DEtection and Characterization of cOastal tiDal wEtlands change (DECODE) on the U.S. Atlantic Coast

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Annual cover map and Landsat Composite images (between June and October each year)
https://gers.users.earthengine.app/view/decodecover

Annual change type map and "Year of the last change"
https://gers.users.earthengine.app/view/decodechange

Study Area and potential layers
https://gers.users.earthengine.app/view/decodelayers

Data download link: http://dx.doi.org/10.17632/5dz3c5tfw9.1
Open source code: https://github.com/GERSL/DECODE

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DECODE – Workflow

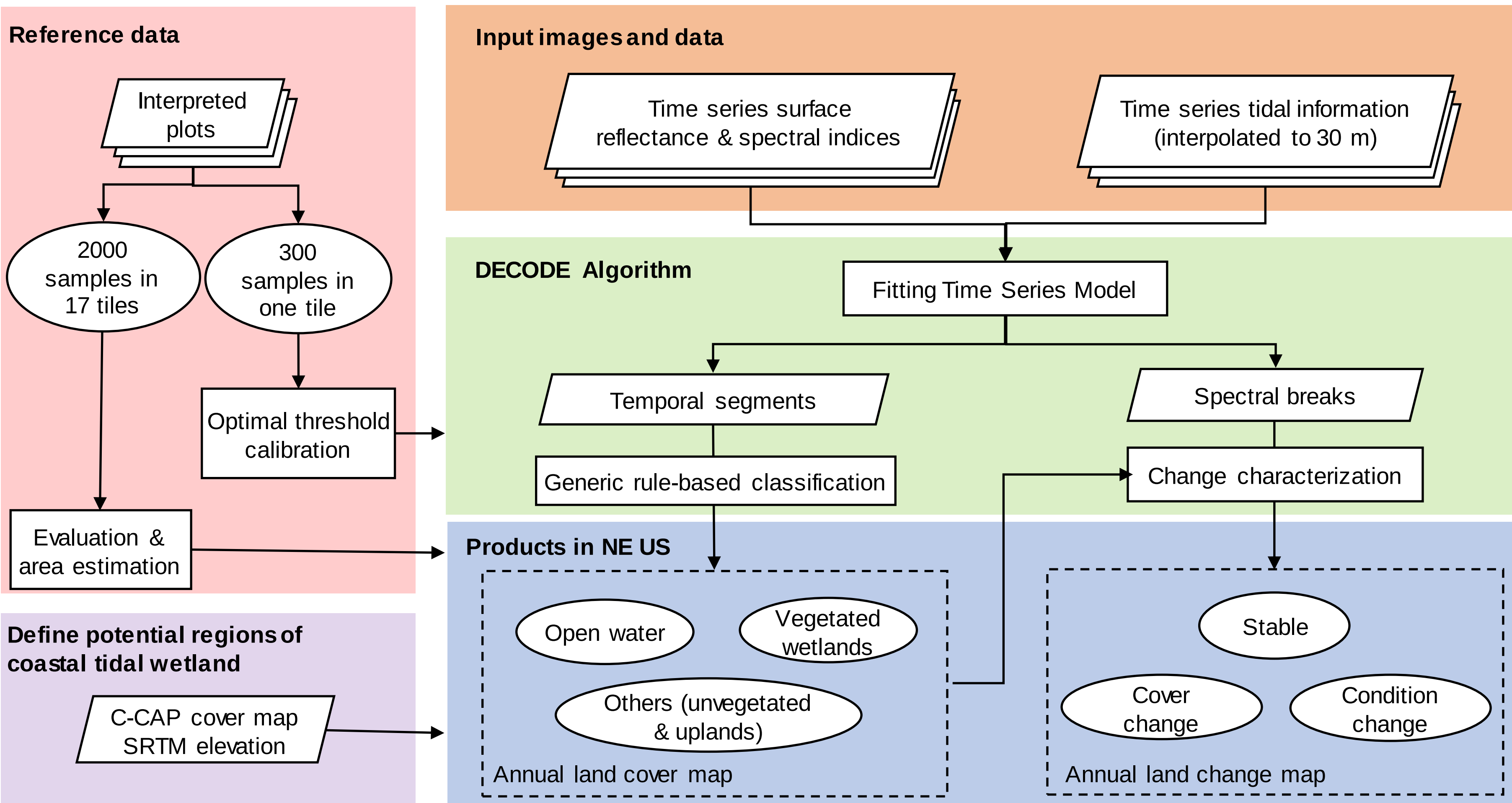
Goal: Provide accurate land cover and land change maps for coastal tidal wetland areas fully automated at 30-m resolution

Input: Landsat images during 1984-2020 and coastal water level information from NOAA

DECODE algorithm, i.e., spectral break detection, land cover classification and change characterization

reference data to calibrate optimal thresholds and assess accuracy

Products in Northeastern United States within the potential **coastal tidal wetland regions**



DECODE – Spectral break detection

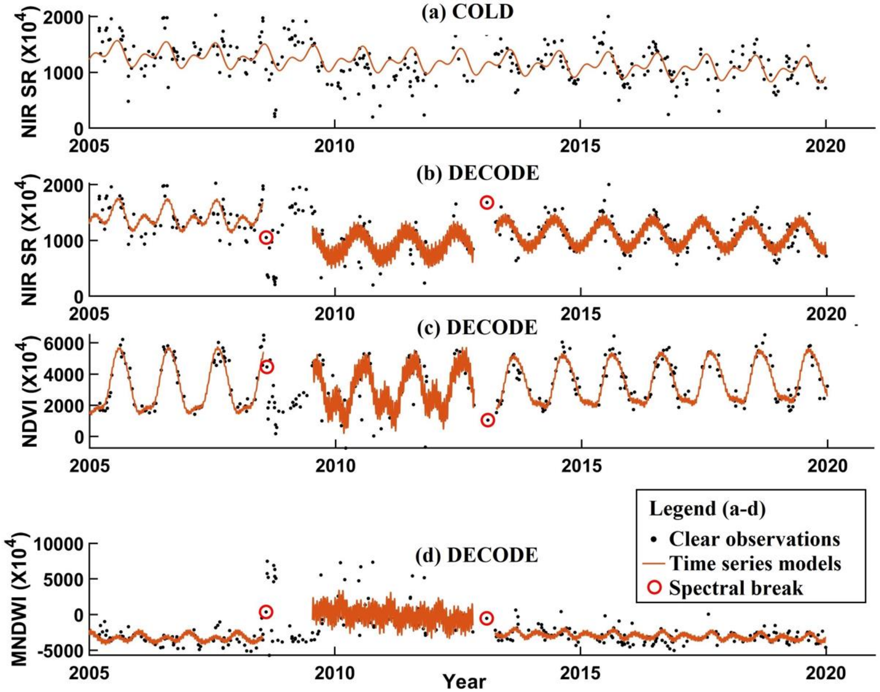
$$\hat{\rho}_{i,x} = a_{0,i} + \sum_{k=1}^{3}\left\{a_{k,i}cos\left(\frac{2k\pi}{T}x\right) + b_{k,i}sin\left(\frac{2k\pi}{T}x\right)\right\} + c_{1,i}x + c_{2,i}w$$

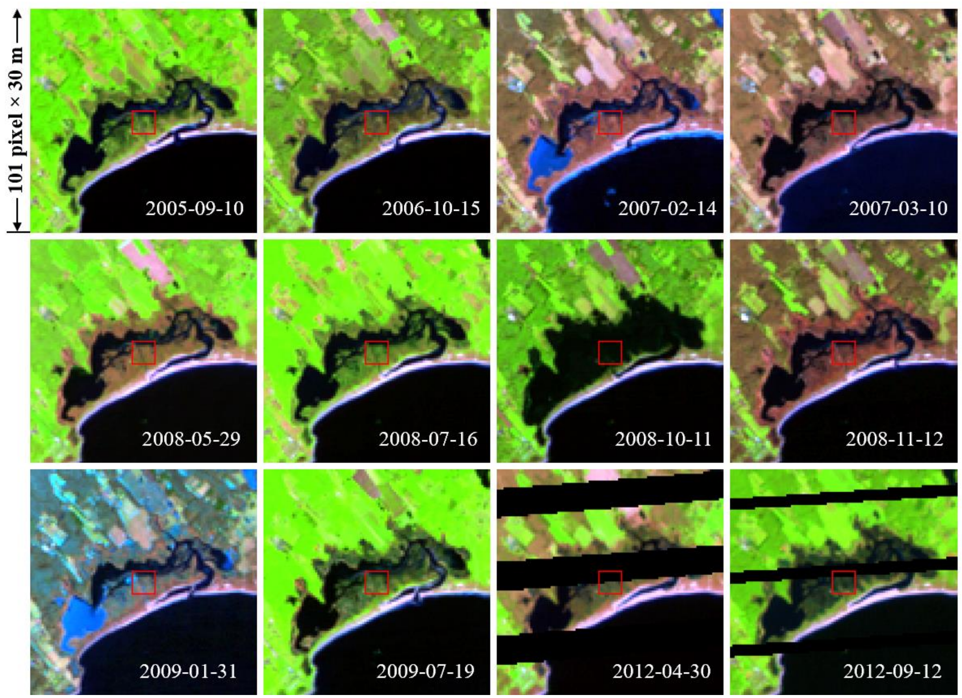
$\hat{\rho}_{i,x}$ is predicted reflectance or index value at x Julian date, T is number of days per year (T = 365.25),

k is temporal frequency of harmonic component, i indicates the variables, including the Landsat bands and spectral indices,

$a_{0,i}$,($a_{k,i}$, $b_{k,i}$), and $c_{1,i}$ are coefficients for overall value, intra-annual change and inter-annual change, respectively,

$c_{2,i}$ is coefficient for tidal variation, w is interpolated tidal water levels (at 10:00 am) on the same date as Landsat observation





The comparison between COLD (a) and DECODE (b, c, d) for break detection and curve fitting by using the harmonic time series model. The time series (a-d) of different variables is derived from the pixel located in the center of the red box within the 12 Landsat image chips below. The image chips are composed of Landsat SWIR, NIR, and red bands with same stretch, and thus they are directly comparable. The Landsat images present the status of Allens Pond Wildlife Sanctuary (41.5153, -71.0079), Dartmouth, Massachusetts during 2007-2009 and in 2012. The wetland connects to Buzzards Bay through a dynamic channel (shown as the images before 2008 and in 2009). In 2008, the channel was closed, and the salt marsh became inundated with freshwater discharge that could not reach the sea (shown as the Landsat image acquired on 2008-10-11). The wetland recovered following rapid management action to reopen the channel (shown as the Landsat image acquired on 2008-11-12), but the impact to the wetland condition sustained and was observed by the Landsat observations.

DECODE – Cover classification

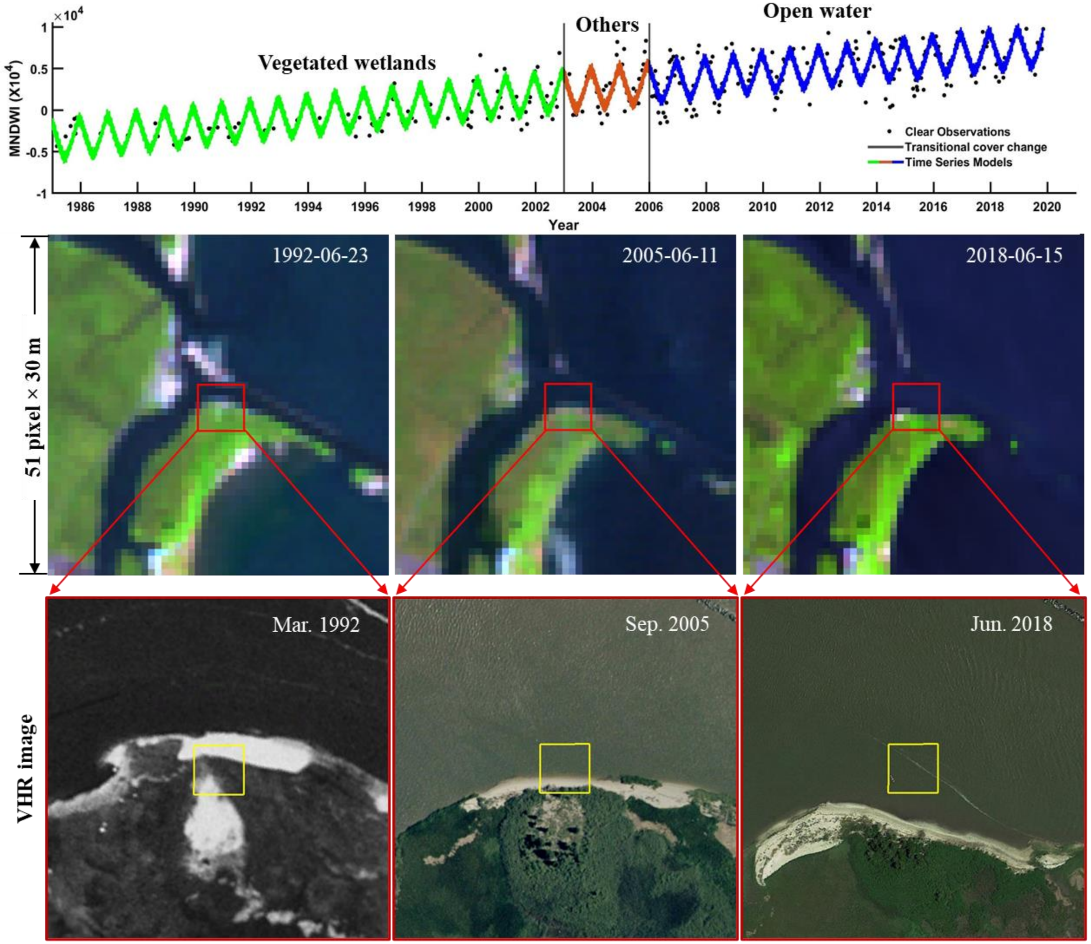
1. A generic rule-based system

- Uses the phenological metrics described by modified normalized difference water index (MNDWI) and normalized difference vegetation index (NDVI) to obtain cover types at annual scale

- **Open water** – standing water bodies throughout a full year
- **Vegetated wetlands** – tidal marsh, forested wetlands, mangrove
- **Others** – uplands, unvegetated wetlands

2. Segment cover type recognition

- **One class per segment** – Only a single cover type for the entire temporal segment
- **Transitional covers** – More than one land cover types could be found in a single temporal segment that experiences gradual and irreversible cover changes (shown as Figure)



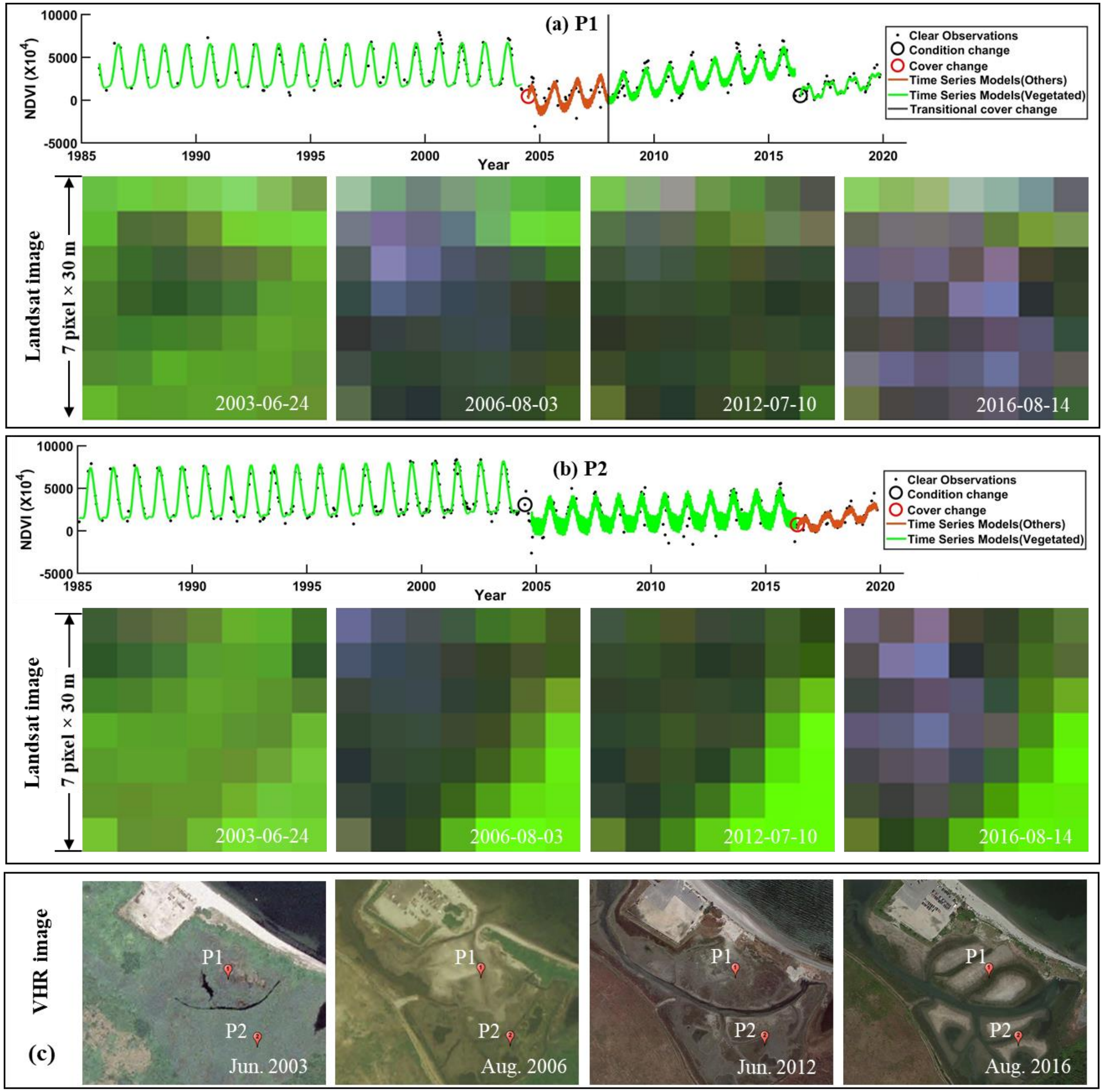
A time series plot located in Cedar Creek estuary, Delaware (38.9453, -75.3132), where land cover was coastal vegetation before 2002, became tidal flats around 2005, and then became open seawater in recent years due to the gradual impact of sea-level rise and tidal erosion. Though no abrupt spectral change is observed in the Landsat time series, the long-term gradual change could still cause categorical land cover change from vegetated, to unvegetated wetland, and water body. The second row are Landsat images (false color composite of Landsat SWIR, NIR, and red bands with same stretch), acquired in three dates. The third row are very high resolution (VHR) images acquired in the same year as Landsat images and present the detailed information within the regions marked in red box of Landsat images. The yellow box shows the land surface capture by one Landsat pixel with time series plot shown in the first row.

DECODE – Change characterization

Two kinds of wetland changes

- **Cover change/conversion** – categorical cover change among vegetated wetland, open water, and others – including unvegetated wetlands and uplands
- **Condition change (cover modification)** – relatively subtle in change magnitude and will not lead to categorial land cover change

  Responsible for majority (84.3%) of the coastal tidal wetland change



Examples of coastal tidal wetland cover and condition change. The site of Sachuest Point National Wildlife Refuge (41.4852, -71.2451), Rhode Island, US, underwent construction and management changes in 2004 and 2016. In 2004, cover change occurred in wetland location (P1), transitioning from tidal marsh into tidal flats, while tidal marsh at location (P2) experienced condition change. In 2016, management action caused (P2) to undergo condition change, while site (P1) experienced cover change from tidal marsh to tidal flats (P2). During the interim period between actions in 2004 and 2016, P1 underwent a transitional cover change, recovering to tidal marsh after several years. The VHR images in the third row show the changes of the wetlands owing to the management and mark out the location of two time series plots P1 (a) and P2 (b). Within (a) and (b), the time series displays the change and cover detected by DECODE for the center pixel of the Landsat images (false-color composite of Landsat SWIR, NIR, and red bands with the same stretch).

DECODE - knowledge gaps and ongoing work

1: How to separate the tidal and non-tidal wetlands from remote sensing satellite data;

2: Analysis of change agent of coastal tidal wetlands: human-induced (restoration or damage) and natural process (sea-level rise or hurricanes) and their impact on blue carbon

3: Model (DECODE) application from U.S. to the global scale