HICO Data User's Proposal

Utilization of HICO in the California Current System For Assessing High Biomass Bloom Events and Net Primary Production

Principal Investigator

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ABSTRACT

We are witnessing a global shift in marine phytoplankton communities within Eastern Boundary Current systems, characterized by increasing biomass, increasing productivity, and potentially, increasingly abundant dinoflagellates. Associated with these changes are increasing frequency and duration of negative impacts to both human and wildlife health since most organisms classified as Harmful Algal Blooms are also dinoflagellates. I propose to focus on Monterey Bay, California to examine the underlying causes of the apparent increase in dinoflagellate blooms. Satellite ocean color can potentially provide an excellent tool for tracking these changes since a nearly 15-year record is available. However, intense blooms can create issues with standard processing of the imagery leading to a potential bias (underestimate) in coastal biomass and productivity. I propose to evaluate whether HICO, which is greatly improved spectral and spatial coverage, can improve our ability to monitor for and understand the ecophysiological responses of high biomass bloom events. Expected outcomes include a direct comparison with ongoing airborne (Headwall, MASTER, AVIRIS) and satellite (MODIS, MERIS, SeaWiFS) datasets available from other projects.

1. Statement of Work/Project Description

Background: Both human populations and marine resources are concentrated in coastal zones. Demands on coastal resources are increasing, leading to dramatic changes in coastal ecosystems. Unfortunately, a lack of understanding of the basic processes governing coastal ecosystems has been a major impediment to adequately monitor or manage these systems. As a result, there is a growing concern about the health and future of the coastal ocean. There is a clear need for better methods to carry out this near-real time change detection and time-series analysis. By definition, these processes require consistent and continuous data collection, which necessitates low-cost, high-reliability sensors. Satellites can clearly fill part of this need. However, current ocean color satellites such as SeaWiFS, MODIS, and the planned VIIRS platform are optimally designed for open ocean imagery, with low return rates and low spatial and spectral resolution. The coastal ocean, in contrast, is one of the most difficult places to accurately retrieve ocean color, for many reasons. First, because ocean color signals are highly variable in space and time due to many dynamic processes, the spatial (1.1 km) and temporal (daily) coverage normally used for the open ocean is of marginal use in coastal waters. Second, water-leaving radiance in the blue, critical for discriminating pigments from colored dissolved material, and UV, potentially useful for both atmospheric correction and identification of features such as "red tides", exhibit low signal/noise, and are often negative using standard reprocessing methods for MODIS and SeaWiFS. Third, the lack of mid-range spectral bands on most existing sensors make it difficult or impossible to detect events such as "red tides" (Dierssen et al., 2006; Ryan et al. 2009), one of the main targets for coastal remote sensing. There is a clear need for high temporal, spatial, and spectral resolution to meet these challenges; until recently, this has required airborne instrumentation (Davis et al., 2007). With the launch of HICO, this project seeks to evaluate whether a geostationary platform is sufficient to track high biomass bloom events in the California Current System (CCS).

Ongoing Projects: A clear advantage for testing HICO in the CCS is that we have a wealth of historical data and ongoing funded projects providing complementary data. A brief summary of the most relevant ones are included:

1) We have established a highly successful partnership between NASA Ames and UCSC. We have built up a ground/water calibration/validation system including atmospheric correction, in-water and ground/above-water radiometry, and measurement of inherent optical properties. To date, we have provided ground-truth for two NASA Student Airborne Research Program (SARP) field campaigns (2009, 2010), an Airship Ventures overflight (with Steve Dunagan, NASA Ames), and numerous airborne/satellite campaigns focusing on red tide dynamics (2006, 2008, 2009, 2010). Kudela's lab group is also providing cal/val for an upcoming NASA HOPE mission in October 2011 that utilizes a combination of the AATS sunphotometer, Headwall UV-VIS radiometer, and Biospherical Instruments single-channel radiometers.
2) Kudela continues to partner with SARP for 2011, and will have access to MASTER overflight data for the Monterey and Santa Barbara Channel regions. If data are available, we would like to include HICO as part of a student project comparing MASTER and satellite platforms for imaging kelp canopy.
3) As part of NASA project NNX09AT01G (" Improving Phytoplankton Pigment and Primary Production Estimates and Change Detection in the California Current using MERIS Data") Kudela (with Mati Kahru and Gregg Mitchell, SIO) has built an in-water matchup database for chlorophyll retrievals of ~1000 data points for the CCS, and we are continuing (3 more years) to compare SeaWiFS, MODIS, and MERIS chlorophyll and NPP retrievals. Access to HICO data will allow us to test new algorithms (more spectral bandwidth) and to test whether spatial variability is biasing the nearshore matchups (by using concurrent high spatial resolution HICO data).

Project Goals: I am requesting access to HICO data to complete the following specific objectives:

1) utilize HICO data as part of the SARP training program, in comparison with MASTER and other satellite platforms;
2) evaluate the bloom dynamics of high-biomass events in the CCS, focusing on Monterey Bay; in particular, compare MERIS MCI, MODIS FLH, and HICO data as a potential tool for identifying and tracking red tides;
3) evaluate spectral shape algorithms using HICO data to specifically predict the presence of dinoflagellates (e.g. Dierssen et al. 2006).
4) Test whether it is possible to track vertical migration of dinoflagellates during high-biomass events by using imagery from multiple time points during a diel cycle.

Advantages of using HICO: Access to HICO data are critical for completing several of the project goals. We have access to limited airborne data that has similar spectral resolution, but a main goal is to demonstrate the utility of hyperspectral satellite sensors for research/monitoring of HAB events such as red tides. Airborne data are too expensive to fill this need, while existing polar-orbiting satellite sensors don't have the spatial or

spectral resolution.

Proposed Data Acquisition: This project focuses primarily on Monterey Bay, but I am also requesting data from CoastColour sites 7, 8, 20 (Santa Barbara Channel, Central California, Oregon/Washington). Ideally, the data would be L2A, but since that is unlikely to be routinely available L1BM data are requested. I am interested in both historical and ongoing data collections for these sites.

CoastColour Site 7: 43.00-50.00 N, 123.00-130.00 W
CoastColour Site 8: 32.50-34.50 N, 116.90-121.00 W
CoastColour Site 20: 36.50-38.50 N, 121.50-123.50 W

2. Biographical Sketch and Facilities

Kudela is a biological oceanographer who focuses on three specific areas related to the fundamental question: what controls phytoplankton growth and distribution in the ocean? Specifically, how do light, nutrients, and physiology interact to determine the rates, processes, and patterns observed in the oceans? These three focus areas are first, bio-optics and remote sensing as a tool for understanding phytoplankton ecology. Second, the development of regional Ocean Observing System efforts. Third, Harmful Algal Blooms (HABs), and the integration of HAB research into OOS activities.

Of specific relevance to HICO, Kudela has been a NASA PI and Ocean Color Science Team member since 1995 (including 3 years of funding as a NASA Global Change Fellow). Past and ongoing activities include the use of in-water optics, airborne platforms, and satellite observations in support of various multidisciplinary programs and partnerships. This includes hosting the GOES Risk Reduction Activities for the HES-CW mission (2006), providing cal/val activities for the NASA Ames COAST/HOPE program (2011), and acting as co-I on NASA and NSF grants for application of satellite remote sensing data for coastal biology. Kudela is also the Director of the Center for Remote Sensing at UCSC, and a member of the IOCCG/GEOHAB Working Group on Remote Sensing of HABs.

Available Facilities: In addition to chlorophyll and NPP database put together for our current NASA project, Kudela has ~10 years of in situ and satellite data for the Monterey Bay, as well as an extensive set of bio-optical instrumentation for field studies. Our lab maintains several servers for satellite data processing and dissemination, and we routinely coordinate with the West Coast CoastWatch progam (NOAA PFEL) and the Central and Northern California Ocean Observing System. Since the requested use of HICO data is primarily for targeted studies, it is not expected that UCSC would serve as a data host, but any matchup data or ancillary information is available through either the Kudela Lab OPeNDAP servers, or through CeNCOOS.

3. Outputs & Deliverables

The primary anticipated outputs from this proposed effort would be peer-reviewed publications using HICO data, and validation of HICO products for the CCS. If successful at generating dinoflagellate-specific algorithms, those would also be made available to the community.

4. References

Davis CO, Kavanaugh M, Letelier R, Bissett WP, Kohler D (2007) Spatial and Spectral Resolution Considerations for Imaging Coastal Waters. Proceedings of the SPIE 6880:1-12

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Ryan J, Fischer A, Kudela R, Gower J, King S, Marin III R, Chavez F (2009) Influences of upwelling and downwelling winds on red tide bloom dynamics in Monterey Bay, California. Continental Shelf Research 29:785-795