Current Conditions, Opportunities and Deficiencies of Using State Coordinate Reference System of North Macedonia From International EPSG and PROJ Databases

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Abstract:

Coordinate reference systems (CRS) represents the mathematical model for location defining of spatial entities within the particular referent frame, which contain geodetic datum, and may contain map projection as well additional parameters. Coordinate reference systems are defined by the OGC (Open Geospatial Consortium) as simple feature access using WKT (well-known text) representation of coordinate reference systems, and support has been implemented by several standards-based geographic information systems by referring to using EPSG (European Petroleum Survey Group) codes defined by the International Association of Oil and Gas Producers (IAOGP).

As part of former Yugoslavia, from 30's of last century, the coordinate reference system that is internationally recognized as "MGI / Balkans zone 7" (EPSG 6316) is in "official use" as State Coordinate Reference System of the Republic of North Macedonia (RNM). It is the legal and technical base for all official spatial data in North Macedonia, based on the provisions of the Law for Real Estate Cadastre.

In international public EPSG registry of geodetic datums, spatial reference systems, Earth ellipsoids, coordinate transformations and related units of measurement, CRS for RNM area is recognizable within 4 EPSG codes 6204, 6316, 8679, and 9945. First code EPSG 6204 represents current state CRS for the entire country area, based on current law, however unfortunately this CRS is official in letter by the law, but it is not in real use for developing the official spatial data published in geoportal of Agency for Real Estate Cadastre (AREC) and NSDI geoportal of RNM. The second code EPSG 6316 is defined to be used for 5 countries of former Yugoslavia that covers area between 19.5°E up to 22.5°E longitude, which does not correspond with the practical and official usage of CRS for working with spatial data in RNM and CRS law definition in RNM. Third code EPSG 8679 has never been used in RNM, which covers eastern part of RNM and Serbia beginning from 22.5°E. Last code EPSG 9945 is truncated nonformal state CRS that is used by AREC in RNM for developing formal spatial data for many decades, that was internationally recognized and defined on 03 March 2022 with change request ID code 2022.009.

By change request with ID 2022.009, on 18 March 2022 usage area of CRS with EPSG 6316 was divided in two extends: first with code 1711 that cover areas of Kosovo, Montenegro, Bosnia and Hercegovina, and Serbia between 19.5°E up to 22.5°E longitude (figure 1), and second one with usage extend code 1148 that covers entire area of North Macedonia (figure 2).

Such dividing area extend of EPSG 6316 in two parts, resulted with excluding area of North Macedonia while using EPSG CRSs' in GIS software, because software by default detects first area extend of EPSG (in this case extend 1711), which means that automatically it excludes (in this case extend 1148) the area of North Macedonia (figure 3) as second one. Due to such excluding, all specific parameters of CRS for second extend area are not able to be used during processing geospatial data. One of main crucial problems is datum transformation between CRS of RNM and other CRSs' with different geodetic datum. During the conference presentation, many examples will be given that prove differences up to 10m during transformation coordinates between CRS in EPSG 6316 to other CRSs' in WGS84 geodetic datum (figure 4).

Next step toward elimination of problems with usage of CRS's for North Macedonian spatial data, is defining single default datum transformation for three CRS's (6204, 6316 and 9945), or instead 6316 to create new one with the extend 1148 for North Macedonia, based on EPSG 6206 for datum transformation between MGI 1901 and WGS84. This is very important and necessary for GIS users in RNM, because currently overlapping with open data such google map etc., is

with very low accuracy. Intention of this research is to develop model for simple and easier usage of CRS's by users in North Macedonia in a case when they overlap official national data with data developed and coming from other sources based on WGS84 datum.

In order to avoid such problems, the "default" datum transformation parameters of EPSG 6316 (+towgs84=682,-203,480,0,0,0,0), should be changed with the transformation parameters defined in EPSG 6206, with the PROJ string definition as in addition: (+proj=tmerc +lat_0=0 +lon_0=21 +k=0.9999 +x_0=7500000 +y_0=0 +ellps=bessel +towgs84=521.748,229.489,590.921,4.029,4.488,-15.521,-9.78 +units=m +no_defs). In this case, for datum transformation to WGS84 for three CRS's of North Macedonia (EPSG 6316 or new one, EPSG 6204, and EPSG 9945), EPSG 6206 should be set as primary/default datum transformation from MGI 1901 to WGS84.

CRS	PROJ STRING (*proposed*)	Datim transformation EPSG code
EPSG 6204	+proj=tmerc +lat_0=0 +lon_0=21 +k=0.9999 +x_0=500000 +y_0=0 +ellps=bessel +towgs84=521.748,229.489,590.921,4.029,4.488,-15.521,-9.78 +units=m +no_defs	6206
EPSG 6316 (or new one)	+proj=tmerc +lat_0=0 +lon_0=21 +k=0.9999 +x_0=7500000 +y_0=0 +ellps=bessel +towgs84=521.748,229.489,590.921,4.029,4.488,-15.521,-9.78 +units=m +no_defs	6206
EPSG 9945	+proj=tmerc +lat_0=0 +lon_0=21 +k=0.9999 +x_0=500000 +y_0=-4000000 +ellps=bessel +towgs84=521.748,229.489,590.921,4.029,4.488,-15.521,-9.78 +units=m +no_defs	6206

As another initiative toward solving such issue of CRSs' with more than one extension such as EPSG 6316 with area extends 1711 and 1148, request for change have been submitted to Proj.org with code #3246 in order to define specific code for EPSG 6316 with second extension 1148 that cover area of North Macedonia. This case can be used as model how to generate alternative way for separate using of all area extensions in a case when CRS use two or more area extensions in its definition in EPSG registry of CRSs' in other cases also. This **resulted with two changes in PROJ: 3588 which enable code using PROJ API to retrieve multiple extents when there are**, so with that software should have the possibility to better use the metadata of EPSG:6316, **as well as 3587 which enable PROJ not to report a +towgs84 string for EPSG:6316 since there are multiple candidates**, so a single good one can't be defined within current version.

Until today, upper issues in a case of North Macedonia and CRS with EPSG 6316 have not been solved. Wider users of GIS software are not able to overlap geospatial data developed by AREC in EPSG 6316 with other geospatial data developed in different geodetic datums, because of horizontal distortions up to 10m (figure 4)!

During conference presentation in ICACI 2023 (https://icc2023.org), model for solving of such problem will be given from academic perspective, which have to be later used and implemented by AREC as NMO (National Mapping Organization) of North Macedonia in the EPSG registry and PROJ databases. The newest initiative for changes in QGIS software with code #53577 for adapting CRS with multiply extends will be presented in conference also!

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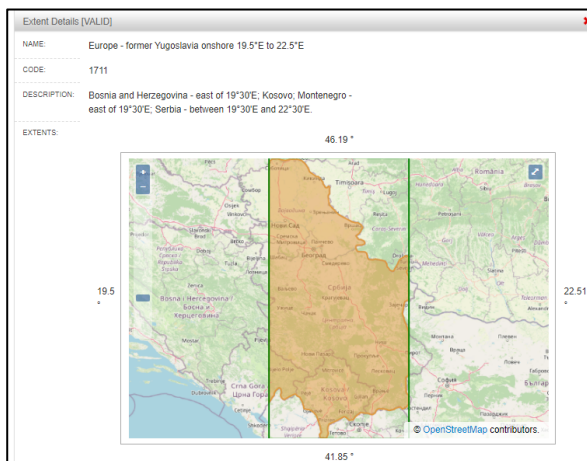
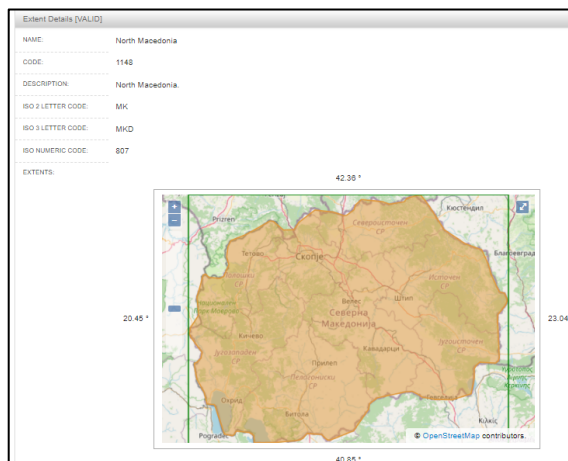Figure 1. EPSG 6316 with area extend 1711

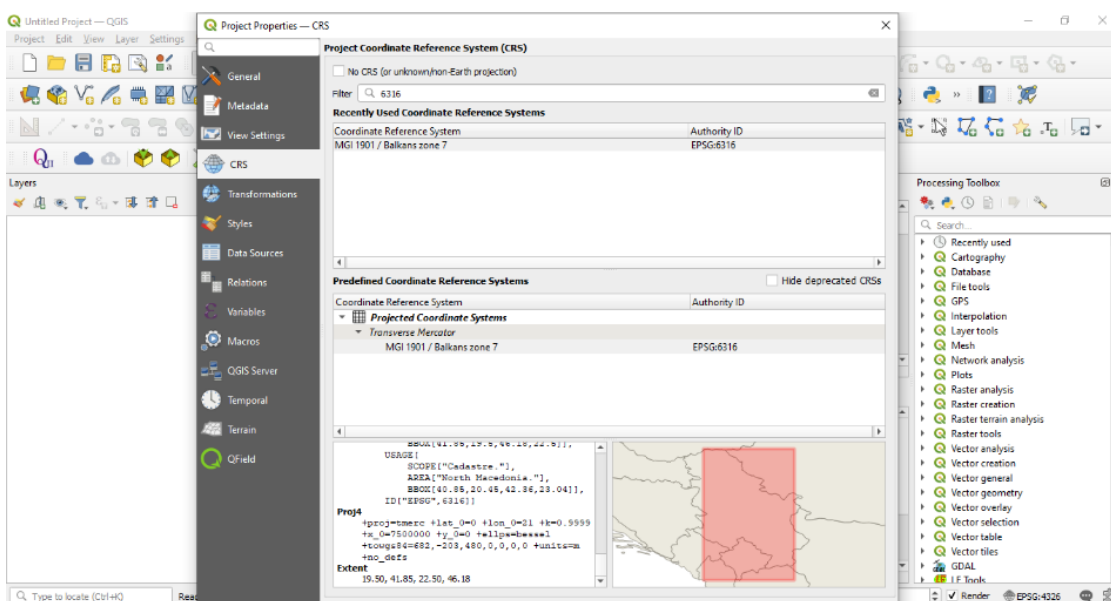Figure 2. EPSG 6316 with area extend 1148

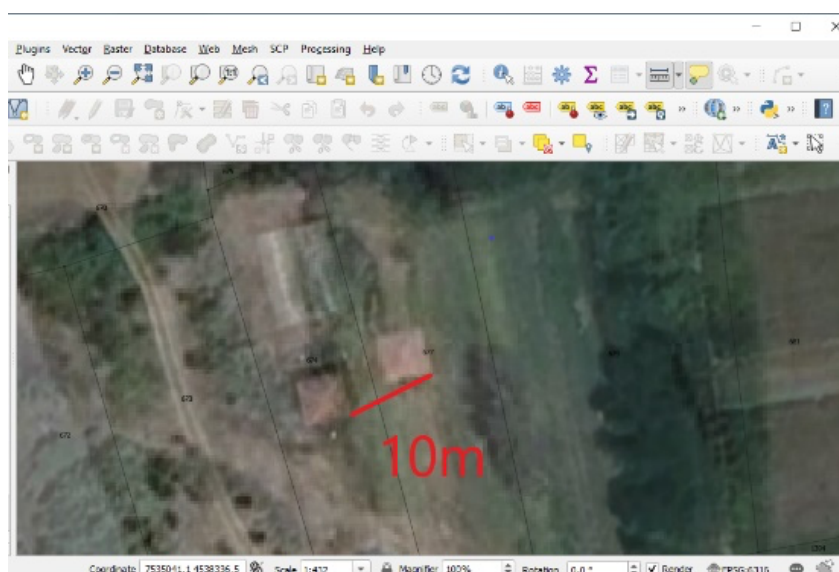Figure 3. Extend of EPSG6316 while using in QGIS

Figure 4. Distortions in a case of transformation between EPSG 6316 to EPSG 32634