Eva Novotná*

Digitized globes for users: metadata, images and facts.

Keywords: digitized globe; metadata, web presentation, users.

Summary: Digitizing globes is an important part of scientific digital editions. As part of the digital humanities, they present new challenges for scientists. Digital editions of globes on the web provide three basic levels of data: metadata, images and facts. Globe maps are also presented. Linking and citations to verified scientific sources are important. Seven virtual globe collections were examined. The visual documents are presented in 2D and 3D and always accompanied by metadata of different levels. Three-dimensional objects can be zoomed, rotated and expanded in the flat map. Special services are also provided, such as image and metadata downloads, data filtering, and prepared groups of globes arranged thematically, chronologically, or by place of publication. There is also a search for historical geographical names. Users can also view the globes with a layer of current state boundaries.

1. Introduction

Terrestrial, celestial and thematic globes document the development of geographical knowledge about the Earth and the universe. Their three-dimensional dimension makes them special objects for metadata description and digital presentation. Various projects have been set up in the past to process collections or unique globes. This paper discusses the existing outputs of digital globe collections for users.

2. Images, facts and metadata

The digital edition of the globe in a web environment provides three levels of information, namely primary image and factual and the secondary metadata. The added values of virtual globes are interactivity, navigation, explorability, adaptability to user needs, updatability, dynamic animations, media integration and easy accessibility (Hurni 2008).

Pictorial presentations of globes are in the form of photographs, graphics, drawings or 3D objects. The user sees not only a model of the Earth or celestial bodies, but also a masterpiece. As a source of factual information, the globe offers specific historical and geographic data written or drawn on a physical, political or astronomical map (Fig 1). It depicts historical hydrology or geomorphology. There are mountain ranges with contemporary information, names and elevations. There are marked forest areas, too. Settlements are described by historical toponyms and often supplemented with detailed information. A map legend explains to the researcher the contemporary extent of the settlements, the region's industry, and the economic and political contexts.

* Ph.D., Map Collection and Geographical library, Faculty of Science of Charles University, Prague, Czech Republic [novotn48@natur.cuni.cz]

Fig. 1 Globe as a scientific visual and factographic document. Jacob Van Langren. Terrestrial globe. Ca 1605. Note about America, LAN II. (Source Province of the Franciscan Brothers, photo by Eva Novotná)

Metadata is important because globes, especially modern ones, contain few descriptive details. They are usually reduced to the title and author and publisher details. For this reason, accurate Mathematical scale information in particularly, as well as detailed physical description data with circumference and diameter, are essential (McEathron 1999).

2 a. Globe maps

Reconstructions of unavailable old globes are often made using globe maps (Fig. 2). The globe gores can be found not only in printed form, but also on print plates (Novotná, 2022). The 3D globe can also be digitally processed into a map unrolled into a flat plane. Globe maps are commonly part of globe presentations.

Fig. 2 An example of a globe map *Zemaljska kruglja* by Jan Felkl[1]. 1855–1870 (Source: Map collection, Charles University)

2 b. Linking of factual information

A metadata record is usually an extract from a bibliographic record. It may be supplemented by references or links. Citations of works describing globes are added. Reputable sources that should be cited and linked to for authenticated information on globes include the monograph *Terrestrial and celestial globes* by E. L. Stevenson (1921), Dutch globes by P. van der Krogt (1993), and studies in the periodical *The Globe Studies* (*Der Globusfreund*). In addition, there are specialist studies of national collections (Dolz, 1996; Lehman, 2010; Márton;, 2010; Mokre, 2008; Mucha 1973; Novotná, 2017; Sumira, 2014 etc.). Information on the restoration of the work is also given.

3.a Virtual Globes Museum, ELTE Eötvös Loránd University, Budapest

The largest Virtual Globes Museum (VGM)[2] represents the collection at the Institute of Cartography and Geoinformatics, ELTE Eötvös Loránd University. More than 170 terrestrial and celestial globes are available on its website. They are arranged chronologically. They are displayed in 2D and 3D, with zoom and rotate functions. It also includes globe maps from which a model of the globe is reconstructed. The metadata has different levels. Searching and filtering is possible (diameter, date, ID, body, publisher, place and country of publication). The interface is in Hungarian, German and English. Recently, researchers have also compiled an interactive geographical name index from the globes. The database contains globes and their names from the last 180 years[3] (Ungvári et al., 2023).

[1] FELKL, Jan. *Zemaljska kruglja*. Not avaible. U Pragu: od J. Felkl-a, 1855-1870. Available also from: https://kramerius.cuni.cz/uk/uuid/
[2] http://vgm.elte.hu
[3] http://terkeptar.elte.hu/vgm/gazetteer

László Perczel's giant manuscript globe with a diameter of 139 cm from 1862 has been made available here (Gede et al., 2011, Fig. 3).

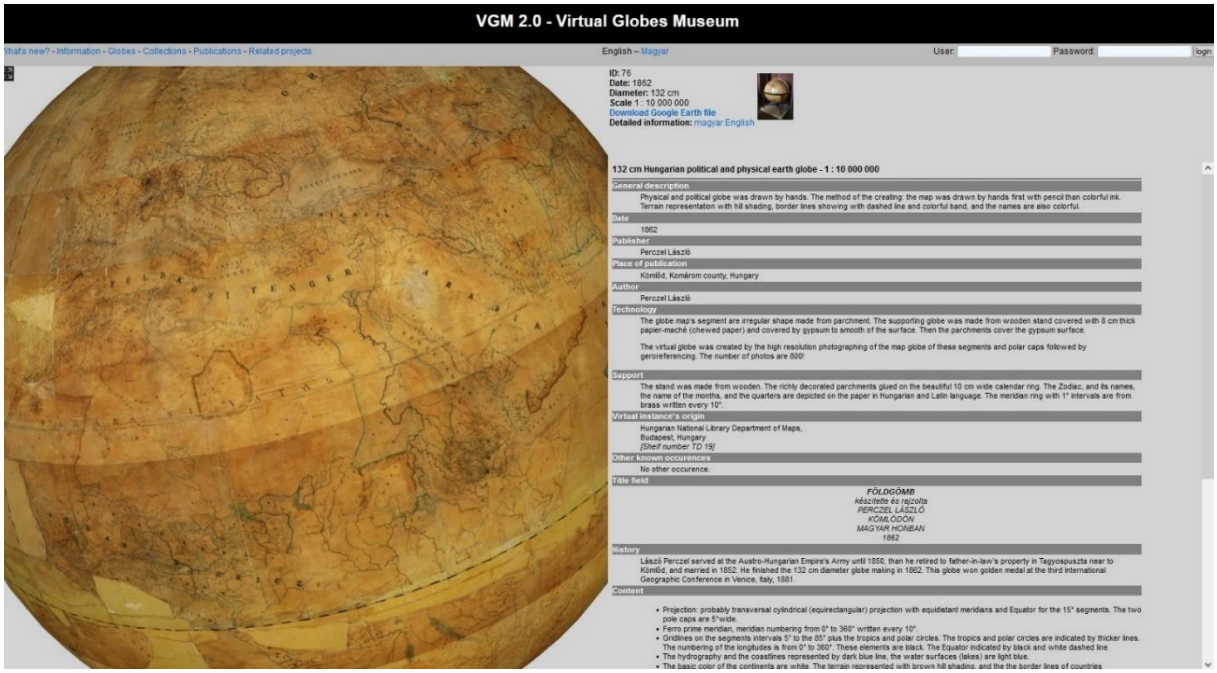

Fig 3. An example of a Hungarian globe with a detailed metadata description including production technology, history and content (cartographic projection, Ferro prime medirian, gridlines and their intervals, numbering of longitudes, hydrology, lettering etc.) László Perczel, 1862 (Source: Virtual Globes Museum)

Among other unique globes, I would like to highlight Willem Janszon Blaeu's globes from the 17th century.[4]

3.b. Globe Collection, Staatsbibliothek zu Berlin

The globe collection consists of 750 described exhibits, some of which are previewed in the catalogue.[5] The oldest of them are a celestial globe by Gerhard Mercator from 1551 and the extremely rare terrestrial globe of the Brothers Sanuto from ca. 1575 (Staatsbibliothek 2024).
In particular, 160 Berlin Globes (Berliner Globen 1790-1855) from the collection are presented as a separate image collection of photographs with metadata.[6] These are arranged by publisher and by theme (by content, date of publication or language). The oldest is the celestial globe Johann Elert Bode (Fig. 4) from 1804[7]. The collection also includes globe maps. Photographs can be downloaded.

[4] http://terkeptar.elte.hu/vgm/2/?lang=en&show=globe&wtf=blaeu&wf=publisher&id=115, http://terkeptar.elte.hu/vgm/2/?lang=en&show=globe&wtf=blaeu&wf=publisher&id=6, http://terkeptar.elte.hu/vgm/2/?lang=en&show=globe&wtf=blaeu&wf=publisher&id=1
[5] https://staatsbibliothek-berlin.de/en/about-the-library/departments/map-department/collections/holdings/globe-collection
[6] https://kartenhighlights.staatsbibliothek-berlin.de/berliner-globen/berliner-globen-die-verlage/
[7] https://kartenhighlights.staatsbibliothek-berlin.de/berliner-globen/berliner-globen-die-verlage/verlag-sotzmann-und-bode/

Fig. 4. Detail of the globe J. E. Bode *Himmelskugel*, 1804. *Berliner Globen 1790-1855* (Source: Staatsbibliothek zu Berlin)

3.c. Globe Museum, Austrian National Library, Vienna

The collection of the Globe Museum[8] contains 836 globes and instruments. 250 of them are exhibited in the museum and the rest are stored in the study collection, which is not accessible to the public.

The bibliographic record in the National Library catalogue is accompanied by photographs that can be zoomed and downloaded (Fig. 5)[9].

[8] https://www.onb.ac.at/en/museums/globe-museum

[9] https://search.onb.ac.at/primo-explore/search?query=any,contains,globen&tab=default_tab&search_scope=ONB_gesamtbestand&vid=ONB&facet=rtype,include,map&mode=basic&offset=0

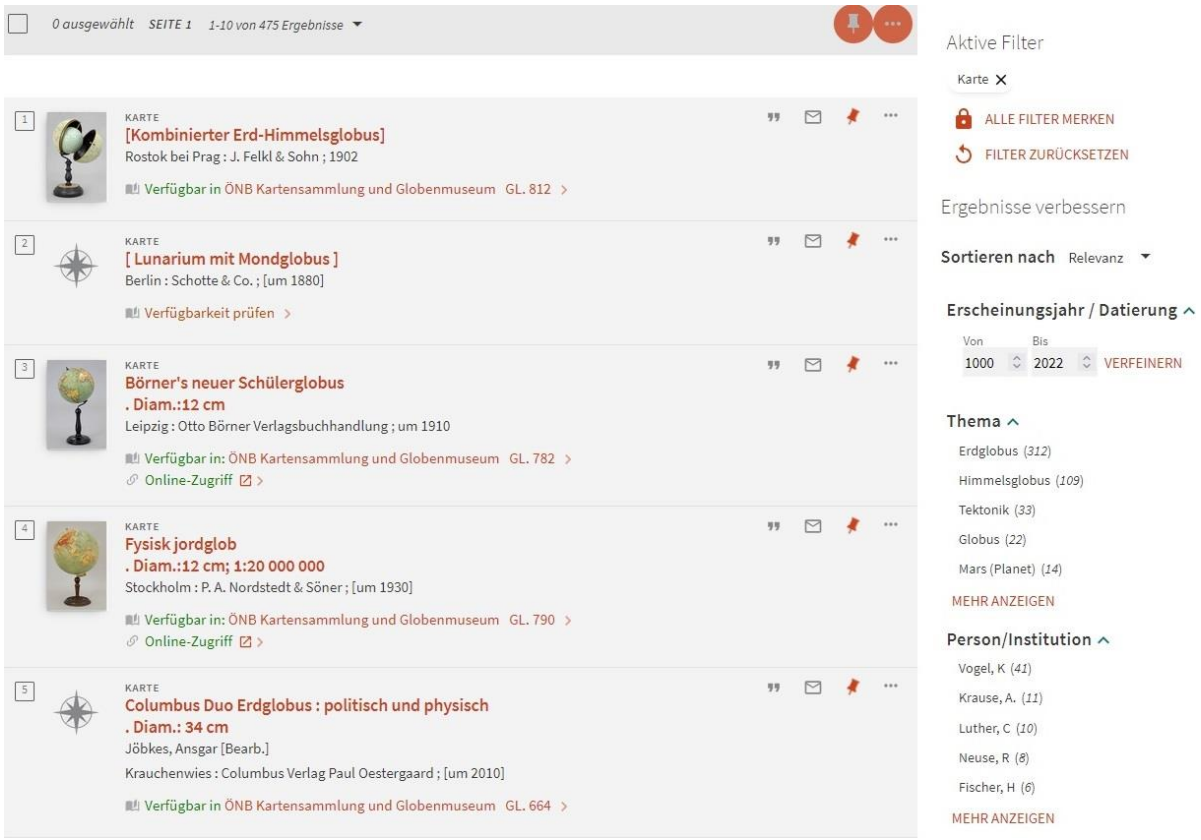

Fig. 5 Search results in the catalogue of the National Library of Austria. Further sorting is possible on the right by date, topics and authors The Primo library discovery service platform (Source: Austrian National Library)

The ÖNB Digital collections include 81photographs of globes with metadata.[10] The objects can be downloaded in full resolution. The oldest relics include a pair of globes by Gerardus Mercator, the terrestrial globe from 1541[11], and the celestial globe from 1551.

3.d Globe Collection, French National Library, Paris

The French National Library has also published a collection of digitized globes in the Gallica digital library (Gallica 2024).[12] The objects are classified by 2D, globe maps (138)[13], armillary spheres and tellurium (12), and 3D objects. They are further subdivided by subject (terrestrial, celestial and metallic), chronologically (medieval, 16th–19th centuries) and by place of production (France, Netherlands, Germany, Italy, UK and Arab World.)

[10] https://onb.digital/search/978235
[11] http://data.onb.ac.at/dtl/2206641
[12] https://gallica.bnf.fr/html/und/cartes/globes?mode=desktop
[13] https://gallica.bnf.fr/services/engine/search/sru?operation=searchRetrieve&exactSearch=false&collapsing=false&version=1.2&query=dc.subject%20adj%20%22en%20fuseaux%22%20%20and%20%28dc.type%20all%20%22carte%22%29%20and%20%28provenance%20adj%20%22bnf.fr%22%29

Fig. 6 Search 3D globes by place of release (Source: Gallica)

Photographs (high resolution) and metadata can be downloaded. Among the unique items, a 24 cm diameter globe by Martin Waldseemüller from 1506[14] is of interest. Another rarity is an Arabic celestial globe from the 11th century[15]. Promotional videos are also available.[16]

3. e Det Kgl. Bibliotek Søren, København

The Royal Danish Library owns and makes available a collection of 37 old celestial globes, mostly made by Will Janszoon Blaeu in 1603 (Fig. 7), based on measurements by Tycho Brahe (Digital collections, 2024).[17]

[14] https://gallica.bnf.fr/ark:/12148/btv1b55008738x/f1.item
[15] https://gallica.bnf.fr/ark:/12148/btv1b550087272/f1.item
[16] e.g.: https://vimeo.com/330490199
[17] http://www5.kb.dk/maps/kortsa/2012/jul/kortatlas/subject510/en?view=list

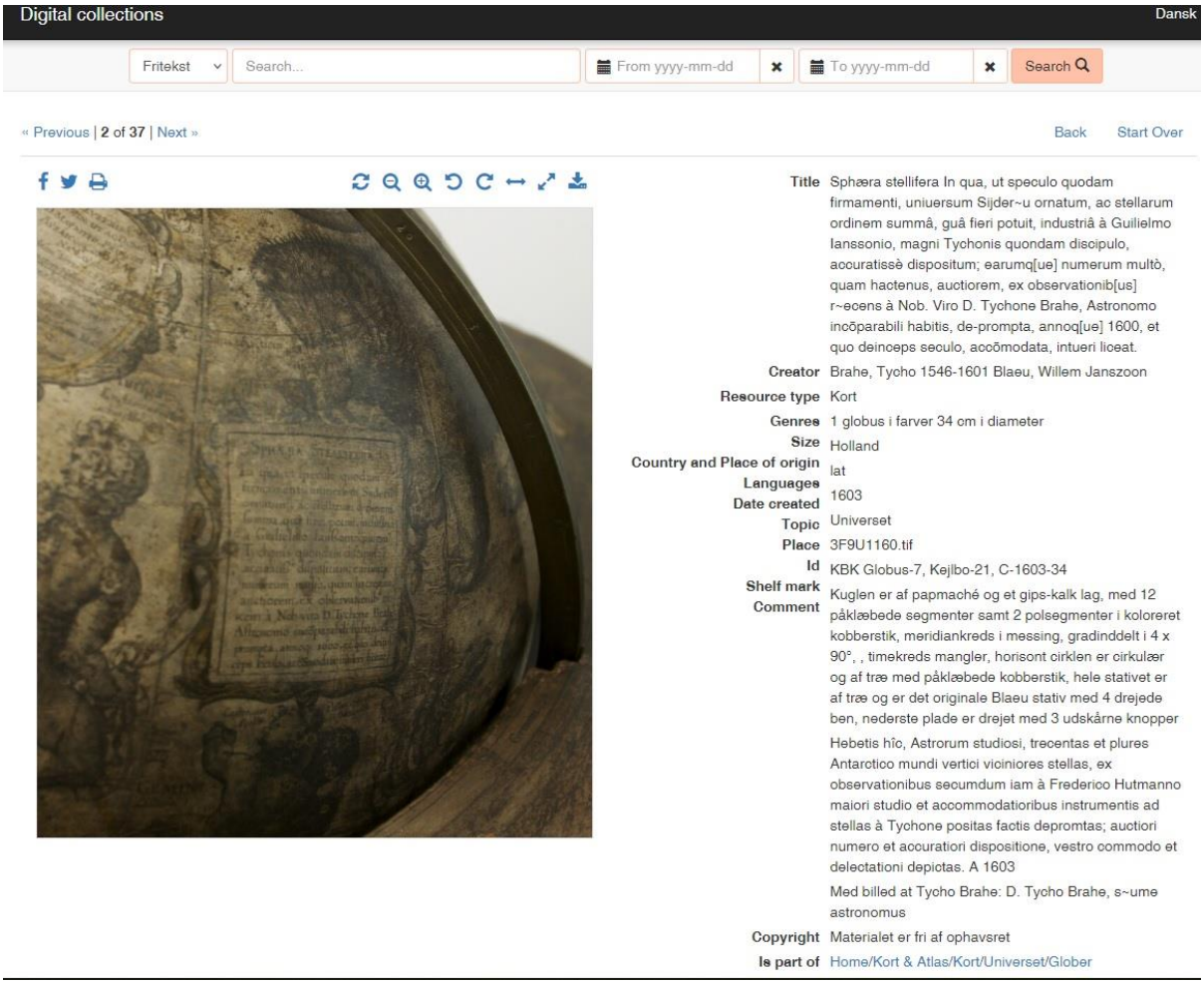

Fig. 7 Detail of W. J. Blaeu's celestial globe and globographic description including Latin texts, 1603 (Source: Det Kgl. Bibliotek Søren)

But there are also other authors. The photographs can be zoomed and downloaded in full resolution. They are accompanied by detailed metadata including transcribed Latin texts /(Fig. 7).

3. f Virtual Globe Collection, Geodetic Research Institute, Zdiby

Approximately one hundred digitized globes from various collections of the Czech Republic are published on the website of the Research Institute of Geodesy, Topography and Cartography (Virtual Map Collection 2024).[18] The 3D globes are georeferenced and the user can use the border layer (Fig. 8).

[18] http://chartae-antiquae.cz/en/globes/

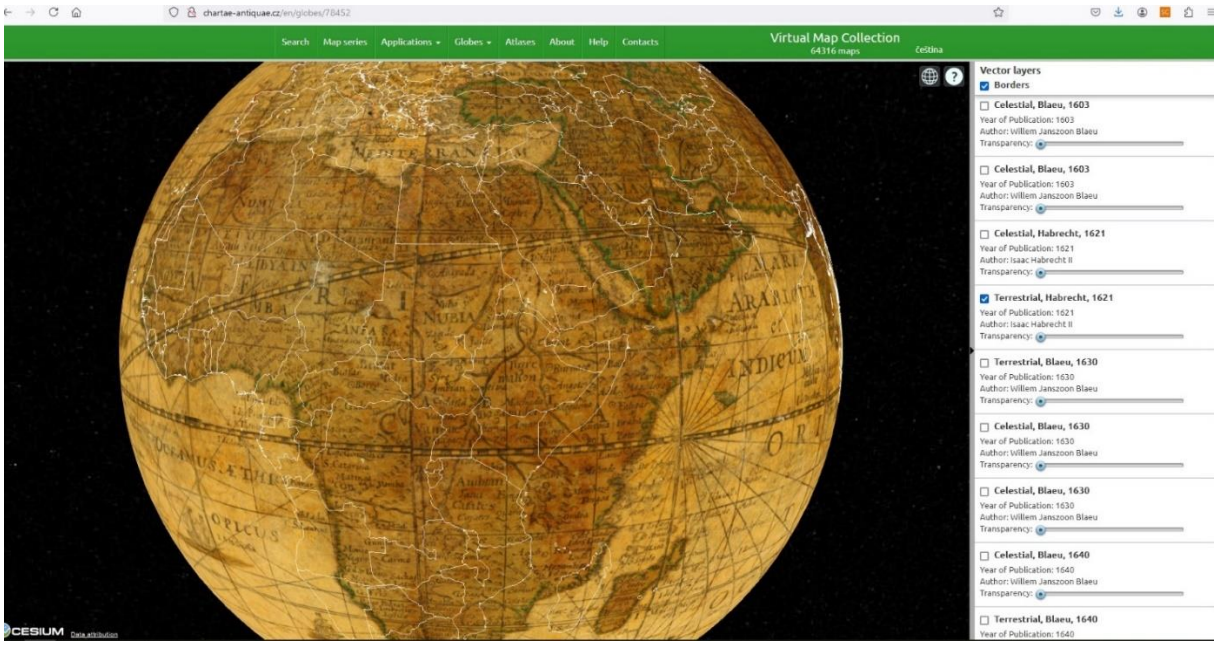

Fig. 8 3D terrestrial globe displayed with a boundary layer, Isaac Habrecht II. 1621 [19](Source: Virtual Globe Collection, Cesium)

The globes can be rotated, zoomed and unfolded in the plane. Globe maps are used to create 3D models. Among the old works in this collection, a pair of Vincenzo Maria Coronelli's globes from the late 17th century, 110 cm in diameter, owned by the National Library of the Czech Republic is remarkable.[20]

3. g Digital globes collection, Map collection of the Faculty of Science Charles University, Prague

The original presentation of globes from 2013 (Hyndráková 2015)[21] was replaced by a new database.[22] This is being tested and research on student satisfaction is underway. The globe collection website has been visited by 11,500 users so far (since 2014). The total number of globes, tellurias and armillary spheres in the collection of maps of Charles University is 189, but not all of them can be published. The digital globe collection contains 97 objects that are not protected by copyright law. In the user interface it is possible to choose between 2D and 3D objects (9 of all) that can be zoomed, rotated or view as a flat map. The images can be downloaded in high resolution. The database allows precise filtering by object (terrestrial, celestial, lunar, tellurian and armillary spheres), by content (physical-geographical, thematic, political), by processing (paired, unfolding, luminous, relief, pneumatic). Outputs are ordered logically. The design of the website is adapted to both computers and mobile devices.

[19] http://chartae-antiquae.cz/en/globes/78916
[20] http://chartae-antiquae.cz/en/globes/76912, http://chartae-antiquae.cz/en/globes/76911
[21] http://www.mapovasbirka.cz/globy/english/index_eng.html
[22] http://mapovasbirkademo.euweb.cz/en/index_en.php

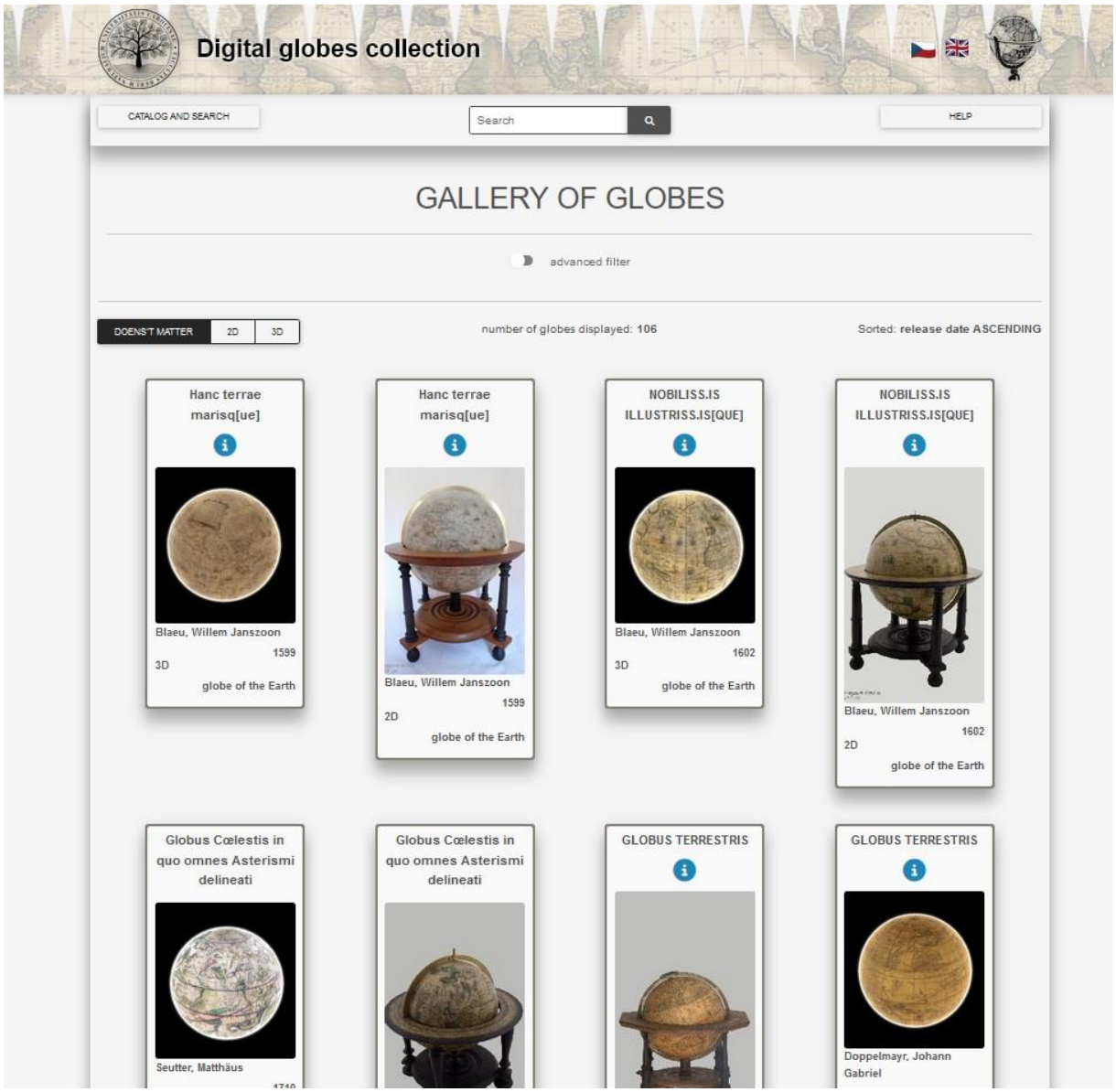

Fig. 9 Web interface of the Globe Gallery, it is possible to view the objects or choose detailed filtering (Source: Map Collection Faculty of Science, Charles University)

Objects are globally described in accordance with the standards and contain at least one category for filtering. Newly validated dimensions have been added. Simplified metadata can be displayed to the user in full in the Charles University Catalogue. The bibliographic record is always completed and corrected after the globe has been investigated. Information on restoration is also given. The 14 old globes include Willem Janszoon Blaeu's work from 1602[23], Jodocus Hondius' *Globus terrestris* from 1613 and Matthäus Seutter's celestial globe from 1710[24].

4. Conclusion

There were presented separate virtual globe collections at the Universities of Budapest and Prague, at the national libraries in Paris, Berlin and Copenhagen, and an aggregated collection at the

[23] http://mapovasbirkademo.euweb.cz:8080/en/php/item_en.php?id=40
[24] http://mapovasbirkademo.euweb.cz:8080/en/php/item_en.php?id=41

Geodetic Institute in Zdiby. Separate virtual presentations of globes are not yet common and are rare. Rather, the metadata of the globes in the online catalogue is supplemented by thumbnails (e.g. the Globe Museum in Vienna, the Globe Collection in Berlin).

The basis for the presentation of the visual information is an overall photograph of the globe with an upstand, sometimes accompanied by a detail with a title cartouche or map legend. These images can be downloaded at various resolutions for selected collections. A total of 520 globes with varying numbers of photographs (excluding two institutions) are made available in the seven collections surveyed.

The curators of the Virtual Collection of the Geogetic Institute of Zdiby understand 2D as a flat map of the globe. This method is also offered by the Map Collection of Charles University.

A 3D presentation of the whole globe collection with zooming and rotation is in the collections in Budapest, Paris and Zdiby; at the University of Prague it is possible to work with part of the collection (9 models). In total, 348 three-dimensional virtual globes are available in these seven collections. Of these, the Virtual Globe Museum in Budapest and the Virtual Globe Museum in Zdiby also offer photographs of the globes (2D image). Thus, the total number of globe photographs increases by 284 to 804 globes.

All globes have descriptive metadata at different levels. In some collections, it is possible to look up detailed bibliographic descriptions in the catalogue.

Most collections also own and display globe maps. The Virtual Globe Museums in Budapest and Zdiby have created new virtual globe models from printed globe gores. Searching, sorting and filtering of user queries is possible in all cases.Jazykové rozhraní je vždy v národním a anglickém jazyce s výjimkou berlínské sbírky.

The specialities of the presentation of the globes are described in detail in the text and in the overview table of the globe collections (Table 1). Certainly the most interesting is the search for interactive geographical names in the Budapest collection.

Only the web pages of the global collection of Charles University in Prague contain an access counter. Over the last decade, 11,500 users have visited it. However, nothing more is known about their needs and behaviour. To this end, a user survey is being conducted in the summer of 2024, the results of which will hopefully be made available to interested parties in the future.

Unless the globe is made available in 3D, where users can conduct the research interactively themselves, the metadata globographic information should be as accurate as possible. Particularly important is information about the zero meridian, cartouche, labels and globe legends. However, it is always necessary to have accurate measurements of the globe's circumference to calculate the scale if it is missing from the metadata.

Attempts to make three-dimensional cartographic monuments accessible are very important. The growing importance of globes is evidenced by the fact that the first Martin Behaim globe was registered in the UNESCO MoW Register in 2023 (Germanisches National Museum 2024). Hopefully, in the future, users will have more opportunities to virtually access these unique monuments. Collection managers can then be satisfied with the perfect description and archiving of the works.

Tab. 1 Summary of virtual globe collections[25]

The name of collection	2D/3D	Number of globes	metadata	Globe maps	Search/filtering	Speciality	Interface language
Virtual Globes Museum, ELTE Eötvös Loránd University, Budapest	2D/3D	170/3D	170	+	+	Interactive geographical names, detailed metadata	Hungarian, German, English
Globe Collection, Staatsbibliothek zu Berlin	2D	160/2D	750	+	+	Berliner Globen 1790-1855	German
Globe Museum, Austrian National Library, Vienna	2D	81/2D	836	+	+	-	German, English
Globe Collection, French National Library, Paris	2D/3D	145/2D; 55/3D	200	+	+	Selected files for 3D globes by subject, date and place of release. Video presentation.	French, English
The Royal Danish Library, København	2D	37/2D	37	+	+	Full transcriptions of Latin texts	Danish, English
Virtual Globe Collection, Geodetic Research Institute, Zdiby	2D/3D	114/3D	114	+	+	Georeferencing, boundary layers, in-plane expansion (2D)170	Czech, English
Digital globes collection, Map collection of Charles University, Prague	2D/3D	97/2D, 9/3D	189	+	+	Detailed filtering, globe maps available from the catalogue	Czech, English

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Gallica Digital Library. In digital form, *https://gallica.bnf.fr*

Det Kgl. Bibliotek. Digital collections. In digital form, h*ttp://www5.kb.dk/maps/kortsa/2012/jul/kortatlas/subject510/en?view=list*

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