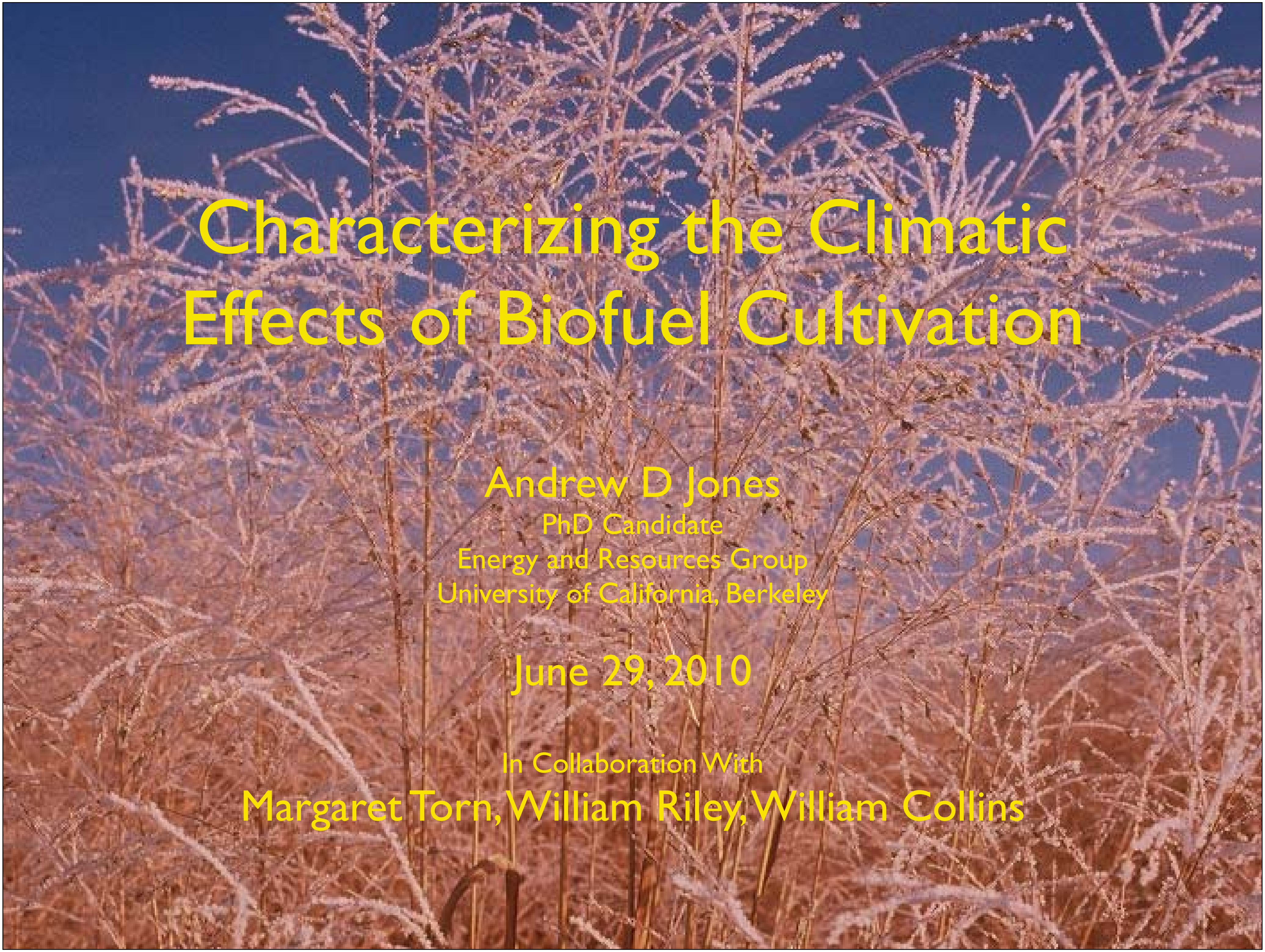


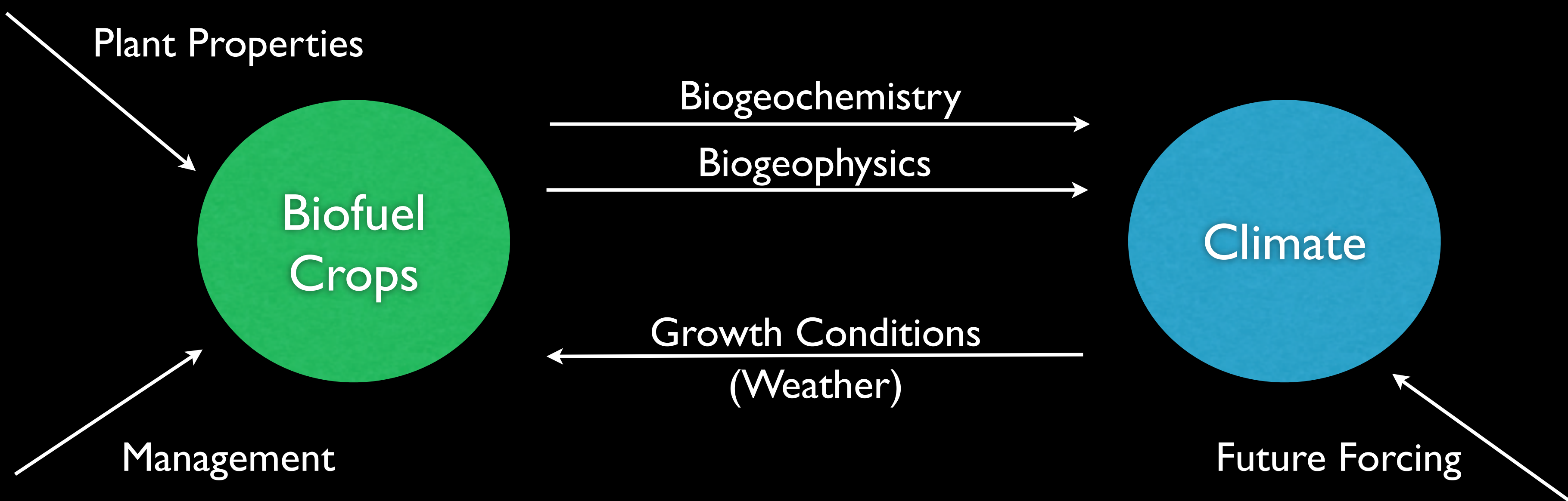
Characterizing the Climatic Effects of Biofuel Cultivation

Andrew D Jones
PhD Candidate
Energy and Resources Group
University of California, Berkeley

June 29, 2010

In Collaboration With
Margaret Torn, William Riley, William Collins

Biofuel - Climate Interactions

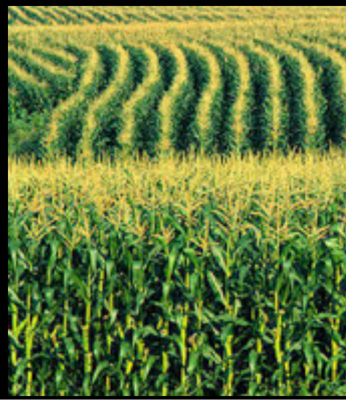


Research Questions

- *Which vegetation properties and management factors most determine climate forcing from biofuel crops?*
- *Given atmospheric feedback, when are biofuel crops likely to represent a climate stabilizing versus a climate destabilizing endeavor?*
    - *Which crop types?*
    - *On what land?*
    - *Under what management?*
    - *At what spatial scales?*
- *Is the supply of biofuel feedstocks robust to changing climatic conditions?*
- *What are appropriate policy approaches to addressing both biogeophysical and biogeochemical climate impacts of biofuel crops?*

Approach

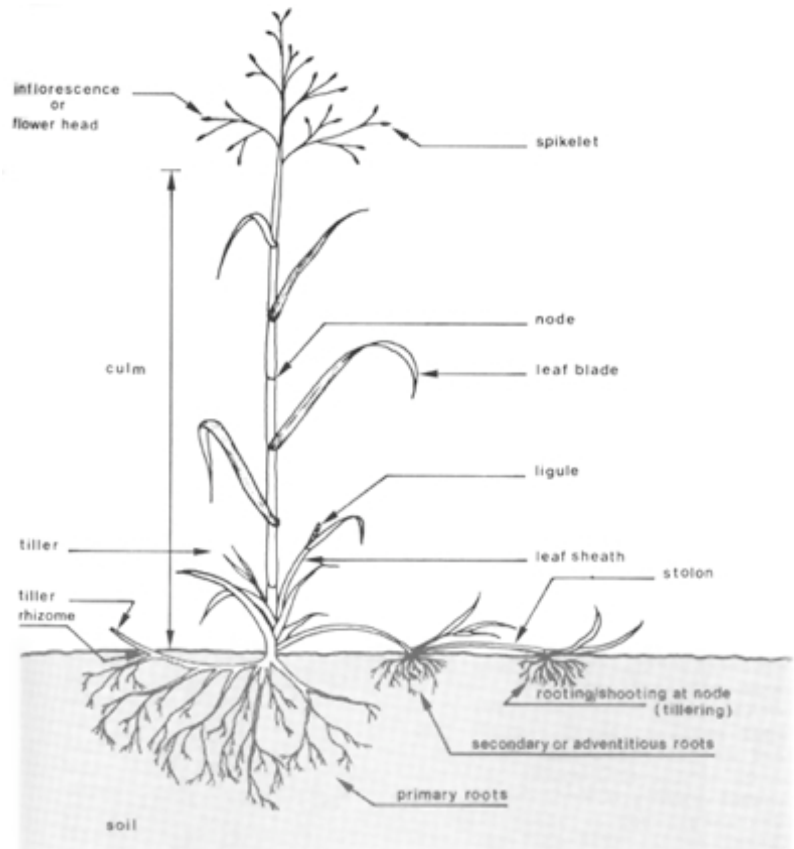
- Develop plant functional types for Community Land Model (CLM)
  - initial focus on c4 grasses
  - new phenology, morphology
  - new management
- Sensitivity Analysis
  - identify important parameters
  - characterize uncertainty in forcing terms
- Constrain parameters
  - literature review
  - tuning to flux measurements
- Coupled Land-Atmosphere Experiments
  - characterize climate outcomes
  - assess yield variability




	Corn	Switchgrass	Miscanthus	Sugarcane
Photosynthetic Efficiency	very high	high	very high	high
Morphology	grain, stover	thinner stems deep roots	canes, rhizomes	canes, sugar
Phenology	narrow peak	longer season	longer season	longer season
Chemical Composition	starch	cellulose lignin	cellulose lignin	sugar
H_20 and N Efficiency	low	high?	high?	low
Management Needs	high inputs, tillage	low inputs? long rotation	low inputs? long rotation	medium inputs short rotation

Morphology

Generic CLM Grass

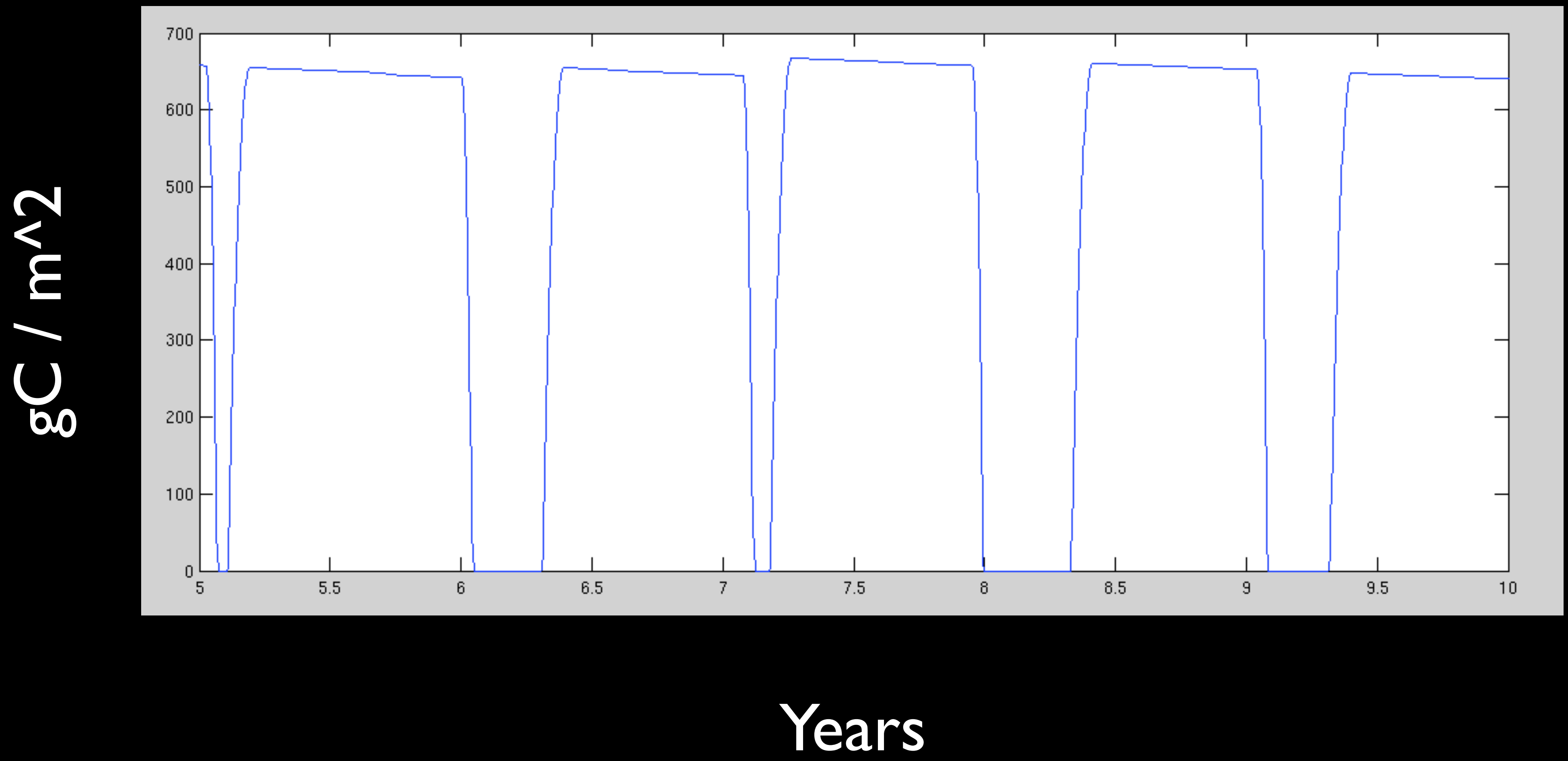


More Realistic Grass

Phenology

- Spring Emergence
- Stem Elongation
- Grain Fill
- Senescence
- Harvest

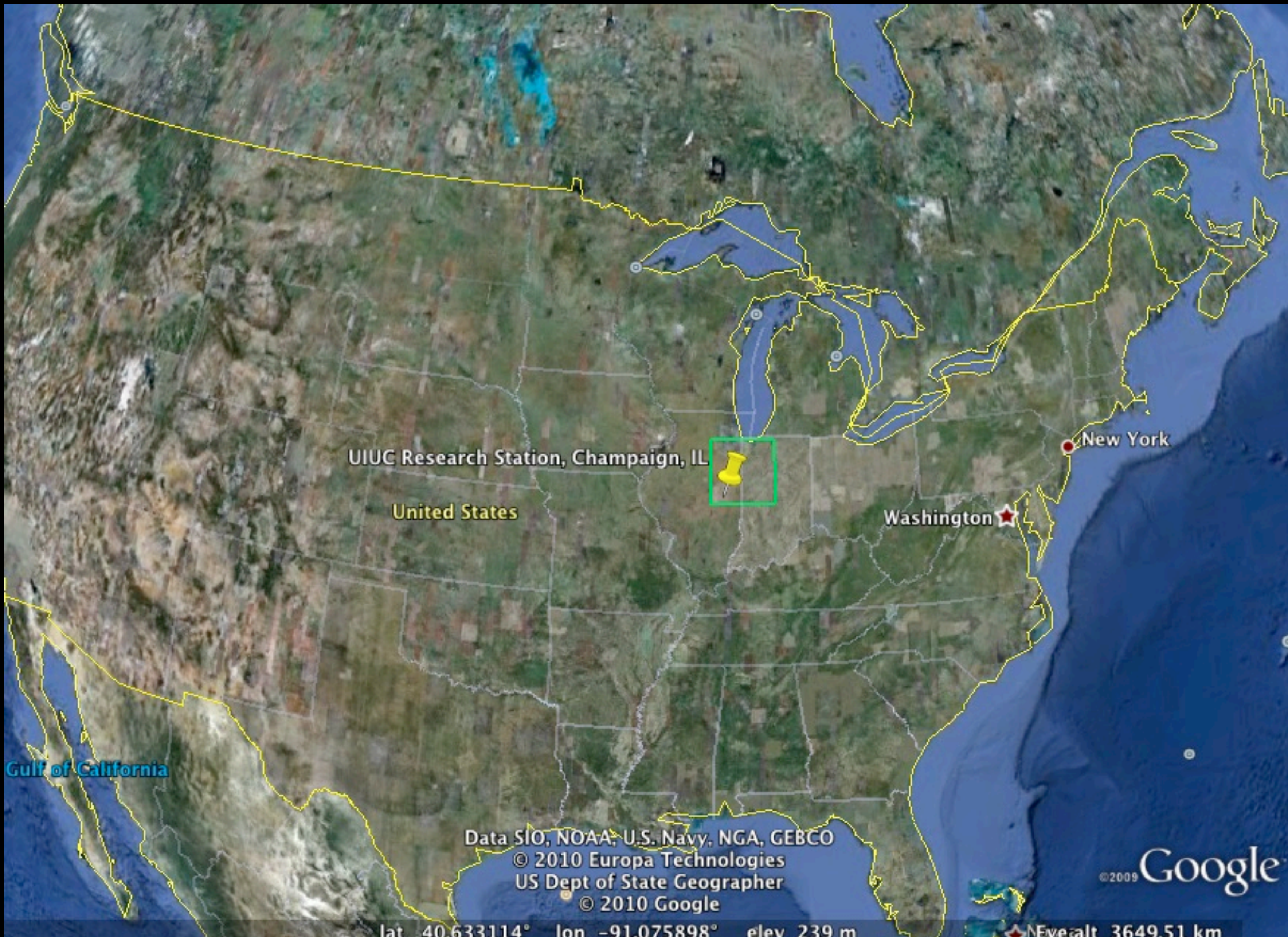
Default CLM C4 Grass Displayed Biomass



Sensitivity Analysis

- Vary 31 of 70+ PFT Parameters
- +/- 50% to range among all grasses, crops
- single point mode for site in Illinois
- 256 30-year runs

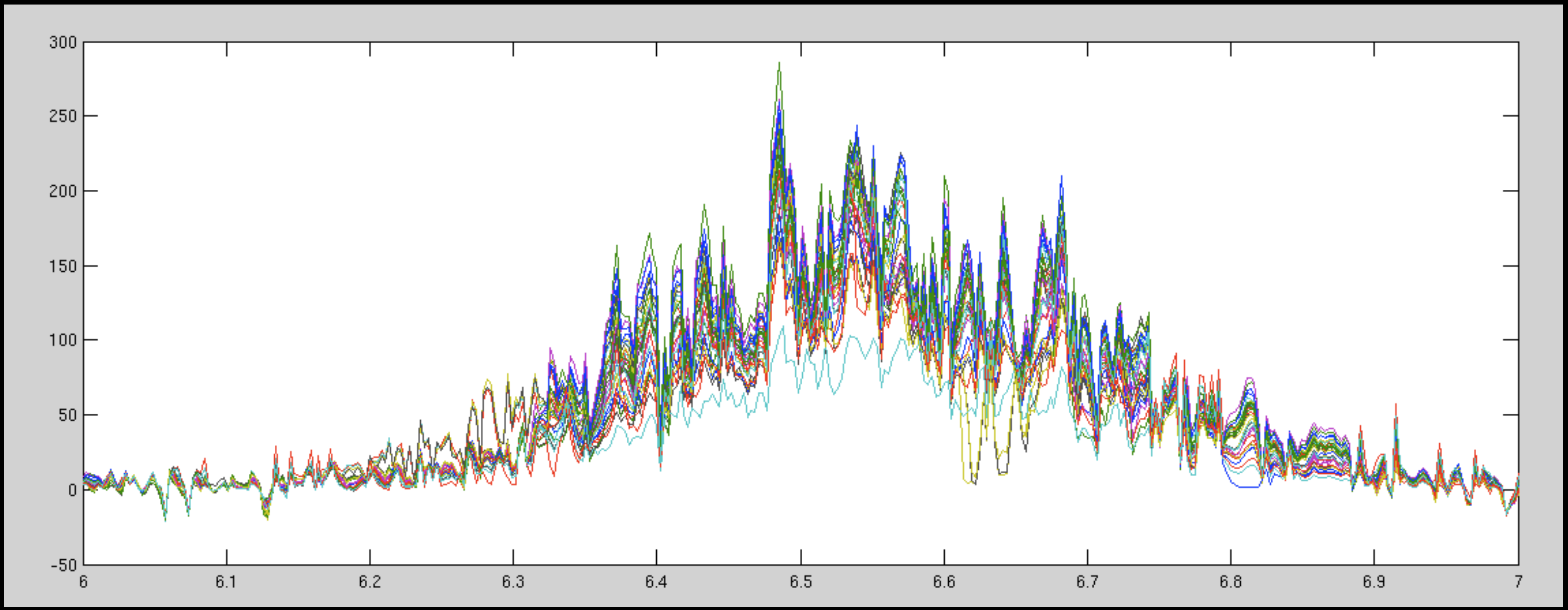
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
1		Type	Parameter Name (in code)	Units	Description	index		c3 arctic grass	c3 non-arctic grass	c3 crop	c4 crop	corn	spring wheat	winter wheat	soybean	c4 grass		min 50	max 50
2	CLM	Aerodynamic	z0mr(i)	-	Momentum roughness length ratio to canopy height	1		0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12		0.06	0.18
3	CLM	Aerodynamic	displar(i)	-	Displacement height ratio to canopy top height	2		0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68		0.34	0.99
4	CLM	Aerodynamic	dleaf(i)	m	Characteristic dimension of leaves in direction of wind flow	3		0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04		0.02	0.06
5	CLM	Photosynthetic	c3psn(i)	1=C3, 0=C4	Photo synthetic pathway	4	~	1	1	1	1	0	1	1	1	0		0	0
6	CLM	Photosynthetic	vcmx25(i)	mmol CO2/m2	Max rate of carboxylation @ 25C	5	X	43	43	50	50	50	50	50	50	24		12	75
7	CLM	Photosynthetic	mp(i)		PFT emprirical parameter = slope of conductance-to-PS relationship	6	X	9	9	9	9	4	9	9	9	5		2	13.5
8	CLM	Photosynthetic	qe25(i)	mmol CO2/mn	Quantum efficiency at 25C	7	~	0.06	0.06	0.06	0.06	0.04	0.06	0.06	0.06	0.04		0.02	0.09
9	CLM	Optical	rhol(I,1)	-	leaf VIS reflectance	8		0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11		0.055	0.165
10	CLM	Optical	rhol(I,2)	-	leaf NIR reflectance	9		0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35		0.175	0.5024
11	CLM	Optical	rhos(I,1)	-	stem VIS reflectance	10		0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31		0.155	0.465
12	CLM	Optical	rhos(I,2)	-	stem NIR reflectance	11		0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53		0.265	0.6737
13	CLM	Optical	taul(I,1)	-	leaf VIS transmittance	12		0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05		0.025	0.075
14	CLM	Optical	taul(I,2)	-	leaf NIR transmittance	13		0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34		0.17	0.488
15	CLM	Optical	taus(I,1)	-	stem VIS transmittance	14		0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12		0.06	0.18
16	CLM	Optical	taus(I,2)	-	stem NIR transmittance	15		0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25		0.125	0.3178
17	CLM	Orientation	xl(i)	+1 = horizonta	leaf/stem orientation index	16	X	-0.3	-0.3	-0.3	-0.3	-0.5	0.65	0.65	-0.5	-0.3		-0.75	0.975
18	CLM	Root Structure	roota_par(i)	1/m	rooting distribution parameter	17	X	11	11	6	6	6	6	6	6	11		3	16.5
19	CLM	Root Structure	rootb_par(i)	1/m	rooting distribution parameter	18	X	2	2	3	3	3	3	3	3	2		1	4.5
20	CLM	Leaf C	slatop(i)	m2 leaf / g car	specific leaf area at top of canopy	19	X	0.03	0.03	0.03	0.03	0.05	0.07	0.07	0.07	0.03		0.015	0.105
21	CLM	Leaf C	dsladlai(i)	m^2/gC	dSLA/dLAI	20		0	0	0	0	0	0	0	0	0		0	0
22	CLM	Leaf CN	leafcn(i)	g C / g N	leaf C:N ratio	21	X	25	25	25	25	25	25	25	25	25		12.5	37.5
23	CLM	Leaf N	flnr(i)	-	fraction of leaf N in Rubisco	22	X	0.09	0.09	0.1	0.1	0.1	0.2	0.2	0.1	0.09		0.045	0.3
24	CLM	Soil Stomata	smpso(i)	mm	soil water potential at full stomatal opening	23	~	-7.4E+04	-7.4E+04	-7.4E+04	-7.4E+04	-7.4E+04	-7.4E+04	-7.4E+04	-7.4E+04	-7.4E+04		-3.7E+04	-1.1E+05
25	CLM	Soil Stomata	smpsc(i)	mm	soil water potential at full stomatal closure	24	~	-2.8E+05	-2.8E+05	-2.8E+05	-2.8E+05	-2.8E+05	-2.8E+05	-2.8E+05	-2.8E+05	-2.8E+05		-1.4E+05	-4.1E+05
26	CLM	Leaf N	fnitr(i)	-	foliage N limitation factor	25	X	0.68	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.64		0.305	0.99
27	CN	PFT Type	woody(i)	1=woody, 0=n	woody lifeform flag	26		0	0	0	0	0	0	0	0	0		0	0
28	CN	Leaf Litter CN	lflitcn(i)	gC / G N	leaf litter C:N	27	X	50	50	50	50	25	25	25	25	50		12.5	75
29	CN	Fine Root CN	frootcn(i)	gC / G N	fine root C:N	28	X	42	42	42	42	42	42	42	42	42		21	63
30	CN	Live Wood CN	livewdcn(i)	gC / G N	live wood (phloem and ray parenchyma) C:N	29		0	0	0	0	50	50	50	50	0		0	0
31	CN	Dead Wood CN	deadwdcn(i)	gC / G N	dead wood (xylem and heartwood) C:N	30		0	0	0	0	500	500	500	500	0		0	0
32	CN	Tissue C Ratio	froot_leaf(i)	g C / g C	new fine root C per new leaf C	31	X	1	2	2	2	2	2	2	2	2		0.5	3
33	CN	Tissue C Ratio	stem_leaf(i)	g C / g C	new stem c per new leaf C	32	X	0	0	0	0	0	0	0	0	0		0	0
34	CN	Tissue C Ratio	croot_stem(i	g C / g C	new coarse root C per new stem C	33	X	0	0	0	0	0	0	0	0	0		0	0
35	CN	Tissue C Ratio	flivewd(i)	-	fraction of new wood that is live (phloem and ray parenchyma)	34		0	0	0	0	1	1	1	1	0		0	0
36	CN	Growth Ratio	fcur(i)	-	fraction of allocation that goes to currently displayed growth, remainder to storage	35	X	0	0	0	0	1	1	1	1	0		0	1
37	CN	Litter Fraction	lf_flab(i)		leaf litter labile fraction	36		0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25		0.125	0.3304
38	CN	Litter Fraction	lf_fcel(i)		leaf litter cellulose fraction	37		0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5		0.25	0.6608


UIUC Research Station, Champaign, IL
United States
New York
Washington
Gulf of California
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
© 2010 Europa Technologies
US Dept of State Geographer
© 2010 Google
©2009 Google
lat 40.633114° lon -91.075898° elev 239 m
Eye alt 3649.51 km

Results

- Sensible Heat Flux
- Latent Heat Flux
- Longwave Radiation
- Change in Soil Carbon
- Biomass Carbon

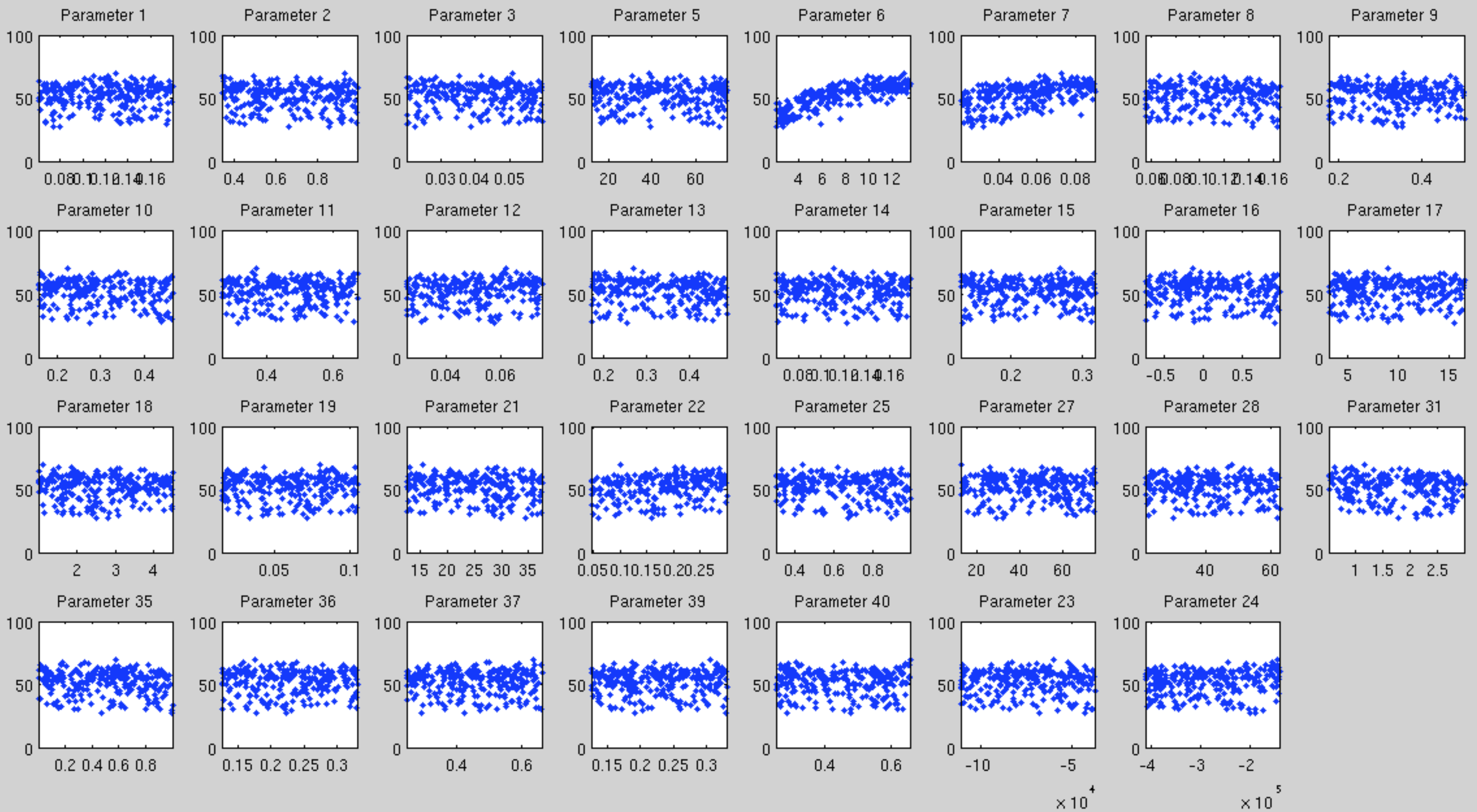
Latent Heat Flux



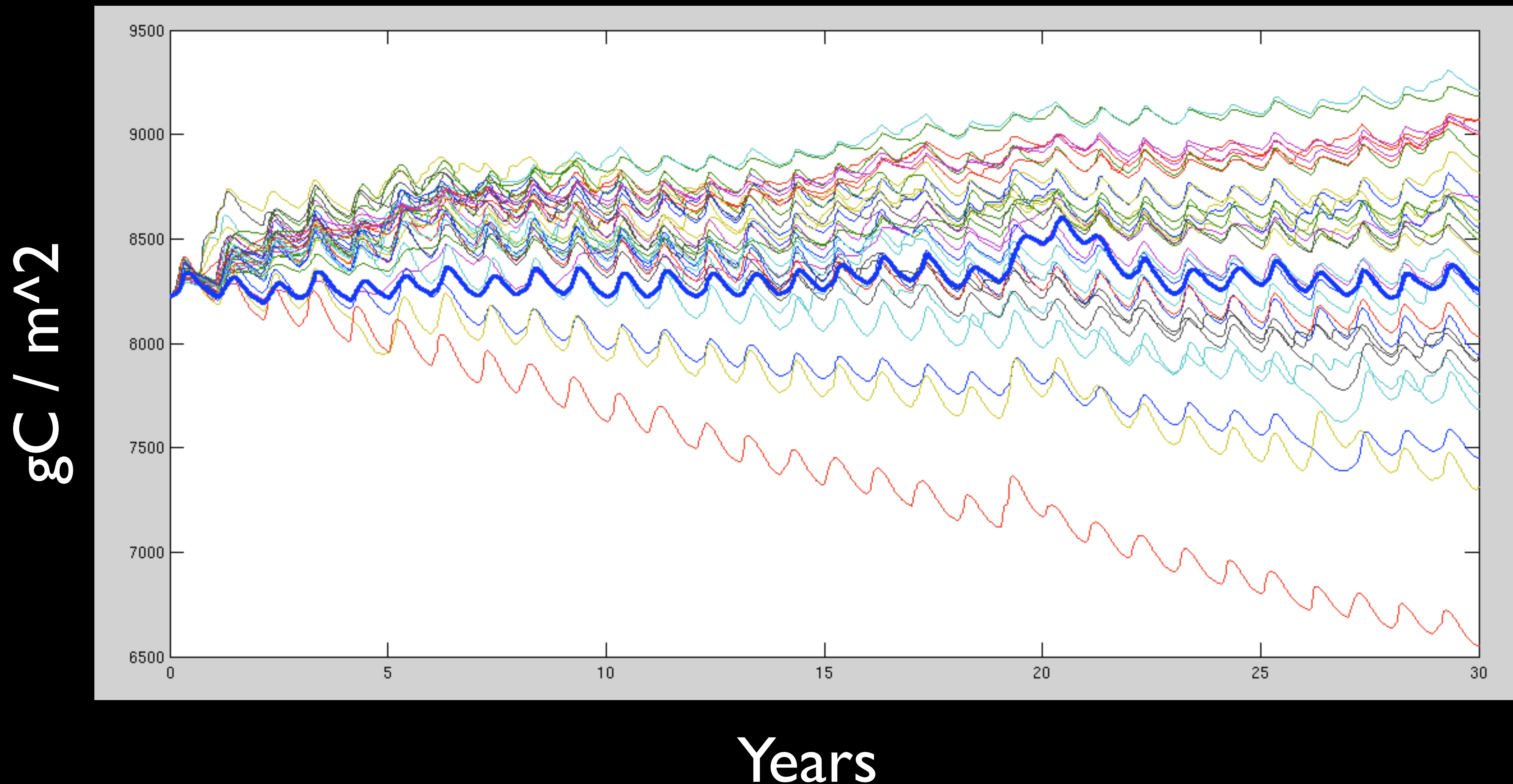
W/m^2

Years

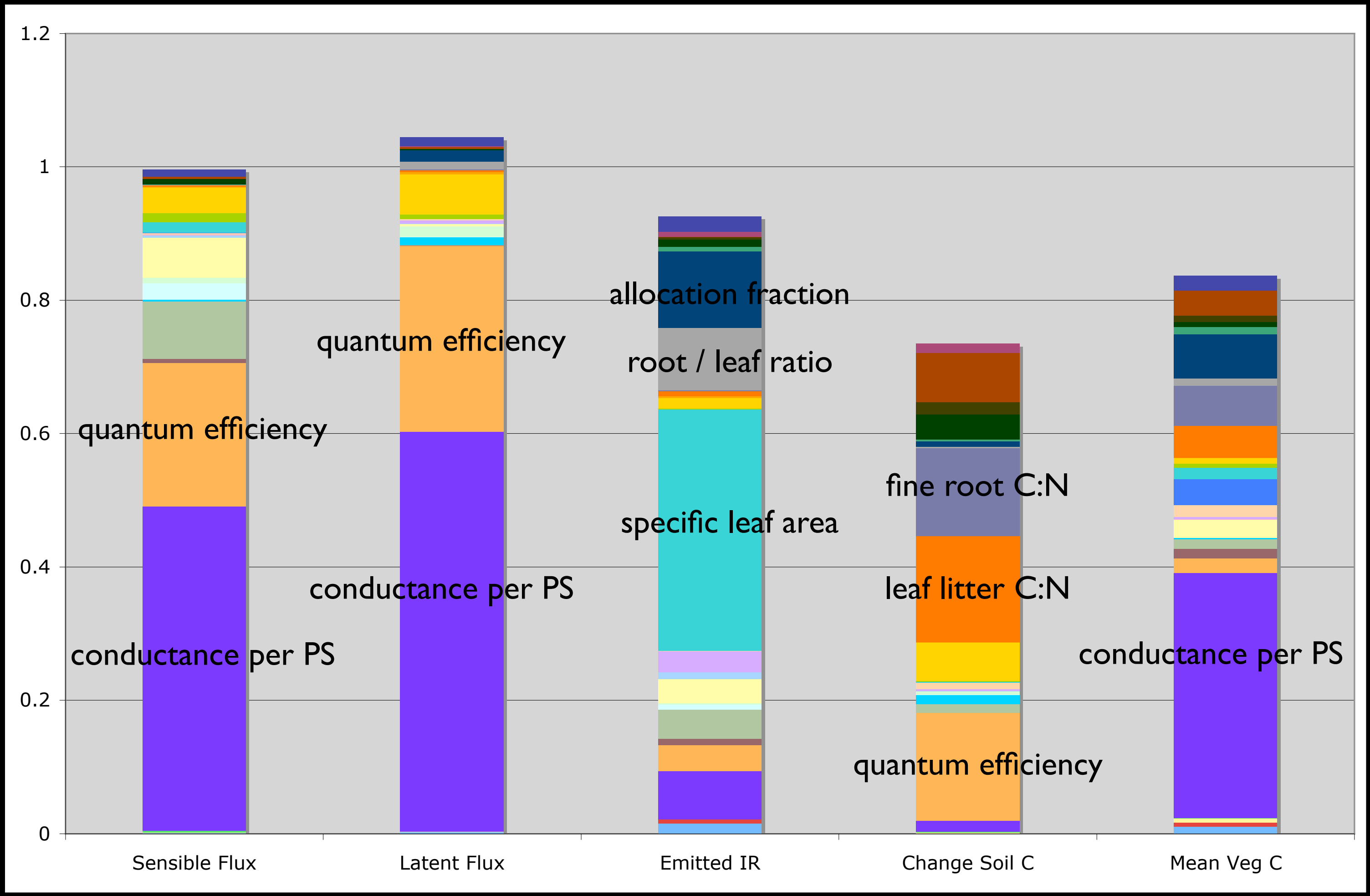
Latent Heat Flux



Change in Soil C



Contribution to Variance



Discussion

- Model structure needs to be improved to capture important dynamics
  - phenology, morphology, fertilization
- Annual average metrics may mask important climate forcings
- Better characterization of uncertainty in inputs may shift priority implied by this sensitivity analysis

Thanks To

- Margaret Torn
- Bill Riley
- Bill Collins
- Sam Levis
- Peter Thornton
- Zack Subin