

Integrated Observation and Modeling of Carbon Cycle Processes Across Terrestrial-Coastal Interfaces: Reducing Uncertainties and Enhancing Linkages to Decision Support



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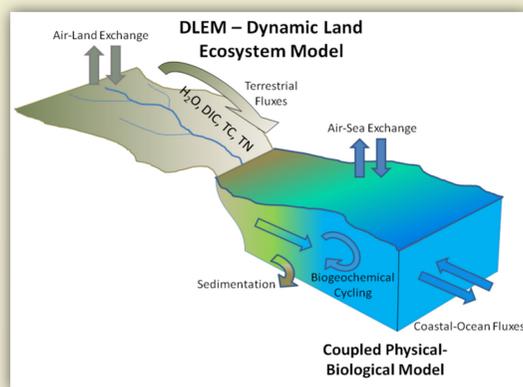
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INTRODUCTION

- Terrestrial-coastal interfaces account for potentially large contributions to global carbon cycling because of relatively high rates of processing and exchange of carbon in these systems. Yet, the magnitude and associated uncertainties of many coastal carbon fluxes and their linkages to terrestrial carbon cycles remain poorly constrained.
- Our current research builds on prior NASA- and NSF-funded efforts, using a combination of models and remotely-sensed and in situ observations in the Mississippi-River Atchafalaya basin and northern Gulf of Mexico to develop georeferenced products and associated uncertainties for land-ocean, coastal air-sea, and coastal to open ocean exchanges of carbon
- The unique nature of our approach, coupling models of terrestrial and ocean ecosystem dynamics and associated carbon processes, allows for assessment of how societal and human-related land use, land use change and forestry (LULUCF) and climate-related change affect terrestrial carbon storage and fluxes, as well as export of materials through watersheds to the coastal margins
- In our current work, we are extending the domain of our observational and integrated terrestrial-ocean ecosystem model system to include the southeastern U.S. and South Atlantic Bight



Schematic representation of coupled terrestrial-ocean model allowing for assessment of how societal and human-related LULUCF, as well as climate change, affect terrestrial carbon sources and sinks, export of materials to coastal margins, and associated carbon processes in the continental margins

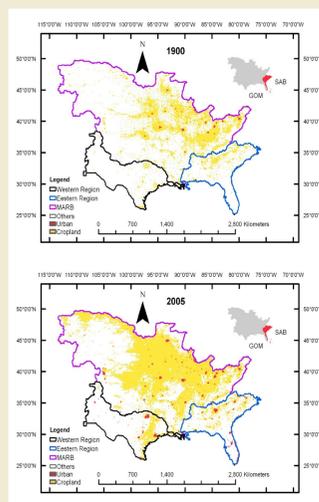
OBJECTIVES

- 1) Expand the spatial domain of our observational and integrated modeling approach to include the Mississippi River basin and southeastern U.S., and examine terrestrial carbon storage and fluxes including characterization and quantification of biomass and carbon stocks and land-atmosphere, land-ocean, and sea-atmosphere fluxes of carbon dioxide and methane;
- 2) Examine different LULUCF scenarios within the terrestrial domain and different climate scenarios to assess effectiveness of carbon management strategies;
- 3) Engage with other CMS projects and stakeholders (e.g., USDA, National Climate Assessment, etc.) to identify user needs related to carbon management and MRV activities, modify and expand the scope of information based on user feedback, and explore possible transition of prototype products to fully operational status

BACKGROUND

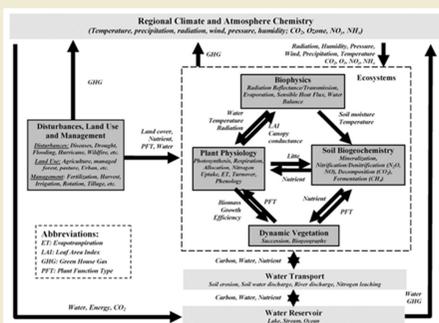
- The South, Southeast and Mississippi-Atchafalaya basin regions are undergoing significant and distinct anthropogenic and climate-related changes
- The South and Southeast regions differ from the MARB in that they are experiencing relatively large increases in population growth and associated development of the rural landscape
- Land-use and land cover in the Mississippi-River Atchafalaya basin is largely characterized by cropland and grassland areas and is heavily influenced by agricultural activities
- In contrast, the South and Southeast has a larger fraction of forested area, representing approximately 60% of the forest land in the conterminous U.S., and has been identified as the largest carbon sink among the six major bioclimatic regions in the nation and the highest potential to be a significant carbon sink in the future due to the large area of young pine forests and increasing plantation forest area
- From an oceanographic and biogeochemical perspective, the Gulf of Mexico and South Atlantic Bight are also very different in that river nutrients and organic and inorganic carbon are delivered to the northern Gulf of Mexico in almost a point source via one large river system, while rivers are nearly uniformly distributed along the South Atlantic Bight coastal region

Trends in land use and land cover from 1900 to 2005.



APPROACH AND RESULTS

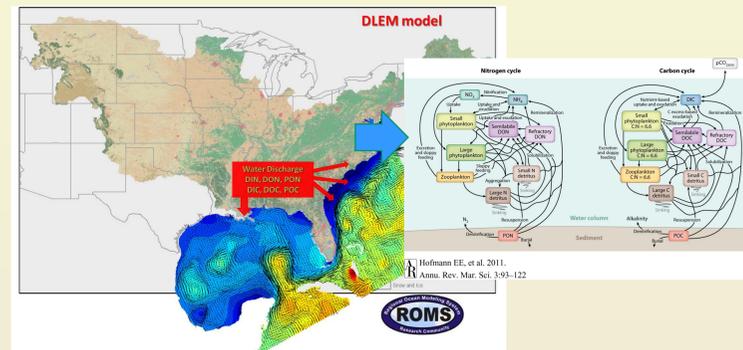
- Our Auburn team (Tian and co-workers) has developed and applied the Dynamic Land Ecosystem Model (DLEM) to quantify terrestrial carbon storage and fluxes including characterization and quantification of soil carbon and vegetation biomass and land-atmosphere fluxes of CO₂ and CH₄



APPROACH (cont.)

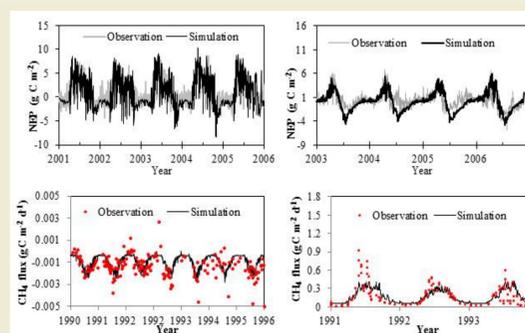
- Our NCSU team (R. He and co-workers) has constructed a regional coupled ocean circulation and marine ecosystem model, a 3-dimensional coastal marine ecosystem modeling system built upon the ROMS regional-scale circulation model

The spatial domain of the DLEM together with sea surface height from the SABGOM ROMS ocean model. Terrestrial exports of C, N and water provide input to the SABGOM ocean physical-biogeochimical model

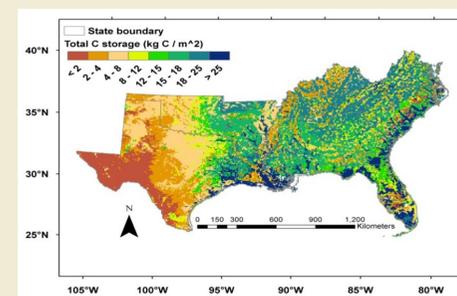


RESULTS

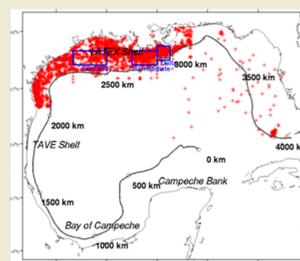
- The DLEM model output for fluxes and carbon inventories shows good agreement with ground-based time-series, as well as satellite observations



Comparison of simulated and observed net ecosystem production (NEP) for US-DK2 AmeriFlux site (deciduous broadleaf forest) (upper left) and US-ARM AmeriFlux site (cropland) (upper right); CH₄ flux for Durham Forest (lower left) and Buck Hollow Bog (lower right)

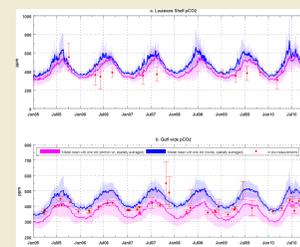


The DLEM model has been used to investigate the effects of climate variability and change, atmospheric CO₂, tropospheric O₃, land cover and land use change (LULUCF), nitrogen deposition, and disturbances (e.g., fire and harvest) on terrestrial carbon storage and fluxes, including CO₂ and CH₄, in terrestrial ecosystems in southeastern US (left) and the entire north America (not shown)

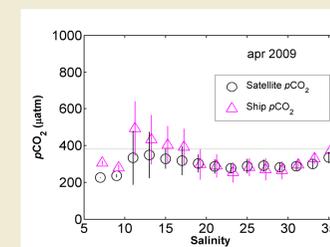


Distribution of ship-based observations used for model validation and refinement

- The ocean model provides output of coastal air-sea flux of CO₂, and coastal-ocean exchanges of DIC, DOC, TOC, DIN, and DON validated against an extensive suite of ship-based and satellite observations

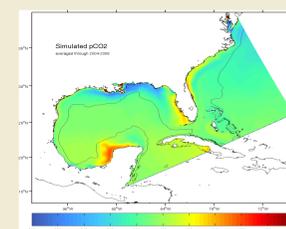


Model simulated time-series of surface water pCO₂ in comparison to ship-based observations (left) and comparison of satellite-derived and ship-based estimates of pCO₂ versus salinity for April 2009 (right)



- The coastal products will be valuable in assessing coastal carbon dynamics as well as ecosystem responses (e.g., water quality changes) as a consequence of management actions on land

- Results from our research are being served on a Google Earth geo-spatial portal which can be accessed at: <http://omgsrv1.meas.ncsu.edu:8080/ocean-circulation/carbon.jsp>



SABGOM ROMS simulated mean pCO₂ (averaged over 2004-2010) in the Gulf of Mexico and Southeastern U.S.



Model outputs of terrestrial DIC leaching and ocean concentrations accessible through geospatial portal

SUMMARY

- This research will allow for assessment of how societal and human-related LULUCF, as well as climate change, affects terrestrial carbon sources and sinks, export of materials to coastal margins, and associated carbon processes in the continental margins
- Methods, models and scenarios such as those in our proposed work have the potential to inform the decision processes related to carbon management and may assist in setting realistic goals for states and the Nation
- Exploring watershed based modeling scenarios coupled with remotely sensed and ship-board survey data will also inform effective water quality, ocean acidification, and restoration policy

ACKNOWLEDGEMENTS

This project is supported by funding from NASA (NX14A073G and prior projects NNX12AB21G, and NNX12AP84G) and NOAA, as well as prior support from NSF, USGS and EPA.

