CAS EE 348E

Monitoring and Management of Coastal Wetlands, Lagoons and Estuaries

Spring 2014: Venice Environmental Program

Instructor: Sonia Silvestri (sonia.silvestri@duke.edu)

Location: BU Venice

Office hours: by appointment

Class location: BU Venice + lagoon (see field trips)

Website: TBD

Course value: 4 credits

Course description:

Of the thirty-two largest cities in the world, twenty-two are located on estuaries, for a total population of about 350 million. Estuaries, lagoons and coastal wetlands provide resources, benefits, and services not just for humans but also for thousands of species of birds, fish, mammals, and other wildlife that live, feed, and reproduce in these environments. The morphology, the biota and the water quality of these areas are characterized by rapid and sometimes extreme changes, in response to natural and anthropogenic pressures. This course provides an introduction to the main processes driving change in these environments, focusing on the strong impacts of climate change and sea level rise from the environmental point of view. The dominant eco-morphological processes in shallow coastal areas will be described and several feed-back processes between vegetation and morphology will be discussed. The course will use the history of the Venice lagoon, as well as descriptions of its more recent modifications, as an illustration of the issues connected with changes in coastal lagoons and estuaries driven by human impacts, induced climatic changes, and natural environmental dynamics.
The students will acquire an operational knowledge of various monitoring technologies, with particular emphasis on satellite remote-sensing tools. Applications to the Venice Lagoon will be discussed in detail through hands-on projects.

Prerequisite: None

Course objectives:

Students will acquire an operational knowledge of the concepts of wetland functions, salt marsh eco-geomorphology, community habitat, primary productivity, and carbon sequestration. In particular, students will develop (1) an understanding of the main natural and anthropogenic drivers of the evolution of environments subjected to tidal forcings, including both biotic and abiotic components; (2) a conceptual understanding of wetland preservation and restoration; (3) the ability to analyze resource and management problems in coastal wetlands and estuaries. A central objective will be the analysis of the impacts of climate change and relative sea level rise on coastal areas using specific examples of protection/restoration activities in the Venice Lagoon. Students will also acquire the skills necessary to use

satellite data and field measurements at an introductory level, and will apply these observations to specific case studies. Targeted field trips will allow students to collect data in the Venice lagoon. They will learn how to organize such field data within Google Earth and how to link GIS and remote sensing data, with the overall purpose of learning how in-situ and remote sensing observations can support our understanding of coastal ecological and morphological dynamics. Students will also gain experience in leading a seminar, writing a final report and in critiquing research papers.

Grading:

Attendance is mandatory. Absence from classes and related activities will be granted only in the event of medical or family emergencies which must be documented and communicated to the instructor.

- assignments on reading papers/labs and in-class discussions 30%
- field trip reports 20%
- final project 25%
- final presentation 10%
- class participation 15%

Class/lab participation:

Classes will consist of lectures, discussions/seminars on assigned readings, discussions on field trips and computer laboratories on GIS and remote sensing (**students will be asked to use their own laptops and install some freely available software. Satellite data and other documents will be made available in a Dropbox folder specifically created for this course**). All students are expected to read all the assigned readings prior to class and to participate in class discussions and give a seminar when required. Students will be expected to ask and answer questions during discussions and participation will contribute significantly to the final grade.

In-class/lab assignments:

One to two research articles per week will be assigned to be critiqued in writing (1 page per paper) and subsequently discussed in class. The critique report will be assigned at the end of the first or the second lesson of the week, and will have to be turned in after 7 days. Every week we will discuss the assigned papers for 10-15 minutes, and designated students (selected the previous week) will be required to lead the discussion. A written report on each field trip will be required from each student (due 7 days after the trip). In the lab, students will learn how to download, analyze and interpret satellite data, and specific exercises will be assigned to gain and gauge basic skills in this field . Lab assignments should be turned in before the following lab session (i.e. one week after).

Field trips:

Four field trips will be organized to visit (1) the Venice lagoon barrier islands protection structures and seagrass prairies, (2) the lagoon natural and restored salt marshes and the MOSE system at the inlets, (3) a Land Reclamation Management Consortium (“Consorzio di Bonifica”) in the southern part of the lagoon

watershed (joint activity with the "Global Climate Change: Science, Economics and Policy" course**)**, (4) a constructed wetland area.

Final project work:

A Final Report on a specific subject chosen by each student (upon discussion with the instructor) will be required at the end of the course, together with a final presentation to be given in class. The Report has to be structured as a paper, with the following sections: Abstract, Introduction, Study Site, Data Analysis, Results and Discussion, References. Examples of possible subjects for the Final Reports are: change detection of a specific coastal area/city; mapping the land use in coastal areas; mapping the vegetation stress in reclaimed lands affected by RSLR (i.e. the southern part of the Venice lagoon watershed).

Academic honesty

Academic misconduct will not be tolerated. Student academic misconduct is clearly explained in the Academic Conduct Code:

http://www.bu.edu/cas/academics/resources/academic-conduct-code/

Students are encouraged to form study groups and discuss assignments. However, providing to other students, or accepting from them printed or electronic copies of their responses to assignments is academic dishonesty. Copying text, tables, or graphs from printed materials, other students' work or internet sources and incorporating such material into assignments without proper attribution is plagiarism. Any student found guilty of academic misconduct will be referred to the Committee on Student Academic Conduct.

Course outline:

The overall course duration is 6 weeks for a total of 42 hrs. In general, the first two days of each week will consist of lectures (90 min each) on the main topics of the course, while the third day will be dedicated to a lab section (90 min) on GIS and remote sensing. Moreover, from Week 1 to Week 4 students will participate to one field trip per week (for a total of 4 field trips of approximately 4 hrs each). Week 6 will be mainly dedicated to the presentation of the final projects and discussion.

Week 1

9 June – 1:00-2:30pm Coastal lagoons, estuaries and deltas: definitions and characteristics. Typical morphological structures and ecological properties of tidal environments. Geomorphological classifications.

11 June – 10:00-11:30pm Biotic and abiotic processes shaping the tidal landscape. Biomorphodynamics. The role of salt marsh vegetation in trapping and stabilizing sediments. The role of phanerogams (seagrass) in retaining and stabilizing the bottom.

11 June – 12:30-2:00pm - Lab 1 What is remote sensing? Why in-situ and remote sensing observations can support our understanding of coastal dynamics? Introduction to the physical basis of remote sensing. Introduction to the remote sensing software.

12 June – 9:00am-1:00pm - **Field trip 1** The barrier islands protection structure (Pellestrina "Museo dei Murazzi") and the seagrass prairies.

Week 2

16 June – 1:00-2:30pm History of the evolution of the Venice Lagoon. Environmental issues faced by Venice in history and the adopted management solutions. Venice as an example of current typical issues of coastal lagoons: depositional/erosional trends, water quality degradation, sea level rise and exceptional high tides.

17 June – 1:00-2:30pm Remote sensing and other monitoring methods applied to the Venice lagoon. Natural adaptation to high tides and multiple equilibria. Natural and restored salt marshes in the Venice lagoon. The MOSE system.

18 June – 1:00-2:30pm - **Lab 2** Digital imagery and fundamentals of image interpretation.

19 June – 9:00am-1:00pm - **Field trip 2** The lagoon natural and restored salt marshes and the MOSE system at the inlets. (joint activity with the "Global Climate Change: Science, Economics and Policy" course**).**

Week 3

23 June – 1:00-2:30pm Climate change and relative sea level rise: theory and examples from around the world. Coastal wetlands, climate change and sea level rise: New Orleans, Venice and other urban examples. Saltwater intrusion in coastal areas: an environmental, social and economical issue .

24 June – 1:00-2:30pm Wetlands: characteristics and definitions. Biogeochemical cycles in wetlands. Wetlands and greenhouse gasses. Peatland: the example of the Zennare basin (southern part of the Venice lagoon watershed).

25 June – 1:00-2:30pm - **Lab 3** The importance of the geospatial analysis. What is a Geographic Information System? The revolution of Google Earth and Google Maps. The use of GIS and remote sensing for the change detection. Assignment of the project works for the final presentations.

26 June – 9:00am-1:00pm - **Field trip 3** "Consorzio di Bonifica Adige-Euganeo" in the southern part of the lagoon watershed. (joint activity with the "Global Climate Change: Science, Economics and Policy" course**).**

Week 4

30 June – 1:00-2:30pm Wetland functions and services with examples from around the world. The role of ecology in the formation and development of wetlands and of coastal marshes. The value of wetlands. Constructed wetlands. Wetland restoration principles and case studies. Constructed wetlands and water quality.

1 July – 9:00am-1:00pm - **Field trip 4** "Ca' di Mezzo", a constructed wetland area near Venice.

2 July – 1:00-2:30pm - **Lab 4** Characteristics of different sensors and their main use to study coastal areas. Downloading satellite images freely available on-line.

3 July – 1:00-2:30pm – Discussion on assigned papers; lab activities in preparation of the final presentations.

Week 5

7 July – 1:00-2:30pm Monitoring the long-term success of restored wetlands. The ecology of wetlands, marshes and coastal areas: plants and organisms and their physiological adaptations to coastal environments.

8 July – 1:00-2:30pm Water quality monitoring options and techniques. Remote sensing of water quality. A comparison of historical changes in quality over time due to anthropogenic activities. Remote sensing applied to the observation of climate change phenomena and measurements.

9 July – 1:00-2:30pm Lab 5 Laser scanners and radar systems. New generation sensors and the future application of remote sensing for coastal environments.

Week 6

14-16 July – 1:00-2:30pm Final presentations of the project works. Discussion.

Reading assignments (I will make the papers available in the Dropbox folder):

Week 1:

Fagherazzi, S., et al. (2012), Numerical models of salt marsh evolution: Ecological, geomorphic, and climatic factors, *Rev. Geophys*., 50, RG1002, doi:10.1029/2011RG000359 **Required reading + critique assignment**

Silvestri S., Defina A., Marani M., 2005. Tidal regime, salinity and salt marsh plant zonation. *Estuarine, Coastal and Shelf Science* 62, 119-130. **Required reading + critique assignment**

Canada Centre for Remote Sensing *Fundamentals of Remote Sensing*, http://www.nrcan.gc.ca/earth-sciences/geography-boundary/remote-sensing/fundamentals/1430 **Required reading**

Suggested readings:

Marani M., S. Silvestri, E. Belluco, N. Ursino, A. Comerlati, O. Tosatto, M. Putti, Spatial organization and ecohydrological interactions in oxygen-limited vegetation ecosystems, *Water Resour. Res*., 42, W06D06, doi:10.1029/2005WR004582, 2006.

Marani, M., A. D'Alpaos, S. Lanzoni, L. Carniello, A. Rinaldo, The importance of being coupled: Stable states, catastrophic shifts and hysteresis in tidal eco-morphodynamics, *Journal of Geophysical Research*, vol. 115, F04004, doi:10.1029/2009JF001600, 2010.

Bertness, M.D. and A.M. Ellison. 1987. Determinants of pattern in a New England salt marsh plant community. *Ecological Monographs* 57:129-147.

Carr, J. A., P. D'Odorico, K. J. McGlathery, and P. L. Wiberg (2012), Stability and resilience of seagrass meadows to seasonal and interannual dynamics and environmental stress*, J. Geophys. Res.*, 117, G01007, doi:10.1029/2011JG001744.

Week 2:

Carniello, L*.*, A. Defina, and L. D'Alpaos *(*2009*),* Morphological evolution of the Venice lagoon: Evidence from the past and trend for the future*,* J. Geophys. Res*.,* 114*, F04002, doi:*10.1029/2008JF001157. **Required reading + critique assignment**

K. Bromberg Gedan, B.R. Silliman, and M.D. Bertness (2009) Centuries of Human-Driven Change in Salt Marsh Ecosystems, *Annual Review of Marine Science*. Vol. 1: 117-141. DOI: 10.1146/annurev.marine.010908.163930 **Required reading + critique assignment**

L. Carbognin, P. Teatini, L. Tosi (2004) Eustacy and land subsidence in the Venice Lagoon at the beginning of the new millennium. *Journal of Marine Systems* Volume 51, Issues 1–4, Pages 345–353. **Required reading**

Marani, M., S. Lanzoni, S. Silvestri, and A. Rinaldo, Tidal landforms, patterns of halophytic vegetation and the fate of the lagoon of Venice, *J. Marine Syst.*, vol.51, 191-210, 2004. **Required reading**

Suggested readings:

Craft, C., Megonigal P., Broome S., Stevenson J., Freese R., Cornell J., Zheng L., Sacco J. The pace of Ecosystem Development of Constructed *Spartina Alterniflora* marshes. *Ecological Applications,* 13(5), 2003, pp. 1417–1432.

Incheol Lee, Soyoung Park, Sunghoon Ryu, and Nobuhisa Kobayashi (2011) Ecological Restoration Index for Evaluation of Artificial Salt Marsh. *Journal of Coastal Research*, 27(5), 959-965.

Orr M., Crooks S., Williams P. B. (2003) Will Restored Tidal Marshes Be Sustainable? *San Francisco Estuary and Watershed Science*, 1-33.

John W. Day, Francesco Scarton, Andrea Rismondo, and Daniele Are. Rapid Deterioration of a Salt Marsh in Venice Lagoon, Italy. *Journal of Coastal Research*, 14(2), 583-590.

Week 3:

Day J.W.Jr., Boesch D.F., Clairain E.J., Kemp G.P., Laska S.B., Mitsch W.J., Orth K., Mashriqui H., Reed D.J., Shabman L., Simenstand C.A., Streever B.J., Twilley R.R., Watson C.C., Wells J.T., Whigham D.F. 2007. Restoration of the Mississippi Delta: Lessons from Hurricanes Katrina and Rita. *Science*, vol. 315, 23 March 2007. Required reading + critique assignment

Gedan, K.B., Kirwan, M.L., Wolanski, E., Barbier, E.B., Silliman, B.R., 2011. The present and future role of coastal wetland vegetation in protecting shorelines: answering recent challenges to the paradigm. *Climatic Change* 106, 7-29. Required reading + critique assignment

Kirwan, M.L., Guntenspergen, G.R., D'Alpaos, A., Morris, J.T., Mudd, S.M., Temmerman, S., 2010. Limits on the adaptability of coastal marshes to rising sea level. *Geophys Res Lett* 37. , pp. 1-5, L23401, doi:10.1029/2010GL045489 Required reading + critique assignment

Chmura G.L., Anisfeld S.C., Cahoon D.R. and Lynch J.C. (2003). Global carbon sequestration in tidal, saline wetland soils. *Global Biogeochemical Cycles*, **17**(4), 1111, doi: 10.1029/2002GB001917, pp: 1 –12. Required reading

Students will be asked to read 20 to 30 pages extracted from the report:
IPCC Fifth Assessment Report 2013. Climate Change 2013: Chapter 13: Sea Level Change. 121p. Required reading

Suggested readings:

C. Craft, J. Clough, J. Ehman, S. Joye, R. Park, S. Pennings,H. Guo, and M. Machmuller (2009). Forecasting the effects of accelerated sea-level rise on tidal marsh ecosystem services. *Front Ecol Environ*; 7(2): 73–78, doi:10.1890/070219

Gledhill, D. K., R. Wanninkhof, and C. M. Eakin. 2009. Observing ocean acidification from space. *Oceanography* 22: 48-59.

Kirwan, M.L., Guntenspergen, G.R. Morris, J.T. 2009. Latitudinal trends in *Spartina alterniflora* productivity and the response of coastal marshes to global change. Glob. Change Biol. 15, pp. 1982-1989.

Week 4:

Barbier, E.B., Hacker, S.D., Kennedy, C., Koch, E.W., Stier, A.C., Silliman, B.R., 2011. The value of estuarine and coastal ecosystem services. *Ecol Monogr* 81, 169-193. Required reading + critique assignment

Vymazal J.(2000). Types of constructed wetlands for wastewater treatment. Ecology and Use of Wetlands, Ricanova 40. Required reading

Zedler, Joy B. 2005. Ecological restoration: guidance from theory. *San Francisco Estuary and Watershed Science* Vol. 3 Iss 2, pp. 1-31. Required reading

Belluco et al. 2006, Mapping salt-marsh vegetation by multispectral and hyperspectral remote sensing, *Remote Sensing of Environment*, 105, 54–67. Required reading

Suggested readings:

Costanza R. R. D'arge, R. Groot, S. Farber, M. Grasso, B. Hannon K. Limburg, S. Naeem, R. V. O'neill, J. Paruelo, R.G. Raskin, P. Sutton & M. Van Den Belt. The Value Of The World's Ecosystem Services And Natural Capital, *Nature*, Vol. 387 (1997), P. 253-260.

Week 5:

Moreno-Mateos D., Power M.E., Comin F.A., Yockteng R. (2012) Structural and Functional Loss in Restored Wetland Ecosystems. PLoS Biol **10**(1): 1-8. e1001247, doi:10.1371/journal.pbio.1001247 Required reading + critique assignment

Volpe V., Silvestri S., Marani M. 2011, Remote sensing retrieval of suspended sediment concentration in shallow waters, *Remote Sensing of Environment* 115 (2011) 44-54. Required reading + critique assignment

C. Solidoro, R. Pastres, G. Cossarini, S. Ciavatta (2004) Seasonal and spatial variability of water quality parameters in the lagoon of Venice. *Journal of Marine Systems* Volume 51, Issues 1–4, Pages 7–18 Required reading

Suggested readings:

Craft C., Broome S. and Campbell (2002). Fifteen Years of Vegetation and Soil Development after Brackish-Water Marsh Creation. Restoration Ecology Vol. 10 n. 2, pp. 248-258.

Collin, A., B. Long, P. Archambault, 2010. Salt-marsh characterization, zonation assessment and mapping through a dual-wavelength LiDAR, *Remote Sensing of Environment* 114: 520–530.

Lu Z. and Kwoun O. (2008) Radarsat-1 and ERS InSAR Analysis Over Southeastern Coastal Louisiana: Implications for Mapping Water-Level Changes Beneath Swamp Forests. *IEEE Transactions on Geoscience and Remote Sensing*, VOL. 46, no. 8, pp. 2167-2184.

Pietro Teatini, Luigi Tosi , Tazio Strozzi, Laura Carbognin, Urs Wegmuller, Federica Rizzetto (2005). Mapping regional land displacements in the Venice coastland by an integrated monitoring system. *Remote Sensing of Environment* 98 : 403 – 413.

R. Pastres, C. Solidoro, S. Ciavatta, A. Petrizzo, G. Cossarini (2004) Long-term changes of inorganic nutrients in the Lagoon of Venice (Italy). *Journal of Marine Systems* 51:179– 189.