

# A Permafrost Benchmark System to evaluate permafrost models



Kevin Schaefer<sup>1</sup>, Elchin Jafarov<sup>2</sup>, Mark Piper<sup>2</sup>, Christopher Schwalm<sup>3</sup>

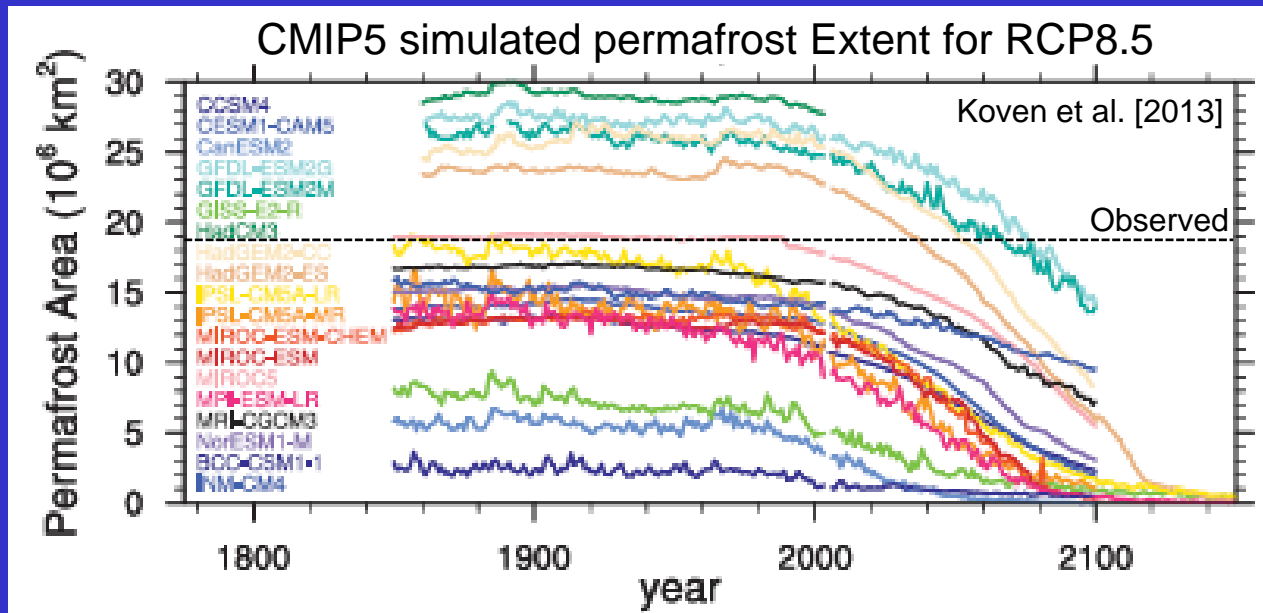
<sup>1</sup>National Snow and Ice Data Center, Cooperative Institute for Research in Environmental Sciences, University of Colorado at Boulder

<sup>2</sup>Institute of Arctic and Alpine Research, University of Colorado at Boulder

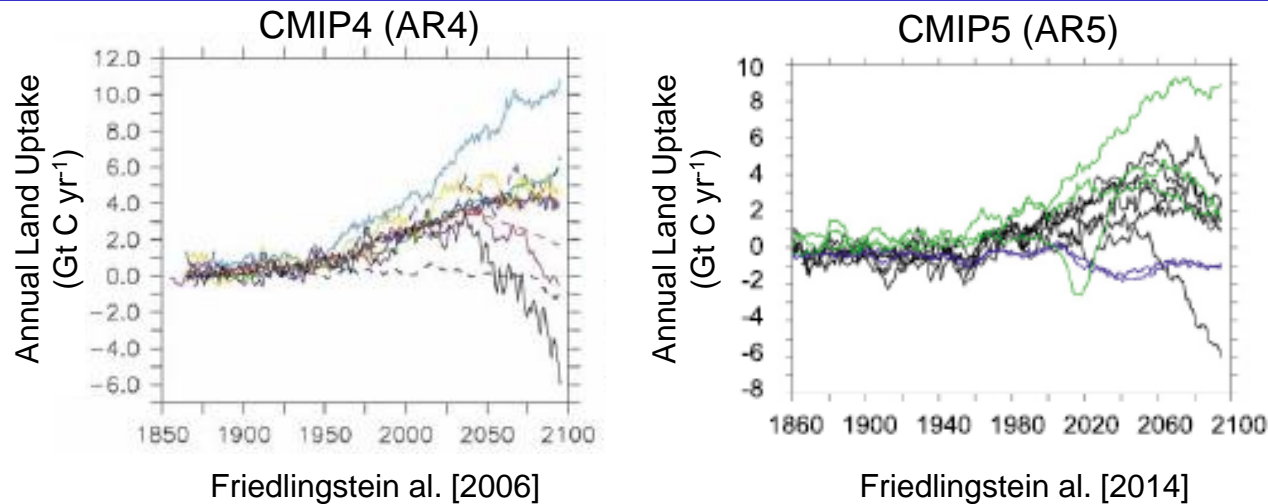
<sup>3</sup>Woods Hole Research Center

# Background

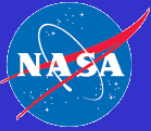
- Permafrost changing fast, but data is sparse
- Policy makers rely on models
- Urgent need to improve simulated permafrost



# Why have Land Models Not Improved?



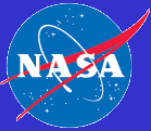
- Dozens of Model Intercomparison Projects (MIPs)
- MIPs are not repeatable
  - Too much effort to set up and execute
  - Data preparation too difficult
  - Too much time between MIPs
- Need cyber-infrastructure (CI) for repeatable model testing



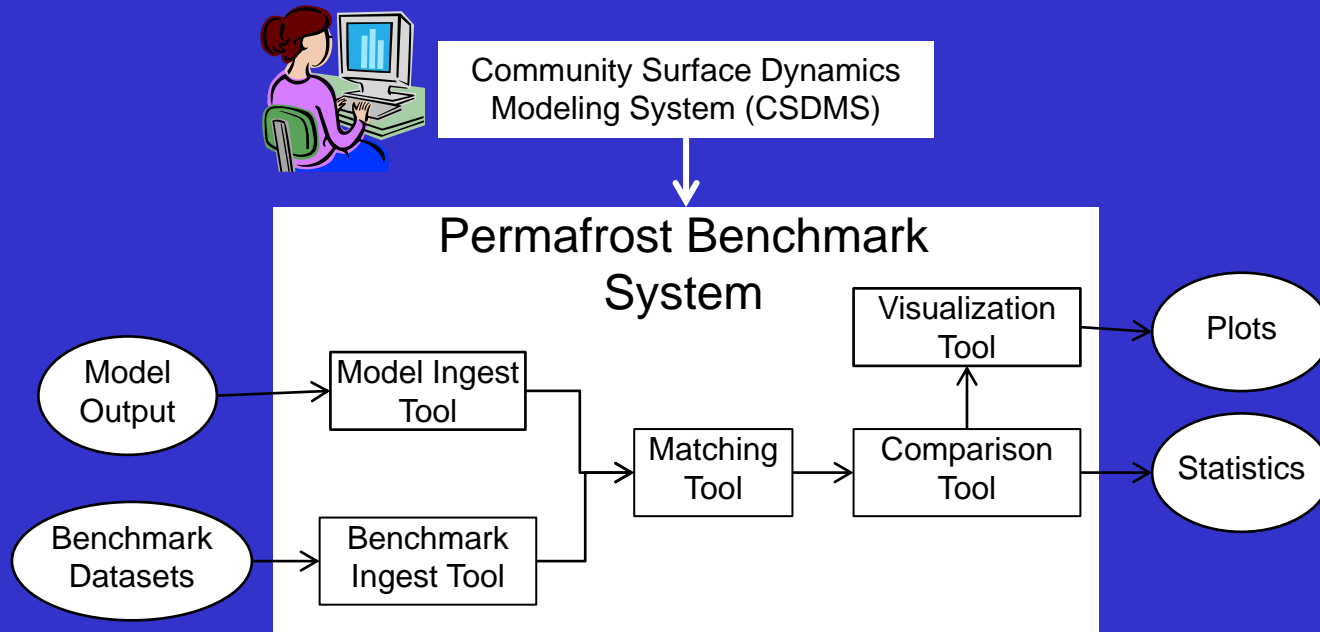
# Permafrost Benchmark System (PBS)

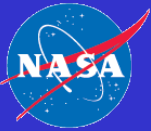


- NASA: Computational Modeling Algorithms And Cyberinfrastructure
- CI for repeatable testing of simulated permafrost dynamics
- Objective 1: Develop benchmark datasets
- Objective 2: Build PBS
- Objective 3: Evaluate global models

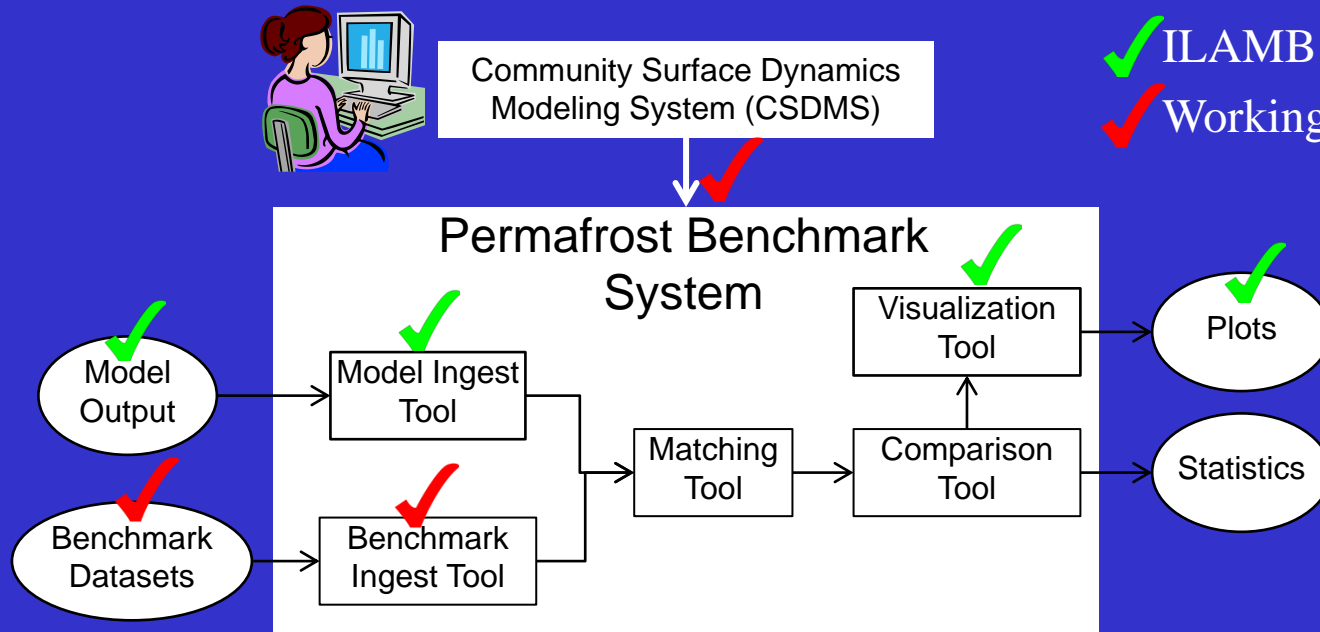


# PBS Architecture



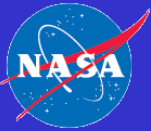


# PBS Status



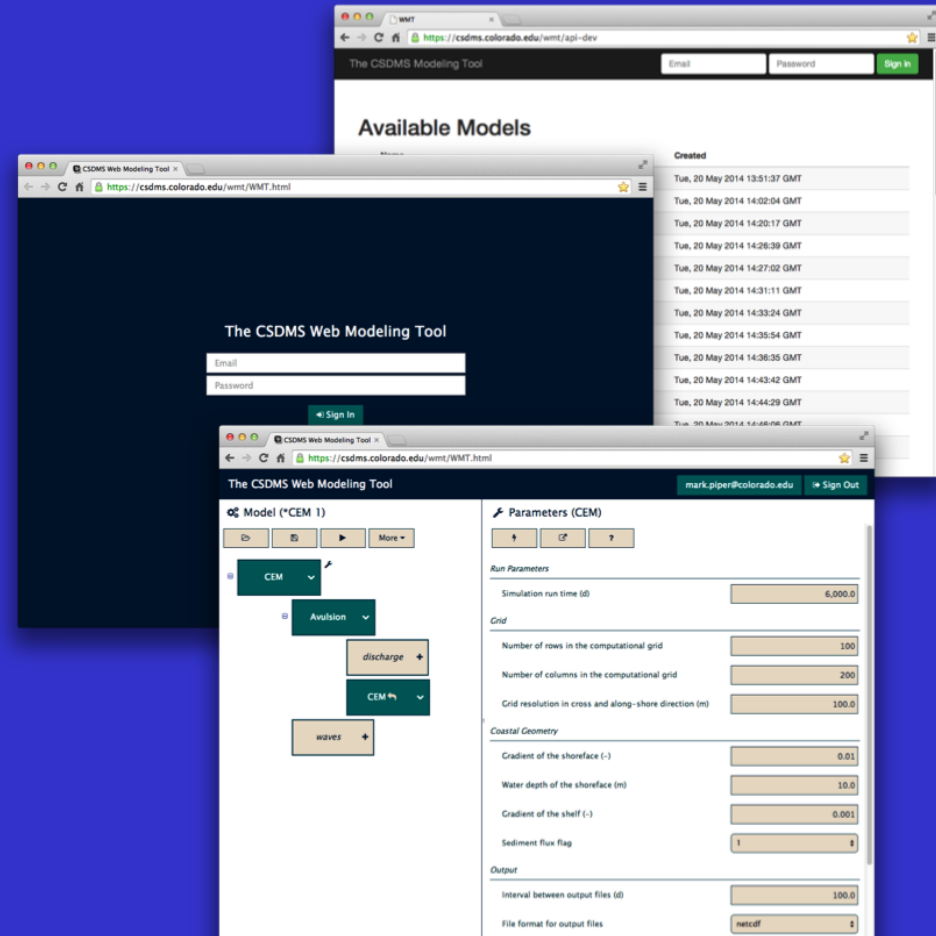
✓ ILAMB  
✓ Working on now

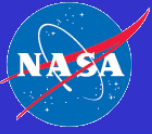
- Collaborating with ILAMB
- Collaborating with 4-5 independent benchmark developers
- Partner with ABoVE



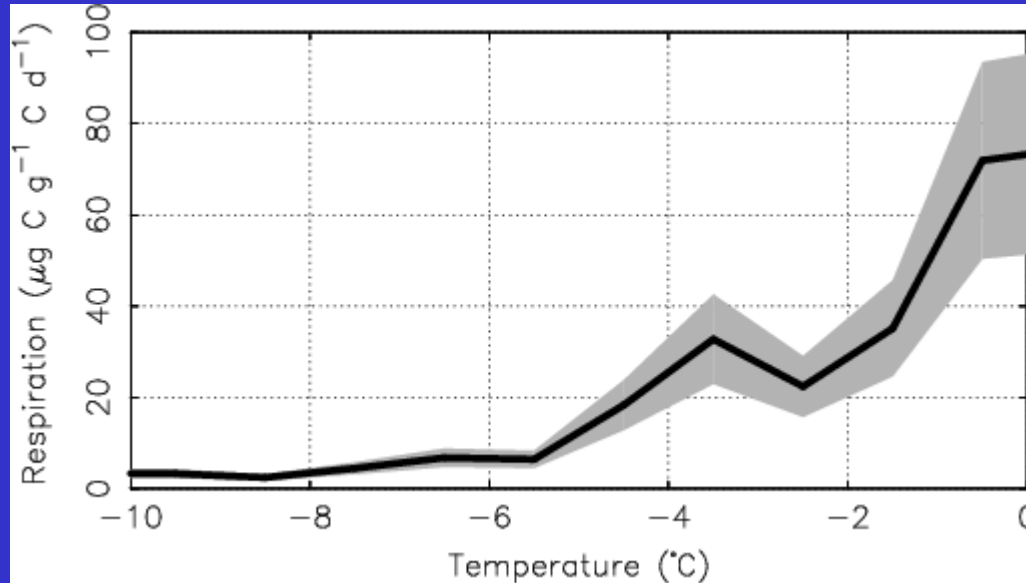
# PBS on CSDMS

- CSDMS
  - Framework to couple models
  - HPC environment
  - Web user interface
- PBS will leverage ILAMB CI
  - Scoring, ingest, outputs, etc.
- PBS will provide ILAMB with
  - Permafrost benchmarks
  - HPC environment
  - Graphical user interface



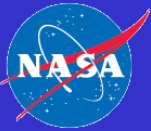


# Respiration Benchmark



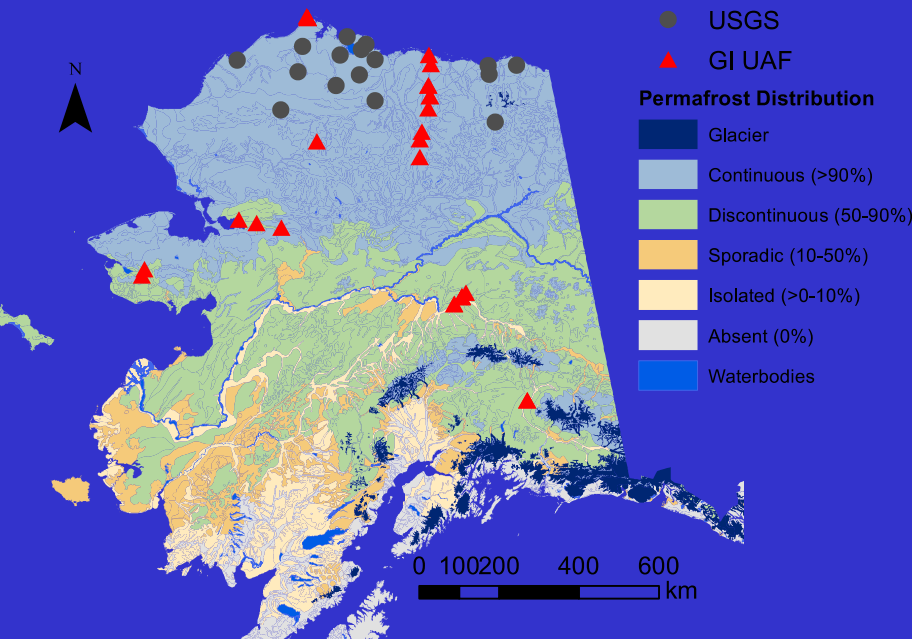
- Respiration vs. Soil Temperature from incubation data
- Evaluate simulated winter respiration
- Uncertainty ~30%
- 150 data points, with ~100 more to extract



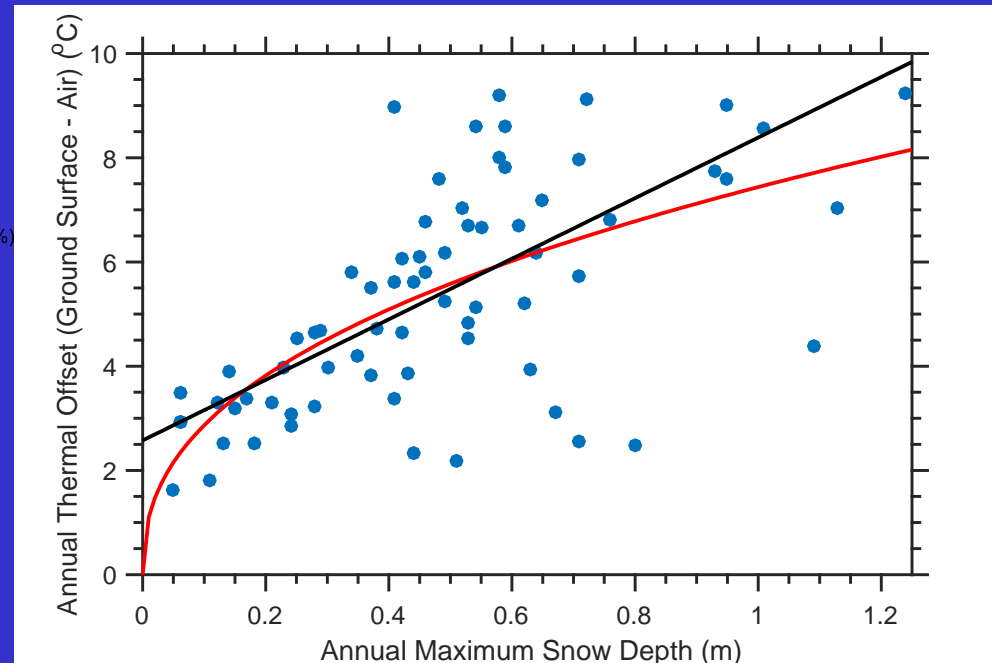


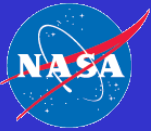
# Alaska Temperature Benchmark

Shallow borehole stations in Alaska

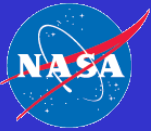


Thermal offset vs. snow benchmark

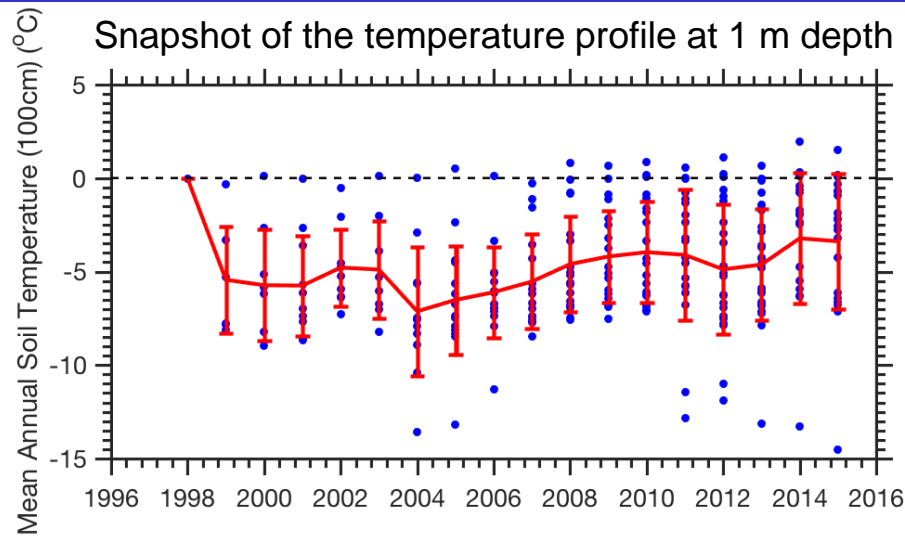




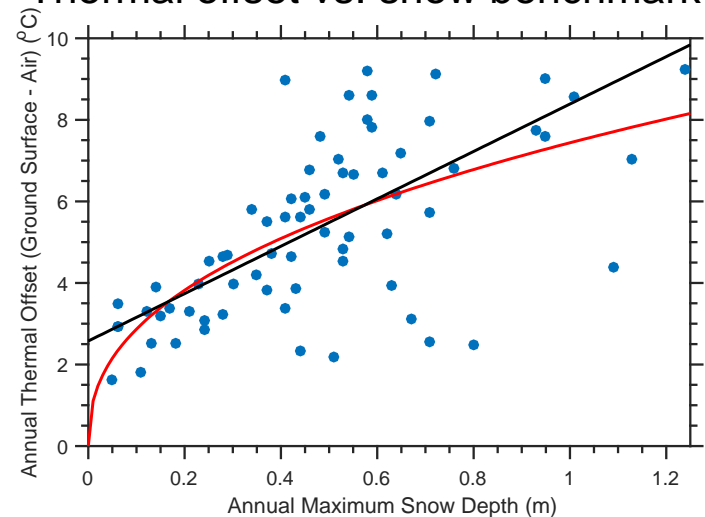
# Thank You

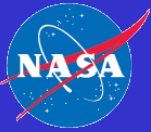


# Alaska Temperature Benchmark



## Thermal offset vs. snow benchmark





# International Land Model Benchmarking (ILAMB)



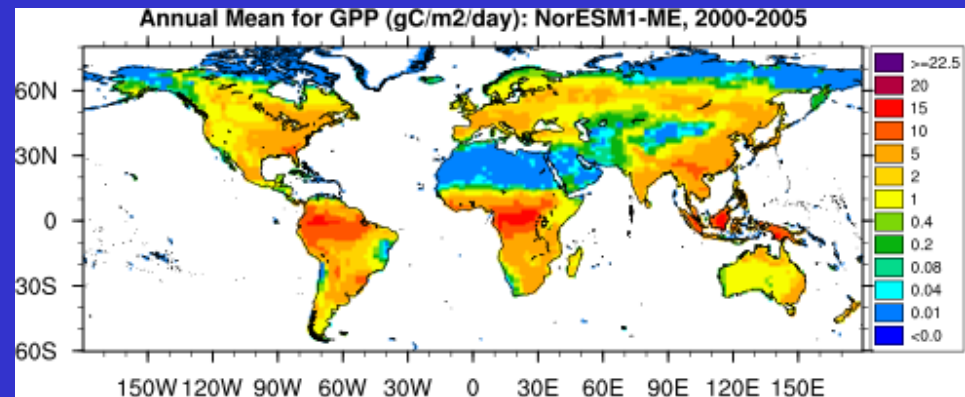
- Scores models against multiple benchmarks
- User chooses variables, metrics, benchmarks
- User can add new metrics and benchmarks
- Tabular, graphical, and web output
- Version 1 released in December 2015

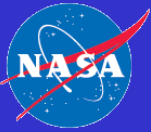
## Metric Document, Scoring Metrics, Data, Model and Overall Diagnostic Information

Metric Document	Rules for Scoring System	Scoring Metrics, Data and Overall Info	Model Data Availability
<a href="#">Click Here</a>	<a href="#">Click Here</a>	<a href="#">Click Here</a>	<a href="#">Click Here</a>

## Overall Scores

	MeanModel	MPI-ESM-LR	NorESM1-ME	BIOME-BGC
<a href="#">Global Variables</a>	0.73	0.68	0.69	0.66
<a href="#">Overall</a>	0.73	0.68	0.69	0.66





# Evaluate MsTMIP and CMIP 5 Models

- MsTMIP: 15 offline land surface models
- CMIP5: 28 fully coupled Earth system models
- Variables: biogeochemistry (e.g., GPP), biophysics (e.g., albedo), and permafrost dynamics (e.g., ALT)
- Error propagation
- Site to global
- Time and space
- Multi-metric
- Composite scoring

