Description of input parameters for Progradation models 10 and 11

Progradation model 10: Half-Gaussian progradation
+ local aggradation with respect to a fixed bathymetry
+ sinusoidal perturbations of the sedimentation profile

Progradation models 10 and 11 are based on progradation model 7. They have an additional feature in which sinusoidal perturbations are added to the sedimentation profile.
The sinusoidal perturbations are a first order representation of bathymetric unevenness in natural systems.

A sinusoidal wave train that tapers out linearly towards both ends (not necessarily over the same distance), is superimposed on the sedimentation profile. The lateral extent of the perturbations can be defined in the input file. The wave train can move laterally with a prescribed velocity (sinus_trans_vel(i)) which is independent of vprograde(i).

Following are the input parameters for progradation model 10:

tprograde(i), h0(i), hinf(i), x0(i), prograde_length(i), vprograde(i), haggrade(i), vaggrade(i), sinus_wavelength(i), sinus_amplitude(i), sinus_trans_vel(i), sinus_taperlength1(i), sinus_taperlength2(i), sinus_taperstart(i), sinus_taperend(i)

tprograde(i)
(REAL *8)
= model time (in seconds) at which the sedimentation according to the following input parameters commences

h0(i)
(REAL *8)
= surface height at x.le.x0(i) (metres)

hinf(i)
(REAL *8)
= limit of surface height at x.eq.infinity (metres)

x0(i)
(REAL *8)
= initial x position where the half-Gaussian part of the profile starts (metres)

prograde_length(i)
(REAL *8)
= Gaussian width of the profile as defined above (metres)

vprograde(i)
(REAL *8)
= progradation velocity (m/s) velocity at which progradation function moves in positive x direction (0.317097d-9 = 0.01m/year). Negative values give retrogradation of the profile but do not result in erosion of sediments above the profile.

haggrade(i)
(REAL *8)
= base level for aggradation (metres)

vaggrade(i)
(REAL *8)
= aggradation velocity (m/s) which is uniform for all x velocities at which sediments aggrade (0.317097d-9 = 0.01m/year). Negative values give degradation of the profile but do not result in erosion of sediments above the profile.

-------------------------All of above have the same definition as in progradation model 7--------
----Additional input parameters for defining the sinusoidal perturbations for progradation------ ---
-----model 10 are shown below. These need to be specified in the same line as the above inputs---

sinus_wavelength(i)
(REAL *8)
= the wavelength of the desired sinusoidal modulation (metres)

sinus_amplitude(i)
(REAL *8)
= the amplitude of the desired sinusoidal modulation (will result in bathymetric changes of twice the amplitude) (metres)

sinus_trans_vel(i)
(REAL *8)
= translational velocity of the sinusoidal modulation (metres/second). The sinusoid wave train moves at this velocity.

sinus_taperlength1(i)
(REAL *8)
= the length over which the sinusoidal modulation will linearly taper out at left end (metres)

sinus_taperlength2(i)
(REAL *8)
= the length over which the sinusoidal modulation will linearly taper out at right end (metres)

sinus_taperstart(i)
(REAL *8)
= position of left taper, where modulation first reaches full amplitude (metres)

sinus_taperend(i)
(REAL *8)
= position of right taper, where modulation last reaches full amplitude (metres)

The bathymetry from the sinusoid wave train S(x) varies as follows (Fig. 1 below):

$$S(x) = \begin{cases} 0 & x < \text{sinusstart} \\ k * \dfrac{(x - \text{sinusstart})}{\text{taperlength1(i)}} & \text{sinusstart} \le x < \text{sinus\_taperstart(i)} \\ k & \text{sinus\_taperstart(i)} \le x \le \text{sinus\_taperend(i)} \\ k * \dfrac{(\text{sinusend} - x)}{\text{taperlength2(i)}} & \text{sinus\_taperend(i)} < x \le \text{sinusend} \\ 0 & x > \text{sinusend} \end{cases}$$

where $\text{sinusstart} = \text{sinus\_taperstart(i)} - \text{sinus\_taperlength1(i)}$

$\text{sinusend} = \text{sinus\_taperend(i)} + \text{sinus\_taperlength2(i)}$

$k = \text{sinus\_amplitude(i)} + \text{sinus\_amplitude(i)} * \text{Sin}\ (2\pi * (x - \text{sinusstart(i)}) / \text{sinus\_wavelength(i)})$

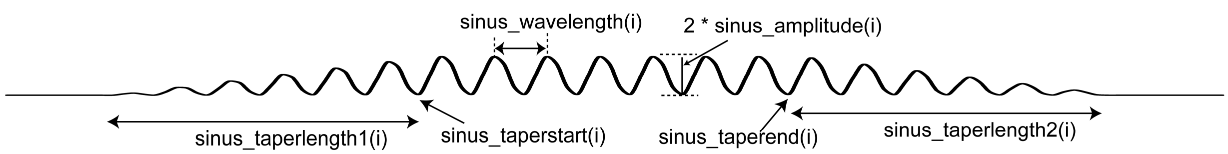

Figure 1. Figure showing the various input parameters for the sinusoidal perturbations and their physical meaning.

S(x) is added to the sedimentation profile which is obtained using the half-Gaussian progradation profile and haggrade(i).

Progradation Model 11

Progradation model 11: Half-Gaussian progradation
+ local aggradation with respect to current surface bathymetry at right end of the model
+ sinusoidal perturbations of the sedimentation profile

This model is similar to progradation model 10 except that the local aggradation is with respect to the current model surface measured as the average elevation of last but ten surface nodes at the right end of the model. All the input parameters are same as in progradation model 10 except that haggrade(i) should NOT be specified in progradation model 11. Therefore the inputs are follows:

tprograde(i), h0(i), hinf(i), x0(i), prograde_length(i), vprograde(i), vaggrade(i), sinus_wavelength(i), sinus_amplitude(i), sinus_trans_vel(i), sinus_taperlength1(i), sinus_taperlength2(i), sinus_taperstart(i), sinus_taperend(i)

Progradation Model 12

Progradation Model 12 allows the user to define sedimentation profiles that are sensitive to the evolving regional bathymetry in a model.

In progradation model 12, the shelf height and the abyssal height (with respect to model origin (0, 0)) of a half-Gaussian progradation profile, and haggrade(i) can all vary within a time interval in one of two different ways:
(1) the user can specify initial bathymetric levels for h0(i), hinf(i) and haggrade(i) which are used as references in calculating h0_t, hinf_t and haggrade_t in each time step (OR)
(2) the user can specify 3 sets of surface nodes corresponding to evolving reference levels for calculating the shelf height and abyssal height of the progradation profile, and the bathymetric level for local aggradation. The averages of the current elevations at these nodes are used by the model as reference heights for calculating h0_t, hinf_t and haggrade_t.

Progradation model 12 has either two or three lines of input parameters depending on the value of sed_reflev_flag(i) (see below)

If sed_reflev_flag(i) = 0, then the sedimentation profile is calculated as mentioned in (1) above. There are two lines of input parameters in the Sopale Nested input file.

Alternatively, if sed_reflev_flag(i) = 1, then the sedimentation profile is calculated as mentioned in (2) above. In this case, there are three lines of input parameters in the Sopale Nested input file.

These are as follows:

tprograde(i), h0(i), hinf(i), x0(i), prograde_length(i), vprograde(i), haggrade(i), vaggrade(i), sinus_wavelength(i), sinus_amplitude(i), sinus_trans_vel(i), sinus_taperlength1(i), sinus_taperlength2(i), sinus_taperstart(i), sinus_taperend(i), vho(i), vhinf(i)

tprograde(i)
(REAL *8)
    = model time (in seconds) at which the sedimentation according to the following input parameters commences
h0(i)
(REAL *8)
    = surface height at x.le.x0(i) (metres)
hinf(i)
(REAL *8)
    = limit of surface height at x.eq.infinity (metres)
x0(i)
(REAL *8)
    = initial x position where the half-Gaussian part of the profile starts (metres)

prograde_length(i)
(REAL *8)
= Gaussian width of the profile as defined above (metres)

vprograde(i)
(REAL *8)
= progradation velocity (m/s) velocity at which progradation function moves in positive x direction (0.317097d-9 = 0.01m/year). Negative values give retrogradation of the profile but do not result in erosion of sediments above the profile.

haggrade(i)
(REAL *8)
= base level for aggradation (metres)

vaggrade(i)
(REAL *8)
= aggradation velocity (m/s) which is uniform for all x velocities at which sediments aggrade (0.317097d-9 = 0.01m/year). Negative values give degradation of the profile but do not result in erosion of sediments above the profile.

sinus_wavelength(i)
(REAL *8)
= the wavelength of the desired sinusoidal modulation (metres)

sinus_amplitude(i)
(REAL *8)
= the amplitude of the desired sinusoidal modulation (will result in bathymetric changes of twice the amplitude) (metres)

sinus_trans_vel(i)
(REAL *8)
= translational velocity of the sinusoidal modulation (metres/second). The sinusoid wave train moves at this velocity.

sinus_taperlength1(i)
(REAL *8)
= the length over which the sinusoidal modulation will taper out (linearly) at left end (metres)

sinus_taperlength2(i)
(REAL *8)
= the length over which the sinusoidal modulation will taper out (linearly) at right end (metres)

sinus_taperstart(i)
(REAL *8)
= position of left taper, where modulation first reaches full amplitude (metres)

sinus_taperend(i)
(REAL *8)
= position of right taper, where modulation last reaches full amplitude (metres)

-----------All the above parameters have the same meaning as in Progradation model 10------------

--------------shown below are the additional parameters for Progradation model 12------------------

vh0(i)
(REAL *8)
= vertical velocity (metres/second) at which h0(i) is moved to h0_t in each time step of duration 'dt' according to
h0_t = h0(i) + vh0(i)*dt (if sed_reflev_flag(i) = 0)

vhinf(i)
(REAL *8)
= vertical velocity (metres/second) at which hinf(i) is moved to hinf_t in each time step of duration 'dt'according to
hinf_t = hinf(i) + vhinf(i)*dt (if sed_reflev_flag(i) = 0)

sed_reflev_flag(i) **(specified on a separate line)**
(INTEGER * 4)

= 0
h0_t and hinf_t are calculated according to the formula discussed above. No additional inputs are required (OR)
= 1
h0_t and hinf_t are calculated by averaging the current surface elevations at nodes specified by the user. Additional inputs are required. These inputs are specified on a separate line by itself and are as follows:

shelf_start_node(i), width1(i), abyssal_start_node(i), width2(i), haggrade_start_node(i), width3(i), offset_h0(i), offset_hinf(i), offset_haggrade(i)

shelf_start_node(i)
(INTEGER * 4)
= reference surface node number whose y position is used in calculating the average shelf height (shelf_height_avg).

width1(i)
(INTEGER * 4)

= number of surface nodes immediately to the right of to shelf_start_node(i) whose y positions are used for calculating average shelf height (shelf_height_avg)

For example, if shelf_start_node(i) = 2 and width1(i) = 2, then the bathymetry at surface nodes 2, 3, 4 will be averaged to get an average shelf height. That is

shelf_height_avg = (yrow(2) + yrow(3) + yrow(4))/3, where yrow( ) is the array containing y positions of surface nodes.

abyssal_start_node(i)
(INTEGER * 4)

= reference surface node number whose y position is used in calculating the average abyssal height (abyssal_height_avg).

width2(i)
(INTEGER * 4)

= number of surface nodes immediately to the right of to abyssal_start_node(i) whose y positions are used for calculating average abyssal height (shelf_height_avg)

haggrade_start_node(i)
(INTEGER * 4)
= reference surface node number whose y position is used in determining the bathymetry haggrade_t for local aggradation

width3(i)
(INTEGER * 4)
= number of surface nodes immediately to the right of haggrade_start_node(i) whose y positions are used for calculating the average base level for local aggradation (haggrade_avg)

offset_h0(i)
(REAL *8)
= vertical offset applied to h0_t calculated using shelf_start_node(i) and width1(i)

offset_hinf(i)
(REAL *8)
= vertical offset applied to hinf_t calculated using abyssal_start_node(i) and width2(i)

offset_haggrade(i)
(REAL *8)

= vertical offset applied to haggrade_t calculated using haggrade_start_node(i) and width3(i)

The above three offsets are applied in each time step of duration ‘dt’ as follows:

h0_t = shelf_height_avg + vh0(i)*dt + offset_h0(i)
hinf_t = abyssal_height_avg + vhinf(i)*dt + offset_hinf(i)
haggrade_t = haggrade_avg + vaggrade(i)*dt + offset_haggrade(i)

h0_t, hinf_t, x0t, prograde_length(i) are used to define a new half-Gaussian progradation profile in each time step. Similarly haggrade_t is the new bathymetric level for local aggradation (Fig. 2).

Note: Sinusoidal perturbations are added after obtaining the sedimentation profile from the half-Gaussian progradation profile and haggrade_t

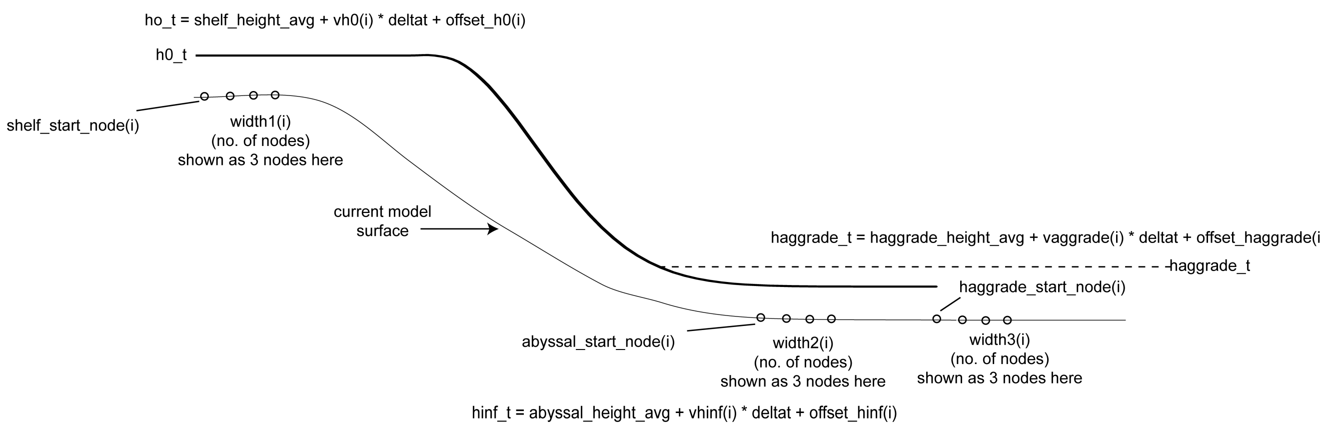

Figure 2. Input parameters for Progradation model 12 and their physical meaning (for case sed_reflev_flag = 1)

Progradation Model 13

Progradation model 13 is based on progradation model 12 and has the added capability of including a second half-Gaussian profile such that it can be used to prograde sediments from both sides of the model, as opposed to just the left side as in all previous progradation models. That is, the total sedimentary profile is a combination of two half-Gaussian profiles as shown in Figure 3, and is composed of a left-side half-Gaussian (as before) and a right-side half-Gaussian which has the opposite orientation (i.e., its surface dips to the left).

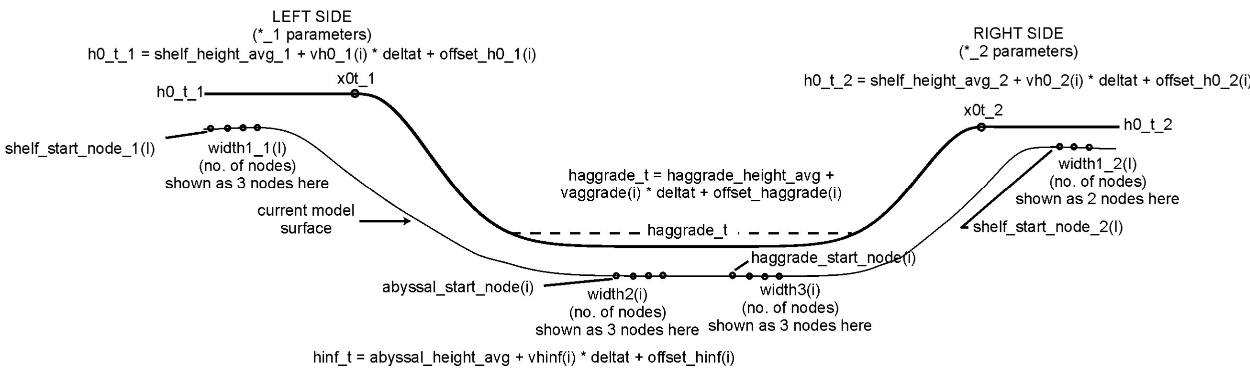

Figure 3. Input parameters for Progradation model 13 and their actual meaning (for sed_reflev_flag = 1 case).

In progradation model 13, both the left-side and right side shelf heights, the abyssal height of the compound progradation profile (with respect to model origin (0, 0)), and haggrade(i) can all vary within a time interval in two different ways:

(1) the user can specify initial bathymetric levels for h0_1(i), h0_2(i), hinf(i) and haggrade(i) which are used as references in calculating h0_t_1, h0_t_2 , hinf_t and haggrade_t (OR)

(2) the user can specify 4 sets of surface nodes. The current elevations at these nodes are used by the model as reference heights for calculating h0_t_1, h0_t_2, hinf_t and haggrade_t.

As in progradation model 12, progradation model 13 allows the user to define sedimentation profiles that are sensitive to the evolving regional bathymetry in a model.

Progradation model 12 has two or three lines of input parameters depending on the value of sed_reflev_flag(i) (see below)

If sed_reflev_flag(i) = 0, then the sedimentation profile is calculated as mentioned in (1) above. There are two lines of input parameters in the Sopale Nested input file.

If sed_reflev_flag(i) = 1, then the sedimentation profile is calculated as mentioned in (2) above. There are three lines of input parameters in the Sopale Nested input file.

The inputs are as follows:

tprograde(i), h0_1(i), hinf(i), x0_1(i), prograde_length_1(i), vprograde_1(i), haggrade(i), vaggrade(i), h0_2(i),x0_2(i),prograde_length_2(i), vprograde_2(i), sinus_wavelength(i), sinus_amplitude(i), sinus_trans_vel(i), sinus_taperlength1(i), sinus_taperlength2(i), sinus_taperstart(i), sinus_taperend(i), vh0_1(i), vhinf(i), vh0_2(i)

[†New parameter for progradation model 13; otherwise parameters have the same definition as those in progradation model 12. For completeness, all parameters are listed.]

tprograde(i)
(REAL *8)

> = model time (in seconds) at which the profile is determined using the input values. For example, at t = tprograde(i), x0t_1 = x0_1(i) and in subsequent timesteps is modified based on the value of vprograde_1(i).

†h0_1(i)
(REAL *8)

> = surface height at x.le.x0_1(i) (metres). This is equivalent to h0(i) in progradation model 12

hinf(i)
(REAL *8)

> = limit of surface height at x.eq.infinity (metres) from half-Gaussian on the left, and x.eq.-infinity (metres) from the half-Gaussian on the right. Note that hinf is the same for each half-Gaussian profile to ensure a continuous profile (i.e., they connect in the middle at the same vertical position).

†x0_1(i)
(REAL *8)

> = initial x position where the left-side half-Gaussian part of the profile starts (metres). At t = tprograde(i), x0t_1 = x0_1(i)

†prograde_length_1(i)
(REAL *8)

> = Gaussian width of the left-side profile as defined above (metres)

†vprograde_1(i)
(REAL *8)

= progradation velocity (m/s) velocity at which the left-side progradation function moves in positive x direction (0.317097d-9 = 0.01m/year). Negative values give retrogradation of the profile but do not result in erosion of sediments above the profile.

haggrade(i)
(REAL *8)

= base level for aggradation (metres). Note that there is only one aggradation calculation in progradation model 13 even though there are two (left and right) half-Gaussian profiles. This is done to ensure that the resulting compound surface is continuous.

vaggrade(i)
(REAL *8)

= aggradation velocity (m/s) which is uniform for all x velocities at which sediments aggrade (0.317097d-9 = 0.01m/year). Negative values give degradation of the profile but do not result in erosion of sediments above the profile.

†h0_2(i)
(REAL *8)

= surface height at x.ge.x0_2(i) (metres).

†x0_2(i)
(REAL *8)

= initial x position where the right-side half-Gaussian part of the profile starts to decrease from h0_2 to hinf, from right to left (metres). At t = tprograde(i), x0t_2 = x0_2(i)

†prograde_length_2(i)
(REAL *8)

= Gaussian width of the right-side profile as defined above (metres)

†vprograde_2(i)
(REAL *8)

= progradation velocity (m/s) velocity at which the right-side progradation function moves in positive x direction (0.317097d-9 = 0.01m/year). Negative values result in progradation from right to left, the intended use. In this case, positive values give retrogradation of the profile but do not result in erosion of sediments above the profile.

sinus_wavelength(i)
(REAL *8)

= the wavelength of the desired sinusoidal modulation (metres)

sinus_amplitude(i)
(REAL *8)

= the amplitude of the desired sinusoidal modulation (will result in bathymetric changes of twice the amplitude) (metres)

sinus_trans_vel(i)
(REAL *8)

= translational velocity of the sinusoidal modulation (metres/second). The sinusoid wave train moves at this velocity.

sinus_taperlength1(i)
(REAL *8)

= the length over which the sinusoidal modulation will taper out (linearly) at left end (metres)

sinus_taperlength2(i)
(REAL *8)

= the length over which the sinusoidal modulation will taper out (linearly) at right end (metres)

sinus_taperstart(i)
(REAL *8)

= position of left taper, where modulation first reaches full amplitude (metres)

sinus_taperend(i)
(REAL *8)

= position of right taper, where modulation reaches last full amplitude (metres)

†vh0_1(i)
(REAL *8)

= vertical velocity at which h0_1(i) is moved to h0_t_1 (metres/second) in each time step of duration 'dt' according to

h0_t_1 = h0_1(i) + vh0_1(i)*dt

This applies to the left-side of the profile (shelf) and is the same as vh0 in progradation model 12.

hinf(i)
(REAL *8)

= vertical velocity at which hinf(i) is moved to hinf_t (metres/second) in each time step of duration 'dt' according to
hinf_t = hinf(i) + vhinf(i)*dt

†vh0_2(i)
(REAL *8)

= vertical velocity at which h0_2(i) is moved to h0_t_2 (metres/second) in each time step of duration 'dt' according to

h0_t_2 = h0_2(i) + vh0_2(i)*dt

This applies to the right-side of the profile (shelf).

sed_reflev_flag(i) (specified on a separate line)
(INTEGER *4)

= 0
h0_t_1, h0_t_2, and hinf_t are calculated according to the formula discussed above. No additional inputs are required.

= 1,

h0_t_1, h0_t_2, and hinf_t are calculated by averaging the surface elevations at nodes specified by the user. Additional inputs are required. These inputs are specified on a separate line by itself and are as follows:

shelf_start_node_1(i), width1_1(i), abyssal_start_node(i), width2(i), haggrade_start_node(i), width3(i), offset_h0_1(i), offset_hinf(i), offset_haggrade(i), shelf_start_node_2(i), width1_2(i), offset_h0_2(i)

†shelf_start_node_1(i)
(INTEGER *4)

= reference surface node number whose y position is used in calculating the average left-side shelf height (shelf_height_avg_1). This is used in calculating h0_t_1 for the left-side half-Gaussian progradation profile based on current model surface (i.e., not a user specified bathymetry)

†widht1_1(i)
(INTEGER *4)

= number of surface nodes to the right of to shelf_start_node_1(i) to be used for surface elevation averaging

For example, if shelf_start_node_1(i) = 2 and width1_1(i) = 2, then the bathymetry at surface nodes 2, 3, 4 will be averaged to get an average left-side shelf height (shelf_height_avg_1)

abyssal_start_node(i)
(INTEGER *4)

= starting surface node number used in averaging the abyssal height. This is used in calculating hinf_t of the progradation profile based on current model surface (ie., not a user specified bathymetry)

width2(i)
(INTEGER *4)

= number of surface nodes to the right of to abyssal_start_node(i) to be used in calculating the average abyssal surface height (abyssal_height_avg)

Bathymetry at nodes abyssal_start_node(i) to (abyssal_start_node(i)+width2(i)) will be averaged to calculate the average abyssal height (abyssal_height_avg). This will be used in calculating the abyssal height for the half-Gaussian progradation profile.

haggrade_start_node(i)
(REAL*8)

= starting surface node number used in determining the bathymetry for aggradation, haggrade_t.

width3(i)
(INTEGER *4)

= number of surface nodes to the right of to haggrade_start_node(i) to be used in calculating the average base level for aggradation (haggrade_avg)

†offset_h0_1(i)
(REAL*8)

= vertical offset applied to h0_t_1 calculated using shelf_start_node_1(i) and width1_1(i)

offset_hinf(i)
(REAL*8)

= vertical offset applied to hinf_t calculated using abyssal_start_node(i) and width2(i)

offset_haggrade(i)
(REAL*8)

= vertical offset applied to haggrade_t calculated using haggrade_start_node(i) and width3(i)

†shelf_start_node_2(i)
(INTEGER *4)

= reference surface node number whose y position is used in calculating the average right-side shelf height (shelf_height_avg_2). This is used in calculating h0_t_2 for the right-side half-Gaussian progradation profile based on current model surface (i.e., not a user specified bathymetry)

†widht1_2(i)
(INTEGER *4)

= number of surface nodes to the right of to shelf_start_node_2(i) to be used for surface elevation averaging

†offset_h0_2(i)
(REAL*8)

= vertical offset applied to h0_t_2 calculated using shelf_start_node_2(i) and width1_2(i)

The offsets are applied in each time step of duration ‘dt’ as follows:

h0_t_1 = shelf_height_avg_1 + vh0_1(i)*dt + offset_h0_1(i)
h0_t_2 = shelf_height_avg_2 + vh0_2(i)*dt + offset_h0_2(i)
hinf_t = abyssal_height_avg + vhinf(i)*dt + offset_hinf(i)

haggrade_t = haggrade_avg + vaggrade(i)*dt + offset_haggrade(i)

h0_t_1, h0_t_2 , hinf_t, x0t_1, x0t_2, prograde_length_1(i), and prograde_length_2(i) are used to define a new compound half-Gaussian progradation profile, with left- and right-side components, in each time step. Similarly haggrade_t is the new bathymetric level for aggradation (Fig. 3).

Note: Sinusoidal perturbations are added after obtaining the sedimentation profile from both the left and right half-Gaussian progradation profiles and haggrade(i).