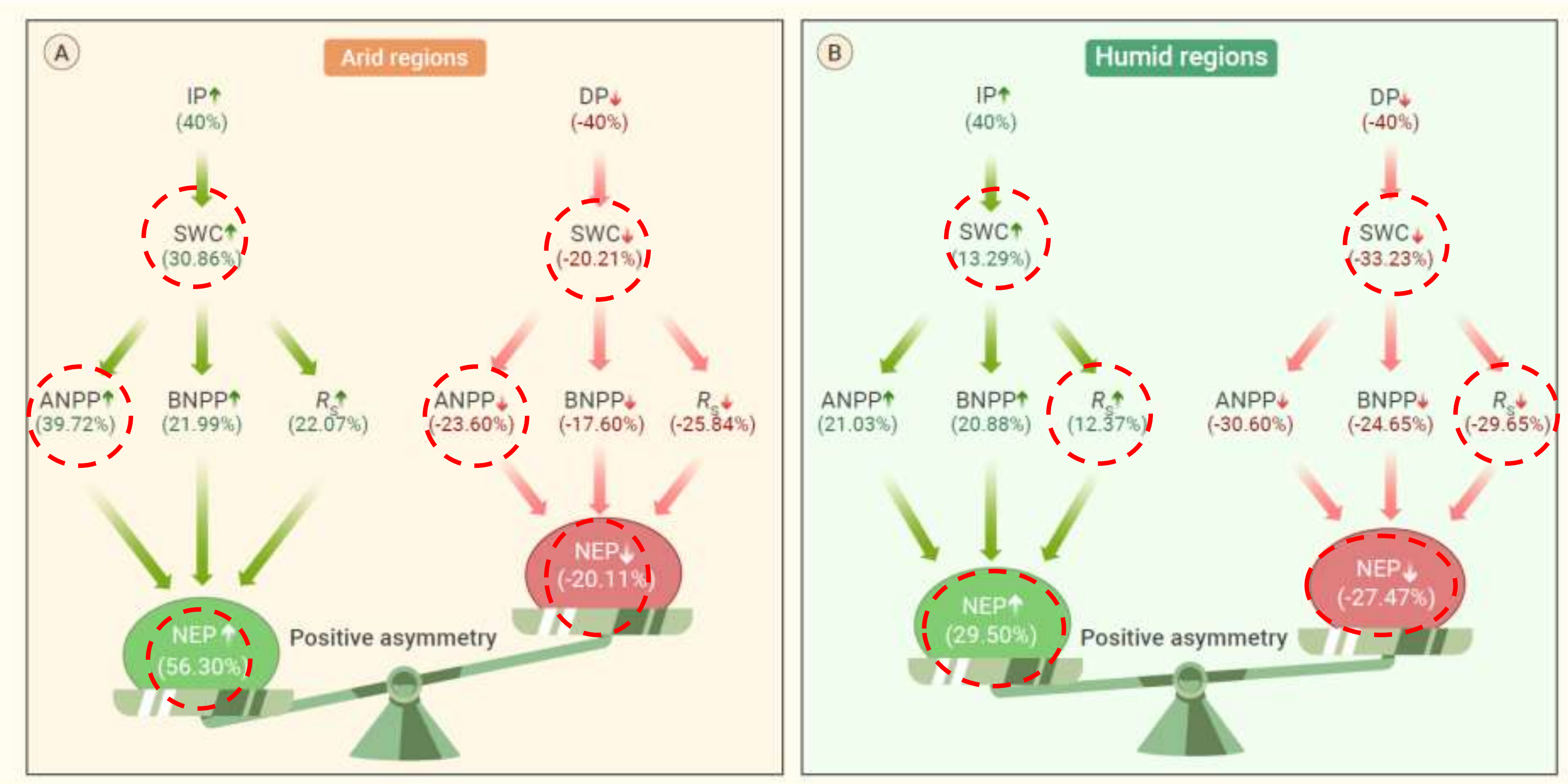
Response of carbon fluxes to normalized SWC

- Same magnitude of change in SWC did not result in asymmetric responses for most carbon processes, suggesting that precipitation change-induced asymmetry in SWC was the key factor causing the asymmetric response of NEP



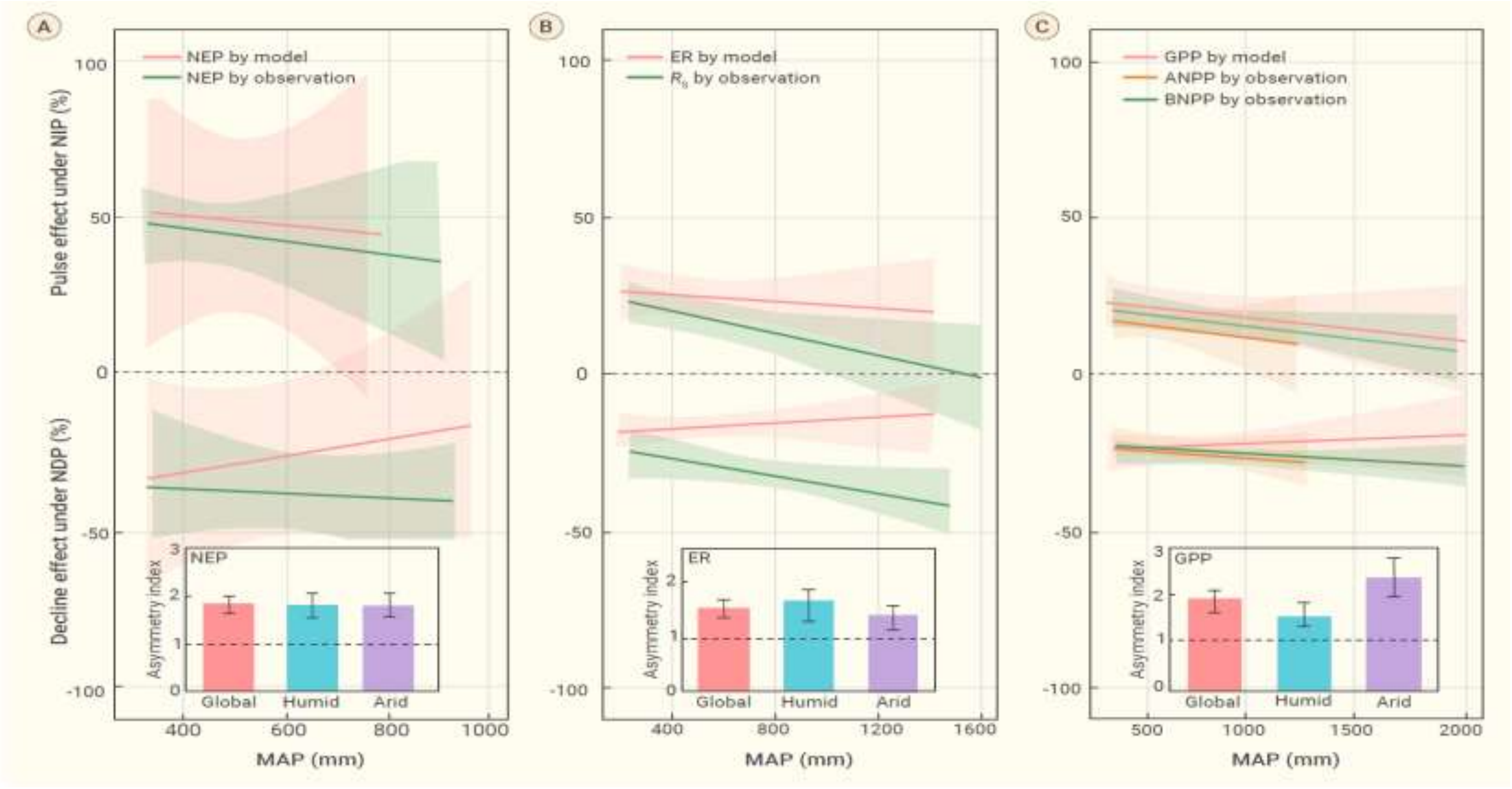
Mechanism of the asymmetric responses of carbon fluxes to precipitation changes

- The positive asymmetry of NPP (arid region) and negative ER (humid region) was mainly contributed to the positive asymmetry of NEP
- SWC is the key factor determining the asymmetric responses



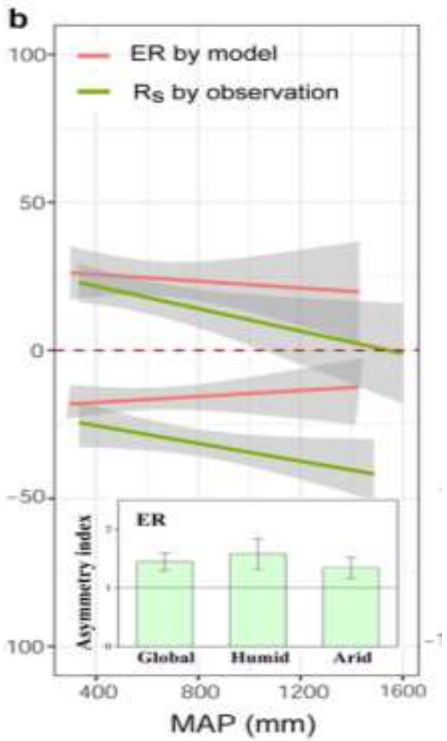
Performance of land models

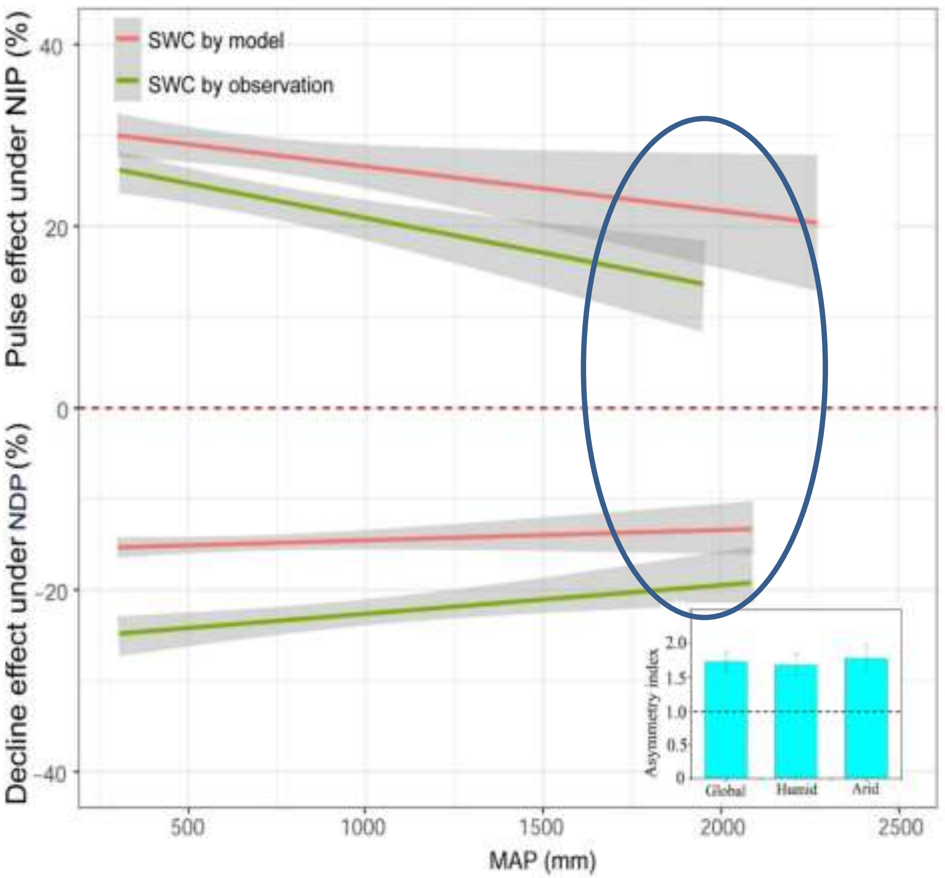
- Models captured the overall positive asymmetry of NEP in response to precipitation change at global scale
- Poor performance in simulating GPP in humid region and ER
- The simulated positive asymmetry of ER was attributed to an overestimated pulse in wet years but an underestimated reduction in dry years



Performance of land models in simulating asymmetric responses of SWC

- Model overestimated the pulse in wet years but underestimated reduction in dry years for SWC, especially in humid regions





Conclusions

- Positive asymmetry of NEP in respond to precipitation changes

$$NEP = GPP - ER$$

	NEP	GPP	ER
arid regions	+	++	+
humid regions	+	-	--

suggests that intensified precipitation IAV may favor terrestrial carbon sink under future climate change scenarios (except extreme anomalies)

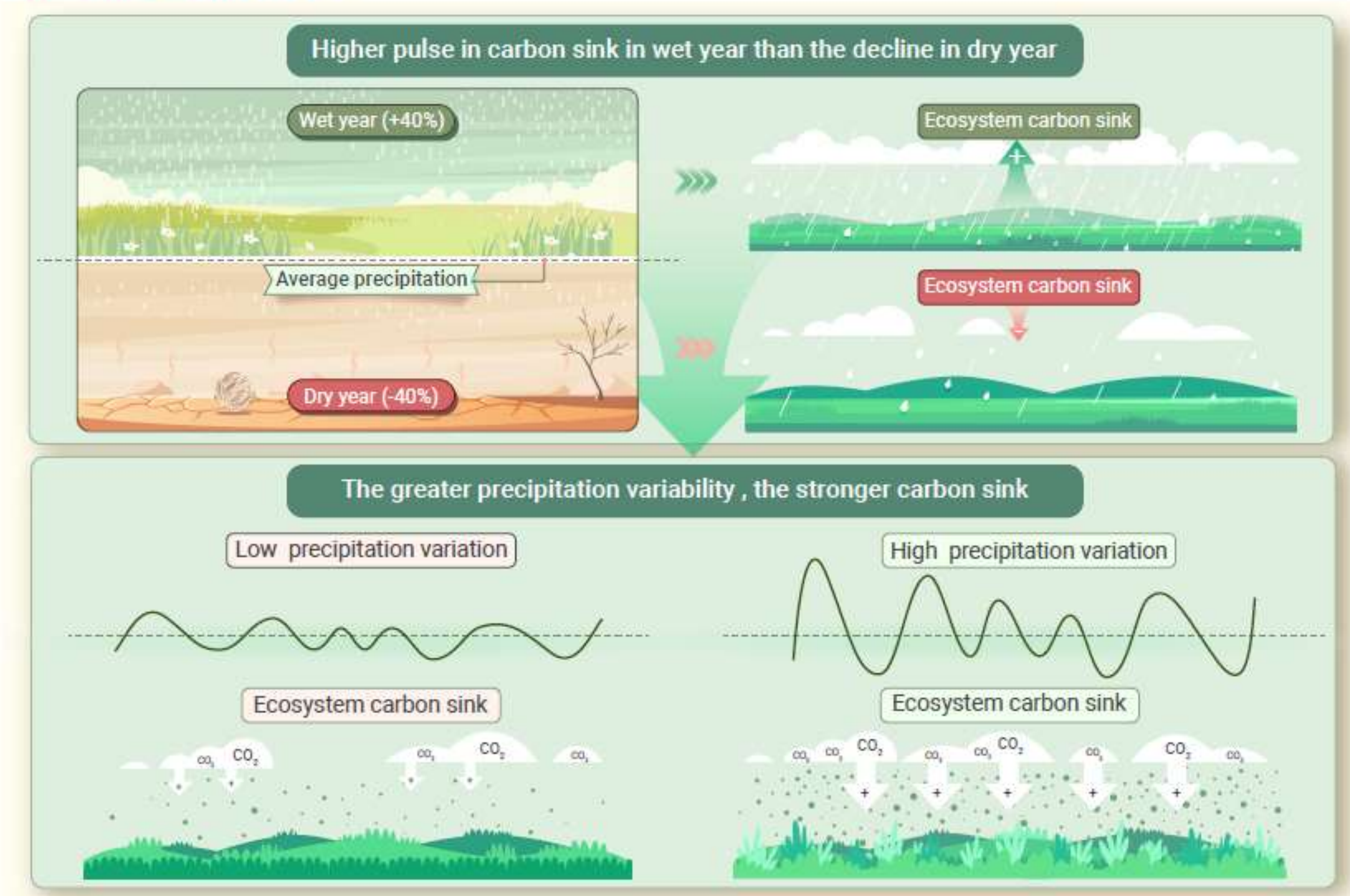
Conclusions

- Models can capture the overall positive asymmetry of NEP in response to precipitation change at global scale
- Models display poor performance in GPP response in humid regions and ER response for the whole world.
- Improvements in simulating the SWC responses is critical to promote model performance

Positive asymmetric responses indicate larger carbon sink with increase in precipitation variability in global terrestrial ecosystems

Licong Dai,[1,2] Yue Yang,[1,2] Xuhui Wang,[3] Guojiao Yang,[1,2] Minqi Liang,[4] and Zhongmin Hu[1,2,*]
*Correspondence: huzm@hainanu.edu.cn
Received: September 6, 2023; Accepted: March 11, 2024; https://doi.org/10.59717/j.xinn-geo.2024.100060

GRAPHICAL ABSTRACT



敬请指正!

huzm@hainanu.edu.cn

戴黎聪

梁敏琪