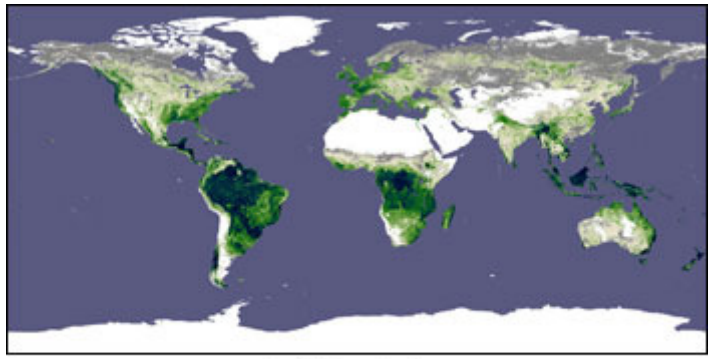
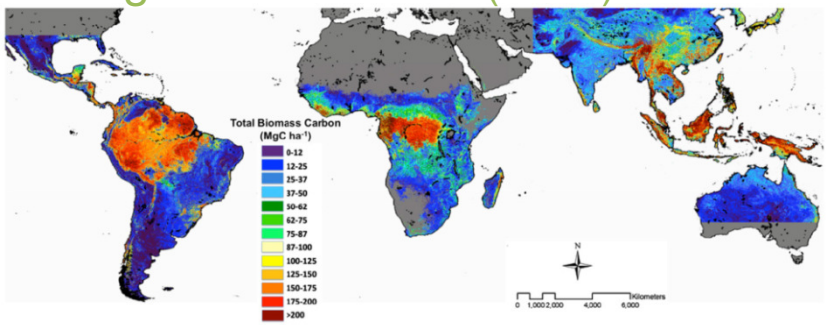
Global Data Assimilation for the Carbon Cycle: challenges, progress and the future

MODIS Leaf Area Index (LAI)



NASA

Above-ground Biomass (AGB)



Saatchi et al. 2011

How can we constrain regional C flux estimates using satellite observations of the terrestrial C cycle?

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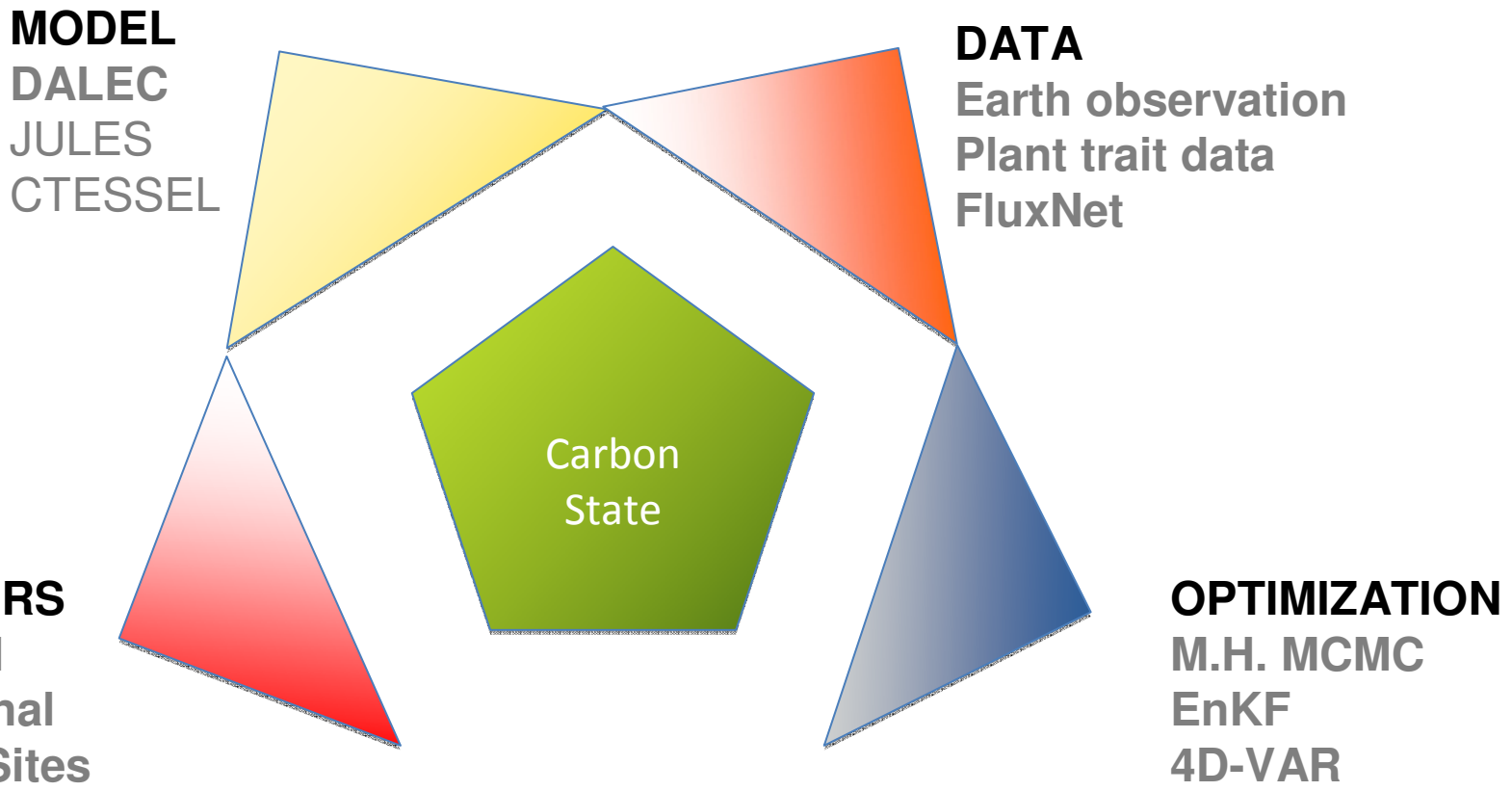
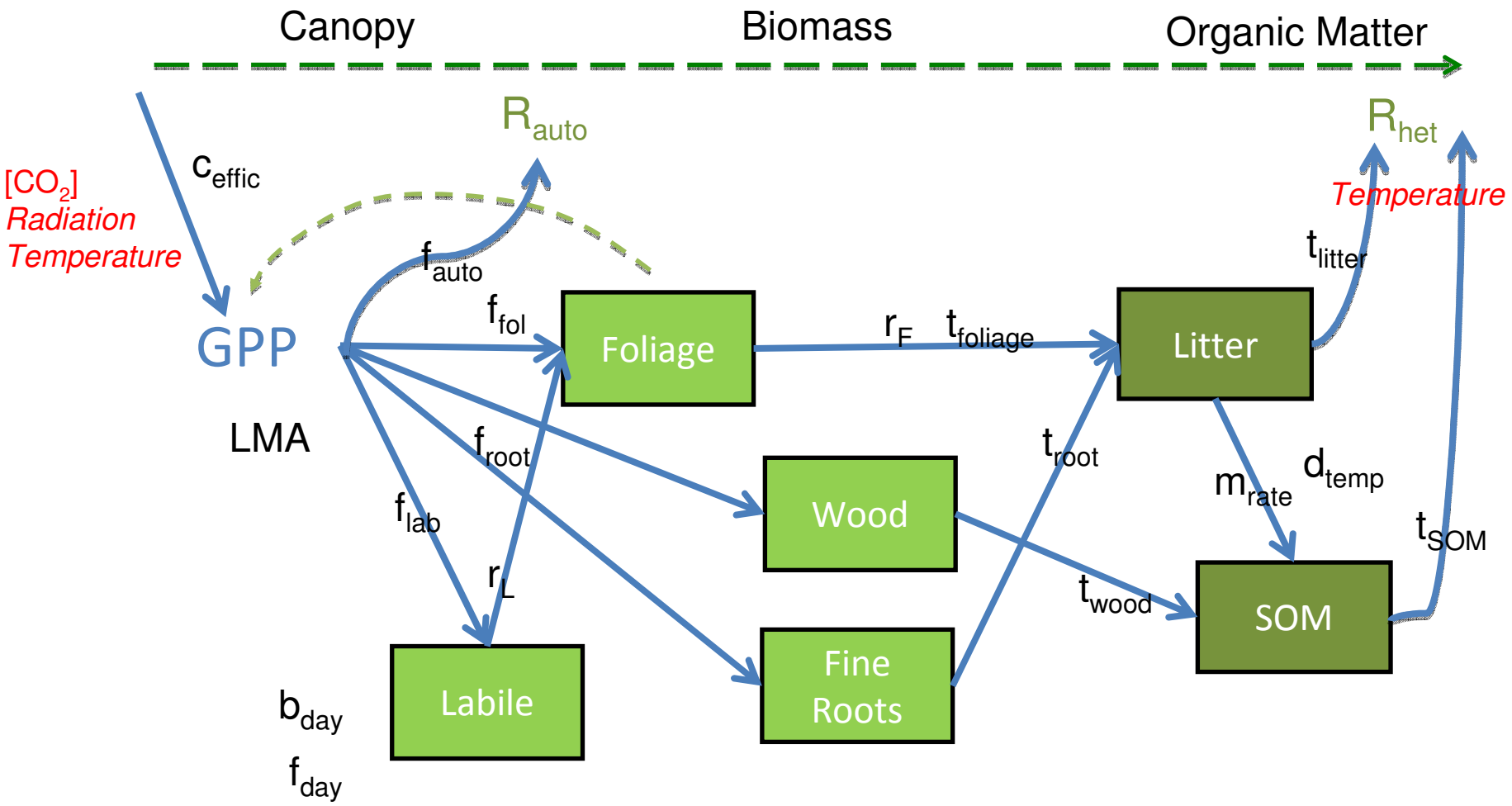
CARDAMOM

CARbon DAta MOdel FraMework



Data Assimilation Linked Ecosystem Carbon (DALEC) model

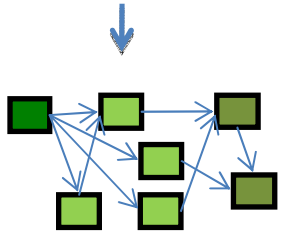


Model Data Fusion (MDF)

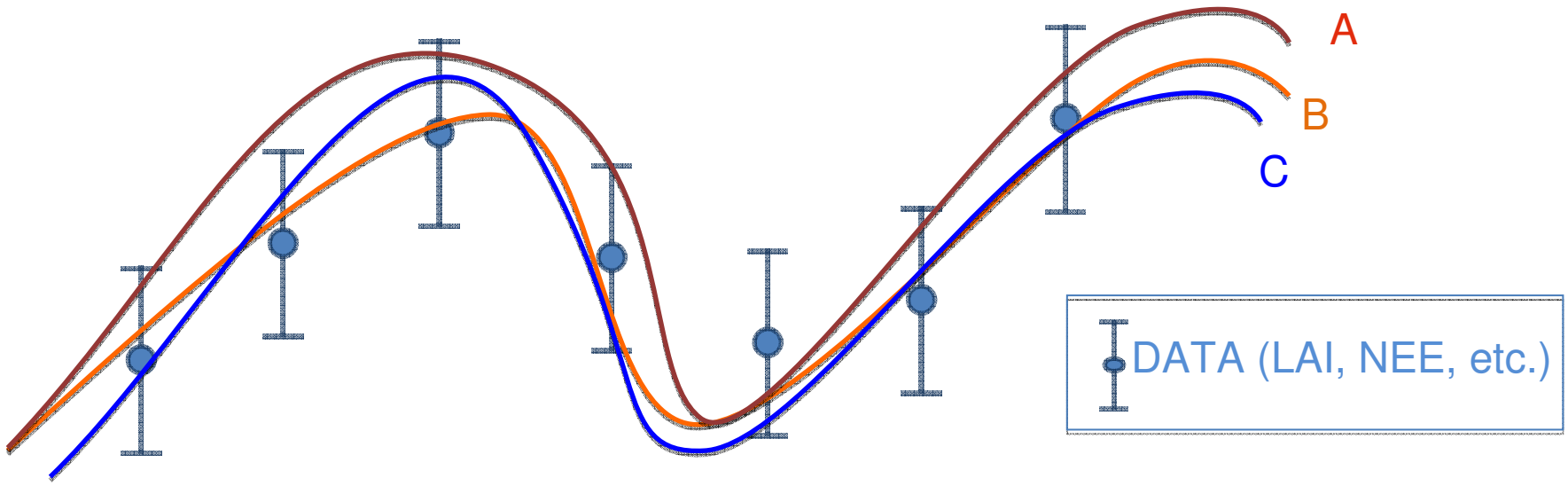
$$p(x|c) \propto p(c|x)\, p(x)$$

Posterior parameter probability	Observation likelihood, given parameters	Prior Parameter Probability

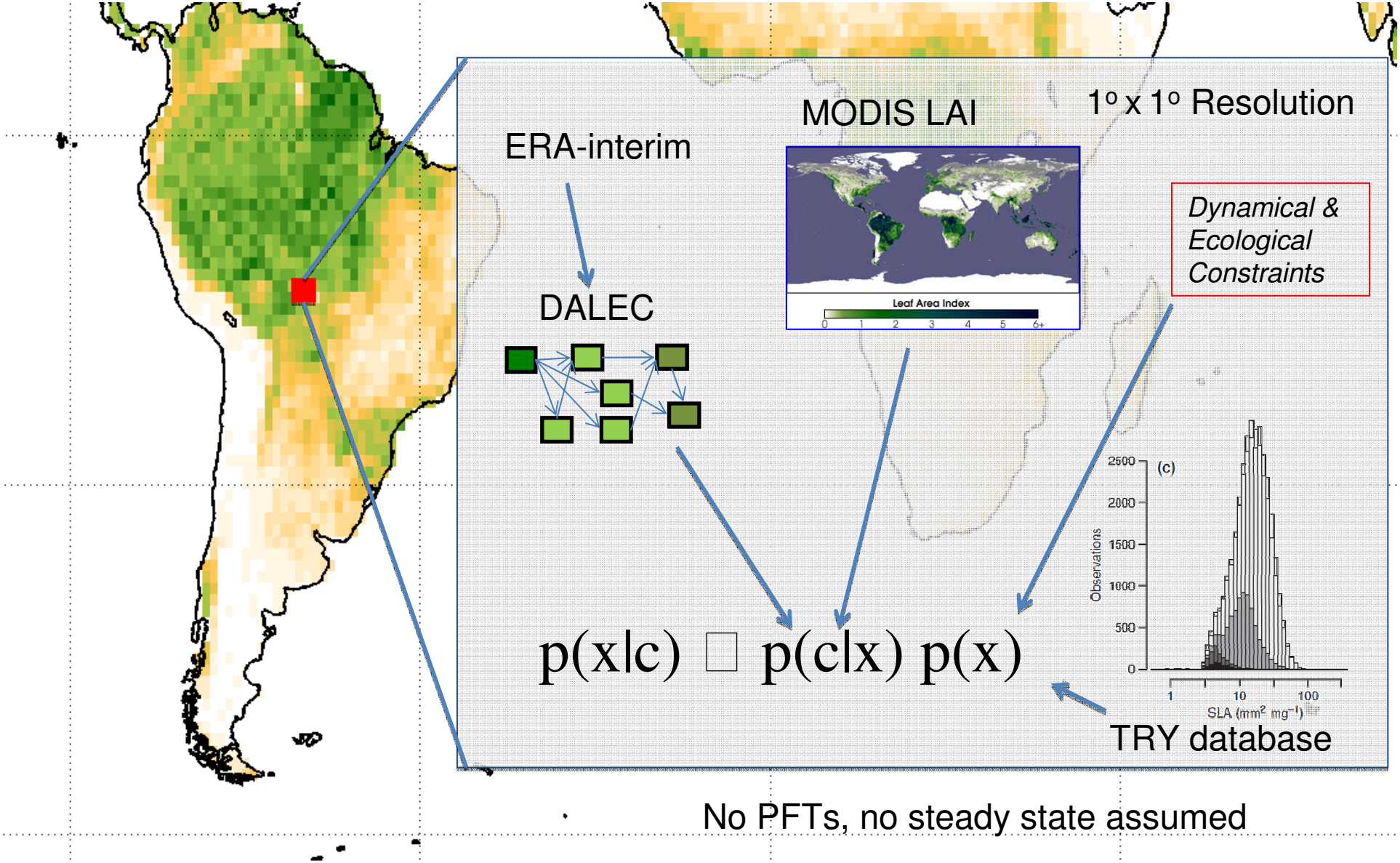
A. $p_1, p_2, \ldots, p_{23}$
B. $p_1, p_2, \ldots, p_{23}$
C. $p_1, p_2, \ldots, p_{23}$



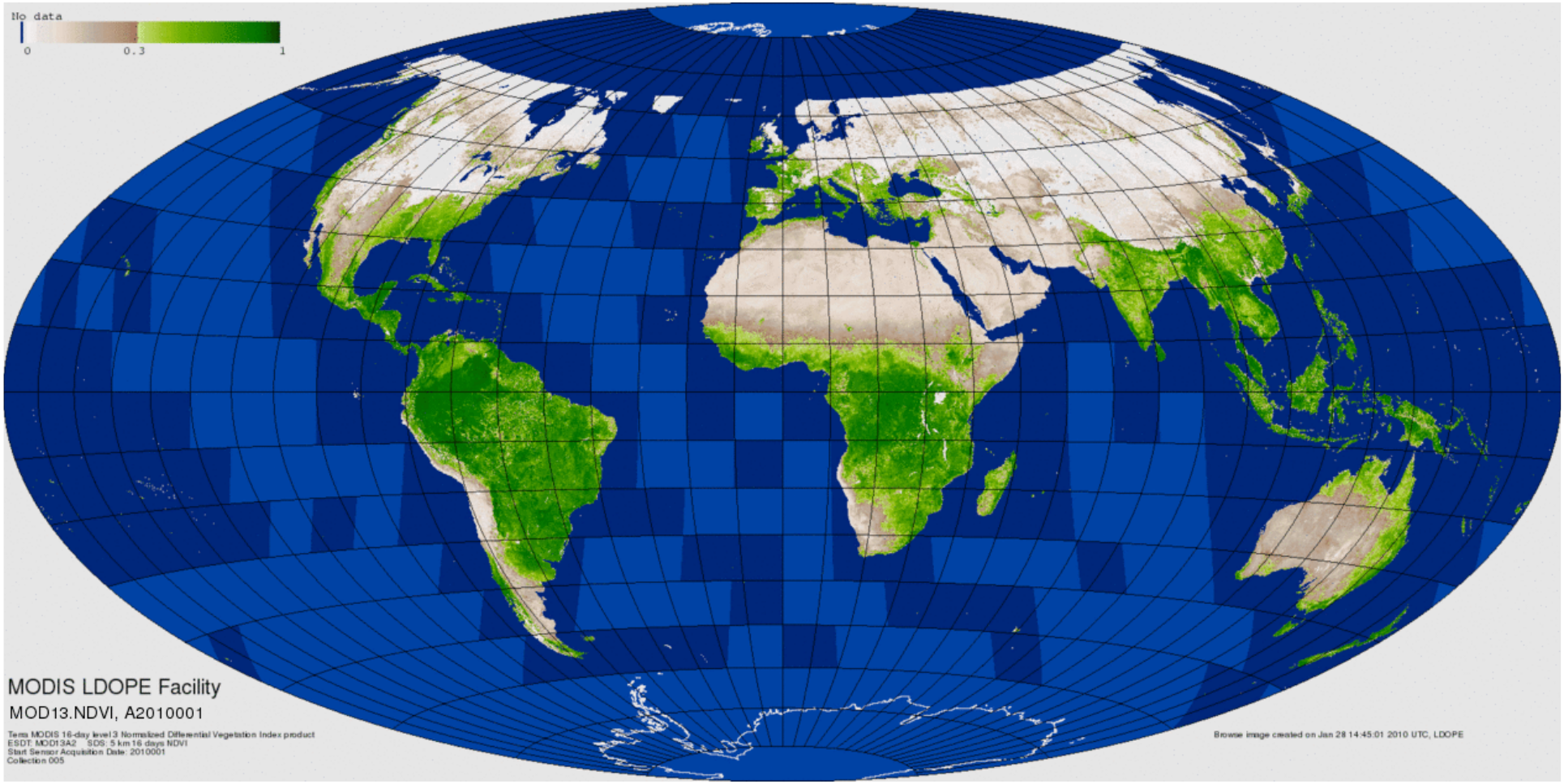
DALEC



Global Implementation



MODIS LAI time series

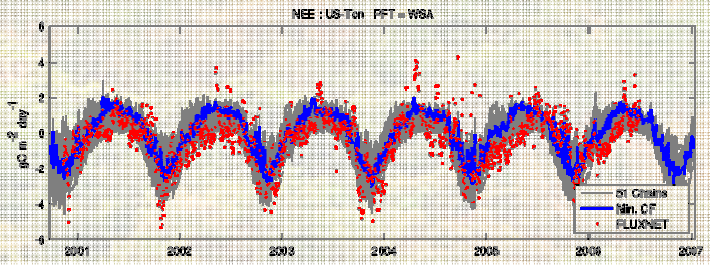


NASA GSFC

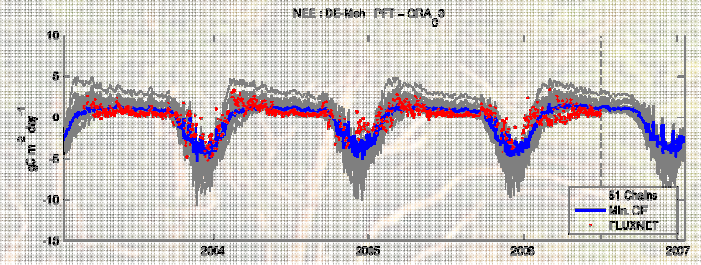
FLUXNET Sites, EC data comparison - preliminary results

DALEC NEE ● FLUXNET EC data

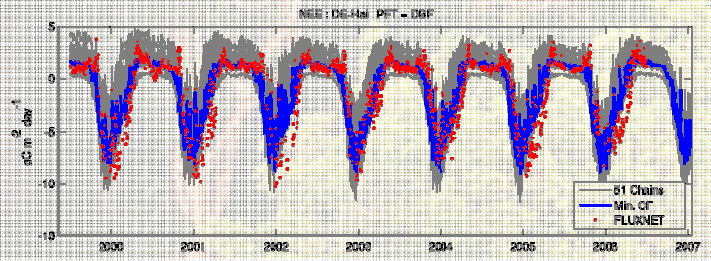
Woody Savana



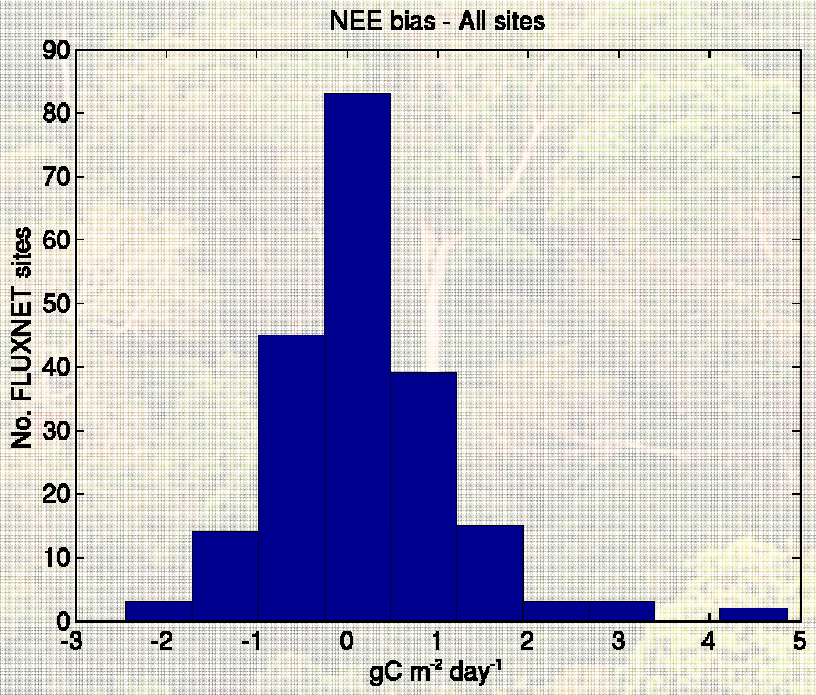
Grassland



Deciduous Broadleaf Forest



208 FLUXNET Sites



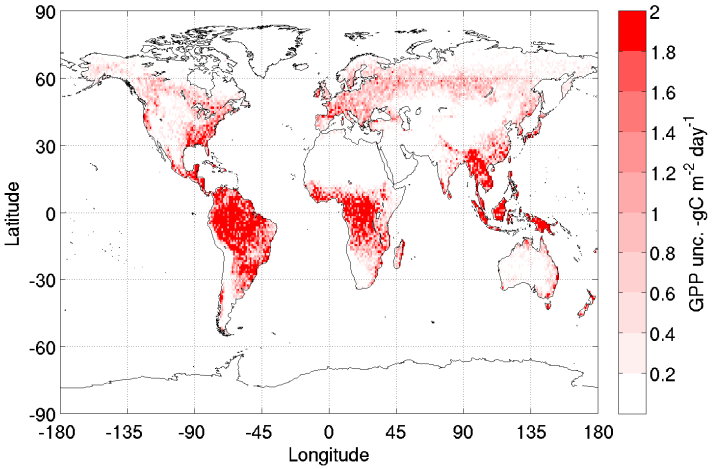
International comparison - This study has been performed within the FLUXCOM project framework

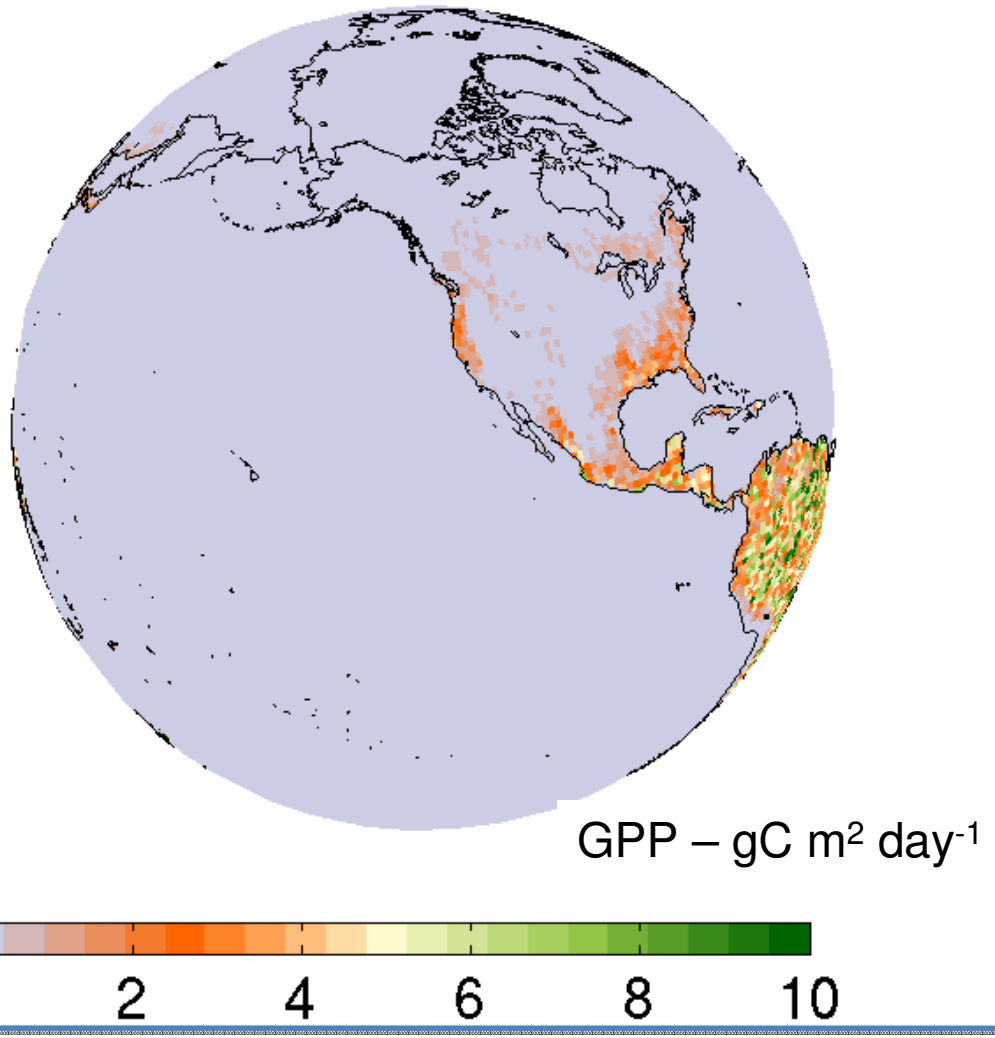
Gross Primary Production (GPP)

Global DALEC MDF

- Assimilation time: 2001-2010
- Resolution: Daily - 1° x 1°
- GPP mean = 103 ± 19 Pg C yr^{-1}

GPP Uncertainty





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Gross Primary Production - Comparison

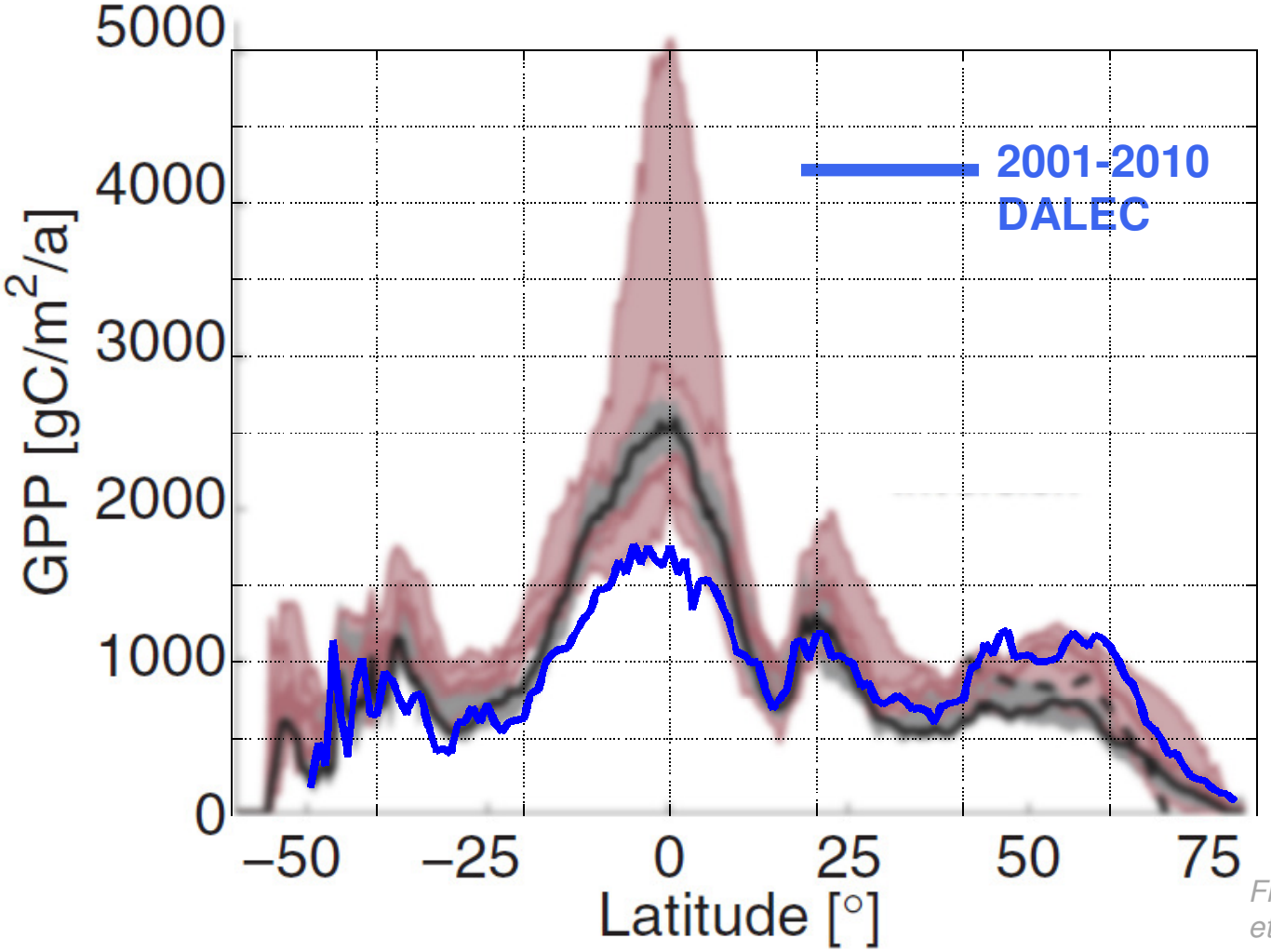

Figure adapted from Beer et al. 2010

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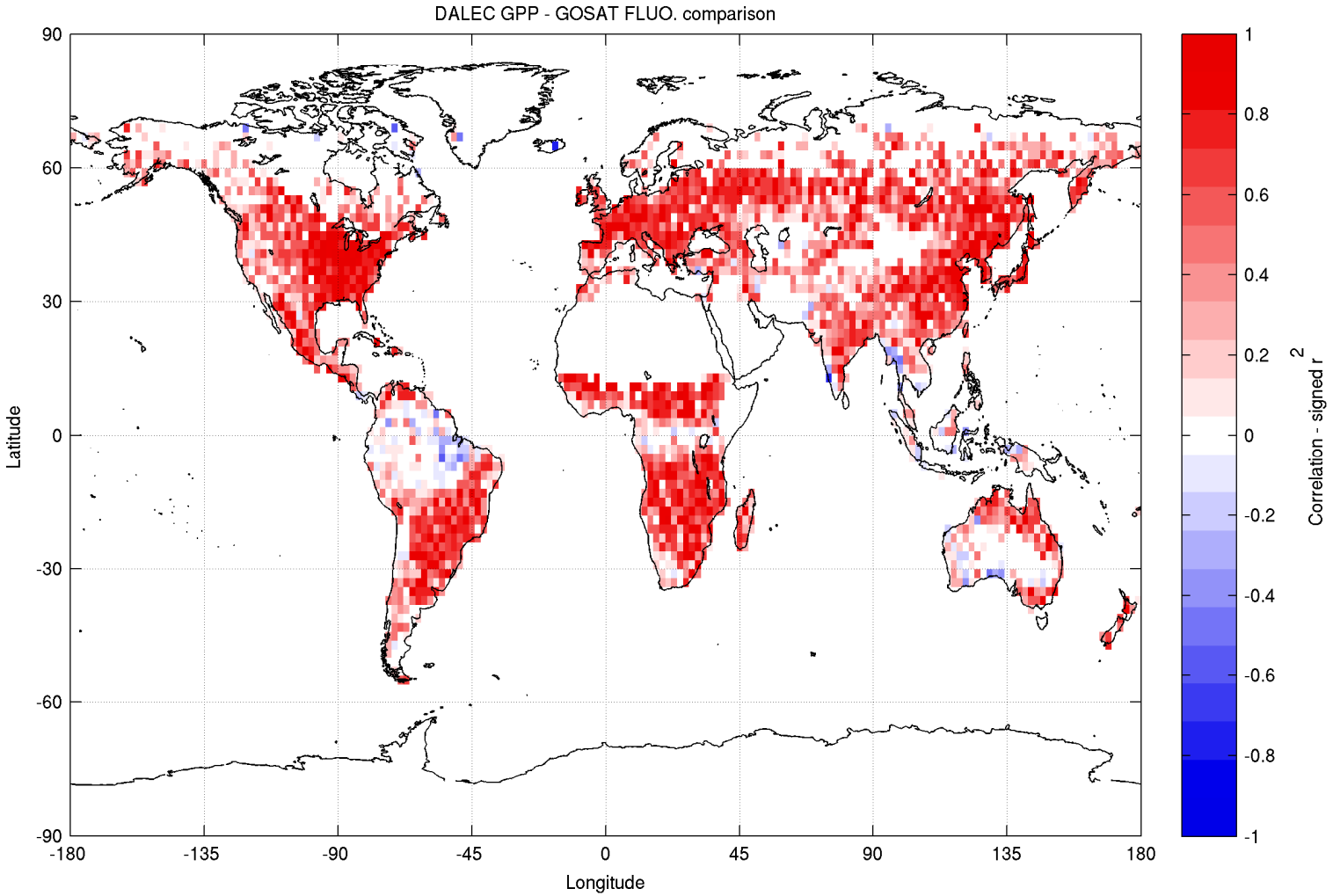
DALEC GPP – GOSAT Fluorescence comparison (r-value)



GOSAT Fluorescence, Frankenberg et al., 2011

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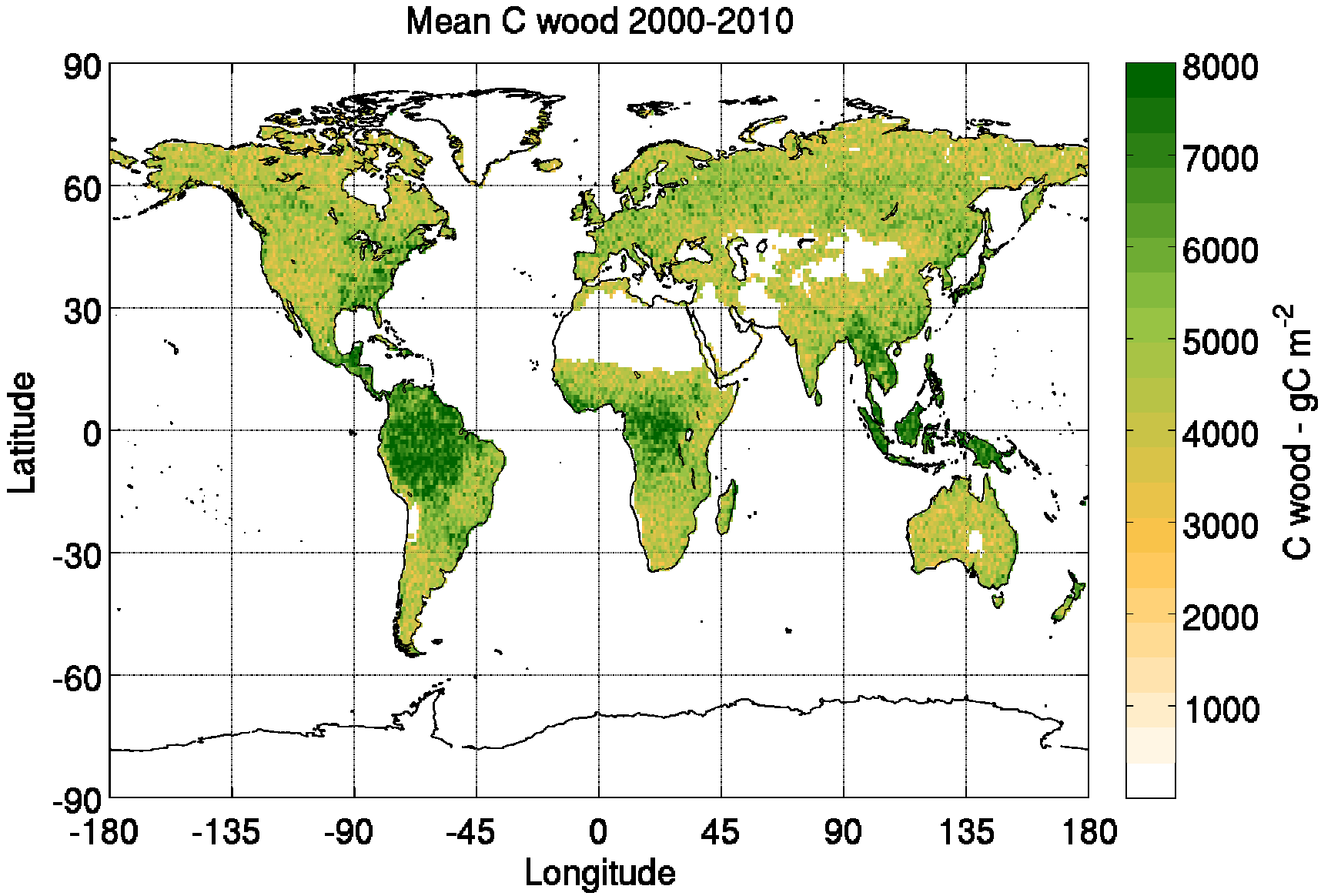
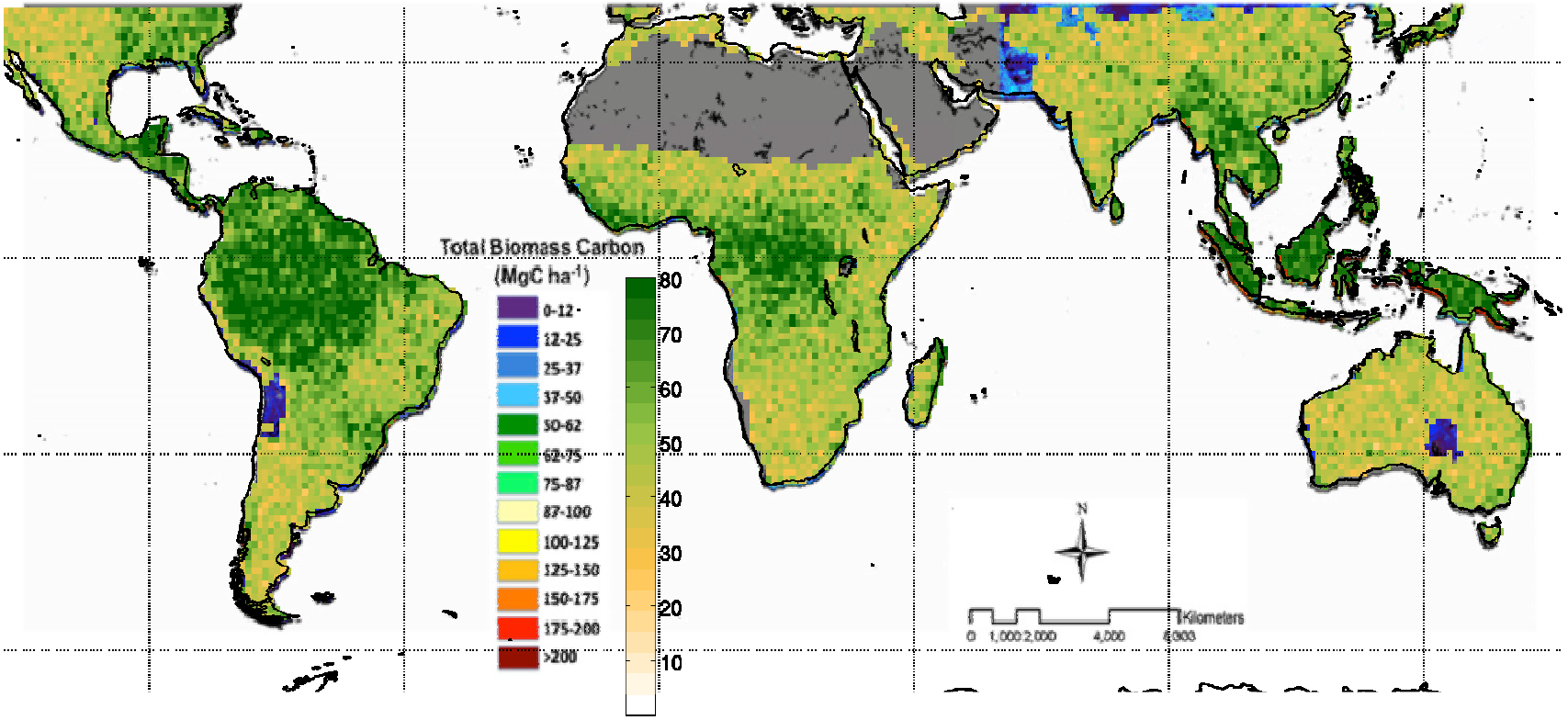
Aboveground Biomass



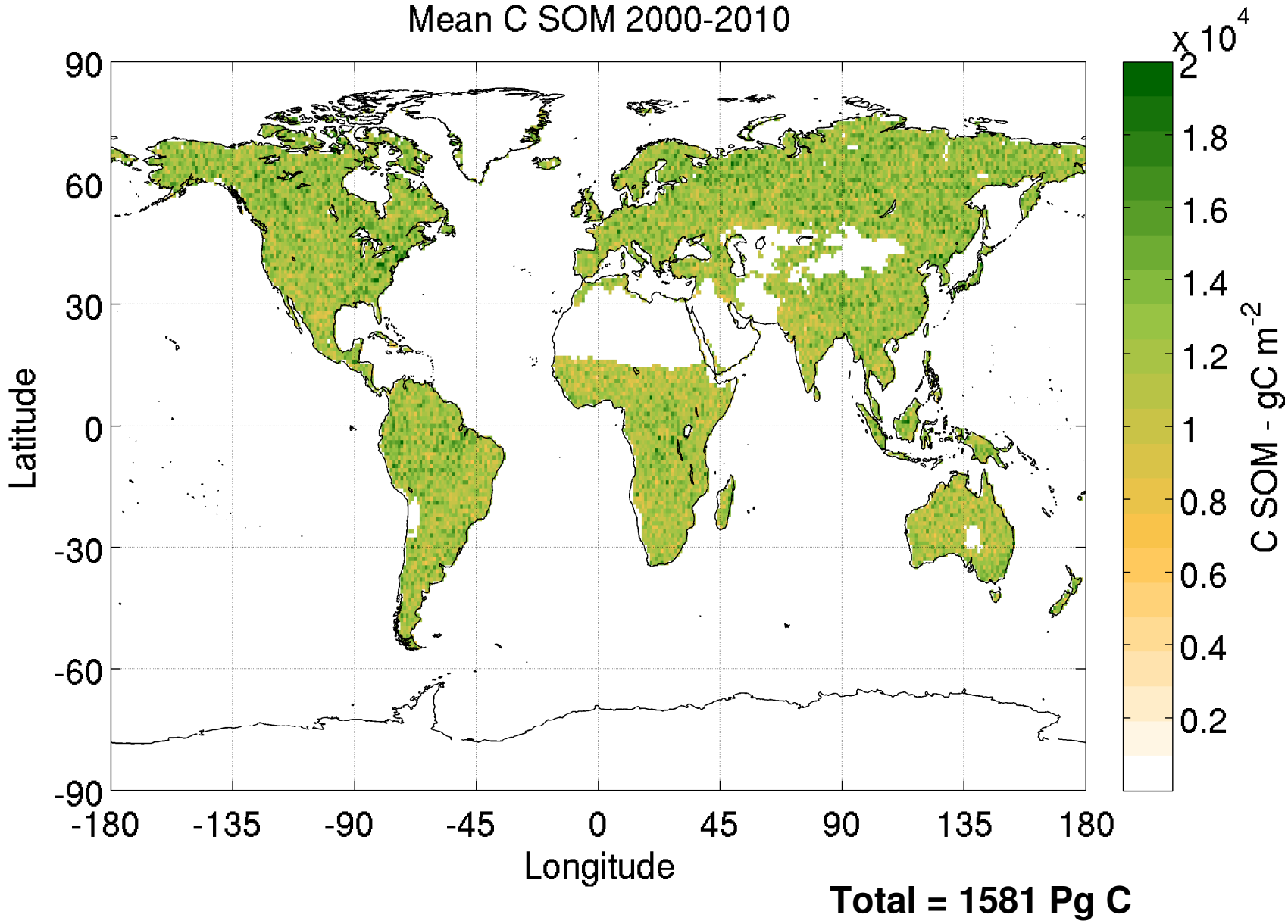
Total = 649.2 PgC

Pan-tropical AGB map

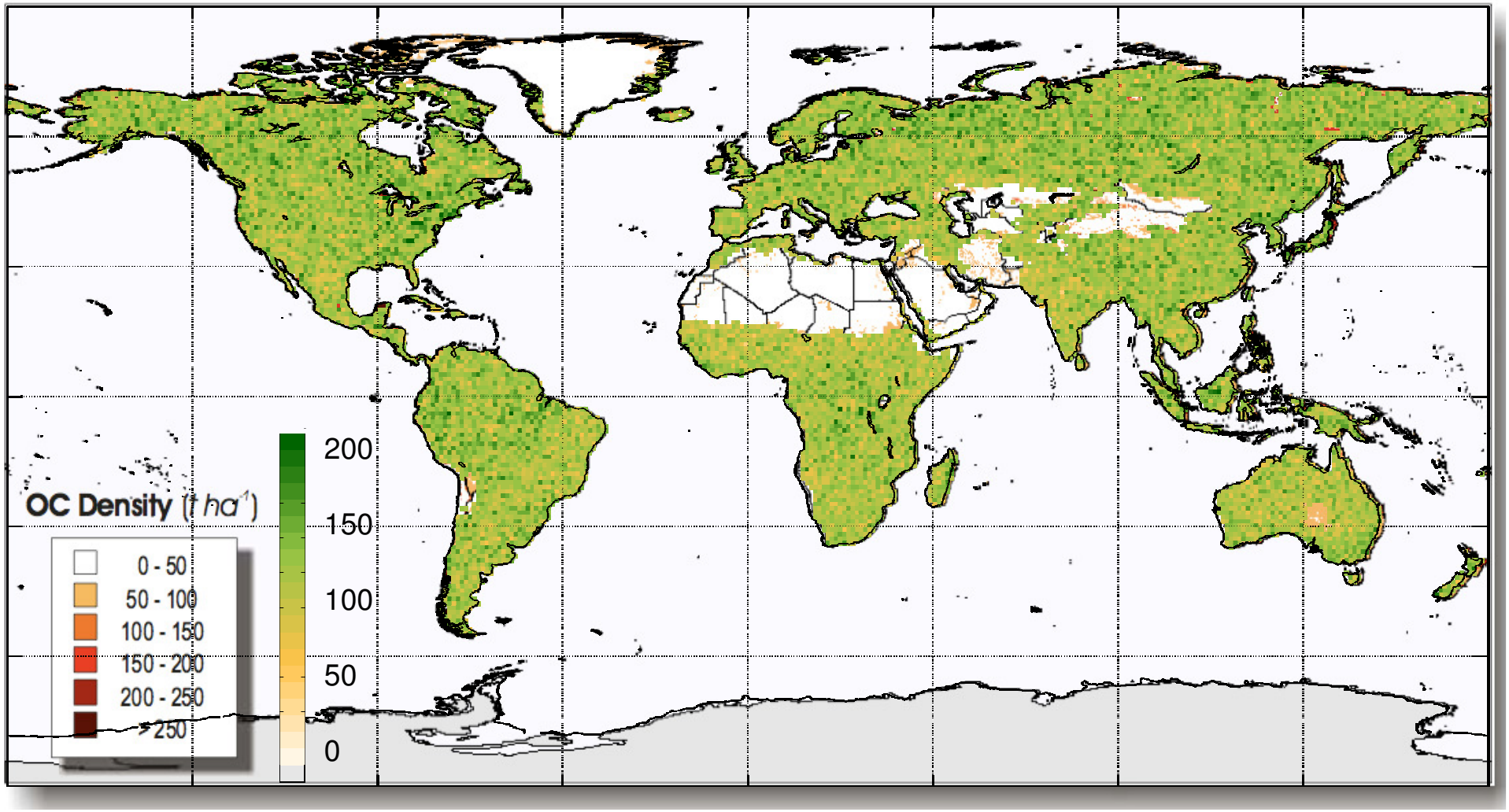


Total AGB (global) = 649 PgC

Soil Carbon

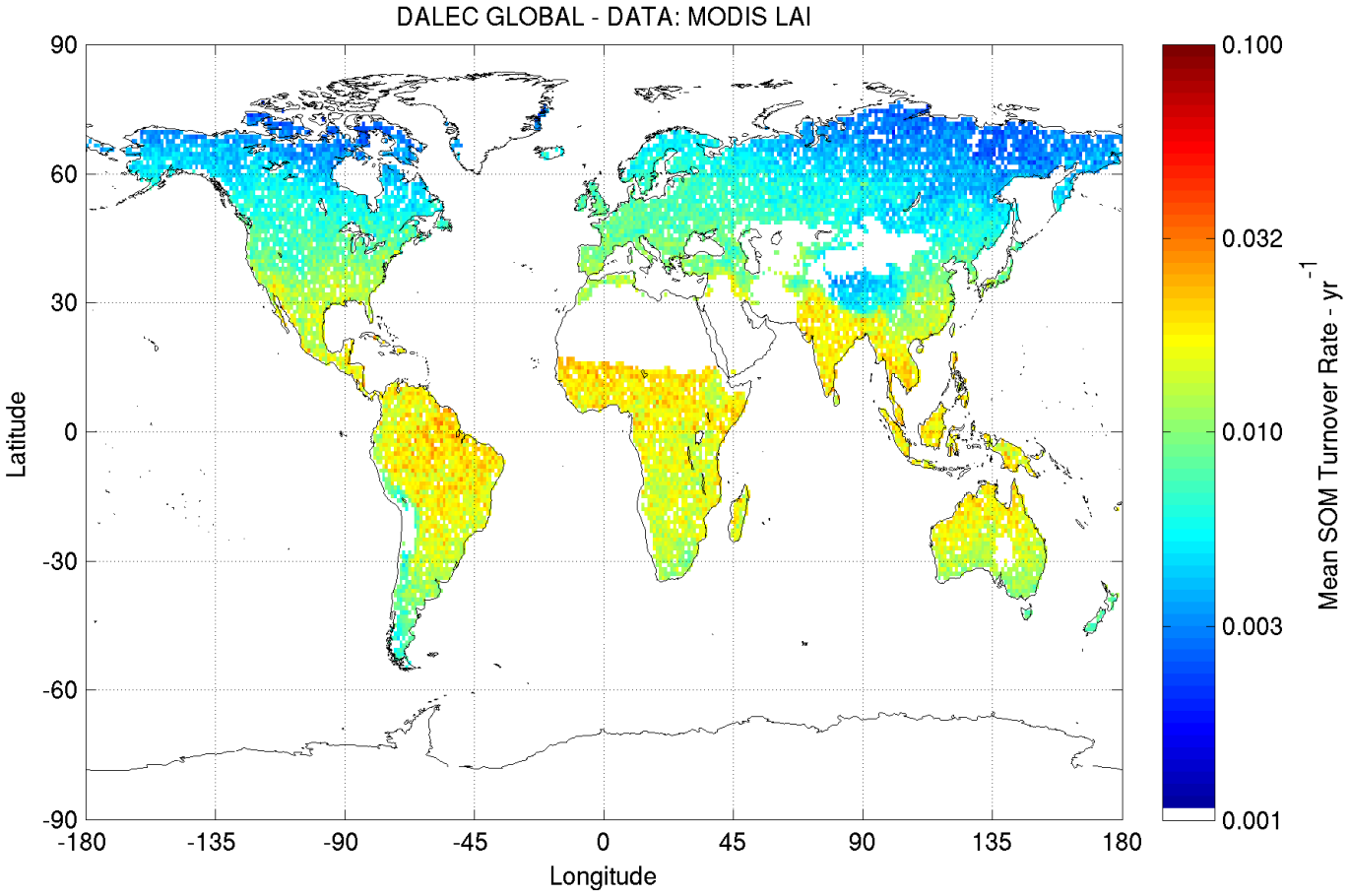

Mean C SOM 2000-2010
x 10^4
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
C SOM - gC m^-2
90
60
30
0
-30
-60
-90
Latitude
-180
-135
-90
-45
0
45
90
135
180
Longitude
Total = 1581 Pg C

HWSD – Soil Carbon

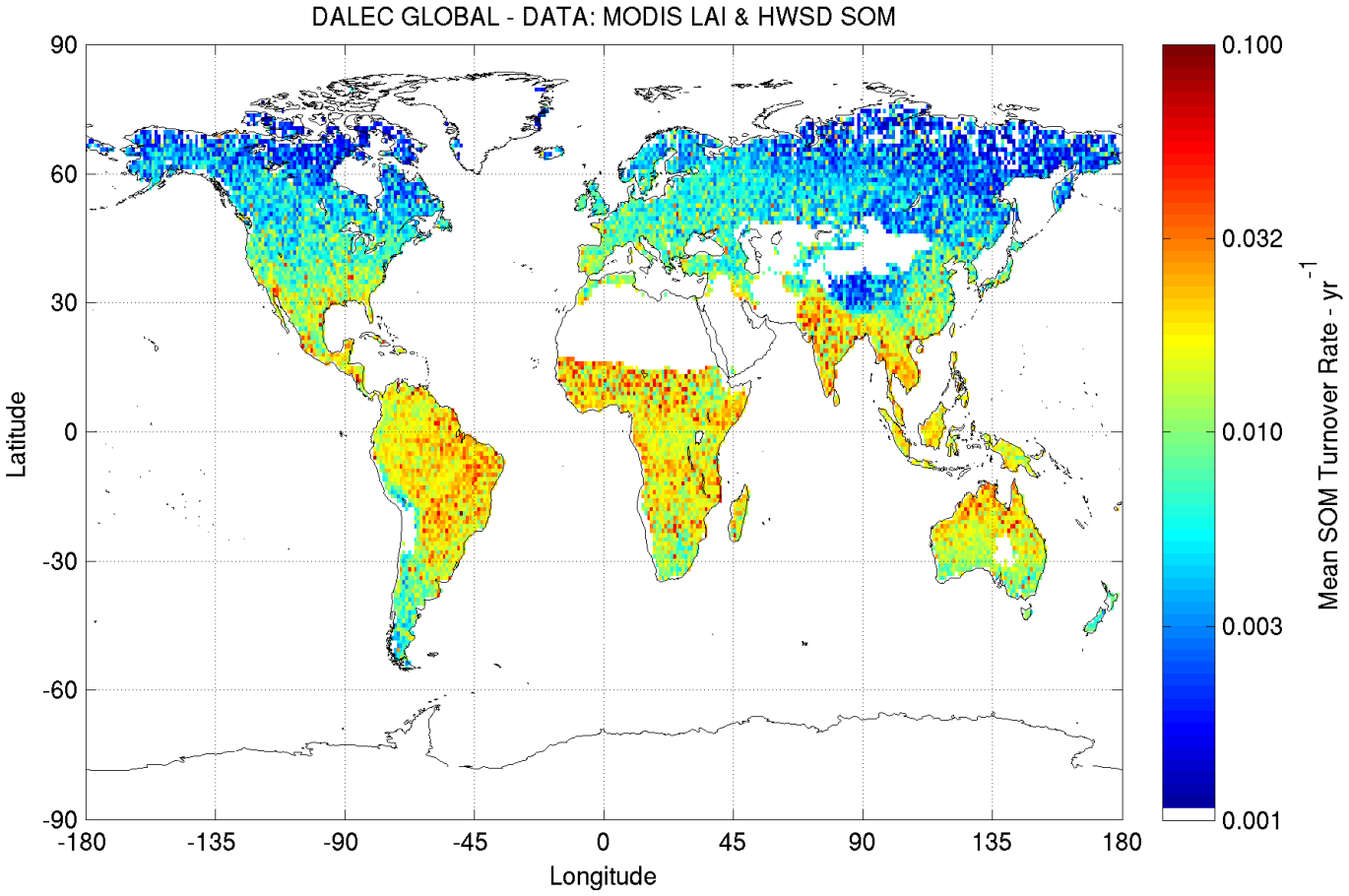


HWSD - Hiederer & Köchy (2011)

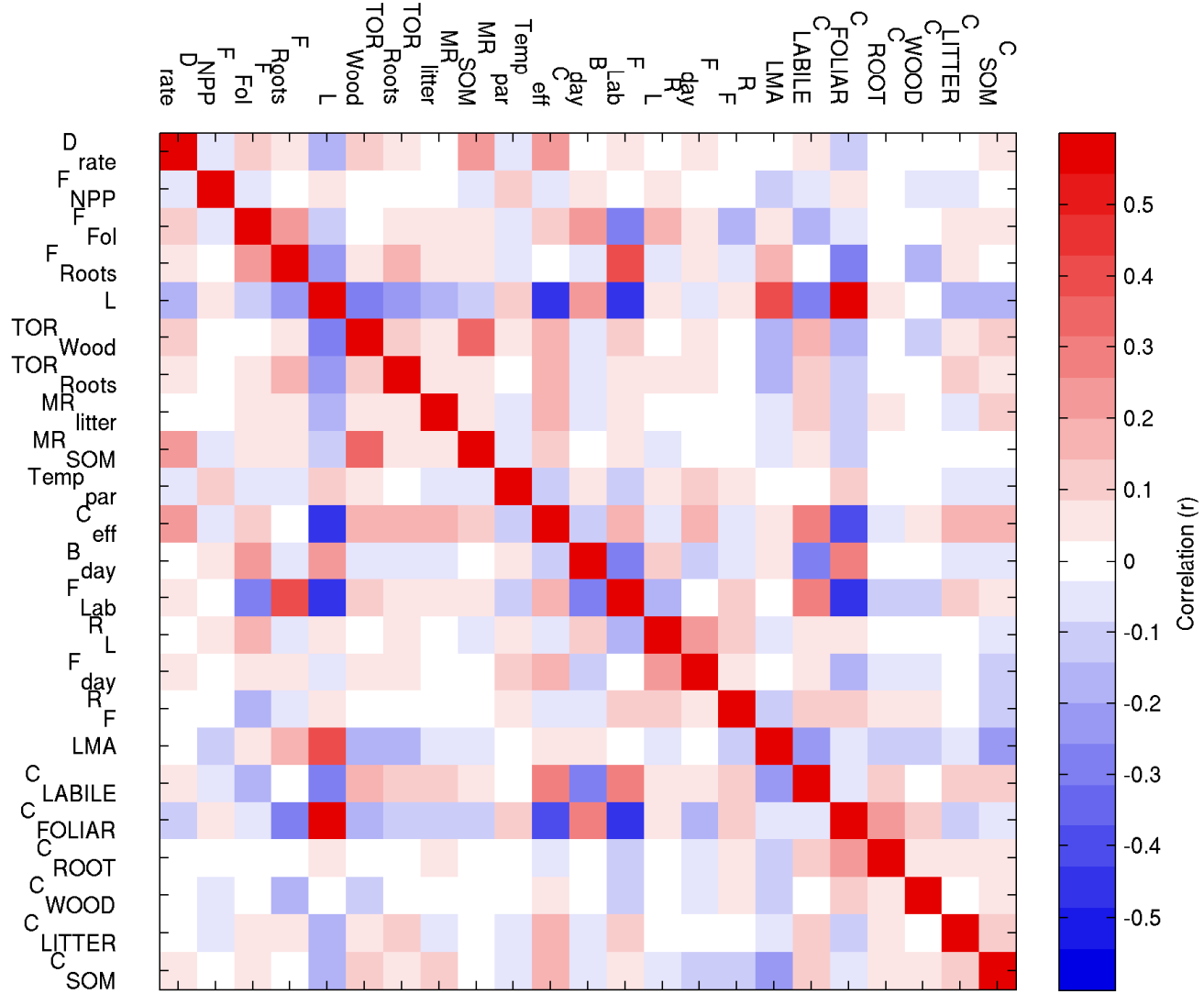
Nominal soil turnover rates



Adjusted soil turnover rates



Global Parameter Correlations



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Summary and Conclusions

1. Fluxes and stocks can be constrained from MODIS LAI
2. Global implementation of DALEC with ecological and dynamic constraints: GPP, AGB and SOM totals encouraging, GPP and AGB spatially resolve key biomes.
3. Parameter estimation indicates information content of assimilated data
4. Non-steady state solutions, emergent PFTs
5. **NEXT**: Integrate AGB maps and fluorescence as priors; include parameter *correlations* from TRY database
6. **O**bserving **S**ystem **S**imulation **E**xperiments can quantify information content of EO concepts

CARDAMOM w/ JULES?

CARbon DAta MOdel FraMework

MODEL

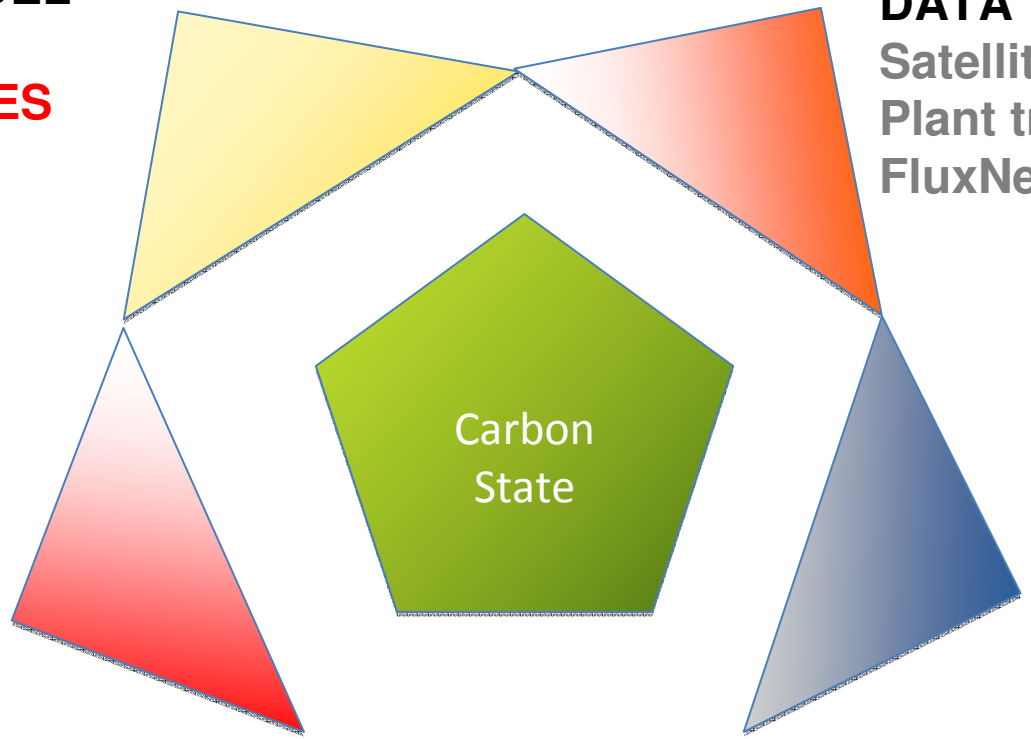
JULES

DATA

Satellite

Plant trait data

FluxNet



DRIVERS

Global

Regional

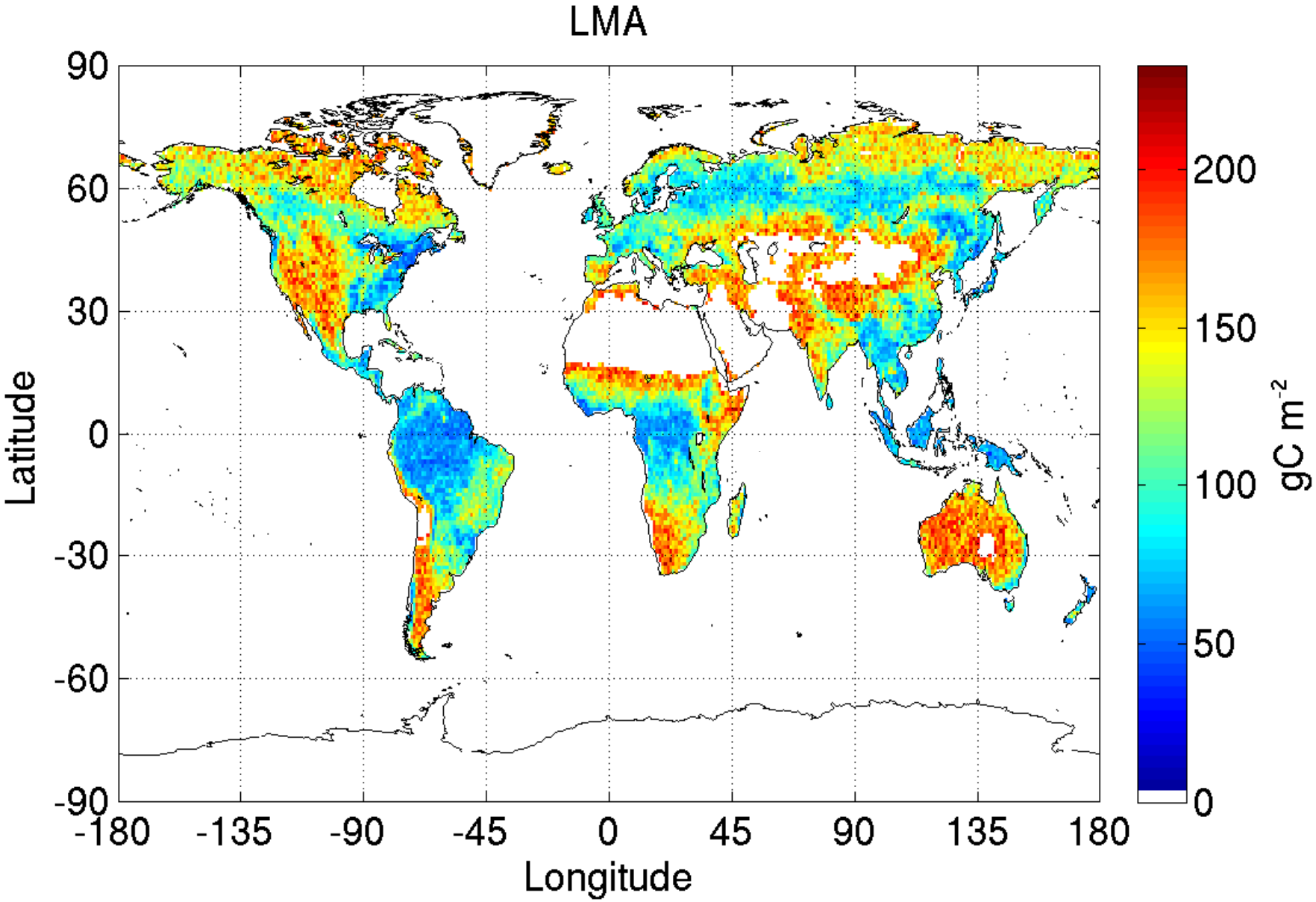
Field Sites

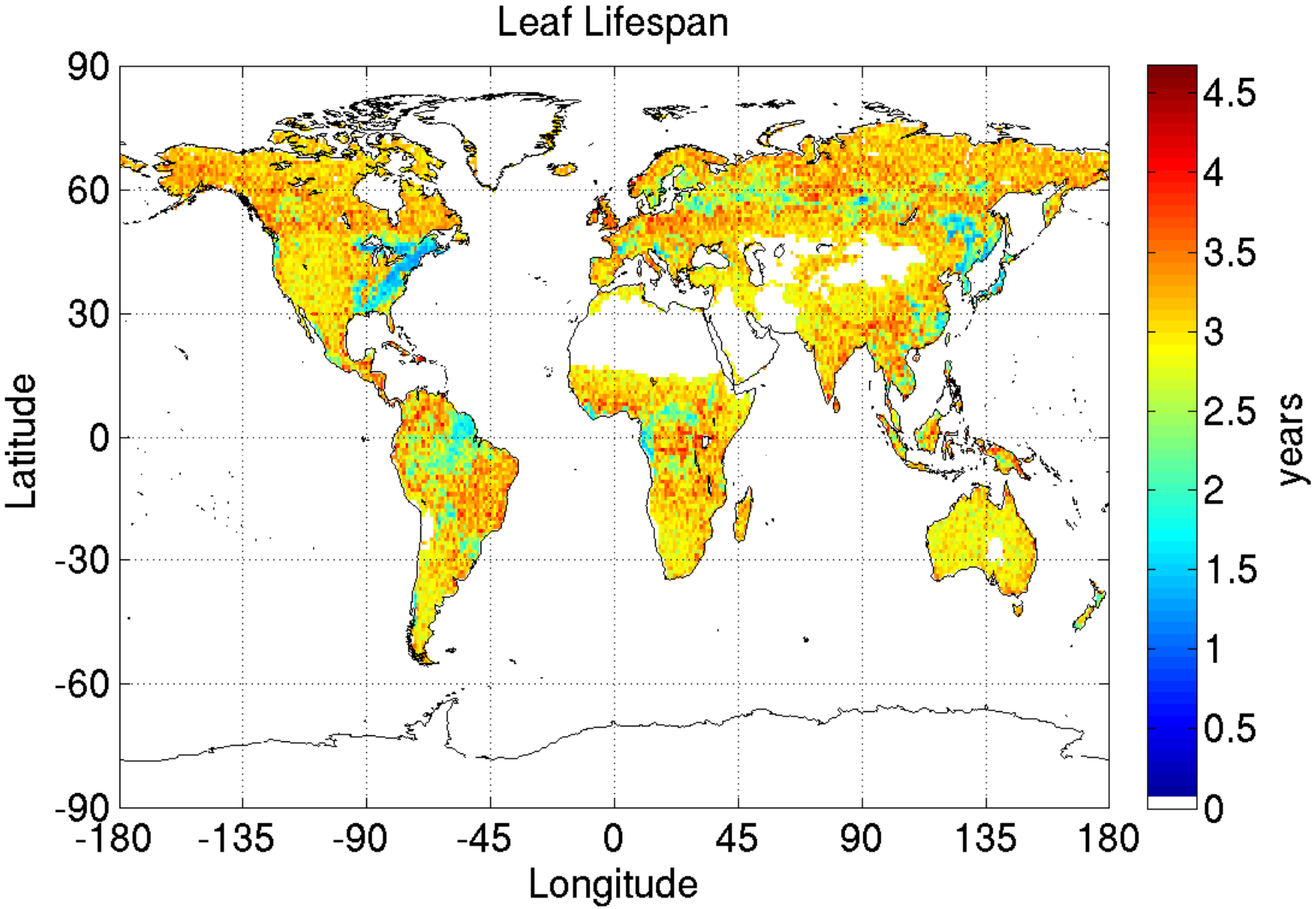
OPTIMIZATION

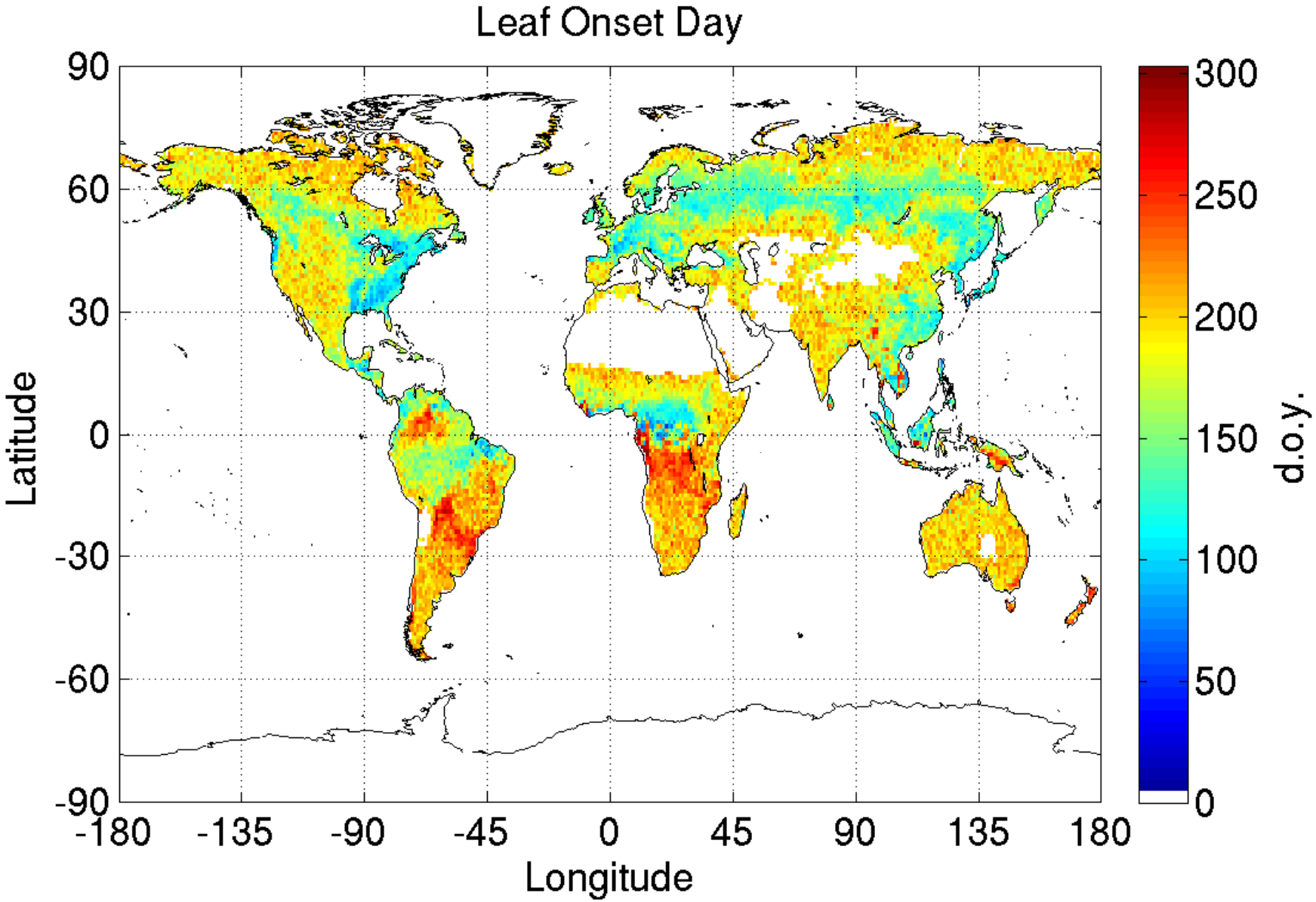
M.H. MCMC

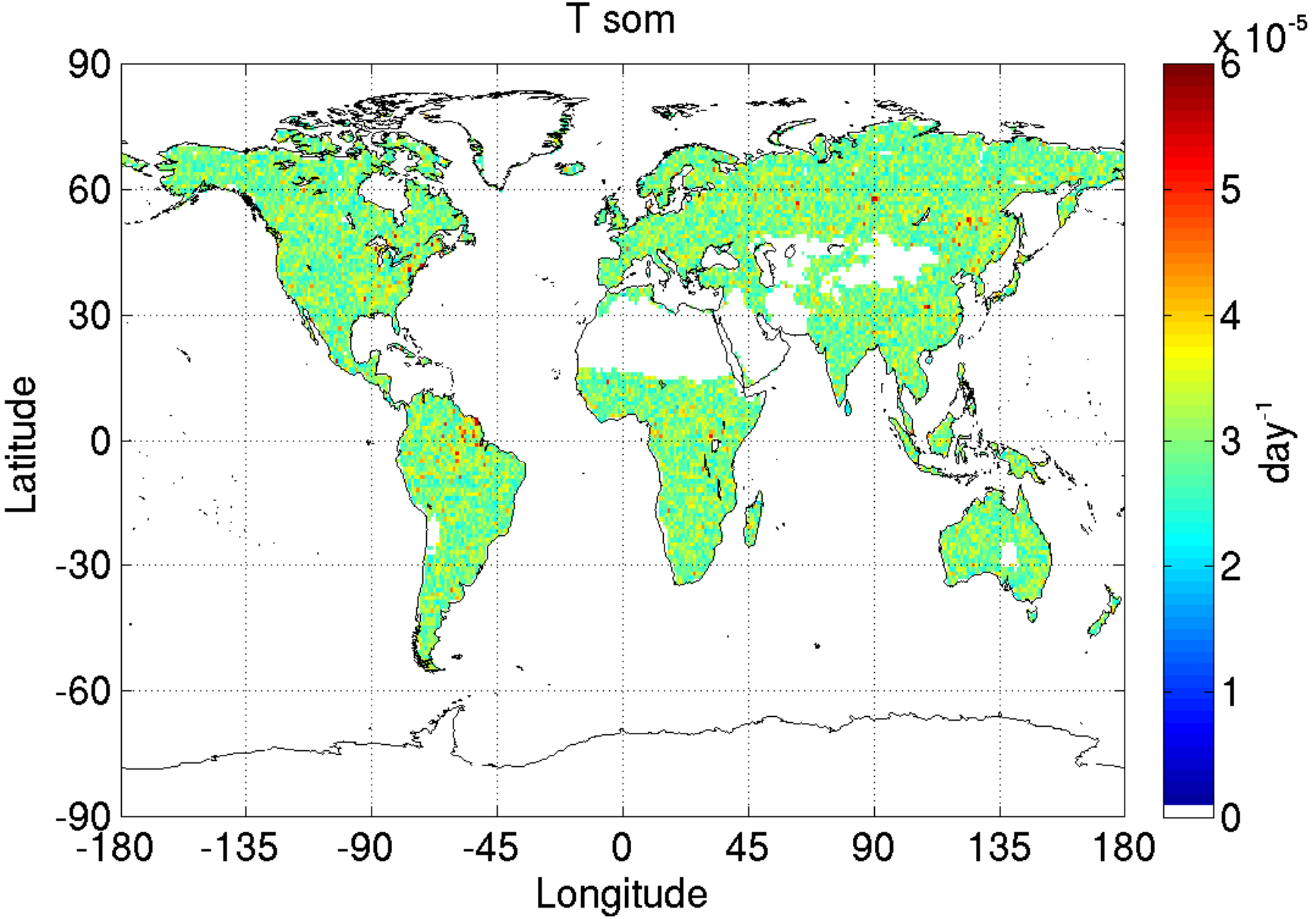
EnKF

4D-VAR

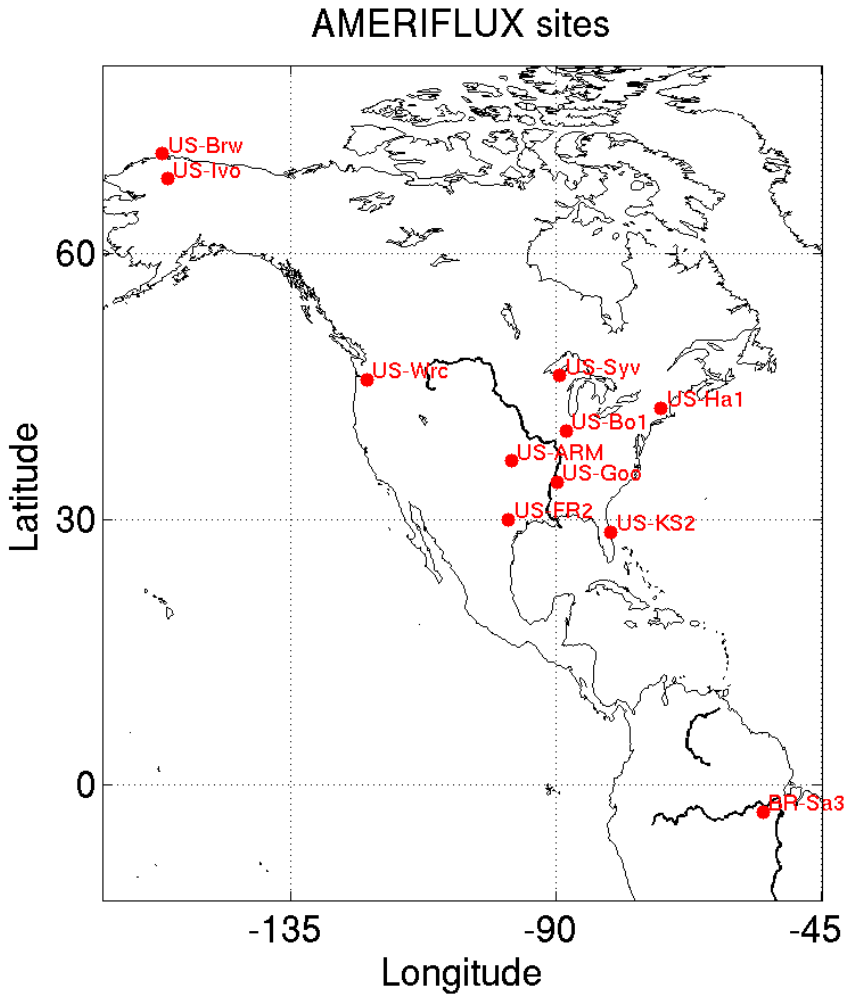

LMA
90
60
30
0
-30
-60
-90
Latitude
-180
-135
-90
-45
0
45
90
135
180
Longitude
200
150
100
50
0
gC m-2


Leaf Lifespan
Latitude
Longitude
years
90
60
30
0
-30
-60
-90
-180
-135
-90
-45
0
45
90
135
180
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0


Leaf Onset Day
Latitude
90
60
30
0
-30
-60
-90
-180
-135
-90
-45
0
45
90
135
180
Longitude
300
250
200
150
100
50
0
d.o.y.


T som
x 10^-5
6
5
4
3
2
1
0
day^-1
90
60
30
0
-30
-60
-90
Latitude
-180
-135
-90
-45
0
45
90
135
180
Longitude

Testing Parameter estimation at 10 AmeriFlux Sites



Testing DALEC & ecological/dynamical constraints

Biomes: Tropical, Sub-tropical, Temperate, Arctic.

Plant Functional Types: Forests, Crops, Grasslands, Shrublands, Woody Savanna.

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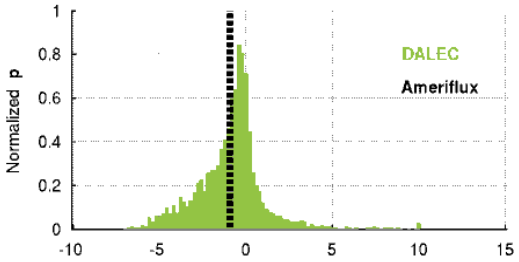
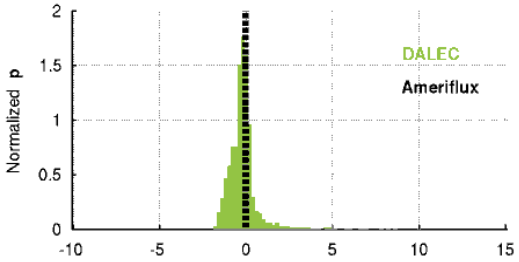
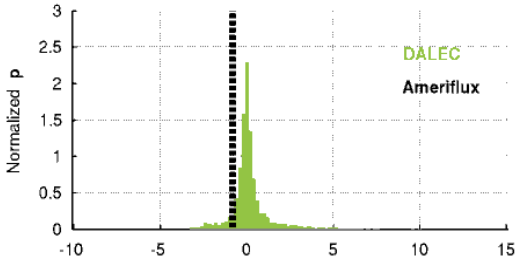
Evergreen Broadleaf



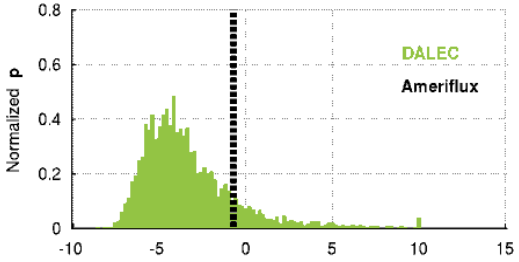
Open Shrubland



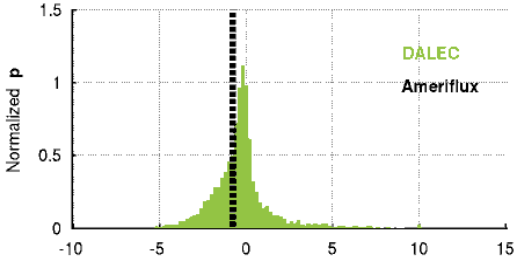
Woody Savanna



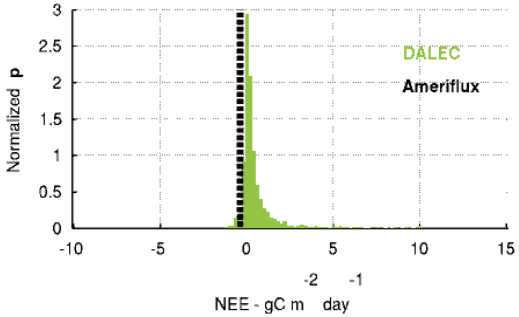
Closed Shrubland



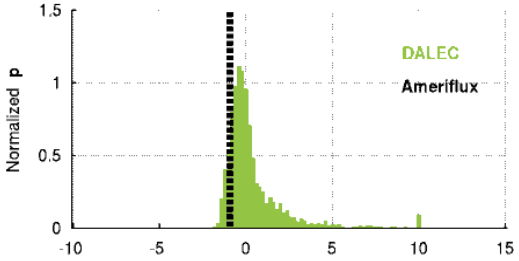
Deciduous Broadleaf



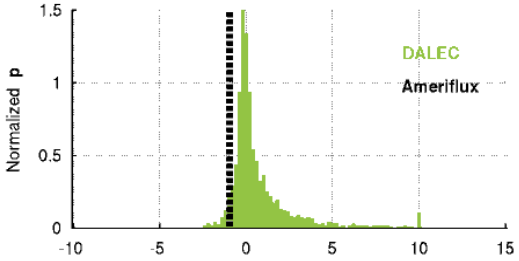
Cropland



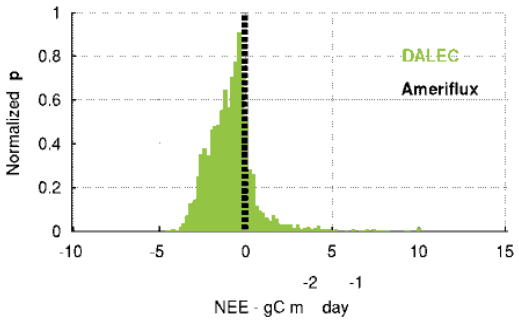
Cropland



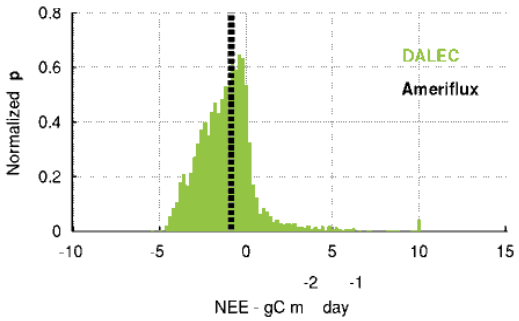
Grassland



Mixed Forest



Evergreen Needleleaf



AmeriFlux
DALEC

Bias
-0.7 – 1.7 gC m^{-2} day^{-1}
RMSE
1.1-2.8 gC m^{-2} day^{-1}

*excluded US-KS2

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