GRACE, 14 years monitoring of the water storage anomaly: how about quantification of total drainable water storage?

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Geodetic Week 2016

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• Surface supplies become less reliable, available and predictable in many regions around the world
• Almost two billion people demand groundwater as their main source of freshwater supply
Question

- How much water is stored at different compartments?
- How does it change with time?
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Quantification of total drainable water storage  
Tourian, Riegger and Sneeuw, 2016
Storage and runoff: a linear relationship

Quantification of total drainable water storage

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Storage and runoff: a linear relationship

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Storage and runoff: a linear relationship

\[ R[t] \iff \Delta M[t + \Delta t] \]

\[ R[t] \iff \Delta M_{\phi}[t] \]
Storage and runoff: a linear relationship

$$R[t] \iff \Delta M[t + \Delta t]$$

$$R[t] \iff \Delta M_\phi[t]$$

$$R[t] = \frac{1}{\tau} (\Delta M_\phi[t] + M_0)$$
Total drainable water storage

Quantification of total drainable water storage

Tourian, Riegger and Sneeuw, 2016
Total drainable water storage

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\[ R_s[t] = \frac{1}{\tau} (\Delta M_\phi[t] + \hat{M}_o) \]
Quantification of total drainable water storage

Tourian, Riegger and Sneeuw, 2016

\[ R_s[t] = \frac{1}{\hat{\tau}} \left( \Delta M_\phi[t] + \hat{M}_o \right) \]
Total drainable water storage: case study

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Results

Quantification of total drainable water storage

Tourian, Riegger and Sneeuw, 2016
## Results

<table>
<thead>
<tr>
<th>Basin</th>
<th>corr</th>
<th>NSE</th>
<th>$\Delta \phi$ [day]</th>
<th>$\tau$ [month]</th>
<th>$M_o$ [mm]</th>
<th>$M_o \times \text{Area}$ [km$^3$]</th>
</tr>
</thead>
<tbody>
<tr>
<td>508</td>
<td>0.85</td>
<td>0.70</td>
<td>10</td>
<td>0.43±0.02</td>
<td>128±1</td>
<td>15±1</td>
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<tr>
<td>507</td>
<td>0.92</td>
<td>0.83</td>
<td>11</td>
<td>1.82±0.04</td>
<td>222±6</td>
<td>272±7</td>
</tr>
<tr>
<td>506</td>
<td>0.92</td>
<td>0.84</td>
<td>10</td>
<td>3.02±0.09</td>
<td>223±8</td>
<td>36±1</td>
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<tr>
<td>503</td>
<td>0.81</td>
<td>0.60</td>
<td>−31</td>
<td>1.78±0.08</td>
<td>299±14</td>
<td>83±4</td>
</tr>
<tr>
<td>505</td>
<td>0.94</td>
<td>0.84</td>
<td>45</td>
<td>4.81±0.22</td>
<td>361±18</td>
<td>132±7</td>
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<tr>
<td>504</td>
<td>0.84</td>
<td>0.67</td>
<td>−25</td>
<td>2.64±0.10</td>
<td>163±6</td>
<td>28±1</td>
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<tr>
<td>501</td>
<td>0.96</td>
<td>0.92</td>
<td>29</td>
<td>1.05±0.01</td>
<td>957±8</td>
<td>306±3</td>
</tr>
<tr>
<td>502</td>
<td>0.96</td>
<td>0.91</td>
<td>18</td>
<td>4.08±0.12</td>
<td>290±9</td>
<td>381±12</td>
</tr>
<tr>
<td>500</td>
<td>0.93</td>
<td>0.87</td>
<td>−4</td>
<td>1.42±0.03</td>
<td>932±21</td>
<td>691±15</td>
</tr>
</tbody>
</table>

Weighted average: \[414±12\] \[\sum 1948±23\]

<table>
<thead>
<tr>
<th>Amazon</th>
<th>corr</th>
<th>NSE</th>
<th>$\Delta \phi$ [day]</th>
<th>$\tau$ [month]</th>
<th>$M_o$ [mm]</th>
<th>$M_o \times \text{Area}$ [km$^3$]</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.94</td>
<td>0.87</td>
<td></td>
<td>30</td>
<td>3.87±0.11</td>
<td>396±12</td>
<td>1863±56</td>
</tr>
</tbody>
</table>

Difference: \[18\] \[85\]
Results

Quantification of total drainable water storage

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Results, interpretation

Quantification of total drainable water storage

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Summary and conclusion

- Runoff and storage behave like a linear time-independent (LTI) system.
- We determine a zero water storage level, at which the discharge becomes zero.
- We quantify the total drainable water storage in Amazon as $396\pm12$ mm.
- The hydraulic time constant of different sub-basins varies between 0.43–4.08 month.
- Comparing the estimated total drainable water storage with the corresponding mean annual input shows two clear distinct linear relationships.
- Linear dependency is found between the length of a basin and the estimated hydraulic time constant.
Still open for future work

- Quantification of river water storage using satellite altimetry
- Quantification of hydraulic time constant $\tau_{riv}$ and storage offset from the obtained river water storage

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Thank you

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