# Migration characteristics and mechanism of the gravel-sand transition in the Yangtze River since 1975

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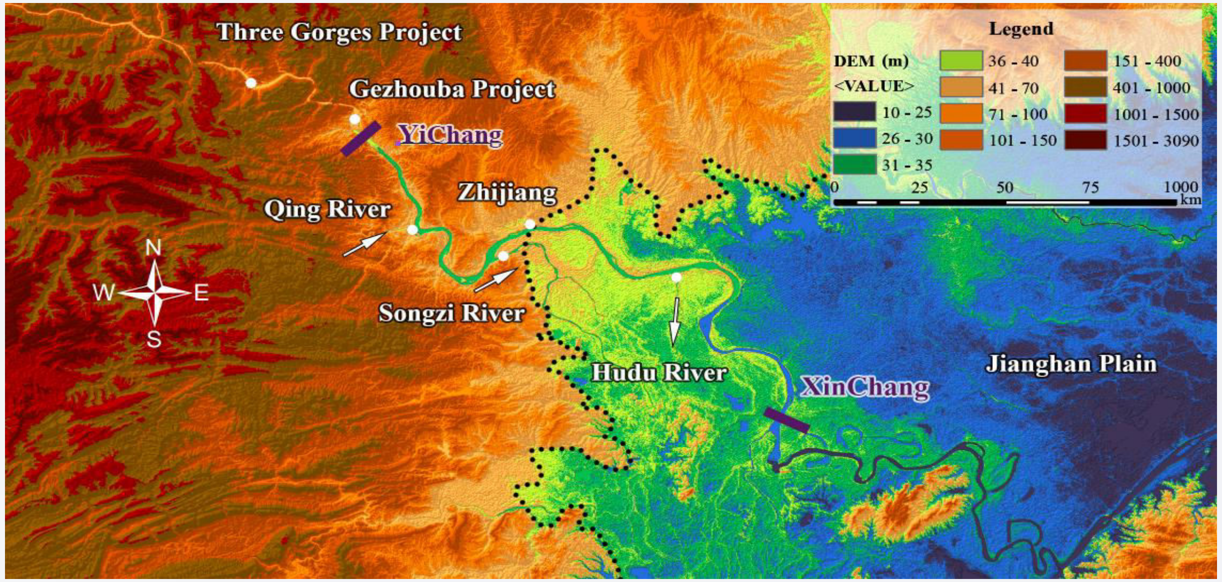
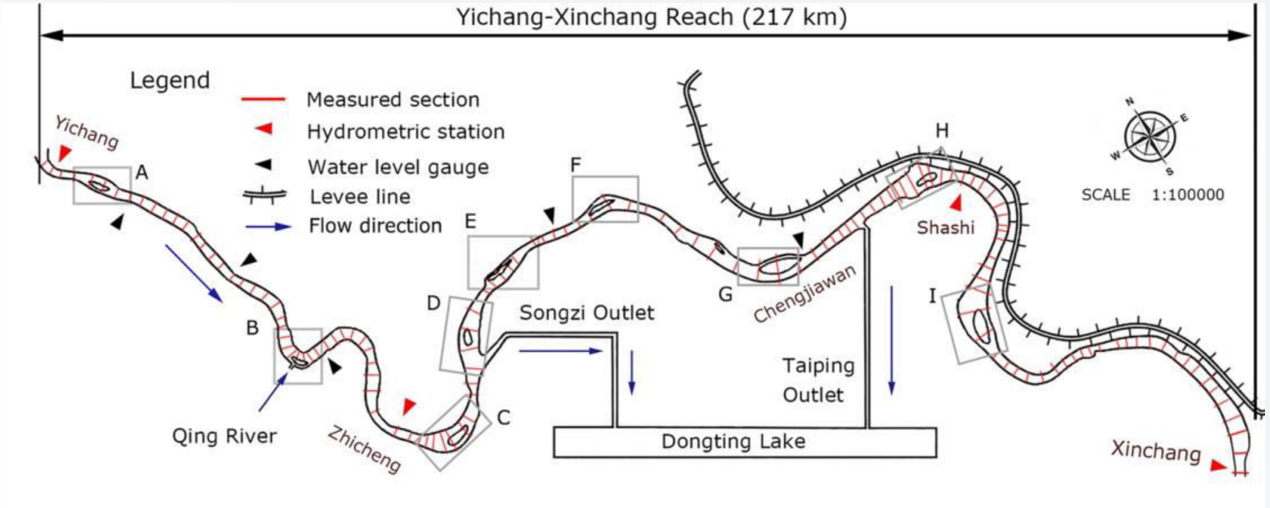
# 1. Background

## ◆ The gravel-sand transition (GST)




- **Gravel-sand transitions (GSTs)** connecting gravel channels and sand channels occur in **various environments and channel scales**.
- **Morphological changes** observed across GSTs **vary with** worldwide large rivers because of environmental setting differences and anthropogenic modifications.
- **The Yichang-Xinchang** reach (YXR; **KM0~217**) within the middle reaches of the Yangtze River as an **archetypical example** of GST in a large and anthropogenically modified system.

# 1. Background

## ◆ Characteristic of the Yangtze GST

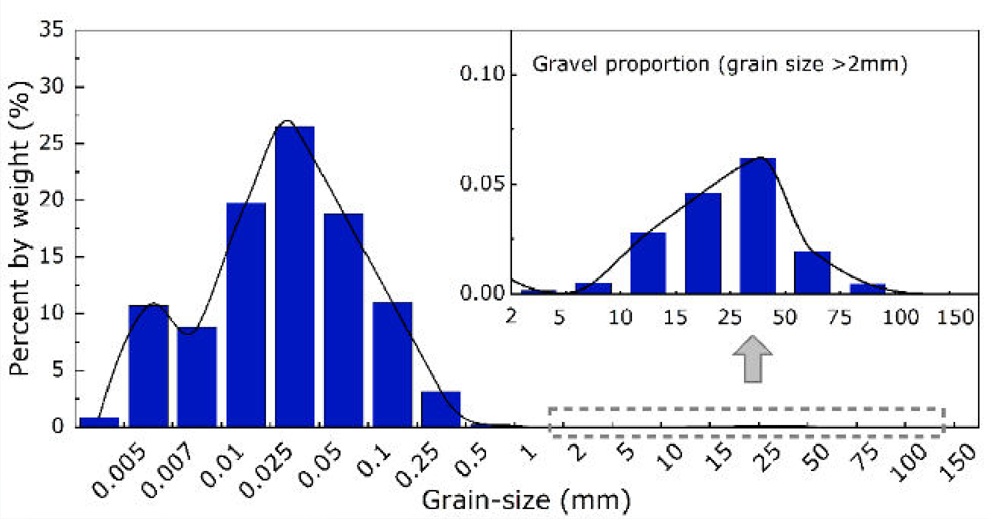
- The sediment provided from upstream comprised **mostly of fine sand**. ⇨ **Modulated by sand transport**

- A variable width ranging from **0.5-4 km**. ⇨ **Large River**

- some bars widely distributed and **two major distributaries** diverting the water to Dongting Lake. (Songzi and Taiping) ⇨ **Complex Morphology**

- The resistant lithology and channelization measures such as the Jingjiang Great Levees. ⇨ **Limited lateral channel migration**

- Frequent interference by human activities. ⇨ **Anthropogenically modified**



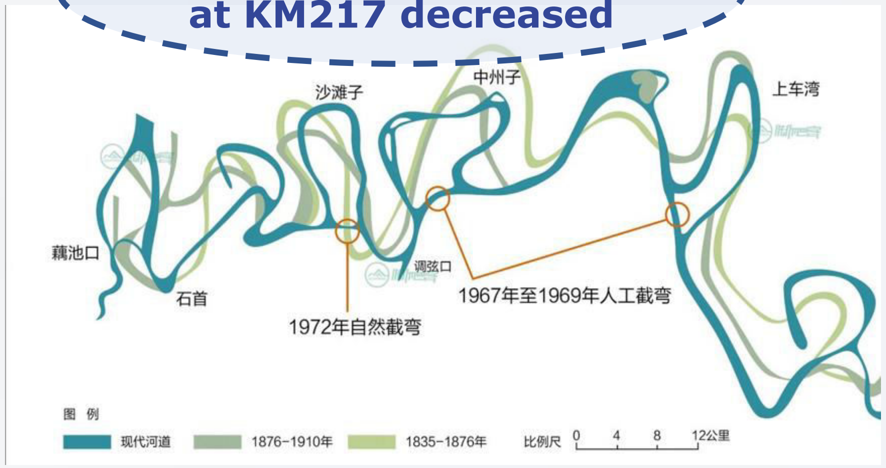

**Grain size distribution of the upstream sediment supply**

**Resistant lithology (Yidu reach)**

**The Jingjiang Great Levees**

# 1. Background

The outlet base level at KM217 decreased




90% of gravel-sized sediment eliminated

Flow-sediment regime altered

**The Jingjiang Meander Cut-off Project (JMC)**

**The Gezhouba Dam (GZB)**

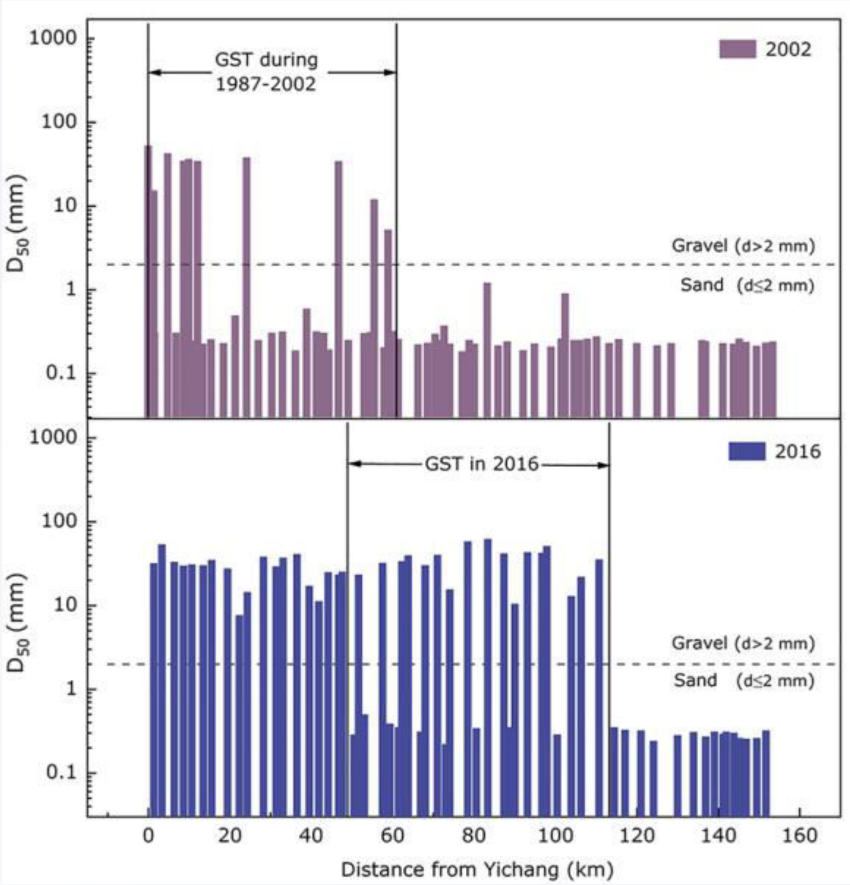
**The Three Gorges Dam (TGD)**

**How does the Yangtze GST adjust in response to human interference, and what controls this adjustment**

# 2. Migration characteristics after damming



## ◆ the Yangtze GST migration




**D50 of successive cross-sections in the downstream direction**


**Bed material samples**

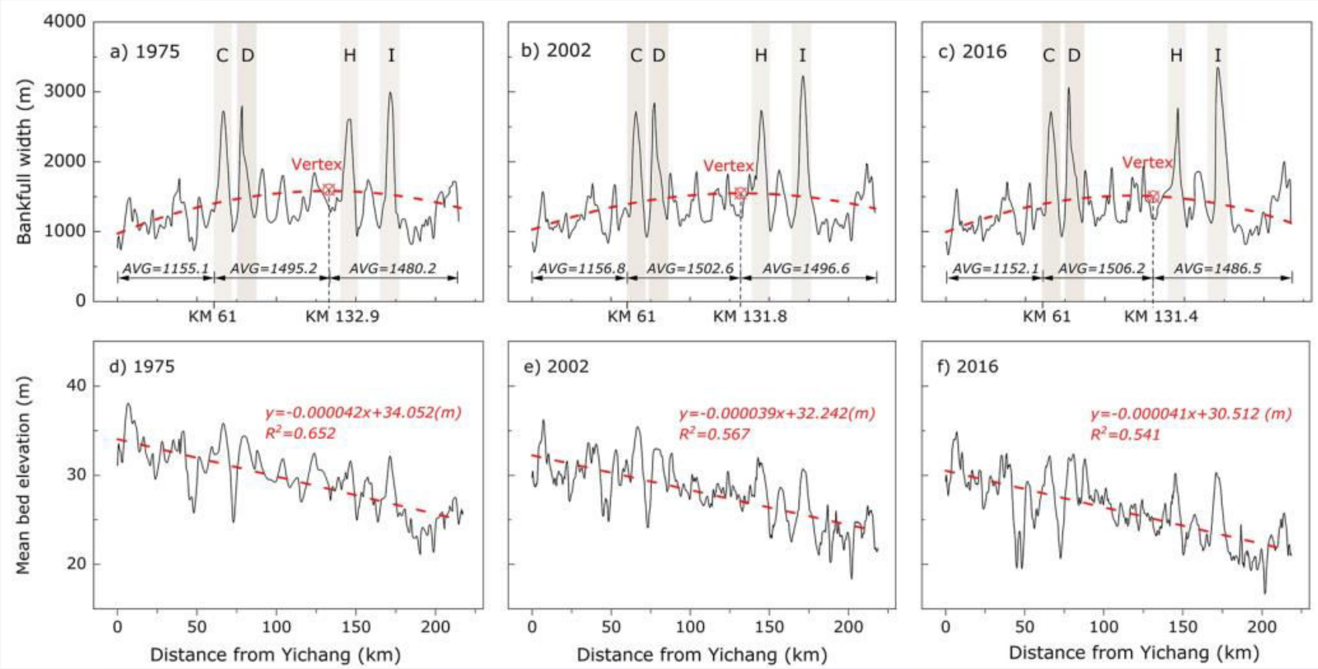
**Identification of the GST Position**

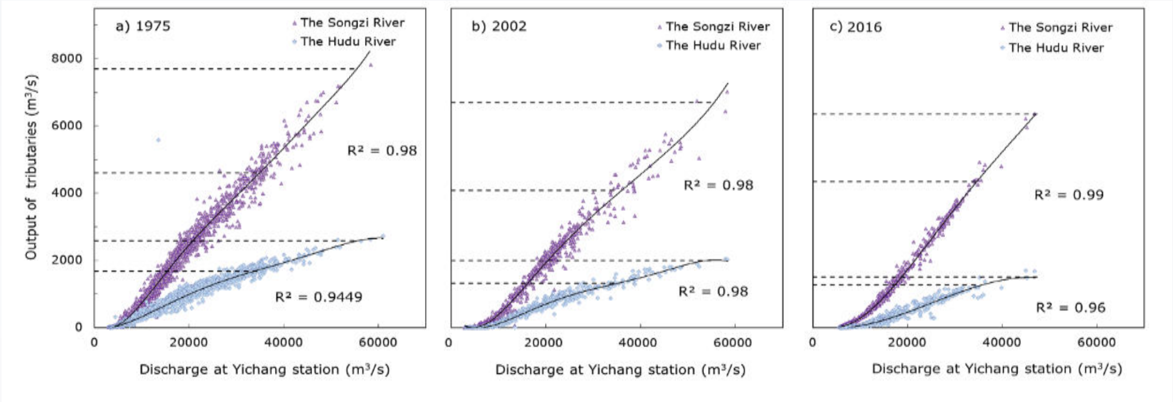
- The surface sand content ➡ **20% ~ 80%**
- **D50** fluctuates between sand and gravel sizes rather than fining monotonically with distance

- The Yangtze River had a non-abrupt GST with a length of **approximately 61 km.**
- The GST location **remained stable** before 2002 but its onset and end migrated **49.5 and 52.2 km** downstream from 2003-2016, respectively.

# 2. Migration characteristics after damming

## ◆ Pattern and adjustments in channel morphology



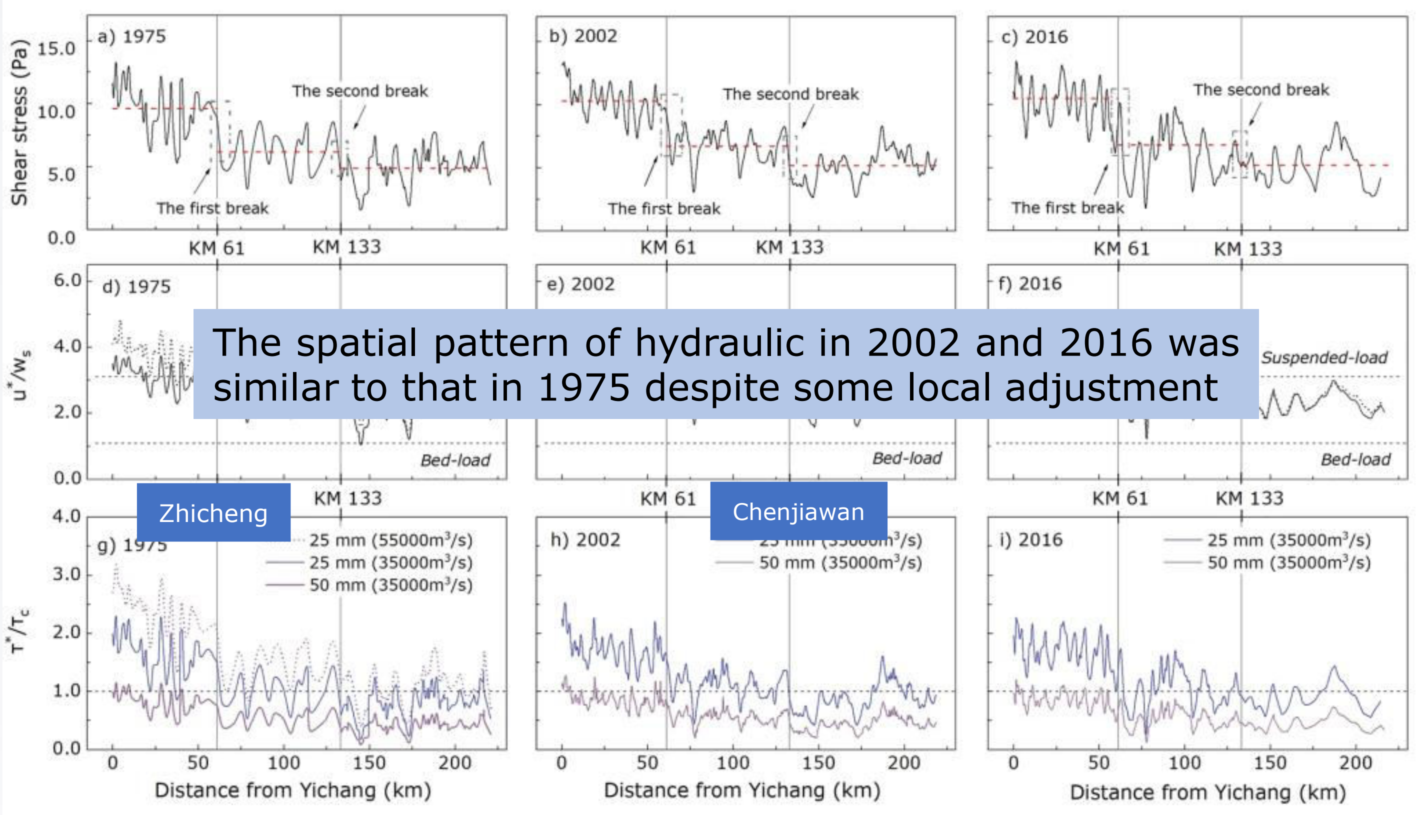

**C, D, H, I show the locations of the bifurcations**

- During the 1975-2016 period, the bankfull width of the YXR remained seemingly stable, exhibited **a parabolic distribution**.
- The bed elevation fluctuated up and down along the YXR, showing **increasing variability** compared to previous surveys.
- the outputs of the Songzi and Taiping outlets decreased by **14.1% and 19.6%** in period 1976-2002, but had no obvious changes in period 2002~2016.

# 2. Migration characteristics after damming



## ◆ Pattern and adjustments in sediment transport




The spatial pattern of hydraulic in 2002 and 2016 was similar to that in 1975 despite some local adjustment

Zhicheng

Chenjiawan

- Only the $u_* / w_s$ ratios within KM 0-61 were close to the threshold value of 3.1, while the $u_* / w_s$ ratios in the remaining regions were predominantly less than 3.1.

① $u_*/w_s$ > **3.1**, predominantly **suspended-load transport**
②**1.1** < $u_*/w_s$ < **3.1**, predominantly **mixed-load transport**
③ $u_*/w_s$ < **1.1**, predominantly **bedload transport**

- The $\tau^*/\tau_c^*$ ratios (D = 50 mm) decreased to less than 1 downstream of KM 61, while those for D = 25 mm were still greater than 1 in some places within KM61-133.

Small gravel continued to **be conveyed downstream** to Chenjiawan (KM 133)

The reach upstream of Zhicheng (KM 61) had **sand transported in suspension**, but the downstream reaches were dominated only by mixed-load transport.

# 3. The factors resulting in GST migration

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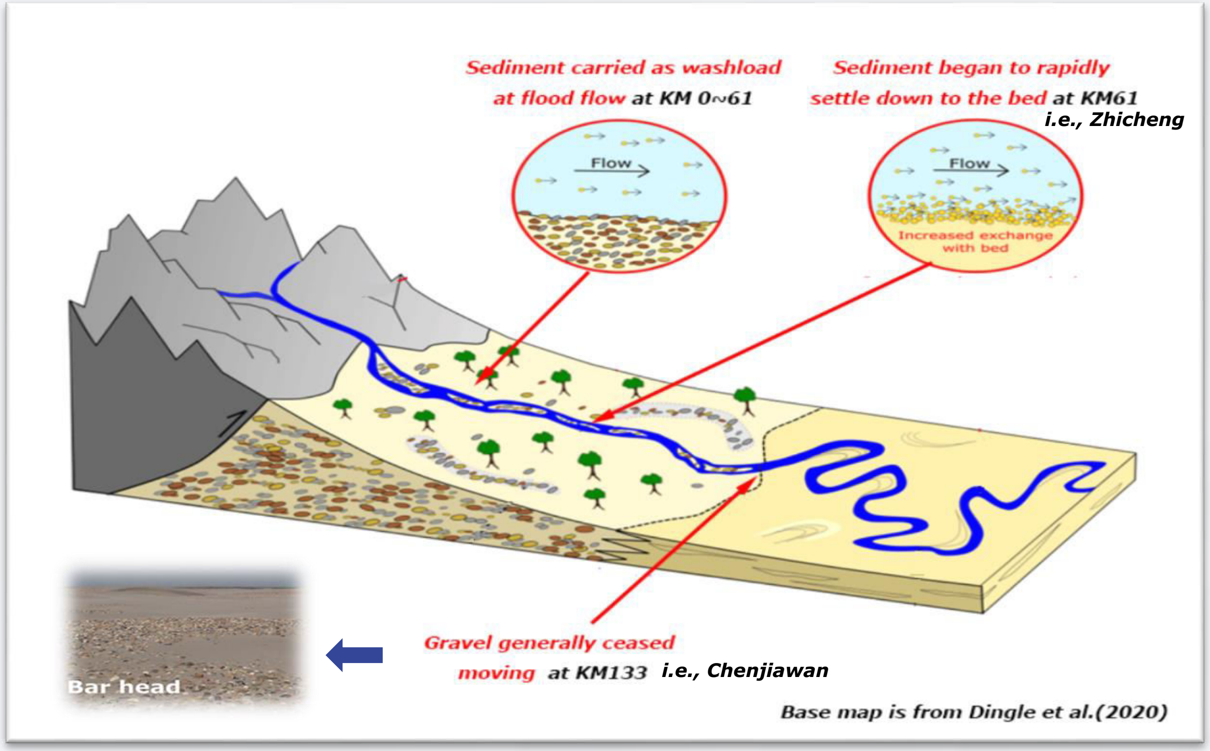
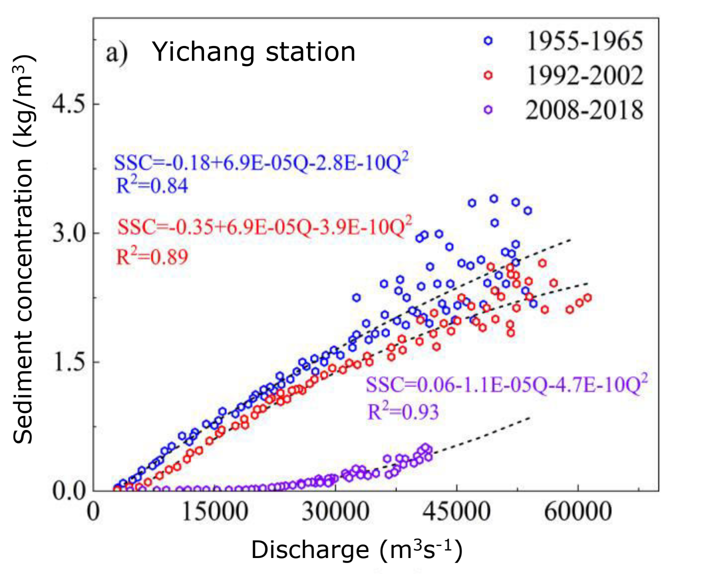
## ◆ Impacts of altered sediment supply

- Patterns of sand and gravel transport : the sand began to rapidly settle down to the bed at Zhicheng, whereas gravel generally ceased moving at Chenjiawan.

The GST position and length depended **on the place where rapid suspension fallout occurred** rather than the place where the load ran out of gravel




Transport capacity of the flows exceeds the incoming suspended load

**Sediment concentration decrease by 90%**

The starved flow upstream KM61 was capable to pick up the finer sand on the bed surface

**$u_*/w_s > 3.1$ at flood flow (KM 0-61)**

The downstream migration of the GST **resulted primarily from** a reduction in the suspended-load supply

Dingle et al.(2020). Sediment dynamics across gravel-sand transitions: implications for river stability and floodplain recycling.

# 3. The factors resulting in GST migration

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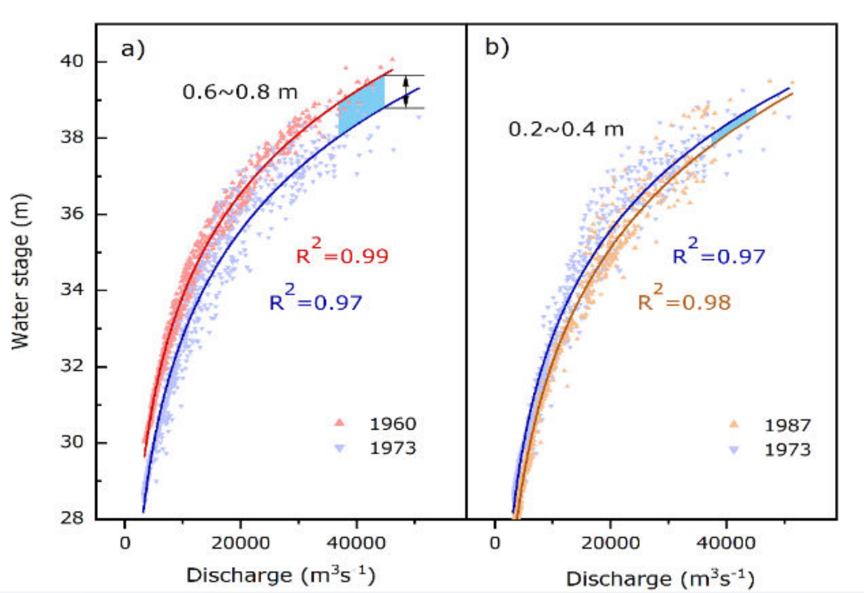
## ◆ Impact of base level adjustment

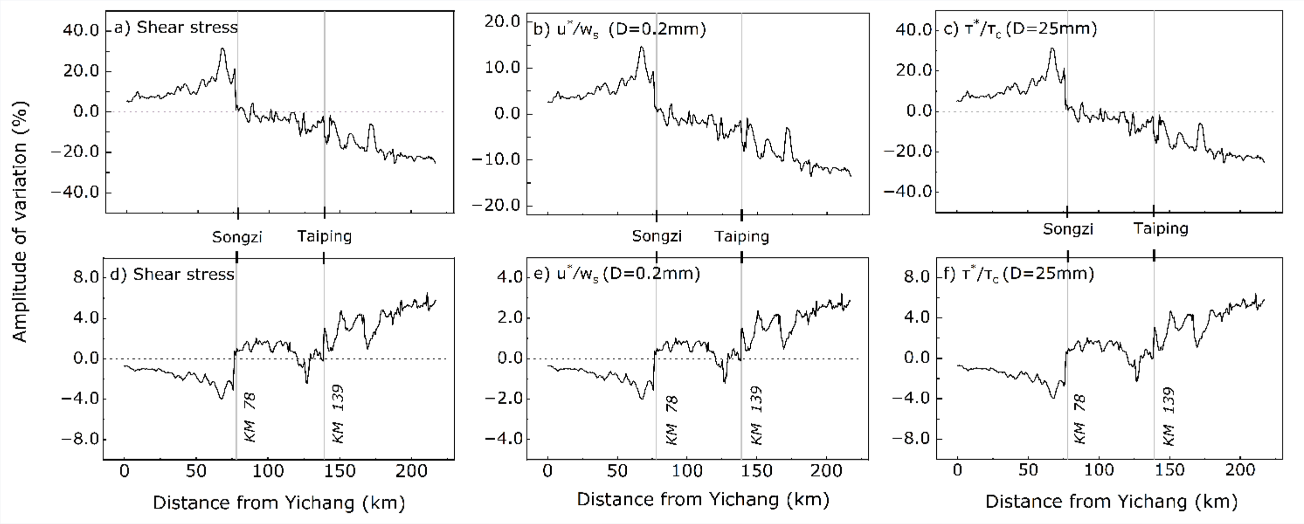
**The stage-discharge relation at Xinchang**




- the decrease in flood level after 1972 was only 0.4m, with the bed gradient downstream of Zhicheng increased by **less than 0.01‱**

## ◆ Impact of distributary streams on the GST

**The presence of the distributaries**




**The decrease in the distributaries**

- The $u_* / w_s$ ratio and $\tau^*/\tau_c^*$ ratio were greater than those predicted with no decrease in outputs, **by 3%, and 6%** at the most.

**the impacts of the distributary output and base level adjustments were limited**

# 4. Conclusion



- The Yangtze GST location remained stable before 2002 but its onset and end **migrated 49.5 and 52.2 km** downstream from 2003-2016, respectively.

- The bankfull width and patterns of sand and gravel transport of the Yangtze GST **remained seemingly stable** in the period 1975~2016.

- The resistant lithologies upstream of Zhicheng (i.e., KM 61), and the Jingjiang Great Levees constraints **determines the stable pattern of the transport mode** at the same discharge in the period 1975~2016.

- The downstream migration of the GST resulted primarily from **a reduction in the suspended-load supply**

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# Thank you

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