CSDMS Breakout session on Delta Morphodynamics

10/14/10

NOTES:

JAMES: Some of the basic understandings of the coastline are incorrect. E.g. modern sea level rise is not uniform, in reality it is spotty because of the geostrophic currents amplifying sea level rise in certain places. Countries are spending billions on storm surge protection. In some instances storm surges do not 'feel' the vegetation as opposed to the common belief that vegetation attenuates the surge. These are a few examples of misconceptions and highlight that there are many areas in which we can make an impact.

SHORT TO MEDIUM TERM GOAL: develop a delta modeling system that incorporates different couplings. What are the basic portions of the delta system? What are the necessary components?

1. Upland River
   a. Controls delivery of sediment, which is influenced by floodplain storage/exchange, and water
   b. Could be parameterized by a single boundary condition rather than resolving it
2. Deltaic portion of the river
   a. Morphodynamic feedbacks, couplings between fluvial, wetlands, and coastal environments
   b. floodplains
3. Coastal/ocean basin
   a. Eustatic sea level rise
   b. Subsidence, relative sea level (local and regional)

What is the time scale of interest? Years to centuries are concerned with human intervention (engineering), etc and millennia and longer refer to self formed deltaic landscapes and building of continental shelf (geologic).

The fault of the engineering scale is that they haven't looked at a long term model to understand what straight jacketing levees will do and how that might change delta morphodynamics. Engineering scale is based on short term models. There is no sense of the accumulated effect.

We need a suite of models that bridges the gap between the 10^2 yr and 10^4 yr time and 10^1 km^2 and 10^3 km^2 spatial scales.

This could be done with different grid scales (a la ROMS). The hierarchy could bridge the scales. And could be done with a number of model widgets that can be combined into a suite of models that can simulate long term delta behavior. Some widgets need to have the same time step as what it is feeding into.

MEDIUM TERM GOAL: What kind of observational data is needed to verify the results? Provide verification data so users can see what different scenarios the model has been verified for. There is a lot of data on network topology that can be used and there are series of serial imagery documenting delta evolution that can be used as a comparison. We should also take advantage of reservoirs with deltas. There is a ~100 yr time scale that we can exploit to see how deltas evolve and use that to verify simulations. We need to verify these delta simulations at large and small scales. What delta morphology metrics are sensitive indicators that can be used to verify models?

LONG TERM GOAL: Putting the human dynamics and the processes/decision making that affect these things in our model. What scale of human decision making do we include? Chemical, water quality, flooding risk, wetland restoration? This can be done with a user changing boundary conditions (e.g. resolving climate change by simply changing Q) or with a decision making model that dynamically changes boundary conditions based on the growth of the delta. Small to medium dams are filling with sediment and are creating hazard. This raises an important question: *For instance, what will happen to delta shape, size, and elevations under different scenarios of sea level rise and human manipulations as dams are removed and sediment flux is restored to a pre-dam level?*

We need to incorporate the mud into the delta simulations. WLD is storing ~30% of the mud that is coming in whereas the LaFourche lobe is storing ~50% of the mud.

What types of models are needed to recognize these goals?

Hierarchical scale that includes multiple time scales. Certain models fit into certain time/spatial scales and decision making can be added. Model components need to be able to adapt to these different time/spatial scales.

We need to couple between different processes, e.g. nearshore sediment transport model coupled with delta evolution coupled with upstream floodplain evolution. Modeling fluvial channel evolution as a diffusional process, coupled with a floodplain model (determines relative agg. rates and avulsions), coupled with a nearshore coastal model. In this context, coupling doesn't actually mean the simultaneous solution of all the equations. Really we mean feedbacks, not coupling.

CSDMS Breakout session II on Delta Morphodynamics

10/15/10

We need a list of steps that will lead to the different goals both over the short and long term. This group will most effectively build a large model(s) with multiple components. We need to make a statement about what model(s) are needed in the next five years to provide a visible document to NSF.

One approach is to develop a series of models that start from broad brush, big picture simulations that predict macro features and move to more detailed simulations with different models that predict finer scale features (i.e. from delta scale to channel scale).

To make CSDMS work, plans and proposals need to be submitted that utilize multiple models in the spirit of CMT. These models may exist or may need to be built.

One potential avenue for investigation is using Delft3D as a platform. Is this the right platform? What else exists? Competitors?

We may not want to limit ourselves to one platform, because, for instance, if one is interested in lobe switching scale a platform other than D3D would be needed.

Perhaps we need two modeling approaches: process-based solving primitive equations vs. rule based, synthetic. One model/platform may not suit all of our needs.

<u>What models do we need??</u>

MODELS FOR UPSTREAM BOUNDARY CONDITIONS (primarily supply Qs): HYDROTREND, CHILD (long time scale), HSPF, AGNSP.

MODELS FOR DELTAIC DYNAMICS: Delft3D, 1D long profile diffusion of fluvial channels, avulsion rules (Mohrig superelevation, SEDFLUX), EFDC , cellular delta models (Man Liang/paola/voller, Seybold).

MODELS FOR COASTLINE PROCESSES: CEM, Delft3D, ROMS, ADCIRC (lots of physics), SLOSH (fast storm surge model), models for subaqueous profiles, models for hyper/hypo flows, Coastal modeling system (CMS), XBEACH, GEOMBEST

MODELS FOR PRODELTA: Winterweerp, Deflt3D, Swenson

MODELS FOR WETLAND EVOLUTION: Jim Morris model, Matt Kirwan model of marsh accretion, Sergio Fagherazzi

MODELS FOR FLOODPLAIN EVOLUTION/DEPOSITION: Washload as floodplain material load (Viparelli Model), Exponential rule of floodplain deposition,

MODELS FOR RELATIVE SEA LEVEL CHANGE: both dynamic and static, SUBSIDE, compaction, eustatic sea level rise

GAPS:

1. models for large scale delta evolution at a time and spatial scale larger/longer than network development. Perhaps combine Kim model with avulsion rules?
2. The study of lakes and their formation within deltas and floodplains is poorly understood. How do they fill in and change with time? Do we have a model for their formation?
3. Megacities and the related subsidence
4. Models for human manipulation (long term goal) that can be dynamic or scenario based
    a. They protect levees
    b. Alter hydrographs, sediment supply, discharge
    c. Construct canals
    d. Construct diversion
    e. Land use upstream (damn dams)
    f. Subsidence (anthropogenic) : extraction, infrastructure
    g. Coastal protection
5. Freshwater marsh evolution, swamps (part of the floodplain)
6. Model integration tools (CMT)
7. What is model uncertainty? What observation sets can we use to compare and test model runs?
8. Any model should include a widget for grain size tracking through deltaic systems. Need capabilities for both the surface and subsurface. What to do with mud?
9. Vegetation and sedimentation, ecomorph dynamics

<u>What are the scientific objectives/questions for the CSDMS five year plan?</u>

1. *What are the fundamental controls on delta size, shape, and elevations?*
    a. *What controls the extent of wetland development in deltaic settings?*
2. *How are those controls modified under different scenarios of sea level rise and human manipulations (e.g. as dams are removed and sediment flux is restored to a pre-dam level)?*
3. *How do coastal sediment redistribution properties interact with fluvial properties (e.g. avulsion)?*
4. *What effects do extreme climate events have on delta geomorphology?*
5. *What are the characteristic time scales of delta location adjustment to external forcings?*
6. *How does the transition between deltas and estuaries occur?*

<u>What are our short, medium, and long-term plans?</u>

SHORT TERM: sedflux model, with diffusional river rules, coupled to CEM.

MEDIUM TERM: More detailed models that can be used on short time and spatial scales. Observational datasets.

LONG TERM: complementary efforts with other models and approaches