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SWOT supporting the livelihood of millions: modeling hydrodynamics of river deltas

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Introduction

- 2.4 billion people (about 40 per cent of the world's population) live within 100 km of the coast, of which, 630M are within 5meters of sea level.
- Science generally related to impact of climate change on -and loss of- coastal ecosystem functions and services.
- Application generally related to impact of climate change and human activity on coastal ecosystems, geomorphology and water quality along the coasts, and feedbacks on population livelihood and migration.
- Coasts and the services they provide are threatened by SLR, storm surges, subsidence and sediment starvation
- Food and Fresh Water Security:
  - The major threat to agriculture on deltas is salinity intrusion and water scarcity, which consequently leads to a shortage of irrigation water and yield reduction[1].
  - Deltaic ecosystems are ecologically significant as they support high biodiversity and a variety of fisheries. They provide a significant source of animal proteins (12-60%[2]) .
  - Since 1990, the contribution of aquaculture to fish production has increased from 13% to 45%[3].

[1]Schneide and Asch, 2020, [2]Lauria et al., 2018,[3]FAO, 2017

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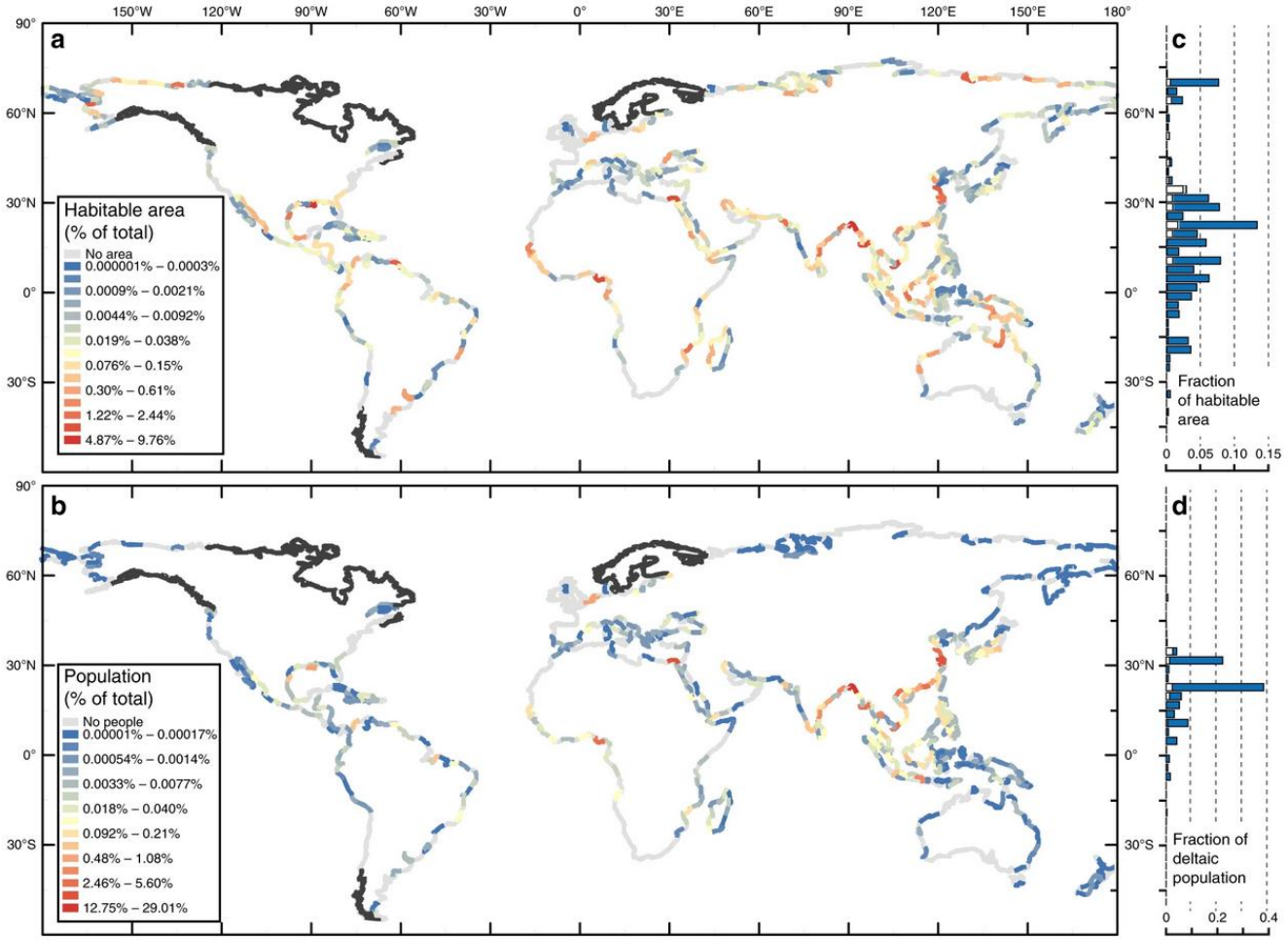
Global Populations on River Deltas

"339 million people lived on river deltas in 2017

89% of those people live in the same latitudinal zone as most tropical cyclone activity."



a, b Total deltaic area and population per 3° lengths of coastline. Lengths of coastlines are colored by the percentage of area or population they contain relative to the entire dataset. Black lines are unmapped shorelines from Caldwell et al.[27]. **c, d** Histograms showing the latitudinal distribution (3° bins) of habitable area and population. White bars show the proportion of area and people in the 100-year storm surge floodplain.

Edmonds et al., Nature comms, 2020

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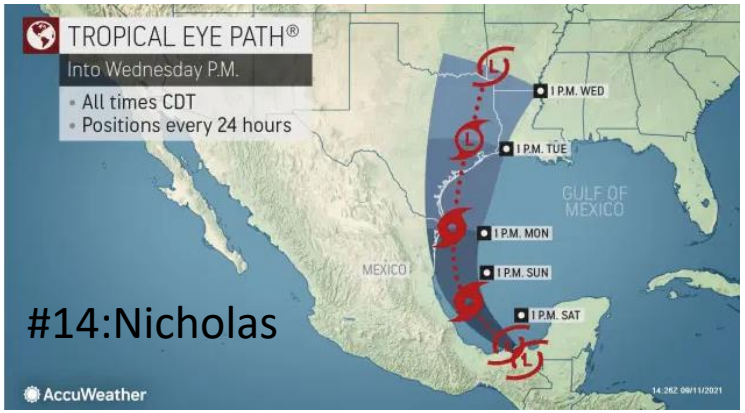
Hurricane/Storm Impacts

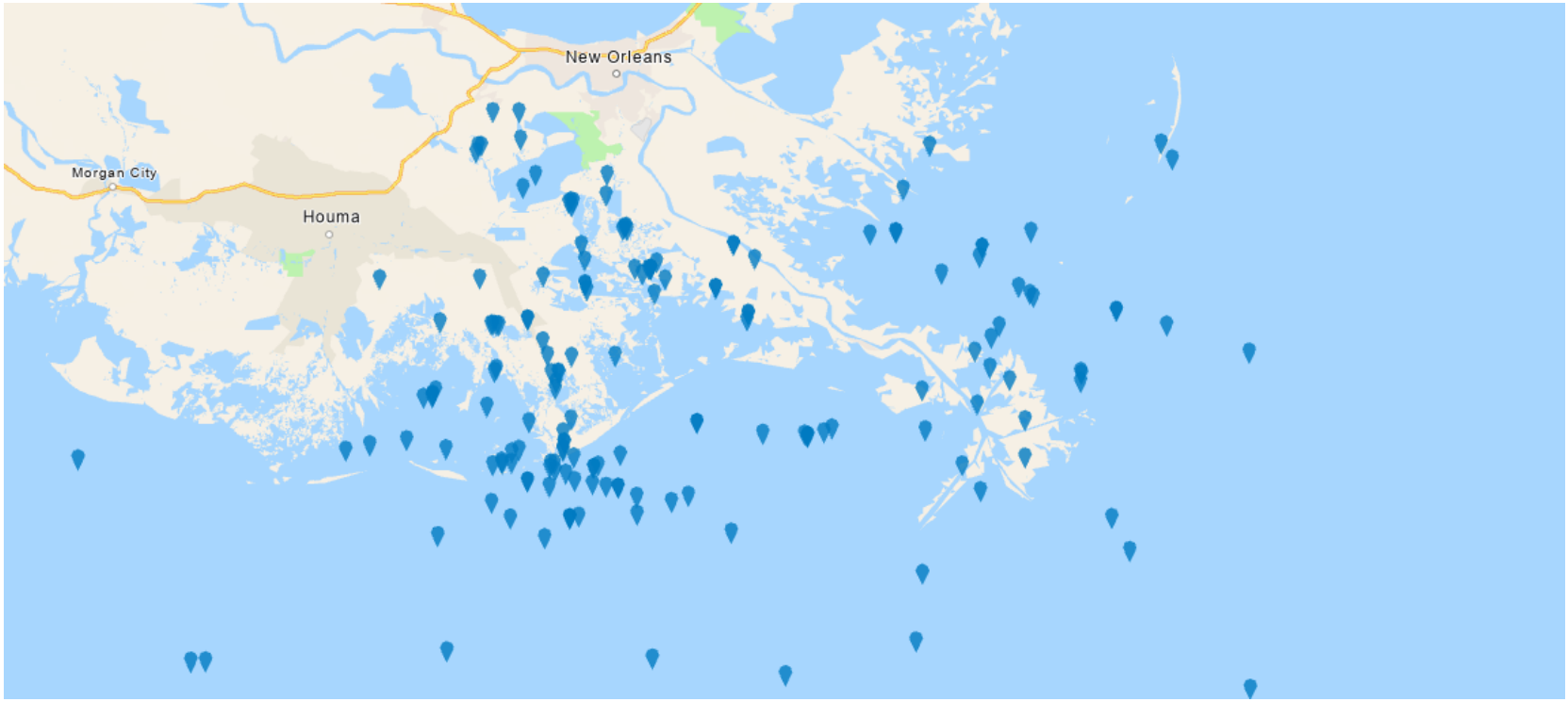
As of Sept 11: Active storms from AccuWeather: Larry, Olaf, Chanthu, Conson



#14:Nicholas

2021: Ana, Bill, Claudette, Danny, Elsa, Fred, Grace, Henry, Ida, Julian, Kate, Larry, Mindy

Transport of Pollutants



Oil Slicks (e.g. Post-Ida) (Collaborations: NASA, EPA, NOAA,
Cathleen Jones JPL working with UAVSAR to detect and monitor oil slicks

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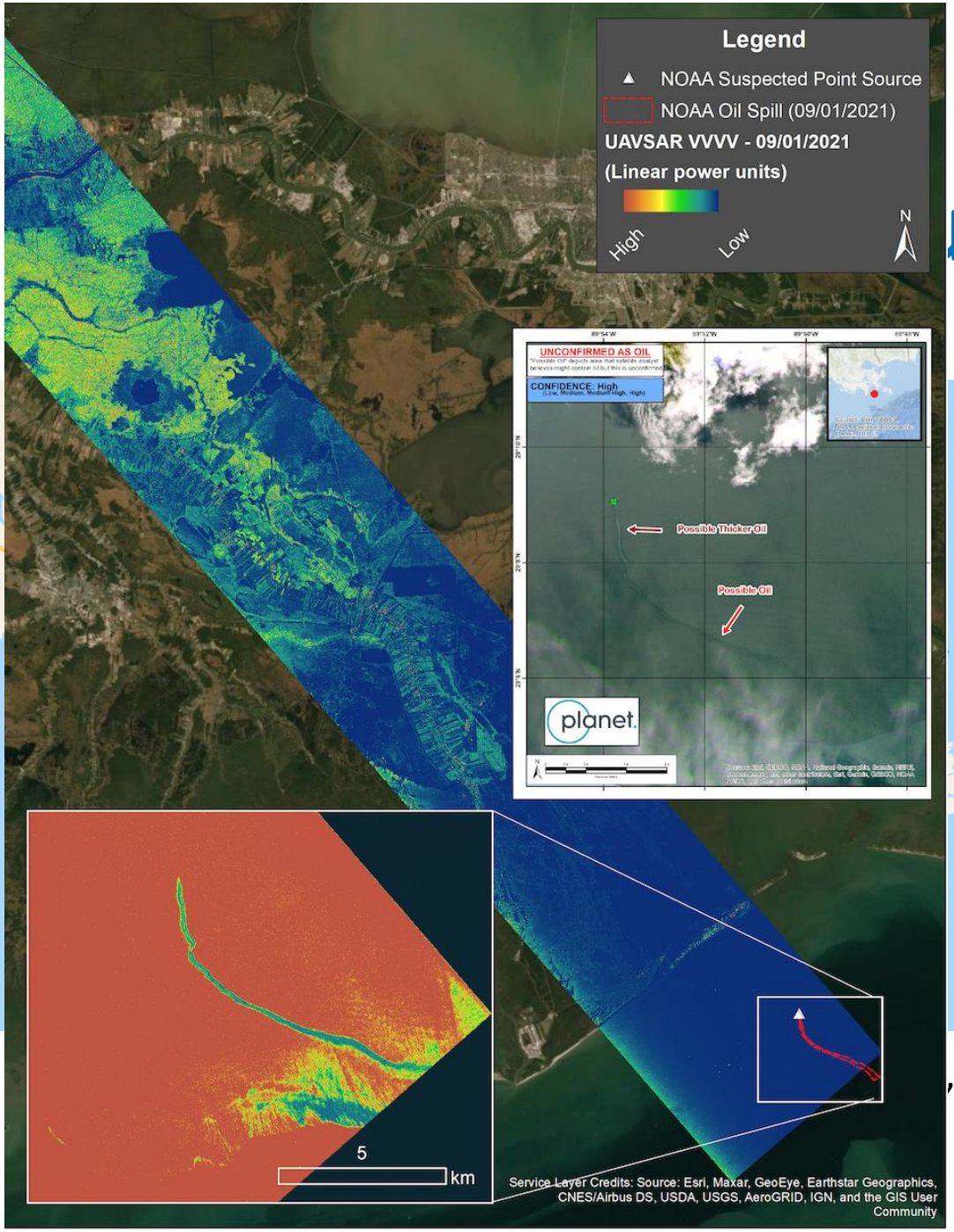
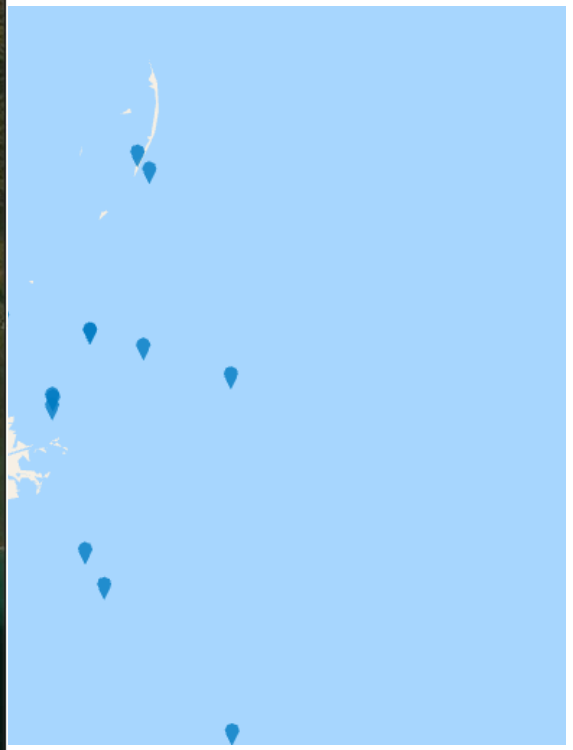
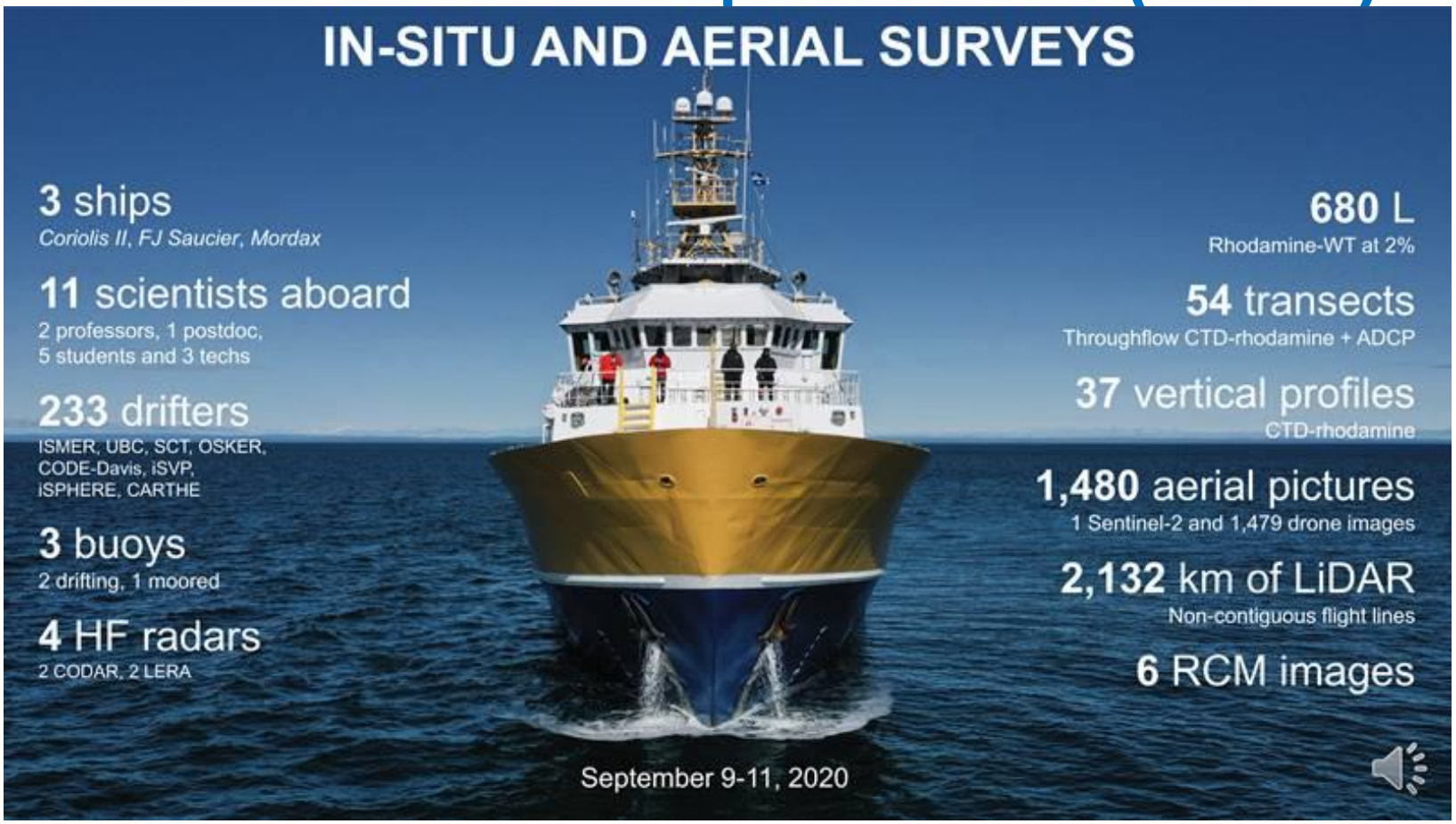
utants





, NOAA,
and monitor oil slicks

Tracer Release Experiment (TReX)



Pascal Matte, ECCC

The overarching objective of TReX in the St. Lawrence is to develop and demonstrate forecasting capabilities of contaminant dispersal and biogeochemical transformation in coastal marine environments.

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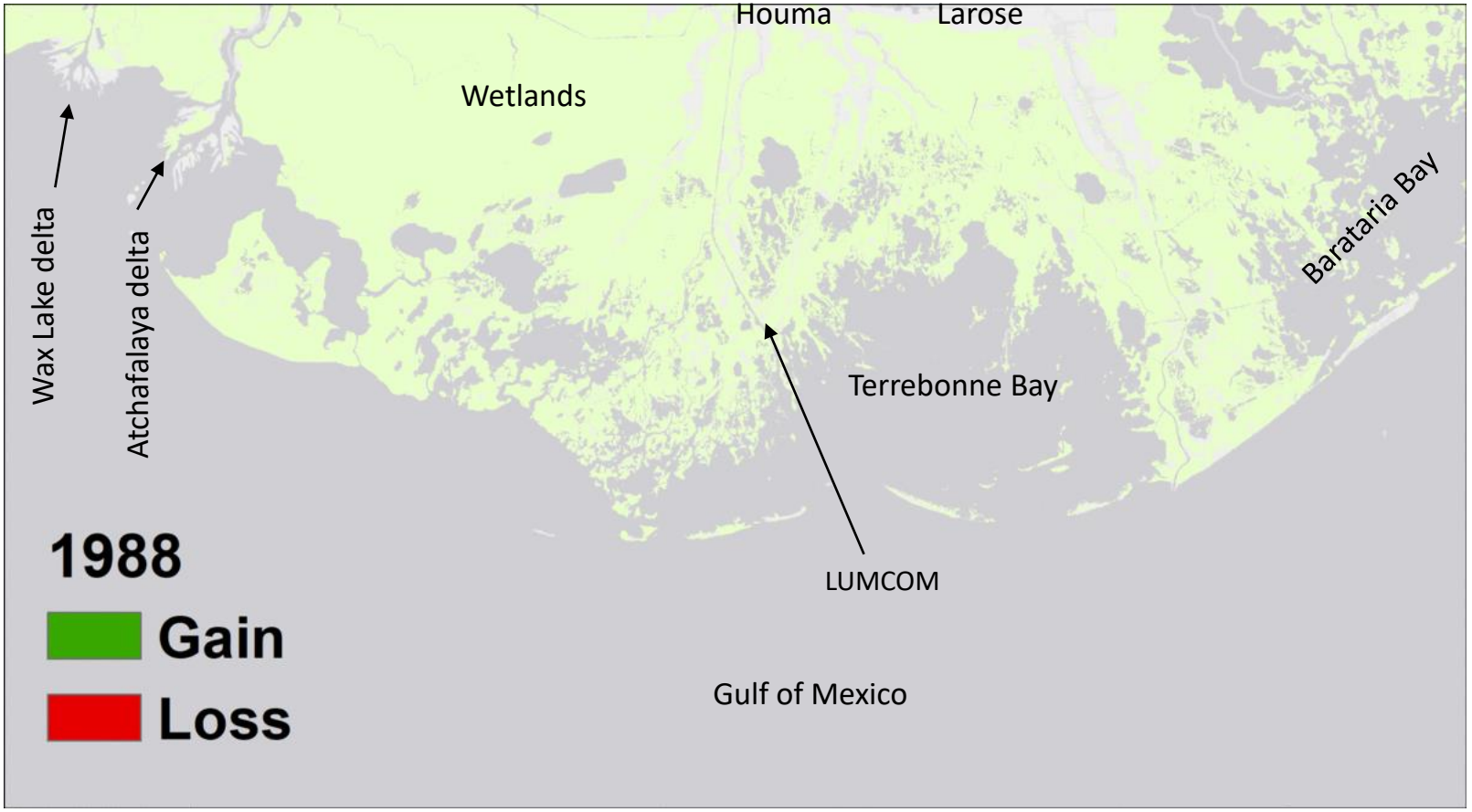
Land-Loss in Coastal Louisiana



Wetland Loss: 1985-2010: 16.57mi^2/yr, 1932-2010: 1,883mi^2 (25% loss or ~Delaware)
On average, this is equivalent to over one football lost field every hour.
Why is some parts of the floodplain building land (green. West of image) and others are losing land (red: Center/East of image)?

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Coastal Protection

Hydrodynamic Models
More than 50 River Deltas & 3 estuaries

- Simulate SWOT data in global river deltas and estuaries
  - To assess of potential and limitations
- Develop SWOT data assimilation methods
  - SWOT to be used for model cal/val globally
- Facilitate adoption by stakeholders
  - Open source
- Use two “Gold” standards:
  - St Lawrence
    - Compare to:
      - Trex Airborne campaign September 2020
      - Operational model (Pascal Matte, ECCC)
  - Mississippi River Model
    - Compare to Delta-X calibrated models

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Hydrodynamic Models
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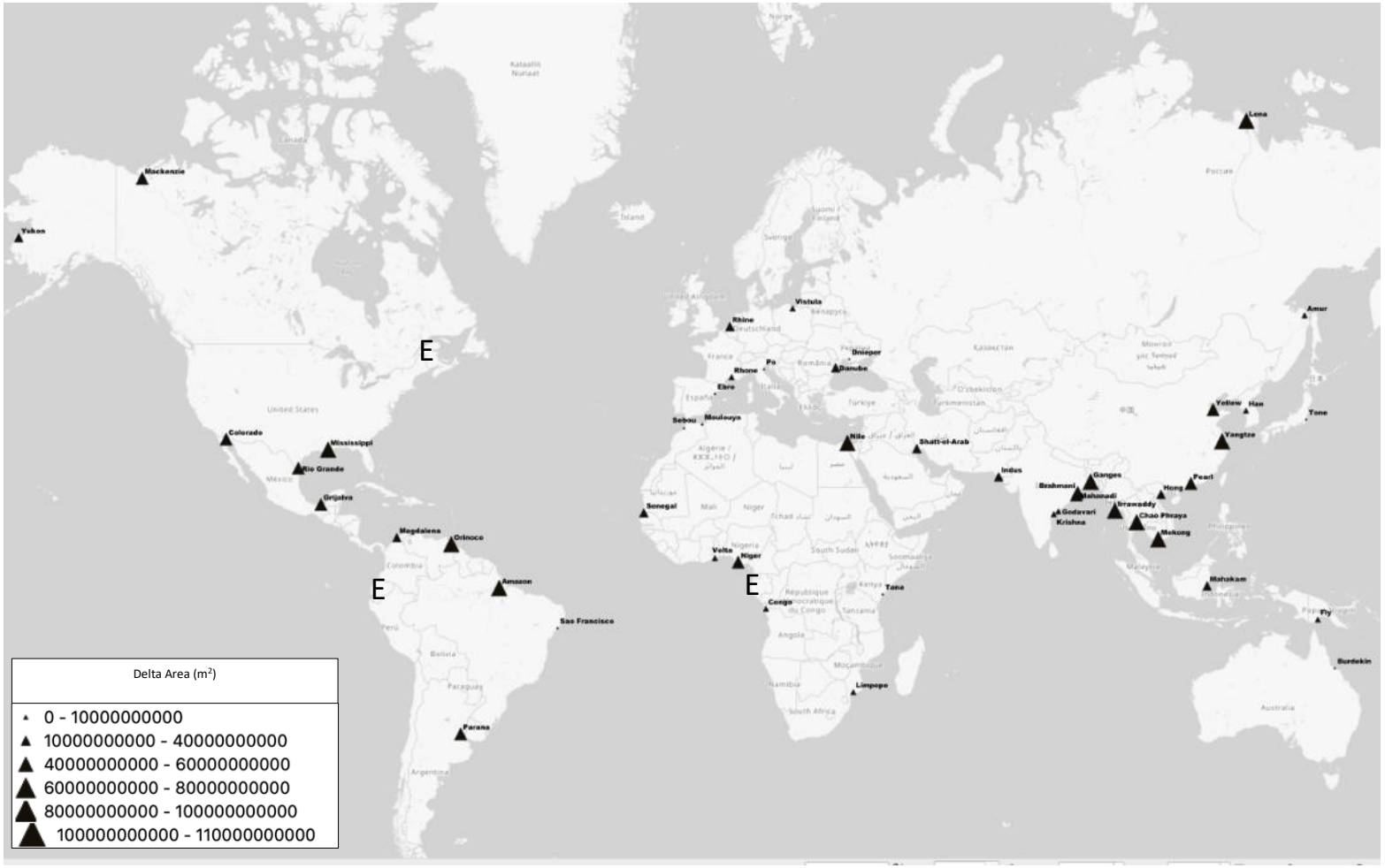

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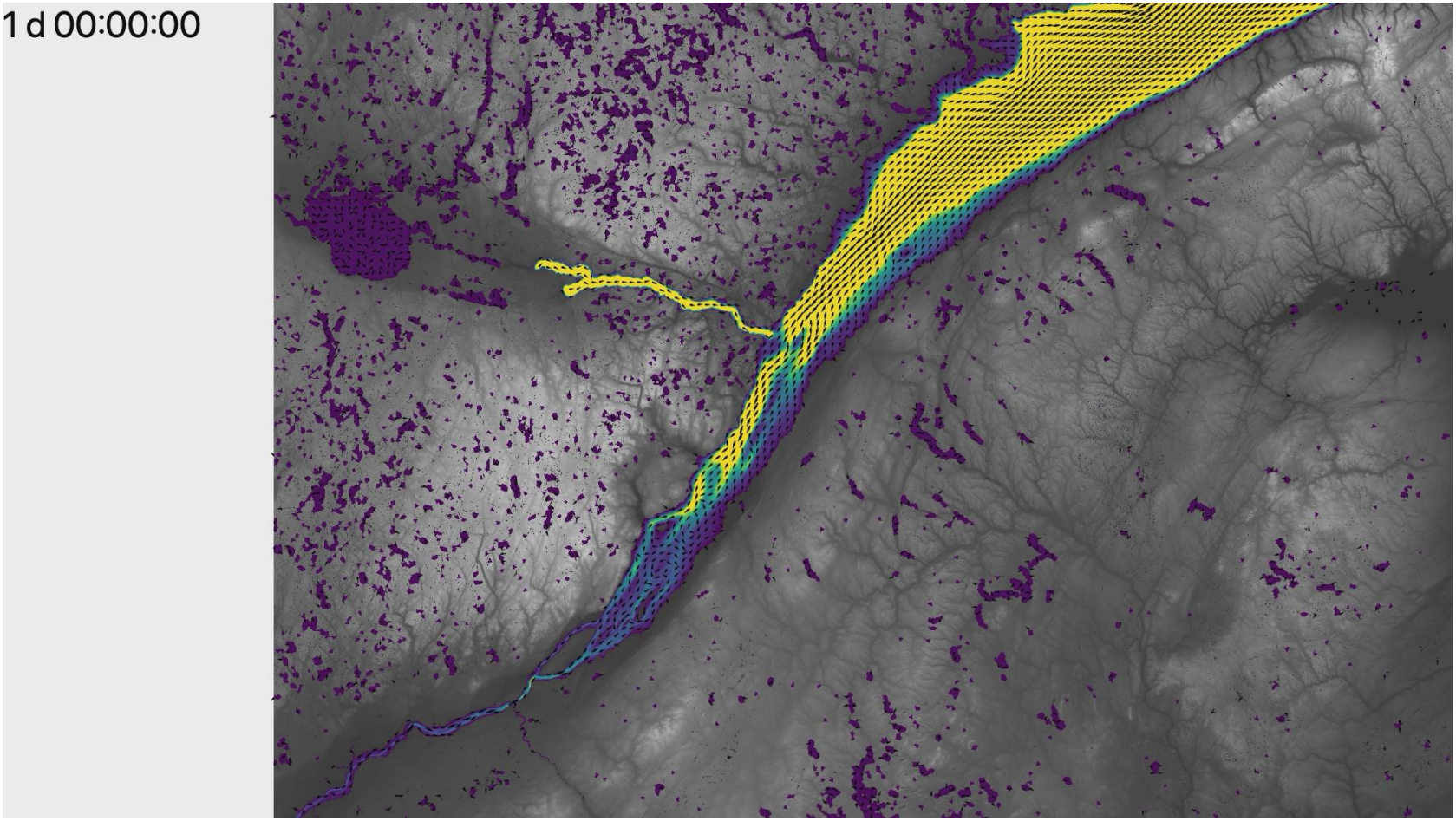
SWOT model of the St-Lawrence



ANUGA (Python) implementation like other global models

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St. Lawrence Lidar (during Trex)

Falling Tide

Slope =
0.0548 cm/km

Model slope =
0.1004 cm/km

9/12 18:54 EST?

Rising Tide

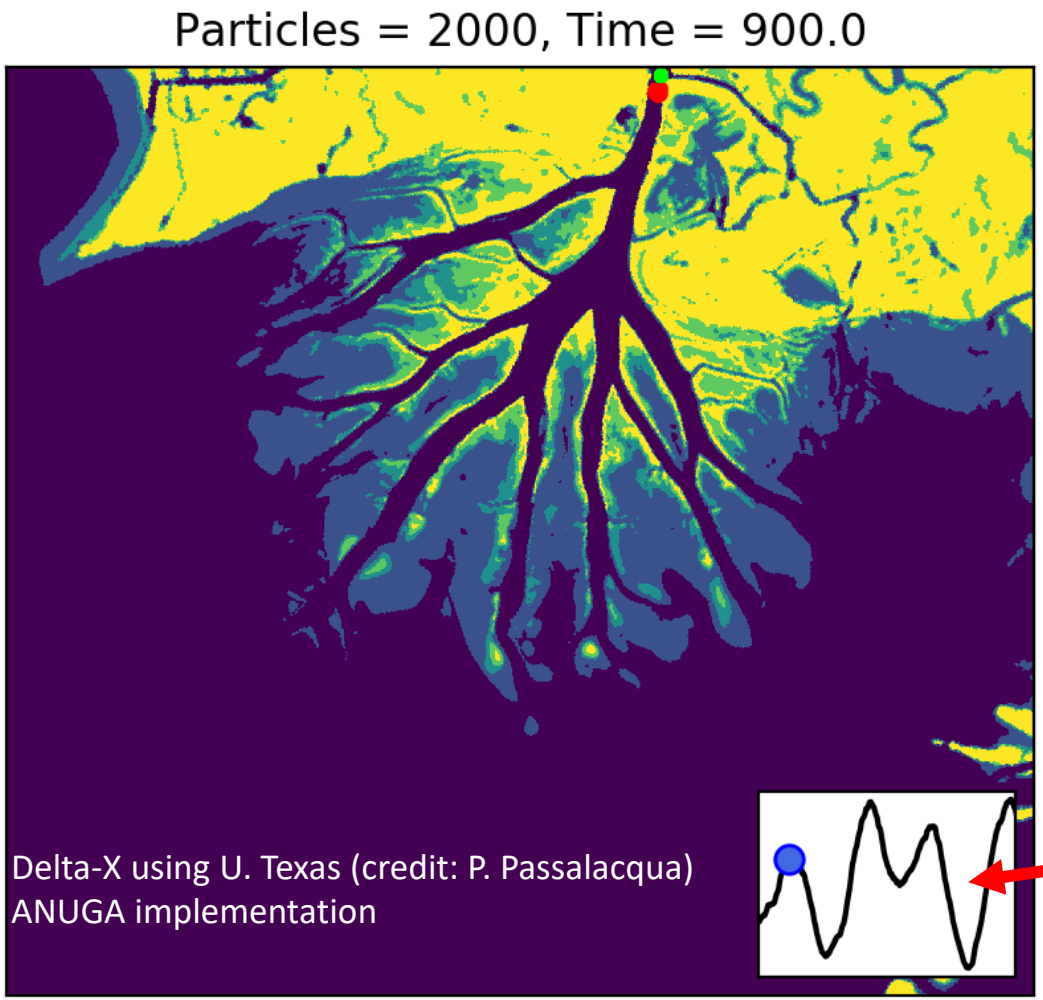
Slope =
-2.07 cm/km

Model slope =
-1.02 cm/km

9/14 15:02 EST?

-2.5m 1m

SWOT 'generic' (global) models to be compared with Delta-X model



Assimilation of SWOT data for cal/val of hydrodynamic models for global deltas and estuaries. Even if not resolving fine details, SWOT provides critical boundary conditions (e.g. tides and range).

The tides and river discharge change the trajectory and sediment deposition rates

To Conclude

- Currently implementing open-source hydrodynamic models, to-soon-be-calibrated with SWOT data, for more than 50 River Deltas and Estuaries around the World.
- Need to:
  - Evaluate fusion of SWOT with other sensors (e.g. NISAR)
  - Test model during ‘steady-state’, phenological and storm surge states.
- These calibrated models can be used to manage, conserve, restore coastal hydrology in order to maintain ecological and socio-economic services (coastal protection, fisheries, agri/acqua cultute, timber, navigation) .
- Timeline
  - Delivery of model database and paper by Spring 2022.
  - Assimilation of SWOT end 2022.

BACKUP SLIDES

Airborne and Spaceborne Instruments

UAVSAR

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

JSC Gulfstream III

These airborne instruments can simulate upcoming NASA Spaceborne Mission

AirSWOT

Ka-band radar interferometer

- Centimeter-level open water surface elevation and surface slope

Dynamic Aviation King Air B200

AVIRIS-NG

Imaging spectroscopy (432 bands a
4m)

- Vegetation species and structure
  classification
- Sediment concentrations in wate

Dynamic Aviation King Air B200

https://deltax.jpl.nasa.gov/