Development of hydrogeological conceptual models of wetlands in datascarce regions

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the Kilombero floodplain, Tanzania and the Namulonge valley, Uganda

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25. Tagung der Fachsektion Hydrogeologie in der DGGV 2016
Grundwasser – Mensch - Ökosysteme
14.04.2016

Motivation

→ agricultural production → Reconcile future food production with environmental protection

→ other ecosystem services → Reconcile future food production with environmental protection

How does agriculture affect water dynamics and composition and vice versa?

→ Need to understand hydrogeological regime and processes!

Conceptual hydrogeological models
(as defined by Bear et al., 1992)

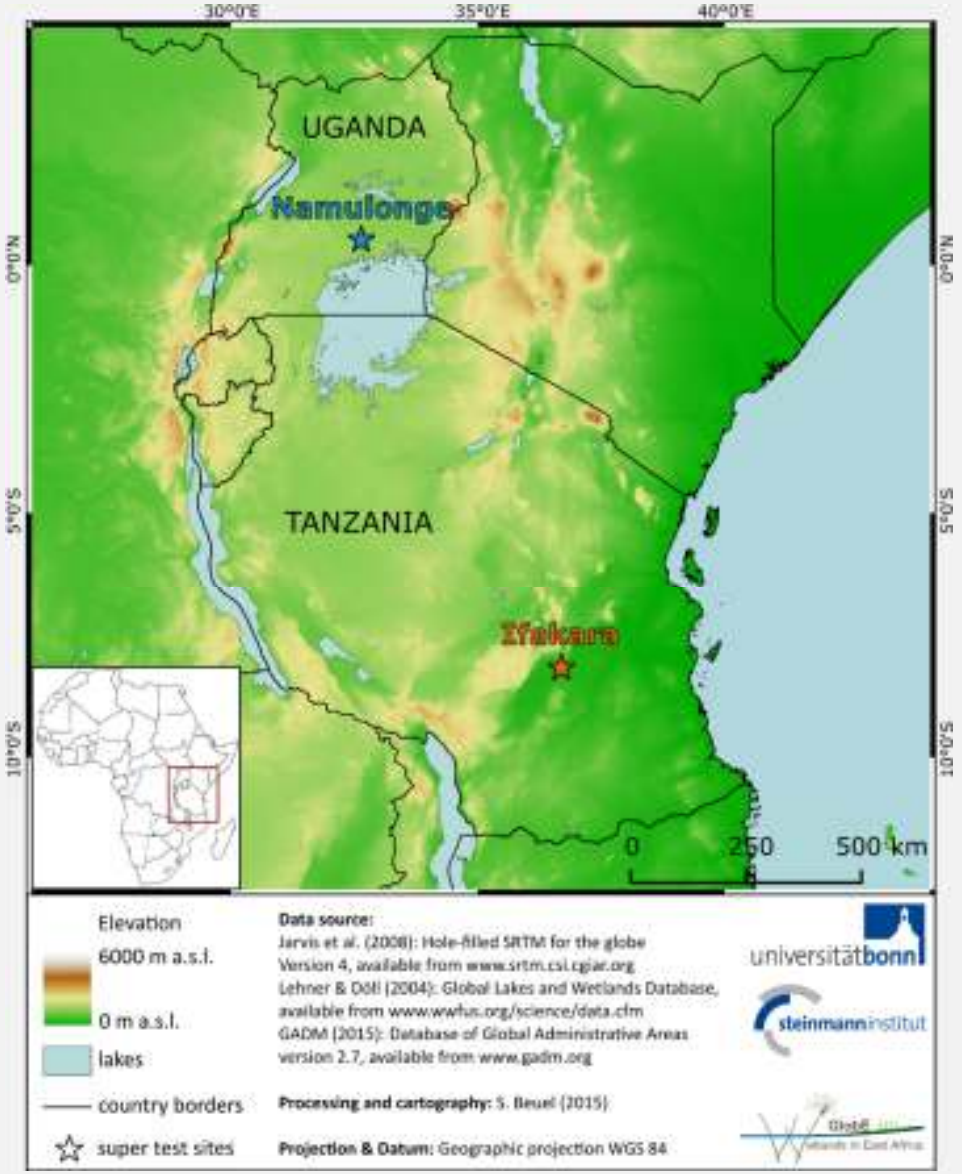
→ Visualization tool for stakeholders and non-hydrogeologists

→ Base for numerical models

Study sites

Namulonge

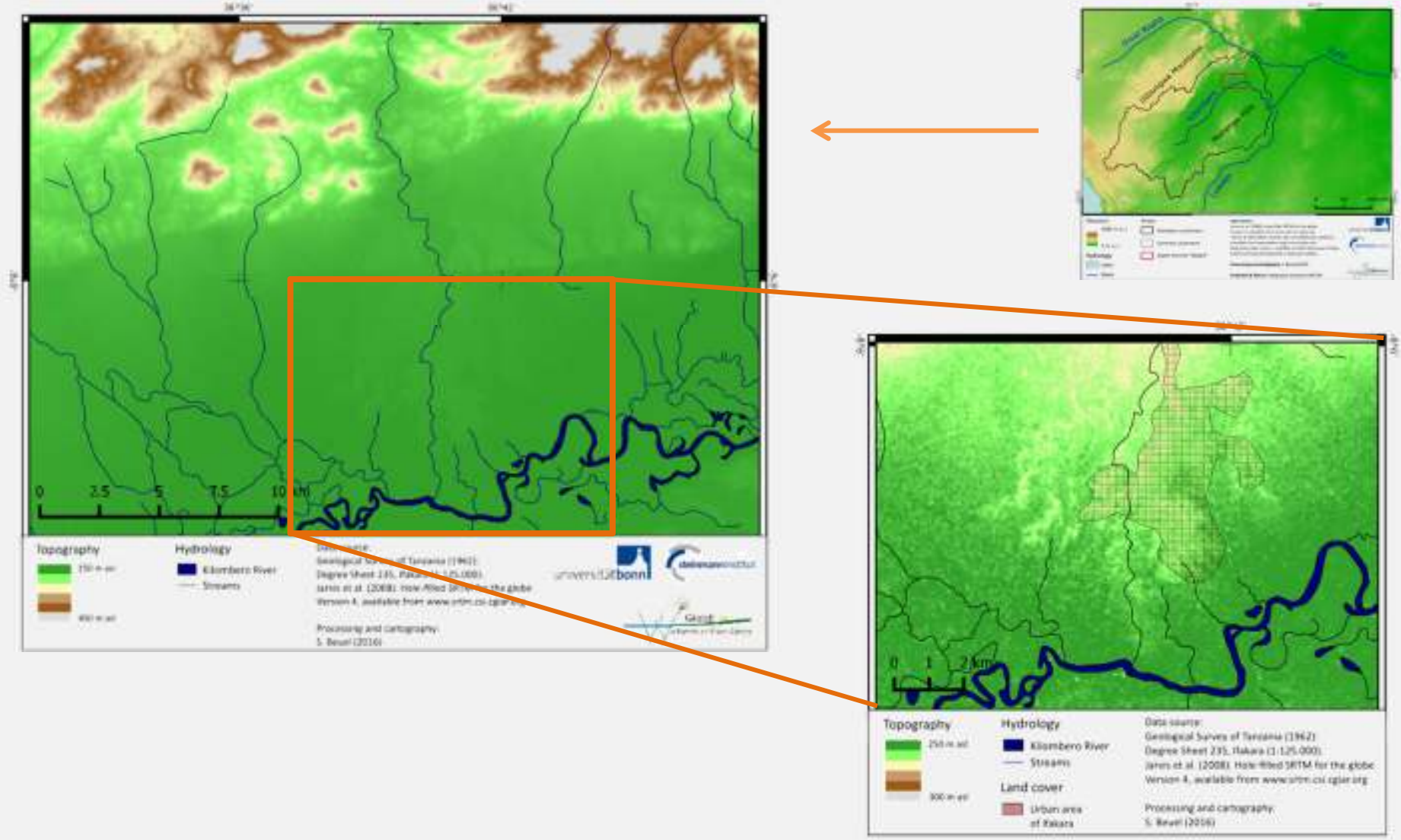
- small valley bottom wetland
- precipitation: 1300 mm/a
- sporadic flooding



Ifakara

- huge floodplain wetland
- precipitation: 1400 mm/a
- annual flooding

Study site - Ifakara



Model development

Development of conceptual hydrogeological models in 3 steps – an iterative process:

Analysis of…

1) Aquifer structure
2) Groundwater dynamics
3) Water composition

Aquifer structure

Analysis of…

1) Aquifer structure

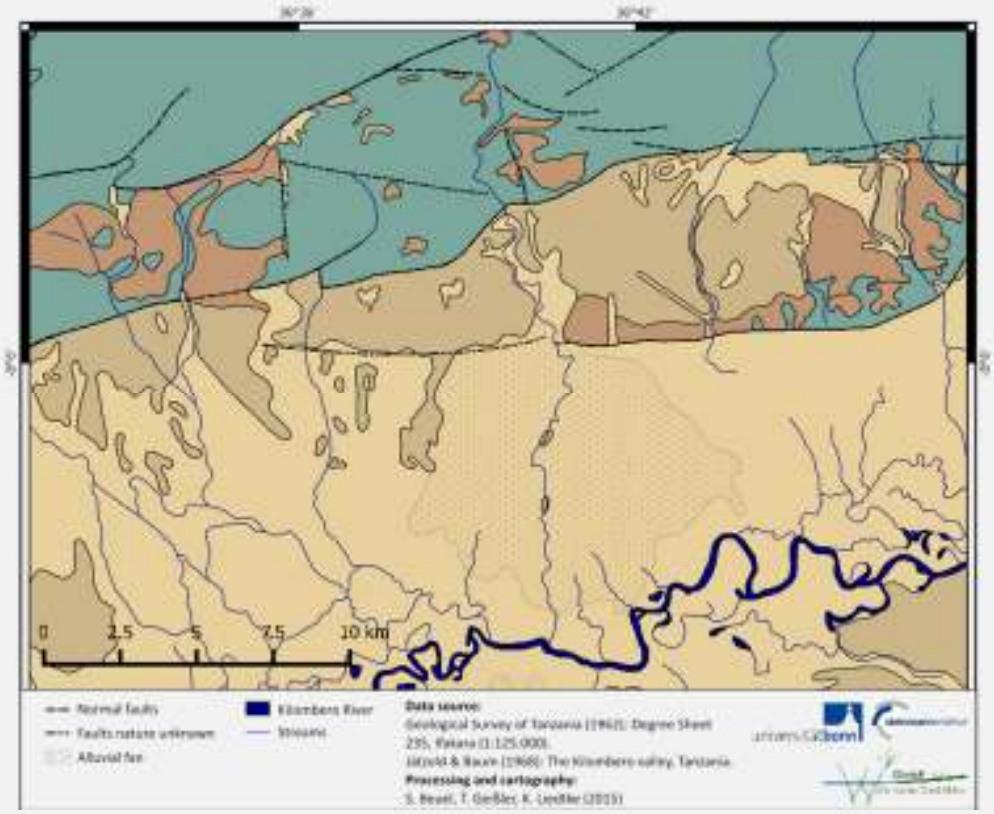
2) Groundwater dynamics

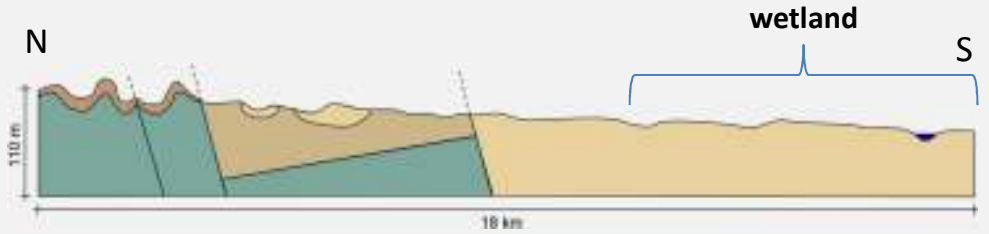
3) Water composition

era	lithological unit	lithological description
Neogene	alluvial sediments	floodplain sediments, sands, silts, clays; dominant grainsize increases from north to south
		alluvial fan sediments, gravels, sands, silts, clays; dominant grainsize decreases from fan mouth to distalareas
	non-alluvial sediments	non-alluvial sands, locally ferruginous [a]
	ferruginized sediments	sandy earths, ferruginized cemented sands and gravels, ferricrete [a]
Neo-proterozoic	metamorphic rocks	gneisses, granulites, amphibolites, pegmatites, migmatites

[a] after Geological Survey of Tanzania (1962)

wetland area





Aquifer structure

Analysis of…

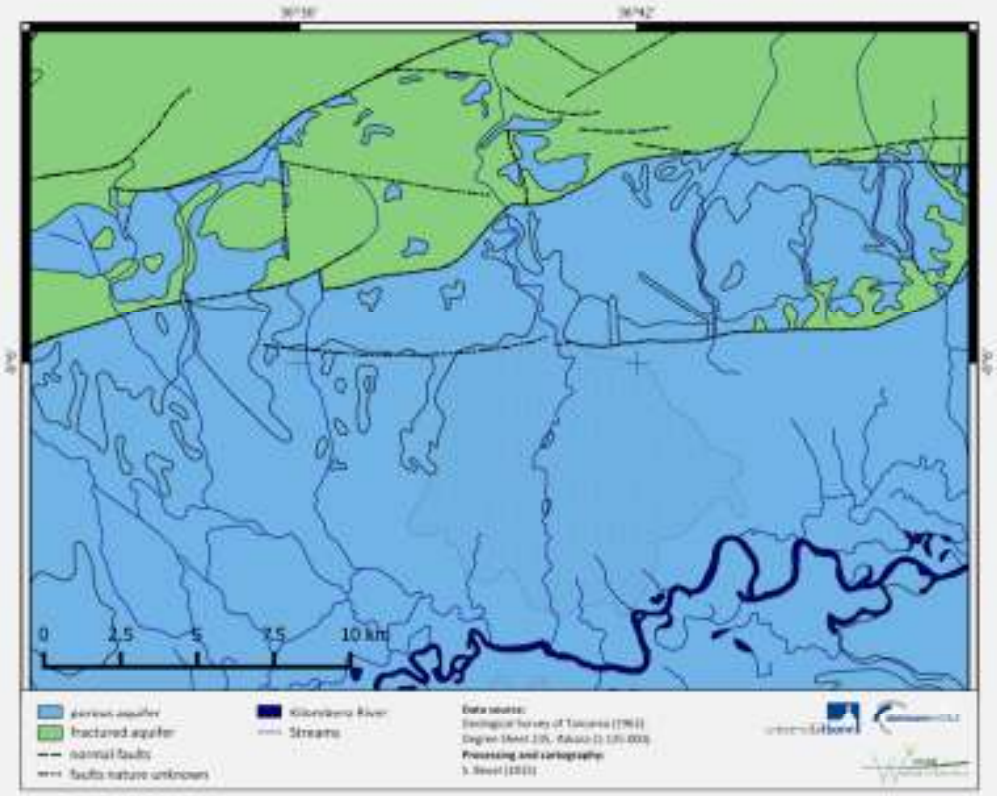
1) Aquifer structure

2) Groundwater dynamics

3) Water composition

era	lithological unit	lithological description	porosity	k-value [m/s]	hydro-strati-graphy
Neogene	alluvial sediments	floodplain sediments, sands, silts, clays; dominant grainsize increases from north to south	porous	10^{-6} - 10^{-2} [a]	AQ1
		alluvial fan sediments, gravels, sands, silts, clays; dominant grainsize decreases from fan mouth to distalareas			
	non-alluvial sediments	non-alluvial sands, locally ferruginous [a]	porous	10^{-6} - 10^{-3} [c]	AQ2
	ferruginized sediments	sandy earths, ferrugi-nized cemented sands and gravels, ferricrete [a]	porous	10^{-6} - 10^{-3} [c]	AQ3
Neo-proterozoic	metamor-phic rocks	gneisses, granulites, amphibolites, pegma-tites, migmatites	fractured	10^{-7} - 10^{-6} [b]	AQ4

[a] after Geological Survey of Tanganyika (1962)
[b] own data
[c] data from Rufiji Basin Water Office



Groundwater dynamics

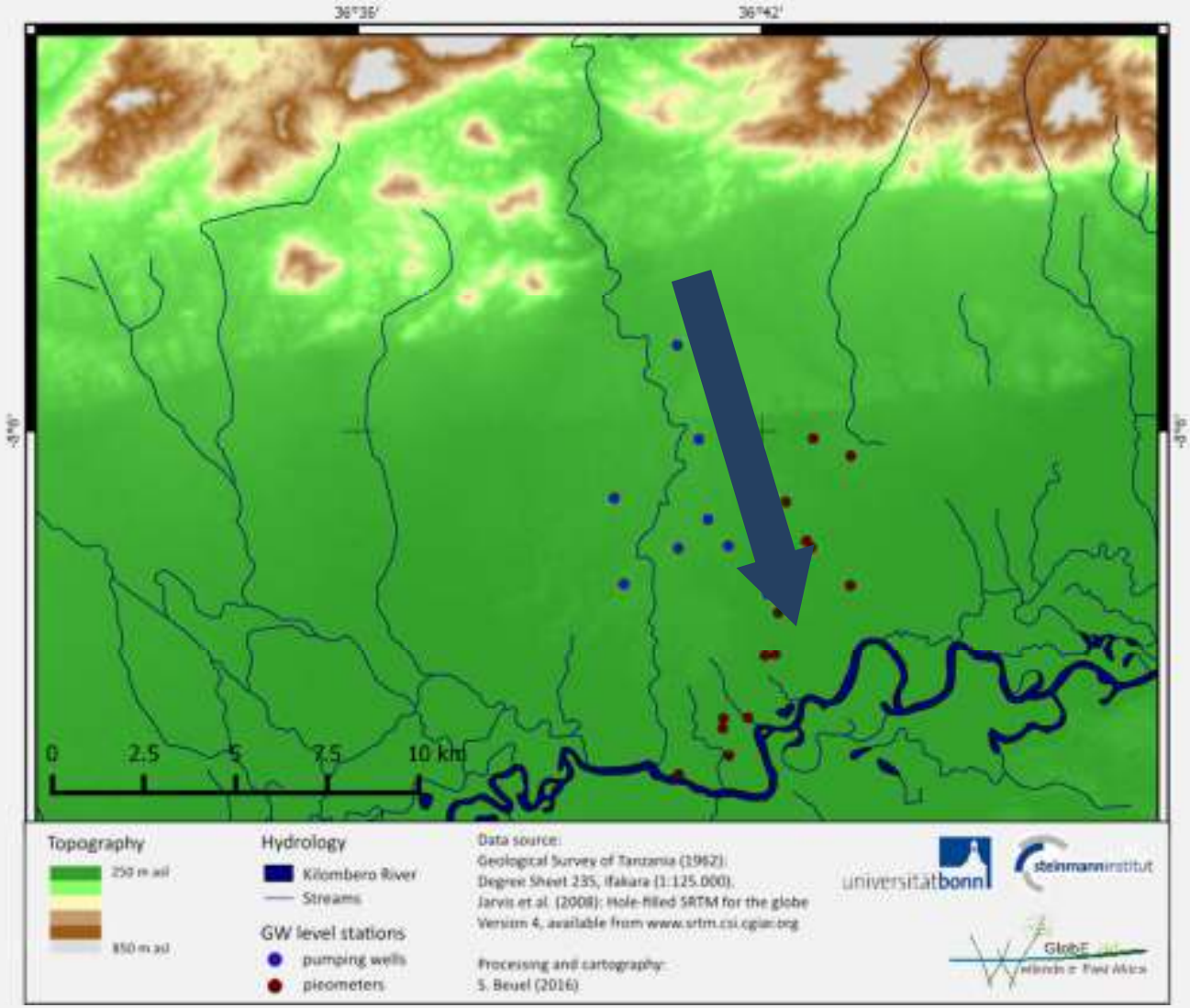
Analysis of…

1) Aquifer structure

2) Groundwater dynamics

3) Water composition

- ✓ **major groundwater flow direction from NNW to SSE (rainy and dry season)**
- ✓ **no indirect groundwater recharge**
- ✓ **contribution of groundwater to wetland water**



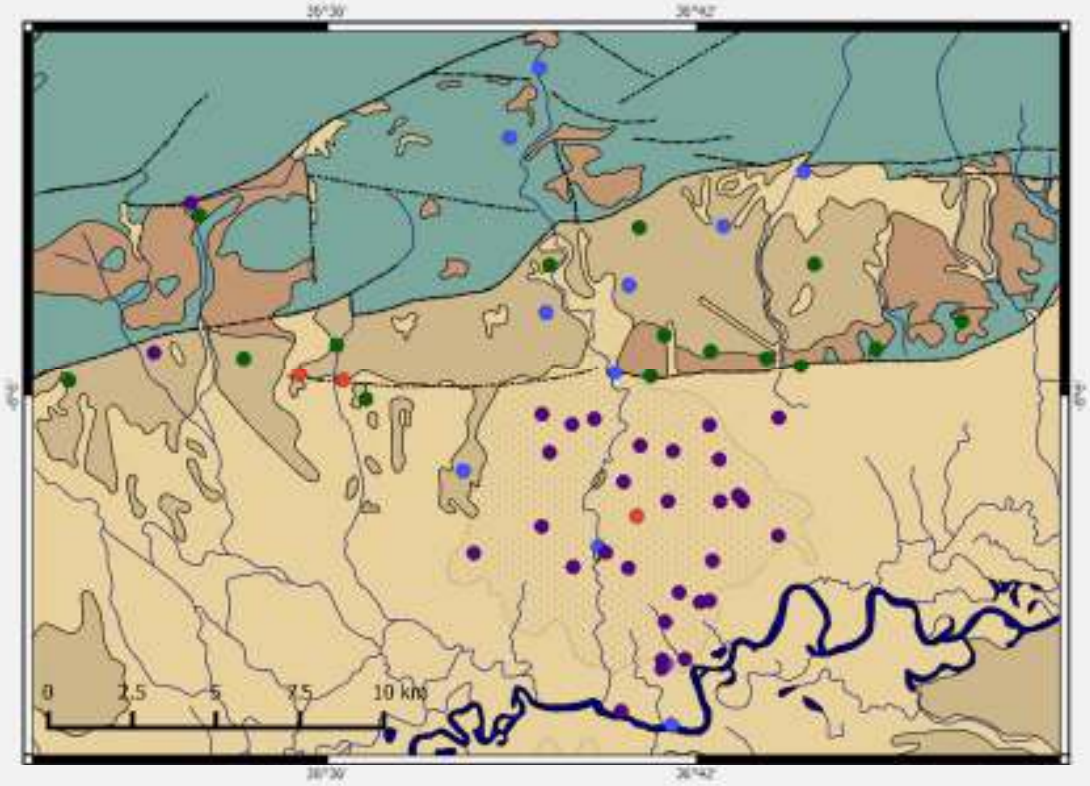
Water composition

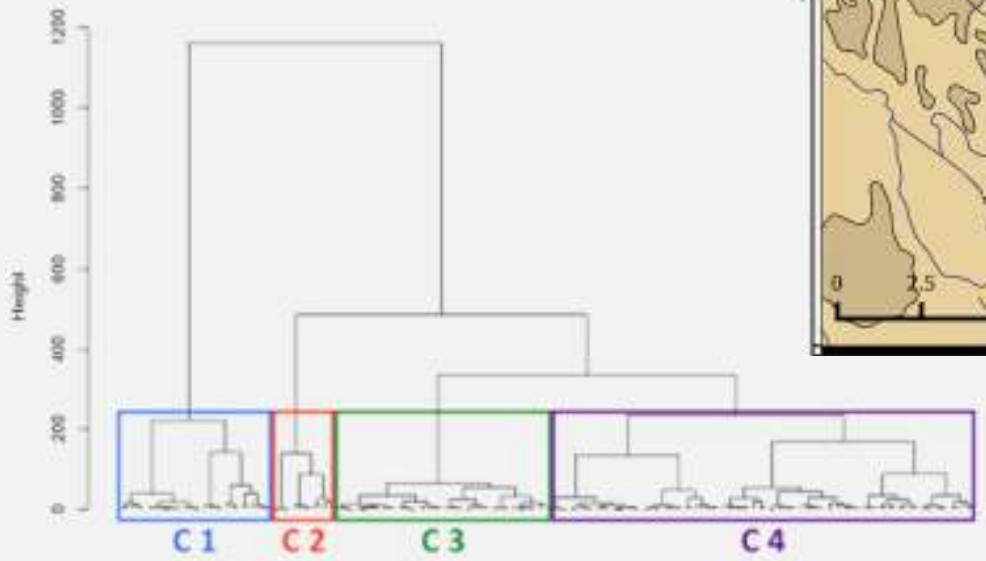
Analysis of…

1) Aquifer structure

2) Groundwater dynamics

3) Water composition





C 1 - surface waters

C 2 - anthropogenic influenced groundwater

C 3 - groundwater mountain fringe

C 4 - groundwater alluvial sediments

- ✓ **major process controlling hydrochemistry – silicate weathering**
- ✓ **no significant temporal variability in hydrochemistry of groundwater**

Water composition

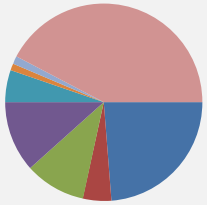
Analysis of…

1) Aquifer structure

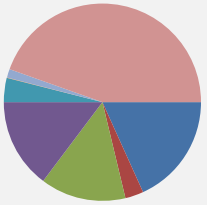
2) Groundwater dynamics

3) Water composition

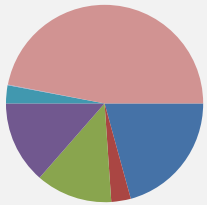
Kilombero river
EC: 43 µS/cm



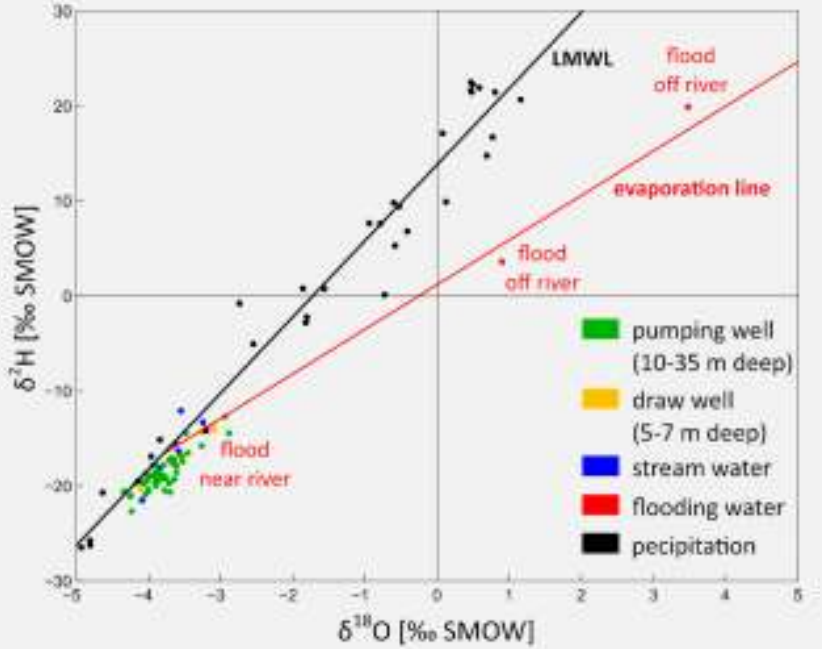
Flood near river
EC: 72 µS/cm

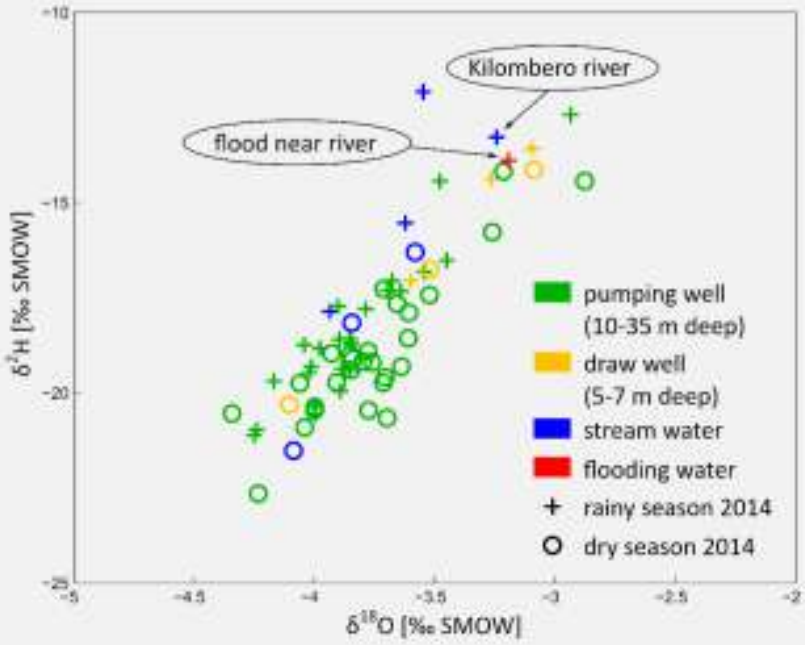


Flood off river
EC: 413 µS/cm



Cl^- NO_3^- SO_4^{2-} HCO_3^- Na^+ K^+ Mg^{2+} Ca^{2+}





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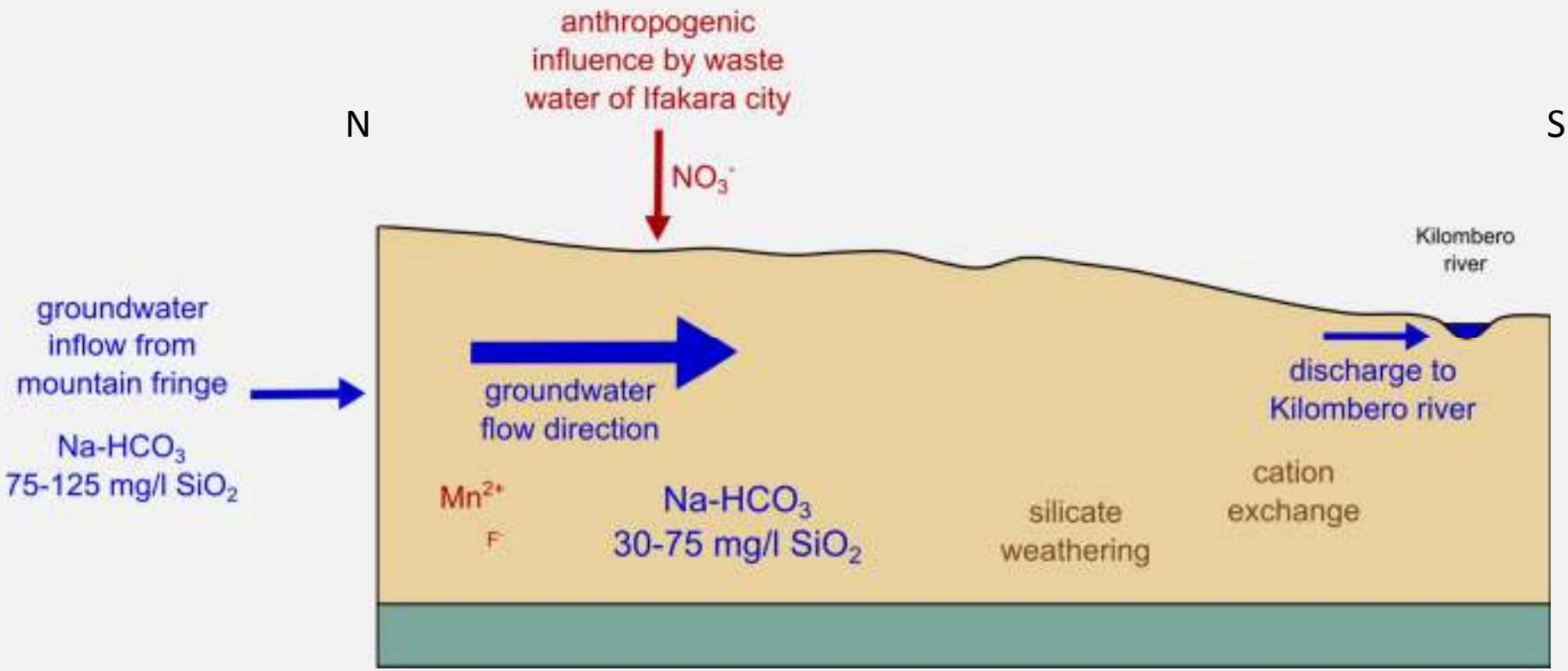
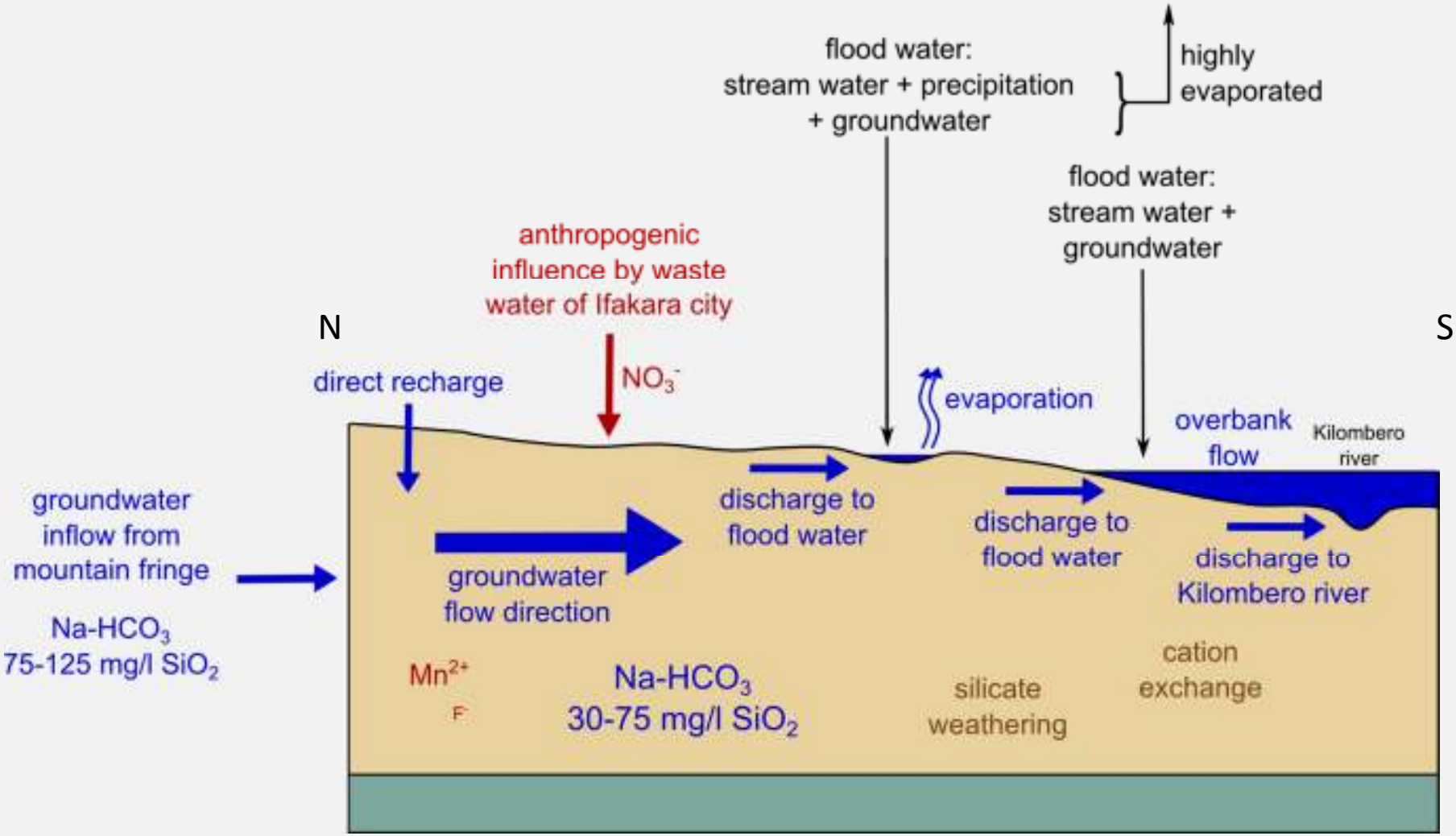
GlobE

Ifakara Tanzania - dry season



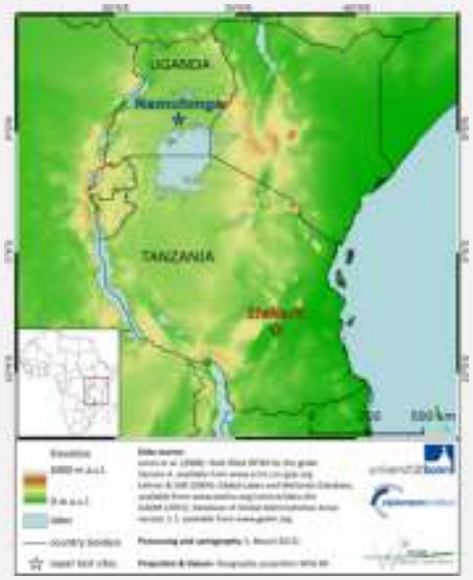
Ifakara Tanzania - rainy season

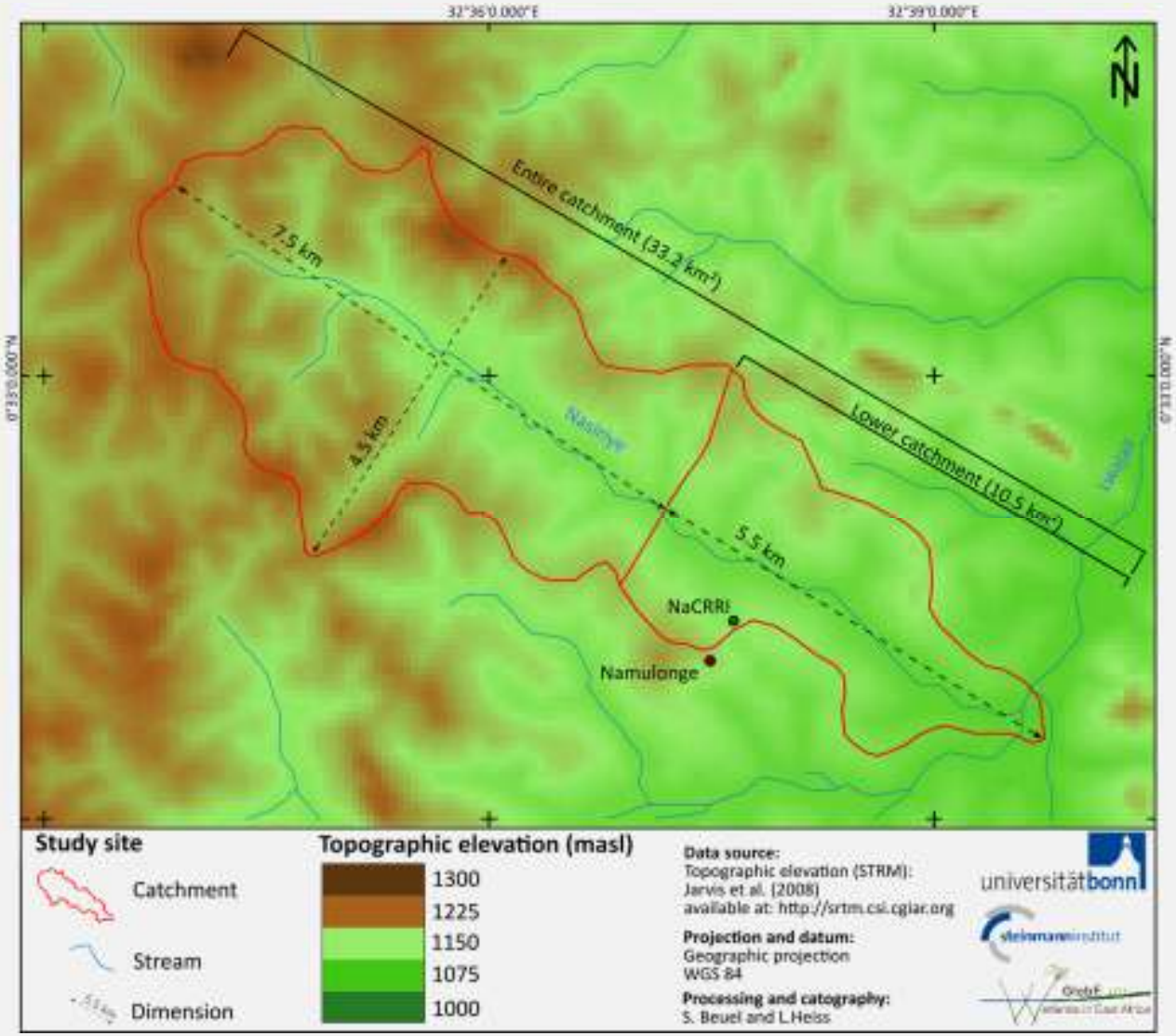


Study site - Namulonge

Namulonge

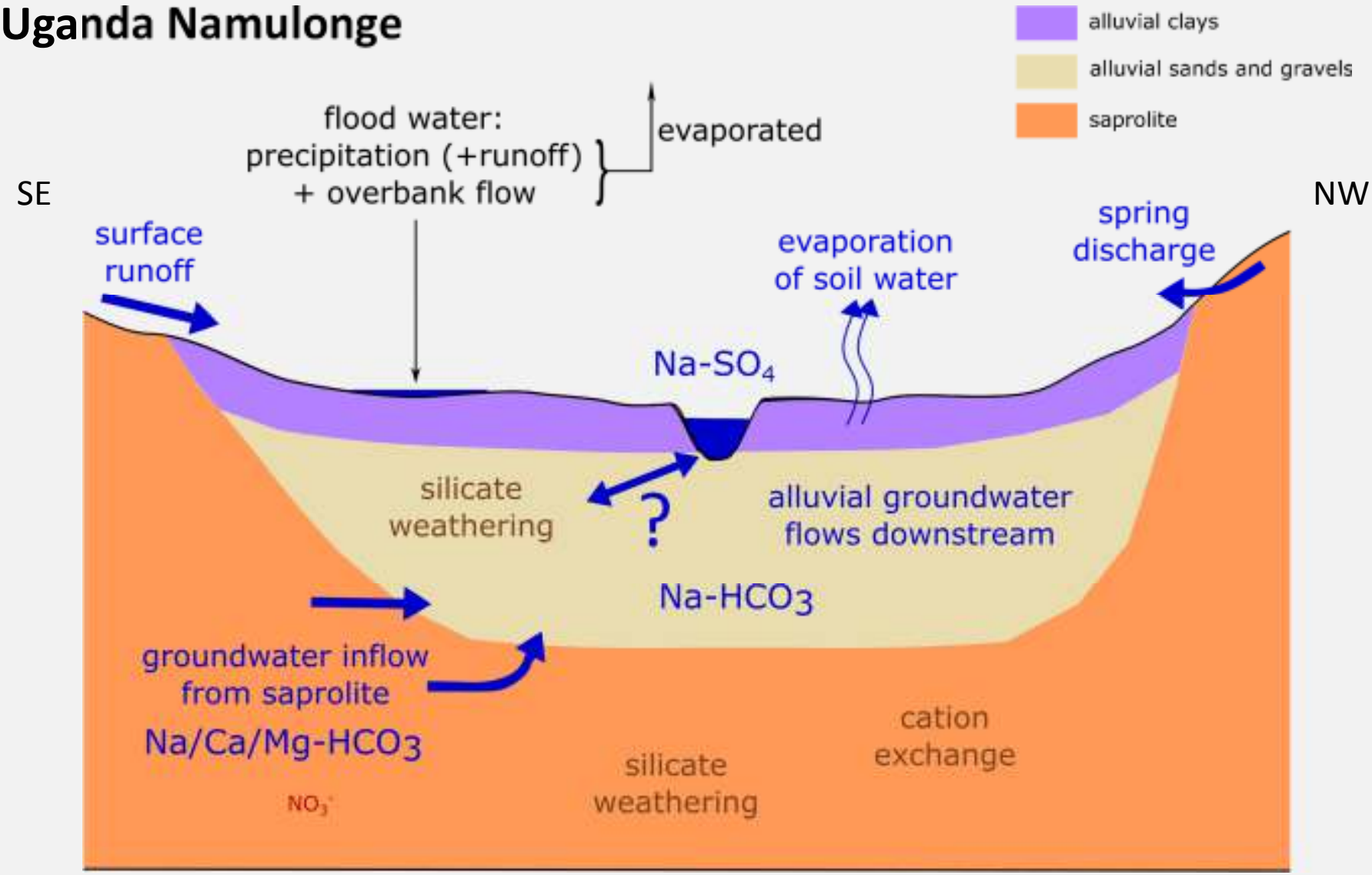
- small valley bottom wetland
- precipitation: 1300 mm/a
- sporadic flooding



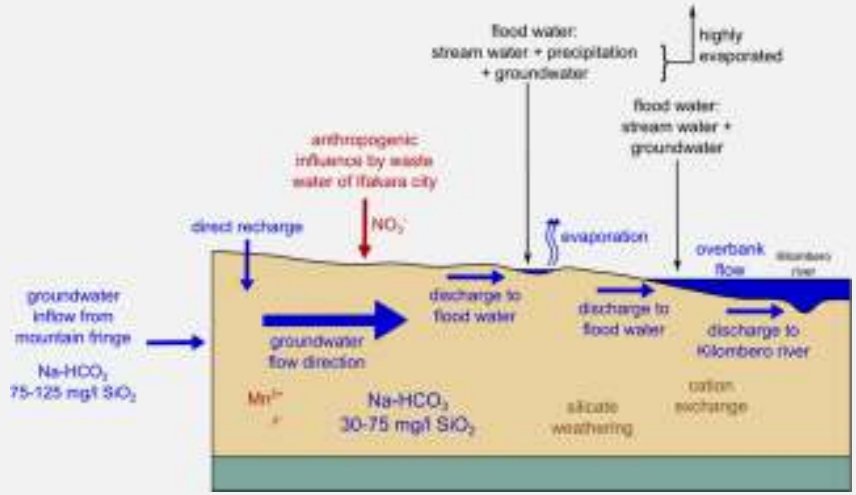


Conceptual models

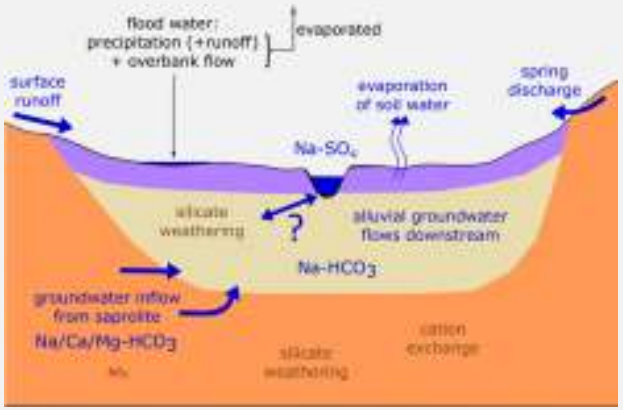
Uganda Namulonge



Conclusions



Ifakara



Namulonge

Two different hydrogeological regimes, similar major flow processes

- Both discharge areas
  - Groundwater contributes to wetland water in terms of quantity and quality
  - Groundwater is not very vulnerable to fertilizer input

Thank you very much for your attention!

Special thanks to….

…. Cissy Akoth, Mathias Behangana, Tina Geißler, Laura Heiß, Francis Kisumu, Katharina Liedtke, Ivan Lyatumi, Salome Misana, Robert Mutebi, John Sama, Michael Ugen, and Martin Ziegler