Reducing Uncertainty in Biogeochemical Interactions Through Synthesis and Computation

RUBISCO SOC working group

Umakant Mishra
Sandia National Laboratory
RGMA PI meeting
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U.S. DEPARTMENT OF ENERGY
Office of Science

RUBISCO

SOC working group participants

UNIVERSITY OF
CENTRAL FLORIDA

- 31 participants from 23 institutions globally.
- Conference calls every last Wednesday of the month at 4:00-5:00 PM EDT.
- Annal meeting at participating institutions.

Two research themes

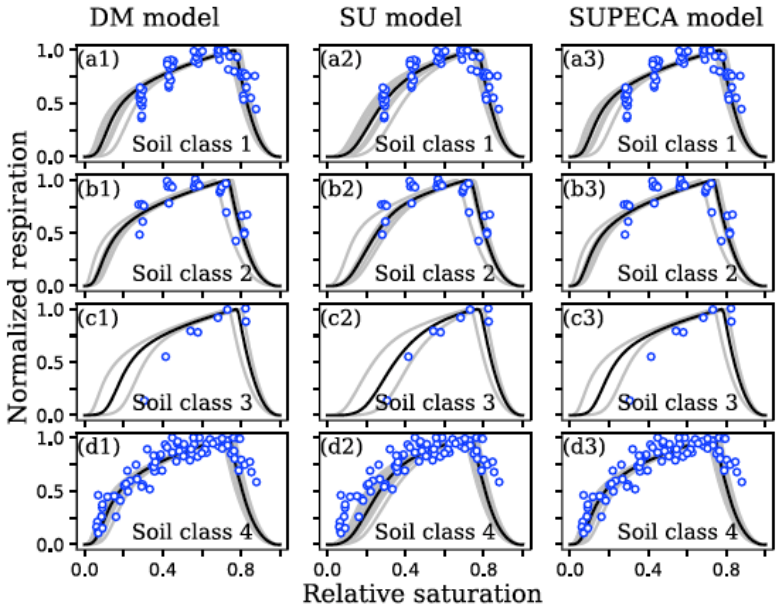
- **Global Data Synthesis**
  - Combine field observations from collaborative sampling networks and databases, including International Soil Carbon Network (ISCN) and published literature
  - Quantify vertical distribution of SOM and responses to controlling mechanisms

- **Model–Data Integration**
  - Develop consistent datasets for initializing, forcing, and benchmarking next-generation of microbially explicit soil carbon models
  - Characterize model structural uncertainty through software frameworks to understand importance of controlling mechanisms

New insights on temperature and moisture sensitivities of SOC decomposition

Jinyun Tang; LBNL

- Temperature sensitivity of SOM has pool characteristic dependence, while moisture does not.
- In absence of in situ observations, measurement setup has strong influence on results.
- Environmental factors like soil moisture can significantly change the values of substrate affinity parameters, implying that a significant part of the observed variability of these trait parameters are not from biological sources but from soil moisture and structure.



Tang and Riley, 2019

Evaluating soil heterotrophic respiration simulated by microbially-explicit global models

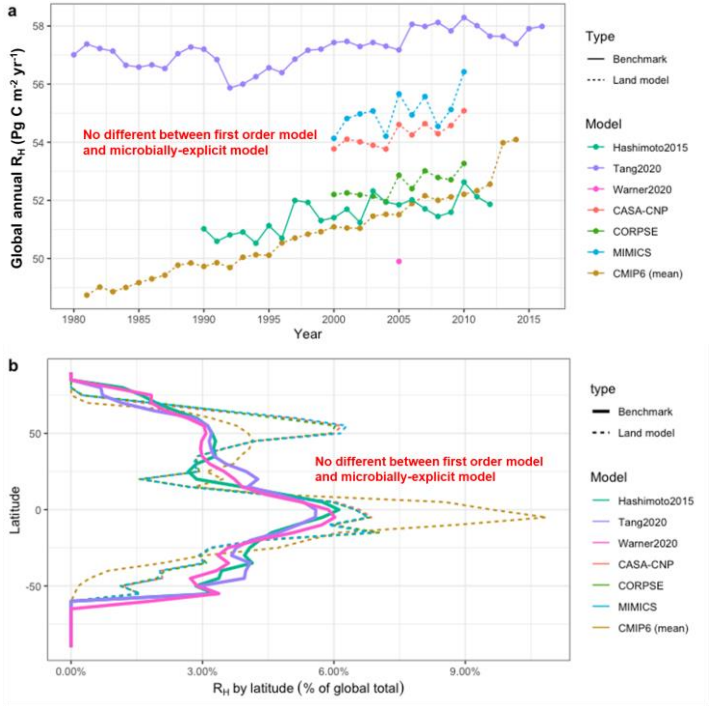
Jian Jinshi; PNNL

- **Used 10,000 field heterotrophic respiration measurements from the global soil respiration database, and outputs from microbially explicit and CMIP models.**

- **Compared daily and site scale measured RH vs model simulated RH.**

- **Site scale data model comparison showed**
- **R2 for CASA-CNP = 7.5%**
- **R2 for CORPSE = 3%**
- **R2 for MIMICS is = 10%.**

- **Found that the mean RH from the models is bigger than the field measurements.**

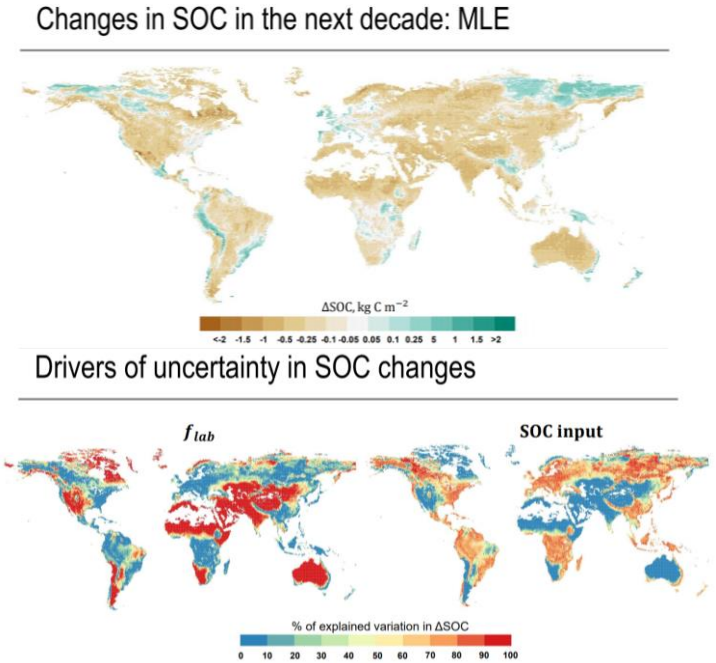


What do observational data products tell us about soil carbon dynamics in the near future?

Sasha Hararuk; UCF

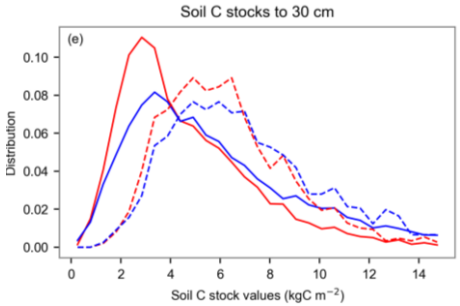
Summary:

- Available observational products yield highly uncertain SOC changes.
- Largest SOC losses – croplands, smallest – temperate forests.
- Some tundra regions will likely accumulate C in the next decade.
- To reduce uncertainty
  - Constrain labile C fractions of SOC stocks
  - Refine SOC input (NPP)



Effects of land cover and land use history on soil carbon depth distributions

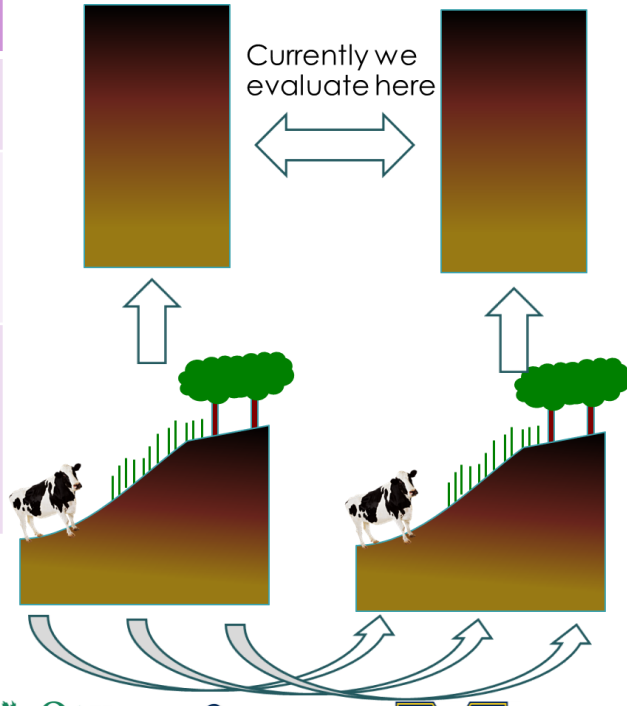
Benjamin Sulman; ORNL



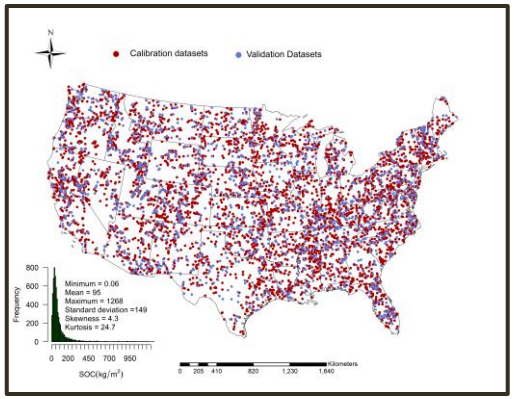
Histograms of soil profiles:
RED: Has Ap horizon (tillage history)
BLUE: No Ap horizon

Solid lines: All soil orders
Dashed lines: Mollisols

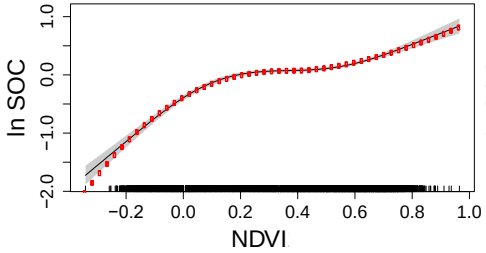
Emerging model features	Evaluation need
Depth-resolved soil carbon layers	Depth distribution of soil carbon
Sub-grid-scale heterogeneity in land use, ecosystems, topography	Sub-grid-scale measurements with site specific metadata
Mineral control on SOM cycling	Soil carbon measurements paired with mineral/parent material/horizon metadata

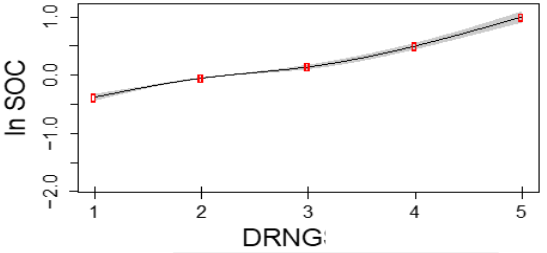


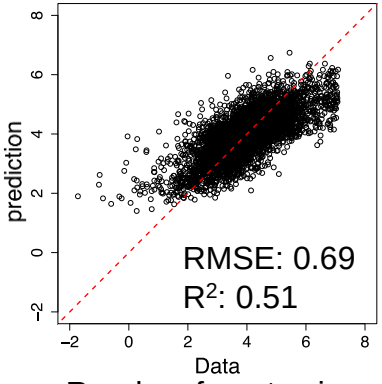
Machine learning to derive functional relationships between environmental factors and SOC stocks



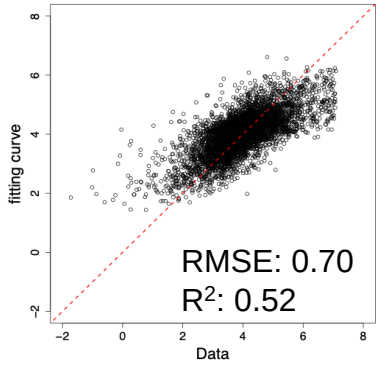
- 6,213 observations
- 31 environmental variables







Random forest using 22 variables



Functional relations of 6 variables

- **Machine learning and GAM models identified six environmental factors as important predictors of SOC stock.**
- **Derived functional relationships of these six environmental factors (PET, DEM, NPP, PPT) explained 52% of the observed variability of continental US SOC stocks.**
- **Functional relationships we derived can serve as important benchmarks to evaluate environmental control representations of SOC stocks in Earth System Models.**

(Mishra et al., in prep.)

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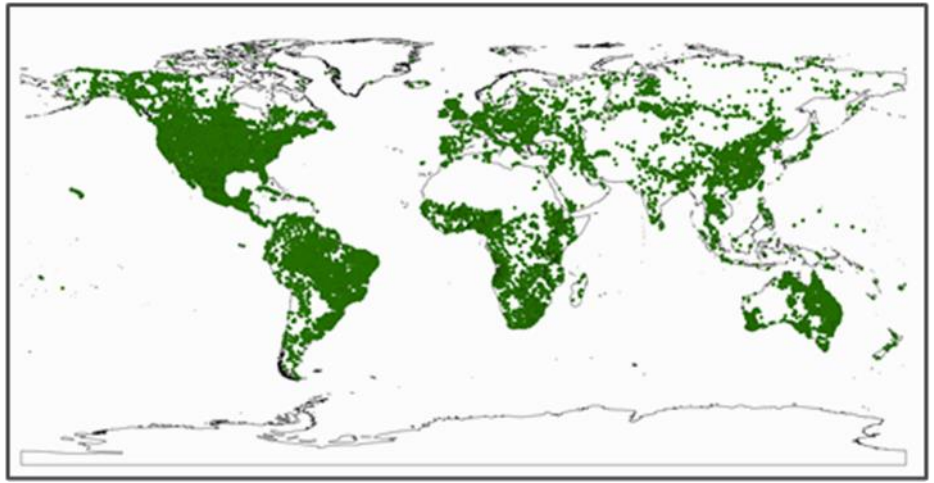
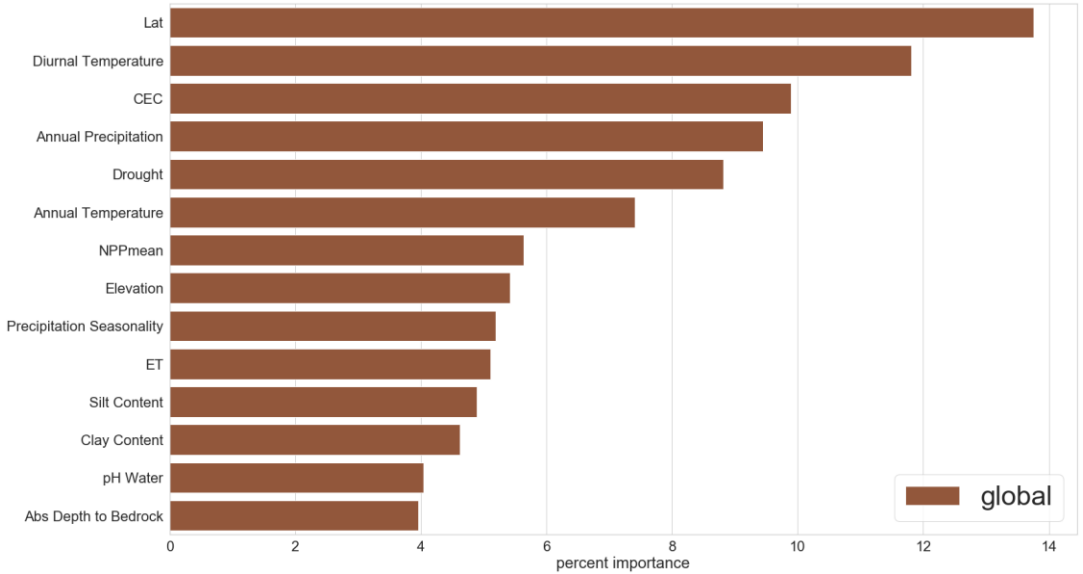
Benchmarking CMIP6 ESM representations of environmental controllers of SOC stocks using machine learning

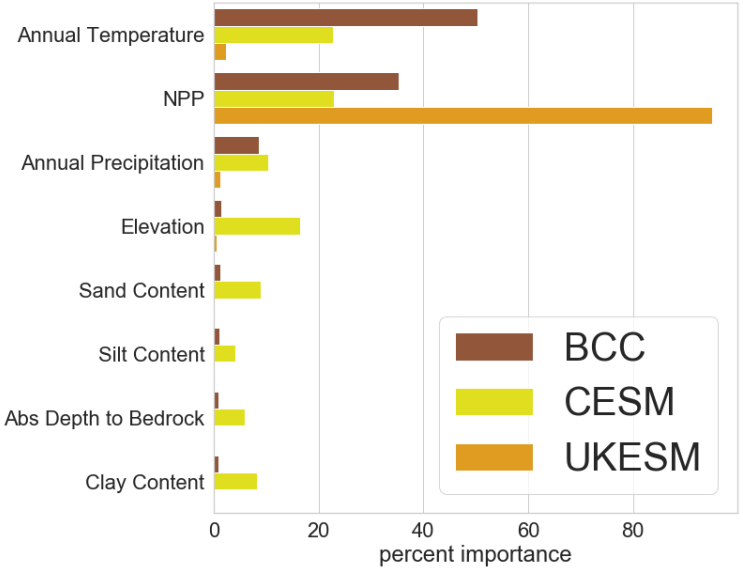


3 ESM datasets from CMIP6
-BCC
-CESM
-UKESM

- ~110,000 SOC profile observations
- 62 Environmental factors

Machine learning derived important environmental controllers of SOC stocks in observations and CMIP6 models

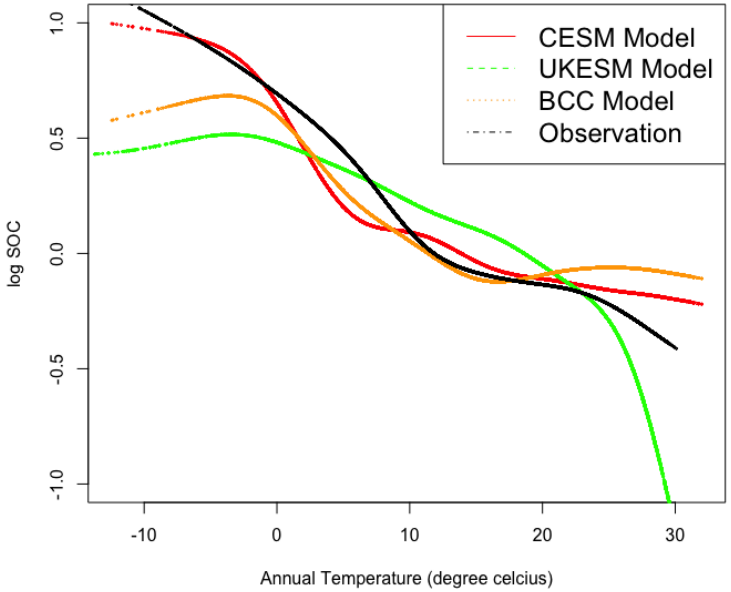


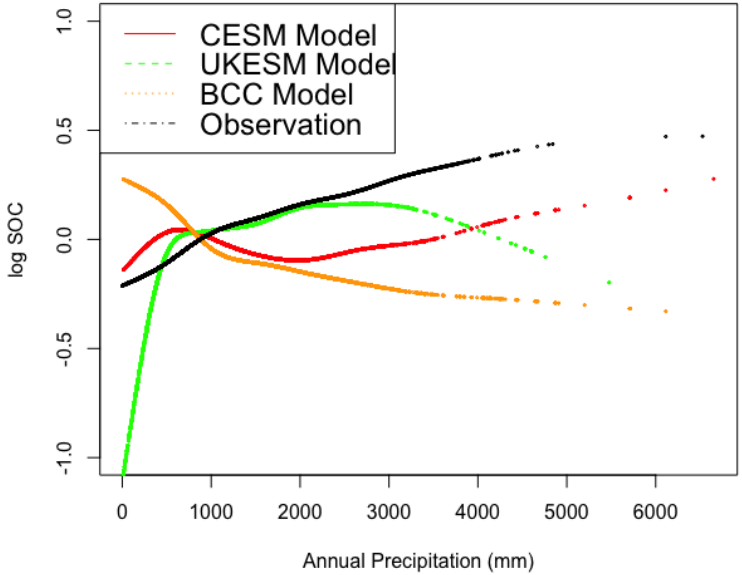


Observation R^2 =0.60

Model R^2 = 0.98 (0.97-0.99)

Control of temperature on SOC stocks is better constrained in CMIP6 models in comparison to precipitation





Splines are showing the GAM derived functional relationships (partial response surfaces between environmental factors and SOC stocks).

(Nyaupane et al., in prep.)

Summary, Outlook & Acknowledgement

- As a group we are making progress in benchmarking SOC dynamics through contributions to literature.
- We have conference calls planned for next couple months, and we will meet at workshop at appropriate time.
- Working in a group is a great way to work with a variety of datasets and analysis techniques to advance the model representation of SOC dynamics.

Regional & Global Model Analysis Program