Quantifying Global Photosynthesis and CO_2 Fertilization with Machine Learning and Eddy Covariance Measurements

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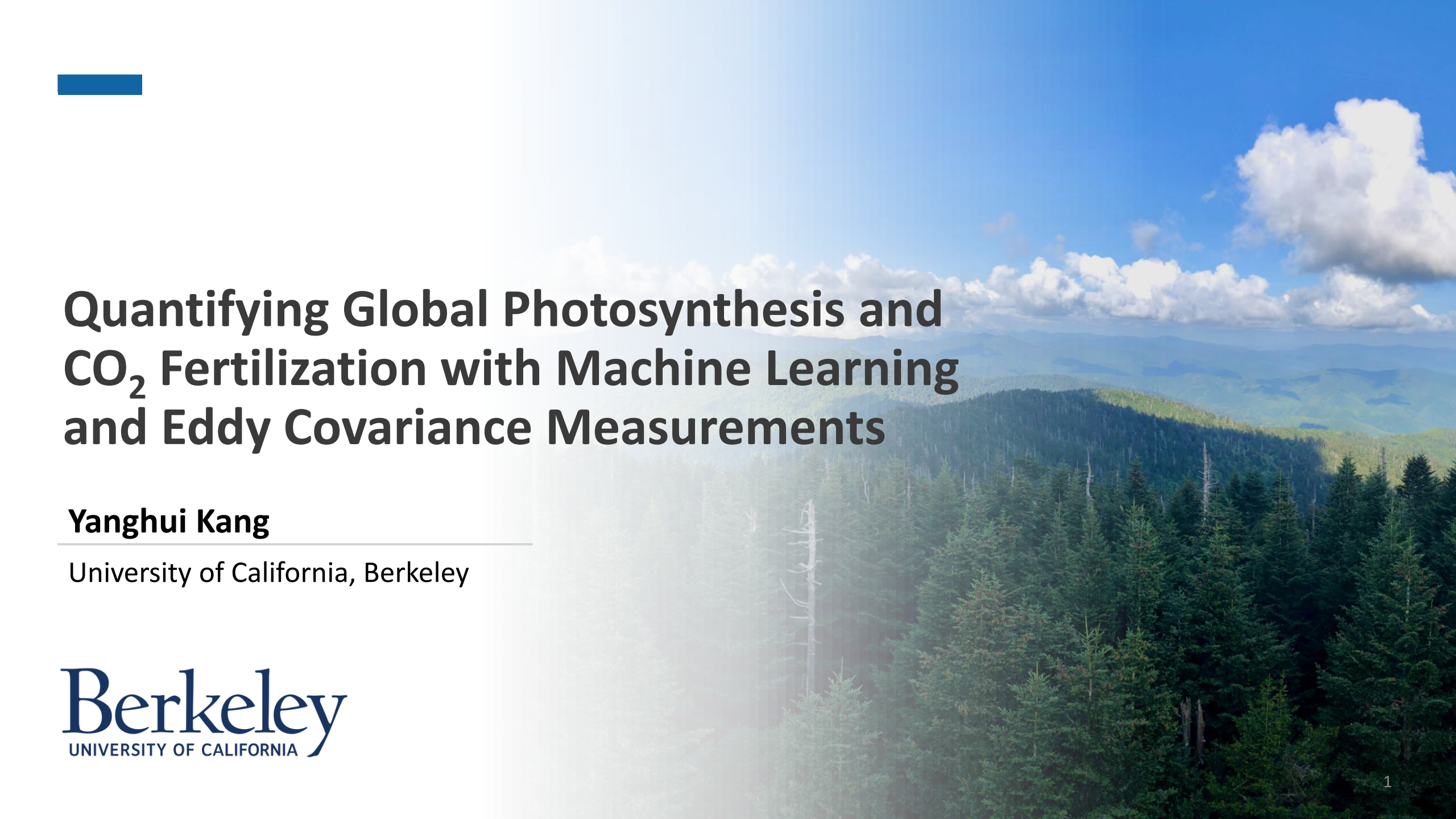
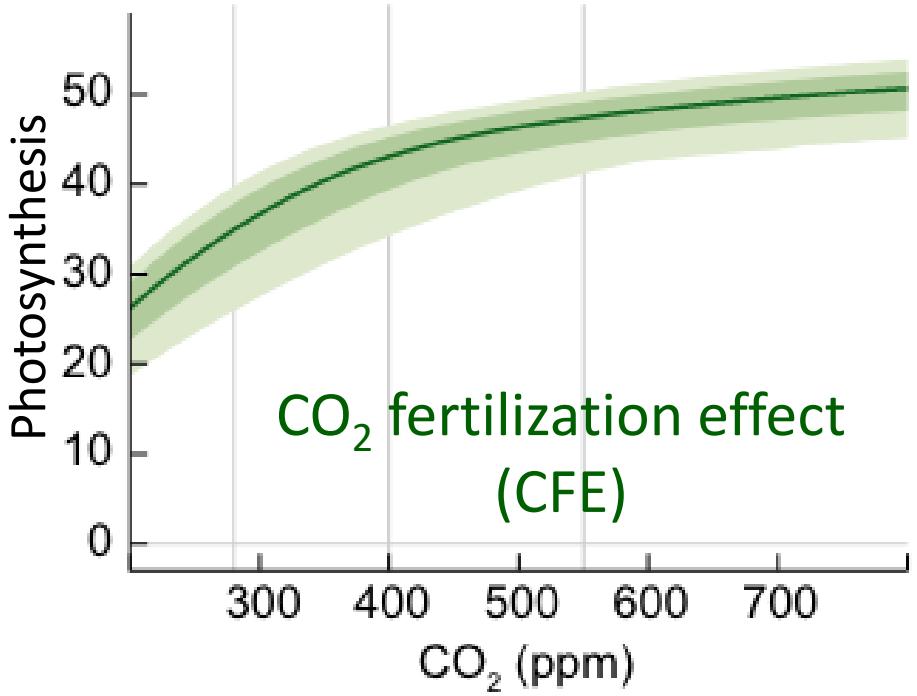
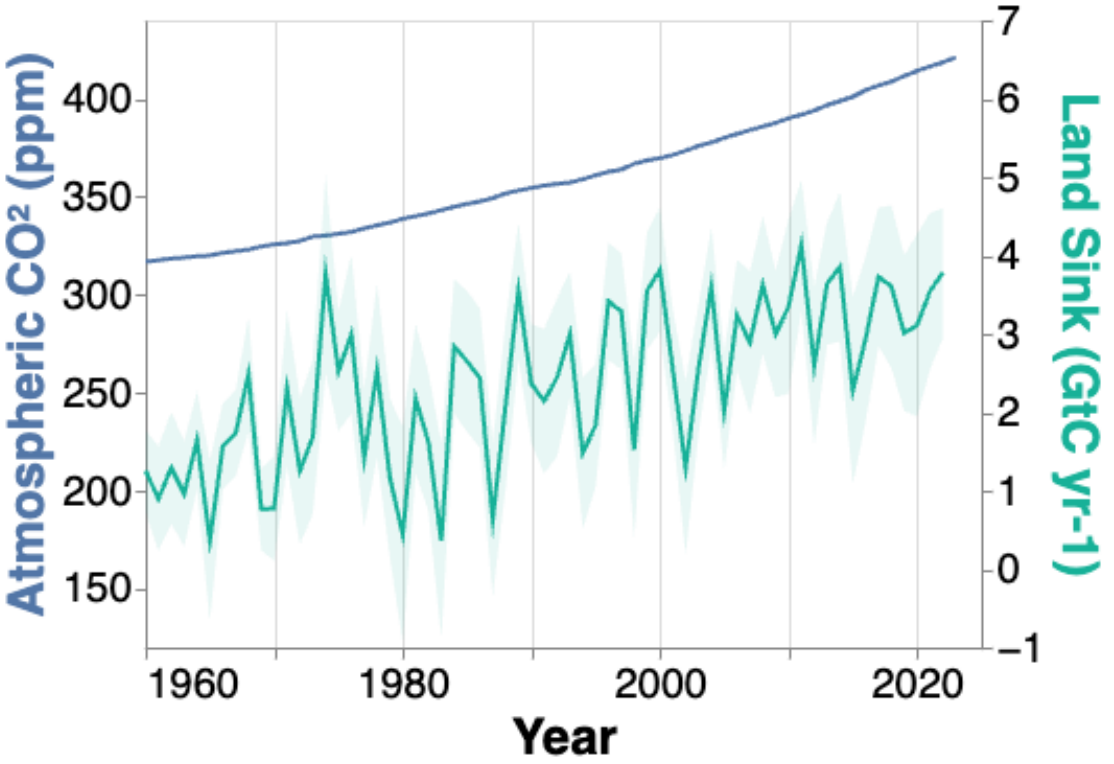


Global Photosynthesis and CO_2 Fertilization

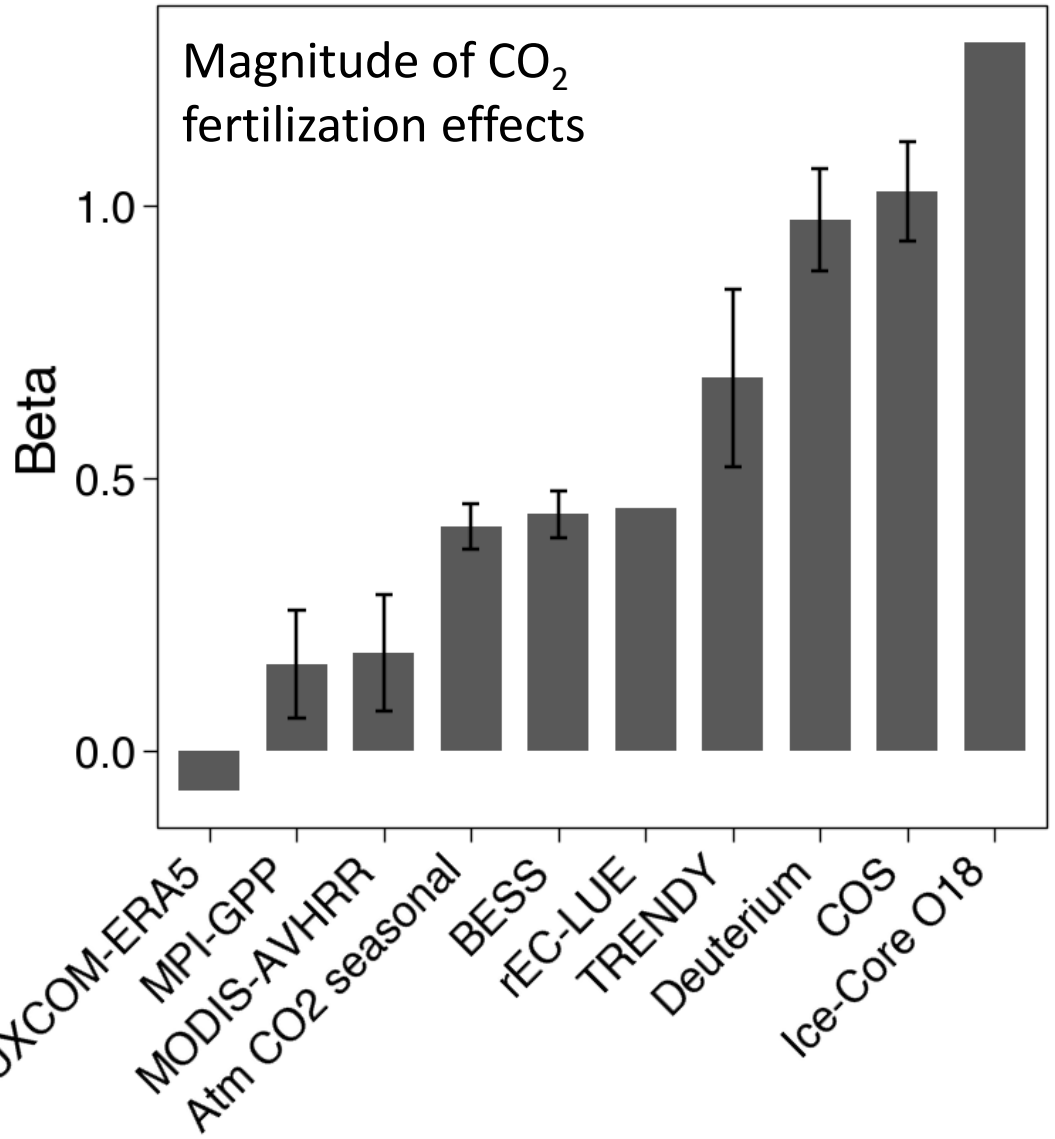


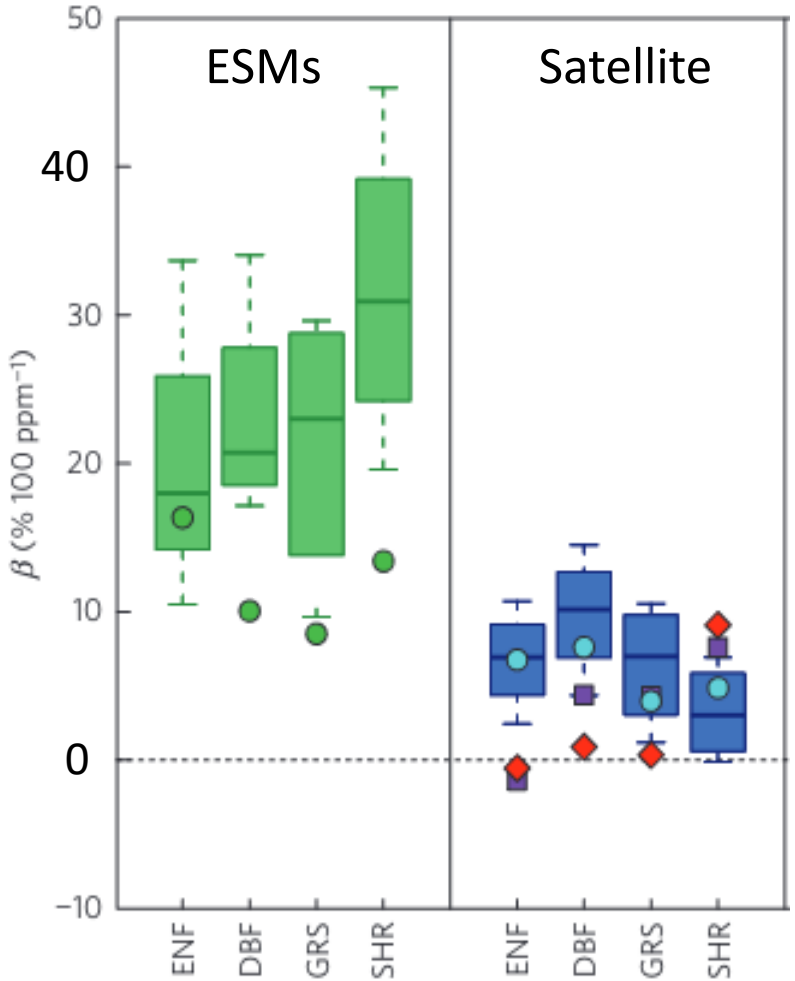


Walker et al., 2020

Friedlingstein et al., 2023

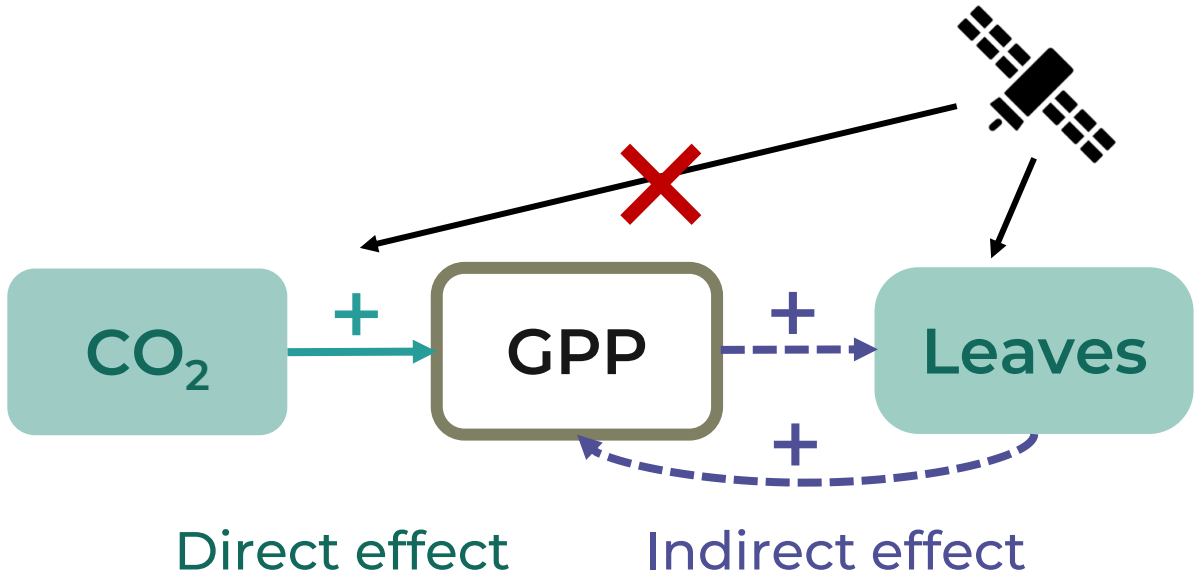
Large uncertainties in CFE and GPP estimates





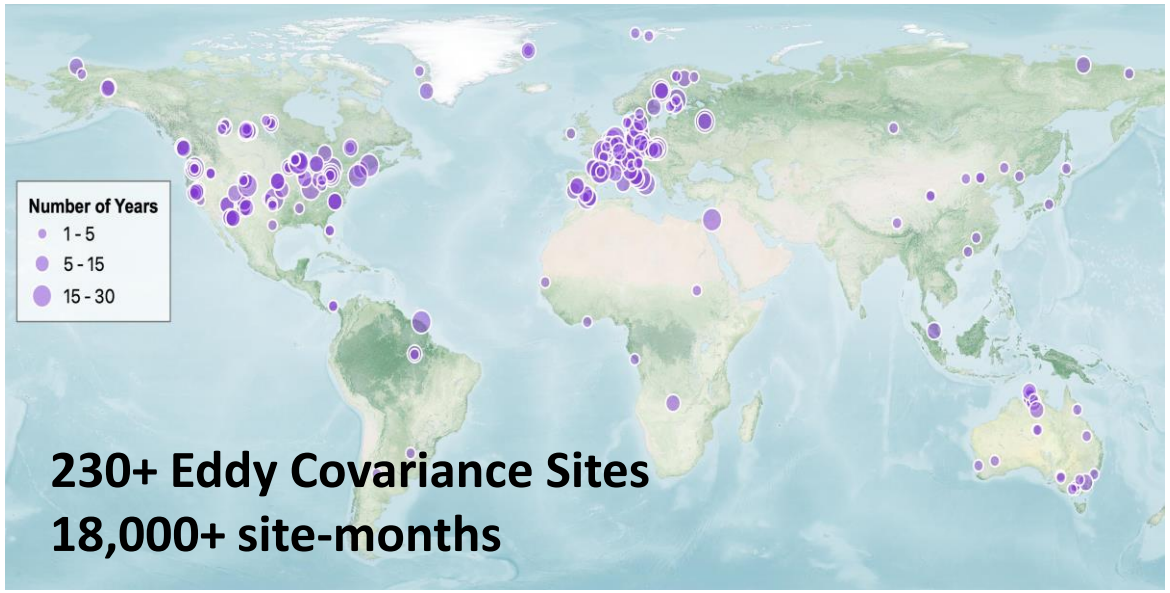
Smith et al., 2016

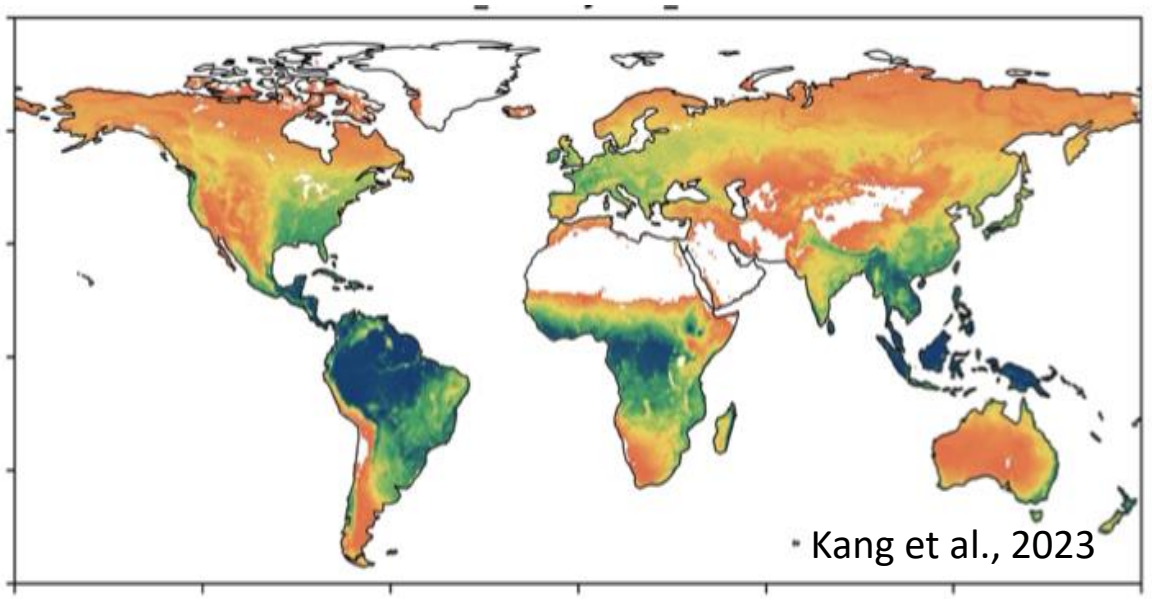
Why do satellites underestimate GPP trends?



Satellite-based estimates, e.g. MODIS, FLUXCOM, overlook the direct CO_2 effects on light use efficiency

CEDAR-GPP: upscaled GPP estimates incorporating CO_2 fertilization





Ground Measurements

Optical, Thermal, Microwave Remote sensing

Climate

Atm. CO_2

→ Machine Learning Upscaling →

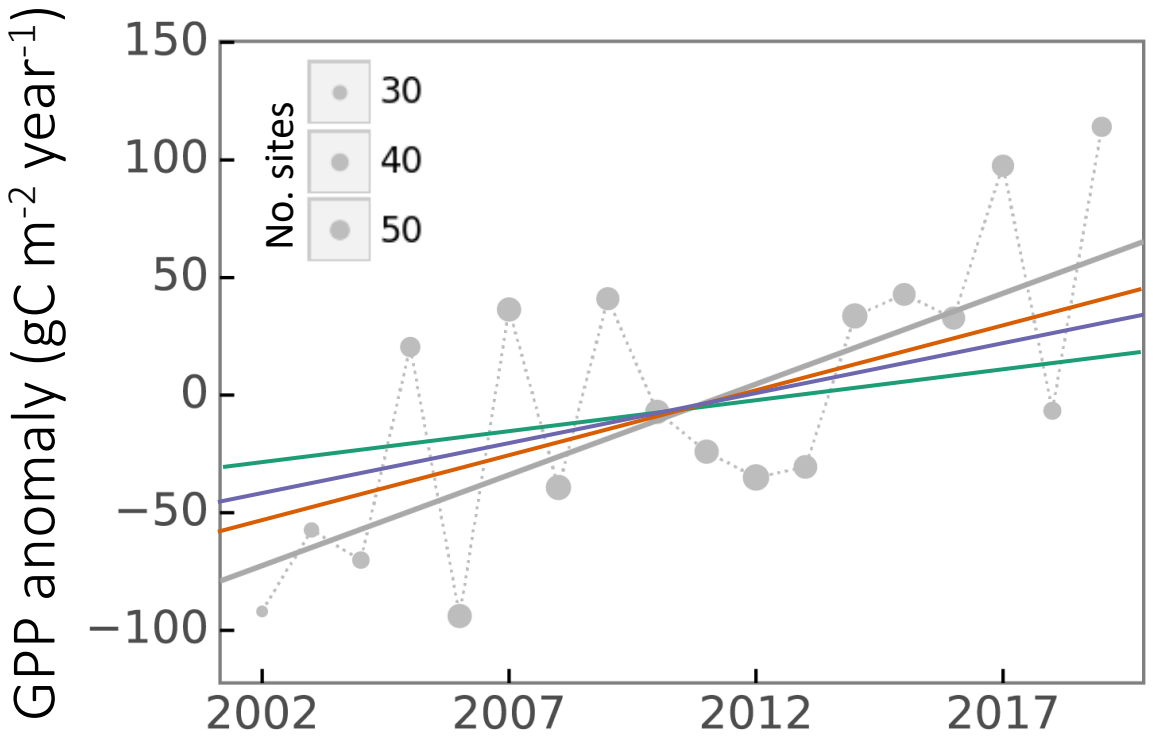
Global Monthly GPP
0.05 ° 1982 - 2020

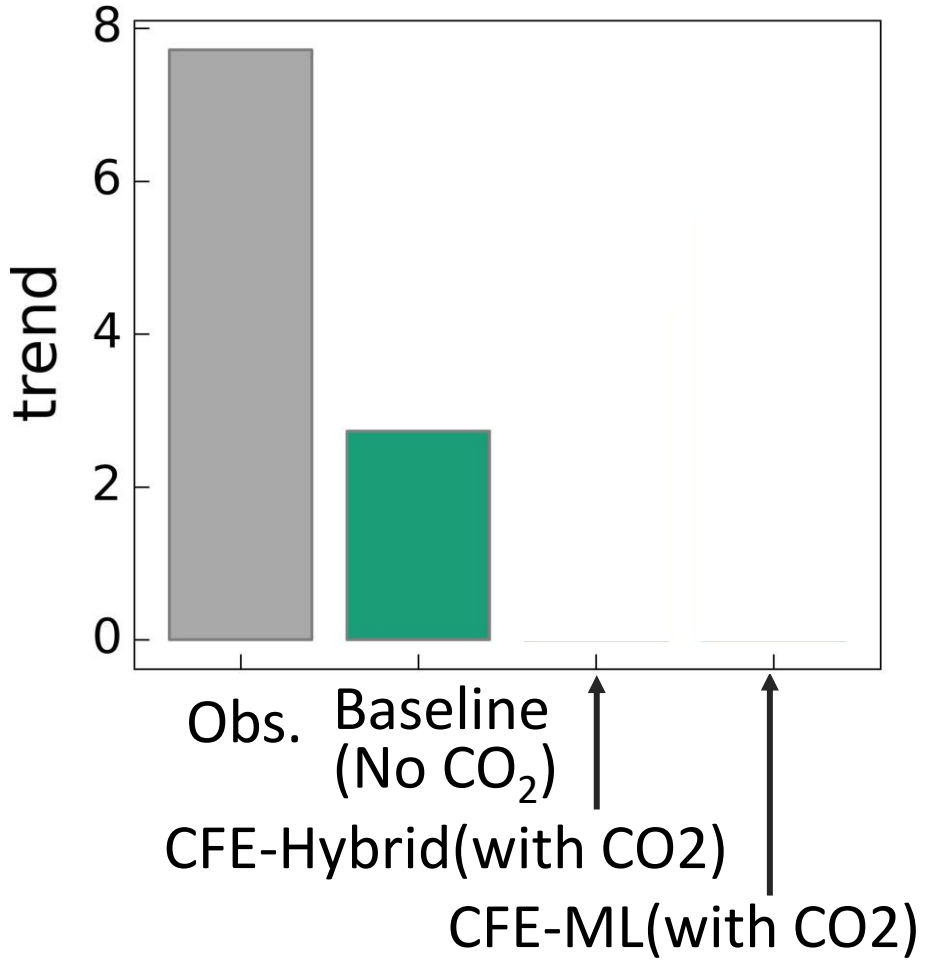
Model inputs and CO_2 fertilization setups

MODEL SETUPS	INPUTS		CO_2 Fertilization	
	Satellite & Climate	CO_2	Direct	Indirect
Baseline	✓	✗	✗	✓
CFE-ML	✓	✓	ML inferred ✓	✓
CFE-Hybrid	✓	✓	Eco-optimality ✓	✓

Kang et al., 2023, ESSD

Considering the direct CO_2 effects improved machine learning prediction of GPP trends at flux tower sites

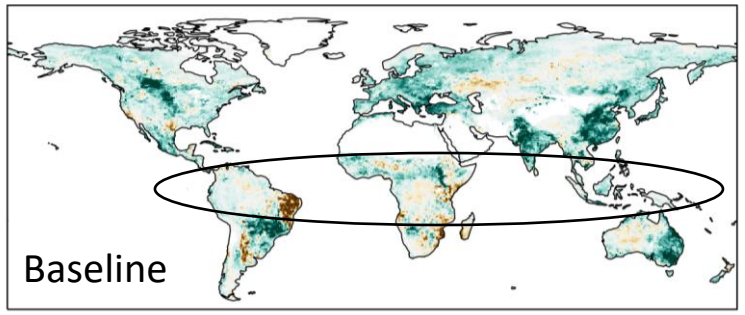


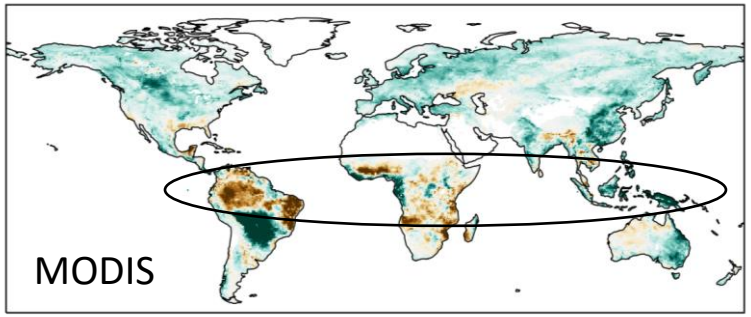


Kang et al., 2023, ESSD

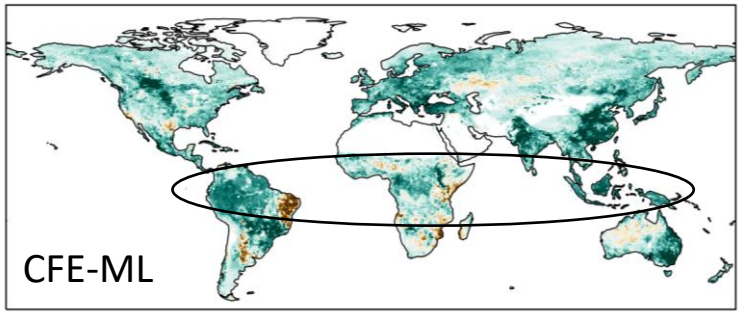
Improved long-term trend in tropics, consistent with TBMs

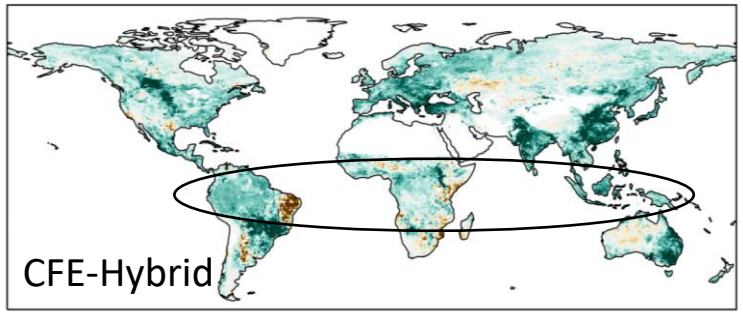
RS: No direct CO_2 effect

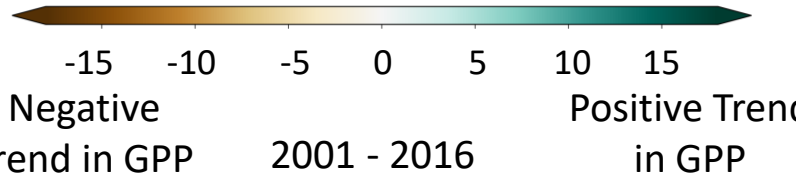




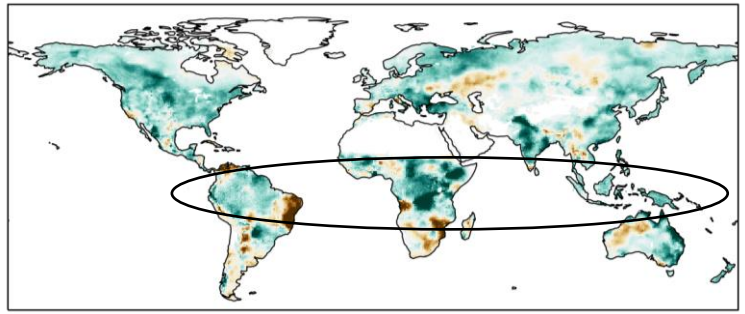
RS: With direct CO_2 effect



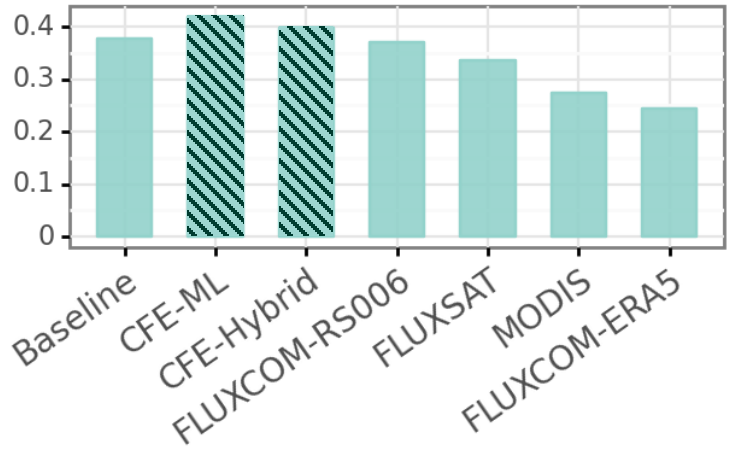




TRENDY Ensemble Mean



Spatial Correlation with TRENDY



Kang et al., 2023, ESSD

Gross Primary Productivity

Kang et al., 2023

Thank you!

- CEDAR-GPP Reconciles discrepancies in GPP trends between satellites and TBMs
- Provide useful benchmarks for TBMs and constraints to the global carbon cycle