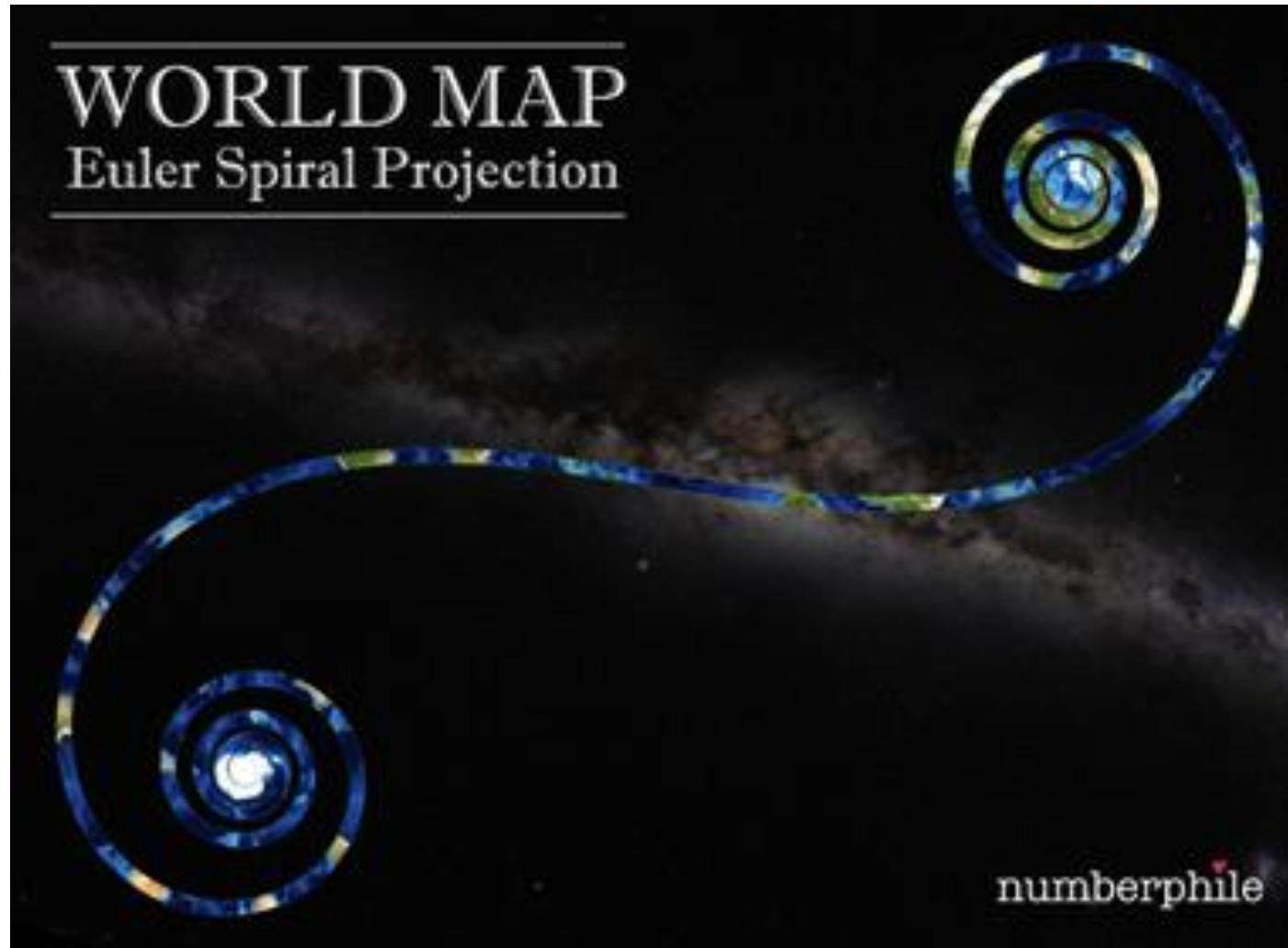


Spatial analyses on a round(ish) planet



No projection is really good

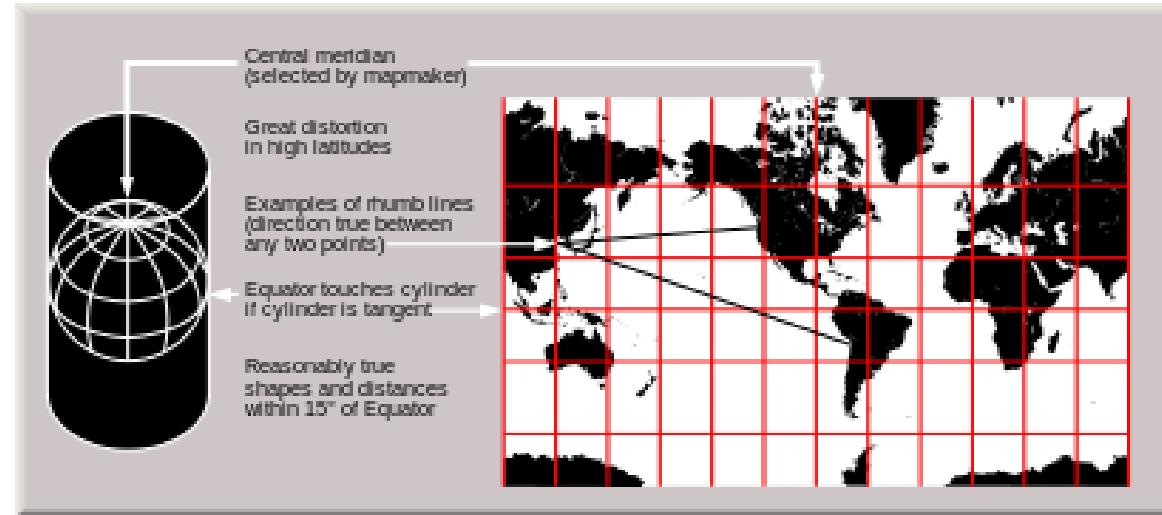


https://youtu.be/wkK_HsY7S_4

Tissot's indicatrix

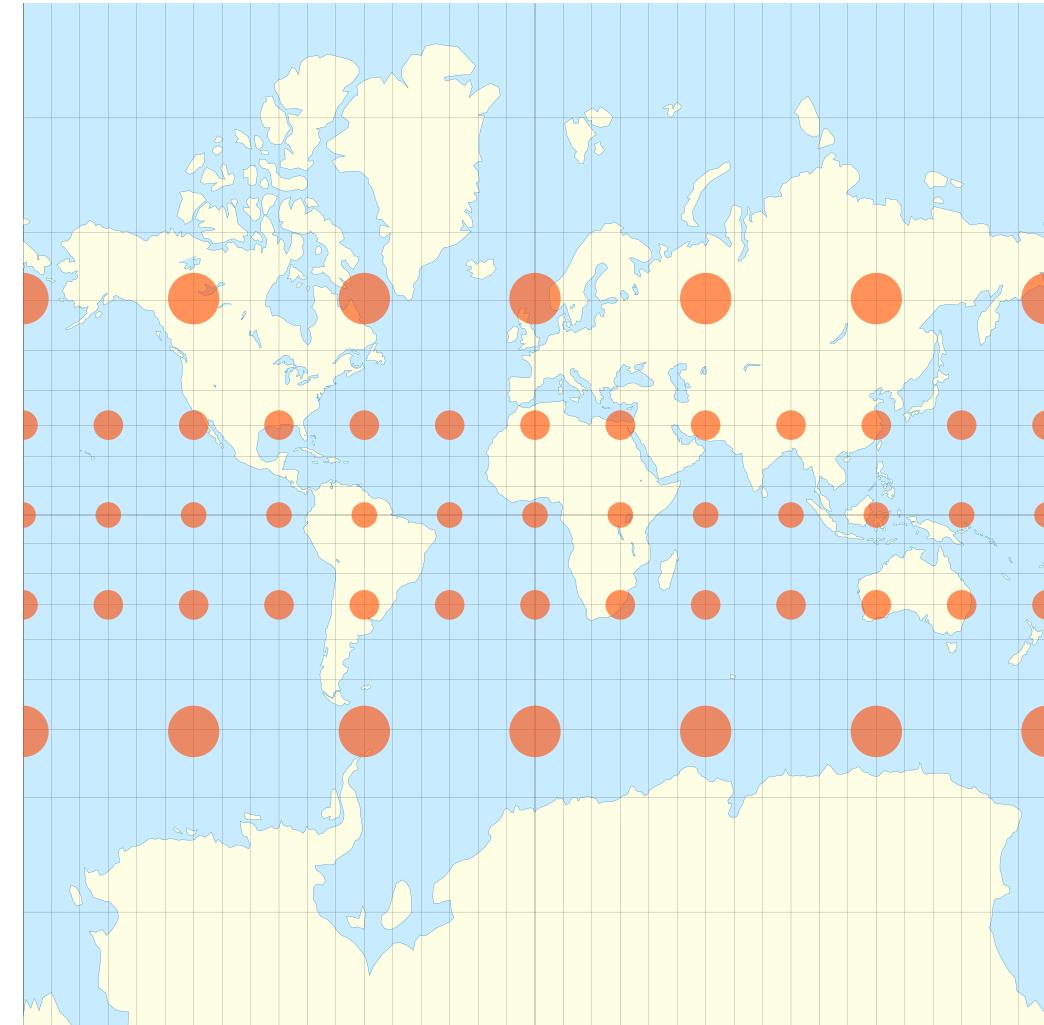


Cylindrical projections

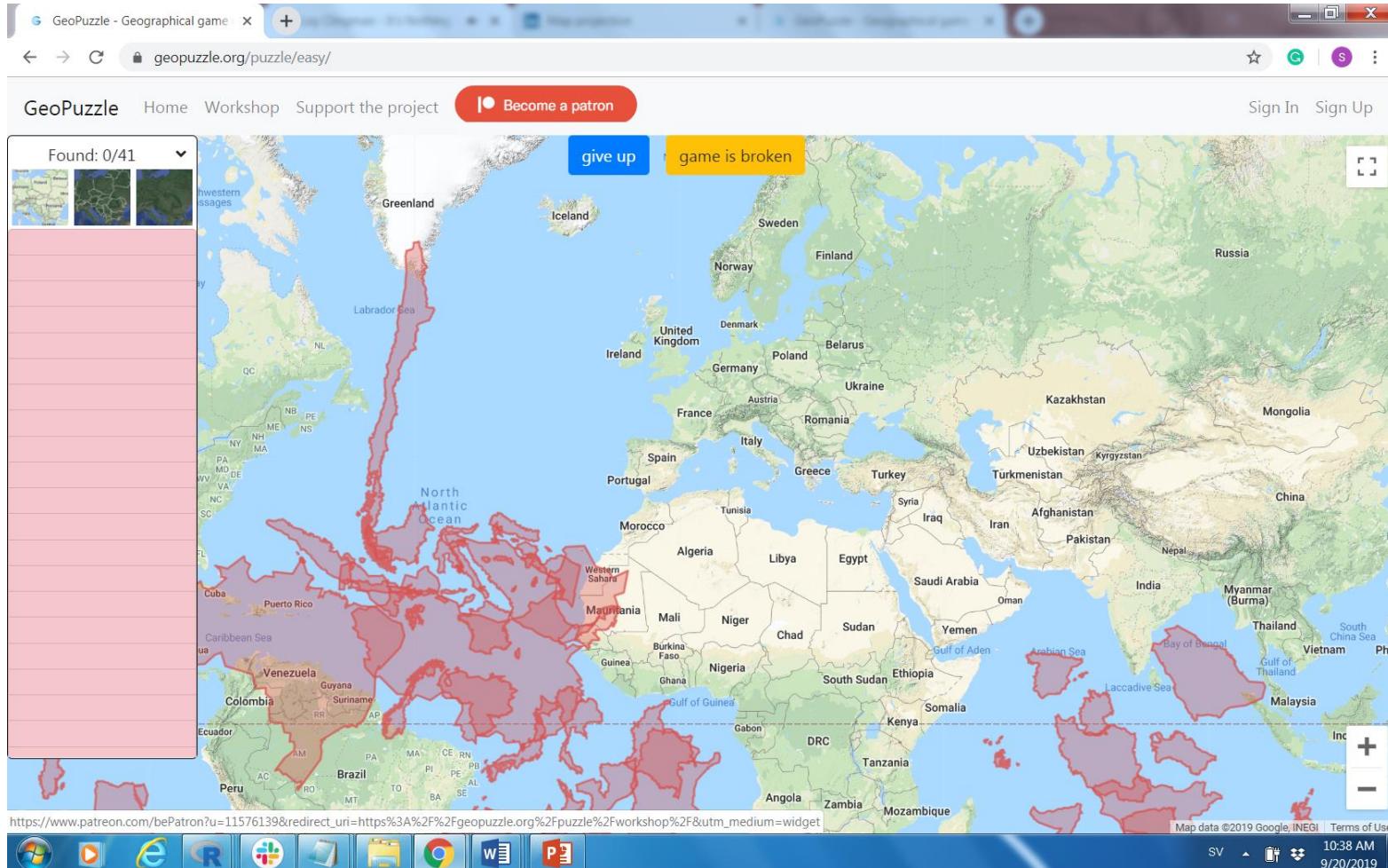


- Conformal: Shape
- Equidistant: (Some) distances
- Equal area: Area

Mercator projection (lat long) (Conformal)



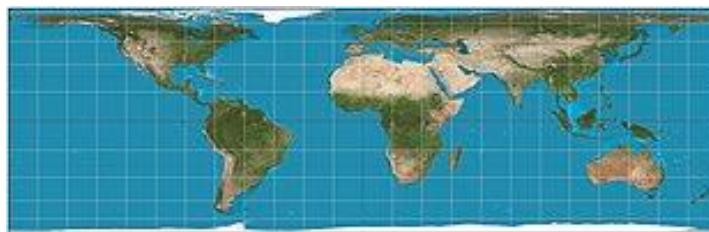
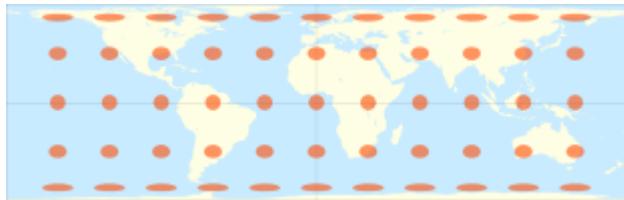
Grossly misassigned sizes



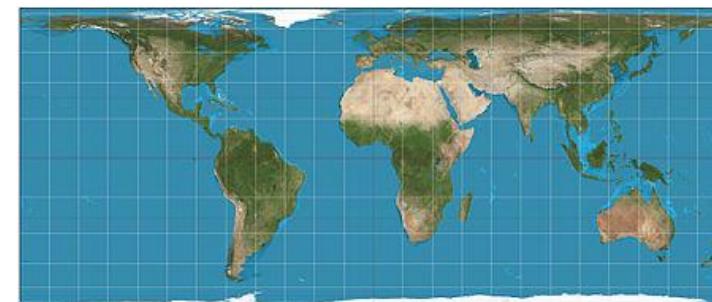
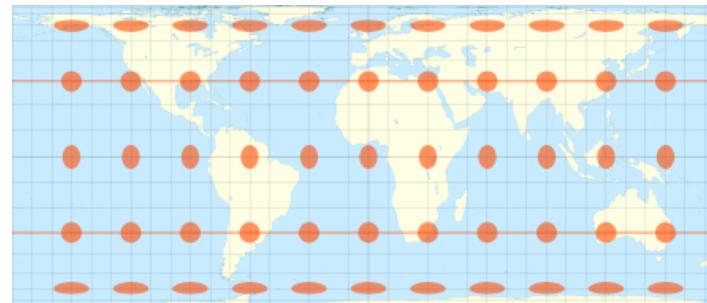
- <https://geopuzzle.org/puzzle/easy/>

Cylindrical equal area (Area)

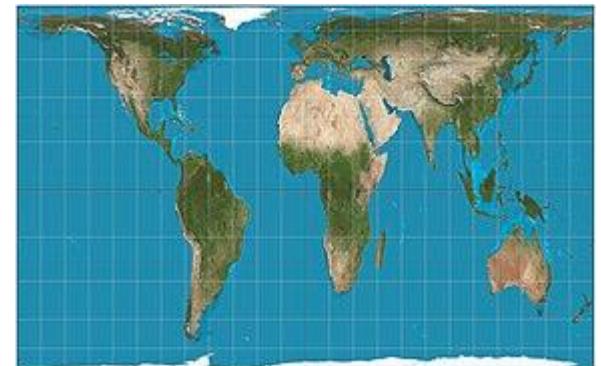
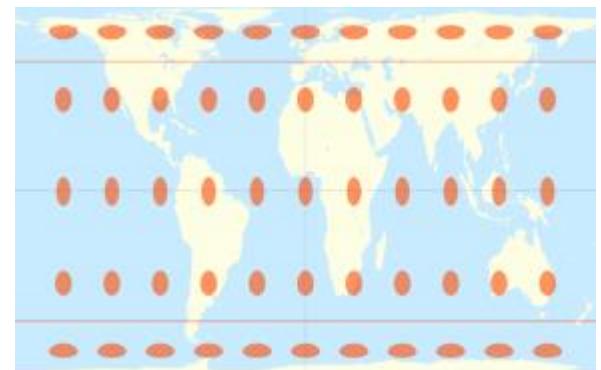
Lambert projection
(0 degrees)



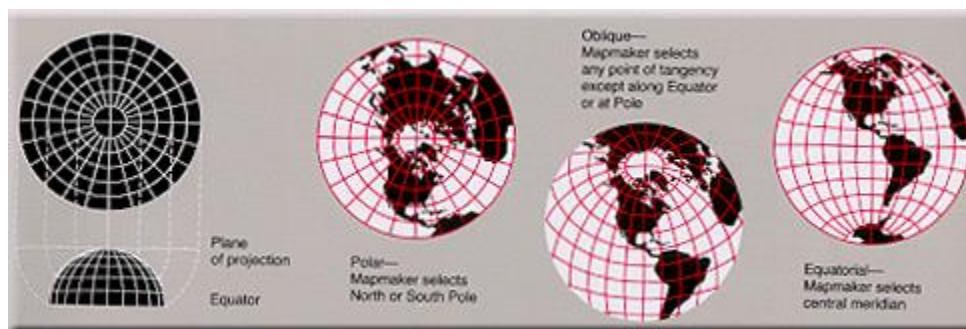
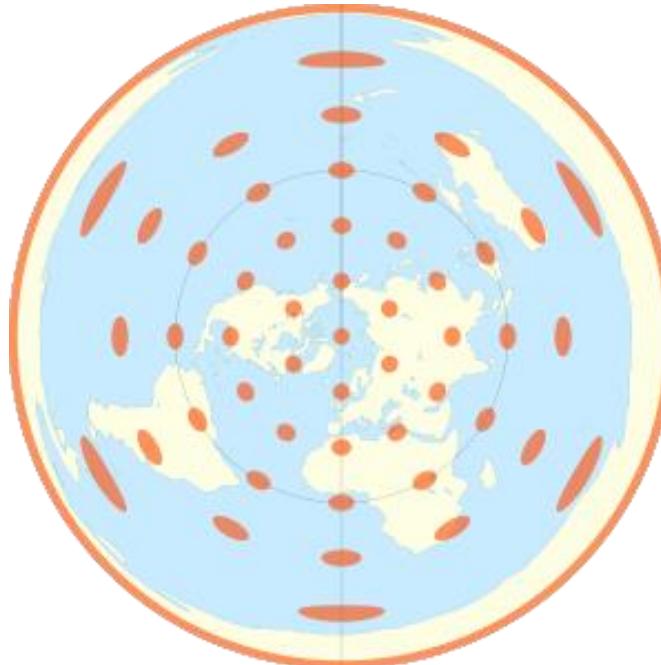
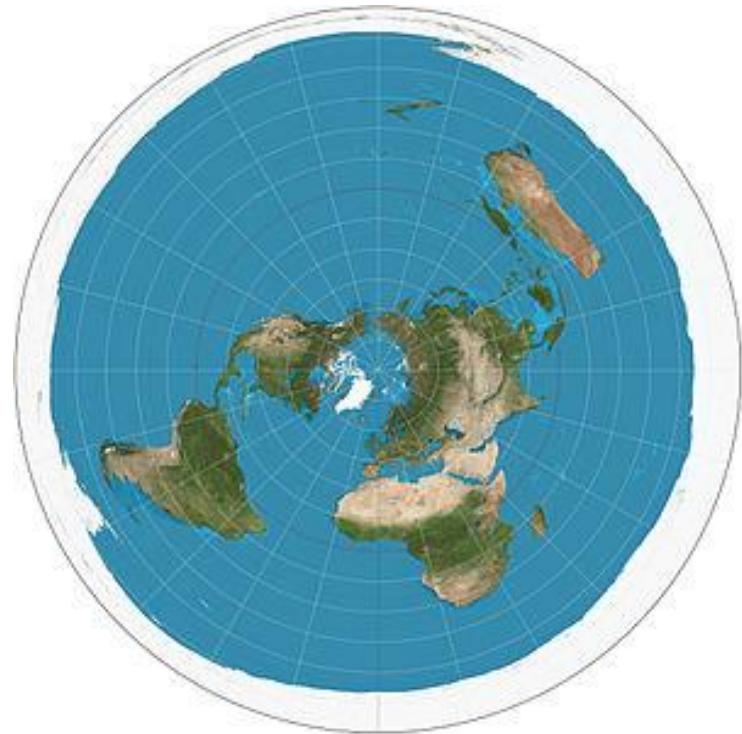
Behrman
(30 degrees)



Gall–Peters projection
(45 degrees)

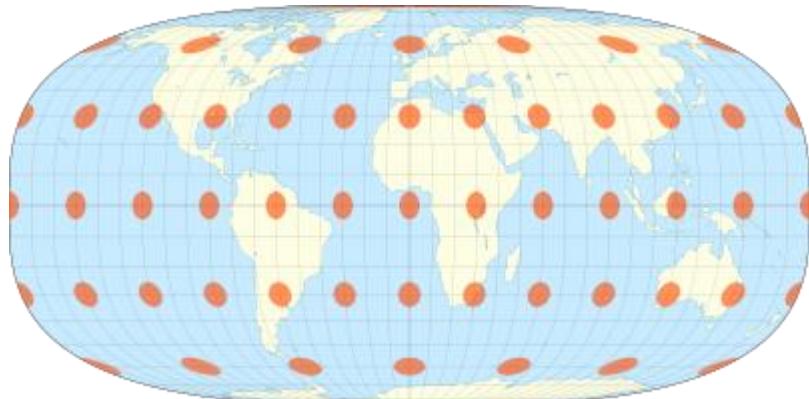
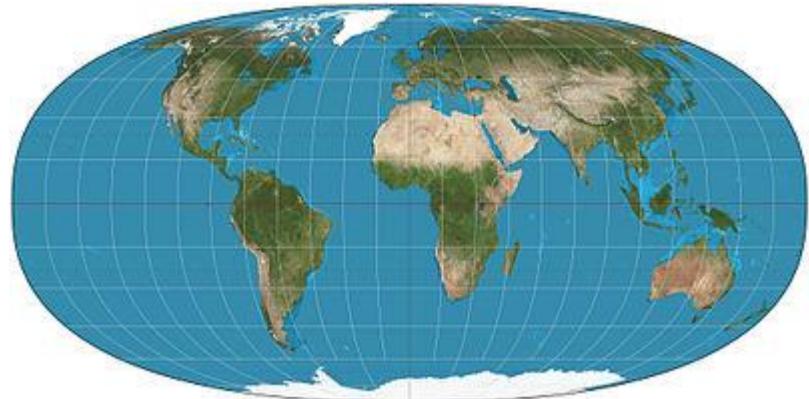


Azimuthal equidistant projection (distance)

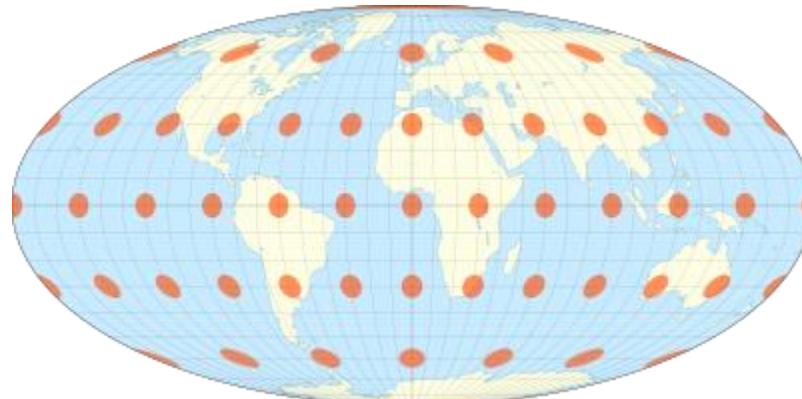
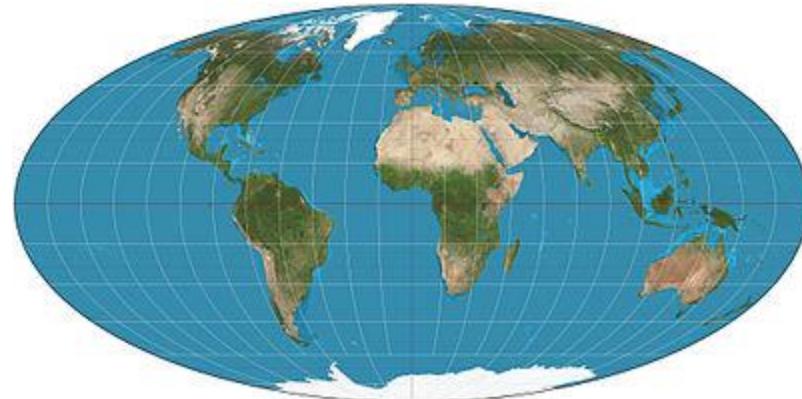


Pseudo-cylindrical projections

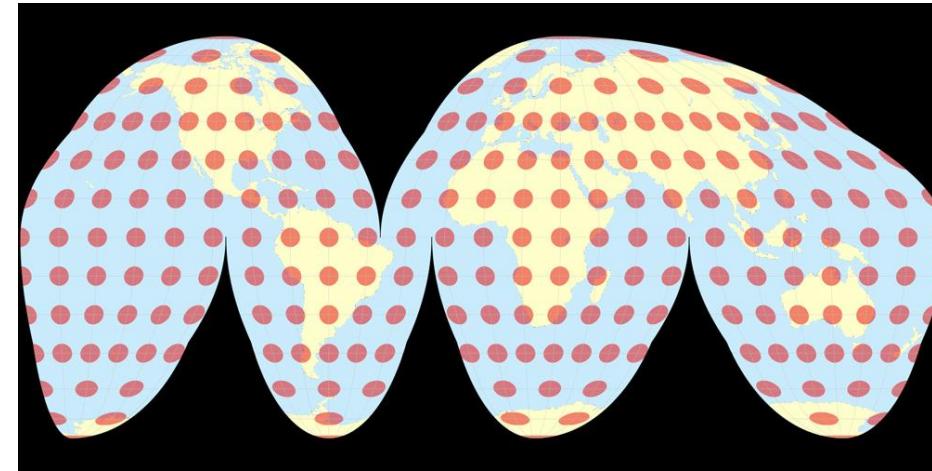
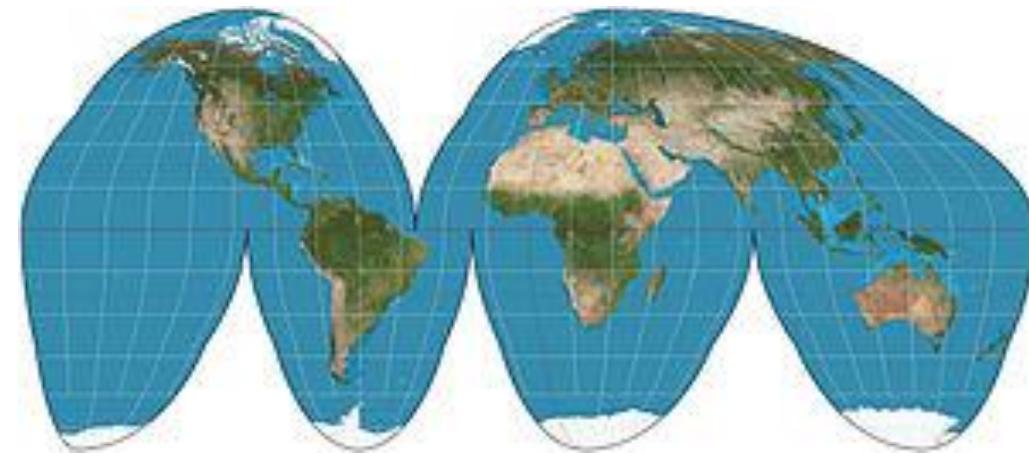
Tobler hyperelliptical projection



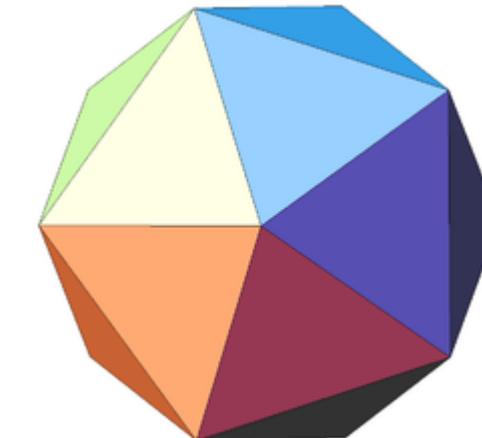
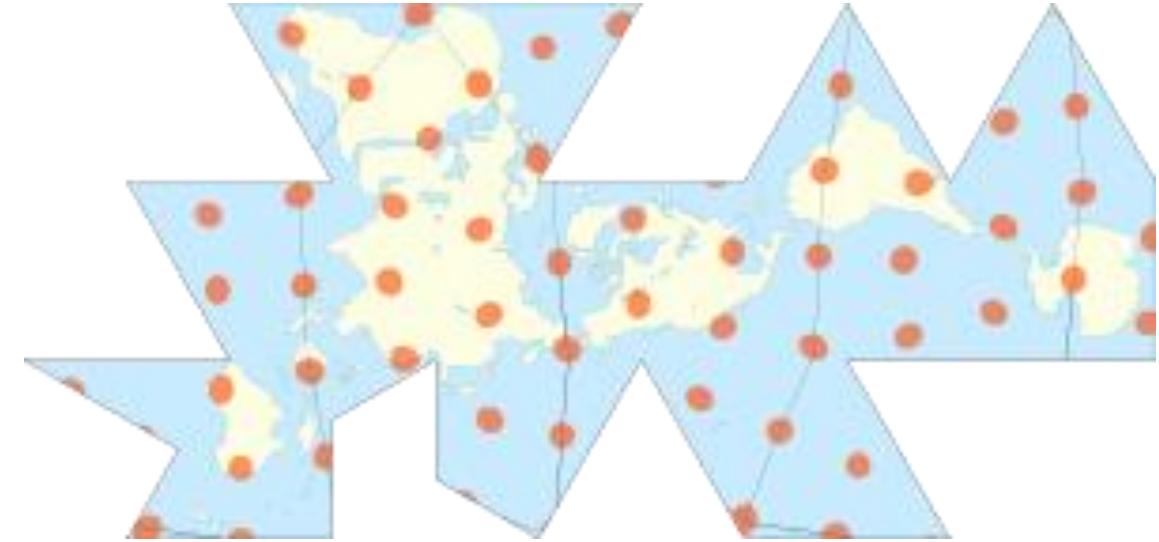
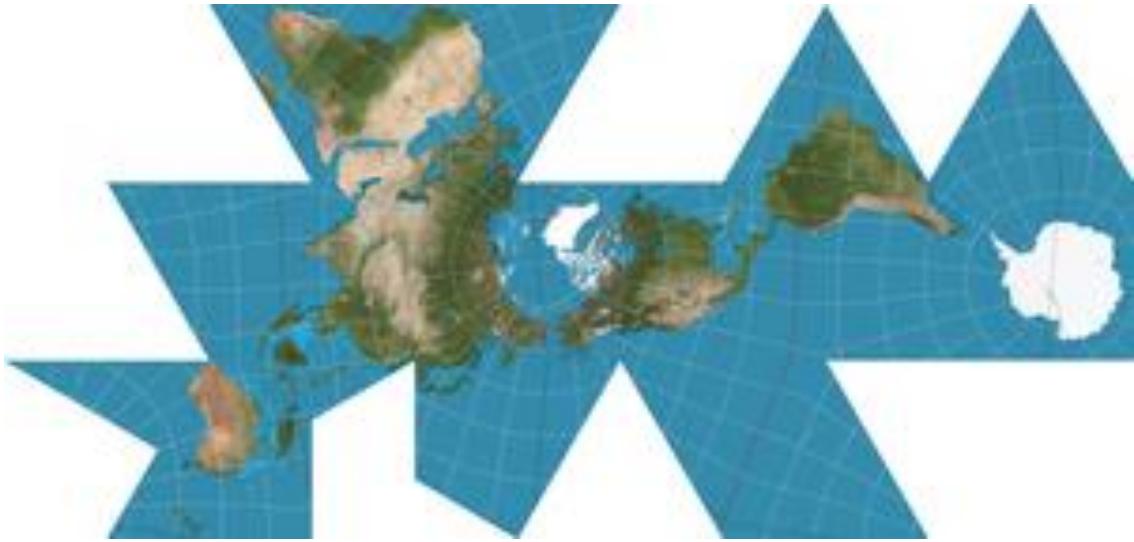
Mollweide projection



Goode homolosine projection



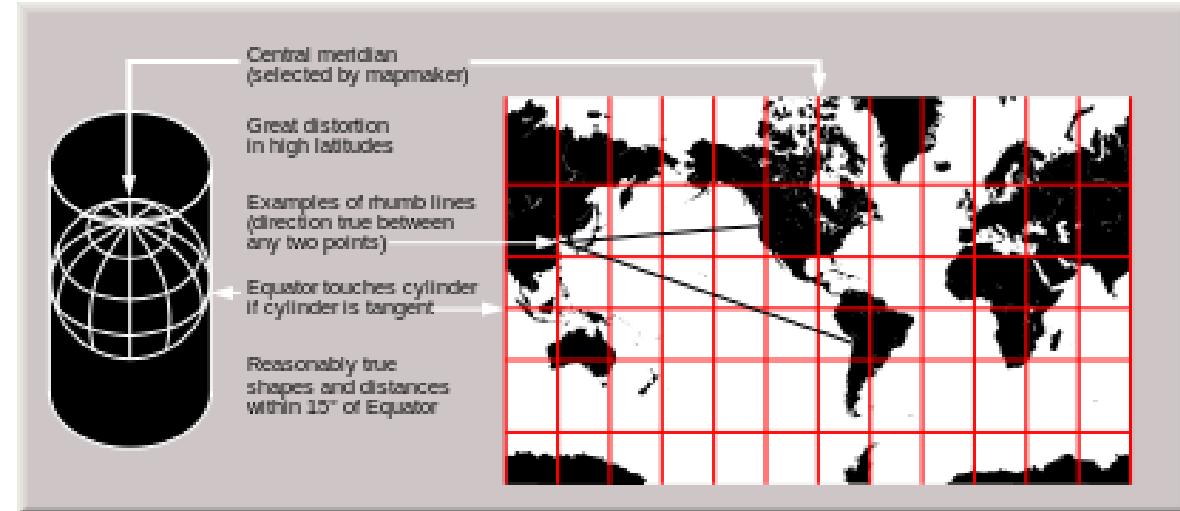
Dymaxion map



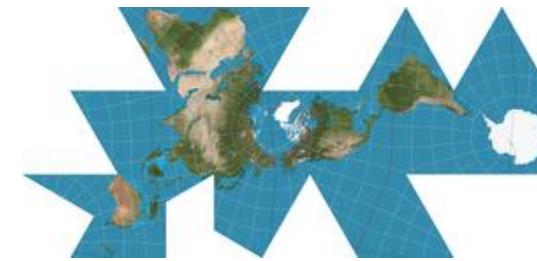
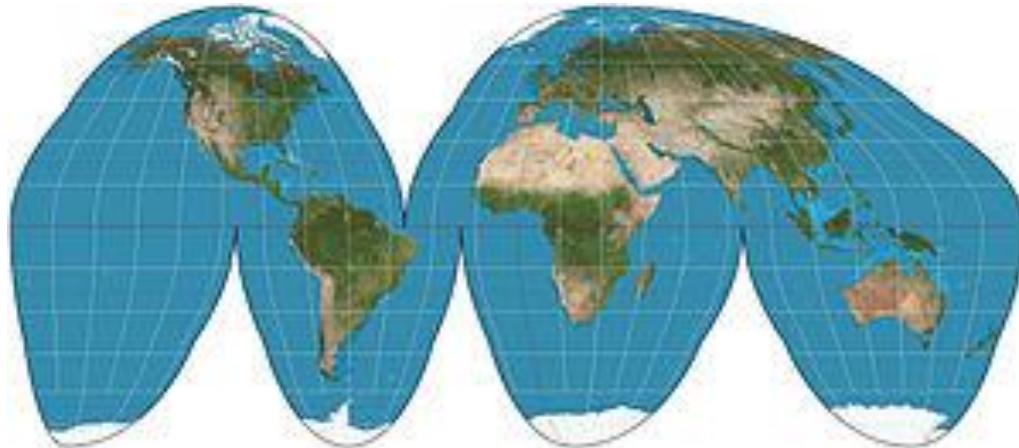
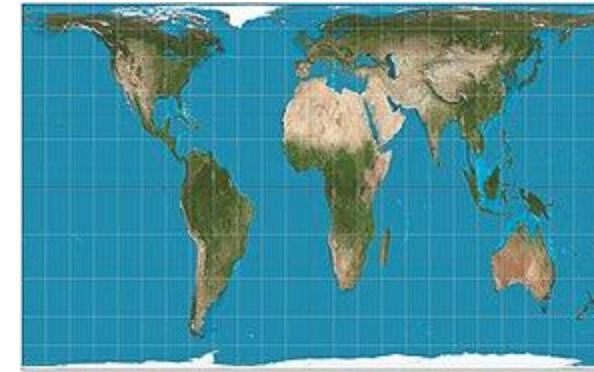
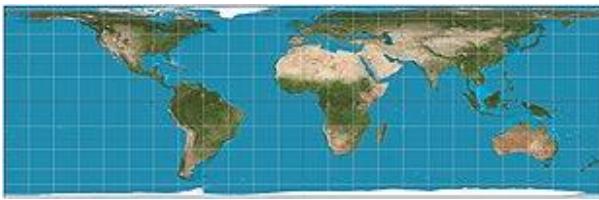
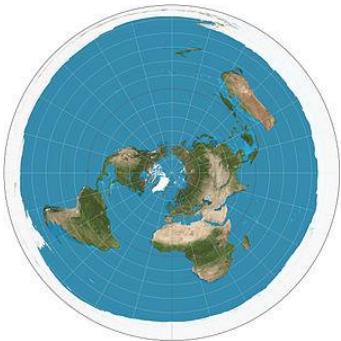
Raster projections: There is no one to one match

Behrman

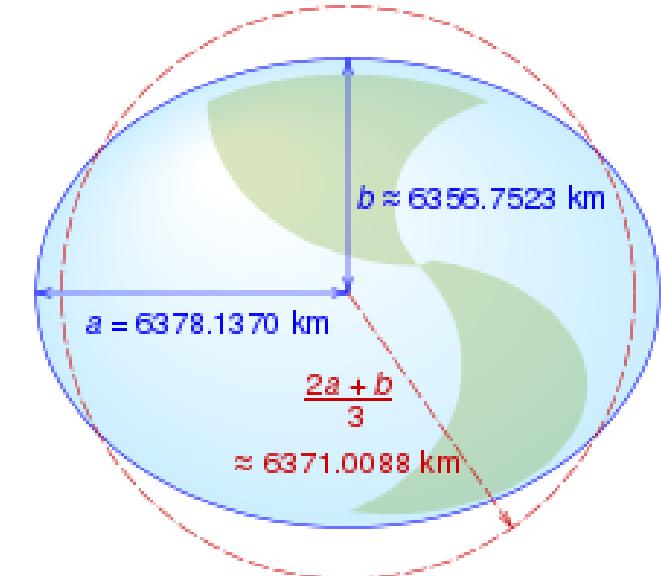
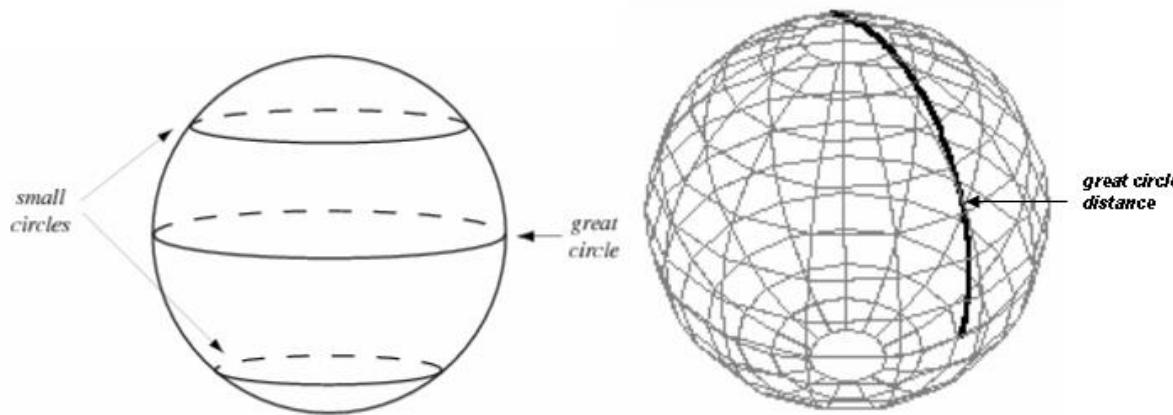
Latitude	Cell height
0	0.7
30	1
90	~10



Distances can rarely be measured

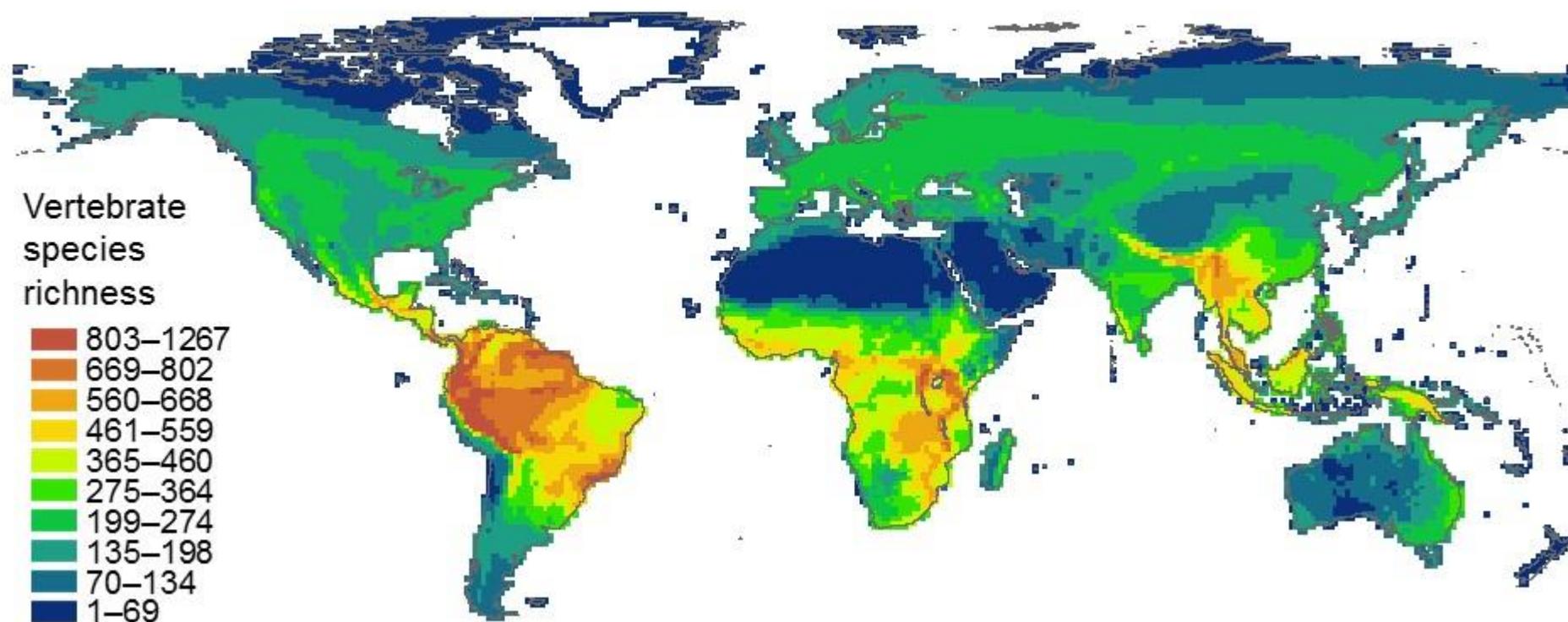


Great circle distance



Spatial analyses: The biology

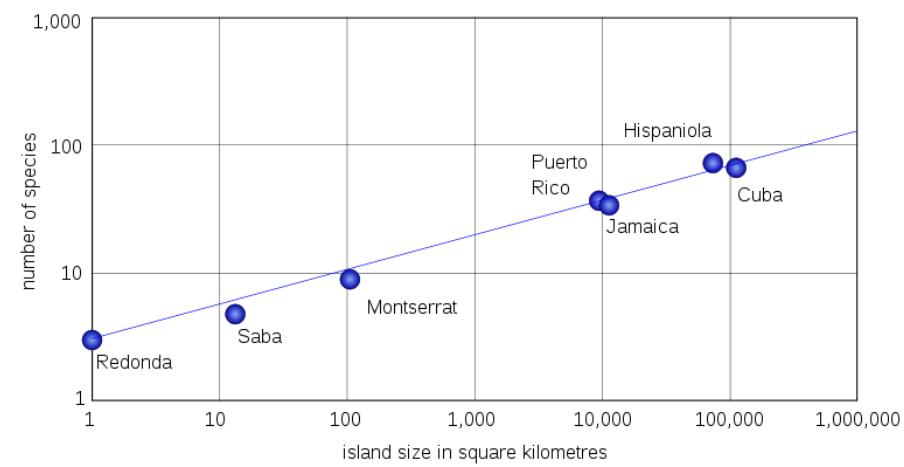
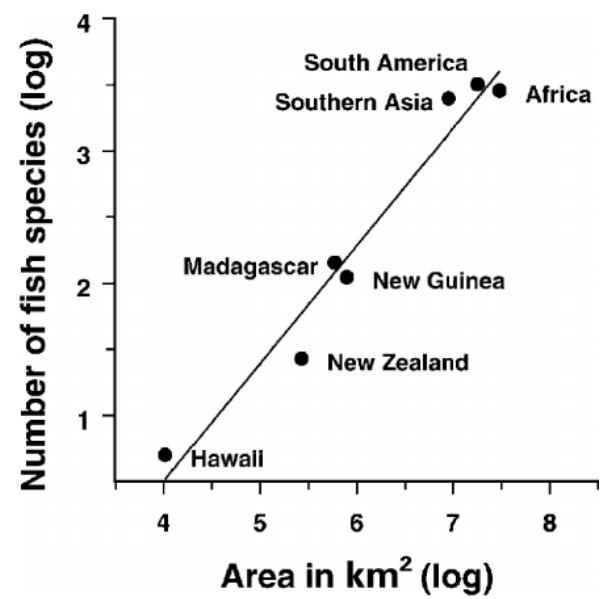
Global biodiversity



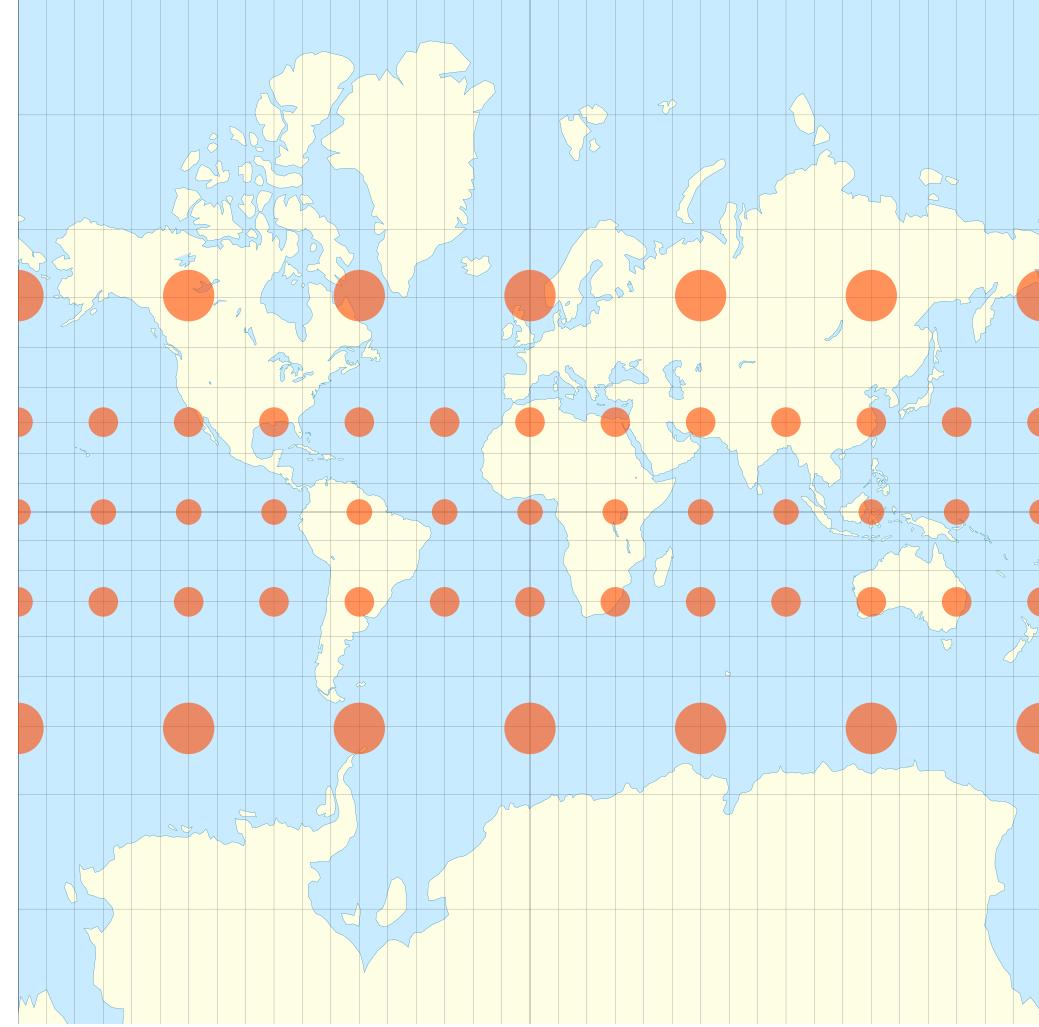
What scale makes sense?



Larger areas have more species



Do not analyze lat long diversity



Cells should be quadratic (if possible)

UDEL v3.01

Ann. mean temperature 1951-80

glb. mean: 8.77 degC

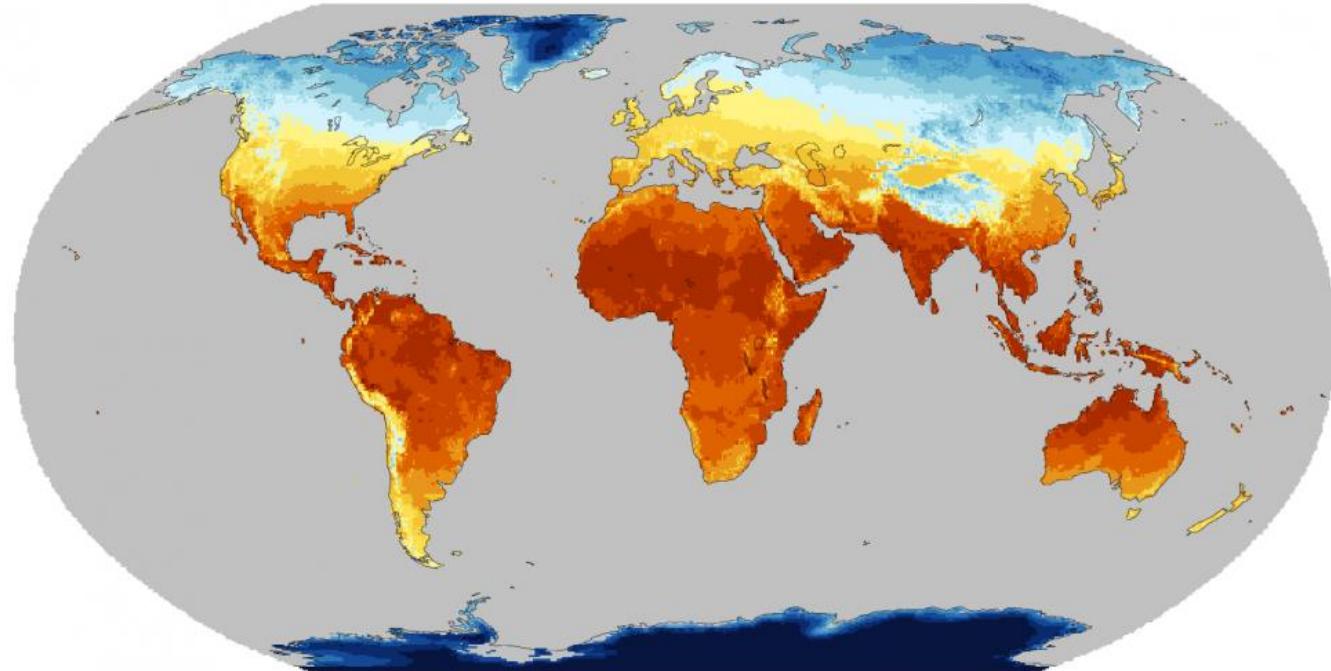
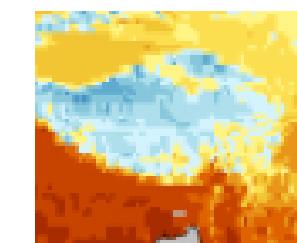
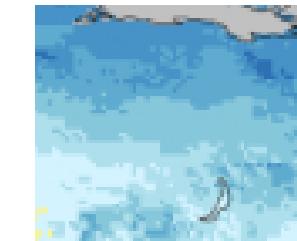
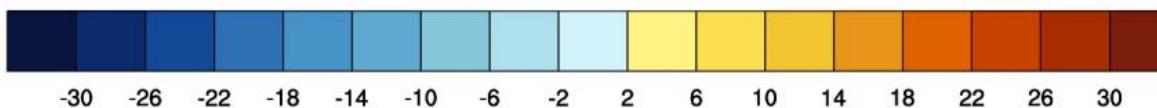
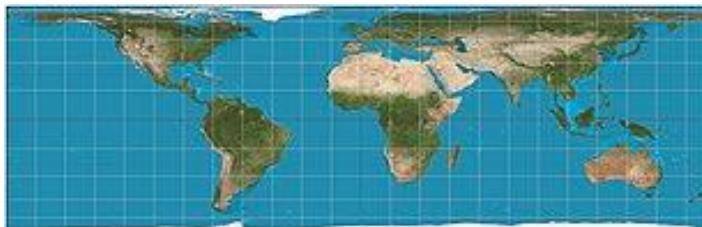
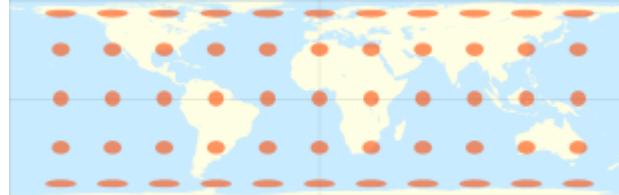


figure credit: National Center for Atmospheric Research, climatedataguide.ucar.edu (D. Schneider)

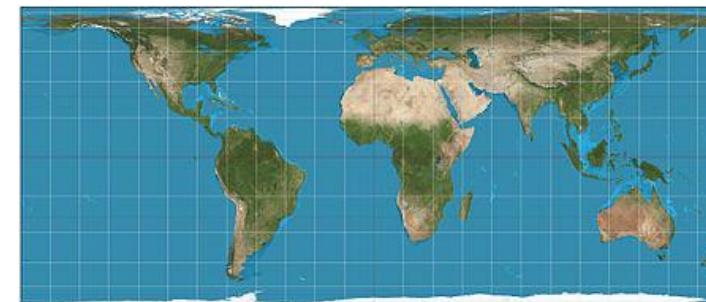
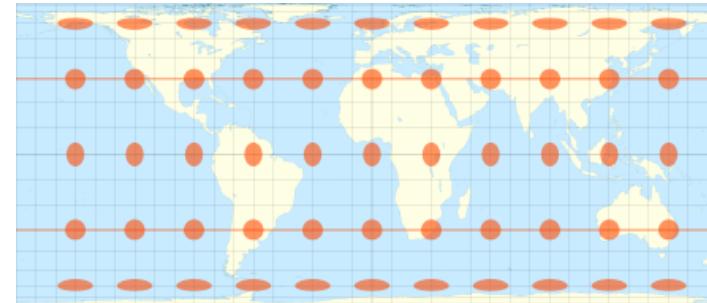


Cylindrical equal area projections are problematic

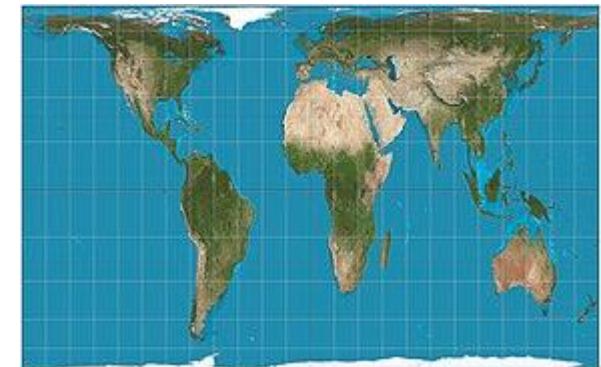
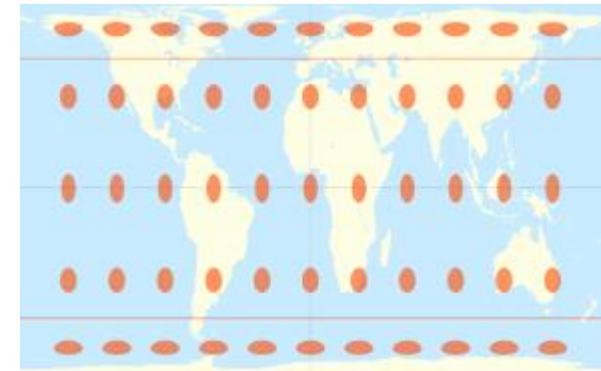
Lambert projection
(0 degrees)



Behrman
(30 degrees)



Gall–Peters projection
(45 degrees)



Think about the biology

BIO1 = Annual Mean Temperature

BIO2 = Mean Diurnal Range (Mean of monthly (max temp - min temp))

BIO3 = Isothermality (BIO2/BIO7) ($\times 100$)

BIO4 = Temperature Seasonality (standard deviation $\times 100$)

BIO5 = Max Temperature of Warmest Month

BIO6 = Min Temperature of Coldest Month

BIO7 = Temperature Annual Range (BIO5-BIO6)

BIO8 = Mean Temperature of Wettest Quarter

BIO9 = Mean Temperature of Driest Quarter

BIO10 = Mean Temperature of Warmest Quarter

BIO11 = Mean Temperature of Coldest Quarter

BIO12 = Annual Precipitation

BIO13 = Precipitation of Wettest Month

BIO14 = Precipitation of Driest Month

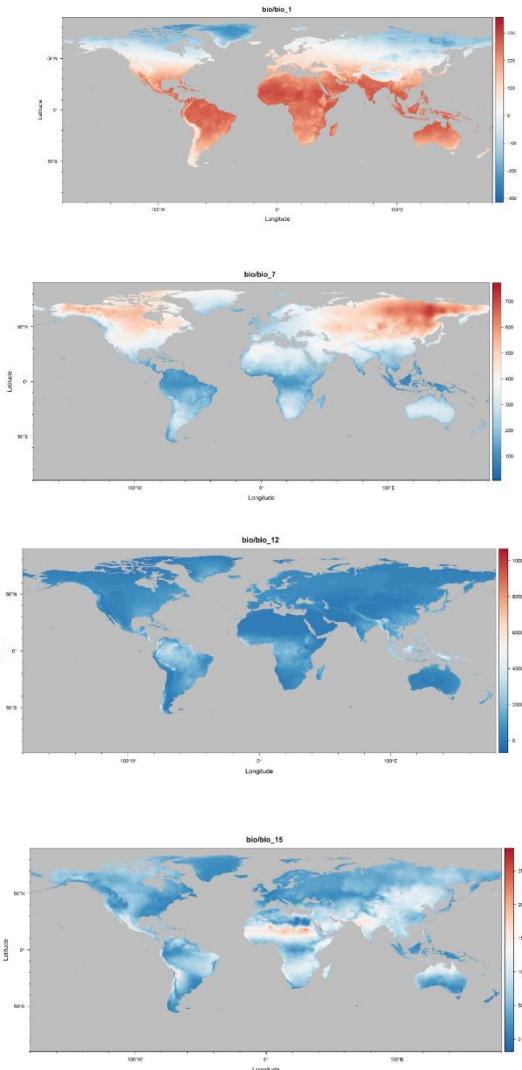
BIO15 = Precipitation Seasonality (Coefficient of Variation)

BIO16 = Precipitation of Wettest Quarter

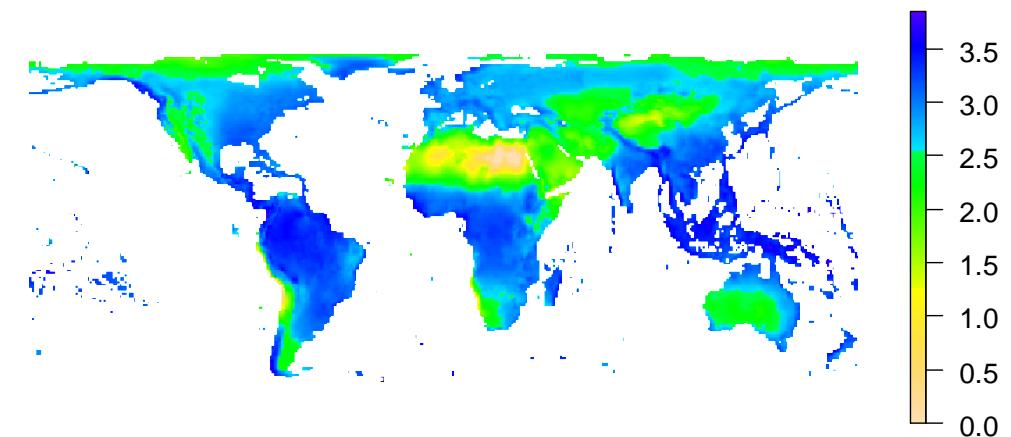
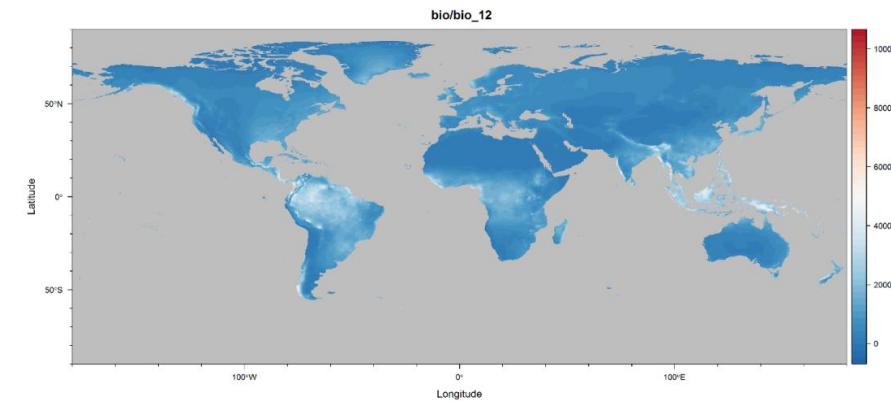
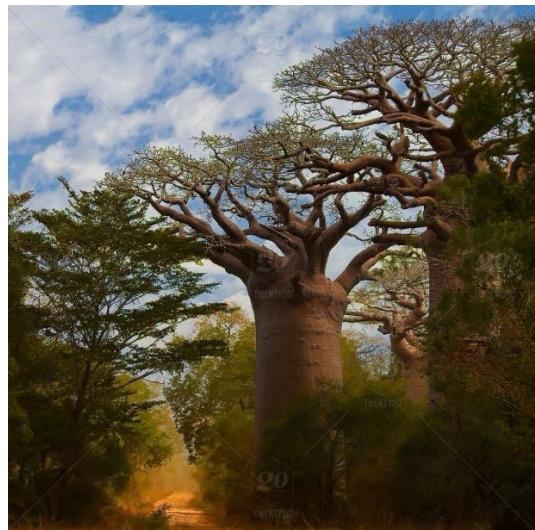
BIO17 = Precipitation of Driest Quarter

BIO18 = Precipitation of Warmest Quarter

BIO19 = Precipitation of Coldest Quarter



Data transformation

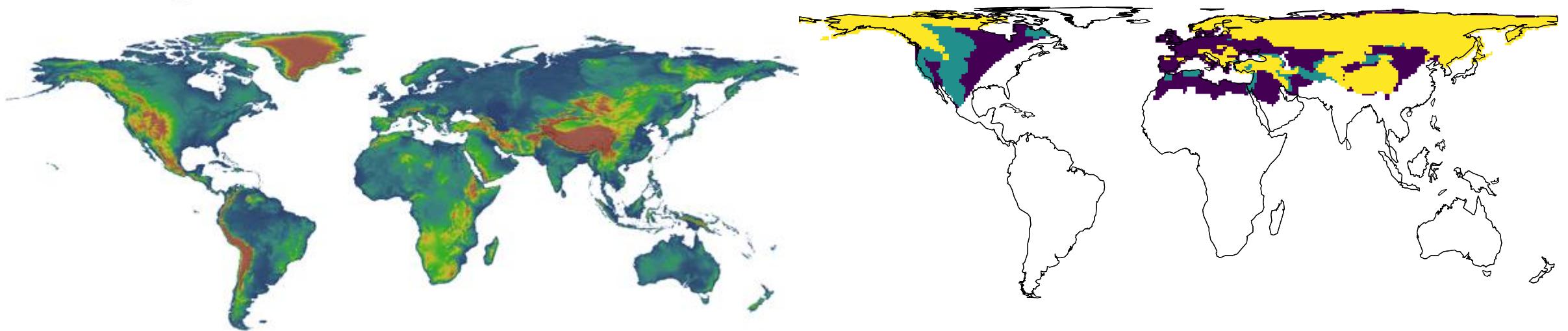


Interannual climatic variation

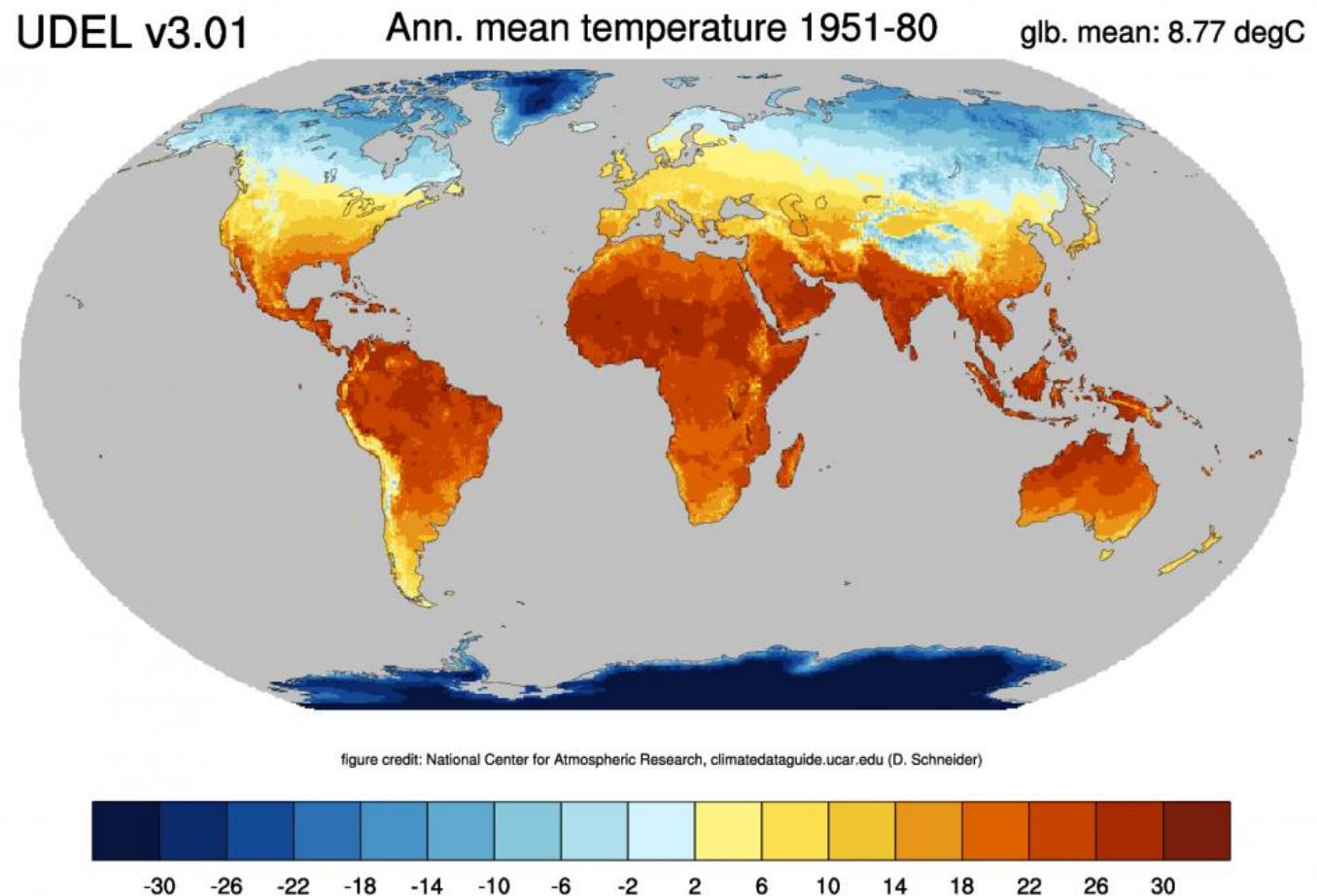


What does predictors mean?

SRTM 90m Digital Elevation Data



Spatial analyses: The analyses



Linear regression

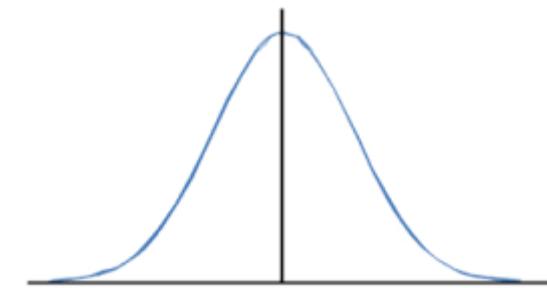
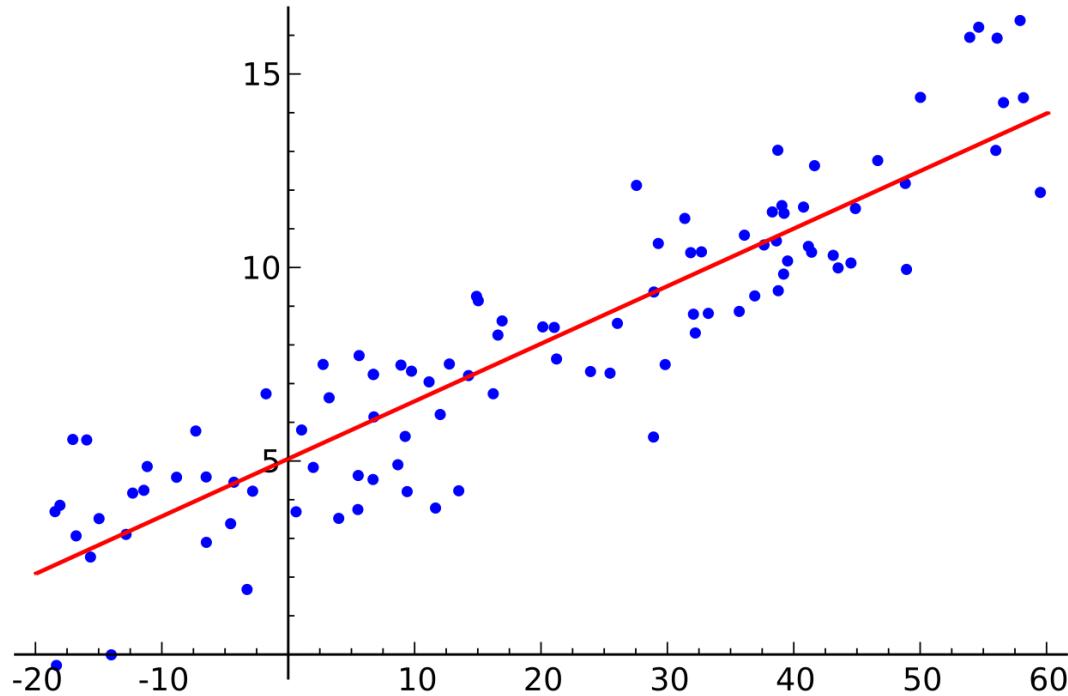
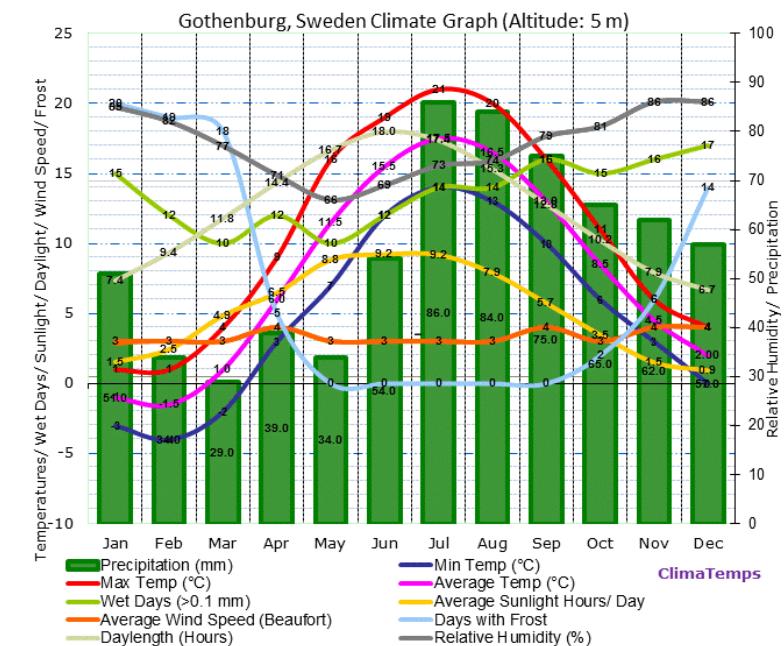
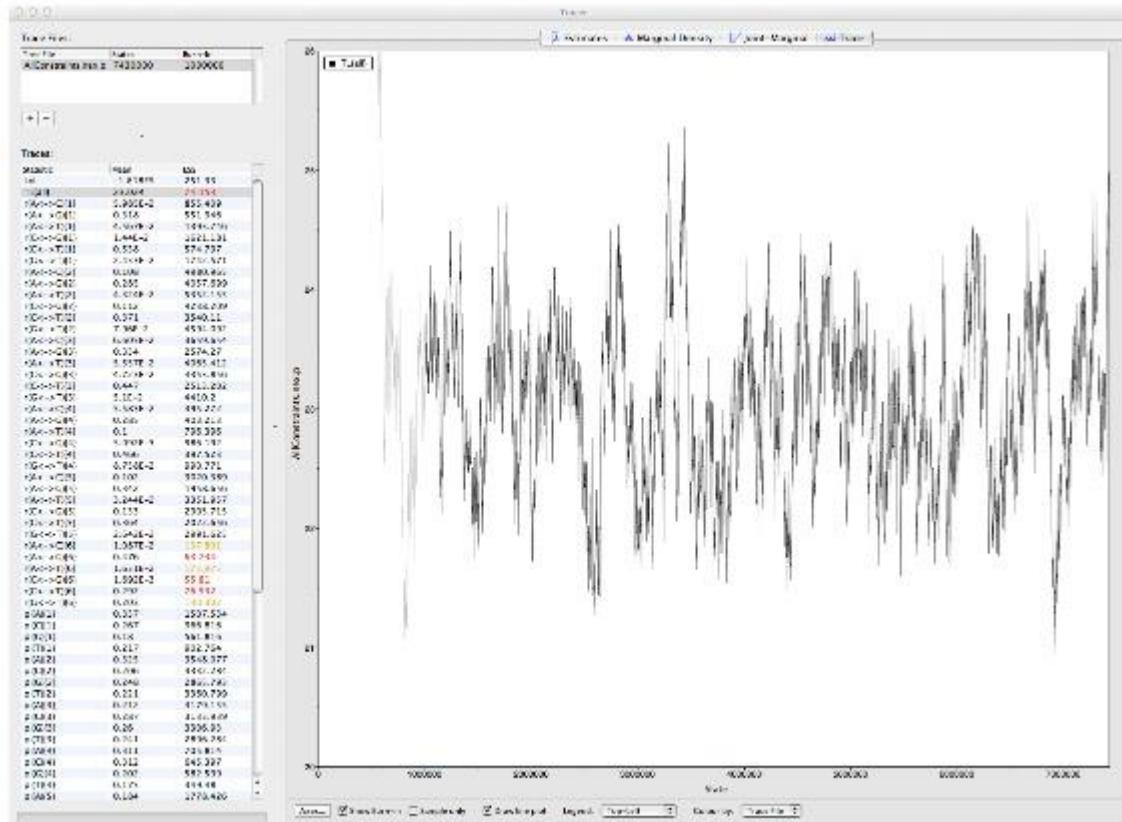


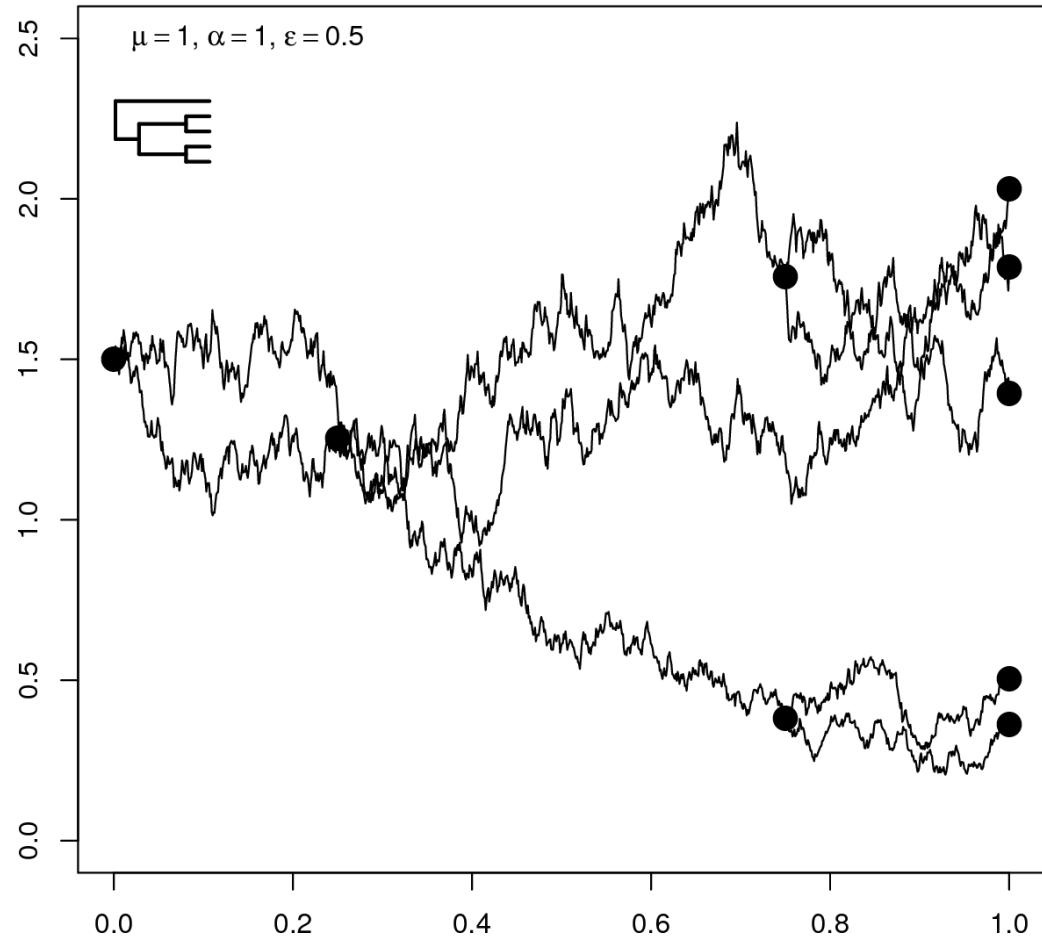
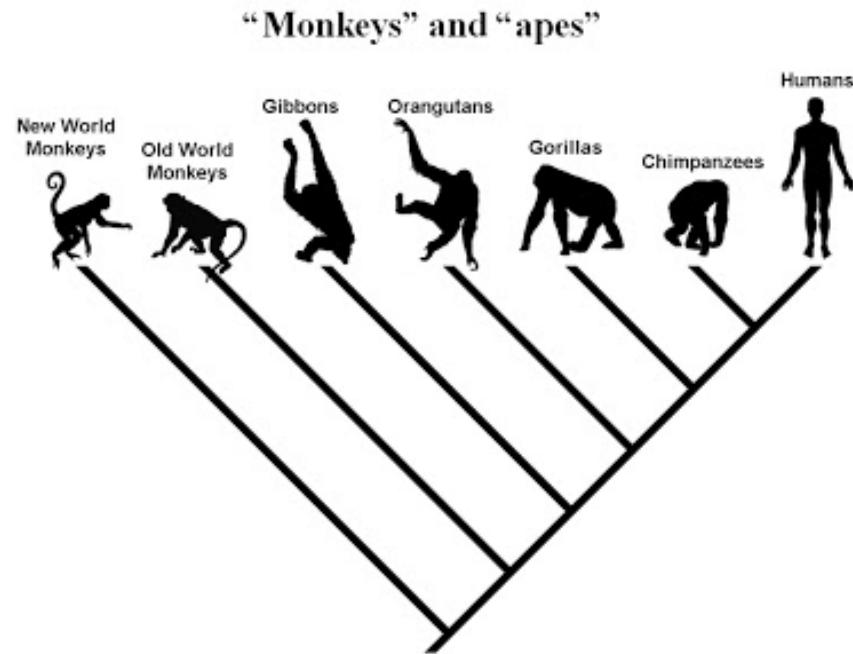
Figure 1 Normal distribution curve.

$$Y_i = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \dots + \varepsilon_i$$

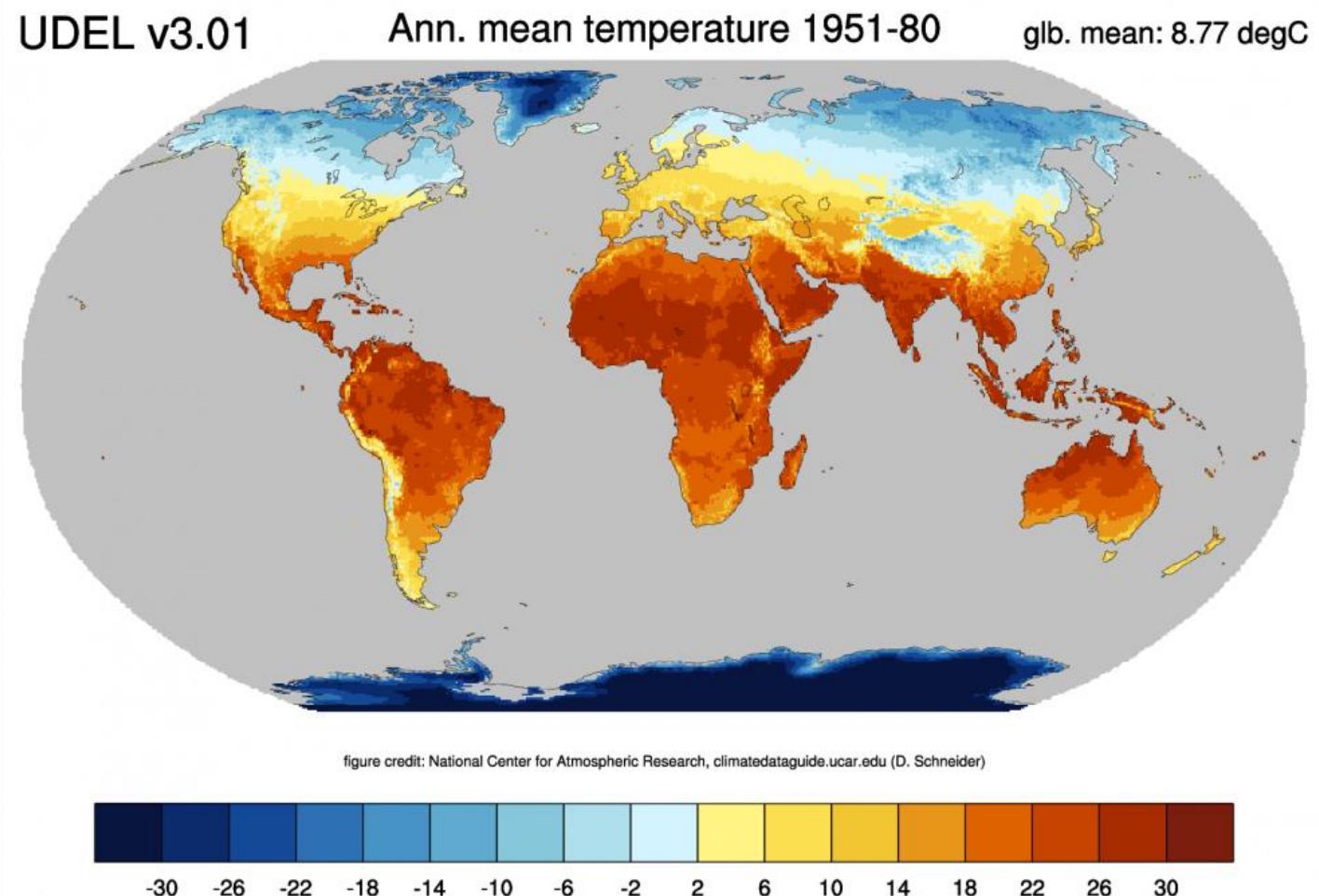
Temporal autocorrelation



Phylogenetic autocorrelation (e.g brownian motion)



Spatial autocorrelation



Formula for Moran's I

$$I = \frac{N \sum_{i=1}^n \sum_{j=1}^n w_{ij} (x_i - \bar{x})(x_j - \bar{x})}{(\sum_{i=1}^n \sum_{j=1}^n w_{ij}) \sum_{i=1}^n (x_i - \bar{x})^2}$$



- Where:

N is the number of observations (points or polygons)

\bar{x} is the mean of the variable

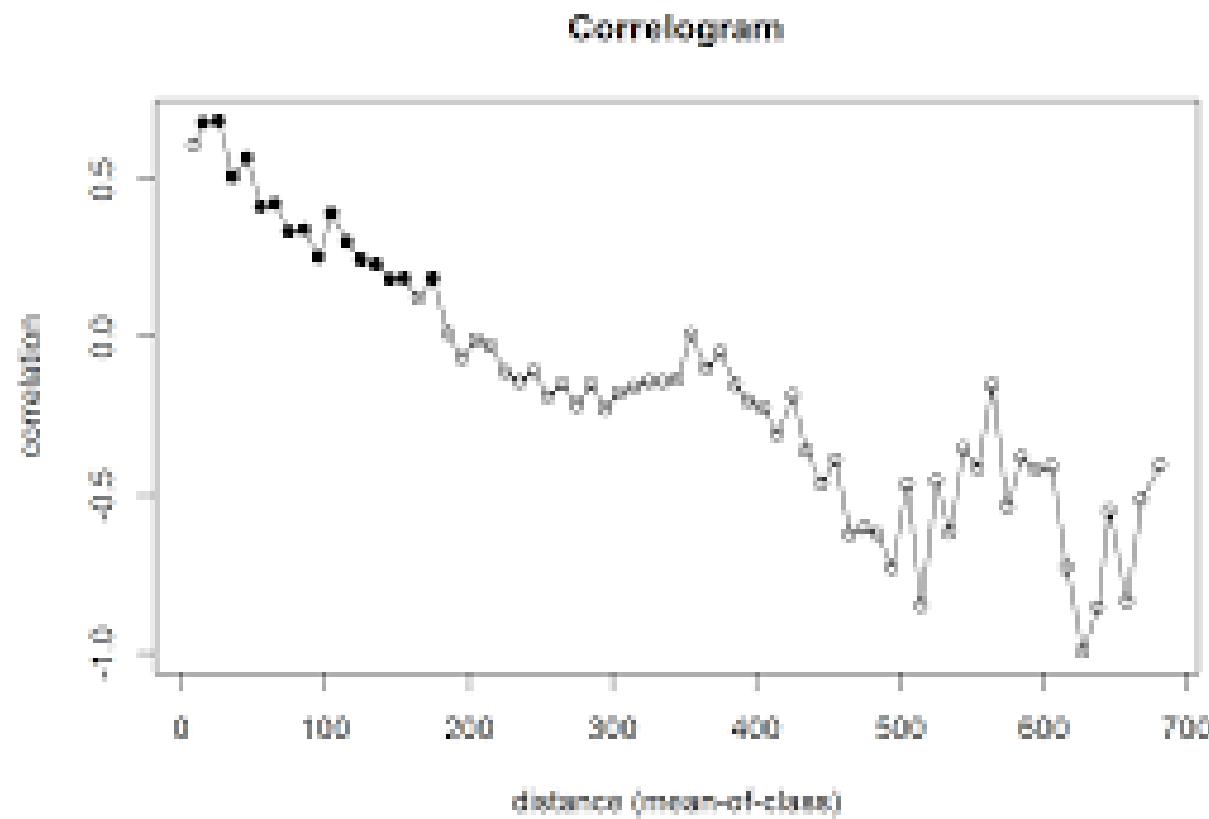
x_i is the variable value at a particular location

x_j is the variable value at another location

w_{ij} is a weight indexing location of i relative to j

(or dumbed down)

Morans I varies between -1 and 1. 1 is perfect positive correlation



Spatial Simultaneous Autoregressive Error Model

$$\text{SAR}_{\text{err}} \quad Y_i = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} \dots + \lambda W u + \varepsilon_i$$

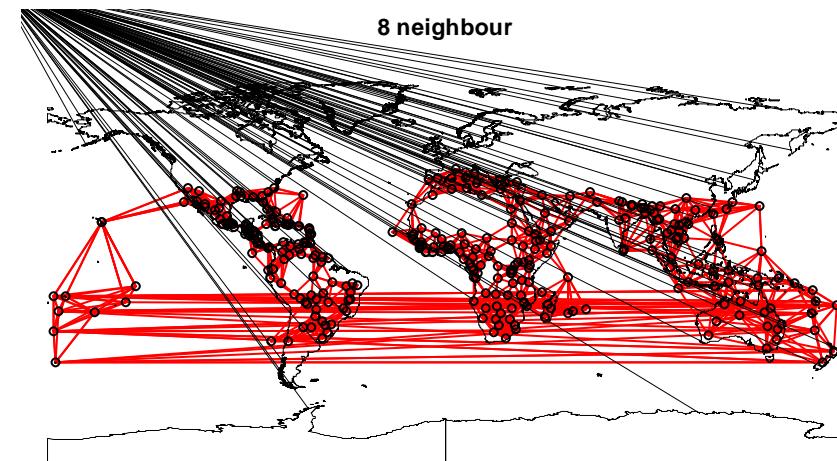
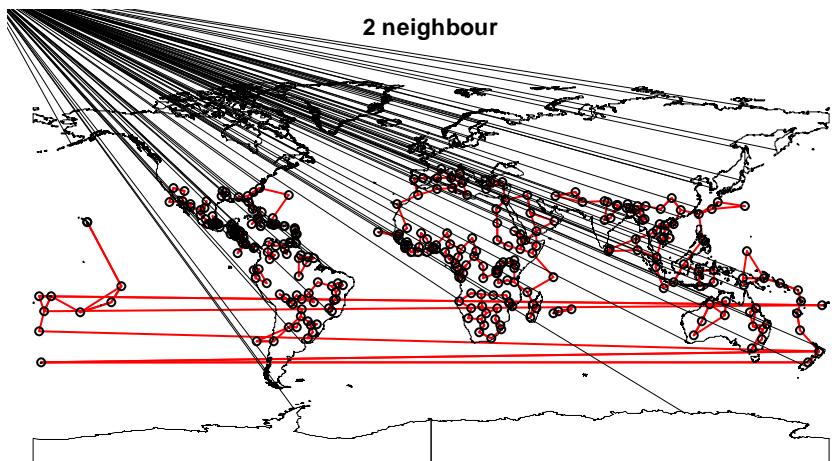
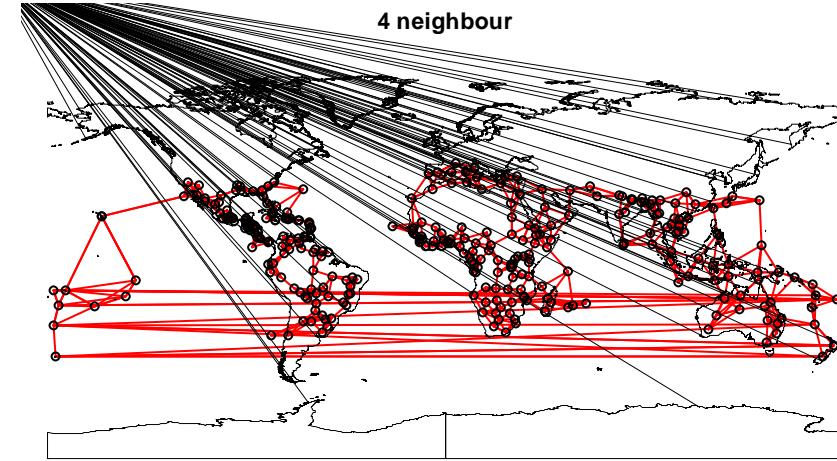
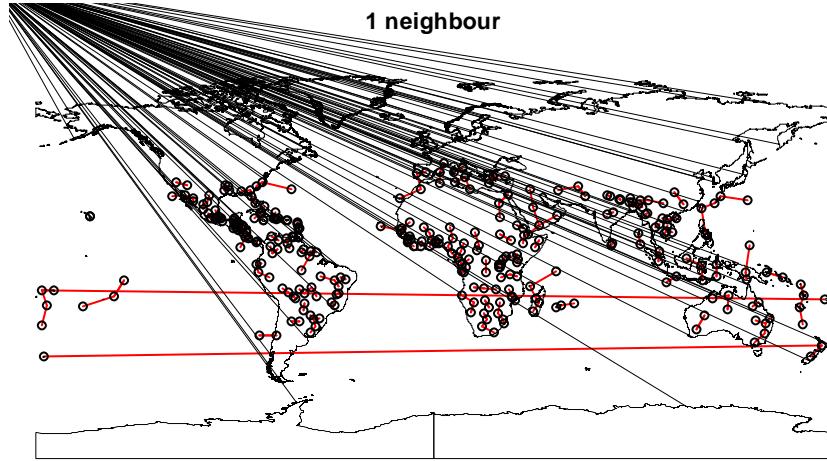
$$\text{LM} \quad Y_i = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} \dots + \varepsilon_i$$

$$\text{SAR}_{\text{lag}} \quad Y_i = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} \dots + \rho W Y_i + \varepsilon_i$$

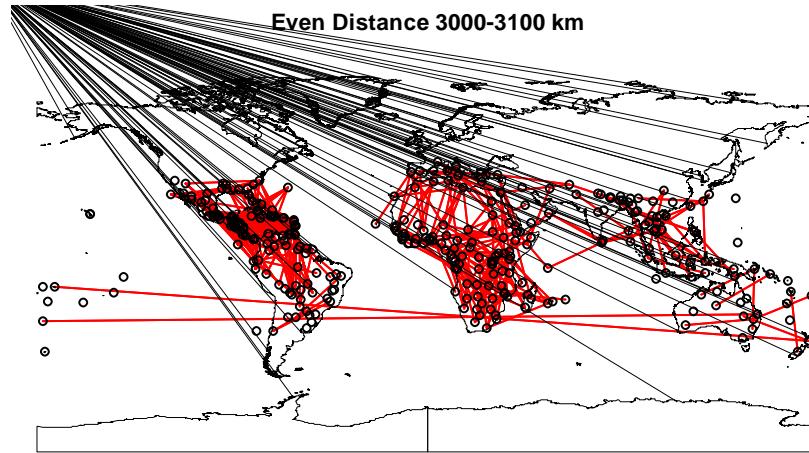
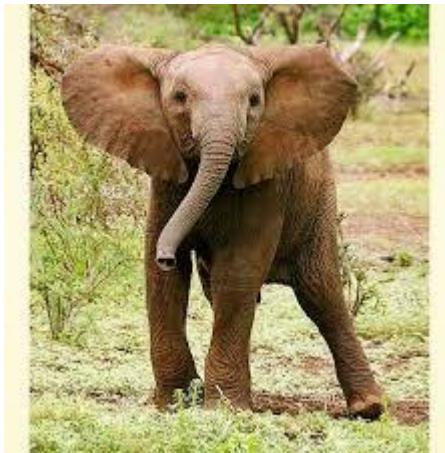
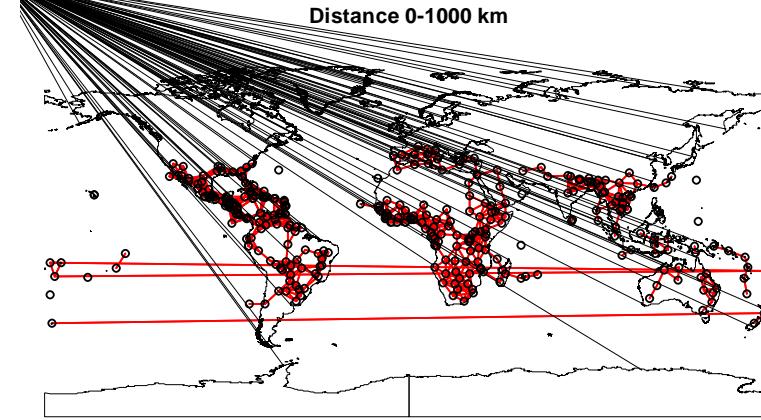
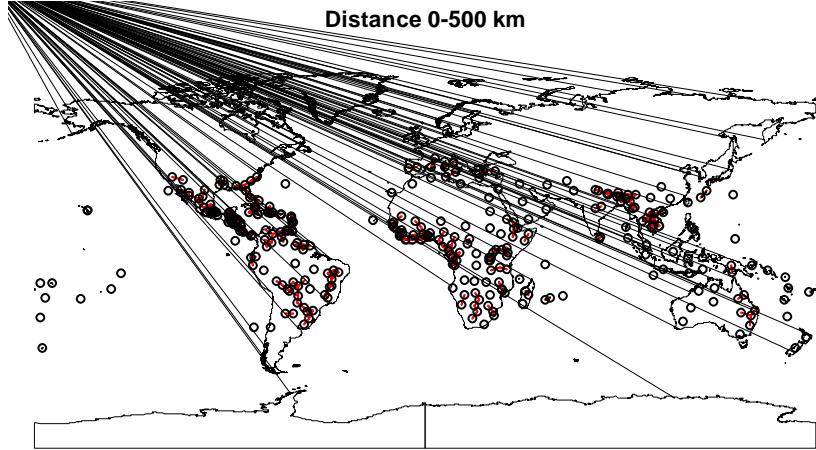
$$\text{SAR}_{\text{mix}} \quad Y_i = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} \dots + \rho W Y_i + \lambda W u + \varepsilon_i$$



Wu: u: Neighborhood: Number



Wu: u: Neighborhood: Distance



Wu: W: Neighborhood: Weight

$$\text{SAR}_{\text{err}} \quad Y_i = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} \dots \lambda W_u + \varepsilon_i$$

- W
 - [[1]] : 0.33 0.33 0.33
 - [[2]] : 0.20 0.20 0.20 0.20 0.20
- B
 - [[1]] : 1 1 1
 - [[2]] : 1 1 1 1 1
- C
 - [[1]] : 0.06 0.06 0.06
 - [[2]] : 0.06 0.06 0.06 0.06 0.06 B
- U
 - [[1]] : 0.0002 0.0002 0.0002
 - [[2]] : 0.0002 0.0002 0.0002 0.0002 0.0002
- S
 - [[1]] : 0.151 0.151 0.151
 - [[2]] : 0.117 0.117 0.117 0.117 0.117

