COMPARATIVE ANALYSIS OF SPECIFIC DEFORMATIONS GEODETIC REFERENCE SYSTEMS IN ROMANIA

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***Abstract**: Based on the theories of Ptolemy emerge so far and Romania various systems cartographic projections: Stereographic 1930, Stereographic 1970 or Universal Transverse Mercator, which are used today. Each of these cartographic projection systems presents both advantages and disadvantages. Analyzing the deformations in the main cartographic projections in our country, using a generic program of transformation of geospatial coordinates from one CRS to another, we can obtain visually appropriate interpretations and make statistics, with the possibility of the percentage, the advantages of using one or the other.*

Based on the above-mentioned criterion, the scientific paper aims to present the implications from the point of view of the linear deformations, which each of these projections generates, as well as a comparative analysis between them, more suggestively, the advantages of cartographic representation in each case.

***Keywords:** cartographic projections, linear deformations, angular deformations*

1. Introduction

In general, the maps currently in existence for Romania are drawn using the following cartographic projection systems: Stereographic - 1930, Stereographic - 1970 or UTM (Universal Transversal Mercator). One of the basic criteria for adopting a cartographic projection for a given cadastral territory is that the relative linear deformation is as small as possible for that geographic area [1]. Analyzing the deformations in the main cartographic projections in our country, using a generic program of transformation of geospatial coordinates from one to another, we can obtain visually appropriate interpretations and make statistics, with the possibility of the percentage, the advantages of using one or the other.

Based on the above-mentioned criterion, the scientific paper aims to present the implications from the point of view of the linear deformations, which each of these projections generates, as well as a comparative analysis between them, more suggestively, the advantages of cartographic representation in each case, using coordinate transformation software PROJ.

2. Comparative analysis of specific deformations Geodetic Reference Systems in Romania

Coordinate operations in PROJ are divided into three groups: Projections, conversions and transformations. Projections are purely cartographic mappings of the sphere onto the plane. Technically projections are conversions (according to ISO standards), though in PROJ projections are distinguished from conversions. Conversions are coordinate operations that do not exert a change in reference frame. Operations that do exert a change in reference frame are called transformations. Transformations coordinate operation in which the two coordinate reference systems are based on different datums [2].

Each map projection has distinct properties, which are analyzed in PROJ by the following factors:

- *Linear deformation module on the meridian or parallel* is the ratio between the length of a linear segment in the plane and the same length on the ellipsoid. If this is equal to 1, the length of the meridians or the parallel is kept and thus the projection is equidistant;
- *Areolar deformation module* is the ratio of differential surface flat and ellipsoid. If this is equal to 1, the projection is equivalent;
- *Angular deformation module* is the maximum difference between an angle in the plane and the corresponding size on the ellipsoid. If this is equal to 0, the projection is consistent.

For all reference coordinate systems in Romania we will use the same contour of the country that we will download from the site open source: http://www.diva-gis.org/datadown (figure 1). After setting the general parameters of each projection using box *projection factors (figure 2)*, we can proceed to determine the three modules of deformation that we want to analyze. These are visible with the pseudo-color spectral palette chosen by the user.

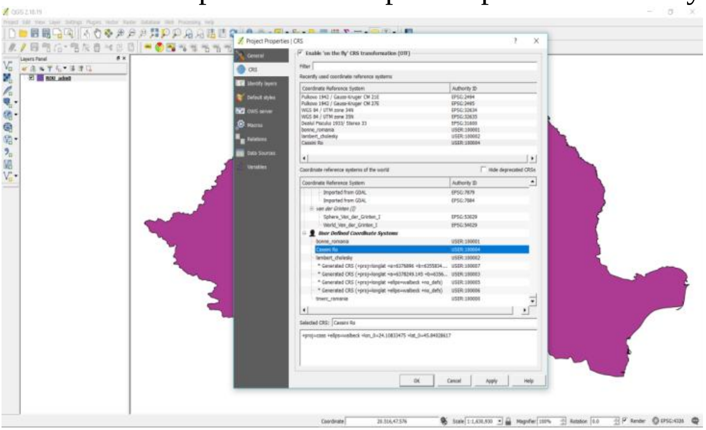

Fig. 1. Contour of the *României* country downloaded from the site: http://www.diva-gis.org/datadown

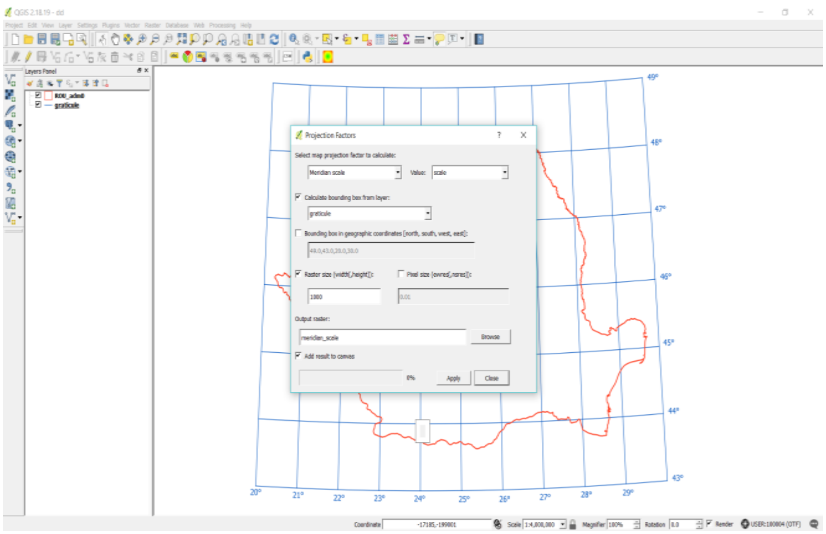

Fig. 2. Setting projection factors in PROJ

We will start with the *Linear Deformation Module* in the meridian direction that will be calculated for the projections: Stereographic 1930 and Stereographic 1970.

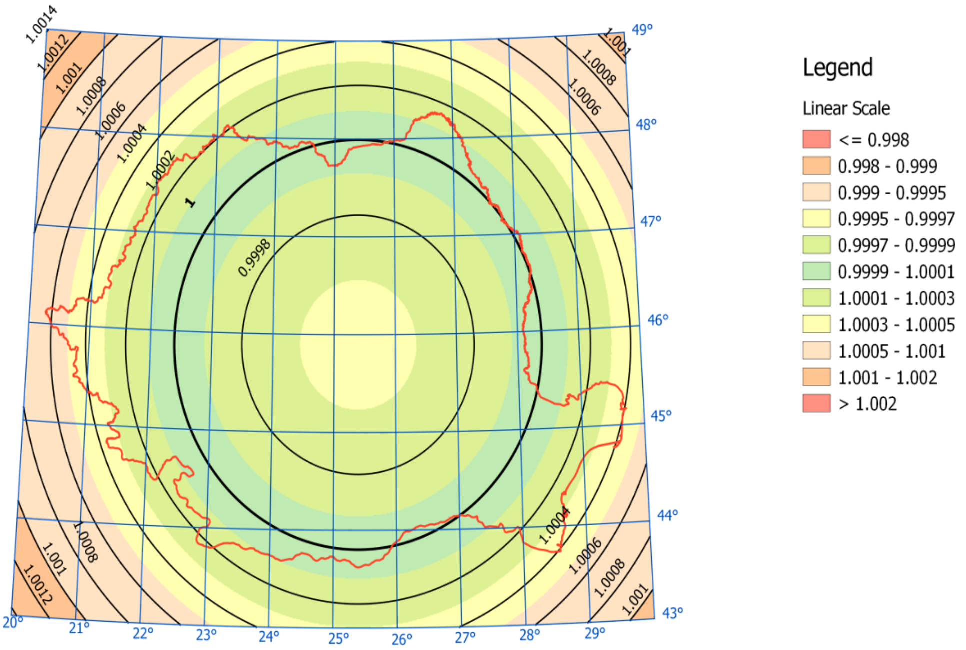

Fig. 3. Linear deformation map of the meridians in Stereographic Projection 1930(1933)

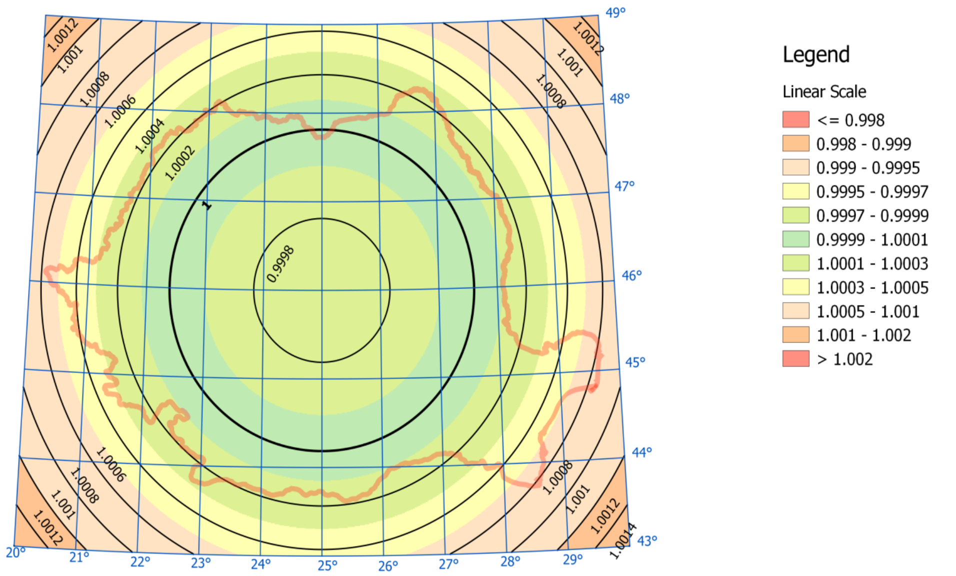

Fig. 4. Linear deformation map of the meridians in Stereographic Projection 1970

The minimum and maximum values for the two projections are as follows:

• For Stereographic Projection 1930: the minimum value is 0.999667 (-0.33m / km) and maximum around 1.0006 (+ 0.6m / km) in the westernmost point of Romania;

• For Stereographic Projection 1970: the minimum value is 0.99975 (-0.25m / km) and maximum around 1.0006 (+ 0.6m / km) in the westernmost point of Romania.

The angular deformation module will be analyzed for the two projections on the meridian. (figure 5 and 6).

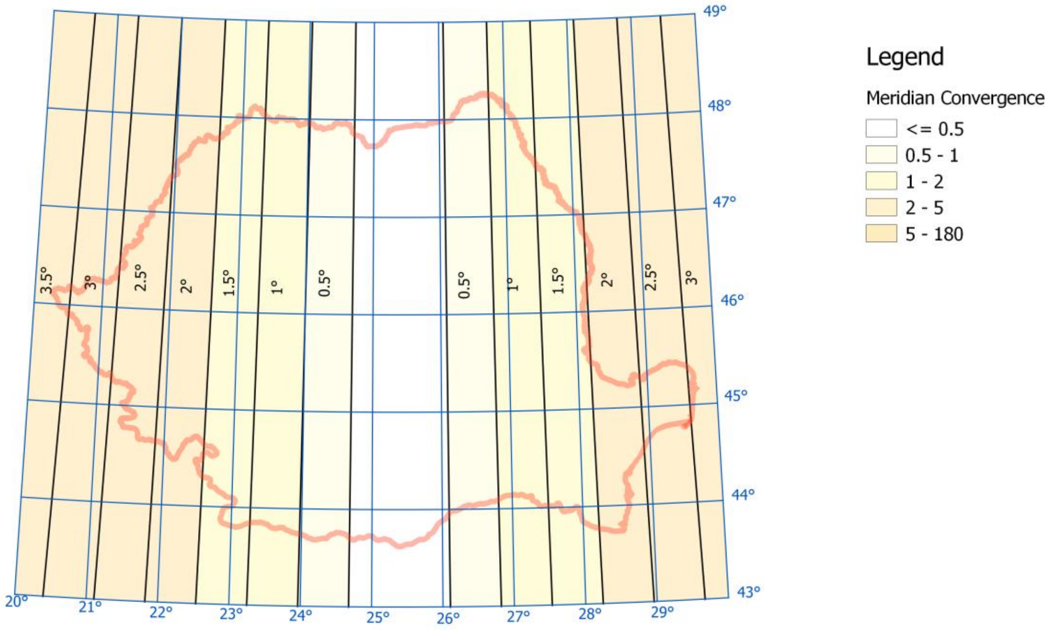

Fig. 5. Map of the meridian convergence angle in Stereographic Projection 1930(1933)

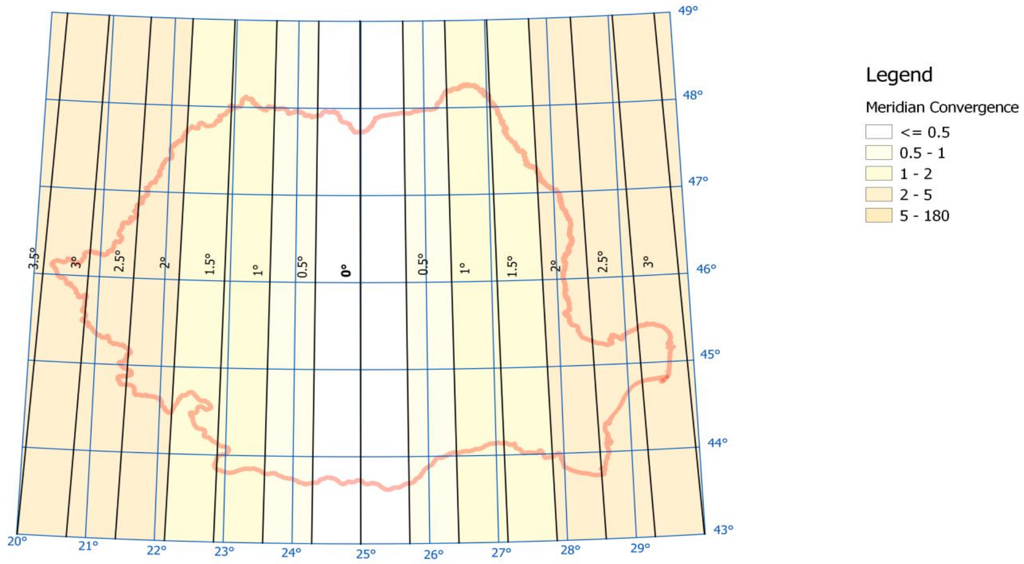

Fig. 6. Map of the meridian convergence angle in Stereographic Projection 1970

As you can see the angle of convergence of the meridians in the two Stereographic Projections has a maximum value of about 3.5 ° in the western part of Romania.

Since these two projections stereographic conform, they argue that the modulus of deformation areolar is the square of the modulus of deformation straight in the direction of the meridians, so that the distribution pattern of deformation areola is similar to the modulus of deformation of straight meridians only values squared, as can also be seen in figures 7 and 8.

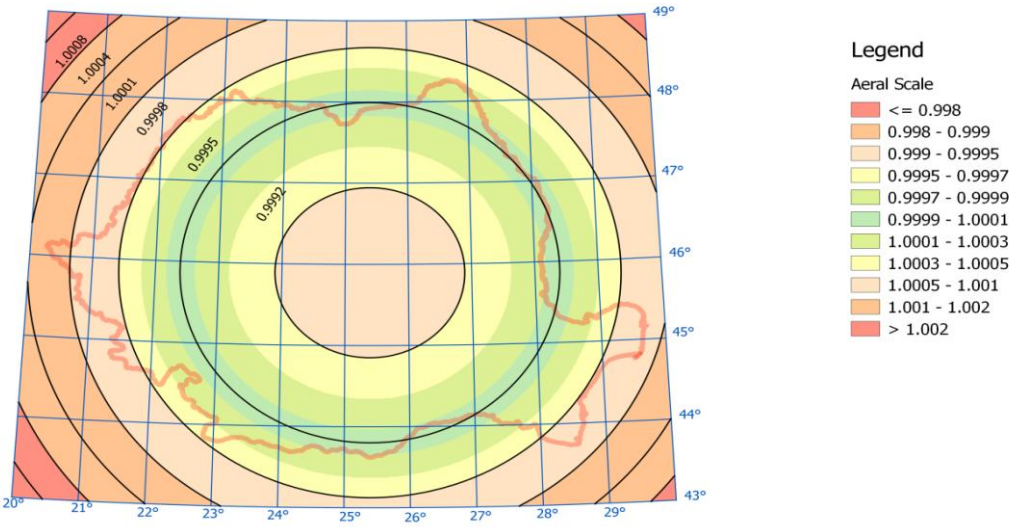

Fig. 7. Map areolar deformation module in Stereographic Projection 1930(1933)

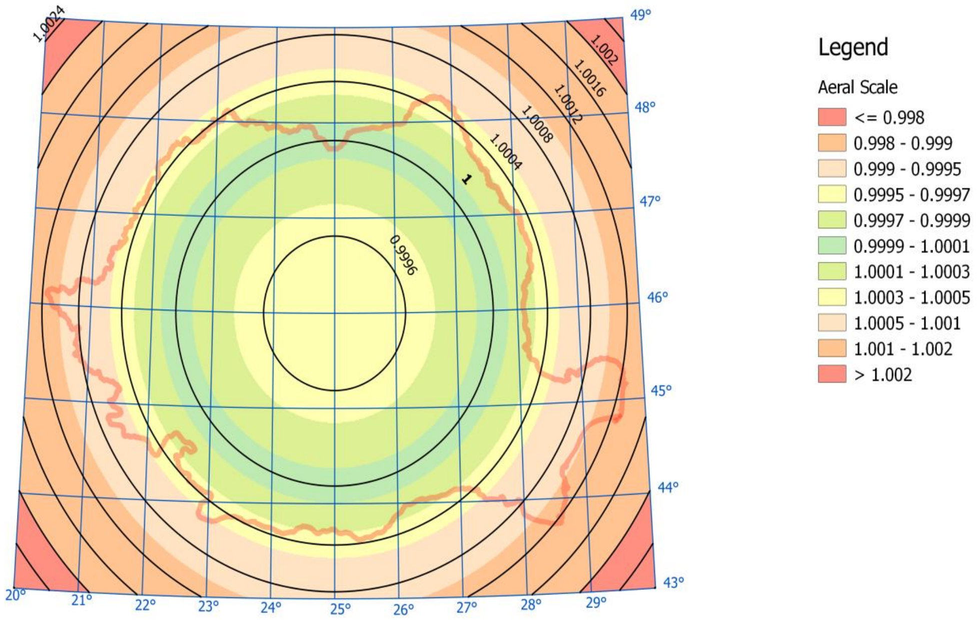

Fig. 8. Map areolar deformation module in Stereographic Projection 1970

Unlike the two stereographic projections, the UTM (Universal Transversal Mercator) projection divided the territory of Romania, Also according transverse cylindrical projection Gauss-Kruger, in two zones: the 34N area and the 35N area. In this case, we will have to analyze the three deformation modules: angle in the meridian direction, the meridian convergence angle and the areolar deformation module separately for each area, following the following steps:

- project ->project properties->CRS->WGS 84 / UNIVERSAL TRANSVERSALĂ MERCATOR zone 34N.
- project ->project properties->CRS->WGS 84 / UNIVERSAL TRANSVERSALĂ MERCATOR zone 35N.

In this projection we will calculate the distortions in relation to the geographical coordinates (north, south, west, east) as follows: for **zone 34**: 48.5,43.5,18,24, and for **zone 35**: 48.5,43.5,24.30 (figure 9).

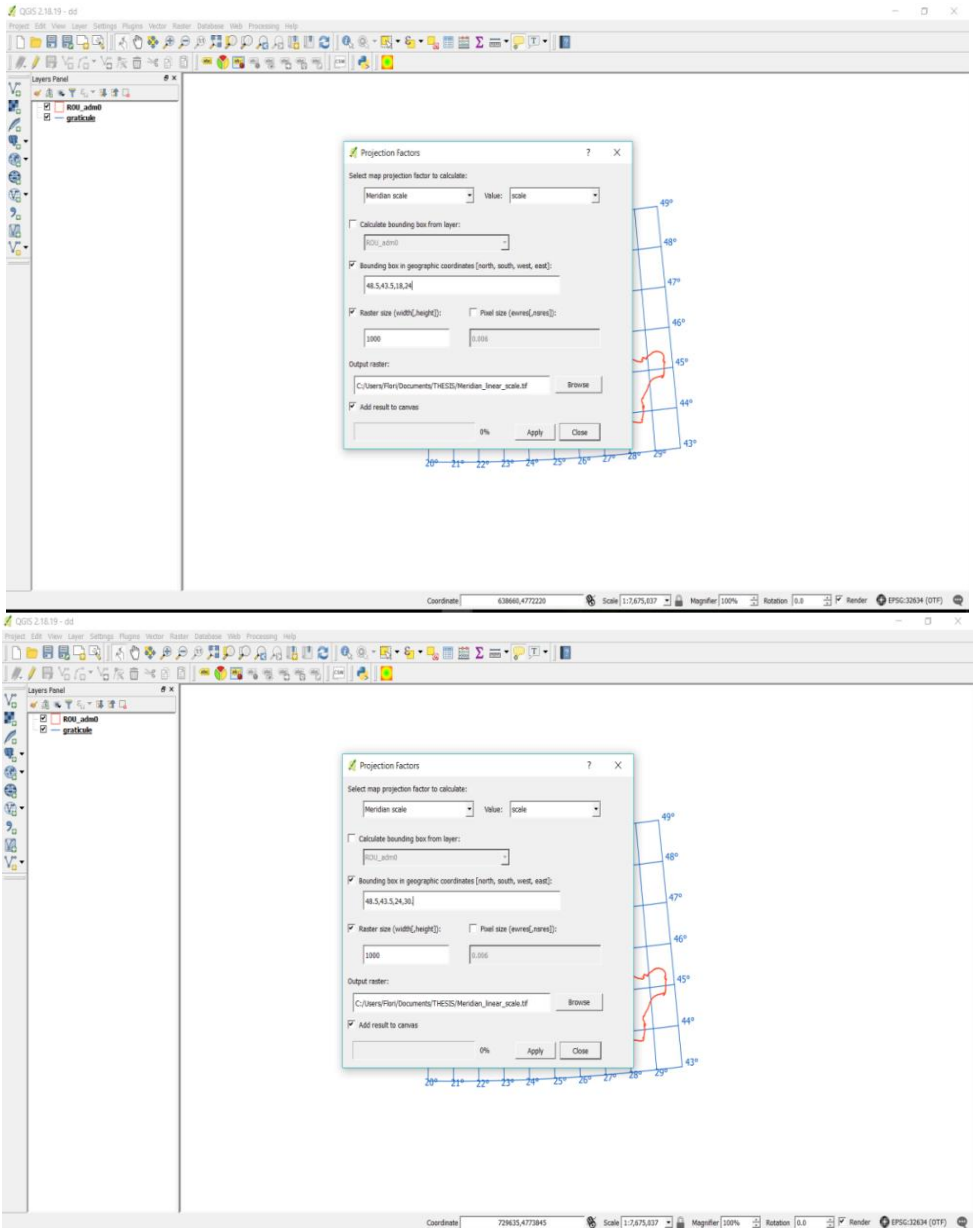

Fig. 9. UTM projection factor on the two areas

The UTM projection has negative linear distortions on the central meridian of -0,4m / km, equilibrating maximum linear distortion at the edges of the area, which for the medium-sized latitudes in Romania does not reach the maximum which is only touched by the Equator, but it is little more than 0.2m / km (figure 10).

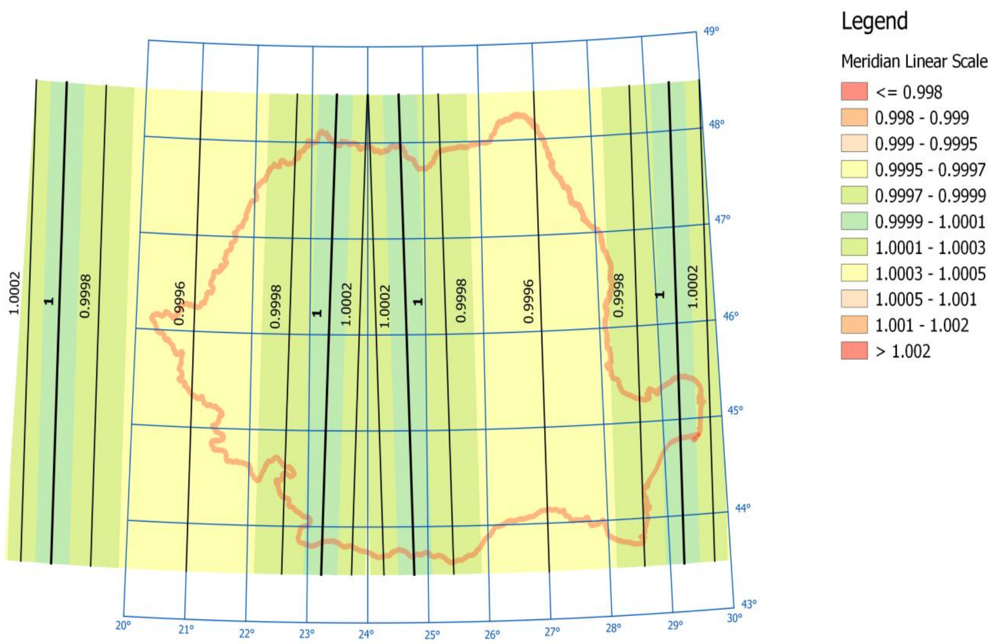

Fig.10. Linear deformation map of the meridians in the projection UTM

Because of the two areas, the meridian convergence in the MERCATOR TRANSVERSAL UNIVERSAL projection, for Romania is smaller than in the other projections analyzed here and reaches a maximum value of approximately 2.5 ° (figure 11).

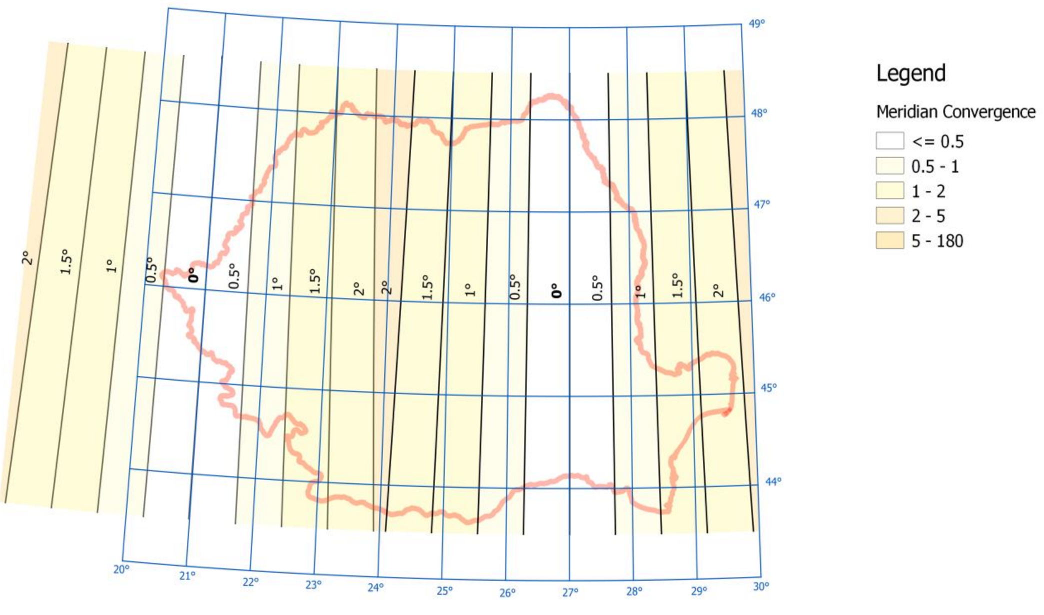

Fig.11. Map of the meridian convergence angle in the projection UTM

Since the UTM projection is conforming, it claims that the deformation modulus is the square of the linear deformation module in the meridian direction, so that the distribution pattern of the deformation is similar to the linear deformation module of the meridians only with square values (figure 11).

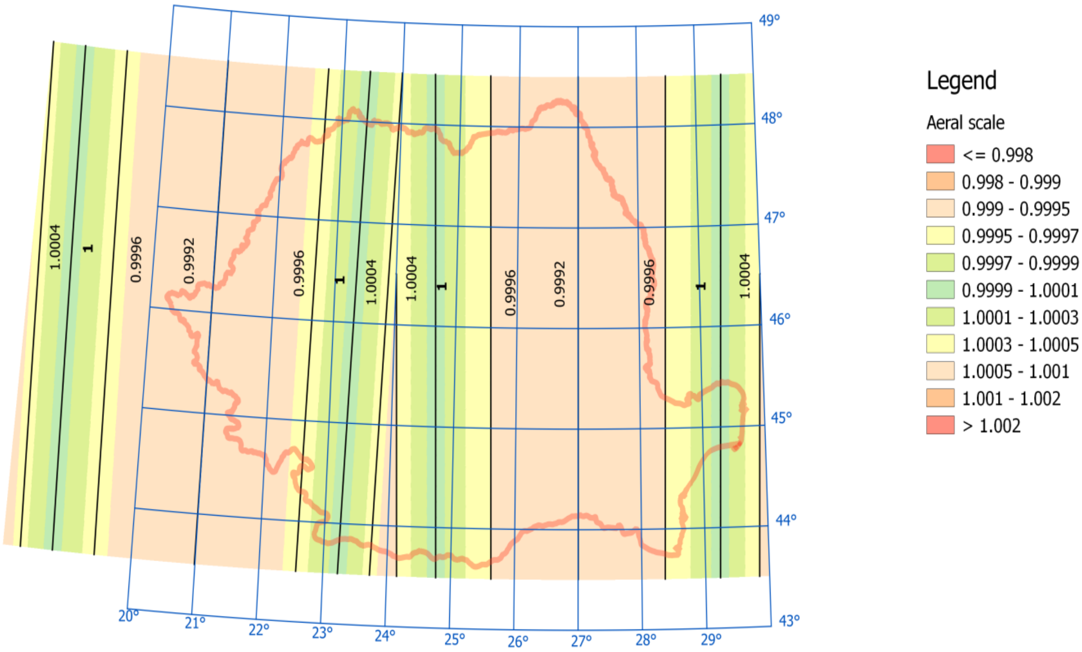

Fig.11. Map of the areolar deformation module in the projection UTM

For an analysis of the linear deformation module on parallels for each projection in part, the parameters for each area on the territory of Romania should be defined. One of the basic criteria for adopting a cartographic projection for a particular administrative territory is that the relative linear deformation is as small as possible for that geographic area.

3. Conclusions

By analyzing the deformation modules: linear, angular and areolar, their thematic maps can be made for the main cartographic projections used in our country, as well as comparison maps, and can obtain a visual interpretation of the favored areas, with the possibility to directly extract numeric values for points of interest on the territory of Romania.

4. References

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4. http://www.diva-gis.org/datadown