

Tuning CLM6: Systematically constraining parametric uncertainty

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> > CLM-PPE community

CLM simulates far more processes than are observed





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Experimental design

Objective 1: Tuning CTSM6 Objective 2: Carbon cycle uncertainty quantification



One-at-a-time ensemble

GPP_global_mean AR_global_mean HR_global_mean NPP_global_mean 175 NBP_global_mean NEP_global_mean ER_global_mean EFLX_LH_TOT_global_mean FCTR_global_mean 150 FCEV_global_mean FGEV_global_mean BTRANMN global mean 125 🛞 FGR_global_mean FSH_global_mean SOILWATER_10CM_global_mean 100 Insitivity (TWS_global_mean QRUNOFF_global_mean SNOWDFF_global_mean H2OSNO_global_mean FSNO_global_mean TLAI_global_mean 75 OAAT FSR_global_mean ALTMAX global mean TV_global_mean TG_global_mean FAREA_BURNED_global_mean - 50 COL FIRE CLOSS global mean TOTVEGC_global_mean TOTECOSYSC_global_mean TOTECOSYSC_global_mean TOTSOMC_1m_global_mean TOTVEGN_global_mean 25 TOTECOSYSN_global_mean crit_onset_gd ACCLII FUN_fracfi accum baseflow ot l upplir

Parameter sensitivity

- Transient (1850-2023)
- CRUJRA forcing

76 Parameters

• Sparse grid

Min, Max



Perturbed parameter ensemble (PPE)

- 56 parameters
- 1500 ensemble members
- Latin hypercube sampling design
- Sparse grid
- Spin-up + 1850-2023
- CRUJRA forcing





Wave 1

- 15 independent PFT parameters
- PFT mean LAI
- Observational target: CLM-SP
- 500 ensemble members





Wave 2

- Tune PFT parameters independently
- Gridded data products
 - \circ GPP, LAI, Biomass, ET



Fractional coverage in a gridcell





Wave 2

- Tune PFT parameters independently
- Gridded data products
 - GPP, LAI, Biomass, ET



	LAI -	0.98	0.96	0.96	0.95	0.95	0.91	0.96	0.96	0.97	0.97	0.96	0.94	0.95
	GPP -	0.96	0.95	0.95	0.95	0.93	0.91	0.95	0.95	0.97	0.96	0.93	0.94	0.96
Tundra	Biomass -	0.97	0.97	0.94	0.95	0.93	0.91	0.96	0.96	0.97	0.95	0.94	0.93	0.95
Boreal shrubland		st -	- el	- el	- ee	- sp	- pi	st -	st -	Ļ	st -	- SS	- pt	ra -
Broadleaf deciduous		ore	anr	anr	tre	and	lar	ore	ore	laro	ore	tree	olar	pu
Boreal forest		info	av	av	ate	ss	rub	e fe	erfo	an	al fe	al t	db	₽
Siberian larch		l ra	als	als	ber	Gra	Sh	rat	nife	eri	lreä	ore	sh	
Conifer forest		ica	pic	pic	l m	0		ədu	õ	Sib	Ba	s b	eal	
Mixed deciduous		do.	Гo	tro	n te			eπ				noi	Bor	
Shrubland		1	·	qn	eer			us t				idu		
Grasslands				0)	rgr			ION				dec		
Broadleaf evergreen					sve			cid				af c		
Subtropical savanna					af e			de				dle		
Tropical savanna					dleë			ed				oai		
Tropical rainforest					oac			Mix				Br		
none					B									

Emulator validation (R2 score)



Ca lib ra tion



Ca lib ra tion



History Matching

- Identifies an ensemble of parameter sets that are in agreement with observations
- Avoids overfitting to limited observations





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Uncertainty quantification

- Identify parameter sets that span some emergent behavior
- Assess sources of uncertainty in the projected strength of the land carbon sink
- Emissions driven runs?





How is this going?

Things that are going well:

- Tuning PFT parameter independently
- History matching methodology is very flexible
 - Iteratively introduce constraints

Things that need to be improved:

- Better constraints (water cycle)
- Emulation is too task specific
- Translating offline tuning to coupled model
- Identifying and addressing structural or functional limitations.



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Xu, Saatchi et al., (2021)





Observationalmean and stdev

Select range of years that have at least 3 observational products. Products must have at least 5 years within range

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200)1		2015

Mean: Sample one product per year. Take the mean. Repeat 10000 times. Stdev: Standard deviation across products for each year. Averaged.

