



CLM(ED)

Structure, key science features
questions, plans

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Contents

- Software and Code updates
- Science Updates
- Tentative Output
- Planning

Software & Code

ED code statistics

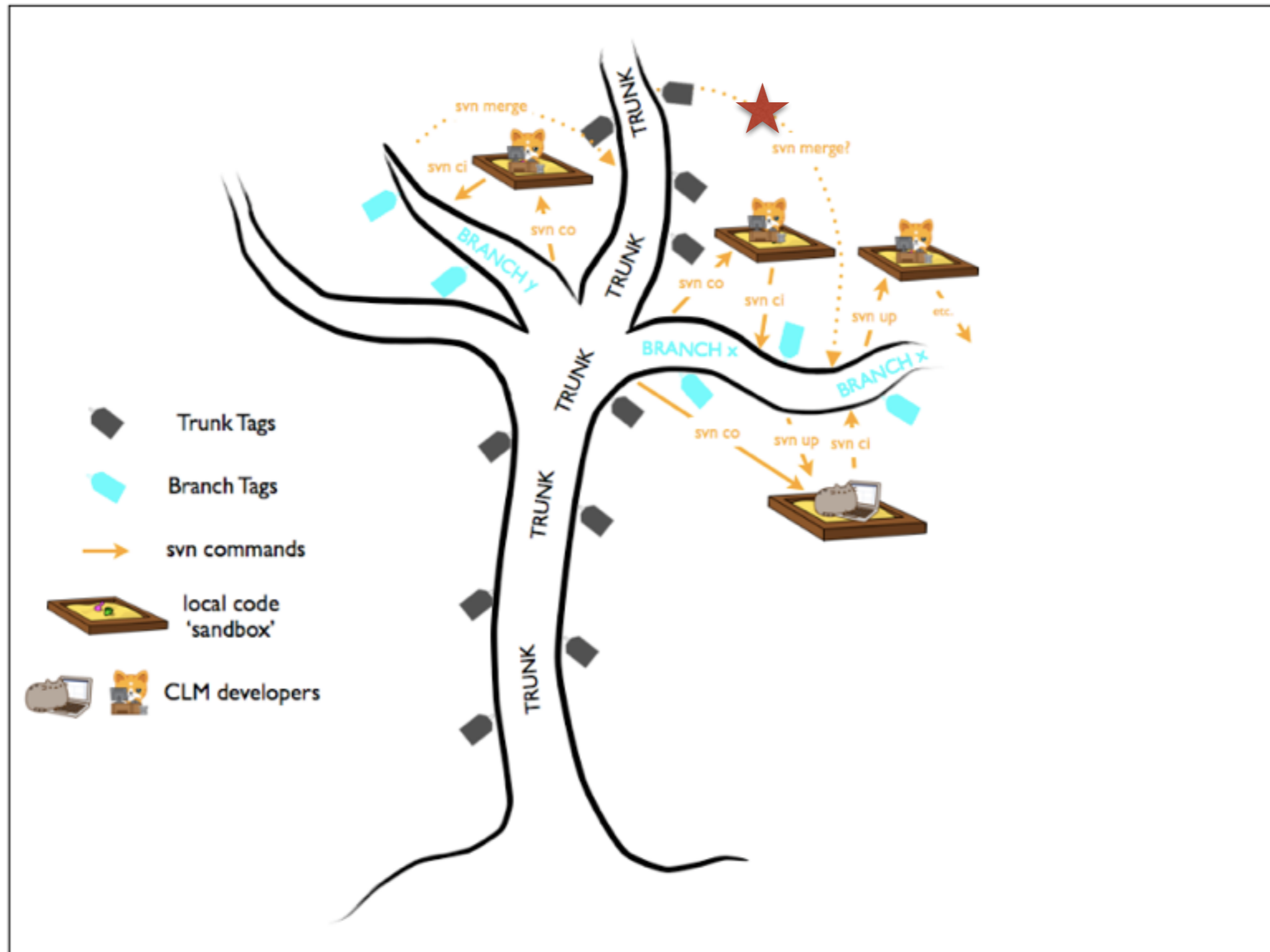
- ED model is called in `clm_driver` and `clm_initialize`
- 12 extra files... (ED*)
- 7995 lines of code in (ED*) files
- In addition, there are 700 lines of new code in `Surface Albedo` & 800 lines of new code in `Canopy_Fluxes`
- All parts of ED can be deactivated by the `use_ed` flag

Where does ED live?

```
rfisher /glade/u/home/rfisher/svn/EDMERGE/EDMERGE_feb21/models/lnd/clm/src/clm4_5/biogeochem $ ls
ch4Mod.F90                CNDEEstablishmentMod.F90    CNRestMod.F90              ED_hMod.F90
ch4RestMod.F90            CNDVLightMod.F90           CNSetValueMod.F90         EDInitMod.F90
ch4varcon.F90            CNDVMod.F90                CNSharedParamsMod.F90    EDMainMod.F90
CNAllocationMod.F90      CNEcosystemDynMod.F90      CNSoilLittVertTranspMod.F90  EDPParamsMod.F90
CNAnnualUpdateMod.F90    CNFireMod.F90              CNSummaryMod.F90         EDPatchDynamicsMod.F90
CNBalanceCheckMod.F90    CNGapMortalityMod.F90     CNVegStructUpdateMod.F90   EDPhysiologyMod.F90
CNC14DecayMod.F90        CNGRespMod.F90            CNVerticalProfileMod.F90   EDRestVectorMod.F90
CNCIsoFluxMod.F90        CNMRespMod.F90            CNWoodProductsMod.F90     EDSPITFIREMod.F90
CNCStateUpdate1Mod.F90   CNDynamicsMod.F90         CropRestMod.F90          initch4Mod.F90
CNCStateUpdate2Mod.F90   CNNitriDenitriMod.F90     DryDepVelocity.F90       MEGANFactorsMod.F90
CNCStateUpdate3Mod.F90   CNNStateUpdate1Mod.F90    DUSTMod.F90              SFPParamsMod.F90
CNDecompCascadeBGCMo.F90  CNNStateUpdate2Mod.F90    EDCanopyStructureMod.F90  STATICEcosysDynMod.F90
CNDecompCascadeCNMod.F90  CNNStateUpdate3Mod.F90    EDCLMLinkMod.F90         VOCEmissionMod.F90
CNDecompMod.F90          CNPhenologyMod.F90        EDcohortDynamicsMod.F90
CNDVEcosystemDynIniMod.F90  CNPrecisionControlMod.F90  EDGrowthFunctionsMod.F90
rfisher /glade/u/home/rfisher/svn/EDMERGE/EDMERGE_feb21/models/lnd/clm/src/clm4_5/biogeochem $ █
```

```
rfisher /glade/u/home/rfisher/svn/EDMERGE/EDMERGE_feb21/models/lnd/clm/src/clm4_5/biogeophys $ ls
ActiveLayerMod.F90        CanopyFluxesMod.F90        H2OSfcMod.F90             SLakeHydrologyMod.F90     SurfaceAlbedoMod.F90
BalanceCheckMod.F90      clm_driverInitMod.F90      Hydrology1Mod.F90         SLakeRestMod.F90         SurfaceRadiationMod.F90
BandDiagonalMod.F90     CLMVICMapMod.F90           Hydrology2Mod.F90         SLakeTemperatureMod.F90  TridiagonalMod.F90
BareGroundFluxesMod.F90  CMakeLists.txt             initSLakeMod.F90          SNICARMod.F90           UrbanInitMod.F90
Biogeophysics1Mod.F90    DaylengthMod.F90           QSatMod.F90              SnowHydrologyMod.F90    UrbanInputMod.F90
Biogeophysics2Mod.F90    FracWetMod.F90             SLakeCon.F90             SoilHydrologyMod.F90     UrbanMod.F90
BiogeophysRestMod.F90    FrictionVelocityMod.F90    SLakeFluxesMod.F90       SoilTemperatureMod.F90
rfisher /glade/u/home/rfisher/svn/EDMERGE/EDMERGE_feb21/models/lnd/clm/src/clm4_5/biogeophys $ █
```

CLM: SVN Code Management Structure



- Revision 56048: /clm2/branch_tags/EDMERGE_tags

- ..
- [EDMERGE n00 clm4 5 19/](#)
- [EDMERGE n01 clm4 5 19/](#)
- [EDMERGE n02 clm4 5 19/](#)
- [EDMERGE n03 clm4 5 19/](#)
- [EDMERGE n04 clm4 5 19/](#)
- [EDMERGE n05 clm4 5 19/](#)
- [EDMERGE n06 clm4 5 19/](#)
- [EDMERGE n07 clm4 5 19/](#)
- [EDMERGE n08 clm4 5 19/](#)
- [EDMERGE n09 clm4 5 19/](#)
- [EDMERGE n10 clm4 5 19/](#)
- [EDMERGE n11 clm4 5 19/](#)
- [EDMERGE n12 clm4 5 35/](#)
- [EDMERGE n12 clm4 5 36/](#)
- [EDMERGE n13 clm4 5 36/](#)
- [EDMERGE n13 clm4 5 37/](#)
- [EDMERGE n14 clm4 5 37/](#)
- [EDMERGE n15 clm4 5 37/](#)
- [EDMERGE n16 clm4 5 37/](#)
- [EDMERGE n17 clm4 5 37/](#)
- [EDMERGE n18 clm4 5 37/](#)
- [EDMERGE n19 clm4 5 34/](#)
- [EDMERGE n20 clm4 5 43/](#)
- [EDMERGE n20b clm4 5 43/](#)
- [EDMERGE n21 clm4 5 43/](#)
- [EDMERGE n22 clm4 5 43/](#)
- [EDMERGE n23 clm4 5 43/](#)
- [EDMERGE n24 clm4 5 43/](#)
- [EDMERGE n24 clm4 5 48/](#)
- [EDMERGE n25 clm4 5 48/](#)
- [EDMERGE n25 clm4 5 49/](#)

EDMERGE branch...

'Trello' site: <https://trello.com/b/xCZWvJWK/cesm-clm-ed-development>

The screenshot shows a Trello board for 'CESM CLM-ED Development'. The board is organized into four columns, each representing a different category of tasks. The 'Done' column on the left contains 10 completed tasks. The 'Software Development Tasks (1st Tag)' column has 7 tasks. The 'Science tasks (1st tag)' column has 7 tasks. The 'Software Development Tasks (2nd Tag)' column has 5 tasks. A right-hand sidebar shows the board's menu, members (including SPM), and an activity log with three recent updates from user 'rosiealice1'.

Done

- New CLM parameter file
- Alter SPITFIRE parameters in new clm_params file
- Restart tests with EDSWITCH off.
- get a global resolution working with mpi-serial
- get a global res. working with MPI multiple pes.
- Divide up CLM(ED) code into a set of sensible modules.
- get rid of init_data module
- fix all indentation in ED files
- check coarse and fine root n pools add up to 1.

Software Development Tasks (1st Tag)

- Refactoring for intent of arguments
- Bit-for-bit restart tests with CLM(ED) on.
- get restarts working within CLM system
- make sure that BGC and CROP can't be combined with ED and that RTM is off if ED is on
- double check ed_init in regards to bounds_clump or bounds_proc
- make sure basic performance is reasonable (mpi and single pe)
- make scripts tag
- move all of the accumulating variables that are hard coded in ED into the main CLM accumulating module.

Science tasks (1st tag)

- Add leaf area optimization routines back in. Test for internal cycling.
- Construct a sensible depiction of stem area index
- Extend ED carbon balance checks to include litter pool dynamics
- fix tree area decline problem
- check fire rate of spread equations
- Determine how to add supplemental N to make the soil model be carbon only...
- Remove the burial code in EDCLM link.

Software Development Tasks (2nd Tag)

- clean up associate blocks
- clean up interfaces
- get ED working with openMP
- add additional ED tests for CLM and CESM tests.
- Complete tech note.
- Complete programmers guide
- Turn off the now redundant two-stream calculations in surface albedo.

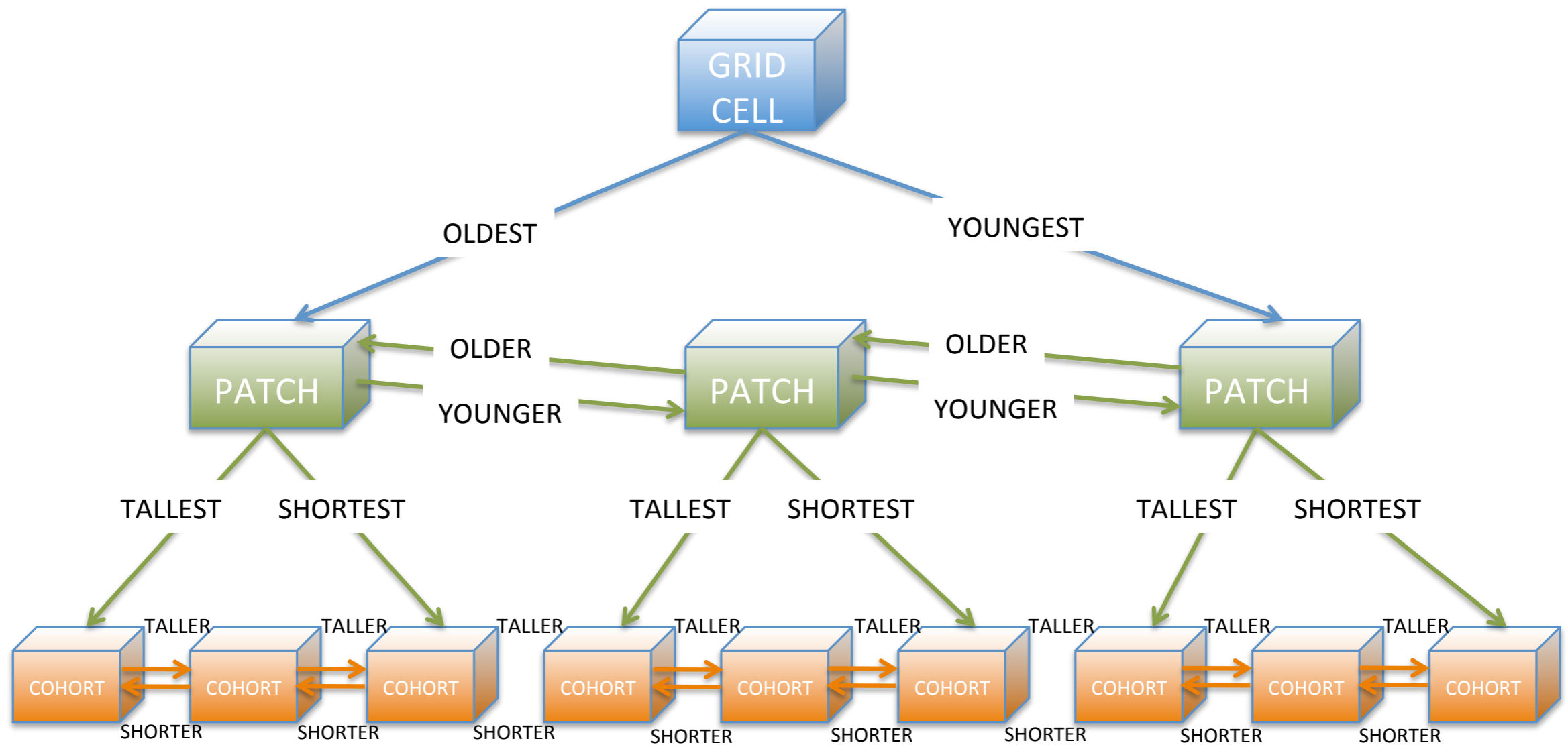
Members

- SPM

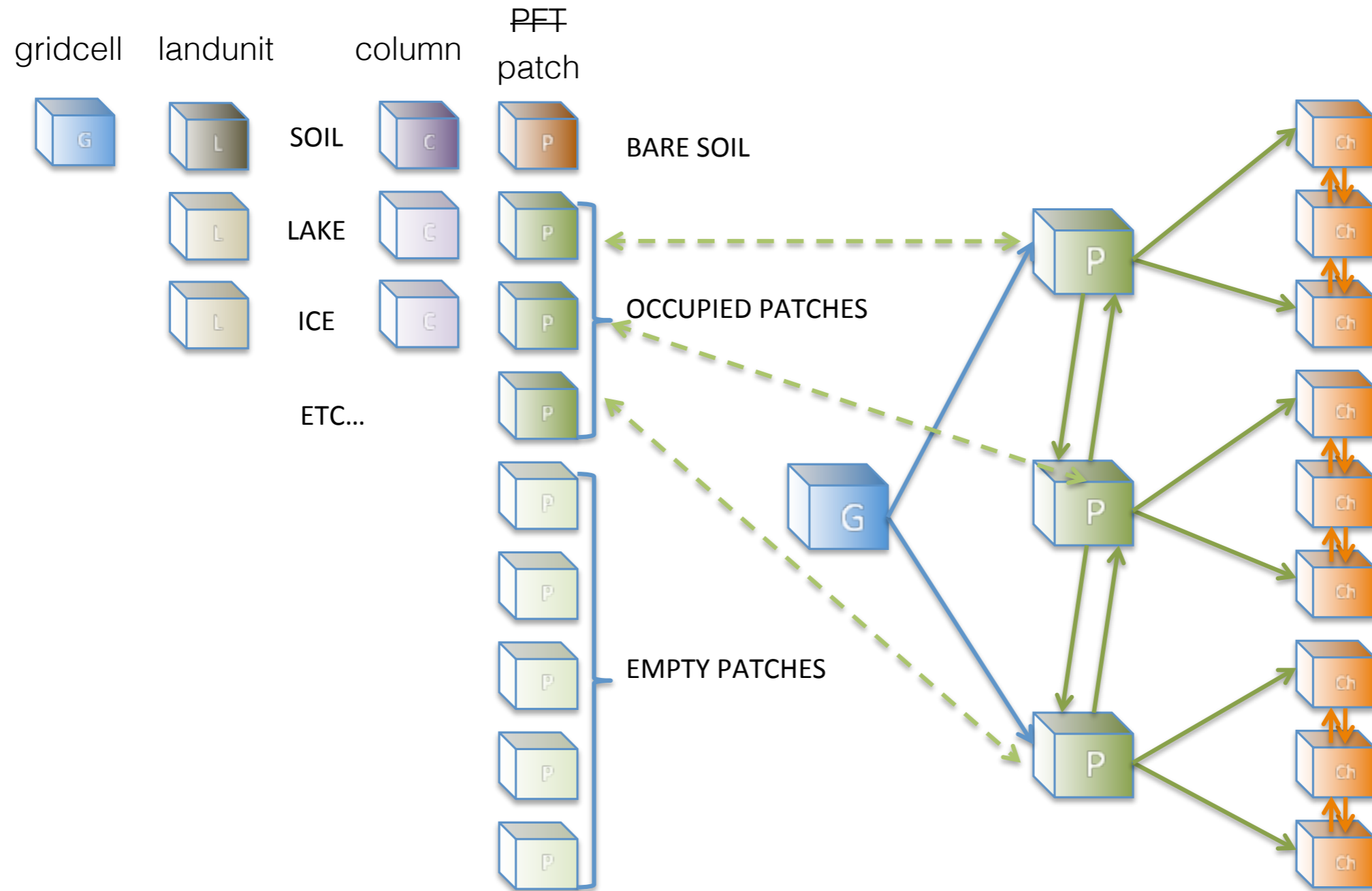
Activity

- rosiealice1 added **Remove the burial code in EDCLM link.** to Science tasks (1st tag). Dec 13 at 4:21 pm
- rosiealice1 added **Determine how to add supplemental N to make the soil model be carbon only...** to Science tasks (1st tag). Dec 13 at 3:44 pm
- rosiealice1 on **Energy balance closures for post-fire systems.**

ED data structure



CLM(ED) data structure.



Scientific Content

adventures in model structure space

Science Features

- Gas exchange (CLM4.5 multi-layer psn; Collatz & Ball-Berry/Medlyn/Lloyd)
- Radiation scheme
- Canopy Structure
- Carbon partitioning
- Leaf area optimization
- Mortality
- Crown area plasticity (trees change shape as canopy closes)
- Phenology (Botta et al. 2001:cold), Dahlin & Fisher, *in prep*: drought)
- Fire
- Seeds

Tech Note (LaTeX version on its way)



1



2



3



4



5



6



7



8



9



10



11



12



13



14



15



16



17

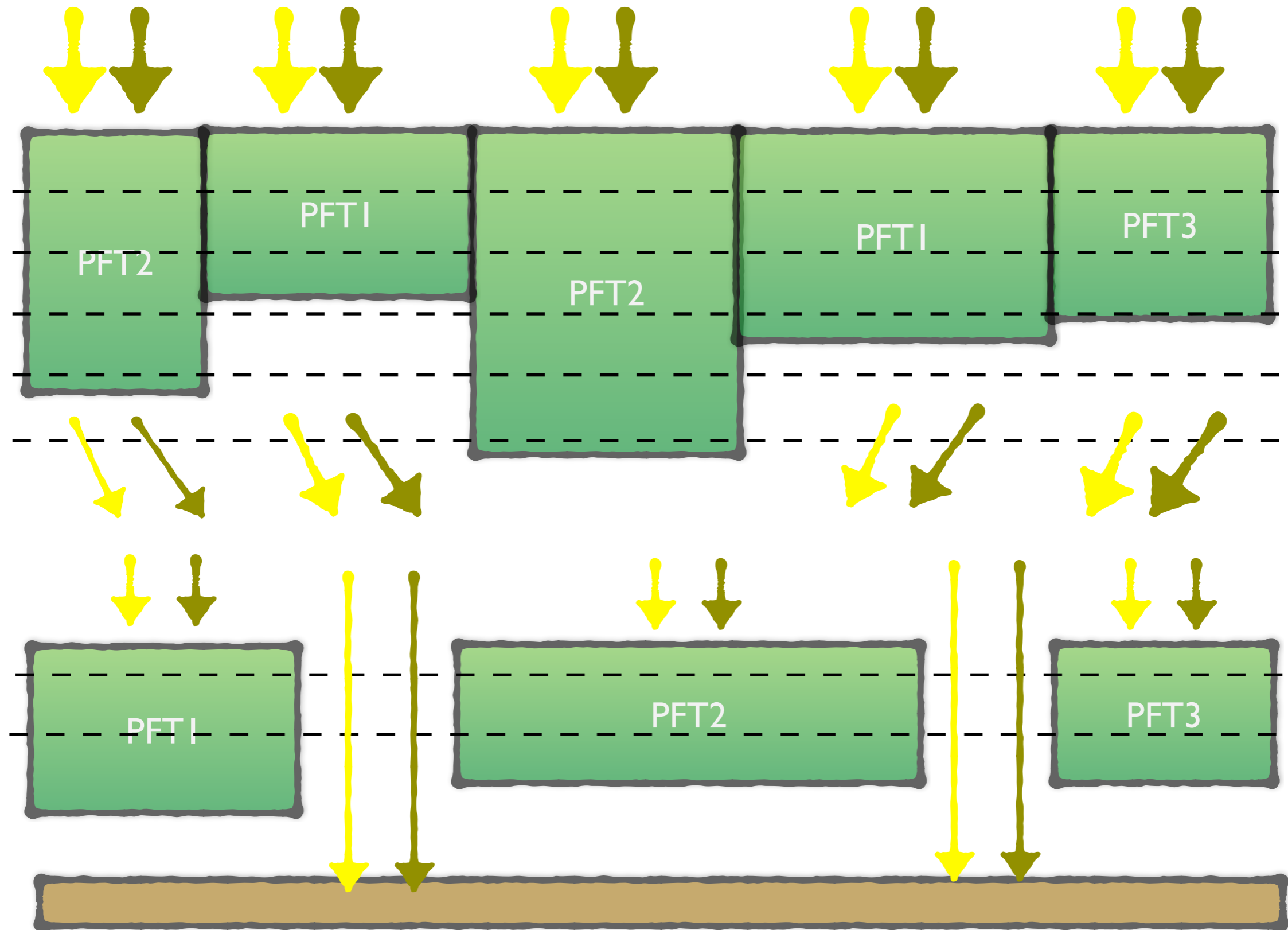


18



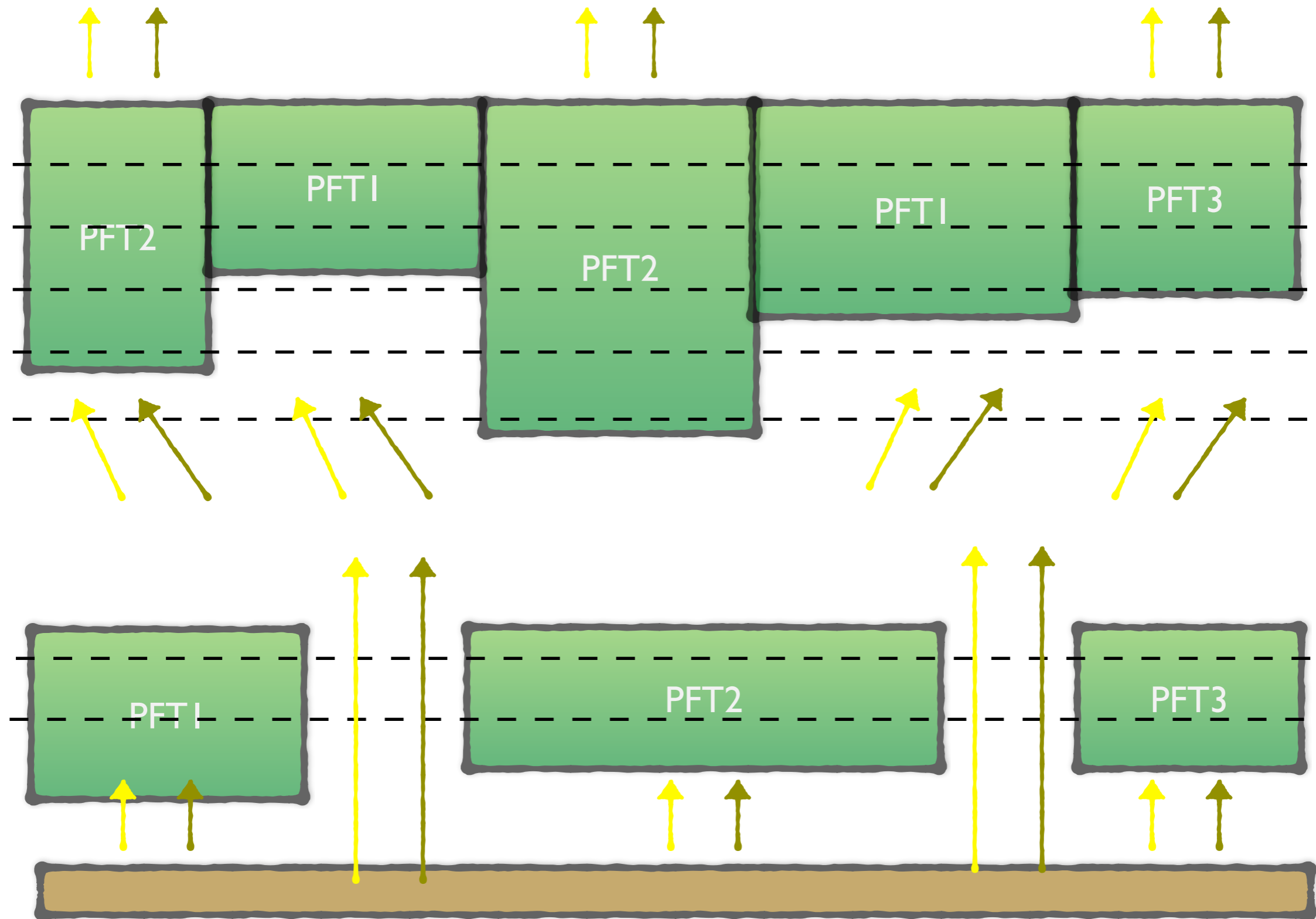
Norman Radiation Scheme as applied to a mixed PFT canopy in CLM(ED)

direct diffuse



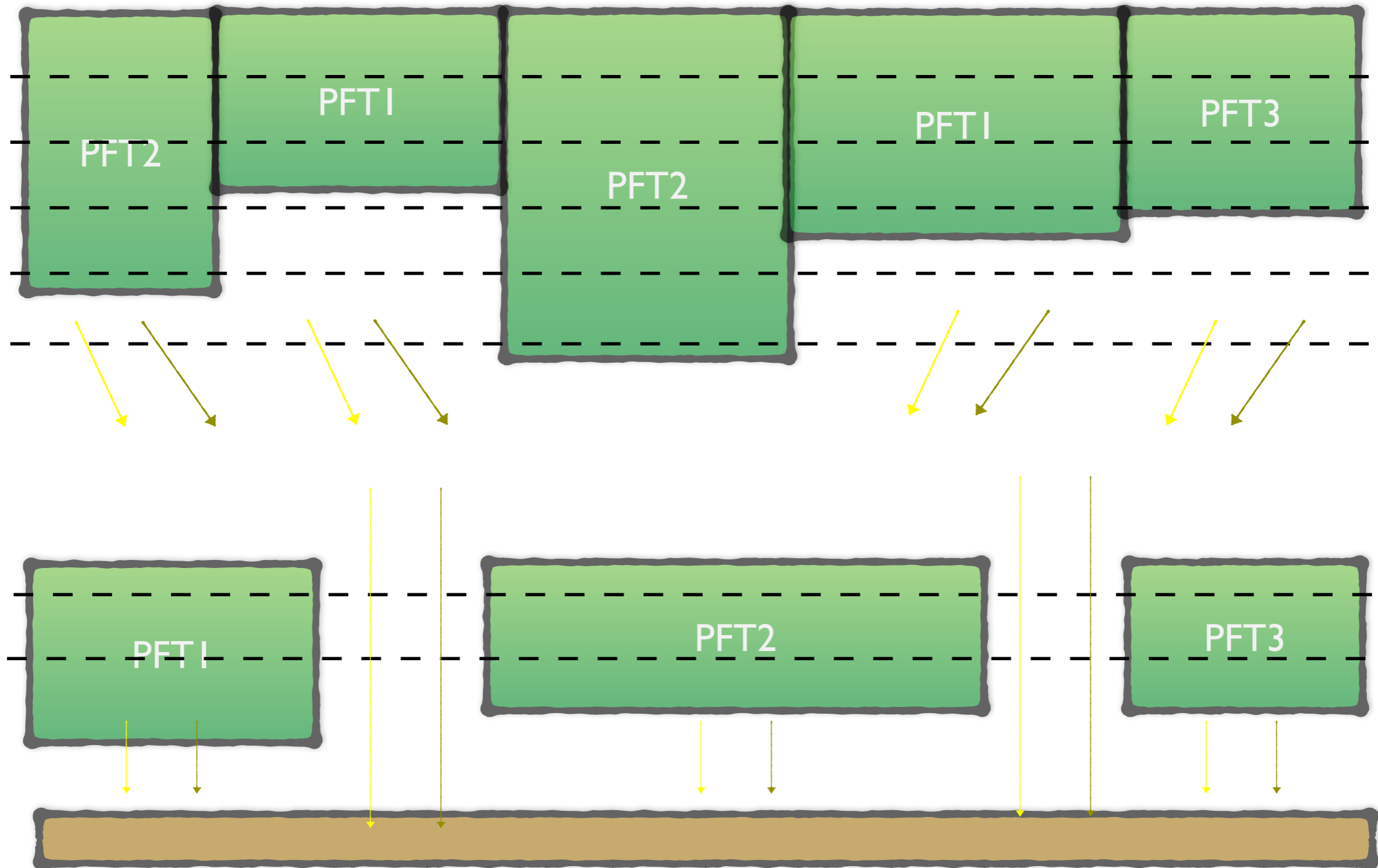
Norman Radiation Scheme as applied to a mixed PFT canopy in CLM(ED)

direct diffuse

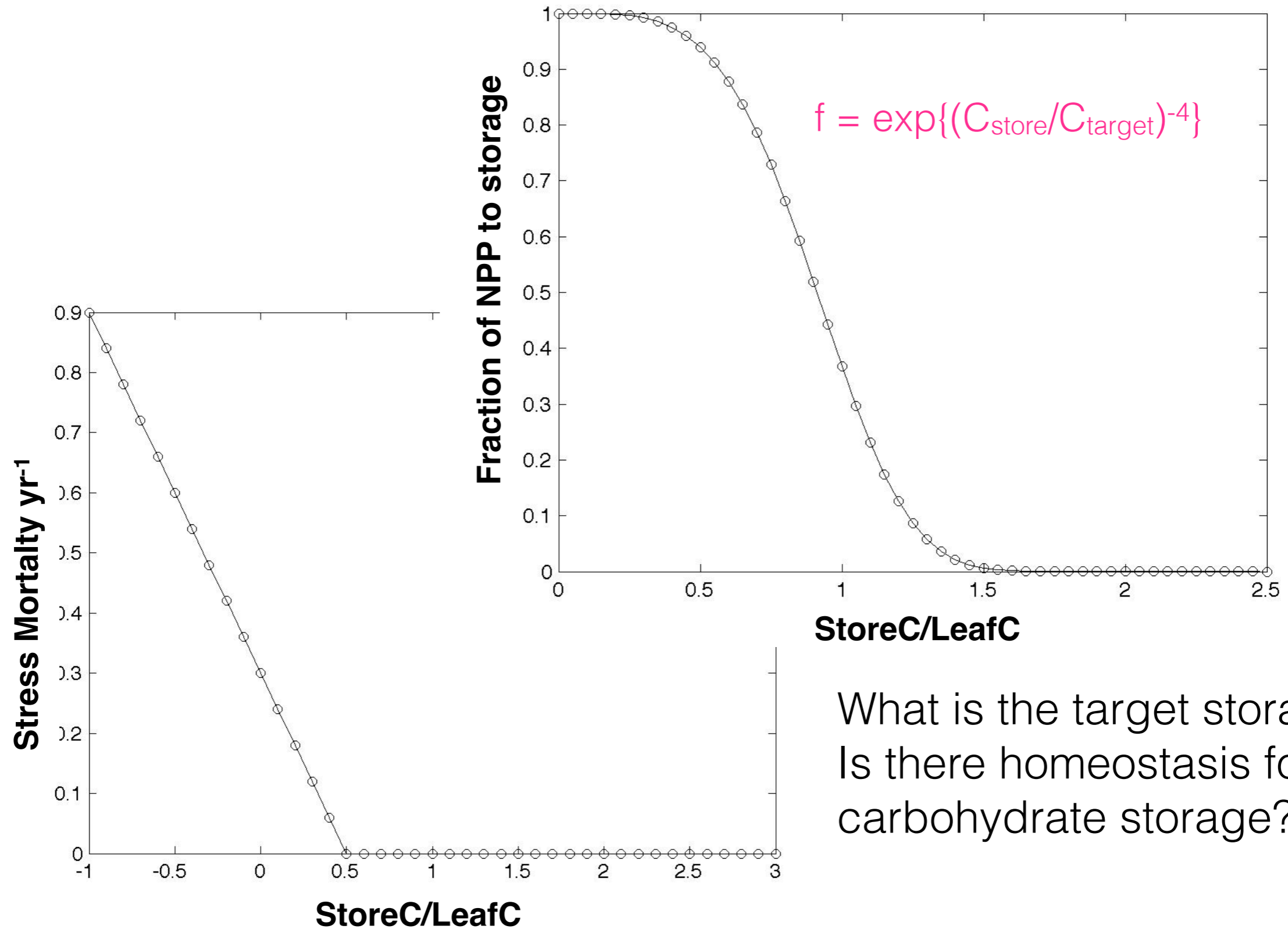


Norman Radiation Scheme as applied to a mixed PFT canopy in CLM(ED)

direct diffuse



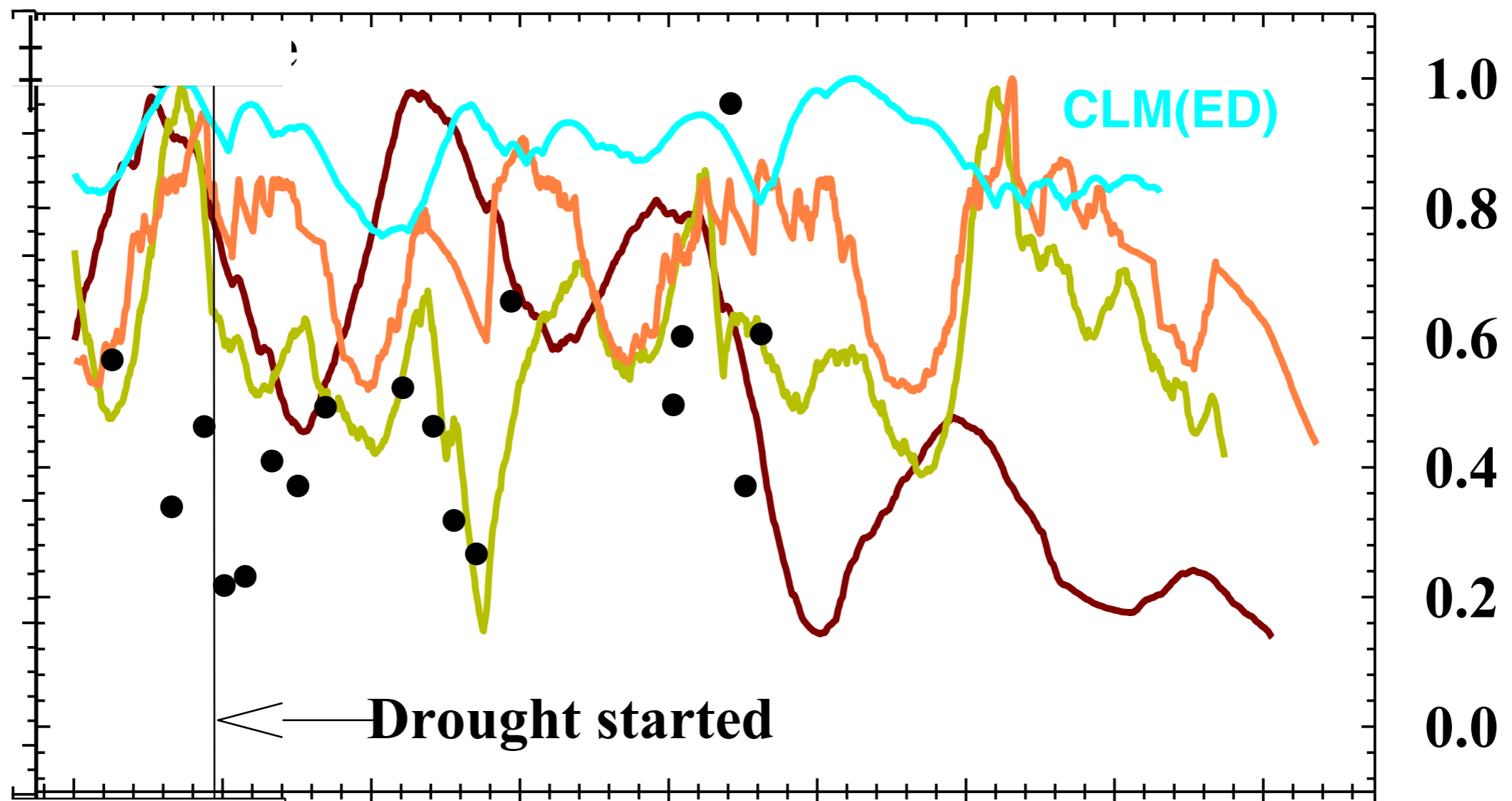
Carbon storage allocation and mortality



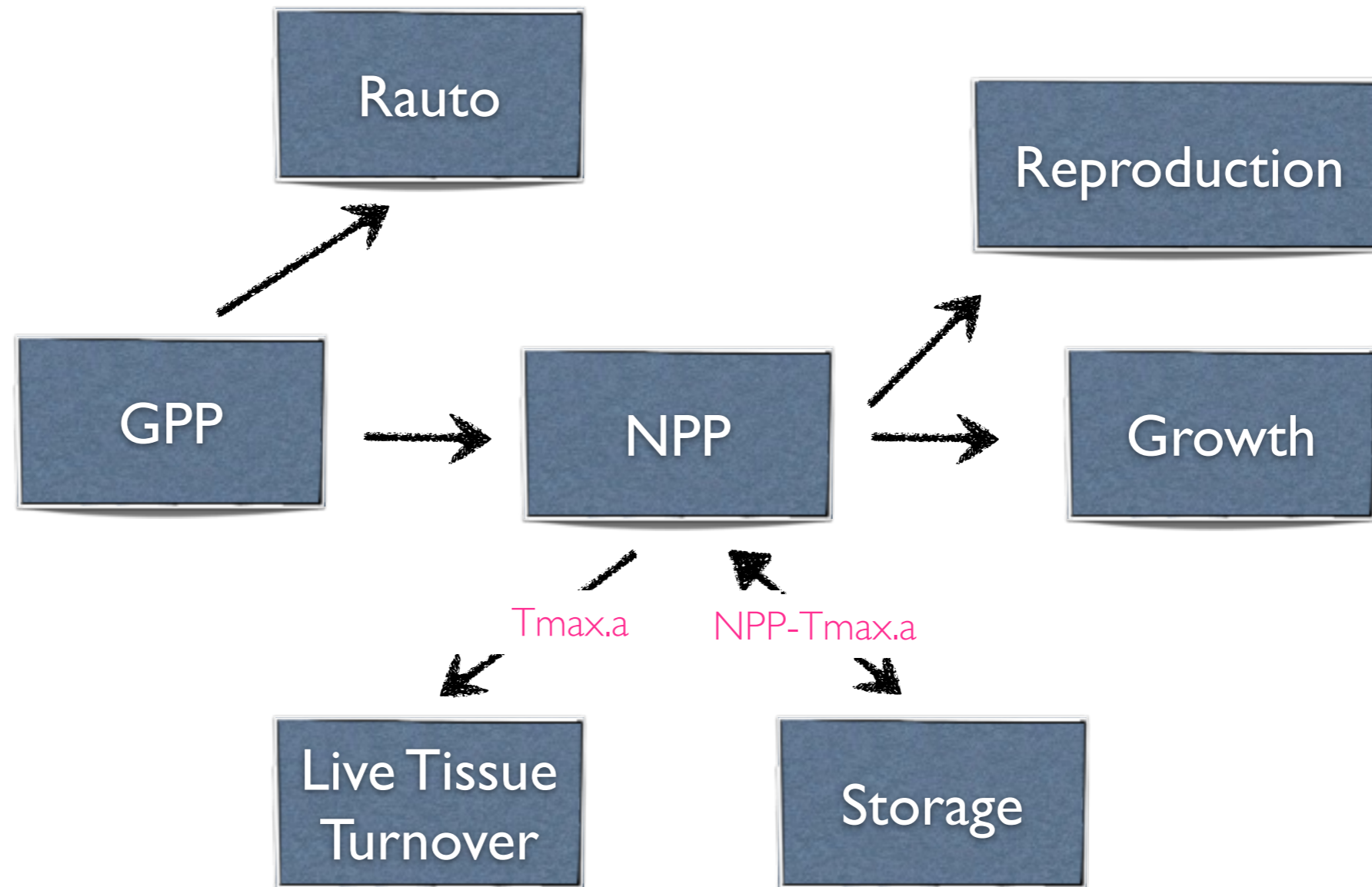
What is the target storage?
Is there homeostasis for
carbohydrate storage?

Is there homeostasis of carbohydrate?

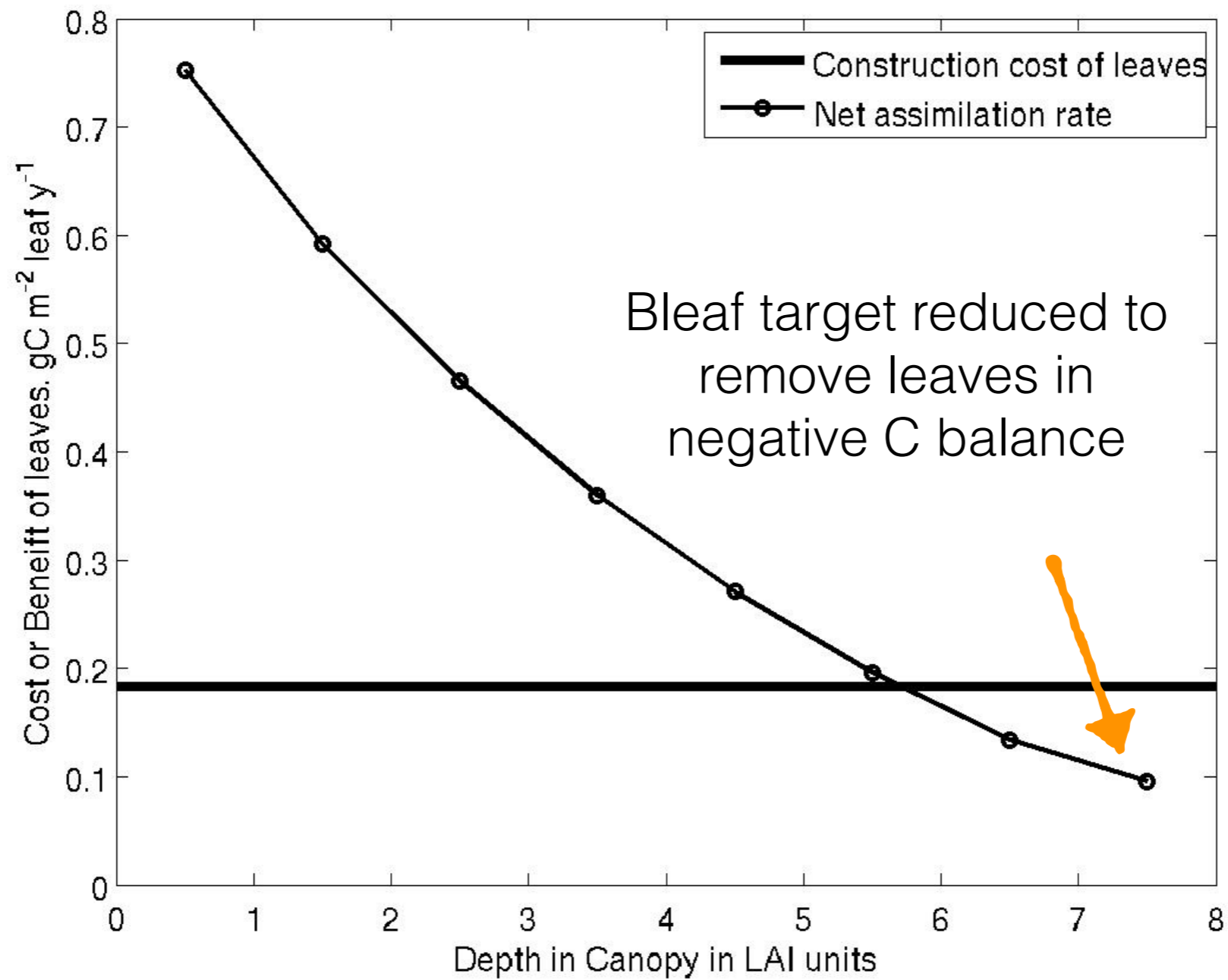
Do we need to consider direct limitation of water & temp on tissue growth (sensu Korner et al.)?



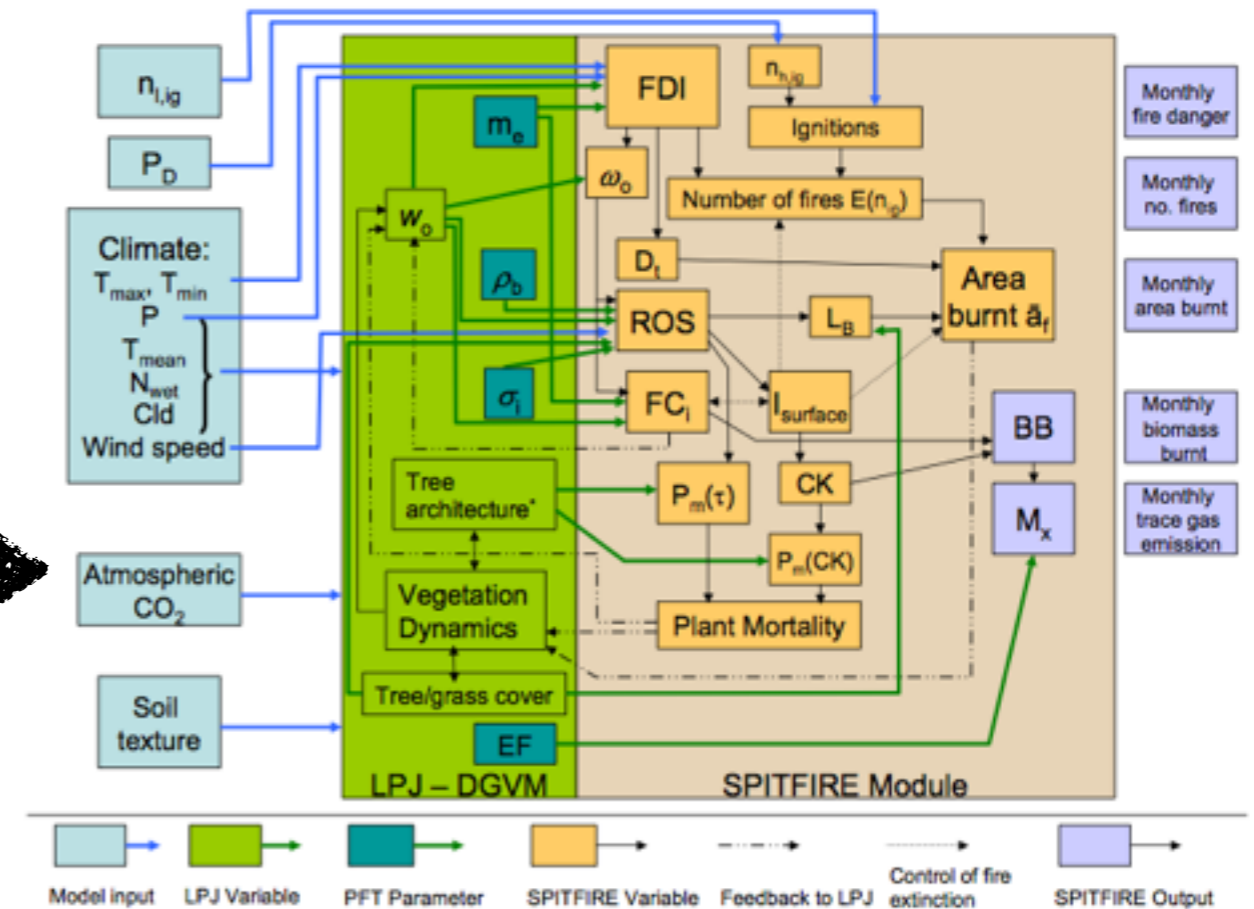
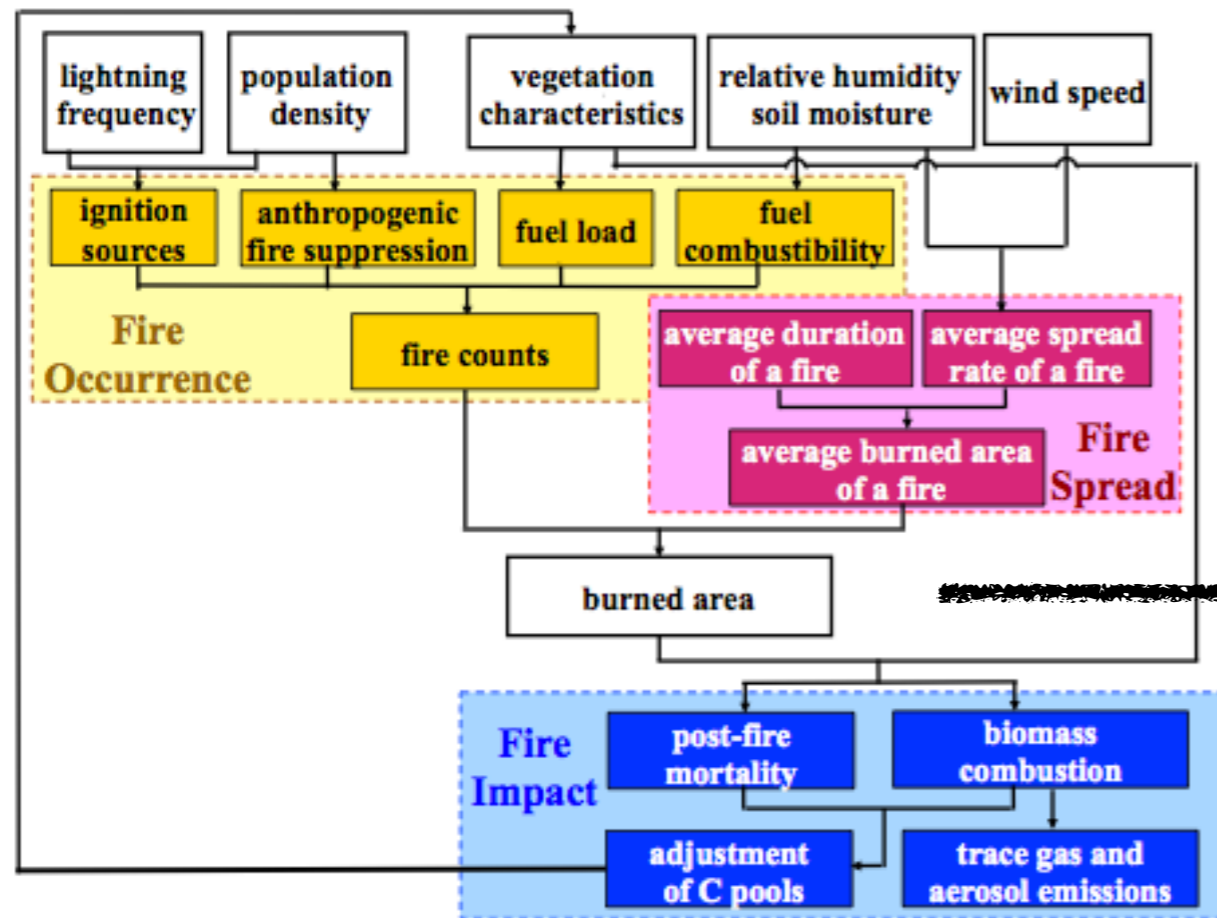
Leaf/Storage balance allocation scheme



Leaf Area Optimization



FIRE

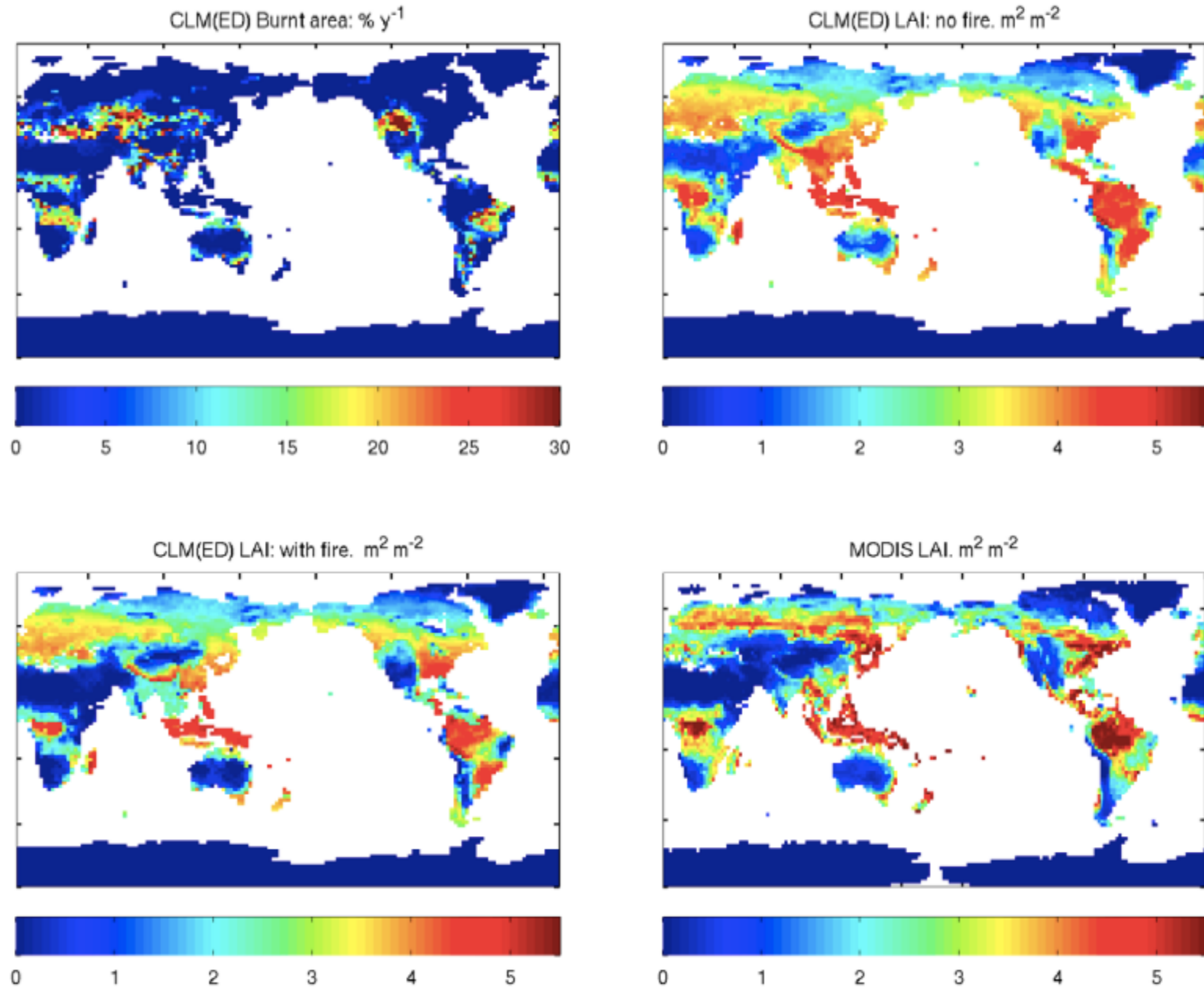


CLM4.5 fire: Li et al. 2012

SPITFIRE: Thonicke et al. 2010

- Collaboration with Allan Spessa (Open Univ.) and Mathew Forest (Goethe Univ. Frankfurt)
- Agricultural, land use and peat fires and ignitions need to interface with the Li & Levis CLM4.5 fire model.
- Numerous modifications required to SPITFIRE implemented to allow size-structured fire impacts

SPITFIRE: Global impact on LAI

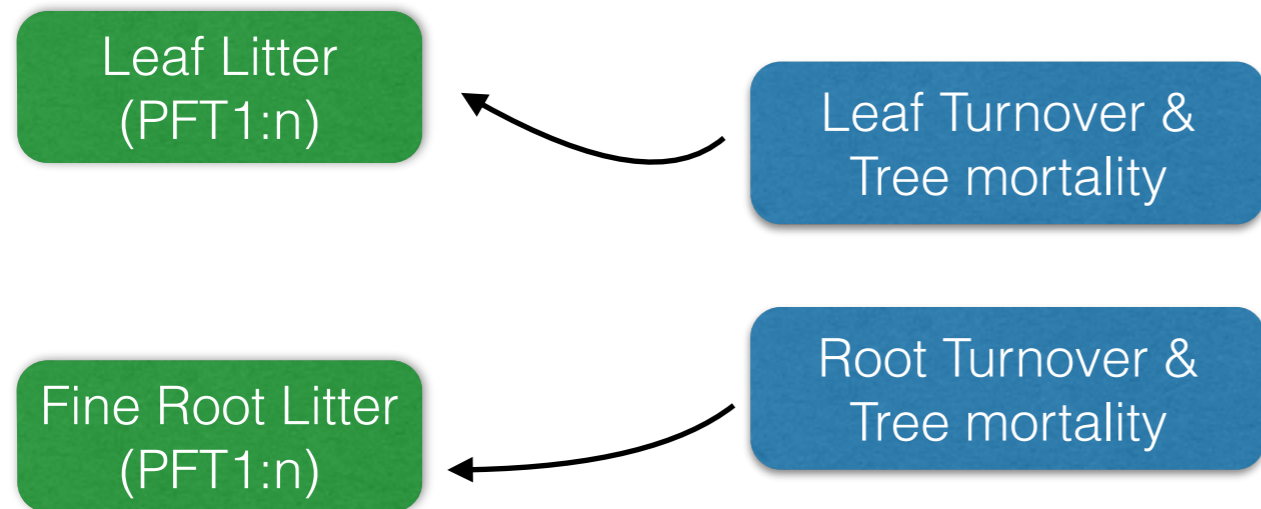


The Impact of Litter

- Fire intensity and spread is impacted by litter size classes
 - Surface Area-Volume Ratio
 - Bulk Density
 - Moisture Content
- Decomposition is impacted by chemical class
 - Lignin, Cellulose, Metabolic
- How can these two qualities of litter be represented?
- - (collaboration with Charlie Koven, LBNL)

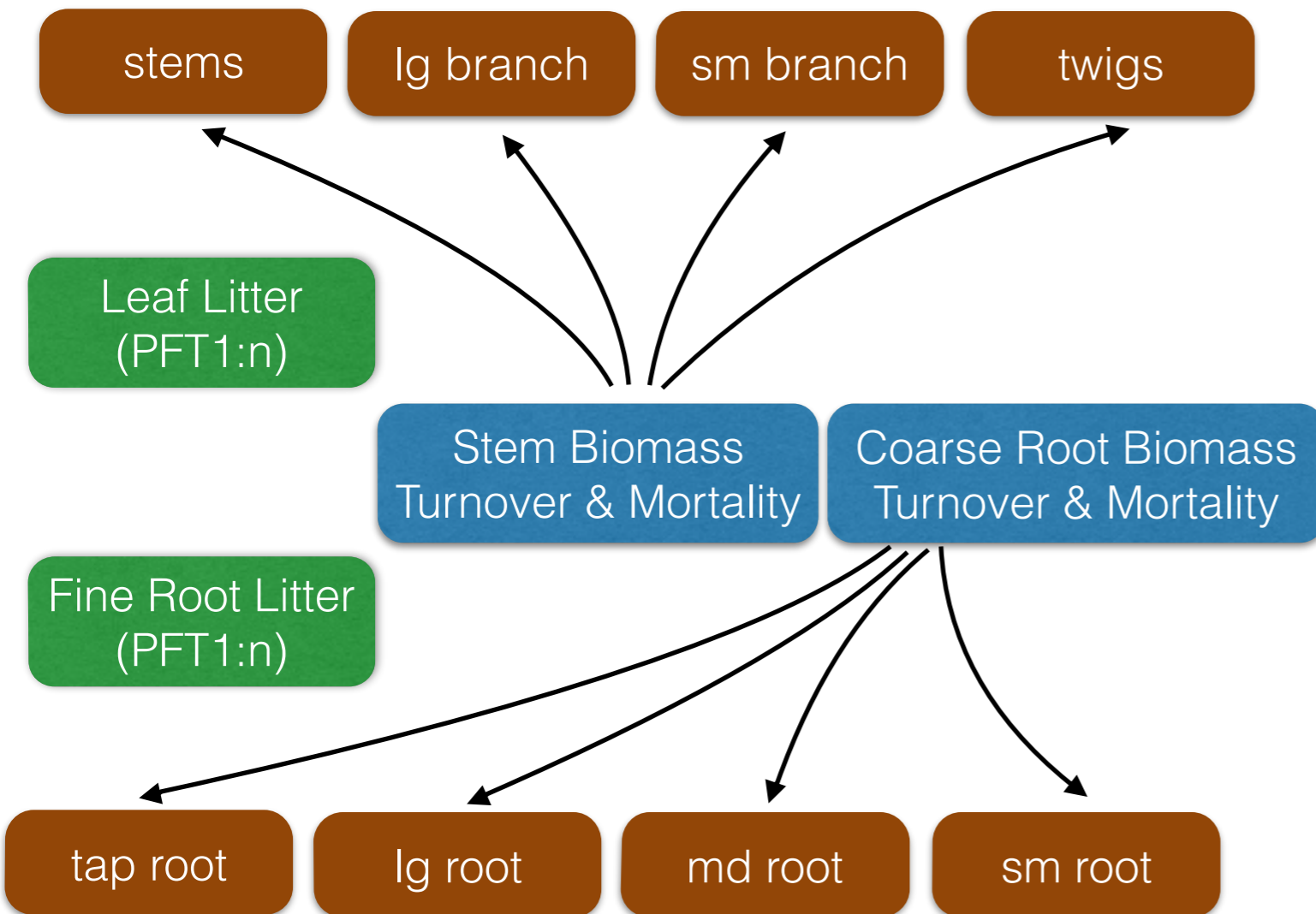
Litter Fragmentation

Fragmenting Pools
Drive Fire Model



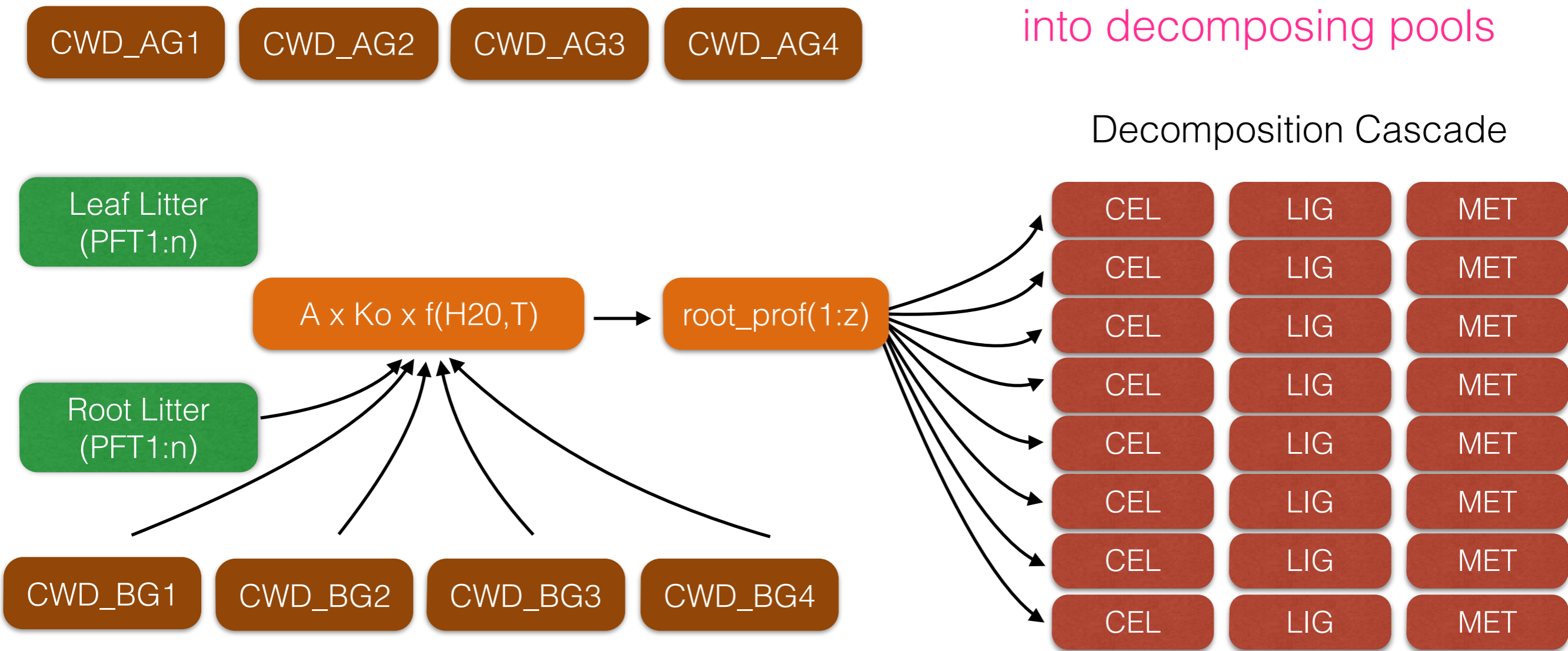
Litter Fragmentation

Fragmenting Pools
Drive Fire Model



Litter Fragmentation

Fragmenting Pools feed into decomposing pools



Decomposition Cascade

Leaf Litter
(PFT1:n)

Root Litter
(PFT1:n)

CWD_AG1

CWD_AG2

CWD_AG3

CWD_AG4

$A \times K_o \times f(H_{20}, T)$

root_prof(1:z)

CWD_BG1

CWD_BG2

CWD_BG3

CWD_BG4

CEL

LIG

MET

CEL

LIG

MET

CEL

LIG

MET

CEL

LIG

MET

CEL

LIG

MET

CEL

LIG

MET

CEL

LIG

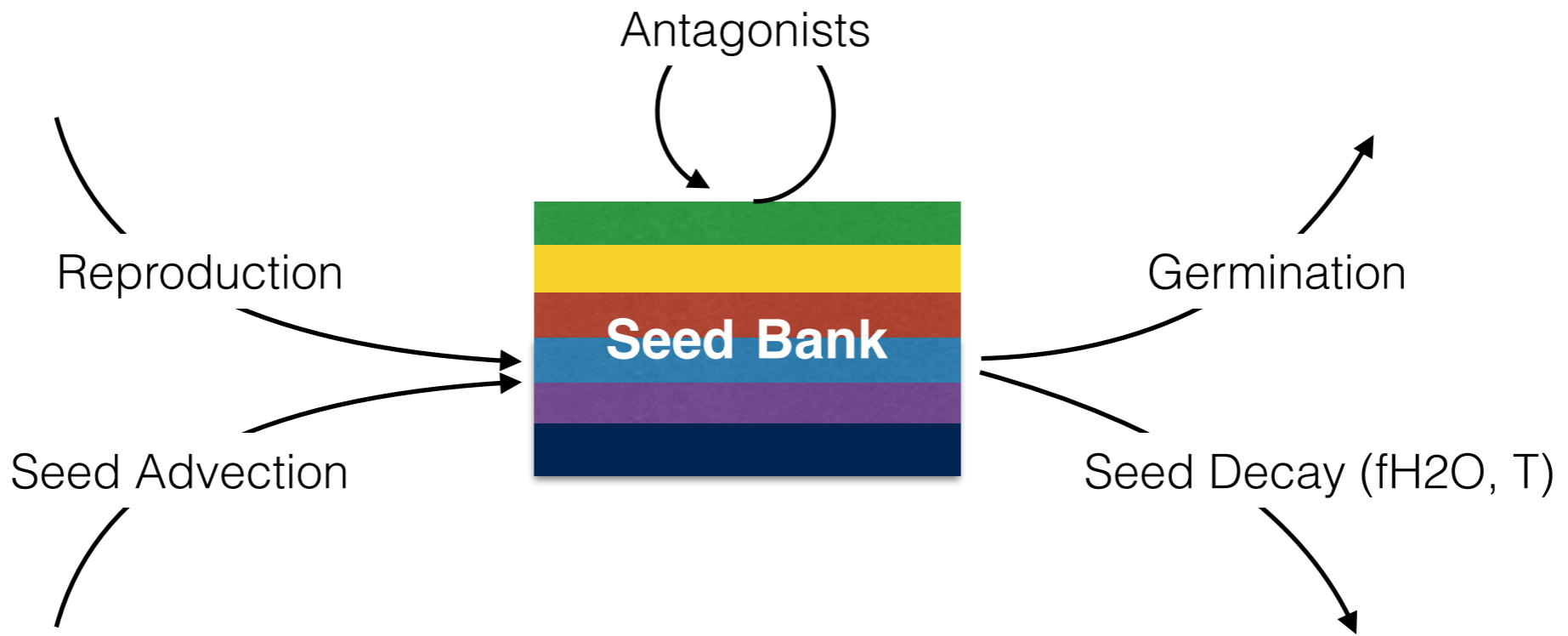
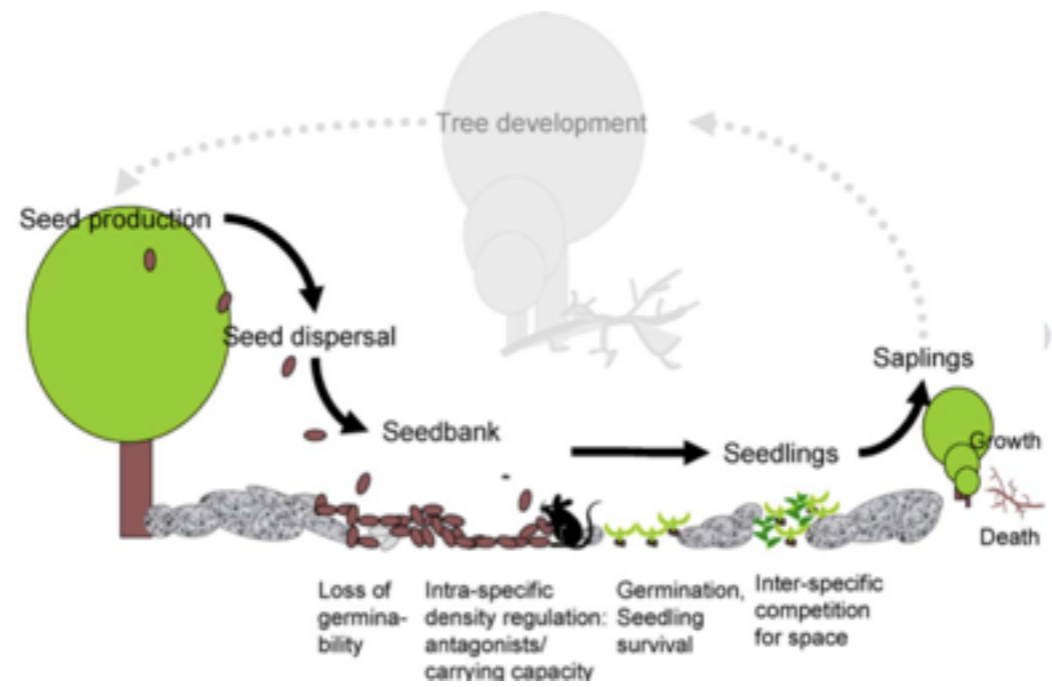
MET

CEL

LIG

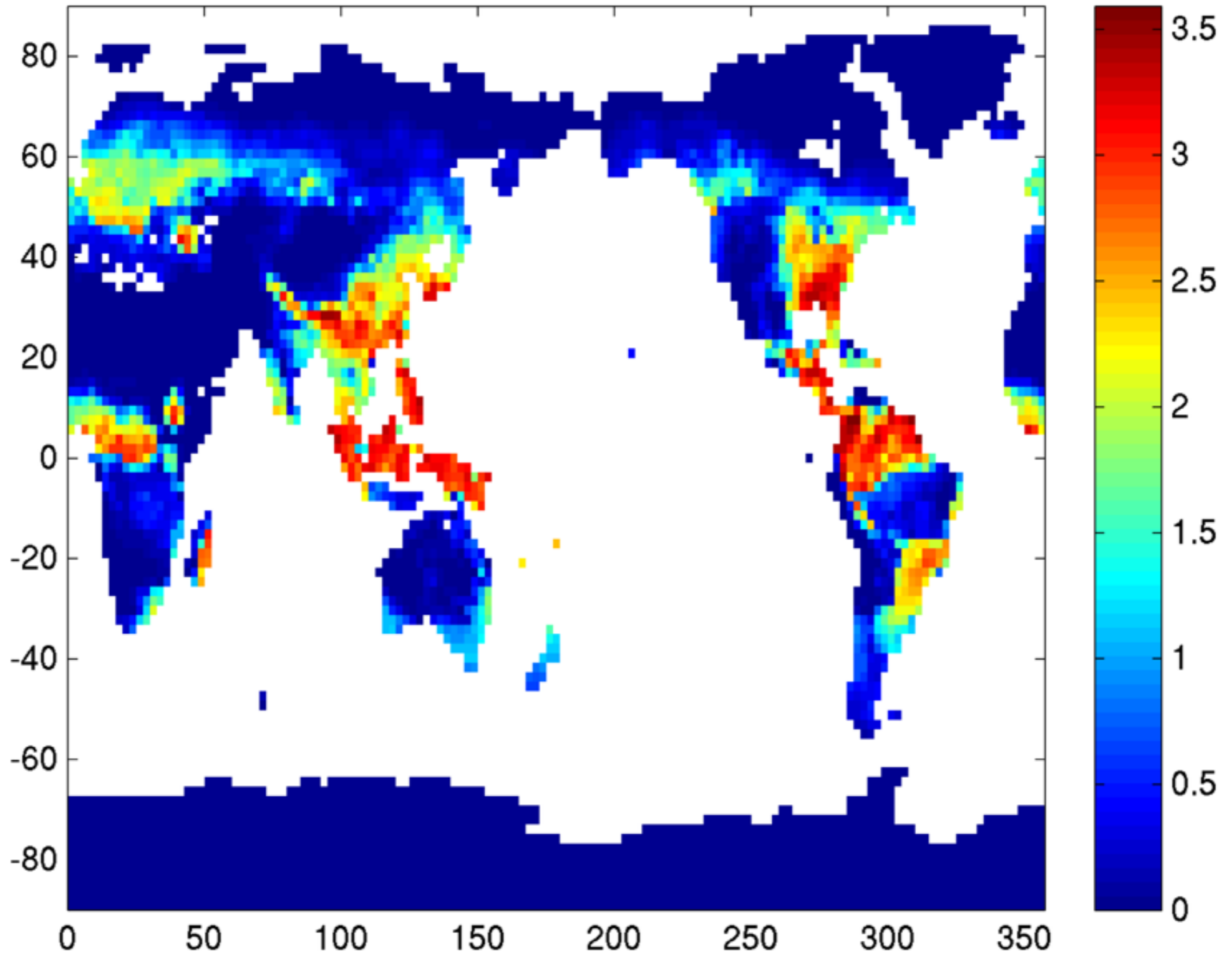
MET

Seed Bank Model...

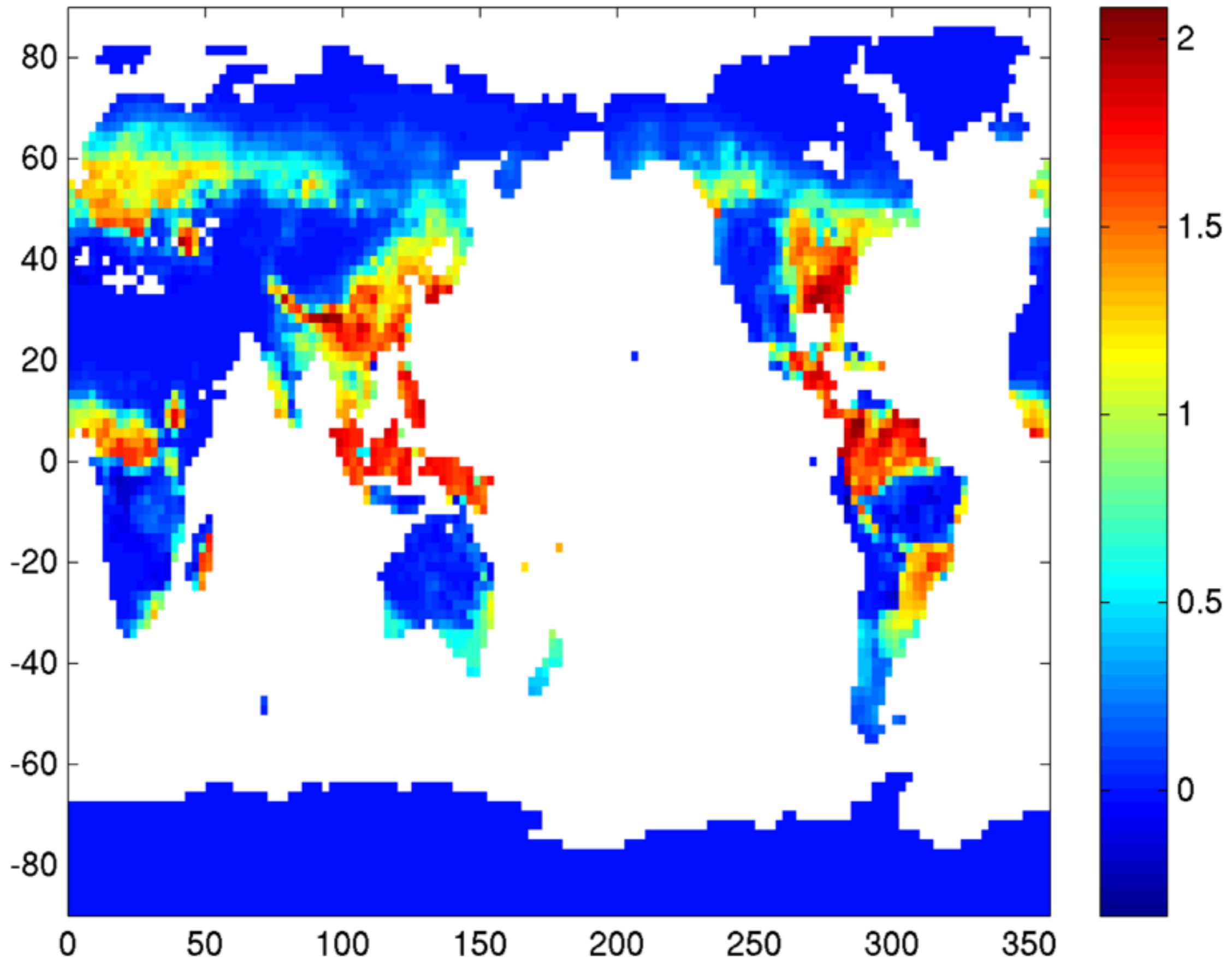


Early Results

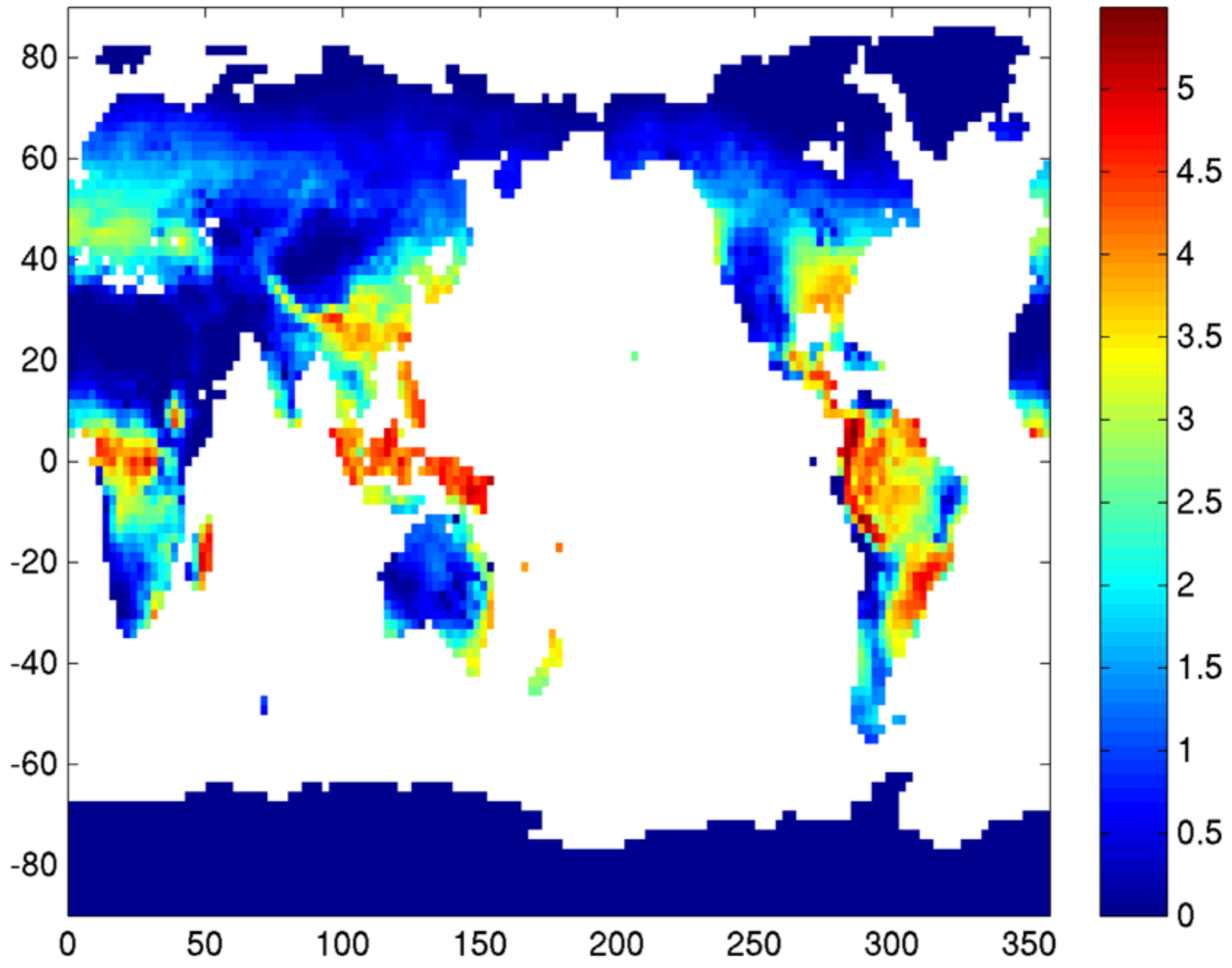
GPP



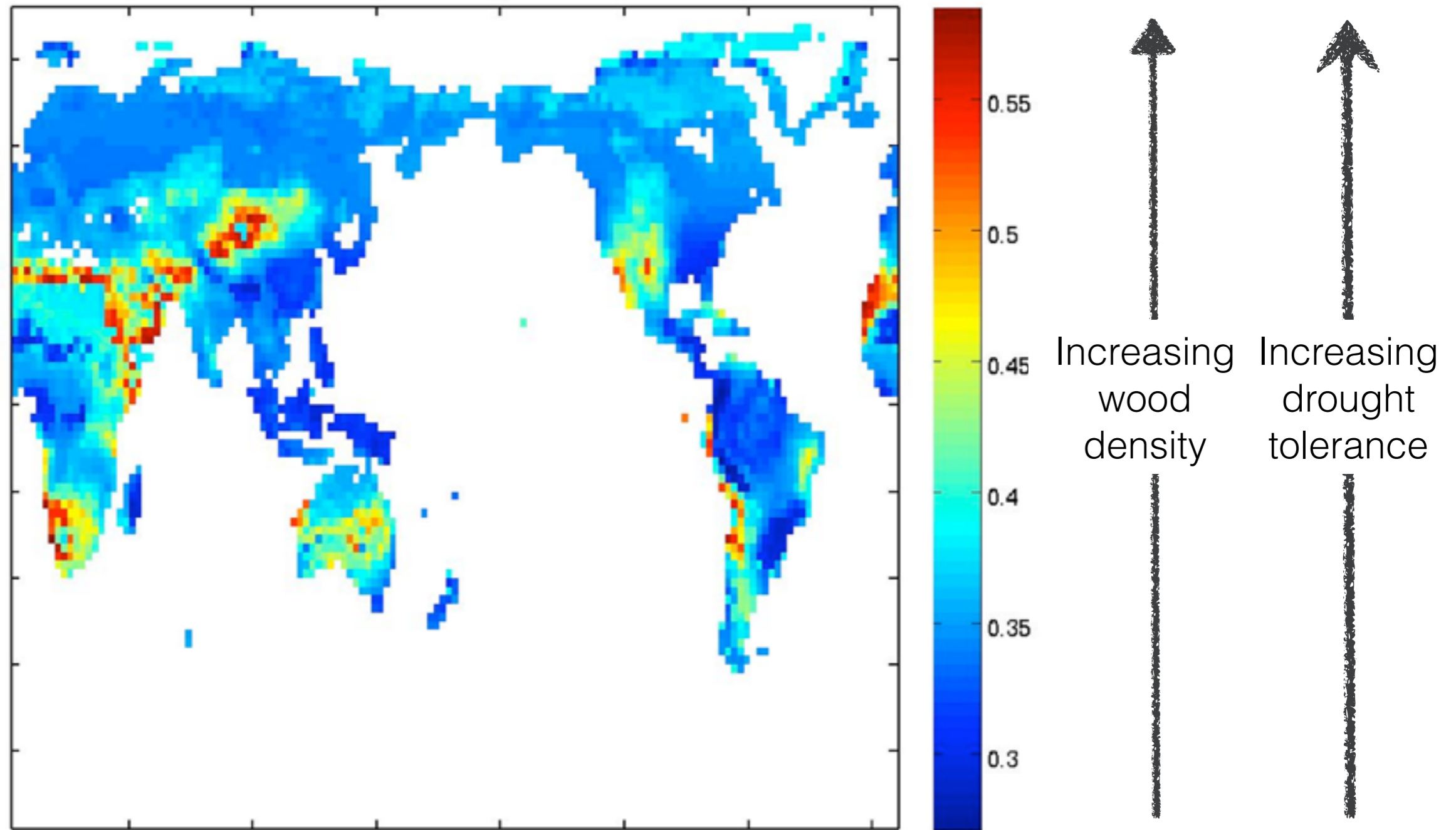
NPP



TLAI



Global emergent wood density patterns



Planning

Timeline (when can I play with it?)

- **Version -1 (EDMERGE branch)** Now. *Access for development only*
 - Runs in PTCLM & some global resolutions, sensible fluxes, energy + water balanced (afaik), NetCDF restarts, s
- **Version 0 (software engineering tag)** May/June. *Access for adding functionality*
 - NetCDF history files, sensible fluxes, balanced energy/water/carbon, sensible memory use, cold & drought phenology, compsets, runs @ alternative resolutions & compilers.
- **Version 1 (science tag)** Oct/Nov. *Access for model testing and implementation*
 - Soil BGC (C-only) , CLM fire coupling, definitive PFTs.
- **Version 2 ('IPCC' tag) ?** *Access for any reason including coupled runs.*
 - Consistent with crops, proscribed vegetation, harvest & land use change (managed forest, pasture), N cycle, VOCs, dynamic landunits.

Next-generation dynamic global vegetation models: learning from community ecology

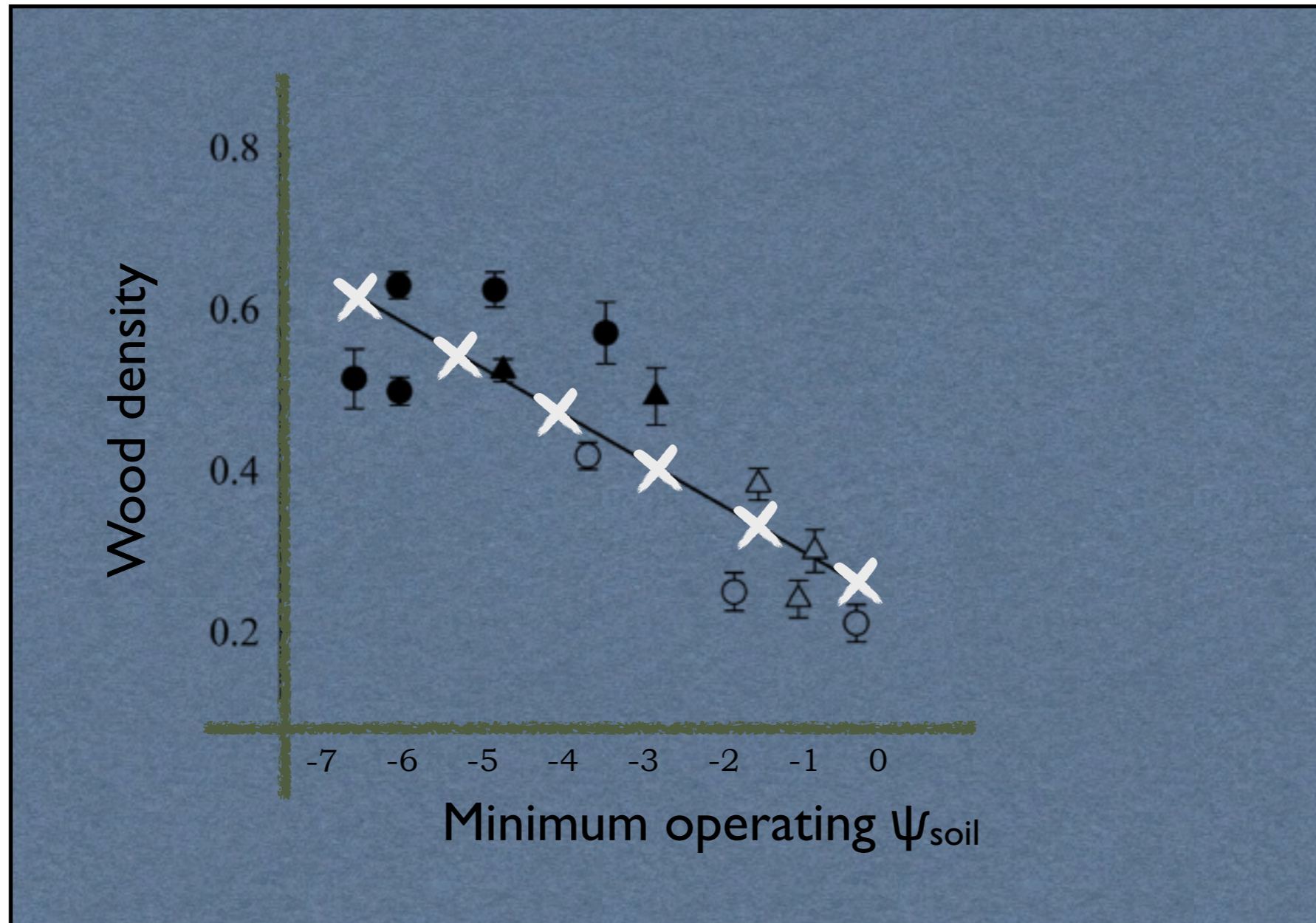
Simon Scheiter¹, Liam Langan² and Steven I. Higgins²

¹Biodiversität und Klima Forschungszentrum (LOEWE BiK-F), Senckenberg Gesellschaft für Naturforschung, Senckenberganlage 25, D-60325, Frankfurt am Main, Germany; ²Institut für Physische Geographie, Goethe-Universität Frankfurt am Main, Altenhöferallee 1, D-60438, Frankfurt am Main, Germany

“The major task for the developer of the kind of DGVM we are proposing is to conceptualize and parameterize life-history tradeoffs.”

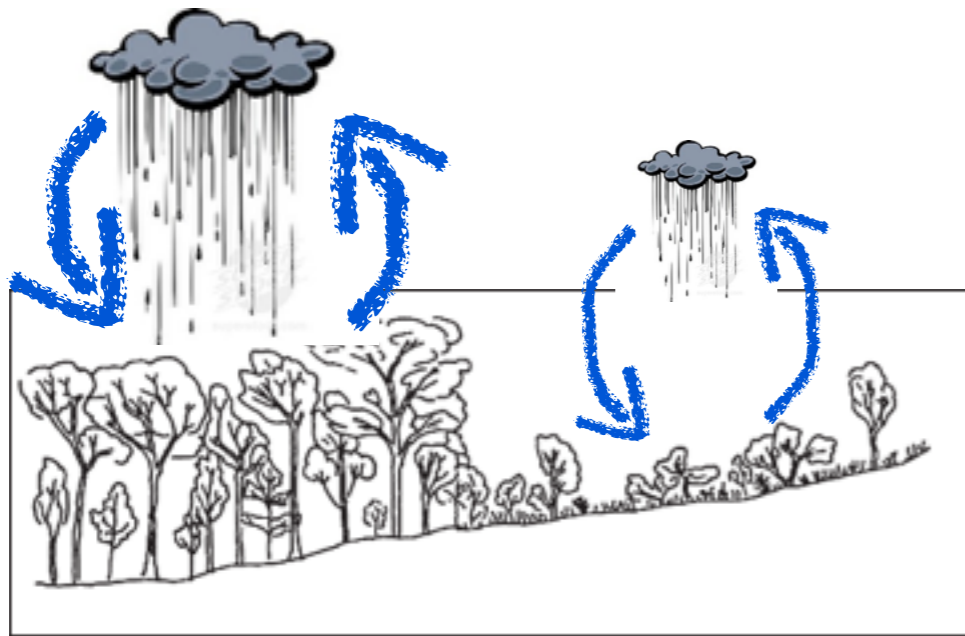
CLM(ED) as a trait filtering model

Do we understand why plants grow where they do?



Example from Bolivia: Markesteijn, Poorter, et al. 2011

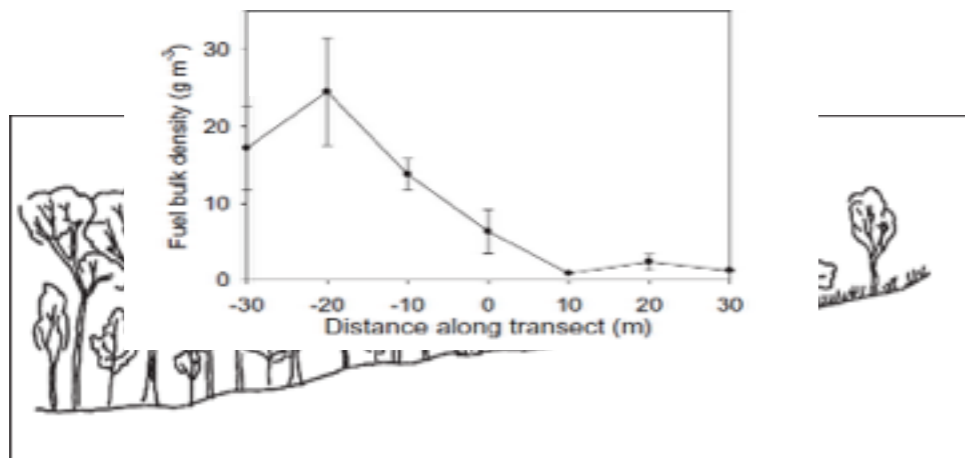
ED-SPITFIRE: Multiple scales of feedback



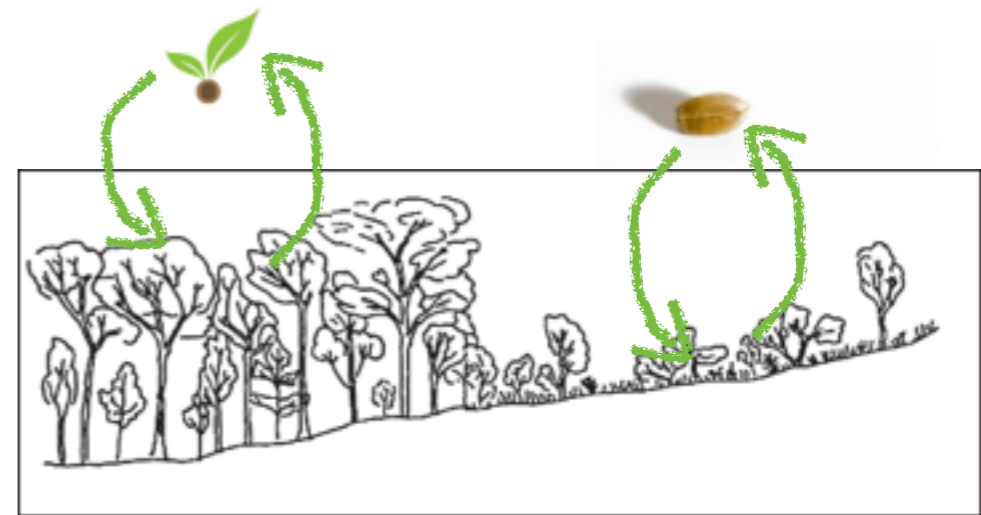
Land-atmosphere feedback



Wind speed feedback



Flammability feedback



Demographic feedback