Integrating textual impact reports and vulnerability information to drought risk analysis

UNI FREIBURG

HYDROLOGY

Veit Blauhut, Kerstin Stahl

Introduction

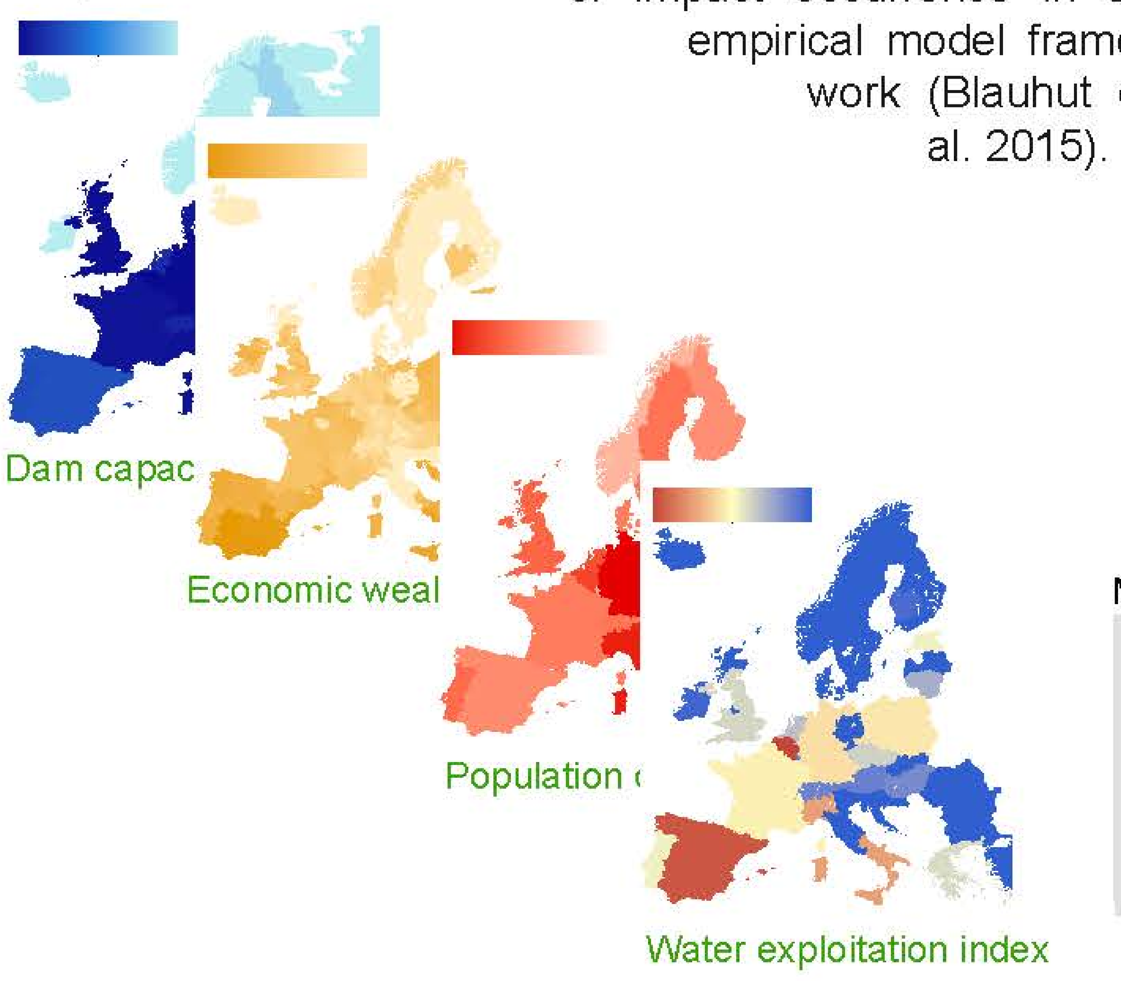
Drought risk in general describes the probability of socio-economic and environmental systems to suffer negative consequences. In the framework of risk assessment, drought risk can be estimated from the risk analysis or vulnerability assessment perspective, combining hazard information either with (I) a quantification of impacts (damage) as a proxy for vulnerability: the impact approach, or with (II) a combination of vulnerability factors: the factor approach. Impact approaches mainly focus on specific sectors, whereas the majority of factor approaches estimates risk for entire systems. For both approaches, criteria for indices- and factor selection applied are rather based on expert knowledge than empirical context.

This work introduces a novel hybrid approach combining hazard information and vulnerability factors to predict the likelihood of impact occurrence in an empirical model framework (Blauhut et al. 2015).

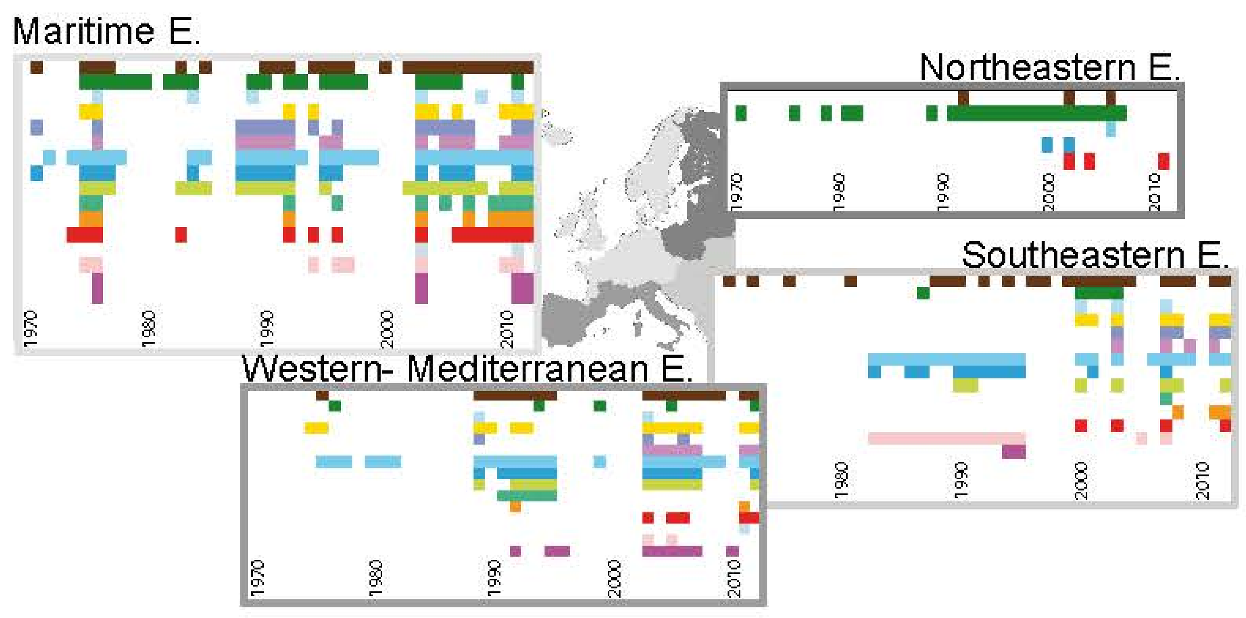
Impact categories

- Agriculture & Livestock f.
- Forestry
- Aquacultures & Fisheries
- Energy & Industry
- Waterborne transport.
- Tourism & Recreation
- Public Water Supply
- Water quality
- Freshwater ecosystems
- Terrestrial ecosystems
- Soil systems
- Wildfires
- Air quality
- Human Health & Public S.
- Conflicts

Step 1



Step 1: Annual drought impact occurrence



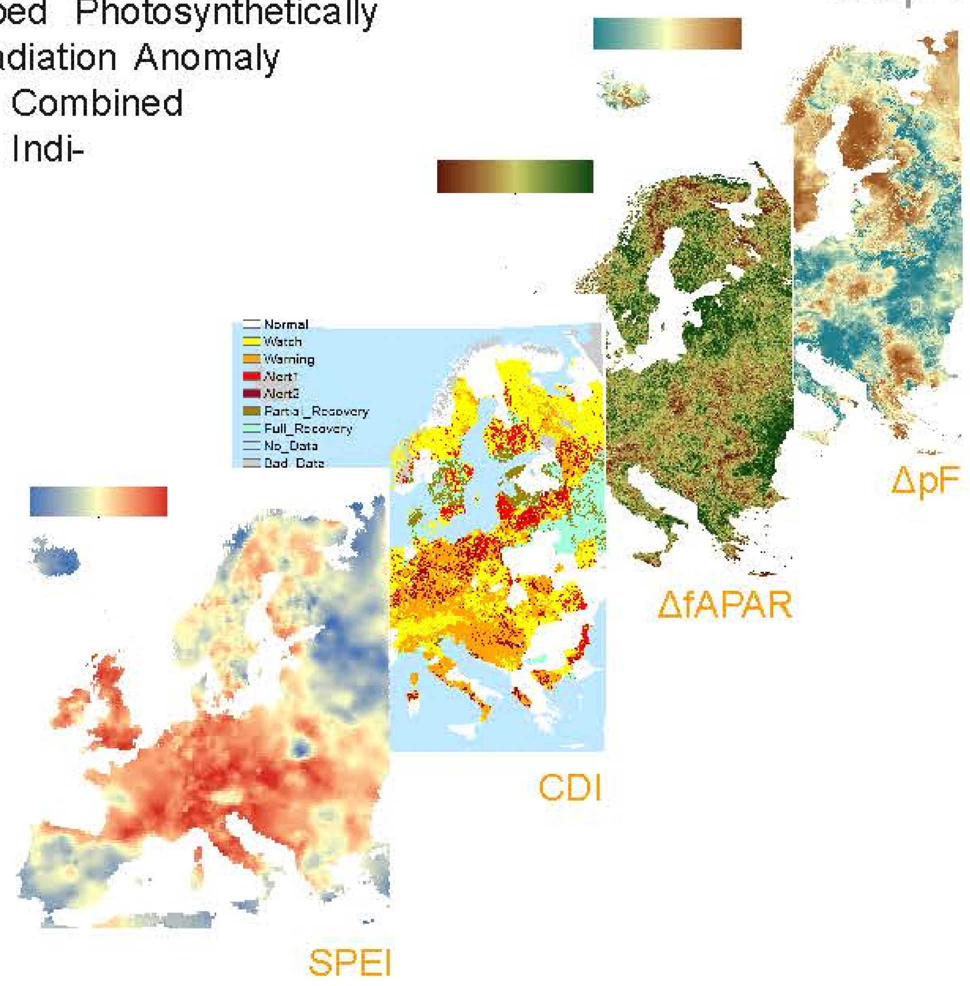
Data

Impact information: The EDII compiles reported information on the negative impacts of past drought events from a variety of information sources. All Reports are: spatially referenced, time stamped to at least the year of occurrence, assigned to one of fifteen impact categories and a number of impact types.

Vulnerability information:
The collection of vulnerability data builds on the experience gained by De Stefano et al. (2015) and was complemented by additional data (e.g. landcover). Furthermore, combined vulnerability factors are analysed (e.g. adaptive capacity). In summary, 69 vulnerability factors were compiled.

Hazard information: The focus of this study is on drought indices that are most common, readily available, monitored, and used operationally for drought monitoringin Europe : Standardized Precipitation Index (SPI), Standardised Precipitation Evapotranspiration Index (SPEI), Soil moisture anomaly (ΔpF), Fraction of Absorbed Photosynthetically Active Radiation Anomaly (fAPAR), Combined Drought Indicator

Step 1



Methodology

Steps to pan-European drought risk maps:

Step 1: Aggregation of all input data to NUTS-combo level (climatologically comparable region across Europe, Blauhut et al. 2015), Hazard information: aggregation to monthly and annual information; vulnerability information: transformation to annual information, impacts: aggreagation to binary & annual signal, due to a lack of scomprehensive data, Europe was split into four climatological comparable macro regions for modelling (center)

Step 2: Analysis of the best combination of one or two hazard indices and up to three vulnerability factors by impact category and macro region based on stepwise multivariable logistic regression models (MLRMs). Starting with hazard indices, the best performing hazard index was selected by predictor significance (p-values) and model performance (AROC). Subsequently, not correlated predictors were selected by model improvement, measured by AROC and the Bayesian Information Criterion (BIC). Accordingly, further predictors were only chosen for the final MLRM if AROC increases or remains constant and BIC decreases.

Step 3: Application of MLRMs to construct drought risk maps for fifteen impact categories and for three hazard levels. For countries with a lack of sufficient vulnerability data, LIO was estimated using the best hazard-only model.

Step 2

$$LIO = \log\left(\frac{LIO_N}{1-LIO_N}\right) = \alpha_M + \sum_j (\beta_{j,M} \cdot V_N) + \sum_i (\beta_{i,M} \cdot H_N)$$

LIO = likelihood of impact occurrence
V_N = selection of vulnerability factors by NUTS-combo region
H_N = selection of hazard indicators by NUTS-combo region

***Selected of best performing predictors**, yellow: hazard indicator with short temporal aggregation, light yellow to brown: SPEI with increasing temporal aggregation (short-, medium-, with long temporal aggregation), light green: vulnerability factors associated with sensitivity, dark green: vulnerability factors associated with adaptive capacity, A. = Area of, GW = Groundwater, norm. = normalised, NC = NUTS-combo region, N2 = NUTS-2 region, SR = Socioeconomic relevance, WR= Water*

	Impact category	Hazard		Vulnerability		
		Predictor 1	Predictor 2	Predictor 3	Predictor 4	Predictor 5
Maritime	A&L	SPEI-06 Jun	SPEI-01 Jun	Groundwater resources	A. inland water bodies, ratio of NC	
	Fo	SPEI-04 Jun	SPEI-24 Nov	Population density and age	Water balance	
	A&F	SPEI-09 Oct		Dams + GW resources		
	E&I	SPEI-06 Jul	SPEI-01 Jun	A. agriculture	Innovation capacity	A. perm irrigated agri, ratio of NC
	WT	SPEI-05 May	SPEI-24 Dec	Groundwater resources	Wate body status	
	T&R	SPEI-04 Apr	SPEI-24 Nov	Groundwater resources	A. inland water bodies, ratio of NC	A. artificial surfaces
	PWS	SPEI-24 Dec	SPEI-04 Jun	Water use	A. agriculture, ratio of NC	Aquatic ecosystem status
	WQ	SPEI-09 Aug	SPEI-02 Dec	Dams & GW resources, norm.	A. agriculture, ratio of NC	S R services
	FE	SPEI-06 Jun	SPEI-12 Feb	Groundwater resources	A. agriculture, ratio of NC	S R industry
	TE	SPEI-09 Aug	SPEI-01 Feb	GW resources, norm.	WR industry	A. forest
	SS	SPEI-06 Jun	SPEI-02 Jan	Drought management tools	A. inland water bodies, ratio of NC	S R services, norm.
	WF	SPEI-05 Aug	SPEI-04 Oct	Drought awareness		
	AQ	SPEI-03 Apr	SPEI-04 Nov	Drought recovery capacity		
	H&P	SPEI-03 Apr	SPEI-12 Dec	Groundwater resources	Water resources development	
	Co	SPEI-04 Jun		Drought recovery capacity	Economic wealth	
Southeastern	A&L	SPEI-06 Aug	SPEI-01 Dec	Population density N2	Drought awareness	A. artificial surfaces, ratio of NC
	Fo	SPEI-05 Oct	SPEI-01 Feb	A. NUTS-combo region	Dams capacity	
	A&F	SPEI-04 Jul	SPEI-24 Mar	Water use Indus		
	E&I	SPEI-06 Aug	SPEI-06 Dec	WR services	A. artificial surfaces, ratio of NC	
	WT	SPEI-06 Sep	SPEI-01 Nov	Public participation	A. agriculture, ratio of NC	A. seminatural areas
	T&R	SPEI-06 Sep	SPEI-24 Jun	Population density and age	A. artificial surfaces, ratio of NC	
	PWS	SPEI-24 Dec	SPEI-03 Sep	Drought awareness	Wate body status	A. seminatural areas, ratio of NC
	WQ	SPEI-24 Mar	SPEI-03 Sep	Aquatic ecosystem status	A. of lakes within region	
	FE	SPEI-02 Jul	SPEI-01 Dec	Drought awareness		
	SS	SPEI-04 Nov	SPEI-01 Aug			
	WF	SPEI-12 Aug	SPEI-01 Feb			
	H&P	SPEI-06 Jan	SPEI-03 Oct	Aquatic ecosystem status	A. forest, ratio of NC	
	Co	SPEI-24 May	SPEI-03 Jan	Drought awareness		
North eastern	A&L	SPEI-03 Jul	SPEI-02 Nov	A. agriculture, ratio of NC	Drought management tools	
	Fo	SPEI-03 Sep	SPEI-06 Jun	A. wetlands, ratio of NC	Population density NC	A. inland water bodies, ratio of NC
	WQ	SPEI-01 May	SPEI-02 Mar	Water use		
	WF	SPEI-01 Apr	SPEI-01 Nov	Drought recovery capacity	SR industry	Groundwater resources
Western-Mediterranea	A&L	SPEI-01 Jan	SPEI-12 Dec	A. agriculture	WR services	Drought management tools
	Fo	SPEI-04 Apr				
	A&F	SPEI-05 Sep	SPEI-04 Mar	A. wetlands, ratio of NC	A. lakes witin region	
	E&I	SPEI-01 Jan	SPEI-03 May	A. inland water bodies	Water exploitation index	
	WT	SPEI-02 Jul		Population density and age	Water use	
	T&R	SPEI-09 Aug	SPEI-01 Dec	Aquatic ecosystem status		
	PWS	SPEI-06 May	SPEI-01 Dec	Aquatic ecosystem status	Socioeconomic relevance agri	A. seminatural areas
	WQ	SPEI-05 May	SPEI-02 Dec	A. seminatural areas	Aquatic ecosystem status	A. lakes within region
	FE	SPEI-06 May	SPEI-01 May	A. seminatural areas	A. not irrigted agri, ratio of NC	A. agriculture, ratio of NC
	SS	SPEI-05 Oct	SPEI-24 Sep	Population density and age		
	WF	SPEI-05 Jun	SPEI-01 Dec	Aquatic ecosystem status	A. artificial surfaces	A. wetlands, ratio of NC
	Co	SPEI-05 May	SPEI-06 Dec	A. seminatural areas	SR agriculture	Population density and age
		Short-	Medium-	Long- temporal aggregation	Sensitivity	Adaptive capacity

Results & Discussion

The results indicate sector- and macro region specific sensitivities of drought indices and vulnerability factors, with the SPEI for a twelve month accumulation period as the overall best hazard predictor. The application of the "hybrid approach" revealed strong regional and sector specific differences in drought risk across Europe (bottom). The majority of best predictor combinations rely on a combination of SPEI for shorter and longer aggregation periods, and a combination of information on landuse and water resources.

Take home messages:

This study suggested objective criteria for drought indices selection and use in risk assessment.

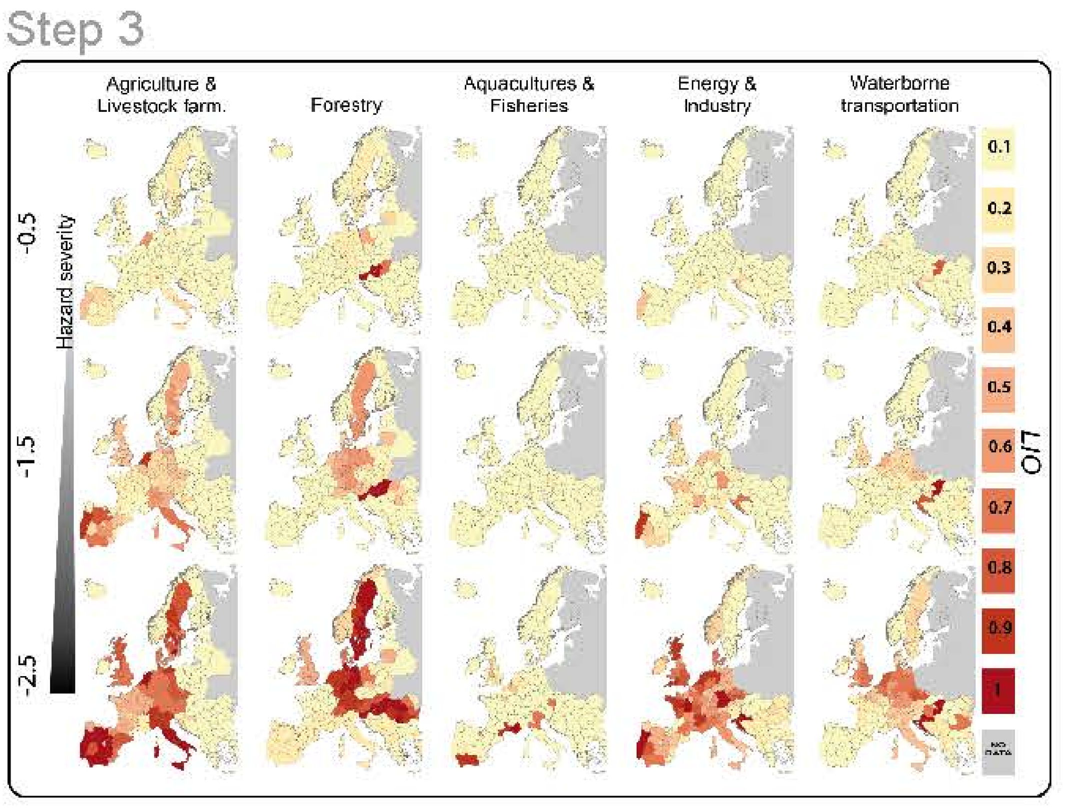
Drought indices and vulnerability factor selection was impact sector specific.

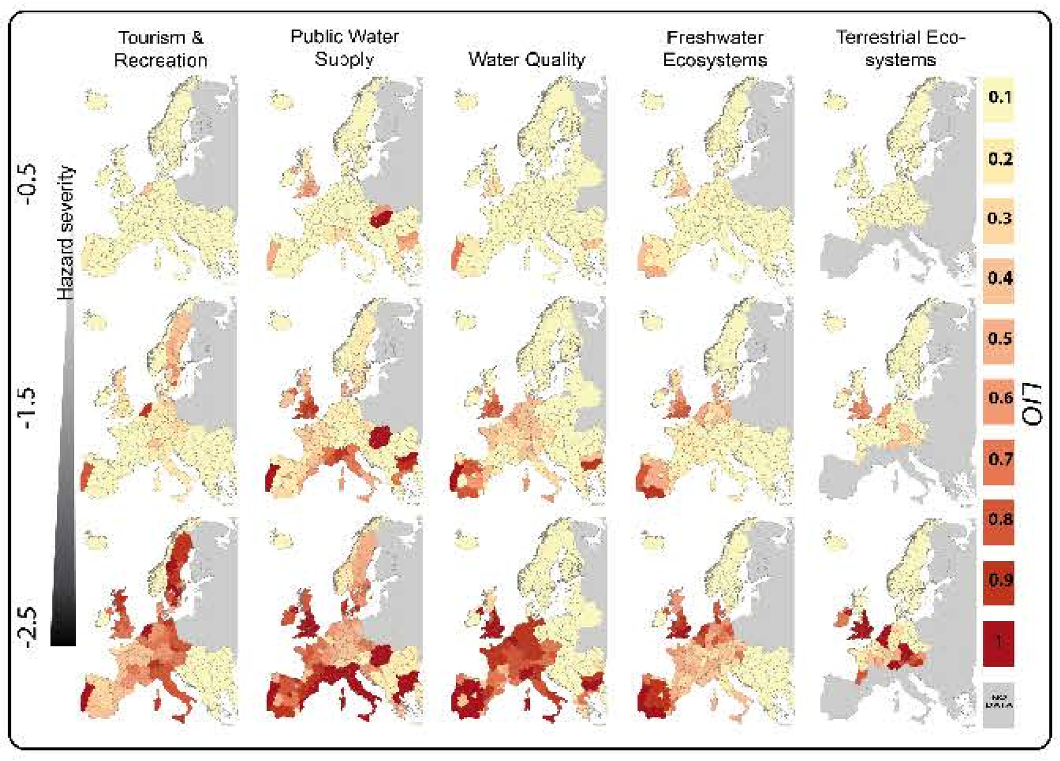
Temporally accumulated indices and vulnerability factor selection was region specific.

The application of vulnerability factors generally improved impact prediction and added plausible spatial detail to the pattern of mapped drought risk.

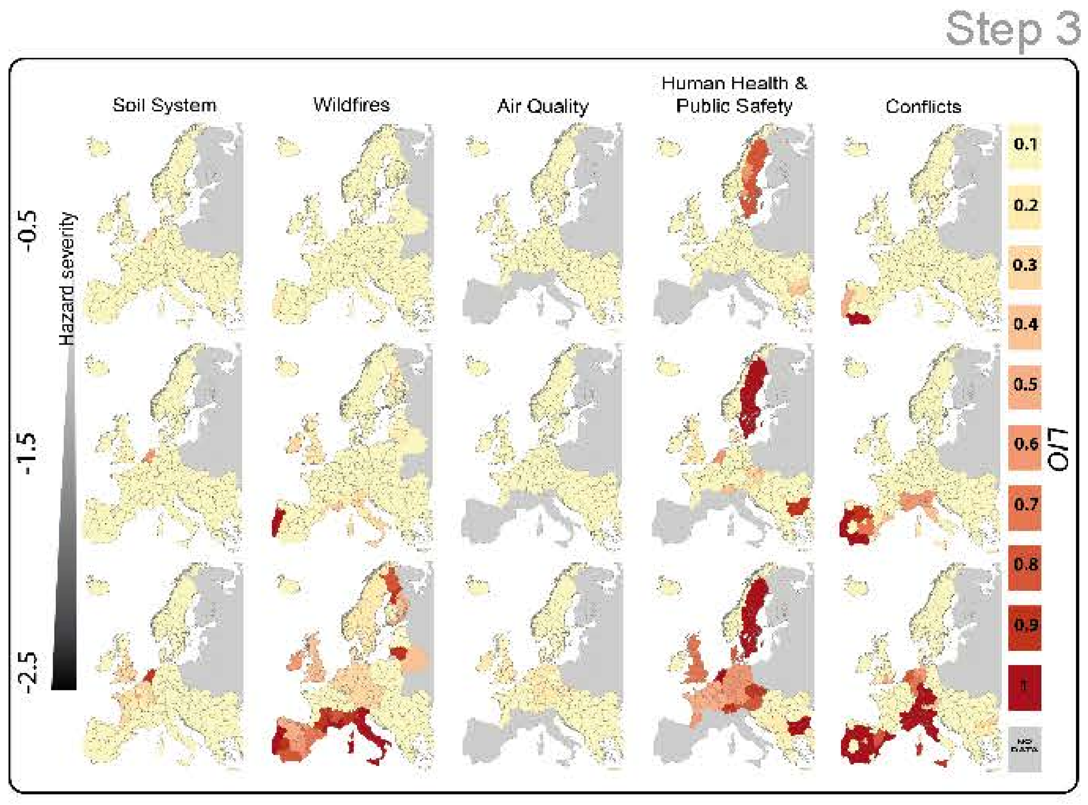
Current applications of drought indices may benefit from revision with regard to their impact-specific power.

Step 3





Step 3



(1) Chair of Hydrology, Albert-Ludwigs-University of Freiburg
veit.blauhut@hydrology.uni-freiburg.de www.hydro.uni-freiburg.de

Blauhut et al.: Estimating drought risk across Europe from reported drought impacts, hazard indicators and vulnerability factors, Hydrology Earth Syst. Sci. Discuss., 12, 12515-12566, doi:10.5194/hessd-12-12515-2015, 2015.
De Stefano et al.: Methodological approach considering different factors influencing vulnerability 12547 – pan-European scale, Drought R&SPI, Technical Report 26, available at: http://www.eu-drought.org/technicalreports, 2015.
Stahl et al.: Impacts of European drought events: insights from an international database of text-based reports, Nat. Hazards Earth Syst. Sci., 16, 801-819, doi:10.5194/nhess-16-801-2016, 2016.

edc