Delta-X: NUMAR Predictive Model for Marsh Accretion Rates and Chemical Properties

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Documentation Revision Date: 2024-09-10

Dataset Version: 1

Summary

This dataset provides input data and model code to run the Marsh Accretion Rates (NUMAR) process model used to predict soil accretion rates and chemical properties for marsh sites in the Mississippi River Delta. NUMAR is a modification of the NUMAN model by Chen and Twilley (1999) that was developed for mangrove environments. This dataset provides Python code, input data in comma separated values (CSV) format, and documentation for installing and running the model in Portable Document Format (PDF).

The input data and model code are provided in one compressed Zip (.zip) file. When extracted from the Zip archive, the input data are provided in comma-separated values (CSV) format and model code are Python (.py) files. In addition, there are two files with instructions on installing and running the code provided in PDF format. There are no output files provided in this dataset.

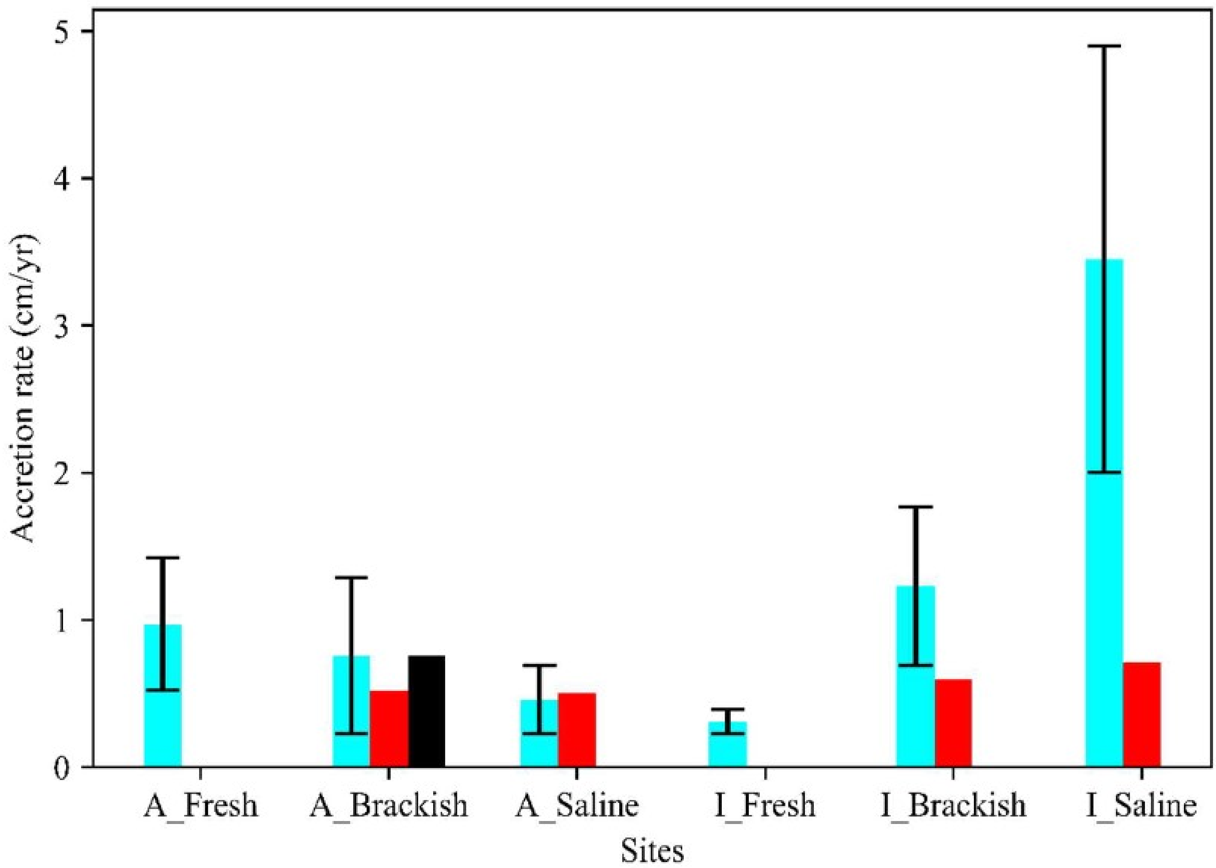

Figure 1. Simulated soil accretion rates based on NUMAR unit mode for each of six sites (blue bar) in Mississippi River Delta compared to the 137-Cs measurements (red bars - unpublished data from Twilley's lab; black bar from Baustian et al. (2021)).

Citation

Twilley, R., P. Biswas, A. Rovai, A.L. Christensen, A.F. Cassaway, I.A. Vargas-Lopez, and S. Kameshwar. 2024. Delta-X: NUMAR Predictive Model for Marsh Accretion Rates and Chemical Properties. ORNL DAAC, Oak Ridge, Tennessee, USA. https://doi.org/10.3334/ORNLDAAC/2354

Table of Contents

1. Dataset Overview

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Project: Delta-X

The Delta-X mission is a 5-year NASA Earth Venture Suborbital-3 mission to study the Mississippi River Delta in the United States, which is growing and sinking in different areas. River deltas and their wetlands are drowning as a result of sea level rise and reduced sediment inputs. The Delta-X mission will determine which parts will survive and continue to grow, and which parts will be lost. Delta-X begins with airborne and in situ data acquisition and carries through data analysis, model integration, and validation to predict the extent and spatial patterns of future deltaic land loss or gain.

Acknowledgement:

This program was funded under the NASA Earth Venture Suborbital-3 Program (grant NNH17ZDA001N-EVS3).

2. Data Characteristics

Spatial Coverage: Atchafalaya and Terrebonne Basins, southern coast of Louisiana, USA

Site Boundaries: Latitude and longitude are given in decimal degrees.

Site	Westernmost Longitude	Easternmost Longitude	Northernmost Latitude	Southernmost Latitude
Atchafalaya and Terrebonne Basins	-91.86	-90.19	29.76	28.72

Data File Information

This dataset includes three files: two files in Portable Document Format (.pdf) and one compressed zip archive (.zip).

NUMAR_Instruction_Manual.pdf file provides instructions for installing and running the model code.

NUMAR_documentation.pdf includes additional details pertaining to input data, model behavior, and sample outputs.

NUMAR_model.zip holds input data and model code are provided in one compressed Zip (.zip) file:

When extracted from the zip archive, the input data are in comma separated values (.csv) format (Tables 1-6), and the model code consists of Python (.py) files.

Input data and variables

Table 1: Variables in **bo_bi_input_file.csv:** input for calibrating self-packing density of organic (bo) and inorganic (bi) matter

Variable	Unit	Description
basin	-	Name of the basin
site	-	Name of the site
depth	$g\ g^{-1}$	Corresponding soil depth (set to the midpoint of each soil cohort segment)
OM*	$g\ g^{-1}$	Organic matter concentration
IM*	$g\ g^{-1}$	Inorganic matter concentration
BD*	$g\ cm^{-3}$	Corresponding bulk density, based on average at each site using all samplings at specified soil depth segments such as 0-10, 10-20, ...)

Table 2: Variables in **bd_comp_graph.csv**

Variable	Units	Description
site	-	Name of the site
depth	cm	Soil depth
bo	$g\ cm^{-3}$	Self-packing density of organic matter (calibrated)

bi	g cm^{-3}	Self-packing density of inorganic matter (calibrated)
OM*	g.g^{-1}	Organic matter concentration
IM*	g g^{-1}	Inorganic matter concentration
measured bd*	g cm^{-3}	Measured bulk density in the field
modeled bd	g cm^{-3}	Calculated BD using the calibrated bo and bi

Asterisks (*) in Tables 1 and 2 denote data from Castañeda-Moya and Solohin (2023b). For each soil depth segment (0-10 cm, 10-20 cm, etc.), average soil properties from the source and depth were assigned to the depth mid-point for convenience.

Table 3: Variables in **grouped_data_biomass.csv**

Variable	Units	Description
basin	-	Name of the basin
site	-	Name of the site
hydrogeomorphic_zone		Hydrogeomorphic zone
depth	cm	Soil depth
biomass	g cm^{-2}	Marsh plant belowground root biomass

Note: The belowground biomass value in Castañeda-Moya and Solohin (2023a) is in g m^{-2} and is expressed as total biomass for each 10-cm depth interval. For NUMAR, those values were converted to g cm^{-2} to be consistent with NUMAR code generating the root biomass at the surface in g cm^{-2} and root attenuation rate in cm^{-1}.

Table 4: Variables in **site_parameters.csv** and **site_parameters_root_turnover.csv**.

Variable	Units	Description	Source
si	g cm^{-2} yr^{-1}	Inorganic matter deposition rate on the soil surface	Cassaway et al. (2024); Twilley et al. (2023)
oms	g cm^{-2} yr^{-1}	Organic matter deposition rate on the soil surface	Cassaway et al. (2024); Twilley et al. (2023)
b0	g cm^{-3}	Self-packing density of organic matter	Estimated from soil property data from Castañeda-Moya and Solohin (2023)
bi	g cm^{-3}	Self-packing density of inorganic matter	Estimated from soil property data from Castañeda-Moya and Solohin (2023)
c0	g g^{-1}	Lignin content in the surface deposit	Fontenot (2022)
c1	g g^{-1}	Ash content in the root biomass	Fontenot (2022)
c2	g g^{-1}	Cellulose content in the surface deposit	Considered negligible. No data available
c4	g g^{-1}	Cellulose content in the root biomass	Wilson (1985)
fc1	g g^{-1}	Lignin content in the root biomass	Fontenot (2022)
kb	yr^{-1}	Belowground decomposition rate of labile organic matter	Fontenot (2022)
kc	yr^{-1}	Cellulose decomposition rate	Means et al. (1985)
kl	yr^{-1}	Lignin decomposition rate	Means et al. (1985)
kr	yr^{-1}	Root turnover rate	Estimated (see model implementation section
r0	g cm^{-2}	Root biomass at the surface	Determined from Castañeda-Moya and Solohin (2023a)
e	cm^{-1}	Root attenuation rate	Determined from Castañeda-Moya and Solohin (2023a)

Note: The file **site_parameters_root_turnover.csv** provides input for **varying_kr.py** to create file to calibrate root turnover. This file lacks the kr field.

Table 5: Variables in **Target_om.csv**

Variable	Units	Description

Site	-	Name of the site
Target_OM	percent	Average organic matter for target site up to 50 cm soil depth in percent dry mass. Data analyzed from Castañeda-Moya and Solohin (2023b)

Table 6: For random NUMAR input file (**site_parameters_random.csv**), there are four additional columns. Average COV for each parameter was considered and applied to all sites):

Variable	Units	Description	Source
si_std	g cm^{-2} yr^{-1}	Average standard deviation of si	Cassaway et al.(2024), Twilley et al. (2023)
oms_std	g cm^{-2} yr^{-1}	Average standard deviation of oms	Cassaway et al.(2024), Twilley et al. (2023)
fc1_std	g g^{-1}	Average standard deviation of fc_1	Cassaway et al.(2024), Twilley et al. (2023)
r0_std	g cm^{-2}	Average standard deviation of r_0	Determined from Castañeda-Moya and Solohin (2023a)

3. Application and Derivation

River deltas and their wetlands are drowning as a result of sea level rise and reduced sediment inputs. The Delta-X mission will determine which parts will survive and continue to grow, and which parts will be lost. Delta-X begins with airborne and in situ data acquisition and carries through data analysis, model integration, and validation to predict the extent and spatial patterns of future deltaic land loss or gain.

4. Quality Assessment

Model predictions were compared to in situ rates at six field sites.

5. Data Acquisition, Materials, and Methods

Model Implementation

Tests were conducted using NUMAR at six different marsh sites situated in both active (Atchafalaya Basin) and inactive (Terrebonne Basin) delta basins, each with varying levels of salinity from fresh to brackish to saline. The active sites included CRMS 0479 (fresh), CRMS 0399 (brackish), and CRMS 0322 (saline), while the inactive basin sites were CRMS 0294 (fresh), CRMS 0396 (brackish), and CRMS 0421 (saline).

Refer to the data file **NUMAR_Instruction_Manual.pdf** for detailed instructions on running the NUMAR code.

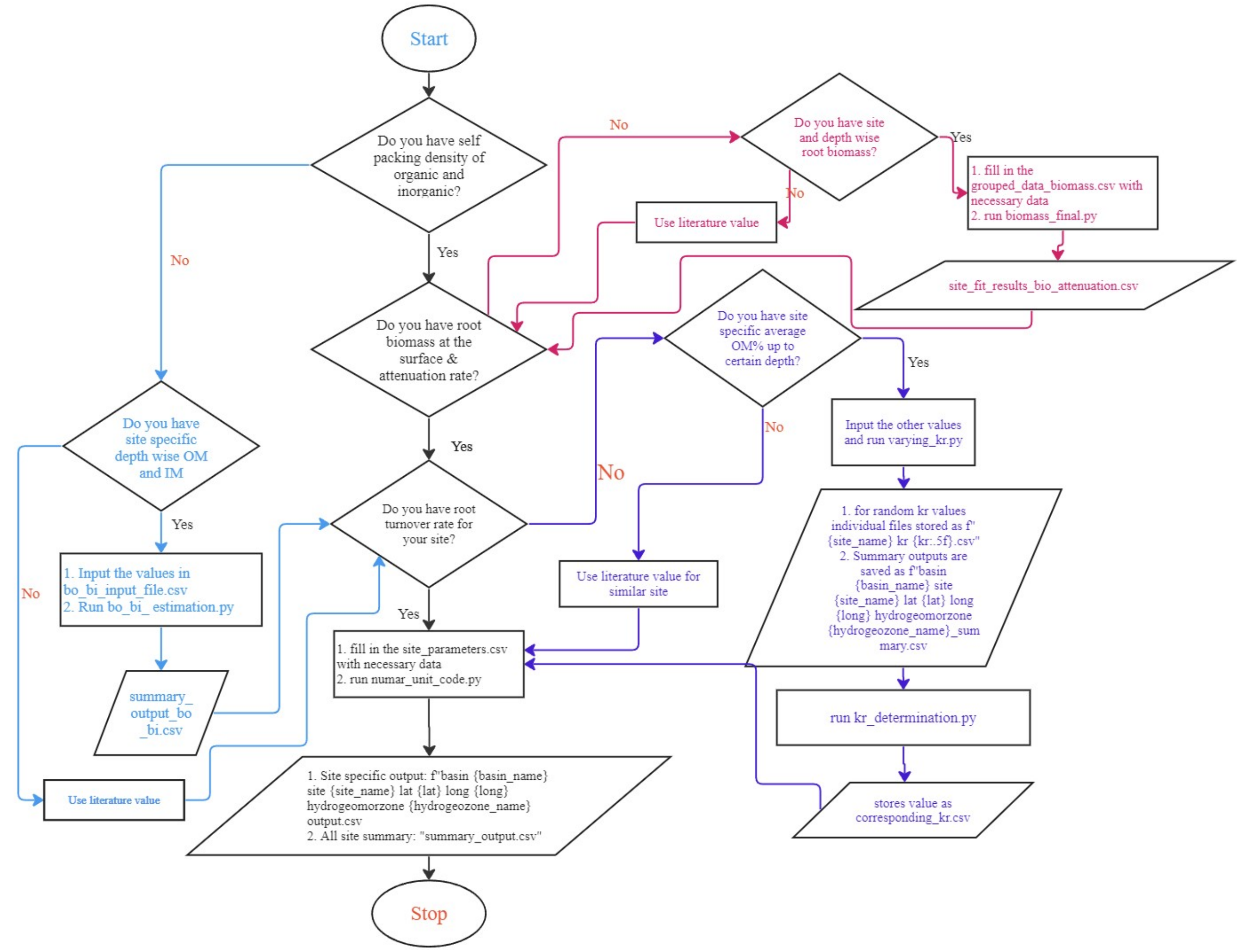

Figure 2. Flow chart for NUMAR model run.

Steps followed

Step 1. Determine self-packing density of organic and inorganic matter. Soil properties (Castañeda-Moya and Solohin, 2023b) such as bulk density (BD), organic fraction, inorganic fraction up to 50 cm depth were available for different sites and used to calculate the self-packing density of organic and inorganic matter through optimization.

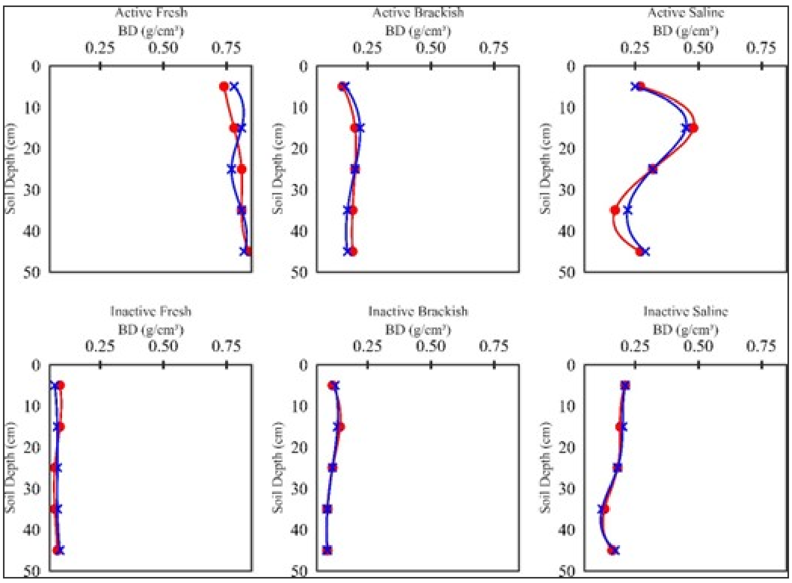

Figure 3. Field observations (red) of bulk density (BD) with simulated BD (blue) at different depths and sites.

Step 2. Estimate root biomass at the surface and attenuation rate. Use optimization through non-linear regression (Levenberg-Marquardt algorithm, see details at *Scipy.Optimize.Least_squares — SciPy v1.12.0 Manual*) to determine best fitting root biomass at the surface and root attenuation rate for sites.

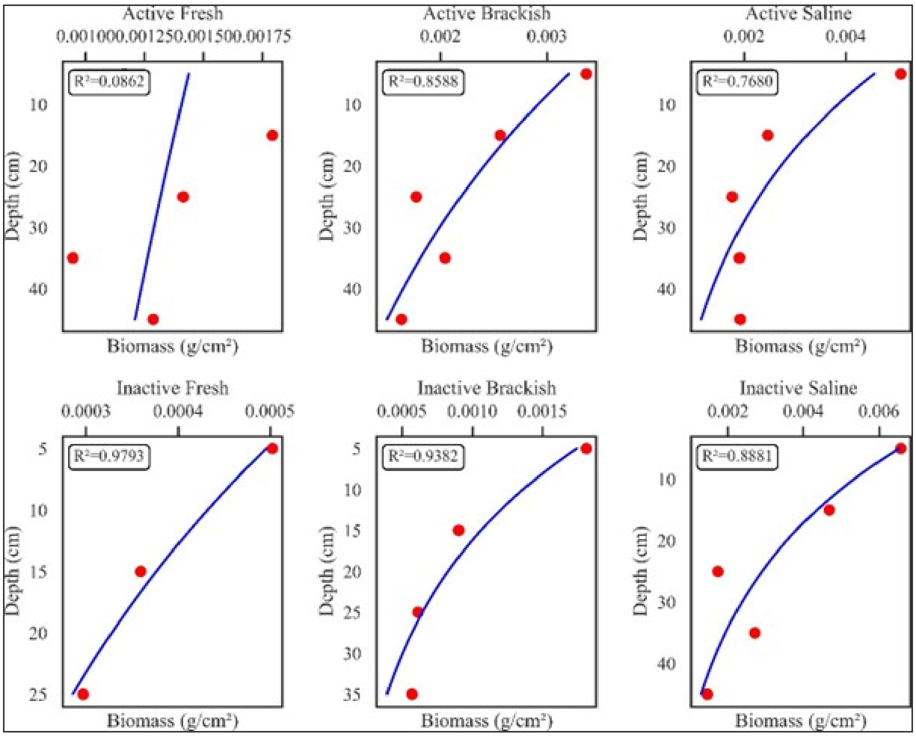

Figure 4. Measured root biomass at the surface and root attenuation rate from mentioned datasets. Blue lines are simulated root biomass profile and red dots are field measurements.

Step 3. Determine root turnover rate (*kr*) for the site. Root turnover rate was determined by drawing random values for *kr* from a uniform distribution [0.04,3.22] then using NUMAR to calculate average percent organic matter to 50 cm depth. The *kr* value that provided the percent organic matter closest to the target value was selected as the *kr* for that site.

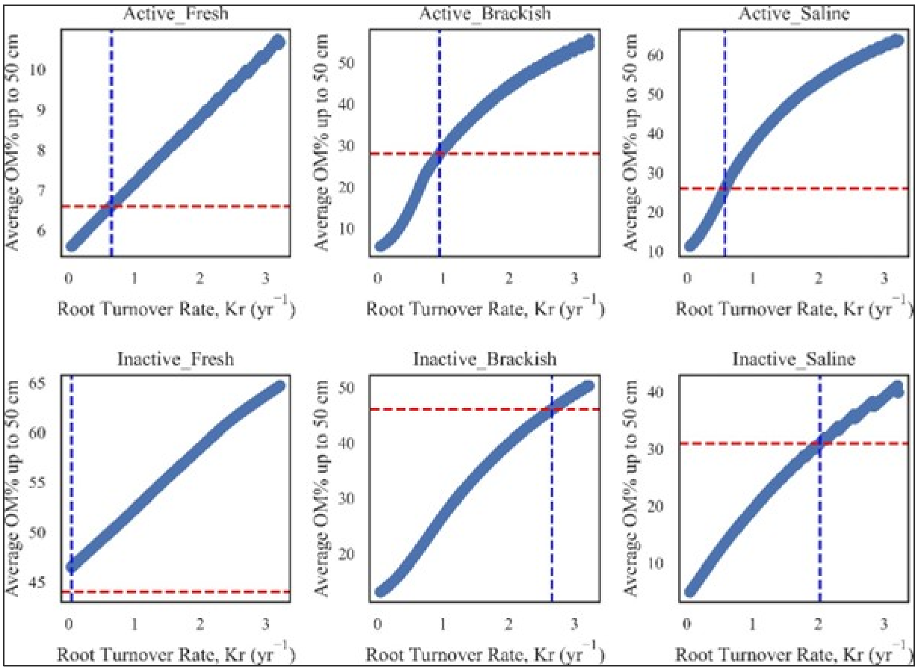

Figure 5. Estimating root turnover from available parameters. Red dotted lines are target organic matter percent up to 50 cm depth. Blue dotted lines are corresponding root turnover.

Step 4. Unit NUMAR using fixed input values: Once all the values are estimated, these are fed to the NUMAR model, and it does the calculation and stores the output data.

Step 5. Randomized unit NUMAR: To observe the site variability, selected parameters (*si*, *oms*, *kr*, *r0*, *fc1*) were assigned random values. In this study, *si*, *oms*, *r0*, and *fc1* were assigned truncated normal probability distributions. Following expert elicitation, *kr* was varied uniformly within ±50% to reflect uncertainty in outcomes. NUMAR stores data for all random events and gives output.

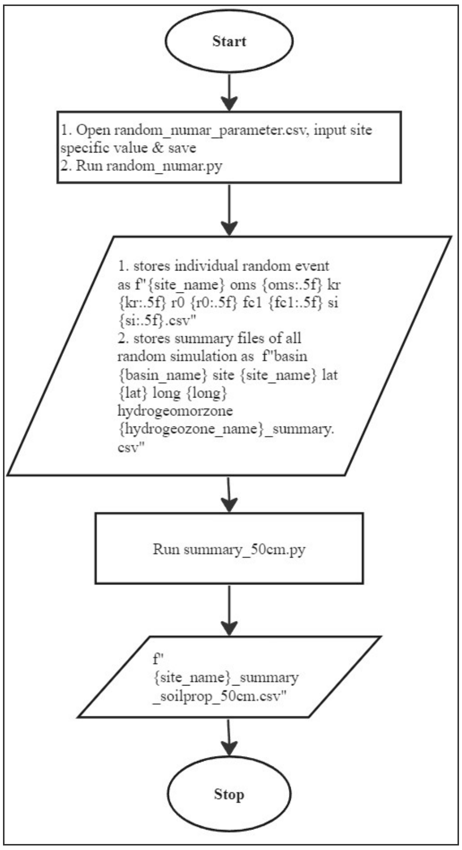

Figure 6. Work flow for NUMAR operation with randomized input values.

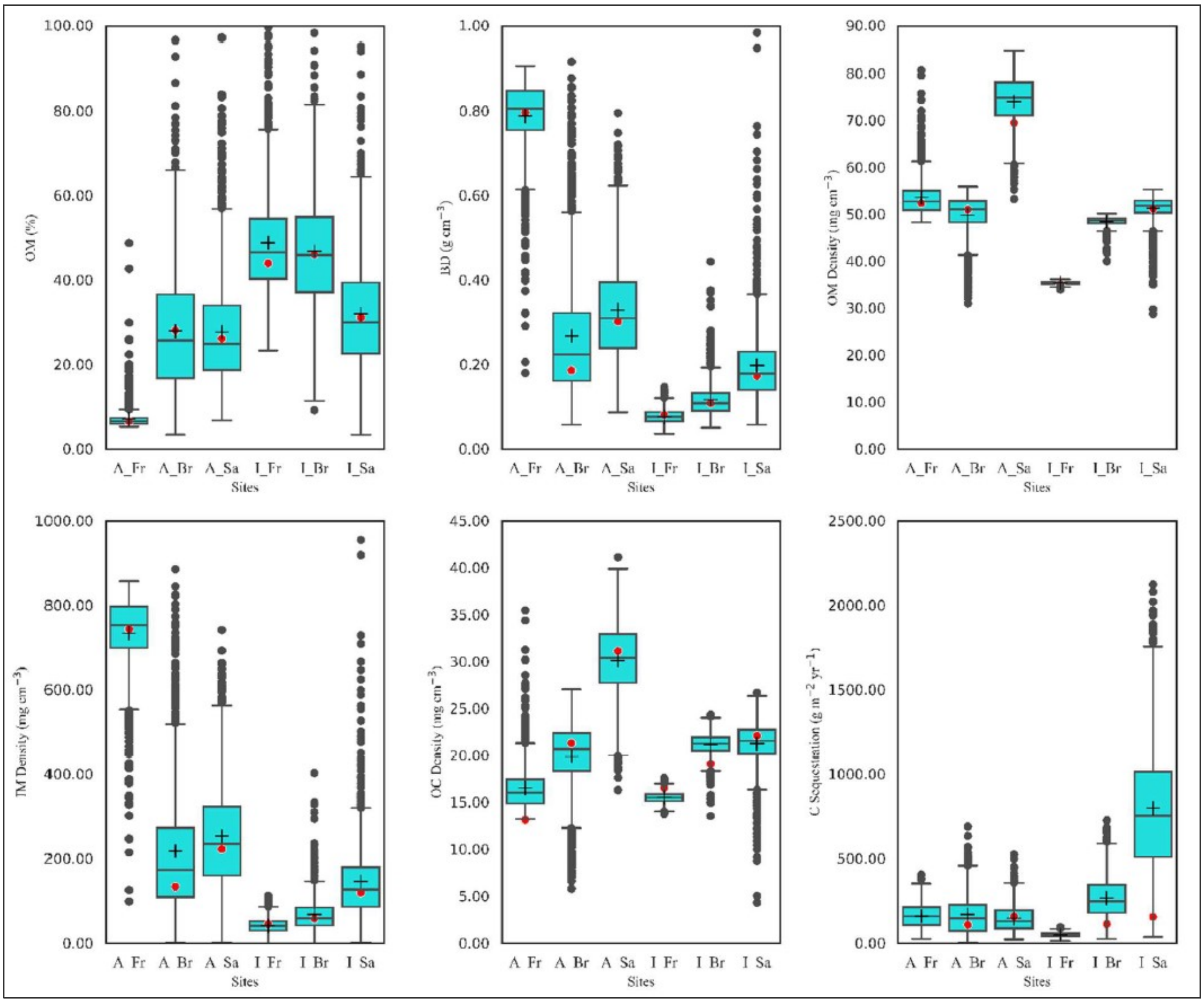

Figure 7. Distribution of soil properties simulated using NUMAR based on site conditions (box plots) compared with field observations (red dots). The six sites include the following: two delta basins (A = Active Basin, I = Inactive Basin) with each of three types of marshes based on salinity (Fr = Fresh, Br = Brackish, and Sa = Saline).

6. Data Access

These data are available through the Oak Ridge National Laboratory (ORNL) Distributed Active Archive Center (DAAC).

Delta-X: NUMAR Predictive Model for Marsh Accretion Rates and Chemical Properties

Contact for Data Center Access Information:

- E-mail: uso@daac.ornl.gov
- Telephone: +1 (865) 241-3952

7. References

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