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GROSSE HERAUSFORDERUNGEN

Hydrological extremes in the Elbe catchment and the „Modular Observation Solutions for Earth Systems (MOSES)“ initiative of the Helmholtz-Gemeinschaft

Dietrich Borchardt and Norbert Kamjunke

MOSES

EXTREMES JUST IN FRONT OF OUR DOOR

Flooding

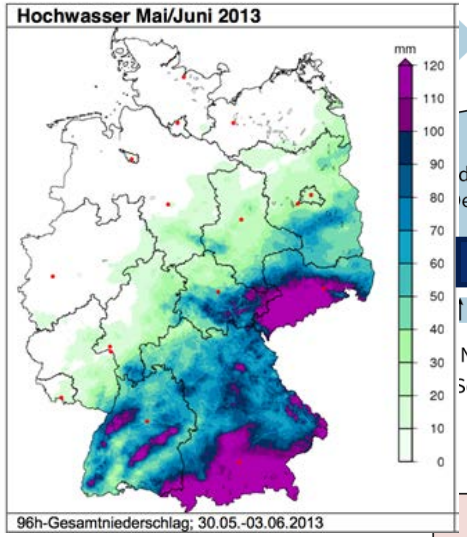
and:
2006
2010
2013

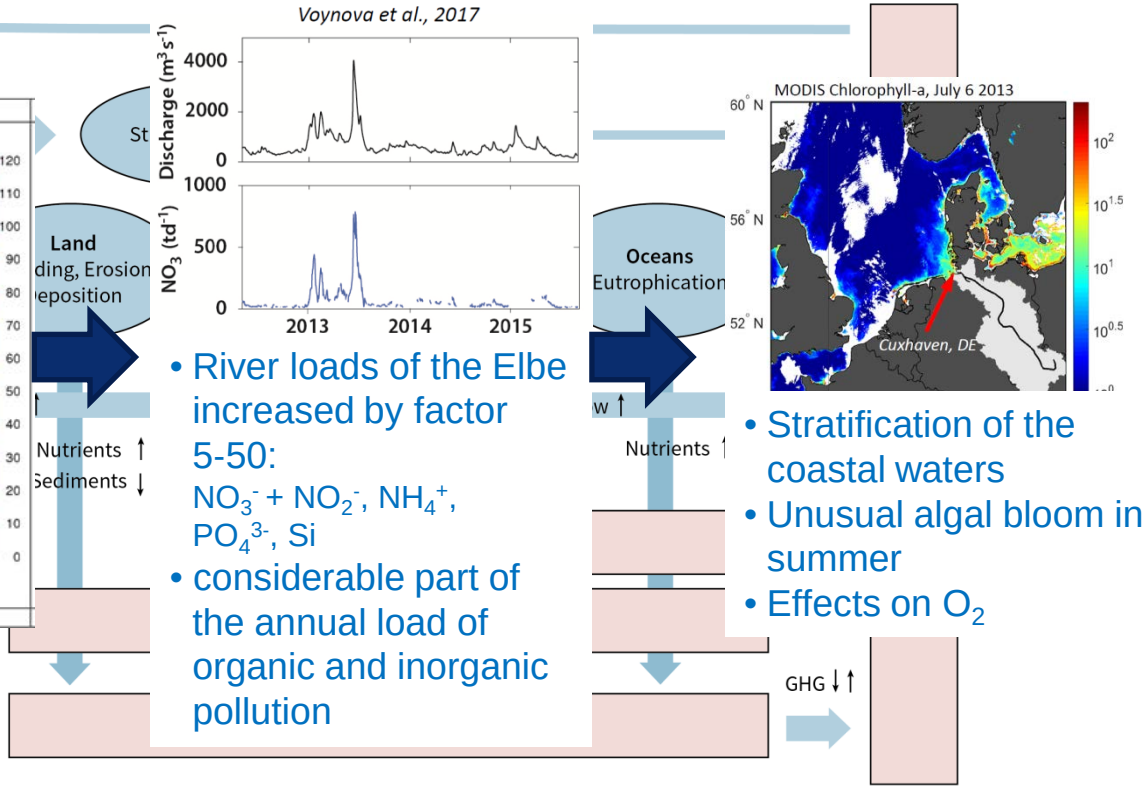
Low flows

more extreme 2015,
and even more extreme 2018

Impact on ecosystem services (DOC in raw water)

Why hydrological extremes?
►event chains



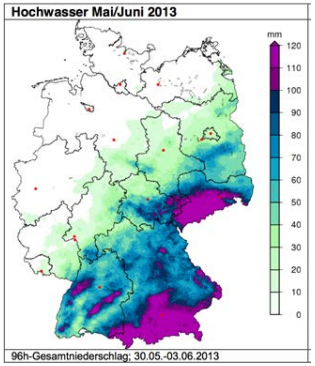


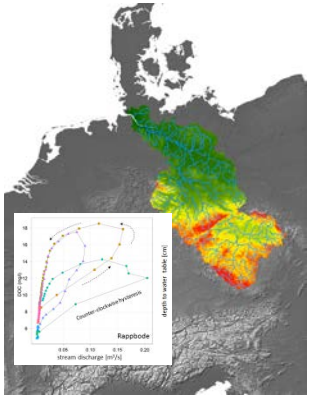
- River loads of the Elbe increased by factor 5-50:
  NO_3^- + NO_2^-, NH_4^+, PO_4^{3-}, Si
- considerable part of the annual load of organic and inorganic pollution

- Stratification of the coastal waters
- Unusual algal bloom in summer
- Effects on O_2

Research questions

- How and to which extent does the small-scale variability of precipitation orology and soil moisture affect the generation of discharge?
- Why does water quality show different long-term trends at high and low discharge (NW↑; HW↓)?

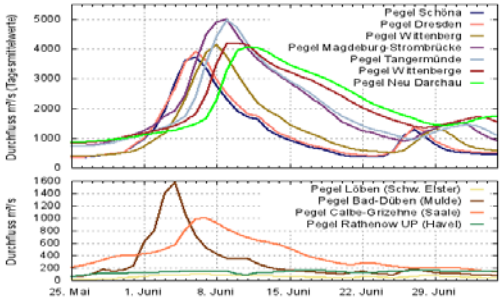




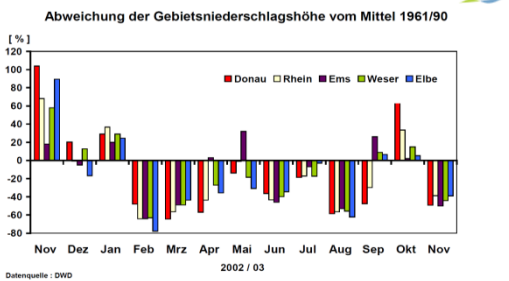
- Why and how does the filter effect of estuaries change at low retention times at high dicharge?
- How do the event-driven matter transport and low discharge/high temperature control the occurence of (toxic) algal blooms and othe ecological long-term changes?

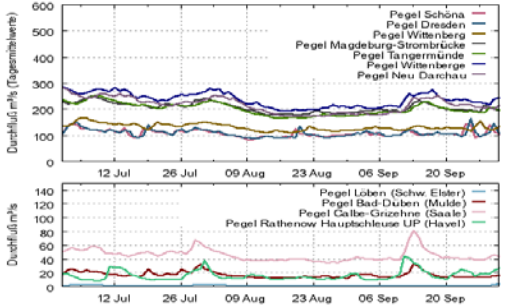
The Elbe catchment as first test region

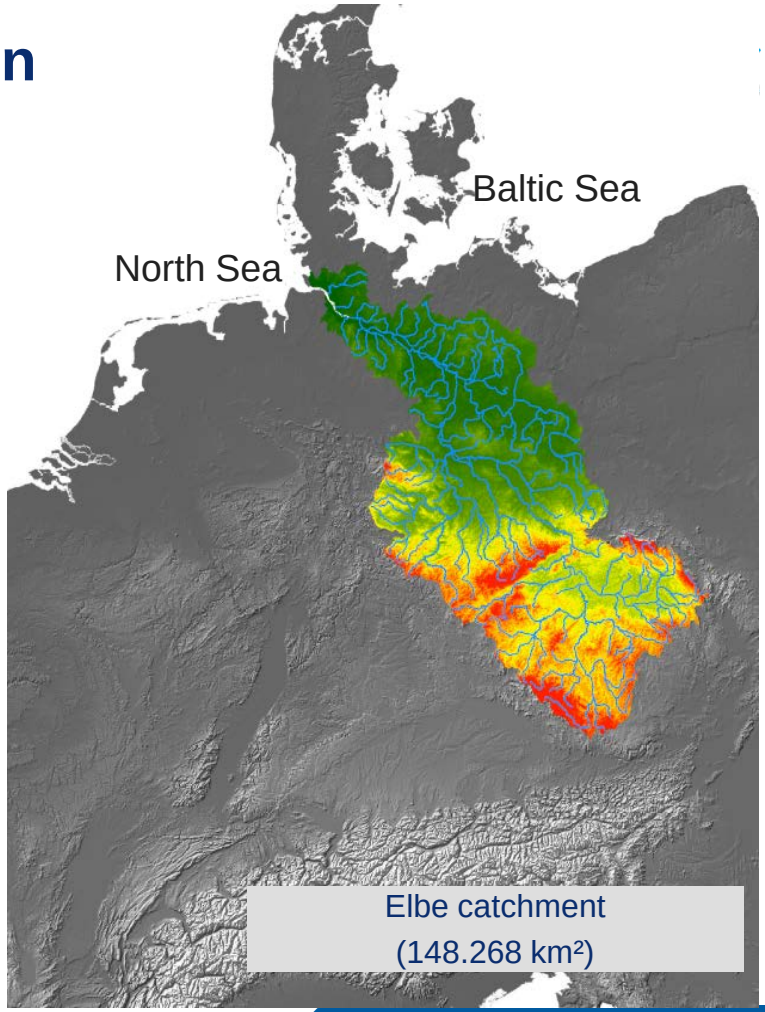
Flood May - June 2002



Drought July - August 2003







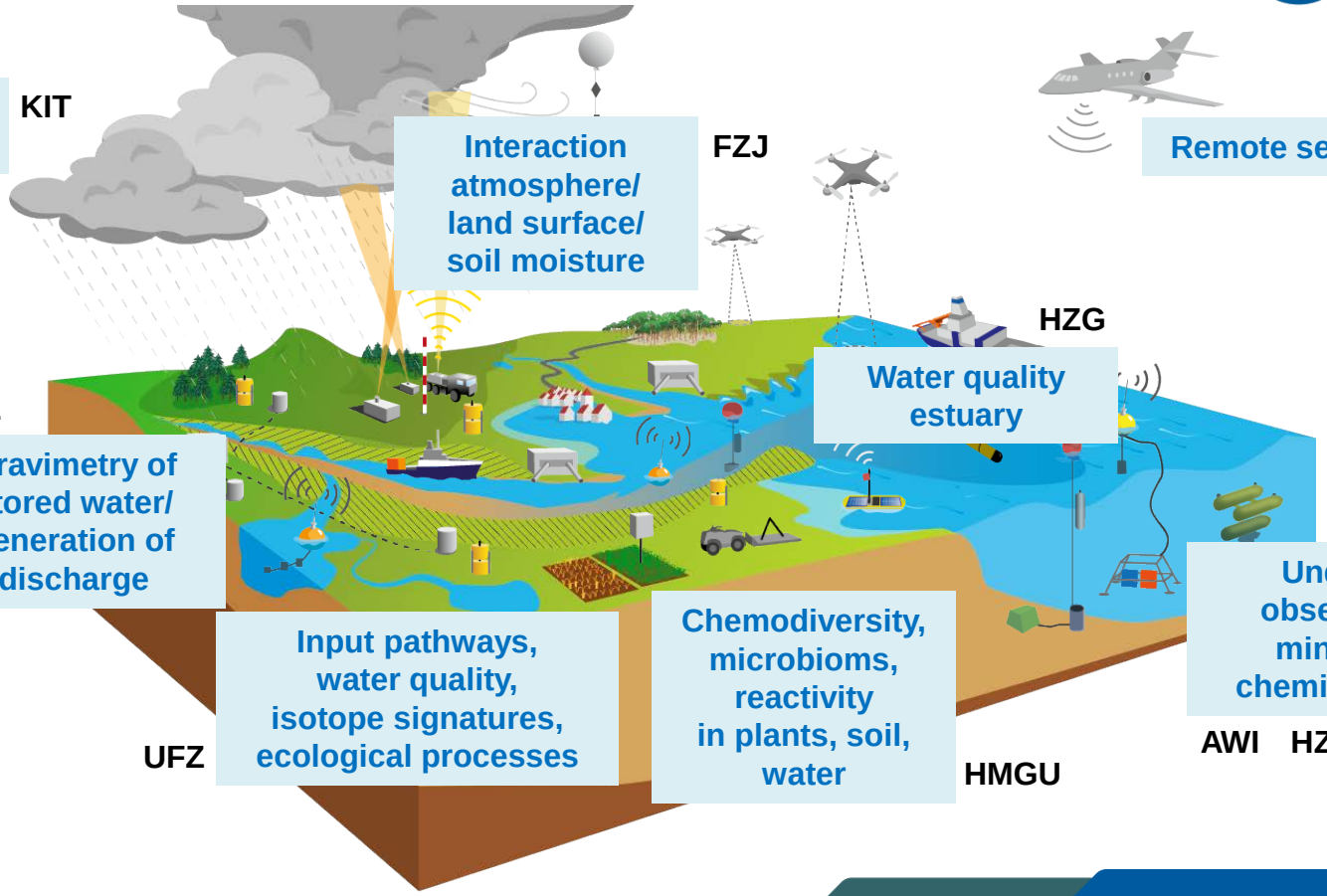
FGG Elbe (2015)

Modules for hydrological extremes

MOSES Module	Consortium	Heat Waves	Hydrologic Extremes	Ocean Eddies	Thaw Events Permafrost
Autonomous Vehicles	GEOMAR, HZG		X	X	X
Fixed Point Observatories	AWI, GEOMAR, HZG		X	X	X
Coastal and Marine Mobile Systems	AWI, GEOMAR, HZG		X	X	X
Permafrost Thaw and Subsidence	AWI, GFZ	X	X		X
Flow and Sediment Dynamics	AWI, GFZ, UFZ	X	X		X
Biota	AWI, HMGU, UFZ, KIT, FZJ	X	X		
Water Balance	GFZ, FZJ, UFZ	X	X		X
Soil and Water Quality	HMGU, UFZ	X	X		
Land-Atmosphere Fluxes	KIT, FZJ, UFZ, GFZ	X	X		X
Atmospheric Dynamics	FZJ , KIT	X	X	(X)	
Atmospheric Chemistry	FZJ, KIT	X	X		X

DLR: Plane-based TANDEM-L System

Measurement systems for hydrological extremes



Special force
Flood events

KIT

Interaction
atmosphere/
land surface/
soil moisture

FZJ

Remote sensing

DLR

HZG

Water quality
estuary

GFZ

Gravimetry of
stored water/
generation of
discharge

Input pathways,
water quality,
isotope signatures,
ecological processes

UFZ

Chemodiversity,
microbioms,
reactivity
in plants, soil,
water

HMGU

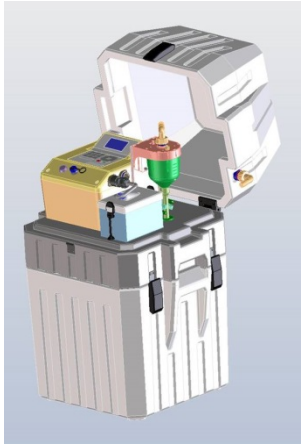
Underwater
observatories,
miniaturized
chemical sensors

AWI HZG GEOMAR

Innovation: Measurement systemes

Balloons for the observation of dynamics and chemistry of the atmosphere

Profiles from surface up to ca. 30 km altitude: temperature, pressure, moisture / water content, horizontal wind, ozone content, clouds / aerosols



Event-based samplers for observation of water quality dynamics

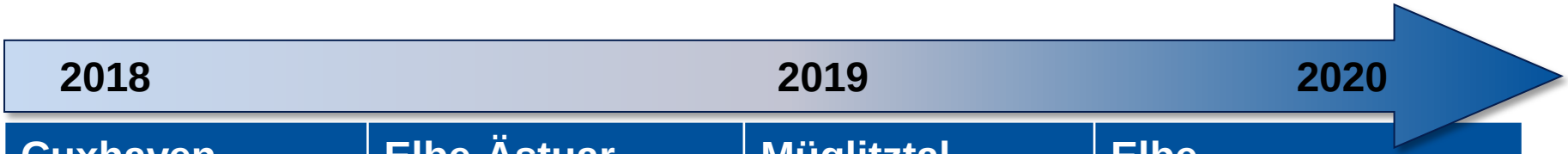
Automatic sampling based on event-driven thresholds:

Water and sediment samples (activ, passiv) coupled with data loggers for temperature, turbidity, conductivity, oxygen and nutrient monitoring

Hydrological extremes

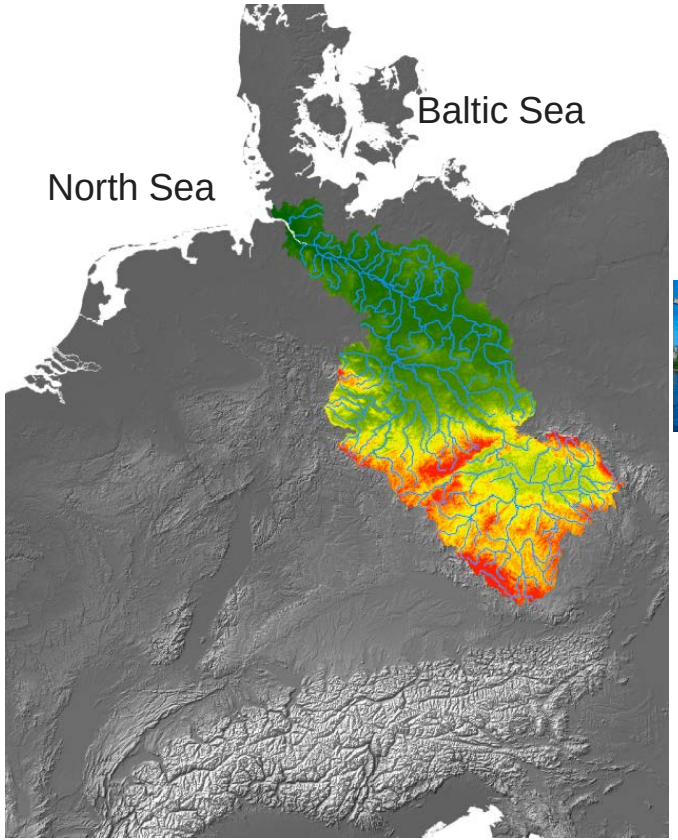
Heat waves

Planed test campaigns



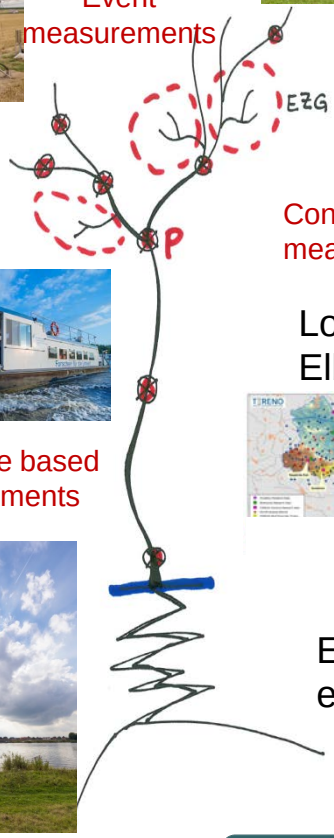
Cuxhaven	Elbe-Ästuar	Müglitztal	Elbe
Test of devices	Test of devices	Test campaign	Test campaign
June 2018	June and October 2018	April – July 2019	2020
Inter-calibration of sensors, adjustment of logistics: water quality parameters	Travel-time based measurement of water quality parameters, transect Geesthacht to Helgoland	Genesis of hydrologically relevant discharge events in small-scale catchments	Dominant processes during dynamic events along an event chain
AWI, GEOMAR, HZG, UFZ	**AWI**, GEOMAR, HZG, UFZ	FZJ, GFZ, **KIT**, UFZ mit Partnern	AWI, FZJ, GEOMAR, GFZ, HMGU, HZG, KIT, **UFZ** mit Partnern

Test campaign Elbe catchment 2020
Conception



Event measurements

Headwaters,
Small/medium catchments

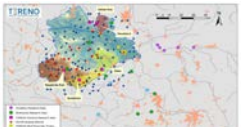


Continuous measurements

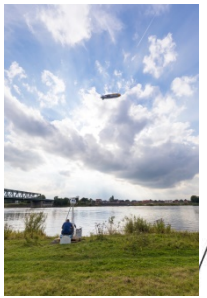
- Müglitztal Erzgebirge
- Bode
- (Ammer)

Travel-time based measurements

Lower Elbe



Measurements/experiments in long-term observatories

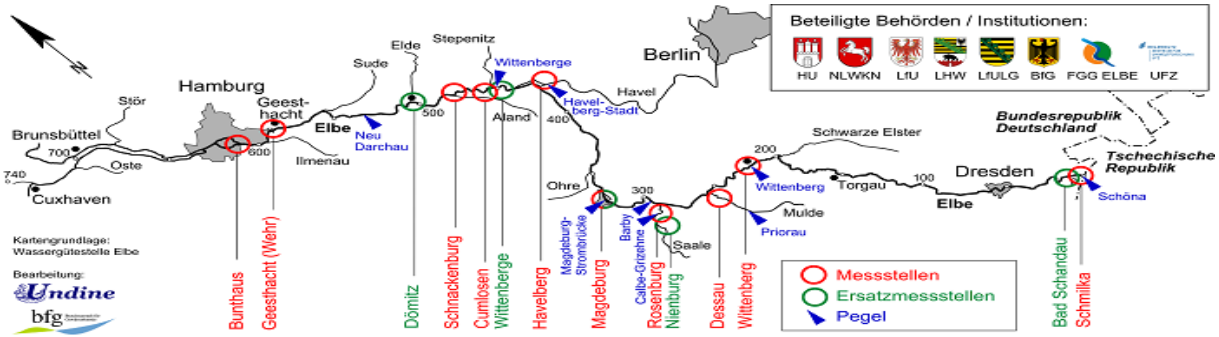


Elbe estuary

- Upstream of Geesthacht
- Downstream of Geesthacht (Tide-Elbe)

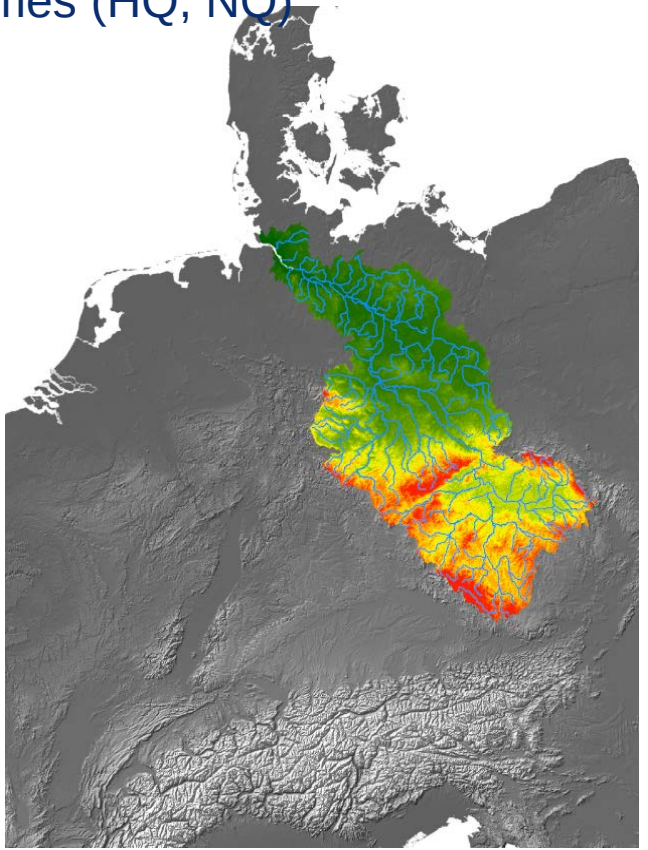
Elbe catchment

Governmental measurement program Hydrological extremes (HQ, NQ)
Trigger thresholds in Germany
Extension to the complete catchment desirable



Pegel	Schöna *Elbe*	Witten-berg *Elbe*	Barby *Elbe*	Witten-berge *Elbe*	Bad Düben 1 *Mulde*	Halle-Trotha *Saale*	Calbe-Grizehne *Saale*	Rathenow UP *Havel*
MHQ	1400 m³/s [5,90 m]				420 m³/s	360 m³/s		
Auslöse-schwelle HW	1400 m³/s [5,90 m]				520 m³/s [6,14 m]	460 m³/s [5,37 m]		
Auslöse-schwelle NW	105 m³/s [0,94 m]	135 m³/s [1,15 m]	210 m³/s [0,75 m]	275 m³/s [1,43 m]	15 m³/s [1,71 m]		45 m³/s [1,92 m]	20 m³/s

FGG Elbe (2015)



What‘s new?

Technical innovation

- Novel sensors (automation, miniaturization)
- Sensor networks
- valuation of digitalization progress

Scientific innovation

- Short- and long-term behaviour of discharge, water storage, water quality, ecosystem status beyond of average trends
- Improved understanding of consequences of climate change and other dynamics
- Event chains in coupled environmental systems (z.B. inland-coast-ocean)

Social relevance

- Hydrological extremes are of regional, national, European and global importance with far reaching consequences for humans and environment
- Climate change/water (extremes) are regarded as No 3 of global risks by the World Economic Forum (after under-/unemployment and failed states/migration)


Thanks!
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