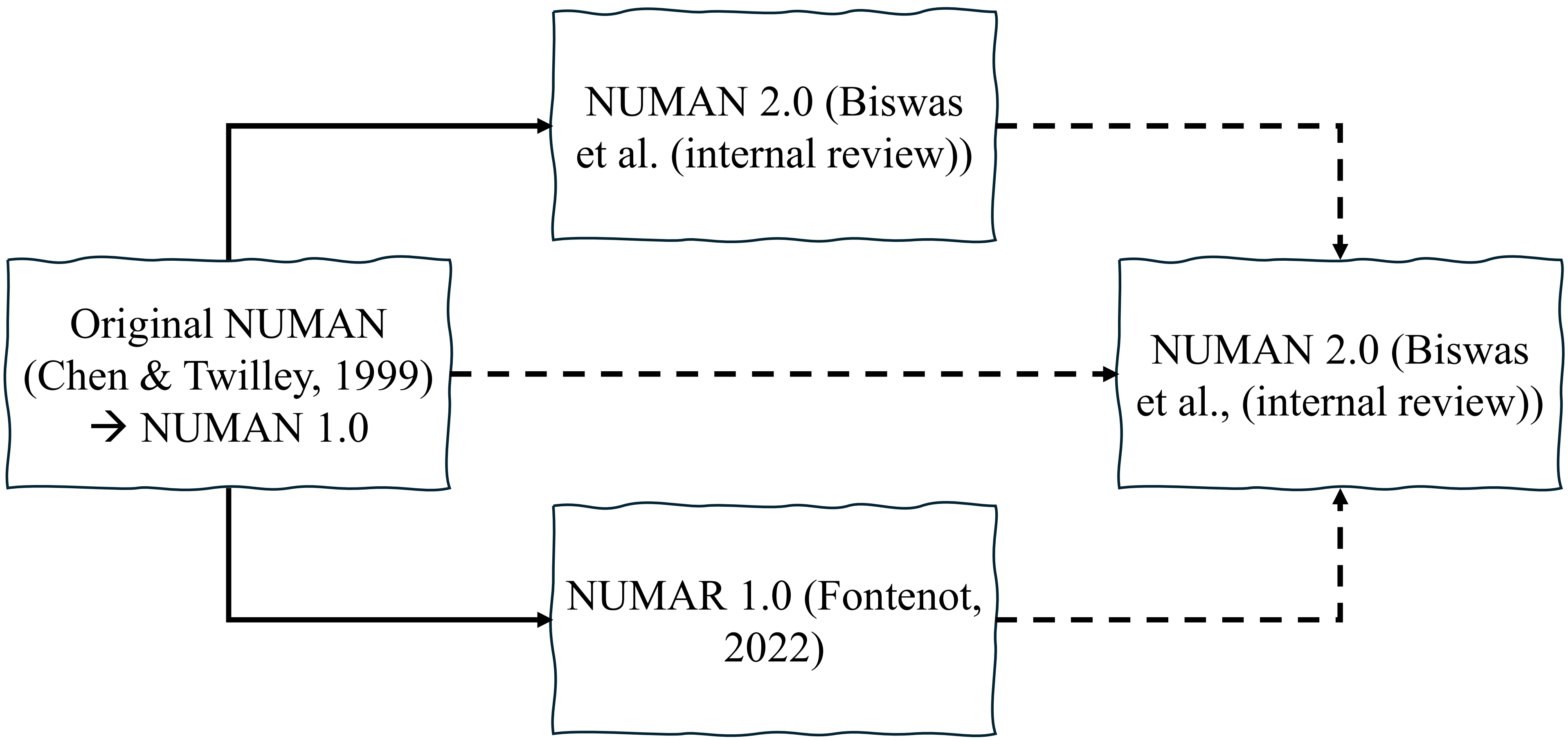
Delta-X Workshop -9th May 2024

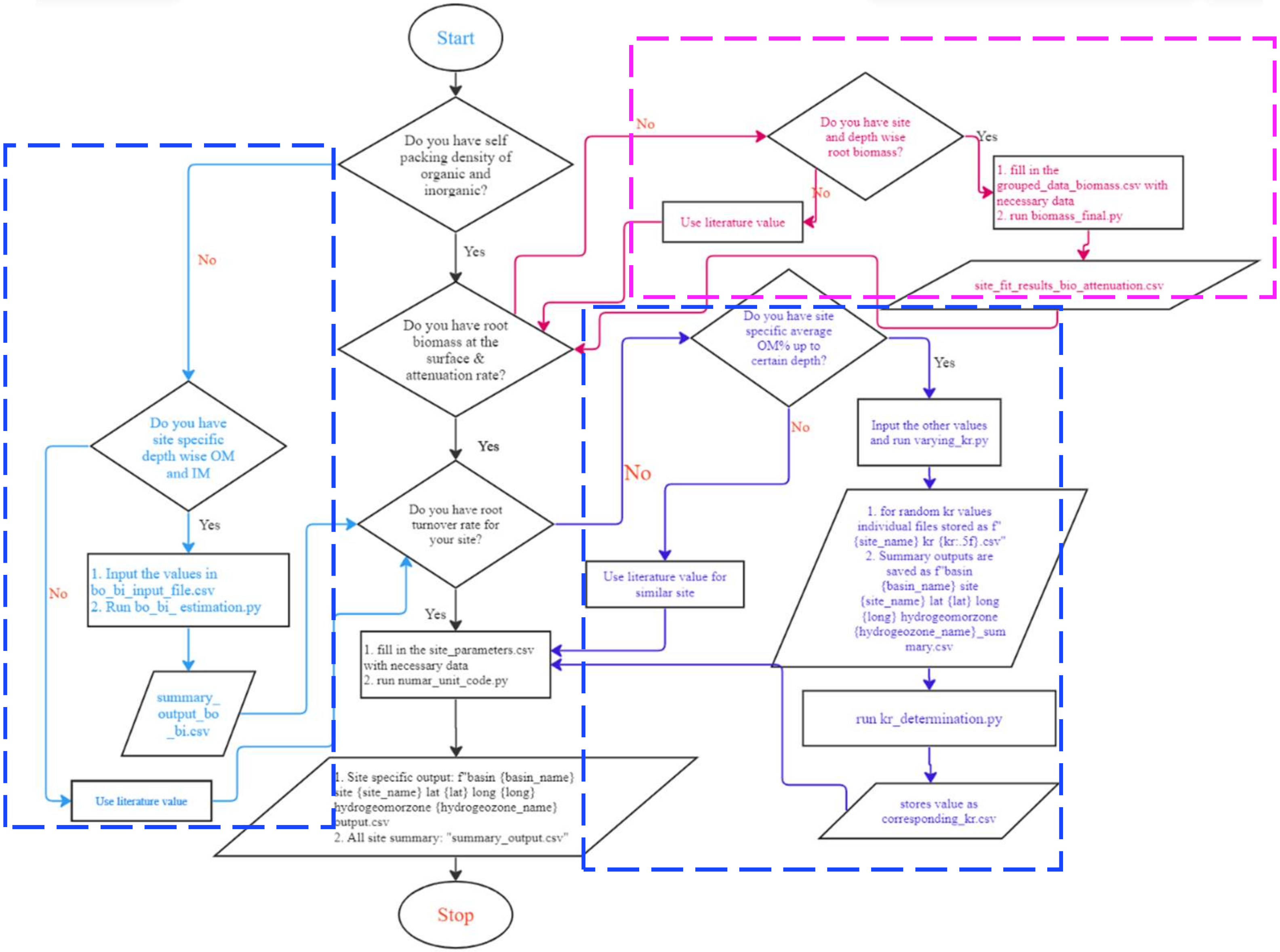
Numerical Understanding of Marsh Accretion & Resilience – NUMAR

Robert R. Twilley[1], Principal Investigator
Andre Rovai [1,2]
Andy Cassaway [4]
Alex Christensen [3]
Ivan A. Vargas-Lopez[1] , Postdoctoral Researcher
Pradipta Biswas[1], Graduate Assistant

[1] Louisiana State University
[2] U.S. Army Engineer Research and Development Center
[3] Jet Propulsion Laboratory, California Institute of Technology
[4] GIS Engineering, LLC

Recap of Evolution




Start
Do you have self packing density of organic and inorganic?
Yes
No
Do you have site and depth wise root biomass?
Yes
1. fill in the grouped_data_biomass.csv with necessary data
2. run biomass_final.py
No
Use literature value
site_fit_results_bio_attenuation.csv
Do you have root biomass at the surface & attenuation rate?
Yes
Do you have site specific average OM% up to certain depth?
Yes
Input the other values and run varying_kr.py
1. for random kr values individual files stored as f"{site_name} kr {kr:.5f}.csv"
2. Summary outputs are saved as f"basin {basin_name} site {site_name} lat {lat} long {long} hydrogeomorzone {hydrogeozone_name}_summary.csv
run kr_determination.py
stores value as corresponding_kr.csv
No
Use literature value for similar site
No
Do you have site specific depth wise OM and IM
Yes
1. Input the values in bo_bi_input_file.csv
2. Run bo_bi_ estimation.py
summary_output_bo_bi.csv
No
Use literature value
Do you have root turnover rate for your site?
Yes
1. fill in the site_parameters.csv with necessary data
2. run numar_unit_code.py
1. Site specific output: f"basin {basin_name} site {site_name} lat {lat} long {long} hydrogeomorzone {hydrogeozone_name} output.csv
2. All site summary: "summary_output.csv"
Stop

Variables Used in the Model

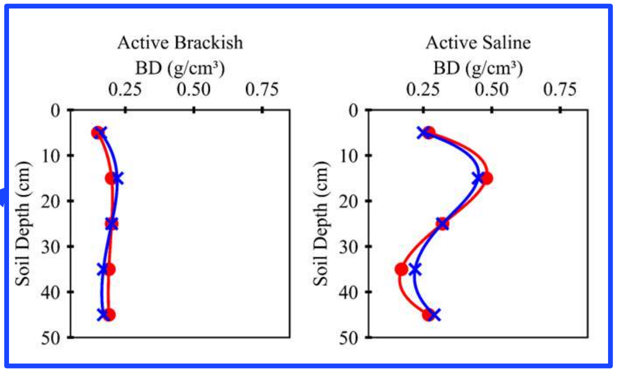
Symbol	Definition	Unit
oms	Organic matter loading rate on the feldspar	$\mathrm{g\ cm^{-2}\ yr^{-1}}$
si	Inorganic matter loading rate on the feldspar	$\mathrm{g\ cm^{-2}\ yr^{-1}}$
$\mathrm{b_o}$	Self-packing density of organic matter	$\mathrm{g\ cm^{-3}}$
$\mathrm{b_i}$	Self-packing density of inorganic matter	$\mathrm{g\ cm^{-3}}$
$\mathrm{c_0}$	Lignin content in the dry mass deposit over feldspar	$\mathrm{g\ g^{-1}}$
$\mathrm{c_1}$	Ash content in the biomass	$\mathrm{g\ g^{-1}}$
$\mathrm{c_2}$	Cellulose content in the surface deposit	$\mathrm{g\ g^{-1}}$
$\mathrm{c_4}$	Cellulose content in the biomass	$\mathrm{g\ g^{-1}}$
e	Root distribution parameter	$\mathrm{cm^{-1}}$
$\mathrm{fc_1}$	Lignin content in the fine roots	$\mathrm{g\ g^{-1}}$
$\mathrm{k_b}$	Belowground decomposition rate of labile organic matter	$\mathrm{yr^{-1}}$
$\mathrm{k_c}$	Cellulose decomposition rate	$\mathrm{yr^{-1}}$
k_l	Lignin decomposition rate	$\mathrm{yr^{-1}}$
k_r	Fine root turnover rate	$\mathrm{yr^{-1}}$
R_0	Live root biomass at the surface	$\mathrm{g\ cm^{-2}}$

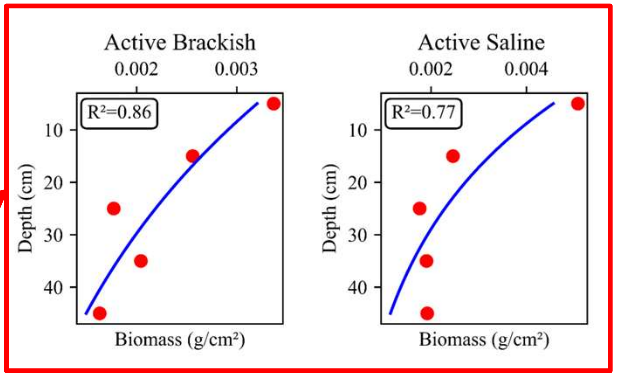
Source of Variables

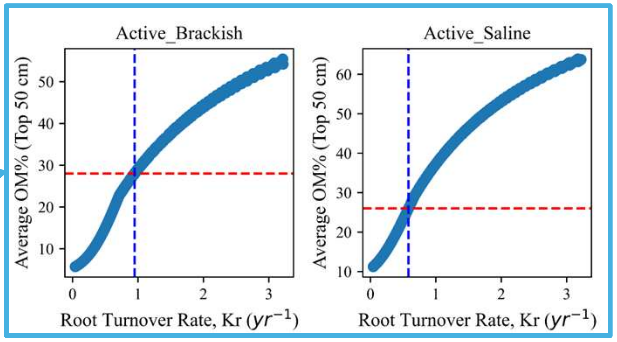
Symbol	Definition	Unit	
oms	Organic matter loading rate on the feldspar	$g\ cm^{-2}\ yr^{-1}$	Cassaway et al. (2024); Twilley et al. (2023)
si	Inorganic matter loading rate on the feldspar	$g\ cm^{-2}\ yr^{-1}$	
c_0	Lignin content in the dry mass deposit over feldspar	$g\ g^{-1}$	Fontenot (2022)
c_1	Ash content in the biomass	$g\ g^{-1}$	
e	Root distribution parameter	cm^{-1}	
fc_1	Lignin content in the fine roots	$g\ g^{-1}$	
k_b	Belowground decomposition rate of labile organic matter	yr^{-1}	
k_c	Cellulose decomposition rate	yr^{-1}	Means et al. (1985)
$\mathbf{k_l}$	Lignin decomposition rate	yr^{-1}	
$\mathbf{c_4}$	Cellulose content in the biomass	$g\ g^{-1}$	Wilson (1985)

Calibrated Variables

Symbol	Definition	Unit
b_o	Self-packing density of organic matter	$g\ cm^{-3}$
b_i	Self-packing density of inorganic matter	$g\ cm^{-3}$
e	Root distribution parameter	cm^{-1}
R_0	Live root biomass at the surface	$g\ cm^{-2}$
k_r	Fine root turnover rate	yr^{-1}







Calibration done using Data from Castañeda-Moya & Solohin (2023)

Calibration of Root Biomass at the surface and Root Attenuation Rate

$$Root\ biomass, R = R_0 \exp(-eD)$$

$$Objective\ function, \min(R_o, e) \sum_{n=1}^{n} \left\| R_{ob,i} - R_{pre,i} \right\|^2$$

R_0 = Root biomass at the surface ($g\ cm^{-2}$)
e = attenuation rate (cm^{-1})
D = Corresponding soil Depth (cm)
Observation data from Casteneda-Moya & Solohin (2023)
n is the respective data points in the array
$R_{ob,i}$= observation data from field-based measurements
$R_{pre,i}$= prediction from iteration

Calibration of Self-packing Density of Organic and Inorganic Matter

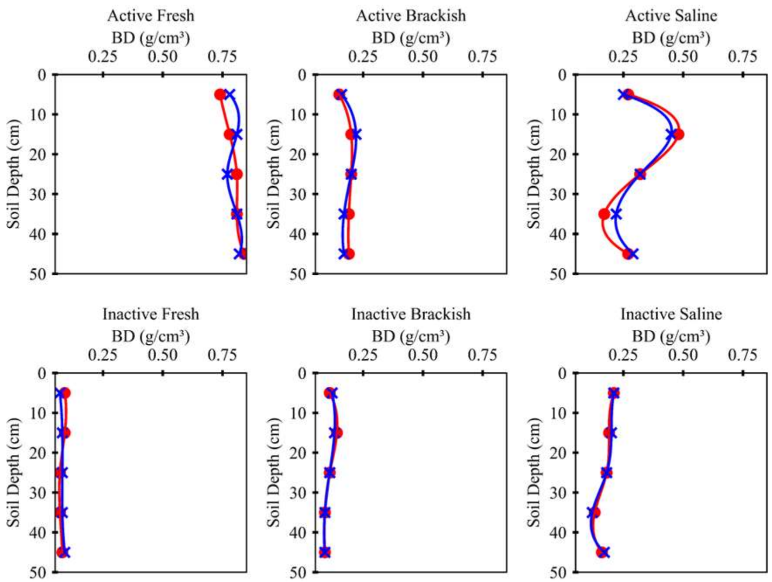
$$BD = \frac{1}{\frac{OM}{b_o} + \frac{IM}{b_i}}$$

$$Objective\ function, \frac{1}{n}\sum_{n=1}^{n} \left\| BD_{ob,i} - BD_{pre,i} \right\|^2$$

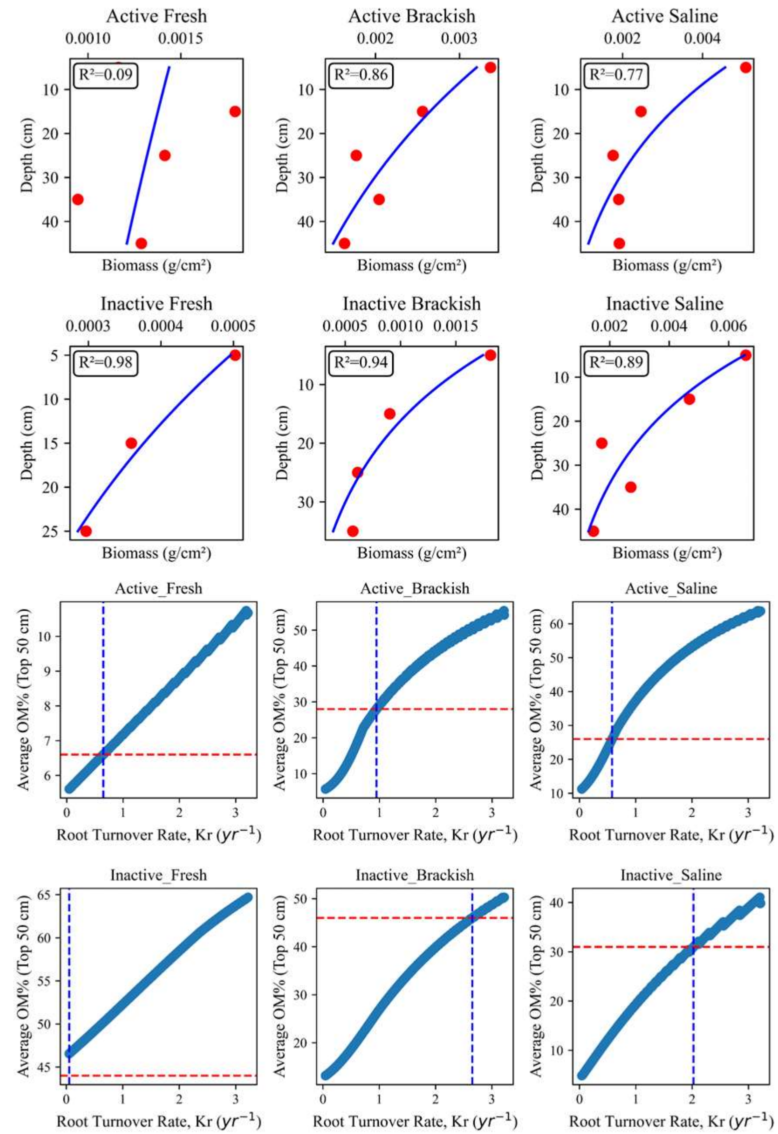
OM, IM= Organic and inorganic matter fraction from field observation ($g\ g^{-1}$)
b_0, b_i = Self packing density of organic and inorganic matter (g cm^{-3})
Observation data from Casteneda-Moya & Solohin (2023)
n is the respective data points in the array
$BD_{ob,i}$= observation data (BD) from field-based measurements
$BD_{pre,i}$= prediction (BD) from iteration

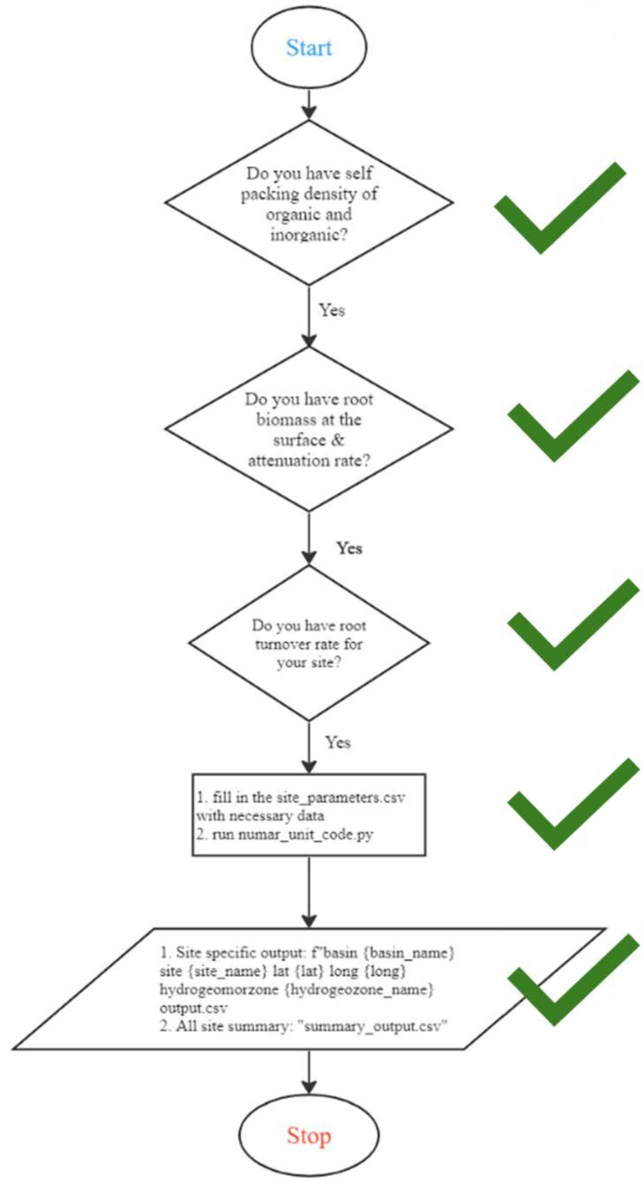
Calibration of Root Turnover Rate

- Root and its turnover are main driver for addition of organic matter in the belowground soil.
- Root turnover can be set in a range
- Once randomized, calculated the top 50cm soils average root turnover rate
- Find the most matching root turnover which produce the nearest OM% aligned with field observation



Calibrated Parameters



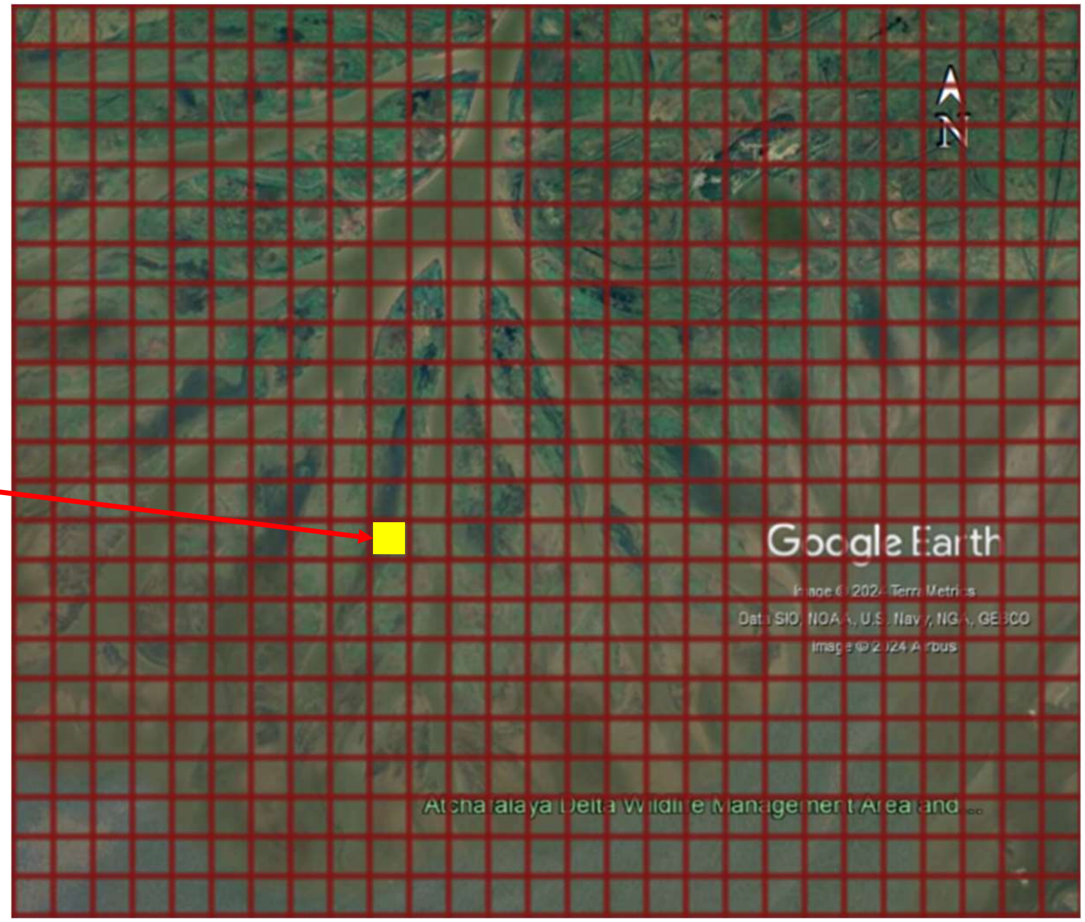

Start
Do you have self packing density of organic and inorganic?
Yes
Do you have root biomass at the surface & attenuation rate?
Yes
Do you have root turnover rate for your site?
Yes
1. fill in the site_parameters.csv with necessary data
2. run numar_unit_code.py
1. Site specific output: f"basin {basin_name} site {site_name} lat {lat} long {long} hydrogeomorzone {hydrogeozone_name} output.csv
2. All site summary: "summary_output.csv"
Stop

Landscape NUMAR

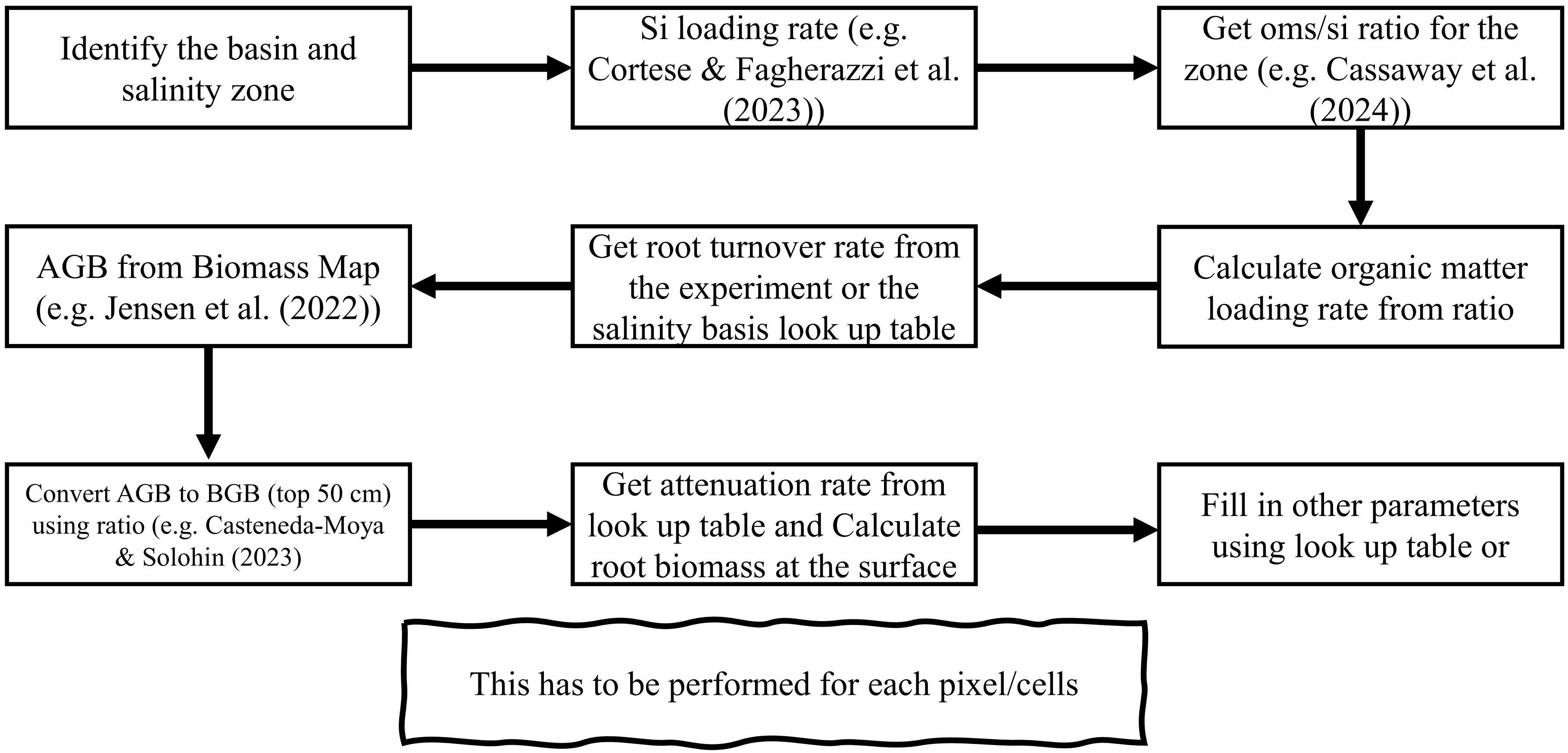
- It’s a direct adaptation of unit NUMAR to landscape.
- Every pixel or eco-geomorphic cells have to be populated with the cell specific parameters.
- Right now, we don’t have enough data to populate all of the cells. But we populated using the site information available for a few of the study sites of Delta-X in different salinity zone.

Landscape NUMAR

Pixel/ cell



Landscape NUMAR General Workflow Overview



Discussion

- The Newest version provides wide range of output variables including soil accretion, bulk density, organic matter content, volume contribution of different source, carbon density, carbon sequestration, necromass etc.
- Parameter uncertainty demands more intensive field study for the population of the cells.
- It’s better not to depend on only one site in each salinity zone for a generalization and population landscape input parameters.
- Mechanistic or process-based model demands precise input parameters to get realistic outputs through simulation.
- Organic and inorganic matter loading rate, self-packing densities, root turnover, root biomass at the surface are among most affecting parameters.
- The model generality have been increased over the years. And it can go beyond marsh environment and can be effective in any other environments.

THANK YOU...
Any questions?