FIG 2018 ISTANBUL

XXVI FIG CONGRESS

6–11 May 2018, İstanbul

Presented at the FIG Congress 2018
May 6-11, 2018 in Istanbul, Turkey

Study of length differences from topography to map projection within the state coordinate systems for some countries on the Balkan Peninsula

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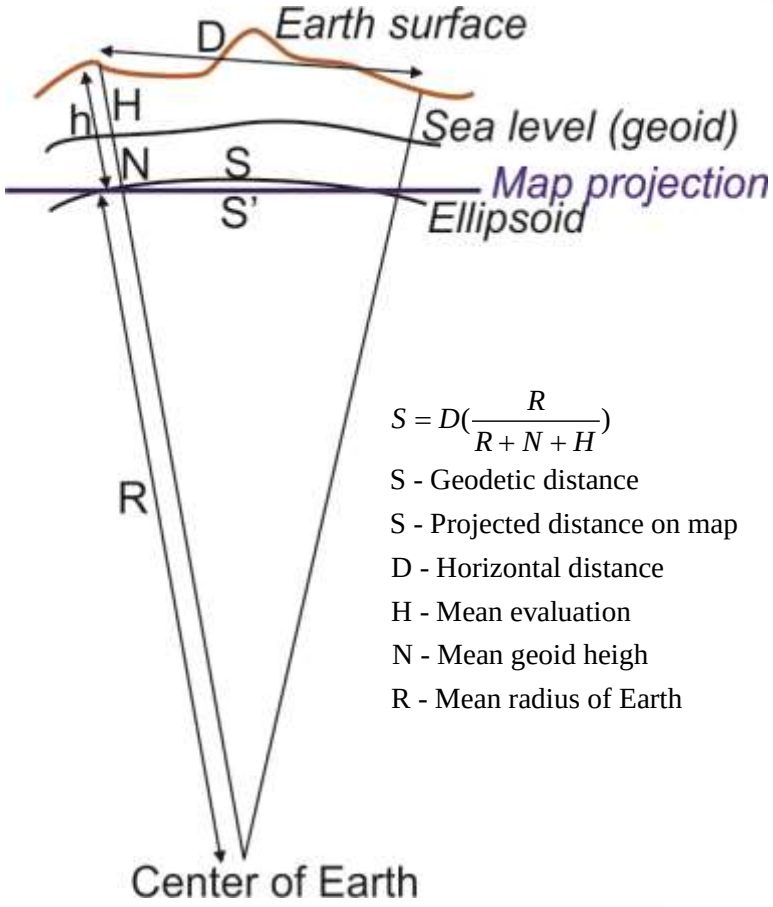
Preface

- Process of *length approximations from topography up to map projection through the see level (geoid) and the referent ellipsoid*
- Criteria for most appropriate map projection for state plan coordinate system - *distortions*
- Meaning of Scale factor and Elevation factor
- Distortions of map projection vs. length differences between topography and map projection



$$S = D(\frac{R}{R+N+H})$$

S - Geodetic distance
S - Projected distance on map
D - Horizontal distance
H - Mean evaluation
N - Mean geoid heigh
R - Mean radius of Earth

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Research objectives

- Calculation of successive reductions/projections between Earth surface, geoid, ellipsoid, and map projection.
- Valuation of the methodology for most appropriate state map projection, by comparing state map projection distortions with differences between the horizontal length on earth surface and on a state map projection.
- Developing GIS database for successive reductions/projections between Earth surface, geoid, ellipsoid, and map projection aimed for practical usage open data.

Concept of the test model

- Criteria for appropriateness of official state coordinate system:
  - largest length differences between the topography and its map projection should reach the same values with opposite prefixes,
  - the mean length differences between the topography and the map projection should have values nearby zero, and
  - the dispersion of negative and positive values in lengths' differences between topography and map projection have to be uniform
- Analyzed values:
  - mean length' differences in 1km on a grid with 1km resolution,
  - range of the length' differences,
  - maximum and minimum length difference values, and
  - areas with positive, negative or zero length differences.

Data sets for the analyzed territory

- Territory: Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Kosova, FYRo Macedonia and Montenegro.
- Point vector grid with 1km distance between points – 328,446 points with
  - ✓Elevation
  - ✓Geoid height
  - ✓Geographical and Cartesian coordinates
- Source data: Global Map, GADM, ASTER GDEM, SRTM, EUDEM, EGM08.
- CRS: Official State plan coordinate systems of seven countries.

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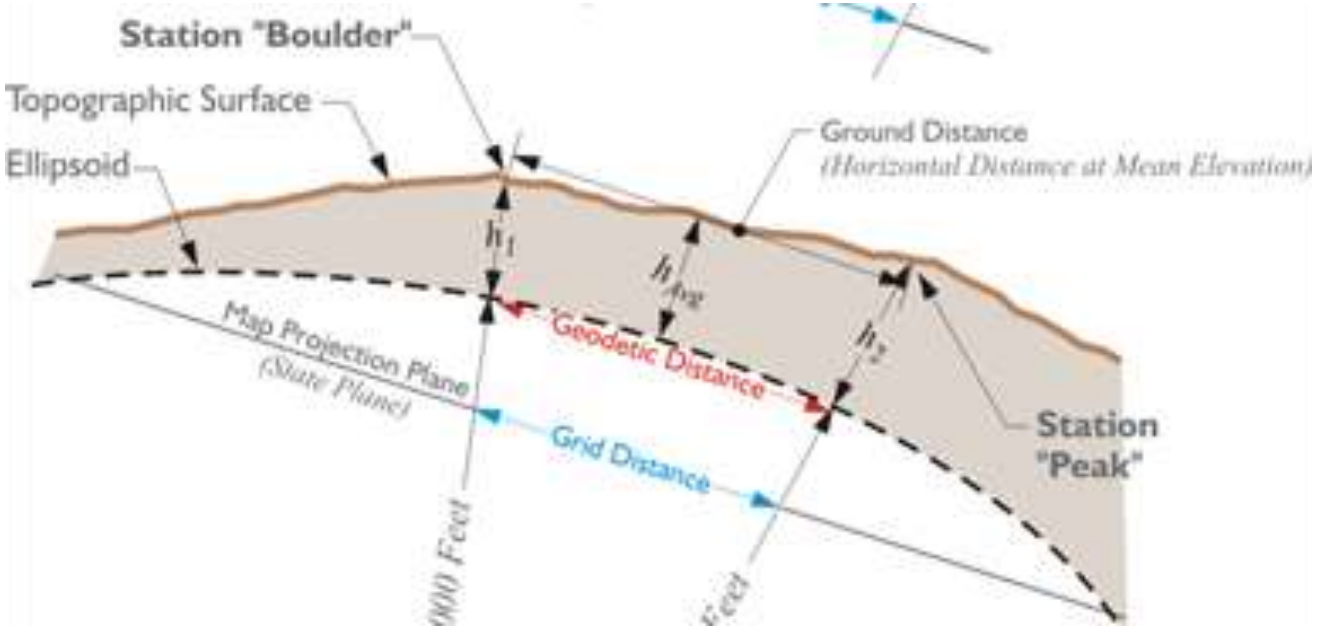
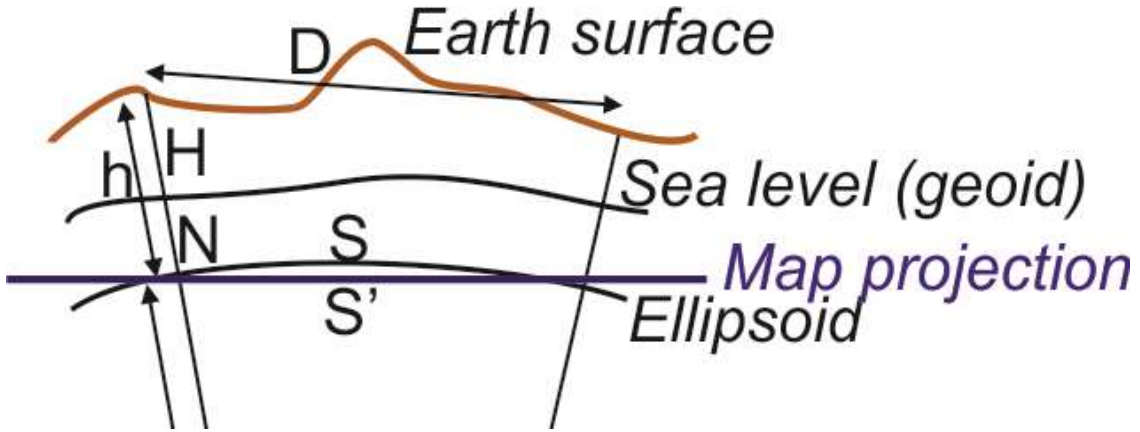
General consideration of relations between the Topography, Geoid model, Earth ellipsoid and Map projection



(Sickle and Dutton, 2017)



Distortions of the map projection can not be considered as main criteria for defining the most appropriate map projection for the state plan coordinate system!

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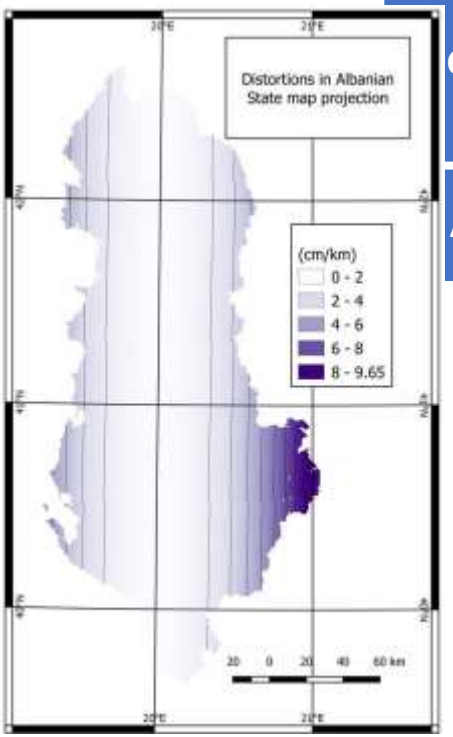
Calculated values in test models

- Length difference of 1km between topography and see level (geoid);
- Length difference of 1km between see level (geoid) and referent ellipsoid;
- Length difference of 1km between referent ellipsoid and state map projection;
- Length difference of 1km between topography and referent ellipsoid; and
- Length difference of 1km between topography and state map projection.

Calculations within the state coordinate system of ALBANIA



Country	Coordinate zones	Points of test model	Distortions between ellipsoid and map projection		Length differences between topography and map projection	
			Average	Range	Average	Range
Albania	1 zone	28303	1.22cm/km	0 to 9.65cm/km	-10.28cm/km	-39.97 to 3.77cm/km

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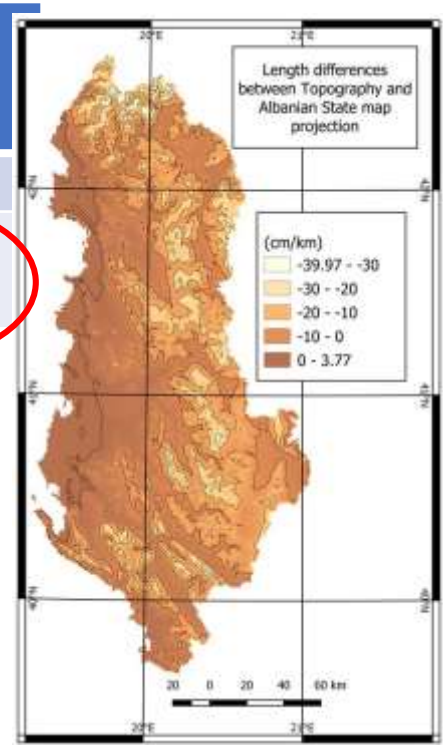
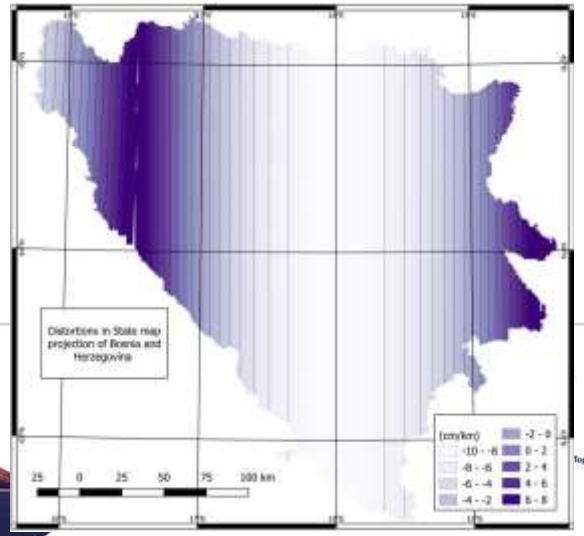
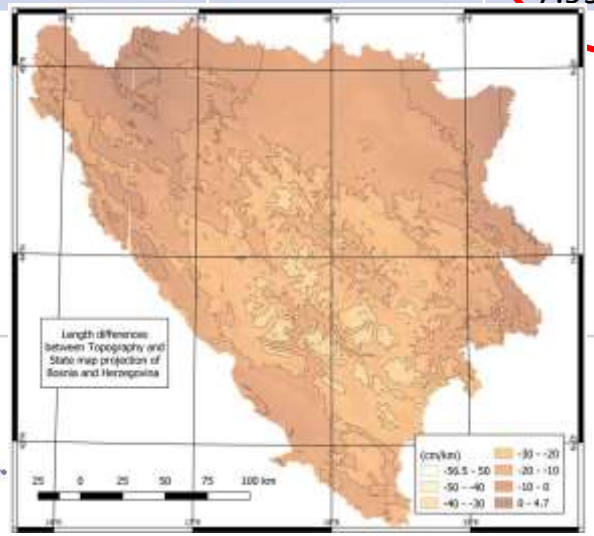


Calculations within the state coordinate system of BOSNIA and HERZEGOVINA

Country	Coordinate zones	Points of test model	Distortions between ellipsoid and map projection		Length differences between topography and map projection	
			Average	Range	Average	Range
Bosnia and Herzegovina	Zone 5	4596	1.47cm/km	-5.845 to 7.75cm/km	-8.65 cm/km	-27.29 to 4.68cm/km
	Zone 6	46471	-5.64cm/km	-10 to 7.99cm/km	-17.28cm/km	-56.49 to 4.43cm/km
	Zone 7	130	6.88cm/km	4.86 to 7.99cm/km	-2.27cm/km	-9.86 to 3.67cm/km
	Whole country	51197	-4.97cm/km	-10 to 7.99cm/km	-16.46cm/km	-56.49 to 4.68cm/km





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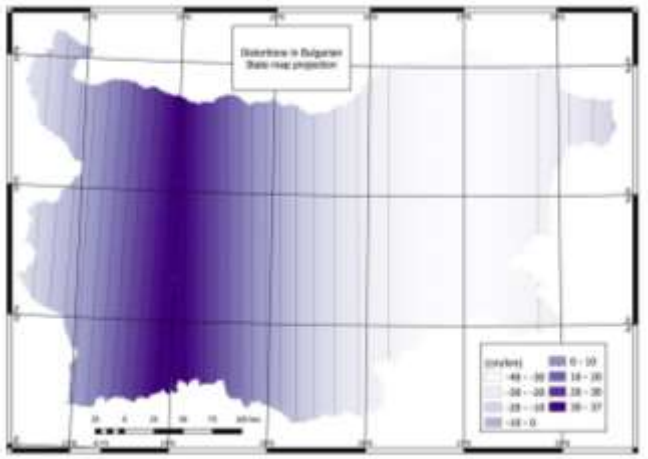
Calculations within the state coordinate system of BULGARIA

Country	Coordinate zones	Points of test model	Distortions between ellipsoid and map projection		Length differences between topography and map projection	
			Average	Range	Average	Range
Bulgaria	UTM 34N	30184	4.88cm/km	-25.07 to 37cm/km	-7.62cm/km	-55.06 to 29.9cm/km
	UTM 35N	80763	-20.09cm/km	-40 to 36.62cm/km	-26.53cm/km	-55.02 to 30.28cm/km
	Whole country	110947	-13.3cm/km	-40 to 37cm/km	-21.39cm/km	-55.06 to 30.28cm/km



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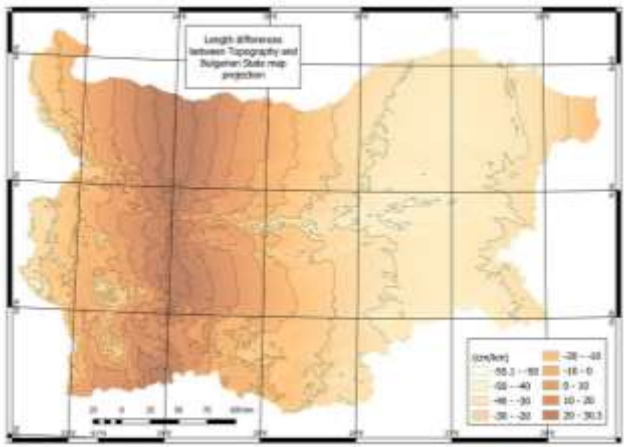

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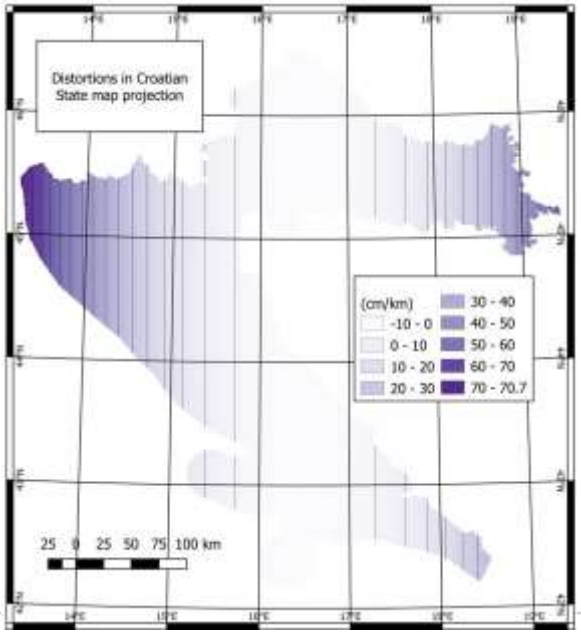
Calculations within the state coordinate system of CROATIA

Country	Coordinate zones	Points of test model	Distortions between ellipsoid and map projection		Length differences between topography and map projection	
			Average	Range	Average	Range
Croatia	1 zone	88160	4.35cm/km	-10 to 70.73cm/km	0.55cm/km	-38.94 to 70.05cm/km



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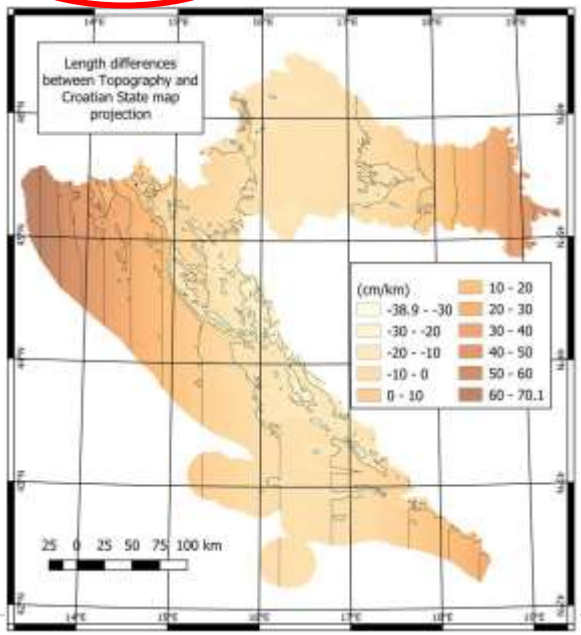

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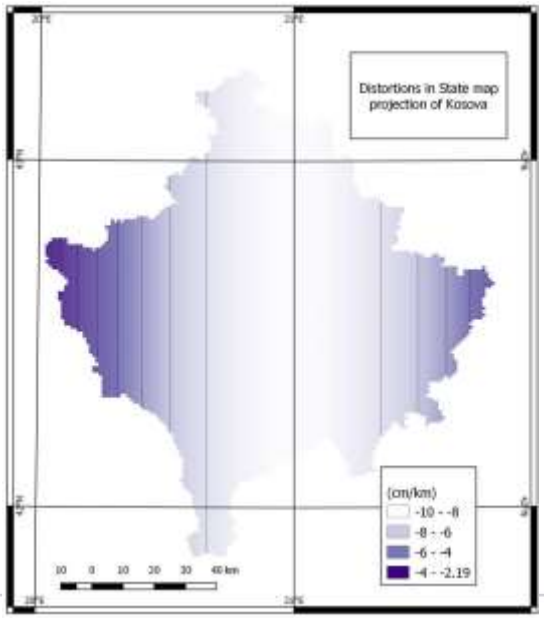
Calculations within the state coordinate system of KOSOVA

Country	Coordinate zones	Points of test model	Distortions between ellipsoid and map projection		Length differences between topography and map projection	
			Average	Range	Average	Range
Kosova	1 zone	10893	-8.72cm/km	-10 to -2.19cm/km	-22.13cm/km	-50.25 to -12.86cm/km



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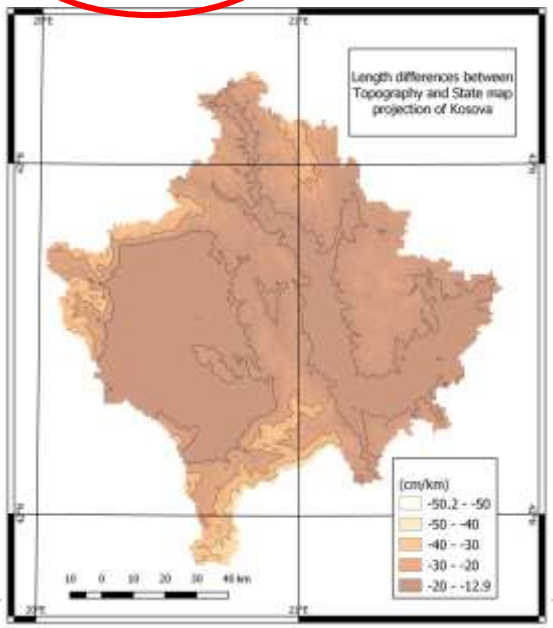

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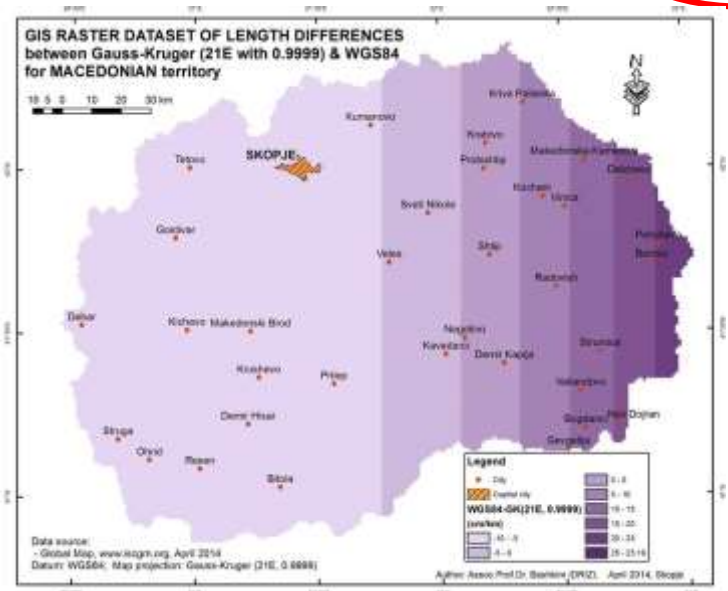
Calculations within the state coordinate system of FYRo MACEDONIA

Country	Coordinate zones	Points of test model	Distortions between ellipsoid and map projection		Length differences between topography and map projection	
			Average	Range	Average	Range
Macedonia	1 zone	25635	-2.27cm/km	-10 to 25.16cm/km	-16.01cm/km	-51.56 to 19.48cm/km

(Idrizi, 2014)



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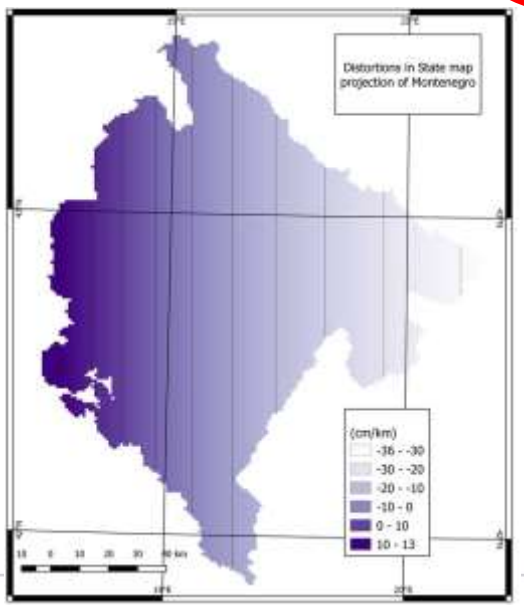
Calculations within the state coordinate system of MONTENEGRO

Country	Coordinate zones	Points of test model	Distortions between ellipsoid and map projection		Length differences between topography and map projection	
			Average	Range	Average	Range
Montenegro	1 zone	13331	-13.07cm/km	-36.06 to 13.01cm/km	-29.81cm/km	-70.46 to 11.21cm/km



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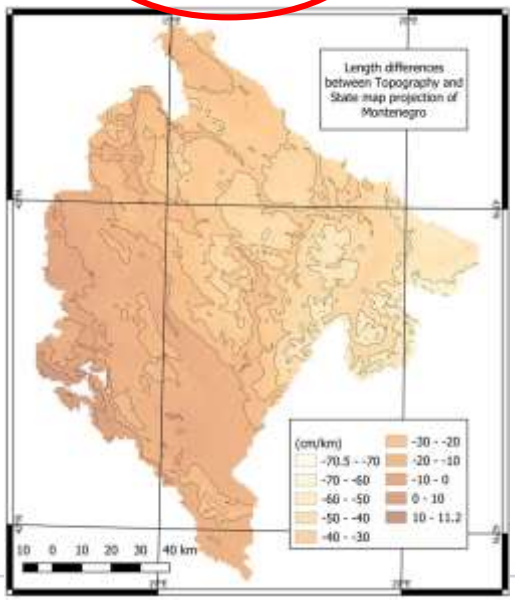

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Results and findings

- Differences between the distortion in state map projections and length differences between the topography and the map projection are too large,
- Largest length differences between the topography and the map projection doesn't reach same values with opposite prefixes,
- Mean length differences between the topography and the map projection in all cases do not have values nearby zero, and
- The range of length differences didn't reach the criteria of uniform dispersion, which was resulted with too large differences between areas with negative and positive linear deformations.

Results and findings (2)

Per five raster datasets for ten projecting zones have been developed (in total 50 rasters):

- per five raster datasets with 1km spatial resolution for the countries with 1 projecting zone (Albania, Croatia, Kosova, FYRo Macedonia and Montenegro),
- 10 raster datasets with 1km spatial resolution for 2 projection zones of Bulgaria, and
- 15 raster datasets with 1km spatial resolution for 3 projection zones of Bosnia and Herzegovina.

GENERAL OUTCOME FROM RESEARCH:

During establishing of the state coordinate systems were not taken into account all length reductions - differences beginning from the topography to the relevant map projection!

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Conclusions

- Successive length differences between four surfaces, must take into account during selecting of a most appropriate state map projection
- Length reductions beginning from the topography to the map projection is indicative for big differences instead of the distortion values.
- In all cases length differences have largely avoided from the expected values.
- Similar problems have an absolute number of the formal state coordinate systems, all over the world.

Contribution

This research aims to contribute to:

- Further studies of defining a new approach for choosing the most appropriate national map projection
- Minimize the length differences between topography and map projection, as well as
- Fulfilment of the criteria/standards for linear differences between referent surfaces in State coordinate systems.

Thank you for your attendance!

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