Representation of Phosphorus cycle in JULES (JULES-CNP)

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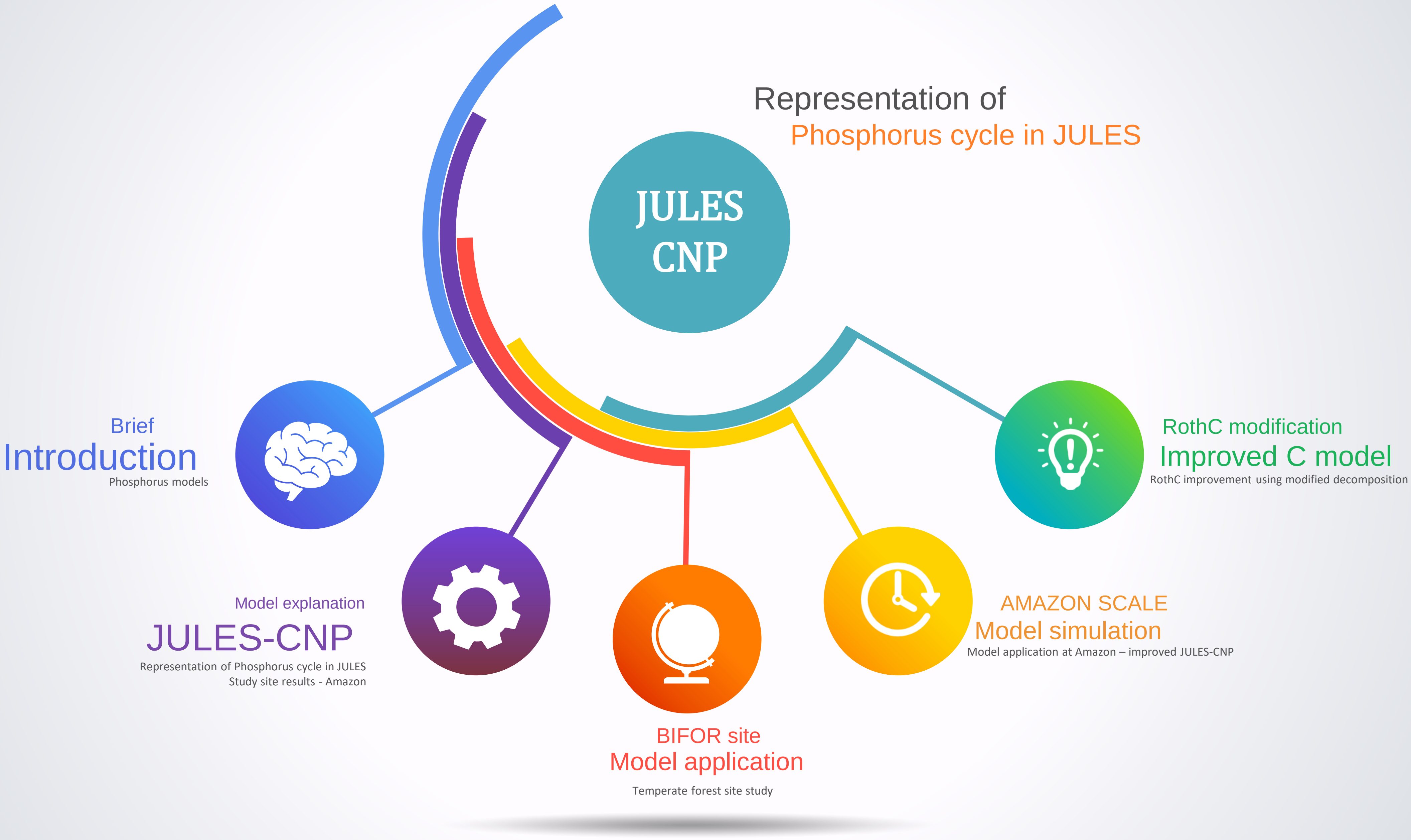
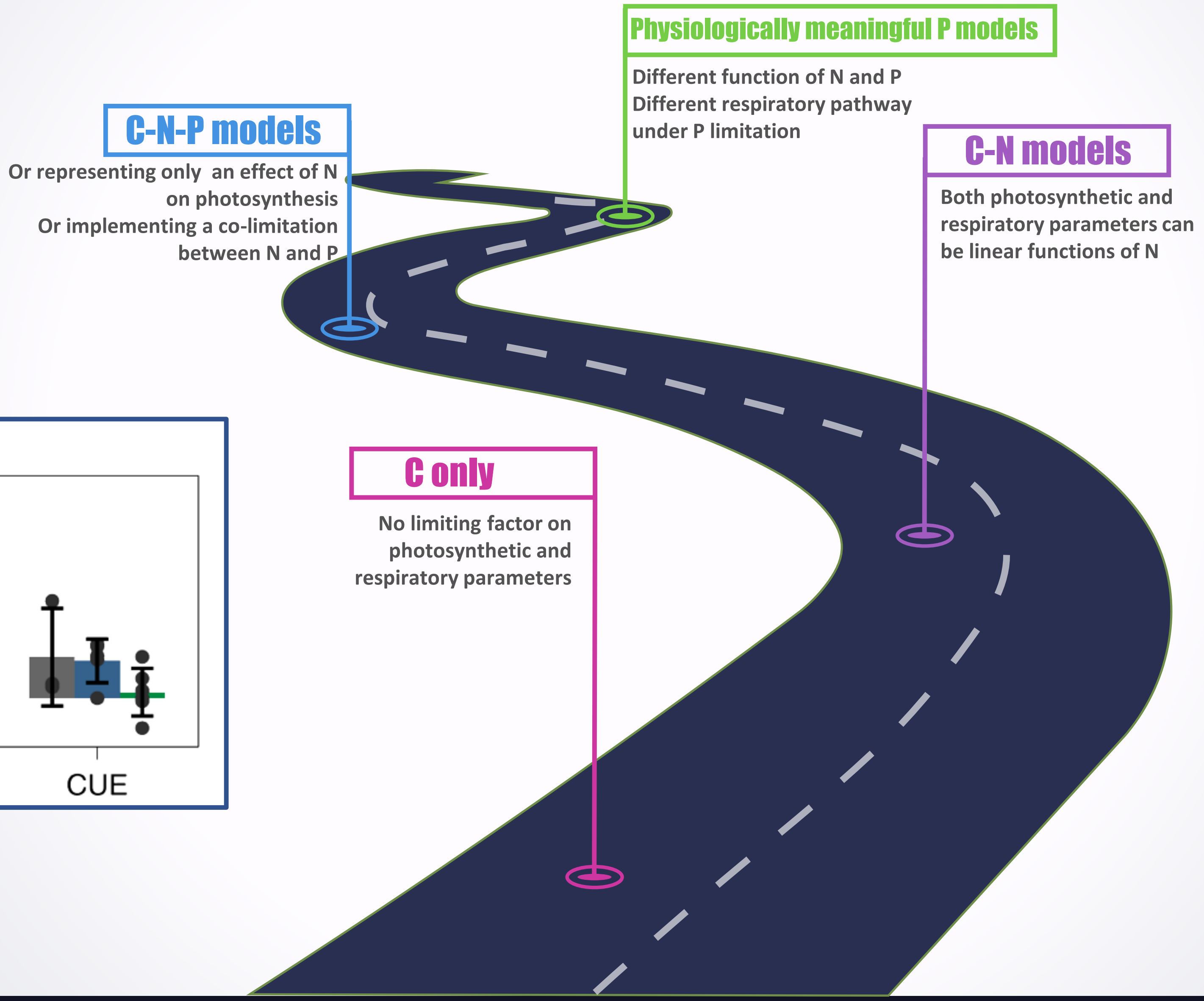
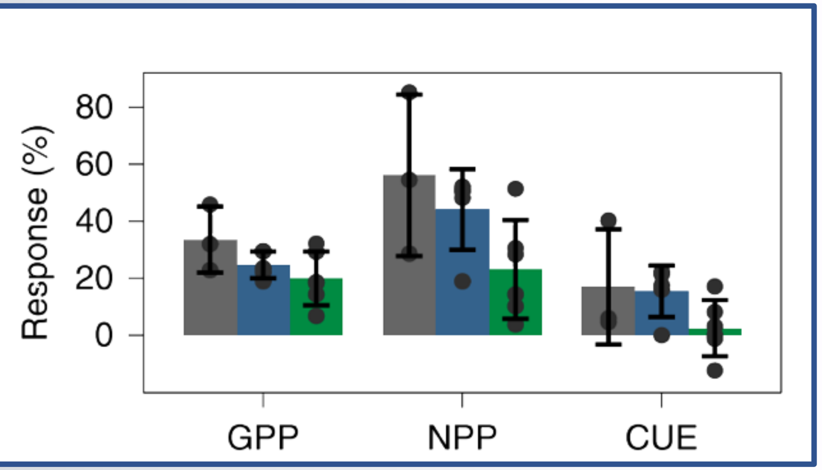


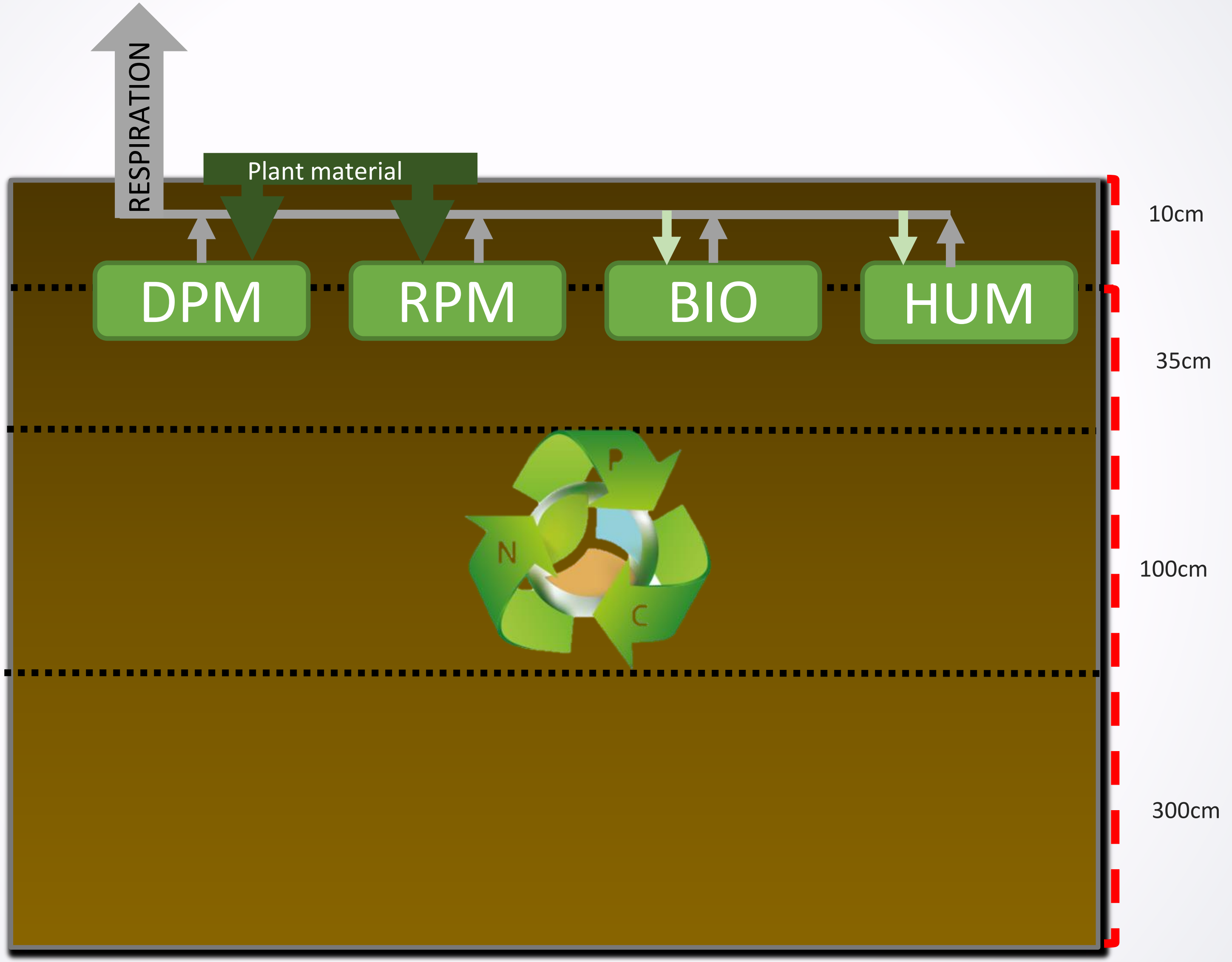
Representation of
Phosphorus cycle in JULES
JULES CNP
Brief
Introduction
Phosphorus models
Model explanation
JULES-CNP
Representation of Phosphorus cycle in JULES
Study site results - Amazon
BIFOR site
Model application
Temperate forest site study
AMAZON SCALE
Model simulation
Model application at Amazon – improved JULES-CNP
RothC modification
Improved C model
RothC improvement using modified decomposition

Review of Land surface models

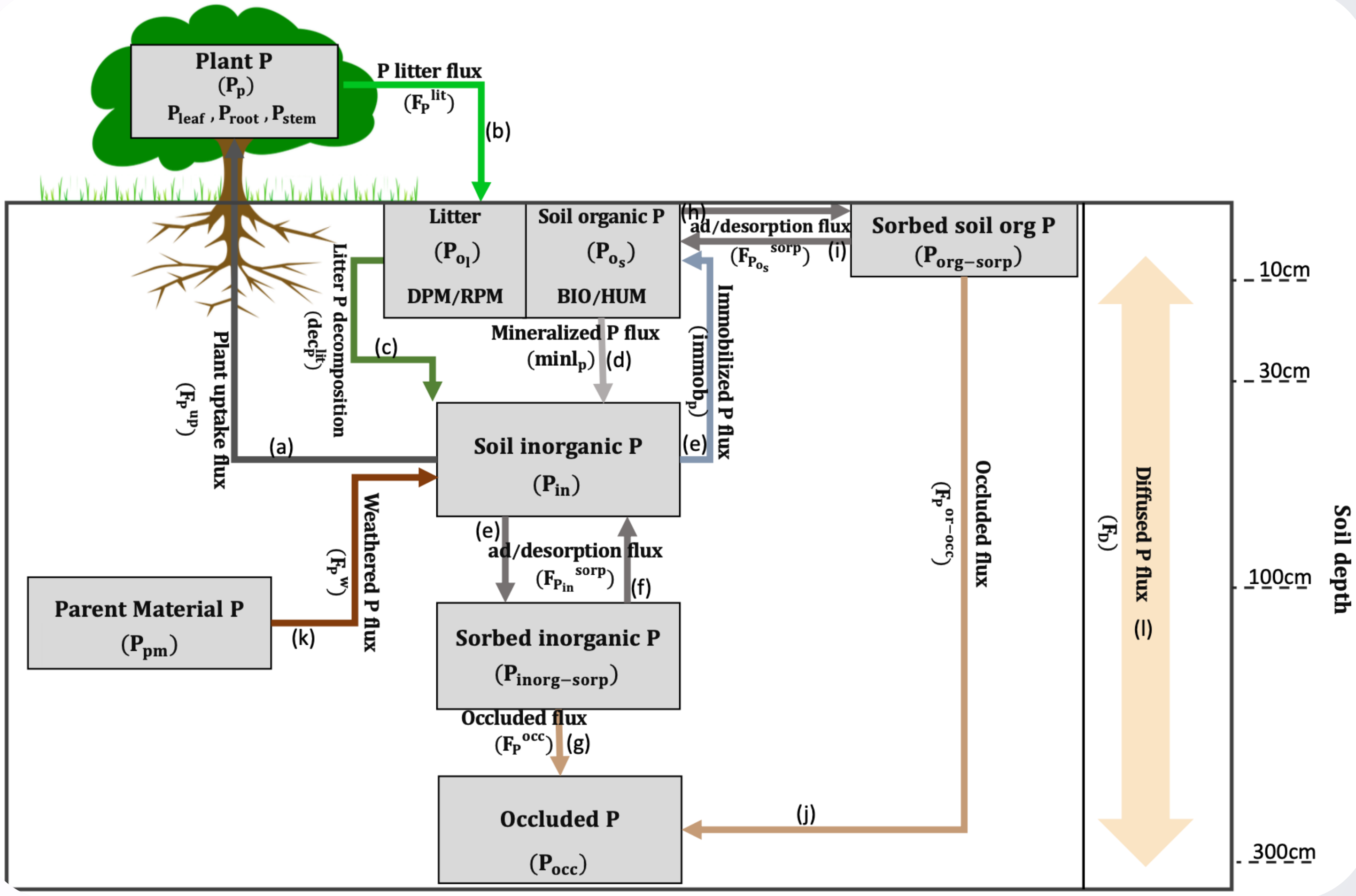




Fleischer et al. 2019

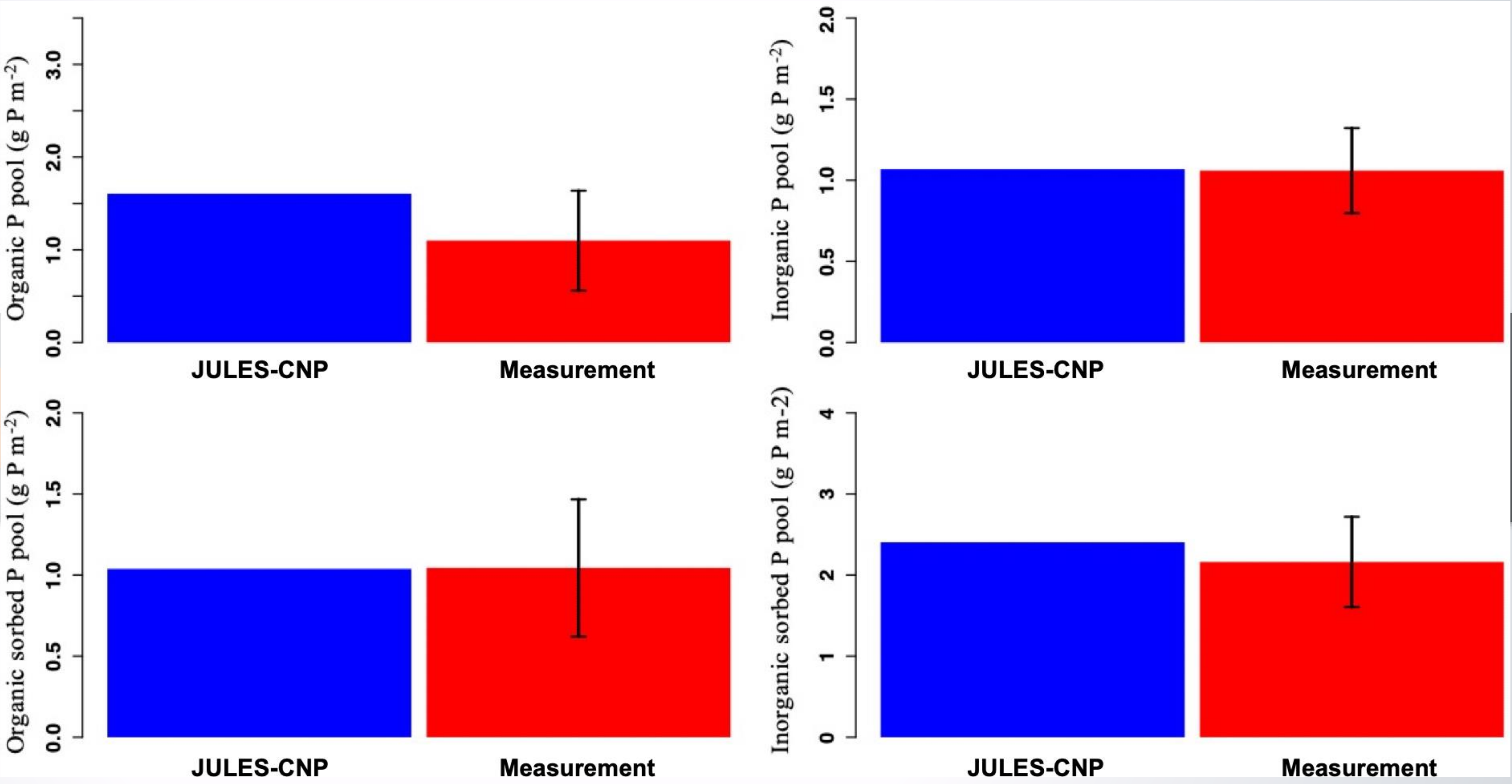

RESPIRATION
Plant material
DPM
RPM
BIO
HUM
P
N
C
10cm
35cm
100cm
300cm

JULES-CNP

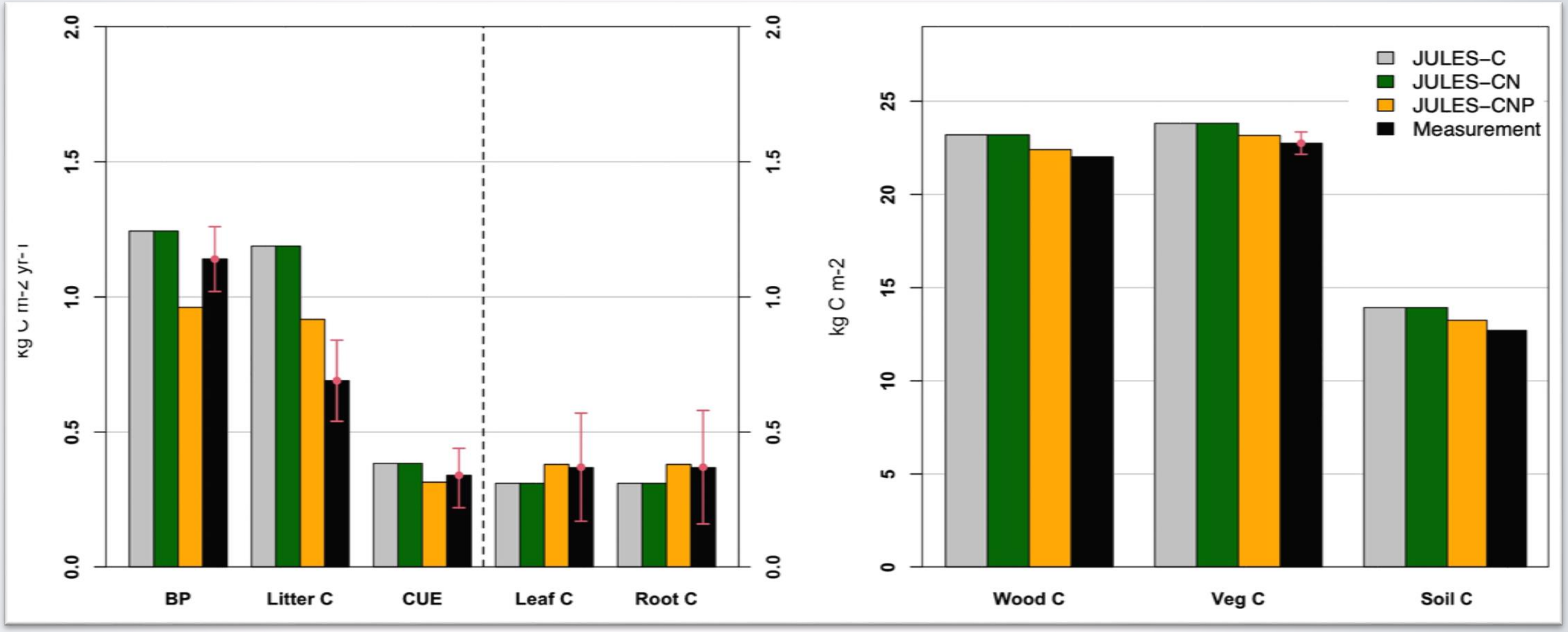


Nakhavali, M. et al., : Representation of phosphorus cycle in Joint UK Land Environment Simulator (vn5.5_JULES-CNP), Geosci. Model Dev. https://doi.org/10.5194/gmd-2021-403

Soil P



Modelled vs. measured soil phosphorus pools under ambient CO_2 (for the soil depth of 0–30 cm). The black line represents the standard deviation.



JULES-C, JULES-CN, and JULES-CNP modelled vs. measured C pools (leaf, root, wood, vegetation, and soil C) (in kg C m^{-2}) and fluxes (BP and litter C) (in kg C m^{-2} yr^{-1}) and CUE under ambient CO_2. Note that CUE is unitless.

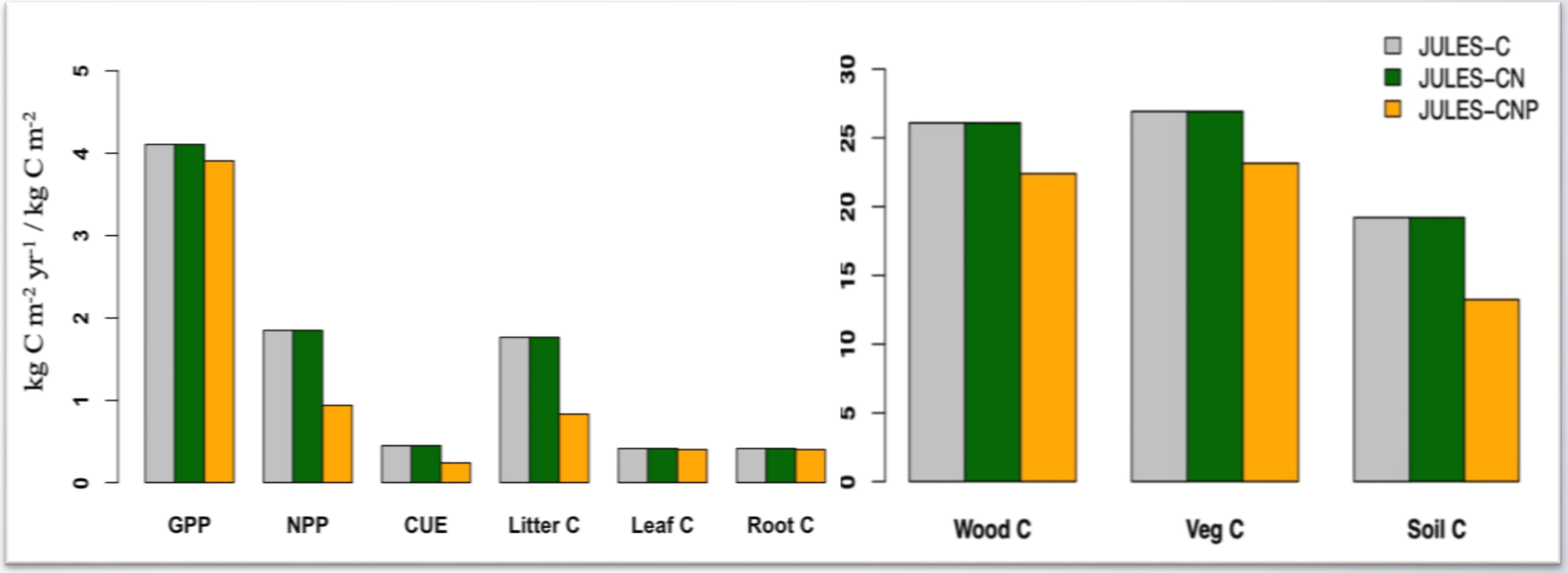
Nakhavali et al. 2022, GMD

	GPP	NPP	CUE	Litter C	Leaf C	Root C	Wood C	Soil C
% Difference between JULES C/CN and JULES CNP under eCO_2	26%	31%	47%	49%	9%	9%	14%	31%

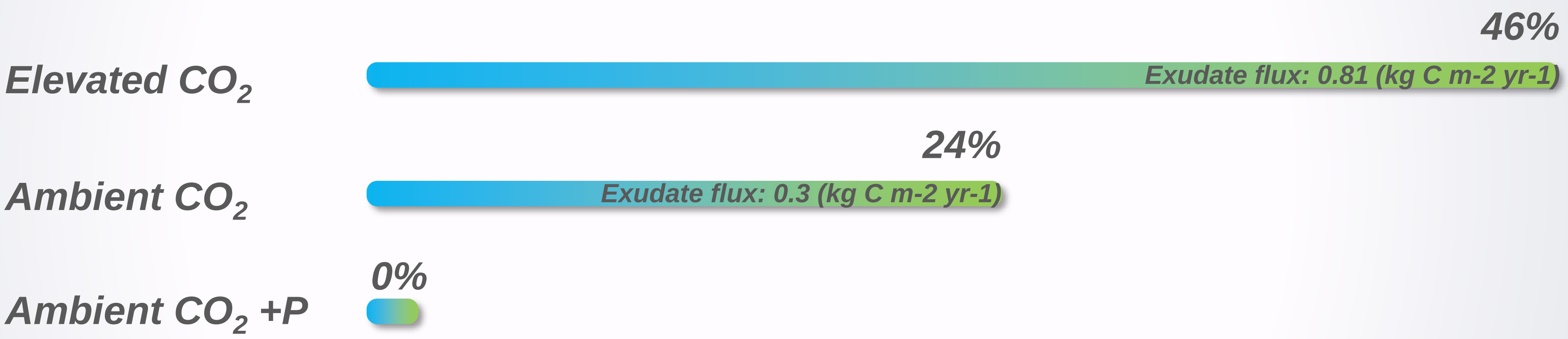
Elevated CO_2

JULES C/CN models: GPP and NPP response is estimated as 36% and 57 %

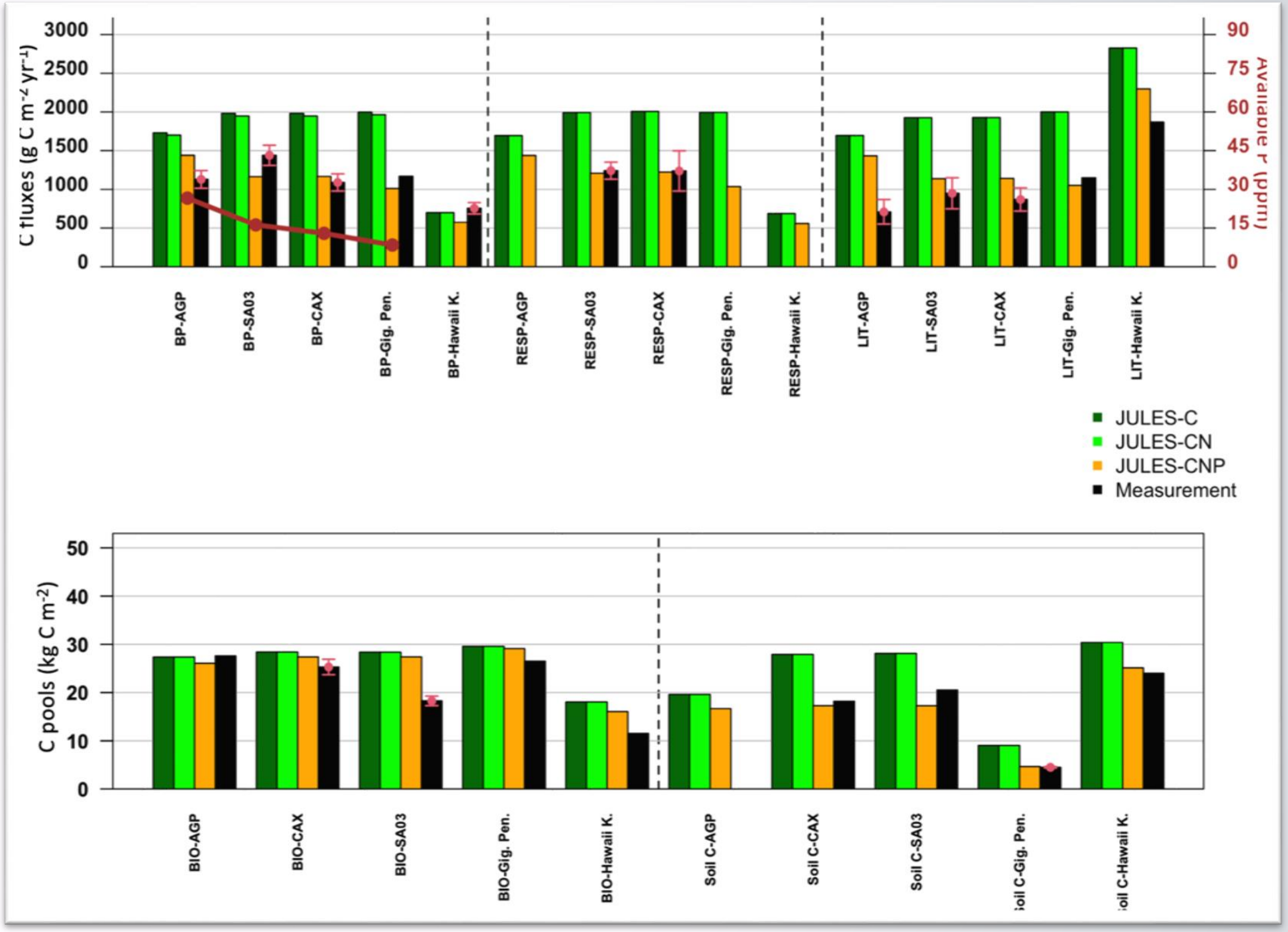
JULES CNP: GPP and NPP response is estimated as 28% and 2%



P limitation over NPP



Additional test sites



Observed and simulated (JULES-C, JULES-CN, JULES-CNP) C fluxes and pools (averaged measurements: red points; SD: red arrows) and available observed P (dark red points and lines, reported in ppm) at test sites across the Amazon (AGP, SA03, CAX), Gigante Peninsula (Gig. Pen.), and Hawaii Kokee (Hawaii)

BIFOR site modelling

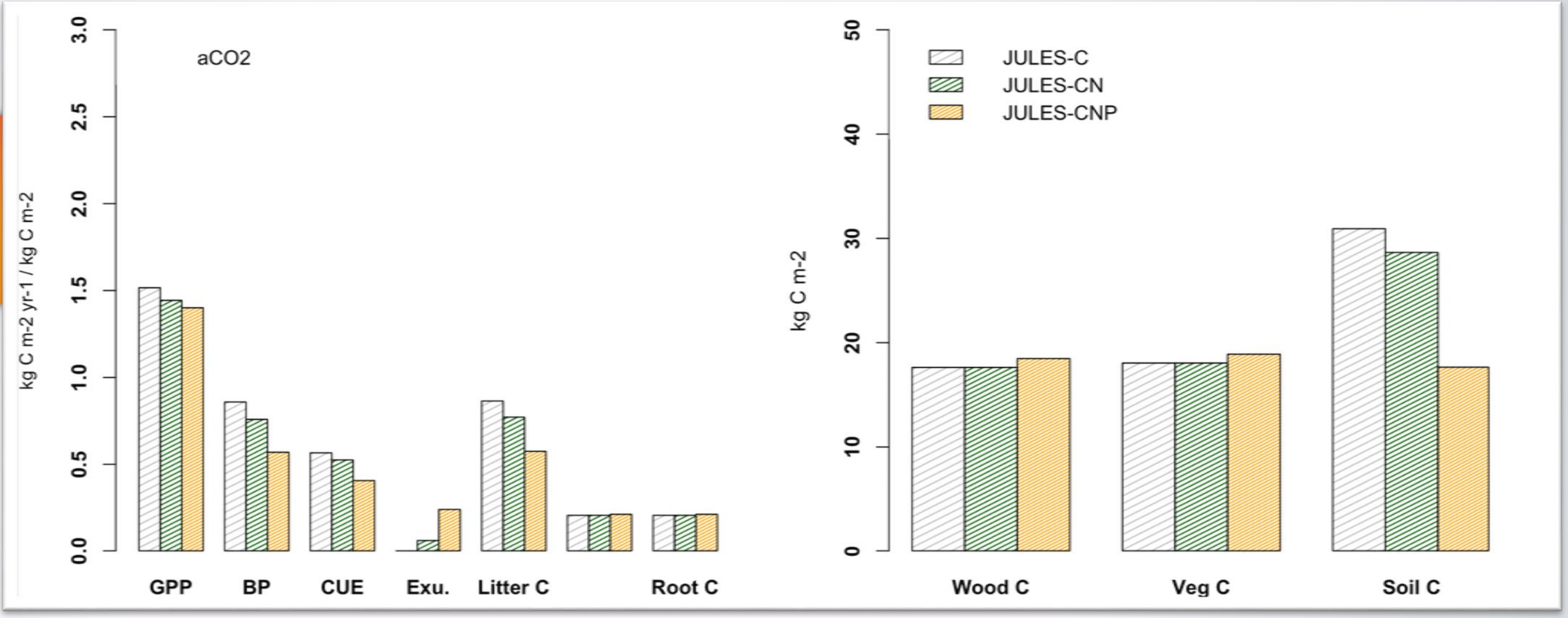
Data and modelling close collaboration

Driving model with observations

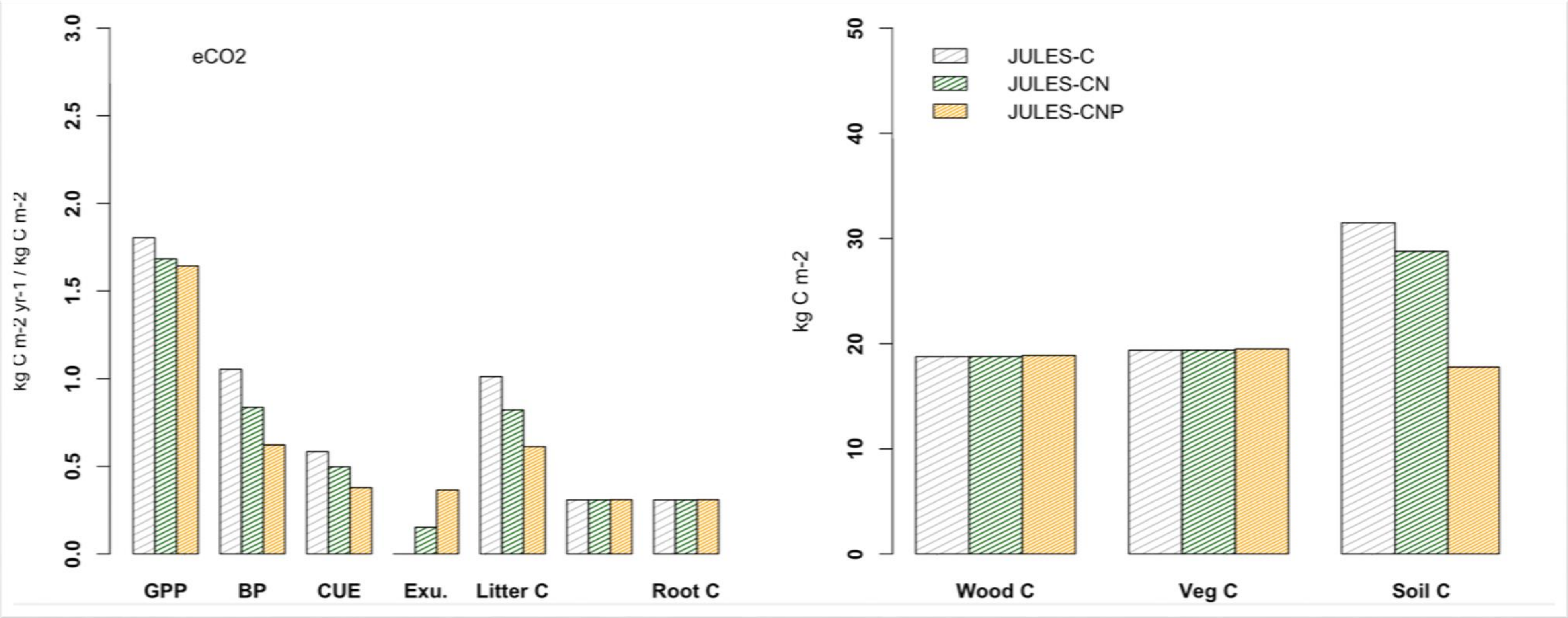
Model calibration for study site

Improve model performance

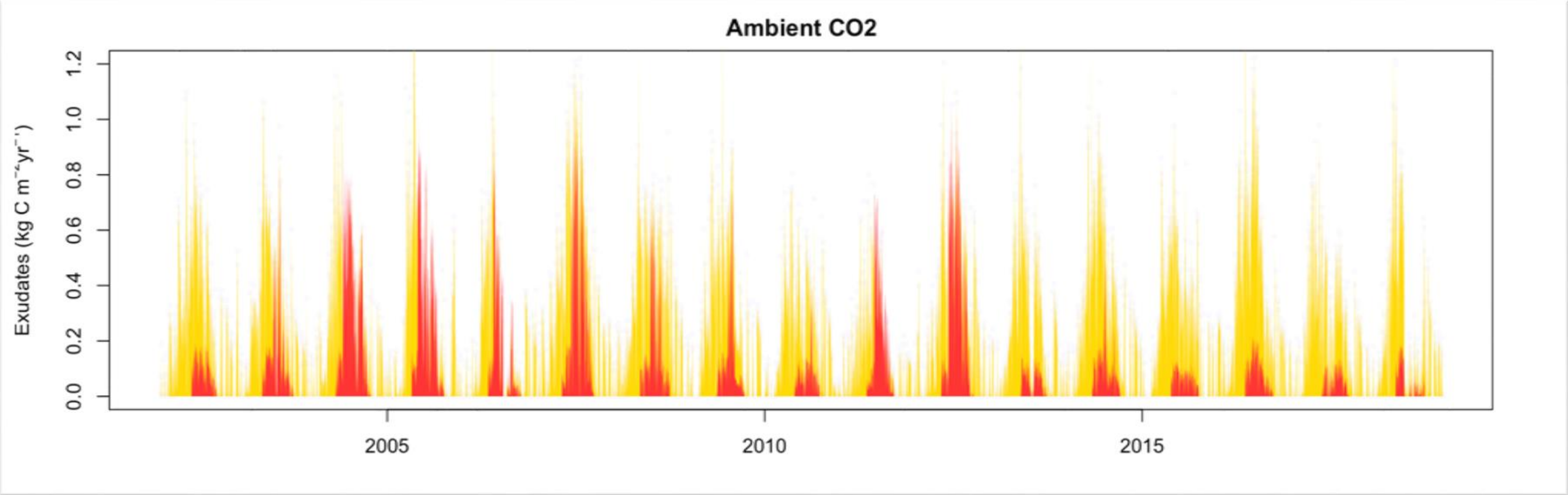
Evaluation of nutrient limitation

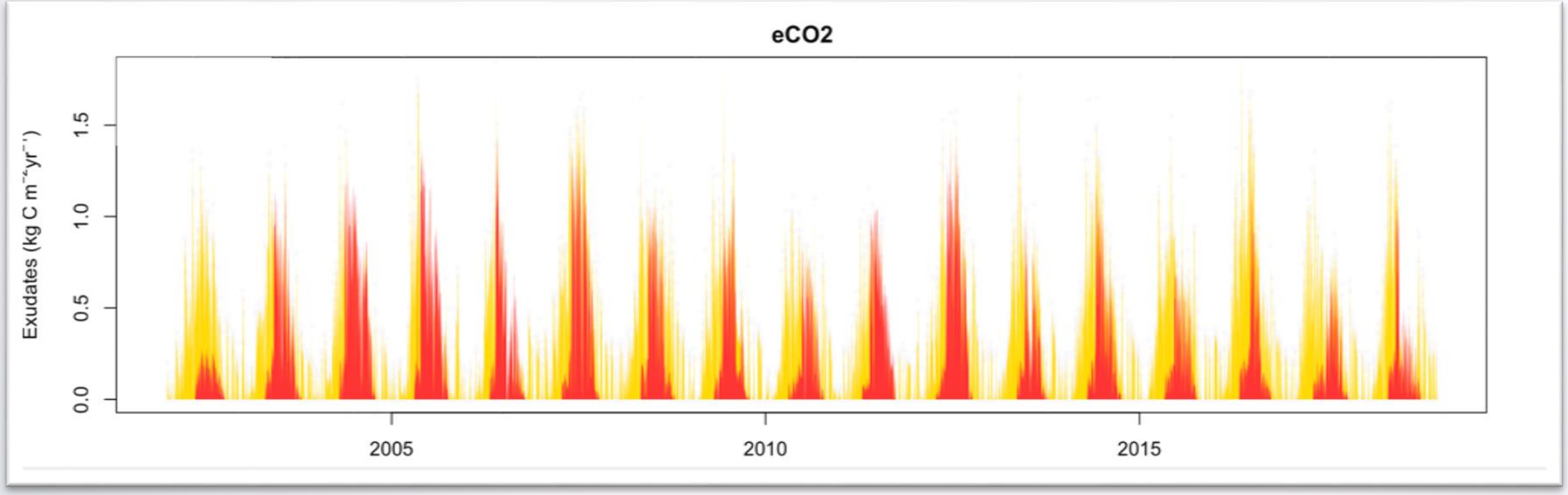


aCO2
kg C m-2 yr-1 / kg C m-2
0.0
0.5
1.0
1.5
2.0
2.5
3.0
GPP
BP
CUE
Exu.
Litter C
Root C
JULES-C
JULES-CN
JULES-CNP
kg C m-2
0
10
20
30
40
50
Wood C
Veg C
Soil C



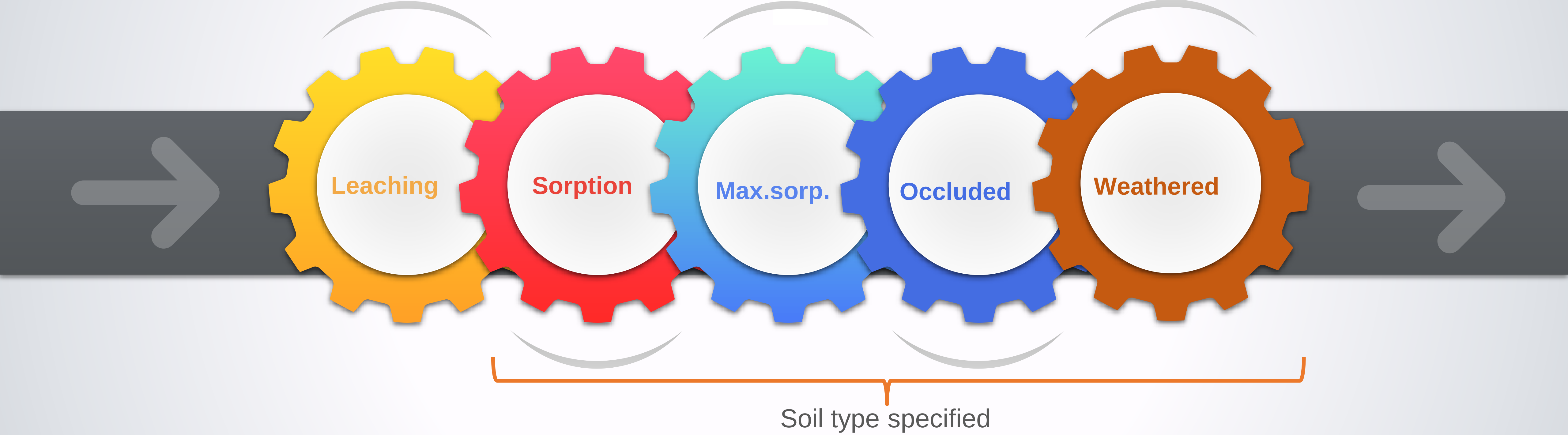
eCO2
kg C m-2 yr-1 / kg C m-2
0.0
0.5
1.0
1.5
2.0
2.5
3.0
GPP
BP
CUE
Exu.
Litter C
Root C
JULES-C
JULES-CN
JULES-CNP
kg C m-2
0
10
20
30
40
50
Wood C
Veg C
Soil C

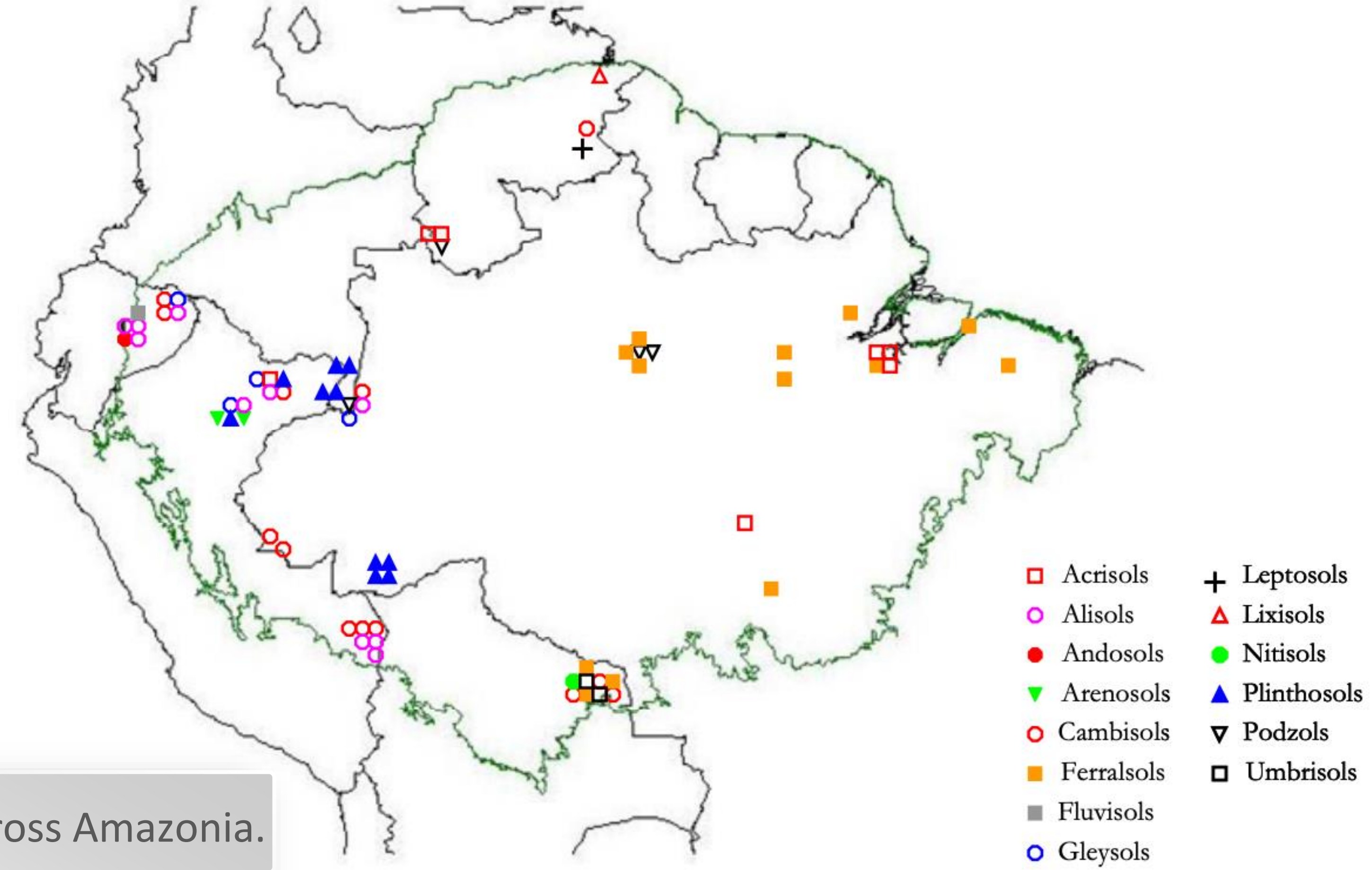

Ambient CO2
Exudates (kg C m⁻²yr⁻¹)
0.0
0.2
0.4
0.6
0.8
1.0
1.2
2005
2010
2015


eCO2
Exudates (kg C m⁻²yr⁻¹)
0.0
0.5
1.0
1.5
2005
2010
2015

N + P lim.

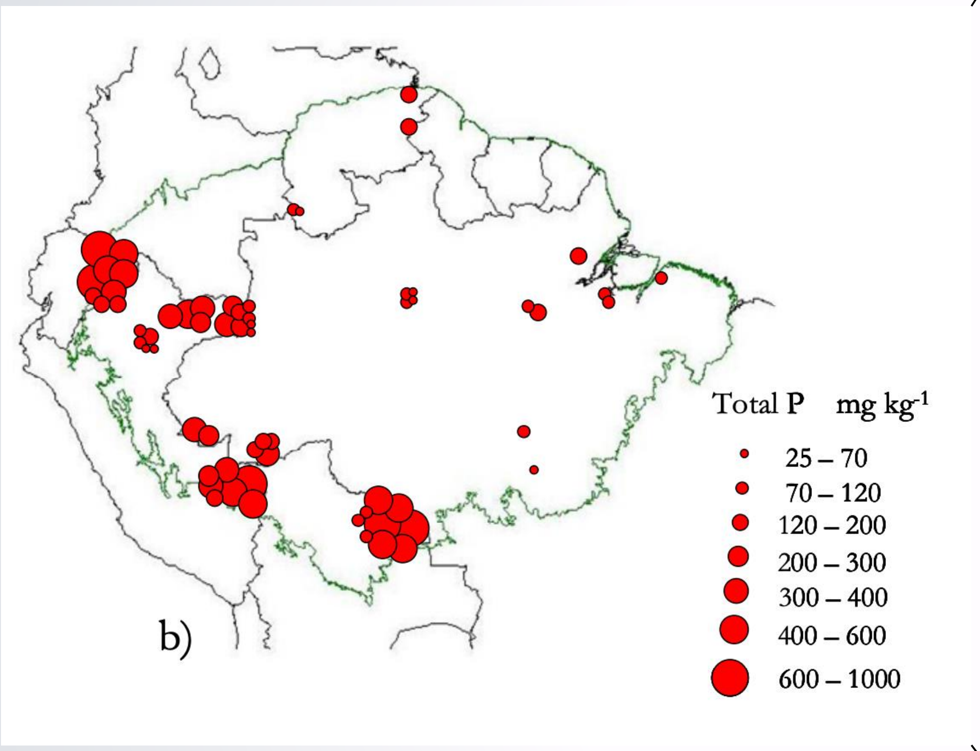
N lim.

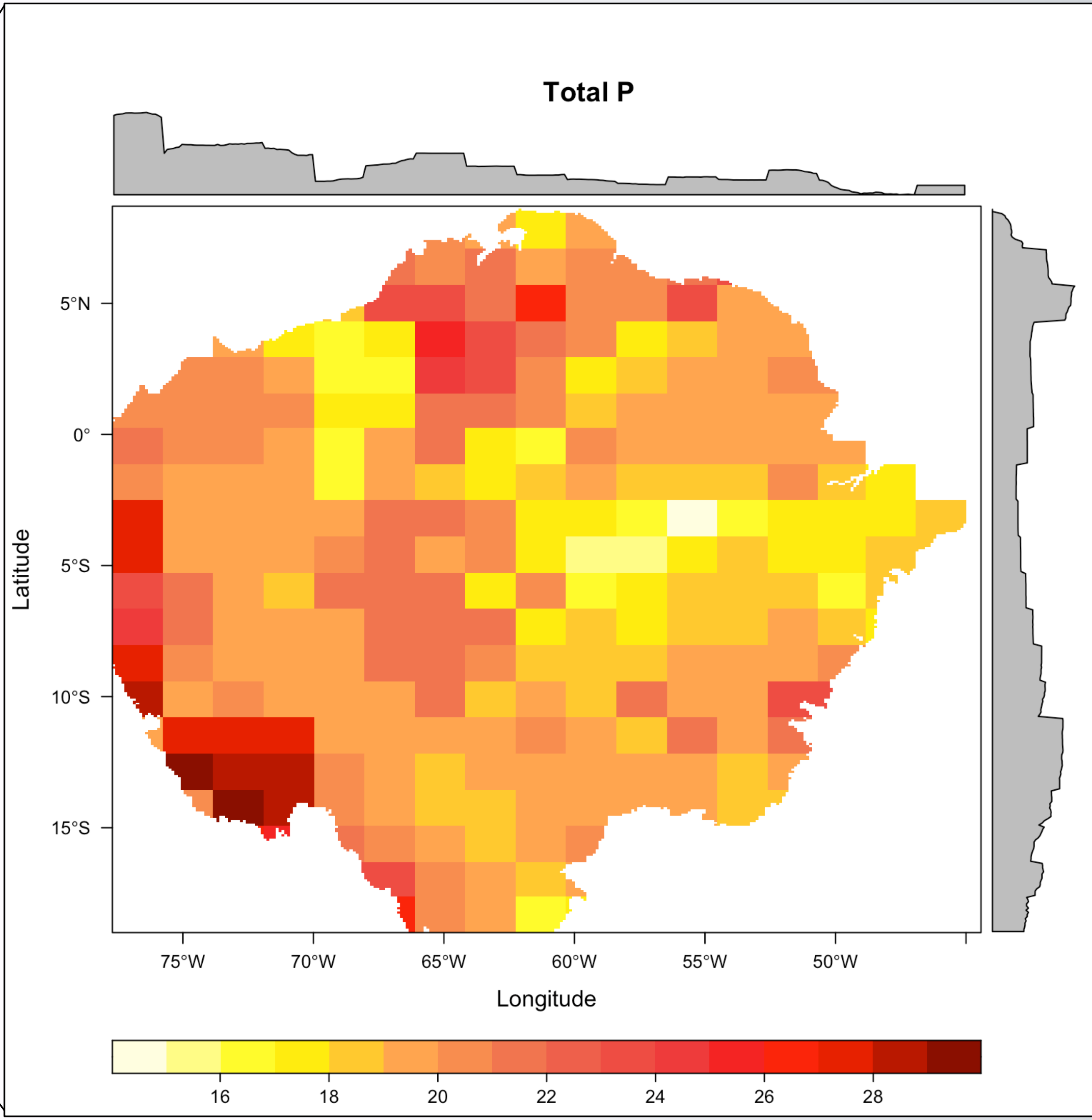

Leaching
Sorption
Max.sorp.
Occluded
Weathered
Soil type specified

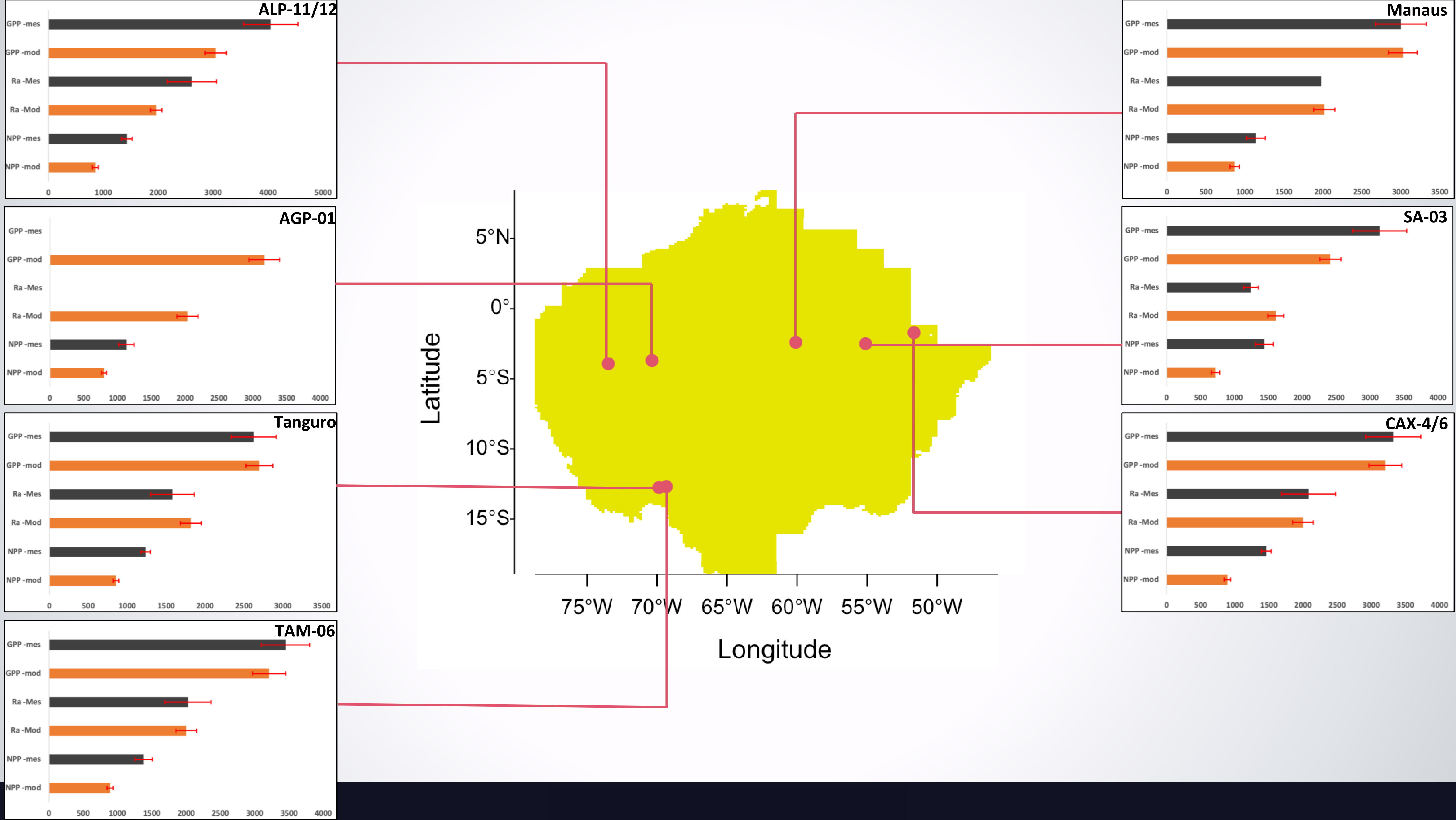


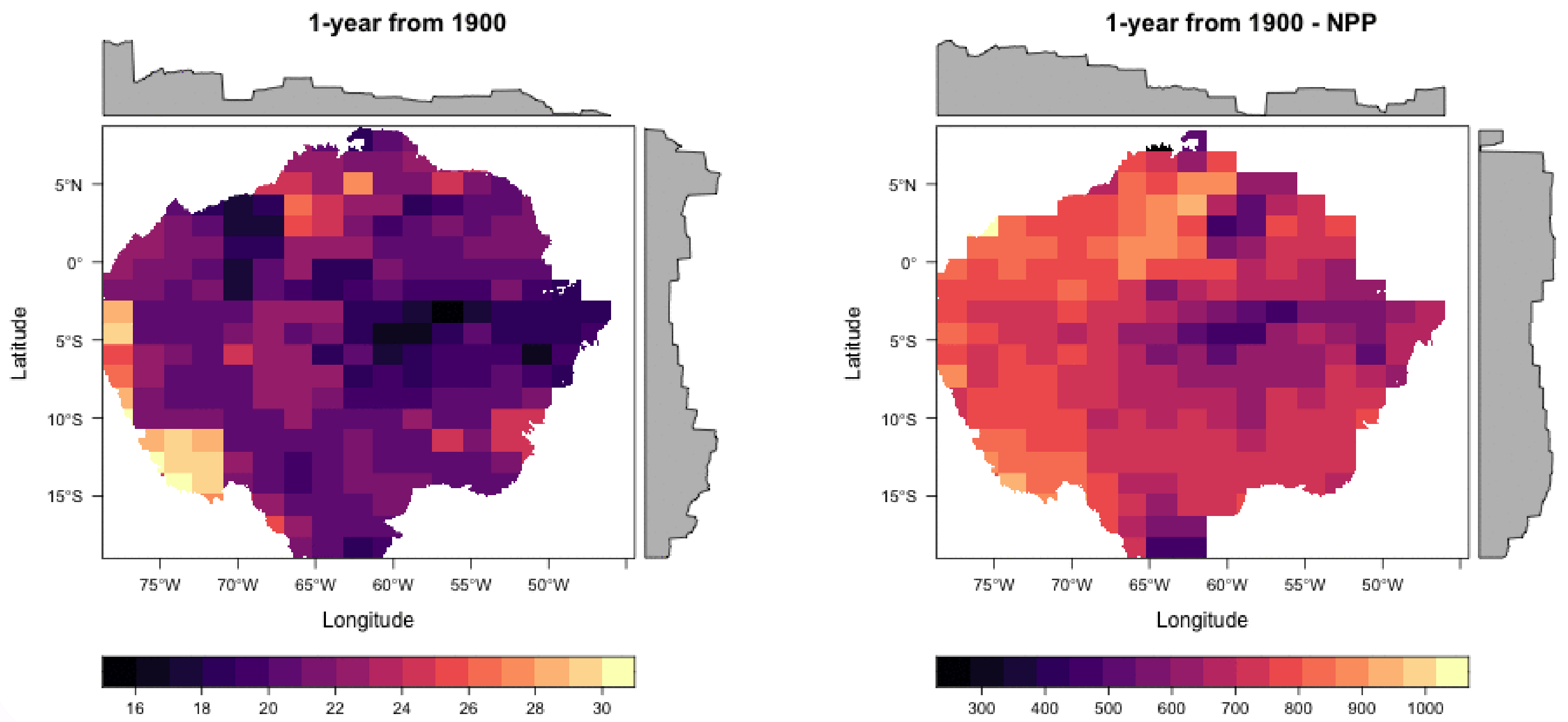
Distribution of identified soil types across Amazonia.

Quesada, C. A, et. al, 2010


Total P mg kg-1
25 – 70
70 – 120
120 – 200
200 – 300
300 – 400
400 – 600
600 – 1000
b)


Total P
5°N
0°
5°S
10°S
15°S
Latitude
75°W
70°W
65°W
60°W
55°W
50°W
Longitude
16
18
20
22
24
26
28


ALP-11/12
AGP-01
Tanguro
TAM-06
Manaus
SA-03
CAX-4/6
GPP -mes
GPP -mod
Ra -Mes
Ra -Mod
NPP -mes
NPP -mod
0
500
1000
1500
2000
2500
3000
3500
4000
5000
5°N
0°
5°S
10°S
15°S
Latitude
75°W
70°W
65°W
60°W
55°W
50°W
Longitude



Historical NPP and total P

Developing JULES to reflect :
Faster Decomposition Under Increased Atmospheric CO2 Limits Soil Carbon Storage

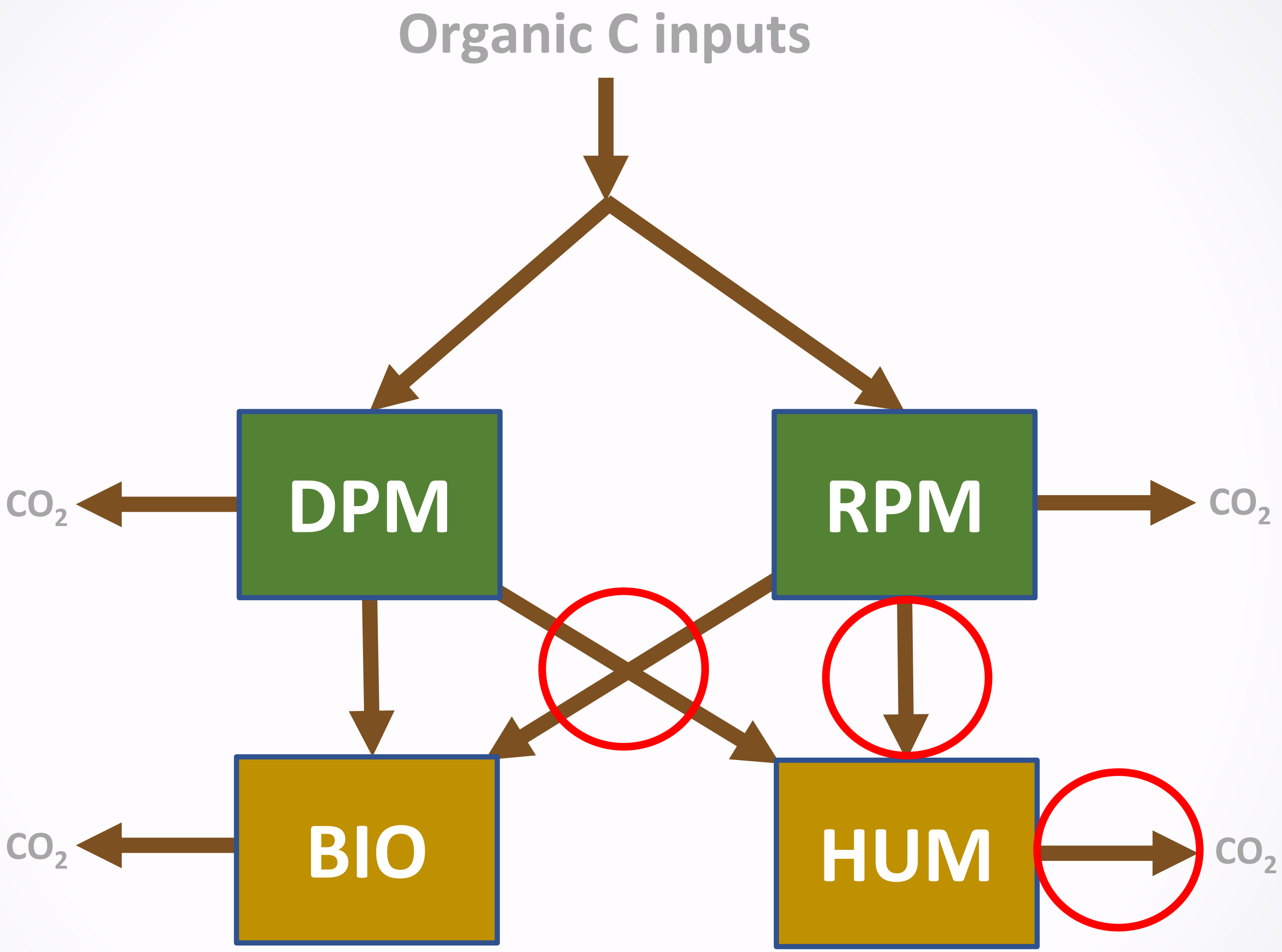
Results from a metanalysis : CO_2 enrichment stimulates both the input (+19.8%) and the turnover of C in soil (+16.5%)

The increase in soil C turnover with rising CO_2 leads to lower equilibrium soil C stocks than expected from the rise in soil C input alone

C loss from decomposition would increase with CO_2 enrichment because:

- **The pool of soil C increased**
- **The rate of decomposition (k) increased**

Incapability of models like JULES to simulate observed Soil C soil stabilization capacity /related to soil texture



Organic C inputs
DPM
RPM
BIO
HUM
CO2
CO2
CO2
CO2

$$\frac{\Delta S_{C_{DPM}}}{\Delta_t} = f_{DPM}\Lambda_C - R_{DPM}$$

$$\frac{\Delta S_{C_{RPM}}}{\Delta_t} = (1 - f_{DPM}\Lambda_C\Big) - R_{RPM}$$

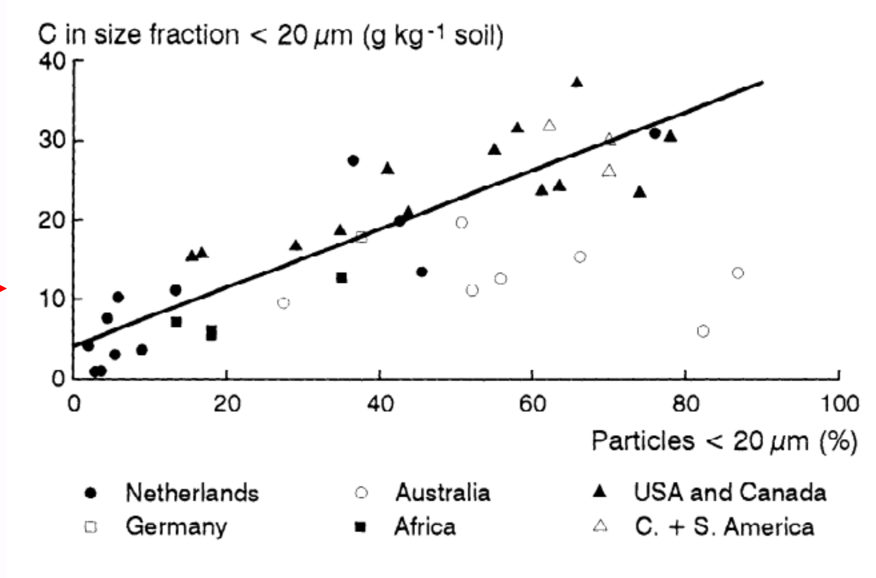
$$\frac{\Delta S_{C_{BIO}}}{\Delta_t} = 0.46(1 - \beta_R)R_S - R_{BIO}$$

$$\frac{\Delta S_{C_{HUM}}}{\Delta_t} = 0.54(1 - \beta_R)R_S\left(\frac{S_{C_{HUM-max}} - S_{C_{HUM}}}{S_{C_{HUM-max}}}\right) - R_{HUM}$$

$$\frac{\Delta S_{C_{HUM}}}{\Delta_t} = 0.54(1-\beta_R)R_S\left(\frac{S_{C_{HUM-max}} - S_{C_{HUM}}}{S_{C_{HUM-max}}}\right) - R_{HUM}$$

Size class[a]	Ecosystem	Intercept	Slope	r^2
0–20 μm	Cultivated	4.38±0.68[b]	0.26±0.01	0.41
	Grassland	2.21±1.94	0.42±0.08	0.44
	Forest	−2.51±0.55	0.63±0.01	0.55
0–50 μm	Cultivated	7.18±3.04	0.2±0.04	0.54
	Grassland	16.33±4.69	0.32±0.07	0.35
	Forest	16.24±6.01	0.24±0.08	0.35
Size class	Clay type	Intercept	Slope	r^2
0–20 μm	1:1	1.22±0.37	0.30±0.01	0.74
	2:1	3.86±0.49	0.41±0.01	0.39
0–50 μm	1:1	5.5±5.93	0.26±0.13	0.38
	2:1	14.76±2.37	0.21±0.03	0.07

Regression equations relating silt plus clay proportion
to silt and clay associated C- Six et al., Plant and Soil 241: 155–176, 2002



Relationship between the maximum amount of C associated
with the particles < 20 μm – Hassnik et. al, Plant and Soil 191: 77–87, 1997

Thanks for your attention

Question?