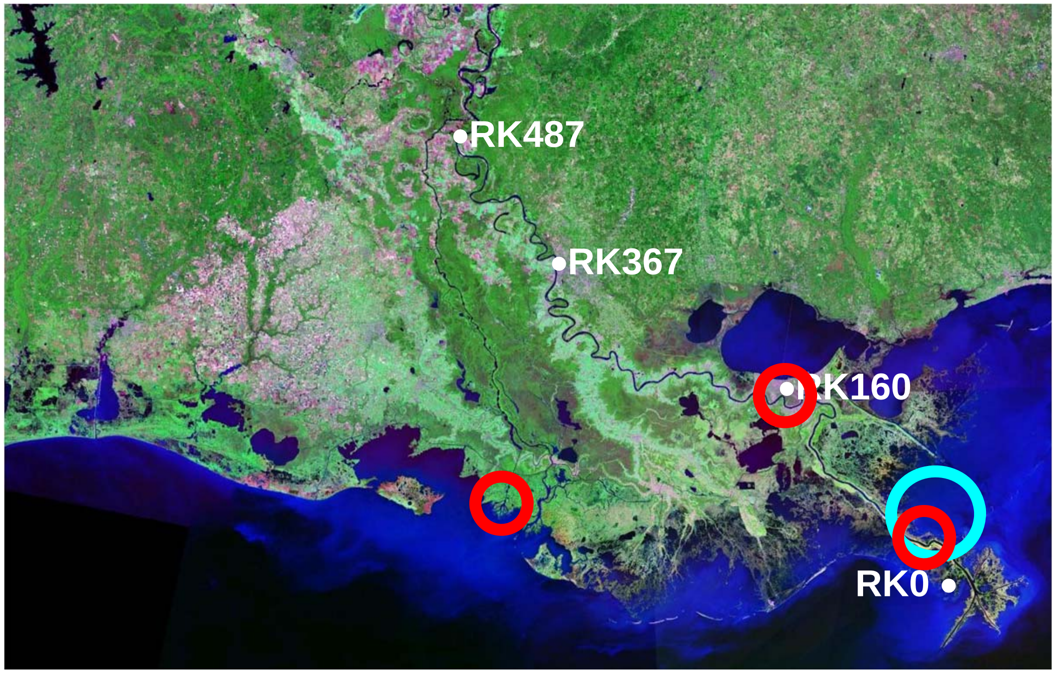
Connecting the Flow and Sediment-Transport in Coastal Rivers to Short- and Long-Term Patterns of Delta Sedimentation



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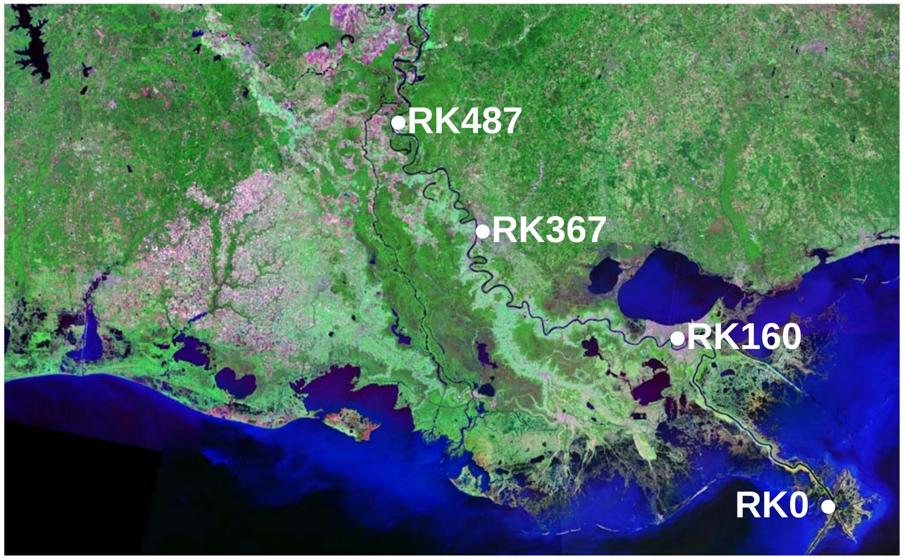
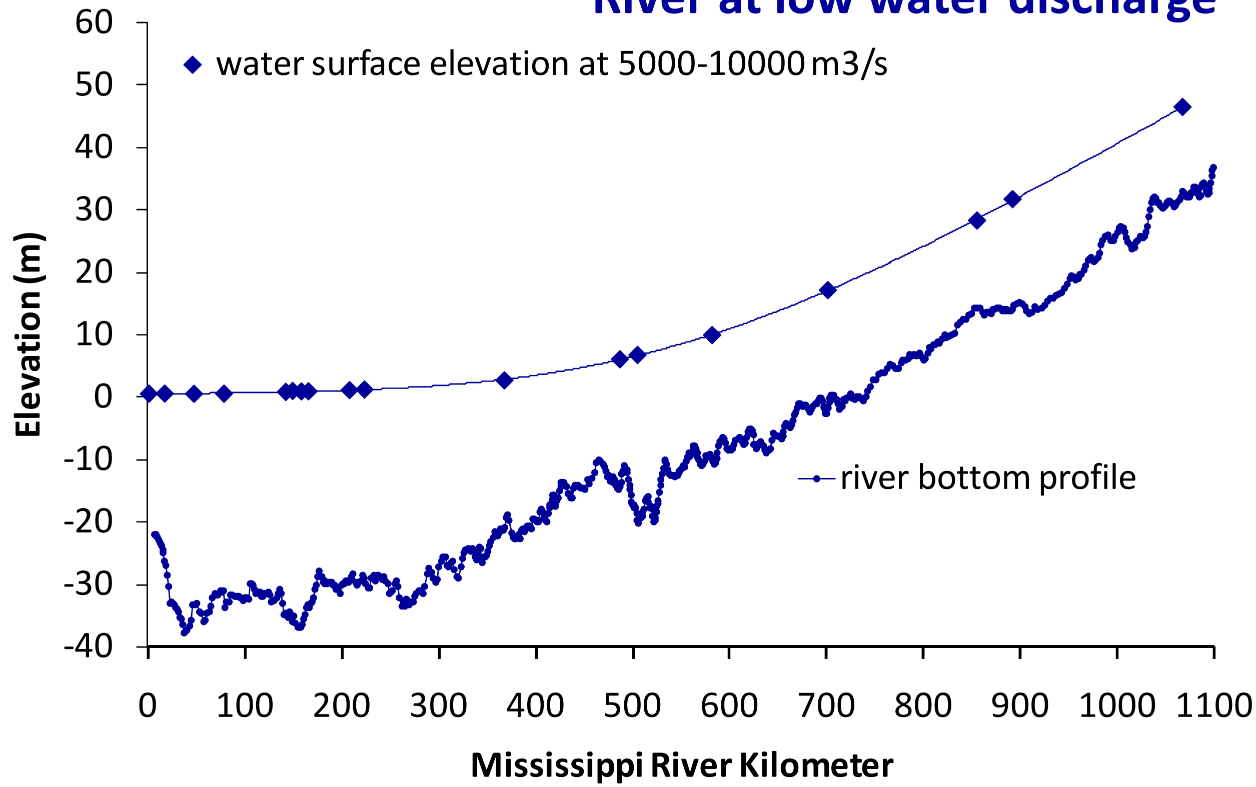
National Center for Earth-surface Dynamics, a NSF STC

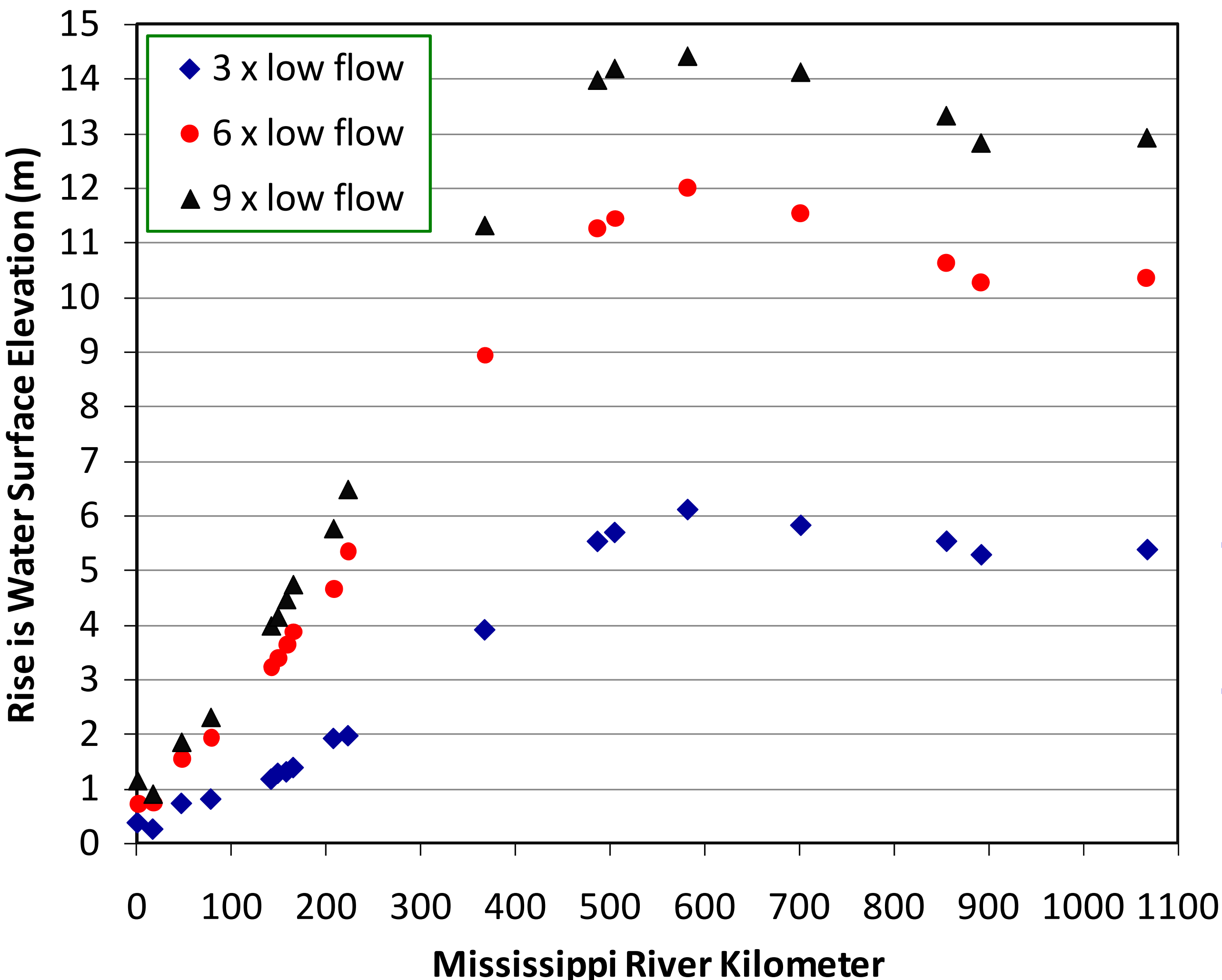
Connecting hydraulics to sediment transport in the lowermost Mississippi River & sand delivery to the river mouth



Water-surface profile for the Mississippi River at low water discharge



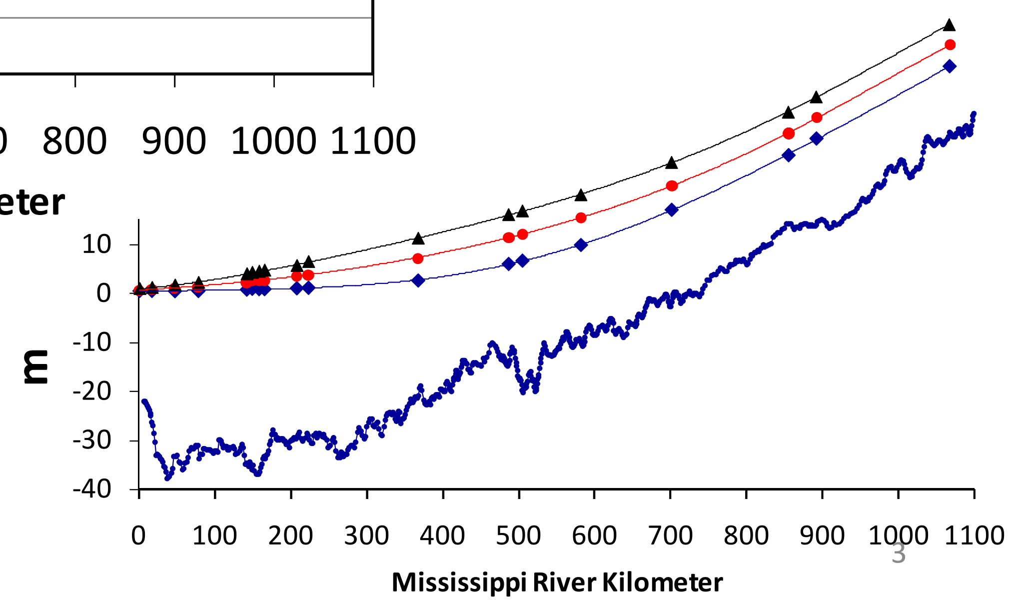
Backwater Zone defined by a divergence of water surface and bed slopes.



Control of Mississippi River Backwater on Flooding

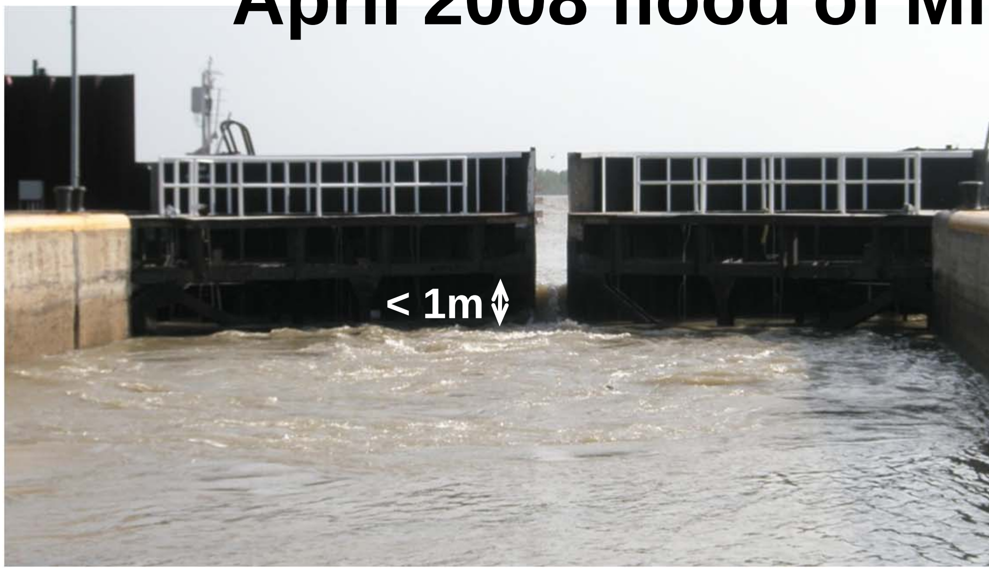
[Significant flooding above RK400, almost no flooding at RK 0]

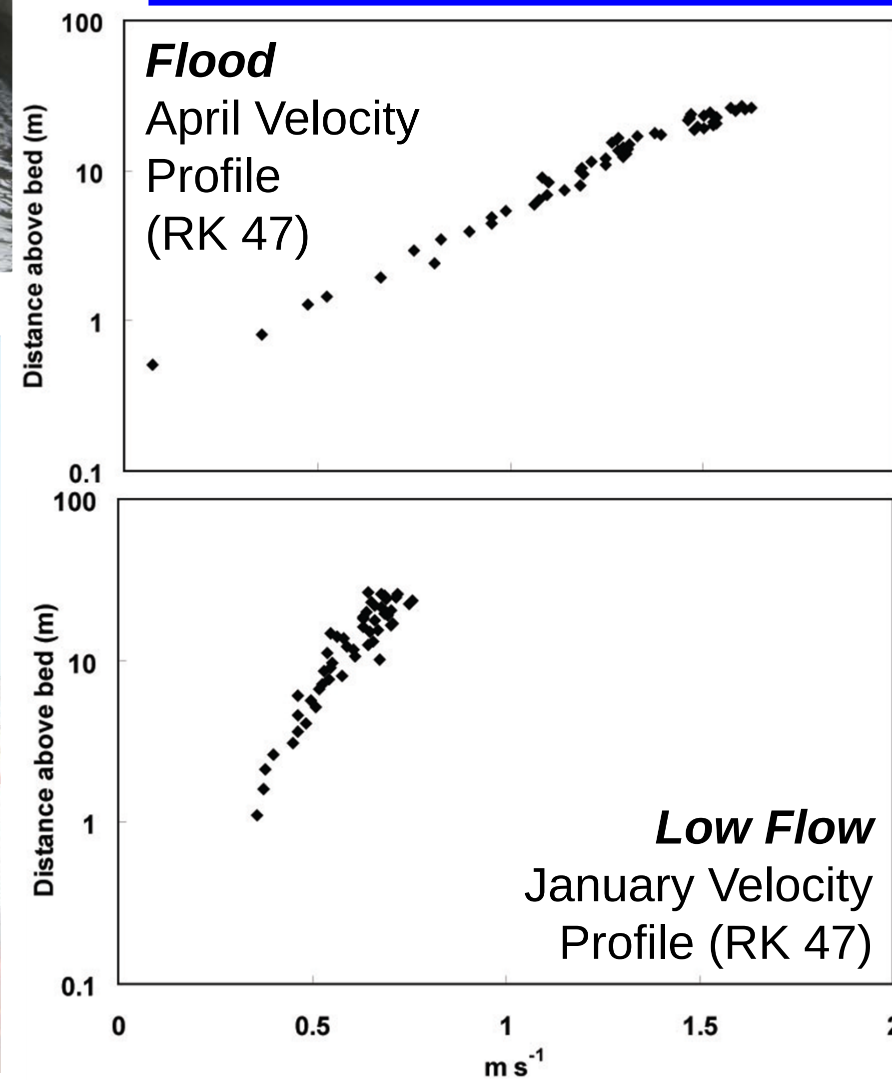
Water-surface profiles for the Mississippi River at low, intermediate and high water discharge



2008 flood of Upper Mississippi River

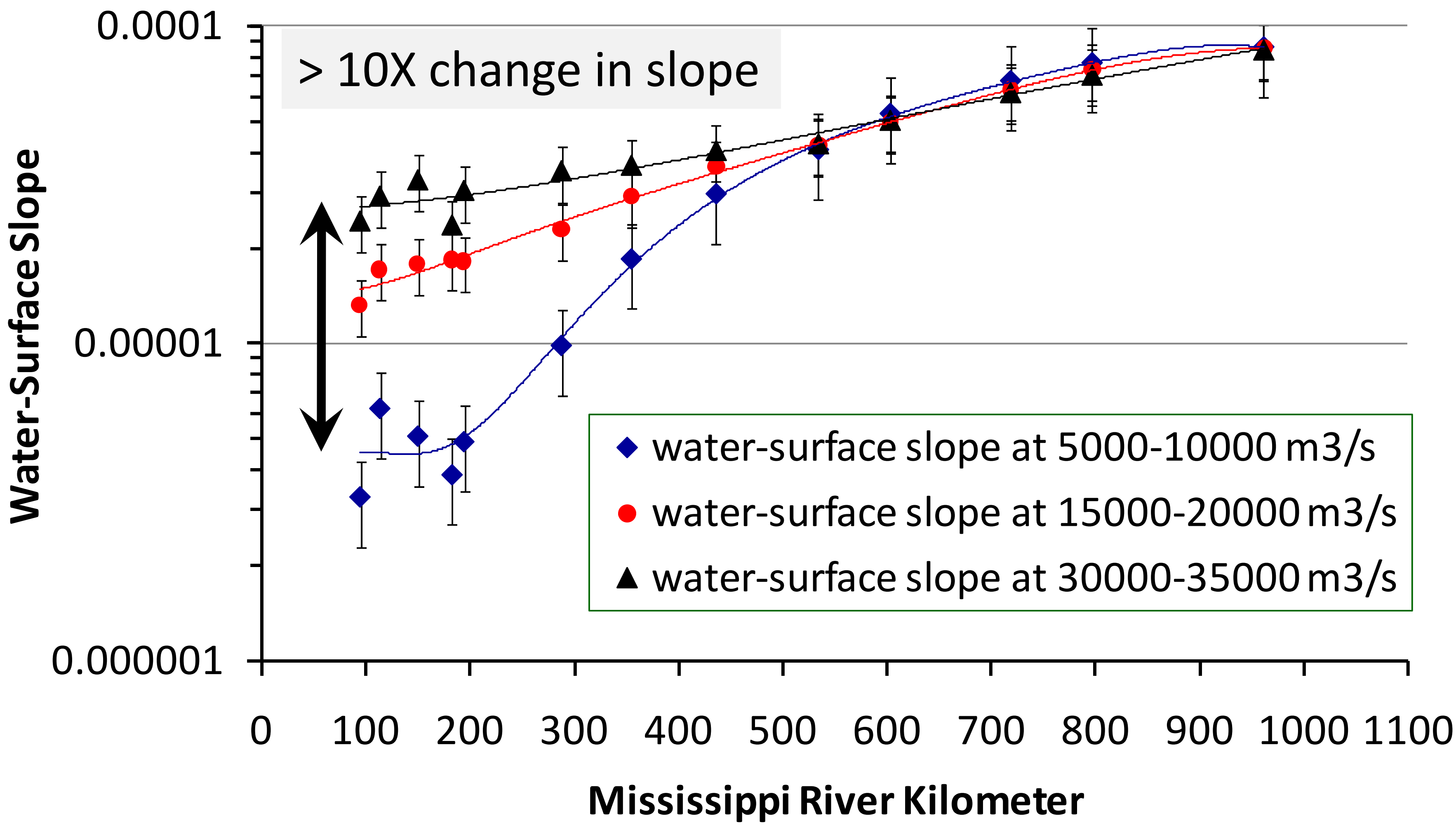
April 2008 flood of Mississippi River at RK 47





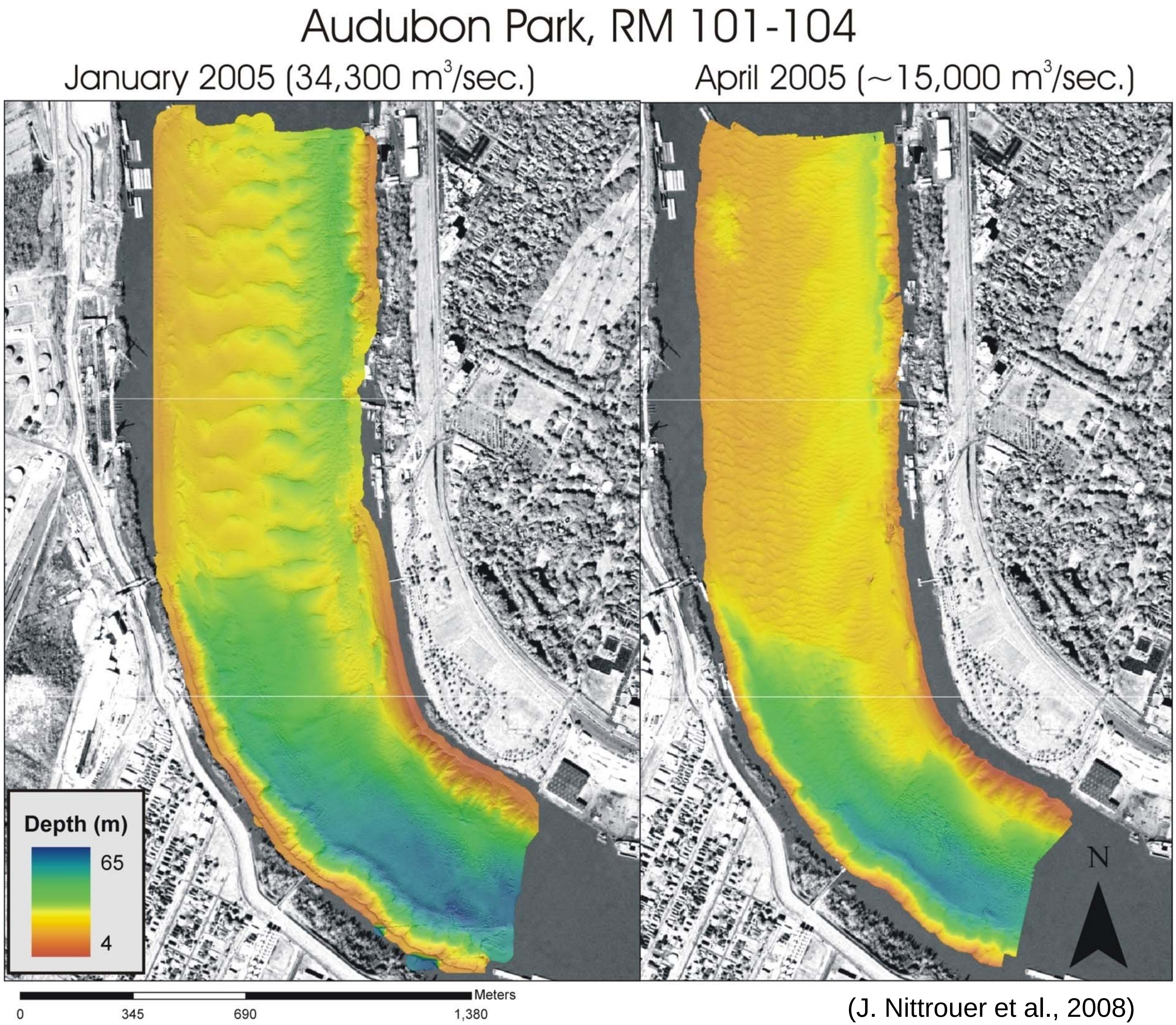
(Nittrouer, Mohrig & Allison, in prep)

Down river water-surface slopes at low, intermediate and high water discharge



How does a time varying *backwater condition* influence sediment transport in this coastal river?

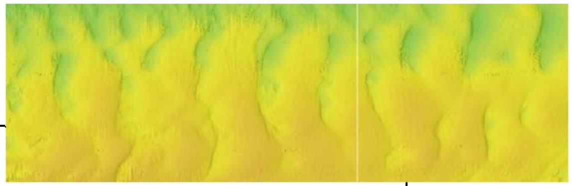
What about bed-material load in lower Mississippi River?

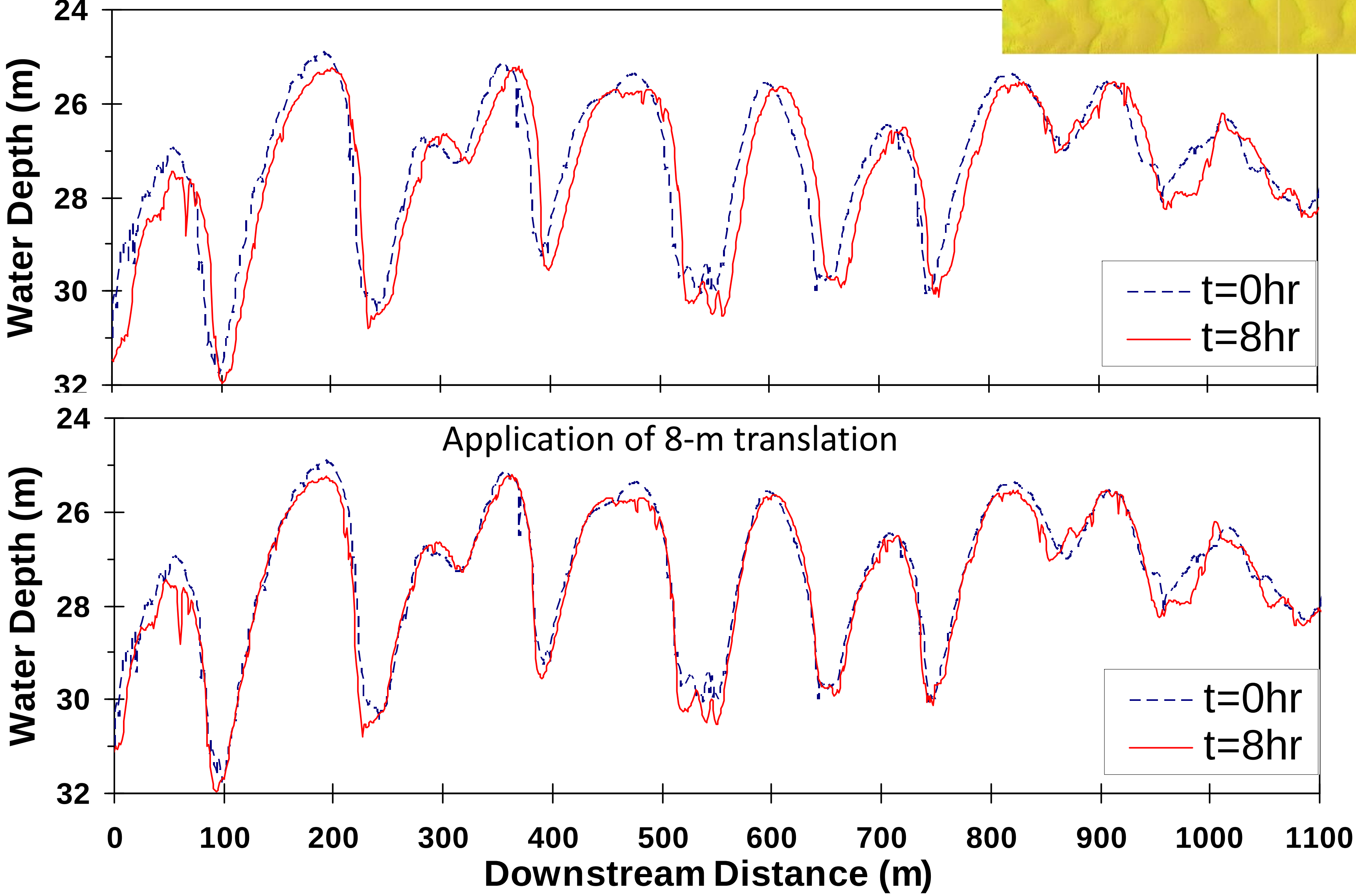


(J. Nittrouer et al., 2008)

Estimating Bed-Material Load from Dune Tracking

High water discharge: 34000 m^3/s

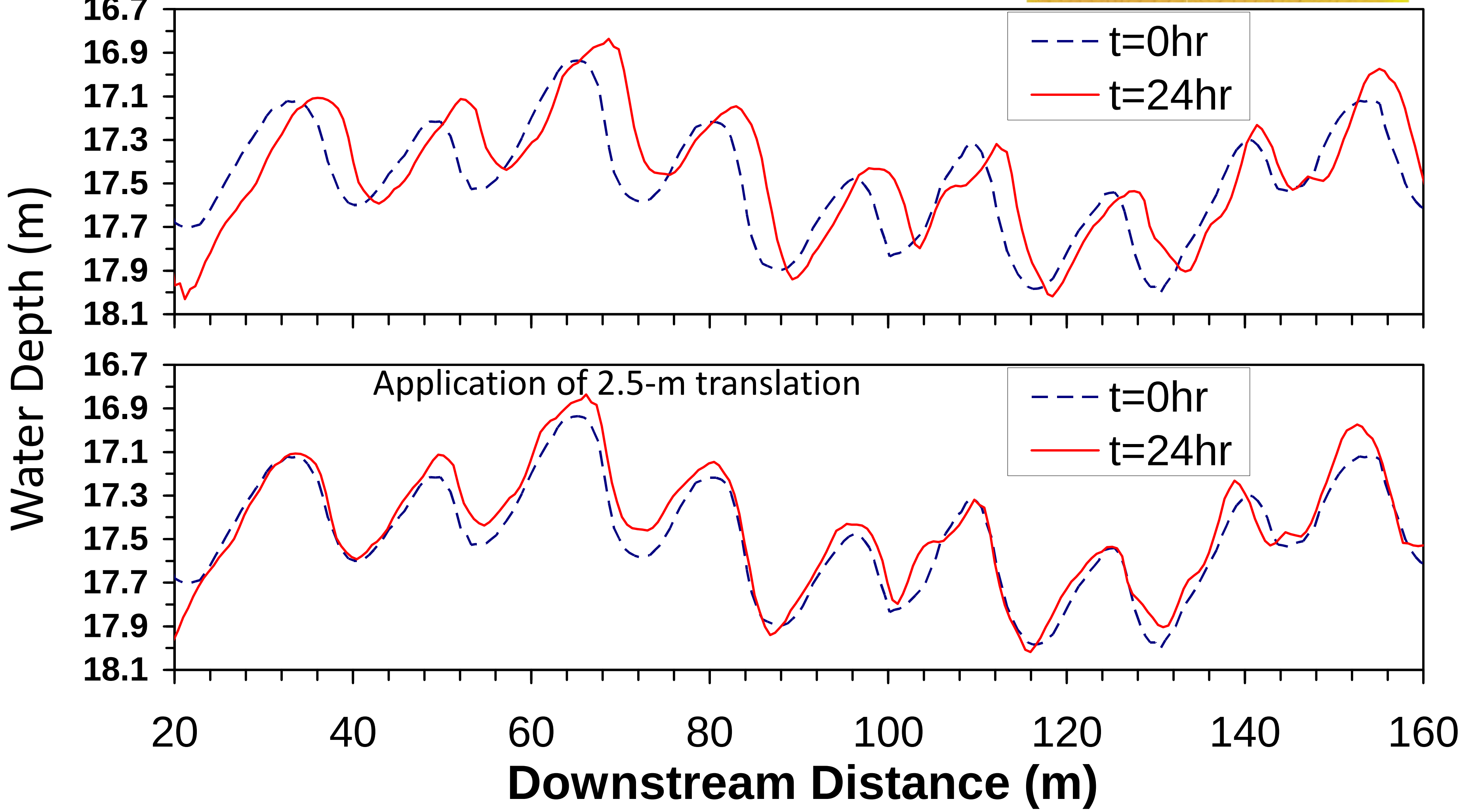




$$q_s = \varepsilon_b C \frac{\langle H \rangle}{2} \cong 0.7\left(\frac{8m}{8hr}\right)\left(\frac{4.1m}{2}\right) = 1.4\,m^2/hr \qquad 1.4\,m^2/hr \times 700m = 1005\,m^3/hr$$

Estimating Bed-Material Load from Dune Tracking

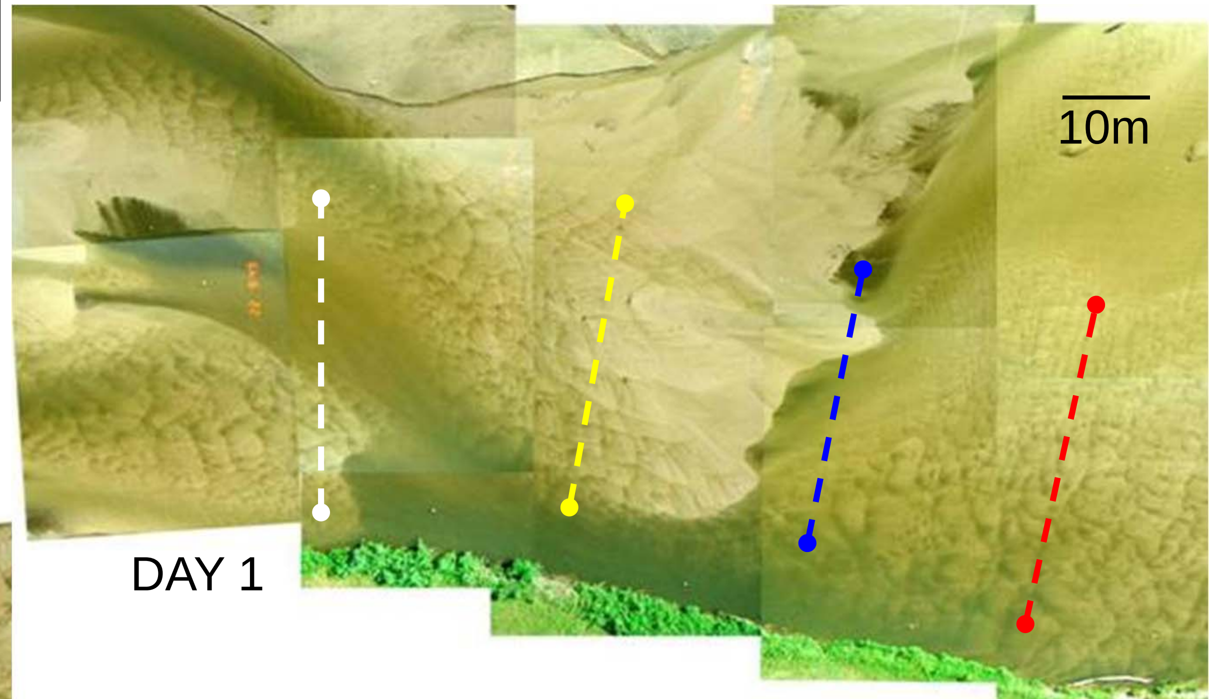
Low water discharge: 6000 m³/s

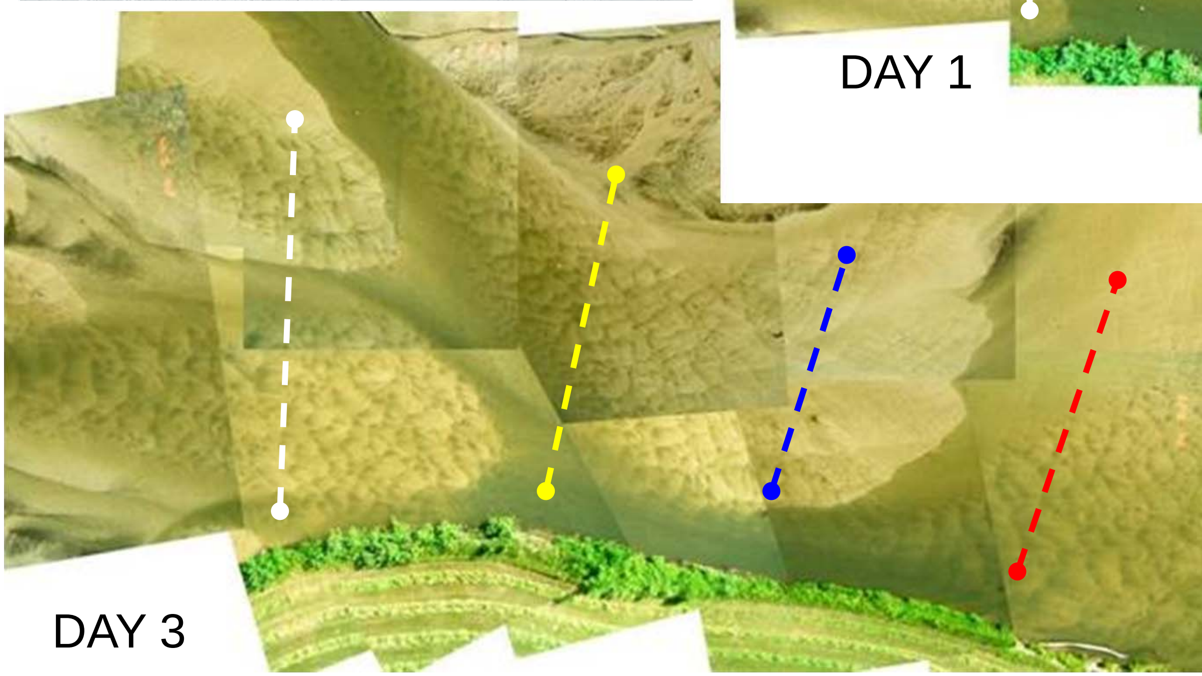


$$q_s = \varepsilon_b C \frac{\langle H \rangle}{2} \cong 0.7 \left(\frac{2.5m}{24hr} \right) \left(\frac{0.47m}{2} \right) = 1.7 \times 10^{-2} \, m^2 / hr$$

$$1.7 \times 10^{-2} \, m^2 / hr \times 700m = 12 \, m^3 / hr$$

Bed-material Discharge (m^3/hr)	Water Discharge (m^3/s) ***N. Loup R.***
8.8	8





Dashed lines connect the same points in each mosaic.

Dunes move ~2.5m/hr
Bars move ~10m/day.

(Mohrig & Smith, 1996)

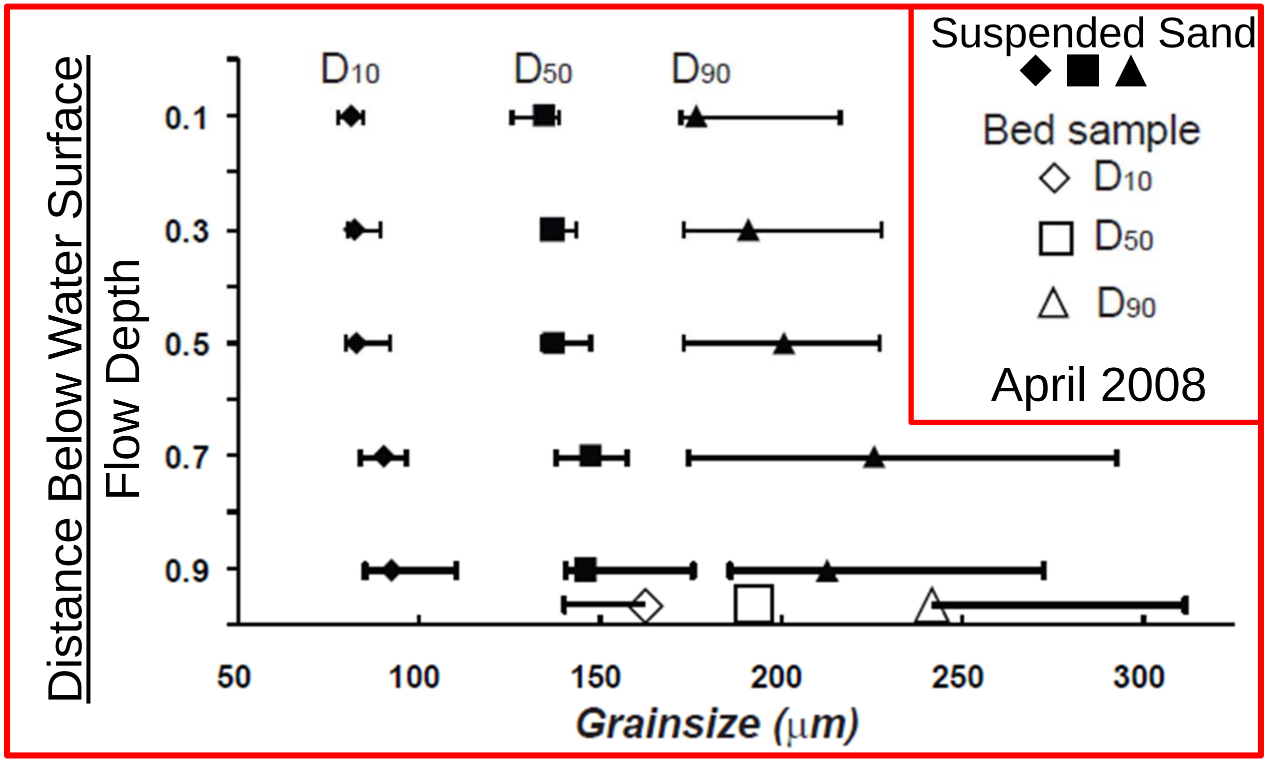
Punctuated transport of sand through the lower river, RK 40

During 2008 flood:
~40 % of sand transport as bed-material load, ~60 % measured in suspension

At low flow all sand transport as bed-material load

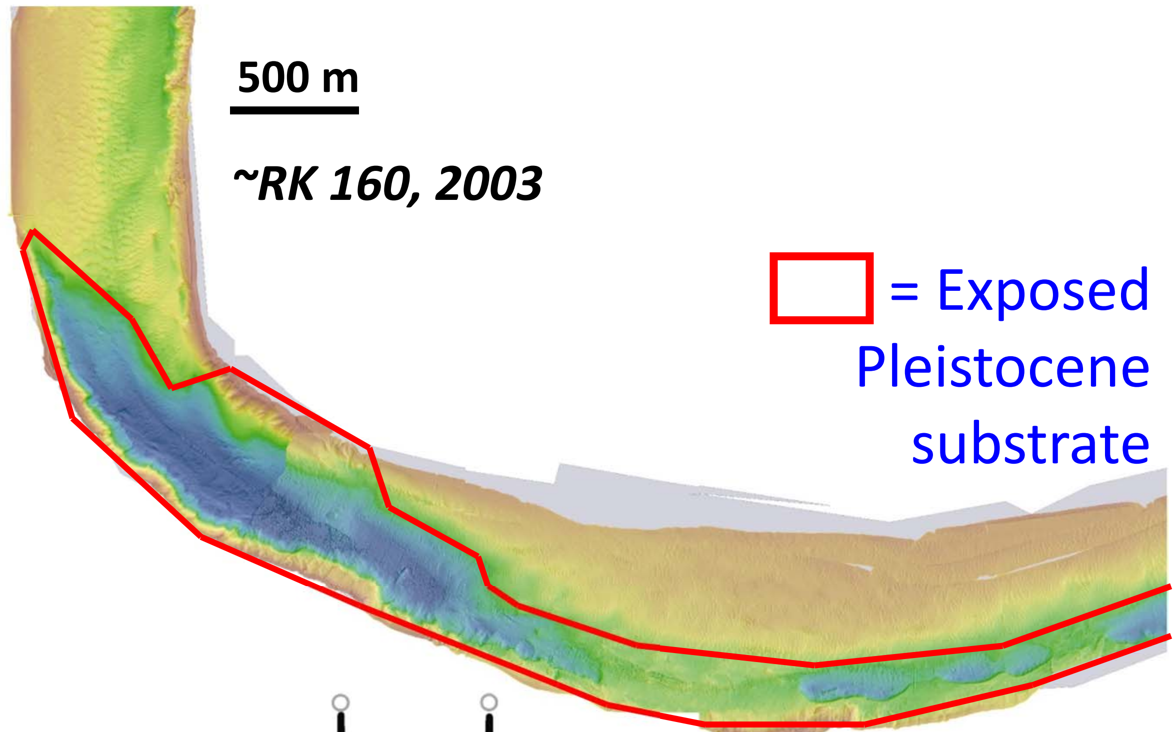
Essentially all of the sand delivery to river mouth happens during floods

Empire Reach (RK40)	Water Discharge (m^3/s)	Sand Discharge (m^3/hr)
April 2008	41,000	3960
January 2008	10,000	32.4

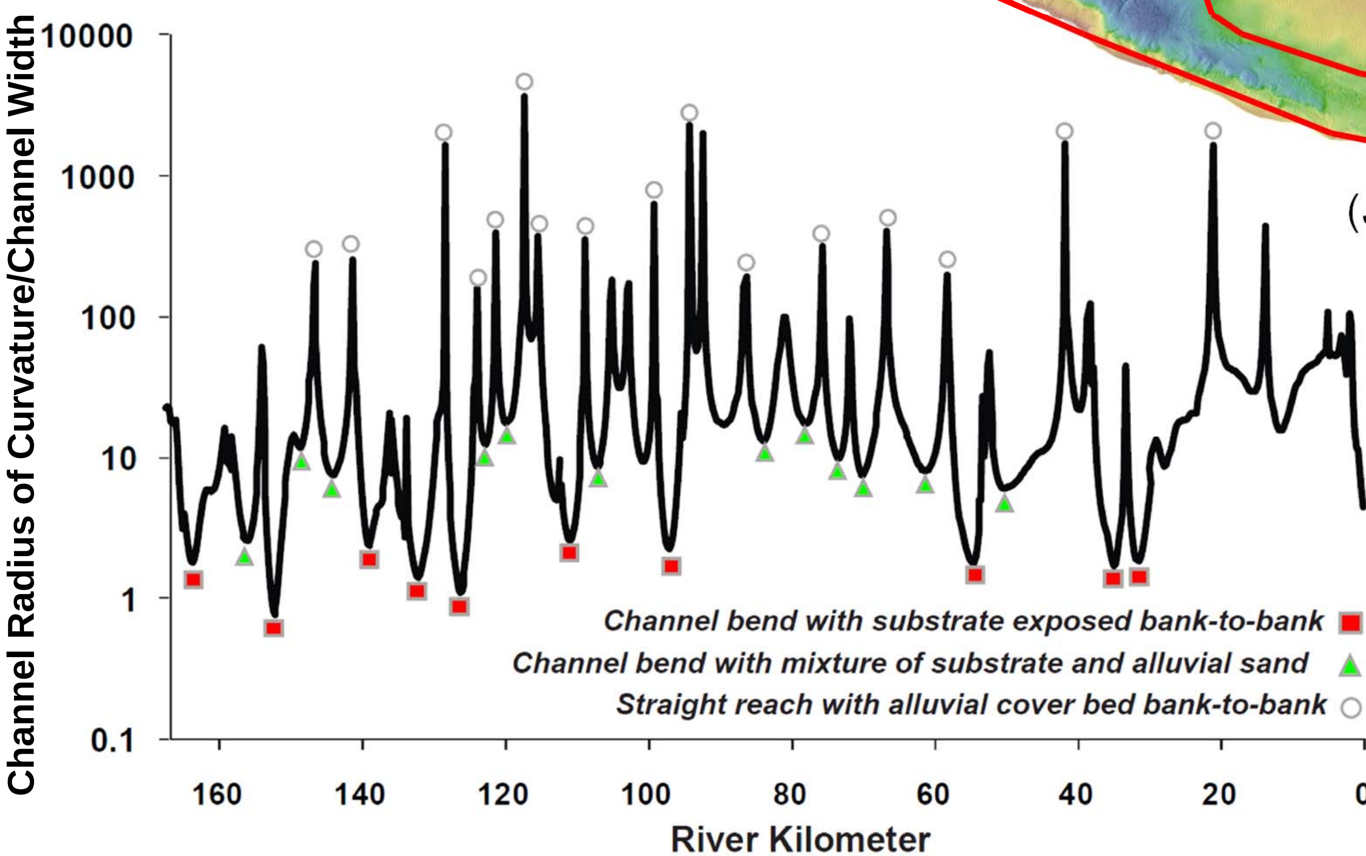


(J.Nittrouer, 2010)

Punctuated Sand Transport and Minimal Storage in Lower Mississippi River: Mixed Bedrock-Alluvial Channel

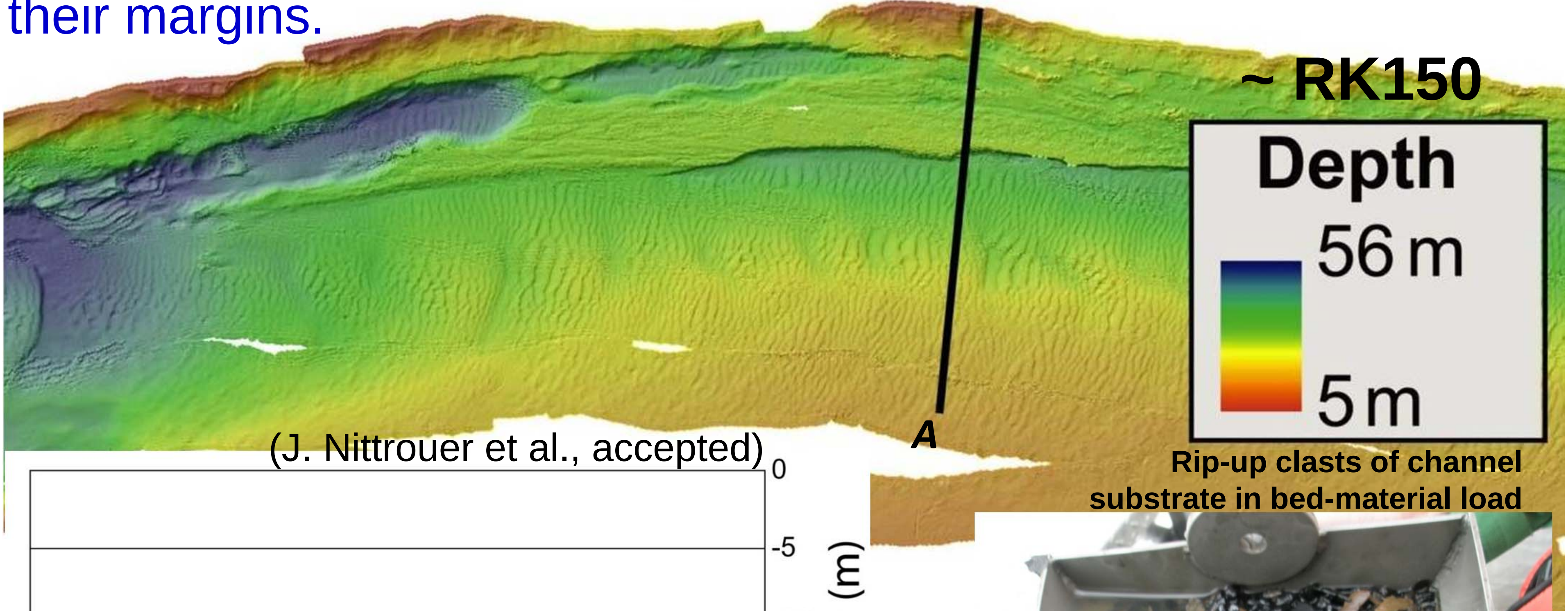


(J. Nittrouer et al., accepted)

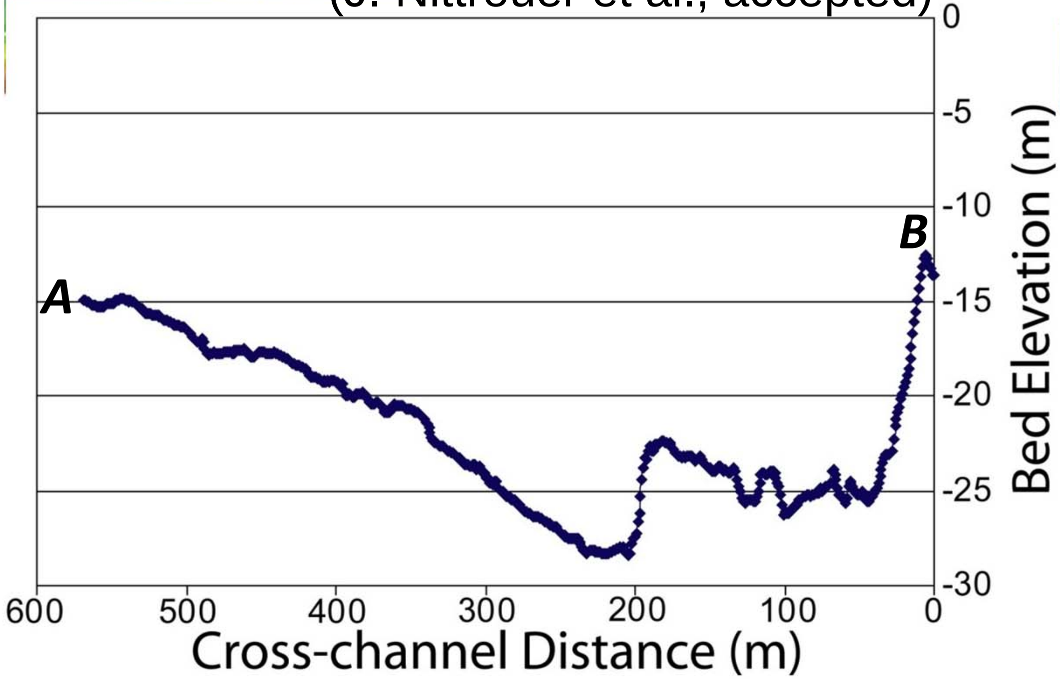


Visit J. Nittrouer poster, T-12, to view the spatial accelerations during flood that minimize alluvial cover of river bed.

Punctuated sand transport drives growth of Mississippi River delta & others in GOM by channels that erode their beds & aggrade their margins.

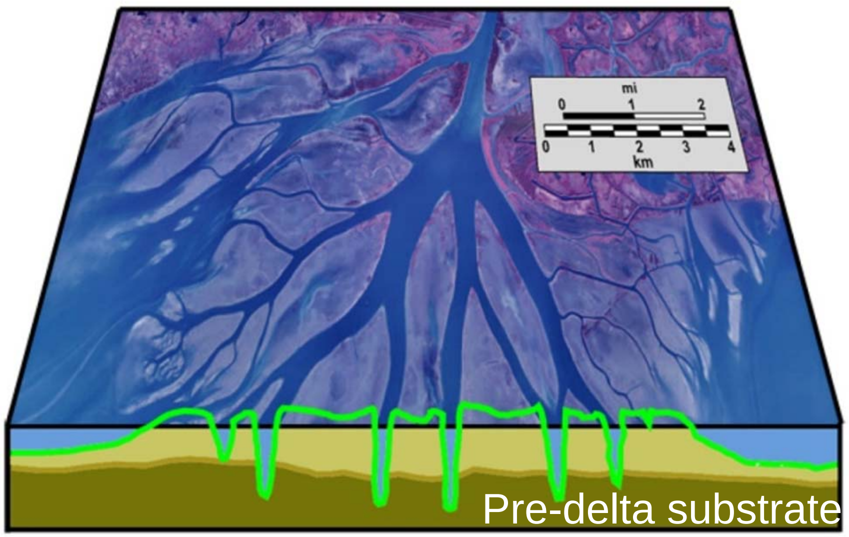


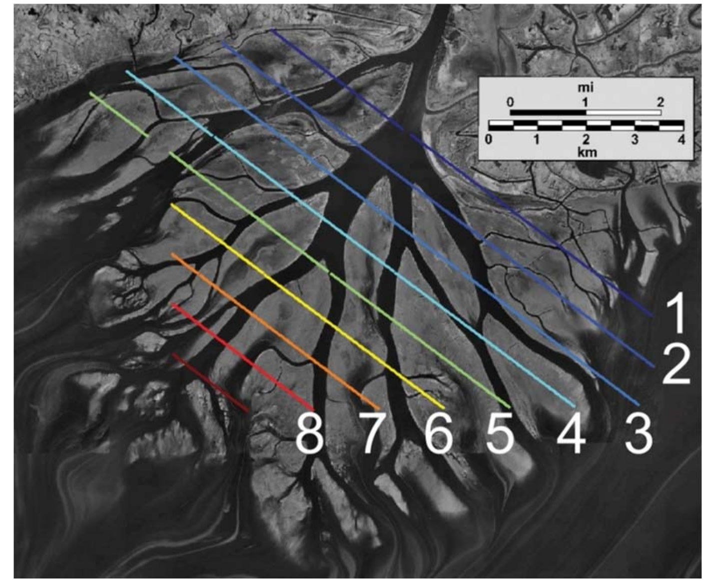
(J. Nittrouer et al., accepted)

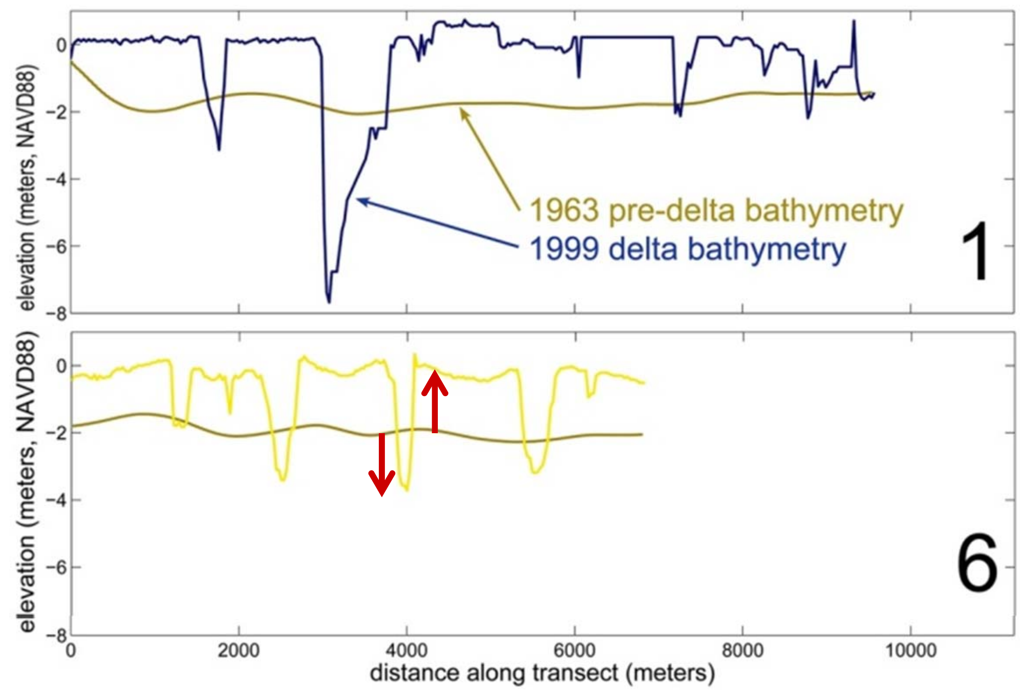


Rip-up clasts of channel substrate in bed-material load

Growth of Wax Lake Delta, Louisiana, by channels that erode their beds and aggrade their margins.





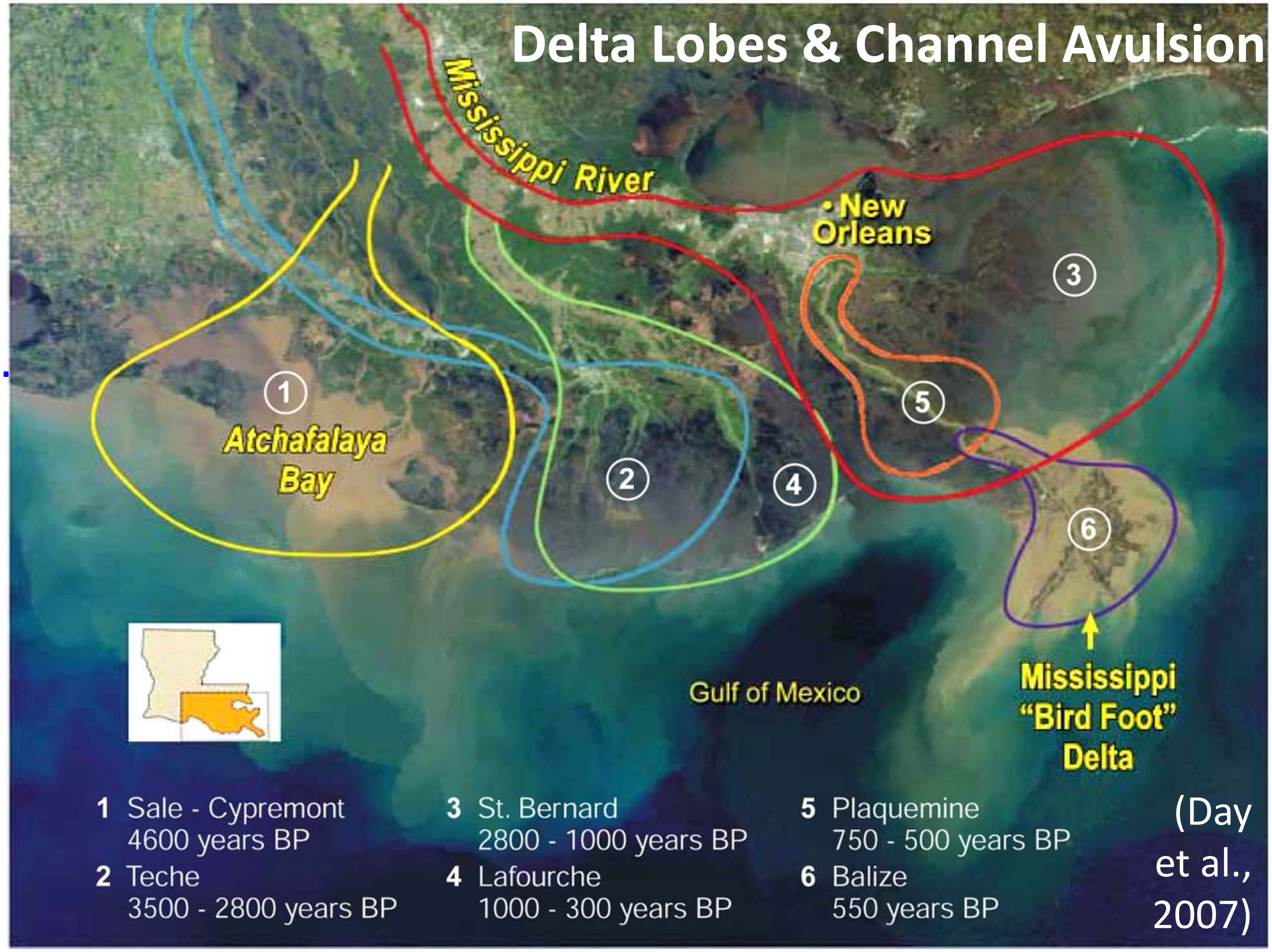


Visit J. Shaw poster, T-14, on Tuesday.

Moving from evaluation of *Topographic Source-to-Sink System* to *Geologic Source-to-Sink System*: Extraction of sediment tied to net subsidence of delta surface.

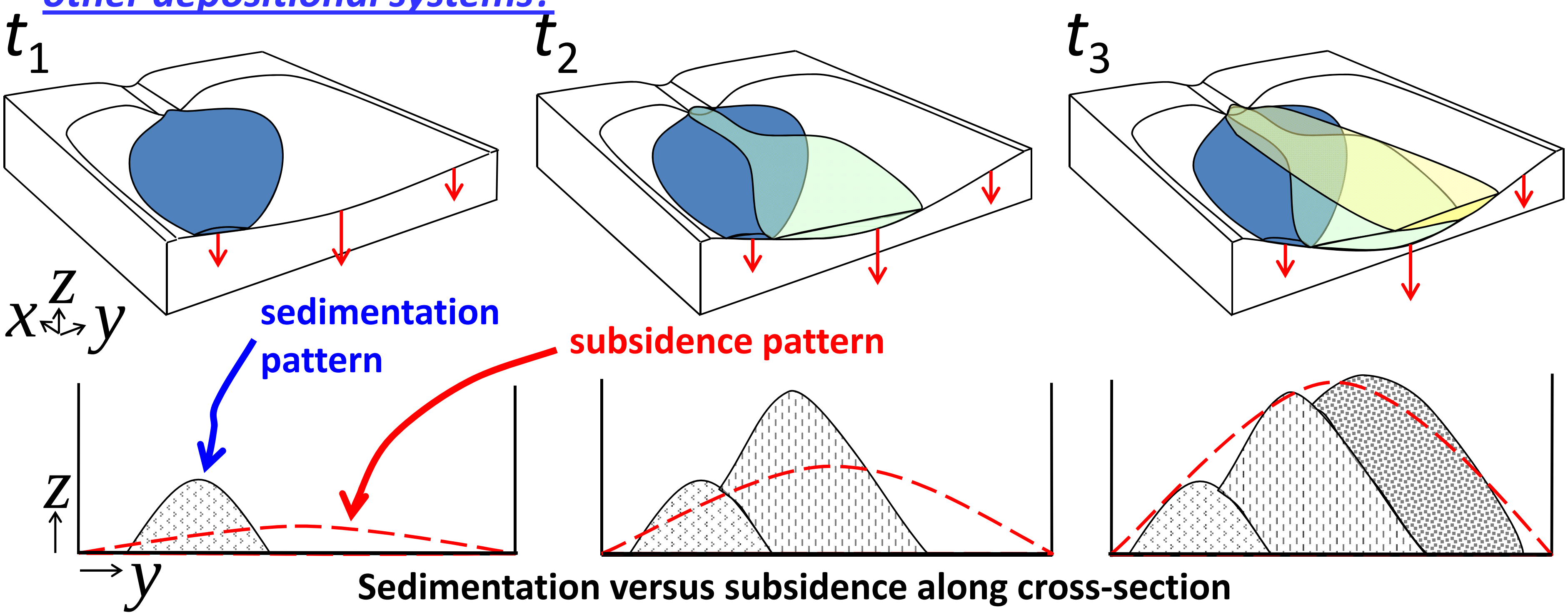
Dynamic delta top is constructed via sedimentation tied to "active" channels.

Subsurface preserves sufficient number of delta lobes and channels to constrain space-time-rate distributions of delta-building elements.



Visit A. Petter poster, T-31, & K. Straub poster, T-27, on Tuesday.

To what degree is delta lobe sedimentation distinct from depositional patterns of other depositional systems?



Sedimentation versus subsidence along cross-section

The transport system must rearrange itself in order to fill space produced by subsidence. (*following method of Sheets et al, 2002; Lyons, 2004; Straub et al, 2009*)

Fit between sedimentation and subsidence patterns can be measured by standard deviation in the following ratio…..

$$\sigma_{ss}(T) = \left(\int_A \left[\frac{r(T;\ x,\ y)}{\hat{r}(x,\ y)} - 1 \right]^2 dA \right)^{1/2}$$

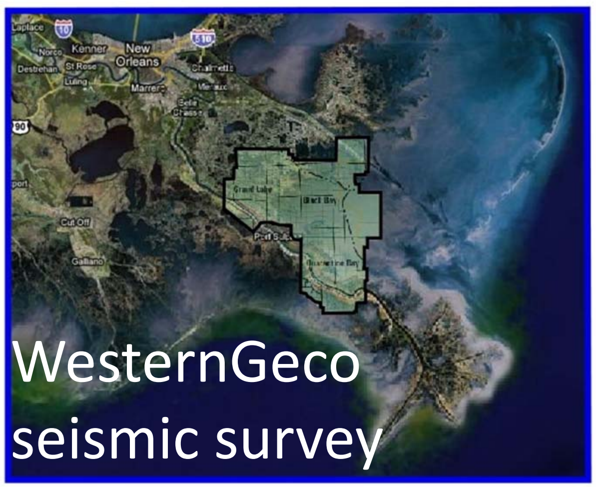
$r(T;x,y) =$ Sedimentation rate at a point for given time increment

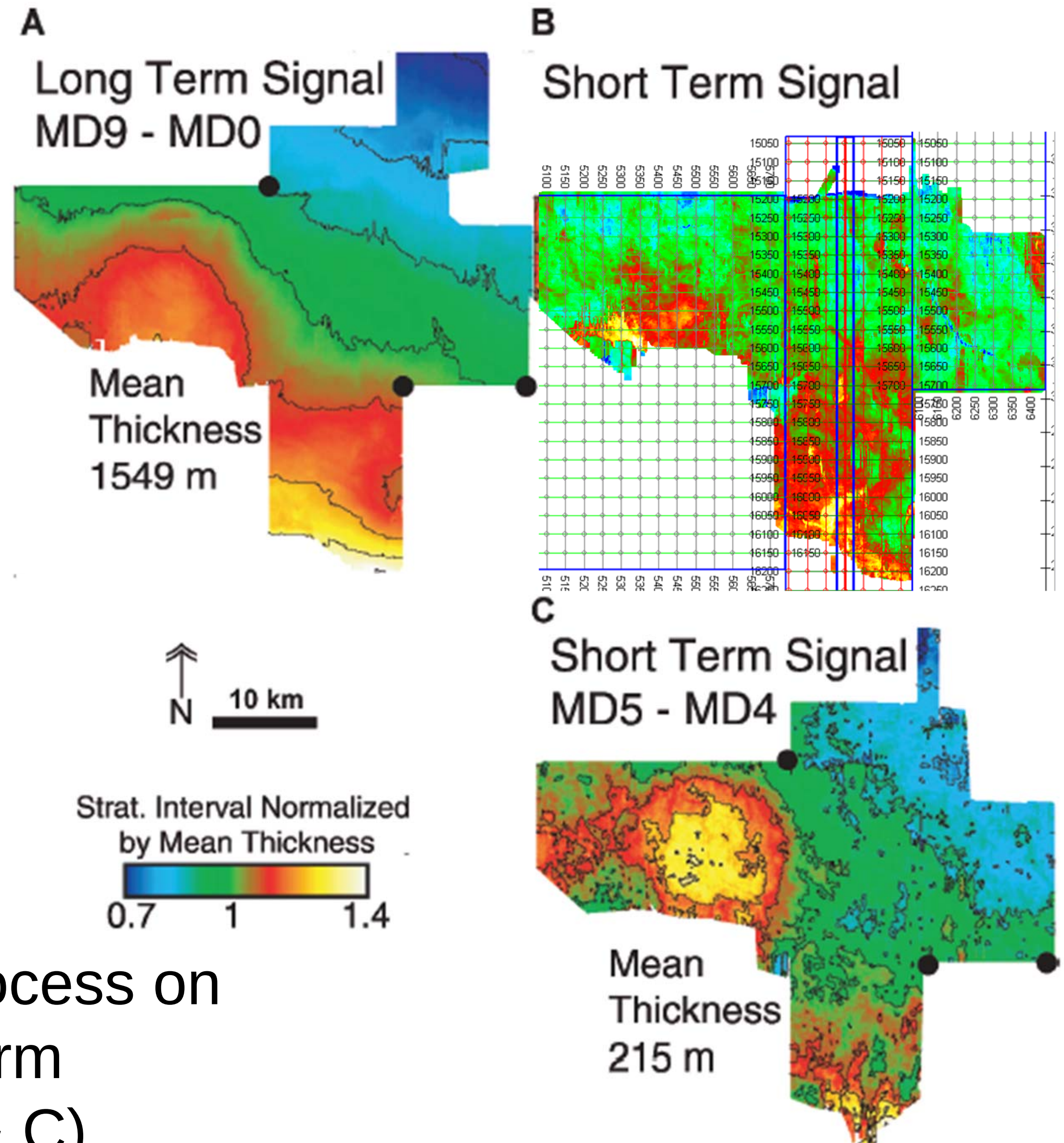
$\hat{r}(x,y) =$ Long-term sedimentation rate at that same point

x, y = horizontal coordinates; A = area

Seismic Volume & Well Data Provide Best Possible Resolution of:

1) Spatially Varying Subsidence Field
2) Long-term Subsidence Rates
3) Arrangement of Channel-Fills

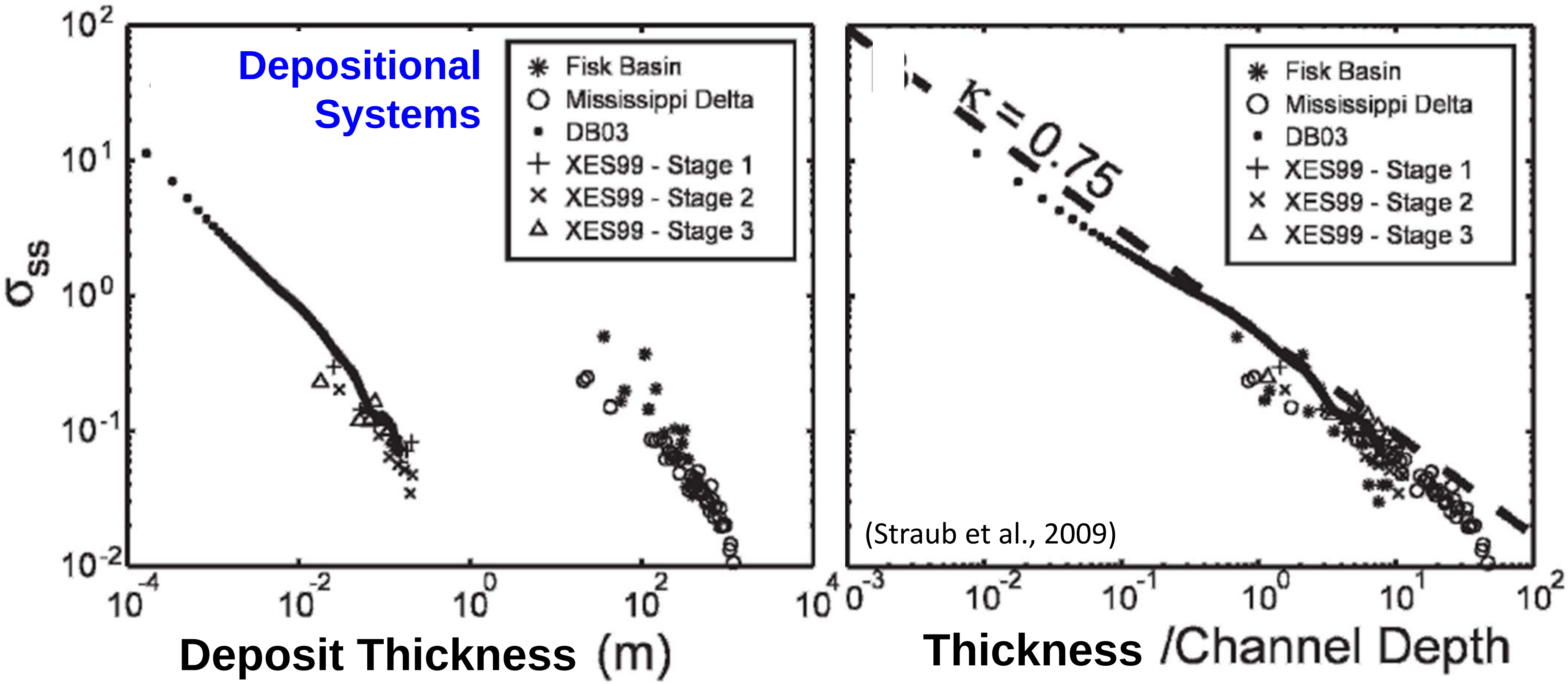




Quantifying depositional process on delta by comparing short-term sedimentation patterns (B & C) against long-term pattern (A).

(Straub et al., 2009)

Depositional stacking patterns for Mississippi Delta and other sedimentary environments



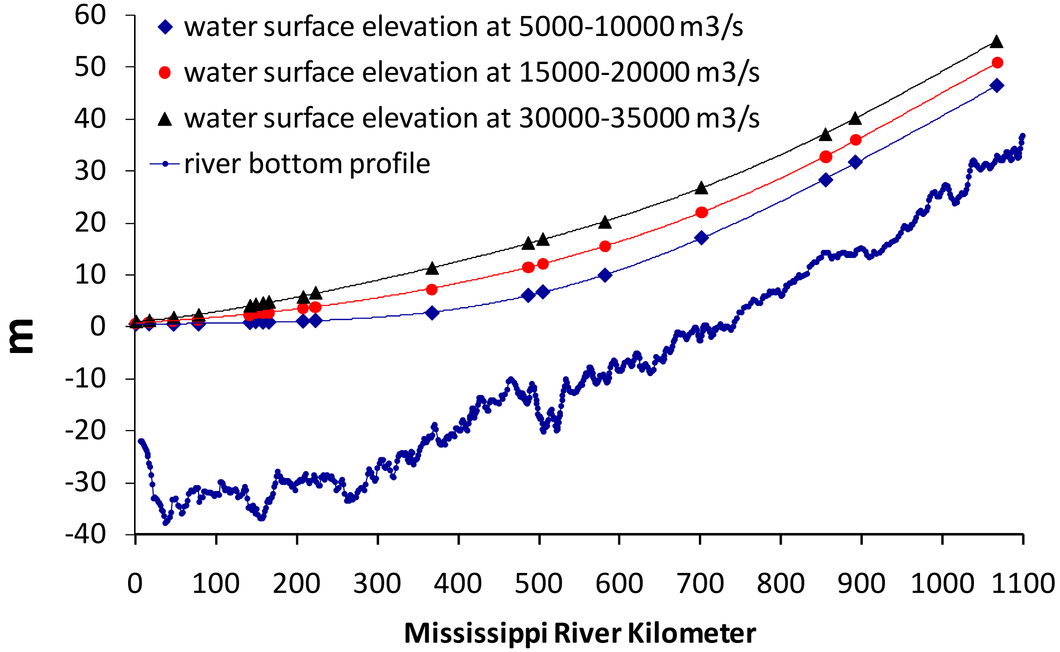
Decay in the standard deviation of sedimentation/subsidence collapses onto a single power-law trend when the measurement window is standardized by the mean channel depth of each system.

$$\sigma_{ss} = 0.33\left(\frac{deposit\ thickness}{channel\ depth}\right)^{-0.75}$$

Visit K. Straub poster, T-27.

Final Points on Modern Delta System (Topographic source-to-sink):

1. Transport in the MRD cannot be accurately predicted without proper treatment of the river plume and marine boundary condition.
2. Spatial changes in cross-sectional area of transporting flows drive sediment-transport patterns that cannot be accurately characterized using water discharge or contributing area.



Final Points on Geologic Delta System (Mass extraction Source-to-sink):

3. Power-law collapse in deposit-stacking data suggests that a stacking behavior ~midway between purely random & prefect compensation in a good starting point for any channelized depositional system.

J. Nittrouer poster, **T-12**, M.Lamb poster, **T-28**, & K. Straub poster, **T27**.