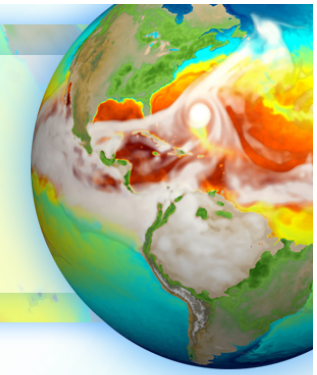

# Different numerical coupling strategies lead to diverging carbon-nutrient interactions

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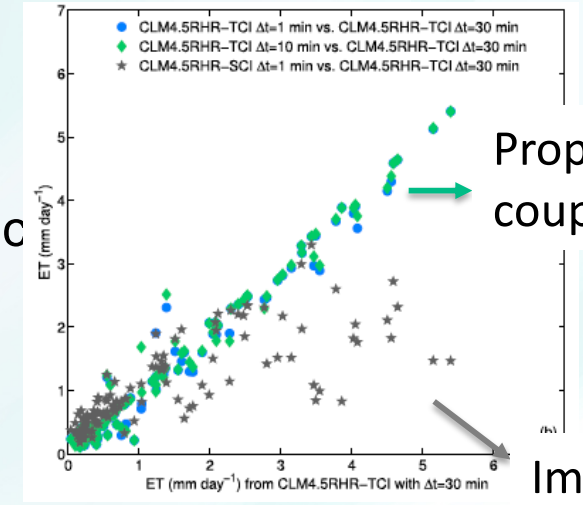
E3SM Energy Exascale Earth System Model

U.S. DEPARTMENT OF ENERGY

# Research motivation

- Carbon and nutrients are closely coupled in ecosystem biogeochemistry
- Approaches for numerical coupling are rarely evaluated, but they potentially have large influenc on the realized model simulations
- With improper numerical coupling, a right model can be wrong or a wrong model can appear as right.

An example of a right model improperly implemented



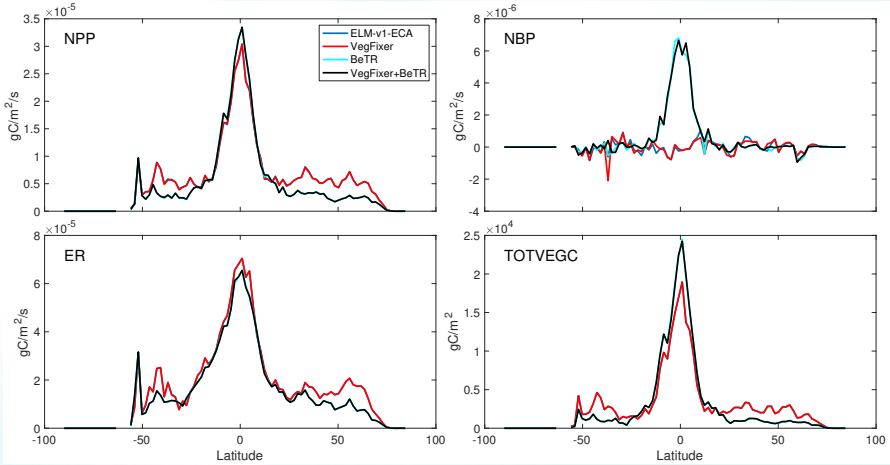

Tang et al. (2015)

# Research design

- Identical parameterization with four coupling strategies between vegetation (carbon, nitrogen, and phosphorus) and soil (carbon, nitrogen and phosphorus) in ELM.
  - A. default ELM-v1
  - B. multiple-nutrient-flux-co-limiting-solver for vegetation carbon and nutrient allocation
  - C. ELM-v1 vegetation solver + BeTR-based multiple-nutrient-flux-co-limiting-solver for soil carbon and nutrients
  - D. multiple-nutrient-flux-co-limiting-solver for both vegetation and soil BGC
- Global simulations and analysis

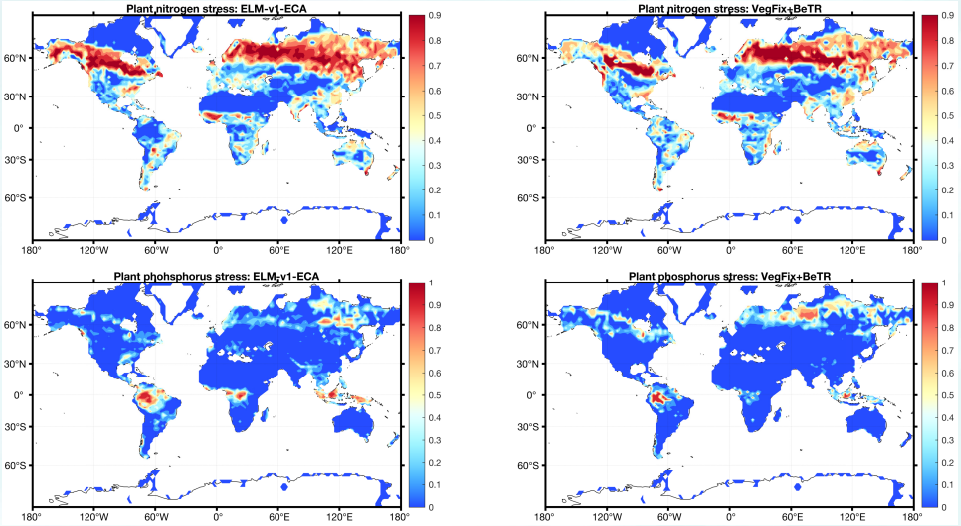
Multiple-nutrient-flux-co-limiting-solver considers the balance among fluxes while ensures all state variables are non-negative.

# Major findings




- The multiple-flux-limiter solver leads to small differences.
- Including reactive transport resulted in significant difference in the tropics.

- In tropics and also in northern America, plant nitrogen stress differ significantly.
- Greater difference in phosphorus stress occurs in the tropics.



# Further steps

- Diagnose mechanisms that result in these differences.
- Model calibrations are being conducted to quantify to what degree the differences in different model implementations can be reduced by using different parameters in the tropics.
- Conduct scenario analyses to quantify model divergence in simulated long term ecosystem dynamics.