Delta-X: Delft3D Broad-Scale Sediment Model, Atchafalaya Basin, MRD, Louisiana, USA

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Dataset Version: 1

Summary

This dataset contains the Delft3D model of the Atchafalaya Basin along the Mississippi River Delta (MRD) in coastal Louisiana. Simulations cover the Delta-X Spring and Fall campaigns in 2021 and include hydrodynamics, waves, and sediment transport. Bottom friction was calibrated using AirSWOT water elevation data, while sediment parameters were calibrated using AVIRIS-NG Total Suspended Solids (TSS) data. All files required to run the simulations are included. Model output of water levels, velocity, and depth-averaged sediment concentration are provided for both campaigns as netCDF files. The dataset includes a netCDF file containing the annual inorganic mass accumulation rates derived from simulations.

There are 13 data files in netCDF (.nc4) format and two zip archives holding 36 model set-up files required to run the simulations.

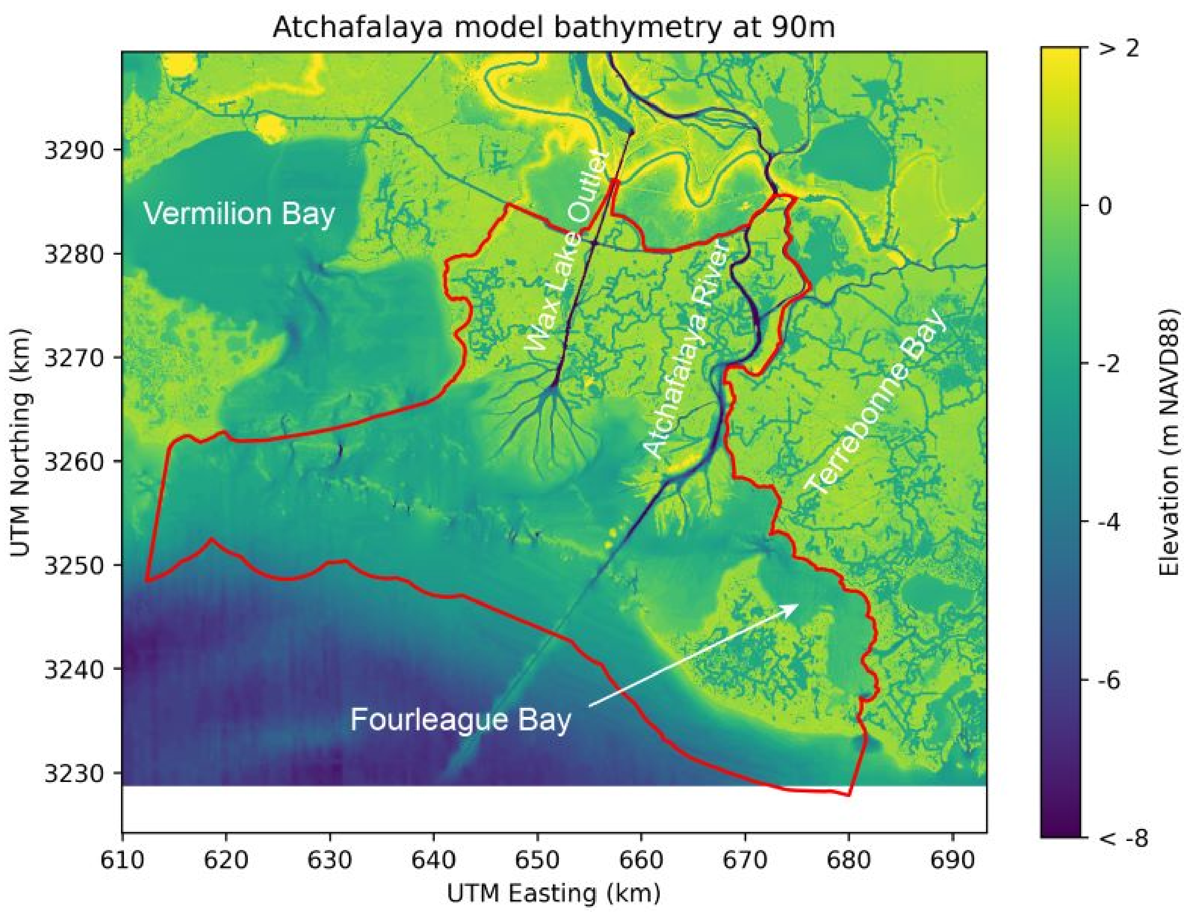

Figure 1. Atchafalaya basin of the Mississippi River Delta, southern coast of Louisiana, USA. Colors illustrate bathymetry measured by elevation (m) above the NAVD88 vertical datum at 90-m resolution.

Citation

Cortese, L., X. Zhang, and S. Fagherazzi. 2023. Delta-X: Delft3D Broad-Scale Sediment Model, Atchafalaya Basin, MRD, Louisiana, USA. ORNL DAAC, Oak Ridge, Tennessee, USA. https://doi.org/10.3334/ORNLDAAC/2302

Table of Contents

1. Dataset Overview

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Project: Delta-X

The Delta-X mission is a 5-year NASA Earth Venture Suborbital-3 mission to study the Mississippi River Delta in the United States, which is growing and sinking in different areas. River deltas and their wetlands are drowning as a result of sea level rise and reduced sediment inputs. The Delta-X mission will determine which parts will survive and continue to grow, and which parts will be lost. Delta-X begins with airborne and in situ data acquisition and carries through data analysis, model integration, and validation to predict the extent and spatial patterns of future deltaic land loss or gain.

Related datasets

Cortese, L., and S. Fagherazzi. 2023. Delta-X: Delft3D Broad-Scale Sediment Model, Terrebonne Basin, MRD, Louisiana, USA. ORNL DAAC, Oak Ridge, Tennessee, USA. https://doi.org/10.3334/ORNLDAAC/2301

Christensen, A.L., J.M. Mallard, J. Nghiem, M. Simard, T.M. Pavelsky, and M.P. Lamb. 2022. Delta-X: Acoustic Doppler Current Profiler Channel Surveys, MRD, Louisiana, 2021, V2. ORNL DAAC, Oak Ridge, Tennessee, USA. https://doi.org/10.3334/ORNLDAAC/2081

Christensen, A.L., M.W. Denbina, and M. Simard. 2023. Delta-X: Digital Elevation Model, MRD, LA, USA, 2021. ORNL DAAC, Oak Ridge, Tennessee, USA. https://doi.org/10.3334/ORNLDAAC/2181

Denbina, M.W., M. Simard, and E. Rodriguez. 2023. Delta-X: AirSWOT L2 Geocoded Water Surface Elevation, MRD, Louisiana, 2021, Version 2. ORNL DAAC, Oak Ridge, Tennessee, USA. https://doi.org/10.3334/ORNLDAAC/2128

Fichot, C.G., and J. Harringmeyer. 2022. Delta-X: AVIRIS-NG L3-derived Water Quality, TSS, and Turbidity, MRD, LA 2021, V2. ORNL DAAC, Oak Ridge, Tennessee, USA. https://doi.org/10.3334/ORNLDAAC/2112

Related publications:

Cortese, L., X. Zhang, M. Simard, and S. Fagherazzi. 2023. Quantifying the impact of storm frequency and intensity on mineral mass accumulation rates of coastal marshes. Journal of Geophysical Research: Earth Surface. In review.

Cortese, L., C. Donatelli, X. Zhang, J.A. Nghiem, M. Simard, C.E. Jones, M. Denbina, C.G. Fichot, J.P. Harringmeyer, and S. Fagherazzi. 2023. Coupling numerical models of deltaic wetlands with AirSWOT, UAVSAR, and AVIRIS-NG remote sensing data, Biogeosciences. In review. https://doi.org/10.5194/bg-2023-108

Acknowledgements

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2. Data Characteristics

Spatial Coverage: Atchafalaya Basin, Mississippi River Delta (MRD) floodplain, southern coast of Louisiana, USA

Spatial Resolution: 90 m

Temporal Coverage: 2021-03-20 to 2021-04-25 (Spring) and 2021-08-10 to 2021-08-28 (Fall)

Temporal Resolution: 1-hour time steps for model output

Site Boundaries: Latitude and longitude are given in decimal degrees.

Site	Westernmost Longitude	Easternmost Longitude	Northernmost Latitude	Southernmost Latitude
Atchafalaya Basin	-91.8697	-90.9994	29.8217	29.1725

Data File Information

There are 13 data files in netCDF (.nc4) format and two zip archives holding 36 model set-up files required to run the simulations.

File naming convention for 10 model output files: *Atchafalaya_d3d_output_<var>_<campaign>.nc4*, where

- *<var>* indicates the output variable. See Table 1.
- *<campaign>* is either "Fall2021" or "Spring2021"

Atchafalaya_IMAR.nc4 holds estimates of annual inorganic mass accumulation rates (imar).

Fall2021_Delft3D_setup_Atch.zip and *Spring2021_Delft3D_setup_Atch.zip* each hold 18 files in text format needed to execute the Delft3D simulation model for the Atchafalaya basin (Table 2).

Data File Details:

The netCDF files hold spatial data in an array projected using the UTM coordinate system: zone 15N, WGS84 datum, EPSG: 32616.
The spatial resolution is 90 m.

The model output files hold simulation output for hourly time steps: Spring has 817 time steps. Fall has 408 time steps.

Table 1. Variables in netCDF files.

Variable	Units	Description
ssc_clay	kg m^{-3}	Depth averaged concentration of clay
scc_sand	kg m^{-3}	Depth averaged concentration of sand
scc_silt	kg m^{-3}	Depth averaged concentration of silt
u	m s^{-1}	East-west component of water velocity
v	m s^{-1}	North-south component of water velocity
wl	m	Water surface elevation above the NAVD88 vertical datum
imar	g cm^{-2} y^{-1}	Annual inorganic mass accumulation rate (IMAR): annual rates of mineral mass deposited on wetlands, estimated from analysis of storm frequency and deposition.

Table 2. Delft3D model input files included in *Fall2021_Delft3D_setup_Atch.zip* and *Spring2021_Delft3D_setup_Atch.zip*.

Filename	Description
925x785_ok.enc	Grid enclosure
925x785_ok.grd	Computational grid definition
bc_data.bct	Boundary conditions
bc_locations.bnd	Boundary cells definition
bottom_friction.rgh	Bottom roughness in every cell expressed as Chezy coefficient
carved_bathymetry.dep	Elevation in meters of every cell (bathymetry) above and below NAVD88
clay_initial_layer_thickness.sdb	Thickness of the initial clay layer at the bottom
flow_gui.out	GUI Output control
M5.mdf	Master file for running the FLOW simulation
m5waves.mdw	Master file for running the WAVE simulation
morph_params.mor	Parameters defining the morphological model
obs.obs	Monitoring points location
sand_initial_layer_thickness.sdb	Thickness of the initial sand layer at the bottom
sed_params.sed	Parameters of sand, silt, and clay fractions
sed_transp_bc.bcc	Boundary conditions of the sediment transport
silt_initial_layer_thickness.sdb	Thickness of the initial silt layer at the bottom
TPAR.bnd	Boundary conditions for the WAVE module
wind.wnd	Wind speed and direction data

3. Application and Derivation

The broad-scale Atchafalaya basin Delft3D model considers river discharge from the Wax Lake Outlet and Atchafalaya River, tidal currents, and wind-generated waves to estimate the mineral sediment transport within the Atchafalaya basin domain. Data produced by the model can be used in water quality studies that need physical variables such as sediment concentration and water velocity.

4. Quality Assessment

Modelled water elevations were validated against AirSWOT imagery (Denbina et al., 2023) and water level gauges data provided by the Coastal Reference Monitoring System (CRMS, https://cims.coastal.la.gov/monitoring-data/). Water discharge was compared with measured discharges (Christensen et al., 2022). Sediment concentration was compared to sediment concentration maps inferred from AVIRIS-NG imagery (Fichot and Harringmeyer, 2022).

5. Data Acquisition, Materials, and Methods

Study area

The Atchafalaya basin is located between the Terrebonne and Teche-Vermilion hydrological basins. The Mississippi River Delta is one of the few areas where land gain has been constantly measured (Parker and Sequeiros, 2006; Couvillion et al., 2017). The Atchafalaya River and Wax Lake Outlet are the two rivers flowing through the basin and are characterized by two hydrological regimes: high river discharge in spring (between January and June) and low river discharge in summer-fall (in September-October). As result of the freshwater discharge, the deltas area is dominated by freshwater marshes and swamps (Twilley et al., 2019).

Methods

The Atchafalaya Basin Delft3D model (Lesser et al., 2004; https://oss.deltares.nl/web/delft3d) is a 2D depth-averaged sediment transport model fully coupled with the SWAN (Simulating Waves Nearshore) model to account for waves. The DEM from Christensen et al. (2023) was resampled at 90 m. The model domain extends to Fourleague Bay at the eastern side and Vermilion Bay on the western side (Figure 1). Calibration and validation of the model was focused only in the Atchafalaya basin and Fourleague Bay. Model boundary conditions are water levels imposed at the Gulf of Mexico side, which were derived from the National Oceanic and Atmospheric Administration (NOAA) station at Eugene Island and water discharge of the Wax Lake Outlet and Atchafalaya measured by the United States Geological Survey (USGS) at Calumet and Morgan City. Wind is applied homogeneously on the bay, and data were taken from the same NOAA station. There are three bottom friction classes: open water, marsh, and forest. The calibration of the open water class was performed using AirSWOT data (Denbina et al., 2023). Three different sediment classes were considered: clay (cohesive fraction), silt (cohesive fraction), and sand (non-cohesive fraction). Sediment parameters of settling velocity and critical bed shear stress for erosion were calibrated using maps of total suspended solids (TSS) derived from AVIRIS-NG data (Fichot and Harringmeyer, 2022). Water-level validation was performed by comparing water level time series recorded at different CRMS gauges. Discharge was validated with Acoustic Doppler Profiler (ACDP) measurements at several cross sections.

More details on the calibration and validation can be found in Cortese et al. (2023a) and Cortese et al. (2023b).

Derivation of inorganic mass accumulation rates

The inorganic mass accumulation rates (IMAR) were from simulations under the high and low discharge regimes. Inorganic mass accumulation computed for the Spring campaign was multiplied by 6 to account for half a year. Inorganic mass accumulation computed for the Fall campaign was multiplied by 6 to account for the second half of a year. Then, the two contributions were summed to obtain the yearly inorganic mass accumulation rates.

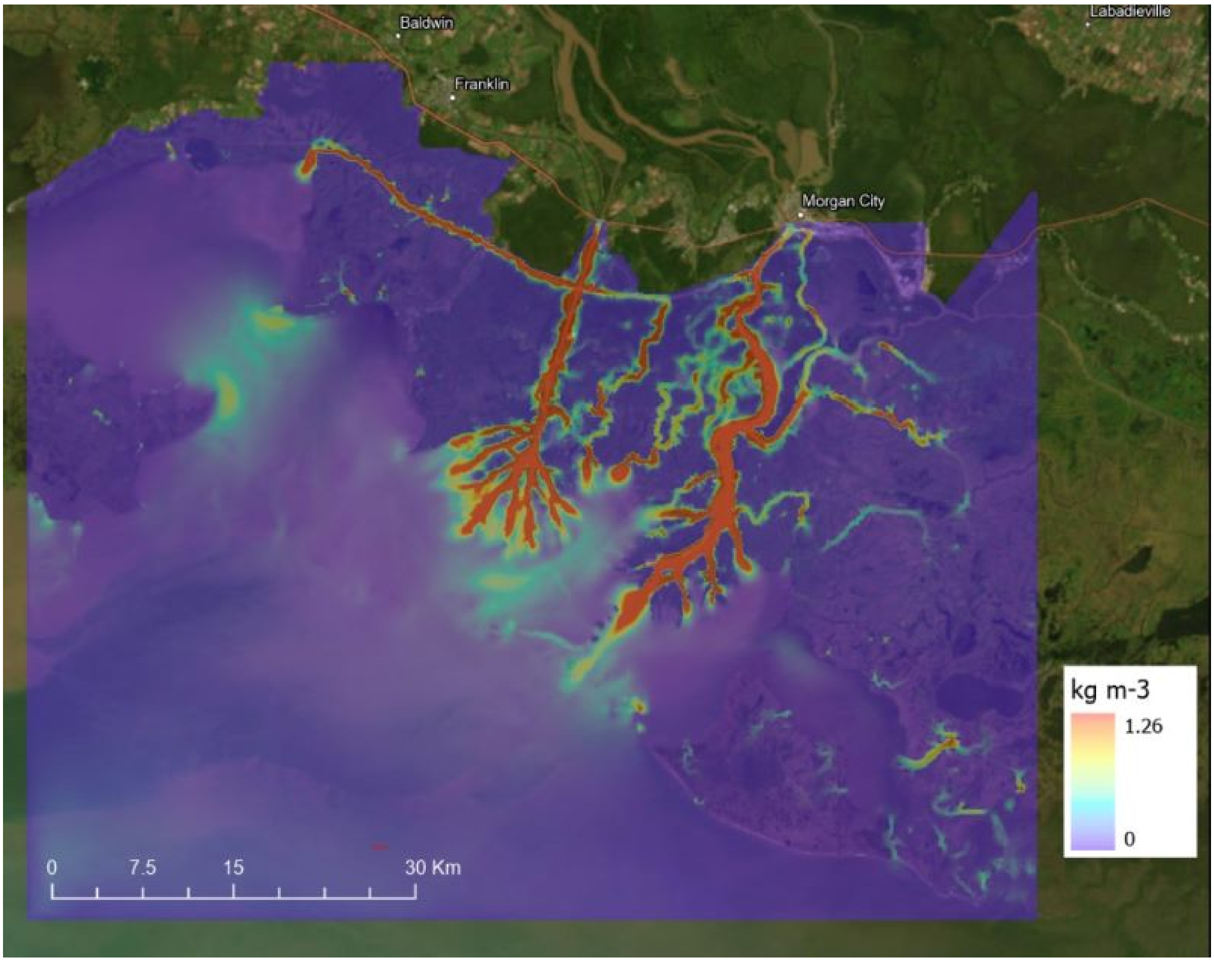

Figure 2. Simulated concentration of clay at 2021-03-20 00:30:00 in Atchafalaya Basin.

6. Data Access

These data are available through the Oak Ridge National Laboratory (ORNL) Distributed Active Archive Center (DAAC).

Delta-X: Delft3D Broad-Scale Sediment Model, Atchafalaya Basin, MRD, Louisiana, USA

Contact for Data Center Access Information:

- E-mail: uso@daac.ornl.gov
- Telephone: +1 (865) 241-3952

7. References

Christensen, A.L., M.W. Denbina, and M. Simard. 2023. Delta-X: Digital Elevation Model, MRD, LA, USA, 2021. ORNL DAAC, Oak Ridge, Tennessee, USA. https://doi.org/10.3334/ORNLDAAC/2181

Christensen, A.L., J.M. Mallard, J. Nghiem, M. Simard, T.M. Pavelsky, and M.P. Lamb. 2022. Delta-X: Acoustic Doppler Current Profiler Channel Surveys, MRD, Louisiana, 2021, V2. ORNL DAAC, Oak Ridge, Tennessee, USA. https://doi.org/10.3334/ORNLDAAC/2081

Cortese, L., and S. Fagherazzi. 2022. Fetch and distance from the bay control accretion and erosion patterns in Terrebonne marshes (Louisiana, USA). Earth Surface Processes and Landforms 47:1455–1465. https://doi.org/10.1002/esp.5327

Cortese, L., and S. Fagherazzi. 2023. Delta-X: Delft3D Broad-Scale Sediment Model, Terrebonne Basin, MRD, Louisiana, USA. ORNL DAAC, Oak Ridge, Tennessee, USA. https://doi.org/10.3334/ORNLDAAC/2301

Cortese, L., X. Zhang, M. Simard and S. Fagherazzi. 2023a. Quantifying the impact of storm frequency and intensity on mineral mass accumulation rates of coastal marshes. Journal of Geophysical Research: Earth Surface, in review.

Cortese, L., C. Donatelli, X. Zhang, J.A. Nghiem, M. Simard, C.E. Jones, M. Denbina, C.G. Fichot, J.P. Harringmeyer, and S. Fagherazzi. 2023b. Coupling numerical models of deltaic wetlands with AirSWOT, UAVSAR, and AVIRIS-NG remote sensing data. Biogeosciences, in review. https://doi.org/10.5194/bg-2023-108

Couvillion, B.R., H. Beck, D. Schoolmaster, and M. Fischer. 2017. Land area change in coastal Louisiana (1932 to 2016). U.S. Geological Survey Scientific Investigations Map. https://doi.org/10.3133/sim3381

Denbina, M.W., M. Simard, and E. Rodriguez. 2023. Delta-X: AirSWOT L2 Geocoded Water Surface Elevation, MRD, Louisiana, 2021, Version 2. ORNL DAAC, Oak Ridge, Tennessee, USA. https://doi.org/10.3334/ORNLDAAC/2128

Everett, T., Q. Chen, A. Karimpour, and R. Twilley. 2018. Quantification of Swell Energy and Its Impact on Wetlands in a Deltaic Estuary. Estuaries and Coasts 42:68–84. https://doi.org/10.1007/s12237-018-0454-z

Fichot, C.G., and J. Harringmeyer. 2022. Delta-X: AVIRIS-NG L3-derived Water Quality, TSS, and Turbidity, MRD, LA 2021, V2. ORNL DAAC, Oak Ridge, Tennessee, USA. https://doi.org/10.3334/ORNLDAAC/2112

Lesser, G.R., J.A. Roelvink, J.A. T.M. van Kester, and G.S. Stelling. 2004. Development and validation of a three-dimensional morphological model. Coastal Engineering 51:883–915. https://doi.org/10.1016/j.coastaleng.2004.07.014

Parker, G. and O. Sequeiros. 2006. Large scale river morphodynamics: application to the Mississippi Delta. Pp. 3-11 in River Flow 2006: proceedings of the international conference on Fluvial Hydraulics. https://www.scopus.com/inward/record.uri?eid=2-s2.0-60749122639&partnerID=40&md5=0d018f3350bb2da0bd0120822e4f5595

Twilley, R.R., J.W. Day, A.E. Bevington, E. Castañeda-Moya, A. Christensen, G. Holm, L.R. Heffner, R. Lane, A. McCall, A. Aarons, S. Li, A. Freeman, and A.S. Rovai. 2019. Ecogeomorphology of coastal deltaic floodplains and estuaries in an active delta: Insights from the Atchafalaya Coastal Basin. Estuarine, Coastal and Shelf Science 227:106341. https://doi.org/10.1016/j.ecss.2019.106341