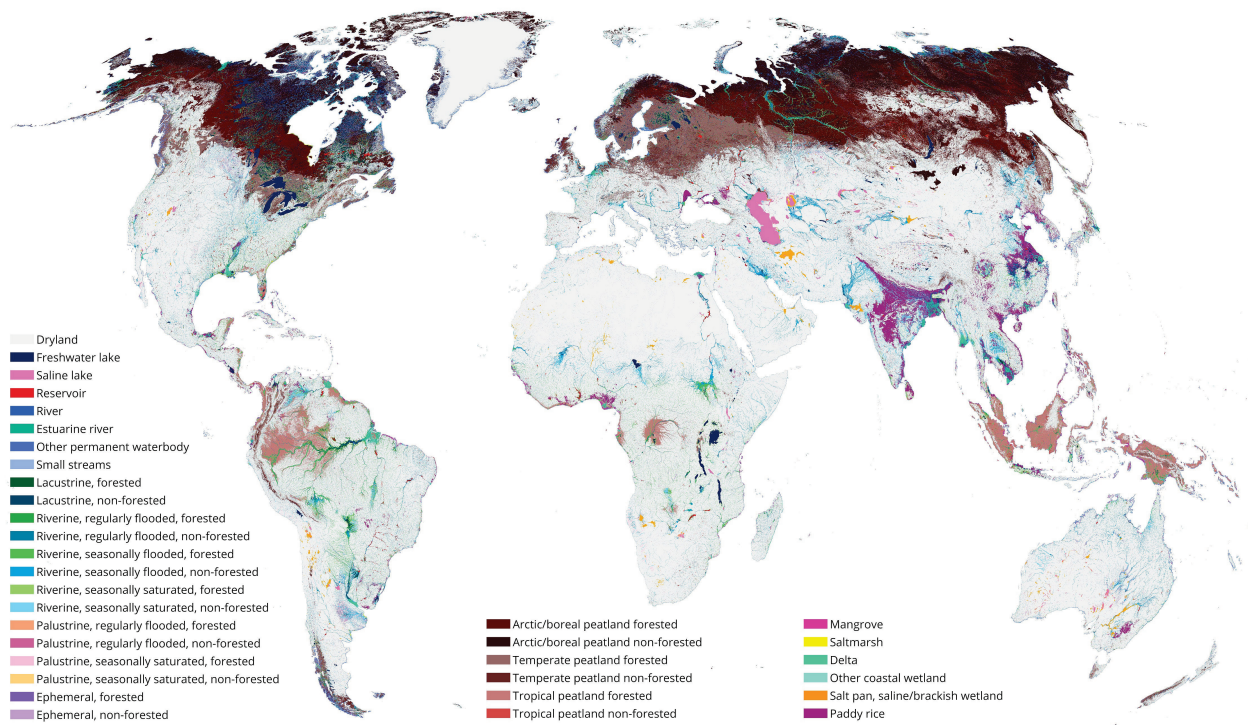# Global Lakes and Wetlands Database (GLWD)

A global harmonized database of the extent of lakes, rivers, and wetlands at 15 arc-second resolution

Technical Documentation – version 2.0 delta

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Dryland
Freshwater lake
Saline lake
Reservoir
River
Estuarine river
Other permanent waterbody
Small streams
Lacustrine, forested
Lacustrine, non-forested
Riverine, regularly flooded, forested
Riverine, regularly flooded, non-forested
Riverine, seasonally flooded, forested
Riverine, seasonally flooded, non-forested
Riverine, seasonally saturated, forested
Riverine, seasonally saturated, non-forested
Palustrine, regularly flooded, forested
Palustrine, regularly flooded, non-forested
Palustrine, seasonally saturated, forested
Palustrine, seasonally saturated, non-forested
Ephemeral, forested
Ephemeral, non-forested

Arctic/boreal peatland forested
Arctic/boreal peatland non-forested
Temperate peatland forested
Temperate peatland non-forested
Tropical peatland forested
Tropical peatland non-forested

Mangrove
Saltmarsh
Delta
Other coastal wetland
Salt pan, saline/brackish wetland
Paddy rice

Note:

This document refers to the <u>pre-release delta version</u> of the new "Global Lakes and Wetlands Database version 2", available at <u>https://figshare.com/s/e40017f69f41f80d50df</u>

This delta version was created for the review process of the accompanying publication. Once the review process is completed, version 2.0 will be released.

1. Background and introduction

In recognition of the importance of inland waters, numerous datasets have been created to map the extents, types, or changes in surface water and wetland areas from digitized historic maps to real-time satellite remote sensing imagery. However, differences in definitions and methods lead to spatial and typological inconsistencies among individual data sources, complicating their complimentary use. The Global Lakes and Wetlands Database (GLWD; Lehner and Döll 2008), with its globally seamless gridded depiction of major vegetated and non-vegetated inland aquatic classes, has emerged over the last decade as a foundational reference map to serve a broad range of applications, from freshwater conservation planning to biodiversity, ecosystem services, greenhouse gas emissions, land surface and hydrological modeling, as well as human and environmental health. Here, we present a new iteration of this map, termed GLWD version 2, by harmonizing and integrating newly available ground- and satellite-based data products. Following the same design principle as its predecessor, the classification of GLWD v2 aims to avoid double-counting of surface water features while differentiating between natural and non-natural lakes, rivers of multiple sizes, and distinguishing several other wetland types by incorporating information on seasonality (permanent vs. intermittent vs. ephemeral); inundation vs. saturation; vegetation cover (forested vs. non-forested); salinity; natural vs. non-natural origins; and a stratification of landscape position and water source (riverine, lacustrine, palustrine, coastal/marine). GLWD v2 represents a total of 18.2 million km^2 of wetlands (13.4% of the global land area excluding Antarctica) classified into 33 types at a grid cell resolution of 15 arc-seconds (approximately 500 m at the equator). The updated GLWD v2 offers an improved baseline representation of inland water extents, their types and intrinsic temporal dynamics representing contemporary conditions. GLWD v2 is tailored towards hydrological, ecological, biogeochemical, and conservation applications, aiming to support the study and protection of aquatic ecosystems around the world.

The development and characteristics of GLWD v2 are fully described by Lehner et al. (in prep.) and can be temporarily cited as:

> *Lehner, B., Anand, M., Fluet-Chouinard, E., Tan, F., Aires, F., Allen, G.H., Bousquet, P., Canadell, J.G., Davidson, N., Finlayson, C.M., Gumbricht, T., Hilarides, L., Hugelius, G., Jackson, R.B., Korver, M.C., McIntyre, P.B., Matthews, E., Nagy, S., Olefeldt, D., Pavelsky, T., Pekel, J.-F., Poulter, B., Prigent, C., Wang, J., Worthington, T.A., Yamazaki, D., Thieme, M. (in preparation). Mapping the world's inland waters: an update to the Global Lakes and Wetlands Database (GLWD v2).*

2. Methods

The methods and workflows used to create GLWD v2 are fully described in Lehner et al. (in prep.). The guiding principle for creating GLWD v2 was to consolidate and harmonize—without duplication—all input data sources to produce a versatile global map of wetland types that is meaningful for a broad spectrum of applications. Results are provided as a series of grids with a target cell size of 15 arc-seconds (i.e., approximately 500 m at the equator) which was chosen as a compromise between the spatial resolution of existing input data sources, computing demands, and ease of use for global applications. The classification scheme of GLWD v2 (see table below) is designed to be manageable (i.e., limited to a reasonable number of classes), deterministic rather than statistically derived, and representative of the needs of various research fields and disciplines. Each of the 33 wetland classes is provided as an individual global map depicting the extent of the respective class as sub-cell fractions. The 33 maps were then combined to derive the total global wetland extent and to identify the dominant wetland class per grid cell.

The 33 lake, river, and wetland classes of GLWD v2 are defined as follows (incl. '00' for dryland):

ID	Class name
01	Freshwater lake
02	Saline lake
03	Reservoir
04	Large river
05	Large estuarine river
06	Other permanent waterbody
07	Small streams
08	Lacustrine, forested
09	Lacustrine, non-forested
10	Riverine, regularly flooded, forested
11	Riverine, regularly flooded, non-forested
12	Riverine, seasonally flooded, forested
13	Riverine, seasonally flooded, non-forested
14	Riverine, seasonally saturated, forested
15	Riverine, seasonally saturated, non-forested
16	Palustrine, regularly flooded, forested
17	Palustrine, regularly flooded, non-forested
18	Palustrine, seasonally saturated, forested
19	Palustrine, seasonally saturated, non-forested
20	Ephemeral, forested
21	Ephemeral, non-forested
22	Arctic/boreal peatland, forested
23	Arctic/boreal peatland, non-forested
24	Temperate peatland, forested
25	Temperate peatland, non-forested
26	Tropical peatland, forested
27	Tropical peatland, non-forested
28	Mangrove
29	Saltmarsh
30	Delta
31	Other coastal wetland
32	Salt pan, saline/brackish wetland
33	Paddy rice
00	*Dryland (non-wetland)*

3. Data format and distribution

a) *Data format, resolution, extent, and projection*

Version 2 of the Global Lakes and Wetlands Database (GLWD) is publicly available for download from the HydroSHEDS website at https://www.hydrosheds.org/prodcuts/glwd. All data layers are provided as

grids at 15 arc-second resolution at global extent (excluding Antarctica), i.e., covering an area from 180° West to 180° East and from 56° South to 84° North. All grids are available in both ESRI© Geodatabase and GeoTIFF formats. The data are projected in a Geographic Coordinate System using the World Geodetic System 1984 (GCS_WGS_1984). GLWD v2 data are available electronically in compressed zip file format. To use the data files, the zip files must first be decompressed. Each zip file includes a copy of the GLWD Technical Documentation and a table containing the legend information (ID and class name) in .csv format.

   b) *Layer names and content*

GLWD v2 data can be downloaded in three separate zip-files, each prepared both in Geodatabase and GeoTIFF format. Each zip-file in Geodatabase format contains one geodatabase which stores multiple grids; each zip-file in GeoTIFF format contains one folder which stores multiple grids.

- **GLWD_v2_delta_area_by_class_ha (either Geodatabase or GeoTIFF folder)**
  Contains all 33 wetland classes (plus drylands) as individual grids showing the extent of the wetland class per pixel in absolute area (i.e., hectares times 10). Individual grid names and contents are:

  o **GLWD_v2_delta_class_[01…33]_ha_x10**
    absolute area of wetland class, in hectares times 10 (i.e., value 15 means 1.5 ha)
  o **GLWD_v2_delta_class_00_ha_x10**
    absolute area of dryland (non-wetland) class, in hectares times 10 (i.e., value 15 means 1.5 ha)

- **GLWD_v2_delta_area_by_class_pct (either Geodatabase or GeoTIFF folder)**
  Contains all 33 wetland classes (plus drylands) as individual grids showing the extent of the wetland class per pixel in relative area (i.e., percent of pixel area). Individual grid names and contents are:

  o **GLWD_v2_delta_class_[01…33]_pct**
    relative area of wetland class, in percent of pixel area
  o **GLWD_v2_delta_class_00_pct**
    relative area of dryland (non-wetland) class, in percent of pixel area

- **GLWD_v2_delta_combined_classes (either Geodatabase or GeoTIFF folder)**
  Contains several global grids assembled by combining all 33 wetland grids. Individual grid names and contents are:

  o **GLWD_v2_delta_area_ha_x10**
    absolute area of all wetland classes combined, in hectares times 10 (i.e., value 15 means 1.5 ha)
  o **GLWD_v2_delta_area_pct**
    relative area of all wetland classes combined, in percent of pixel area
  o **GLWD_v2_delta_main_class**
    dominant wetland class within pixel (in cases of ties, the lower wetland class is chosen); value 0 indicates inland pixels without any wetland coverage
  o **GLWD_v2_delta_main_class_50pct**
    dominant wetland class within pixel, only for pixels where the total wetland extent exceeds 50% (in cases of ties, the lower wetland class is chosen); value 0 indicates inland pixels where dryland (non-wetland) dominates

4. License, disclaimer and acknowledgement

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Version 2 of the Global Lakes and Wetlands Database (GLWD) is licensed under a Creative Commons Attribution 4.0 International License. By downloading and using the data the user agrees to the terms and conditions of this license. A copy of the license is available at http://creativecommons.org/licenses/by/4.0/. Notwithstanding this free license, we ask users to refrain from redistributing the data in whole in its original format on other websites without the explicit written permission from the authors. GLWD v2 is available for public download at https://www.hydrosheds.org.

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In no event shall the authors be liable for costs of procurement of substitute goods or services, lost profits, lost sales or business expenditures, investments, or commitments in connection with any business, loss of any goodwill, or for any direct, indirect, special, incidental, exemplary, or consequential damages arising out of the use of the Global Lakes and Wetlands Database (GLWD) and any related materials, however caused, on any theory of liability, and whether or not the authors have been advised of the possibility of such damage. These limitations shall apply notwithstanding any failure of essential purpose of any exclusive remedy.

4.4 Citations and acknowledgements

The initial concept for the creation of GLWD v2 was designed at a workshop coordinated and hosted by the Global Carbon Project in Washington, DC. Funding for the development of GLWD v2 was provided by World Wildlife Fund US, The Nature Conservancy, and by McGill University, Montreal, Canada.

Citations and acknowledgements of the Global Lakes and Wetlands Database (GLWD), version 2, should be made as follows (note that the following citation is only temporary until final publication):

Lehner, B., Anand, M., Fluet-Chouinard, E., Tan, F., Aires, F., Allen, G.H., Bousquet, P., Canadell, J.G., Davidson, N., Finlayson, C.M., Gumbricht, T., Hilarides, L., Hugelius, G., Jackson, R.B., Korver, M.C., McIntyre, P.B., Matthews, E., Nagy, S., Olefeldt, D., Pavelsky, T., Pekel, J.-F., Poulter, B., Prigent, C., Wang, J., Worthington, T.A., Yamazaki, D., Thieme, M. (in preparation). Mapping the world's inland waters: an update to the Global Lakes and Wetlands Database (GLWD v2).

We kindly ask users to cite the Global Lakes and Wetlands Database (GLWD) in any published material produced using the data. If possible, online links to the GLWD website should be provided (https://www.hydrosheds.org/prodcuts/glwd).

5. References

Lehner, B., Döll, P. (2004). Development and validation of a global database of lakes, reservoirs and wetlands. Journal of Hydrology 296(1-4): 1-22. https://doi.org/10.1016/j.jhydrol.2004.03.028