The Unified North American Soil Map and Its Implication on the Soil Organic Carbon Stock in North America

Yaxing Wei*, Shishi Liu, Deborah Huntzinger, Anna Michalak, Wilfred M. Post, Robert B. Cook, Kevin Schaefer, and Michele M. Thornton

Environmental Sciences Division
Oak Ridge National Laboratory

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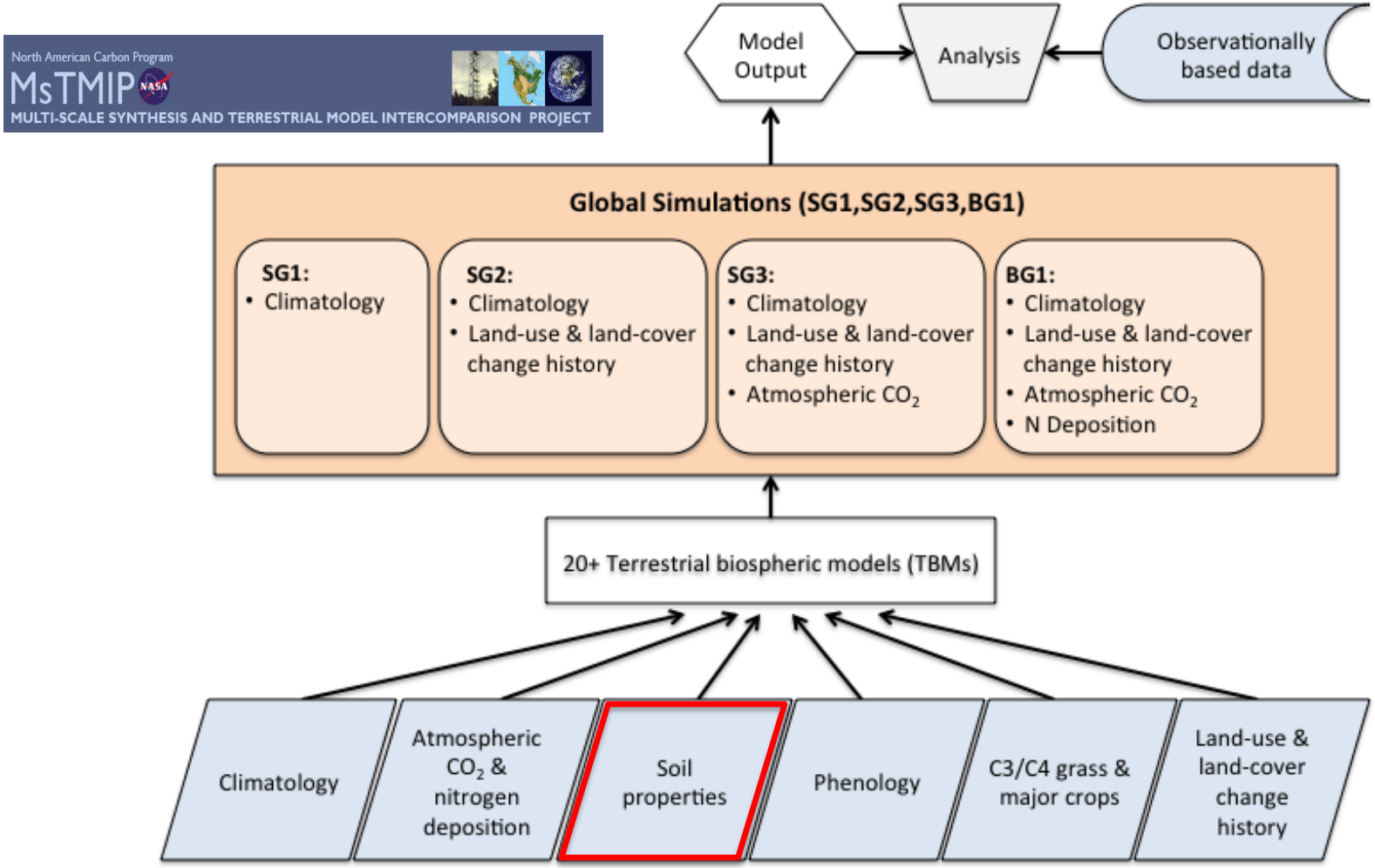
Introduction

- MsTMIP: Multi-scale Synthesis and Terrestrial Model Intercomparison Project



Modified from Huntzinger et al., Geoscientific Model Dev.(2013)

Introduction

- Soil data for North American carbon modeling relies on subset of global datasets: e.g. FAO-UNESCO, WISE, HWSD.
- UNASM – Unified North American Soil Map
  - Gridded data
  - 0.25-degree spatial resolution
  - Two soil layers: 0-30 cm and 30-100cm

Methodology

- Source Data
  - U.S. General Soil Map (STATSGO2)
  - Soil Landscapes of Canada (SLC) version 3.2 and 2.2
  - Harmonized World Soil Database (HWSD) Version 1.21
  - The Northern Circumpolar Soil Carbon Database (NCSCD)
    - Modify soil organic carbon

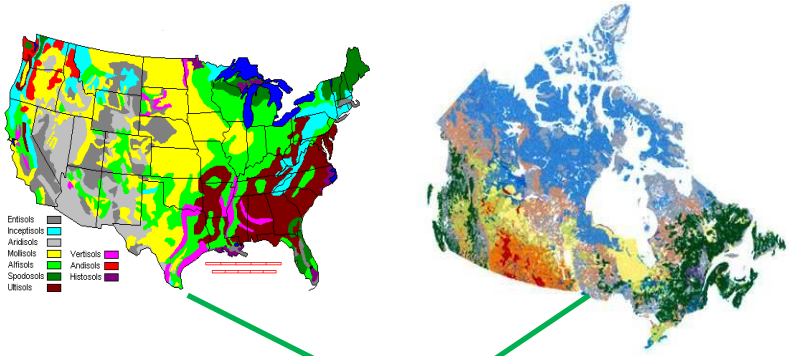
Methodology (Con't)

- Procedures
  - Regrid each data source into 0.25-degree by selecting the dominant soil type/properties
  - Merged data sources into a seamless soil map.
    - STATSGO2 > SLC 3.2 > SLC 2.2 > HWSD 1.21
  - Harmonize data into two standard layers.
    - Depth-weighted average (e.g. gravel fraction)
    - Mass-weighted average (e.g. sand fraction)
  - Quality control.
    - Filtering outlier values, sand+clay+silt=100% when necessary, etc.
  - Modify Soil Organic Carbon in UNASM using NCSCD.

Methodology (Con't)

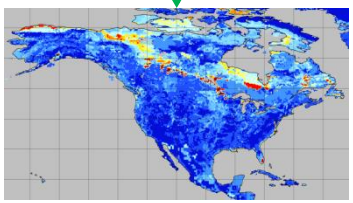
STATSGO2 (U.S.)

SLC3.2&2.2 (Canada)

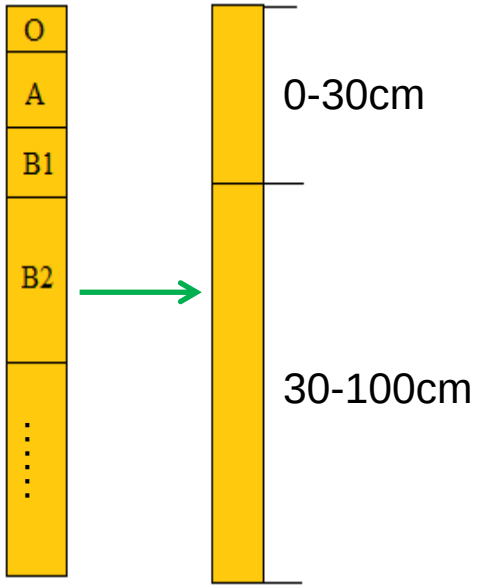


Filled with HWSD

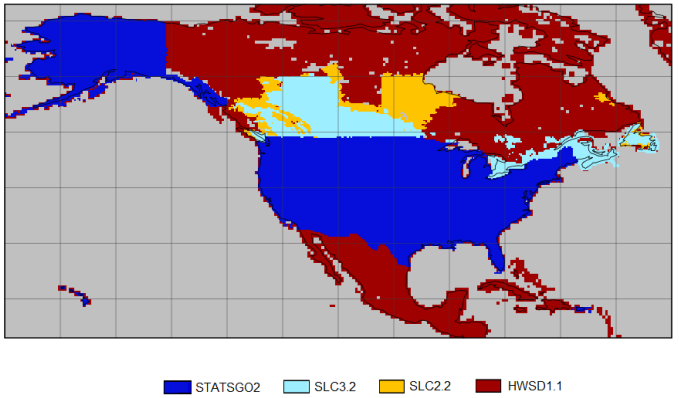
UNASM



Harmonization



Source Code



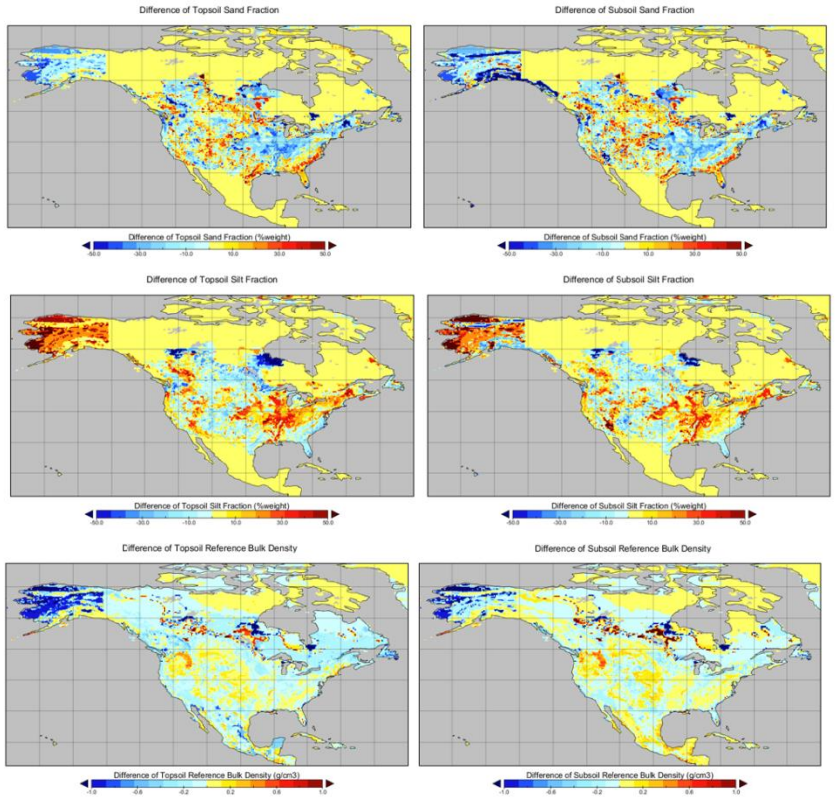
Sources of UNASM

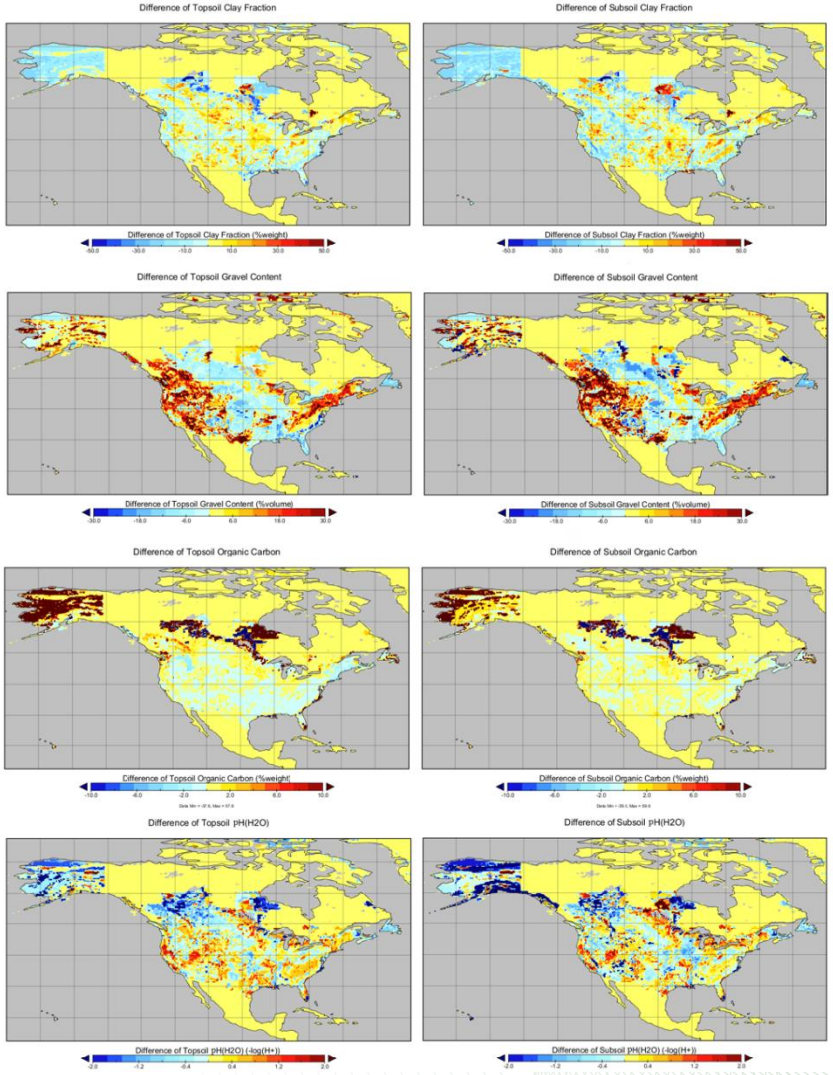
Soil Properties

Table 1. Soil depth, source code, and attributes of top soil layer (0-30 cm) and sub soil layer (30-100 cm).

Soil Attribute	Abbreviation	Units
Maximum Soil Depth	Soil Depth	cm
Source Code	Source	na
Topsoil Sand Fraction	t_{sand}	% weight
Topsoil Silt Fraction	t_{silt}	% weight
Topsoil Clay Fraction	t_{clay}	% weight
Topsoil Gravel Fraction	t_{gravel}	% volume
Topsoil Organic Carbon	t_{oc}	% weight
Topsoil pH (H_2O)	t_{ph}	$-\log(H^+)$
Topsoil Bulk Density	t_{bd}	g/cm^3
Subsoil Sand Fraction	s_{sand}	% weight
Subsoil Silt Fraction	s_{silt}	% weight
Subsoil Clay Fraction	s_{clay}	% weight
Subsoil Gravel Fraction	s_{gravel}	% volume
Subsoil Organic Carbon	s_{oc}	% weight
Subsoil pH (H_2O)	s_{ph}	$-\log(H^+)$
Subsoil Bulk Density	s_{bd}	g/cm^3

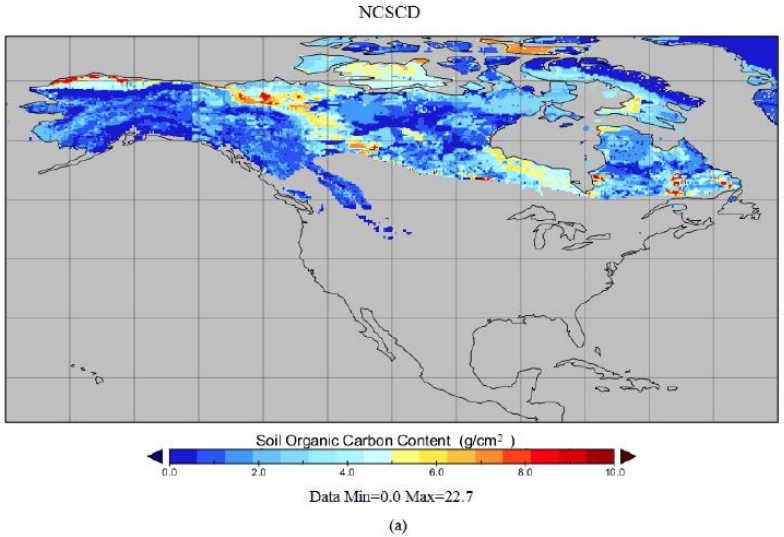
Comparison between UNASM and HWSD 1.21





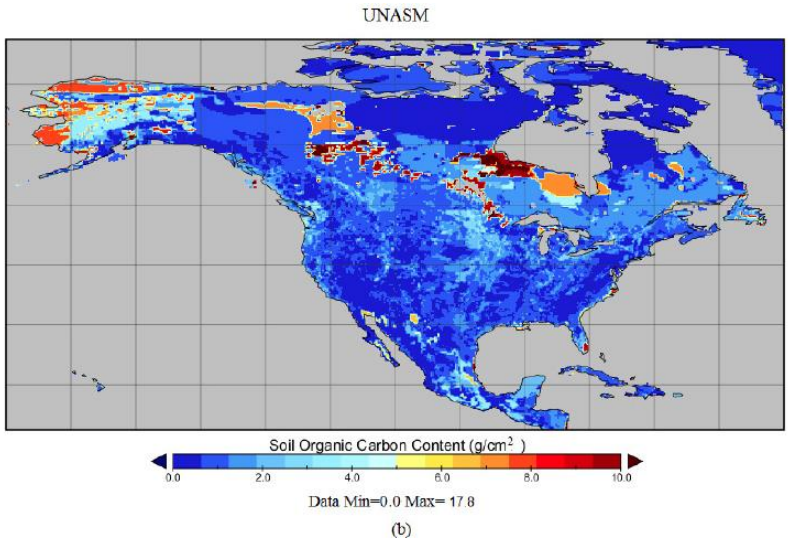
The difference map between the UNASM and the subset of the HWSD 1.21 for each soil property. The topsoil ranges from 0 to 30 cm and the subsoil ranges from 30 to 100 cm

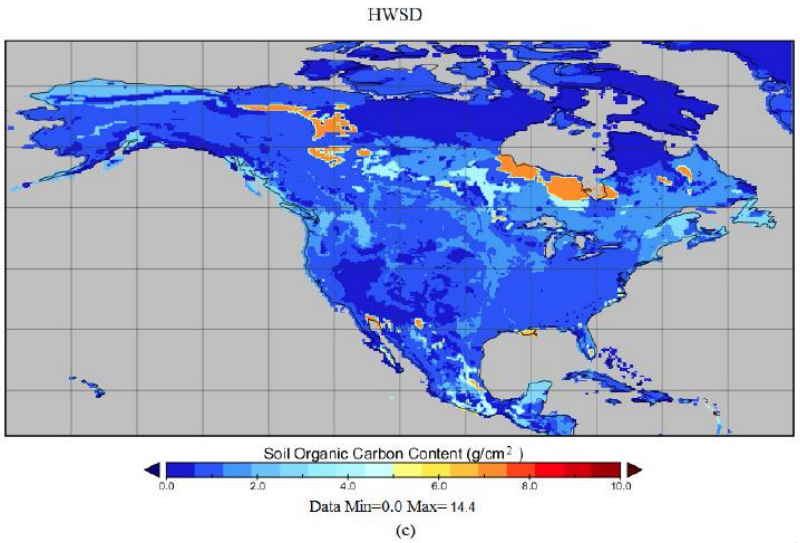
Soil Organic Carbon Content (SOCC)



SOCC = OC × BD × T × (1-Gravel)

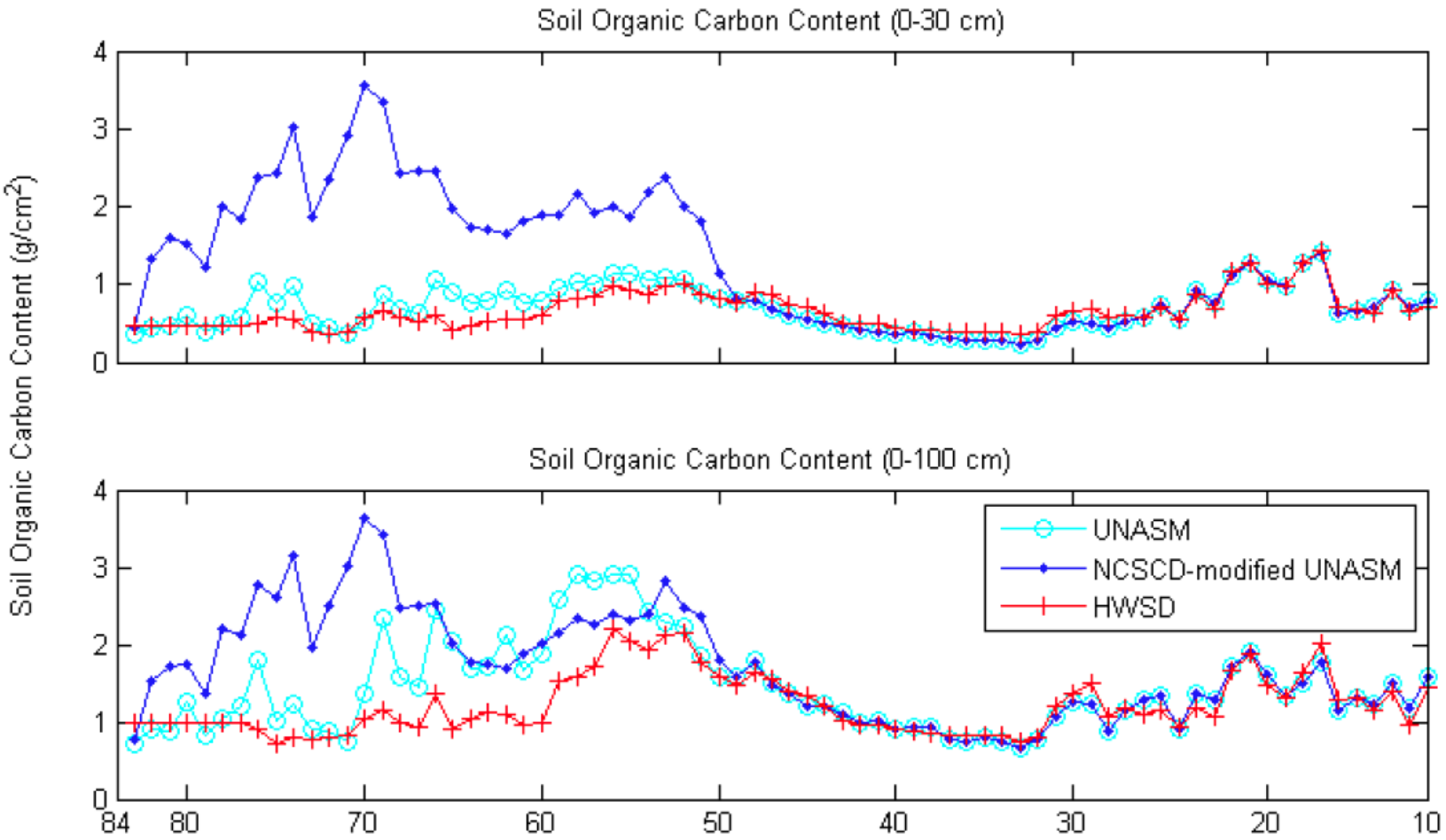
OC: soil organic carbon concentration
BD: soil bulk density
T: thickness
Gravel: gravel fraction





SOCC in the top 100 cm soil profile derived from (a) NCSCD, (b) UNASM, and (c) HWSD 1.21.

SOCC of NCSCD-modified UNASM



The latitudinal mean SOCC in (a) the 0–30 cm and (b) the 0–100 cm soil profile.

Estimation of Soil Organic Carbon Mass (SOCM)

$$SOCM = SOCC \times A$$

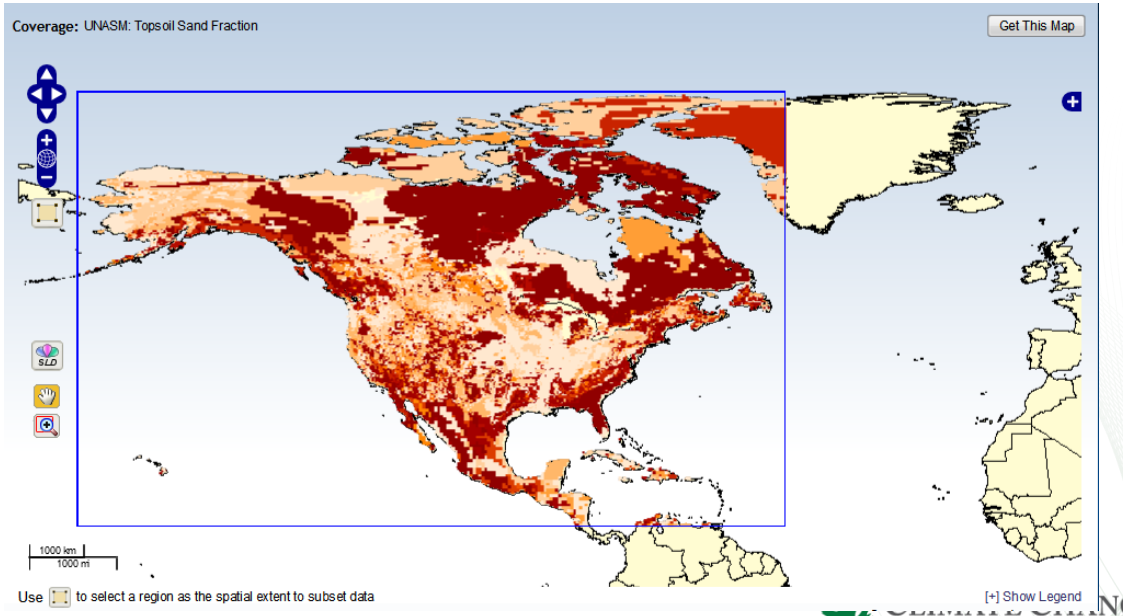
SOCC: soil organic carbon content
A: the area of each cell

Soil Layer	Needle Trees (Pg)	Broad Leaf Trees (Pg)	Mixed Trees (Pg)	Shrubs (Pg)	Grasses (Pg)	Crops (Pg)	Total (Pg)
NCSCD-modified UNASM Soil Organic Carbon Map							
0–30 cm	53.08	8.02	2.37	44.43	1.73	5.72	272.50
0–100 cm	68.27	12.93	3.36	51.63	4.64	13.04	365.96
HWSD 1.21							
0–30 cm	28.45	9.14	1.58	15.22	1.93	5.05	154.86
0–100 cm	59.37	14.55	3.06	29.17	4.21	10.28	296.70

The total SOCM and SOCM for major vegetation types in the top 0–30 cm and the 0–100 cm soil profile in North America derived from the NCSCD-modified UNASM soil carbon map and HWSD 1.21.

Data Visualization and Access

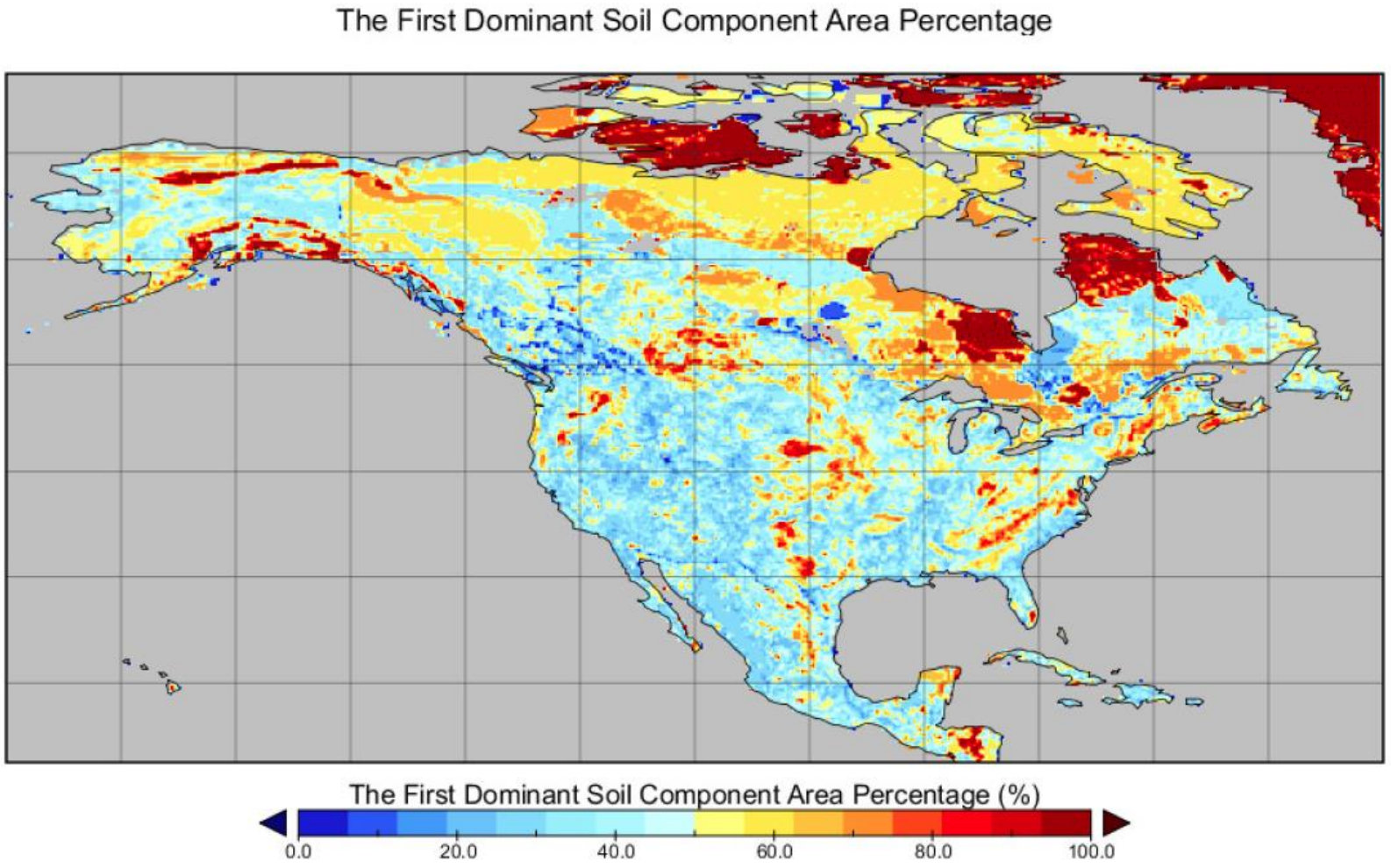
- The UNASM data has been archived at the ORNL DAAC
  - Data can been ordered/downloaded from http://daac.ornl.gov.
- The ORNL DAAC provides interactive visualization and subset to the UNASM data set in its SDAT tool.
  - http://webmap.ornl.gov/wcsdown/dataset.jsp?ds_id=1424



Discussion

- The UNASM provides more detailed and up-to-date soil information than the HWSD 1.21. The pronounced difference between UNASM and HWSD occurs in Alaska and central Canada around the major lakes.
- The NCSCD-modified UNASM soil organic carbon map demonstrates more details in the spatial distribution of SOCC and the large potential of soil organic carbon stock in high latitudinal regions.
- Method improvement: calculate gridded SOC by combining all soil types instead of choosing only dominant soil type.

Discussion


The First Dominant Soil Component Area Percentage
The First Dominant Soil Component Area Percentage (%)
0.0
20.0
40.0
60.0
80.0
100.0