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www.uni-potsdam.de/en/umwelt/research/hydrology-and-climatology

Hydrological Research:

Experiences and conclusions from the past four decades

Abschiedsvorlesung / Farewell Lecture

Potsdam, 20. Mai 2026

… there is always some development….

Pfalz, 1962

UP Bot. Garden, 2000

Foz do Iguaçu, Brazil, 2005

Golm, some day

Chile 2006

Ötztal, Austria, 2022

Roorkee, India, 2025

Peculiarities of hydrology

1. Water is absolutely fascinating … and a necessity for all life on Earth

=> The analysis and management of water resources are key issues for humanity

Morning evapo

Thunderstorm in Bavaria, 2016

on after a rainstorm,
pain, Sept. 2005

Blue Nile downstream Lake Tana, Ethiopia

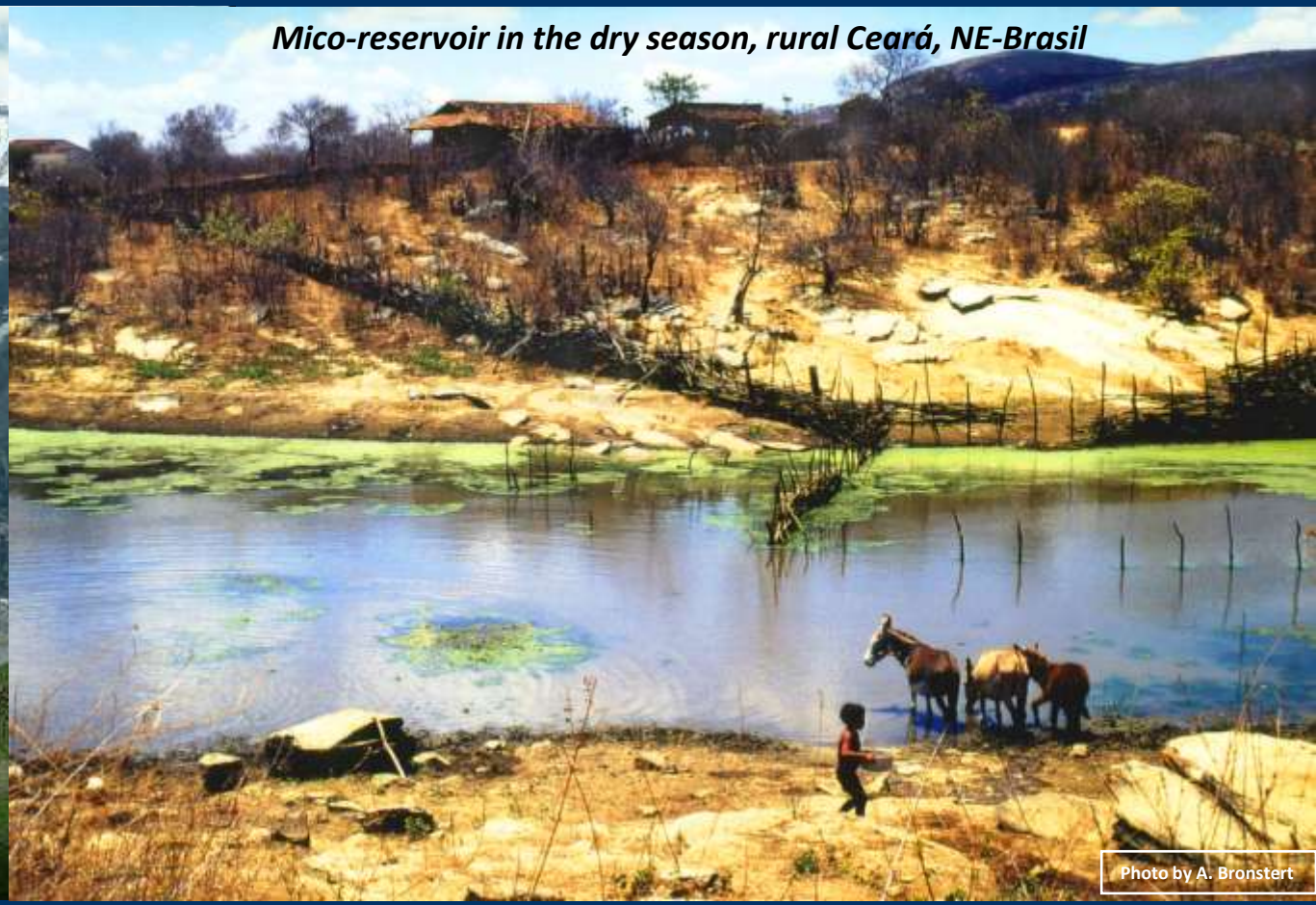
Braunsbach, Germany, May, 2016

Reservoir Spremberg during summer

Potsdam park during summer

Peculiarities of hydrology

2. There is particular variation in hydrological systems across regions and over time
   => Critical regions and periods are of particular interest



Peculiarities of hydrology

3. Water demand and use by humans and nature also vary greatly across space and time

   => Critical periods and regions are of particular interest

Potsdam

Bauern verzwe

Die Dürre sorgt für Ernteausfä
bereitet sich auf Finanzhilfen

Die Dürre trocknet auch Maisfelder a

Trockenheit in Brandenburg

Umweltminister stuft Lage in Gewässern als "super-ernst" ein

Video: Brandenburg aktuell | 12.08.2020 | A. Hewel & S. Schiller | Bild: rbb/Daniel Jore

13.08.20 | 12:23 Uhr

Brandenburg erlebt den dritten Dürresommer in Folge. Flussteile liegen trocken, Seepegel sinken, die Durchflussmenge der Spree ist auf einen Bruchteil gesunken. Umweltminister Vogel setzt nun auf ein Niedrigwasserkonzept. Es geht vor allem um eins: Wasser sparen.

Wassermangel in Brandenburg

Die Ausflugsseen verschwinden

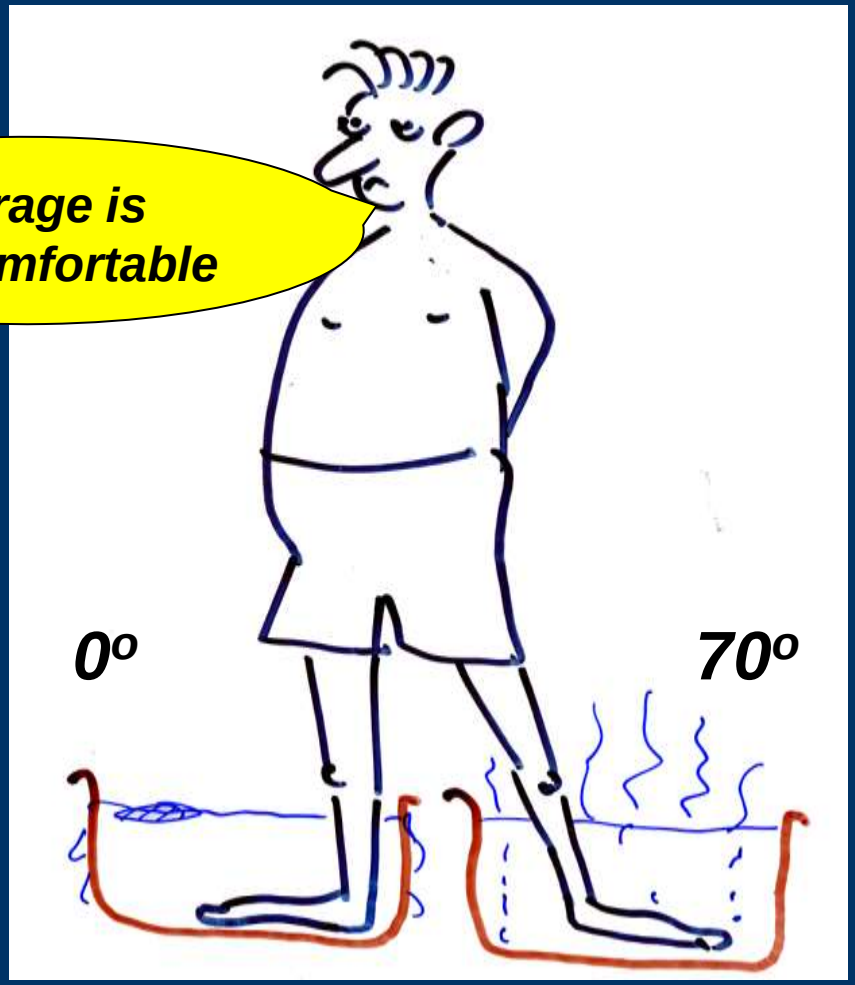
2020 war viel zu trocken in Brandenburg. Bäume wie Seen und Flüsse leiden unter
zunehmenden Trockenheit. Und sogar das Welterbe ist in Gefahr.

Der niedrige Wasserstand lässt sich erkennen: der Große Seddiner See (Potsdam-Mittelmark)
Foto: Patrick Pleul/dpa/picture alliance

POTSDAM *taz* | Preußenkönig Friedrich II. wird der Ausspruch zugeschrieben, mit der Trockenlegung des Oderbruchs habe er im Frieden eine Provinz erobert. Nun vergrößert sich die Landfläche

Peculiarities of hydrology

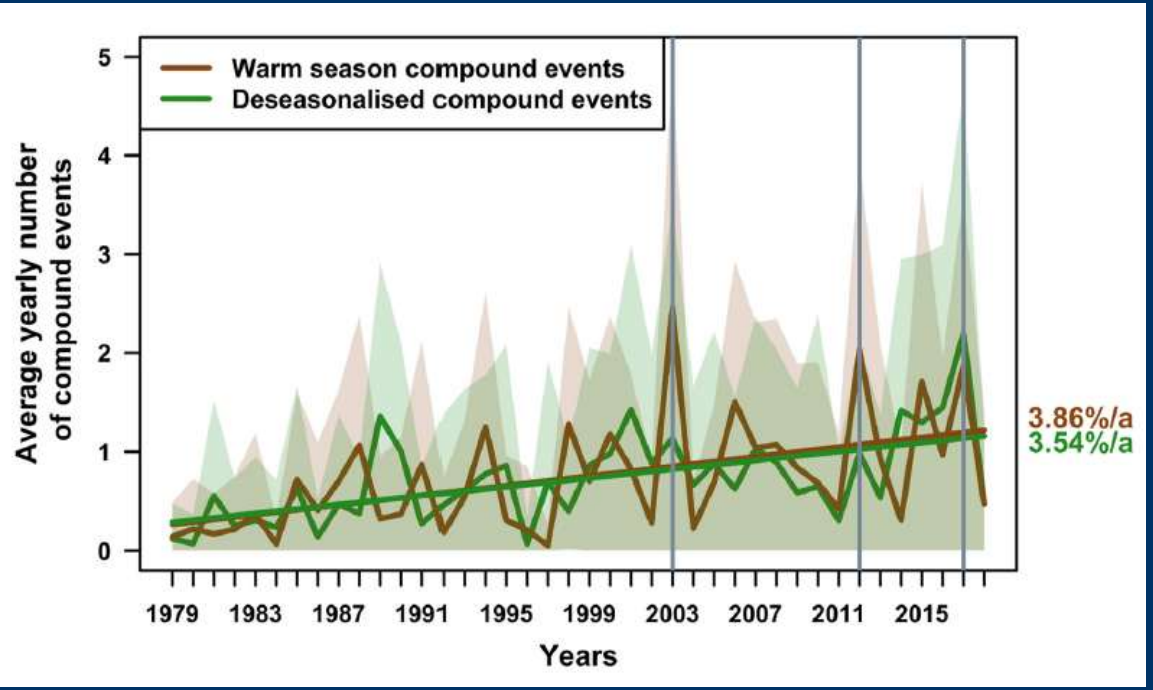
4. Hydrological risks, both hazards and vulnerability, require a probabilistic approach



from Wolfgang Kinzelbach

Peculiarities of hydrology

5. The terrestrial Hydrosphere is under change: Water management; land use; water engineering; warming climate … and, inter alia, interaction with the lithosphere (less known)



Chnages of compound-events“ (‚hot & dry‘) 1979/1998 - 1999/2018 in the Mediterranean region (Vogel, Paton, Aich, Bronstert; *Weather and Climate Extremes*, 2021)

Blatten, Switzerland, 28th May, 2025

Hykli-Research topics: organized by subject matter…

- **Particularly important hydrological conditions: semi-arid, mountainous, urban regions;**

Isábena catchment, Aragon/Catalonia, Spain, 2005

Jaguaribe basin, Ceará, NE-Brazil, 2006

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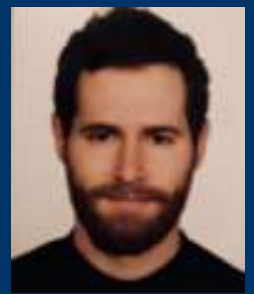
High-mountain hydro-met station, Hochjoch, 2018; Italy/Austria

Fundusbachs Valley, Ötztal Alps, Austria



MSc-Landschaftspraktika Ostalpen, Sept. 2023; Sept. 2008

Hykli-Research topics: organized by subject matter…

- **Particularly important hydrological conditions: semi-arid, mountainous, urban regions;**

Urban-hydrology test area Kreuzberg, Berlin

„Extra-urban“ area Reichenbach (near Würzburg), 2021

Hykli-Research topics: organized by subject matter…

- Particularly important hydrological conditions: semi-arid, mountainous, and urban regions; **but also groundwater-dominated, agricultural or forested landscapes; coastal regions; tropical areas…**

Große Grabenniederung, near Gülpe, Havelland, Germany

With scientists from Japan, near Gülpe, Havelland, Germany

Rain forest near Malalcahuello, South Chile

Dune breach at Hüttelmoor, Baltic Coast, Germany

Hykli-Research topics: organized by subject matter…

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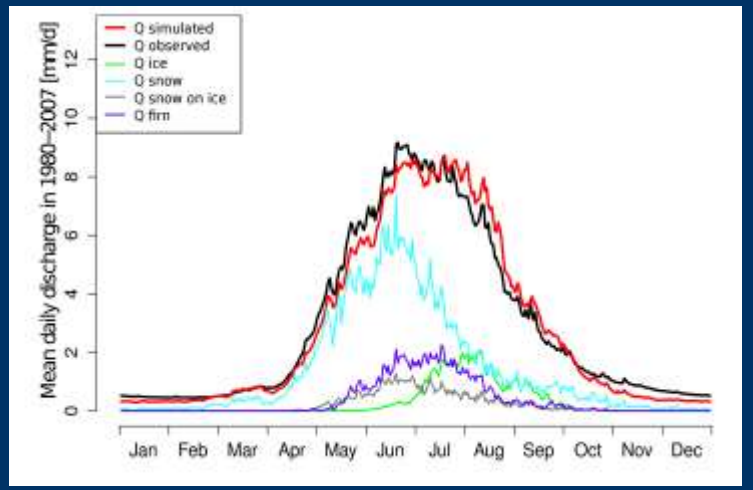
- **Water and sediment dynamics**

The „dynamic sediment cascade“, at Villacarli, NE-Spain

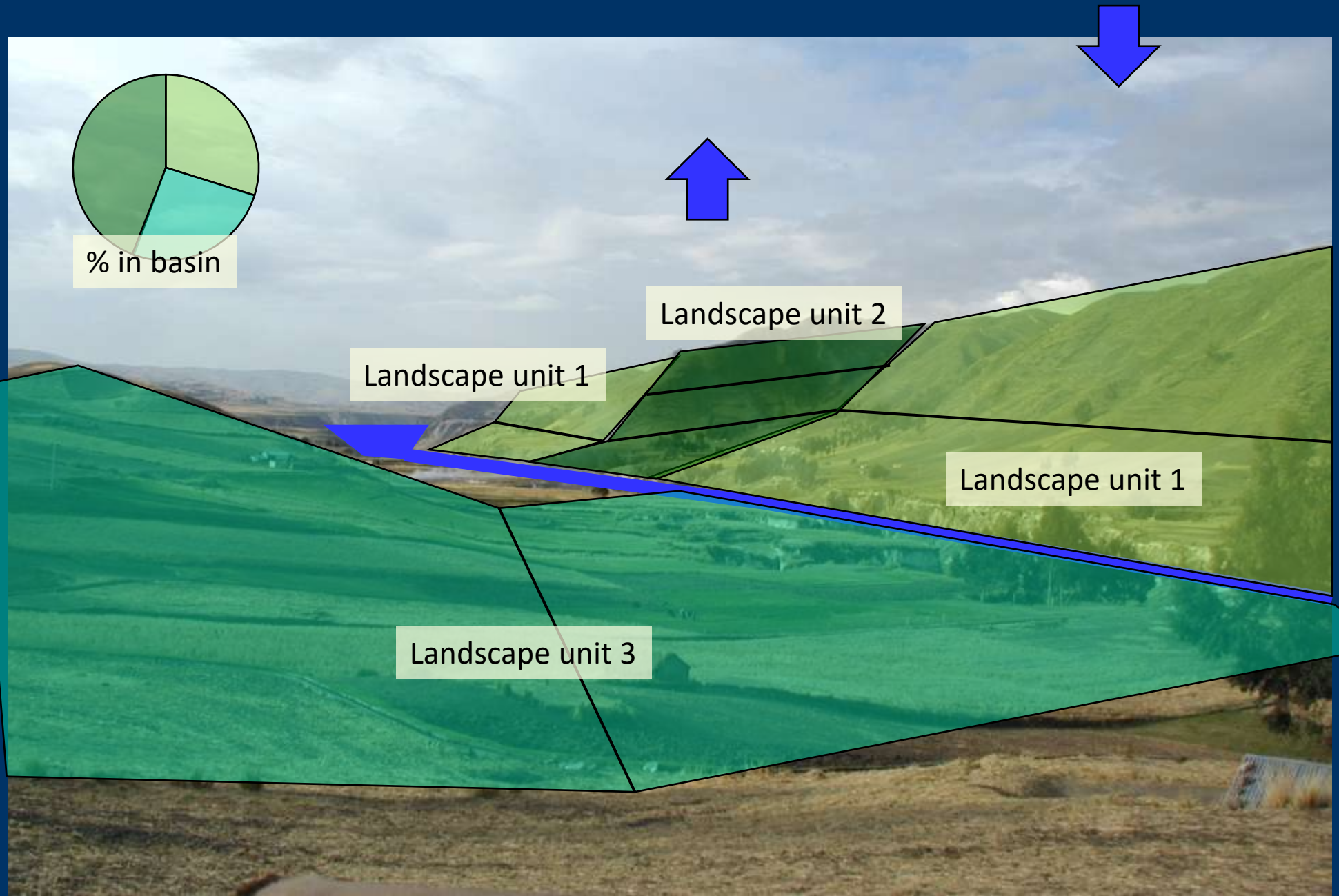
Sediment source areas after deglaciation. Vernagtferner, Tyrol, Austria

Deposition of suspended sediments in the Barasona reservoir, Èsera River, Spain

Discharge of Ötztaler Ache, Tyrol, Austria: simulations of different runoff components



The Wasa-Sed Model: a development over > 20 years



Hykli-Research topics: organized by subject matter…

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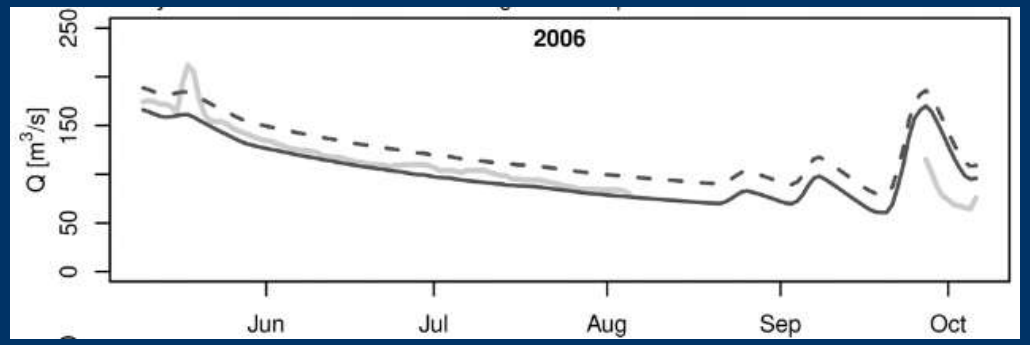
- Water and sediment dynamics
- **Water cycle: potential uses, system changes (including but not limited to climate change), systems interactions**

The Sao Francisco River Basin, Central Brazil …

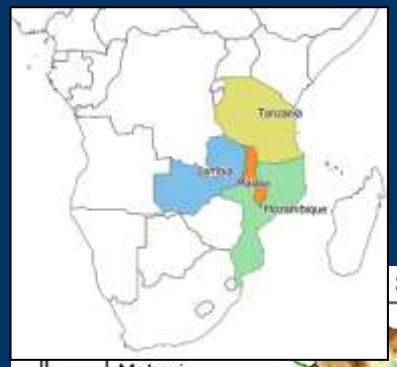
- 641,000 km²; 2,900 km; 13 million inhabitants
- SW – most developed Region of Brazil, NE – less developed
- part of Brazilian “drought polygon”
- water resources heavily managed by reservoirs and water diversions
- land surface is intensively used by mining and agriculture
- Upper part of the basin, located in Minas Gerais, yields 75% of runoff
- ~50 hydro-electric power plants
- siltation - a major issue for water and electricity management: e.g. the Cachoeira Dourada reservoir lost ca. 40% volume in 50 years

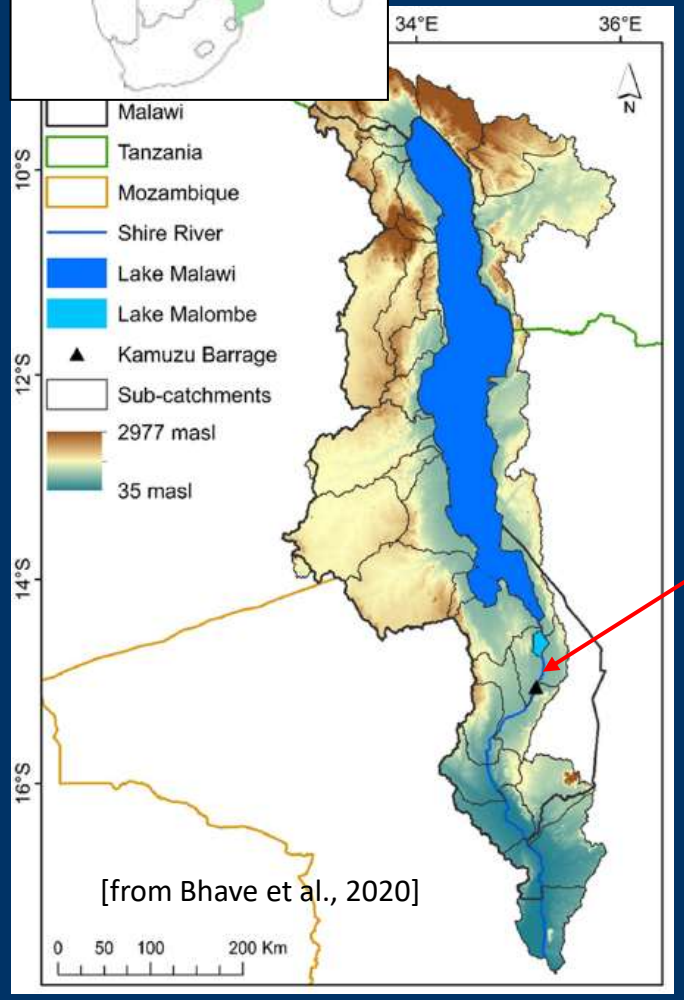


Modelled (black) and observed (grey) discharge with (solid) and without irrigation (dashed) for sub-basin 15 in the dry season of 2006

Lake Malawi Basin, Malawi and Tanzania, SE-Africa…

Lake Malawi and its catchment area:
A socio-economically important but fragile hydro-system in the tropics

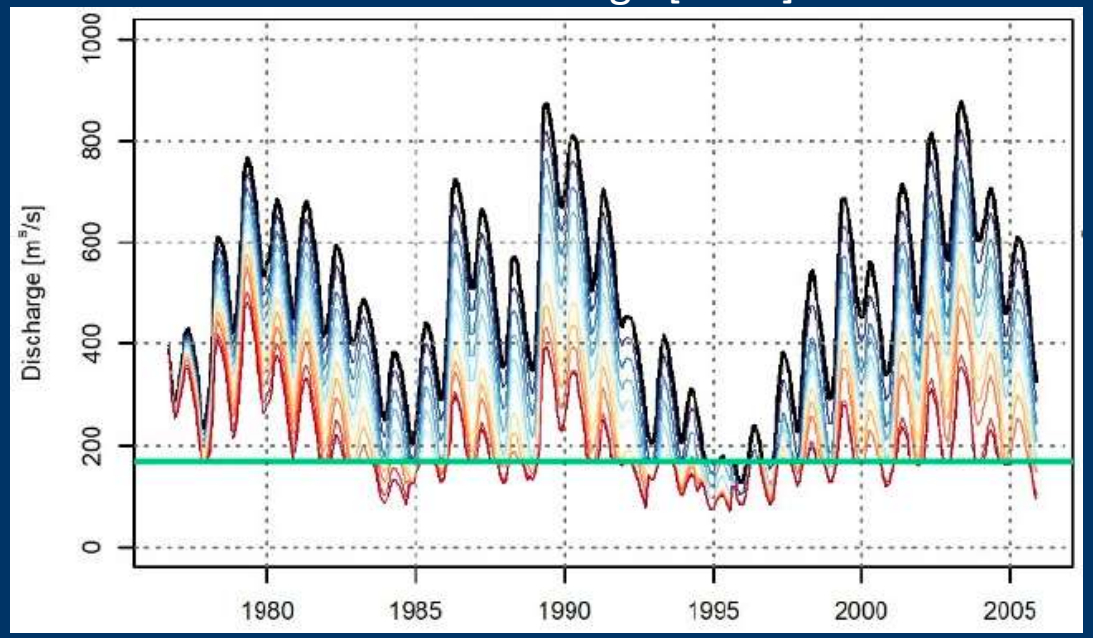




[from Bhave et al., 2020]

- 2. largest lake of Africa
- 95.750 km² (catchment); 28.750 km² (lake surface)
- ***Lake feeds the Shire River at the lake-outlet***
- ***Shire River produces alle electricity of Malawi***
- Below 471 m.a.s.l.
  ➔ no more river discharge

Shire River discharge [m^3s^{-1}]



[Mtilatila et al., 2020, Hydrology]

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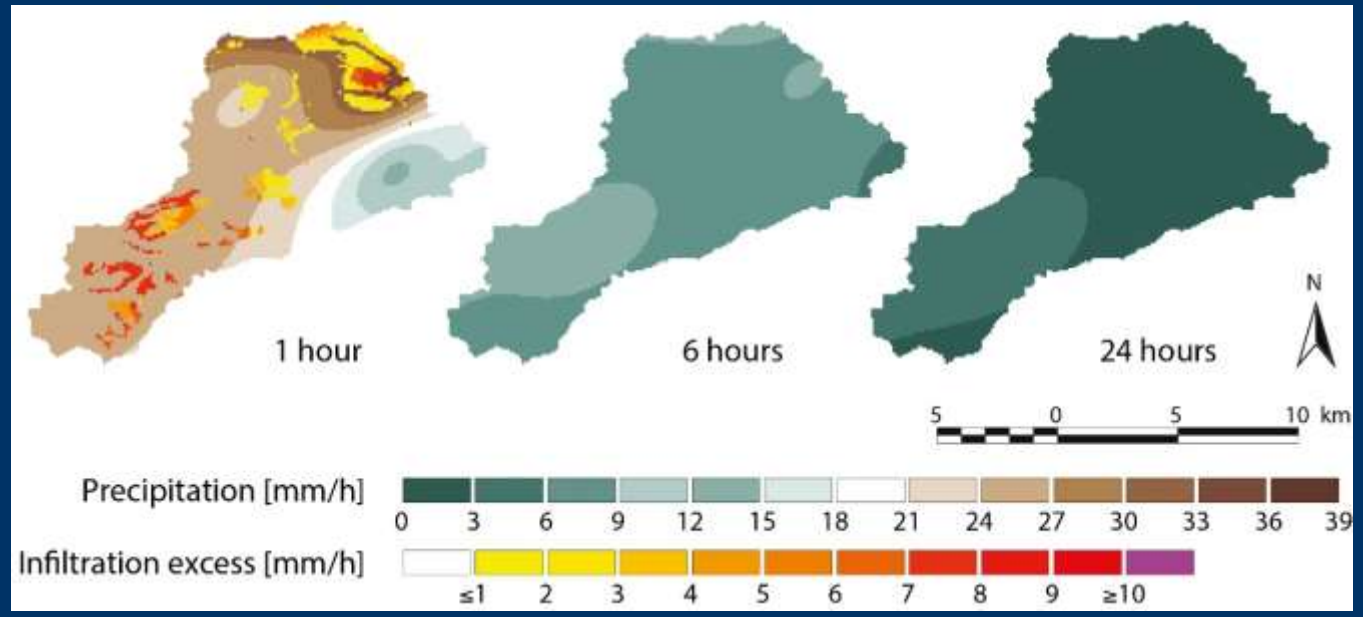
- Water and sediment dynamics
- Water cycle: potential uses, system changes (including but not limited to
  systems interactions
- **Hydrological extremes: understanding, predictions, simulation chang**

- **NatRiskChange: DFG-funded Research and Training Group: 2015 - 2024**

Hydrological predictions: Frankenbach flash flood study

New knowledge is generated by combining field research, data analysis and modelling



Simulated infiltration excess (IE) rates in the Lein catchment during the flash flood event of 28.6.1994: Temporal resolution: 1, 6, 24 hrs; Yellow, reddish and pink colours in the left panel denote the maximum IE-rates. The pattern of max. rain intensities is sketched in the background in olive colours (Bronstert et al., 2023).

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- Water and sediment dynamics
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- Hydrological extremes (floods or droughts): understanding, predictions, simulation changes
- **Something special: “forensic hydrology”; “disturbance hydrology”**

Forensic Analysis of the Braunsbach Flash flood at 29. May 2016

(A_C = 6.3 km²)

before

during

after

$Q_{reconstructed}$: ~ 120 m³/s ⇔

"Q_{100}": ~ 12 m³/s (design value)

➔ Food for thought

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- Hydrological extremes (floods or droughts): understanding, predictions, simulation changes
- Something special: “forensic hydrology”; “disturbance hydrology”

All these questions require suitable data and methods:

➔ **Data collection (in the field)**

➔ **Hydrological modeling (in our work, mostly “process-oriented,” at various scales)**

➔ **innovative data analysis (e.g., rain radar; reservoir levels; suspended sediments; measurement campaigns; data pools (with gov. agencies and others); rem. sensing**

Some final numbers…

Lehrstuhl für Hydrologie und Klimatologie („HyKli“)

www.uni-potsdam.de/en/umwelt/research/hydrology-and-climatology

successful doctoral thesis and defences (since 2001)

- 31 (+7) as main supervisor (28,5 funded from external project money)
- 66 as 2nd supervisor / evaluator

Successful Diploma- and Master-thesis: 73, since 2000

37 externally funded research projects (since 2000)

Funding organization	number of projects	approx. €	staff #PhD-students	staff #Postdocs		Remarks
BMBF	7	3.350.000	7	4		
DFG	5	9.750.000	6	4,5		including NatRiskChange
Worldbank	1	200.000		1		
DAAD	6	800.000	6	0,5		
AvH-Foundation	2	200.000		2		guest scientists from India and Spain
VW-Foundation	1	80.000		1		
EU	3	750.000	2	2		
HGF	1	150.000	1			
UBA	1	300.000	2			
CNPq (Brazil)	2	300.000	2			
CAPES (Brazil)	1	150.000		1		guest professor from Brazil
Uni Potsdam	1	20.000	1			(from running institute's funds)
Brandenburg	1	35.000	1			
others*	5	100.000				**flexible funds (nice!)**
						* Danish Env. Agency, AlpS; Uni Innsbruck; Agro-Industry Assoc.; LfU Baden-Württemberg; International Office of BMBF
total	**37**	**16.185.000**	**28**	**16**		

…several more from other members of our working group

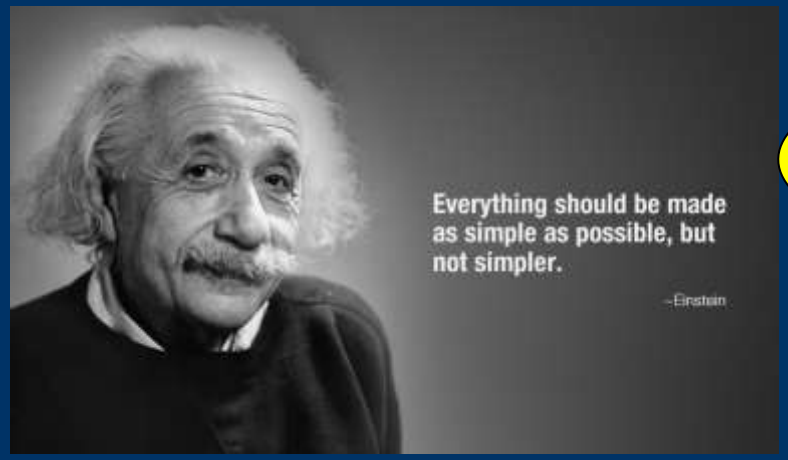
Conclusions: quo vadis hydrological science

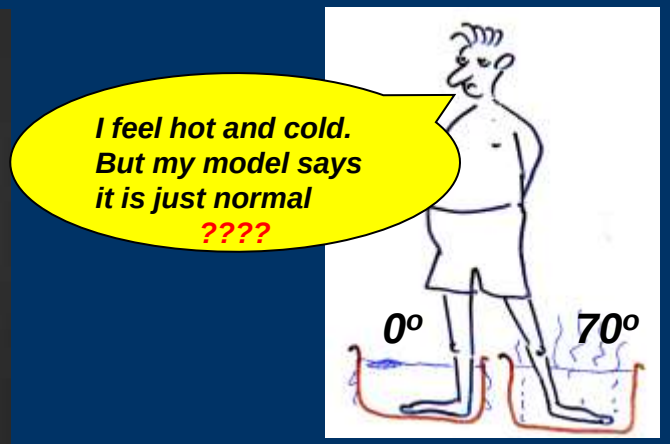
- The importance of hydrology (and other environmental disciplines) is based on practical questions.
- Therefore, we must provide answers to these questions - or at least aim to do so.
- The most important scale is the “management scale”
  (space: “meso-scale,” i.e., ~10 km^2 – 100,000 km^2; time: hours to decades)
- Regional <=> national <=> international
- Communication of questions, knowledge, data…, with people and policymakers

Conclusions: about methods…

- "Close observation" and a mechanistic understanding are key
- Simplify as much as possible but not more!!
- Caution: Averaging (or oversimplification) hides variability and hinders new knowledge
- One learns a lot from analysing extremes / „outliers"
- Links to related disciplines are key to new knowledge
- Disturbance Hydrology: surprise, surprise!

- but: how do we arrive at a broader understanding: "upscaling"? Remote sensing?
- Targeted, "exploratory" measurement campaigns AND modelling
- AI cannot help (much) here





Conclusions: towards joint progress…

- Collaboration: cultivate exchange with and support for colleagues
- Discuss questions and problems: this is the start to new knowledge
- Be persistent: even if „seniors“ disagree
- Competition is good (as long as fair and respectful)
- Be brave and make your own decisions => **Administration only where (absolutely) necessary**
- We are fortunate to be engaged in such a fascinating and relevant science!
- After all: there is more than science and a life beyond science: Have fun and enjoy.

Special thanks…

…to university officials who supported me a lot …




… and to colleagues and friends from nah und fern…
















Special thanks…

…to technicians and administration…



…my nice colleagues from the IUG and other institutes at MNF…

…and all the students over the last 27 years

from BSc and MSC GEE and MSc CLEWS…

Thank you so much

… to everyone I've had the opportunity to work with
… to all students who were interested in the last decades

… and for your attention and patience today !

Axel Bronstert

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