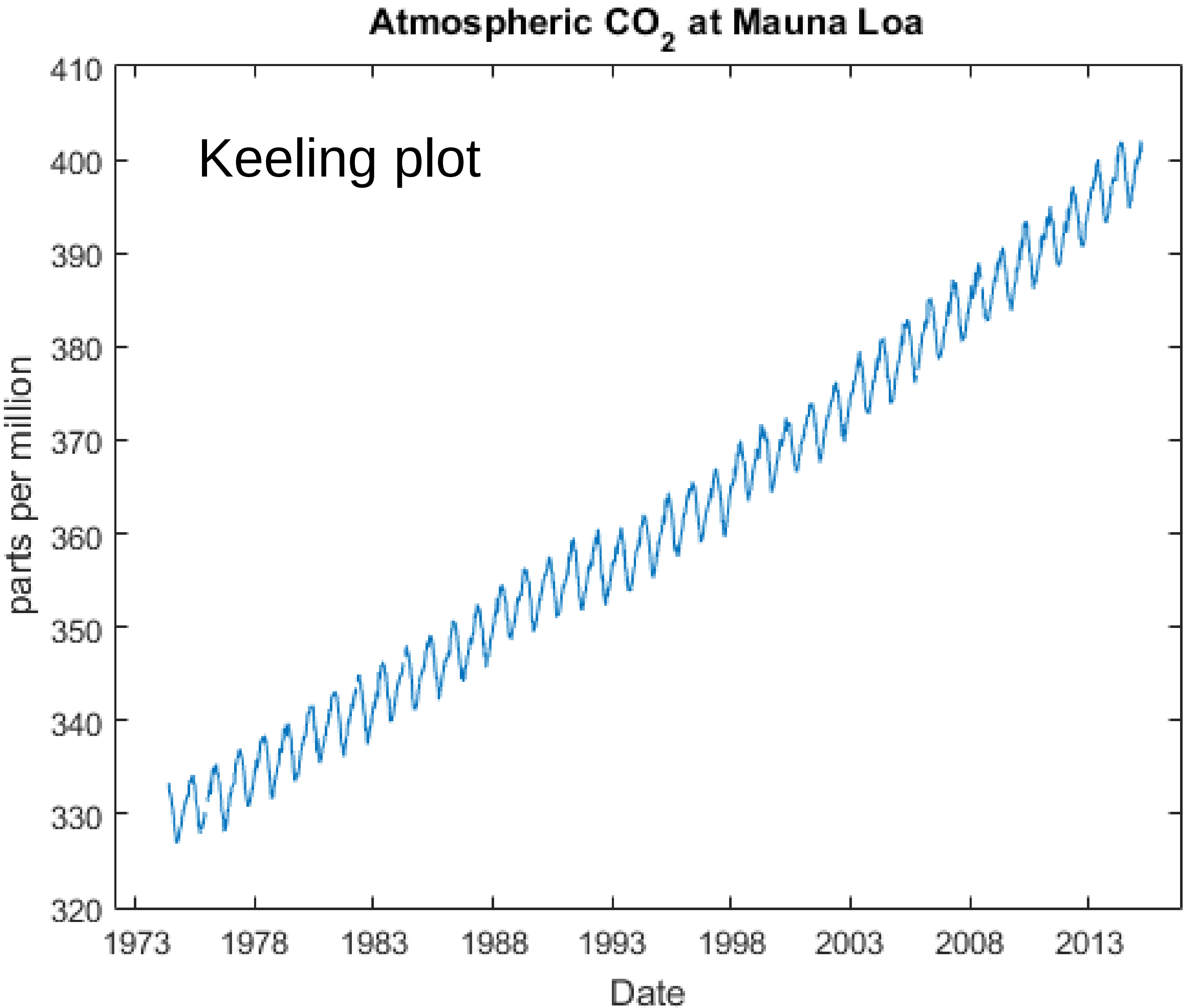
Interannual variability of ecosystem carbon exchange: from observation to prediction

Shuli Niu (牛书丽), Zheng Fu, Yiqi Luo, Paul C. Stoy, Trevor F. Keenan, Benjamin Poulter, Leiming Zhang, Shilong Piao, Xuhui Zhou, Han Zheng, Jiayin Han, Qiufeng Wang, Guirui Yu

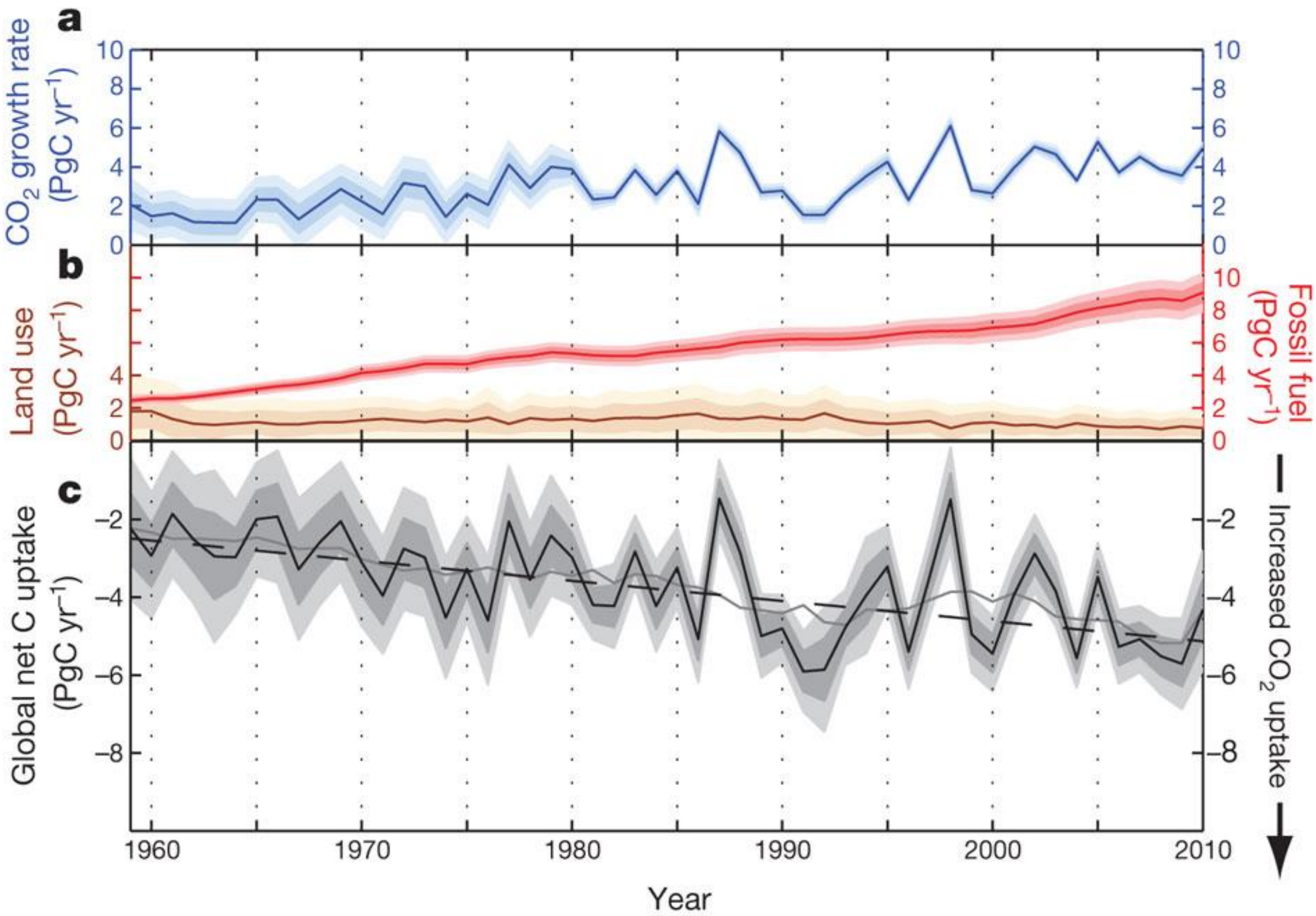
Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences

Aug 18, 2017

Atmosphereic CO_2 concentration

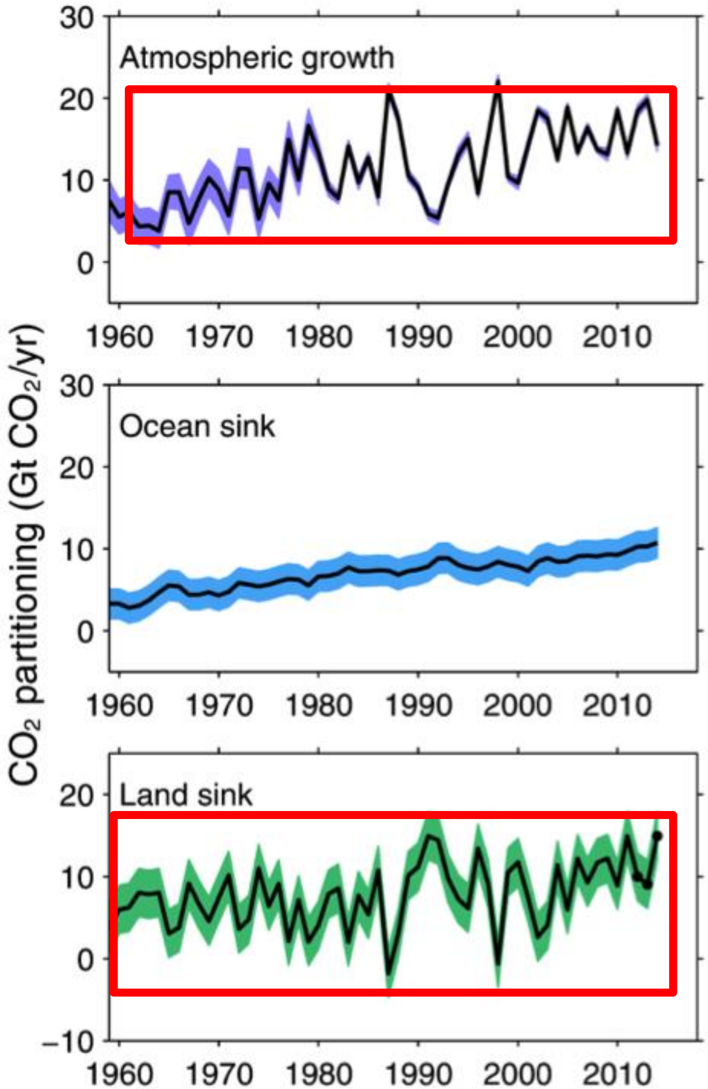


IAV of atmosphereic CO_2 growth rate



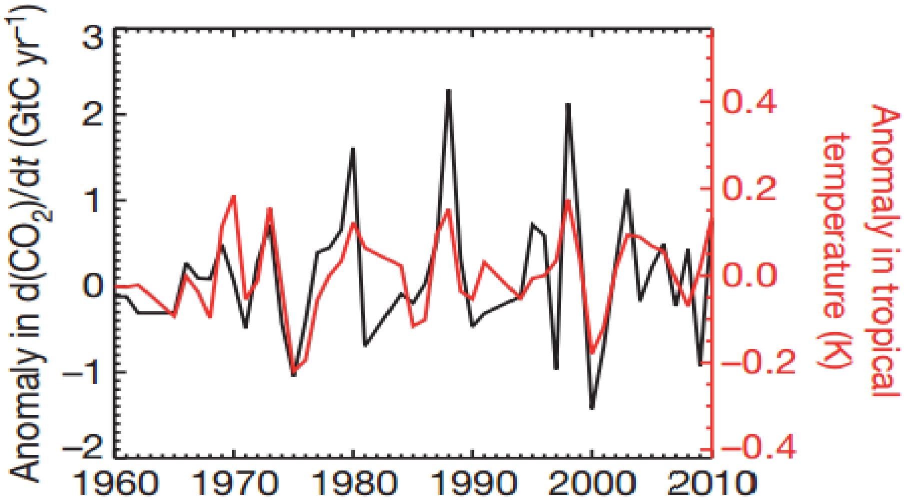
Ballantyne et al. 2012 *Nature*

IAV of land C uptake dominates the IAV of atmospheric CO_2 growth rate

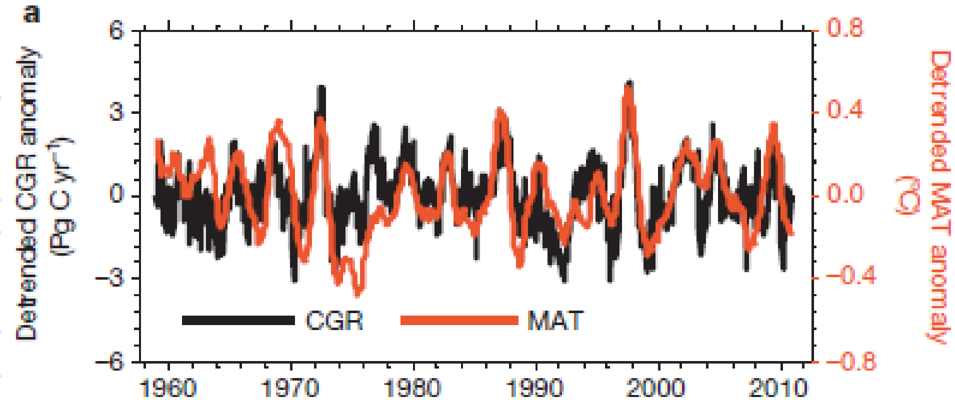


Global Carbon Budget 2015

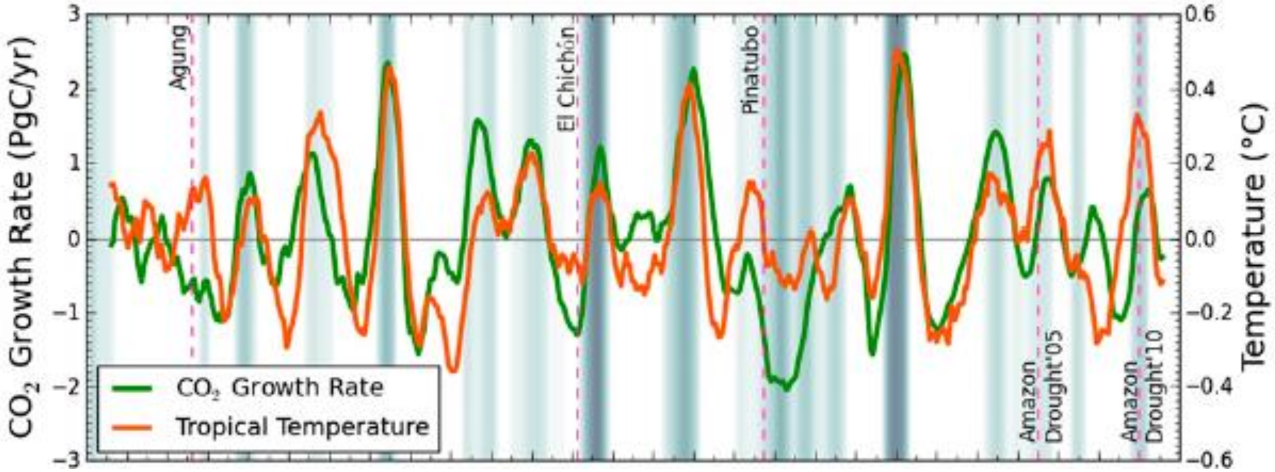
Causes of land C IAV: tropical temperature



Cox et al. 2013 *Nature*

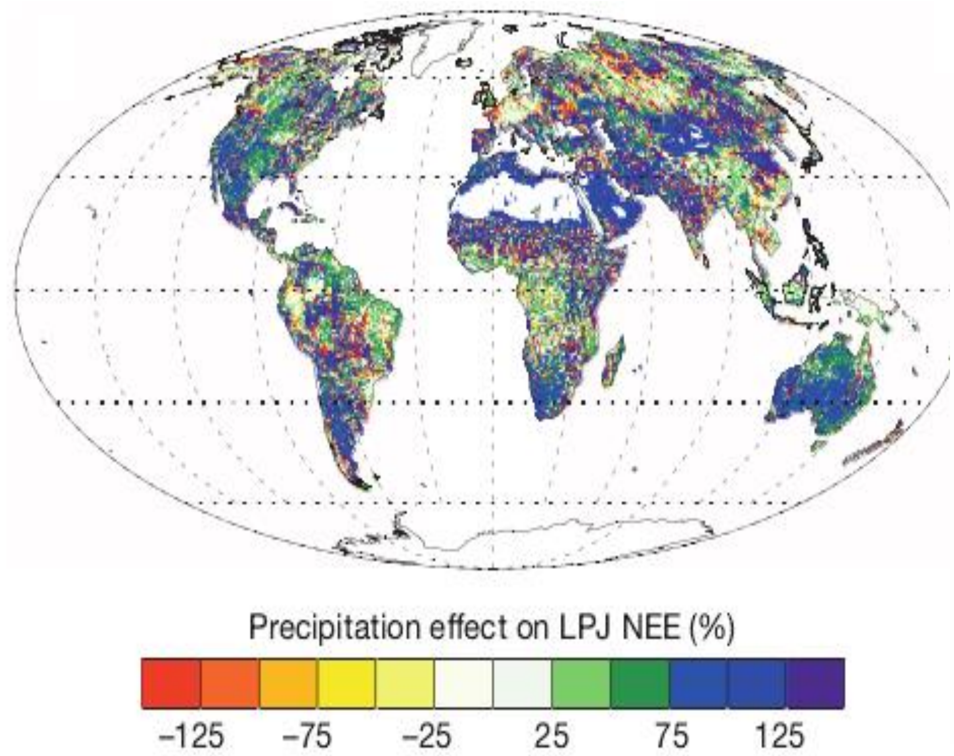


Wang et al. 2014 *Nature*

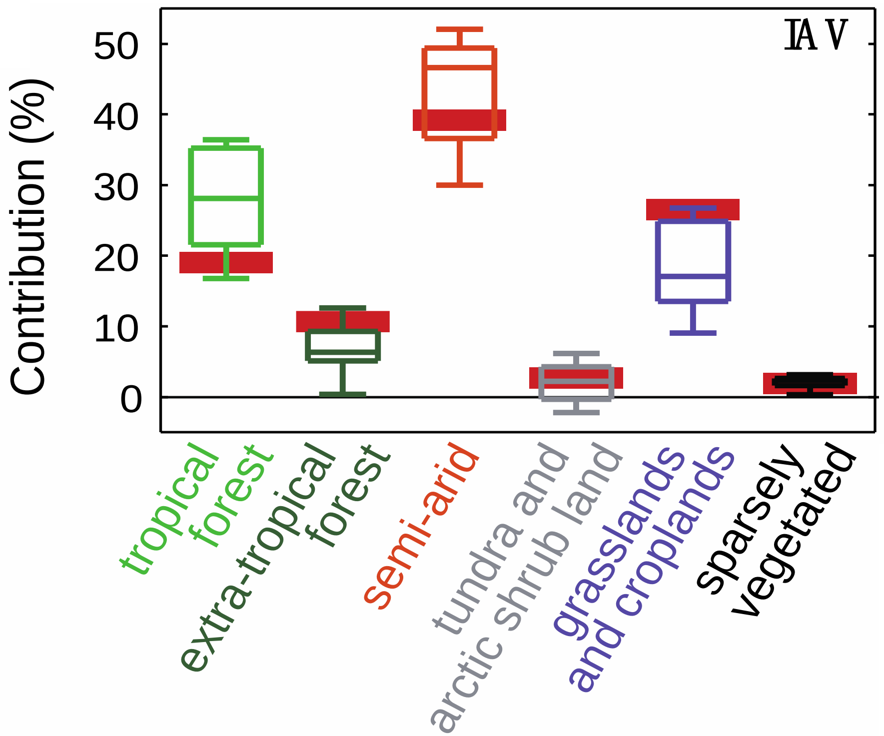


Wang et al. 2013 *PNAS*

Causes of land C IAV: precipitation in semiarid area

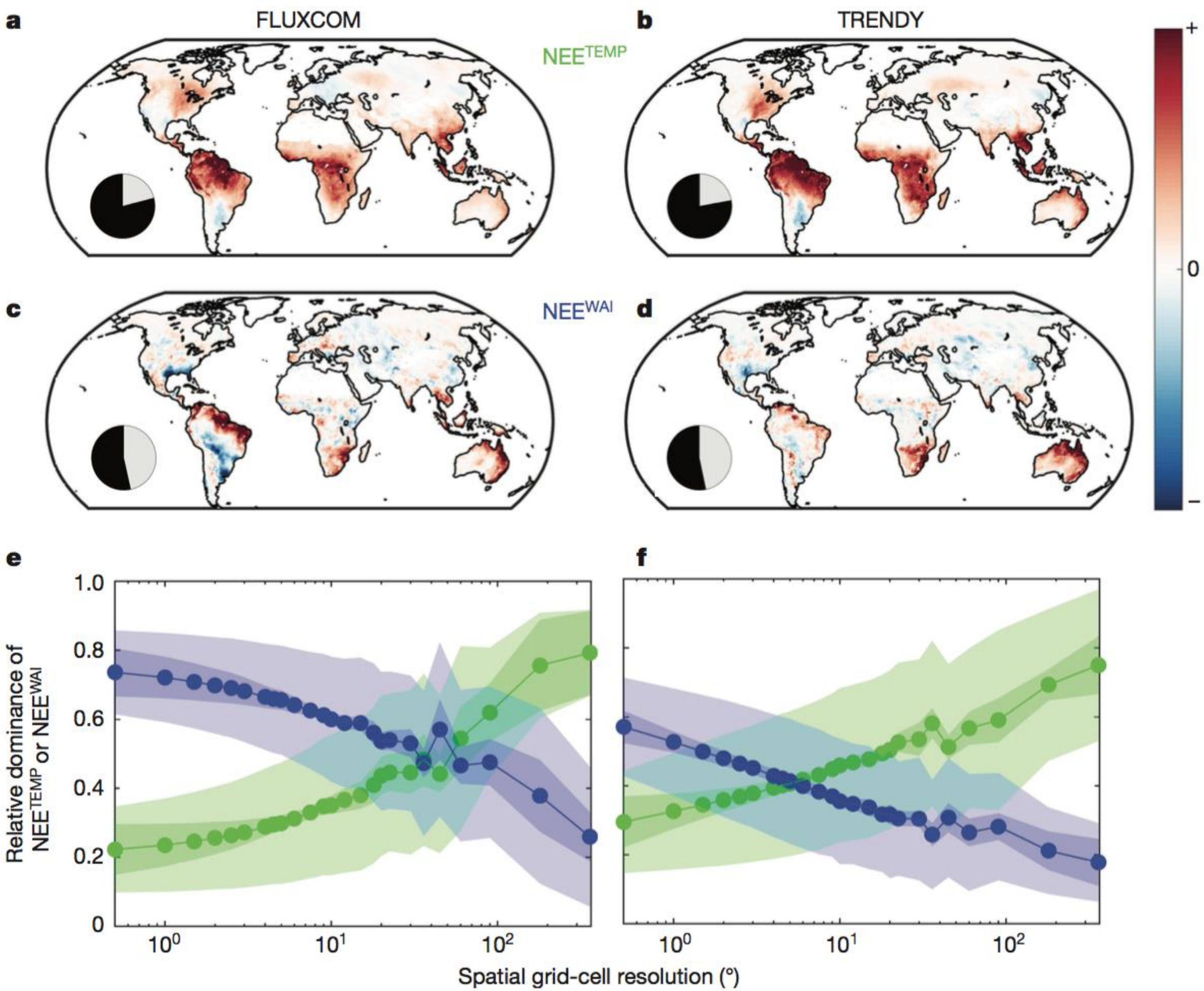


Poulter et al. 2014 *Nature*



Ahlstrom et al. 2015 *Science*

Scale matters! Explained the paradox?

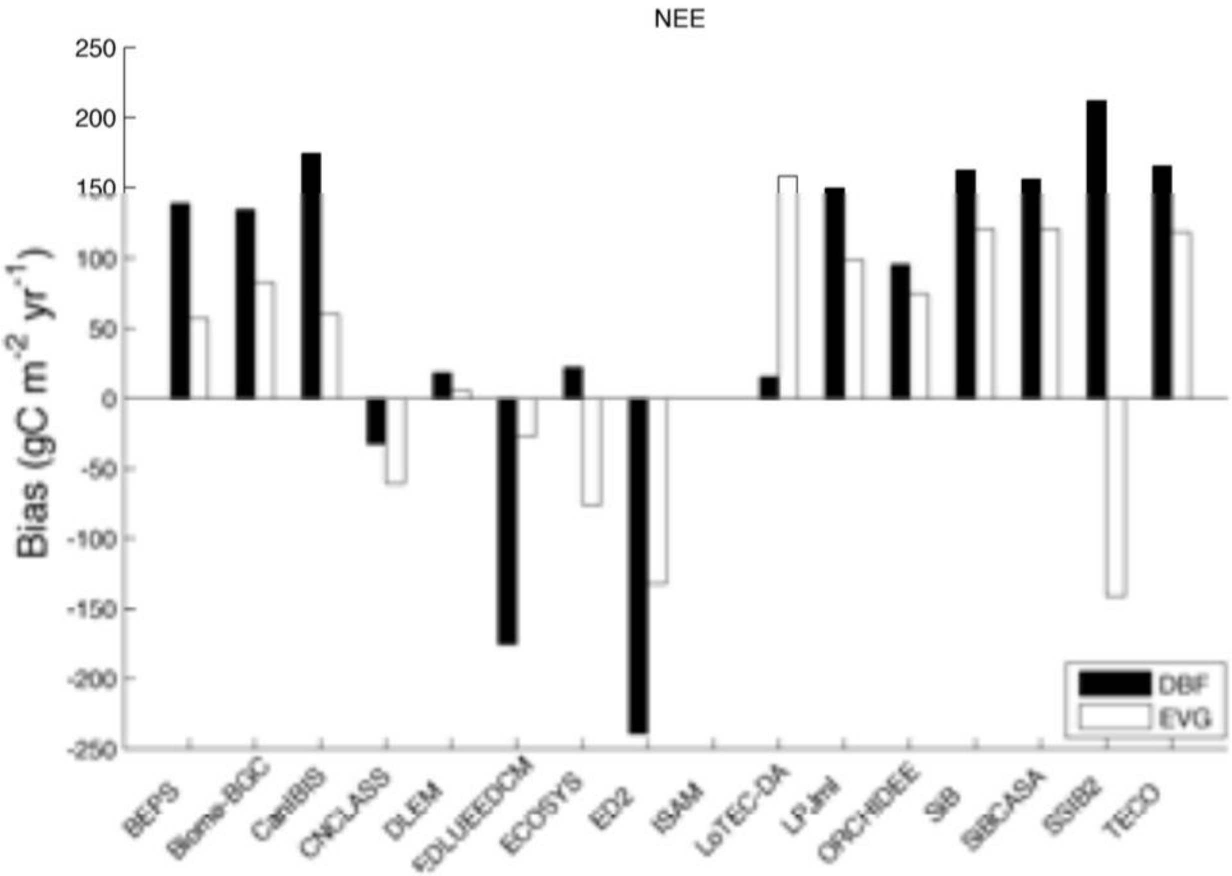


Jung et al. 2017 *Nature*

Model prediction of IAV of land C cycle

Site scale model performance- terrible!

None of the models fell within measurement uncertainty

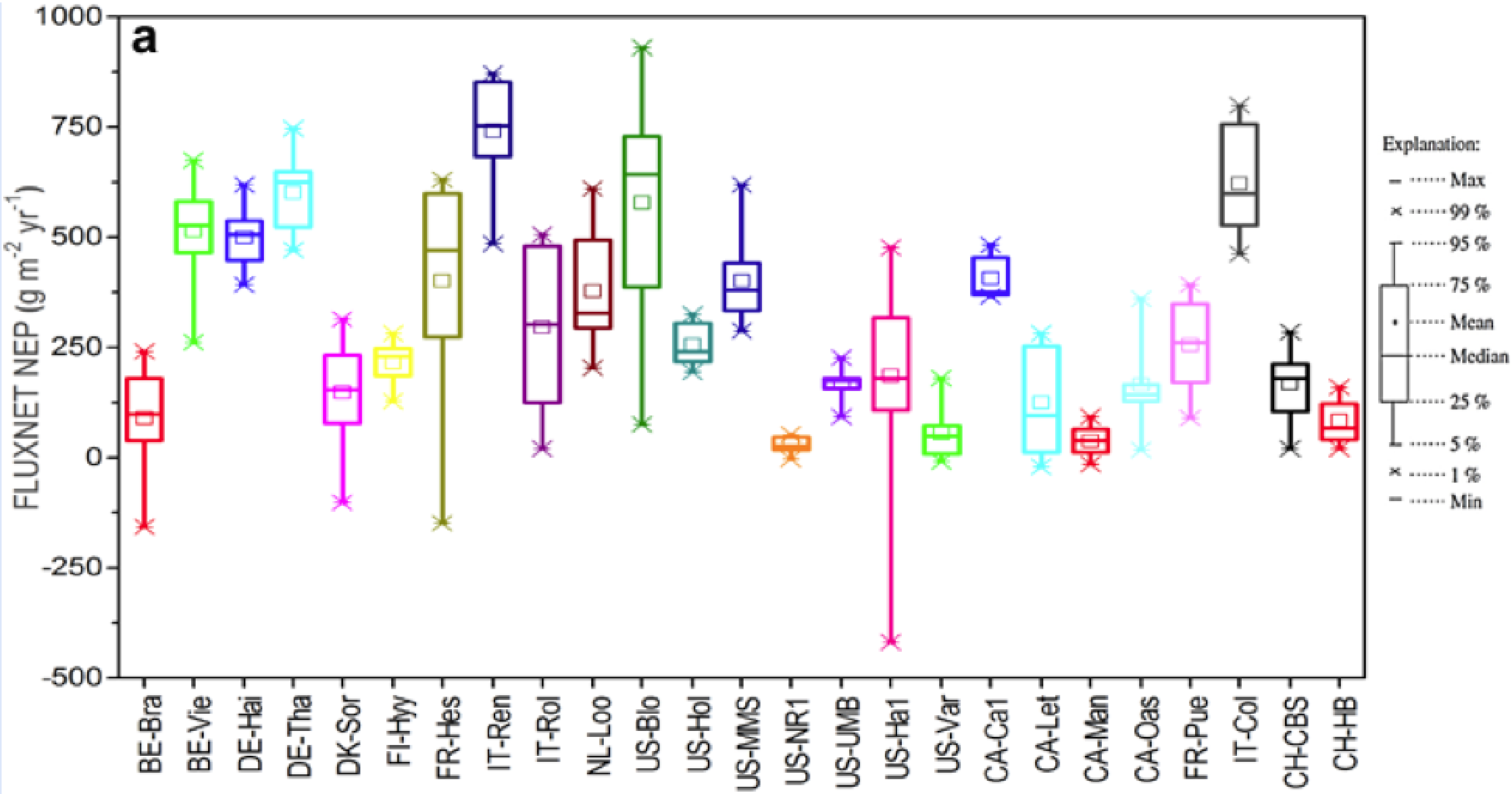


Due to the difficulties in reproducing biogeochemical mechanisms: phenology, lagged response…

Keenan et al. 2012. GCB

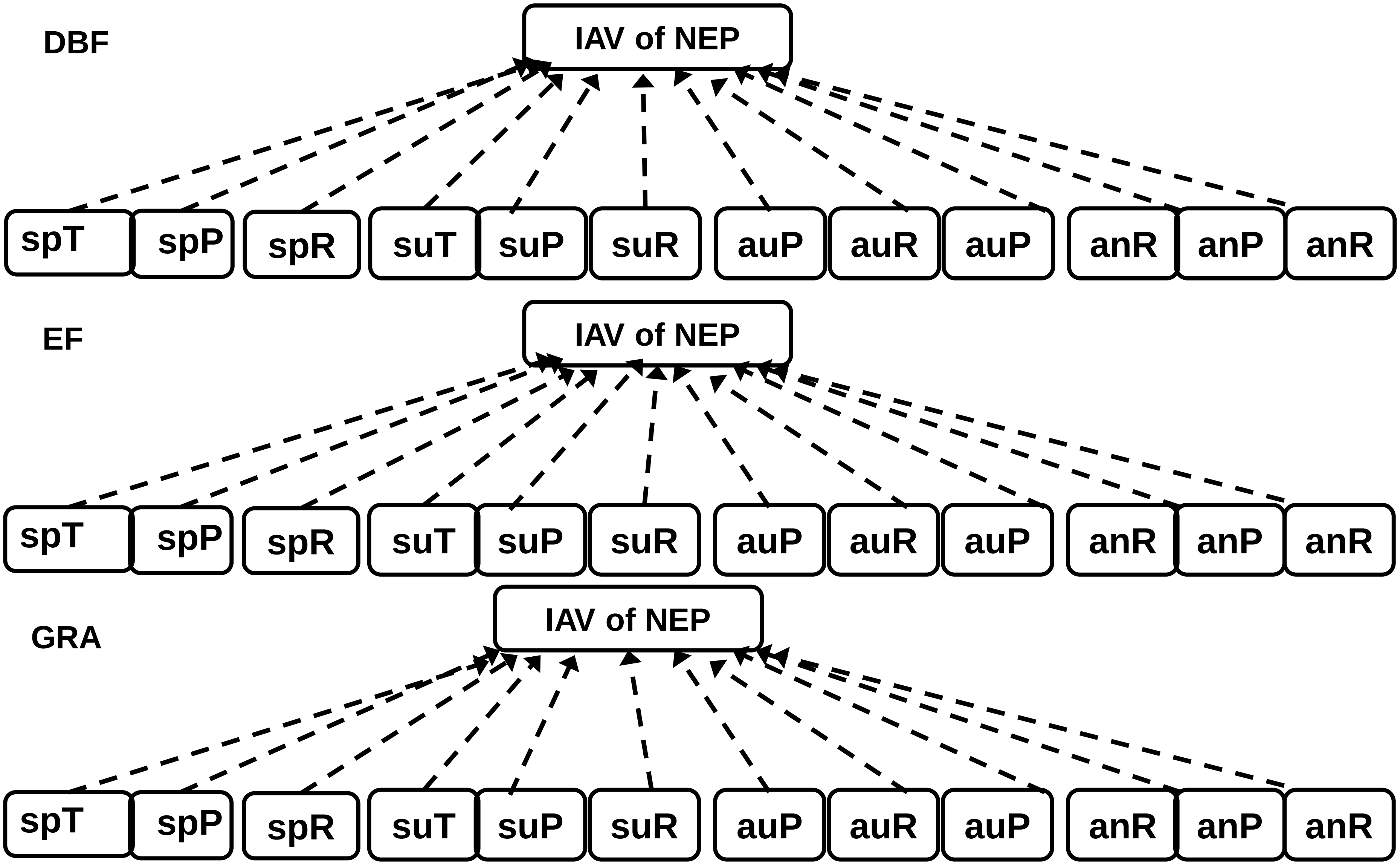
What are the key biogeochemical mechanisms underlying the IAV of ecosystem NEE?

IAV of NEE- fluxnet sites

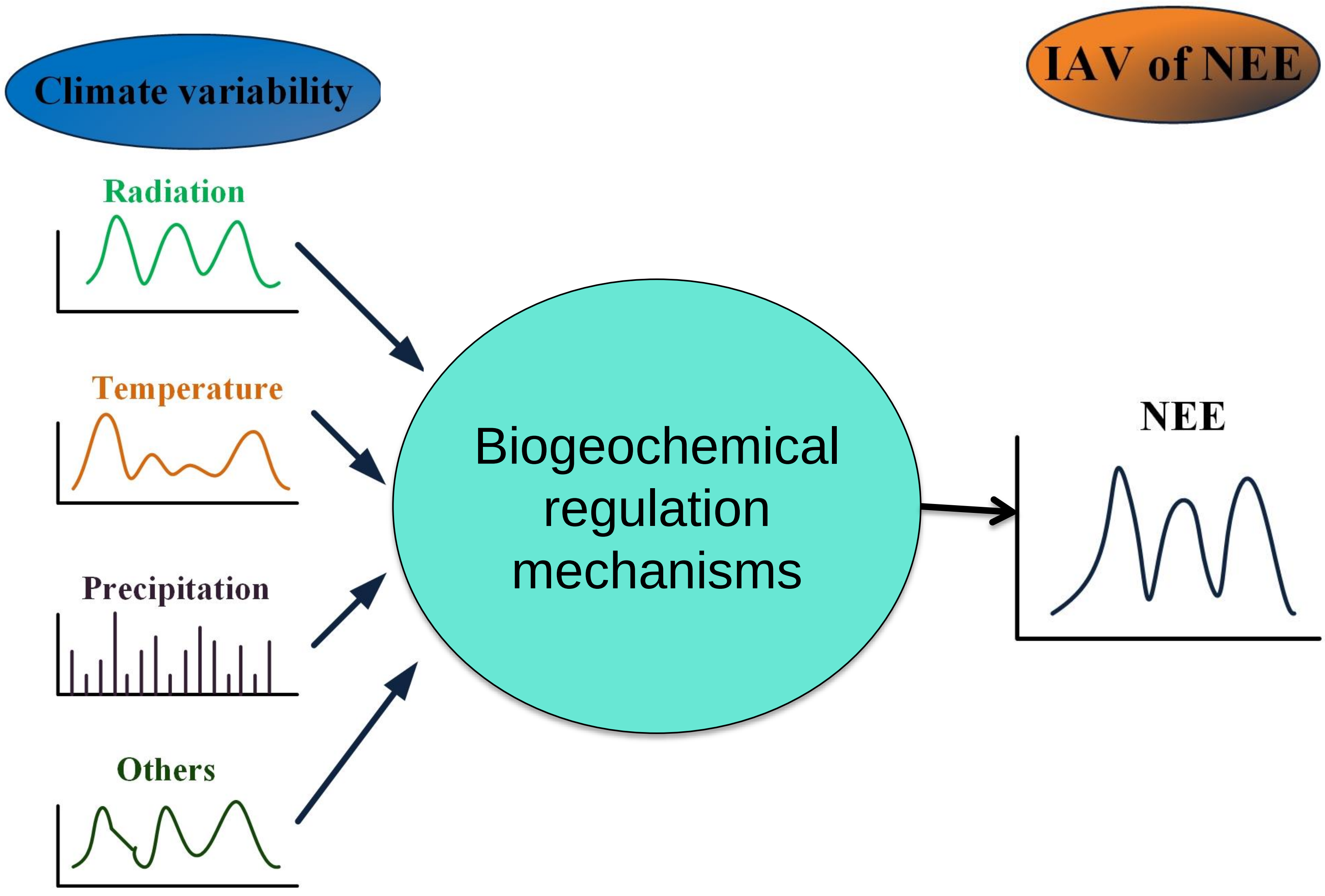


Fu et al. 2017. AFM

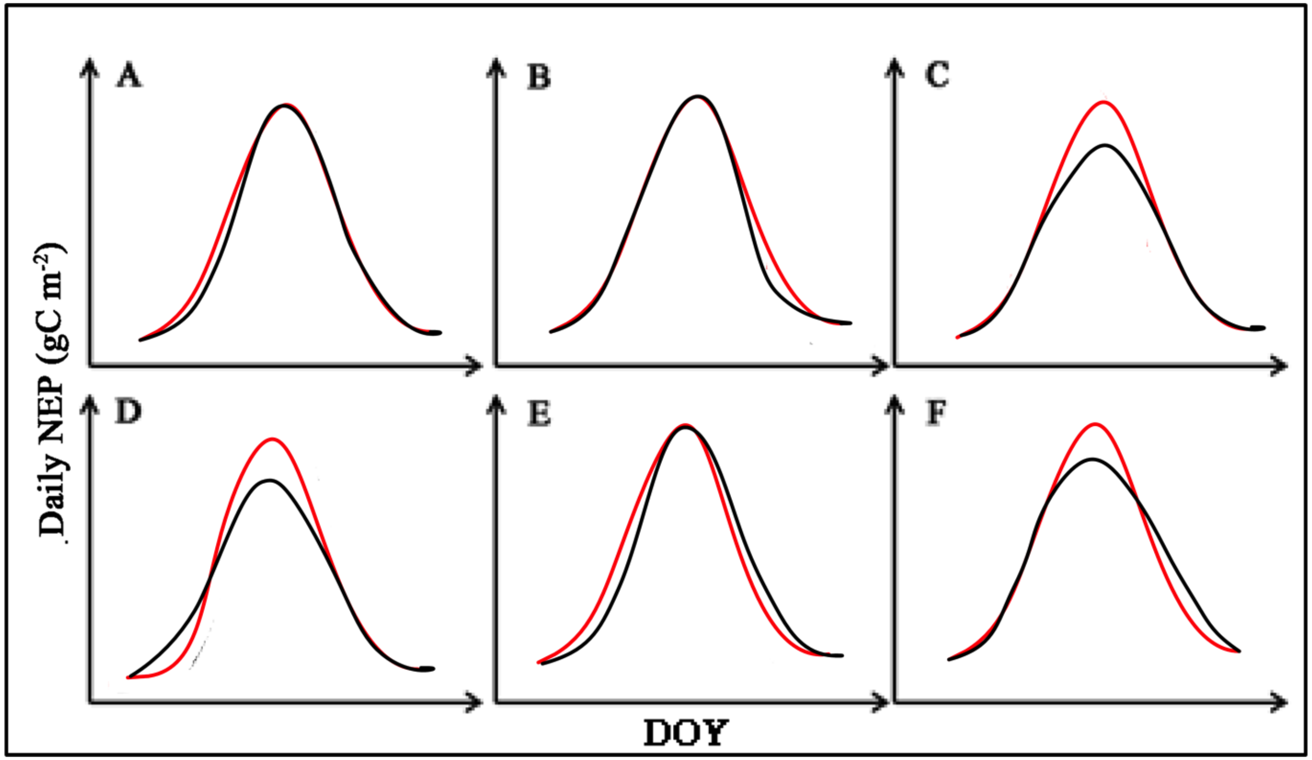
No significant correlation between IAV of NEP and anomalies of climate factors



Conceptual diagram



Possible mechanisms

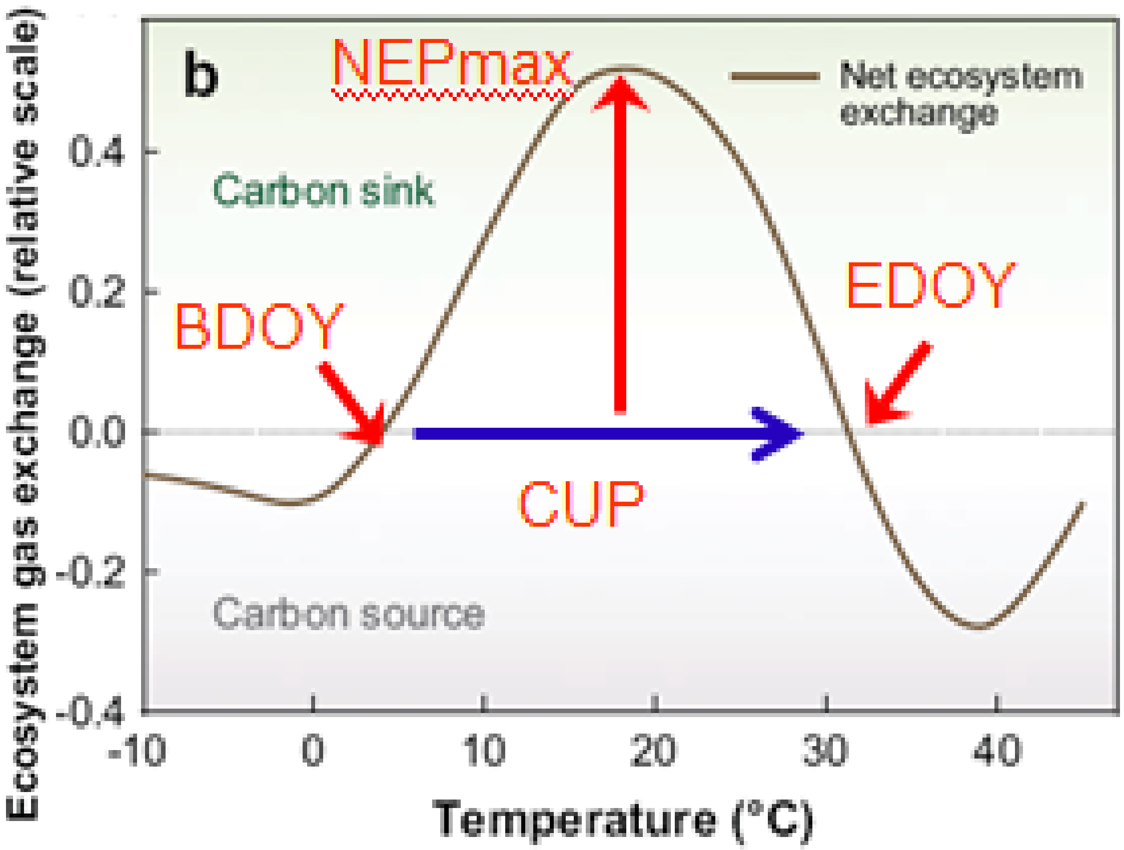


Ultimate causes of IAV of NEP: climate factors: T, PPT, Rg …

Proximate causes of IAV of NEP: biogeochemical regulations

Fu et al. 2017. ERL

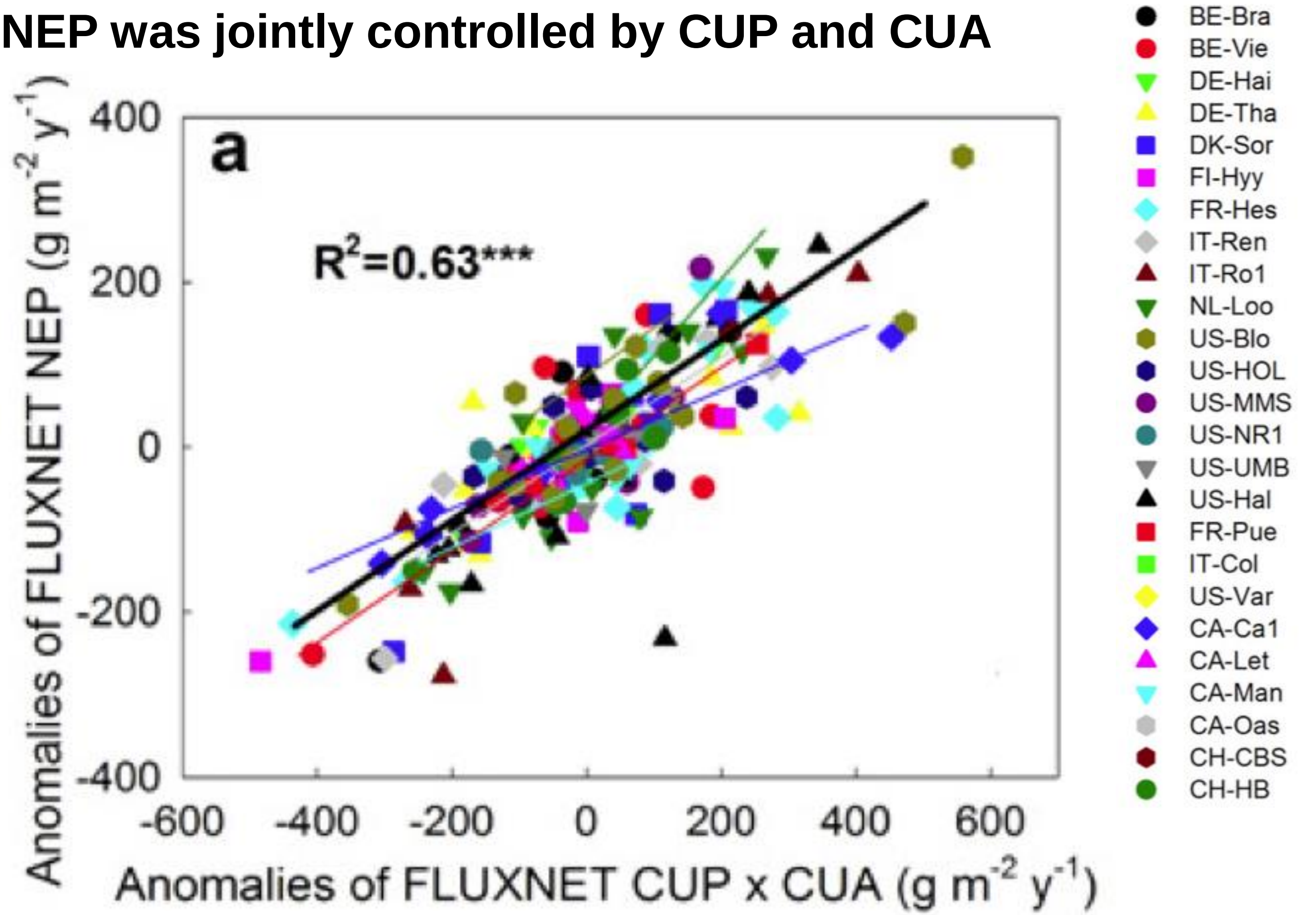
Quantify the key processes



Fu et al. 2017. ERL

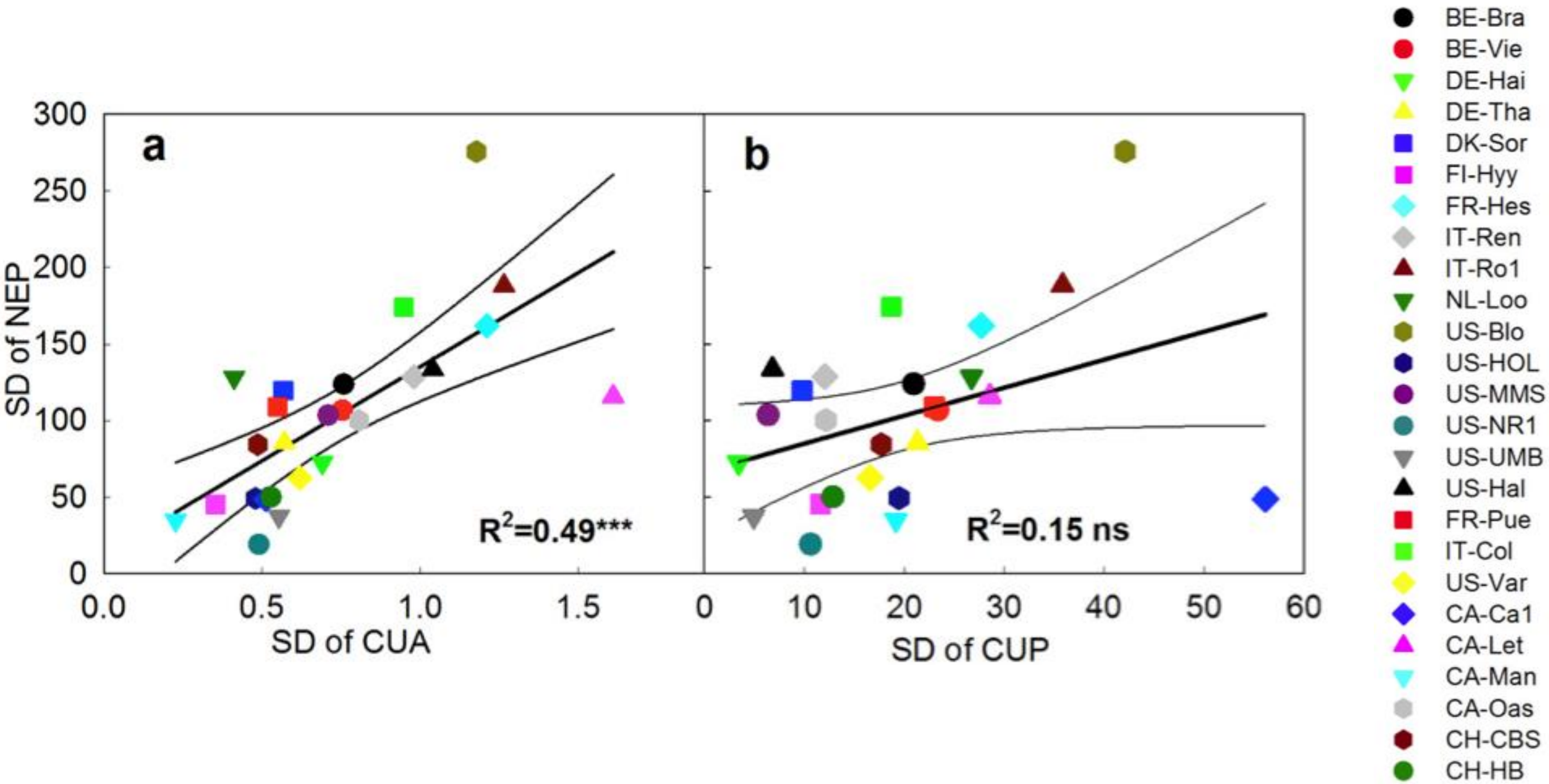
IAV of NEP and the determinants

NEP was jointly controlled by CUP and CUA



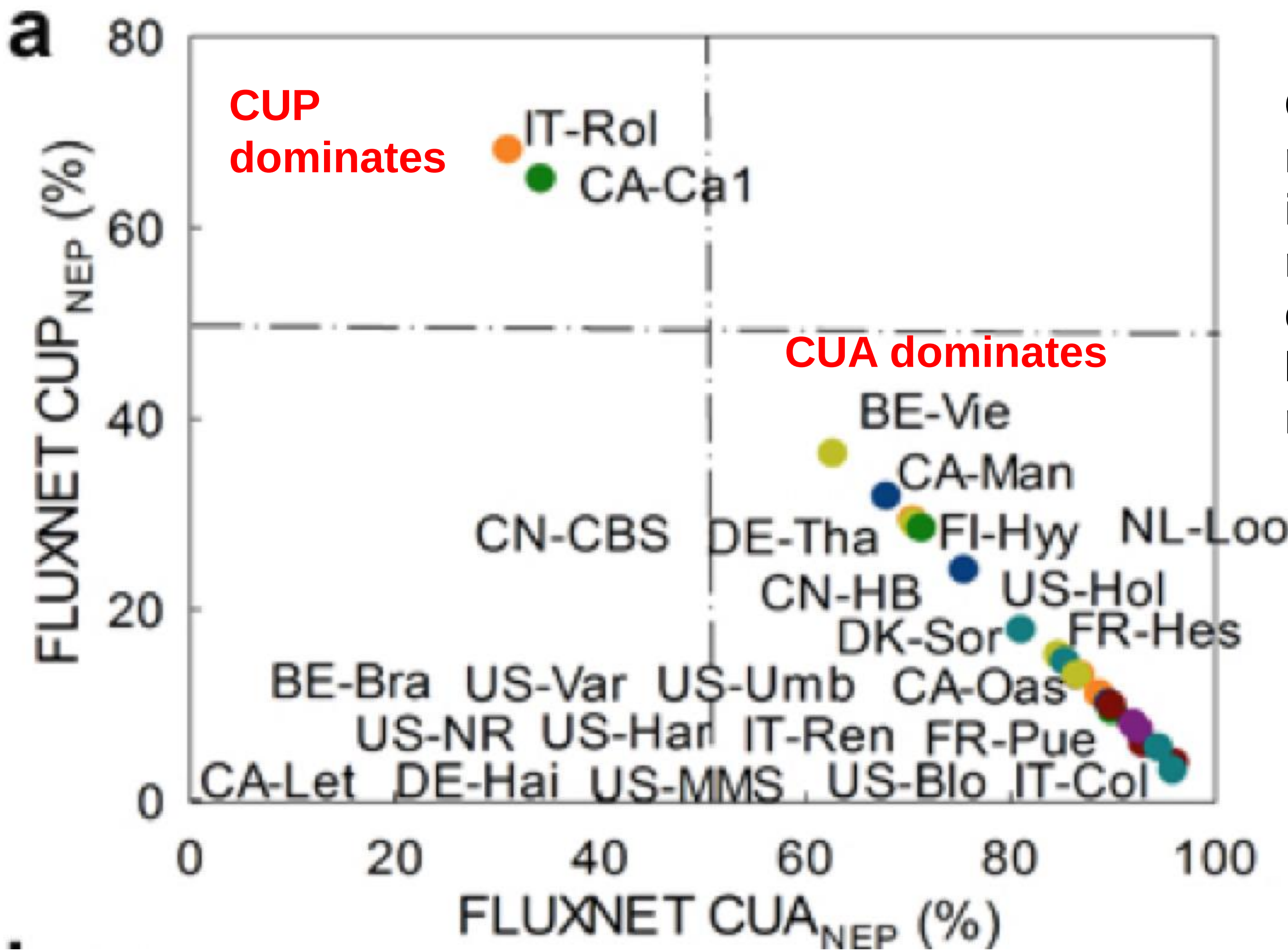
Niu et al. 2017. in revision

IAV of NEP vs. IAV of CUA and CUP



Niu et al. 2017. in revision

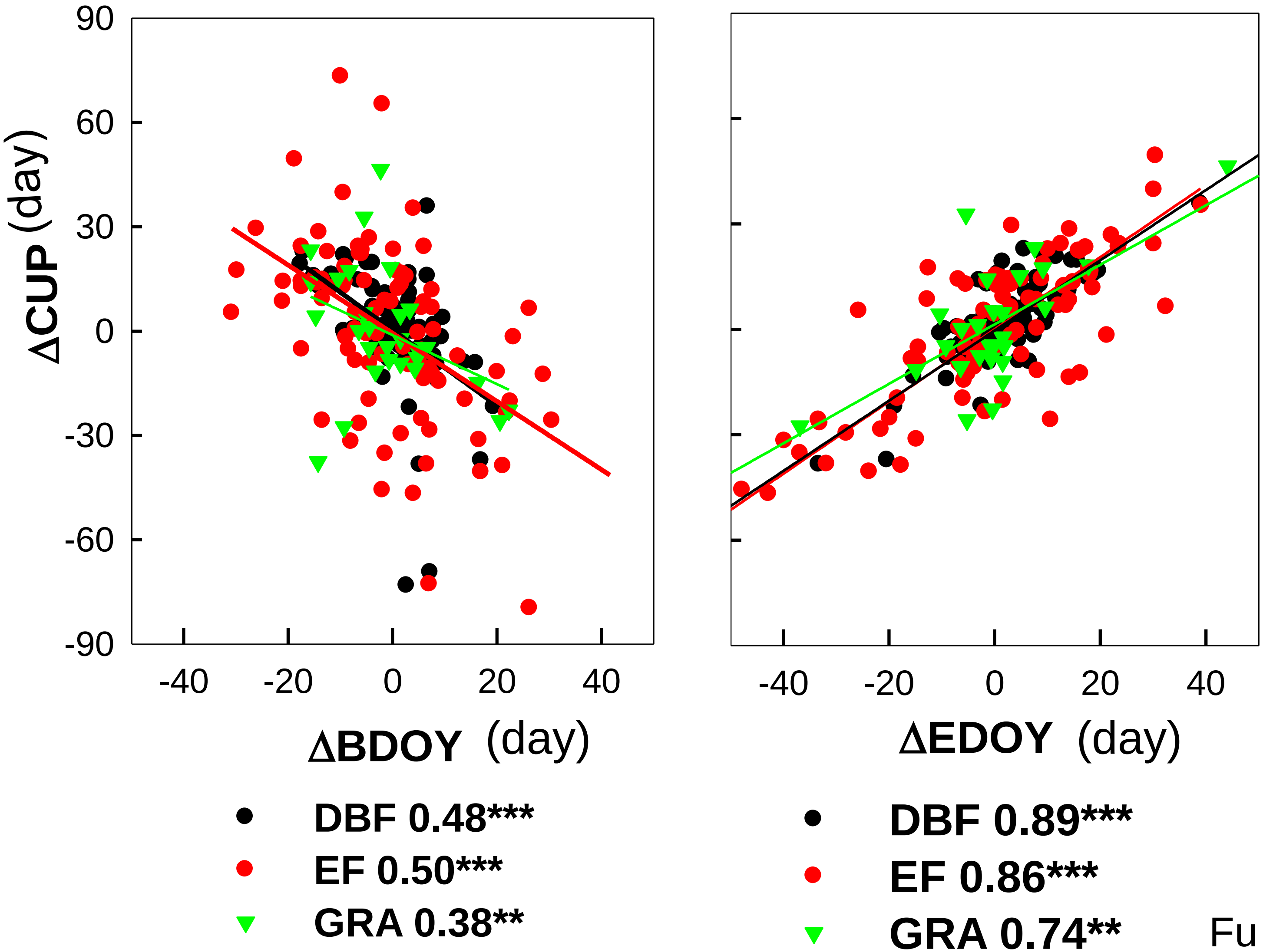
Relative importance of the two processes



CUA played more important role in determining IAV of NEP at most site

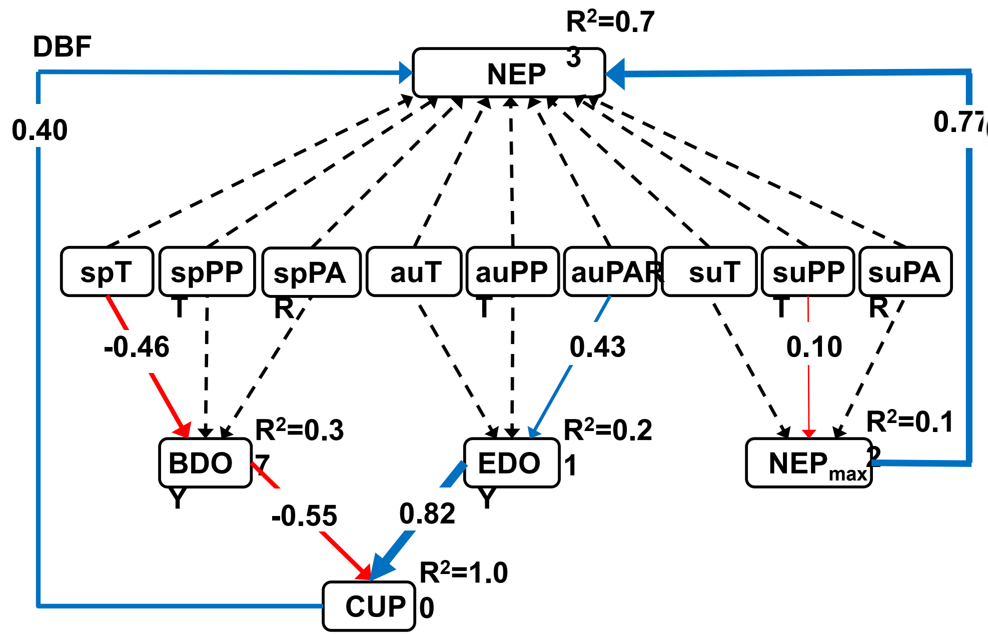
Niu et al. 2017. in revision

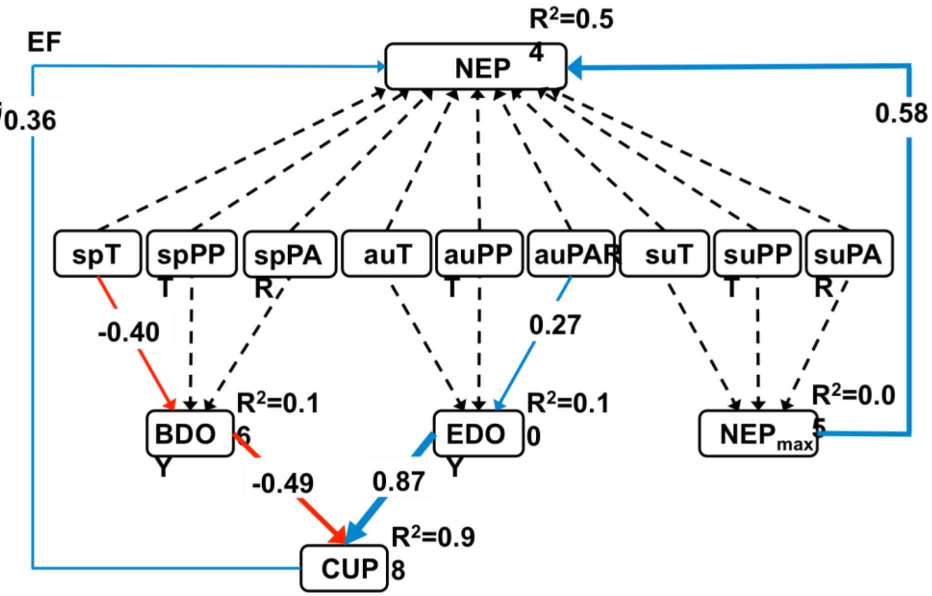
IAV of CUP vs. IAV of BDOY or EDOY

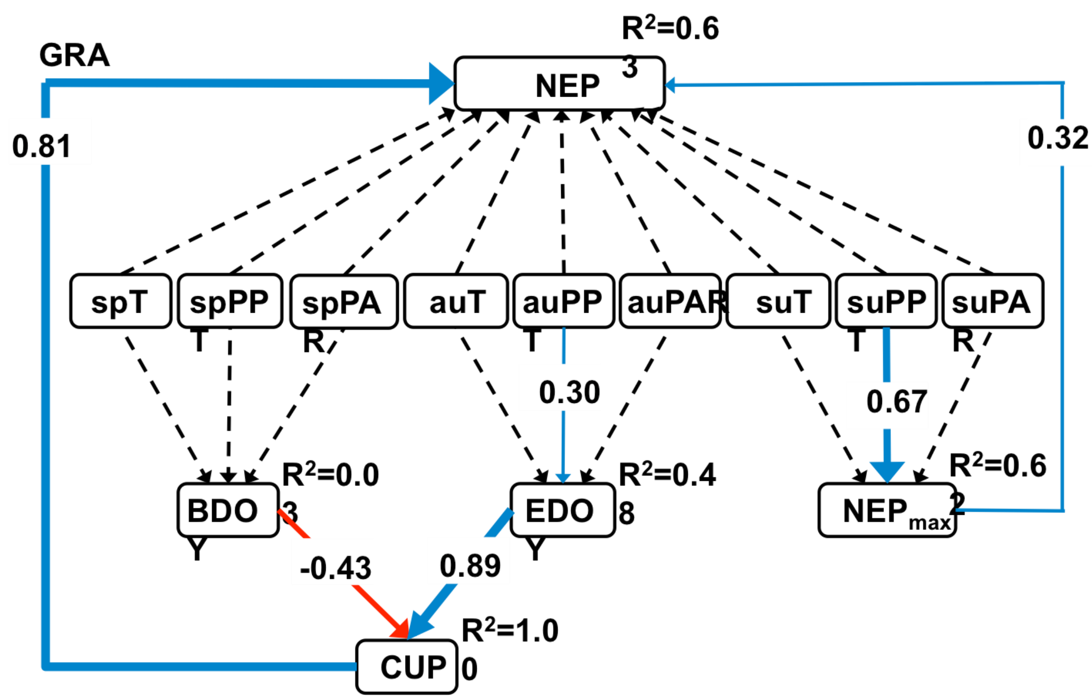


Autumn phenology played more important role than spring phenology in controlling IAV of CUP.

Fu et al. 2017. AFM



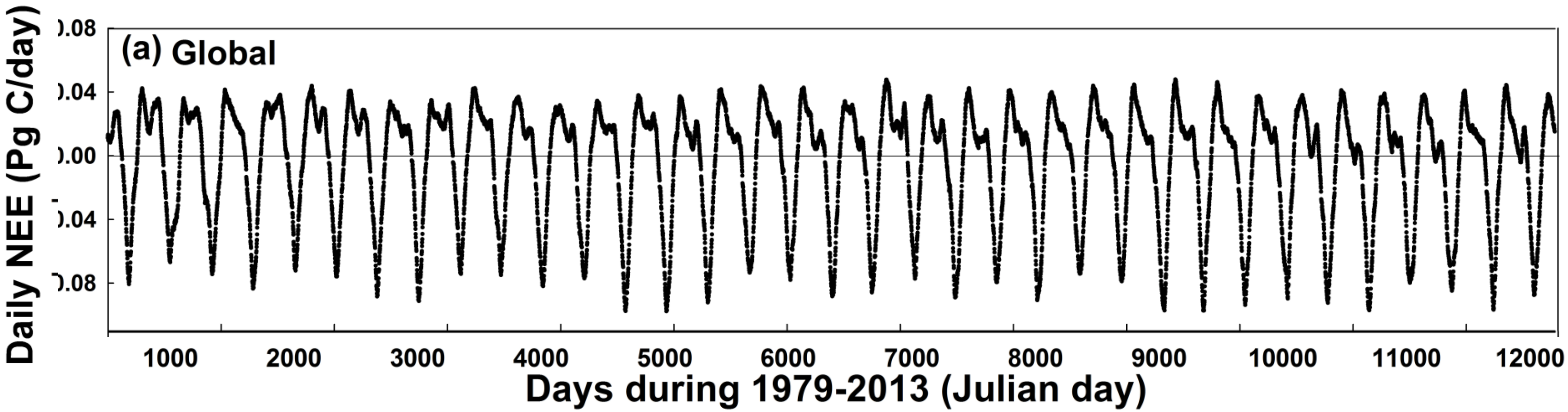




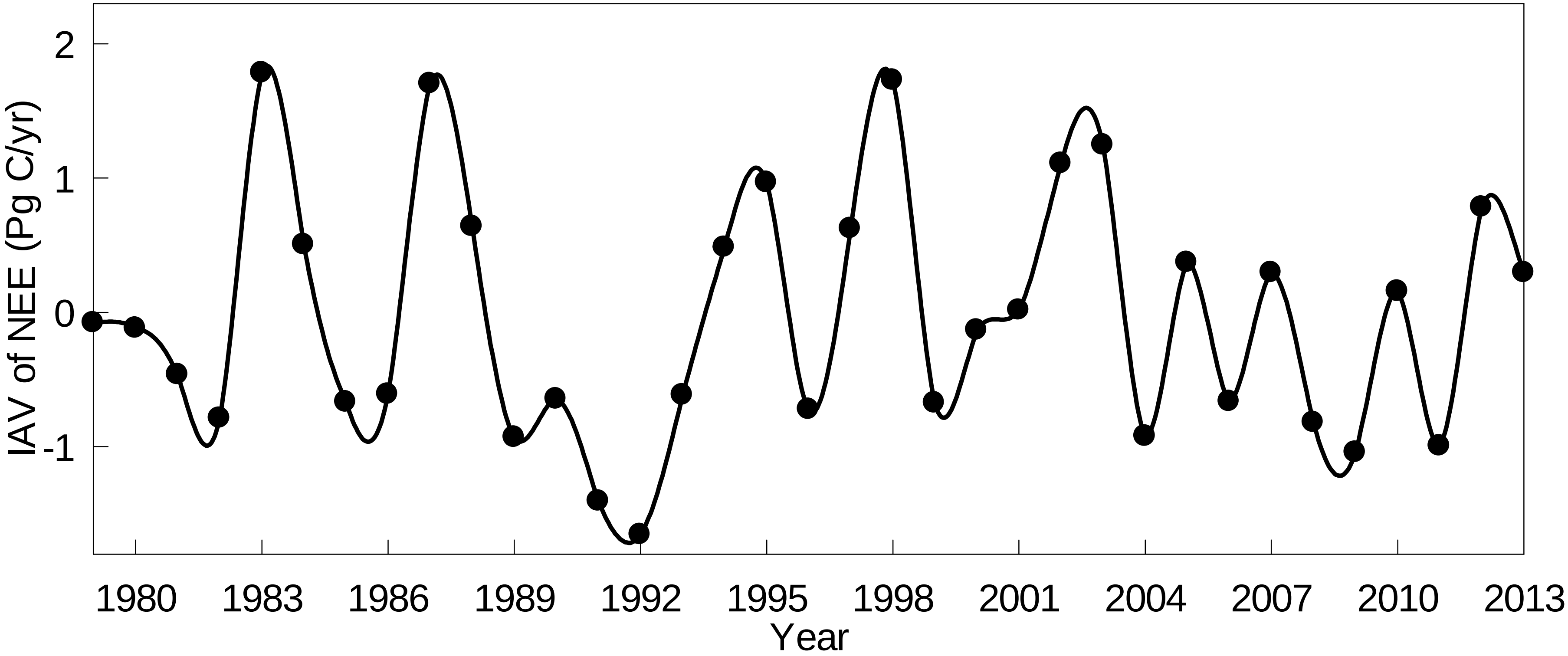
Climate variables did not directly but indirectly affect IAV of NEE via biogeochemical regulations

Fu et al. 2017. AFM

Global scale?

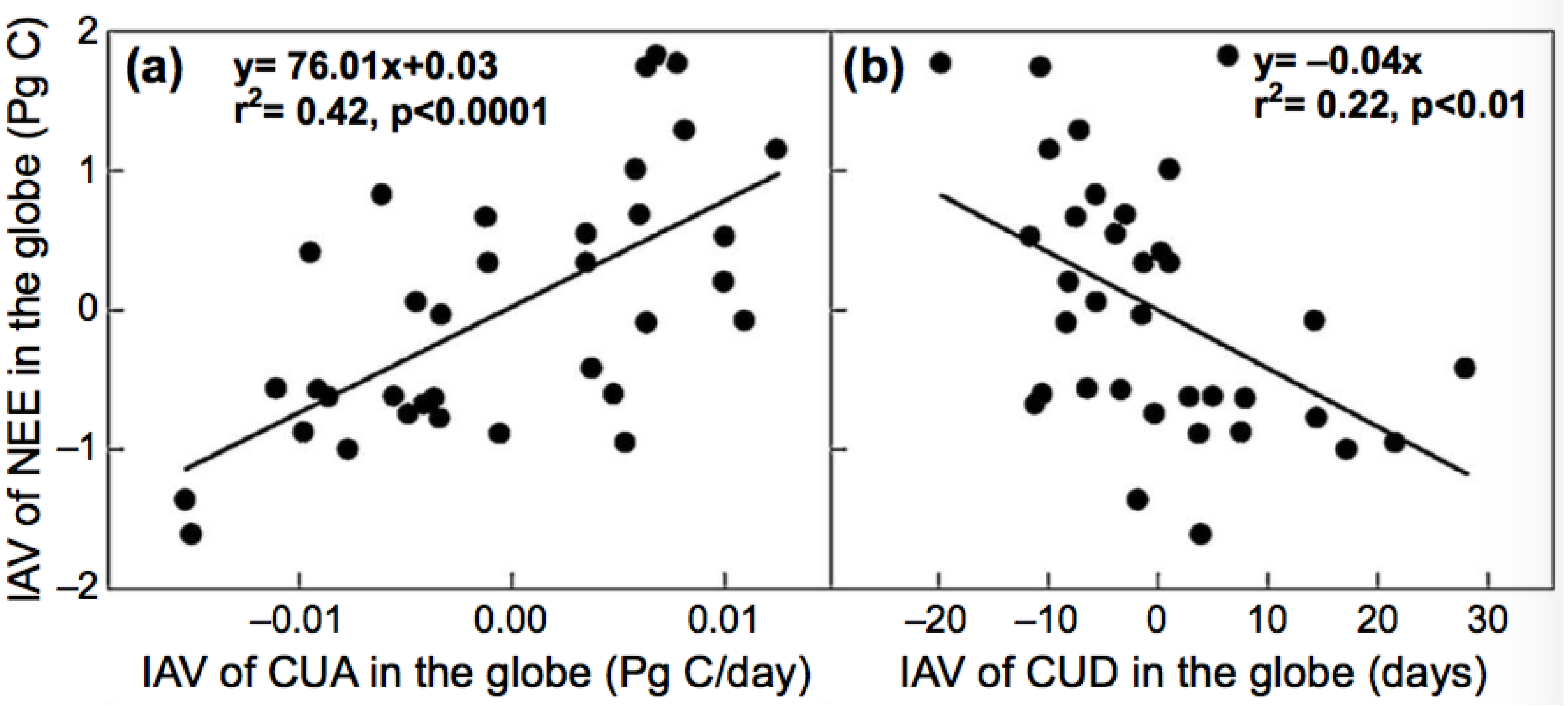


IAV of global land NEE

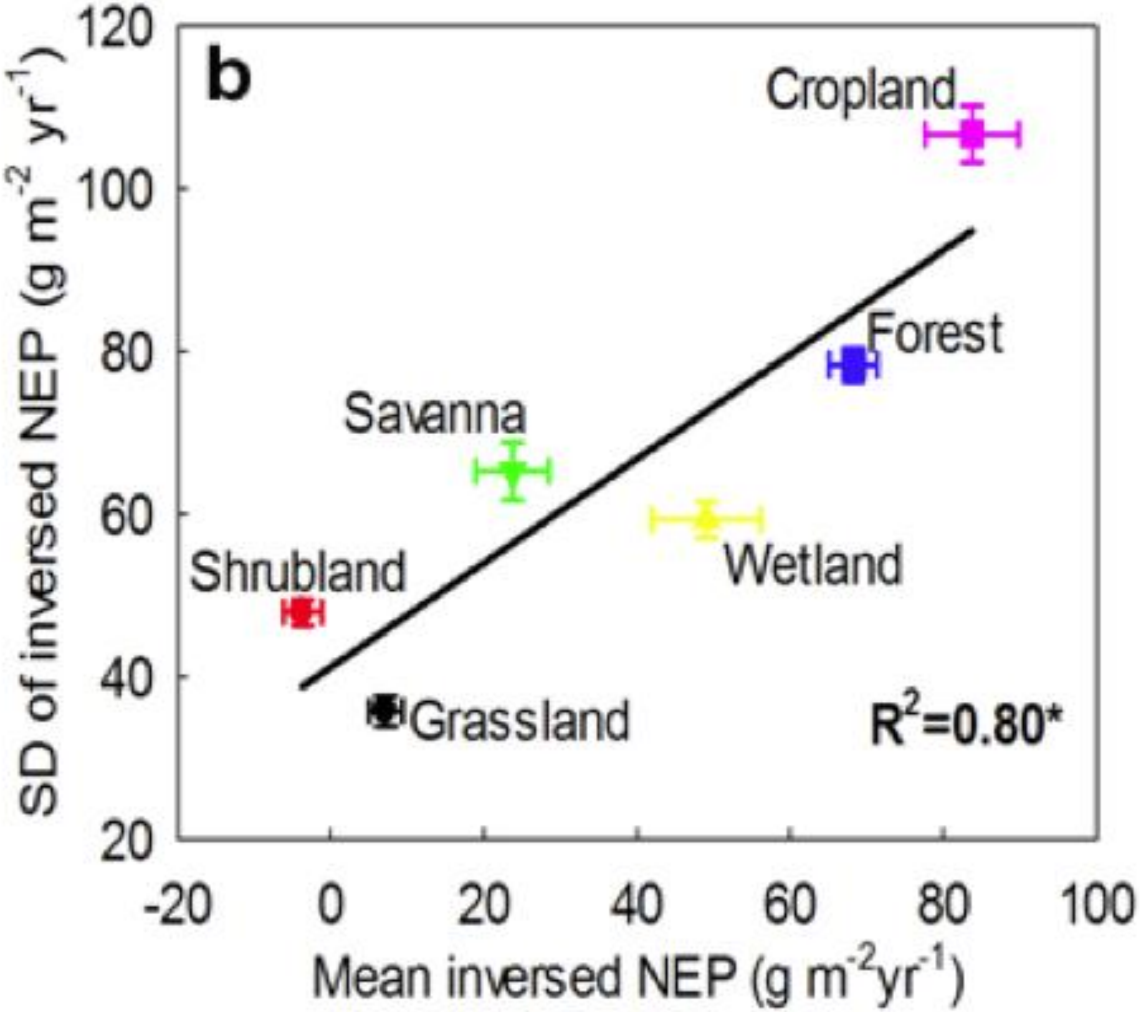


Fu et al. 2017. ERL

IAV of global NEE vs. CUA, CUP

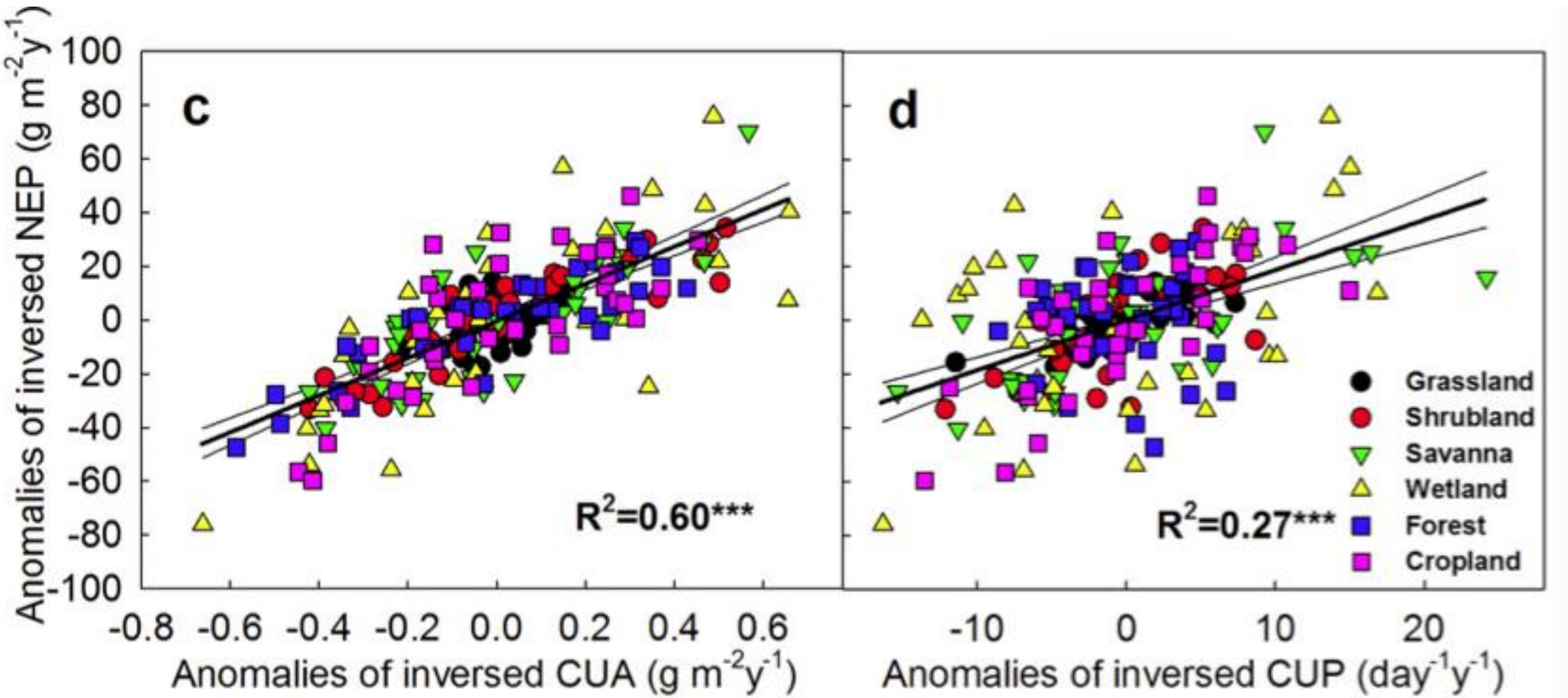


Different vegetation types?



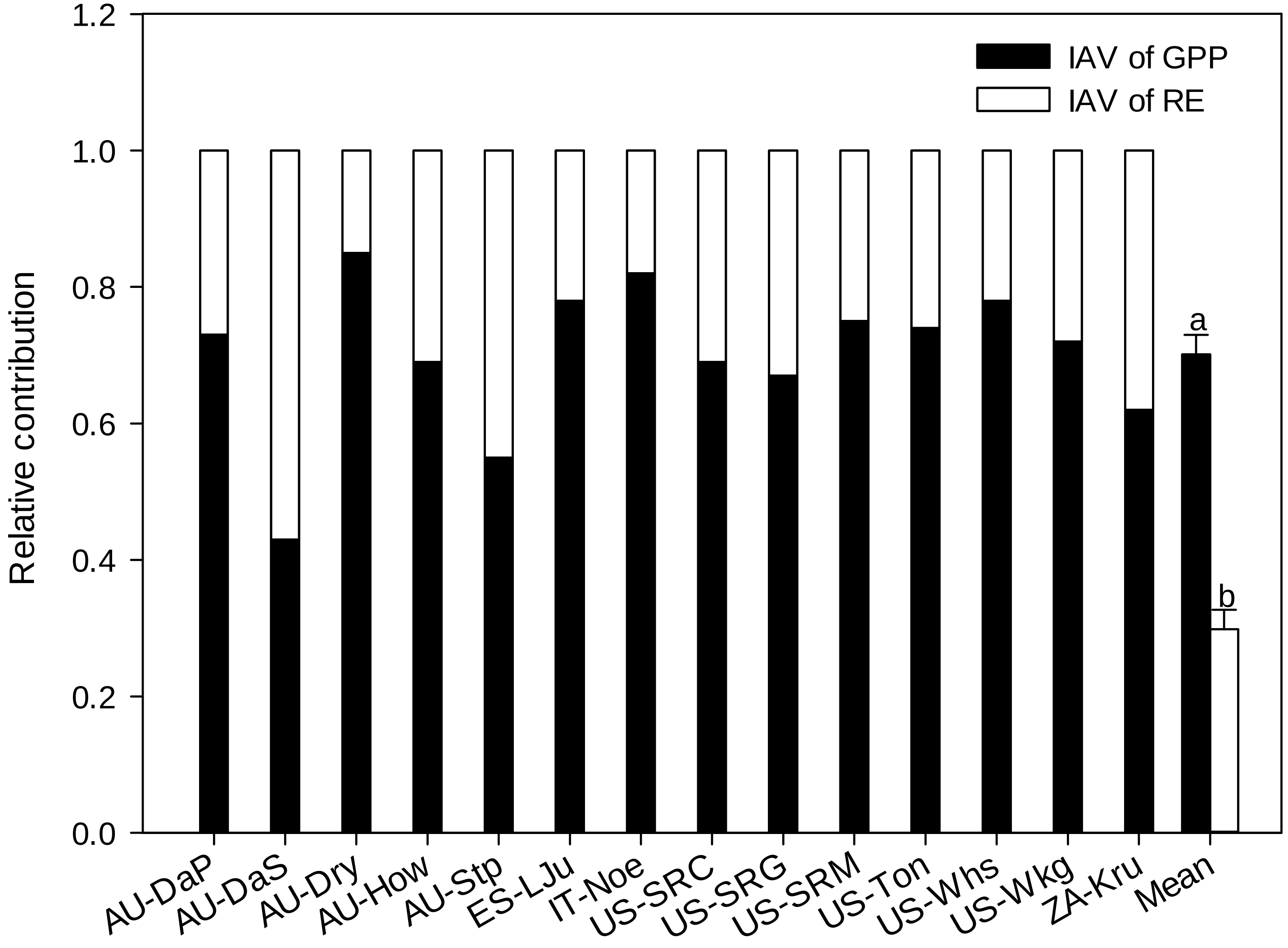
Fu et al. 2017. ERL

IAV of global NEE vs CUA, CUP



Fu et al. 2017. ERL

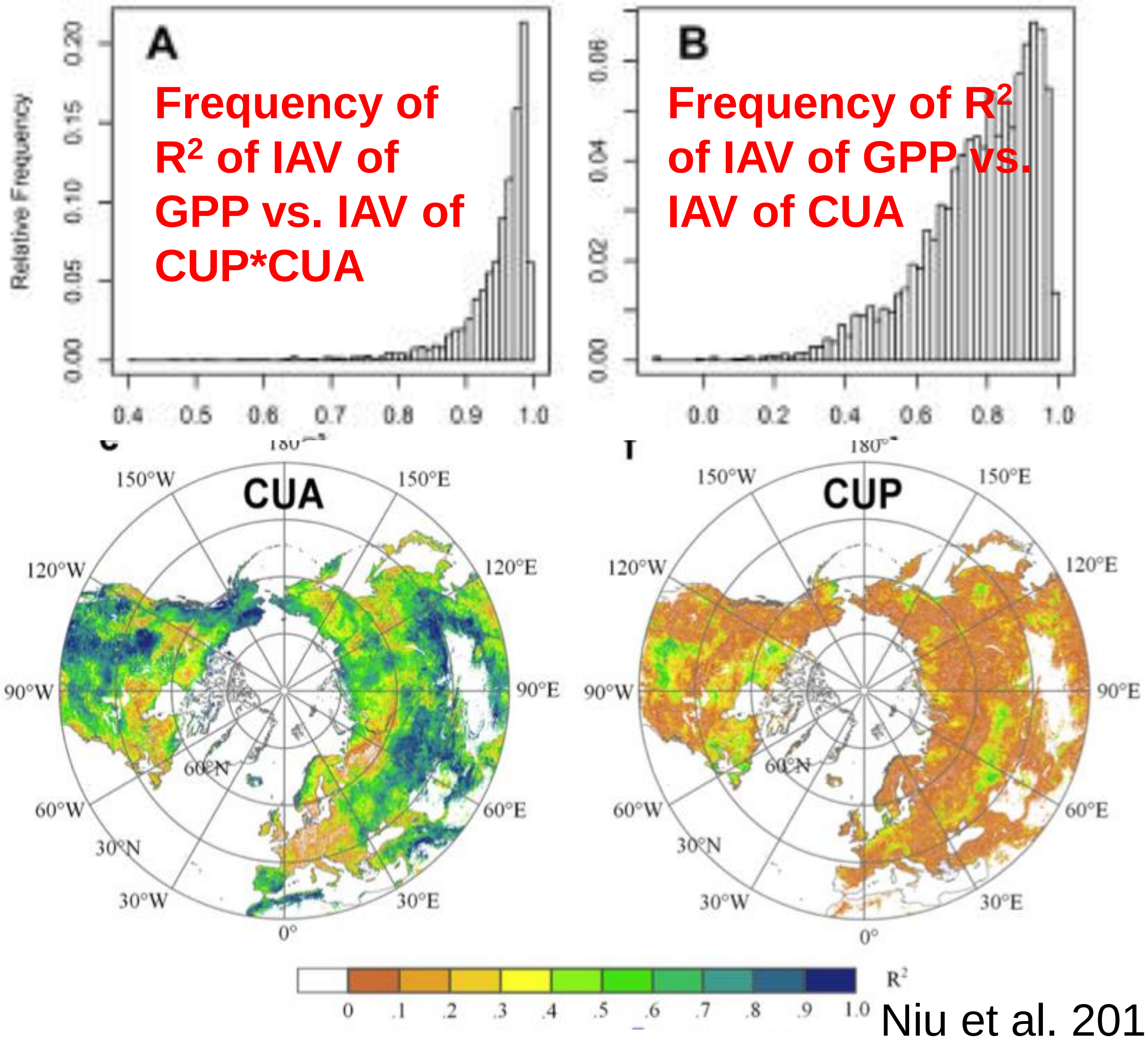
IAV of NEE was largely due to IAV of GPP



Fu et al. in preparation

IAV of MODIS-GPP and its attributions to CUP and CUA

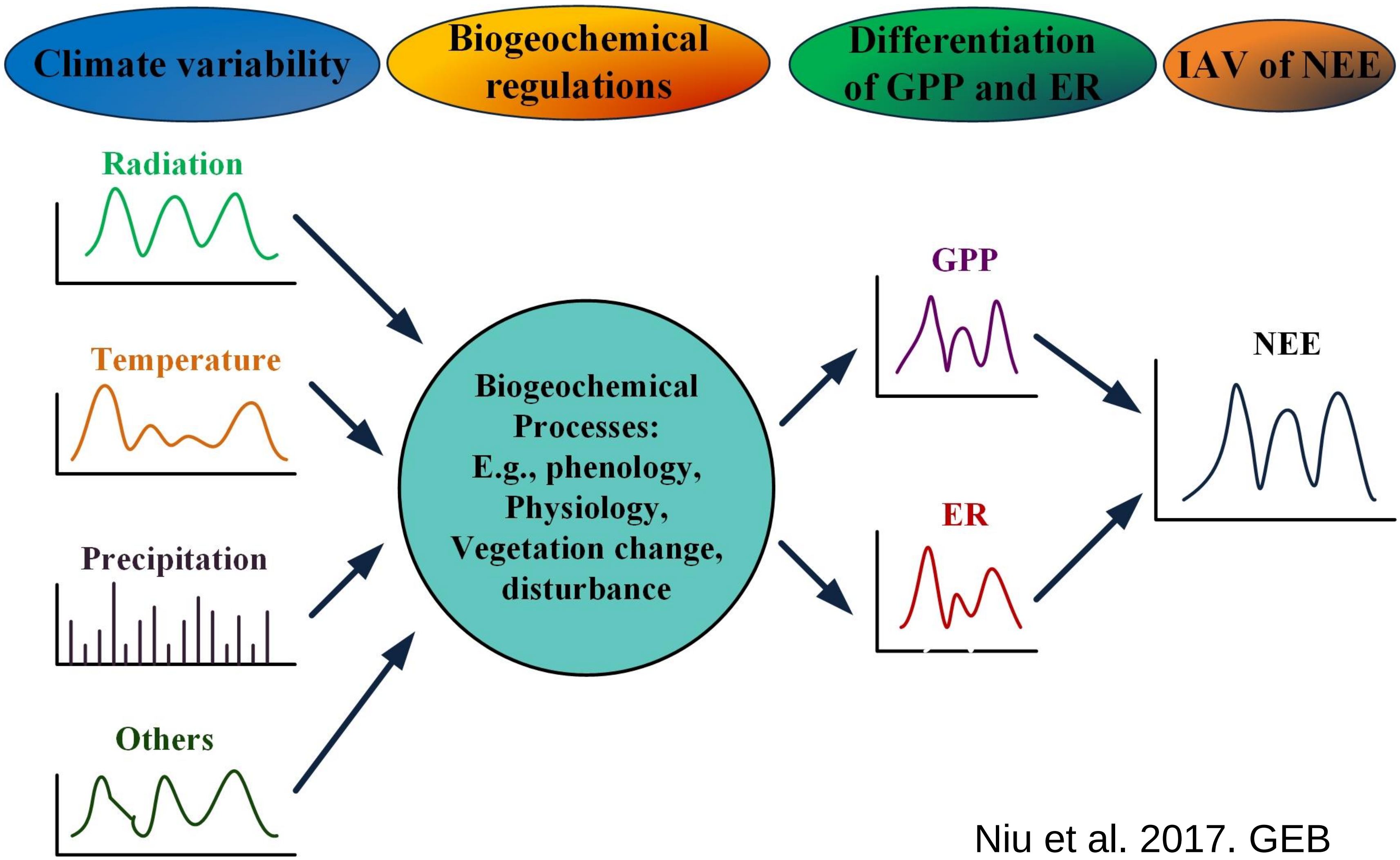
The relative importance of ΔGPP_{max}



The relative importance of ΔCUP

Niu et al. 2017. in revision

Specified conceptual diagram



Niu et al. 2017. GEB

Where we are standing and where should we go?

	Global	Regional	Ecosystem
Phenomena	Variation in yearly growth rate of atmospheric CO_2 concentration	Yearly anomalies of regional NEE under heat waves, large-scale drought, and fires	Yearly variation in NEE observed by eddy-flux towers, NPP from long-term ecological research sites, tree rings.
Driving factors	Primarily anomalies of temperature	Anomalies of both temperature and precipitation, with varying roles in different regions.	Temperature, precipitation, radiation, and disturbances play different roles in different ecosystems.
Biological mechanism or attributes	Attribute to different regions, among which tropical and semi-arid areas contribute most.	Not well examined yet	Differential climate sensitivity of photosynthesis vs. respiration. Carbon uptake amplitude plays more important role than carbon uptake period
Model predictive skill	No mechanistic models yet tested except some statistical models	Land models used to examine IAV in different regions	Models perform poorly, mainly due to a lack of model calibration of phenological and physiological responses, and lag mechanisms
Recommendation for future research	Explore which regions contribute most to the global IAV, and how these contributions are changing in a changing climate	Reveal the drivers and causes of IAV of NEE in different regions	Promote long-term observations especially in less-studied areas. Better understand biological mechanisms. Use data-model fusion approaches to improve model prediction.

Niu et al. 2017. GEB

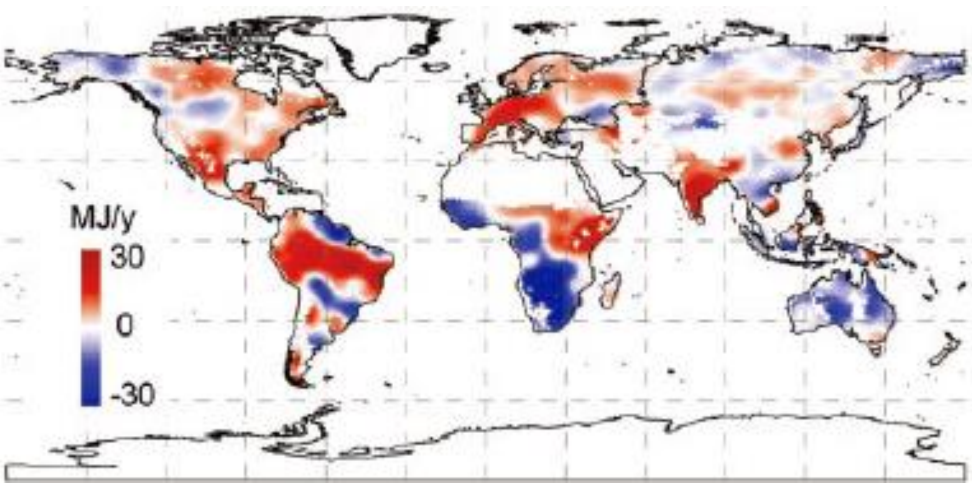
Thanks for your attention!

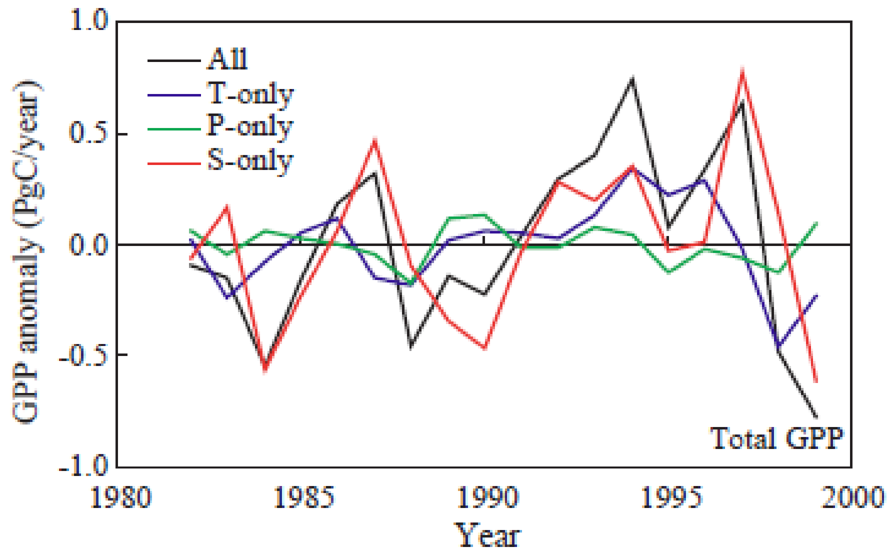
Questions? sniu@igsnrr.ac.cn

Summary

- IAV of NEE largely explained by CUA and CUP
- The maximum NEP plays major role in controlling IAV of C fluxes
- Climate variables indirectly affect IAV of NEE via their influences on the biogeochemical regulations.

Causes of land C IAV: radiation





Nemani et al. 2003 *Science*

Ichii et al. 2005 *GPC*