ANUGA Model Tutorial
Wax Lake & Atchafalaya Basin

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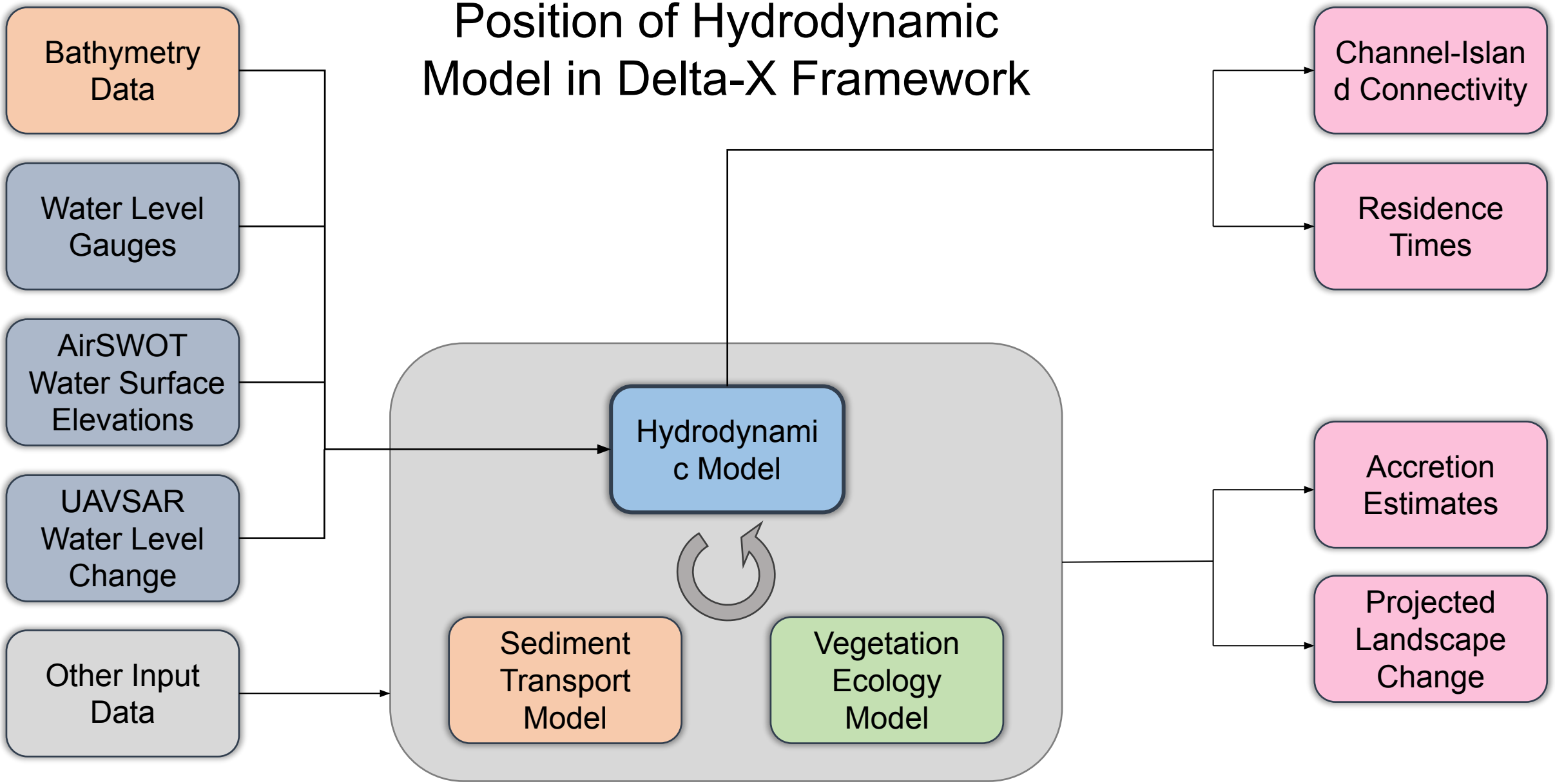
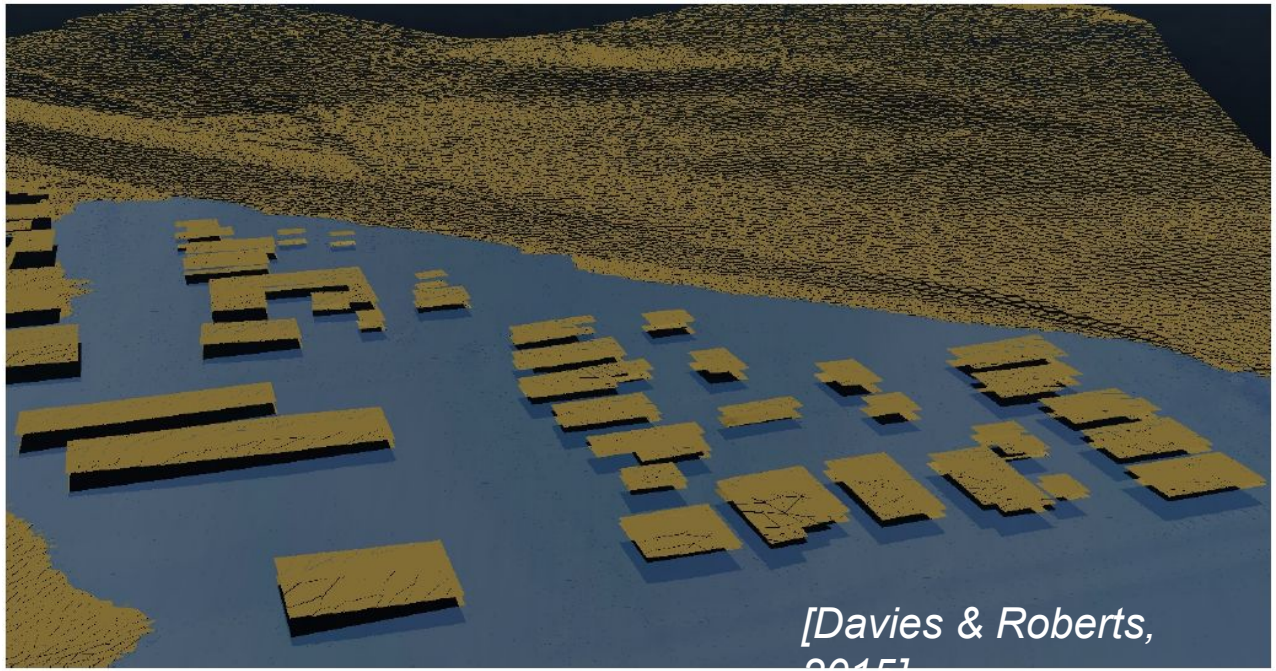
Overview

- Introduction to ANUGA software
- Description of Atchafalaya study basin
- Domain and mesh construction
- Model inputs, boundary conditions
- Treatment of friction
- (Google Colab) Code run-through
- Model outputs

Position of Hydrodynamic Model in Delta-X Framework



Why ANUGA?



Some advantages of ANUGA:

- Free and open-source
- Written in Python (and some C)
- Easy to customize, add features
- Uses a flexible unstructured mesh
- Developed for coastal flooding (e.g. tsunami's, dam breaks)
- Very stable treatment of wetting/drying front

GitHub.com/GeoscienceAustralia/anuga_core

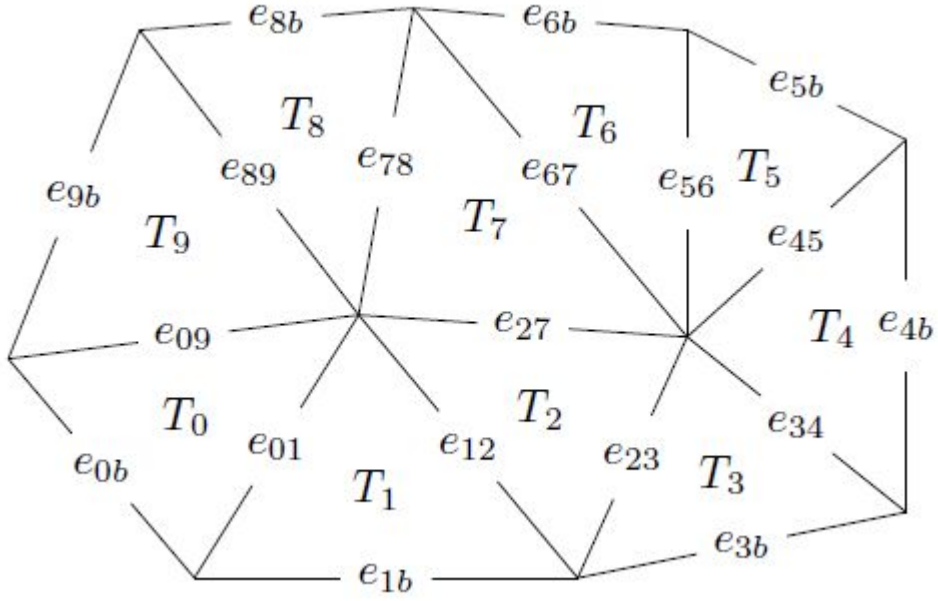
Default ANUGA software includes:

- Discharge
- Tides
- Wind
- Rainfall
- Mesh Refinement
- Manning's friction parameterization
- Parallel functionality

Features we have added:

- Vegetated friction (Baptist)
- Pre-processing algorithm for mesh refinement using imagery
- Lagrangian particle tracking model (dorado)
- Sediment transport model (Caltech)

Under the hood:



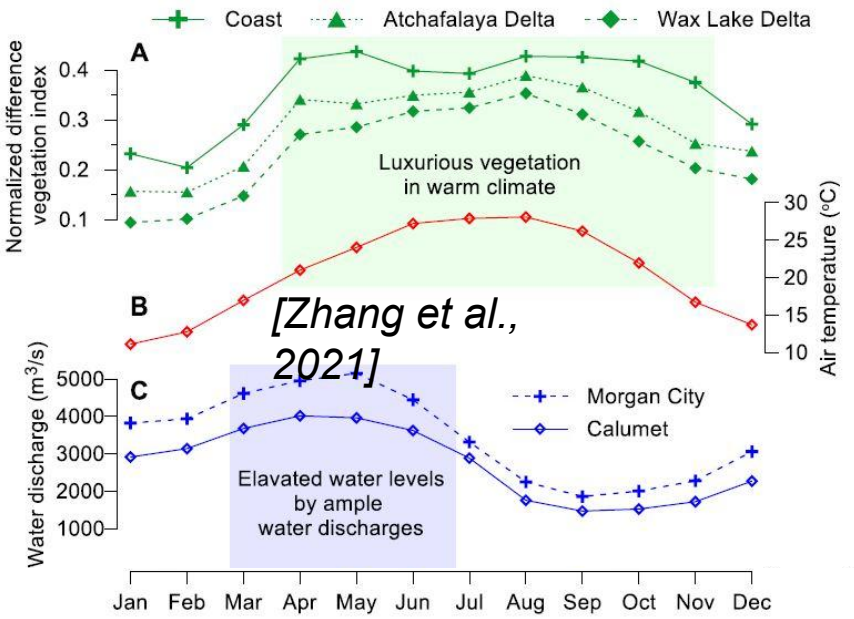
- The ANUGA model uses the finite-volume method on unstructured triangular grid
- Solves depth-integrated (i.e. shallow-water) wave equations:

$$\frac{\partial}{\partial t}\begin{pmatrix} h \\ uh \\ vh \end{pmatrix} + \frac{\partial}{\partial x}\begin{pmatrix} uh \\ u^2h + gh^2/2 \\ uvh \end{pmatrix} + \frac{\partial}{\partial y}\begin{pmatrix} vh \\ vuh \\ v^2h + gh^2/2 \end{pmatrix} = \begin{pmatrix} 0 \\ gh\left(S_{0,x} - S_{f,x}\right) \\ gh\left(S_{0,y} - S_{f,y}\right) \end{pmatrix}$$

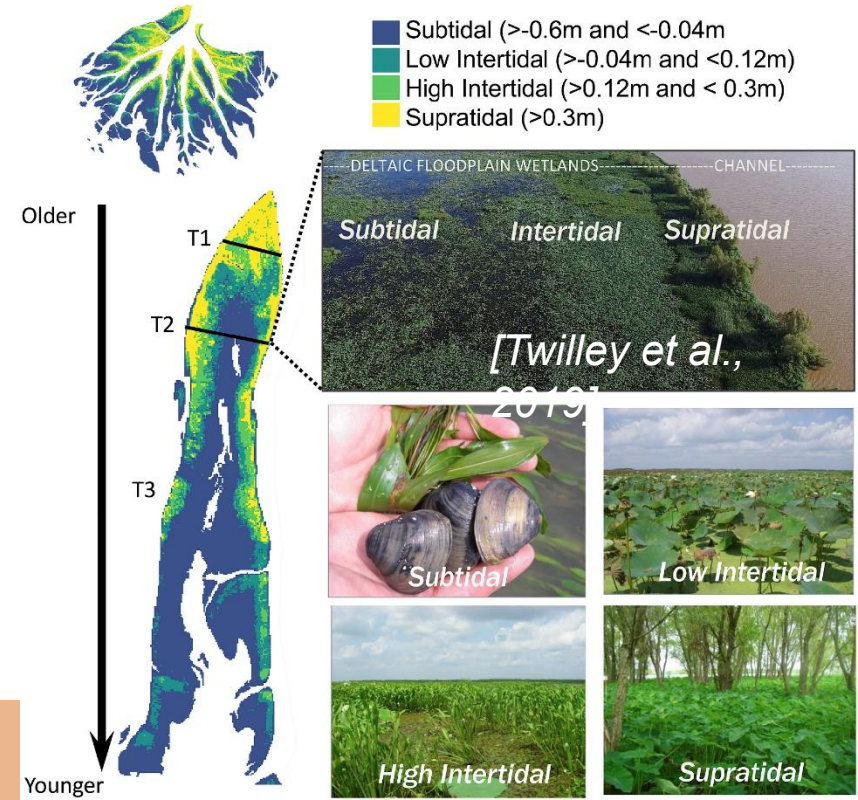

1984
Wax Lake Outlet
Atchafalaya River
Atchafalaya Site Context
N
5 km

Atchafalaya System:
Complex & Dynamic

- Discharge dominated (freshwater)
- Tidal amplitude ~30cm
- Channel widths ~$O(10^1 - 10^3)$ meters
- Varying degrees of channel-wetland connectivity spatially
- Distinct vegetation zonation by elevation
- Seasonal phase between floods and vegetation density



[Zhang et al., 2021]



[Twilley et al., 2019]

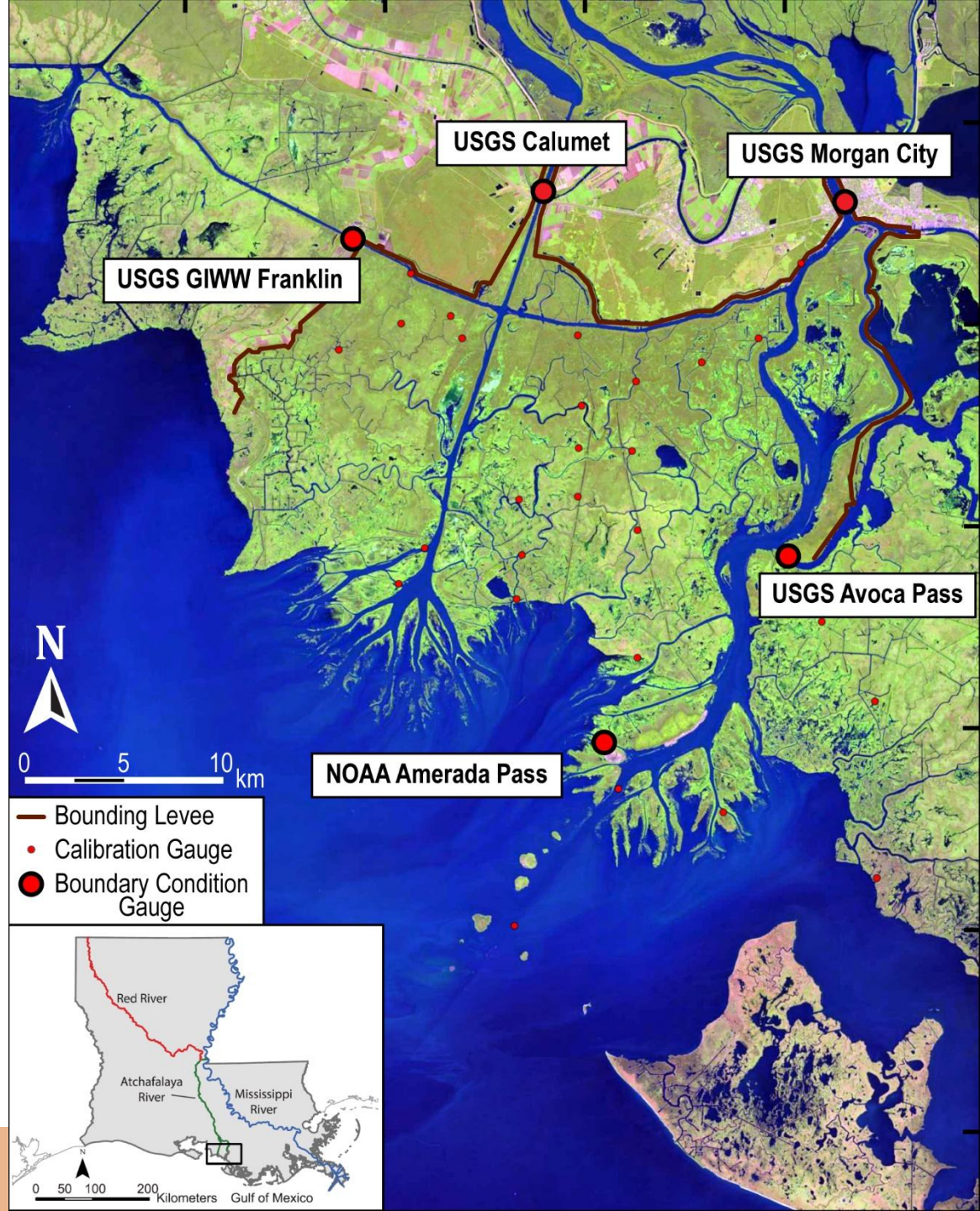
WLAD Model Design

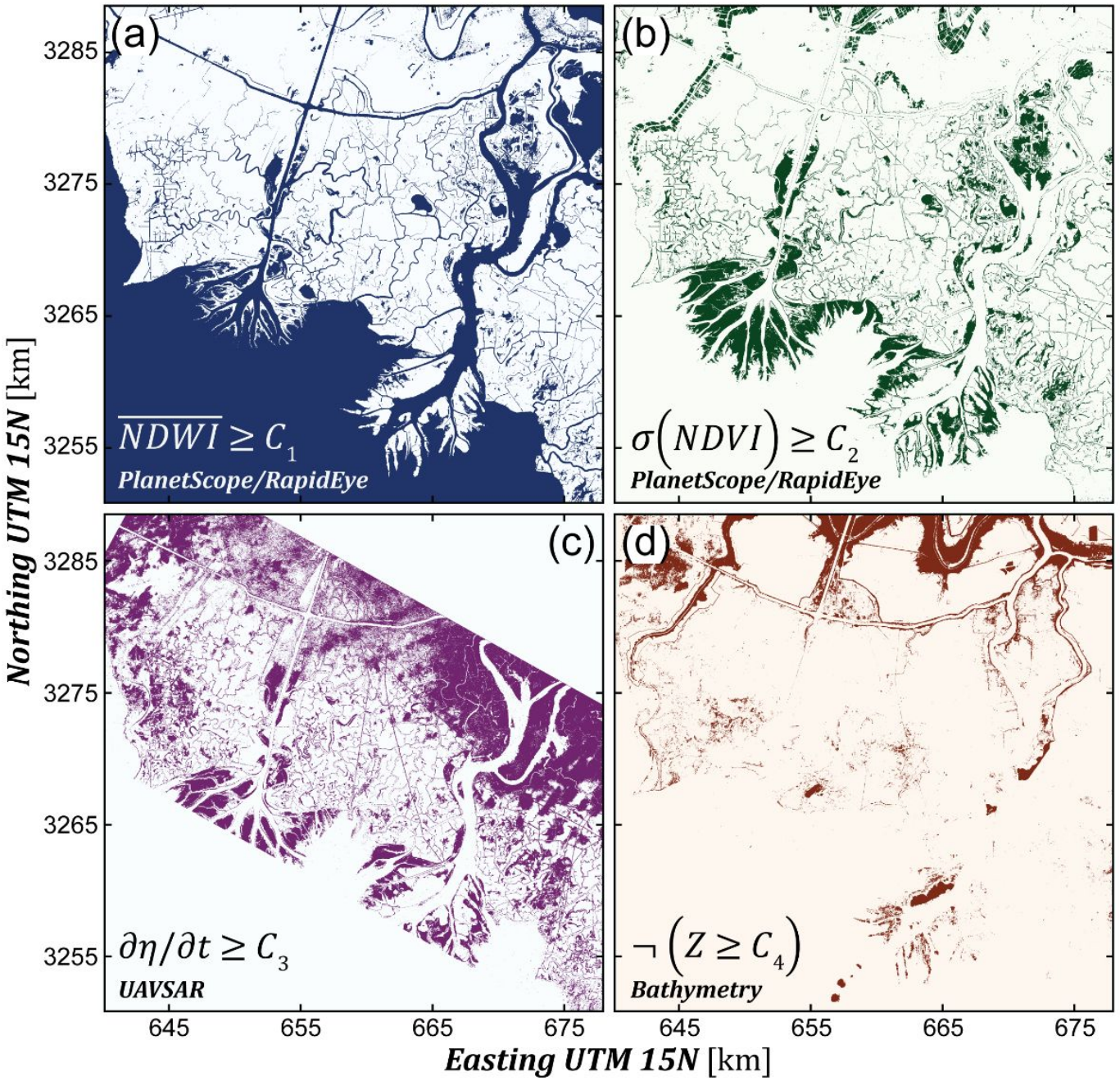
Boundaries closely follow levees to close system mass-balance

Inflows/outflows provided by long-term monitoring stations

Mesh resolution optimized to capture channel/wetland flows across scales

Interior performance calibrated to in-situ and remote sensing data





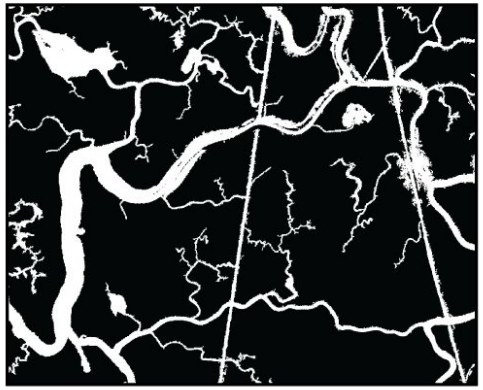
Mesh optimized using remote sensing data

- 28 Planet Labs optical images spanning 2009-2020
- 5 UAVSAR interferograms of water level change over 2.5 hours in October 2016
- Bathy/topo mosaic

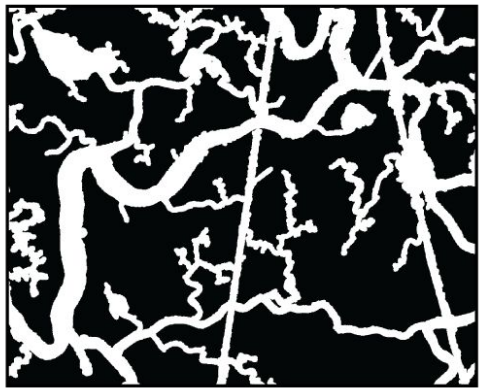
Input layers: Water presence, wetland vegetation, tidally active, not topographically disconnected

(I) Input Mask

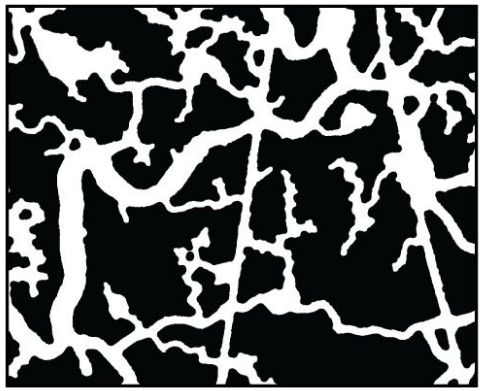
(II) Connectivity Filter



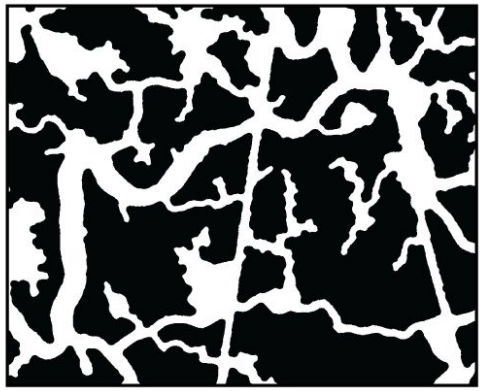
(III) Dilate Channel Width



(IV) Smooth Channel Boundaries

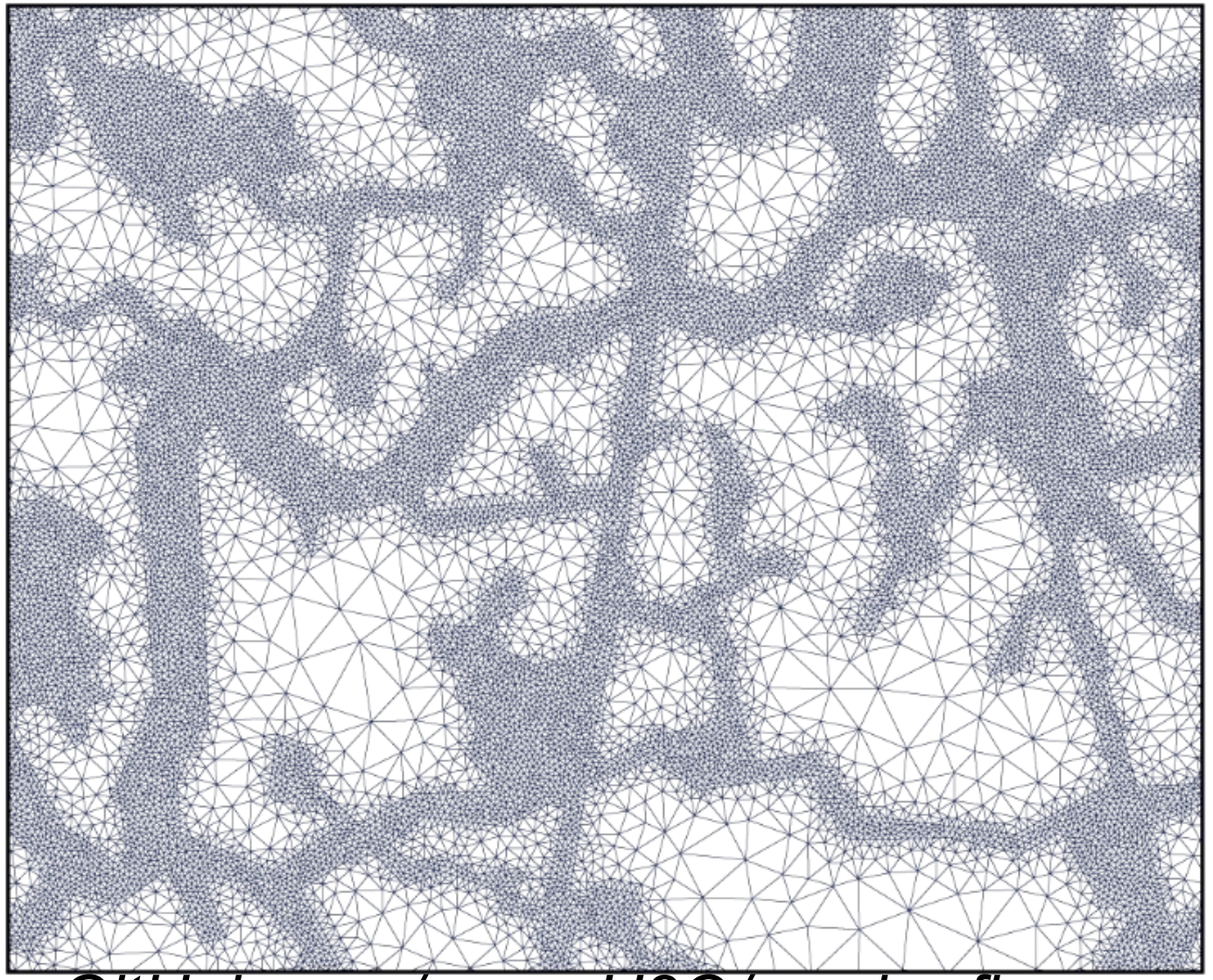


(V) Filter Islands

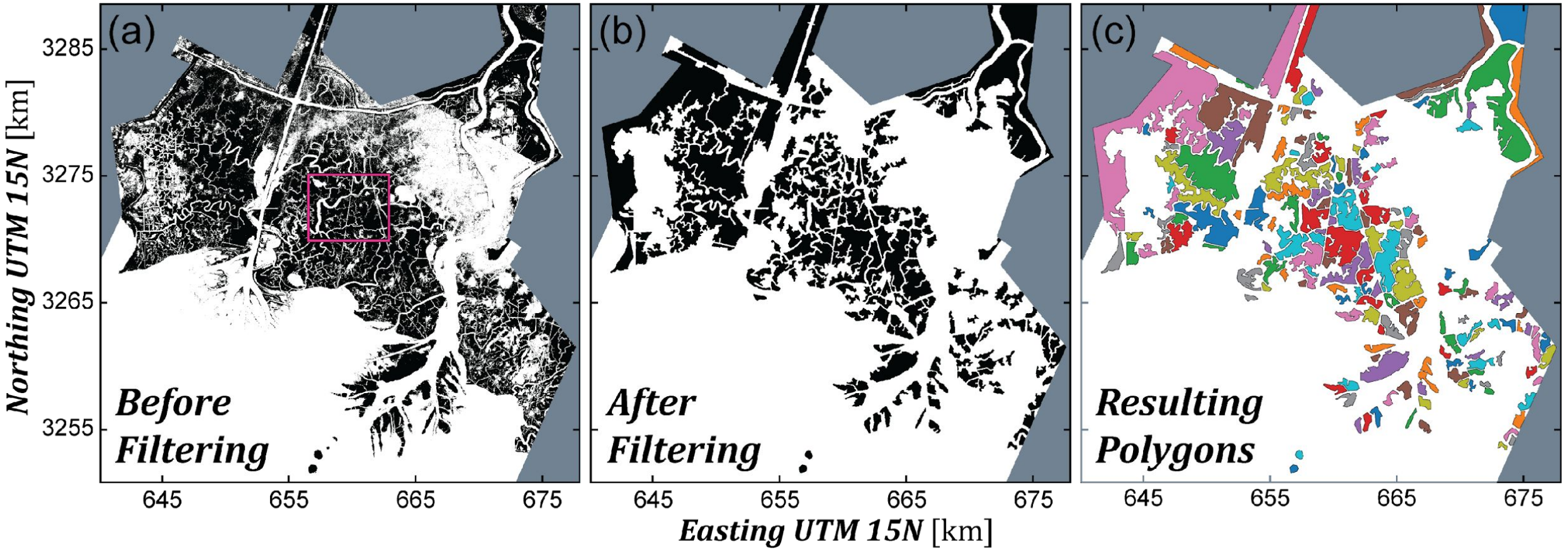


(VI) Decimate Polygons

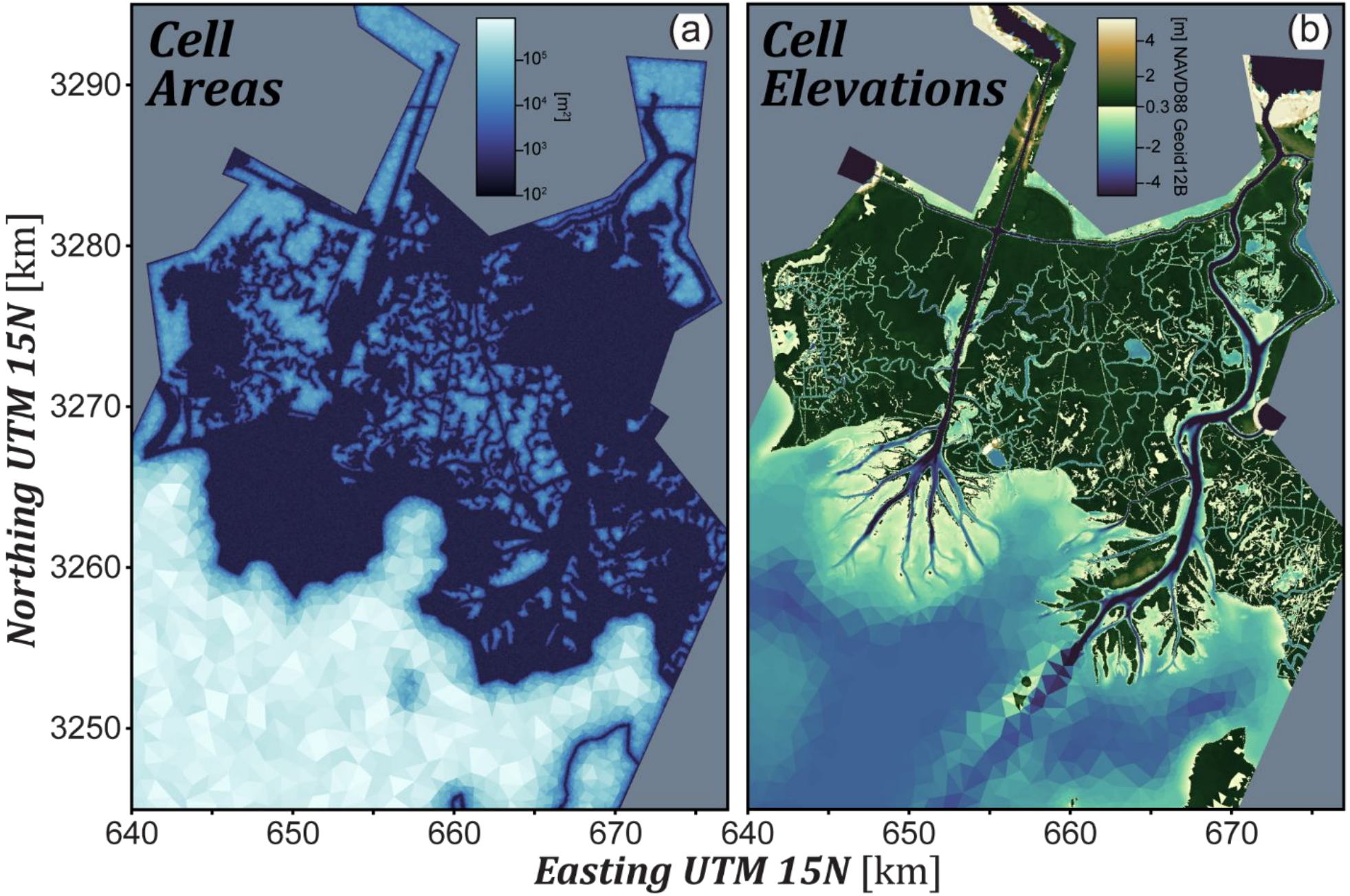
(VII) Resulting ANUGA Mesh



GitHub.com/passaH2O/meshrefinement

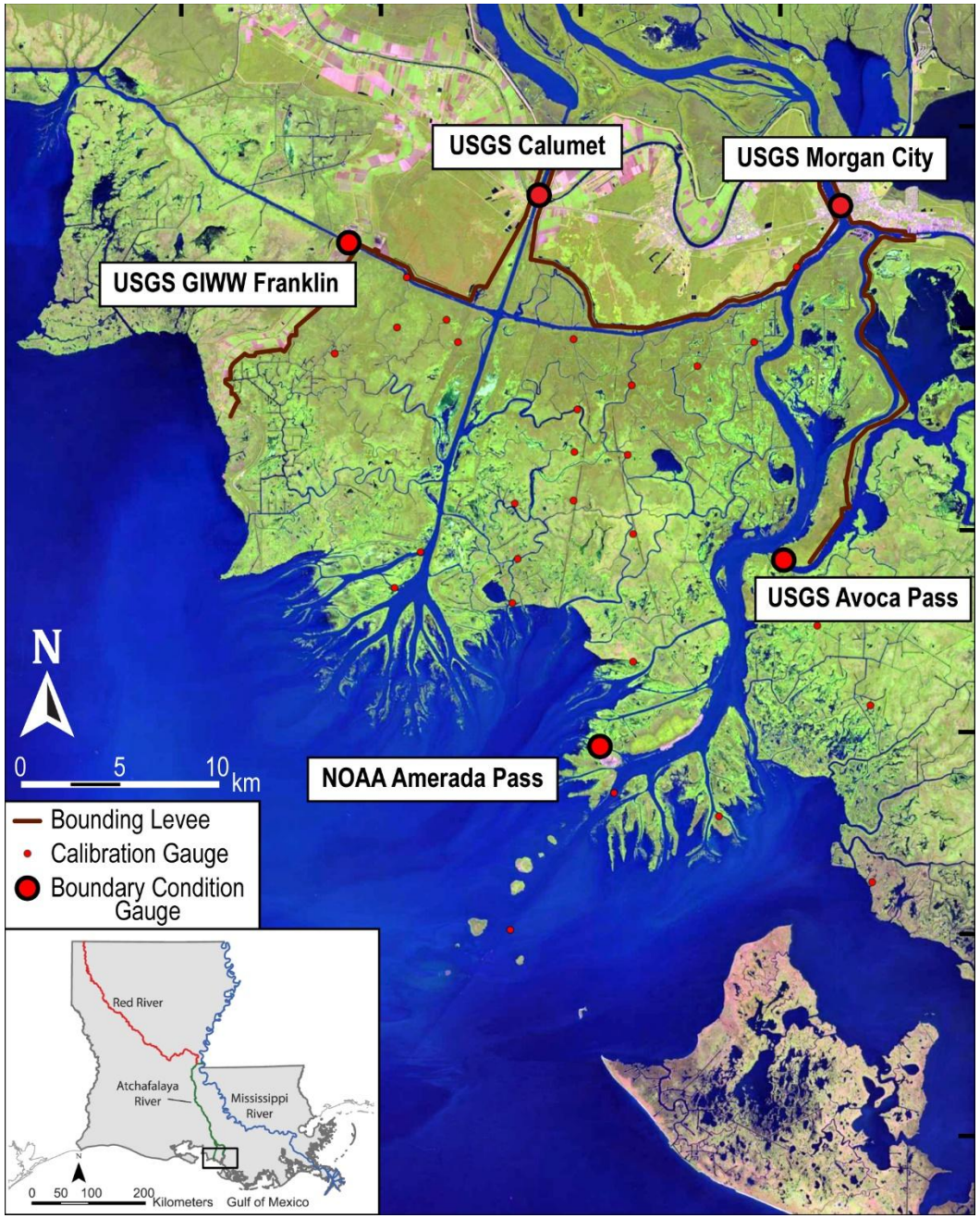


Based on remote sensing data, ~180 regions sufficiently inactive over long and short time-scales to coarsen the mesh. Testing shows no reduction in accuracy


Cell Areas
(a)
10^5
10^4
10^3
10^2
[m²]
Cell Elevations
(b)
4
2
0.3
-2
-4
[m] NAVD88 Geoid12B
3290
3280
3270
3260
3250
Northing UTM 15N [km]
640
650
660
670
Easting UTM 15N [km]

Boundary Conditions

- Calumet: Discharge
- Morgan City: Discharge
- GIWW Franklin: Discharge (up to 2019), afterwards derived from water level rating curve
- GIWW Avoca: Historical USGS ADCP transects averaged by month
- LAWMA or Eugene: Tides and Wind



Parameterizing roughness

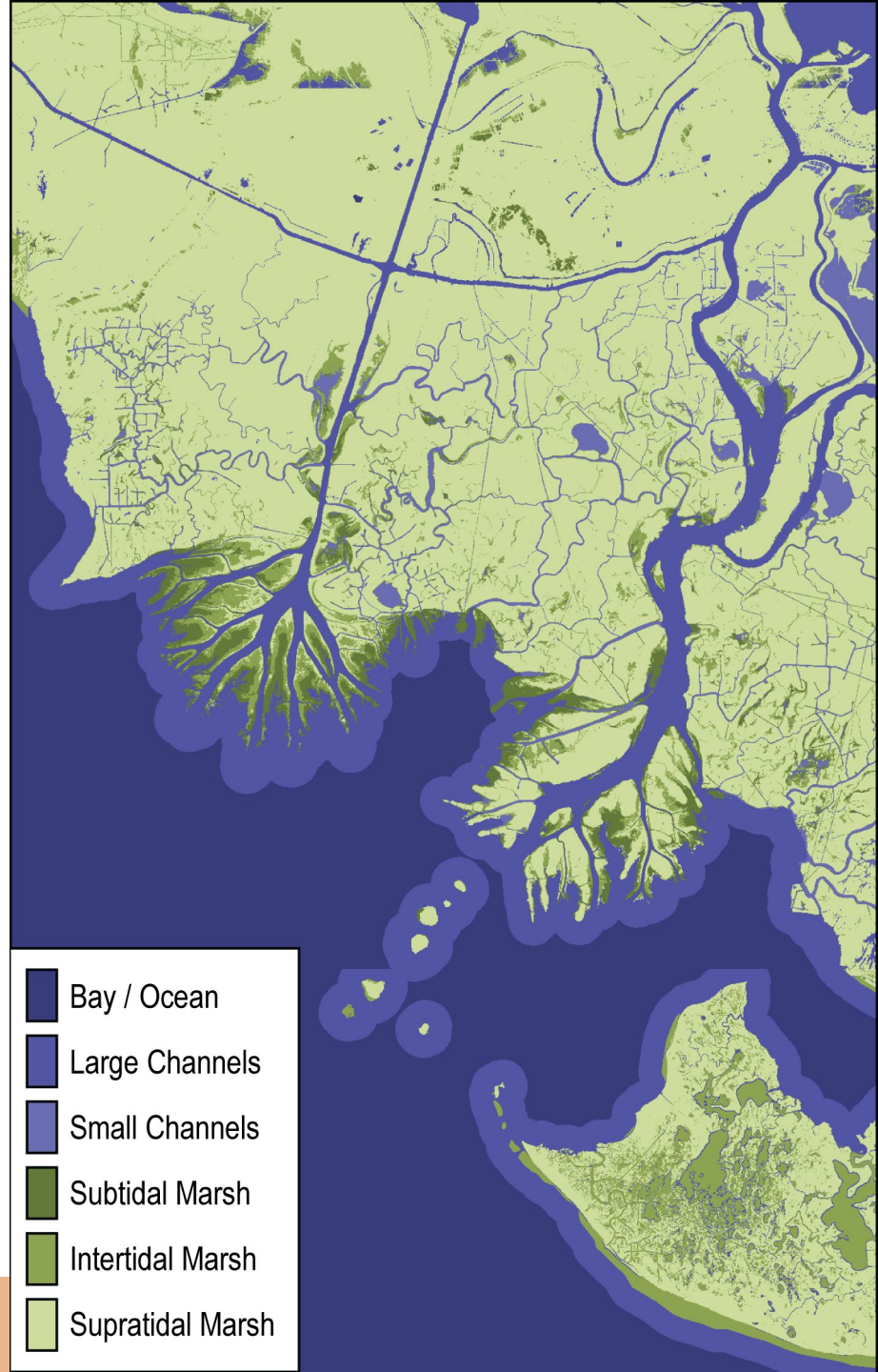
Friction classification map based on remote sensing and topography

Three open water classes use Manning's:

$$C_z = \frac{h^{1/6}}{n}$$

Three vegetated classes use Baptist:

$$C_v = \sqrt{\frac{1}{(1/C_b^2) + (C_D m D h_v / 2g)}} + \frac{\sqrt{g}}{\kappa} \ln\left(\frac{h}{h_v}\right)$$



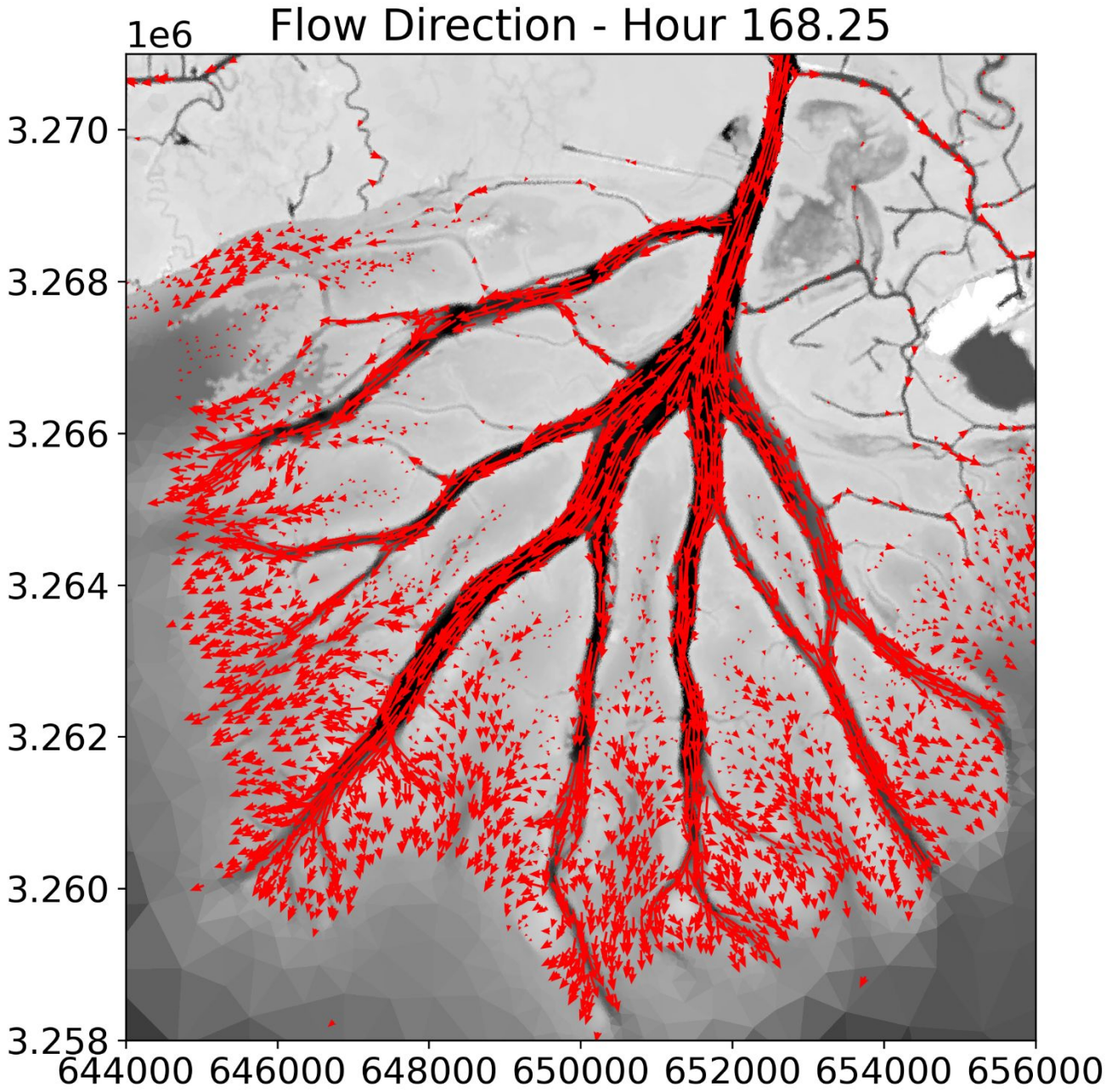
Code run-through

Go to:

GitHub.com/wrightky/ANUGA_DXWorkshop

and click “Open in Colab”

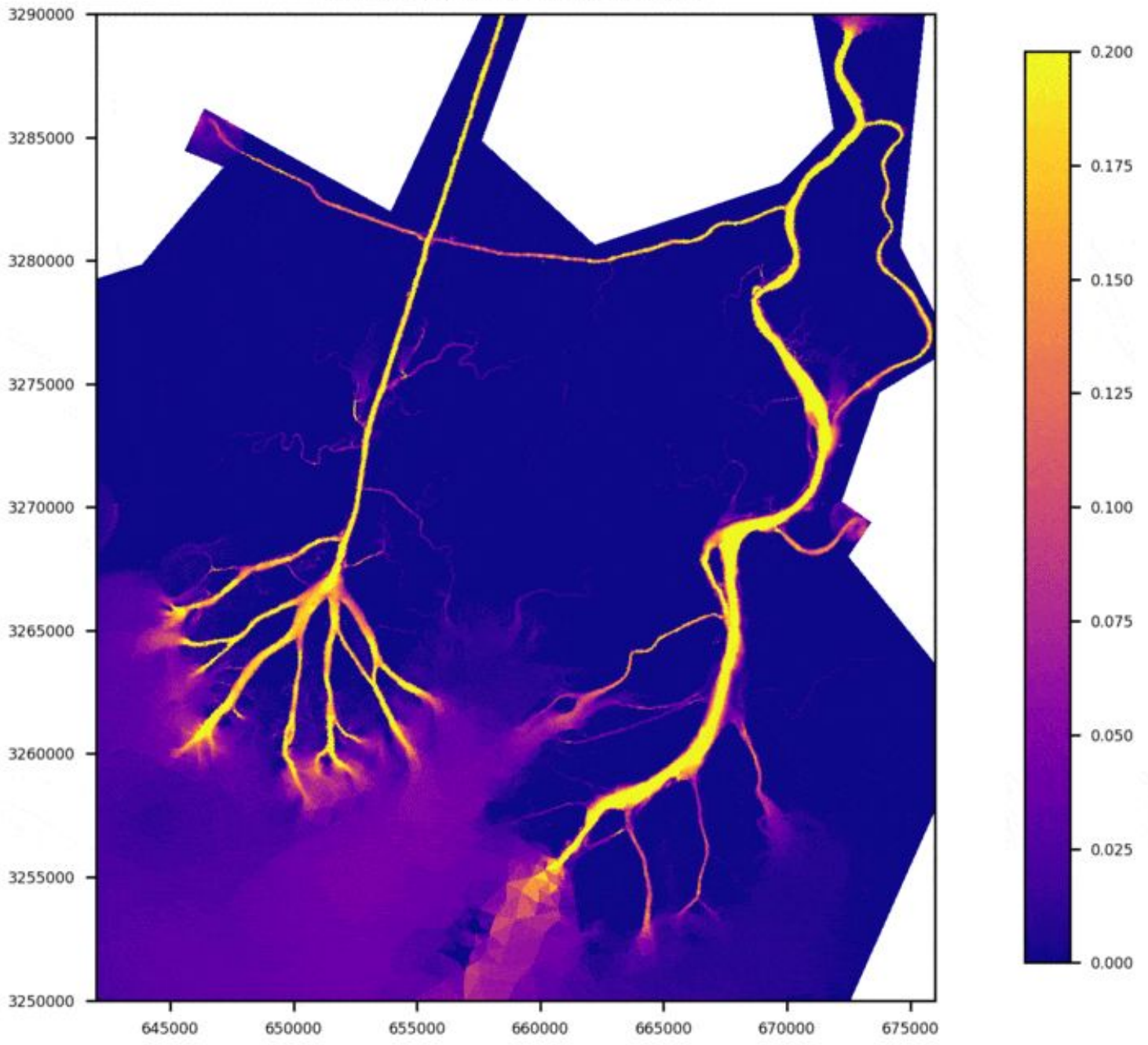
Flow Direction



2021 March 27

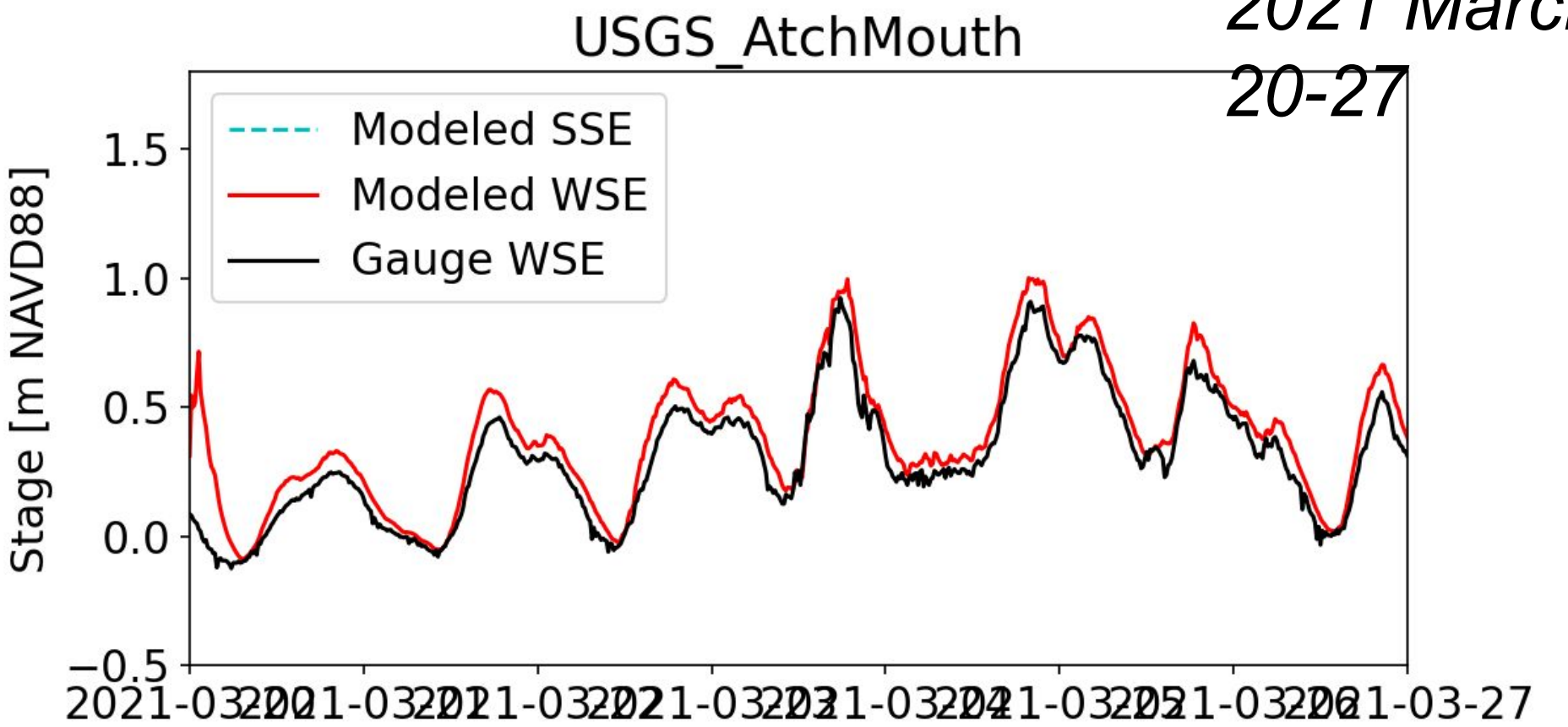
Flow velocity

2016 October 15-16

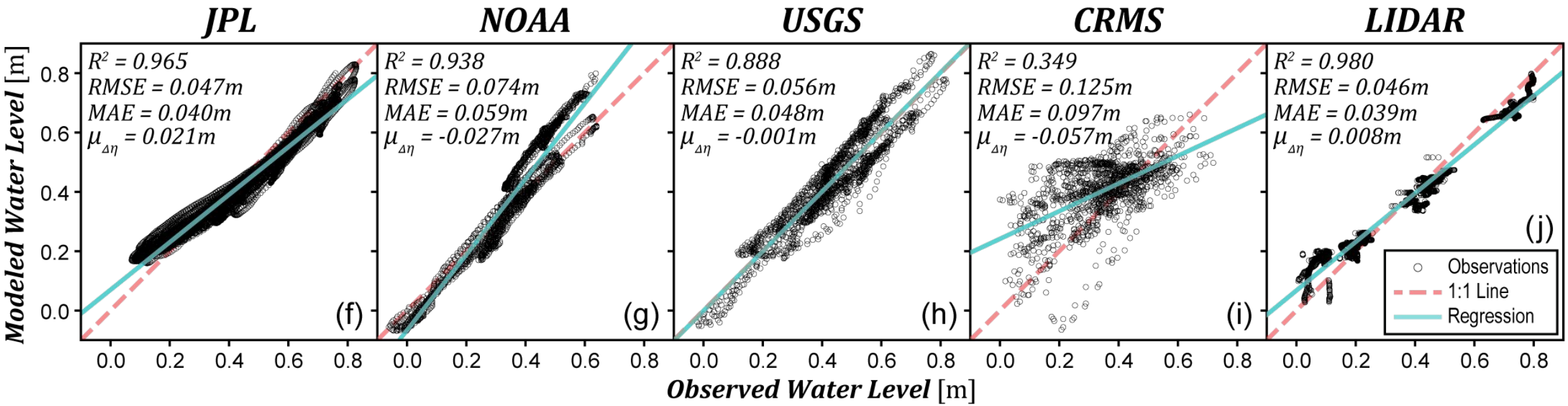


Inspect output water level at each gauge

2021 March 20-27



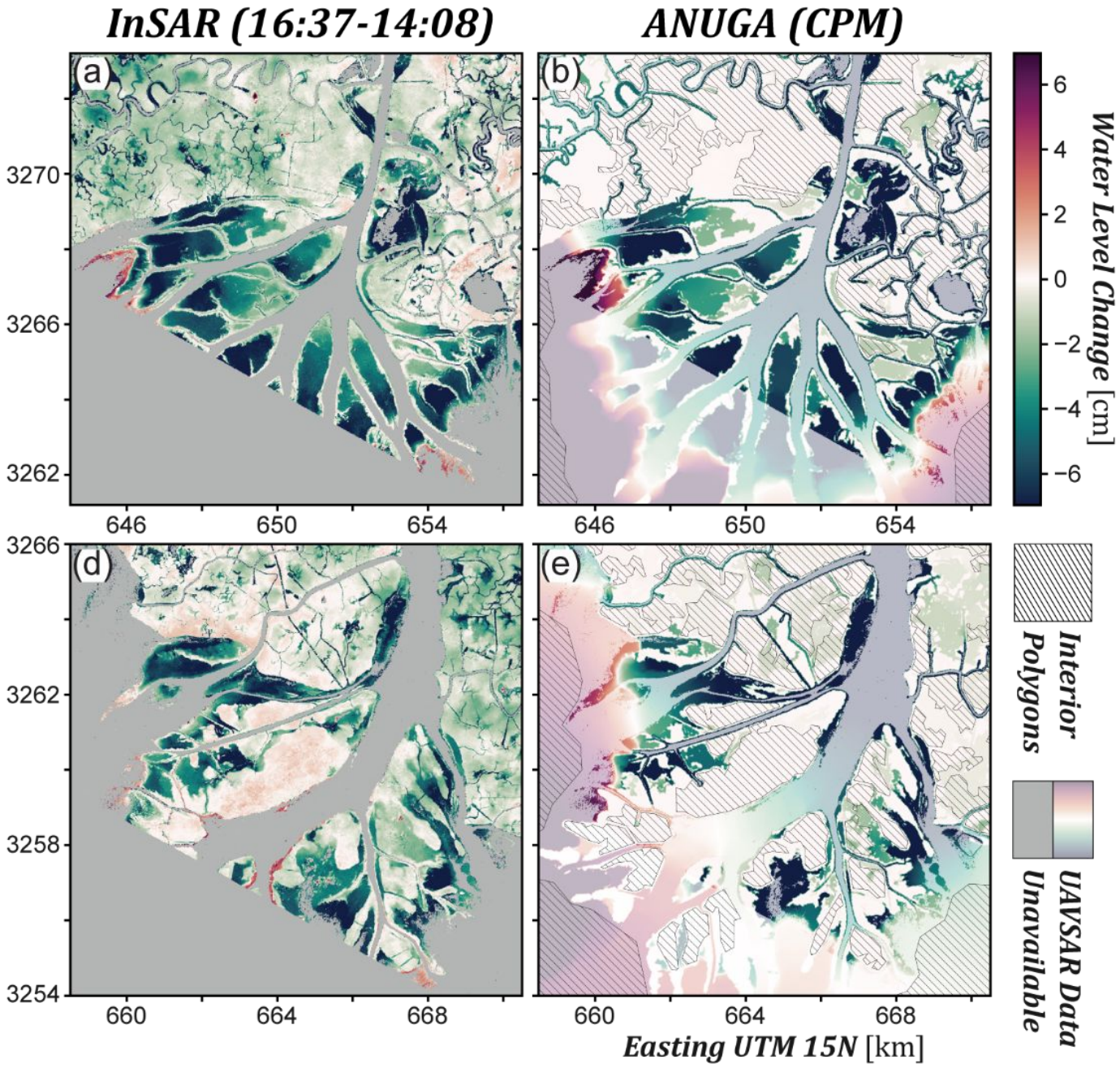
Inspect output water level at all gauges



2016 October 15-18

Compare change in water level to InSAR

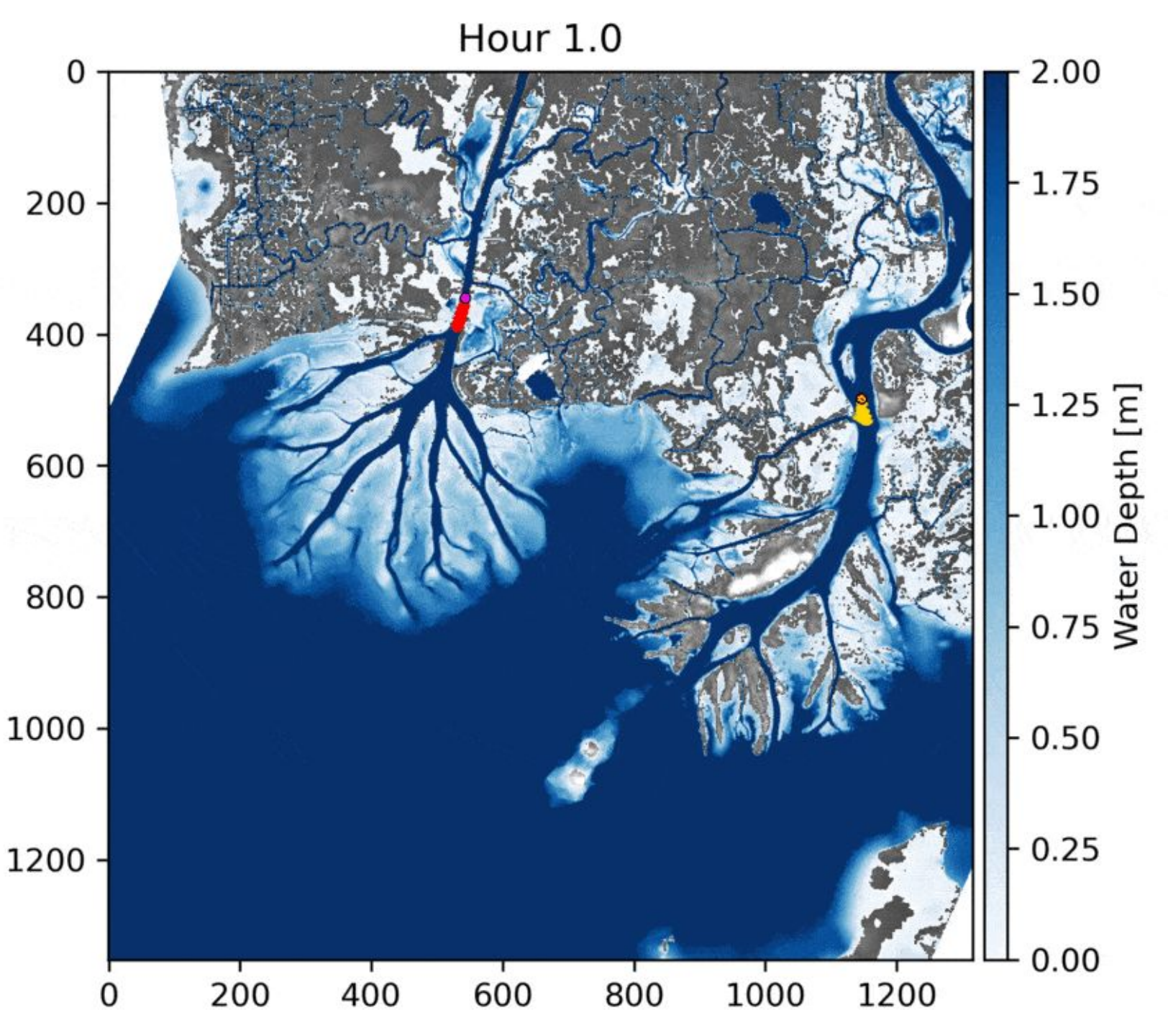
2016 October 16 14:08-16:37

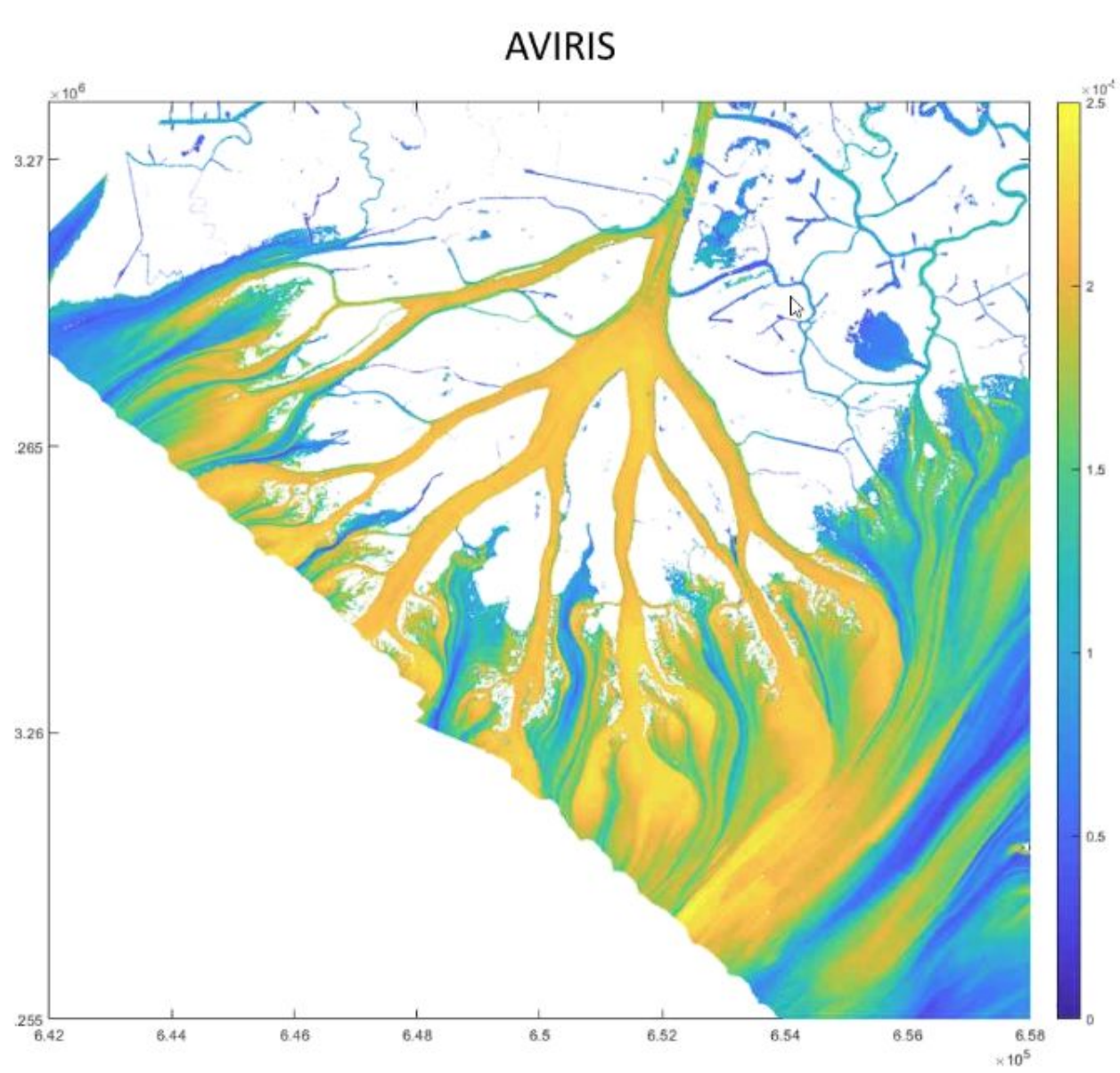


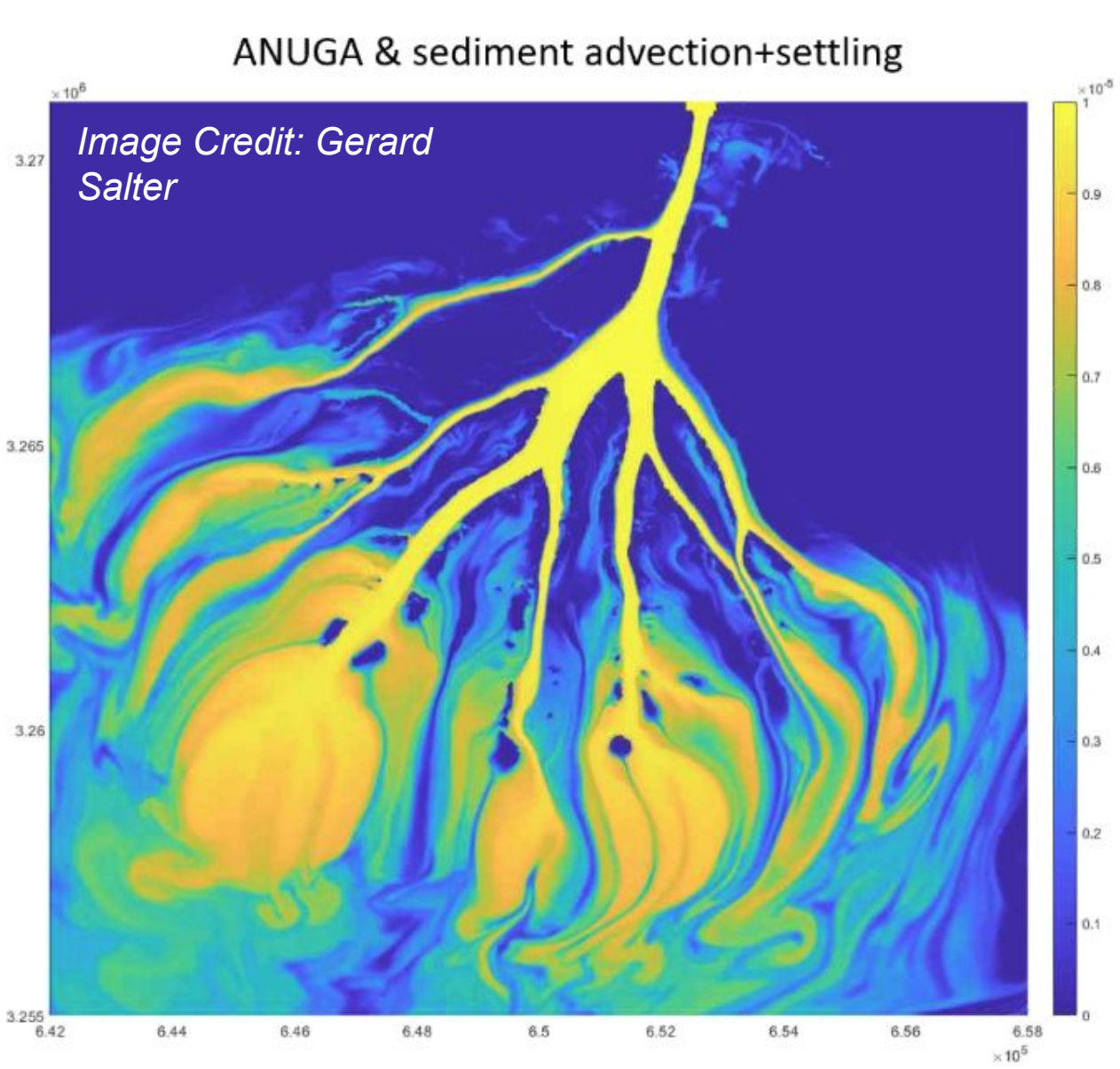
Add Lagrangian particles with dorado

Compute RTDs & nourishment areas

GitHub.com/passaH2O/dorado







Add sediment transport module (Caltech)