

## AFRICA: COMPARATIVE ANALYSIS OF MODERN REMOTE SENSING DATA AND OLD MAPS (BY HAND-ATLAS VON AFRIKA, 1831)

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Abstract: Cartography, despite its long history, up to the present day remains one of the most relevant areas of research in the world. It considers modeling and displaying of spatial objects, which tend to change and, therefore, science itself must change as well. The article proposes a methodology for the analysis of old maps, based on comparative-analytical method, using remote sensing data. Its application allows us to evaluate the accuracy of old maps and to better understand the features of the cartographic school of past eras.

Key words: old maps, gis, karl ritter, maps reliability

### 1 Introduction

Cartography, despite its long history, up to the present day remains one of the most relevant areas of research in the world. It considers modeling and displaying of spatial objects, which tend to change and, therefore, science itself must change as well. As it develops, many important new developments have appeared in cartography, including research using methods of remote sensing of the earth. For the study of ancient maps, geographic information systems are more frequently being used, due to their capabilities there is an opportunity to track changes in objects mapping. [Cillis, g., statuto, d., picuno, p. 2019]. One of the areas of cartography is an atlas mapping. As it is known, atlas is a systematic collection of maps that form an integral cartographic work. An atlas makes it possible to describe basic properties of geographical systems and how their functioning in more detailed way. Old maps and atlases serve as evidence of past states of space and time, and represent valuable data sources for the history of the world. [Blanco, a., de bustamante, i., pascual-aguilar, ja2019]. Therefore, we can conclude that analysis of the mapping features used in such geographical atlases can help to assess the development of cartographical science.

By the middle of the sixteenth century, German cartography was considered to be one of the most advanced in the world, especially in the field of design and publication of maps. It is worth noting that in many countries, along with military topographic departments, civilian cartographic institutions have also begun to emerge, providing the creation of general geographical, special and thematic maps. During the nineteenth century there was a rapid development of German cartographic science. Germany was an infant as a single state and therefore there was a great need for compiling new topographic maps of both the state itself and overseas territories and colonies. Among the cartographic works of this period, the German company Justus Perthes, which published the world atlas of Stieler (1823), the physical atlas of G. Berghouse (1836-1841), which included a volume of text descriptions and 90 sheets of thematic maps, stands out clearly. It was this company that published the most accurate and complete maps in Germany in the 19th century [Lj. Demhardt, 2003]. Maps of the company were distinguished by their geographical reliability and informativeness and often served as models for other publishers. Since the mid-nineteenth century, this publishing house has become known for its innovative design and drawing of maps, as well as a center for

foreign research cartography. The atlas of this particular company was used in this study. [Lj. Demhardt, 2000]

### 2 Materials And Methods

Compact atlas of the African continent (German: "Hand-Atlas von Afrika"), authored by the famous German geographers Karl Ritter and Franz August Ezel, was published in Berlin in 1831 [Arantes, I. 2016]. This cartographic work has 14 different maps in its composition, which together create an integral and detailed description of the continent. From a very voluminous introduction to the atlas, you can find out that it serves as an addition to the 1st volume of the fundamental work of Karl Ritter, "Die Erdkunde im Verhältnis zur Natur und zur Geschichte des Menschen", which was published in 1822 and devoted to Africa [Schenk, W. 2018]. In the annotation for each map, a link to a page from the book is given, where the main description of the part of the continent that is depicted. The publisher of this manual atlas was George Andreas Reimer, a German publisher and book dealer.

To study the atlas in this paper, comparative and analytical methods were mainly used. Initially, a detailed analysis of all maps included in this atlas was carried out. So one can identify all key features of mapping objects, determine how maps correspond to trends of cartography development and how they reflect the reality of a particular era.

The next stage of the study was the selection of a number of maps of the atlas, and their subsequent digitization and import into GIS software. In this case, the digitization was a scan of the necessary maps. For the analysis, maps of various scales depicting large relief forms were selected. Maps for comparative analysis were the "Map of Africa" (German Karte von Afrika), the "Map of the Southern Tip of Africa" (German Karte des südlichen Endes Afrikas) and their modern analogues, made in the same geographical projections, as well as a section of the base map of ArcGIS servers (Table 1). This base map is an orthophotomap and consists of satellite images of a number of satellites: Terracolor (small and medium-sized scales from 600 to 72 thousand), Spot (from 288 to 72 thousand), Digital Globe, GeoEye, Ikonos, Aerogrid and IGN Spain. This is very convenient in the context of searching for satellite images for a particular region of interest, such an orthophotomap has several advantages for conducting a qualitative study of the territory.

Table 1. List of the compared maps

The atlas map	Modern map
Karte von Afrika (1822)	Map of Africa (2015)
Karte des südlichen Endes Afrikas	Suidelike Afrika (1972)
	Satellite image of South Africa (basemap – portal for ArcGIS)

Then, a comparative analysis of the selected atlas maps was carried out by superimposing them on modern analogs and on the base map section of the servers of the geographic information system. This combination of data in comparison can provide more information when you analyze old maps. We can get an additional way to check by comparing with modern maps. Orthophotoplans can often be made in a different cartographic projection than the map under study. So we can get more map distortion. This is especially true for maps that show a very large area. This was done in order to determine and most clearly identify all the inaccuracies of the old maps in comparison with modern ones. To do this, use the spatial reference function of the raster at least 4 points [Heitzler, M., Hurni, 2020].

Using this method, of course, inaccuracies cannot be avoided, however, the presence of the most recognizable and characteristic objects on the compared maps can more accurately make a binding. This method using geographic information systems and remote sensing data provides a fairly visual approach to the study of old maps, when other more accurate procedures are not available [Dmitry a. Shcheglov, 2016].

### 3 Results And Discussion

Overlay and comparative analysis on the example of two maps that are part of the investigated atlas made it possible to assess the degree of their reliability. It was possible to identify that these maps have a fairly high accuracy of the description of the territory, but at the same time have a number of inaccuracies and distortions. A description and results of the comparative analysis are presented below.

#### 3.1 Comparative Analysis Of The Atlas Map Of Africa

This map of africa is made in a pseudo-cylindrical cartographic projection. To avoid large distortions, a modern political map was found, which was created in the same projection. It is worth noting that most modern maps use an azimuthal transverse projection to more accurately represent the african continent. Comparison with a modern analog will be more effective for studying really large areas. It is better suited for depicting the equatorial part of the planet. When superimposed, we can observe that, on the whole, the map compiled in the first half of the 19th century practically coincides with the modern one (figure 1).

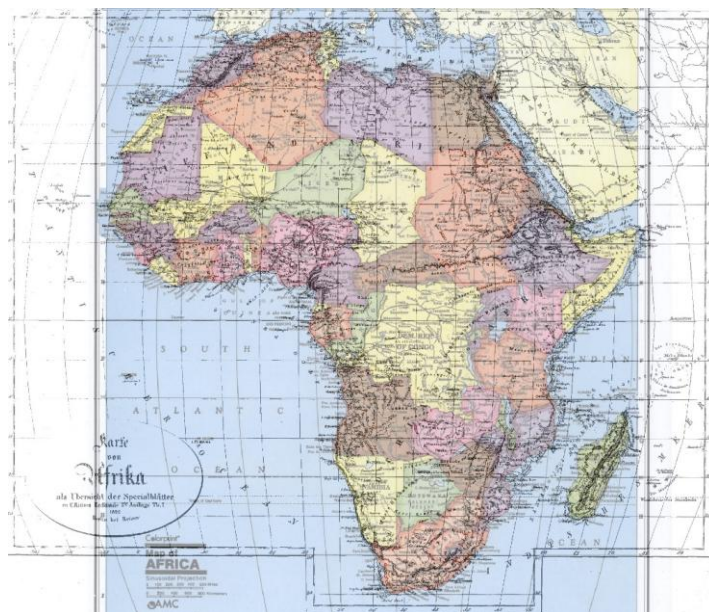


Fig 1. 19th century map overlay on a 21st century political map

However, there are a number of inaccuracies. The main differences can be seen along the northwestern coast of africa, right up to the gulf of guinea - a mismatch with the real border of the coastline and islands (figure 2). Also, one of the main inaccuracies is the image of lake nyasa - on the map of the sixteenth century it is located northeast of the true location (figure 3). A noteworthy detail is that the map does not contain some large

geographical features, such as lake victoria. This is due to the fact that it was discovered in 1858, that is, 27 years after the publication of this atlas [R. Finsterwalder / e. Hueber, ernst (1943): vermessungswesen und kartographie in afrika, berlin, pp. 272-273.]. At the time of the creation of this map, this site was one of the poorly studied due to inaccessibility.

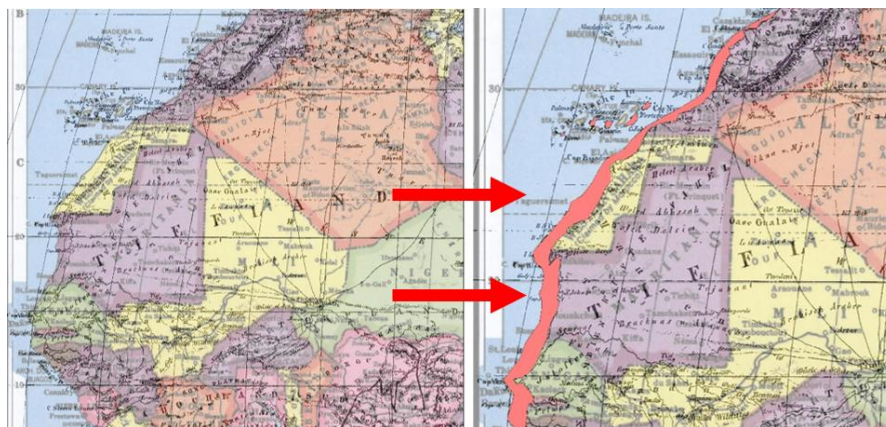


Fig 2. Inaccuracy of the north-west coast of africa (неточность северо-западного побережья африки)

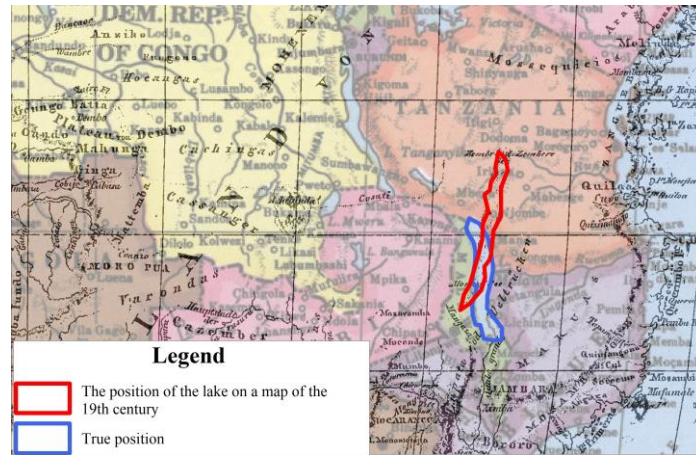


Fig 3. Location of lake nyasa on old and modern maps

A significant part of the map is quite accurate. The author of the map described in detail a large part of the coast of africa. The coast of the southern end of the continent, the areas adjacent to the coasts of the gulf of aden and the red sea, are made with a

very high level of detail (figure 4). As for the display of river networks on the continent, they are depicted quite accurately. For example, the author almost reliably showed the course of the Nile river.

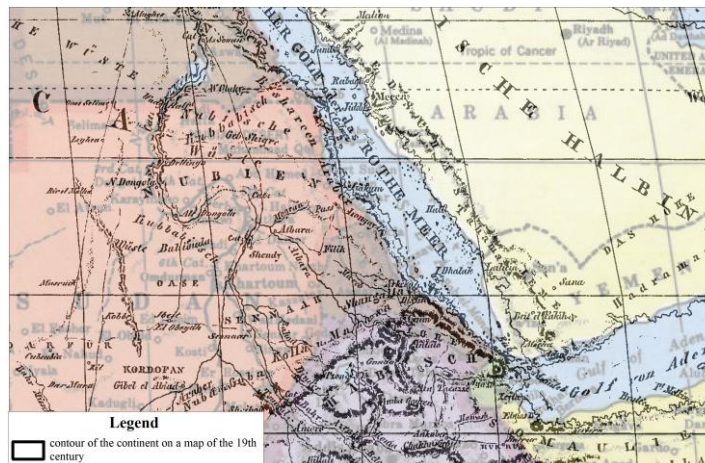


Fig 4. Map accuracy in the gulf of aden and the red sea

**3.2 Comparative Analysis Of The Atlas Map Of Southern Africa**

This map of south africa is made in secant conic projection. We can use the orthophotomap for comparison with old maps because it is quite appropriate and allows us to determine the map's accuracy. when superimposed on the base map section,

some inaccuracies are revealed. First of all, there is a mismatch with the western and eastern coastlines. However, at the same time, the author of the map was able to display in some detail the extreme southern part of the mainland (figure 5). When enlarging the scale of the orthomosaic, one can evaluate the accuracy of the image of the coast.







Fig 5. An atlas map overlay on a satellite image from arcgis basemap

When comparing the cartographic material of the 19th century with a modern physical map. Then there is an additional comparison of the sixteenth century's map with the modern physical one. We would like to note the uniformity of the overlay of the coastline, however, the image errors of the western and eastern

coasts are again confirmed. As for the display of relief elements, there are coincidences (figure 6). The author of the map of the sixteenth century was very able to show the terrain using the hatching method.

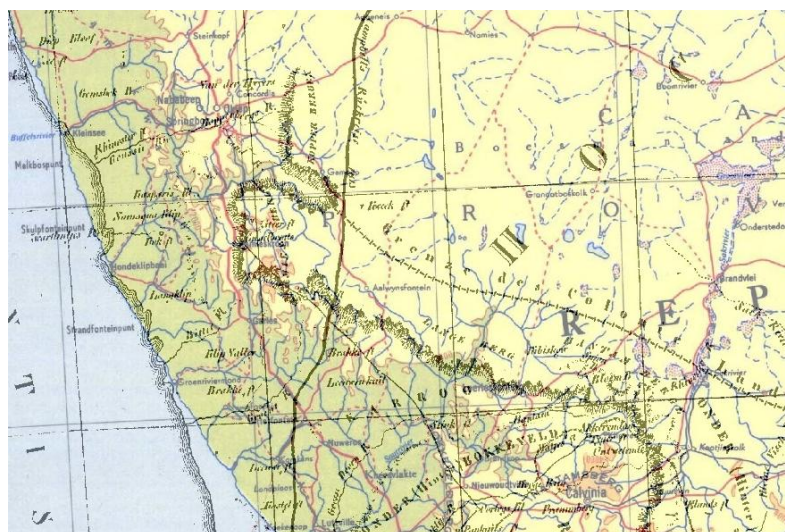
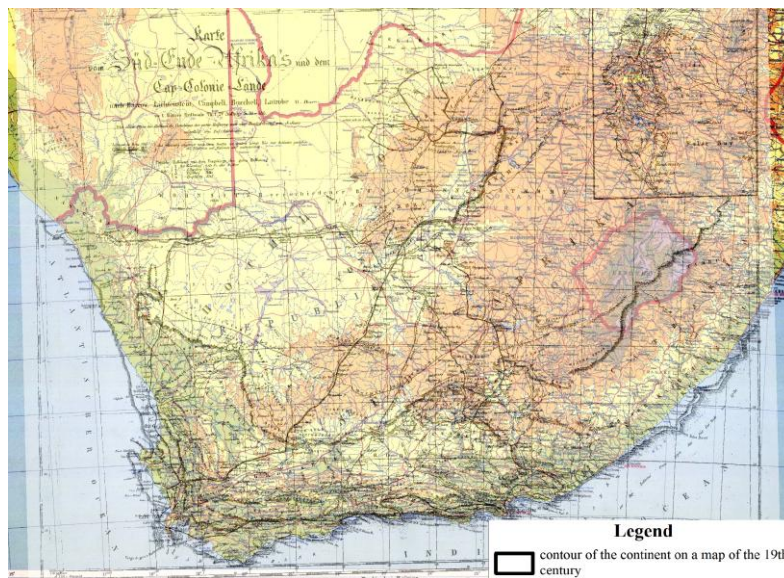


Fig 6. An atlas map overlay on a modern physical map

#### 4 Results

A comparative-analytical method for studying old maps using geographic information systems and remote sensing data gives the most obvious result, helps to identify which objects have the greatest distortions and which vice versa are depicted with high accuracy [Miraglia, m. 2019]. Usage of such satellite images of the surface, namely the similar orthophotomaps provided by arcgis servers, can significantly facilitate and make faster work on searching and downloading necessary data for remote sensing of the earth.

Many inaccuracies in the location of objects within the continent can be explained by their change over time, as well as the inaccessibility and difficult conditions for conducting field work. In general, coastal territories and islands have the greatest distortions on the maps (table 2).

Table 2. Simplified representation of object distortions on maps of the 19th-century atlas of africa

Objects	Distortion		
	High	Medium	Low
Coastline	High	Medium	Low
Islands	High	Medium	Low
Terrain elements	High	Medium	Low
River systems	High	Medium	Low

#### 5 Conclusions

This investigation allowed us to study and evaluate the degree of reliability of 19th century maps. Using two maps as an example, a comparative analysis was carried out using geographic information systems and remote sensing data. Once again, it should be noted that this method, in the absence of more accurate ones, can provide visual information and identify the features of mapping, identify inaccuracies. It is concluded that maps under study have a fairly high description accuracy, but at the same time have a number of inaccuracies and distortions. The analysis of geographical objects, including in tabular form, on their degree of distortion in comparison with modern maps is conducted.

In general, the combination of comparing modern maps and remote sensing data with old maps is extremely effective. Their application for the needs of old cartography studies is able to provide visual changes in territories and cartography itself over time.

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#### Literature:

- Arantes, I. (2016). Carl ritter: educator and geographer. *Geographia-uff*, 18(36), 207-212. Doi:10.22409/geographia2016.836.a13750
- Blanco, a., de bustamante, i., pascual-aguilar, j.a. Using old cartography for the inventory of a forgotten heritage: the hydraulic heritage of the community of madrid (2019) *science of the total environment*, 665, pp. 314-328.
- Cillis, g., statuto, d., picuno, p. Historical maps processed into a gis for the assessment of forest landscape dynamics (2019) *public recreation and landscape protection - with sense hand in hand... Conference proceeding*, pp. 180-184
- Dmitry a. Shcheglov, "the accuracy of ancient cartography reassessed: the longitude error in ptolemy's map," *isis* 107, no. 4 (december 2016): 687-706. <https://doi.org/10.1086/689763>
- I.j. Demhardt (2003):german contributions to the cartography of south west and east africa from mid 19th century to world war i. *Icc-2003 proceedings*, 10-16 august 2003, pp.893-907.
- I.j. Demhardt (2000): developing cartography from namaqua- and damaraland to namibia: milestones of south west african surveying and mapping, in: *die erde*, vol. 131, pp. 285-309 (here: pp. 293).
- Miraglia, m. Applications of the historical cartography and the geographical information technologies in the environmental history [aplicaciones de la cartografía histórica y las tecnologías de la información geográfica en la historia ambiental] (2019) *revista de historia regional*, 24 (1), pp. 24-41.
- Schenk, w. (2018). Carl ritter and his "geography of asia". *The beginnings of scientific geography in the early 19th century. Erde*, 149(4), 274-275.
- Heitzler, m., hurni, l.cartographic reconstruction of building footprints from historical maps: a study on the swiss siegfried map (2020) *transactions in gis*, 24 (2), pp. 442-461.
- R. Finsterwalder / e. Hueber, ernst (1943): *vermessungswesen und kartographie in afrika*, berlin,pp. 272-273.

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