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POSTER ABSTRACTS

Potential changes in carbon, nutrient and sediment delivery to and carbon accumulation in coastal oceans of the eastern United States

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Land use and land cover distributions are primary determinants of terrestrial fluxes of carbon, sediments and nutrients to coastal oceans. Carbon, sediment and nutrient delivery to coastal waters have already been significantly altered by changes in population and land use, resulting in modified patterns of coastal production and carbon storage. Continued population growth and increasing agricultural areal extent and intensity are expected to accelerate these changes.

The USGS LandCarbon project developed prospective future land use and land cover projections based on IPCC scenarios A1b, A2, B1 to 2050 as the basis for a multitude of biogeochemical assessments. We assessed the impacts on delivery of total organic carbon, nutrients and sediments to the coastal ocean and concomitant carbon storage. Fluxes were estimated using the SPARROW model, calibrated on historic water quality measurements.

Significantly greater fluxes of nutrients and sediments to coastal waters by 2050 are projected by the model. For example, for the Eastern United States, projected nitrate fluxes for 2050 are projected to be 16 to 52 percent higher than the baseline year, depending on scenario. Projected changes in total organic carbon fluxes were lower, ranging from 2 to 4 percent. As a consequence of these changes, an associated increase in the frequency and duration of coastal and estuarine hypoxia events and harmful algal blooms could be expected. Model estimates indicate that prospective future nutrient and sediment fluxes will increase carbon storage rates in coastal waters by 18 to 56 percent in some regions.

High-resolution distribution of particulate organic matter from surface underway systems – a tool to assess carbon stocks in ocean margins

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A semi-automated filtration system was connected to surface underway systems of two research vessels (RV Wecoma, USCGS Healy) to collect suspended particle samples from surface waters along the west coast of the US and western Arctic margin of North America. Over 2,000 filter samples were collected along the ships' tracks and used to measure the concentration of particulate organic carbon (POC) and nitrogen (PN) in surface waters off California, Oregon and Washington as well as the Bering, Chukchi and Beaufort Seas. In-situ measurements of temperature, salinity, chlorophyll fluorescence, and beam attenuation were combined with the data from individual samples to provide a near-synoptic, spatial distribution of particulate organic matter along these regions. Marked contrasts in the concentrations and compositions (e.g., C/N, Chl/POC, Cp/POC ratios) of particulate organic matter were observed among different water masses in both margins, including those impacted by river discharge, recent upwelling and seasonal ice melt. These measurements represent a compelling proof of concept that surface underway POM surveys are both feasible and informative approaches to investigate carbon dynamics along ocean margins. Combined with sensor data, from either underway systems and/or remote sensing platforms (e.g., satellites, gliders), we illustrate the potential of these measurements to better understand physical-biological interactions in the coastal ocean and estimate changes in stocks and fluxes of organic matter in highly dynamic coastal waters.

The geographic concentration of blue carbon in soil across the continental US: The early results

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Saltwater wetlands have the potential to be bought and sold as relatively rich reservoirs of carbon in the context of sequestration projects. However, little is known about the geographic distribution of this potential, and no coarse scale investigation has addressed this ecosystem service at the continental scale. Our objective was to determine blue carbon stocks in coastal wetland soils in the United States and categorize the potential for projects by estuarine basin, state, and wetland type. We linked National Wetlands

Inventory (NWI) data with the Soil Survey Geographic Database (SSURGO) through spatial analysis within a Geographic Information System (GIS). We then calculated and mapped soil organic carbon for the first 15 cm of depth, across the continental US. Results were filtered by state, estuarine basin, wetland type, and accumulation rate, and ranking lists for each categorization were produced. The results showed that belowground carbon accumulation is concentrated in specific regions, with the richest and largest reservoirs in the Gulf and Atlantic southeastern estuaries, for example mangrove zones in Florida. Salt marshes on the southern Pacific Coast were relatively low in carbon due to small areas of coverage and the presence of sandy and inorganic soil. The geomorphic position of a wetland within a given estuary, for example on an exposed barrier island versus recessed towards inflowing headwaters, accounted for a greater degree of soil carbon variation than the wetland type, for example woody mangroves versus herbaceous marshes. The potential of a blue carbon sequestration project in relation to its location could be influential in determining wetland policy, conservation, and restoration in the coming decades.

Long-term alkalinity decrease and acidification of estuaries in southwestern United States

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More than four decades of alkalinity and pH data (late 1960s to 2010) from Texas estuaries and coastal sites collected by the Texas Commission for Environmental Quality (TCEQ) were analyzed for temporal changes. The majority (18 out of 27) of these estuaries showed a significant long-term reduction in alkalinity at a rate of -2.5 ~ -21.6 $\mu M\ yr^{-1}$. 15 estuaries exhibited significant pH trends (i.e., either increase or decrease), with 10 showing significant pH decreases at a rate of -0.0022 ~ -0.0099 yr^{-1}. Furthermore, a recent (2013) survey in the Mission Aransas Estuary in south Texas showed conspicuous drawdown of specific alkalinity (i.e., alkalinity/salinity ratio), indicating active alkalinity consumption in this estuary. The observed long-term estuarine alkalinity decrease is likely caused by reduction in riverine alkalinity export, a result of precipitation declines under drought conditions in the southwestern United States and freshwater diversion for human consumption, the latter may have caused alkalinity loss within reservoirs due to increased water residence time. Regardless of the cause, a decrease in estuarine alkalinity inventory will likely have negative impacts on shellfish production because of increased acidification in estuarine waters. In addition, subsequent reduction in alkalinity export from these estuaries to the ocean margin could also decrease the resilience of the coastal environment against future ocean acidification.

Distribution and seasonal variability of the inorganic carbon system in the Middle Atlantic Bight ocean margins

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Globally continental shelves are a sink of atmospheric carbon dioxide (CO_2). However, we know little about why a shelf is a source or a sink of the CO_2. During the Ocean Margins Program (OMP) conducted between 1993-1996, the CO_2 system parameters in the Mid-Atlantic Bight (MAB) ocean margin was studied extensively. While sea-surface pCO_2 and air-sea CO_2 fluxes were published, water column inorganic carbon parameters have not been published nor synthesized.

In the MAB region, the carbon dynamics of coastal system is complex due to a mix of three water sources including river water, the fresh, cold, and southward-flowing Labrador Coast Current (nearshore) and the salty, warm, northward-flowing Gulf Stream (offshore). The main seawater masses are inner shelf water, shelf water related to cold pool water, and Gulf Stream water, each has its characteristics of inorganic carbon parameters. The OMP data suggested clear seasonal differences in the temperature-salinity diagram with the shelf water and surface Gulf Stream water being warmer in summer than in spring. The diapycnal mixing was active, across potential density of 26 and 27, between the shelf water and Gulf Stream water in both seasons. The cold pool water may result from the Labrador Coast Current in winter and spring, the mean of dissolved inorganic carbon concentration during summer (2083±22 μmol/kg) is significantly higher than during spring (2007±34 μmol/kg). The total alkalinity concentration exhibited conservative mixing with salinity, but with a bend at salinity value ≈ 32 in summer. These preliminary results only showed the simple seasonal difference, and more research is needed.

Dramatic variability of the carbonate system at a temperate coastal ocean site (Beaufort, North Carolina, USA) is regulated by physical and biogeochemical processes on multiple timescales

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Increasing atmospheric carbon dioxide (CO_2) from anthropogenic sources is acidifying marine environments resulting in potentially dramatic consequences for the physical, chemical and biological functioning of these ecosystems. If current trends continue, mean ocean pH is expected to decrease by ~0.2 units over the next ~50 years. Yet, there is also substantial temporal variability in pH and other carbon system parameters in the ocean resulting in regions that already experience change that exceeds long-term projected trends in pH. This points to short-term dynamics as an important layer of complexity on top of long-term trends. Thus, in order to predict future climate change impacts, there is a critical need to characterize the natural range and dynamics of the marine carbonate system and the mechanisms responsible for observed variability. Here, we present pH and dissolved inorganic carbon (DIC) at time intervals spanning 1 hour to >1 year from a dynamic, coastal, temperate marine system (Beaufort Inlet, Beaufort NC USA) to characterize the carbonate system at multiple time scales. Daily and seasonal variations of the carbonate system are largely driven by temperature, alkalinity, and the balance between primary production and respiration, but high frequency change (hours to days) is further influenced by water mass movement (e.g., tides) and stochastic events (e.g. storms). Both annual (~0.3 units) and diurnal (~0.1 units) variability in coastal ocean acidity are similar in magnitude to 50-year projections of ocean acidity associated with increasing atmospheric CO_2. The environmental variables driving these changes highlight the importance of characterizing the complete carbonate system rather than just pH. Short-term dynamics of ocean carbon parameters may already exert significant pressure on some coastal marine ecosystems with implications for ecology, biogeochemistry and evolution and this shorter term variability layers additive effects and complexity, including extreme values, on top of long-term trends in ocean acidification.

New strategies to quantify the CO_2 exchange at the air-water interface along the Land-Ocean Aquatic Continuum

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Until recently, the role of the Land-Ocean Aquatic Continuum (LOAC) in the global carbon cycle was largely overlooked and the connection between the terrestrial and oceanic realms was merely treated as a conservative lateral transport. It is now acknowledged that significant amounts of carbon are exchanged between the atmosphere and the different compartments of the LOAC. The current global estimates of these fluxes, however, remain associated to large uncertainties. Here, we present three approaches developed to provide improved regionalized estimates of the CO_2 exchange at the air water interface for rivers, estuaries and continental shelf seas. For rivers, our method relies on statistical models using multiple regressions calibrated with the global hydrochemical database GLORICH, which contains pCO_2 estimates for > 6000 locations. For estuaries, generic reactive transport models are run in parallel at a 0.5 degree resolution using idealized geometries and data from the GLOBALNEWS database as boundary conditions. For continental shelf waters, spatial extrapolations are performed using a global multi-scale segmentation and local flux estimates derived from $3 \cdot 10^6$ pCO_2 measurements extracted from the SOCAT data product. The strategies developed for rivers and continental shelf seas are applied at the global scale and predict an atmospheric

CO_2 source of 0.5 PgC yr^{-1} and a sink of 0.2 PgC yr^{-1} for rivers and continental shelf seas respectively. Preliminary results are also presented for the estuarine strategy through an application to the Eastern Coast of the US.

The Great Lakes Evaporation Network (GLEN): Building an integrated observing system for Great Lakes flux measurements

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The North American Great Lakes constitute the largest freshwater surface in the world. Beginning in the late 1990s – a period that commenced with a strong El Niño event – the Great Lakes experienced a regime shift in winter ice cover and summer water temperatures that resulted in higher summer evaporation rates, followed shortly thereafter by a dramatic decline in water levels. Recent research suggests that evaporation rates over the lakes have remained high since then, due primarily to warmer summer water temperatures and an earlier start to the evaporation season. On the other hand, cold, high-ice winters such as 2013-14 cause occasional deviations from this trend, highlighting the large interannual variability in the Great Lakes system and the continued need for long-term observations. A growing ensemble of in situ measurements – including offshore eddy flux towers, buoy-based sensors, and vessel-based platforms – are being deployed through an ongoing bi-national collaboration to reduce uncertainties in the Great Lakes water balance, provide a more robust basis for short- and long-term projections, and fill a significant gap in over-lake flux measurements and related meteorological data. Here, we provide an overview of this initiative, currently referred to as the Great Lakes Evaporation Network (GLEN). Although the network was initiated in response to the need for improved estimates of Great Lakes evaporation, it is intended to be of utility to a wide range of applied and basic research needs – not just evaporation and water levels. As such, we provide an overview of the latest data collection efforts, the current and planned array of instrumentation and platforms, and the network of CO_2 and carbon flux observations that are likely to be of interest to participants in the Coastal CARbon Synthesis (CCARS) workshop and the Great Lakes research community.

Looming hypoxia on outer shelves caused by reduced ventilation in the open oceans: Case study of the East China Sea

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The discharge of nitrate and phosphate from Changjiang (Yangtze River) has increased in recent decades. Eutrophication off the mouth of Changjiang has subsequently become a serious problem, as evidenced by the hypoxia area reaching 12,000 km^2. This study demonstrates that in the wider East China Sea (ECS) the nitrate and phosphate concentrations in the Kuroshio Intermediate Water (KIW) have also increased, but the dissolved oxygen (DO) concentration has decreased since as early as 1982, most likely owning to reduced ventilation in the North Pacific Intermediate Water (NPIW). Conversely, the Kuroshio Tropical Water (KTW) has decreased in the nitrate and phosphate concentrations yet increased in DO concentration. As KIW contributes substantially to the upwelling, the nitrate and phosphate concentrations in the bottom water on the outer shelf of the ECS appear to have increased as well, but the DO has decreased. Given that the nutrient inputs from both the land and the Kuroshio Current have increased, yet the input of DO from the Kuroshio has decreased, more severe eutrophication, acidification and hypoxia may occur in the entire ECS. Similar processes may also affect other shelves that come into contact with NPIW.

Characterizing structural properties of saltmarshes with hyper-portable ground-based LiDAR

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Saltmarsh carbon cycling is heavily moderated by structural properties such as the volume of photosynthetically active vegetation, and the surface area of creek banks and mudflats available for chemical exchange. The acquisition of high-resolution and three-dimensional structure of the saltmarsh vegetation, creek-bed and mudflat topography and of the vegetation-water interface would therefore be highly beneficial in understanding saltmarsh carbon dynamics and quantifying carbon budgets.

The opportunity to collect these data is afforded by the University of Massachusetts Boston Canopy Biomass LiDAR (CBL). The CBL is an inexpensive, highly portable, fast-scanning, time-of-flight, terrestrial laser scanning (TLS) instrument, originally

conceived by the Katholieke Universiteit Leuven (KUL) and refined in collaboration with the Rochester Institute of Technology (RIT).

Portable terrestrial LiDAR such as the CBL can augment satellite and airborne data since a much higher temporal resolution can be achieved thanks to the logistic ease and low cost of deployment. This is particularly useful in saltmarsh ecosystems, which have fine-scale temporal dynamics, and thus measurements can be taken in response to potentially geochemically significant events, such as storm-caused surges from river or ocean, or point-source contamination.

The University of Massachusetts Boston CBLs have been successfully deployed in preliminary sampling efforts in saltmarsh systems in Massachusetts including Plum Island Long Term Ecological Research sites, UMB's Nantucket Island field station, Thompson Island, and remnant saltmarshes on the highly urbanized Neponset estuary draining into Boston Harbor.

Herein we outline the considerations for hyper-portable lidar deployment in saltmarshes, including logistics, sampling schemes, processing and analysis of structural properties utilizing data from our preliminary saltmarsh deployments in Massachusetts.

Physical drivers of Lake Michigan biogeochemistry

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The biogeochemical cycling of carbon and nutrients in large bodies of water is heavily dependent on the thermal and three-dimensional transport structure. Observational data of these characteristics in Lake Michigan are limited in time and space. A lakewide modeling study evaluated using observations offers finer spatial and temporal resolution, while also identifying regions of spatial heterogeneity that can motivate future observational studies. The eddy-resolving MIT general circulation model was configured to Lake Michigan at 1-minute resolution to resolve the seasonal cycle of productivity and to assess internally driven spatial heterogeneity for 2007-2010. Winter circulation is cyclonic while summer circulation is anticyclonic. The circulation is largely determined by the wind stress direction and differs somewhat from previous model studies due to a different dominant wind direction in these years. Physics are the primary cause of spatial differences in simulated primary productivity. Summer westerly winds drive coastal upwelling along the western shore that contributes substantially to summer productivity. Surface pCO_2 is controlled by solubility (temperature), modulated by biological uptake of dissolved inorganic carbon (DIC) and isothermal mixing of DIC-rich water in winter.

Monitoring seagrass distribution and disturbance with multi-frequency sidescan sonar

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Seagrass meadows are highly productive coastal ecosystems. They provide food and shelter for fishes, crustaceans, shellfishes, turtles, manatees, ducks, and may other animals and birds. In addition, they contribute a significant amount of carbon buried annually in the sea, although they occupy only a small percentage of global coastal areas. Recent studies have shown that seagrasses can sequester twice as much carbon per unit area as the temperate and tropical forests. But unlike terrestrial forests, they store most of the carbon underground, not in the above-ground plant materials. Unfortunately, seagrass areas around the world are being lost at a rapid rate, largely due to anthropogenic disturbances, such as increased turbidity from coastal development and boat scars and bottom trawling from recreational and commercial activities. Mapping the distribution of seagrass areas and the intensities and patterns of disturbances is of utmost importance to protect these valuable coastal ecosystems. Yet, no routine methods exist for large-scale and repeated mapping of seagrasses. Remote sensing from satellite and aerial platforms is of limited use due to water's interference on visible and NIR spectral signals. Turbidity and waves introduce additional limitations on optical remote sensing. Radar and lidar remote sensing have not been found useful in retrieving seagrass information, either.

A few published studies indicate that active hydroacoustic techniques have the potential to detect the presence/absence of seagrass meadows. These studies have used single frequency sonar data to map seagrass, with limited success. In this study we demonstrate a method of using multi-frequency sonar data to map the distribution and disturbance of seagrasses in the Laguna Madre bay of Texas along the Gulf of Mexico. We used boat-mounted sidescan sonar transducers with three different frequencies (namely 262, 455 and 800 kHz) to obtain transects of bay-floor images. These multi-band images were post-processed to filter out noise and to determine the threshold values of acoustic bounce intensity for each band. A mosaic of the bay-floor study area was created from adjacent georeferenced transects. We used image segmentation and pattern recognition methods to map boat-scars and other disturbance features in the seagrass beds, and validated these maps with underwater video and still photographs of the study area. Our results show that multi-frequency sonar data can potentially be used for routine and repeated mapping of large-scale seagrass areas.

Global carbon budget and its anthropogenic perturbation in the land-ocean Aquatic continuum

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A substantial amount of atmospheric carbon taken up on land through photosynthesis and chemical weathering is transported laterally along the aquatic continuum from upland terrestrial ecosystems into the ocean. So far, global carbon budget estimates implicitly assumed that the lateral transport and the myriad of transformation processes along this aquatic continuum have remained unchanged since pre-industrial times. We show here that the anthropogenic perturbations to the land-ocean aquatic continuum may have increased the flux of carbon to inland waters by as much as 1 Pg C yr^{-1} since preindustrial times, mainly by enhanced carbon exports from soils. Most of this input to upstream rivers is either lost back to the atmosphere by CO_2 outgassing (~0.4 PgC yr^{-1}) or sequestered in sediments (~0.5 PgC yr^{-1}) along the freshwater-estuarine-coastal waters continuum, leaving only a perturbation carbon input of ~0.1 PgC yr^{-1} to the open ocean. Our revised estimate also results in 0.9 PgC yr^{-1} carbon storage in terrestrial ecosystems in agreement with recent forest inventories. The anthropogenic perturbations to the land-ocean aquatic continuum carbon fluxes are thus significant and need to be taken into consideration in global anthropogenic CO_2 budgets.

Coastal freshwater influence on pCO_2 at the Gray's Reef mooring (NBDC-41008)

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3. High-resolution ocean and atmosphere pCO_2 time-series measurements from mooring GraysRf 81W 31N. http://cdiac.esd.ornl.gov/ftp/oceans/Moorings/GraysRf_81W_31N/. Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, US Department of Energy, Oak Ridge, Tennessee. doi: 10.3334/CDIAC/OTG.TSM_GRAYSRF_81W_31N

Whether and why a particular continental shelf acts as a source or a sink of CO_2 to the atmosphere is still heavily debated. In order to address this question, various CO_2 monitoring platforms have been deployed in coastal regions around the world, which provide near-real time observations of surface ocean pCO_2. The South Atlantic Bight (SAB), influenced by freshwater input from rivers, runoff, and salt marshes as well as the Gulf Stream (GS), has been monitored for surface pCO_2 (air and water) at the Gray's Reef (GR) mooring site since 2006. Until now, however, the sources of variability influencing surface ocean CO_2 dynamics at this site have not been investigated. The GR mooring is located where both coastal and oceanic oceanographic processes likely influence CO_2 dynamics. The objectives of this analysis of time series observations from

July, 2006 through October, 2013 are to determine: 1. the sources of variability of pCO_2 and the air-sea CO_2 flux (FCO_2); and 2. if the area is a net source or a sink of CO_2. We hypothesize that during periods of greater discharge: pCO_2 will be higher and the FCO_2 will be more positive (either outgassing or closer to equilibrium with the atmosphere), as the greater quantities of labile organic matter delivered to the coastal ocean during higher discharge periods will be available for bacterial remineralization which will increase the *in situ* pCO_2 concentration. Using daily means of pCO_2 and FCO_2, and measured predictors (sea surface temperature [SST] and salinity [SSS], and wind) we looked for relationships over the whole time series, however, could not find strong relationships as expected; likely due to the fact that there are large gaps in time series observations (up to several months) as well as complexity of the system and simplicity of linear analyses. We determined, however, that we could still analyze the sources of variability by defining specific conditions. To address the hypothesis that freshwater discharge is an important source of variability, we decided to use river discharge to identify our specific conditions. Since adequate river discharge data was not available and we cannot account for water exchange with salt marshes, we assume that SSS at the GR mooring reflects the effects of all freshwater discharge in the region at this point. Based on previously published salinity data for the core of the GS of 35.84 ± 0.2 we estimate that GS waters in the region could be approximated by the lower end of this value range (35.64). Therefore, we distinguish daily mean high freshwater discharge (low salinity) using SSS < 35.64 and low freshwater discharge (high salinity) SSS ≥ 35.64. Furthermore, since we were unable to determine one time lag for freshwater discharge influence, observations were analyzed using daily means rather than the higher frequency three hour data. During low salinity conditions the mean pCO_2 concentration (404 ± 70 ppm) was higher than high salinity conditions (382 ± 68 ppm). For low salinity conditions linear relationships between daily mean SST and SSS explain up to 80% of the variability in pCO_2 ($p < 0.001$; $n = 775$; $RMSE = 26$) and SST, SSS, and wind explain up to 60% of FCO_2 variability ($p < 0.001$; $n = 741$; $RMSE = 3.63$). During high salinity periods linear relationships explained up to 63 and 52% of variability with higher *RMSE* for pCO_2 and FCO_2, respectively. During both conditions, SST is the most important influence for both pCO_2 and FCO_2 variability. Over the course of the time series (1,516 days), during low salinity conditions there was less net drawdown of CO_2 (sum FCO_2 was -0.0066 mol m^{-2}) than during high salinity conditions (sum FCO_2 was -1.58 mol m^{-2}). We caution the use of a sum to compare these conditions as there are an unequal number of days of high and low salinity, however, there was a three order of magnitude difference in drawdown during low salinity conditions and FCO_2 was close to equilibrium. From these preliminary analyses based on high and low salinity due to freshwater discharge, we conclude that the site is a net sink for CO_2 even when freshwater discharge is high and bacterial respiration is likely high due to input of large quantities of fluvial labile organic matter. We further conclude that the sources of variability that influence CO_2 dynamics are first dependent on freshwater discharge and then SST.

Increase in dissolved inorganic carbon flux from the Mississippi River to Gulf of Mexico due to climatic and anthropogenic changes over the 21st century

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It is recognized that anthropogenic factors have had a major impact on carbon fluxes from land to ocean during the past two centuries. However, little is known about how future changes in climate, atmospheric CO_2 and land use may affect riverine carbon fluxes over the 21st century. Using a coupled hydrological-biogeochemical model, the Dynamic Land Ecosystem Model, driven by future climate, atmospheric CO_2, and land use data under both low and high emissions scenarios, this study examines the potential changes in dissolved inorganic carbon (DIC) export from the Mississippi River basin to the Gulf of Mexico during 2010-2099 attributable to climate-related conditions (temperature, precipitation), atmospheric CO_2 and land use changes. Annual DIC export was projected to increase with average rates of 65% under the high emissions scenario (A2) and 35% under the low emissions scenario (B1) between the 2090s and the 2000s. Climate-related changes along with rising atmospheric CO_2 together would account for over 90% of the total increase in DIC export through the 21st century. Our findings support the view that that riverine carbon flux from this region would be continuously enhanced as indirect and direct anthropogenic perturbation is intensified in the future.

Dissolved organic carbon fluxes in the Mid-Atlantic Bight

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Continental margins play an important role in the global carbon cycle, accounting for 10-30% of global marine primary production while comprising only 7-10% of the global ocean surface area. These regions are estimated to be a net carbon sink of atmospheric CO_2 on the order of 0.25 Pg C yr^{-1} but carbon fluxes across continental margins from land to the open ocean are not well constrained. We developed satellite algorithms to

retrieve surface water concentrations of dissolved organic carbon (DOC) and combined the satellite data with physical circulation models to estimate the cross-shelf fluxes of DOC for the U.S. Middle Atlantic Bight (MAB). Satellite DOC was computed through seasonal relationships of DOC with absorption of chromophoric dissolved organic matter (a_{CDOM}). The multi-year (2010-2012) time series of satellite-derived DOC stocks shows that freshwater discharge modulates the magnitude and seasonal variability of DOC on the continental shelf. Annual average integrated DOC fluxes for the study domain are: input of 12 Tg C yr^{-1} across the south western boundary (Cape Hatteras), input of 19 Tg C yr^{-1} across the north eastern boundary (Georges Bank), and export of 29 Tg C yr^{-1} across the cross-shelf boundary (along the 100-m isobath). The estimated average annual DOC input from the estuaries to the MAB domain is 0.5-1.3 Tg C yr^{-1}. Thus, DOC export across the cross-shelf boundary is only 3 Tg C yr^{-1} smaller than the sum of all DOC inputs (32 Tg C yr^{-1}) considered in this study. Other processes that may contribute significantly to the DOC budget are net biological production, photodegradation, and loss from sediments.

Interannual and seasonal patterns and controls of carbon fluxes from the Mississippi River Basin to Gulf of Mexico

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Previous studies have indicated that anthropogenic disturbances play a key role in controlling terrestrial carbon export from the world's major river basins at a century time scale. However, a comprehensive characterization is lacking of the temporal and spatial patterns of riverine organic and inorganic C fluxes (DIC, POC, and DOC) and their responses to major land environmental and climate change over the whole Mississippi River basin at seasonal, annual, and decadal time scales. In this study, we incorporated carbon processes in stream and rivers into a process-based global land model (DLEM) for simulating carbon cycling and transport at the terrestrial-aquatic interface. Our process-based simulations estimated that the average annual exports of dissolved organic carbon, particulate organic carbon, and dissolved inorganic carbon from the Mississippi River basin in the 2000s were 2.6 ± 0.4 Tg C yr^{-1}, 3.4 ± 0.3 Tg C yr^{-1} and 18.8 ± 3.4 Tg C yr^{-1}, respectively. Climate variability determined seasonal and interannual variations in C export from the basin, but land use change contributed the largest to C export over a

century scale. Relative to the 10-year average, the largest increase of C export is about 32% in a wet year (2008) and the largest decrease is up to 38% in an extreme dry year (2006). These results imply that increasing frequency of extreme drought and flooding events may substantially alter terrestrial C pathways as well as the functioning of coastal ecosystems.

Anthropogenic and climatic influences on carbon fluxes from eastern North America to the Atlantic Ocean: A process-based modeling study

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The magnitude, spatiotemporal patterns and controls of carbon fluxes from land to oceans remain uncertain. Here we applied a process-based land model (DLEM) with explicit representation of carbon processes in stream and rivers to examine how changes in climate, land conversion, management practices, atmospheric CO_2, and nitrogen deposition affected carbon fluxes from eastern North America to the Atlantic Ocean, specifically Gulf of Maine (GOM), Mid-Atlantic Bight (MAB), and South Atlantic Bight (SAB). Our simulated results indicate that the mean annual fluxes (± 1 standard deviation) of dissolved organic carbon (DOC), particulate organic carbon (POC) and dissolved inorganic carbon (DIC) in the past three decades (1980-2008) were 2.37 ± 0.60 Tg C yr-1, 1.06 ± 0.20 Tg C yr-1 and 3.57 ± 0.72 Tg C yr-1, respectively. Carbon export demonstrated substantially spatial and temporal variability. For the region as a whole, the model simulates a significant decrease in total riverine carbon flux from 1901 to 2008 as a result of a decreasing DIC flux; there were no significant trends in the DOC and POC fluxes. In the SAB, however, there were significant declines in all three carbon forms and in the MAB, DIC and POC fluxes declined significantly. The only significant trend in the GOM was a DIC flux increase. Climate variability was the primary reason for interannual variability in carbon export. Land use change was the primary factor contributing to decreases in C export while N deposition and atmospheric CO_2 increases were the primary cause of increased export.

Seasonal and interannual variations in the dissolved oxygen budget of an urbanized tidal river: The Upper Delaware Estuary

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The dissolved oxygen budget was diagnosed from oxygen concentration measurements in the upper Delaware Estuary between 1970 and 2014. The region was found to be heterotrophic, with net oxygen consumption greater in the tidal-fresh portion than in the oligohaline portion. Net oxygen consumption decreased substantially over the study period, with June-July values declining from 6-10 mol m^{-2} mon^{-1} in the 1970s to 3-4 mol m^{-2} mon^{-1} from the 1990s onward, a change presumably due to improvements in wastewater treatment, though a comparison with biological oxygen demand measurements in wastewater was equivocal. Combining the results with historical primary production measurements, respiration rates were estimated to be highly seasonal and positively correlated with temperature, with Q_{10} values ranging between 1.4 and 2.3. The degree of heterotrophy was great, with annual respiration being several times annual primary production. Exchange with the atmosphere is the main process that balances the net oxygen consumption throughout the study region, with advection also an important process in the tidal-fresh portion. A slight decline in oxygen concentration in the 2000s was found to be due to an increase in net oxygen consumption as opposed to weaker oxygen inputs from the atmosphere or advection.

Carbon fluxes and exchanges at the tidal wetland-estuarine-atmosphere interface

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Serving as a link between the land and the ocean, tidal wetlands are exposed to a wide variety of anthropogenic and natural stressors. Among our most valuable natural resources, these rich in biodiversity and highly productive ecosystems are hot spots of biogeochemical exchanges and transformations. Here we discuss new results on the amount and directions of biogeochemical tidal exchanges at the marsh-estuary interface. Detailed microbial and photochemical degradation experiments and high resolution bio-optical observations in tidal freshwater and salt systems of the Eastern US coast provide insights on the quality and fate of the organic compounds exported from tidal marshes and their influence on near-shore biological processes, biogeochemical cycles and optical variability. Impacts of anthropogenic activities and resulting air-pollution on estuarine biogeochemistry and water-quality are also discussed. High resolution model runs were performed using the Community Multi-scale Air Quality (CMAQ) model, to examine atmospheric composition along the shoreline where processes such as sea and bay breeze circulations often favor the accumulation of atmospheric pollutants, leading to aggravation of air pollution levels and impacting coastal ecosystems far away from emission sources.

Modeling long-term carbon accretion in tidal wetlands: Research approaches to meet policy needs for U.S. inventories and carbon markets

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Coastal "blue carbon" storage by tidal wetlands has occurred for millennia by transgression, progradation and accretion of organic sediments, in response to gradual sea level rise. Recent attention toward C budgets in vegetated tidal wetlands is in part due to increased awareness of their C sequestration services, as well as more opportunities to incorporate these services into national policies or market driven incentives for wetland protection and restoration. Our research focuses on quantifying past, current and future C storage in tidal wetland soils and vegetation. We are using multiple approaches to improve C accounting and projections, especially linking historical and current accretion rates and process-based models with remotely sensed data (e.g. LiDAR, spectral, RADAR) for empirical quantification and model validation.

This poster contributes to the CCARS science plan discussion by illustrating key concepts necessary to constrain tidal wetland soil C burial flux rates and methane fluxes. We summarize current literature and research goals of an upcoming NASA-funded research project to document and project spatial and temporal variability in carbon accumulation rate (CAR) among U.S. coastal wetlands. The IPCC default value for long-term (>50 yr) soil C burial in tidal wetlands is 1.4 T C/ha/yr. Where site-specific tidal wetlands are keeping pace with sea level rise, long-term CAR's range from 0-8 T C/ha/yr. Further, impounded wetlands undergoing restoration have been shown to bury 3-17 T C/ha/yr.

Both empirical data and process-based models suggest that CAR may be most strongly influenced by accommodation space (indexed by initial **tidal elevation** or **<u>relative</u> SLR,** RSLR) and in-situ **plant biomass.** "Accommodation space" is a way to describe potential soil volume accumulation. As such, marshes low in the tidal frame (e.g. subsided lands) have a high initial opportunity for accretion, whereas accretion rates at elevations higher in the tidal frame are typically very similar to RSLR (mm/yr). Across >100 U.S. sites, sediment (or mass) accretion predicts > 60% of the variability of long-term CAR in tidal marshes, as measured by dated profiles (^{137}Cs, ^{210}Pb, ^{14}C) or marker horizons and sediment elevation tables (SETs). Multiple projections of a marsh accretion model

(Marsh Equilibrium Model, MEM) show the sensitivity of C accretion to RSLR and plant biomass, both through organic inputs and sediment trapping.

Improved documentation and quantification of elevation, plant biomass, salinity, community structure and suspended sediment through remotely sensed products can reduce spatial and temporal uncertainty in past, current and future CAR assessments. Linking these multiple approaches to generate a tidal wetland verified protocol for national and market policy requirements is the next step.

Modeling pCO$_2$ variability in the Gulf of Mexico

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A three-dimensional coupled physical-biogeochemical model was used to simulate and examine temporal and spatial variability of surface pCO$_2$ in the Gulf of Mexico (GoM). The model is driven by realistic atmospheric forcing, open boundary conditions from a data-assimilative global ocean circulation model, and observed freshwater and terrestrial nutrient and carbon input from major rivers. A seven-year model hindcast (2004–2010) was performed and was validated against in situ measurements. The model revealed clear seasonality in surface pCO$_2$. The air-sea flux is estimated based on the multi-year mean of the model results. Overall, the GoM is a CO_2 sink with a flux of 1.34×10^{12} mol C yr^{-1}, which, together with the enormous fluvial carbon input, is balanced by the carbon export through the Loop Current. In addition, a sensitivity experiment was performed where all biological sources and sinks of carbon were disabled. In this simulation surface pCO$_2$ is elevated by ~70 ppm, suggesting that biological uptake is the most important reason for the observed CO_2 sink. Factors controlling the spatial distribution of surface pCO$_2$ and uncertainties in the carbon budget estimation are also discussed.