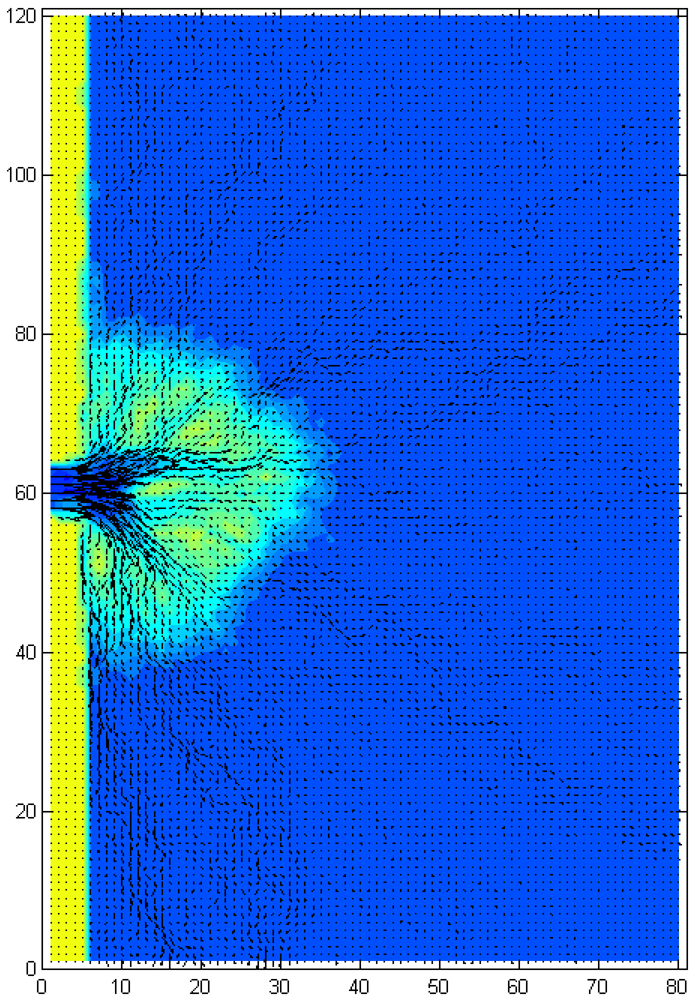
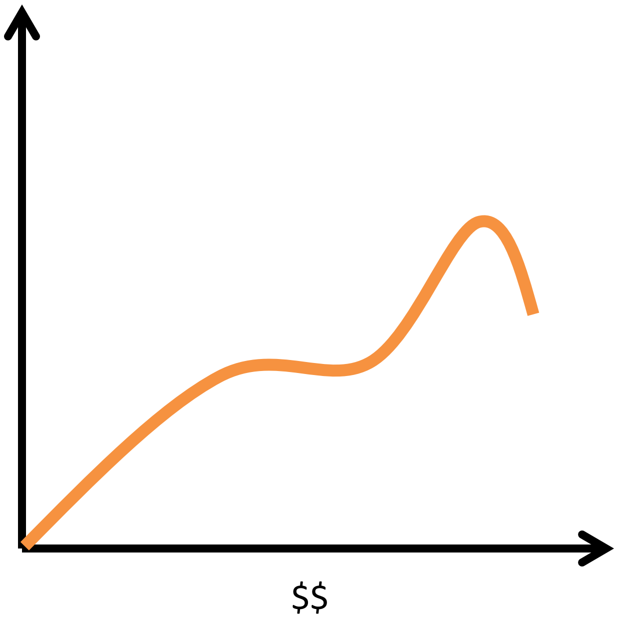


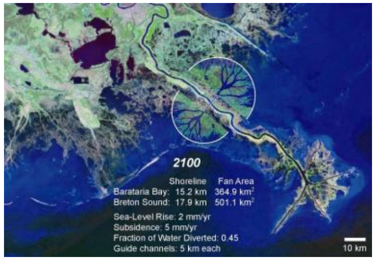
A Reduced-Complexity Channel-Resolving Model for Delta Formation

Man Liang
Vaughan Voller
Chris Paola

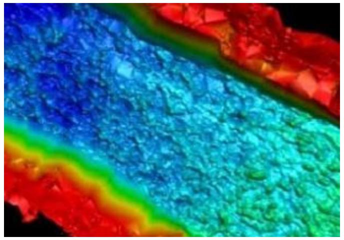
SAFL University of Minnesota

A little philosophy…

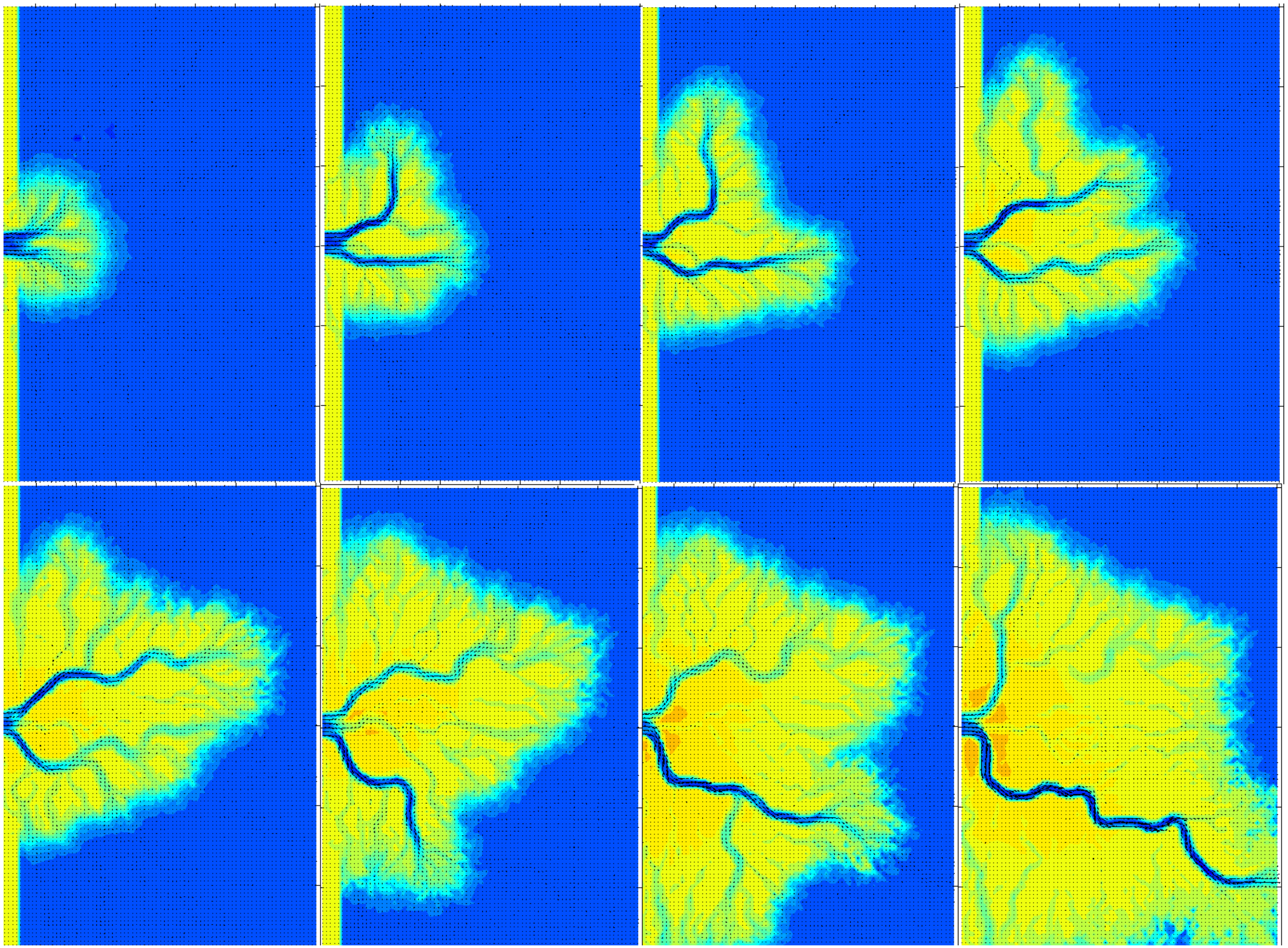




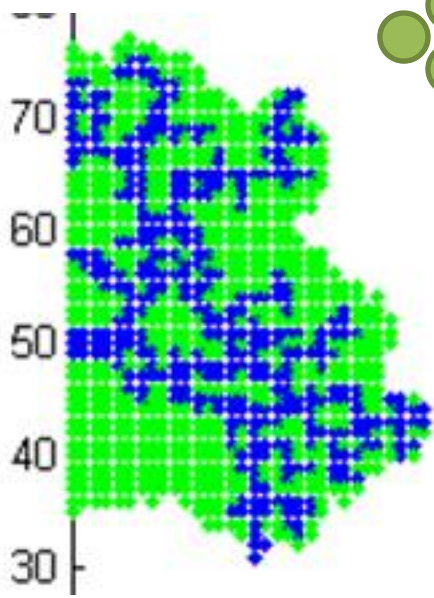
(Kim et al.)

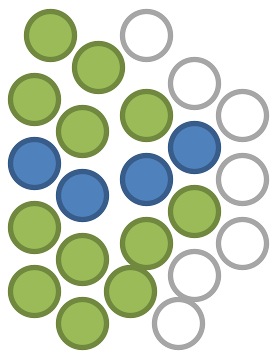


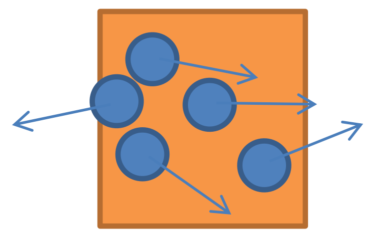
SAFL OSL scan

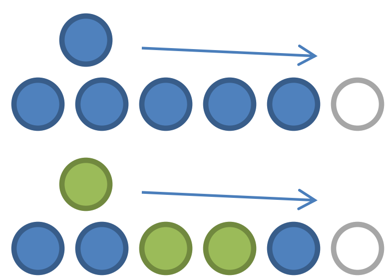


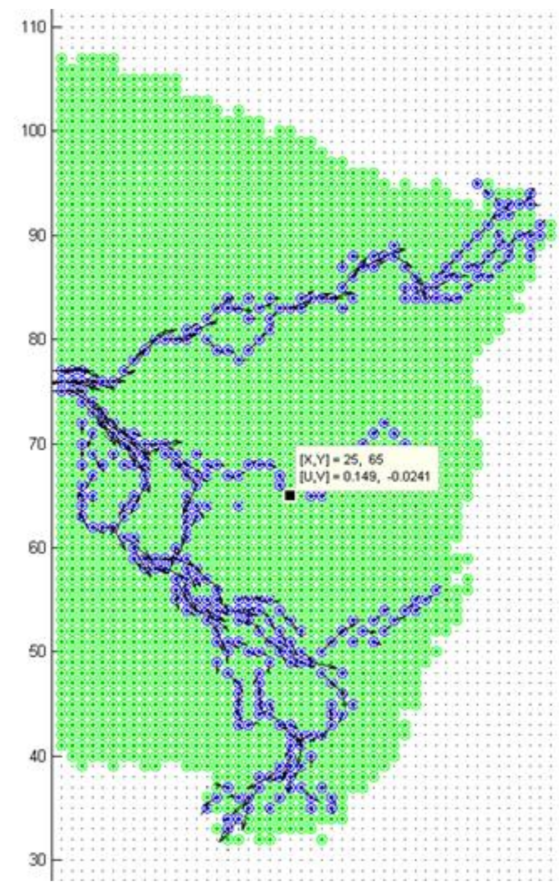
Two particles random walk model

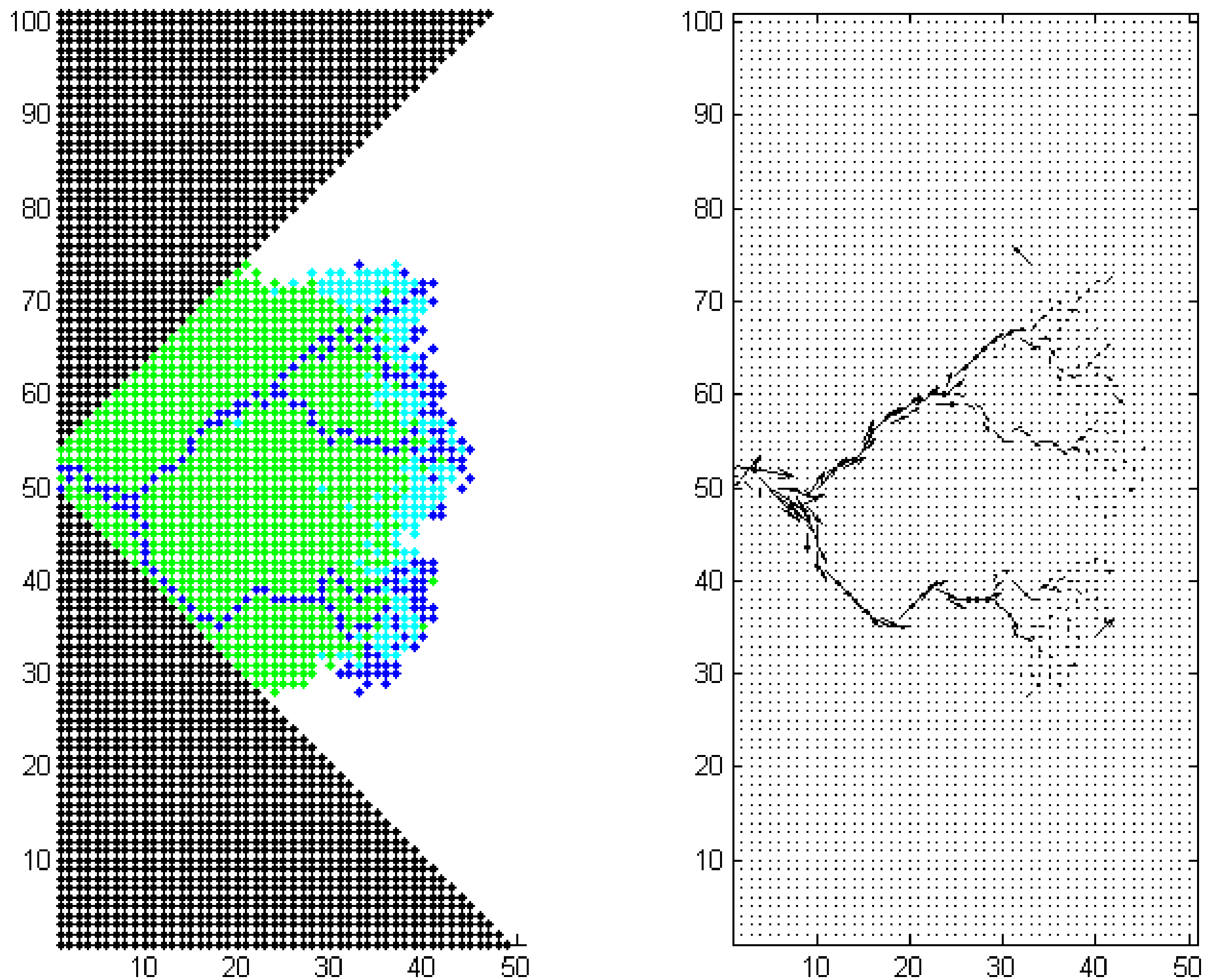








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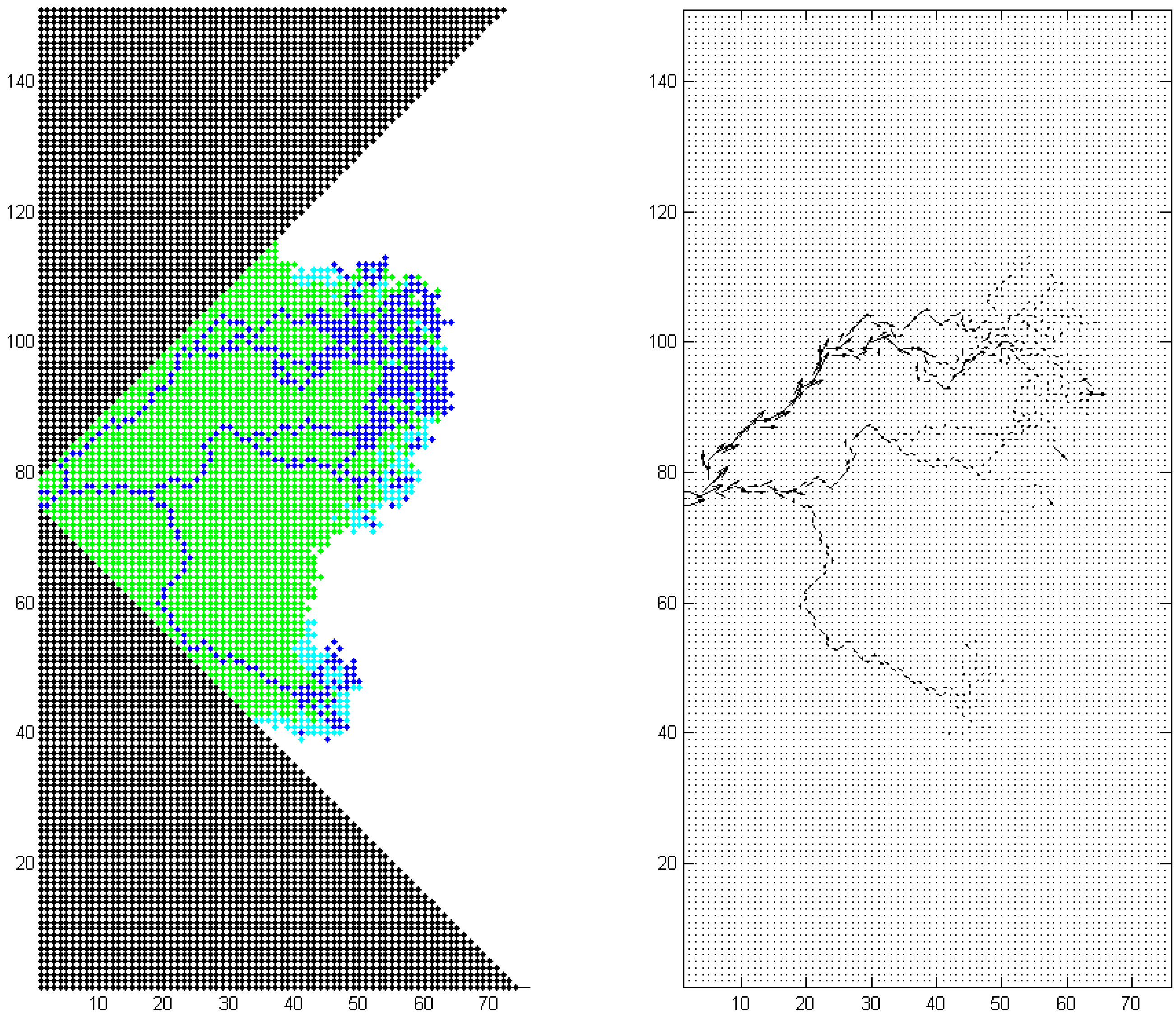

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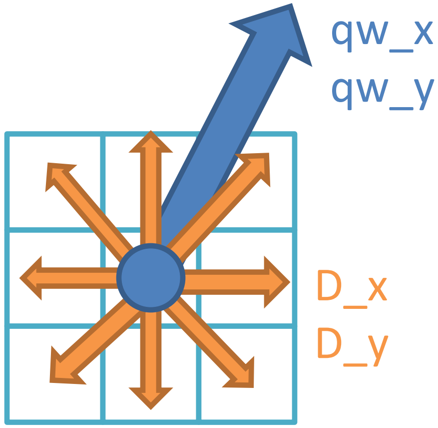
qw_x
qw_y
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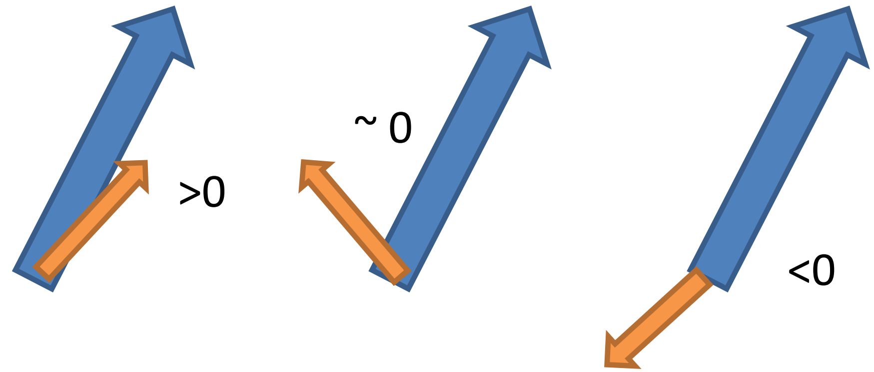
D_y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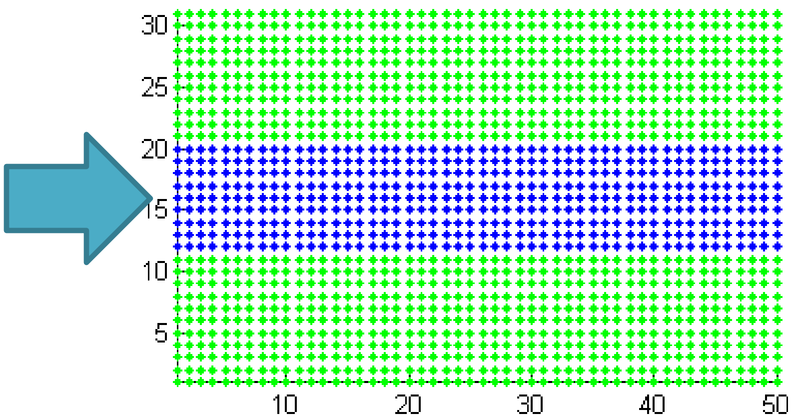
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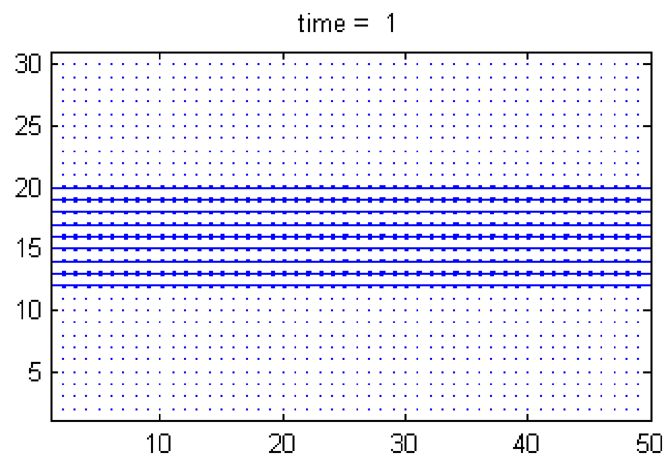
10 20 30 40 50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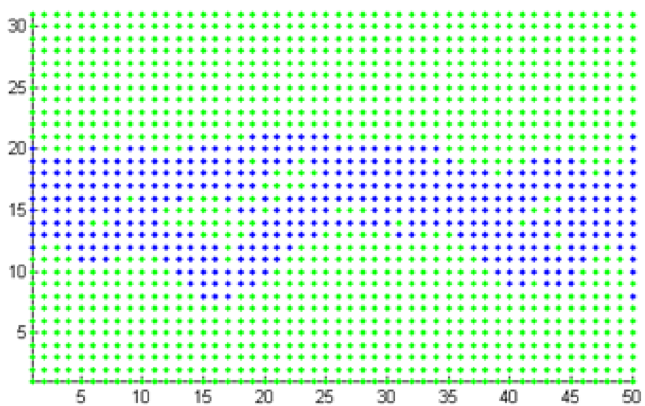
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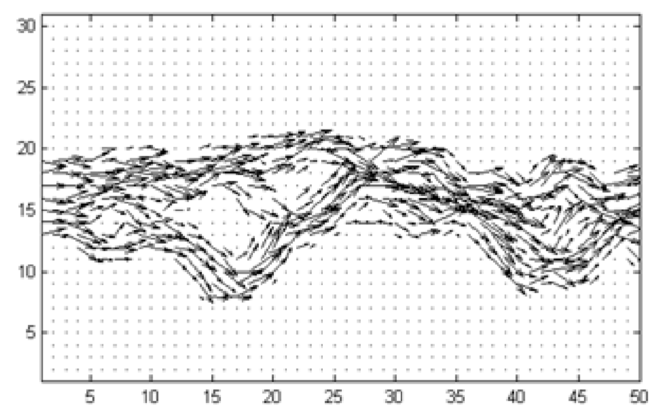
5 10 15 20 25 30 35 40 45 50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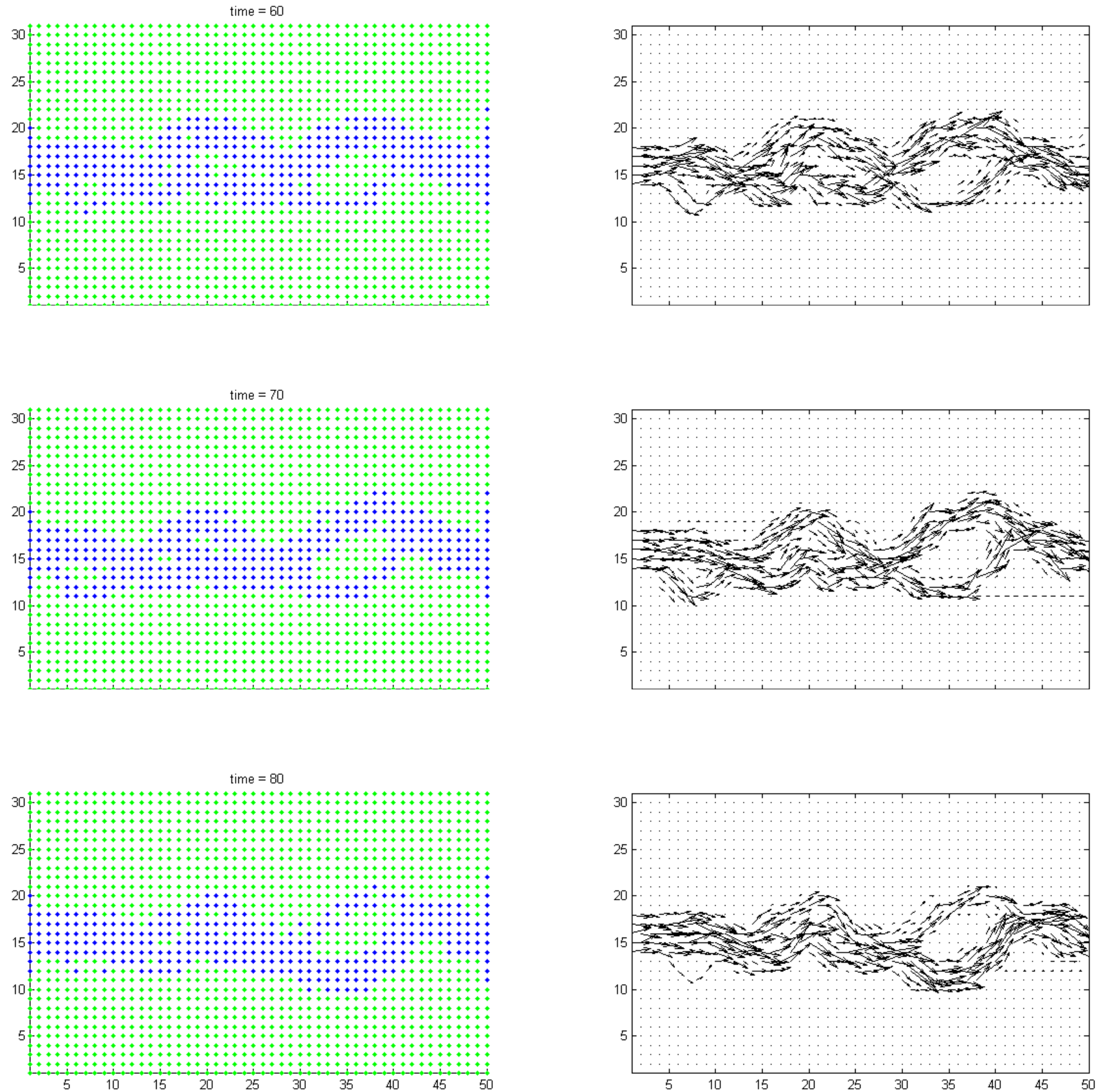
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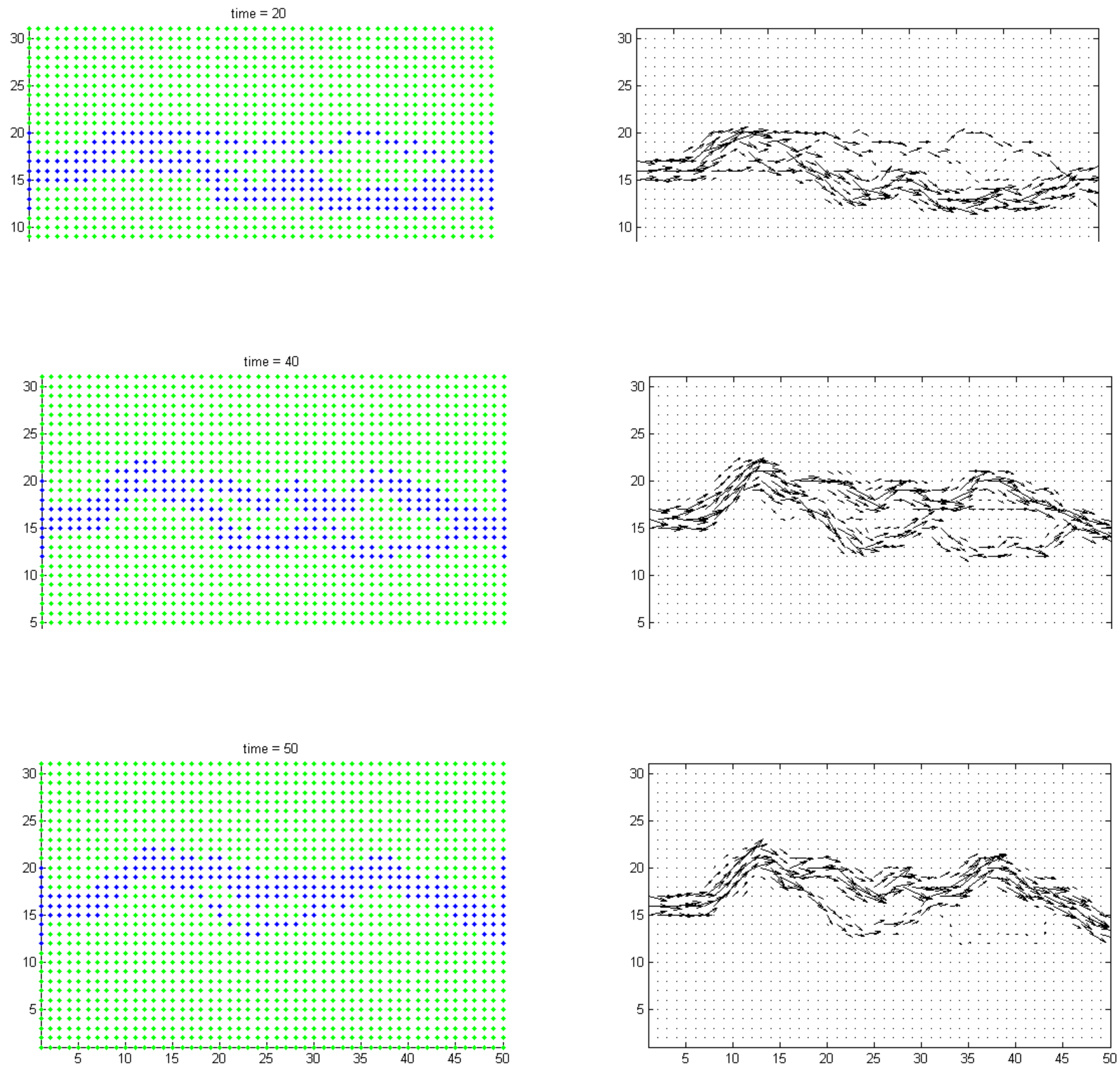
time = 80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time = 50
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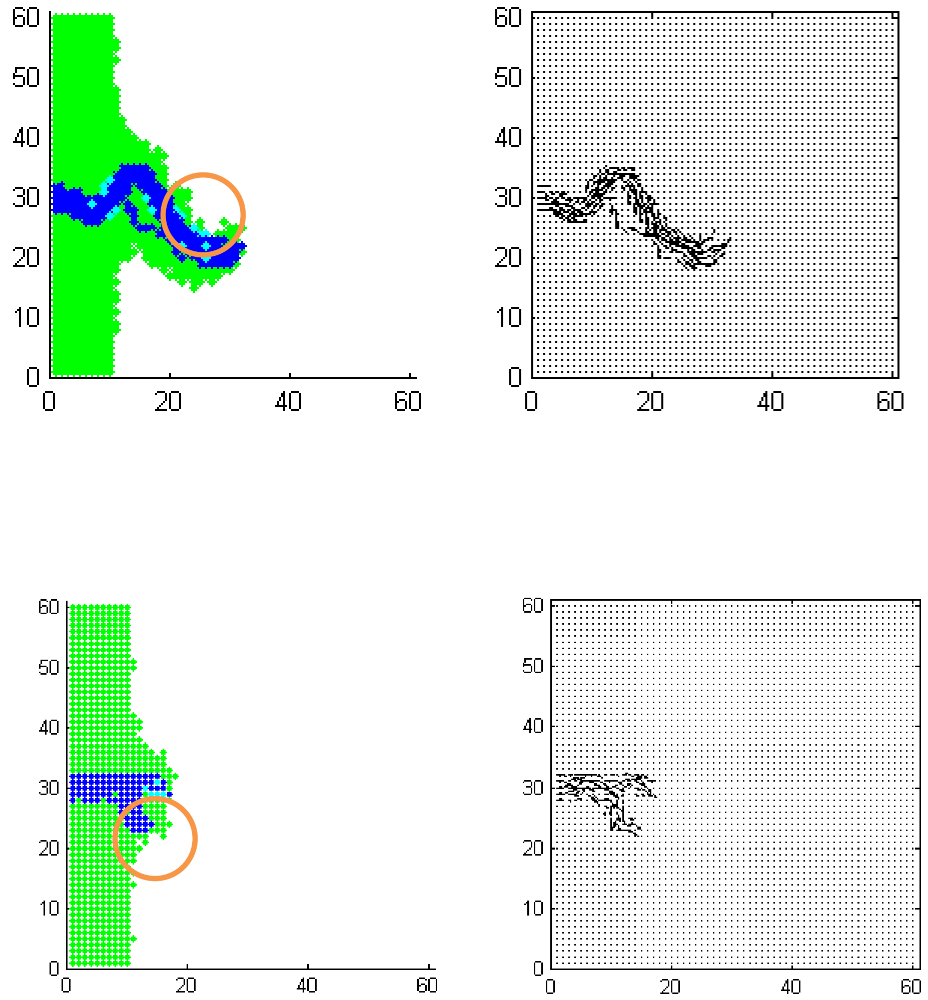
5 10 15 20 25 30
5 10 15 20 25 30 35 40 45 50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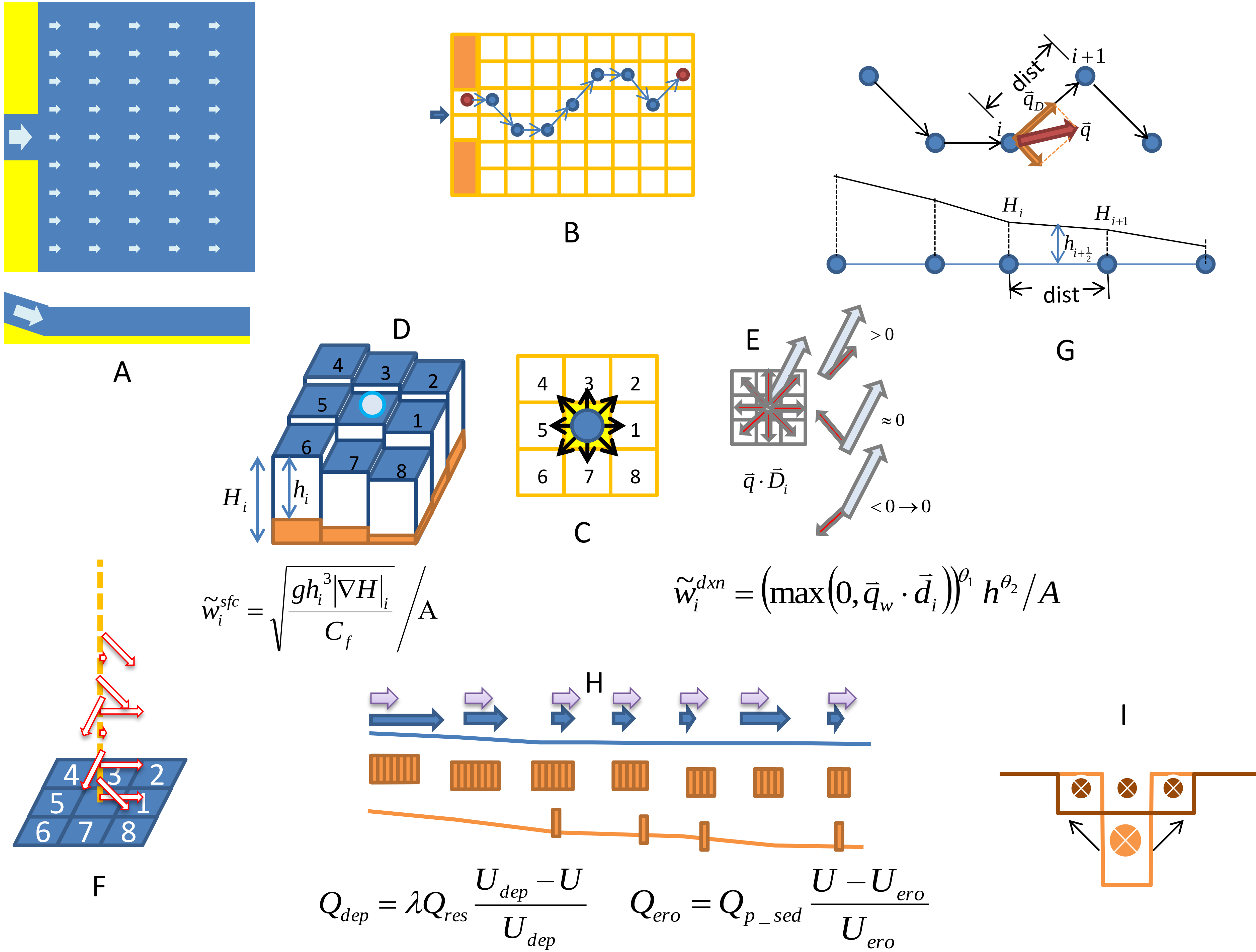
A
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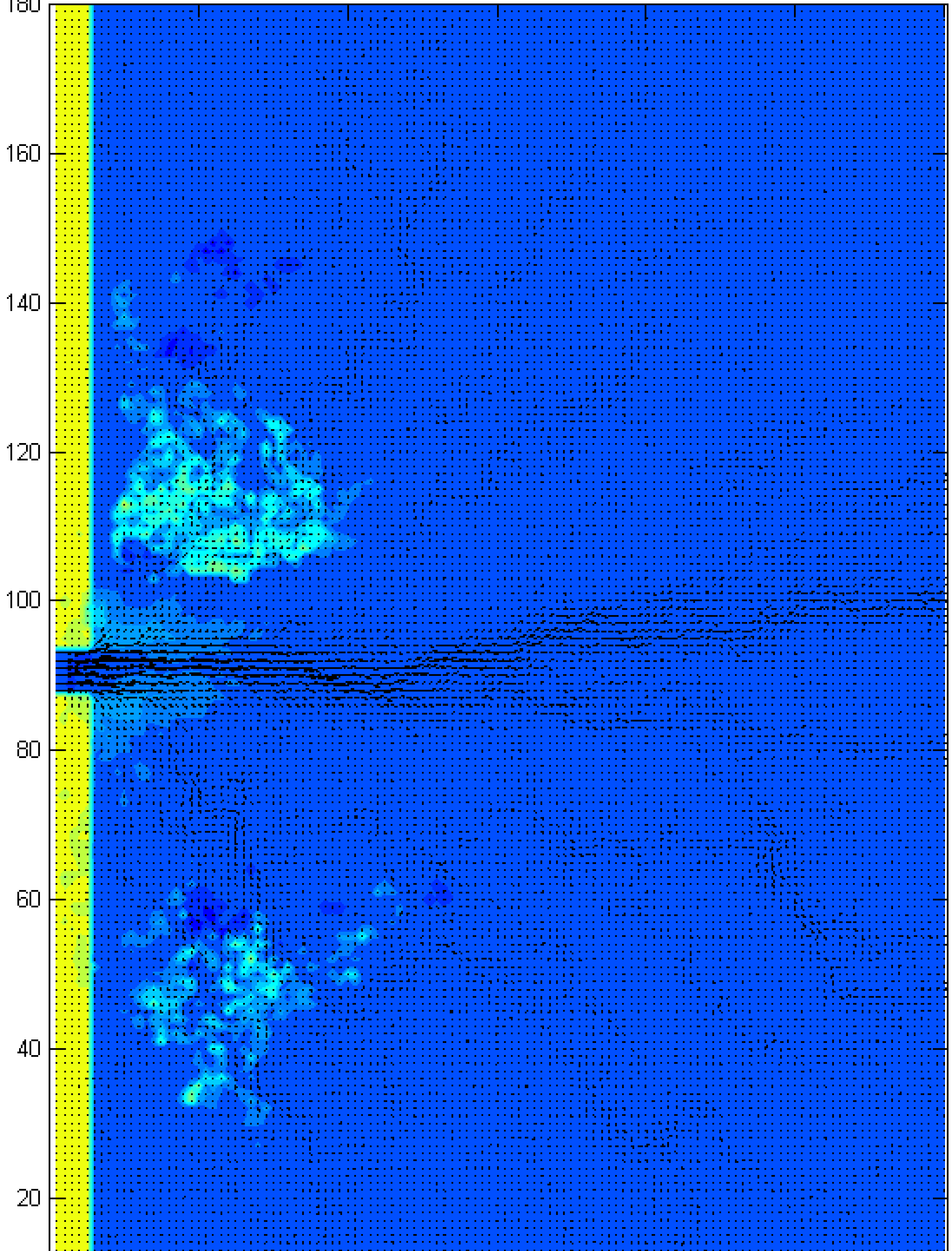
G
H
I
4 3 2 5 1 6 7 8
H_i
h_i
$\vec{q} \cdot \vec{D}_i$
> 0
≈ 0
$< 0 \rightarrow 0$
dist
$i+1$
i
$\vec{q}_D$
$\vec{q}$
H_i
H_{i+1}
$h_{i+\frac{1}{2}}$
$\tilde{w}_i^{sfc} = \sqrt{\frac{g h_i^3 |\nabla H|_i}{C_f}} \Big/ A$
$\tilde{w}_i^{dxn} = \left(\max\left(0, \vec{q}_w \cdot \vec{d}_i\right)\right)^{\theta_1} h^{\theta_2} / A$
$Q_{dep} = \lambda Q_{res} \frac{U_{dep} - U}{U_{dep}}$
$Q_{ero} = Q_{p\_sed} \frac{U - U_{ero}}{U_{ero}}$

- Intuition is a good first test
- Flow solver is so much simplified, so what do we lose from it?
- Where the randomness comes from?
- Effects of parameters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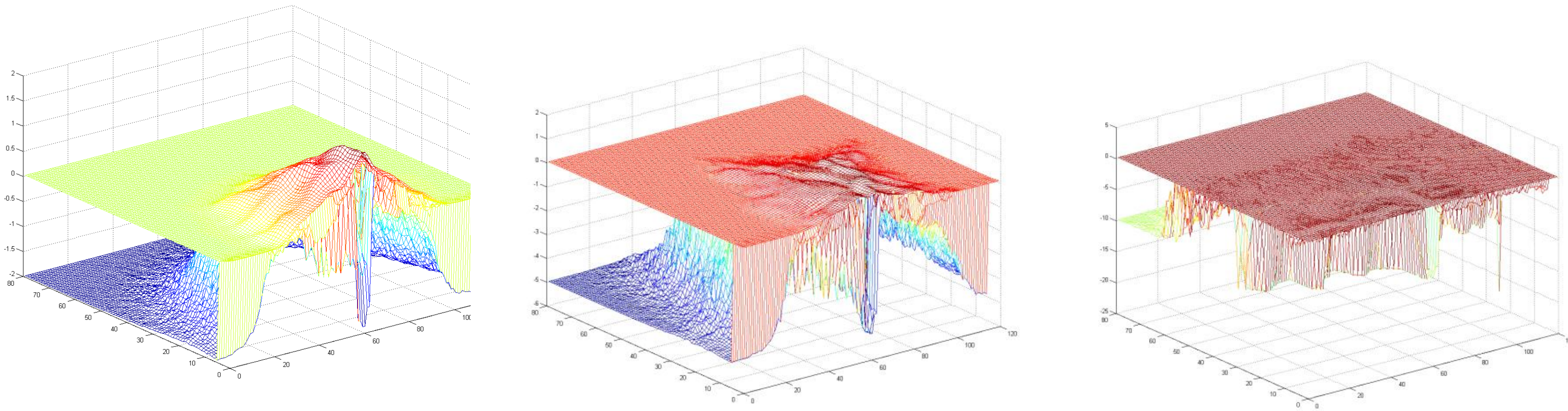
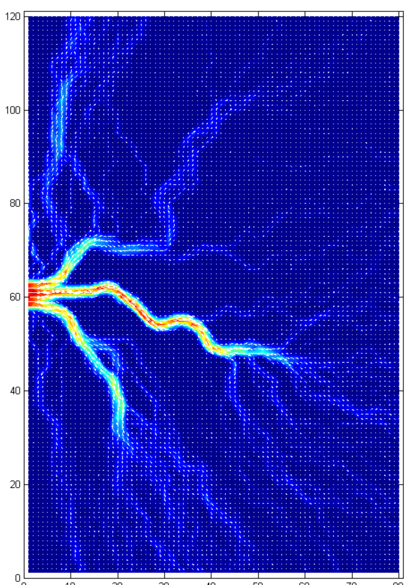
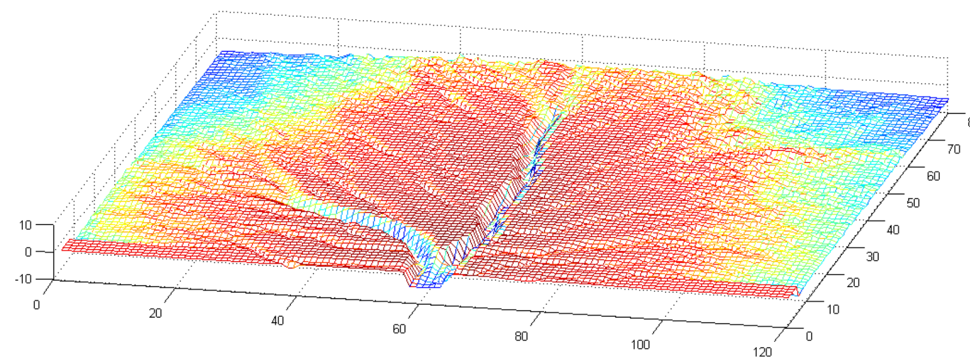
Basic Variables



Free surface

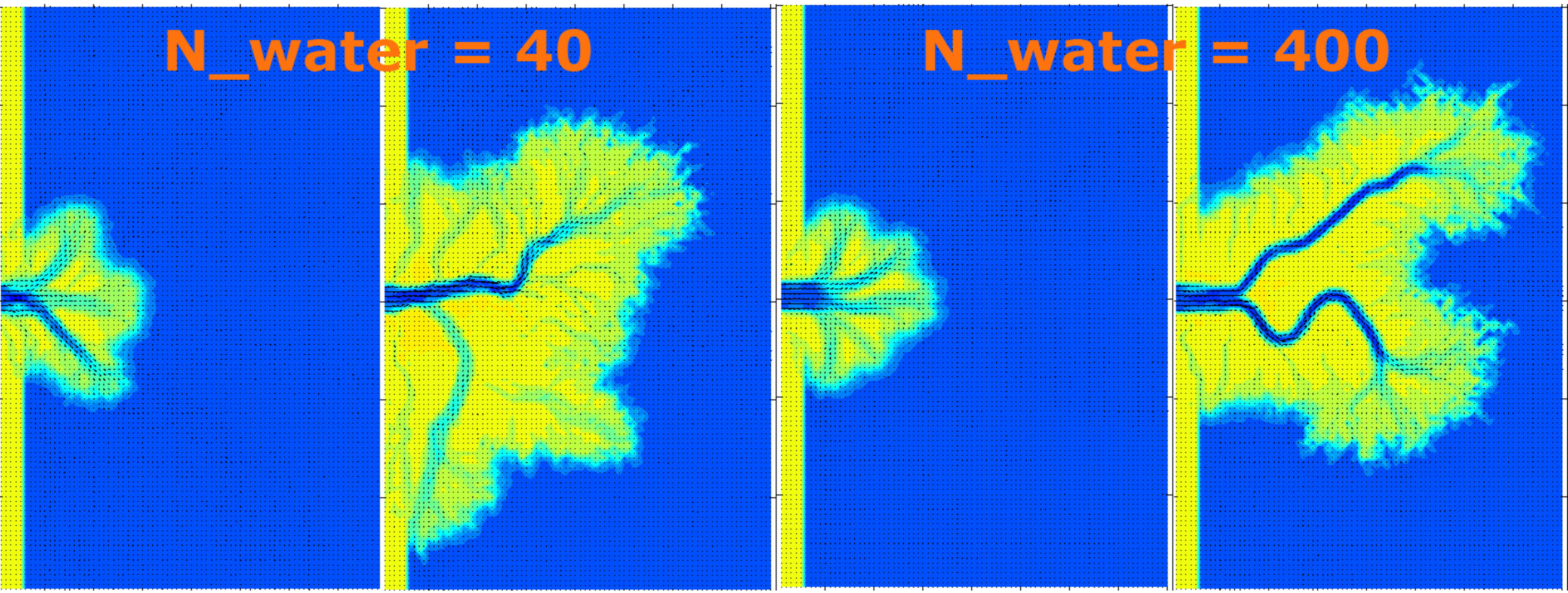


Flow vector

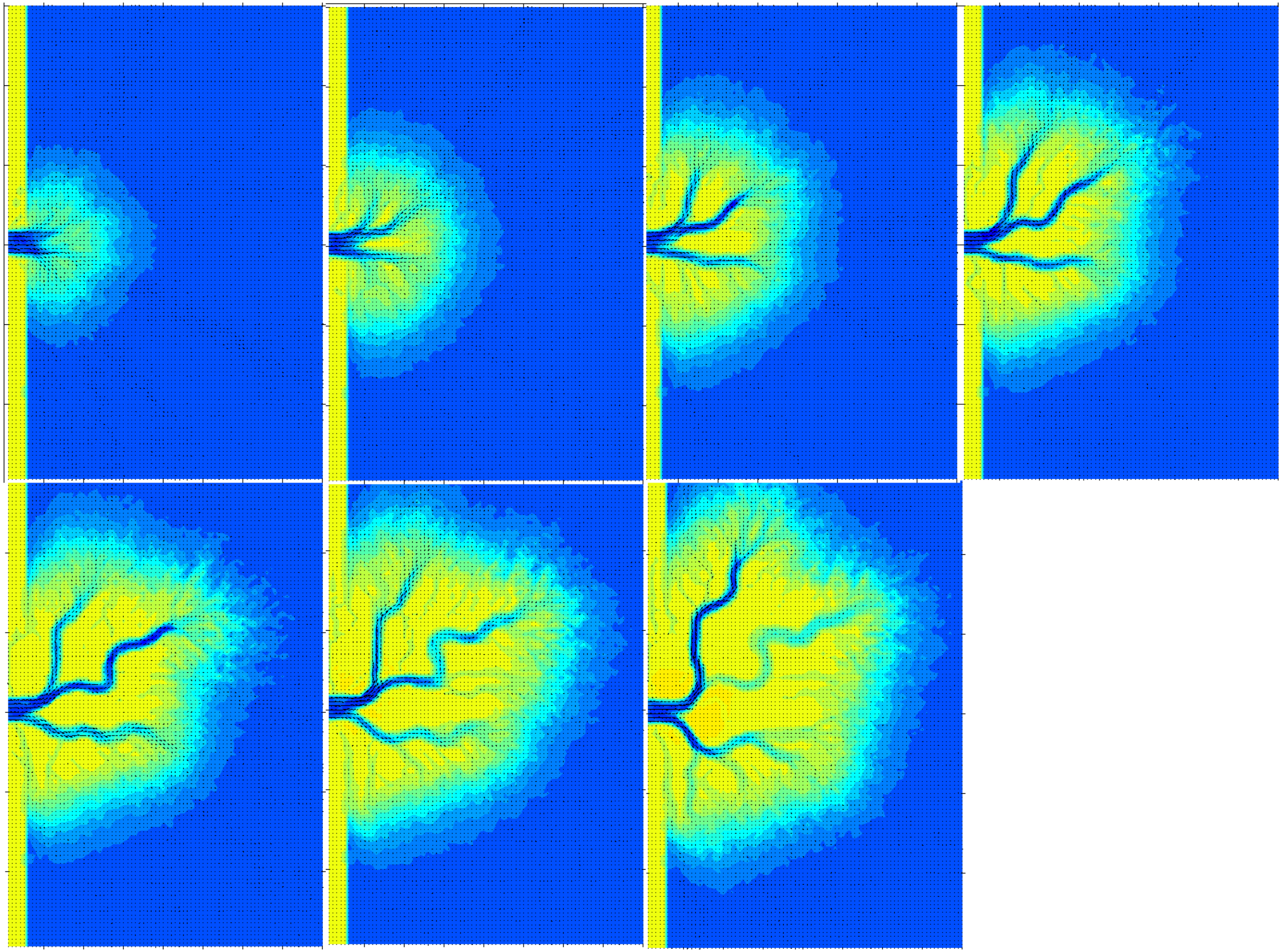


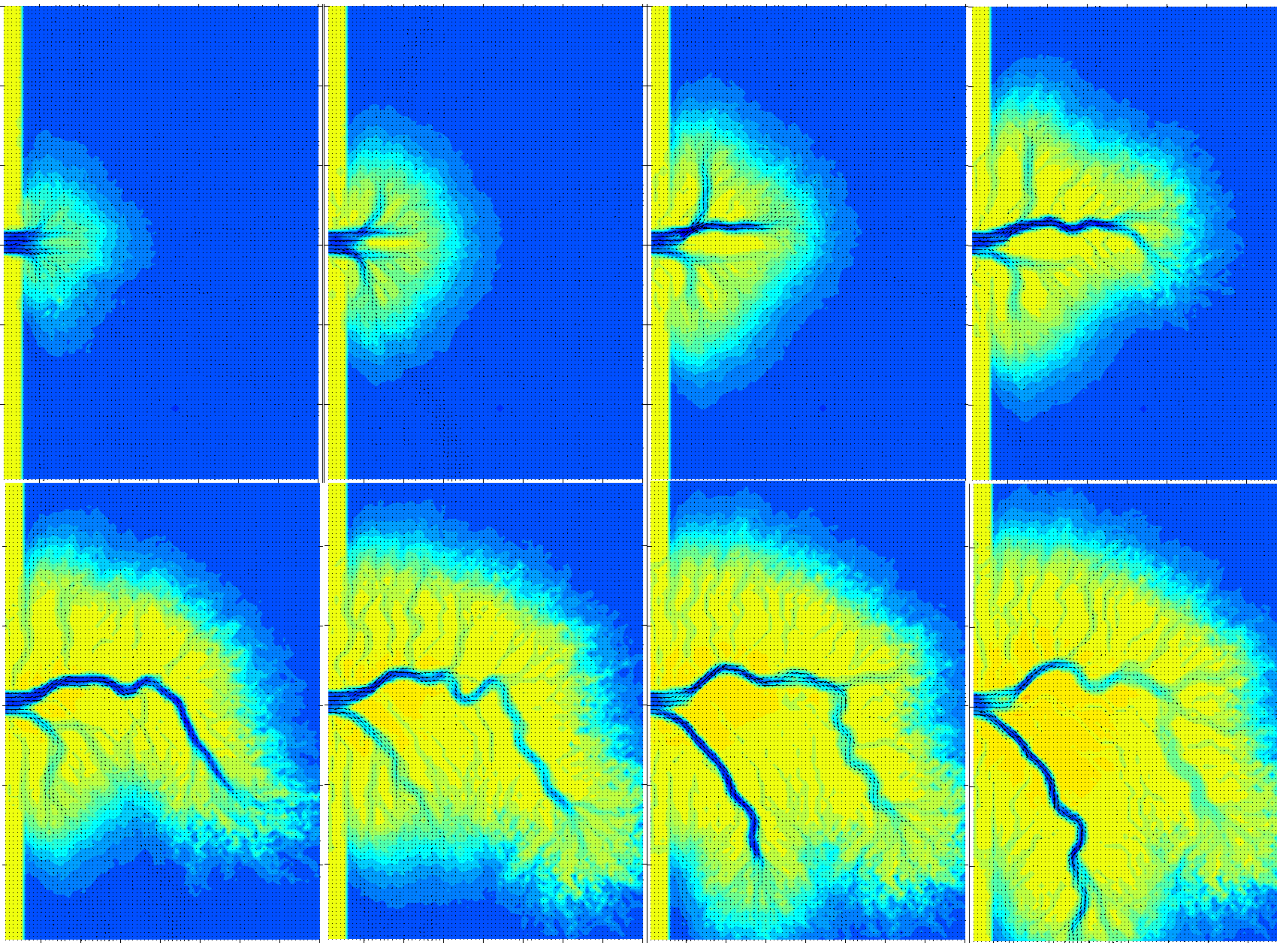
Bed elevation

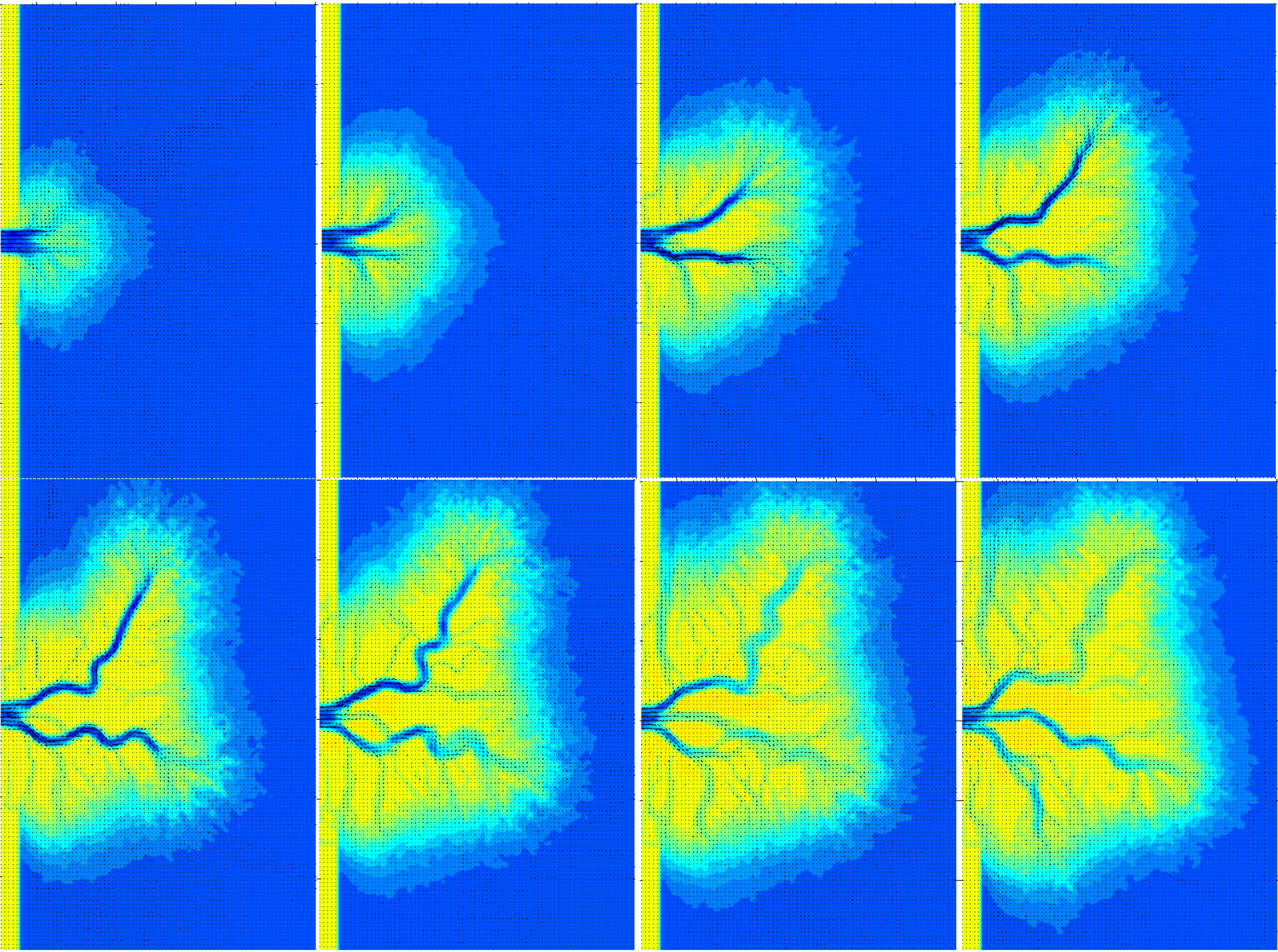
Change # of packages



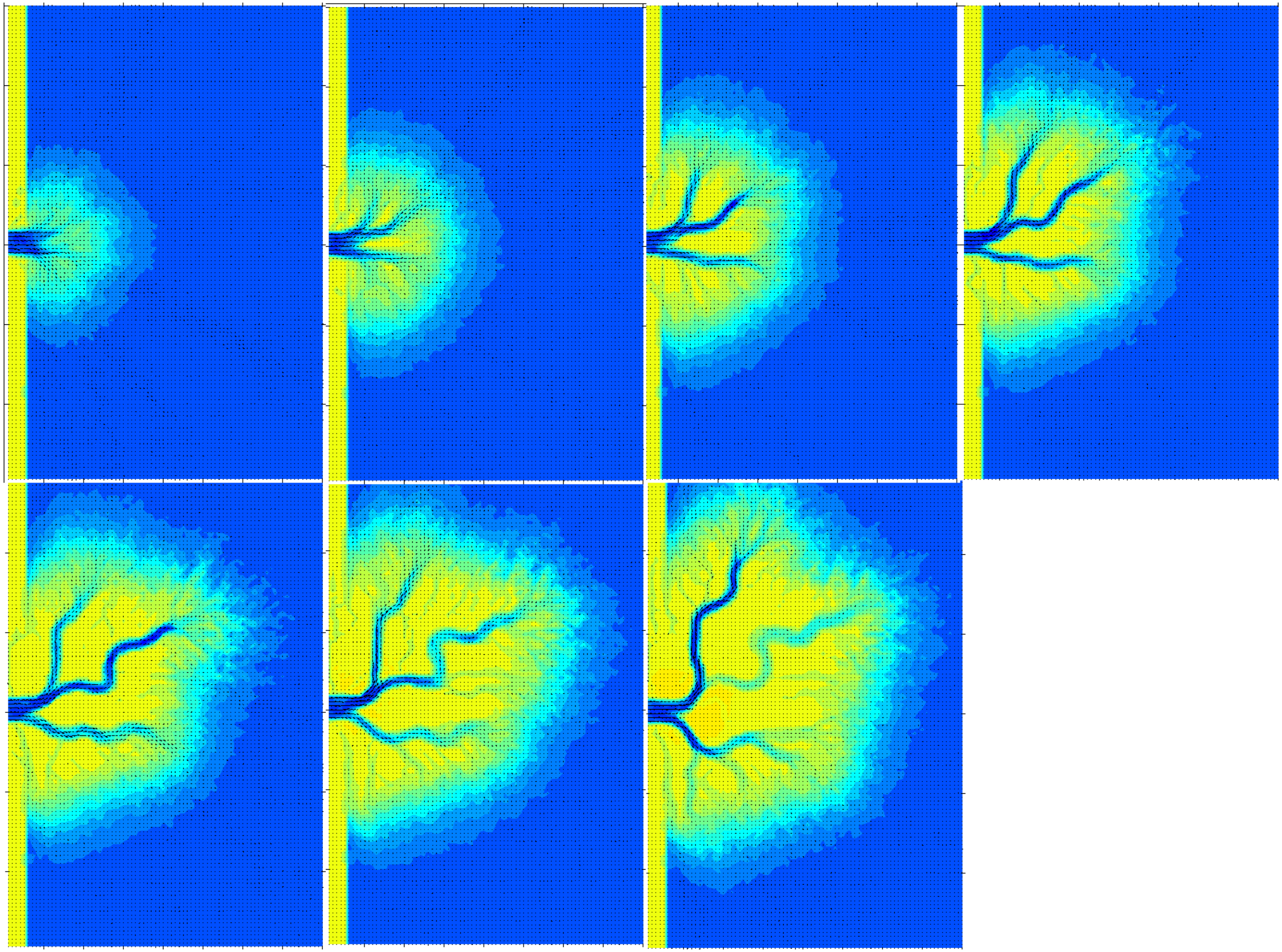
Internal Randomness (variations of the base case)

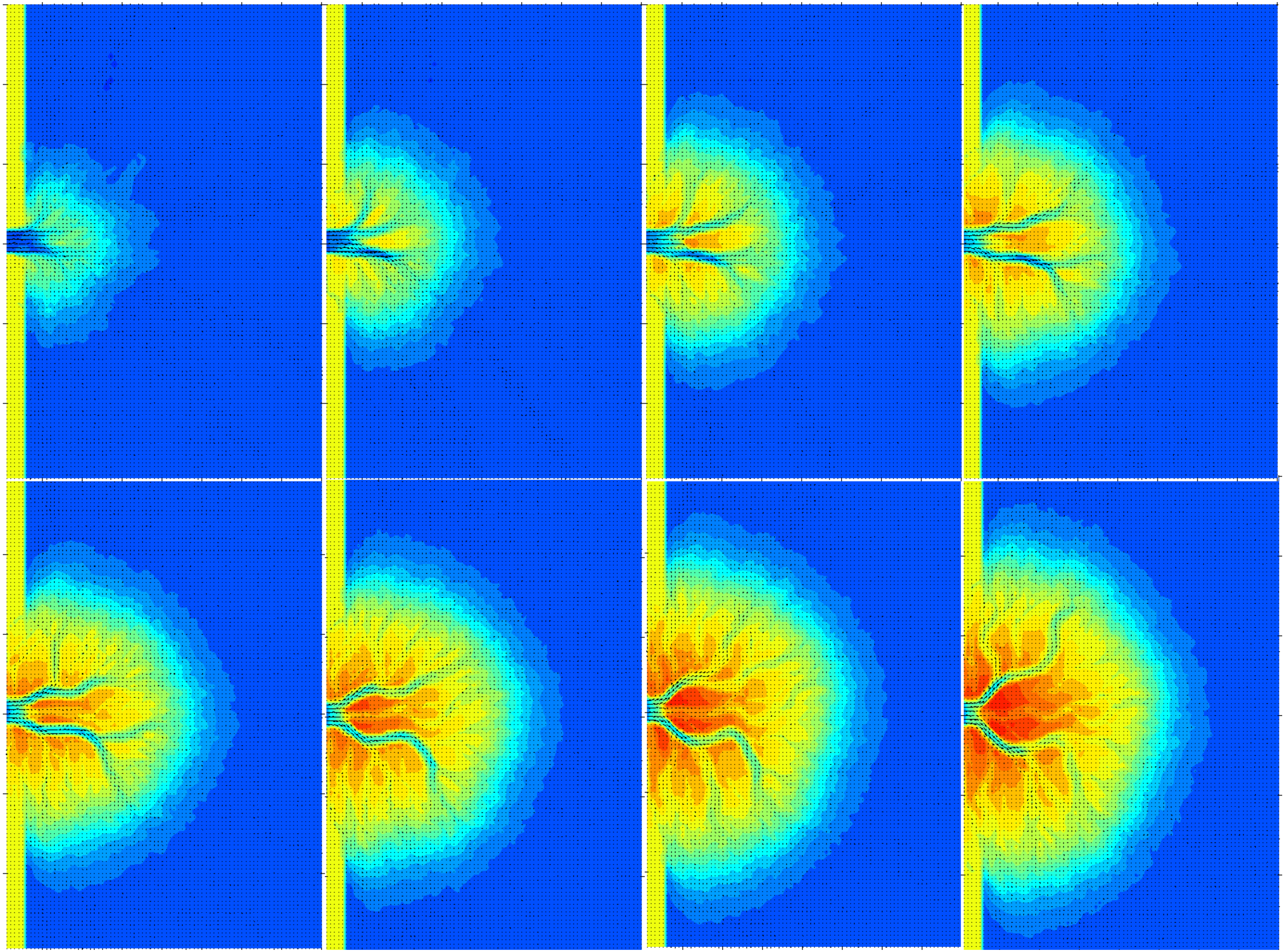


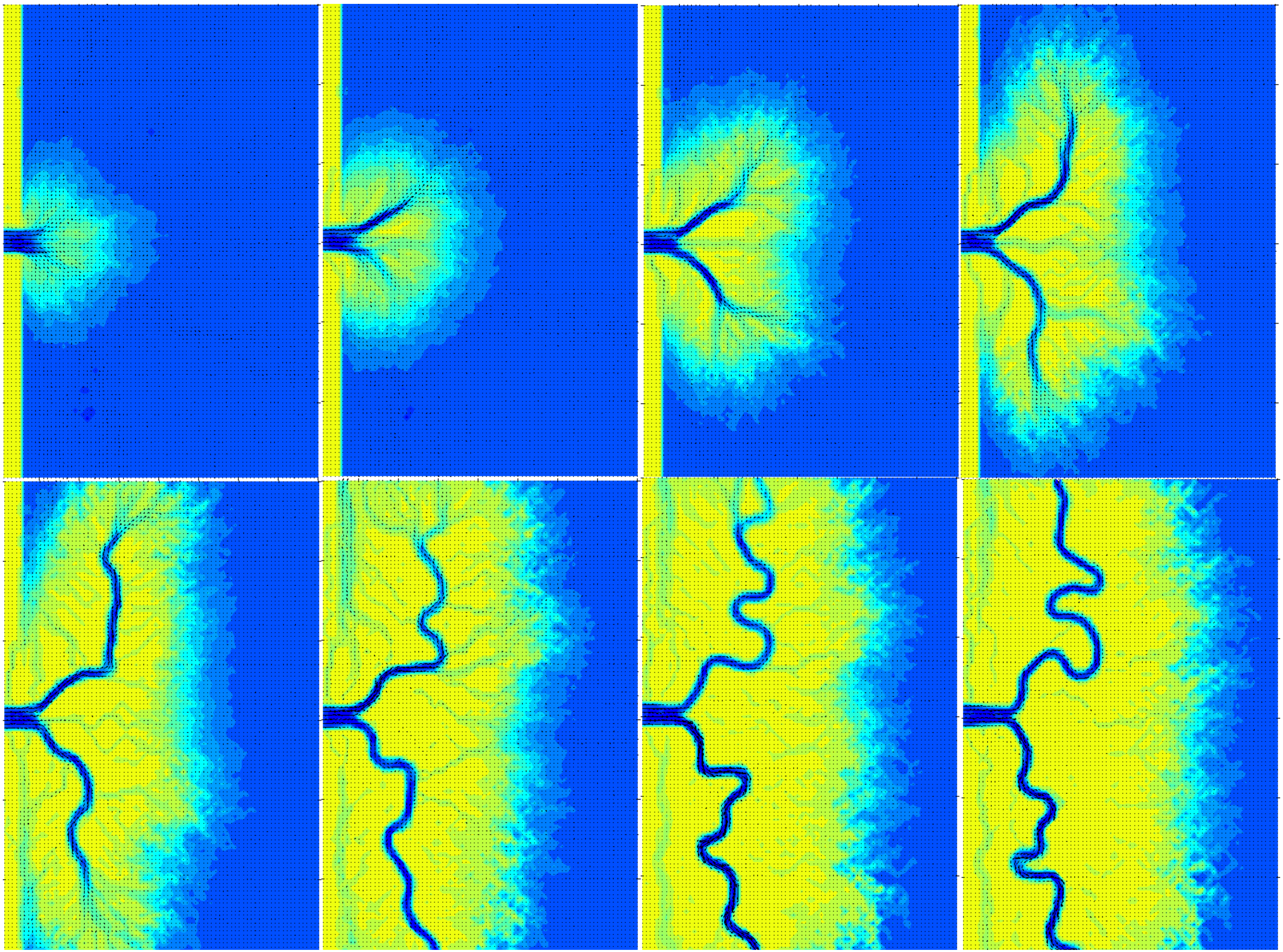


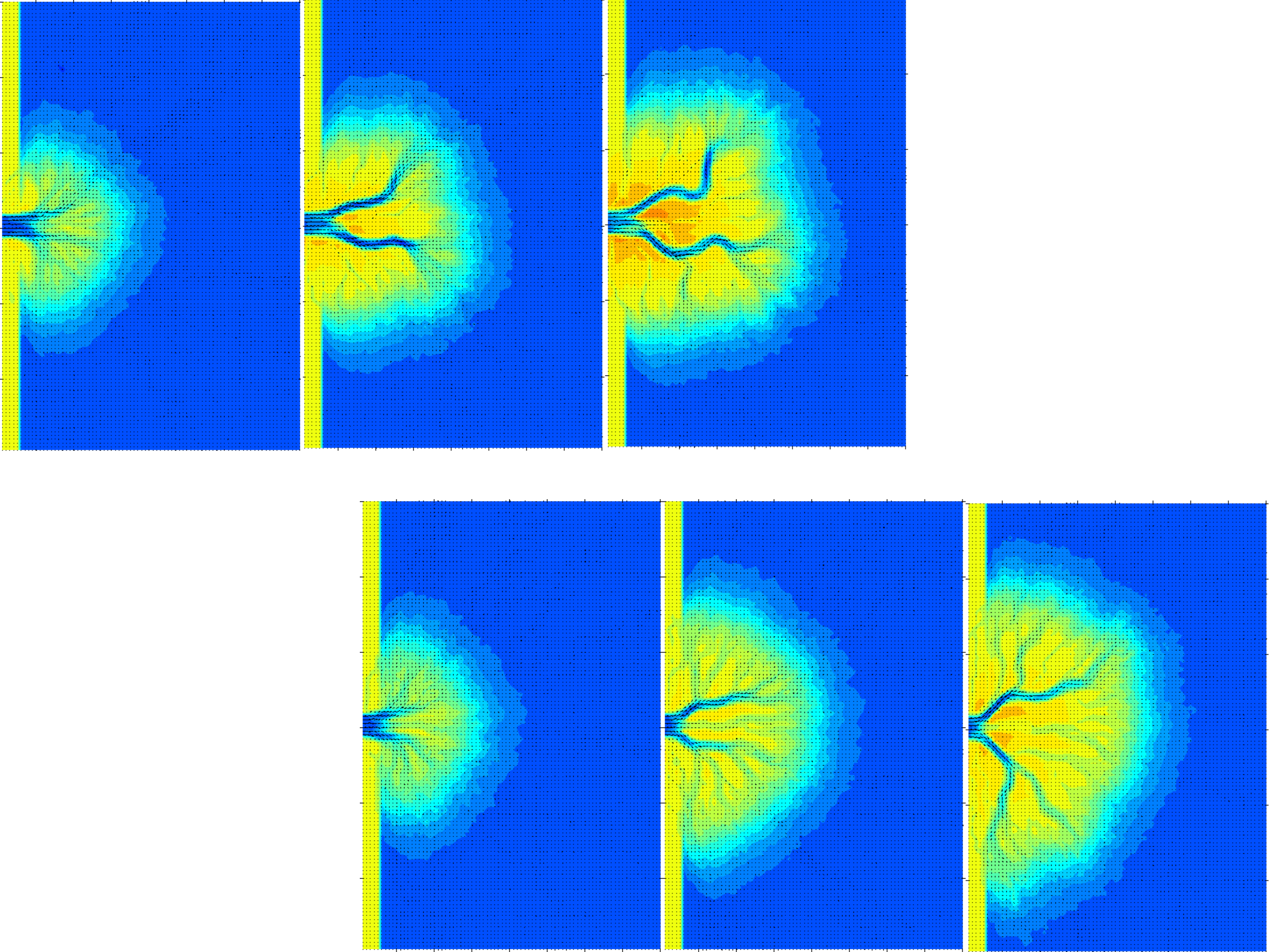


Varing Fr#

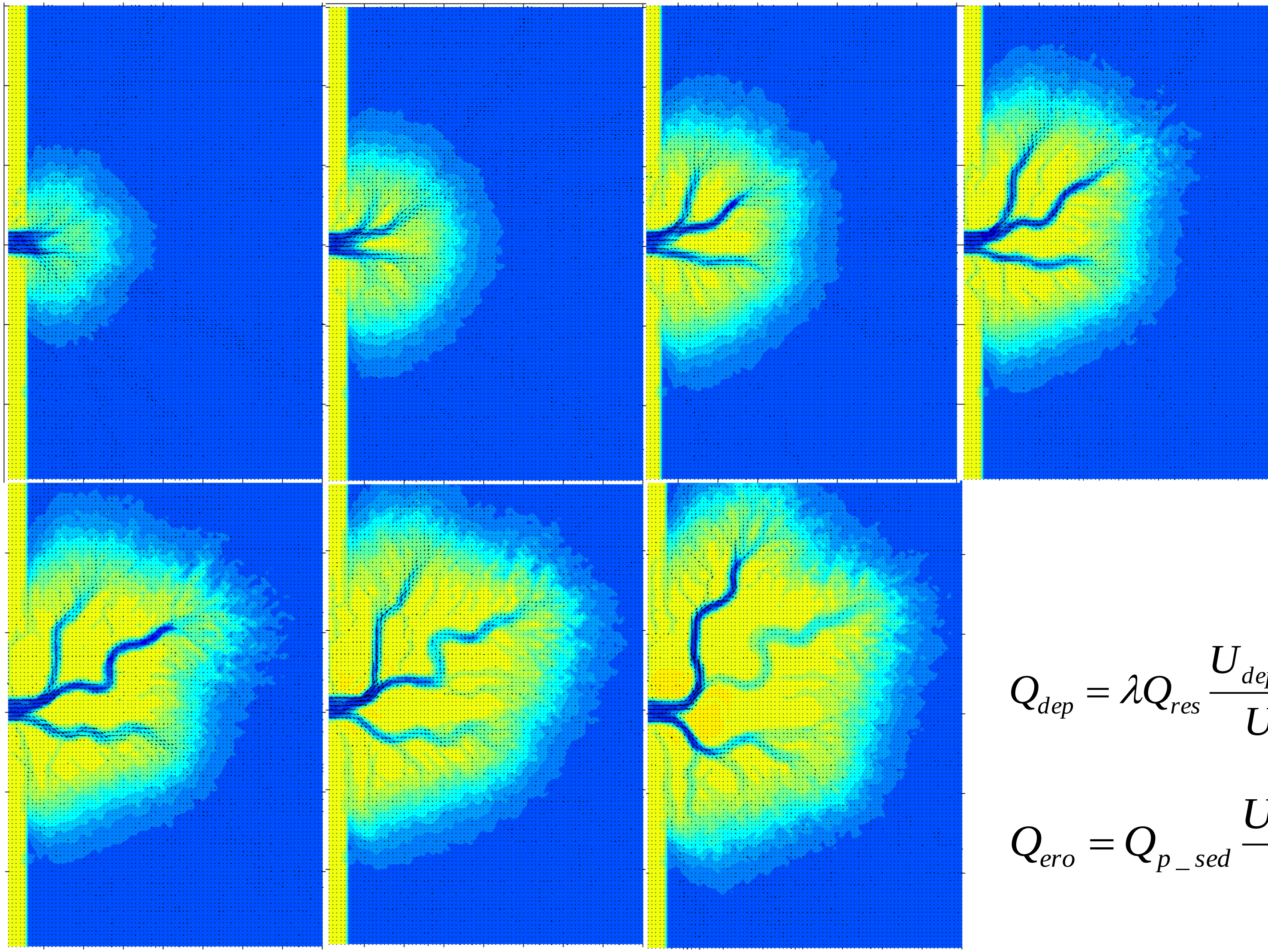






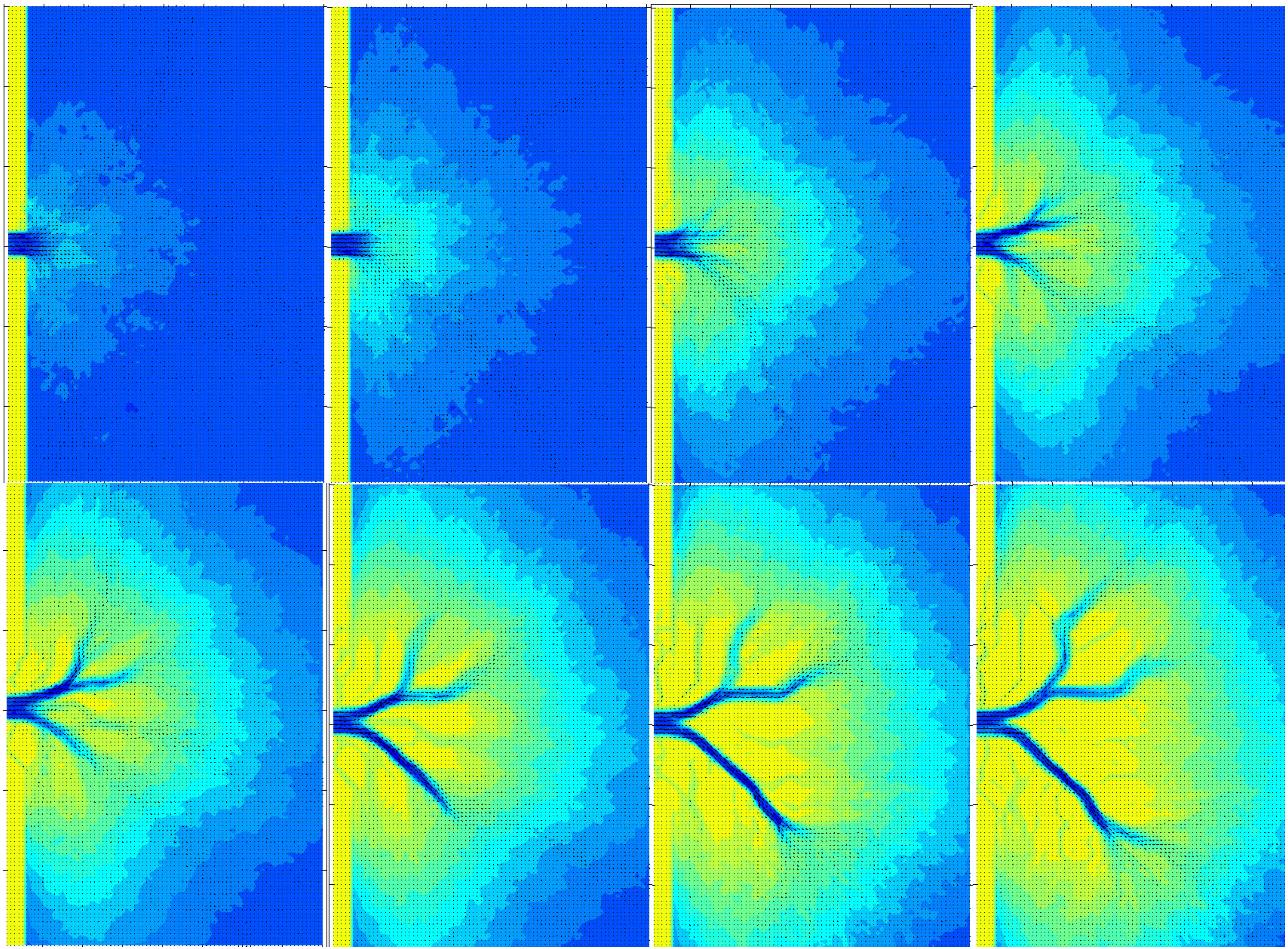


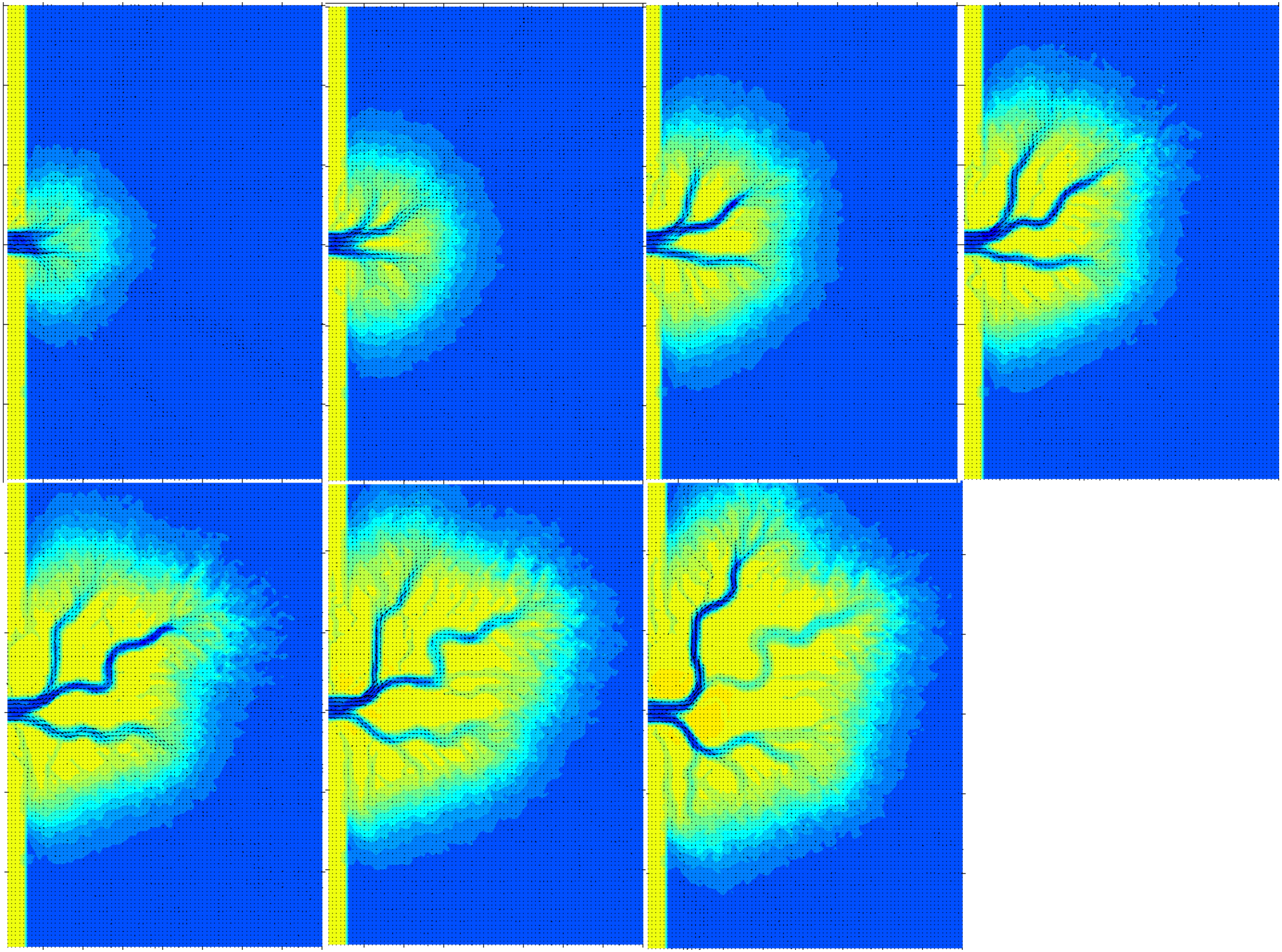
Effects of sedimentation coefficients

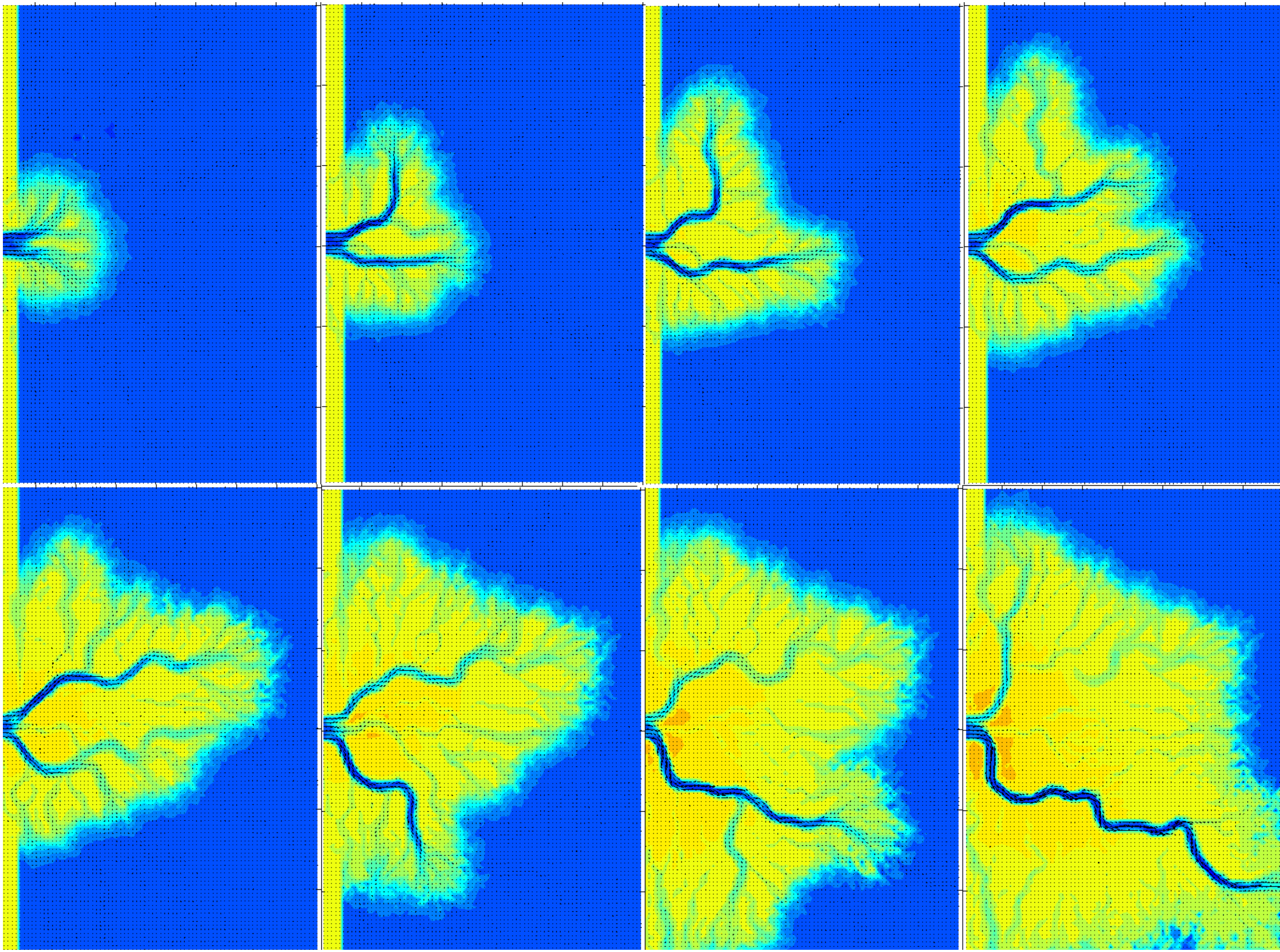


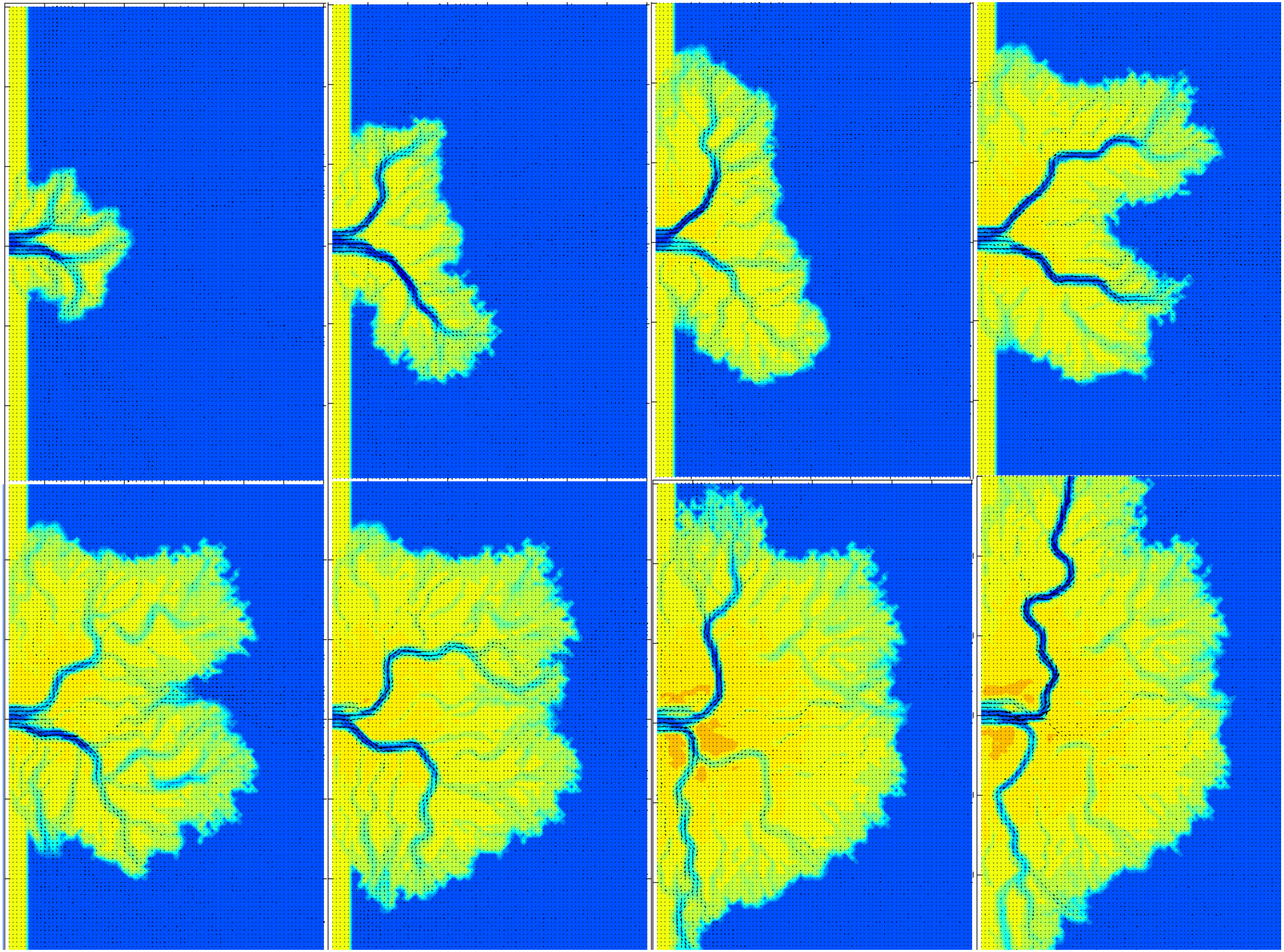
$$Q_{dep} = \lambda Q_{res} \frac{U_{dep} - U}{U_{dep}}$$

$$Q_{ero} = Q_{p\_sed} \frac{U - U_{ero}}{U_{ero}}$$

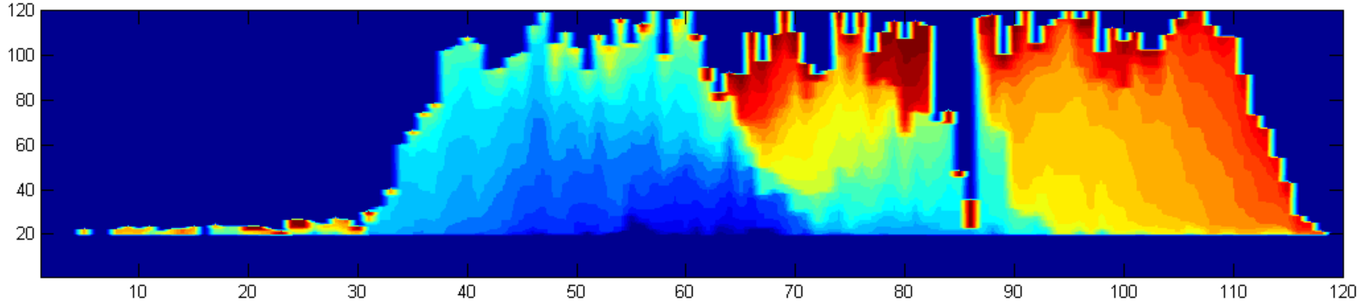


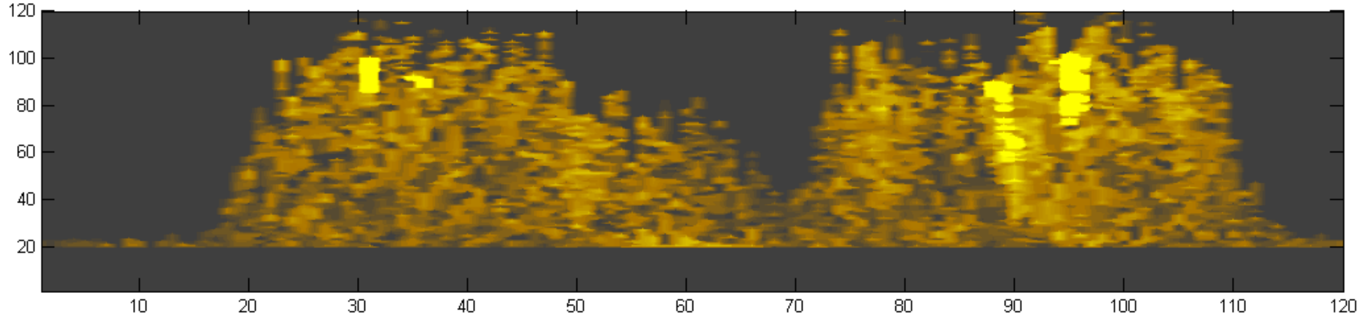






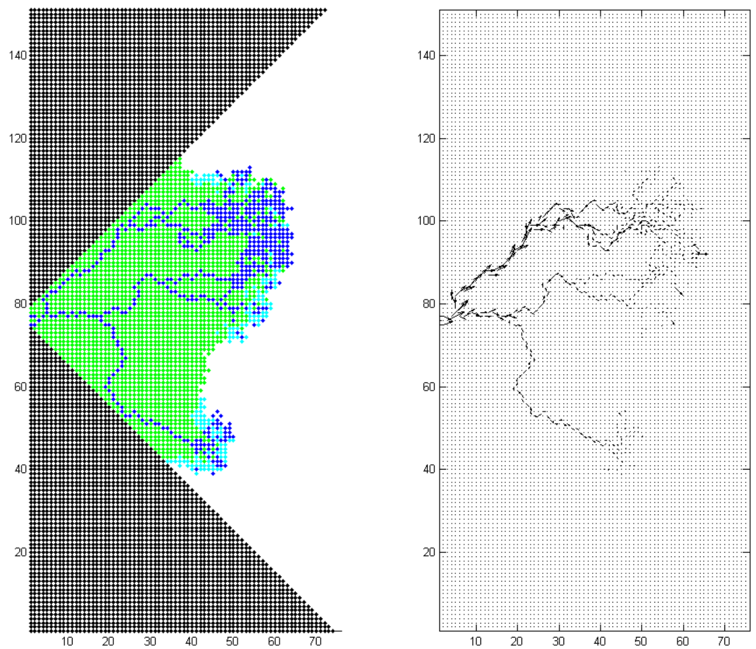
• Stratigraphy potential





What’s Next

- Improve sediment transport (bed load, grain size, etc.)
- Maybe.. improve flow solver
- Statistical analysis
- Add: wave, vegetation, sea-level, etc.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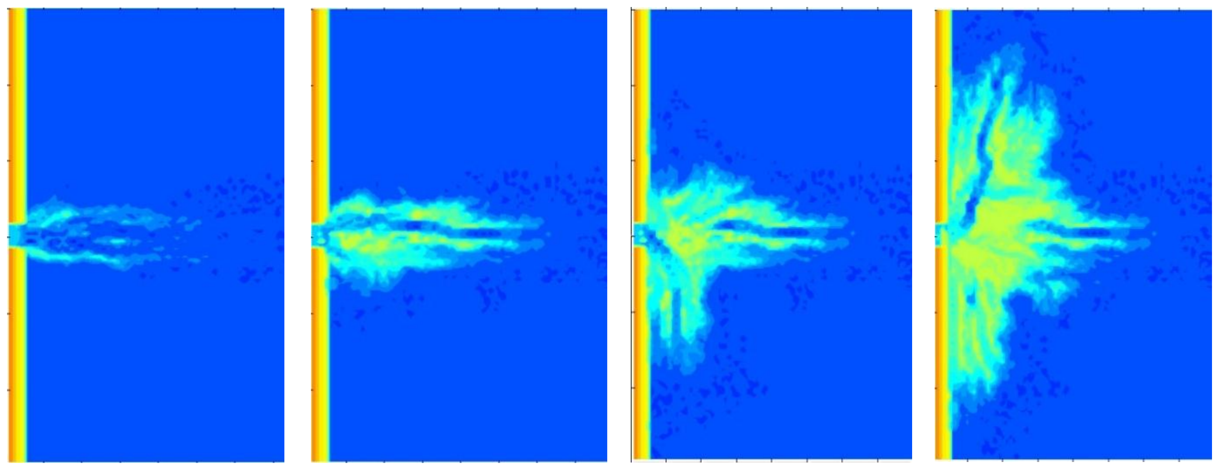
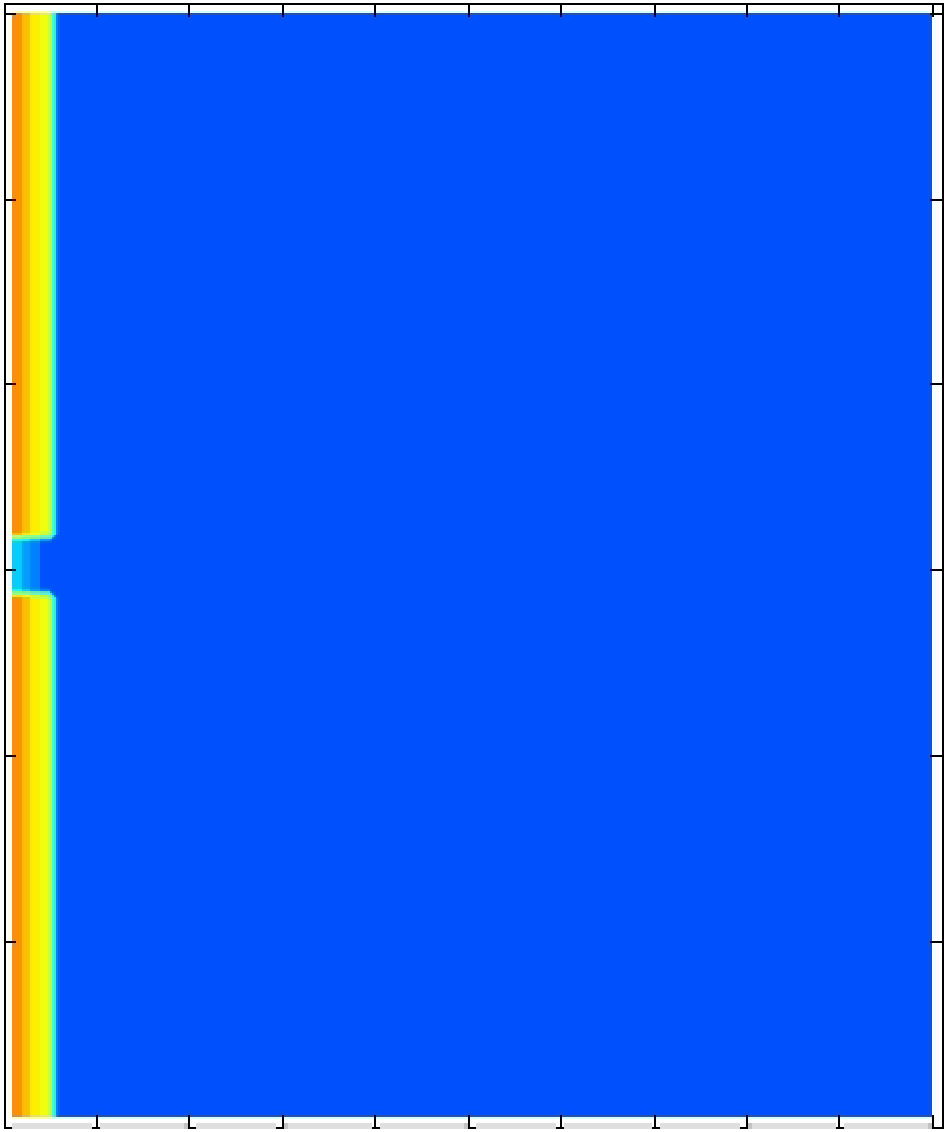
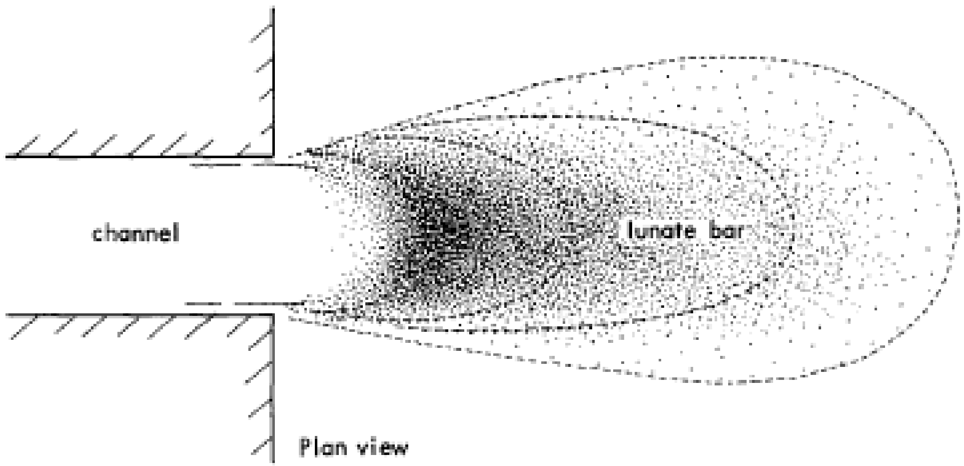
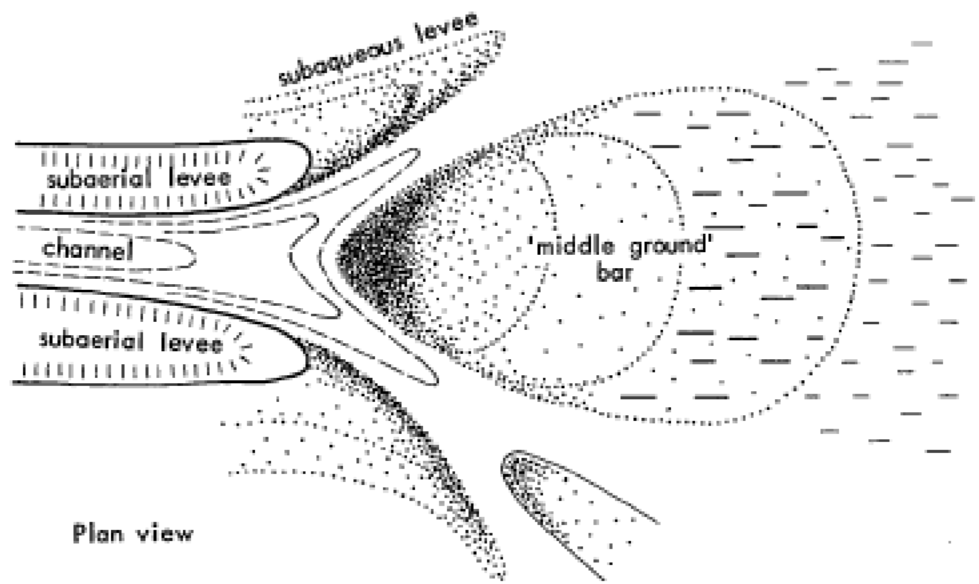




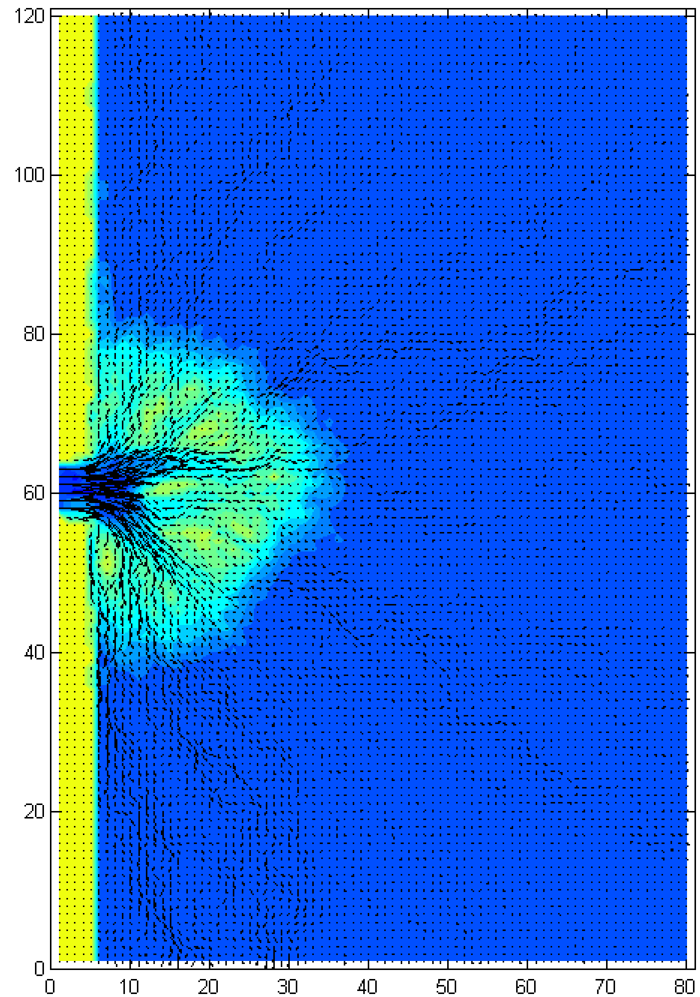


channel
lunate bar
Plan view



subaqueous levee
subaerial levee
channel
subaerial levee
'middle ground' bar
Plan view

Wright, 2006



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Reduced Hydrodynamic Model

Continuity $\nabla \cdot \vec{q} = 0$

Momentum $h\vec{u} \cdot \nabla \vec{u} = -gh\nabla(h+\eta) - C_f |\vec{u}|\vec{u}$

inertial $\sim \frac{HU^2}{L}$ gravititional $\sim \frac{gH^2}{L}$

$$\text{inertial}/\text{gravitational} \sim \frac{U^2}{gH} = Fr^2 << 1$$

Continuity $\nabla \cdot \vec{q} = 0$

Momentum $0 = -gh^3\nabla(h+\eta) - C_f |\vec{q}|\vec{q}$

$$|\vec{q}| = \sqrt{\frac{g}{C_f} h^3 |\nabla(h+\eta)|} \qquad \vec{q} = -\frac{g}{C_f|\vec{q}|} h^3 \nabla(h+\eta)$$

$$\nabla \cdot \left(-\frac{g}{C_f|\vec{q}|} h^3 \nabla h - \frac{g}{C_f|\vec{q}|} h^3 \nabla \eta \right) = 0$$

Define nonlinear diffusivity $K = \frac{g}{C_f|\vec{q}|}$

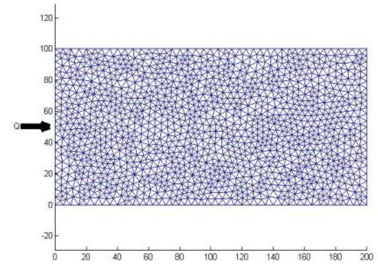
And linearize the diffusion equation with Kirchhoff's transformation $\psi = \int_0^h \alpha^3 d\alpha$

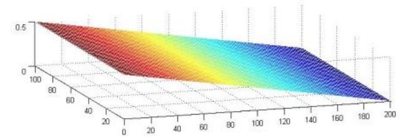
$$\nabla \cdot (K\nabla\psi + S) = 0$$

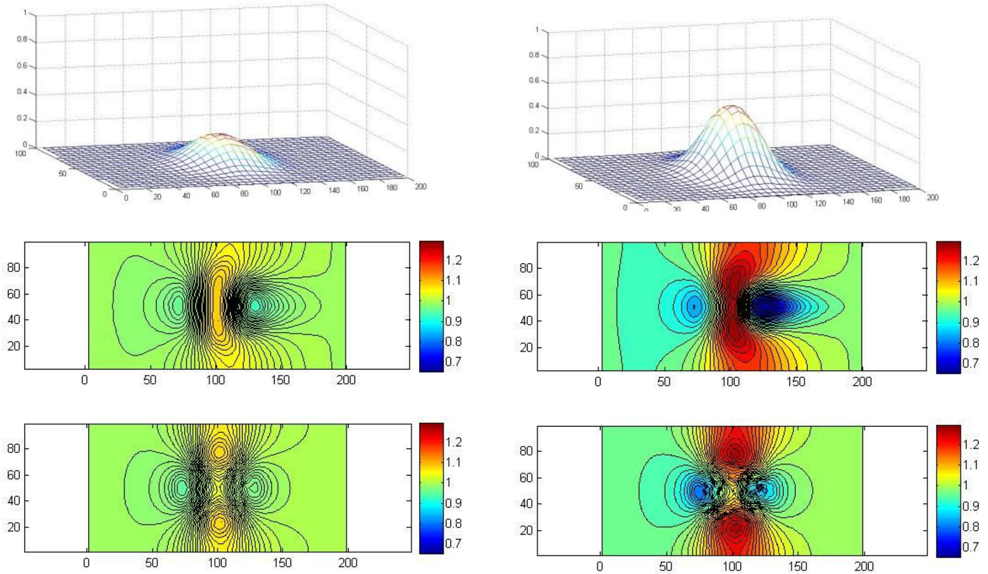
where $K = \frac{g}{C_f|\vec{q}|} = \frac{g}{C_f \sqrt{\left| \frac{g}{C_f} \nabla\psi + \frac{g}{C_f} (4\psi)^{3/4} \nabla\eta \right|}}$

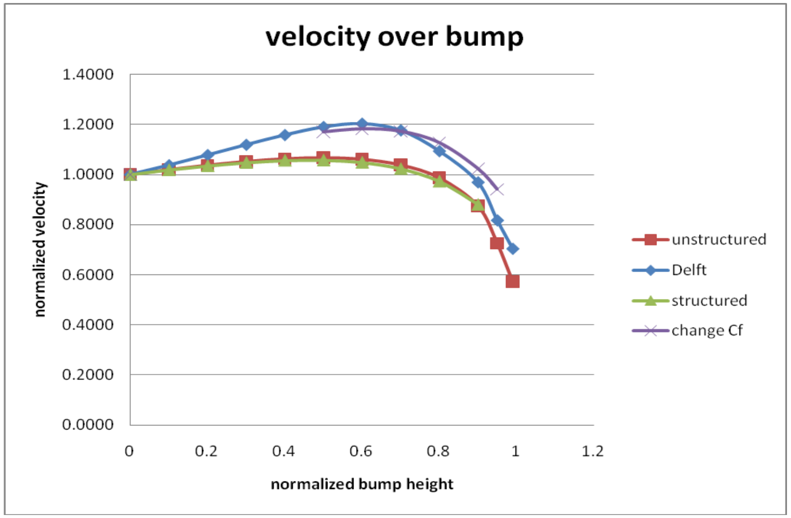
and $S = K(4\psi)^{3/4}\nabla\eta$ can be considered as a source term.

TEST PROBLEM: the critical mouth bar height needed to divert flow around the bar.









Basic cellular water router:

$$|\vec{q}| = \sqrt{\frac{g}{C_f} h^3 \left|\nabla(h+\eta)\right|}$$

$$\varpi_i \propto \sqrt{\frac{g}{C_f} \bar{h}_i^3 \left|\nabla(h+\eta)\right|_i} \qquad i = 1,2,3.$$

$$\sum_{i=1,2,3} \varpi_i = 1$$