

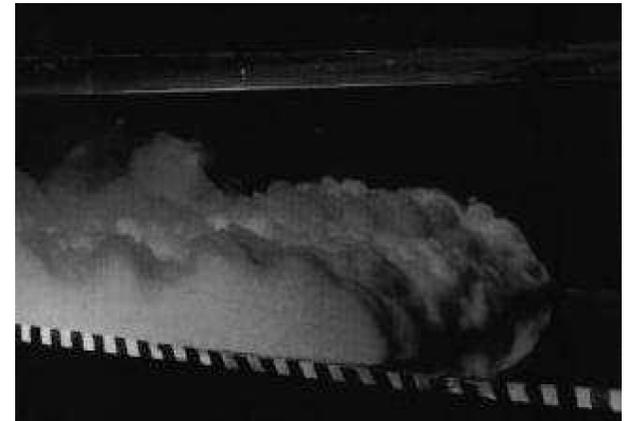
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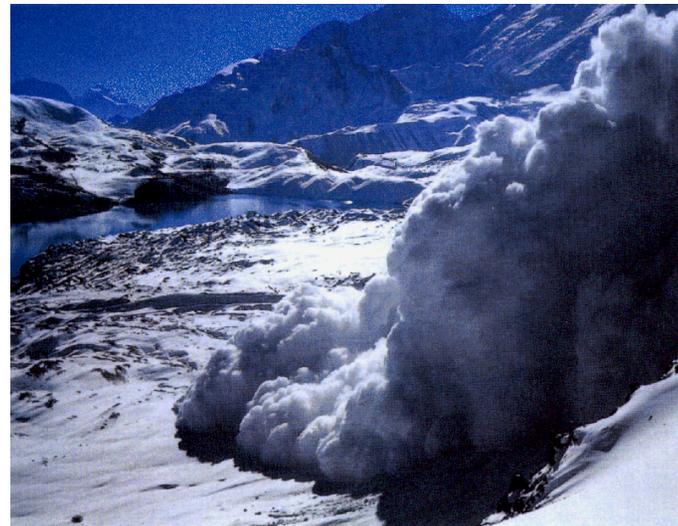
Gravity Currents

- Mainly horizontal flows
driven by density differences
- Sources for the density differences include:
 - Temperature
 - Salinity
 - Particulate

Compositional



Salinity driven G.C.



Snow (particulate) driven G.C.

High Resolution LES of Gravity Currents

Background:

- Extensive work on constant-density steady fully-turbulent channel flow past arrays of identical obstacles (2D ribs and dunes)
- Extensive work conducted for GCs propagating over a flat smooth surface
- Present work: a gravity current interacts with an array of obstacles

Applications:

- In most practical applications in river and ocean engineering, the GC propagates over a deformed bed containing large-scale bedforms (e.g., dunes, ripples)
- On hilly terrains, retarding obstacles in the form of ribs are used to reduce the impact of an avalanche with buildings situated downstream of the obstacles. **IMPACT FORCES**

Gravity Currents Propagating in a Channel With Large-Scale Obstacles

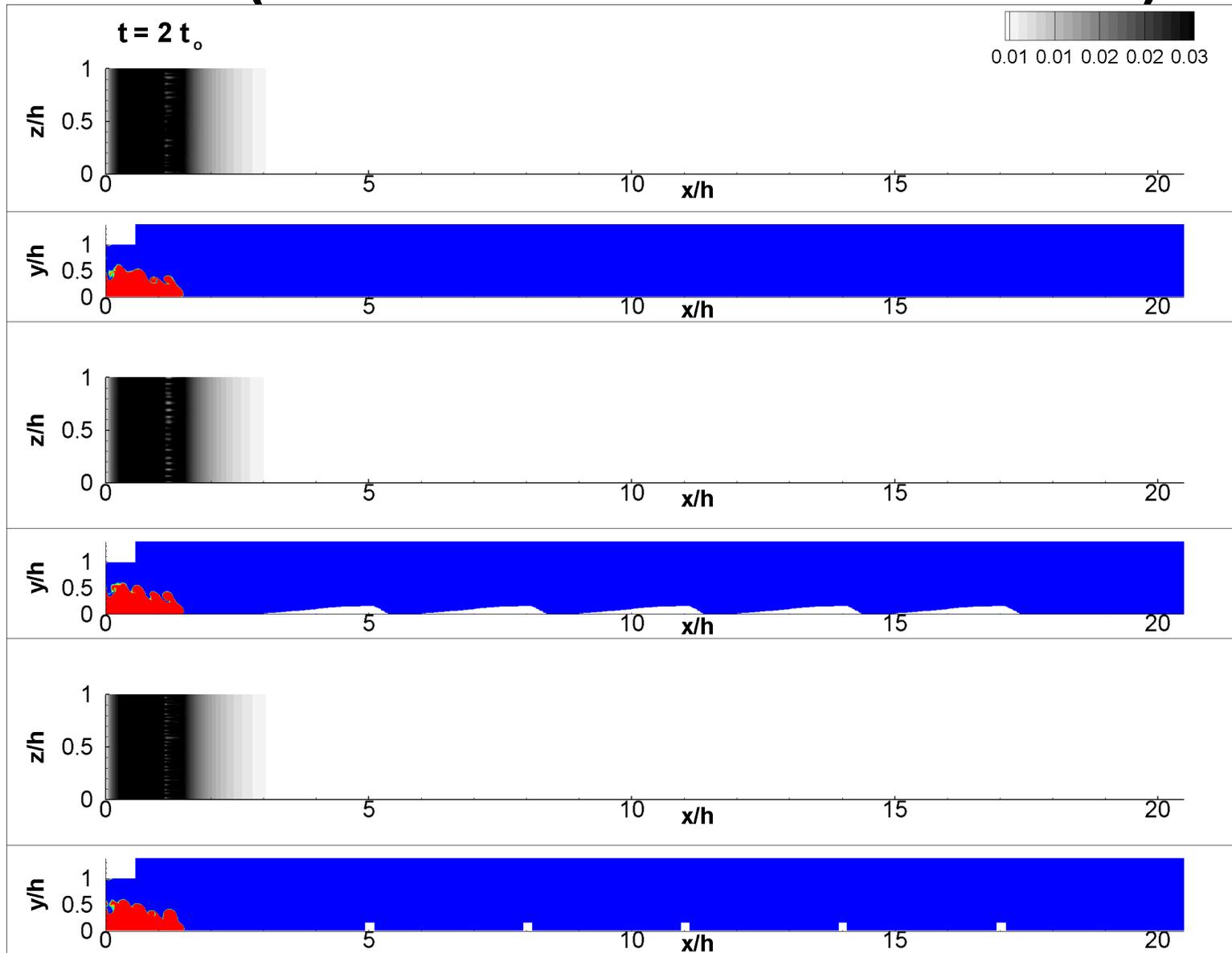
We are interested in evaluating the capacity of GCs propagating over an array of identical obstacles to entrain sediment from the loose channel bed and to carry it downstream for some distance in the form of a turbidity current.

First step:

- Study how the structure, front velocity, energy balance and sediment entrainment capacity of a compositional GC is affected by the presence of the obstacles
- Study the effect of the shape and size of the obstacles
- Study the effect of the Reynolds number

-Information on the spatial and temporal distributions of the bed shear stress is critical to evaluate the capacity of the GC to entrain sediment

Evolution of GC with a low volume of release (Flat bed vs. Dunes vs. Ribs)



Flow in Natural Streams

RIVER CONFLUENCES AND SHALLOW MIXING LAYERS

River confluences are:

- common elements of river networks
- characterized by complex large-scale turbulent motions
- play an important role in regulating the movement of sediment through braided river systems (Paola, 1997)

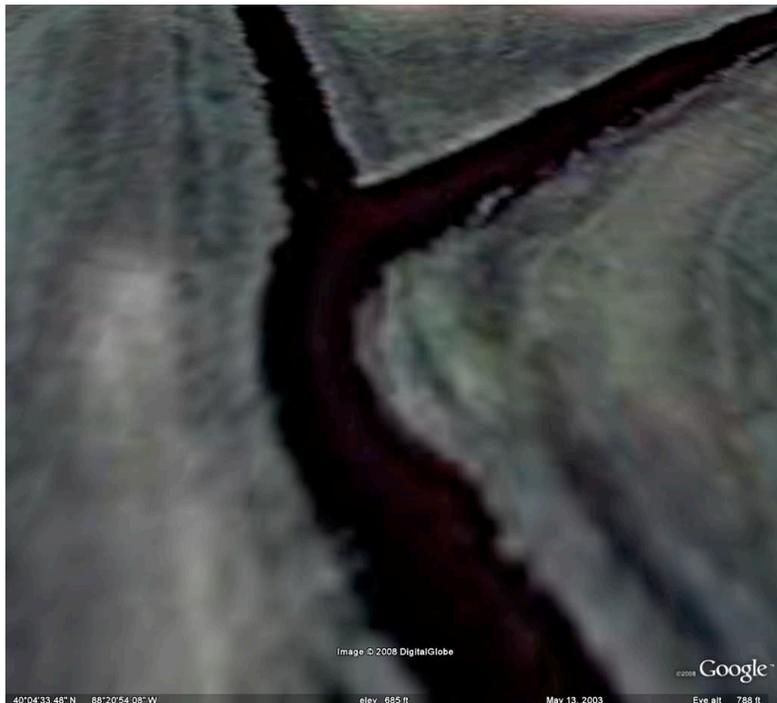


APPROACH:

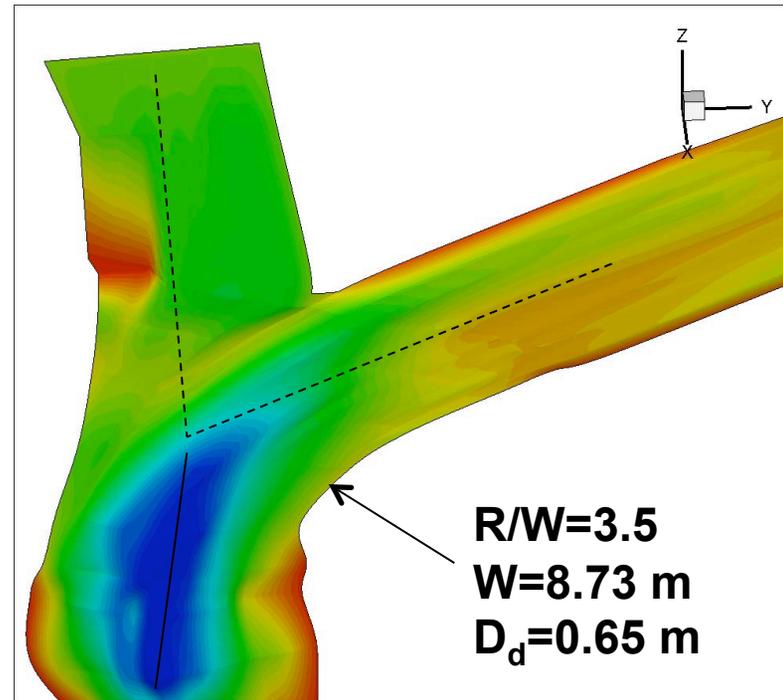
- conduct 3D Detached Eddy Simulation at field conditions

TEST CASE: Small River Confluence in Illinois

- Asymmetrical confluence with concordant bed
- Angles: 0° , 60° , Velocity and momentum (ρQU) ratios ~ 1.0
- **Mixing layer development driven by difference in directions of the streams**
- $Re \sim 166,000$ ($D=0.4\text{m}$ $U=0.44\text{ m/s}$), $Fr=0.24$
- Maximum scour depth $2.92D$
- Field data available for validation

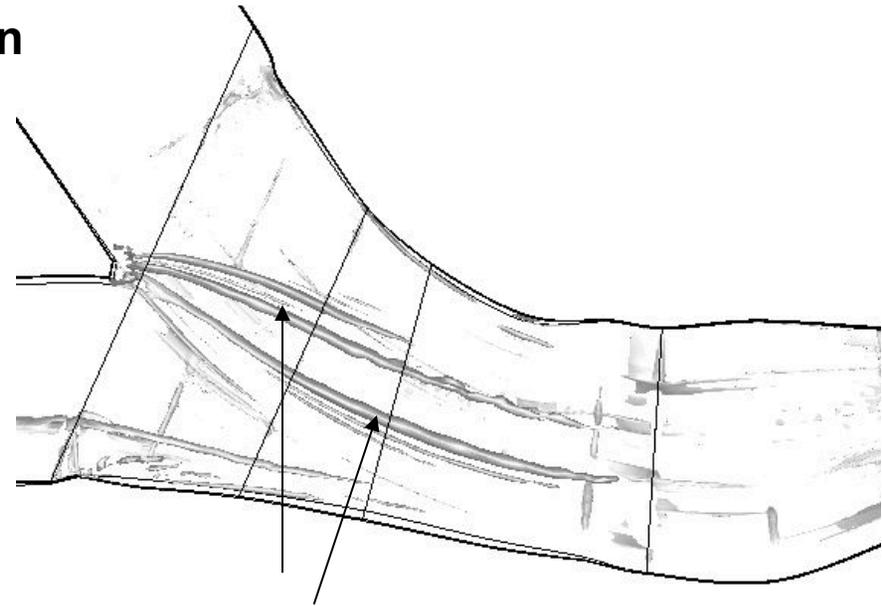
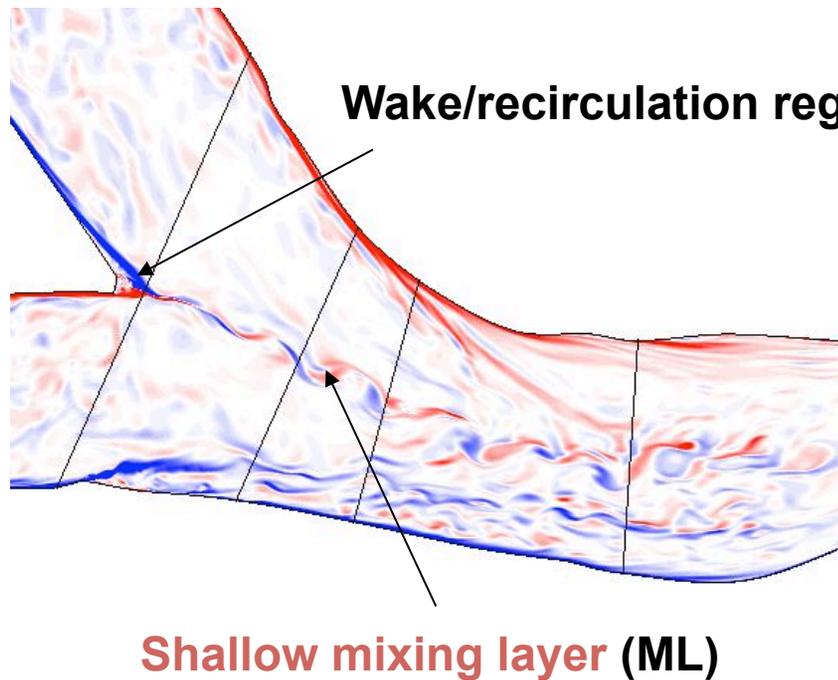


Google view



Bathymetry

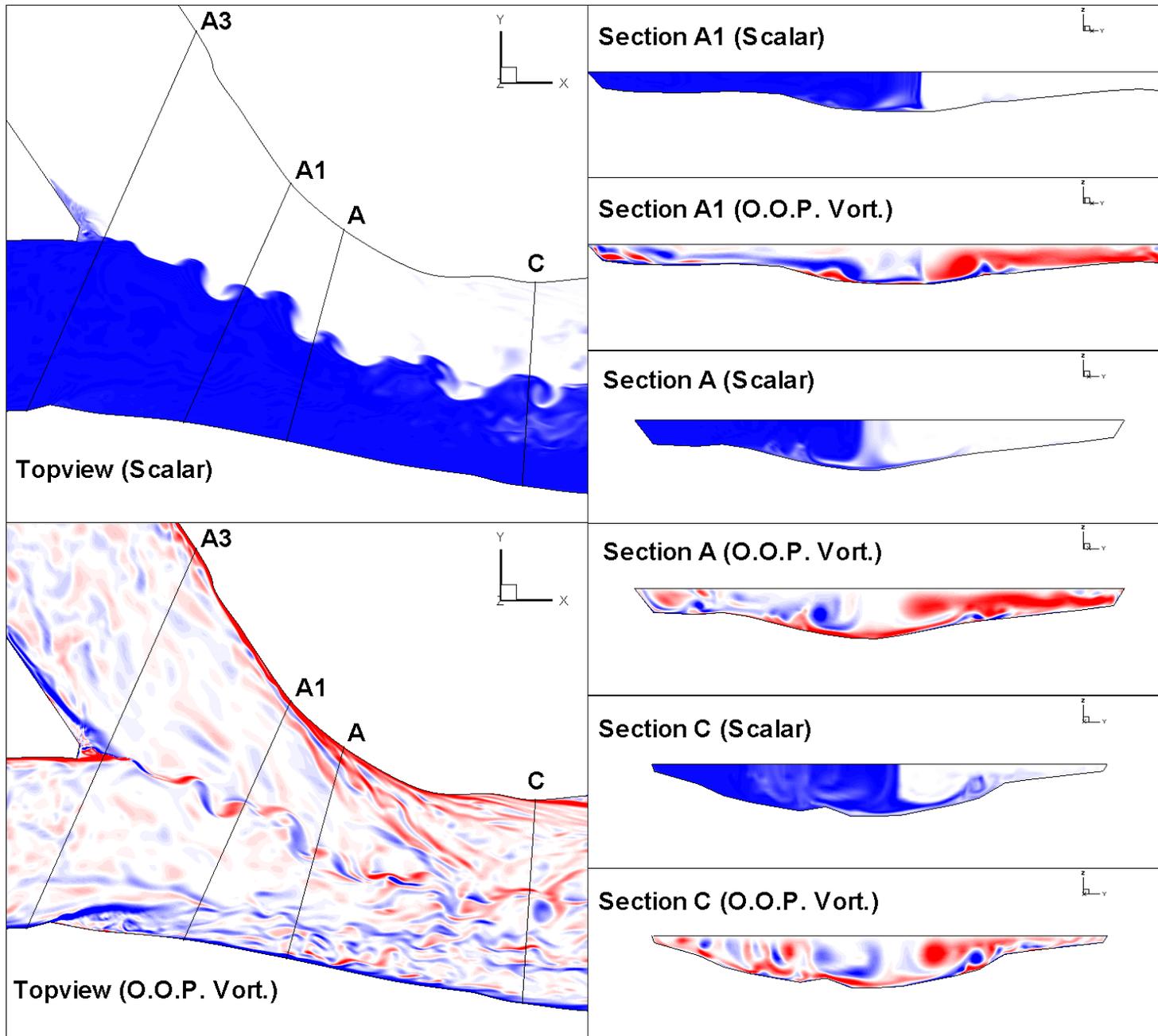
Confluences between **non-parallel** streams



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- Sediment entrained by the **strong streamwise-oriented vortical cells** is the main cause for the large dimensions of the scour holes (scour depth up to 5 times mean channel depth, Best & Ashworth, Nature 1997) observed to form downstream of river confluences.
- Mass exchange processes and thermal mixing between the two streams are strongly affected by the SOV.

DYNAMICS OF THERMAL MIXING



Large-scale engulfing by the ML eddies promotes mixing

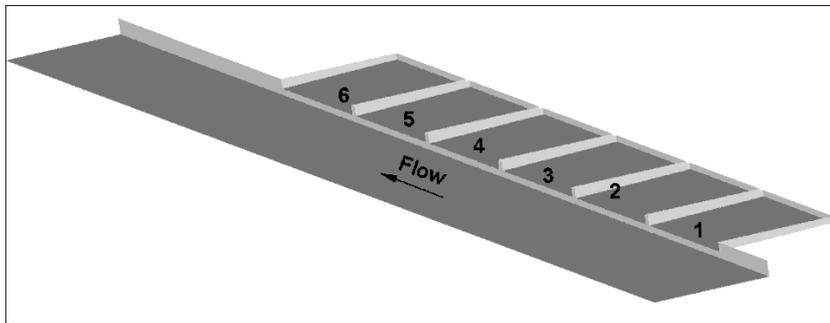
Large-scale oscillations of SOV cells play an important role in the mixing between the two streams

Flow and mass exchange processes between groyne fields and main channel

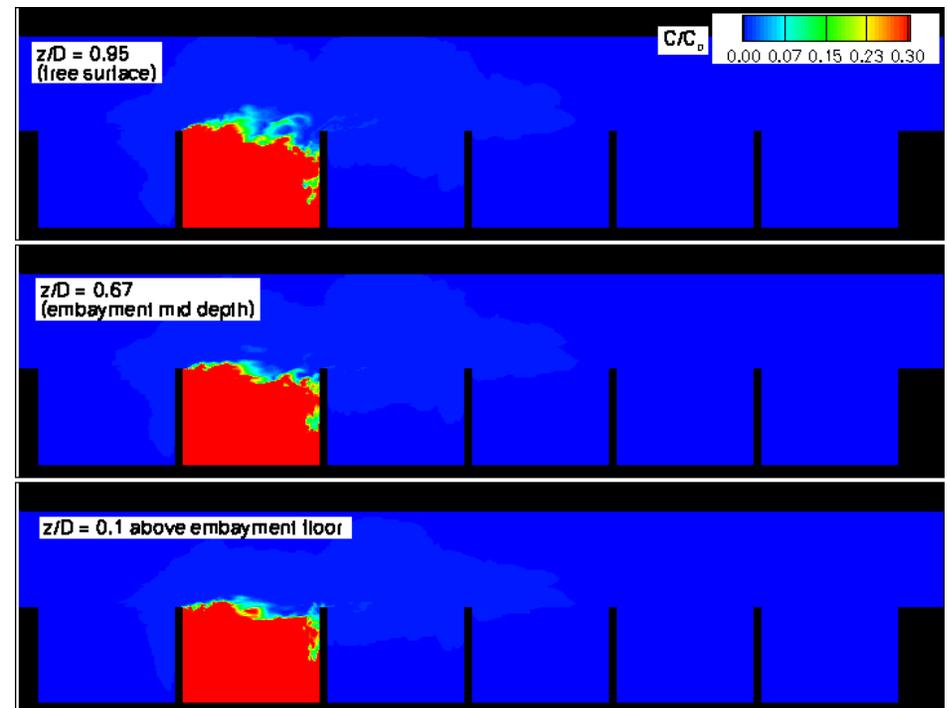
- Groynes are one of the most **effective approaches to stabilize eroding banks** and to sustain navigable channels at proper depth.
- Utilized in river restoration projects (e.g., restore fish habitat in degraded streams)
- In the case of accidental pollution, a series of groynes can **substantially modify the dispersion of the pollutant cloud** in the river reach.
- Use LES to quantify the **particle residence times** inside the embayments. This is of great importance in many eco-hydraulics projects (e.g., study phytoplankton dynamics and algal growth).



Groynes on the Mississippi River



Test case corresponding to the expt. of Uijttewaal et al. (2004), $Re=35,000$



Investigation of scour mechanisms at different stages of the erosion deposition process for bridge piers and abutments using LES and DES

Goal: Investigate role of large scale coherent structures in the sediment entrainment processes and their dynamics (e.g., bi-modal oscillations of the main necklace vortex). Estimate quantities that are difficult to obtain experimentally (τ , p'^2)

