The Delta-X Framework: A Reality Check for Hydrodynamic, Sediment Transport and Ecogeomorphic Models

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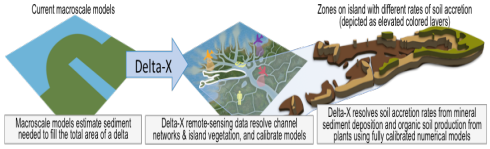
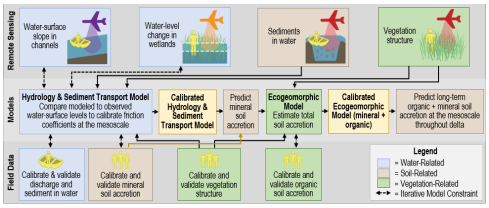
The goal of Delta-X is to develop hydrodynamic and ecogeomorphic models calibrated with remote sensing measurements to quantify the contributions of allochtonous sediment deposition and autochtonous plant production to soil elevation, and forecast the vulnerability and resilience of deltaic systems. The Delta-X framework is fully implemented in the Mississippi River Delta in April and September 2020, during the high and low river discharge. This poster highlights results obtained with data acquired during the Delta-X measurement demonstration campaigns of Spring 2015 and Fall 2016. The Delta-X implementation flies 3 airborne instruments to observe high frequency tidal processes along the coast. Two radars measures hydrological processes and an imaging spectrometer estimates water quality and vegetation structure. These measurements are used to calibrate the hydrodynamic and ecogeomorphic model parameters, which are then used to predict mid- and long-term soil accretion rates.

Concept

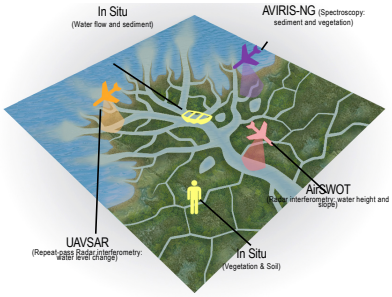
Delta-X takes models to scale of hydrogeomorphic zones (~1 ha)



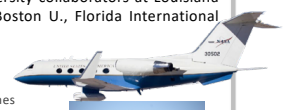
Models are calibrated with airborne and field data.



Aircrafts fly simultaneously, with boats carrying GPS, ADCPs, sonars, water sampling and spectrometers. Demonstration campaigns were in the Spring 2015 and Fall 2016. The Delta-X implementation uses two radars to measure hydrodynamic processes while the imaging spectrometer measures water and vegetation spectra.



JPL's airborne instrument assets: UAVSAR, AirSWOT and AVIRIS-NG. Field in with University collaborators at Louisiana State U., U. North Carolina, Boston U., Florida International U., U. Texas, Caltech, WHOI.



UAVSAR
- L- band Radar, full-pol, 6m
- Water level changes within marshes
- Map of channel network

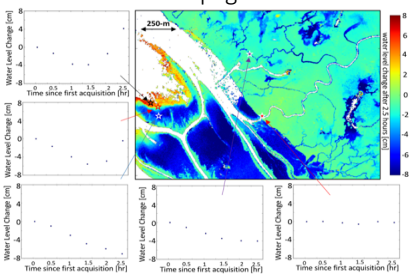
AirSWOT
Ka-band radar interferometer
- Centimeter-level open water surface elevation and surface slope

AVIRIS-NG
Imaging spectroscopy (432 bands at 4m)
- Vegetation species and structure
- Sediment concentrations in water

Field data
In channels and islands
- Vegetation species and structure
- Above and below ground biomass
- Sediment accretion
- Water Quality (Sediment characteristics)

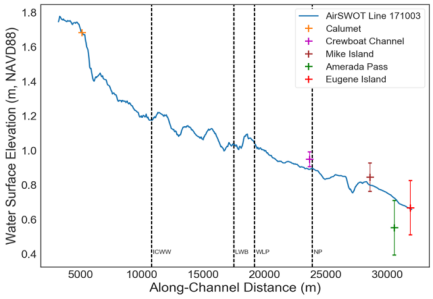
Measurements

Tide Level and Propagation in Wetlands



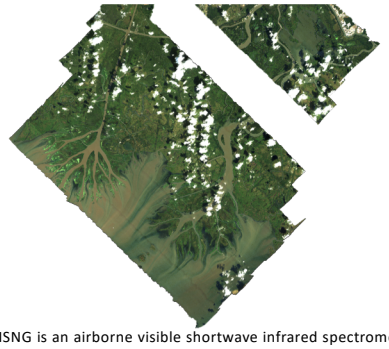
UAVSAR measures changes in water level within marshes. Because of its ability to rapidly repeat measurements (every ~30 minutes), this airborne remote sensing instrument can monitor high frequency processes like tides flowing in and out of marshes. Each image pixel acts as a water level gauge, enabling observation of tide propagation across the wetlands. These measurements are used to estimate channel-island connectivity, resistance to flow due to vegetation, and transport of water into wetlands.

Water Surface Elevation and Slope



AirSWOT measures water surface elevation and slope with accuracies better than 1cm/km (Denbina et al., 2019). These spatially continuous and nearly instantaneous measurements enable monitoring of river slope and discharge along all of its reaches. These synoptic views of water surface topography and variations in slopes highlight interactions between intersecting channels, changes in channel geometry and overflow to wetlands.

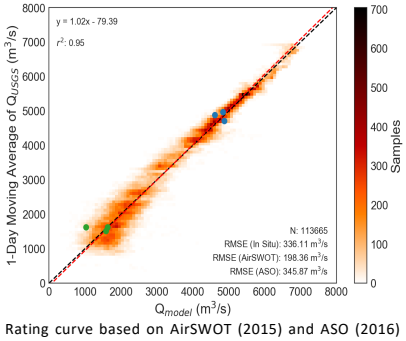
Water and Vegetation Reflectance Spectra



AVIRISNG is an airborne visible shortwave infrared spectrometer measuring reflectance between 380 to 2510 nm for every pixel within the scene. For each image pixel, a spectrum is available to estimate vegetation as well as water reflectance properties. The image above water corrected for atmospheric effect (other than clouds) and bidirectional reflectance related to viewing and sun geometry (Jensen et al., 2019).

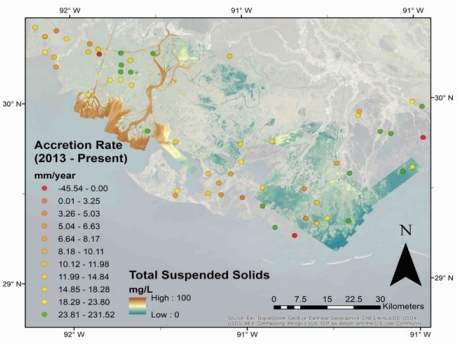
Modeling

Instantaneous River Discharge



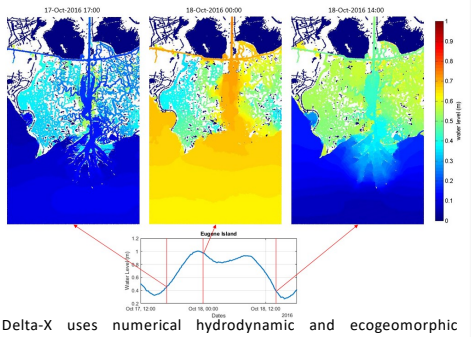
Rating curve based on AirSWOT (2015) and ASO (2016) measurements of water surface elevation and slope enables estimation of water discharge in rivers (e.g. Wax Lake outlet). The plots shows discharge estimated from remote sensing compared to in situ measurements at the USGS Calumet station for Spring 2015 (blue dots) and Fall 2016 (green dots). Red dots are from gauge.

Water Quality and Vegetation Biomass



Total Suspended Sediments from AVIRIS-NG vs in situ (CRMS) accretion rates. The concentrations are estimated within 20mg/L from AVIRISNG reflectance spectra providing landscape-scale observations of sediment availability. We observed that the waters of the region-growing Atchafalaya basin (West) contain more suspended sediment than found in waters of the Terrebonne basin. The latter is largely disconnected from the Mississippi River and loosing land.

Hydrodynamic Model Calibration



Delta-X uses numerical hydrodynamic and ecogeomorphic models for mid- to long-term prediction of soil accretion across the landscape. The hydrodynamic model parameters are calibrated by iteratively comparing model outputs with remote sensing and field observations. In particular, flow resistance due to bottom and vegetation friction can be estimated by observation of tidal wave propagation. AVIRISNG-derived maps of vegetation structure and above ground biomass serve to upscale flow resistance and also calibrate organic soil accretion models.