Global Surface Water Storage Dynamics Using Satellite Remote Sensing

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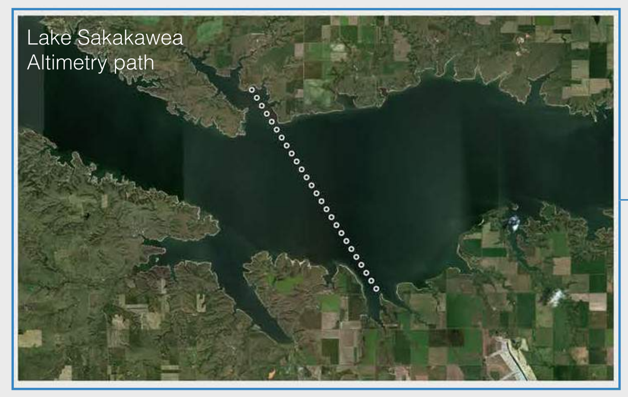
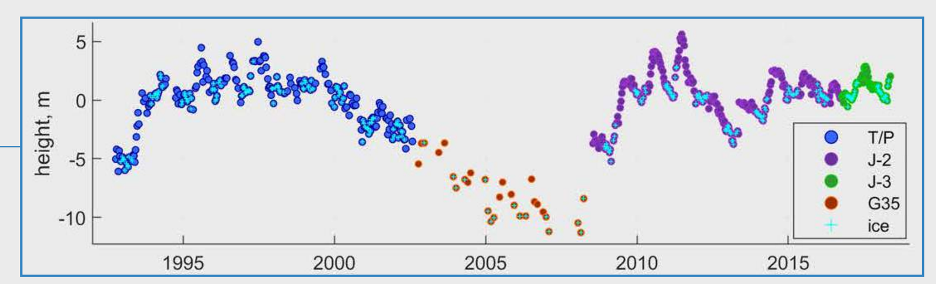
- Surface water storage data are scarce and often inaccessible in many regions of the world, limiting our ability to understand surface water balance at the global scale. Satellite remote sensing can play a pivotal role in providing otherwise unavailable surface water storage data.
- Here we summarize results of the integration of long-term satellite remote sensing data collected by optical and microwave sensors to produce long-term (beginning with the launch of Topex/Poseidon in 1992) global surface water storage data for large lakes, reservoirs, and rivers.
- We use data produced by multiple satellite altimetry missions, including but not limited to Topex/Poseidon (T/P), Jason-1, -2, and -3, with surface extent estimated from Moderate Resolution Imaging Spectroradiometer (MODIS) from 2000 on.
- We leverage from relationships between surface area and height, allowing us to produce estimates of storage variations even during periods when either of the variables are not available, so as long as there are strong relationships between the two during an overlap period.
- The intent of the project is to produce the most complete possible satellite-derived records over the period from T/P launch up to the launch of the Surface Water and Ocean Topography (SWOT) mission, planned for 2021, with the goal to provide long-term, consistent, and calibrated records of surface water cycle variables so to baseline future SWOT products.

Global Reservoir and Lake Monitoring (G-REALM)

- G-REALM10 merged T/P, Jason-1, and Jason-2 time series of relative water level variation with respect to the 9-year (1993-2001) mean T/P level at 10-day intervals [1, 2].
- G-REALM35 was created using the ENVISAT time series of relative water level variation with respect to the mean level of a given ENVISAT reference cycle at 35-day intervals.
- Lake ice conditions were assessed using information from multiple sources available (i.e., literature, MODIS/Terra Snow Cover Daily Global product MOD10A1).



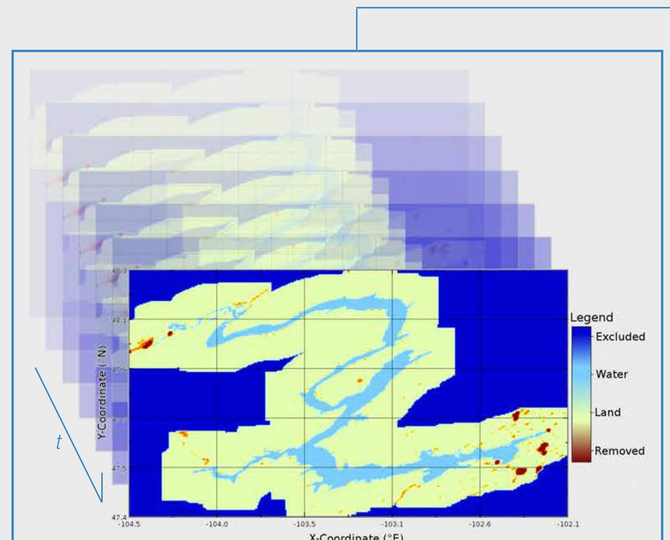


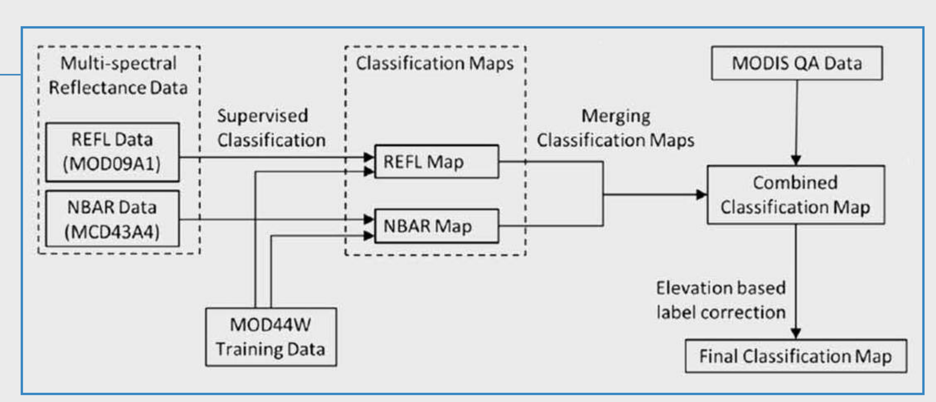
Birkett et al., "G-REALM: a lake/reservoir monitoring tool for water resources and regional security assessment". 2018 AGU Fall Meeting, Session H51S-1570.

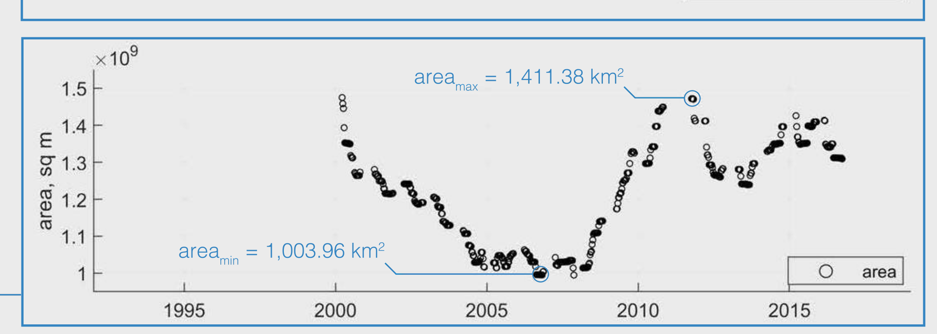
Ricko et al., "Investigating regional scale reservoir level modeling". 2018 AGU Fall Meeting, Session GC31E-1306.

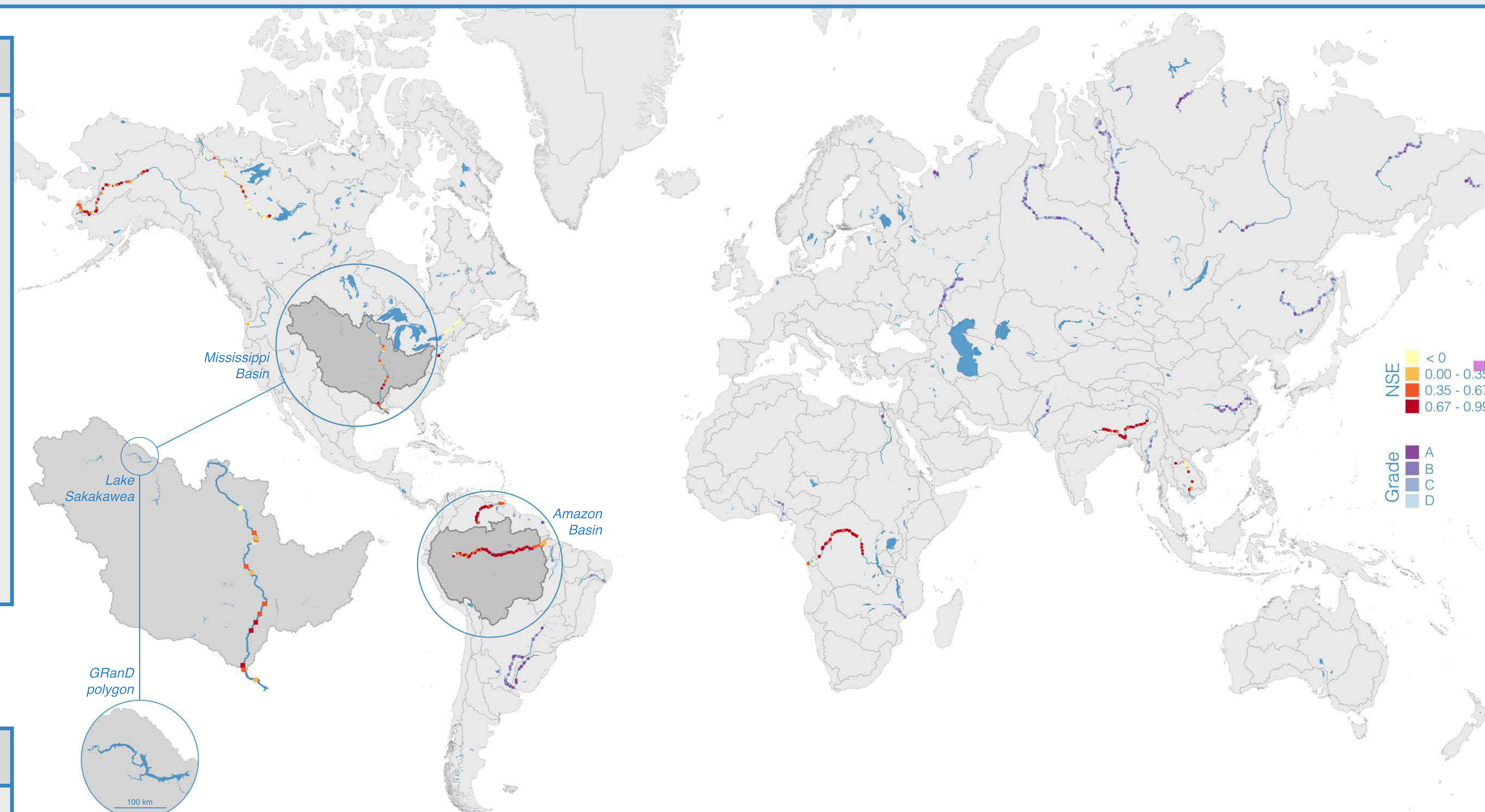
Global Optical Lake Area (GOLA)

- The GOLA time series estimates lake/reservoir surface area from Terra/Aqua MODIS satellite optical imagery with spatial resolution 500 m and temporal resolution 8-day.
- Area is processed with limits established by an input vector polygon defined using: (i) the Global Reservoir and Dam (GRanD [3]) database and the Global Lakes and. Wetlands Database (GLWD [4]) with quality check ensured by visual comparison with high resolution satellite imagery, or (ii) drawn by hand using high resolution imagery.
- Data from two multispectral reflectance data products are used as an input to the water/land classification algorithm (Collection 5 MCD43A4 and MOD0911), and static water/land classification labels are used to train the classification model (MOD44W) [5].









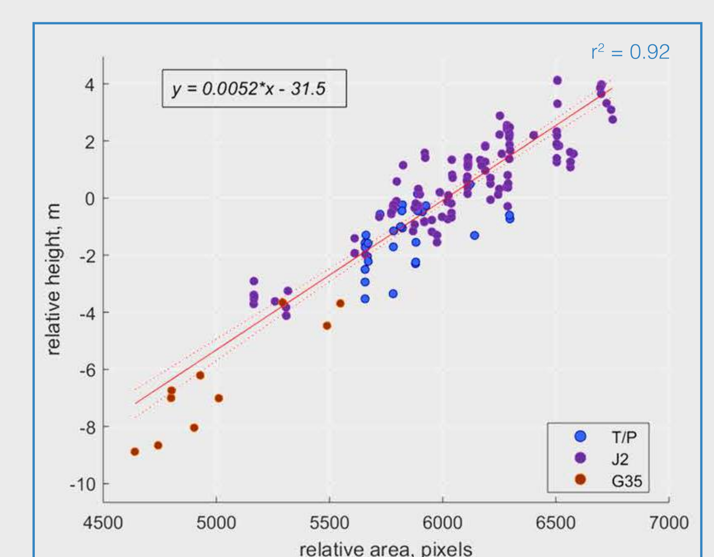
Storage Variation

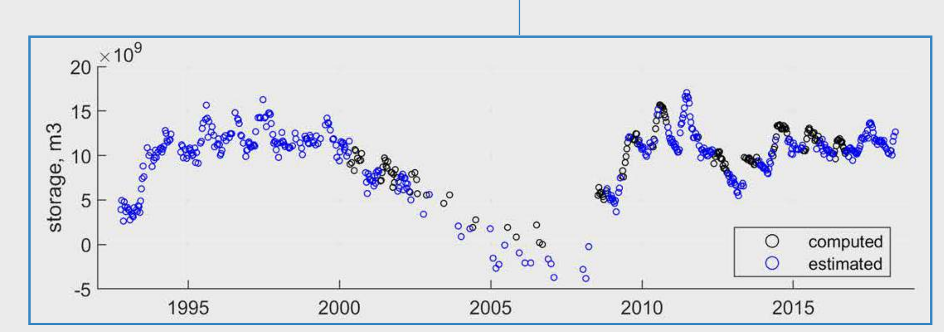
- During overlapping periods from 2000 to 2010, G-REALM and GOLA are used to derive the elevation-area relationship for 435 lakes/reservoirs globally.
- A linear regression is used to approximate the relationship between altimetry (h) and surface area (A), $A = f(h)$. This relationship is applied to estimate surface area from altimetry periods when GOLA is unavailable (1992-1999), and the inverse function $h = f\text{-}1(A)$ to estimate altimetry for periods when G-REALM is unavailable during the MODIS era.
- Based on the approach in [6], storage variation (ΔV) is estimated using increments of volume corresponding to change in area (from smallest to the next to smallest) as:

$$\Delta V = (A_{t+1} + A_t)(h_{t+1} + h_t)/2$$

where A_t and ht are surface area and altimetry at the smallest step t, and A_{t+1} and h_{t+1} are surface area and altimetry at the next incremental step $t+1$.

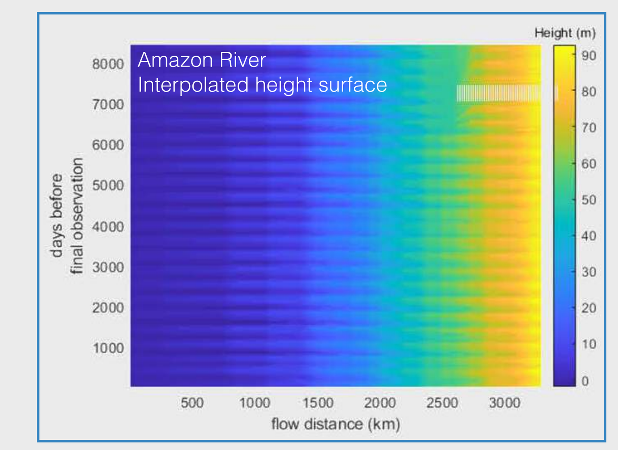
- The storage variation equation can be simplified into a single variable function, either as a function of altimetry from G-REALM or as a function of surface area from GOLA by substituting the elevation-area relationship into it.

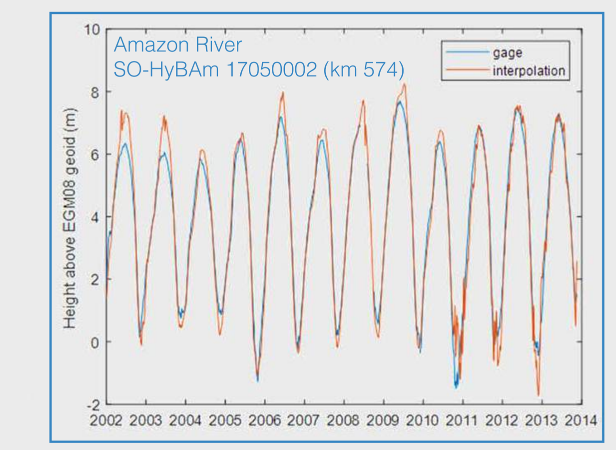




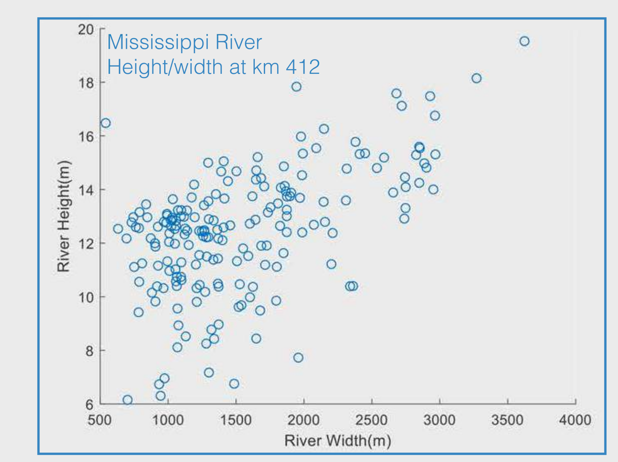
Global River Radar Altimeter Time Series (GRRATS)

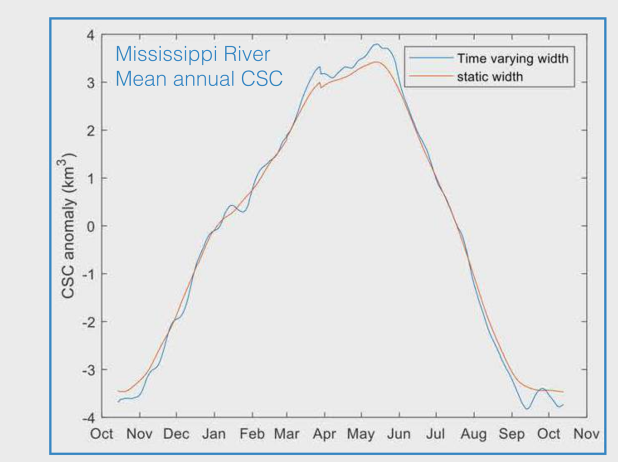
- River heights from OSTM/Jason-2 and Envisat were conformed to simulate river gauges via virtual stations (VSs) to provide global satellite altimetric river height data and promote the use of satellite data for river hydrology.
- 932 VSs on 39 rivers with width >900 m, with 729 VSs unique to GRRATS.





- Bilinear interpolation of height anomaly over a time-flow distance grid was produced.
- Current version includes ERS1, ERS2, T/P, Jason-2, and Envisat altimetry.
- Cubic Spline Smoothing was performed with iterative reweighted values.





- Well sampled at 1 km sections have >9 width measurements and height/width correlation >0.5
- 264 of 2651 1-km sections are well sampled (9.96%)
- Time varying widths amplitude = 7.6
- Static widths from GRLW amplitude = 6.9
- Difference of 0.72 km^3
- Average static amplitude = -9.4%

Coss et al., "River channel storage change: a critical component of terrestrial water storage in major world rivers". 2018 AGU Fall Meeting, Session H31K-2084.

Acknowledgements and References

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