Understanding the relative contributions of sediment delivery and plants production to resilience of the Mississippi River Delta to sea level rise

Marc Simard (PI) & Cathleen Jones (DPI)

https://Deltax.jpl.nasa.gov

Jet Propulsion Laboratory
California Institute of Technology

Marc.simard@jpl.nasa.gov

Solving pressing Earth system Science issues: NASA's Earth Venture Suborbital – 3

(NASA's Science Mission Directorate/Earth Science Division)

- ACTIVATE:

Aerosol Cloud Meteorology Interactions over the Western Atlantic Experiment

- DCOTSS:

Dynamics and Chemistry of the Summer Stratosphere

- Delta-X:

Resilience of River Deltas

- IMPACTS:

Investigation of Microphysics and Precipitation for Atlantic Coast-Threatening Snowstorms

- S-MODE:

Submesoscale Ocean Dynamics and Vertical Transport

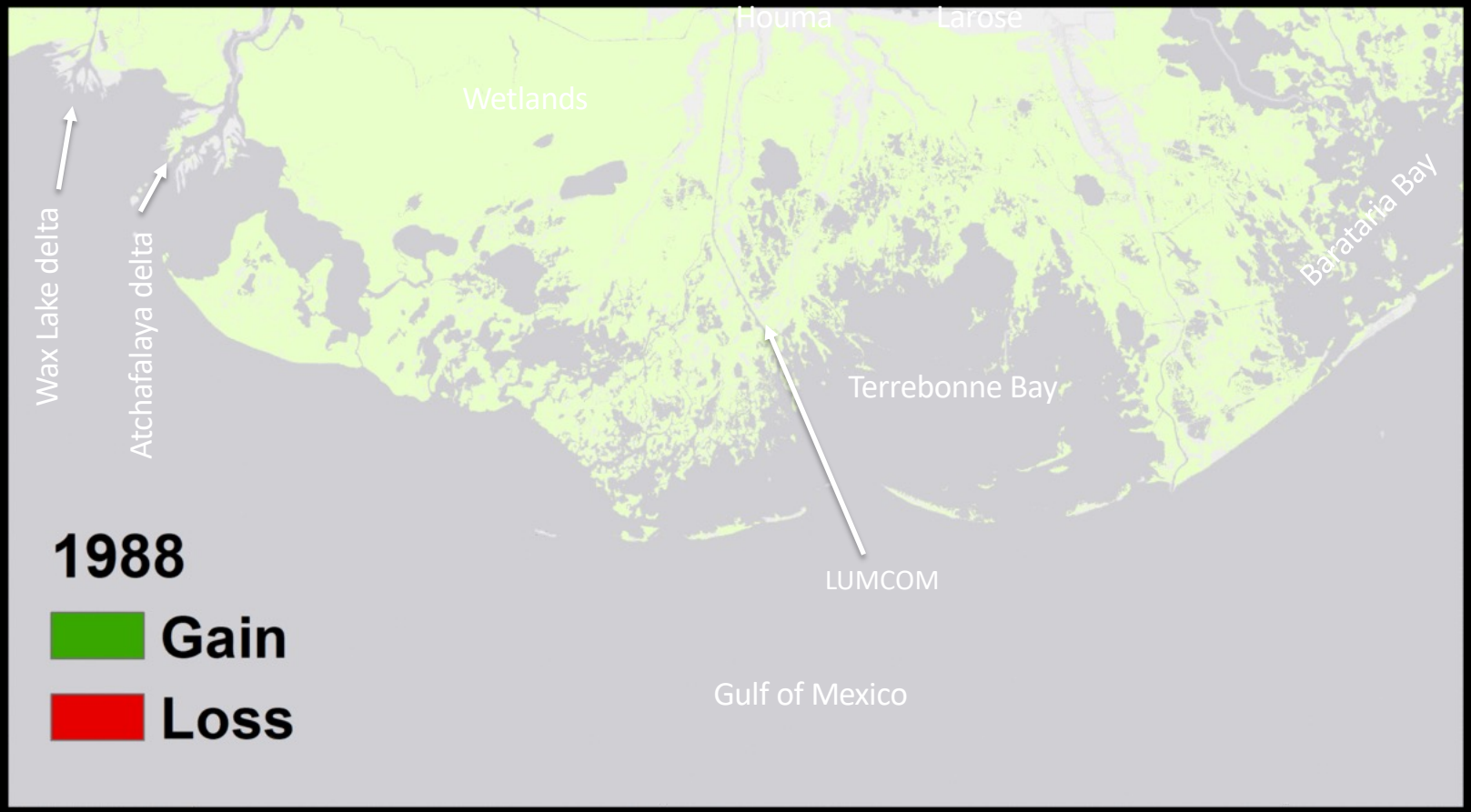
Jet Propulsion Laboratory
California Institute of Technology

Marc.simard@jpl.nasa.gov

12 Co-Investigators from 8 different institutions from 6 coastal states

- **California**:
  - Jet Propulsion Laboratory, California Institute of Technology (M. Simard, C. Jones, E. Rodriguez, D. Thompson)
  - Caltech (M. Lamb)
- **Louisiana**: Louisiana State University, Baton Rouge (R. Twilley)
- **Texas**: University of Texas, Austin (P. Passalacqua)
- **Florida**: Florida International University (E. Castañeda)
- **North Carolina**: University of North Carolina (T. Pavelsky)
- **Massachusets**:
  - Boston University (C. Fichot & S. Fagherazzi)
  - Woodshole Oceanographic institution (L. Giosan)

Land-Loss in Coastal Louisiana

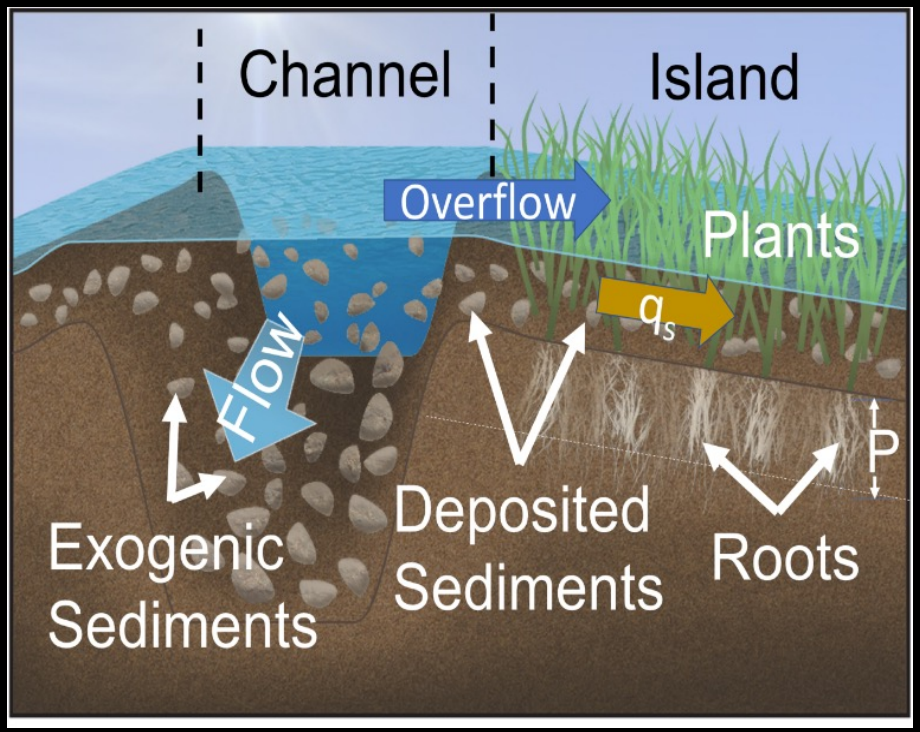


Jet Propulsion Laboratory
California Institute of Technology

Marc.simard@jpl.nasa.gov

Delta-X goal and objectives

Which parts of the Mississippi River Delta will survive and continue to grow, and which parts will be lost?



Science goal: to quantify the mesoscale patterns of soil accretion that control land loss and gain, and to predict the resilience of deltas under projected RSLR.

Objective 1: *Evaluate the role of vegetation in determining soil accretion rates within deltaic wetlands.*
Objective 2: *Evaluate the role of distributary channel-network densities and associated sizes of deltaic islands on soil accretion rates.*

Jet Propulsion Laboratory
California Institute of Technology
Marc.simard@jpl.nasa.gov

Two Soil accretion processes

Jet Propulsion Laboratory
California Institute of Technology
Marc.Simard@jpl.nasa.gov

The Delta-X Framework Implementation

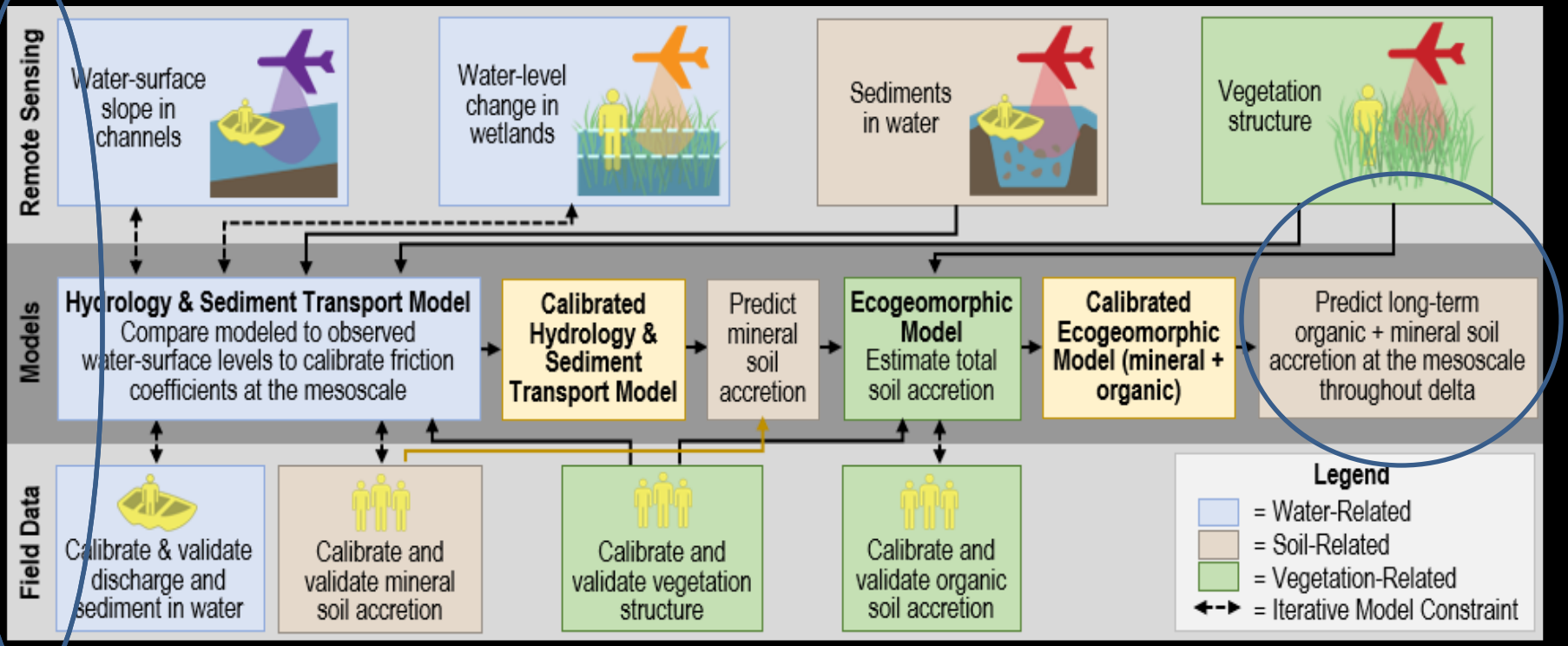
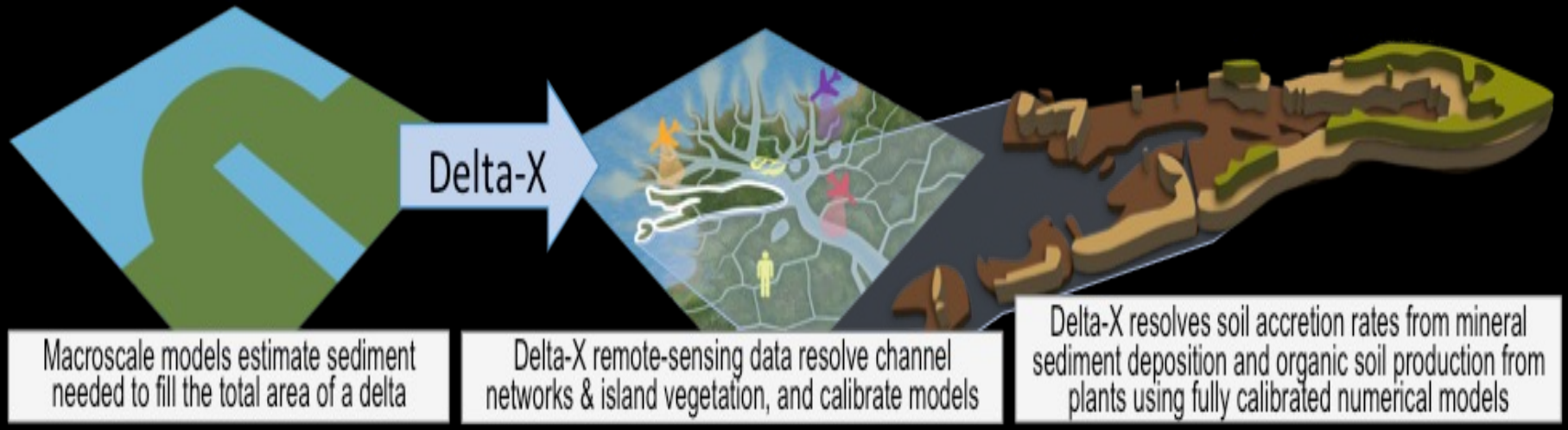


Figure 4: *Delta-X calibrates a hydrology and ecogeomorphic model with remote-sensing and in situ data. Two airborne radar instruments observe the water surface elevation changes, and an imaging spectrometer measures vegetation type and structure and sediment concentrations in water. Modeled water-surface elevation and slopes are compared to remotely sensed observations to invert the friction coefficient. The hydrology model's mineral sedimentation rate outputs are used as inputs in the ecogeomorphic model. Once the numerical ecogeomorphic model is calibrated, it is run independently of observations to predict long-term soil accretion under projected [illegible], river discharge, and sediment supply*

Jet Propulsion Laboratory
California Institute of Technology
Marc.simard@jpl.nasa.gov

From Bathtub to ecogeomorphic scales
The mesoscale concept

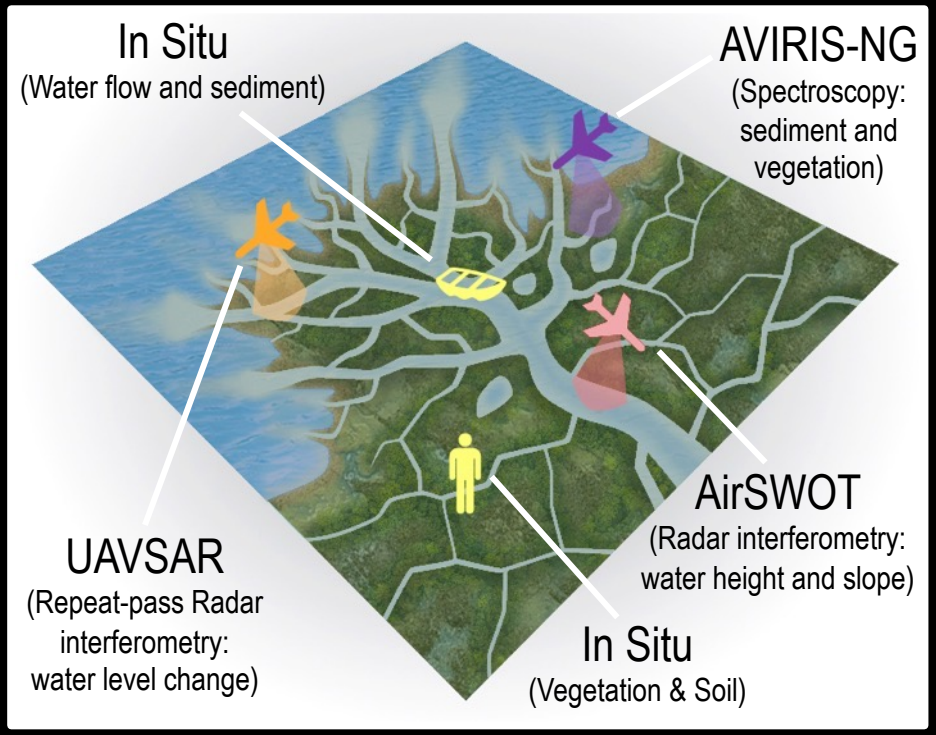


Delta-X makes breakthrough advances in the study of deltaic evolution, moving beyond coarse areal averaging of delta mass balance, to resolve mesoscale features using remote-sensing and in situ measurements. This cross-disciplinary study, encompassing hydrology, ecology, and geomorphology, calibrates numerical models of sediment transport, ecological production, and soil accretion.

Jet Propulsion Laboratory
California Institute of Technology
Marc.simard@jpl.nasa.gov

Earth Venture Suborbital 3 Delta-X

Delta-X Science Question: Will river deltas completely drown, or some parts of these deltas accumulate sufficient sediments and produce enough plants to keep pace with RSLR ?



- ✓ Delta-X uses airborne radar to measure the flow of water and hyperspectral remote sensing to estimate sediment concentrations in water. These observations are used to calibrate hydrodynamic and ecosystem productivity models.
- ✓ Only airborne remote sensing can capture the rapid hydrodynamic processes occurring through the coastal continuum (i.e. river discharge and ocean tides).
- ✓ Delta-X delivers fully calibrated hydrology and ecosystem productivity models to predict which parts of the delta will survive SLR.

Jet Propulsion Laboratory
California Institute of Technology

Marc.simard@jpl.nasa.gov

Water Quality And Dynamics


Water Quality


Water Flow (ADCP)


Water Level


Water Flow, turbity, grain size distribution

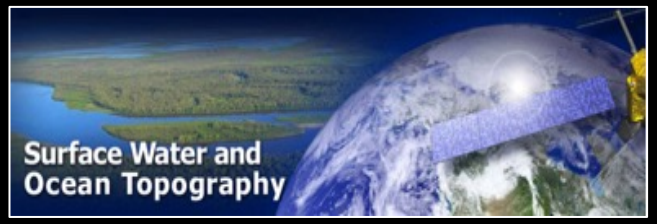
Delta-X Instruments

UAVSAR (for NISAR)

- L- band Radar, full-pol, 6m
- Shallow bathymetry,
- Above Ground Biomass AGB
- Water level changes within marshes
- Water surface velocity

AirSWOT (for SWOT)

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



AVIRIS-NG (for SBG and more)

- Imaging spectroscopy (425 bands)
  - 380-2510nm, 5nm
- High spatial resolution (~4m)
- Vegetation species and structure Water quality

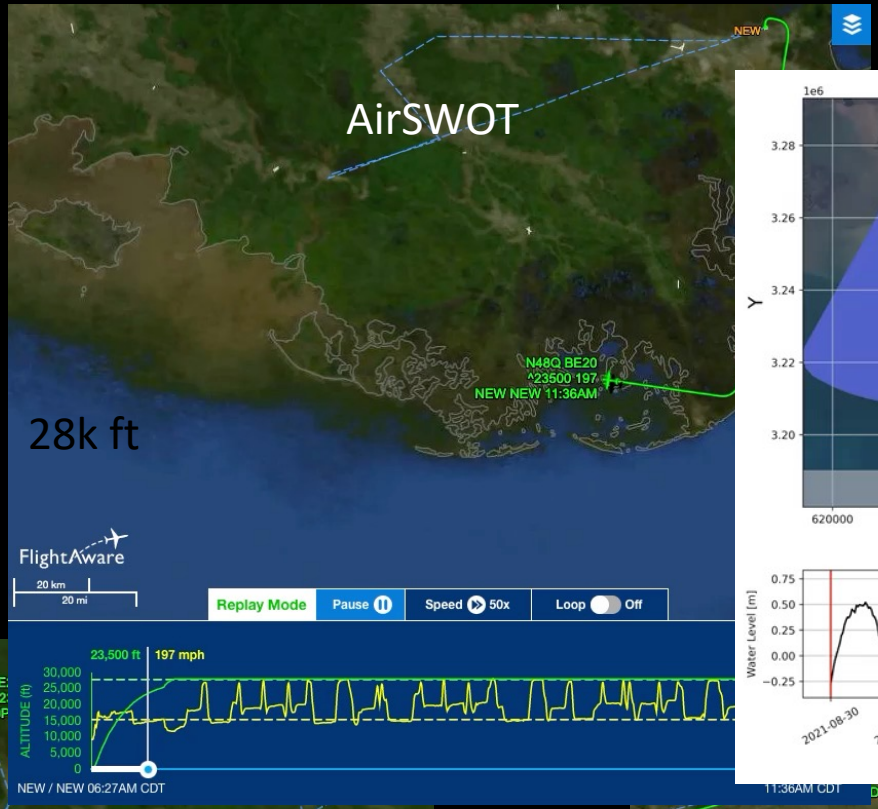
Jet Propulsion Laboratory
California Institute of Technology

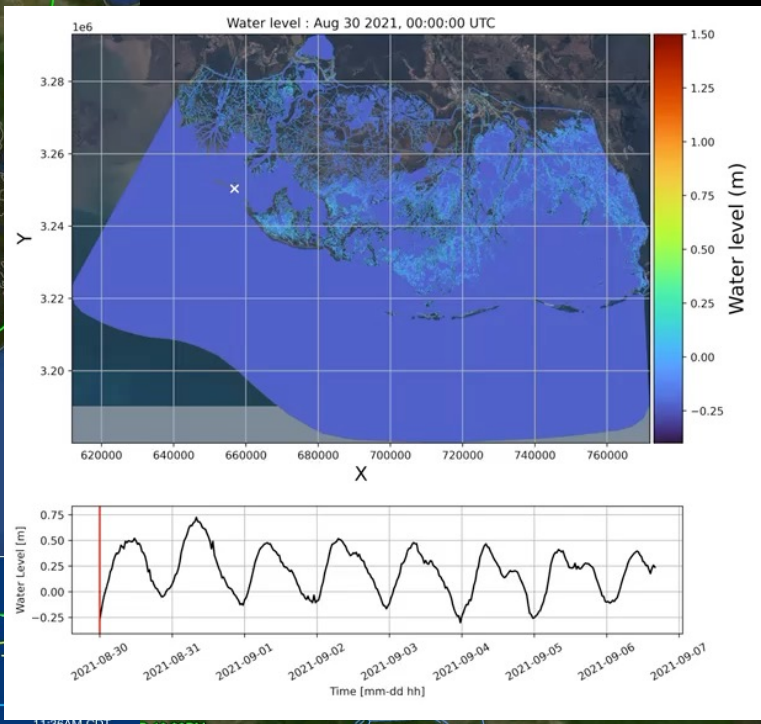
Marc.simard@jpl.nasa.gov

Flights in Spring and Fall 2021 at different tidal phases

AirSWOT

28k ft





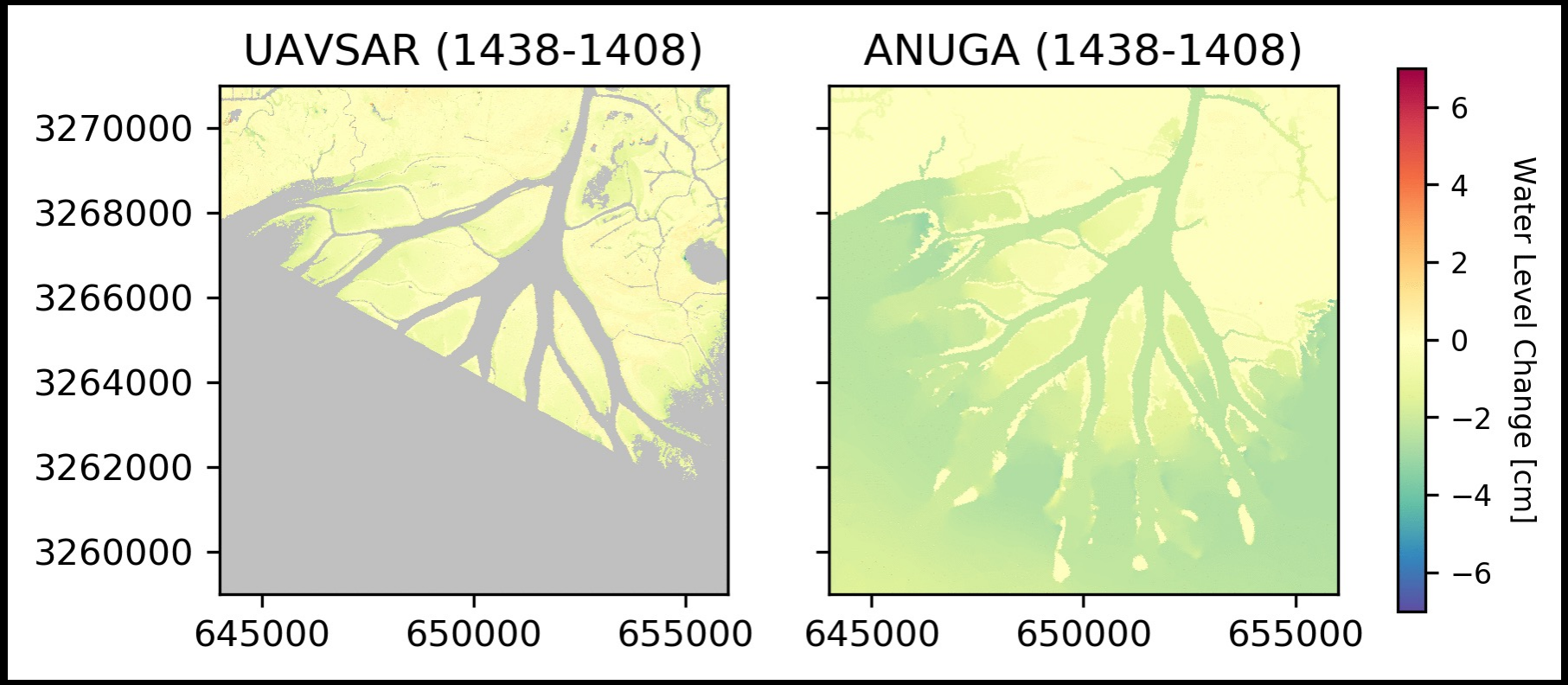
AVIRISNG

Water Quality and Vegetation lines

15k ft

37k ft

Model calibration and validation

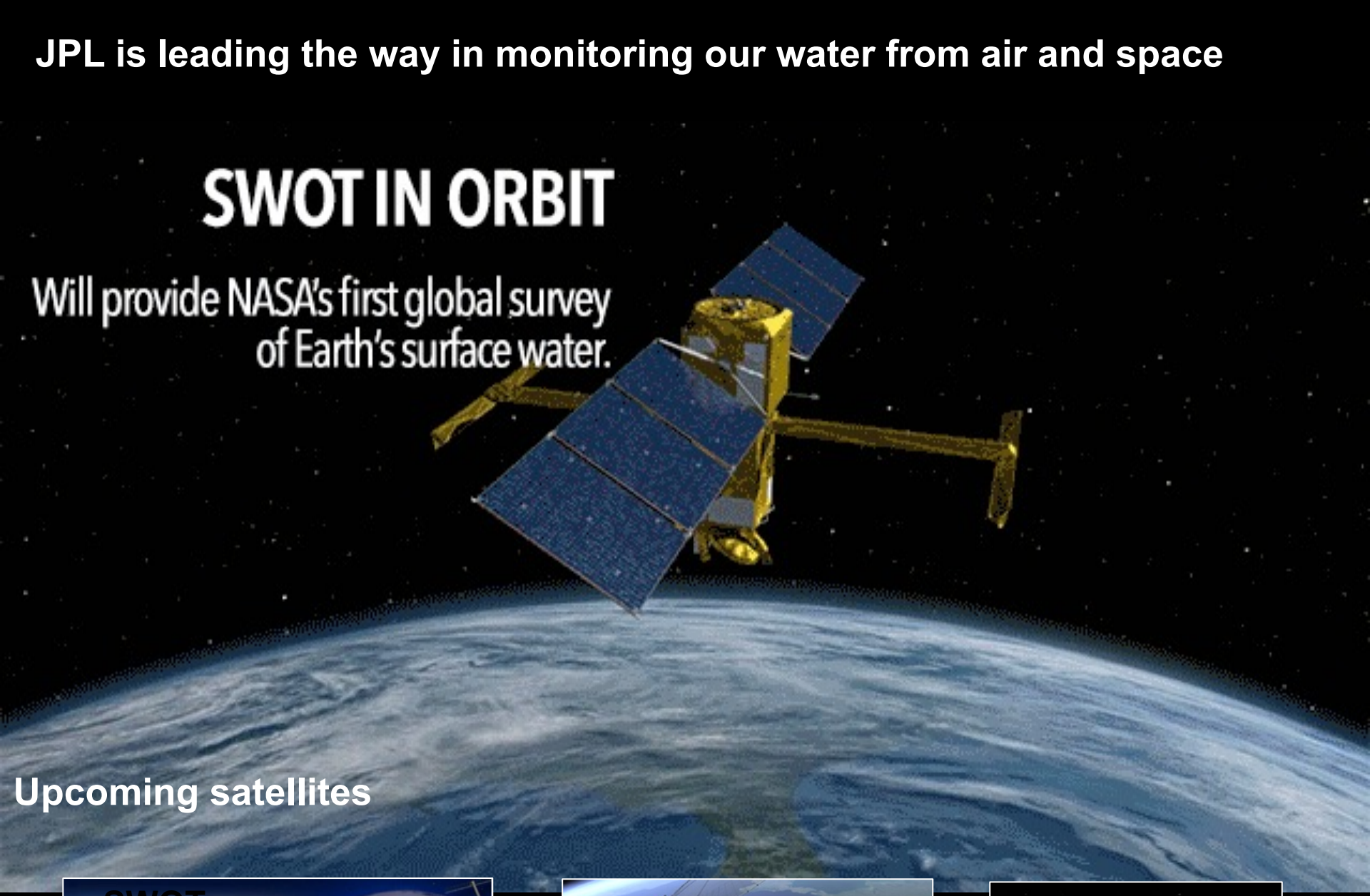


Observed (UAVSAR and AirSWOT) and modeled (U. Boston and U. Texas) water level changes.

Jet Propulsion Laboratory
California Institute of Technology

Marc.simard@jpl.nasa.gov

JPL is leading the way in monitoring our water from air and space



Upcoming satellites

NISAR
(2024)

Altitude 747km at 98° incl.
SweepSAR 240km
12m mesh antenna
L- and S-band capable full pol.
HH and HV background
Incl angle 33-47°
Spatial res: ~7m
Repeat-pass 12 days.

Monitor globally:

- Forests (every 6 days)
- Ice and snow (every 12 days)
- Earthquake and volcanoes (every 12 days)
- Ground displacement(every 12 days)

January 2023

The Opportunity of Measurements from Above

Simultaneous measurement over large areas

UAVSAR

- **Masure water flow under vegetation**

King Air B200

AVIRIS-NG

- **Vegetation species and structure classification**
- **Sediment concentrations in water**

AirSWOT

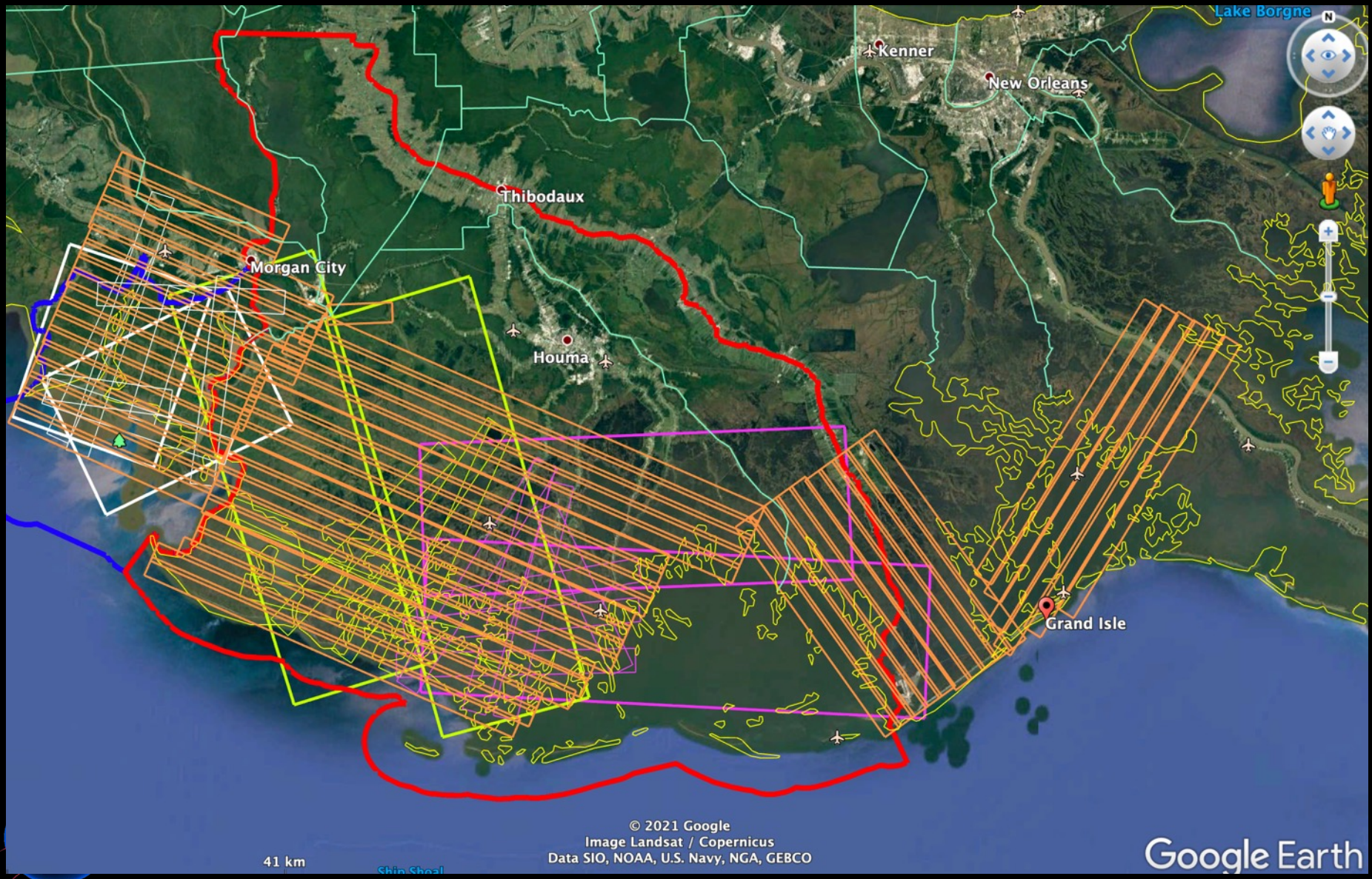
- **Measure river and lake discharge**

Mississippi River Delta Floodplain

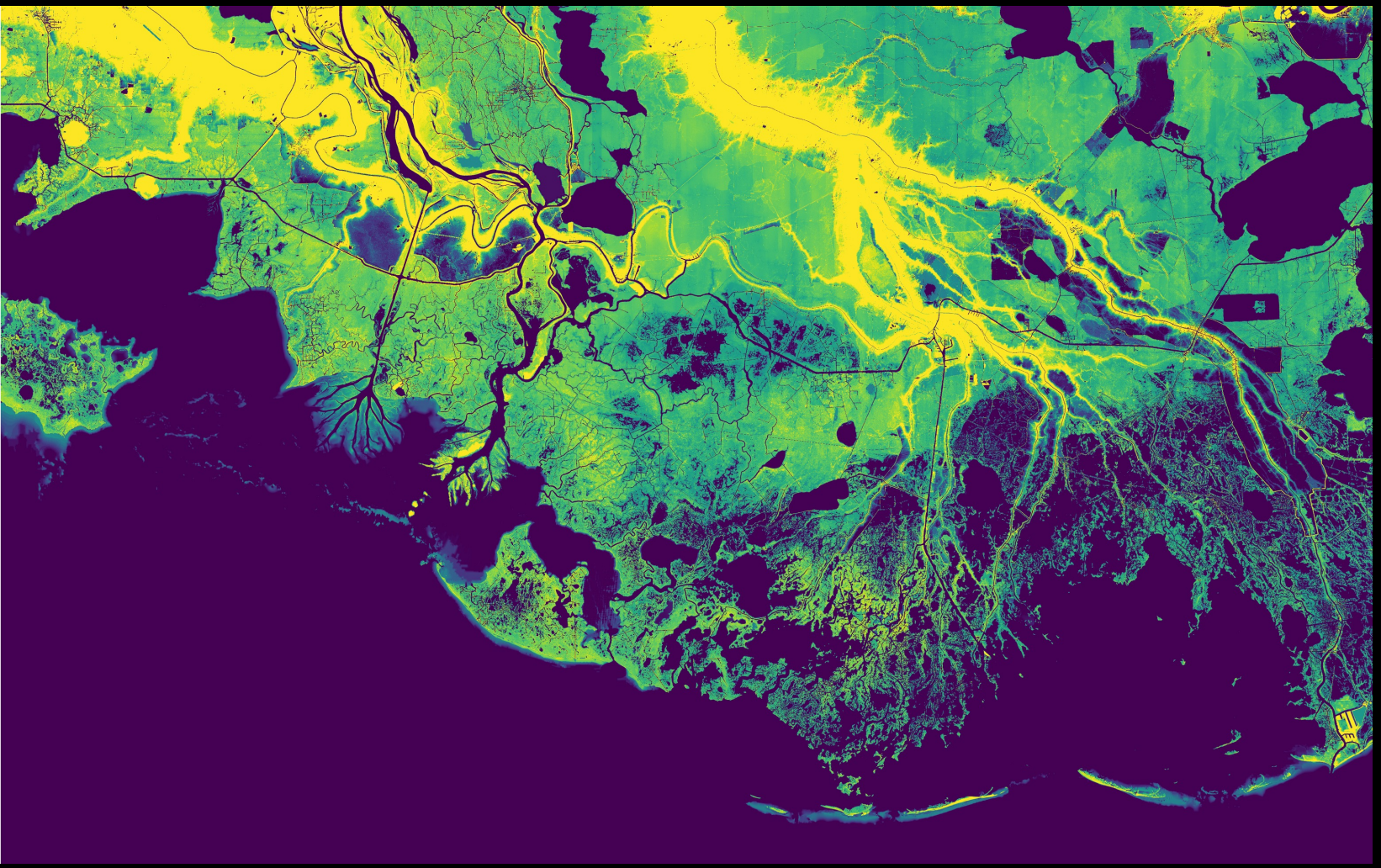
Jet Propulsion Laboratory
California Institute of Technology

Marc.simard@jpl.nasa.gov

Airborne remote sensing data coverage



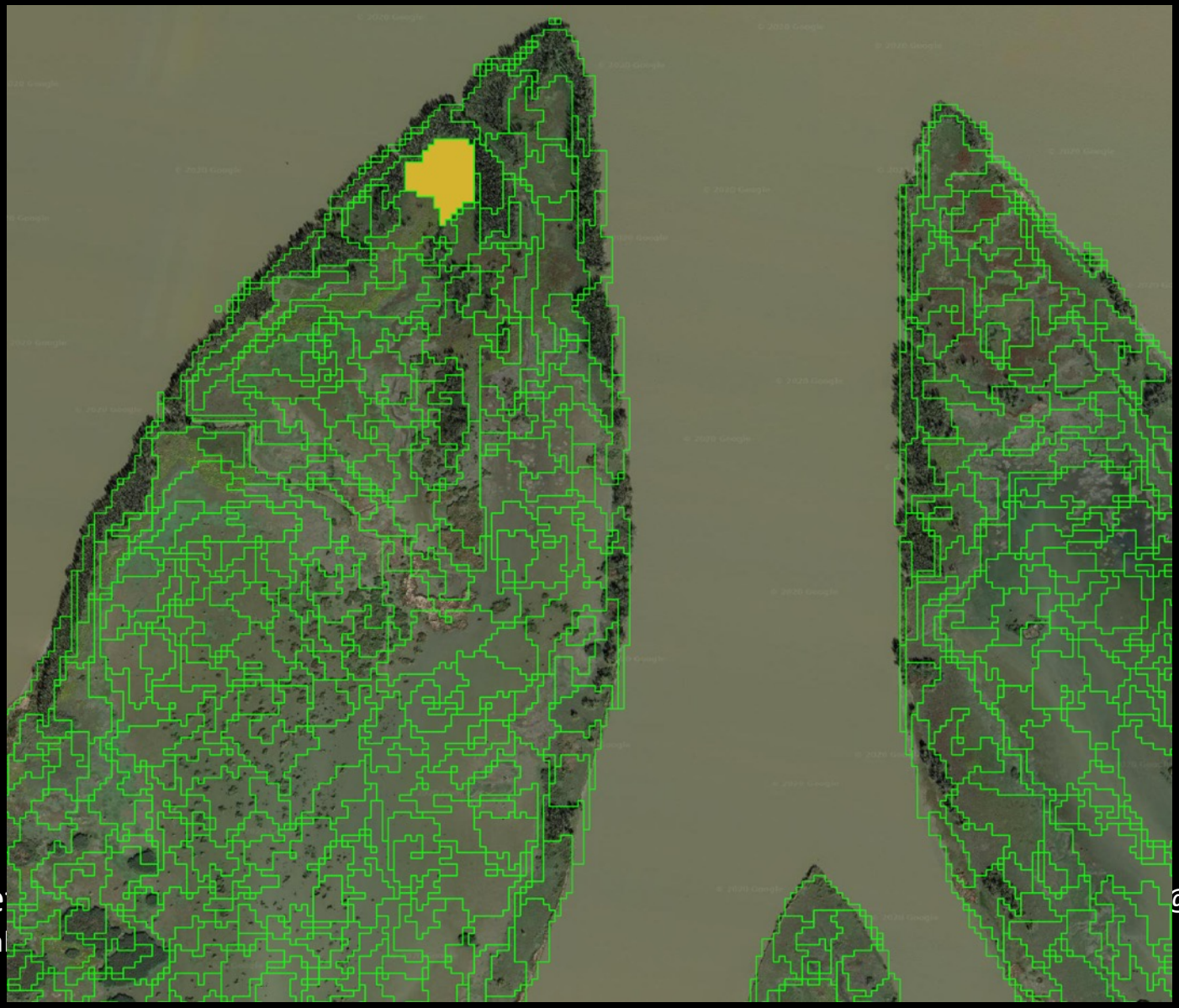
Recreating a new DTM for the Atchafalaya and Terrebonne Basins based



Jet Propulsion Laboratory
California Institute of Technology

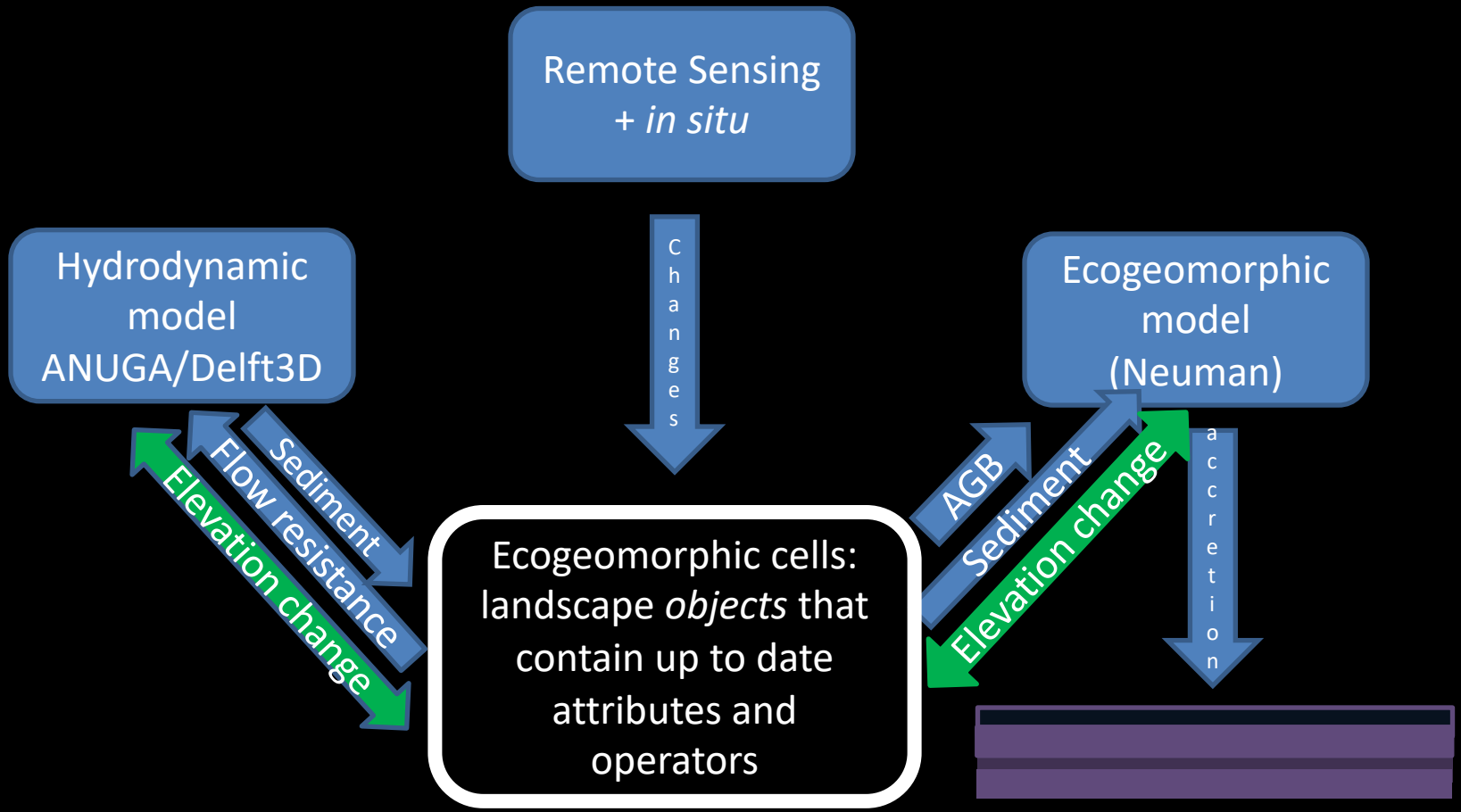
Marc.simard@jpl.nasa.gov

We use the concept of “ecogeomorphic cells”, representing small homogeneous areas (~1ha), and predict their trajectory in time.



Je
Ca
@jpl.nasa.gov

Using ecogeomorphic cells as the 'connector'



Jet Propulsion Laboratory
California Institute of Technology

Marc.simard@jpl.nasa.gov

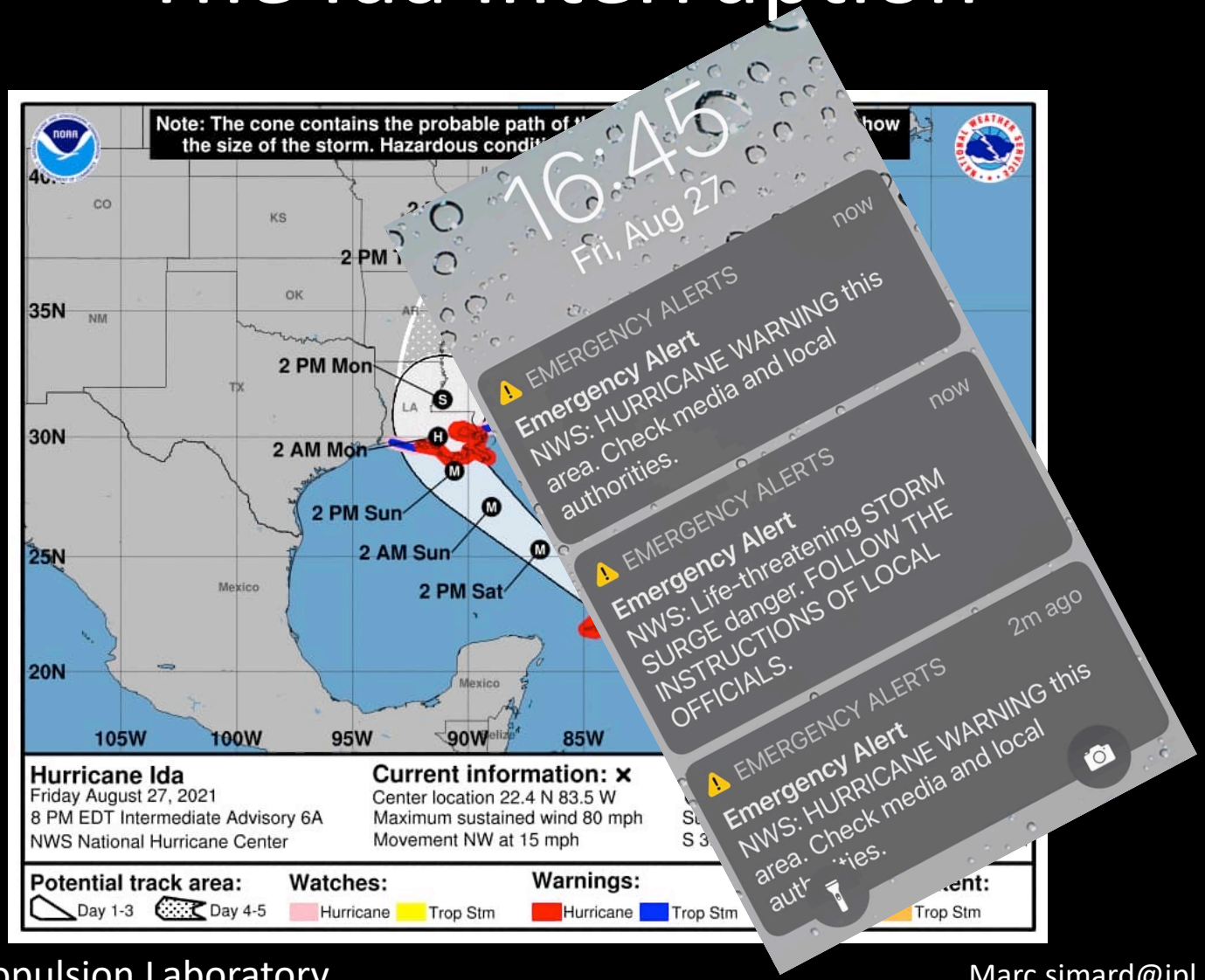
Delta-X Airborne Campaign

- Spring campaign 2021: March 21st - April 22nd (including in situ)
  - 3/27/21 - 4/6/21 AVIRIS-NG flights
  - 3/26 - 4/18 AirSWOT flights
  - 3/27 – 4/18 UAVSAR flights.
- Fall campaign 2021: August 16th - September 26th (including in situ)
  - 8/21/21-9/12/21 AirSWOT flights
  - 9/1/21-9/12/21 UAVSAR flights
  - 8/18/21-8/25/2021 AVIRISNG flights
- Pre-Delta-X campaigns
  - May 2015 (Spring)
  - October 2016 (Fall)

Jet Propulsion Laboratory
California Institute of Technology

Marc.simard@jpl.nasa.gov

The Ida Interruption



Jet Propulsion Laboratory
California Institute of Technology

Marc.simard@jpl.nasa.gov

May 8th Agenda

Time (CT)	Topic	Presenter
8:00 – 8:30	Meet and greet	
8:30 – 9:30	Introduction	Marc Simard Cathleen Jones Yang Zheng
9:30 – 9:45	Hydrodynamic modeling with ANUGA: introduction	Antoine Soloy
	Break 15'	
10:00 – 12:00	Hydrodynamic modeling with ANUGA: model run	Antoine Soloy
	Lunch 90'	
13:30 – 14:30	Hydrodynamic modeling with ANUGA: simulations	Antoine Soloy
14:30 – 15:15	Demonstration of Dorado sediment transport	Muriel Brückner Antoine Soloy
	Break 15'	
15:30 – 17:00	Demonstration of Dorado sediment transport	Brückner, Soloy
17:00 – 17:30	Hands-on exercises and discussions	Brückner, Soloy

May 9th Agenda

Time (CT)	Topic	Presenter
8:00 – 10:00	Hydrodynamic Modeling of Deltas using Delft3d	Ali Payandeh
	Break 15'	
10:15 – 12:00	The fate of Deltas - Delft3d Morphodynamic modeling	Ali Payandeh
	Lunch 90'	
13:30 – 15:00	Sediment transport model	Dongchen Wang
	Break 15'	
15:15 – 17:15	NUMAR model, data, and how to use them	Robert Twilley Pradipta Biswas Ivan Vargas-Lopez Alex Christensen Muriel Brücker
17:15 – 18:30	River Model Tour	Ali Payandeh
18:30 – 18:45	Close-out	

Jet Propulsion Laboratory
California Institute of Technology
Marc.simard@jpl.nasa.gov

What's Next for the Delta-X Team

1. Predict which parts of the Mississippi River Delta will survive and which part will drown under relative sea level rise.
   - Validate hydrodynamic and ecogeomorphic models
   - Refine model prediction with landscape evolution (e.g. storm impacts, coastline and shore erosion
2. Maintain continuity by reaching out and enabling science and applications communities to use Delta-X datasets and models
3. Publish results in scientific literature

Jet Propulsion Laboratory
California Institute of Technology

Marc.simard@jpl.nasa.gov