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Global water scarcity reduction requires water quality solutions

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What is water scarcity?

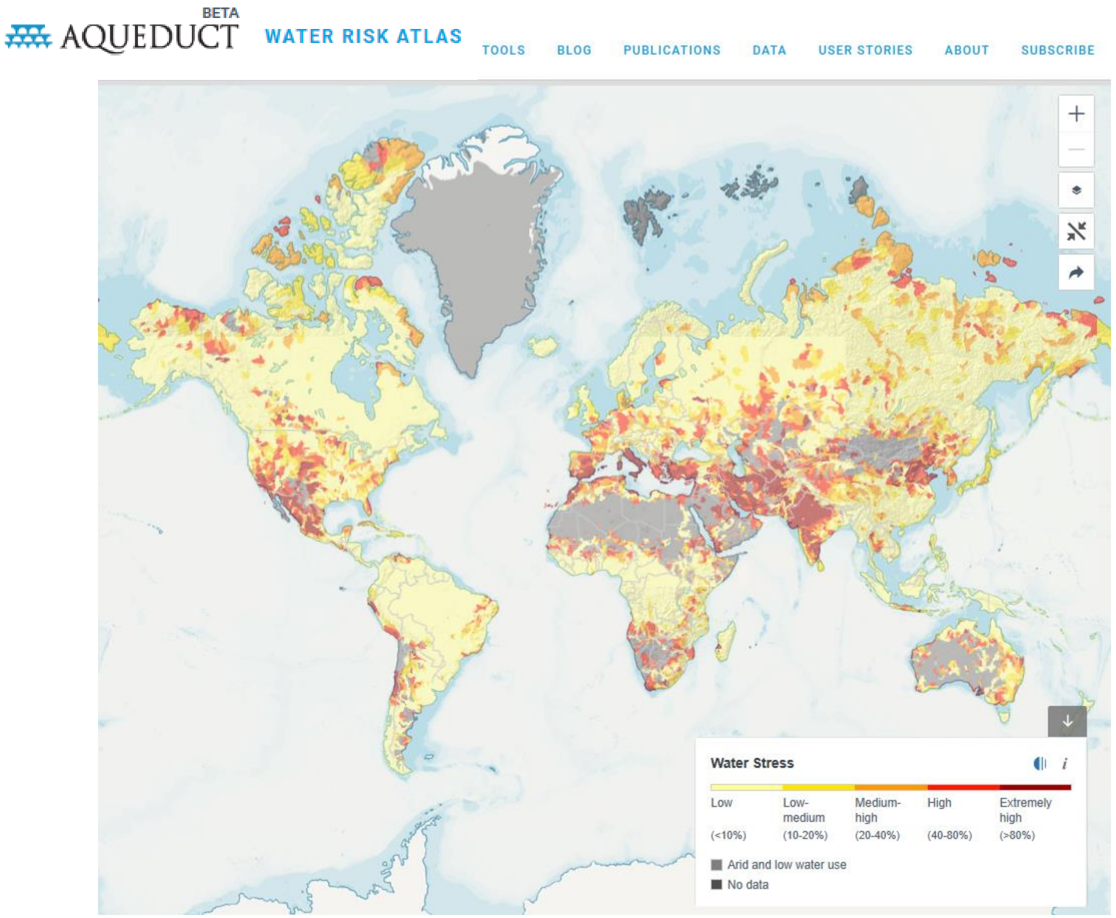
- ‘Demand for water by all sectors and the environment cannot be fully satisfied due to the impact of water use on supply or quality of water’ (*Liu et al, 2017, Earth’s Future*)

- Previous studies focussed on **water quantity**

Water scarcity = $\dfrac{\text{water use}}{\text{water availability}}$

‘criticality ratio’

SDG6.4.2



World Resources Institute (2019)

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 domestic water

Objective of NWO-VENI project:
To develop a new concept and **indicators** of **water scarcity** including **water quality**

NWO

Veni, Vidi, Vici

Rethinking water scarcity

van Vliet et al. (2017)
Nature Geoscience

Quality matters for water scarcity

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

Quality requirements for water differ by intended use. Sustaina
different uses will not only need to account for demand in wate
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.

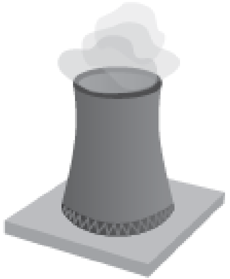
$$WSq = \frac{\Sigma_{j=1}^{n} (D_j + dq_{i,j})}{Q - (EFR + dq_{i_{eco}})} \qquad (1)$$

with:

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

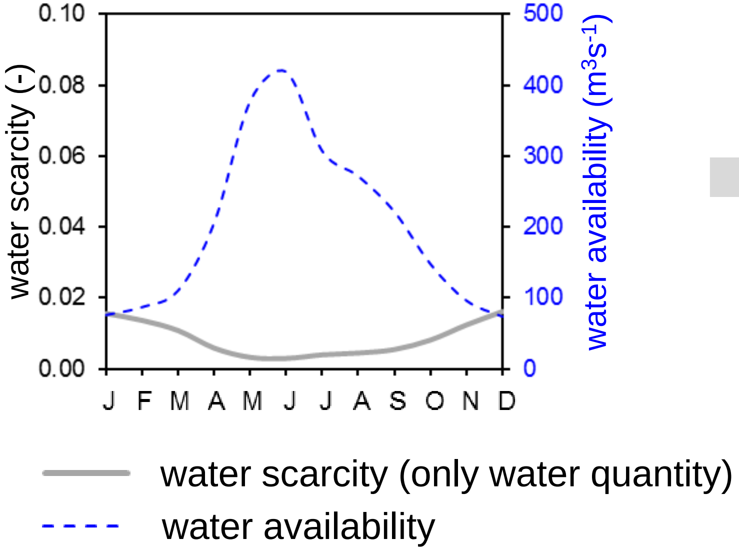
Where WSq is the water scarcity including water quality (-); D is water withdrawal for sector j (m^3 s^{-1}); Q is water availability (m^3 s^{-1}); EFR is the environmental flow (quantity) requirements (m^3 s^{-1}); dq is extra water withdrawals for dilution to obtain acceptable quality for sector j 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).

Quality matters for water scarcity

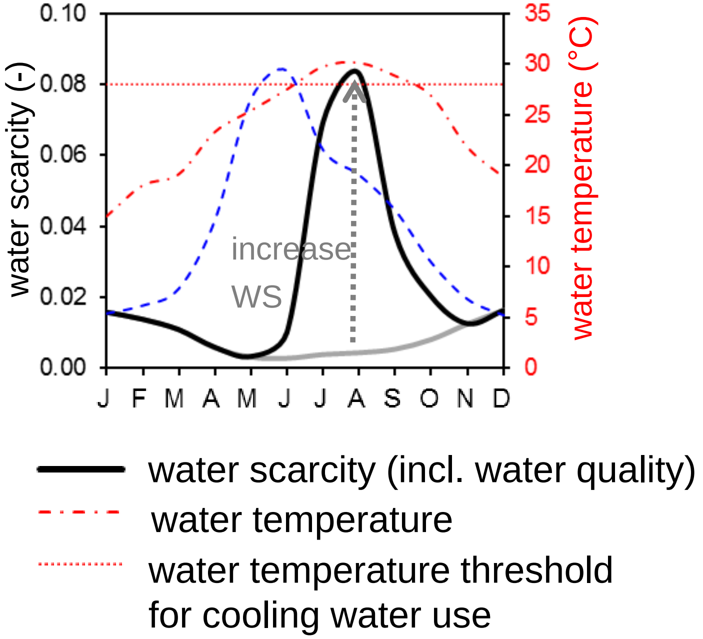


energy sector
water temperature
(Pearl river)

energy water scarcity
only water quantity

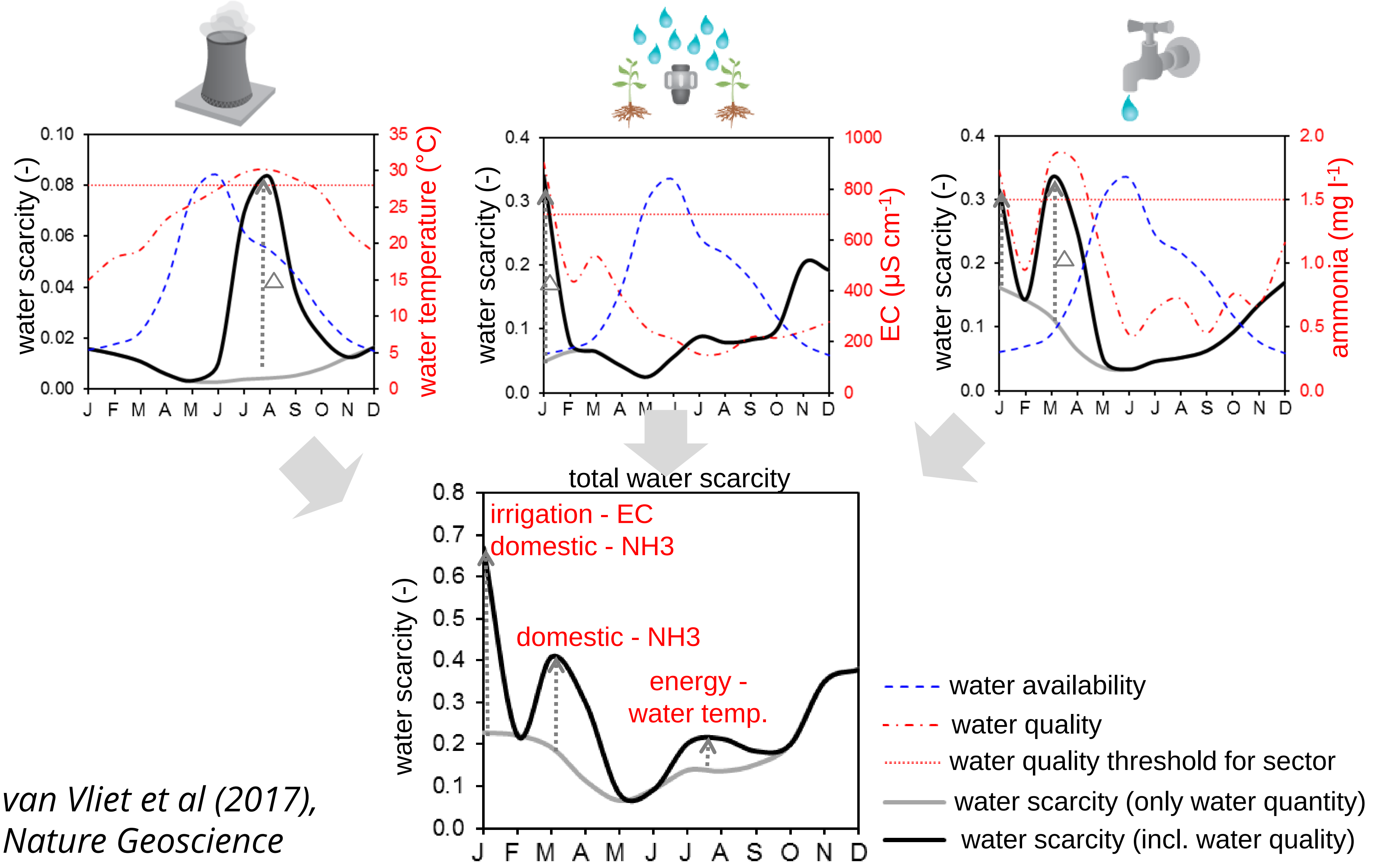


energy water scarcity
including water quality



van Vliet et al. (2017), Nature Geoscience

Sectoral water scarcity



van Vliet et al (2017), Nature Geoscience

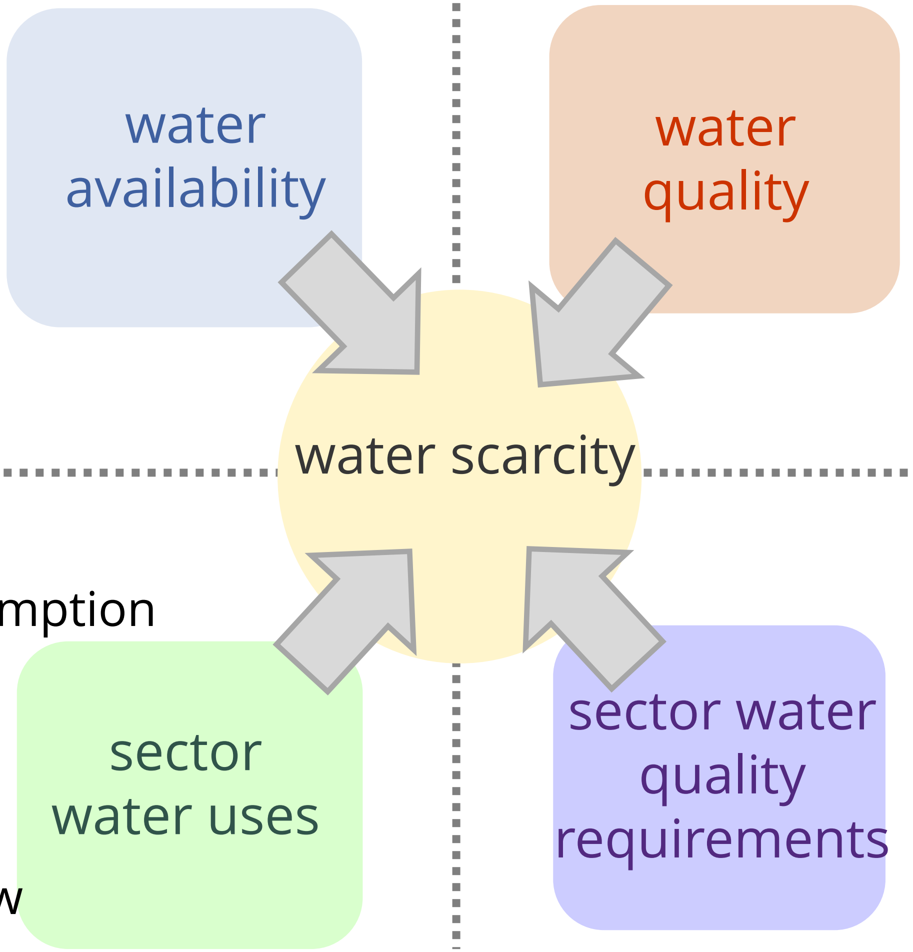
Water scarcity concept

water quantity

- global hydrological model output (0.5°)

water quality

- water temperature
- salinity (TDS)
- organic pollution (BOD)
- nutrients (TN, TP)



water supply

water demands

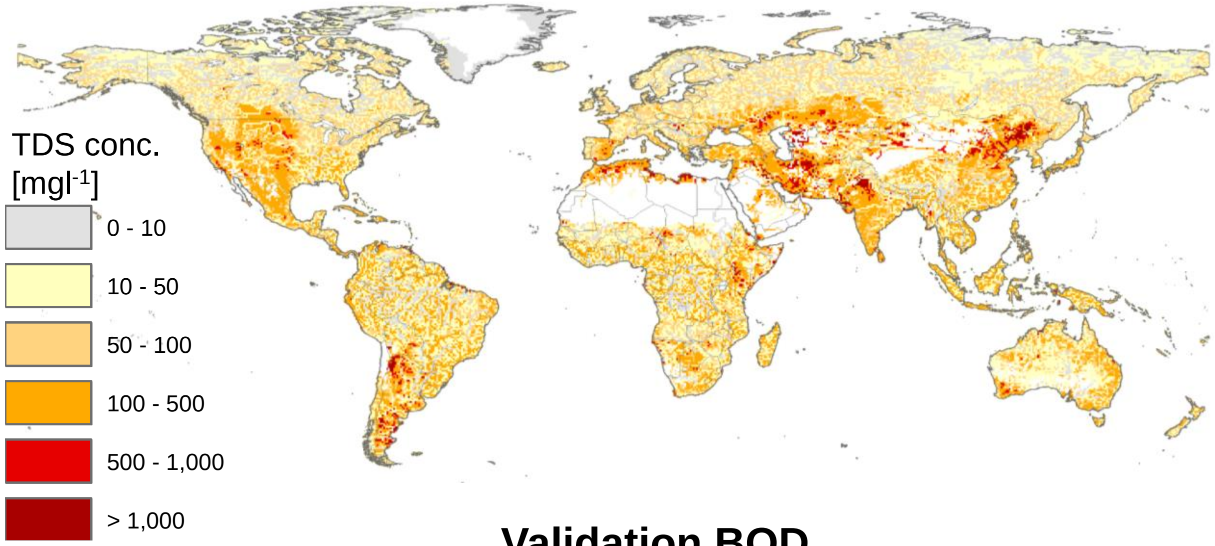
- withdrawal, consumption
  - irrigation
  - domestic
  - energy
  - manufacturing
- environmental flow requirements

- water quality standards per sector and for ecosystem health

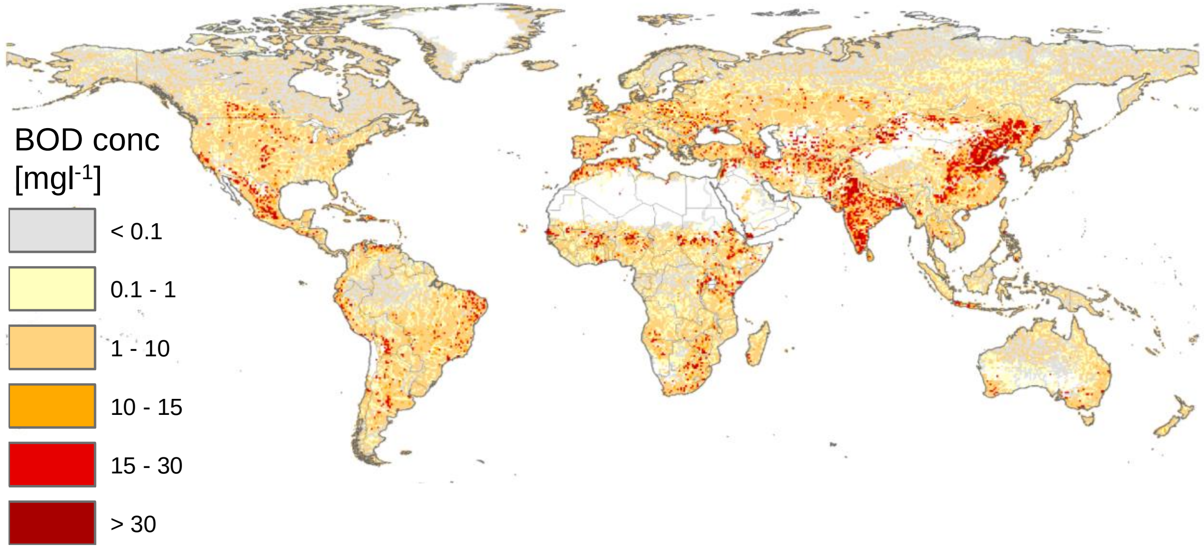
Global surface water quality modelling

Average concentrations for 2000-2010

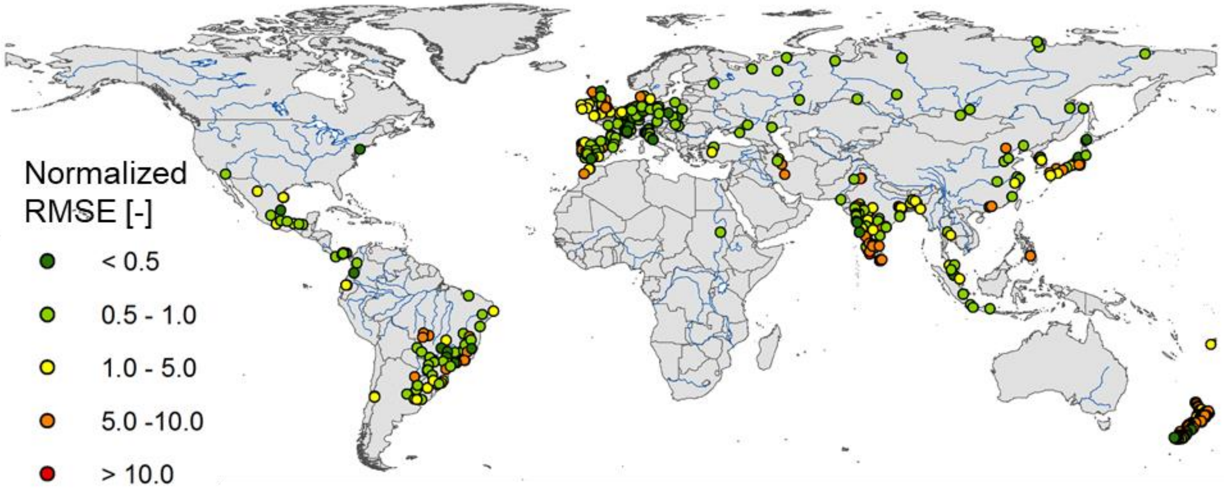
salinity (TDS)

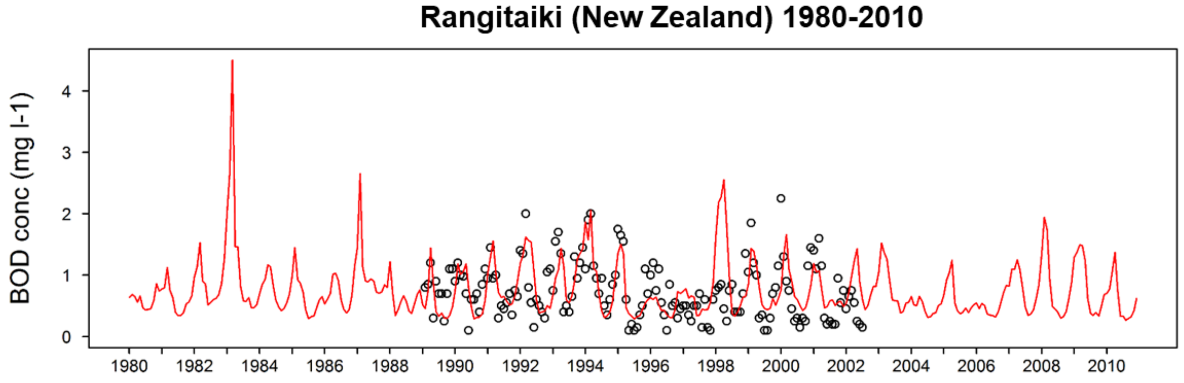


organic pollution (BOD)



Validation BOD

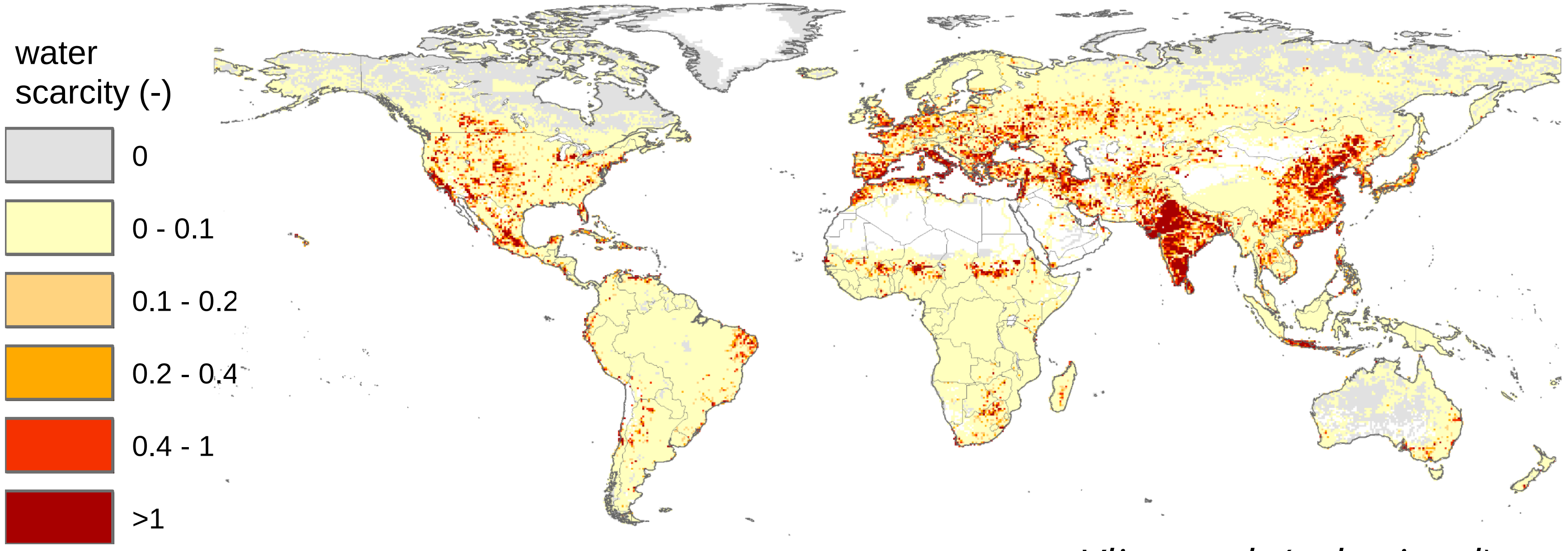




van Vliet et al. (2019), COSUST; van Vliet et al. (submitted)

Surface water quality impacts on global water scarcity

Average water scarcity including water quality
(based on monthly timeseries for 2000-2010)



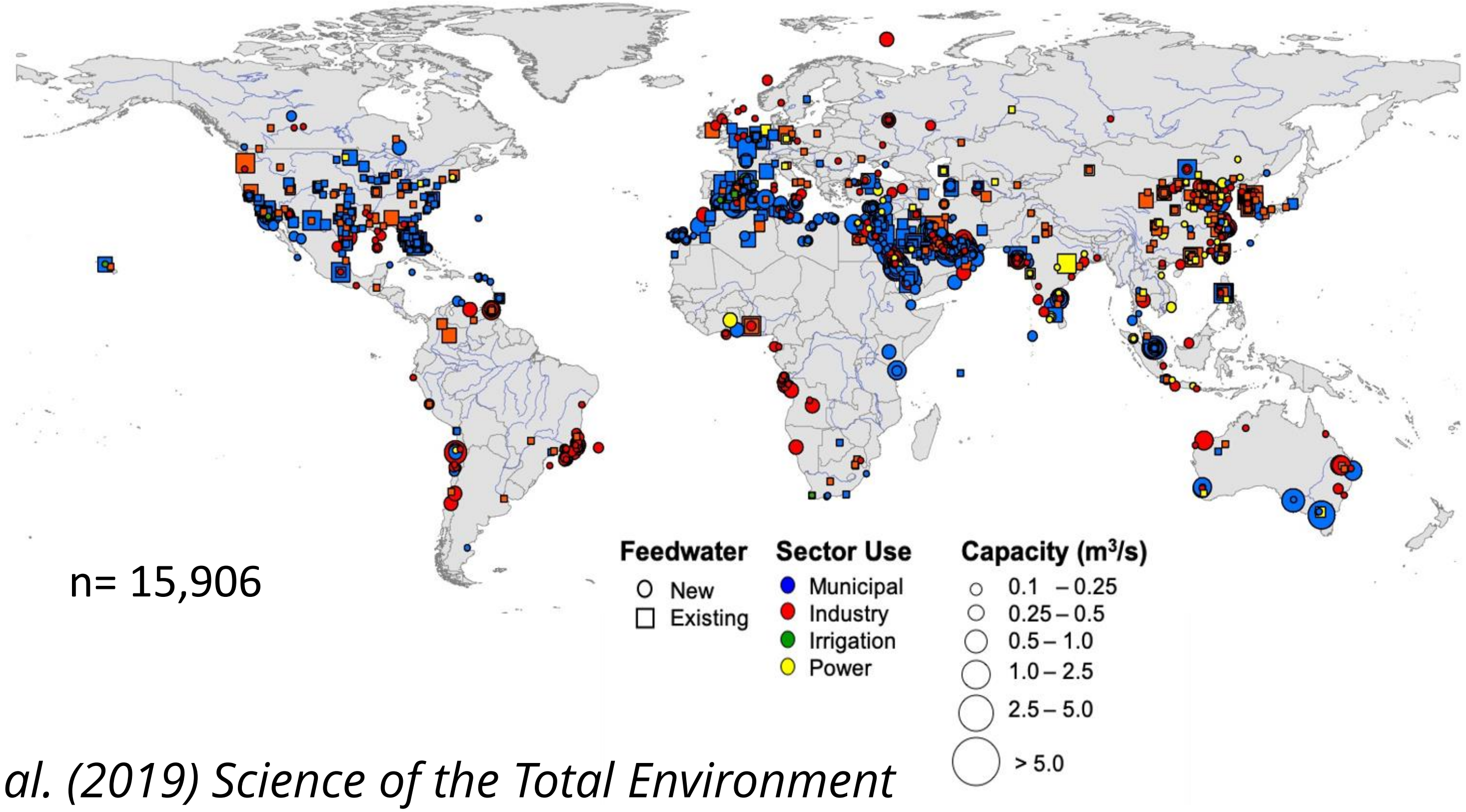
van Vliet et al. (submitted)

- Increases in **world's population under severe water scarcity** from **30%** (only water quantity) to **40%** (both water quantity and quality)
- **Water scarcity** driven by both **water quantity** and **quality** issues in **hotspots** regions of the world

Technological solutions to reduce water scarcity

- Expansion in desalination (inland/sea water) for domestic, manufacturing and energy uses
- Expansion in treated waste water reuse for irrigation

present-day desalination capacity



n= 15,906

Jones et al. (2019) Science of the Total Environment

Conclusions

- **Quality** matters for **water scarcity**
- **New water scarcity concept and indicators** including **water quality** and **water scarcity mitigation options** (desalination, treated waste water reuse)

→ **Regional hotspots** of **water scarcity**, both in terms of **water quantity** and **quality**.

→ **Causes**, **impacts** and **solutions** to reduce the gap between supply and demand of water of a suitable quality

Questions?

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