

Global evaluation of the nutrient enabled version of land surface model ORCHIDEE-CNP (v1.2)



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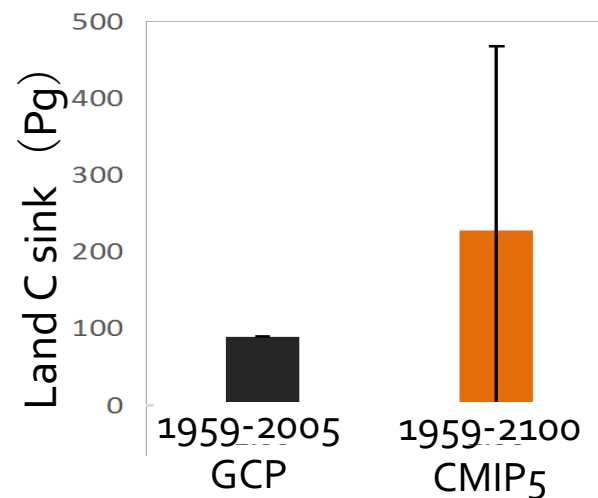
Background

P influences plant growth and metabolic process

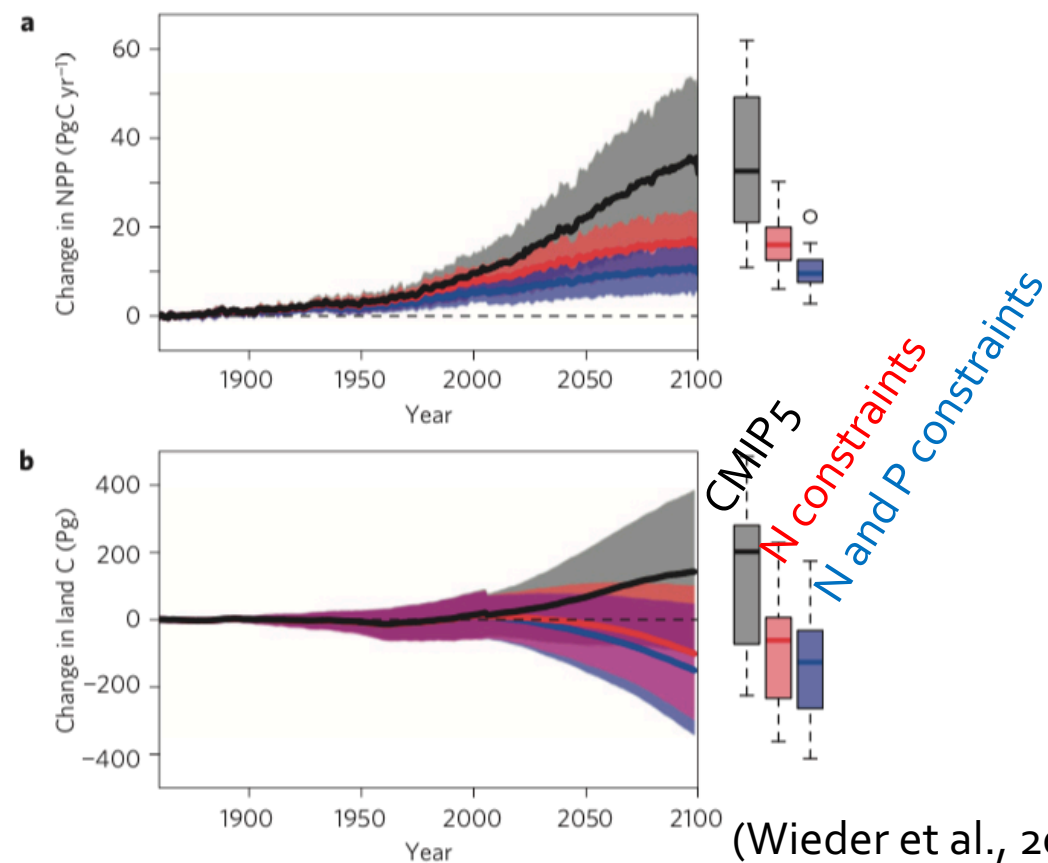


- ATP
- DNA, RNA
- Phospholipid

Dose P limit future land C sink ?



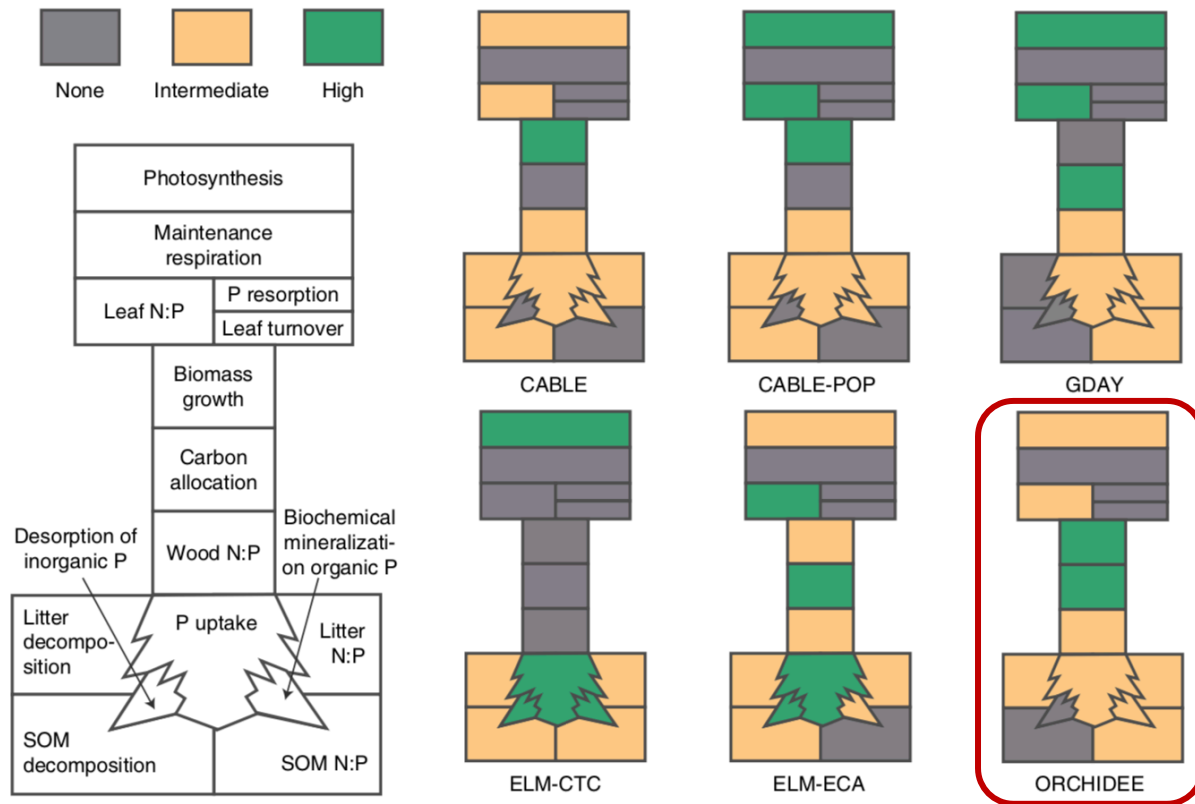
Book-keeping method to explore the effect of N and P on future land C sink



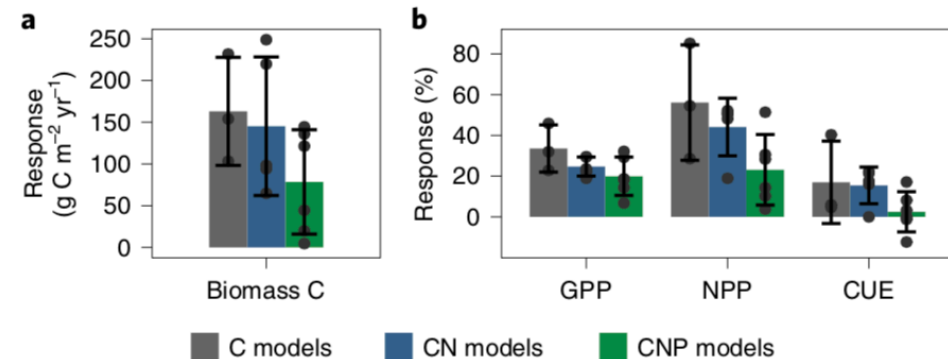
This approach has large uncertainties and relies on unproven assumptions (Brovkin & Goll, 2015).

Background

Represent the complex interactions between N, P and C in a land surface model (LSM)



(Fleischer et al., 2019)

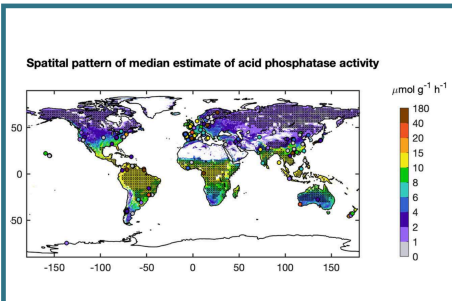


- The response of biomass and C fluxes under eCO₂ are very uncertain among CNP models.
- The critical processes in CNP models are poorly constrained by current observational data.
- Previous evaluation remains very limited: only C fluxes and storages.

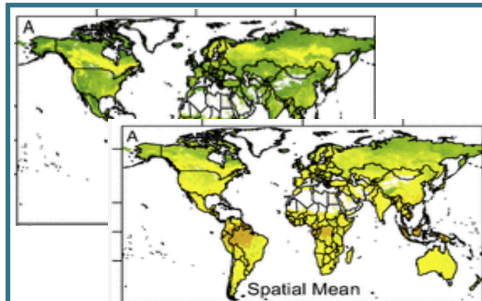
More comprehensive evaluation is required and is feasible with increasing datasets and knowledges for N and P cycles.

Nutrient datasets

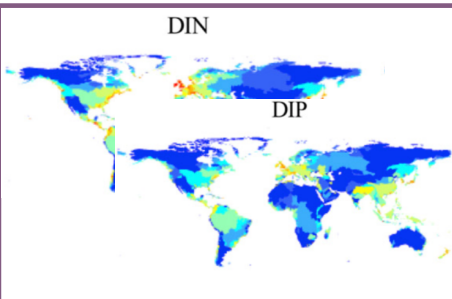
Global metrics based on **measurements** or from **process-based models**.



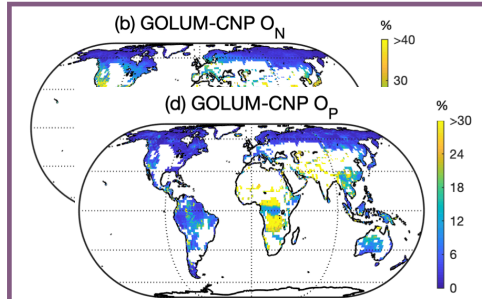
Acid phosphatase activity (Sun et al., 2020)



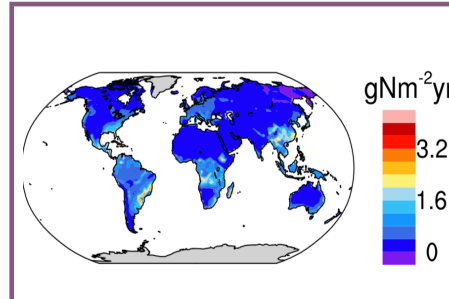
Leaf N and leaf P (Butler et al., 2017)



GlobalNews2: N and P load to river (Mayorga et al., 2010)

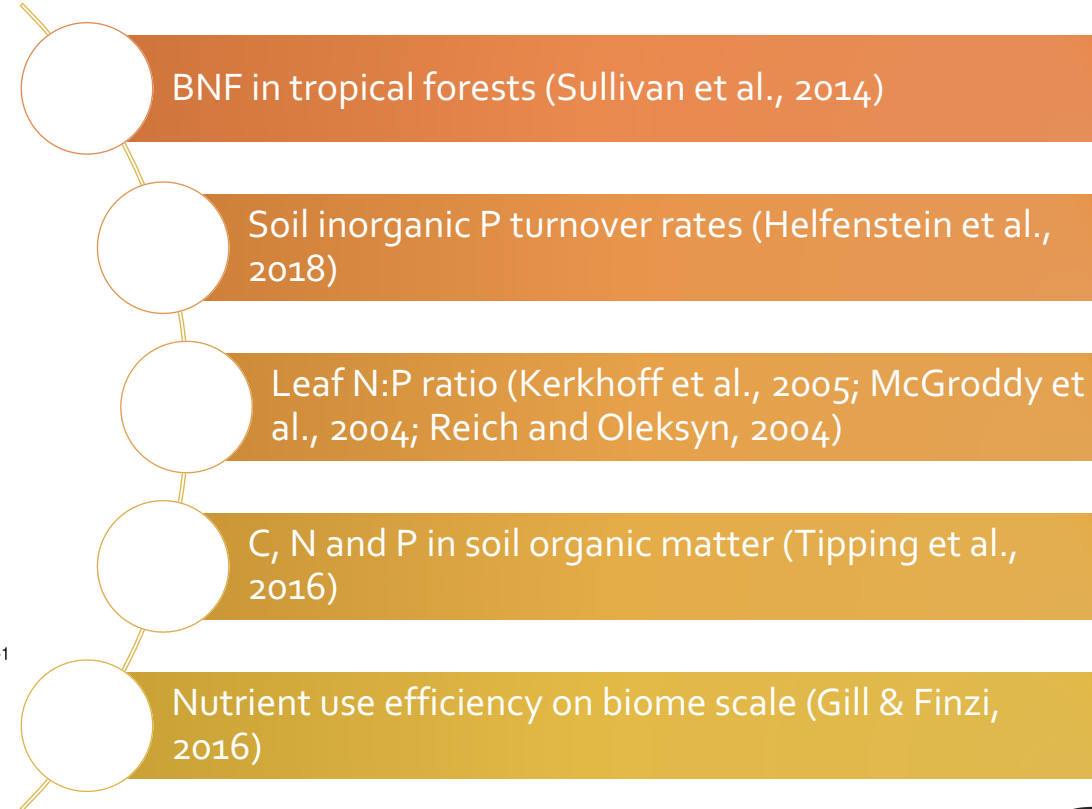


GOLUM-CNP: N and P openness (Wang et al., 2018)

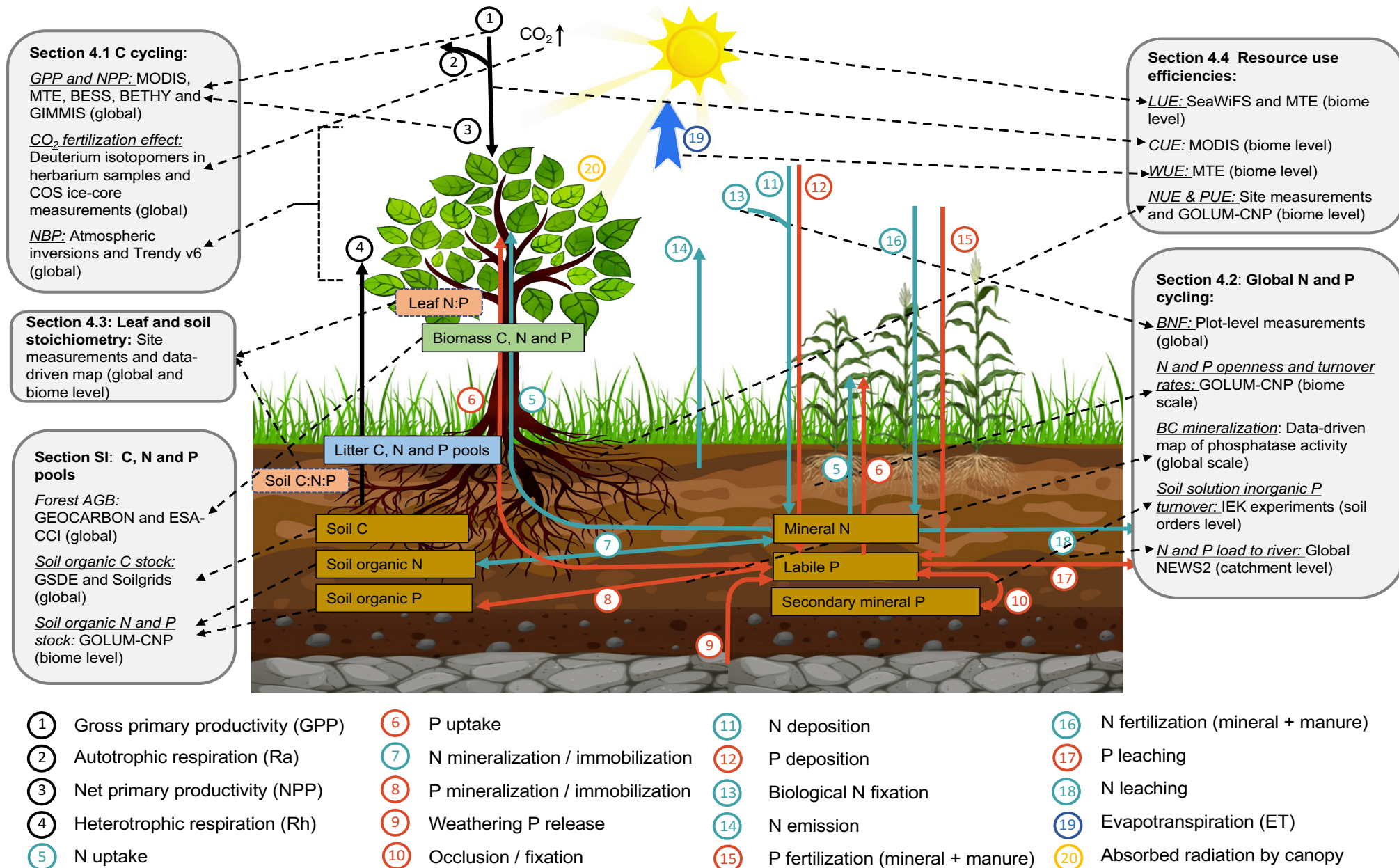


CABLE: Bio N fixation (Peng et al., 2019)

Data pool of site level measurements

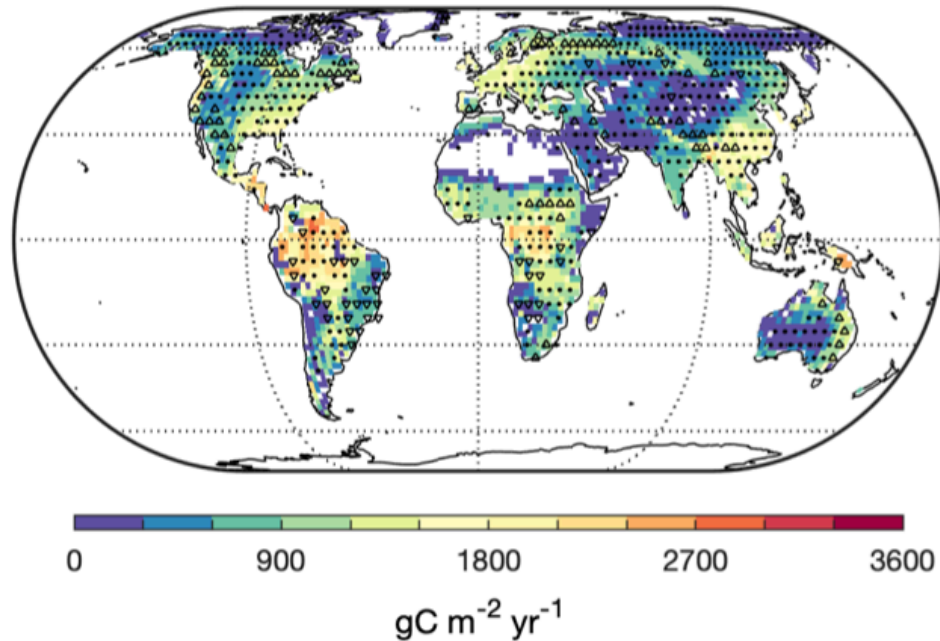


C, N and P cycles in ORCHIDEE-CNP



Spatiotemporal of C cycling

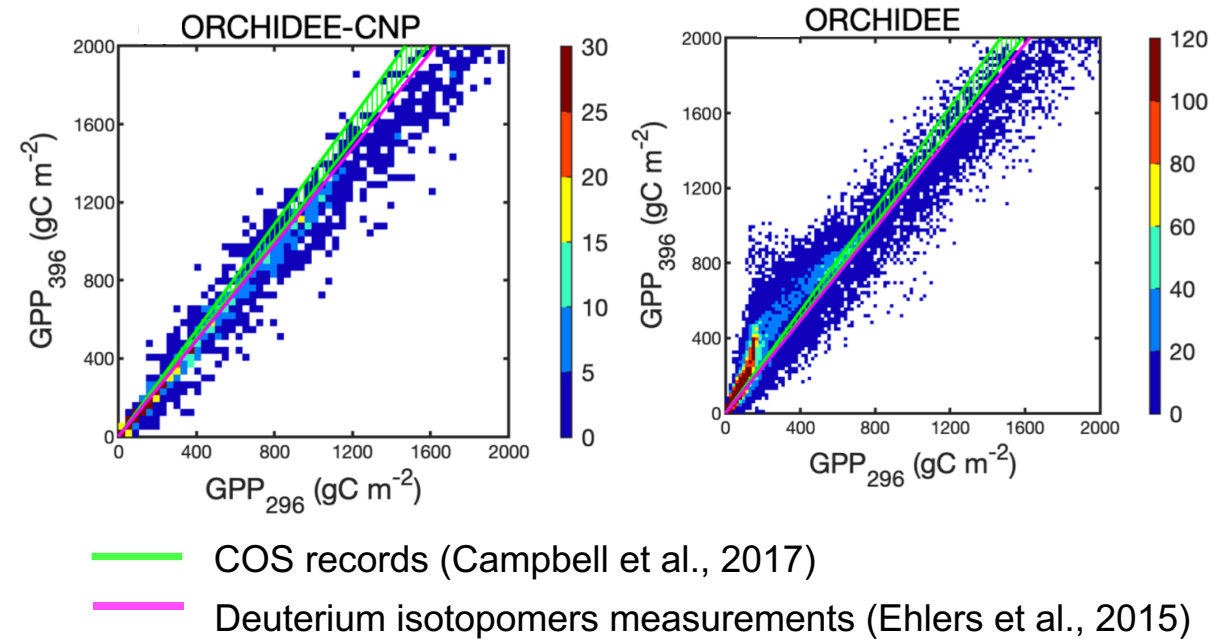
Global pattern of GPP



- **lie within** the ranges of estimations
- △ **higher** than the upper limits of estimations
- ▽ **lower** than the lower limits of estimations

CO₂ fertilization effect

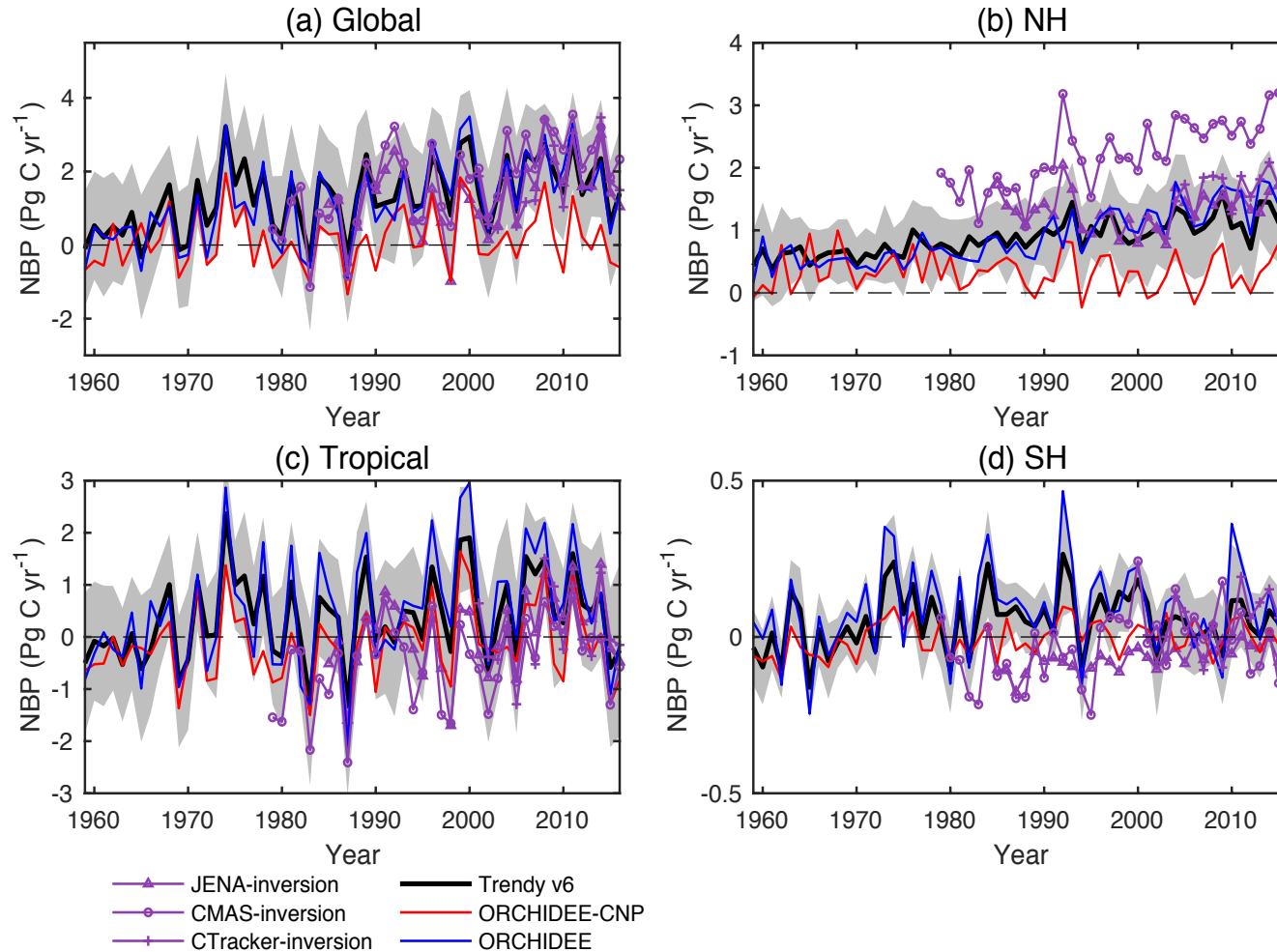
$$E_{co2} = \frac{GPP_{396}}{GPP_{296}}$$



- Modeled E_{co2} by ORCHIDEE-CNP for all natural biomes is **slightly lower** than the measurement.
- ORCHIDEE-CNP show a smaller and **more realistic** value of E_{co2} compared with ORCHIDEE.

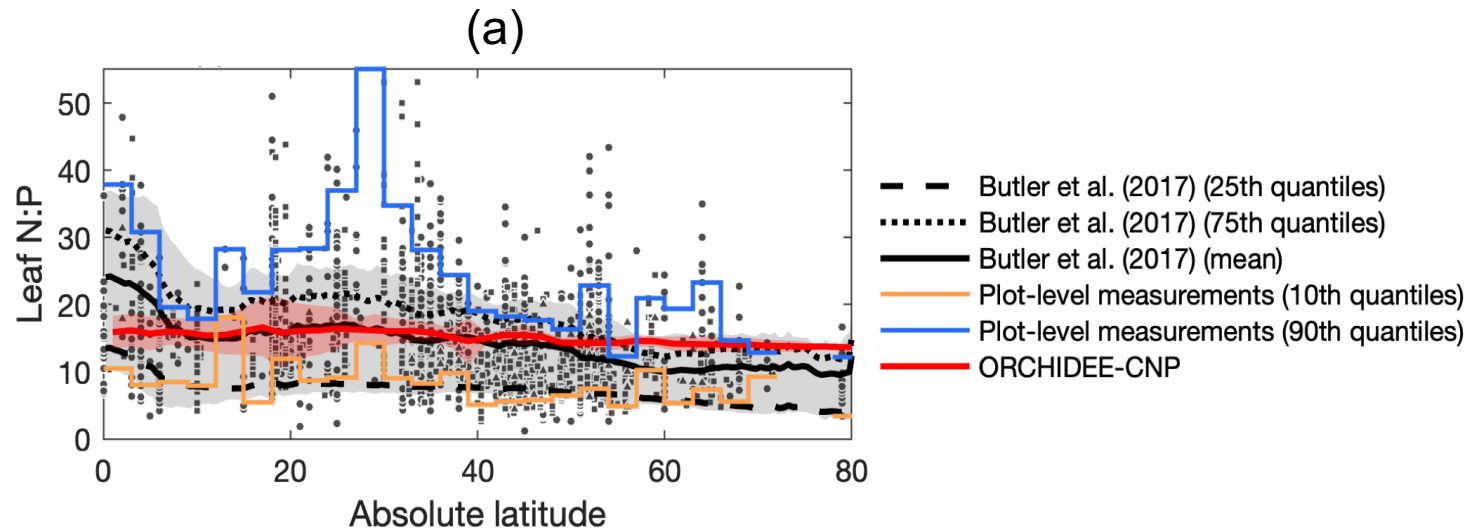
Spatiotemporal of C cycling

NBP

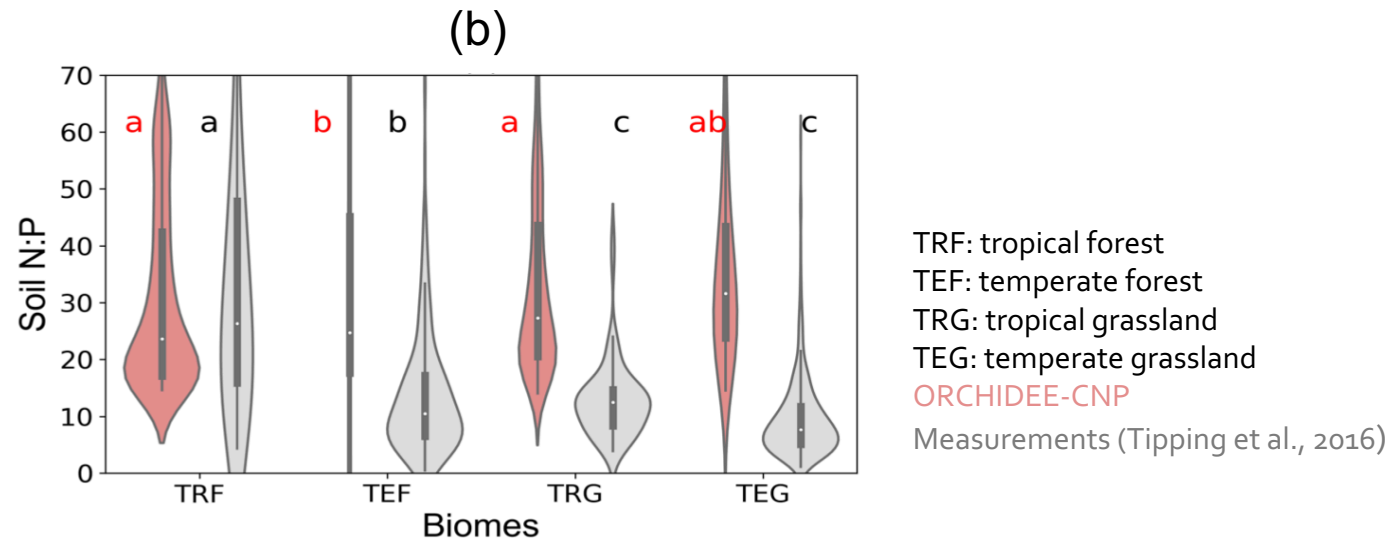


- ORCHIDEE-CNP simulates a **much lower** global NBP, but still falling within 1-sigma standard deviation of NBP from Trendy v6 models.
- ORCHIDEE-CNP simulates a **smaller** NH C sink than Trendy v6 models and inversion data.

Stoichiometry pattern of soil and leaf

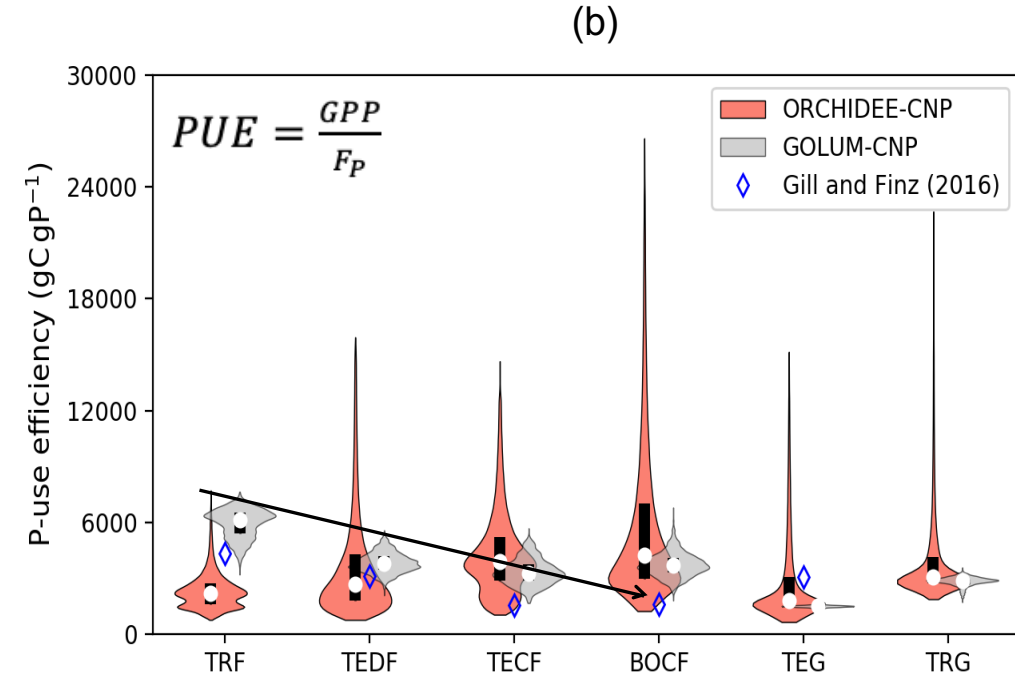
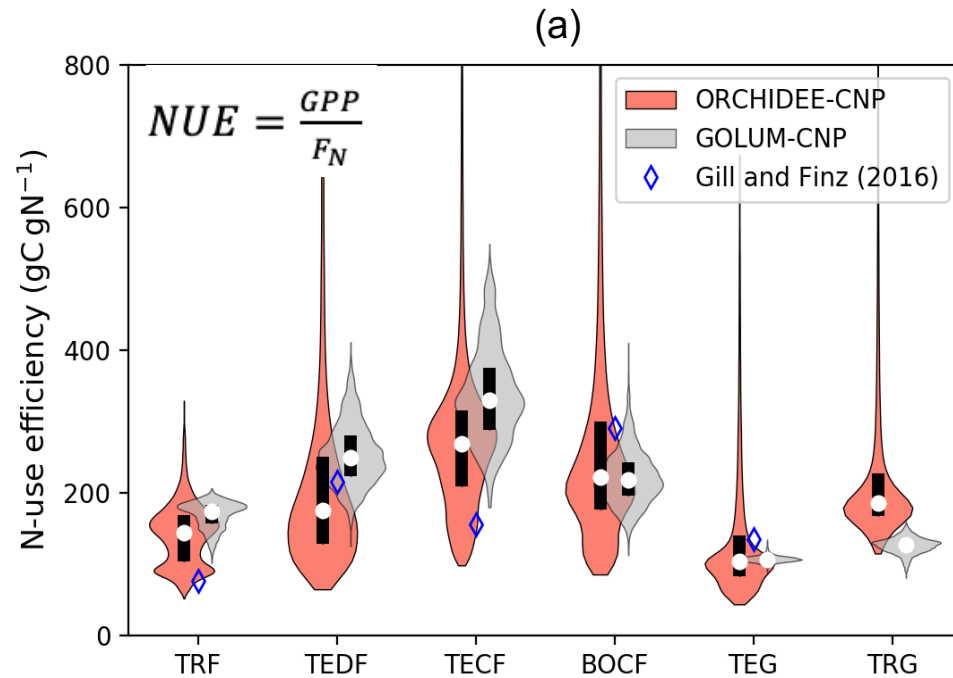


- Modelled latitudinal distribution of leaf N:P ratios remained within the 10~90th quantiles of the site level data .
- ORCHIDEE-CNP **cannot capture** the observed **decline** in leaf N:P ratios with increasing latitude.



- ORCHIDEE-CNP simulates **comparable** soil N:P ratios than measurements for tropical forests.
- ORCHIDEE-CNP **overestimates** the observed N:P ratios in temperate forests, tropical and temperate grasslands soils.

Nutrient use efficiency



ORCHIDEE-CNP cannot capture the decreasing PUE from tropical forest to temperate forest.

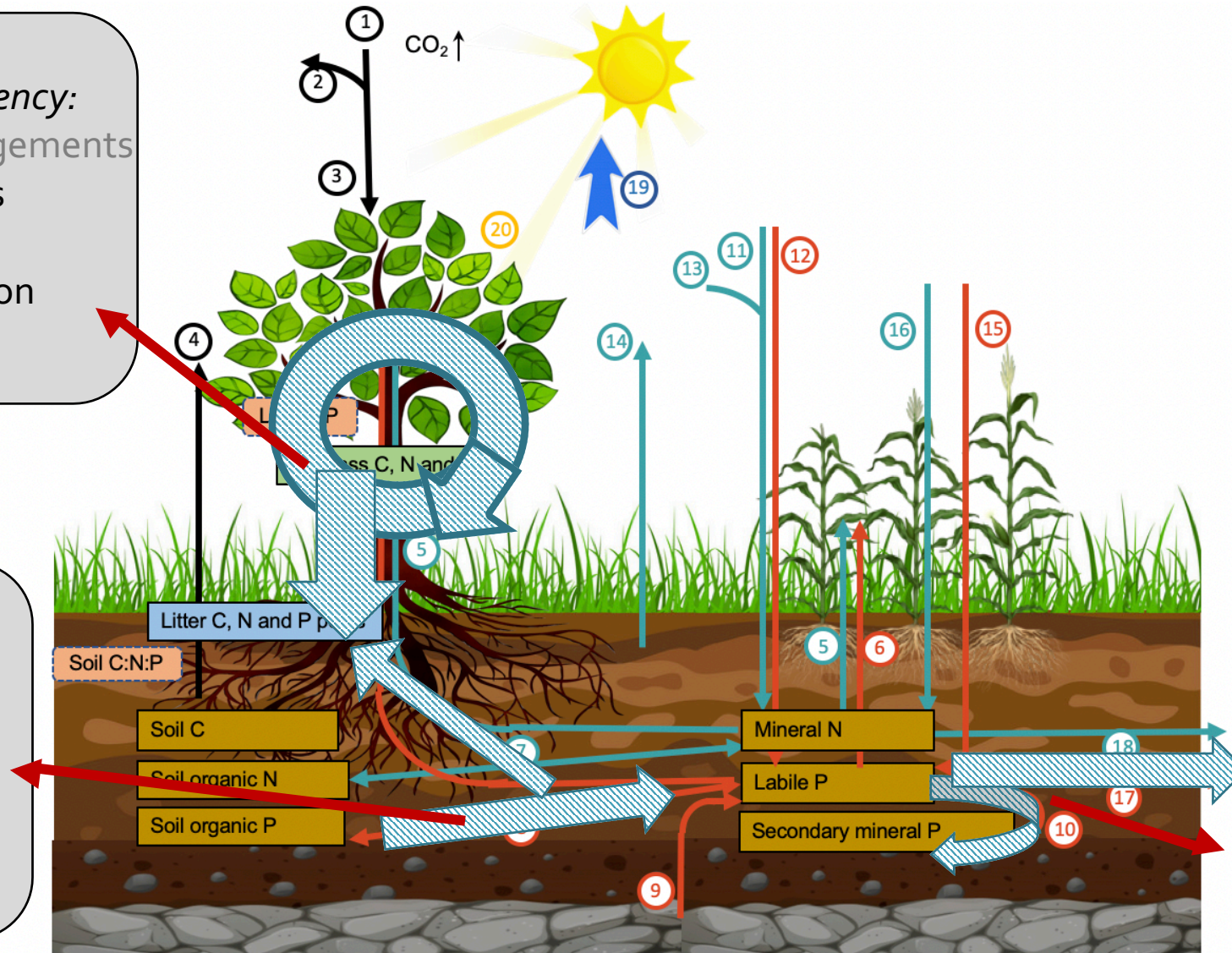
Processes need to be improved in ORCHIDEE-CNP

Biomass production efficiency:

- (1) Forest age and managements
- (2) Responses of biomass production to eCO_2
- (3) Canopy light absorption
- (4) Phenology dynamics

Soil C-N-P dynamics:

- (1) P mineralization and uptake by plants.
- (2) The regulation of nutrient on SOM decomposition and microbial dynamics.



Inorganic P dynamic :

- (1) Refine related processes (e.g. occlusion) by using new datasets.
- (2) Responses of inorganic P turnover rates to eCO_2

Lack of nutrient effects on SOM decomposition lead to an accumulation of SON and SOP

Changes of accumulated immobilized nutrient and net nutrient input

