A Primary Productivity Algorithm for SLAMM

Gary L Brown

Research Hydraulic Engineer

ERDC-CHL

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The following document details the primary productivity algorithm that has been developed for implementation into SLAMM. As per the suggestion of the SLAMM developers, this algorithm has only been implemented as a stand-alone FORTRAN code. The implementation into SLAMM is to be performed by the developers, so that they can implement it in a manner consistent with their overarching code management philosophy.

Primary Productivity

For the purposes of this algorithm, primary productivity refers only to wetland vegetation. It includes both above ground and below ground production. Both mechanisms are lumped into a general organic production term, which in turn is used to modify bed elevation.

Source Material

This algorithm is based on the relative elevation sub-model presented in the following source:

> Couvillion, Brady, R, Gregory D. Steyer, Hongqing Wang, Holly J. Beck, and John M. Rybczyk (2013). "Forecasting the Effects of Coastal Protection and Restoration Projects on Wetland Morphology in Coastal Louisiana under Multiple Environmental Uncertainty Scenarios" *Journal of Coastal Research: Special Issue 67 - Louisiana's 2012 Coastal Master Plan Technical Analysis: 29-50. 2013*

The algorithm includes both primary productivity and marsh collapse.

Algorithm Basics

The algorithm is intended to be a simple, general algorithm that can be populated with observed and/or theoretical spatially varying parameters. It allows the user to specify these inputs. This allows the user to subject the inputs to Monte Carlo sampling, so that uncertainty analyses can be conducted appropriately.

Note that future implementations could invoke look-up tables for some of the parameters, but these tables must be designed such that Monte-Carlo sampling can be conducted using the information in the table.

The input parameters are given as follows. All inputs are expected in consistent units.

- Mineral sediment flux (M L^{-2} T^{-1})
- Soil Bulk Density (M L^{-3})
- Organic Content Fraction at Equilibrium
- Marsh Collapse Depth (L)

Using these parameters, the algorithm computes an updated bed elevation. The updated bed elevation is based on the assumption that mineral sediment flux is in equilibrium with the organic flux (from primary productivity) and hence both contribute to the change in bed elevation. If the marsh collapse threshold is violated, the organic flux is set to 0 (i.e. primary production ceases).

Figure 1 depicts an example of the algorithm responding to an accelerating sea level rise. In this example, there is zero subsidence: hence, eustatic sea level rise is the only stress. Initially, the marsh is growing, and the depth is decreasing. However, as sea level rise accelerates, the depth increases until the threshold criterion is met (in this case, 0.2 meters). At this point, organic production ceases, the bed elevation increase decelerates, and the depth of inundation accelerates.

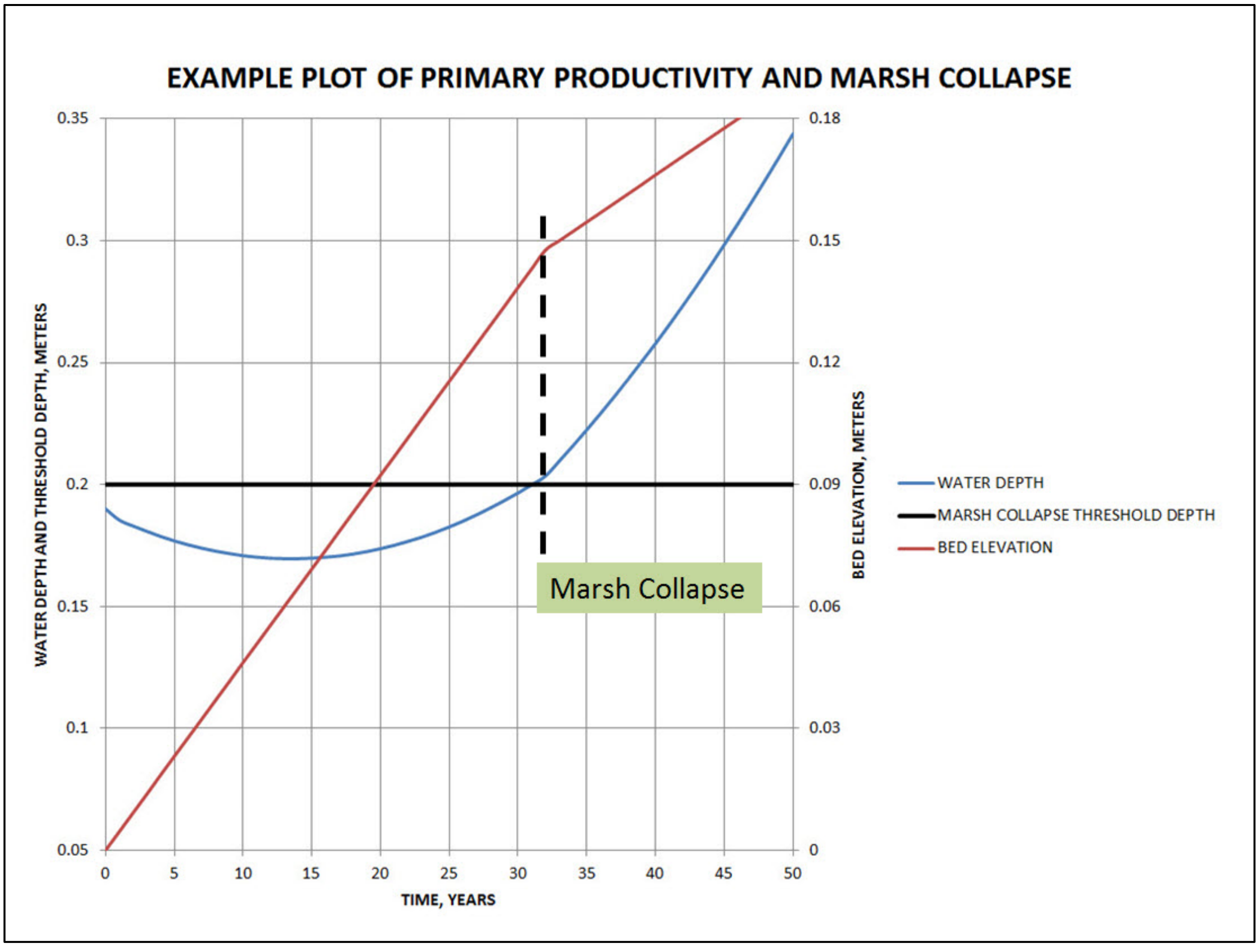

Figure 1: Example of Primary Productivity Algorithm With Marsh Collapse Due to Accelerating Sea Level Rise

Notes on Implementation

Currently in SLAMM, the mineral sediment flux is applied in units of $L\ T^{-1}$. This means that the bulk density of the sediment bed is implicit in the estimated deposition rate. In order to implement this algorithm into SLAMM, it will be necessary to convert the mineral sediment flux into mass units, and to include the marsh bulk density as an additional input parameter.

Each of the inputs given above can be assigned as single valued inputs, or as spatially varying inputs. Research is ongoing (some of it contained in the paper referenced here) to populate these parameters that are appropriate for specific marsh types. But project specific data are always preferable if they are available.

The marsh collapse threshold depth is a function of species, location, and salinity. Again, some of these data are given in the reference paper. However, a specific algorithm or look-up table for the collapse threshold depth as a function of these parameters is omitted from the primary productivity algorithm, because such an implementation would not allow for an independent perturbation of the marsh collapse threshold depth in a Monte Carlo analysis.