*ISSN: 1857-9000, EISSN: 1857-9019*

DOI: 10.5281/zenodo.17957598

# Assessment of the Kosovo National Coordinate System (KOSOVAREF01) and Evaluation of Alternative Systems

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**Keywords:** CRS, Kosova, Kosovaref01, map projections

**Abstract:**

Coordinate Reference Systems (CRSs) provide the mathematical framework for defining the locations of spatial entities within a reference frame, which includes a geodetic datum and, in many cases, a map projection and additional parameters. In practice, the term Spatial Reference System (SRS) is often used interchangeably with CRS. Each CRS is linked to a local or global datum and defines a specific domain of validity within which the relationship between coordinates and physical locations can be reliably maintained. National mapping agencies are responsible for selecting appropriate map projections and their corresponding geodetic reference systems.

The Republic of Kosova, located in Southeast Europe, adopted its national CRS, KOSOVAREF01, in 2001, based on the ETRS89 geodetic datum. Prior to this, Kosova used the coordinate system known as FryRef30 (internationally recognized as MGI/Balkan Zone 7), established in 1924 during its inclusion in the former Yugoslav Federation. The principal differences between the old and new systems lie in their respective datums and ellipsoids. When defining the parameters of KOSOVAREF01 between 1999 and 2001, the reference map projection and parameters were derived from FryRef30, obviously without sufficient scientific analysis. This resulted in systematic negative deformations across the entire territory of Kosova. The distortion values range from –10 cm/km along the central meridian to –2.1 cm/km at the westernmost point (Figure 1), with a mean distortion of –8.7 cm/km. Consequently, horizontal distances of 1 km measured on the topographic surface are reduced on the map by an average of –22.13 cm/km, with values ranging from –50.25 to –12.86 cm/km (Figure 2).

Although KOSOVAREF01 was introduced in 2001, it was not officially registered in the EPSG database until April 2019, when change request EPSG 2019.042 was accepted, assigning nine EPSG codes to Kosova's national CRS.

To evaluate alternative projections suitable for Kosova's territory, several CRS configurations were tested. The Gauss–Krüger projection with scale factors 0.99996 and 0.999967, as well as a tangential variant without negative deformations, were analyzed. With a scale factor of 0.99996, deformations range from –4 to +3.9 cm/km, with a mean of 2.93 cm/km over the national territory and 3.06 cm/km in urban areas. The variant with a scale factor of 0.999967 produces deformations between –3.3 and +4.6 cm/km, with a mean of 2.46 cm/km overall and in cities. The tangential case yields improved uniformity, with deformations between 0 and +7.9 cm/km, and mean values of 1.3 cm/km across the country and 0.96 cm/km in cities.

In the stereographic tangential projection, all distortions are positive, ranging from 0 to +4.18 cm/km, with mean values of 1.17 cm/km for the national area and 0.9 cm/km in cities. Two extended variants were also tested, using negative central deformations of –2.1 cm/km (scale factor 0.999979) and –1.9 cm/km (scale factor 0.999981). The first yielded deformation intervals of –2.1 to +2.08 cm/km, with mean values of 1.08 cm/km nationwide and 1.21 cm/km in cities, while the second resulted in –1.9 to +2.28 cm/km, with averages of 0.94 cm/km and 1.07 cm/km, respectively.

In the Lambert Conformal Conic projection, the tangential case produced deformations between 0 and +7.69 cm/km, with mean values of 1.15 cm/km across the country and 0.9 cm/km in cities. Introducing a negative central deformation of –3.8 cm/km (scale factor 0.999962) yielded deformation intervals from –3.8 to +3.89 cm/km, with mean values of 2.85 cm/km nationally and 2.95 cm/km in cities.

Because of the relatively small area of Kosova, the UTM projection introduces substantial distortions, ranging between –32.11 and –40 cm/km, with mean values of 38.7 cm/km nationwide and 39.04 cm/km in cities.

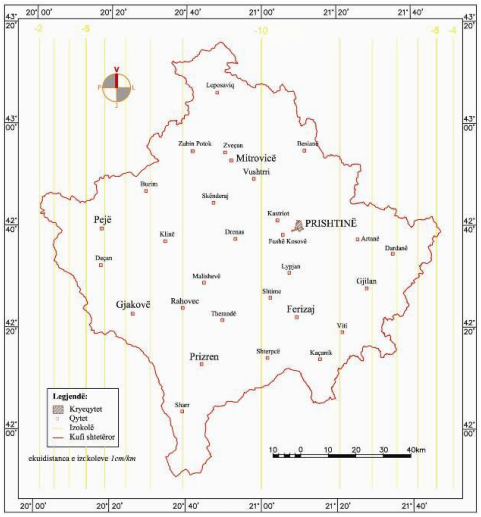


*Figure 1. Map deformations in KOSOVAREF01.*

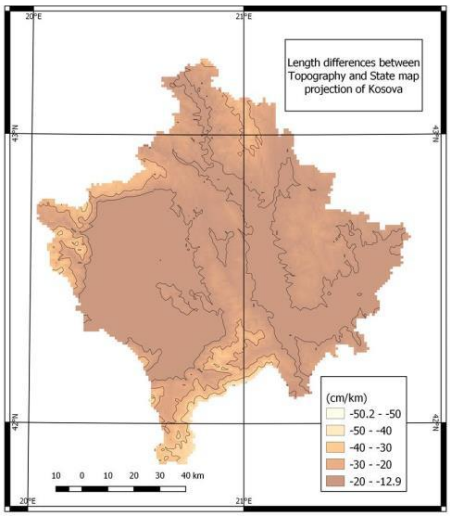


*Figure 2. Length differences between topography and map projection in KOSOVAREF01*

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