**Diurnal Ocean Color Measurements are needed for Continental Ocean Margins and Lacustrine Ecosystem Science**

1. **What are the key challenges or questions for Earth System Science across the spectrum of basic research, applied research, applications, and/or operations in the coming decade?**

Our estuaries, coastal oceans and lakes are critically important as habitat for aquatic life, as highly productive ecosystems, fresh water and protein sources for human consumption, as strong economic drivers for coastal communities, and as a highly dynamic interface between land and ocean carbon and nutrient cycles. Coastal and lacustrine ecosystems are highly dynamic, economically valuable and particularly sensitive to both natural and human induced change. Coasts will be exposed to increasing risks over the coming decades given future projections for sea level rise, increasing population growth, increasing severity and frequency of extreme events, and increasing degradation of coastal ecosystems (IPCC, 2014). Approximately 50% of the world's human population lives in coastal regions generating about 46% of global economic activity (LOICZ, 2014). In order to sustain food production and ecological health while still maintaining economic growth in coastal regions, we must move quickly toward a better understanding of several key questions, as highlighted below:

*How are the productivity and biodiversity of coastal marine and lacustrine ecosystems changing, and how do these changes relate to natural and anthropogenic forcing, including local to regional impacts of climate variability?*

Coastal ecosystems are less than 5% of the global ocean but account for ~15-21% of the global ocean net primary production, the majority of marine living resources harvested for human consumption, and approximately 35-44% of the global ocean sequestration of carbon from the photic zone occurs within continental margins. Coastal ecosystems also receive the great majority of anthropogenic inputs (except CO2) from rivers and coastal runoff and by nature of their proximity to dense coastal populations. The dynamics of net community production and biodiversity are expected to change in response to changes to riverine fluxes, atmospheric inputs, ocean acidification, human activities including coastal development and pressure on wild fisheries, or climate induced changes in physical processes affecting the status of upwelling and nutricline depth.

*How are variations in exchanges across the land-ocean interface related to changes within the watershed, and how do such exchanges influence coastal and open ocean biogeochemistry and ecosystem dynamics?*

Exchanges of materials from land to ocean are a function of seasonal discharge dynamics, atmospheric deposition, and land surface attributes that are influenced by a host of natural and anthropogenic processes. Land to ocean subsidies of nutrients, labile carbon, light attenuating substances, net buffering capacity and pollutants can have profound effects on wetland, estuarine, riverine and coastal ocean ecosystems, including commercially important fish and shellfish populations. Pollution is altering ecosystems in many regions suffering from population pressure, and ecosystems dominated by mangroves are disappearing as a result of increasing marine protein demands requiring more intensive aquaculture.

*How do short-term coastal and open ocean processes interact with and influence larger scale physical, biogeochemical and ecosystem dynamics?*

The large-scale response of ocean circulation, biogeochemistry and ecosystems to climatic, atmospheric and anthropogenic forcing is the integral of processes occurring on smaller and shorter scales. Examples include vertical mixing, horizontal advection, upwelling, air-sea exchange, primary production, grazing, and respiration. The interplay of such dynamic processes drives the transfer of matter and energy on regional and global scales, affecting ecosystem function and human societal well-being. Gaining a more detailed understanding of how microorganisms respond to highly ephemeral, spatially varying processes at small spatial and temporal scales is therefore central to attaining a predictive understanding of the longer term and larger scale consequences of environmental change.

*How do episodic hazards, contaminant loadings, and alterations of habitats impact the biology and ecology of the coastal zone?*

The effects of episodic hazards, such as hurricanes and other extreme storms, floods, tsunamis, chemical spills, *Sargassum* landing on beaches, and harmful algal blooms are especially challenging to observe. Yet it is these events that can have the most severe and lasting effects on coastal ecosystems and threaten the health of humans using those waters. Additionally, anthropogenic influences through land use and other activities alter wetland and riparian habitats, alter watershed flow, increase sediment loads, and cause blooms of toxic algae, thereby harming aquatic plants, invertebrates, fish and wildlife and human health.

**2. Why are these challenges/questions timely to address now especially with respect to readiness?**

Addressing these key science questions requires an innovative observational approach to enable quality space-based observations at high enough temporal and spatial resolutions to capture the dynamic processes. On a geostationary orbit, NASA’s GEO-CAPE mission would provide this novel capability and is already at a high science and technology readiness level. This readiness has been the focus of the NASA GEO-CAPE mission design and science working groups that have been meeting regularly since 2009. These GEO-CAPE pre-formulation teams along with other NASA investments have resolved the technological and scientific challenges involved to address the scientific questions discussed herein. Furthermore, the Korea Institute of Ocean Science and Technology (KIOST**)** has demonstrated the feasibility and utility of geostationary ocean color observations with the Geostationary Ocean Color Imager (GOCI) sensor launched in 2010.

1. **Why are space-based observations fundamental to addressing these challenges/questions?**

Geostationary ocean color observatories are capable of sampling at high temporal frequency (e.g., hourly) over spatial scales of less than 0.5 km. Only geostationary observations are capable of providing the crucial link between high-frequency surface observations of moderate spatial extent and global satellite retrievals from low Earth Orbit (LEO) sensors with limited temporal resolution. High spectral resolution will be needed for discriminating various aquatic constituents, including identification of phytoplankton functional groups. Moreover, a geostationary vantage point would have the ability to resolve biological variability at sub-hourly to diurnal time scales. The combined high temporal and spatial resolutions will permit more detailed assessments of the extent and duration of damage to coastal habitats from pollution events, disasters and alterations. More frequent observations also improve the detectability of day-to-day variations in processes, and lead to more cloud-free observations to reduce uncertainties resulting from less-frequent observations.

*a. Can existing and planned U.S. and international programs provide the capabilities necessary to make substantial progress on the identified challenge and associated questions? If not, what additional investments are needed?*

Our present capabilities to remotely observe coastal processes from space are critically limited in their temporal, spatial, and spectral resolution. Present LEO observations on average can provide one or two observations per week at most locations after discounting cloud cover, thus cannot capture the highly dynamic processes characteristic of coastal regions, transformation rates, and net growth processes at diurnal time scales. Further, retrievals from coastal waters pose additional challenges including the need for better spectral and spatial resolution, increased signal-to-noise ratios (SNR), and complexities in calibration and validation efforts compared to open ocean retrievals.

Investments in geostationary missions offer a solution to these issues and will enable new perspectives into coastal science. The data collected with unprecedented temporal and spatial resolution will more accurately guide coastal ocean science and policy, including partnerships with environmental managers and operational practices.

*b. How to link space-based observations with other observations to increase the value of data for addressing key scientific questions and societal needs;*

Watershed processes must be considered over spatial extents of tens to millions of square kilometers and varying time scales (hours to decades). It will be necessary to employ an integrated suite of models, remotely sensed data and targeted in situ observations in order to understand processes controlling fluxes on land, their coupling to riverine systems, delivery of materials to the coastal ocean and the corresponding coastal ecosystem responses. It will be important to foster international and interagency partnerships linking to other such observations around the globe (e.g., Korea’s GOCI-II, Europe’s OCAPI) within a global observation framework that includes LEO, surface, and deep water observation networks.

*c. The anticipated scientific and societal benefits; and d. the communities involved*

*Geostationary Ocean Color* data will be used by aquatic biologists and biogeochemists to gain new knowledge needed to address the questions outlined above. It will also inform the general public, federal, state, and local governments to assess designated use integrity and the ability to sustain human health and ecosystem services. The 2010 Deepwater Horizon oil disaster, which had both episodic and longer-term effects on the environment, is one example where data from such a mission would have been extremely valuable. High frequency monitoring of harmful algal blooms will permit informed management decisions that promote conservation of fisheries and protection of human health. Other severe impacts can result from loss of coastal marshlands due to sea level rise that occurs so gradually that it is difficult to observe, or episodic severe weather events that can rapidly alter coastal morphology. In the future, major U.S. ports along the U.S. East Coast and Gulf of Mexico are planning to accommodate the new generation of super-cargo ships, which will be able to pass through the Panama Canal once expansion is completed in 2016. Monitoring of the impacts of dredging operations, as well as future shipping and potential accidents, would be valuable uses of geostationary observations, as effective response and prediction relies on accurate and timely information that is updated frequently.