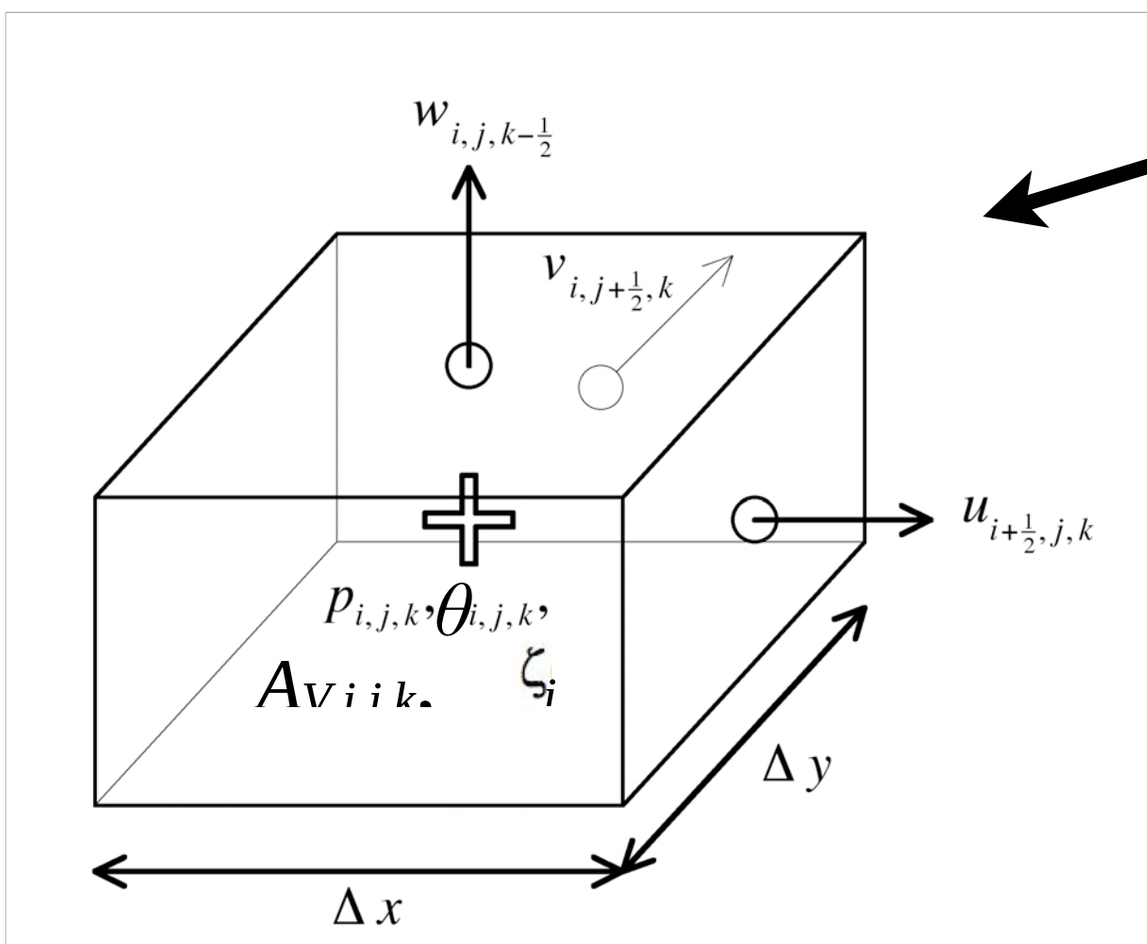
3D Model

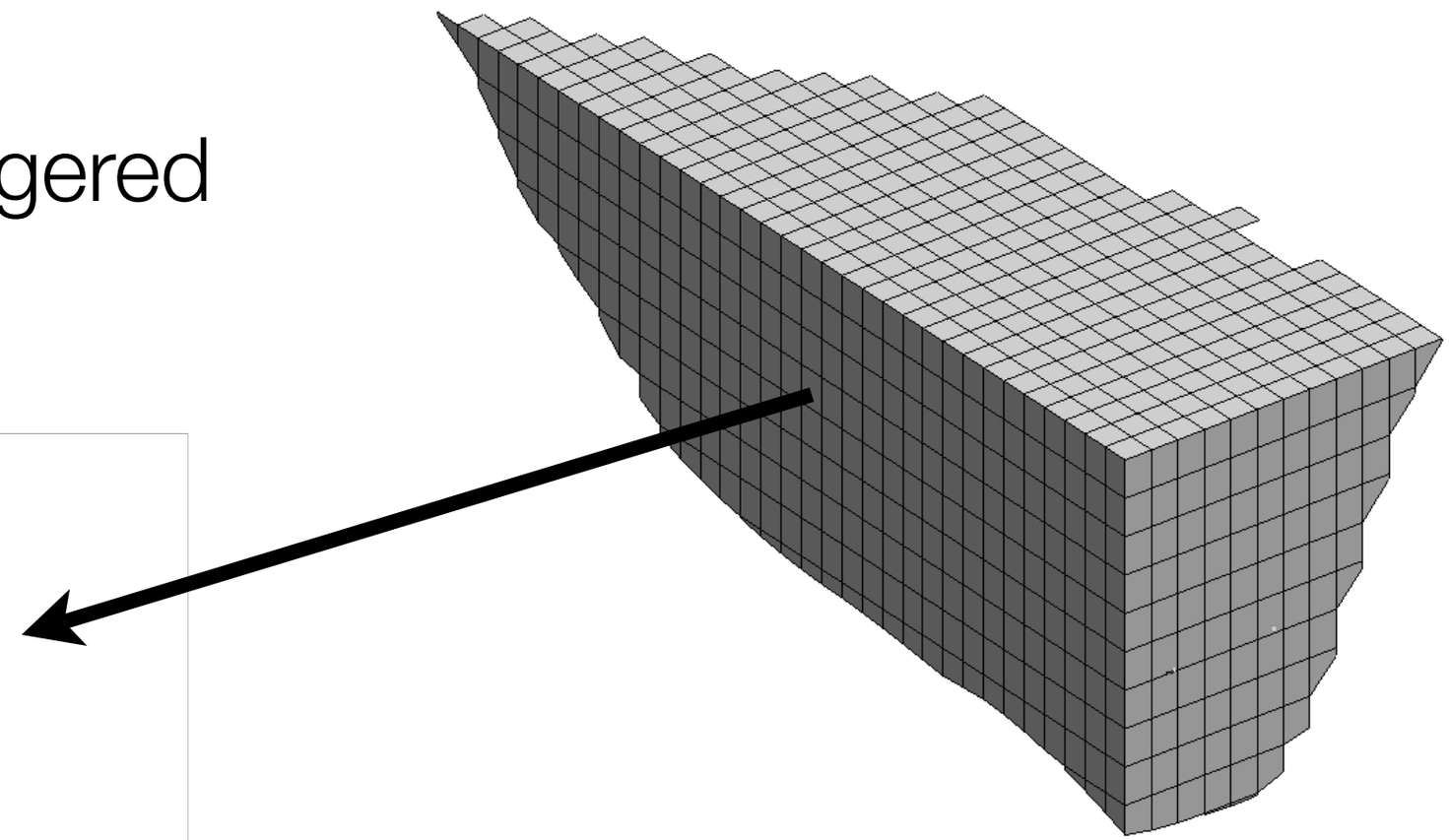
Si3D = **S**emi-**i**mplicit **3 D**imensional

- Developed at University of California Davis in Geoff Schladow's reseach group
- Pete Smith (1997) created core routines and benchmarked using canonical flows
- Francisco Rueda (2001) further developed for field applications
- Utilized by USGS, University of Granada, and others

SI3D: Spatial Discretization

Finite volume staggered
Cartesian grid

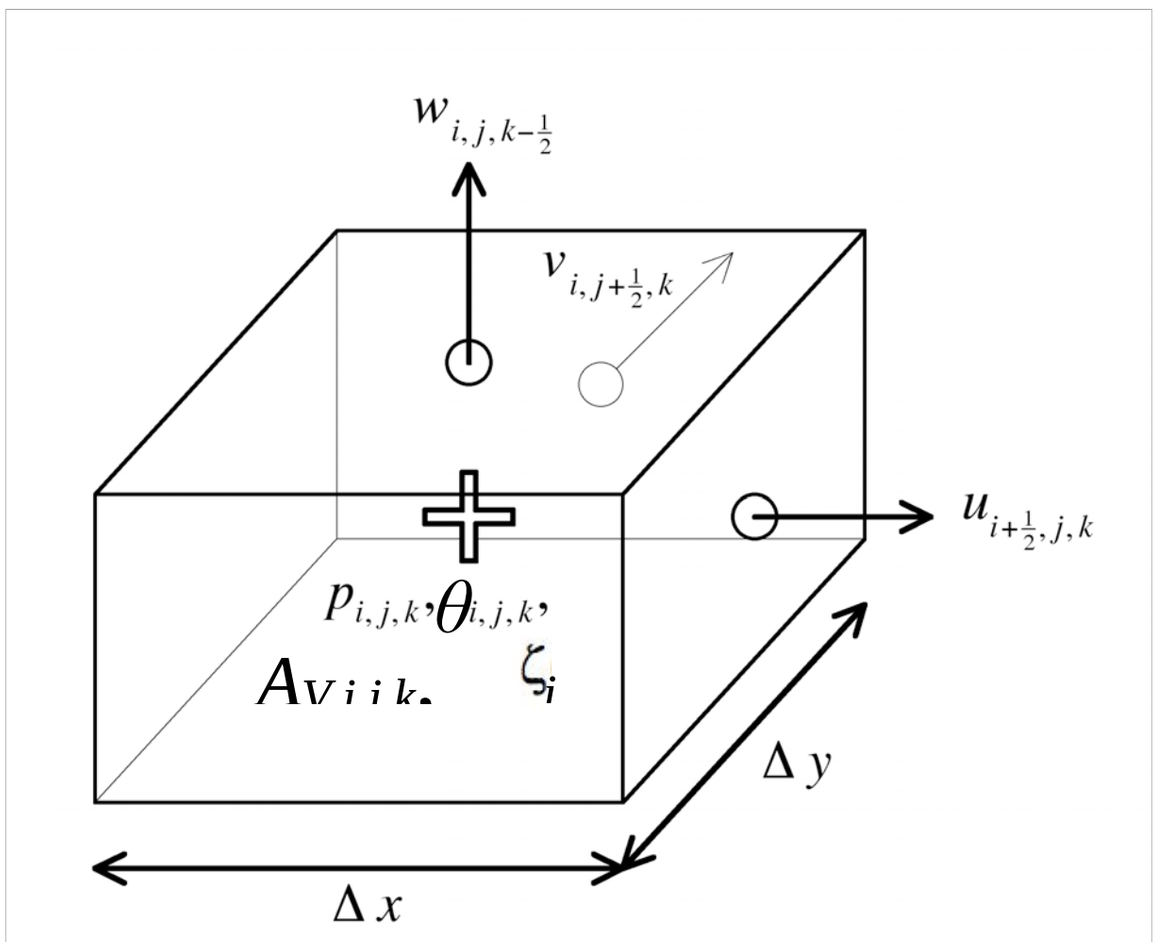




SI3D: Governing Equations

Reynolds Averaged

- Conservation of Mass
- Conservation of Momentum
- Conservation of Energy
- Conservation of Tracer Mass



SI3D: Initial and Boundary Conditions

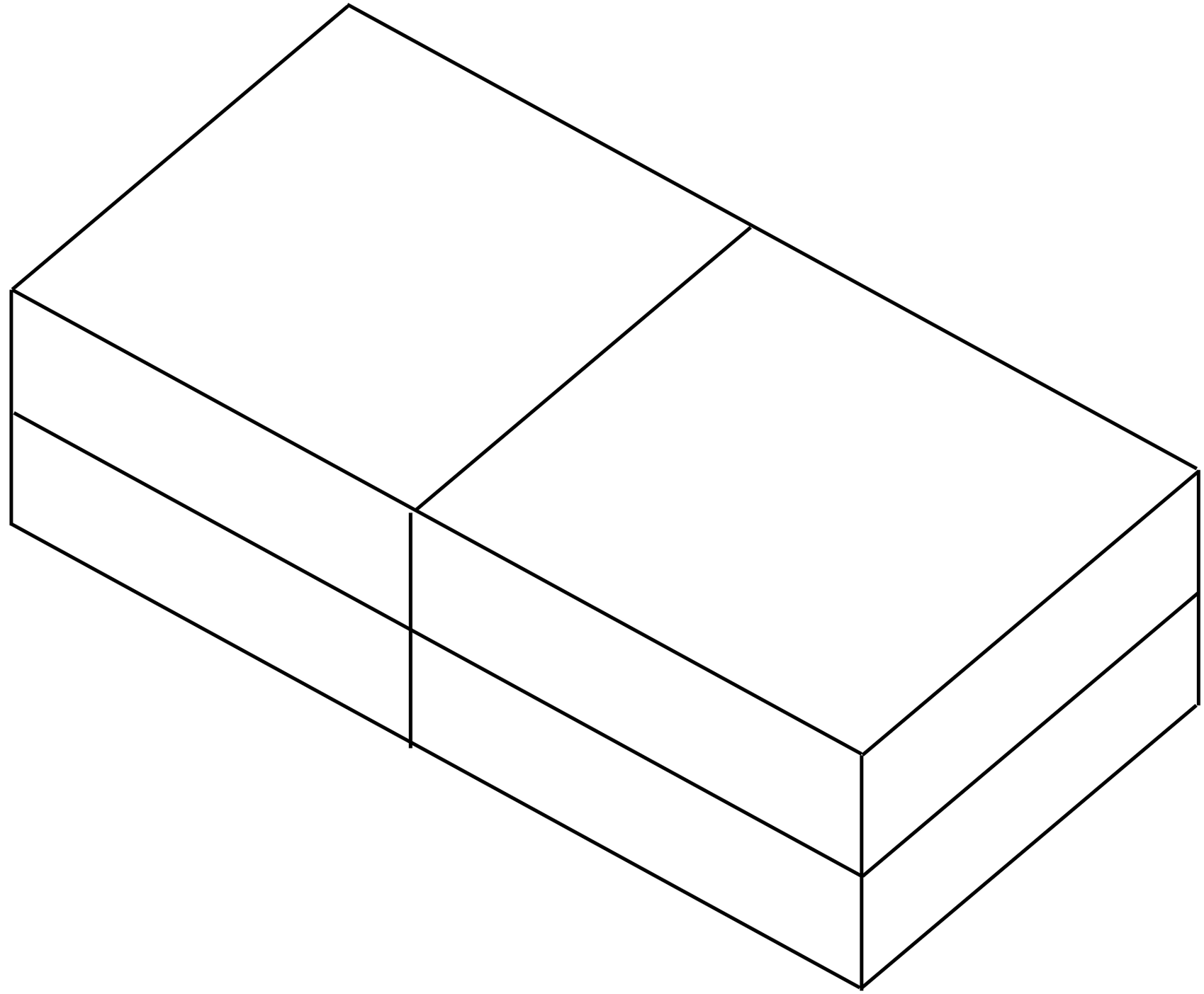
Initial Condition

- Vertical temperature profile

Boundary Conditions

- Meteorological variables (including wind)
- Tributary flow rates and temperatures
- Water surface elevation at one boundary

SI3D: Transport Between Cells



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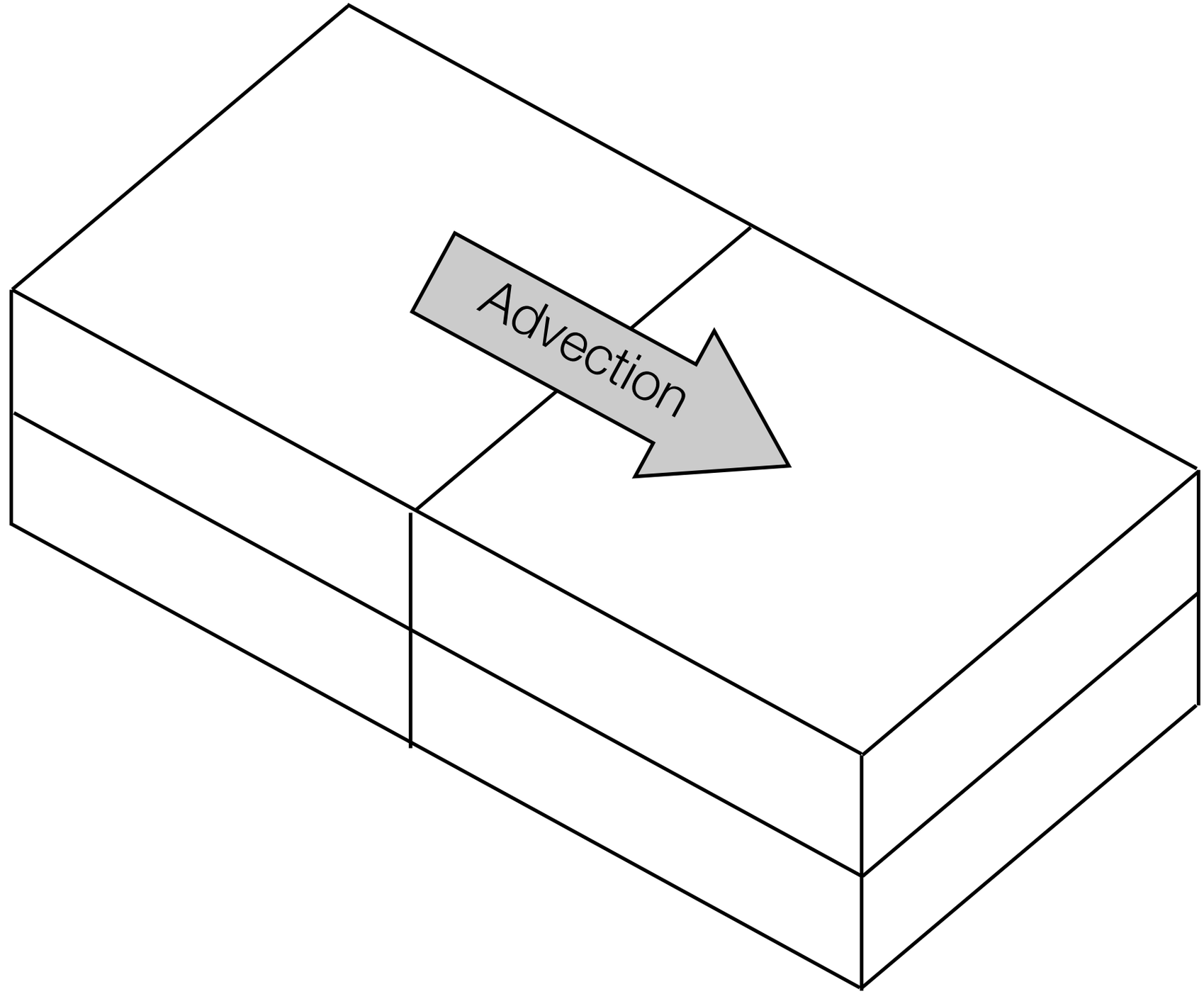
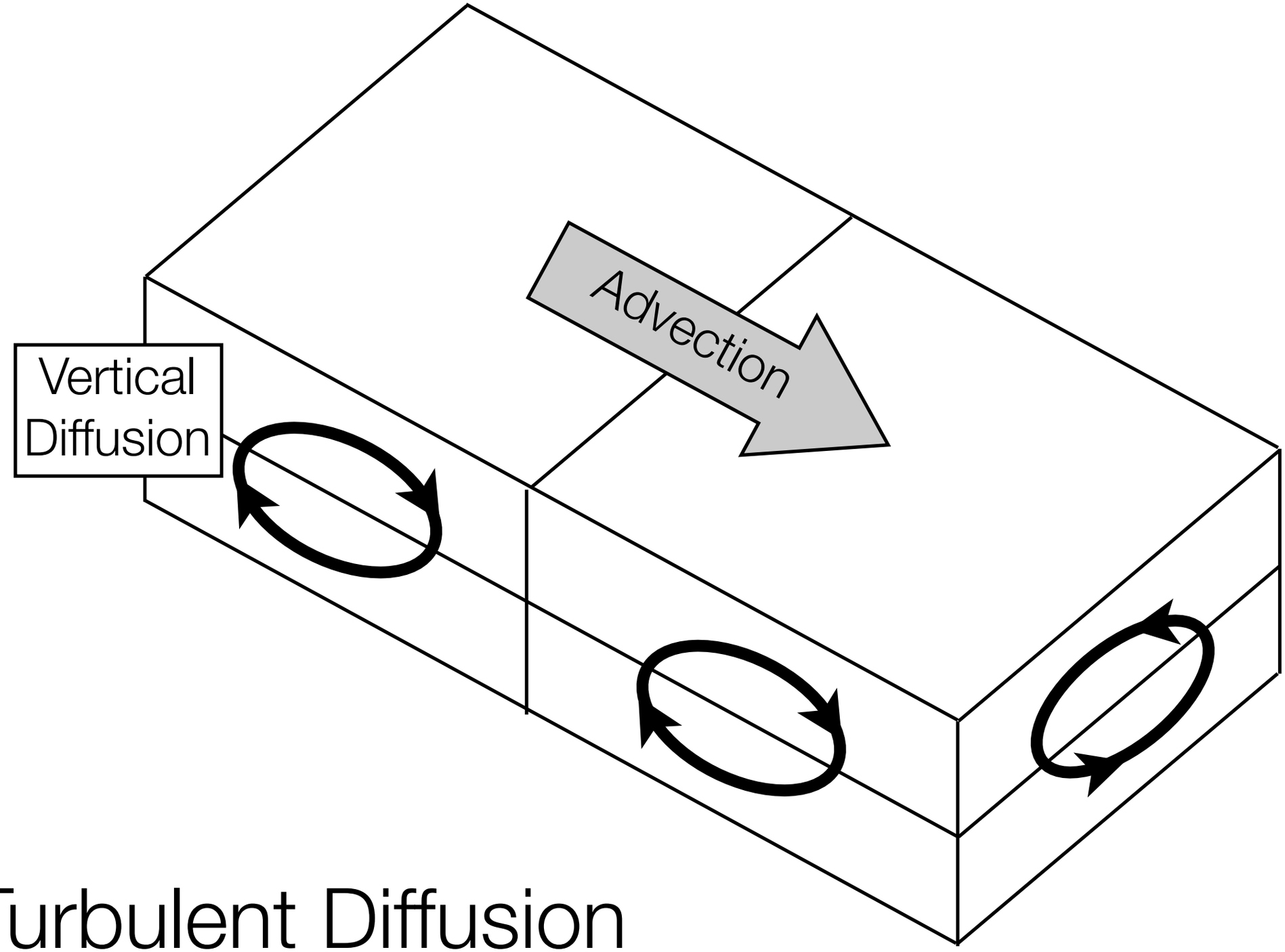


Advection

- upwind differencing for mometum
- flux limiter methods for scalars

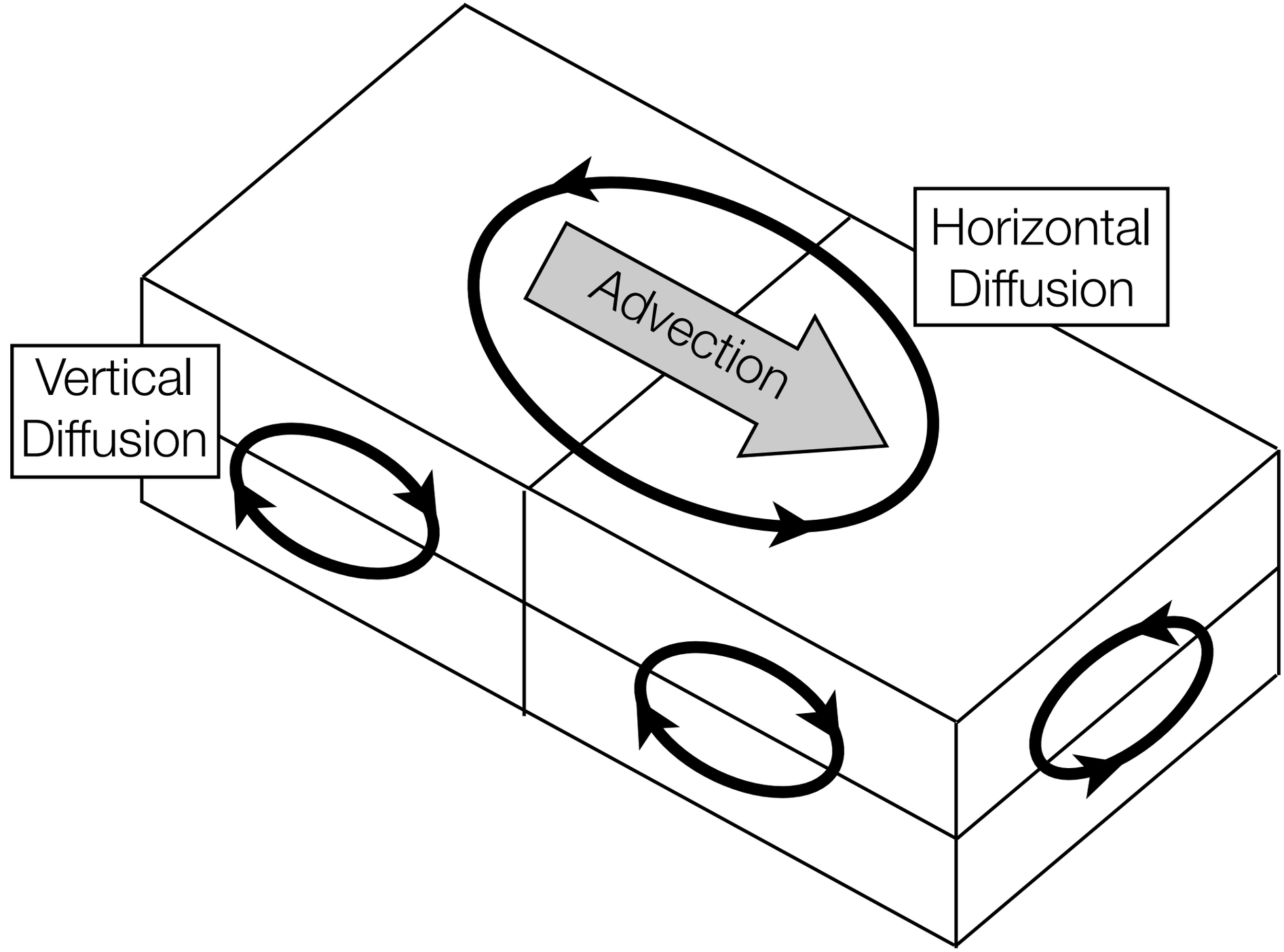
SI3D: Transport Between Cells



Vertical Turbulent Diffusion

- GOTM suite of turbulence models for vertical eddy diffusvity ν_V
- Mellor-Yamada 2.5-level scheme

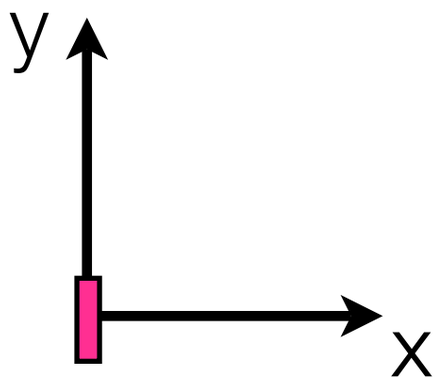
SI3D: Transport Between Cells



Horizontal Turbulent Diffusion

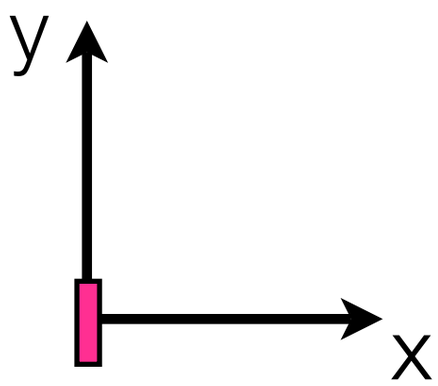
- Constant horiztonal eddy diffusivity ν_H

SI3D: Adding Point Sources



SI3D: Adding Point Sources

➡ Constant v_H is good for **passive** point sources



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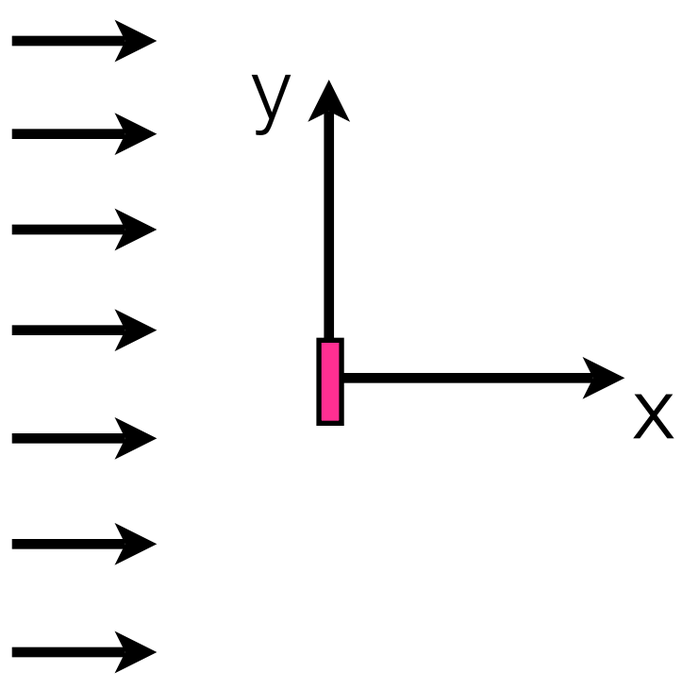

Ambient flow drives advection and diffusion of plume

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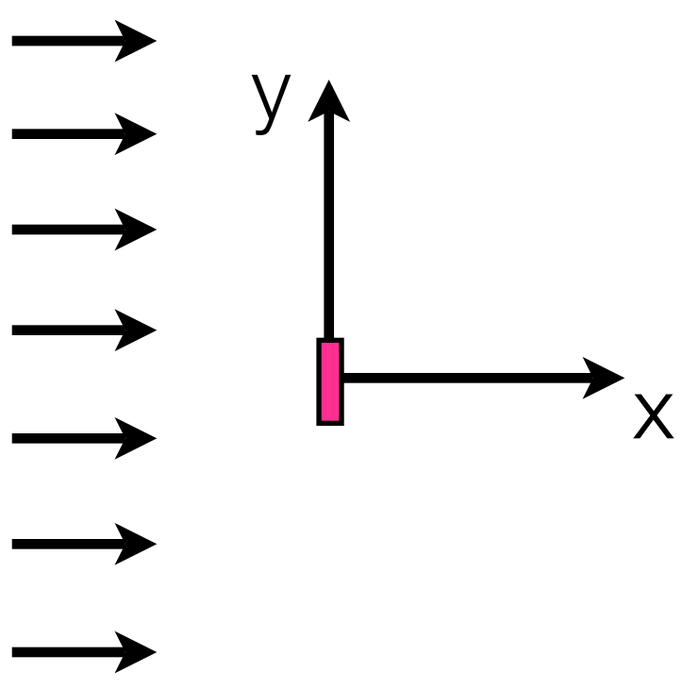

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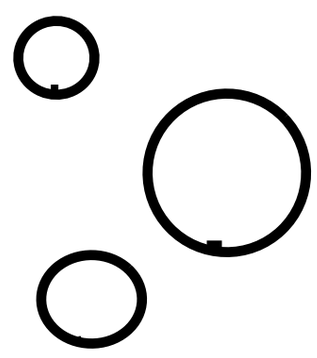

Ambient turbulence is well-approximated by v_H = constant

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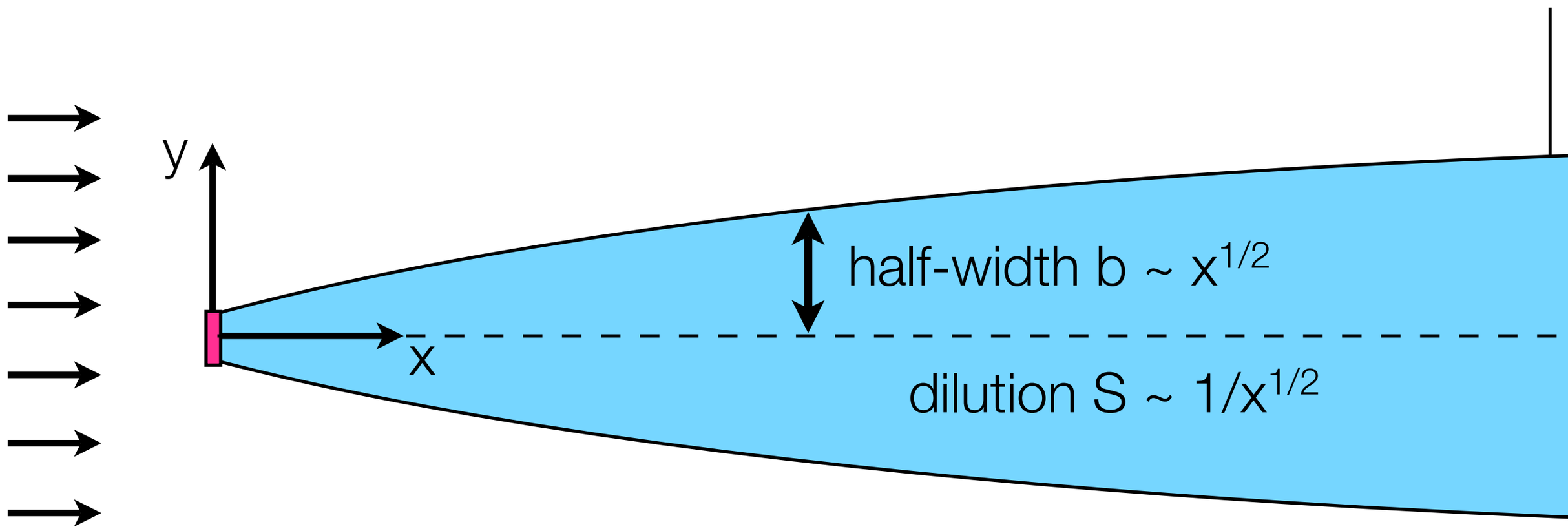

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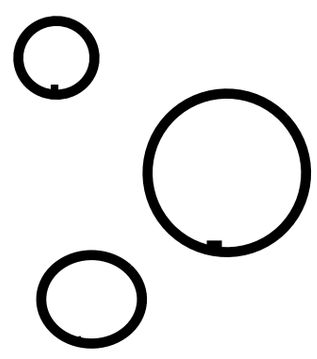

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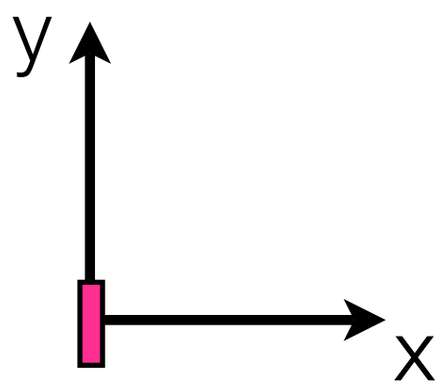
SI3D: Adding Point Sources

➡ Lake Source Cooling outfall is not a passive source!



SI3D: Adding Point Sources

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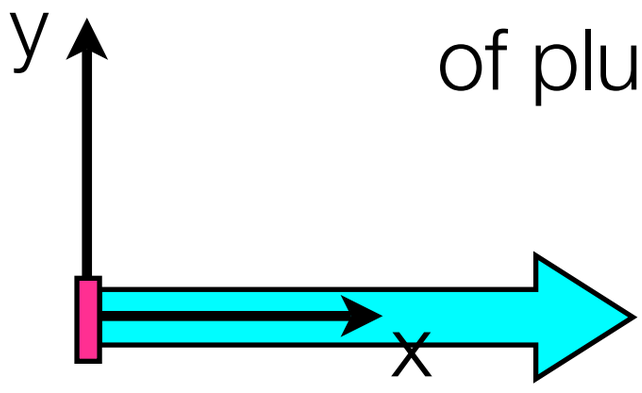
Jet momentum drives
advection and diffusion
of plume



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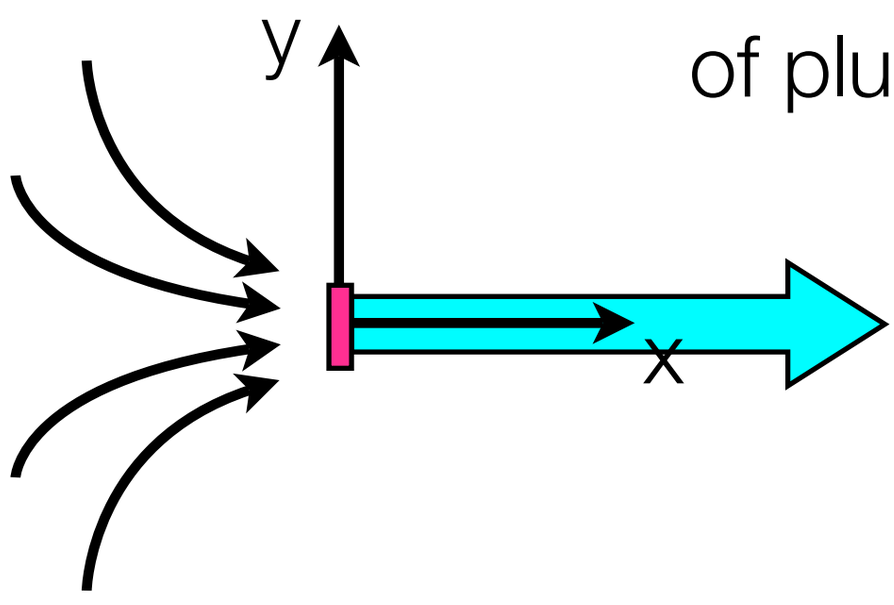

Disturbance in water surface drives strong back entrainment

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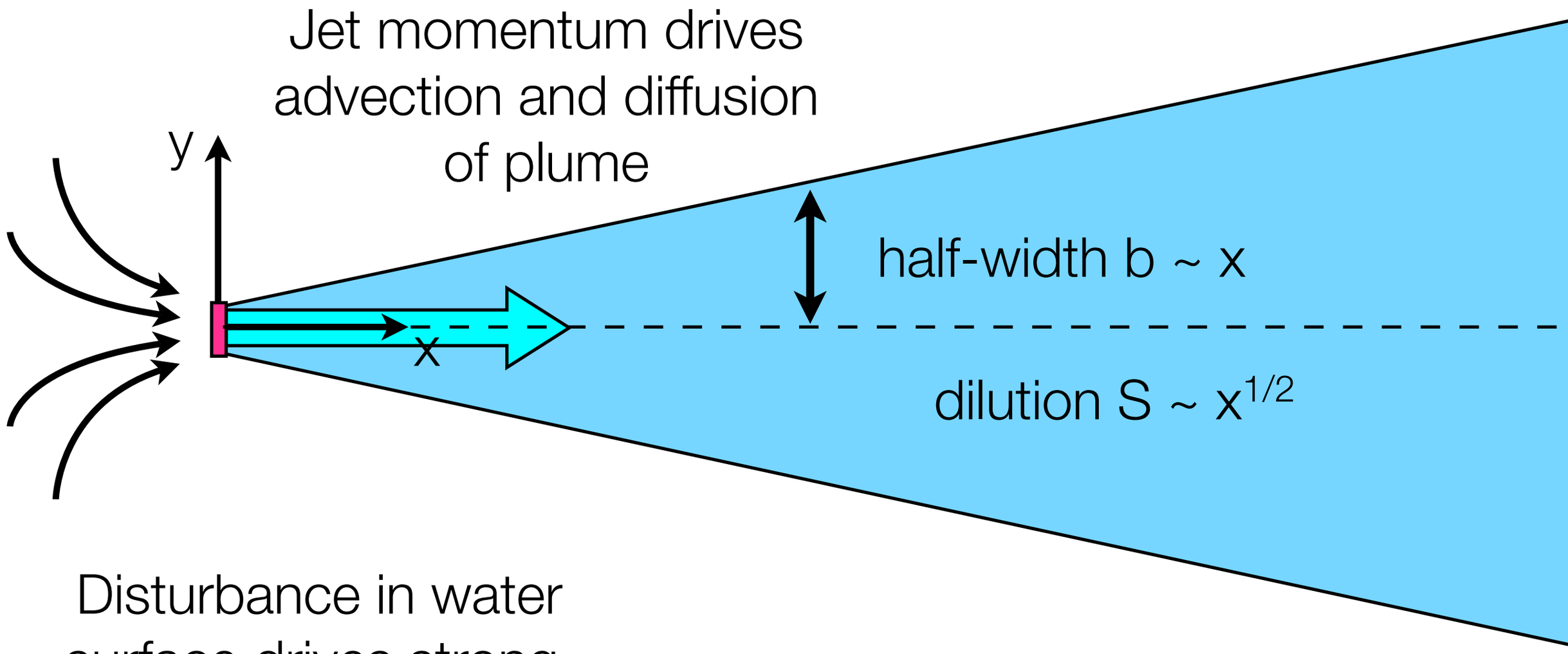

Disturbance in water
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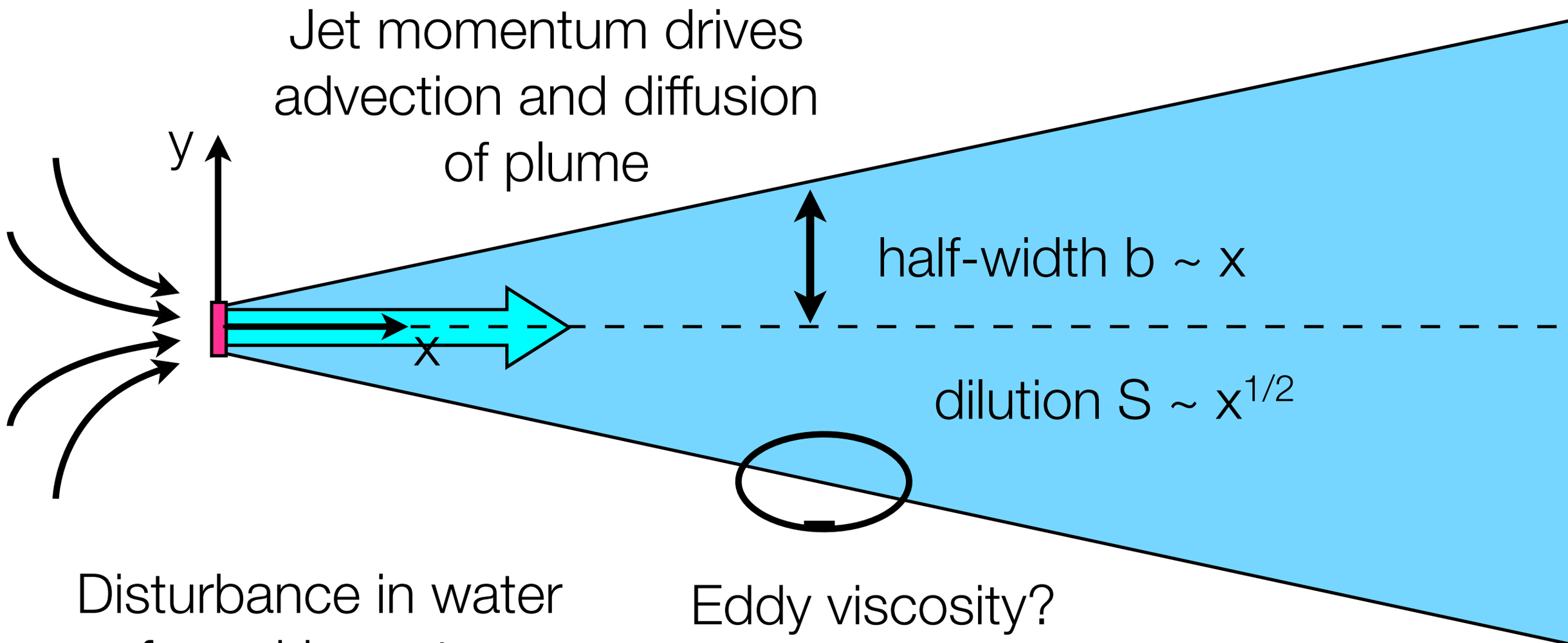

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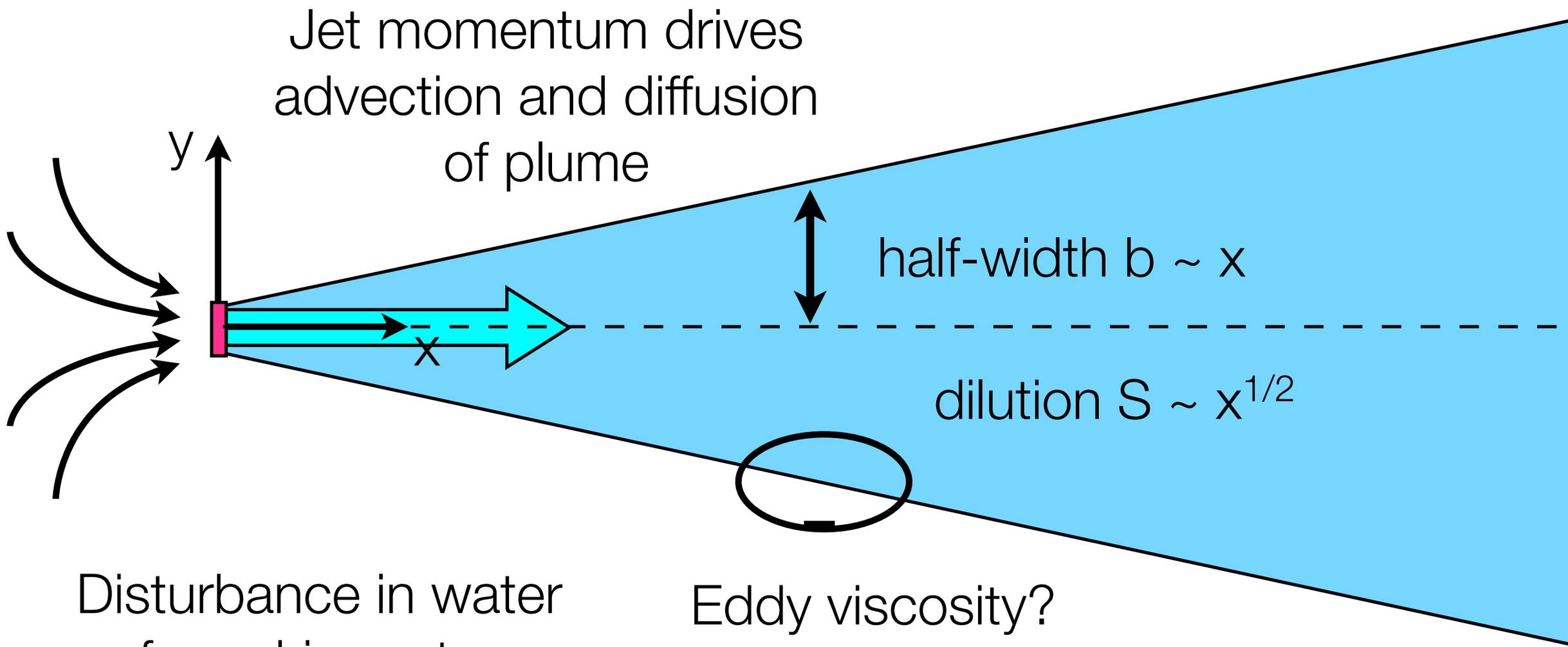
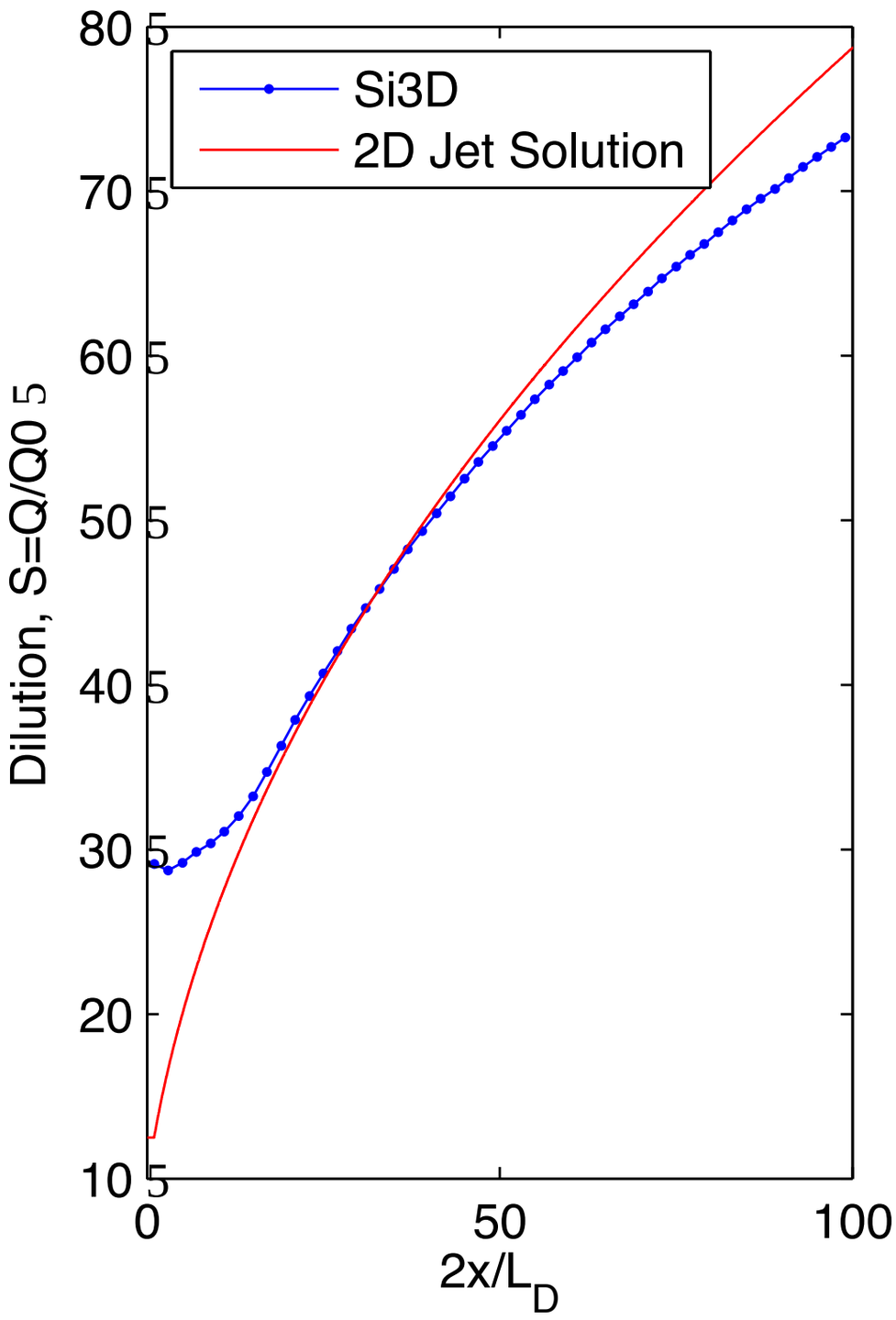


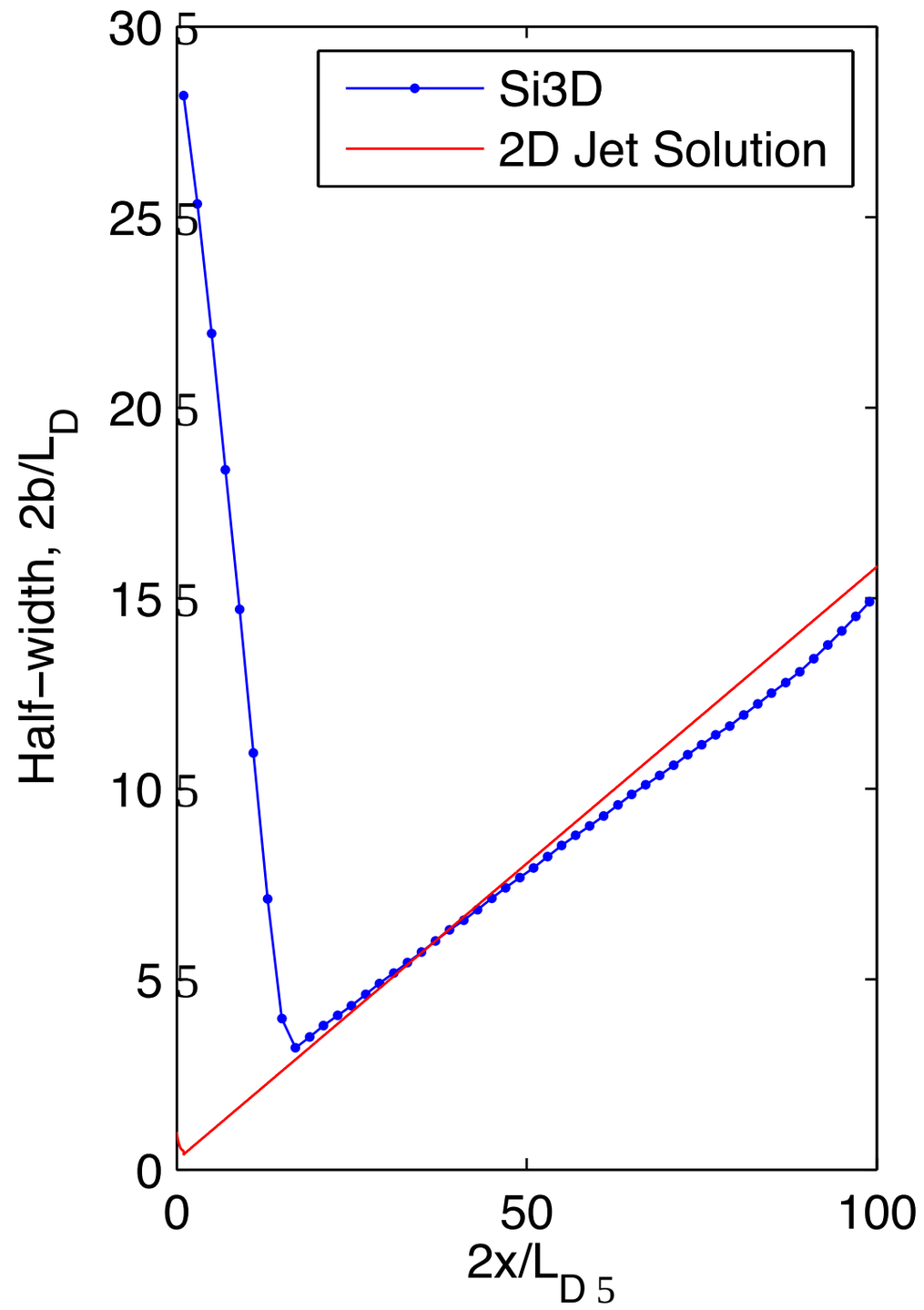
Disturbance in water surface drives strong back entrainment

Eddy viscosity?

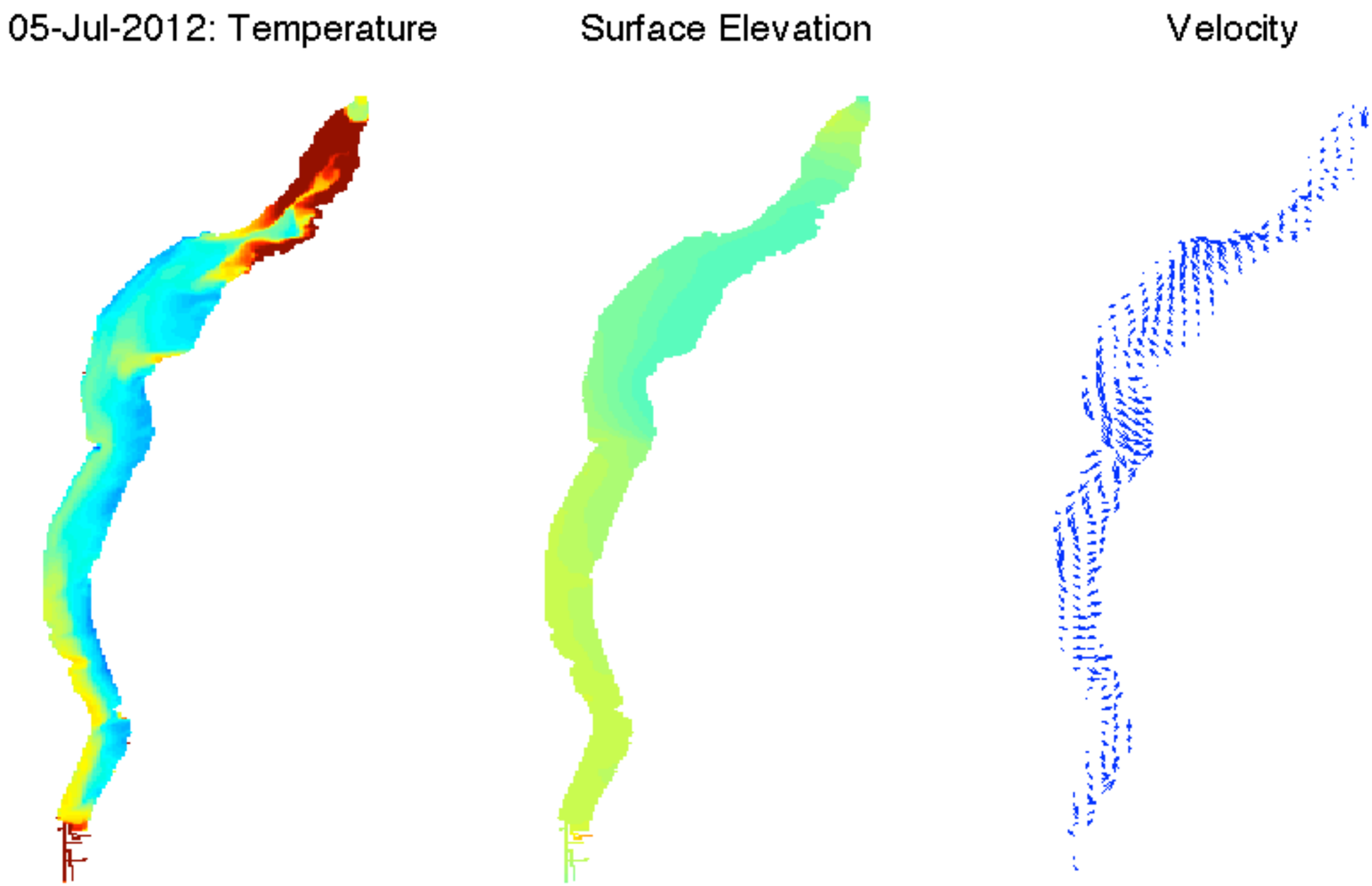
$\nu_H \sim x^{1/2}\exp(-y^2/x^2)$ seems to work!

SI3D: Adding Point Sources





SI3D: Output



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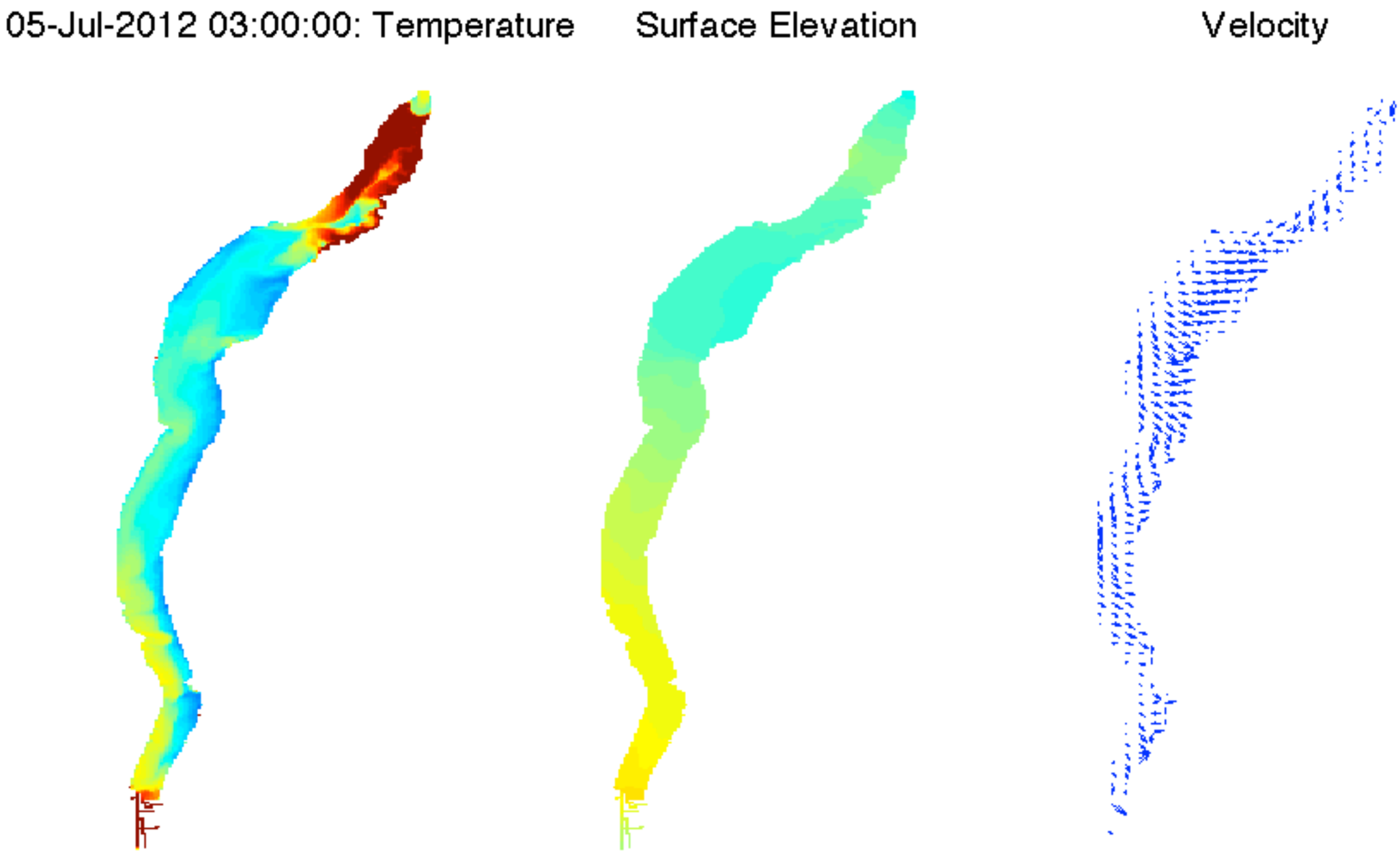
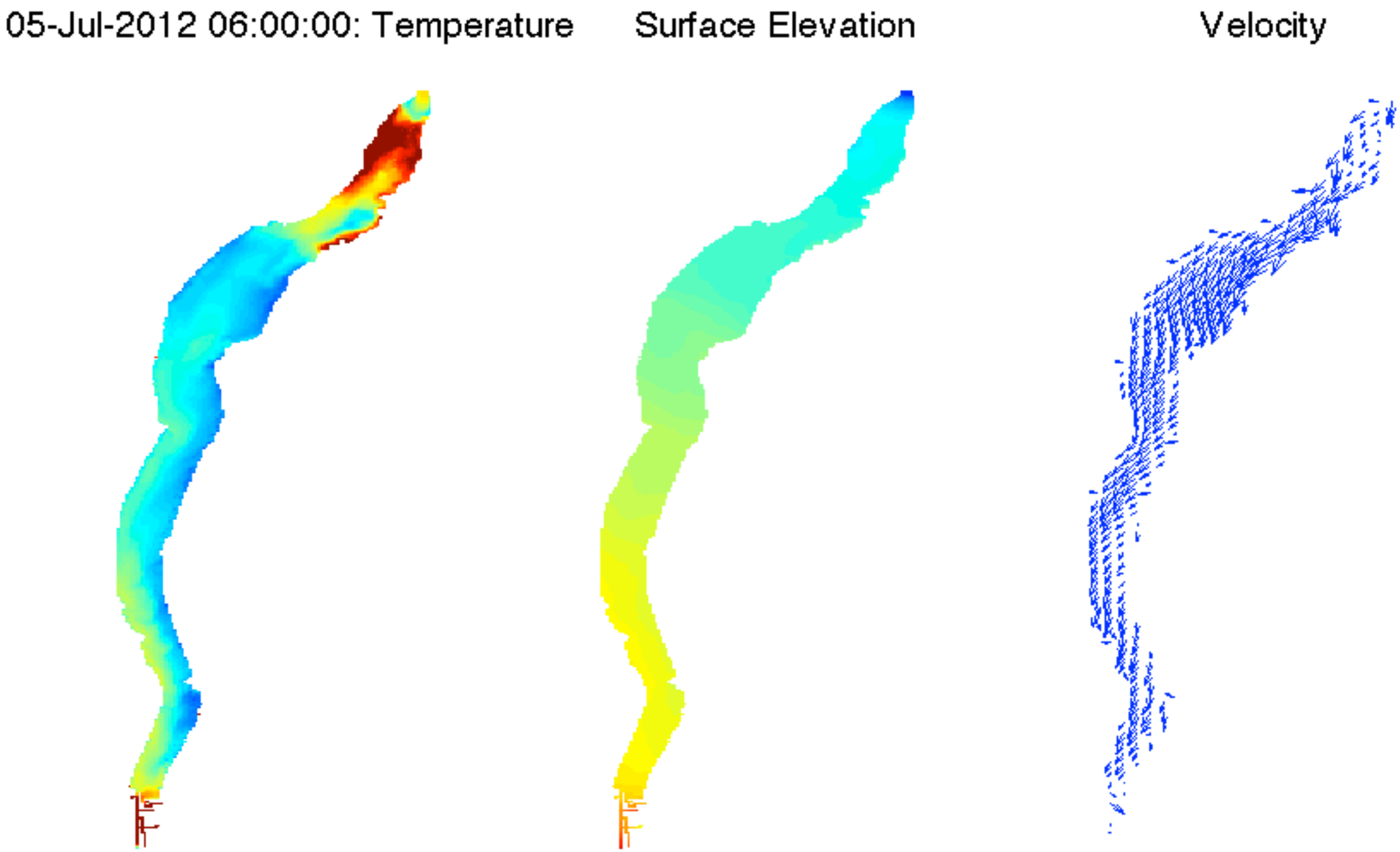
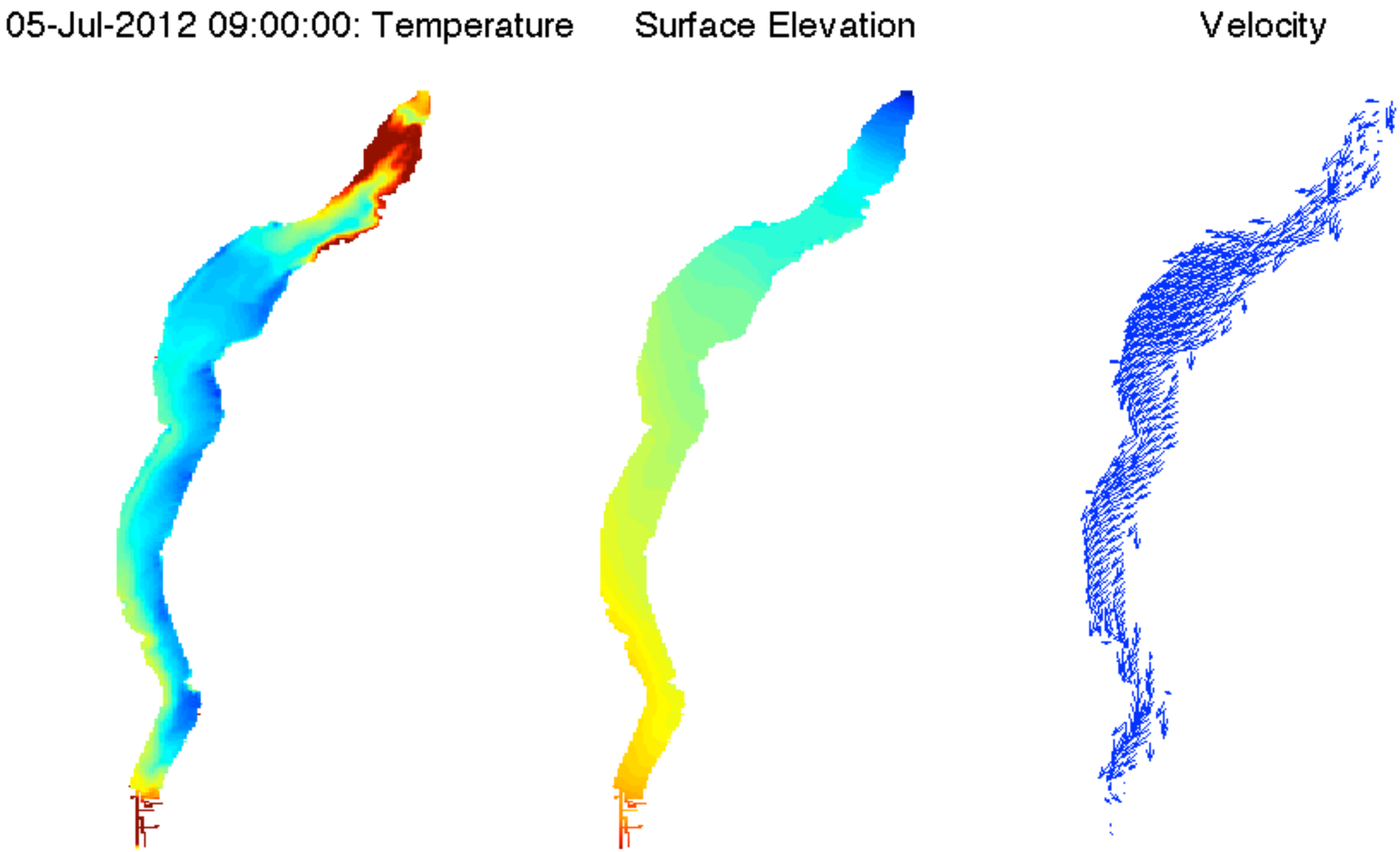

05-Jul-2012 03:00:00: Temperature
Surface Elevation
Velocity

SI3D: Output


05-Jul-2012 06:00:00: Temperature
Surface Elevation
Velocity

SI3D: Output


05-Jul-2012 09:00:00: Temperature
Surface Elevation
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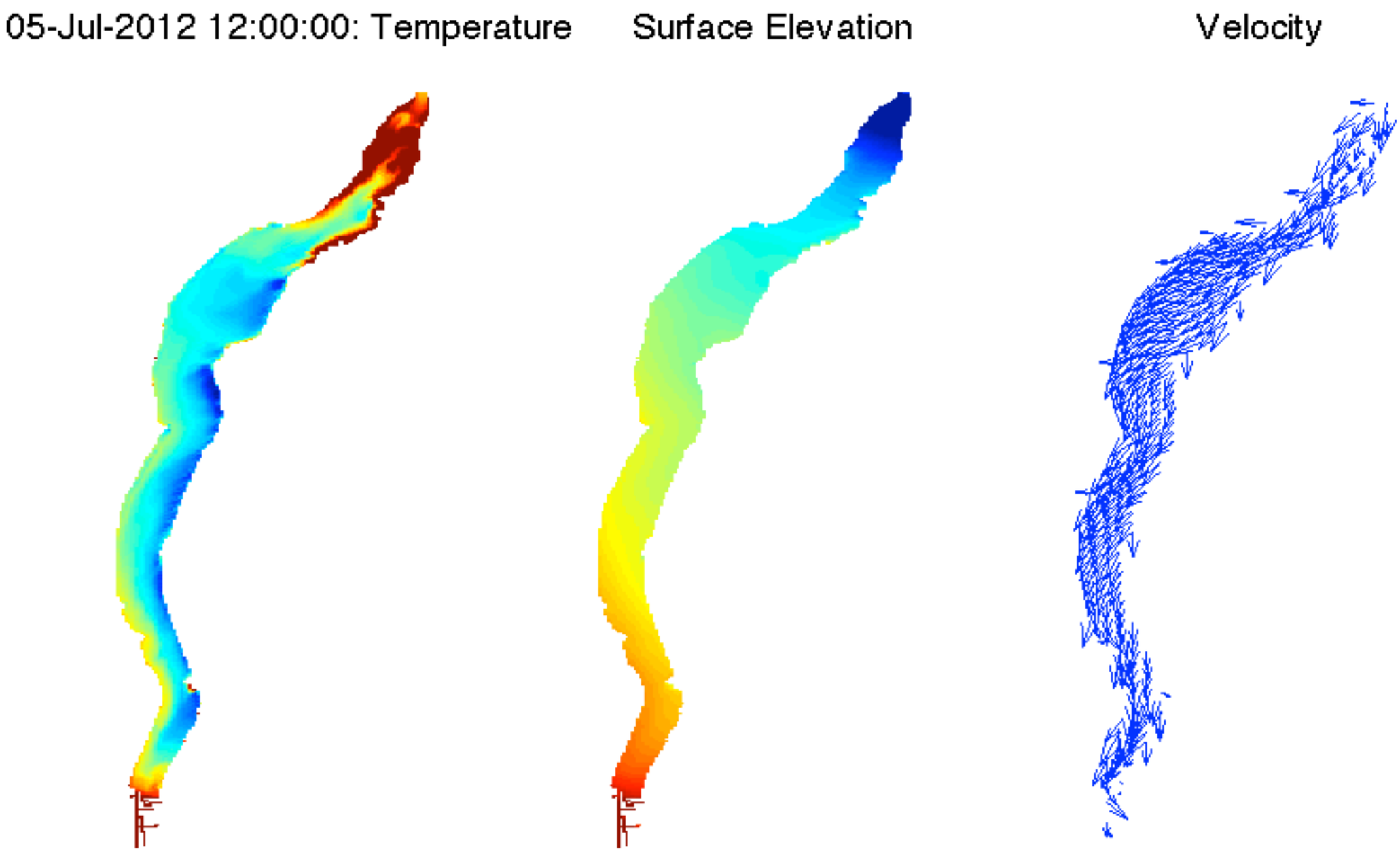
05-Jul-2012 12:00:00: Temperature
Surface Elevation
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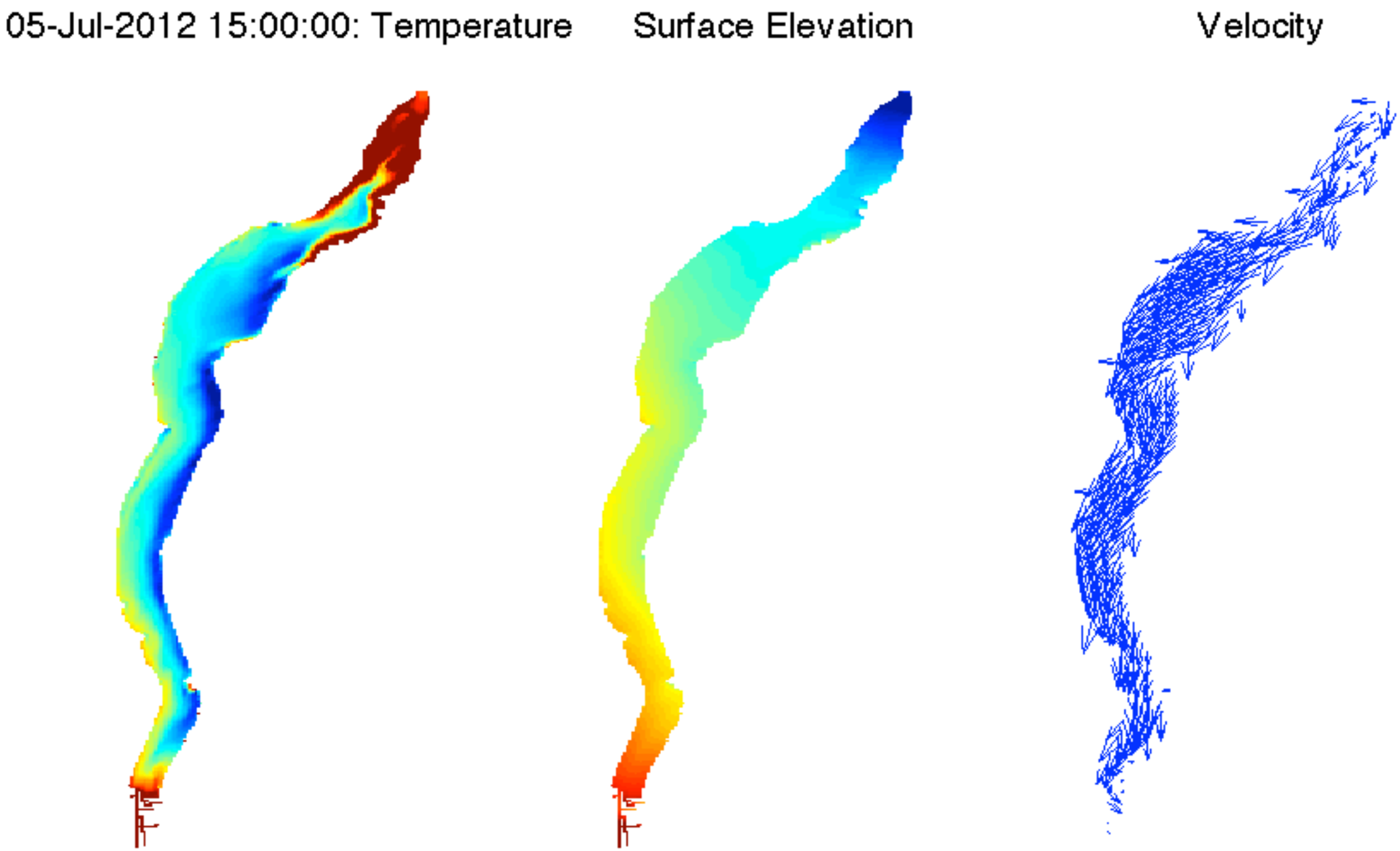
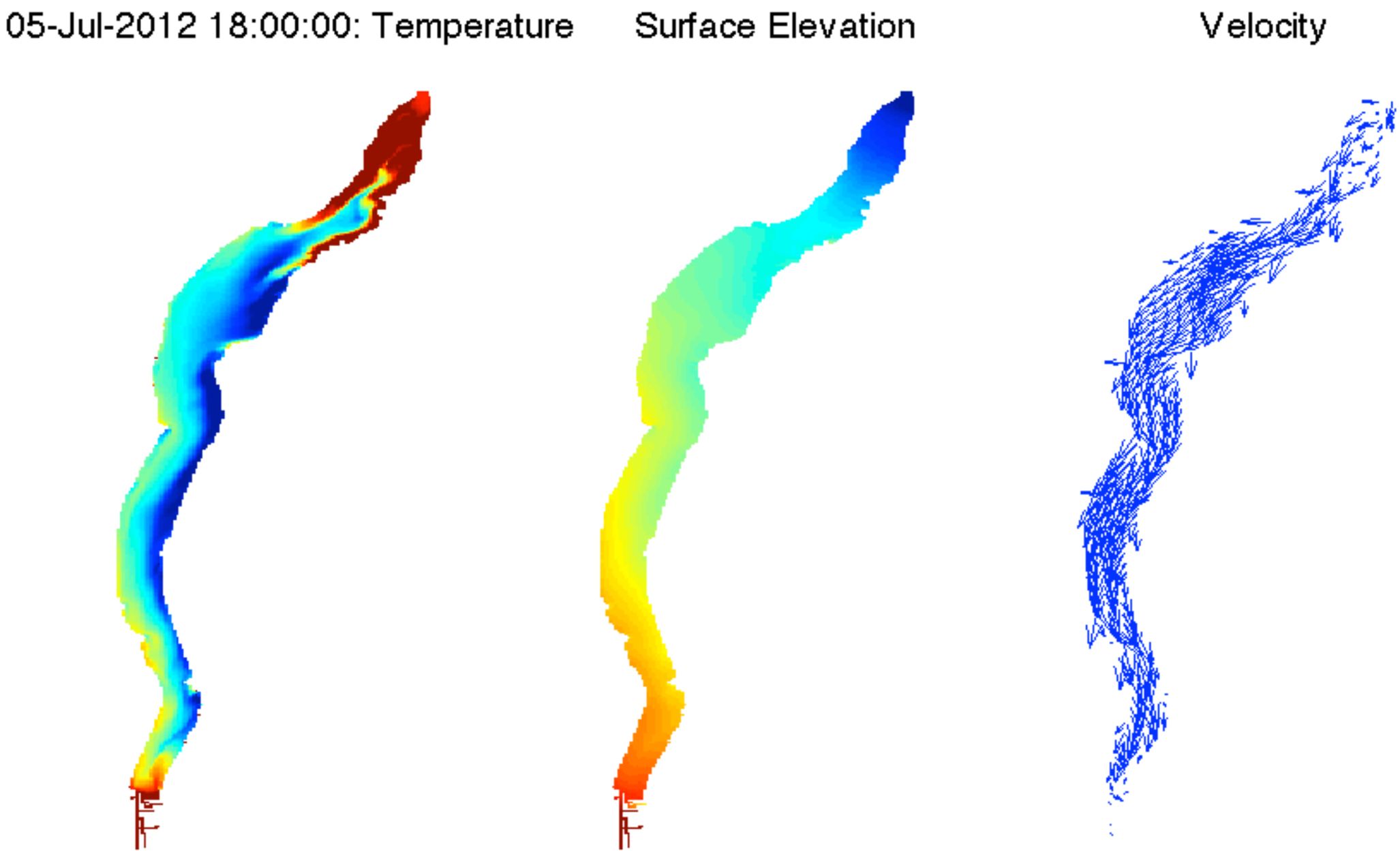
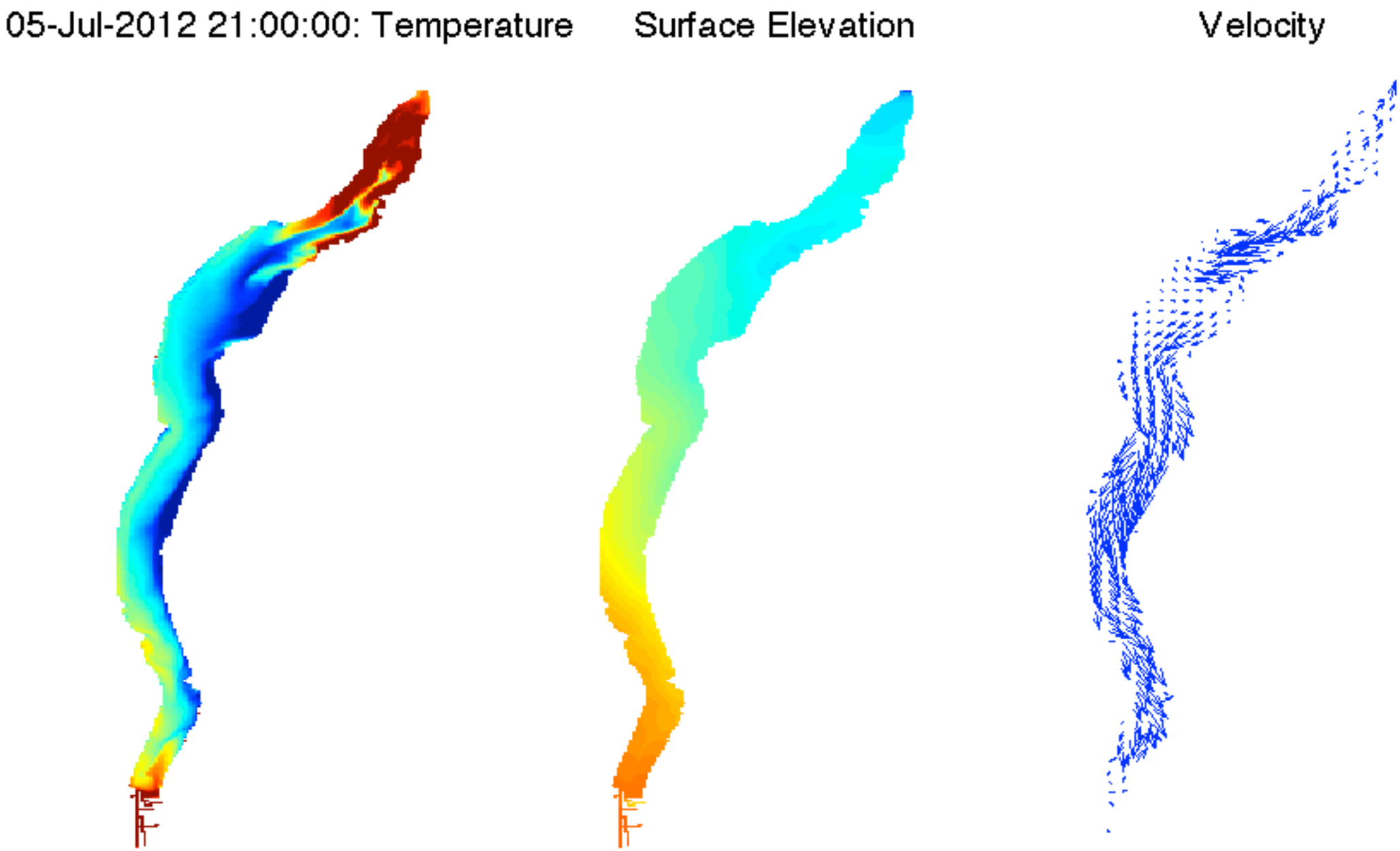

05-Jul-2012 15:00:00: Temperature
Surface Elevation
Velocity

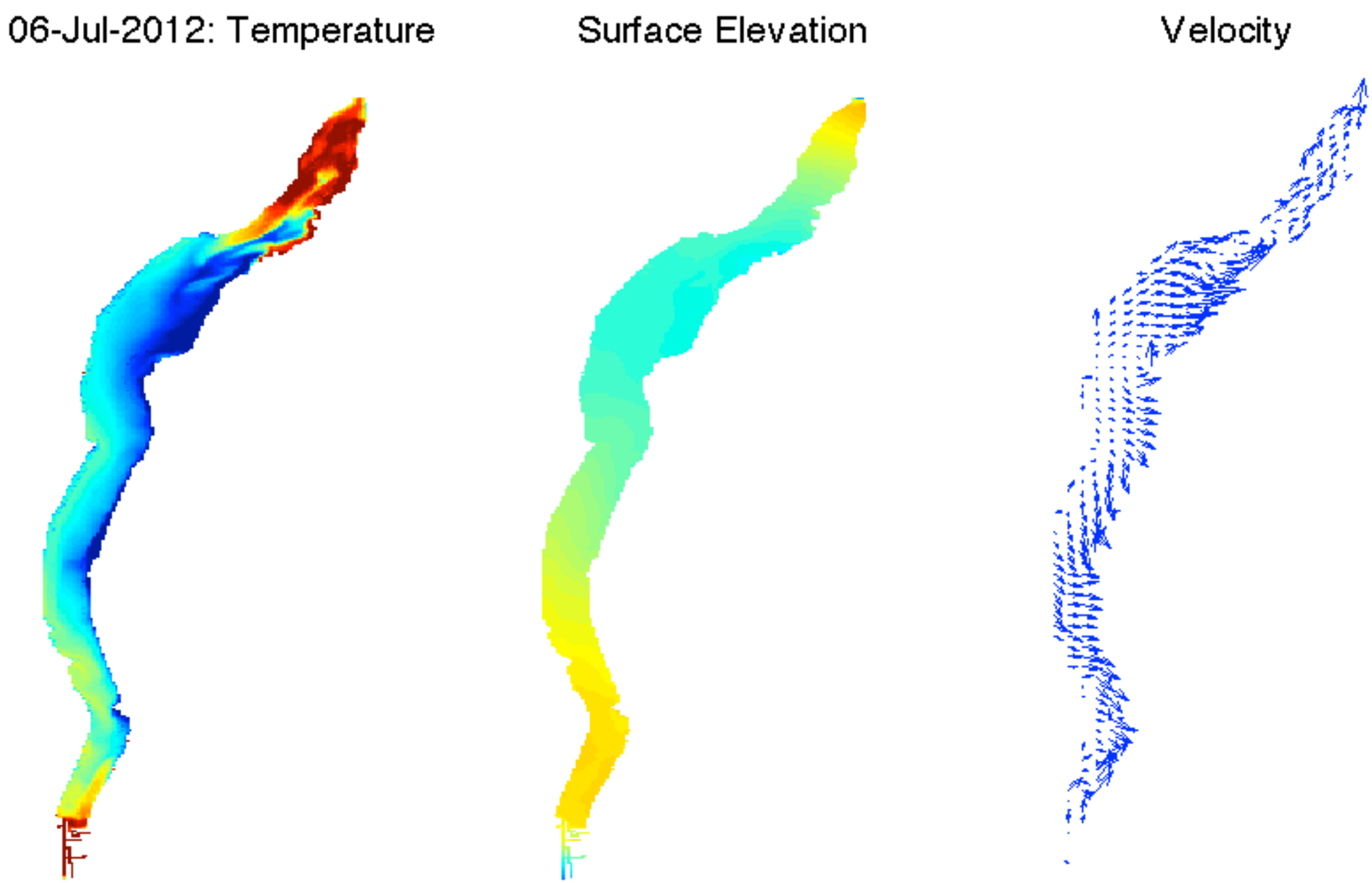
SI3D: Output


05-Jul-2012 18:00:00: Temperature
Surface Elevation
Velocity

SI3D: Output


05-Jul-2012 21:00:00: Temperature
Surface Elevation
Velocity

SI3D: Output



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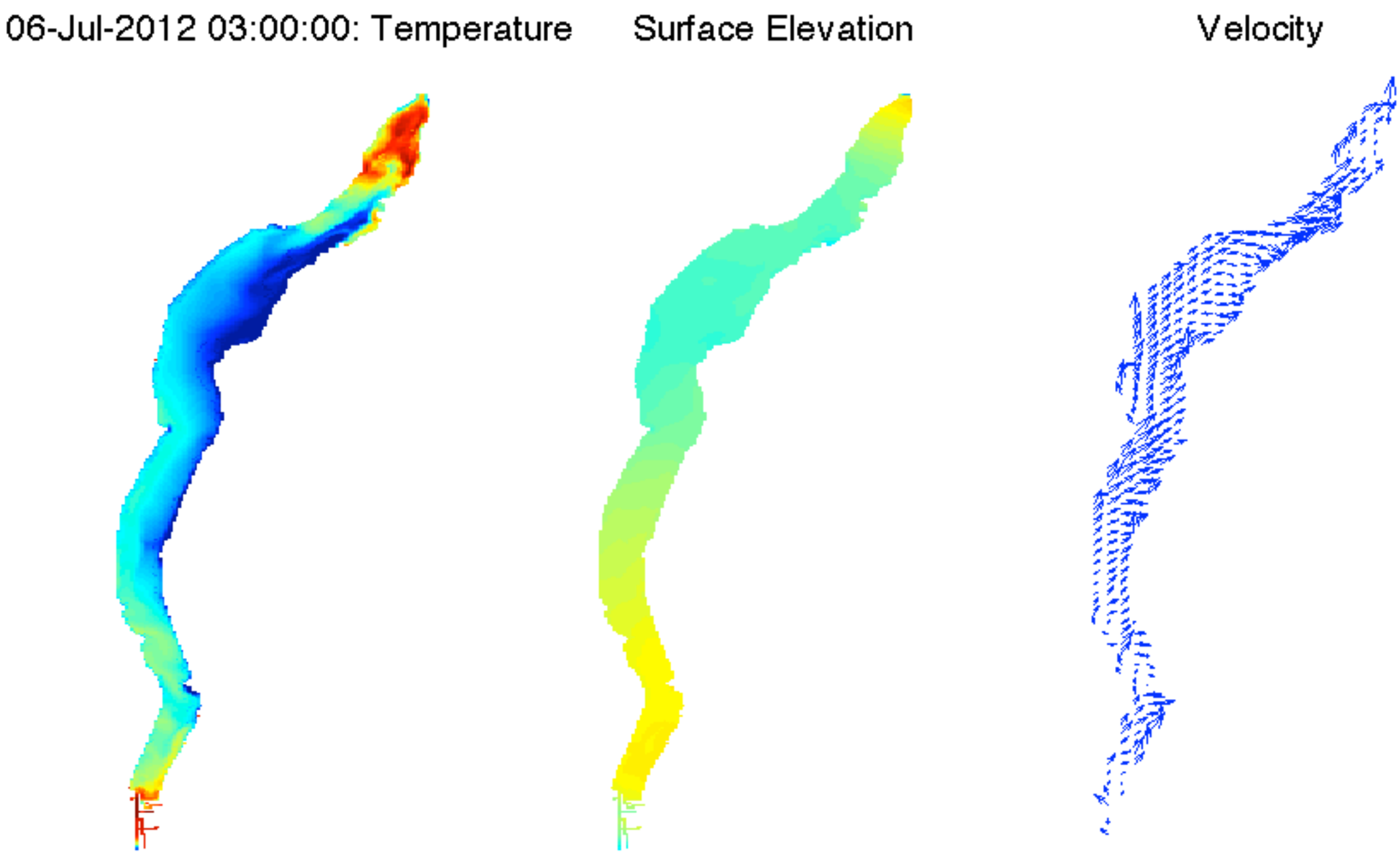
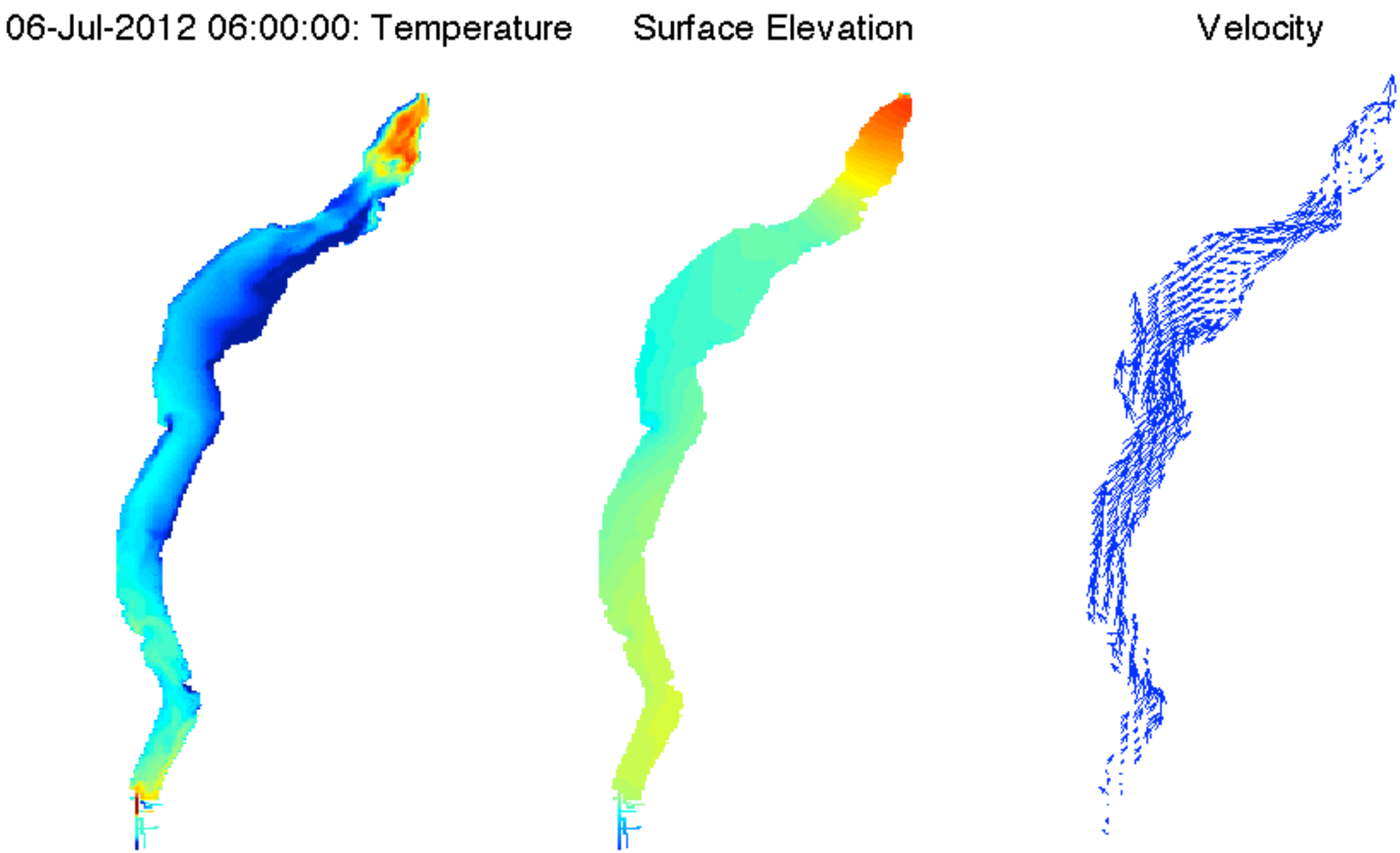
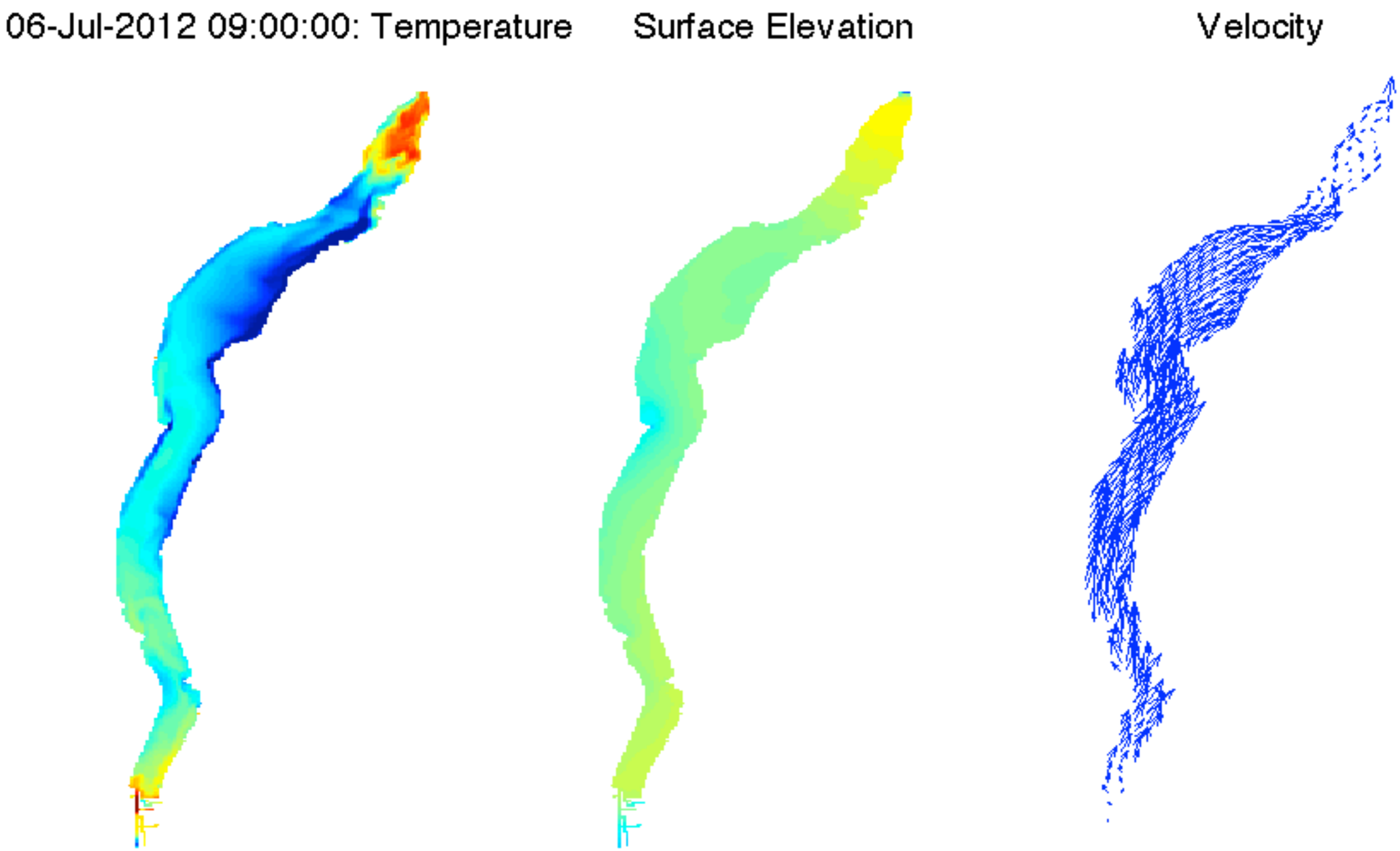

06-Jul-2012 03:00:00: Temperature
Surface Elevation
Velocity

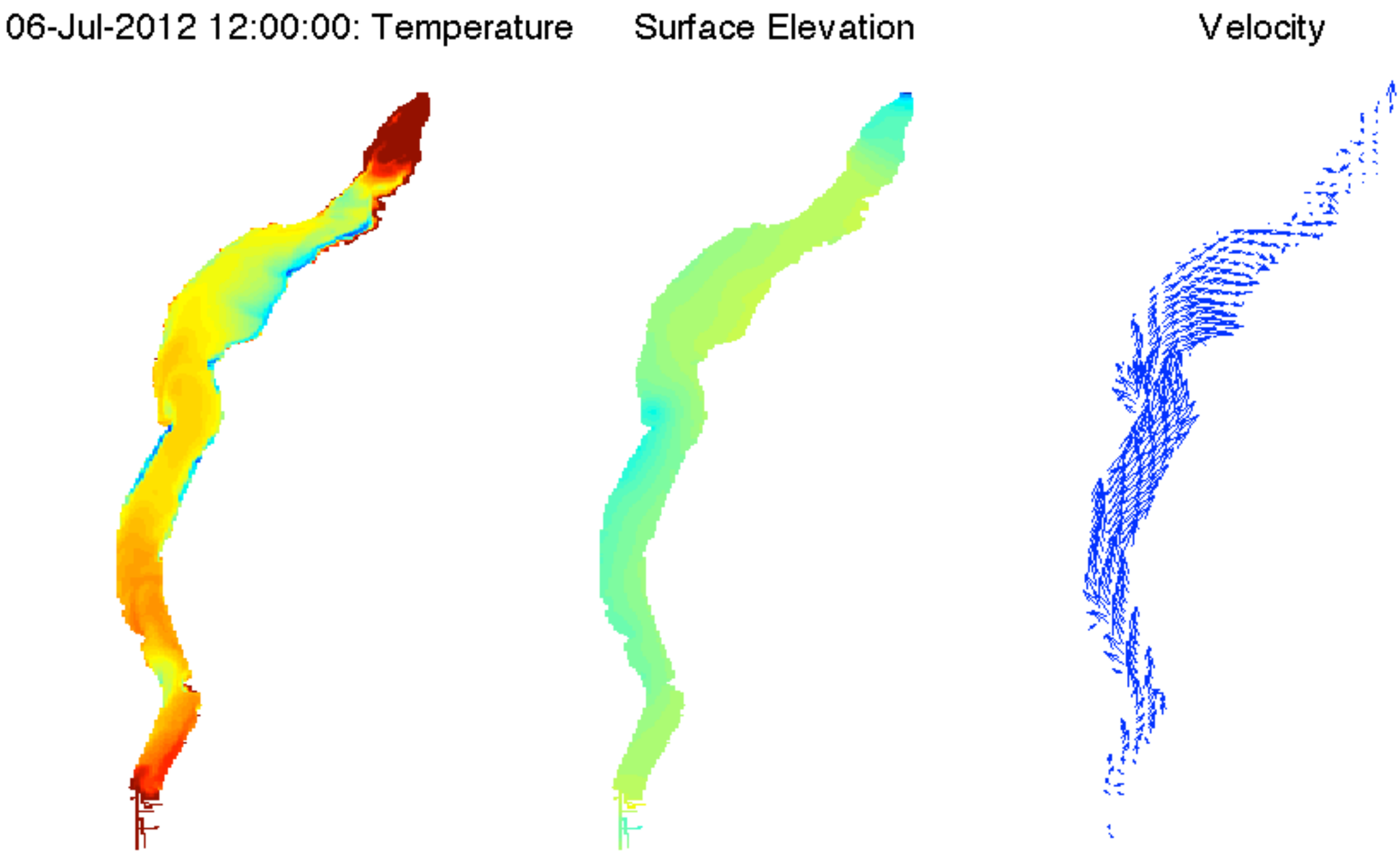
SI3D: Output


06-Jul-2012 06:00:00: Temperature
Surface Elevation
Velocity

SI3D: Output


06-Jul-2012 09:00:00: Temperature
Surface Elevation
Velocity

SI3D: Output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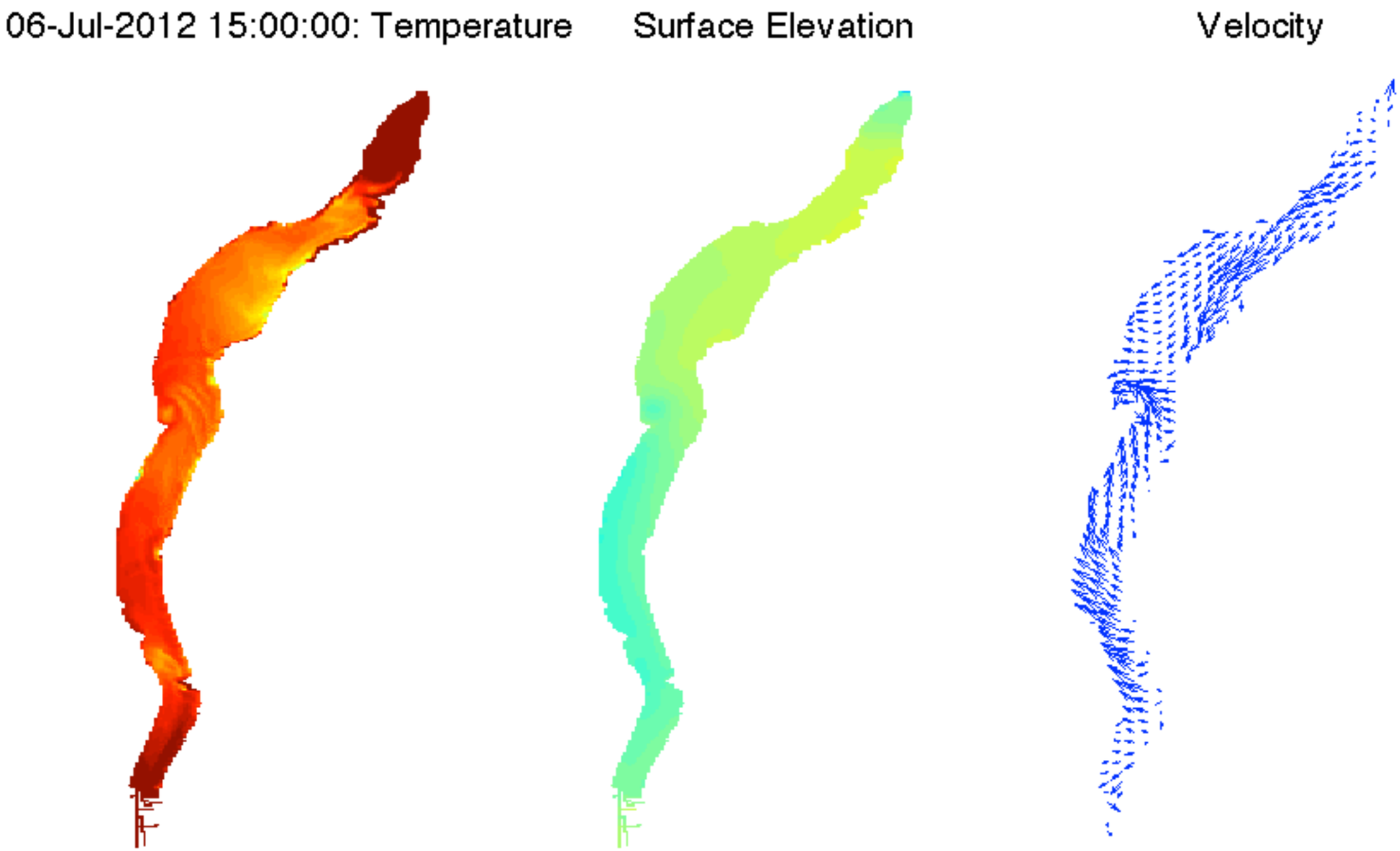
06-Jul-2012 15:00:00: Temperature
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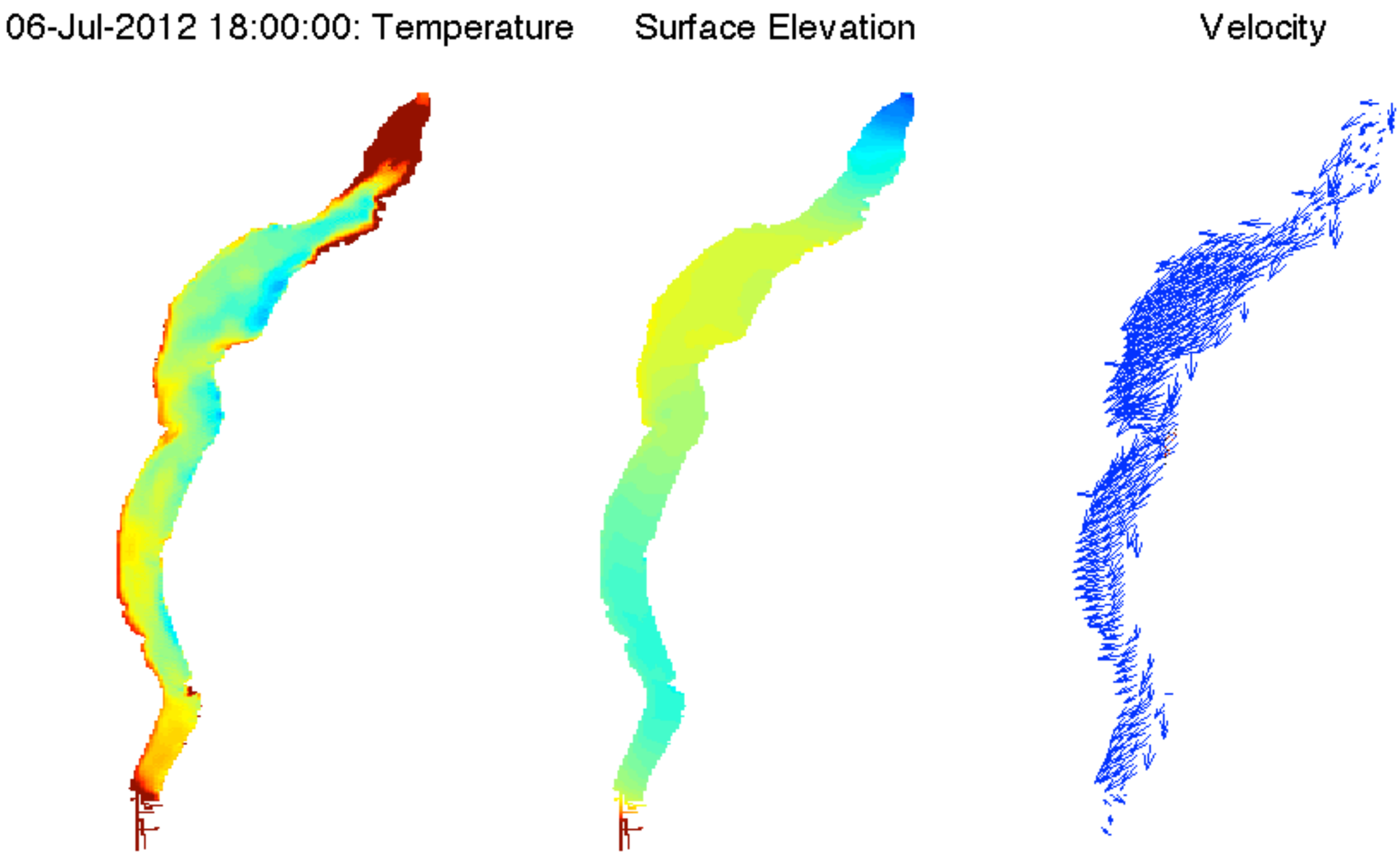
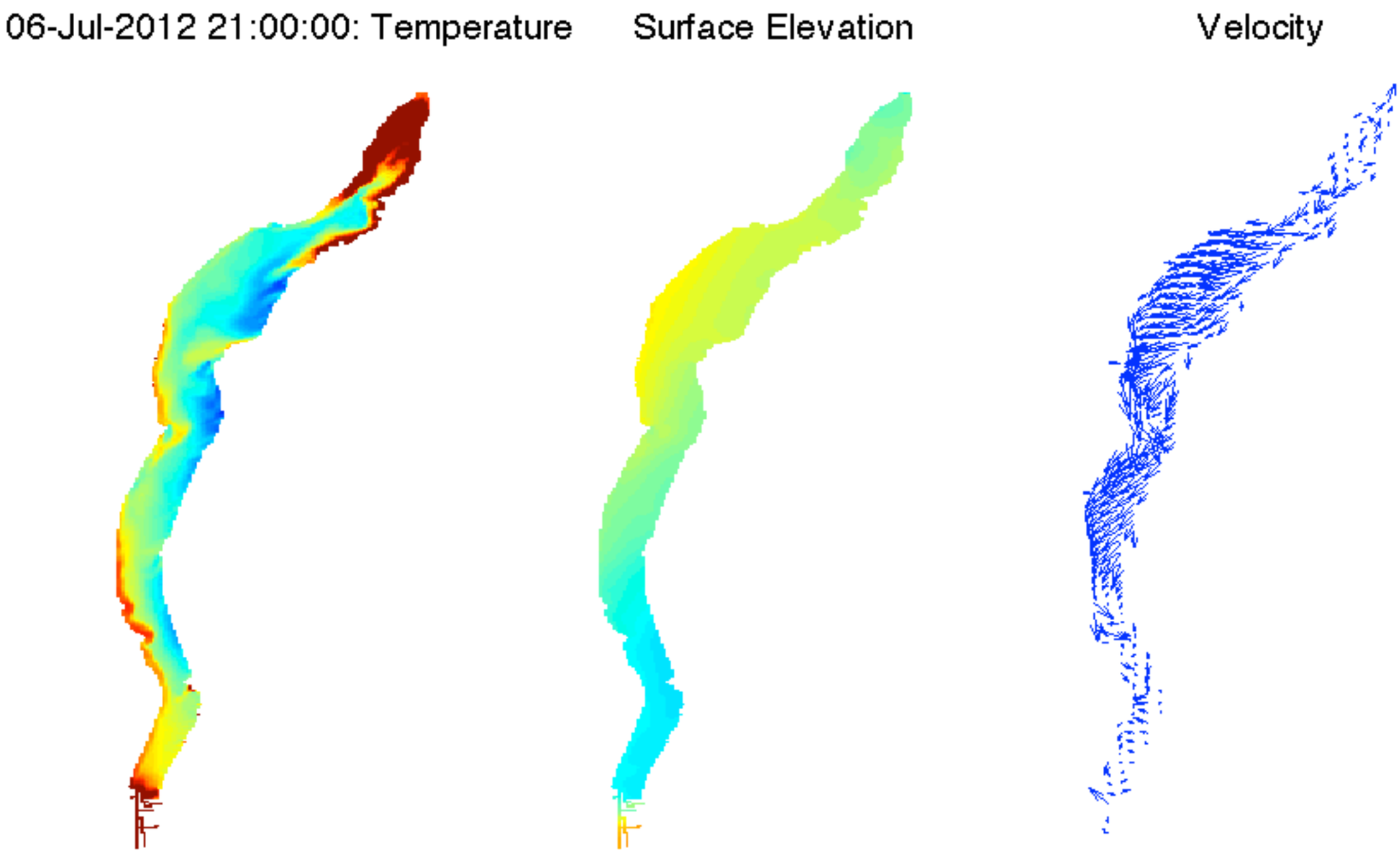
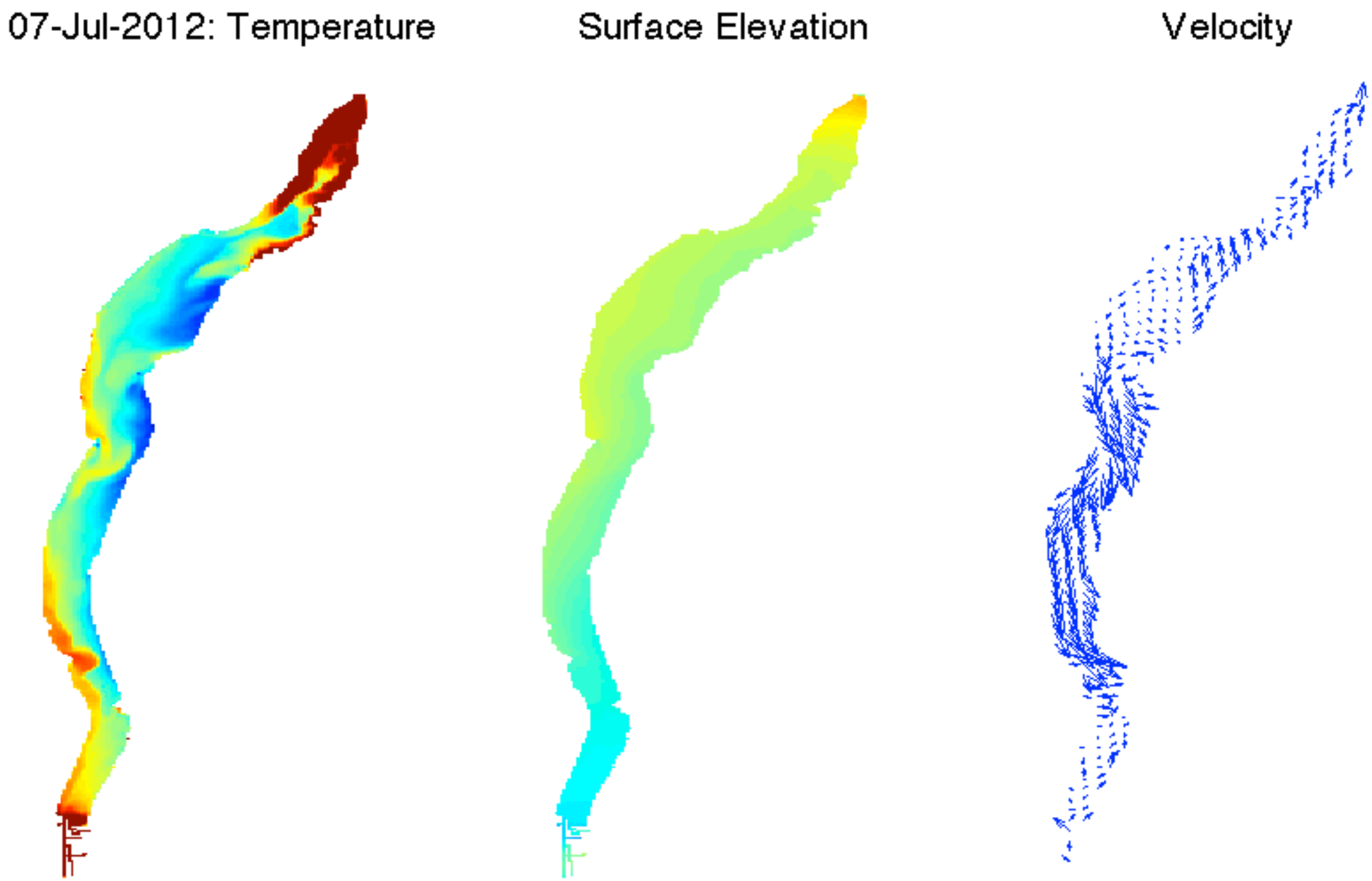
SI3D: Output


06-Jul-2012 18:00:00: Temperature
Surface Elevation
Velocity

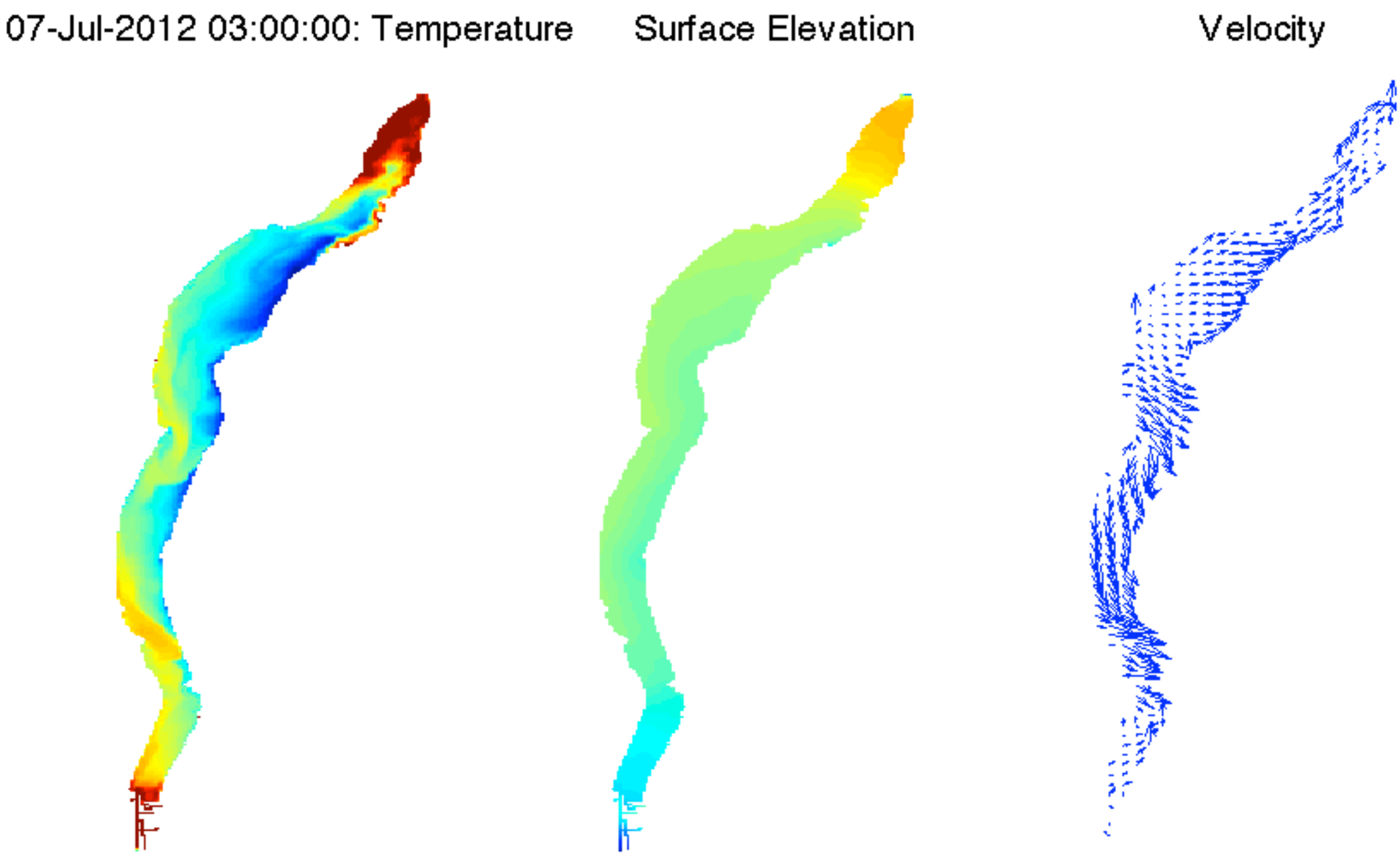
SI3D: Output


06-Jul-2012 21:00:00: Temperature
Surface Elevation
Velocity

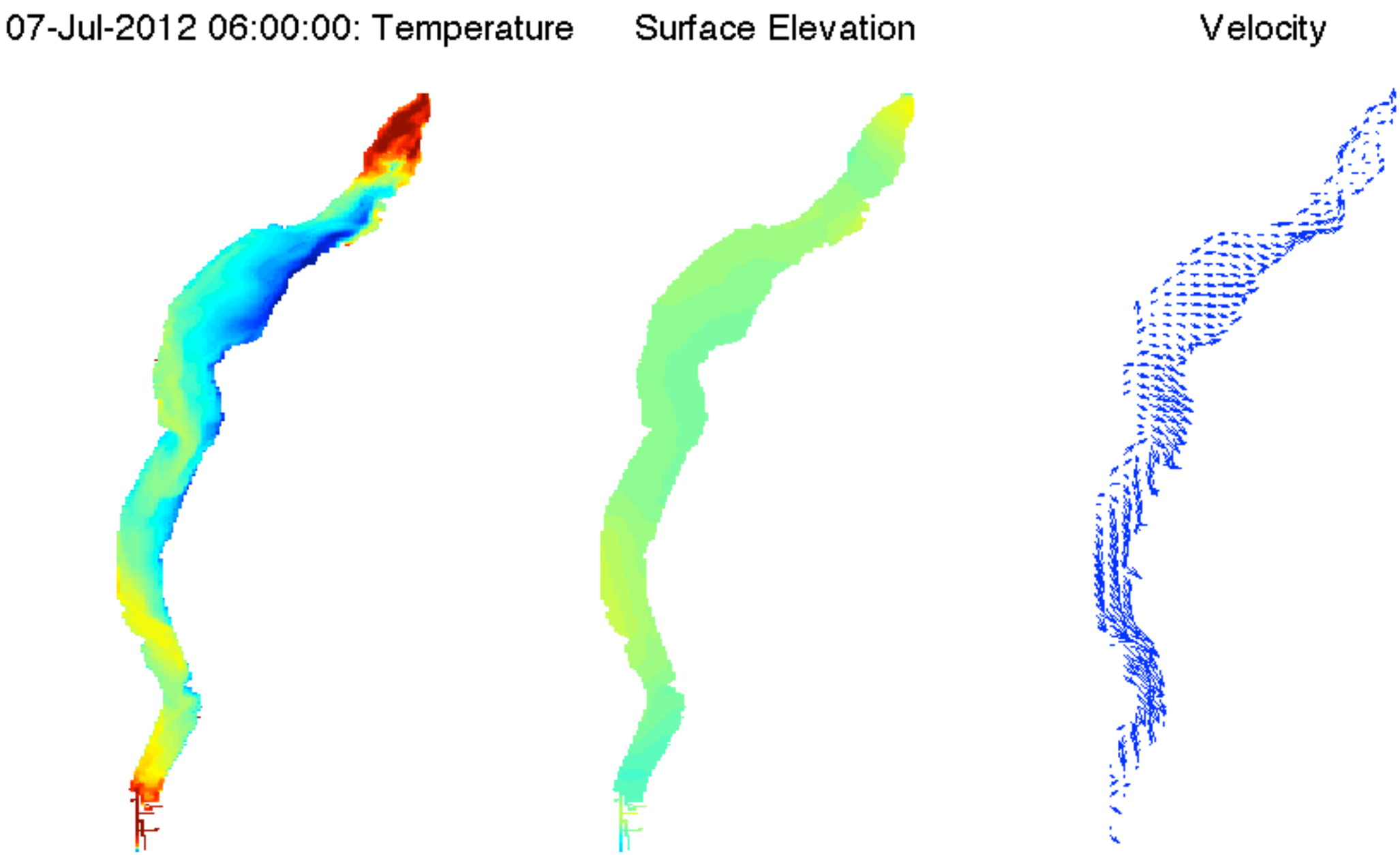
SI3D: Output



SI3D: Output


07-Jul-2012 03:00:00: Temperature
Surface Elevation
Velocity

SI3D: Output


07-Jul-2012 06:00:00: Temperature
Surface Elevation
Velocity

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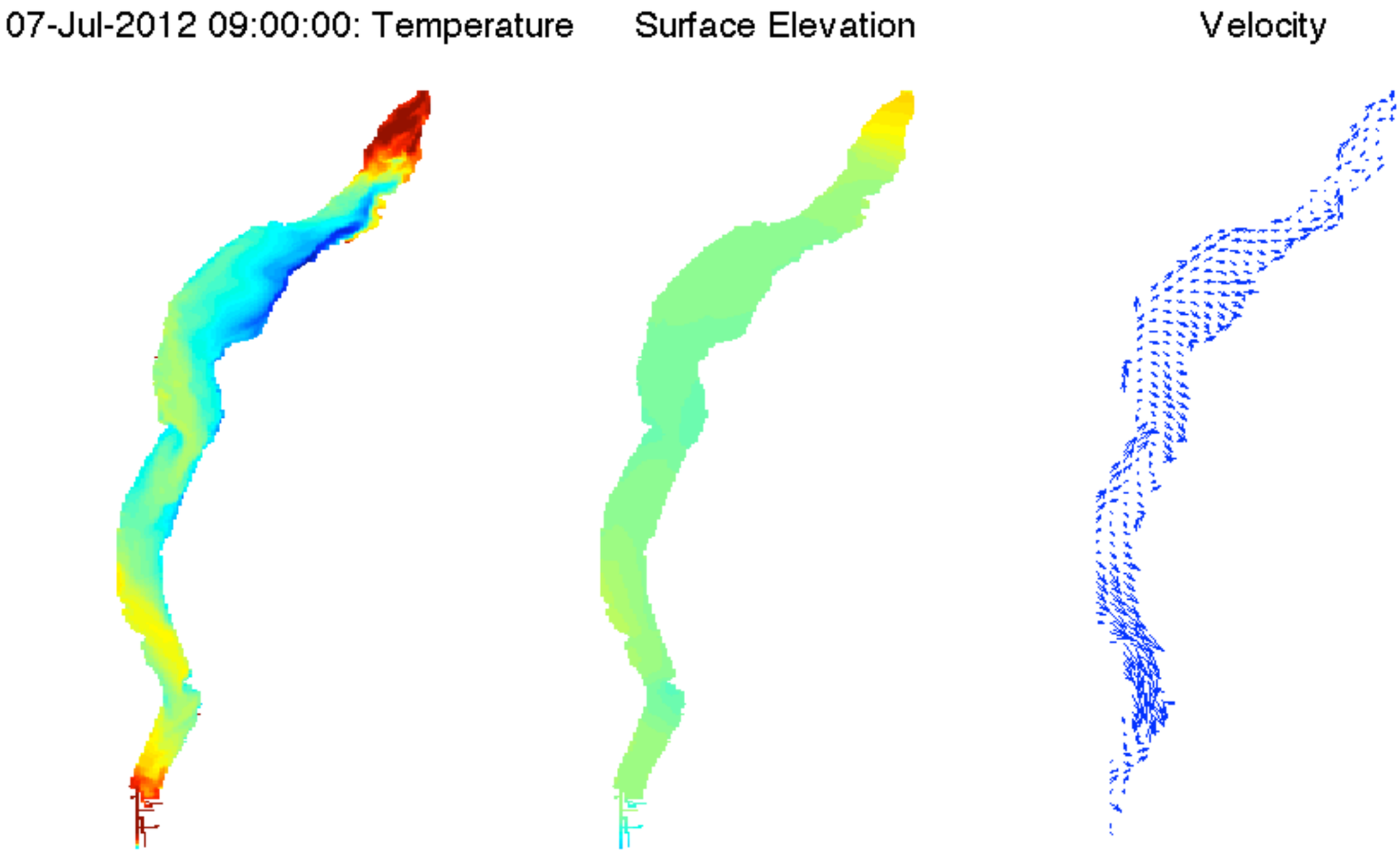
07-Jul-2012 09:00:00: Temperature
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Velocity

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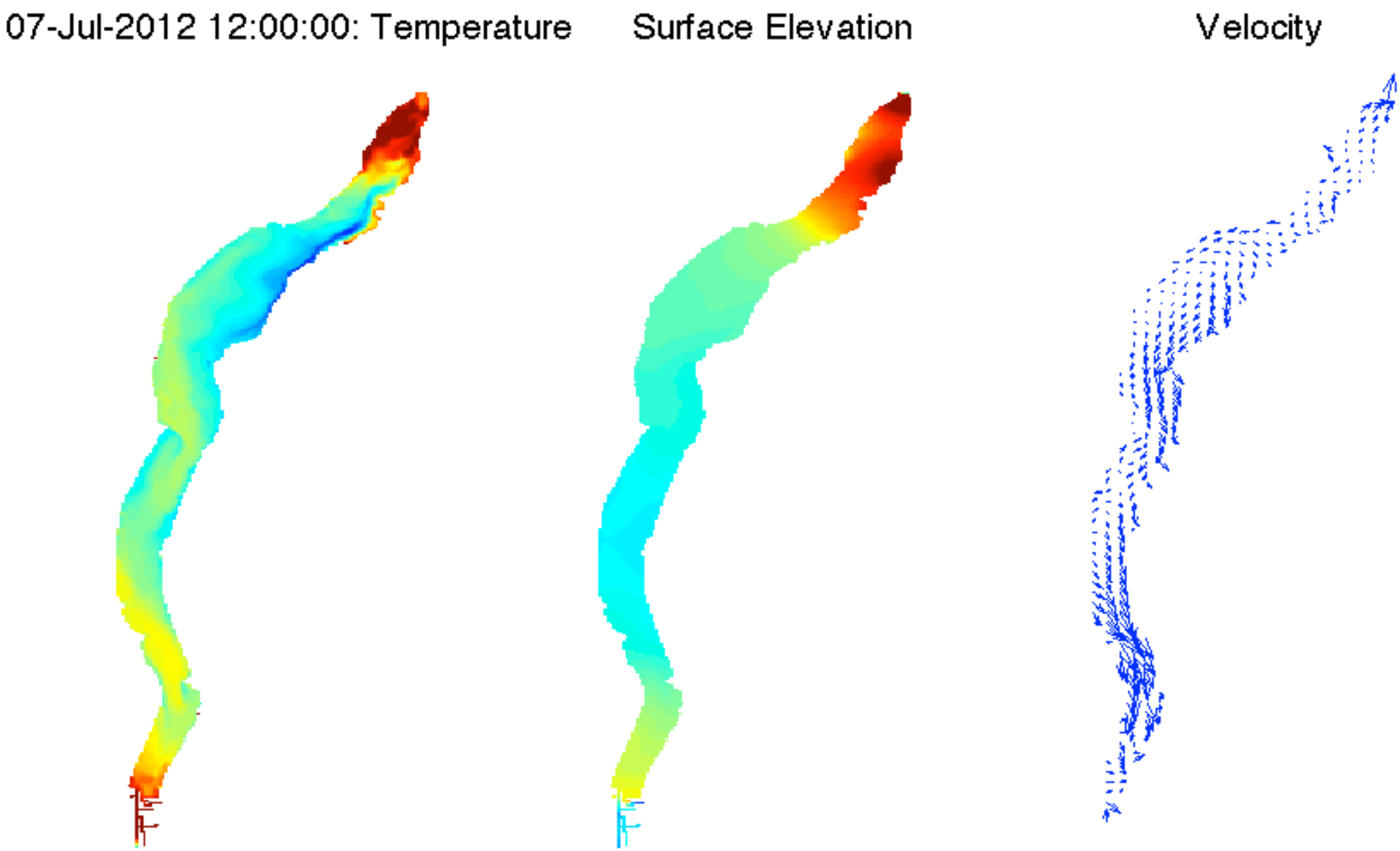
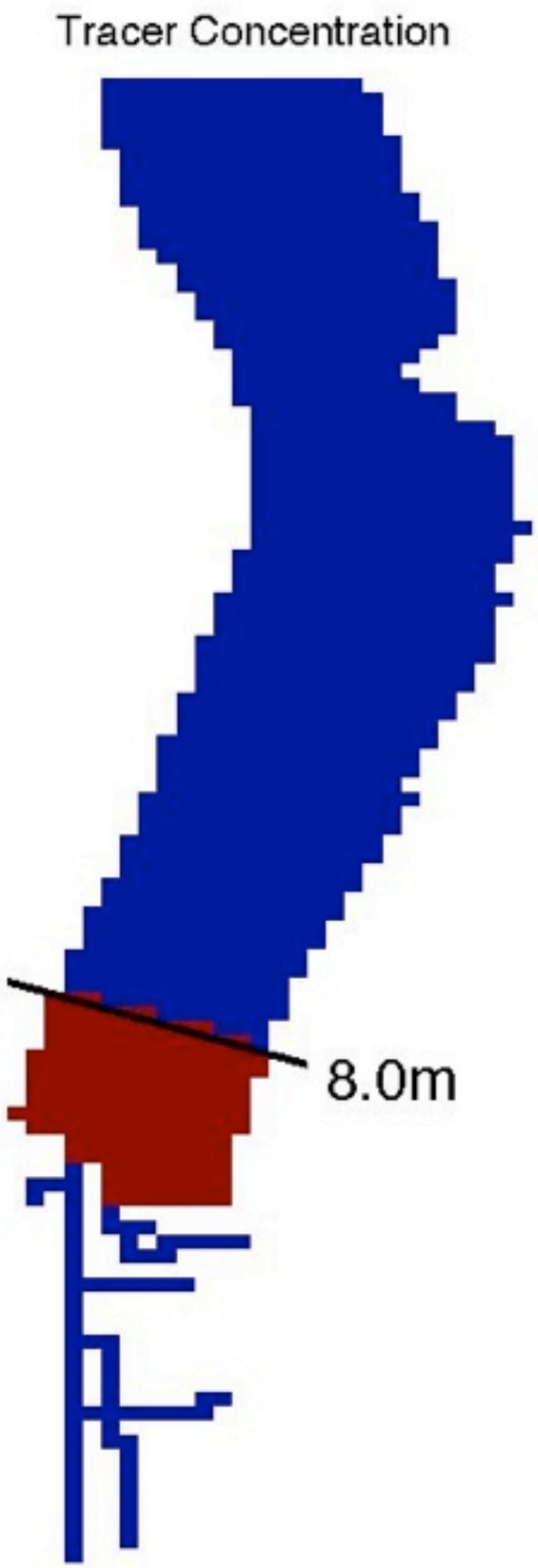
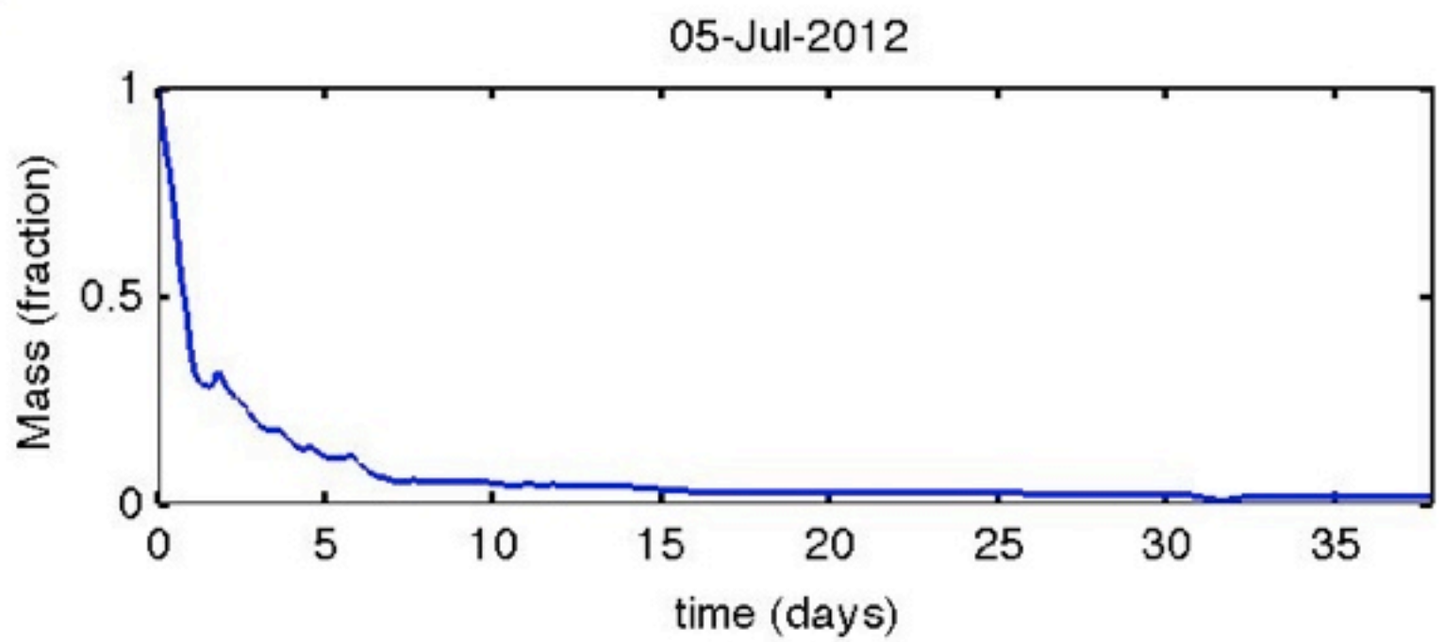

07-Jul-2012 12:00:00: Temperature
Surface Elevation
Velocity

SI3D: Flushing Time Experiments





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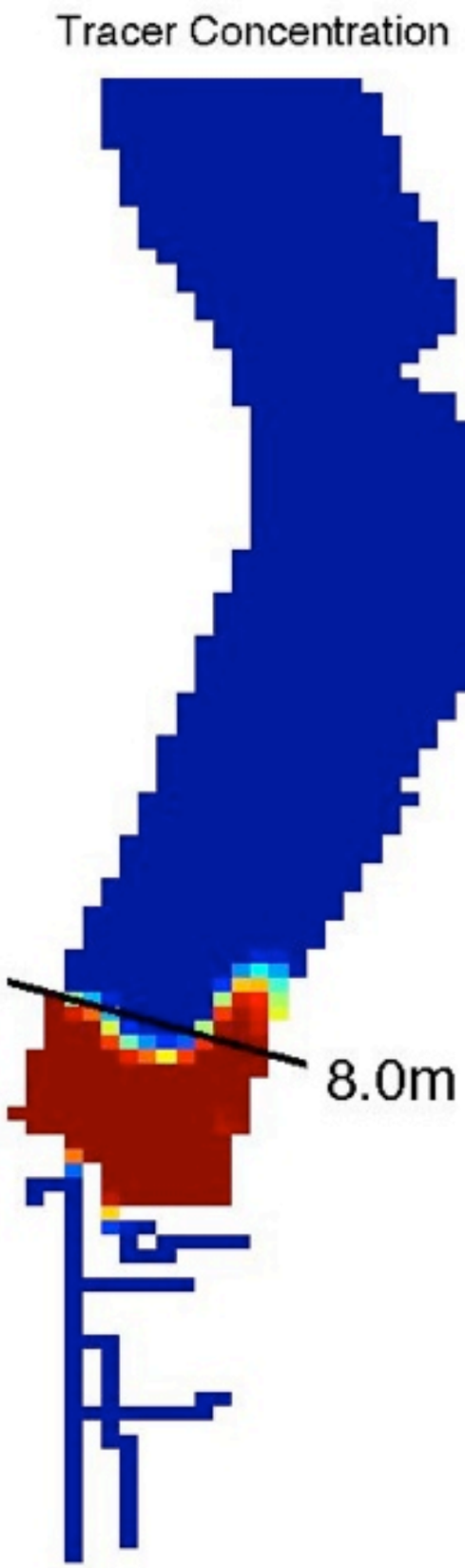
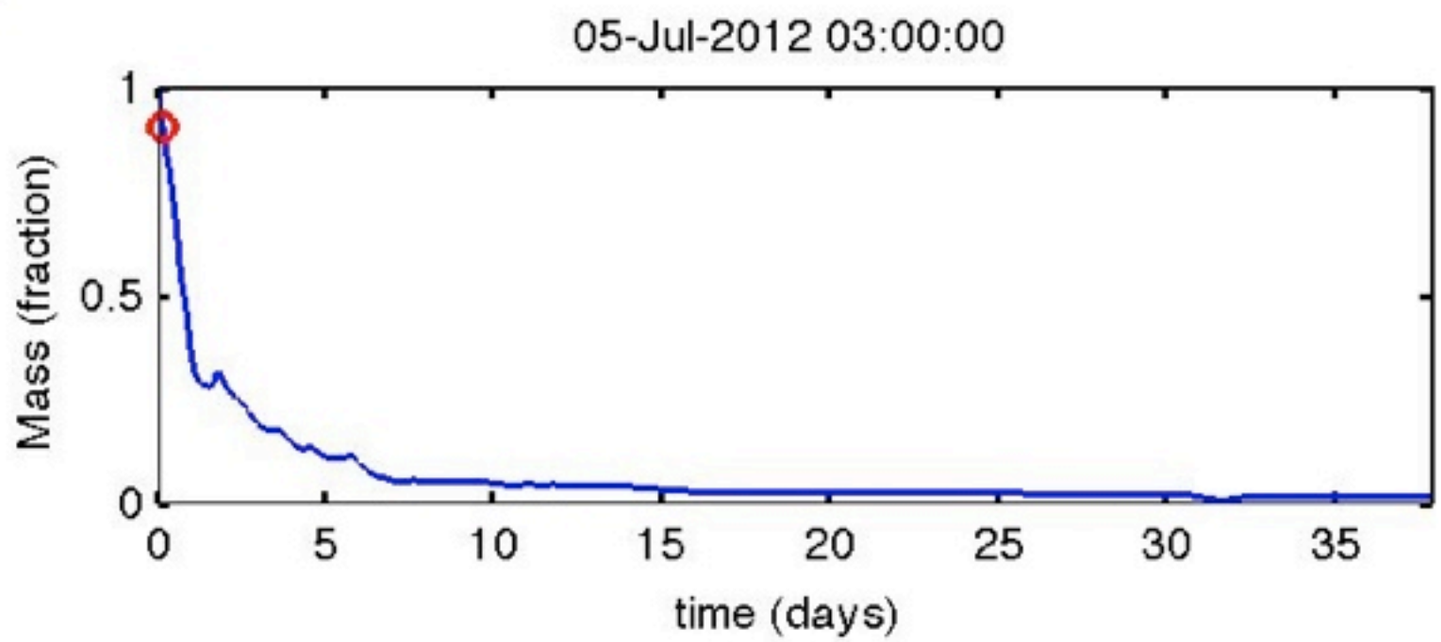
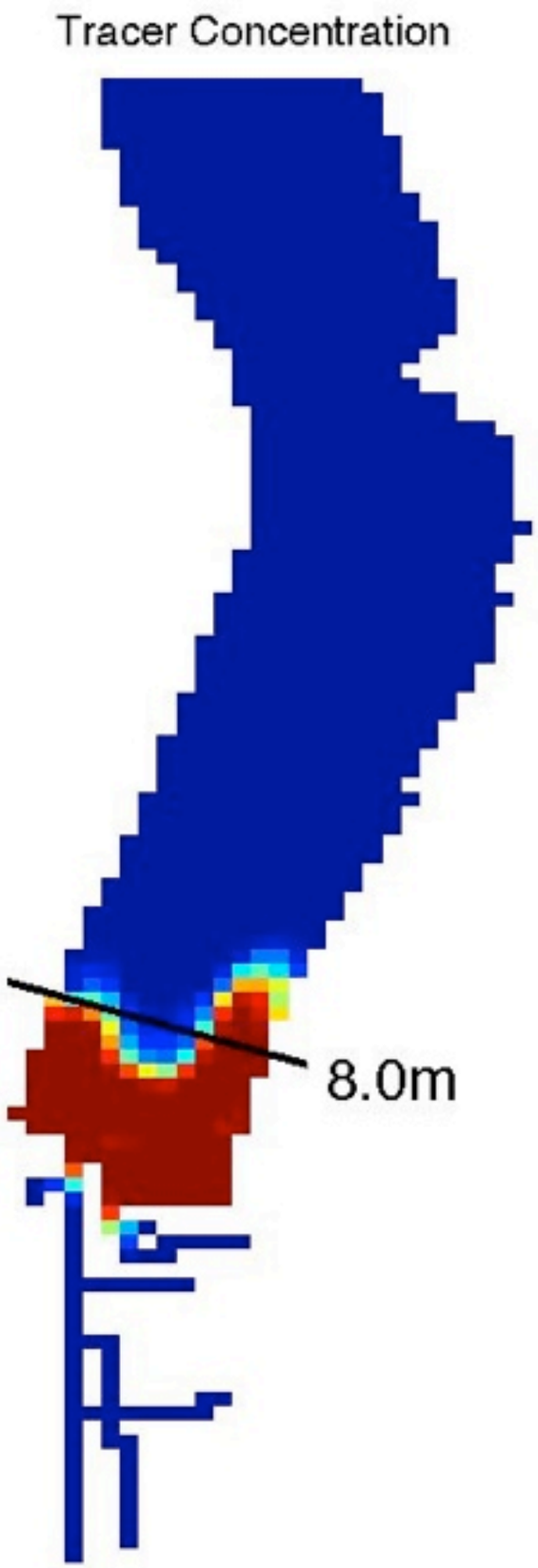
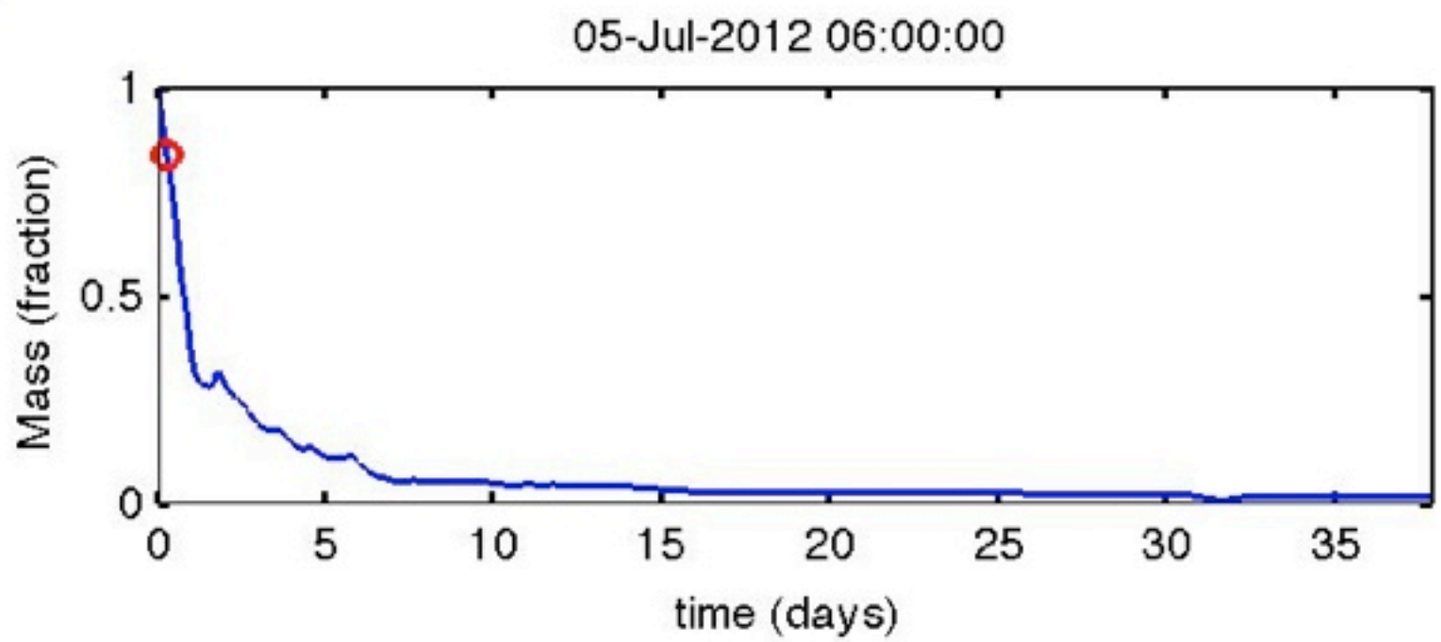




SI3D: Flushing Time Experiments





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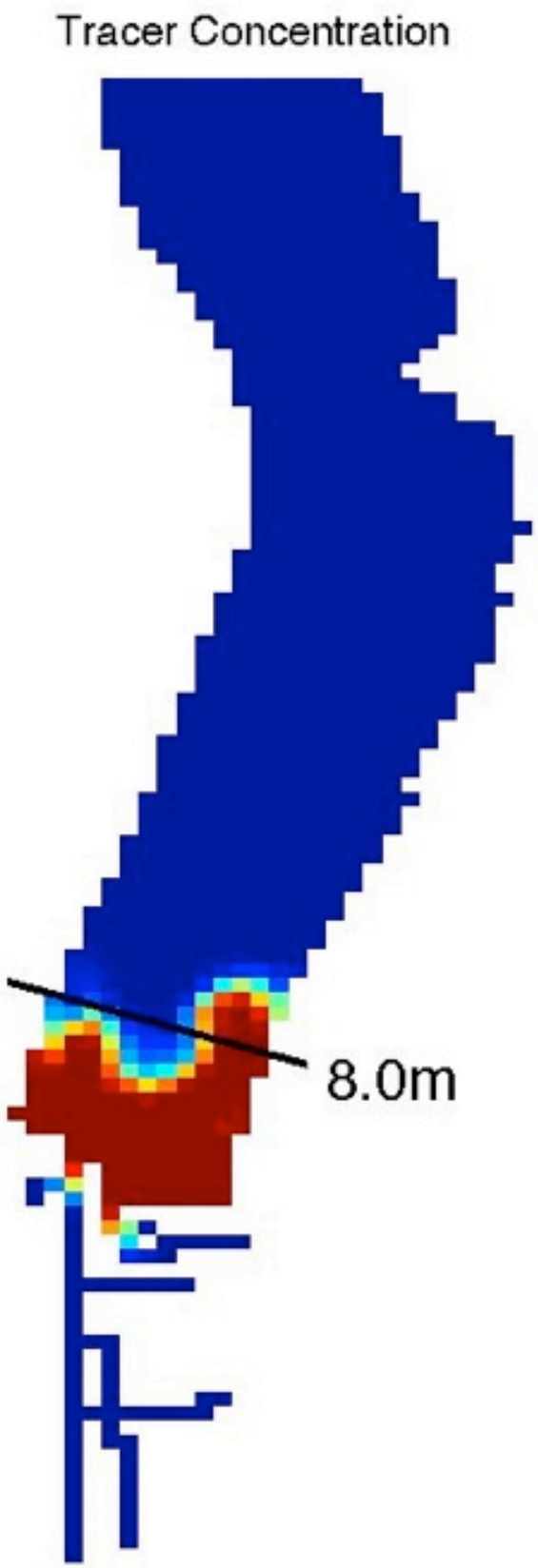

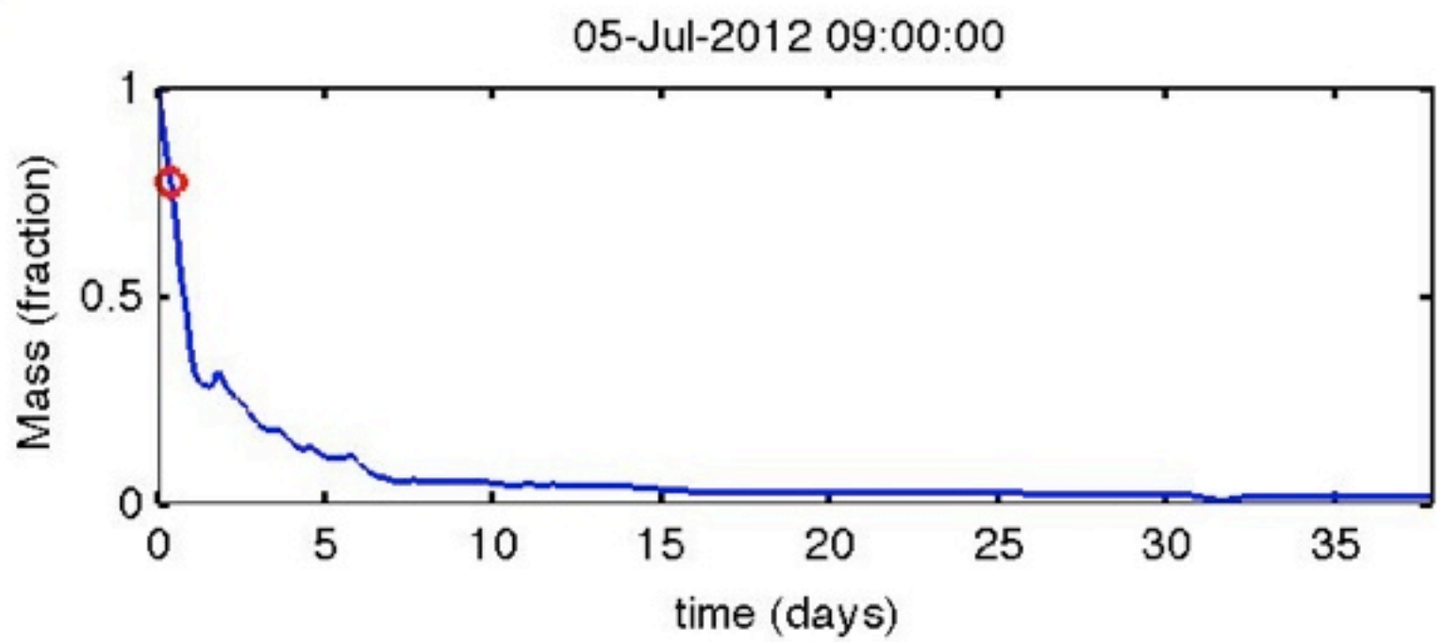

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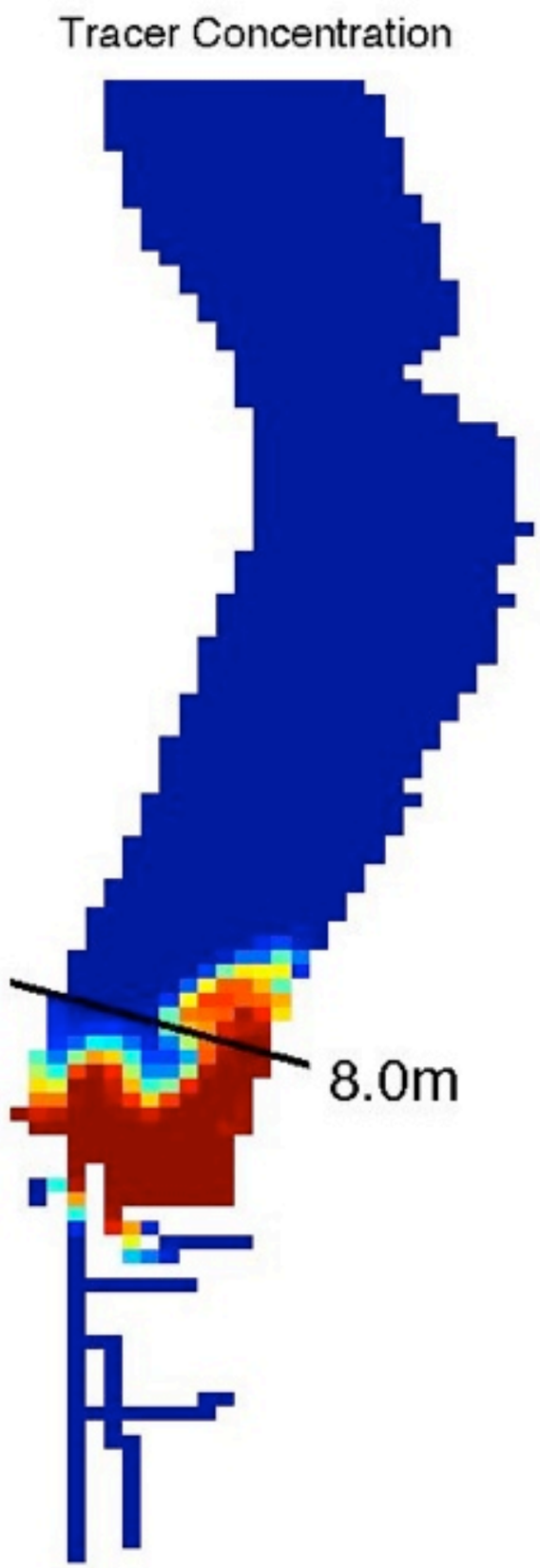

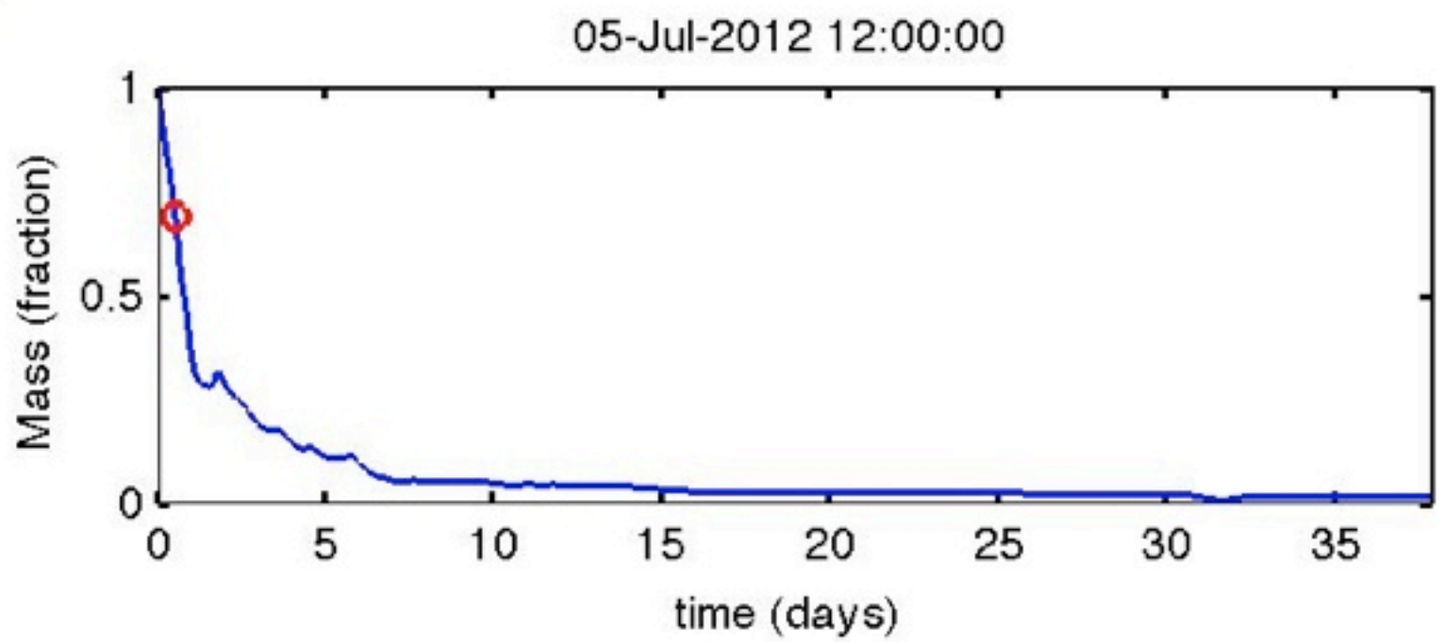

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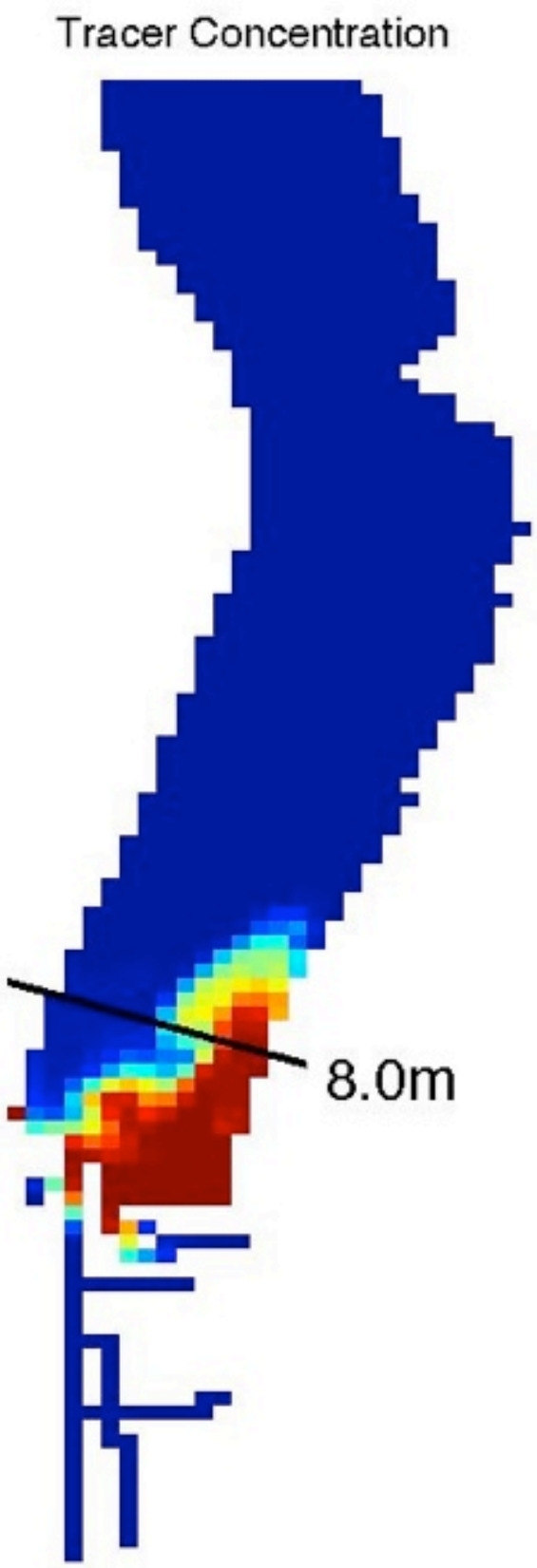

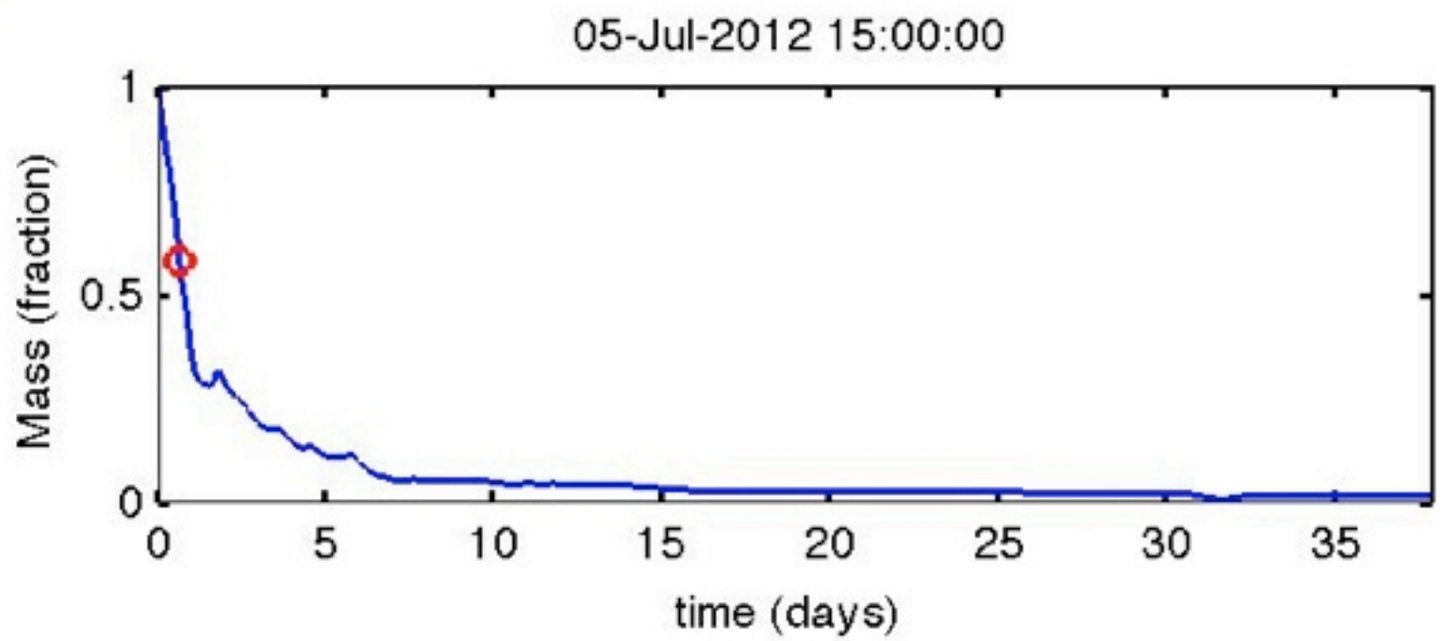

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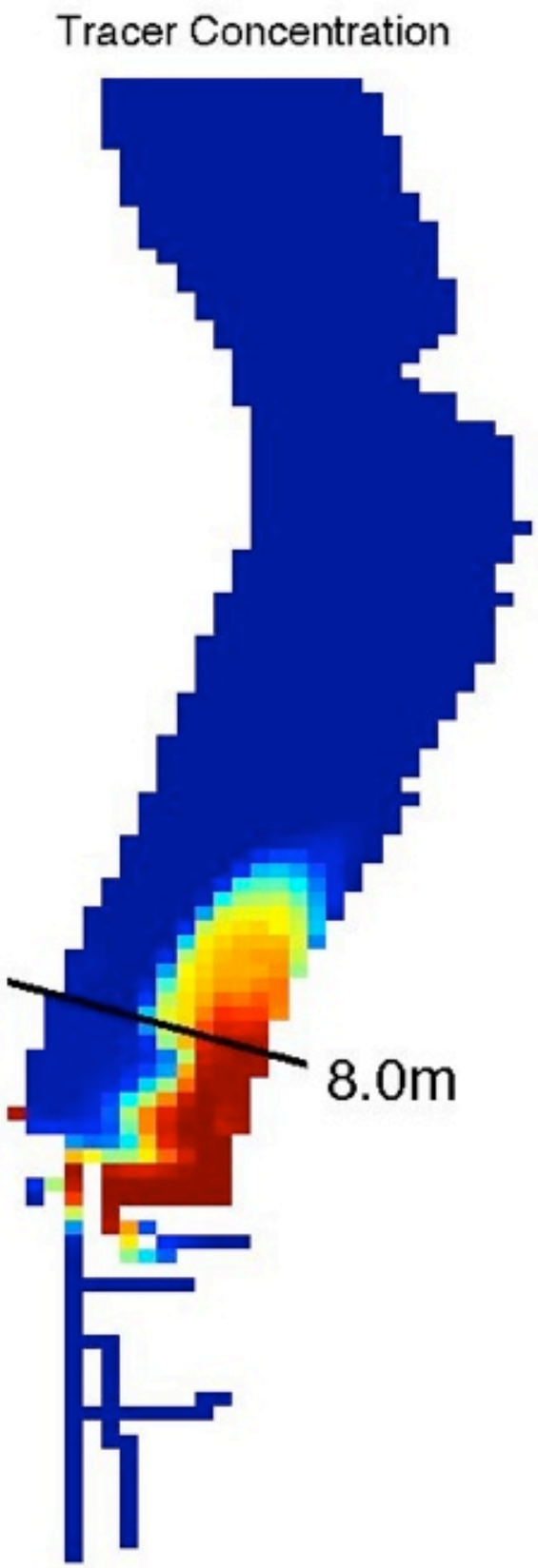

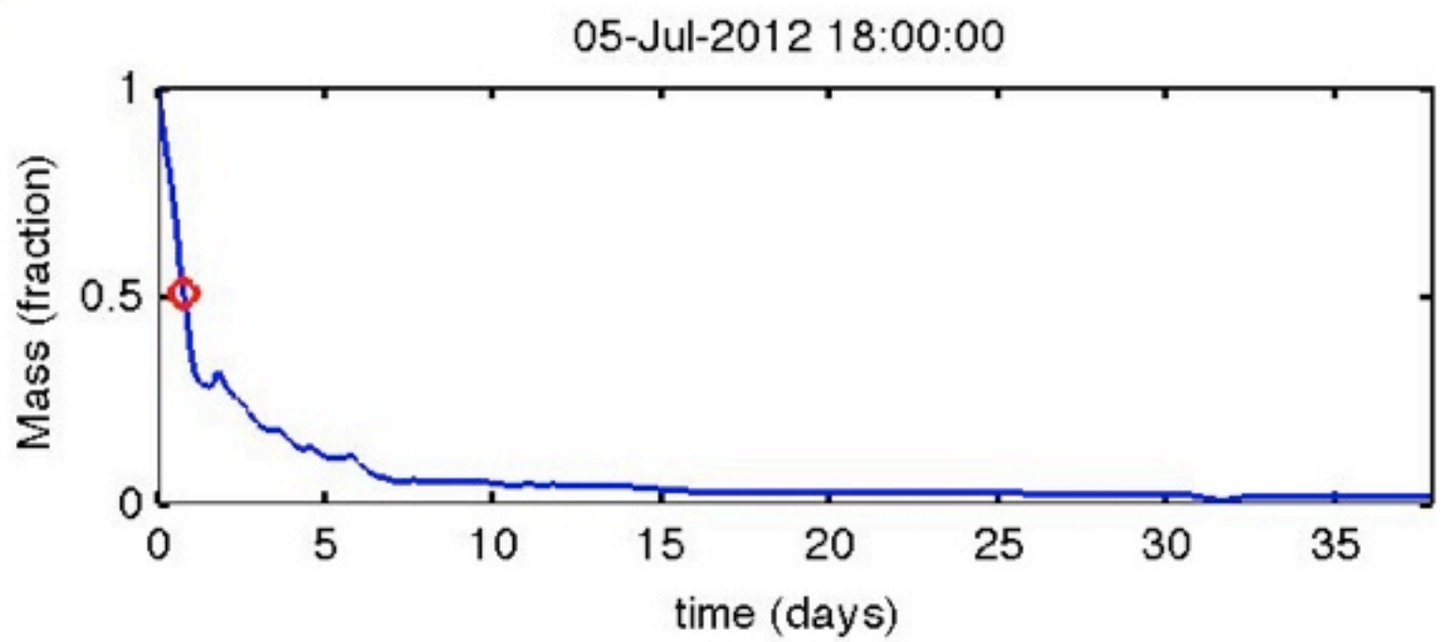

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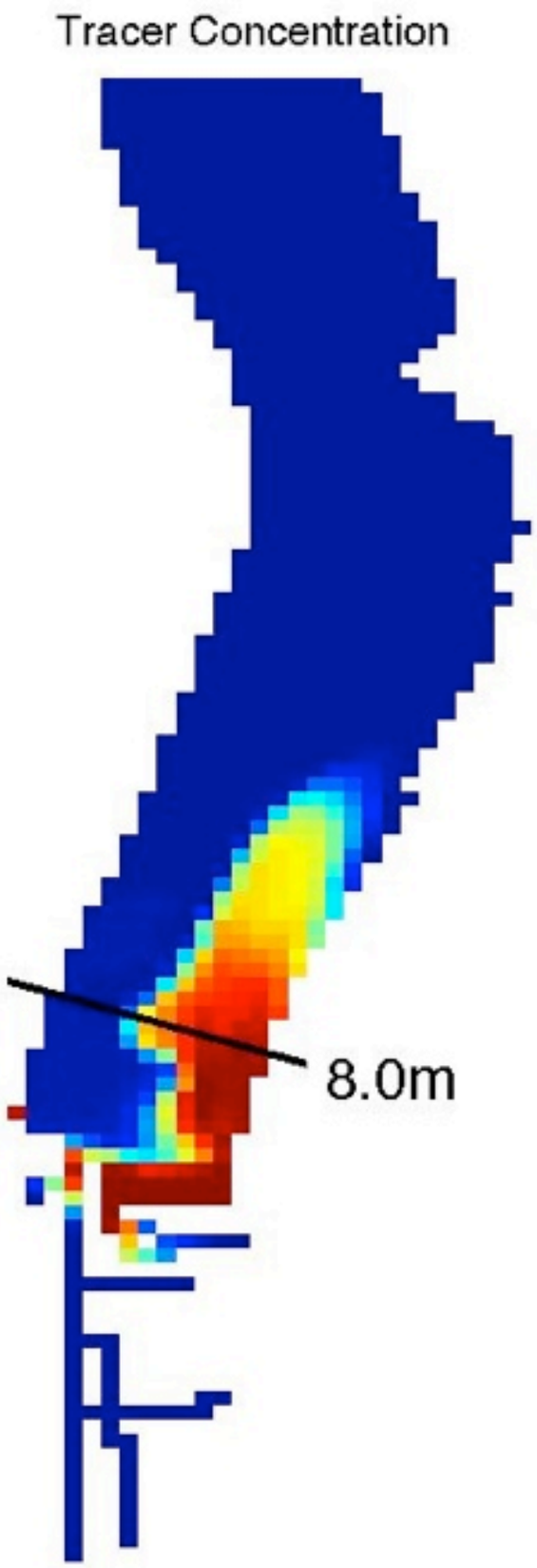

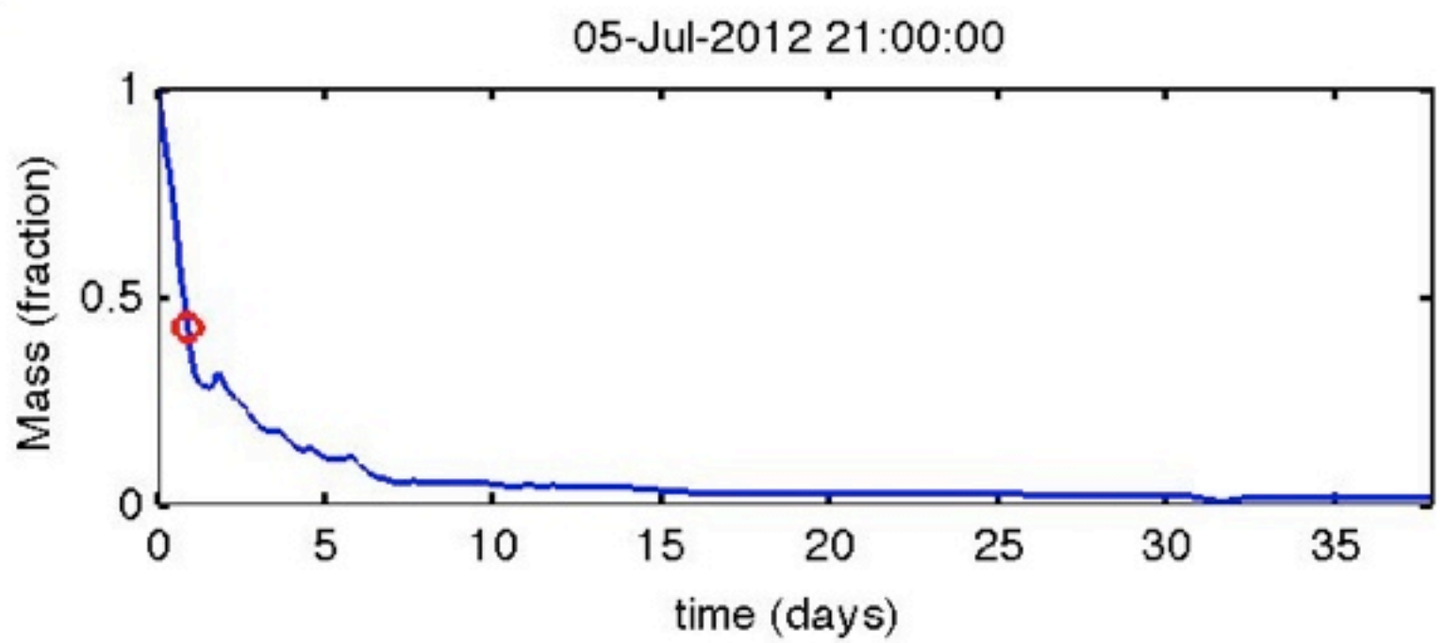

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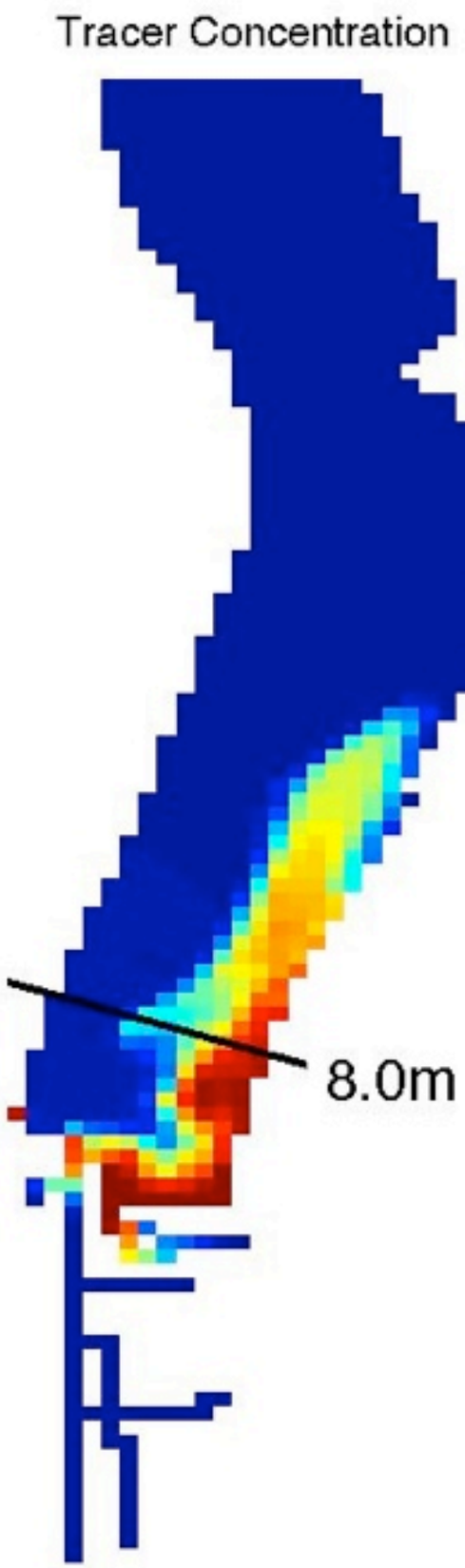

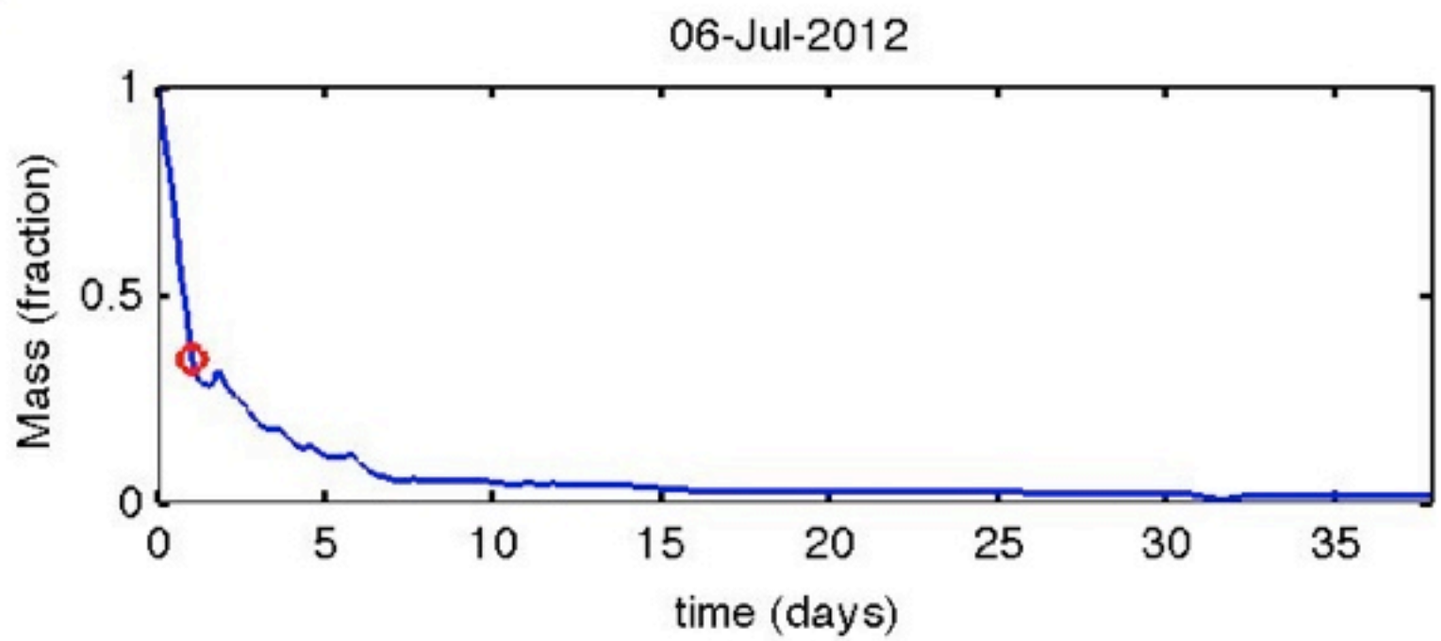

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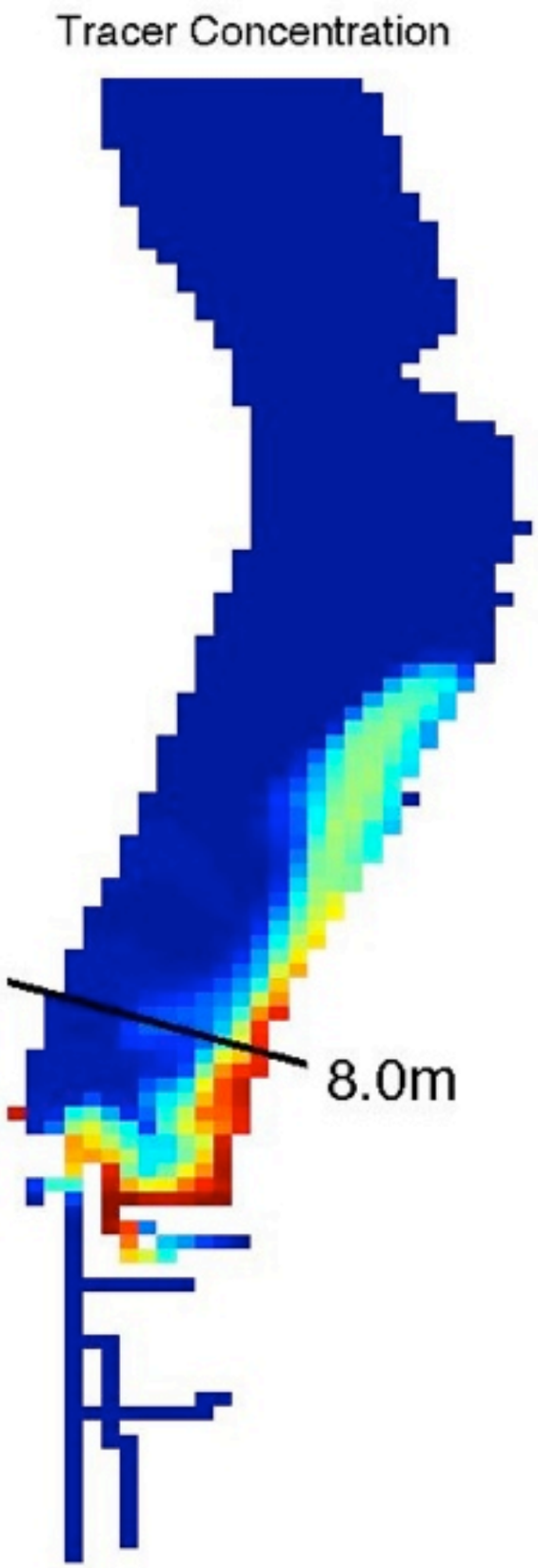

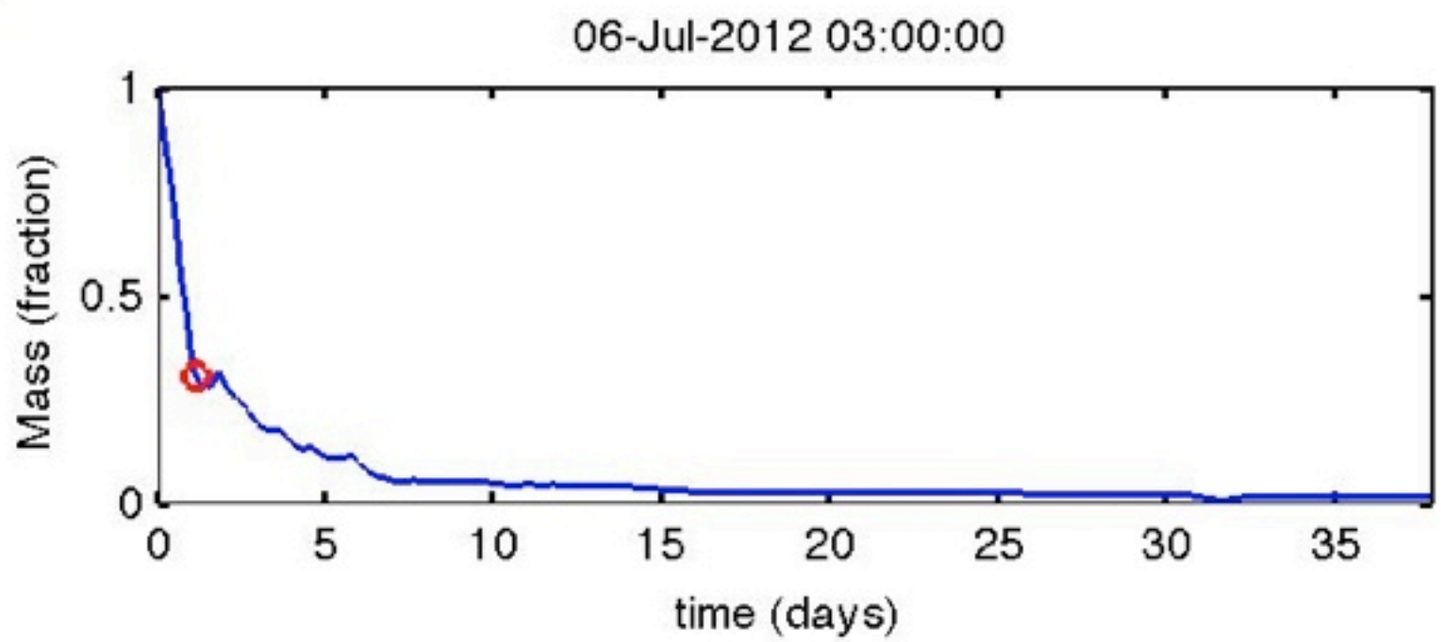

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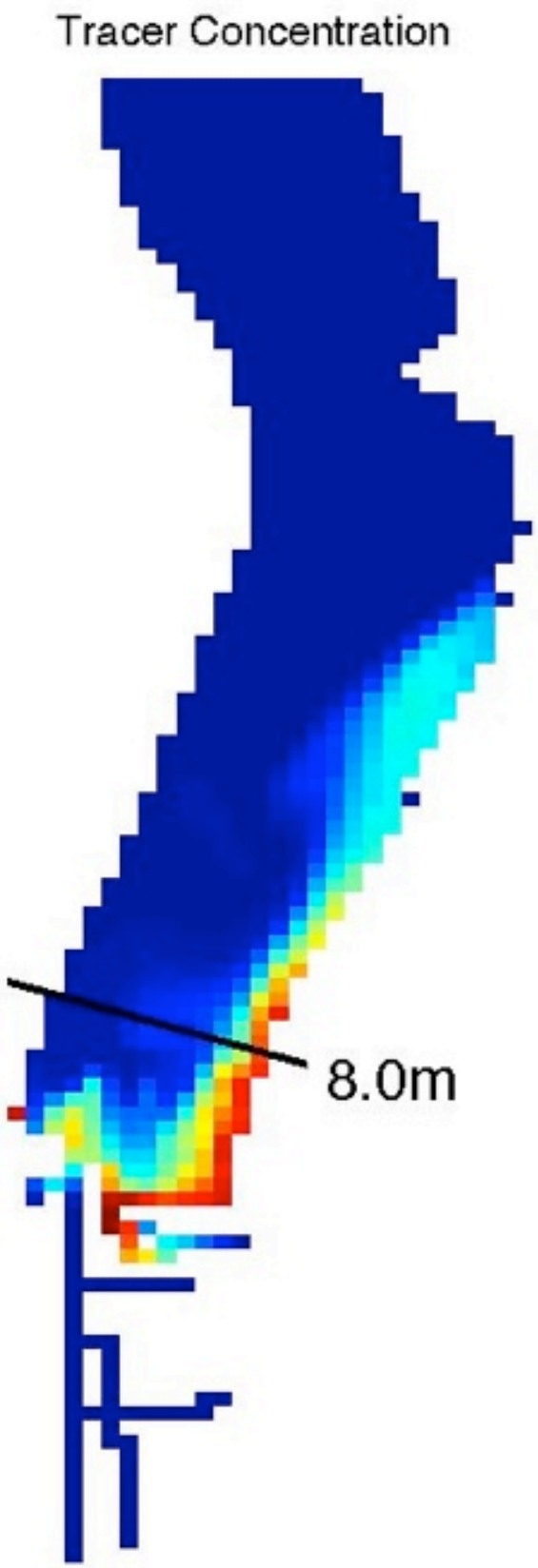

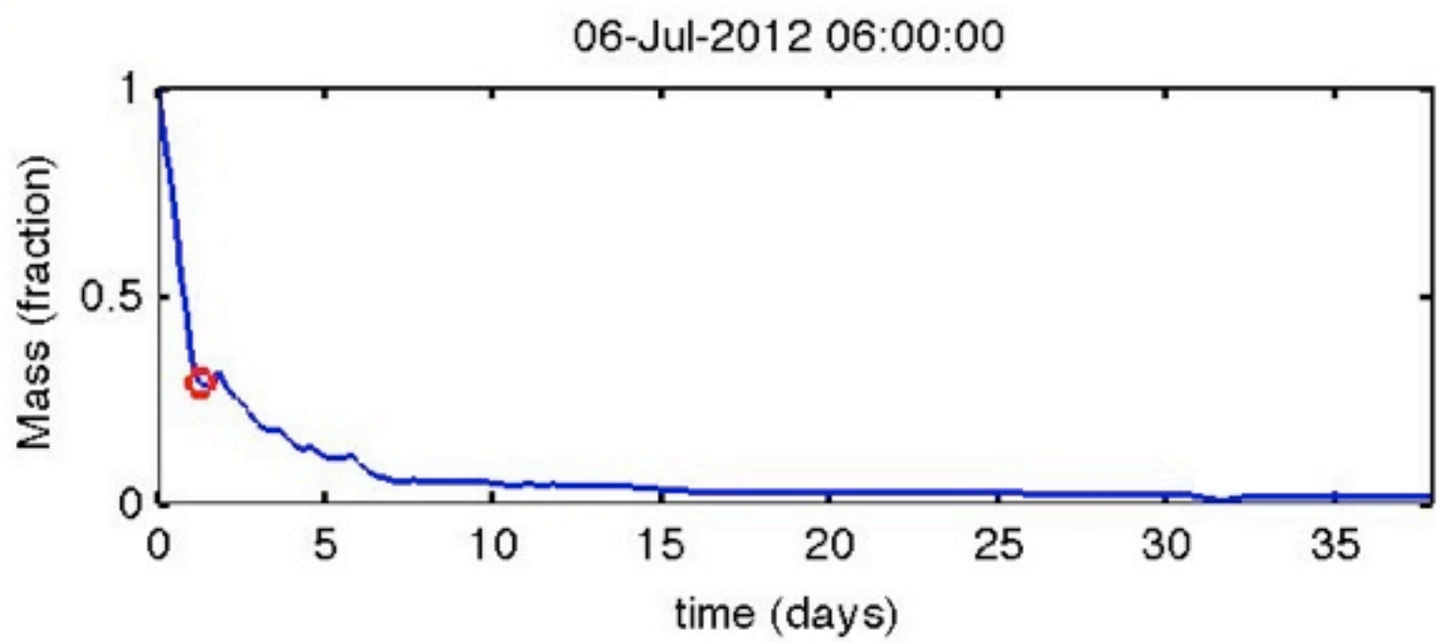

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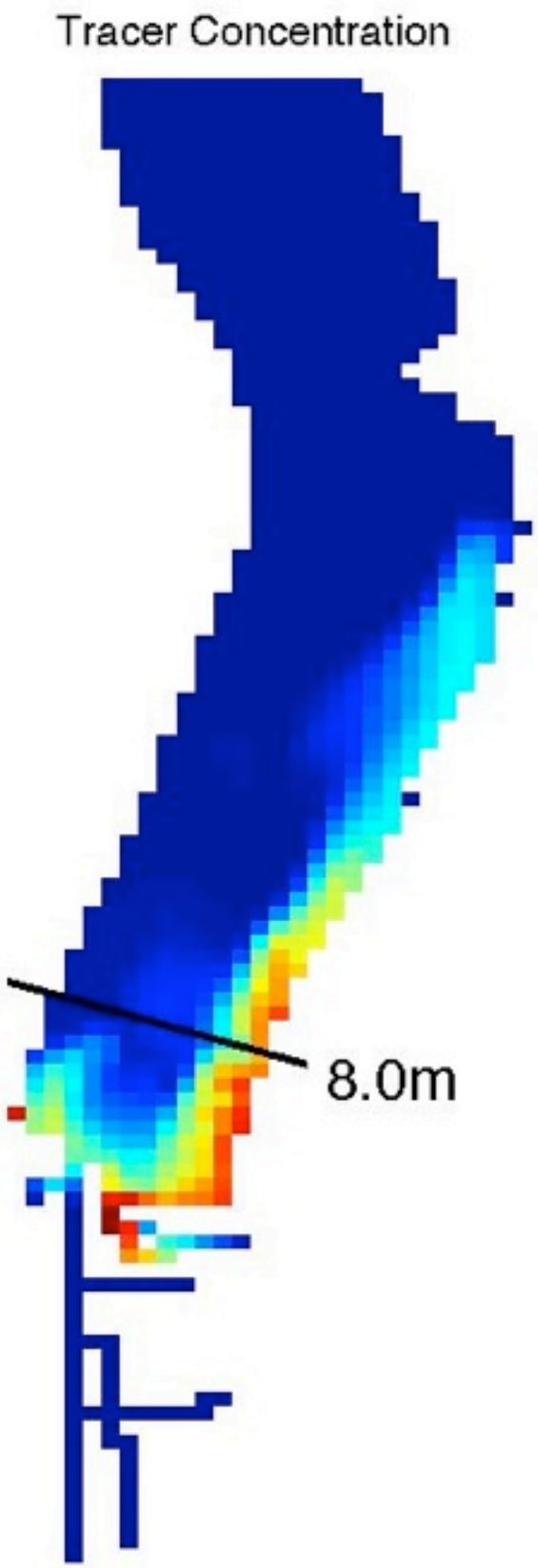

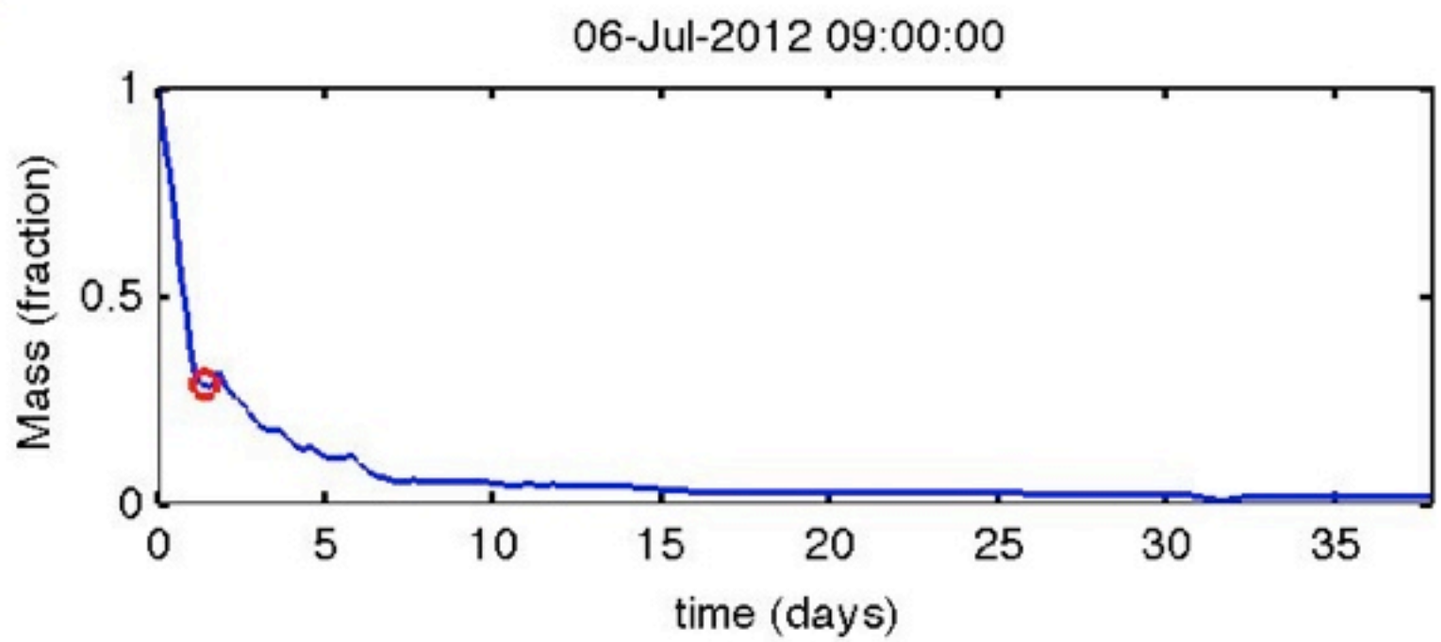

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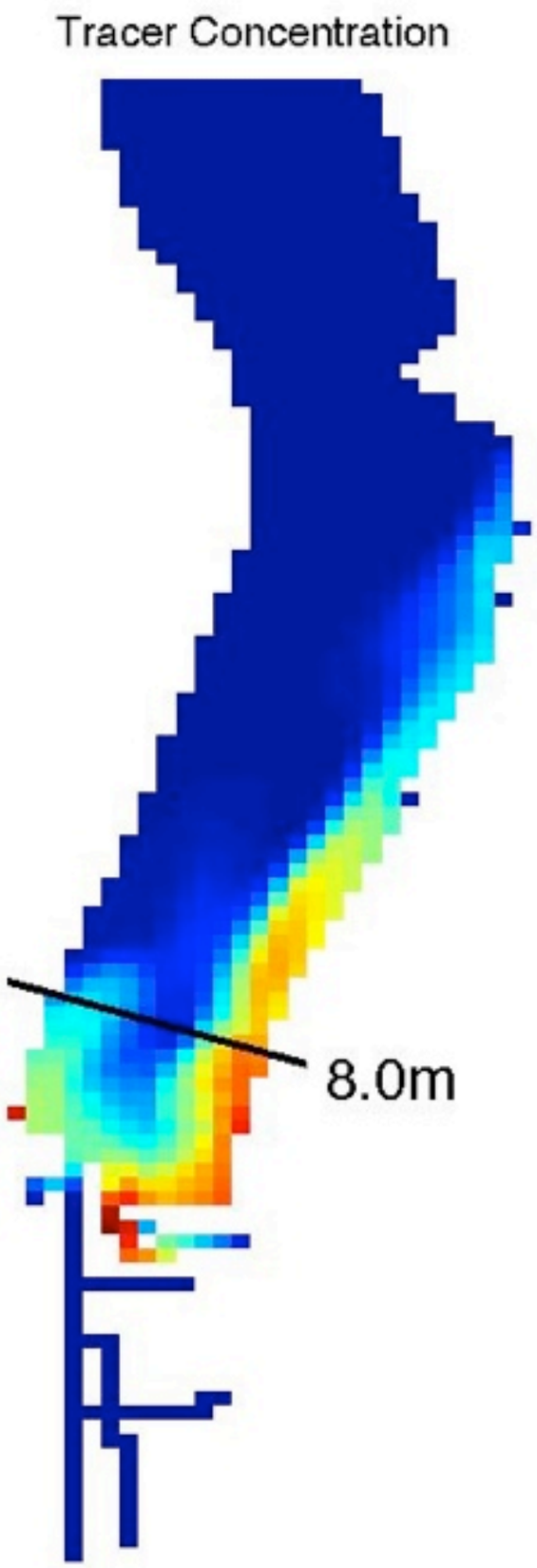

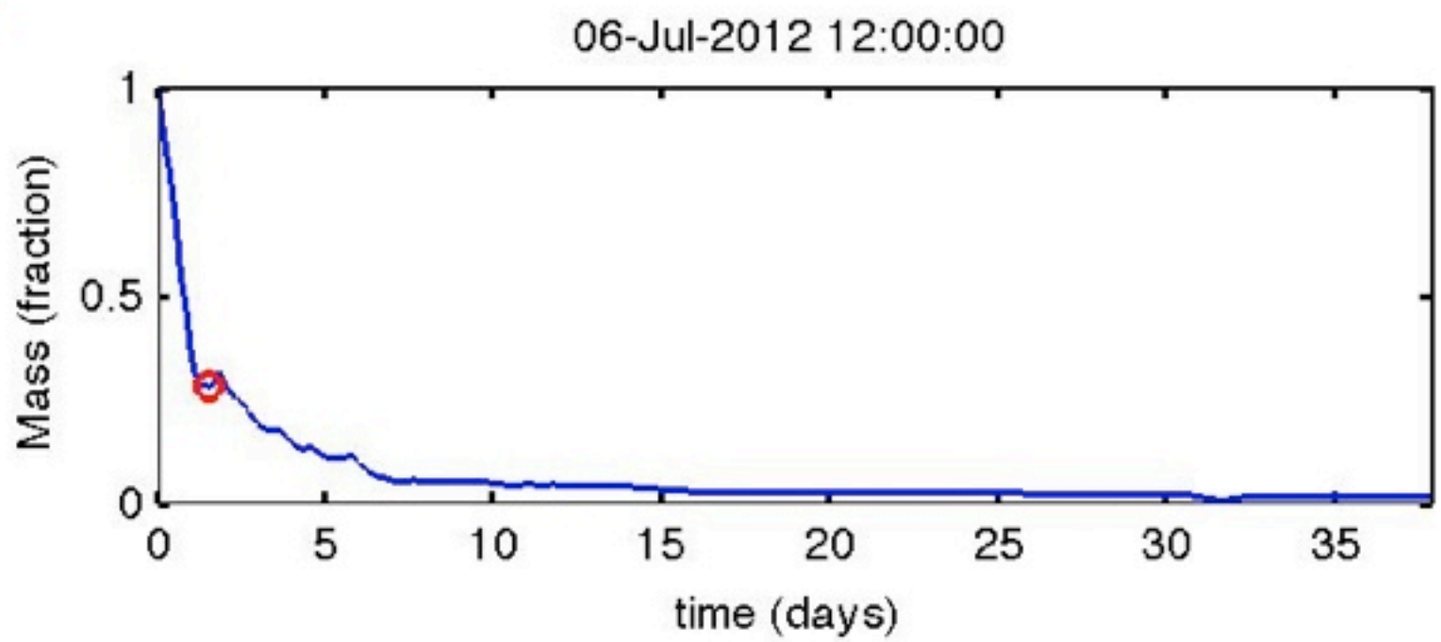

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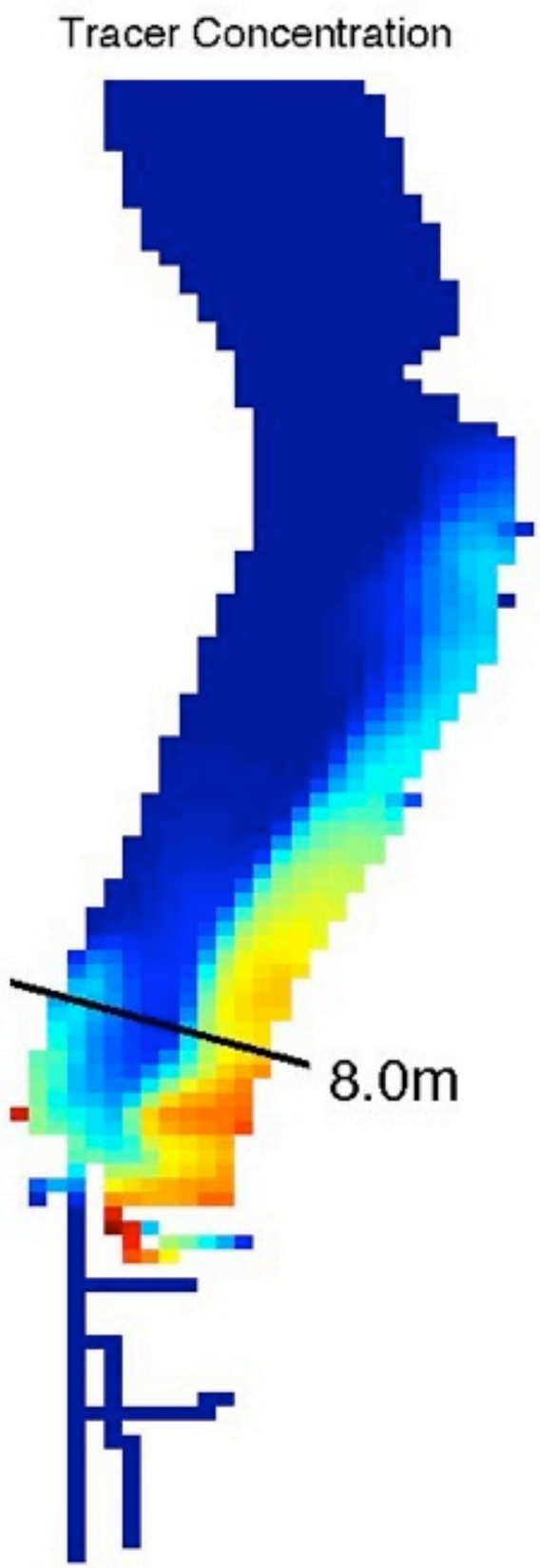

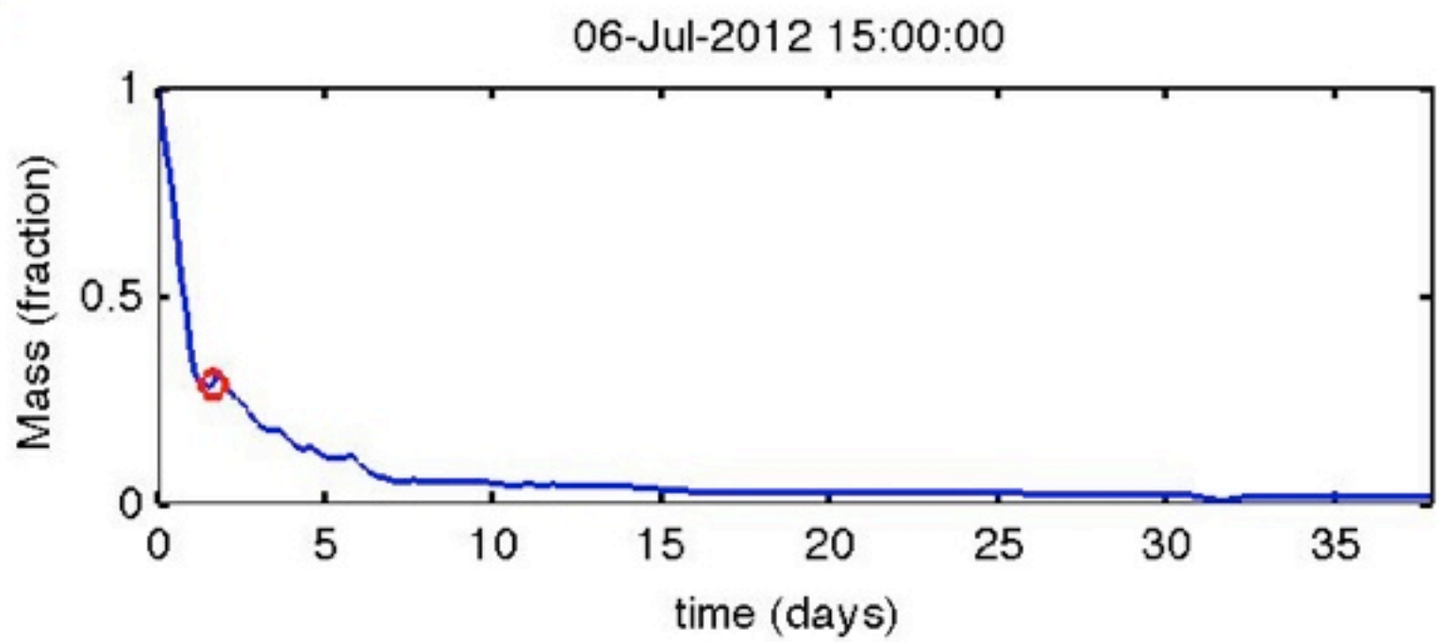

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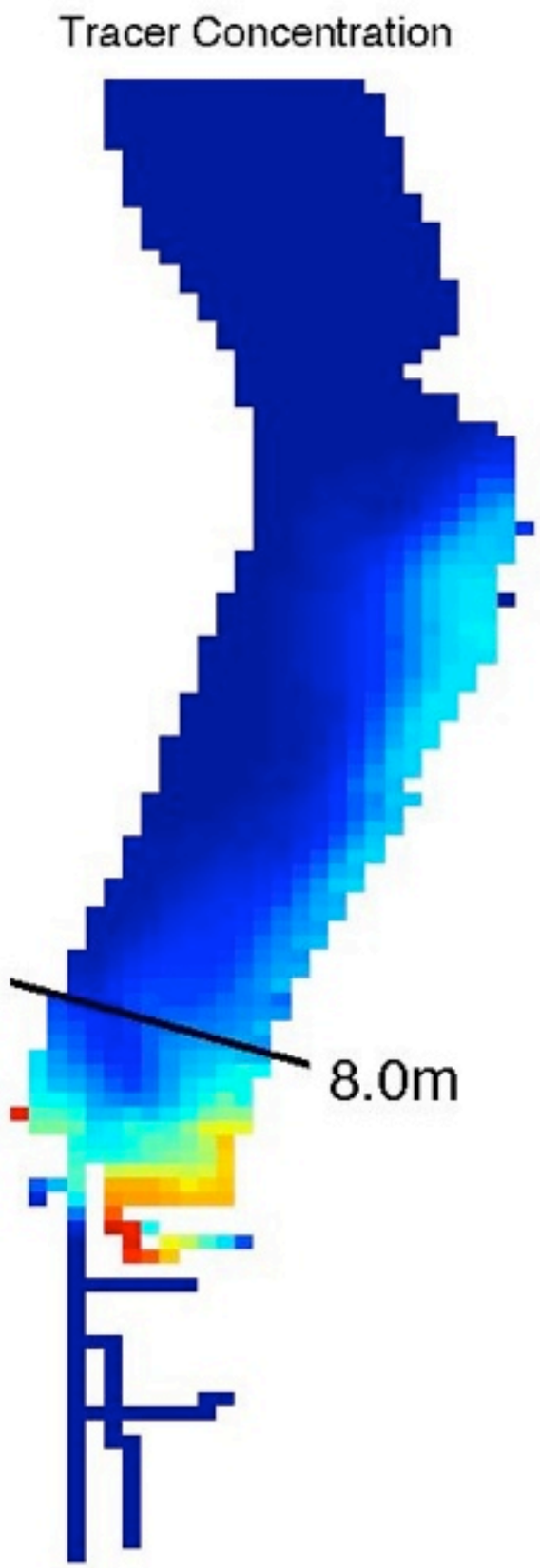

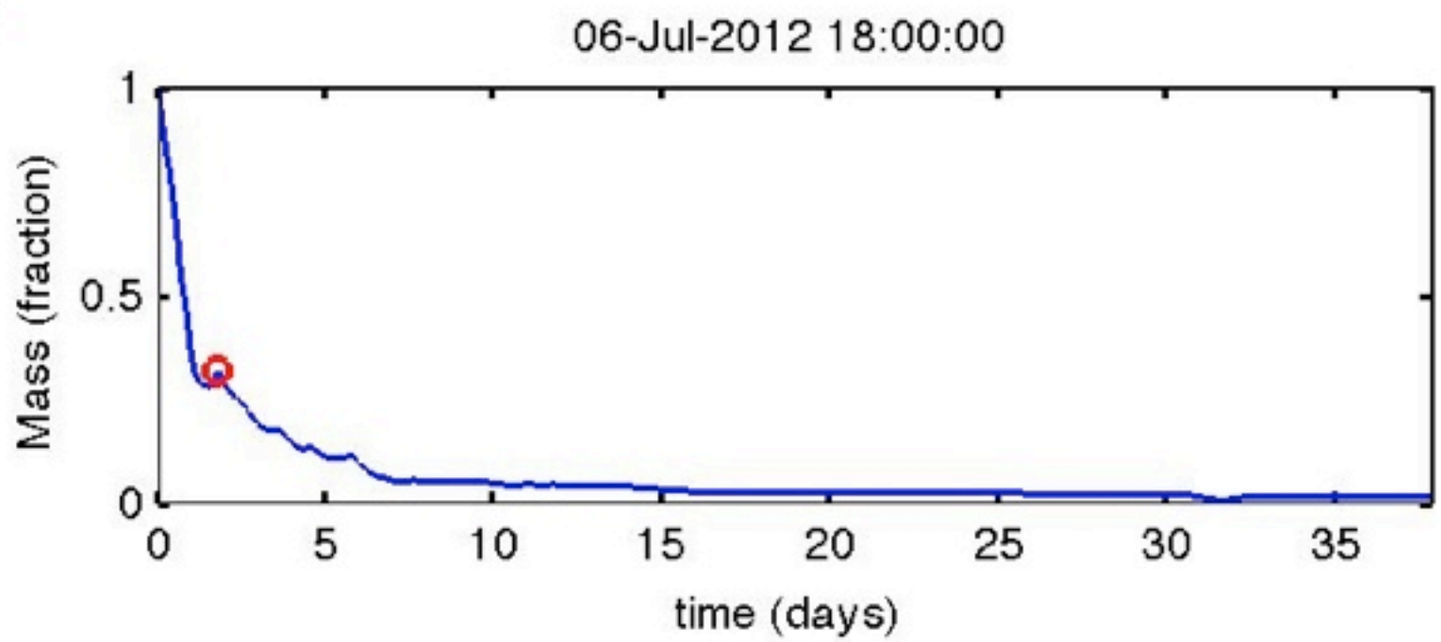

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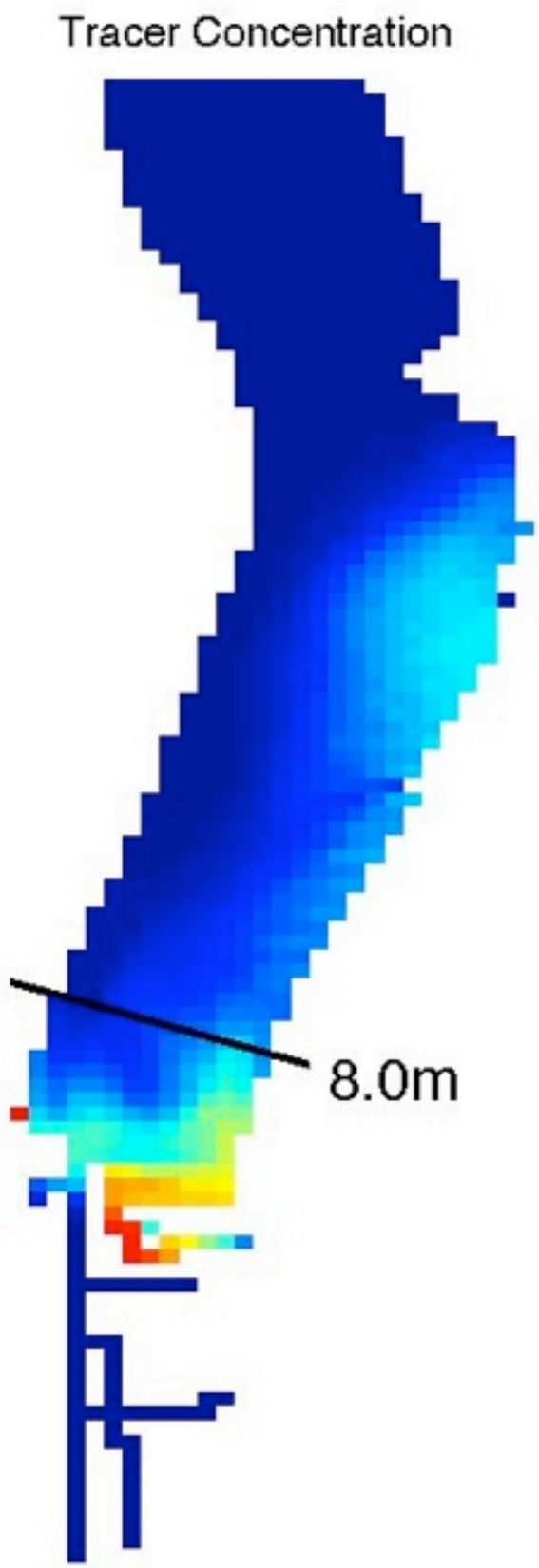

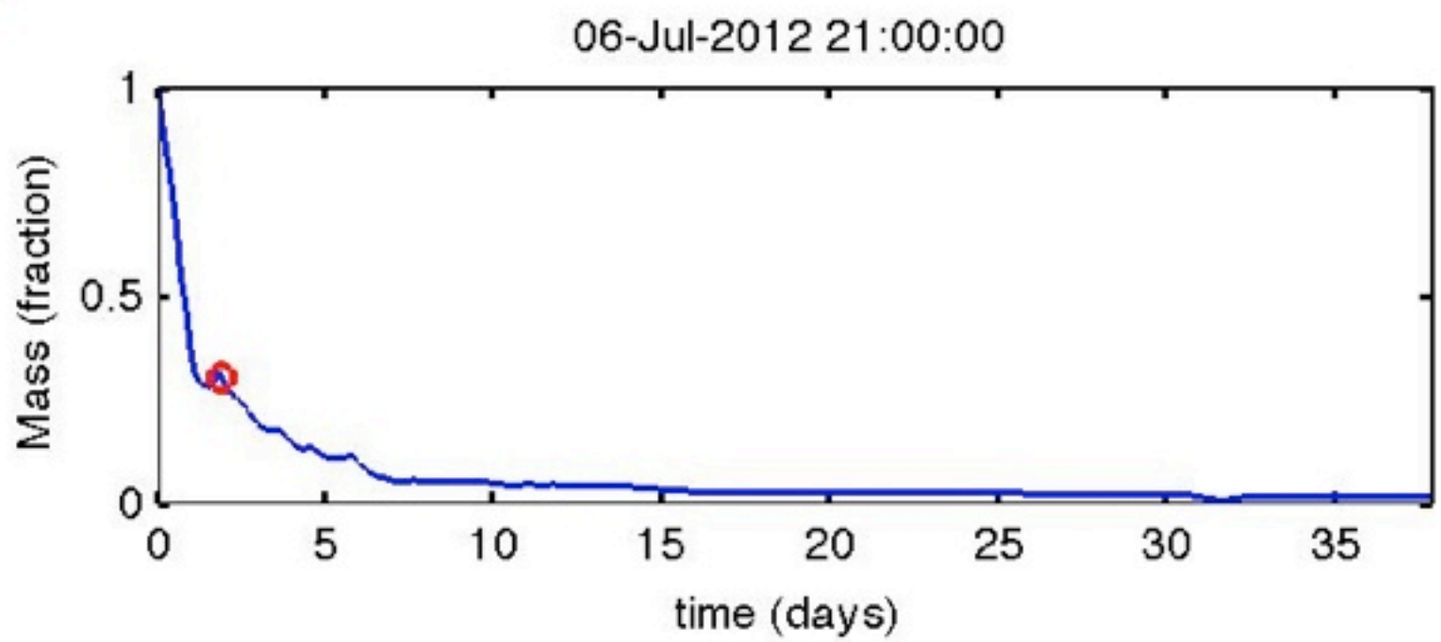

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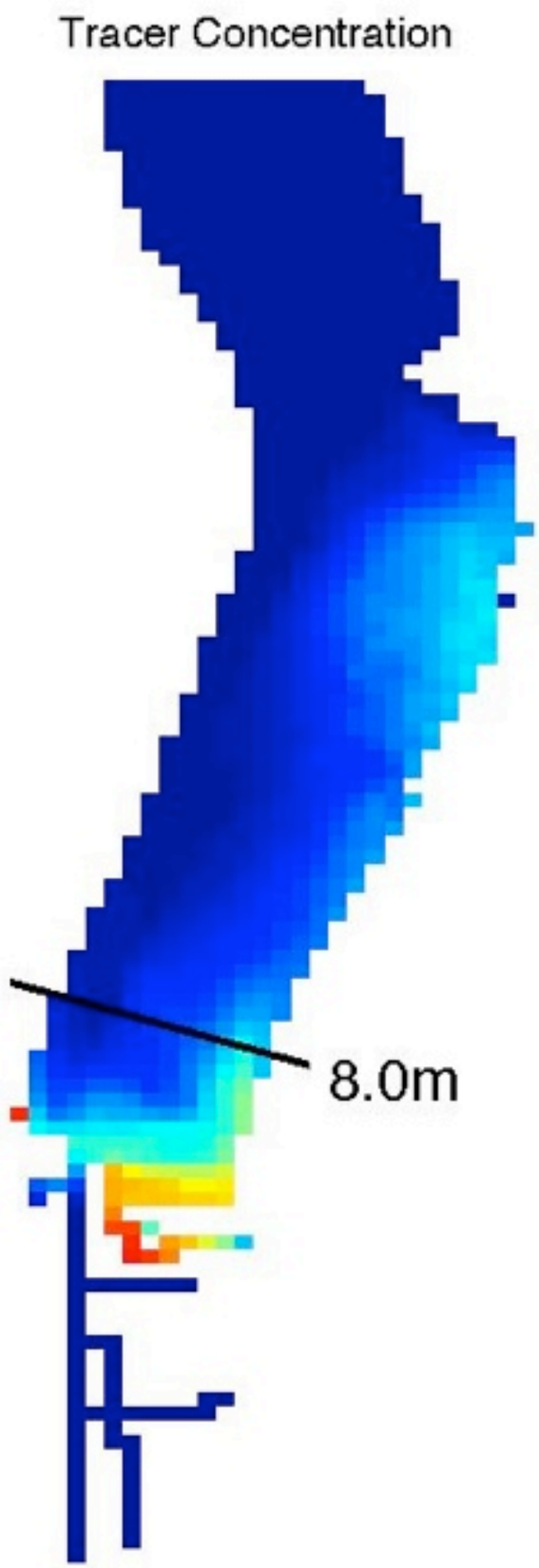

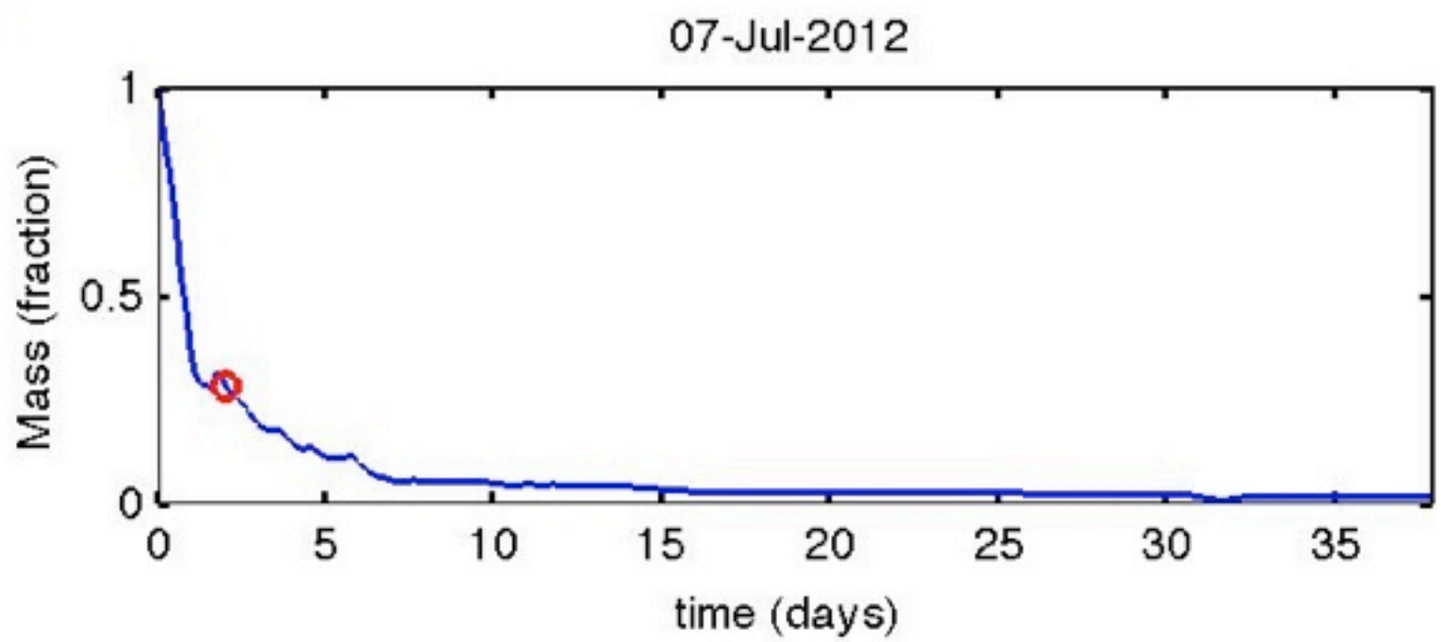

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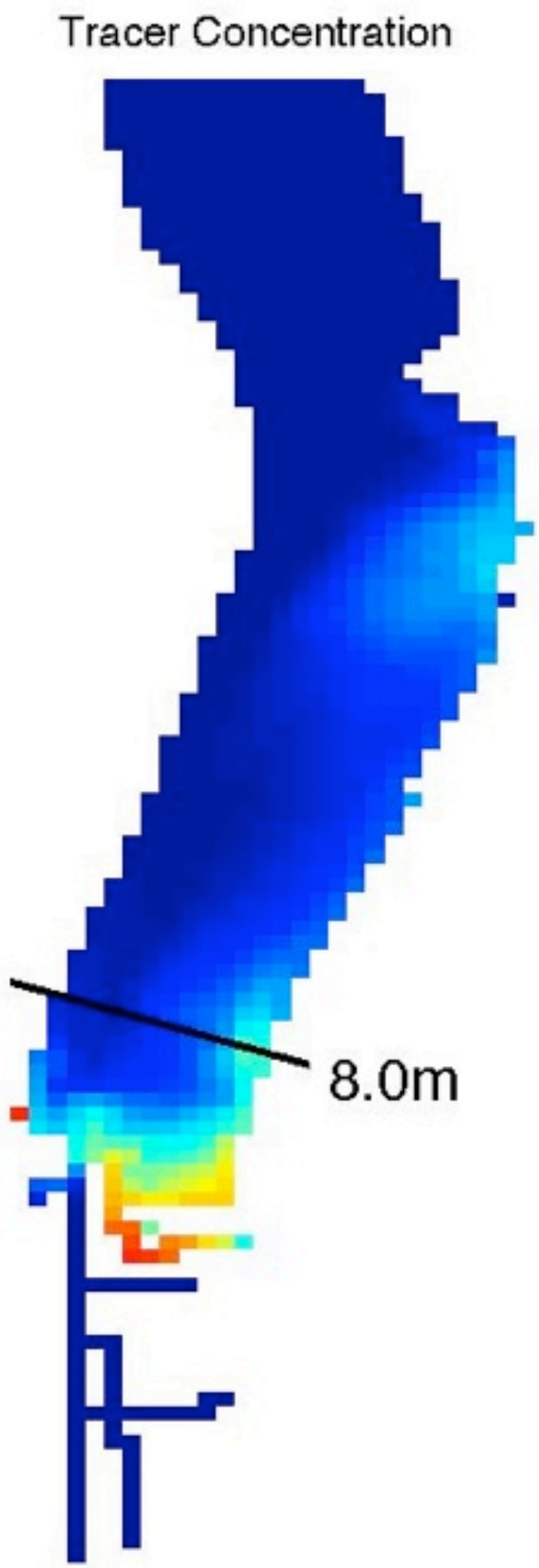

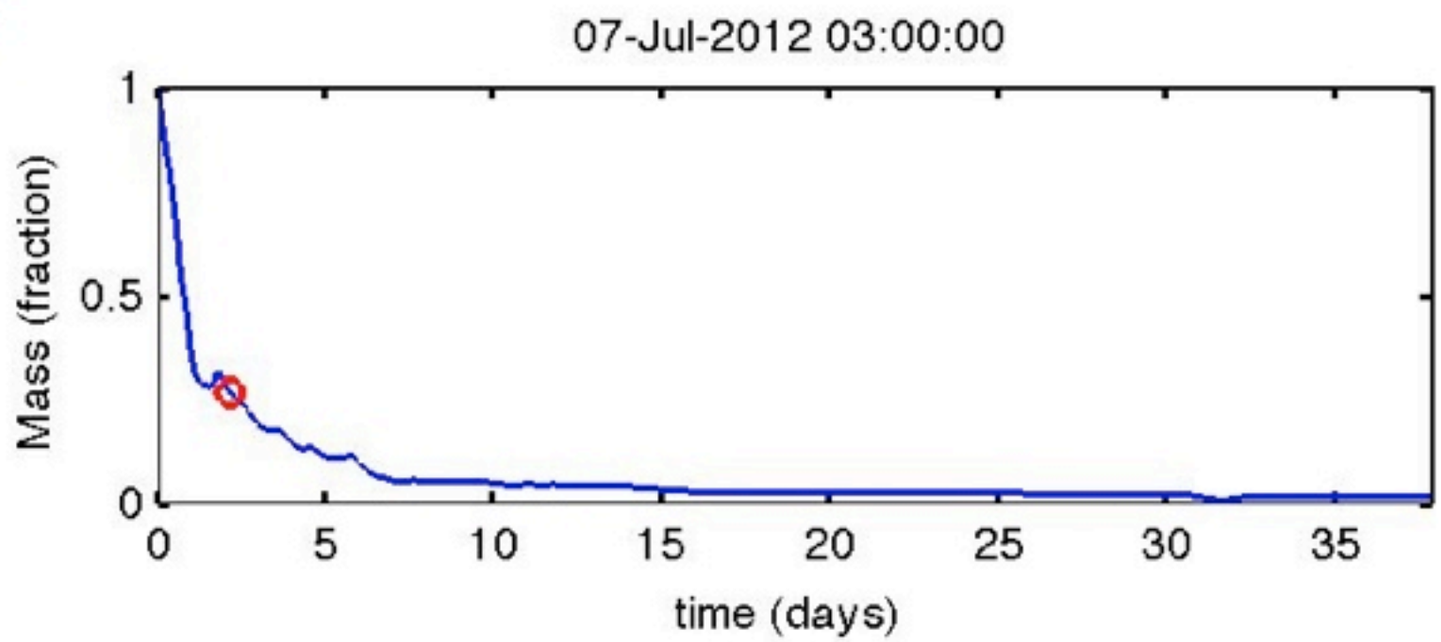

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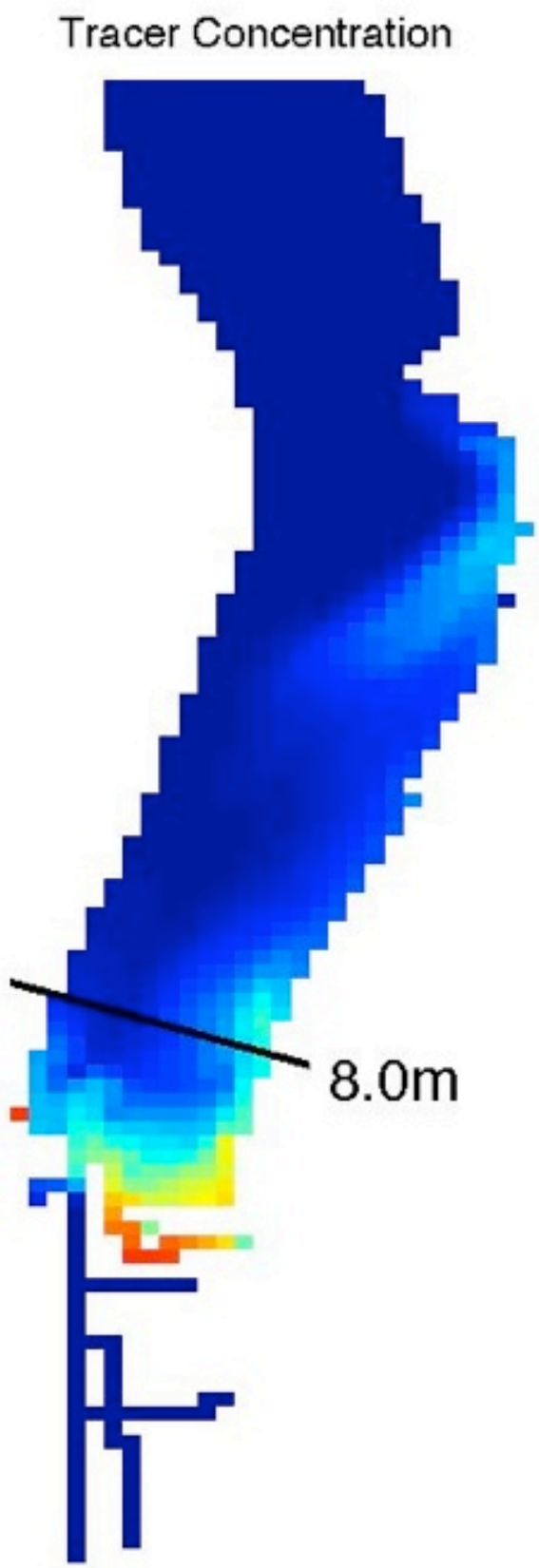

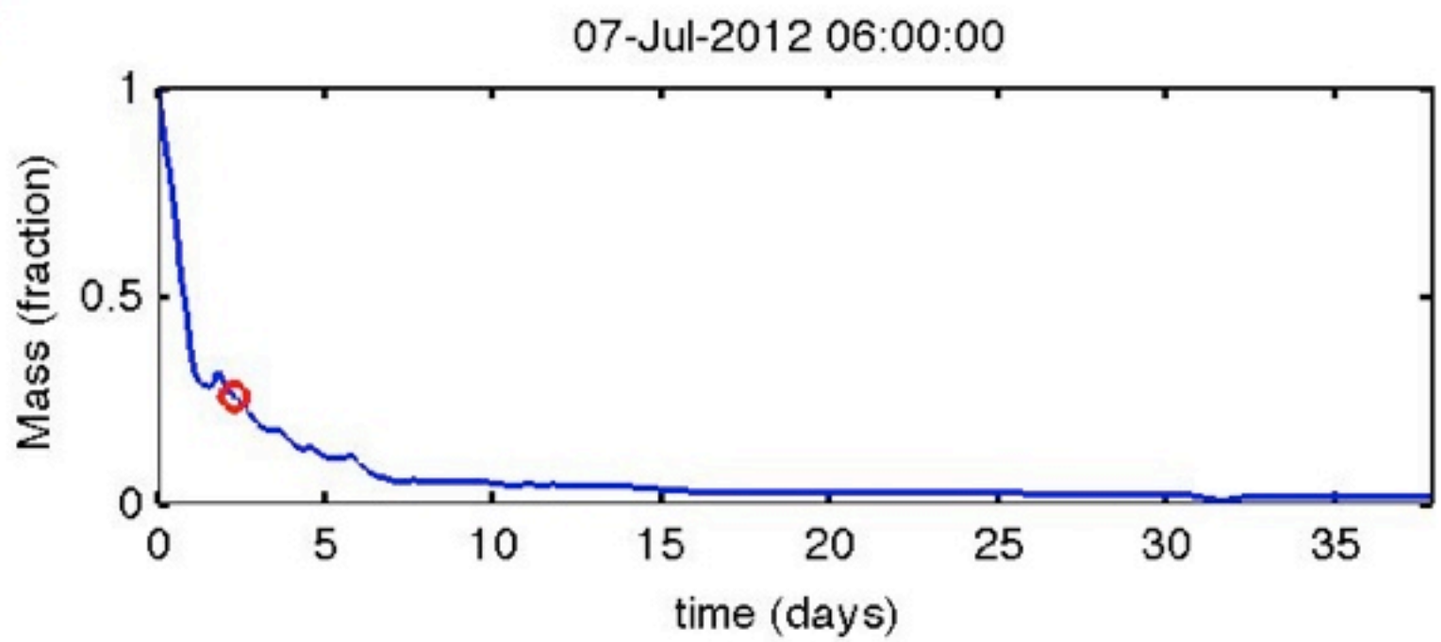

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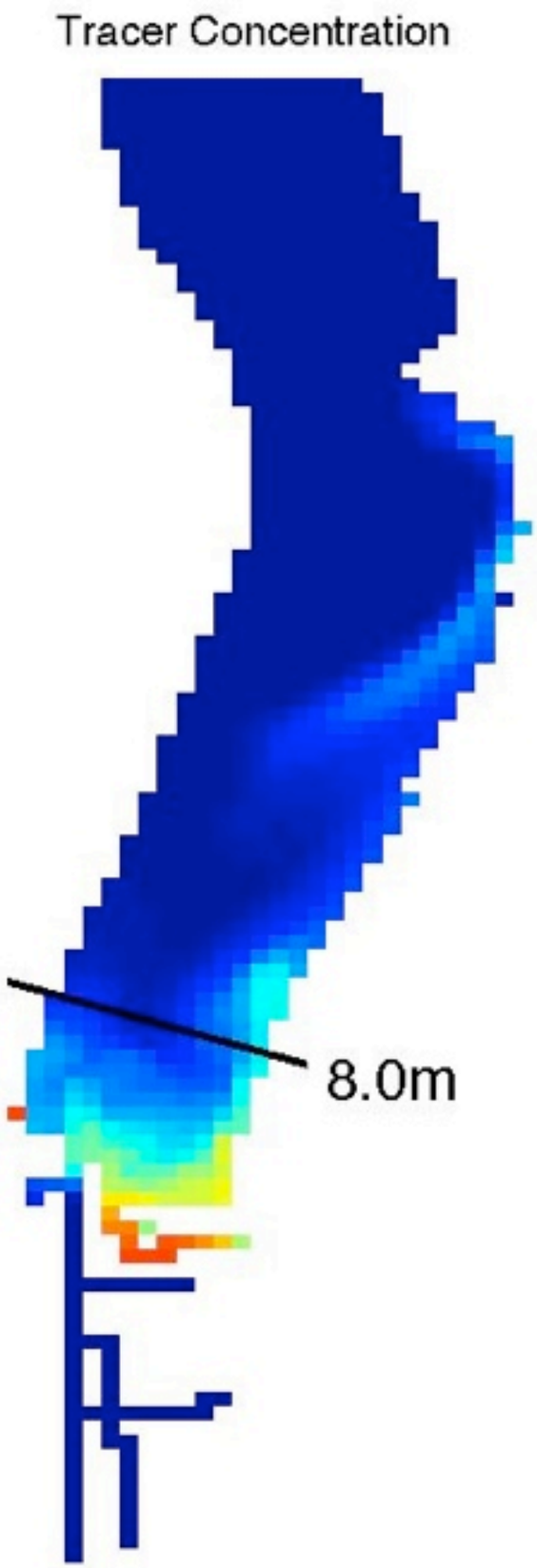

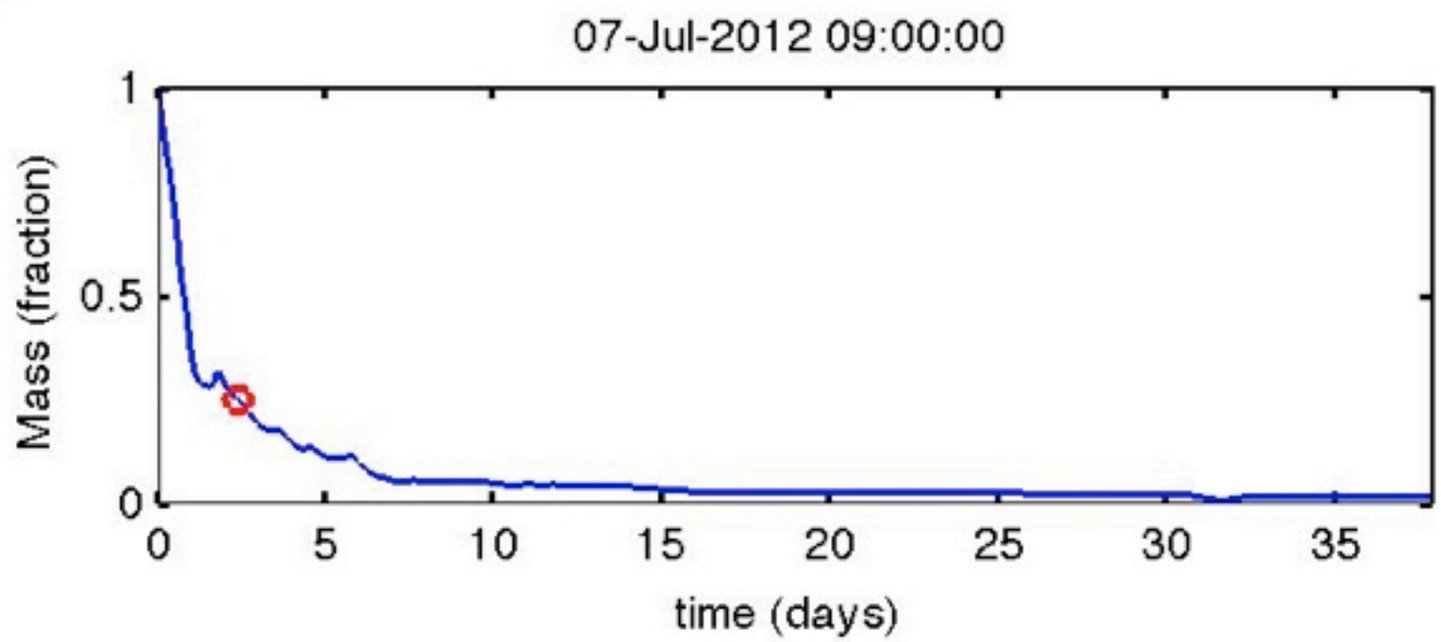

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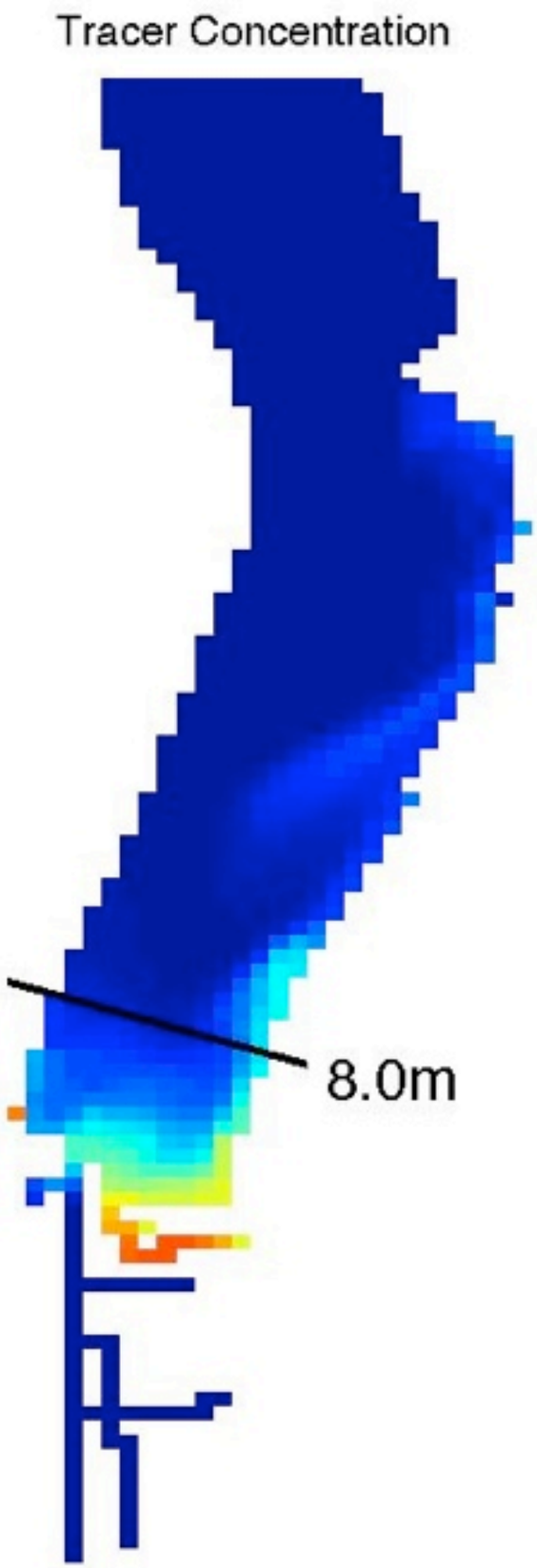

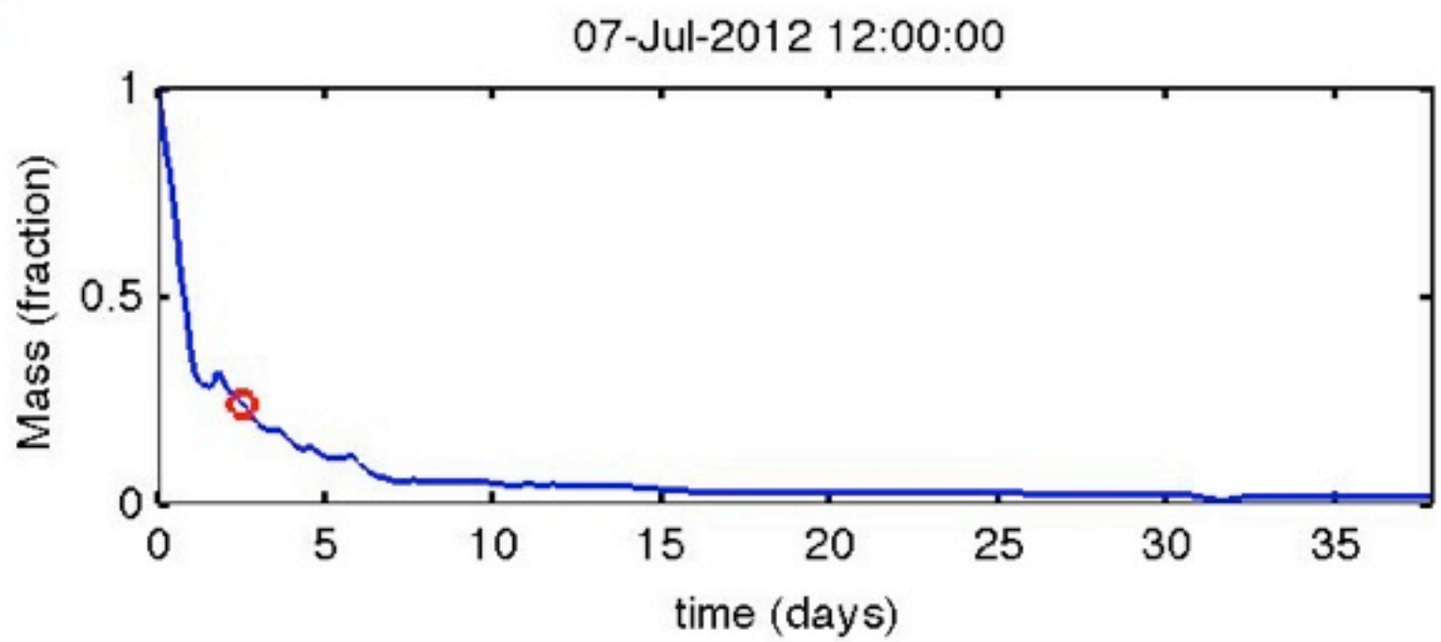

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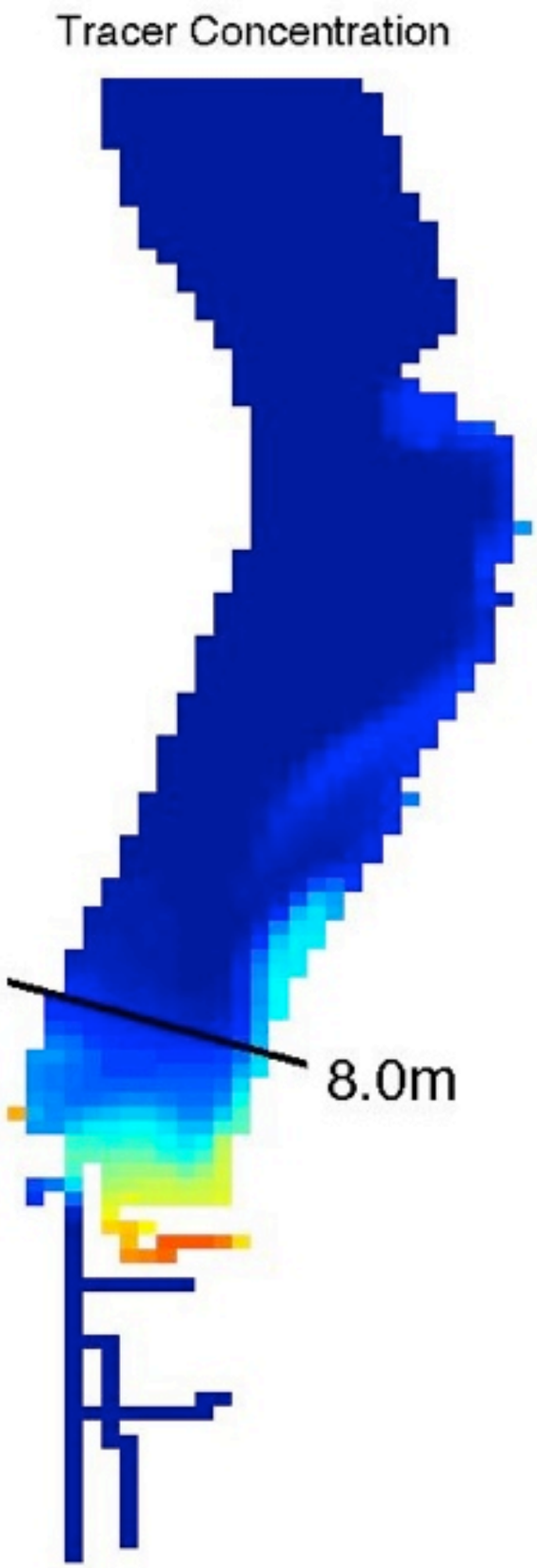

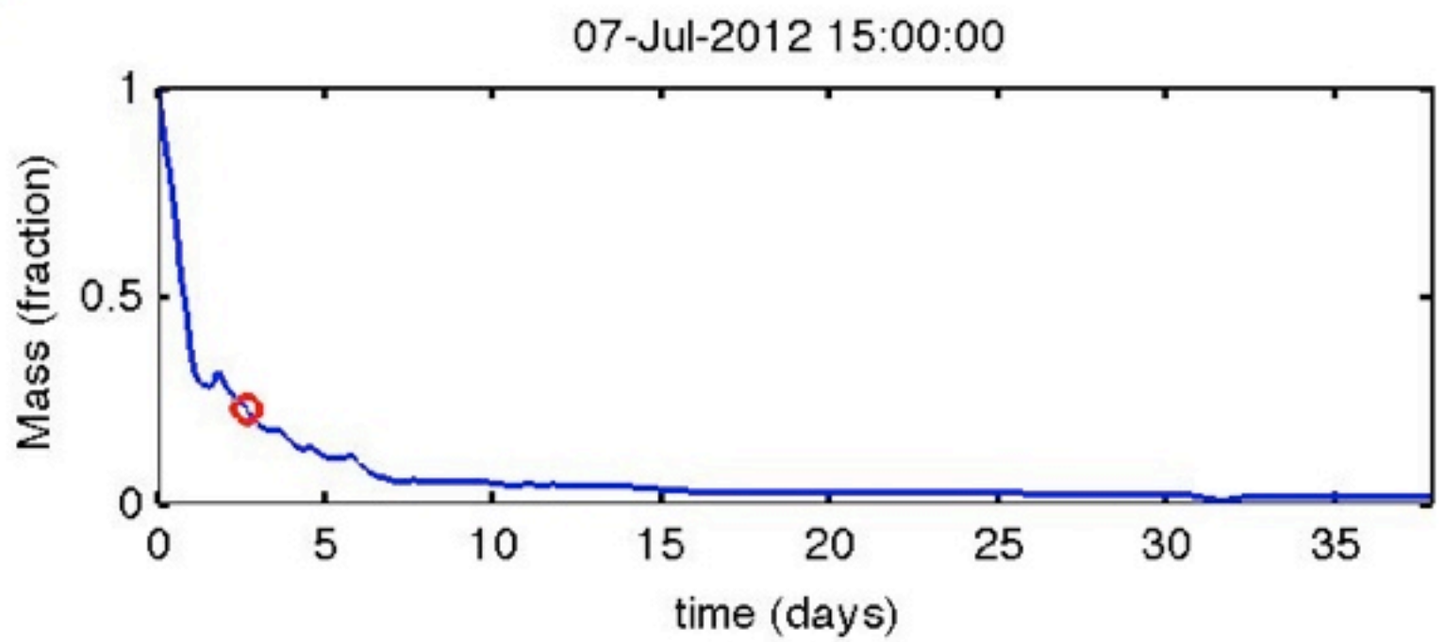

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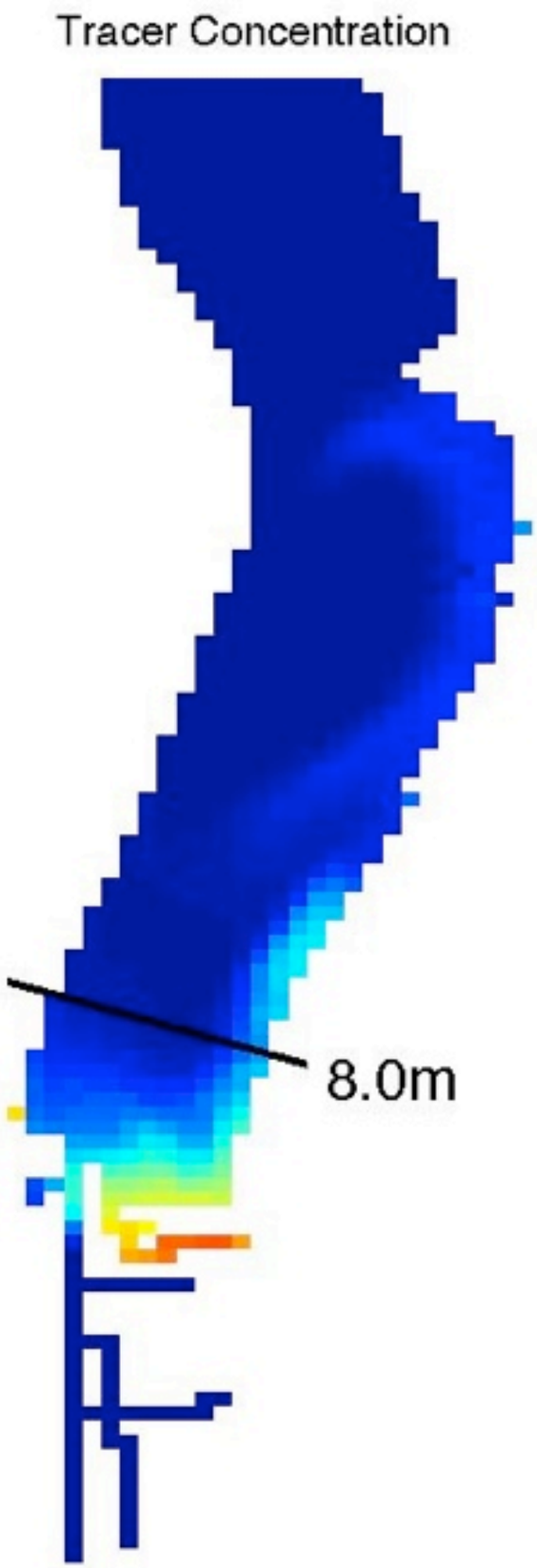

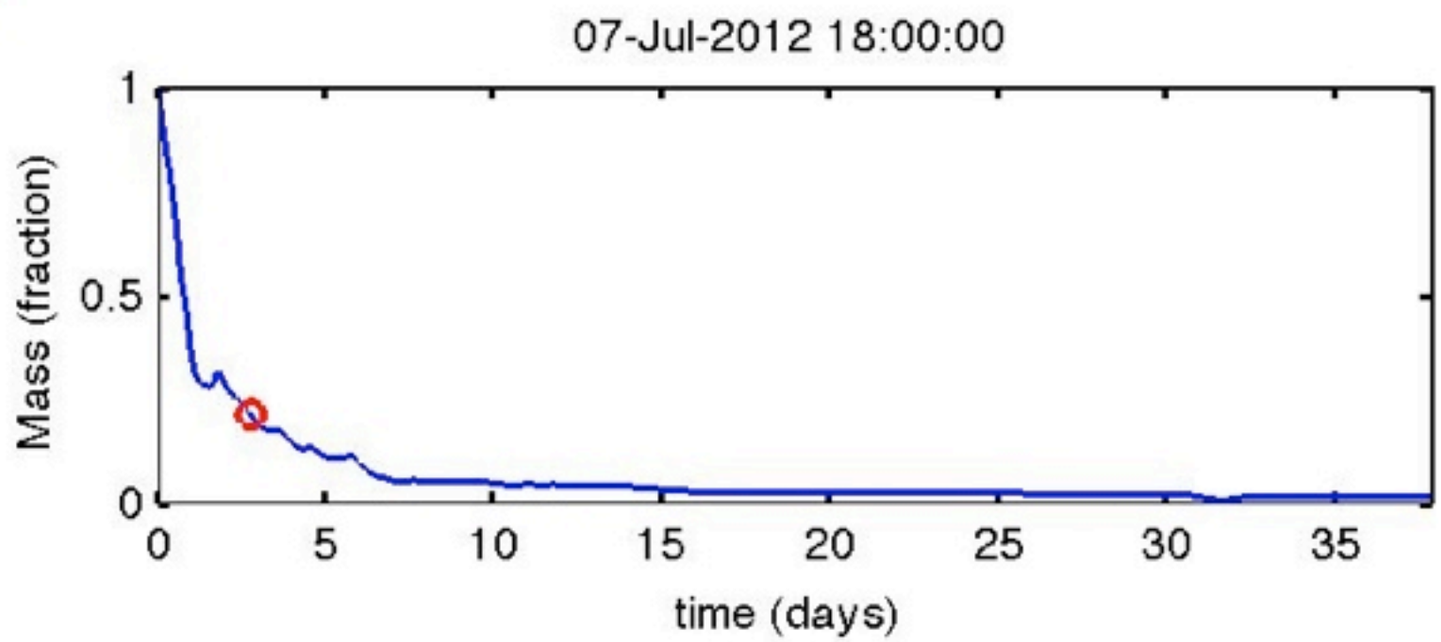

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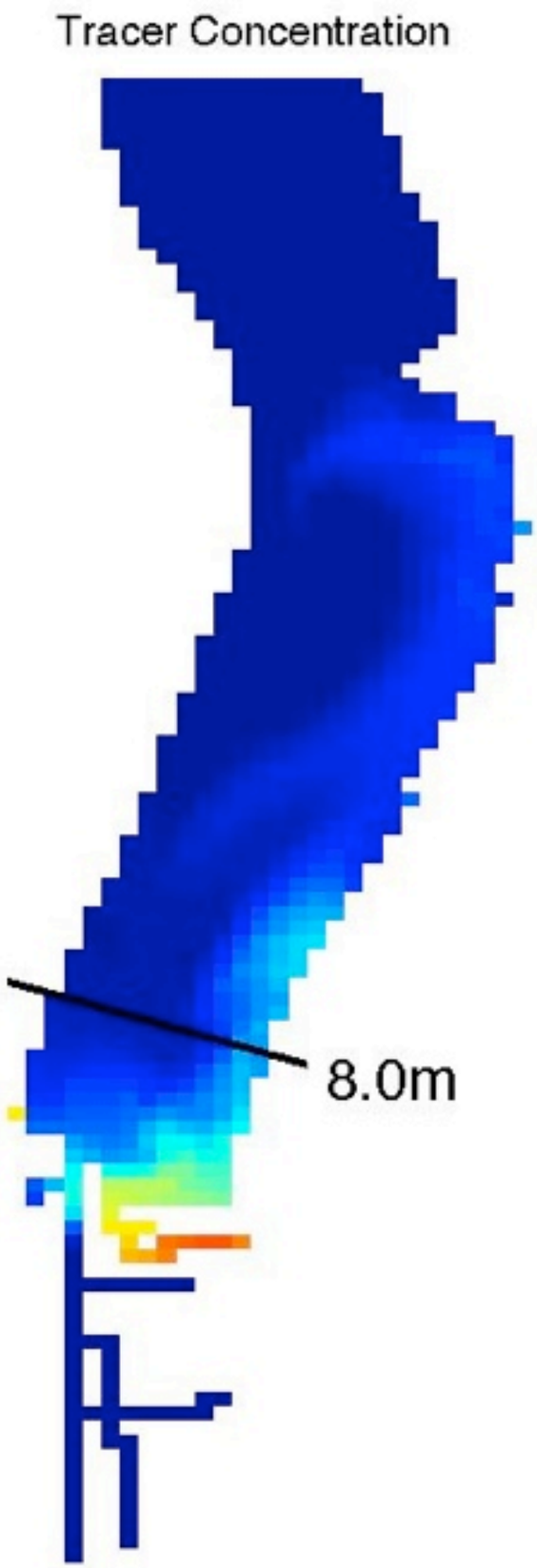

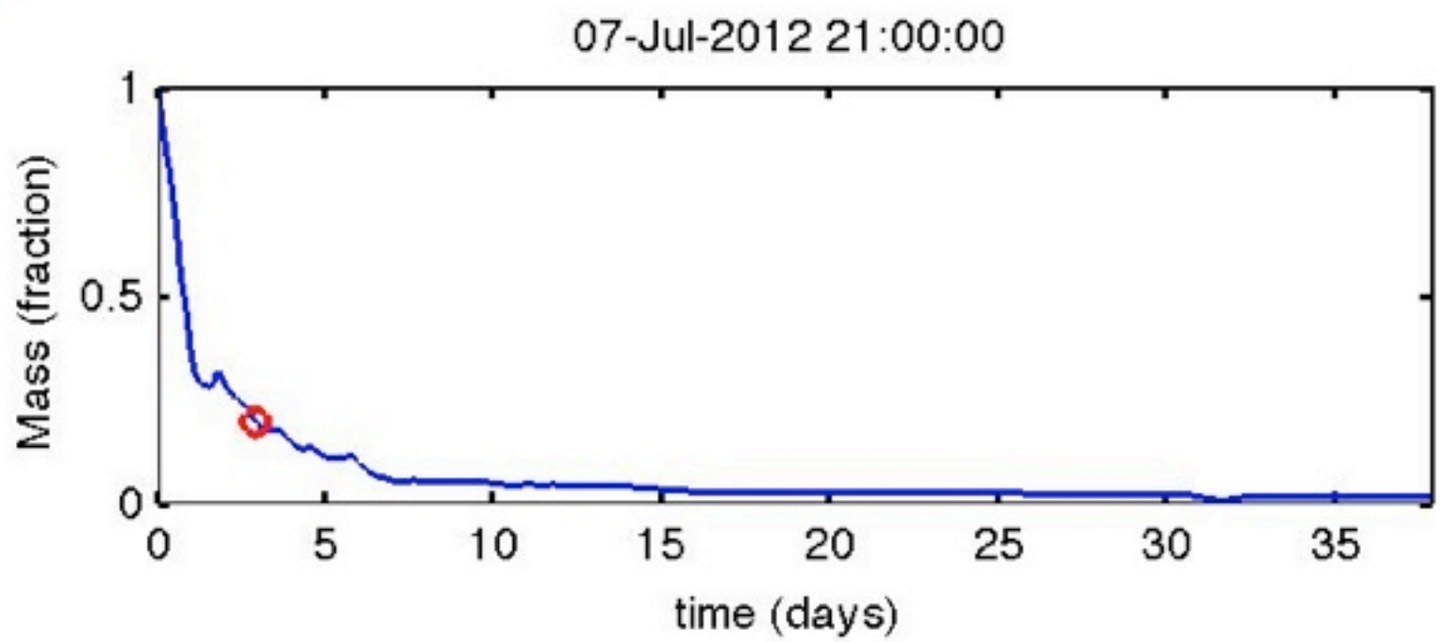

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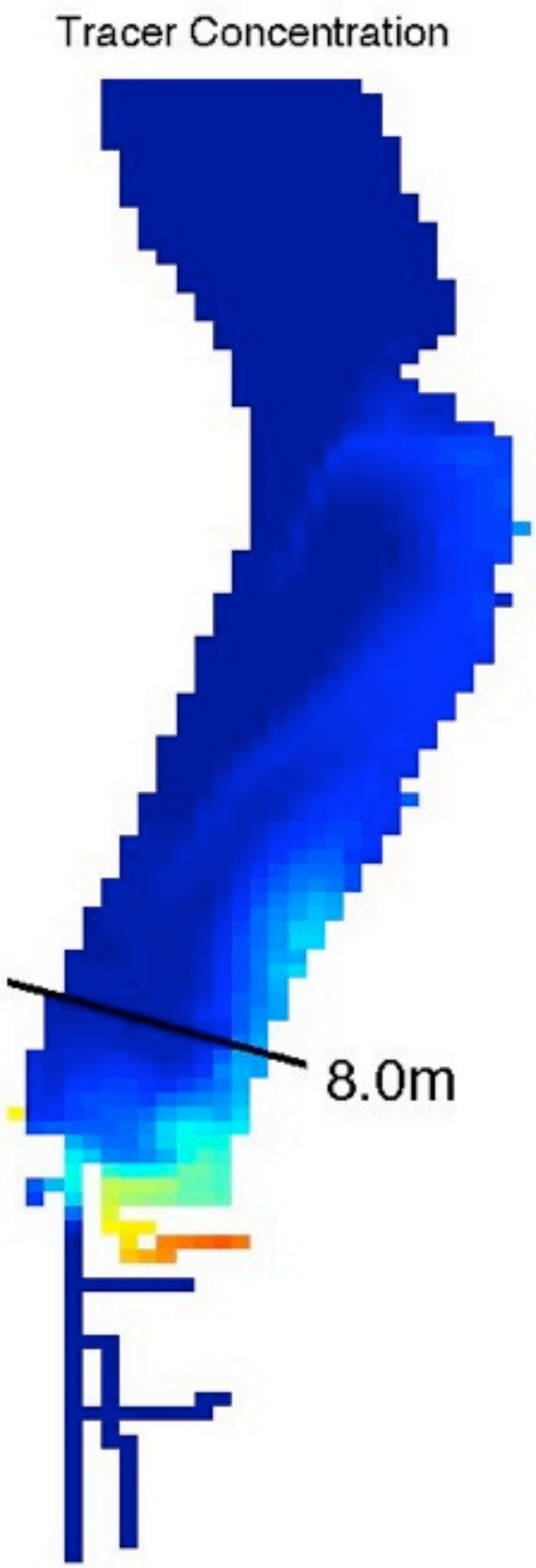

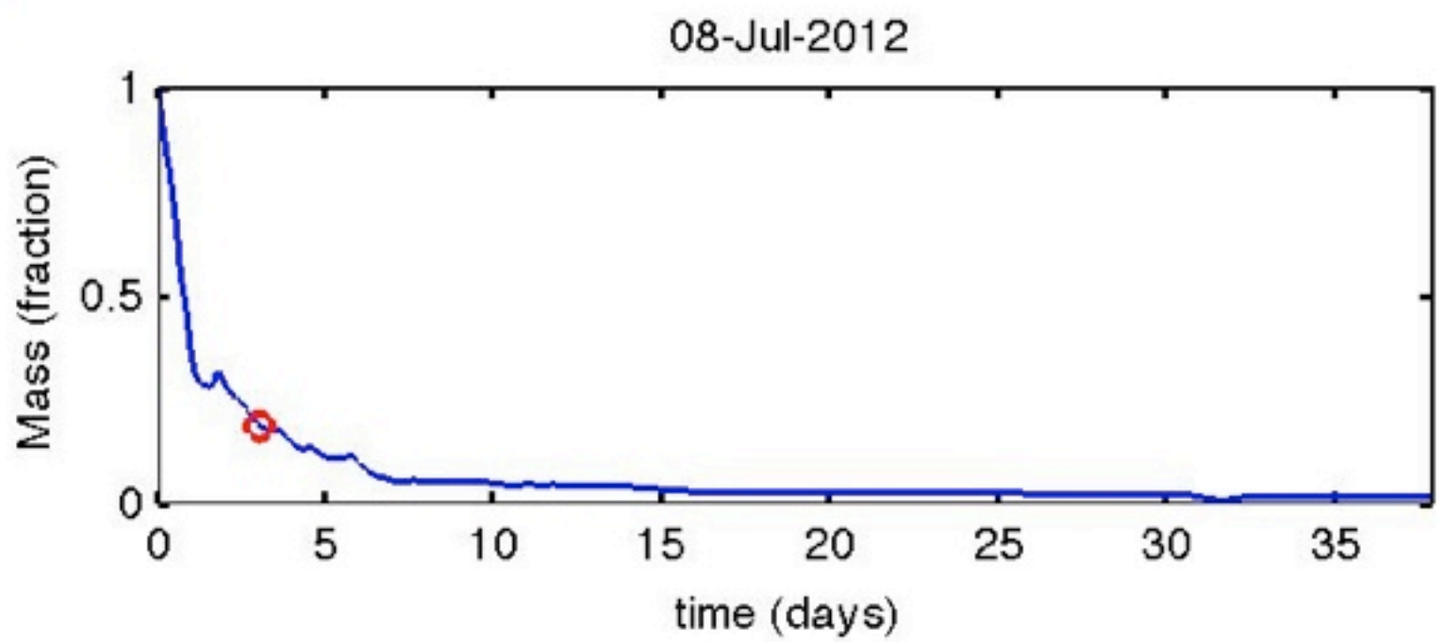

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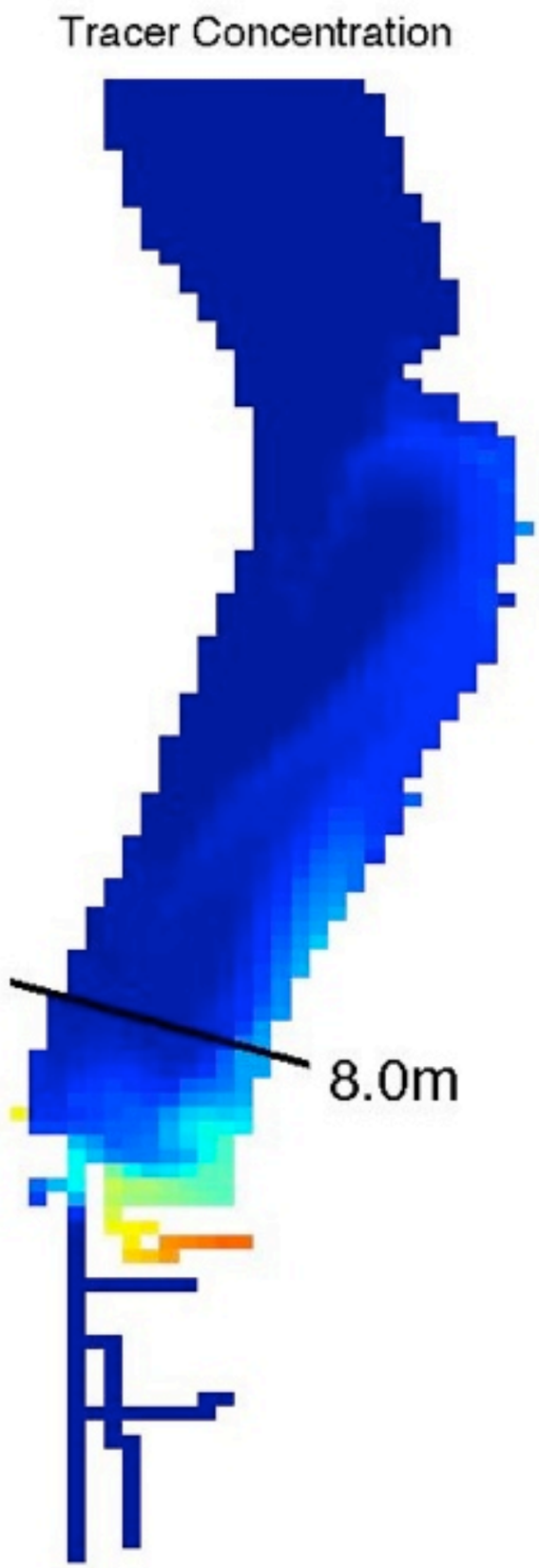

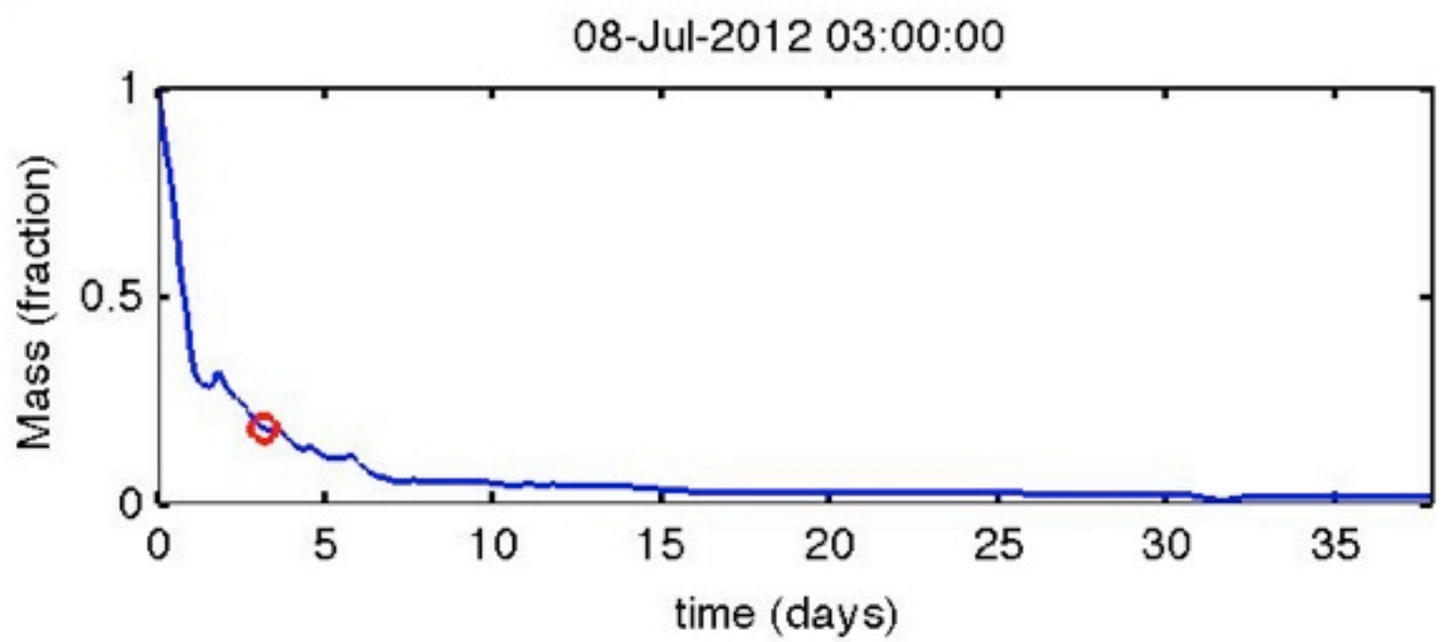

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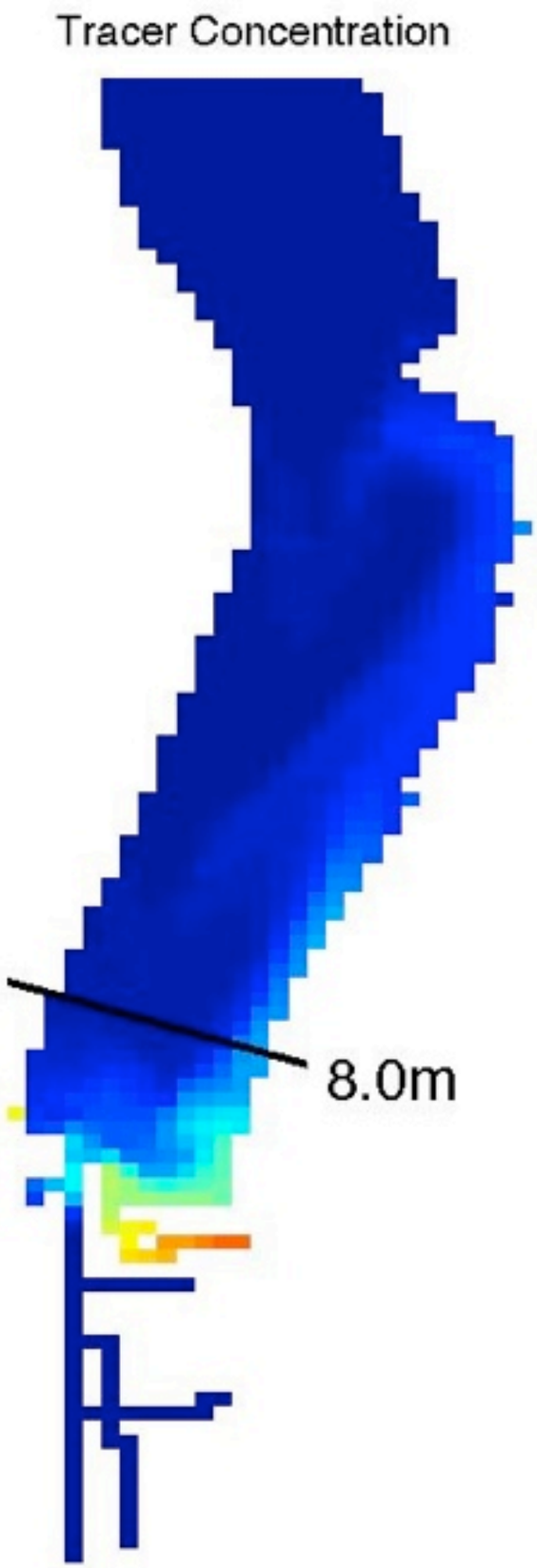

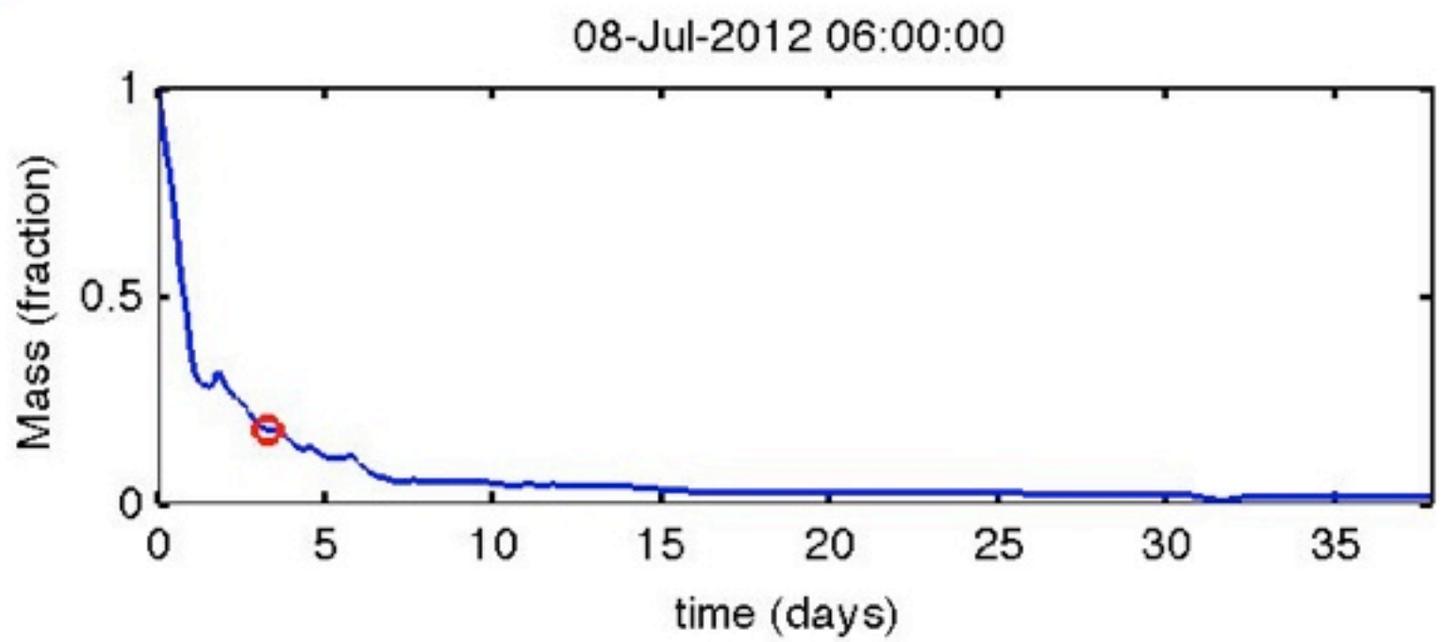

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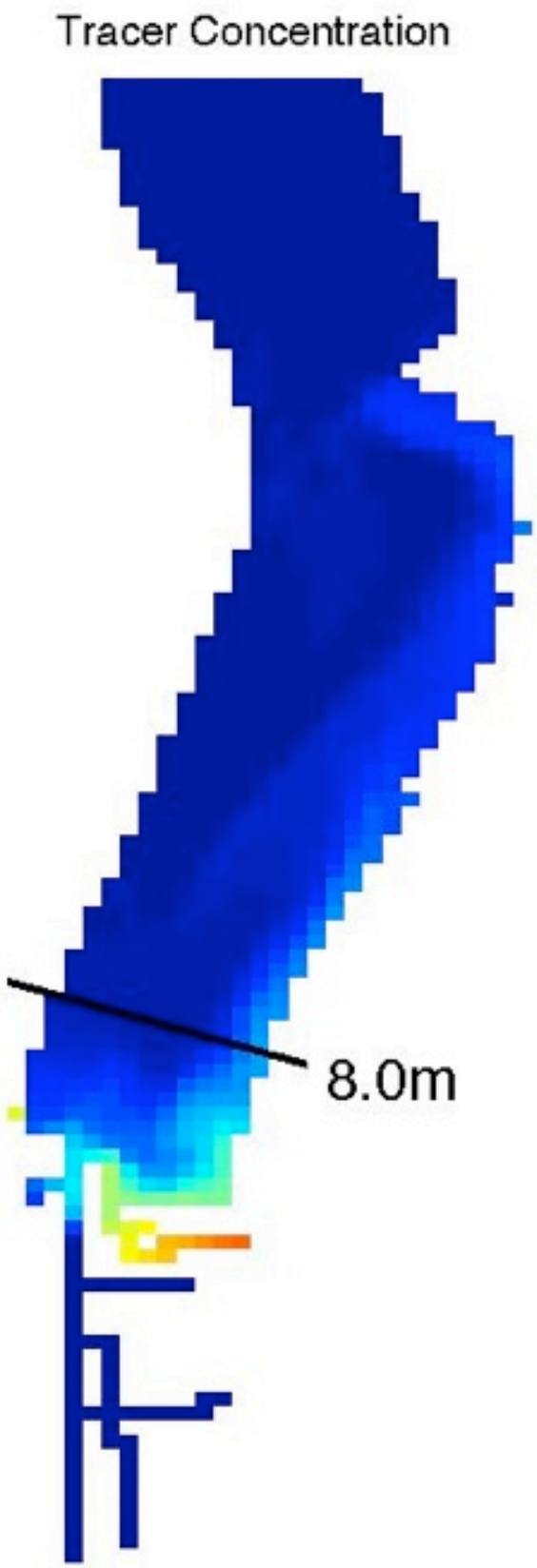

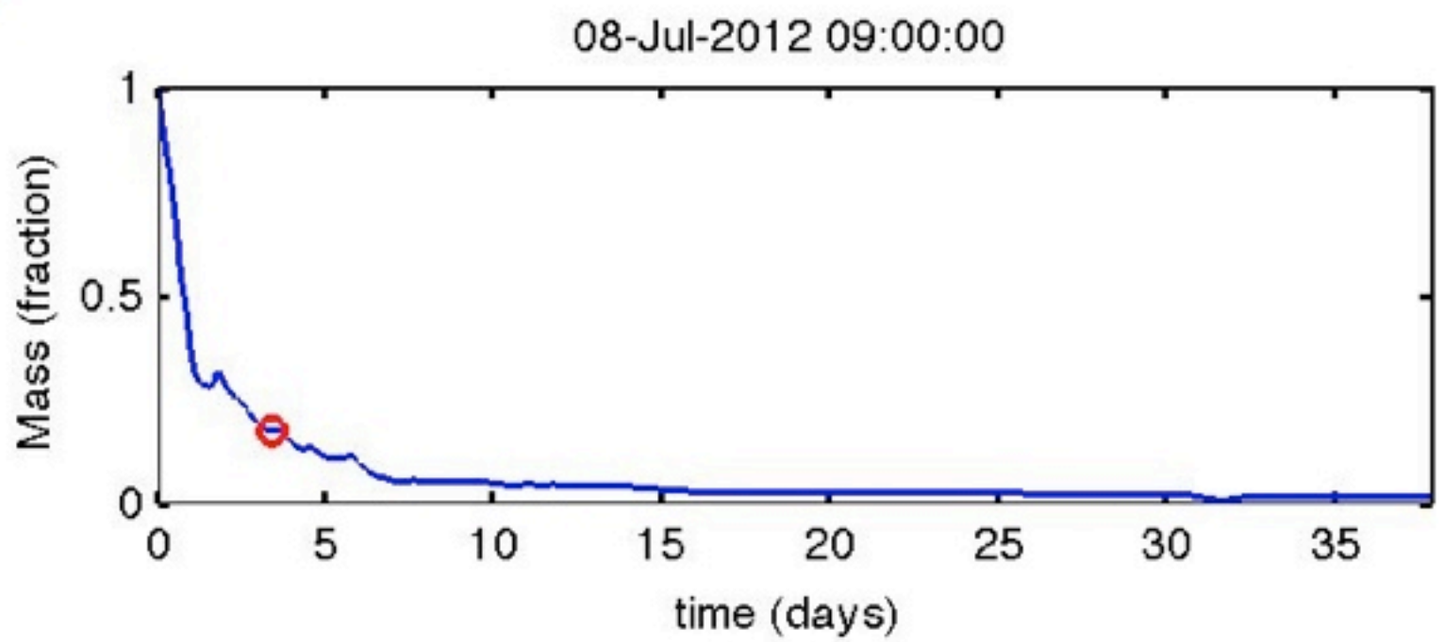

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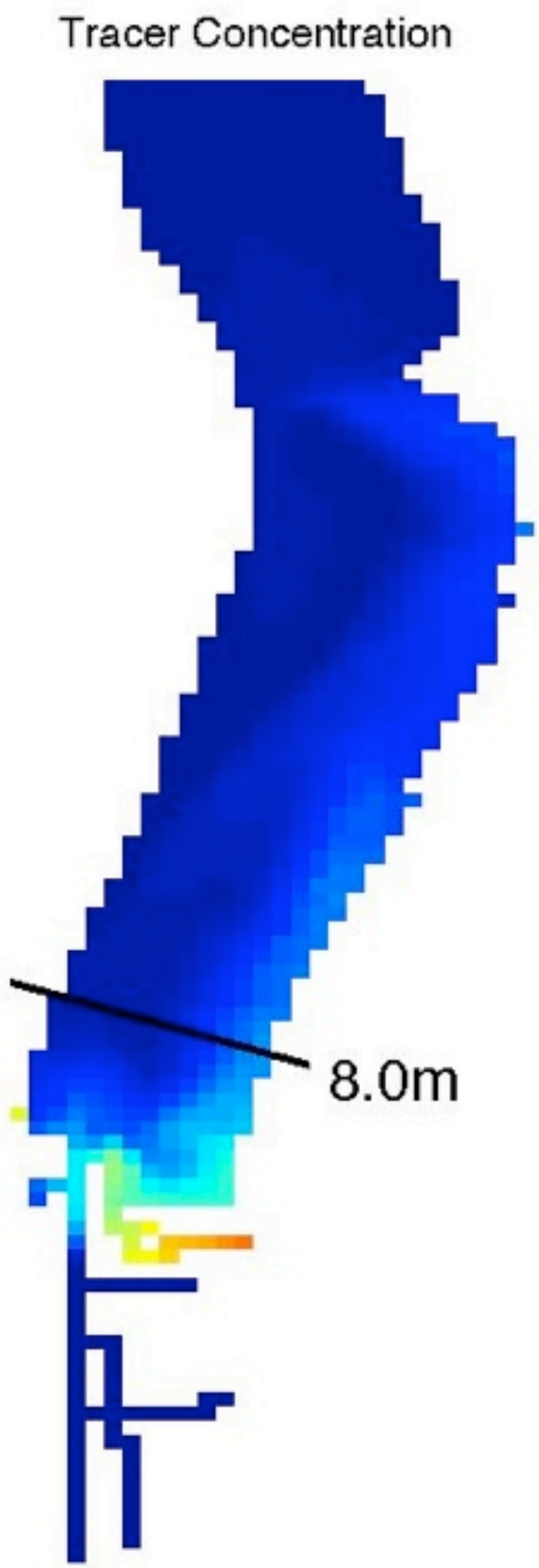

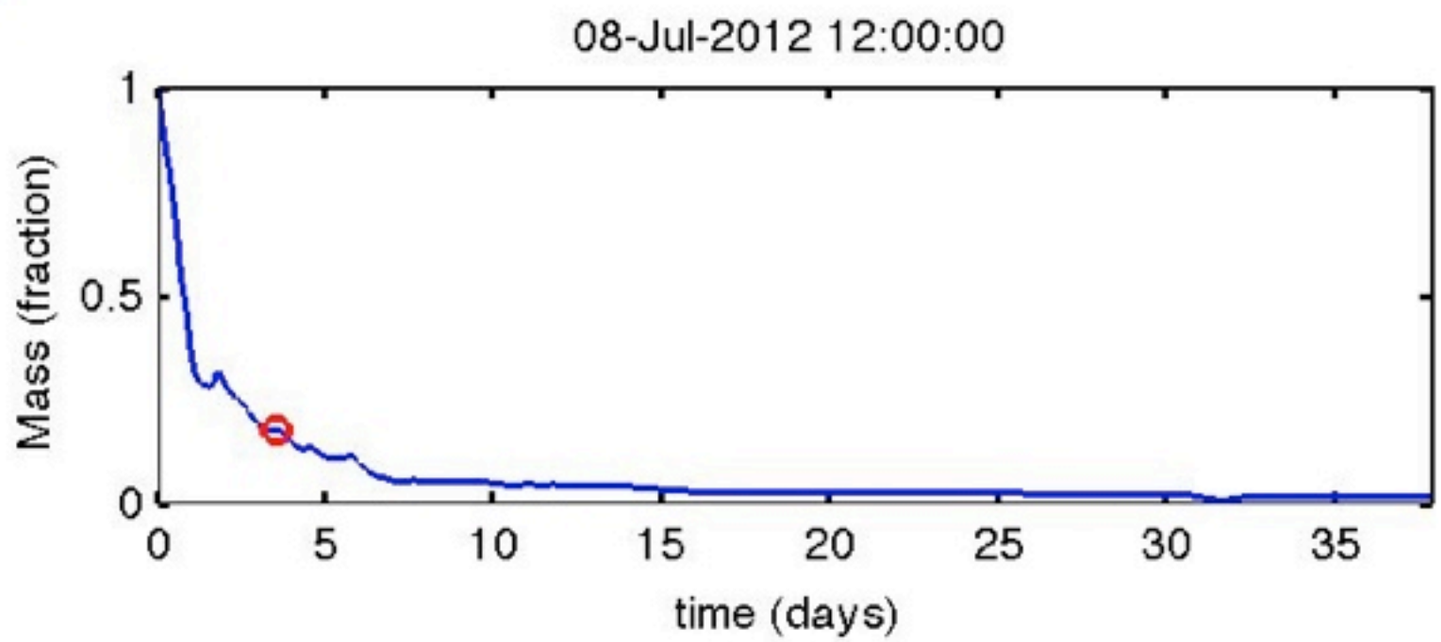

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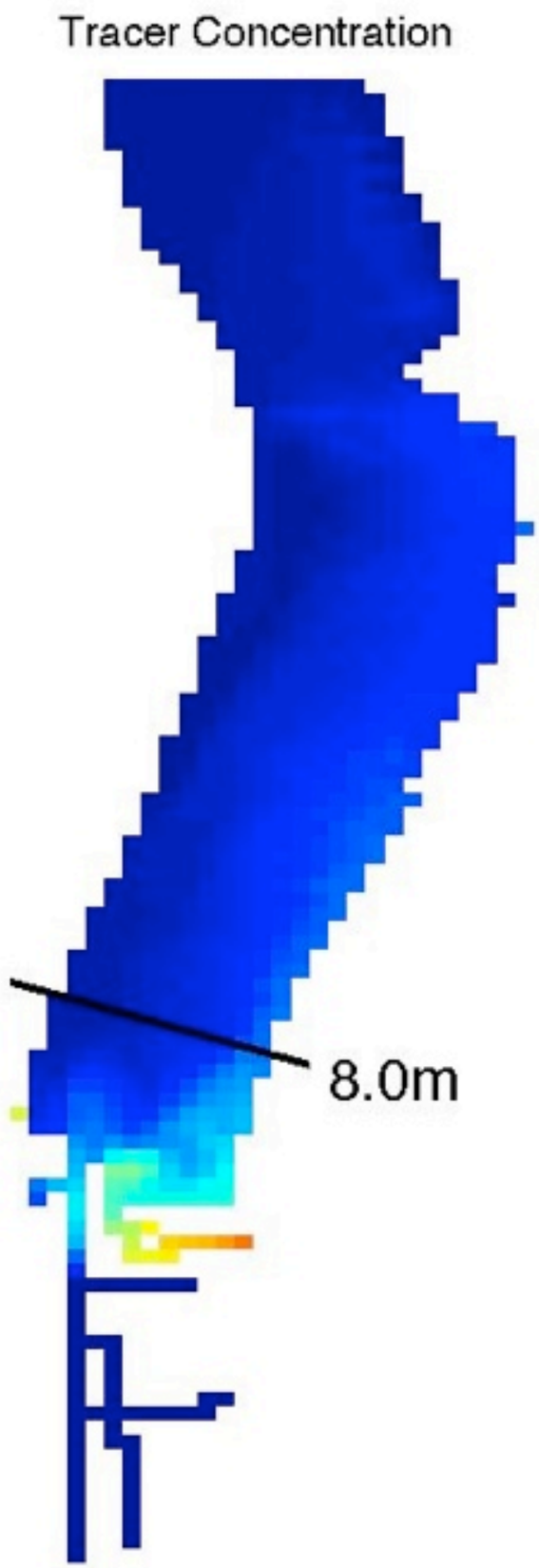

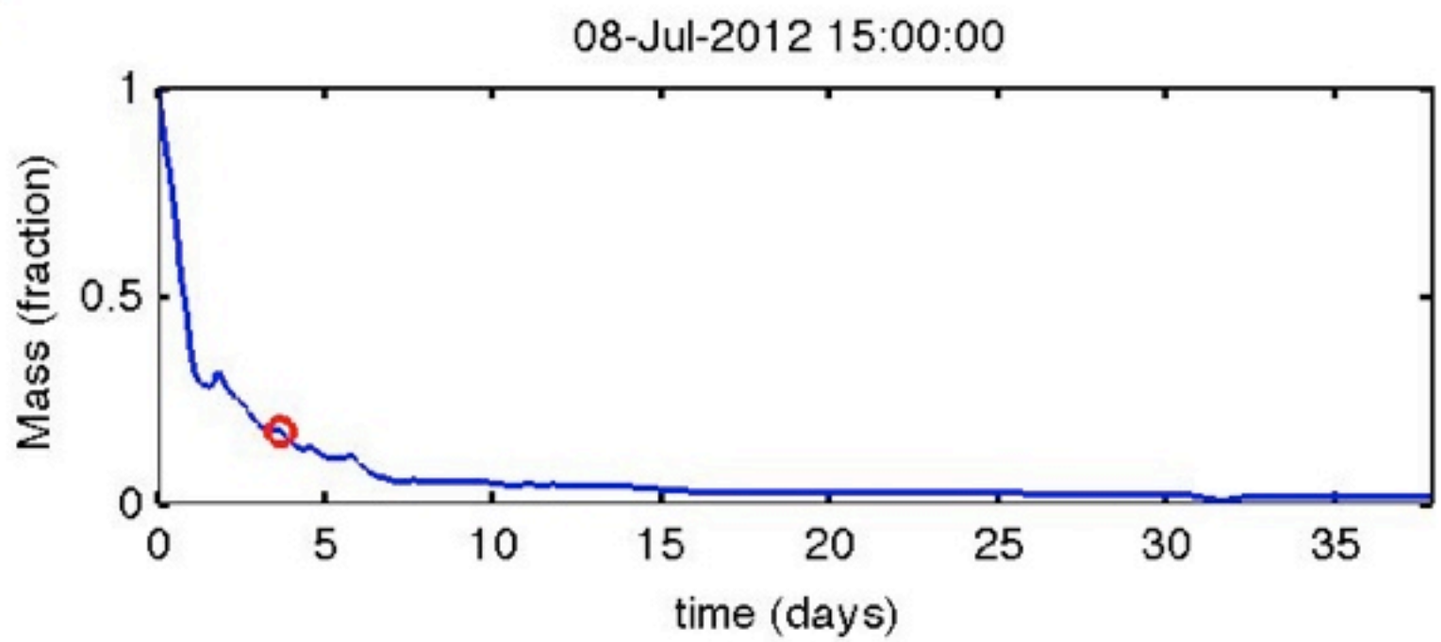

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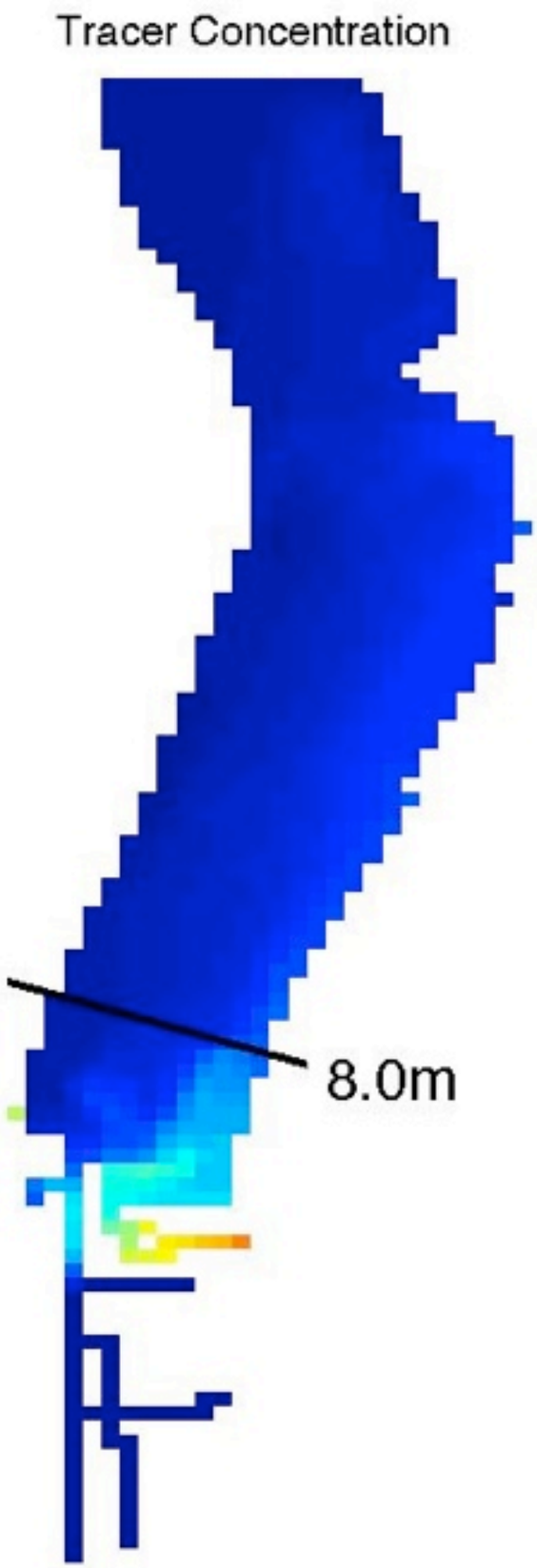

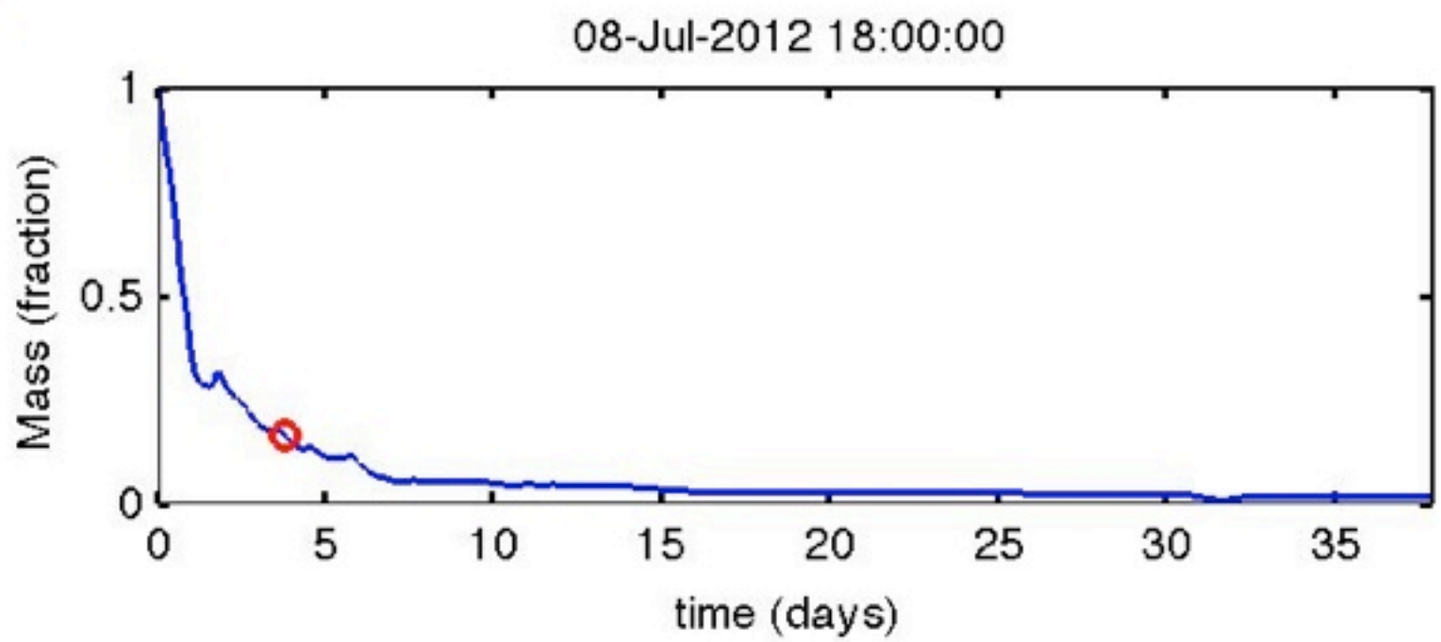

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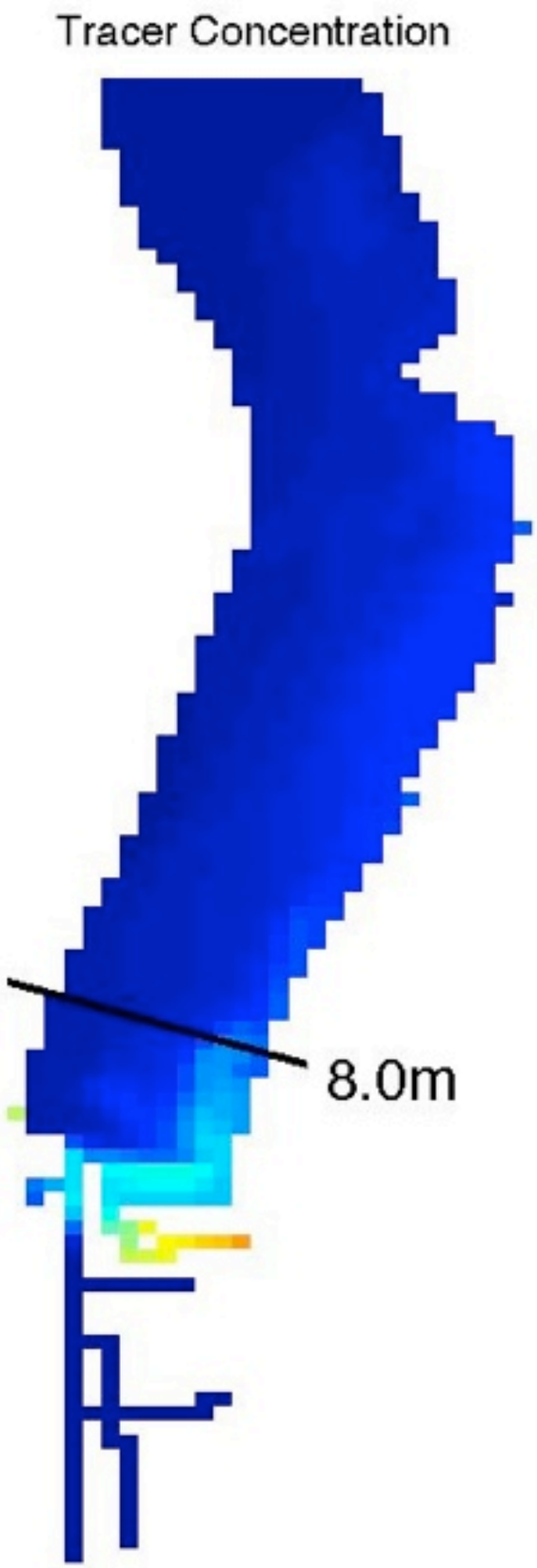

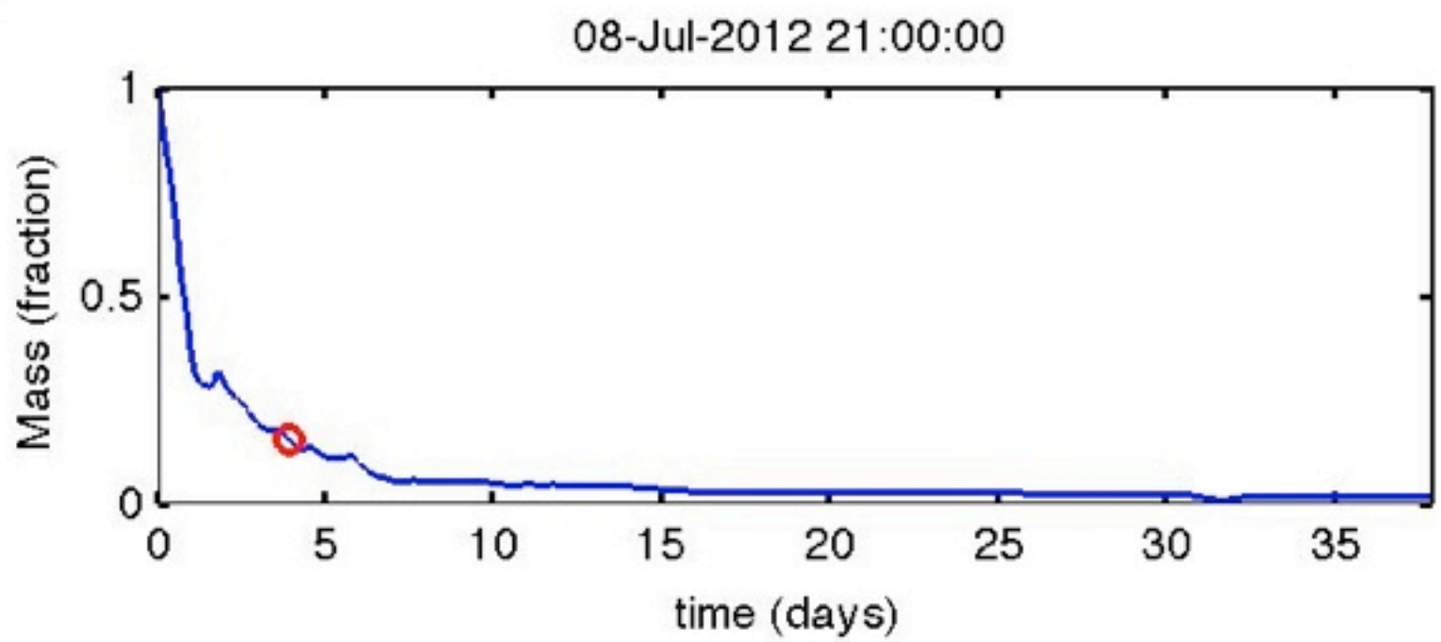

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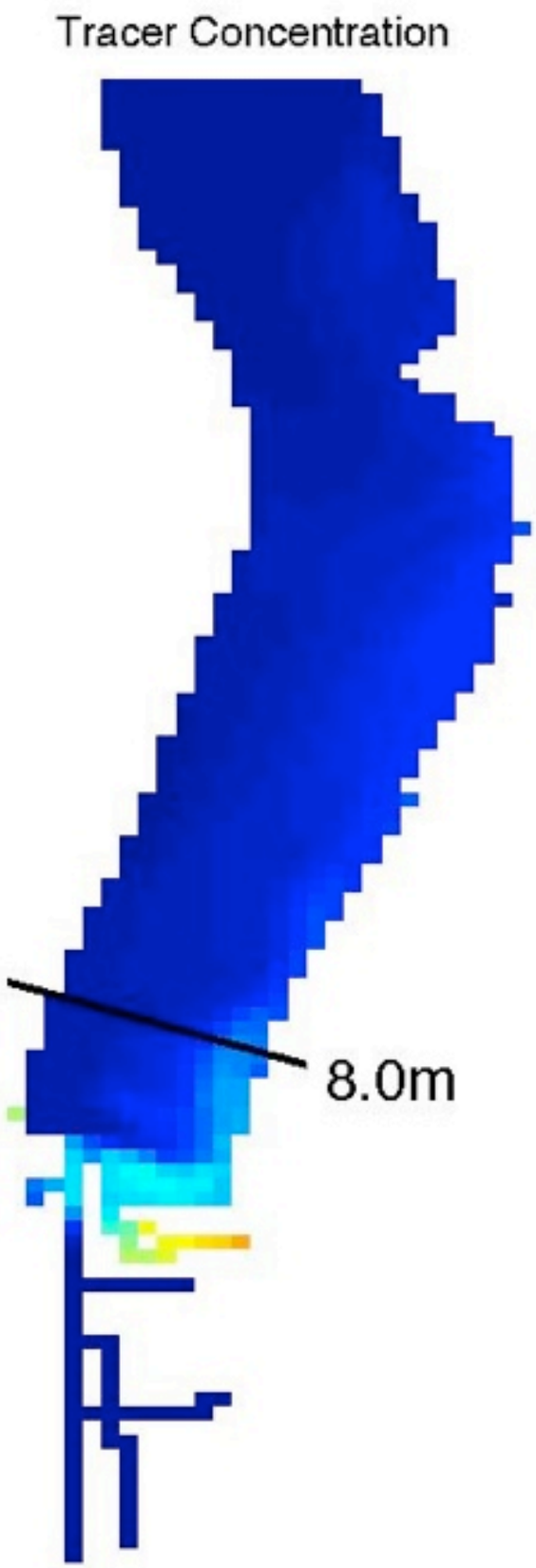

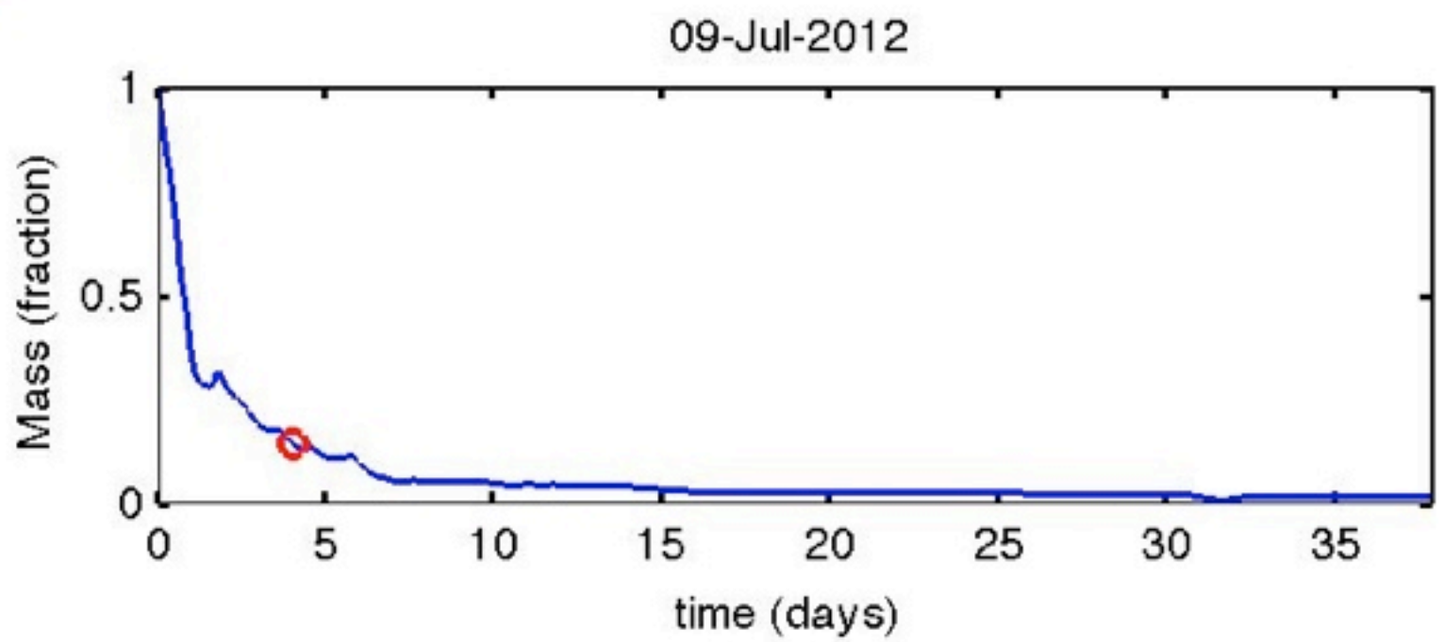

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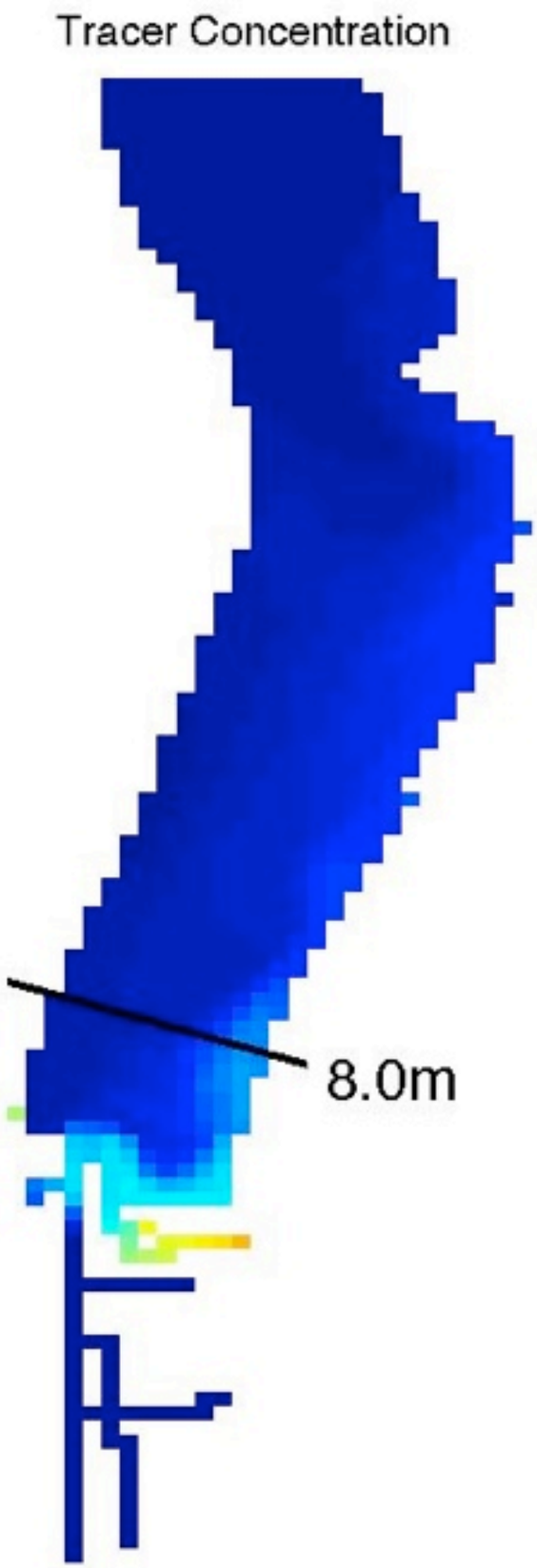

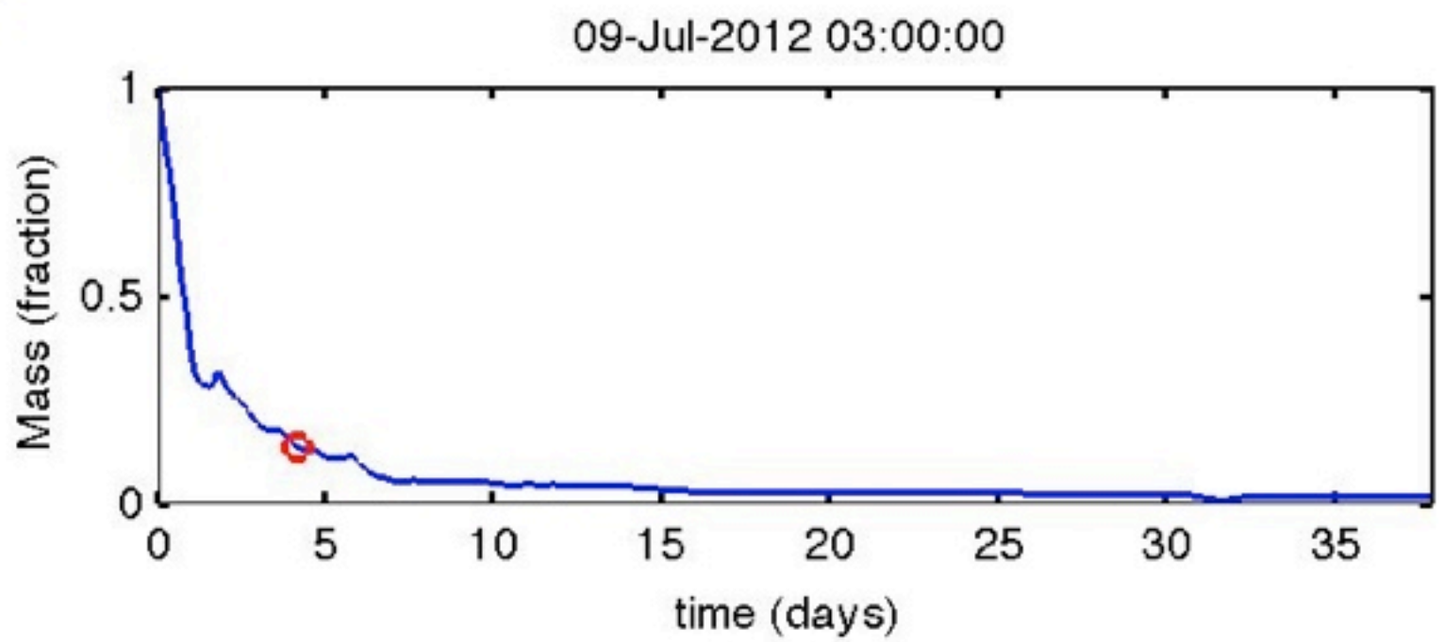

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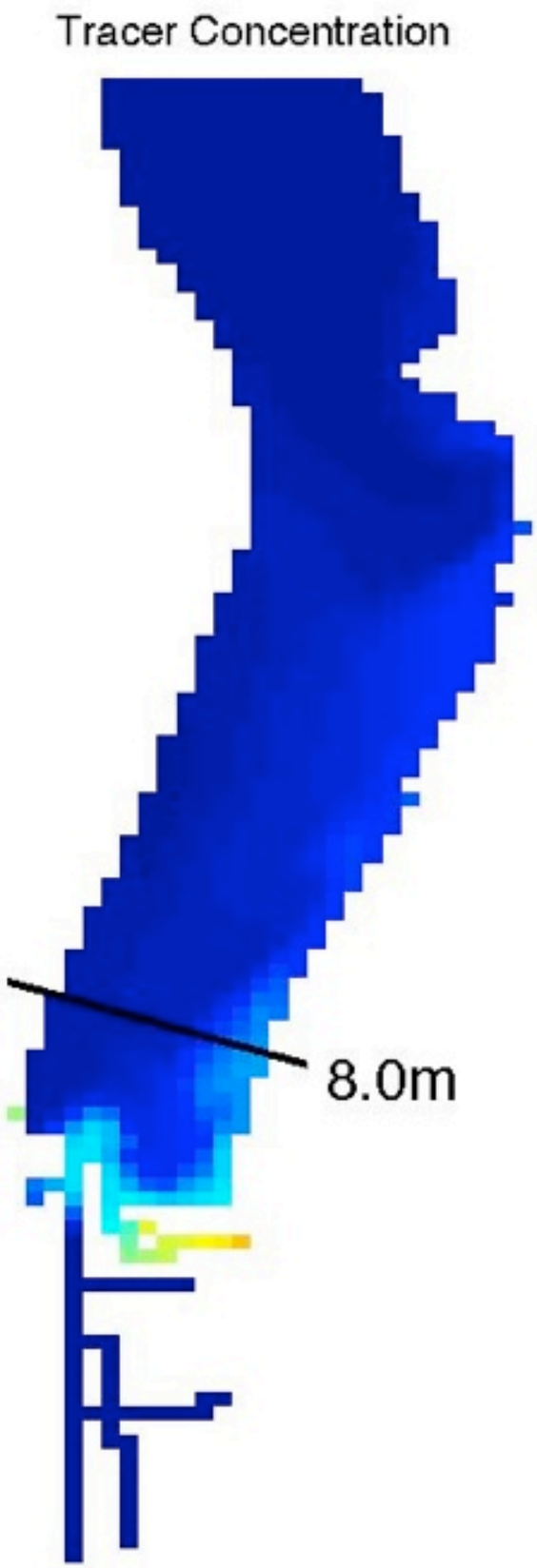

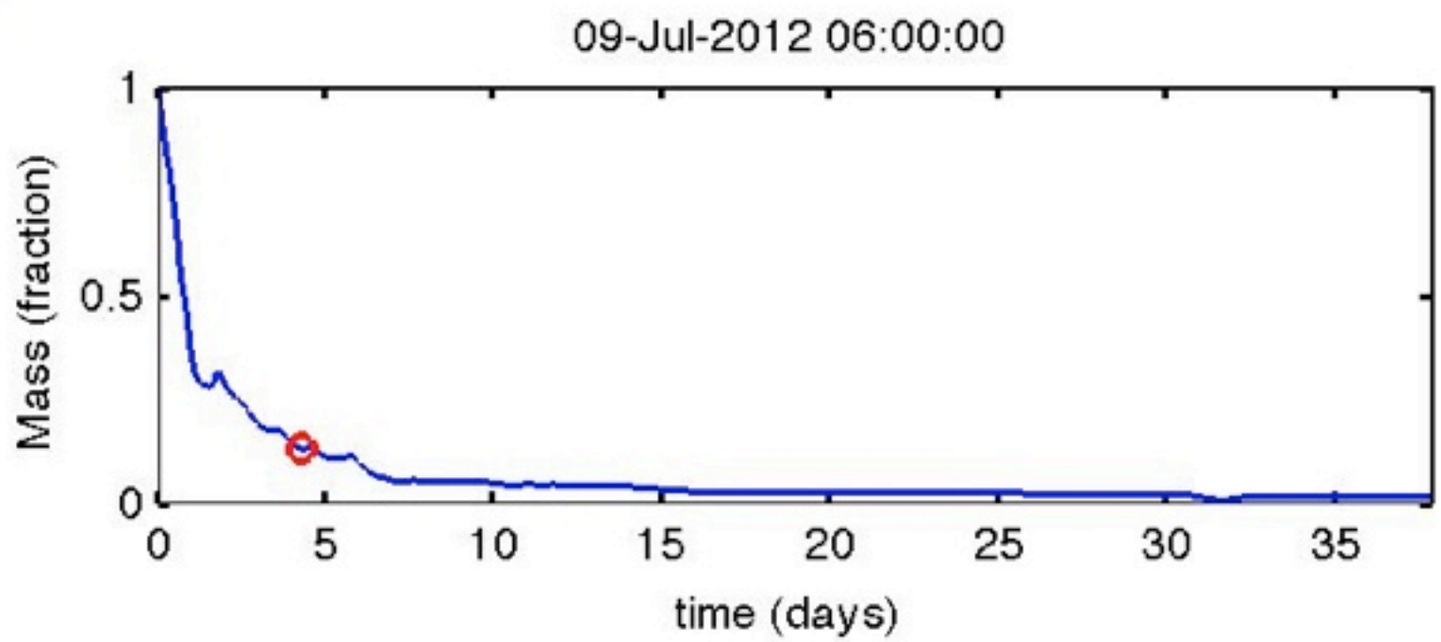

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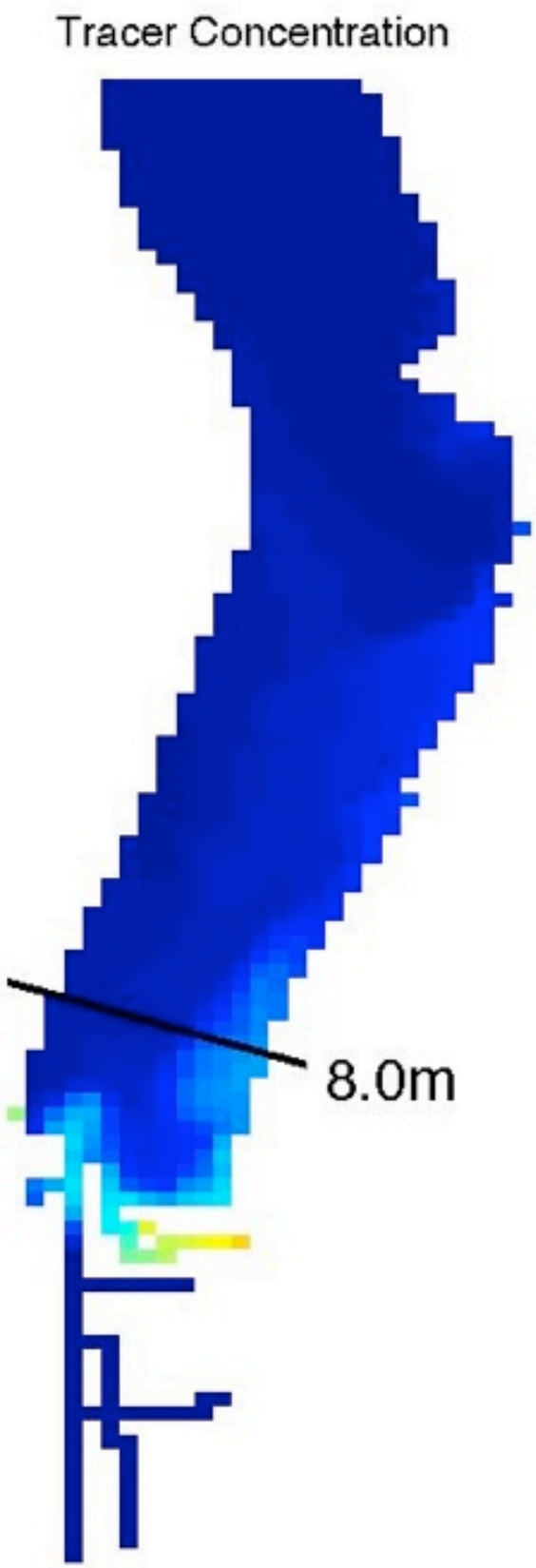

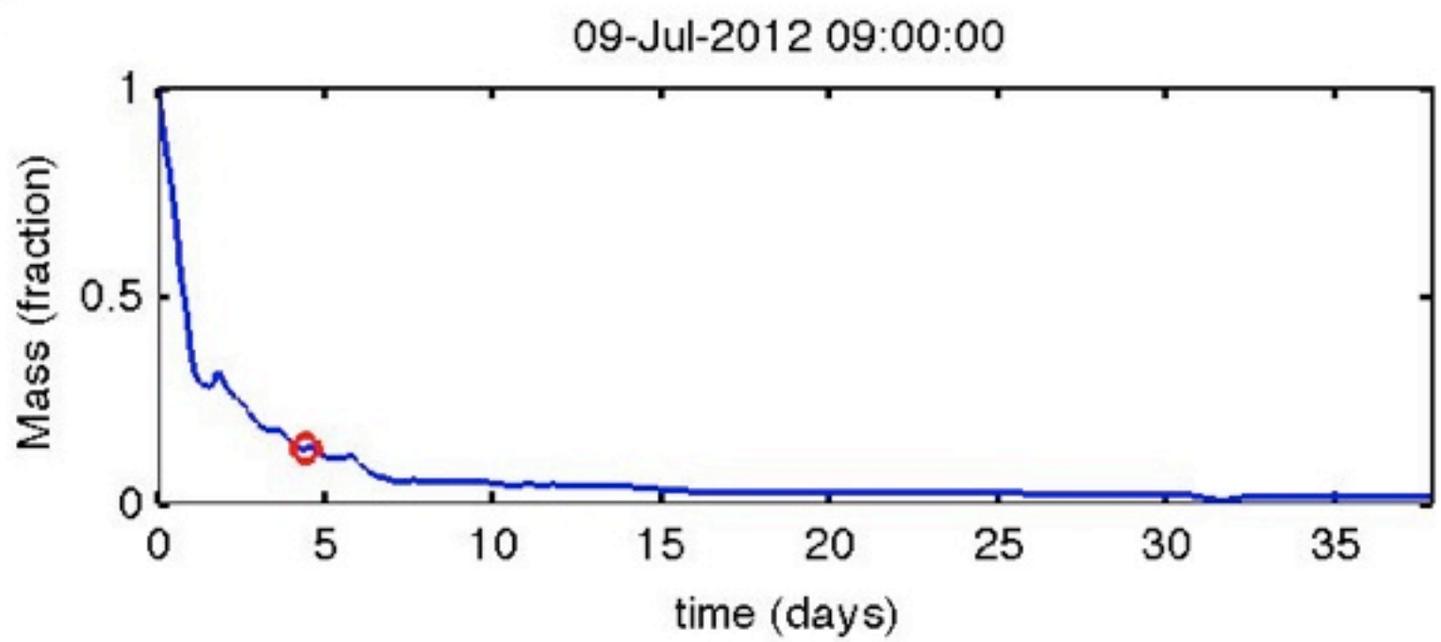

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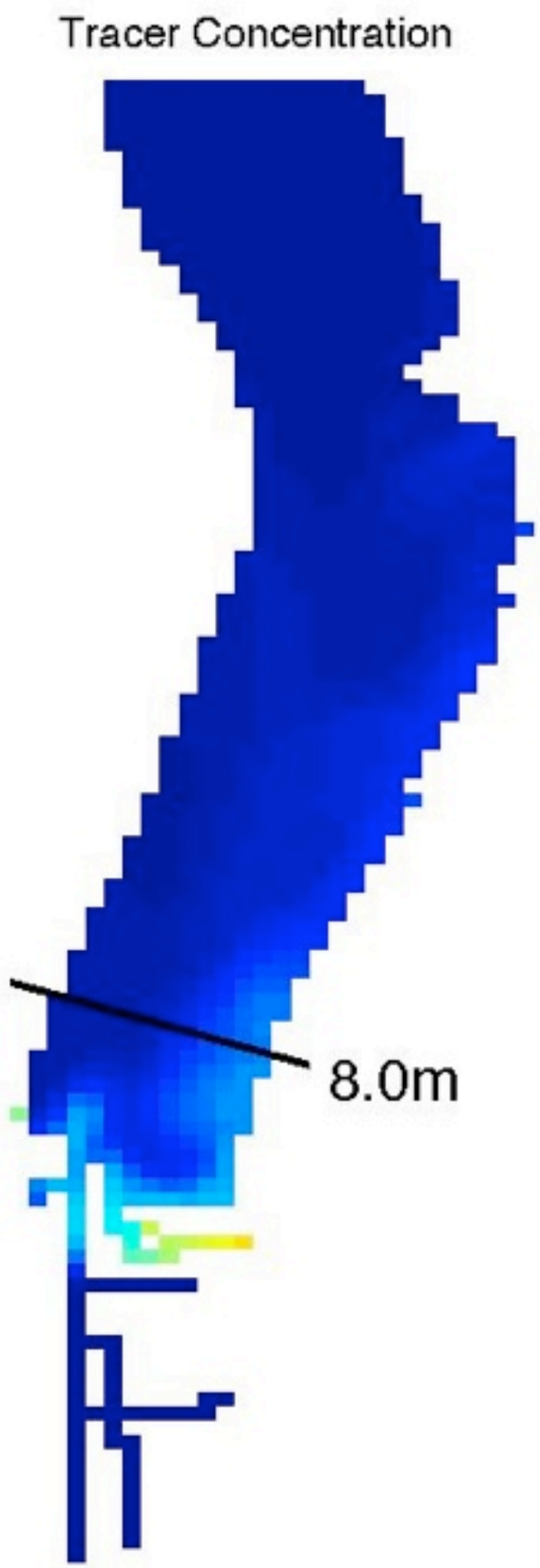

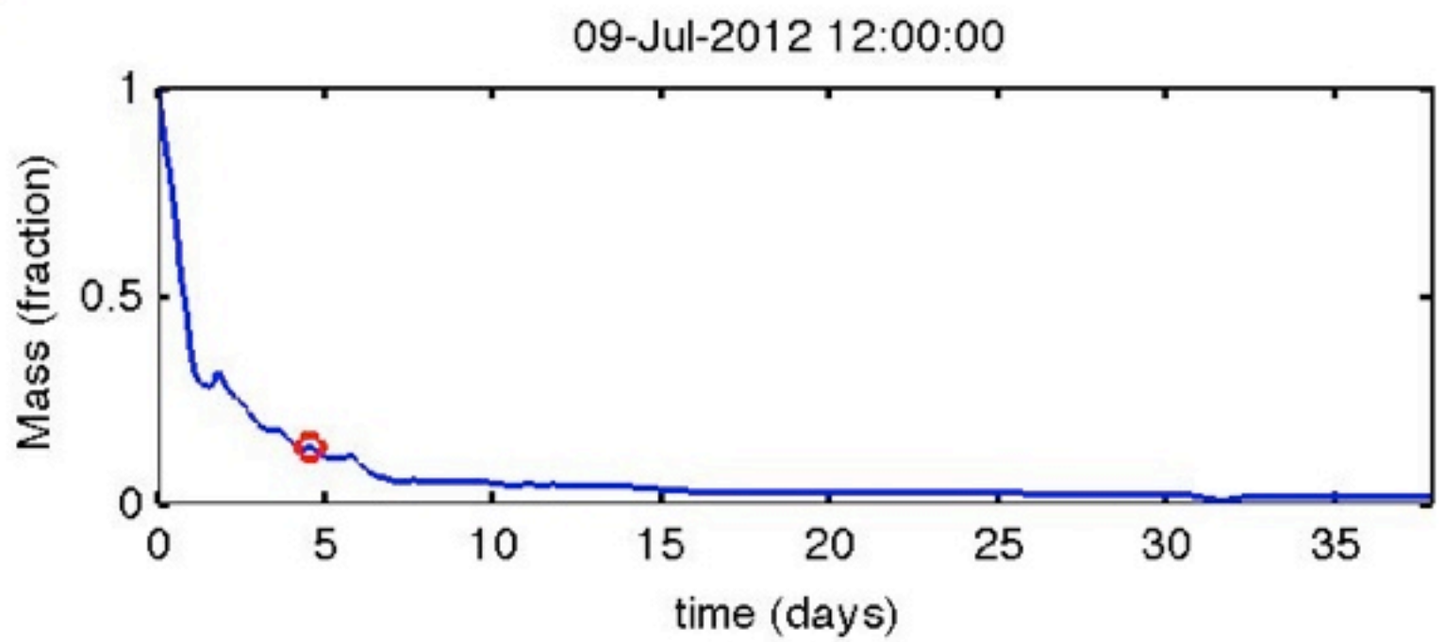

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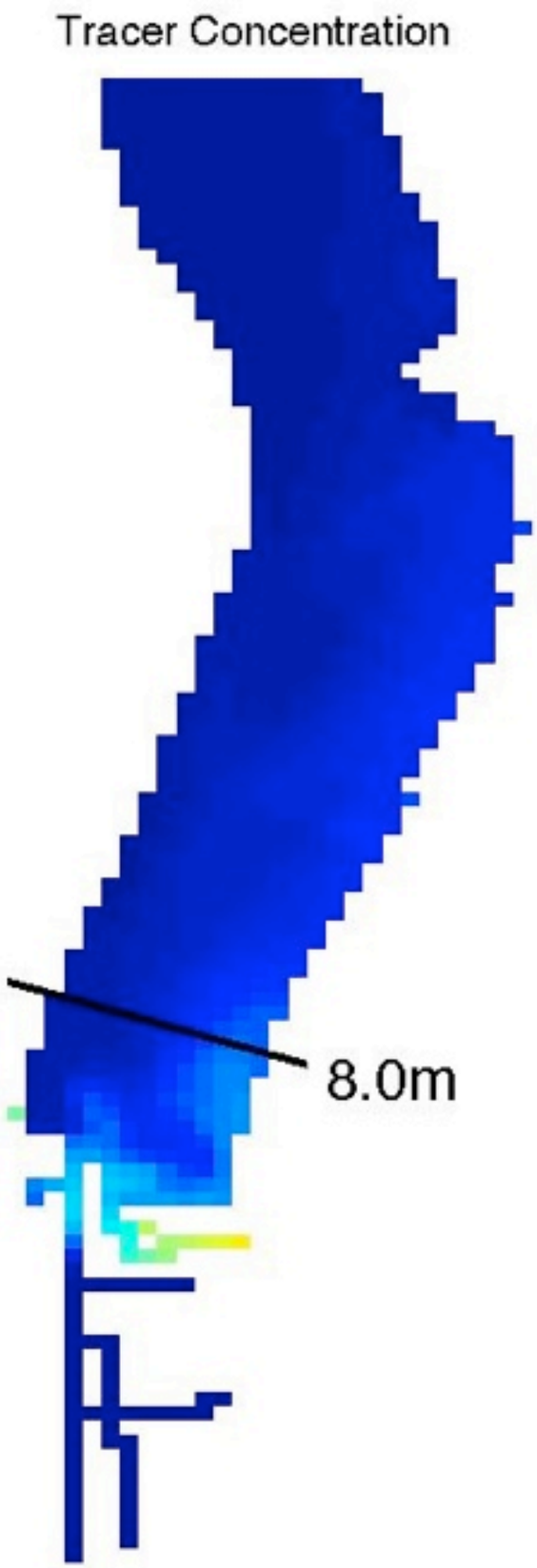

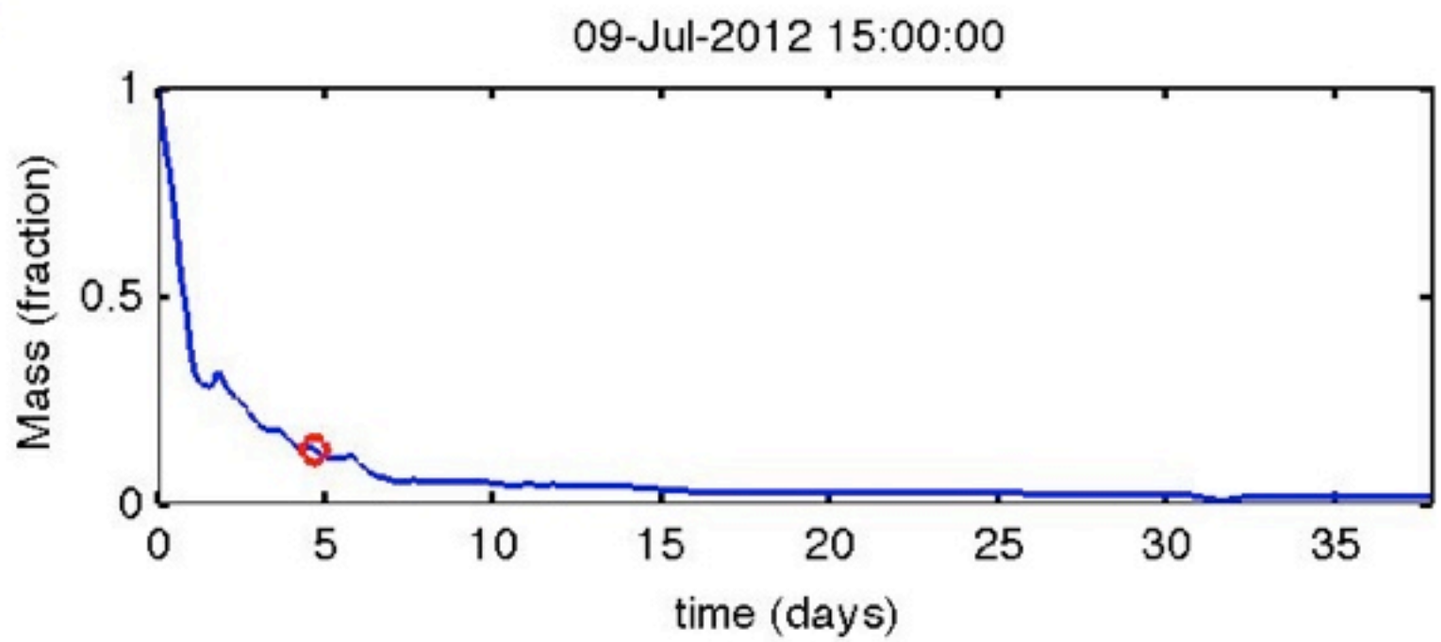

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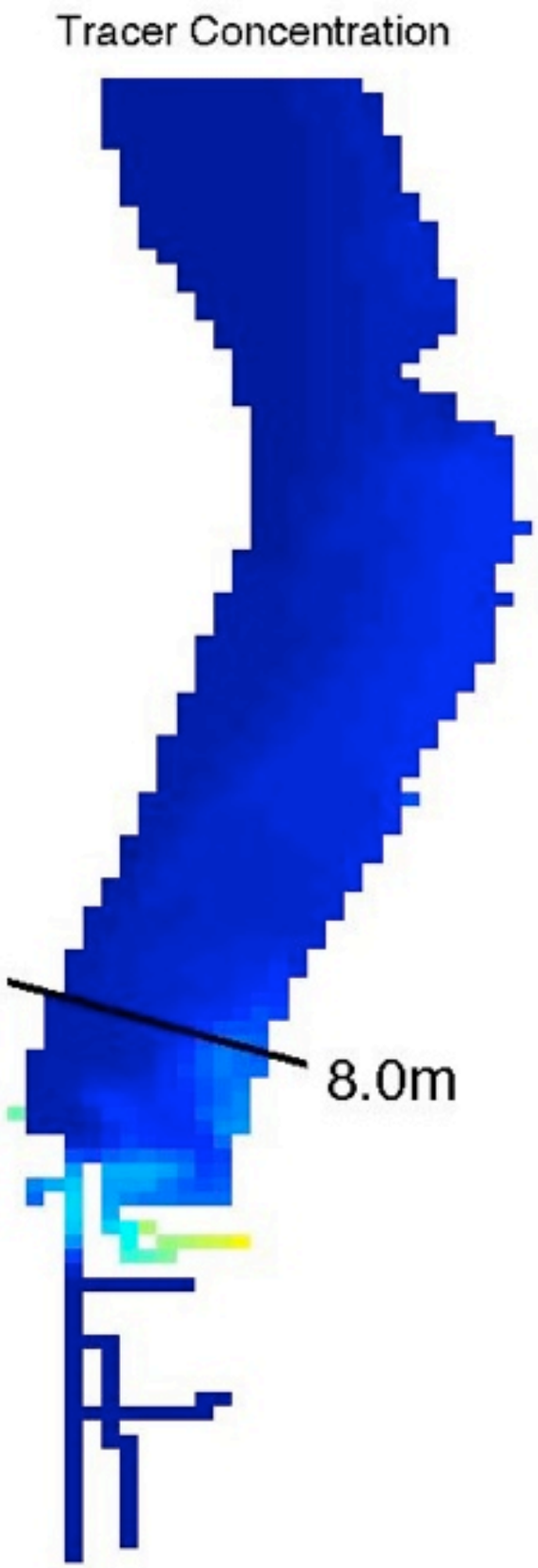

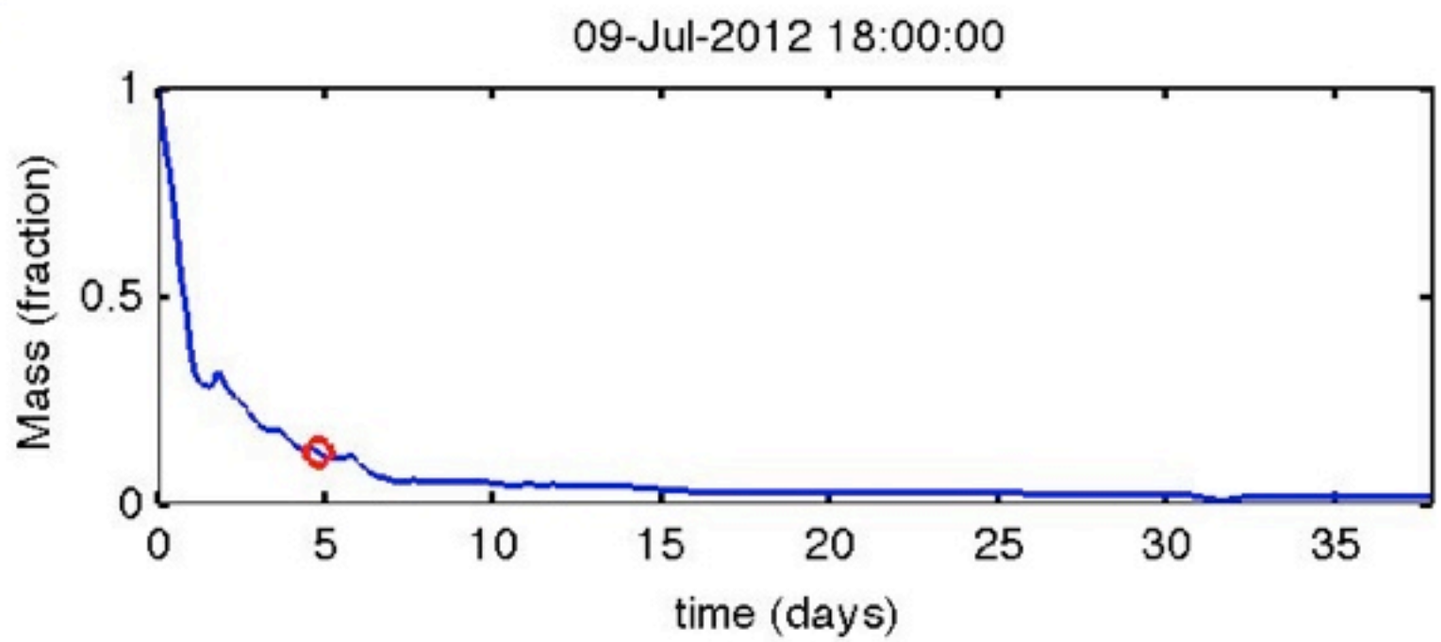

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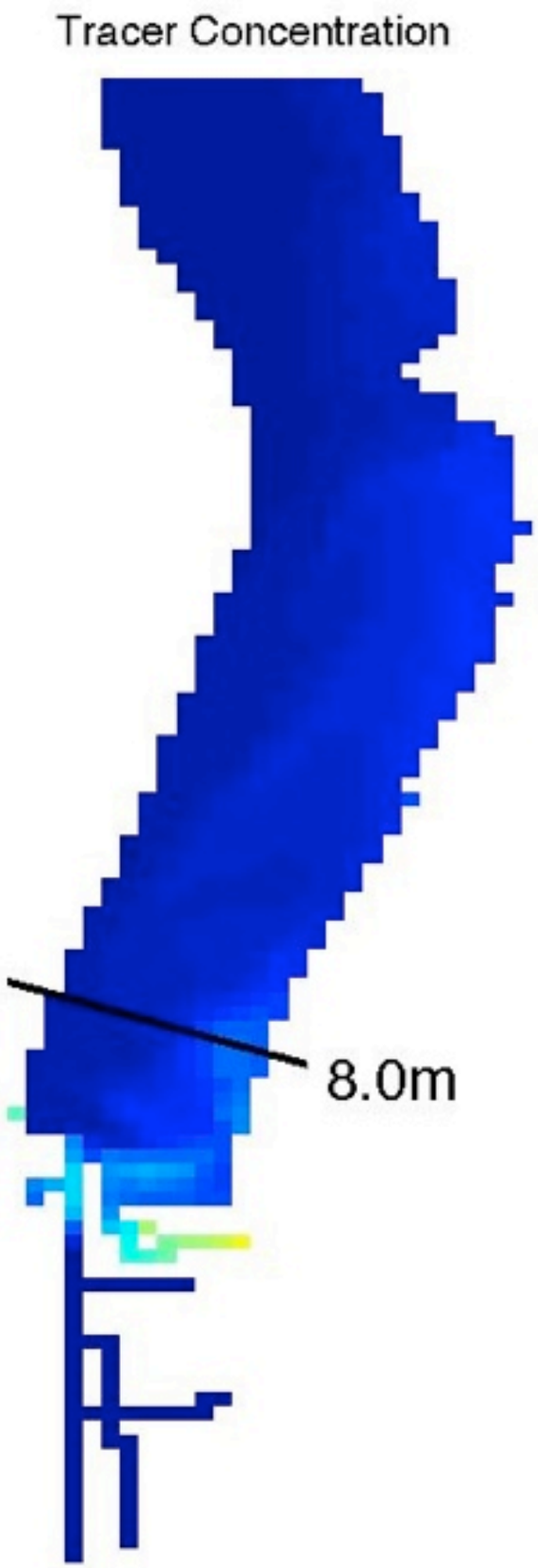

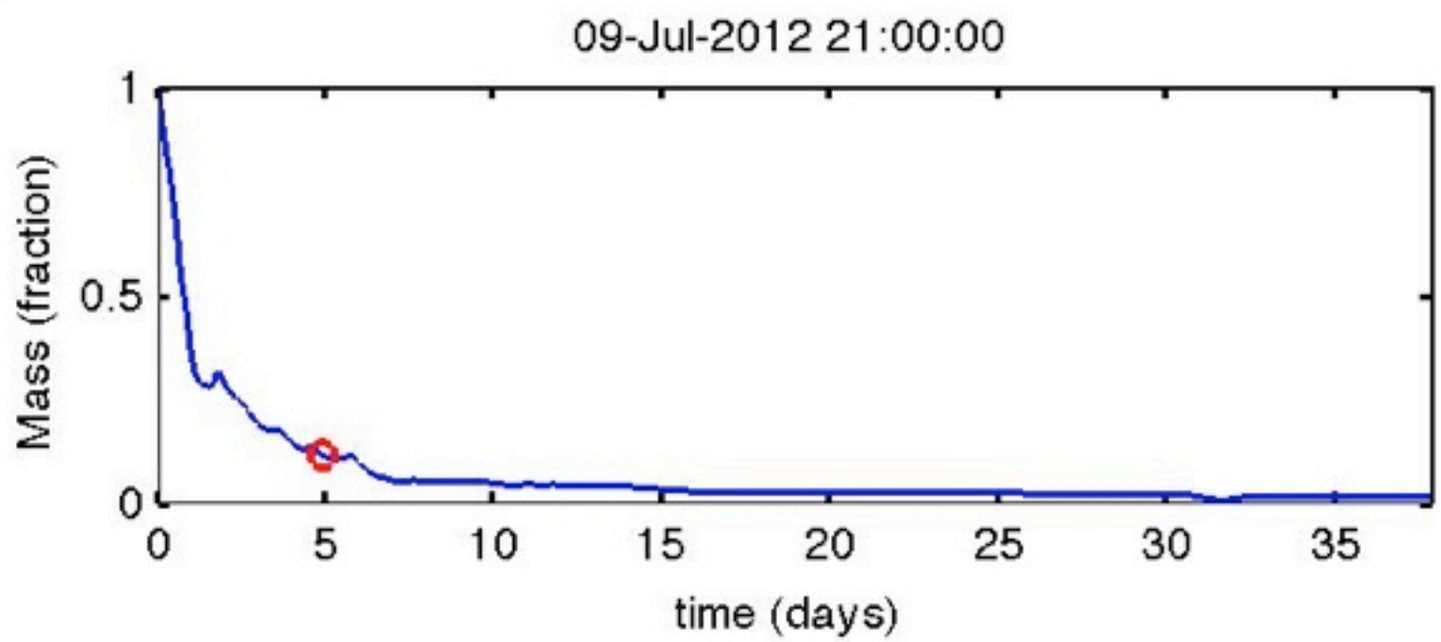

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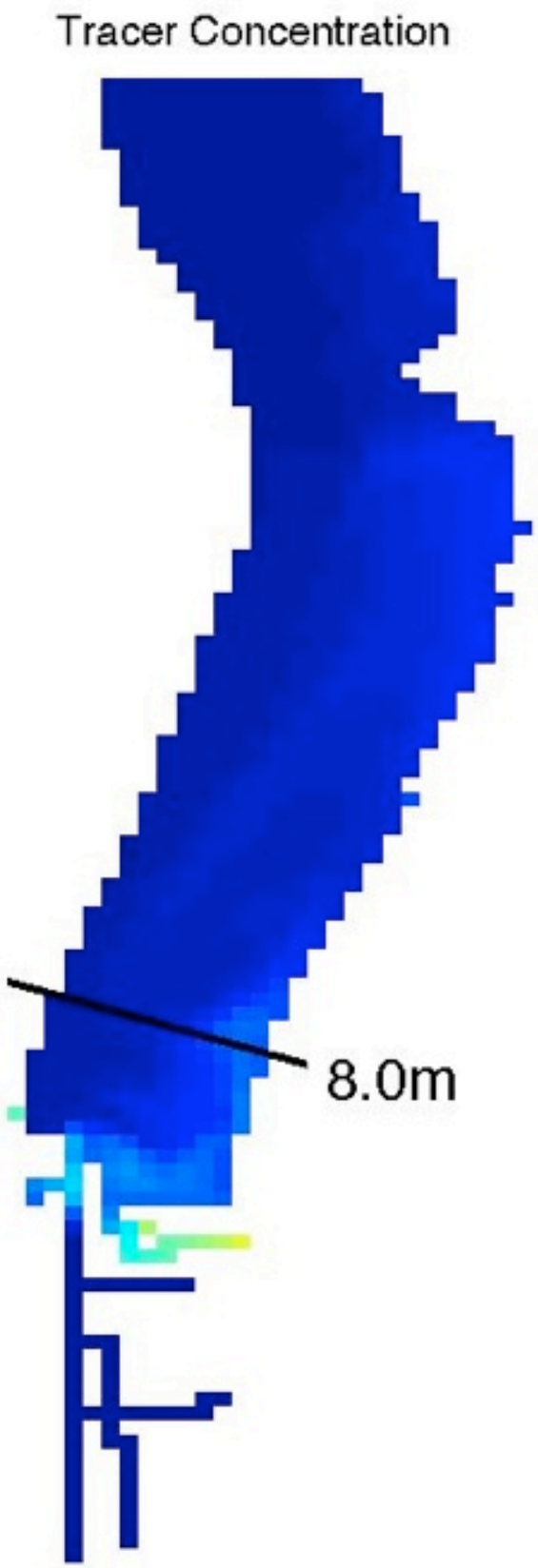
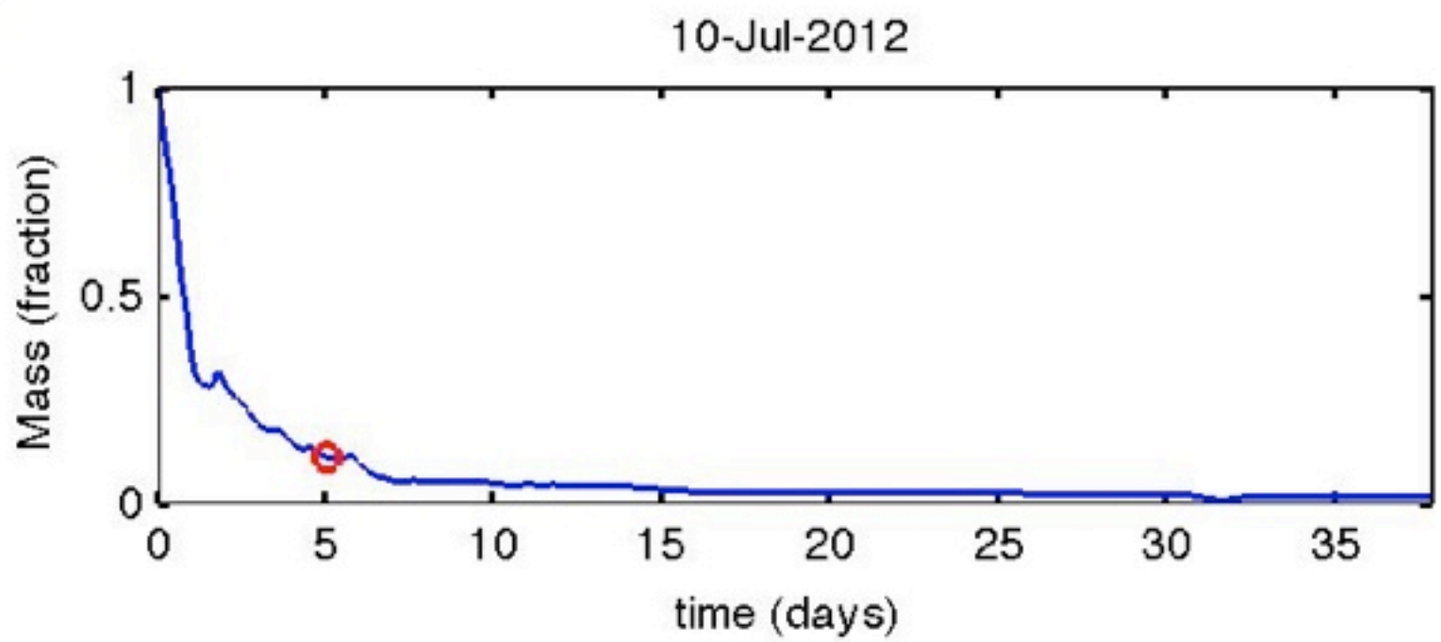
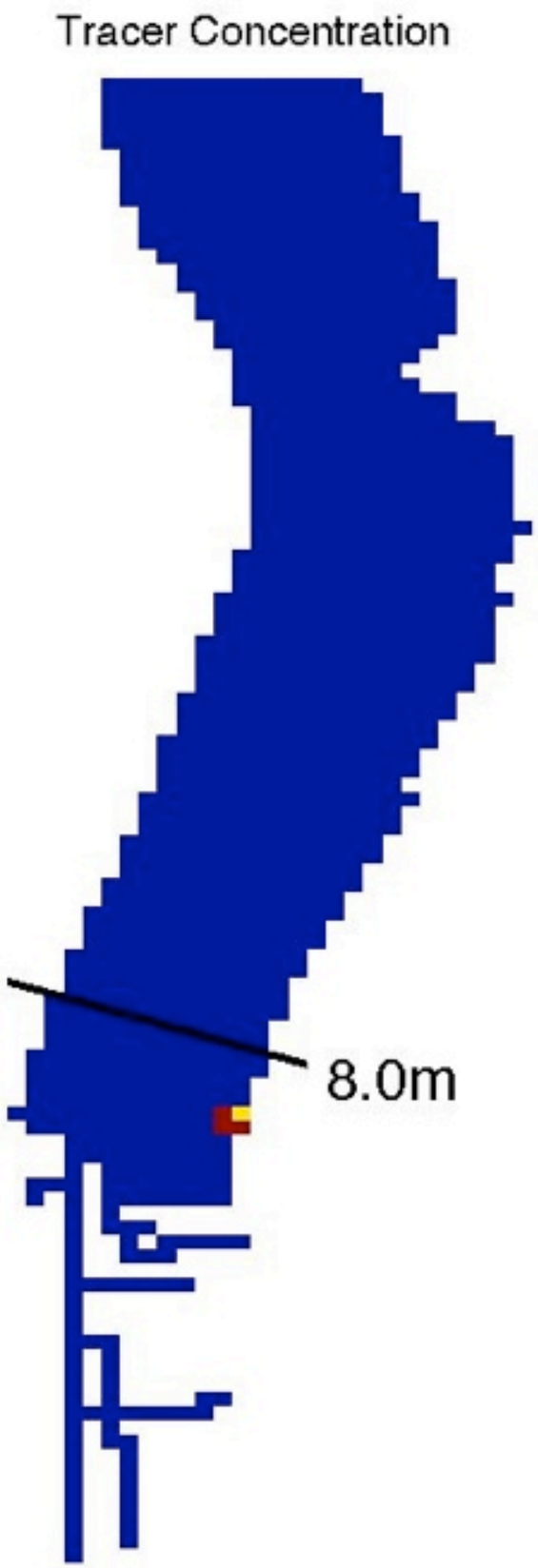
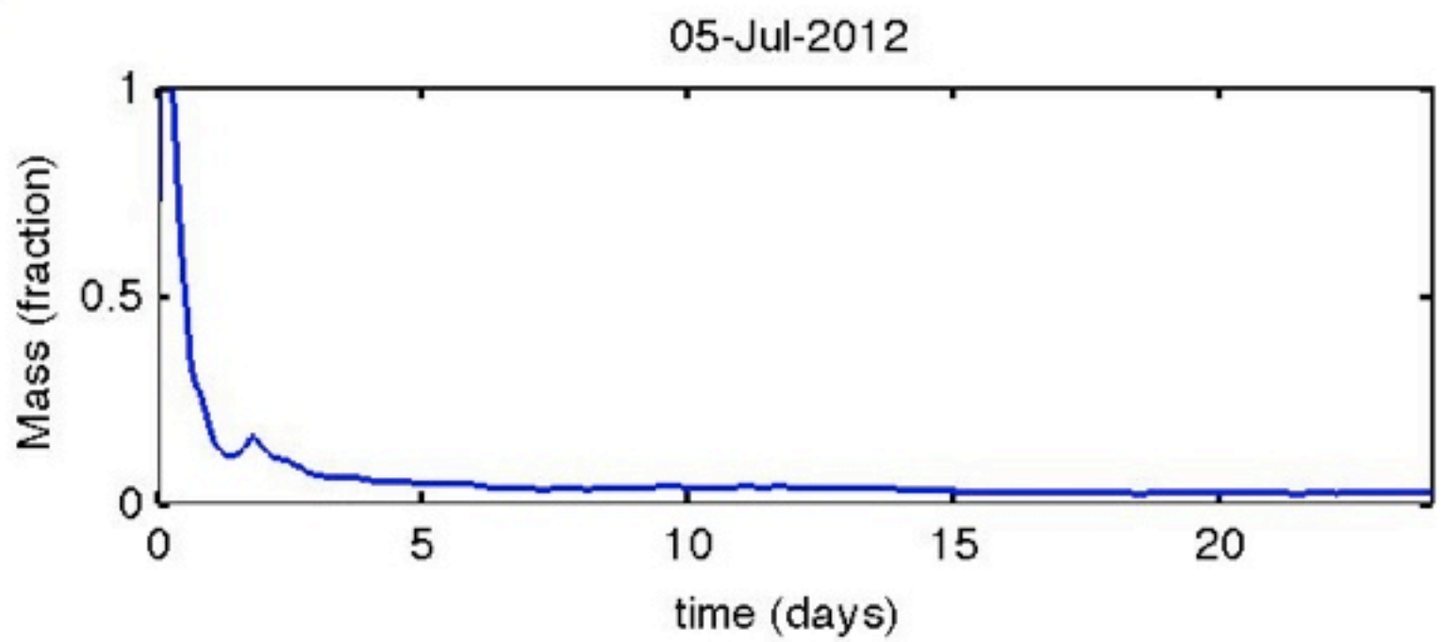




SI3D: Residence Time Experiments





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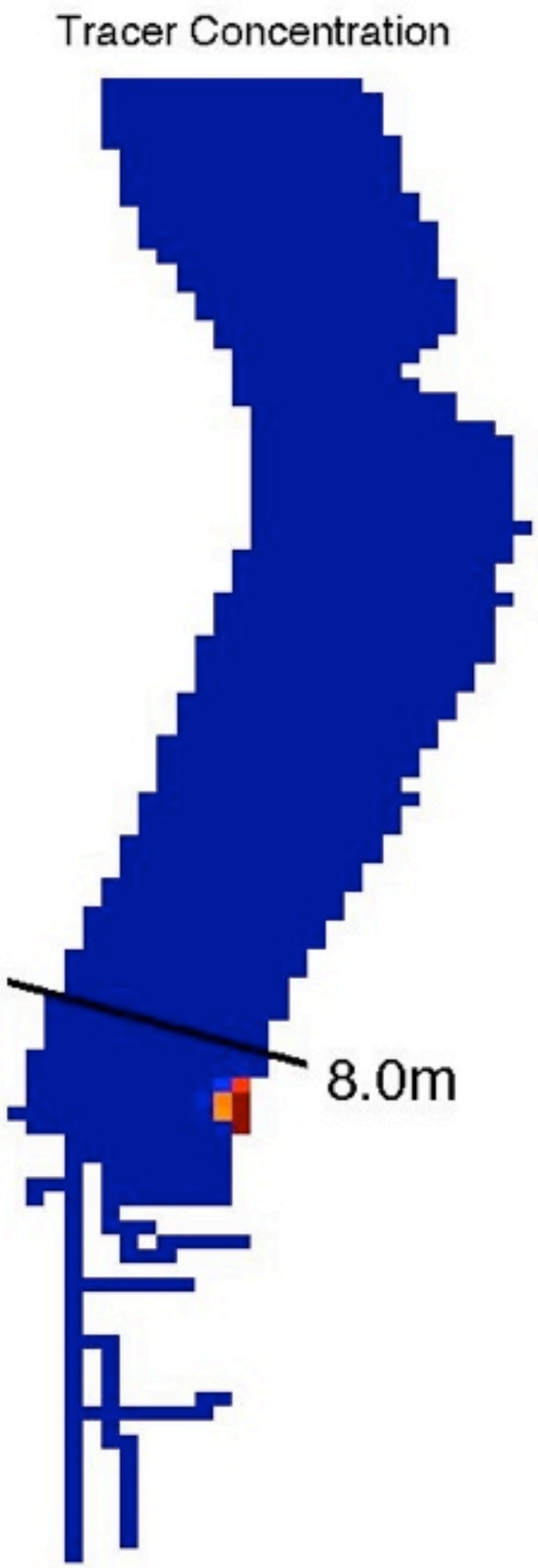

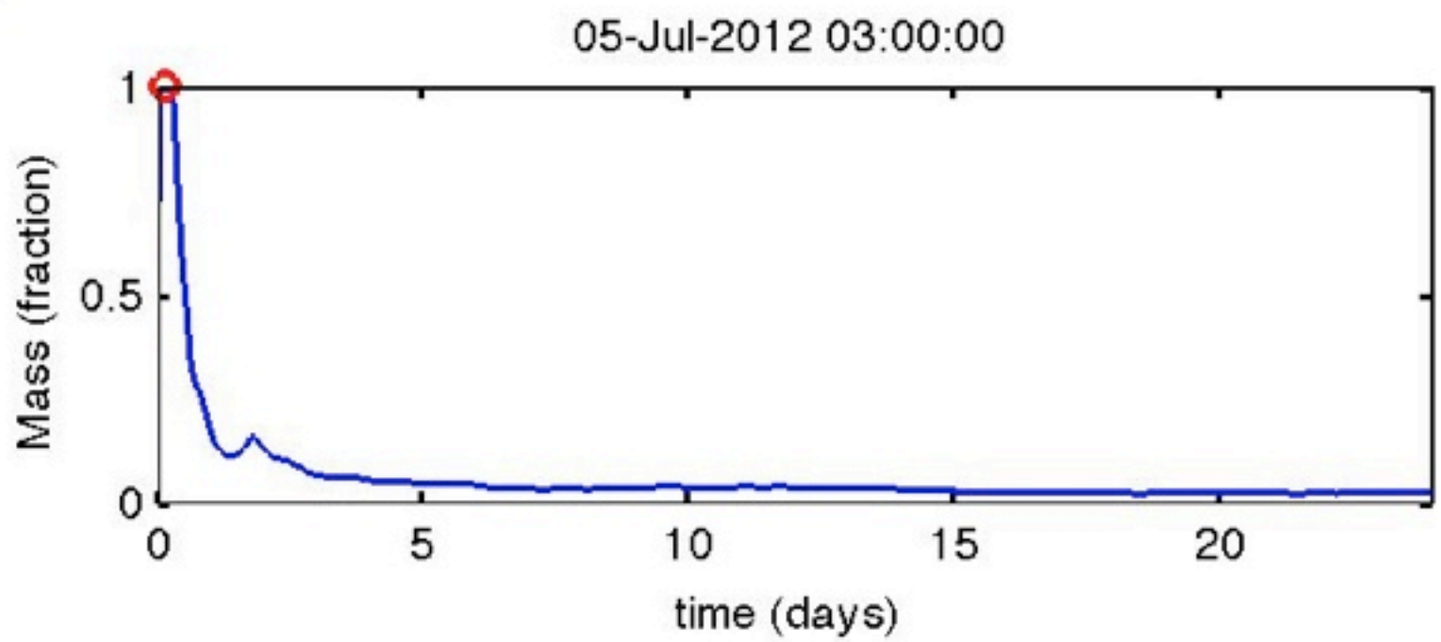

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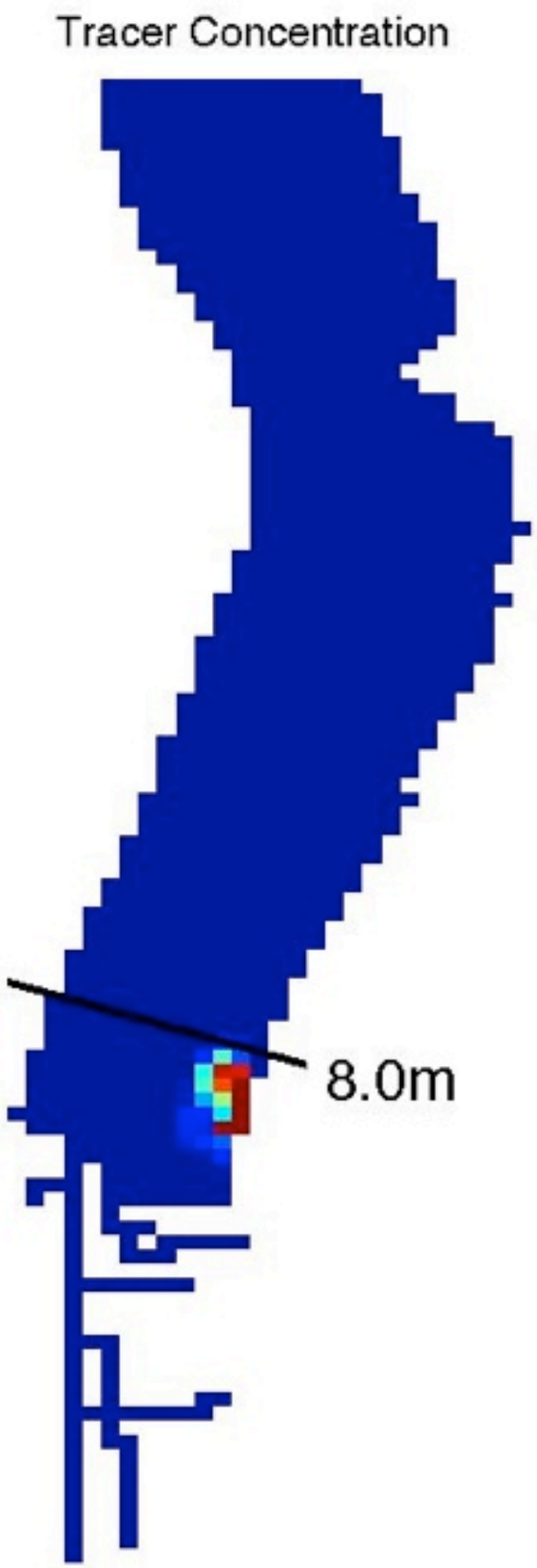

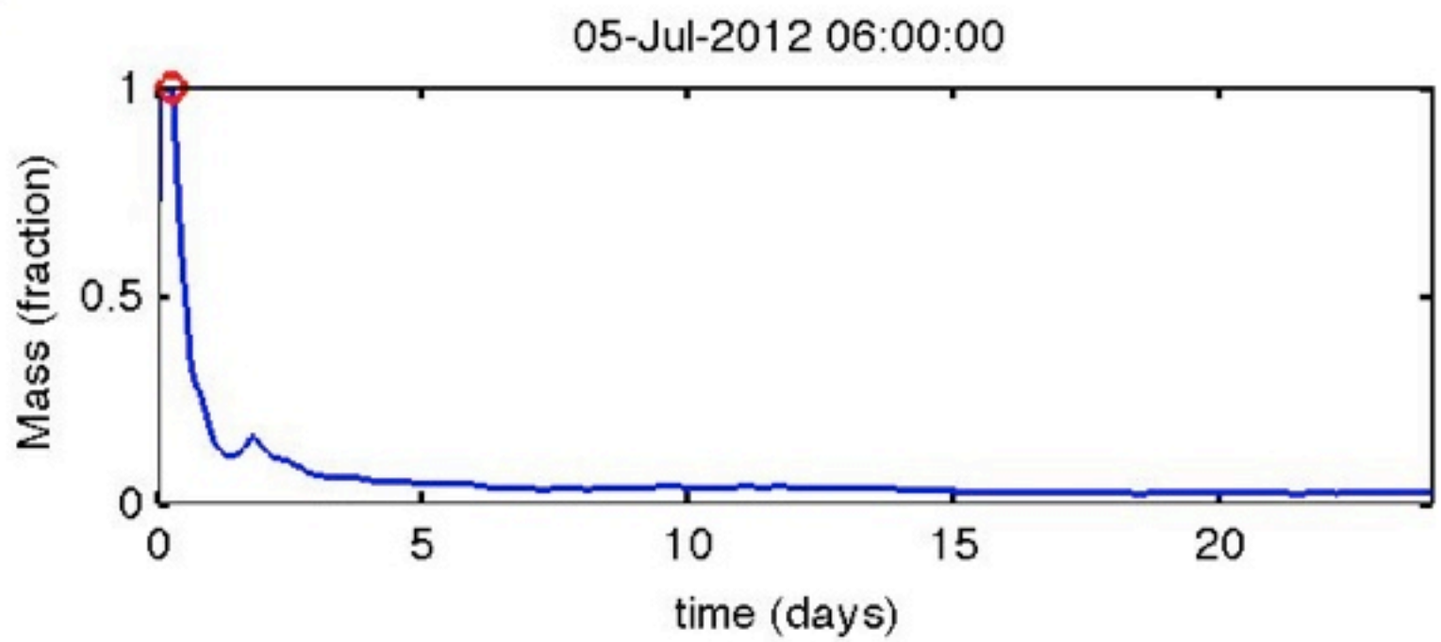

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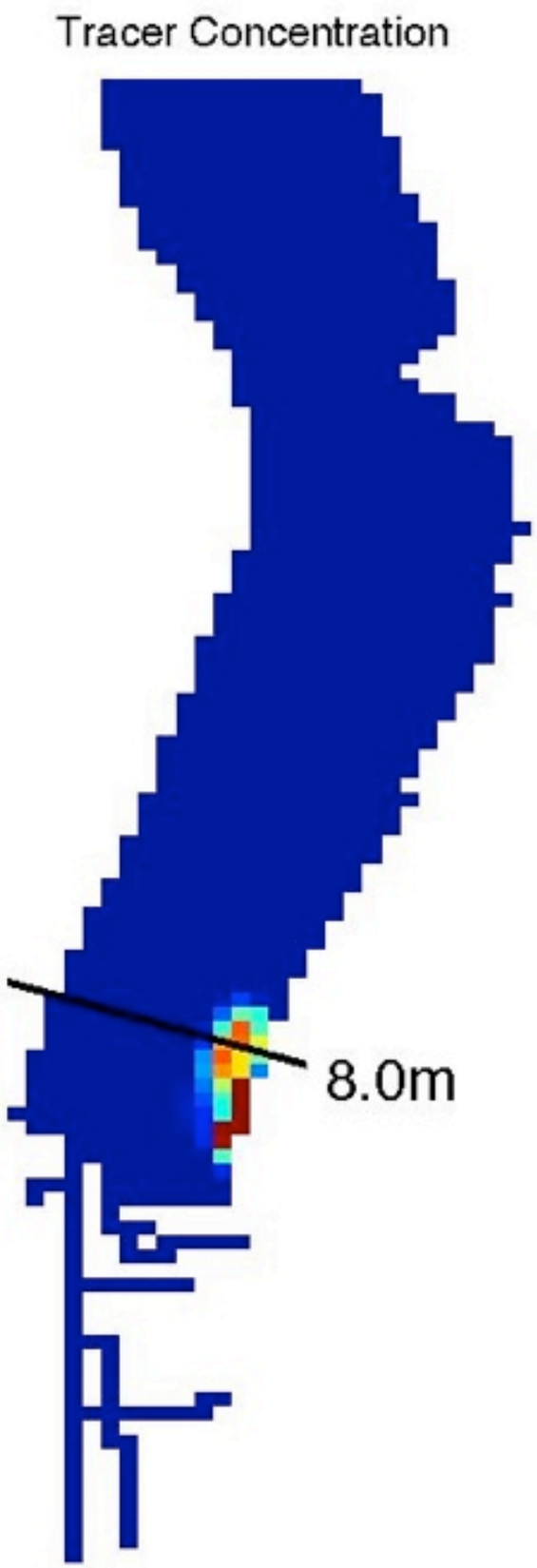

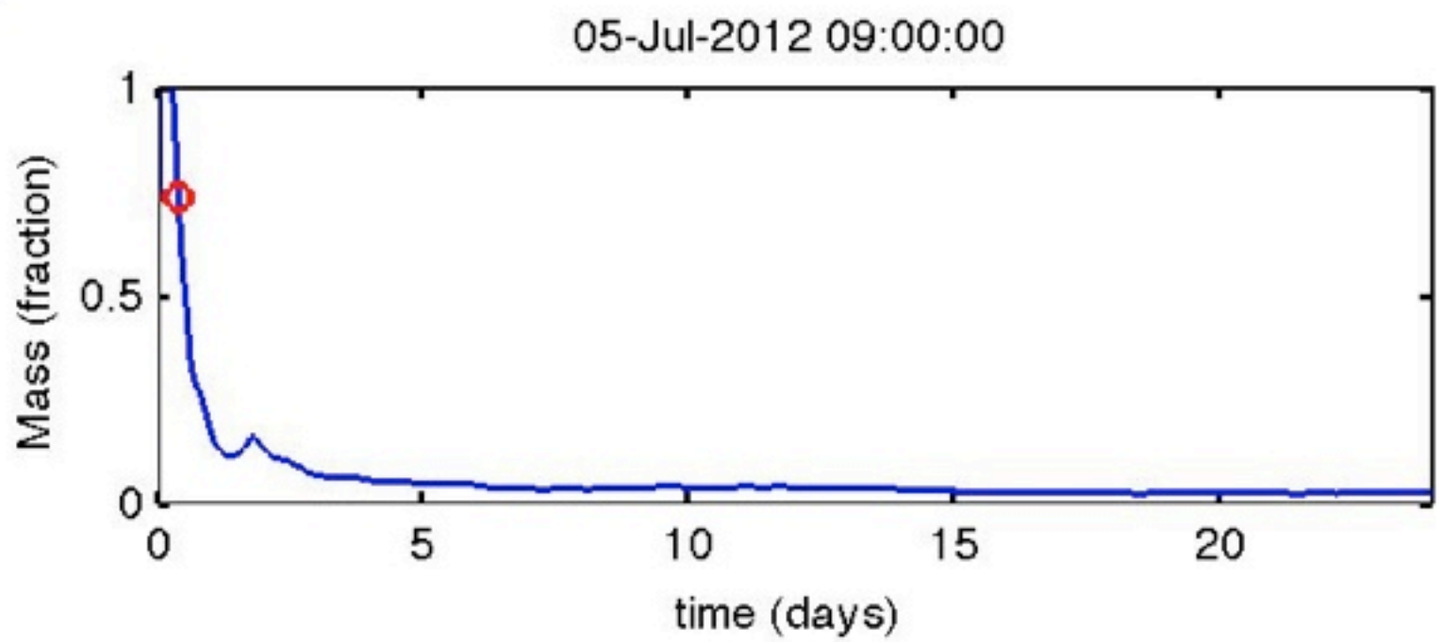

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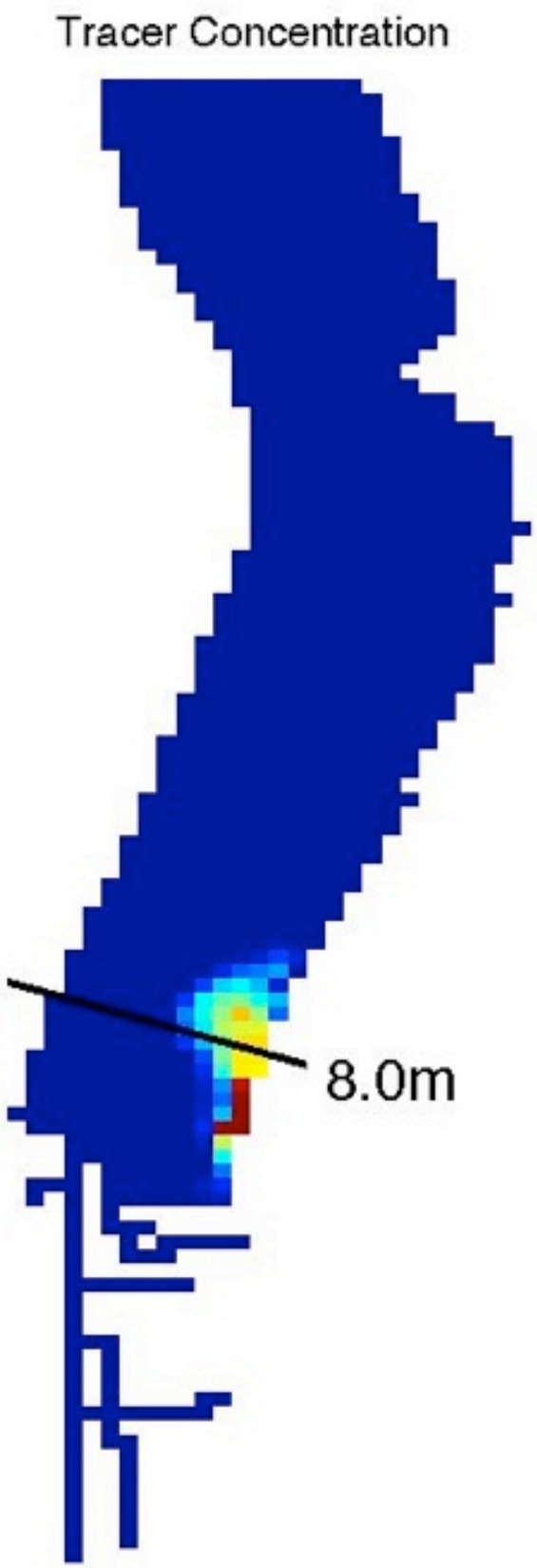

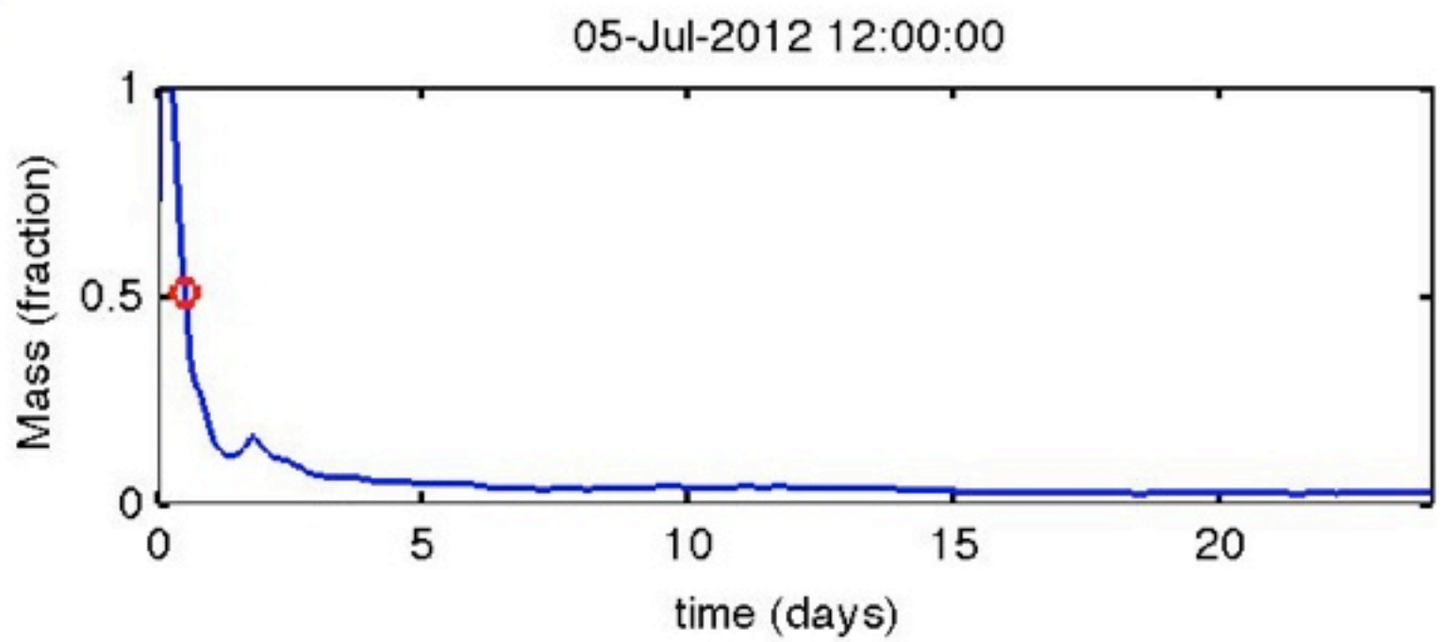

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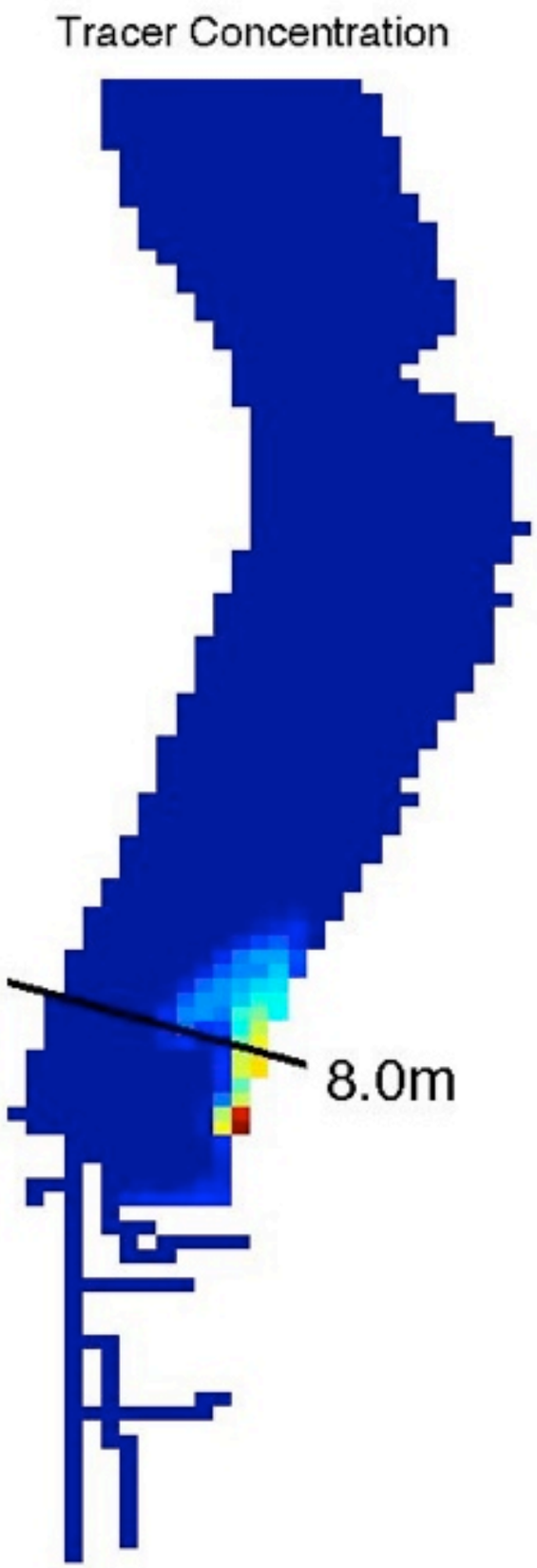

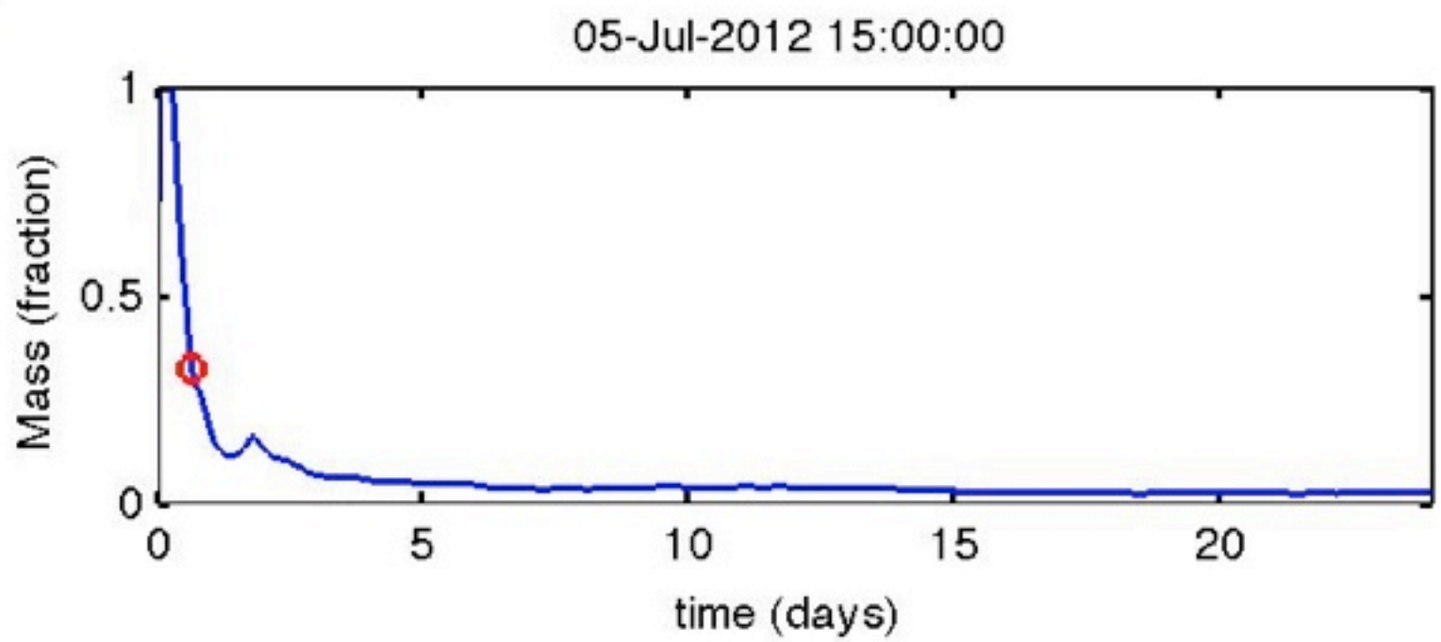

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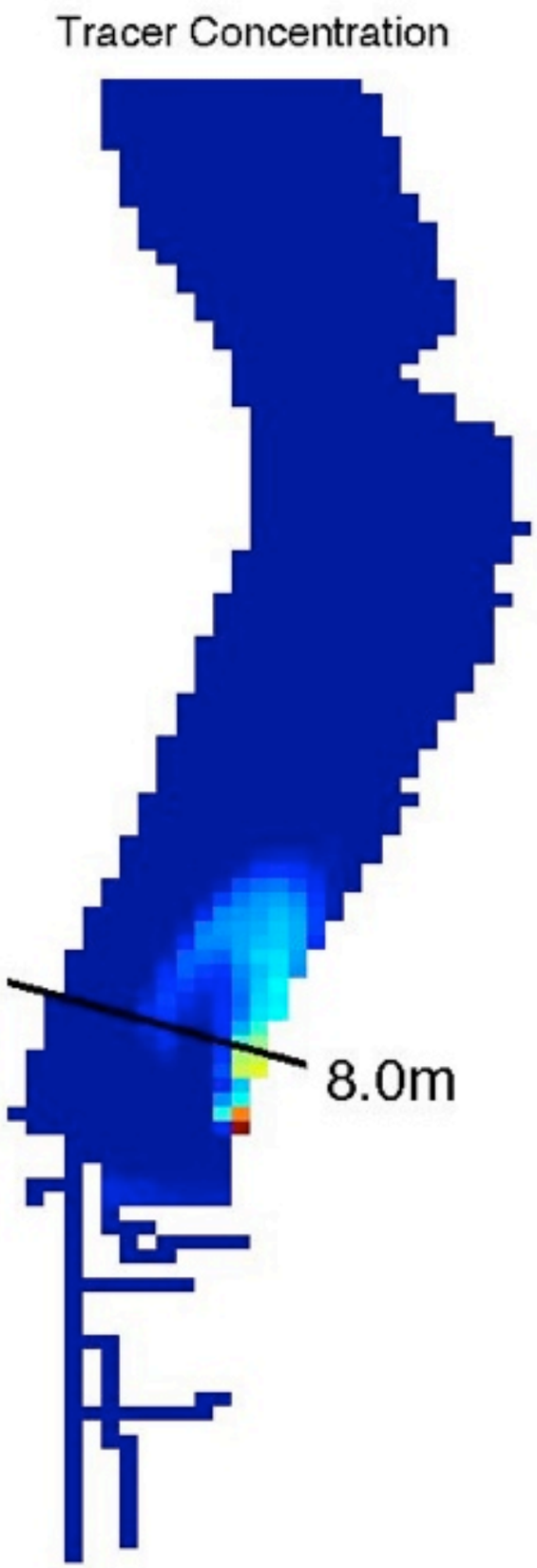

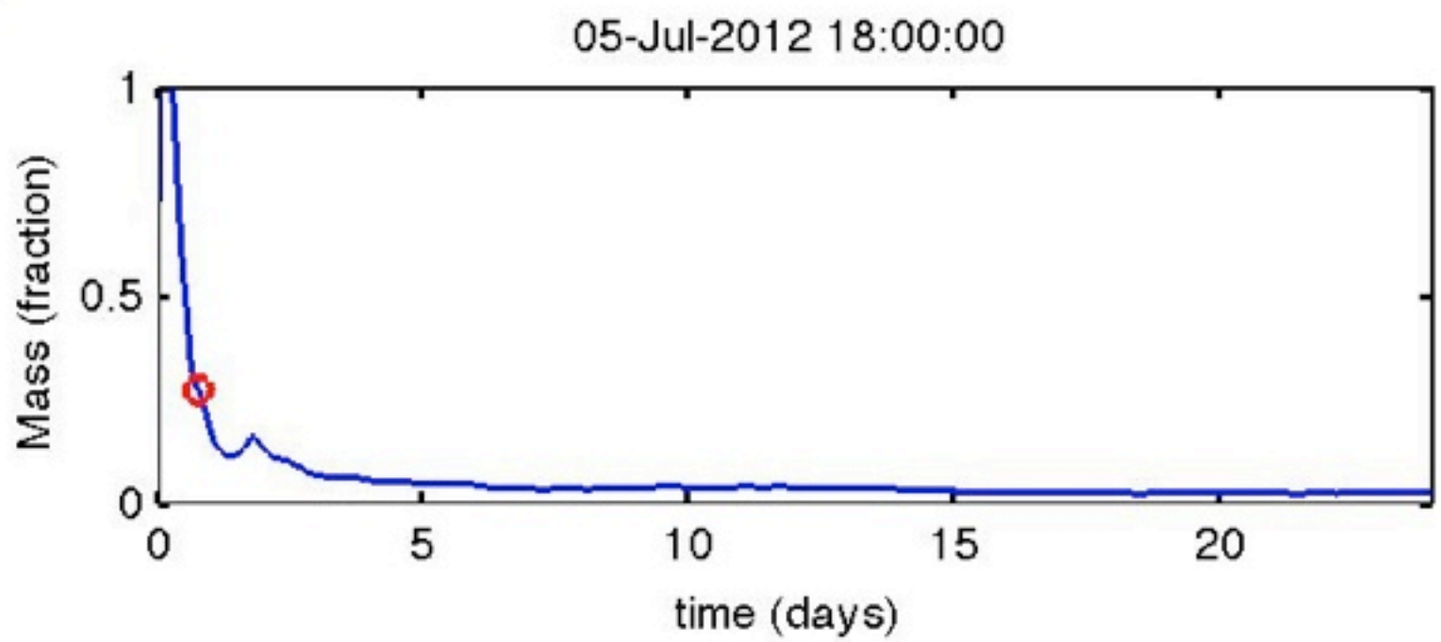

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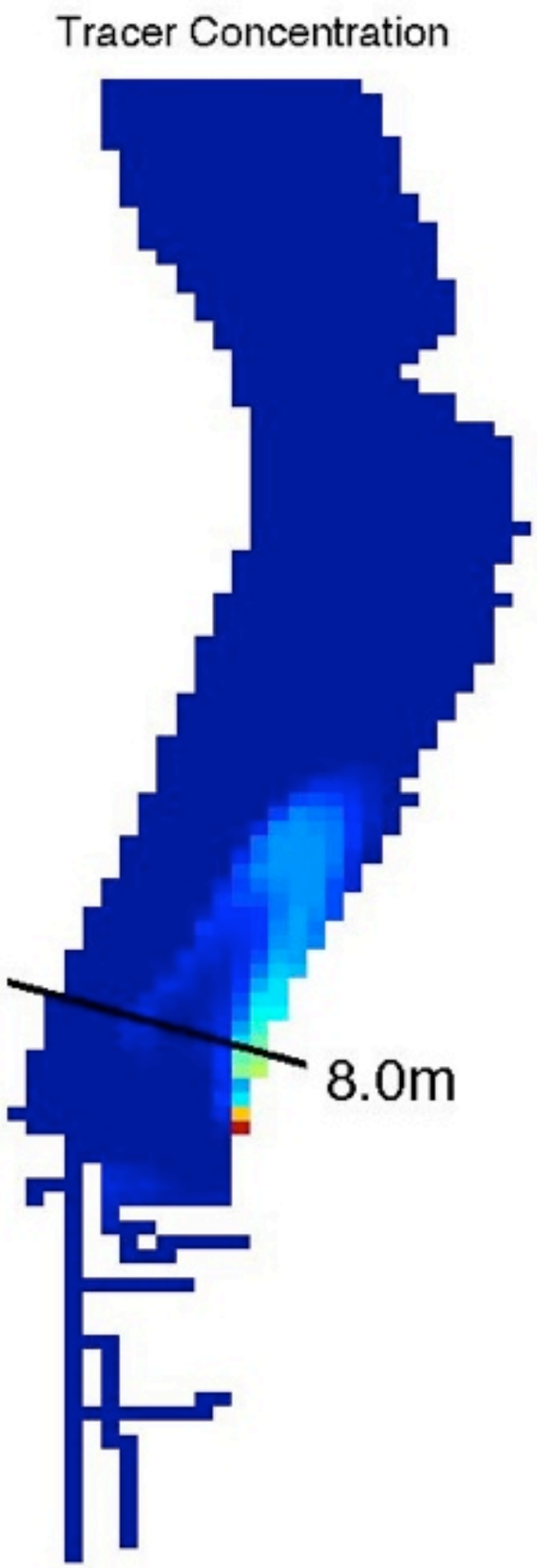

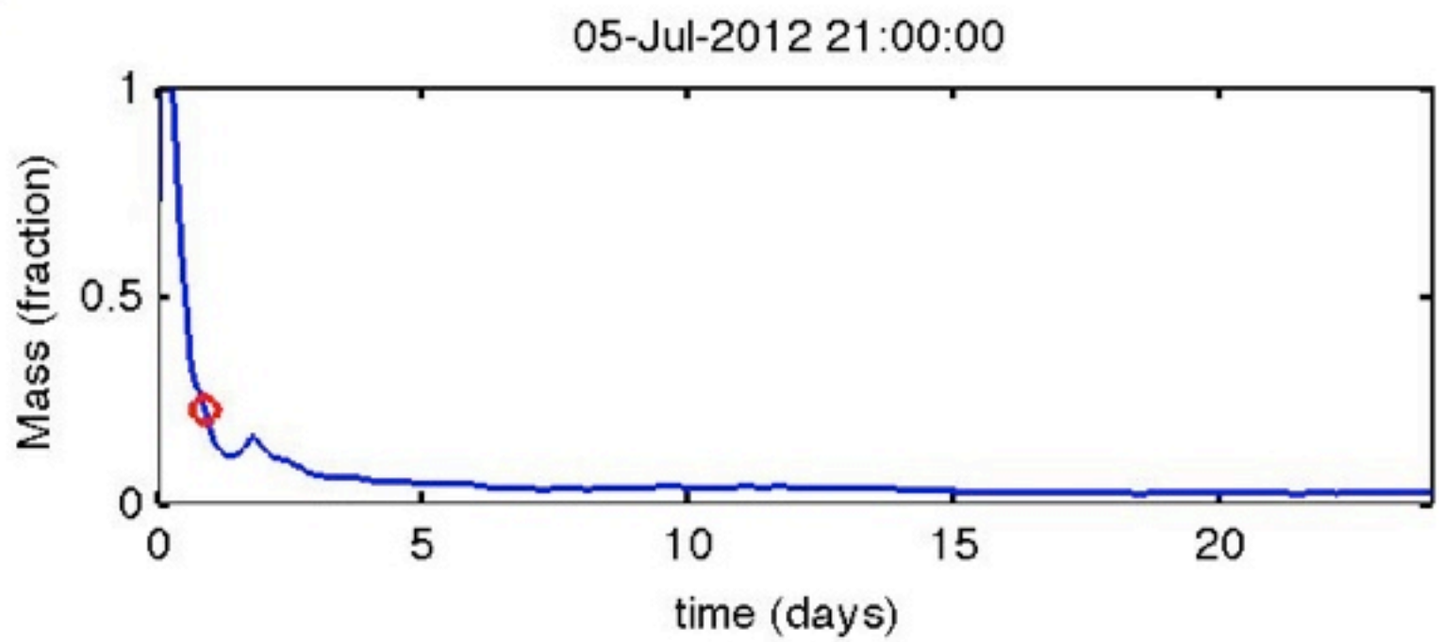

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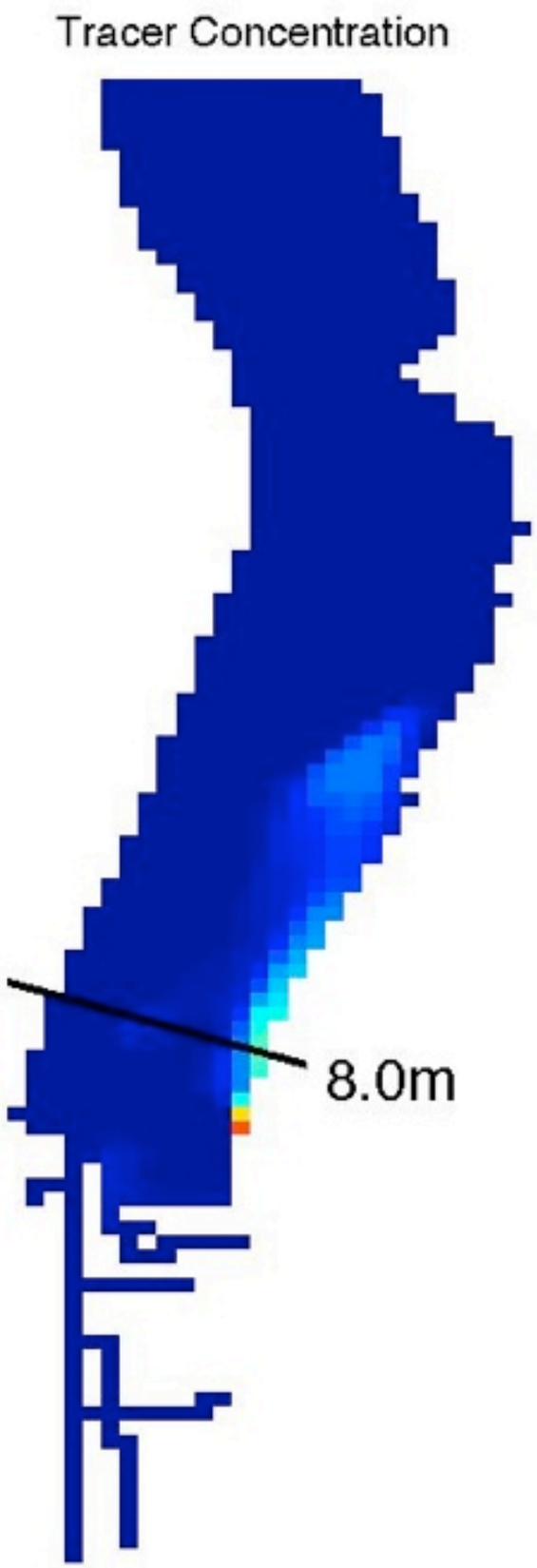

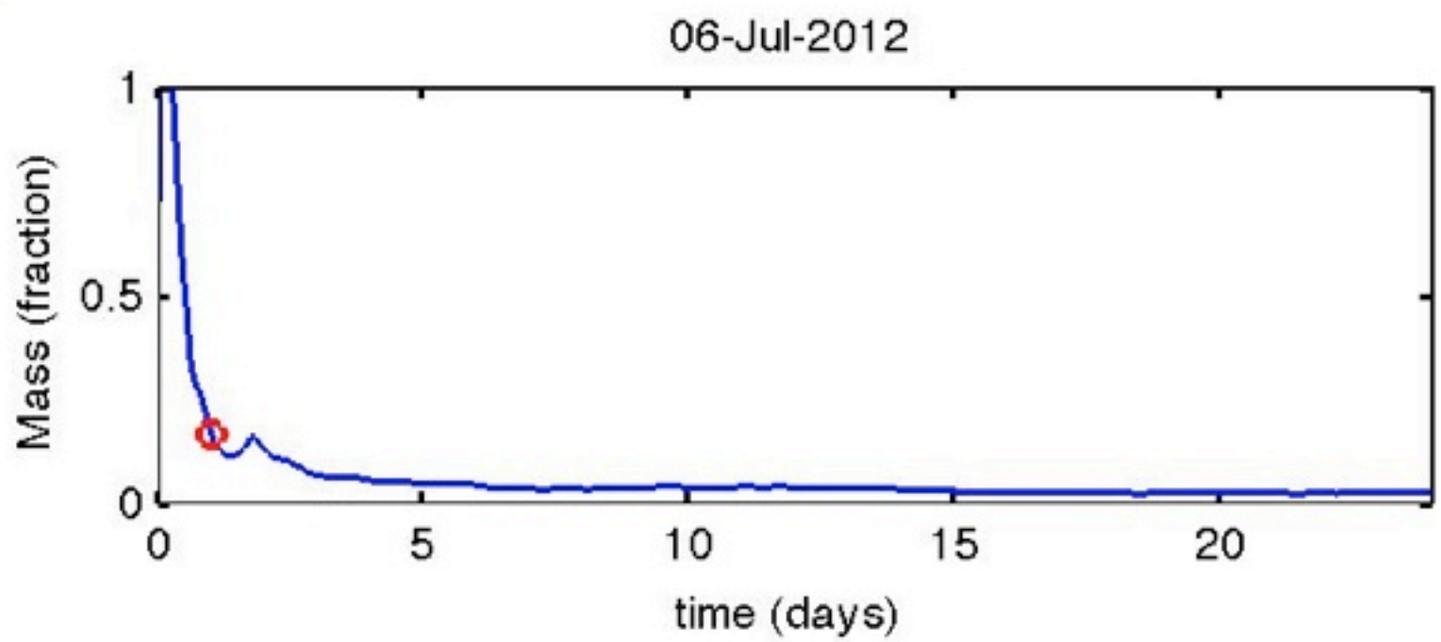

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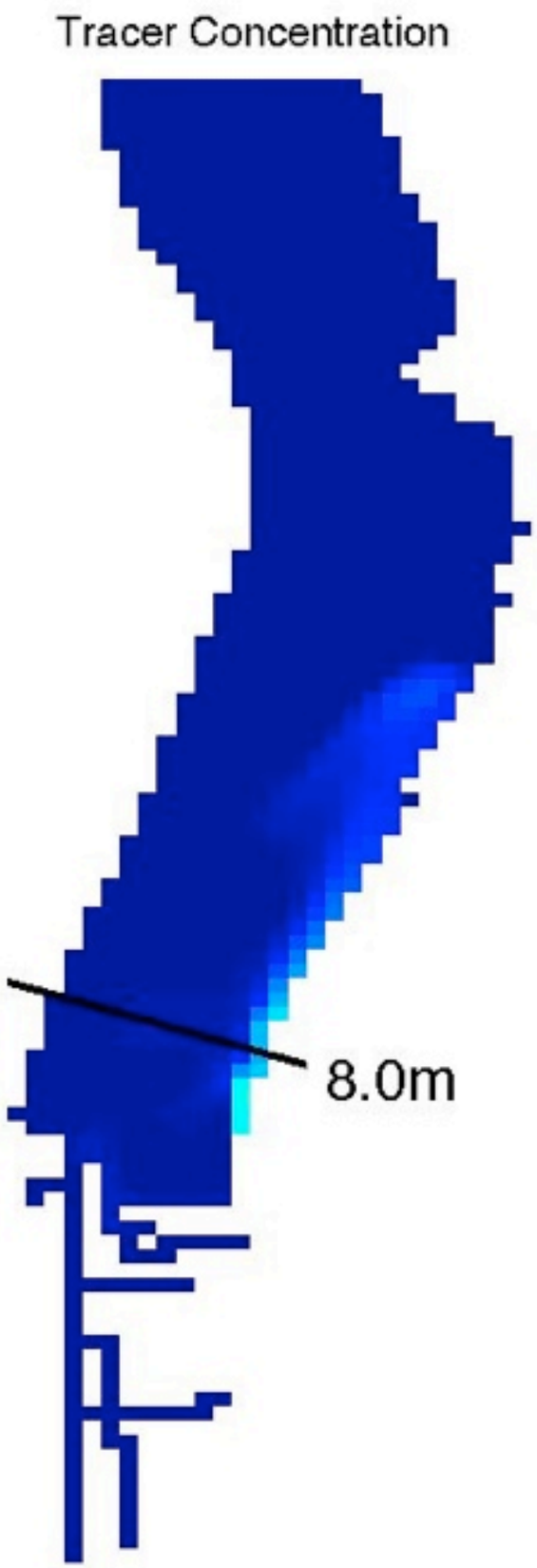

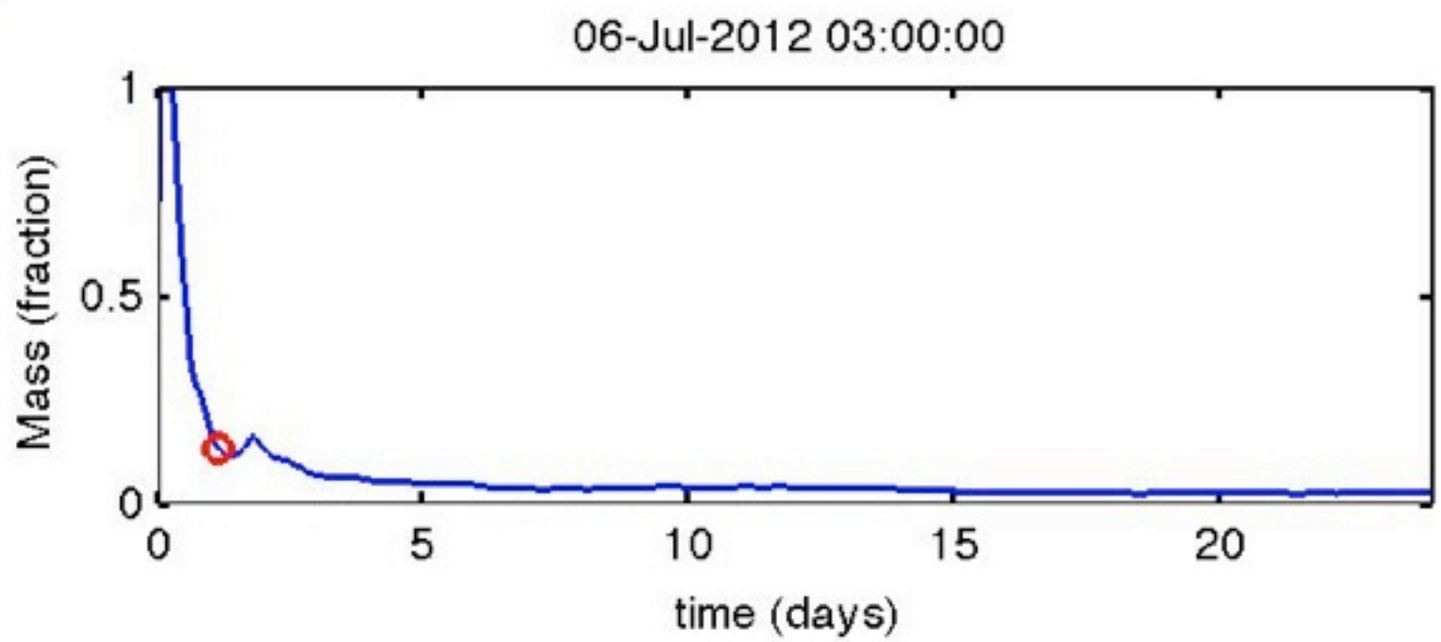

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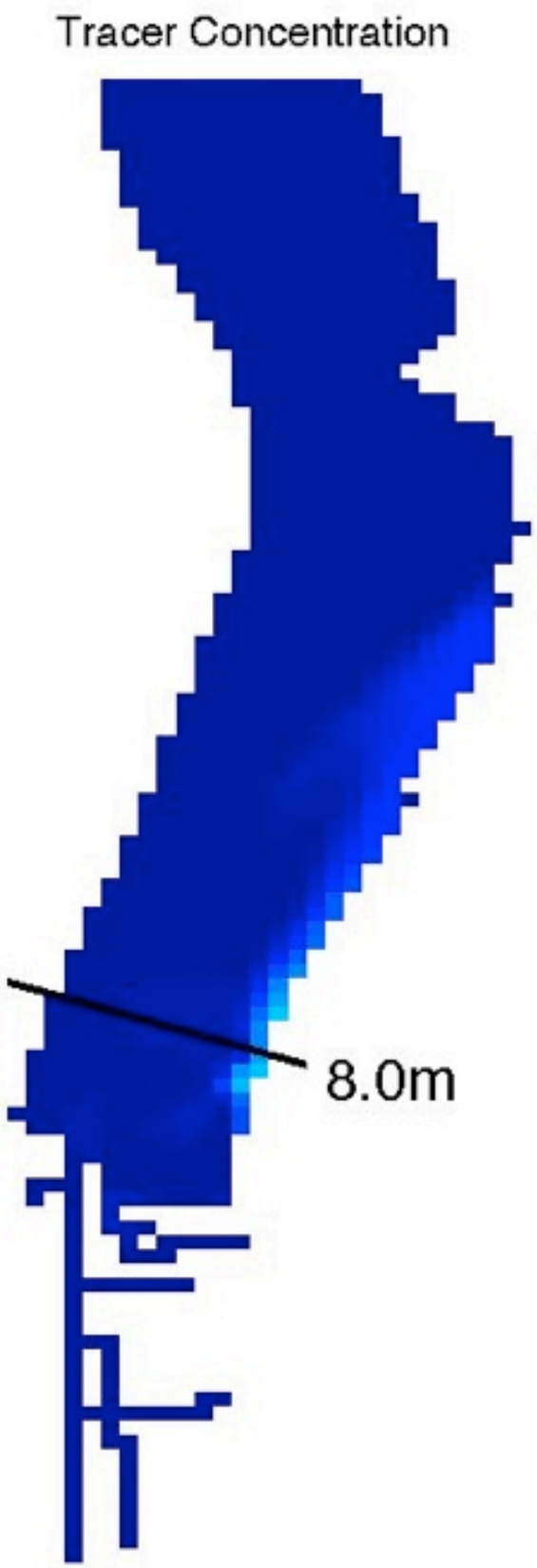

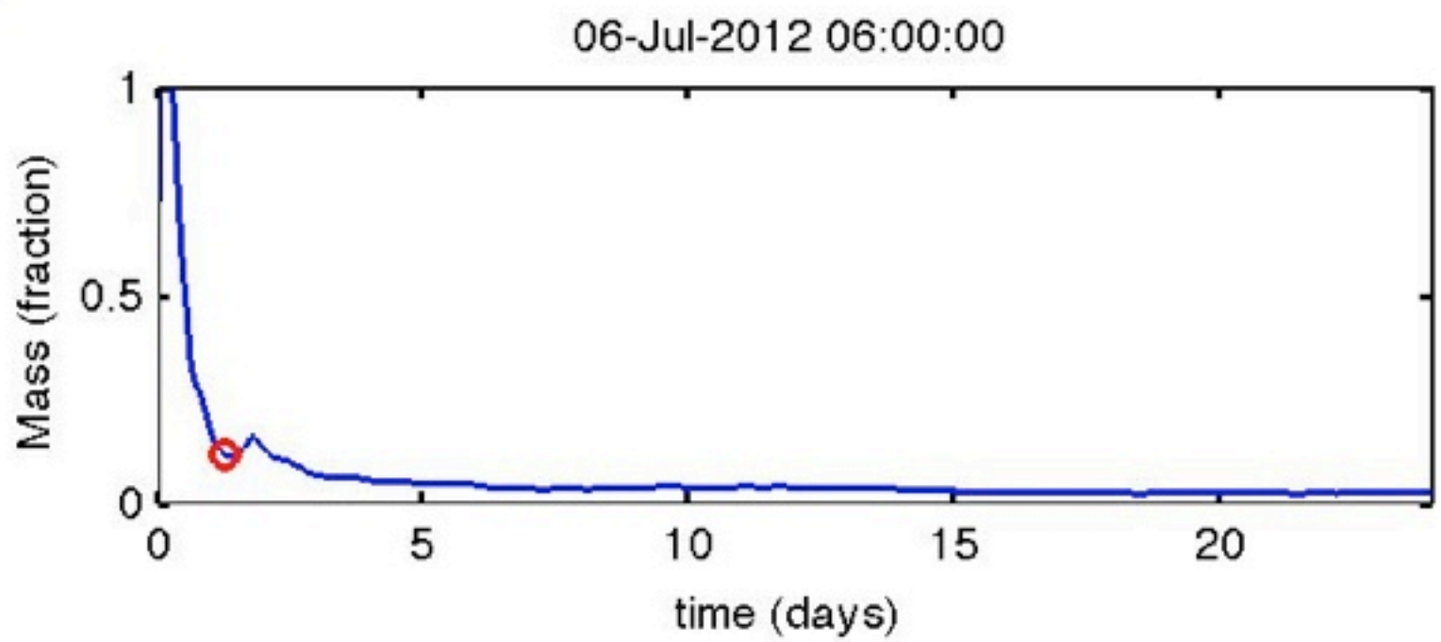

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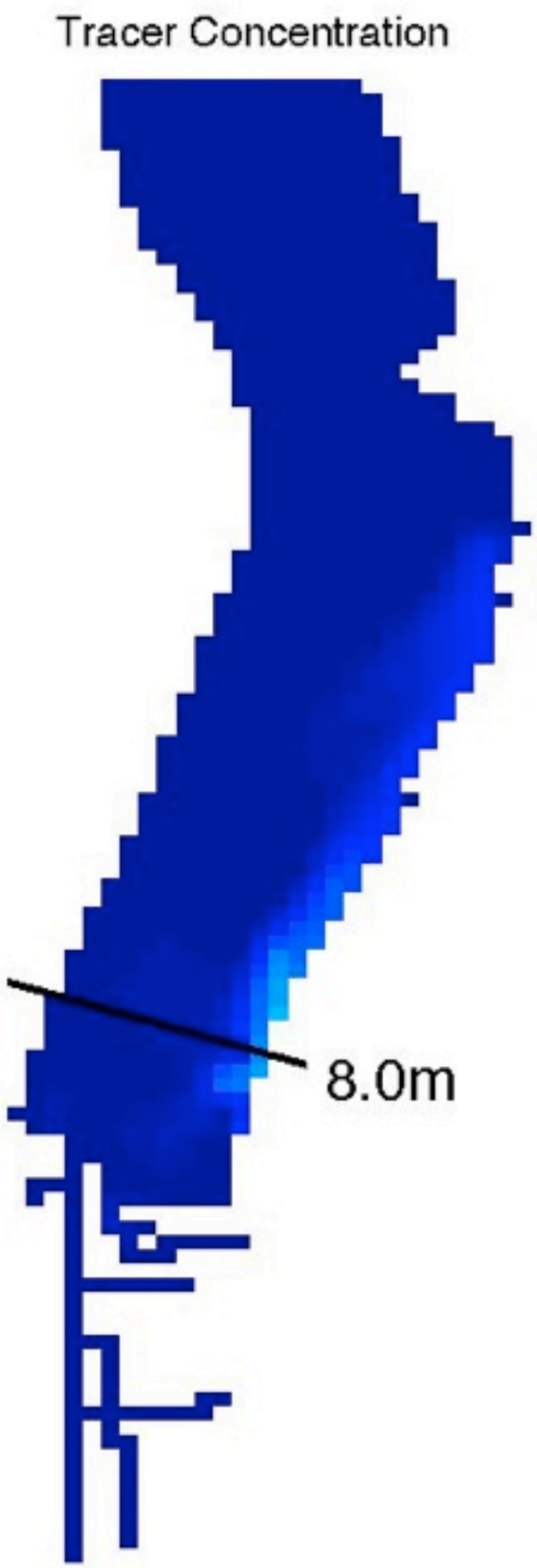

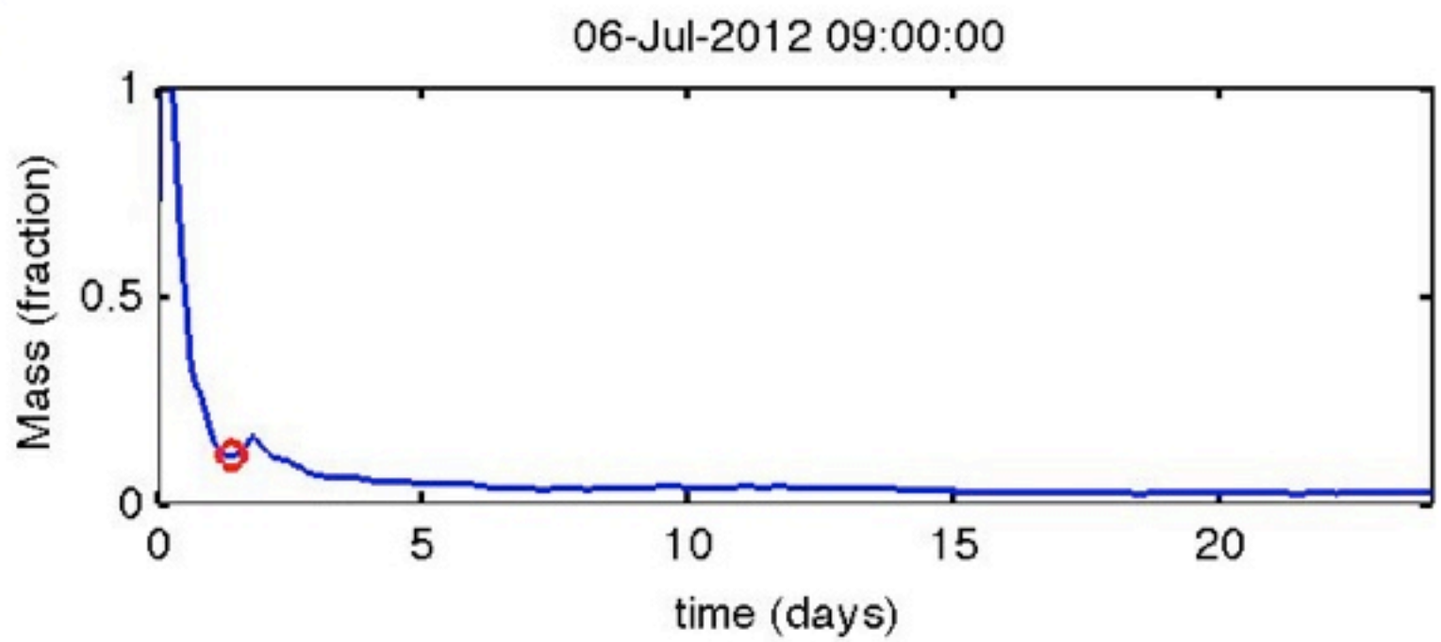

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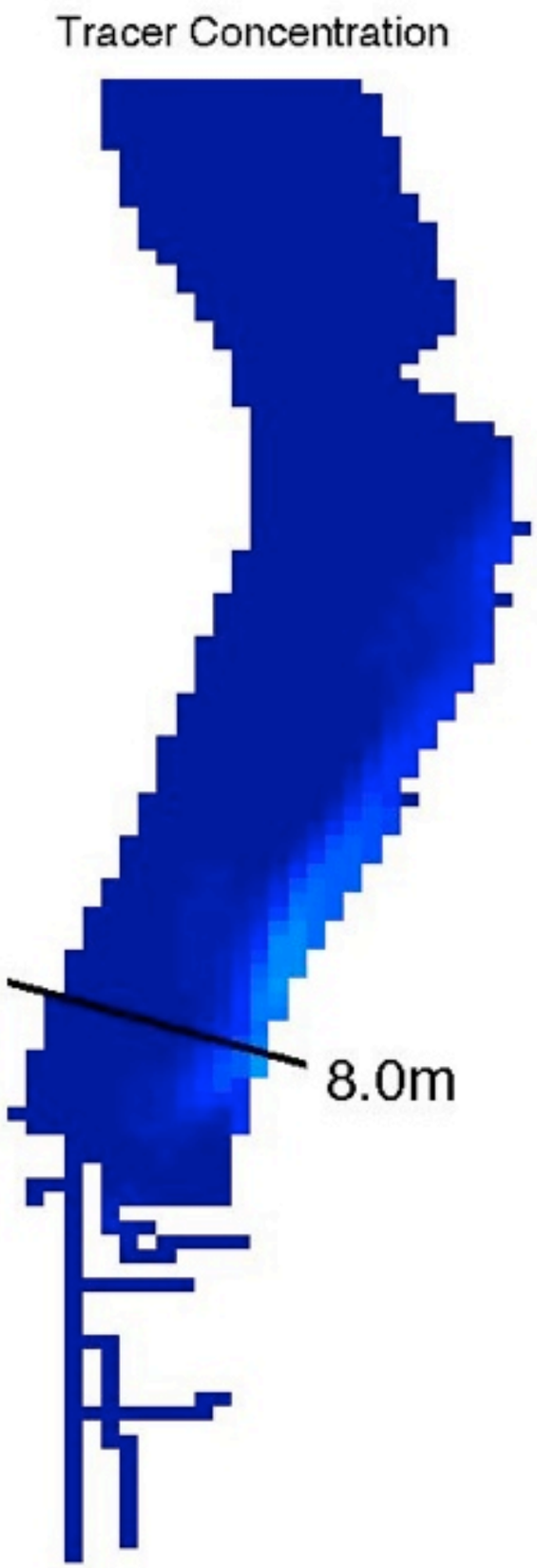

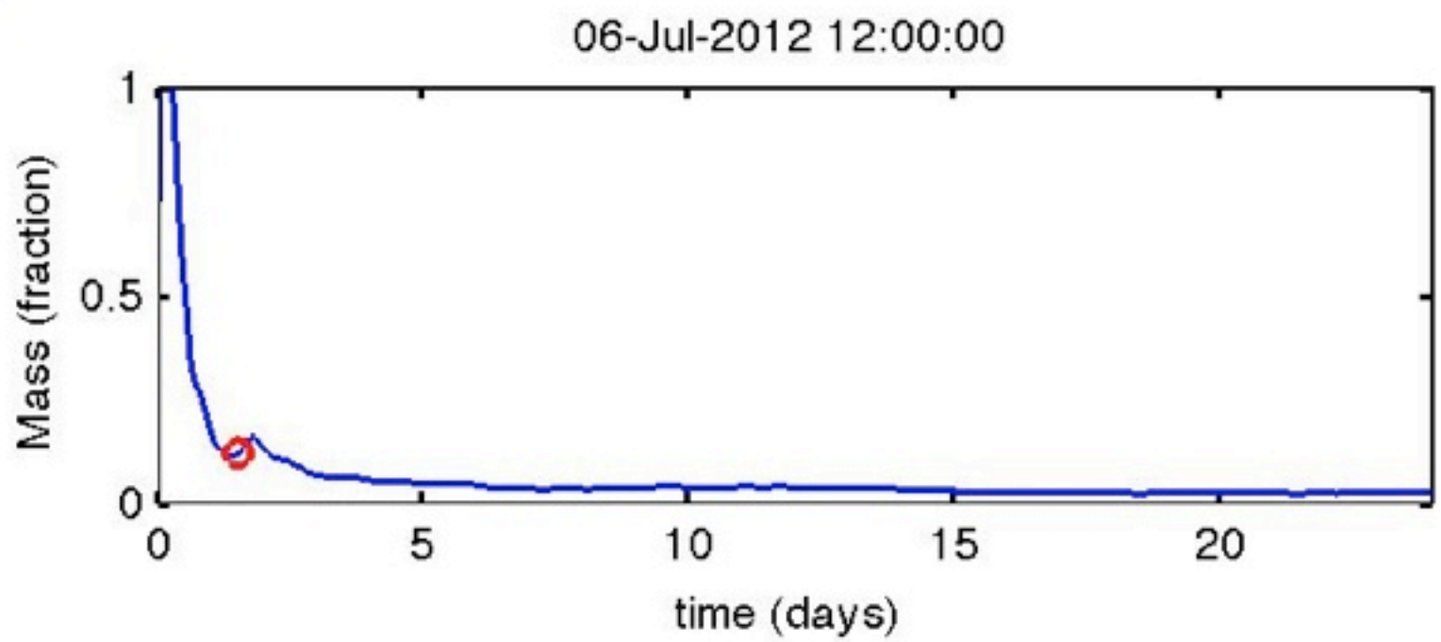

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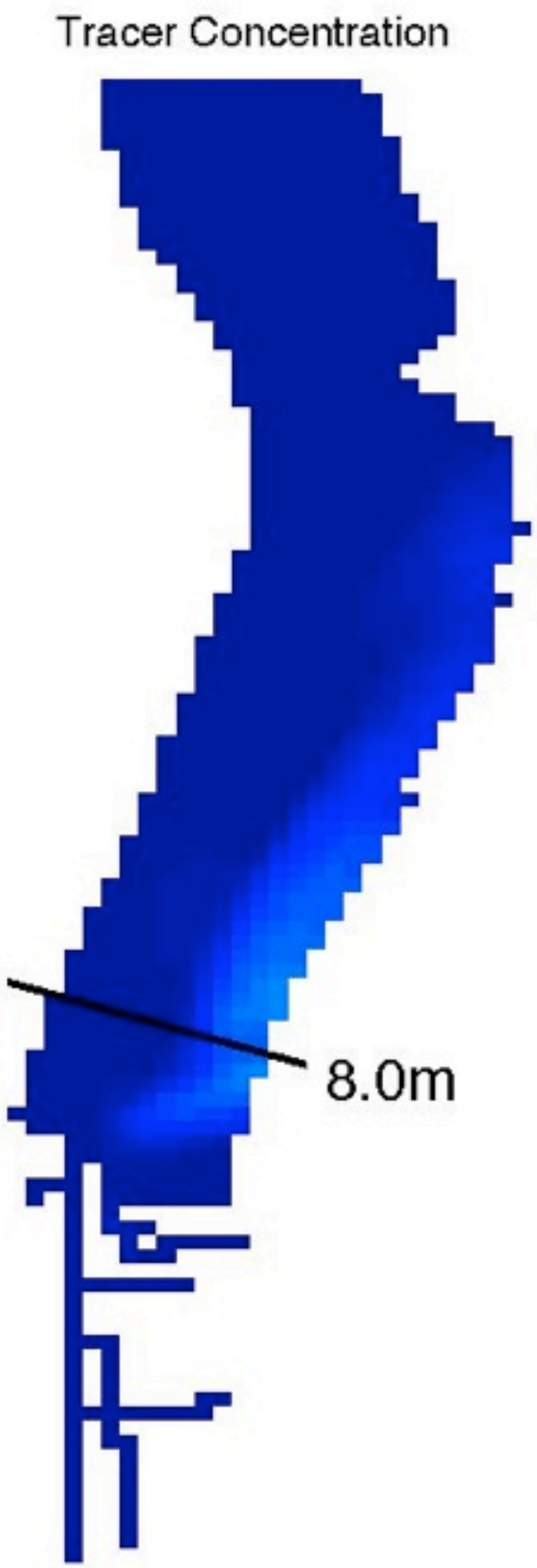

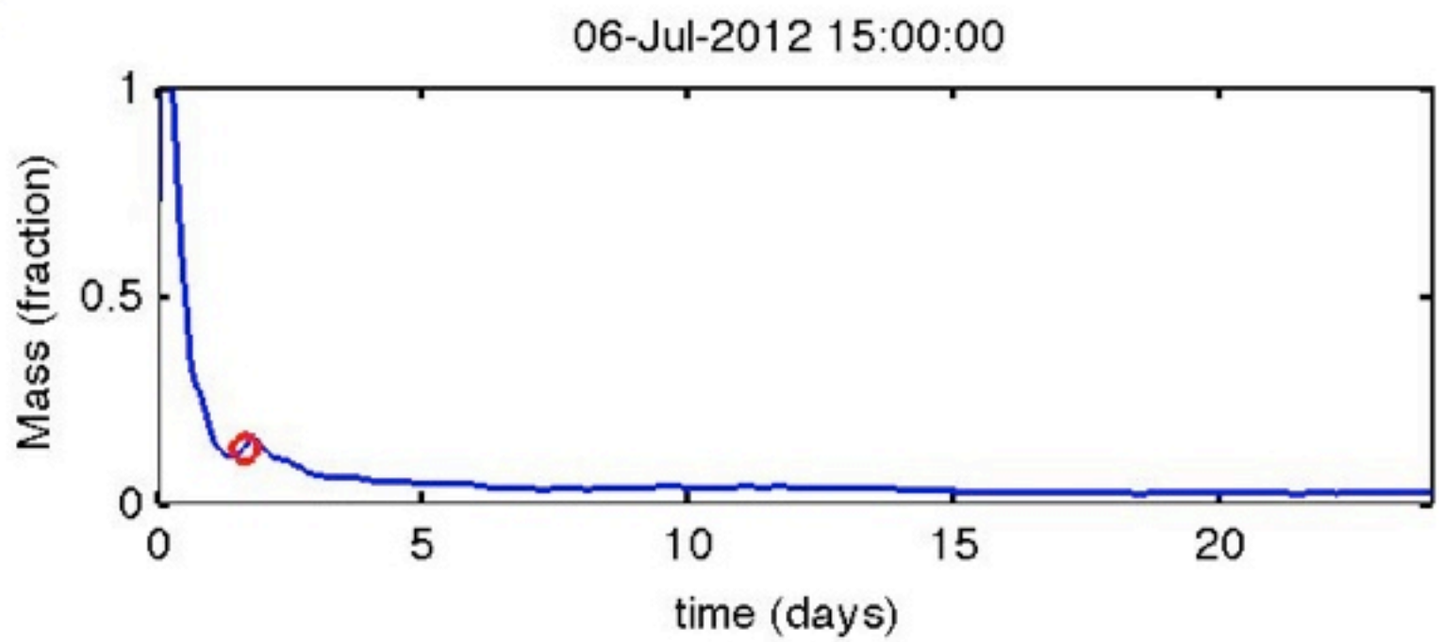

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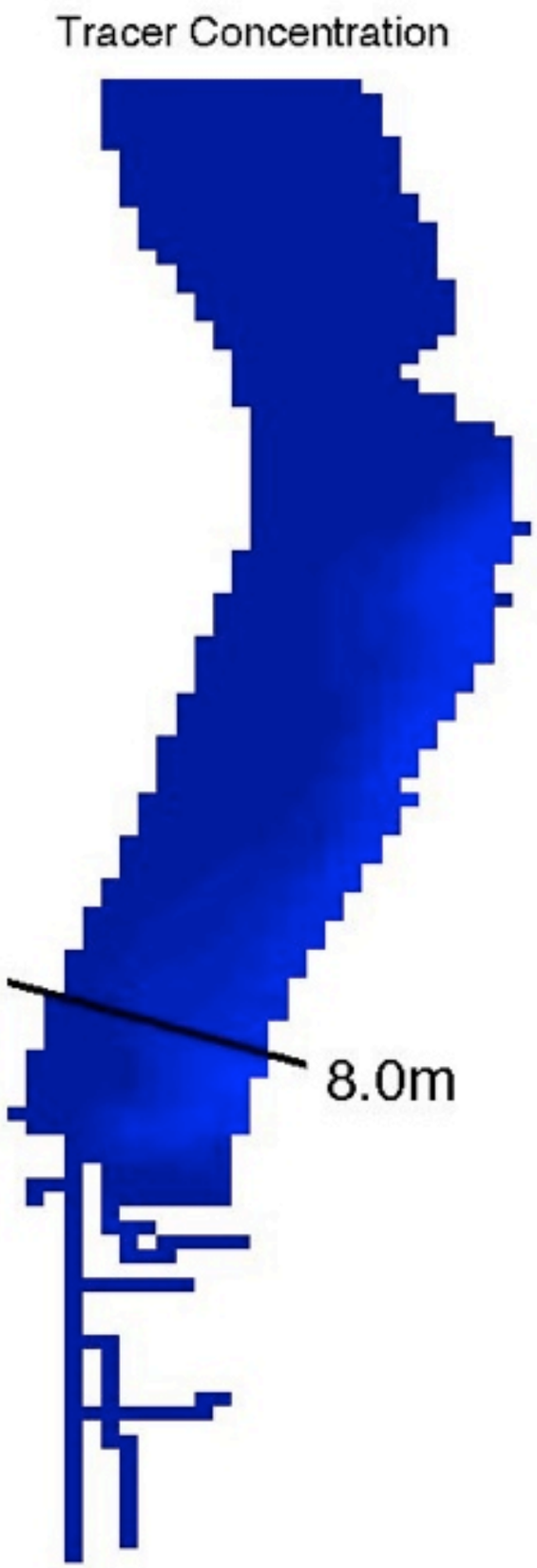
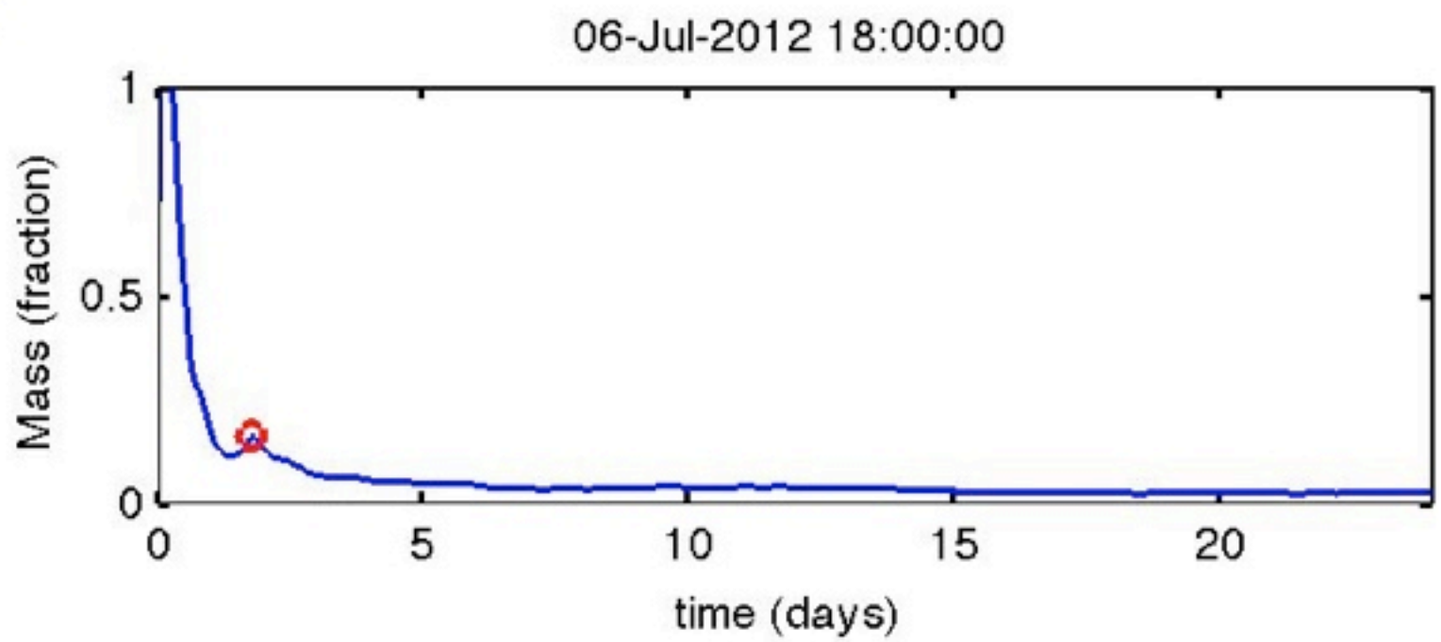
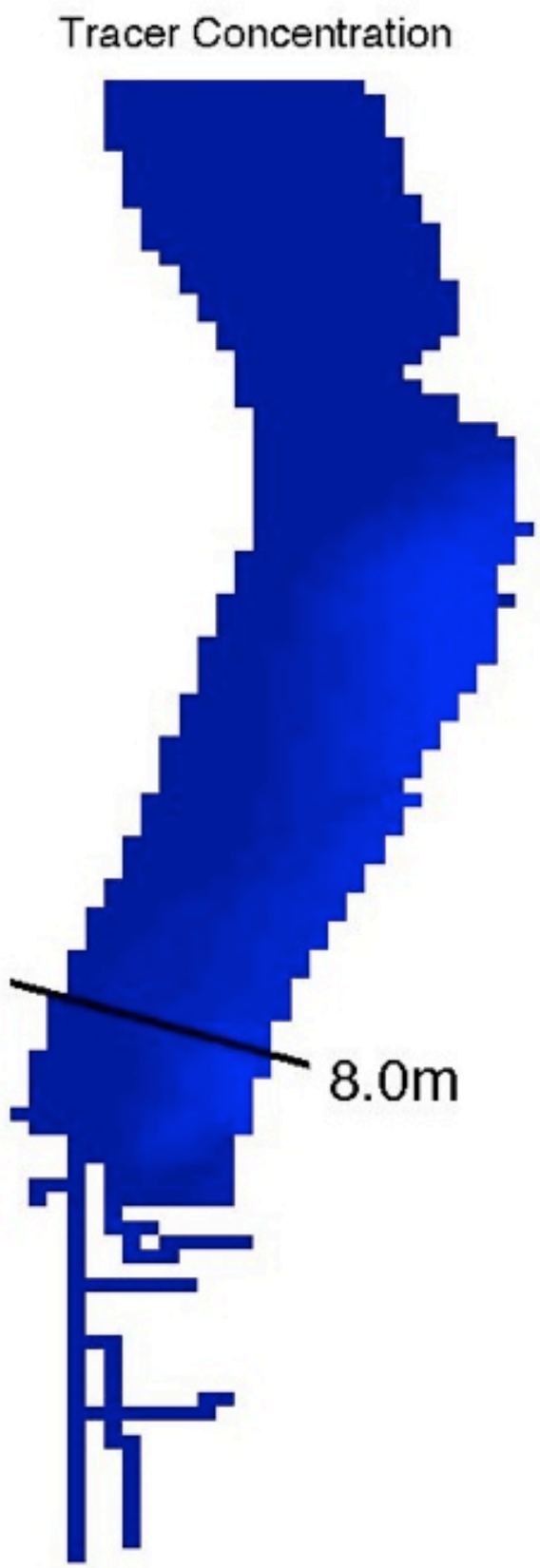
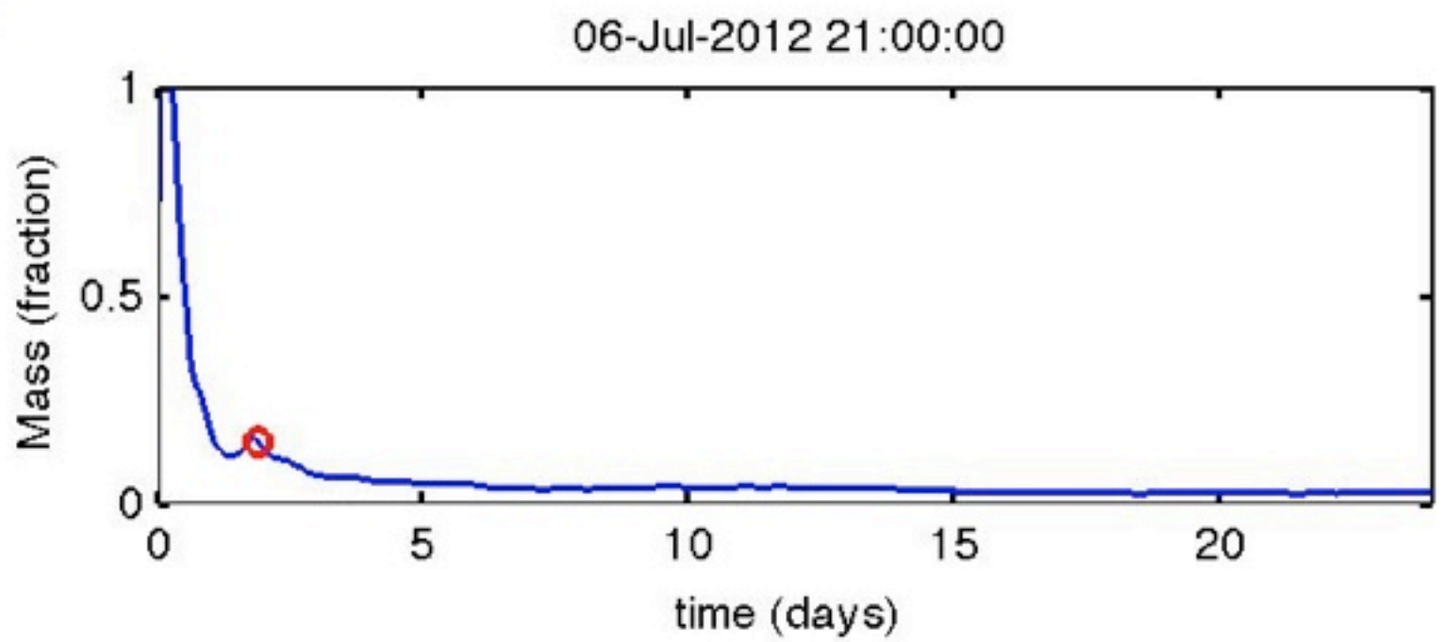




SI3D: Residence Time Experiments





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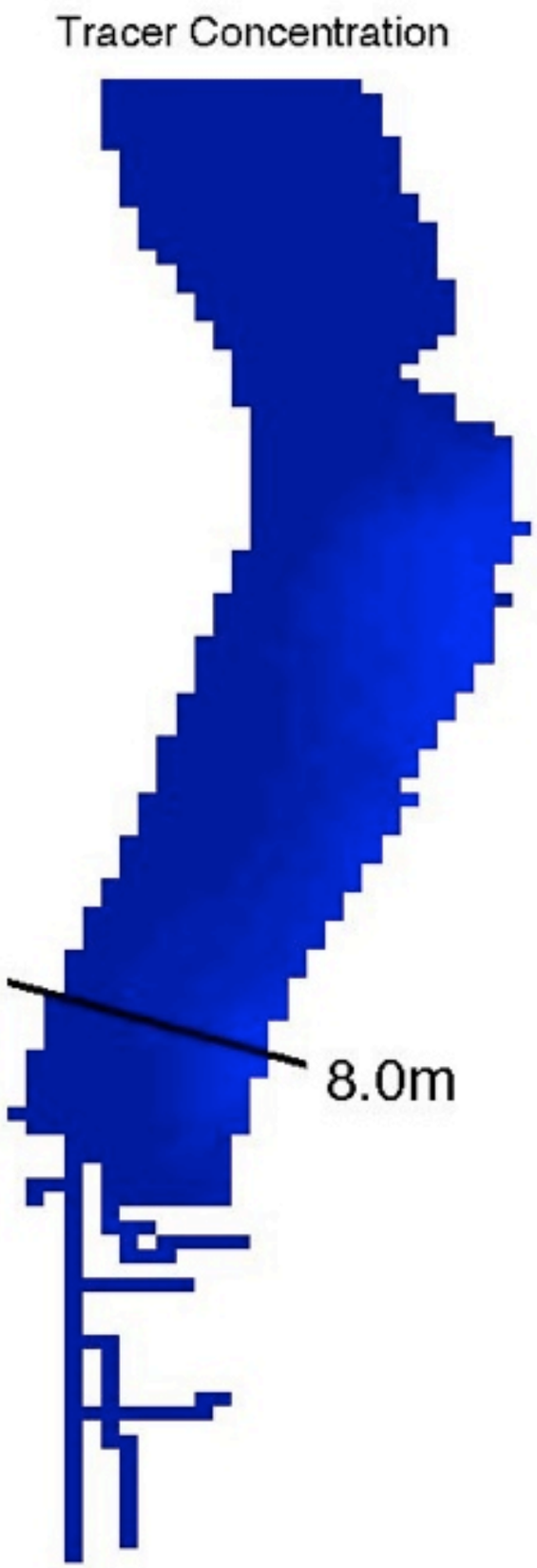

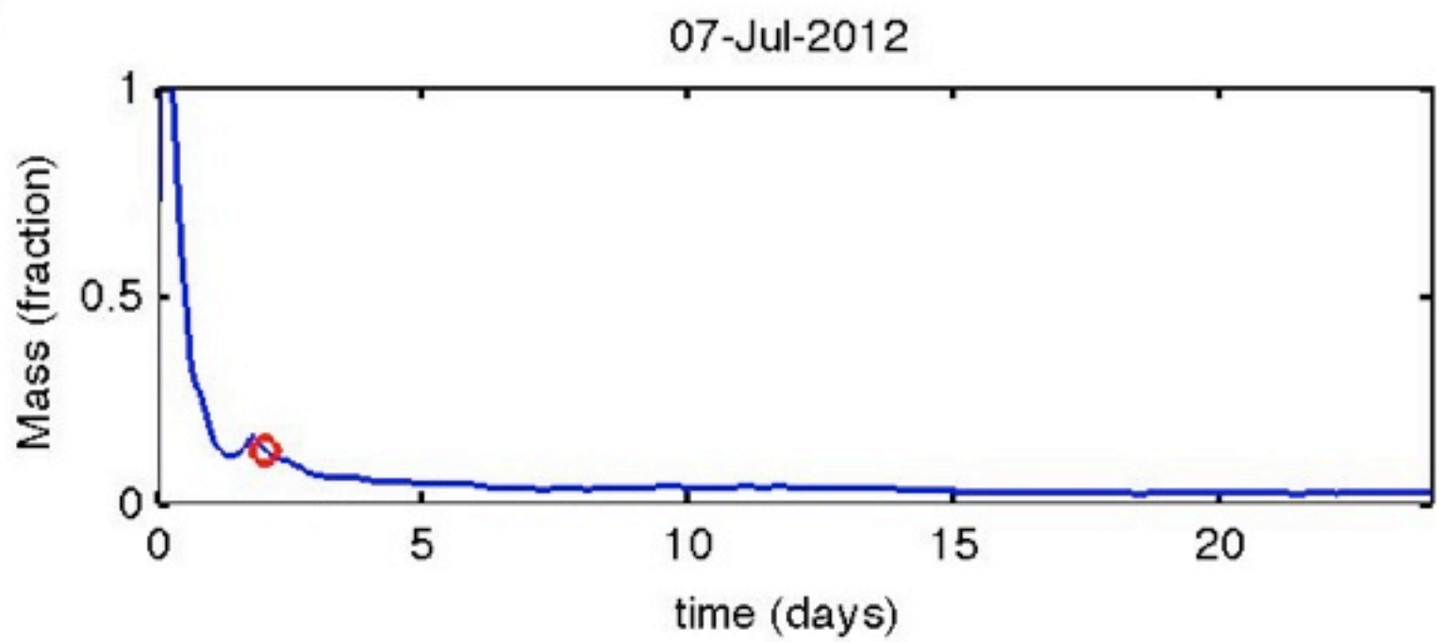

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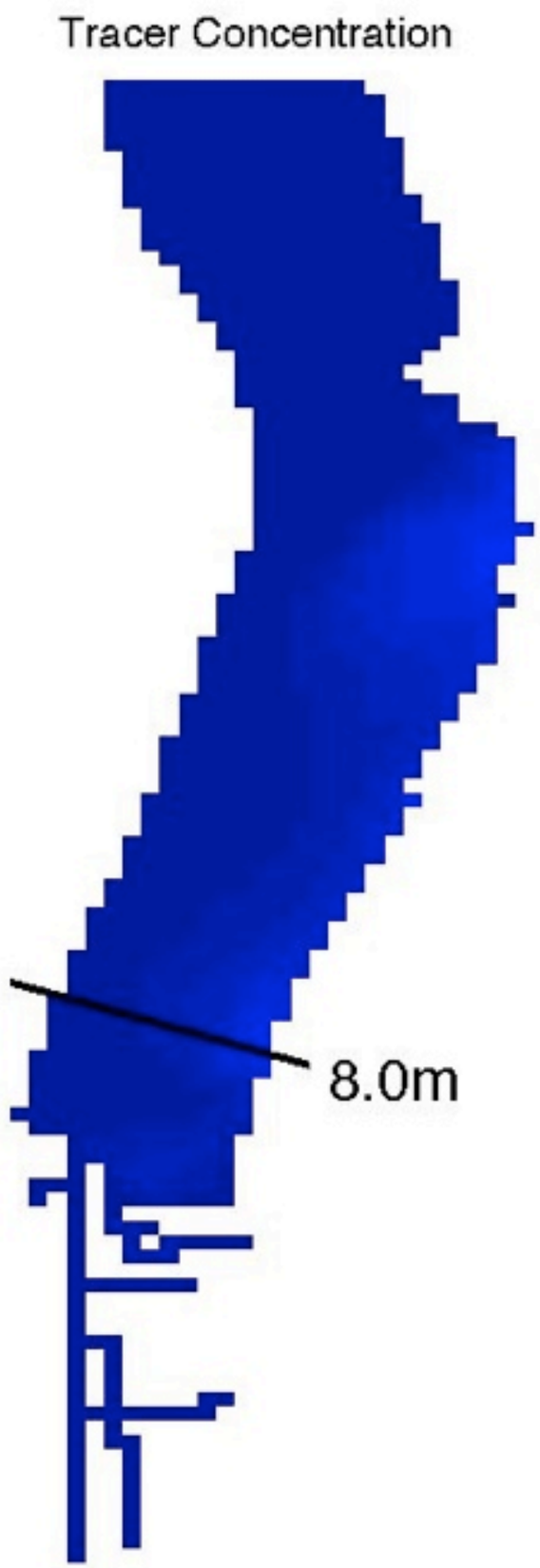
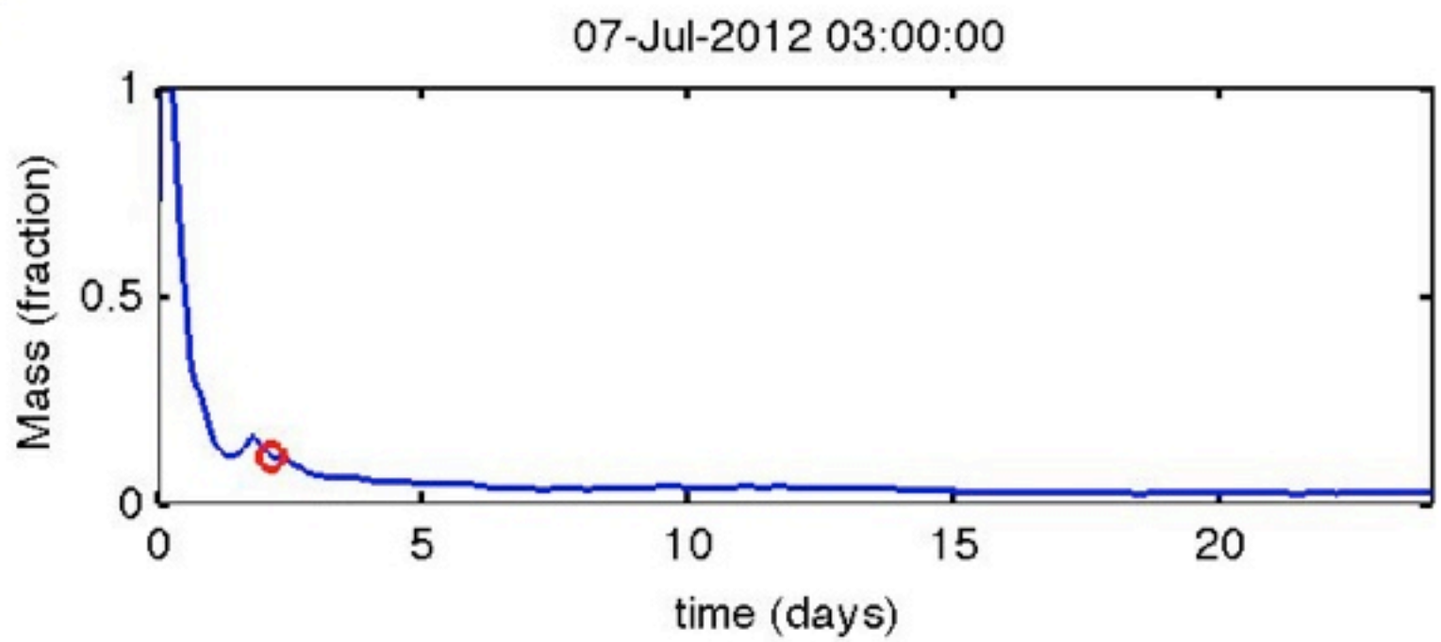
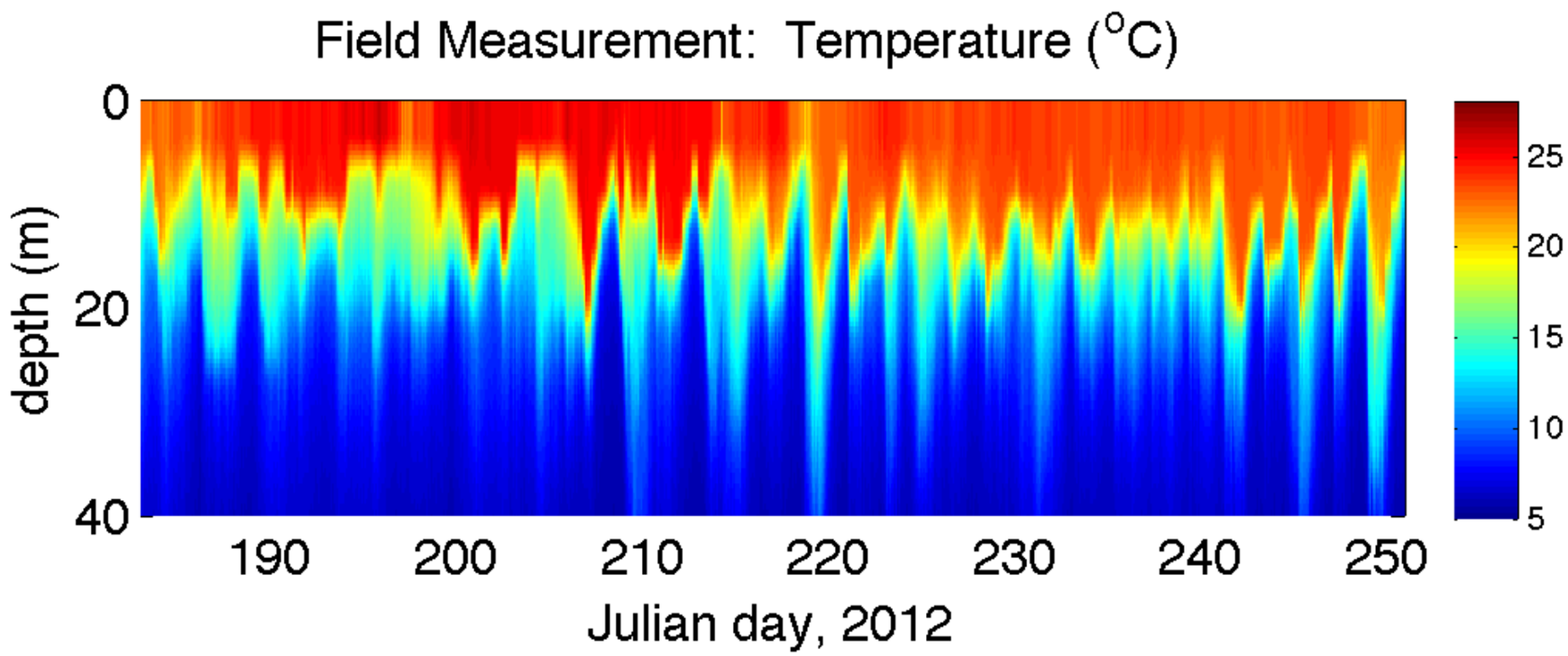
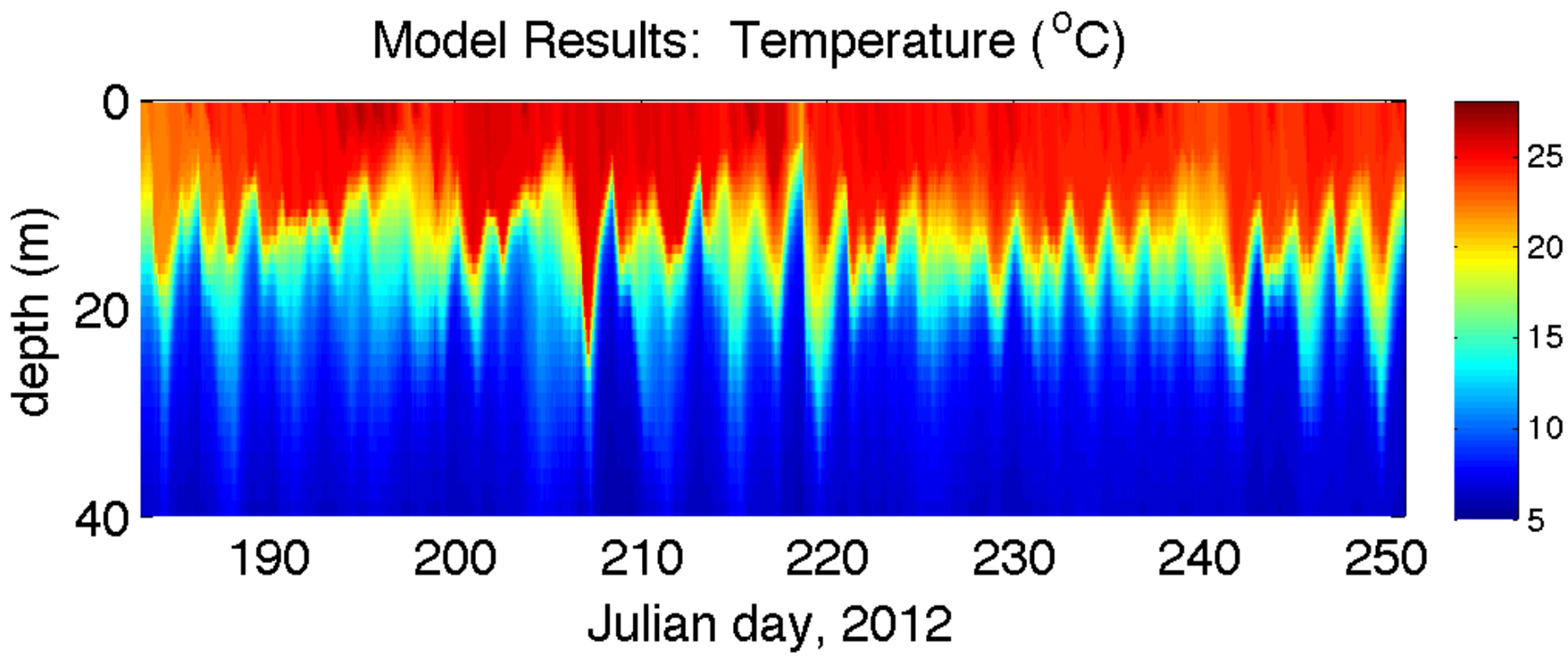




SI3D Validation: Summer 2012





SI3D Results: 2012 Shelf Flusing Times

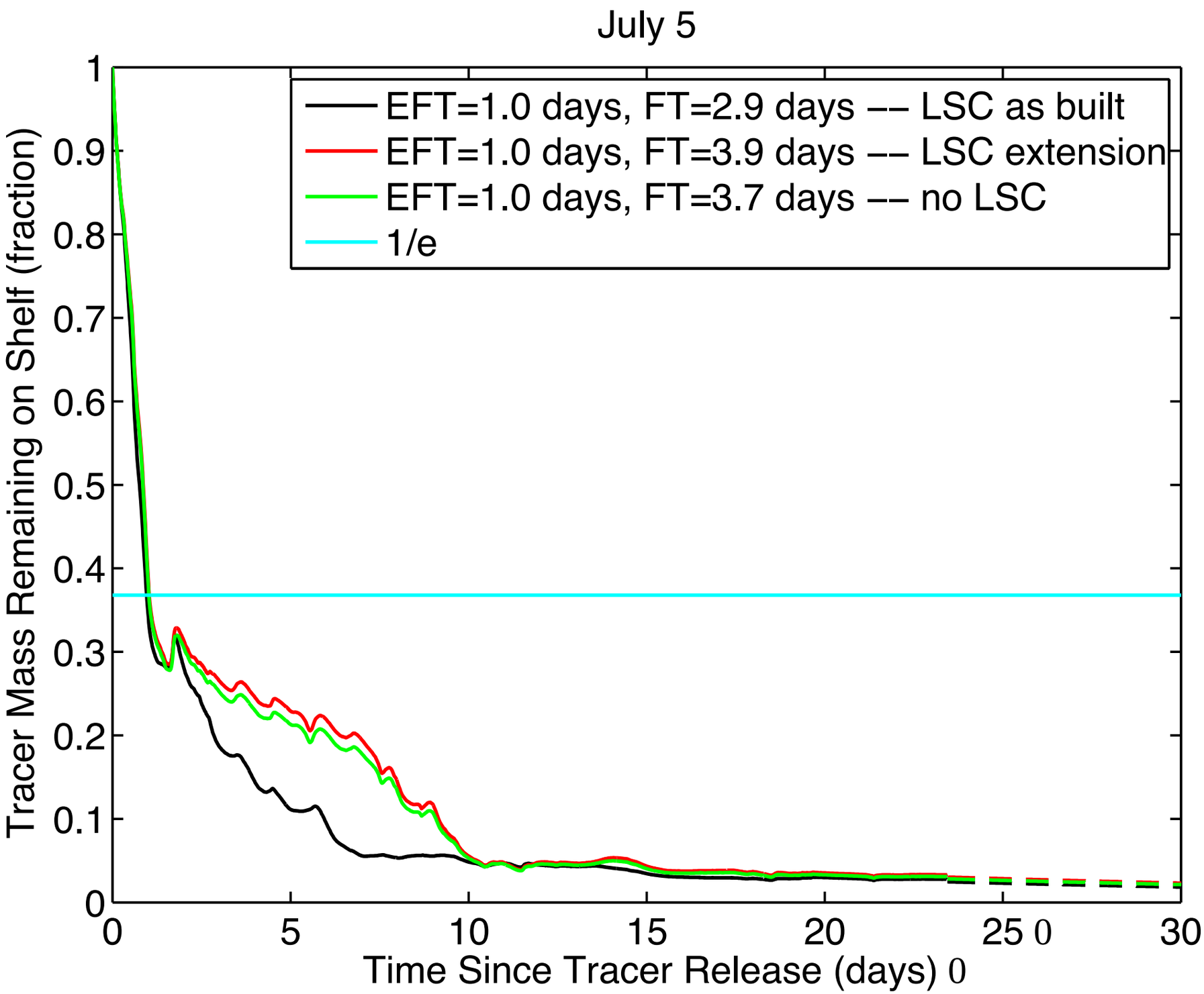
➡ 6 flushing time experiments (so far):

July 5
July 16
August 5
August 16
September 5
September 16

On each date, 3 cases:

1. LSC outfall as built
2. LSC outfall extension
3. No LSC outfall

SI3D Results: 2012 Shelf Flusing Times



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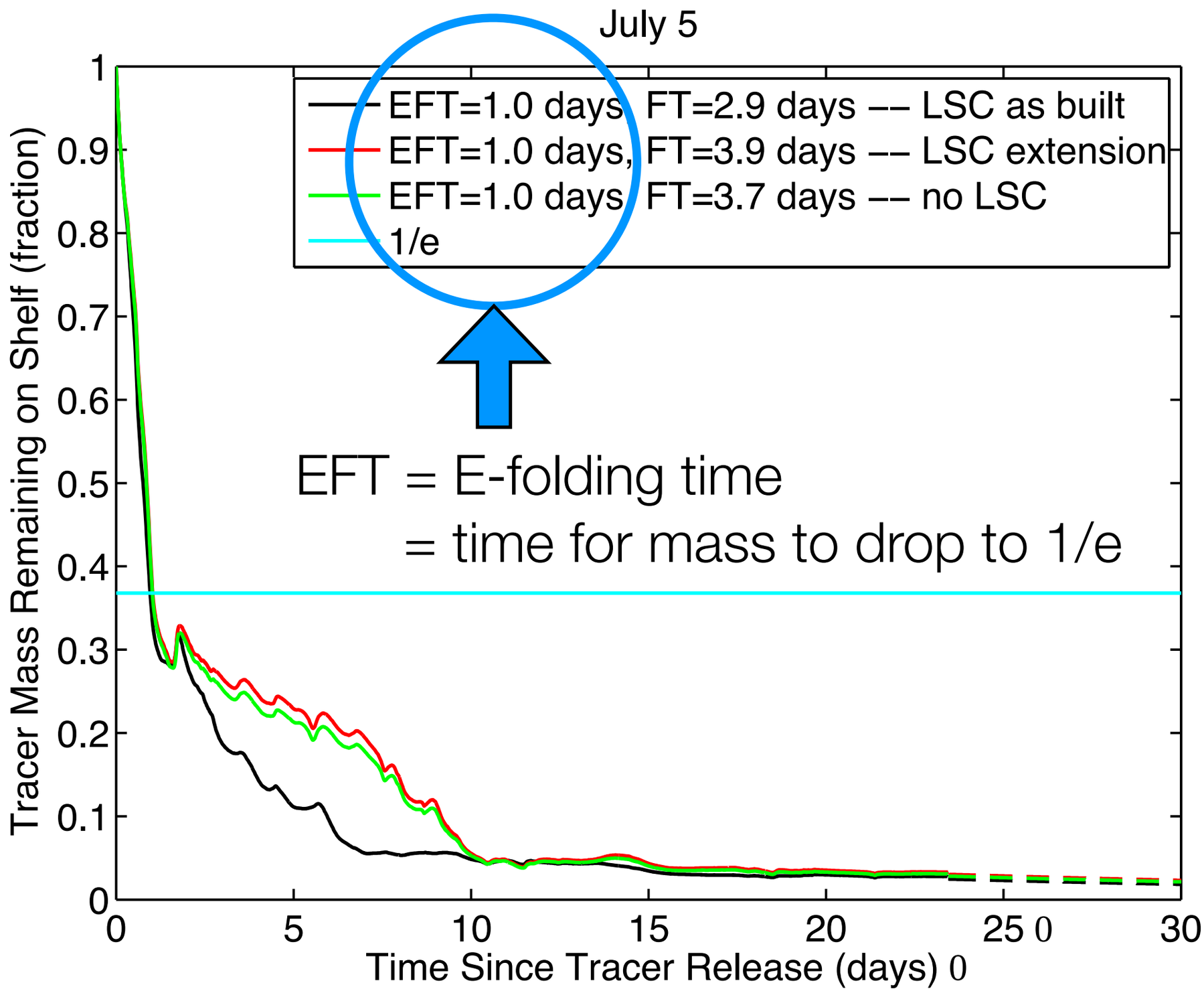

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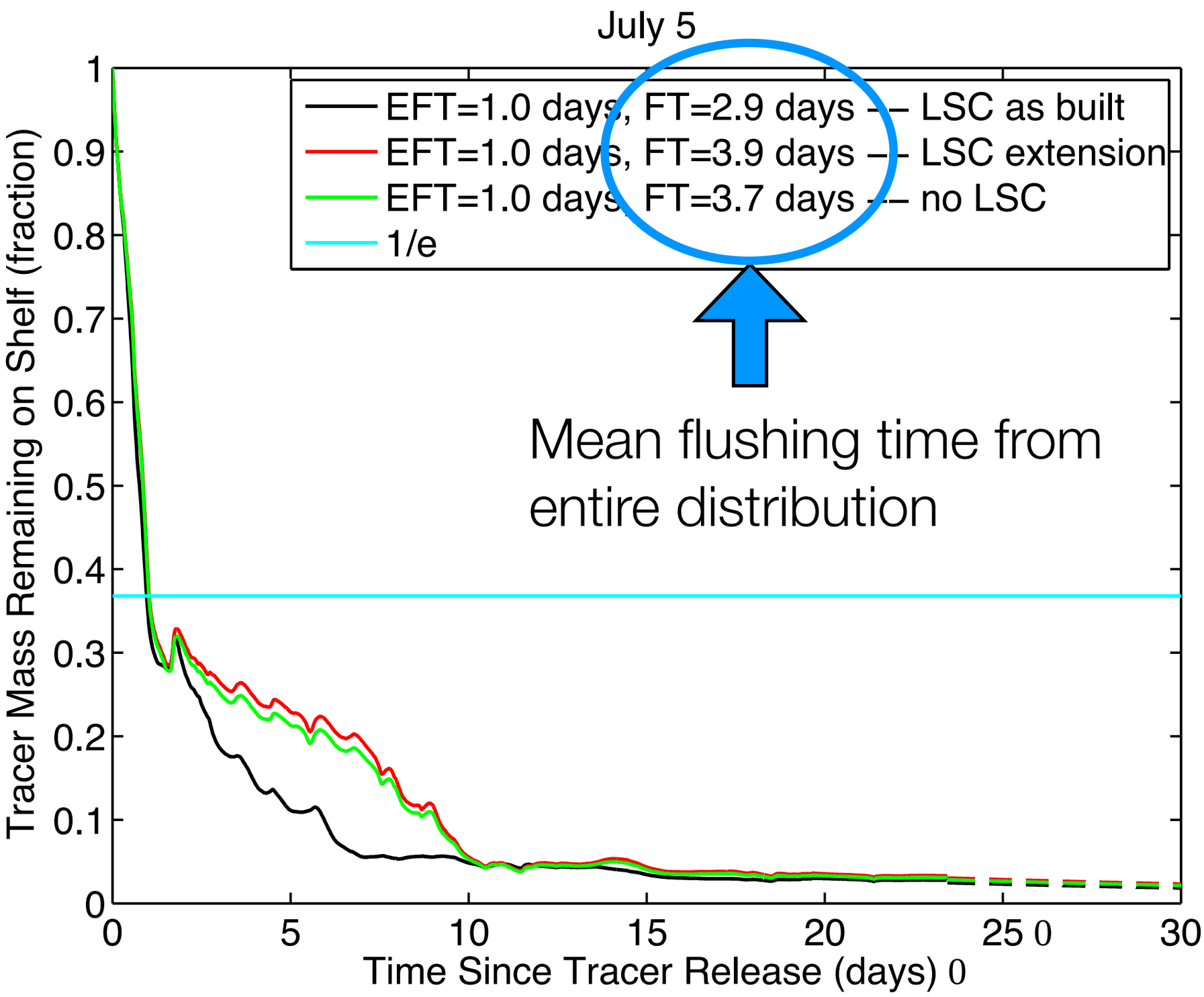

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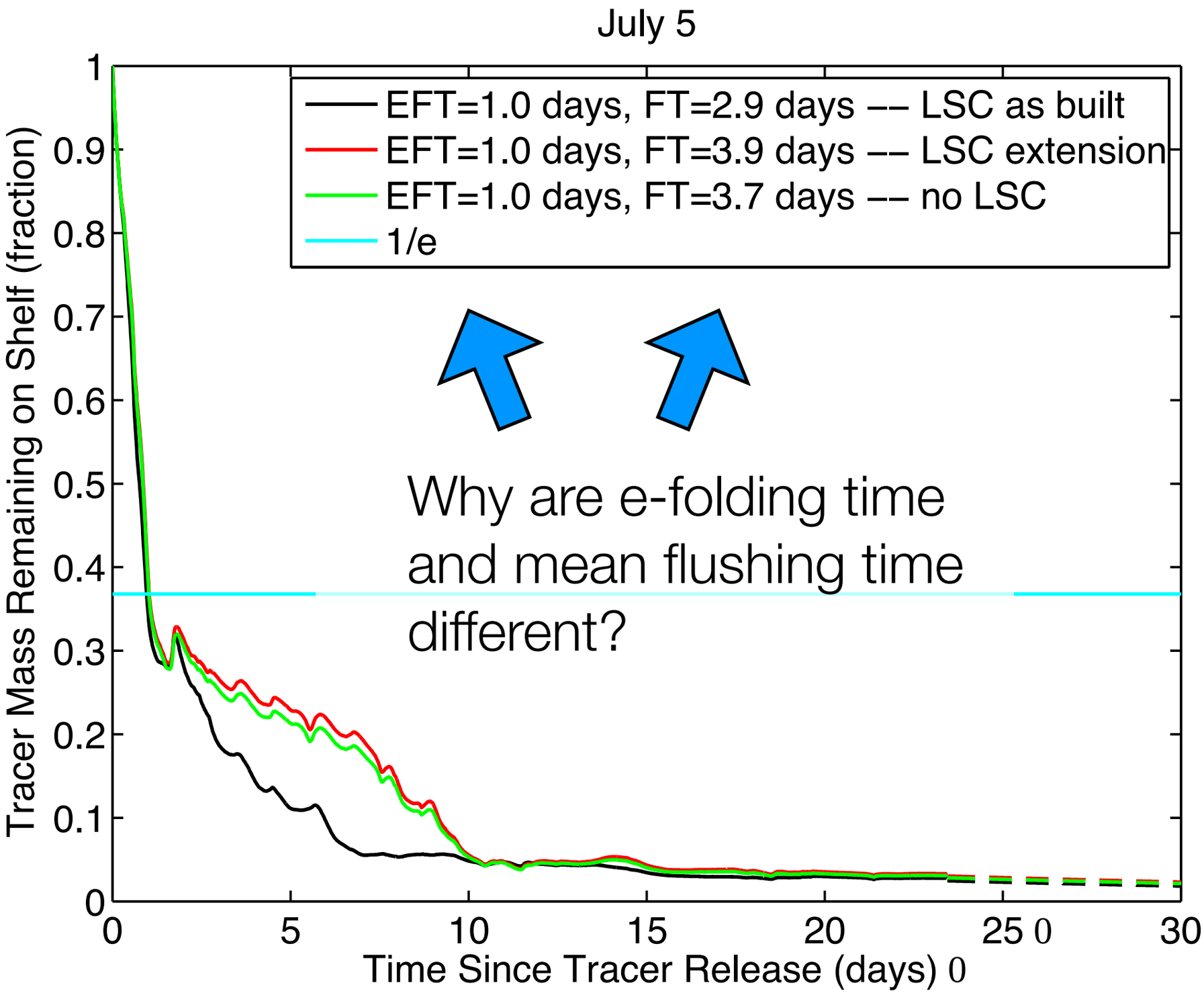

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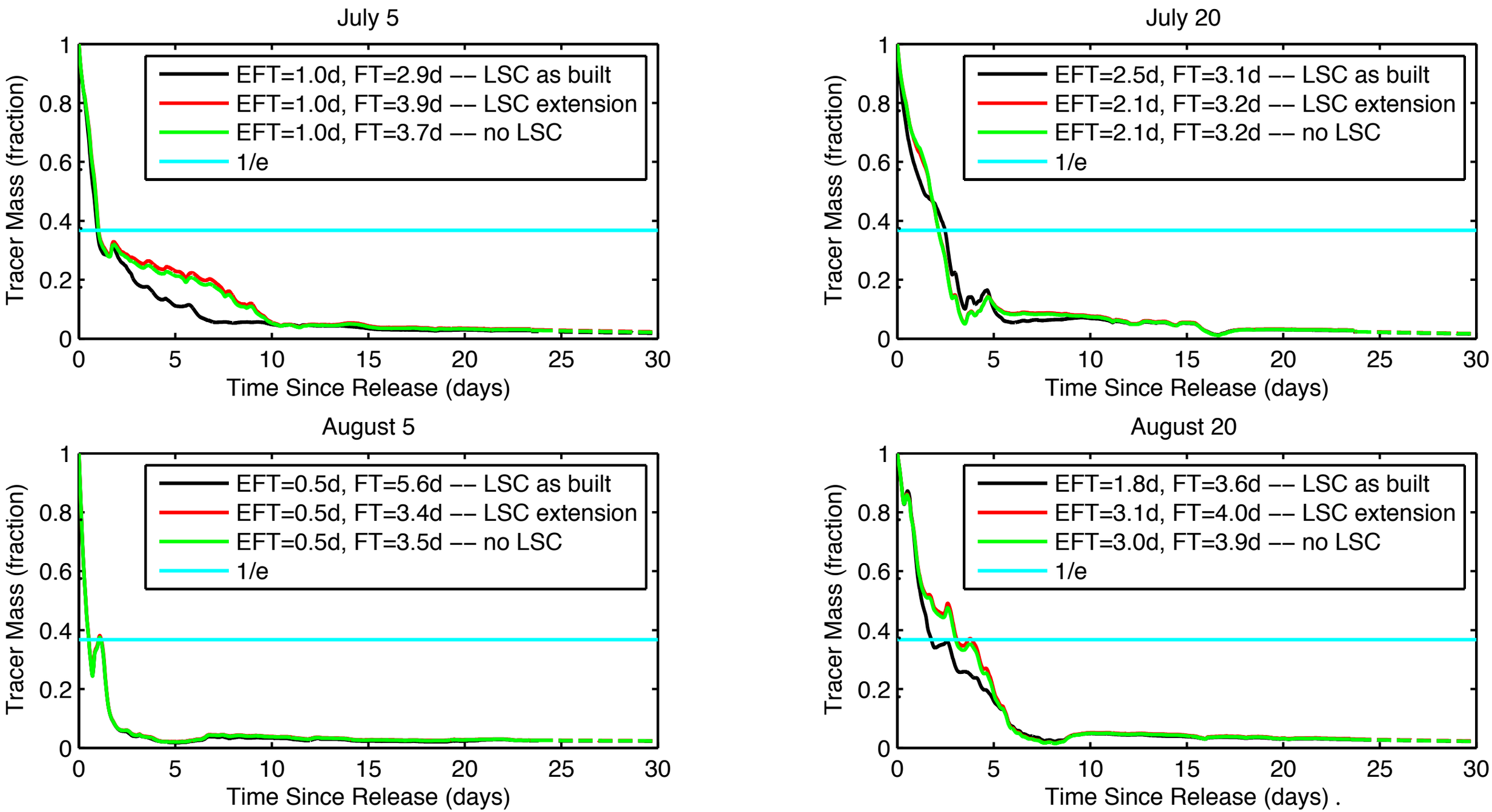
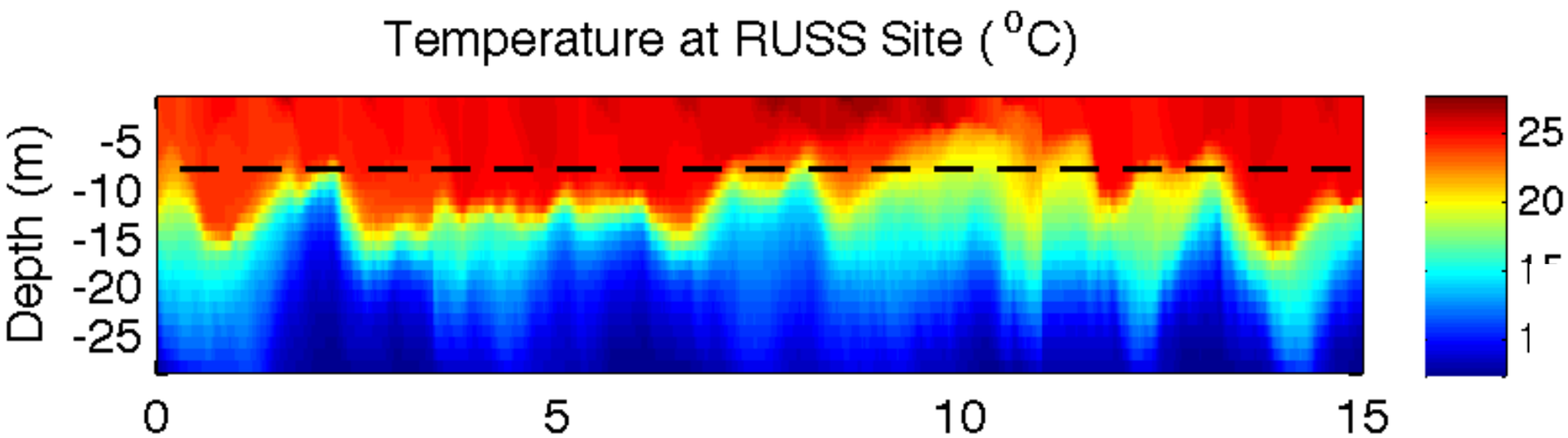
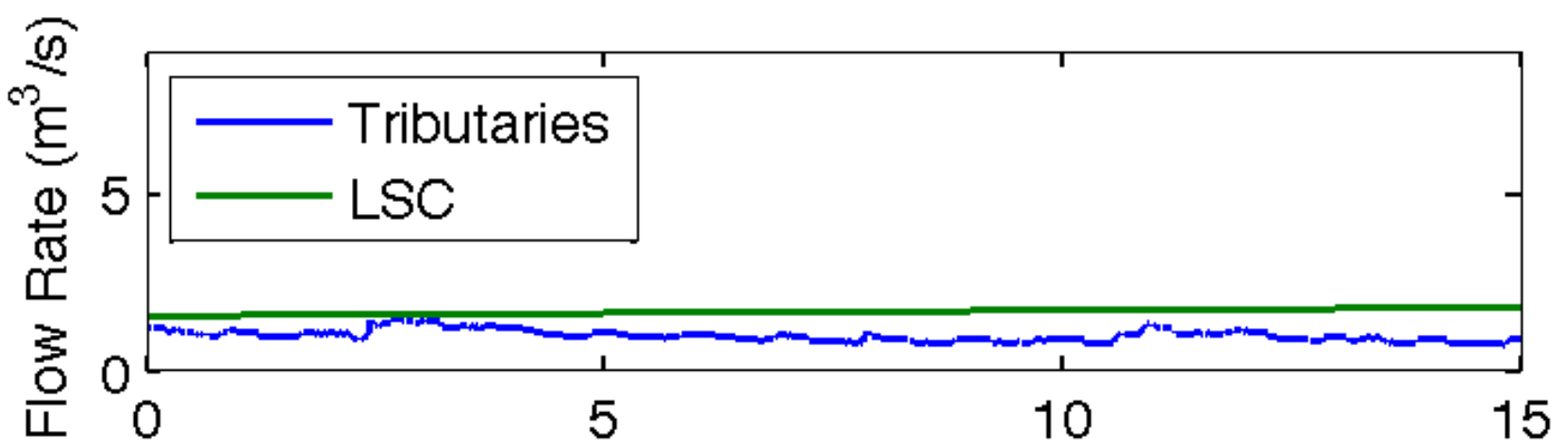
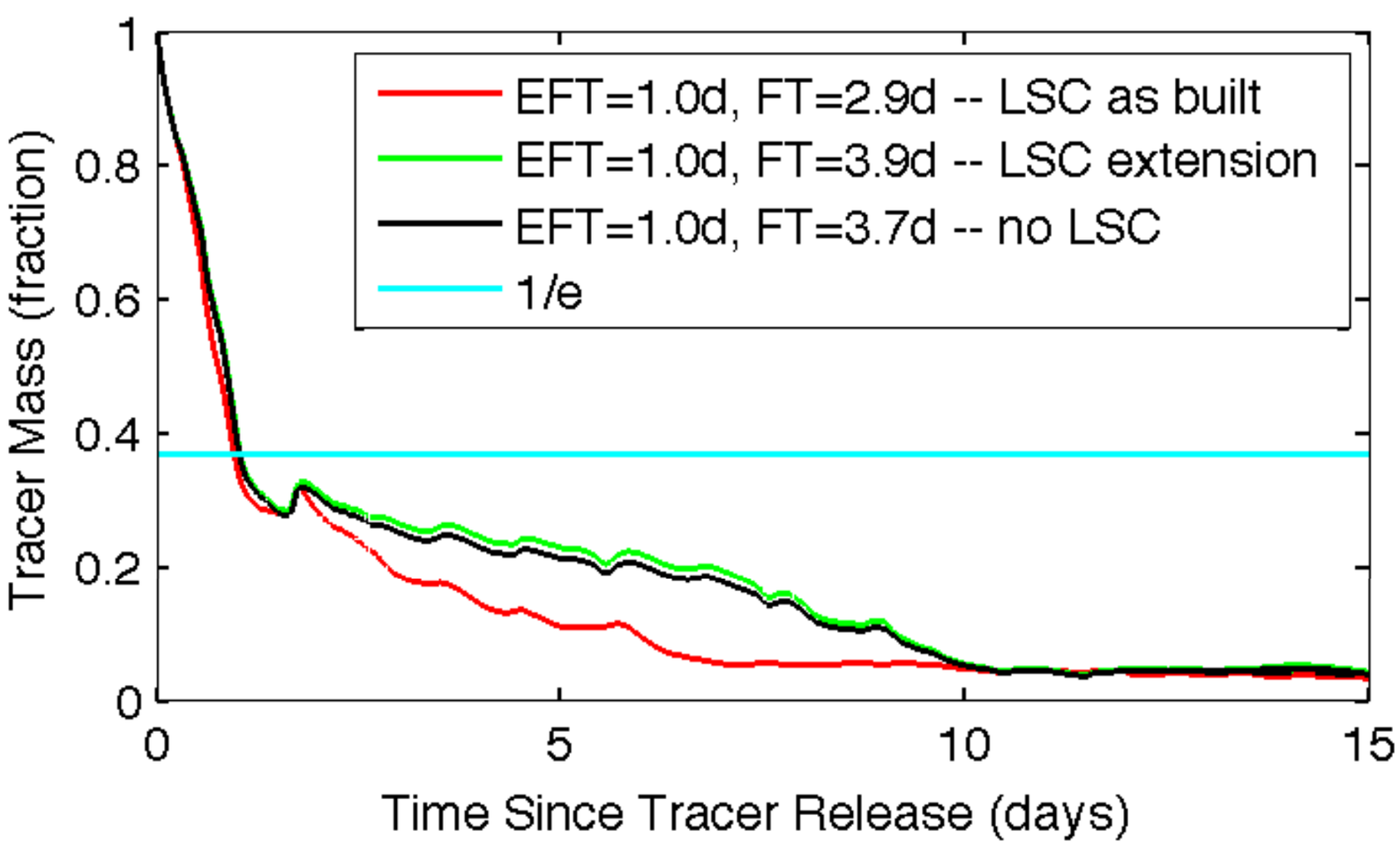
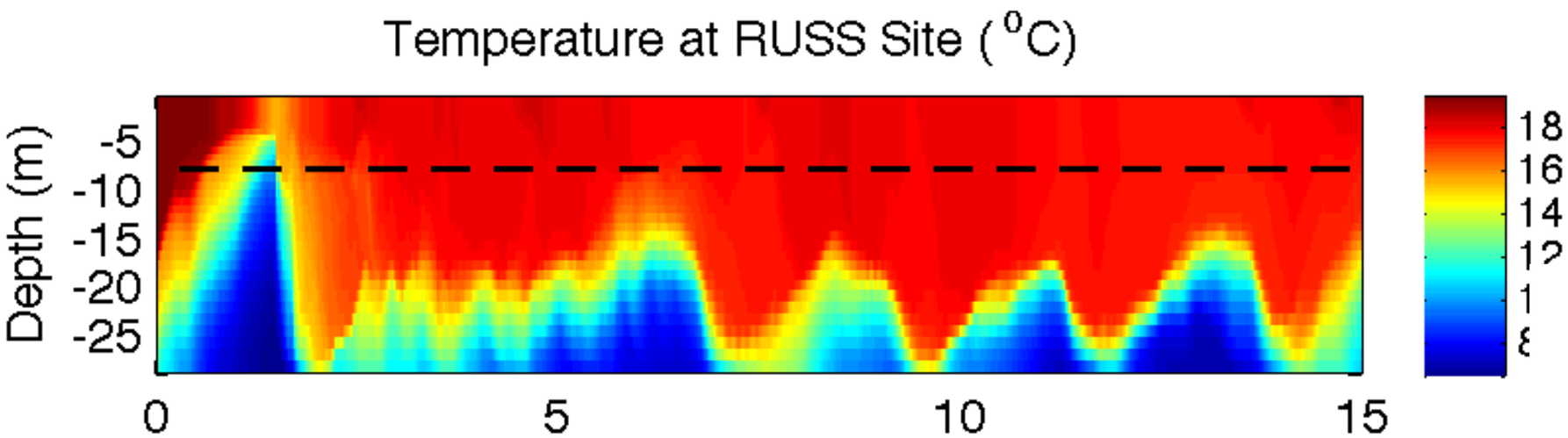


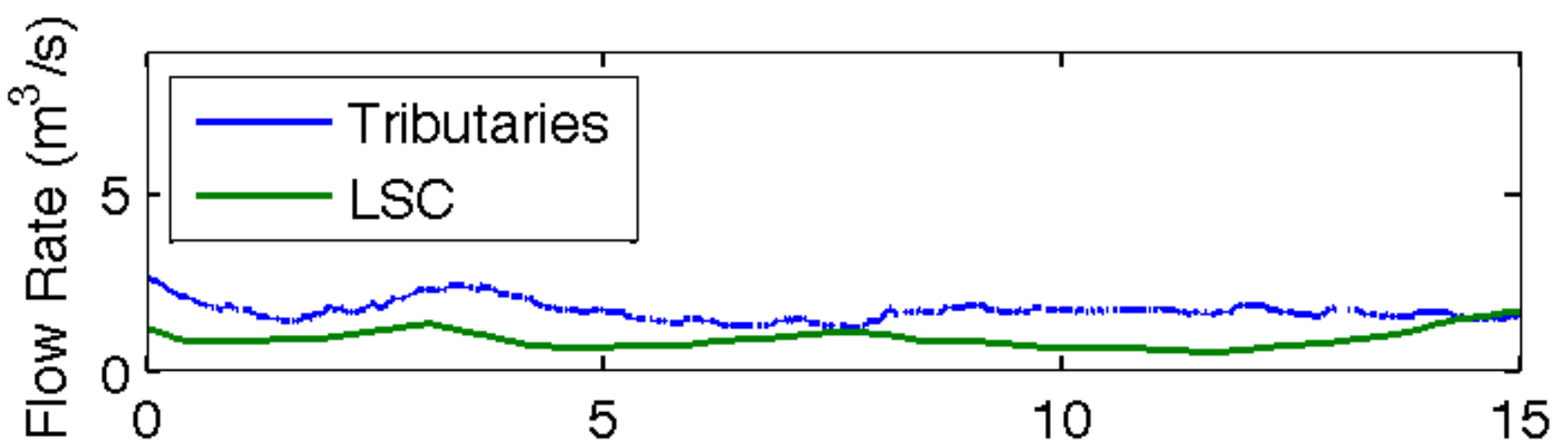


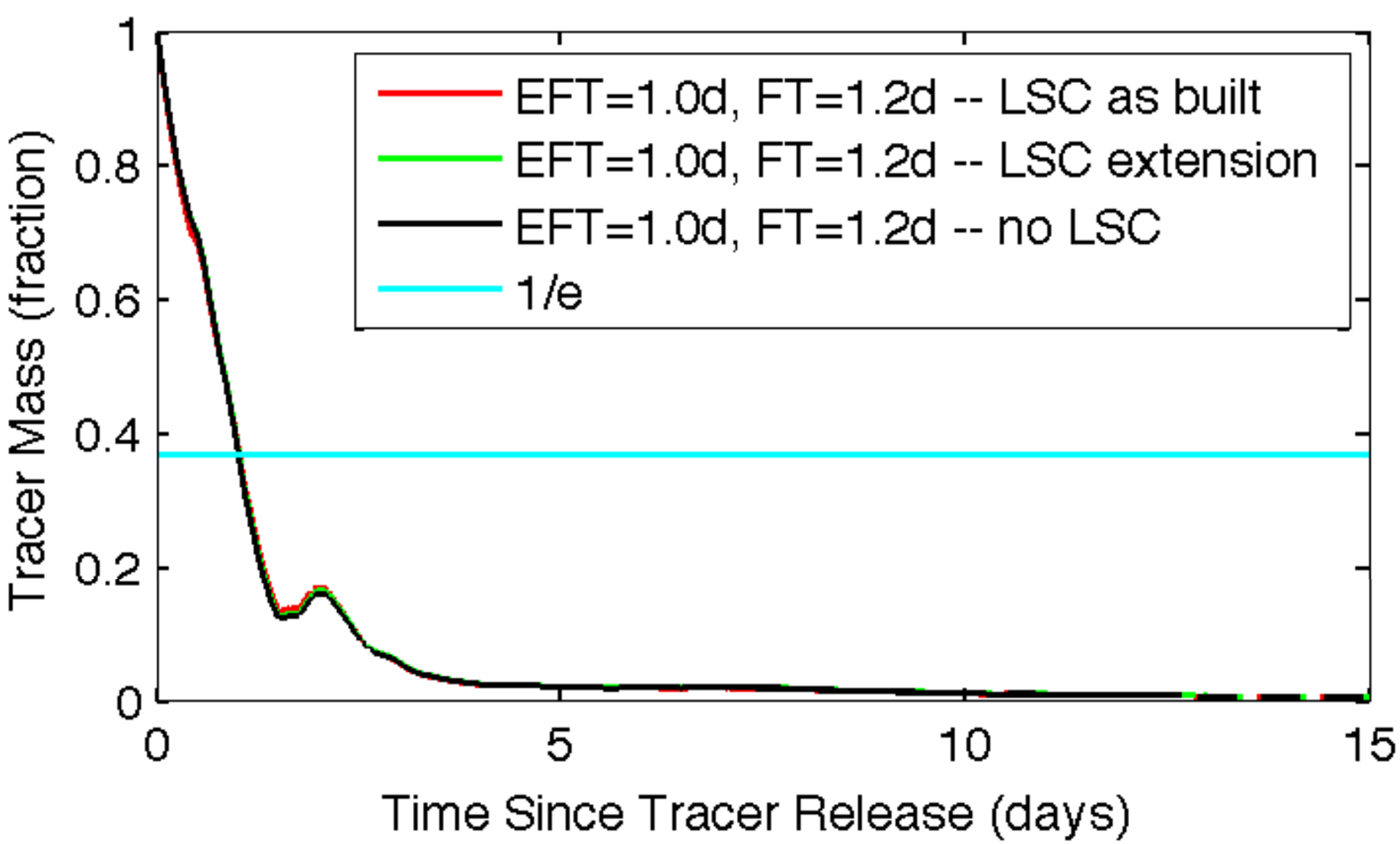




What Physical Processes Control Flushing Time?







What Physical Processes Control Flushing Time?

Work in Progress

- Refine grid to 25m x 25m on shelf
- Improve near field model for point sources on shelf
- Validate SI3D using 2012 velocity, water surface elevation, and possibly herbicide release data (not just temperature)
- Calculate flushing times for summers other than 2012
- Compute/compare residence times for point sources, tributaries, and LSC sampling sites
- Correlate flushing/residence times to physical forcing
- Continue to develop model for outfall extension
- Support UFI estimates of bulk transport coefficients