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Geoscientific Model Development Discussions
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Interactive comment on "CoastalME version 1.0: a Coastal Modelling Environment for simulating decadal to centennial morphological changes" *by* Andrés Payo et al.

Anonymous Referee #1

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Referee Comments

General comments

This paper describes a large scale coastal behavioural model intended to allow simulation and forecast of evolution in coastal features over decades for the purposes of coastal management. The model will eventually include various modules representing natural processes and human intervention on a range of coastal features, including cliffs, beaches, inlets, and estuaries, but only beaches and cliffs are represented in the present version.

The paper does not attempt to validate the model against observations; the authors

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Discussion paper

have explicitly left that task to another paper. Instead, the paper describes the model philosophy and framework, and provides some mechanistic details and results of two test cases.

Sediment-transport models represent processes with a mix of fundamental physics, empiricism, and heuristics. Physics in CoastalME is limited to conservation of mass and wave energy. Empirical formulae are used for longshore transport, and heuristic models are used to represent the beach shape (Dean profiles) and vertical distribution of erosion rates (f1) on cliff faces. The equations for longshore transport rate, beach profiles, and cliff erosion depend on calibration coefficients including Kls, A, R, and the profile f1. These coefficients do not have universal values, but depend on grain-size distributions, assumptions about underlying stratigraphy, rock properties, wave climate, and other site-specific variables that might evolve over time. In addition, CoastalME depends on a number of user-specified parameters that are likely to change results, including the raster cell size, the spacing of shore-normal profiles, the selection of closure depth, timing of cliff collapse, the distribution and relative erodibility of non-cohesive sediment, the depth to non-erodible basement, and others.

The paper uses mostly prose, rather than equations or diagrams, to portray the model mechanics. This makes some of the sections long, sometimes confusing, and ultimately not sufficiently informative. Said another way, it would not be possible to reproduce the model structure or even the fundamental grid / profile / polygon geometry based on this description. Some well-designed diagrams with formulae showing how profiles relate to the raster grid would be helpful. Several of the figures describe aspects of other models, and they could be removed and replaced with diagrams specific to CoastalME.

The authors argue that CoastalME provides an alternative object-oriented approach that combines advantages of both raster-based and vector based structures. The model is a work in progress, and the potential for coupling more landscape objects remains to be achieved. The advantages of the raster-vector combination are not readily apparent in the two cases presented, and the approach seems to require a lot of iteration and smoothing. Overall, the present model formulation does not appear to be usable for the purpose of informing coastal management, and the paper does only a fair job of describing the model.

The authors deserve great credit for providing open-source code. The model is easy to find on github, and builds easily on Linux. The same is true for SCAPE. The code is well commented and documented with Doxygen. However, I could not fine input files to run a demo cases.

Specific comments

p7 l8 I do not agree that the "most general" way to account for sediment is in a 2DH grid. Maybe you mean "most common". p8 I do not agree with the argument that small cells are required by fast-moving information. Small cells improve resolution, especially of sharp fronts, as long as numerical diffusion is limited. Note that CFL constraints apply to explicit formulations; time steps can be greater than CFL with implicit formulations.

Section 3.1 l17 says the model preferentially locates profiles on capes, but this does not appear to be the case in Fig 9 or Fig 10. As mentioned below, a figure showing how raster cells are associated with profiles and sediment fluxes would be helpful. Does the random spacing of profile change the results? What artefacts are being avoided by doing this?

Section 3.2 If I understand this correctly, wave properties are calculated for each cell, based on properties of the seaward cell, which accounts for local refraction and breaking. I don't think this method conserves global wave energy and allows it to be focused on regions of converging wave-propagation rays (ie., headlands) or away from bays. I think this is evident in Fig 10, where it appears that wave energy is not concentrated on the tips of the cusps. COVE uses an approach to decrease wave energy in shadow zones (but not, as far as I can tell, to concentrate energy on headlands) but this is not yet implemented in CoastalME. In keeping with the modular approach to CoastalME, it seems like a raster-based wave model like SWAN could be used here.

Section 3.3

Eqns 4 and 5 are bulk transport equations calibrated to the median grain size. It is not clear that they should be applied separately to fractions of the unconsolidated sediment, or what the coefficients would be in that application.

The description of sediment flux and net erosion or deposition is confusing and could be improved with a figure and/or equations (e.g., the discrete version of Eqn. 3, with f defined). It is not clear where the fluxes are located (at profiles or between them) and whether the supply-limited contribution from an eroding cell is ameliorated by contributions to that cell from upstream. It is also not clear how the varying sizes of the polygons are accounted for in f(dQ/ds), because the relationship between dn/dt and elevation changes (or displacement of Dean profiles) depends on the varying polygon areas (or profile lengths). The text at the bottom of p.18 tries to explain how this is done, but does not mention polygon area, and indicates that erosion or deposition is accommodated by changing the profiles at polygon edges, rather than over the entire polygon. It is difficult to see how this can be done in a consistent way that conserves mass, adjusts profiles as grain size changes, and does not produce unrealistic discontinuities. The authors state that two profiles could merge if they if they intersect offshore, and on p19, l13, they indicate that sediment flux is pro-rated according to the shared length of the boundaries. This has the potential transporting sediment among polygons that mate only at depth, bypassing a shallower polygon, which seems unrealistic.

All of this sounds very iterative and ad hoc, but maybe some diagrammed examples would clarify the process.

p. 19 l24-27. Smoothing the grid is a diffusive procedure, as is smoothing the coastline.

Section 3.4

Most modelers use the term periodic, rather than “mobius”, to refer to boundary conditions that feed output from one boundary back into the model at the opposite boundary.

Section 3.5

I have not seen an equation for f1 in either this paper or the SCAPE papers I have read. It seems like an interesting heuristic approach, and it would be helpful if the curve of f1 derived from Fig 5b in Walkden and Hall (2005) was specified.

This section describes the cliff erosion process with the prose approach that could be improved with a figure showing how the Dean profile is applied.

References

A few of the references refer to ephemeral sites like Wikipedia that don't always serve as a reliable citation. No DOIs are provided.

Following references are incomplete: Hutton 2014 Payo 2014 Stive 1997 Terwindt, 1990 van Rijn, 2002 Walkden, 2015

Fig. 1 This could be omitted or replaced with a figure that represent the geometry of CoastalME. Fig. 2. This could be omitted or replaced with a similar figure that represents the processes in CoastalME. Fig 3. This could be omitted. Fig 4. This is a key figure that could be improved. One flaw is that it shows profile changes at the depth of closure...I would assume that no changes should occur at or seaward of this depth. A zoomed in figure that shows the relationship between the raster cells, the boxy coastline found byt tracing the raster, the smoothed version of the coastline, the projection of the shore-normal profiles, and the raster cells associated with each profile that "share" sediment with adjacent profiles. Fig 6. This could be omitted. The directional convention is a level of detail needed to make input files, but not to describe the model. Fig 7. This figure could be eliminated. Text in Section 2.3 covers this in better detail. Fig 8. This figure is illegible. It might be useful in a developers guide, but this paper does not deal with the object structure in detail. It could be eliminated. Fig 9. Why are the profiles not parallel in panel b? Why is the spacing so variable in all panels? Why are there no profiles on the capes in panel d? Can this figure be used to show the association with the raster grid and the polygonal sections? Fig 10. Same questions about profile location and spacing. In addition, the distribution of wave energy does not look right. Wave heights should be highest on the headlands, especially in the 270 deg. case. Fig. 11. This is a good figure. A similar figure showing how the sediment is redistributed to make a Dean profile would be helpful.

Technical corrections Eqn. 1. Missing g in denominator of second term on right Eqn. 4. Kls is not defined. Eqn. 5. the coefficient 2.33 assumes seawater density of 1030 kg/m3 (van Rijn, 2005), not the value of 1025 kg/m3 specified on l16. Eqn. 6. the dimensions in this equation don't work out...the right side has dimensions of m-2 s-1...so volume transport per meter width. It might be good to define immersed weight transport and show the relationships between I, volume transport, and mass trasport. Eqn. 8. The slope should be dzs/dys or tan(alpha), but not tan(dzs/dys). Eqn. 9. Same comment.

Typos p2 l20 pool of well-understood open-access models... p4 l4 models (Murray... p4 l27 Volumetric model(s) represent . . . p5 l5 COVE is inspired by the Coastal Evolution Model. . . p6 l11...geometrically constrained by human interventions p7 l3 Sediment is stored as . . . or in suspension p7 l9 last phrase does not seem to make sense p8 l17 Lewy Condition p25, l4 all three

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