

Global Lakes and Wetlands Database GLWD

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Summary

Drawing upon a variety of existing maps, data and information, a new Global Lakes and Wetlands Database (GLWD) has been created. The combination of best available sources for lakes and wetlands on a global scale (1:1 to 1:3 million resolution), and the application of GIS functionality enabled the generation of a database which focuses in three coordinated levels on (1) large lakes and reservoirs, (2) smaller water bodies, and (3) wetlands.

Level 1 (GLWD-1) comprises the shoreline polygons of the 3067 largest lakes (area $\geq 50 \text{ km}^2$) and 654 largest reservoirs (storage capacity $\geq 0.5 \text{ km}^3$) worldwide, and includes extensive attribute data. Level 2 (GLWD-2) comprises the shoreline polygons of permanent open water bodies with a surface area $\geq 0.1 \text{ km}^2$ excluding the water bodies contained in GLWD-1. The approx. 250,000 polygons of GLWD-2 are attributed as lakes, reservoirs and rivers. Level 3 (GLWD-3) comprises lakes, reservoirs, rivers and different wetland types in the form of a global raster map at 30-second resolution. For GLWD-3, the polygons of GLWD-1 and GLWD-2 were combined with additional information on the maximum extents and types of wetlands. Class 'lake' in both GLWD-2 and GLWD-3 also includes man-made reservoirs, as only the largest reservoirs have been distinguished from natural lakes. GLWD-2 and GLWD-3 do not provide detailed descriptive attributes such as names or volumes.

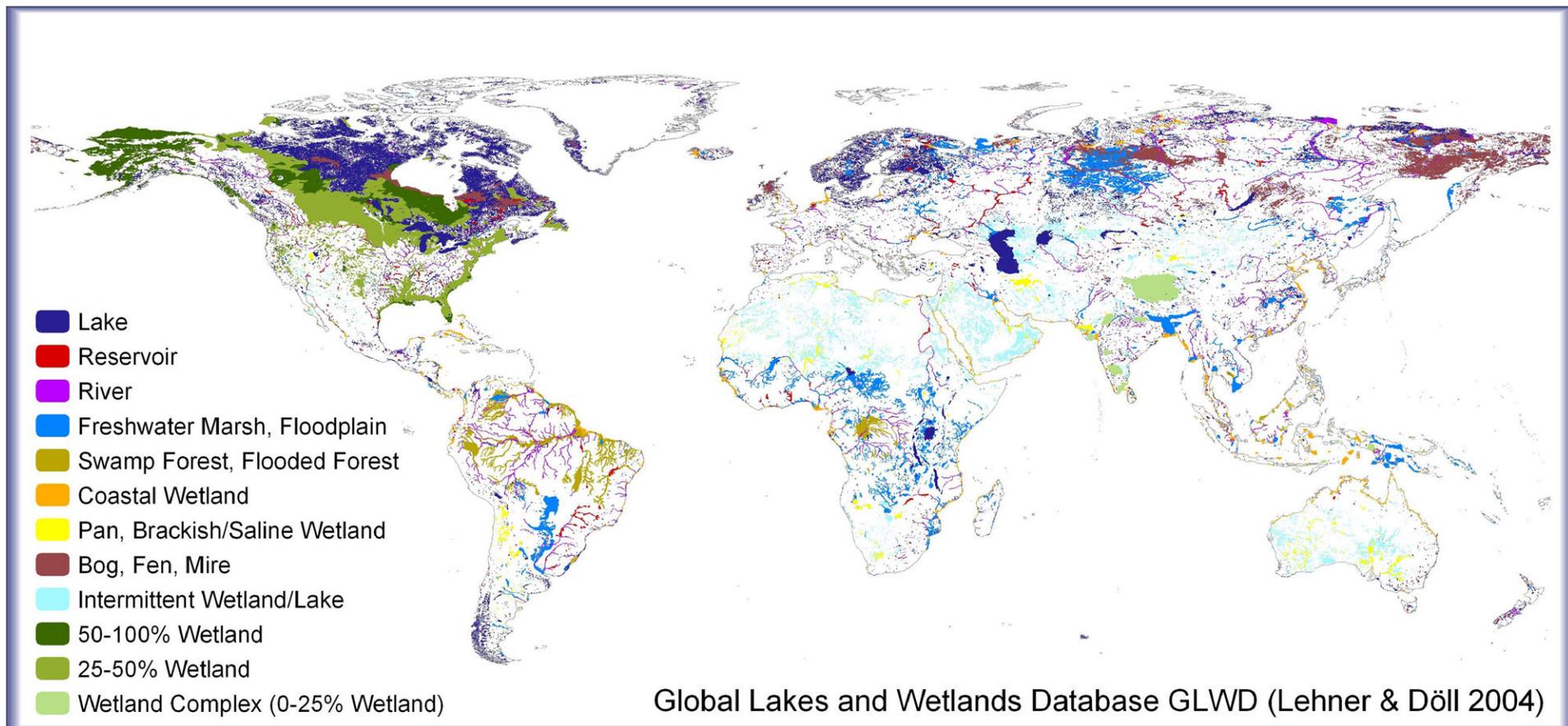
In a validation against documented data GLWD proved to represent a comprehensive database of global lakes $\geq 1 \text{ km}^2$ and to provide a good representation of the maximum global wetland extent. GLWD-1 and GLWD-2 constitute two global polygon maps to which existing lake registers, compilations or remote sensing data can be linked in order to allow for further analyses in a GIS environment. GLWD-3 may serve as an estimate of wetland extents for global hydrology and climatology models, or to identify large-scale wetland distributions and important wetland complexes.

According to GLWD, lakes and reservoirs cover a total of approx. 2.7 million km^2 or 2.0% of the global land surface area (except Antarctica and glaciated Greenland), while wetlands are estimated to reach about 8-10 million km^2 , or 6.2-7.6%. An extrapolation of GLWD data suggests that the total number of global lakes may reach or even exceed 1.5 million for lakes $\geq 10 \text{ ha}$, and 15 million for lakes $\geq 1 \text{ ha}$. With these numbers, lakes may cover about 3.2 million km^2 , or 2.4% of the total global land surface.

The data is available for free download (for non-commercial scientific, conservation and educational purposes) at: <http://www.wwfus.org/science/data.cfm>

For further details on map generation and validation, as well as for citation, please refer to:

Lehner, B. and Döll, P. (2004): Development and validation of a global database of lakes, reservoirs and wetlands. *Journal of Hydrology* 296/1-4: 1-22.



Main data sources applied to generate GLWD

| Data set | Information included in generation of GLWD data set | | |
|--|--|---|-------------------------------------|
| | Level 1 | Level 2 | Level 3 |
| MGLD (MSSL Global Lakes Database, Birkett and Mason 1995) | Yes | No | Yes |
| LRs (Large Reservoirs, Vörösmarty et al. 1997) | Yes | No | Yes |
| WRD (World Register of Dams, ICOLD 1998) | Only to complete LRs | No | No |
| DCW (Digital Chart of the World, hydrography layer, ESRI 1993) | Class 'Permanent' $\geq 50 \text{ km}^2$ | Class 'Permanent' $\geq 0.1 \text{ km}^2$ | All classes $\geq 0.1 \text{ km}^2$ |
| ArcWorld (ArcWorld 1:3M, hydrography layer, ESRI 1992) | 'Lakes' $\geq 50 \text{ km}^2$, 'Reservoirs' $\geq 0.5 \text{ km}^3$ | 'Lakes' and 'Reservoirs' $\geq 0.1 \text{ km}^2$ | All classes $\geq 0.1 \text{ km}^2$ |
| WCMC (global wetlands map, WCMC 1993) | 'Lakes' $\geq 50 \text{ km}^2$, 'Impoundments' $\geq 0.5 \text{ km}^3$ | 'Lakes' and 'Impoundments' $\geq 0.1 \text{ km}^2$ | All classes $\geq 0.1 \text{ km}^2$ |
| GLCC (Global Land Cover Characterization, Loveland et al. 2000, in 'Global Ecosystem' classification) | No | No | Class 'Bog, Fen, Mire' |

References of main data sources applied to generate GLWD

- Birkett, C.M., Mason, I.M. (1995): A new global lakes database for a remote sensing program studying climatically sensitive large lakes. *Journal of Great Lakes Research* 21(3): 307-318.
- ESRI (Environmental Systems Research Institute) (1992): ArcWorld 1:3 Mio. Continental Coverage. Redlands, CA. Data obtained on CD.
- ESRI (Environmental Systems Research Institute) (1993): Digital Chart of the World 1:1 Mio. Redlands, CA. Data obtained on 4 CDs (also available online at <http://www.maproom.psu.edu/dcw/>).
- ICOLD (International Commission on Large Dams) (1998): Word Register of Dams. 1998 book and CD-ROM. ICOLD, Paris.
- Loveland, T.R., Reed, B.C., Brown, J.F., Ohlen, D.O., Zhu, J, Yang, L., and Merchant, J.W. (2000): Development of a global land cover characteristics database and IGBP DISCover from 1-km AVHRR data. *International Journal of Remote Sensing* 21(6/7): 1303–1330 (available online at <http://edcdaac.usgs.gov/glcc/glcc.html>).
- Vörösmarty, C.J., Sharma, K.P., Fekete, B.M., Copeland, A.H., Holden, J., Marble, J., Lough, J.A. (1997): The storage and aging of continental runoff in large reservoir systems of the world. *Ambio* 26(4): 210-219.
- WCMC (World Conservation Monitoring Centre) (1993): Digital wetlands data set. Cambridge, UK. Data obtained from WCMC in 1999.

Description of GLWD-1 data set

File name: glwd_1 (shapefile components *.shp, *.shx, *.sbn, *.sbx, *.dbf, *.avl)
 File size: 16.4 MB (6.0 MB zipped)
 File format: ArcView Polygon Shapefile
 Data format: 3721 polygons; 28 columns in attribute table
 Spatial resolution: Source data 1:1 to 1:3 million
 Projection: Geographic, degrees longitude and latitude
 Spatial domain: Global land area (except Antarctica and glaciated Greenland)
 File contents: Each polygon is characterized by a set of attributes as following (continued on next page):

| Column | Description |
|------------|--|
| Glwd_id | Unique polygon identification number (1-3721) |
| Type | Assigned type: Lake or Reservoir |
| Lake_name | Name of lake or reservoir |
| Dam_name | Name of dam |
| Poly_src | Source of polygon outlines: DCW ESRI (1993): Digital Chart of the World 1:1 Mio. ArcWorld ESRI (1992): ArcWorld 1:3 Mio. WCMC WCMC (1993): Global wetlands map Circle introduced circle polygon at location of reservoir with missing shoreline |
| Area_skm | Surface area in km ² , as calculated from polygon outlines |
| Perim_km | Perimeter in km, as calculated from polygon outlines |
| Long_deg | Longitude of polygon center in degrees |
| Lat_deg | Latitude of polygon center in degrees |
| Elev_m | Mean elevation in meters, as derived from HYDRO1k data set (USGS 2000) |
| Catch_tskm | Watershed (catchment) area in 10 ³ km ² , as derived from HYDRO1k data set (rough estimate only – for details see Lehner & Döll 2004) |
| Inflow_cms | Mean inflow into lake or reservoir in m ³ /s, as derived from downscaled discharge values of the global water model WaterGAP (rough estimate only – for details see Lehner & Döll 2004) |
| Volume_ckm | Reservoir volume (storage capacity) in km ³ , as provided by ICOLD (1998) or Vörösmarty et al. (1997) or as derived from statistics (see column Vol_src) |
| Vol_src | Source of reservoir volumes: ICOLD as provided by ICOLD (1998) ICOLD_cor corrected ICOLD (1998) value (e.g. errors in the order of magnitude) ICOLD_LRs as provided by ICOLD (1998) and Vörösmarty et al. (1997) LRs as provided by Vörösmarty et al. (1997) LRs_cor corrected Vörösmarty et al. (1997) value (e.g. errors in the order of magnitude) Statistics calculated by applying statistically derived equation (see Lehner & Döll 2004): $Volume_ckm = 0.009208 * (Area_skm^{1.114})$ |
| Country | Main country of lake or reservoir, as derived from country layer of ArcWorld (ESRI 1992) |
| Sec_cntry | Other countries of international lakes or reservoirs (“+2”, etc. stands for “plus 2 other countries”) |

Table GLWD-1 continued

| | |
|------------|---|
| River | Name of dammed river, as provided by Vörösmarty et al. (1997) |
| Near_city | Name of nearest city to dam, as provided by Vörösmarty et al. (1997) |
| Mgld_type | Type of lake, as provided by Birkett and Mason (1995): open lake with significant surface or subsurface outflow closed lake without significant surface or subsurface outflow (inland sink) closedx lake, probably without significant surface or subsurface outflow (inland sink) res Reservoir |
| Bm_area | Surface area in km ² , as provided by Birkett and Mason (1995) |
| Lrs_area | Reservoir area in km ² , as provided by ICOLD (1998) or Vörösmarty et al. (1997) or as derived from statistics (see next column) |
| Lrs_ar_src | Source of 'Lrs_area' values: ICOLD as provided by ICOLD (1998) ICOLD_cor corrected ICOLD (1998) value (e.g. errors in the order of magnitude) ICOLD_LRs as provided by ICOLD (1998) and Vörösmarty et al. (1997) LRs as provided by Vörösmarty et al. (1997) LRs_cor corrected Vörösmarty et al. (1997) value (e.g. errors in the order of magnitude) Other other data source Statistics calculated by applying statistically derived equation (see Lehner & Döll 2004): $Lrs_area = (3.42 * Volume_ckm) / Dam_height$ |
| Lrs_catch | Catchment area of reservoir in km ² , as provided by ICOLD (1998) |
| Dam_height | Height of dam in m, as provided by ICOLD (1998) or Vörösmarty et al. (1997) |
| Dam_year | Year of completion of dam, as provided by ICOLD (1998) or Vörösmarty et al. (1997) |
| Use_1 | Main purpose/use of reservoir, as provided by ICOLD (1998): c flood control f fish breeding h hydropower i irrigation n navigation r recreation s water supply x others |
| Use_2 | Second purpose of reservoir, see Use_1 |
| Use_3 | Third purpose of reservoir, see Use_1 |

Description of GLWD-2 data set

File name: glwd_2 (shapefile components *.shp, *.shx, *.sbn, *.sbx, *.dbf, *.avl)
 File size: 96.5 MB (31.5 MB zipped)
 File format: ArcView Polygon Shapefile
 Data format: 244,892 polygons; 7 columns in attribute table
 Spatial resolution: Source data 1:1 to 1:3 million
 Projection: Geographic, degrees longitude and latitude
 Spatial domain: Global land area (except Antarctica and glaciated Greenland)
 File contents: Each polygon is characterized by a set of attributes as following:

| Column | Description |
|----------|---|
| Glwd_id | Unique polygon identification number, continued from GLWD-1 (3722-248613) |
| Type | Assigned type: Lake, Reservoir or River |
| Poly_src | Source of polygon outlines: DCW ESRI (1993): Digital Chart of the World 1:1 Mio. ArcWorld ESRI (1992): ArcWorld 1:3 Mio. WCMC WCMC (1993): Global wetlands map |
| Area_skm | Surface area in km ² , as calculated from polygon outlines |
| Perim_km | Perimeter in km, as calculated from polygon outlines |
| Long_deg | Longitude of polygon center in degrees |
| Lat_deg | Latitude of polygon center in degrees |

Description of GLWD-3 data set

File name: glwd_3 (folders 'glwd_3' and 'info', legend 'glwd_3.avl')

File size: 26.9 MB (8.4 MB zipped)

File format: Grid in ArcView/ArcInfo coverage format

Data format: integer values, for coding see legend below

Spatial resolution: 30 x 30 second

Projection: Geographic, degrees longitude and latitude

Spatial domain: Global land area (except Antarctica and glaciated Greenland)

File contents: Grid cells are coded as following:

| Cell value | Lake or Wetland Type |
|------------|--|
| 1 | Lake |
| 2 | Reservoir |
| 3 | River |
| 4 | Freshwater Marsh, Floodplain |
| 5 | Swamp Forest, Flooded Forest |
| 6 | Coastal Wetland (incl. Mangrove, Estuary, Delta, Lagoon) |
| 7 | Pan, Brackish/Saline Wetland |
| 8 | Bog, Fen, Mire (Peatland) |
| 9 | Intermittent Wetland/Lake |
| 10 | 50-100% Wetland |
| 11 | 25-50% Wetland |
| 12 | Wetland Compex (0-25% Wetland) |