VEGETATION MODELING APPLICATIONS AND A PROPOSED LOUISIANA VEGETATION DYNAMICS MODEL

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MISS DELTA
Mississippi River Delta Transition Initiative

INTRODUCTION

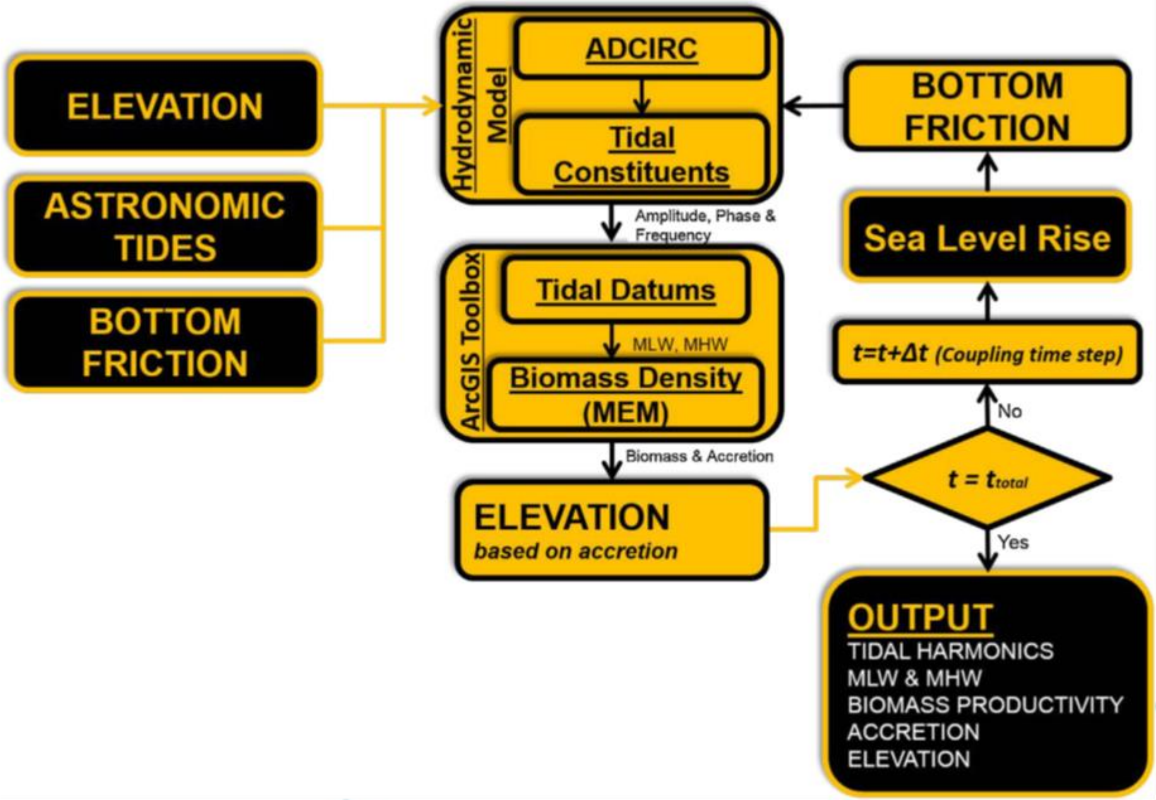
- Coastal Louisiana is a dynamic and vulnerable landscape shaped by **hydrology**, **sediment transport**, and **vegetation dynamics**.
- Vegetation plays a critical role in:
  - **Stabilizing landforms**
  - **Reducing erosion**
  - **Enhancing sediment deposition**
- Accurate vegetation modeling is essential for:
  - **Restoration planning**
  - **Long-term sustainability of the coast**

OBJECTIVES

- **Compare** existing ecogeomorphic models used in coastal and deltaic systems.
- **Highlight differences** in:
  - Vegetation growth and mortality representation
  - Coupling with hydrodynamic and morphodynamic models
  - Computational efficiency and ecological realism
- **Identify gaps** in current models that motivate the development of the **Louisiana Dynamic Vegetation Model (LDVM)**.

MARSH EQUILIBRIUM MODEL (MEM)

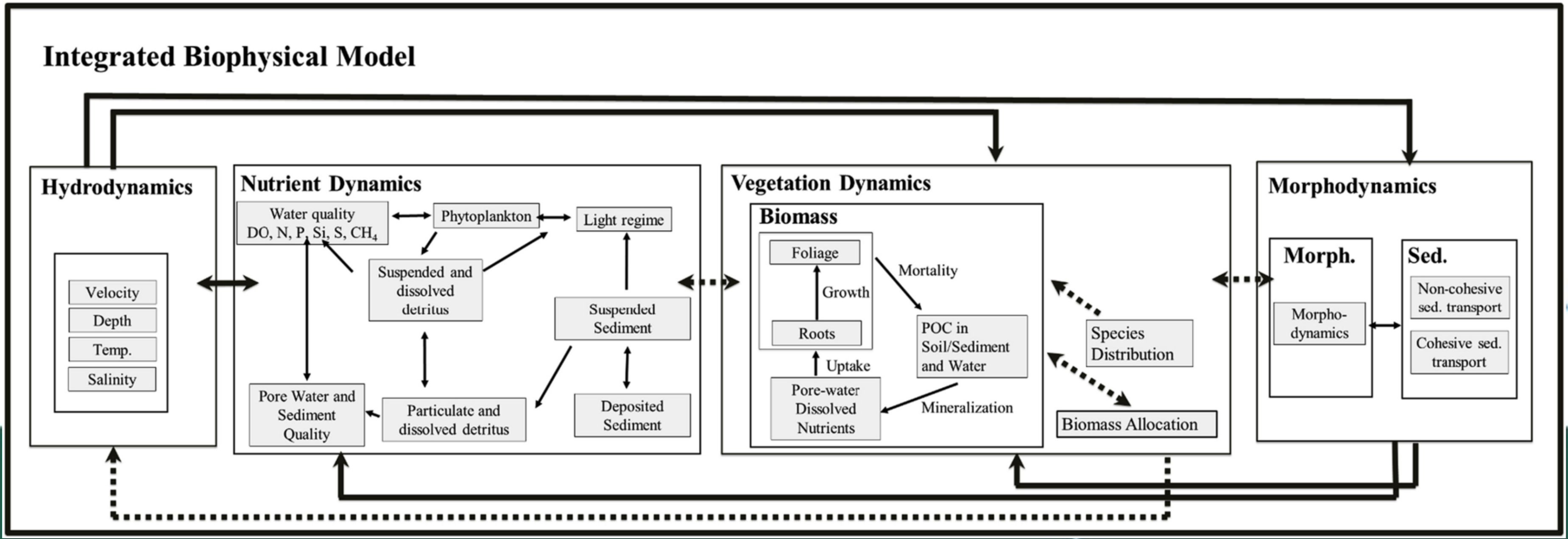
- Simulates marsh accretion based on hydroperiod-driven biomass and sediment load
- Coupled with ADCIRC to assess SLR impacts (Alizad et al., 2016)
- **Marsh Types:** saline
- **Key Outputs:** Biomass density, accretion
- **Limitations:** No flow resistance; coarse 5-year time step



(Morris et al. 2002; Alizad et al., 2016)

INTEGRATED BIOPHYSICAL MODEL (IBM)

- Simulates interactions among hydrodynamics, morphodynamics, nutrients, and vegetation
- **Marsh Types:** Fresh, intermediate, brackish, saline
- **Key Outputs:** Biomass (live/dead), POM, spatial distribution of 7 taxa
- **Limitations:** High complexity and computational cost



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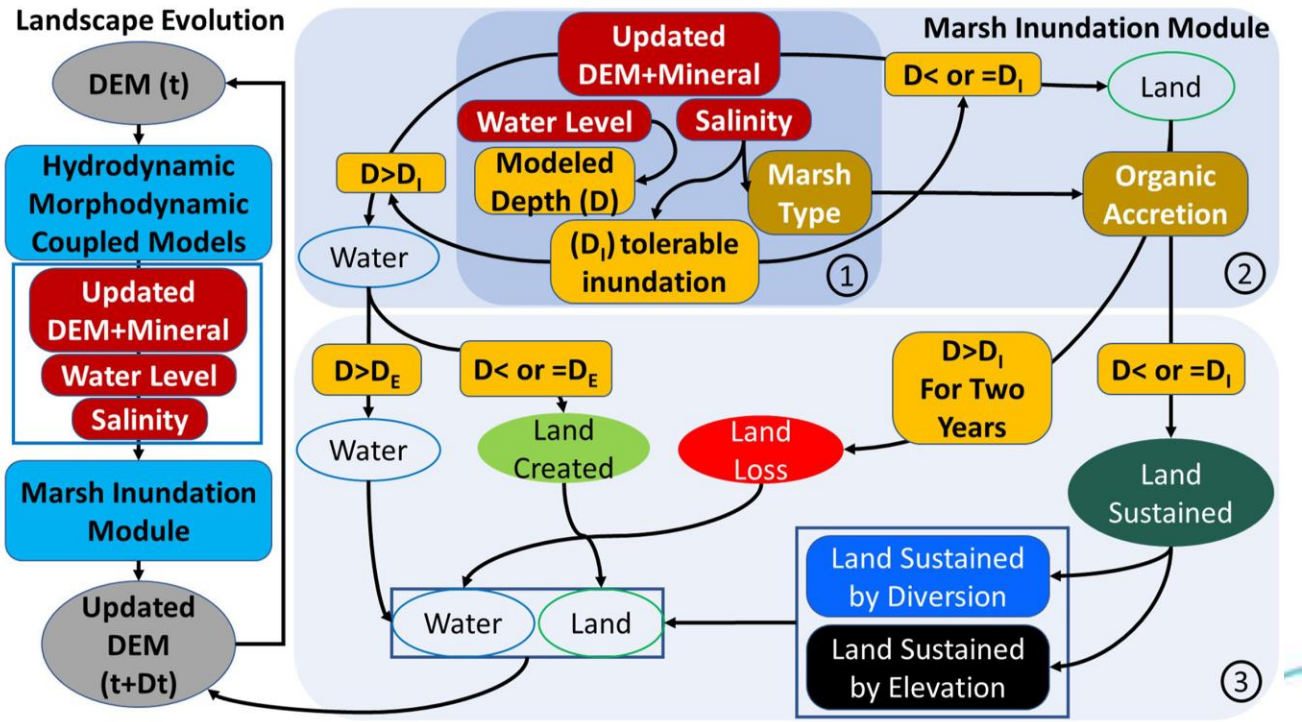
(Baustian et al., 2018)

SIMPLIFIED BIOPHYSICAL MODEL (SBM)

- Developed to reduce IBM complexity
- Coupled with Delft3D; uses salinity and inundation frequency
- **Marsh Types:** Intermediate, brackish, saline
- **Key Outputs:** Biomass accretion
- **Limitations:** No flow resistance; simplified vegetation dynamics



(Khalifa et al., 2024)

TRACHYTOPES – DELFT3D

- Calculates bed roughness using formulas (e.g., Baptist)
- Uses detailed plant geometry (stem height, diameter, and density)
- Considers vegetation seasonality (in FM version)
- **Key Outputs:** Roughness, flow resistance
- **Limitations:** Fixed vegetation zones; no biomass accumulation

(Deltares, 2025)

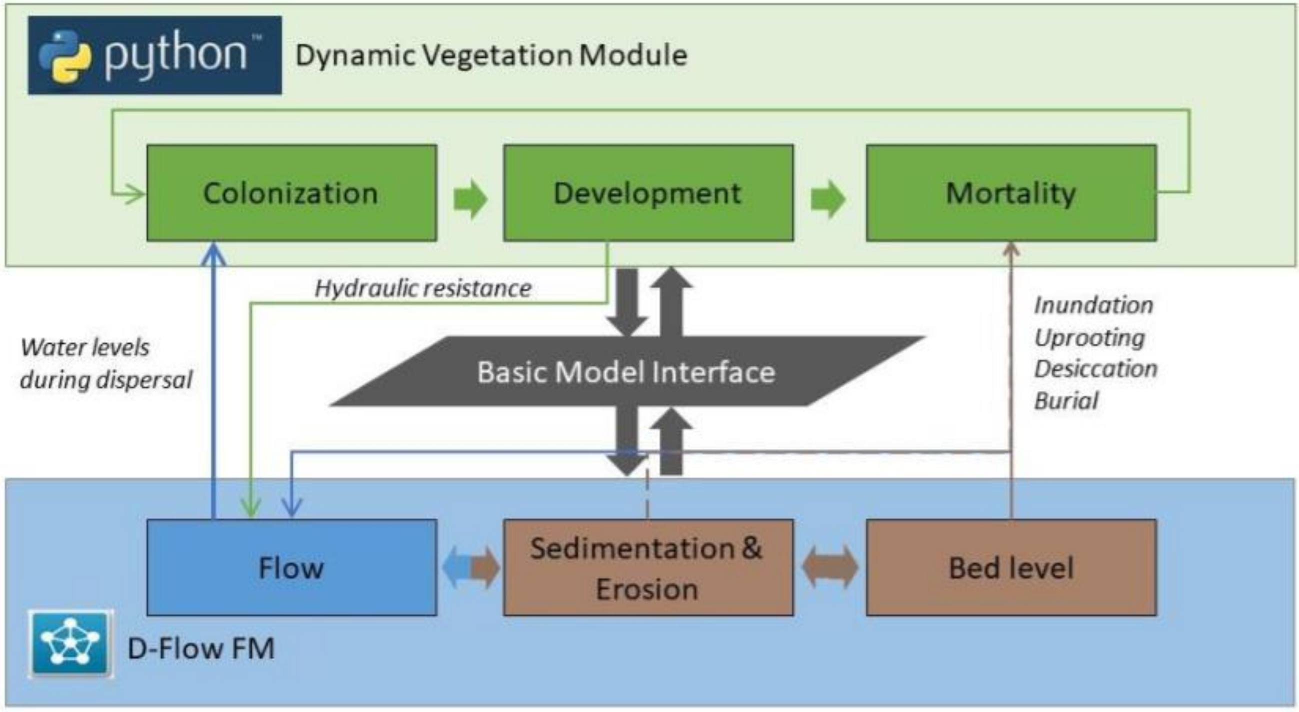
(RIGID) 3D VEGETATION MODEL – DELFT3D

- Simulates vertical vegetation structure and 3D flow effects
- Uses detailed plant geometry (stem height, diameter, and density)
- **Key Outputs:** Roughness, flow resistance (3D)
- **Limitations:** Fixed zones; no biomass accumulation; high computational cost

(Deltares, 2025)

DYNAMIC VEGETATION MODULE - DELFT3D-FM

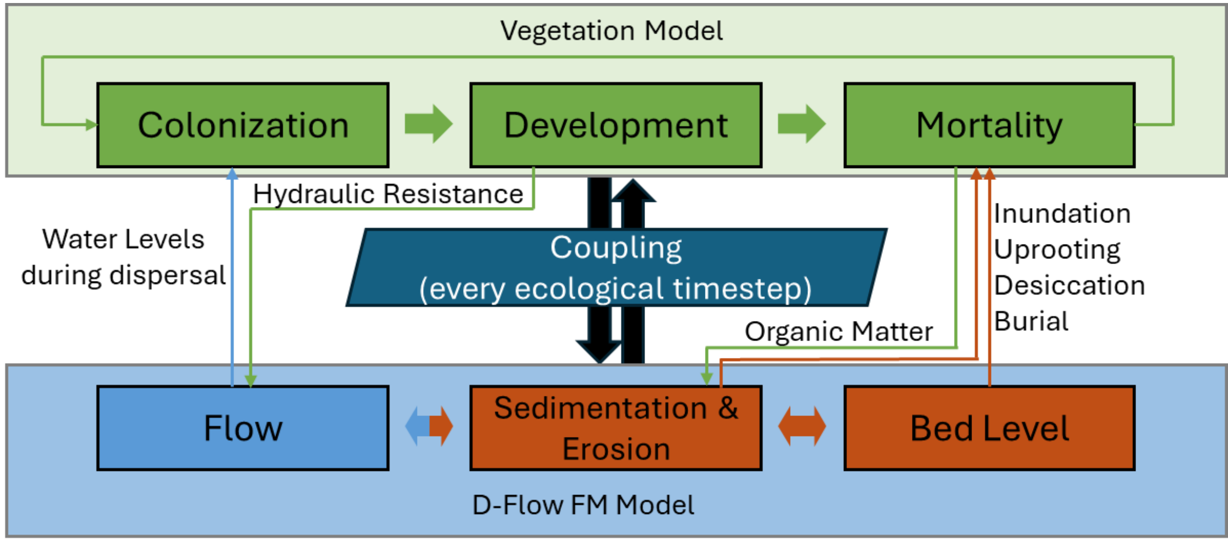
- Python-based ecological model coupled with D-Flow
- Simulates colonization, growth, and mortality (age-dependent)
- **Key Outputs:** Roughness, flow resistance
- **Limitations:** No biomass accumulation; single-core only; data intensive



(Deltares, 2025)

LOUISIANA DYNAMIC VEGETATION MODEL (LDVM)

- Builds on the DVM with an improved performance for long-term simulations
- Simulates colonization, growth, mortality, and **organic accumulation**
- **Advantages:** Parallel computing
- **Limitations:** data intensive



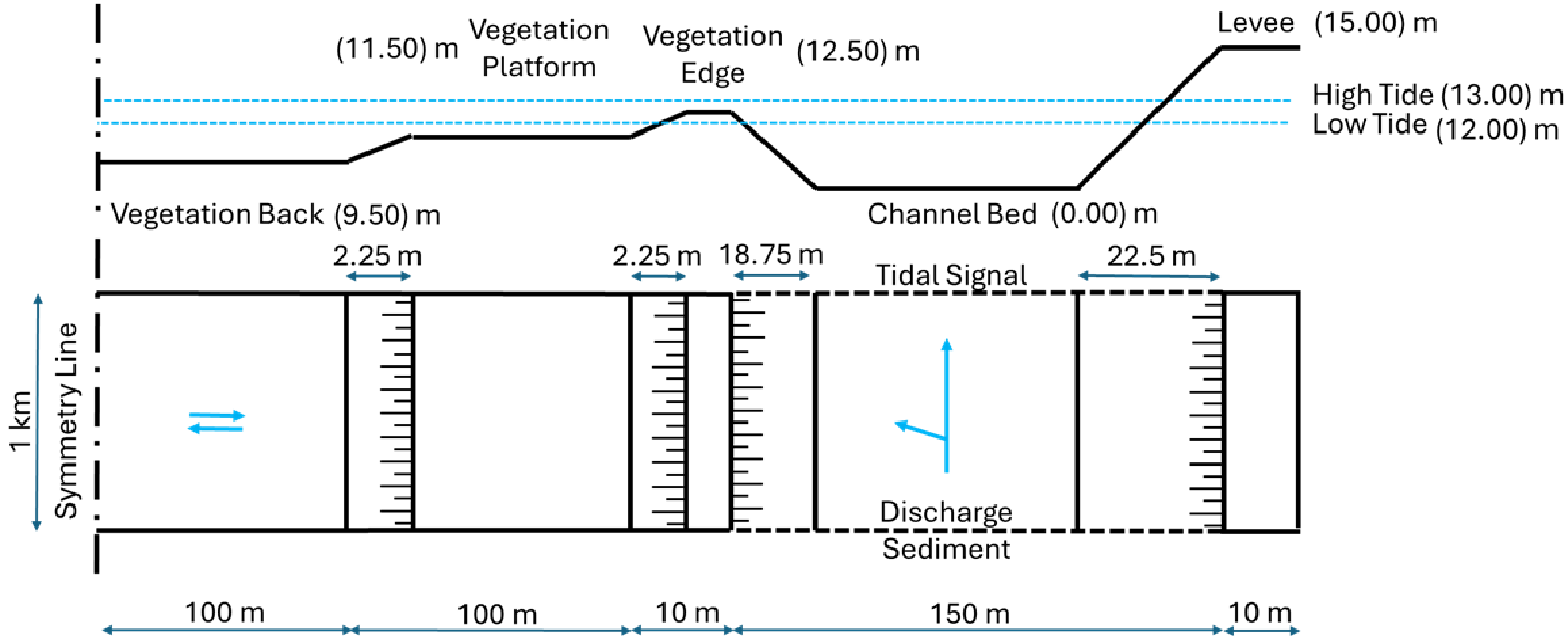
Conceptual diagram of the LDVM showing vegetation dynamics and organic matter accumulation for efficient long-term eco-geomorphic simulations. (Adapted from Deltares, 2025)

VEGETATION MODELS COMPARISON

Model	Roughness and Flow Resistance by Vegetation	Ecological Time Step	Computationally Expensive	Salinity Impacts Vegetation Development	Vegetation Model Complexity	Accounts for Seasonality	Biomass Accumulation
Trachytopes	Y	NA	N	N	Low	Y	N
MEM	N	5 years	N	N	Low	N	Y
IBM	Y	1 year	Y	Y	High	N	Y
SBM	N	1 year	N	Y	Low	N	Y
DVM/NBS	Y	2-4 weeks	Y	N	Moderate	Y	N
LDVM	Y	2-4 weeks	N	Y	Moderate	Y	Y

CONCEPTUAL DESIGN FOR LDVM

- Includes river channel, vegetation zones, levee, and tidal boundary
- Uses field data from MRD and ARB for calibration
- Designed for flexibility and process isolation



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CONCLUSION & CLOSING REMARKS

- Existing vegetation models vary in complexity, ecological realism, and computational demands.
- Most models lack full integration of vegetation dynamics, spatial variability, and organic accumulation.
- The **LDVM** addresses these gaps by combining hydrodynamics, morphodynamics, and vegetation processes in a flexible, scalable framework.
- This model is designed to support **long-term, process-based simulations** critical for **coastal restoration planning** in Louisiana.

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THANK YOU!