3D Webcartographic Tools for Planetary Science Outreach

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ABSTRACT: Despite the new advances in planetary science and the new detailed imagery and maps, results in astrogeology communicated by maps rarely reach the general public and especially children. Also, planetary maps are more likely to be produced by astrogeologists for other professionals than cartographers for the general public. The authors developed planetary cartographic websites for outreach purposes. These sites use a playful approach to the theme, as the main target groups are children and teenagers. We present three recently developed planetary cartographic tools that target youth audiences.

At http://childrensmaps.wordpress.com, newly produced, specialized planetary virtual globes are now available for the youths in 11 languages. The globes are based on the planetary map series for children developed in the co-production of graphic artists and members of the ICA Commission on Planetary Cartography.

At http://terkeptar.elte.hu/em/?lang=en, "Blind Mouse on the Moon and Mars" helps disseminating topographic knowledge of the two best known Solar System bodies. The task is to find the place of features on a virtual globe based on their description. This tool can be used by educators as extracurricular activity. The game, originally developed using the recently deprecated Google Earth API, is currently being refactored to use the Cesium API.

At http://mercator.elte.hu/~saman/countrymovers/, "Country Movers" is a tool to visualize size differences of planets and relative sizes on their surfaces. The outline of a chosen country or US state can be placed and moved on the surface of another planet, keeping its original size. This comparison can be done either on the surface of a rotatable globe model or on a 2D map in Web Mercator projection. This latter can also be also used to illustrate the area distortions of the map projection.

KEYWORDS: Planetary science, webcartography, virtual globes, edutainment

Introduction

People's best learning experiences come when they are engaged in activities that they enjoy or care about. (Resnick, 2004). This is the basic idea behind the concept of "Edutainment" or "Playful learning". This concept can be used in the field of planetary science as well. There are examples of such projects, e.g. Sornig et al (2011) organized planetary science workshops for 13-15 years old pupils. Brown-Simmons et al (2009) created a game engine for Earth and planetary science related topics.

In the field of geography, there are several edutainment web sites, usually connected to some kind of map – typing "edutainment geographic game" into any search engine will reveal plethora of such games. Simonné-Dombóvári (2014) devoted a full PhD thesis on the topic. However, there are no initiatives to use edutainment for planetary science using planetary web maps, especially 3D visualization techniques. As the authors of this paper previously participated in various projects involved planetary cartography, virtual globes as well as web map games, they decided to merge these fields, and create webcartographic tools to help learning and understanding various aspects of our Solar System fellows.

Review of existing projects

Planetary maps are produced for several reasons. Professional mapping is done for mission planning (landing site selection or targeting future observations) or science (geological maps). Engineering maps help landing site selection and surface navigation and may show terrain trafficability, using boulder distribution or slopes maps. Geological maps show inferred geological units with or without their ages, as determined from surface terrain patterns, topography, albedo or chemical differences. While photomosaics and topographical maps are also used for science as base maps, these types of maps are the most commonly used ones in outreach.

There are four main planetary science outreach tools and platforms that use maps to communicate NASA's astrogeological results via maps: MarsTrek, which is the official online NASA platform for outreach (but is also being further developed for mission planning), Google Mars (both its web-based and Google Earth based platform), and the outreach maps in the USGS image mosaic and topographic map series (Hare et al. 2015) which has static pdf and printed versions. Planetary maps for outreach are also regularly produced at National Geography.

In the followings we present three independent planetary cartographic tools that have been developed specifically for education and public outreach on a nonprofit basis and includes approaches and functions that are not existing in the above described platforms.

Planetary maps and globes for children

When reaching out for the youngest generation, our primary aim was not to provide the most accurate knowledge about planetary bodies, but simply to make children aware of the existence of such objects. Therefore, maps of six members of our Solar System (Venus, the Moon, Mars, Io, Europa, and Titan) were created by graphic artists (Hargitai et al. 2015), who were instructed to let their fantasy unleashed and add unique narratives to their maps, so on their drawings some of these planets and satellites became inhabited by funny extraterrestrial creatures to draw the attention of the kids. At the same time the maps depict the most important features of the bodies at their correct positions as the artists used georeferenced imagery as geometric base. The maps also contain references to mythological persons (like Aphrodite and Artemis on Venus) and legends (like the one of Io, daughter of Inachus), as well as indications of all the landing sites (in the case of Moon, Venus and Mars). All the maps have two versions: a printable flat map (Figure 1) and a rotatable, zoomable virtual globe (Figure 2).

Figure 1. Map of Venus for children

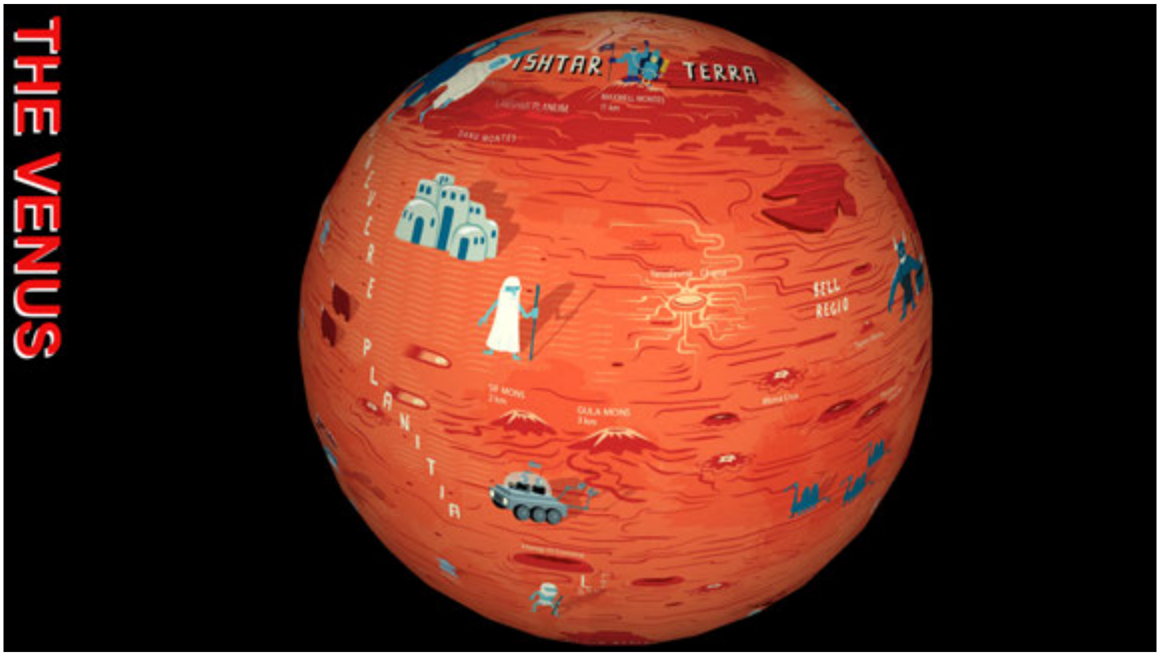

Figure 2. Online rotatable virtual globe of Venus

After publishing the maps, children raised several questions regarding the corresponding planets and satellites and the stories and figures on these drawings. Based on these questions, descriptions of the planets and the myths depicted on the maps were created in a form understandable for children and published on the webpage http://childrensmaps.wordpress.com in 11 languages.

Blind Mouse on the Moon and Mars

Mute maps are traditional tools of teaching geography. As they became rather obsolete in the era of Web 2.0, authors of the Blind Mouse web map games created websites based on the edutainment principle (mixing education and entertainment, e.g., Russell, 2000, Kereszturi, 2009), blending the idea of mute maps (called literally "blind maps" in Hungarian, that's the origin of the name of the game) into an interactive web map game.

The original Blind Mouse game was developed as part of a master thesis by Dombóvári in 2005. The goal is to place ten randomly chosen objects on a map without labels. Scores are calculated from the average displacement of these objects. The levels of this game correspond to the topographic requirements of primary schools, of secondary school final exams and of university geography courses, set in the Hungarian National Core Curriculum. The game proved to be useful and soon became popular among primary and secondary school pupils and teachers.

With the emergence of virtual globe engines, a new version of this game was developed (Simonné-Dombóvári and Gede, 2011), using the Google Earth API (Google, 2012). While the base concept remained the same, the themes were changed to fit the nature of the 3D interactive globe: instead objects within a specific country, global sets of points are used such as capital cities of the world.

As Mars and the Moon is also available in the Google Earth API, it was an obvious step to extend the geographic coverage of the game beyond the Earth in the new version called "Blind Mouse on Mars" (Gede, Hargitai and Simonné-Dombóvári, 2013). Although the imagery of Mars and the Moon offered by Google is very impressive, a traditional, abstracted map is more adequate for educational purposes. Therefore globe maps created in a project of the ICA Commission on Planetary Cartography (Shingareva et al. 2005) were added as optional overlays. These maps use well-designed hypsometric relief representations, using a yellow-orange-brown color scheme for Mars (Figure 3), and blue-yellow for the Moon (Figure 4), enhanced by relief shading.

Planetary feature names are rather unknown for the general public, so unlike the previous, "Earth" versions of the game, these planetary maps are no longer "mute" (i.e. without toponyms). This way the game supports the dissemination of this knowledge. The names on the Moon are bilingual (Latin and English), while the Mars map has Latin nomenclature.

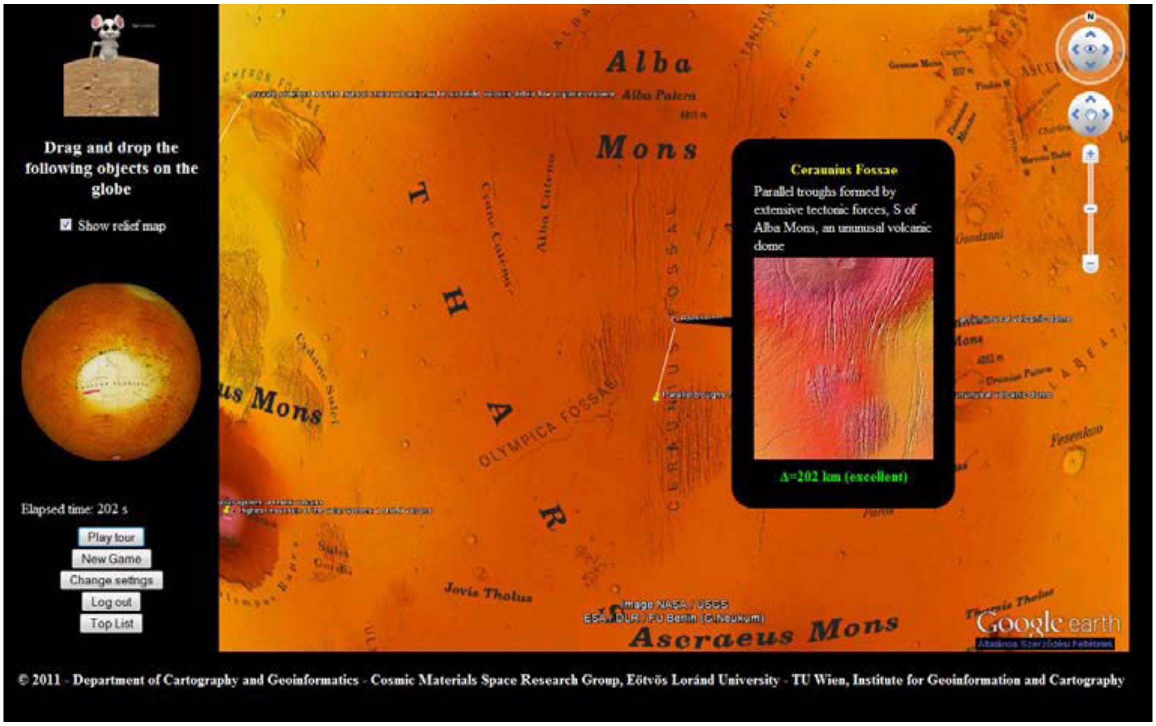

Figure 3. "Tour" layout with answers of the "Blind Mouse on Mars" module (http://terkeptar.elte.hu/em).

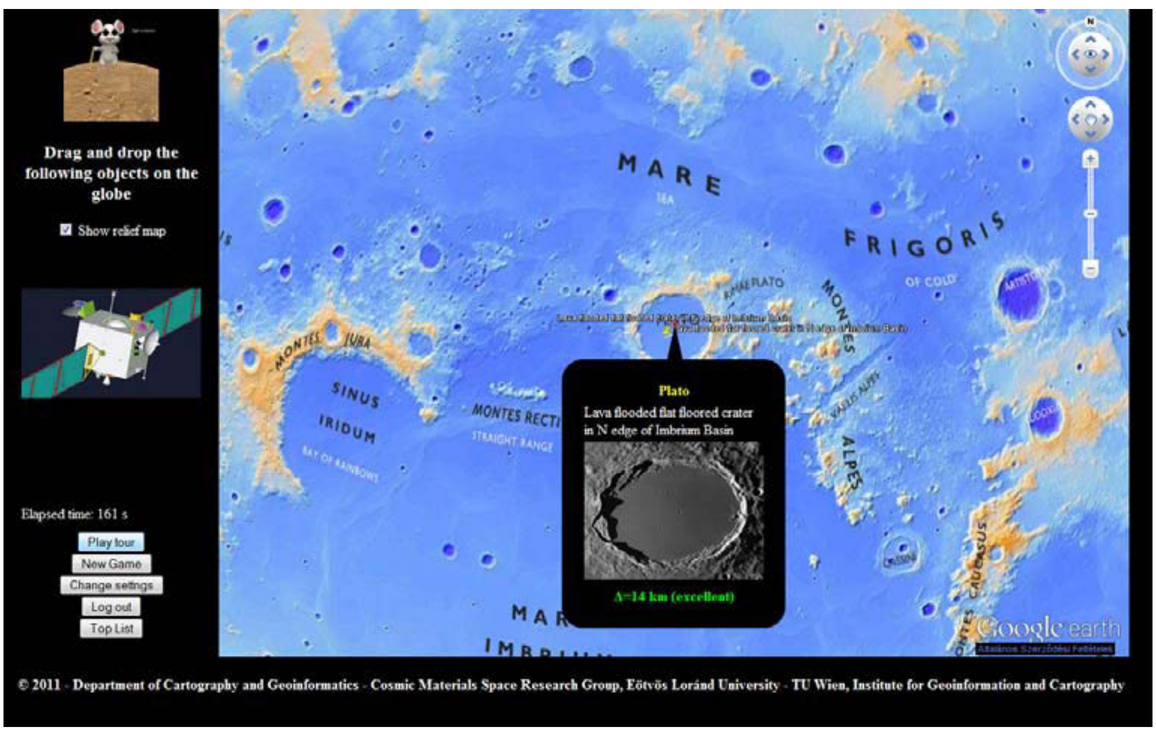

Figure 4. The "Blind Mouse on the Moon" module (http://terkeptar.elte.hu/em).

The aim of the game is to check our knowledge of positioning and identifying map features. Two types of game are available on each celestial body: finding the right place for ten objects defined by a short description, and a planetary quiz with ten random questions that can be answered with the help of the planetary globe.

At the end of the game, an animated "virtual trip" guide the users over the objects, showing short descriptions and evaluating the rate of misplacement for each one.

Apart from dissemination of planetary topographic knowledge, this game also improves players' map-reading skills. The overlay maps are thoroughly edited, but using uncommon (and different) color schemes for hypsometry, forcing map readers to abstract from the well-known colors of terrestrial maps.

Unfortunately, the Google Earth API became deprecated by the end of 2014. Although it is still running in 2016, the Blind Mouse on the Moon and Mars game is currently being refactored to use Cesium, an open-source, WebGL-based virtual globe API (Cozzi 2013).

Country Movers

Estimating sizes on planetary surfaces is a difficult task because of the lack of familiar landmarks and also due to the different radius of various planets and satellites. With the creation of the Country Movers website (http://mercator.elte.hu/~saman/countrymovers/) authors tried to help this problem.

The base idea of this website is rather simple: it is much easier to estimate the size of a feature when we can compare it to a well-known object. Therefore, users can place and move around the outline of any country or US state on the map of a handful of planetary bodies (Earth, Moon, Mars, Io, Titan). The country and the celestial body can be chosen from drop-down lists, while the current outline can be moved by simple mouse drag and drop. For example, demonstrating the real size of Olympus Mons on Mars is easy by placing the polygon of Hungary next to it (Figure 5). When drawing the outline on an extraterrestrial body, the radius differences of planets are taken in account.

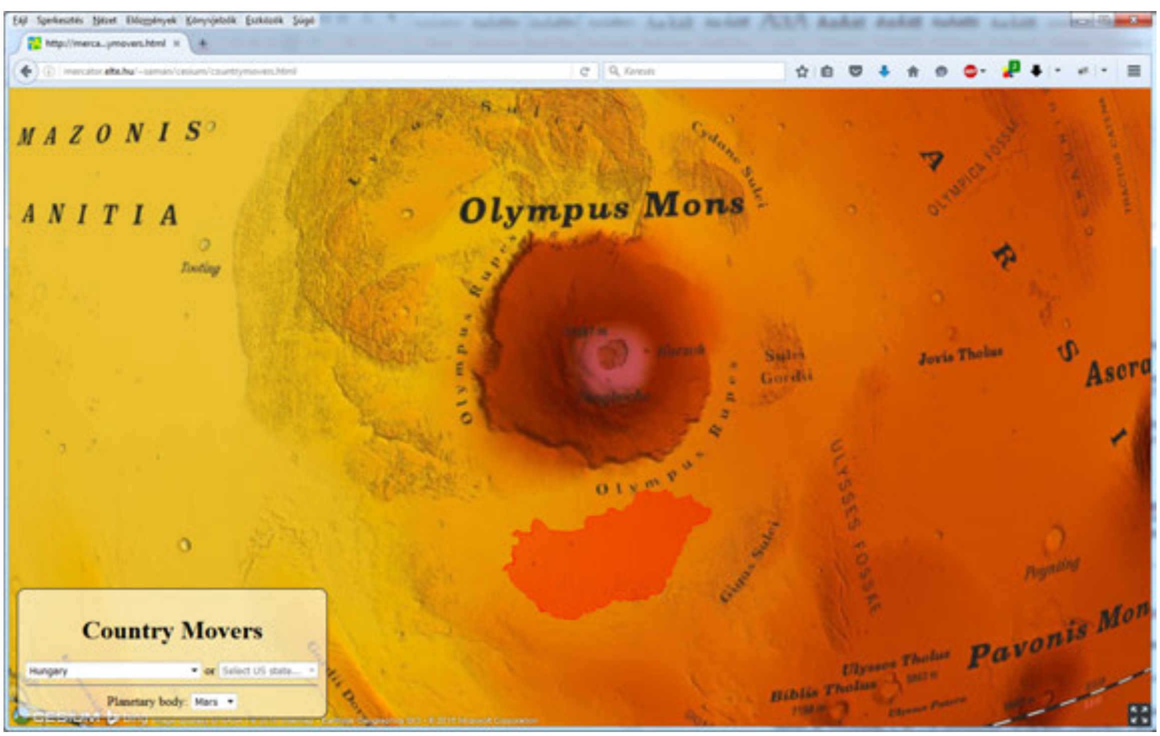

Figure 5. Comparing the size of Olympus Mons to Hungary with Country Movers

When calculating the current place and shape of a moved polygon, spherical trigonometric equations are used. The method is the following: For each node, its spherical distance (using the respective sphere radius) and bearing is calculated from the clicking position in the original shape. When moving the shape, the new position of the node will be in the same distance and angle from the current mouse position, ensuring, that the shape and the size of the shape will more or less the same – naturally not exactly when the celestial body is changed as it is impossible to project a spherical shape between spheres with different radii without any distortion.

The site offers two different views: a flat map in Mercator projection, and a virtual globe (powered by Cesium API). The flat version also can be used to demonstrate the high area distortions of the Mercator projection e.g. by moving Greenland to lower latitudes (Figure 6).

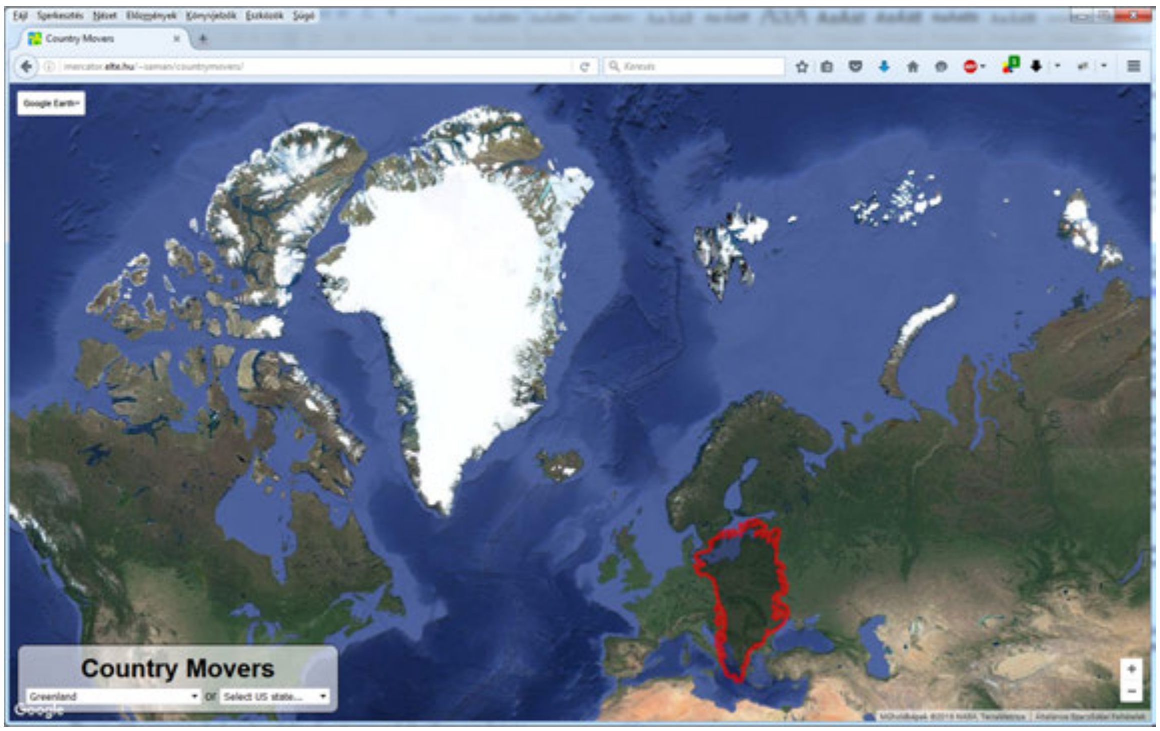

Figure 6. The flat map interface of Country Movers can be used to demonstrate the area distortions of Mercator projection.

The virtual globe version is a useful tool to demonstrate the size differences of the planetary bodies. As an example, Australia on the Moon would cover almost a hemisphere, as it is shown on Figure 7.

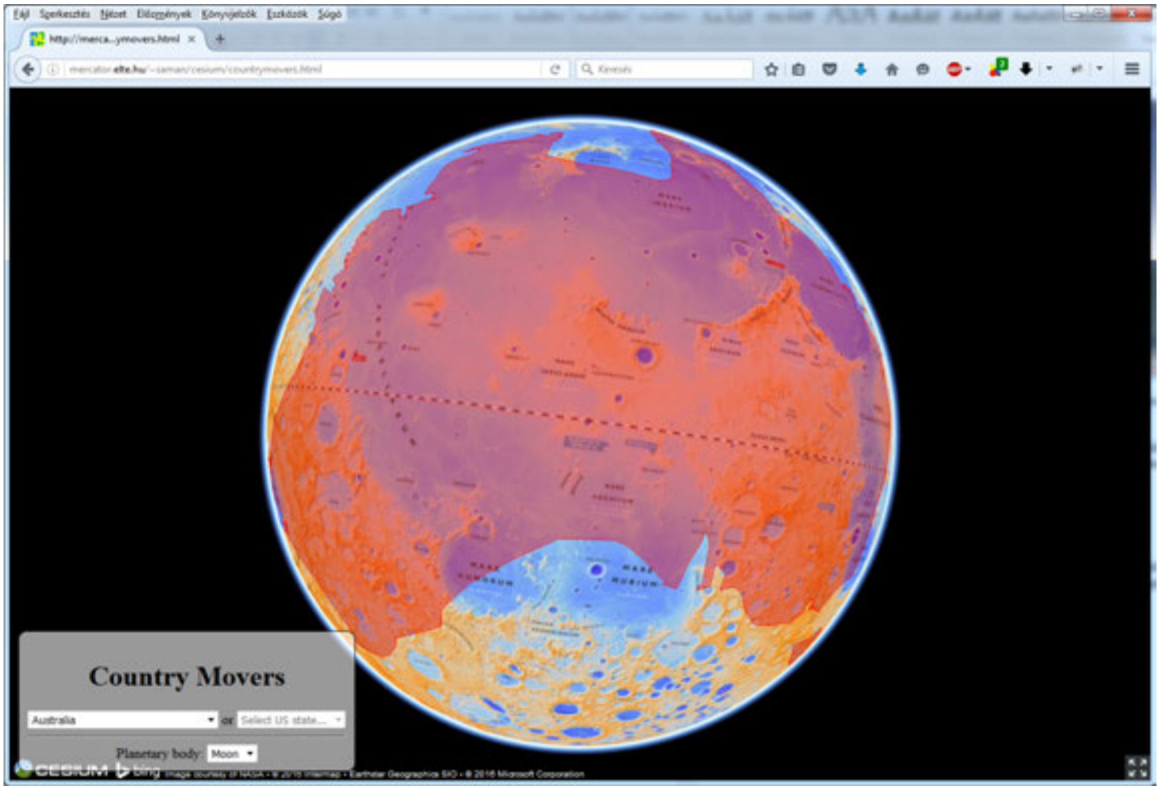

Figure 7. Fitting Australia on the Moon in the virtual globe version of Country Movers.

Conclusions

The 3D planetary cartographic websites introduced in this paper may help popularizing planetary science and disseminating its knowledge. The children planetary map series along with the virtual globe versions can be used even in kindergartens and in early classes of primary school, raising children's attention to the topic.

The "Blind Mouse on the Moon and Mars" offers a playful approach to learn topographic information about the two most researched Solar System bodies, and to practice reading extraterrestrial maps.

The "Country Movers" helps understanding the different sizes of planets and satellites, and estimating dimensions of their surface features.

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