The Ecosystem Demography model

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Contents of this talk

1. Introduction to ED model
2. Implications for physiology
3. ED-JULES coupling
4. Ongoing model development + testing
Ecosystem Demography Model
Moorcroft et al. (2001)

PFT-based tile structure.

TRIFFID

- NL tree
- BL tree
- Bare Gd
- C3
- C4
- Shrub

Age–since-last-disturbance based tile structure.
ED model structure

- In ED, tiles are defined by common ‘age since disturbance’.
- Tiles are characterised by 1D canopy structure.
- Within tiles are of ‘cohorts’, of trees.
- **Cohorts** are groups of trees with similar characteristics:
  - (PFT, height)
- In JULES, each cohort = a layer of leaf area of given PFT.
- Different PFTs can exist in the same canopy…
Canopy Structure

Jules canopy layers

<table>
<thead>
<tr>
<th>Grass</th>
<th>Shrub</th>
<th>BL Tree</th>
<th>NL Tree</th>
</tr>
</thead>
<tbody>
<tr>
<td>60 y.o.</td>
<td>30 y.o.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15 y.o.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 y.o.</td>
<td>5 y.o.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Pros and cons of ED model

- Advantages (compared to existing DGVM’s)
  - Vertical competition for light among PFTs
  - Regeneration after disturbance (succession)
  - ‘Tree scale’ parameters – constrain with observations
  - Age structure: good for fire, grazing and soil CNP cycling models.

- Disadvantages
  - Increased complexity of output/analysis
  - Untested at global scale
Implications for physiology

- Previously modelled by TRIFFID, now by ED:
  - 1. Plant functional type description
    - QUERCC (Lloyd) developing new empirical PFT description.
    - Derived from ordination analysis of largest existing vegetation datasets (RAINFOR, GLOPNET, TROBIT)
    - Completed for Amazonia, ongoing for Boreal + Savanna
    - No. PFTs will increase. Extent depends on model speed.
  - 2. Phenology
    - Simplistic phenology currently implemented.
    - Requires updating
Implications for physiology

3. Disturbance (fire and tree fall)
   - Fire model development funded to begin soon (Reading)
   - Derivation of mortality parameters from permanent sample plot data (RAINFOR, etc.). Modelling of intrinsic and extrinsic mortality will be implemented.
   - Tiling structure defined by disturbance models.

4. Growth and Allocation
   - Allometric relationships defined empirically within the PFT definitions.

5. Nutrients
   - New CN cycling model under development in QUERCC (Oxford, Aberdeen etc…)
   - Nutrient conditions will affect growth and competitive interactions.
No alterations required.

1. Canopy gas exchange
2. Hydrology
3. Stomatal Conductance
ED-JULES coupling

- ED is written in Fortran 90, and uses pointers and structures, not arrays, for memory efficiency.
- ED is called in the same place/time as TRIFFID
- It passes the same data back and forth except…
- …detailed canopy structure, which is only used in photosynthesis routines, not affecting the rest of JULES.
**ED-JULES coupling**

- MOSES/JULES (fluxes)
  - NPP per cohort
  - Met drivers for soil and phenology models

- ED (veg dynamics)
  - Tile structure (NTILES, FRAC, TILE_PTS) vegetation properties
  - Tile Properties (LAI, CAN_HT)
  - Detailed Vegetation Structure (No cohorts, PFT, LAI, Height)
Amazon Biomass Estimates

Models

TRIFFID

ED

Observations

Source: Saatchi et al. GCB, 2007
544 biomass plots
19 separate EO data layers
LAI of Africa in y2000

Figures c/o Jiafu Mao.
Global LAI distribution in ED (no needleleaf)
Conclusions

- ED is a radically different format to other DGVMs.
- ED is a mechanism for including better ecological scale understanding in a DGVM.
- Un-calibrated ED-IMOGEN represents contemporary forest cover well, so far.
- Biomass estimates are within the observed ranges.
Developments

- Globalisation: Inclusion of ‘interim’ PFT’s
- Phenology modelling
- Preparation for QESM deadline - October
Developments

- ED is a mechanism for including better ecological scale understanding in a DGVM.
- We can construct new hypotheses to explain vegetation distribution.
  - Evergreen vs. Deciduous (Nutrients? Temperature? Light regime?)
  - Tree vs. Grass (Light? Water? Nutrients?)
  - Shrubs vs. Trees (Nutrients? Water logging?)
- If we get this wrong, the responses to climatic forcing will also be wrong.
Global LAI

Myneni et al. 1997

IMOGEN_ED LAI