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The mechanism of foliar physiological parameters restricting foliar assimilation of atmospheric mercury in typical forest ecosystems

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Report outline

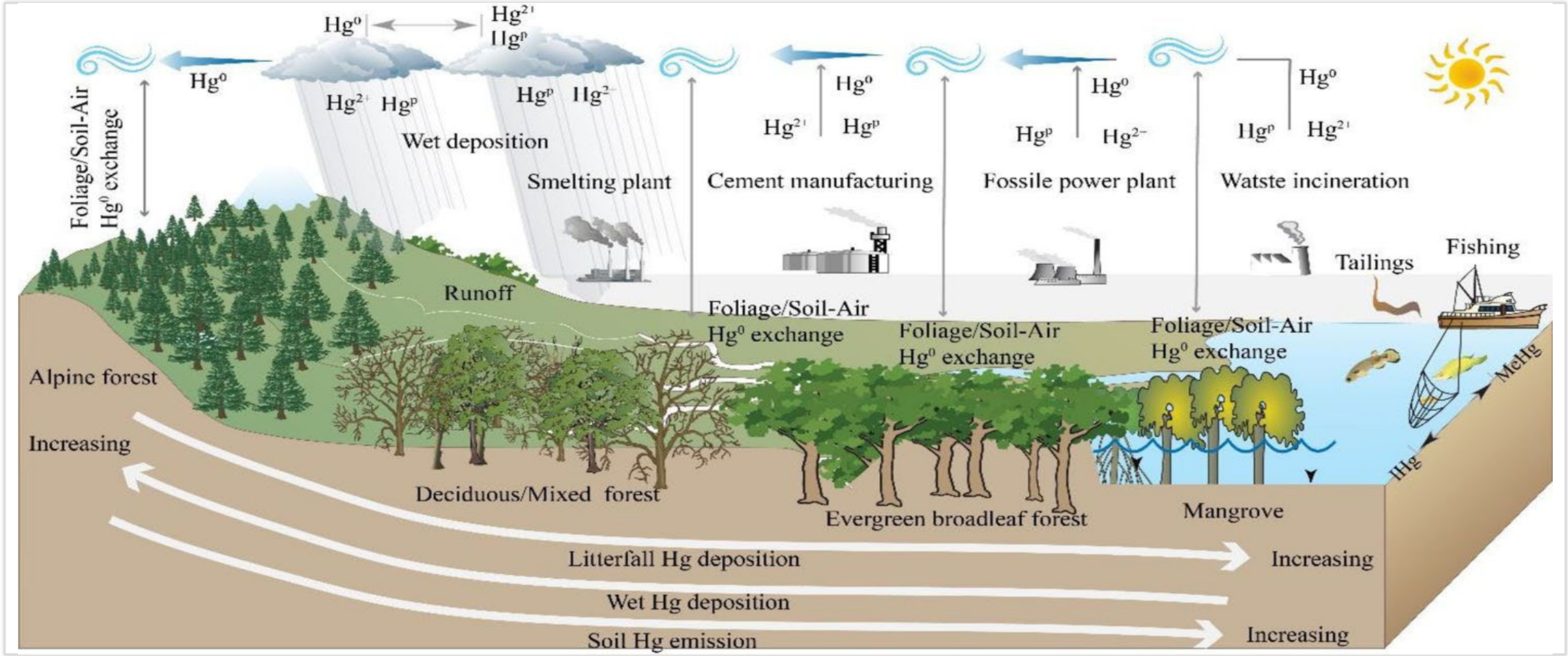
一 Introduction

二 Methods

三 Results and discussion

四 Conclusions

1 Introduction

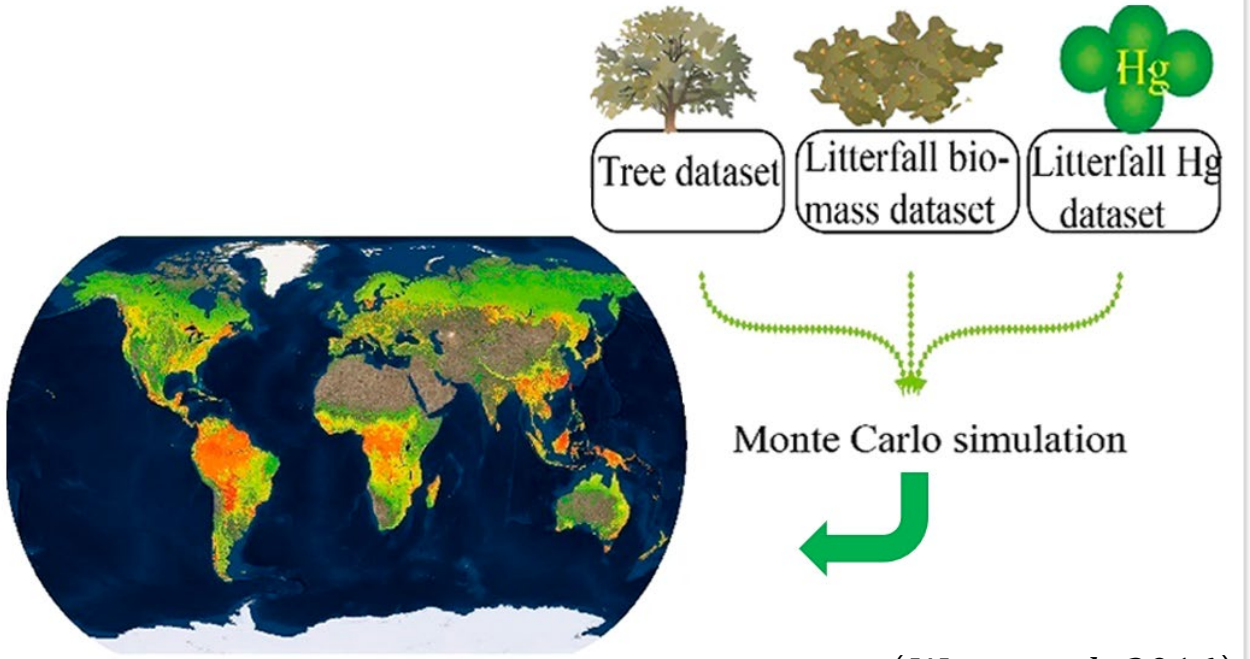


(Wang et al., 2021 *)*

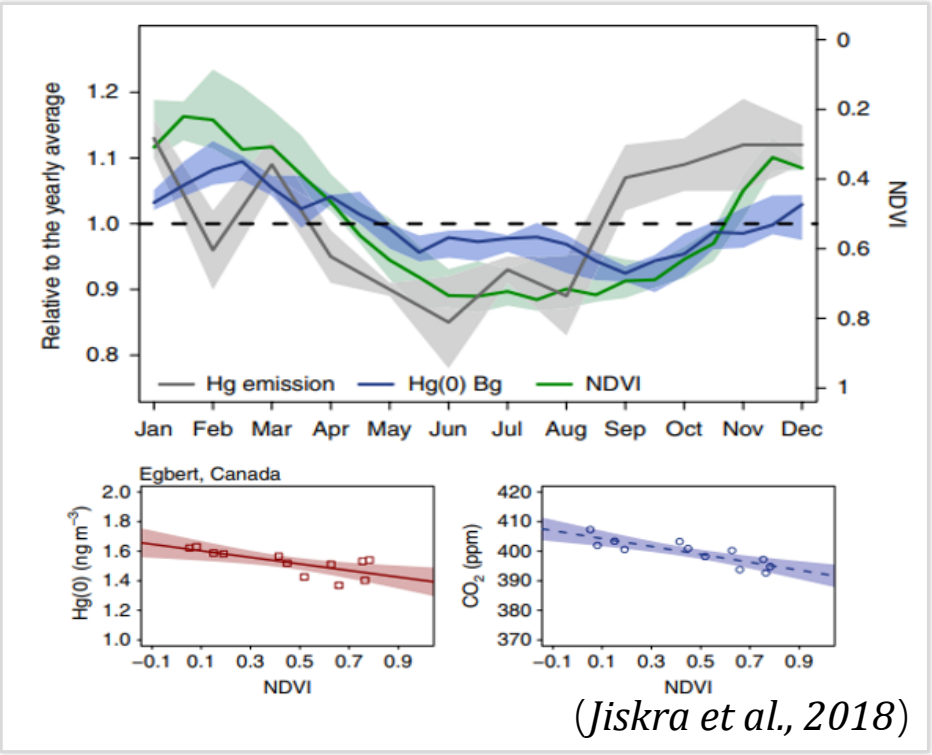
Forest ecosystem is an important Hg reservoir globally

1 Introduction

Foliar uptake of Hg^0 → the main input of atmospheric Hg^0 into terrestrial ecosystems



(*Wang et al.*, 2016)

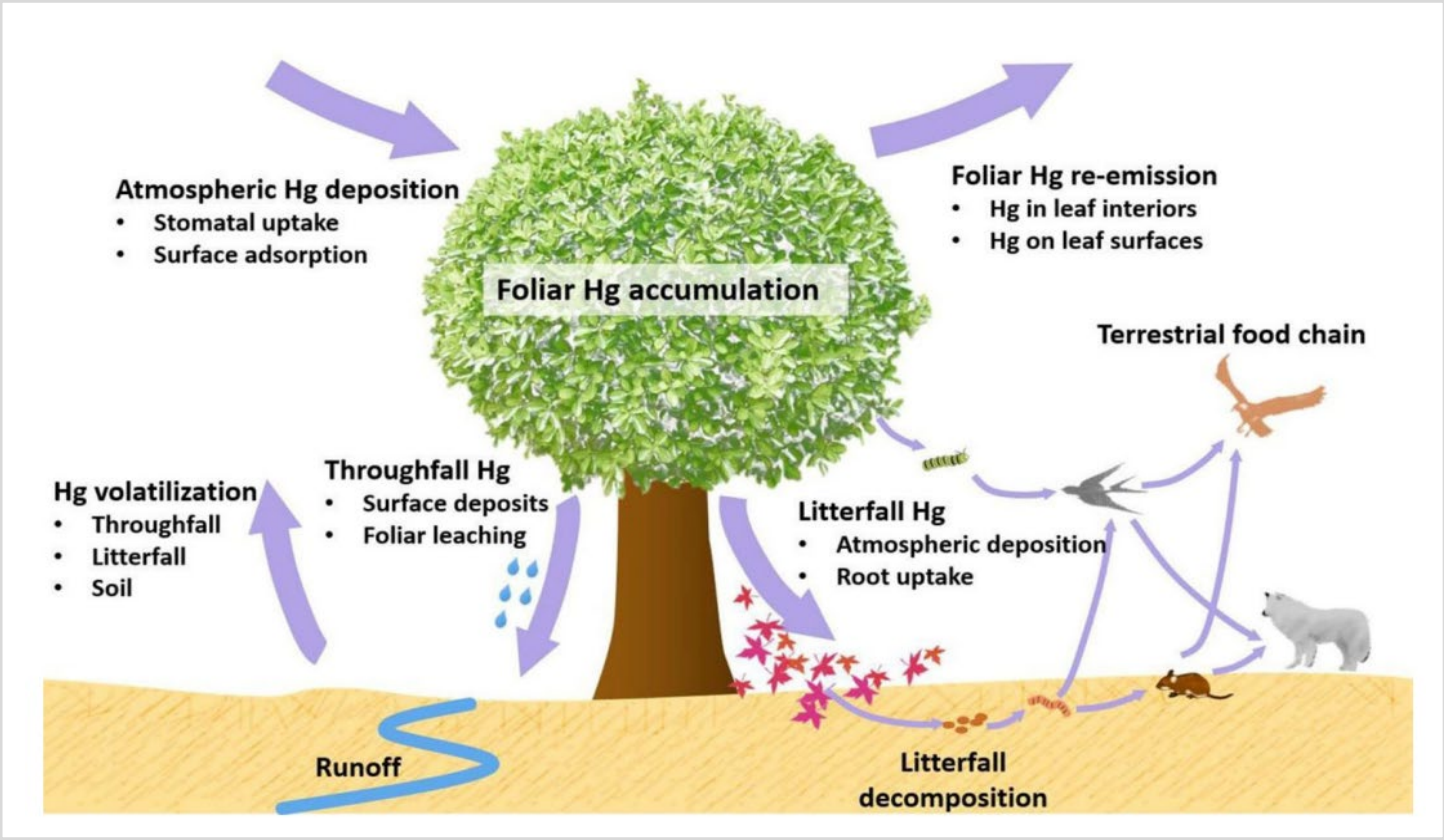


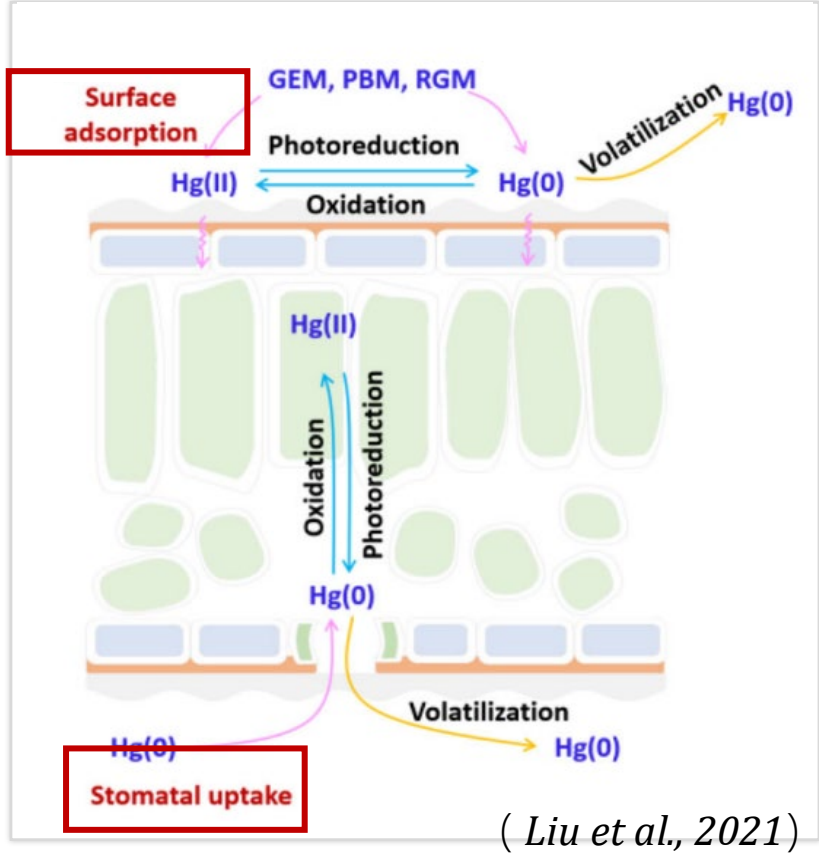
(*Jiskra et al., 2018*)

- ***Regulate the spatial and temporal distribution of Hg^0 in the global atmosphere***

1 Introduction

Atmospheric Hg^0 uptake by foliage is closely related to the foliar physiological characteristics

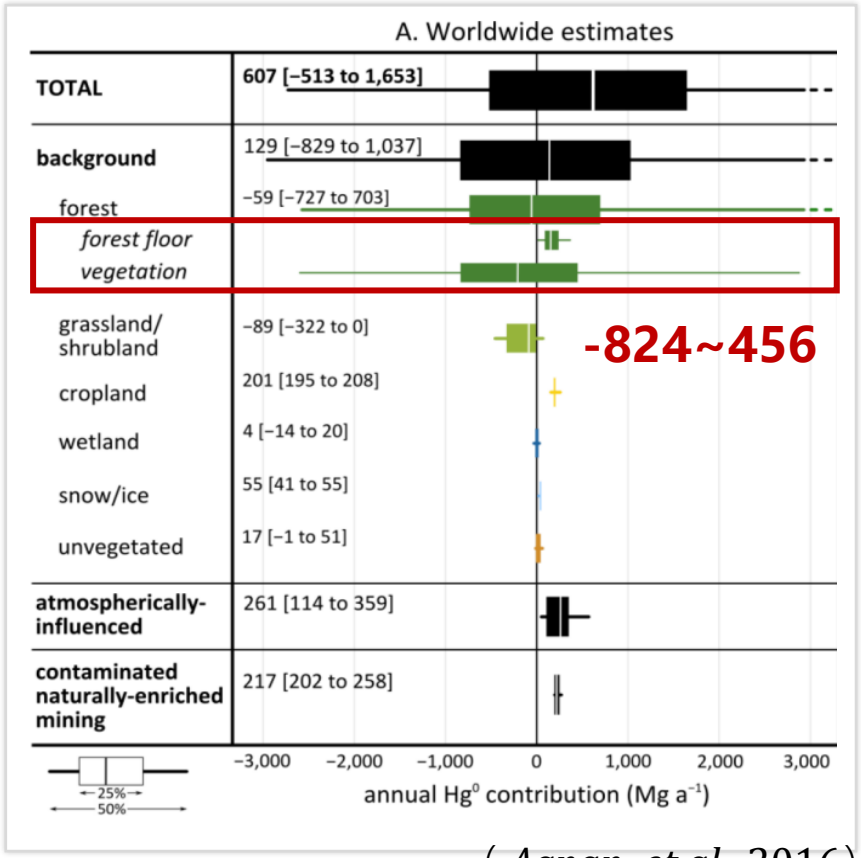




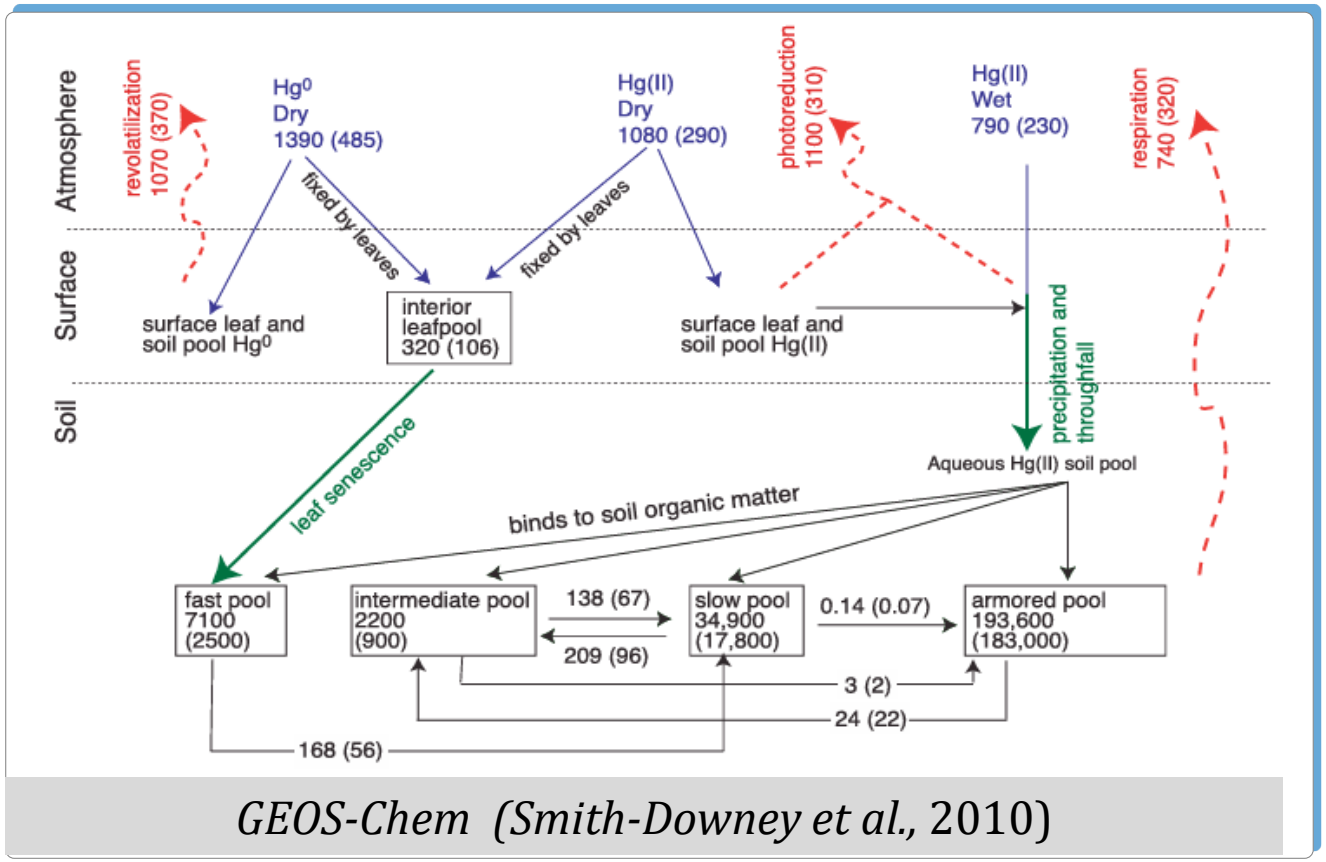
(*Liu et al., 2021*)

Present knowledge on the mechanism of atmospheric Hg^0 uptake by foliage remains deficient

1 Introduction



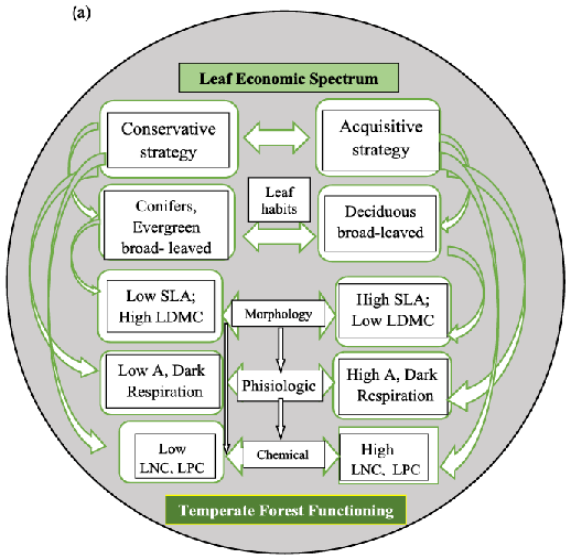
(*Agnan et al.*, 2016)



GEOS-Chem (Smith-Downey et al., 2010)

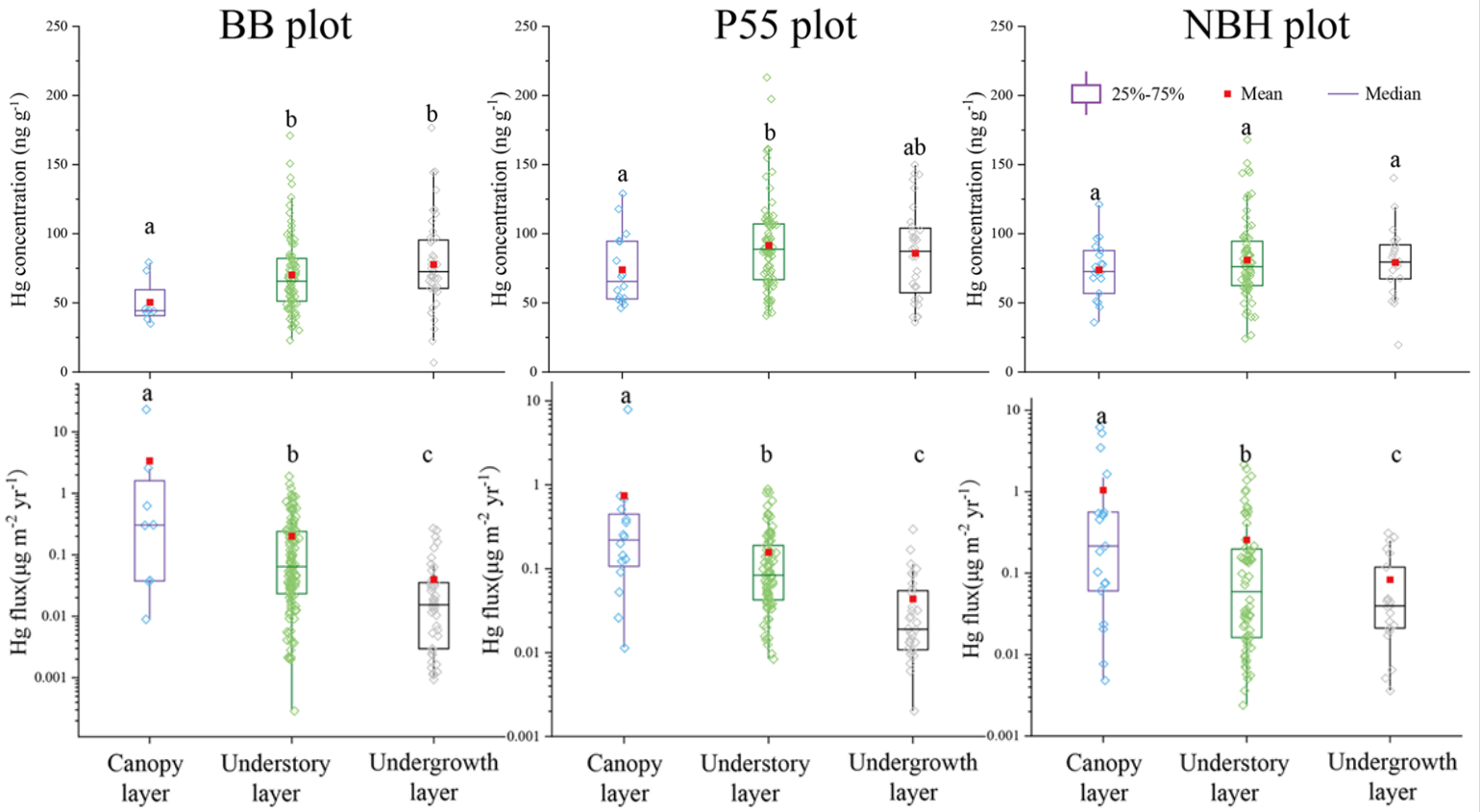
- ***Current global Hg transport model failing to accurately quantify the contribution of vegetation Hg uptake***

1 Introduction



Variation in the plant physiological and functional traits were compatible with the survival strategies of vegetation

(*Rawat et al.*, 2021)



(*Xia et al., 2022*)

- ***Foliar Hg concentration varies significantly among different ecological niches***
- ***Hg concentration and Hg flux were noteworthily different under various hydrothermal gradients***

Key scientific question and hypothesis

Scientific Question

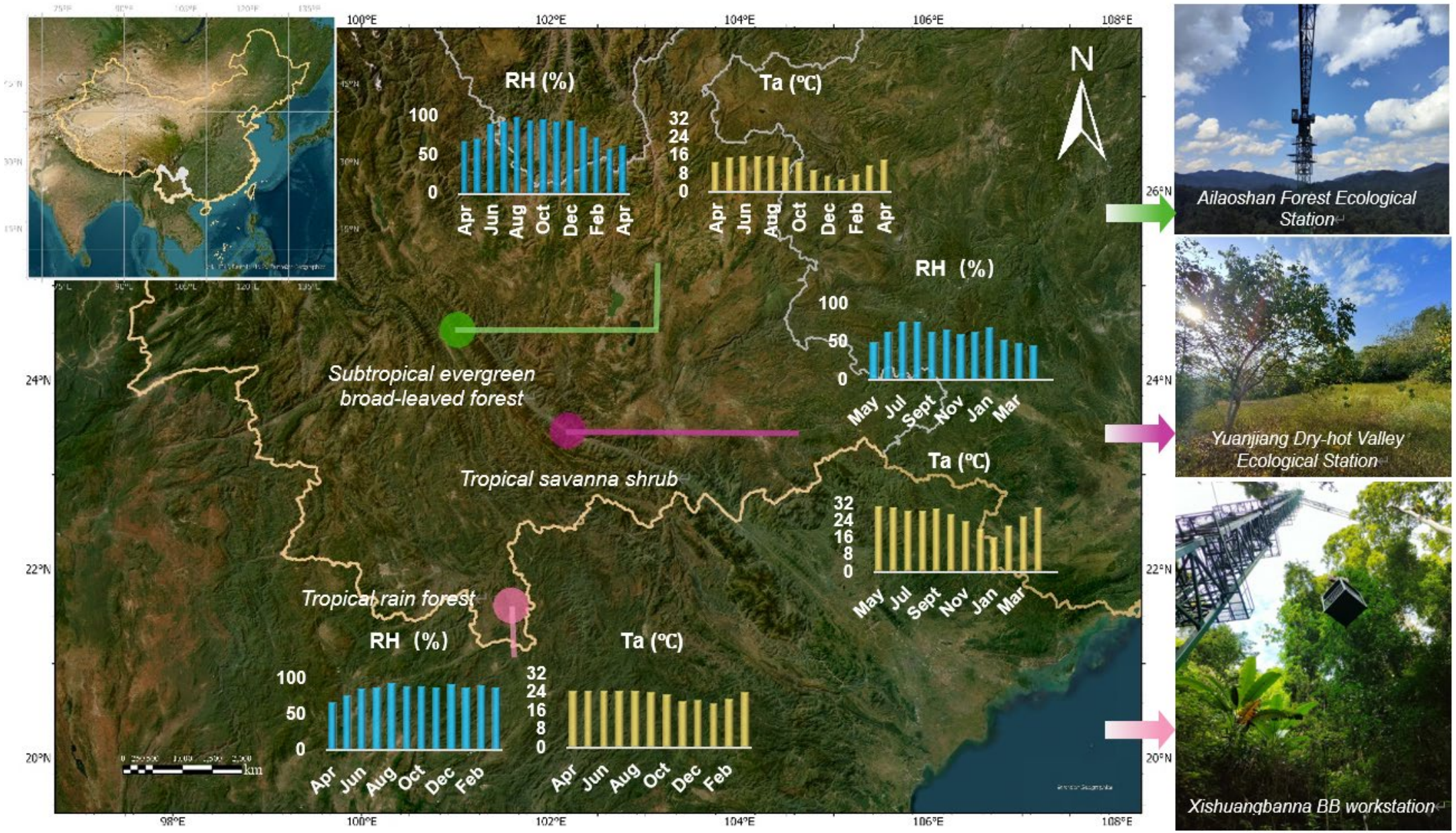
What is the control mechanism of atmospheric-leaf mercury exchange process ?

- ***What is the relationship between foliar Hg uptake rate and foliar physiological parameters under various climate patterns and different canopy structure scales?***

Scientific Hypothesis

- ✓ ***Hg^0 exchange process between atmosphere and foliage is restricted by environmental factors and foliar physiological characteristics***

2.1 Study Sites



2.2 Experiment Setting

➢ Research method and observation index

Automatic meteorological station H21-USB

- Atmospheric temperature (Ta)
- Atmospheric relative humidity (RH)
- Photosynthetically active radiation (PAR)

Canopy crane

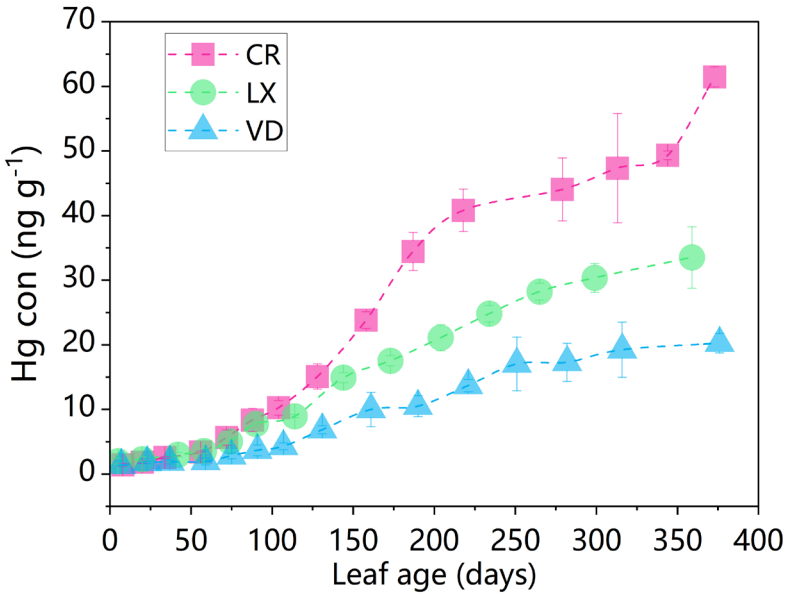
- Net Photosynthetic rate (A)
- Transpiration rate (E)
- Stomatal conductance (gsw)
- Water vapor deficit (VPD)
- ...

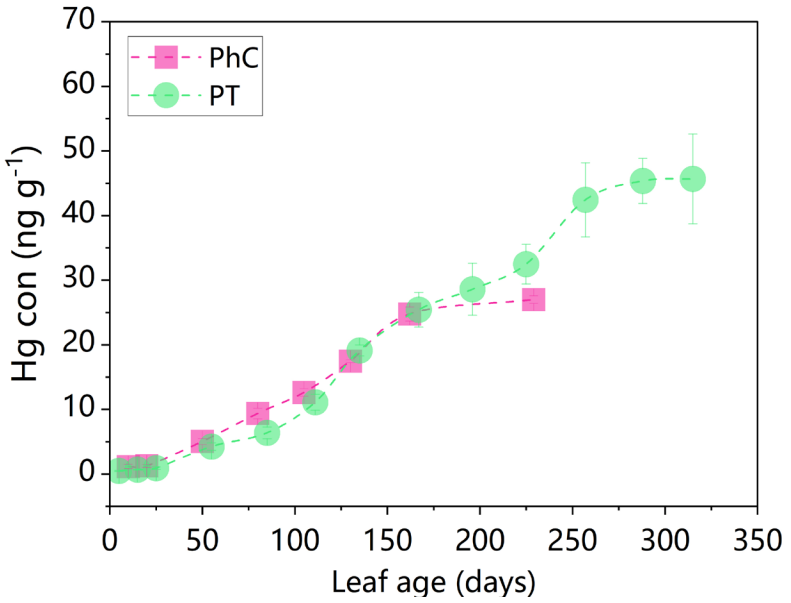
Portable photosynthesis system (Li-6800, Li-COR, Lincoln, NE, USA)

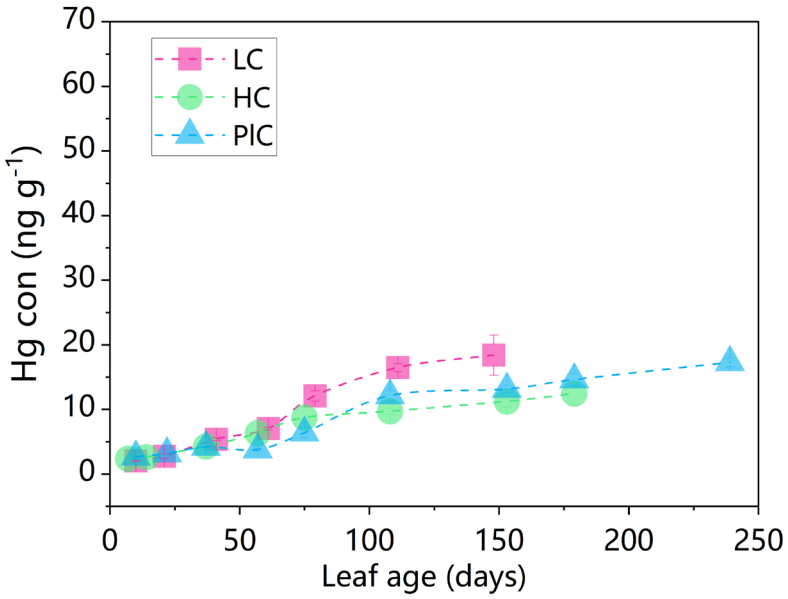
- Foliar Hg concentration
- Foliar Hg uptake rate

3 Results And Discussion

3.1 Characteristics of Hg concentration during leaf growth cycle





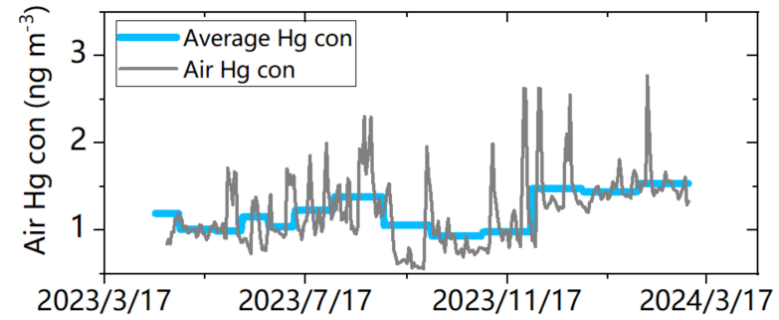


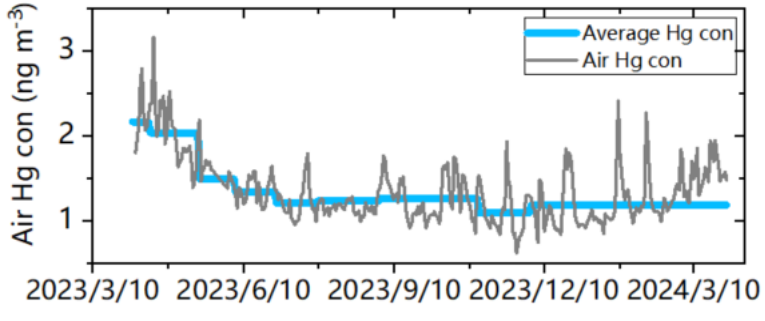
ALS Subtropical forest ***XSBN tropical rain forest*** ***YJ tropical savanna shrub***

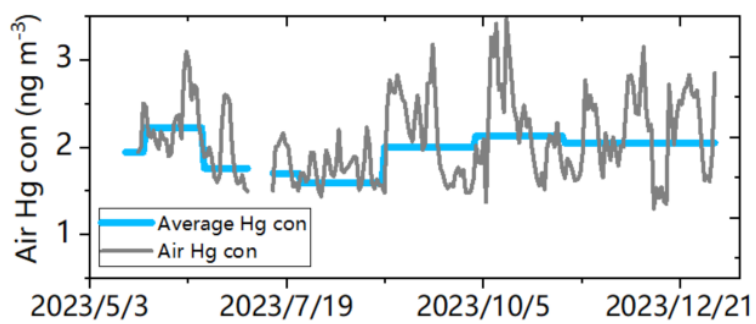
- ***Foliar Hg concentration → Early stage: Increase slowly; Mid-term : increase rapidly; End: increase slowly***
- ***Foliar Hg concentration of YJ was significantly lower than that of XSBN (p=0.042) and ALS (p=0.015)***

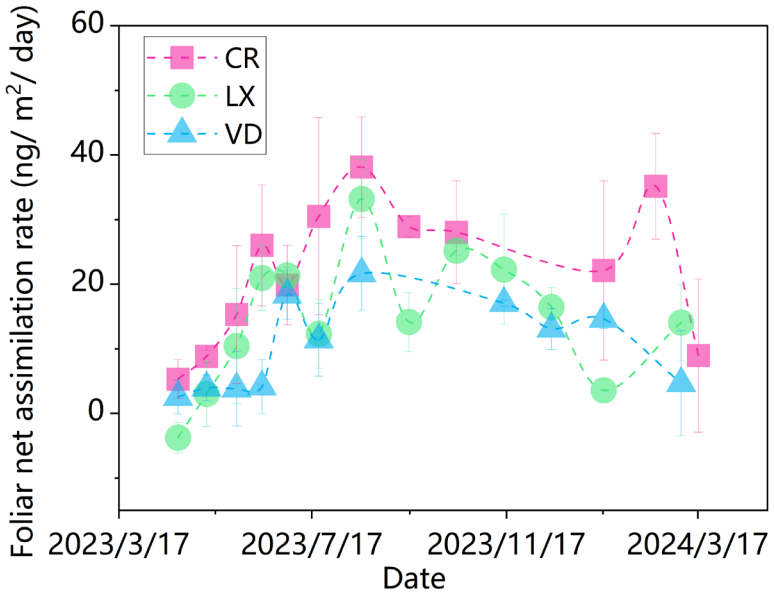
3 Results And Discussion

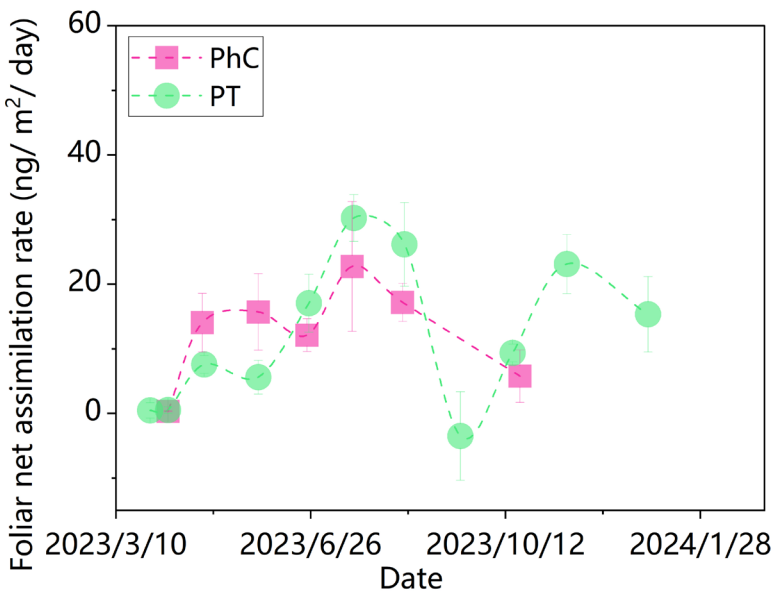
3.2 Characteristics of net Hg assimilation rate during leaf growth cycle

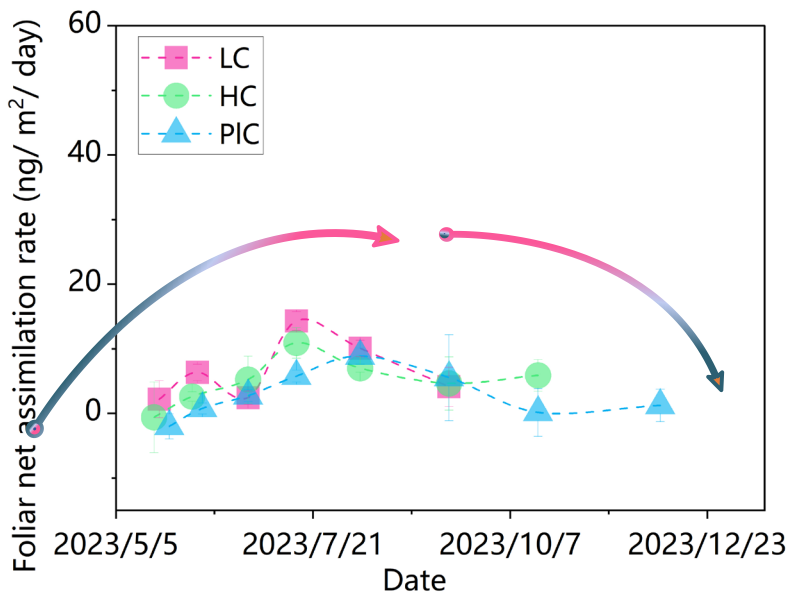












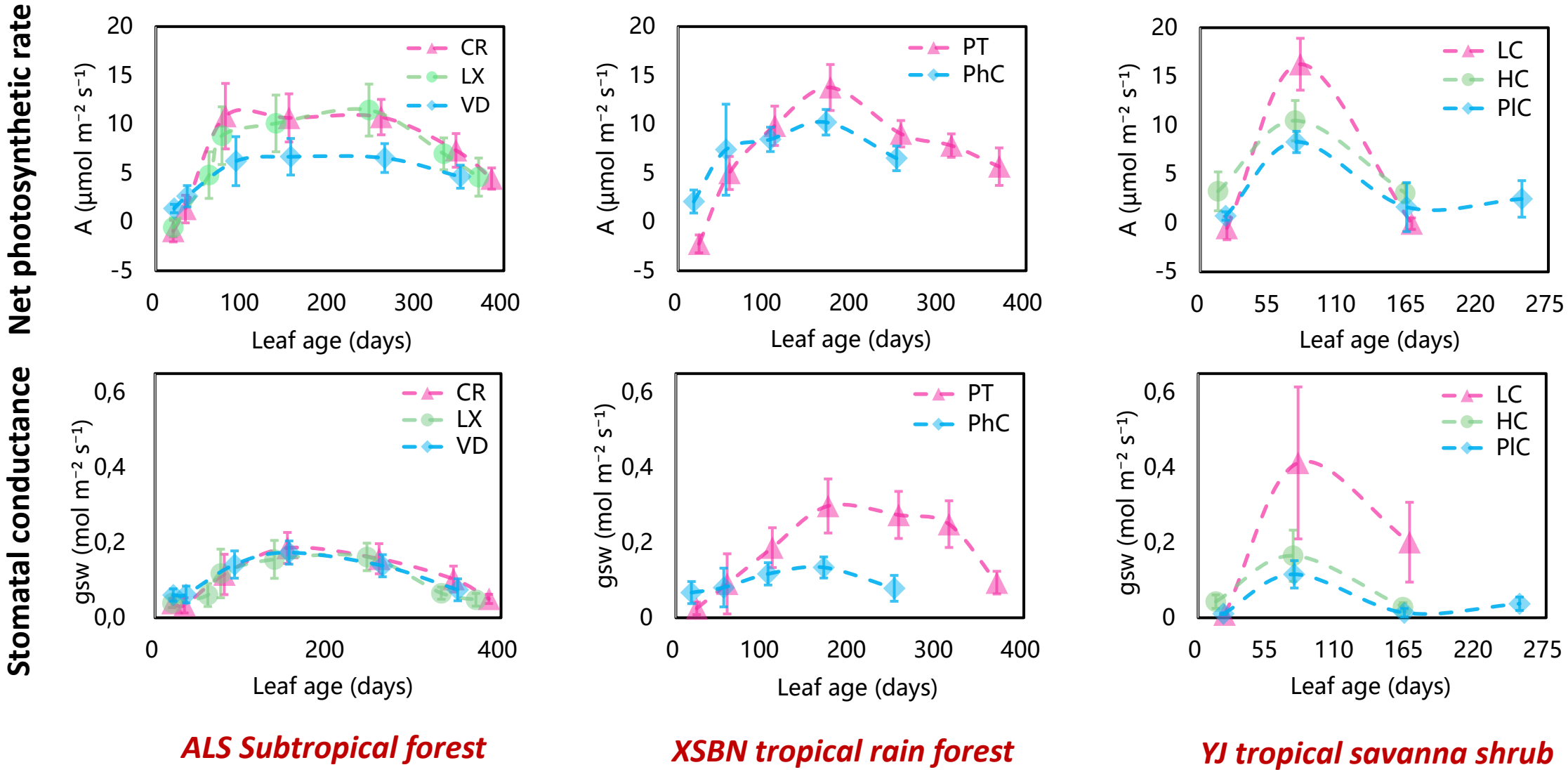
ALS Subtropical forest

XSBN tropical rain forest

YJ tropical savanna shrub

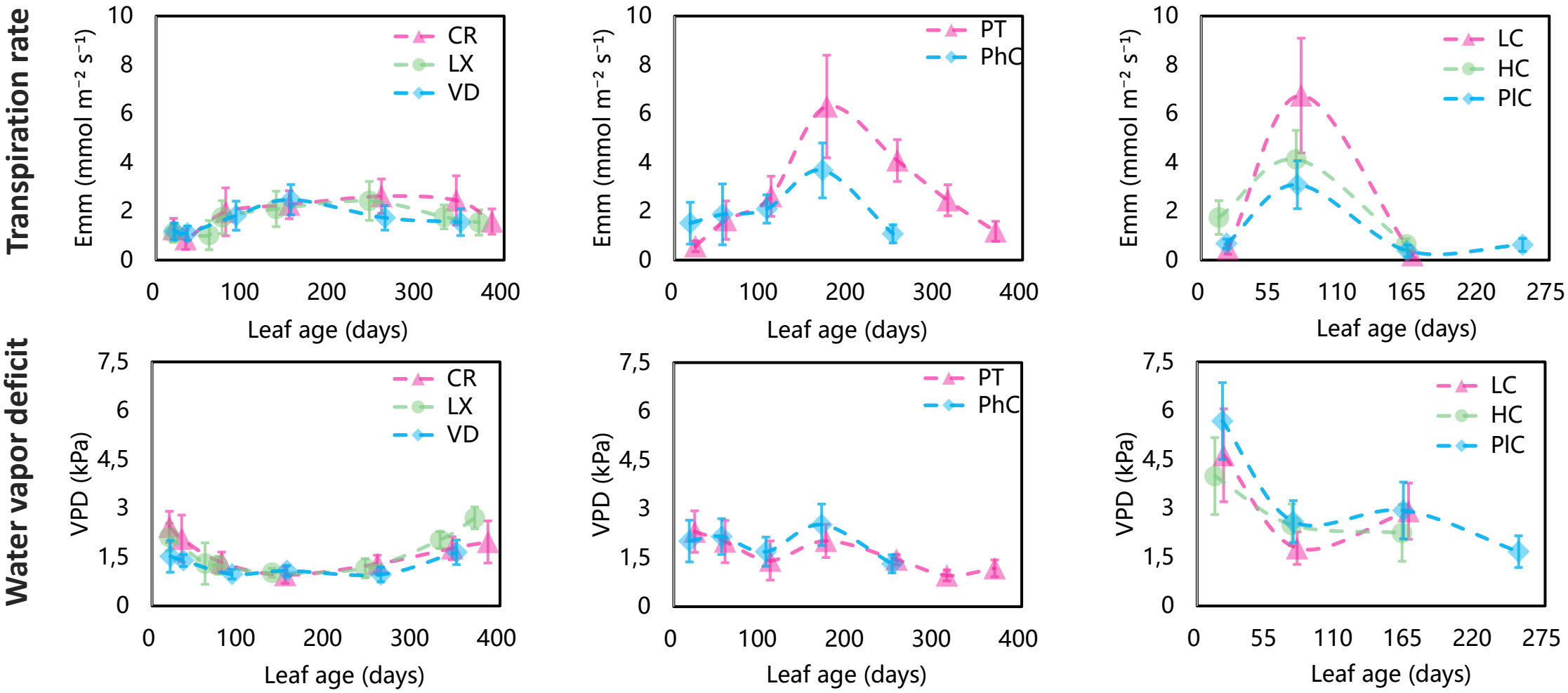
3 Results And Discussion

3.3 Characteristics of physiological parameters in leaf growth cycle



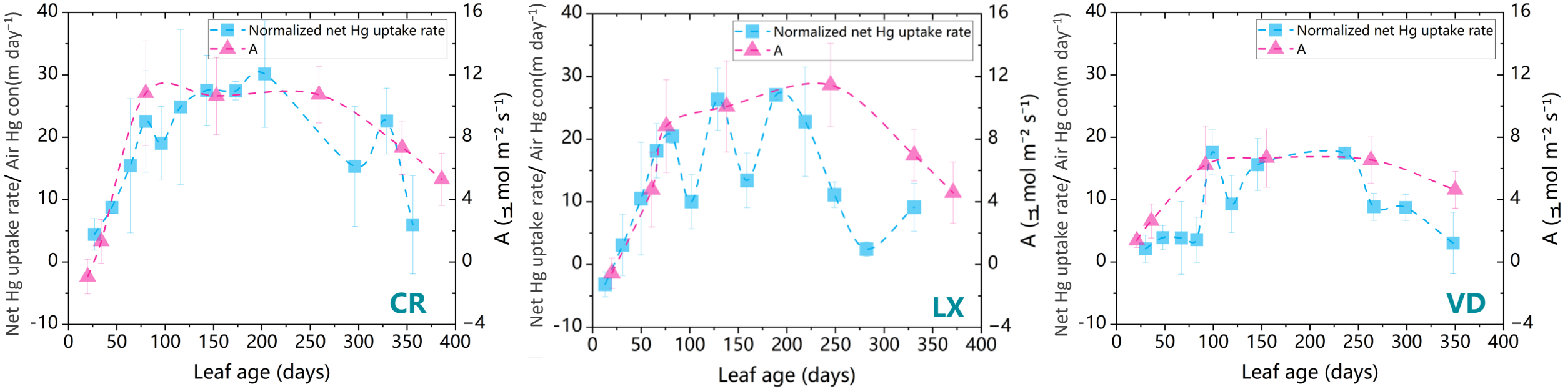
3 Results And Discussion

3.3 Characteristics of physiological parameters in leaf growth cycle



3 Results And Discussion

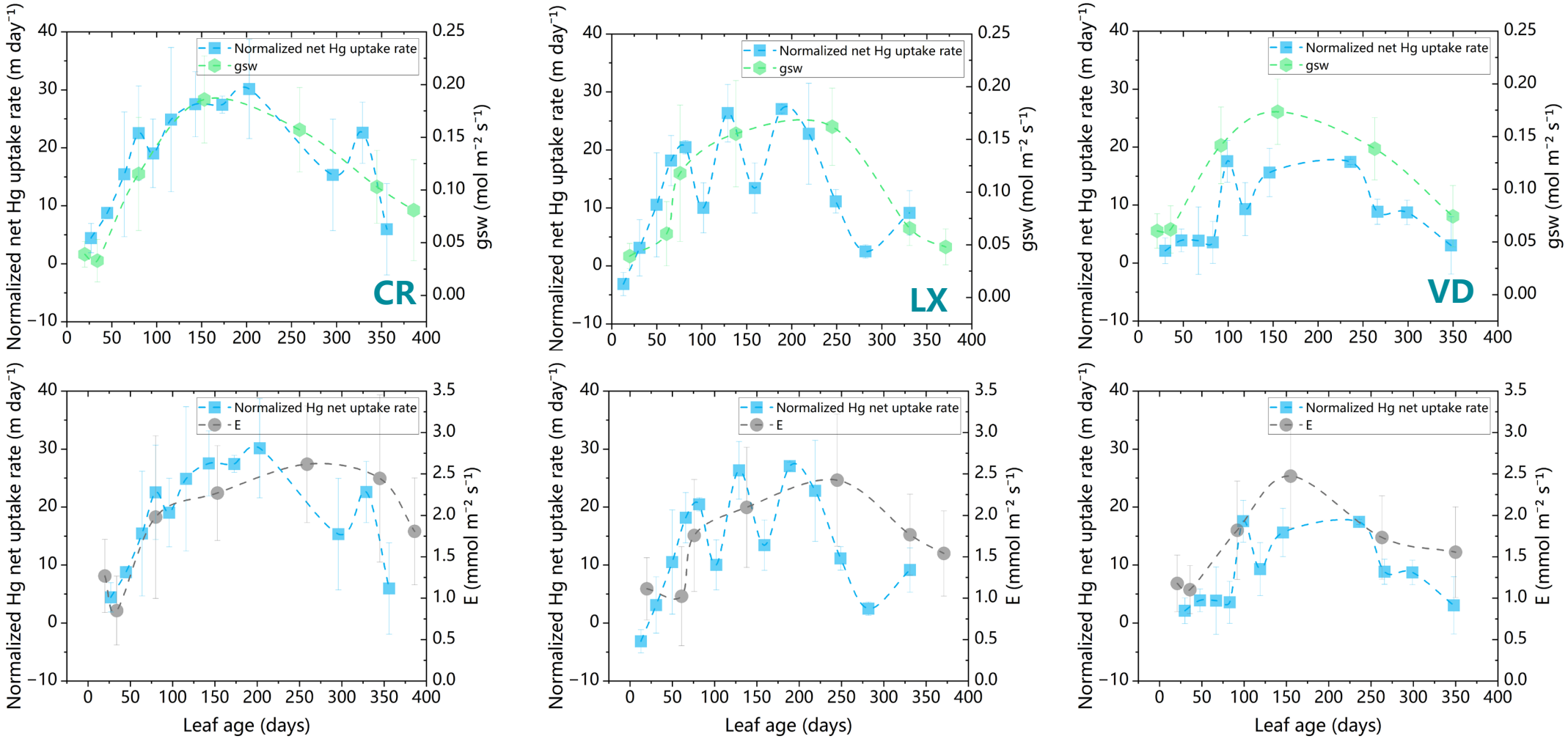
3.4 Normalized net Hg uptake rate and physiological parameters _ ALS Subtropical forest



- *Normalized Hg net uptake rate and net photosynthetic rate were basically consistent*
- *Higher leaf Hg(0) uptake capacity may be related to reactive oxygen species produced during photosynthesis and photorespiration*

3 Results And Discussion

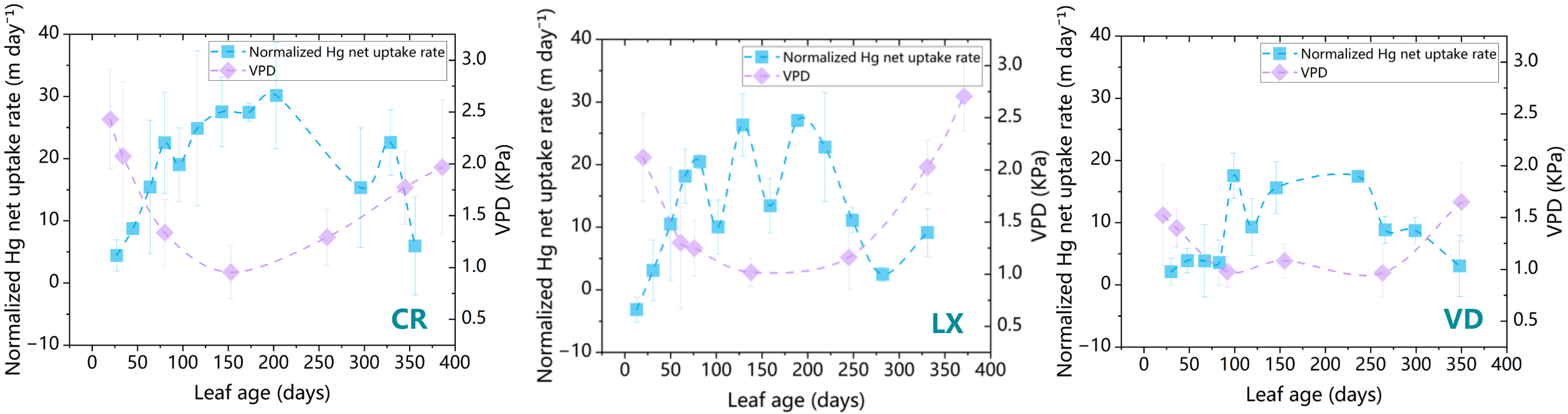
3.4 Normalized net Hg uptake rate and physiological parameters _ ALS Subtropical forest



Trees will adjust the transpiration rate by controlling the stomatal aperture of leaves, so as to cope with the change of the pressure deficit of saturated water

3 Results And Discussion

3.4 Normalized net Hg uptake rate and physiological parameters _ ALS Subtropical forest

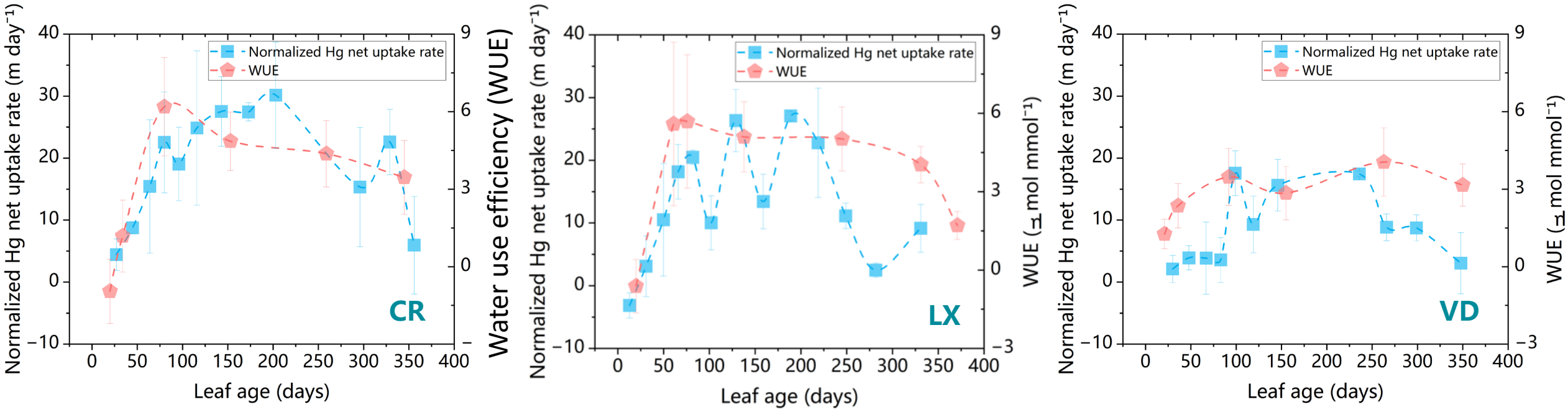


Under the condition of high VPD, the uptke of Hg(0) by stomata is inhibited

- **Reduced diffusion of Hg(0) from the atmosphere to binding sites in leaves due to stomatal closure and reduced mesophyll conductance may be responsible for the decreased rate of net mercury accumulation under most water stress conditions**

3 Results And Discussion

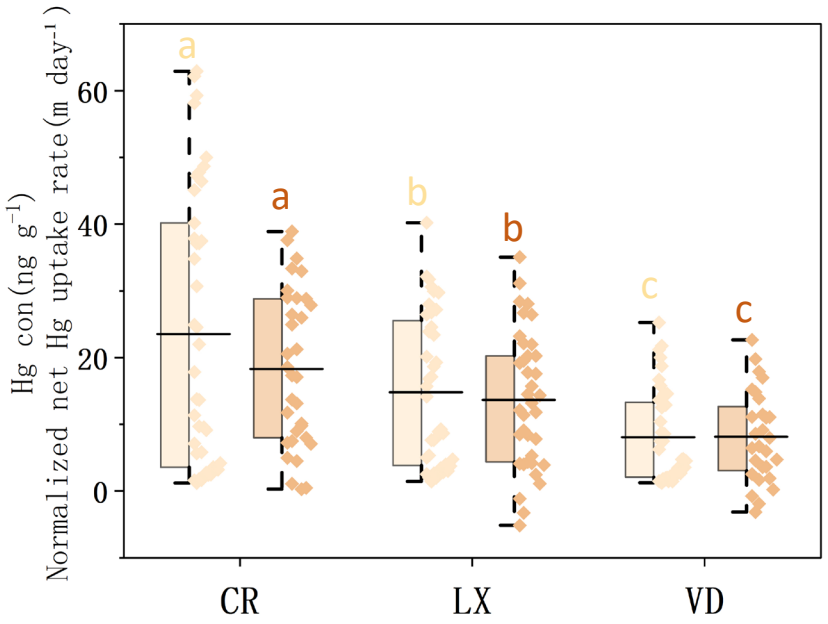
3.4 Normalized net Hg uptake rate and physiological parameters _ ALS Subtropical forest

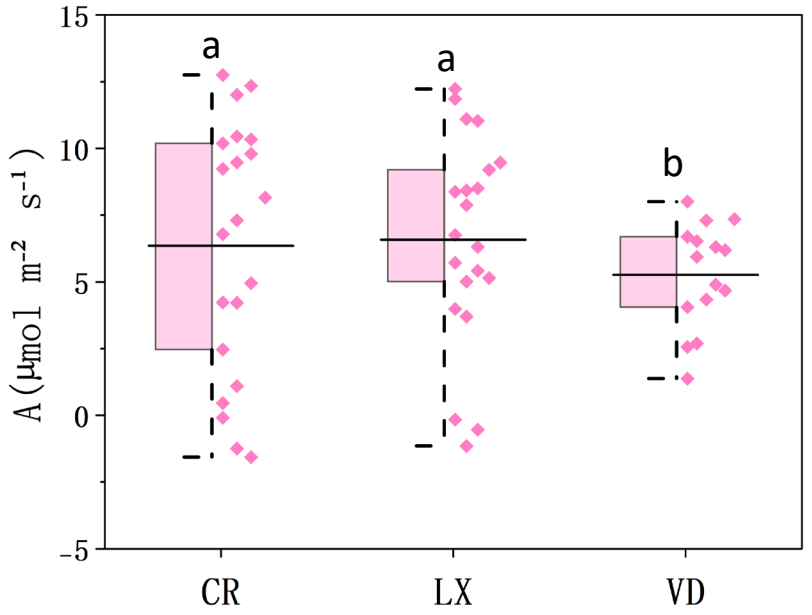


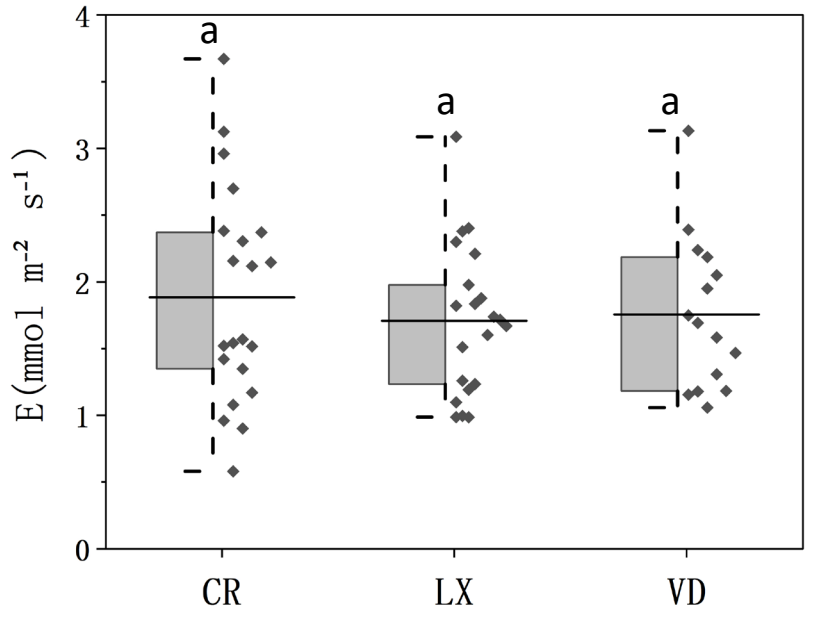
- *The ratio of water loss to carbon gain, known as **water use efficiency**, is the core of the global water, energy and carbon cycle*
- *The increase of water use efficiency has a series pivotal effects on ecosystem function and feedback to the climate system*

3 Results And Discussion

3.4 Normalized net Hg uptake rate and physiological parameters _ ALS Subtropical forest



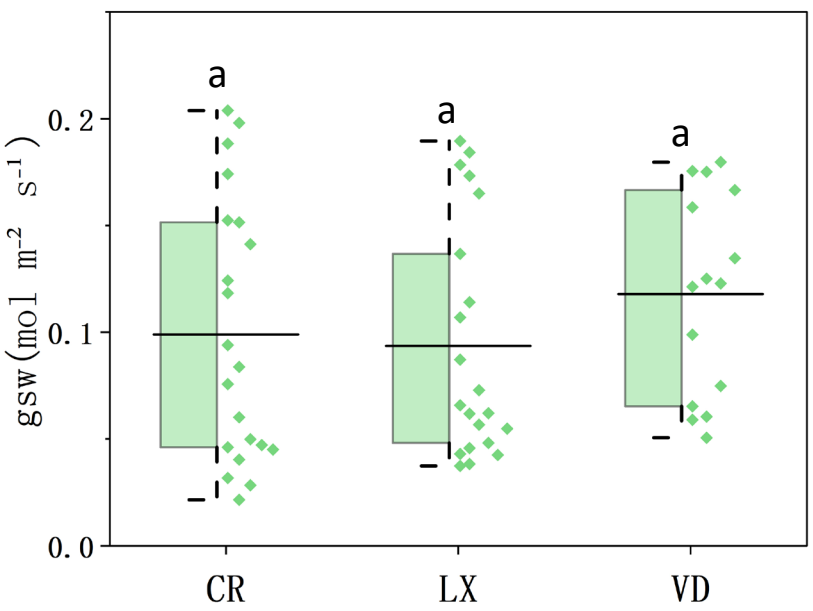


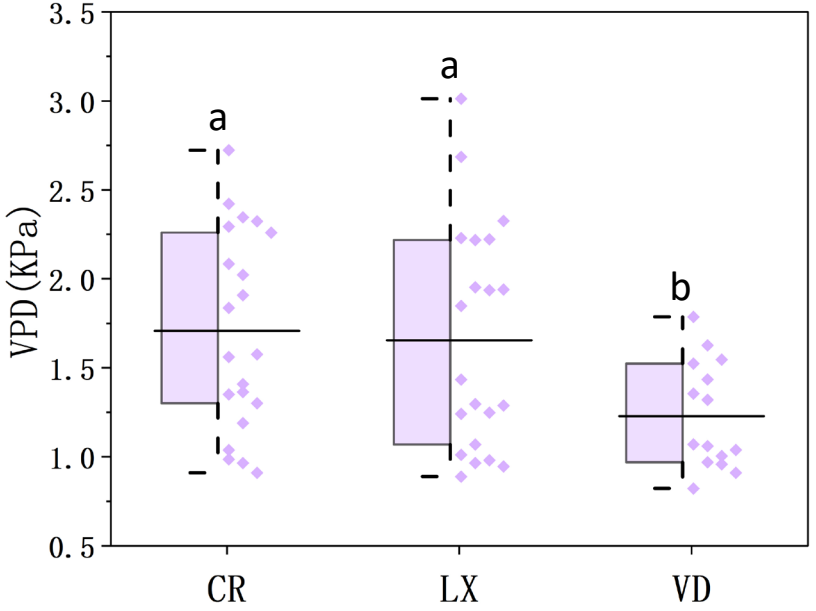


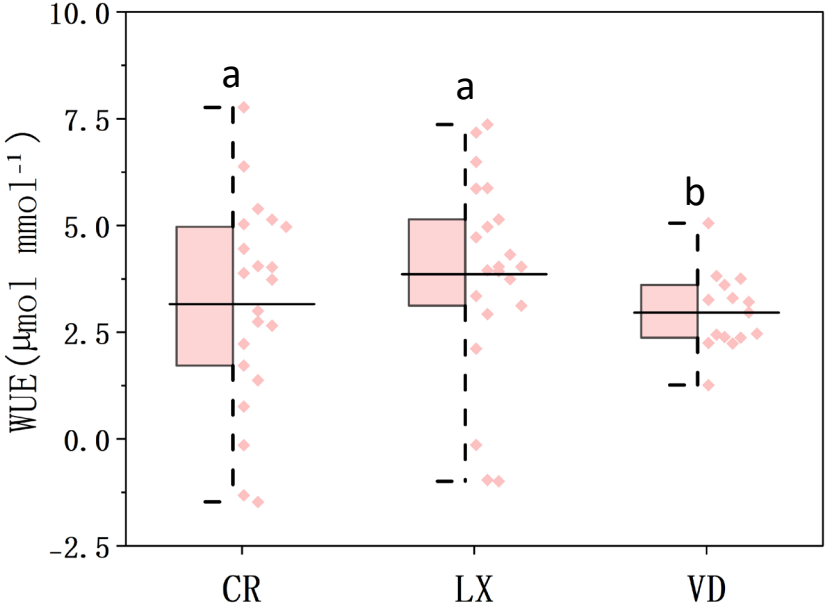
- *Hg concentration and uptake rate of VD in subcanopy were significantly lower than that of LX ($p<0.05$) and CR($p<0.001$) in canopy*
- *To maximize light acquisition, VD has a lower dry matter content compared to CR and a larger specific leaf area compared to LX*

3 Results And Discussion

3.4 Normalized net Hg uptake rate and physiological parameters _ ALS Subtropical forest



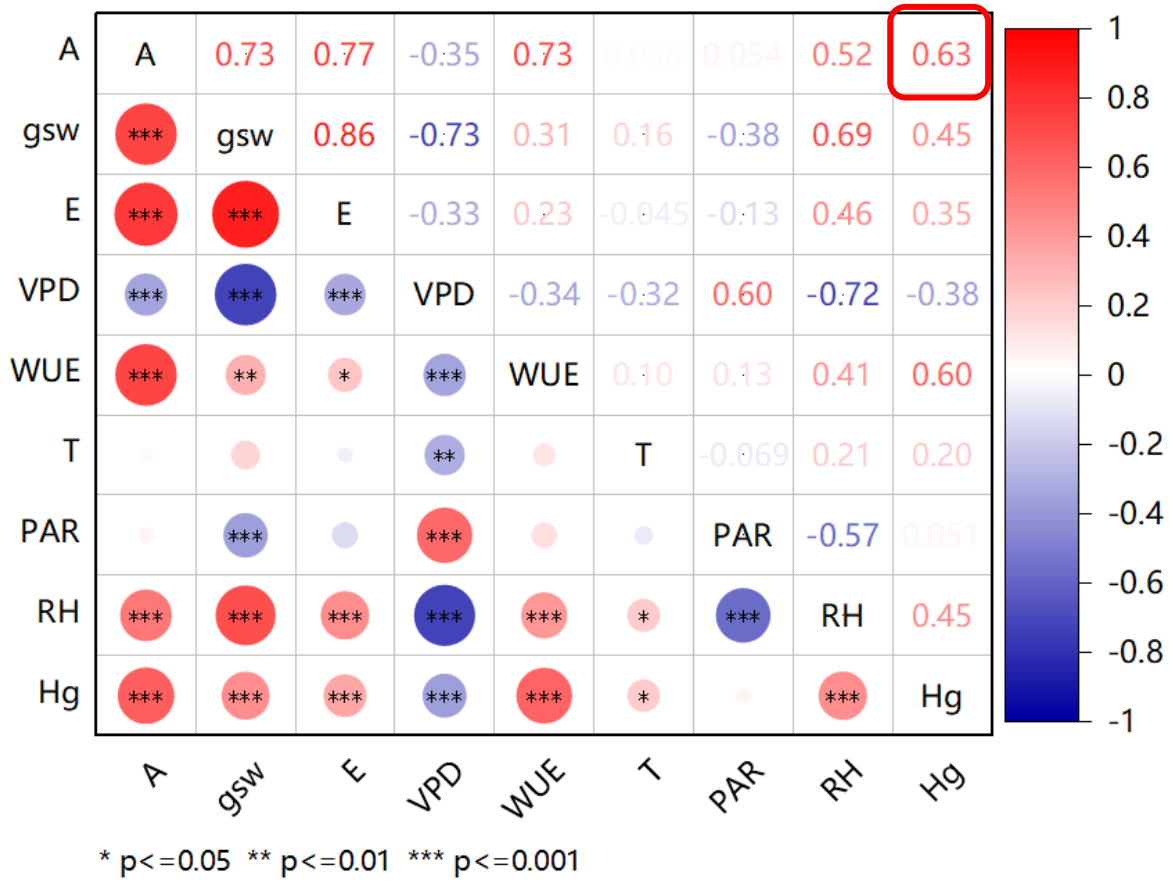




- *The water vapor deficit of VD was significantly lower than that of the top two species*
- ***Atmospheric relative humidity/Water vapor deficit** was not the main factor limiting foliar Hg uptake in subtropical forest*

3 Results And Discussion

3.4 Spearman correlation analysis of normalized net Hg uptake rate_ALS Subtropical forest

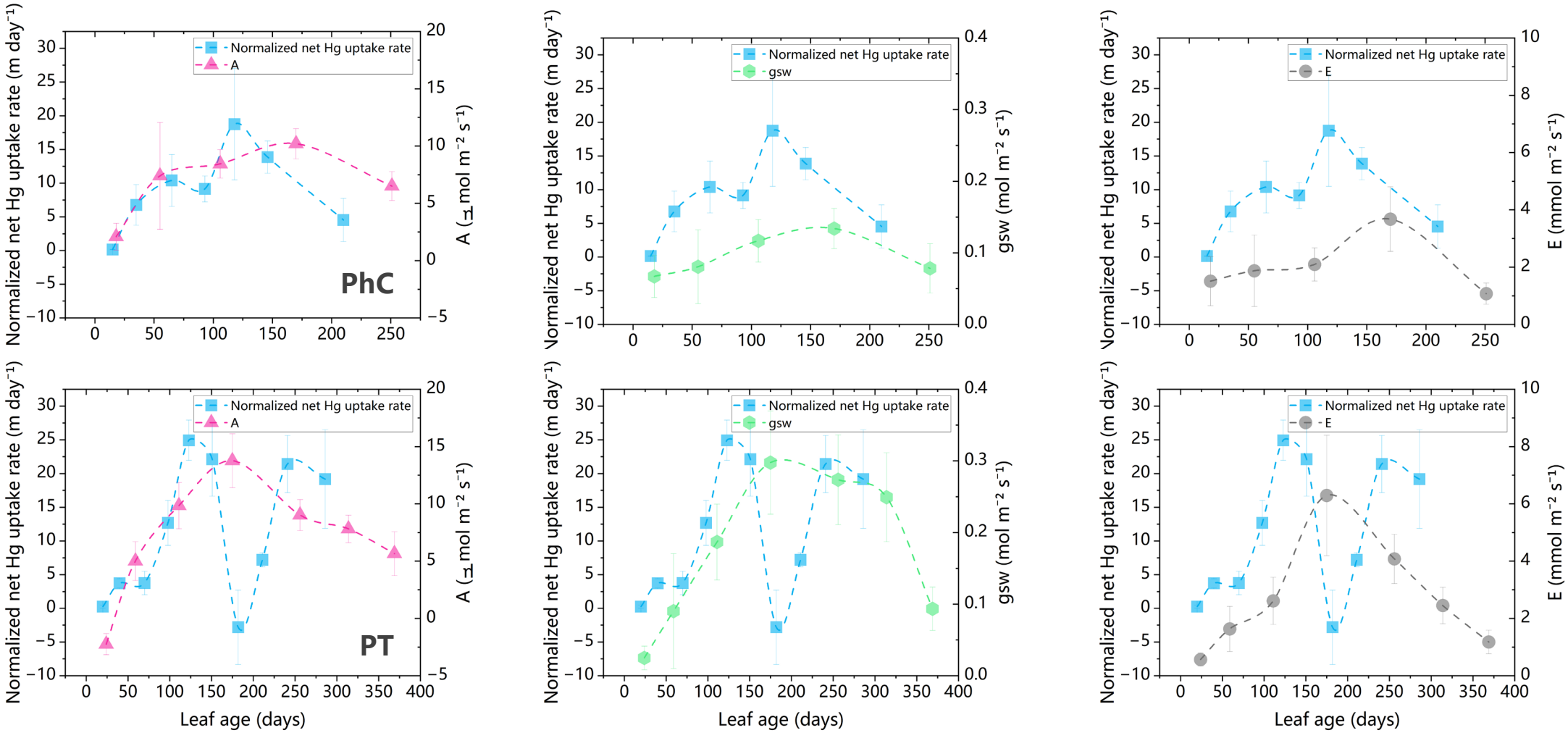


- *A, gsw, E and WUE were significantly positively correlated*
- *RH was the key control factor of A, gsw and E*
- *VPD was negatively correlated with A, gsw, E and WUE*
- *Low RH environments resulted in elevated VPD, accompanied by high PAR*

***Net photosynthetic rate** may be the key factor limiting foliar mercury uptake in subtropical forest*

3 Results And Discussion

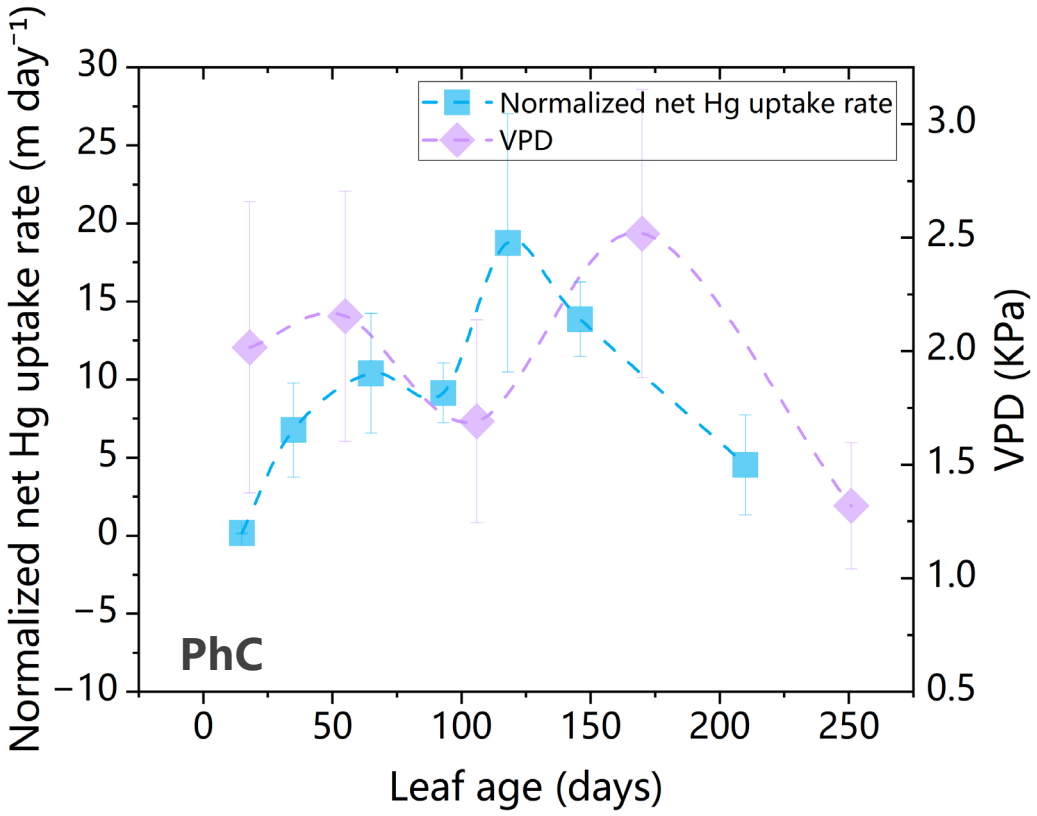
3.4 Normalized net Hg uptake rate and physiological parameters_ XSBN tropical rain forest

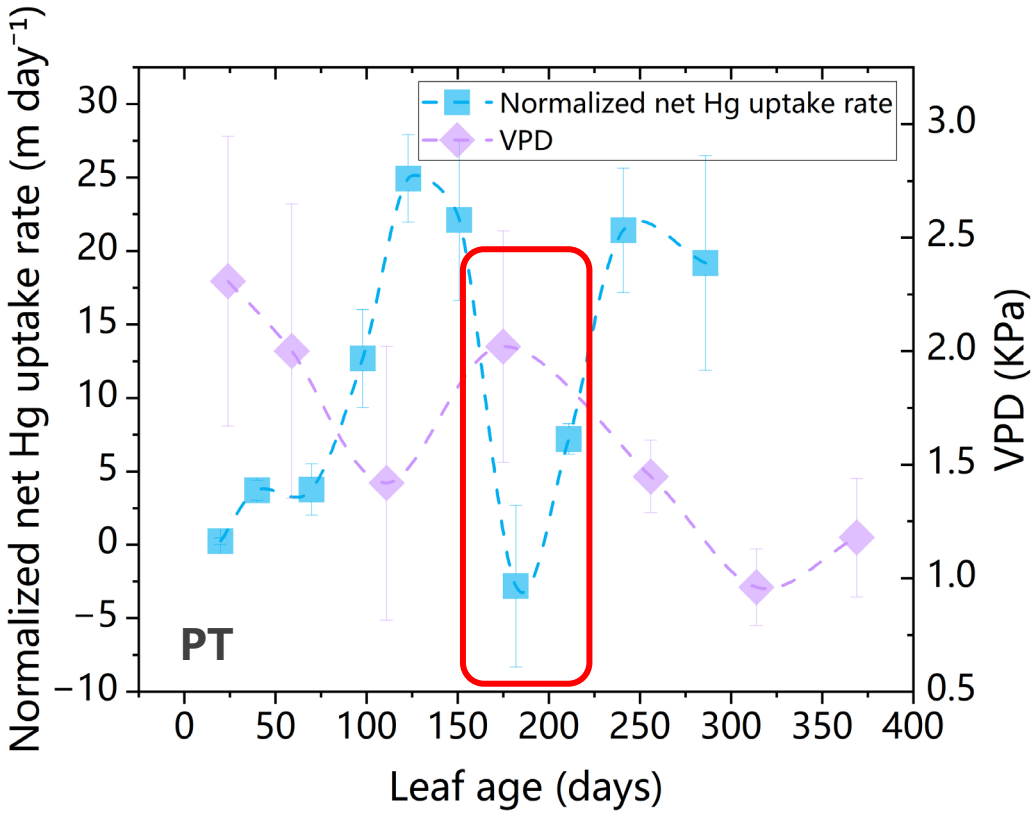


The higher net Hg uptake rate of various tree species corresponded to stronger physiological activity

3 Results And Discussion

3.4 Normalized net Hg uptake rate and physiological parameters_ XSBN tropical rain forest

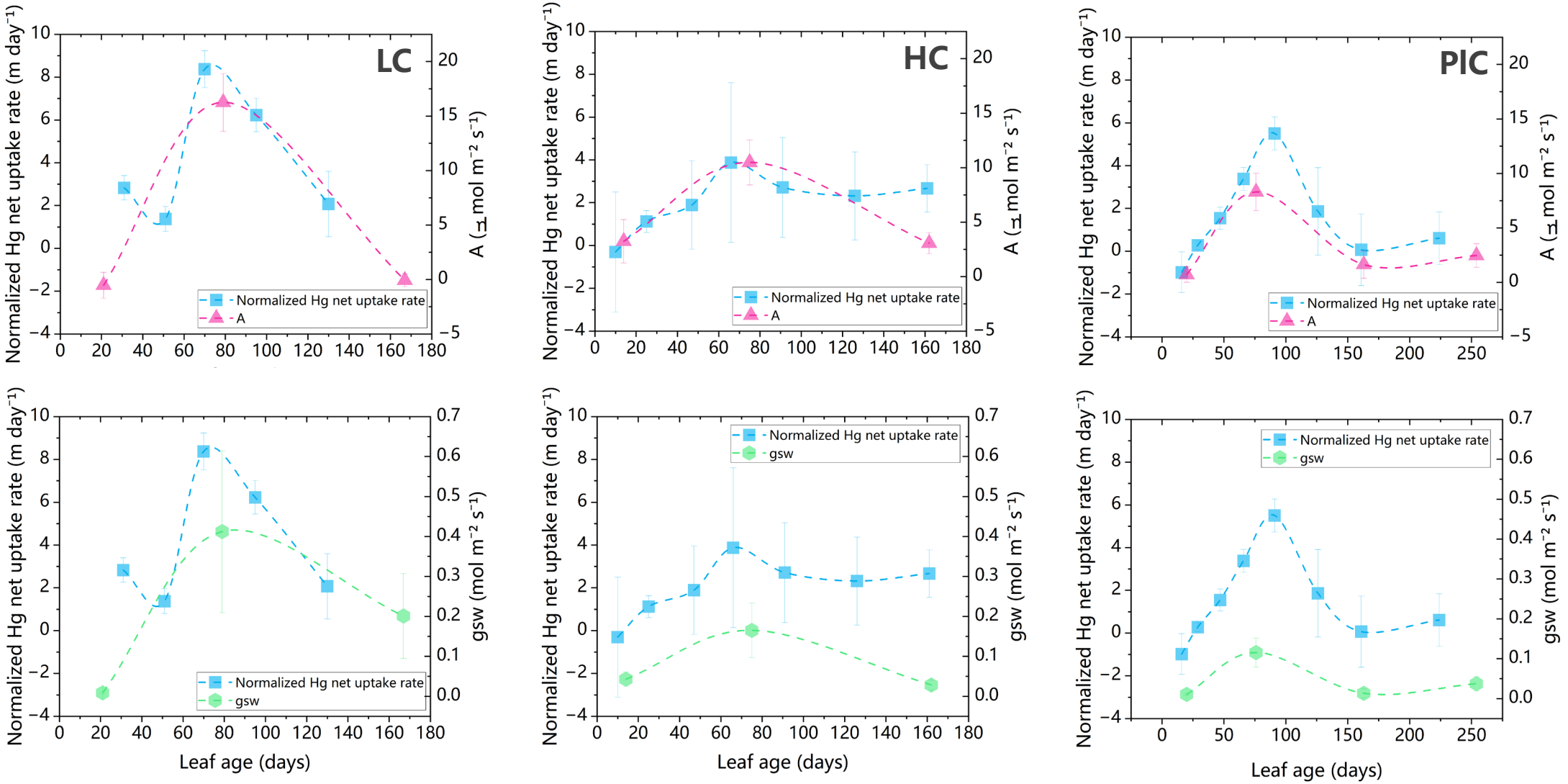




- ***The sharp decrease of the uptake rate of PT leaves during the growth period may be related to the increase of foliar water vapor deficit***

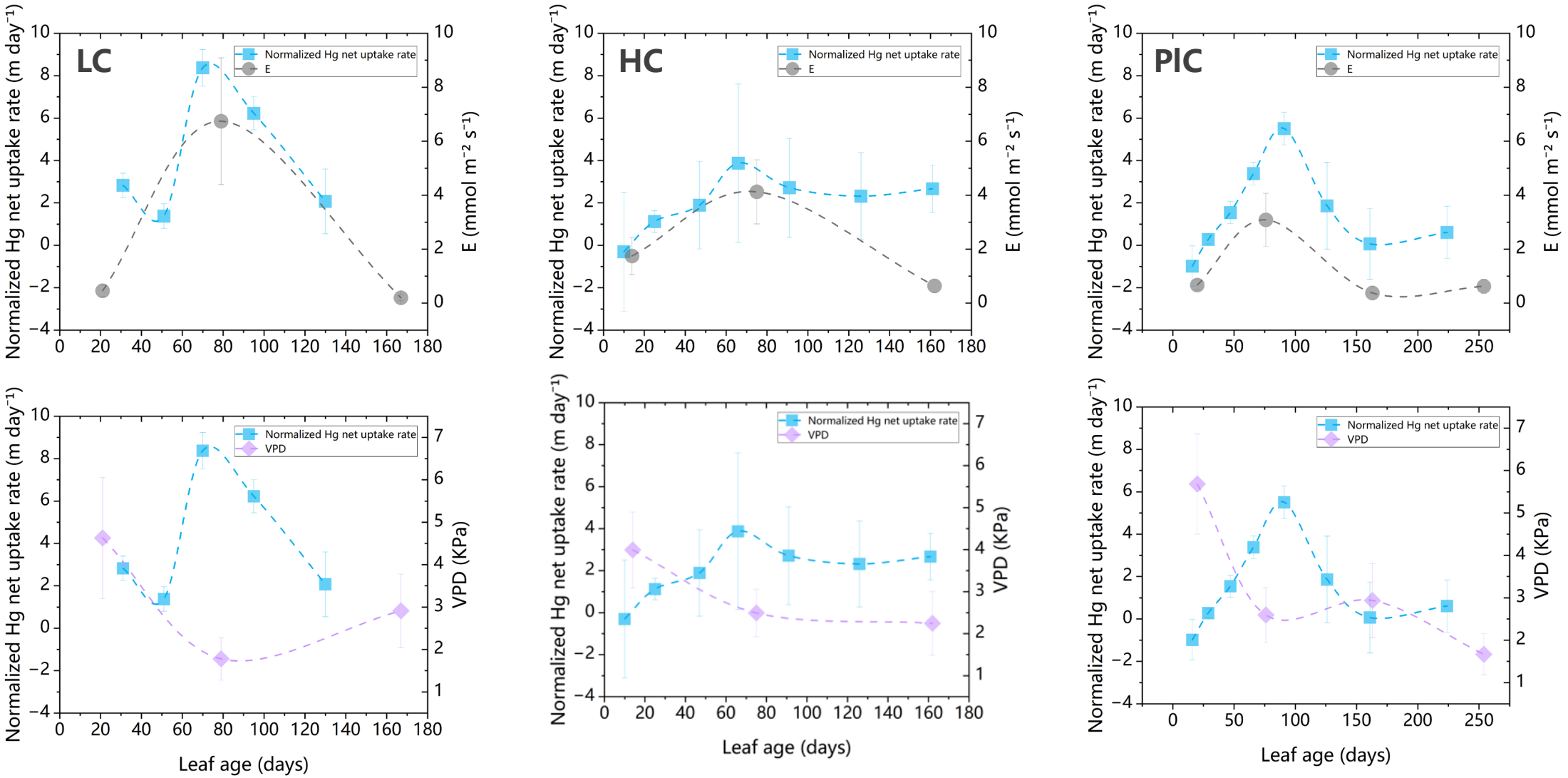
3 Results And Discussion

3.4 Normalized net Hg uptake rate and physiological parameters_YJ tropical savanna shrub



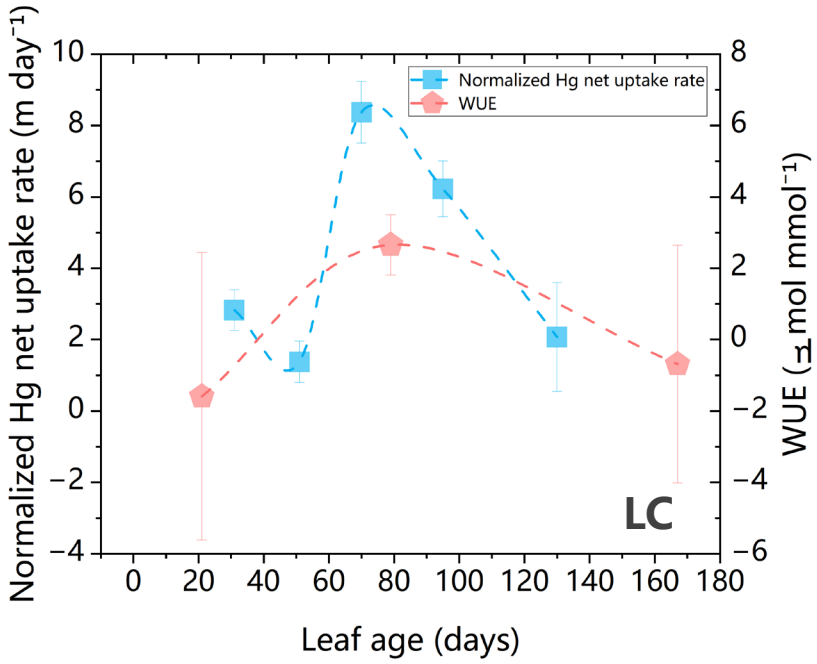
3 Results And Discussion

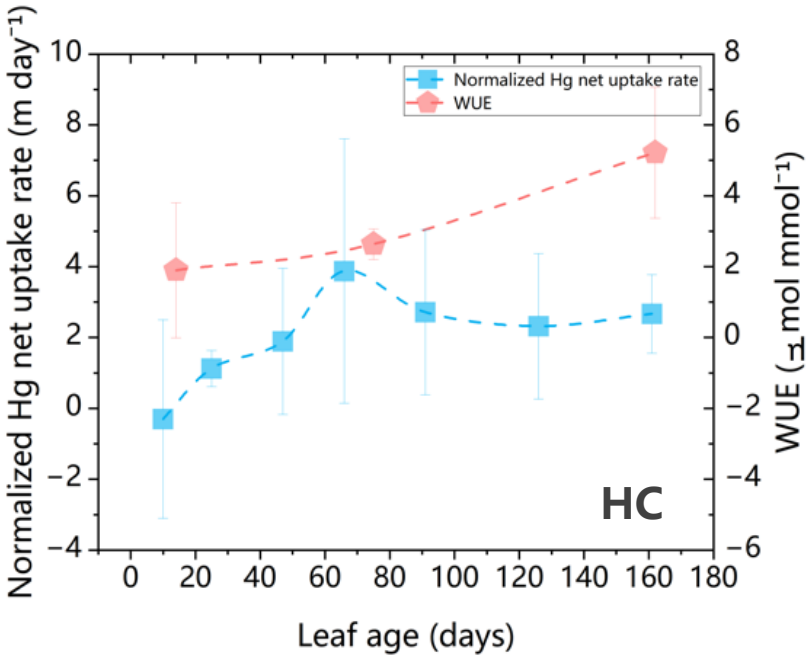
3.4 Normalized net Hg uptake rate and physiological parameters_YJ tropical savanna shrub

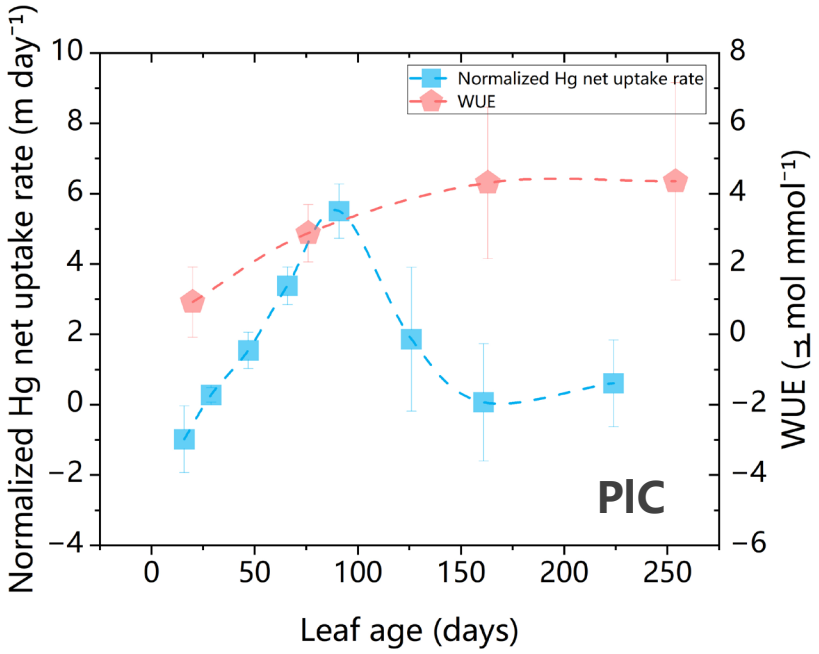


3 Results And Discussion

3.4 Normalized net Hg uptake rate and physiological parameters_YJ tropical savanna shrub





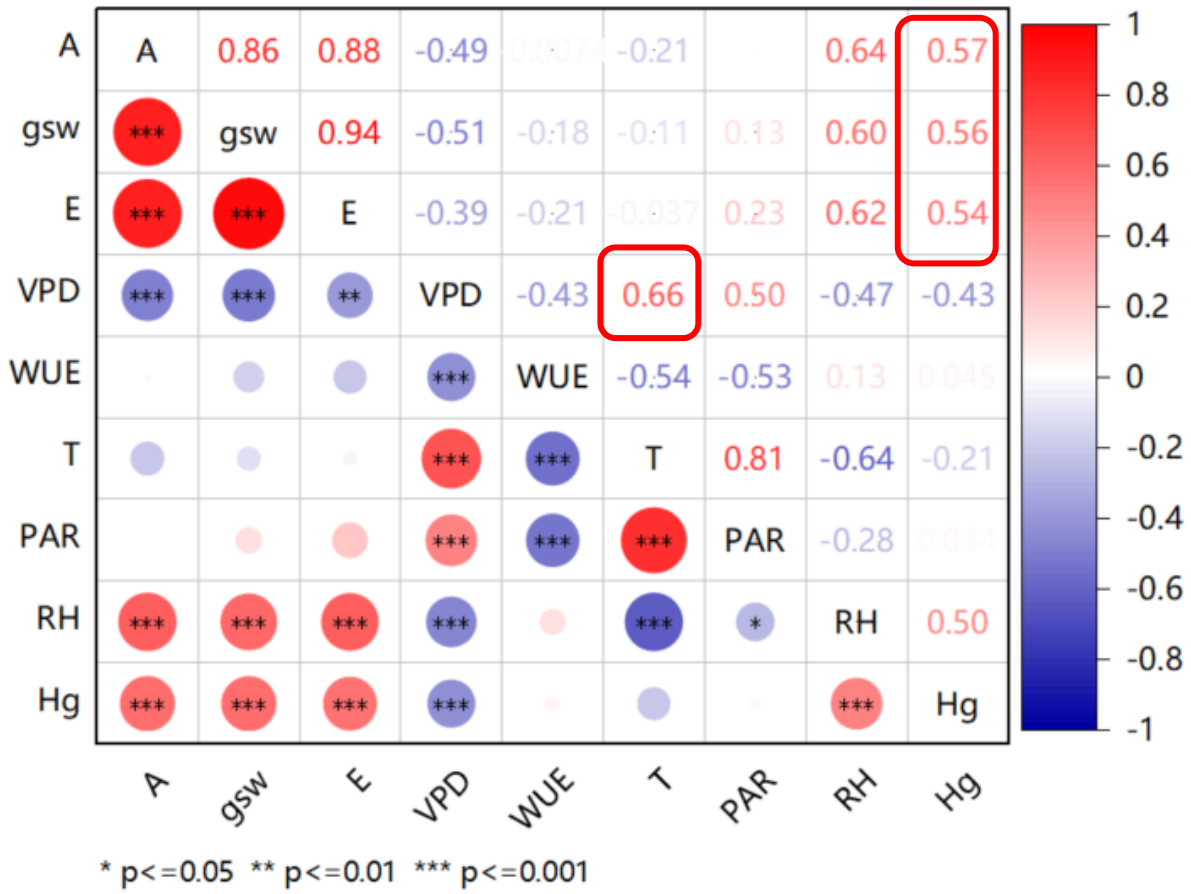


The inconsistency of WUE among tree species may be related to the difference of leaf phenology and drought resistance

- *The thickness of PIC leaves is the largest, which enhances drought resistance of plants*
- *The spongy tissue cells in HC leaves are less and the intercellular space is larger, forming a large aerated tissue, which is conducive to increasing the air and water reserves.*

3 Results And Discussion

3.4 Spearman correlation analysis of normalized net Hg uptake rate_YJ tropical savanna shrub

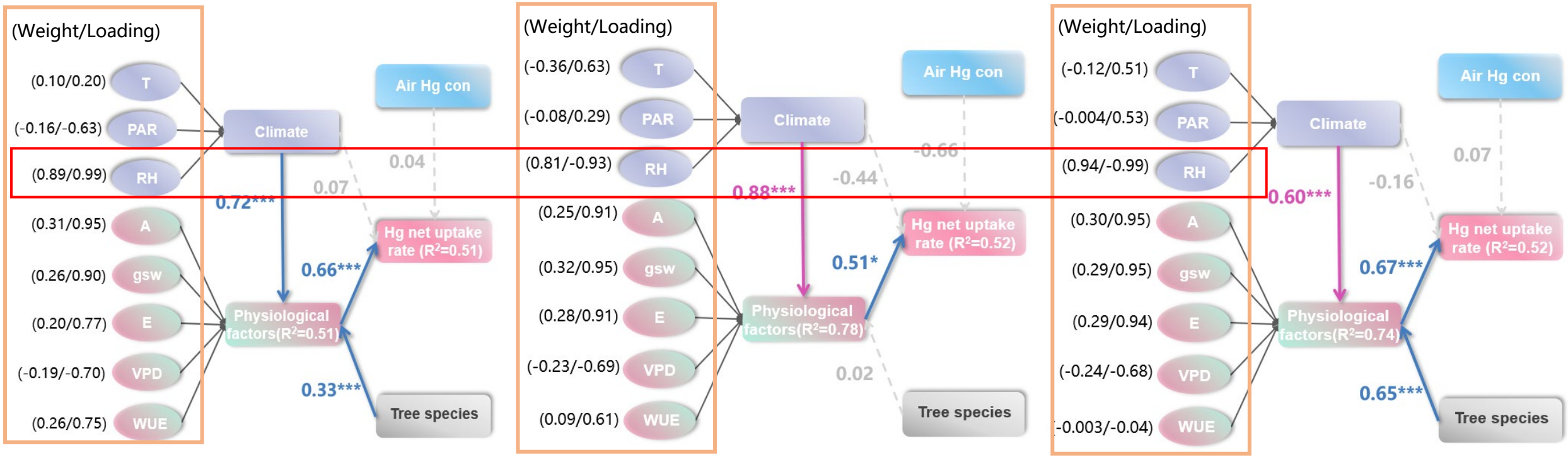


- *A, gsw, E and WUE were significantly positively correlated*
- *RH was the key control factor of A, gsw and E*
- *VPD was negatively correlated with A, gsw, E and WUE*
- *Low RH environments resulted in elevated VPD, accompanied by high PAR*

Stomatal conductance and its effects on photosynthesis and transpiration may be pivotal limiting factors for foliar uptake of atmospheric Hg^0 in tropical savanna shrub

3 Results And Discussion

3.5 PLS-PM Model _ Analysis of factors affecting Hg uptake in forest ecosystems under different hydrothermal conditions



GOF = 0.55

ALS Subtropical forest

GOF = 0. 62

XSBN tropical rain forest

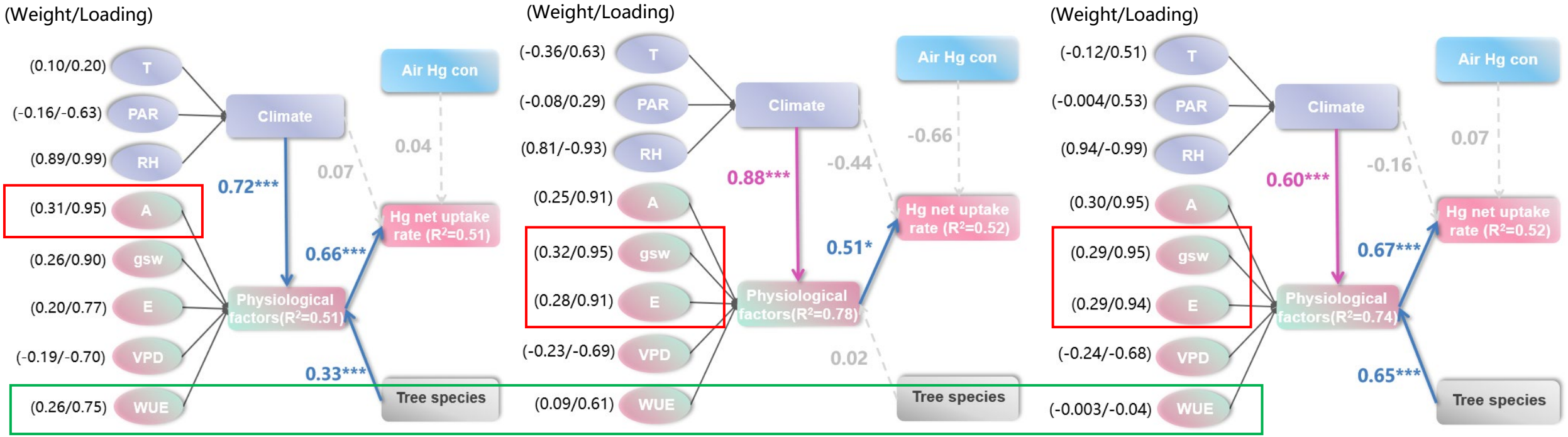
GOF = 0.61

YJ tropical savanna shrub

- ***Atmospheric relative humidity plays a crucial role in controlling leaf physiological activities in both three ecosystems***

3 Results And Discussion

3.5 PLS-PM Model _ Analysis of factors affecting Hg uptake in forest ecosystems under different hydrothermal conditions



GOF = 0.55

ALS Subtropical forest

GOF = 0. 62

XSBN tropical rain forest

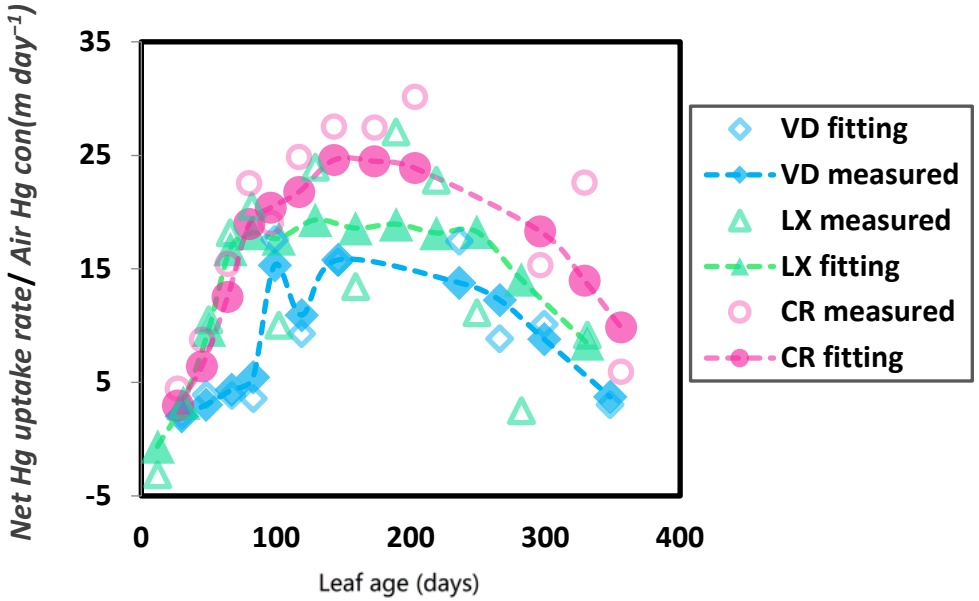
GOF = 0.61

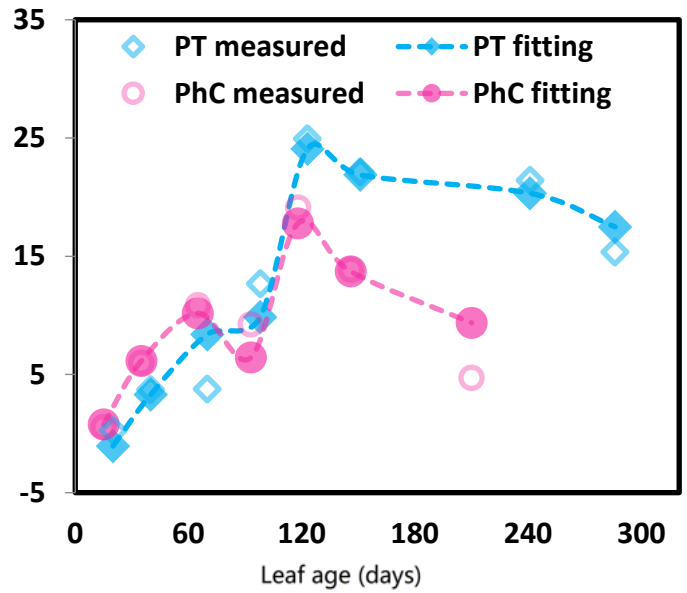
YJ tropical savanna shrub

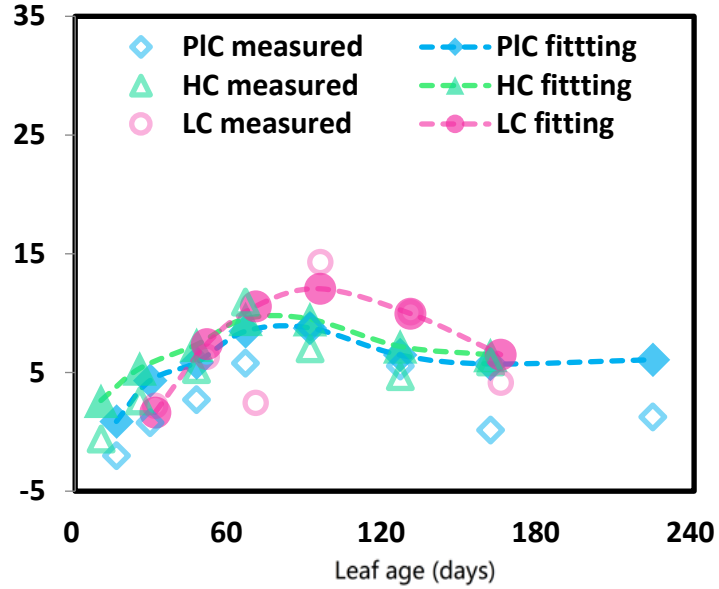
The difference in WUE among the three forest ecosystems may be caused by the decoupling of photosynthesis and transpiration in the tropics

3 Results And Discussion

3.6 Ridge regression model _ Simulate the foliar normalized net Hg uptake rate







*CR：0.36*A+50.71*gsw-5.75*VPD+1.41*E+0.09*RH+5.40 (R^2=0.71)*

*LX：0.34*A+1.00*WUE-4.39*VPD+0.18*RH-2.22 (R^2=0.54)*

*VD：336.56*gsw- 29.81*A+57.91*E+38.23*WUE-94.16 (R^2=0.81)*

*PhC：5.18*A+694.07*gsw+5.85*T-2.21*RH-54.91 (R^2=0.98)*

*PT：37.71*gsw-2.93*VPD+0.11*RH+0.16*PAR-19.63 (R^2=0.86)*

*LC：2.27*A-2.79*T-0.037*PAR-9.86*WUE+92.95 (R^2=0.94)*

*HC：25.68*gsw-1.01*T-5.94*WUE+32.04 (R^2=0.97)*

*PlC：44.70*gsw-0.70*VPD+0.19*T-3.48 (R^2=0.89)*

ALS Subtropical forest

$$\frac{\text{Net Hg uptake rate}}{\text{Air Hg con}} =$$

*0.73*A+40.74*gsw+1.10*WUE*

Adj R^2=0.54, p<0.001, k=0.25

XSBN tropical rain forest

$$\frac{\text{Net Hg uptake rate}}{\text{Air Hg con}} =$$

*0.20*A+21.86*gsw+0.96*E-0.24*WUE 2.53*VPD +0.14*RH -3.86*

Adj R^2=0.56, p<0.05, k=0.2

YJ tropical savanna shrub

$$\frac{\text{Net Hg uptake rate}}{\text{Air Hg con}} =$$

*0.15*A+0.14*RH-6.88*

Adj R^2=0.65, p<0.001, k=0.05

4 Conclusions

① *Foliar Hg concentration of various tree species in different ecosystems exhibits a linear upward trend during leaf growth*

② *Under the condition of high VPD, the uptke of Hg(0) by stomata is inhibited*

③
- *Net photosynthetic rate may be the key factor limiting foliar mercury uptake in subtropical forest*
- *Stomatal conductance may be the pivotal limiting factors for foliar uptake of atmospheric Hg^0 in tropical*

Thank You!

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