



A data set of distributed global water withdrawal from 1960 to 2017

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Abstract

More and more high-resolution data sets are simulated worldwide and used in various research. However,
 in addition to the improvement in accuracy, the practical significance of the spatial distribution of data must also
 be considered. Considering that the most accurate water withdrawal data are mainly provided by the state, water
 is mainly concentrated on artificial surface and cultivated land. Whenever possible, using data published by
 regional or national governments and interpolating and extending them to specific land uses will maximize data
 accuracy. Based on this, we provide a set of water withdrawal intensity products from 1960 to 2017 distributed
 to the administrative units or the corresponding regions. The data set fills the gaps in the multi-year data set of
 the accurate intensity of water withdrawal. The datasets described in this article are publicly and freely available
 through the FigShare. The DOI for the data is <https://doi.org/10.6084/m9.figshare.10012559.v1> (Yan et al., 2019).

Introduction

The requirement and utilization of water resources vary with time and geographical changes (Snow, 2005).
 According to the United Nations World Water Development Report 2018, with the rapid growth of the global
 population, the demand for water is expected to increase by nearly one third by 2050 (Houngbo, 2018). The
 increase in water demand makes it difficult to make decisions about water allocation, and has affected the



27 development of industries that are critical to sustainable development, especially food and energy production.
28 The demand competition of water withdrawal further exacerbates the risk of regional conflicts. According to the
29 United Nations World Water Development Report 2018, about 1.5 billion people in 80 countries and regions,
30 which account for 40% of the world's total population, are under-resourced, and about 300 million people in 26
31 countries are extremely short of water (Peter, 2018). Studying the changes in world water withdrawal patterns,
32 accurately analyzing the water withdrawal intensity structure, can reveal the regional characteristics of the water
33 withdrawal and the regularity of water space distribution, and has important practical significance in promoting
34 the harmonious and sustainable development of economy and resources of the world.

35 Water withdrawal intensity is the main forms of water consumption and the main indicator of regional
36 development differences (Nouri, 2015). Water withdrawal intensity refers to the water consumption in the global,
37 continental, national and even smaller administrative regions, economic zones and other land areas within a
38 specific geographical area. The traditional water withdrawal evaluation usually takes the country as the minimum
39 administrative unit with low spatial resolution, and the data usually reflects the summary or average value within
40 a statistical unit, failing to reveal the spatial distribution differences of socio-economic data within the statistical
41 unit (Balk et al., 2006; Doxsey et al., 2015). With the continuous development of high-resolution grid data,
42 higher requirements are put forward for global grid data, and subnational data also have more application
43 potential. Most of the sources of water withdrawal data released by the world bank, FAO and other international
44 organizations are based on national governments or statistical departments. However, these data may deviate
45 from the real water withdrawal data of a country or region due to statistical caliber, and there is almost no
46 continuous long series of water withdrawal data globally. Moreover, most of the data released by international
47 organizations is based on national scale and lacks finer regional data. Therefore, appropriate methods are needed
48 to modify the data and distribute them to the corresponding spatial location.

49 This data set includes a set of water withdrawal intensity products distributed to the administrative units, a
50 set of water withdrawal intensity products distributed to artificial surface and cultivated land, and an EXCEL
51 file for the total amount of water withdrawal of different countries.

52 Data cover almost all regions of the world. Water withdrawal data include 214 national units and 616
53 national or sub-national units. Because of the difficulties in obtaining regional data in some countries, sub-



national data are replaced by national data. However, there may be some errors in the statistics and collection of the original water withdrawal data, which may lead to deviations between the data set and the real water withdrawal data. With the reference of the official data available, the accuracy of the data set is sufficient to meet the current research. This water withdrawal data set fills the blank of complete water withdrawal sequence data and provides products that can reflect the spatial and temporal changes of water withdrawal in the world. Therefore, it can be used as the basic information for the study of global climate change, environmental resources, regional economy and political decision-making. With the improvement of the accuracy of the original data acquisition in the future, the data set can be amended and supplemented.

Name	Acquisition Year	Source	Spatial Resolution	Format/ Pixel Type & Depth	Spatial Reference	Spatial Coverage
Globeland 30	2000/2010	National Geomatics Center of China (NGCC)	1" (~30m)	@	GCS WGS 1984	Global
National boundaries	2015	National Geomatics Center of China (NGCC)	1km	ESRI polygon shapefile	GCS WGS 1984	Global
Subnational boundaries	2015	National Geomatics Center of China (NGCC)	1km	ESRI polygon shapefile	GCS WGS 1984	Global
Population/Water Withdrawal	1960-2017	World Bank	@	Excel	@	Global
Water Withdrawal	1960-2017	Food and Agricultural Organization	@	Excel	@	Global
Water Withdrawal	1960-2017	UN data	@	Excel	@	Global
Population/ Water Withdrawal	@	Government or statistical bureau	@	Excel	@	Nation

Table 1. Input datasets, used to produce the global water withdrawal products

Name	Temporal extent	Spatial Resolution	Format/ pixel Type & Depth	Spatial Coverage
*_widyear_1km	1960~2017	1000 m	TIFF/flt32	Continent
*_winyear_sr	1960~2017	1000 m	TIFF/flt32	Continent
*_Coutry_W_Data	1960~2017	@	Excel	Continent
*_lu10	2000/2010	1000 m	TIFF/flt32	Continent
*_lu80	2000/2010	1000m	TIFF/flt32	Continent

Table 2. The global water withdrawal products

Methods

In this chapter, we describe in detail the method of dataset generation, including data collection, data modification and interpolation extension, and grid data generation.

First, the collection of water withdrawal data. Collect as much as possible of the national and sub-national



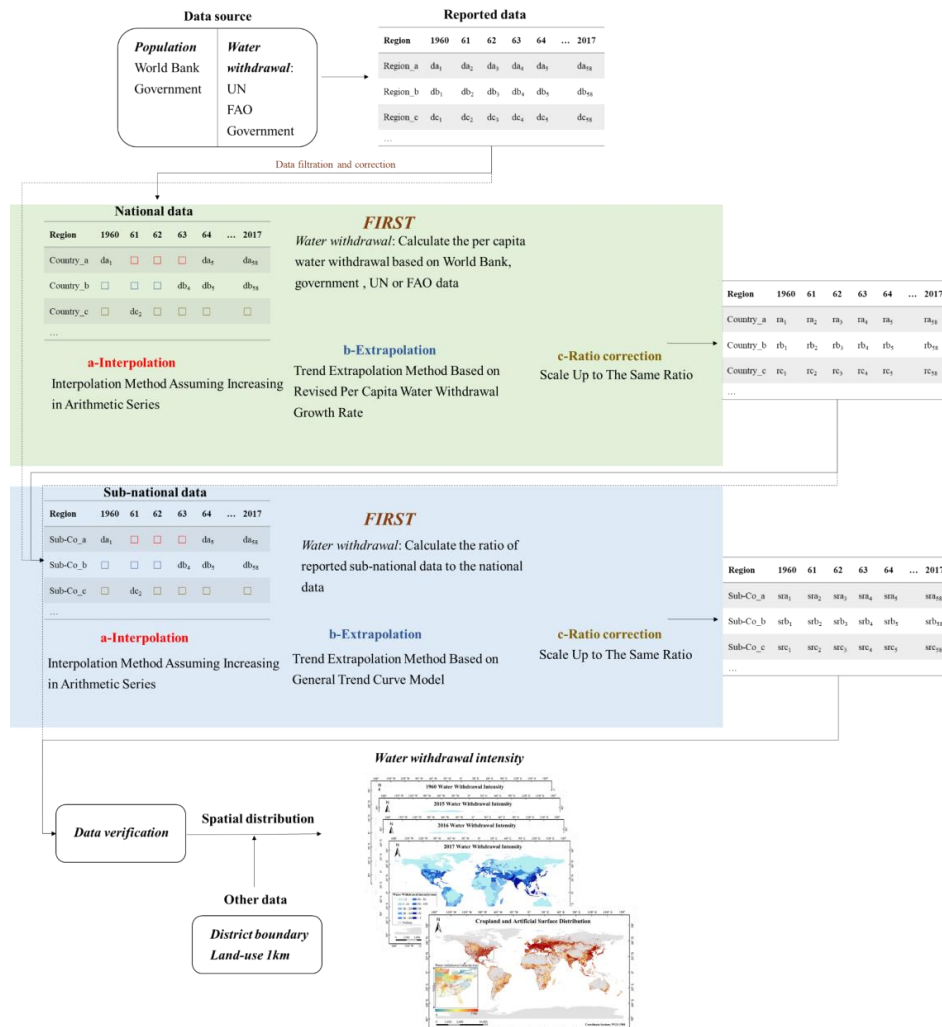
68 permanent population and water withdrawal data released by governments and institutions on a global scale, and
69 then obtain the per capita water withdrawal data.

70 Second, establish a national defect data interpolation model. Based on the shape of the sample data scatter
71 plot, determine the most appropriate curve model. Simulation modeling is implemented using EXCEL or
72 MATLAB.

73 Third, establish a sub-national defect data interpolation model. After completing the national data
74 interpolation, determine the best interpolated or extended model for the simulation of defect sub-national data.
75 Simulation modeling is implemented using EXCEL.

76 Fourth, create spatial distribution grids. Spread the water withdrawal intensity to the administrative unit,
77 and, artificial surface and cultivated land.

78 Fifth, data verification. We divide the measured data into calibration and verification period, re-interpolate
79 the data using the data of calibration period, and then verify the simulation accuracy by using the data of
80 verification period and the simulation.



81

82 **Figure 1.** Schematic outline to produce the global water withdrawal products

83 *Data collection and pretreatment*

84 The data sources include government population data for xx nation and xx sub-nation, government water
 85 withdrawal data for xx nations and xx sub-nations, national population and water withdrawal data from the World
 86 Bank, and national population and water withdrawal data from FAO, water withdrawal data from the United
 87 Nation, national population and water withdrawal data from Eurostat, and Globeland30 data for 2000 and 2010.

88 Globally, it is believed that the accuracy rate of census results obtained by counting the population of
 89 various administrative units in the country is the highest at present when a large amount of manpower and



90 material resources are spent by the country itself (Honjo et al., 2015). In addition to the census conducted every
 91 certain year, the statistical department gets high accuracy rate by calculating the overall figures according to the
 92 sample survey of population changes and the random sample survey of fertility rate in some areas and some
 93 units. To sum up, we believe that the data released by the government on the statistical official website is the
 94 most reliable.

95 Secondly, when national population data are missing, it is generally believed that the data of the World
 96 Bank and FAO are authoritative. When the data of World Bank and FAO are complete, the World Bank data
 97 prevails as reference population data. When the length of World Bank data is shorter than that of FAO, the FAO
 98 data is used as reference population data (Kumar et al., 2019).

99 For water withdrawal data, FAO and UN data are generally considered authoritative when government
 100 water withdrawal data is missing. When the FAO and UN data are both complete, the FAO data is used as a
 101 reference for water withdrawal data.

102 *Interpolation and extrapolation of national water withdrawal data*

103 The total amount of water withdrawal in various countries varies greatly, but the per capita water withdrawal
 104 of the country generally remains within a certain range. Therefore, we first calculate the per capita water
 105 withdrawal of the reference data, and then interpolate and extrapolate the missing per capita water withdrawal
 106 data. The methods can be summarized as the following five categories (Deichmann et al., 2001; Balk et al.,
 107 2006; Tobler et al., 1997).

108 (1) Interpolation Method Assuming Increasing in Arithmetic Series

109 If discontinuities exist in per capita water withdrawal data, and the number of data increases in arithmetic
 110 series according to the judgement, then linear interpolation method can be used based on linear model of
 111 arithmetic series growth. This method is suitable for interval data interpolation with short interruption time and
 112 relatively uniform data growth scale. The interpolation model is as follows:

$$113 \quad P_{Nk} = \left[\frac{I(j) - I(i)}{j - i} \cdot (k - i) + I(i) \right] \cdot P_{Wk} \quad (1)$$

114 Where, P_{Nk} is the per capita water withdrawal data for the k year, $i \leq k \leq j$, $I(j)$ and $I(i)$ are the ratios of government
 115 data to reference data for the j year and i year, respectively.



116 (2) Trend Extrapolation Method Based on Revised Per Capita Water Withdrawal Growth Rate

117 If there are continuous points in the data, we assume that the per capita water withdrawal versus time curve
 118 is consistent with the S curve, that is, the per capita water withdrawal shows only a slow change in the first years
 119 and the last years. We first calculate the growth rate of per capita water withdrawal in the last two years or the
 120 first two years, adjust the final growth rate proportionally to reflect the subsequent changes, and adjust the first
 121 growth rate proportionally to reflect the previous changes. Equation (2) represents a method of extrapolating the
 122 previous missing value data, and Equation (3) represents a method of extrapolating the subsequent missing value
 123 data.

$$124 \quad \begin{cases} s_i = \frac{w_i - w_{i+1}}{w_{i+1}} \\ s_{i-1} = s_i \cdot (1 - \theta) \\ w_{i-1} = w_i \cdot (1 + s_{i-1}) \end{cases} \quad (2)$$

$$125 \quad \begin{cases} s_j = \frac{w_j - w_{j-1}}{w_{j-1}} \\ s_{j+1} = s_j \cdot (1 - \theta) \\ w_{j+1} = w_j \cdot (1 + s_{j+1}) \end{cases} \quad (3)$$

126 Where w_{i-1} is the missing per capita water withdrawal value for time step $i-1$, s_{i-1} is the missing reverse order
 127 growth rate value for time step $i-1$, w_i and w_{i+1} are the first two known per capita water withdrawal value for
 128 time step i and $i+1$, and s_{i-1} is the known reverse order growth rate value for time step $i-1$. For equation (3), w_{j+1}
 129 is the missing per capita water withdrawal value for time step $j+1$, s_{j+1} is the missing growth rate value for time
 130 step $j+1$, w_{j-1} and w_j are the last two known per capita water withdrawal value for time step j and $j-1$, and s_j is the
 131 known growth rate value for time step j . In order to ensure that the per capita water withdrawal in the front of
 132 the sequence or in the latter part of the sequence does not change too fast, the equation introduces θ to represent
 133 the correction coefficient for the growth rate, which is generally in the range of 0.1 to 0.2.

134 (3) Scale Up to The Same Ratio

135 If there is only one data collected, the per capita water withdrawal of that year will be used for all years.

136 (4) MATLAB Smoothing Spline Fitting

137 For water withdrawal data with long time spans and more data but many intervals, we use MATLAB
 138 smoothing spline to provide smooth interpolation over time, taking into account the equilibrium of per capita
 139 water withdrawal fluctuations.



140 (5) Proximity of Adjacent Region

141 If no national water withdrawal data is collected, based on the country's level of development and
 142 geographic location, the per capita water withdrawal of adjacent countries with similar development levels is
 143 selected as an approximate value for the country's per capita water withdrawal value.

144 *Interpolation and extrapolation of sub-national water withdrawal data*

145 First, the ratio of the sub-national data to the national data of the known year is calculated, and then the
 146 interpolation and extrapolation methods are used to calculate the ratio of the missing values, and finally sub-
 147 national data is obtained by the national data and the ratio. The methods can be summarized as the following
 148 four categories.

149 (1) Interpolation Method Assuming Increasing in Arithmetic Series

150 If there is a discontinuity in the sub-national data, we believe that the change in the ratio of the sub-national
 151 to national data is basically increased by the arithmetic progression. Similar to the country, then linear
 152 interpolation method can be used based on linear model of arithmetic series growth. The interpolation model is
 153 as follows:

$$154 \quad I(j) = \frac{P_{Rj}}{P_{Nj}}, I(k) = \frac{I(j) - I(i)}{j - i} \cdot (k - i) + I(i) \quad (4)$$

155 Where, P_{Rj} and P_{Nj} are sub-national data and national data for j year, respectively, $I(j)$ and $I(i)$ are the known
 156 ratios of sub-national data to national data for the j year and i year, and $I(k)$ is the ratio of the sub-national data to
 157 the national data of the interpolated year.

158 (2) Trend Extrapolation Method Based on General Trend Curve Model

159 If there are continuous points in sub-national data, then the interpolation can be obtained by building a
 160 general trend curve model based on the ratio of sub-national data to national data. General trend curve models
 161 used in interpolation are usually conic, cubic and exponential curves, and sometimes other trend line models are
 162 also used. Which trend line model is more suitable can be judged and selected through multiple simulation results.
 163 For the poor fitting effect, the extrapolated year directly selects the adjacent $I(i)$ value with the known data year.

$$164 \quad P_{Gk} = F(k) \cdot P_{Rk} \quad (5)$$

165 Where, P_{Gk} is the sub-national data for k year, and $F(k)$ is the curve model for the ratio of sub-national data to



166 national data in the k year.

167 (3) Scale Up to The Same Ratio

168 If there is only one year of sub-national data, then the sub-national data will be scaled up to the same ratio
 169 according to the ratio of sub-national data to the national data of the corresponding year.

$$170 \quad I = \frac{P_G}{P_R}, \quad P_{Gi} = I \cdot P_{Ri} \quad (6)$$

171 Where, I is the ratio of sub-national data to national data.

172 (4) Based Entirely on Government Data

173 If there is a complete government data, the government data is used as the final sub-national result

174 *Spatial distribution*

175 Using remote sensing data, including Landsat 5 Thematic Mapper, Landsat 7 Enhanced Thematic Mapper
 176 Plus (ETM+), image data of HJ-1 and local BJ-1, the Chinese Government carried out a comprehensive method
 177 based on pixel classification, object extraction and knowledge checking in 2000 and 2010. Ten first-level remote
 178 sensing mappings of land surface waters, wetlands, woodlands, grasslands, shrubs, artificial land surface, arable
 179 land, glaciers and permanent snow, tundra, bare land, etc. were made in the two base years
 180 (www.globeland30.com). Among them, artificial surface and cultivated land are the place where the water
 181 withdrawal is mainly concentrated. Therefore, this paper fully considers the indicative role of specific land use
 182 types. In the spatial distribution, it is assumed that the water is only used on artificial surface and cultivated land.

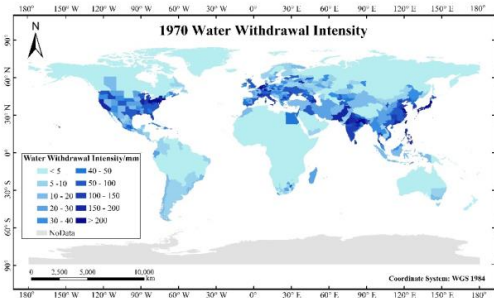
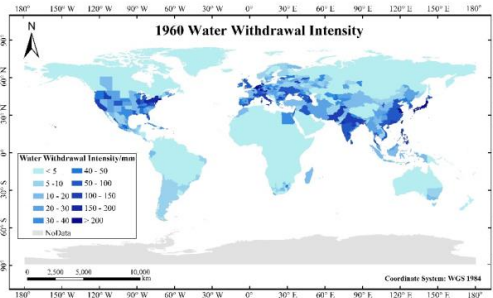
183 Spatial distribution, which means that the data is distributed to a meaningful area. First, based on ArgGIS
 184 Desktop 10.2, convert the global 853 scenes land use grid into a vector format, and then extract the global
 185 artificial surface and cultivated land. The water withdrawal intensity on the grid are expressed as follows
 186 (Salvatore et al., 2005):

$$187 \quad WU_R = \frac{U_R}{A_R}, \quad WU_{RJ} = \frac{U_R}{A_{RG}} \quad (7)$$

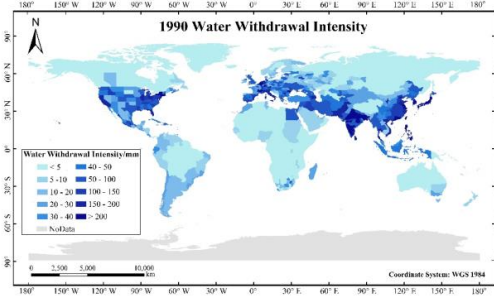
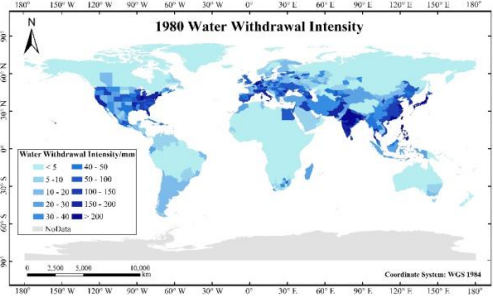
188 Where, WU_R is the water withdrawal intensity of an administrative unit, respectively, WU_{RJ} is the water
 189 withdrawal intensity on the artificial surface and cultivated land of an administrative unit, U_R is the water
 190 withdrawal of an administrative unit, and A_R and A_{RG} are the area of an administrative unit, and the area of
 191 artificial surface and cultivated land of an administrative unit.



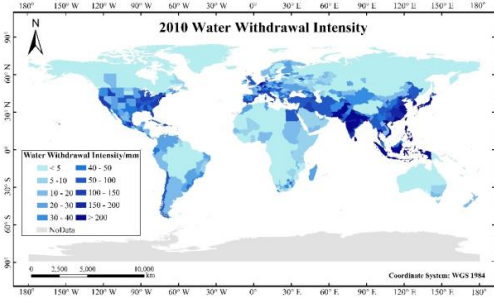
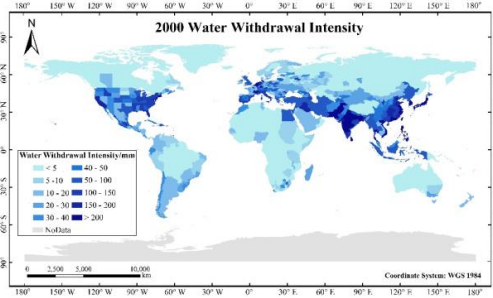
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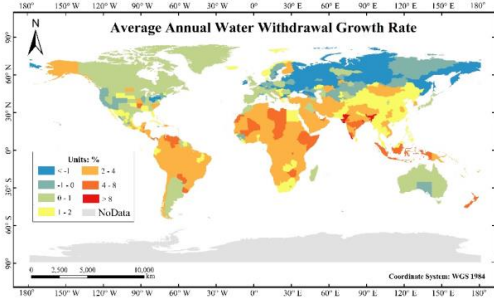
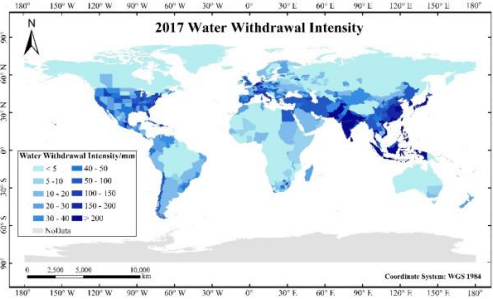
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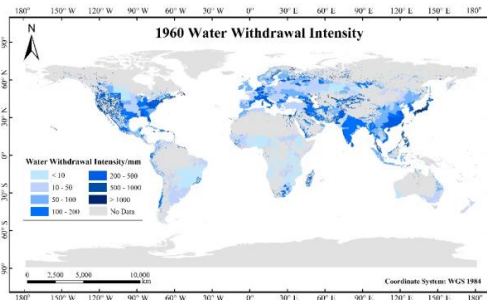


196 **Figure 2.** Maps of gridded regional water withdrawal intensity of administrative units for seven selected years
197 and the average annual water withdrawal growth rate over the study period of 1960–2017. Derived from a

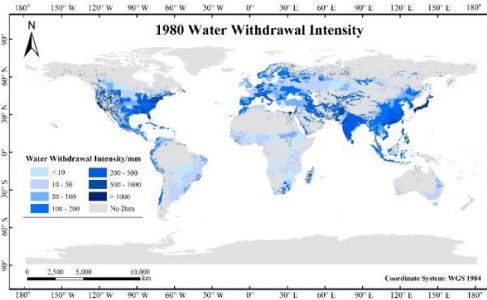


198 combination of sub-national and national data.

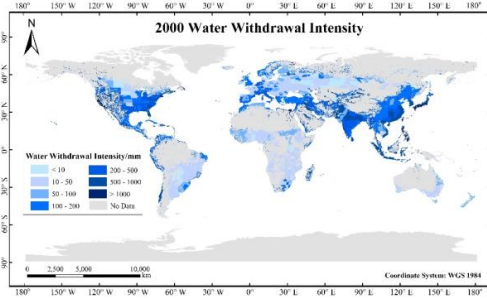
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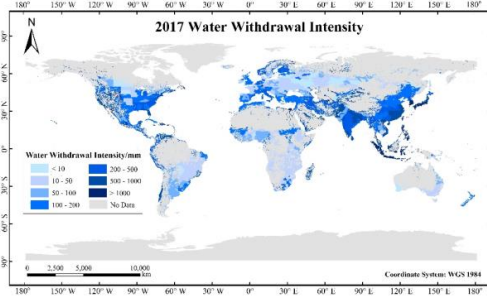
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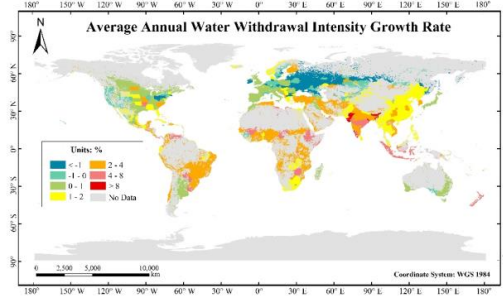
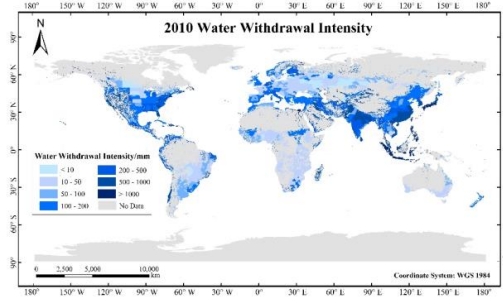
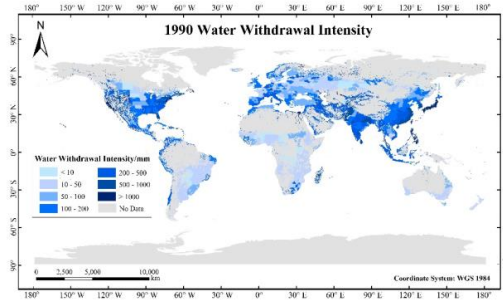
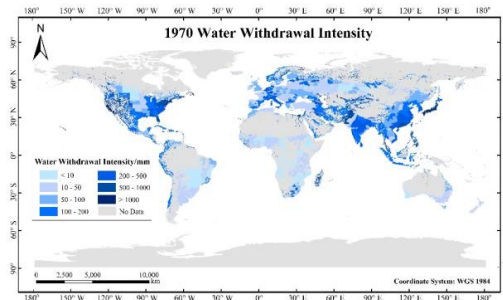
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203 Figure 3. Maps of gridded regional water withdrawal intensity of the artificial surface and cultivated land for





seven selected years and the average annual water withdrawal intensity growth rate over the study period of 1960–2017. Derived from a combination of sub-national and national data.

Technical Validation

To make the dataset more transparent, we have compiled detailed data sources for water withdrawal for each country, and the data is available as a separate Excel spreadsheet. These data sources, including the World Bank, FAO, the United Nations, and officially released data, are relatively accurate. Since some of the dataset was obtained by the interpolation and extrapolation, we performed verification for the reliability of the dataset.

For the water withdrawal data, we selected several countries with more official data, and verified the interpolation and extrapolation method, that is, selected some measured data for interpolation and extrapolation, and compared with other measured data. China and India have a large proportion of water withdrawals in the world and more official data, so we verified these two countries. The results show that the deviation of the data is mostly within $\pm 10\%$, and the reason for the large deviation of some points is due to the large annual fluctuation of official data. Therefore, it can be considered that the dataset derived from the existing water withdrawal data is accurate.

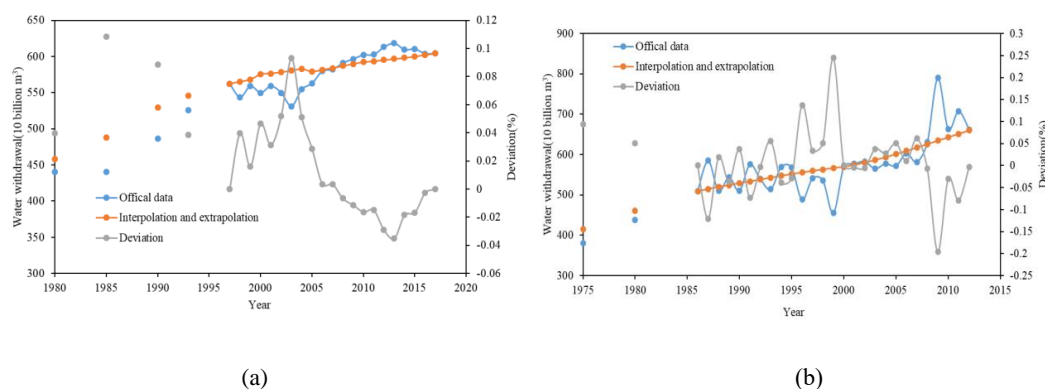


Figure 4. Verification of the population data, (a) China, (b) India.

Data availability

The output datasets described in this article are publicly and freely available through the figshare website (<https://figshare.com/s/c360fd4227f5cb5f4873>) (Yan et al., 2019). The dataset includes 4 sets of raster data and 1 sets of Excel spreadsheet data, which are published separately on each continent. Abbreviations for each



continent are as follows: NA-North America, SA-South America, EU-Europe, AS-Asia, AF-Africa, OC-Oceania.

The data includes the following:

*_winyear_sr: water withdrawal intensity grid datasets distributed on the national or sub-national administrative units, and the unit is mm.

*_widyear_1k: water withdrawal intensity grid datasets distributed on the artificial surface and cultivated land grids, and the unit is mm.

*_lu10: the cultivated land grid datasets and the resolution is 1km.

*_lu80: the artificial surface grid datasets and the resolution is 1km.

*_Coutry_W_Data.xlsx: original documents of national water withdrawal data, including year, World Bank data, FAO data, UN data, government published data, and revised water withdrawal data, with a unit of 10,000m³.

* indicates AF, AS, EU, NA, OC and SA.

Conclusions

The product set is designed to fill the blanks of complete water withdrawal sequence data, enhance the accuracy and spatial variability of water withdrawal data, and can reflect the space-apace changes of water withdrawal. The data products reveal the changes in the pattern of water withdrawal. In particular, it is of great significance to master the scale of water withdrawal in regions where data are difficult to access to.

The product offers the water withdrawal products of the minimum administrative units and the artificial surface-cultivated land products, and a set of EXCEL files of the revised total water consumption in different countries. The data can be edited to meet the needs of various users.

The trend interpolation and extrapolation in the product are conducted under the assumption that the water withdrawal maintains a certain natural growth and they cannot timely reflect the sudden changes in water withdrawal caused by major disasters (i.e. extreme floods and earthquakes), wars and large-scale migration. Given the mobility and flexibility of human activities, there may be some errors in the above data in many countries/regions. Therefore, users are encouraged to make up for the error by using recently updated data or data from specific sources.

At present, we have not collected related data of a few countries/regions, such as Mauritania, Madeira Island, St. Helena, Christmas Island, British Indian Ocean territory, the Vatican, Svalbard Island and Jan Mayen Island,



252 Guadeloupe (France), St Pierre et Miquelon, Na Varsa Island, Anguilla, Montserrat, Martinique, Clipperton
 253 Island (France), Midway Islands, Virgin Islands (British), Netherlands Antilles, United States Miscellaneous
 254 Islands, Pitcairn Islands, Norfolk Island, Heard-und McDonald- Island, Bouvet Island, South Georgia and South
 255 Sandwich Island, Cocos (Keeling) Islands, Prince Edward Island, Wake Island (America), French Territory in
 256 The South, Falkland Islands, etc. Most of these areas are uninhabited or sparsely populated, so there are few
 257 records of water withdrawal data. In the data set, they are treated as no-value areas. We intend to add more data
 258 sets to the product in the future so as to further improve its spatial and temporal coverage.

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263 **Author contributions**

264 D.Y., B.W., T.Q. and H.W. designed the study and provided guidance. X.L. and Y.Y. drafted the manuscript.
 265 X.L., Y.Y., K.W., Z.L., J.W. and M.L. undertook data processing and assembly. S.H., F.L., S.L., W.B., T.X., X.S.,
 266 Z.M., C.S., M.L., M.W., Y.H., H.L., Y.N., B.D., M.G., A.G., and A.A. were involved in data collection.

267 **Competing interests**

268 The authors declare no competing interests.

269 **References**

- 270 Balk, D. L., Deichmann, U., Yetman, G., Pozzi, F., Hay, S. I. and Nelson, A.: Determining global population
 271 distribution: methods, applications and data. *Adv. Parasitol.*, 62, 119–156, 2006.
- 272 Deichmann, U., Balk, D., and Yetman, G. *Transforming Population Data for Interdisciplinary Usages: From*
 273 *Census to Grid*. Palisades, NY: NASA Socioeconomic Data and Applications Center (SEDAC), CIESIN,
 274 Columbia University, 20 pp, 2001.
- 275 Doxsey-Whitfield, E., MacManus, K. Adamo, S. B., Pistolesi, L., Squires, J., Borkovska, O. and Baptista,
 276 S. R.: Taking advantage of the improved availability of census data: A first look at the Gridded Population of the
 277 World, Version 4 (GPWv4). *Papers in Applied Geography*, 1, 226–234, 2015.
- 278 Honjo, H., Sano, M., Miki, H., Sakaguchi, H.: Statistical properties of approval ratings for governments.
 279 *Physica A*, 428, 266-272, 2015.
- 280 Houngho, G. F.: *The United Nations World Water Development Report 2018: Nature-Based Solutions for*
 281 *Water*, UNESCO, 36 pp, 2018.



- 282 Kumar., P. S., Carolin, C. F.: Water withdrawal and conservation—Global scenario, in: Water in Textiles
 283 and Fashion, Consumption, Footprint, and Life Cycle Assessment, edited by: Muthu, S. S., 61-75,
 284 <https://doi.org/10.1016/B978-0-08-102633-5.00004-X>, 2019.
- 285 Nouri, N: Water withdrawal and consumption reduction analysis for electrical energy generation system.
 286 Dissertations & Theses - Gradworks, 2015.
- 287 Peter, H. G.: The World's water, Volume 9. The Pacific Institute for Studies in Development, Environment,
 288 and Security Oakland, California, 78 pp, 2018.
- 289 Salvatore, M., Pozzi, F., Ataman, E., Huddleston, B. and Bloise, M.: Mapping global urban and rural
 290 population distributions. Environment and Natural Resources Working Paper 24. Food and Agri. Org. UN
 291 Corporate Document Repository, <http://www.fao.org/docrep/009/a0310e/a0310e00.htm>, 2005.
- 292 Snow, R. W., Guerra, C. A., Noor, A. M., Myint, H. Y. and Hay, S. I.: The global distribution of clinical
 293 episodes of Plasmodium falciparum malaria, Nature 434, 214–217, 2005.
- 294 Tobler, W., Deichmann, U., Gottsegen, J., and Maloy, K.: World population in a grid of spherical
 295 quadrilaterals. International Journal of Population Geography, 3, 203-225. [https://doi.org/10.1002/\(SICI\)1099-1220\(199709\)3:3<203::AID-IJPG68>3.0.CO;2-C](https://doi.org/10.1002/(SICI)1099-1220(199709)3:3<203::AID-IJPG68>3.0.CO;2-C), 1997.
- 297 United Nations, Department of Economic and Social Affairs, Population Division. World Population
 298 Prospects: The 2015 Revision, DVD Edition. <http://esa.un.org/unpd/wpp/DVD/>, 2015.
- 299 Yan, D. H., Weng, B. S., Qin, T. L., Wang, Hao., Li, X. N., Yang, Y. H., Wang, K.: A dataset of distributed
 300 global water withdrawal from 1960 to 2017. figshare. Dataset. <https://doi.org/10.6084/m9.figshare.10012559.v1>,
 301 2019.