A simple approach for developing storylines of flood impacts under various global warming levels

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PRESENT

UNprecedented Simulated Extremes using ENsembles

Hindcasts ECMWF

1997

downscaled data tests:
✓ fidelity
✓ independence
✓ stability
✓ tails
✓ daily cycle

integrity and plausibility

pooling
GEV   scenarios ($P_{ini, mj, yk}$, $T_{ini, mj, yk}$)

storylines
e.g. worst case [Rhine]

Hydrological model

$E_{pot(T)} P_{liq} + M_{(T)}$
SRmax
SRinit   Td $ln(T_0)$
Smax   SZM   CHV

DECIPHeR
Coxon et al. 2018

Here we present a *simple method* to expand the UNSEEN method (Thompson et al. 2017, Kelder et al. 2020) to develop storylines under various global warning levels.
We selected precipitation scenarios with different spatio-temporal patterns for estimated return periods between 100 and 1000 years from pooled reforecasts/hindcasts from ECMWF (ENSext and SEAS5), providing 8400 years of plausible weather sequences.

We use reforecasts/hindcasts to extend our knowledge on the risk of unprecedented floods.

FUTURE

Clausius-Clapeyron scaling

CC storylines
e.g. worse worst case [Rhine]

downscaling QM

+7% / °C

Switzerland
Emme,Wiler
Modeled area
Precip. scenario
Worst case
40
60
80
100
120
150
180
210
250
300
400

0 25 50 75 100 km

Emme Wiler (26000)
scenario: 03d–1000y_05 (Worst Case)

Legend:
Q
Q +1°C
Q +1.5°C
Q +2°C
Q +3°C
Q +4°C
P window
P +1°C
P +1.5°C
P +2°C
P +3°C
P +4°C

$Q_{max,obs}$ = 2.55 mm/h
$Q_{max,present}$ = 5.20 mm/h
$PMF_{Viviroli}$ = 5.22 mm/h
PMF_{Felder} = 5.34 mm/h
PMFs: see Viviroli et al. 2022

date [day, month]

The selected scenarios are perturbed by increasing the precipitation intensity according to the Clausius-Clapeyron relation for five different global warming levels (GWLs), and used to run coupled hydrologic-hydraulic simulations.

CONSEQUENCES

Impacts

Hydraulics and exposure

Max PRC, max Q and impact increase per GWL

P_{max} [mm h^{-1}]
Q_{max} [m^3 s^{-1}]
Buildings [number]
Residents [number]
Buildings damage [CHF]
Workplaces [number]

% increase

GWL [°C]

Flood impact
Precipitation intensity

The results show that **record-breaking, high-impact river floods are possible under the current atmospheric conditions**, and **climate change substantially aggravates** flood impacts.

The development of storylines of extreme flood events with a high spatial and temporal resolution are a valuable tool to explore, describe, and communicate extreme events and their dynamics.
Such instruments are **key for developing an informed vision and comprehensive protective measures** in terms **of flood risk management and emergency response**.

References
Coxon G, Freer J, Lane R, Dunne T, Howden NJK, Quinn N, Wagener T, Woods R. 2018. DECIPHeR v1: Dynamic fluxEs and ConnectIvity for Predictions of HydRology. *Geosci Model Dev.* , 12, 6.
Kelder, T., Müller, M., Slater, L.J., Marjoribanks, T.I., Wilby, R.L., Prudhomme, C. et al. 2020. Using UNSEEN trends to detect decadal changes in 100-year precipitation extremes. *Climate and Atmospheric Science*, 3, 47.
Munz, L., Mosimann, M., Kauzlaric, M., Martius, O., Zischg,A. P. 2024. Storylines of extreme precipitation events and flood impacts in alpine and pre-alpine environments under various global warming levels, *Science of The Total Environment*, Volume 957, 177791, https://doi.org/10.1016/j.scitotenv.2024.177791.
Viviroli, D., Sikorska-Senoner, A. E., Evin, G., Staudinger, M., Kauzlaric, M., Chardon, J., Favre, A.-C., Hingray, B., Nicolet, G., Raynaud, D., Seibert, J., Weingartner, R., and Whealton, C.: Comprehensive space–time hydrometeorological simulations for estimating very rare floods at multiple sites in a large river basin, *Nat. Hazards Earth Syst. Sci.*, 22, 2891–2920, 2022.
Thompson, V., Dunstone, N.J., Scaife, A.A., Smith, D.M., Slingo, J.M., Brown, S. et al. 2017.High risk of unprecedented UK rainfall in the current climate. *Nature Communications*, 8, 107.