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# Using Sentinel data to support hydrological modelling in data scarce regions

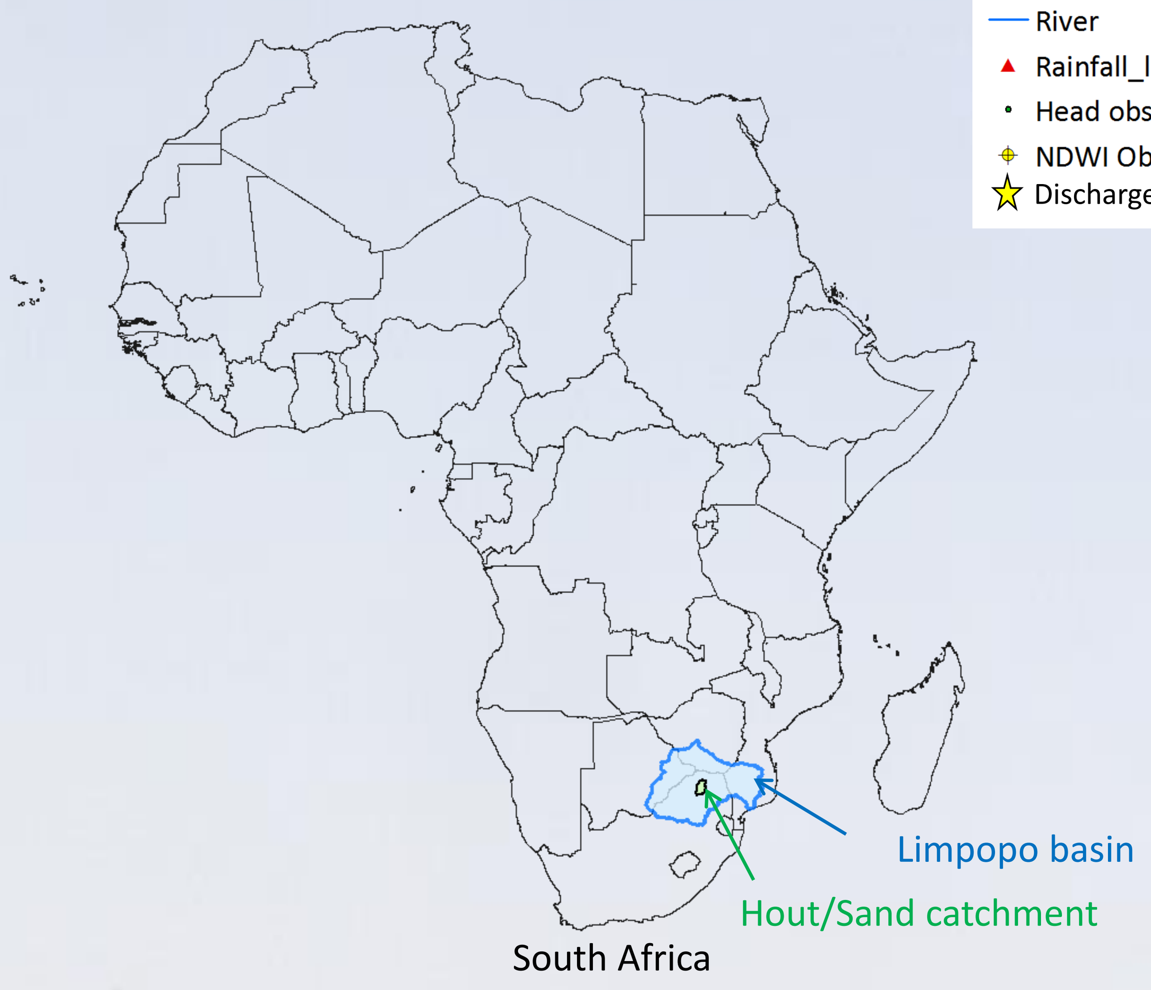
Rena Meyer[1]*, Wenmin Zhang[1], Rasmus Fensholt[1], Karsten Høgh Jensen[1]

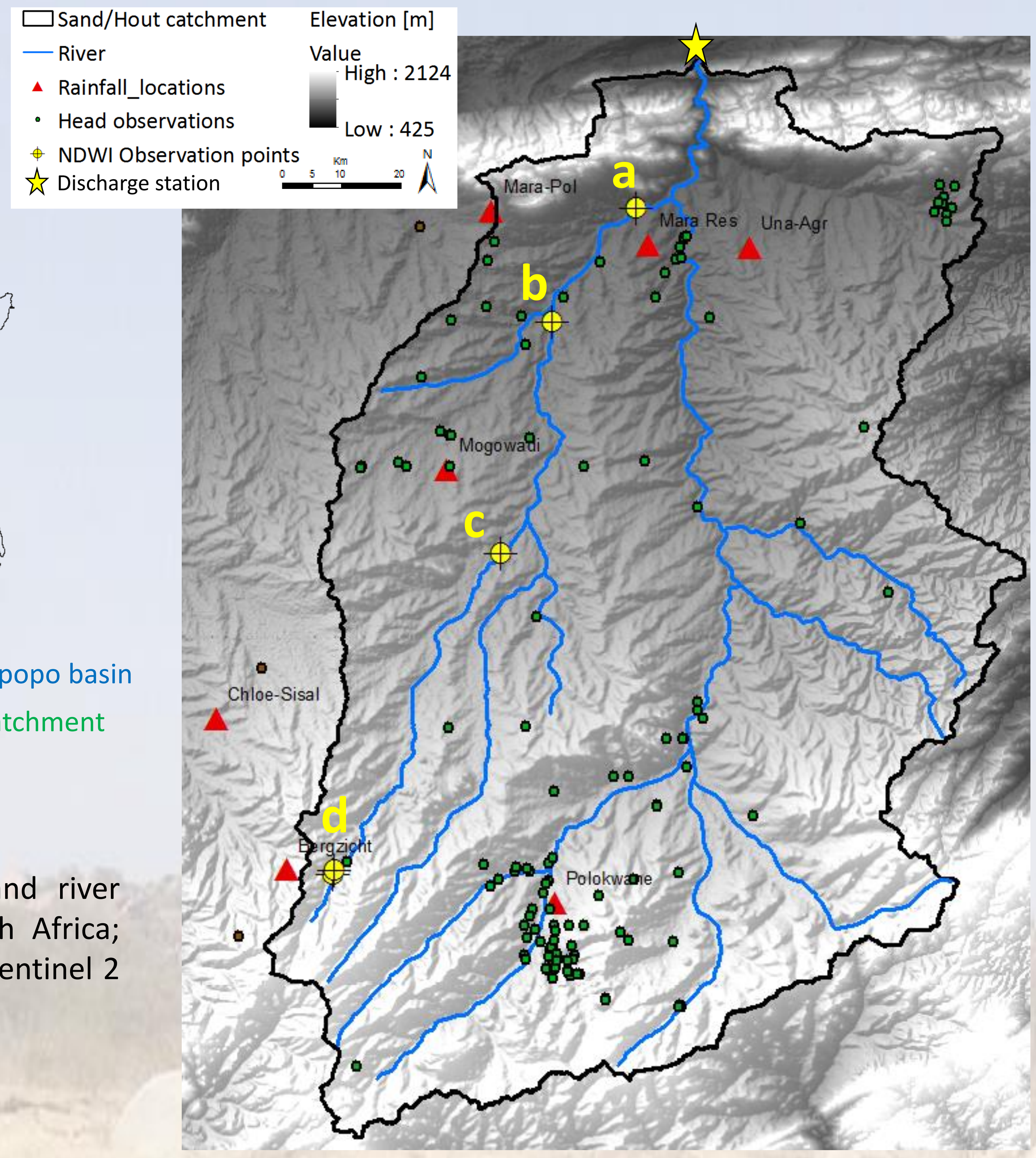
[1]Department of Geosciences and Natural Resource Management, University of Copenhagen, Denmark (*correspondence: reme@ign.ku.dk)

## Abstract

Integrated hydrological modelling of large catchments in remote areas is often challenged by scarcity of observation data. In the present study we investigate the use of Sentinel data that provide high temporal and spatial resolution, to identify flow in an ephemeral river system, the 7730 km$^2$-large Hout/Sand catchment, located in the North East of South Africa. In this region, groundwater resources form the major part in water supply for public demands and agricultural production which is an important economic sector with a dramatic increase of water demand. To enhance the sustainability of groundwater use and support local water management, a distributed integrated hydrological model (MikeShe) is applied to investigate groundwater recharge and flow processes. Rainfall occurs only event-based and as a result groundwater recharge is highly uncertain. Recharge mechanisms comprise focused recharge from the ephemeral river after rain events, diffuse recharge and irrigation recharge. Normalized difference water index (NDWI) are calculated from Sentinel 2 data to identify surface water in the river system. The location and extent of the surface water are used 1) to locate a field investigation site and 2) to calibrate and validate the integrated hydrological model based on time-series analysis.

## Material & Methods




Figures 1 & 2: Investigation area: the Hout/Sand river catchment is located in the North East of South Africa; available observation data is indicated as well as Sentinel 2 observation points (a-d).

### Catchment characteristics:

- 7700 km$^2$ area; wet season Oct-April; dry season May-Sept
- Water supply for domestic, agricultural and industrial use depends on groundwater
- Agriculture major economic sector depends on groundwater for irrigation
- Rainfall occurs only event-based → ephemeral river flow
- Groundwater recharge processes are highly uncertain → sustainable groundwater use?
- Scarce observation data

### Objectives:

- Use Sentinel 2 – derived water indices to identify river flow to:
  1) support identification of possible field investigation areas
  2) validate regional hydro(geological) model
- With the aim to better understand and quantify recharge mechanisms in order to enhance sustainable groundwater management.

### Methods:

Modified Normalized difference water index (mNDWI) [1, 2]:

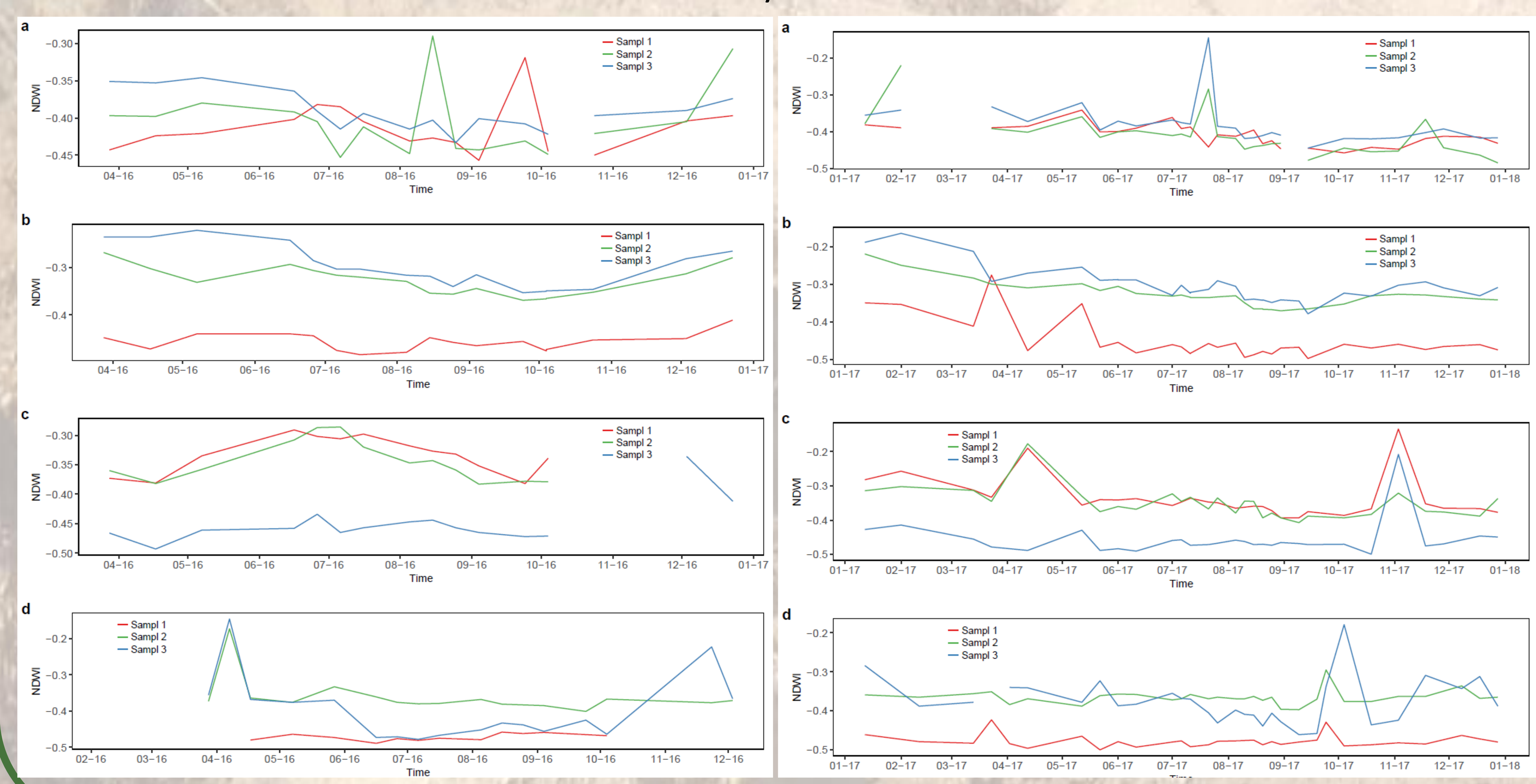
$$mNDWI = (green - MIR)/(green + MIR)$$

mNDWI relative to average of dry season ($mNDWI_{dry}$) [3] :

$$\Delta mNDWI\ (\%) = \frac{mNDWI_{dry} - mNDWI}{mNDWI_{dry}} * 100$$

## First Results

- Water index analysis shows a negative mNDWI at all locations throughout the years 2016 and 2017 (Figures 3 & 4), → in principle no occurrence of water. Possible reasons: shallow, highly turbid river water. Therefore, time-series analysis of the relative change (ΔmNDWI) compared to the average of dry season values was conducted (Figures 5 & 6).
- At locations b and d clear relation between ΔmNDWI and seasonality, increase in wet and decrease in dry season for 2016 and 2017. At location c no clear relation to seasonality in 2016, but in 2017. At location a no relation to seasonality is observed in 2016 or 2017.



Figures 3 & 4: Variation of the mNDWI at the four locations (a-d) for the years 2016 and 2017.

Figures 5 & 6: Variation of the ΔmNDWI at the four locations (a-d) for the years 2016 and 2017.

## Next Steps

### More on Satellite Data:

- Investigate other high-resolution remote sensing products and indices that could potentially complement observations (e.g. soil moisture, land cover)
- Remote sensing-derived catchment-scale responses (e.g. GRACE) for model validation
- ... Ideas from the esa-course ...

### Field Investigations:

- Cross-section through the river to monitor water table fluctuation & conceptualize recharge mechanisms on a local scale

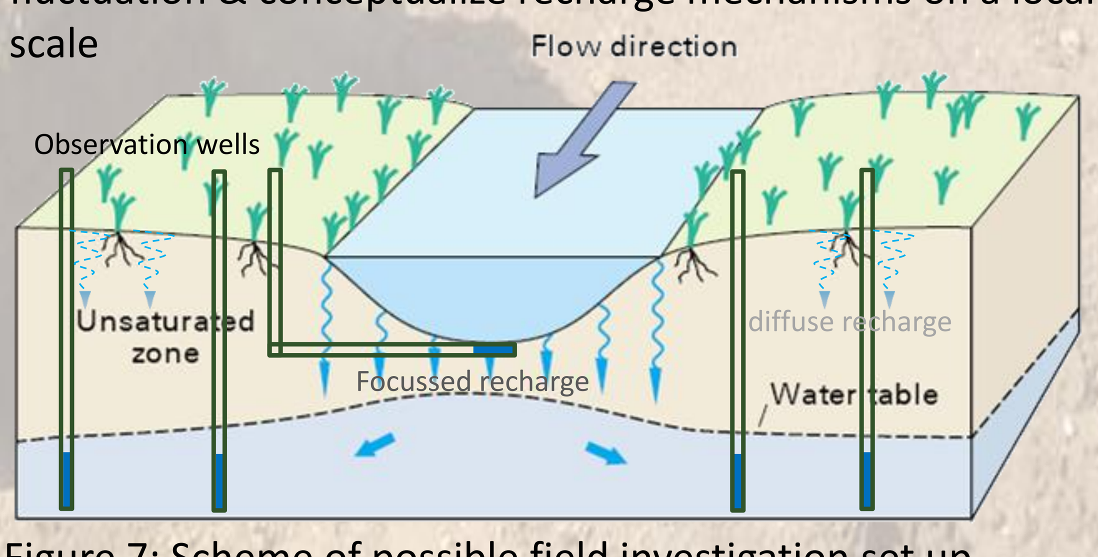



Figure 7: Scheme of possible field investigation set up.

### Integrated Surface-Subsurface Hydrogeological Model:

- Surface water-groundwater interaction
- Human activities (irrigation, abstraction)
- Catchment scale analysis & quantification of recharge mechanisms, water balances → sustainable gw management
- Input & validation complemented by remote sensing
- Scenario analysis

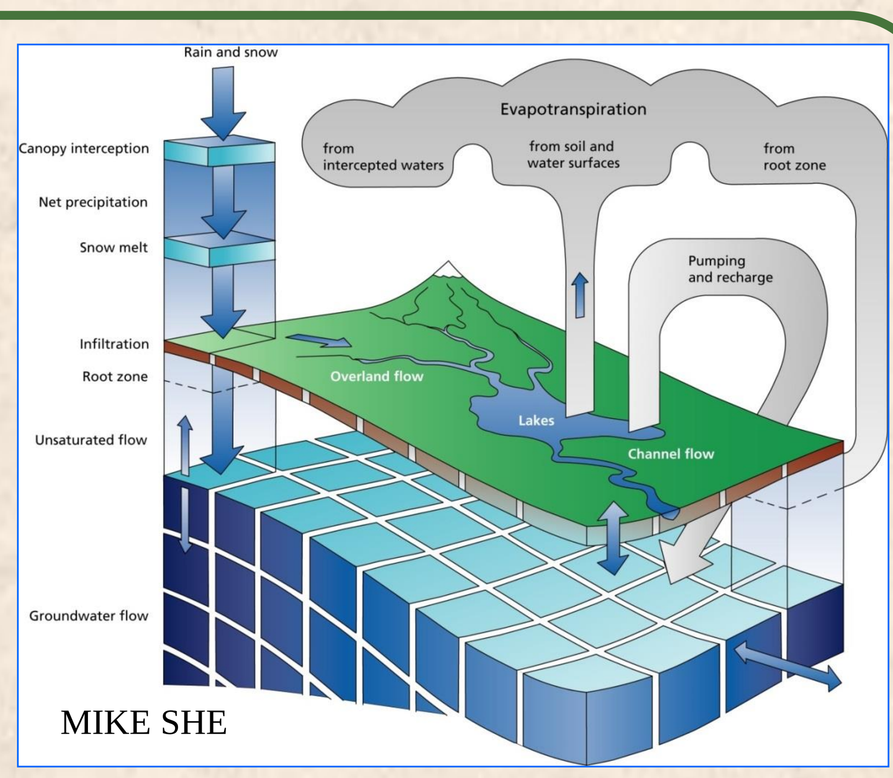



Figure 8: Scheme of integrated hydrogeological model MikeShe.

## References

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[3] Walker, D., Smigaj, M., Jovanovic, N., Kingdom, U., Resource, N. and Africa, S.: Ephemeral sand river flow detection from Sentinel-2 imagery : a new methodology, , 1–21, n.d.

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