Appendix A. Proposal Format

HICO Data User's Proposal

Title of Proposal
Quantifying seagrass species and growing status by using HICO hyperspectral data

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Abstract/project summary

Seagrass meadows play important roles in coastal ecosystems as a habitat for many marine organisms, as traps for sediment, and as buffers against wave actions. Corpus Christi Bay system comprises the second most extensive coverage of seagrass on the Texas coast. The objective of this proposal is to obtain species distribution and growing status of seagrass in Corpus Christi Bay system from HICO hyperspectral imagery.

The seagrass meadows in Corpus Christi Bay system usually grow in relatively narrow shallow (less than 1.5 m deep) and clear water areas along the bay shores. The relatively narrow areas make medium spatial resolution (one kilometer) satellites such as SeaWiFS and MODIS imagery no practical for operationally monitoring seagrass. This project will explore the utility of using in-situ hyperspectral measurements and hyperspectral ocean color imagery from HICO sensor for the submerged aquatic vegetation. This project will produce maps of seagrass distribution and species composition and growing status in Corpus Christi Bay system at 90 m spatial resolution. Outcome of the project also will enable us to estimate the productivity of these seagrasses throughout the region, and consequently, enhance the monitoring of critical seagrass habitat, water quality, and coastal ecosystems in the region.

1. Statement of work/project description

Goals

The objective of this proposal is to obtain presence and growing status of seagrass meadows in Corpus Christi Bay system by spectral analysis from in-situ hyperspectral measurement and HICO hyperspectral imagery to support operational seagrass monitoring. This project will 1) obtain spectral characteristics of seagrasses at different growing stages; 2) examine and develop water correction algorithms for HICO imagery; 3) classify bottom types; 4) assess the capability of identifying seagrass species and growing status by 90m pixel HICO imagery.

Importance

Seagrasses are recognized as an important indicator species that reflect the overall health of coastal ecosystems, support high biodiversity and are sensitive to changes in water quality. Fluctuations in seagrass distribution and abundance can indicate significant environmental disturbances or merely typical responses to natural processes (Pulich, 1999). There are five seagrass species: *Halophila englemannii* (Star Grass), *Syringodium Filiforme* (Manatee Grass), *Halodule beaudettei* (Shoalgrass), *Thalassia testudinum* (Turtle Grass), and *Ruppia maritima* (Widgeon Grass) growing in Corpus Christi Bay system (Dunton et al., 2011). Species composition is a key parameter for monitoring incipient stress effects. Replacement of a colonizing species, e.g. *Halodule*, with the climax species, *Thalassia*, may represent normal succession in a grass bed over time, the opposite direction of succession, from *Thalassia* to *Halodule*, is more likely to indicate some disturbance or stress to the grass bed. In addition, seagrass leaf production shows clear seasonal trends with rates increasing in spring and summer, and decreasing in fall and winter (Kaldy and Dunton, 2000). In spring, leaf production rates increase primarily due to the creation of new leaves, while higher leaf production rates in summer are due to increased growth of existing leaves (Hemminga et al., 1999). The rate of leaf turnover has an effect on the colonization by epiphytes (Mann 2000).

Thus hyperspectral imagery of seagrass blades and meadows, particularly acquired during increasing and decreasing stages, bring critical information of seagrass condition, which is indispensable for monitoring of the health of coastal ecosystems (Davis et al., 2004). However, currently, spectral features and quantitative remote sensing modeling of the submerged aquatic vegetation are not sufficiently developed, particularly in Texas. We propose to use the latest space-borne coastal ocean remote sensing technology, HICO hyperspectral remote sensing, to identifying seagrass species composition and distribution, and to determining seagrass growth status.

Statement of work

This proposal will use 90m spatial resolution HICO hyperspectral ocean color imagery to mapping seagrass species composition and distributions, and quantifying seagrass growing status in Corpus Christi Bay system. So far, the framework of the proposal has been developed. The proposed project will be carried out in four phases:

Phase I – Data collection, field work and spectral library

Ocean Optics spectrometers and spectrometer and SOC7100 hyperspectral camera will be used for *in-situ* and laboratory radiometric observation. The study sites will be visited by bi-weeks summer and fall and by month winter and spring. These spectral data will be analyzed and mined to obtain seagrass spectral signatures.

Phase II – Water column correction

Water column optical properties strongly influence upwelling radiance from bottom (Mobley, 1994; Lee et al., 1999). A physics based approach will be used to retrieve bottom reflectance from HICO imagery. The existing water correction algorithms will be compared with on HICO imagery.

Phase III – Classification

The classification scheme focuses on three levels: 1) deep water, bare soil, and seagrass meadows; 2) continuous or patchy seagrass meadows; 3) seagrass species and growing status. The level 2 means extensive, lush underwater meadows vs. fragmented ones, containing numerous open bare patches. Patchy beds are generally considered disturbed or stressed (Robbins and Bell 1994). The level 3 will explore the capability of identifying seagrass species and growing status by 90m pixel HICO imagery.

Phase IV – Accuracy assessment

Accuracy of mapping presence and growing status of seagrass meadows will be evaluated against survey data by field works. Error matrix for the experiment will be produced with both producer's and user's accuracy, overall accuracy and kappa efficient.

Study site, current state of art and background

The study sites are Redfish Bay, bay side of Corpus Christi Bay, and north side of Kennedy Causeway (Figure 1). The PI was awarded a seed grant by the Texas Research and Development Fund (2012) for seagrass mapping. An algorithm for water column correction has been developed, and the Object-based seagrass mapping using WorldView-2 imagery has been published (Su and Gibeaut, 2013). Spectral analysis and classification of EO-1 Hyperion imagery are ongoing.

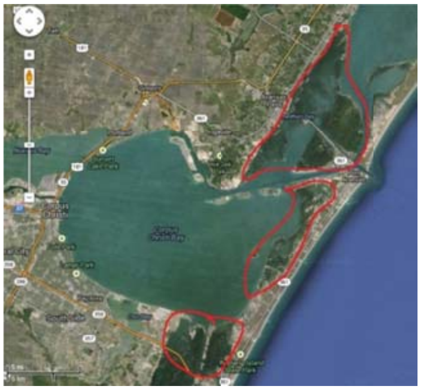  Study sites at Texas coast

Figure 1. The three red line areas are Redfish Bay (27.9078°N and 97.11277°W), bay side of Corpus Christi Bay (27.76833°N, 97.1483°W), and north side of Kennedy Causeway (27.6633°N, 97.2326°W) from upper to bottom, respectively.

Advantages of using HICO data

HICO data have very high SNR (>200 to 1 for a 5% surface albedo) and fine spatial resolution (90 m GSD). These properties make HICO data very suitable for seagrass mapping on Texas coastal area, because water-leaving radiance from seagrass meadows and other substrate usually is low, and seagrass distributes in relatively narrow areas along bay side. In addition, HICO data can cover repeatedly our study sites with no data users' cost. This creates an opportunity to acquire temporal spectral characteristics of seagrass meadows. On the contrary, high expense of airborne hyperspectral imaging limits its availability and practice.

HICO data will advance our understanding of the study sites by accumulating multi-temporal hyperspectral images over the seagrass areas. The images acquired during increasing stages and decreasing stages of seagrass leaf production create an opportunity not only to identity seagrass species by phonological difference, but also estimate growing status of seagrass in the Coastal Bend of Texas.

2. Biographical sketch and available facilities

The PI focuses on remote sensing of coastal environment recent 5 years. The PI has been over 15 years' experience in remote sensing image processing, classification techniques and algorithm development, modeling and inversion using satellite and aerial imagery. The PI has published more than 40 peer-reviewed papers. The PI also is a Certified Mapping Scientist – Remote Sensing, American Society of Photogrammetry and Remote Sensing (ASPRS) (RS195).

Education

2000	Ph.D. in Remote Sensing	Chinese Academy of Sciences
1995	M.Sc. in Geographic Information Systems	Chinese Academy of Sciences
1986	B.Sc. in Mathematics	Xinjiang University

Professional employment since 2004

2012 – present	Associate Research Scientist,	Texas A&M University - Corpus Christi
2008 – 2012	Research Associate,	Texas A&M University - Corpus Christi
2007 – 2008	Post-doc Research Associate,	University of North Carolina at Chapel Hill
2004 – 2007	Post-doc Research Associate,	Montclair State University

Selected peer-reviewed journal papers (last 5 years)

1. **Su, L.** and Gibeaut, J., 2013, Statistics-based Classification of Water and Land Lidar Points in Estuary and Coastal Areas, *Photogrammetry and Remote Sensing* (revised manuscript)
2. **Su, L.** and Gibeaut, J., 2013. *An Inter-Sensor Calibration and Atmospheric Correction System of Long-Term Time Series of AVHRR HRPT Data for Coastal water. GIScience and Remote Sensing*, April, 2013
3. **Su, L.**, Huang, Y., Chopping, M.J., Rango, A., 2011, Variations in reflectance with seasonality and viewing geometry: Implications for semi-arid vegetation mapping with MISR data. *International Journal of Remote Sensing*, 32(23):8183-8193p.
4. Song, C., Dickinson, M. B., **Su, L.**, Su, Z., Yaussey, D., 2010, Estimating Average Tree Crown Size Using Spatial Information from Ikonos and QuickBird Images: Across-sensor and across-site comparisons. *Remote Sensing of Environment*, 114(5):1099–1107p.
5. **Su, L.**, Huang, Y., 2009, Support Vector Machine (SVM) Classification: Comparison of Linkage Techniques using a Clustering-Based Method for Training Data Selection. *GIScience & Remote Sensing*, 46(4):411-423p.
6. **Su, L.**, 2009, Optimizing Support Vector Machine Learning by Using Pre-clustering for Semi-arid Vegetation Mapping, *Photogrammetry and Remote Sensing*, 64(4): 407-413p.
7. **Su, L.**, Huang, Y., Chopping, M.J., Rango, A., Martonchik, J.V., 2009, An Empirical Study on the Utility of BRDF Model Parameters and Topographic Parameters for Mapping Vegetation in a Semi-arid Region with MISR imagery, *International Journal of Remote Sensing*, 30(13):3463-3483p.
8. Chopping, M.J., Moisen, G., **Su, L.**, Laliberte, A., Rango, A., Martonchik, J.V. and Peters, D.P.C., 2008, Large Area Mapping of Southwestern forest Crown Cover, Canopy Height, and Biomass Using MISR. *Remote Sensing of Environment*, 112(5): 2051-2063p.
9. Chopping, M.J., **Su, L.**, Rango, A., Martonchik, J.V., and Peters, D.P.C., 2008, Remote Sensing of Woody Shrub Cover in Desert Grasslands using MISR with a Geometric-Optical Canopy Reflectance Model. *Remote Sensing of Environment*, 112(1):19-34p.
10. **Su, L.**, Chopping, M.J, Rango, A., Martonchik, J.V., and Peters, D.P.C., 2007, Differentiation of Semi-Arid Vegetation Types Based on Multi-Angular Observations from MISR and MODIS. *International Journal of Remote Sensing*, 28(6):1419-1424p.
11. **Su, L.**, Chopping, M.J, Rango, A., Martonchik, J.V., and Peters, D.P.C., 2007, Support Vector Machines for Recognition of Semi-arid Vegetation Types using MISR Multi-angle Imagery. *Remote Sensing of Environment*, 107(1-2):299-311p.

Data, instruments and software in-house

1. Instruments: Ocean Optics spectrometer and SOC7100 hyperspectral Camera now are available and ready for field works.
2. Remote sensing data: two scenes WorldView-2 imagery and one EO-1 Hyperion of Corpus Christi Bay and Redfish Bay. Two scenes of aerial hyperspectral imagery of Redfish Bay.

3. GIS data: bathymetric map of Corpus Christi Bay, and bathymetric lidar of Redfish Bay.
4. Software: ENVI and eCognition will be used for spectral library construction and classification. ArcGIS will be used to manage remote sensing and GIS data. IDL/Microsoft Visual Studio will be used to develop the proposed optical simulator of aquatic ecosystems.

3. Output and deliverables

1. A seagrass spectral library.
2. Spectral significance of seagrass leaf, epiphyte and macro algae at their different growth stages, and spectral significance of associated substrates.
3. Algorithms for water column correction and hyperspectral spectral analysis.
4. Seagrass species and presence maps, and seagrass growing status map.
5. Attend an annual HICO team meeting to present research results.

4. References

1. Davis, C.O., G.M. Lamela, T.F. Donato, and C.M. Bachmann, 2004. Coastal Margins and Estuaries. Manual of Remote Sensing Vol. 4. Remote Sensing for Natural Resource Management and Environmental Monitoring. Ustin, S.L., ed., 2004. ASPRS. John Wiley and Sons, New York 736p.
2. Dunton, K., W. Pulich, and T. Mutchler, 2011. Final Report for a Seagrass Monitoring Program for Texas Coastal Waters: Multiscale Integration of Landscape Features with Plant and Water Quality Indicators. Coastal Bend Bays & Estuaries Program, Corpus Christi, Texas.
3. Kaldy, J.E. and K.H. Dunton, 2000. Above- and below-ground production, biomass and reproductive ecology of *Thalassia testudinum* (turtle grass) in a subtropical coastal lagoon, *Marine Ecology Progress Series*, 193:271-283.
4. Hemminga, M.A., N. Marba, and J. Stapel, 1999. Leaf nutrient desorption, leaf lifespan and the retention of nutrients in seagrass systems, *Aquatic Botany*, 65:141-158.
5. Lee, K.S. and K.H. Dunton, 1996. Production and carbon reserve dynamics of the seagrass *Thalassia testudinum* in Corpus Christi Bay, Texas, USA, *Marine Ecology Progress Series*, 143:201-210.
6. Lee, Z.P., K.L. Carder, C.D. Mobley, R.G. Steward, and J.S. Patch, 1999. Hyperspectral remote sensing for shallow waters: 2. Deriving bottom depths and water properties by optimization, *Applied Optics*, 38(18):3831-3843.
7. Mann, K.H., 2000. Ecology of Coastal Waters: With Implications for Management. 2nd. Wiley-Blackwell, 2000, MA, USA.
8. Mobley, C.D. 1994. Light and Water: radiative transfer in natural waters, Academic Press, New York.
9. Pulich, W.Jr., 1999. Ch.1 Introduction, in Seagrass Conservation Plan for Texas – 1999. Texas Parks and Wildlife.
10. Su, L. and J. Gibeaut, 2013. Mapping Seagrass Meadows in Redfish Bay with WorldView-2 Imagery. Proceedings of ASPRS 2013 Annual conference, March 25-28, 2013, Baltimore, MD, USA.