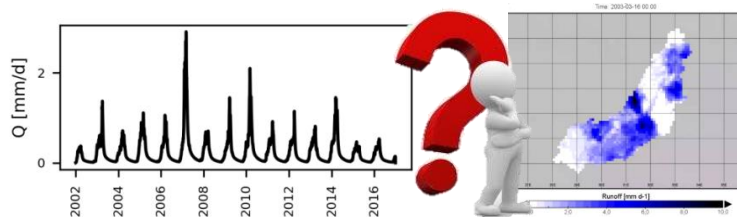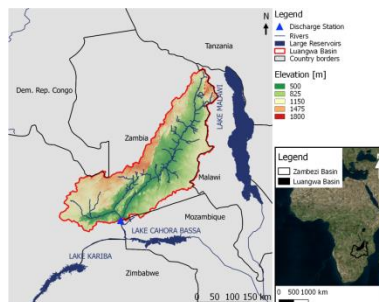# Learning from satellite observations:
Increased understanding of catchment processes through stepwise model improvement

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Introduction

Luangwa Basin
- Area: 150 000 km^2
- Length: 770 km
- Limited in-situ observations
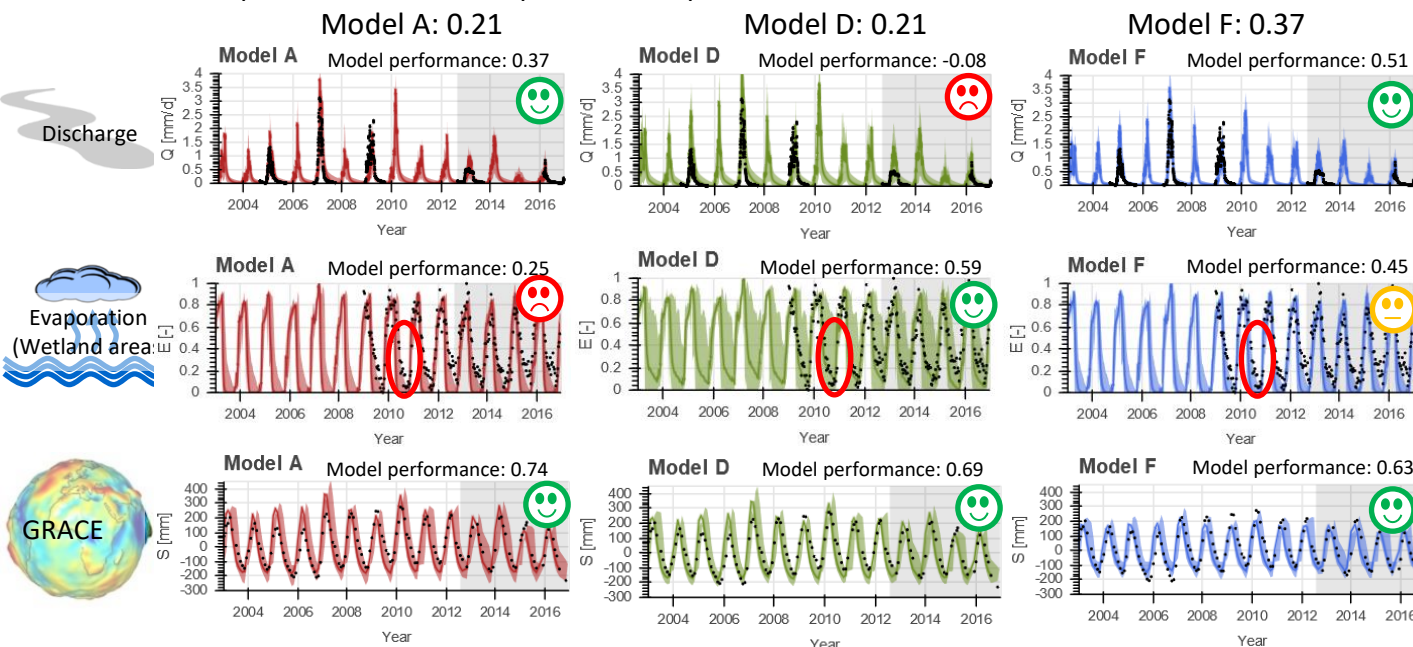- Unknown water availability in space & time

Goal

Can we use satellite observations to improve our understanding of the hydrological processes in the Luangwa Basin?

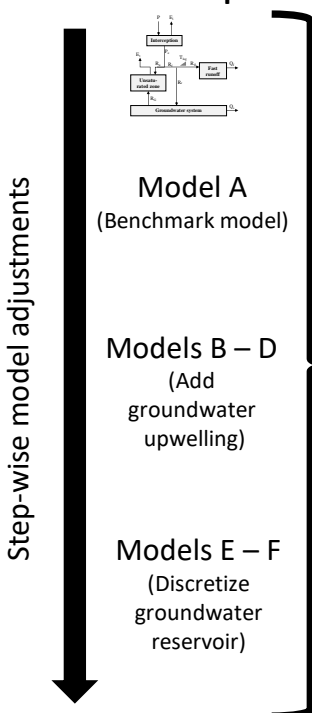## Approach

Model development

Model calibration/validation

Step-wise model adjustments

Calibration (2002 – 2012)
Validation (2012 – 2016)

Model A (Benchmark model)

Strategy 1

Discharge
Discharge Evaporation GRACE

Models B – D (Add groundwater upwelling)

Strategy 2

Models E – F (Discretize groundwater reservoir)
Discharge Evaporation GRACE
Discharge Evaporation GRACE

Hydrological Model

Plateau | Hillslope | Terrace | Wetland

Unsaturated zone
Groundwater
Groundwater upwelling
Distance from stream

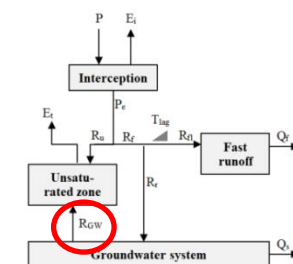Height above nearest drain (HAND)

Landscapes: Plateau, Hillslope, Terrace, Wetland

Distributed model (10 x 10 km)
Landscape based sub-grid processes
Lumped groundwater reservoir

Model adjustments:
- Models B – D: Include groundwater upwelling as function of the (un-) saturated zone
- Models E – F: Discretize the slow responding reservoir

Results

Calibrated with respect to multiple variables

Overall model performance with respect to multiple variables:

Model A: 0.21
Model D: 0.21
Model F: 0.37

Discharge
Model A Model performance: 0.37
Model D Model performance: -0.08
Model F Model performance: 0.51

Evaporation (Wetland area)
Model A Model performance: 0.25
Model D Model performance: 0.59
Model F Model performance: 0.45

GRACE
Model A Model performance: 0.74
Model D Model performance: 0.69
Model F Model performance: 0.63

Model	Groundwater upwelling (R_{GW})	Groundwater reservoir
A	$R_{GW} = 0$	Lumped
B	$R_{GW} = \left(1 - \frac{S_u}{S_{u,max}}\right) \cdot C_{max}$	Lumped
C	$R_{GW} = \frac{\min(S_s, S_{s,ref})}{S_{s,ref}} \cdot C_{max}$	Lumped
D	$R_{GW} = \left(\frac{\min(S_s, S_{s,ref})}{S_{s,ref}}\right)^{\gamma} \cdot C_{max}$	Lumped
E	(see Model C)	Semi-distributed
F	(see Model C)	Distributed

Observed
Model A ($E_{SP,E} = 0.18$)
Model D ($E_{SP,E} = 0.24$)
Model F ($E_{SP,E} = 0.23$)

Observed
Model A ($E_{SP,S} = -0.14$)
Model D ($E_{SP,S} = -0.04$)
Model F ($E_{SP,S} = 0.09$)

*Note: model performances values are valid for the validation time period 2012 – 2016

Conclusion

Can we use satellite observations to improve our understanding of the hydrological processes in the Luangwa Basin?

YES!

The overall model performance improved the most when including groundwater upwelling from a distributed groundwater reservoir and calibrating with respect to multiple variables simultaneously.

→ Satellite-based observations can play an important role in improving our understanding of hydrological processes!

More info on the ZAMSECUR project:
https://zamsecur.wixsite.com/home