ABoVE Modeling Working Group

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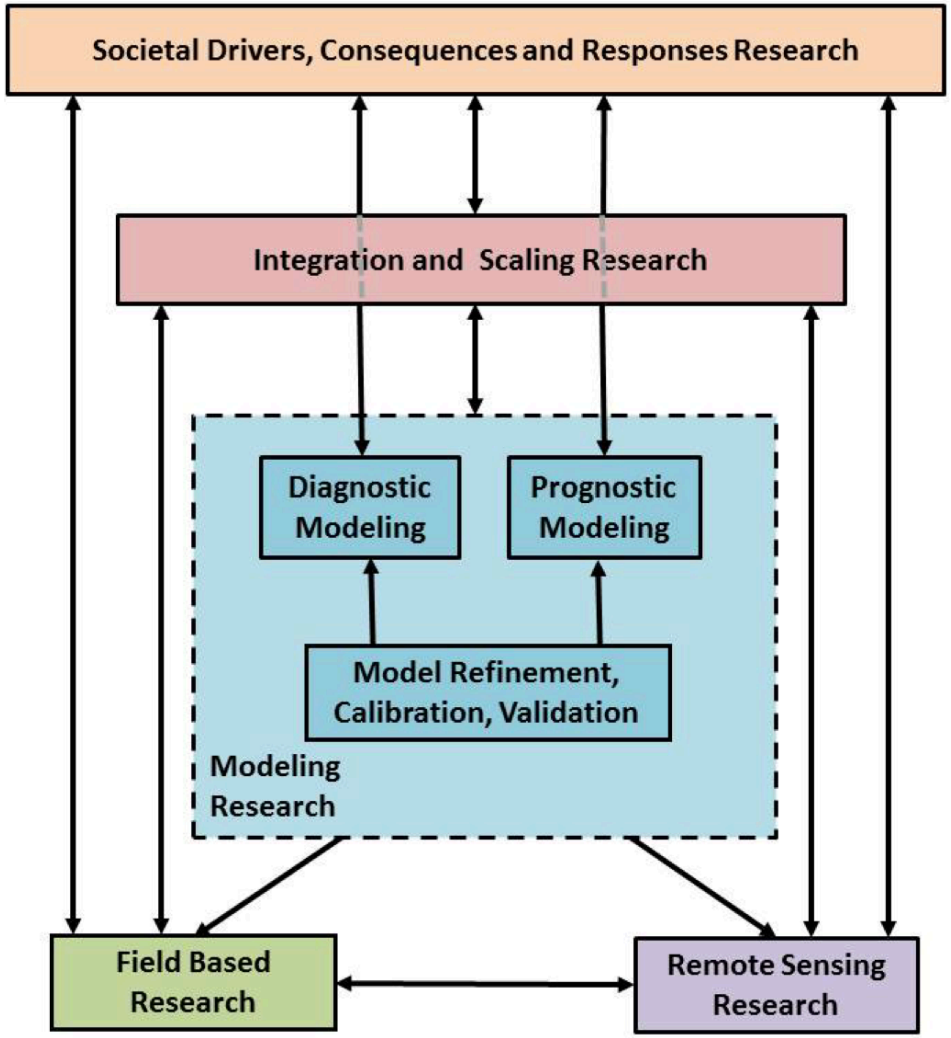
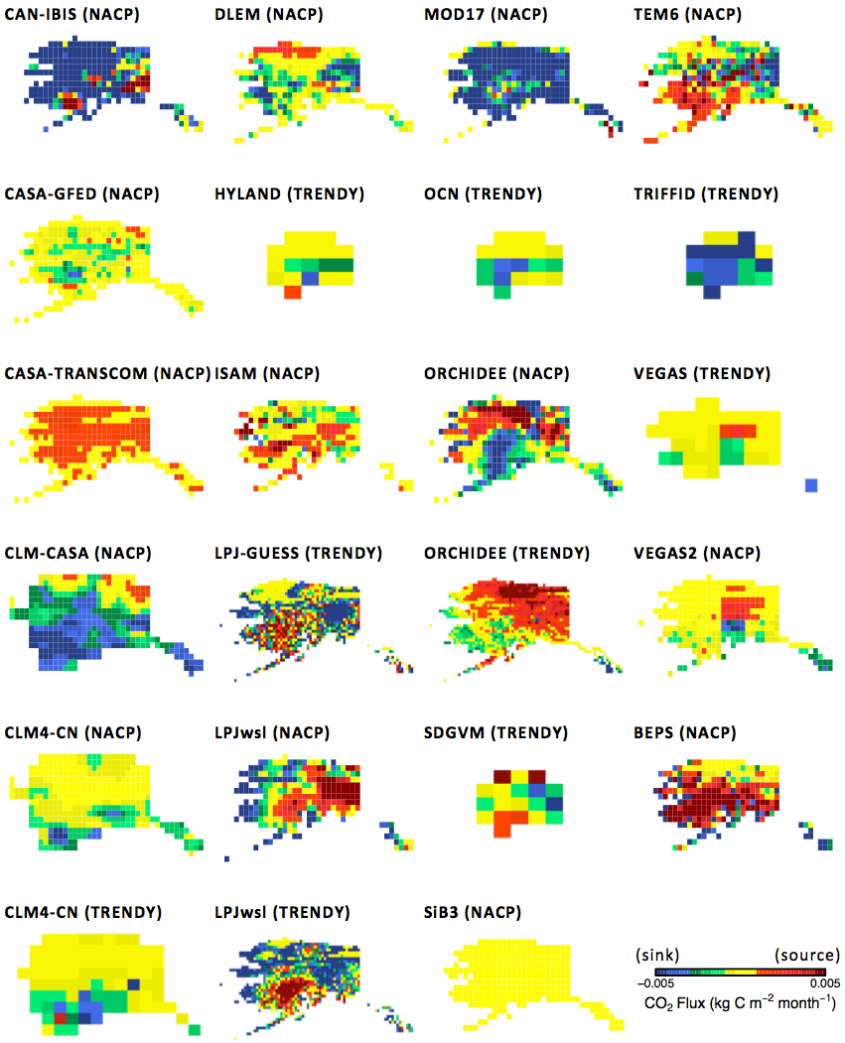
YU ZHANG (CCMEO)

Above: modeling group working.
(note- not the ABoVE Modeling Working Group)

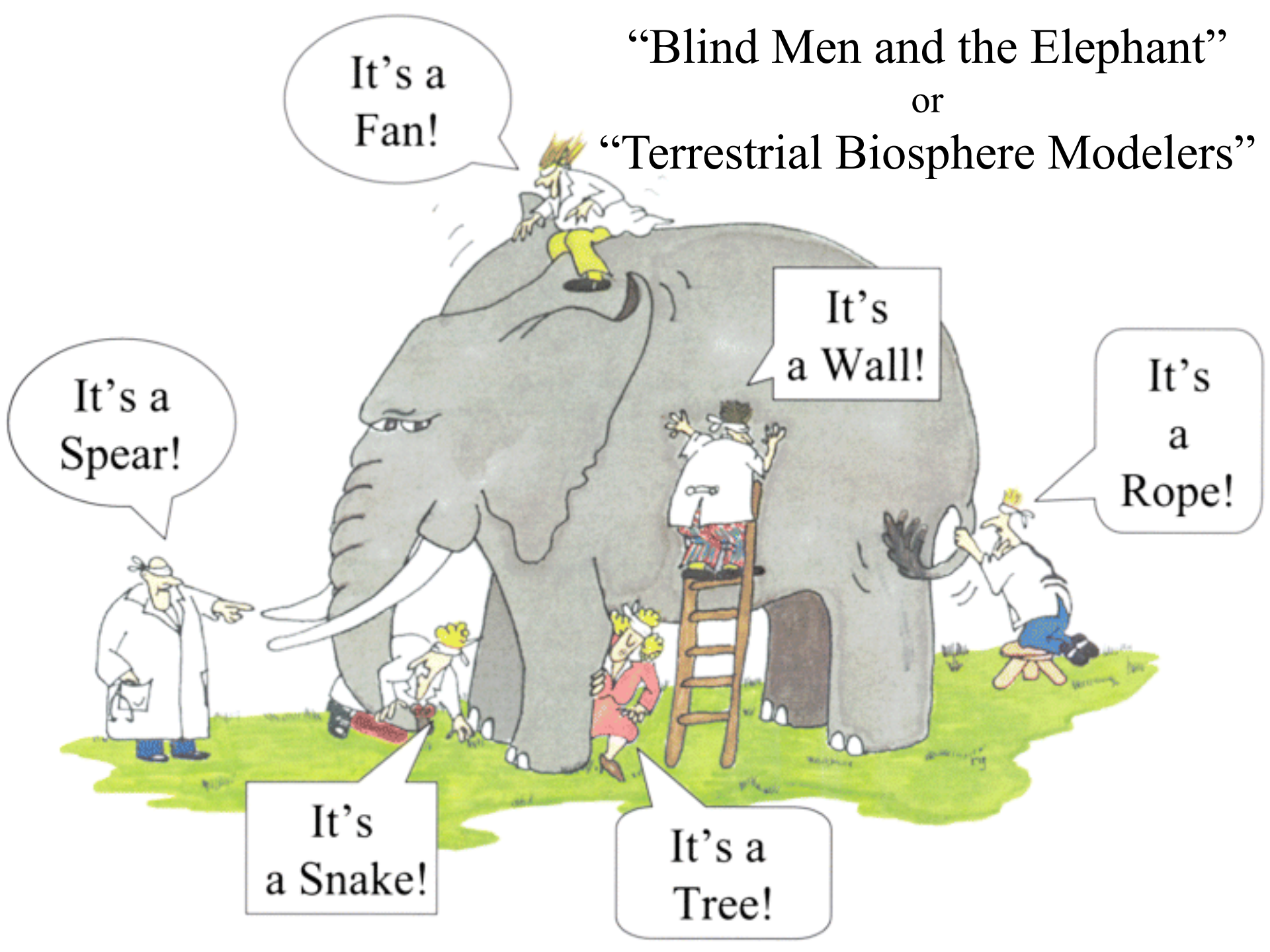


From the ABoVE Concise Experiment Plan (ACEP): modeling research is positioned at the interconnecting center of the ABoVE activities.



From *Fisher et al.* (2014): Terrestrial biosphere models exhibit every possible combination of net carbon flux dynamics in AK.

"Blind Men and the Elephant"
or
"Terrestrial Biosphere Modelers"



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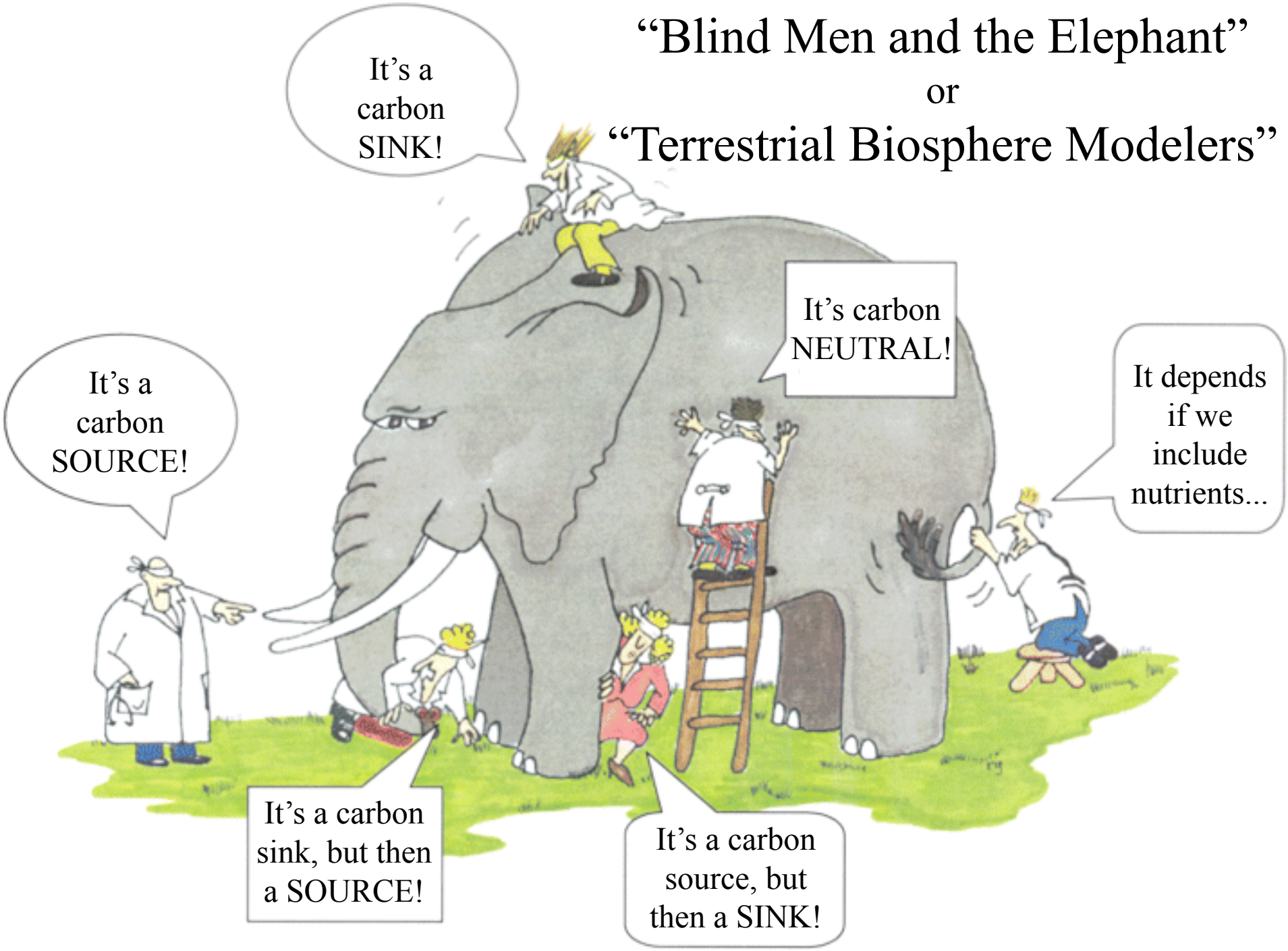
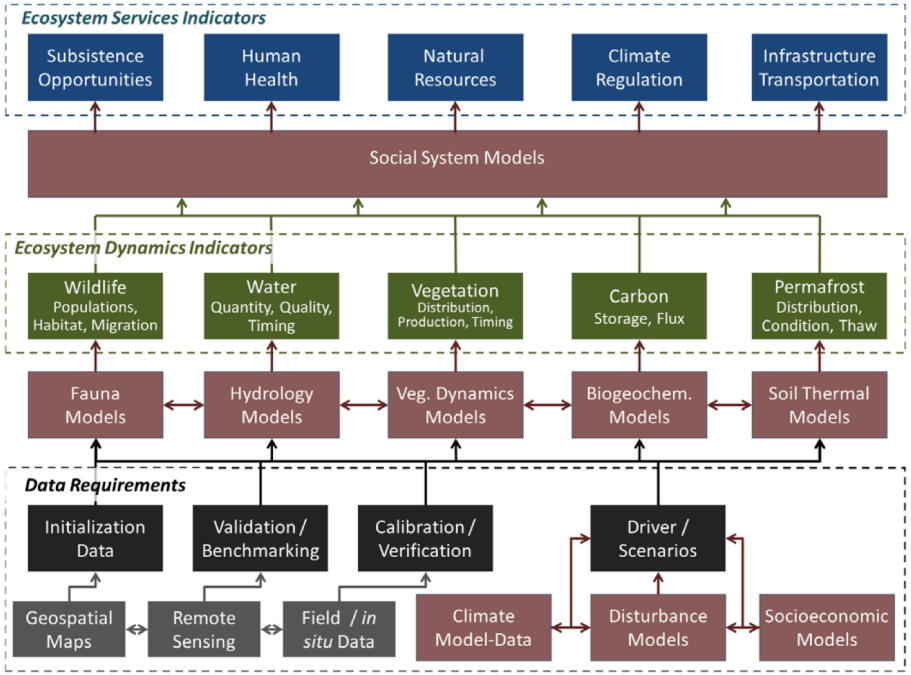


Science Objectives

Overarching ABoVE Modeling WG Objective:

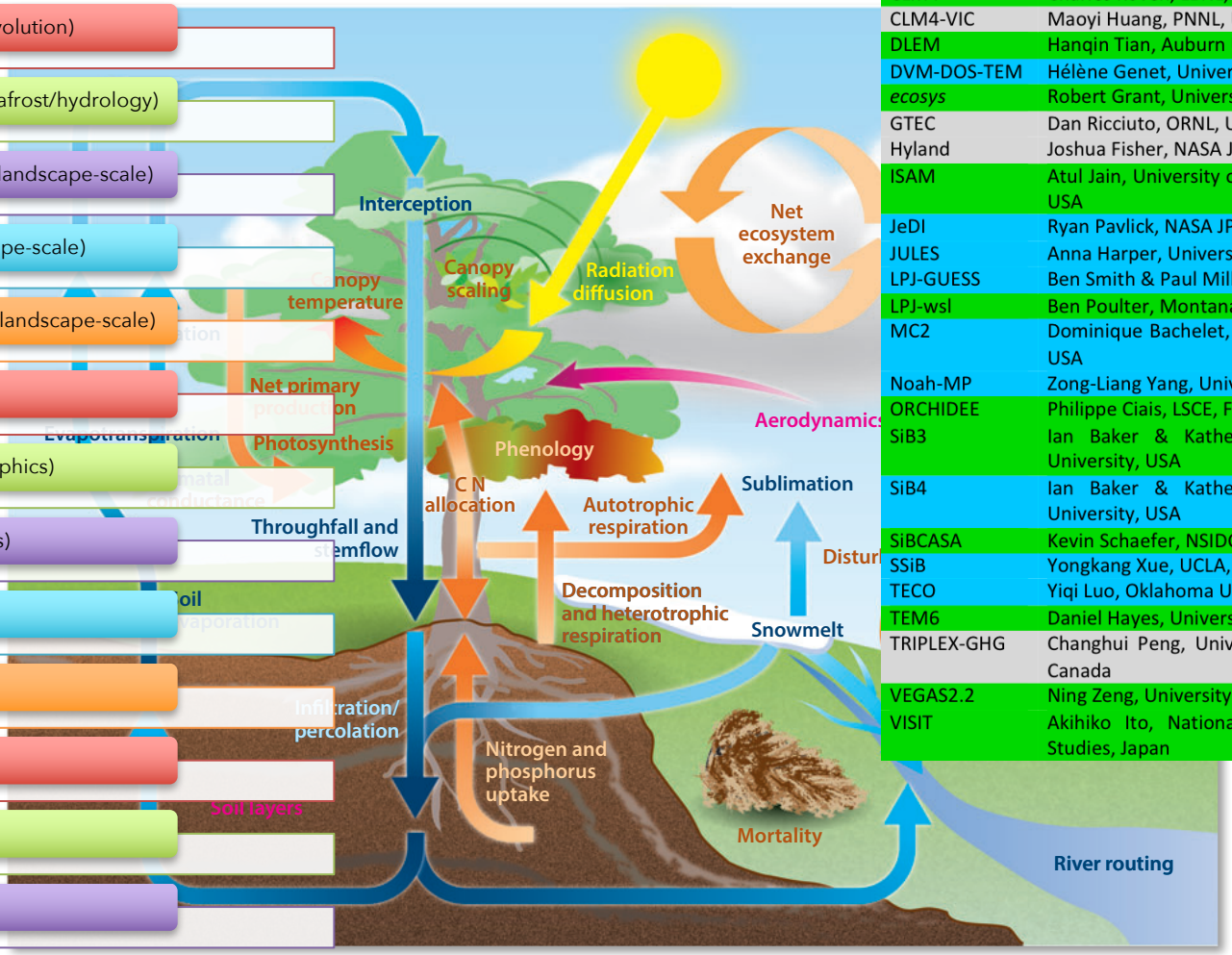
Integrate ABoVE datasets into global modeling community, and facilitate model improvement in simulation of ABR dynamics for the ABoVE Indicators



From the ABoVE Concise Experiment Plan (ACEP): the full modeling plan stated as required by ABoVE. The modeling elements for ABoVE Phase I will fully complete 2 out of the 3 components: the *Data Requirements* (black) and the *Ecosystem Dynamics Indicators* (green).

Modeling

- SnowModel (snowpack evolution)
- SUTRA4.0 (coupled permafrost/hydrology)
- PFLOTRAN (hydro-focus, landscape-scale)
- ATS (hydro-focus, landscape-scale)
- TCF-PWBM (hydro-focus, landscape-scale)
- CanFIRE (fire)
- UVAFME (forest demographics)
- ED2 (forest demographics)
- CASA
- TCF
- PVPRM
- CARDOMAM
- LUE models



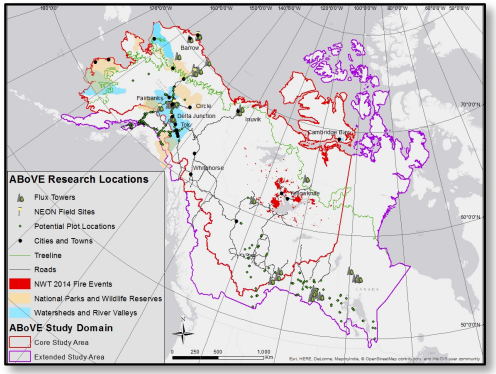
Model	Collaborator(s)
aDVGM2	Simon Scheiter, Senckenberg Gesellschaft für Naturforschung, Germany
Biome-BGC	Weile Wang, NASA Ames, USA
CABLE	Yiqi Luo, Oklahoma University, USA
CLASS-CTEM	Altaf Arain, McMaster University, Canada
CLM4	Charles Koven, LBNL, USA
CLM4-VIC	Maoyi Huang, PNNL, USA
DLEM	Hanqin Tian, Auburn University, USA
DVM-DOS-TEM	Hélène Genet, University of Alaska Fairbanks, USA
ecosys	Robert Grant, University of Alberta, Canada
GTEC	Dan Ricciuto, ORNL, USA
Hyland	Joshua Fisher, NASA JPL, USA
ISAM	Atul Jain, University of Illinois at Urbana-Champaign, USA
JeDI	Ryan Pavlick, NASA JPL, USA
JULES	Anna Harper, University of Exeter, UK
LPJ-GUESS	Ben Smith & Paul Miller, Lund University, Sweden
LPJ-wsl	Ben Poulter, Montana State University, USA
MC2	Dominique Bachelet, Conservation Biology Institute, USA
Noah-MP	Zong-Liang Yang, University of Texas, USA
ORCHIDEE	Philippe Ciais, LSCE, France
SiB3	Ian Baker & Katherine Haynes, Colorado State University, USA
SiB4	Ian Baker & Katherine Haynes, Colorado State University, USA
SiBCASA	Kevin Schaefer, NSIDC, USA
SSiB	Yongkang Xue, UCLA, USA
TECO	Yiqi Luo, Oklahoma University, USA
TEM6	Daniel Hayes, University of Maine, USA
TRIPLEX-GHG	Changhui Peng, University of Quebec at Montreal, Canada
VEGAS2.2	Ning Zeng, University of Maryland, USA
VISIT	Akihiko Ito, National Institute for Environmental Studies, Japan

Fisher et al., 2014. Modeling the terrestrial biosphere. *Annual Review of Environment and Resources* 39: 91-123.

Figure 2

The terrestrial biosphere as represented in terrestrial biosphere models.

Domain



0 20

Multimodel std. dev TotSoilCarb
(2003; kg C m^{-2})

Uncertainty in Modeled Soil Carbon Across the ABoVE Domain

Modeling Approaches: Driver Data

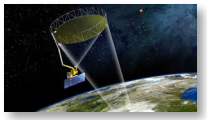
Environmental driver and initialization datasets being organized within the ABoVE Science Cloud available for ABoVE modeling research

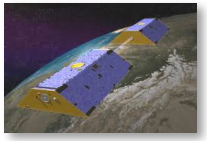
Driver data sets	Source	Temporal Resolution	Temporal Extent	Spatial Resolution	Spatial Extent
Climate fields (surface air temperature, precipitation, radiation, winds, humidity, etc.)	NARR	hourly	1970s-2000s	0.25°	North America
	DAYMET	daily	1980 - 2014	1 km^2	North America
	SNAP	monthly	1901-2009	2 km^2	ABoVE Domain
Potential vegetation	SYNMAP	-	-	0.25°	Global
	EOSD	-	-	1 km^2	Canada
	CAVM	-	-	1 km^2	Circumarctic tundra
Area burned	Canadian Large Fire Database	annual	1950s-2014	1 km^2	Canada
	AK Interagency Database	annual	1950s-2014	1 km^2	Alaska

Spaceborne & Airborne Remote Sensing

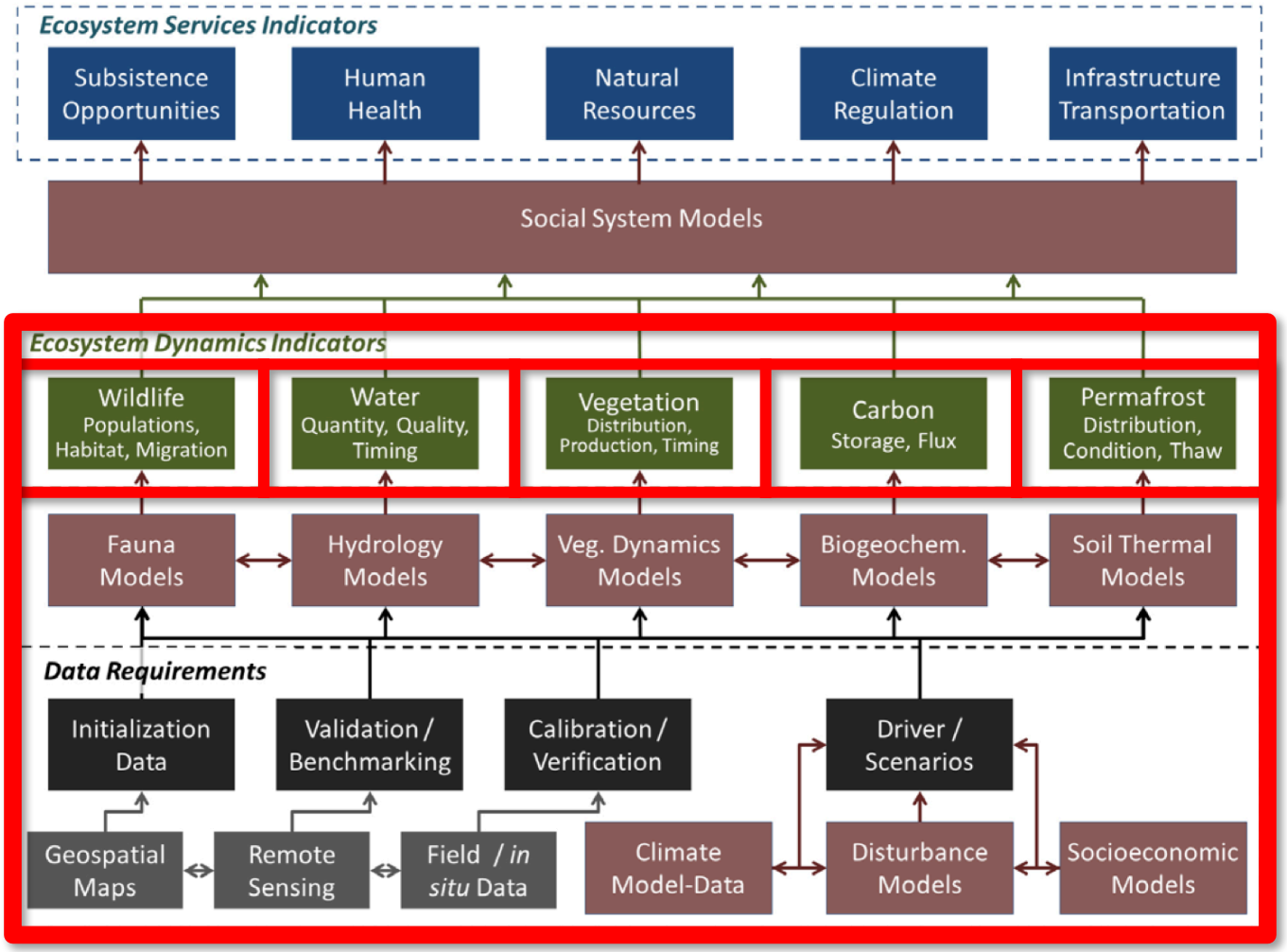
Table 1. Benchmarking data to be used in our project spans the full range of Indicators for ABoVE ecosystem dynamics.

Variable	Dataset	Coverage
Carbon Dynamics		
NDVI, EVI, LAI, fAPAR, NPP	MODIS	Global; weekly; 2002-2013
Soil Carbon Stocks / Depth	Pedons	Regional; static; 100 km
Soil Carbon Residence Time	Incubations	Local; static; 1 m
CO_2 fluxes	AmeriFlux, MPI-BGC	Local/global; hourly; 1 km
CO_2, CH_4 concentration	CARVE, GOSAT, OCO-2/3, SCIAMACHY	Regional/global; weekly; 1-3 km
Biomass	ICESat/GLAS, G-LiHT, GEDI, CFS	Regional/global; static; 0.25-1 km
Canopy height	ICESat/GLAS, G-LiHT, GEDI	Regional/global; static; 1 km
Water Dynamics		
Soil moisture	SMAP, SMOS, ISMN	Local/regional/global; <weekly; 3-9 km
Evapotranspiration	MODIS, ECOSTRESS	Regional/global; <weekly; 0.05-1 km
Total Water Column	GRACE	Global; monthly; >100 km
Snow characteristics	NASCN, NOAA Snow Cover, MODIS	Regional/local; weekly-annually; 1 km
Energy Dynamics		
Soil, surface temperature	GTN-P, BOREAS, MODIS	Local/regional/global; weekly-static; 1 km
Freeze/thaw	SMAP	Regional/global; <weekly; 3 km
Active layer depth	InSAR, CALM/GTN-P	Regional; static; 1 m
Albedo	MODIS, VIIRS	Global; weekly; 1 km
Fire counts, burnt area	MODIS	Global; weekly; 1 km
Net radiation	MODIS	Global; weekly; 1 km





Modeling Outputs

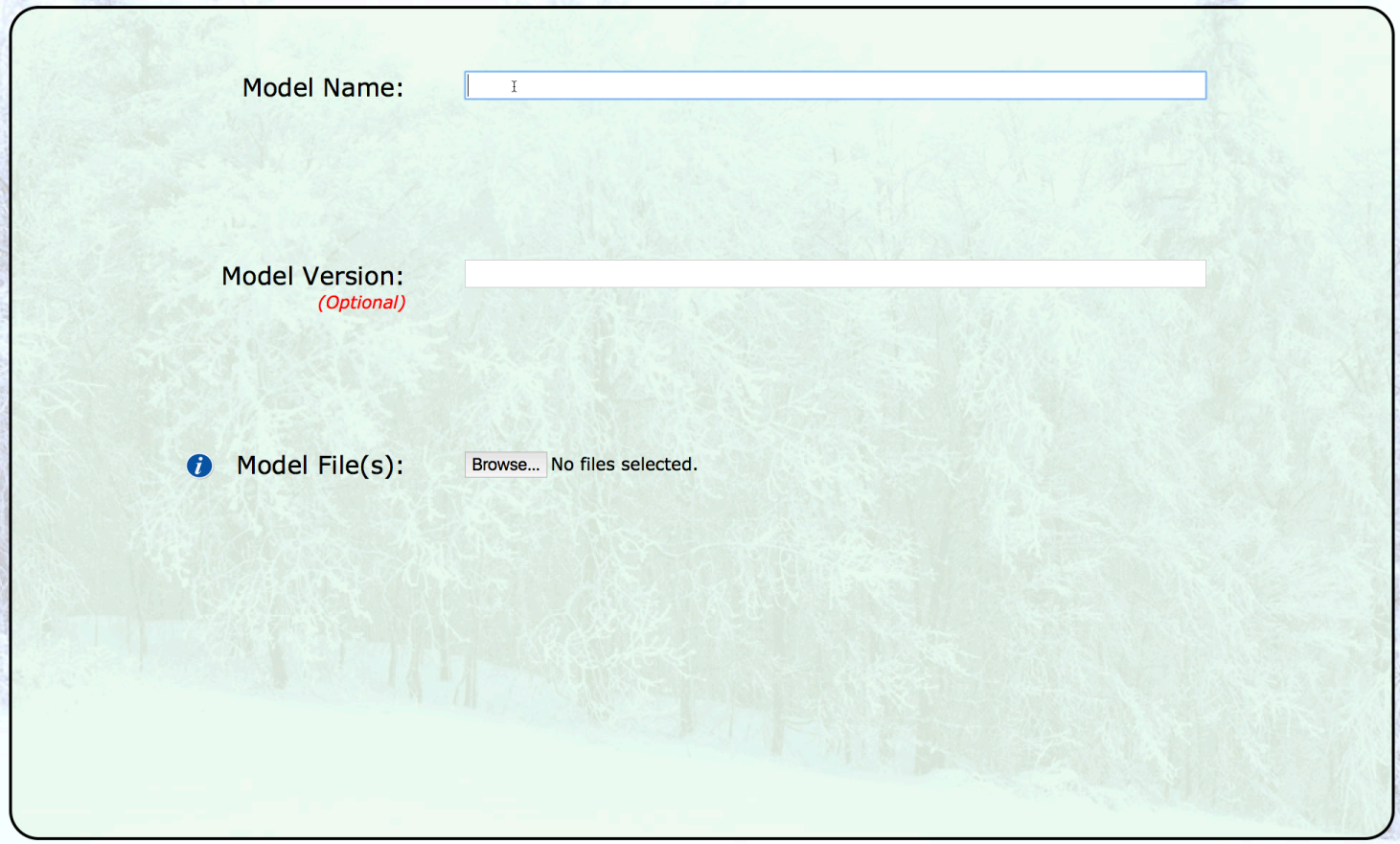


Model Upload

Upload Model

About

Model Upload

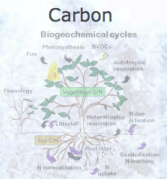


Website

Benchmarking System

About

Website



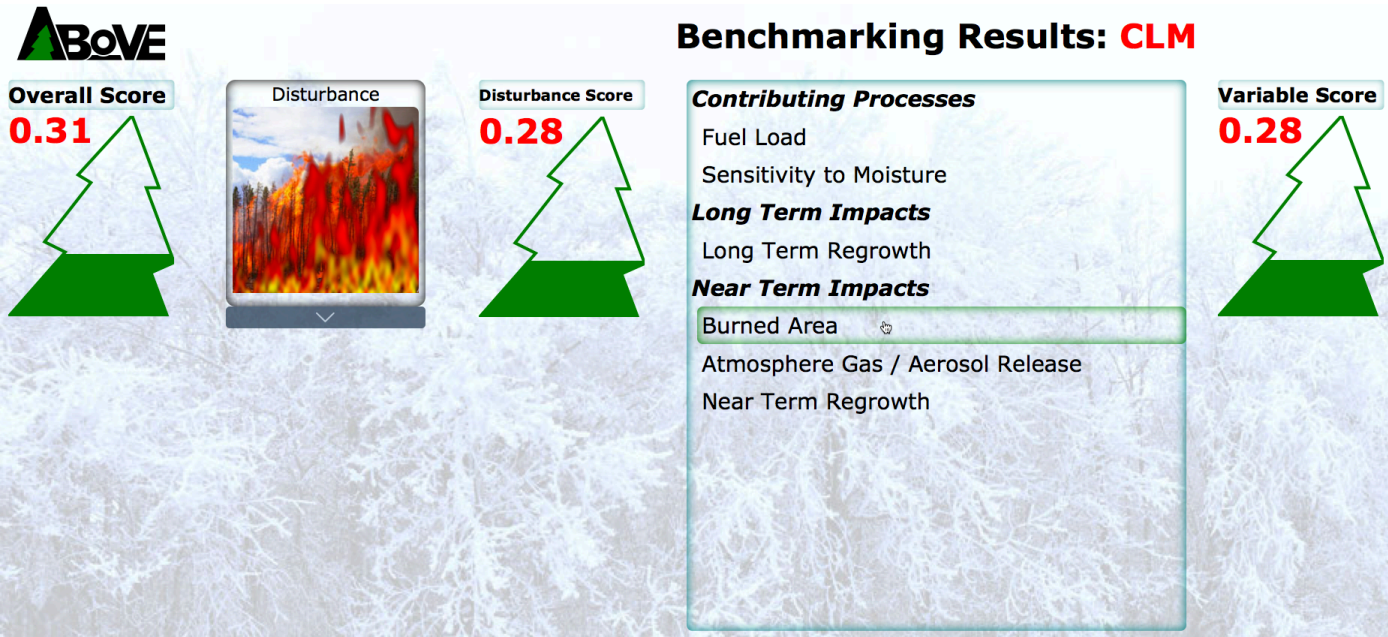
Benchmarking Results: CLM

Disturbance

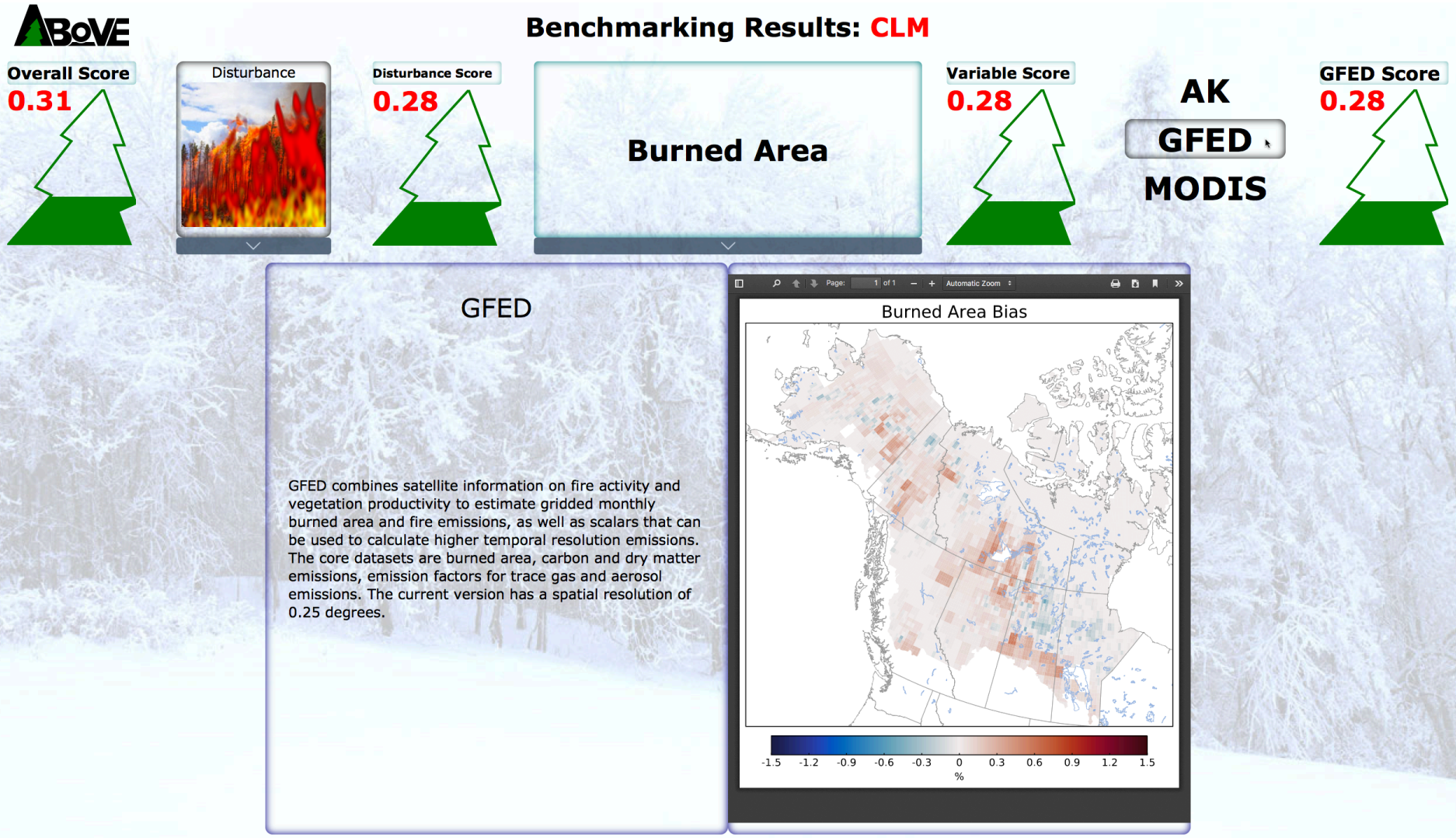
Fire (and, to a lesser extent, insects and pathogens) is included in many terrestiral biosphere models (TBMs). While fire sparks are difficult to model in an exact sense (they are typically represented as probabilistic in prognostic models), the pre-cursers to fire and extent (fuel load, quality, distribution, moisture) should be captured in models. TBMs will be evaluated in their representation of fire pre-cursers prior to remotely sensed fire observations. While spatial data on wildfire occurrence, extent, and severity are readily available across Alaska and Canada, information on other important disturbances such as insects, pathogens, rapid thaw events (thermokarst) and land use change are not.

Weight: 33%

Website


ABoVE
Benchmarking Results: CLM
Overall Score
0.31
Disturbance
Disturbance Score
0.28
Contributing Processes
Fuel Load
Sensitivity to Moisture
Long Term Impacts
Long Term Regrowth
Near Term Impacts
Burned Area
Atmosphere Gas / Aerosol Release
Near Term Regrowth
Variable Score
0.28
Burned Area
Fires are an important source of atmospheric trace gases and aerosols and they are the most important disturbance agent on a global scale. In addition, deforestation, peatland fires, and areas that see an increase in the frequency of fires add to the build-up of atmospheric CO2.
Weight: 100% of Disturbance Variables

Website


Benchmarking Results: CLM
Overall Score
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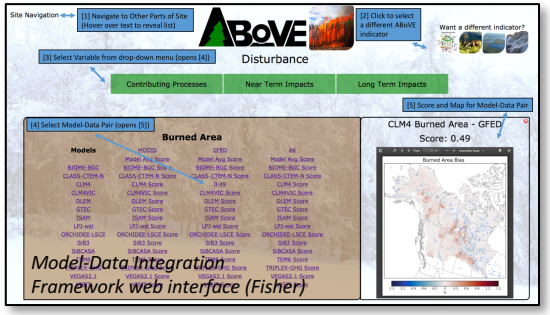
0.28
AK
GFED
MODIS
GFED Score
0.28
GFED
GFED combines satellite information on fire activity and vegetation productivity to estimate gridded monthly burned area and fire emissions, as well as scalars that can be used to calculate higher temporal resolution emissions. The core datasets are burned area, carbon and dry matter emissions, emission factors for trace gas and aerosol emissions. The current version has a spatial resolution of 0.25 degrees.
Burned Area Bias
-1.5 -1.2 -0.9 -0.6 -0.3 0 0.3 0.6 0.9 1.2 1.5
%

Modeling Working Group

Joshua B. Fisher (Chair), Scott Goetz, Daniel Hayes, Deborah Huntzinger, Elchin Jafarov, John Kimball, Chip Miller, Walt Oechel, Mark Piper, Chris Potter, Brendan Rogers, Kevin Schaefer, Christopher Schwalm, Hank Shugart, Jackie Shuman, Eric Stofferahn, Stan Wullschleger, Yu Zhang

Model-Data Integration Framework

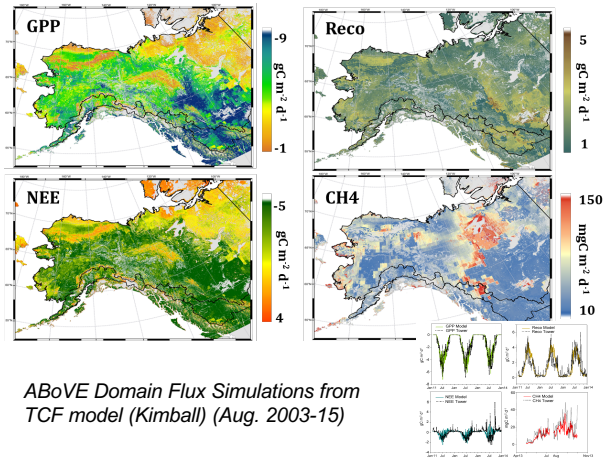
- **Model-Data integration and benchmarking system software for ABoVE** with International Land Model Benchmarking (ILaMB) framework and the ABoVE Science Cloud *Fisher Project*
- Survey distributed to 23 modeling groups around the world to collate national and international remote sensing and other **data needs for model improvements** in the ABR *Fisher Project*
- **Model uncertainty maps** for the ABoVE domain produced and distributed to the ABoVE Science Cloud to target data acquisitions *Fisher Project*
- **Existing ABoVE datasets collation**; links with the Permafrost Carbon Network *Fisher Project*
- **Permafrost Benchmarking System** *Schaefer Project*



Model-Data Integration Framework web interface (Fisher)

Model Development

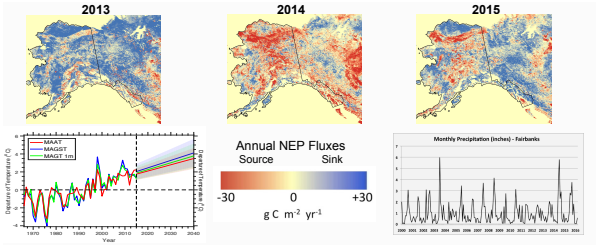
- **UVAFME model development**: changing temperature thresholds for tree growth; mortality sensitivity to fire; mortality-type indicators; species traits parameterization *Shugart Project*
- **TEM model development**: fire effects on carbon cycling; permafrost dynamics; changes in net primary productivity with climate change; thermokarst mapping *Fisher Project*
- **TCF model development**: incorporation of SMAP, MODIS, AMSR-E, and MERRA2 data; evaluation with in situ sites in AK and CN *Kimball Project*



ABoVE Domain Flux Simulations from TCF model (Kimball) (Aug. 2003-15)

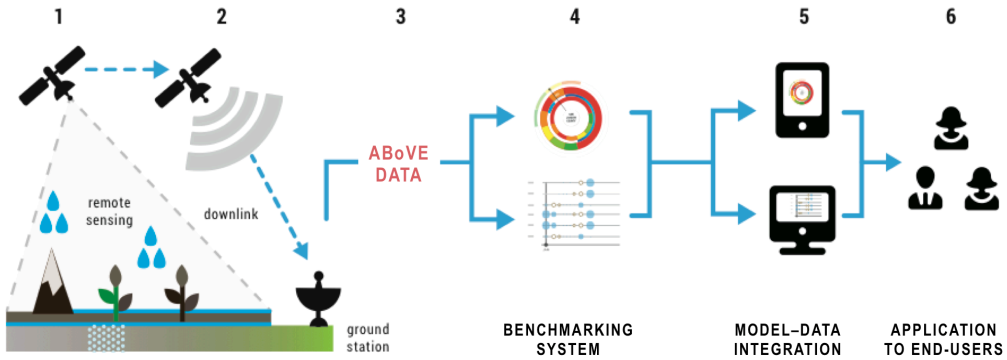
Latest Modeling Results

- **Thermokarst mapping** *Fisher Project*
- **Permafrost dataset production** *Jafarov Project*
- **Thermal conductivity, CO_2 flux response to active layer depth** *Kimball Project*
- **CO_2 fluxes (GPP, Rh, NEE), CH_4 emissions, and soil organic carbon stocks** at 1 km resolution *Kimball Project*
- **Fractional open water inundation** at 5 km, 10-day resolutions from 2002-2015 (Du et al. 2016: *RSE*) *Kimball Project*
- **Freeze-thaw classification** at 6 km, daily (AM, PM) resolutions *Kimball Project*
- **Net Ecosystem Production** for 2013-2015, sensitivity to fire, temperature, and moisture from CASA model *Potter Project*



Reference: Potter, C., S. Klooster, and V. Genovese, 2013, Alaska ecosystem carbon fluxes estimated from MODIS satellite data inputs from 2000 to 2010, *Carbon Balance and Management*, 8:12. http://www.cbmjournal.com/content/8/1/12

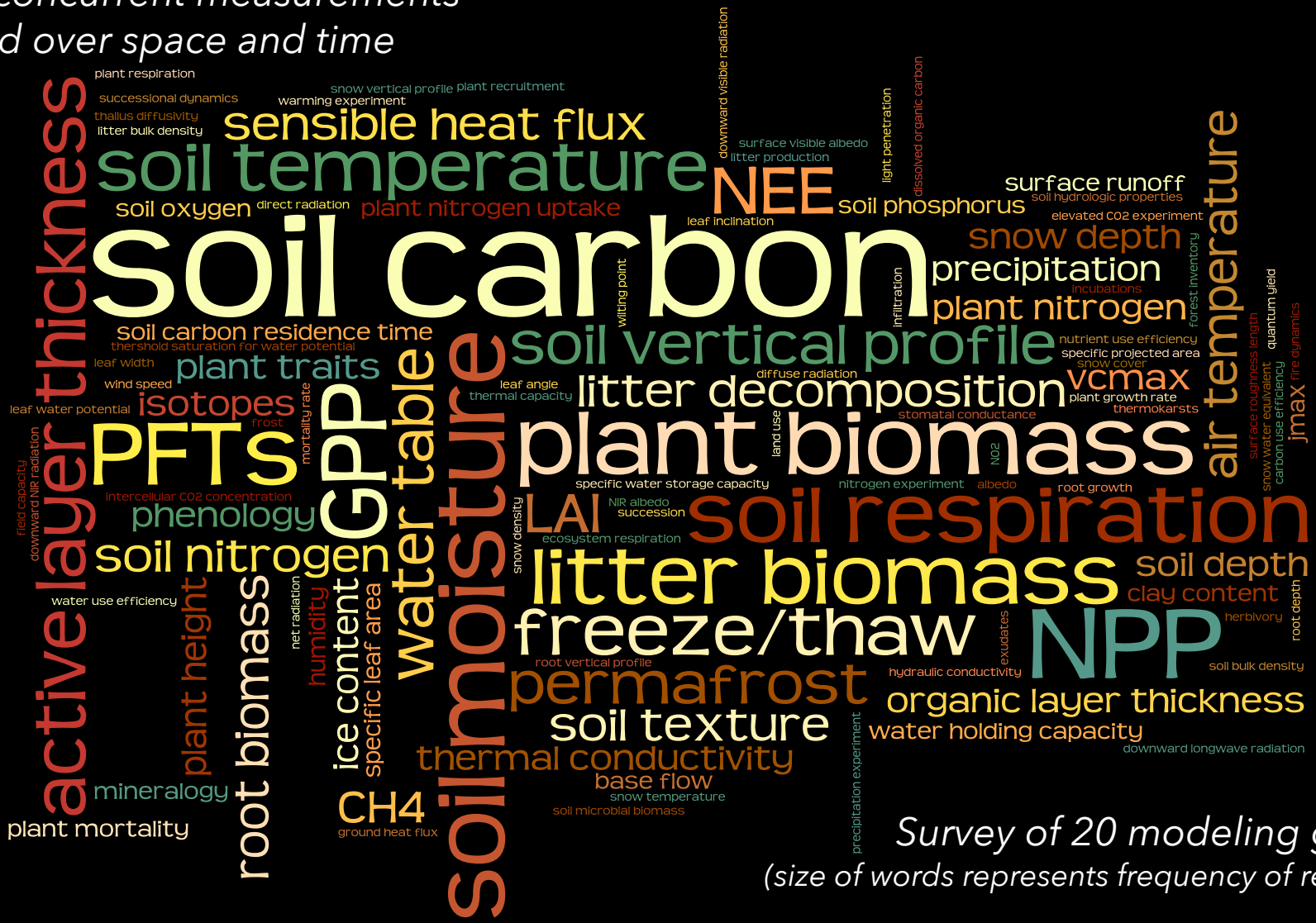
Other expected products / outcomes



- **"Lessons Learned"** report to guide preparations for ABoVE Phase II modeling research addressing **Ecosystem Services** objectives.
  - Direction and guidance for new and continued field and remote sensing data collections, model refinements and developments, and opportunities for integration across multiple modeling teams and other research activities within ABoVE.
  - In Year 3 we will begin to establish the links to the Ecosystem Services datasets and modeling requirements, following the foundation and setup we will establish throughout Phase I. **For example, this includes using permafrost projections to inform infrastructure decisions (e.g., roads, pipelines built on thawing permafrost).** The focus will be on engagement with interdisciplinary research teams toward a goal of science–data interoperability, including linking TBM frameworks with social systems to develop hypotheses related to ABoVE's Ecosystem Services Objectives.

Measurements Needed by Modelers

Note: concurrent measurements needed over space and time



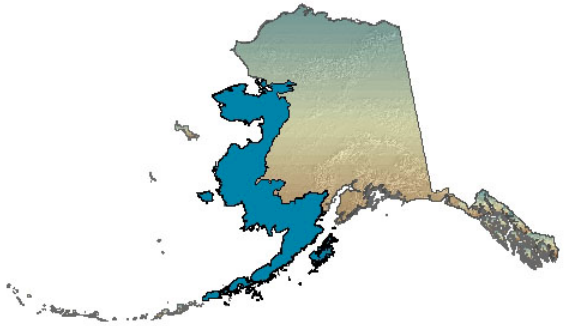
Survey of 20 modeling groups

(size of words represents frequency of response)

Institutional Collaborations

Arctic Landscape Conservation Cooperative

Western Alaska LCC



Northwest Boreal Landscape Conservation Cooperative

AK CSC
Alaska Climate Science Center

USGS
science for a changing world
Alaska Science Center

Natural Resources Canada | Ressources naturelles Canada

Canada

Summary

- Multiple modeling activities for ABoVE
- Model-Data Integration Framework (MoDIF) being built for ABoVE
- Significant effort of integration of data and models forthcoming
- Model developments for ABR dynamics foundation for ABoVE Phase II