**Coast Line Evolution**

**(Student version)**

*Contributed by Fei Xing and Irina Overeem, CSDMS*

1. **Introduction**

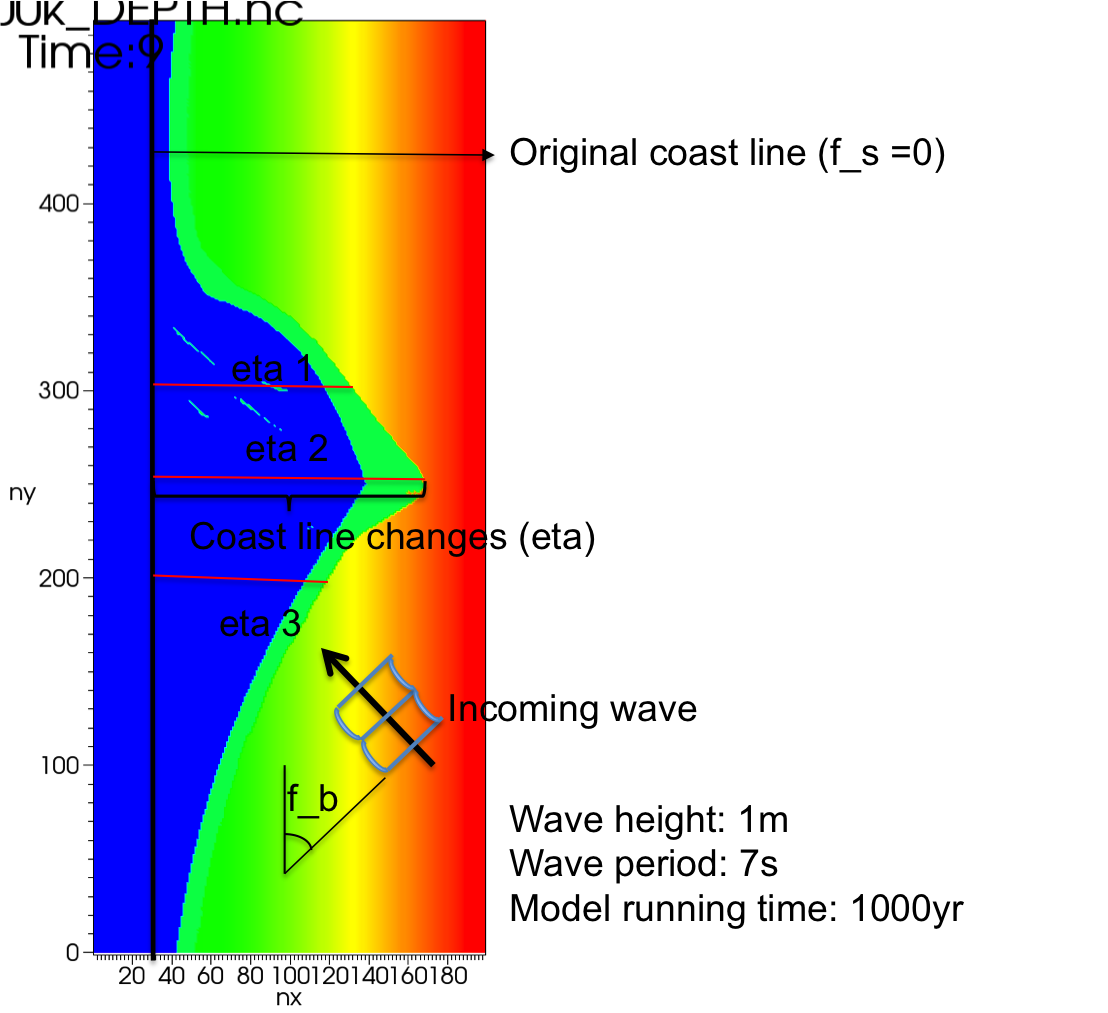
Coasts are often highly scenic and contain abundant natural resources. The majority of the world’s population lives close to the sea. It has been estimated that about 3 billion people (50%) live within 60km of the world’s shorelines. The original development of urbanized societies was associated with deltaic plains in semi-arid areas, and the first cities appeared shortly after the geomorphological evolution of these plains (Day et al., 2007). The coast plays an important role in global transportation, and is a major tourist destination.

The shoreline is where the land meets the sea, and its location and morphology is continually changing under the influence of changing environmental conditions. Coastal scientists have attempted to understand the shoreline in relation to the processes that shape it, and interrelationships with the adjacent shallow marine and terrestrial hinterland environments. Explaining the geomorphological changes that are occurring on the coast is becoming increasingly important in order to manage coastal resources in a sustainable way even when sea level is rising or wind and ocean conditions are changing.

**2 Model Approach**

Here, we focus on sandy, wave-dominated coastlines on time-scales ranging from years to millennia and on a spatial scale ranging from kilometers to hundreds of kilometers. Shoreline evolution results from gradients in wave-driven alongshore sediment transport. We use a 'one-line' modeling approach, where the cross-shore dimension is collapsed into a single data point. We calculate the coastline evolution with different ocean dynamics, mainly wave dynamics. The following figure shows the main output parameters; including the amount of sediment transported alongshore (Qs), the alongshore current (Sxy), and the shoreline position changes (eta).

Controlling parameters are sediment input (e.g. sediment from the river in Figure 1), and wave climate. Wave climate includes parameters like wave height, wave period, wave angle with the coastline, and breaking wave height, which is the critical height at which waves collapse. In the spreadsheet CoastLineEvolution\_practise.xls, it shows the equations to calculate Qs, eta, and Sxy.



One model that can model coastline evolution processes more elaborately is CEM. The Coastline Evolution Model (CEM). More detailed information on CEM can be found on this website: (http://csdms.colorado.edu/wiki/Model:CEM)

Related literature:

Ashton A.D. and Murray A.B., 2006a. High-angle wave instability and emergent shoreline shapes: 1. Modeling of sand waves, flying spits, and capes. Journal of Geophysical Research,111, F04011, 19pp. Doi: 10.1029/2005JF000422

Ashton A.D., and Murray A.B., 2006b. High-angle wave instability and emergent shoreline shapes: 2. Wave climate analysis and comparisons to nature. Journal of Geophysical Research,111, F04012, 17pp. Doi: 10.1029/2005JF000423

**3 Questions**

*Question 1*

*A coast is the transitional zone between land and ocean, which factors do you think will influence its evolution? (Hint: deltas are build of sediment, think about which factors control the amount of available sediment amount and transporting agents)*

*Question 2*

*2A Transport of sediment alongshore is determined by alongshore currents, which results of wave activity. Waves induce a radiation stress in the alongshore direction, which then drives the alongshore current.*

*Worksheet ‘Sxy’ in your spreadsheet allows calculation of alongshore currents. Which are the main factors that determine the Sxy and why? What happens to the alongshore current if wave height increase? How about wave angle, at what angle will we get the maximum alongshore current (Hint: attain this through plotting a graph of Sxy as a function of wave angle)?*

*2B Your workheet ‘Qs’ shows the equations for calculation of alongshore sediment flux. What happens to Qs when wave height increase? How much would the range of wave heights in the United States be today? (http://www.intellicast.com/Travel/Weather/Marine/Waves.aspx)*

*Plot a graph of Qs as a function of wave height, and pay attention to the wave height ranges (Hint: use the range for US today, or for a major hurricane).*

*2C What happens to Qs when the wave period increases? Plot a graph of Qs as a function of wave height, and pay attention to the wave period ranges (see the following figure, we are looking at wind-driven waves). Compare the difference of trend with the relationship between Qs and wave height.*

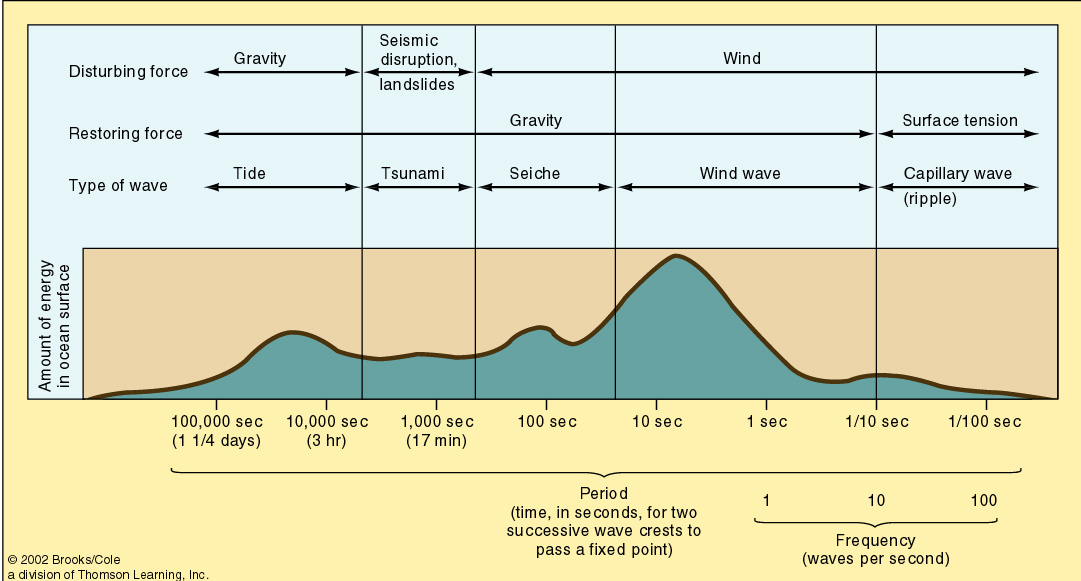


Figure 2 Ranges of wave periods

*2D What happens to Qs when the breaking wave height increase? Plot a graph of Qs as a function of breaking wave height. Notice that breaking wave height depends on water depth, waves will break when waterdepths are smaller that 1/7 of wave height. Will Qs be larger in shallow water, or in deep water?*

*2E What happens to Qs when the angle of incoming wave and shoreline changes? Plot a graph of Qs as a function of wave angle; what will happen if wave angle is 0, or 90°? When will Qs get its maximum?*

*Question 3*

*Worksheet ‘eta’ shows the equation to calculate coastline changes with time, what are the factors that determine the value of eta? Try to formulate a hypothesis on how the different factors will work and why. Subsequently plot the graph of eta as a function of these factors and describe the relationships.*

*Question 4*

*Consider a delta system that has archieved an equilibrium status, which means that the incoming sediment is the same as that eroded by ocean dynamics (for example,* wave *activities). What will happen if a dam is constructed in the basin, which greatly decrease the sediment flux to the delta? Can you give an example? What would happen when the storm frequency increases because of global warming?*

**4 References**

Komar, P.D., 1998. The Generation of Waves and Their Movement Across the Sea in Beach Processes and Sedimentation (Second Edition), 160~168.

Komar, P.D., 1998. Wave-Generated Currents in the Nearshore Sea in Beach Processes and Sedimentation (Second Edition), 336~365.

Anderson, R.S. and Anderson S.P., Geomorphology: The mechanics and Chemistry of Landscapes. P512~514.