The critical importance of multi-decadal groundwater level observations for informing robust climate change impact assessments: lessons from sub-Saharan Africa

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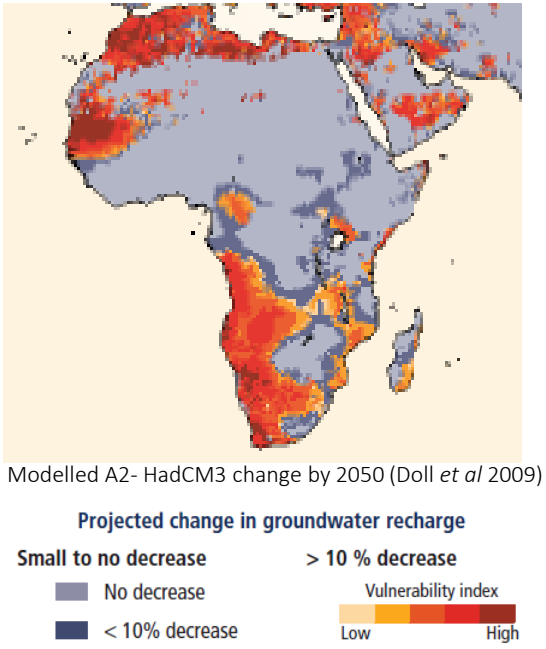
How might recharge change in the future?

- Groundwater is of fundamental importance to strategies for poverty reduction in tropical Africa
- Understanding the sustainability of more widespread groundwater abstraction for improving water and food provision is a key challenge
- The hydraulic processes governing groundwater recharge that sustains this resource, and their sensitivity to climatic variability and change, remain poorly constrained.



Modelled A2- HadCM3 change by 2050 (Doll *et al* 2009)

IPCC AR5 (2014): "*The uncertainties in projected groundwater recharge that originate in the hydrological models have not yet been explored*"

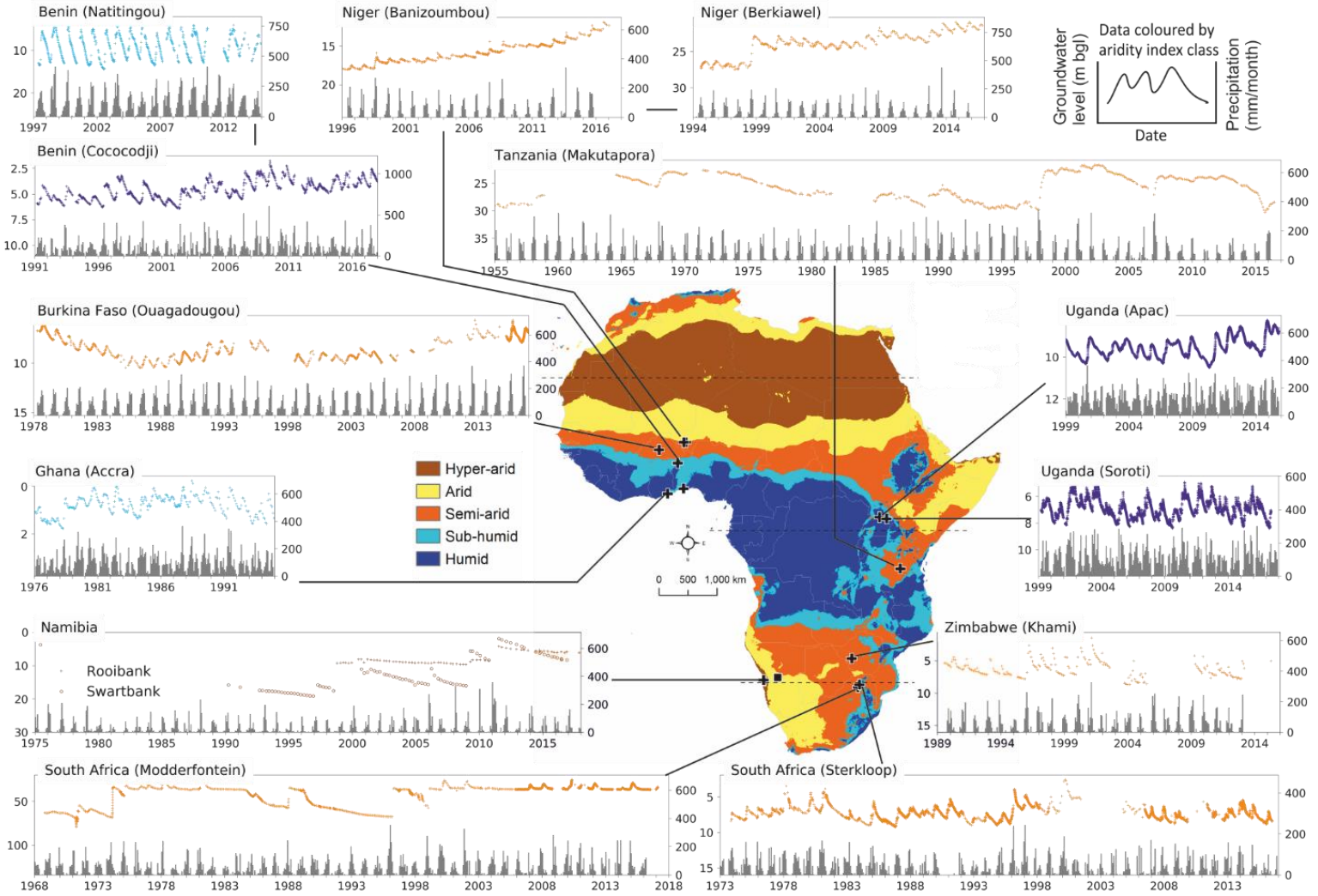
⇒ *Global hydrological models (GHMs) are not yet well validated against groundwater data*

⇒ *More research needed to quantify climate sensitivity of recharge from field data…..*

Empirical basis for recharge sensitivity in Africa

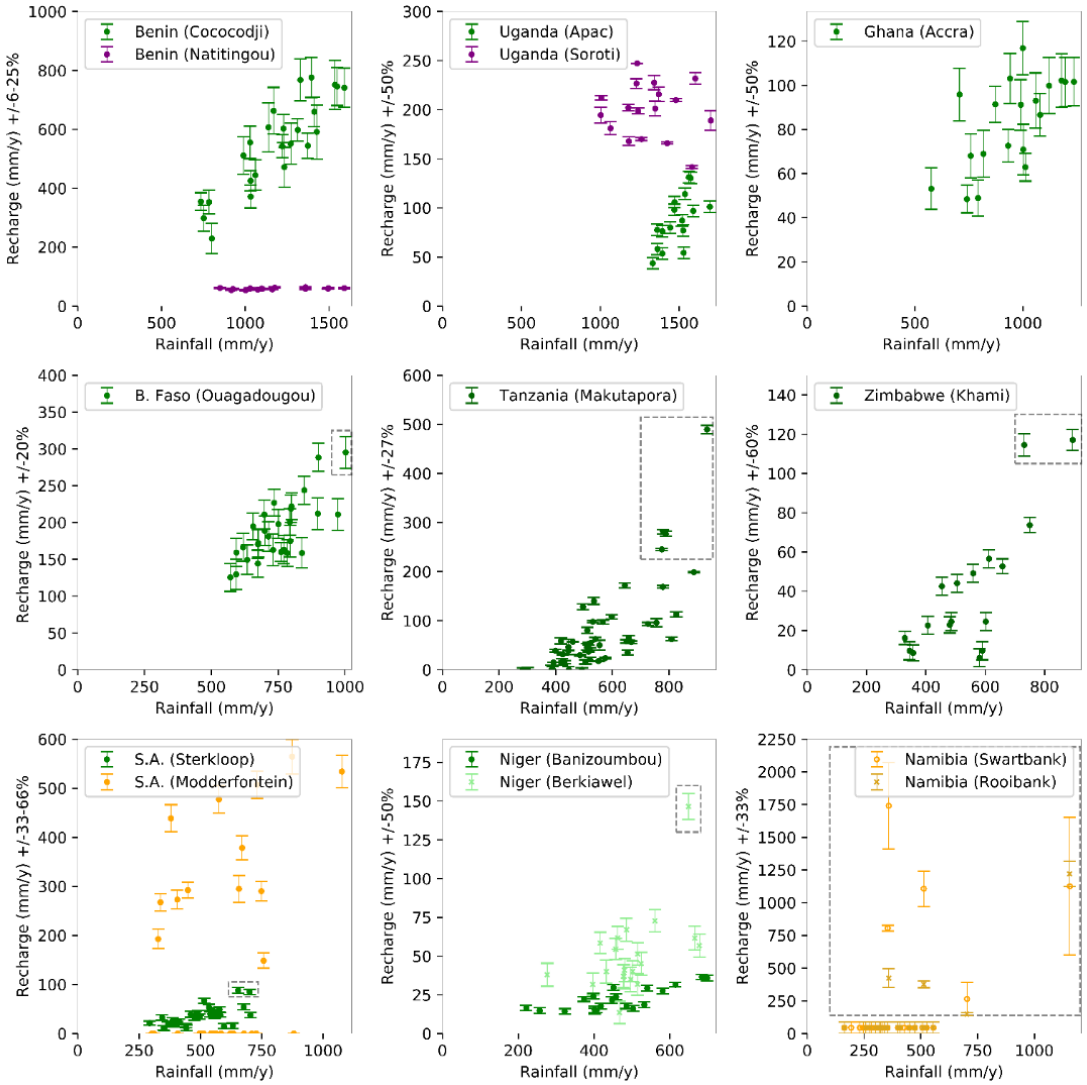
Here we present results from *The Chronicles Consortium* initiative, which has collated multi-decadal groundwater hydrographs and co-located rainfall records across tropical Africa to better understand climate controls, among others, on groundwater recharge.

https://www.un-igrac.org/special-project/chronicles-consortium



Cuthbert *et al.* (*2019*) https://www.nature.com/articles/s41586-019-1441-7

Empirical basis for recharge sensitivity in Africa



THREE TYPES OF Precipitation-Recharge SENSITIVITY:

1. **Consistent recharge despite large variations in precipitation**
2. **Increasing recharge above a threshold**
3. **Complex P-R relationships**

IPCC AR5 (2014):

*"Climate change is projected to reduce renewable water resources in most dry subtropical regions. (**robust evidence, high agreement**)"*

⇒ *Current IPCC consensus is questionable for drylands*

⇒ *Over-reliance on models unconstrained by field data*

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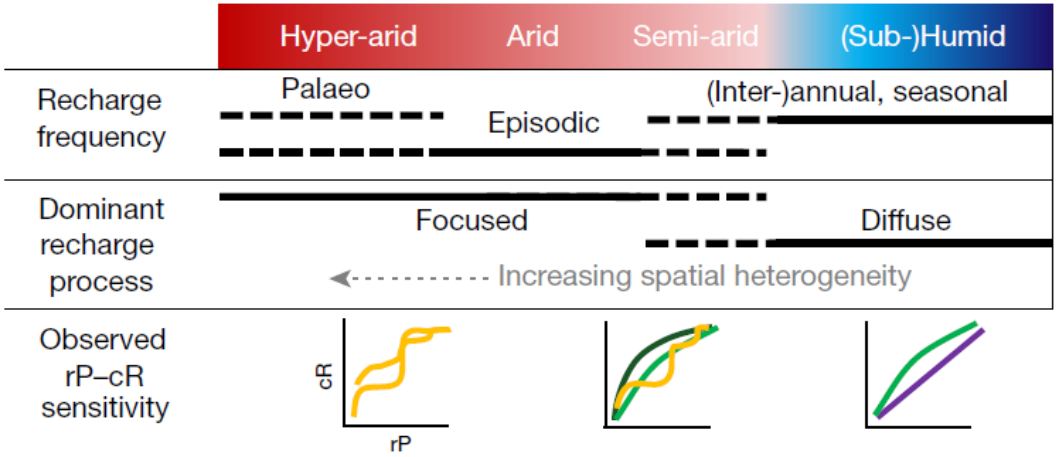
Summary

We find that recharge in more arid environments is generally highly dependent on infrequent large rainfall events causing focused recharge through losses during ephemeral overland flows.

This process is not included in any large scale hydrological or land surface models, and these events are often driven by synoptic climate controls, which are themselves poorly constrained in existing climate models.



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In more humid locations, we find surprisingly linear relationships between rainfall and recharge indicating an apparent lack of threshold behaviour that is embodied in most hydrological models and hypothesise this is due to prevalence of preferential flow processes in the soil zone.

While aridity exerts a strong control on the predominant recharge process, geological variations can dominate the observed sensitivity of recharge to climate variability.

Cuthbert *et al.* (*2019*) https://www.nature.com/articles/s41586-019-1441-7

TAKE HOME MESSAGES

- **Our results reveal the critical importance of long-term observational records for understanding the sensitivity of recharge to climate processes with implications well beyond Africa.**
- **This especially true in dryland environments where interpretations of short records would miss fundamental, episodic climate-controls on recharge expressed in longer records.**
- **We conclude that without a sound long-term observational basis for groundwater-climate sensitivity, climate change forecasts cannot be confidently constrained.**

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LETTER

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Observed controls on resilience of groundwater to climate variability in sub-Saharan Africa

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