Ocean Sciences

OS21A WCC: 25 Tuesday 0830h

Physical Processes in Salt Marshes and Barrier Islands

Presiding: **S Fagherazzi,** University of Virginia**; T Sun,** Florida State University

OS21A-01 0830h

Retrospective and Prospective of our Current Modeling Effort on the Initiation and the Development of Tidal Channels

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Tidal channels are one of the most common and prominent geomorphic features on salt marshes. Because of their much smaller resistance to water flow compared with that of the densely vegetated marsh area, well developed tidal channels often function as arteries and carry significant amount of water as well as sediments during both the flood and ebb period of salt marshes hydraulic cycle. Therefore features of tidal channels, such as their drainage densities, overall network structures and spatial distributions, as well as the geometries of individual channels, determine to a very large degree, the overall hydrology of the salt marshes, and consequently, the ecology of the salt marshes.

Recently, a simple model has been developed focusing on the initiation as well as the evolution and development of tidal channels. Despite the simplicity of the model, many important features of the tidal channels development, such as the well known fact of the rapid growth and extension of the channel networks in the young and fresh marshes, and the subsequent retreat and reduction of channel networks in the mature and old marshes, have all been faithfully reproduced. The effort has also been made to delineate the relative effect of different hydraulic parameters, such the local marsh elevation, tidal range, and the flow resistance coefficient of the salt marsh vegetation, in terms of their importance to the equilibrium value of the tidal channel drainage density.

The model is entirely built from the physical perspective of the salt marsh environment, namely the biological components has been compressed and simplified to two parameters, which are the vegetation encroachment rate and the flow resistant coefficient. The model can however be extended to include many key ingredient of the bio-geo-chemical interactions. The current model does provide a framework for future development of much more sophisticateds models that can capture the essencial bio-geo-complex processes of salt marshes.

OS21A-02 0845h INVITED

Riparian vegetation controls on channels formed in non-cohesive sediment

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Riparian vegetation can significantly influence the morphology of a river, affecting channel geometry and flow dynamics. In channels formed in non-cohesive material, vegetation is the main source of bank cohesion and could affect the overall behavior of the river, potentially constraining the flow from a multi-thread channel to a single-thread channel. To examine the effects of riparian vegetation on streams formed in non-cohesive material, we conducted a series of physical experiments at the St. Anthony Falls Laboratory. The first set of experiments examines the effects of varying densities of vegetation on braided stream dynamics. Water discharge, sediment discharge, and grain size were held constant. For each run, we allowed a braided system to develop, then halved the discharge, and seeded the flume with alfalfa (*Medicago sativa*). After ten to fourteen days of growth, we returned the discharge to its original value and continued the run for 30-36 hours. Our results show that the influence of vegetation on the overall river pattern varied systematically with the spatial density of plant stems. The vegetation reduced the number of active channels and increased bank stability, leading to lower lateral migration rates, narrower and deeper channels, and an increase in channel relief. All these effects increased with vegetation density. Vegetation also influenced flow dynamics, increasing the variance of flow direction in the vegetated runs, and increasing scour depths through strong downwelling where the flow collided with relatively resistant banks. This oblique bank collision provides a new mechanism for producing secondary flows. We found these bank collision driven secondary flows to be more important than the classical curvature-driven mechanism in the vegetated runs. The next set of experiments examines more closely how the channel pattern evolves through time, allowing for both channel migration and successive vegetation growth. In these on-going experiments, vegetation is reseeded following repeat high flow events, simulating the natural process of vegetation encroachment on the floodplain and channel.

OS21A-03 0900h INVITED

Salt-Marsh patterns: networks and vegetation

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Salt-Marshes in tidal environments are characterised by complex patterns both in their geomorphic and ecological features. Such patterns arise through the elaboration of a network structure driven by the tidal forcing and through the interaction between hydrodynamical, geophyisical and ecological components (e.g. microphytobentos and vegetation).

The presentation will introduce experimental ad theoretical work aimed at the characterisation of network morphological features and vegetation patterns by use of direct survey, remote sensing and mathematical modelling. Tools for a complete description of network geometry will be introduced. In particular, a detailed description of meandering characteristics and branching properties by means of a simplified hydrodynamical model will be discussed. Techniques for the determination of the spatial organisation of vegetation will also be described and links to hydrodynamics and sediment circulation will be addressed.

OS21A-04 0915h INVITED

Comparative Geomorphology of Salt and Tidal Freshwater Marsh Environments

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Temperate estuaries include a spectrum of coastal marshes ranging from highly saline near the ocean to fresh in tributaries with substantial watershed drainage. While the hydrologic, sedimentary, and geomorphic dynamics of salt marshes have been thoroughly investigated, those aspects of tidal freshwater marshes have only begun to be addressed. Based on a recent burst in research on tidal freshwater systems in Chesapeake Bay by different universities, an attempt is made here to provide comparative geomorphology. In terms of similarities, both have tidal channels whose hydraulic geometry is primarily controlled by the tidal prism. Both show decreasing sedimentation and increasing organics with elevation and distance from channels. At seasonal to interannual time scales, the morphodynamics of both show similarities in the interplay among hydroperiod, vegetation, and geomorphology. Rather than simply evolving from youth to maturity, both systems exhibit strong evidence for dynamic equilibrium between process and morphology.

Despite these similarities, there are key differences that motivate further research of tidal freshwater marshes. First, whereas salt marshes are limited by sediment supply, tidal fresh ones may not be limited depending on upstream basin size. E.g., fringing marshes along Pumunkey River have very low sediment supply, while deltaic marshes in Bush River and Sassafras River are not supply-limited. Instead, the growth of deltaic fresh marshes is transport limited, as winds and tides can only generate low momentum and turbulence for sediment transport. As illustrated in multiple systems, a constant availability of sediment leads to higher sedimentation in fresh marshes. Second, in high latitude salt marshes where the tidal range is large and the climate cold, ice acts as a strong erosional agent. In fresh marshes, ice serves to sequester sediment and buffer the erosional impact of autumnal vegetation dieback. Third, the high spatial variation in plant associations in fresh marshes allows for a finer control of spatial patterns in sedimentation and erosion than is possible in salt marshes. Finally, the landscape position of fresh marshes places them near riparian forests that can supply large amounts of organics thereby promoting accretion.

URL: http://lawr.ucdavis.edu/faculty/gpast/wetlands.html

OS21A-05 0930h INVITED

Salt Marsh Transgression and Tidal Creek Development: The Role of Ecological Processes

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Salt marsh transgression into upland areas is accompanied by changes in the marsh plant community that may result from geomorphologic changes brought about by the accumulation of sediment organic matter. We hypothesize that high rates of belowground plant production in the mid-marsh zone create a topographically elevated region that traps storm-tide water in the high marsh. The trapped, standing water results in significantly lowered plant production or death and, ultimately, collapse of the peaty sediment substrate. As the unvegetated areas coalesce, they form preferred flow paths that erode, thereby extending tidal creeks into new areas of the salt marsh. Four years of data from sediment elevation tables (SETs), sediment deposition over feldspar marker layers, and organic matter accumulation measurements in three marsh zones, combined with topographic surveys, are consistent with this mechanism of state change from high marsh to low marsh.

OS21A-06 0945h INVITED

Properties of Intertidal Sediment Mobilized by Rainfall, North Inlet, SC

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The intertidal zone fringing estuaries is transitional between shallow marine and terrestrial environments. Consequently, intertidal sediment transport and topographic form results from interactions between marine and terrestrial processes. We conducted sprinkler irrigation experiments on a low tide marsh surface to determine the effects of rainfall on OM and nutrient redistribution. We irrigated 1'2 m plots in the high marsh, low marsh, and creek bank. We also flood irrigated 1'3 m plots to simulate tidal flows. Particulate matter in runoff was evaluated for density, organic matter content (OM), organic carbon (OC), and Nitrogen (N) content. The OM, OC, and N contents were consistently higher than those of the substrate. Also, particulate C/N ratios were 13-15, lower than the substrate values of 16-21. The low C/N ratios may be due to a mixed terrestrial-marine source of OM. These observations also indicate that N is mobilized preferentially over OC. Time series of OM density and C/N show a near steady response despite changes in particle density; this indicates that rainfall processes preferentially and consistently mobilize low C/N ratio OM. Estimates of rainfall driven OC fluxes represent 3-20% of annual primary productivity.

OS21A-07 1020h

Mapping of Tide and Tidal Flow Field Along a Tidal Creek With Vessel-based Observations

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Vessel-based acoustic Doppler current profilers (ADCPs) have long been used to measure only velocity profiles in numerous applications. In the present study, a vessel-towed ADCP is used to obtain data to infer both the tidal flow and tidal elevation along the

Okatee Creek, South Carolina. This is an area surrounded by extensive coverage of inter-tidal salt marsh. A small vessel towing the ADCP repeatedly occupies a 10 km track meandering through the system within a complete tidal cycle during both neap and spring tides. While the velocity profiles are used to infer relevant harmonic constants, the water depth recorded by the four beams of the ADCP is used to extract the harmonic constants of the tidal elevation as well as the mean water depth. The phase difference between tidal elevation and velocity provides a more complete picture of the tide. In our study, the phase difference is found to be about 95 degree, indicating a standing tidal wave condition. Tidal amplitude is found to have relatively small variation along the creek while the velocity amplitude decreases significantly upstream, indicating a strong frictional attenuation. Statistical analysis demonstrates that higher percentage of variabilities of elevation and velocity can be explained during spring tides than neap tides: tidal signals during spring tides are not only stronger but also “purer” or having less spread in the energy spectrum. The analysis also shows that higher percentage of variabilities are explained at the given tidal frequencies for the along channel velocity than for the cross channel velocity: the along channel velocity is “purer” than the cross channel velocity. When only a M2 and mean components are included in the harmonic analysis, about 65% and 82% of the covered area along the ship track, during neap and spring tides respectively, have “good fit” for elevation: 60% or more of the variability at a given location can be explained by the tidal and mean components. By adding the M4 component in the harmonic analysis, an additional 6% and 2% of the covered area have “good fit” for elevation for neap and spring tides, respectively. For the velocity field, similar conclusions hold except that by adding the M4 component an additional 12% of the covered area has “good fit” for the neap tide data, in contrast to an improvement of only 2% for the spring tide data. The methodology presented here can be applied in tidal creek systems and channel systems of estuarine environment to obtain high -resolution distribution of tide and velocity field and to validate fine grid numerical models.

OS21A-08 1035h

Hydrodynamic, sedimentological and morphological processes on Banzu intertidal sand-flat, Tokyo Bay, Japan

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Hydrodynamics, sediment suspension and morphological response on Banzu intertidal sand-flat in Tokyo Bay, Japan, were examined through a 6-year survey of bed levels and a short-term field measurement programme performed for 16 days in winter 2000 when fluvial discharge from the adjacent river was negligible. The results of the cross-spectral analysis show that on Banzu Flat semidiurnal or shorter-period components of the current velocity fluctuation were strongly affected by tides and waves, whereas diurnal or longer-period components were induced mostly by the wind. The short-term variation of the wave height was caused by the water depth variation due to the tide, yet the long-term variation of H1/3 fluctuated mostly in response to the variations of the water depth and the wind velocity. The topography data shows that the sandy tidal flat has a morphological process consisting of a long-term gradual accretion together with short-term episodic erosions and the following accumulations. The long-term accretion rate is estimated to be only about 3.8 cm/y on the basis of the bed profile data. However, the topography of the flat fluctuated by approximately 8 cm during the 16-day measurement when significant wave height was in excess of 0.8 m, which was relatively large for shallow waters in Tokyo Bay. Modes of bottom sediment movement during the deployment were subsequently examined using the Shields parameter; the short-term topography changes, particularly erosions, are found highly correlated with the sediment suspension. Episodic erosions occurred with high turbidity, which was caused by the combination of relatively high waves and strong ebb-tidal current, accelerated by wind blowing in the same direction between high water and mean water during ebb tide. The bed elevation appears to have risen as the wave height lowered after these erosions, resulting in short-term erosions and accretions in response to the tides. Hence, the tides and the waves have a significant influence on the hydrodynamics and associated morphological processes on the tidal flat.

OS21A-09 1050h

Observations of Tidal-Current Profiles

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This study aims to better understand the characteristics of the tidal- current profiles and the near-bed boundary layer structures off the southwestern coast of Taiwan. The velocity profile was measured by a upward-looking, broadband, 1200 KHz RDI ADCP held by a metal quadripod sitting motionlessly on the seabed. Six experiments were conducted under various experimental conditions of calm, windy or rainy weather, each lasted 10 to 30 days. In some experiments an optical backscattering sensor (OBS) was also used to measure the water turbidity or sediment concentration. The water depths of the deployment range between 15 and 18 m. The profiling range obtained was from 1.5 m to 13 m above the seabed, and was broken up into uniform segments (called velocity bins) with 0.5-m vertical spacing. Twenty-minute averaged velocity profiles have been fitted to a logarithmic form with 4 percent accuracy. The friction velocity (u*) and roughness length (z0) are then derived from the slope and intercept of the best-fitted semi-log straight lines. Our results show that the profile shape and friction velocity vary tidally, the latter reaches O (0.06) ms-1 during peak current flows. The magnitude of z0 is large and scattered, but it shows a general trend of decrease with increasing flow speed. The observed log-layer height increases, and the bottom drag coefficient (CD) decrease, respectively with increasing flow speed. Measurements also show that water turbidity increases substantially with large drainage of a nearby river during the rainy season, as a result the z0 and CD also increase. Finally, harmonic analysis of the tidal currents indicates significant changes between winter (homogeneous) and summer (stratified) conditions. In winter the vertical variation of orientation and phase is small, whereas in summer there was a 15Xorientation and 25X phase difference (the bottom currents lead the surface currents) between the near surface and near bed regions.

OS21A-10 1105h

Sediment Resuspension under Combined Wave-Current Conditions in the Great Bay Estuary System, NH

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As a basis for this numerical modeling study, it was hypothesized that the combined effects of tidal flow and surface waves can produce enough tidal stress to cause the sediment resuspension in the shallow waters of the estuary. To test this hypothesis, the Styles and Glenn (2000) Bottom Boundary Layer Model (BBLM) was coupled to a Dartmouth barotropic estuarine circulation model with mud flat wetting and drying (ADAM2) and a wave model called ACES. ADAM2 was forced by the predicted sea level data at Portsmouth Harbor, NH. ACES was forced by "local" wind data to estimate the surface waves that were input into BBLM, along with ADAM2 currents, to simulate a more accurate bottom stress and the corresponding resuspended sediment particle concentration. The coupled ADAM/BBLM model results were compared with observations for 16 November 1999. The coupled ADAM/BBLM model simulations were consistent with the basic observed structures, which included high sediment concentrations on the mud areas relative to those in the channels. The setup for the coupled ADAM/BBLM model system is that there are enough sediment particles on the bottom of the estuary so that the "locally" resuspended sediment particle concentrations are mostly determined by the combined tidal/wave bottom shear stress. Research shows us that for a "typical" 3.24-second (0.72-m wave height) surface wave propagated from the northwest across Great Bay into water depths around 3 meters, where with typical bottom current velocity of about 10 cm/s, the enhanced bottom shear velocity is greater than 2 cm/s, causing "locally" resuspended sediment particle concentration of about 10 mg/l. Typically, for the same surface waves, no bottom sediment resuspension occurred in water depths of more than 8 m. Specifically, bottom sediment particles in water depths of 3.60 m are 10 times more likely to be resuspended by the combined bottom tidal/wave shear stress than those in 7.44 m.

OS21A-11 1120h

How and Where do Tides Incise Channels in a Tidal Basin?

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Tidal channels are a common element of the salt marsh and tidal flat landscape. A conceptual model is presented to shed light on the origin and location of tidal channels in a basin. Numerical simulations show that the redistribution of momentum from flat areas to the channel location contributes to increase the channel deepening. A small initial incision then produces a self-sustained transfer mechanism that is responsible for the channel development. Moreover, under general conditions, it is possible to split the tidal motion in a component depending on the basin planar geometry and a component that depends on bottom topography. This division is particularly effective considering that the boundaries of tidal basins (often determined by the shape of paleovalleys) and their bottom are subject to modifications occurring at different timescales. From the distribution of water discharge derived within this framework it is shown that tidal channels are then more likely located near tidal inlets and where the basin shape forces the tidal flow in narrow areas. The momentum redistribution then further develops the channels and produces their typical elongated shape.

URL: http://www.people.virginia.edu/˜sf9t

OS22A WCC: Hall D Tuesday 1330h

General Contributions Posters

Presiding: **M Cai,** University of Maryland**; W Brown,** University of Massachusetts

OS22A-01 1330h POSTER

Coastal Hazard Analyses and the Dynamic Capabilities of GIS

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The dynamic synthesis and analysis capabilities of Geographic Information System software (GIS) are uniquely suited for assessments of coastal flood hazards across barrier islands. The ability of GIS to georeference and unify datasets of various temporal and spatial scales is enabling coastal scientists and engineers at Dewberry and Davis LLC, in support of the Federal Emergency Management Agencys National Flood Insurance Program, to evaluate changes over time to coastal barriers along the Atlantic Ocean and Gulf of Mexico shorelines. Utilizing GIS technology the geomorphic evolution of barriers, both storm induced and anthropogenic, is introduced into coastal models with increased flexibility and efficiency.

The dynamic nature of GIS enables professionals at Dewberry and Davis LLC to rapidly assess the impacts of environmental changes in the littoral zone such as hardened seawall construction, beach nourishment projects, and storm induced erosion. In the GIS environment, sensitivity analyses in response to these episodic, catastrophic, and human-induced changes across barrier islands become possible at lower cost and with greater precision than feasible with standard methods.

Advancement and proliferation of coastal digital datasets, particularly digital terrain data and digital aerial imagery, necessitate a high level of flexibility in the process of modeling coastal hazards. Professionals at Dewberry and Davis LLC are continually developing customized extensions to enhance the functionality of GIS in the development of flood hazard modeling and mapping relative to the dynamic nature of the coastal zone.

OS22A-02 1330h POSTER

The volumetric flux through Deception Pass, Washington and its effects on the circulation in the Whidbey Basin.

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The volumetric flux through Deception Pass, Washington will be determined by using tidal height differences between Bowman and Cornet Bays, which are located on the seaward and landward sides of Deception Pass respectively in Deception Pass State Park. Hydrolab sensors for measuring temperature, salinity and fluid depth will be attached to public boat docks in each of these bays. The numerical Puget Sound Regional Synthesis Model, PRISM, will be run with and without the flux through Deception Pass and compared to determine theoretically whether or not the