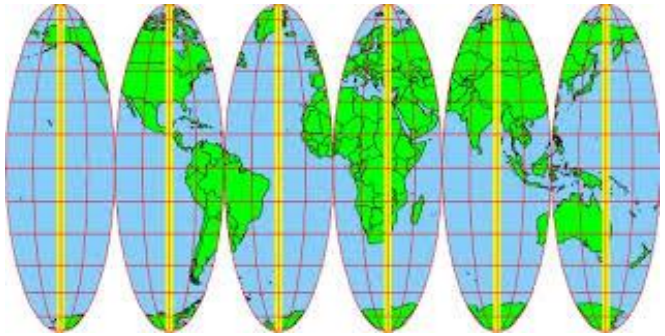
Kyrgyz State Technical University

Reference Systems in Geodesy

5. General Projection Theory.
Classification of map projections.



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Course/module description *(Reference Systems in Geodesy)*

Course provider (institution): Razzakov Kyrgyz State Technical University (KSTU)
Course title: Reference Systems in Geodesy (D.2.1.)
Target group: PhD Students (620100 – Geodesy and Remote Sensing Direction. Geodesy and Geoinformation Technologies Program)
Type (compulsory/optional): Compulsory
Number of ECTS credits allocated (if applicable); estimated workload: 10 ECTS (300 academic hours)
Mode of delivery (face-to-face/ distance learning etc.); number of contact hours: 90 class hours (45 - lectures, 45 – labs) and 210 hours for the self study
Language of instruction: Kyrgyz/Russian/ English
Prerequisites and co-requisites (if applicable): Fundamentals of Geodesy/Engineering Geodesy, knowledge of English for reading literature and communication
Course aims: Introducing students to geodetic computations on the sphere, elippsoid and map projection planes, definition of geodetic reference systems and transformations among different systems.
Learning outcomes: After taking this course, the students should (be able to do): 1. understand of principles of geodetic science 2. be able to perform advanced compuations on the surface of reference ellipsoid 3. have excellent understanding of different types of map projections and be able to compute map projection coordinates 4. be familiar with concepts of time and celestial coordinates 5. be aware of astro-geodynamic phenomena which affect definition of reference systems such as earth rotation, gblobal tectonics, earth tide etc 6. have deep insight on celestial and terretrial reference systems including ICRF, ITRF, WGS84, KYRG-06 and PZ-90 7. have good understanding of triangulation-based coordinate systems and different height systems 8. be able to investigate differences ámong different reference systems and have ability to make transformations

Course/module description *(Reference Systems in Geodesy)*

Course content:

1. Introduction. History of geodetic science
2. Spherical trigonometry; Geometry of ellipsoid
3. Geodetic coordinates
4. Geodetic lines
5. **General projection theory。Classification of map projections.**
6. Azimuthal projections. Conical projections
7. Cylindrical projections. UTM.
8. Celestial coordinates
9. Concept of time. Principles of astronomical positioning.
10. Earth rotation. Earth Orientation Parameters (EOP).
11. Geodynamics: global tectonics, crustal motion, earth tide/permanent tidal effects
12. Celetial vs terretrial reference systems. Transformation from ICRF to ITRF. WGS84. UTM. Kyrg-06
13. Astrogeodetic triangulation. Pulkova-42
14. Gravity, geoid and height systems
15. Transformation between traingulation-based coordinate systems and 3D coordinate systems

Recommended or required reading and other learning resources/tools:

- Course teaching materials available through the university ELMS;
- Instant messaging, blog and personal electronic communication platforms;

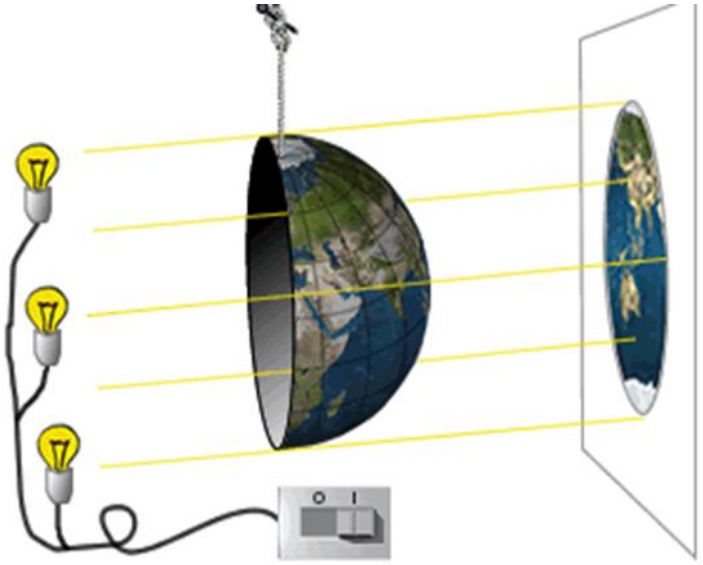
Required literature:

1. Метод и системы координат в геодезии. Н.А. Телеганов, Г.Н. Тетерин. Учеб. Пособие. Новосибирск: СГГА, 2008. 143 с.
2. Системы координат в геодезии. В. Л. Клепко, А. В. Александров. Научная монография, Екатеринбург 2011, 116 с.
3. Высшая геодезия. Учебник / Б. Т. Мазуров. Новосибирск: СГУГиТ, 2016. 203 с.
4. Map Projections. Erik W. Grafarend, Friedrich W. Krumm. Springer-Verlag Berlin Heidelberg 2006, 713 p.

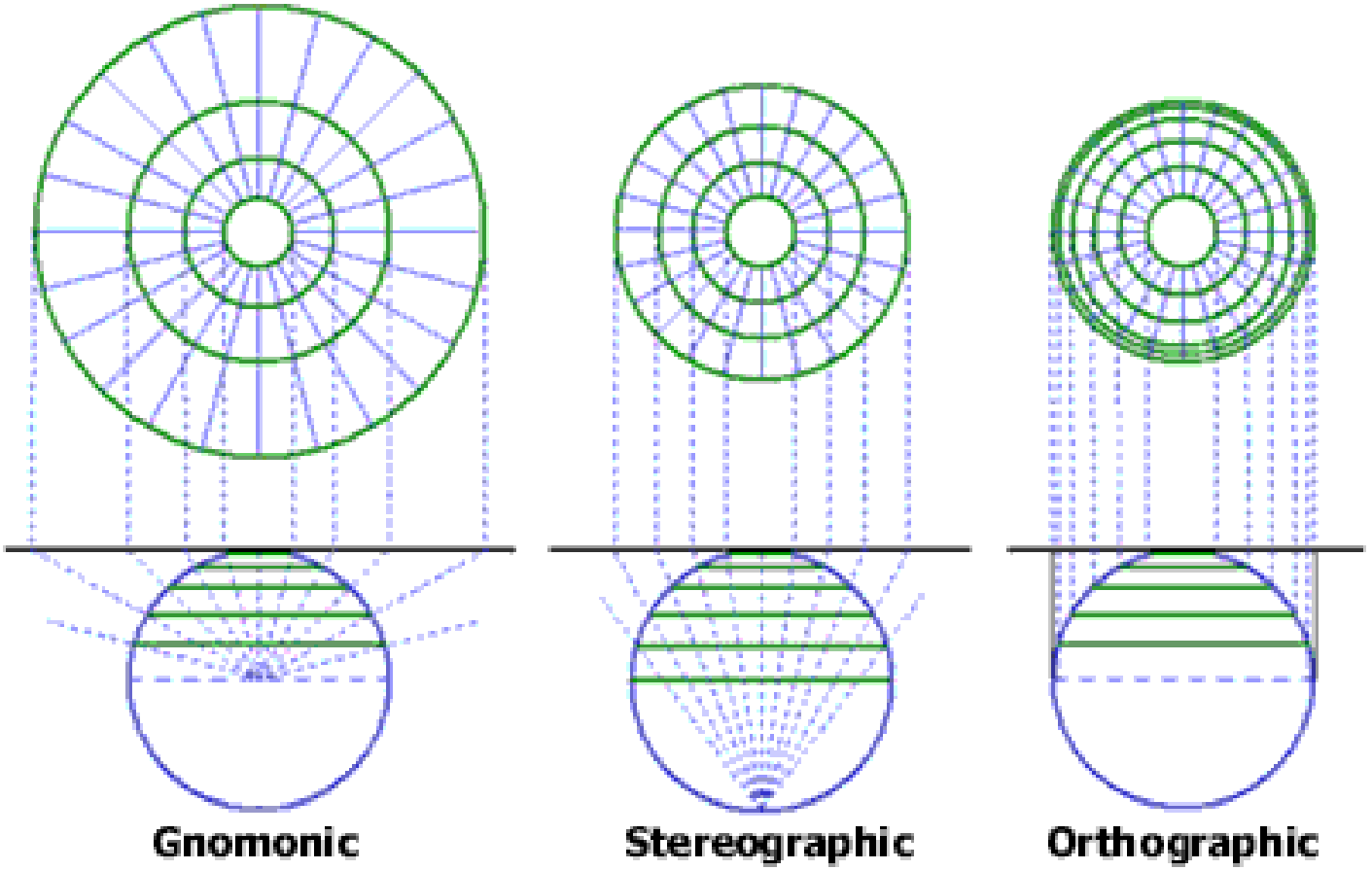
About map projection

A map projection is one of many methods used to represent the 3D surface of the Earth on the 2D plane in cartography.

Each pair of geographical coordinates (latitude/longitude) is replaced by a pair of coordinates of a flat, Cartesian system.

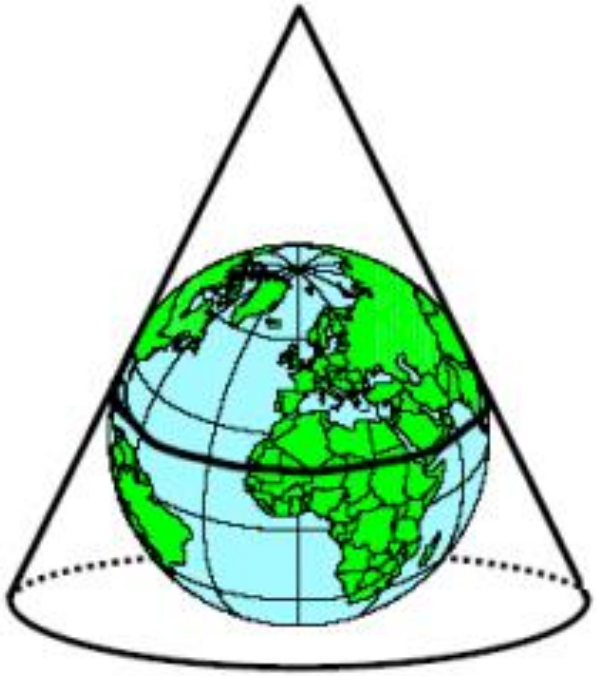


Map projections types (light Sources)

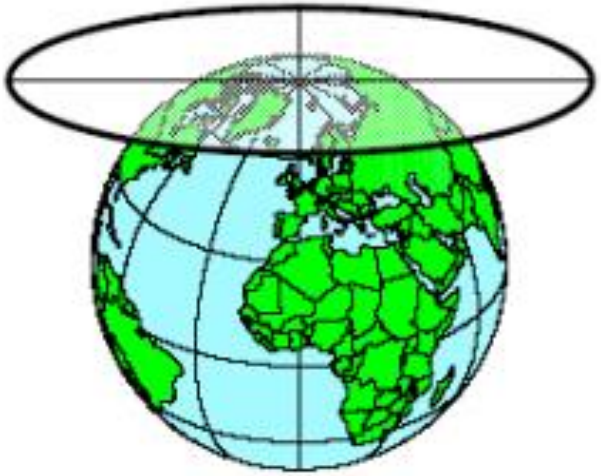


Map projections types (projection surfaces)

Cylindrical

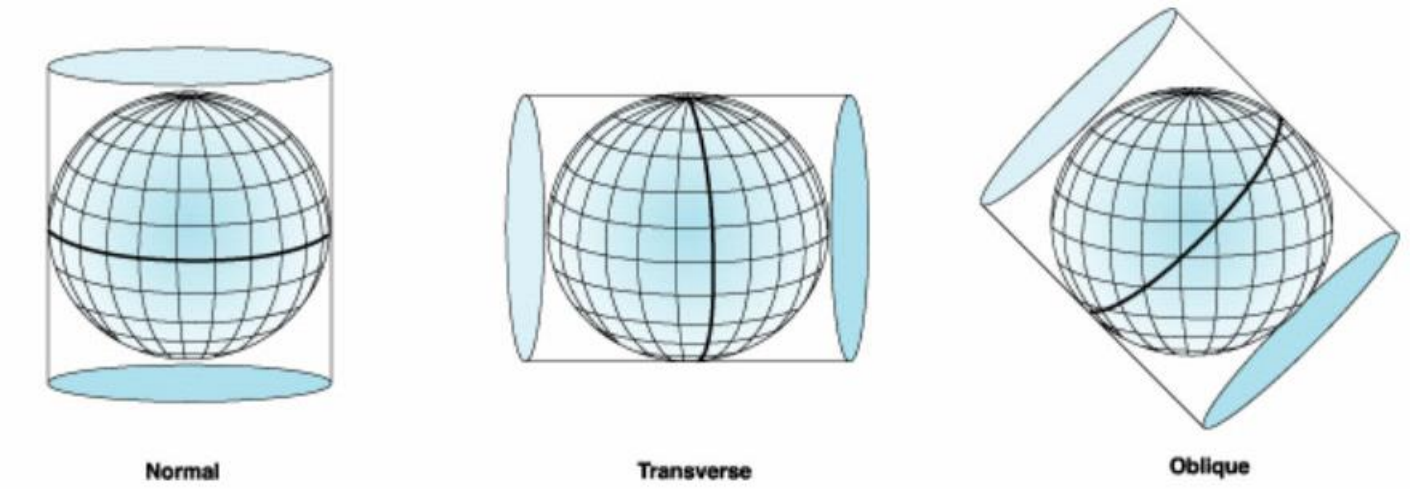


Conical



Planar / Azimuthal

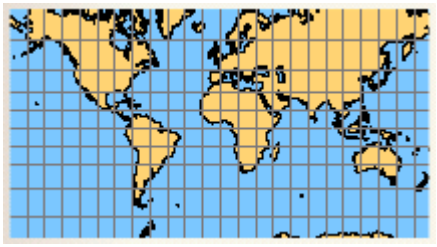
Map projection aspects

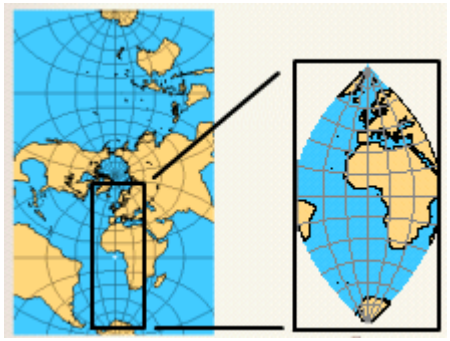


https://desktop.arcgis.com/

Cylindrical map projections

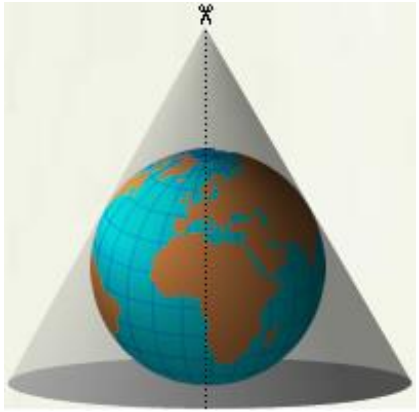
- It is preferable to show the surface of the entire globe in a normal aspect.
- Limited areas of the earth's surface in large scale maps are better to design in a transverse aspect.
- The coordinate systems of many countries are based on transverse cylindrical projections.

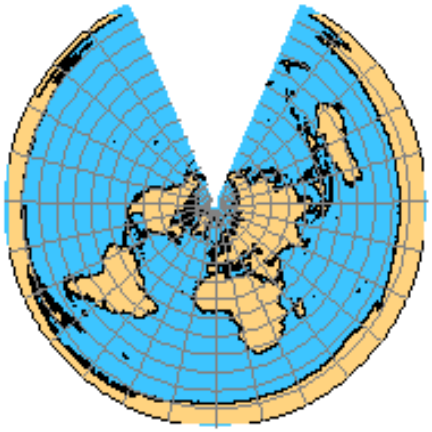




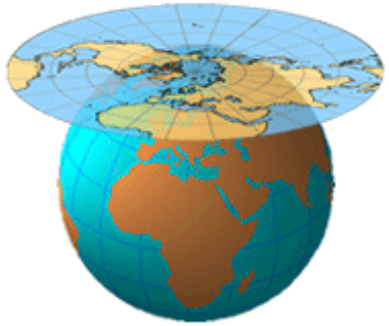
Conical and Azimuthal map projections

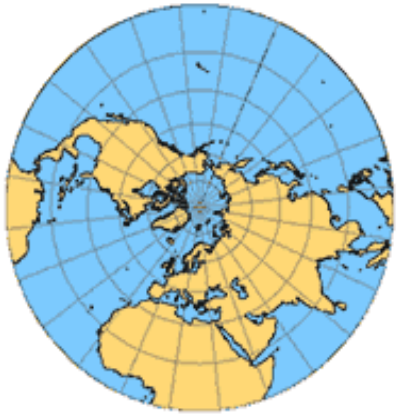
- Conical projections
  - Projected onto a conical surface
  - Often used for small to medium scale maps and mid-latitude areas





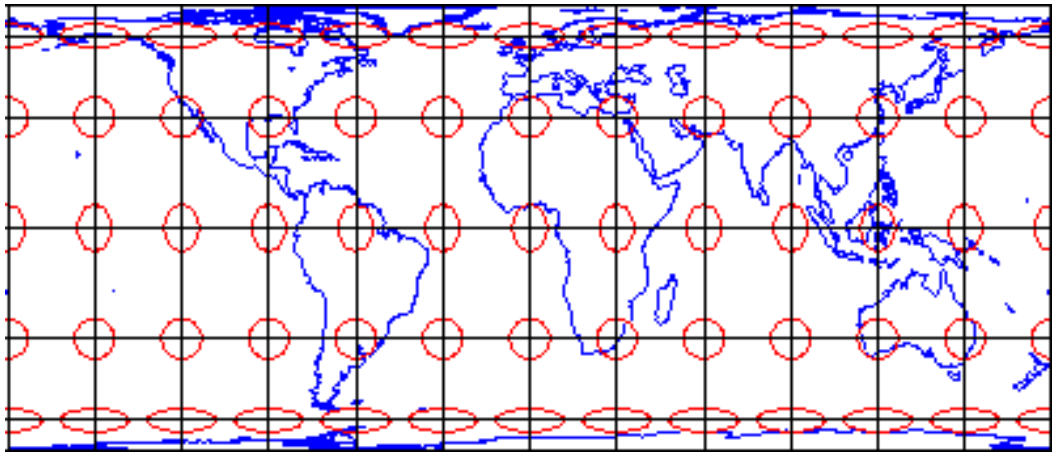
- Planar/azimuthal projections
  - Projected on a plane surface
  - Used to depict hemispheres or small areas of the Earth's surface
  - Often have a polar aspect (the plane touches the Earth's pole)



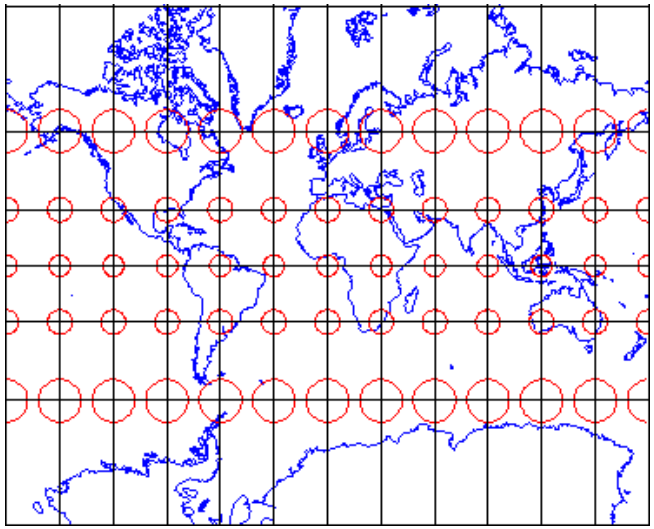


Map projection properties – 1
(there is no perfect map)

The equal area map projections aim to preserve the area relationships of all parts of the globe.

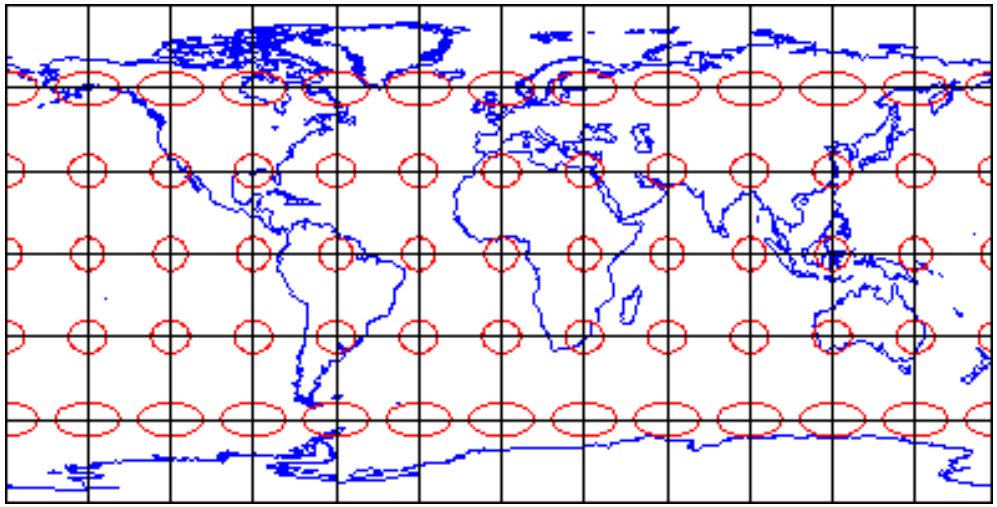


The conformal map projections preserve angles around points, and shape of small areas.

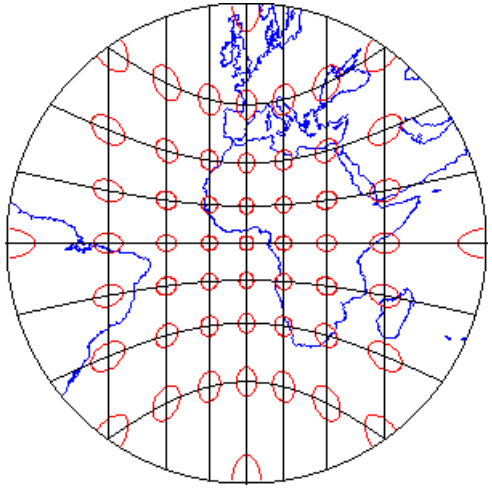


Map projection properties – 2
(there is no perfect map)

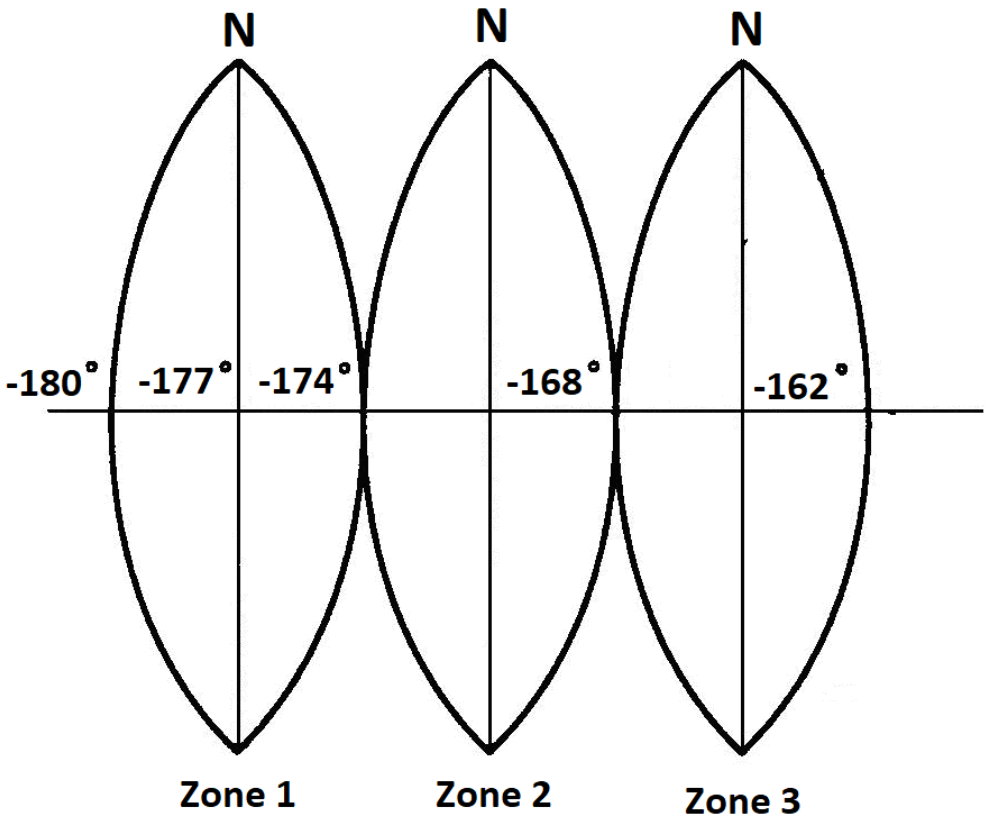
The equidistant map projection aims to preserve great circle distances.

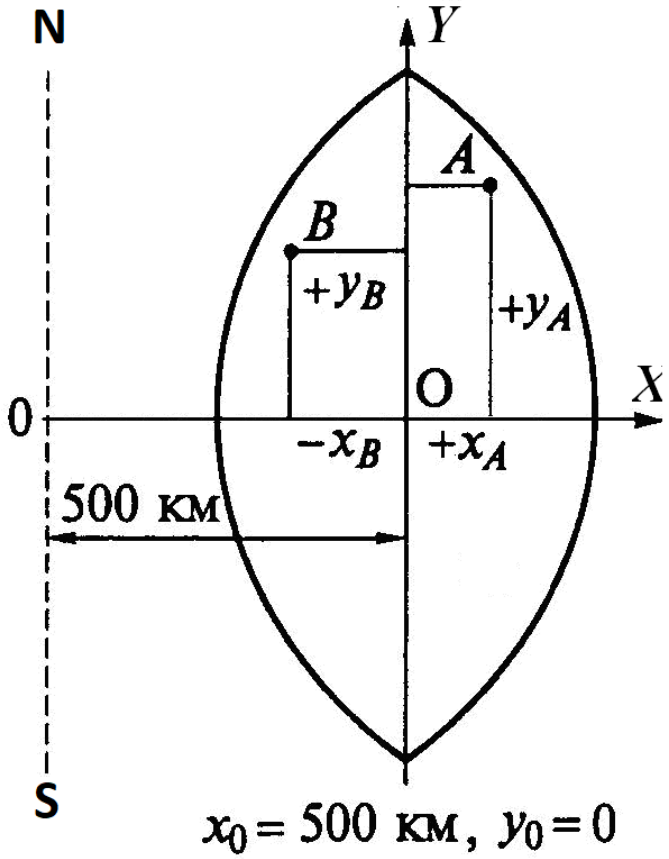


The azimuthal/planar map projection, also known true direction map as the projection, preserves direction from one point to all other points in the map.

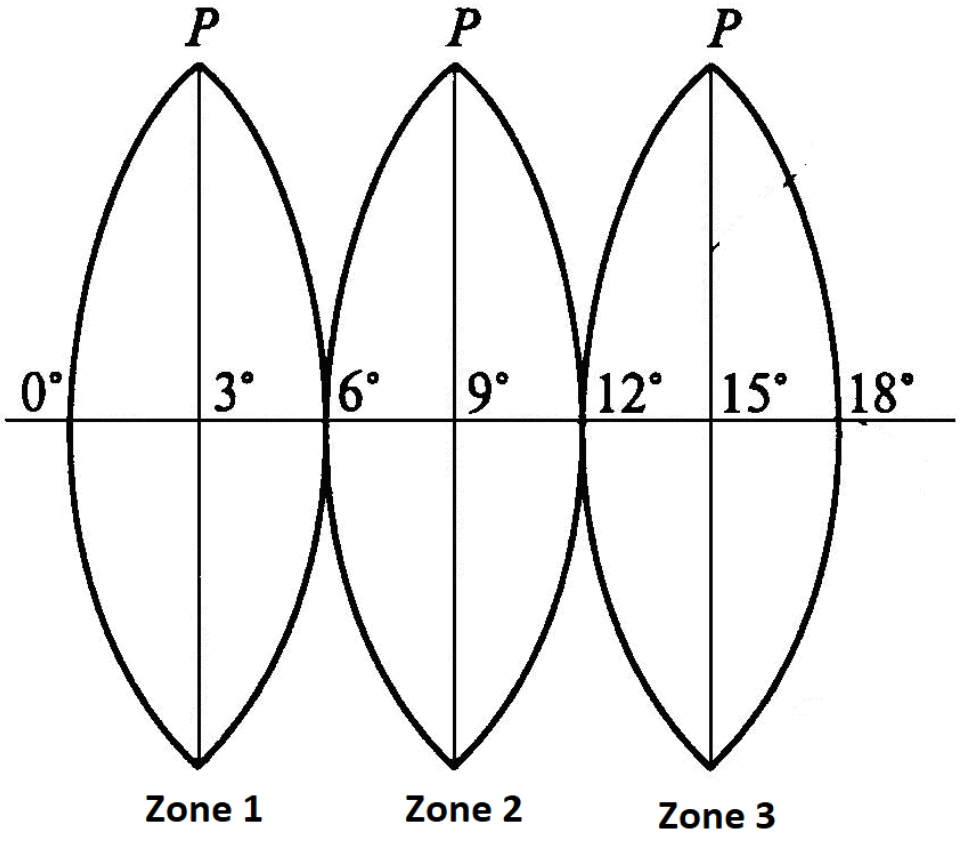


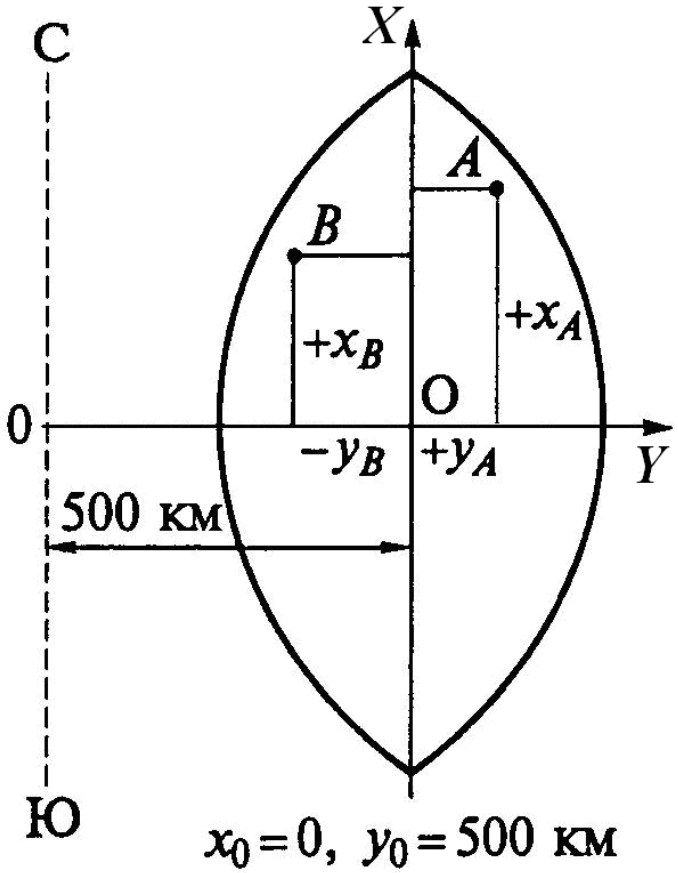
Map projection parameters
(False easting - UTM)



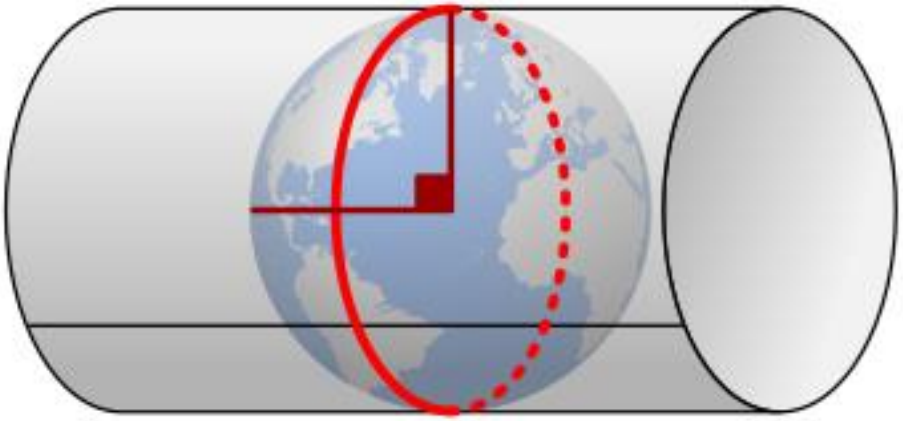


Map projection parameters
(False easting – Pulkovo 1942)

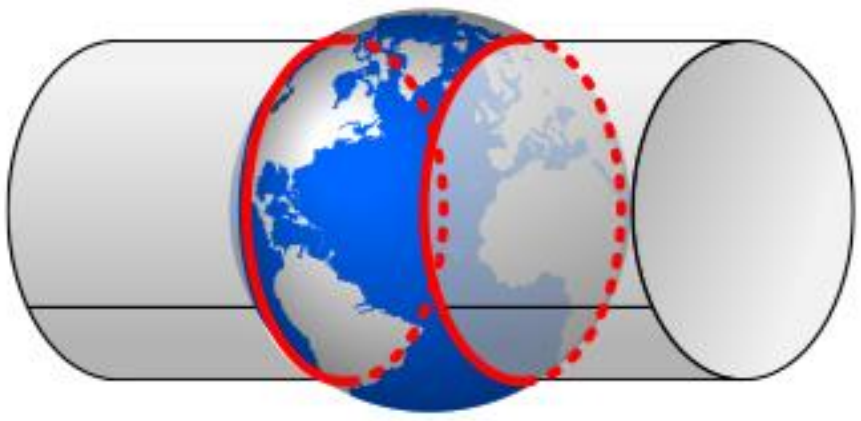




Map projections parameters
(Projection scale)

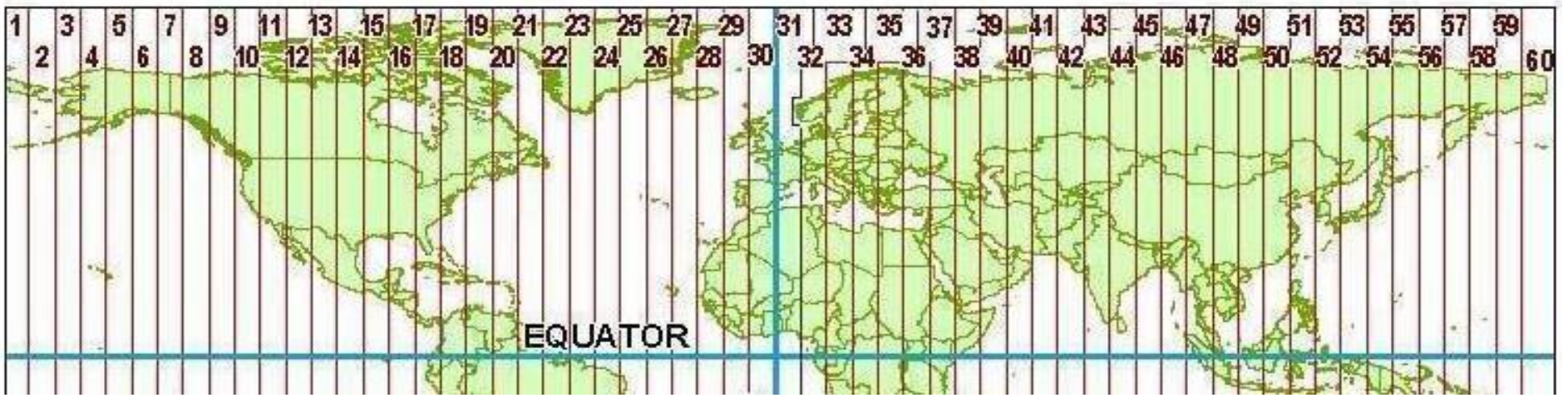


Gauss-Kruger Projection
Scale = 1



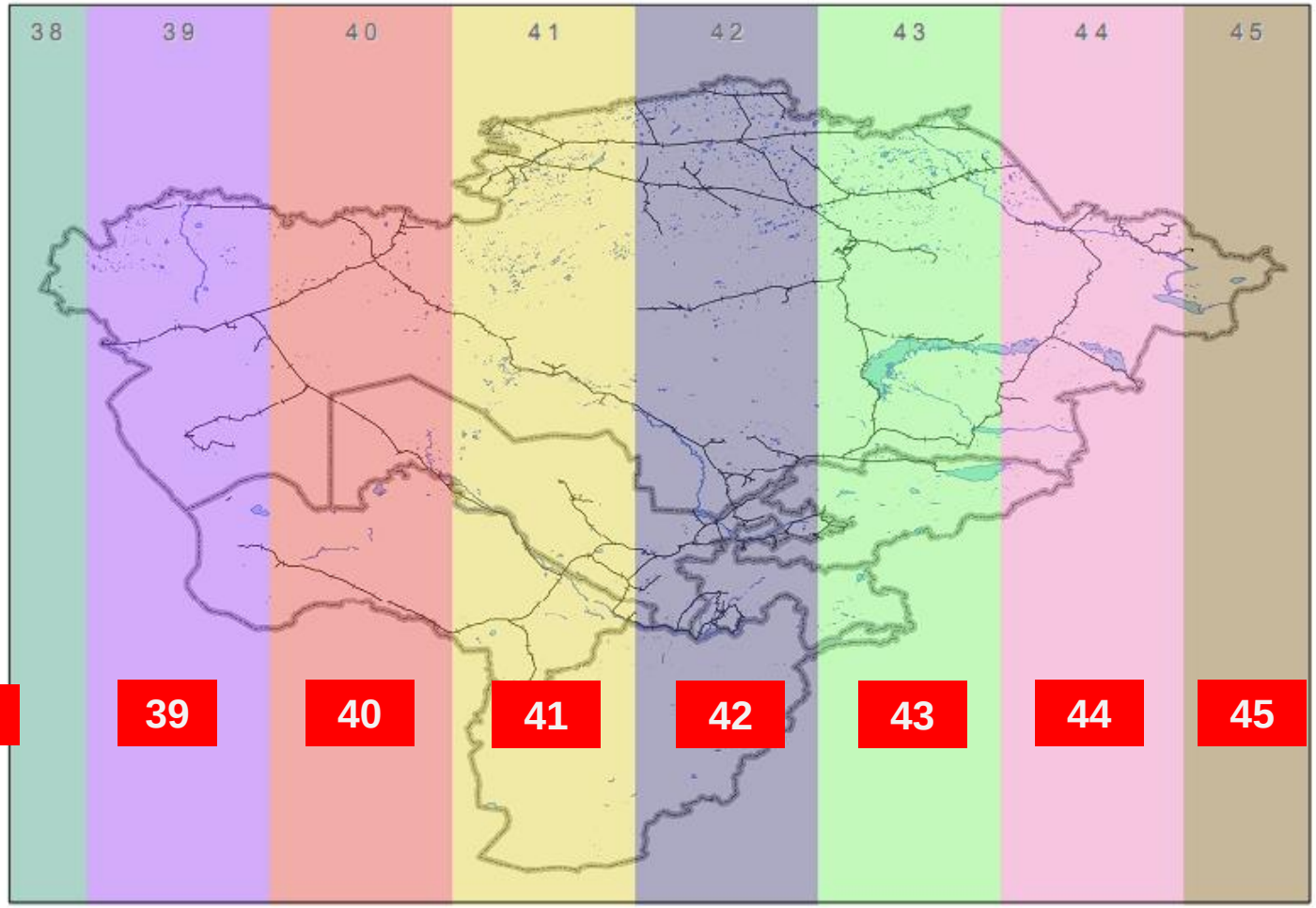
UTM Projection
Scale = 0,9996

Commonly Used Map Projections
(Universal Transverse Mercator - UTM)



- Based on WGS84 ellipsoid
- Has 6° zones from 180°
- WGS 84 / UTM zone 43N (EPSG:32643) – main UTM zone for Kyrgyzstan (42N and 44N zones are applied too)
- False easting (X): 500 000 m
- False northing (Y): 0
- Central meridian of the zone 43N: 75°
- Projection scale: 0,9996 (secant projection)

Commonly Used Map Projections
(Universal Transverse Mercator - UTM)



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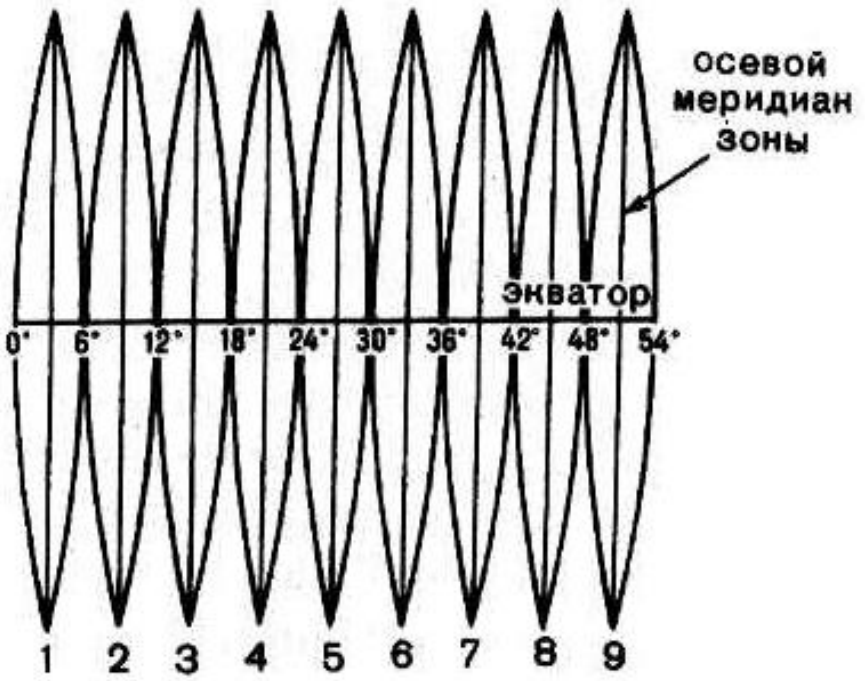
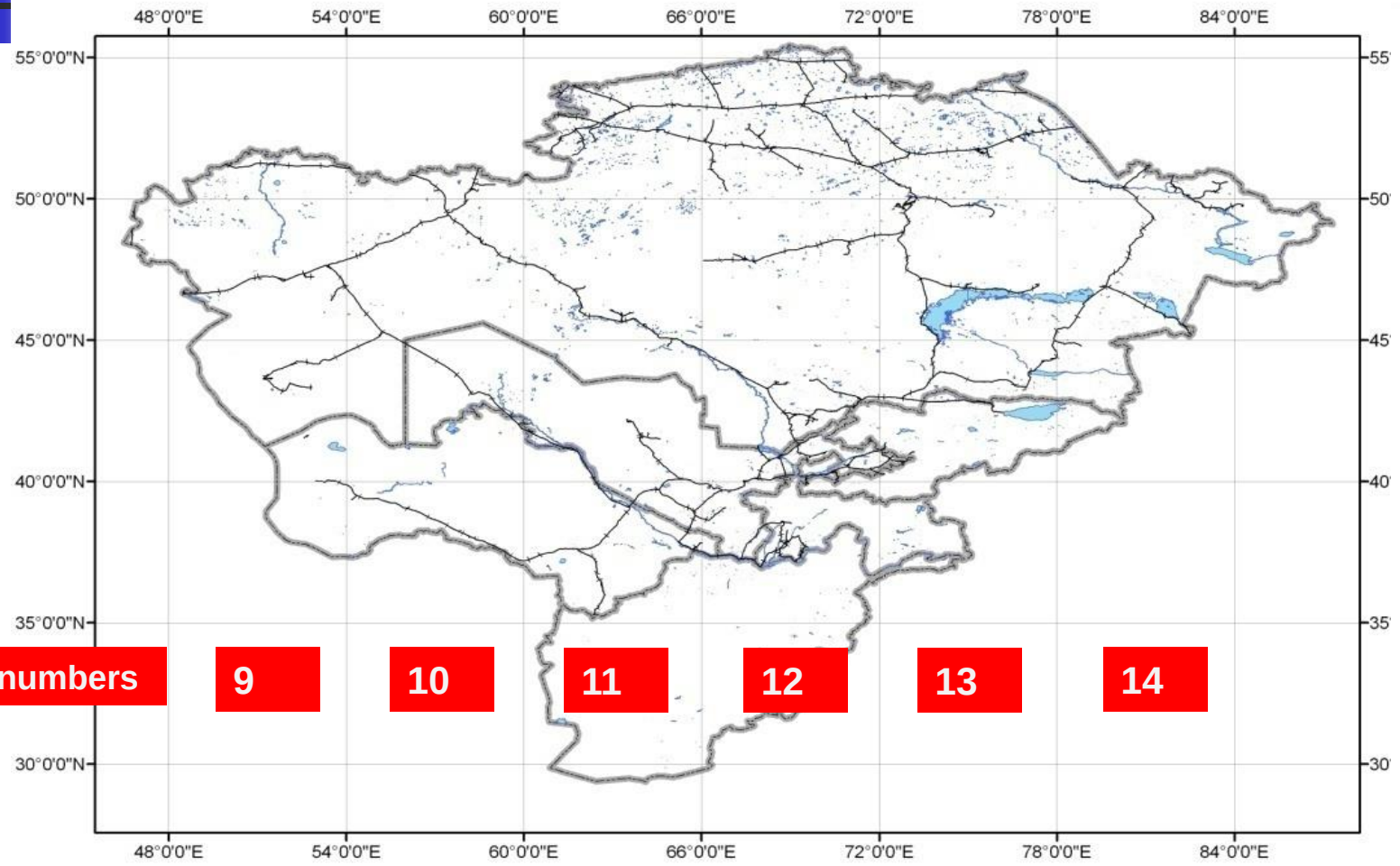
Commonly Used Map Projections
(Gauss-Krüger - Pulkovo 1942)

- Based on Krasovsky 1942 ellipsoid
- Has 6° / 3° zones from 0°
- Pulkovo 1942 / Gauss-Kruger zone 13 (EPSG:28413) – main projection zone for Kyrgyzstan (12 and 14 zones are applied too)
- False easting (X): 500 000 m
- False northing (У): 0
- Central meridian of the zone 13: 75°
- Projection scale: 1 (tangent projection)



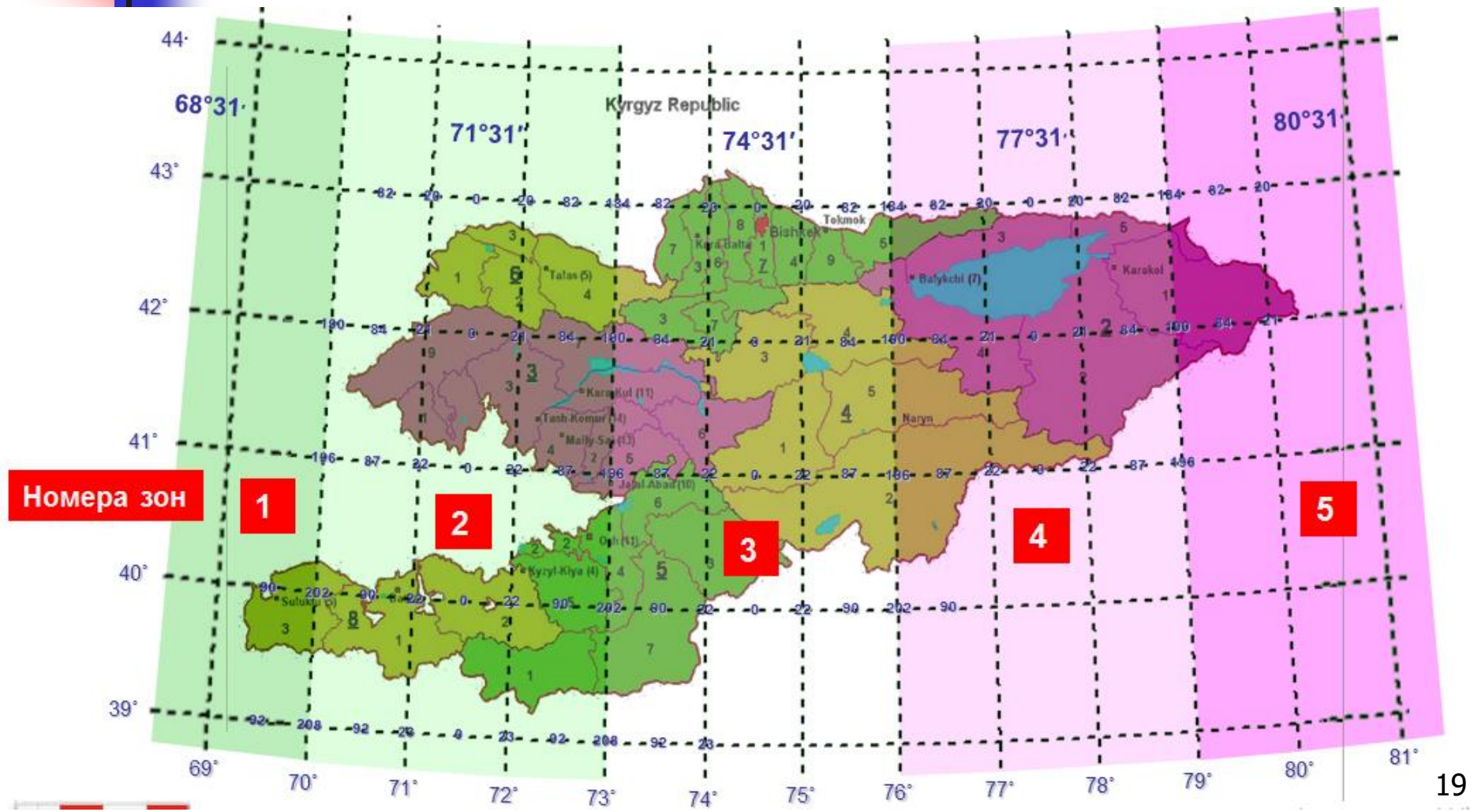
Commonly Used Map Projections

(Gauss-Krüger - Pulkovo 1942)

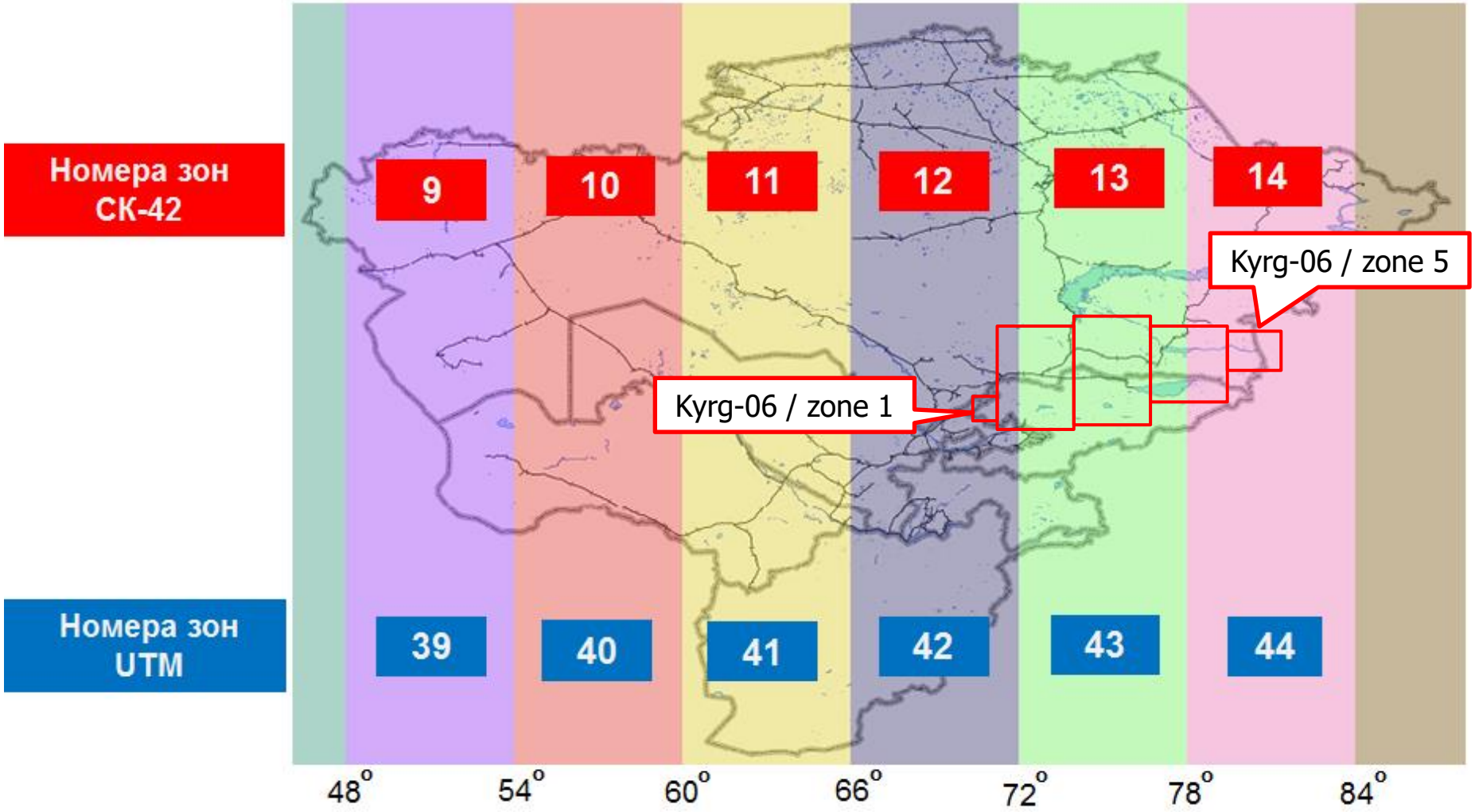


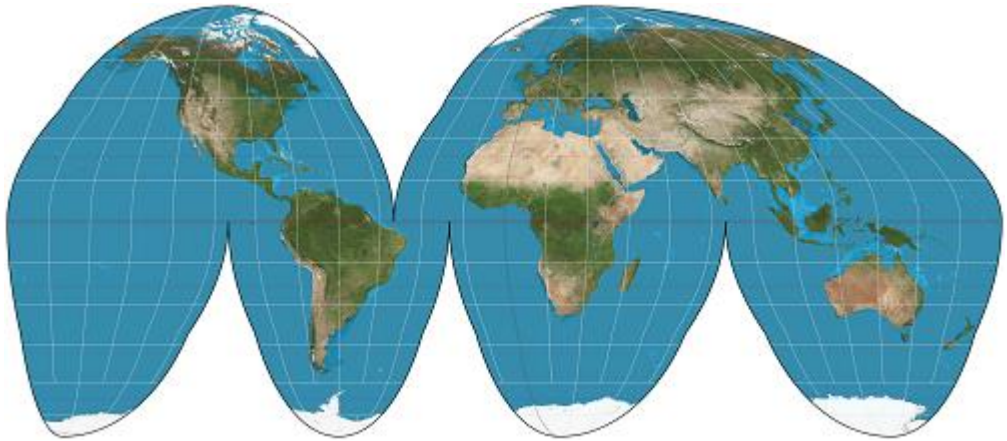
Zone numbers	9	10	11	12	13	14

Commonly Used Map Projections
(Kyrg-06, ITRF-2005, Transverse Mercator, 3°)



Comparison of UTM, Pulkovo 1942 and Kyrg-06 projection zones





Thanks for your attention!