中国科学院青藏高原研究所
Institute of Tibetan Plateau Research
Chinese Academy of Sciences

第二十届中美碳联盟年会
(US-China Carbon Consortium, USCCC)

Changing vegetation growth on Tibetan Plateau and its impact on carbon uptake

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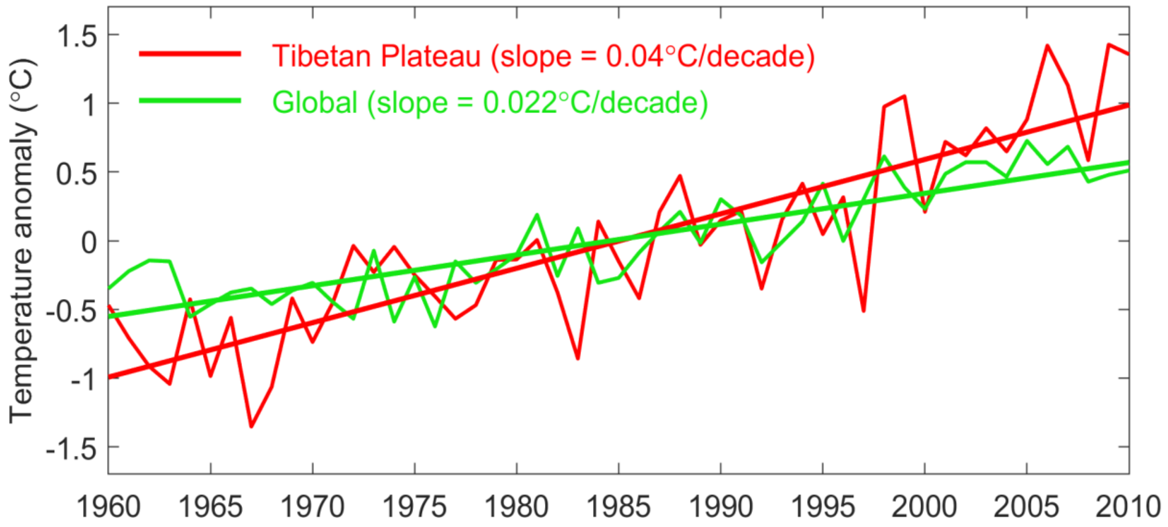
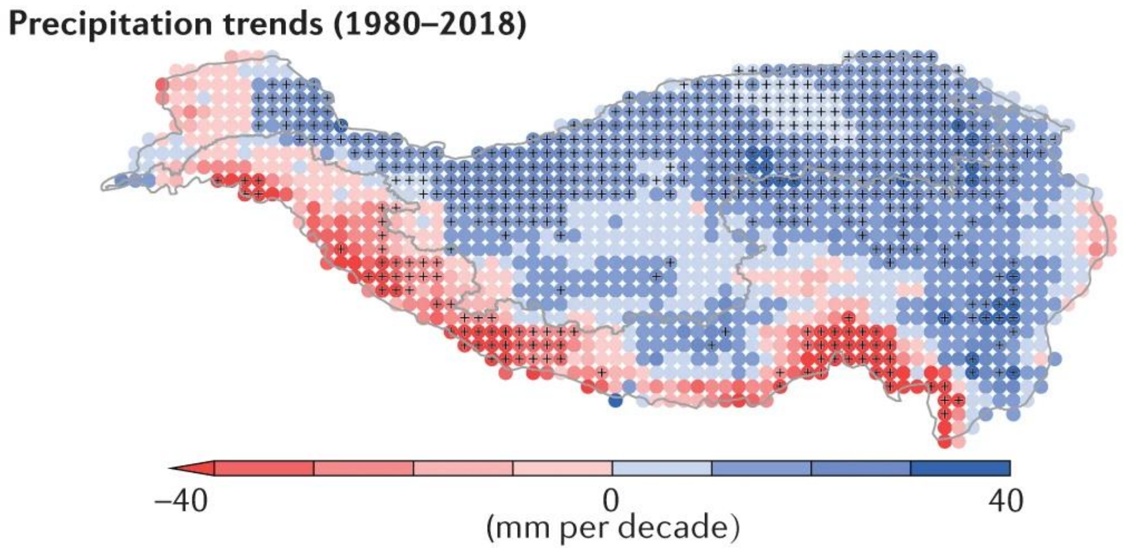
Background

Rapid climate change on Tibetan Plateau

Warming at a rate twice of global average



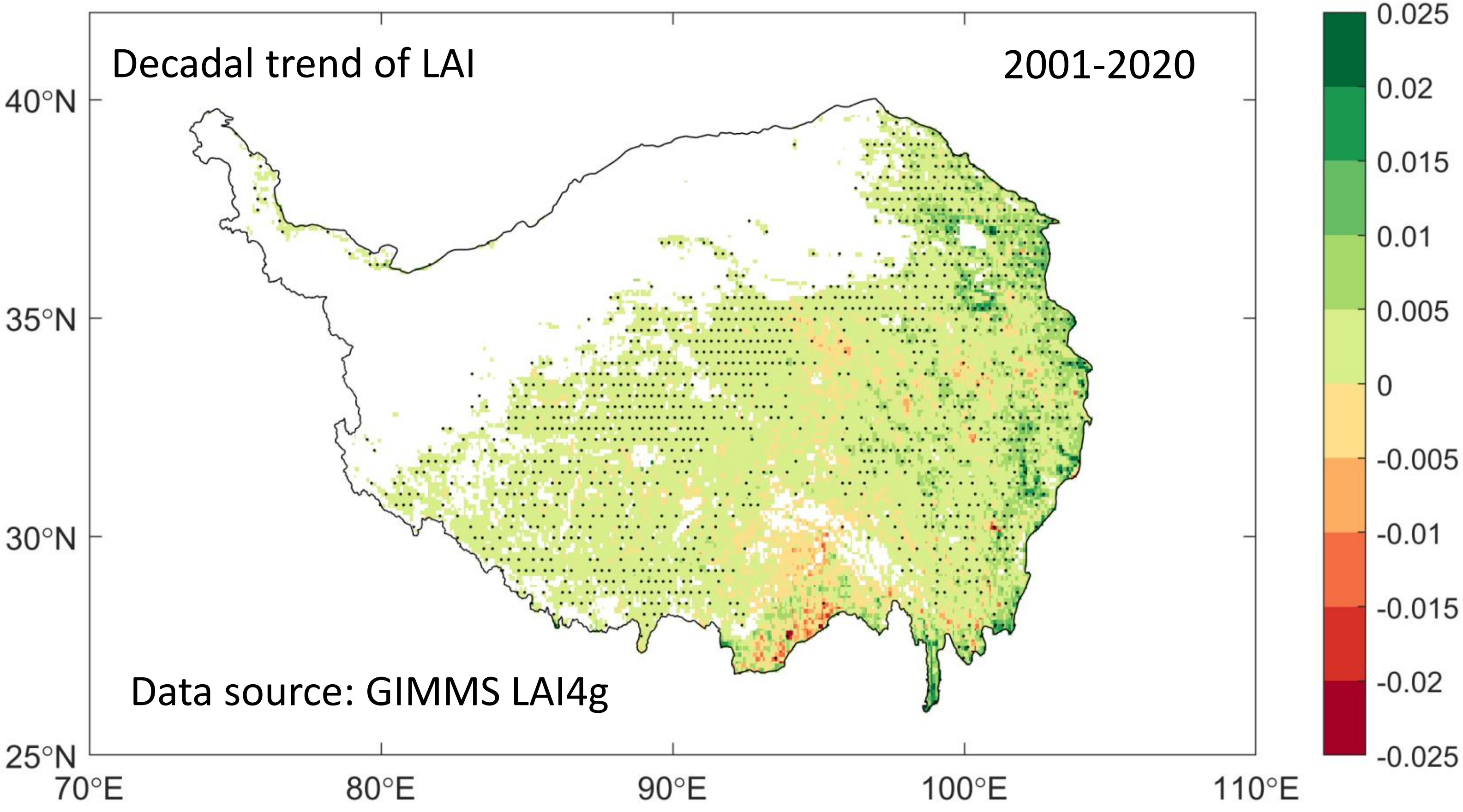
Widespread wetting in endorheic basins



(Yao et al., 2022)

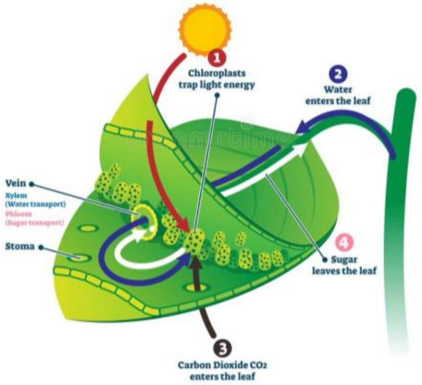
Background

Vegetation greening on Tibetan Plateau



Scientific question

How is vegetation greening contributing to ecosystem carbon uptake?



Driving factors

T_{air}, Soil moisture, VPD, CO_2 ……

1. leaf photosynthesis

Physiology

V_{cmax}, J, g_s

Canopy structure

LAI

2. carbon allocation phenology

3. Canopy radiation transfer

GPP

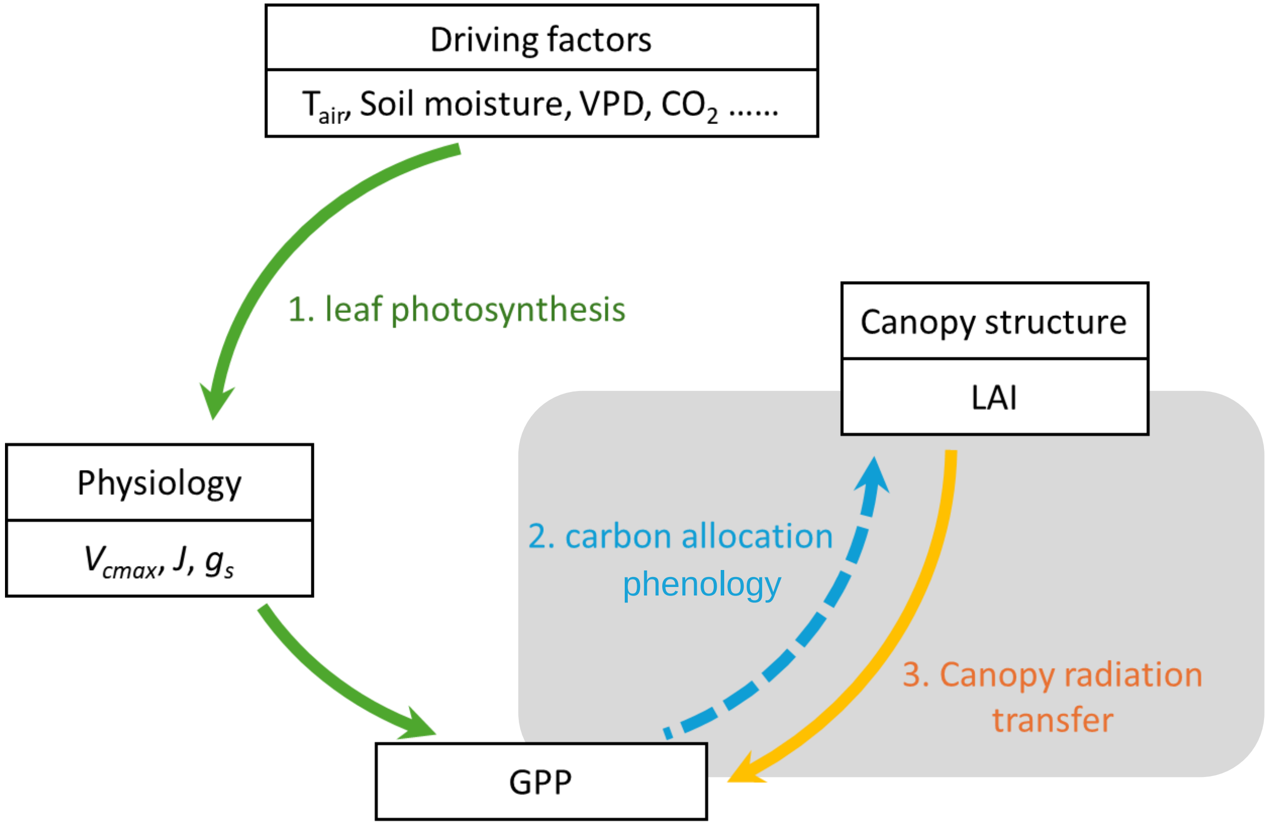
1. Contribution of vegetation greening to decadal trend of GPP

process-based photosynthesis model

$$A_n = min\begin{Bmatrix} A_v \\ A_j \\ A_p \end{Bmatrix} - R_d$$ (Farquhar model)

$$A_n = g_s(C_a - C_i)$$ (Fick's law)

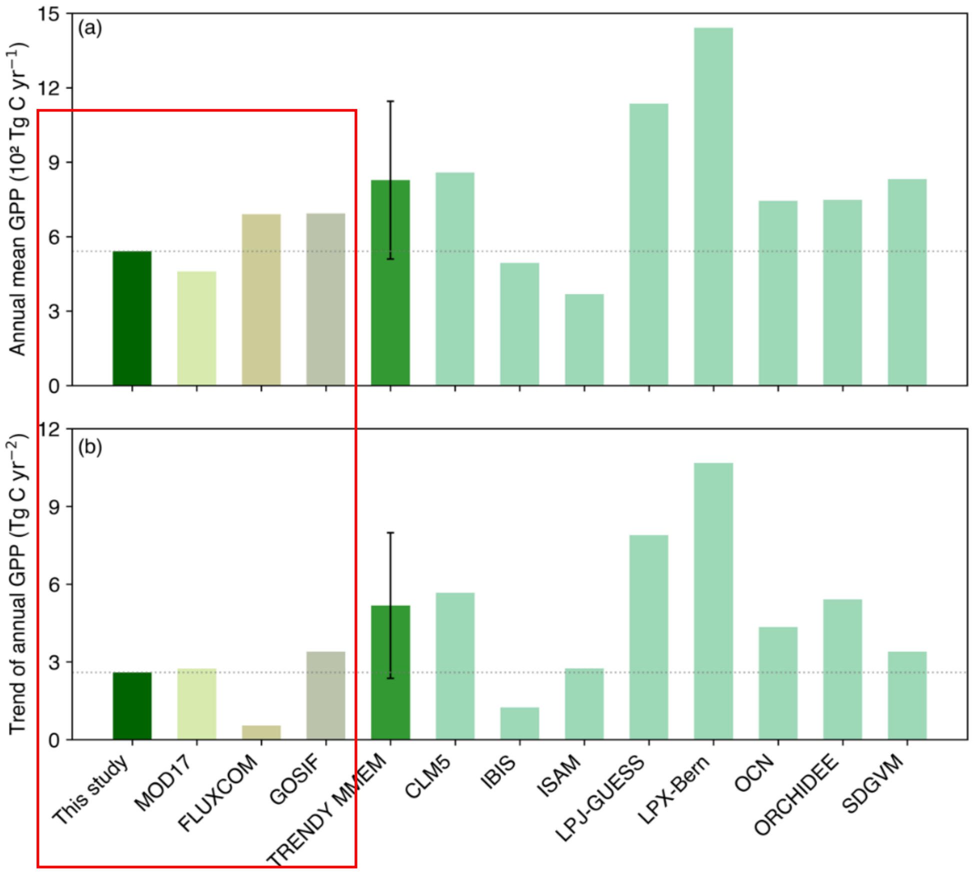
$$g_s \approx g_0 + 1.6\left(1 + \frac{g_1}{\sqrt{D}}\right)\frac{A_n}{C_a}$$ (Medlyn model)

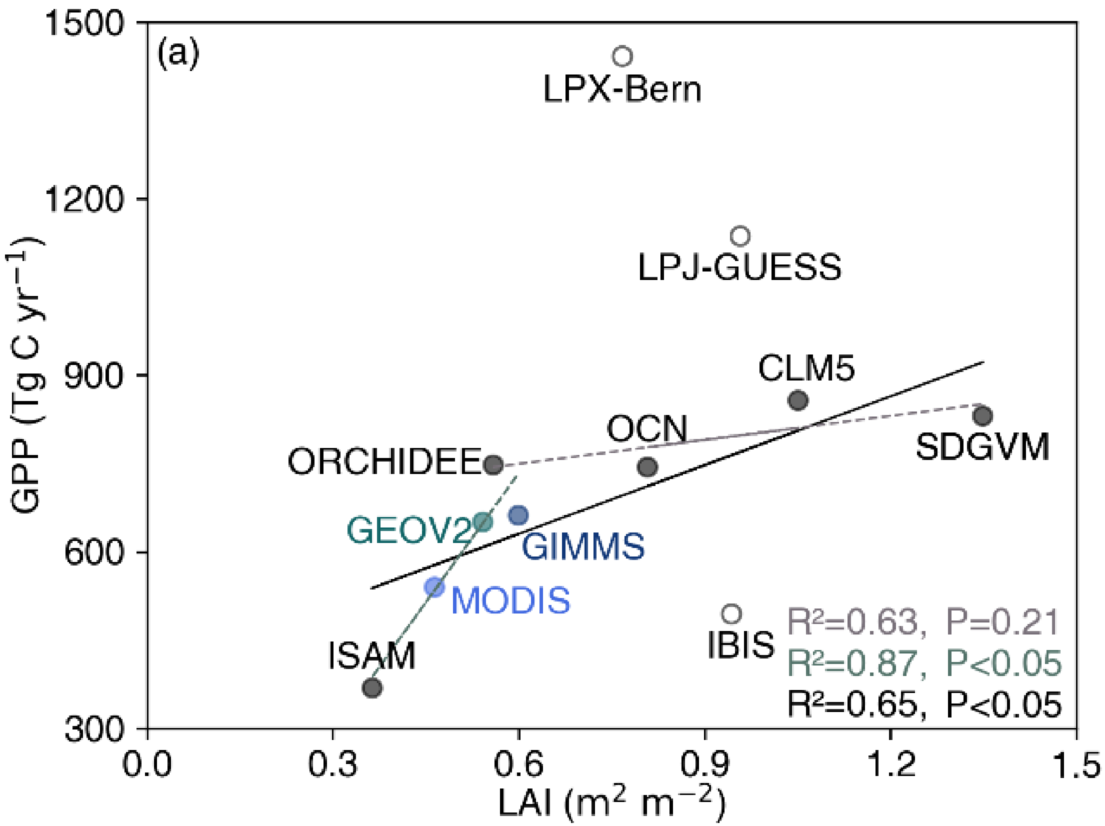


(Chen, Liu* et al. 2024, Agricultural and Forest Meteorology)

1. Contribution of vegetation greening to decadal trend of GPP

Acceptable uncertainties after we control LAI in the process-based model

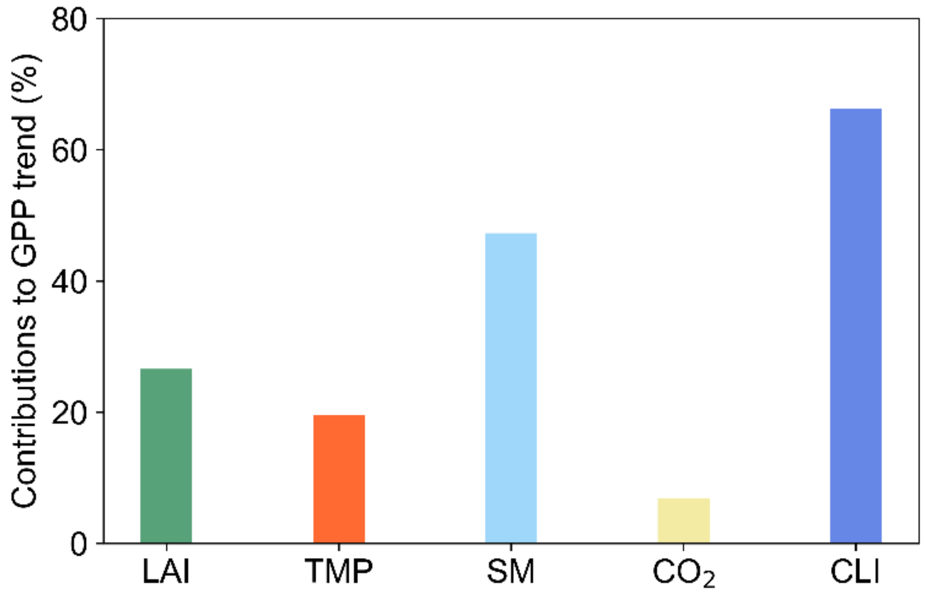




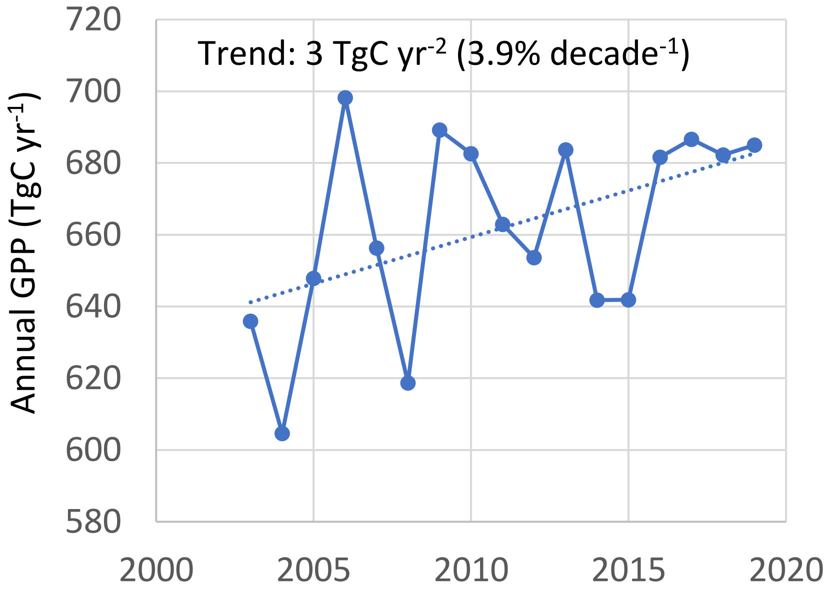
(Chen, Liu* et al. 2024, Agricultural and Forest Meteorology)

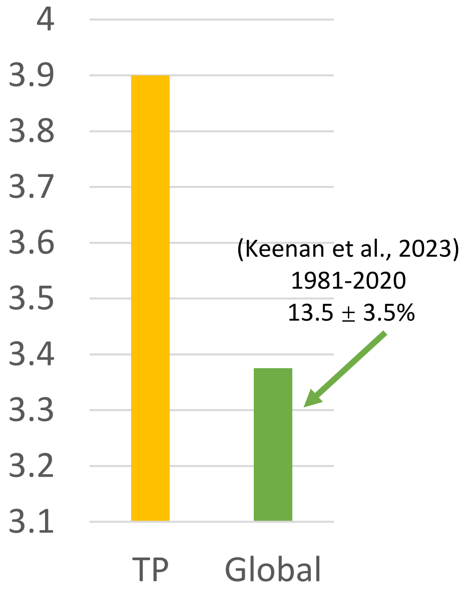
1. Contribution of vegetation greening to decadal trend of GPP

Greening contributed to 27% of increasing GPP



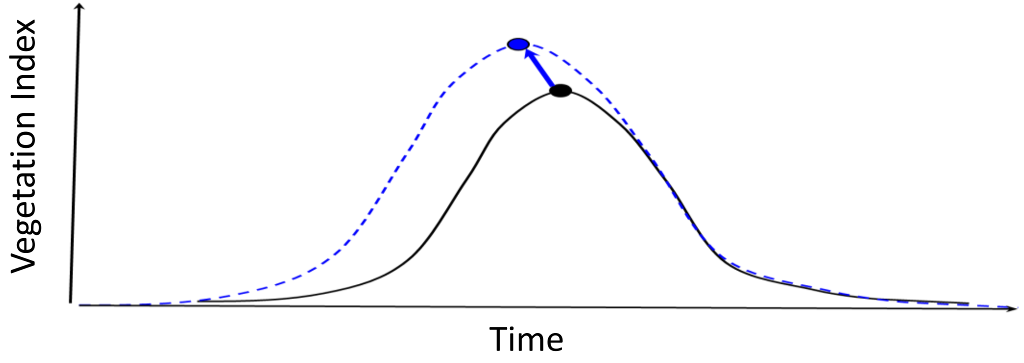
GPP is increasing with a rate around 3.9% per decade



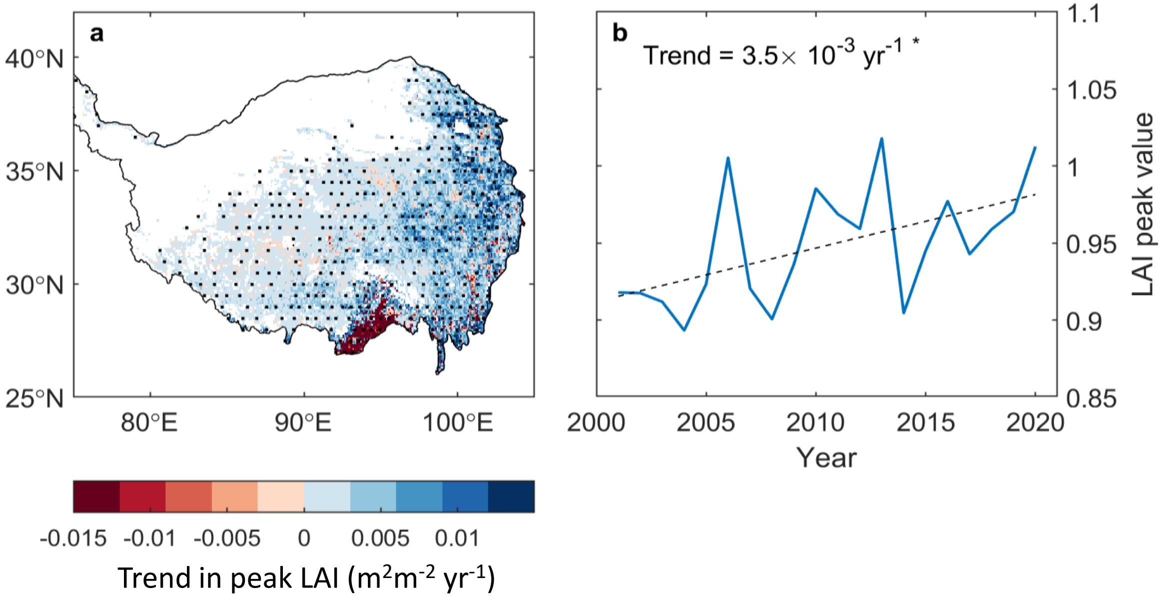


(Chen, Liu* et al. 2024, Agricultural and Forest Meteorology)

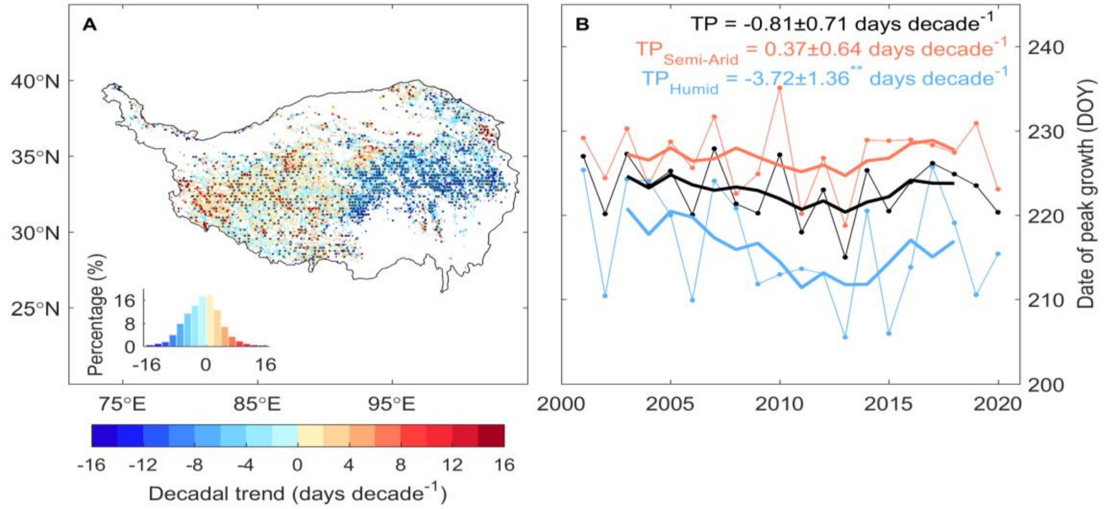
2. Shifts in the phenology of vegetation growth



Enhancing peak values



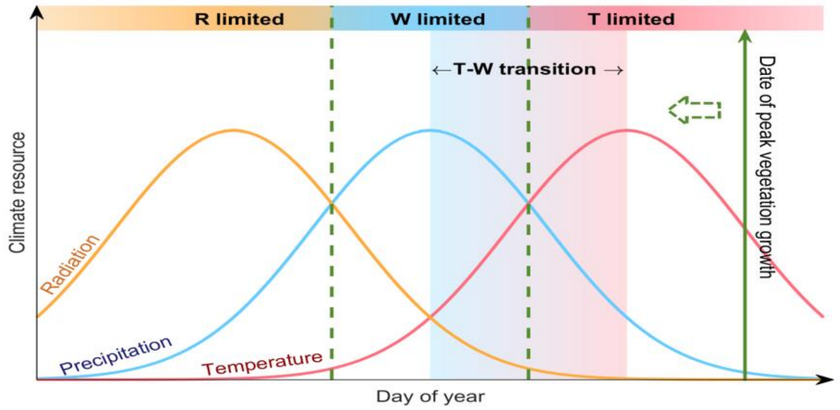
Advancing peak timing



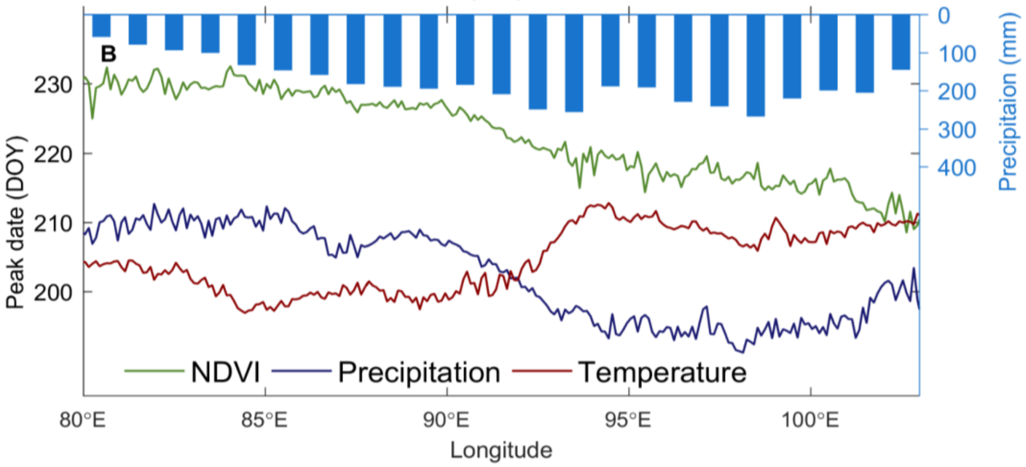
(Xu, Liu* et al., 2023, Frontiers in Plant Science)

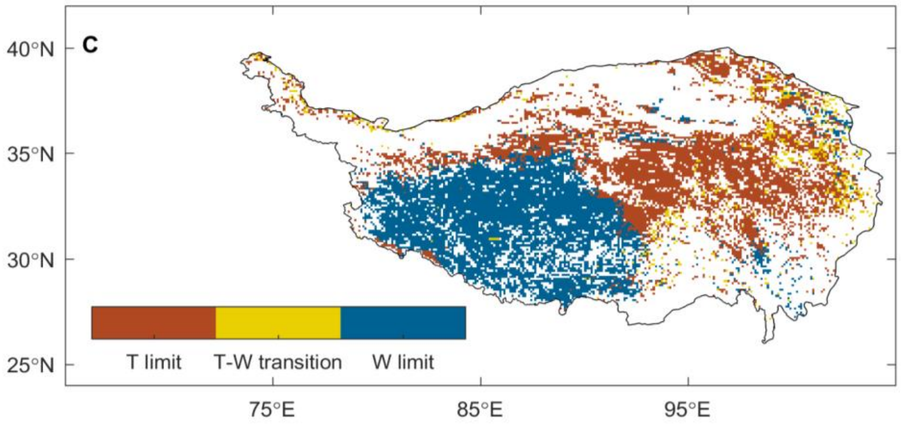
2. Shifts in the phenology of vegetation growth

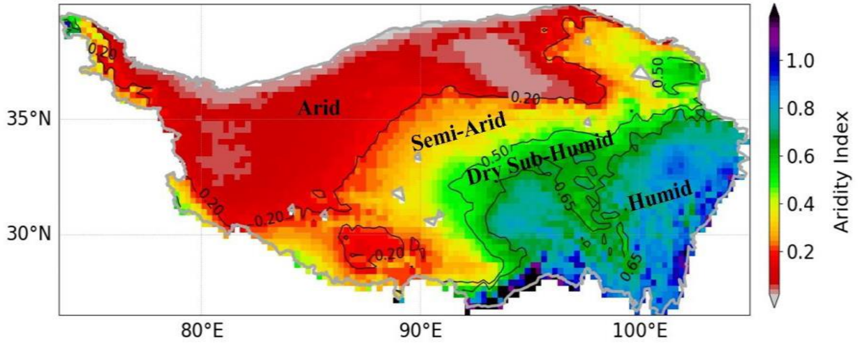
Framework based on the “laws of minimum”



(Parker et al., 2019, Global Change Biology)



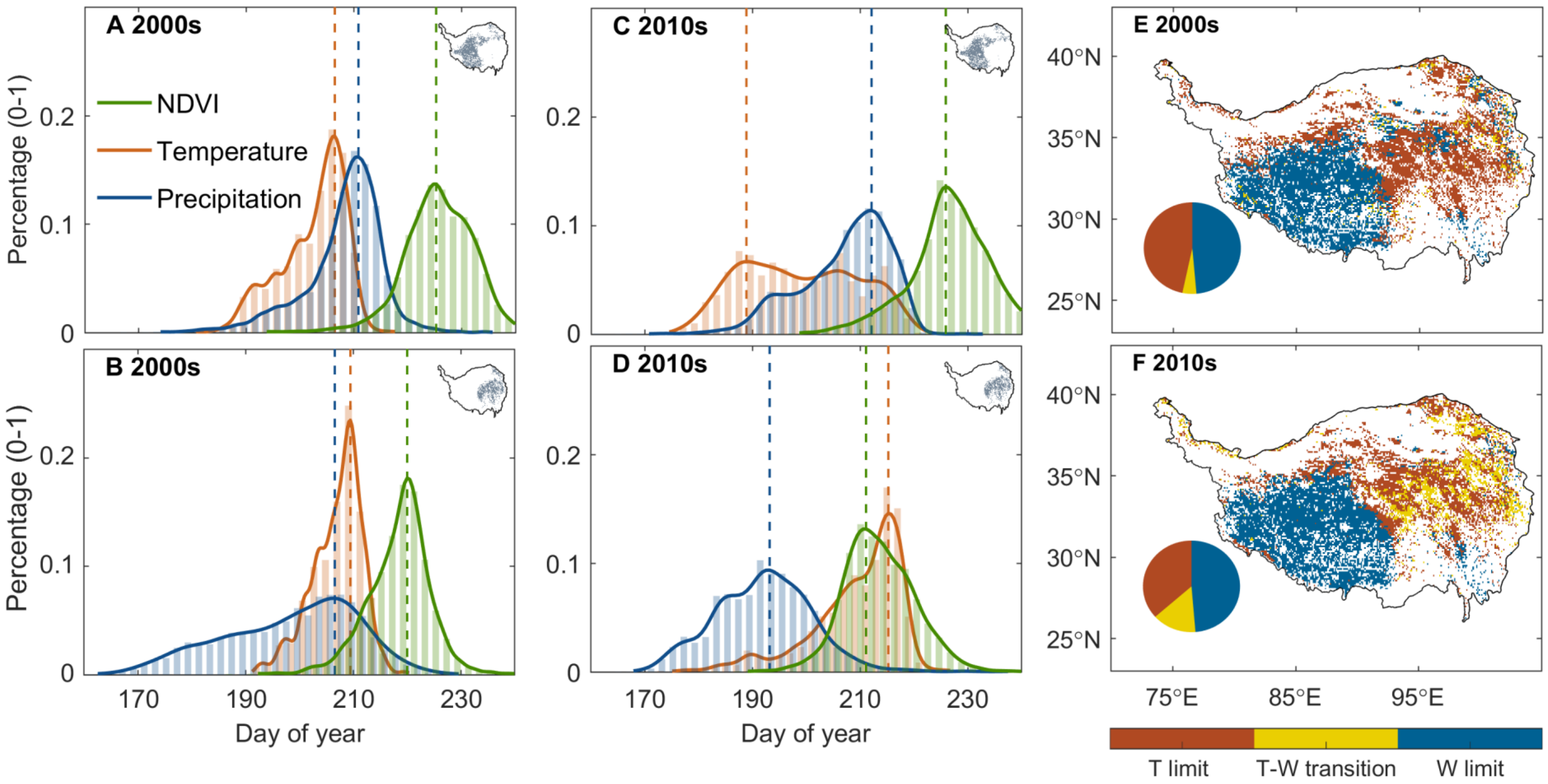




(Xu, Liu* et al., 2023, Frontiers in Plant Science)

2. Shifts in the phenology of vegetation growth

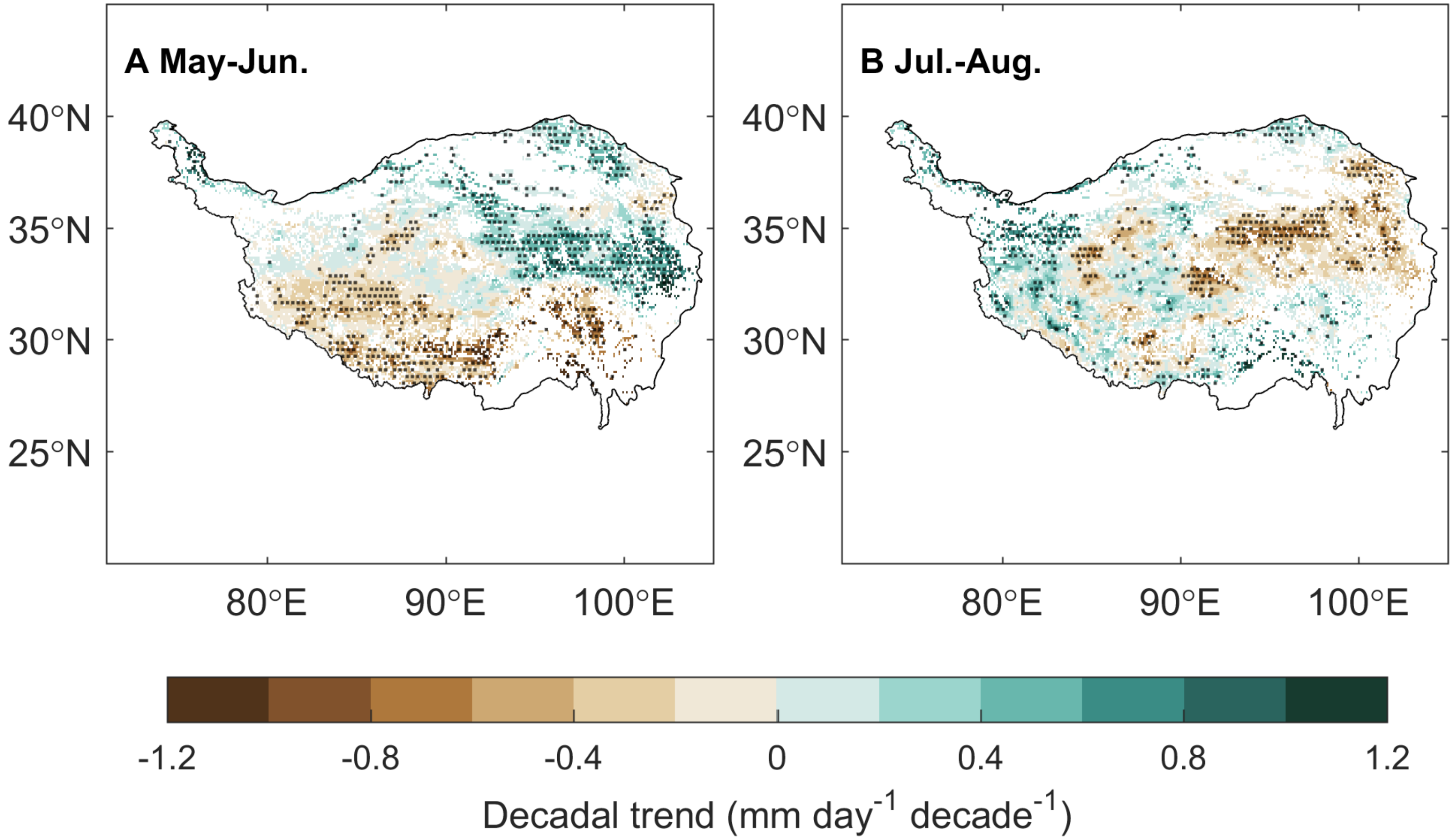
10% of the grasslands over the Tibetan Plateau is facing increasing water stress during peak season in summer



(Xu, Liu* et al., 2023, Frontiers in Plant Science)

2. Shifts in the phenology of vegetation growth

External driver: precipitation is decreasing during late green-up stage

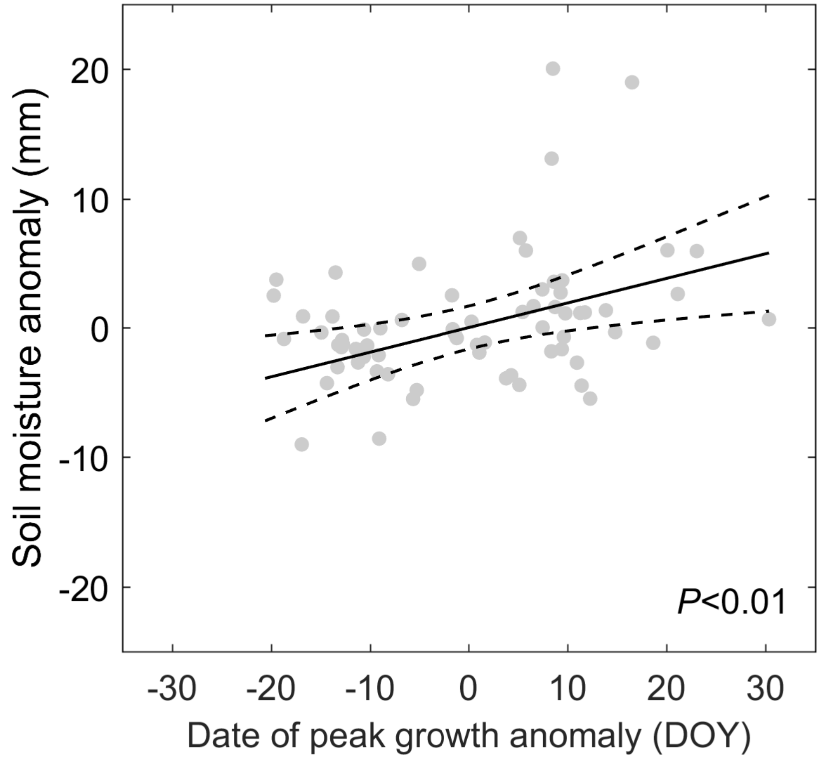


(Xu, Liu* et al., 2023, Frontiers in Plant Science)

Data source: reanalysis product of Indian Monsoon Data Assimilation and Analysis reanalysis (IMDAA) project

2. Shifts in the phenology of vegetation growth

Endogenous driver: rapid growth in early green-up stage exploit soil water and suppress growth during peak season



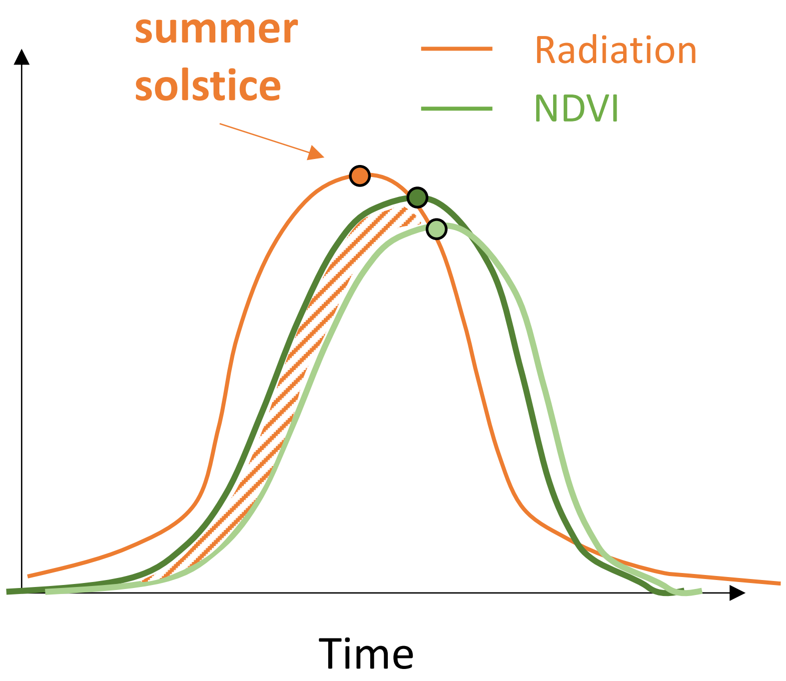
- We conducted partial correlation analysis by relating soil moisture with the date of peak growth, while controlling the precipitation.

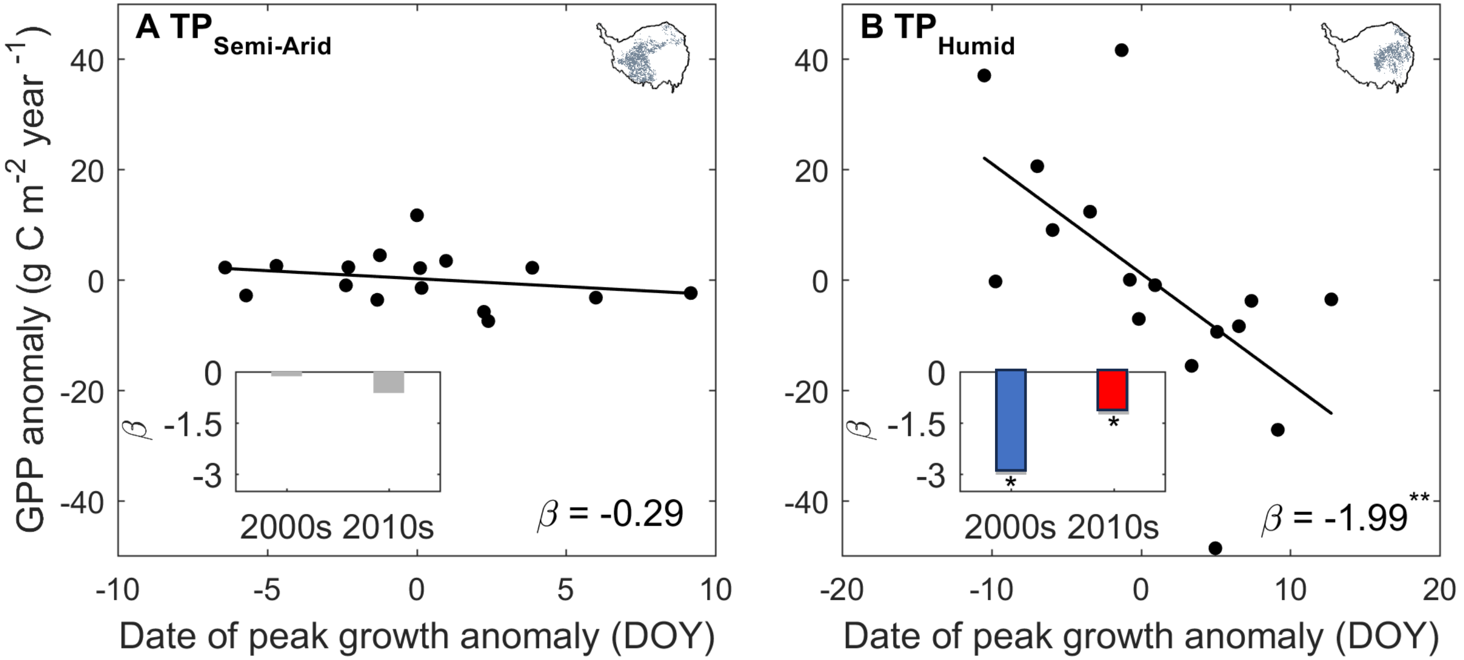
- Years with earlier peak of vegetation growth also show lower soil moisture.

(Xu, Liu* et al., 2023, Frontiers in Plant Science)

3. Implication for shifting phenology on ecosystem carbon uptake

Advancing peak growth stimulates ecosystem production, but this impact is weakening due to increasing water limitation





(Xu, Liu* et al., 2023, Frontiers in Plant Science)

Take home message

1. Increasing carbon uptake on Tibetan Plateau is primarily driven by warming and wetting climate through leaf physiology instead of canopy greening.

2. An enhanced and spring-ward shift of peak vegetation growth is accompanied by abundant water resources in early growing season, as well as increasing water limitations during the peak season.

3. Spring-ward shift of peak vegetation growth could benefit ecosystem carbon uptake, but this impact is weakening during past two decades.

Welcome collaboration

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- Google scholar page: https://scholar.google.com/citations?user=XIk38mIAAAAJ&hl=en

References:

1. Chen SY, **Liu D***, Zhang Y, Zheng RS, Wang T. (2024) Data-constrained modeling of terrestrial gross primary production over the Tibetan Plateau for 2003–2019. *Agricultural and Forest Meteorology*. 355: 110129. DOI: https://doi.org/10.1016/j.agrformet.2024.110129

2. Xu CY, **Liu D***, Wang XY, Wang T. (2023) Shifting from a thermal-constrained to water-constrained ecosystem over the Tibetan Plateau. *Frontiers in Plant Science*. 14, 1125288. doi: 10.3389/fpls.2023.1125288.