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A database of global wetland validation samples for wetland mapping

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Abstract A database of global wetland validation samples (GWVS) is the foundation for wetland mapping on a global scale. In this work, a database of GWVS was created based on 25 "wetland-related" keyword searches of a total of 3,506 full-text documents downloaded from the Web of Science. Eight hundred and three samples from a total of 68 countries and 141 protected areas were recorded by the GWVS, including samples of marine/coastal wetlands, inland wetlands and human-made wetlands, at ratios of 53 %, 41 % and 6 %, respectively. The results exhibit spatial distribution among Terrestrial Ecoregions of the World, the World Database on Protected Areas and the Database of Global Administrative Areas. Within most of the biomes, protected areas and countries examined, the very low concentration of samples requires more attention in the future. The greatest concentration of samples within a single biome is found in the tropical and subtropical moist broadleaf forest biome, accounting for 27 % of the total samples, while no sample is found in the biome of tropical and subtropical coniferous woodland. Greater efforts are expected to be made to record samples in Oceania, Central Europe, Northern Europe, Northern Africa, Central Africa, Central America, the Caribbean, and midwestern South America. Our data show that it is feasible to map global wetlands using Landsat TM/ETM+ at 30-m resolution. The continued improvement of the GWVS sharing platform should be reinforced in the future, making a strong contribution to global wetland mapping and monitoring.

Keywords GWVS · Remote sensing · Wetland mapping · Wetland monitoring · Protected area

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1 Introduction

As of August 2014, more than 2,187 wetlands have been designated as Wetlands of International Importance, covering a total area of 208.6 Mha (Ramsar, 2014). The products of global wetlands are the foundation of wetland research, management and conservation. They play a critical role in studies of habitat and biodiversity [1–4], carbon cycling [5–8] and public health [9, 10]. They are also essential in improving the performance of ecosystem, hydrological and atmospheric models [11]. The extent and distribution of global wetlands need to be determined first.

Remote sensing has proven to be a useful technique for monitoring the components of the global surface [12–14] and has a high application potential for wetlands [15, 16]. The European Space Agency, in collaboration with the Ramsar

Secretariat, launched the GlobWetland project in 2003, and the overall objective of GlobWetland was to facilitate the integration of remote sensing techniques into the conservation and management of wetlands [17]. Although the capabilities of remote sensing in terms of spatial, temporal and spectral resolution is increasing, an reliable and affordable global wetland map is still not derived from remote sensing with high resolution and complete categories. The only current wetland maps at a global scale were extracted from several types of global land cover maps derived from remote sensed data at 1 km and 300 m scales [18].

However, the methods by which wetlands have been identified or classified using global datasets have varied, and the results have often been incompatible or inconsistent [19]. The global mean per-pixel agreement measured with class-specific consistency is high for open water and low for wetlands [14]. Areas classified as wetlands in a pixel in one dataset are rarely classified as wetlands in the same pixel in the other datasets [18]. Although Envisat ASAR Global Monitoring Image Mode Product (GM) is capable of capturing not only the extent but also the dynamics of wetland areas, a global wetland map has not been made by GM at 1-km resolution [15]. The current wetland mapping products on a global scale such as Global Lake and Wetland Database (GLWD) and the Ramsar site database cannot match either the need for global wetland dynamic monitoring or the need for understanding their internal processes.

After the first set of wetland maps of China derived from Landsat and CBERS-02B, images between 1978 and 2008 were produced [20], and a synergistic approach with census and spatially explicit datasets was used to create a 1-km wetland map for China [21], a finer resolution (30 m) observation and monitoring of global land cover was then produced in China [14]. Zhao et al. [22] built a global validation dataset based on interpreting Landsat TM/ETM+ images and other high-resolution imagery from Google Earth for a total of 38,644 predetermined sample locations with a systematic unaligned sampling scheme. Further research is necessary to build a database of global wetland validation samples (GWVS) including more comprehensive wetland types that can benefit from wetland mapping derived from remote sensing on a global scale.

Three ways to validate samples are shown as: (1) image acquisition; (2) field investigation; and (3) data from a third party. The interpretation of wetlands derived from remote sensing images and developed by an automatic classification method should be based on components and texture features such as vegetation, hydromorphic soil and hydrology. In this paper, we establish the preliminary database of GWVS from the Web of Science by searching for wetland-related keywords, which benefits global wetland mapping and monitoring.

2 Constructing a global validation dataset: data and methods

2.1 Data and classification scheme

The articles for the study were downloaded from the Web of Science. The keywords for wetland-related searches are shown in Table S1. A total of 40,449 documents were found from the Web of Science between January 2008 and July 2012, and only 3,506 full-text documents were downloaded for sampling. The definitions of wetland are still a debatable issue [23, 24], and more than 60 definitions of wetlands are found in the world. However, there is still no widely accepted classification for wetlands with scientific significance on a global scale. Fortunately, the wetland classification of the Ramsar Convention has played an important role in wetland management on a global scale, and the most significant aspect is that category I of the Ramsar wetland classification system is widely approved for wetland classification. However, category II of the Ramsar classification system includes some generalised wetland types and overly specific types. The Ramsar marine/coastal wetlands of type (D, E, G) and type (J and K) have been merged into coastal mudflats and lagoons in GWVS, respectively (Table S2). The Ramsar inland wetlands of type (W and Xf), type (Sp, Ss, Tp, Ts and R), type (Y and Zg), type (M and N), type (O, P and Q) and type (U and Xp) have been merged into swamp, marsh, spring, river, lake and peatland, respectively. Ramsar human-made wetlands of type (2 and 6), type (1 and 5) have been merged into water storage areas and salt field/fish farm, respectively (Table S2).

2.2 Sampling and interpretation

The information “Author”, “Published time”, “Title” and “Journal” of wetland-related papers was converted from “.enl” to “.xls” in EndNote X4 Software, and “ID”, “Organisation of first author”, “Country”, “Site name”, “Survey time”, “Latitude”, “Longitude”, “Elevation”, “Area_ha”, “Wetland type”, “Overview”, “Physical features”, “Ecological features”, “Verified”, “Dimension of sample (m)”,“The year of high resolution imagery in Google Earth”, “Image clear or not” and “Remarks” was added to the database header. The information of central coordinate was changed into the same degree mode by using the mid functions (correct to 7 decimal places). Take the functions as an example:

$$\begin{aligned} \mathrm{N}29^{\circ}14'45'' &= \mathrm{MID}(\mathrm{A1},2,2)+\mathrm{MID}\ (\mathrm{A1},5,2)/60 \\ &\quad +\mathrm{MID}(\mathrm{A1},8,2)/3600 \\ &= 29.2458333, \end{aligned} \tag{1}$$