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Modelling global water stress a monthly time scale

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Background and aim

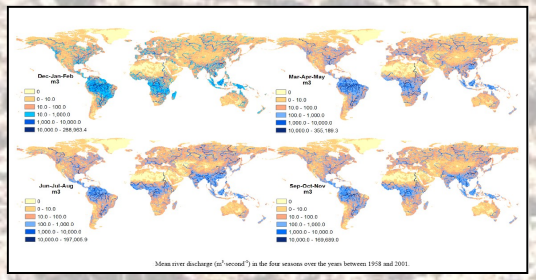
Until now analyses on global water stress are based on yearly averages. But demand and availability are often out of phase.

Our aim: estimate global water stress at monthly time steps.

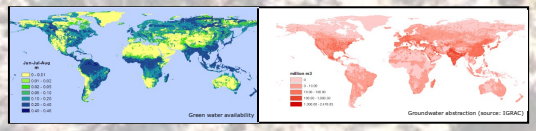
Methods

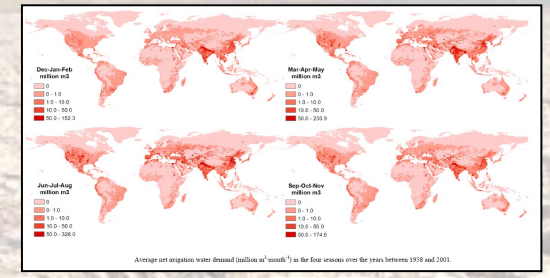
Availability for 1958-2001 calculated with global hydrological model PCR-GLOBWB forced with CRU (downscaled with ERA40), including upstream water, reservoirs, desalinisation, groundwater abstraction and green water (i.e. soil water available for irrigated crops)

Demand (year 2000) consisting of agricultural (rainfed, irrigation, livestock), domestic and industrial water demand.



Mean river discharge ($m^3 \cdot second^{-1}$) in the four seasons over the years between 1958 and 2001.





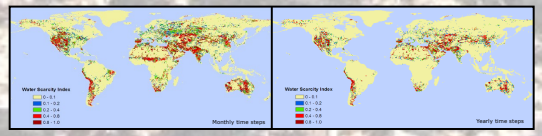
Average net irrigation water demand (million $m^3 \cdot month^{-1}$) in the four seasons over the years between 1958 and 2001.

Comparison previous analyses

Population (100 millions) under different degrees of blue water stress with different spatial resolutions.

Degrees of water stress	No stress	Low stress	Moderate stress	High stress	Total	Year[28]	Spatial resolution	Temporal resolution
Per capita water availability ($m^3 \cdot capita^{-1} \cdot year^{-1}$)	> 1,700	-	1,700 - 1,000	<1,000				
Rws	Rws < 0.1	0.1≤ Rws < 0.2	0.2≤ Rws < 0.4	0.4≤Rws				
Country based estimates								
WHO (1997)	17	21	14	5	57	1995	Country	Year
Arnell (1999a)	-	-	14	4	52	1990	Country	Year
Vörösmarty et al. (2000)	20	17	15	5	57	1995	Country	Year
Oki et al. (2001)	18	15	15	8	56	1995	Country	Year
Watershed based estimates								
Alcamo et al. (2000)	-	-	-	21	57	1995	Watershed	Year
Revenga et al. (2000)	31	-	7	17	57[21]	1995	Watershed	Year
Oki et al. (2001)	12	5	12	27	56	1995	Watershed[22]	Year
Arnell (2004)	-	-	8	14	57	1995	Watershed	Year
Grid based estimates								
Vörösmarty et al. (2000)	32	4	4	18	58	1995	0.5°	Year
Oki et al. (2001)	28	6	6	17	57	1995	0.5°	Year
Arnell (2004)	-	-	8	26	57	1995	0.5°	Year
Islam et al. (2007)	38	5	6	12	61	2000	0.5°	Year
This study	**40**	**6**	**6**	**9**	**61**	**2000**	**0.5°**	**Year**
This study	**30**	**8**	**8**	**15**	**61**	**2000**	**0.5°**	**Month**

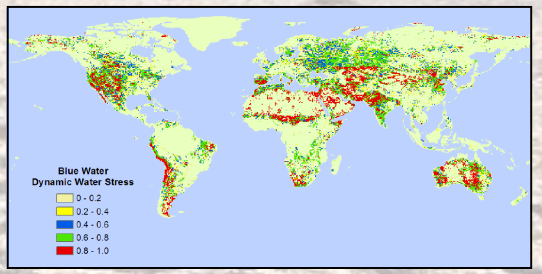
Comparison monthly and yearly



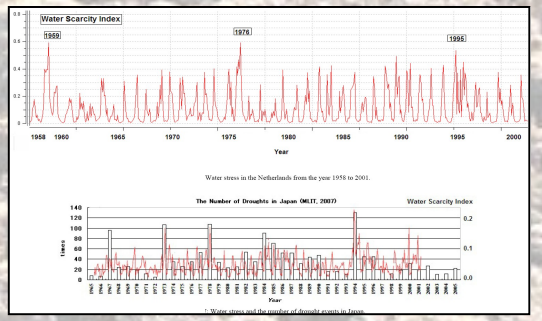
Dynamic water stress

Based on insights from ecohydrology (Porporato et al., AWR, 2001) we can calculate a dynamic water stress measure based on duration, recurrence of stress and severity when in stress:

$$WS_{dynamic} = \left(\frac{\overline{\sum T_{SW}}}{kT_{zeaz}} \right)^{1/\sqrt{n_t}}$$



Some validation



: Water stress and the number of drought events in Japan

Conclusion

Water stress from monthly analysis is more severe than from yearly analysis

Dynamic water stress distinguishes areas with frequent and prolonged water stress from those with incidental water stress