What if ILAMB, LVT, et al were in a web application?

Gab Abramowitz (gabsun@gmail.com UNSW Australia)

- All users could have equal access (no setup / local resources required)
- All plots and meta-data could be viewed side-by-side in custom web pages
  - Including comparison with results from other research groups internationally
- MIPs could effectively become automatic AND ongoing
- Provenance and meta data could be stored & data mined systematically
  - Capture performance history throughout model development
  - Aid reproducibility
- API could allow automatic testing /continuous integration (e.g. Jenkins)
- Mirrored installations at HPC nodes could avoid data upload bottlenecks while maintaining a single web presence
- Ability to include new evaluation packages as they develop

- How would it actually work? Come and take a look… Poster A.1

A.2 The Python-based ILAMB Benchmarking System

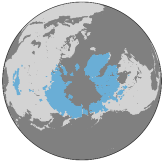
The package has been designed with the intention that users can add their own benchmarks to the system. This is done by implementing a custom version of what we call a *confrontation*.

Confrontation

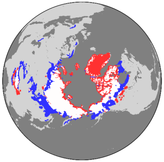
- The benchmark dataset - a CF-compliant netCDF4 file
- The analysis routines which extract comparable quantities from the model results, perform analysis, render output images, and prepare the HTML output.

Permafrost

- Poster will detail how this is done by an example.



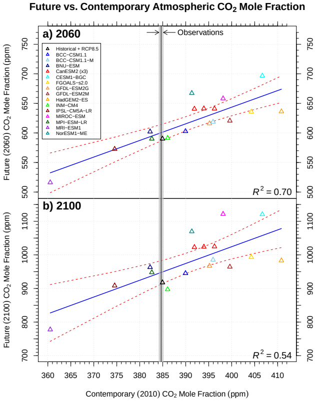
CCSM4 Extent



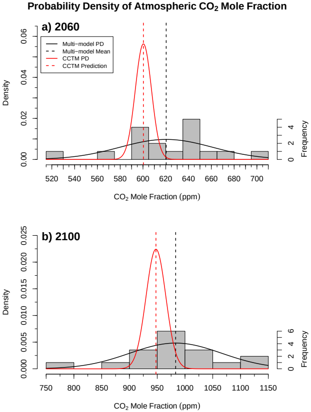
Bias

Emergent Constraint Developed from CMIP5 ESMs

An emergent constraint based on carbon inventories was applied to constrain future atmospheric CO_2 projections from CMIP5 ESMs.



- Much of the model-to-model variation in projected CO_2 during the 21st century is tied to biases that existed during the observational era.
- Model differences in the representation of concetration–carbon feedbacks and other slowly changing carbon cycle processes appear to be the primary driver of this variability.
- Range of temperature increases at 2100 slightly reduced, from $5.1 \pm 2.2°C$ for the full ensemble, to $5.0 \pm 1.9°C$ after applying the emergent constraint.



Best estimate using Mauna Loa CO_2

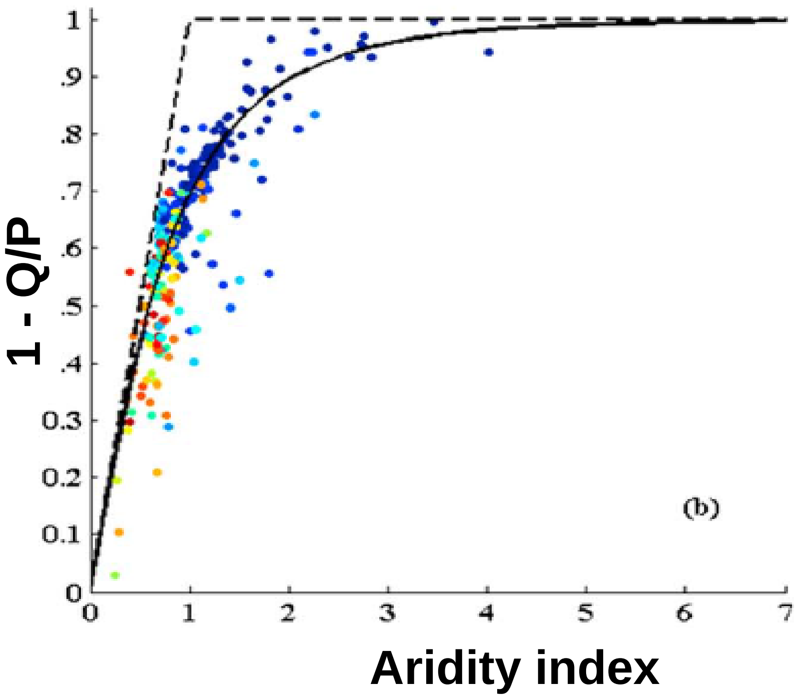
At 2060: 600 ± 14 ppm, 21 ppm below the multi-model mean
At 2100: 947 ± 35 ppm, 32 ppm below the multi-model mean

Hoffman, Forrest M., James T. Randerson, Vivek K. Arora, Qing Bao, Patricia Cadule, Duoying Ji, Chris D. Jones, Michio Kawamiya, Samar Khatiwala, Keith Lindsay, Atsushi Obata, Elena Shevliakova, Katharina D. Six, Jerry F. Tjiputra, Evgeny M. Volodin, and Tongwen Wu. February 2014. "Causes and Implications of Persistent Atmospheric Carbon Dioxide Biases in Earth System Models." *J. Geophys. Res. Biogeosci.*, 119(2):141–162. doi:10.1002/2013JG002381.

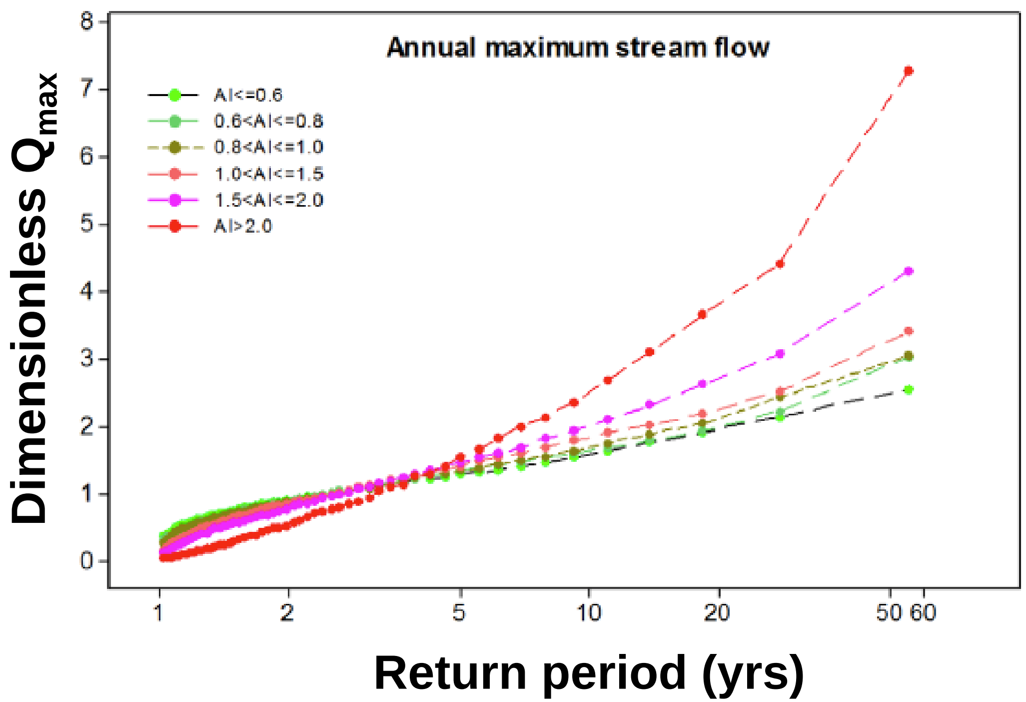
Hydrological Metrics for Earth System Modeling

Hong-Yi Li, Wei Wang, L. Ruby Leung (PNNL)

Aridity index ⟷ Annual mean Q/P



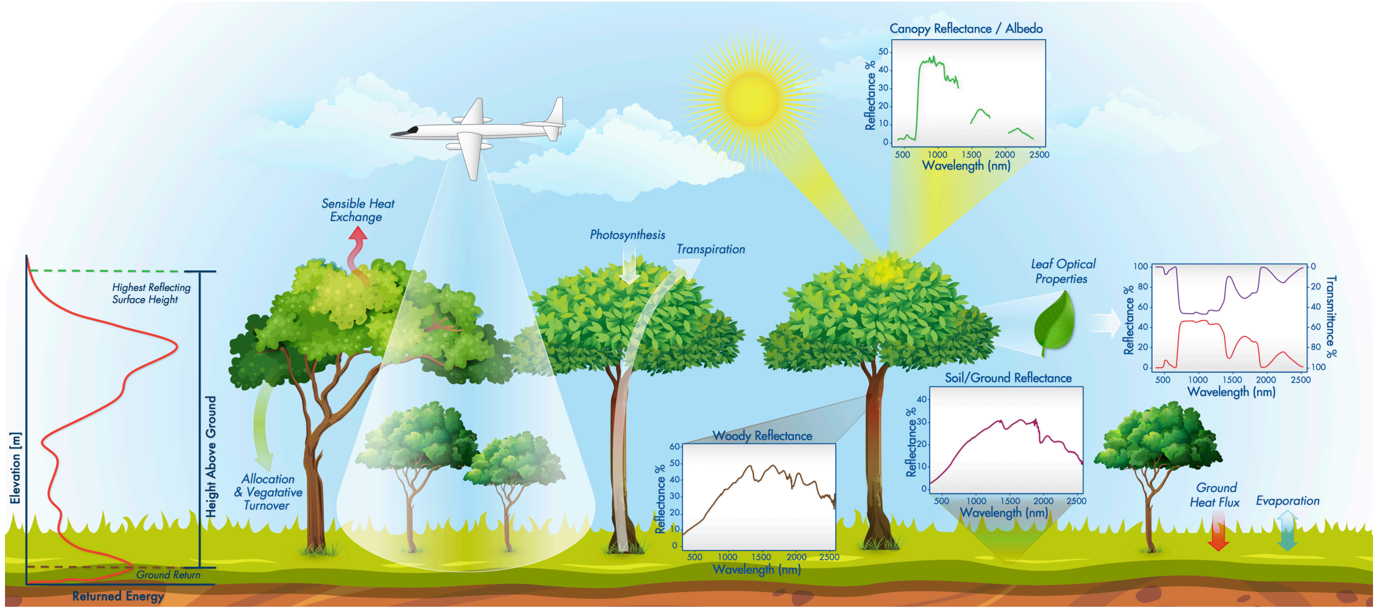
Aridity index ⟷ Floods

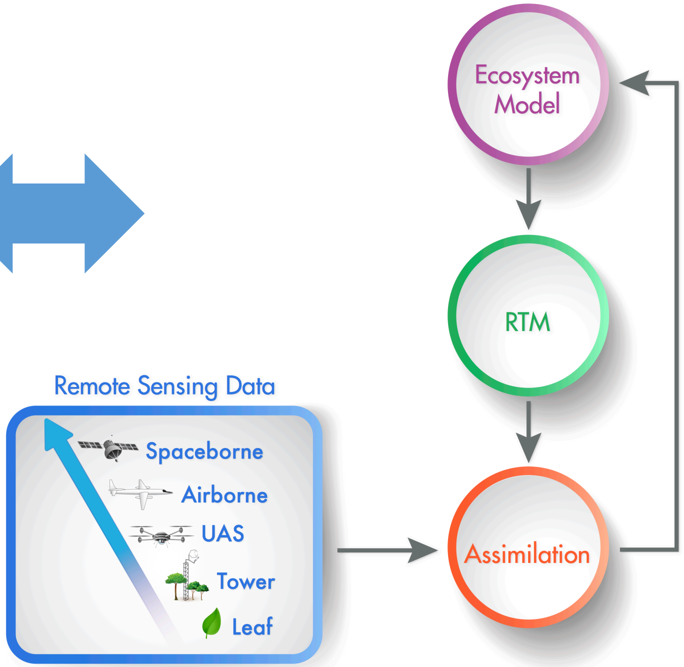


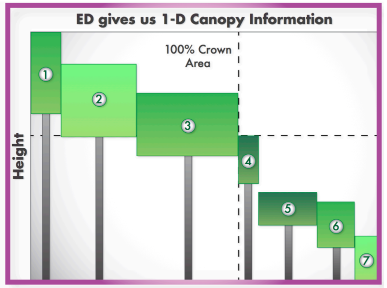
- Natural watersheds exhibit emergent linkages among annual mean and inter- and intra-annual variability of streamflow and floods
- These relationships arising from interconnections between different hydrological processes can be used as metrics for hydrologic simulations
- Can Earth system models reproduce these linkages, and the underlying process interconnections?

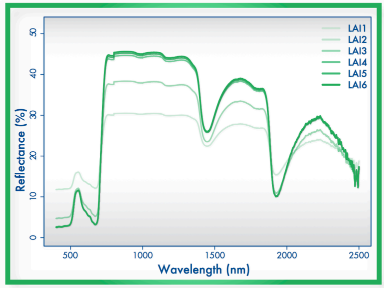
Reducing the uncertainty in the projection of the terrestrial carbon cycle by fusing models with remote sensing data

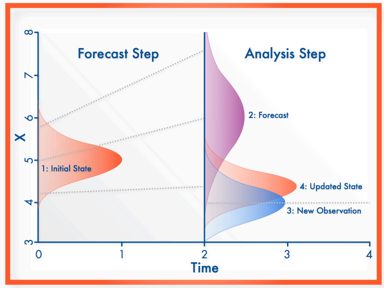
Shawn Serbin[1], Toni Viskari[12], Phil Townsend[3], Alexey Shiklomanov[4], Mike Dietze[4]











Provide the capacity to benchmark and evaluate internal model representations of canopy radiative transfer and *directly* assimilate remote sensing observations to inform relevant processes

Acknowledgements: This project was funded by NASA Terrestrial Ecology grant NNX14AH65G

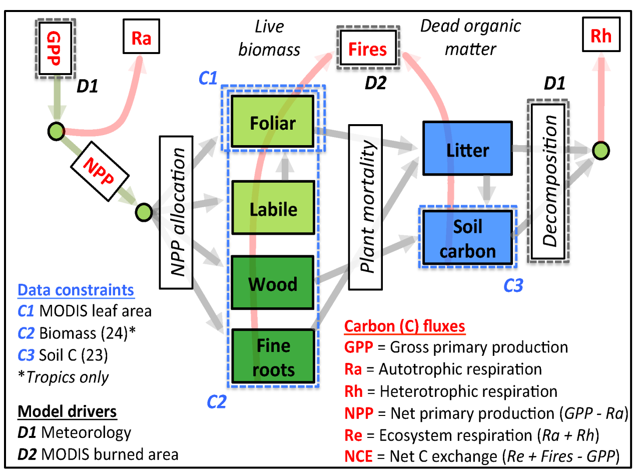
Benchmarking C cycle retrievals: an example using carbon use efficiency

Mathew Williams, Jean-François Exbrayat, A. Anthony Bloom, T. Luke Smallman, Chris Jones

National Centre for Earth Observation
NATURAL ENVIRONMENT RESEARCH COUNCIL

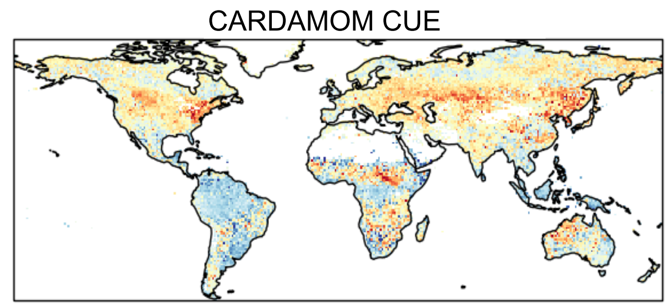
THE UNIVERSITY of EDINBURGH
School of GeoSciences

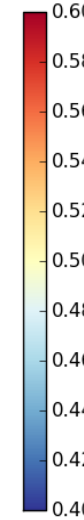
- Global carbon cycle modelling suffers from a lack of observations and systematic evaluation
- Data assimilation approaches can constrain simple models using multiple data-streams
- CARDAMOM produces potentially very useful information about relationships between carbon cycle variables or processes
- Models have never been tested in this way before and there is a real gap for this type of process-based evaluation



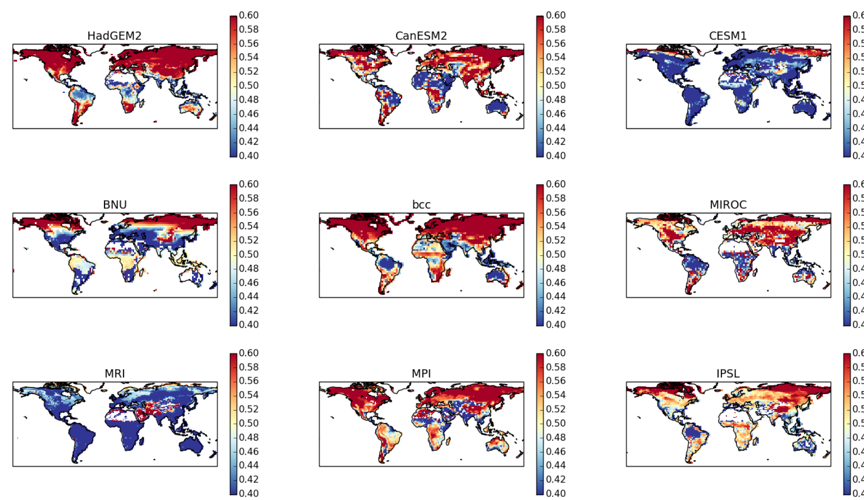
CARDAMOM: Diagnostic ecosystem C balance model DALEC2 and datasets used to retrieve 1° × 1 °C state and process variables

Use CARDAMOM estimated carbon use efficiency (NPP:GPP) to evaluate ESM carbon cycling





CUE from selected ESMs



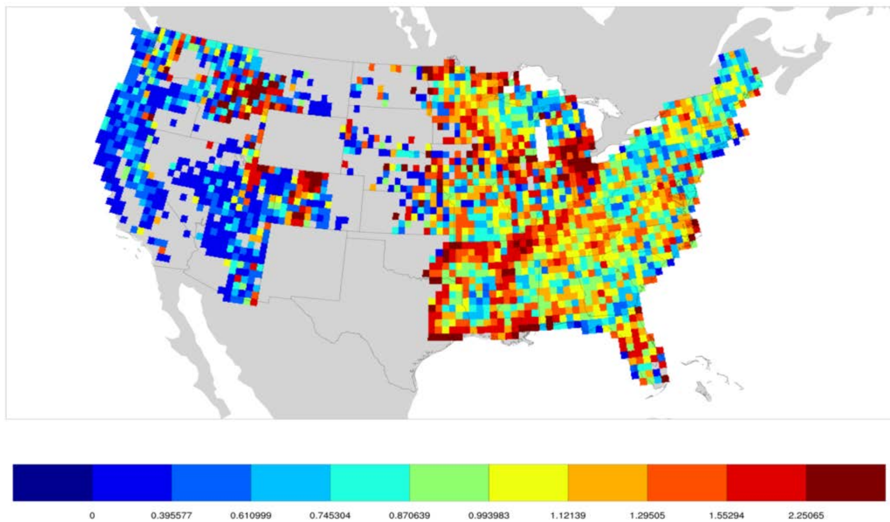
Q: Why is there a tendency for CUE to increase at high northern latitudes (this is not suggested by CARDAMOM)

Vegetation dynamics benchmarking based on forest inventory data

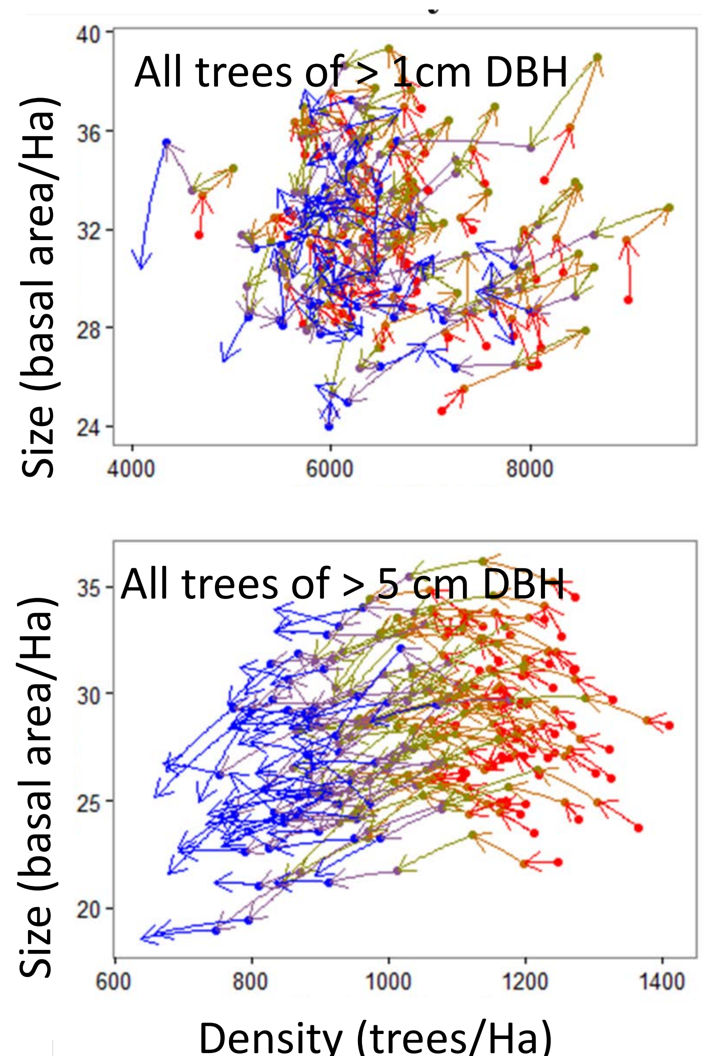
Daniel Johnson[1], **Chonggang Xu[1]**, Rosie Fisher[2], Ryan Knox[3], Stuart Davis[4], Chris Woodall[5], Nate McDowell[1]

1: Los Alamos National Laboratory; 2: National Center for Atmospheric Research; 3: Lawrence Berkeley National Laboratory; 4: Smithsonian Institution; 5: USFS.

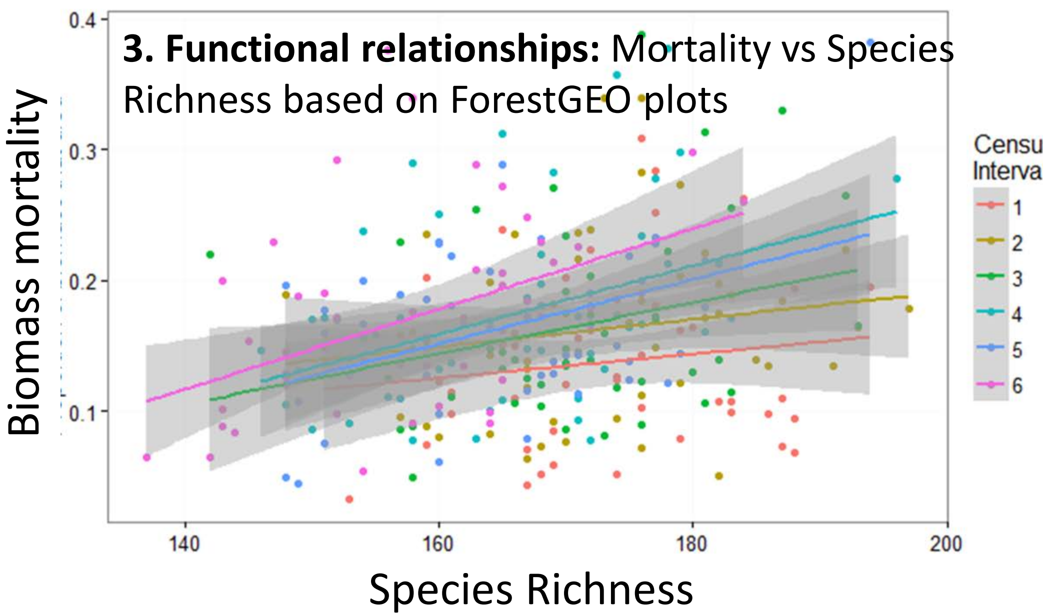
1. Demographic metrics: Tree mortality rate based FIA



2. Successional trajectories



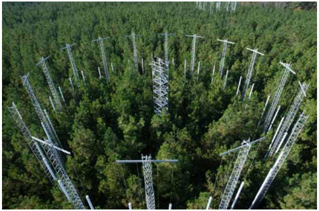
3. Functional relationships: Mortality vs Species Richness based on ForestGEO plots



FREE AIR CO_2 ENRICHMENT (FACE) MODEL-DATA SYNTHESIS

- Aim to examine how well our ecosystem models replicate observed responses to a step change in CO_2 ($\uparrow \sim$40 %).

Oak Ridge, Tennessee



Duke, North Carolina

- But not to find a **best** model, trying to avoid metrics...

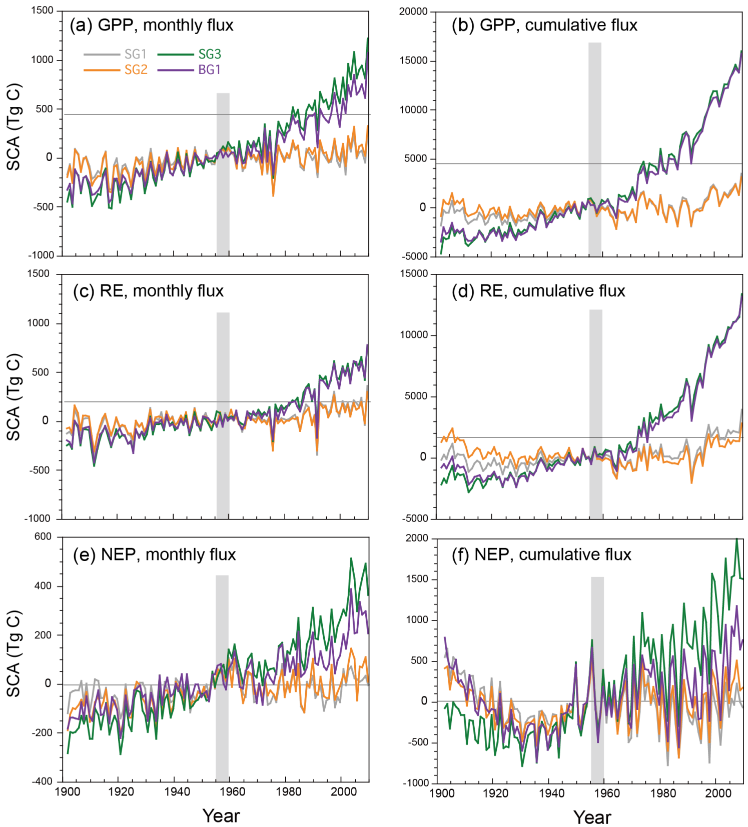
- We applied 11 process based models (C & C-N) to the Duke and Oak Ridge FACE experiments.

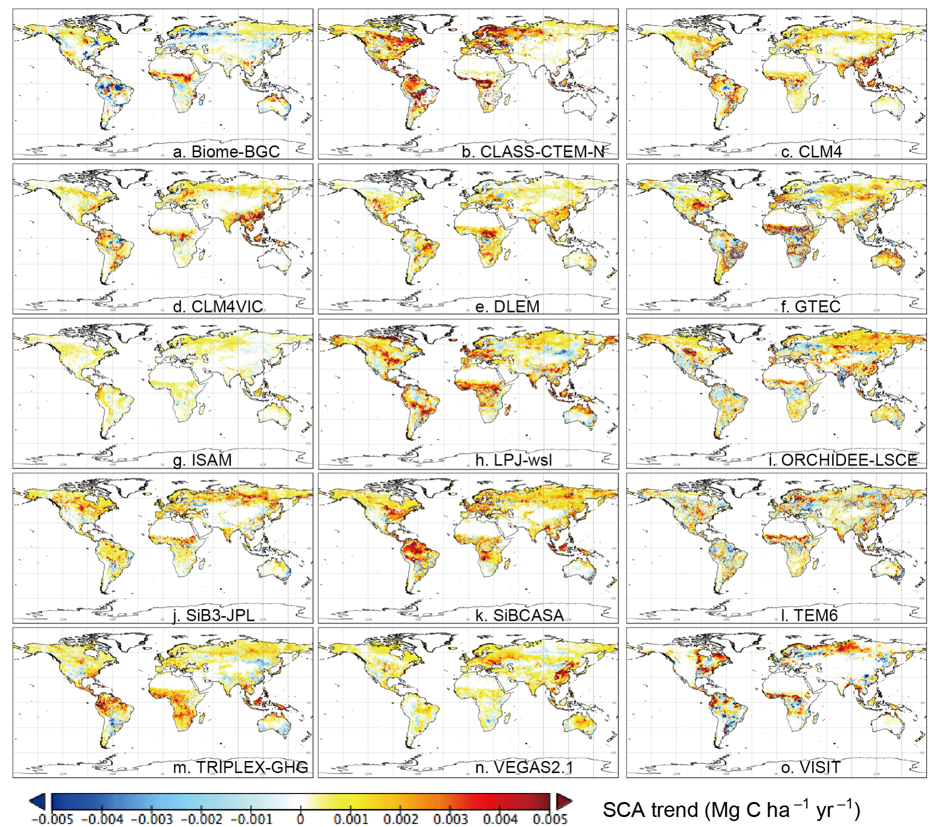
Decadal trends in the seasonal-cycle amplitude of terrestrial CO_2 exchange resulting from the ensemble of terrestrial biosphere models

North American Carbon Program MsTMIP

Akihiko Ito and MsTMIP model groups, Tellus B (in press)

- Increase of seasonal-cycle amplitude (SCA) of atmosphere–ecosystem CO_2 exchange
- Comparison of 15 models and factorial experiments (climate, CO_2, land-use, and N)
- Considerable impact of elevated CO_2 (left) and inter-model variability (right)

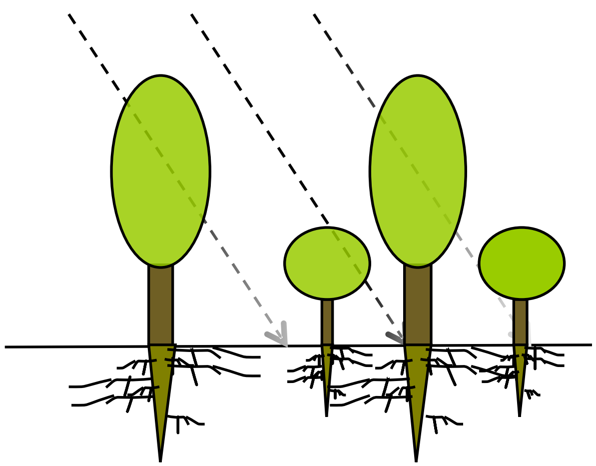


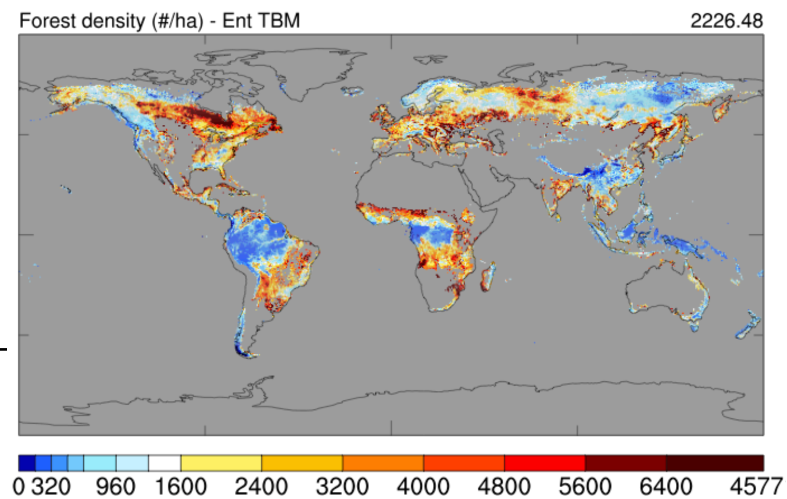


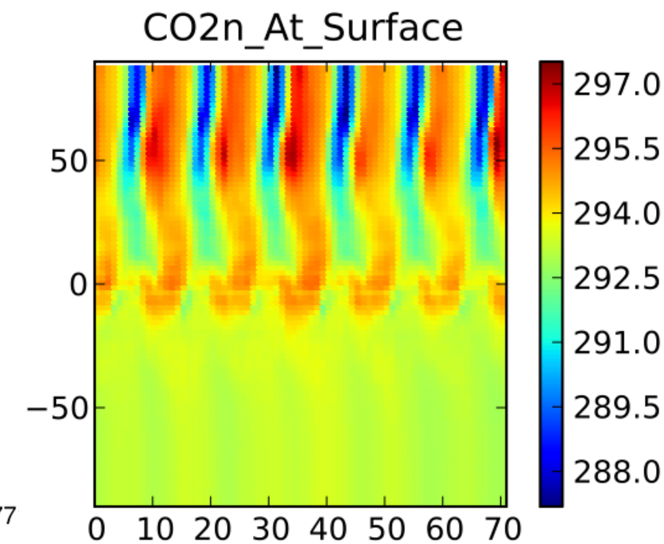
References: Keeling et al. (2015), Graven et al. (2013), Gray et al. (2014), Zeng et al. (2014), Forkel et al. (2016)

Goddard Institute for Space Studies
at Columbia University in New York

Height-Structured Vegetation and the Carbon Cycle in the NASA GISS Earth System Model/ Ent Terrestrial Biosphere Model







Nancy Y. Kiang[1], Igor Aleinov[2], Wenge Ni-Meister[3], Wenze Yang[7], Yeonjoo Kim[4], Crystal Schaaf[5], Anastasia Romanou[2], Qingsong Sun[5], Tian Yao[6], Feng Zhao[7], Zhuosen Wang[7]

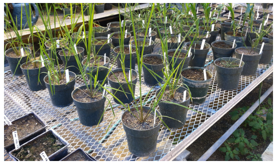
[1]NASA Goddard Institute for Space Studies, [2]Columbia University, [3]CUNY Hunter College, [4]Yonsei University, [5]UMass-Boston, [6]USRA/NASA GSFC, [7]Univ. of Maryland

From the leaf to the land surface: using data and models to improve (a single) land model processes

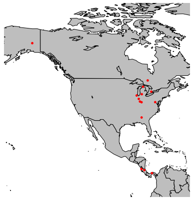
Nick Smith[1], Danica Lombardozzi[2], & Jeff Dukes[1]
[1]Purdue University, IN, USA; [2]National Center for Atmospheric Research, CO, USA

Observations ⟷ **Models**

Scale

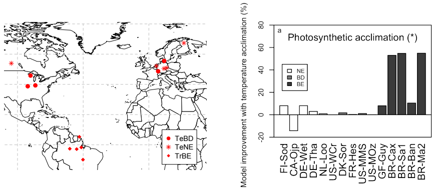
(a)  Greenhouse experiment

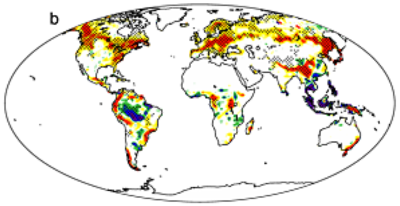
(b)  In situ experiment

(c)  Leaf observations

(d)  Canopy observations

Leaf models in R  (1)

1-point LSM simulations  (2)

Global LSM simulations  (3)

The Model-Data Integration Framework for NASA's Arctic Boreal Vulnerability Experiment (ABoVE)

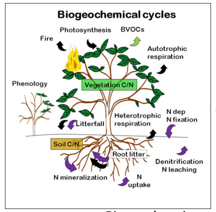
Eric J. Stofferahn[1,*], Joshua B. Fisher[2], Daniel J. Hayes[3], Deborah N. Huntzinger[4], Christopher R. Schwalm[5]

1 – Jet Propulsion Laboratory, California Institute of Technology; 2 – Jet Propulsion Laboratory; 3 – University of Maine; 4 – Northern Arizona University; 5 – Woods Hole Research Center

* - Corresponding Author: ericstofferahn@gmail.com

Disturbance

Disturbance



Carbon Pools and Biogeochemistry

Biogeochemistry

Hydrology

Hydrology

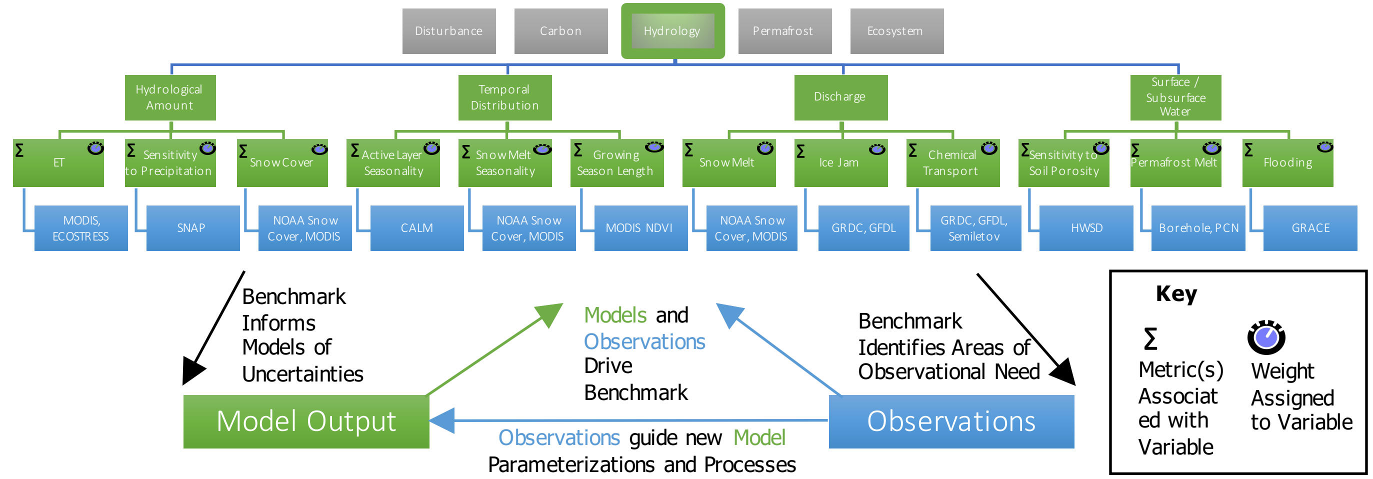
Permafrost

Permafrost

Flora / Fauna and Ecosystem Function

Flora / Fauna

The Benchmarking System



North American Carbon Program
MsTMIP
MULTI-SCALE SYNTHESIS AND TERRESTRIAL MODEL INTERCOMPARISON PROJECT

MsTMIP

Biome-BGC	LPJ-wsl
CABLE	MC1
CLASS-CTEM-N+	ORCHIDEE-LSCE
CLM4	ORCHIDEE-JPL
CLM4-VIC	TEM6
DLEM	SiBCASA
ECOSYS	SiB3-JPL
GTEC	TRIPLEX-GHG
Hyland	VEGAS
ISAM	VISIT
JULES	

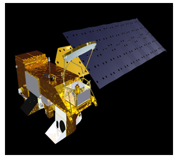
TRENDY	
HYLAND	JULES
LPJ	LPJ-GUESS
CLM4	ORCHIDEE
OCEAN	SDVGM
VEGAS	

Permafrost Carbon Network

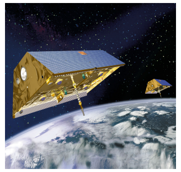
NACP

CALM
Circumpolar Active Layer Monitoring

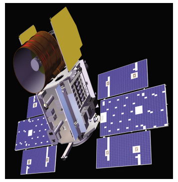
CALM



MODIS (On Aqua)



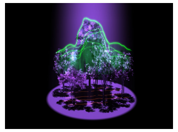
GRACE



ICESat

SMAP

OCO-2



GEDI

ECOSTRESS

NASA

Caltech

Woods Hole Research Center

1865 The University of Maine

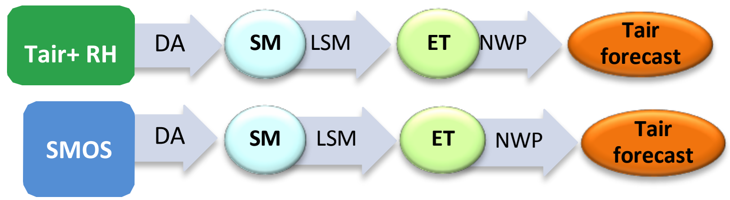
Northern Arizona University

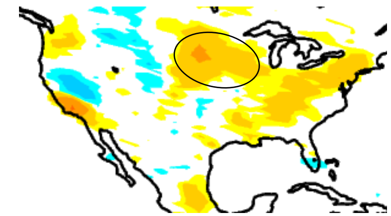
Diagnosing the downstream performance of the European Center for Meteorological Weather Forecasting (ECMWF) land data assimilation system.

Thomas R.H. Holmes ,Concepcion Arroyo, Wade T. Crow , Martha Anderson

ECMWF experiments assimilate separately:

- CTRL (Operational): Tair 2m & RH acquired in situ observations from weather stations
- EXPT (Ongoing research): **SMOS L-band TB**.
  Currently showing degraded Tair for the 24 hr forecast over the Central US

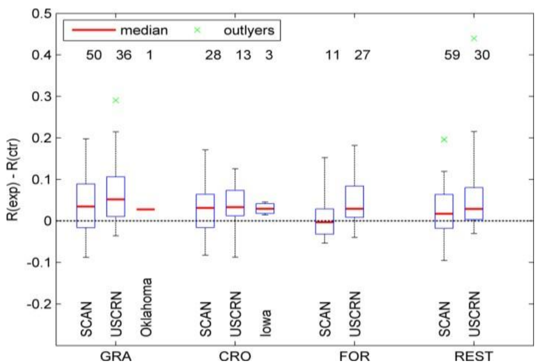




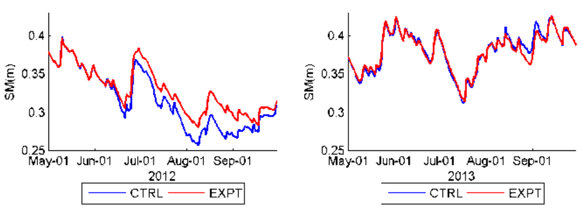
Mean absolute difference error Tair

SOIL MOISTURE ANALYSIS (0-7cm)

ECMWF experiments vs. 273 ground stations: SCAN, USCRN, Iowa and Oklahoma 'super sites'.



Difference in correlation between SM in situ networks and ECMWF (*EXPT-CTRL*) by land use.

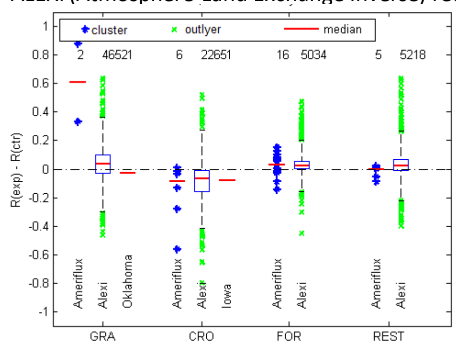


Example of 1st meter soil water content in corn belt.

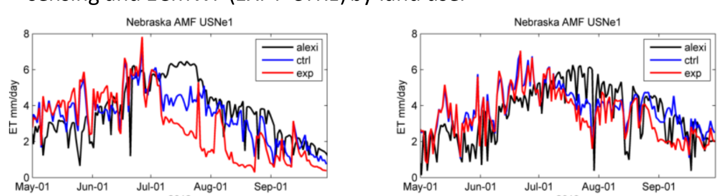
➢**Soil moisture DA:**
Surface layer: Improvement in temporal correlation and little change in soil moisture bias (CTRL Vs EXP)
Total water: significant regional biases

ET 24 hr FORECAST

ECMWF ET forecasts vs. 31 in situ locations from AMERIFLUX and spatially-continuous remote sensing ALEXI (Atmosphere-Land Exchange Inverse) retrievals:

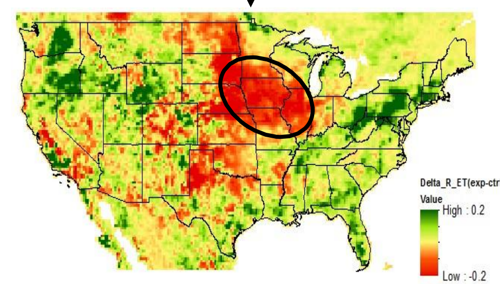


Difference in correlation between ET in situ , remote sensing and ECMWF (*EXPT-CTRL*) by land use.

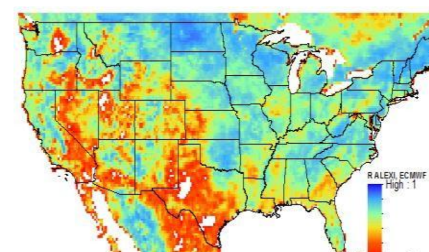


Example of ET time series in corn belt.

- ➢**By using RS we revealed a degraded temporal correlation in ET over the corn belt.**
- ➢**This degraded ET is linked to a large reduction in ET during the drought year (2012).**
- ➢**The break-down in forecast performance over the corn belt is not explained by the SMOS DA and points to an issue within the LSM .**



Difference in correlation between ET ALEXI and ECMWF (*EXPT-CTRL*)

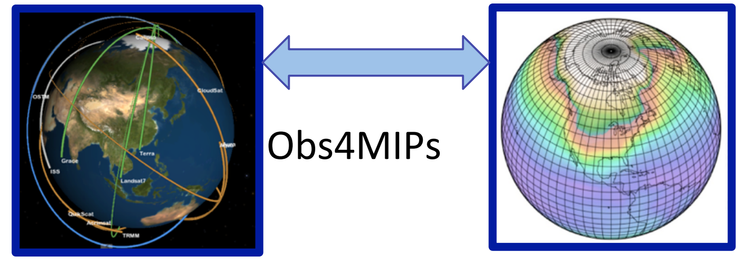


Correlation ALEXI and ECMWF (*CTRL*)

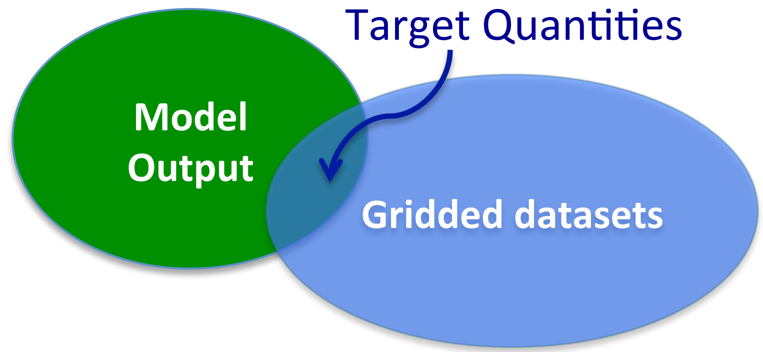
➢**We demonstrate the use of ALEXI as a benchmark in LSM evaluation**

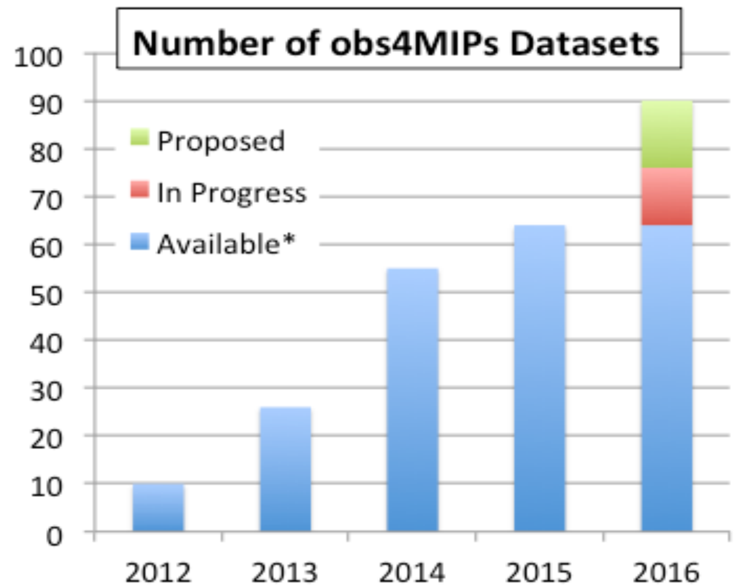
obs4MIPs

https://www.earthsystemcog.org/projects/obs4mips



- A Project for identifying, documenting and disseminating observations for climate model evaluation
- Data sets accessible on the ESGF alongside CMIP model output, adhering to the same data conventions to facilitate research
- Guided by the World Climate Research Program (WCRP) Data Advisory Council





…. and growing!

Global 0.5 deg Hourly Land Surface 2m Air Temperature Datasets for Model Evaluations

Xubin Zeng (University of Arizona), Aihui Wang

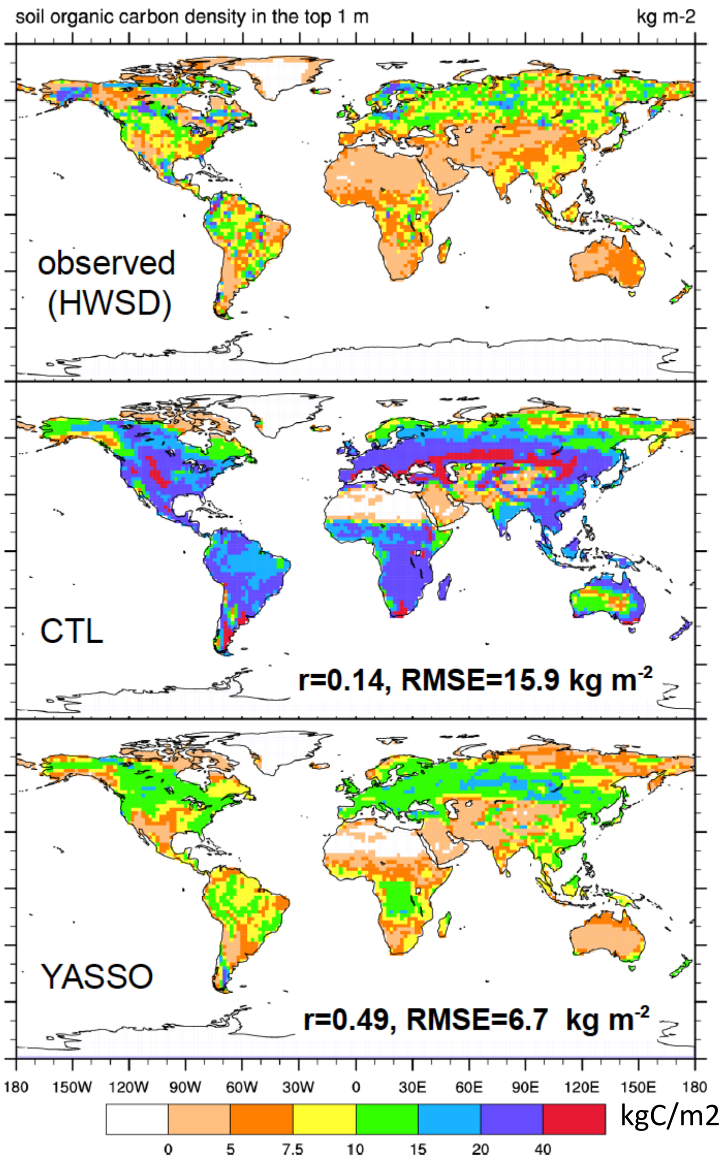
Who should come to our poster?

- If you compare earth system model (ESM) monthly mean T2m (averaged over all time steps) over land with reanalysis datasets (because reanalysis T2m is not good enough)
- If you compare ESM monthly mean T2m with global in situ datasets (e.g., CRU) (because you compare "apple" with "orange")
- If you do the right thing by saving monthly averaged diurnal cycle of T2m from models but compare its range with CRU diurnal temperature range DTR = Tx – Tn (because, again, you compare "guava" with "pomegranate")
- If you adjust reanalysis T2m using CRU Tm = (Tx + Tn)/2 to drive your land surface models (because this does not adjust the diurnal temperature range)

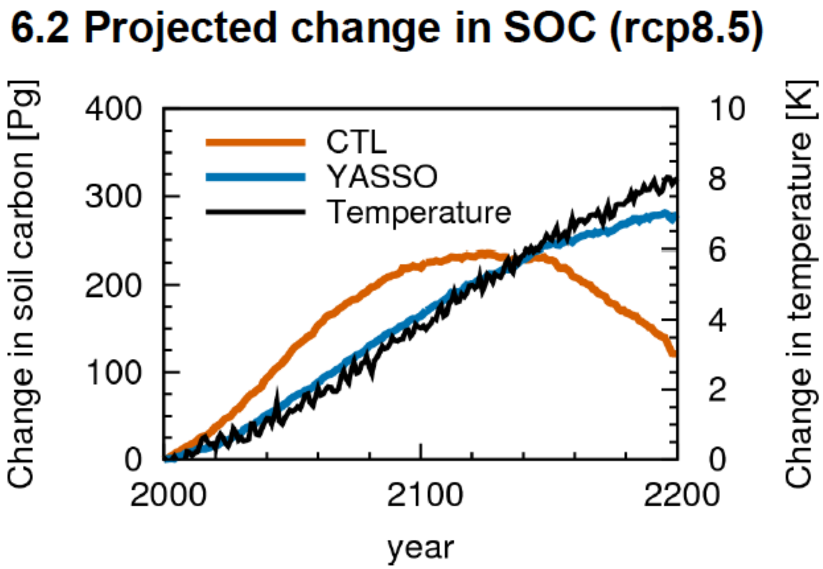
Bottom line: we have the new global datasets to help you solve these problems.

Performance of the new soil carbon module in JSBACH

D.Goll, V. Brovkin, T. Raddatz, J. Liski, and T. Thum



mean over yrs 1986–2005



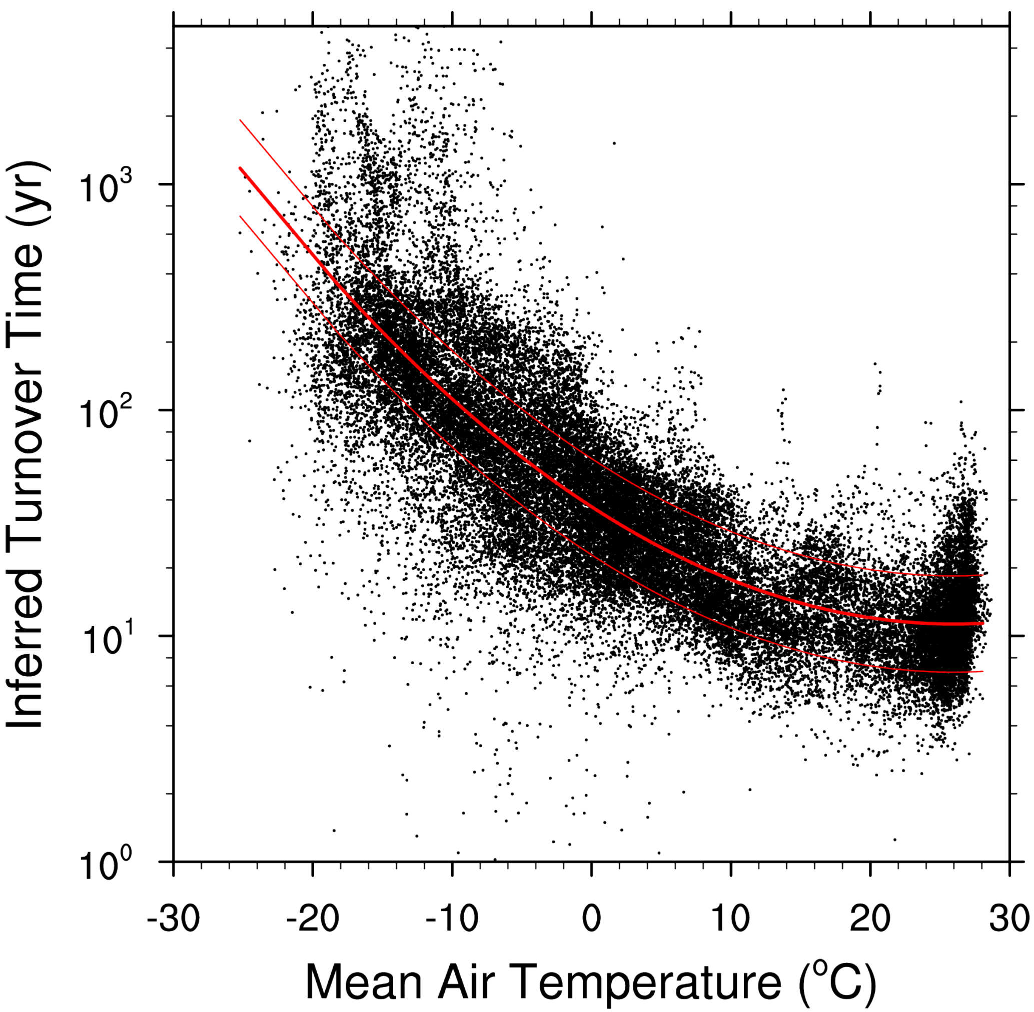
CTL: CMIP5 version of JSBACH

YASSO: JSBACH with YASSO by Lieski et al.

Goll et al., GBC, 2015

A benchmark and diagnostic of climatological temperature control on soil carbon turnover

C. D. Koven[1], G. Hugelius[2], D. M. Lawrence[3], W. Wieder[3]
(1) Lawrence Berkeley Lab; (2) Stockholm University; (3) NCAR



At our poster, we will:

1. Explain how we constructed this figure and why we think it is useful.
2. Derive a “climatological Q_{10}” from this relationship and show that it separates the world into “emergent” and “non-emergent” regimes based on whether or not the instantaneous and climatological Q_{10}s agree.
3. Show a simplified scaling theory that explains the change in sensitivity from temperate to cold climates.
4. Benchmark several CMIP5 (all linear ODE-based) soil carbon models to show that they all have problems.
5. Benchmark some newer soil carbon model approaches, including a linear PDE-based model (CLM4.5) and a nonlinear ODE-based model (MIMICS) that show some promise.

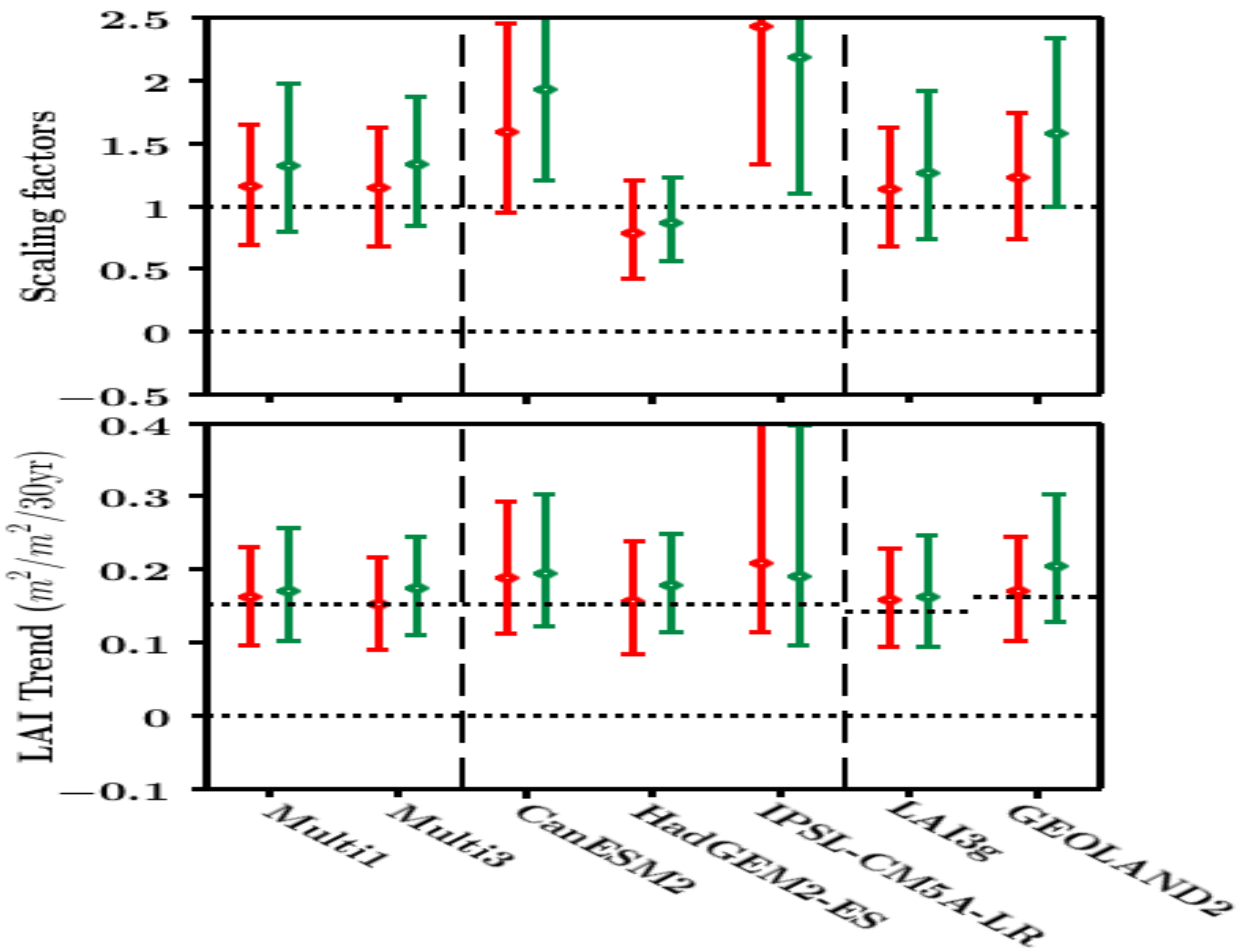
A framework of detecting and attributing terrestrial ecosystem dynamics

Climate Change Science Institute
Oak Ridge National Laboratory

Jiafu Mao and coauthors

U.S. Department of Energy
Office of Science

Optimal D&A results for 1982–2011 time series of LAI anomalies



Optimal fingerprint methods

$$Y = \sum x_i \beta_i + \epsilon_{IV}$$

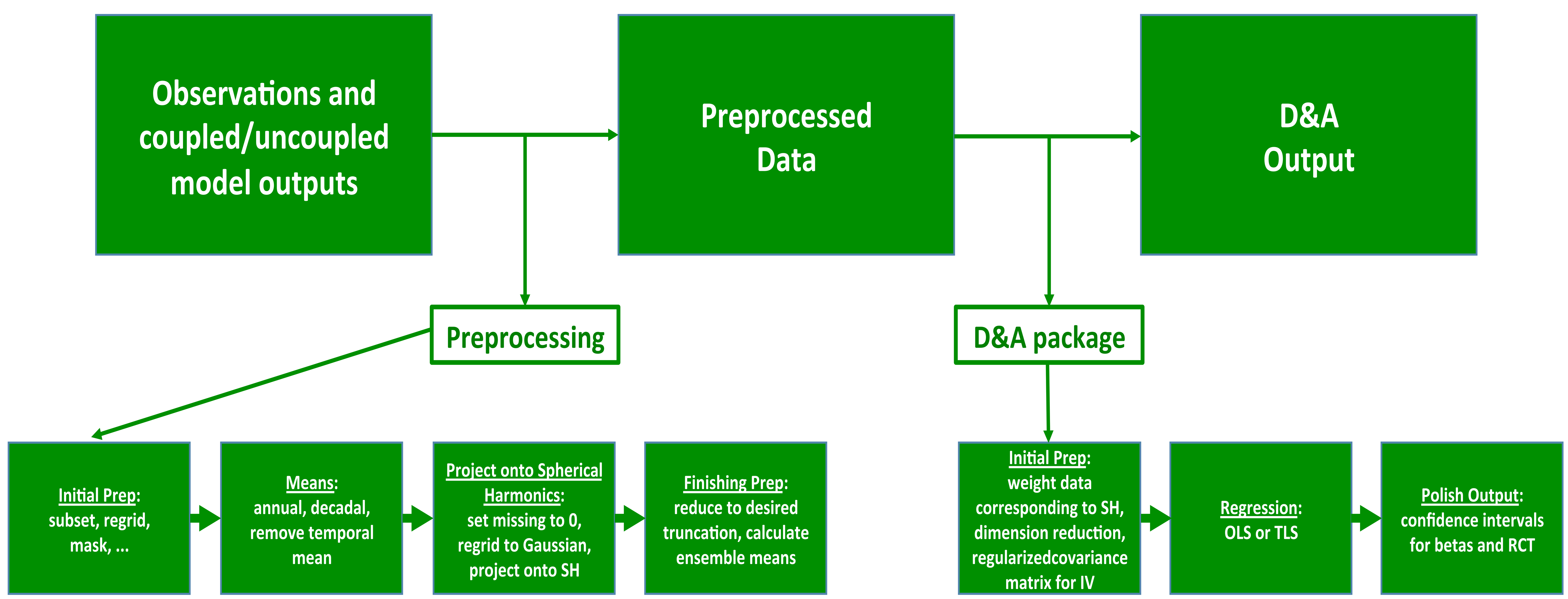
Y → observations

$\boldsymbol{x_i}$ → forcings from coupled model simulations

$\boldsymbol{\varepsilon_{IV}}$ → estimated internal variability from models

$\boldsymbol{\beta}$ → scaling factors

Diagram for the application of the D&A methods onto the terrestrial dynamics

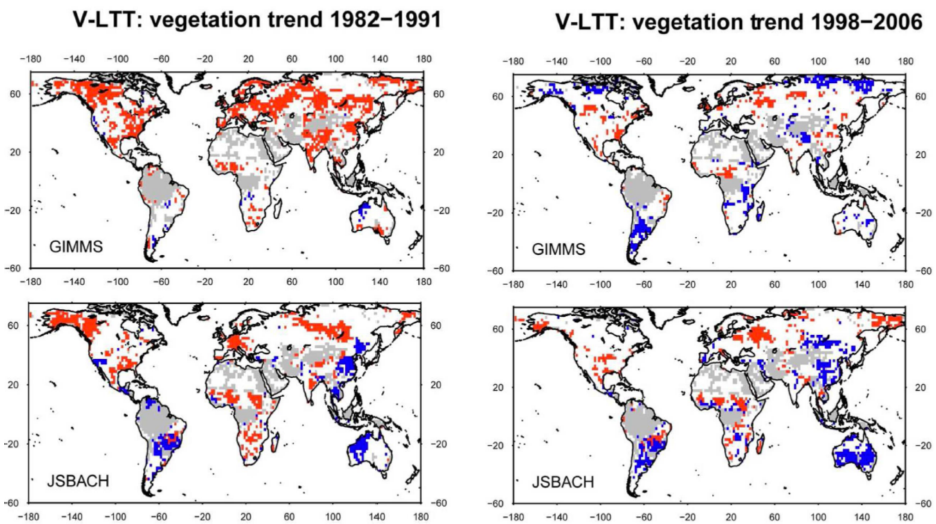


Sponsored by the U.S. Department of Energy, Office of Science, Biological and Environmental Research (BER) programs, and performed at Oak Ridge National Laboratory (ORNL). ORNL is managed by UT-Battelle, LLC, for the U.S. Department of Energy under contract DE-AC05-00OR22725. Please contact maoj@ornl.gov for further information.

JSBACH performance in comparison to observations and other models

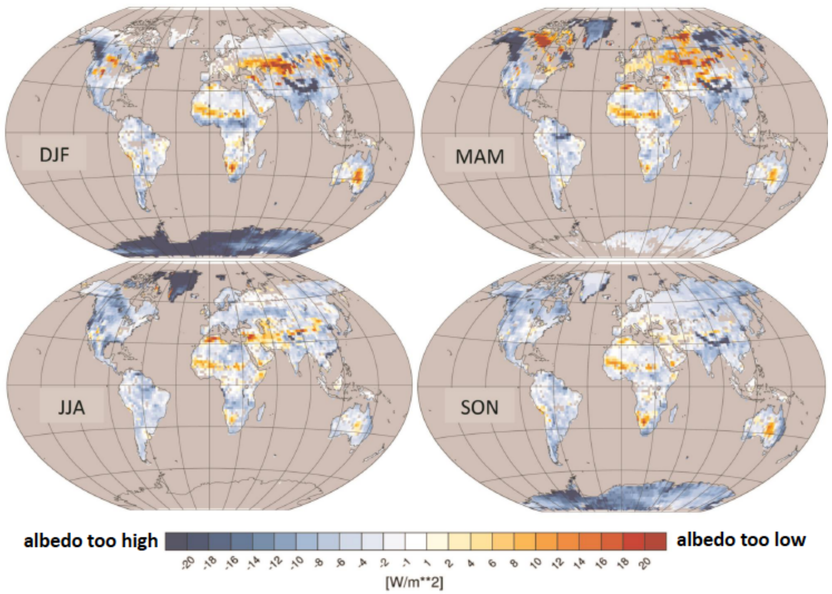
T. Raddatz, V. Brovkin, A. Loew, S. Hagemann, C. Reick, D. Dalmonech, and S. Zaehle
MPI for Meteorology & Biogeochemistry

Vegetation greennees



Dalmonech & Zaehle, 2013, Biogeosciences

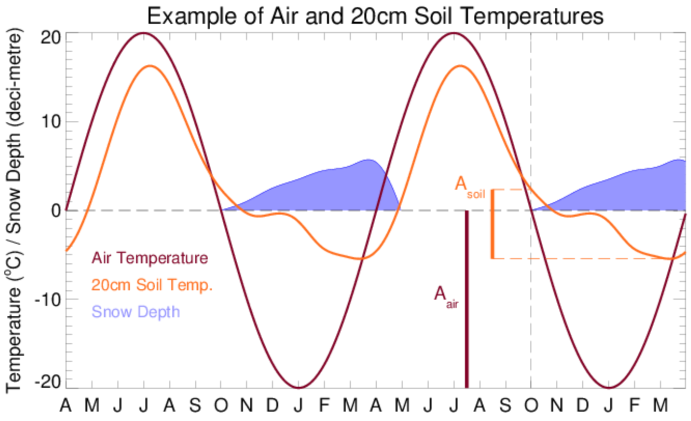
Surface albedo (JSBACH vs MODIS)



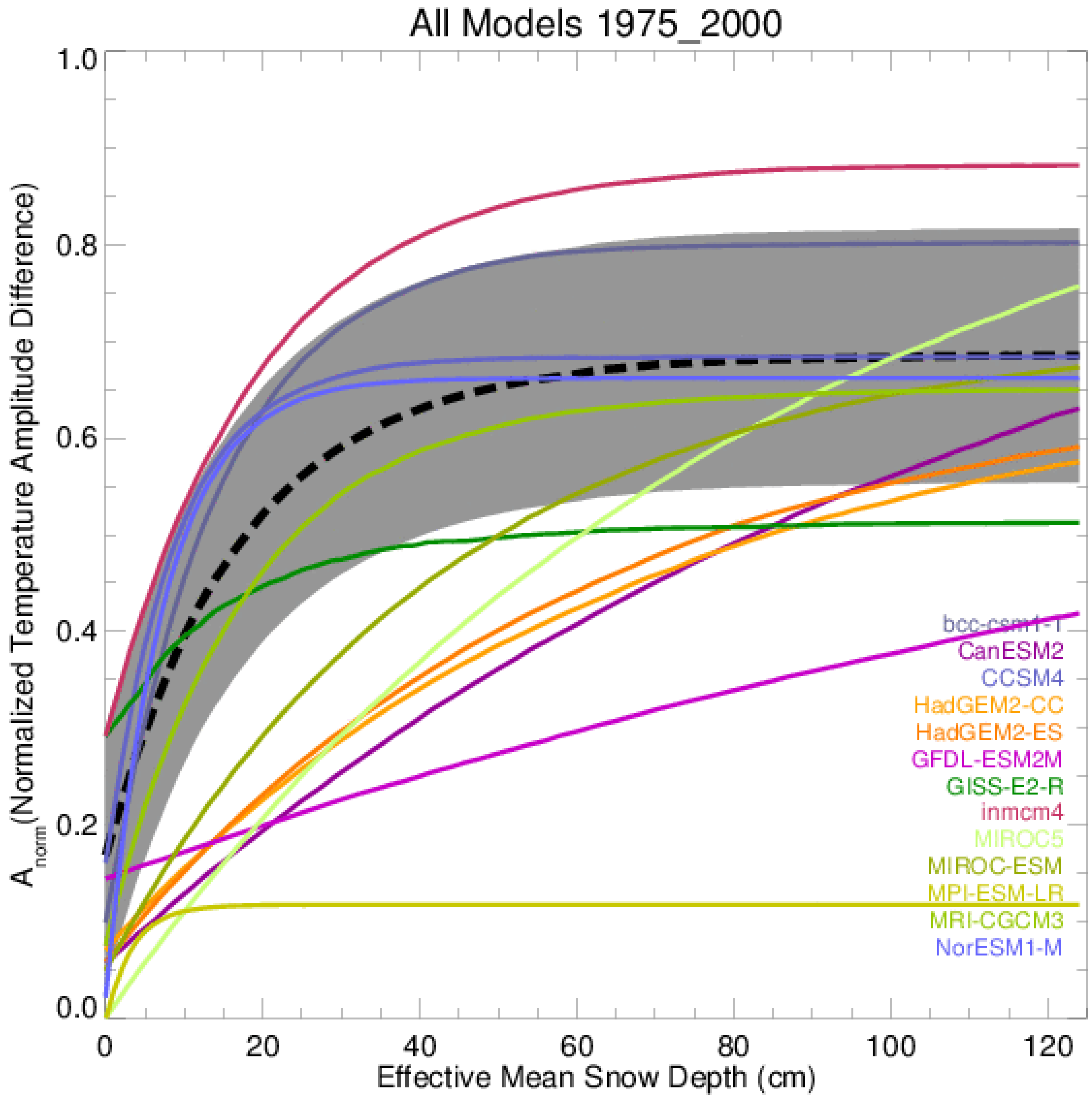
Brovkin et al., 2013, J Adv Model Earth Syst

More on the poster: evaluation of vegetation cover, carbon, hydrology

Process Evaluation: Heat Transfer with Snow

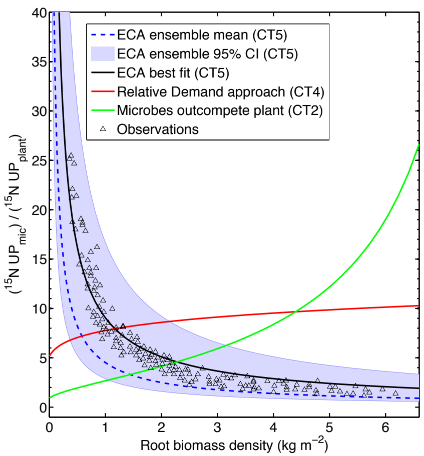


$$A_{norm} = \frac{A_{air} - A_{soil}}{A_{air}}$$



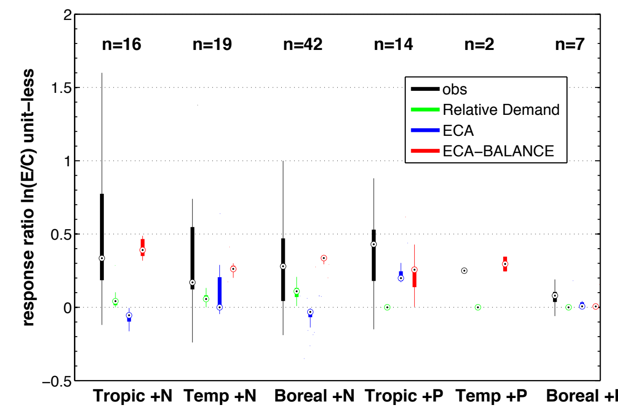
Slater et al., in prep

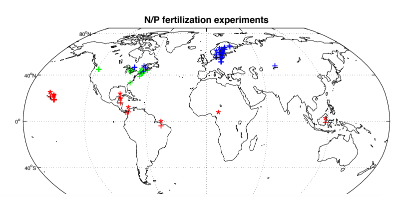
Benchmarking N/P competition
(Qing Zhu & William J. Riley LBNL)

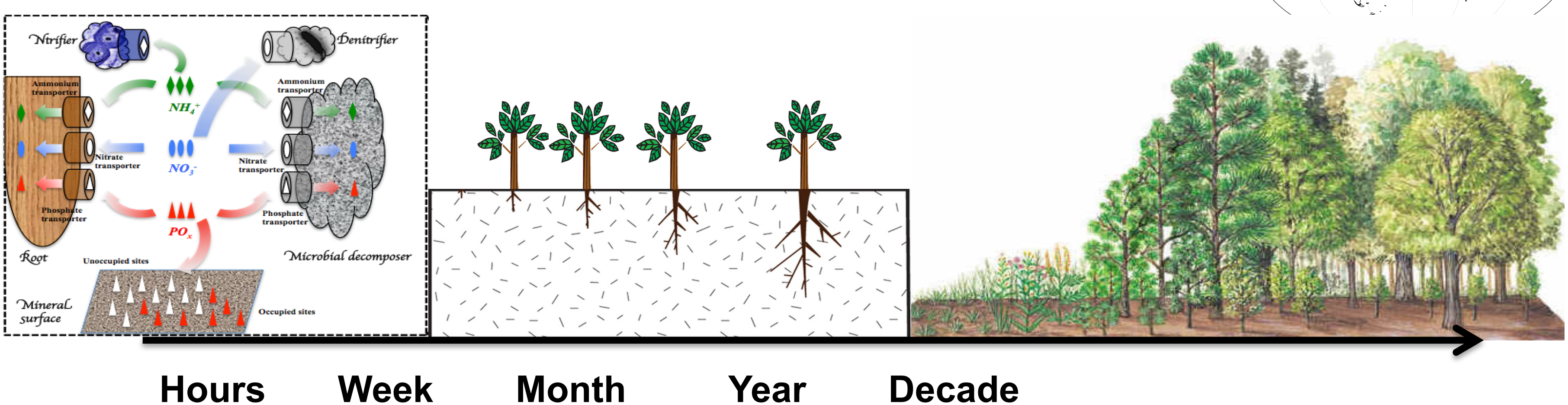


Short-term competition (hours - days):
Equilibrium Chemistry Approximation
vs. Relative Demand
vs. Microbes Outcompete Plants

Long-term competition (~ years):
Functional Balance Approach + ECA
vs. Fixed allocation + RD
vs. Dynamic allocation + ECA



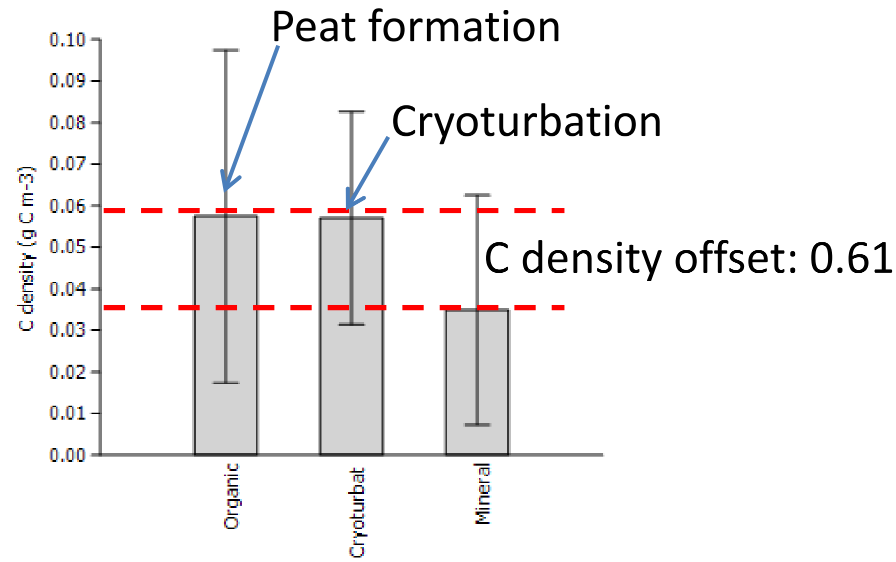




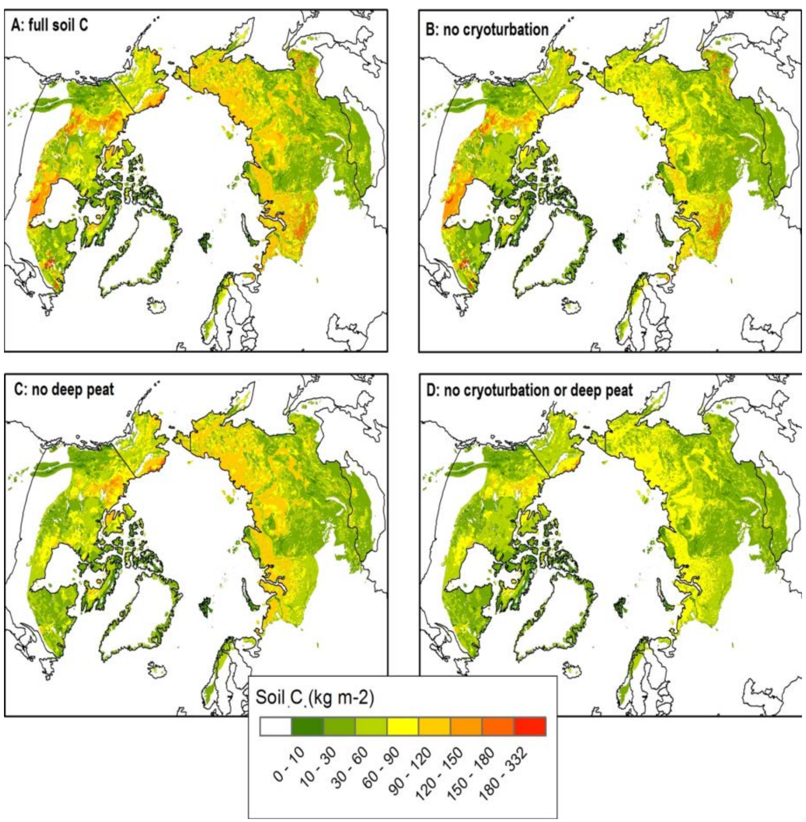
Benchmarking specific processes of permafrost soil C formation

G., Hugelius, A. D. McGuire, T. J. Bohn, E. J. Burke, S. Chadburn, G. Chen, X. Chen, D. J. Hayes, E. E. Jafarov, C. D. Koven, S. Peng and K. M. Schaefer

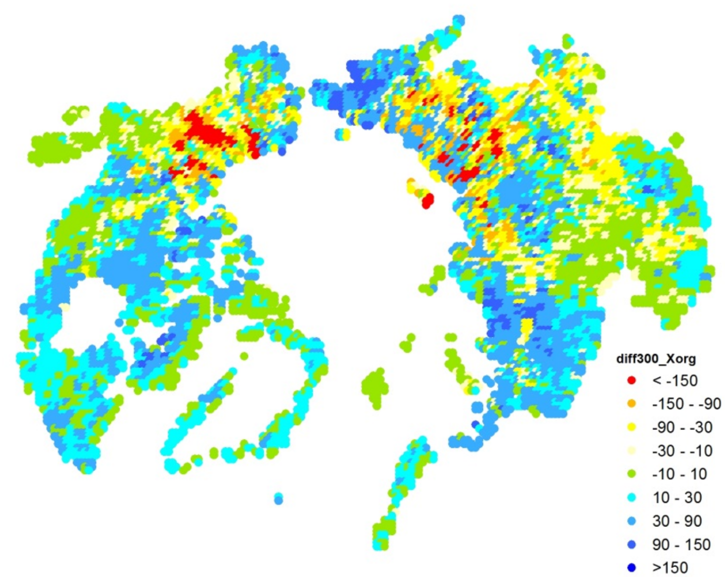
1. Detailed pedon data (n: >500)



2. Create adapted maps for benchmarking



3. Spatial analyses against modelled soil C



Ambiguous Numerical Coupling of Carbon and Nitrogen Dynamics is Fatal for Quality Carbon-Climate Feedback Predictions

Jinyun Tang and William J. Riley (LBNL)

Problem

Nutrient limitation is equivalent to ensuring positive solution of the equation

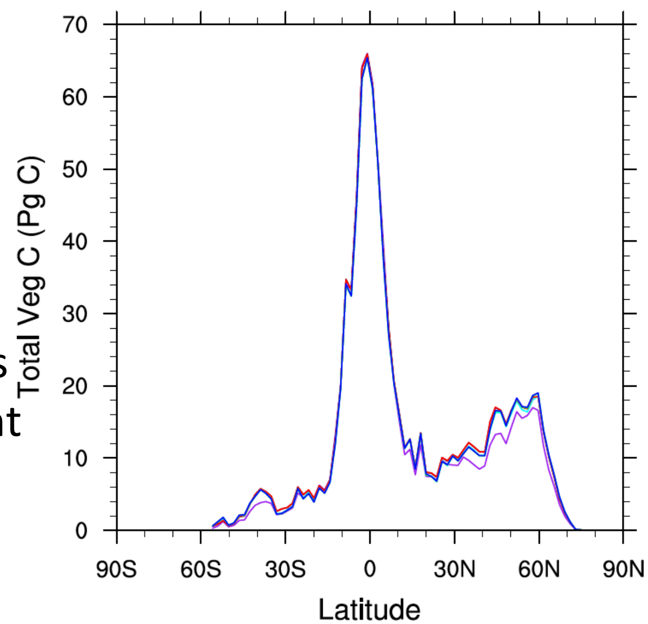
$$\frac{dS}{dt} = F_{S,input} - F_{S,uptake}$$

Existing solution

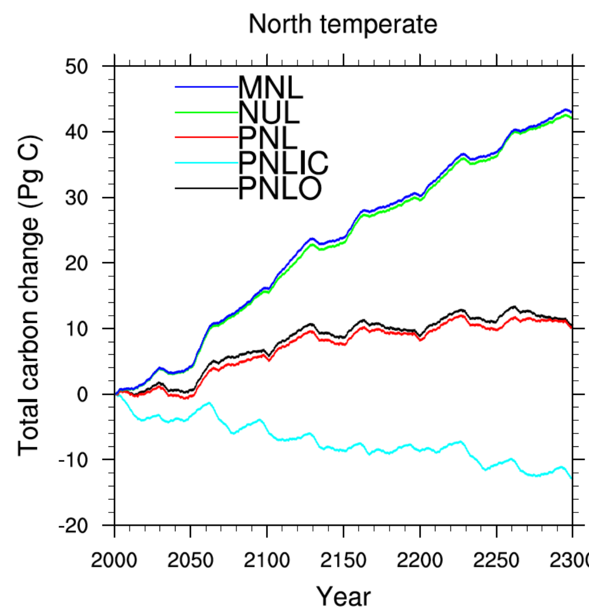
Actual numerical approaches diverge and result in different coupling of carbon-nitrogen dynamics

Predictions

They lead ACME to predict similar vegetation C for 1990-2000.



But future carbon dynamics are wildly different.



Proposed improvements

New developments should explore

- How to ensure a robust and consistent coupling between carbon and nutrient dynamics.
- How the quality of existing model applications are affected by inconsistent CN coupling.