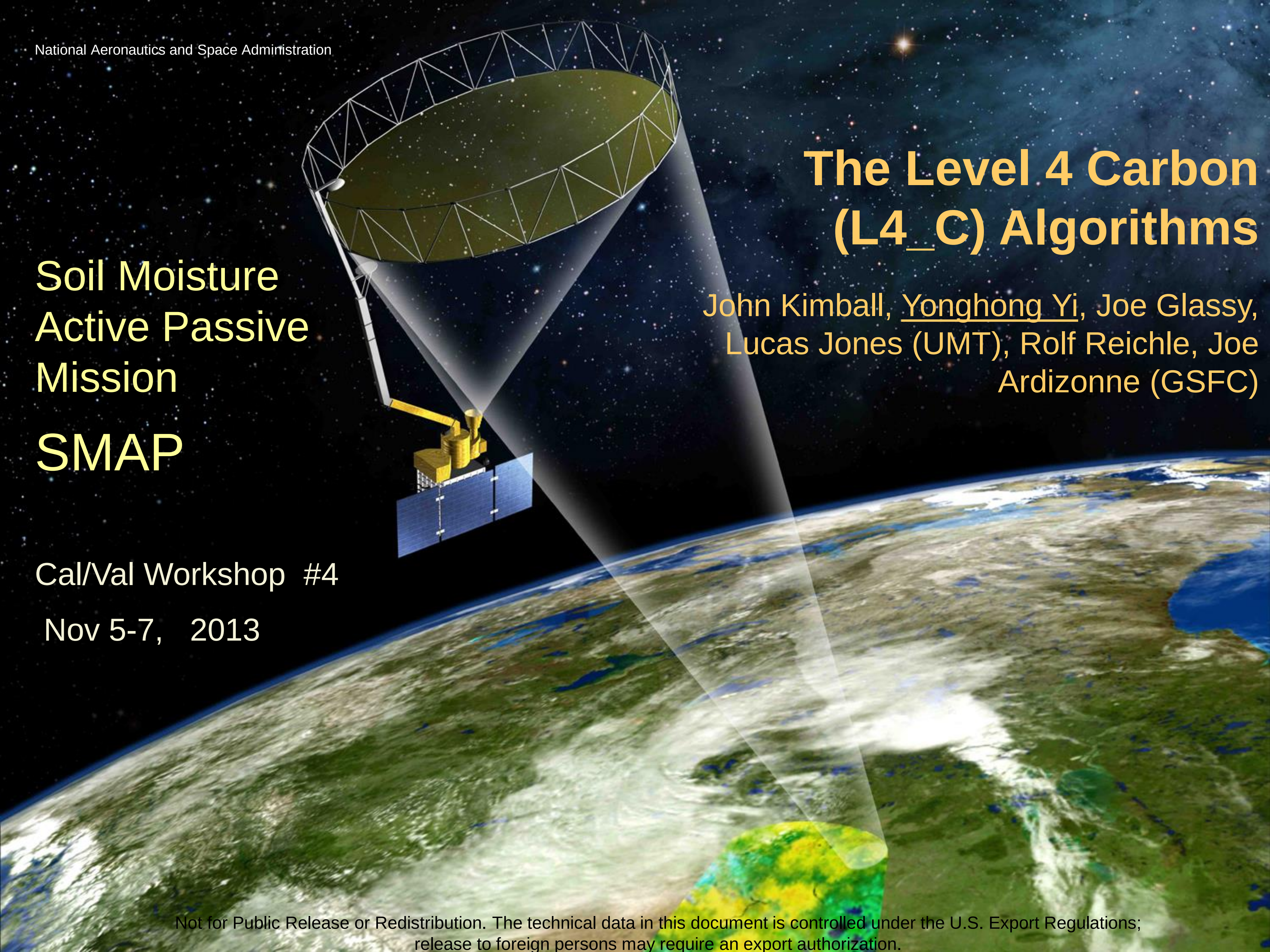


National Aeronautics and Space Administration

The Level 4 Carbon (L4_C) Algorithms

John Kimball, Yonghong Yi, Joe Glassy, Lucas Jones (UMT), Rolf Reichle, Joe Ardizonne (GSFC)

Soil Moisture Active Passive Mission

SMAP

Cal/Val Workshop #4

Nov 5-7, 2013

L4_C Product Requirements & Uncertainty

SMAP science objectives addressed:

- Quantify net ecosystem CO_2 exchange (NEE) in boreal landscapes;
- Improve understanding of processes linking terrestrial water, carbon & energy cycles;

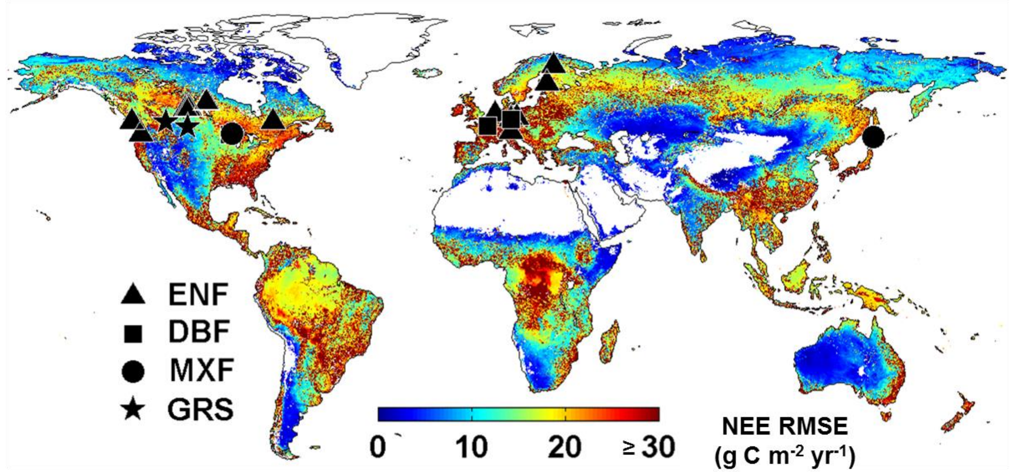
Product requirements:

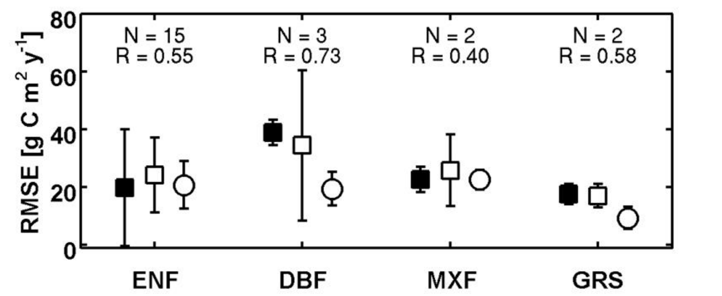
- Determine NEE daily, seasonal & annual variability & heterogeneity;
- Link NEE with component C fluxes (GPP, R_{eco}) & primary moisture & thermal constraints to GPP & R_{eco};

Product success criteria:

- Emphasis on northern (≥45°N) land areas;
- NEE accuracy (RMSE) commensurate with tower based C-fluxes (RMSE ≤30 g C m^{-2} yr^{-1}).

[1]Estimated Error Budget (RMSE) for NEE





[1]Derived from MODIS, FT-ESDR & MERRA inputs

L4_C Product Summary

Net Ecosystem CO_2 Exchange (NEE)

•**Approach**: Apply LUE & soil Decomp. Algs. driven by SMAP & other ancillary inputs;

•**Dynamic Inputs**: FT (L3_SM_A); SM, T_s (L4_SM); R_{sw}, VPD, T_{mn} (GMAO); FPAR (MODIS);

•**Outputs**: NEE (validated); GPP, R_h, SOC, EC & QA metrics (research);

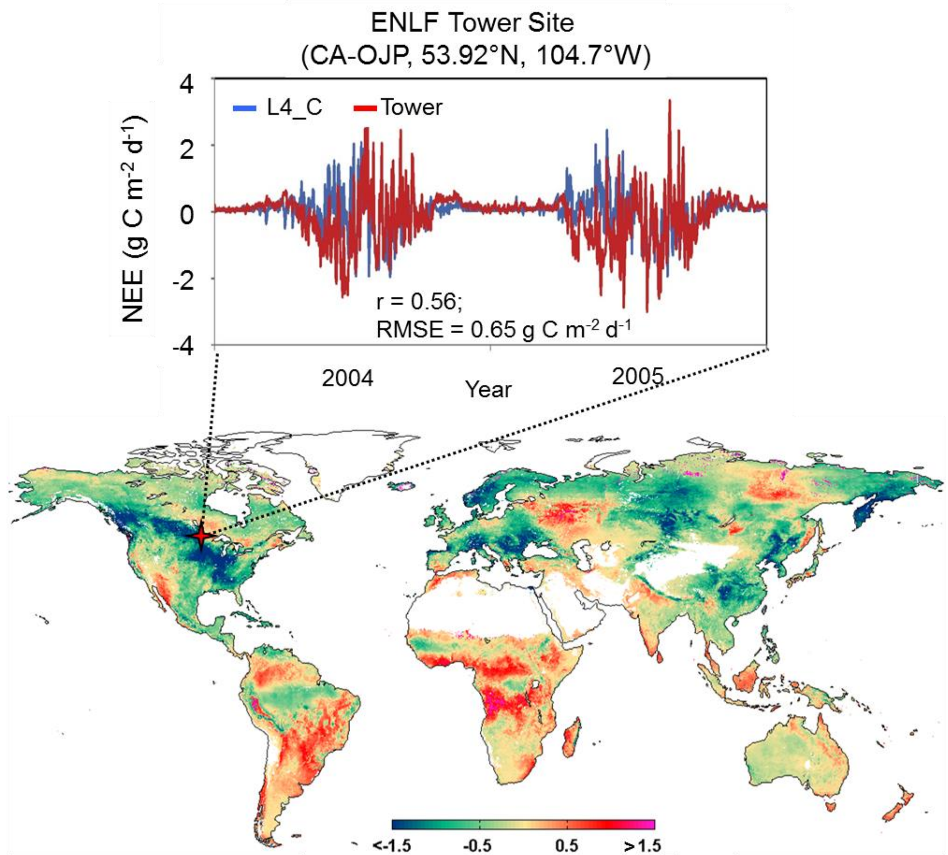
•**Domain**: Global vegetated areas;

•**Resolution**: 9 km (1 km processing);

•**Temporal fidelity**: Daily;

•**Accuracy**: Emphasis on northern land areas; NEE RMSE ≤ 30 g C m^{-2} yr^{-1} relative to tower C-flux Obs.

L4_C Product Example



L4_C NEE (DOY 196, g C m^{-2} d^{-1})

Pre-launch L4_C Cal/Val Activities

Model initialization:

•Site, region & global L4_C simulations using tower (FLUXNET), satellite (MODIS, AMSR) & reanalysis (MERRA) drivers;

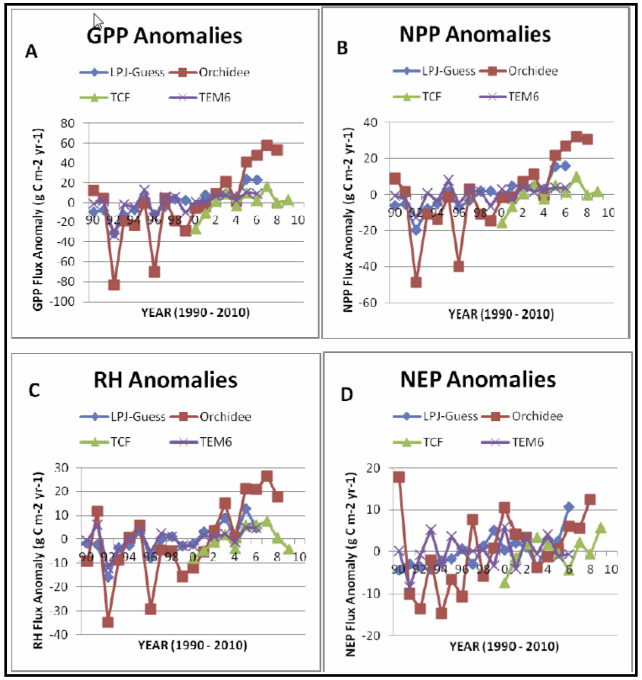
Model calibration and evaluation:

•Model calibration (BPLUT) and options assessment using FLUXNET & global C products (MOD17, MTE, SOC inventories, model intercomparisons);

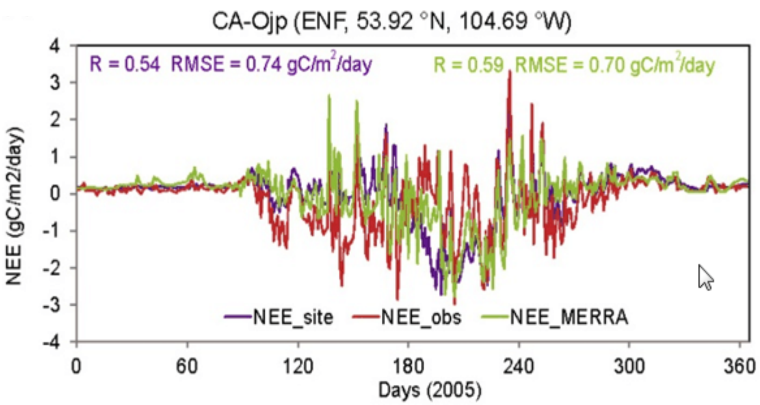
Ancillary data assembly:

•SOC, FPAR climatology, etc.

[1]Model Intercomparison Studies

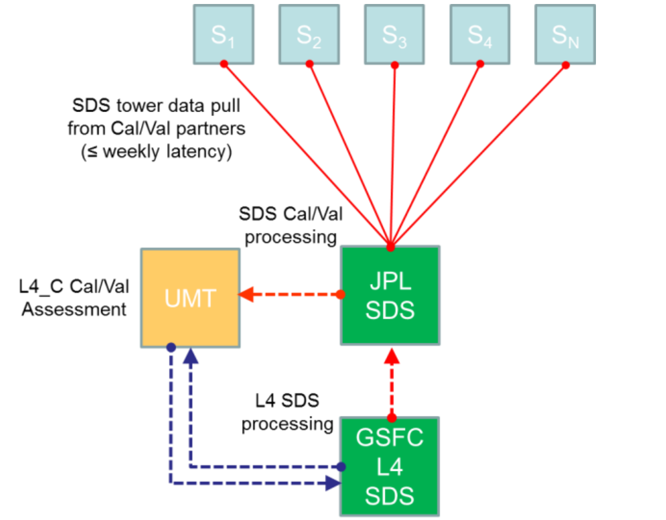


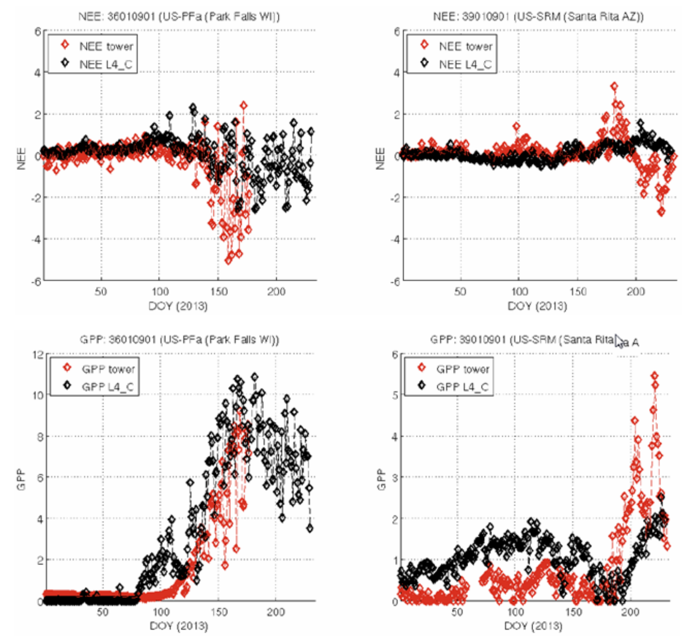
[2]Model Sensitivity & Calibration Studies



[1]McGuire et al. 2012. *Biogeosci Discuss*. 9.
[2]Yi et al., 2013. *JGR - Biogeosci*. 118.

Rehearsal 1 Objectives for L4_C Product





Primary:

- Test delivery & reliability of near real-time tower data from participating core tower site partners;
  - ✓ ~weekly latency; daily fidelity; well characterized uncertainty
- Test JPL matchup tools & data transfer logistics;
- Test UMT software tools & resources for evaluating matchups.

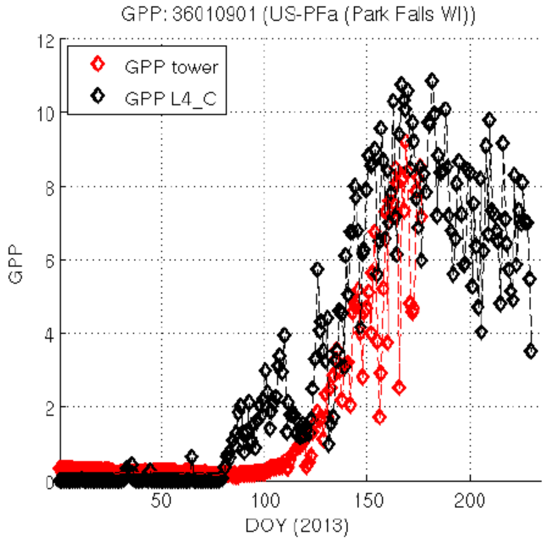
Secondary:

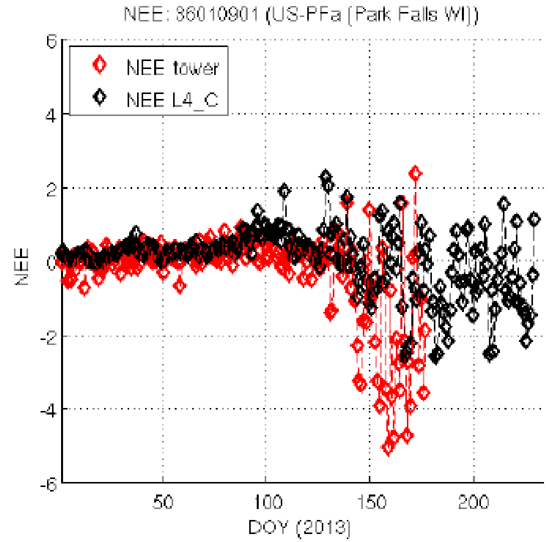
- Test primary L4_C validation activities.

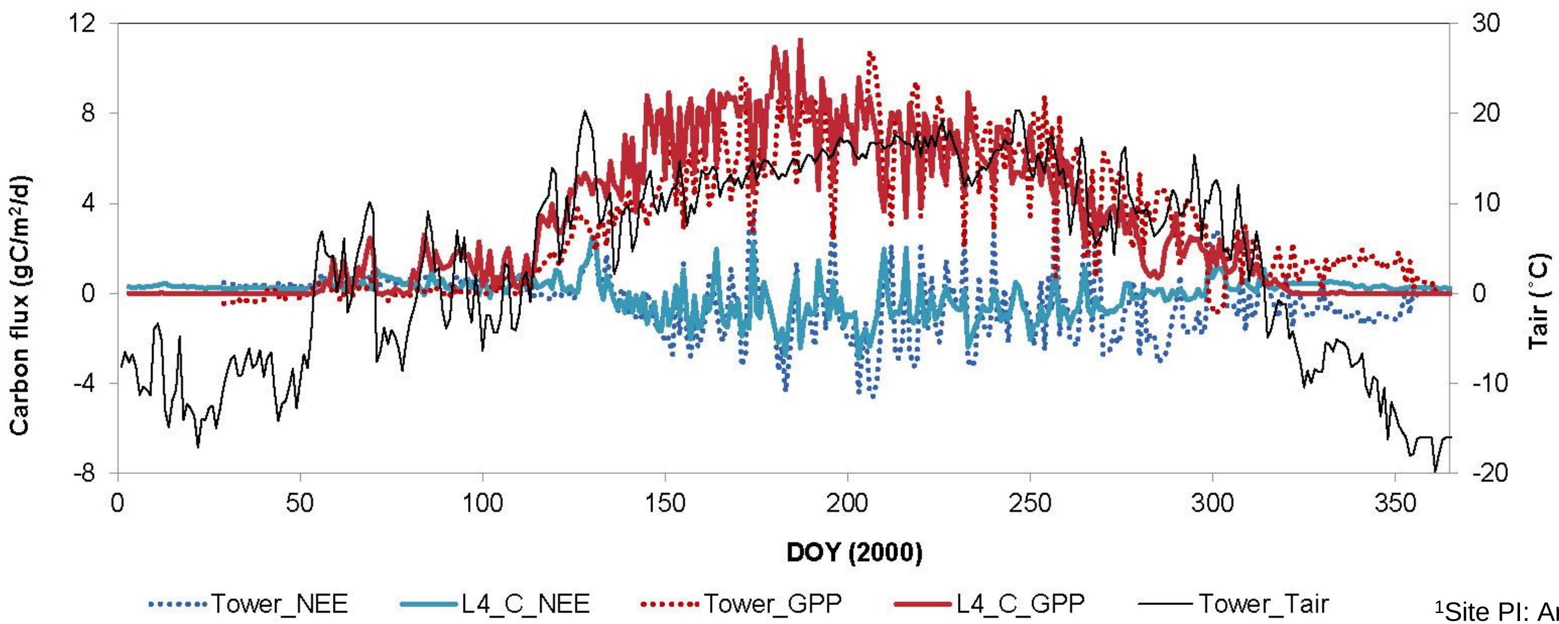
Constraints:

- Match-ups not temporally consistent;
- Limited number of core sites;
- Prototype L4_C software with coarse (0.5˚) model outputs & Met. drivers (MERRA).

Phenology Representation (US-PFa[1], Mixed Forest)

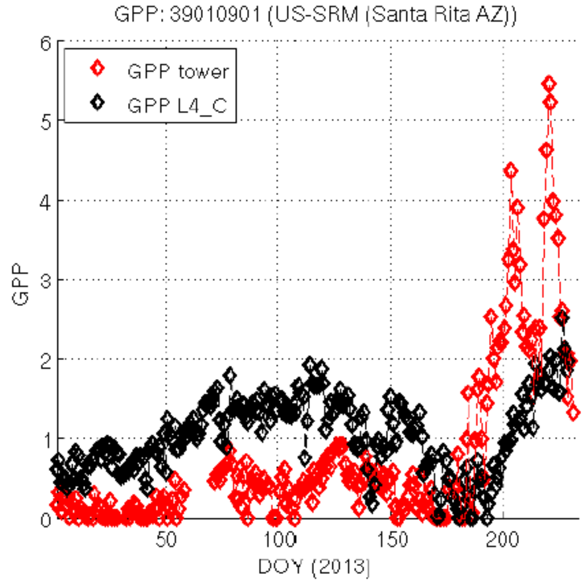


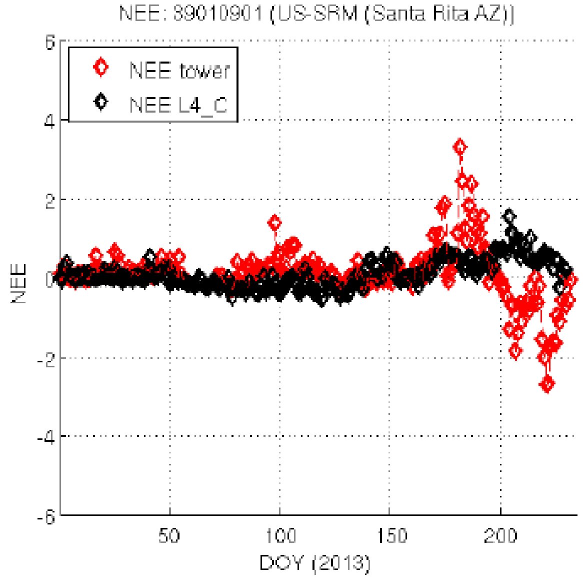


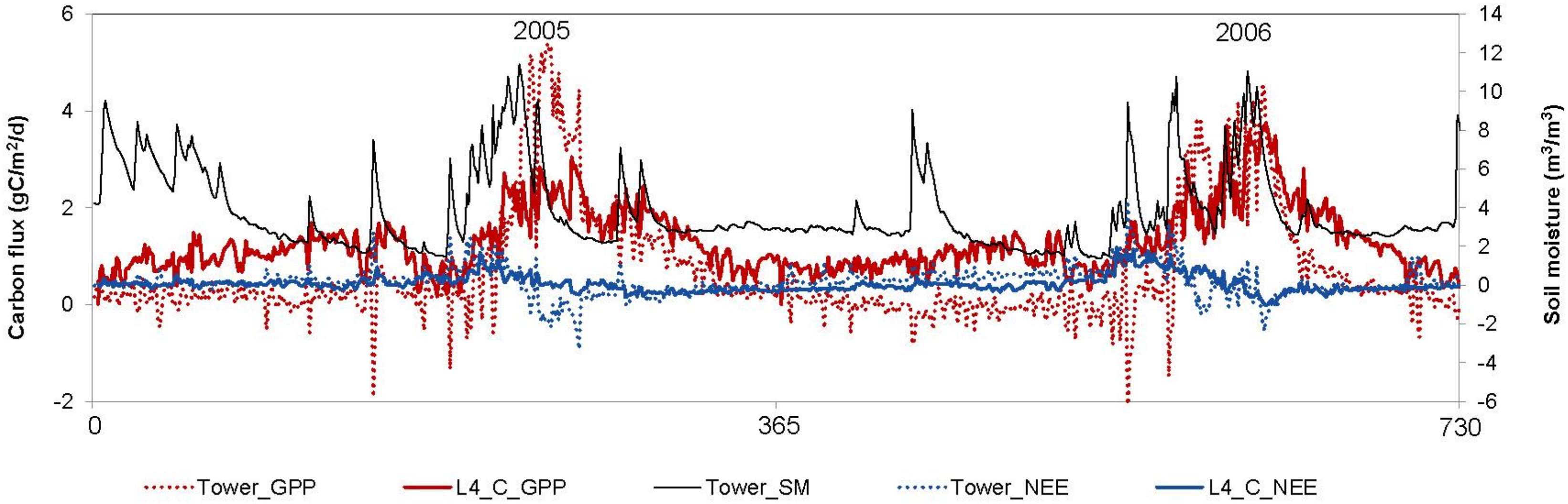


[1]Site PI: Arlyn Andrews

Water Stress Characterization (US-SRM², Woody Savanna)







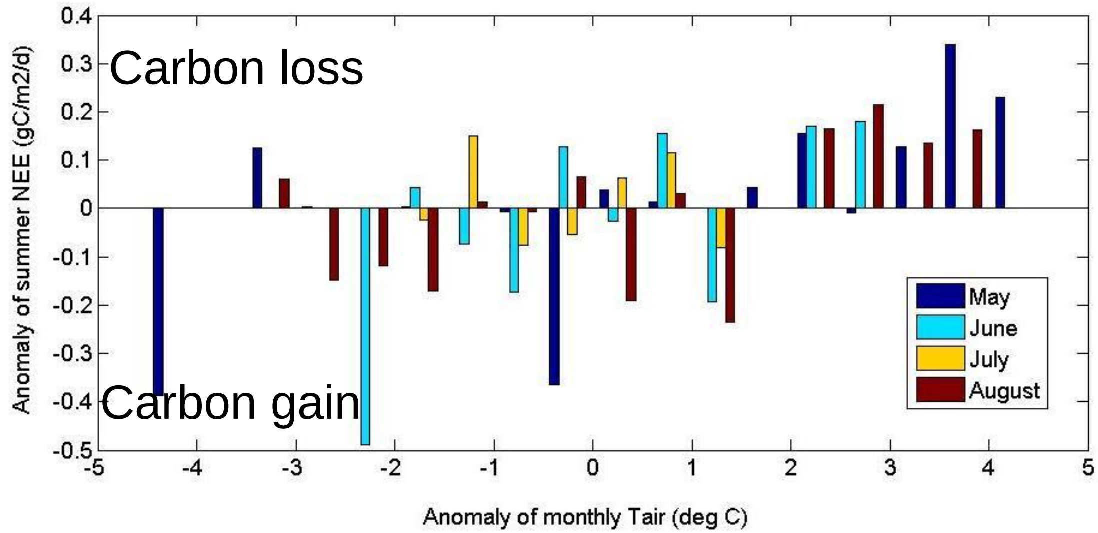
²Site PI: Russell Scott

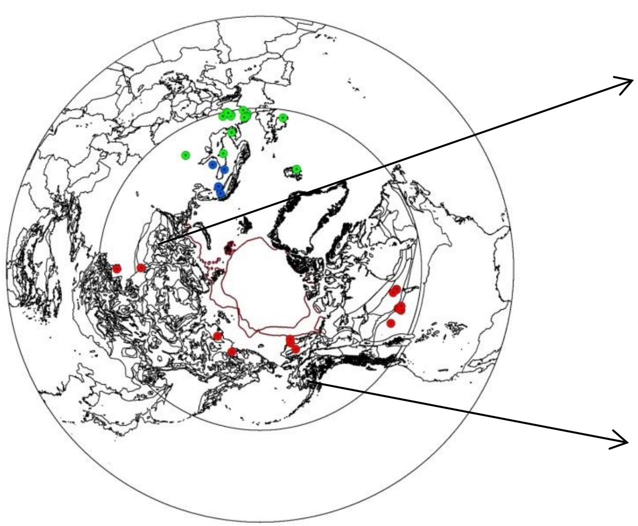
Soil Moisture Constraints in Boreal/Arctic C Cycle

Important role of soil moisture in boreal/arctic C cycle:

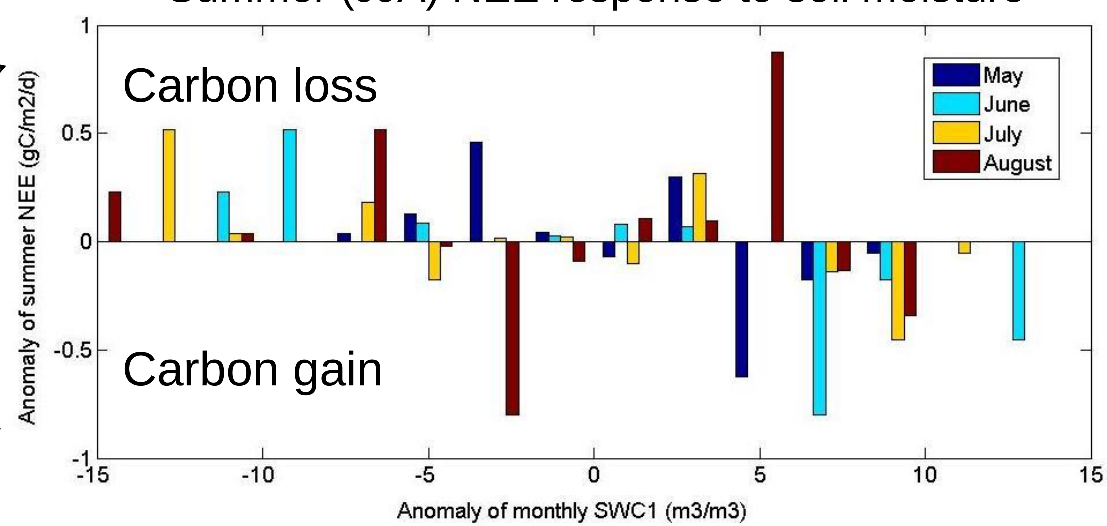
- Decoupling of soil moisture & temperature in boreal/arctic area;
- Potentially different responses of GPP and R_{eco} to soil moisture.

Summer (JJA) NEE response to air temperature





Summer (JJA) NEE response to soil moisture



L4_C Cal/Val Rehearsal 2

More tower sites for validation:

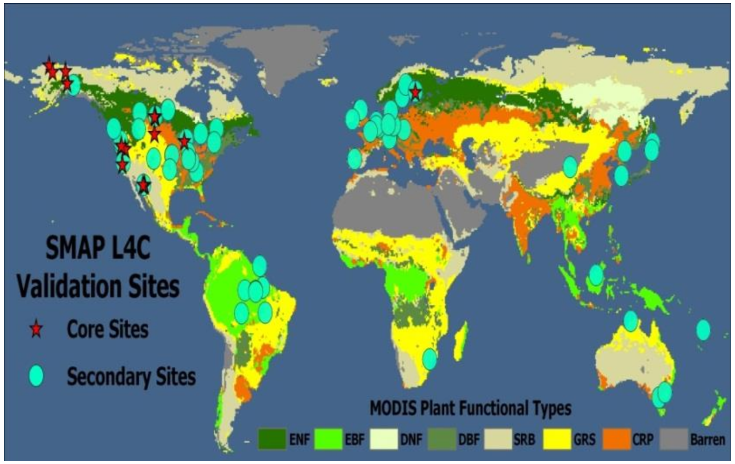
- Involve all (~17) core tower sites, emphasizing northern biomes;
- Secondary sites (~80), global representation.

Mature L4_C software for comparisons:

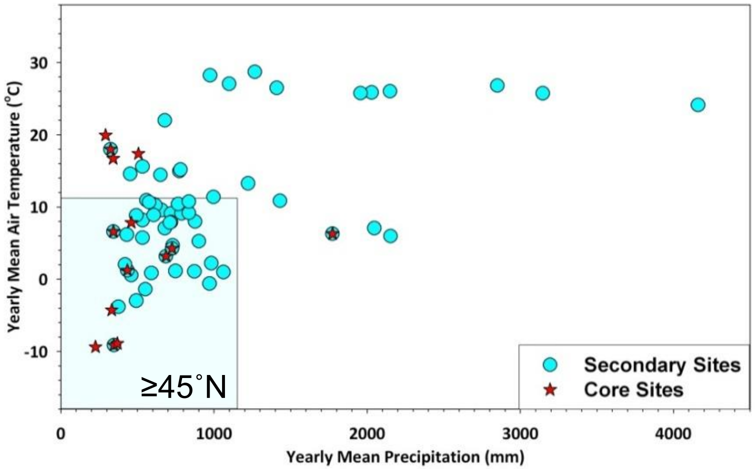
- Co-located in space & time (core sites);
- Tower footprint vs. 1-9 km outputs;
- Model sensitivity runs to distinguish relative error sources (L4_C simulator)

Synergistic land C products:

- L4_C simulator outputs
- MODIS (MOD/MYD17) GPP
- Soil Carbon (SOC) inventories [static]
- Upscaled, Obs. based C products (MTE)
- Field campaigns (AirMOSS, SMAPVEX)



L4_C Validation Sites in Climate Space

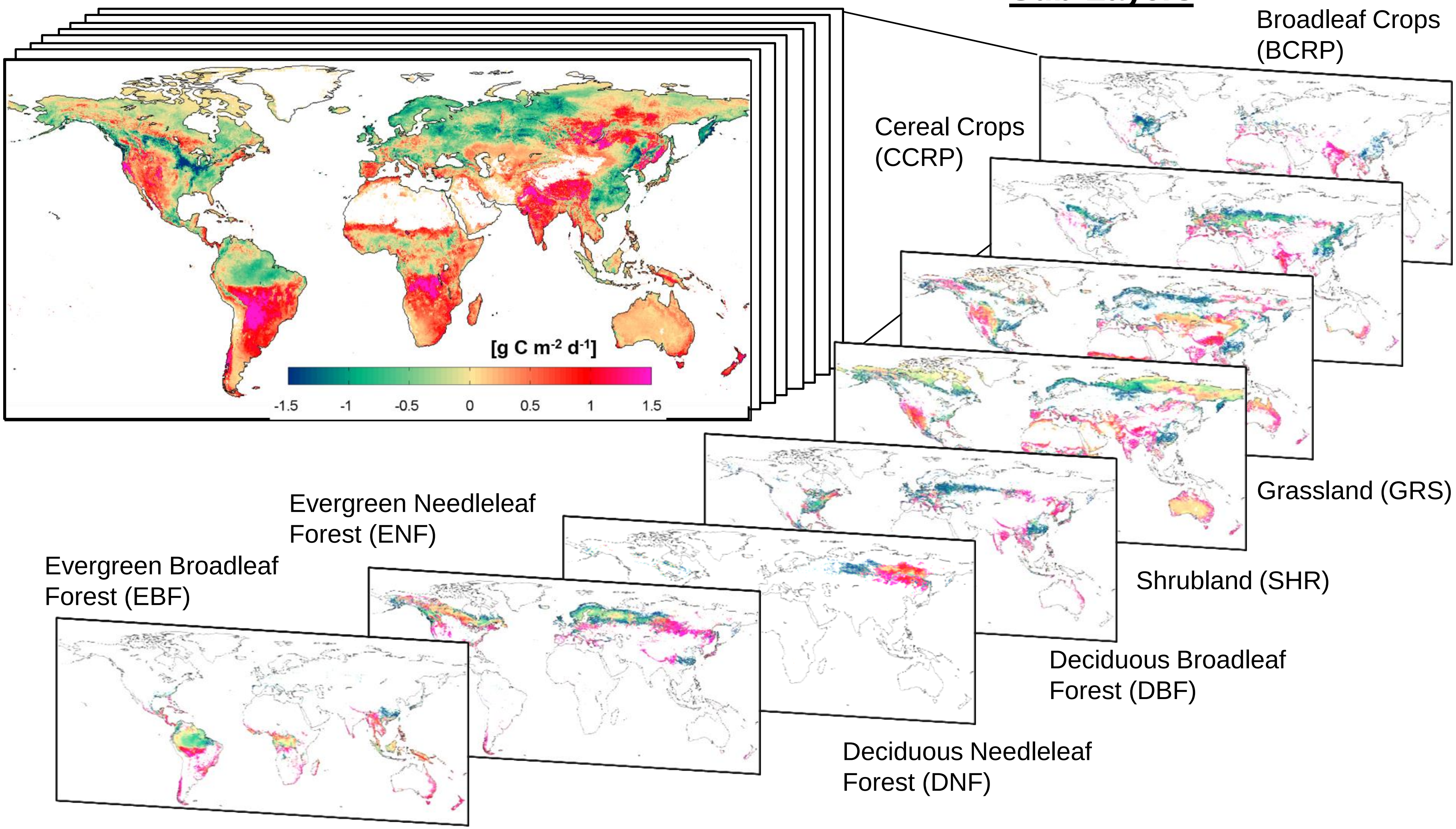


BACKUP SLIDES

L4_C Product Example: NEE, July 20

NEE 9 km Grand Average

NEE 9 km by PFT Average Sub-Layers

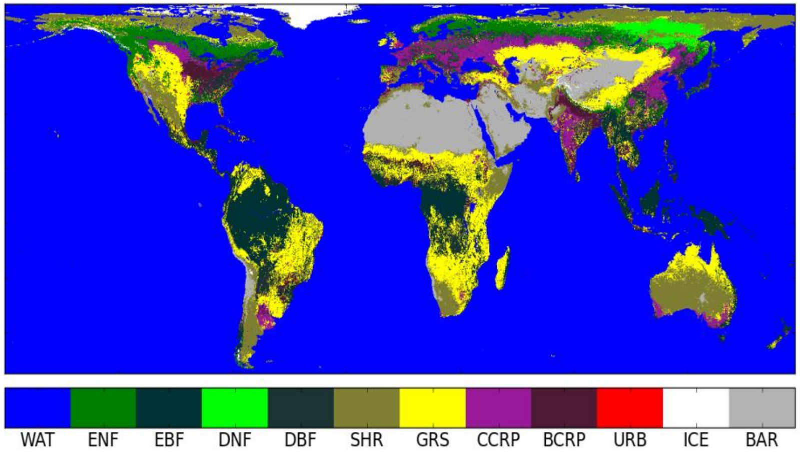


L4_C Biome Property Look-up Table (BPLUT)

- Defines PFT biophysical response characteristics for each 1-km grid cell
- Calibrated using global tower network observations (FLUXNET)
- Flexible design for global operational processing

Parameter	Units	Plant Functional Type (PFT)							
		ENF	EBF	DNF	DBF	GRS	SRB	CCRP	BCRP
ε_{mx}	(g C MJ^{-1})	1.10	1.20	1.10	1.20	0.85	0.85	1.10	1.10
Min_{Tmn}	(° C)	-8.0	-8.0	-8.0	-6.0	-8.0	-8.0	-8.0	-8.0
Max_{Tmn}	(° C)	8.3	9.1	10.4	9.9	12.0	8.8	12.0	12.0
Min_{VPD}	(Pa)	500	1800	500	500	752	500	500	500
Max_{VPD}	(Pa)	4000	4000	4160	4160	5500	4455	5071	5071
Min_{SM}	(% Sat.)	20	20	20	20	20	20	20	20
Max_{SM}	(% Sat.)	70	70	70	70	70	70	70	70
F_{FT}	(DIM)	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
NF_{FT}	(DIM)	1	1	1	1	1	1	1	1
C_{fract}	(DIM)	0.49	0.71	0.67	0.67	0.76	0.62	0.78	0.78
CUE	(DIM)	0.55	0.45	0.55	0.55	0.6	0.6	0.55	0.55
R_a:GPP	(DIM)	0.45	0.55	0.45	0.45	0.4	0.4	0.45	0.45
K_{mx}	(d^{-1})	0.0301	0.0301	0.0301	0.0301	0.0301	0.0301	0.0301	0.0301
K_{str}:K_{met}	(%)	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0
K_{rec}:K_{met}	(%)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
T_{opt}	(° C)	20.0	25.0	20.0	25.0	25.0	25.0	25.0	25.0
SM_{opt}	(% Sat.)	60	60	60	60	60	60	60	60
a	(DIM)	9.90	9.90	9.90	9.90	9.90	9.90	9.90	9.90
b	(DIM)	-6.13	-6.13	-6.13	-6.13	-6.13	-6.13	-6.13	-6.13
c	(DIM)	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50

MODIS (MCD12Q1) Land Cover Classification



- PFT classes: Evergreen needleleaf forest (ENF), evergreen broadleaf forest (EBF), deciduous needleleaf forest (DNF), deciduous broadleaf forest (DBF), grassland (GRS), shrubland (SRB), cereal crop (CCRP), broadleaf crop (BCRP)

- Masked areas: Barren (BAR), Urban (URB), permanent ice/snow (ICE), open water (WAT)