Using remote sensing to understand carbon flow and its transformations from upland ecosystems into the coastal ocean

Project Description

Preface- This proposal is a follow-on to an ongoing NASA IDS project, submitted by this same interdisciplinary research team, which highlights the complex interactions occurring at the interface between land and the coastal ocean, in the Penobscot River System, representing the largest watershed in Maine. Our first project succeeded in qualitatively and quantitatively describing the carbon transport from the upper watershed to coastal Gulf of Maine. We established optical proxies based on the fluorescence and inherent optical properties of the POC and DOC (absorption and scattering) for biogeochemical characteristics that are difficult to detect in situ. Because certain optical proxies can only be measured in situ, we have calibrated the relationships between these proxies and remotely-derived variables in order to apply synoptic remote sensing approaches to our study area, specifically using ocean color data from SeaWiFS and MODIS. Moreover, we have incorporated this terrestrial carbon source into a coastal circulation model so as to understand the fate and transport in the marine environment. This study has demonstrated that even in this major watershed, which is rich in dissolved organic carbon, little of the terrestrial DOC is escaping the estuary, Penobscot Bay, into the coastal waters, except during recent extraordinary flood events. Thus, the focus of this renewal proposal is on the transformations that occur in the dissolved and particulate organic carbon pools, both to define them and model them. Knowledge of these transformations will improve the optical proxy approach and ultimately improve the remote sensing algorithms for DOC and POC quantification in Case II waters. Our specific interests are (1) how the freshwater suspended particulate and dissolved material that originates from the land impacts coastal marine ecosystems, and (2) the time and space scales of that impact. Because of the chemical complexity of the terrestrially-derived material, we have chosen to use carbon as our currency, in both the particulate and dissolved phases and in both the organic and inorganic forms. Moreover, this is in keeping with the U.S. Climate Change Science Program goals of coupled carbon-climate modeling (NASA IDS research goal sub-element#4).

Our project is highly complimentary to the NASA IDS research themes, as it seeks to understand the "watershed dynamics by connecting processes that occur in upland ecosystems with coastal marine ecosystems through their shared hydrology". <u>The proposed work is most related to the subelement #1, Landscapes to coasts: hydrological connectivity and the impacts of environmental processes</u>. Specifically, we address several topics of special interest listed within this subelement. We will define 1) " the entire path of particulates and solutes from the land and river environments to the coastal ocean", 2) "effects (impacts and feedbacks) of climate or weather-related events, such as storms and associated effects such as terrestrial runoff, on biological production and ecological responses within the coastal zone", 3) "cycling (e.g., transformation, transport, deposition) of terrestrial runoff and associated materials to and within ocean margin waters", 4) "impacts of climate variability and change, weather events, and/or land-use change on aquatic biodiversity upstream and in the coastal zone". Using field data in combination with historical data sets will allow us to address the ecosystem response to such forcing functions as land use, coastal eutrophication, longer-term interannual variations (e.g. North Atlantic Oscillation [NAO]), and climate change. Variables that will be measured include variations in particulate and dissolved carbon pools, carbon transformations, and algal species changes (microscopic enumeration).

Parts of our proposed work will be relevant to three more sub-elements of the original NASA IDS program: 1) "Global sea level in a varying and changing climate" (specifically, we will incorporate a 100-year database on the Maine rivers to examine terrestrial water storage and the extent to which it is likely to change, 2) "Biodiversity and disturbance" (our long term data sets allow us to elucidate the effects of storm events, and human disturbance on carbon transport, transformations through the riverine and coastal ecosystem and planktonic species changes) and 3) "Coupled carbon-climate modeling" (by defining the linkages between the terrestrial and marine systems in their biogeochemistry and geophysical components, we can predict how the carbon cycle responds to environmental change and to improve our ability to detect this variability). Moreover, our long-term databases from Maine rivers and the Gulf of Maine allows us to relate the terrestrial and marine variability to short-term climate phenomena such as the North Atlantic Oscillation. This proposal first introduces the Maine watershed and the Gulf of Maine, then focuses specifically on the temporal and spatial characteristics of it particulate and dissolved organic carbon pools originating in the Penobscot River watershed, as they flow downstream, through the Penobscot Bay estuary and into the Gulf of Maine continental shelf waters