# Evaluation of Fire Parameterizations in CLM-CN and Its Climatic Impact

**Ying Sun and Robert E. Dickinson**

*Department of Geological Sciences*
*Jackson School of Geosciences*
*The University of Texas at Austin*

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# Outline

1. Motivation
2. Approaches
3. Experiment Design
4. Results
5. Summary

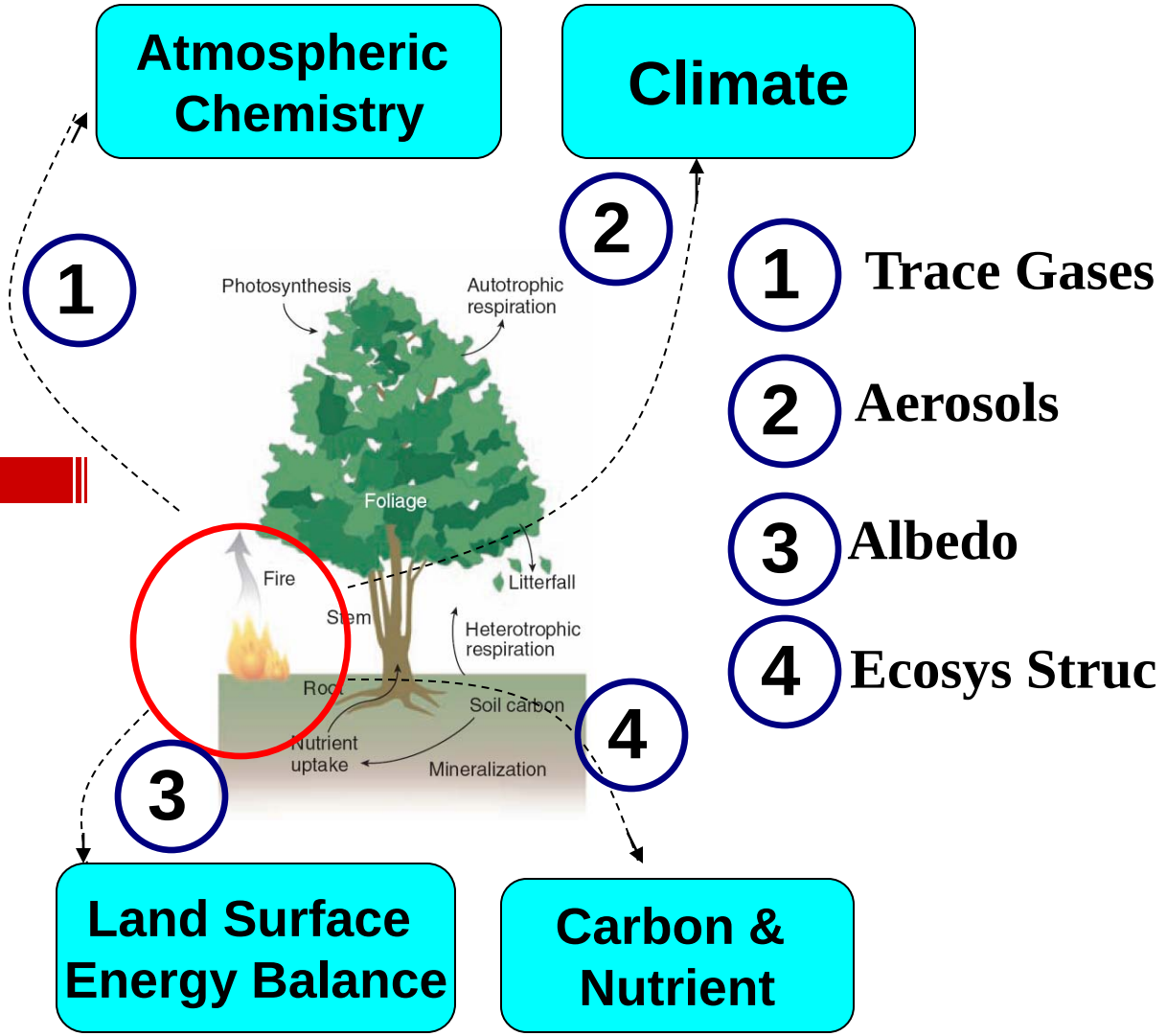
# Outline

# Motivation

Terrestrial Ecosystem

Coupled Climate-Carbon Cycle Models

Global Change Prediction



# Outline

# Approach

## Fire Occurrence Probability

$$P(m) = \exp[-\pi \cdot (\frac{m}{m_e})^2]$$

## Area Burned

$$A(s) = s \cdot f(s)$$

$$f(s) = \exp(\frac{s'}{a \cdot s'^3 + b \cdot s'^2 + c \cdot s' + d})$$

**Minfuel = 100 gC/m²**

**A.**

**Statistical Scheme (Thonicke et al, 2001)**

**LPJ-DGVM**

***Pros: 1 var***

***Cons: 4 parameters***

# Approach

## Fire Occurrence Probability

$$P_f = P_b P_m P_i$$

## Area Burned

$$a(t) = \pi \frac{l}{2} \frac{w}{2} = \frac{\pi}{2} (u_p + u_b) v t^2$$

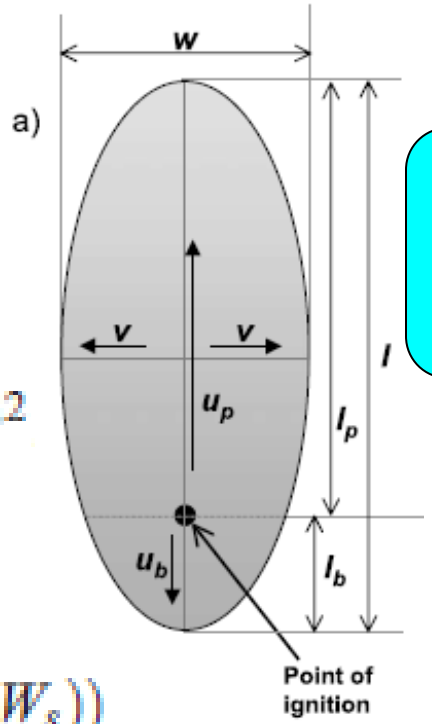
$$u_p = u_{\max} \quad g(W_s) h(\beta_{root}),$$

$$L_B = 1 + 10.0(1 - \exp(-0.017 W_s))$$

## Extinguishing Fire

$$\overline{a} = \mathbf{E}\left(a_* \tau^2\right) = a_* \frac{(1-q)(2-q)}{q^2} = a_* \Theta(q)$$

$$A = P_f \overline{a} \frac{A_g}{1000}$$




## B.

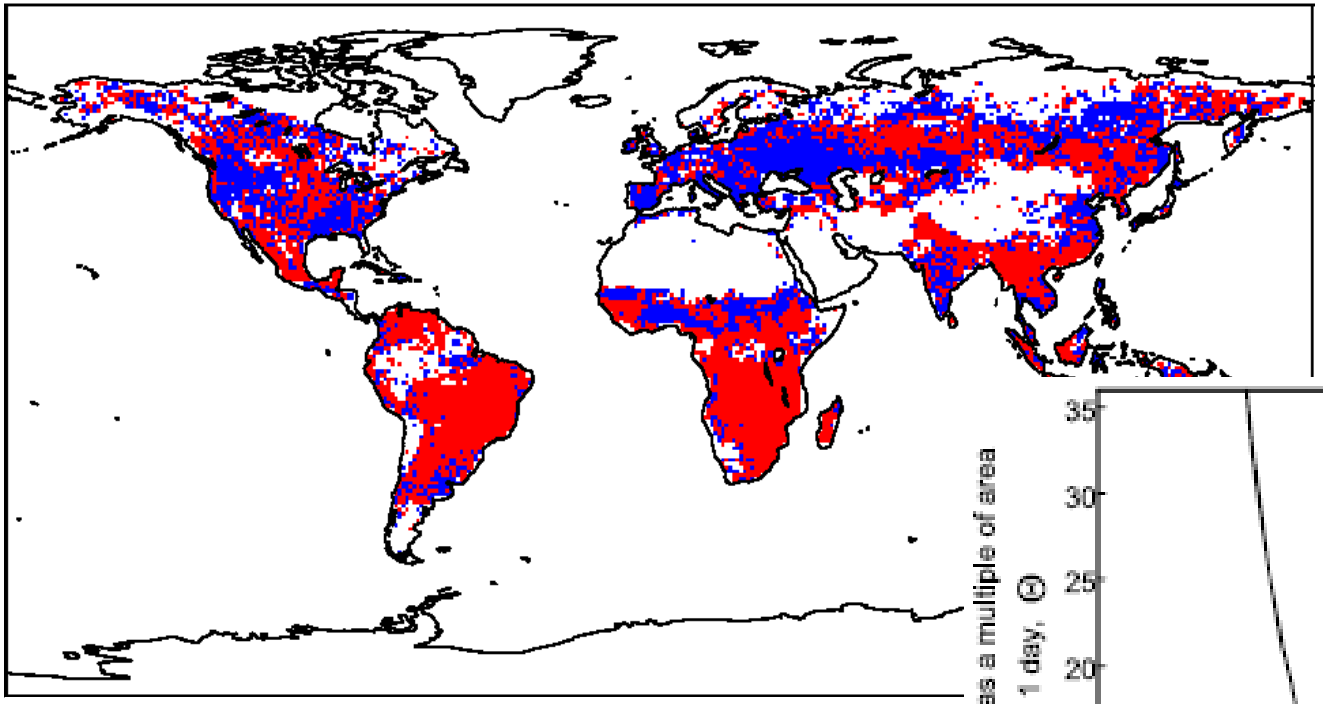
**Process-based Scheme (Arora & Boer, 2005)**

**CTEM**

***Pros: Details***

***Cons: General ??? Sensitivity***

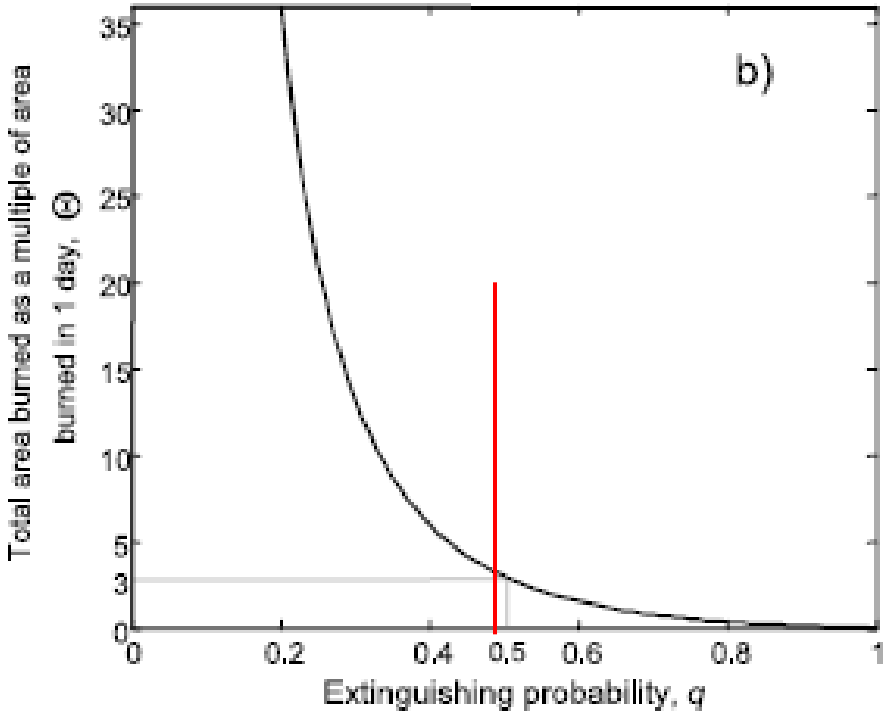
# Approach




Correlation Coefficient: Ws ~ A

**B.**

(Arora & Boer, 2005)



# Approach

## Flammability Estimation

$$F(t)_{i,j} = 10^{Z(T(t)_{i,j})}\left(1 - \frac{RH(t)_{i,j}}{100}\right) VD(t)_{i,j} \exp\left(-c_3 R(t)_{i,j}\right)$$

$$Z(T) = a\left(\frac{T_s}{T} - 1\right) + b \cdot \log\left(\frac{T_s}{T}\right) + c\left(10^{d\left(1-\frac{T}{T_s}\right)} - 1\right) + f\left(10^{h\left(\frac{T}{T_s}-1\right)} - 1\right)$$

**C.**

**Global Parameterization (Pechony & Shindell, 2009)**

**Ubiquitous Model**

### Ignition Sources

$$N_{fire} = F(I_N + I_A) f_{NS}$$

### Fire Suppression

$$f_{NS} = c_1 + c_2 \exp(-\omega PD)$$

**P: GPCPv2**
**T: NCAR/NCEP**
**LAI: MODIS**
**PD: GPWv3**

***Pros: Simple + Global***

***Cons: P ???***

# Outline

# Experiment Deign

**Statistical Scheme:**
$m_s = m/m_e$

**Global Par:**
**Flammability F**

**GFEDv2: A**

**NCEP: T**

**CLM: RH, $m_s$**

**$C_R$, W**

$$F(t)_{i,j} = 10^{z(T(t)_{i,j})} \left(1 - \frac{RH(t)_{i,j}}{100}\right) VD(t)_{i,j} \exp\left(-c_R R(t)_{i,j}\right)$$

$$\left(\frac{m}{\rho}\right)_{m_e} * w$$

**CLM-CN**

**Assume: Ubiquitous**

# Experiment Design

## Expt1: Comparison of 2 Fire modules

| Run | Fire Module | Time period |
|---|---|---|
| CN-CTL | Default (Thonicke et al, 2001) | 1997-2004 |
| CN-MOD | Reparameterization | 1997-2004 |

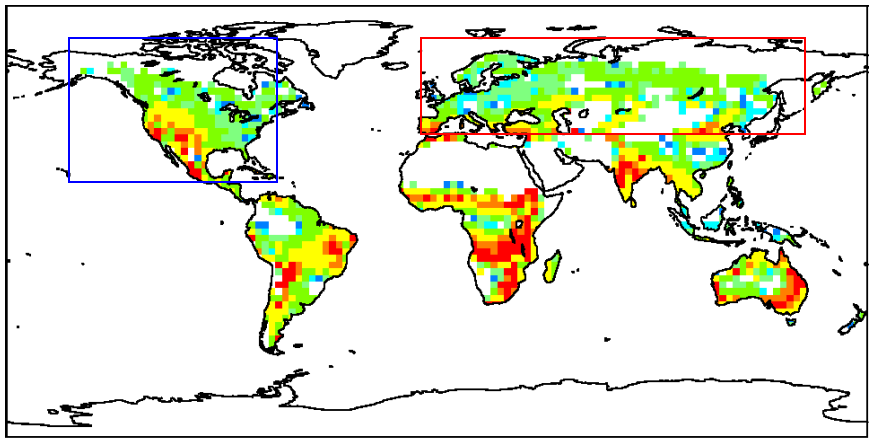
## Expt2: Sensitivity of Terrestrial and Climatic Changes to Estimated Fires

| Run | Fire Module | Time period |
|---|---|---|
| 1. CNT | ON | 1948-2004 |
| 2. DEF | OFF | 1948-2004 |
| 3. MOD1 | MODIS (scaled) | 1948-2004 |
| 4. MOD2 | MODIS | 1948-2004 |

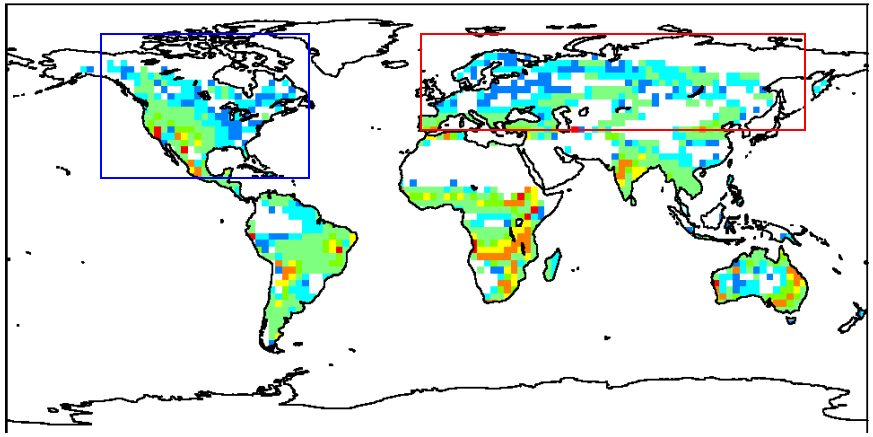
# Outline

# Results

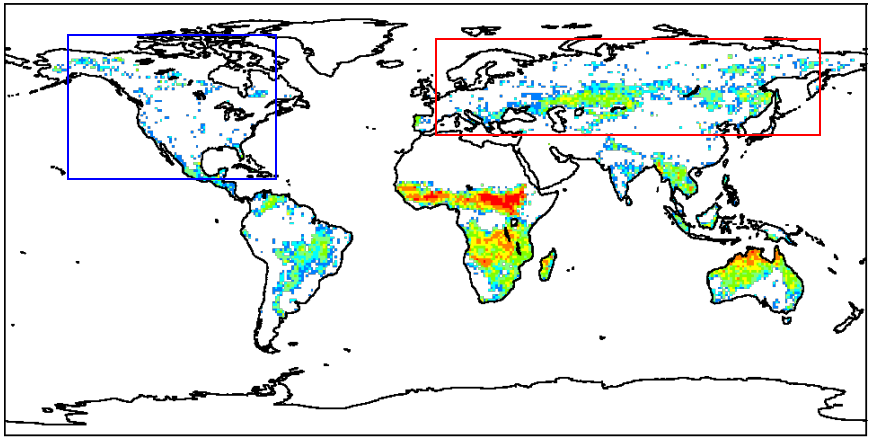
CN-CTL

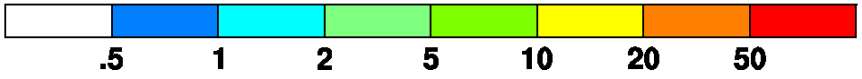


CN-MOD



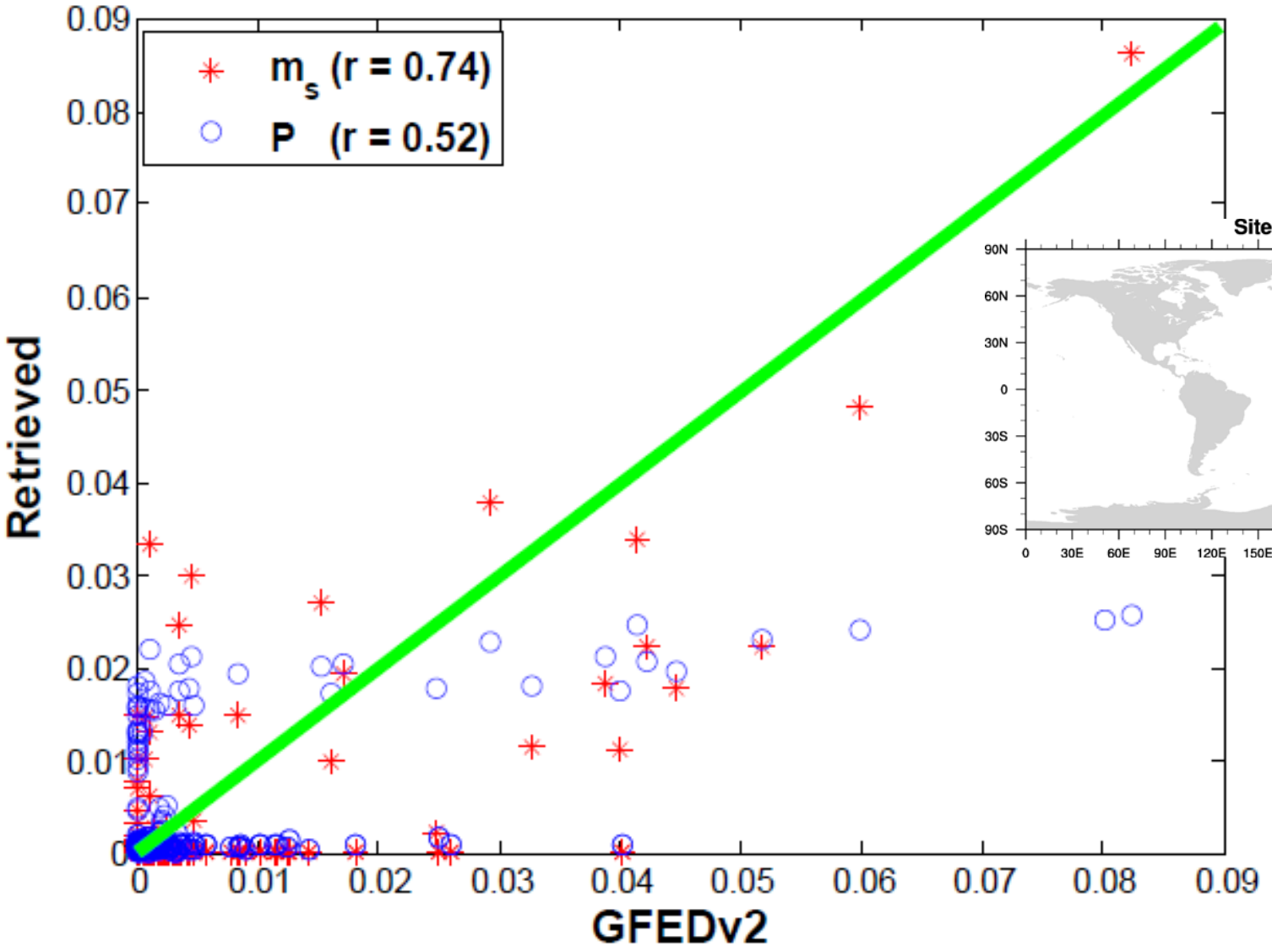
GFEDv2

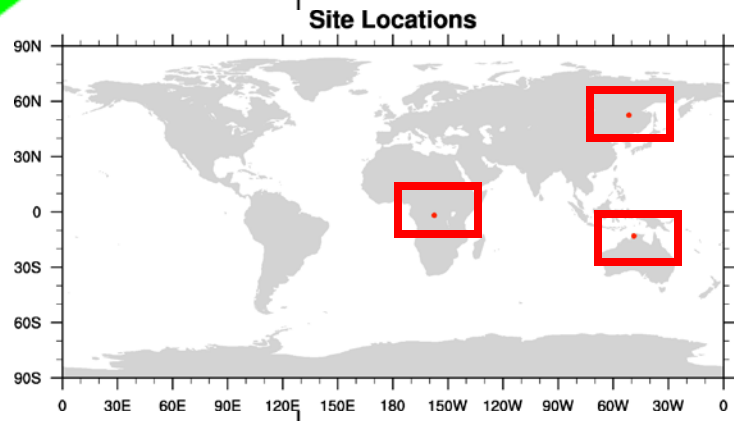




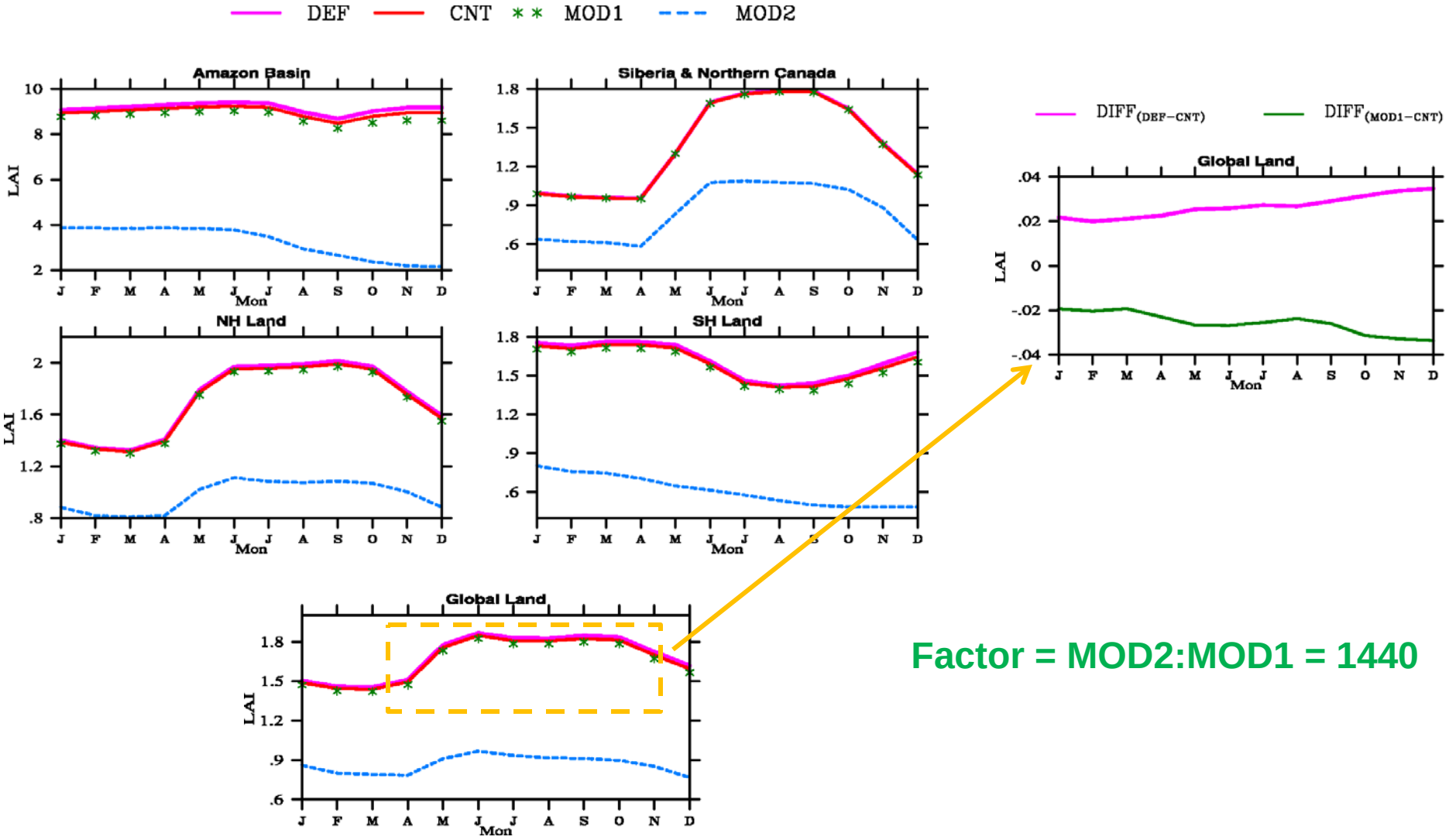

Annual Fractional Burned Area (%)

# Results


m_s (r = 0.74)
P (r = 0.52)
Retrieved
GFEDv2
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
0
0.01
0.02
0.03
0.04
0.05
0.06
0.07
0.08
0.09

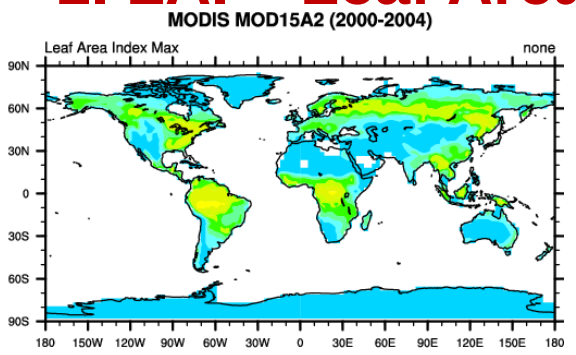

Site Locations
90N
60N
30N
0
30S
60S
90S
0
30E
60E
90E
120E
150E
180
150W
120W
90W
60W
30W
0

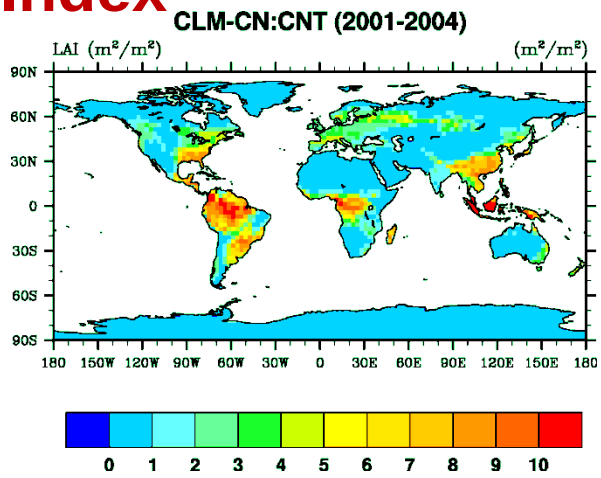
# Results

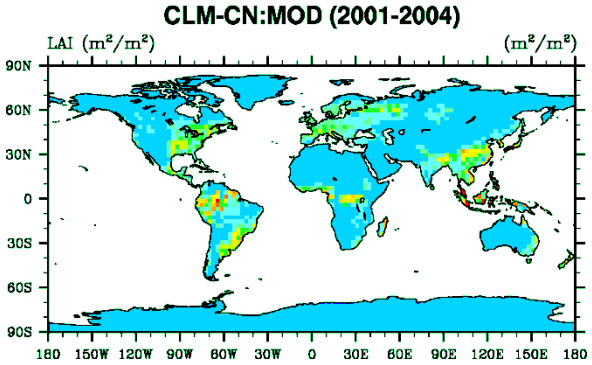

DEF
CNT
MOD1
MOD2
Amazon Basin
Siberia & Northern Canada
NH Land
SH Land
Global Land
LAI
Mon
J F M A M J J A S O N D
DIFF(DEF−CNT)
DIFF(MOD1−CNT)
Global Land
Factor = MOD2:MOD1 = 1440

# Results

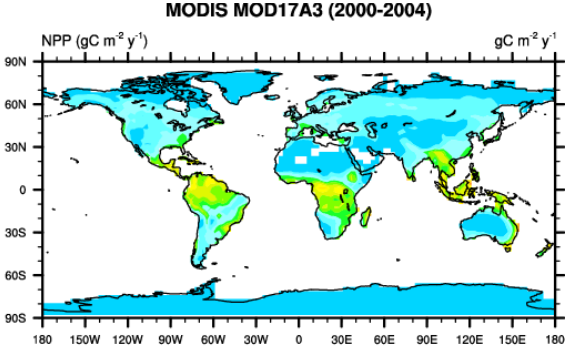
## 1. LAI – Leaf Area Index

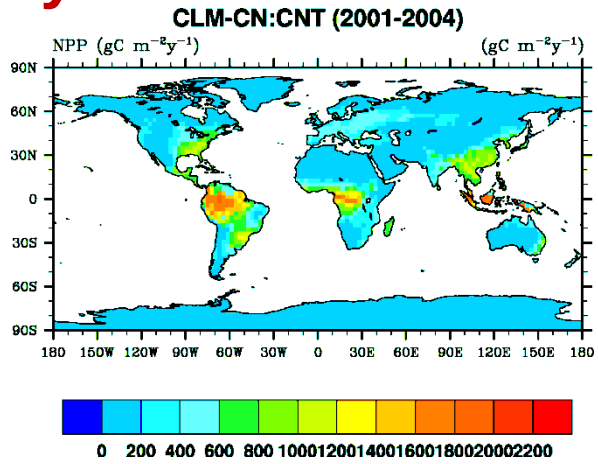


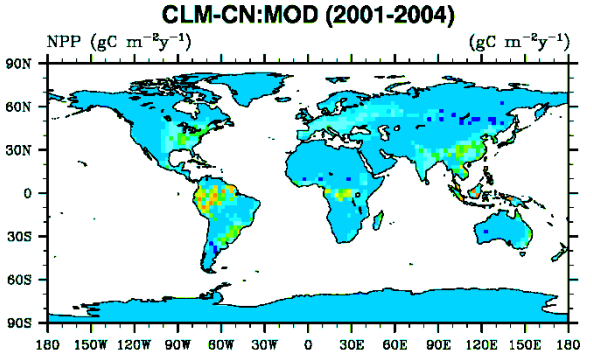




## 2. NPP – Net Primary Production

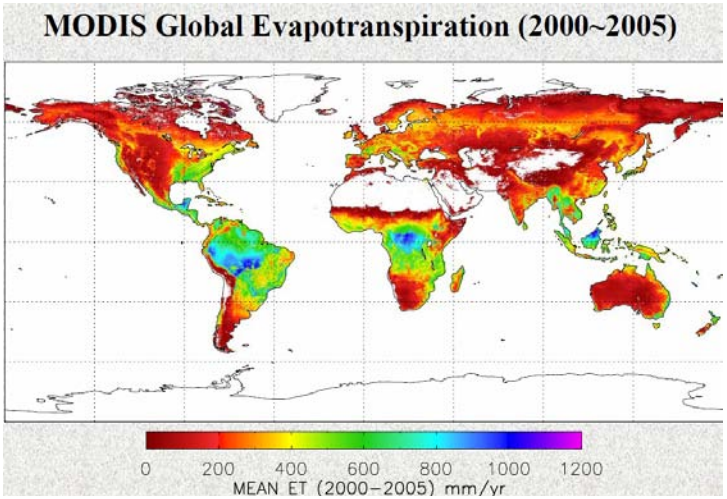


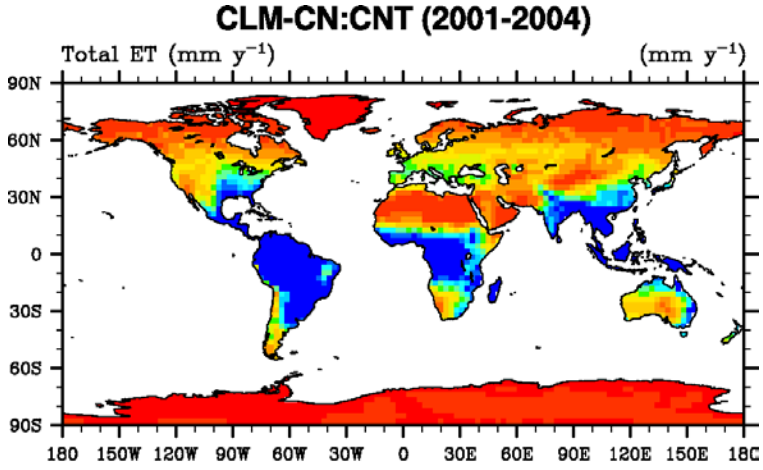



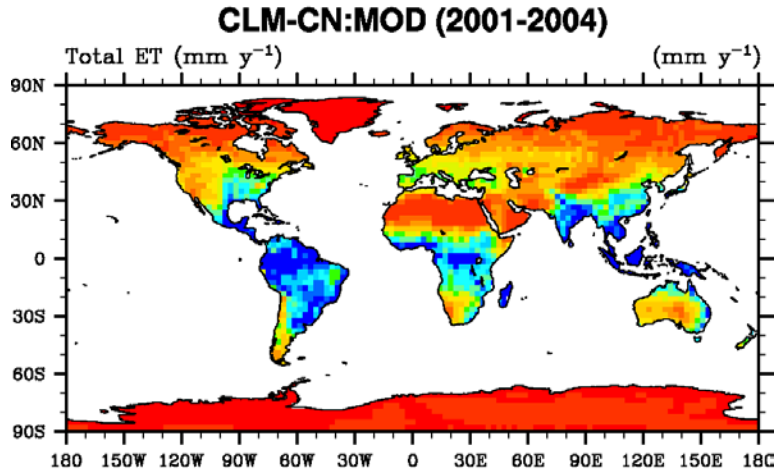
# Results

## 3. ET – Evaptranspiration




(Zhao, 2007)

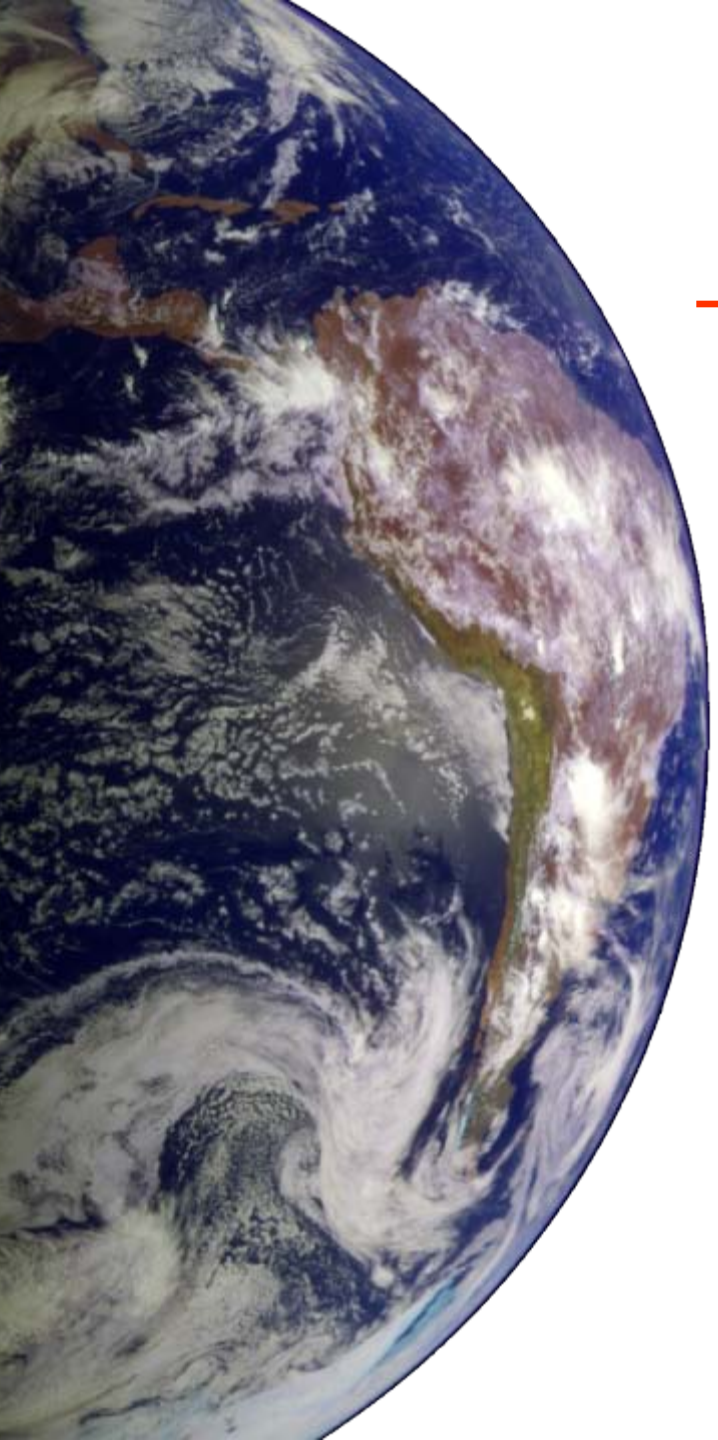



# Outline

# Future Work

- ✓ Transient Simulation
  - ✓ Deforest Fires
    - ✓ Anthropogenic Influence
      - ✓ Ignition Distribution
        - ✓ Fire Activity ~ ENSO



# Acknowledgements

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## Thank you for attention!

## Questions and Comments?