

Dave Lawrence, Wednesday 2, 2006

DGVM – Carbon cycle

What exists now and is likely to be part of the “core” ESM for AR5 (taken together, these pieces “close” the carbon cycle)

- Ocean biogeochemistry with simple ecosystem model (NPZ: nutrient, phytoplankton, zooplankton)
- Terrestrial carbon cycle models (typically without nitrogen?) including natural fire
- Biogeophysical models of water and energy exchange
- Vegetation dynamics – including age class succession, limited PFTs - simple succession
- Anthropogenic land use/cover change (transient) – translate into carbon fluxes
- Land management – agricultural activity on cropland, irrigation, forestry

Issues:

- Will require integration of terrestrial carbon cycle model, land use/land management, and DGVM capabilities (not necessarily trivial)
- NOTE that terrestrial carbon cycle depends heavily on the climate simulation. A set of metrics are required (to be delivered to the developers of the physical model) that need to be met in order for a meaningful simulation of the carbon cycle to be performed (COPPEN classification?).
- Coupling surprises!
- Can information be provided that essentially makes up the difference for models that don't get all the components into the model, e.g. biophysical properties that represent land use/DGVM?

“Vanguard” elements not likely to be incorporated into a significant number of ESMs

- Nitrogen in carbon cycle
- Fire (human management impact)
- River biogeochemistry
- Micronutrient limits (Fe) on ocean biogeochemistry
- Ocean bottom carbon chemistry, calcite (important on 300-1000 yr timeframe)
- Reactive gases, e.g. methane, VOC sources
- Advanced DGVM with improved succession due to more species
- Urban – transient
- High resolution land – improve explicitly spatial terrestrial processes
- Impact of ozone on vegetation

Coupling frequency

- In most cases synchronous coupling, although a hierarchy is used for DGVM (daily to weekly for phenology, monthly to yearly for dynamic biogeography)

Timescale of feedback

- DGVM – 1 to 100 years
- Carbon cycle (terrestrial plus ocean) - 10 years no global feedback, carbon cycle feedbacks may not kick in globally for 30 years, but biogeophysical (and regional) feedbacks may occur on shorter timescale

Computer resources

- Terrestrial carbon cycle (core): < 20%, around 3-5%(?) increase to atmosphere/land cost although storage goes up considerably (large increase in prognostic variables) (Note that increase in CPU resources may be larger if model needs to move to sub-grid tiling to accommodate DGVM capability)
- Ocean biogeochemistry (core): 2 to 5x cost to ocean model due to large increase in number of tracers; storage also goes up considerably

Scenario requirements

- Consistent land use and land management (irrigated, crop type, forestry, grazing) scenarios. Gridded information required. Disturbance history required (is this a responsibility of the scenario generation?). Future disturbance? Smooth transition of history to future
- Nitrogen deposition
- Ozone concentration near the surface
- CO₂ emissions (disaggregated or “gridded,” where grids can be very large, e.g. US, Europe) ? To be used for diagnostic purposes?

Improvements

- Better representation of agriculture (types, phenology, management)
- More consideration of how to deal with errors in AOGCM (e.g precip, temp)
 - Flux corrections?
 - Tune vegetation model or land model to get, for example, a rainforest in the Amazon (is ecology wrong or climate wrong)?
 - What are the “show stoppers”/metrics?
- Improved constraints on carbon cycle through methods other than observations (TRANSCOM modeling activity, OCMIP)
- Ocean – flux of CO₂ at interface, eddy mixing parameterizations, use of ARGO float information
- Improved observations required –
 - Southern hemisphere, ocean and land (carbon stocks, land use/management patterns)
 - Soil moisture
 - Satellite measurements of vegetation structure