River discharge estimation using channel width measurements from satellite imagery (MODIS)

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Introduction

River discharge is a critical component of the global hydrological water cycle.

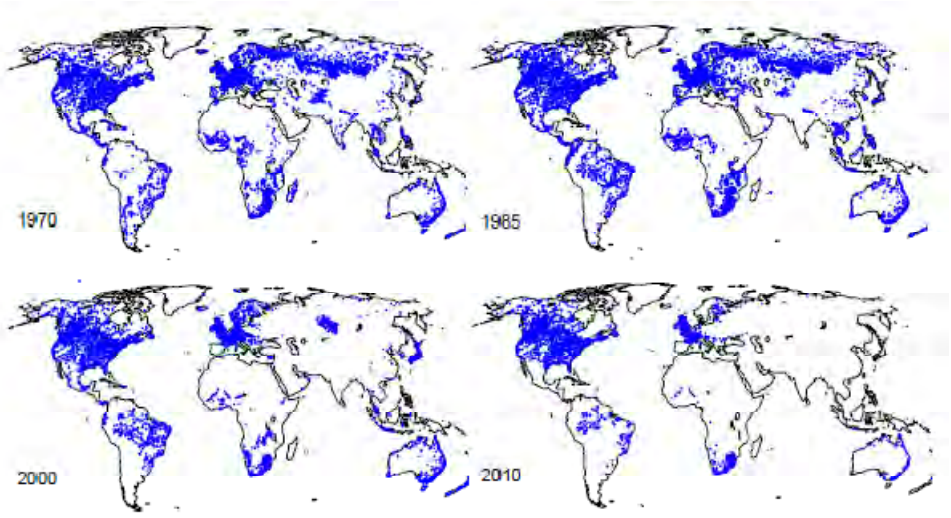
Flow of water in rivers is a substantial resource for human societies and natural ecosystems.

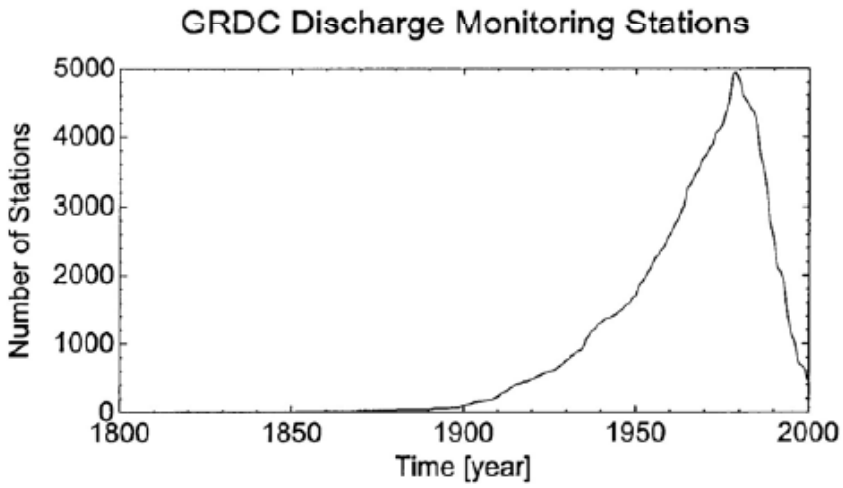
It is a key parameter in natural hazard monitoring.

Problem statement

For more than a century, ground based measurements have been applied to estimate the river discharge.

The number of in situ stations are reduced since 1980





Alternative

Therefore the interest to apply remote sensing data for hydrological purposes is increased.

Spaceborne observation techniques have potential to monitor river discharge. *

- Total water storage (GRACE)
- Water level (Altimetry missions)

Optical satellite and SAR imagery missions have the ability to monitor the change in water area.

* Sneeuw N, Lorenz C, Devaraju B, Tourian MJ, Riegger J, Kunstmann H, Bárdossy A (2014) Estimating runoff using hydro-geodetic approaches: Status and challenges. Surveys in Geophysics DOI 10.1007/s10712-014-9300-4

Objective

Find a relationship between river width and discharge

- Monitoring the river width near the in situ station within a certain time period.

- Establishing a relationship between discharge and river width
  - Empirical approach
  - Quantile approach*

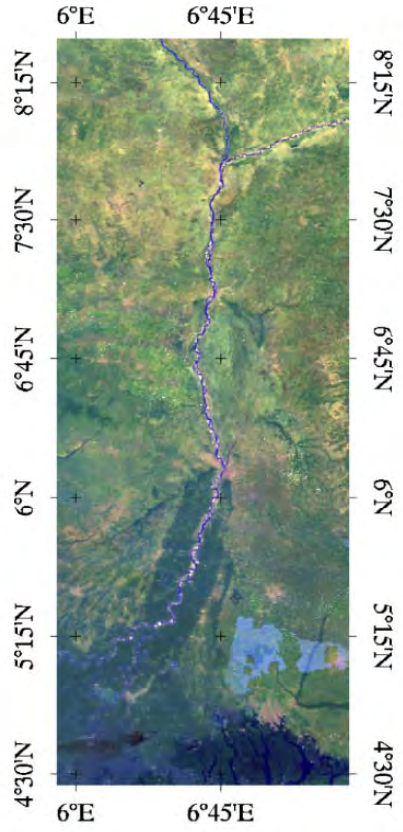
Estimation of discharge

* Tourian MJ, Sneeuw N, B´ardossy A (2013) A quantile function approach to discharge estimation from satellite altimetry (ENVISAT). Water Resources Research, DOI :10.1002/wrcr.20348.

Study Area and Dataset

The inland delta of the Niger river is one of the most fragile ecosystems of Sub-Saharan Africa.

Patterns of land cover and land use extremely vary due to the pre-flood and post-flood of Niger river and its tributaries.

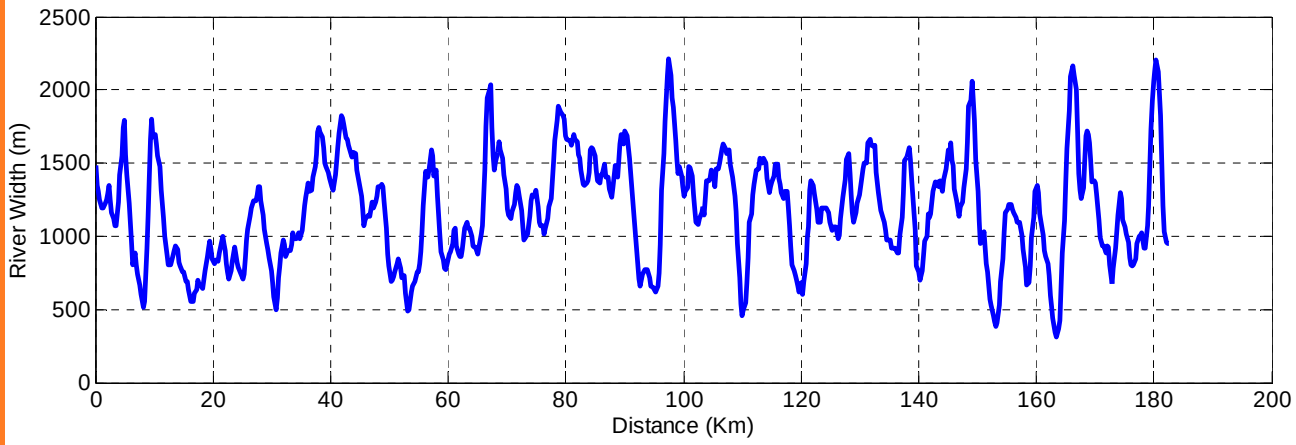


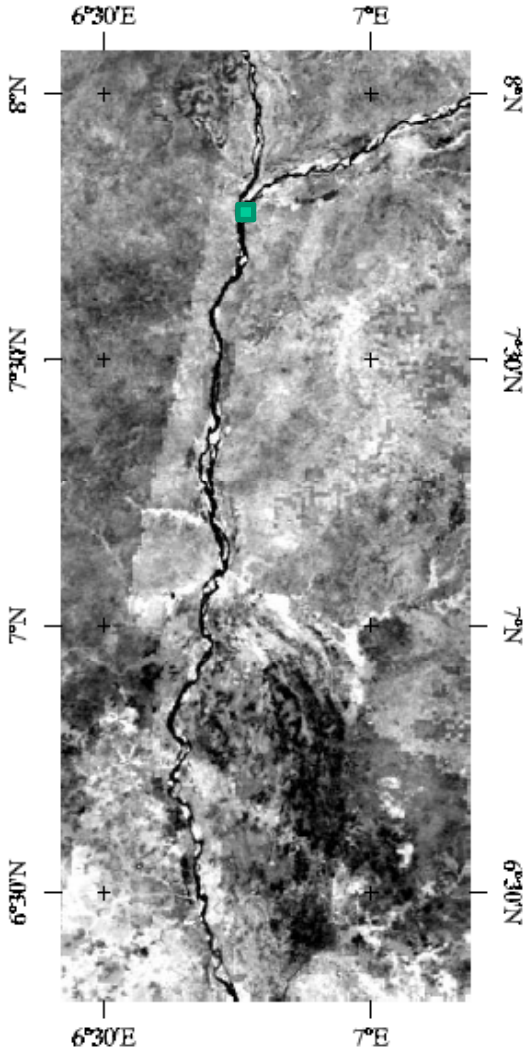
Dataset

- Satellite image : MODIS Surface-Reflectance Product (MOD09) with 7 days temporal and 250 m spatial resolution from 2000 until 2014.

- River discharge : daily discharge from GRDC
  Station coordinate : Lat. 7 48’00” , Lon. 6 46’00”

River Width





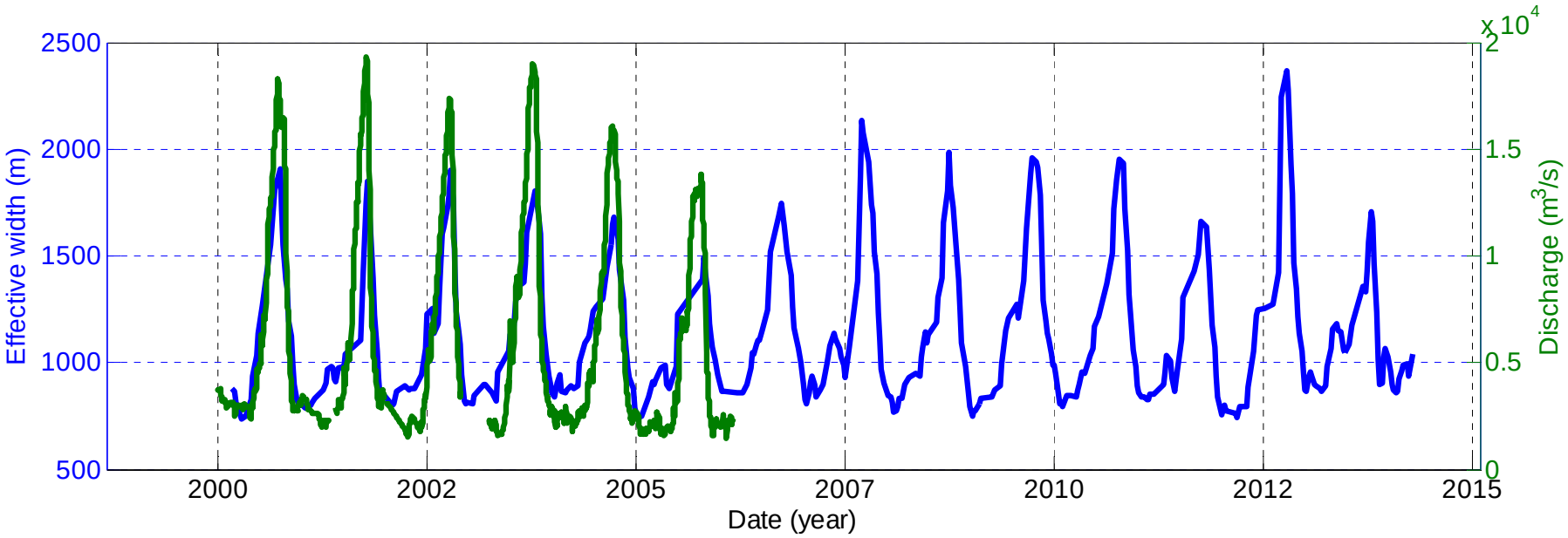
Effective width : The water surface area within a braided reach divided by the reach length*

The relationship between discharge and width will be stable if the examined lenght is longer than 2 or 3 times floodplain vally width.

*Smith, L. C., B. L. Isacks, A. L. Bloom, and A. B. Murray. (1996) Estimation of Discharge From Three Braided Rivers Using Synthetic Aperture Radar Satellite Imagery: Potential Application to UngagedBasins. Water Resources Research

River Width

Reach average: 30 km



Estimation of River Discharge

We assume that there is a power-law relationship between river discharge and width.

$$Q = bw^a$$

Q : discharge
W : river width
b,a : constant coefficient

Empirical approach

Training period : 2000 – 2004

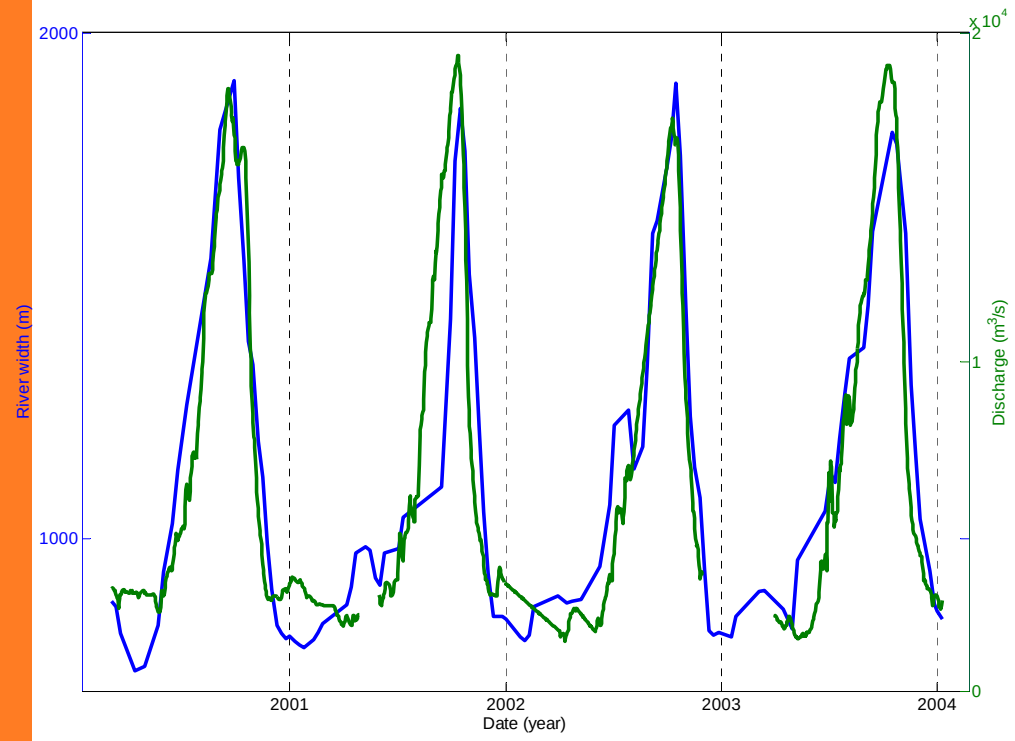
Quantile approach

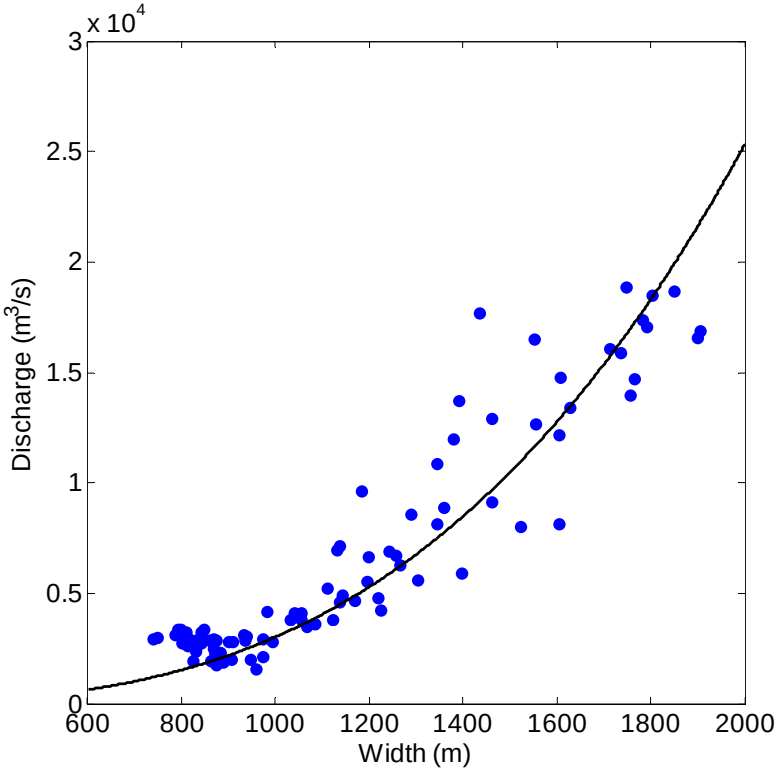
Discharge :
Training period : 1970 – 2000

River width :
Training period : 2000 – 2004

Validation period : 2004 – 2006

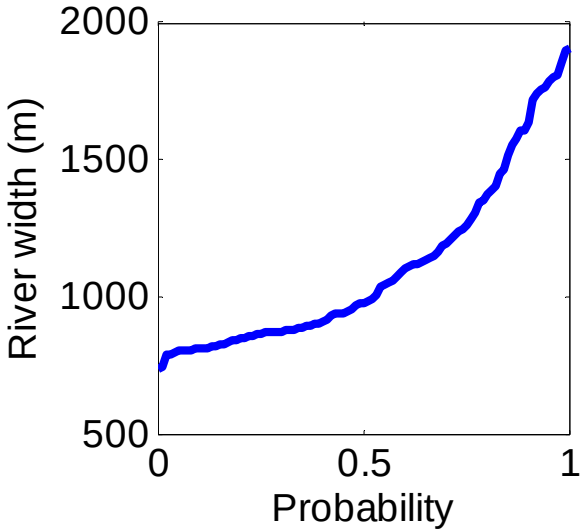
Estimation of River discharge: **Empirical approach**

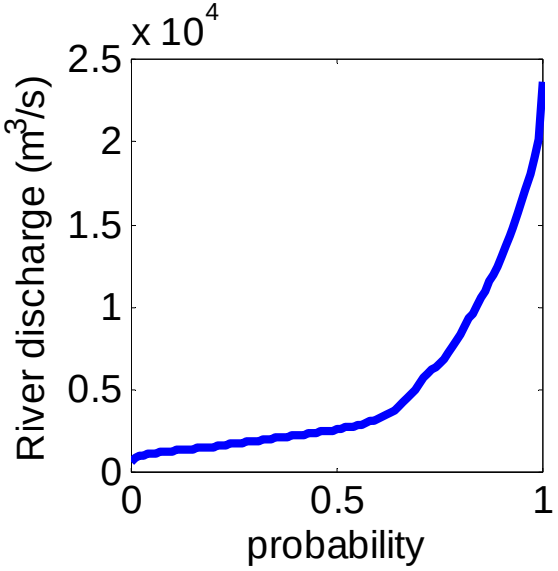


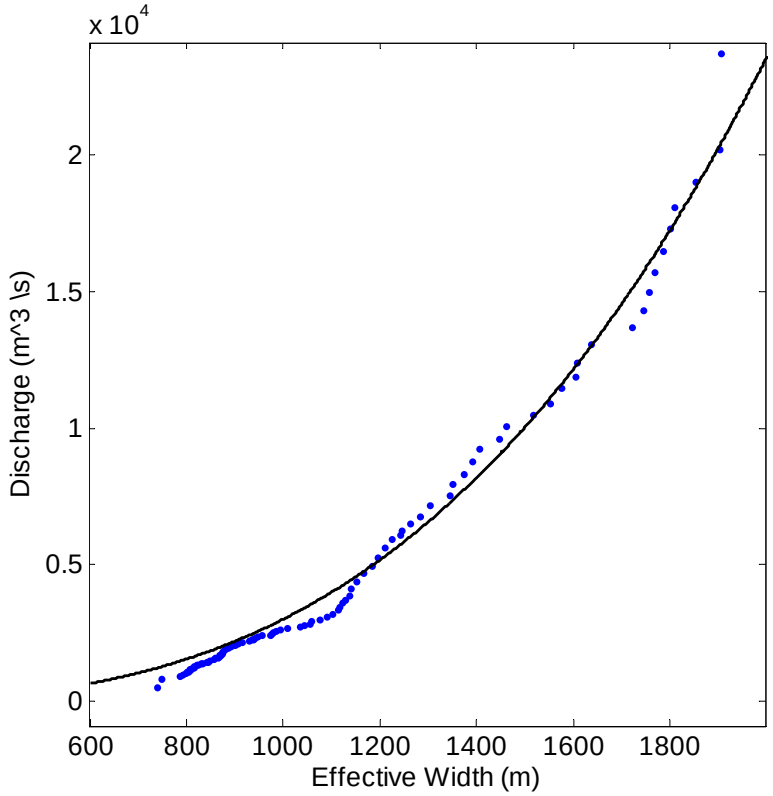


$$Q = 1.8 \times 10^{-6} w^{3.07}$$

Estimation of River discharge: **Quantile approach**

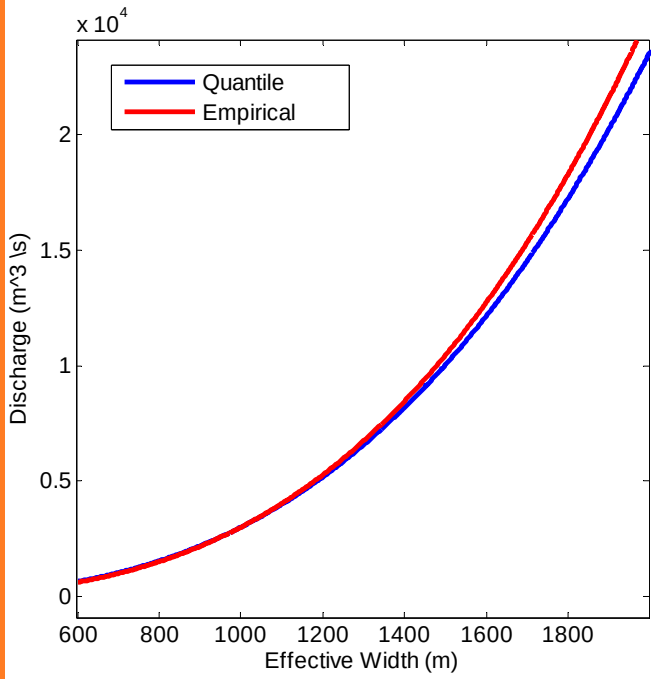


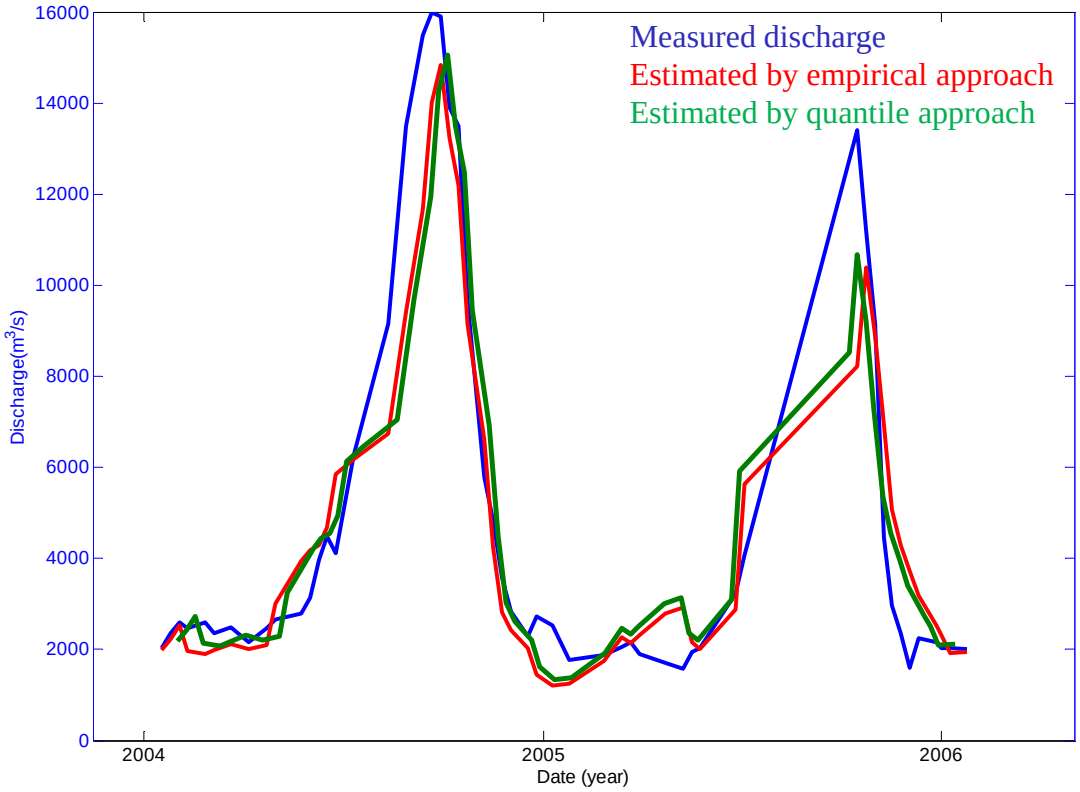




$$Q = 3.7 \times 10^{-6} w^{2.97}$$

Estimation of River discharge





Empirical approach

Relative RMS: ~9%
NSE : 0.89

Quantile approach

Relative RMS: ~11%
NSE : 0.87

Conclusion & Outlook

Satellite imagery has a great potential to use for hydrological purposes.

The minimum channel width sensitive with respect to the spatial resolution must be studied.

The performance of quantile approach using river width is promising due to relatively dense temporal resolution.

Combination of water area and water level simultaneous measurements could lead to water volume monitoring

GIS

Thank you for your attention

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