Water Scarcity and Droughts: a Global Perspective

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Copernicus for Water Management workshop, 29 May 2018, Brussels

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Copernicus Europe's eyes on Earth

European Commission

Outline

1. Dimensions of **droughts** and **water scarcity**

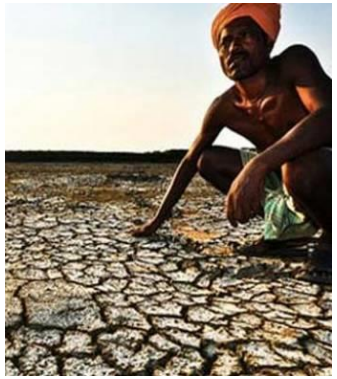
2. **User needs** on water scarcity and droughts

3. **Water quality** in **water scarcity** assessments

3. **Examples of information services** for droughts and water scarcity

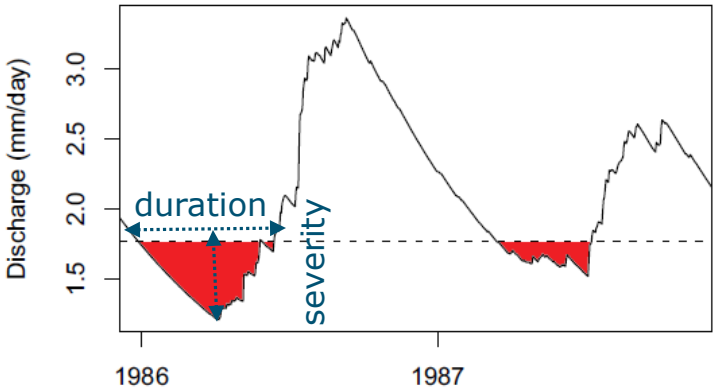
Types and dimension of droughts

Drought: *a prolonged period of abnormally low precipitation, leading to low water resources availability*



- **Meteorological** droughts → rainfall, snowfall
- **Agricultural** droughts → soil moisture
- **Hydrological** droughts → streamflow/groundwater

- **Several drought indicators** reflecting different types and dimension of drought
- **Drought dimensions**: *severity, duration, frequency, timing*



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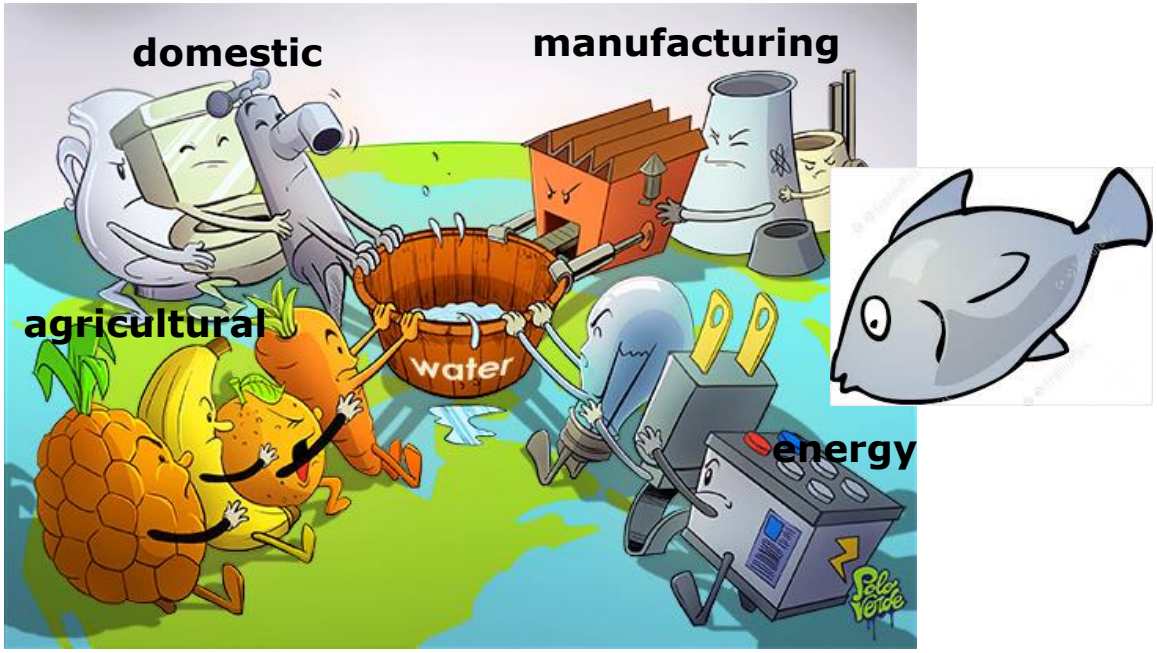
What is water scarcity?

Water scarcity: *demand for water by all sectors (incl. environment) cannot be satisfied fully due to the impact of water use on supply or quality of water*

- Indicators for water scarcity

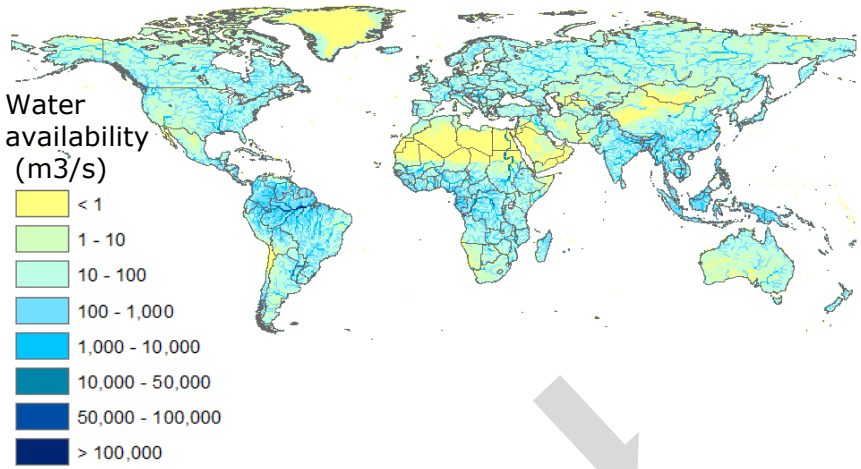
$$\textbf{Criticality ratio} = \frac{\text{water use}}{\text{water availability}}$$



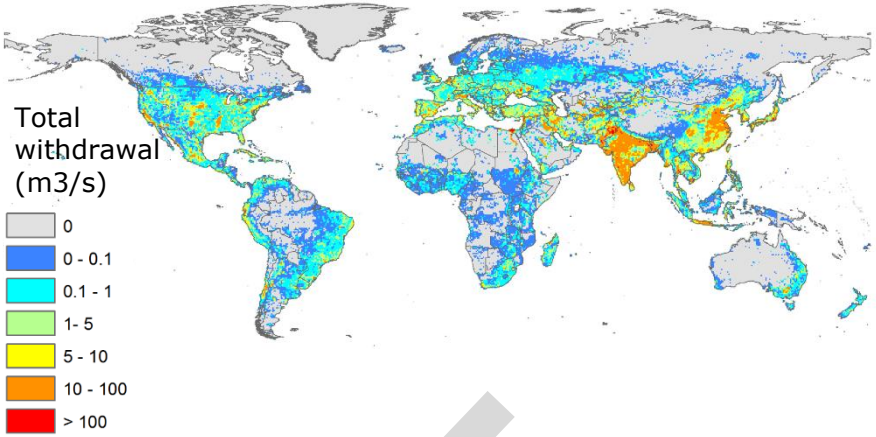
Source: Water and sanitation program, 2016

Water scarcity modelling assessment

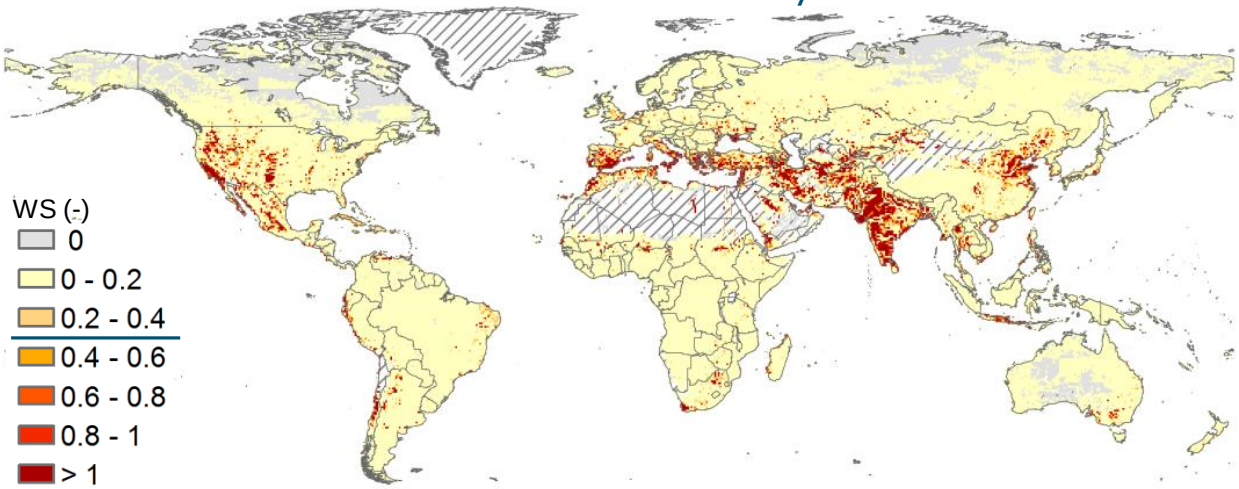
Water availability (m3/s) (VIC)



Total water withdrawals (m3/s)



Water scarcity



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Rethinking water scarcity

Usability of water depends on:

1) Sufficient water quantity

2) Suitable water quality:

- Water temperature → cooling of power plants
- Salinity, nutrients → irrigation and drinking water

→ New water scarcity-indicators and model information systems including water quality

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NWO Veni, Vidi, Vici

Rethinking water scarcity – new indicators

commentary

Quality matters for water scarcity

Michelle T.H. van Vliet, Martina Flörke and Yoshihide Wada

Quality requirements for water differ by intended use. Susta
different uses will not only need to account for demand in w
and salinity, nutrient levels and other pollutants.

Box 1 | Water scarcity by sector including water quality.

We propose to assess water scarcity as the ratio of sectoral water withdrawals of acceptable water quality to the overall water availability (equation (1)). Our index considers, in addition to the required sectoral water withdrawals, also the extra water withdrawal required to obtain water of acceptable quality for each sector by dilution. In case water quality requirements are not met for a certain sector, we estimate the extra amount of water to dilute and lower concentrations below the threshold of a relevant water quality parameter according to sectoral guidelines. A water quality dimension for freshwater ecosystems can be added to the environmental flow requirements by including the relevant water quality parameters and their thresholds for freshwater ecosystems.

$$WSq = \frac{\Sigma_{j=1}^{n}(D_j + dq_{i,j})}{Q - (EFR + dq_{i_{eco}})} \qquad (1)$$

with:

$$dq_{i,j} = \begin{cases} 0, & C_i \leq Cmax_{i,j} \\ \left(\frac{Q \cdot C_i}{Cmax_{i,j}} - Q\right), & C_i > Cmax_{i,j} \end{cases}$$

Where WSq is the water scarcity including water quality (-); D is water withdrawal for sector j ($m^3 s^{-1}$); Q is water availability ($m^3 s^{-1}$); EFR is the environmental flow (quantity) requirements ($m^3 s^{-1}$); dq is extra water withdrawals for dilution to obtain acceptable quality for sector j and water quality parameter i ($m^3 s^{-1}$); C_i is actual water quality level of water quality parameter i (unit depends on water quality parameter considered; for example, mg l^{-1} for concentrations, °C for water temperature); and $Cmax_{i,j}$ is the maximum water quality threshold for water quality parameter i for water use sector j (for example, mg l^{-1}, °C).

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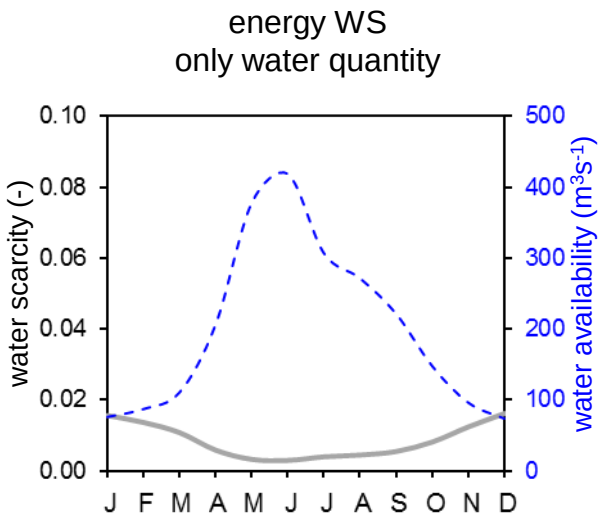
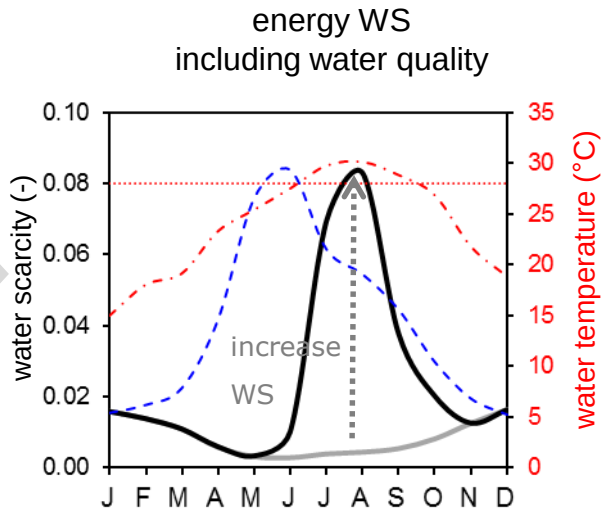
Quality matters for water scarcity

energy sector
water temperature
(Pearl river)



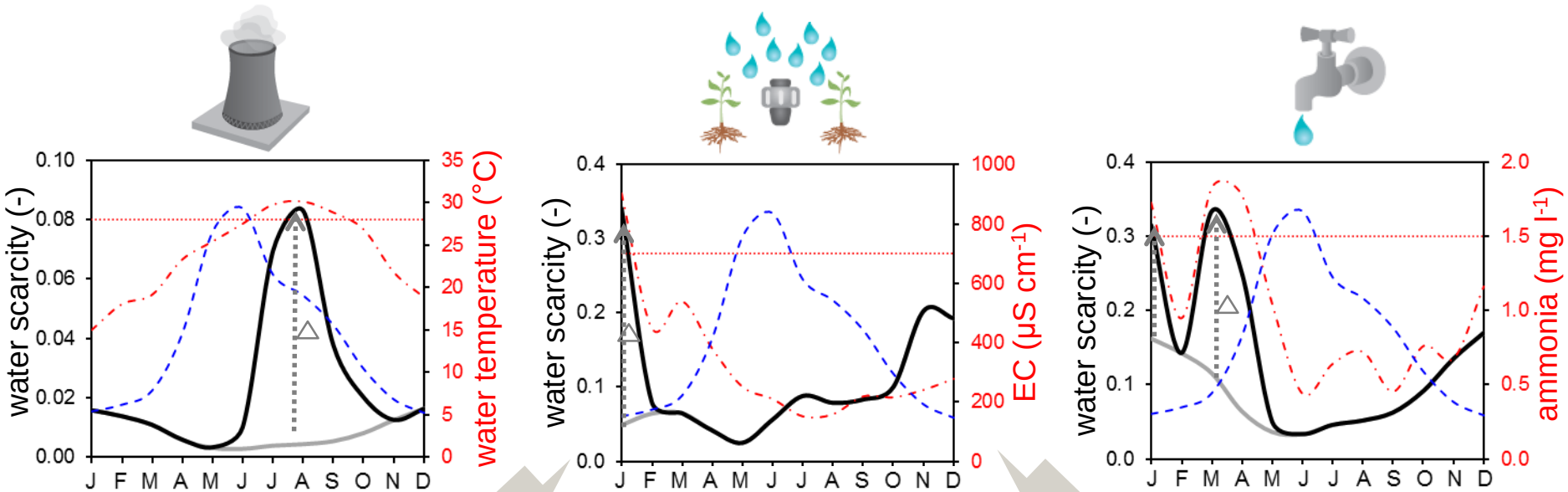


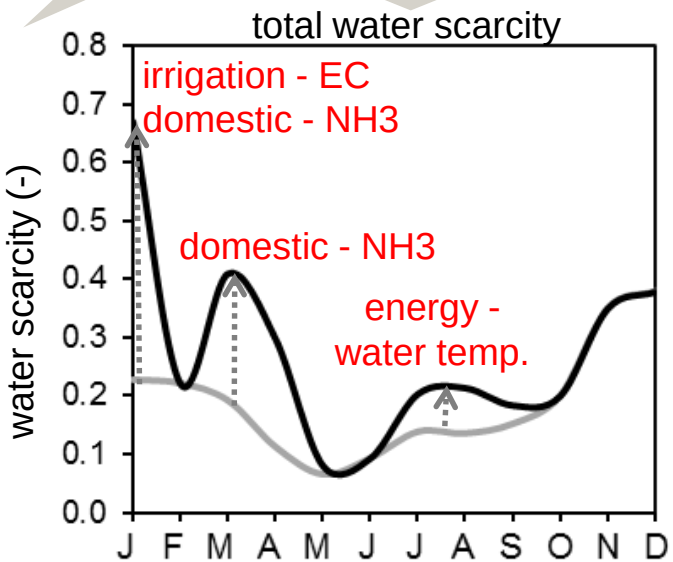
WS (only water quantity)
water availability

WS (incl. water quality)
water temperature
water temperature threshold for cooling water use

van Vliet et al (2017), nature geoscience

Quality matters for water scarcity





- water availability
- water quality
- water quality threshold for sector
- water scarcity (only water quantity)
- water scarcity (incl. water quality)

van Vliet et al (2017), nature geoscience

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From scientific data to information services

→ **Drought** and **water scarcity indicators** should be **tailored** to the **user needs**

- Users need ***reliable, accurate and easily accessible data***
  - →Multi-model water assessments (→ ensembles)
  - →Data portals and online water information services

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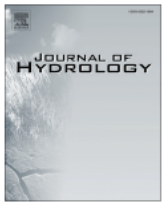
Contents lists available at ScienceDirect

Journal of Hydrology

journal homepage: www.elsevier.com/locate/jhydrol



European scale climate information services for water use sectors

CrossMark

Michelle T.H. van Vliet [a], Chantal Donnelly [b], Lena Strömbäck [b], René Capell [b], Fulco Ludwig [a,*]

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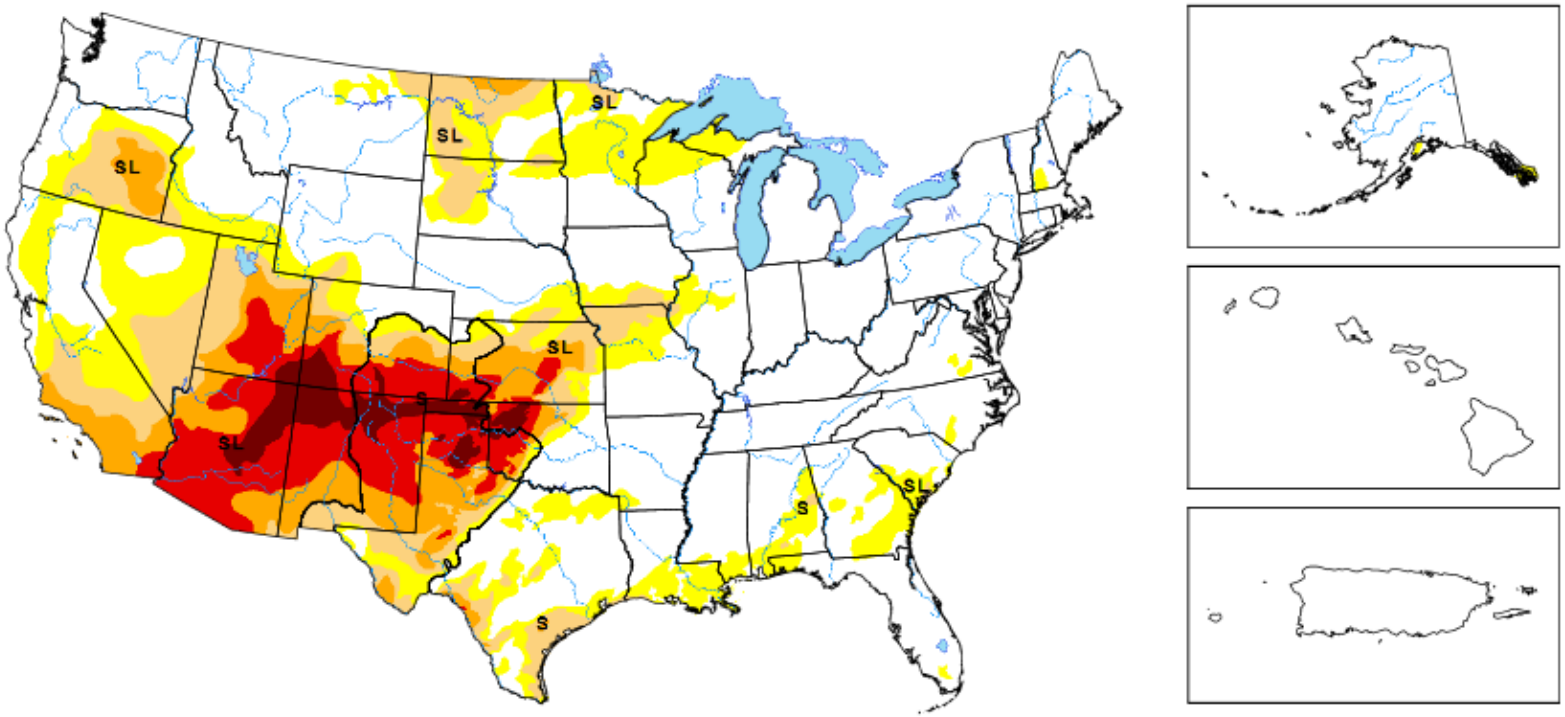
US drought monitoring



The data cutoff for Drought Monitor maps is each Tuesday at 8 a.m. EDT. The maps, which are based on analysis of the data, are released each Thursday at 8:30 a.m. Eastern Time.

Intensity and Impacts

- None
- D0 (Abnormally Dry)
- D1 (Moderate Drought)
- D2 (Severe Drought)
- D3 (Extreme Drought)
- D4 (Exceptional Drought)

- Delineates dominant impacts

S - Short-Term impacts, typically less than 6 months (e.g. agriculture, grasslands)

L - Long-Term impacts, typically greater than 6 months (e.g. hydrology, ecology)

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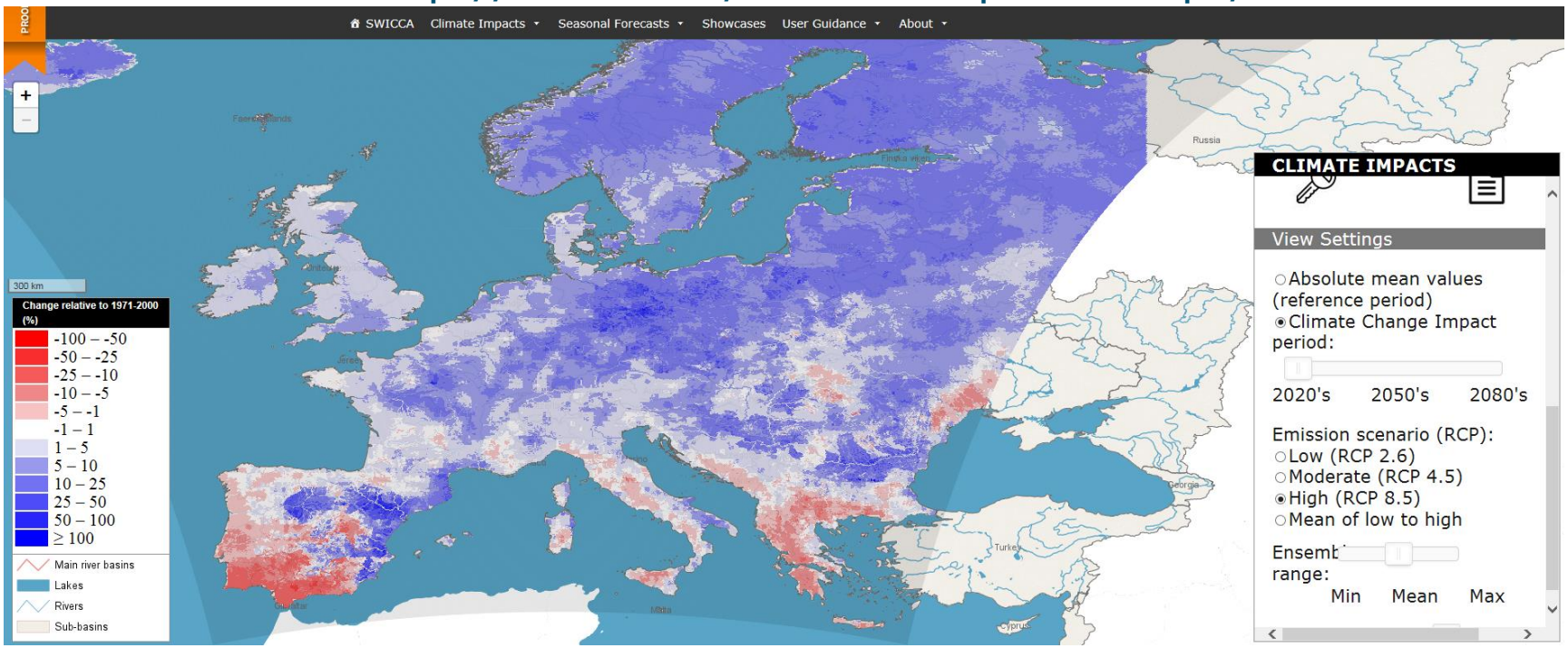
http://droughtmonitor.unl.edu/

Copernicus project C3S_441_Lot1_SMHI (SWICCA)

http://swicca.eu/climate-impacts-maps/



- Long-term projections of changes in water resources availability and water quality under climate for Europe
- New C3S project water and climate services at global scale

Conclusions

- **Drought** and **water scarcity indicators** should be **tailored** to the **user needs**
- Users need ***reliable, accurate and easily accessible data***

of droughts and water scarcity

  - Soil moisture, groundwater, surface water availability
  - Sector water use
  - Water quality

- ***Quality matters for water scarcity***
  → need for *water scarcity indicators* and *information services* including *water quality*
- New projects on climate and water information services

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WUR involvement Copernicus Climate Change Data Store (C3S)

- **C3S_52_ Lot2_IEA**: EQC Europe, multi sector user needs (a.k.a. *SECTEUR*)
- **C3S_441_Lot1_SMHI:** SIS Europe, PoC water (a.k.a. *SWICCA*
- **C3S_422_Lot1_global_SMHI**: SIS Global, PoC multi sector (a.k.a. *GLORIOUS*)
- **C3S_422_Lot1_global_WEnR**: SIS Global, PoC agriculture (a.k.a *CRUCIAL*)
- **COP_010_Lot2_WEnR:** C3S wide, learning services
- **C3S_424_Lot1_SMHI:** SIS Europe, Operational (surface) water 5km

SIS = Sectorial Information System
EQC = Evaluation and Quality Control
PoC = Proof of Concept

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Thank you very much

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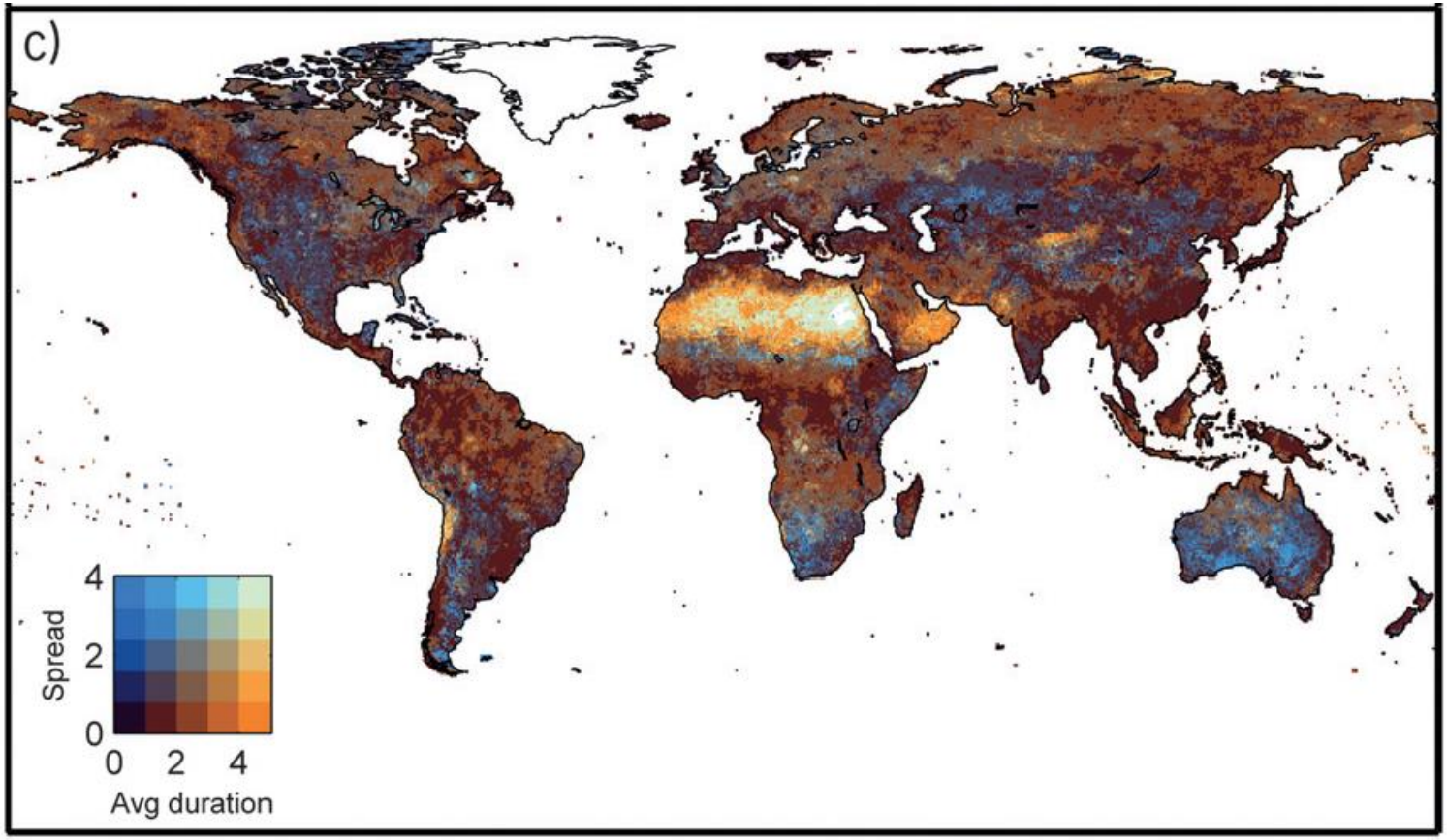
Extra slides

Global hydrological droughts

Average duration of hydrological droughts (in months) over 1968–2001 based on results of 10 global hydrological models



Van Huijgevoort et al (2013), J of Hydrometeorology

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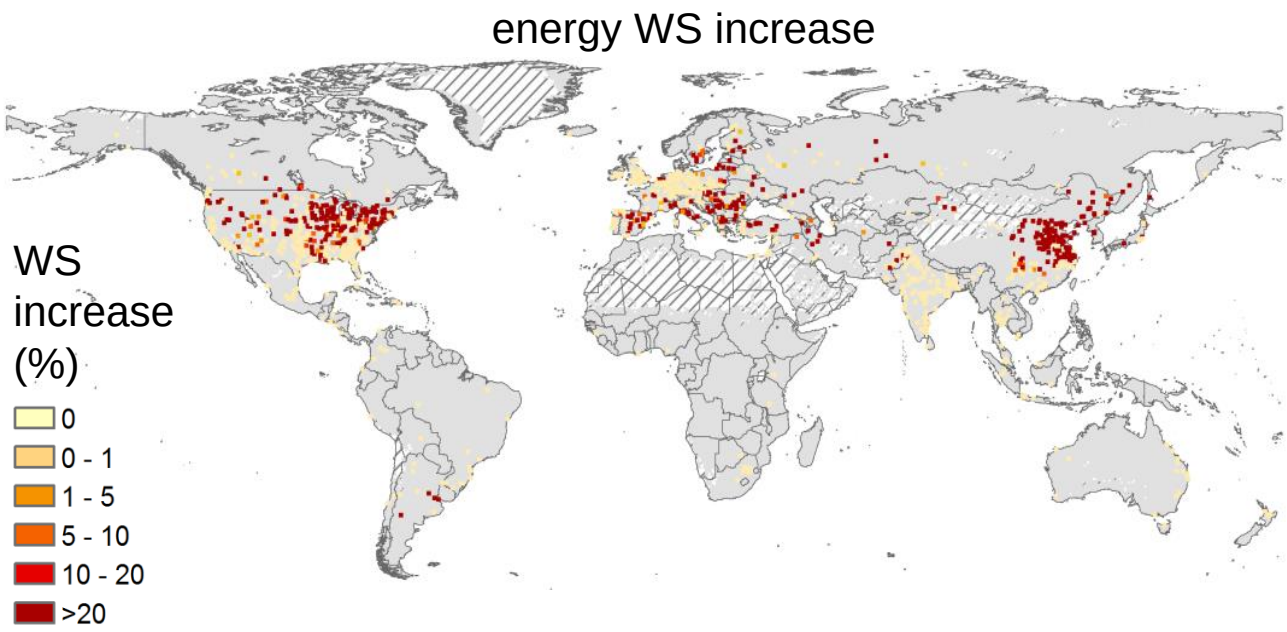
Global impacts of water quality in WS



van Vliet et al (2017), nature geoscience

- Increase of >20% in WS for one-third of thermoelectric power plants by including water temperature in WS calculation

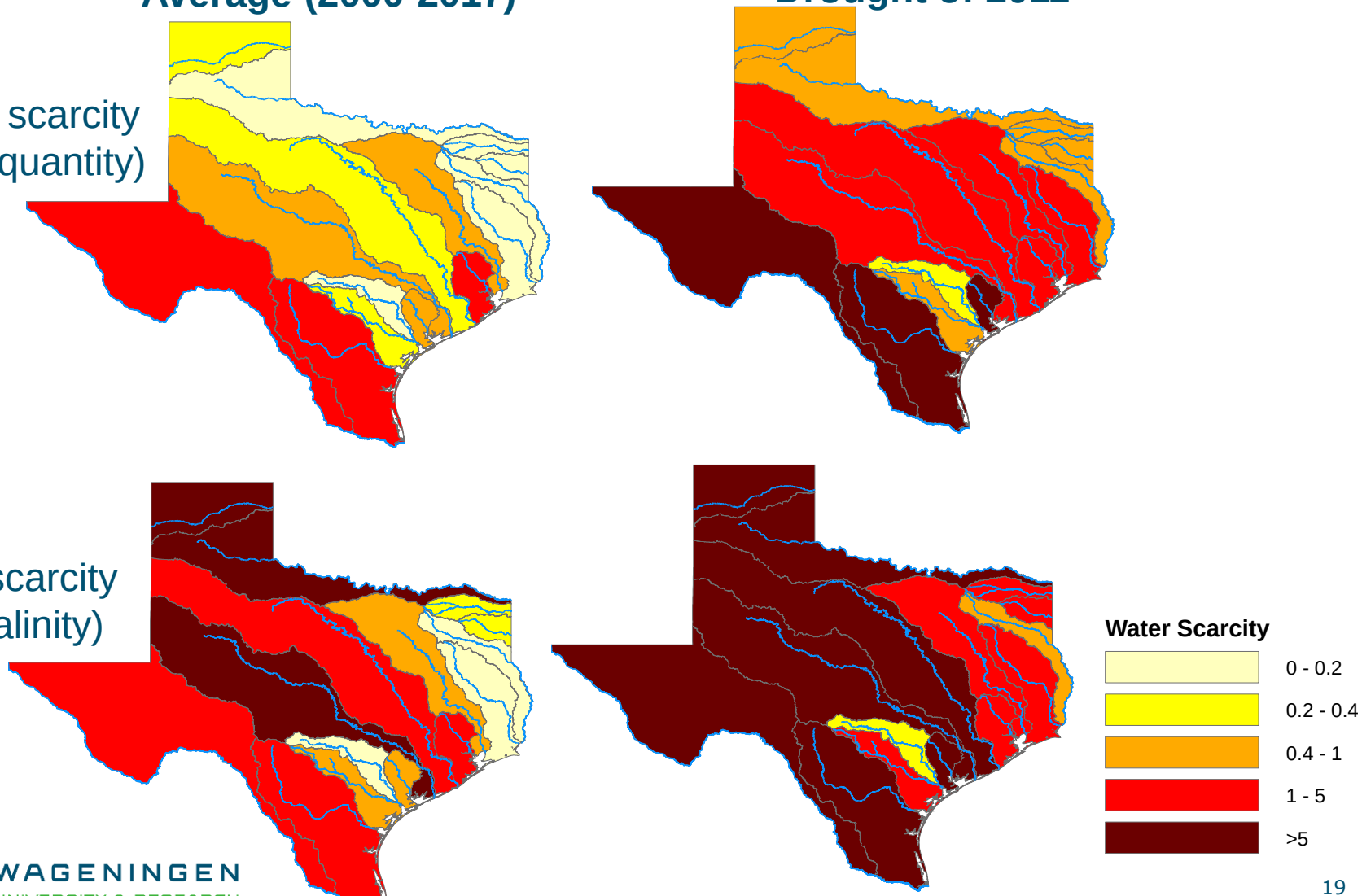
Water scarcity during droughts in Texas

Average (2000-2017)

Drought of 2011

water scarcity
(only quantity)

water scarcity
(incl. salinity)



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Jones & van Vliet (in review)

Indicators for water use sectors

Table 1
Selection of hydrological indices, units and definitions and associated water use sectors.

Hydrological index	Unit	Definition	Other sectors
Risk and safety			
$Q_{max_1:10yr}$	$m^3 s^{-1}$	1 in 10-year flood	Agriculture, energy
Q_{10}	$m^3 s^{-1}$	10th percentile streamflow (streamflow drought)	Agriculture, energy
QDdays = *ndays* ($Q < Q_{10}$)	–	Number of days per year with streamflow drought (flow less than 10th percentile flow)	Agriculture, energy
$QD_{avg} = \frac{\sum max(0,(Q-Q_{10}))}{ndays(Q<Q_{10})}$	$m^3 s^{-1}$	Mean flow deficit (of the days defined as streamflow drought)	Agriculture, energy
Agriculture			
SM_{10}	mm	10th percentile soil moisture	
SMDdays = *ndays* ($SM < SM_{10}$)	–	Number of days per year with soil moisture drought (soil moisture less than 10th percentile soil moisture)	
$SMD_{avg} = \frac{\sum max(0,(SM-SM_{10}))}{ndays(SM<SM_{10})}$	mm	Mean soil moisture deficit (of the days defined as soil moisture drought)	
Energy sector			
Hydropower potential			
Q_{avg}	$m^3 s^{-1}$	Mean streamflow	
GP (see Eq. (1))	(MW)	Gross hydropower potential	
Cooling water use potential thermoelectric power			
Tw_{avg}	°C	Mean water temperature	Environment
TwLdays = *ndays* (Tw > 23°C)	–	Number of days that critical limit for inlet river water for cooling water use is exceeded	Environment
Environment			
DO_{avg}	$mg\ l^{-1}$	Mean dissolved oxygen concentration	
TN_{avg}	tonnes/km²/year	Mean total nitrogen load to surface waters	
TP_{avg}	tonnes/km²/year	Mean total phosphorous load to surface waters	

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Van Vliet et al (2015), Journal of Hydrology