Preliminary study on characteristics and changes of annual runoffs and sediment loads of Changjiang River main channels

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Tasks

🔹 Correlation among annual runoffs and sediment loads, their influential factors, and flow-sediment relationship is established

🔹 4 types of analytical methods on annual runoffs and sediment loads are summarized ---- probability-statistics analysis, fitted-line analysis, correlation analysis and accumulated-curve analysis

🔹 Based on 1950-2005 observed data of five key hydrographic gauging stations ---- Cuntan, Yichang, Jianli, Hankou and Datong, characteristics and changes of annual runoffs and sediment loads of Changjiang River main channels are preliminarily analyzed
Contents

1. Runoff-sediment load, influential factors and flow-sediment relationship
2. Four types of analytical methods on annual runoffs and sediment loads
3. Preliminary analysis on annual runoffs and sediment loads
1. Runoff-sediment load, influential factors and flow-sediment relationship (1/3)

Fig.1. Runoffs and sediment loads, influential factors and flow-sediment relationship
1. Runoff-sediment load, influential factors and flow-sediment relationship (2/3)

Fig. 2. Illustration of Lane’s formula on flow-sediment relationship $QS \propto Q_s D_{50}$
1. Runoff-sediment load, influential factors and flow-sediment relationship (3/3)

Fig.3. Five key hydrographic gauging stations of Changjiang River
2. Four types of analytical methods on annual runoffs and sediment loads

--- Method 1: probability-statistics analysis

**Objective:** to study spatial and temporal characteristics and changes of annual runoffs and sediment loads

**Approaches:** probability analysis & statistics analysis

<table>
<thead>
<tr>
<th>Recurrent time (yr)</th>
<th>500</th>
<th>100</th>
<th>50</th>
<th>10</th>
<th>2</th>
<th>Avg.</th>
<th>Variation Coefficient $C_v$</th>
<th>Deviation Coefficient $C_s$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency (%)</td>
<td>0.2</td>
<td>1</td>
<td>2</td>
<td>10</td>
<td>50</td>
<td></td>
<td>0.10</td>
<td>0.49</td>
</tr>
<tr>
<td>Annual runoff $W$ ($10^8$ m$^3$)</td>
<td>5900</td>
<td>5550</td>
<td>5390</td>
<td>4950</td>
<td>4330</td>
<td>4364</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Annual sediment Load $G_s$ ($10^8$ t)</td>
<td>9.07</td>
<td>8.24</td>
<td>7.81</td>
<td>6.64</td>
<td>4.70</td>
<td>4.71</td>
<td>0.32</td>
<td>-0.55</td>
</tr>
</tbody>
</table>

*Tab.1. Partial results of probability analysis at Yichang station*
2. Four types of analytical methods on annual runoffs and sediment loads

---- Method 1: probability-statistics analysis

Fig.4. Probability curve of annual sediment loads at Yichang station
2. Four types of analytical methods on annual runoffs and sediment loads

--- Method 1: probability-statistics analysis

Fig.5. Statistic analysis of annual runoffs and sediment loads at five key stations of Changjiang River

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2. Four types of analytical methods on annual runoffs and sediment loads

---- Method 2: fitted-line analysis

Objective: to study quantitative and qualitative changes of annual runoffs and sediment loads

Approaches: regression-line analysis & moving-average-line analysis

**Regression-line Eq.:**

\[ W = -3.7151T + 4469.8 \]

**Fitted-line analysis of annual runoffs and sediment loads at Yichang station**

**Regression-line Eq.:**

\[ G_s = -0.0444T + 5.97 \]

**Fitted-line analysis of annual runoffs and sediment loads at Yichang station**
2. Four types of analytical methods on annual runoffs and sediment loads

---- Method 3: correlation analysis

Objective: to study characteristics and changes of the flow-sediment relationship

Approach: regressing analysis

![Flow-sediment relationship at Yichang station](image)

Fig.8. Flow-sediment relationship at Yichang station

\[ R^2 (1950-2005) = 0.3294 \]
2. Four types of analytical methods on annual runoffs and sediment loads

---- Method 4: accumulated-curve analysis

**Objective:** to study relative changes of annual runoffs and sediment loads in order to further explore reasons behind the changes

**Approach:** double-accumulated curves

![Double-accumulated curves at 5 key stations of Changjiang River](image)

**Average-line Eq.:** $T_{Gs} = 0.0012T_W - 2.7778$

**Notes:** Markers of “1981”, “1993” and “2002” show respectively years of initial operation of Gezhouba Project, ending of Gezhouba Project downstream souring, and initial impounding of TGP
2. Four types of analytical methods on annual runoffs and sediment loads

---- Method 4: accumulated-curve analysis

**Yichang station**

Average-line Eq.: \( T_{Gs} = 0.00115T_{W} + 2.02327 \)

**Jianli station**

Average-line Eq.: \( T_{Gs} = 0.001T_{W} - 0.8274 \)
2. Four types of analytical methods on annual runoffs and sediment loads

---- Method 4: accumulated-curve analysis

**Hankou station**

Average-line Eq.: \( T_{Gs} = 0.0006T_W - 5.3408 \)

**Datong station**

Average-line Eq.: \( T_{Gs} = 0.0005T_W - 5.6997 \)
### 3. Preliminary analysis on annual runoffs and sediment loads

#### Results

<table>
<thead>
<tr>
<th>Method 1 (W) /10^8m³</th>
<th>Control Basin Area/km²</th>
<th>Statistic time</th>
<th>Main Results</th>
<th>Changes of annual runoffs</th>
<th>Changes of annual sediment loads</th>
<th>Flow-sediment relationship</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cuntan</td>
<td>Yichang</td>
<td>Jianli</td>
<td>Hankou</td>
<td>Datong</td>
<td></td>
</tr>
<tr>
<td>Location</td>
<td>Upstream-CR &amp; TGP-</td>
<td>Middle-CR</td>
<td>Middle-CR</td>
<td>Middle-CR &amp; Lower-JR</td>
<td>Lower-CR</td>
<td></td>
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<tr>
<td></td>
<td>ingoing</td>
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<tr>
<td>Basics</td>
<td>Control Basin Area/km²</td>
<td>Statistic time</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>86.66</td>
<td>1952-2005</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>100.55</td>
<td>1950-2005</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>258.8</td>
<td>1951-2005</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>170.54</td>
<td>1954-2005</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>1953-2005</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>All-year Avg.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3477</td>
<td>4364</td>
<td>3551</td>
<td>7117</td>
<td>9034</td>
<td></td>
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<tr>
<td></td>
<td>1951-1960 Avg.</td>
<td>3575</td>
<td>4377</td>
<td>3015</td>
<td>7153</td>
<td>9155</td>
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<tr>
<td></td>
<td>1961-1970 Avg.</td>
<td>3689</td>
<td>4552</td>
<td>3387</td>
<td>7317</td>
<td>8989</td>
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<td></td>
<td>1971-1980 Avg.</td>
<td>3285</td>
<td>4187</td>
<td>3516</td>
<td>6764</td>
<td>8517</td>
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<tr>
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<td>1981-1990 Avg.</td>
<td>3518</td>
<td>4433</td>
<td>3893</td>
<td>7108</td>
<td>8897</td>
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<td>1991-2000 Avg.</td>
<td>3361</td>
<td>4336</td>
<td>3860</td>
<td>7288</td>
<td>9616</td>
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<tr>
<td></td>
<td>2001-2005 Avg.</td>
<td>3400</td>
<td>4183</td>
<td>3724</td>
<td>7167</td>
<td>8865</td>
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<tr>
<td></td>
<td>Cv</td>
<td>0.11</td>
<td>0.10</td>
<td>0.12</td>
<td>0.12</td>
<td>0.14</td>
</tr>
<tr>
<td></td>
<td>Cs</td>
<td>0.25</td>
<td>0.49</td>
<td>-0.02</td>
<td>0.85</td>
<td>1.09</td>
</tr>
<tr>
<td></td>
<td>P=1%</td>
<td>4460</td>
<td>5550</td>
<td>4510</td>
<td>9530</td>
<td>12900</td>
</tr>
<tr>
<td></td>
<td>Method2</td>
<td>Mw</td>
<td>-0.0014</td>
<td>-0.0009</td>
<td>0.0051</td>
<td>-0.000001</td>
</tr>
<tr>
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<td>MGS</td>
<td>-0.0104</td>
<td>-0.0094</td>
<td>-0.0016</td>
<td>-0.0102</td>
<td>-0.0119</td>
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<tr>
<td></td>
<td>Method3/R²</td>
<td>0.69</td>
<td>0.57</td>
<td>0.33</td>
<td>0.05</td>
<td>0.19</td>
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<tr>
<td></td>
<td>Method4</td>
<td>See Fig.9</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Flow-sediment relation</td>
<td>Good</td>
<td>Acceptable</td>
<td>Poor</td>
<td>Random</td>
<td>Random</td>
</tr>
</tbody>
</table>

Tab.2. Analysis on annual runoffs and sediment loads of Changjiang River
3. Preliminary analysis on annual runoffs and sediment loads
   ----Conclusions

(1) Characteristics of annual runoffs & sediment loads
   From upstream to downstream, annual runoffs increase while annual 
   sediment loads keep relative stable, and flow-sediment relationship becomes 
   gradually random

(2) Changes of annual runoffs & sediment loads
   During 1950-2005, annual runoffs basically keep unchanged, while annual 
   sediment loads show slight declination with average decreasing rates of about 
   1% and further featured with sensible decrease in 1990s and obvious 
   reduction after 2000; fluctuations of annual sediment loads are roughly 10- 
   times larger than annual runoffs

(3) Relationship between change of runoff-sediment load & hydro 
   projects
   For impacts of Gezhouba Project and TGP during 135m-NWL impounding 
   stage, changes of upstream incoming runoffs and sediment loads are the 
   dominant factors responsible for downstream runoffs and sediment loads 
   changes and scouring, and their influences are relatively larger than effects of 
   the Projects’ regulation on downstream flow and sediment transport
3. Preliminary analysis on annual runoffs and sediment loads

---- Further issues

- Quantitative contribution of each influential factor to changes of annual runoffs and sediment loads
- Separate quantitatively the influences of changes of upstream incoming runoffs and sediment loads and TGP operation on downstream runoffs, sediment loads and scouring
- Correlation between changes of runoffs and sediment loads and river fluvial processes etc.
Preliminary study on characteristics and changes of annual runoffs and sediment loads of Changjiang River main channels

- Sediment Physical Model of Dam Region of TGP (Three Gorges Project)
- Flood-control Physical Model of TGP Downstream Channels

Thanks

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