Uncertainty Quantification in the BGC Feedbacks SFA

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Sources of Uncertainty and Error

Model Uncertainty:

- Parameter uncertainty
- Structural uncertainty
- Algorithmic uncertainty
- Initial conditions
- Boundary conditions

Observational Uncertainty:

- Sensor/instrument uncertainty
- Inadequate resolution or representativeness (sampling uncertainty)
- Model uncertainty in product generation (e.g., satellite products, reanalysis products)

Errors in models, observing systems, analysis, and regridding also challenge our ability to trust both models and observations.

Common Challenges and Solutions

Challenges:

- Model forcing uncertainties
  - Precipitation amount and distribution biases
  - Solar radiation biases (due to clouds and aerosols)
  - Land use change characterization
- Representativeness uncertainty and spatial mismatch
- Carbon cycle disequilibrium

Solution Strategies:

- Compare models with a broad range of independent observational data
- Synthesis research to investigate components of model uncertainty (does parameter or structural uncertainty dominate?)
- Sensitivity analysis to identify parameters and forcing variables that strongly influence projections
- Increase demand for realistic uncertainty characterization of observational data
- Plant functional type (PFT)-level output
- Improve uncertainty propagation

Testing Uncertainties from Model Forcing

- Comparing model simulations with ILAMB (CLM40cn, CLM45bgc_CRUNCEP, CLM45bgc_GSWP3)
- Multiple "truths," benchmark the forcing, benchmark the benchmarks?

Global Variables (Info for Weightings)

	CLM40cn	CLM45bgc_CRUNCEP	CLM45bgc_GSWP3
Aboveground Live Biomass	0.61	0.61	0.67
Burned Area	0.36	0.49	0.51
Gross Primary Productivity	0.70	0.75	0.76
Leaf Area Index	0.52	0.52	0.57
Global Net Ecosystem Carbon Balance	0.51	0.58	0.52
Net Ecosystem Exchange	0.49	0.48	0.49
Ecosystem Respiration	0.65	0.70	0.74
Soil Carbon	0.44	0.50	0.61
Summary	0.54	0.58	0.61
Evapotranspiration	0.74	0.77	0.79
Latent Heat	0.80	0.82	0.84
Terrestrial Water Storage Anomaly	0.63	0.63	0.60
Summary	0.72	0.74	0.74
Albedo	0.73	0.74	0.75
Surface Upward SW Radiation	0.77	0.76	0.79
Surface Net SW Radiation	0.86	0.85	0.87
Surface Upward LW Radiation	0.93	0.93	0.94
Surface Net LW Radiation	0.78	0.78	0.86
Surface Net Radiation	0.79	0.79	0.81
Sensible Heat	0.76	0.76	0.79
Summary	0.80	0.79	0.82
Surface Air Temperature	0.91	0.91	0.94
Precipitation	0.75	0.75	0.76
Surface Downward SW Radiation	0.87	0.87	0.90
Surface Downward LW Radiation	0.90	0.90	0.94
Summary	0.82	0.82	0.84
Overall	0.65	0.68	0.70

Notes: 4 Categories are divided: Ecosystem and Carbon Cycle, Hydrology Cycle, Radiation and Energy Cycle, and Forcings.

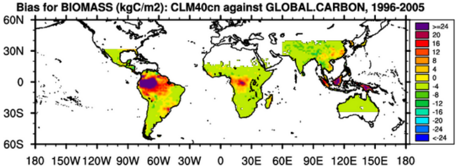
Forcing Influence on Aboveground Live Biomass

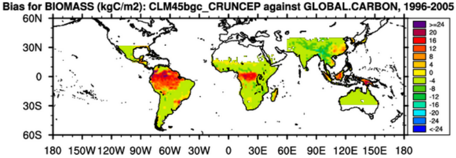
Diagnostic Summary for Aboveground Live Biomass: Model vs. GLOBAL.CARBON

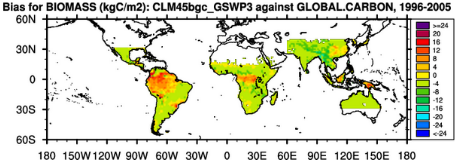
	Global Patterns		Scoring (Info)		
	Annual Mean (PgC)	Bias (PgC)	Global Bias	Spatial Distribution	Overall
Benchmark [Saatchi et al. (2011)]	351.4	-	-	-	-
CLM40cn	483.9	132.4	0.48	0.50	0.49
CLM45bgc_CRUNCEP	437.2	85.8	0.47	0.58	0.52
CLM45bgc_GSWP3	354.6	3.2	0.56	0.73	0.64

Notes: In calculating overall score, rmse score contributes double in comparison with all other scores.

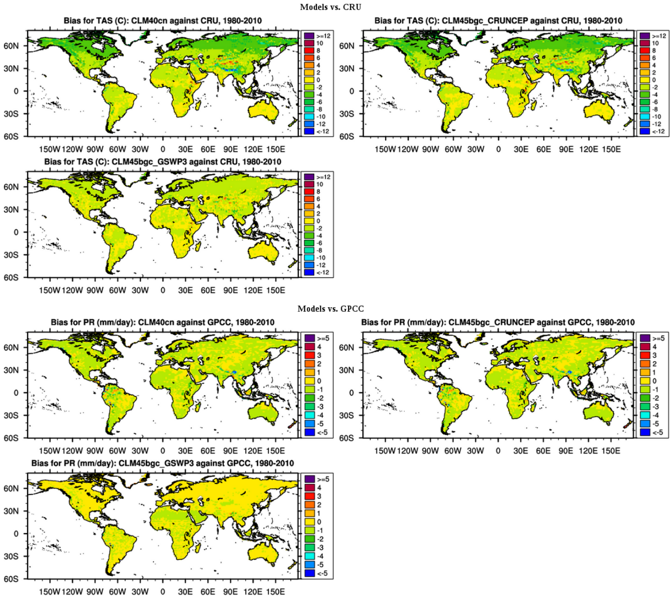
Models vs. GLOBAL.CARBON







Benchmarking the Forcing: Temperature and Precipitation



Benchmarking the Forcing: ET vs. Precipitation