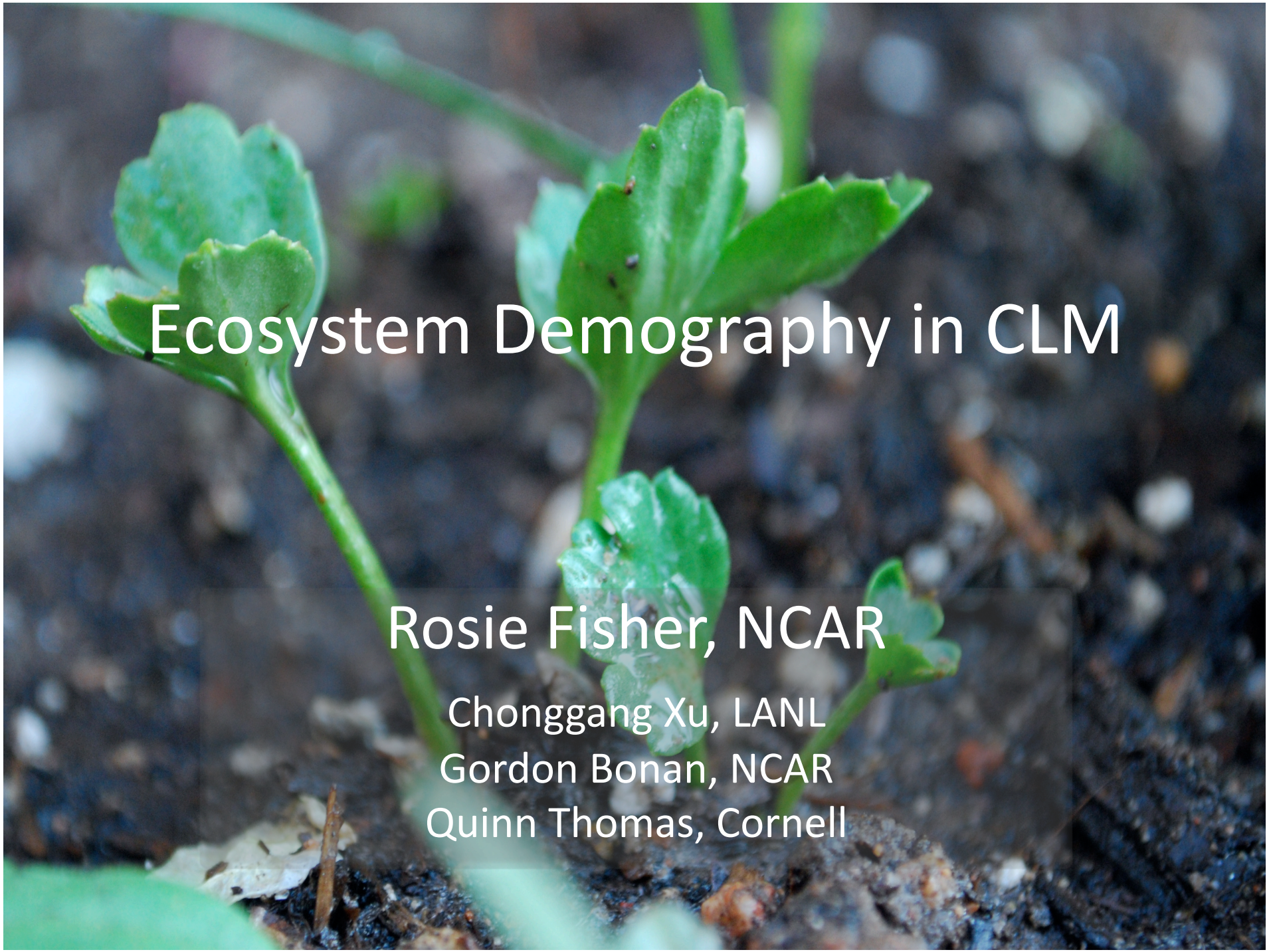


Ecosystem Demography in CLM

Rosie Fisher, NCAR

Chonggang Xu, LANL

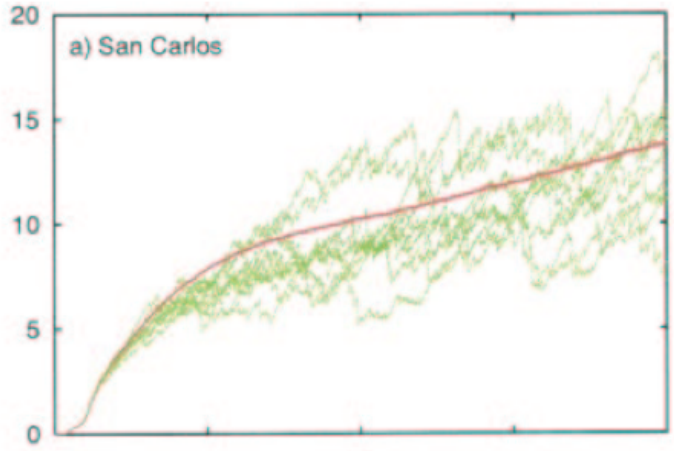
Gordon Bonan, NCAR

Quinn Thomas, Cornell

A METHOD FOR SCALING VEGETATION DYNAMICS: THE ECOSYSTEM DEMOGRAPHY MODEL (ED)

P. R. MOORCROFT,[1,3] G. C. HURTT,[2] AND S. W. PACALA[1]

By conditioning appropriately on the occurrence of these events, we derive a size- and age-structured (SAS) approximation for the first moment of the stochastic ecosystem model. With this approximation, it is possible to make predictions about the large scales of interest from a description of the fine-scale physiological and population-dynamic processes without simulating the fate of every plant individually.



$$\underbrace{\frac{\partial}{\partial t}p(a,t)}_{\text{change in age structure}} = \underbrace{-\frac{\partial}{\partial a}p(a,t)}_{\text{aging}} \underbrace{-\lambda(a,t)p(a,t)}_{\text{disturbance}}$$

$$\underbrace{\frac{\partial}{\partial t}n(\mathbf{z},\mathbf{x},a,t)}_{\text{change in plant density}} = \underbrace{-\frac{\partial}{\partial z_s}[g_s(\mathbf{z},\mathbf{x},\bar{\mathbf{r}},t)n(\mathbf{z},\mathbf{x},a,t)]}_{\text{growth in stem}}$$

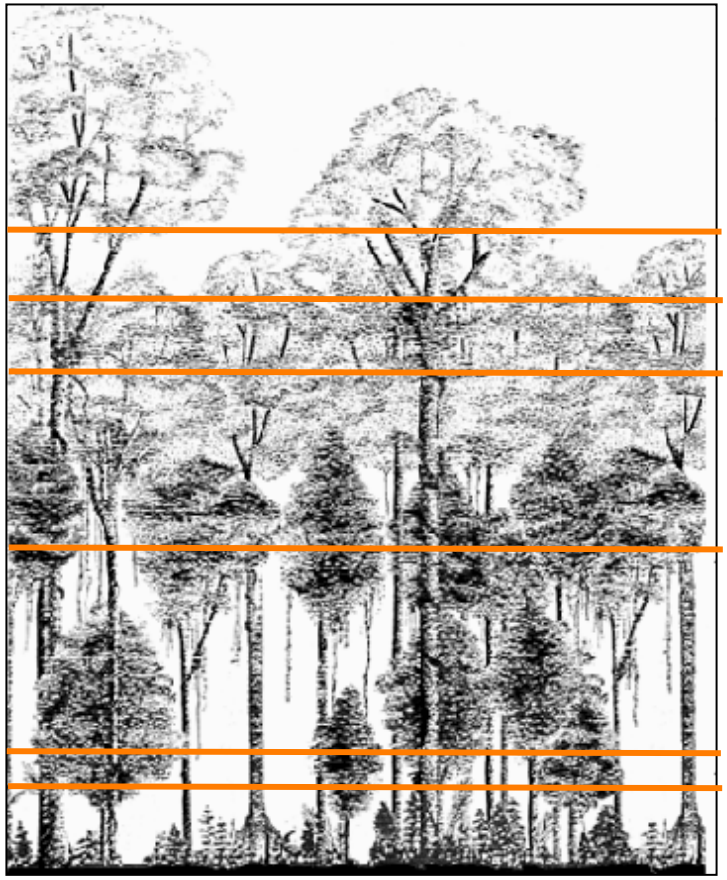
$$\underbrace{-\frac{\partial}{\partial z_a}[g_a(\mathbf{z},\mathbf{x},\bar{\mathbf{r}},t)n(\mathbf{z},\mathbf{x},a,t)]}_{\text{growth in active tissue}}$$

$$\underbrace{-\frac{\partial}{\partial a}n(\mathbf{z},\mathbf{x},a,t)}_{\text{aging of plant commumity}}$$

$$\underbrace{-\mu(\mathbf{z},\mathbf{x},\bar{\mathbf{r}},t)n(\mathbf{z},\mathbf{x},a,t).}_{\text{mortality}}$$

Ecosystem Demography Model (ED)

Moorcroft, Hurtt and Pacala. (2001)



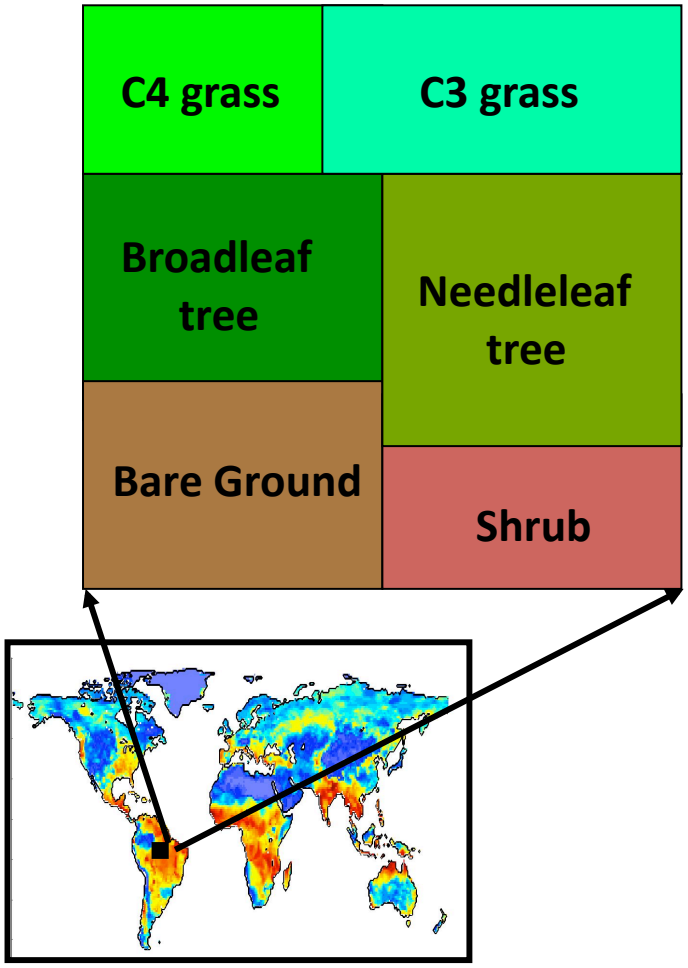
Population represented by set of 'average representative individuals' or cohorts.

They represent all trees of similar
1. PFT.
2. Height.
3. Successional stage.

CLM concepts of sub-grid tiling

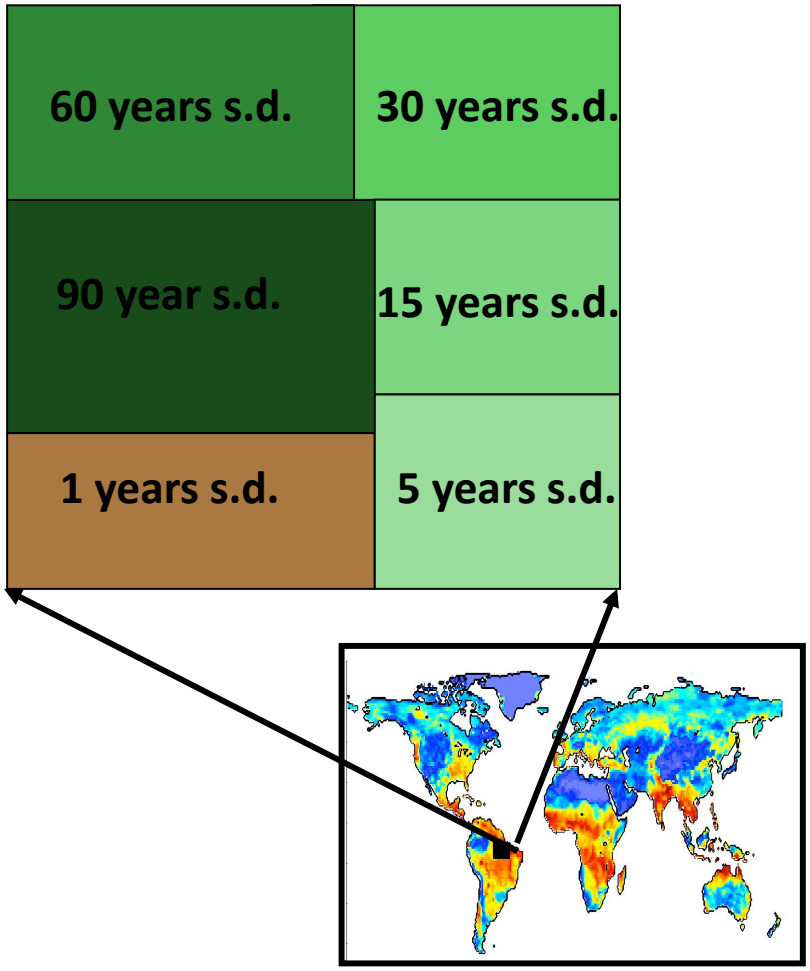
PFT-based structure.

clm3%l%g%c%p%... where P = PFT



Age-since-disturbance (s.d.) structure.

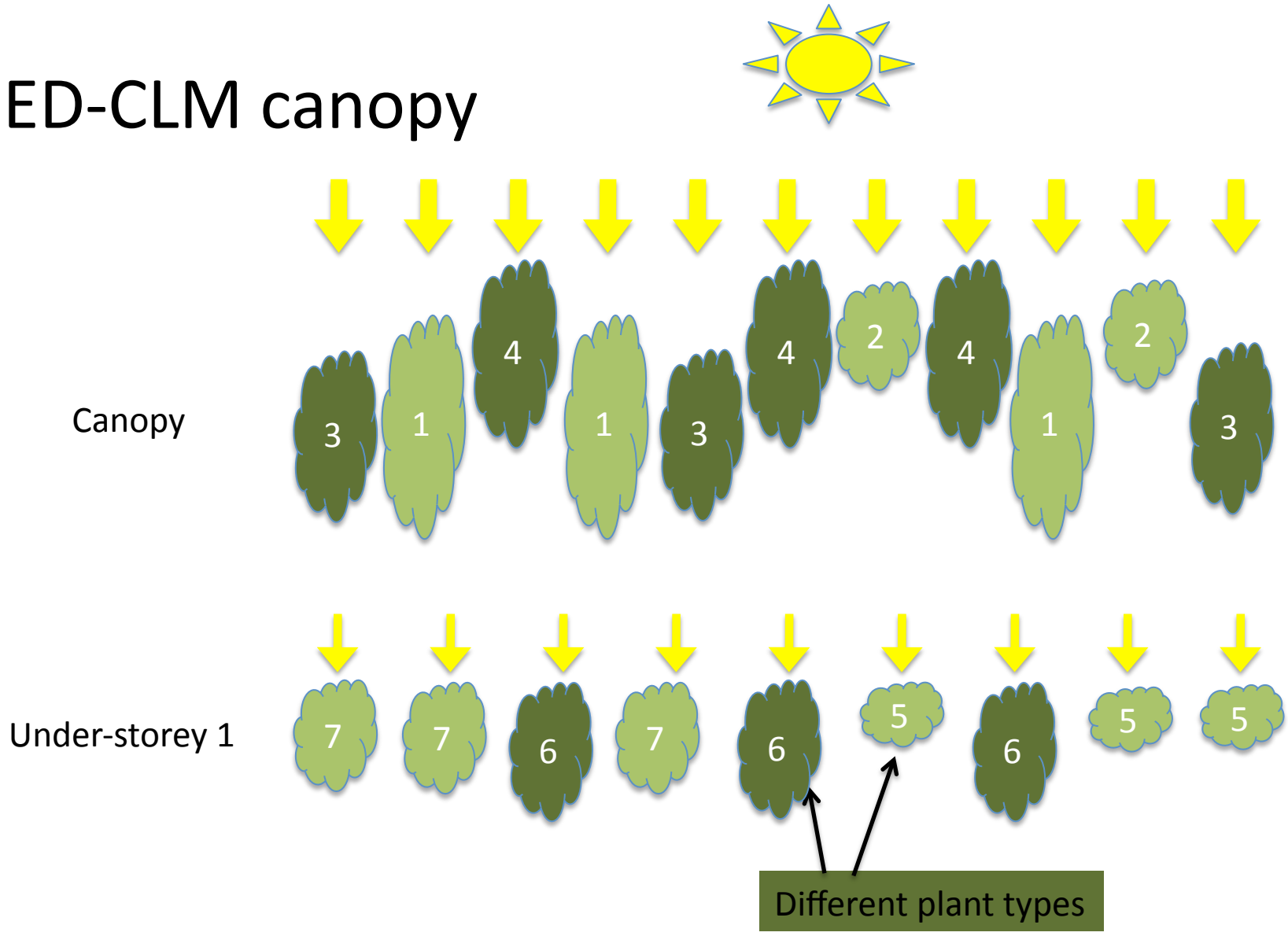
clm3%l%g%c%p%... where P = PATCH



Key modifications to original ED1 model

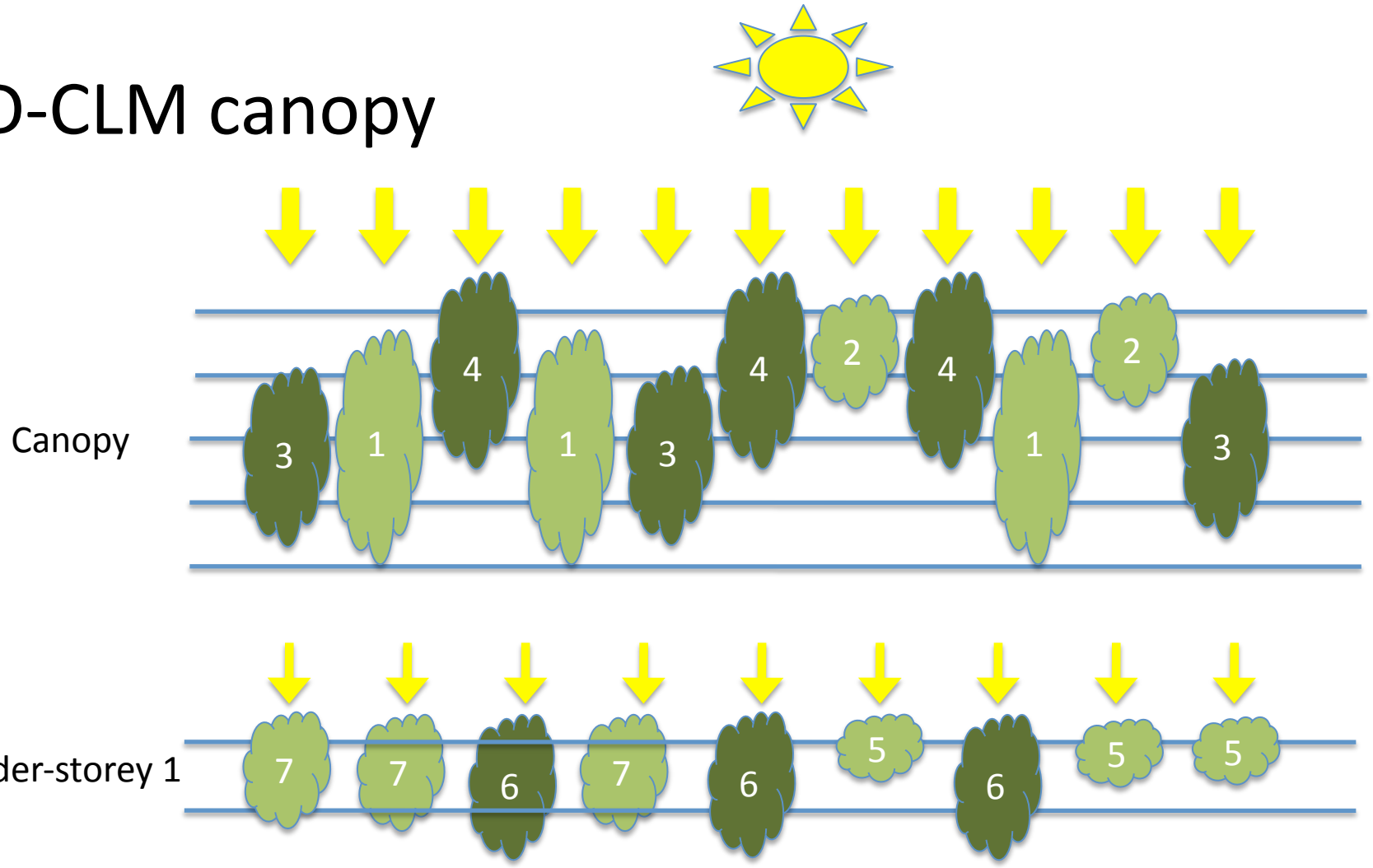
- 1. Consideration of space
  - Original model has no concept of space occupied by tree canopies.
  - Leads to overfilling of area and too much biomass.
  - Modified to include canopy/under-storey dynamics
- 2. Parameterization of co-existence
  - How tall do you have to grow to get in the canopy?
  - Do height differences make a big difference (deterministic) or a small difference (neutral theory) to success?
  - Fisher et al. (2010)
- 3. Leaf optimisation

ED-CLM canopy



Positions are for diagrammatic purposes only.
There is no concept of the spatial location of individual trees

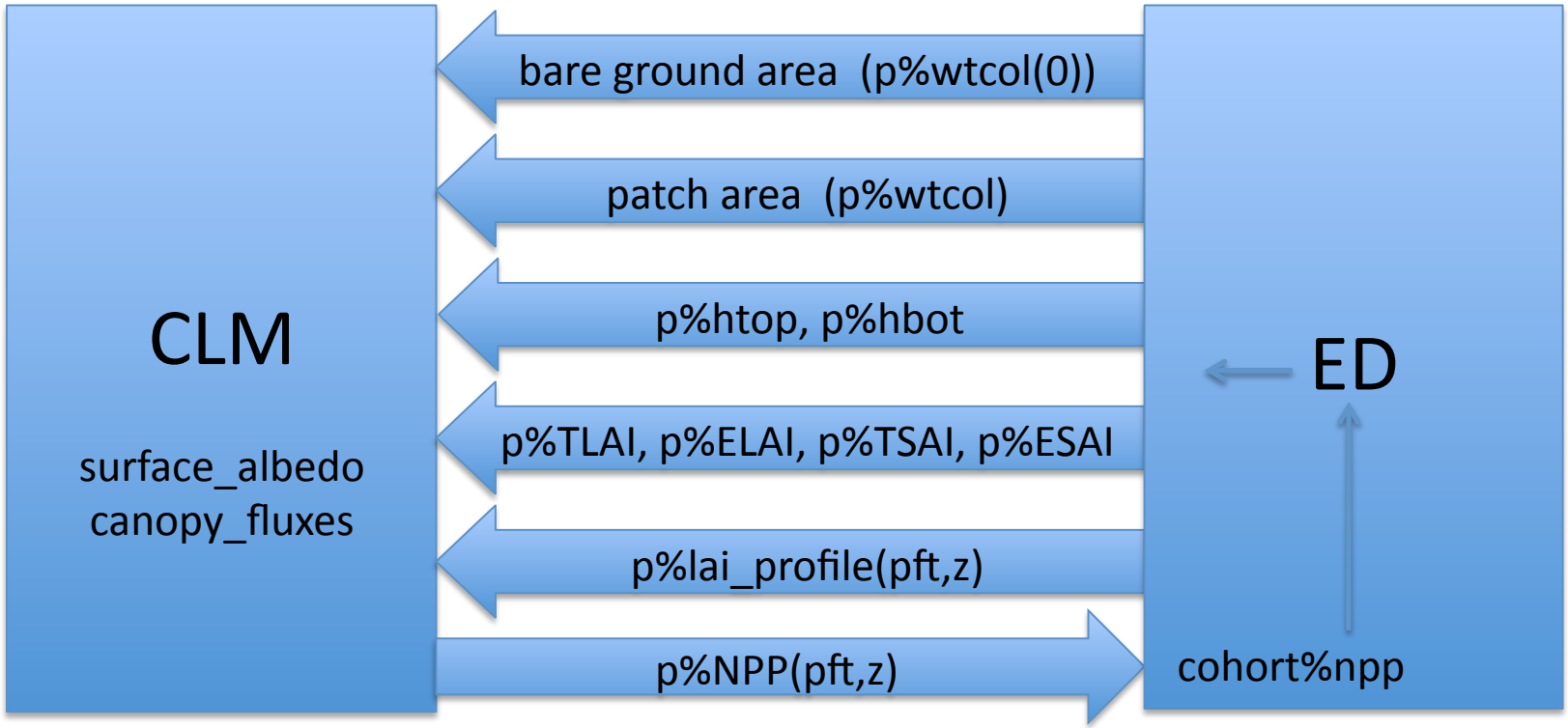
ED-CLM canopy



Canopy model repeated in each patch
Different PFTs exist in the same canopy
Each PFT can have cohorts of different height
Leaf properties vary with canopy depth

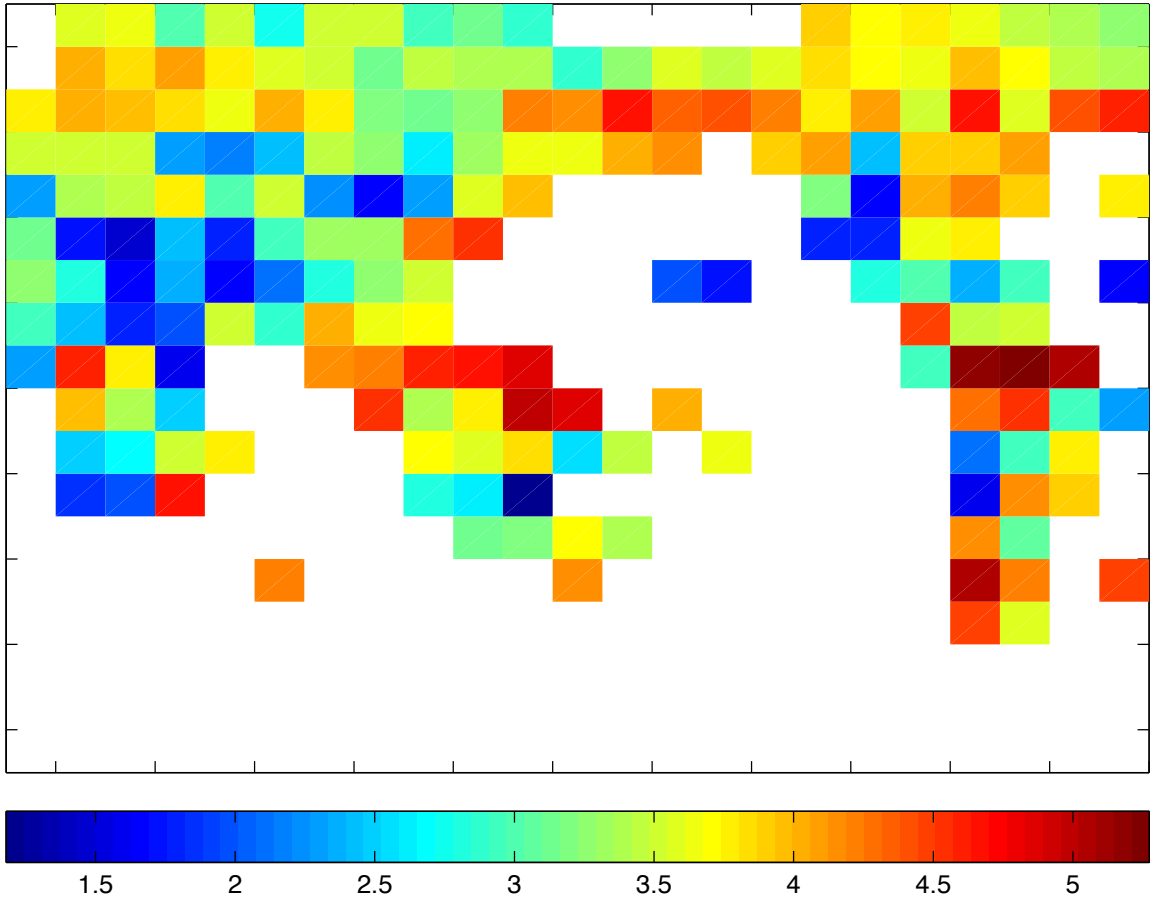
→ NPP (PFT , layer , sun/shade)

ED-CLM code structure

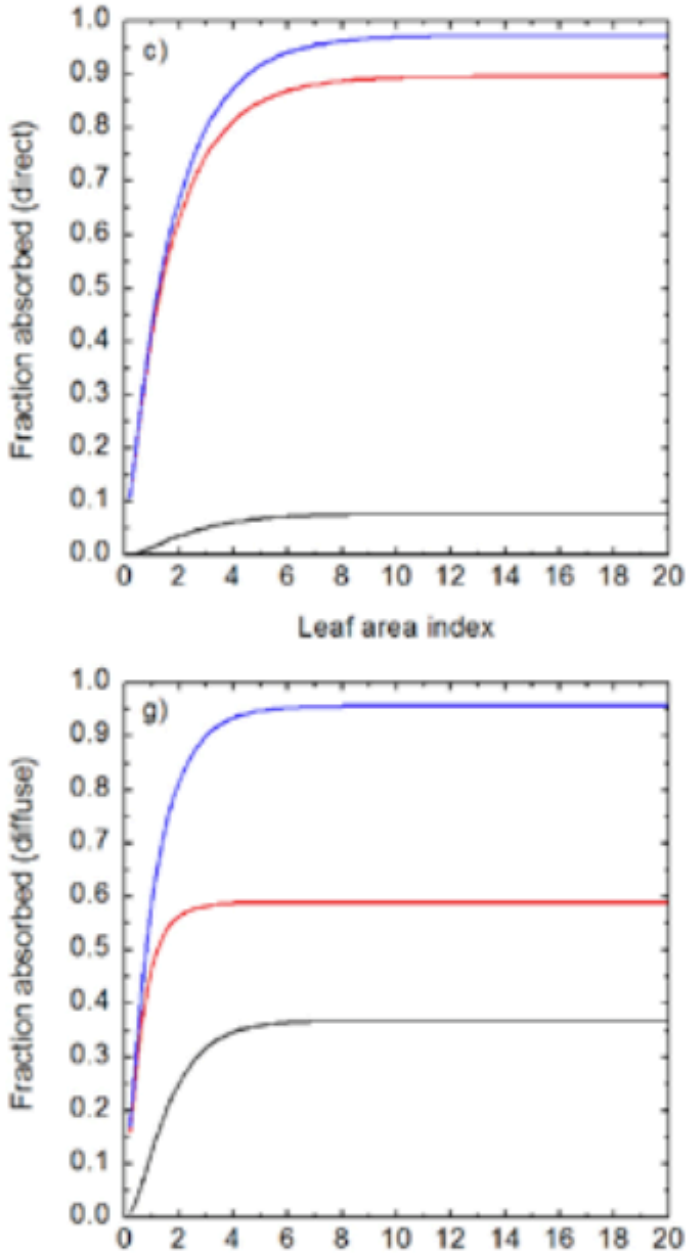


Daily exchange of NPP and canopy structure

EDCLM leaf area index @ 10 x 10 degrees



Output generated using Beers Law canopy simplifications



Canopy model

- Direct and Diffuse Radiation streams
- Sunlit and Shaded leaves
- At each canopy layer
- For each plant functional type
- Last part of connection between photosynthesis and demography model.
- Slow timescale components of ED running fine with proscribed NPP

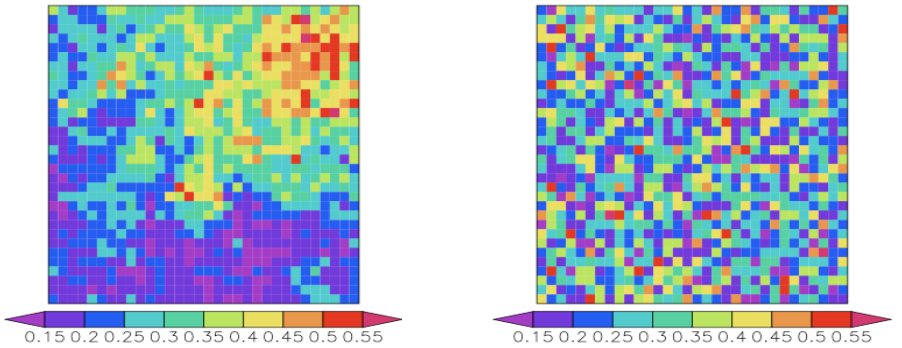
Bonan et al. 2011

Plans and collaborations for ED-CLM

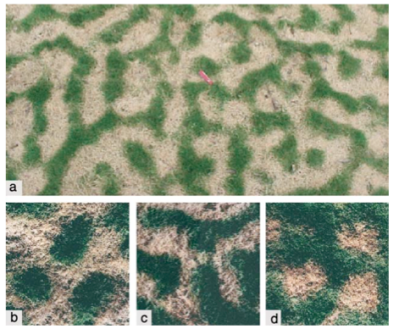
- 1. The plan: ED will be an option in the next release of CLM(4.5)
- 2. Inclusion of Nitrogen limitation
  - Based on CLM-CN + modifications (N store, mineralization, dynamic foliar N) cx@lanl, rqt@cornell, sz@mpi etc..
- 3. Introduction of migration and seed bank (cx@lanl, el@mit).
- 4. Land-use change – primary, secondary, pasture (cx@lanl)
- 5. Standing dead biomass (cx@lanl)
- 6. Wind-induced mortality (jqc@lbnl)
- 7. Optimal allocation scheme (rqt@cornell, er@mbl)
- 8. SPITFIRE fire simulation
- 9. Benchmarking
  - ILAMB/CLAMP2 benchmark data – FLUXNET, biomass, light response curves
  - FIA data (pw@lanl, dp@microsoft)
  - RAINFOR mortality datasets (Borneo and Amazonia pm@edinb)
  - Manipulation data (INTERFACE & tropical plots)
  - Satellite derived mortality data (sg,pw,cx,nm@lanl, sr@montana)

Some Unresolved Ecology

- 1. Sub-grid patterning and inter-patch movement of water, nutrients, energy, fire, seeds, etc.



- 2. Spatial heterogeneity in soil resources (is competition symmetric or not?)



- 3. How much do resource and recruitment competition affect diversity?