Drought-induced C Allocation Shifts Strongly Reduce Post-Drought C Uptake in French Guiana

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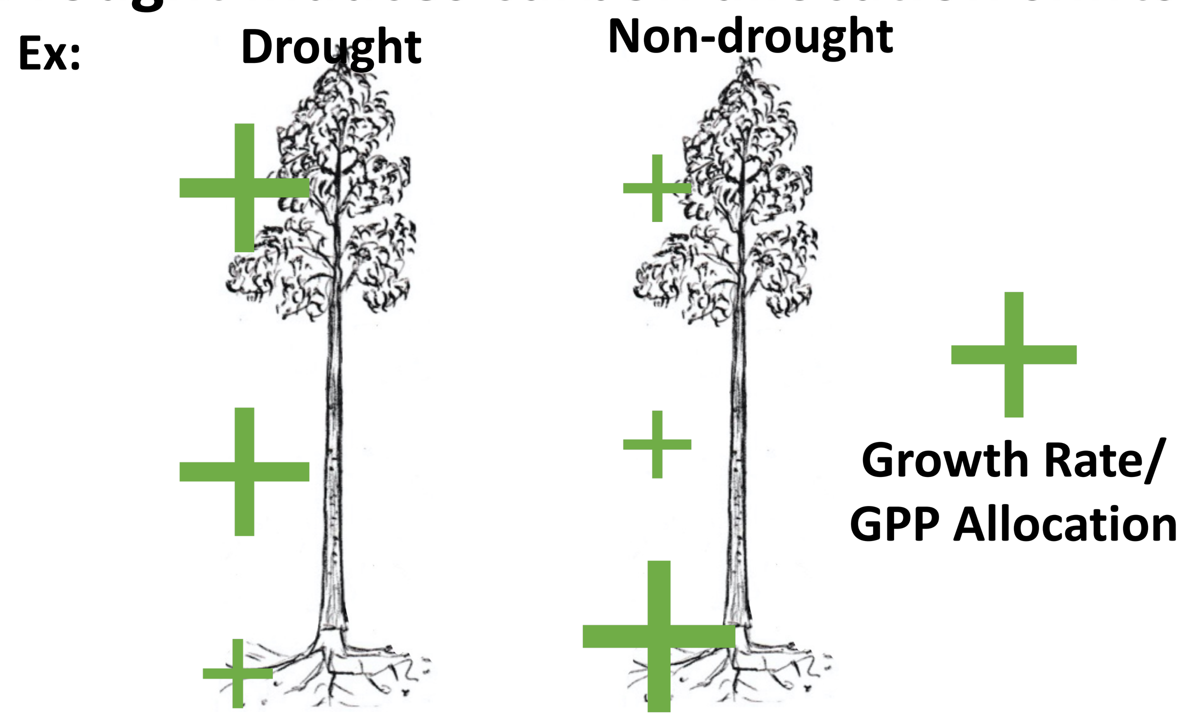
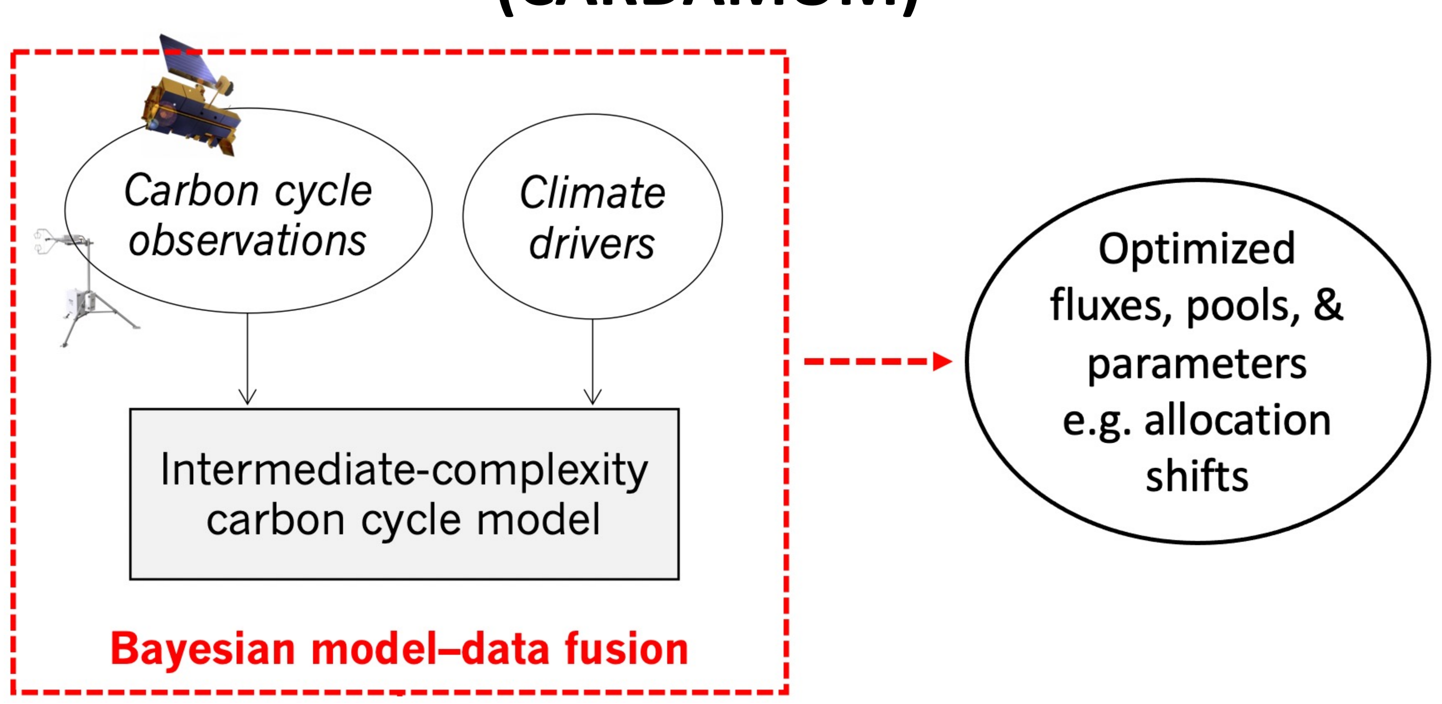
1 Drought induces carbon allocation shifts



- Drought can affect the allocation of carbon to different plant parts, which in turn effects future photosynthesis through changes in leaf area & water uptake ability
- However, direct measurement of C allocation changes as a function of water availability are difficult to acquire
- Unclear how much these shifts affect post-drought carbon fluxes

Hypothesis:
- **We can infer C allocation shifts with model-data fusion**
- **Drought induced C allocation shifts can reduce post-drought carbon uptake by reducing foliar allocation and increasing root allocation**

2 Model: CARbon DAta MOdel FraMework (CARDAMOM)

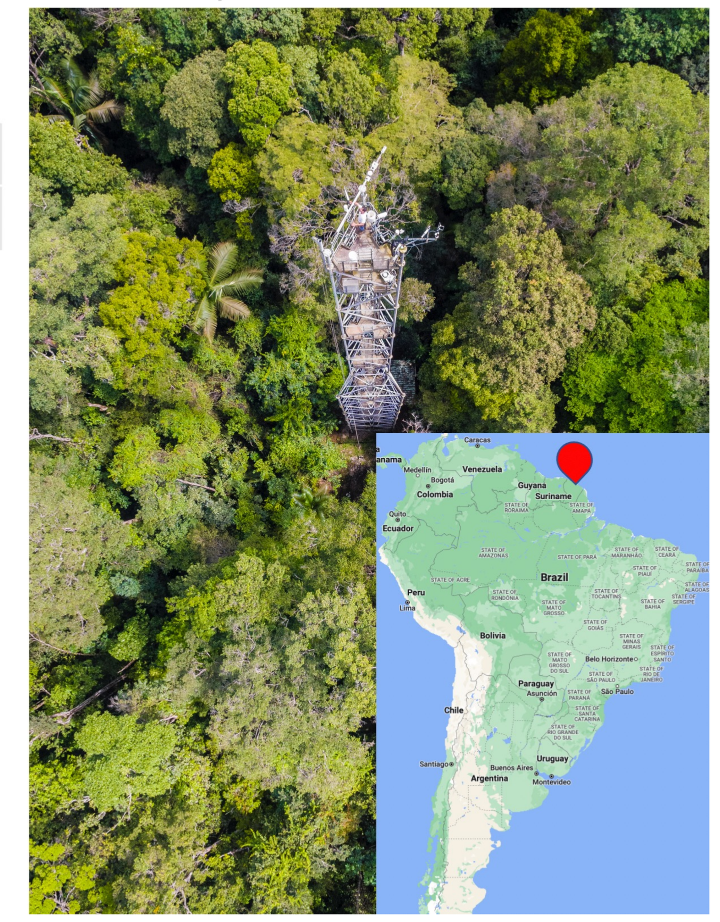


- CARDAMOM optimizes (thus inferring) parameters of its carbon cycle model DALEC to match assimilated data
- Implemented a dynamic allocation structure within DALEC, which shifts allocation of gross primary productivity (GPP) as a function of plant available water (PAW)
- Compare against original static allocation structure

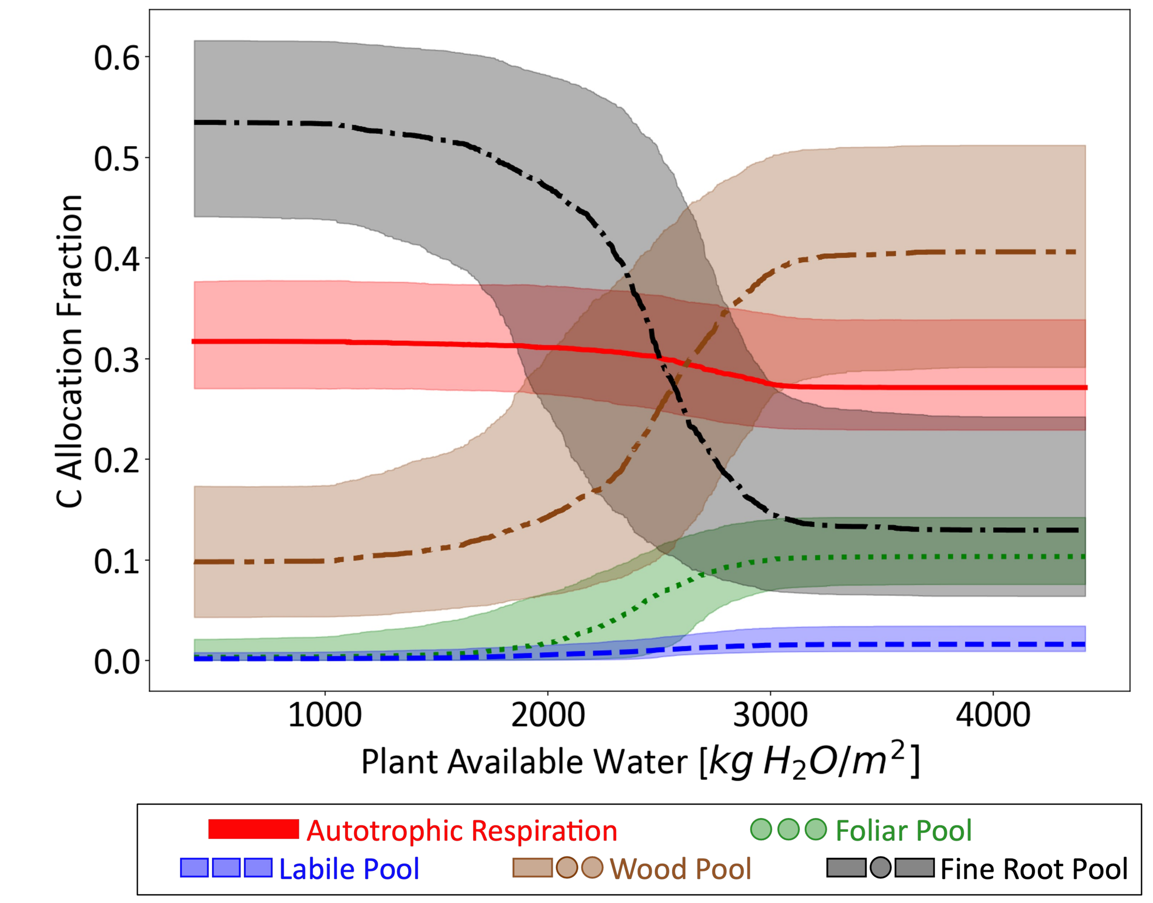
3 Model performance at Guyaflux flux tower, French Guiana

Measurement	Metric	Static	Dynamic
Predicted NBE	R^2	0.19	0.19
	RMSE ($gC/m^2/d$)	0.69	**0.67**

- Assimilate data from 2004-2020 from Guyaflux tower and in-situ measurements
- Dynamic model and static model have same skill for NBE predictions
- Dynamic allocation model performs better than static allocation model for assimilated NBE, ET, LAI, and wood biomass data

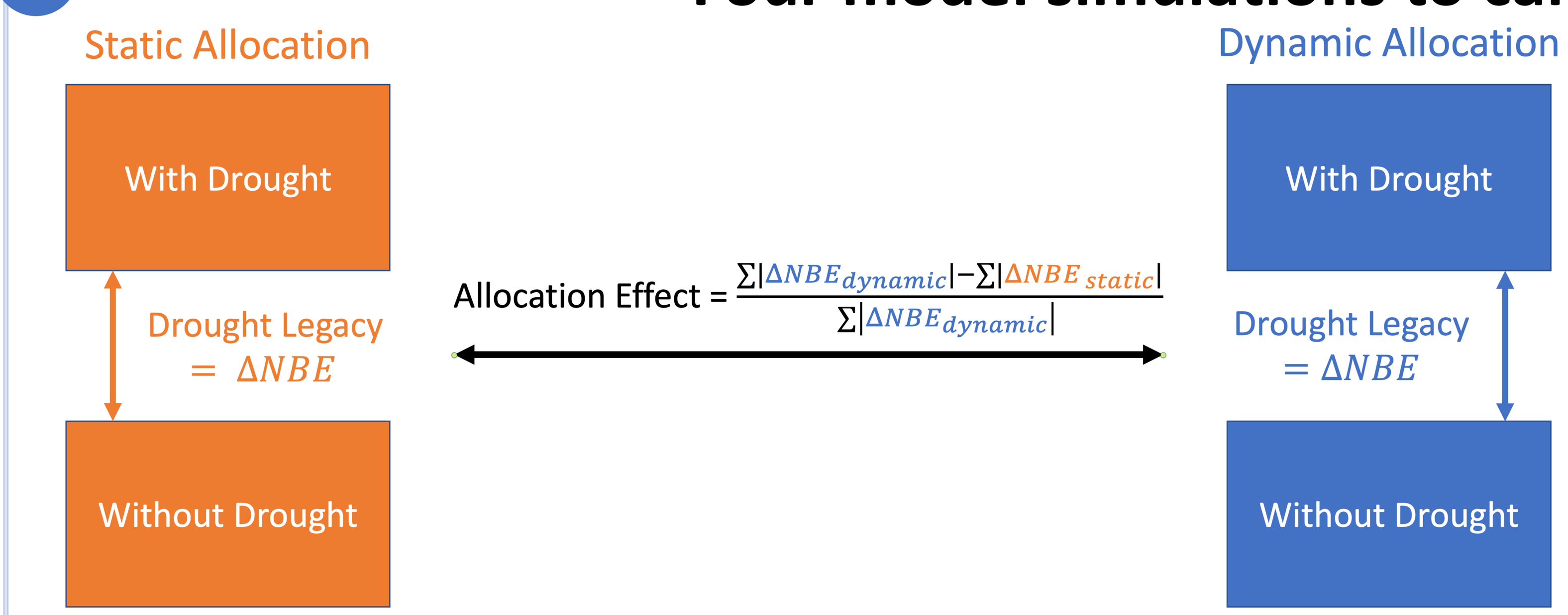


Inferred C allocation shifts due to water availability



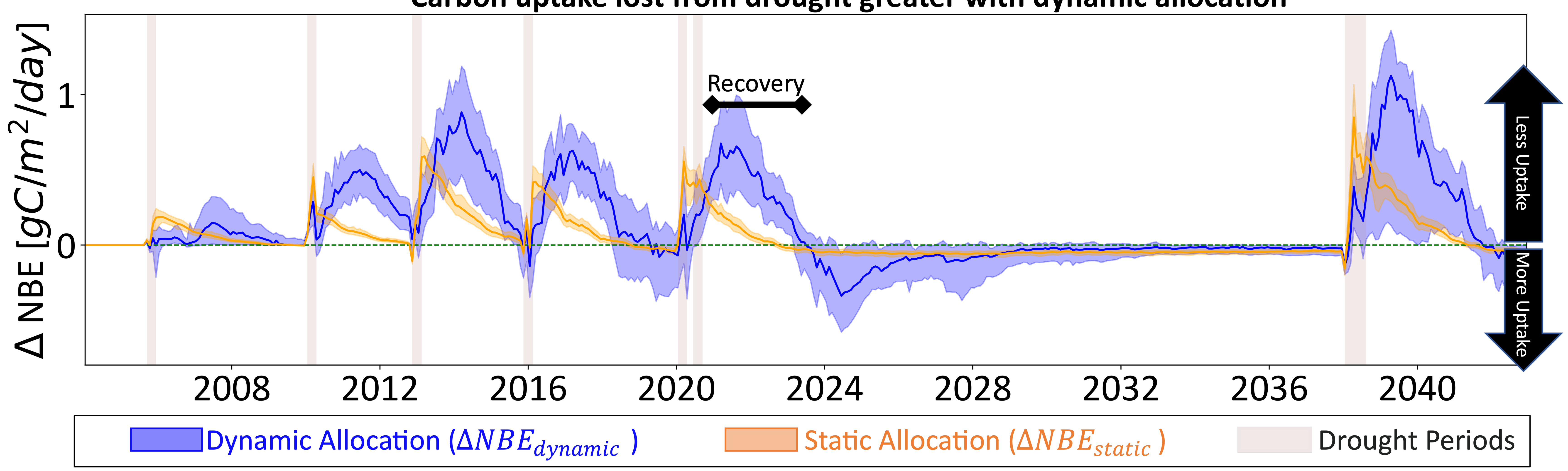
- Infer increasing root allocation and decreasing foliar & wood allocation during drought
- Wood allocation decrease consistent with in situ dendrometer measurements of wood growth (Wagner et al., 2011)

4 Four model simulations to calculate how allocation shifts impact NBE post-drought



- To incorporate more drought behavior, we scaled ERA-5 Land meteorology data from 1981-2004 and appended it to the end of the flux tower meteorology record (2004-2020)
- For "drought removed" scenarios we replaced DALEC driver drought meteorology, where standard precipitation and evaporative index (SPEI) < -1 for at least three months, with their monthly average

Carbon uptake lost from drought greater with dynamic allocation



- Across six droughts dynamic allocation, on average, ≈tripled post-drought C uptake lost during recovery 13.7 $gC/m^2/d$ [5.35 (25^{th} %) – 18.85 (75^{th} %)] compared to static allocation 4.9 $gC/m^2/d$ [3.7 (25^{th} %) – 6.1 (75^{th} %)]. Furthermore, dynamic allocation delayed the peak of drought impacts past the drought period.
- Dynamic allocation contributed 65% [46% - 75%] (25^{th}-75^{th} percentile) to NBE drought legacies: Relative allocation shift effect = $\frac{\sum|\Delta NBE_{dynamic}| - \sum|\Delta NBE_{static}|}{\sum|\Delta NBE_{dynamic}|}$
- Previously it was unknown how much this plant water feedback impacted drought NBE legacy effects

5 Takeaways

- **Can infer allocation shifts at a wet tropical site using model-data fusion**
- **Allocation shifts can reduce net C uptake lost during recovery and extend the peak of drought effects by changing foliar and root allocation**

6 Future Work

- **Infer carbon allocation shifts across the pan-tropics using NASA-based NBE (CMS-Flux), LAI (MODIS), and total water storage (GRACE). We will also use satellite derived solar induced florescence (GOSAT), methane fluxes (GOSAT), and aboveground biomass.**