

the CN–DGVM coupling

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Goal: Merge two efforts

CLM-CN

- Lead: Peter Thornton
- Since: CLM3.5
- Based on:
Biome-BGC
of Running et al.

CLM-DGVM

- Lead: Sam Levis
- Since: CLM3.0
- Based on:
LPJ-DGVM
of Sitch et al.

Goal: Merge two efforts

CLM-CN

Simulates:

- C and N in veg & soil
- Vegetation structure

CLM-DGVM

Simulates:

- C in veg & soil
- Vegetation structure and distribution

CN + DGVM → CNDV

Subroutine	CN	DGVM	CNDV
NDep/Fixation	Hourly	-	Hourly
MRespiration	Hourly	Hourly	Hourly
Decomp/Allocation	Hourly	Hourly/Annual	Hourly
Phenology	Hourly	Hourly	Hourly
GRespiration	Hourly	Hourly	Hourly
GapMortality	Hourly	Annual	H: with mods
FireArea/Fluxes	Hourly	Hourly/Annual	H: with mods
NLeaching	Hourly	-	Hourly
VegStructUpdate	Hourly	Annual	H: with mods
LightCompetition	-	Annual	Annual
Bioclimatology	Satellite: Annual	Annual	Annual
Establishment	New C: Annual	C → %pft: Annual	Annual

Beyond the Coupling

- Let prescribed crops coexist with simulated natural vegetation
- Introduce shrubs (Xubin's group, other)
- Increase DGVM sophistication
- Introduce crop model

CN → CNDV

- Subroutine driver1, every hour:
 - Call CNEcosystemDyn
 - Call ...
 - Call GapMortality ← constant% vs growth efficiency
 - Call Fire ← $P^{new} = \frac{P^{old} C_{wood}^{new}}{C_{wood}^{old}}$ and $C_{leaf}^{ann\ max}$
 - Call NLeaching
 - Call VegStructUpdate ← CN's $d, h, tlai, tsai$ vs LPJ's
- Subroutine driver2, every year:
 - Call dv
 - Call Bioclimatology & LightCompetition
 - Call Establishment ← NOW WITHOUT SAPLINGS
 - Call dvreset & resetWeights

CN → CNDV

Establishment

LPJ: Existing pfts may establish saplings every year

Allometric eqns with $lai_{sapl}=1.5$ calculate c_{sapl}

$c + c_{sapl}$ and $P + P_{establ} \rightarrow d, ca, lai \rightarrow FPC$

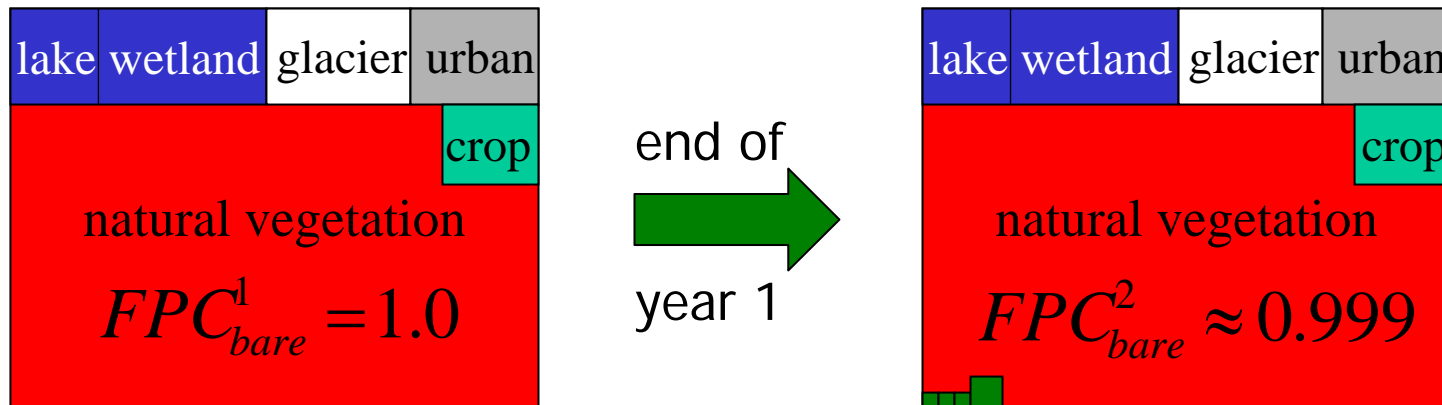
CNDV: New/Expand. pfts get $C_{leaf}=10$ gC m⁻² pft area

Assume FPC_{init} to convert units and calculate

c and $P + P_{establ} \rightarrow d, ca, lai \rightarrow FPC$

CNDV year 1

- Initial Vegetation $\rightarrow C_j^1 = P_j^1 = FPC_j^1 = 0, j \in [1, npft]$
- Year-long Bioclimatology accumulators
- End-of-Year Establishment $\rightarrow C_j^2, P_j^2, FPC_j^2 \geq 0$



CNDV year 2

- Hourly biogeophysics and biogeochemistry
Alloc., Mortality, Fire, VegStructUpdate →

$$\Delta C_j^{alloc}, \Delta C_j^{mort} + \Delta C_j^{fire} \Rightarrow P_j^{new} = \frac{P_j^{old} C_{j,wood}^{new}}{C_{j,wood}^{old}}, \quad LAI_j, SAI_j, h_j^{top}, h_j^{bot}$$

– End-of-year processes

- First guess → $C_j^3, P_j^3 \Rightarrow FPC_j^3$
- Competition for Light → $FPC_{trees>0.95}^{excess}, FPC_{tree+grass>1}^{excess} \Rightarrow \Delta P_j$
- Establishment → $C_j^3, \Delta P_j \Rightarrow P_j^3, FPC_j^3$
- VegStructUpdate → $LAI_j, SAI_j, h_j^{top}, h_j^{bot}$

End-of-Year y Processes

First guess FPC_j^{y+1}

$$\left. \begin{aligned} c_j^{y+1} &= f(C_j^{y+1}, P_j^{y+1}, FPC_j^y) \\ d_j &= f(c_{j,wood}^{y+1}) \\ ca_j &= f(d_j) \\ fpc_j &= f(sla_j, ca_j, c_{j,leaf}^{y+1}) \end{aligned} \right\} \Rightarrow FPC_j^{y+1} = ca_j fpc_j P_j^{y+1}$$

End-of-Year y Processes

Light and Establishment

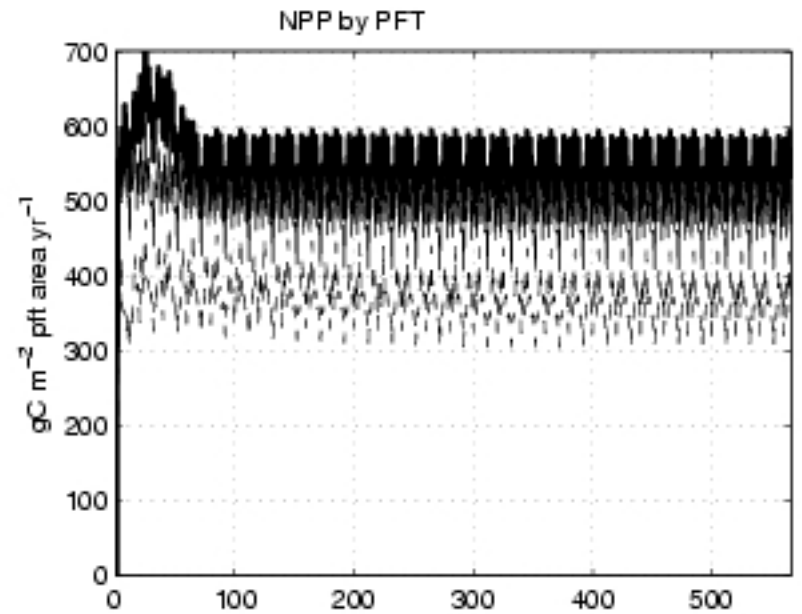
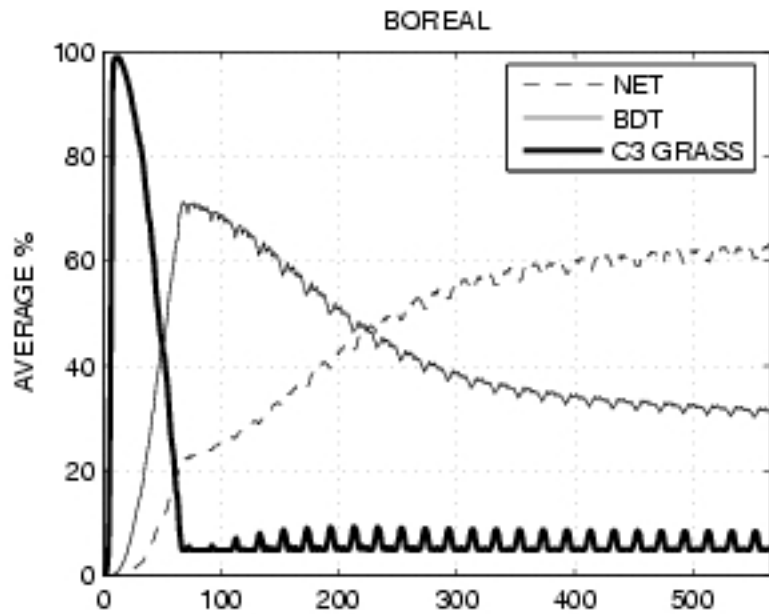
$$C_j^{y+1} = C_j^y + \left(\Delta C_j^{alloc} + \Delta C_j^{mort} + \Delta C_j^{fire} \right)$$

$$P_j^{y+1} = P_j^y + \left(\Delta P_j^{mort} + \Delta P_j^{fire} \right) + \Delta P_j^{light} + \Delta P_j^{estab}$$

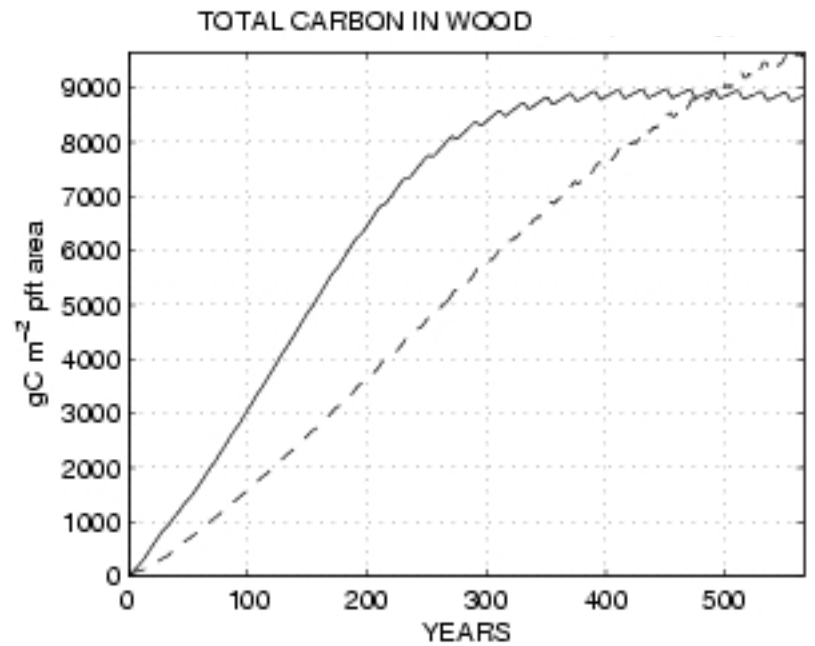
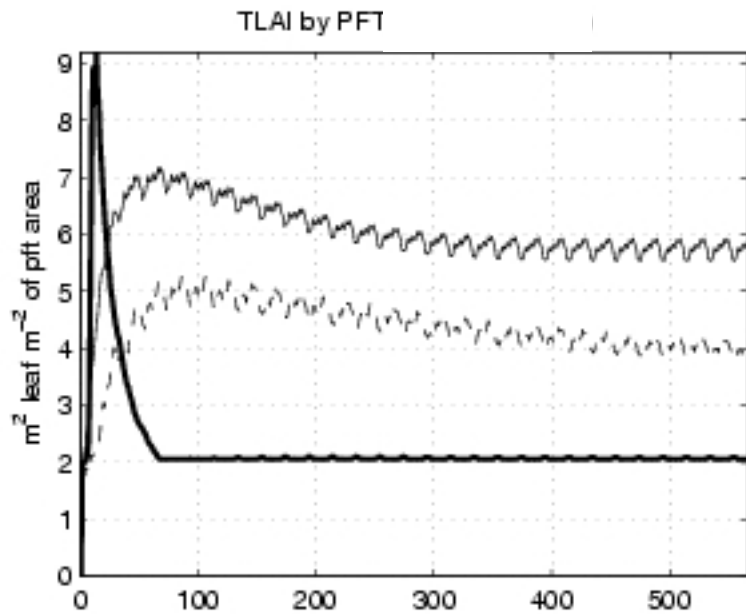
FPC_j^{y+1} updated in Light and Establishment

CN → CNDV

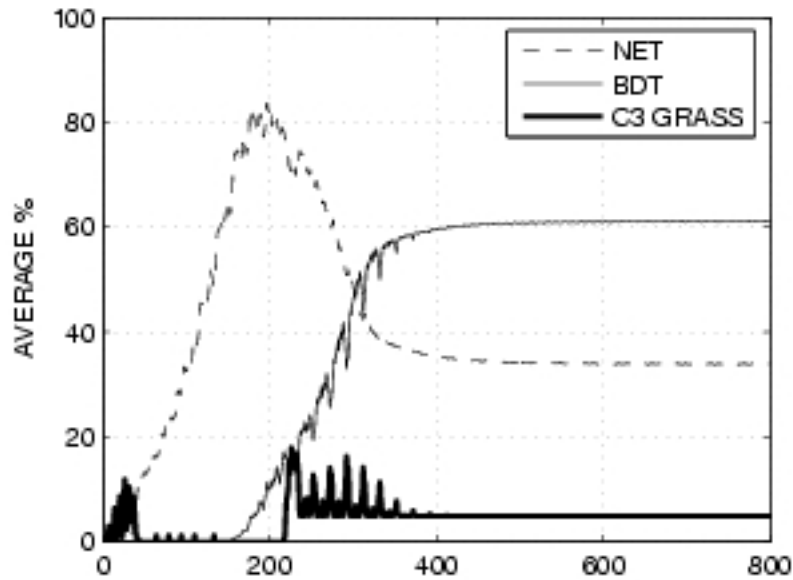
- Results from the first attempt (2006)



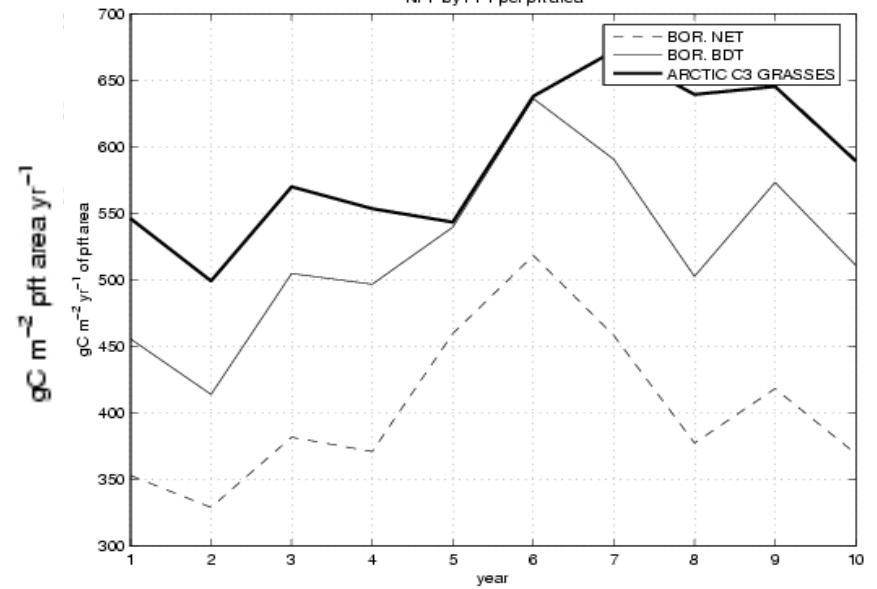
CLM-DGVM



BOREAL

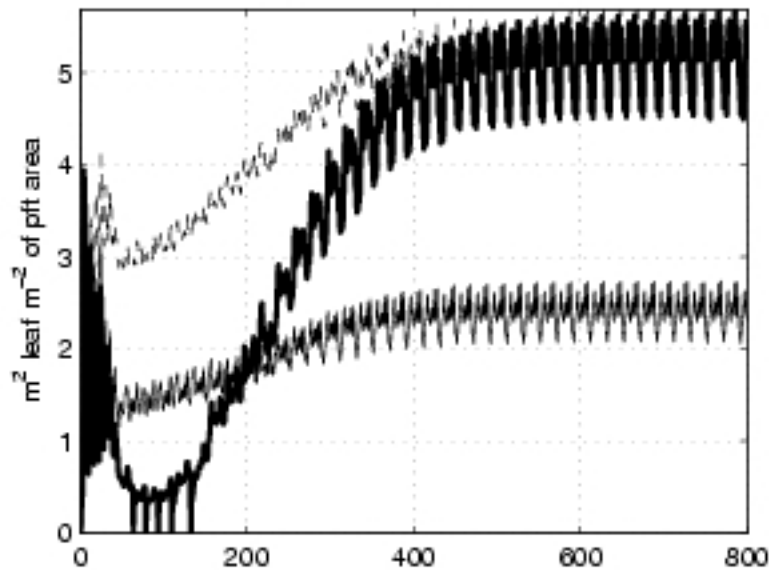


NPP by PFT per pft area

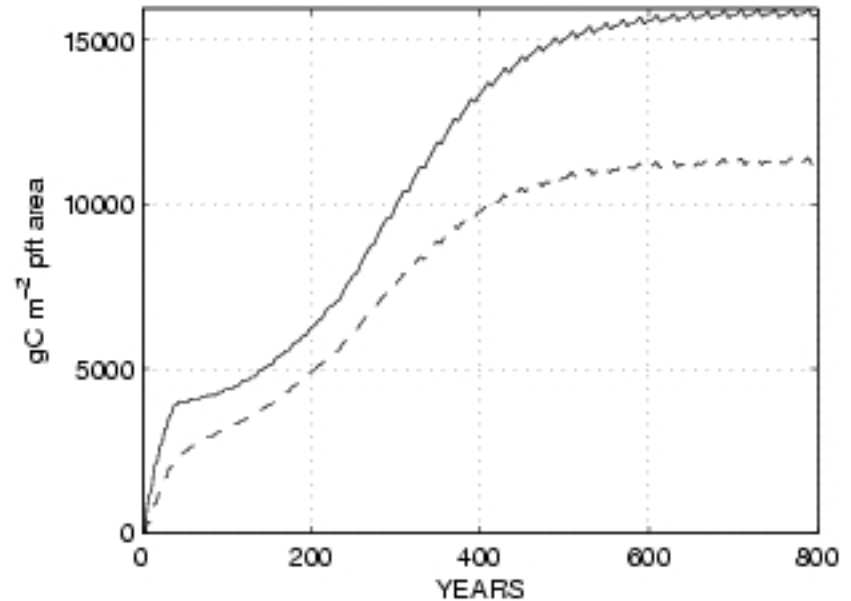


CNDV with CN Mortality LPJ *d*

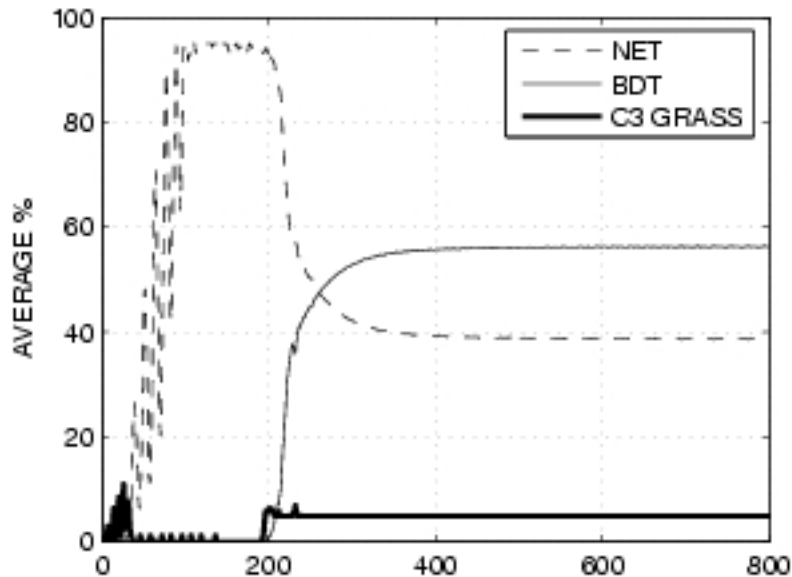
TLAI by PFT (if CN, then July)



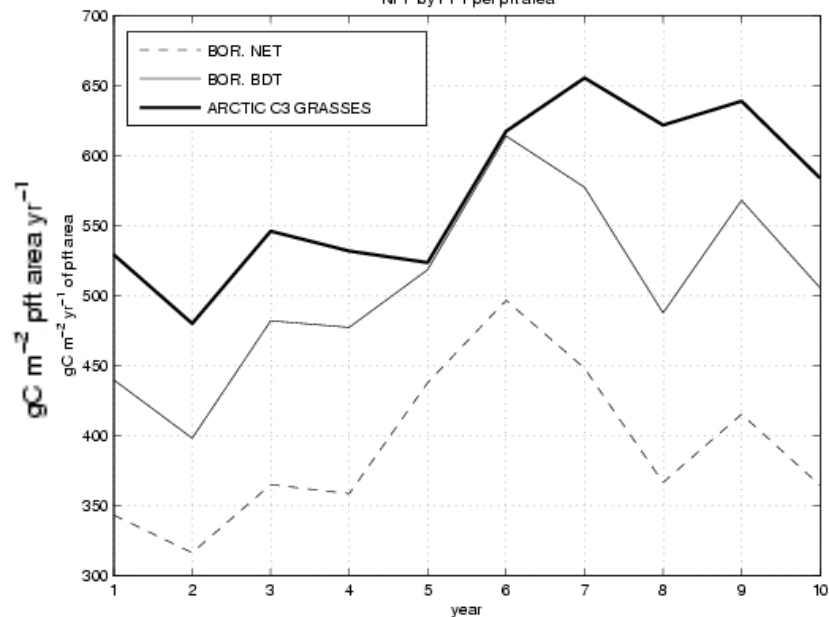
TOTAL CARBON IN WOOD (if CN, then July)



BOREAL

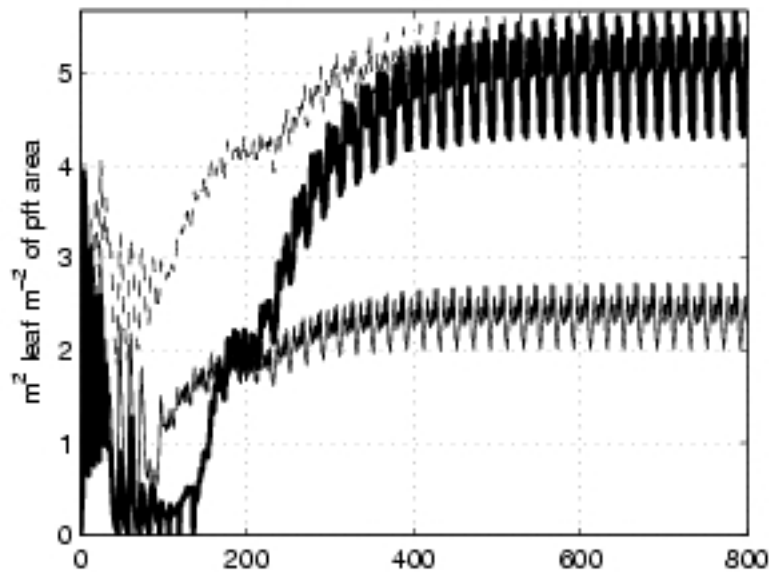


NPP by PFT per pft area

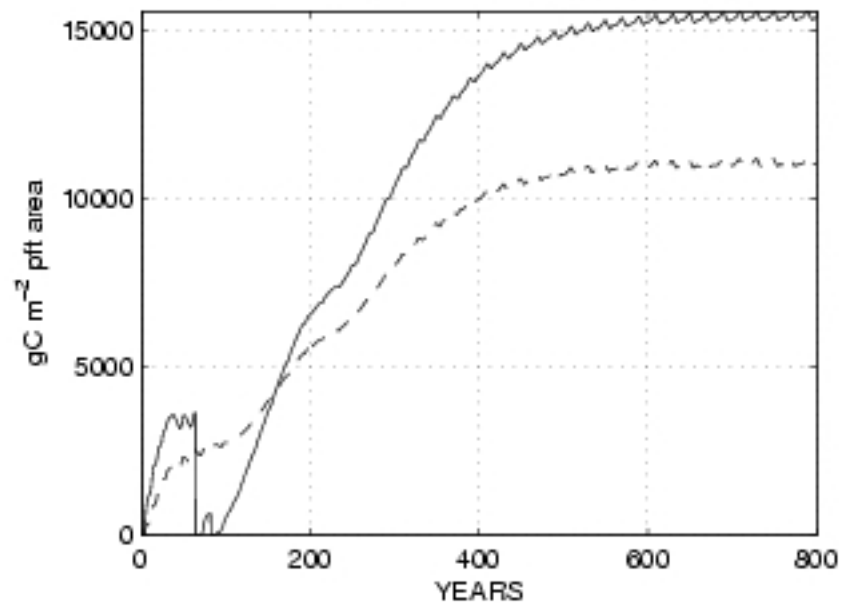


CNDV with CN Mortality CN d

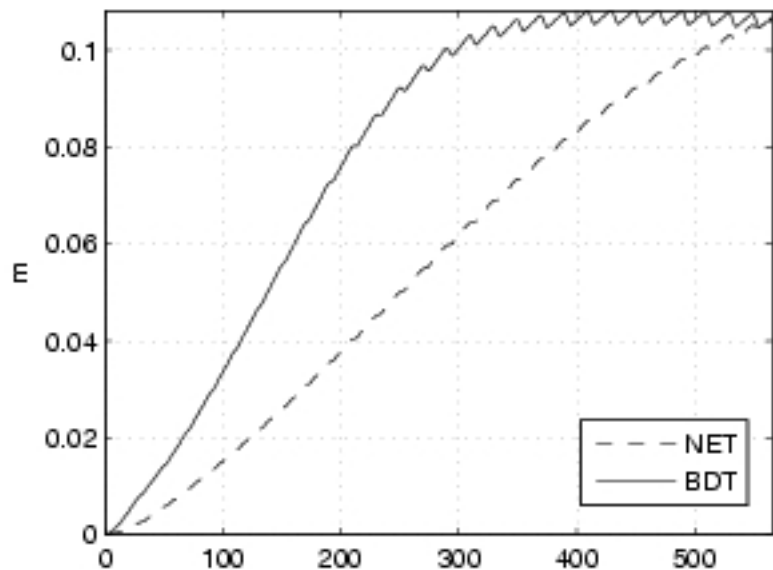
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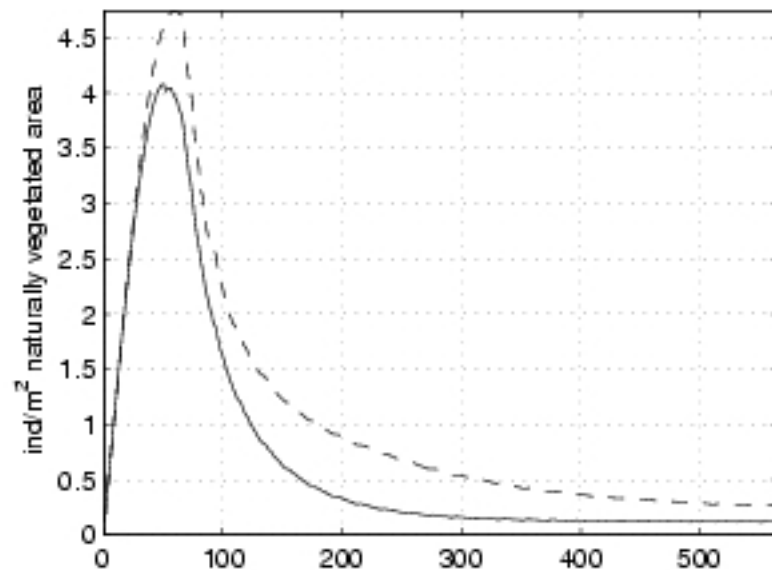
TOTAL CARBON IN WOOD (if CN, then July)



BOREAL TREE DIAMETER

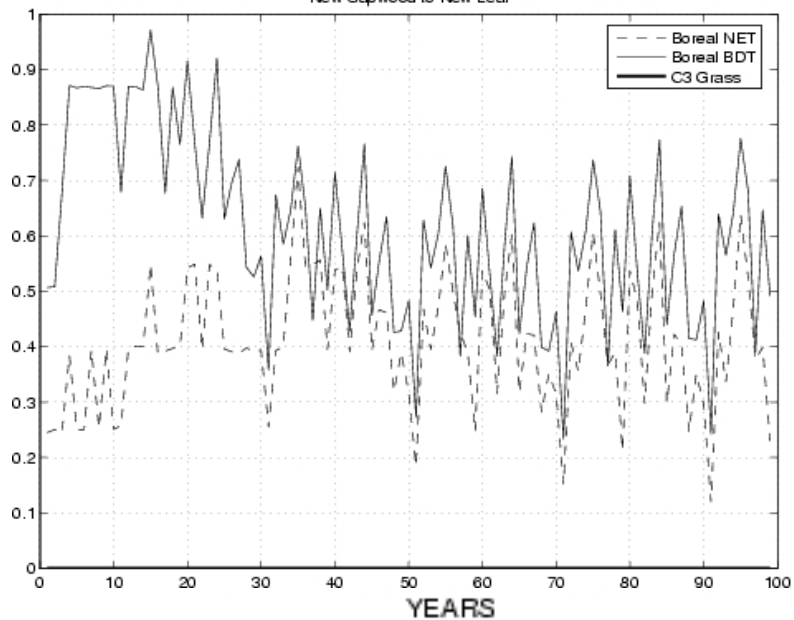


BOREAL TREE # of INDIVIDUALS

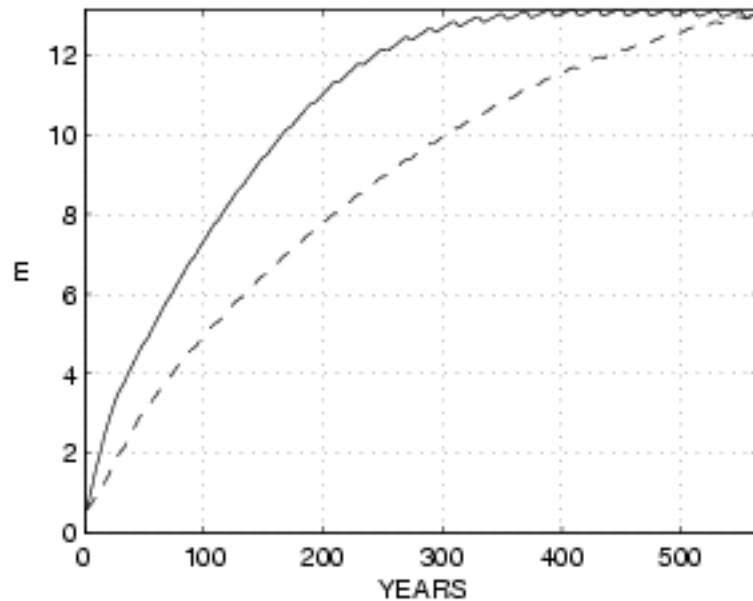


CLM-DGVM

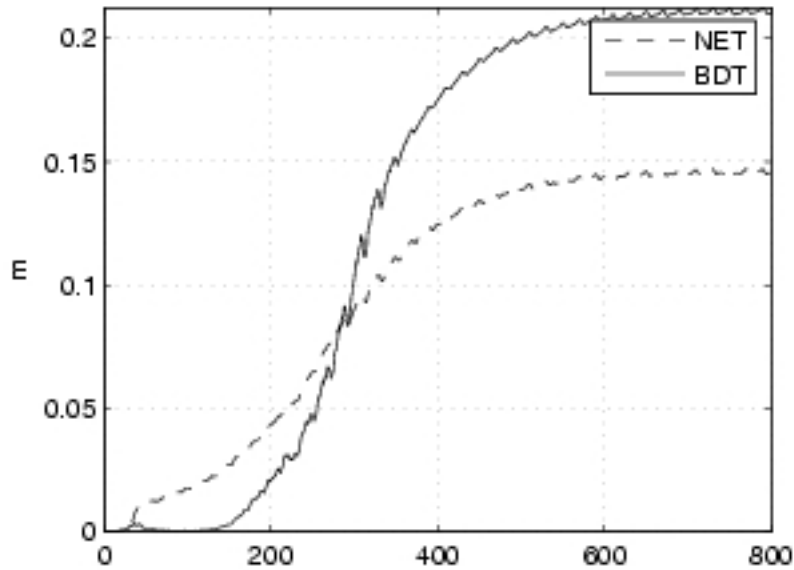
New Sapwood to New Leaf



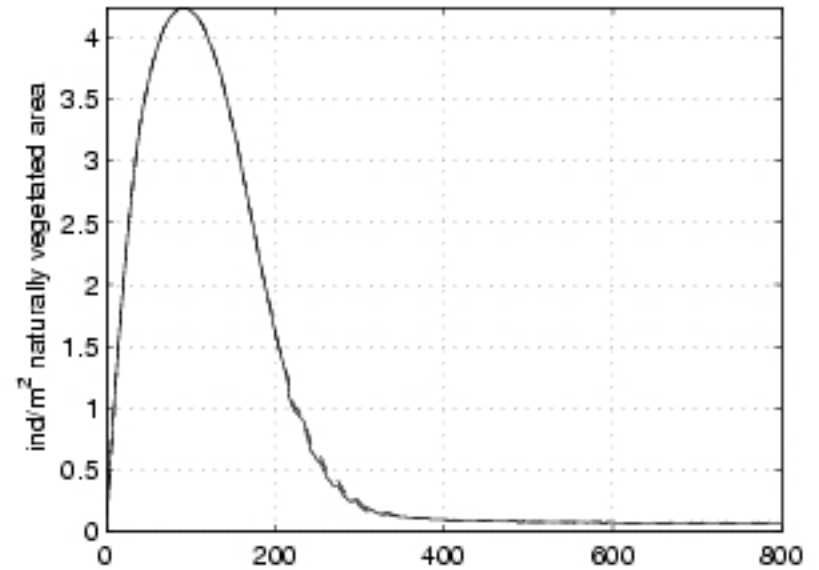
BOREAL TREE HEIGHT (if CN, then July)



BOREAL TREE DIAMETER

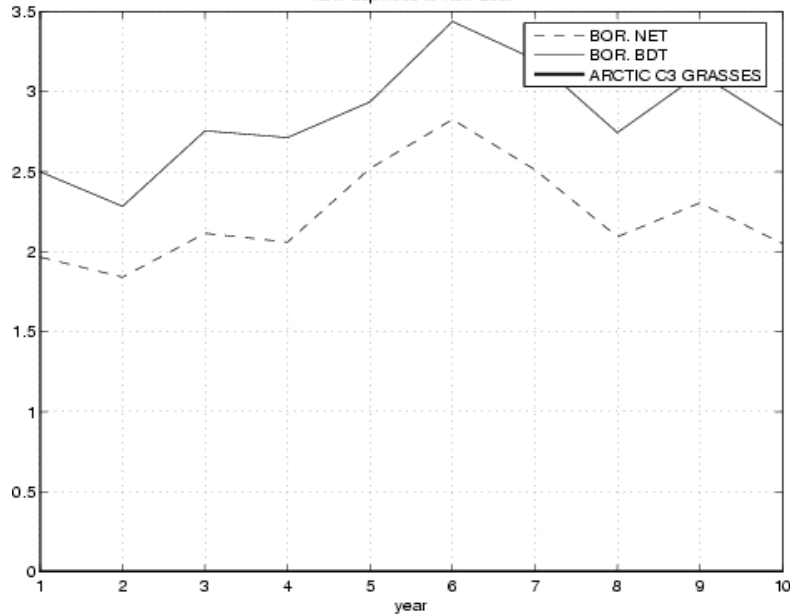


BOREAL TREE # of INDIVIDUALS

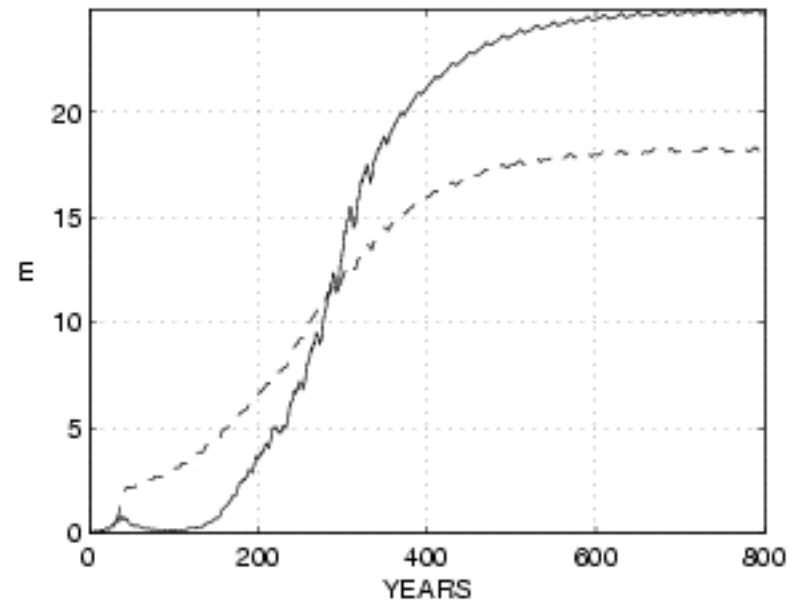


CNDV with CN Mortality LPJ *d*

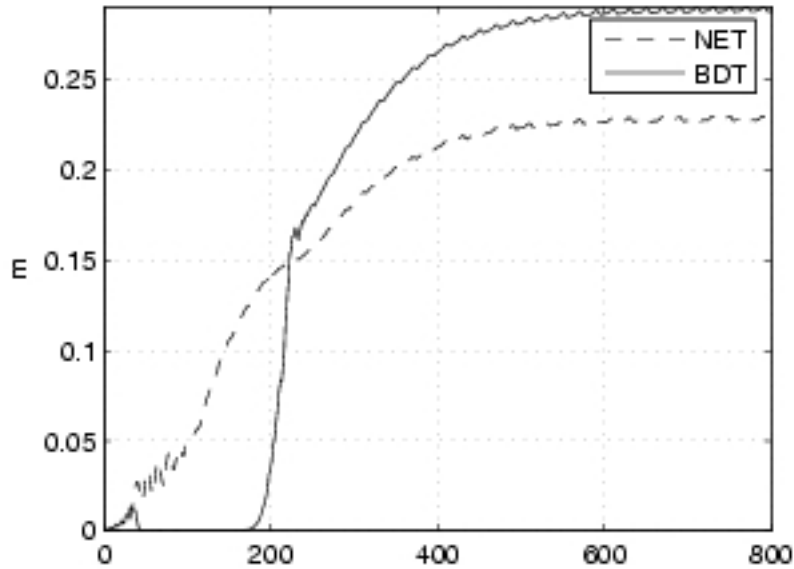
New Sapwood to New Leaf



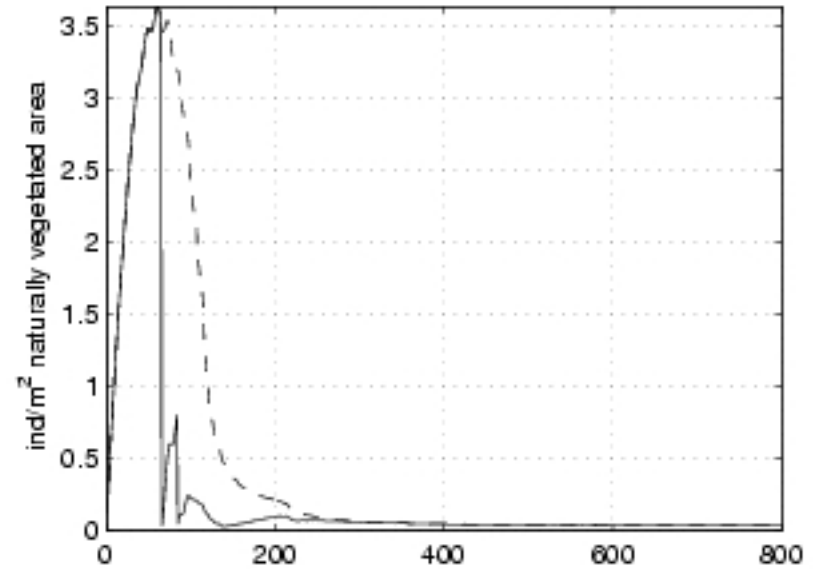
BOREAL TREE HEIGHT (if CN, then July)



BOREAL TREE DIAMETER

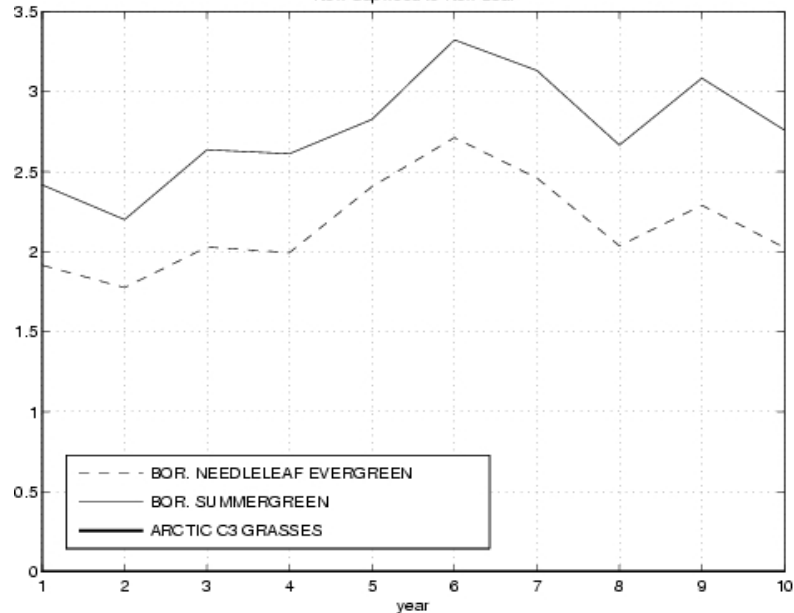


BOREAL TREE # of INDIVIDUALS

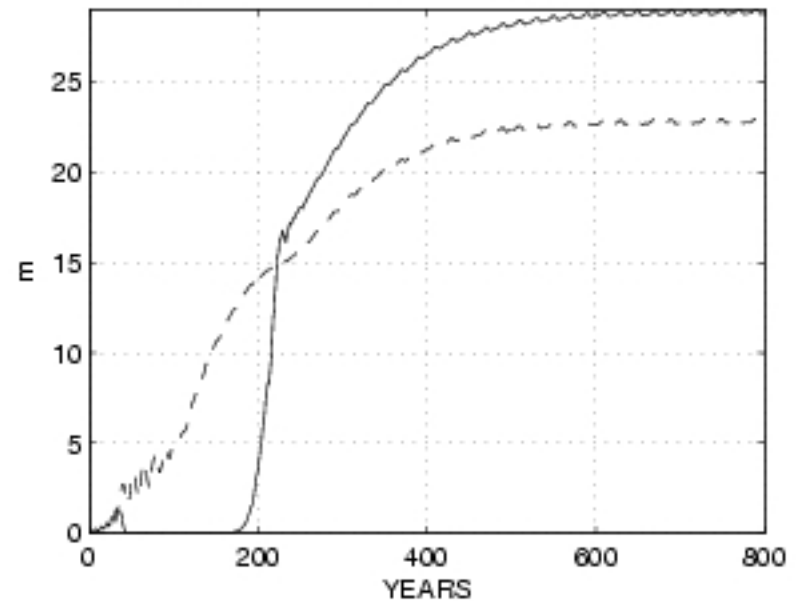


CNDV with CN Mortality CN d

New Sapwood to New Leaf



BOREAL TREE HEIGHT (if CN, then July)



Follow-up Work

- Repeat with clm3.5
- Interp. P and FPC to hourly (Peter: done?)
- Add other LPJ concepts to CNDV? For example,
 1. 100% mortality for $NPP_{ann} \leq 0$?
 2. Boreal-pft heatstress?
 3. Age and size classes by extending “avg individual”
- Repeat CNDV work with CASA?