Background

Land restoration is the primary objective of river diversion projects, such as the $2,200 million Mid-Barataria sediment diversion project. Long-term assessment of restoration projects can help a better understanding of how much human remedial actions can reverse wetland degradation and to what extent by space and time. Ground-based observation from gauge stations or field surveys can provide point-based assessment data. However, the acquisition of field data in a long-term and large geographic area can be costly, subjective, and tedious. Remote sensing provides a synoptic view and an effective solution for the assessment of the changing environment. Generally, the most important variables related to river diversion are sediment transportation, land surface elevation, and vegetation abundance near the diversion. Recent land monitoring satellites including Sentinel-2A & 2B and Landsat 8 & 9 can show vegetation abundance and suspended sediment concentration in water. In addition, the upcoming NASA's SWOT (Surface Water and Ocean Topography) satellite will deliver global coverage of water surface elevation data with a 21-day returning period using its high-precision (<10 cm) Ka-band interferometry SAR. The water height data then can be converted to discharge rate for ungauged river segments. On the other hand, Unmanned Aircraft Systems (UAS) can obtain centimeter-resolution images for ground-truthing or deriving surface flow velocity. The combination of these technologies makes long-term monitoring for river diversion and land restoration projects feasible at large space and time scales. In the Big Data Era, cloud-based systems such as Google Earth Engine provide online global data and processing services. Deployed on the cloud, long-term monitoring projects require minimum cost because once the correct workflow has been calibrated and implemented on the cloud, all the data processing will be automated on the cloud. Furthermore, cloud-based platforms can expedite the dissemination of knowledge to stakeholders and local communities.

Objective

The objective of the proposed research is to make ready a cloud-based tool with multi-source remote sensing data, including the above-mentioned satellites and UAS to retrieve sediment transportation, land and water surface elevation, and vegetation abundance for assessment of the magnitude and extent of land restoration near the Mid-Barataria river diversion area.

Research activities

The following four research tasks will be accomplished
1. Satellite models for sediment discharge at the river diversion site

Both discharge rate and sediment concentration have been monitored by USGS water stations. At the immediate upstream of the planned Mid-Barataria sediment diversion site, there is one functioning station providing water height, discharge rate, and suspended sediment data. The historical gauge data will be used to drive the stage-discharge rating of the river channel near the diversion. The stage-discharge rating will be combined with the water surface elevation data from NASA's SWOT satellite to estimate the river discharge rate downstream of the diversion

site, which is not gauged. When river diversion is activated in the future, the difference between the upstream and downstream of the diversion can be used to estimate the sediment load transported to the wetland, if the suspended sediment concentration is known. Sentinel-2A and 2B satellite images will be used to estimate sediment concentration in the channel. We will use the USGS water quality station data and our in-situ water samples to calibrate the satellite model.

2. Inter-annual and seasonal trends of vegetation abundance and wetland elevation change

Vegetation abundance can be a useful indicator for land restoration. However, because it is highly dynamic during growing seasons, it is difficult to evaluate if the change is associated with river diversion or other factors. First, we will establish a long-time series of vegetation abundance data from the constellation of Sentinel-2A and 2B and Landsat 8 and 9. Then, inter-annual and seasonal trends will be retrieved from the time series by using decomposition models such as the STL (Seasonal and Trend decomposition using Loess) algorithm. The inter-annual trend can be treated as the change caused by land restoration. Similarly, the wetland surface elevation time series will be constructed from the SWOT satellite data and the laser altimetry data from the ICESat-2 satellite and analyzed with the STL algorithm.

3. UAS surveys of suspended sediment, flow velocity, and vegetation abundance

To compensate for the uncertainty of satellite models, we plan to fly a UAS carrying multispectral cameras for detailed mapping of suspended sediment concentration, flow velocity, and vegetation abundance. These data can be used to validate and calibrate satellite models. Specifically, the flight of UAS is controlled to obtain images with 75% side lap and end lap so that flow velocity can be obtained from adjacent images using the image matching algorithm. The water flow speed across the river cross-section will be converted to discharge rate to validate the satellite-based estimation.

4. Cloud-based implementation

The satellite data mentioned above, including Sentinel 2A&B, and Landsat 8&9, have been made available on Google Earth Engine (GEE). GEE supports both Javascript and Python for requesting data and geoprocessing services. Using python scripts, we will request cloud computing on selected image pixels stored on the server to calculate vegetation abundance, sediment concentration, and other models. The outcome data product will be shared through the ArcGIS Online platform as web maps and applications including story maps and dashboards to disseminate data and knowledge to the general public.

Significance and relevance to the Master Plan

The project is closely pertaining to the 2017 Coastal Master Plan, specifically the river sediment diversion projects. The research will contribute data products and knowledge to river diversion and wetland restoration research. The cloud-based implementation is one innovative component of the proposed research, which although challenging, will maximize the value of remote sensing data as the input to coastal restoration studies. Furthermore, the tool can be transferred to other wetland river diversion project areas.