

# Users Guide

## GEOMBEST++ Seagrass

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### **1: Introduction**

Large-scale coastal evolution results from physical processes interacting with a volume of erodible sediment. Waves, currents and tides, rework the sediment to create shoreface morphology that attempts to attain an equilibrium profile with respect to these processes (Swift and Thorne, 1991; Wright, 1995; Cowell et al. 1999). The geological framework, however, may prevent development of an equilibrium profile through the presence of lithified stratigraphic units that outcrop on the shoreface (Riggs et al., 1995, Pilkey et al., 1993). The geological framework also defines the accommodation space, which in conjunction with sea level and sediment supply, controls shoreline transgression or regression (Curry, 1964; Roy et al., 1994).

This guide describes the seagrass version of “GEOMBEST++” (Geomorphic Model of Barrier, Estuarine, and Shoreface Translations + marsh + waves), a morphological-behaviour model that simulates the evolution of coastal morphology and stratigraphy, resulting from changes in sea level, and sediment volume within the shoreface, barrier and estuary. GEOMBEST++ differs from other large-scale behaviour models (e.g. Bruun, 1962; Dean and Maumeyer, 1983; Cowell et al., 1995; Niedoroda et al., 1995, Stive & de Vriend, 1995 and Storms et al., 2002) by relaxing the assumption that the initial substrate (i.e stratigraphy) is comprised of an unlimited supply of unconsolidated material (typically sand). The substrate is instead defined by distinct stratigraphic units characterized by their erodibility and sediment composition. Accordingly, the effects of geological framework on morphological evolution and shoreline translation can be simulated. This version of GEOMBEST++ differs from the previous version (Lauzon et al., 2018) by adding seagrass dynamics to the back-barrier bay realm of the model domain.

Model development aimed to create a numerical model flexible enough to quantify relevant coastal behavior with a minimum number of parameters. The first part of this guide describes these parameters and thereby synthesizes what are considered to be fundamental controls on large-scale coastal evolution. The second part of the guide describes how to install GEOMBEST+ and use it to a) quantitatively reconstruct coastal morphology and stratigraphy, and b) predict shoreline translation resulting from changes in sea level, sediment delivery, and other parameters. **For insights regarding how to obtain values for input parameters we refer the reader to Stolper et al. (2005), Moore et al., (2010), Moore et al., (2011), Walters et al. (2014), and Lauzon et al. (2018).**

### **2: Spatial domain and definitions**

GEOMBEST++ simulates coastal evolution within a 3-dimensional grid where x, y and z represent cross-shore, long-shore and vertical dimensions respectively. The cross-shore dimension incorporates part or all, of the continental shelf and the beach.

Dunes, a washover plain, floodtide delta and estuarine basin are also included if present. These morphological sub-units have recently been defined as a “coastal tract” by Cowell et al. (2003a) to provide a single definition for the cross-shore coastal domain relevant to large-scale coastal evolution.

GEOMBEST++ divides the coastal tract into three functional realms defined as the shoreface, barrier, and backbarrier bay/marsh (Figure 1). Evolution of these realms is handled differently in GEOMBEST++, although each are linked via sediment exchange to evolve the coastal tract. The shoreface extends from the seawards edge of the spatial domain to a cross-shore location corresponding to the highest elevation of marine-derived sediment. This location is defined as the crest and may represent the top of the dune, berm, or flood-delta depending on the application. The barrier incorporates the region from the crest to the landwards extent of marine-derived sediment, which can extend into and overlap with the bay/marsh, continuing landwards beyond this point.

The long-shore dimension may comprise a single coastal tract or several adjacent coastal tracts for a quasi-3 dimensional application. Each coastal tract in a quasi-3D application would typically represent a long-shore region where it is assumed that, a) the long-shore morphology and stratigraphy are homogenous, and b) there are no gradients in long-shore sediment flux. These assumptions are made for the relevant modeling scales and would typically not involve sediment flux attributed to sub-decadal time scales or morphological variation at sub-kilometer space scales. Each coastal tract is represented in GEOMBEST++ as a vertical cross-section, which defines the dimensions of stratigraphic units comprising the coastal tract (see Section 4.3).

Feedback between cross-shore and long-shore evolution can be simulated by exchanging sediment volume between coastal tracts. This approach can be implemented using several simulations with existing 2-Dimensional (cross-shore) models (e.g. Dillengurg et al., 2000) but it is made easier with GEOMBEST++ since the evolution of several adjacent tracts can be examined in a single simulation.

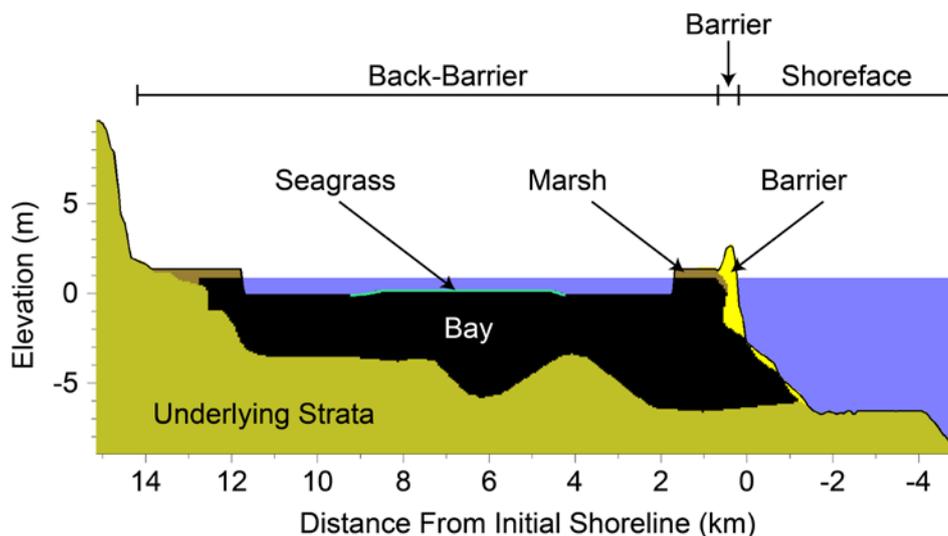


Figure 1: Example model output from the seagrass version of GEOMBEST++ for a low-gradient barrier island coast. GEOMBEST++'s three functional realms are defined as well as the distinct stratigraphic units that comprise this example of a coastal tract.

### **3: Conservation of Sediment Volume**

The concept that coastal evolution can be quantified according to rules governing sediment conservation is fundamental to all morphological-behaviour models. GEOMBEST++'s sediment conservation rules are similar to those of the Shoreface Translation Model (Cowell et al., 1995) and accordingly involve three sediment grain classes typically representing sand, mud and organic. Sand volume is conserved within the study domain while mud volume is removed from the study domain if it is eroded at the shoreface. In the estuary however, mud is conserved within the study domain while sand is removed if it is eroded from the estuary. The volume of mud and organics exerts control over coastal evolution by altering the accommodation space below, and landwards of the shoreface. Mud/organic volume may comprise a proportion of the initial stratigraphy or may be introduced to the tract through estuarine and marsh infilling (Section 4.6). All GEOMBEST++ calculations are based on volumes of compacted sediment since compaction is not simulated in the model.

### **4: Model parameters**

#### **4.1: Equilibrium profile**

The assumption that cross-shore morphology will attempt to attain an equilibrium form in relation to oceanic forces and sea level is an established concept in coastal research. Bruun (1954) and Dean (1991) have, among others, represented the shoreface profile as a concave up curve of the form  $h = Ax^m$  where  $h$  = water depth,  $x$  is the distance offshore,  $A$  is a constant commonly related to grain size (Dean & Maumeyer, 1983) and  $m$  is a scaling parameter typically set to 2/3. Compound shorefaces, which divide the shoreface into a bar-berm section and a shorerise section, have also been presented by Inman et al. (1993) and Cowell et al. (1999). In GEOMBEST++, a cross-shore equilibrium profile is specified for each coastal tract. This profile represents the form that the coastal morphology will attain assuming constant (or time-averaged) processes, an erodible substrate and instantaneous response to changing sea levels.

GEOMBEST++'s equilibrium profile is specified by a series of points ( $x, z$ ) interpolated by straight lines. Any number of points may be specified to allow adequate approximation of any theoretical or empirically-derived cross-shore equilibrium profile. The equilibrium profile may extend to the shelf edge and therefore seawards of the region typically defined as the shoreface. This seawards extension of the equilibrium profile is consistent with growing awareness that sediment flux across the entire shelf is important for understanding and predicting large-scale coastal change (Wright, 1995, Cowell et al., 2003). The equilibrium profile also extends landwards to define the surface of the subaerial beach and primary dunes.

Pilkey et al. (1993) and Theiler et al. (1995, 2000) question the applicability of equilibrium profiles such as those described above to coastal modelling. They argue that cross-shore shoreface morphology may be dominated by the underlying geology and therefore never achieve an equilibrium profile. Cowell et al. (1995) and Niedoroda et al. (1995) also note that deeper and less energetic parts of the tract (i.e. the mid shelf) may take thousands of years to attain elevations in equilibrium with oceanic forces. GEOMBEST++ accounts for the factors leading to shoreface disequilibrium described above. Although a theoretical equilibrium profile is specified in the model, this profile may never be achieved due parameters defining a) the geological framework, and b) the time dependant profile response. These factors are described in sections 4.3 and 4.4 respectively.

## **4.2: Sea Level Change**

Predicting shoreface response to sea-level rise has its origins in the Bruun Rule. This analytical model assumes that a profile of invariant form is shifted vertically according to sea-level rise and landwards to a location where the volume of sediment eroded from the upper shoreface balances the volume of sediment deposited offshore (i.e. sediment is conserved). The Bruun Rule has also been generalized to account for “barrier island scenarios” where the shoreface translates over a substrate with a lower gradient than the shoreface toe (Dean and Maumeyer, 1983). In this case, sediment eroded from the shoreface is balanced by sediment deposited to the backbarrier (via overwash and tidal inlet processes) rather than offshore. Numerical implementation of the Bruun Rule has more recently been provided by Cowell et al, (1995). In their model, behaviour resembling the original and generalized Bruun Rule emerges in response to differences between the slopes of the shoreface and the underlying substrate.

Morphological evolution in GEOMBEST++ is driven by disequilibrium stress resulting from differences in elevation between the tract surface and the equilibrium profile. Sea-level change creates disequilibrium stress by vertically displacing the equilibrium profile. The resultant morphological evolution may involve a net loss or gain of sediment volume as the tract surface evolves to the elevations defined by the equilibrium profile. GEOMBEST++’s numerical scheme searches for a horizontal location of the equilibrium profile resulting in a morphological response that conserves sediment volume within the spatial domain. A single solution exists in all cases where the shoreface translates over a seawards-sloping substrate. GEOMBEST++’s approach to calculating shoreface evolution is therefore similar to the Bruun approach with an importance difference that the real morphology can be out of equilibrium with oceanic processes due to substrate characteristics and time-lag effects. Additional parameters provide flexibility to include the effect of estuarine infill, backbarrier deposition (from overwash and dune building) and open sediment budgets resulting from long-shore processes or beach nourishment.

## **4.3: Initial Morphology/Stratigraphy**

Initial morphology and stratigraphy is represented in GEOMBEST++ via a series of discrete stratigraphic units (Figure 1). The boundaries of these stratigraphic units are defined by a series of points (x, z) interpolated with straight lines. Each stratigraphic unit is characterized by a) its sand ratio, and b) its erodibility as represented by an

erodibility index. The sand ratio affects the evolution of tract morphology through the implementation of the sediment conservation rules outlined in Section 3. The erodibility index (in conjunction with a depth-dependant response rate described in Section 4.4) determines the rate at which sections on the coastal tract are able to erode.

For shoreface erosion, the erodibility index of each stratigraphic unit ranges from 0 to 1. A value of 1 characterises stratigraphic units whose erosion is unconstrained by sediment cohesiveness. Conversely, a value of 0 characterises lithified stratigraphic units that cannot be eroded. A value of 0.5, for example, characterises stratigraphic units that are eroded at half the rate of units with a value of 1. The erodibility index and sand ratio allows the model to simulate coastal evolution in the unconsolidated sand-rich environments that are typically modelled (e.g. Storms et al, 2002; Cowell et al, 2003b) as well as settings where cohesive strata outcrop on the shoreface surface (e.g. Riggs et al., 1995, Pilkey et al., 1993, Wright & Trembanis, 2003). Examples include the Outer Banks of North Carolina where Holocene Barriers are perched on Pleistocene sediment (Riggs et al., 1995), South-Eastern Australia where beaches are backed by lithified cliffs (Thom et al., 1992), and Cedar Island (Virginia, USA) where semi-lithified marsh deposits are exposed on the shoreface (Wright & Trembanis, 2003).

Tract stratigraphy affects shoreface morphology if the erodibility index of stratigraphic units outcropping on the shoreface is too low to allow the shoreface to erode to its equilibrium profile. In this case part of the shoreface will remain shallower than its equilibrium depth. The stratigraphy also affects the horizontal translation of the shoreline since this is controlled by rules conserving sediment volume. For example, the lithification of the shoreface prevents the release of sediment that may otherwise be transported to the beach. This results in increased shoreline transgression during periods of sea level rise (SLR). Similarly, the erosion of sand-rich stratigraphic units releases more sand than erosion of mud-rich stratigraphic units, which also reduces shoreline transgression.

#### **4.4: Depth-Dependant Shoreface Response Rate**

Rates of sediment erosion and resuspension depend on the total near-bed energy, which results predominately from wave orbital velocities on the inner shelf and geostrophic flows on the outer shelf (Wright, 1995). Total near-bed energy decreases offshore due to the attenuation of wave orbital velocities with increased water depth. Accordingly, the rate at which the shoreface morphology attains equilibrium decreases with increasing water depth since the energy required to evolve the shoreface profile is depth dependant. While the surfzone responds to changing water levels in hours the mid-shelf may take thousand of years to reach equilibrium (Wright, 1995, Cowell et al., 1999).

In GEOMBEST++, a depth depth-dependent shoreface response rate is specified by a series of data points defining a function relating depth with the maximum vertical shoreface response. This flexible approach allows the concept of a closure depth to be implemented (i.e. instantaneous shoreface response specified to a particular depth with no morphological change below this depth). Alternatively, it is possible to set the shoreface response to be proportional to total near-bed wave energy or any other

depth-dependant relationship deemed appropriate for an application. The shoreface response could potentially be calibrated empirically from long-term offshore survey data (e.g. List et al., 1997, Gibbs & Gelfenbaum, 1999), or inversely by searching for parameter values that produce simulated outcomes consistent with measured morphology and stratigraphy (e.g. Cowell et al, 1995). This second option may be appropriate for estimating shoreface response at depths where morphological response cannot be measured directly.

#### **4.5: Backbarrier Deposition**

Backbarrier deposition results from the combined effects of dune-building, overwash, and tidal inlet processes, which deposit marine-derived sediment landwards of the crest. Backbarrier morphology is defined in GEOMBEST++ by the backbarrier portion of the equilibrium profile (landwards of the crest) and the deposition of overwash. The equilibrium profile defines the surface of the primary dune, thereby maintaining the morphology of the island.

Past the point of the dune limit (landwards extent of the equilibrium profile), backbarrier deposition is defined by the parameters for overwash. The overwash volume flux parameter gives the total volume of sediment to be deposited, representing the sum of all of the overwash events over a given period of time. The length and thickness of the overwash deposit will be determined by the overwash accretion rate parameter, which sets the maximum thickness of the overwash flat directly behind the dune limit. The rest of the overwash volume is then deposited in a logarithmic decay beyond that point. Thus, for a given overwash volume flux, a higher accretion rate will yield a shorter and thicker overwash fan, and a lower accretion rate will yield a longer and thinner overwash fan.

#### **4.6: Bay and Marsh Infilling**

Bay infilling is represented in GEOMBEST++ as a rate at which the substrate landwards of the crest is accreted with mineral or organic (e.g. saltmarsh) sediment. The sand/mud ratio of bay deposits can be specified and can vary through time to simulate different fluvial or tidal contributions relating to estuarine maturity (Roy, 1984). The deposition of bay sediments is determined by a parameter for the flux of sediment across the bay over a given time period. An accretion rate is then determined based on the width of the bay. The model assumes a rapid approach to the equilibrium depth by instantaneously adjusted the bay bottom each time step to a new equilibrium depth. The specific equilibrium depth for each time step is determined by an empirical relationship with fetch, chosen using a depth-fetch lookup table. The total volume of sediment that is eroded to maintain this depth is then available for transport to the marsh (along with sediment eroded from the marsh edge, discussed below). The bay may not reach its equilibrium depth if the bay sediment flux (and thus accretion rate) is insufficient to offset sea level rise.

Marsh infilling occurs at both the landward and the barrier boundaries of the estuary, partitioning the sediment available from bay erosion equally between the two. The marsh will be filled up to sea level using just the bay sediment class, but above sea level, filling is augmented by the addition of organic sediment which accounts for 50% of the accretion rate. The maximum height of the marsh is set as the high water

line, which will vary depending on the tidal prism. Similarly to the bay, marshes can be eroded by wind waves. The strength of these waves is related to the fetch and depth of the bay and a user-determined wind speed. Marsh edge erosion is determined by the wave power at the marsh edge (Mariotti and Fagherazzi, 2013) from which a volume of marsh sediment to be eroded is calculated. Sediment eroded from the marsh is combined with the sediment eroded from the bay and available for redeposition in the back-barrier. Under this set of rules, for a given sediment input, the marsh platform boundary will either prograde or erode depending on the rate of sea level rise (Mariotti and Fagherazzi, 2010).

Bay and marsh infilling affects barrier translation by influencing bay accommodation space. High rates of bay infilling favour shallow bays and wide marsh platforms with limited accommodation space whereas low rates of bay accretion are typically associated with deeper bays and narrow or non-existent marsh platforms, which provide a larger accommodation space. The bay accommodation space in turn determines the volume of sand required to maintain a barrier of constant width during transgression. More sand must be transported to the backbarrier if the bay accommodation space is relatively large. This results in more shoreface transgression because the sand deposited in the backbarrier comes from shoreface erosion. Conversely, high rates of bay infilling are associated with lower rates of shoreface transgression during a period of SLR.

#### **4.7: Seagrass Dynamics**

The model grows seagrass in the bay within available habitat. Habitat is determined by the depth of the bay and a user-defined percent bay cover (PBC), which defines the (cross-shore) limits of seagrass growth within the center of the bay. Presently the meadow is centered within the bay in the model. The shoot density of the meadow is also determined by depth via an empirical depth-shoot density lookup table, with meadows at greater depths more sparse.

Seagrass reduces the equilibrium depth of the bay by attenuating wave and current shear stresses acting on the sediment bed, and reduces the height of waves reaching the edges of the marsh. The width and shoot density of the seagrass meadow impacts these dynamics, with wider and denser meadows decreasing equilibrium depths and wave heights more than smaller and sparser meadows. In the model, cells with seagrass will have a shallower equilibrium depth than bare cells; their equilibrium depths are selected from a section of the depth-fetch lookup table parameterized specifically for when seagrass is present. When seagrass is present, the equilibrium depth of the bare portions of the bay surrounding the meadow is determined by using an effective fetch calculated from the attenuated wave height rather than the full fetch of the bay (i.e. seagrass also influences the depth of the bay not covered by vegetation). The height of waves traveling over the seagrass meadow decay exponentially, and can regrow over the fetch separating the meadow from the far marsh edge. The reduction in wave height reaching the far marsh edge results in a reduction in the volume of marsh edge erosion.

### **5: Installing GEOMBEST++**

GEOMBEST++ is written in Matlab and reads in a series of Excel files containing the input data for simulations. Accordingly, both Matlab and Excel software are required to run GEOMBEST++. The current version of GEOMBEST++ requires Matlab v. 7.0.4 and Excel 2003 or newer. To use GEOMBEST++ first set up a directory “C:\GEOMBEST++” and then create subdirectories titled “Input1”, “Input2”, “Input3”, “Input4”, etc. “Output1”, “Output2”, “Output3”, “Output4”, etc. and “Program.” The “Program” directory stores the GEOMBEST++ function files. All GEOMBEST++ Matlab files must be copied to this directory. The “Input” and “Output” directories contain the input and output data for simulations. You may specify as many input and output folders as you like. Multiple input and output directories will allow you to run multiple simulations simultaneously on a single computer.

## 6: Input File Formats

A minimum of four excel files are required to run a GEOMBEST++ simulation: an “erosionresponse” file, an “accretionresponse” file, a “run#” file, and a “tract#” file. If the simulation involves a single coastal tract then the files must be titled “erosionresponse”, “accretionresponse”, “run1” file and “tract1.” Quasi-3D simulations require additional files with sequential numbers. For example a simulation involving 3 tracts within a littoral cell also requires a “run2” and “run3” file as well as a “tract2” and “tract3” file. These files must conform to the strict format outlined in the following sections. If you are running multiple simulations of the same tract, you can use the multiple input and output files to keep track of your simulations. **Caution:** Note that the run# and tract# files will have the same name (tract1, run1, etc., see below) for all simulations and so attention to organization is critical. We suggest noting the changes made in each simulation in a readme file and then moving this file, as well as the input and output folders for each simulation, to a unique folder having an identifying name. Our convention, for example, has been to name each run with using the date and run number on that date as the identifier, e.g., the first simulation run on February 20, 2010 would be titled 02\_20\_10\_01 and would be placed in a folder having this name.

### 6.1: “erosionresponse” file

The “erosionresponse” file specifies the maximum amount of erosion (vertical change) that can occur on the substrate. In the following example there is no erosion at a depth of 100 m and a possible 1 m/yr erosion rate at a depth of 5 meters (effectively instantaneous with regard to slow changes in sea level). Any number of data points may be entered in the “erosionresponse” file. The maximum erosion rates at elevations inbetween the depths for which a rate is specified are determined by linear interpolation. Keep in mind that these values set the depth for the base of the shoreface in the model. An equilibrium profile will not occur below this depth.

Depth-dependant response rate	
Elevation (m)	Response rate (m/yr)
-100	0
-20	0

-5	1
100	1

### 6.2: “accretionresponse” file

The “accretionresponse” file specifies the maximum rate of accretion or deposition (vertical change) that can occur on the substrate. In the following example, there is no accretion at a depth of 100 m and a possible 1 m/yr accretion rate at a depth of 5 meters (effectively instantaneous with regards to slow changes in sea level). The maximum accretion rates at elevations between are determined through a linear interpolation of the data points. Any number of data points may be entered in the “accretionresponse” file. Remember that this file also affects the base of the shoreface.

Depth-dependant response rate	
Elevation (m)	Response rate (m/yr)
-100	0
-20	0
-5	1
100	1

### 6.3: “run#” file

The “run#” file defines the parameter values at each time step within a simulation. In the following example there is a simulation period of 200 years divided into 20 10-year steps. The number of substeps is 1, which means that there are no sub-steps between the user-defined 10-year intervals. If two substeps were specified then the time intervals would be reduced to 5 years. The user can enter any number of timesteps. The timesteps do not have to have the same interval but note that using variable timesteps will prevent you from being able to plot ghost traces of model output at equally spaced time intervals.

*Sea-level change* refers to the elevation of the sea at the end of the time interval relative to the original sea level of 0 meters at timestep 1. The change in sea-level elevation between timesteps is the rate of sea-level rise. In the example, the sea level rises 0.4 m in the first 100 years and then another 0.4 m in the second 100 years of the simulation.

The *exogenous sand volume* specifies the rate at which sediment is added to, or subtracted from, the shoreface. Here it is set to zero.

The *overwash accretion rate* gives the maximum vertical accretion rate for the overwash fan, in units of mm/year.

*Overwash volume flux* is the volume of overwash sand to be deposited over a given period of time, in units of m<sup>3</sup>/yr.

*High water* gives the elevation of the high water line, determined from the tidal prism, and marks the maximum elevation to which the marsh can grow, in meters.

*Export flux* determines the percentage of suspended sediment eroded from the bay bottom and marsh edge that is lost from the system (e.g. through tidal inlet processes); enter values between 0 and 1

*Decay coeff* specifies the coefficient for exponential wave height decay over seagrass meadow

*Seagrass* specifies whether seagrass is allowed the opportunity to grow in that time step; binary determination for presence or absence of seagrass (1 = seagrass, 0 = no seagrass)

*Percent bay cover* gives the percentage of the bay that is viable seagrass habitat; enter values between 0 and 1

Runfile1	Substeps	1											
Time	Sea-level change (m)	Bay Sediment Flux (m <sup>3</sup> )	Back-barrier Width	Exogenous sand volume (m <sup>3</sup> /m tract width/yr)	Overwash rate (mm/yr)	Overwash volume	High water	Wind speed	Export flux (%)	Erosion coeff	Decay coeff	Seagrass	Percent bay cover
10	0	47.5	300	0	1	0.2	0.5	8	0	0.14	0.01	1	0.5
20	0	47.5	300	0	1	0.2	0.5	8	0	0.14	0.01	1	0.5
30	0	47.5	300	0	1	0.2	0.5	8	0	0.14	0.01	1	0.5
40	0	47.5	300	0	1	0.2	0.5	8	0	0.14	0.01	1	0.5
50	0	47.5	300	0	1	0.2	0.5	8	0	0.14	0.01	1	0.5
60	0	47.5	300	0	1	0.2	0.5	8	0	0.14	0.01	1	0.5
70	0	47.5	300	0	1	0.2	0.5	8	0	0.14	0.01	1	0.5
80	0	47.5	300	0	1	0.2	0.5	8	0	0.14	0.01	1	0.5
90	0	47.5	300	0	1	0.2	0.5	8	0	0.14	0.01	1	0.5
100	0	47.5	300	0	1	0.2	0.5	8	0	0.14	0.01	1	0.5
110	0.02	10	300	0	1	0.2	0.5	8	0.15	0.14	0.01	1	0.5
120	0.04	10	300	0	1	0.2	0.5	8	0.15	0.14	0.01	1	0.5
130	0.06	10	300	0	1	0.2	0.5	8	0.15	0.14	0.01	1	0.5
140	0.08	10	300	0	1	0.2	0.5	8	0.15	0.14	0.01	1	0.5
150	0.1	10	300	0	1	0.2	0.5	8	0.15	0.14	0.01	1	0.5
160	0.12	10	300	0	1	0.2	0.5	8	0.15	0.14	0.01	1	0.5
170	0.14	10	300	0	1	0.2	0.5	8	0.15	0.14	0.01	1	0.5
180	0.16	10	300	0	1	0.2	0.5	8	0.15	0.14	0.01	1	0.5
190	0.18	10	300	0	1	0.2	0.5	8	0.15	0.14	0.01	1	0.5
200	0.2	10	300	0	1	0.2	0.5	8	0.15	0.14	0.01	1	0.5

#### 6.4: “tract#” file

The “tract#” file defines the geometry of the stratigraphic units comprising the coastal tracts. The following example shows part of a “tract#” file. The first 3 rows define the dimensions of the grid cells. The cell length (x) corresponds to the horizontal dimension of the tract, the cell width (y) is the alongshore dimension, and the cell height (z) is the vertical dimension. Below that are the names, sand proportion, and

erodibility index of each stratigraphic unit. The “Data points” entry specifies the number of points defining the shape of each stratigraphic unit. The data defining the shape of each stratigraphic unit comprises a series of (x, z) values that specify the upper surface of each stratigraphic unit. X values begin at the offshore edge of the grid (zero value) and increase onshore.

cell length (x)	50									
cell width (y)	1									
cell height (z)	0.1									
name	Equilibrium morphology		Active sand body		Marsh		Bay		Strat1	
sand proportion	1		1		0		0.6		0.75	
erodibility index	1		1		1		1		1	
Data points	58		24		2		31		152	
	39208	-7.06	40326.3	-0.27	39292.7	-5.3	41951.2	-0.23	44561.9	4.4
	39198.6	0.47	40324.3	-0.12	39190.7	-5	41901.9	-0.28	44541.9	4.37
	39178	0.93	40323.1	-0.01			41841.9	-0.37	44501.9	4.3
	39138.6	1.35	40315.3	0.14			41821.9	-0.38	44281.9	4.21
	39098	1.79	40310.7	0.29			41801.9	-0.38	44261.9	4.2

## 7: Running GEOMBEST+

To use the provided sample inputs, copy the contents of “C:\GEOMBEST++\Example Inputs\Sample Simulation Input” and paste into an “Input#” folder in “C:\GEOMBEST++.” In order to view results of the sample simulation without running the simulation, the user may copy the contents of “C:\GEOMBEST++\Example Inputs\Sample Simulation Output” and paste into an “Output#” folder in “C:\GEOMBEST++.” Then, follow the procedures described in the following section to create representations of the results.

To run GEOMBEST++, open Matlab and set the working directory to “C:\GEOMBEST++\Program.” Then type main(1), main(2), main(3) or main(4) at the command prompt to start the simulation. The entered number specifies the input directory from which the input files are read and the output directory to which the output files are saved (this number is also known as the “file thread”). Main(1) will read the input files from the input1 folder and save the results in the output1 folder, main(2) will run the simulation using files in the input2 folder and save the results in the output2 folder, etc. To conduct multiple simultaneous simulations, it is necessary to open multiple instances of Matlab (one for each simulation to be run). Then, GEOMBEST++ can be run from each instance of Matlab, by specifying the relevant input number. Note: Please remember here, that input files and output files for each simulation will have the same name and so an organized filing system is critical to keeping track of inputs and outputs.

The program “removetemp” efficiently deletes the contents of all input and output files. Double-click on the file name to execute the function. Be sure to have transferred the contents of the input/output files to alternate locations before running this program in order to save information. Reformatting the name of the input/output folder will prevent it from being cleared by “removetemp.”

## 8: Viewing Results

There are three main GEOMBEST++ functions that can be used to view simulation results, `plottract`, `plotshore`, and `plotsurface`. To use these functions, type the function name at the command prompt with the desired parameter values entered. All of the functions will automatically save the results in the “Output#” folder as a Matlab figure file, a JPEG image file, and a portable document format (PDF) (except `plottractblackwhite`, which does not currently contain the relevant lines of code). Uses and input guidelines for each function are described below.

### 8.1 Plottract Function

`Plotblackwhite(a,b,c,d,e,f)` and `plottractcolour(a,b,c,d,e,f)` plot stratigraphic results in black and white and colour respectively. Ghost surfaces allow the user to track the profile morphology throughout the simulation. The input parameters are identical for both functions and are as follows:

a = the file thread (1-4) (For example, file thread 1 will plot the simulation from the input1 folder and save results in the output1 folder, while file thread 2 will plot the simulation from the input2 folder and save in the output2 folder)

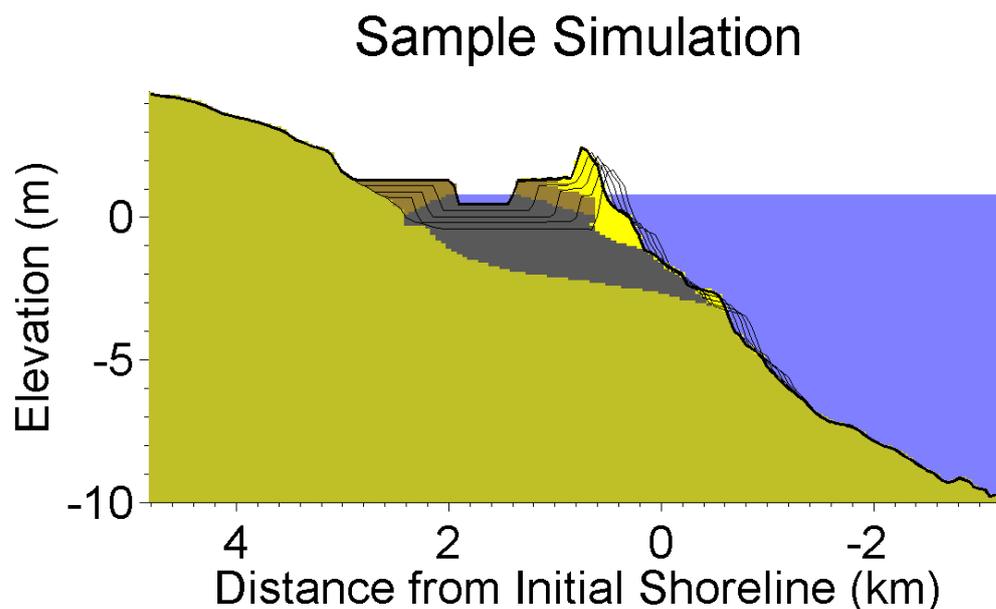
b = the final timestep to plot (Note that timesteps are offset by 1 because the initial condition counts as timestep 1. Thus, if there are 5 actual timesteps specified in the simulation, the final timestep to plot will be timestep 6.)

c = the tract number

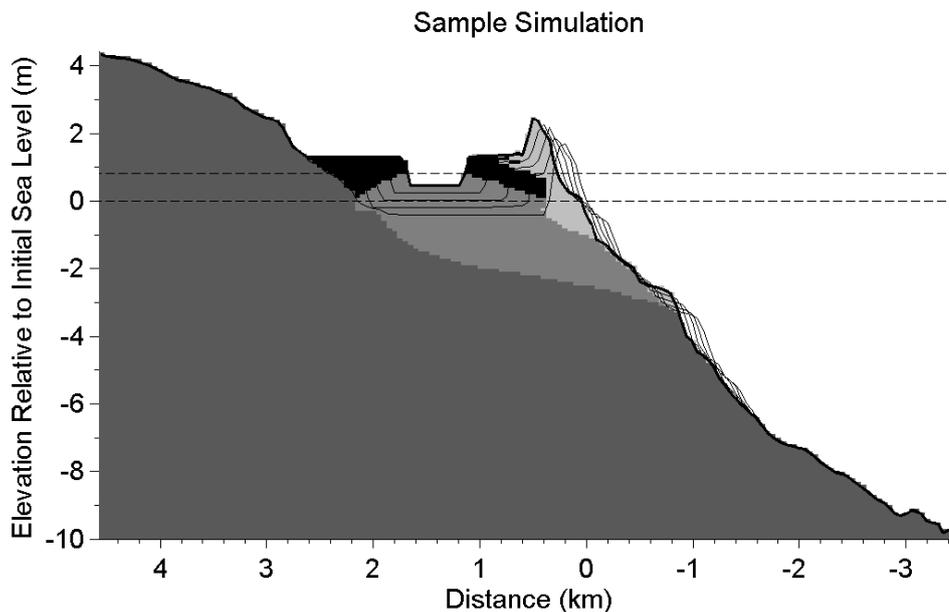
d = the first timestep to plot (as a ghost surface)

e = the number of timesteps to plot as ghost surfaces (for example e = 1 will plot every timestep as a ghost surface while e = 2 plots every second timestep as a ghost surface)

f = ‘Sample Simulation’ (must be in single quotations): This will be the title of the figure and part of the file name.



Input = `plottractcolour(1,21,1,1,5,'Sample Simulation')`



Input = plotblackwhite(1,21,1,1,5,'Sample Simulation')

Several other matlab files are saved to the output file directory. These include; shorelines.mat (the position of the shoreline at each timestep), surface.mat (the surface elevations at each x centroid for each timestep), strat.mat (a structure with the stratigraphic data for the tract), xcentroids.mat (the value of each cell centroid along the x axis), zcentroids.mat (the value of each cell centroid along the z axis), celldim.mat (the cell dimensions), and SL.mat (the sea level at each timestep).

The data contained within shorelines.mat is particularly useful since it records the shoreline location through time. To view this data, type `load('C:\GEOBEST+\Output1\shorelines.mat')` at the Matlab command prompt, or alternatively double click on the shorelines.mat file from within windows explorer.

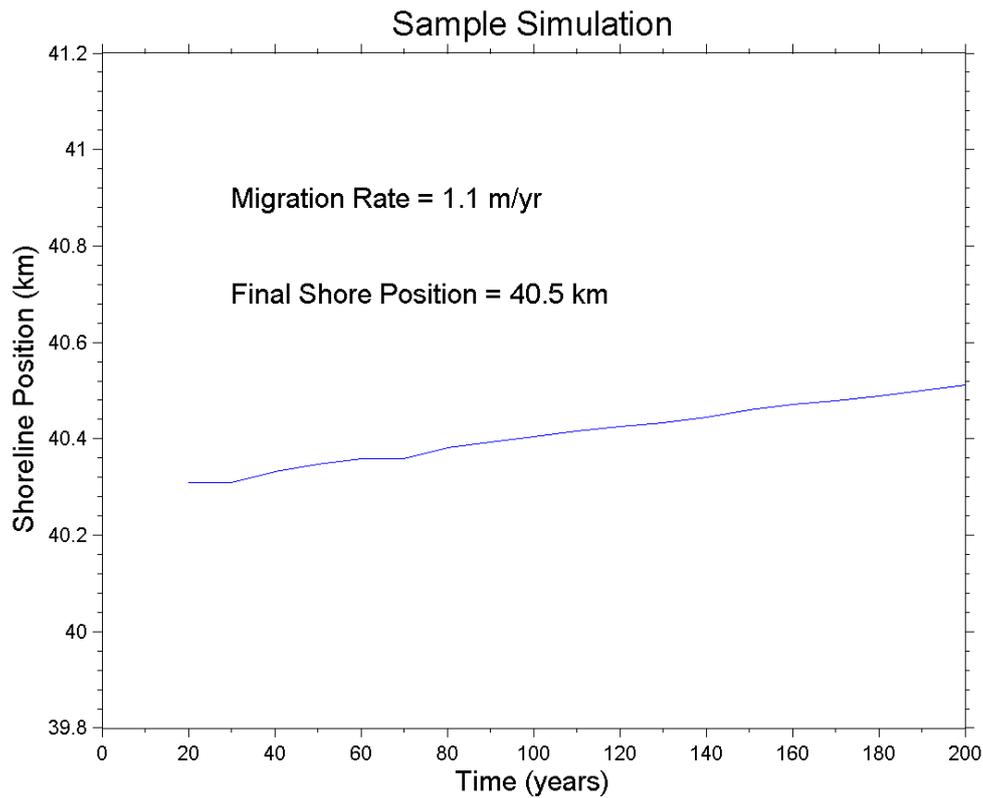
## 8.2 Plotshore Function

Plotshore (a,b,c) creates a graph of shoreline position throughout the simulation. The plot also provides the average transgression rate and the precise final shore position. The input parameters are as follows:

a = the file thread (1-4): (For example, file thread 1 will plot the simulation from the input1 folder and save in the output1 folder, whilst file thread 2 will plot the simulation from the input2 folder and save in the output2 folder)

b = the number of years between timesteps (remember substeps, i.e. one substep = 100 yrs, two substeps = 50 yrs)

c = 'modelrun' (must be in single quotations)



Input = plotshore(1,10,'Sample Simulation')

### 8.3 Plottractmov

Plottractmov(a,b,c) creates a Matlab video and an avi video file, compiled from the plottractcolour plots of each time step for a simulation.

a = the file thread (1-4): (For example, file thread 1 will plot the simulation from the input1 folder and save in the output1 folder, whilst file thread 2 will plot the simulation from the input2 folder and save in the output2 folder)

b = the final timestep that you want to be shown in the animation.

c = 'modelrun' (must be in single quotations)

```
Input = plottractmov(1,21,'Sample Simulation')
```

## Runs that Crash

Use `block = ts` before crash in `main.m` and put a breakpoint at line 70 (`break =0`) to stop program before crash. Run `saveblock.m` using `saveblock(filethread)` to save the workspace and variables needed for plotting routines described above. Now the results prior to crash can be plotted for inspection.

## Troubleshooting

If you get the following error:

```
??? Error using ==> interp1
The values of X should be distinct.
```

```
Error in ==> buildgrid at 61
horizon = interp1(strat(j,s + 1).elevation(:,1),strat(j,s +
1).elevation(:,2),xcentroids);
```

```
Error in ==> main at 38
buildgrid;
```

This error typically means that you have a repeating x value in one of your tract files. To fix this problem, open your tract file in excel. You can either visually search for a repeating x value or create a simple formula in a new column in excel which will find the difference between adjacent x-values. If this difference is 0, you have a repeating value. Once you have located the repeating value, delete that point. Be sure to change the data points count in the altered tract to reflect the new number of data points in that tract. Before you save and close your file, be sure you have deleted the new columns you added while troubleshooting.

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