

Sedimentation Patterns and Transport Pathways Linking River Mouth to Remote Depocenters in the Ganges-Brahmaputra Delta, Bangladesh*

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Abstract

The combined Ganges-Brahmaputra Rivers in Bangladesh (GB) deliver more than 750 million metric tons of sediment annually to the world ocean through a highly energetic coastal zone, where sediments are reworked daily by tides, winds, waves, and annually by seasonal monsoons and cyclones. Sediment delivery to the coast has kept pace with sea level rise since the early Holocene, allowing subaerial growth of the delta. However, the abandoned lower delta is disconnected from any major tributary source of sediments, and therefore relies on sediment delivery from the ocean side via tides, cyclones, and summer monsoons. The dispersal and transport mechanisms of these sediments beyond the river mouth have been only partially quantified. To further refine our understanding of the spatial and temporal distribution of sediment delivery to the lower delta, sediment traps were widely distributed across the abandoned delta just prior to the 2008 monsoon season, and recovered following cessation of floodwaters. Sediments recovered during the flood season were analyzed by gamma spectroscopy to determine whether they were fluvial- or marine-sourced. An innovative approach using short-lived radioisotopes as environmental tracers (⁷Be and ²³⁴Th) was used to differentiate between sediments instantaneously delivered to the abandoned GB lower delta plain during the flood pulse and those reworked onto tidal islands by dry-season tides and waves. Initial results indicate much higher annual accretion rates than previously thought and differing delivery pathways between the traditionally named “active” and “abandoned” portions of the delta. These results and other recent studies are changing the way we view the exchange of sediment across the terrestrial-marine boundary by introducing major alongshore and onshore components of river-sediment dispersal.

Reference

Kuehl, S.A., T.M. Hariu, and W.S. Moore, 1989, Shelf sedimentation off the Ganges-Brahmaputra river system: Evidence for sediment bypassing to the Bengal fan: *Geology*, v. 17/12, p. 1132-1135, doi: 10.1130/0091-7613(1989)017.

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Organization

I. System

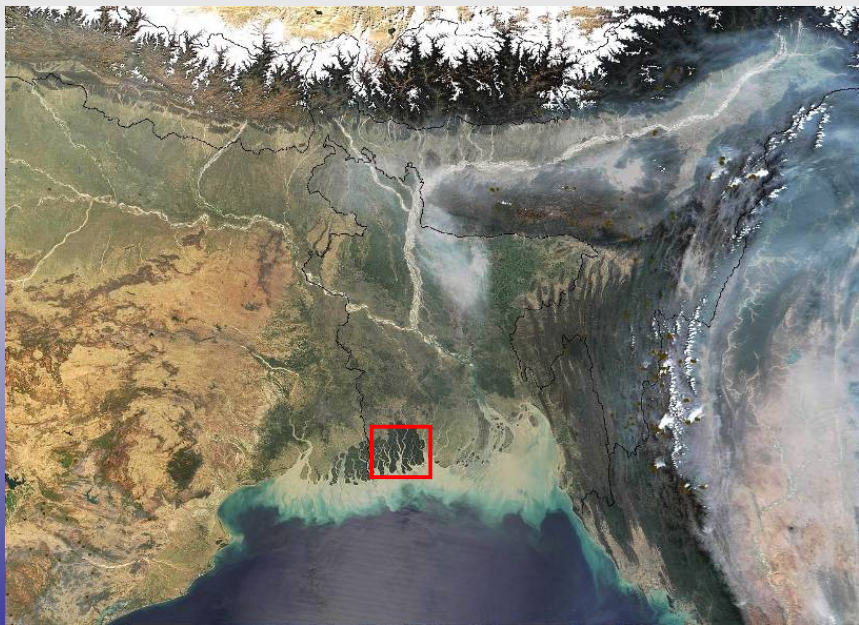
*II. Transport
processes*

*III. Strategy &
Techniques*

IV. Results

V. Conclusions

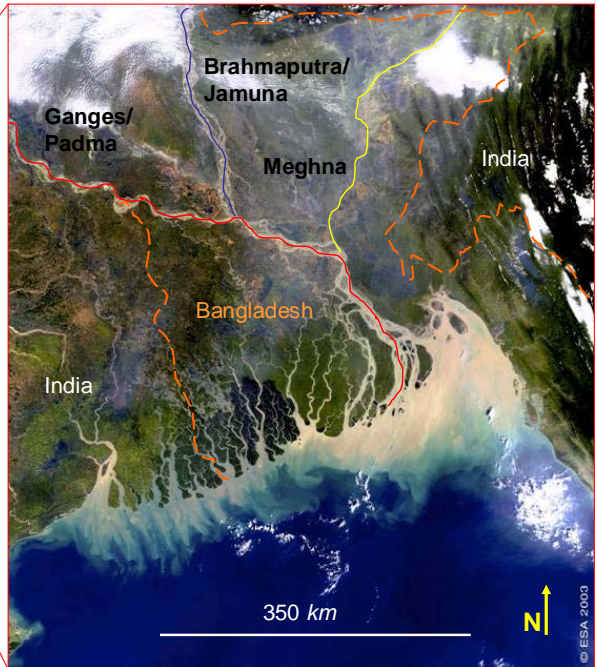


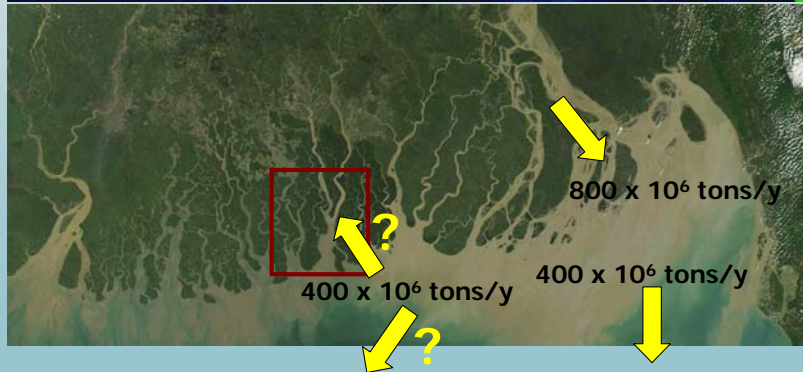
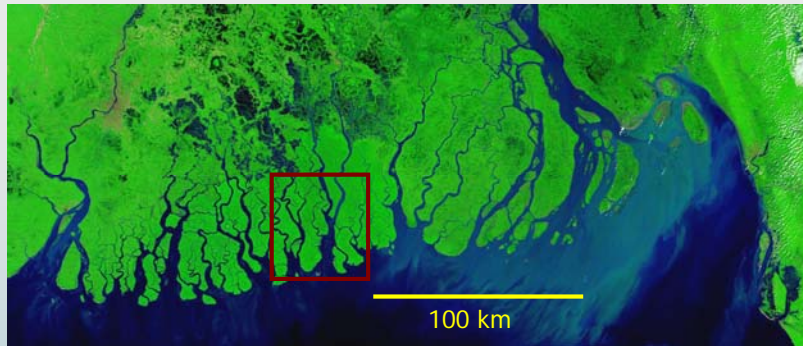


Ganges-Brahmaputra Delta System

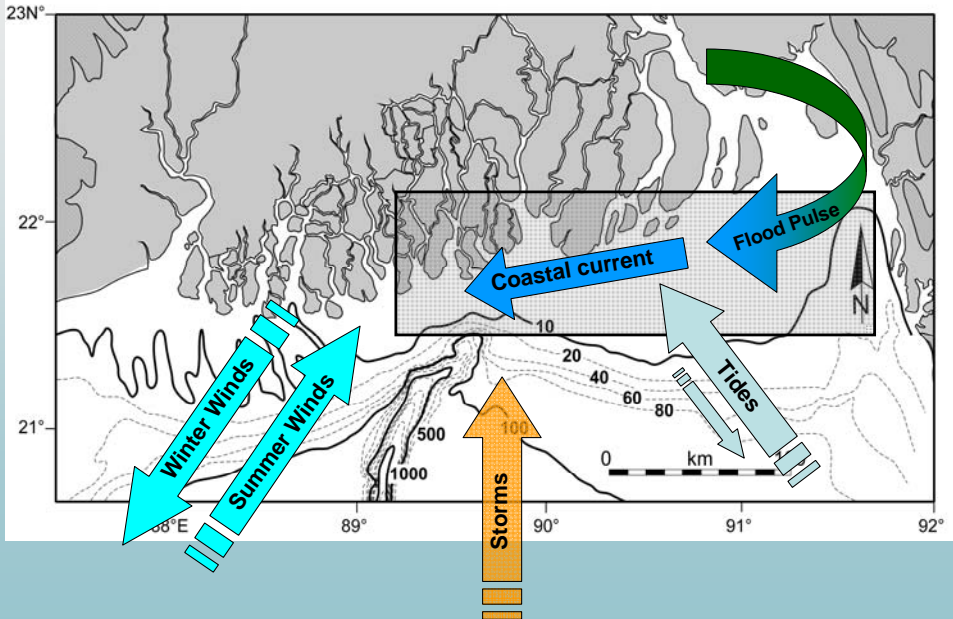
Depositional setting:

1. **Bengal Basin:** largest depositional feature by volume (*Knebl et al. 1989*)
2. **2nd Largest combined sediment discharge:**
 $Q_{s\ wet} \sim 992 \times 10^6 \text{ tons/y}$
(vs. $Q_{s\ dry} \sim 93 \times 10^6 \text{ tons/y}$);
Amazon: $\sim 1150 \times 10^6 \text{ tons/y}$
Mississippi: $\sim 250 \times 10^6 \text{ tons/y}$
3. **Fine-grained:**
60% silts and clays
(50% of Q_s is bedload)
4. **Abandoned lower delta plain:**
siltation of Ganges offtakes =
no landward sediment source





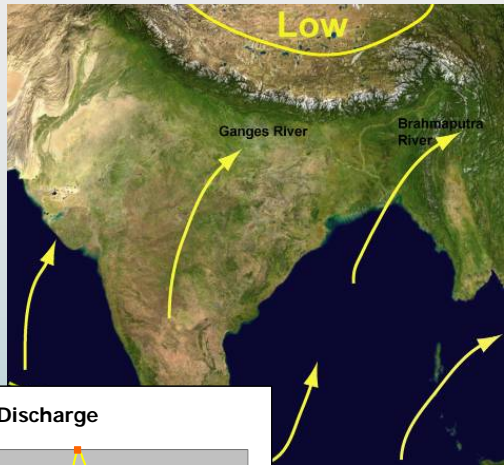
"Black Box": co-mingling of fluvial and marine processes



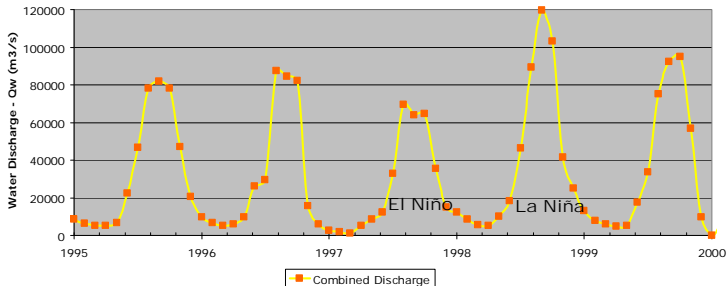
Southwest Asian Monsoon

River Discharge:

80% of water and 95% of sediment discharged during SW monsoon



Ganges-Brahmaputra River Discharge

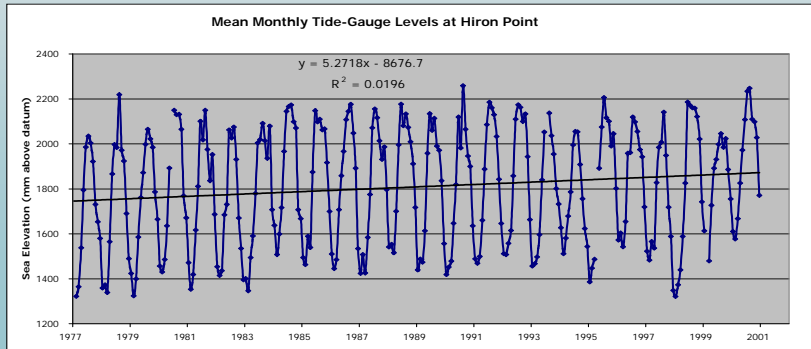


Monsoon set up and relative sea level rise

Sea Level:

~0.5 cm/yr relative SLR

(Additional 80 cm setup from onshore monsoon winds)

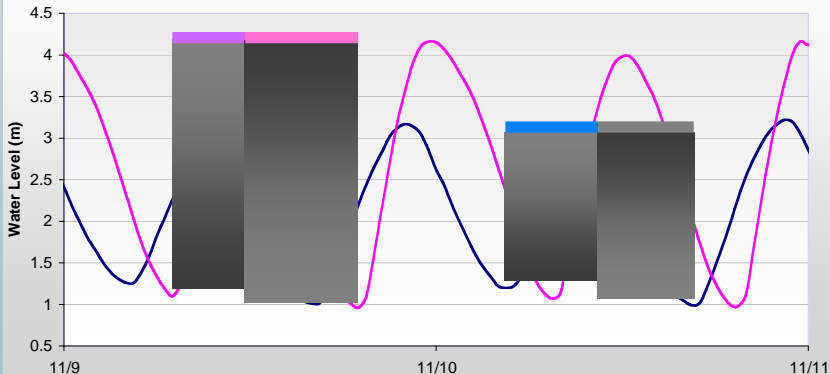


Significant tide deformation within deltaplain channels ...

- ~ 2 hour phase delay
- ~ 1 m amplification of flooding tide
- ~ 2 hour flood-dominant asymmetry

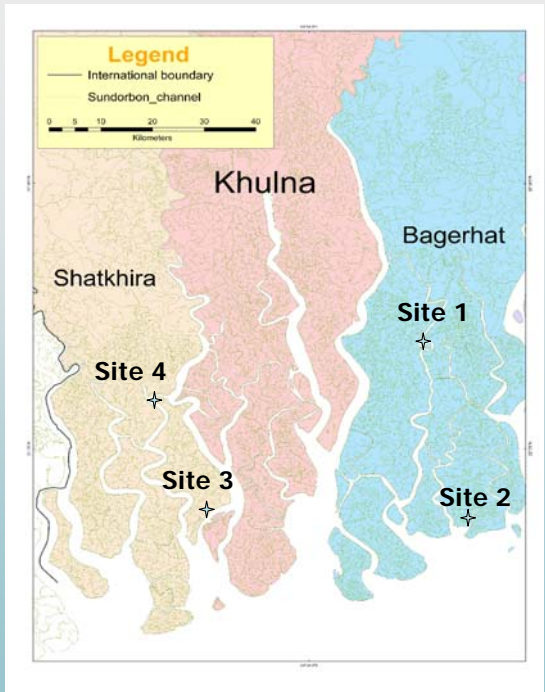


Tidal Fluctuations at Hiron Point and Mongla in Nov 2007



Sampling strategy: spatial

- Direct measurements: sediment traps
- 2 coastal sites (E & W); 2 ~80km inland sites (E & W)
- 3 transects x 4 stations; up to 500m from creek bank
- Variety of stream orders



Sampling strategy: temporal

- Monsoon season deployment
- Gamma Spectroscopy
- ^7Be measurements
- Cosmogenic radioisotope ($t_{1/2} = 53.3$ days)
- Particle reactive; preferentially sorbs to fine-grained sediment
- Tracer of terrestrially sourced flood-pulse sediments



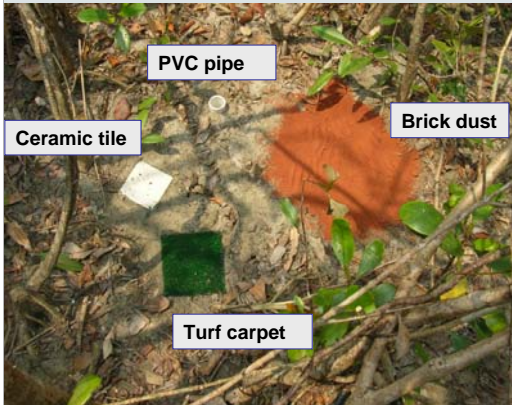
Direct Measurements: lower delta plain

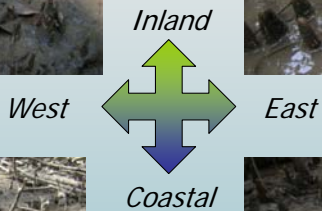


Accretion associated with seasonal flood pulse

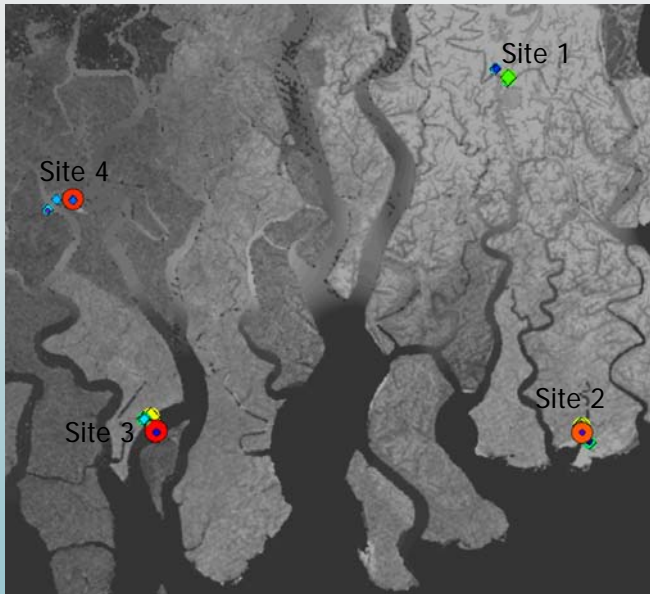
March 2008: pre-monsoon

Oct 2008: post-monsoon

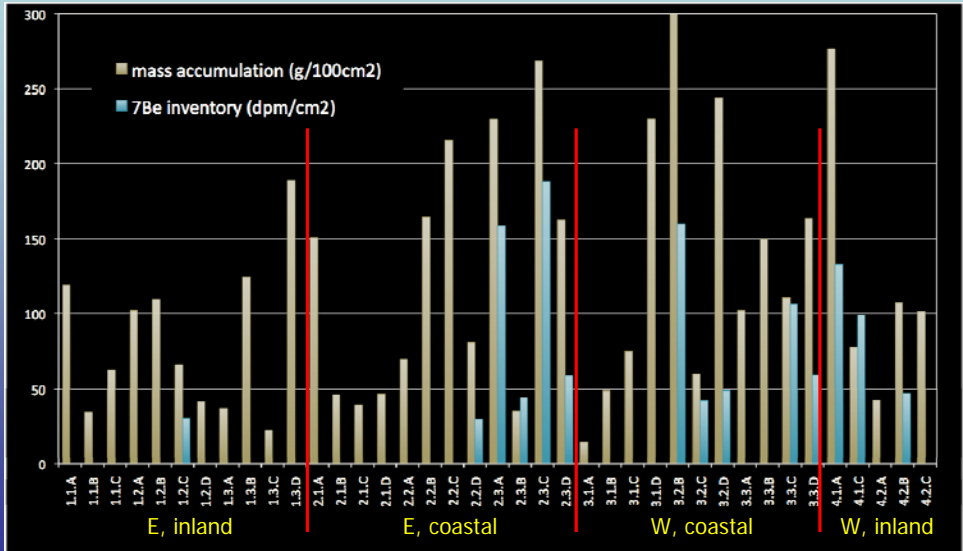




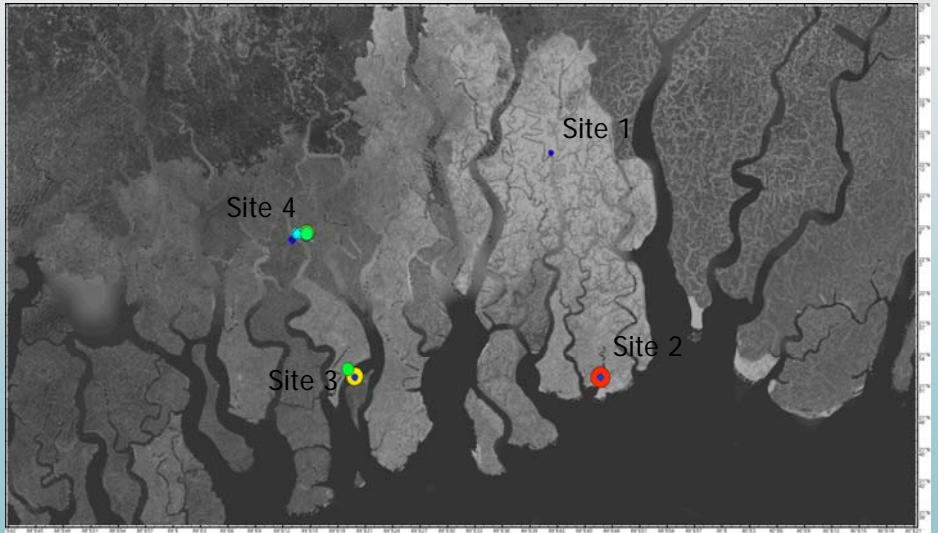
Mass Flux (g/cm^2)



- ~1 cm/yr average accretion rate
- ~1/3 of sediments derived from seasonal plume dispersal

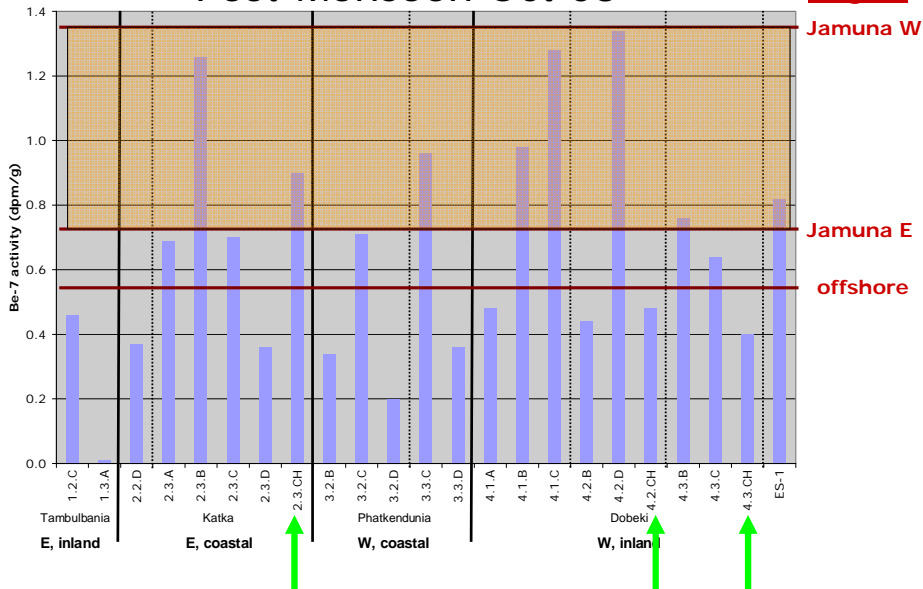


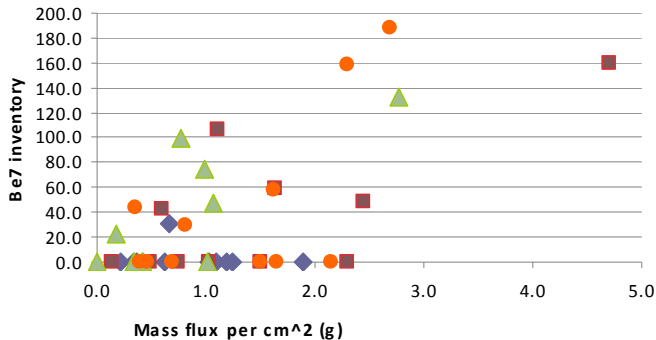
^7Be inventory



Post-Monsoon Oct 08

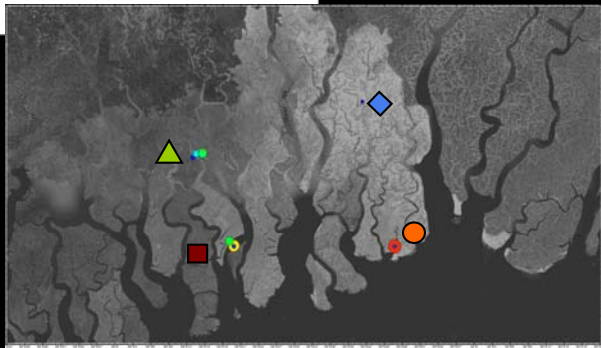
Aug 06





~ 1/3 sediments
from flood pulse
...remaining 2/3
diluted w/older
material?

- ◆ East-Inland
- East-Coastal
- ▲ West-Inland
- West-Coastal



Conclusions

Rapid accretion of $\sim 1\text{cm/yr}$:

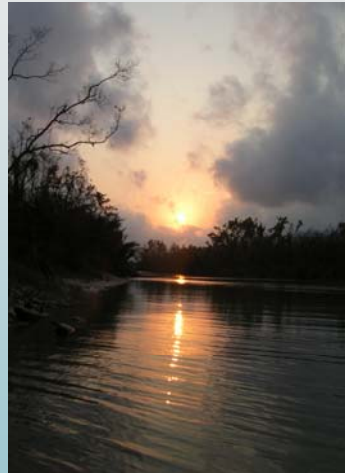
- **double** SLR of $\sim 5\text{mm/yr}$
- accounts for $\sim 10\%$ of discharge, or $\sim 100 \times 10^6$ tons of sediment

Accretion is tightly coupled with flood pulse

- emphasizes importance of 80cm monsoon setup
- flood-dominant tidal asymmetry

Accreted material may be a mixture of “fresh” flood pulse + reworked “older” material, ala temporary depocenter

Local patterns are variable, but track according to overbank, etc.



A close-up photograph of a sandy beach. The sand is light-colored and textured with numerous small, dark specks. Several large, dark, wet-looking paw prints are visible, particularly in the center and lower right. The word "Questions?" is overlaid in black text on the right side of the image.

Questions?