Analysis of the Land carbon cycle in the IPSL-CM6: from a statistical down-regulation of photosynthesis to a full carbon - nitrogen implementation

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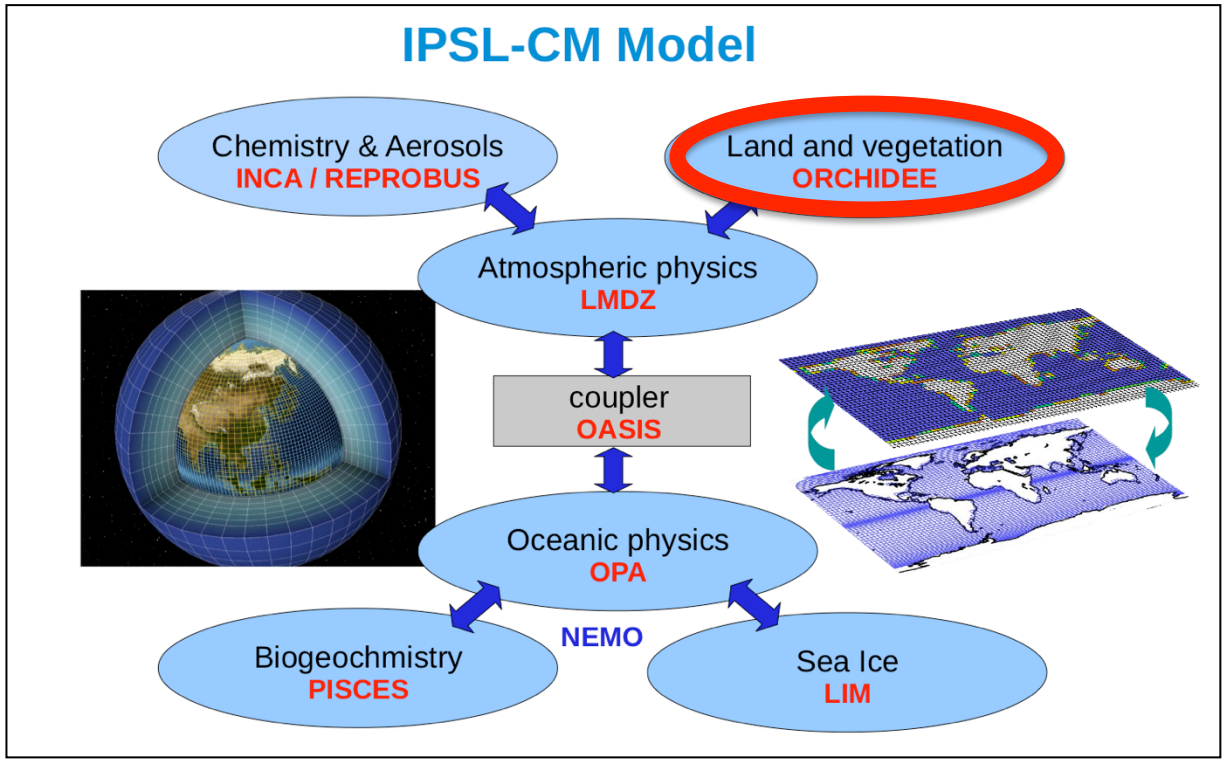
ORCHIDEE
LAND SURFACE MODEL



4 versions of the Land CO2 fertilisation

1. **IPSL- CM5** : No down regulation
   high sensitivity of land fluxes to [CO2] (high beta factor)
2. **IPSL- CM6-P1** : A surrogate of full Nitrogen cycle with a strong "down regulation" of Vcmax as a function of [CO2]atm

$$\mathrm{Vcmax} = \mathrm{Vcmax25} \cdot (1 - \mathrm{coef\_down\_reg} \cdot \log(\mathrm{CO2}/380))$$

Sellers et al., 1996

3. **IPSL-CM6-P2** : An updated downregulation curve to avoid large GPP reduction above 700 ppm

$$\mathrm{Vcmax} = \mathrm{Vcmax25} \cdot (1 - \mathrm{coef\_down\_reg} \cdot (\mathrm{CO2} - 380)/(\mathrm{CO2} + \mathrm{coef\_curve}))$$

4. **IPSL-ORCHIDEE-CN** : includes Nitrogen cycle in ORCHIDEE (run underway)

Tunning of the “down regulation”

1. **IPSL-CM5** : No down regulation
   high sensitivity of land fluxes to [CO2] (high beta factor)
2. **IPSL-CM6-P1** : Strong Vcmax “down-regulation” function CO_2
3. **IPSL-CM6-P2**: Revision of “down-regulation”

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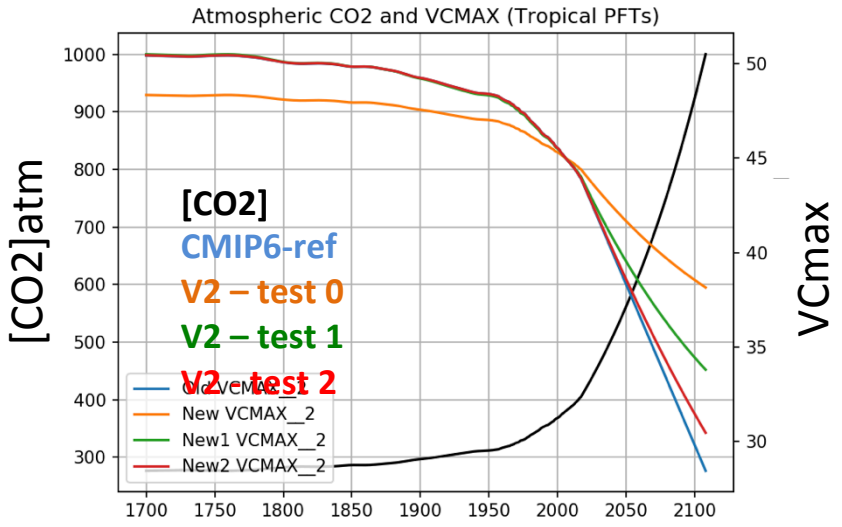

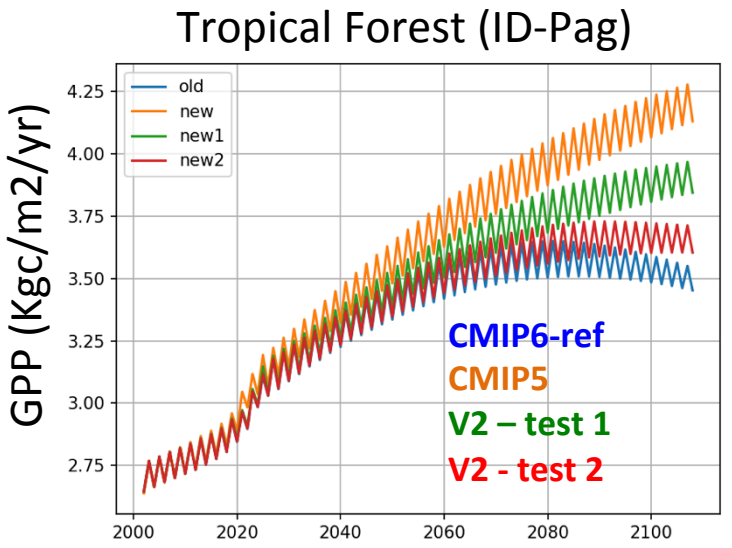

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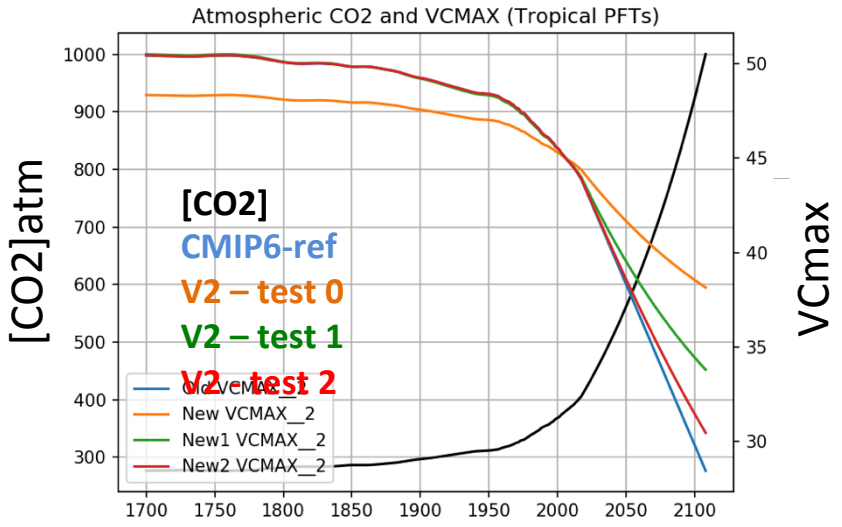
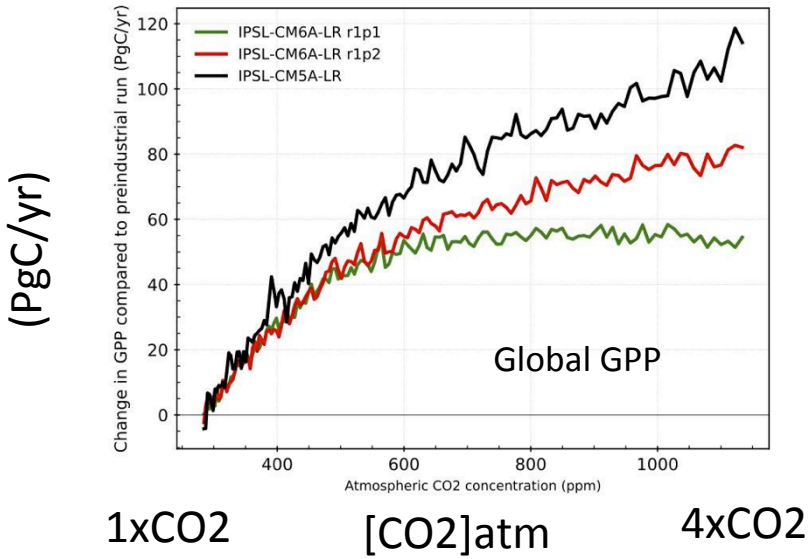
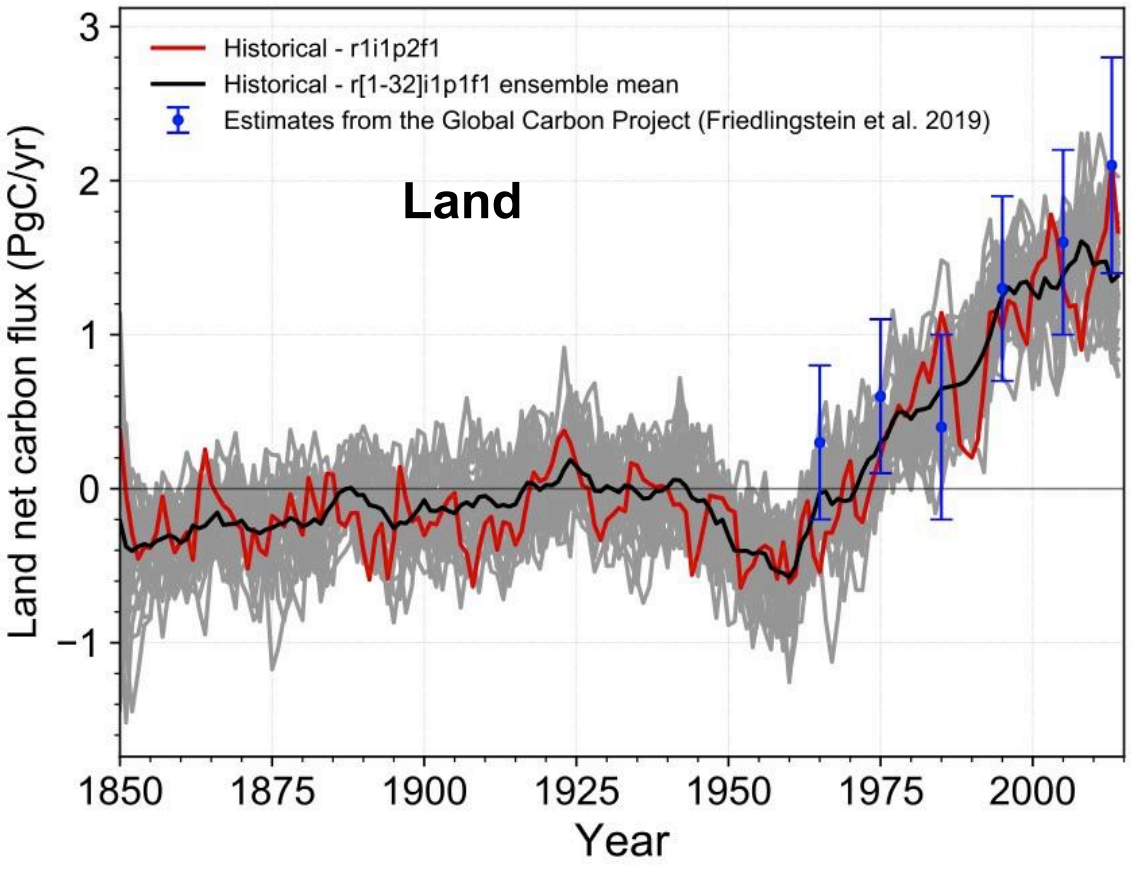




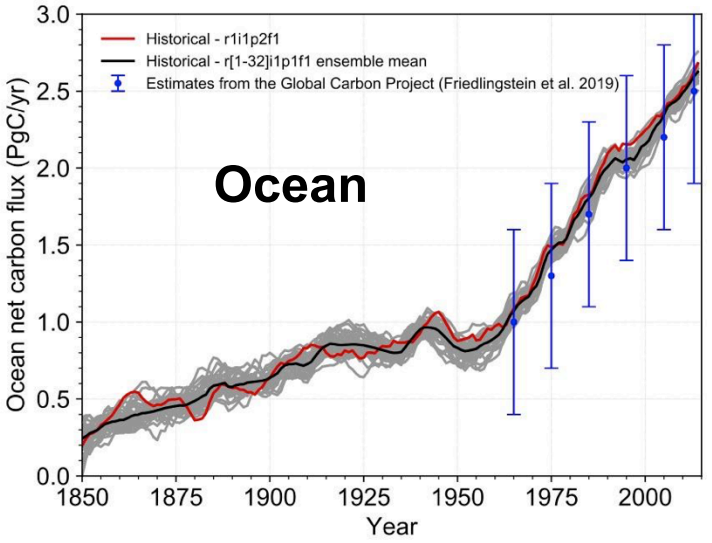
Historical period…



IPSL - CM6 - r1-32 P1

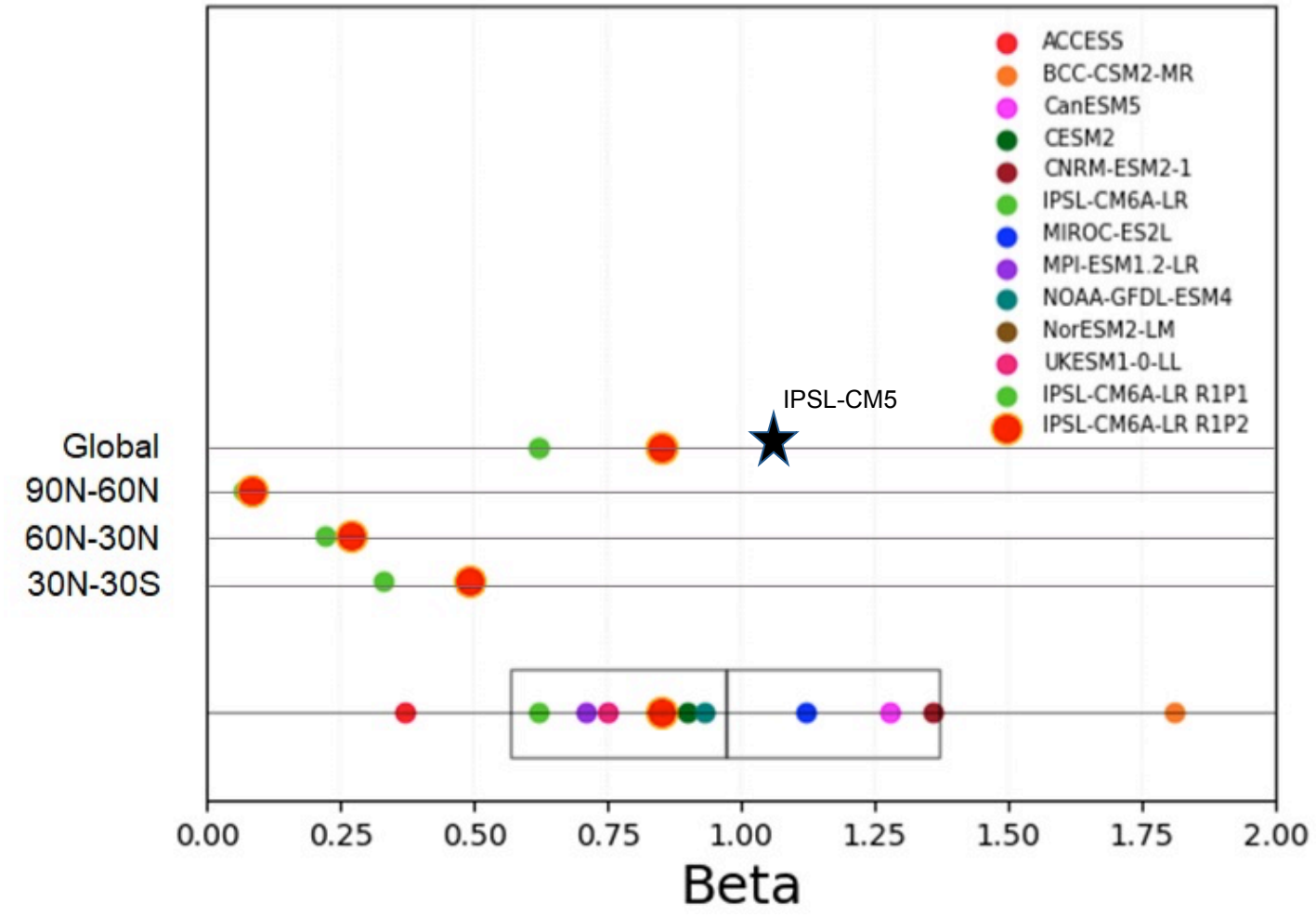
IPSL - CM6 - r1 P2

Data Range from GCP



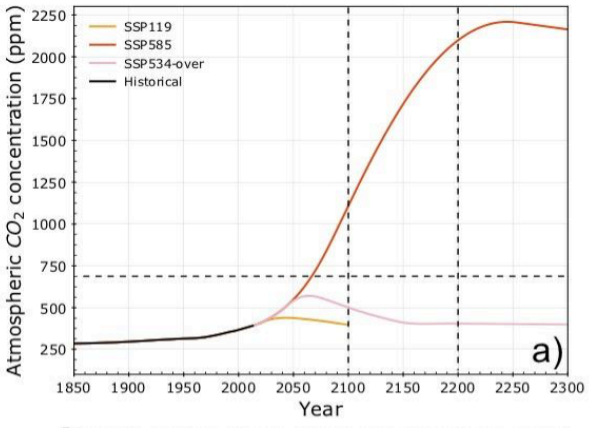
Carbon - concentration feedback

1% CO2 simulations up to 4xCO2: Comparison with other models (Arora et al. 2020)

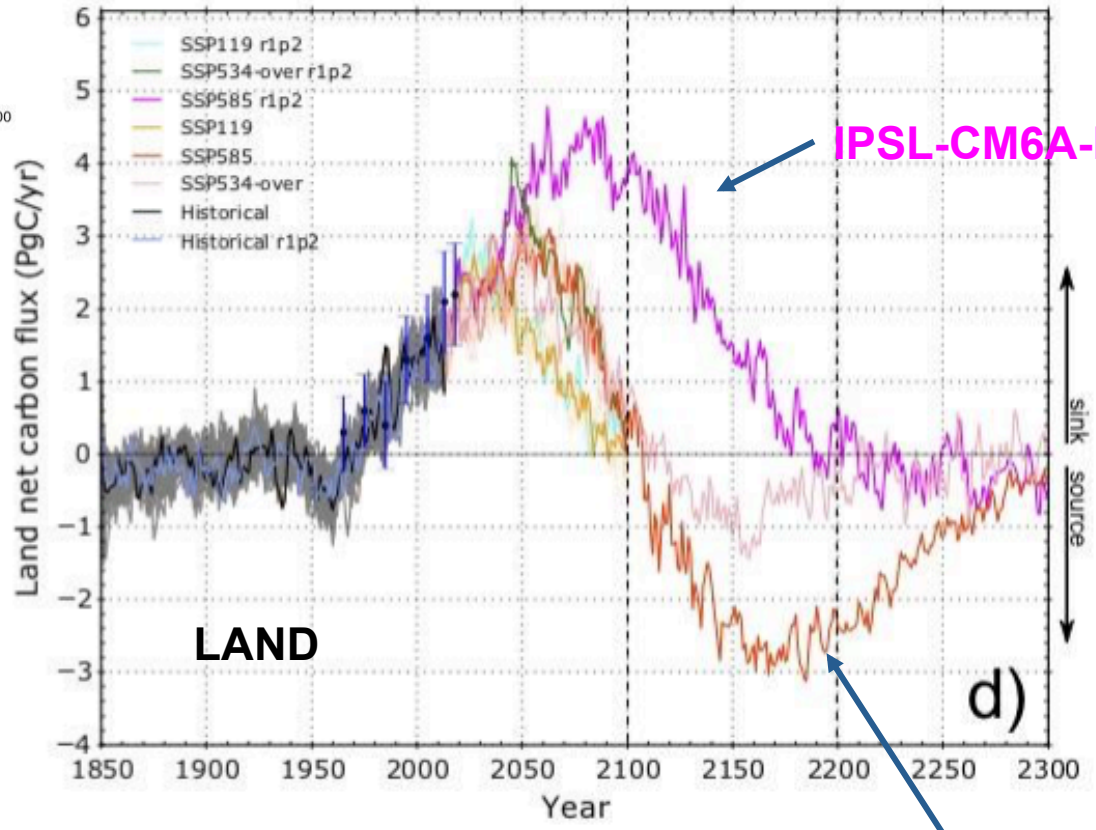


	IPSL-CM5	/ IPSL-CM6 r1p1	/ IPSL-CM6 r1p2	
Beta_land =	1.13	/ 0.62	/ 0.85	PgC.ppm^{-1}

Future scenarios: SSP5-8.5

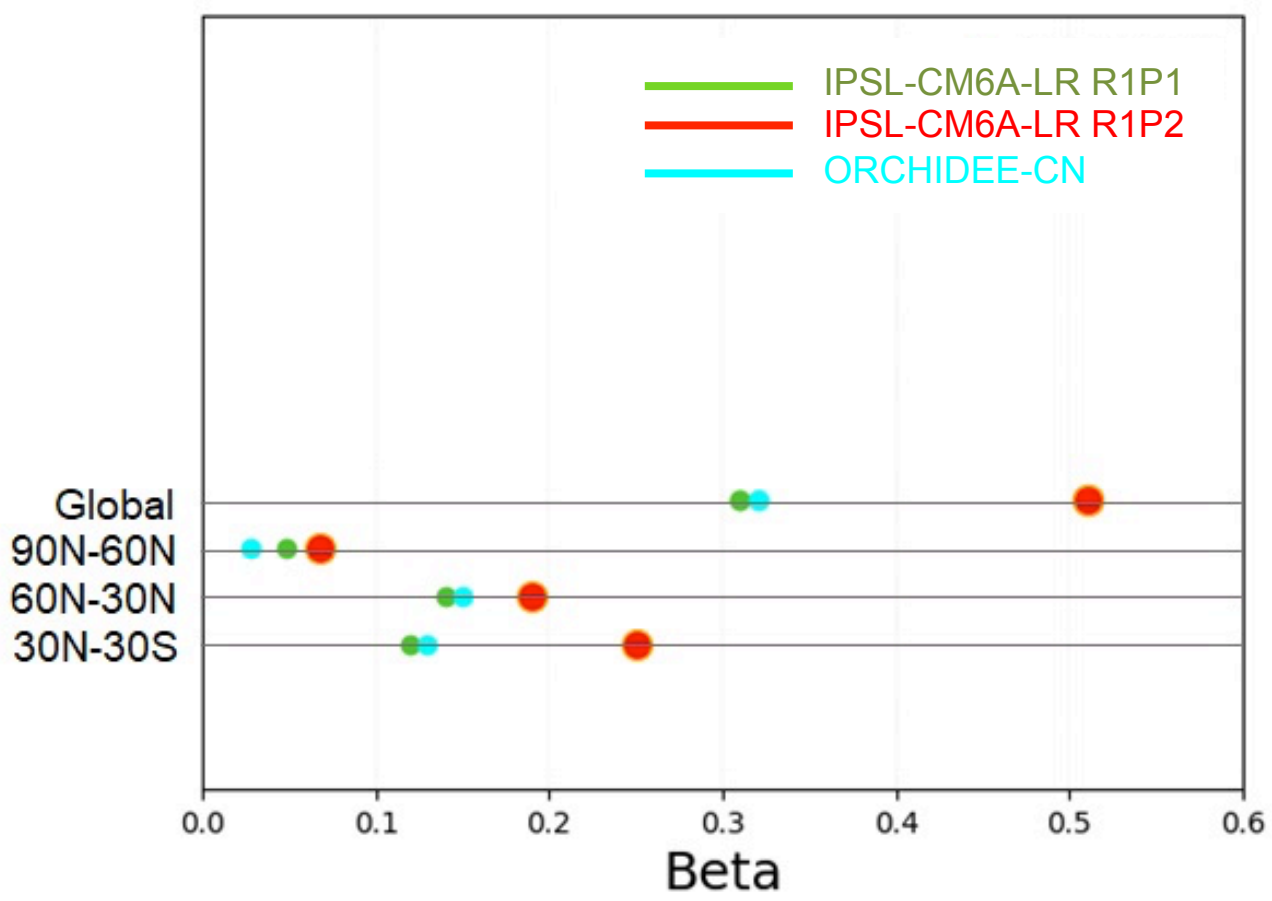


⇒ Very different behaviour between P2 & P1 downregulation parametrizations !



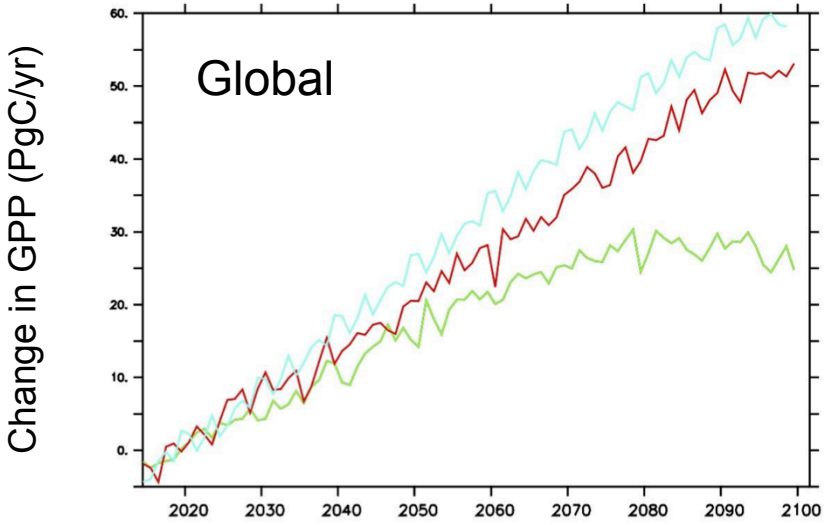
With the Nitrogen Cycle: SSP5-8.5

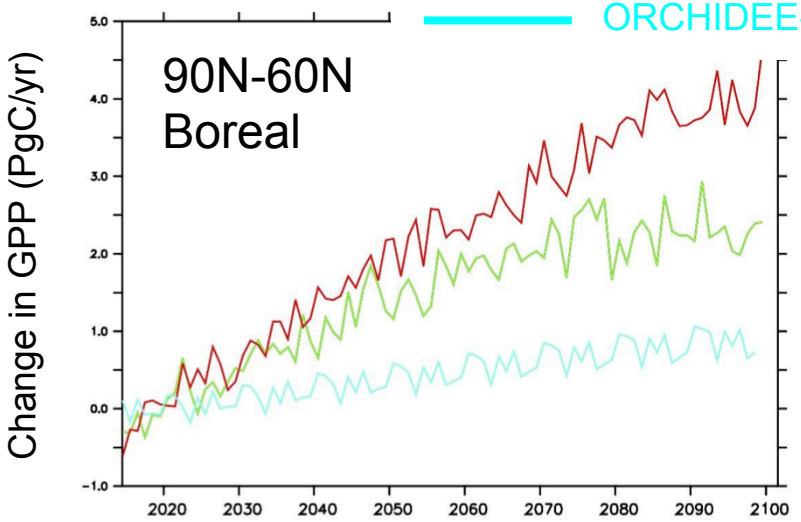
Carbon–concentration feedback over land (Beta factor)
for the period 2015 - 2100

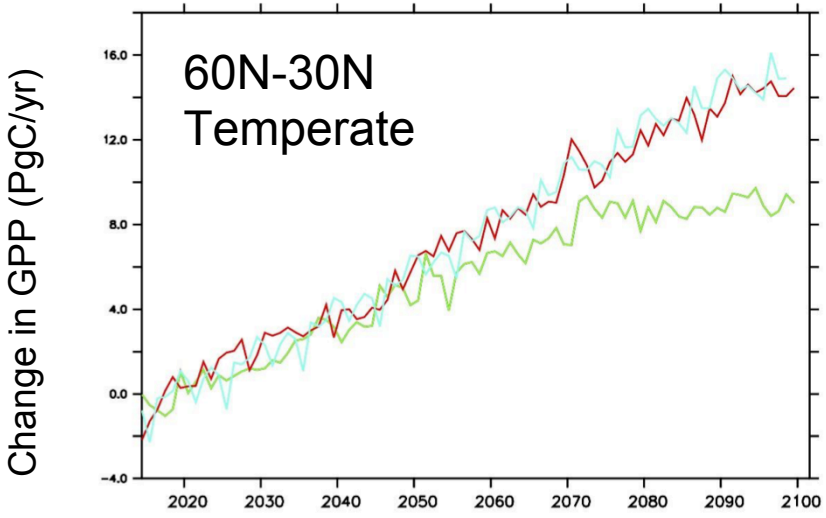


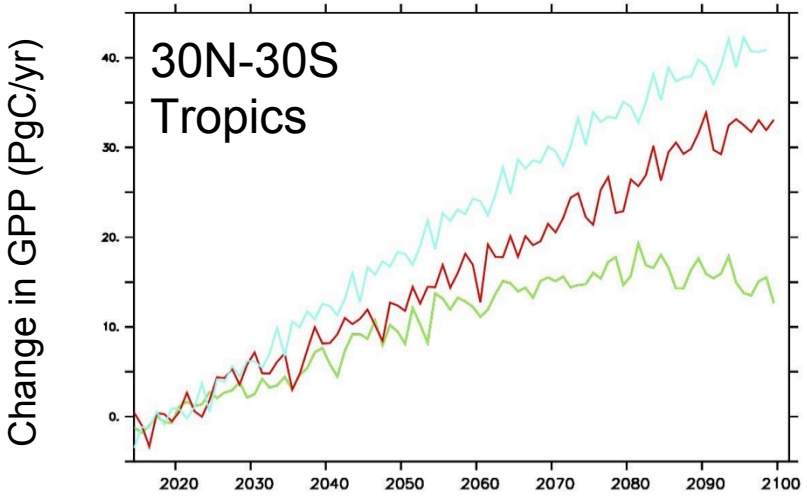
With the Nitrogen Cycle : SSP5-8.5

IPSL-CM6A-LR R1P1
IPSL-CM6A-LR R1P2
ORCHIDEE-CN



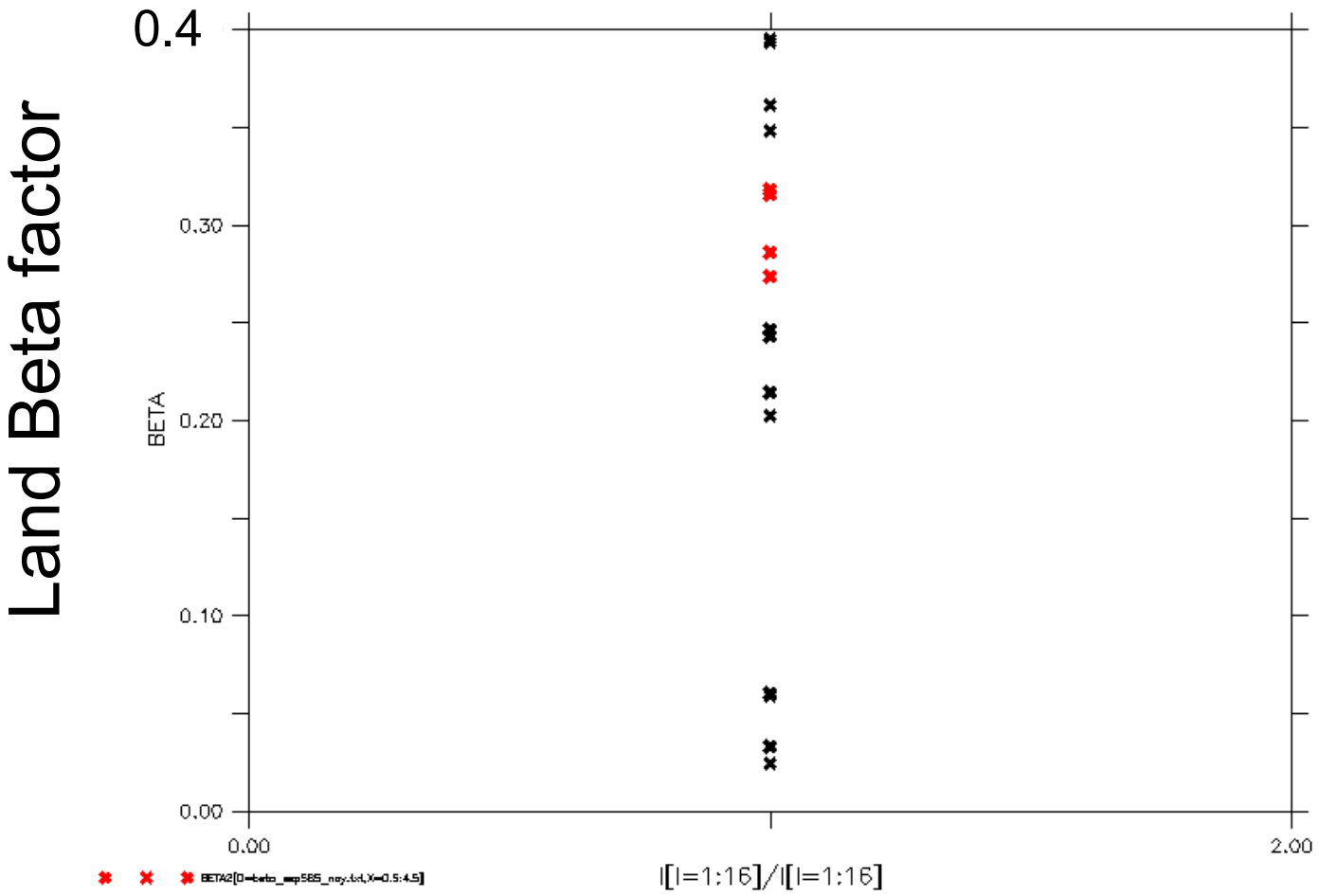






Nitrogen Cycle : SSP5-8.5

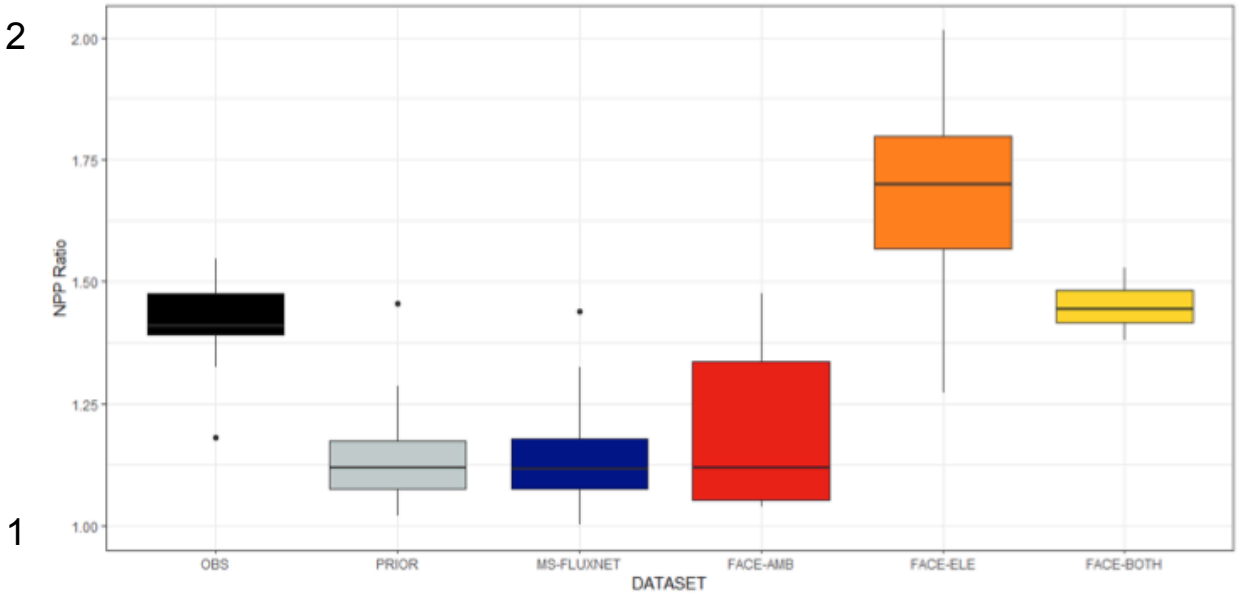
➔ Defferent beta factors using SSP5-8.5 CO2 trajectory but various Land Cover change , NHx / NOY deposition, Fertilisation



Using FACE data to further constrain ß

- Optimisation of ORCHIDEE params at FACE sites (Oak Rige & Duke)
- ~ 20 params optimised against annual NPP data and LAI data

DUKE : NPP Ratio: NPP Elevated / NPP Ambiant



Obs **Prior** **FluxNEt optim.** **Ambiant optim** **Elevated optim** **Both optim**

⇒ ORCHIDEE - CN Prior underestimates the change of NPP with doubling CO2

⇒ NEED to optimise against both Ambient and Elevated CO2 data to fit the observed NPP ratio

Summary….

- CO2 fertilisation is still not “robustly modeled” (at least in ORCHIDEE model)
- Using two statistical downregulation formulation can lead to very different “beta factors”
- Using a process-based Nitrogen cycle will decrease the land beta factor of IPSL model
- But it will also change the spatial distribution of the relative contribution of each ecosystem to “beta”
- Optimising the model responses with FACE data seems a way forward ! (but only a few set of sites !)
- BUT GPP / NPP increase does not mean more C storage ! (root exudate, …)

ORCHIDEE Biogeochemical development related to Crescendo !

ORCHIDEE TRUNK

ORCHIDEE - OCN

ORCHIDEE "Forest" Branch

ORCHIDEE High lat. Branch

CRESCENDO Contribution:

- **N cycle**
- **Permafrost**
- **Forest dynamic**

ESM2025 start