Jet Propulsion Laboratory
California Institute of Technology

dorado
Lagrangian particle transport

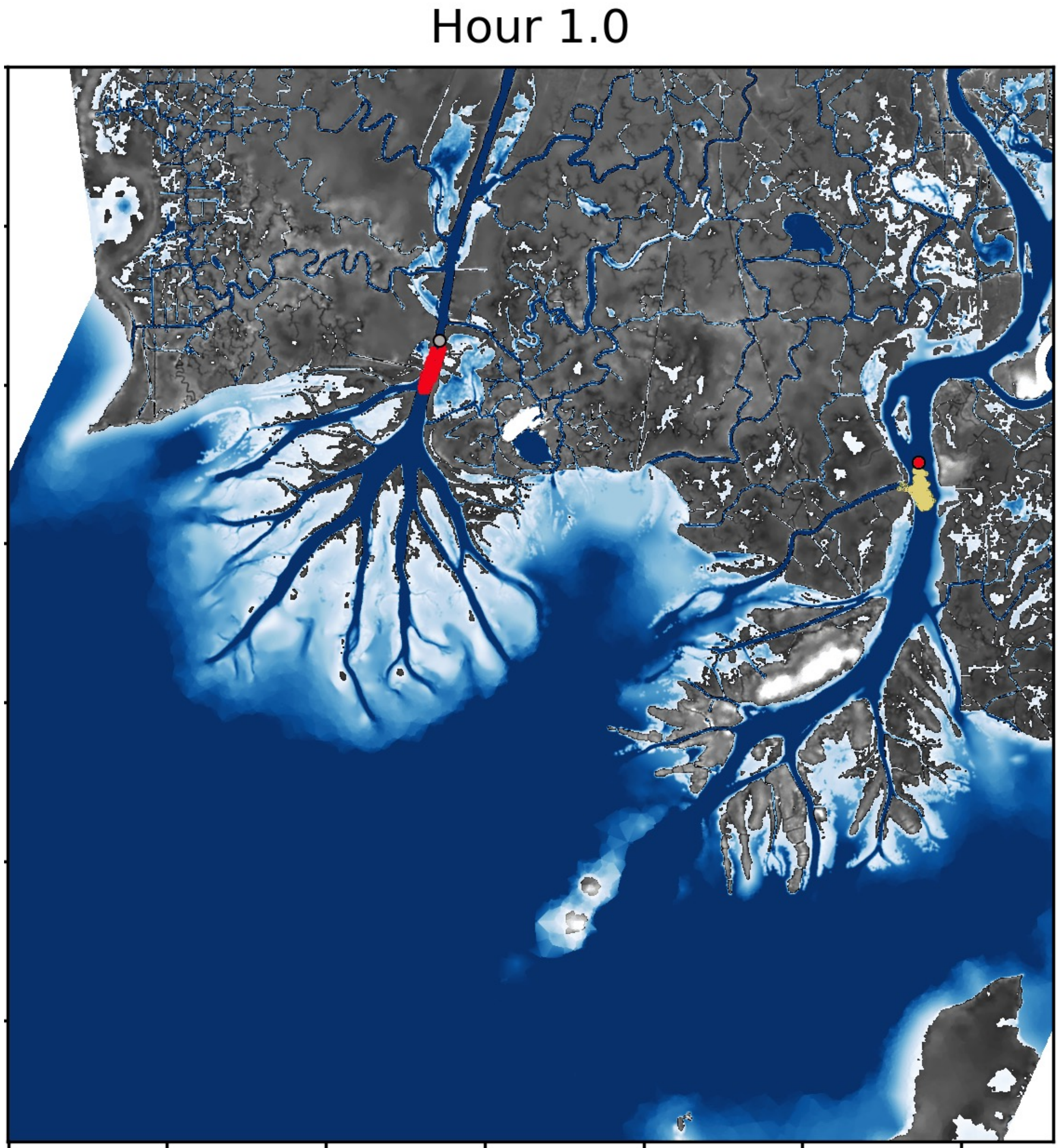
https://passah2o.github.io/dorado/index.html

Delta-X Workshop 2024
May 8th, Baton Rouge

Muriel Brückner
Assistant Professor
Louisiana State University

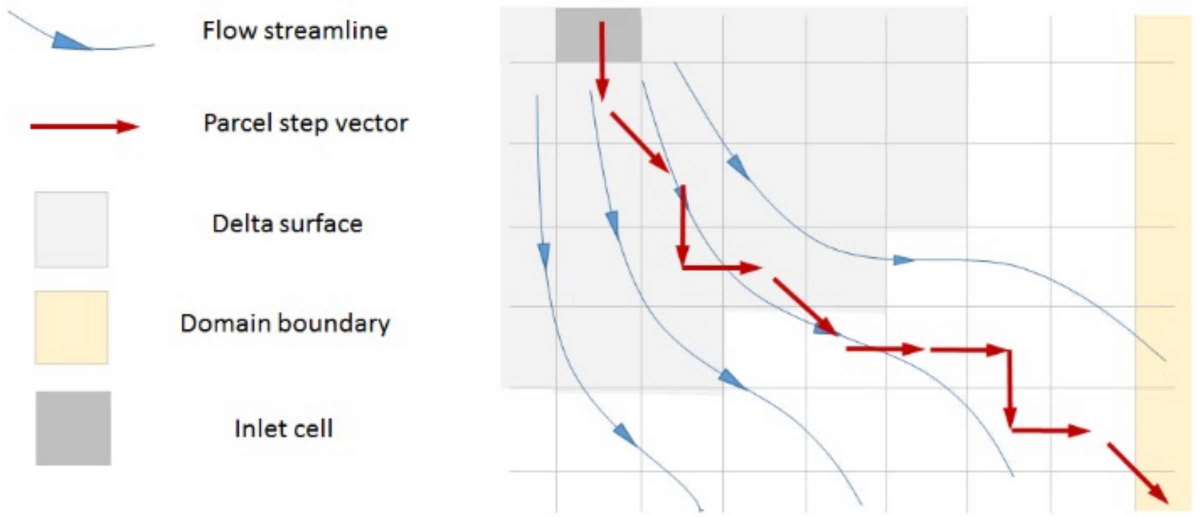
Antoine Soloy
Postdoctoral Researcher
JPL

URS Clearance **CL#24-2353**

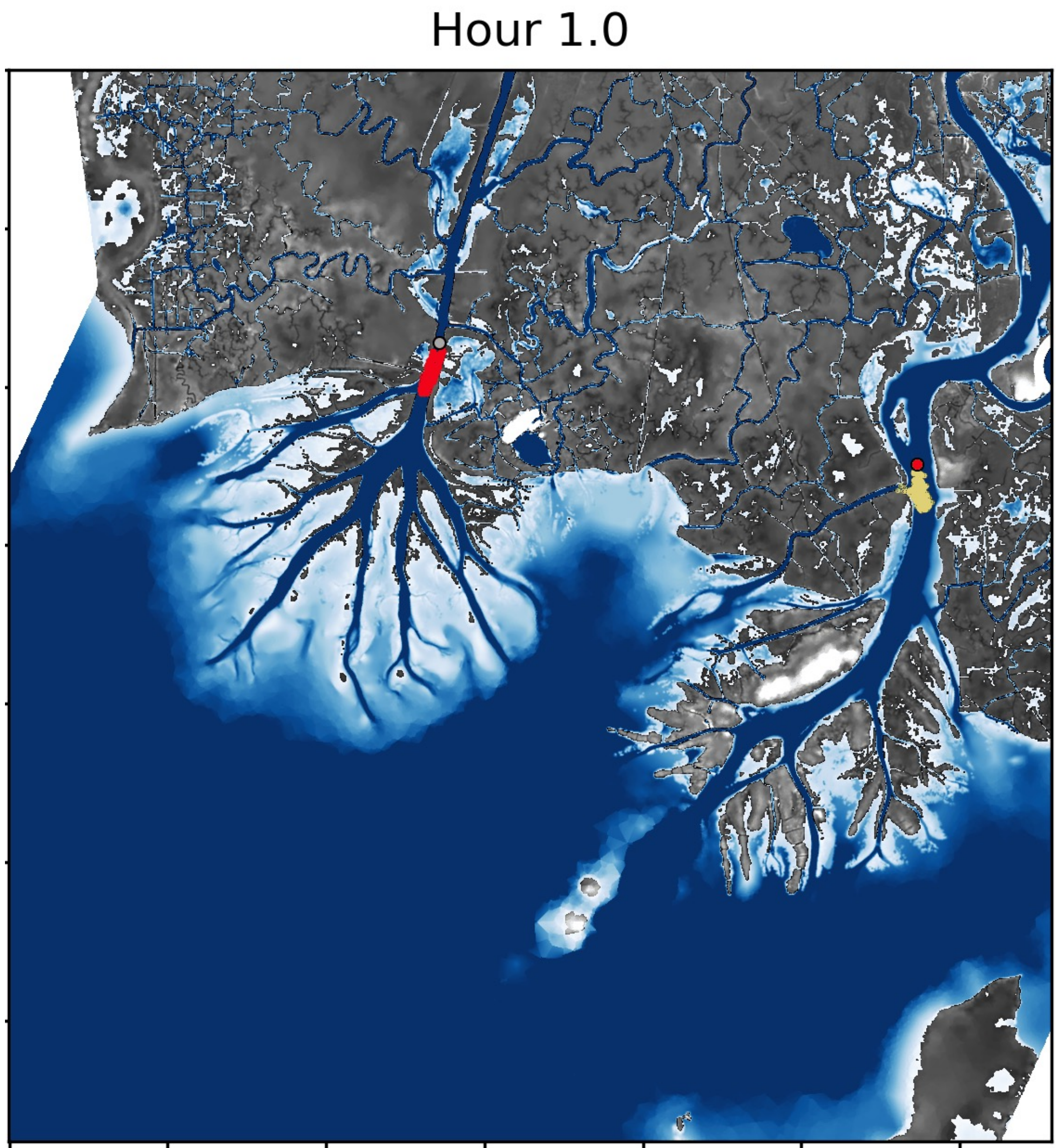


Reduced-complexity approach – weighted random walk

- cellular routing scheme
- Stepping defined by a set of rules



Liang et al. (2015)



Reduced-complexity approach – weighted random walk

- transport direction (flow/water level gradient)
- resistance in downstream cell

Liang et al. (2015)

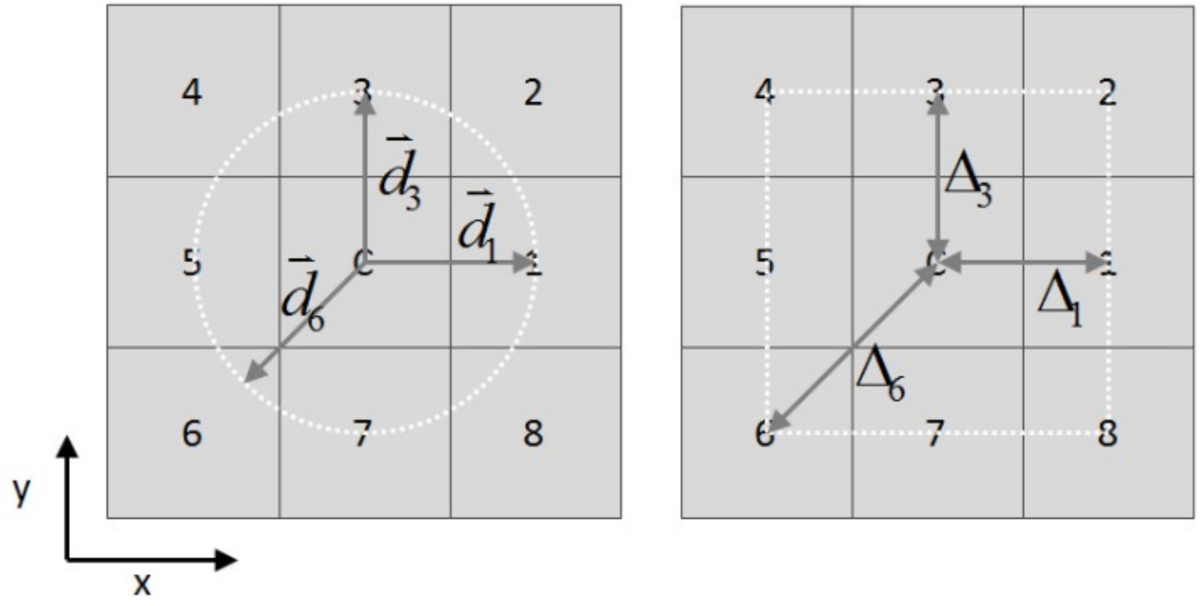
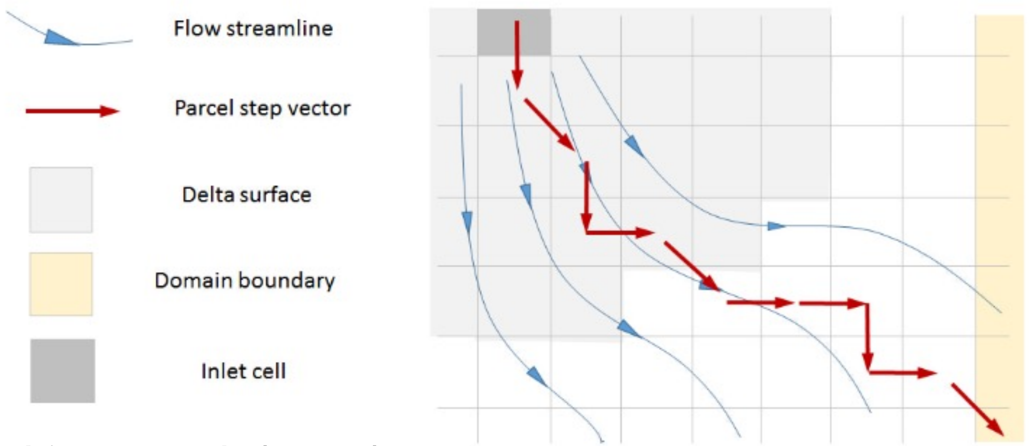


Figure 3. Definition of cellular direction $\boldsymbol{d}_i$ and cellular distance Δ_i. For example, $\boldsymbol{d}_1 = (1, 0)$, $\boldsymbol{d}_6 = (-\frac{1}{\sqrt{2}}, -\frac{1}{\sqrt{2}})$, $\Delta_1 = 1$, $\Delta_6 = \sqrt{2}$.

dorado – weighted random walk

- F*: transport direction based on inertia and water surface slope

(1) $$F^* = \gamma F_{sfc} + (1-\gamma)F_{int}$$



Liang et al. (2015)

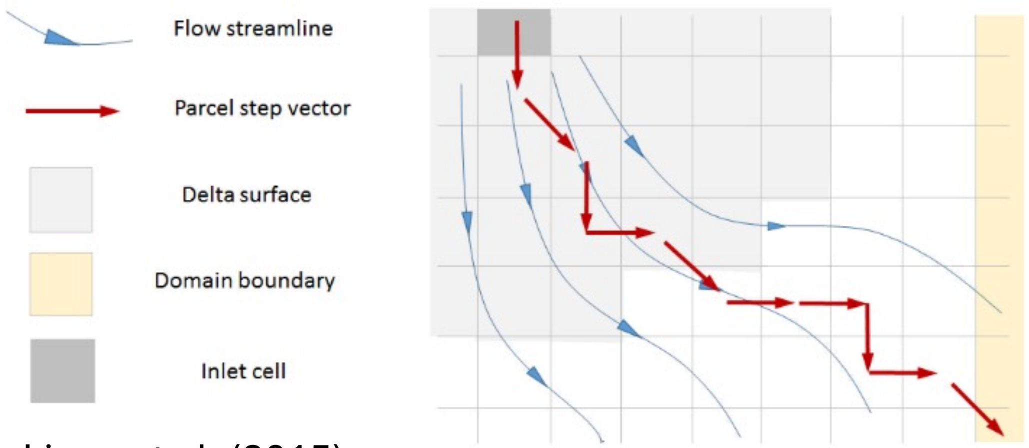
dorado – weighted random walk

- F*: transport direction based on inertia and water surface slope

Routing direction Surface gradient Inertial component

$$F^* = \gamma F_{sfc} + (1 - \gamma) F_{int} \quad (1)$$

Indirect diffusivity



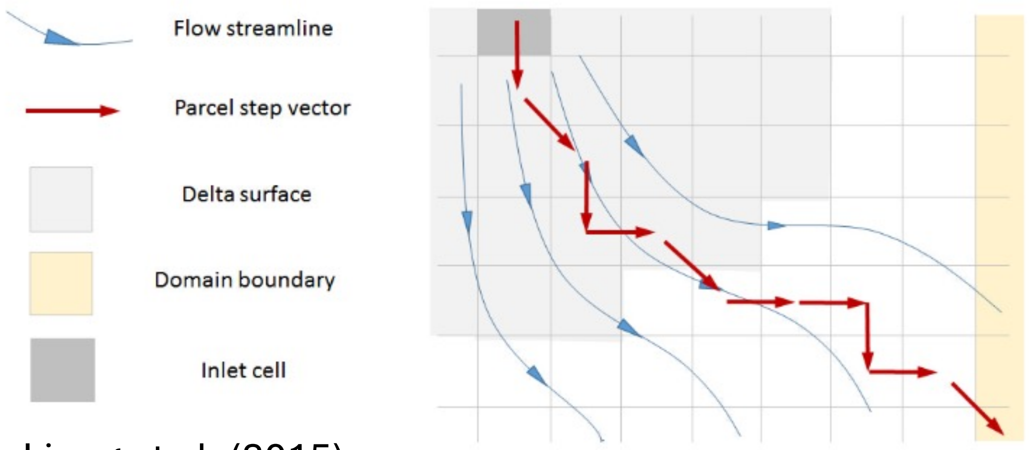
Liang et al. (2015)

dorado – weighted random walk

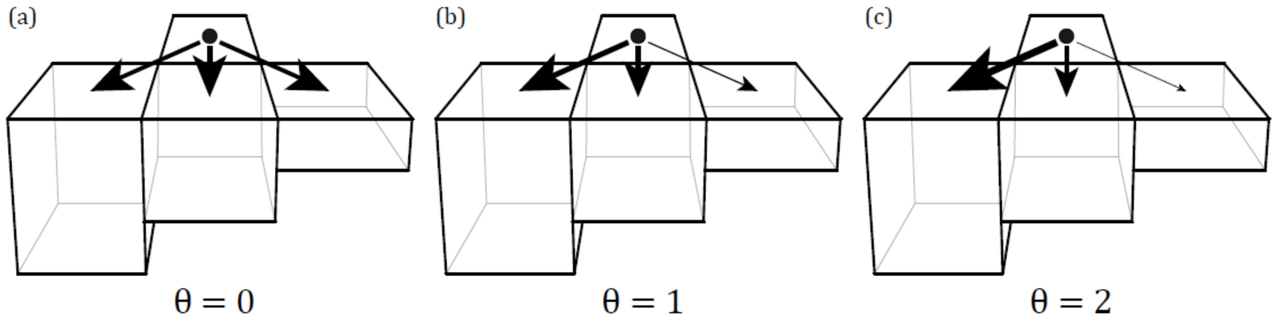
- w_i: weighting of the particles towards deeper water

(1) $$F^* = \gamma F_{sfc} + (1-\gamma) F_{int}$$

(2) $$w_i = \frac{h_i^\theta \max(0, F \cdot d_i)}{\Delta_i}$$



Liang et al. (2015)



Wright et al. (2022)

dorado – weighted random walk

- w_i: weighting of the particles towards deeper water

(1) $$F^* = \gamma F_{sfc} + (1 - \gamma) F_{int}$$

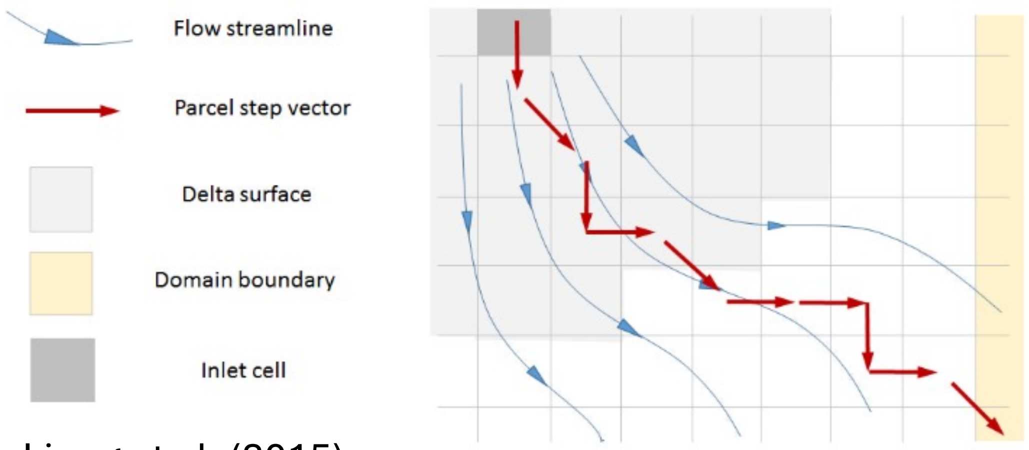
Local water depth

Unit vector

Relative weight

(2) $$w_i = \frac{h_i^\theta \max(0, F \cdot d_i)}{\Delta_i}$$

D8 cellular distance



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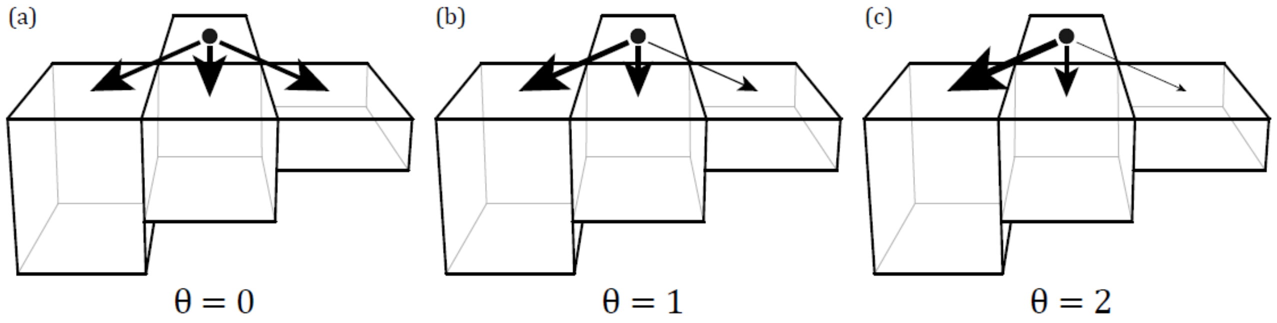

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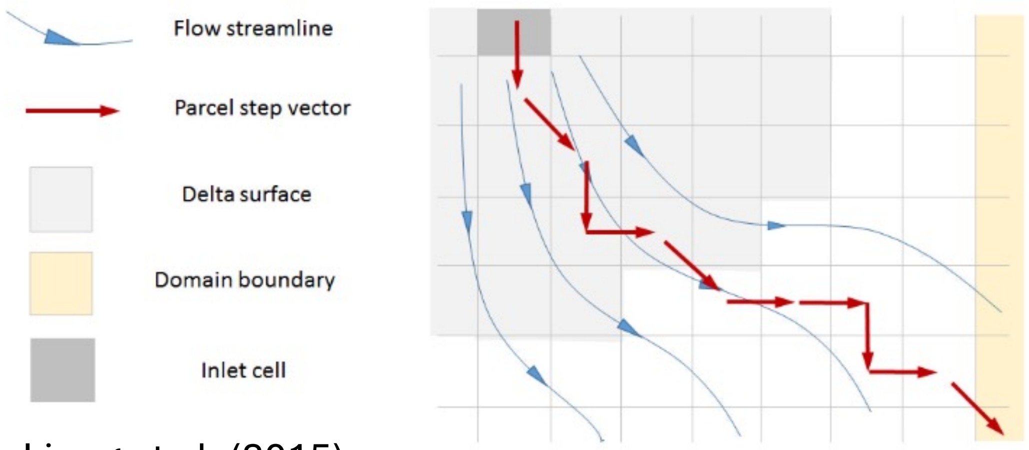
Dependence on water depth

D8 cellular distance



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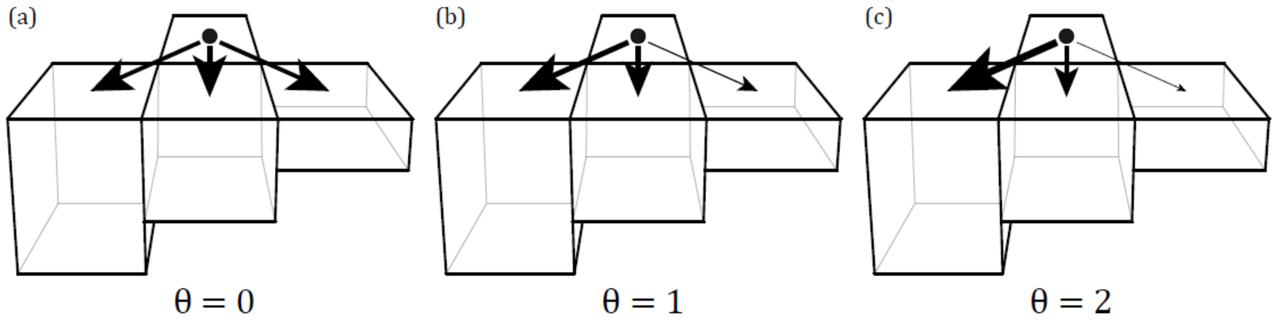
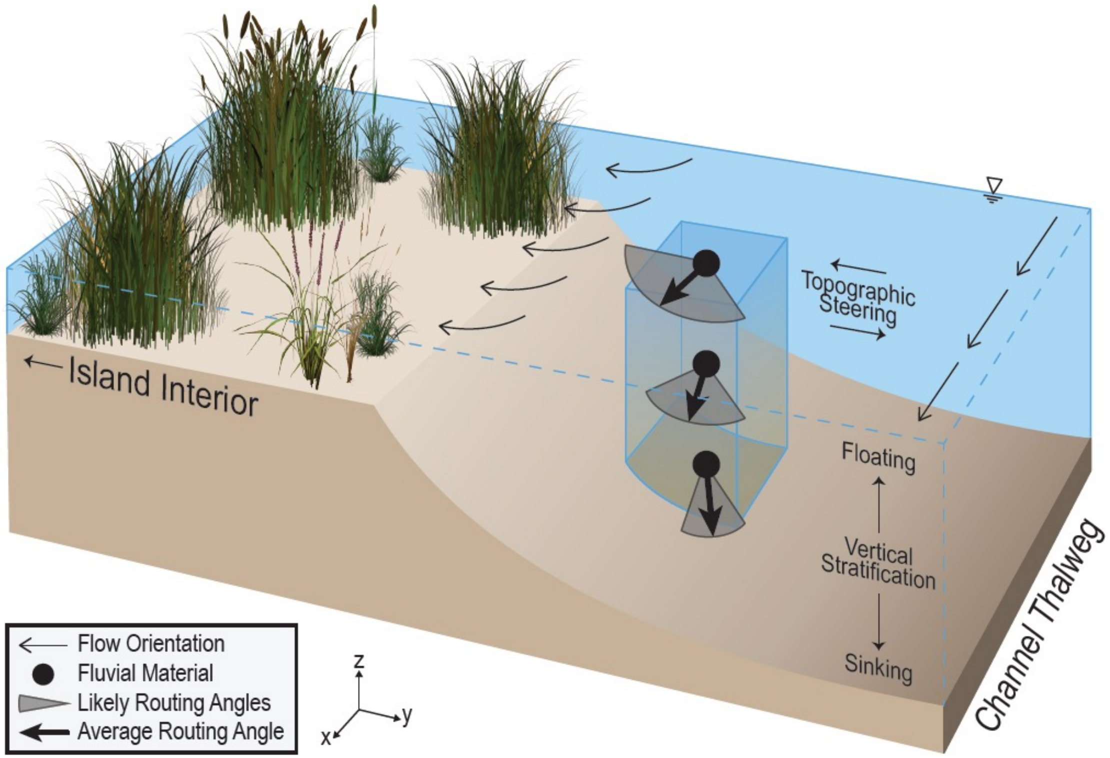
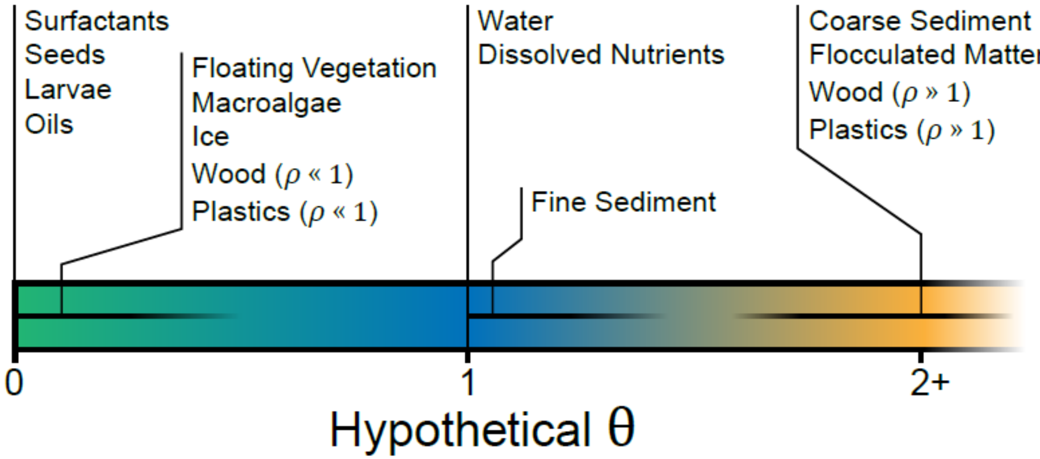


Wright et al. (2022)

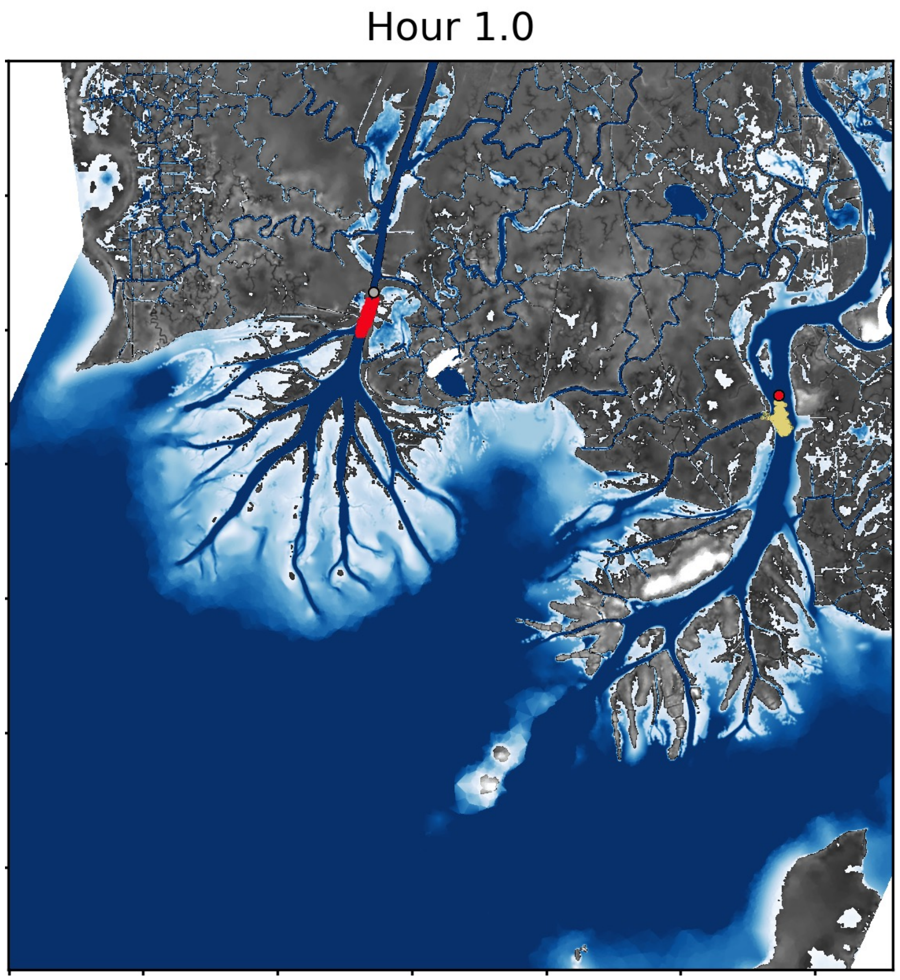
Particle routing depends on the water depth

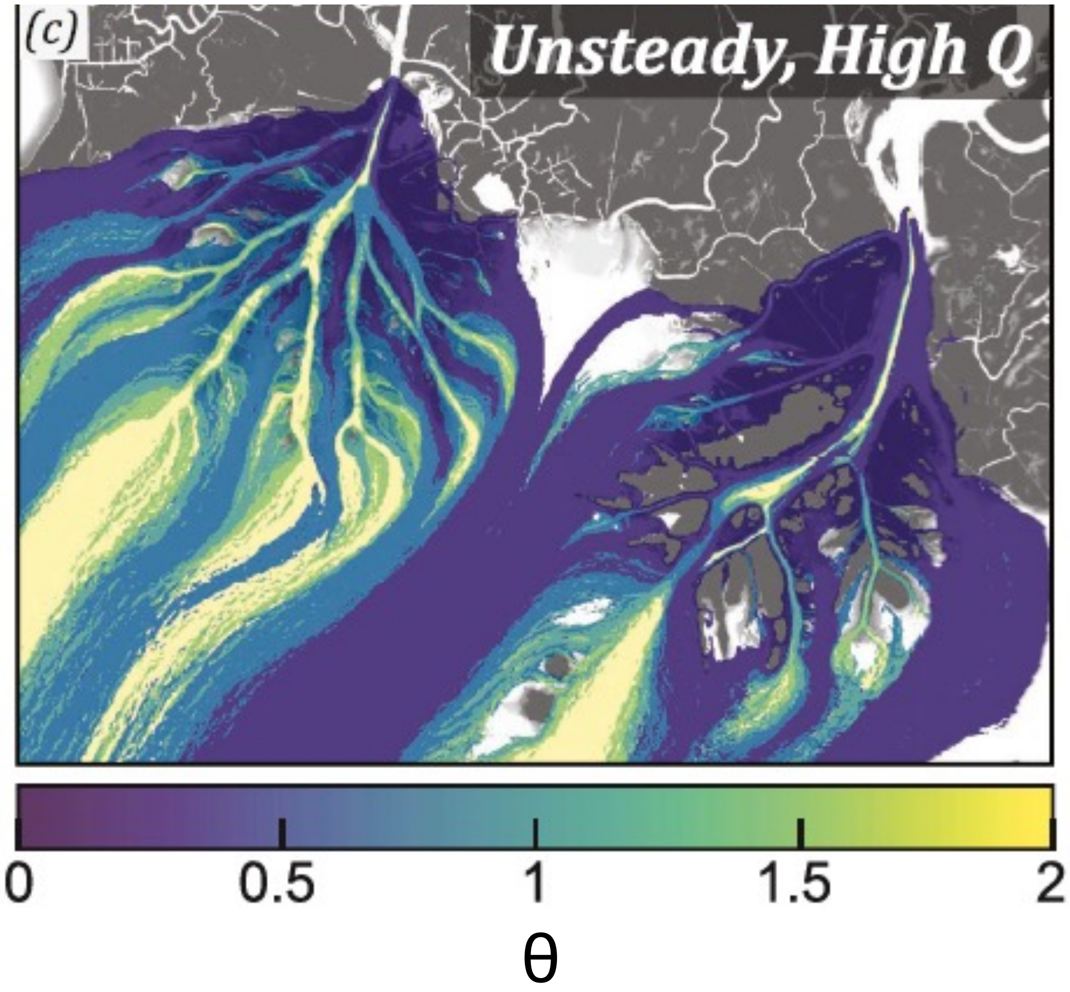




Wright et al. (2022)

Transport pathways can be estimated





Wright et al. (2022)

How can this be useful?

- Flow path relative to particle properties
- Probability of nourishment of an area depending on seeding location (particles entering an area)
- Residence times or exposure times in an area

Potential for deposition, nutrient uptake, algal bloom production, …

Compared to sediment transport models/morphodynamic models time-efficient, straightforward, lower calibration efforts

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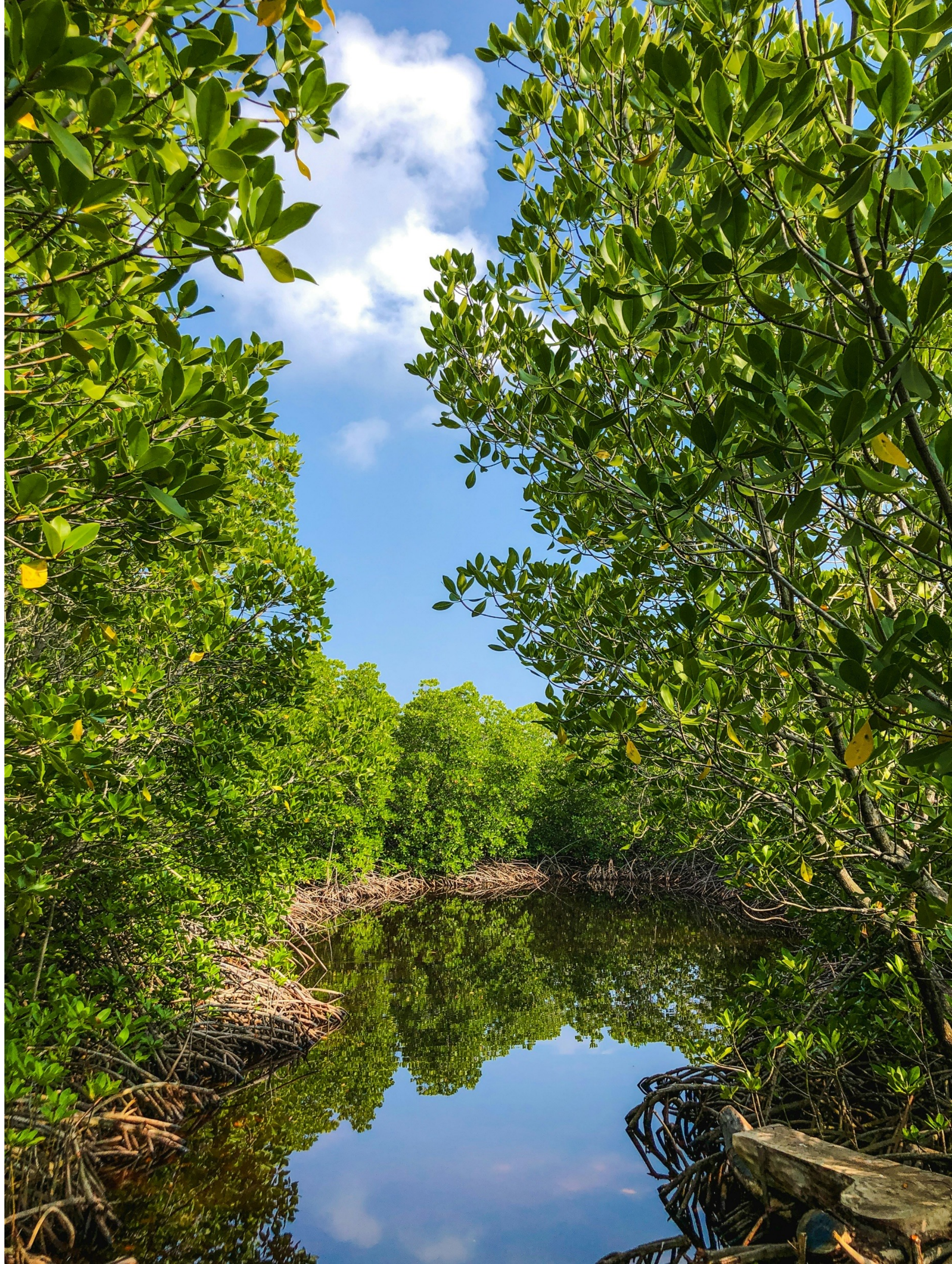
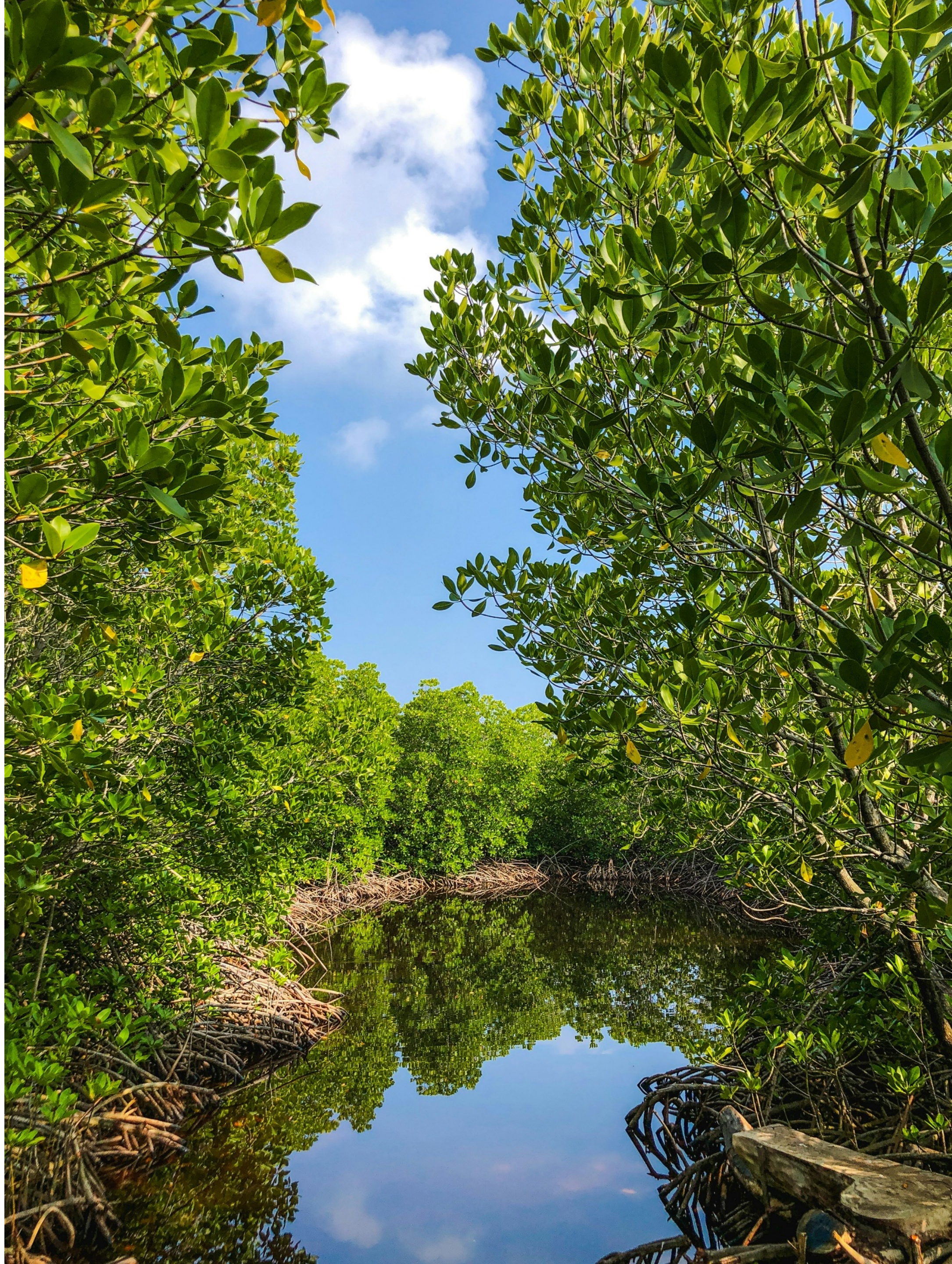
Nourishment of wetlands



Nourishment of wetlands

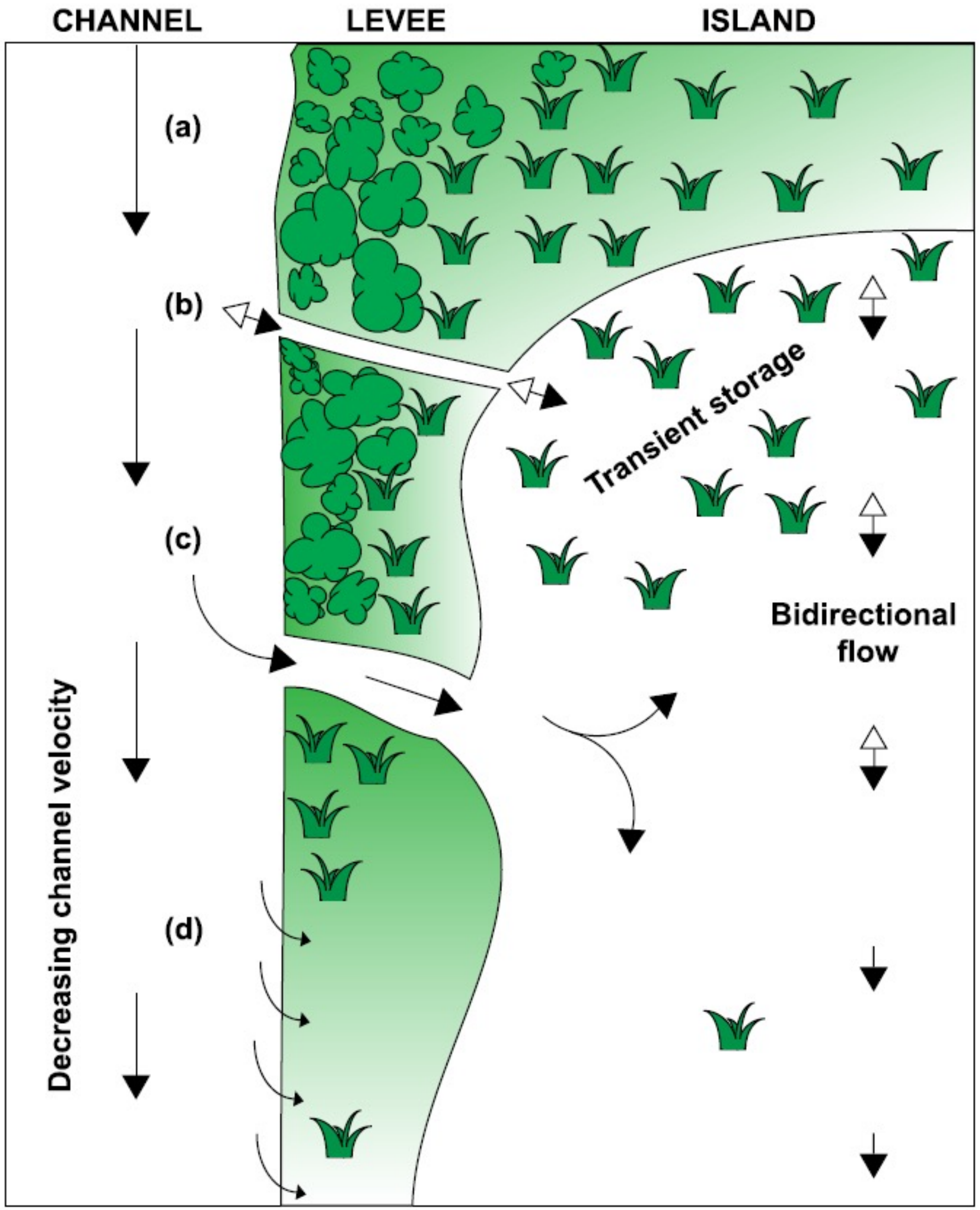
What type of particles enter wetlands and under which conditions?



Nourishment of wetlands

What type of particles enter wetlands and under which conditions?

How does channel-island connectivity affect nourishment of wetlands?

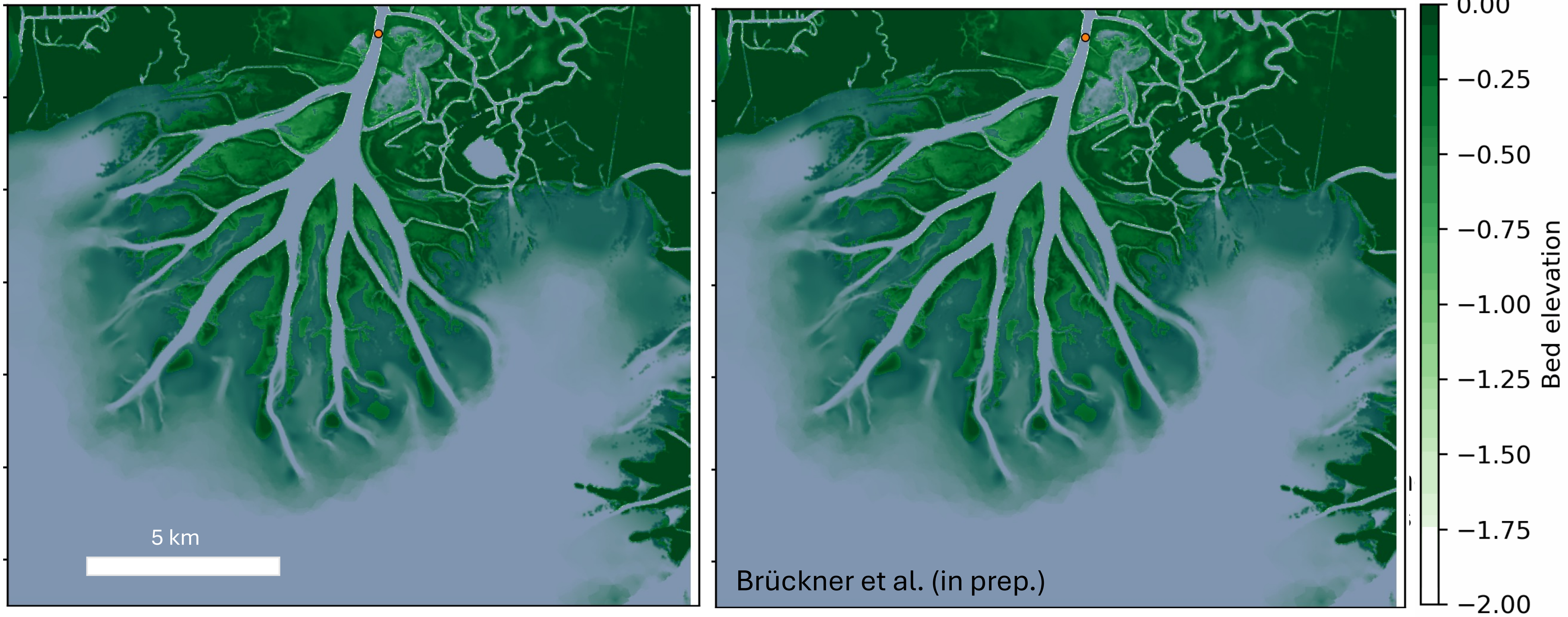


Hiatt & Passalacqua (2015)

Sand and mud transport in Wax Lake Delta

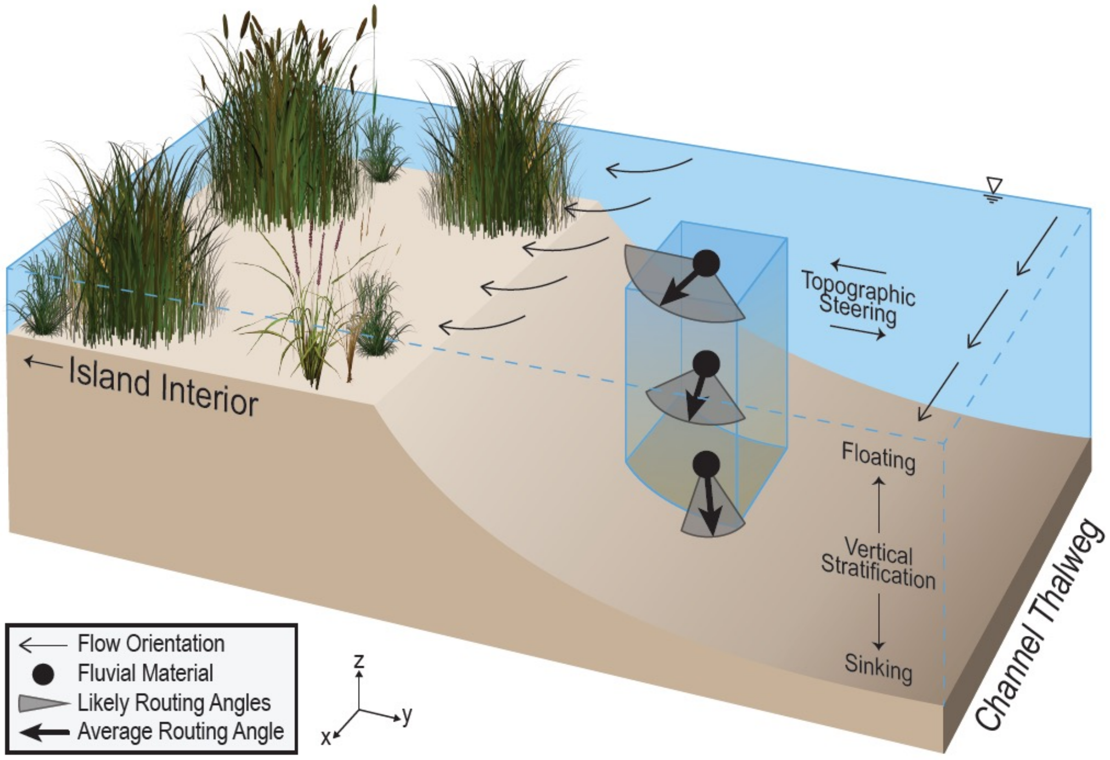
High connectivity:
low vegetation density, high river discharge

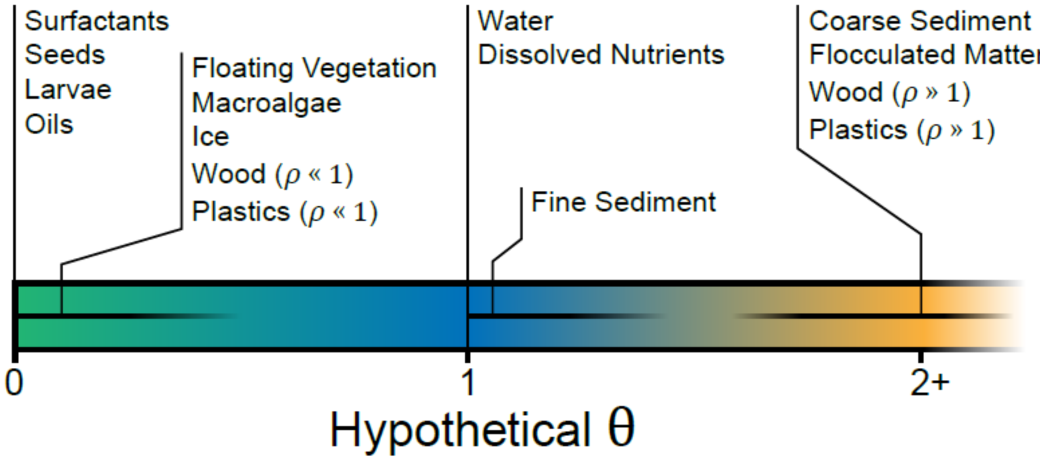
Low connectivity:
high vegetation density, low river discharge



Particle routing depends on the water depth

- mud θ = 1.25 and sand θ = 2.0





Wright et al. (2022)

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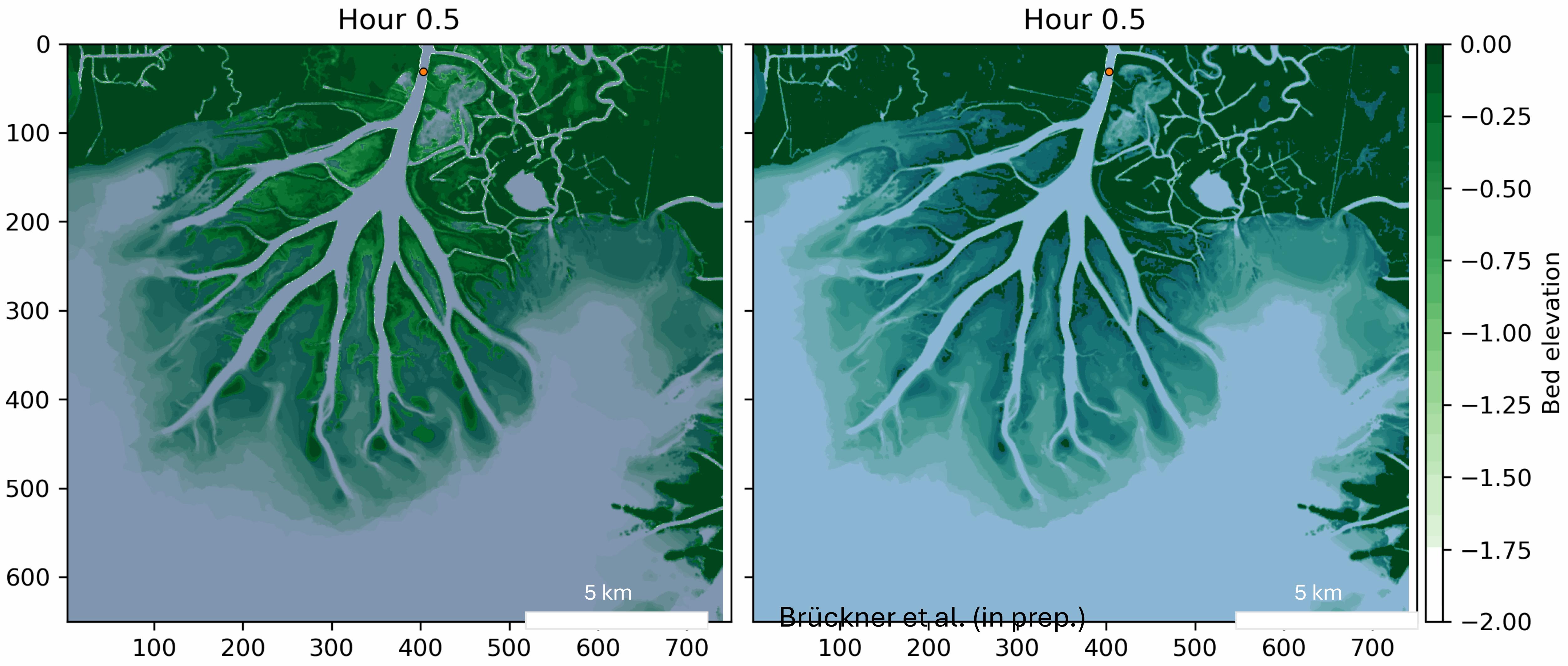

Nourishment = relative number of particles entering an area/domain

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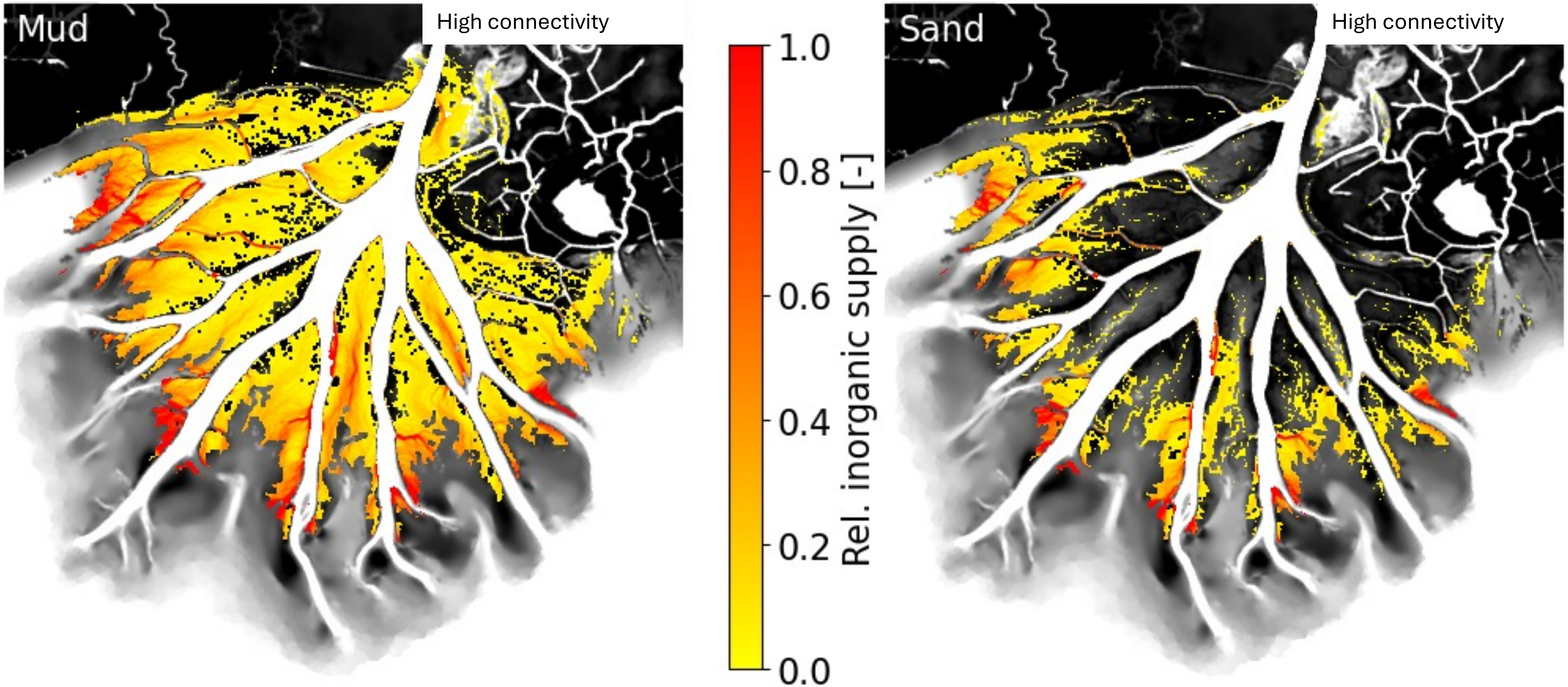
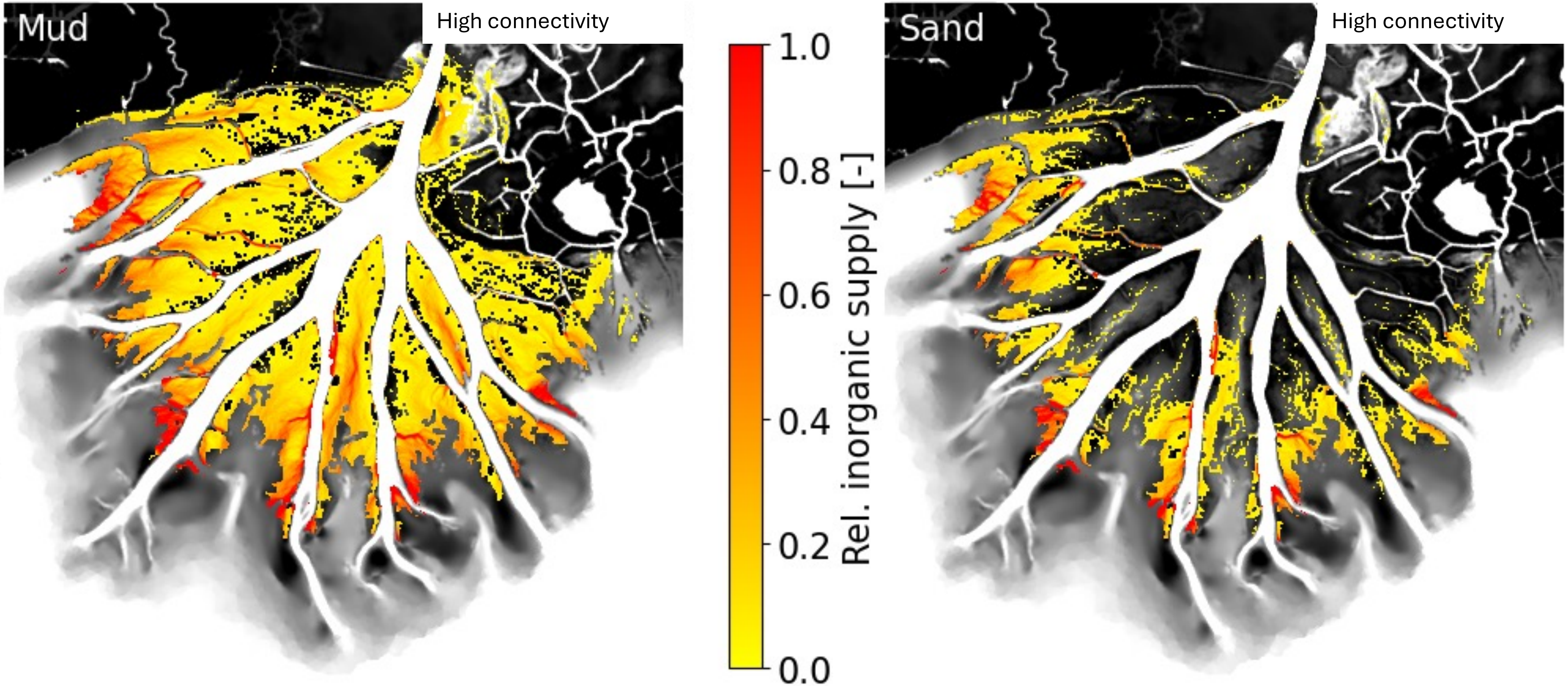


Brückner et al. (in prep.)

Local nourishment of the inner islands depends on connectivity/particle properties



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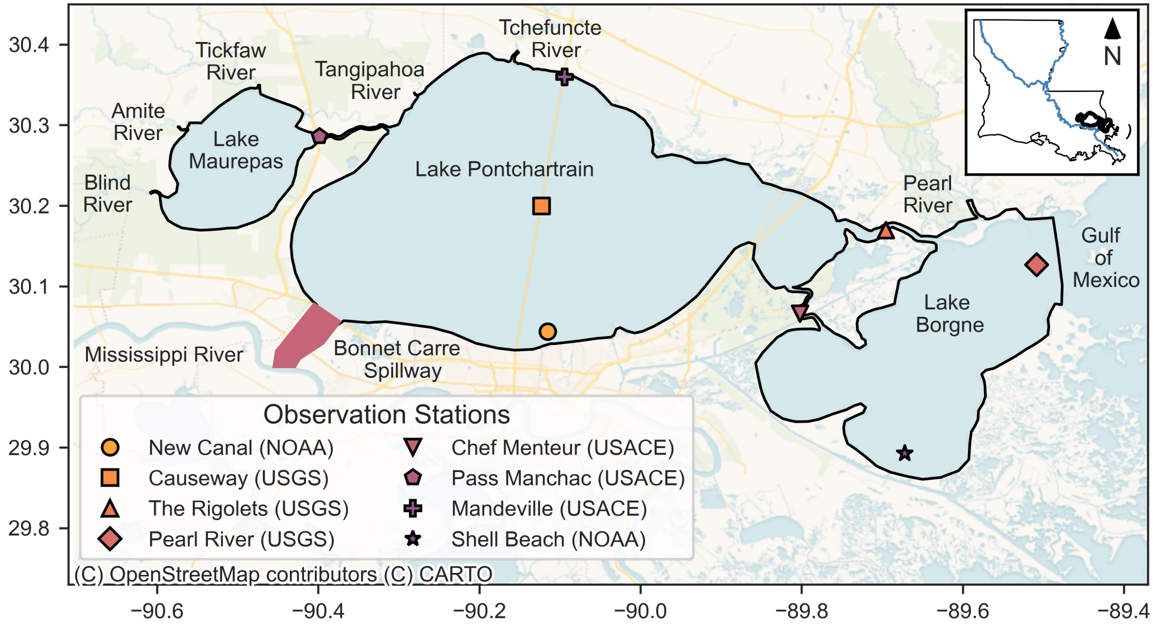
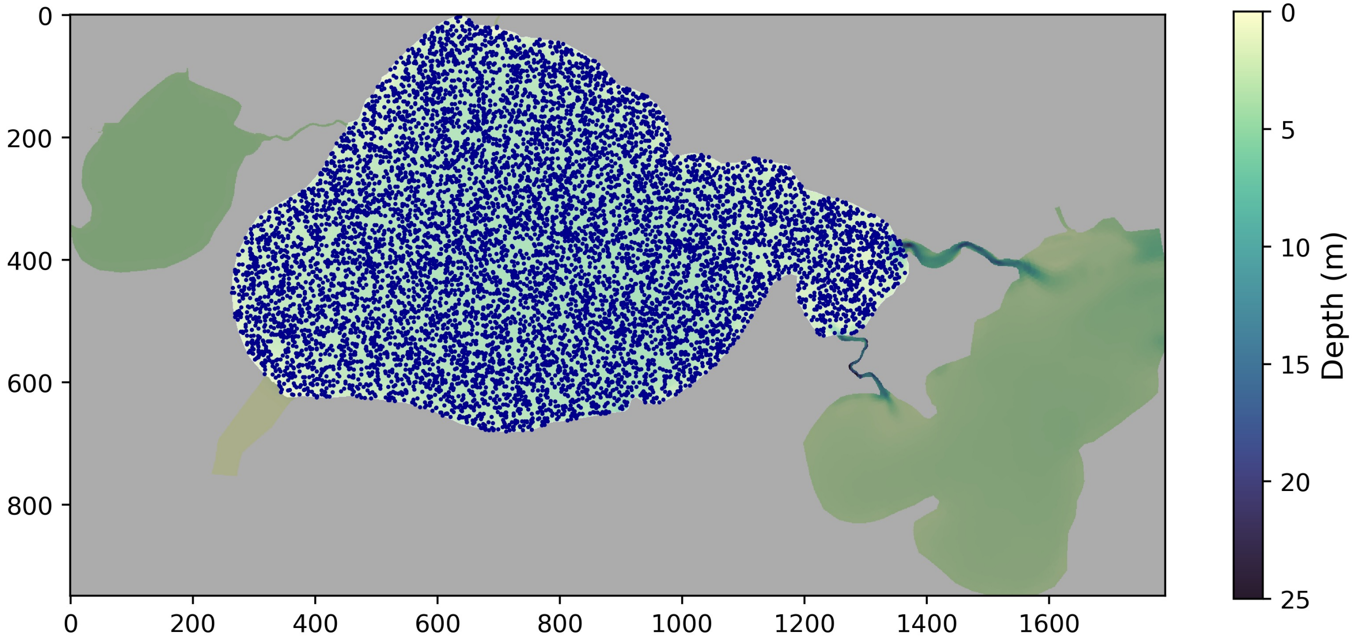
Compared to sediment transport models/morphodynamic models time-efficient, straightforward, lower calibration efforts

How are water exposure times affected by varying discharge scenarios in Lake Pontchartrain?





Turner et al. (in prep.)

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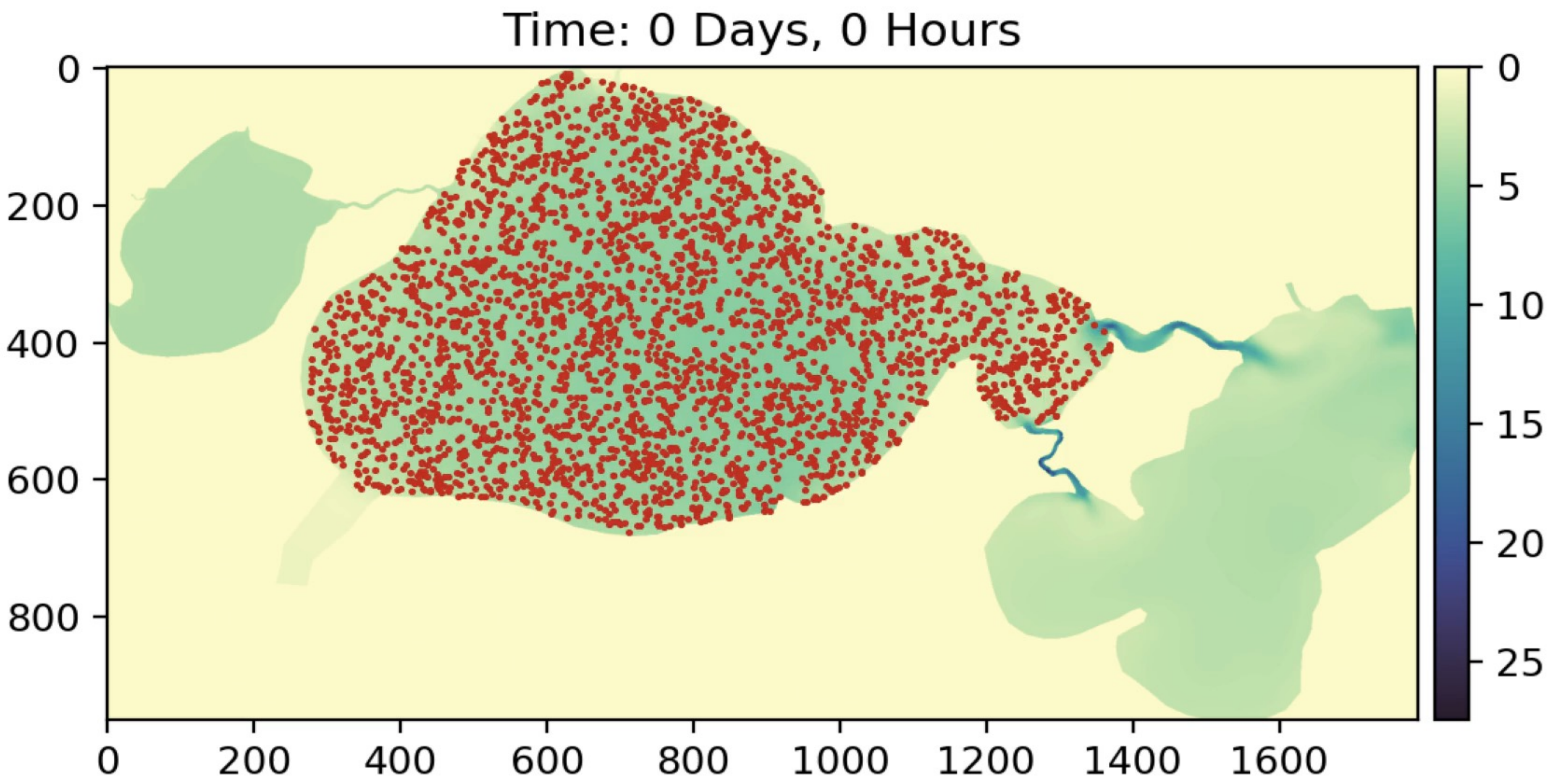
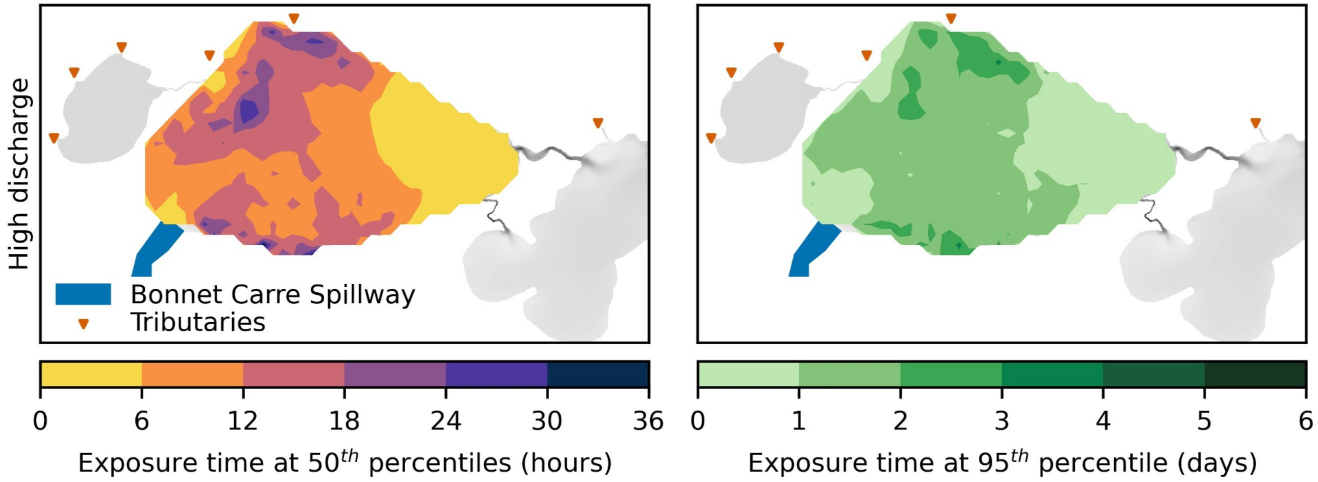
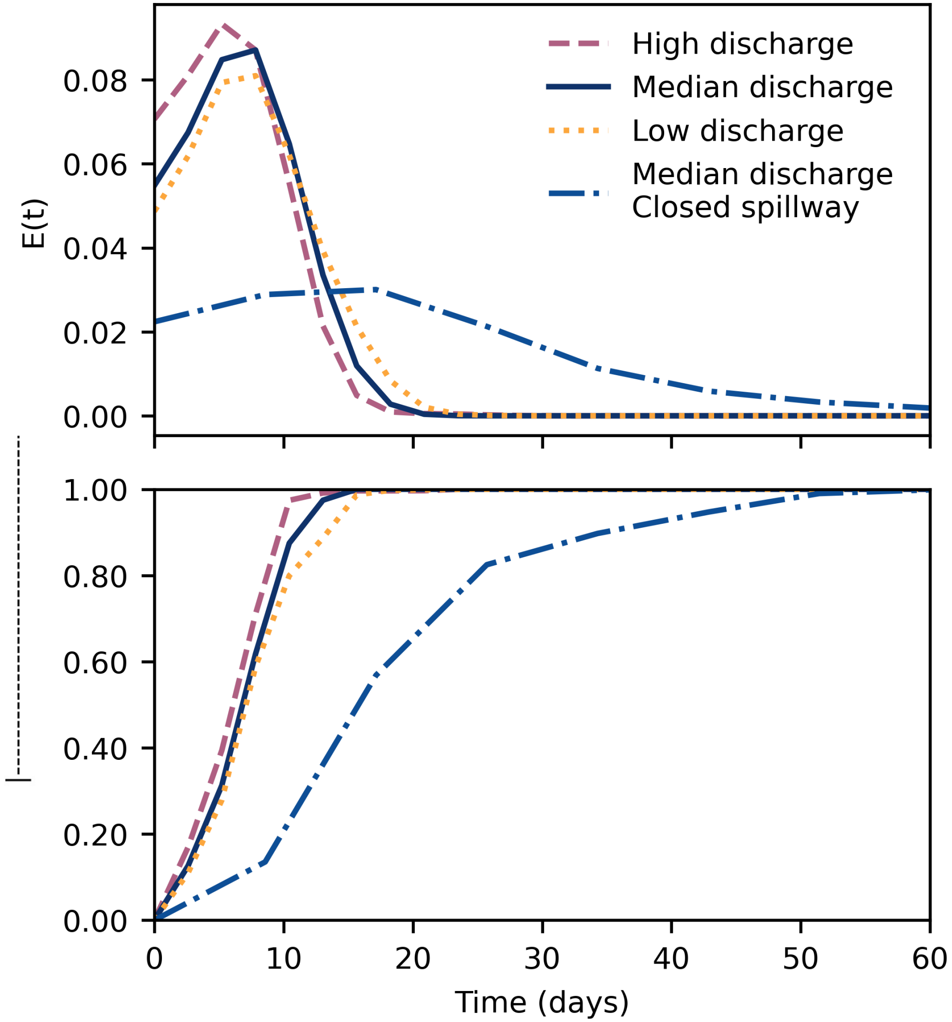


Turner et al. (in prep.)

How are water exposure times affected by varying discharge scenarios in Lake Pontchartrain?

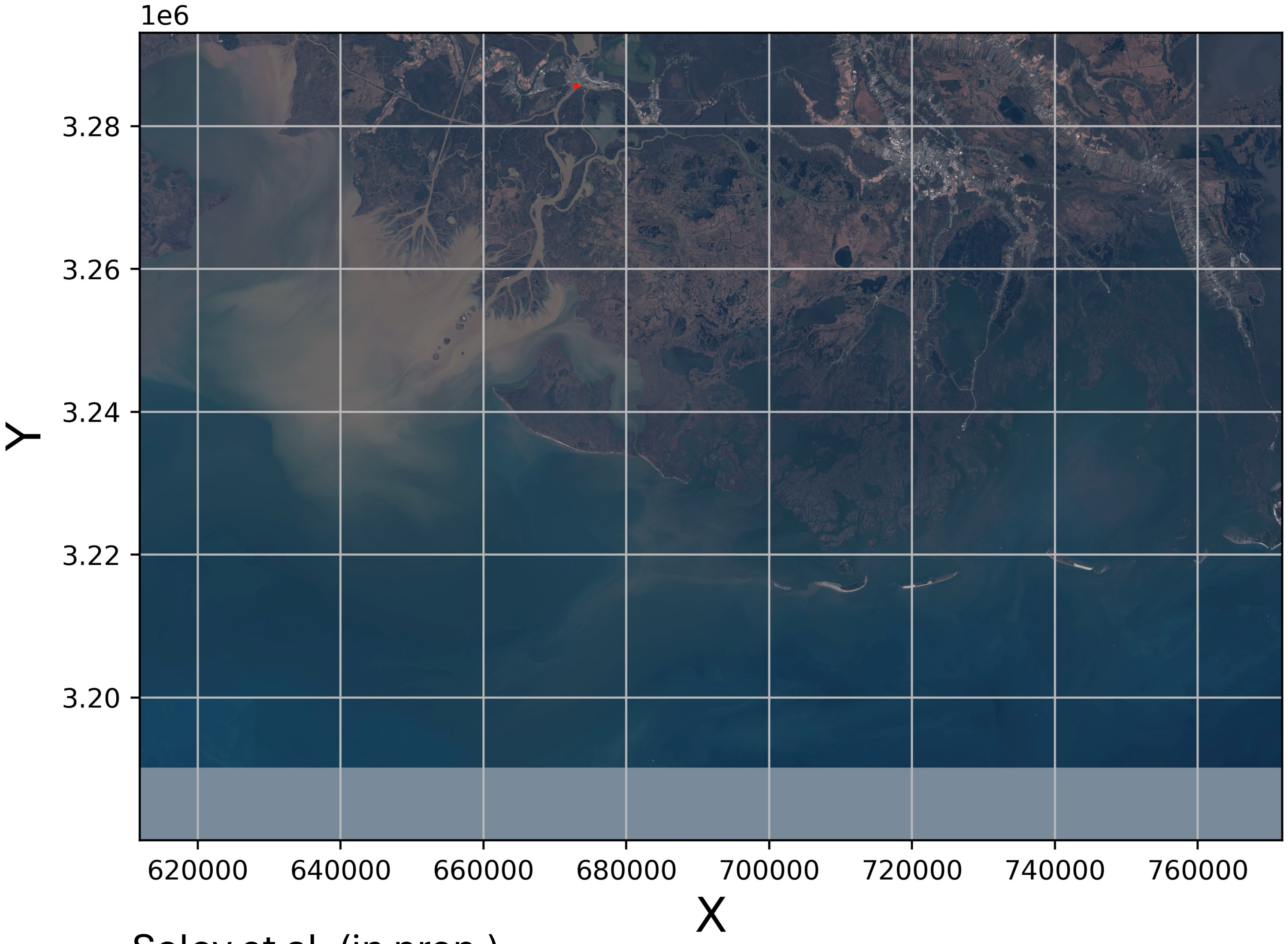
- Calculate exposure times (number of particles entering the area)
- Identify „flushing“-scenarios





Turner et al. (in prep.)

Dorado allows for easy and efficient upscaling

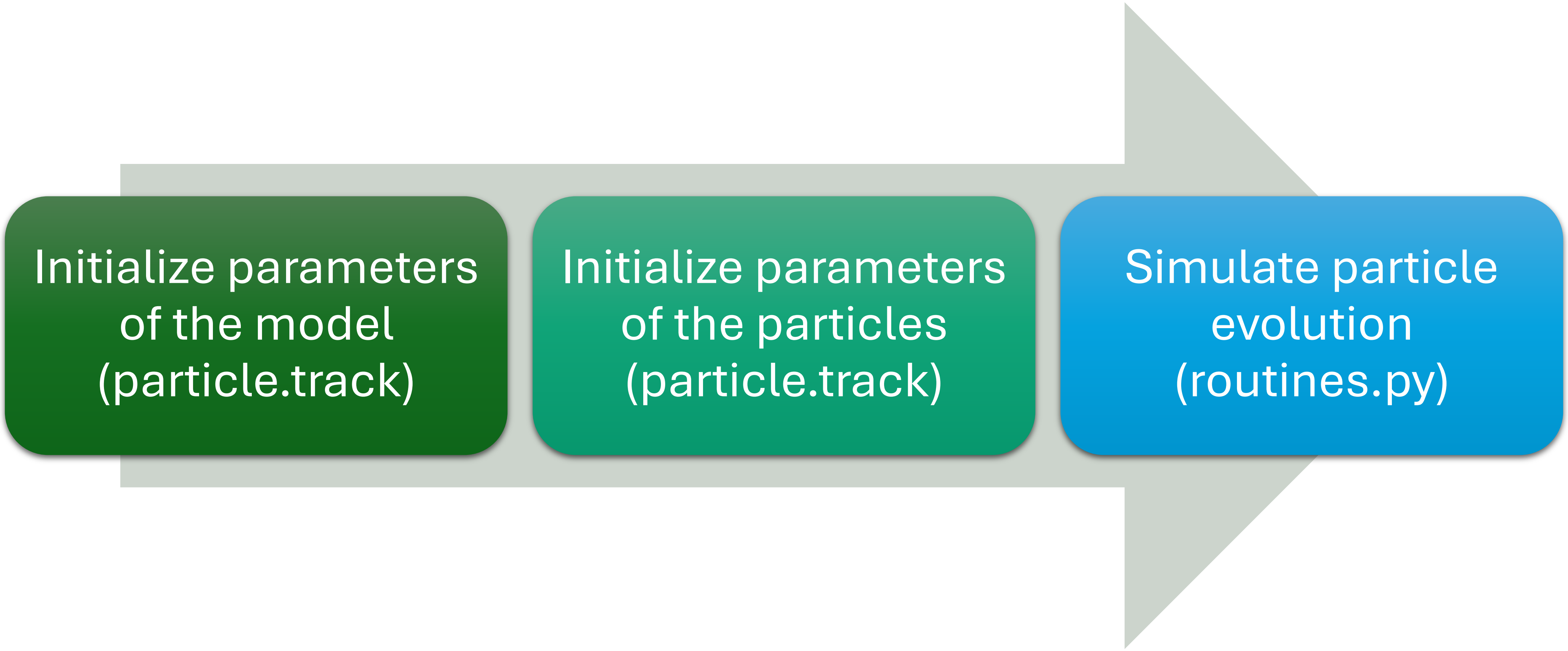


Soloy et al. (in prep.)

For this research project,

- Dorado was modified to allow sediment settling and entrainment mechanisms
- Particles are seeded at the most upstream points along the river and followed for 4 weeks
- Seasonal patterns are studied and compared before and after the construction of a major river bypass.

The workflow in *dorado*



The workflow in *dorado*

Initialize parameters of the model (particle.track)

Initialize parameters of the particles (particle.track)

Simulate particle evolution (routines.py)

Initialize parameters: Class modelParams()

- grid cell length (*dx*);
- 2 of 3: water depth (*depth*), water stage (*stage*), topography (*topography*)
- 1 of 2: water velocity (*u* and *v*), water discharge (*qx* and *qy*)

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- <u>1 of 2:</u> water velocity (*u* and *v*), water discharge (*qx* and *qy*)

<u>Optional</u>: define theta and gamma

The workflow in *dorado*

Initialize parameters of the model (particle.track)

Initialize parameters of the particles (particle.track)

Simulate particle evolution (routines.py)

Initialize parameters: Class generate_particles()

- Number of particles (*Np_tracer*)
- Seeding location (list of coordinates/indices *seed_xloc*, *seed_yloc*

The workflow in *dorado*

Initialize parameters of the model (particle.track)

Initialize parameters of the particles (particle.track)

Simulate particle evolution (routines.py)

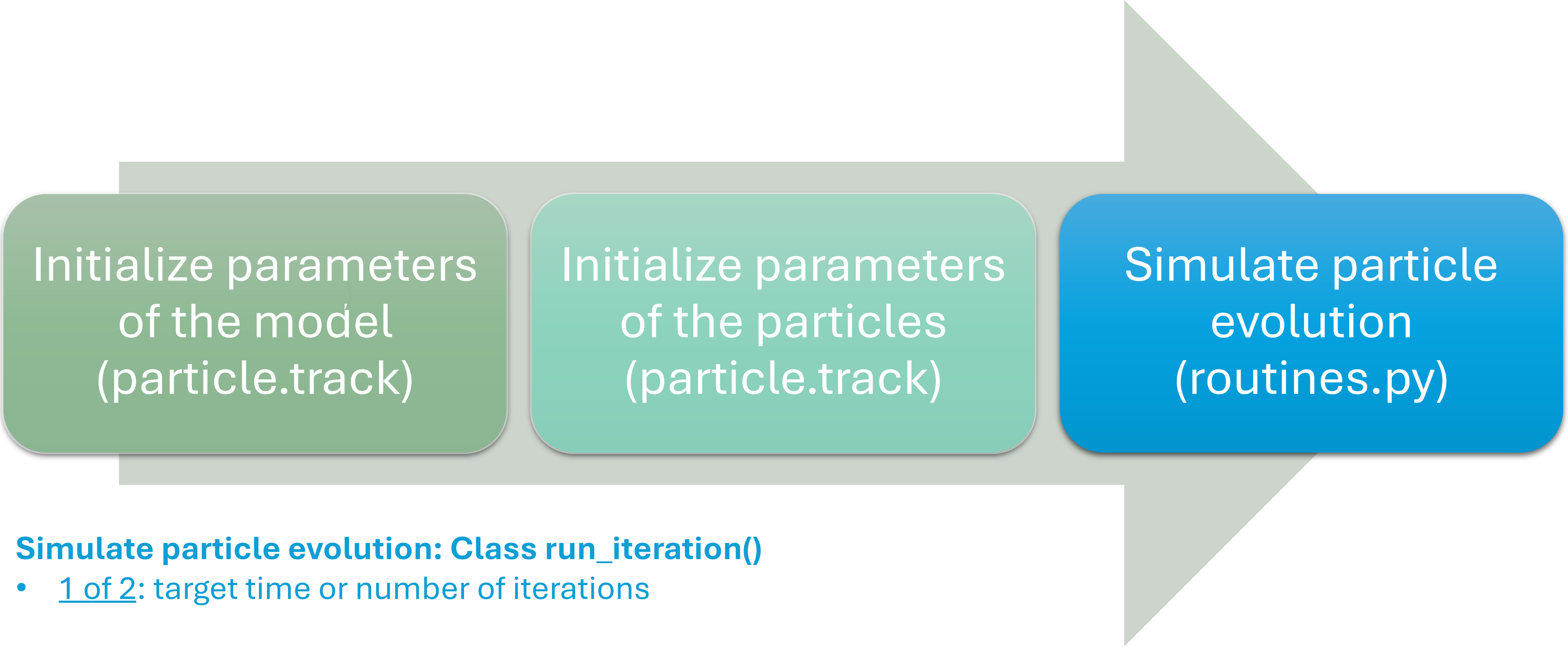
Initialize parameters: Class generate_particles()

- Number of particles (*Np_tracer*)
- Seeding location (list of coordinates/indices *seed_xloc*, *seed_yloc)*

Optional:

- *seed_time* (time that particles will be run – useful for several seeding instances)
- *method* (random or exact)
- *previous_walk_data* (dictionary of x/y locations and travel times - when several seeding instances)

The workflow in *dorado*

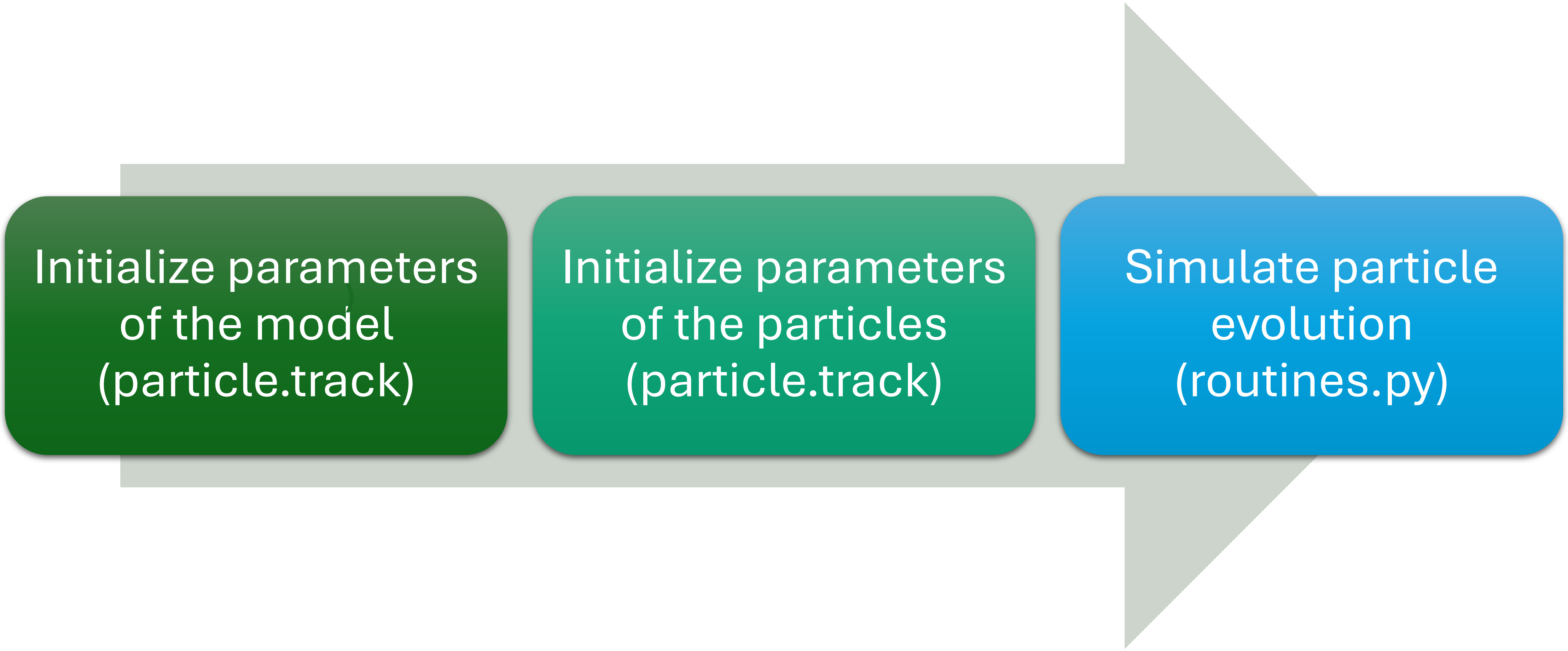


Simulate particle evolution: Class run_iteration()

- <u>1 of 2</u>: target time or number of iterations

Options to use wrappers provided in routines.py (*steady_plot(), unsteady_plots()*)

The workflow in *dorado*



Functionalities can be found in the dorado documentation (passah2o.github.io/dorado) or in the installation folder on your machine

To access the scripts: navigate to your installation folder or to passah2o.github.io/dorado

- Default path is your C-drive (Windows)