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Supplementary Materials for

Four billion people facing severe water scarcity

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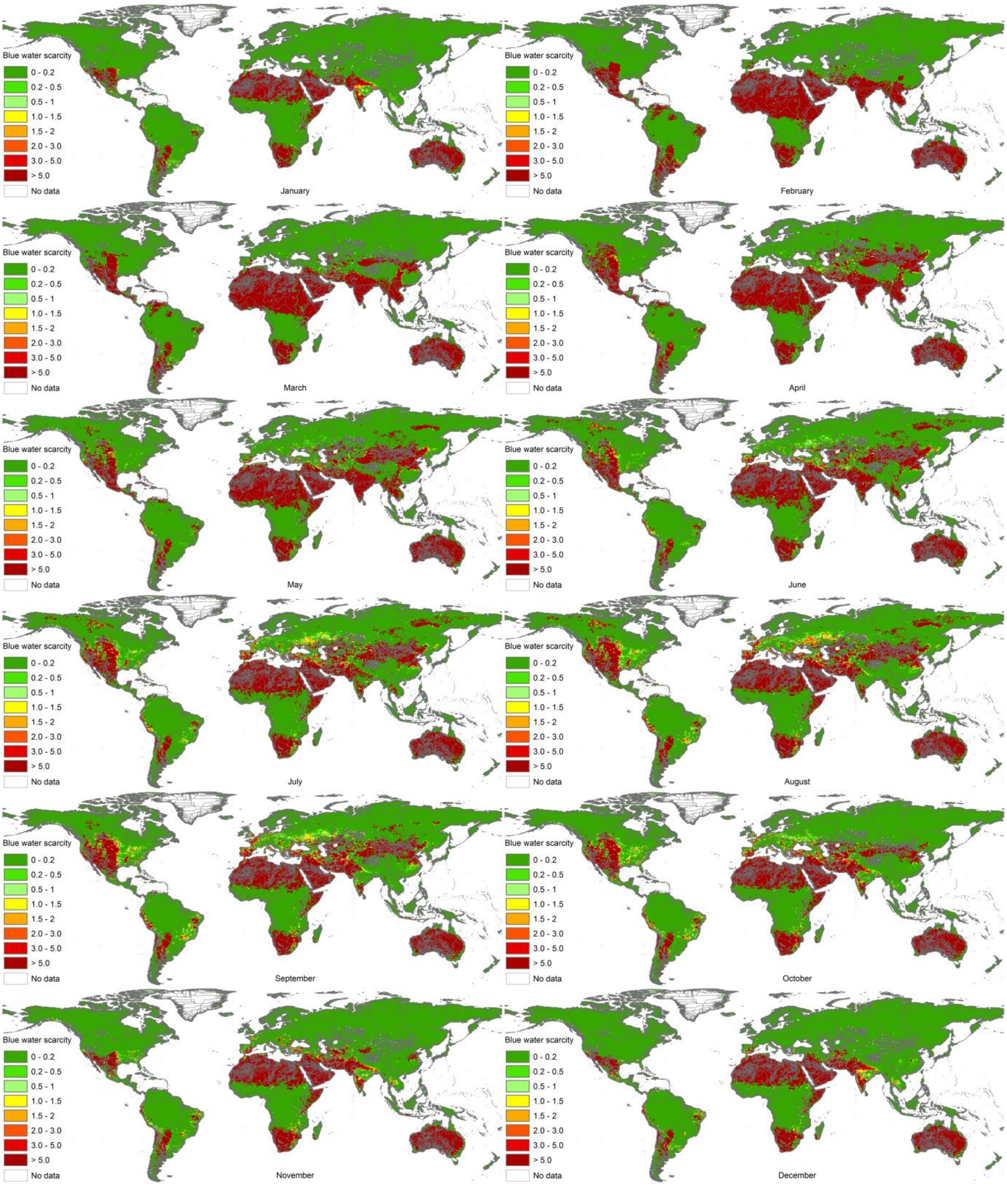

Fig. S1. *Average monthly blue water scarcity at a spatial resolution of 30 × 30 arc min. Period 1996-2005.*

Supplementary Discussion

The assumptions behind previous studies that estimated the number of people facing severe water scarcity are summarised in Table S1. The first two studies listed in the table measure water scarcity as the natural runoff available per capita, with 1000 m^3/cap/y as a threshold for severe water scarcity. The disadvantage of this measure is that it tells little about actual water scarcity, since the water footprint of a population is not necessarily in the same basin as in which it lives (*40*). In all studies, with the exception of Wada et al. (*13*, *14*), Hanasaki et al. (*12*) and Hoekstra et al. (*15*), water scarcity was estimated on annual basis. The latter two studies are the only ones that account for environmental flow requirements. Hanasaki et al. (*12*), however, do not really measure water scarcity but measure the extent to which crop water requirement are met.

Previous studies underestimated water scarcity and hence the number of people facing severe levels by evaluating water scarcity (a) at the level of too large spatial units (per river basin), (b) at annual rather than monthly basis, and/or (c) excluding environmental flow requirements. Measuring at too large spatial scale or at annual basis hides the water scarcity that manifests itself in specific parts of river basins and specific parts of the year. In order to account for that shortcoming, the traditional threshold value for severe water scarcity has been, rather arbitrarily, set at 0.4, meaning that annual withdrawal in a river basin should not exceed 40% of annual runoff. Assuming that, on average, water consumption is 60% of total water withdrawal, this is equivalent to requiring that annual water consumption should not exceed 24% of annual runoff. This threshold contains implicit assumptions regarding environmental flow requirements and fails to capture variability within the year and within a basin. By taking the presumptive standard on environmental flow requirements, we require that monthly water consumption remains below 20% of monthly runoff, but we speak about severe water scarcity only if monthly water consumption exceeds 40% of monthly runoff. By estimating water scarcity at a high spatial and temporal resolution we thus have been able to better capture true water scarcity, and by considering environmental flow requirements and water consumption rather than gross abstraction, we were also able to use a water scarcity measure that has a straightforward interpretation: in the current study, WS reflects the fraction of water available for consumptive activities that has been consumed.

Table S1. *Comparison of results between the current study and previous studies.*

Study	Year	Coverage	Spatial resolution	Temporal resolution	Measure of water use*	Measure of water availability**	Threshold for severe water scarcity	Population under severe water scarcity (billions)	Remark
Kummu et al. (*28*)	2005	Global	Sub-basins	Annual	Population size	Natural runoff	< 1000 m^3/cap/y	2.3	
Islam et al. (*27*)	2000	Global	30 arc minute	Annual	Population size	Natural and actual runoff	< 1000 m^3/cap/y	1.8 - 3.1	Lower estimate refers to case where all water from upstream grid cells is fully available; the upper estimate to when it is fully consumed.
Hanasaki et al. (*12*)	1995	Global	60 arc minute	Monthly	Withdrawal	Actual runoff minus environmental flow requirement	Cumulative water withdrawal to demand ratio < 0.5	2.4-2.5	
Alcamo et al. (*29*)	1995	Global	Basin	Annual	Withdrawal	Natural runoff	Water withdrawal / availability > 0.4	2.1	
Alcamo et al. (*30*)	1995	Global	Basin	Annual	Withdrawal	Natural runoff	Water withdrawal / availability > 0.4	2.3	
Oki et al. (*8*)	1995	Global	30 arc minute and basin	Annual	Withdrawal	Actual runoff	Water withdrawal / availability > 0.4	1.7-2.7	The lower estimate for the grid level assessment, the higher estimate for the basin assessment
Oki and Kanae (*11*)	1995	Global	30 arc minute	Annual	Withdrawal	Actual runoff	Water withdrawal / availability > 0.4	2.4	
Vörösmarty et al. (*2*)	1995	Global	30 arc minute	Annual	Withdrawal	Actual runoff	Water withdrawal / availability > 0.4	1.8	
Wada et al. (*13*), (*14*)	2000	Global	30 arc minute	Monthly	Consumption	Actual runoff	Water consumption / availability > 0.4	1.7-1.8	
Hoekstra et al. (*15*)	1996-2005	405 major river basins	Basin	Monthly	Consumption	Natural runoff minus environmental flow requirement	Water consumption / availability > 2	2.7	People facing severe water scarcity at least one month / year
Current study	1996-2005	Global	30 arc minute	Monthly	Consumption	Actual runoff minus environmental flow requirement	Water consumption / availability > 2	4.0	People facing severe water scarcity at least one month / year

* Water withdrawal refers to gross water abstraction; water consumption refers to net water abstraction, also called blue water footprint.

** Actual runoff refers to natural runoff minus upstream water consumption.