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Using radar altimetry in catchment models
Example application on the Zambezi River Basin

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Introduction

Hydrological models are widely used to predict water availability and inform water management plans. However models usually have very large uncertainties especially in areas where data to constrain the model is scarce or non existent.

Remote sensing data has offered spatially distributed datasets where none were previously available. One such dataset is radar altimetry which allows for the tracking of water level variations in rivers.

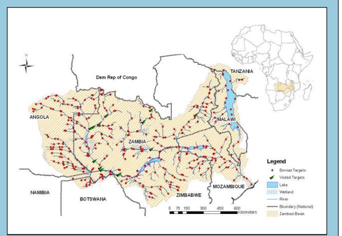
The Zambezi River basin covers $1.39 \cdot 10^6$ m^2 and flows through 8 countries. It is the main water resource in Southern Africa and is characterised by strongly seasonal rainfall and major hydroelectric dams.

This study is the preliminary phase in using radar altimetry in models of the Zambezi River basin.

Objective / Main Steps

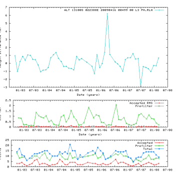
The objective of the study is to establish rating curves relating radar altimetry values to discharge for “virtual stations” over the Zambezi and compare calculated data to in-situ data when available. The main steps are:

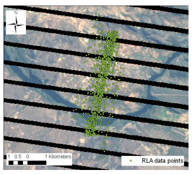
- Analyse data from virtual stations for the Zambezi and its tributaries
- Measure cross sections and flow velocities in Zambia
- Model discharge from altimetry based on remote sensing only
- Model discharge from altimetry based on remote sensing and with field data
- Assess the quality of the results



Altimetry to Discharge - 1

The altimetry product used is the RLH product from the Envisat mission. The satellite ground track crosses the river network at over 400 ”virtual stations”.

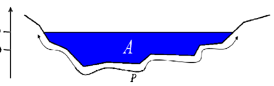




To calculate discharge (Q in m^3/s) from altimetry at these points, empirical equations derived from Manning’s equation which need only the area (A in m^2), the wetted perimeter (P in m) and the slope (S) are then used.

The following is an example of such an equation as calibrated by Dingman and Sharma (1997):

$$Q = 1{,}564 A^{1{,}173} R^{0{,}4} S^{-0{,}0543 Log_{10} S}$$



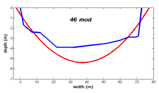
where R=A/P

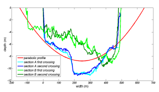
Altimetry to Discharge - 2

Two methods are used to determine the physical parameters:

- **based on remote sensing data only:**

  the section is approximated as a parabolic function passing through 4 points corresponding to width and level measurements from landsat and altimetry. The slope is extracted from Shuttle Radar Topography Mission imagery .





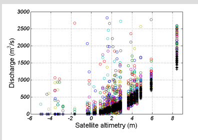
- **using field data:**

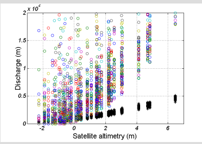
  discharge and cross section were measured. A and P are then known as a function of depth and the following equation can be used:

$$Q = Q_{meas} \cdot \left(\frac{A}{A_{meas}}\right)^{1,573} \cdot \left(\frac{P_{meas}}{P}\right)^{0,4}$$

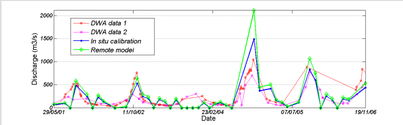
Results

Running a Monte Carlo simulation to take into account the uncertainties of the input parameters in the discharge calculation, the following results are obtained.





Color circles are discharges from the remote sensing model and black crosses for the in-situ calibrated model. The figure to the right is from a section with irregularities such as sand banks.



No data was available at dates overlaping with altimetry data. The comparison presented here is with historical data shifted in time.

Conclusion / Next Steps

- Discharge calculations from remote sensing data only remain highly uncertain
- The use of in-situ data significantly reduces the uncertainty on the discharge calculations
- In spite of the uncertainties, radar altimetry shows potential as a data source in the basin
- The morphology of the river at a virtual station has a strong influence on the quality of the results

Further work

The altimetry data used so far can be improved with a better selection algorithm to keep only data points which are located on the river.

Data assimilation of radar altimetry to a spatially distributed model of the Zambezi River basin to update state variables such as discharge and soil water content will be carried out.

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