Supplementary Material for: Modelling dynamic coastal vegetation establishment and ecosystem engineering in hydro-morphodynamic models with DYCOVE

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1 Model description for the tidal flat model in DFM and delta model in ANUGA

The tidal flat model domain in Delft3D Flexible Mesh was based on the model in Bij de Vaate et al., (2020) with an initially flat, erodible slope that is 2,000-m long in the sloped direction and 700 m in width (Fig. S1). The bottom elevation was set to -1.6 m, and the top elevation was set to 1.6 m. The initial bed consisted of 5 m of erodible sand with a D_{50} grain size of 0.1 mm. All sediment transport properties and model settings were adopted from Bij de Vaate et al. (2020). Bed level updates were computed based on mass conservation with the Exner equation (see Deltares (2025) for more detail).

Vegetation dynamics in DYCOVE were only simulated on the upper half of the flat with the finer grid resolution. The settings for the vegetation parameters are summarized in Table S1. All values were taken from Bij de Vaate et al. (2020).

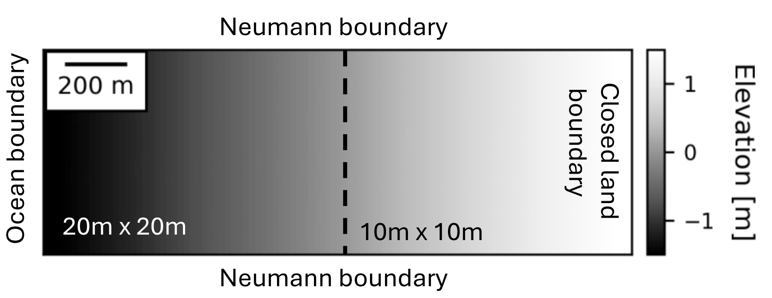

Figure S1: Initial bathymetry and boundaries used in the tidal flat DYCOVE-DFM model. The sloped bathymetry was interpolated on a 20m x 20m computational grid close to the ocean boundary and on a 10m x 10m grid on the upper half of the domain where vegetation computations were applied.

The Wax Lake Delta (WLD) model in ANUGA used the topo-bathymetry of 2016 as presented in Wright et al. (2022) (Fig. S2) and discharge and tidal boundaries were forced using simplified average hydrographs based on average values from gauge stations at the WLD Outlet and average tidal ranges (U.S. Geological Survey, 2025) (Fig. S2a). We used an ECOFAC of 30 on the hydrodynamic time, meaning that one day of hydrodynamics was set to be representative of 30 days (or one month) of ecological forcing. One year of ecological change was based on 12 days of hydrodynamic time, covering 12 tidal cycles and the annual hydrograph including spring flood and low water in autumn and winter. This type of scaling is common in models that accelerate ecological or morphological processes based on recurring water level signals. Vegetation parameters for the WLD model (Table S1) were derived from a variety of literature-based sources for the two vegetation types based on Nelumbo lutea and Colocasia esculenta (Carle et al., 2015; Castañeda-Moya & Solohin, 2023; Jean-Louis and Hiatt, 2025).

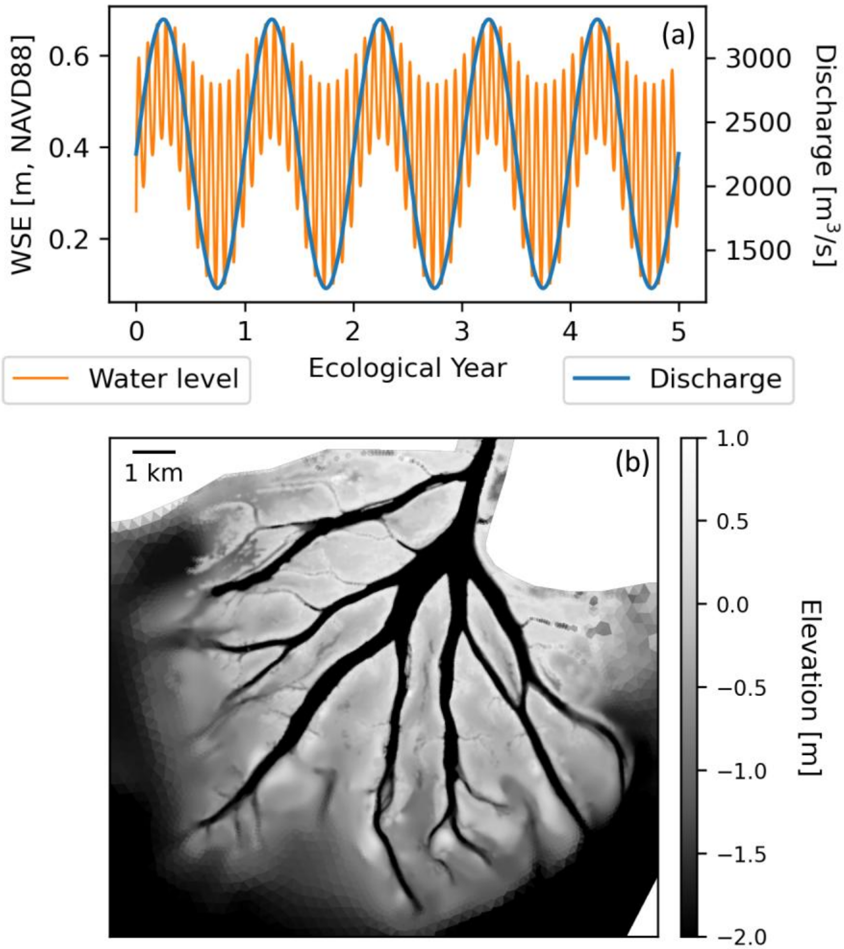

Figure S2: (a) Synthetic hydrograph for the WLD model based on averaged USGS gauge data, representing five years of ecological time with an ECOFAC of 30 (ETS = 1 month). Each diurnal tidal signal represents one ecological month. The water level shown is the modelled water level at the starred location in Fig. 5. (b) Initial bathymetry from 2016 used in the Wax Lake Delta model based on Wright et al. (2022).

We assessed sensitivity of the vegetation predictions to different ecological scaling factors in the WLD model both for the number of ETS (couplings) and the length of each ETS (12 and 24 hours) (Fig. S3). We ran a baseline simulation with the same parameter combinations as the reported model results in the main manuscript, but we modified ETS-related parameters (see relevant parameters in Table S1) such that we can scale them when doubling or bisecting the number of ETS. We tested three additional simulations with ecological time scaling factors of 15, and 30 (Table S2). An ECOFAC of 15 (half of original) with constant simulation time results in twice the number of couplings per year, and so we doubled all ETS-related parameters and halved the initial colonization fraction (due to doubling of colonization events) (Fig. S3b). We did the opposite for an ECOFAC of 60 (Fig. S3c). Lastly, we ran a simulation with an ECOFAC of 15 but held the number of couplings at 12 with an ETS length to 48 hours. These changes in ecological time scaling had little effect on the resulting vegetation distribution for the WLD model.

The simulation with the largest scaling (ECOFAC=60) produces reduced vegetation cover for Nelumbo in the lower parts of the islands (Fig. S3c), but the overall pattern of the two species remains the same. Lower vegetation cover in this scenario is likely due the reduction in colonization events, which may limit vegetation to adjust to the changing water levels as well as in simulations with a larger number of colonization timesteps. While the increase in colonization fraction may not be able to fully compensate for that difference, the reduction in vegetation is minimal.

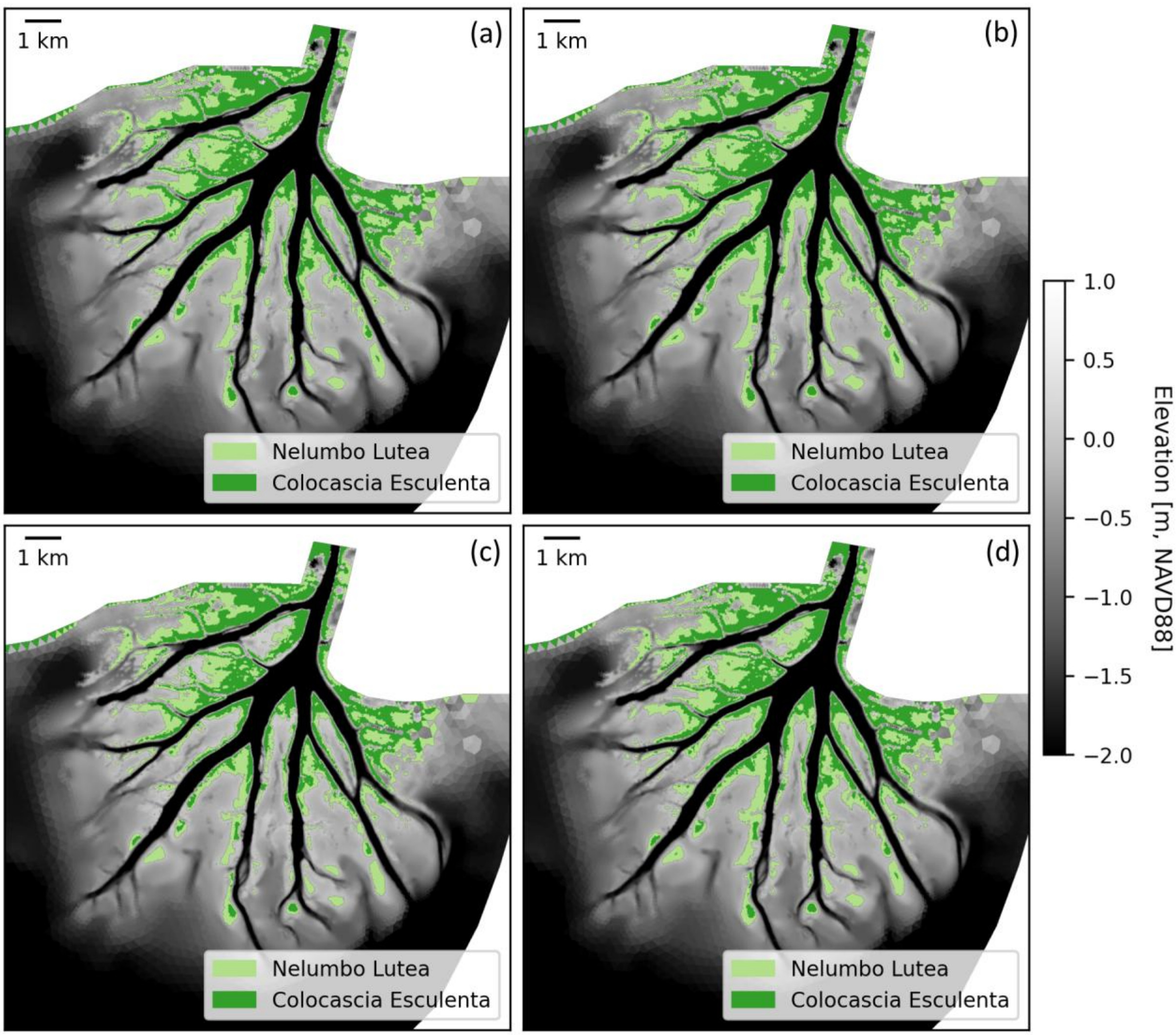

Figure S3: Distribution of modelled vegetation types during ETS 8 (August) for the following combinations of ECOFAC, couplings per year, and coupling duration (in hydrodynamic hours) as listed in Table S2: (a) 30, 12, 24; (b) 15, 24, 24; (c) 60, 6, 24; (d) 15, 12, 48.

Table S1: DYCOVE vegetation definitions for the two simulation test sets. LS: life-stage.

Set 1: Tidal flat model							**Set 2: WLD model**	
Variable [unit]	**Variable name in DYCOVE**	**Salicornia procumbens**	**Spartina anglica**		**Puccinellia maritima**		**Nelumbo lutea**	**Colocasia esculenta**
			LS 1	**LS 2**	**LS 1**	**LS 2**	**LS 1**	**LS 1**
Colonization and growth properties								
Initial stem height [m]	*stemht_0*	0.05	0.15		0.05		0.3	0.3
Maximum summer stem height [m]	*stemht_max*	0.4	0.8	1.3	0.2	0.35	1.8	2.0
Winter stem height [m]	*stemht_winter_max*	0.05	0.4	0.4	0.2	0.2	0.11	0.2
Initial stem diameter [m]	*stemdiam_0*	0.01	0.003		0.004		0.015	0.015
Maximum stem diameter [m]	*stemdiam_max*	0.015	0.003	0.005	0.004	0.005	0.02	0.015
Initial root length [m]	*rootlength_0*	0.05	0.05		0.02		0.5	0.5
Maximum root length [m]	*rootlength_max*	0.15	0.2	1.0	0.15	0.15	1.0	0.5
Stem density [1/m²]	*stemdens*	190	700	700	6500	6500	200	200
Stem drag coefficient [-]	*drag*	0.9	1.1		0.7		1.1	1.0
Colonization fraction [-]	*fraction_0*	0.2	0.6		0.3		0.3	0.3
Colonization method	*col_method*	1	1		1		1	3
Colonization probability	Set directly	40 %	14 %		14 %		100 %	100 %
Maximum age until senescence	*age_max* (for total plant age) *years_max* (for life-stages)	1	1	9	1	9	5	5

Mortality properties								
Min. flooding mortality thresh. [-]	*flood_no_mort*	0.5	0.4	0.4	0.35	0.35	N/A	0.5
Max. flooding mortality thresh. [-]	*flood_all_mort*	8.83	4.4	4.4	2.85	2.85	N/A	1.25
Min. velocity mortality thresh. [m/s]	*uproot_no_mort*	0.15	0.15	0.25	0.25	0.5	1.0	0.8
Max. velocity mortality thresh. [m/s]	*uproot_all_mort*	0.483	0.483	0.583	0.583	0.833	1.1	0.9
Min. desiccation mortality thresh. [-]	*desic_no_mort*	N/A	N/A	N/A	N/A	N/A	0.5	N/A
Max. desiccation mortality thresh. [-]	*desic_all_mort*	N/A	N/A	N/A	N/A	N/A	1.25	N/A
Seasonal representation								
Colonization timesteps	*start_col_ets; end_col_ets*	2; 4	2; 4		2; 4		3; 6	3; 6
Growth timesteps	*start_growth_ets; end_growth_ets*	2; 9	2; 9		2; 9		3; 10	3: 10
Start winter period	*winter_ets*	10	10		10		11	11

Table S2: Ecological time scale parameters for WLD sensitivity tests. Simulation ID letter corresponds to panels in Fig. S3.

Simulation	ECOFAC	No. ETS per year	ETS duration (hydrodyn. hours)
A	30	12	24
B	15	24	24
C	60	6	24
D	15	12	48

2 Equations used to assess model performance

$$Precision = \frac{TP}{TP + FP} \tag{S1}$$

$$Recall = \frac{TP}{TP + FN} \tag{S2}$$

$$F1\ score = 2 * \frac{Precision * Recall}{Precision + Recall} \quad \text{(S3)}$$

References

Carle, M. V., Sasser, C. E., & Roberts, H. H. (2015). Accretion and vegetation community change in the Wax Lake Delta following the historic 2011 Mississippi River flood. *Journal of Coastal Research*, *31*(3), 569-587.

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