ELM-FATES progress updates: Impacts of modeling global vegetation demography and dynamic plant competition

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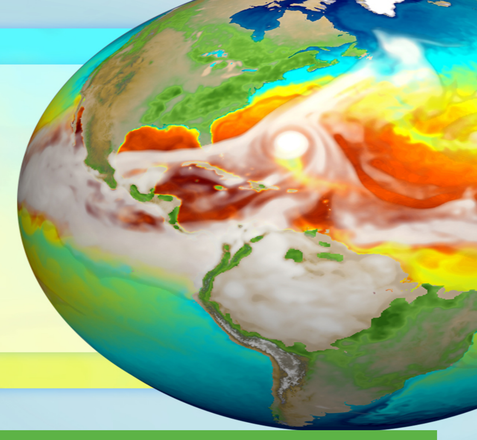
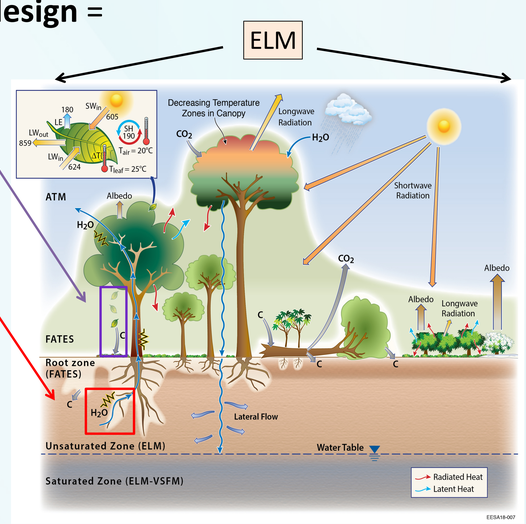


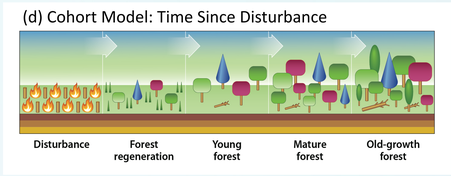
Objective and Background

Objective = global application of plant demography and trait-based dynamic vegetation (via FATES) within an Earth System Model (E3SM).

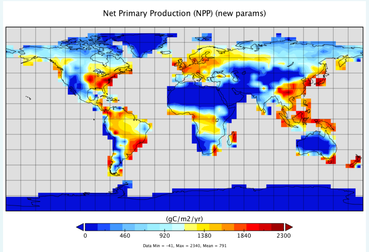
Vegetation demography within Earth System Models (ESMs) will better represent plant ecology, and vegetation processes that govern sensitive fluxes of carbon (C source or sinks), energy, water (ET, drought stress).

Model design =





Motivation = over-productive vegetation, higher C sink, more water vapor



MODIS: mean 525 (gC /m2/yr)

ELM-FATES: mean 829
New ELM-FATES: mean 791

ELM-FATES & PFT Trait Parameterization

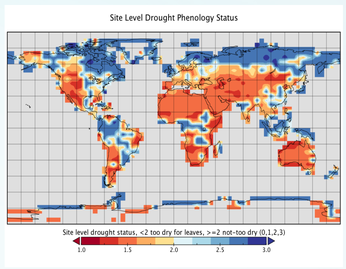
FATES Model (Functionally Assembled Terrestrial Ecosystem Simulator)

- Carbon pools, fluxes, allocation; litter fluxes; phenology; regeneration, growth, mortality, photosynthesis, respiration, plant hydraulics represented by **FATES.**
- Varying age and size structure resulting from disturbances and plant competition – more realistic canopy radiation and light competition through canopy.
- Removal of **bioclimatic envelopes**!
- Canopy physics, soil BGC, land surface hydrology, energy balancing, by **ELM**.

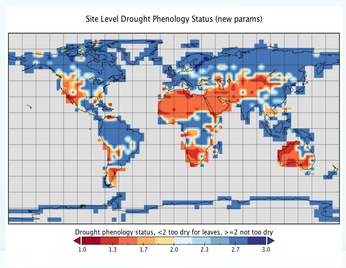
Global PFT Distribution Experiments: 1) Default FATES runs; 2) updates to PFT parameterization more realistic to competing vegetation.

Parameter Changes:

- Leaf production vs. storage allocation parameter (very influential)
- Vcmax from Bonan et al. 2011
- SLA from TRY (ELM-FATES for now is largely influenced by leaf economic tradeoffs)
- Max. DBH (Important for allometry. Default values little too high)
- Decreased shrub initial height at recruitment (Important for allometry)
- **Phenology changes under water stress (R. Fisher)



Red = drought stress area, but trees here persisted anyway. Water stress not being triggered.

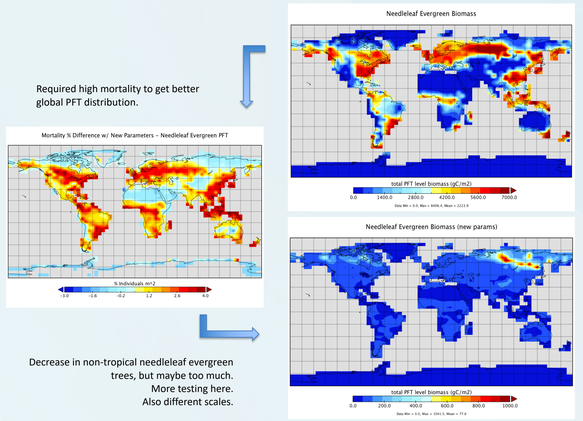


Increased soil moisture threshold for leaf drop to occur in drought water-stressed trees. Shift to more >= 2 status, not too dry.

Global simulations using ELM-FATES

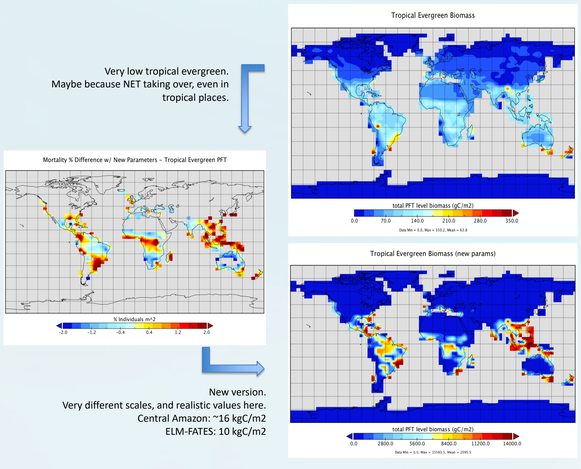
Since reporting at the 2019 E3SM All Hands Meeting:

- Large refractor to hydraulics code.
- Nutrient cycling coupled between ELM and FATES
- Size and age dependent mortality
- Phenology fixes to deciduous trees**
- Current version of ELM-FATES has 12 PFTs
- Narrowed down to 8 PFTs for testing purposes, but still represent life forms in all biomes
- 5 trees, 2 shrubs, 1 grass
- **Compared current default FATES against version with parameterization updates**
- Largest challenge – global PFT distribution, while maintaining mechanistic level of trait-filtering.



Required high mortality to get better global PFT distribution.

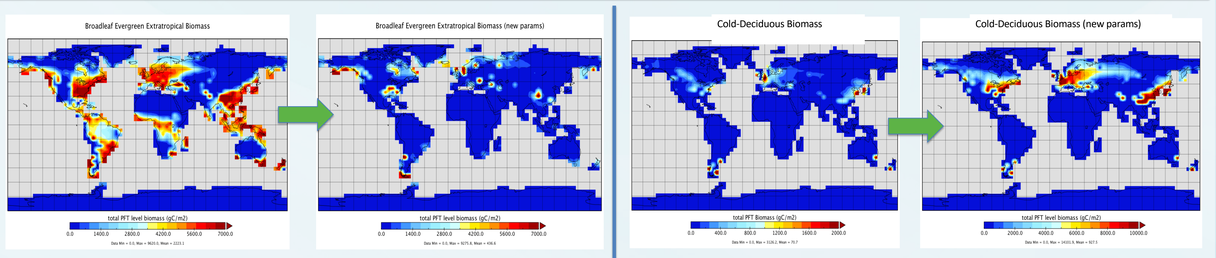
Decrease in non-tropical needleleaf evergreen trees, but maybe too much. More testing here. Also different scales.



Very low tropical evergreen. Maybe because NET taking over, even in tropical places.

New version. Very different scales, and realistic values here. Central Amazon: ~16 kgC/m2

ELM-FATES: 10 kgC/m2



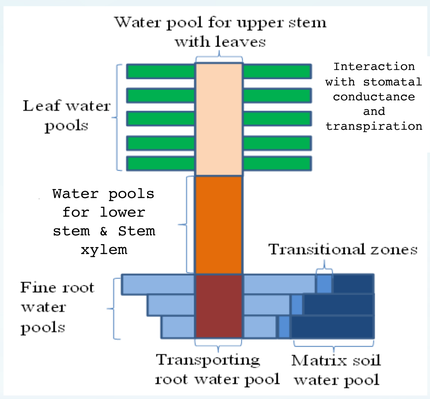
Improved regional distribution of broadleaf evergreen, but very patchy and localized. Same scales.

Regional distribution remained similar, but increased and more realistic biomass.

Expected Impact and Next Steps

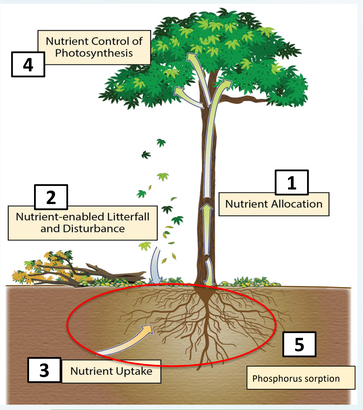
Next steps to investigate for model improvement:

- Continental-scale arctic tundra simulations investigating shrubification (new postdoc hire)
- Testing soil and vegetation BGC nutrient cycling (in progress).
- Testing site level and global plant hydraulics



Simplified FATES hydraulics schematic, Xu et al. in prep. Testing underway in boreal forests.

FATES modular nutrient competition connecting to ELM soil-BGC



Via Ryan Knox (NGEE-Tropics)

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E3SM Energy Exascale Earth System Model

e3sm.org

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