Non-structural carbohydrates and the variability of global carbon fluxes

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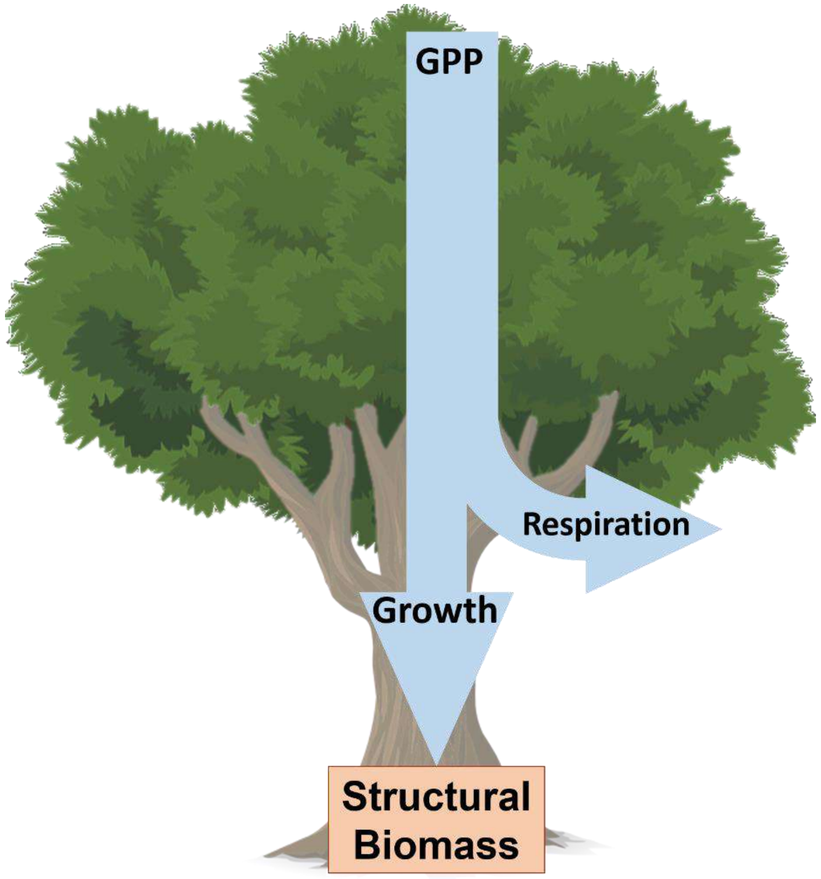
GW4+ Doctoral Training Partnership

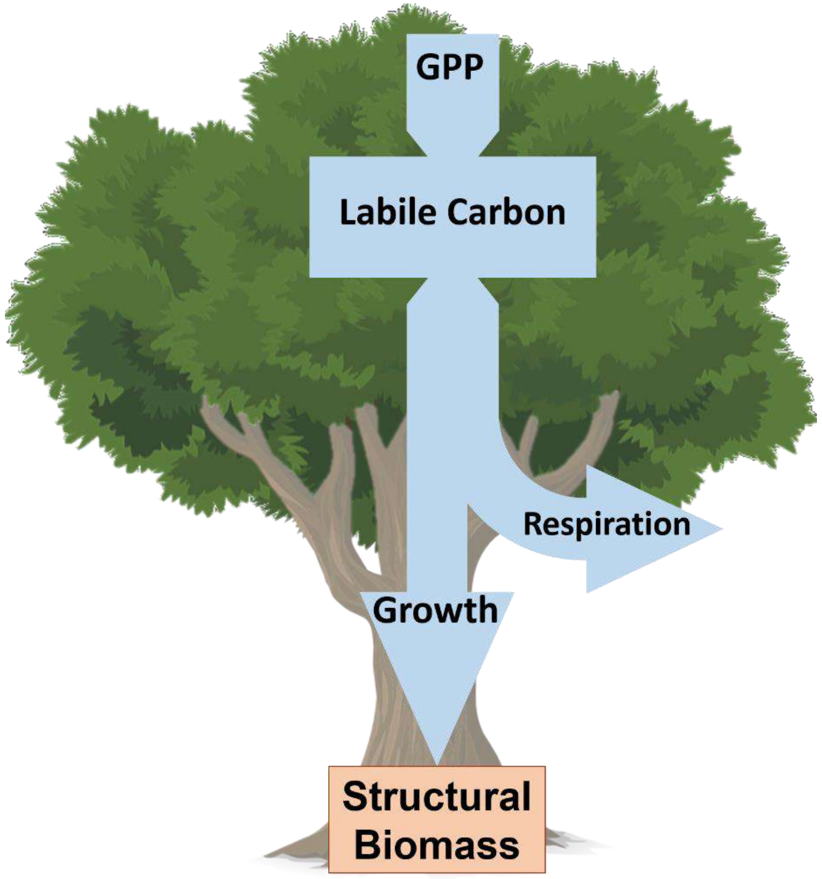
UNIVERSITY OF EXETER

What are Non-structural carbohydrates?



$$R_p + G = GPP$$

SUPPLY = DEMAND



$$R_p + G \neq GPP$$

SUPPLY ≠ DEMAND

The impact of a simple representation of non-structural carbohydrates on the simulated response of tropical forests to drought

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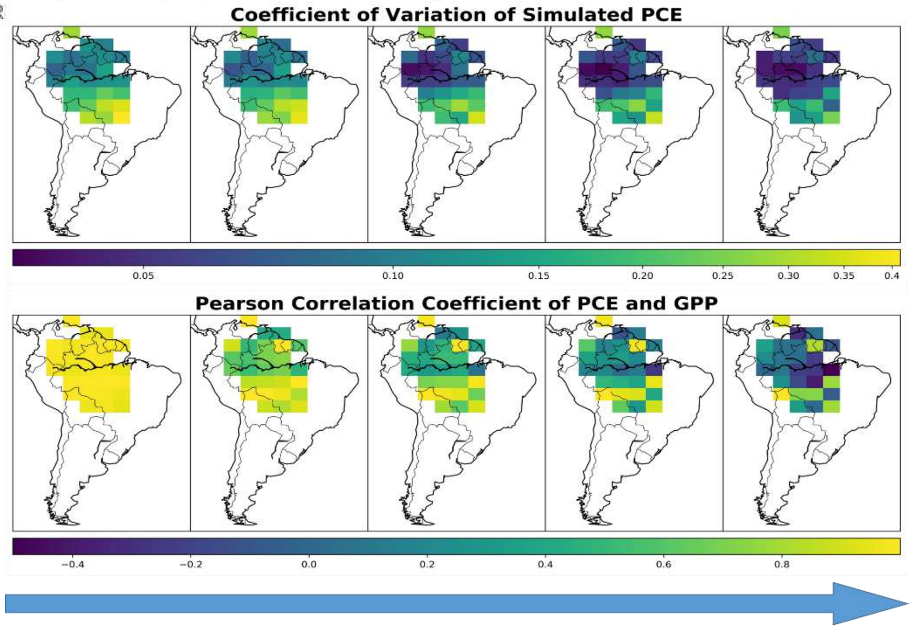
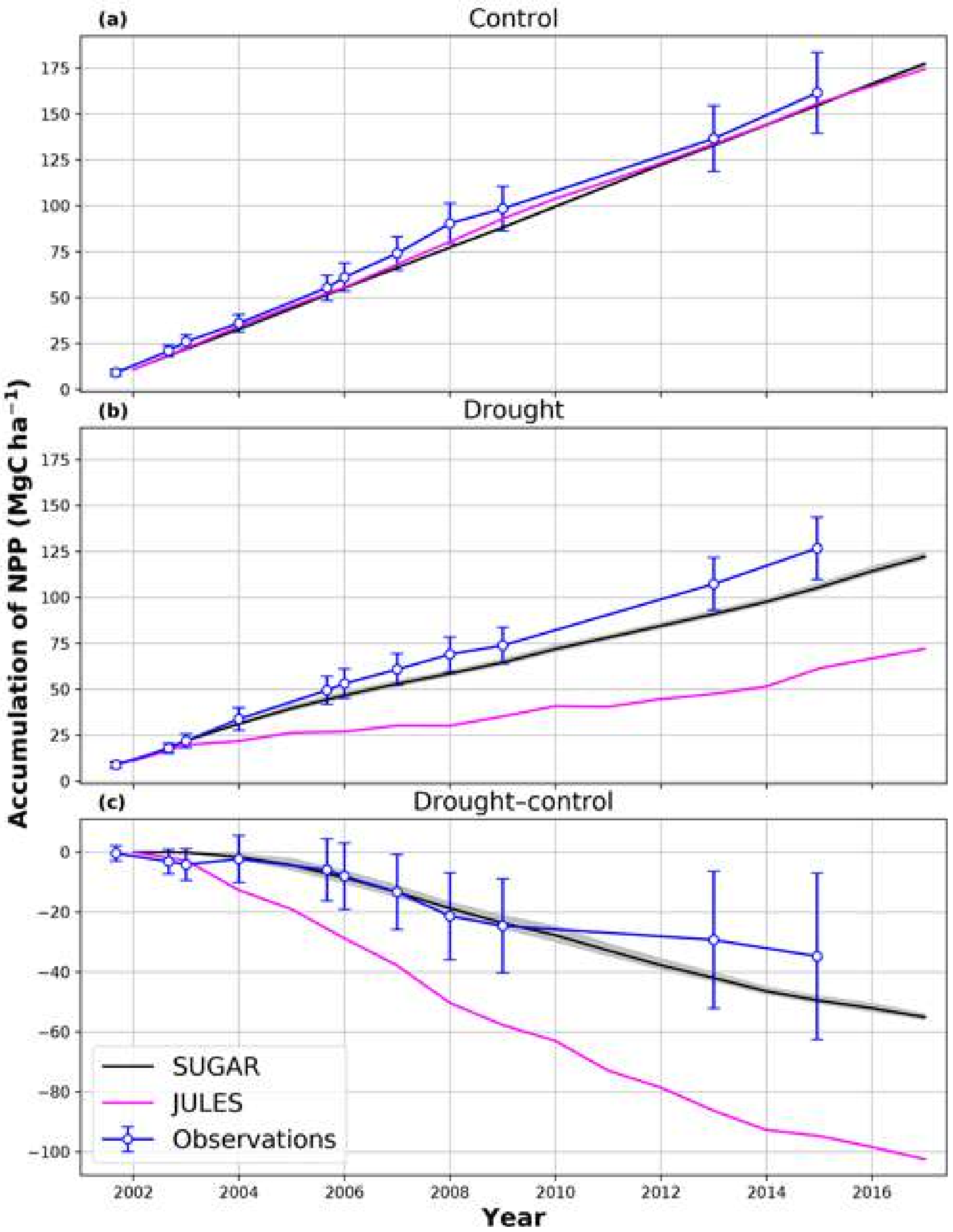


Carbohydrate Content



Aims:

- To investigate the role of NSC at a global scale and across inter-annual time-scales
- Assess the role that NSC has in determining respiration rates in relation to the Growth-Maintenance Respiration Paradigm

The growth-maintenance respiration paradigm

$$R = kP + cW$$ (McCree, 1970)

Photosynthesis → R_g

Biomass → R_m

- R depends on productivity and biomass

=> Two distinct components

Model	Maintenance Respiration	Growth Respiration	Reference
CLASS-CTEM	$R_{m_L} = s_L V_m f_{25}(Q_{10}) f_{par}$ $R_{m_i} = 2.64 \times 10^{-6} s_i l_{v,i} C_i f_{25}(Q_{10})$ where: $i = S, R$ (stem or root) $l_{v,i} =$ live fraction of stem or root $C_i =$ stem or root carbon mass $s_i =$ base respiration rate (constant) $V_m =$ maximum catalytic capacity of rubsico $f_{par} = \frac{1}{k_n}(1.0 - e^{-k_n LAI})$	$R_g = \epsilon_g max\{0, GPP - R_m\}$ where: $\epsilon_g = 0.15$	(Melton and Arora, 2016)
LPJ-GUESS	$R_{m,t} = 0.0548 r \frac{C_t}{cton_t} exp\left[308.58\left(\frac{1}{56.02} - \frac{1}{T - 45.87}\right)\right]$ where: $t =$ tissue type $r =$ PFT-specific coefficient $C_t =$ carbon content of tissue t $cton_t =$ C-N mass ratio of tissue t $T =$ ambient temperature	$R_g = 0.25(GPP - R_m)$	(Smith et al., 2001, 2014)
JULES-ES	$R_{p_m} = 0.12 R_{d_c}\left(\beta + \frac{N_r + N_s}{N_l}\right)$ where: R_{d_c} = dark respiration β is a soil moisture stress factor N_i for $i = l, s, r$ are the nitrogen contents of leaves, stem and root respectively	$R_{pg} = r_g(GPP - R_{pm})$ where: $r_g = 0.25$	(Clark et al., 2011)
ISAM	$R_{m_i} = k_i \frac{C_i}{CN_i} g(T)$ where: $i =$ leaf, stem, root $C_i =$ carbon content of component i $k_i =$ maintenance coefficient at 20° ℃ for component i $CN_i =$ C:N ratio of component i $T =$ Temperature	$R_g = max\{0, r_g(GPP - R_m)\}$ where: $r_g = 0.25$	(Song et al., 2013)

An alternative perspective

PRIMARY RESEARCH ARTICLE | Full Access

Plant respiration: Controlled by photosynthesis or biomass?

Alessio Collalti, Mark G. Tjoelker, Günter Hoch, Annikki Mäkelä, Gabriele Guidolotti, Mary Heskel, Giai Petit, Michael G. Ryan, Giovanna Battipaglia, Giorgio Matteucci, Iain Colin Prentice,

First published: 03 October 2019 | https://doi.org/10.1111/gcb.14857 |

Is NPP proportional to GPP? Waring's hypothesis 20 years on FREE

A Collalti, I C Prentice

Tree Physiology, Volume 39, Issue 8, August 2019, Pages 1473–1483,
https://doi.org/10.1093/treephys/tpz034
Published: 17 May 2019 **Article history** ▾

Plant growth and respiration re-visited: maintenance respiration defined – it is an emergent property of, not a separate process within, the system – and why the respiration : photosynthesis ratio is conservative

John H. M. Thornley

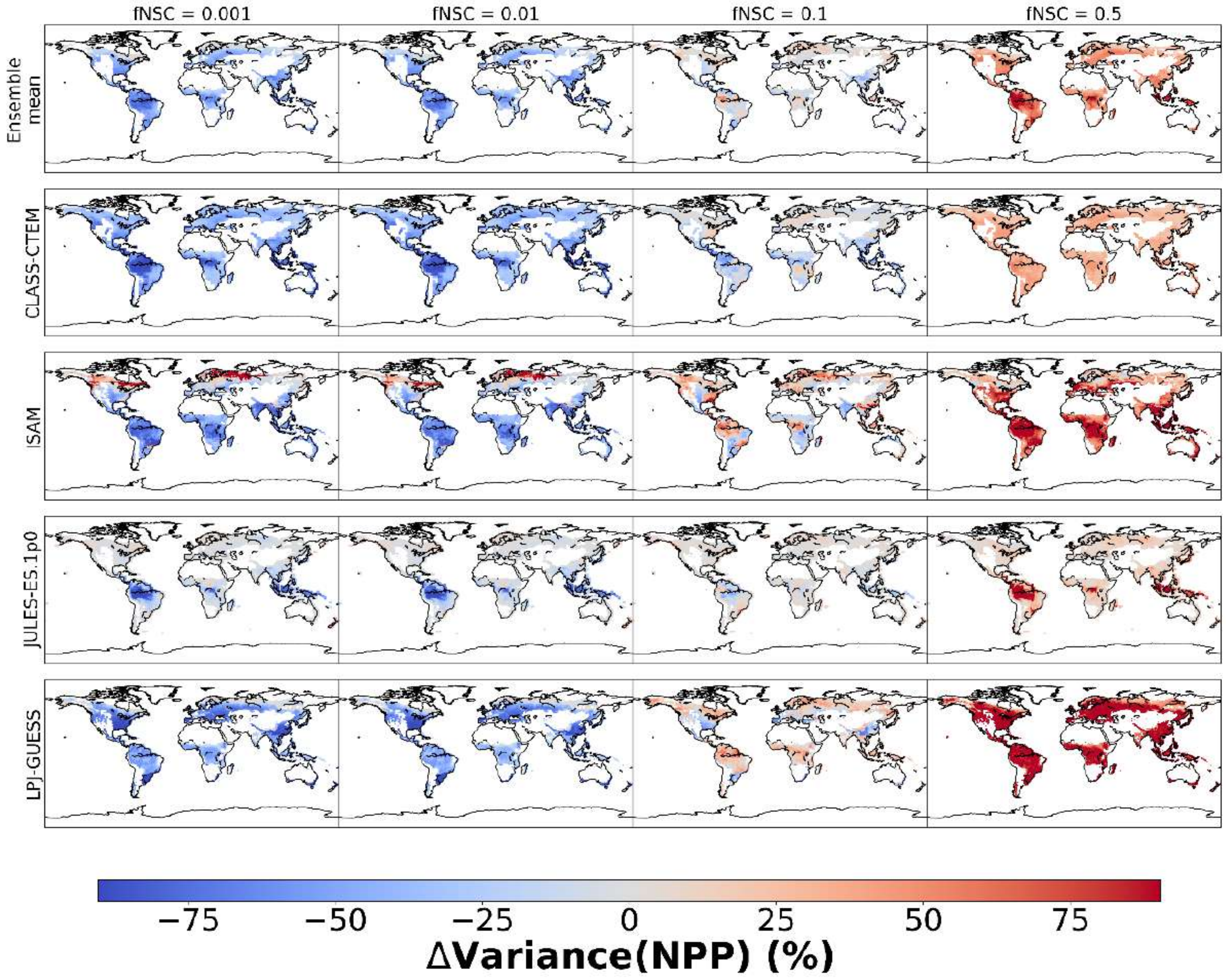
Annals of Botany, Volume 108, Issue 7, November 2011, Pages 1365–1380,
https://doi.org/10.1093/aob/mcr238
Published: 26 September 2011 **Article history** ▾

Methods

1. Pass GPP, Ra, Biomass outputs from CLASS-CTEM, ISAM, LPJ-GUESS, JULES (TRENDY v.8) through SUGAR
2. Assess changes to variability of NPP

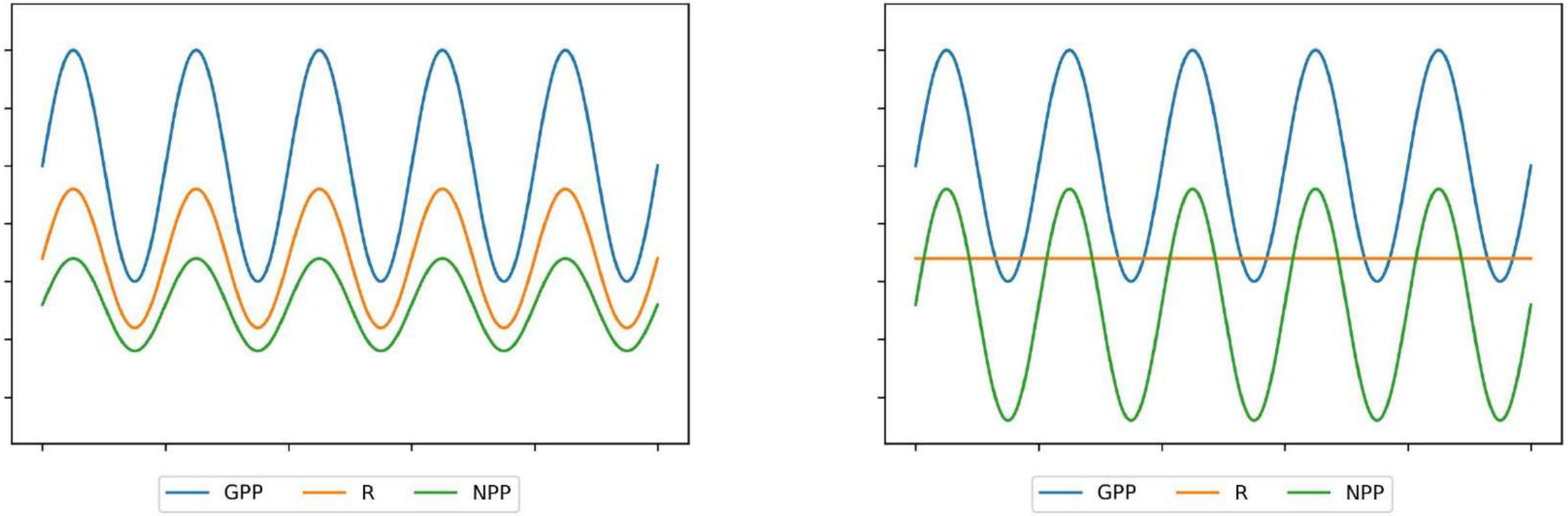
- Repeat for different NSC turnover rates

Results



- Fast NSC turnover:
  - Decrease in NPP variability
- Slow NSC turnover:
  - Increase in NPP variability

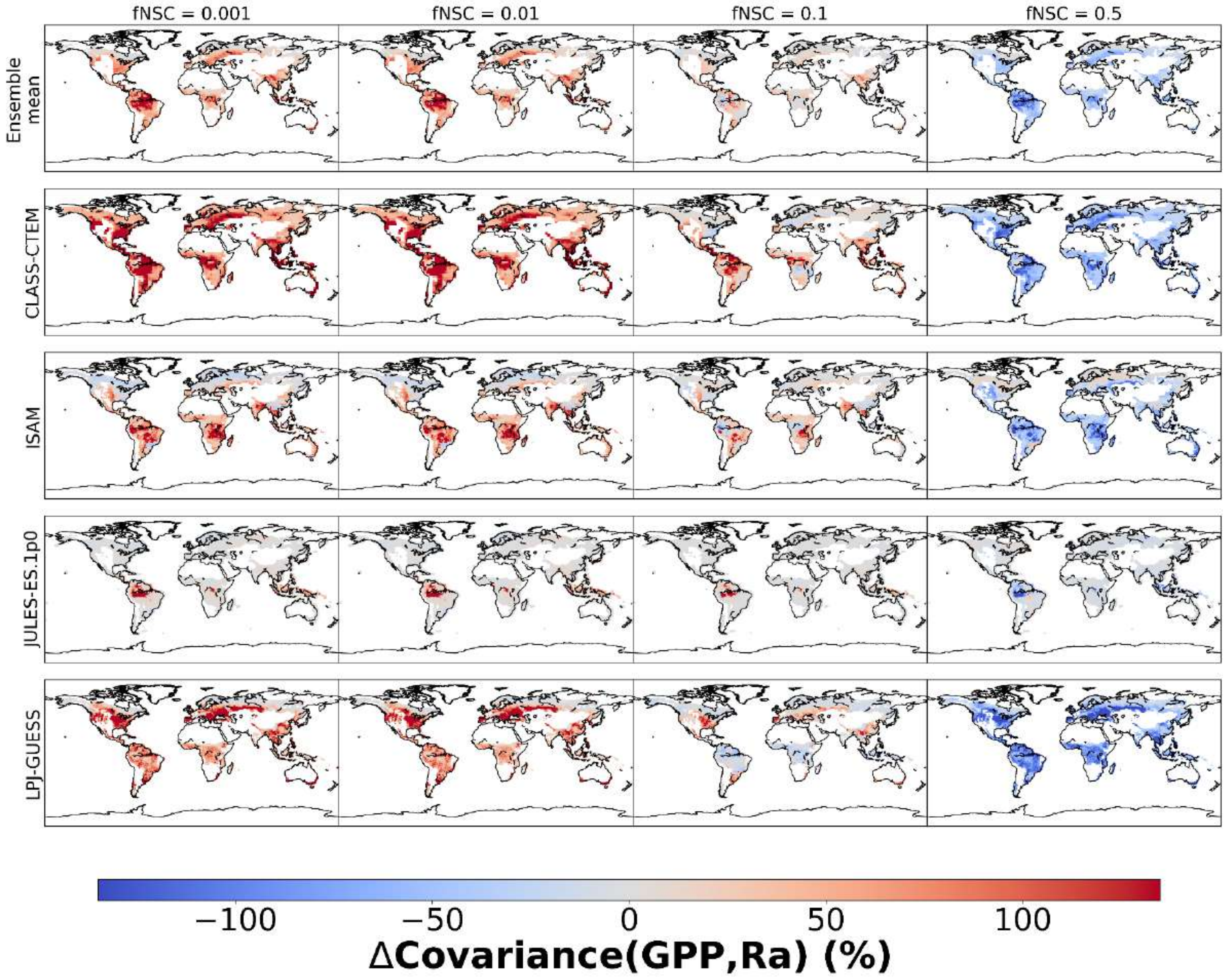
Covariance of GPP and Ra



FAST

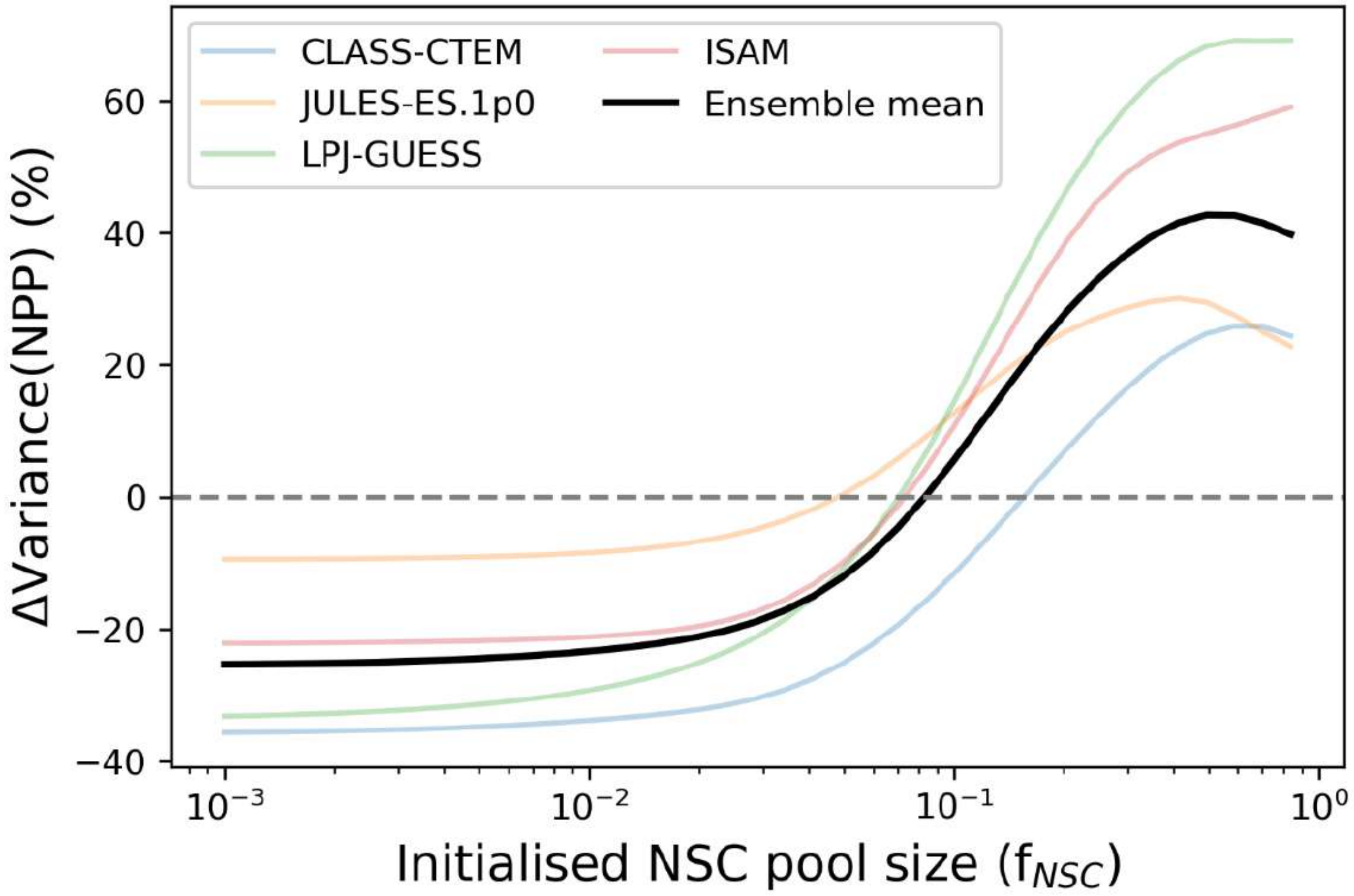
SLOW

Results



- Fast NSC turnover:
  - R is controlled by GPP
- Slow NSC turnover:
  - R is controlled by biomass and temperature

Results



Model	[NSC]: Δvar(NPP)=0
CLASS-CTEM	15.6%
JULES-ES.1p0	4.8%
LPJ-GUESS	7.06%
ISAM	7.35%

Ecosystem	Estimate	Reference
Tropical forest	8%	Wurth (2005)
Temperate forest	4%	Furze (2019)

Thanks for listening!